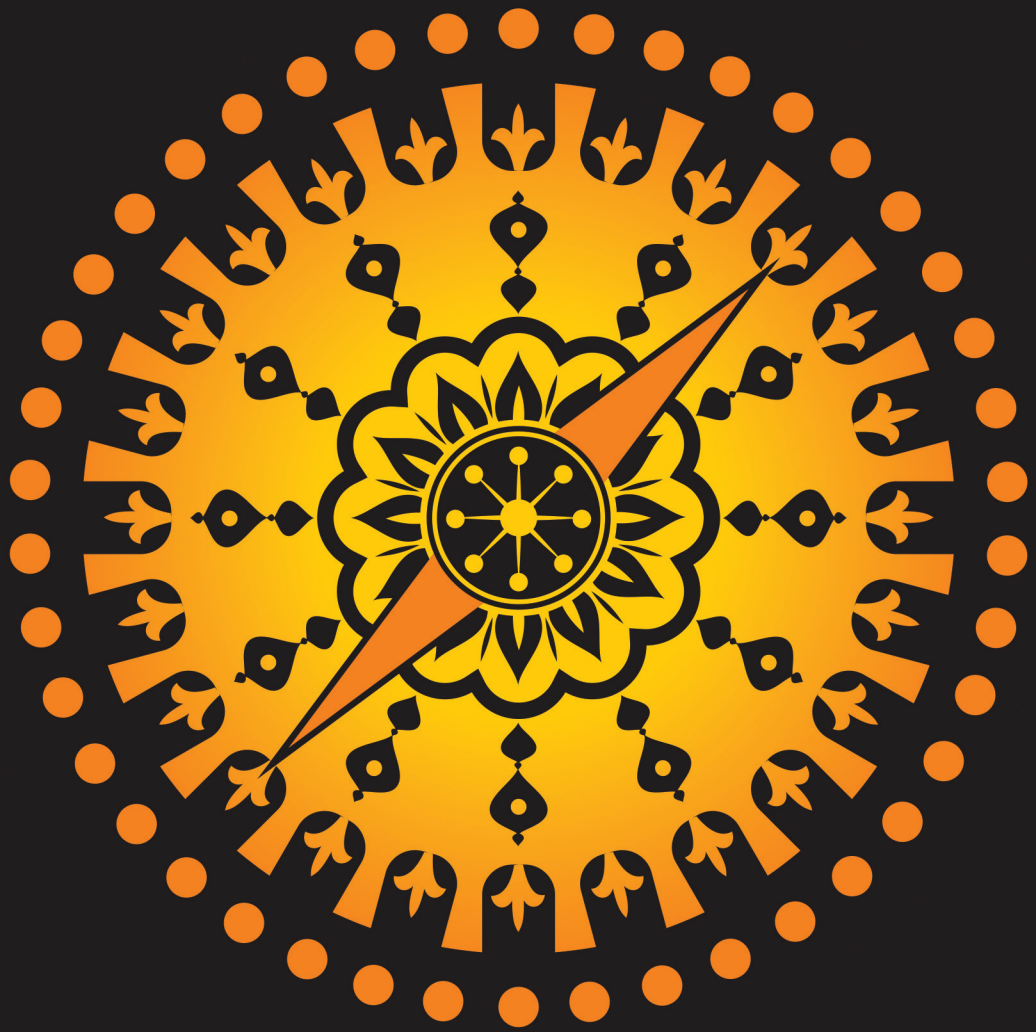
PROGRAM AND ABSTRACTS



# pages goa 2013

## 4TH OPEN SCIENCE MEETING

## THE PAST: A COMPASS FOR FUTURE EARTH

13 - 16 FEBRUARY

PAGES
PAST GLOBAL CHANGES

# THE PAST: A COMPASS FOR FUTURE EARTH

PAGES

PAST GLOBAL CHANGES

## 4th OPEN SCIENCE MEETING

Goa, India – 13 - 16 February 2013

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**Contents:**

## Welcome on behalf of the LOC

Welcome to PAGES Goa 2013!

The National Centre for Antarctic and Ocean Research, an autonomous research centre under the Ministry of Earth Sciences (Government of India) warmly welcomes the PAGES community to Goa. We are glad that PAGES has accepted our invitation to hold the 4th PAGES Open Science Meeting and the 2nd Young Scientist Meeting at Goa.

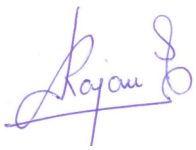
India is endowed with unique geomorphologic systems like the Himalayas, desert, large and small rivers, lakes of all dimensions in various climatic domains (ranging from humid to hyper arid) and surrounded by the distinctive Indian Ocean. These settings along with substantive historical and pre-historic records make India an ideal laboratory to test hypotheses relating to human-climate-environment interaction and better inform the future planning strategies. The changing climate and its visible strain on ecological and environmental systems in this part of the world necessitate an integrated approach in understanding the past, present and future of the monsoon systems and their global interactions.

India has a large community of scientists working in various aspects of palaeoclimatic research and has made substantive investments during the past decade in developing new laboratories and programmes for global change research. We sincerely hope that the 4th PAGES Open Science Meeting and the 2nd Young Scientist Meeting, happening for the first time in Indian subcontinent, would provide ample opportunities for scientist networking and developing new research collaborations. The excellent response to Goa meeting by the palaeo community is highly gratifying.

Success of any international conference of this magnitude requires generous funding support. I wish to place on record the generous funding we have received from the Ministry of Earth Sciences, Government of India, which helped us to support large number of international scientists as well as Indian scientists. I further like to thank the National Institute of Ocean Technology (Chennai), Indian National Centre for Ocean Information Services (Hyderanad), and Indian Institute of Tropical Meteorology (Pune) for helping us to make this conference a success.

I am confident that Goa with its magnificent beaches, rich cultural heritage, delectable cuisine and wonderful people will provide an ideal locale for a relaxed yet scientifically intense workshop. I look forward to an excellent meeting that would enhance the scientific knowhow on global change and would lead to tangible scientific outputs.

I wish you a fruitful meeting and a pleasant stay in Goa!



*S. Rajan*

*Chairman, Local Organizing Committee*

## Welcome on behalf of PAGES

PAGES (Past Global Changes) is a core project of the International Geosphere-Biosphere Programme (IGBP). It serves the Global Change community by supporting science aimed at understanding the Earth's past climate and environment, with the ultimate goal of assisting future projections. While the specific themes have shifted over the years, the underlying role of PAGES has always remained that of an integrative mediator between paleoscience disciplines and communities, and between observational and predictive Global Change science.

PAGES 1st Open Science Meeting (OSM) was held in the UK in 1998, the second 2005 in China, and the third 2009 in the USA. We now have the pleasure of welcoming you to the forth PAGES OSM, being held in India. The choice of location, for the fist time following a competitive bidding process, reflects that PAGES is committed to involving the international paleoscience community in a truly global sense. Bridging national boundaries and cultural differences for the benefit of the science is considered part of the mandate of PAGES. We are therefore grateful for the engagement of our local hosts and all organizers, and for the generous support from our Indian and international co-sponsors (page 26), who collectively provided the ground for this meeting.

As in previous PAGES OSMs, the meeting is designed to encourage interaction between scientists from all career levels, disciplines and regions. Furthermore, we anticipate that the meeting will inspire new ideas for ongoing and new PAGES activities. However, the context of this 4th OSM is particularly dynamic because the institutional and financial infrastructure of Global Change science is in motion. This is reflected by the ongoing transition of the large Global Change programs, including the above-mentioned IGBP, into one super-program. Drivers of this transition are wishes to integrate aspects of natural and social sciences, and to involve various users of Global Change research.

The new super-program is called "Future Earth – research for global sustainability". With that information in mind you can read between the lines of the title of this PAGES OSM "The Past: A Compass for Future Earth". Indeed, an added objective of this meeting is to stimulate discussions about how we can make sure that "Past Global Changes" continues to flourish, both, as a subject for exciting research and as a community-driven coordination project (PAGES).

The time scales for environmental sustainability are in all cases longer than political turnover, in most cases longer than a human generation, and in many cases even longer than the historical record. Thus, sustainability in the true sense can only be assessed with a long-term view on earth system dynamics. Among all core projects across all Global Change programs, this view is only provided by PAGES. It is therefore exclusively in our hands to contribute with long-timescale science to the goals of Future Earth.

We wish everyone a fruitful and stimulating meeting, and a very pleasant stay in Goa.

*Thorsten Kiefer and Lucien von Gunten*

*PAGES Executive Director and Science Officer*

*Hubertus Fischer and Alan Mix*

*PAGES Co-Chairs*

## Acknowledgements: OSM Sponsors


**Main Sponsors:**

MoES, Ministry of Earth Sciences, India
www.dod.nic.in

NCAOR, National Centre for Antarctic and Ocean Research, Goa, India
www.ncaor.gov.in

NSF, National Science Foundation, USA
www.nsf.gov

SNSF, Swiss National Science Foundation, Switzerland
www.snf.ch

**Other Sponsors:**

APN, Asia-Pacific Network for Global Change Research
www.apn-gcr.org

START, System for Analysis, Research and Training
www.start.org

IGBP, International Geosphere-Biosphere Programme, Brazil Regional Office
www.inpe.br/igbp/

NOAA, National Oceanic and Atmospheric Administration, USA
www.noaa.gov

NIOT, National Institute of Ocean Technology, India
www.niot.res.in

INCOIS, Indian National Centre for Ocean Information Services, India
www.incois.gov.in

IITM, Indian Institute of Tropical Meteorology, India
www.tropmet.res.in

OCCR, Oeschger Centre for Climate Change Research, University of Bern, Switzerland
www.oeschger.unibe.ch

IAS, International Association of Sedimentologists
www.sedimentologists.org

## Acknowledgements: OSM Committees and Organizers

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Lucien von Gunten, *Science Officer*
Saadia Iqbal, *Science Communicator*
*Barbara Gerber, Conference Coordinator*

# MEETING PROGRAM

**TUESDAY, 12 FEBRUARY**

19:00 Ice breaker at Cidade de Goa

**WEDNESDAY, 13 FEBRUARY**

**09:00-10:30 BLOCK 1 - Welcome & Plenary Session (Grande Sala)** Chair: S. Rajan

09:00-10:00 Welcome ceremony
Invocation
welcome addresses by representatives from politics, hosts, and organizers
Inauguration and lighting of lamp
Inaugural address

10:00-10:30 Plenary Talk: **Ashok Singhvi - Land-sea correlation: Pitfalls and remedies**

10:30-11:00 Coffee break

**11:00-12:30 BLOCK 2 - Oral sessions**

**Grande Sala**

**OSM01 Monsoons in Space and Time: Patterns, Mechanisms and Impacts**

Chair: Rajeev Saraswat, Ralph Schneider

*History of the Indian Monsoon recorded in Andaman Sea sediments*
**Ed Hathorne**, Liviu Giosan, Tim Collett

*Impact of insolation, fresh water fluxes and ice-sheet on Early Holocene monsoon characteristics*
**Pascale Braconnot**, Charline Marzin, Masa Kageyala, Anne-Marie Lézine

*Can South-West monsoon intensification develop a reduced condition in the Bay of Bengal sediments?*
**Jinnappa Pattan**, Ishfaq Ahmad Mir, Gopal Parthiban, Supriya Karapurkar, Vishnu Matta, Pothuri Naidu, S W A Naqvi

*The role of Asian monsoon dynamics for Late Quaternary lake level changes at the north-eastern Tibetan Plateau*
**Elisabeth Dietze**, Gregori Lockot, Kai Hartmann, Bernd Wünnemann,, Bernhard Diekmann, Georg Stauch

*What is the influence of Tibetan Plateau on the Asian summer monsoon? Barrier versus heating effect*
**Guangshan Chen**, Zhengyu Liu, John Kutzbach

*A high-resolution record of West African Monsoon variability for the past 530,000 years from Lake Bosumtwi, southern Ghana*
**Nicholas McKay**, Jonathan Overpeck, Timothy Shanahan, Erik Brown, John Peck, Clifford Heil, John King, Chris Scholz

**Sala de Banquete**

**OSM03 New Approaches to Data Assimilation and Data-Model Comparison**

Chair: Hugues Goosse

*Assimilation of time-averaged pseudo and real proxies for climate reconstruction*
**Nathan Steiger**, Gregory Hakim, Eric Steig, David Battisti, Gerard Roe

*Skill and reliability of climate model ensembles at the Last Glacial Maximum and mid-Holocene*
**Julia Hargreaves**, James Annan, Rumi Ohgaito, Andre Paul, Ayako Abe-Ouchi

*Lake Isotope – Climate Model comparisons: an iterative approach to improved palaeoclimate understanding?*
**Matthew Jones**, Steven Phipps

**OSM13 Past Warm Periods Informing the Anthropocene**

Chair: Stijn De Schepper

*About the difficulty to find a Pleistocene analogue to the Holocene and Anthropocene*
**André Berger**, Qiuzhen Yin, Nicholas Herold

*Pliocene Marine Isotope Stage (MIS) M: caused by a hiccup in the closure of the Panamanian Gateway*
**Jeroen Groeneveld**, Stijn De Schepper, B. David A. Naafs, Martin J. Head, Jan Hennissen, Cederic Van Renterghem, Stephen Louwye

*The relative roles of $CO_2$, palaeogeography and vegetation in determining late Miocene climate: results from a terrestrial model-data comparison*
**Catherine Bradshaw**, Daniel Lunt, Rachel Flecker, Ulrich Salzmann, Matthew Pound, Alan Haywood, Jussi Eronen

12:30-14:00 Lunch

**14:00-15:30 BLOCK 3 - Oral sessions**

**Grande Sala**

**OSM01 (Continued)**

Chair: Rajeev Saraswat, Ralph Schneider

*Novel precipitation isotope records address a long-standing debate about East Asian cave oxygen isotope records*
**Elizabeth Thomas**, Steve Clemens, Tim Herbert, Yongsong Huang, Warren Prell, Jaap Sinninghe Damsté, Youbin Sun

*Deglaciation in the tropical Indian Ocean driven by interplay between the regional monsoon and global teleconnections*
**Rajeev Saraswat**, David Lea, Rajiv Nigam, Andreas Mackensen, Dinesh Naik

*Assessing the severity of monsoon decline during Heinrich events*
**Syee Weldeab**

*Long term Monsoon variability inferred from lake sediments on the Tibetan Plateau*
**Roland Mäusbacher**, Zhu Liping, Daut Gerhard, Doberschütz Stephan, Wang Junbo, Haberzettl Torsten

*Glacial to Holocene changes in African monsoon according to deuterium isotope signals from alkenones and n-alkanes*
**Ralph R Schneider**, Guillaume Leduc, Yiming Wang, Julian Sachs, Nils Andersen

*Monsoon Climate Sensitive Tree-Ring Chronologies of Teak* (Tectona grandis L. F.) *from central India and their teleconnection with ENSO*
**Hemant Borgaonkar**

**Sala de Banquete**

**OSM16 Open Session on Latest Highlights in Paleoscience**

Chair: Denis-Didier Rousseau, Liping Zhou

*A global reconstruction of temperature changes at the Last Glacial Maximum*
**James Annan**, Julia Hargreaves

*A unique long proxy record from Sokli in the central area of Fennoscandian glaciations drastically changes classic concepts of glaciations, vegetation and climate in N Europe during the Late Pleistocene*
**Karin F. Helmens**

*Mid-Brunhes shift in continental weathering intensity and its feedback with atmospheric $CO_2$: insights from a new ice core proxy*
**Jochen Schmitt**, Barbara Seth, Peter Köhler, Jane Willenbring, Hubertus Fischer

*Antarctic deglaciation rewritten – highly dynamic ice-sheet disintegration during meltwater pulses and contribution to sea-level rise*
**Michael E. Weber**, Peter U. Clark, Rupert Gladstone, Axel Timmermann, Gerrit Lohmann, Gerhard Kuhn, Daniela Sprenk

*Is the current rapid warming of the Antarctic Peninsula unprecedented?*
**Robert Mulvaney**, Nerilie Abram, Richard Hindmarsh, Carol Arrowsmith, Olivier Alemany

*Millennial and sub-millennial scale variations in rainfall revealed by chinchilla rat* (Abrocoma) *middens over the last 16,400 years in the central Atacama Desert*
**Claudio Latorre**, Francisco J. Gonzalez, M. Ignacia Rocuant, John Houston, Maisa Rojas

15:30-16:00 Coffee break

# MEETING PROGRAM

**WEDNESDAY, 13 FEBRUARY (continued)**

**16:00-18:00** **BLOCK 4 - Poster Sessions**

## OSM01 Monsoons in Space and Time: Patterns, Mechanisms and Impacts

Chair: Rajeev Saraswat, Ralph Schneider

**OSM01-19** *Abrupt changes in the strength of the Indian Summer Monsoon during late glacial to Holocene evidenced by episodic increases in Ayeyarwady outflow to the Andaman Sea*
**Sijinkumar A.V.**, B.N. Nath

**OSM01-07** *Documentary reconstruction of rainfall variability over western India, 1781-1860*
**George Adamson**, David Nash

**OSM01-30** *Paleoclimatogy in the South Equatorial Indian Ocean*
**Celsa Almeida**, Maruthadu Sudhakar, Manish Tiwari

**OSM01-08** *Monsoon circulation strength inferred from a multicentury tree-ring stable isotope chronology from southeast Asia*
**Kevin Anchukaitis**, Mary Gagen, Brendan Buckley, Dario Martin-Benito, Caroline Ummenhofer, Le Canh Nam

**OSM01-29** *Indian monsoonal rainfall variation in last 100 ka: A case study from western part of India*
**Sayak Basu**

**OSM01-01** *Investigation of extreme Phases of the Indian Summer Monsoon during the last Millennium using the Regional Climate Model COSMO-CLM*
**Daniel J. Befort**, Stefan Polanski, Gregor C. Leckebusch, Ulrich Cubasch

**OSM01-05** *Monsoonal variability during the Holocene: An integrated data and modeling study*
Eli Biton, **Hezi Gildor**, Gabriele Trommer, Michael Siccha, Michal Kucera, Marcel van der Meer, Stefan Schouten

**OSM01-33** *Quantified paleo-seasonality of the West African Monsoon in Senegal*
**Matthieu Carré**, Moufok Azzoug

**OSM01-36** *Intellectual Structure Of Monsoon Research- A Bibliometric Study*
**Prabir G Dastidar**, Olle Persson

**OSM01-32** *History of terrestrial precipitation in the Amazon basin (South America) during the last 240 ka*
**Aline Govin**, Janis Ahrens, David Heslop, Matthias Zabel, Stefan Mulitza, Cristiano M. Chiessi

**OSM01-24** *Climate instability and monsoon variability during the past 45,000 years in NW China derived from desert lake records*
**Kai Hartmann**, Bernd Wünnemann

**OSM01-35** *Glacial terminations and periodicities for the last 800 kyr: Constraints from the bulk magnetic susceptibility record, the southeastern South China Sea*
**Selvaraj Kandasamy**, Victor Manuel Velasco, Wille Soon, Min-Te Chen, Teh-Quei Lee, Shuh-Ji Kao

**OSM01-18** *Variation in the Indian Summer Monsoon intensity during the Bølling-Ållerød and Holocene*
**Pratima Kessarkar**, V. Purnachadra Rao, S.W.A. Naqvi, Supriya Karapurkar

**OSM01-23** *Late-Pleistocene-Holocene basin filling by Himalayan sediments in Great Rann of Kachchh: A palaeoclimatic perspective*
**Nitesh Khonde**, Deepak Maurya, Ravi Bhushan, Archana Das, Parul Joshi, Laxman Chamyal

**OSM01-16** *Reconstruction of precipitation and primary productivity during Holocene using geochemical proxies from deep sea cores from the internal seas of the Philippines*
**Ronald Lloren**, Fernando Siringan, Alyssa Peleo-Alampay

**OSM01-17** *High resolution Indian summer monsoon variability record during the last deglaciation*
**Mahjoor Ahmad Lone**, Syed Masood Ahmad, Chuan Chou Shen , Anil Kumar

**OSM01-02** *Simulation of the East Asian Summer Monsoon during the Last Millennium with the MPI Earth System Model*
**Wenmin Man**, Tianjun Zhou, Johann Jungclaus

**OSM01-06** *Do instrumental data co-vary with the paleoclimate proxy records of Southern India?*
**Busnur Manjunatha**, Keshava Balakrishna, K.N. Prakash Narasimha

**OSM01-12** *Holocene climatic variability in lake Sonkul sediments (Kirghizstan, central Tien Shan): a monsoon influence in western Central Asia?*
Marie Mathis, **Philippe Sorrel**, Stefan Klotz, Hedi Oberhänsli

**OSM01-14** *Increased transport of summer monsoon moisture to the Higher Himalaya in the early Holocene*
**Narendra Kumar Meena**, Anil Kumar Gupta

**OSM01-11** *Incrusions of shorther wetter phases of SW Monsoon in an overall dry middle to late Holocene palaeoenvironment of Pookode Lake, South India*
Veena Nair M.P.**, Hema Achyuthan**, Christopher Eastoe

**OSM01-31** *Nd-Sr-Hf isotopes in fine detritus material in Red Sea cores as tracers of Sahara – Arabia dust storms and monsoonal rains during the past 140 ka*
Daniel Palchan, **Ahuva Almogi-Labin**, Mordechai Stein, Yigal Erel, Steve L. Goldstein

**OSM01-28** *Sr isotope study of Kaveri river – a potential proxy to infer the paleo-intensities of SW and NE monsoon in south India*
**Jitendra Kumar Pattanaik**, S. Balakrishnan, Rajneesh Bhutani

**OSM01-10** *Hydrological changes in the Gulf of California during the past 6200 cal yr BP and their relationship with ITCZ and North American Monsoon variability*
**Ligia Pérez-Cruz**, Jaime Urrutia-Fucugauchi

**OSM01-03** *Analysis of the South American Monsoon for the mid-Holocene considering the results of 7 different PMIP3-model outputs*
**Luciana Prado**, Ilana Wainer, Cristiano Chiessi

**OSM01-20** *Stepwise strengthening of Indian Summer Monsoon in the Bay of Bengal during last Glacial-Interglacial: Possible North Atlantic Tele-connection*
**Sanjeev Raghav**, Manish Tiwari, Koushik Dutta, G V Ravi Prasad

**OSM01-26** *Reconstruction of late Quaternary climate changes as derived from a pollen record from Lahaul Himalaya, Himachal Pradesh, India*
**Suman Rawat**, A. K. Gupta, S. J. Sangode, N. R. Phadtare, H. C. Nainwal

**OSM01-04** *Regional monsoon dynamics from small but complex paleoclimate networks*
**Kira Rehfeld**, Bedartha Goswami, Nora Molkenthin, Franziska Lechleitner, Sebastian F. M. Breitenbach, Ola Kwiecien, Norbert Marwan, Jürgen Kurths

**OSM01-15** *Holocene history of climate, vegetation and anthropogenic disturbance from core monsoon zone of central India as reflected in lacustrine sediments of Lonar Crater, Maharashtra*
**Nils Riedel**, Martina Stebich, Philip Menzel, Ambili Anoop, Saswati Sarkar, Sushma Prasad, Martin Wiesner, Dirk Sachse, Nathani Basavaiah

**OSM01-22** *Millennial-scale proxy records of the North American Monsoon from the arid northern Mexico over the last glacial period and Holocene*
**Priyadarsi D. Roy**

# MEETING PROGRAM

**WEDNESDAY, 13 FEBRUARY (continued)**

**16:00-18:00 BLOCK 4 - Poster Sessions (continued)**

**OSM01-09** *Fluctuations in the Indonesian-Australian Monsoon: New insights from the Flores stalagmite record.*
**Nick Scroxton**, Linda Ayliffe, Mike Gagan, John Hellstrom, Wahyoe Hantoro, Hamdi Rifai, Bambang Suwargardi

**OSM01-25** *Synchronous summer and winter monsoon breakdown in the Arabian Sea during glacial cold phases*
**Arun D. Singh**, Simon Jung, Kate Darling, Raja Ganeshram, Tara Ivanochko, Dick Kroon

**OSM01-21** *Variability in the strength of Monsoonal winds in the Western Arabian Sea since the Last Glacial Maximum: Evidence from Planktic Foraminifera and Oxygen isotope records*
**Ashutosh Singh**, Manish Tiwari, R Ramesh, Devesh Sinha

**OSM01-34** *Tropical Variations of the Global Monsoon Precipitation during Last Interglacial (Eemian)*
**Umesh Singh**, Qiuzhen Yin, Andre Berger

**OSM01-13** *Holocene vegetation and climate dynamics in Northeast China inferred from palynological analyses of the Sihailongwan maar lake sediments*
**Martina Stebich**, Frank Schlütz, Jens Mingram, Jiaqi Liu

**OSM01-27** *First Sub-centennial to Centennial Scale SST Record from the Eastern Arabian Sea*
**Manish Tiwari**, Siddhesh Nagoji, Kartik Thammisetti, Raja S. Ganeshram

### OSM03 New Approaches to Data Assimilation and Data-Model Comparison

Chair: Hugues Goosse

**OSM03-05** *Contrasting changes in vegetation and West African wind systems over the west African Sahel region during Heinrich Stadial 1*
**Ilham Bouimetarhan**, Matthias Prange, Enno Schefuß, Lydie Dupont, Jörg Lippold, Stefan Mulitza, Karin Zonneveld

**OSM03-11** *Oceanographic data-model comparisons: What exactly are we doing? A late Miocene case study*
**Catherine Bradshaw**, Rachel Flecker, Daniel Lunt, Ana Christina Ravelo, Eirik Vinje Galaasen, Howard Spero

**OSM03-17** *Exploring the causes of enhanced recent growth in high-elevation bristlecone pines using stable isotope dendroclimatology*
**Rory Clisby**, Iain Robertson, Mary Gagen, Charles Hipkin

**OSM03-13** *Megadroughts in Millennium-Length Forced and Control Simulations and their Comparison to the Proxy-derived North American Drought Atlas*
Sloan Coats, **Jason Smerdon**, Richard Seager, Benjamin Cook, J. Fidel Gonzalez-Rouco

**OSM03-06** *Integrated climate-proxy modeling using the isotope-enabled SPEEDY-IER with a focus on tropical climate*
**Sylvia Dee**, David Noone, Julien Emile-Geay, Nikolaus Buenning

**OSM03-15** *Reconstructions of the climate states over last centuries using particle filtering*
Svetlana Dubinkina, **Hugues Goosse**, Violette Zunz, Yoann Sallaz-Damaz

**OSM03-10** *Data assimilation of climate proxies in a set of 30 model simulations using the Ensemble Kalman Filter*
**Jörg Franke**, Jonas Bhend, Stefan Brönnimann

**OSM03-07** *Stable Water Isotopes in a Coupled Atmosphere-Vegetation Model: Comparison of simulation results with observational and proxy data*
**Barbara Haese**, Martin Werner, Britta Beckmann, Gerrit Lohmann, Enno Schefuß

**OSM03-03** *The global ocean during the mid-Holocene: A multi-sensor sea surface temperature reconstruction (MARGO-6k) and evaluation of the CMIP5 mid-Holocene simulations*
**Ines Hessler**, Sandy Harrison, Michal Kuchera, Stefan Mulitza, Claire Waelbroeck, data contributes MARGO-6k

**OSM03-08** *Modelling oxygen and deuterium isotopes over the last 120 ka in a fully-coupled atmosphere-ocean GCM*
**Ruza Ivanovic**, Paul Valdes, Joy Singarayer

**OSM03-01** *A simple approach to assessing the accuracy of age models from Holocene sediment cores*
**Darrell Kaufman**, Nicholas Balascio, Nicholas McKay, Hanna Sundqvist

**OSM03-19** *Biases in the diurnal temperature range in an ensemble of regional climate models and their possible causes*
**Jan Kysely**, Eva Plavcova

**OSM03-18** *How did the late-glacial no-analog plant communities in eastern North America arise? Testing competing hypotheses through model-data comparison*
**Yao Liu**, Simon Brewer, Stephen T. Jackson

**OSM03-16** *Using data assimilation to estimate the consistency between different proxies and model results*
Aurélien Mairesse, **Hugues Goosse**, Pierre Mathiot, Svetlana Dubinkina

**OSM03-02** *Model-data comparisons of Holocene treeline dynamics in Fennoscandia and European Russia*
**Jesse Morris**, Keyan Fang, Heikki Seppä, Sakari Salonen, Paul Miller, Hans Renssen

**OSM03-12** *The importance of external forcing on the climate of the last millennium*
**Andrew Schurer**, Gabriele Hegerl, Simon Tett, Michael Mann, Steven Phipps

**OSM03-04** *Holocene thermal maximum in Europe: Data and model simulations*
**Heikki Seppä**, Hans Renssen, Oliver Heiri, Thierry Fichefet, Hugues Goosse, Didier M. Roche

**OSM03-09** *Triple water vapor isotopic ($H_2^{18}O$, $HD^{16}O$, $H_2^{17}O$) measurements above the Greenland Ice Sheet and importance for interpretation of ice cores*
**Hans Christian Steen-Larsen**, Renato Winkler, Frédéric Prié, Amaelle Landais, Valérie Masson-Delmotte, Camille Risi, Barbara Stenni

**OSM03-14** *Evaluation of historical climate simulation with High-resolution global atmospheric model*
**Sumin Woo**, Jai-Ho Oh, Kyoung-Min Lee

### OSM13 Past Warm Periods Informing the Anthropocene

Chair: Stijn De Schepper

**OSM13-08** *Surface ocean conditions in the eastern Nordic Seas during the Pliocene*
**Carin Andersson**, Bjørg Risebrobakken, Erin McClymont, Lisbeth Jensen

**OSM13-04** *Modeled variability of land vegetation and carbon during the Holocene*
**Tim Brücher**, Victor Brovkin, Veronika Gayler

# MEETING PROGRAM

**OSM13-12** *How to glaciate the Northern Hemisphere in a globally warm world?*
**Stijn De Schepper**, Jeroen Groeneveld, B. David A. Naafs, Cédéric Van Renterghem, Jan Hennissen, Martin J. Head, Stephen Louwye

**OSM13-06** *Interglacial vegetation dynamics revealed from land-cover estimates and potential disturbance factors*
**Petr Kuneš**, Piotr Kolaczek

**OSM13-05** *Can variations in orbital and greenhouse gas forcing explain the North Atlantic sea-surface temperature evolution during the Last Interglacial?*
Petra M. Langebroek, **Kerim H. Nisancioglu**

**OSM13-14** *Modelling the influence of evolving vegetation on past greenhouse climates*
**Claire Loptson**, Dan Lunt

**OSM13-13** *The Miocene Mi-events: New paleobiological and paleotemperature data from Porcupine Basin, SW Ireland*
**Stephen Louwye**, Willemijn Quaijtaal, Stefan Schouten, Timme Donders

**OSM13-03** *New insights into the Holocene Thermal Maximum: Feedback and triggering mechanisms*
**Francesco Muschitiello**, Dan Hammarlund, Barbara Wohlfarth

**OSM13-07** *Investigating the Uncertainty in the HadCM3 Model using a Perturbed Physics Ensemble in a Warmer World Palaeoclimatic Setting*
**James Pope**, Matthew Collins, Alan Haywood, Harry Dowsett, Daniel Lunt

**OSM13-10** *Characterizing conditions of the Nordic Seas water column through the Pliocene*
**Bjørg Risebrobakken**, Carin Andersson, Erin McClymont, Lisbeth Jensen

**OSM13-15** *Understanding the range of climates that can be simulated by perturbing uncertain climate parameters within their range of uncertainty for the early Eocene warm paleoclimate*
**Navjit Sagoo**, Paul Valdes, Rachel Flecker

**OSM13-02** *Evaluation of the ratio of natural and anthropogenic forcing in the regression of the Aral sea during the Medieval Warm Period*
**Renato Sala**, Jean-Marc Deom

**OSM13-11** *Refined $pCO_2$ reconstruction in Pliocene warmth*
**Osamu Seki**

**OSM13-09** *A comparative study of large scale atmospheric circulation in the context of future scenario (RCP4.5) and past warm climate (mid-Pliocene)*
**Yong Sun**, Gilles Ramstein, Camille Contoux, Tianjun Zhou

**OSM13-01** *Multiple drivers of long-term hypoxia in the Baltic Sea: A pilot biomarker study*
**Lovisa Zillén**, James Bendle, Christopher Gallacher

### OSM16 Open Session on Latest Highlights in Paleoscience

Chair: Hubertus Fischer

**OSM16-01** *Chronology of deposition of coastal Red dunes (Teri sands) in South India and its palaeoenvironmental implications*
**Linto Alappat**, P. Morthekai, A.Vidyasagar, S. Srinivasalu, D. V. Reddy, A.K. Singhvi

**OSM16-17** *Dynamics of a Snowball Ocean*
**Yosef Ashkenazy**, Hezi Gildor, Martin Losch, Francis Macdonald, Daniel Schrag, Eli Tziperman

**OSM16-24** *U-Pb age model for an Early Pleistocene stalagmite from Corchia Cave (Italy)*
**Petra Bajo**, Russell Drysdale, Jon Woodhead, John Hellstrom, Giovanni Zanchetta

**OSM16-22** *Norwegian Research School in Climate Dynamics (ResClim)*
**Sarah Berben**, Tore Furevik

**OSM16-09** *Testing the tree-ring parameter Blue Intensity, a new inexpensive path towards robust low-frequency reconstructions of late Holocene summer temperatures?*
**Jesper Björklund**, Hans Linderholm

**OSM16-16** *You are what you eat: Differences in the chemical composition of organic-walled dinoflagellate resting cysts and its implications for preservation*
**Kara Bogus**, Kenneth Neil Mertens, Johan Lauwaert, Ian C. Harding, Henk Vrielinck, Karin Zonneveld, Gerard J.M. Versteegh

**OSM16-15** *Climate controlled size variability of diatom Fragilariopsis kerguelensis in the Southern Ocean*
**Xavier Crosta**, Sunil Shukla, Giuseppe Cortese, G.N. Nayak

**OSM16-08** *DNA barcoding from lake sediments: An unprecedented "deep" view of past vegetation dynamics and human land-use*
**Charline Giguet-Covex**, Johan Pansu, Pierre Taberlet, Ludovic Gielly, Fabien Arnaud, Jérôme Poulenard, Philippe Choler, Pierre-Jérôme Rey, Pierre-Jérôme Rey, Fernand David, Isabelle Domaizon

**OSM16-02** *Nonlinear Method for Climate Field Reconstruction*
Sami Hanhijärvi, **Atte Korhola**

**OSM16-07** *Intercontinental Ash: The correlation of the Alaskan White River Ash to the European AD 860B tephra*
**Britta Jensen**, Sean Pyne-O'Donnell, Gill Plunkett, Duane Froese, Paul Hughes, Jonathan Pilcher, Valerie Hall

**OSM16-18** *Evidence of a wetter LIA (Little Ice Age) in the Indian Himalaya, India: Evidence from a ca. 400 yr. old stalagmite record*
**Bahadur Singh Kotlia**, S. M. Ahmad, Jian-Xin Zhao, Ming Tan, Wuhui Duan

**OSM16-10** *Changes in sea level on the coast of São Paulo during the Holocene and landslides in the Serra do Mar – Brazil*
**Francisco Sergio Bernardes Ladeira**, Regina Célia de Oliveira, Estéfano Seneme Gobbi

**OSM16-11** *Greenhouse effect of Upper Cretaceous - analysis by paleosols of Marí lia Formation/Bauru Group/Brazil*
**Francisco Sergio Bernardes Ladeira**

**OSM16-06** *The ice core record of atmospheric methane: Chemistry-climate interactions on tens to thousands of years*
**James Levine**, Eric Wolff, Anna Jones, Manuel Hutterli, Louise Sime, Oliver Wild, Peter Hopcroft, Paul Valdes, Alex Archibald, Glenn Carver, Nicola Warwick, John Pyle

**OSM16-05** *Unraveling groundwater and surface water interaction in Central Kenya Rift lakes: Implications for Paleohydrology*
**Lydia A. Olaka**, Andreas Musolff, Ulrich Kniess

**OSM16-25** *Species distribution and oxygen isotope composition in modern planktic foraminifers in the Fram Strait (Arctic Ocean)*
**Theodora Pados**, Robert F. Spielhagen

**OSM16-14** *Multiproxy study of a Tertiary sedimentary section along Madhwali Nadi, western Kutch, Gujarat: Implications on Palaeoenvironment and Age*
**Parminder S. Ranhotra**, S. K. Patil, Lalitha S., D. Senthil Nathan

**OSM16-23** *A brief history of climate – the northern seas from Last Glacial Maximum to global warming*
**Bjørg Risebrobakken**, Tor Eldevik, Anne Bjune

# MEETING PROGRAM

**WEDNESDAY, 13 FEBRUARY (continued)**

**16:00-18:00 BLOCK 4 - Poster Sessions (continued)**

**OSM16-21** *Biomarkers – a new potential method to study highly humified peat components?*
**Tiina Ronkainen**, Erin McClymont, Minna Väliranta, Eeva-Stiina Tuittila

**OSM16-20** *Coralline algal and larger benthic foraminiferal facies in an Upper Palaeocene shallow water, reefal carbonate platform (Meghalaya, North-Eastern India): Exploring the palaeoenvironmental implications*
**Suman Sarkar**, Amit Ghosh

**OSM16-12** *Abrupt climate change during the last glacial cycle on the Qinghai-Tibetan Plateau reconstructed using multiple organic geochemical proxies from Lake Qinghai, China*
**Elizabeth Thomas**, Jiangtao Zhao, Yongsong Huang, Steven Colman, Steven Clemens, Zhisheng An

**OSM16-04** *Modelling the Bolling-Allerod rapid warming event.*
**Paul Valdes**, Peter Hopcroft

**OSM16-13** *Reconstructing peatland water tables using transfer functions for plant macrofossils and testate amoebae: A methodological comparison*
**Minna Väliranta**, Antony Blundell, Dan Charman, Edgar Karofeld, Atte Korhola, Ülle Sillasoo, Eeva-Stiina Tuittila

**OSM16-03** *On the existence and the origin of the mid-Brunhes Event*
**Qiuzhen Yin**, Andre Berger

18:30 Beach Soccer

**THURSDAY, 14 FEBRUARY**

**09:00-10:30 BLOCK 1 - Plenary Session** Chair: Michael Schulz

09:00-09:30 Plenary Talk: **David Sauchyn - Extending baseline hydrology from decades to centuries: Implications for water resource engineering**

09:30-10:00 Plenary Talk: **Anil Kulkarni - State of the Himalayan cryosphere**

10:00-10:30 Plenary Talk: **James Syvitski - Rivers and deltas in the Anthropocene**

10:30-11:00 Coffee break

**11:00-12:30 BLOCK 2 - Oral sessions**

**Grande Sala**

**OSM12 Climate change: Physical forcings and biogeochemical feedbacks**
Chair: James Levine, Jérôme Chappellaz

*Continental-scale temperature variability over the Common Era*
**Chris Turney**, Members PAGES 2K

*The role of dust in glacial-interglacial cycles*
Rotem Bar-Or, **Hezi Gildor**, Caryn Erlick

*New $CO_2$ and $\delta^{13}CO_2$ ice core records on carbon cycle changes during the last glacial cycle*
**Hubertus Fischer**, Jochen Schmitt, Robert Schneider, Bernhard Bereiter, Fortunat Joos, Markus Leuenberger, Thomas Stocker, Peter Köhler, Jerome Chappellaz

*High resolution characterization of the Indian monsoon over the last glacial period from Bitoo Cave, northern India*
**Gayatri Kathayat**, Hai Cheng, Ashish Sinha, R. L. Edwards

*Were glacial-interglacial changes in the biological pump driven primarily by the marine ecosystem response to ocean temperature and iron fertilization?*
**Eric Galbraith**

*Silicon and carbon isotope reconstructions of Holocene productivity of the sea ice zone of the Southern Ocean (east Antarctica)*
Virginia Panizzo, Julien Crespin, **Damien Cardinal**, Aldo Shemesh, Xavier Crosta, Nadine Mattielli

**Sala de Banquete**

**OSM11 Biodiversity and Refugia - Lessons Learned from the Past**
Chair: Sheri Fritz, Kathy Willis

*Non-linear responses of vegetation to orbital forcing across the temperate to tropical transition in South America*
**Keith Bennett**

*Glacial refugia of Cedrus atlantica in Morocco: New records bring new interpretations*
**Rachid Cheddadi**, Majda Nourelbait, Bruno Fady, Ali Rhoujjati

*Using elevational gradients to discuss the origin of the highly biodiverse neotropical table mountains of northern South America*
**Sandra Nogué**, Valentí Rull, Teresa Vegas-Vilarrúbia

**OSM14 Natural and Human Effects on Ecosystem Processes**
Chair: Mukund Kajale

*Regional-scale dynamics in humid, late Holocene broadleaf forests*
**Neil Pederson**, James Dyer, Ryan McEwan, Amy Hessl, Cary Mock, David Orwig, Harald Reider, Ben Cook

*Long-term perspectives on landscape structure, ecological change and biodiversity during the Quaternary; comparisons between NW European Pleistocene fossil beetle assemblages*
**Nicki Whitehouse**, David Smith, Danielle Schreve

*Assessing the importance of climate and human activity on past and present fire dynamics*
**Cathy Whitlock**, David McWethy, Virginia Iglesias, Janet Wilmshurst

12:30-14:00 Lunch

**14:00-15:30 BLOCK 3 - Oral sessions**

**Grande Sala**

**OSM07 Sensitivity of the Cryosphere: Past and Future**
Chair: Olga Solomina, Anders Carlson

*What paleo ice sheets can say about future sea-level rise*
**Anders Carlson**

*Melting of Northern Greenland during the last interglacial*
**Kerim Hestnes Nisancioglu**, Andreas Born

**Sala de Banquete**

**OSM08 Natural and Anthropogenic Transformation of Land Cover During the Holocene**
Chair: Carsten Lemmen, Marie-José Gaillard

*Human Impact on Vegetation and Soils in Northern Karnataka, India: Integrating Archaeological and Palaeoecological Data from the Last 5000 Years*
**Kathleen Morrison**

# MEETING PROGRAM

*Exploring the potential of sea salt as a proxy for sea ice extent on glacial-interglacial timescales*
**James Levine**, Xin Yang, Anna Jones, Eric Wolff

*Highly branched isoprenoid (HBI) biomarkers as a new Antarctic sea-ice proxy in deep ocean glacial age sediments*
**Lewis Collins**, Claire Allen, Jennifer Pike, Dominic Hodgson, Kaarina Weckstrom, Guillaume Masse

*Sensitivity of the Greenland ice sheet to the Holocene thermal maximum*
**Benoit Lecavalier**, Leanne Wake, Glenn Milne,, Shawn Marshall, Matthew Simpson, Philippe Huybrechts

*Global and regional patterns in the Holocene glacier fluctuations records*
**Olga Solomina**, Mikhail Alexandrin, Vladimir Matskovsky

*From forest to farmland and moraine to meadow: Integrated modeling of Holocene land cover change*
**Jed O. Kaplan**, Mirjam Pfeiffer, Kristen M. Krumhardt, Basil A. S. Davis, Marco Zanon, Pamela M. Collins, Achille Mauri

*Assessing the early Iron Age landscape and human activities in southern India: phytolith and archaeological studies of a Megalithic burial site*
**Premathilake Rathnasiri**, Prasad Srinivasan, Anupama Krishnamurthy, Rajan K., Yathees Kumar V.P.

*Land cover-climate interactions in NW Europe, 6000 BP and 200 BP – first results of the Swedish LANDCLIM project*
**Anna-Kari Trondman**, Marie-José Gaillard, Shinya Sugita, Ralph Fyfe, Jed Kaplan, Laurent Marquer, Florence Mazier, Anne Birgitte Nielsen, Anneli Poska, Gustav Strandberg

*Soil erosion processes and long-term human-environment-interactions in central Europe and SE-USA*
**Markus Dotterweich**

*Holocene Vegetation and Climate history of Peninsular India from terrestrial archives: Problems and Prospects*
**Anupama Krishnamurthy**, Prasad Srinivasan

15:30-16:00 Coffee break

**16:00-18:00 BLOCK 4 - Poster Sessions**

### OSM07 Sensitivity of the Cryosphere: Past and Future

Chair: Olga Solomina, Anders Carlson

**OSM07-15** *Mountain glaciers reaction on the Holocene climate changes in Central Asia in contrast to glaciers behavior in mountain systems of continental edges*
**Anna Agatova**, Roman Nepop, Andrey Nazarov, Ljubov' Orlova

**OSM07-12** *Glacier expansion during the Late Quaternary in the monsoon dominated Goriganga valley, Central Himalaya, India*
**Sheikh Nawaz Ali**, Rabiul Biswas, Anil Shukla, Navin Juyal

**OSM07-02** *Projected 21st Century Decline Snow Cover Overlying the Arctic Sea Ice and Implications for the Sea Ice and Arctic Climate in CESM/CCSM*
**Benjamin Blazey**

**OSM07-10** *Detailed reconstructions of fluctuations of seven glaciers during the "Little Ice Age" in the Northern Caucasus Russian Federation*
**Irina Bushueva**

**OSM07-17** *Glacial response to environmental change in the upper Ravi basin of North Western Himalaya*
**Pritam Chand**

**OSM07-18** *Impact of De-glaciation and snow cover changes on the local water balance and develop adaptation strategies in the upper Ravi basin of North Western Himalaya*
**Pritam Chand**

**OSM07-07** *Late Weichselian glacial history of the southern Yermak Plateau*
**Teena Chauhan**, Riko Noormets, Tine. L. Rasmussen

**OSM07-03** *High-resolution reconstruction of southwest Atlantic sea-ice and its role in the carbon cycle during marine isotope stages 3 and 2*
**Lewis Collins**, Jennifer Pike, Claire Allen, Dominic Hodgson

**OSM07-04** *Testing the GCM matrix method for indirectly coupling climate models to ice sheet models.*
**Edward Gasson**, Dan Lunt, Mark Siddall, David Pollard

**OSM07-16** *Holocene Climate in Western Mongolia from an Altai Ice Core*
**Pierre-Alain Herren**, Anja Eichler, Horst Machguth, Tatyana Papina, Leonhard Tobler, Alexander Zapf, Margit Schwikowski

**OSM07-08** *Data-model comparison of the Late Weichselian Svalbard-Barents Sea ice sheet – for better constraints of postglacial isostatic uplift*
**Anne Hormes**, Endre Gjermundsen, Willy Fjeldskaar

**OSM07-20** *Cataloguing of glaciers of the river basins Koksu Aan Kyunes (Chinese part of Ile River basin) by materials of space monitoring*
**Larissa Kogutenko**, Alexandr Kokarev, Alexandr Yegorov

**OSM07-19** *Change of glacial systems of Kazakhstan*
**Alexandr Kokarev**, Alexandr Yegorov, Igor Severskiy

**OSM07-06** *Inferring the Source Distribution of Meltwater Pulse 1A using Near- and Far-Field Data and Modelling Constraints*
**Jean Liu**, Glenn A. Milne, Robert E. Kopp, Peter U. Clark

**OSM07-11** *Glacier hazards caused by glacier shrinkage and climate change: Case study of Russian Caucasus*
**Dmitry Petrakov**

**OSM07-14** *Holocene Climate vis-à-vis Glacier history from Garhwal Himalaya: A Multiproxy approach*
**Parminder S. Ranhotra**, Amalava Bhattacharyya, Indra Bir Singh, N. Basavaiah

**OSM07-05** *Environmental records in permafrost of East Siberian Arctic during the MIS2 Stadial and the MIS3 Interstadial*
**Natalia Rudaya**, Andrei Andreev, Sebastian Wetterich, Vladimir Tumskoy, Lutz Schirrmeister

**OSM07-09** *Reconstruction of the past 2000 years of ocean and glacier variability in Sermilik Fjord, SE Greenland, based on sediment archives*
Andreea Stoican, Camilla S. Andresen, Marit-Solveig Seidenkrantz, Kurt K. Kjaer, Antoon Kuijpers, Guillaume Massé, **Kaarina Weckström**

**OSM07-13** *Reconstructing spatial and temporal patterns of former glaciation along the Tian Shan*
**Arjen P. Stroeven**, Casey Beel, Robin L. Blomdin, Marc W. Caffee, Yixin Chen, Alexandru T. Codilean, Natacha Gribenski, Jonathan M. Harbor, Clas Hättestrand, Jakob Heyman, Mikhail Ivanov, Christine Kassab, Yanan Li, Yingkui Li, Nathaniel A. Lifton, Gengnian Liu, Dmitry Petrakov, Irina Rogozhina, Ryskul Usubaliev

**OSM07-01** *Evaluation of the sea ice proxy $IP_{25}$ against observational and diatom proxy data in the SW Labrador Sea*
**Kaarina Weckström**, Guillaume Massé, Lewis Collins, Sami Hanhijärvi, Ioanna Bouloubassi, Marie-Alexandrine Sicre, Marit-Solveig Seidenkrantz, Sabine Schmidt, Thorbjørn Andersen, Morten Andersen, Brian Hill, Antoon Kuijpers

# MEETING PROGRAM

**THURSDAY, 14 FEBRUARY (continued)**

**16:00-18:00** **BLOCK 4 - Poster Sessions (continued)**

### OSM08 Natural and Anthropogenic Transformation of Land Cover During the Holocene

Chair: Carsten Lemmen, Marie-José Gaillard

**OSM08-02** *Holocene Vegetation changes in the Cauvery Floodplains, southern India: A case study*
**Stephen A**, P. P Mohapatra, Anupama Krishnamurthy, Prasad Srinivasan, Pramod Singh

**OSM08-20** *Holocene vegetation estimates for selected regions in Bohemia (Czech Republic)*
**Vojtech Abraham**, Libor Petr, Helena Svitavská-Svobodová, Radka Kozáková, Petr Pokorný, Petr Kuneš

**OSM08-13** *A large-scale erosion anomaly (2nd c. BC- 4th c. AD) in NW Alps: A locally-defined onset of the Anthropocene?*
**Fabien Arnaud**, Laurent Astrade, Manon Bajard, Jean-François Berger, Yves Billaud, Emmanuel Chapron, Christian Crouzet, Fernand David, Philip Deline, Elise Doyen, Charline Giguet-Covex, Jérémy Jacob, Melaine Le Roy, Laurent Millet, Jérôme Poulenard, Sidonie Révillon, Pierre-Jérôme Rey, Pierre Sabatier, Anaëlle Simonneau, Pierre Taberlet, Boris Vannière

**OSM08-10** *Early Neolithic diets at Baijia, Wei River valley, China: Stable carbon and nitrogen isotope analysis of human and faunal remains*
**Pia Atahan**, John Dodson, Xiaoqiang Li, Xinying Zhou, Songmei Hu, Liang Chen, Fiona Bertuch, Kliti Grice

**OSM08-08** *Impact of monsoonal variation on vegetation and climate change as inferred from late Holocene sediment of Garbhanga reserve forest, Assam, north east India: A pollen based study*
Samir Kumar Bera, **Kanupriya Gupta**, Azizur Rahman

**OSM08-12** *Southern Westerlies postglacial dynamics at Central Chilean Patagonia (Rio Cisnes valley, 44°S)*
**María Eugenia de Porras**, Antonio Maldonado, Flavia Quintana, Cesar Méndez, Omar Reyes

**OSM08-09** *Late Holocene vegetation vis á vis climate dynamics from Hasila wetland, western Assam, Northeast India: Pollen and diatom record*
**Swati Dixit**

**OSM08-14** *Grazing activities and vegetation history in the Pyrenees inferred from palaeoecological data*
**Galop Didier**, Mazier Florence, Cugny Carole, Rius Damien

**OSM08-07** *Palynological methods for land-cover reconstruction in semi-arid Peninsular India*
Anupama Krishnamurthy, **Prasad Srinivasan**, Aravajy S, Ponnuchamy R, Stephen A, Anusree A.S.

**OSM08-11** *Climate and Vegetation Dynamics in the Lake Victoria Region of East Africa during the Holocene: Evidence from Phytolith analysis*
**Julius Lejju Bunny**

**OSM08-15** *Integrated prehistory of people and environment: Linking the global scale to regional narratives*
**Carsten Lemmen**, Aurangzeb Khan, Kai W Wirtz, Detlef Gronenborn

**OSM08-16** *Towards an Earth System Model with Interactive Culture: Feedback effects between land use change and global climate change*
**Carsten Lemmen**, Kerstin Haberkorn

**OSM08-19** *REVEALS-based reconstruction of regional vegetation and land cover for evaluation of a dynamic vegetation model along N-S and W-E transects in NW Europe*
**Laurent Marquer**, Marie-José Gaillard, Shinya Sugita, Anneli Poska, Anna-Kari Trondman, Florence Mazier, Anne Birgitte Nielsen, Ralph Fyfe, Bent Vad Odgaard, Teija Alenius, John Birks, Anne E. Bjune, Jörg Christiansen, Thomas Giesecke, Mihkel Kangur, Tiiu Koff, Malgorzata Latalowa, Jutta Lechterbeck, Heikki Seppä

**OSM08-06** *Late Holocene variations from Lake Rutundu, mount Kenya*
**Christine Omuombo**, Daniel Olago, Stephen Rucina, David Williamson

**OSM08-04** *Holocene climate and environmental changes in the Horton Plains, Sri Lanka*
**Rathnasiri Premathilake**

**OSM08-01** *Human impact on lowland rainforest and early maritime dispersal of bananas: Evidence from Sri Lanka*
**Rathnasiri Premathilake**

**OSM08-18** *Deforesting Europe: Towards a pollen-based reconstruction of Holocene land cover change*
**Neil Roberts**, Jessie Woodbridge, Ralph Fyfe

**OSM08-05** *Lonar Crater, central India: Pollen transport processes and pollen vegetation relationships in tropical dry deciduous forests as reflected in modern lake sediments and surface soils*
**Martina Stebich**, Nils Riedel, Philip Menzel, Ambili Anoop, Sushma Prasad, Saswati Sarkar, Dirk Sachse, Martin Wiesner, Nathani Basavaiah

**OSM08-03** *Changes in Land-use and Land-cover from the Iron Age to Medieval period in the Central Eastern Tamil Nadu: A preliminary investigation*
**Selvakumar V**, Ramji M.S., Gowrisankar S, Tangadurai T, Kalaiselvai J.

**OSM08-17** *Exploring the spatio-temporal archaeological and landscape dynamics of early farming communities using Bayesian approaches*
**Nicki Whitehouse**, Phil Barratt, M. Jane Bunting, Rick Schulting, Meriel McClatchie, T. Rowan McLaughlin, Rob Marchant, Amy Bogaard, Sue Colledge

### OSM011 Biodiversity and Refugia - Lessons Learned from the Past

Chair: Sheri Fritz, Kathy Willis

**OSM11-01** *Resilience of an ancient tropical forest landscape to 7500 years of environmental change in the Western Ghats, India*
Shonil Bhagwat, **Sandra Nogue**, Kathy Willis

**OSM11-02** *Biodiversity and land cover change in Europe over the Holocene: A functional approach based on pollen data*
Pam Collins, **Basil Davis**, Jed Kaplan

**OSM11-12** *Development and application of Australian lacustrine ostracod-based transfer functions*
**Chris Gouramanis**, Stuart Halse, Patrick De Deckker, Daniel Wilkins

**OSM11-11** *Interglacial variability from the Middle Pleistocene up to the Holocene after molluscan assemblages and geochemical records from NW European tufa sequences*
**Nicole Limondin-Lozouet**, Julie Dabkowski

**OSM11-09** *Genetic differentiation in the Patagonian-fueguian rodents Abrothrix olivaceus and A. longipilis (Rodentia: Cricetidae) associated to the major Pleistocene-Holocene climatic changes: Using molecular data to the global changing assessment*
**Matias Mora**

# MEETING PROGRAM

**OSM11-08** *Late Quaternary palaeoenvironments of the southern Cape, South Africa: Palynological evidence from three coastal wetlands*
**Lynne Quick**, Michael Meadows, Brian Chase, Andrew Carr, Mark Bateman, Torsten Haberzettl, Jussi Baade, Roland Mäusbacher

**OSM11-13** *The response of planctic foraminifera to oceanic environmental changes during cenomanian-turonian transition of Karai Shale, Uttattur group, southern India*
Shanmugavalli G., **Venkatachalapathy R.**

**OSM11-07** *Marine and terrestrial response of the Black Sea/Northern Anatolia region to rapid climatic variability during the marine isotope stage 3*
**Lyudmila S. Shumilovskikh**, Helge W. Arz, Hermann Behling

**OSM11-04** *Eastern Andean Patagonia (40°-51°S) vegetation and climate variability during the Holocene related to southern westerlies fluctuations and recent human interactions. Impacts on Patagonian forests and steppe plants communities*
**Gonzalo Sottile**, Ma. Alejandra Marcos, Florencia P. Bamonte, Marcos E. Echeverría, Ma. Eugenia De Porras, Marcela S. Tonello, Ma. Virginia Mancini, Ma. Martha Bianchi

**OSM11-03** *Late-Holocene climate and environmental history in the Lake Victoria basin: A sediment-based evidence from pollen, charcoal, $\delta^{13}C$ isotope, spores and blue-green algae*
**Casim Umba Tolo**, Julius B Lejju, Morgan Andama, David Taylor

**OSM11-06** *Using the fossil record to reassess the functioning of the southern Levant as a biodiversity pool during European glaciations*
**Lior Weissbrod**, Mina Weinstein-Evron

**OSM11-10** *Reviewing Late Quaternary Megafaunal Extinction: The case-study of Sri Lanka*
**Poorna Yahampath**, Jinadasa Katupotha, Gamini Adikari, M.A.C.M. Kumari

## OSM012 Climate change: Physical forcings and biogeochemical feedbacks

Chair: James Levine, Jérôme Chappellaz

**OSM12-02** *A multiproxy examination of the toarcian oceanic anoxic event, Arroyo Lapa, (north and south) Neuquen Basin, Argentina*
**Aisha Al Suwaidi**, François Baudin, Susana Damborenea, Stephen Hesselbo, Hugh Jenkyns, Miguel Manceñido, Richard Pancost, Alberto Riccardi, Chris Siebert

**OSM12-12** *A multidisciplinary laboratory study using iron oxide 'markers' from modern drylands dust towards adapting this methodology for characterizing Quaternary dust, their source areas and transport paths*
**Subir Banerjee**, Kimberly Yauk, Richard Reynolds, Harland Goldstein, Thelma Berquo, Bruce Moskowitz

**OSM12-14** *Synchronous variations in terrigenous flux to the Bay of Bengal and solar insolation: Implications to solar forcing on monsoon system*
**Ravi Bhushan**, Sunil K Singh

**OSM12-10** *Reconstruction of the Late Quaternary climatic change from glaciogenic varve deposits in Lahaul and Spiti, N-W Himalaya*
**Archna Bohra**

**OSM12-08** *Precession forcing of fire activity in subtropical southern Africa over the past 170,000 years*
**Anne-Laure Daniau**, Maria Fernanda Sánchez Goñi, Philippe Martinez, Dunia H. Urrego, Viviane Bout-Roumazeilles, Stéphanie Desprat, Jennifer R. Marlon

**OSM12-07** *Holocene carbon fluxes in the tropical peatlands of Southeast Asia: The contrasting roles of changing sea-level and climate*
**René Dommain**, Hans Joosten, Paul H. Glaser

**OSM12-06** *Biogeochemical constraints from carbon monoxide measured in firn air and ice cores*
Xavier Faïn, **Jérôme Chappellaz**, Daniele Romanini, Zhihui Wang, Thomas Blunier, Christopher Stowasser, John Mak, Rachel Rhodes, Vas Petrenko, Ed Brook, Joe McConnell, Jeff Severinghaus, Matthias Bigler

**OSM12-11** *The lightning-biota climatic feedback*
**Hezi Gildor**, Alon Shepon

**OSM12-05** *Effect of climate change on agriculture and health in India*
**Rabindra Kumar**, J. Nagendra Babu

**OSM12-04** *Seasonal variability of atmospheric aerosol over the North Indian region during 2010*
**Sarvan Kumar**, Abhay Kumar Singh

**OSM12-15** *Plio-Pleistocene evolution of nutrient cycling in the Benguela upwelling system: A chlorin-specific $\delta^{15}N$ approach*
**Guillaume Leduc**, Hisami Suga, Nana Ogawa, Johan Etourneau, Ralph Schneider, Nao Ohkouchi

**OSM12-20** *Effects of Large Volcanic Eruptions on Global Summer Climate and East Asian Monsoon Changes during the Last Millennium: Analysis of MPI-ESM simulations*
**Wenmin Man**, Tianjun Zhou

**OSM12-03** *Tracking carbon dynamics and climate forcing through Holocene peatland development by combining palaeoecological information and modern carbon flux measurements*
**Paul Mathijssen**, Minna Väliranta, Eerika Niemelä, Annalea Lohila, Juha-Pekka Tuovinen

**OSM12-01** *The late Pleistocene-Holocene climatic transition record in the alluvial sequences of central Argentina (33-38° S)*
**Adriana Mehl**, Marcelo Zárate

**OSM12-16** *Variations in planktonic foraminifera shell calcification in the eastern Arabian Sea during the Holocene*
**Sushant Naik**, Shijo Matthews, Shital Godad, Pothuri Divakar Naidu

**OSM12-19** *Diatom based sea-ice reconstruction over the past 95,000 years in the Indian Ocean sector of Southern Ocean*
**Abhilash Nair**, Rahul Mohan, M.C Manoj, Meloth Thamban

**OSM12-21** *High-resolution multi-proxy climatic reconstruction off Myanmar suggestive of climatic modulations due to solar forcing during the past ~489 years*
**Rajani Panchang**, Rajiv Nigam

**OSM12-18** *First results of the paleolimnological research in Tundra polygons (the project POLYGON)*
**Viktor Sitalo,** Dmitry Subetto, Lutz Schirrmeister, Sebastian Wetterich, Andrea Schneider

**OSM12-13** *Accelerator Mass Spectrometry: Revealing subtle signals in ice sheets*
**Andrew Smith**

**OSM12-09** *Late Glacial-Holocene Elemental and Stable Isotope Records from the Southeastern Arabian Sea*
**Yoganandan Veeran**, Selvaraj Kandasamy, S.J Kao, Ravi Prasad G. V, Koushik Dutta, Krishnaiah C, Gangadhara Bhat H

**OSM12-17** *How can ice cores constrain our knowledge of the likelihood of damaging solar flare events?*
**Eric Wolff**, Juerg Beer, Matthias Bigler, Mark Curran, Jack Dibb, Markus Frey, Michel Legrand, Joe McConnell

# MEETING PROGRAM

**THURSDAY, 14 FEBRUARY (continued)**

**16:00-18:00** **BLOCK 4 - Poster Sessions (continued)**

**OSM14 Natural and Human Effects on Ecosystem Processes**

Chair: Mukund Kajale

**OSM14-04** *Late Quaternary environmental change at Lake McKenzie, in subtropical eastern Australia: evidence from sedimentary carbon, nitrogen and biomarkers*
**Pia Atahan**, Henk Heijnis, Pierre Le Métayer, Kliti Grice, Kathryn Taffs, Sarah Hembrow, John Dodson

**OSM14-06** *Diatoms as Environmental Indicators to Infer Past Conditions in Relation to Acidity (Humedal de Batuco, Regíon Metropolitana, Chile Central)*
**Maria Laura Carrevedo**, Claudio Latorre, Blas Valero Garcés, Ana Moreno

**OSM14-11** *Mapping biomes of India using Holdridge Life Zone Model – identifying footprints of climate change*
**Anusheema Chakraborty**, Pawan Kumar Joshi, Aniruddha Ghosh, Gopala Areendran

**OSM14-07** *Foliar and total soil $\delta^{15}N$ as a proxy for precipitation in the Atacama Desert*
**Francisca P. Díaz**, Claudio Latorre

**OSM14-03** *Treeline dynamics at high mountain of Manaslu Conservation Area, Central Nepal: Climate change or land use is the main driver?*
**Narayan Prasad Gaire**, Dinesh Raj Bhuju

**OSM14-08** *Monsoon variability and carbon sequestration dynamics: Evidence from tree-rings*
**Suresh Hebbalalu**, Hemant Borgoankar, Amar Sikder, Sukumar Raman

**OSM14-09** *Permafrost melting and ecotoxicological consequences in a periglacial lake in the Eastern Alps: Answers from the past and present*
**Boris Ilyashuk**, Karin Koinig, Elena Ilyashuk, Richard Tessadri, Roland Psenner

**OSM14-01** *Late Holocene biological assemblages of Mansar Lake (District Nagpur, Maharashtra, India) in the context of Palaeoecology and neo-ecosystem dynamics*
**Mukund Kajale**, Sharayu Sathe, Sanjay Eksambekar, Sharad Rajaguru

**OSM14-05** *Geochemical signals of organic matter in sediments of Pichavaram mangrove-estuarine complex, Southeastern coast of India: Implications of anthropogenic influence*
**Rajesh Kumar Ranjan**, Joyanto Routh, AL. Ramanathan, J. Val Klump

**OSM14-02** *Holocene environmental variability – a high-resolution study from northeast Finland*
**Shyhrete Shala**, Minna Väliranta, Karin F. Helmens, Tomi P. Luoto

**OSM14-10** *Mid to Late Holocene climatic history of rangelands from Spiti Valley, Trans-Himalayas*
**Indrani Suryaprakash**, Anusree A.S., Chandra Mohan Nautiyal, Charu Dutt Mishra, Mahesh Sankaran

19:00-21:00 Public lecture and discussion: **Rajendra K. Pachauri - Climate Change and implications for global society**
Chair: S. Rajan, Expert panel: Cathy Whitlock, Gavin Schmidt, Robert Wasson, Stefan Rahmstorf, Ashok K. Singhvi (moderator)
*Followed by a panel discussion and a "high tea" arranged by NCAOR*
*Venue: The Cardium, National Institute of Oceanography, Dona Paula*

**FRIDAY, 15 FEBRUARY**

**09:00-10:30** **BLOCK 1 - Plenary Session** Chair: Alan Mix

09:00-09:30 Plenary Talk: **Jessica E. Tierney - Indo-Pacific climate during the Common Era: New perspectives from land and sea**

09:30-10:00 Plenary Talk: **Martin Claussen - Tipping points in biogeophysics**

10:00-10:30 Plenary Talk: **Martin Visbeck - Selected topics on ocean dynamics in the wider context of climate variability and global sustainability**

10:30-11:00 Coffee break

**11:00-12:30** **BLOCK 2 - Oral sessions**

**Grande Sala**

**OSM02 Regional Climate Variability Over the Last 2000 Years**

Chair: Steven Phipps

*Antarctic temperature changes during the last millennium: evaluation of simulations and reconstructions (solicited talk)*
**Hugues. Goosse**, M. Braida, X. Crosta, A. Mairesse, V. Masson-Delmotte, P. Mathiot, R. Neukom, H. Oerter, G. Philippon, H. Renssen, B. Stenni, T. van Ommen, E. Verleyen

*A 2000-year synthesis of marine-derived SST records: Results from the Ocean2k project*
Working Group PAGES/Ocean 2k, **Guillaume Leduc**

*Temperature and moisture variability across Africa during the last 2000 years*
**David J. Nash**, Brian M. Chase, Asfawossen Asrat, Stefan W. Grab, Anne-Marie Lézine, Sharon E. Nicholson, Timothy M. Shanahan, Mohammed Umer, Dirk Verschuren

*A 2000-yr European Summer Temperature Reconstruction from the PAGES 2k Regional Network and Comparisons to Millennium-Length Forced Model Simulations*
**Jason Smerdon**, Johannes Werner, Ulf Buntgen, Fredrik Charpentier Ljungqvist, Jan Esper, Laura Fernandez-Donado, J. Fidel Gonzalez-Rouco, Juerg Luterbacher,

**Sala de Banquete**

**OSM06 Past Changes in Fluvial Systems, Floodplains and Estuaries**

Chair: Onkar S. Chauhan, Peter Gell, Rajiv Sinha

*Deciphering landscape dynamics from the Late Quaternary stratigraphic records of the interfluves and valleys of the southern Ganga plains (solicited talk)*
**Sampat K. Tandon**, Rajiv Sinha, Martin R. Gibling, Mayank Jain

*Exploring the Channel Connectivity Structure of the August 00 Avulsion Belt of the Kosi River: Application to Flood Risk Assessment*
**Rajiv Sinha**, Kumar Gaurav, Shashwat Chandra, Sampat Tandon

*Channel forming discharge and longitudinal rivers profiles as drivers of landscape diversity in the Ganga plains*
**N.G. Roy**, R Sinha

*Forests, large floods and sediment transport (solicited talk)*
**Robert Wasson**

*Evidence for transformation of floodplain lake and wetland ecosystems at a regional scale due to agriculture and water resource development in south east Australia*
**Michael Reid**, Peter Gell, John Tibby, Jennie Fluin, Matthew Tighe

# MEETING PROGRAM

Danny McCarroll, Sebastian Wagner, Eugene Wahl, Heinz Wanner, Eduardo Zorita

*Mechanisms for European summer temperature response to solar forcing over the last millennium*
**Didier Swingedouw**, Laurent Terray, Jérôme Servonnat, Joel Guiot

*On the role of sea ice at the onset of the Little Ice Age*
**Flavio Lehner**, Andreas Born, Christoph C. Raible, Thomas F. Stocker

*Late Holocene Hypolimnetic Anoxia in Lake Victoria at Napoleon Gulf as inferred from Geochemical Proxies*
**Morgan Andama**, Julius B. Lejju, Casim Umba Tolo, Grace Kagoro-Rugunda, Immaculate Ssemmanda, Janet Ayebare

12:30-14:00 Lunch

**14:00-15:30** **BLOCK 3 - Oral sessions**

**Grande Sala**

**OSM02 (continued)**

Chair: Guillaume Leduc

*Covariability of precipitation and sea surface temperature changes in Northern Chilean Patagonia during the last 2000 years*
**Sebastien Bertrand**, Konrad Hughen, Julio Sepúlveda, Silvio Pantoja

*Solar and volcanic forcing of the Southern Hemisphere climate over the past 1500 years*
**Steven Phipps**, Duncan Ackerley, Josephine Brown, Mark Curran, Matt Fischer, Ailie Gallant, Joelle Gergis, Helen McGregor, Raphael Neukom, Christopher Plummer, Samantha Stevenson, Tas van Ommen

*Data and model perspectives on the Indian Ocean Zonal Mode over the past millennium*
**Bronwen Konecky**, James Russell, Mathias Vuille, Yongsong Huang

*Simulated and reconstructed Atlantic gyre circulation and its relationship with the North Atlantic Oscillation during the past 600 years*
**Odd Helge Otterå**, Trond Dokken, Øyvind Lie, Helene R. Langehaug, Iselin Medhaug, Carin Andersson

*Shifting winds over the North Sea: how Anglo-Dutch documentary evidence enables the reconstruction of changes in prevailing wind during the Little Ice Age, 1630-1700*
**Dagomar Degroot**

*Reconstruction of tropical ocean SST trends during the last millennium: Results from the PAGES/Ocean2K project*
**Nerilie Abram**, Jessica Tierney, Kevin Anchukatis, Cyril Giry, Kelly Kilbourne, Casey Saenger, Henry Wu, Jens Zinke, the PAGES/Ocean2K working group

**Sala de Banquete**

**OSM15 The Role of Ocean Circulation in Climate Dynamics**

Chair: Arun D. Singh, Devesh K Sinha

*Influence of the tropical hydrologic cycle on Atlantic meridional overturning at the end of the last interglacial*
**Benjamin Blazey**, Matthias Prange, Andrè Paul, Aline Govin

*Stability of the thermohaline circulation during MIS in a comprehensive climate model: Towards a dynamical understanding of Dansgaard-Oeschger events*
**Matthias Prange**, Xiao Zhang, Ute Merkel, Michael Schulz

*Increase proportion of Antarctic Intermediate Water off northern Chile (7°S) in glacial periods over the past million years*
**Gema Martínez-Méndez**, Dierk Hebbeln, Mahyar Mohtadi, Mieke Thierens,, Frank Lamy, Tim Freudenthal

*Mid-Holocene amplification of century scale climate variability - potential interhemispheric linkages*
**Eystein Jansen**, Carin Andersson, Jostein Bakke, Dokken Trond, Øyvind Lie, Matthias Moros, Atle Nesje, Odd Helge Otteraa, Bjørg Risebrobakken

*Millennial scale variability in the upstream Agulhas Current*
**Margit H. Simon**, Ian R. Hall, Kristina L. Arthur, Benjamin R. Loveday, Frank J. C. Peeters, Stephen Barker, Martin Ziegler

*Reduced flow of North Atlantic Deep Water into the Arabian Sea during Last Glacial Maxima: Evidence from 187 Os/ 188 Os of the Arabian Seawater*
Goswami Vineet, **Sunil Kumar Singh**, Ravi Bhushan

15:30-16:00 Coffee break

**16:00-18:00** **BLOCK 4 - Poster Sessions**

**OSM02 Regional Climate Variability Over the Last 2000 Years**

Chair: Steven Phipps, Guillaume Leduc

**OSM02-01** *An Expanded Archive Facilitating Temperature Reconstructions of the Past Two Millennia from Paleo Proxies*
**David Anderson**, Eugene Wahl, Anju Shah, Bruce Bauer, Charles Buckner, Edward Gille, Carrie Morrill

**OSM02-34** *How subsurface temperature data may help to reconstruct past climate*
**Vladimir Cermak**

**OSM02-35** *Results of Long-Term Temperature-Time Monitoring at the Geothermal Observatory Sporilov, Prague (The Czech Republic)*
**Vladimir Cermak**, Jan Safanda, Petr Dedecek, Milan Kresl

**OSM02-25** *Last 2000 years environmental changes in Lake Pa Kho, Northeast Thailand*
**Sakonvan Chawchai**, Barbara Wohlfarth, Akkaneewut Chabangborn, Maarten Blaauw, Paula J Reimer, Sherilyn Fritz, Malin Kylander, Ludvig Löwemark, Carl-Magnus Mörth

**OSM02-26** *Tree-ring reconstructed boreal summer temperature anomalies for temperate East Asia since 800 C.E.*
Edward Cook, Paul Krusic, **Kevin Anchukaitis**, Brendan Buckley, Takeshi Nakatsuka, Masaki Sano, Asia 2k Group Members

**OSM02-02** *Relationship between sea ice variability and atmospheric circulation during the last millennium in Antarctic Peninsula*
**Xavier Crosta**, Loic Barbara, Sabine Schmidt, Johan Etourneau, Guillaume Massé

**OSM02-13** *Two-thousand-year climate reconstruction of the Altai region with annual time resolution and the search of natural cycles with length from 3 to 1,000 years*
Andrey Darin, **Ivan Kalugin**, Natalya Maksimova, Tatiana Markovich, Aleksandr Mordvinov, Dmitryi Ovchinnikov, Yakov Rakshun

**OSM02-14** *Garabashi glacier (Central Caucasus) mass balance reconstructions inferred from tree-rings*
**Ekaterina Dolgova**, Vladimir Matskovsky

**OSM02-05** *Sea ice, biological production and nutrient cycling reconstructed at an unprecedented time resolution in the Adélie Basin, East Antarctica, for the last 2,000 years*
**Johan Etourneau**, Philippine Campagne, Francisco Jimenez, Irina Djouraev, Nana Ogawa, Carlota Escutia, Rob Dunbar, Naohiko Ohkouchi, Xavier Crosta, Guillaume Massé

**OSM02-06** *Multi-annual variability of the Peruvian Oxygen Minimum Zone across the last millenium*
**Sophie Fleury**, Philippe Martinez, Xavier Crosta, Karine Charlier, Olivier Ther, Thomas Blanz, Ralph Schneider

**OSM02-24** *Dendrochronological studies in Nepal: Current status and future prospects*
**Narayan Prasad Gaire**, Dinesh Raj Bhuju

# MEETING PROGRAM

**FRIDAY, 15 FEBRUARY (continued)**

**16:00-18:00 BLOCK 4 - Poster Sessions (continued)**

**OSM02-15** *High altitude tree-ring chronology from Malari Glacier, western Himalaya, India, and its climatic implications*
**Naveen Gandhi**, H.P. Borgaonkar

**OSM02-30** *Northern alpine ecosystems: Is temperature one climate factor, influencing to spruce and larch light-ring formation?*
**Marina Gurskaya**

**OSM02-38** *Climatic and environmental changes in the Barents Sea during the last 2ka: Response to variations in the Atlantic water inflow and NAO index*
**Elena Ivanova**, Ivar Murdmaa, Bjørg Risebrobakken, Anne de Vernal

**OSM02-37** *$\delta^{13}C$ and $\delta^{15}N$ in Soledad Basin and Magdalena Margin of Baja California, Mexico for the last 2 ky*
**Miryam Juarez**, Alberto Sanchez, Oscar González

**OSM02-12** *Paleorainfall variations in Southern India during the past 3154 years: Evidence from Pookot Lake record*
**Sandeep K**, Shankar R, Warrier A K, Weijian Z, Xuefeng Lu

**OSM02-39** *Unraveling the mysteries of chrysophyte resting stages – distribution of chrysophyte cysts in Finland*
**Sanna Korkonen**

**OSM02-23** *Climatic Fluctuations in the last ~2,000 years from Garhwal Himalaya (India) by using multi-proxy analyses*
**Bahadur Singh Kotlia**, Lalit Mohan Joshi, Nathani Basavaiah, N. C. Barui

**OSM02-27** *Isotope composition of the deep ice core from Elbrus Western plateau (the Caucasus)*
**Anna Kozachek**, Vladimir Mikhalenko, Alexey Ekaykin

**OSM02-33** *Lake Geneva sediments as archive for past environmental changes and human activity since the last 3000 years*
**Katrina Kremer**, Juan Pablo Corella, Stéphanie Girardclos

**OSM02-28** *Climatic signal in tree-ring width chronologies of European Russia: Spatial change and perspectives for paleoclimatic reconstructions*
**Vladimir Matskovsky**

**OSM02-07** *Landscape (Palaeo)limnology: A multi-lake approach to understanding climate change and human disturbance in south-eastern Australia over the last 500 years*
**Keely Mills**, Peter Gell

**OSM02-40** *Hydrological and Climatological Changes in the Trondheimsfjord/Norway during the late Holocene inferred from Benthic Stable Isotopes and Dinocyst Assemblages*
**Gesa Milzer**, J. Giraudeau, S. Schmidt, J. Faust, J. Knies, F. Eynaud, C. Rühlemann

**OSM02-22** *A 576-year annual minimum temperature history for the source region of the Yangtze River*
**He Minhui**, Yang Bao

**OSM02-04** *2k ice core records from the Weddell Sea region of Antarctica*
**Robert Mulvaney**

**OSM02-10** *Late Quaternary paleoceanography of the southwestern Indian Ocean*
**Dinesh K. Naik**, R. Saraswat, N. Khare, A.C. Pandey, A. Mackensen, R. Nigam

**OSM02-18** *Pluvials, Droughts, Energetics, and the Mongol Empire*
**Neil Pederson**, Amy Hessl, Baatarbileg Nachin, Oyunsanaa Byambasuren

**OSM02-11** *Was the Medieval Warm Period Global? Evidences from the Gulf of Kachchh Coast, Western India*
**S. P. Prizomwala**, Nilesh Bhatt, W Winkler, I Hajdas, A. M. Hirt

**OSM02-19** *Correlation between pollen spectra and vegetation of southwestern Madhya Pradesh, India*
**M. F. Quamar**, M.S. Chauhan

**OSM02-03** *Dust, sea salt and moisture source variability in central Draonning Maud Land, East Antarctica during the last millennium: Role of Southern Annular Mode and El-Niño-Southern Oscillation*
**Waliur Rahaman**, Meloth Thamban

**OSM02-32** *Marine records of environmental change in the NE Atlantic (west coast of the Iberian Peninsula) over the past 150 years – a dinoflagellate cyst perspective*
**Sofia Ribeiro**, Ana Amorim, Fátima Abrantes, Marianne Ellegaard

**OSM02-09** *Reconstructing the past millennium of hydrologic variability in the Western Tropical Pacific using the hydrogen isotopes of lipid biomarkers*
**Julie Richey**, Julian Sachs

**OSM02-08** *Late-Holocene climate variability in southern New Zealand:*
*A multi-proxy study of laminated lake sediments from Lake Ohau to reconstruct regional climate*
**Heidi Roop**, Marcus Vandergoes, Richard Levy, Gavin Dunbar, Sean Fitzsimons, Jamie Howarth, Bob Ditchburn, Gary Wilson, Jennifer Purdie

**OSM02-20** *Climate change in south India during the past two centuries inferred from geothermal and meteorological observations*
**Sukanta Roy**, David S. Chapman

**OSM02-16** *Variations in discharge from the Qilian mountains, northwest China, and its effect on the agricultural communities of the Heihe basin, over the last two millennia*
**Akiko Sakai**, Mitsuyuki Inoue, Koji Fujita, Chiyuki Narama, Jumpei Kubota, Masayoshi Nakawo, Tandong Yao

**OSM02-41** *The missing ocean - Generation of high resolution records of sea surface temperature for the Common Era*
**Jeff Salacup**, Timothy Herbert, Warren Prell

**OSM02-31** *Millennial-length drought reconstructions for southern and central Fennoscandia*
**Kristina Seftigen**, Edward Cook, Hans Linderholm, Jesper Björklund

**OSM02-21** *Climatic response of tree-ring density parameters of conifers from western Himalaya, India: Implications in dendroclimatology*
**Amar Sikder**, Hemant Borgaonkar

**OSM02-17** *Tree ring inferred seven century long Satluj river discharge records from the Indian Himalaya*
**Jayendra Singh**, Ram R. Yadav

**OSM02-43** *Do baobabs have annual tree rings for high-resolution palaeoclimatology?*
*An approach using wood anatomy and stable isotopes.*
**Franziska Slotta**, Gerd Helle, Ingo Heinrich, Karl-Uwe Heußner, Elisha Shemang, Frank Riedel, Pavel Tarasov

**OSM02-36** *Sensitivity of the forest-grassland ecotone to historical rainfall variation in pristine open woodland savanna of equatorial East Africa*
**Immaculate Ssemmanda-Nakimera**, Vanessa Gelorini, Dirk Verschuren

**OSM02-29** *Multiproxy evidence of environmental changes during last 1800 years recorded in coastal peatland of Puck Lagoon (southern Baltic)*
**Szymon Uscinowicz**, Wojciech Jeglinski, Grazyna Miotk-Szpiganowicz, Jacek Pawlyta, Natalia Piotrowska, Mariusz Galka, Malgorzata Witak

# MEETING PROGRAM

**OSM02-42** *An updated pseudoproxy evaluation of four climate field reconstruction methods using improved emulations of real-world conditions*
**Jianghao Wang**, Julien Emile-Geay, Dominique Guillot, Jason E. Smerdon

## OSM06 Past Changes in Fluvial Systems, Floodplains and Estuaries

Chair: Onkar S. Chauhan, Peter Gell, Rajiv Sinha

**OSM06-01** *Response and recovery from the effects of 100 years flood: Significance of long term slope-channel coupling in Damodar River, North-Eastern India*
**Sujay Bandyopadhyay**, Ritendu Mukhopadhyay, Debasis Ghosh

**OSM06-03** *Hydrological and Nutrient budget of Bhitarkanika Mangrove Estuary, East coast of India*
**Rita Chauhan**, AL Ramanathan, TK Adhya

**OSM06-04** *Rapid ecological changes following altered hydrological connectivities with the Yangtze River in Zhangdu Lake (China) over the past 200 years*
**Xuhui Dong**, Min Yao, Xiangdong Yang, Qinghui Zhang, Yangmin Qin

**OSM06-05** *Sedimentary archives of wetland-river interactions: The lower Murray River, Australia*
**Peter Gell**, Rosie Grundell, Michael Reid

**OSM06-09** *To study the chemical weathering and clay mineralogy of the sediments in Brahmaputra river and two of its tributaries to understand the carbon sequestration by weathering*
**Sumi Handique**, Jyotilima Saikia, Seema Talukdar

**OSM06-10** *A Preliminary study on the removal of earth materials from the river basins in Sri Lanka*
**Upali De Silva Jayawardena**

**OSM06-22** *River channel response to climate change and human impact: Case study of Russian plain*
**Irina Kargapolova**

**OSM06-11** *A simulation of the Neolithic transition in the Indus valley*
**Carsten Lemmen**, Aurangzeb Khan

**OSM06-15** *Submarine fill of a drowned large incised valley. The legacy of eustatic and climatic forcing*
**Vittorio Maselli**, Fabio Trincardi, Alessandra Asioli, Alessandro Ceregato, Federica Rizzetto, Marco Taviani

**OSM06-12** *Mid-Holocene environmental changes deduced from sedimentary records in the lower reaches of the Yeongsan River, Korea*
**Wook-Hyun Nahm**, Jaesoo Lim

**OSM06-06** *Neogene Palynofloral evolution of Ramganga Basin, Uttarakhand, India*
**Samir Sarkar**

**OSM06-21** *The development of sand dunes around Lake Balkhash and Ili delta in Southeast Kazakhstan: the effects from hydrological environment changes and the Holocene Climate changes, in Central Eurasia*
**Akio Sato**, Toshihiko Sugai, Kunihiko Endo, Reisuke Kondo, Hitoshi Shimizu, Tatsuro Chiba, Jean-marc Deom, Takashi Chiba, Yasunori Nakayama

**OSM06-13** *Geochemistry of buried river sediment in Ghaggar plains, NW India: Inferences on Late Quaternary palaeoclimate*
**Ajit Singh**, Debajyoti Paul, Sunil K. Singh, Rajiv Sinha

**OSM06-14** *Stratigraphic response to Late Quaternary monsoonal fluctuations in a buried valley complex in Ghaggar plains, NW India*
**Ajit Singh**, Kristina Thomsen, Rajiv Sinha, Sanjeev Gupta, Jan-Peter Buylaert, Andrew Murray, Mayank Jain

**OSM06-16** *Sea level and coastal changes during the Holocene in the Cauvery River delta, southern India*
**Pramod Singh**, P.P. Mohapatra, Z.A. Malik, S. Doradla, A.H. Laskar, J. Saravanavel, C.J. Kumanan, M.G. Yadava, S. Balakrishnan, Anupama Krishnamurthy

**OSM06-17** *The rise and fall of palaeo-megalake Bungunnia and the birth of the Murray-Darling basin in southeastern Australia: New palaeomagnetic and cosmogenic nuclide constraints on rates of geomorphological change*
**Ian Snowball**, Eeva Haltia-Hovi, Sandra McLaren, Ala Aldahan, Per Sandgren

**OSM06-02** *Main stem- tributary sedimentation in response to flood events during last 1000 years in lower Narmada basin, India*
**Alpa Sridhar**, Ravi Bhushan, Shraddha Band, Laxmansingh Chamyal

**OSM06-18** *Fluvial response to 3-2 ka sea-level lowering: An example of the latest Pleistocene to Holocene incised-valley fills in the Tokyo Lowland, central Japan*
**Susumu Tanabe**, Yoshiro Ishihara

**OSM06-19** *Early diagenetic processes of clay matters in decadal time-scale in tropical coastline sediments – case study in Vietnam*
**Nguyen Thi Minh Ngoc**

**OSM06-20** *Fluvial packages as archives to the Late Quaternary climatic fluctuations in SW Saurashtra, western India*
**Vishal Ukey**, Nilesh Bhatt

**OSM06-07** *Depositional Environment of intertidal Mudflat and Mangrove Environments with Time within a Tropical (Vaitarna) Estuary, West coast of India*
**Samida Volvoikar**, Ganapati Nayak, Aninda Mazumdar

**OSM06-08** *Fossil Diatoms as a flood indicator in a large shallow floodplain lake*
**Xiangdong Yang**, Qian Wang

## OSM15 The Role of Ocean Circulation in Climate Dynamics

Chair: Arun D. Singh, Devesh K Sinha

**OSM15-09** *Sub-centennial Holocene fluctuations of Atlantic water inflow and sea ice distribution in the western Barents Sea, European Arctic*
**Sarah Berben**, Katrine Husum, Patricia Cabedo Sanz, Simon Belt

**OSM15-04** *Location of the Marine ITCZ in the Atlantic Ocean over the last 30 ka*
**Caroline Cleroux**, Peter deMenocal, Jennifer Arbuszewski

**OSM15-07** *Eastern South Pacific water mass geometry during the last glacial-interglacial transition*
**Ricardo De Pol-Holz**, Dharma Reyes, Mahyar Mohtadi

**OSM15-06** *Reconstructing Plio-Pleistocene Intermediate Water Temperatures Using Mg/Ca of Infaunal Foraminifera (Uvigerina peregrina)*
**Aurora Elmore**, Erin McClymont, Harry Elderfield, Sev Kender, Benjamin Petrick

**OSM15-08** *Holocene Atlantic bottom water inflow at the western Barents Sea margin, European Arctic*
**Diane Groot**, Steffen Aagaard-Sørensen, Katrine Husum

**OSM15-12** *Suborbital ice-sheets variability in the subpolar North Atlantic during the Early and Mid-Pleistocene (MIS 31–19) as a response of low-latitude forcing*
**Iván Hernández-Almeida**, Francisco Javier Sierro, Isabel Cacho, José Abel Flores

# MEETING PROGRAM

**FRIDAY, 15 FEBRUARY (continued)**

**16:00-18:00 BLOCK 4 - Poster Sessions (continued)**

**OSM15-03** *Antarctic linkages to the deep water flow variability during the past 95000 years in the Indian sector of the Southern Ocean*
**M C Manoj**, Meloth Thamban, Rahul Mohan

**OSM15-02** *Cold-water corals of the West: North Carolina contribute to a North Atlantic basin study*
**Lelia Matos**, Furu Mienis, Norbert Frank, Claudia Wienberg, Dierk Hebbeln

**OSM15-01** *Mo isotopes in tropical estuaries: Implication to paleo-redox proxy*
**Waliur Rahaman**, Sunil K. Singh, Vinai K. Rai

**OSM15-05** *Evolution of the Mediterranean Outflow Water and its oceanographic - climatic implications: Preliminary Results of IODP Expedition 339 in the Gulf of Cadiz and west off Portugal*
**Arun D Singh**, F Javier Hernández-Molina, Dorrik Stow, Carlos Alvarez-Zarikian, Scientists Expedition IODP 339

**OSM15-13** *Late Neogene planktic foraminiferal events of ODP Site 762B, Exmouth Plateau, eastern Indian Ocean: Regional Diachrony and evidence of late Pliocene Ocean Circulation Changes*
Ashutosh Singh, **Devesh Sinha**

**OSM15-15** *Meeting the challenge of global high resolution paleoclimate modelling.*
**Paul Spence**

**OSM15-14** *Oxygen Isotope–Salinity Relationship for Paleosalinity estimation in distinct water masses of Indian & Southern Ocean*
**Kartik Thammisetti**, Manish Tiwari, Siddhesh Nagoji

**OSM15-11** *Oceanographic and climate variability in the Bay of Bengal over the last 60 kyr BP: Foraminiferal evidences*
**Komal Verma**, Santanu Bhattacharya, Mirtunjay Chaturvedi, Subhradeep Das, Sumit Jaiswal, Arun D. Singh

**OSM15-10** *Seasonality reconciles the discrepancies of sea surface temperature evolution in the Indian Ocean during the last deglaciation*
Yiming Wang, **Guillaume Leduc**, Marcus Regenberg, Nils Andersen, Thomas Blanz, Thomas Larsen, Ralph Schneider

**OSM15-16** *Control of the Northern Hemisphere Ice Sheets on Glacial Climate Stability*
**Xu Zhang**, Gerrit Lohmann

19:00-22:00 Conference Dinner & Cultural Event (International Centre Goa)

**SATURDAY, 16 FEBRUARY**

**09:00-10:30 BLOCK 1 - Oral sessions**

**Grande Sala**

**OSM09 Climate Impact on Human Evolution and Civilizations**
Chair: Dhananjay A. Sant, Martin Ziegler

*Early human speciation, migration and brain expansion driven by African climate pulses*
**Mark Maslin**, Susanne Shultz

*Variable Impact of climate change on populations of archaic humans and modern humans inferred from archaeological evidence*
**Sheila Mishra**, Navin Chauhan, Ashok Singhvi

*Late Pleistocene to Holocene climate and seasonality in North Africa from $\delta^{18}O$, $\delta^{13}C$ and Mg/Ca analysis of marine and terrestrial mollusc shells (Haua Fteah, Libya)*
**Amy Prendergast**, Rhiannon Stevens, Tamsin O'Connell, Chris Hunt, Graeme Barker

*Integration of regionally resolved decline models for the Indus Valley Culture*
**Carsten Lemmen,** Aurangzeb Khan

*Central American rainfall changes over the past ka and implications on the Classic Maya society*
**Sebastian Breitenbach**, Douglas Kennett, Valorie Aquino, Yemane Asmerom, Jaime Awe, James Baldini, Patrick Bartlein, Brendan Culleton, Claire Ebert, Christopher Jazwa, Martha Macri, Norbert Marwan, Victor Polyak, Keith Prufer, Harriet Ridley, Harald Sodemann, Bruce Winterhalder, Gerald Haug

*Medieval climate change and the end of the Norse settlements in Greenland*
**Sofia Ribeiro**, Antoon Kuijpers, Marit-Solveig Seidenkrantz, Naja Mikkelsen

**Sala de Banquete**

**OSM04 Climate Modes in the Past**
Chair: Ed Hathorne, Nerilie Abram, Manish Tiwari, Thomas Felis

*Historical mega-droughts in the medieval Levant and Nile Valley*
**Mordechai Stein**, Kate Raphael, Yochanan Kushnir

*Shifts in sea surface temperature on centennial to interannual timescales in the Gulf of Mexico since 1734 CE*
**Kristine DeLong**, Christopher Maupin, Jennifer Flannery, Terrence Quinn, Ke Lin, Chuan-Chou Shen

*Holocene history of ENSO in the Eastern Tropical Pacific reconstructed from Peruvian mollusk shells*
**Matthieu Carré**, Sara Purca, Rommel Angeles Falcon, Julian P. Sachs

*The Tropical Pacific climate response to the changing forcing over the last glacial cycle*
**William Roberts**, Paul Valdes

*Regional differences in Indonesian rainfall and their relation to ENSO and IOD mode*
**Eva M. Niedermeyer**, Mahyar Mohtadi, Alex L Sessions, Sarah Feakins

*Proxy and model evidence for ENSO-mediated coupled Pan-Pacific drought and pluvial modes in North America and Asia*
**Kevin Anchukaitis**, Edward Cook, Brendan Buckley, Jessica Tierney, Johann Jungclaus

10:30-11:00 Coffee break

**11:00-12:30 BLOCK 2 - Poster Sessions**

**OSM04 Climate Modes in the Past**

Chair: Ed Hathorne, Nerilie Abram, Manish Tiwari, Thomas Felis

**OSM04-01** *Climate variability and warming on the Antarctic Peninsula during the last millennium*
**Nerilie Abram**, Robert Mulvaney, Jack Triest, Eric Wolff, Sepp Kipfstuhl, Luke Trusel, Francoise Vimeux, Louise Fleet, Carol Arrowsmith

**OSM04-02** *SST and Salinity Variations Associated with ENSO and IOD: Records from Indonesian Corals*
**Sri Yudawati Cahyarini**, Intan Suci Nurhati, Miriam Pfeiffer, Jens Zinke, Mutiara Putri, Edvin Aldrian, Wolf-Chr. Dullo

**OSM04-03** *Low frequency variability of the Arctic Oscillation (AO) and ENSO during the Holocene recorded in the spatial pattern of Northern Hemisphere extra-tropical temperatures*
**Basil Davis**, Achille Mauri, Jed Kaplan, Christoph Raible, Flavio Lehner

# MEETING PROGRAM

**OSM04-04** *Sub-seasonally resolved coral records of northern Red Sea climate during the Holocene and the last interglacial*
**Thomas Felis**, Norel Rimbu, Saber Al-Rousan, Henning Kuhnert, Martin Kölling, Gerrit Lohmann

**OSM04-05** *The Holocene climatic fluctuations in the Ukrainian steppe based on multidisciplinary study of the banded deposits of the lake Saki (Crimea)*
**Natalia Gerasimenko**, Dmitriy Subetto, Volodymyr Bakhmutov, Lidia Dubis

**OSM04-06** *Recent accumulation rate and impurity seasonality derived from NEEM firn cores*
**Gideon Gfeller**, Matthias Bigler, Daiana Leuenberger, Olivia Mini, Hubertus Fischer

**OSM04-07** *Developing South Atlantic Coral Paleoclimate Records from Rocas Atoll, Brazil*
**K. Halimeda Kilbourne**, Ruy Kenji Papa de Kikuchi

**OSM04-08** *Mid-Holocene regional reorganization of climate variability: Analyses of proxy data in the frequency domain*
**Carsten Lemmen**, Kai W Wirtz, Gerrit Lohmann

**OSM04-09** *The Summer North Atlantic Oscillation: Character and teleconnections over the last millennium*
**Hans Linderholm**, Jee-Hoon Jeong, Chris Folland, Baek-Min Kim, Tinghai Ou

**OSM04-10** *Mid- to Late Holocene temperature and salinity changes in the Southwestern Atlantic*
**Renata Hanae Nagai**, Cristiano M. Chiessi, Silvia H.M. Sousa, Henning Kuhnert, Stefan Mulitza, Michel M. Mahiques

**OSM04-11** *Coral Records of South China Sea Throughflow's Thermohaline Variations over the Last Century*
**Intan Suci Nurhati**, Sri Yudawati Cahyarini, Ed Boyle

**OSM04-12** *Multi-proxy study of a Lake from mainland Gujarat: Understanding mid-late Holocene climatic fluctuations*
**Rachna Raj**, Vandana Prasad, Anjum Farooqui, Anupam Sharma, Binita Phartiya, Supriyo Chakraborty, Subhash Bhandari, Abha Singh

**OSM04-13** *A 65 ka stalagmite paleoclimate record from northern Venezuela: A record of Caribbean climate change*
**Julie B. Retrum**, Luis A. González, R. Lawrence Edwards, Stacy M. Tincher, Hai Cheng, Franco Urbani

**OSM04-14** *Relationship between the variations of the location of the ITCZ in the West Pacific and ENSO in different climatic contexts*
**Marion Saint-Lu**, Pascale Braconnot, Matthieu Lengaigne, Olivier Marti

**OSM04-15** *High resolution climatic record from the Kumaun Himalaya: A speleothem study*
**Jaishri Sanwal**, B.S. Kotlia, S.M. Ahmad, C.P. Rajendran, Kusala Rajendran

**OSM04-16** *Late Quaternary climatic signals from the Kumaun lesser Himalaya: Evidence from a fluvio-lacustrine deposit*
**Jaishri Sanwal**, C.P. Rajendran, M.S. Sheshshayee, Kusala Rajendran

**OSM04-17** *New insights on last glacial ice-sheet dynamics and retreat deduced from Southeastern Weddell Sea sediment*
**Daniela Sprenk**, Michael E. Weber, Gerhard Kuhn

**OSM04-18** *Indian Ocean dipole mode and its relation with the Indian summer monsoon variability at multi-centennial to millennial timescales*
**Manish Tiwari**, Siddhesh Nagoji, Kartik Thammisetti, Rahul Mohan

**OSM04-19** *Sub-centennial to centennial scale changes in productivity in the Eastern Arabian Sea: Implications to the Indian summer monsoon variability since mid-Holocene*
**Manish Tiwari**, Siddhesh Nagoji, Kartik Thammisetti

**OSM04-20** *Response of planktic foraminifera to oceanic environmental changes during cenomanian - Turonian transition in SE India*
**Raju Venkatachalapathy**, G Shanmugavalli

### OSM05 Abrupt Changes and Extreme Events - Assessment and Risks

Chair: Pierre Francus, Pierre Antoine

**OSM05-04** *Abrupt climatic events in continental Europe during MIS 5 (Early-glacial / 112-70 ka): Highlighting a new reference record at Dolni Vestonice (Czech Republic)*
**Pierre Antoine**, Denis-Didier Rousseau, Markus Fuchs, Sebastian Kreutzer, France Lagroix, Olivier Moine, Christine Hatte, Caroline Gauthier, Jirí Svoboda, Lenka Lisa

**OSM05-01** *Analysis of tree-ring data of fir (Abies densa) in relation to climate vis-à-vis movement of Zemu glacier, Eastern Himalaya*
Amalava Bhattacharyya, **Mayank Shekhar**, Santosh K. Shah, Vandana Chaudhary

**OSM05-09** *Abrupt Climate Change- Past and Present and Future Meet*
**Peter Carter**

**OSM05-06** *Abrupt changes in lake sediment properties are not always reflecting regional abrupt changes: Example from varved Lake Yoa, Northern Chad.*
**Pierre Francus**, Hilde Eggermont, Dirk Verschuren, Stefan Kröpelin

**OSM05-03** *4100 years long tree-ring record of extreme temperature events in the Yamal Peninsula*
**Lyudmila Gorlanova**, Rashit Hantemirov

**OSM05-05** *Gravel beaches: Signals of changing*
**Helena Granja**, José Pinho

**OSM05-07** *Seasonal and centennial cycles of carbonate mineralisation during the past 2500 years from varved sediment in Lake Shira, South Siberia*
**Ivan Kalugin**, Andrey Darin, Denis Rogozin, Gennady Tretyakov

**OSM05-08** *Millennial and orbital climate variability in West Antarctica*
**Bradley Markle**, Eric Steig, Ed Brook, WAIS Divide Project Members, Todd Sowers, T. J. Fudge, Spruce Schoenemann, Andrew Schauer, Cecilia Bitz, Qinghua Ding, Emily Newsom, Ken Taylor

**OSM05-02** *Tree-ring-based long-term snowfall records for Western Himalaya, India*
**Ramratan Yadav**, Mahendra R Bhutiyani

### OSM09 Climate Impact on Human Evolution and Civilizations

Chair: Dhananjay A. Sant, Martin Ziegler

**OSM09-10** *Correlation between the climatic and geological events and changing of archaeological cultures in SE Altai (Russia) during the Late Holocene*
**Anna Agatova**, Roman Nepop, Igor Sljusarenko, Vladimir Myglan, Valentin Barinov, Andrey Nazarov

**OSM09-07** *Regional integration of lake sediment and archaeological archives: Holocene climate variability and socio-evolutionary pathways in Cappadocia, central Anatolia*
**Samantha Allcock**

**OSM09-04** *Dating the earliest human occupation of Western Europe: New evidences from the fluvial terraces system of the Somme basin (North France)*
**Pierre Antoine**, Nicole Limondin-Lozouet, Marie-Hélène Moncel, Jean-Luc Locht, Jean-Jacques Bahain, Pierre Voinchet, Patrick Auguste

# MEETING PROGRAM

**SATURDAY, 16 FEBRUARY (continued)**

**11:00-12:30 BLOCK 2 - Poster Sessions (continued)**

**OSM09-01** *Megalake Chad occurrences in the Pliocene: An insight into early hominid environment*
**Camille Contoux**, Gilles Ramstein, Anne Jost, Mathieu Schuster, Pierre Sepulchre, Pascale Braconnot

**OSM09-08** *Impacts of climate variability and Maya settlement on Laguna Tuspán (Petén, Guatemala) during the past 5000 years*
**Sophie Fleury**, Bruno Malaizé, Philippe Martinez, Viviane Bout-Roumazeilles, Jacques Giraudeau, Didier Galop, Alexandre Torneberg, Kees Nooren, Karine Charlier, Pierre Carbonel, Marie-Charlotte Arnauld

**OSM09-17** *Extreme Weather, Famine, Dynasty Revolution, and the Possible Connection to Volcanic Activities over the Past 1500 years in China*
**Chaochao Gao**

**OSM09-11** *Assessing impacts of climate variability on the demography of pre-Hispanic societies from the Atacama Desert over the past three millennia*
**Eugenia Gayo**, Claudio Latorre, Calogero Santoro

**OSM09-16** *History of climate: 2000 Leagues overseas*
**Alain Gioda**, Mike Baker

**OSM09-22** *Mineral Magnetic studies to indicate Paleo-anthropogenic loading of particulate matters in the Mumbai and Delhi metropolitan regions*
**Swapnil Guadadhe**, Satish Sangode, Shiva Kumar Patil, Dilip Chate, Dhananjay Meshram

**OSM09-21** *Regime shifts in past ecosystems of maar lakes: Lessons for building ecological resilience to future climate change*
**Giri Kattel**, Frank Sirocko, Paul Augustinus

**OSM09-02** *Palaeoenvironments of the Olorgesailie Basin during Mid-Late Pleistocene inferred from Phytolith analyses*
**Rahab Kinyanjui**, Michael Meadows, Lindsey Gillson

**OSM09-15** *On the sensitivity of the simulated European Neolithic transition to climate extremes*
**Carsten Lemmen**, Kai W Wirtz

**OSM09-06** *Modeling and simulation of Holocene hunter-gatherer and agro-pastoral groups to explore the role of climate in population behaviour*
**Marco Madella**, Andrea Balbo, Carla Lancelotti, Bernardo Rondelli, Xavi Rubio, Alexis Torrano, Matthieu Salpeteur, Victoria Reyes-Garcia, P. Ajithprasad, Andreas Angourakis

**OSM09-09** *Human responses to monsoon variability in South East Asia: Cambodian pre-Angkor and Angkor periods*
**Naoko Nagumo**, Toshihiko Sugai, Sumiko Kubo

**OSM09-20** *Recent climate change in West Africa and adaptation strategies proposed by rural population*
**Timothee Ourbak**, Benoit Sarr

**OSM09-12** *Peat in the desert: A local environmental history for the Holocene in semi-arid Jordan, and its comparison to the evolution of societies*
**Claire Rambeau**

**OSM09-14** *Climate change and the Plague of Justinian*
**Neil Roberts**, Matthew Jones, Warren Eastwood, Jessie Woodbridge, Samantha Allcock, Jonathan Dean

**OSM09-05** *The effect of late Holocene precipitation changes on natural resources and human society in northern Europe*
**Gunhild Ninis Rosqvist**, Melanie Leng

**OSM09-18** *Evidence of Human-Animal-Climate interaction in lower reaches of Narmada Valley, Western India*
**Dhananjay Sant**, K Krishnan, Vijay Sathe, S. N. Rajaguru, Prabhin Sukumaran, Parth Chauhan

**OSM09-19** *Examining the relationships between Holocene climate change, hydrology and human society in Ireland*
**Philip Stastney**

**OSM09-13** *The impact of environmental change on past human societies in the Central Peloponnese (Greece)*
**Ingmar Unkel**, Helmut Brückner, Walter Dörfler, Timothy Filley, Jeannette Forsén, Christian Heymann, Haydn Murray, Oliver Nelle, Arndt Schimmelmann, Christine Shriner, Helen Zagana

**OSM09-03** *Development of modern human behaviour linked to rapid climate change*
**Martin Ziegler**, Margit Simon, Ian R. Hall, Stephen Barker, Chris Stringer, Rainer Zahn

### OSM10 Sea Level Change and the Coastal Zone: Threats for Human Societies

Chair: Yusuke Yokoyama

**OSM10-07** *Diversity of mangrove plants in relation to palaeoenvironment during Quaternary Period in Bengal Basin*
**Nimai Chandra Barui**, Payel Roy

**OSM10-16** *Effects of sea level changes and tectonics on scalping the Late Quaternary deposits along the Southern Saurashtra coast, Western India*
**Subhash Bhandari**

**OSM10-01** *Deciphering natural trends from anthropogenically induced changes in coastal areas: Example of the hypoxia in the Lower Estuary of St. Lawrence, eastern Canada*
**Anne de Vernal**, Claude Hillaire-Marcel, Benoit Thibodeau, Dhahri Nouha

**OSM10-14** *Chemical Fractionation of Metals in Sediment cores of Intertidal regions along Ulhas Estuary, Mumbai, India*
**Lina Fernandes**, Ganapati N Nayak

**OSM10-10** *Identification of Tsunami deposits and their impact on coastal zones: A study case of the Boca do Rio estuary (Algarve, Portugal)*
Eric Font, **Cristina Veiga-Pires**, Manuel Pozo, Silvia Nave, Susana Costa, Francisco Ruiz Muñoz, Manuel Abad, Nuno Simões, Silvia Duarte

**OSM10-03** *Anthropogenic impact in coastal Baltic Sea over the last 2000 years using biological proxies*
**Anupam Ghosh**, Wenxin Ning, Helena L. Filipsson

**OSM10-04** *Late Holocene environmental change inferred from coastal lake and estuarine sediments in the Wilderness area, southern Cape, South Africa*
**Torsten Haberzettl**, Roland Mäusbacher, Bastian Reinwarth, Siegfried Clausnitzer, Sarah Franz, Kelly Kirsten, Jussi Baade, Thomas Kasper, Lynne Quick, Gerhard Daut, Michael Meadows

**OSM10-13** *Postglacial-Holocene relative sea level data from the White Sea Coast, Russia*
**Vasily Kolka**, Olga Korsakova

**OSM10-11** *Postglacial RSL changes of White Sea according the lithological and micro-paleontological data (Kandalaksha Bay, NW Russia)*
**Olga Korsakova**, Vasily Kolka, Nadezhda Lavrova

# MEETING PROGRAM

**OSM10-15** *Tectonic geomorphology of the Holocene marginal marine basin of the Great Rann of Kachchh, Western India: Implication for pattern of emergence during historical times*
**Deepak Maurya**, Nitesh Khonde, Archana Das, Laxman Chamyal

**OSM10-08** *Analysis of Mangroves vegetation history from Kanjani (Kerala), the South West coast of India*
**Sandhya Sharma**, Amalava Bhattacharyya

**OSM10-06** *Mangrove and coastal environment changes during the Holocene in the Mahanadi Delta, India*
**Shilpa Singh**

**OSM10-09** *Persistent non-solar forcing of Holocene storm dynamics in coastal sedimentary archives*
**Philippe Sorrel**, Maxime Debret, Isabelle Billeaud, Samuel L. Jaccard, Jerry F. McManus, Bernadette Tessier

**OSM10-12** *Holocene sea-level change in Sri Lanka and melting history of Antarctic ice sheet*
**Yusuke Yokoyama**, Yosuke Miyairi, Jun'ichi Okuno, Kazuhisa Goto, Tsuyoshi Haraguchi, Hiroyuki Matsuzaki

**OSM10-05** *Holocene evolution of Qing'ao embayment, Southern China*
**Fengling Yu**, Adam D Switzer, Bishan Chen, Zhuo Zheng, Deli Wang

**OSM10-02** *Assessment of the Possible Impact of Climate Change on Fresh Water – Saline Water Interaction in the Coastal Aquifers of Bangladesh due to Sea-level Rise*
**Anwar Zahid**, Khurshid Jahan

12:30-14:00 Lunch

**14:00-15:30** **BLOCK 3 - Oral sessions**

**Grande Sala**

**OSM10 Sea Level Change and the Coastal Zone: Threats for Human Societies**
Chair: Yusuke Yokoyama

*Uncertainty on future sea level rise - implications for planning and the role of scientist qua advisor*
**Per Wikman-Svahn**

*Anthropocene changes in particulate and dissolved fluxes from major rivers and their impact on coastal processes: methodological issues (solicited talk)*
**Claude Hillaire-Marcel**

*Erosion of Arctic permafrost coasts and mobilization of dissolved organic carbon (DOC) from ground ice*
**Michael Fritz**, Nicole Couture, Hugues Lantuit

*The probable drivers of contemporary Effective sea level rise rate in southwest Bangladesh*
John Pethick, **Julian Orford**

*What can we learn from recent catastrophic coastal events in Vietnam, India, Philippines and Thailand?*
**Adam Switzer**, Christos Gouramanis, Ying Sin Lee,, Charles Bristow, Charles Rubin, Kruawun Jankaew, S. Srinivasalu, Lam Dinh Doan, Fernando Siringan, Que Dinh Hoang

*Using sea-level proxy data to constrain future sea-level rise*
**Stefan Rahmstorf**

**Sala de Banquete**

**OSM05 Abrupt Changes and Extreme Events - Assessment and Risks**
Chair: Pierre Francus, Pierre Antoine

*Regional reconstructions of the past extreme flood activity from Alpine lake sediments*
Bruno Wilhelm, **Fabien Arnaud**, Pierre Sabatier, Jean-Jacques Delannoy

*The Indian Monsoon anomaly at 4k; dynamical analogs and cultural implications*
**Max Berkelhammer**, Ashish Sinha

*A high resolution dust flux record of the last glacial period from northwestern Chinese Loess Plateau*
**Liping Zhou**, Jintang Qin

*The last rapid decline of lake levels on the Tibetan Plateau*
**Torsten Haberzettl**, Thomas Kasper, Sascha Fürstenberg, Thomas Grau, Karoline Henkel, Hao Long, Sabine Miehe, Youliang Su, Gerhard Daut, Peter Frenzel, Junbo Wang, Liping Zhu, Roland Mäusbacher

*Extreme Events: Himalayan Floods*
**Shipra Chaudhary**, Y.P. Sundriyal, Navin Juyal, R. J. Wasson

15:30-16:00 Coffee break

**16:00-18:00** **BLOCK 4 - Plenary Session and Future Earth Discussion** Chair: Liping Zhou

16:00-16:30 Plenary Talk: **Martin Jones - Food economics in (pre-)historical times**

16:30-17:00 Plenary Talk: **Kathy Willis - Climate change and biodiversity**

17:00-17:45 Plenary Discussion: **Future Earth**

17:45-18:00 Closing

**SUNDAY, 17 FEBRUARY**

**Field Trips**

## General Information and Social Activities

### Local Transports

Transport between the conference venues and all official meeting Hotels / guest houses will be arranged by the local organizing committee. Participants staying at other places must organize their own transport to the venue. Since the venue is away from main roads, the public transport system is not reliable and you may have to arrange a taxi.

Free transportation will be arranged on all conference days between the hotels and guest houses at 8.30 hrs in the morning and immediately after the evening session, except on days when there is an event following the sessions. A Transport desk operates during the conference days and any emergency requirements should be informed at the desk.
Participants who would like to travel around Goa may seek the respective hotels to arrange transportation. Transportation for all official field trips will be organized by the local organizing committee.

Free airport drops from the designated conference venues will be arranged on 17 and 18 February, if your departure details are made available to the Transport desk situated outside the plenary hall.

### Venue

PAGES 4th OSM is held at Cidade de Goa Beach Resort, Dona Paula, Goa (see map). The inaugural session and all plenary sections is held at *Grande Sala*. The parallel oral sessions are at *Grande Sala* and *Sala de Banquete*. Breakout sessions and group meeting can be held at *Harmonia*, if booked with the conference office in advance. Poster sessions are held at *Mandovi* lawns and *Zuari* lawns.


Map 1: Meeting venue - Cidade de Goa (http://www.pages-osm.org/osm/location/venue)

## General Information and Social Activities

**Internet Access**
Free WiFi is available at the meeting halls. The WiFi access details are provided with the registration kit.

**Conference Office**
Conference office will be next to the Grande *Sala*. Proper signages will be provided during the meeting days.

**Registration Desk**
OSM Registration desks are located at the SDB Terrace, next to the *Sala de Banquete* hall. Registration desk operates during 15.00 – 20.00 hrs on 12 February (Tuesday) and 08.00 – 11.00 hrs on 13 February 2013 (Wednesday). Thereafter, registration can be done at the Conference Office.

**Welcome Reception**
An ice breaker and buffet dinner is held at the beach front of Cidade de Goa (entry near to the swimming pool) on 12 February starting from 19.00 hrs. Participants and accompanying persons are welcome!

**Lunch and Breaks**
Morning tea/coffee breaks and buffet lunch is arranged at the Multi-Function Area and the adjacent Courtyard; the Laranja Restaurant is also available for the participants who like to have a relaxed seating. Post lunch tea/coffee breaks are arranged at the sea-facing Zuari lawns among the Posters.

**Conference Dinner**
The conference dinner and associated cultural event is held on Friday, 15 February (19.00 – 22.00 hrs) at the *Laran* Lawn, a terraced outdoor venue at the International Centre Goa. Free transportation is arranged between all official OSM accommodation sites. Participants and accompanying persons are welcome!

**Public lecture**
The public lecture is delivered by Dr. Rajendra K. Pachauri, Director-General of The Energy and Resources Institute (TERI), New Delhi, India & Chair of the Intergovernmental Panel on Climate Change (IPCC). The lecture is followed by a panel discussion with eminent scientists and interactions with the audience.

Date & Time: Thursday 14 February, 19.00 hrs
Venue: The Cardium, National Institute of Oceanography, Dona Paula

The event concludes with a "High Tea" reception arranged by NCAOR. Free transportation will be provided between the venue and all accommodation sites. The exact timings of the buses will be placed at the notice board outside the plenary halls.

**Plenary sessions**
All plenary sessions take place at the *Grande Sala*.

**Oral Presentations**
Oral presentations are held as parallel sessions at the *Grande Sala* and at the *Sala de Banquete*. Two oral sessions run in parallel. Each block of 1.5 hours consists of six 15-minute talks (including 2 minutes for discussion and 1 minute for switchover).

Speakers are kindly asked to upload their presentations directly in the respective halls **no later than 15 minutes before the start of their session block**. Mac and PC laptops are available to speakers. Presentation can be made using Powerpoint, Keynote or Adobe software.

## General Information and Social Activities

**Poster Presentations**
Open air poster exhibition and sessions sre held at the sea-facing *Zuari* lawns. Each poster is on display during two entire days and will be presented during the scheduled poster sessions (see program).

Posters should be put up in the morning on the first day allocated to its presentation (Wednesday or Friday respectively) **on the board labeled with your poster number**. Presenters should be in attendance during the poster session. All posters must be removed by the owners on the evening of the second day. Any poster remaining after the due time will be discarded by the organizers.

Posters from the following sessions are displayed on Wednesday and Thursday:
OSM01, OSM03, OSM07, OSM08, OSM11, OSM12, OSM13, OSM14, OSM16

Posters from the following sessions will be displayed on Friday and Saturday:
OSM02, OSM04, OSM05, OSM06, OSM09 OSM10, OSM15

**Beach Soccer**
The PAGES Soccer Cup is played on the evening of Wednesday, 13 February in the form of a beach soccer tournament.

Location & Time: Cidade de Goa Beach, kick-off at 18:30 hrs

Transportation is arranged to the respective places of OSM accommodation after the soccer cup.

**Field Trips**
Four field trips are being organized on 17th February. *All participants should contact the registration desk for confirmation and get their field booklets and sign a declaration form as required by the organizers.*

The 3-day field trip to "Deccan Traps" is organized from Mumbai and will end at Mumbai. Please note that the participants taking part in this field trip will be picked up from Mumbai domestic airport on 17th February at 9 AM. **Participants should arrange their own transport from Goa to Mumbai.** The booking for this field trip is already closed and a detailed program has already been mailed to all participants. For any clarifications, you may contact the concerned field guides as given in the programme and guidelines.

Three one-day local trips are being organized to visit Central Goa, South Goa and North Goa on the 17 February. Please check the PAGES conference website for trip details. Depending on availability, registrations for the remaining places of the one-day field trips can be made at the registration desk and in the meeting office.

The one-day field trips will **start at 08.30 hrs and will end at 18.30 hrs.** All necessary transportation between the places of accommodation, lunch and refreshments will be provided. The trip details will be provided by e-mail or at the registration desk.

## Public Lecture

***Chair**: S. Rajan, National Centre for Antarctic and Ocean Research*

***Date and time:** Thursday, 14 February – 19:00-21:00*

***Location:** The Cardium, National Institute of Oceanography, Dona Paula*

**19:00-19:45 Lecture**

### Climate Change and implications for global society

*Rajendra K. Pachauri*

*Director-General of the Energy and Resources Institute (TERI), New Delhi, India & Chair of the Intergovernmental Panel on Climate Change (IPCC)*

Dr. Rajendra K. Pachauri is the Chief Executive of The Energy and Resources Institute (TERI). TERI does original research and provides knowledge in the areas of energy, environment, forestry, biotechnology, and the conservation of natural resources to governments, institutions, and corporate organizations worldwide. Dr. Pachauri is also Chancellor of TERI University and Chairman of the Intergovernmental Panel on Climate Change (IPCC). IPCC along with former Vice President Al Gore was awarded the "Nobel Peace Prize" in 2007. Dr. Pachauri was the Founding Director of the Yale Climate and Energy Institute (YCEI) from July 2009 until June 2012, following which he was appointed as Senior Adviser to YCEI. He has been active in several international forums dealing with the subject of climate change and its policy dimensions.

**19:45 - 20:30 Discussion**

### Questions from the audience to an expert panel

*Moderation: Ashok K. Singhvi (Physical Research Laboratory, Ahmedabad, India)*

Expert panel:

- Rajendra K. Pachauri (Energy and Resources Institute, New Delhi, India)
- Cathy Whitlock (Institute on Ecosystems, Montana State University, USA)
- Robert Wasson (Department of Geography, National University of Singapore)
- Gavin Schmidt (NASA-Goddard Institute for Space Studies, USA)
- Stefan Rahmstorf (Potsdam Insitute for Climate Impact Research, Germany)

**20:30 – 21:00 Reception**

### High Tea reception

Sponsored by the National Centre for Antarctic and Ocean Research

## Wednesday, 13 February

10:00-10:30

### Land-sea correlation: Pitfalls and remedies

*Ashok Singhvi*

To date, most land–sea or land–land correlations have been made, and are being made, by assuming a synchronicity of events, processes, and resulting changes on land and in the oceans. In such studies, it is implicitly assumed that, like marine or ice core records, terrestrial archives are created/accreted continuously, and that terrestrial sediment attributes behave in the same manner as those of the ocean or ice proxies. Based on this assumption, identical periodicities in the response of terrestrial systems have been inferred in numerous cases and major conclusions have been drawn. A further complication is the use of multi-proxy data with the simplistic assumption that all proxies respond to forcing in a synchronous manner and that the larger the number of proxies, the better. Direct dating of geological archives using modern chronometric methods have necessitated changes in this conventional wisdom. I shall present three chronometrically constrained case studies of dryland responses to monsoon changes:

1) clear evidence of lagged Aeolian system response
2) spatially different soil formation chronologies on the same stratigraphic boundaries
3) variable timing of the desiccation of lacustrine systems within a small spatial domain

These cases defy conventional wisdom and suggest the importance of determining temporal and spatial gradients and proxy responses based on robust chronologies. The need now is to more completely understand proxies by determining their thresholds, response styles, and timescales by establishing sound chronologies. Blending field evidence with chronometry is essential, along with recognition of the nature of events being dated by a particular method. This information will be needed for proper land use-landcover planning and for climate modeling under anticipated environmental change scenarios. A powerful yet simple and analytical approach to this problem is one of system dynamics that explicitly includes feedbacks, delays, and response types. Such approaches will be crucial for paleoscience to truly serve as a compass for future Earth.

*A.K. Singhvi — Geosciences Division, Physical Research Laboratory Ahmadabad, India*

## Thursday, 14 February

09:00-09:30

### Extending baseline hydrology from decades to centuries: Implications for water resource engineering

*Dave Sauchyn*

Standard practices in water resource management and engineering assume a certain reliability of water supplies and stationarity of the hydrologic regime based on the analysis of hydrometric data. Paleohydrology and climate modeling undermine these assumptions by revealing scales and extremes of hydroclimatic variability outside the scope of instrumental records. Generally, professional planners and hydrological engineers regard the tangible evidence from climate proxies with less skepticism than model projections and thus paleoclimate reconstructions are a gateway for introducing practitioners to concepts of climate variability and change. Tree rings are particularly familiar. The tree-ring reconstruction of annual and seasonal water levels is based on the correlation between watershed wetness (water stored in plants and soil) and runoff.

However, in western Canada cold weather processes, including snow accumulation and melt, glacier runoff and frozen soils, dominate the hydrology. We are challenged to capture this cold season hydroclimate signal using biological proxies. This talk explores attempts to improve the tree-ring reconstruction of streamflow that is produced primarily by snowmelt. We also describe applications of paleohydrology to regional climate adaptation in Canada's western interior, where water is limiting ecologically and economically, and recent temperature trends, notably higher winter temperatures, are mostly favorable circumstances. Less favorable and more challenging consequences of regional climate change are shifts in precipitation and surface water supplies among seasons, years and decades. While adjustments to water practices, polices and structures to manage high-frequency variability in hydroclimate are familiar and feasible, novel adaptive strategies are required to address hydroclimate trends and decadal variability. The recognition and analysis of this low-frequency variability is important for our understanding of the regional climate regime, and for water resource planning and management for infrequent events, specifically sustained drought.

*D. Sauchyn, J. St. Jacques, S. Lapp, C. Perez-Valdivia, J. Vanstone — Prairie Adaptation Research Collaborative University of Regina, Regina, Canada*

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09:30-10:00

### State of the Himalayan cryosphere

*Anil Kulkarni*

The Himalaya region has one of the largest concentrations of glaciers and many rivers such as the Indus, Ganga, and Bramhputra originate from glacier bound regions. However, this source of water may be influenced in the future, as the Himalayan cryosphere is constantly changing. Therefore, the retreat of Himalayan glaciers and its impact on water availability is being discussed extensively in scientific and public forums in India. Conventionally, the health of glaciersis assessed through changes in glacial length. This could be misleading, as a change in length may be caused by numerous climatically sensitive and other terrain parameters. These influences can produce complex patterns of glacial retreat and may lead to erroneous conclusions. Therefore, it would be useful to understand changes in glacial mass to assess future changes in glacial extent.

Measurements of mass budget for glaciers in the Kara-

**Plenary Talks**

koram-Himalaya (K-H) region are relatively few and cover only a short duration. The available data suggest that mass budget over large parts of the Himalaya region has been negative over past decades. Estimates suggest that glaciers in the K-H region are losing mass at the rate of approximately 19.58±11.42 Gt per year. However, the loss in mass of many small glaciers located in a low altitude range could be as high as 1000 kg $m^{-2}$ $y^{-1}$. These small glaciers and ice fields are important sources of water for many mountain communities.

In addition to changes in temperature and precipitation, in the future, glacial retreat and mass balance will be further influenced by the formation of glacier lakes and the deposition of black carbon in accumulation areas. Therefore, continuous monitoring is needed to understand the changing dynamics of Himalayan glaciers. In my talk, I will discuss these issues and also discuss the present state of Himalayan cryosphere.

*A.V. Kulkarni — Divecha Center for Climate Change, Indian Institute of Science, Bangalore, India*

10:00-10:30

## Rivers and deltas in the Anthropocene

*James Syvitski*

For over two decades, PAGES has been putting key global environmental parameters and trends into context with scientific underpinning. What has the earth experienced in its past in terms of $CO_2$, surface temperature, sea level rise, sea ice extent, behavior of glaciers and ice sheets, forest cover, and so on? Just how resilient IS our planet? Research on global sustainability needs the context that PAGES continues to provide and is necessary within the IGBP and IPCC communities. However the scientific challenges facing PAGES scientists are not be underestimated as they employ proxy data from the Holocene, calibrated with observations from the modern Anthropocene — a time when the human species had a major impact on the Earth's surface. Although physics remain physics, humans have intervened against the force of gravity, decelerated and accelerated natural processes, focused energy, altered or destroyed ecosystems, and altered the earth's climatology. Using the present as a key to the past must proceed with this knowledge.

My contribution is to understand and predict the global delivery of water and sediment to the coastal ocean and with particular reference to deltas. What is the state of the art in predicting these fluxes through the Holocene before and after the human footprint was large? Holocene river flow was a simple balance of precipitation, evapotranspiration and runoff, while accounting for the transient storage terms of groundwater pools, lake levels, snow and ice balance. Climate therefore was the major driver of Holocene floodplains and deltas.

During the Anthropocene in contrast, humans changed river systems into unnatural conduits of water, sediment, carbon, nutrients and pollutants. Today we significantly store freshwater in reservoirs, changing the timing and nature of flooding. We have built great canals, straitened rivers, constrained channels with stop-banks and levees, diverted water from one drainage basin to another, substituted irrigation canals for distributary channels, and pulled large amounts water out of groundwater pools. Deforestation, mining and agriculture has introduced much fresh sediment into these waterways; fluvial sediment loads doubled on average, and deltas rapidly grew during the early Anthropocene. Subsequently we have built a major dam (>15 m in height) every day for the last 110 years, on average, sequestering hundreds of Gt of sediment and carbon in reservoirs and greatly limiting the transport of sediment to the coast. Today deltas are subsiding at rates four times larger than the sea level is rising, on average; with subsurface mining (oil, gas or groundwater) being the main culprit. Coastal retreat has accelerated from m/y to km/y; saltwater intrusion has turned soils saline.

The PAGES community can collectively help us to understand the W5 (what, where, when, who, why) on how humans created the Anthropocene. Furthermore PAGES can place this global footprint of humans into a context where we can begin to develop effective policies and protocols for supporting global sustainability.

*J.P.M. Syvitski — CSDMS Integration Facility, INSTAAR, U. Colorado-Boulder, CO, USA*

## Friday, 15 February

09:00-09:30

## Indo-Pacific climate during the Common Era: New perspectives from land and sea

*Jessica E. Tierney*

Climate variability in the Indian Ocean/Indo-Pacific Warm Pool - the deep convective core of tropical atmospheric circulation exerts enormous influence on patterns of rainfall in Indian Ocean Rim countries. While mechanisms driving interannual variability e.g., El Niño are relatively well-understood, those responsible for lower-frequency modulations of rainfall are not, in part because they cannot be studied using the instrumental record alone. Paleoclimate evidence of recent climatic change extends the instrumental record and thus allows for study of these important lower-frequency climate dynamics. However, a clear picture of Indo-Pacific climate during the Common Era is only just now emerging from still-sparse proxy networks.

This talk will present several new proxy syntheses of last millennium Indo-Pacific climate, including 1) a synthesis of hydroclimate in coastal East Africa and 2) a synthesis of sea-surface temperatures in the Indian and western Pacific Oceans, compiled as part of the PAGES Ocean2K project, a subsidiary of the global PAGES2K effort. Both products yield fundamental insights into the agency of the Indian vs. Pacific ocean in driving regional decadal-to-centennial scale rainfall, improving our knowledge of internal variability in the tropical climate system as well as its response to external forcings.

*J.E. Tierney — Woods Hole Oceanographic Institution, USA*

Plenary Talks

09:30-10:00

## Tipping points in biogeophysics

*Martin Claussen*

Large-scale changes in climate and vegetation that appear to be abrupt in comparison with external forcing frequently occurred in the past. Such changes are interesting from the dynamical systems point of view because they could come as a surprise: Even if the change in the forcing is known, the onset of the resulting climate and vegetation change cannot precisely be predicted. Furthermore, abrupt changes are of high socio-economic relevance, if they occur 'so rapidly and unexpectedly that human and natural systems have difficulties adapting to it'. An illustrative example from the Holocene is the abrupt onset and, at least regionally, abrupt termination of the African Humid Period which is associated with large changes in the Saharan ecosystems and human cultures. From climate simulations and geological data the picture of an abrupt termination of the African Humid Period and abrupt expansion of the Sahara around 5,500 years ago emerged, and the Sahara was viewed as one of the "tipping elements" of the Earth system. More recent data and climate modeling lead to a critical reassessment. Here, a more comprehensive view is proposed. It is shown that abrupt change can result from a strong biogeophysical feedback or, alternatively, from intrinsic threshold behaviour of hydrological systems and ecosystems. Strong feedback in one region can lead to 'induced tipping' in other, seemingly stable regions. Finally, biodiversity affects the strength of biogeophysical feedback. In conclusion, the nature of abrupt change cannot be determined from statistical analysis of palaeo time series without knowledge of the underlying biogeophysical processes.

*M. Claussen — Max-Planck-Institut for Meteorology, Hamburg, Germany*

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10:00-10:30

## Ocean circulation

*Martin Visbeck*

The mean and time-variable ocean circulation plays an essential role in the regional redistribution of heat, freshwater, carbon, oxygen, and nutrients. On the largest scale, arguably, the global overturning circulations regulate many aspects of the global climate. New observations in the North Atlantic Subpolar Subtropical gyre demonstrate the inherent variability of the Atlantic Meridional Overturning Circulation (AMOC) and the challenge toward fully observing and understanding its dynamics. In the Southern Hemisphere the cross-Antarctic Circumpolar Current flows are thought to play a substantial role in the ocean's uptake of heat and carbon. Recent observations and model studies suggest that local eddy dynamics need to be taken into account to estimate meridional fluxes. Finally wind driven circulation in the subtropical regions plays a fundamental role in observed changes in subpolar freshwater budgets and regional subtropical sea level trends.

All these cases demonstrate that the rich spectrum of ocean dynamics needs to be considered when estimating changes in regional ocean heat uptake, $CO_2$ budgets, and possibly even more for estimates of future ocean acidification, freshwater budgets and associated changes in subpolar stratification. The complexity of the challenge demands large-scale coordination of ocean observations, research activities, and efforts to inform the public on sustainability issues in the marine realm.

*M.Visbeck — Co-chair of WCRP's Climate Variability and Predictability project (CLIVAR). GEOMAR, Helmholtz Centre for Ocean Research Kiel, Germany*

## Saturday, 16 February

16:00-16:30

## Food economics in (pre-)historical times

*Martin Jones*

Contemporary food economics lean heavily towards the food species that currently dominate our food chain, in particular three grass species that equate with over half the biological energy moving through that chain. This economic emphasis upon the 'big three' - bread wheat, rice and maize - is mirrored by a corresponding emphasis on scientific research effort and crop breeding. The three species consequently figure centrally in discussions of future food security and climate change.

In the deeper, millennial history of agriculture, their predominance in this scale is relatively recent, largely postdating the 17th century Columbian Exchange of Old and New World crops. For much of prehistory, they were consumed alongside a range of equally significant grain and tuber crops. Among these other food sources were taxa with ecological attributes quite different from the relatively demanding 'big three' of the modern world.

By looking back in time through the archaeological record pf crop plant plants, it is possible to elucidate the evolutionary ecology of a range of hardier food sources that played a considerable role in environmental extremes in the past, and may consequently offer potential benefits in the environmental challenges of the future.

In this presentation, I shall explore the archaeology of prehistoric energy foods, with particular reference to those taxa that exhibit ecological resilience in circumstances of seasonal and hydrological stress, in the context of changing cultural patterns and climatic histories.

*M. Jones — Department of Archaeology, University of Cambridge,UK*

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16:30-17:00

## Climate change and biodiversity

*Kathy Willis*

Traditionally, research to determine the impacts of climate change on biodiversity has tended to focus on direct spe-

**Plenary Talks**

cies interactions. Much excellent work has been carried out for a whole range of plant and animal species to determine rates and directions of species movements in response to climate change and palaecological studies have provided many important insights into this work. More recently, however, the focus has shifted somewhat from attention on the individual species/communities, to the influence of climate change on the ecosystem services provided by biodiversity. These services, which provide the benefits that humans receive from the natural functioning of healthy ecosystems, are derived from ecosystem processes and functions (i.e. the physical, chemical and biological interactions between organisms and their environment) and are typically organized into four groups: supporting (e.g. nutrient cycling), regulating (e.g. erosion protection, carbon storage), provisioning (e.g. timber and fuel) and cultural services.

Many governments are now assessing the ecosystem services provided by their in-country biodiversity and devising policies for their conservation and management. Achieving sustainable management of ecosystems, however, depends upon the availability of accurate information about the variation in ecosystem service provision across space and time and an understanding of responses of ecosystem components to drivers of change. What is becoming increasingly apparent from these assessments is that whilst there is considerable information and methodologies available to map a static picture of current ecosystem service provision, far less is known about variations through time and drivers of change. This talk will highlight, through examples, the huge potential of palaeoecological research in filling this important knowledge gap and providing information that is of direct relevance not only to the scientific community but to governments and habitat managers involved in local, regional and global landscape planning.

*K. Willis — Department of Zoology, University of Oxford, UK*

## OSM01: Monsoons in Space and Time: Patterns, Mechanisms and Impacts

Convenors: Rengaswamy Ramesh, Rajeev Saraswat, Ralph Schneider, Pinxian Wang

Poster

### Abrupt changes in the strength of the Indian Summer Monsoon during late glacial to Holocene evidenced by episodic increases in Ayeyarwady outflow to the Andaman Sea

***Sijinkumar A.V.***[1], B.N. Nath[2]

[1]Department of Post Graduate Studies & Research in Geology, Govt. College Kasaragod, Kerala, 671123, India, [2]National Institute of Oceanography (Council of Scientific and Industrial Research), Dona Paula, Goa, 403004, India

Paleoclimatic records from the Andaman Sea are rare and limited to oxygen isotopic and magnetic properties. We used the downcore variation of a low salinity dwelling planktic foraminifer *Neogloboquadrina dutertrei* as a proxy for tracking salinity changes associated with Ayeyarwady River outflow into the Andaman Sea. Age controls of the cores are based on accelerator mass spectrometry (AMS) dates on mixed planktic foraminifera. Annually, a huge amount of fresh water reaches the Andaman Sea from the Ayeyarwady catchment with the most of outflow occurring during the summer to late fall. As a result of a fresh water influx, salinity reduces to a minimum value during July to August. Reconstruction of late Quaternary salinity changes would give inferences on the Ayeyarwady outflow, which in turn is governed by the strength of the Indian summer monsoon. The comparison of downcore variation of *N. dutertrei* and earlier record of $\delta^{18}O$ seawater ($\delta^{18}O_{sw}$) matches exceptionally well and supports the former to use as a salinity proxy. The high abundance of *N. dutertrei* during early Holocene and Bølling/Allerød (BA) suggest low salinity, wet climate and freshened Andaman Sea surface water driven by enhanced Ayeyarwady outflow resultant of strengthened summer monsoon. The lower abundance of *N. dutertrei* during deglacial, Younger Dryas (YD) and mid- to late-Holocene suggests reduced Ayeyarwady outflow and direct precipitation as a result of weakening of summer monsoon. Last glacial maximum (LGM) was characterised by similar or slightly reduced Ayeyarwady outflow and summer monsoon than present. The comparison of temporal variation of *N. dutertrei* of north and south Andaman cores suggest highest Ayeyarwady outflow has occurred during early Holocene as a result of enhanced summer monsoon. These results corroborate earlier findings of substantial hydrologic changes in the Indian monsoon system during the last deglaciation - Holocene and consistent with the Mg/Ca-SST and oxygen isotope based summer monsoon reconstruction.

Poster

### Documentary reconstruction of rainfall variability over western India, 1781-1860

***George Adamson***[1,2], David Nash[1]

[1]School of Environment and Technology, University of Brighton, [2]Department of History, University of Sussex

Analyses of the climatic forcings affecting long-term variability of the Indian summer monsoon are constrained by a lack of reliable rainfall data before the late 19th century. With this limited data set, suspected multi-decadal fluctuations in monsoon strength, and fluctuations in the relationship between the El Niño Southern Oscillation (ENSO) and monsoon rainfall levels, remain largely speculative. Dendroclimatic reconstruction is problematic within peninsular India, and climatic reconstruction using teak is only in its infancy. Extensive qualitative and quantitative meteorological information for the pre-instrumental period exists, however, within documentary archives. Until now these have been largely unexplored for historical climatology. This paper will present the first semi-quantitative reconstruction of monsoon rainfall using documentary sources, focussing on western India for the period 1781-1860.

Three separate reconstructions are generated, for Bombay (Mumbai), Pune and an area of southern Gujarat bordering the Gulf of Khambat. These reconstructions follow a standard content analysis methodology as pioneered for historical climatology in Europe, ranking monsoon severity on a 5-point scale to correspond with the Indian Meteorological Department's 5-Parameter Statistical Ensemble Forecasting System. The reconstructions for Bombay and Pune are calibrated against existing instrumental rainfall data. A composite chronology is generated for western India as a whole from the three reconstructions, termed the Western India Monsoon Rainfall (WIMR) chronology. This chronology exhibits four periods of generally deficient monsoon rainfall (1780-85, 1799-1806, 1830-1838 and 1845-1857) and three periods of generally above-normal rainfall (1788-1794, 1813-1828 and 1839-1844). Ten widespread droughts are evident, in 1790, 1803, 1812, 1824, 1833, 1838, 1845, 1847-48, 1850 and 1855.

The WIMR chronology is compared against existing climatic reconstructions. The chronology exhibits good agreement with a dendroclimatic reconstruction for Kerala. Comparisons against reconstructions of the cross-equatorial ('Somali') jet and ENSO suggest stationarity in correlations between the reconstruction instrumental periods, indicating robustness in the methodology. The relationship between ENSO and WIMR exhibits peaks and troughs in correlation, as experienced in the instrumental period. Our results suggest a regular long-term fluctuation in the ENSO-monsoon relationship, although further long-term reconstructions of monsoon rainfall will be necessary in order to validate this. The study also highlights uncertainty in existing published rainfall records for 1817-1846 for western India.

Poster

## Paleoclimatogy in the South Equatorial Indian Ocean

***Celsa Almeida***[1], Maruthadu Sudhakar[2], Manish Tiwari[1]

[1]NCAOR, [2]Ministry of Earth Sciences, India

The Southern Equatorial Indian Ocean surface circulation is chiefly dominated by the eastward flowing Equatorial Countercurrent (ECC) and the westward South Equatorial Current (SEC) which extends from 10°S during the North-East monsoon Period. The ECC current is absorbed into the easterly South West Monsoon Current in SW monsoon period in the entire region north of 5°S while the west flowing Southern Equatorial Current expands slightly towards north, reaching 6°S in September. Physical observations have supported model studies giving evidence of an upwelling ''dome"-like feature present in the South West Tropical Indian Ocean (55°E–65°E, 5°S–12°S) during the North East Monsoon.
A calcareous ooze core SK 248 GC-01 collected at 6°S 62°E in the Southern Equatorial Indian was examined to study the paleoclimatology of this region using Stable isotopic analyses and estimation of Calcium Carbonate percentage (to determine variations in productivity). An age model was constructed with oxygen stratigraphic curve matching and AMS $^{14}C$ dates. Cooling events were recorded at ~4.5 BP, 11,786 BP and 21,634 BP (Last Glacial Maximum/LGM). The $CaCO_3$ percentage variation indicates low productivity in the LGM.

Poster

## Monsoon circulation strength inferred from a multicentury tree-ring stable isotope chronology from southeast Asia

***Kevin Anchukaitis***[1,2], Mary Gagen[3], Brendan Buckley[2], Dario Martin-Benito[2], Caroline Ummenhofer[1], Le Canh Nam[4]

[1]Woods Hole Oceanographic Institution, Woods Hole, MA, USA, [2]Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY, USA, [3]Department of Geography, Swansea University, Swansea, UK, [4]Lam Dong Silvicultural Experiment Research Center, Dalat City, Lam Dong Province, Vietnam

The large-scale dynamic circulation of the Asian monsoon over the last several centuries can be inferred from the oxygen isotope ratios of the annual rings of long-lived tropical conifer species from southeast Asia. Here, we present replicated, multicentury stable isotope series from Fokienia hodginsii growing in the Bidoup Nui Ba National Park site in the southern highlands of Vietnam. This isotope chronology is significantly negatively correlated with summer monsoon surface wind speeds over the Bay of Bengal and the adjacent region, indicating that stronger (weaker) onshore winds are associated with lower (higher) oxygen isotope values. Ring width and isotopes show particular coherence at multidecadal time scales, and together allow past precipitation amount and circulation strength to be disentangled. Estimates of the strength of past monsoon circulation provide data for validating general circulation model simulations of the response of the Asian monsoon to changes in radiative forcing and an independent estimate against which to evaluate long-term changes in the Asian monsoon as reflected in other terrestrial and marine proxies as well as forced last millennium general circulation model simulations.

Poster

## Indian monsoonal rainfall variation in last 100 ka: A case study from western part of India

***Sayak Basu***[1]

[1]Department of earth science, Indian Institute of science education and research

Indian monsoon, a seasonally reversing wind, is one of the regular and reliable events in tropical calendar. During summer period, strong heating over the Tibetan Plateau causes moisture influx from the Indian ocean which is responsible for heavy rainfall over the Indian subcontinent. It is generally believed that during the Miocene time the Indian monsoon evolved which is linked to uplift of the Tibetan plateau. From the isotopic study of the Ganga Plain soil carbonates, Agrawal et al. (2012) have suggested that during last 100 ka period of intensified monsoon is linked to the interglacial period and lowering of rainfall up to 15% compared to the present is observed during last glacial maxima. The reconstruction was based on "amount effect" in rainfall. However, amount effect based studies can be erroneous for the Indian sub-continent as the monsoon receives water from two vapor sources viz. Bay of Bengal (BOB) and Arabian Sea whose isotopic compositions are different. Although variability of paleo-monsoon caused by the influence of BOB source is studied previously, no such temporally continuous terrestrial record is available for the Quaternary sediments of Western India where the vapor source is Arabian Sea. In attempt to produce continuous paleo-monsoonal record for last 100 ka, soil carbonates and soil organic matters have been collected from two cliff sections, Aritha and Rayka, of the Gujarat alluvial plain. The oxygen isotopic ratio of the soil carbonates varies from -1.9 to -5.2‰. Using these variations, we have suggested that for last 100 ka, rainfall over Gujarat has experienced three periods of intensified rainfall at 70, 54 and 47 ka with fluctuations. The $\delta^{13}CSC$ values varies from 2.2 to -8.8‰ and $\delta^{13}CSOM$ ranged from -26.5 to -21.2‰, suggestive of mixed $C_3$ and $C_4$ vegetation type in Gujarat for last 100 ka..

Poster

## Investigation of extreme Phases of the Indian Summer Monsoon during the last Millennium using the Regional Climate Model COSMO-CLM

***Daniel J. Befort[1]***, Stefan Polanski[1], Gregor C. Leckebusch[1,2], Ulrich Cubasch[1]

[1]Freie Universität Berlin, Institute of Meteorology, Berlin, Germany, [2]School of Geography, Earth and Environmental Sciences, University of Birmingham, UK

Climatic conditions of the Indian subcontinent are characterized by the Indian summer monsoon (ISM) regime, accounting for about 80% of the total annual rainfall amount over this region.
Changes of ISM intensity during the Holocene are documented in proxy data archives, but the number of these archives over India is relatively low and not homogeneously distributed. Therefore these data archives provide no information about the spatial and physical structure of the ISM.
The work presented here is embedded in the interdisciplinary project HIMPAC (Himalaya – Modern and Past Climates). In this project geological information, e.g. from lake sediments or pollen, are combined with meteorological data from global and regional climate models. In our research we focus on the variability of the Indian summer monsoon during the last millennium on the basis of five ensemble simulations. They were performed using the fully-coupled global climate model ECHAM5/JSBACH/MPIOM/HAMMOC in a resolution of T31L19. Three time periods of 200 years length, called Medieval Warming Period (900-1100), Little Ice Age (1515-1715) and Recent Climate (1800-2000), were selected and simulated at an increased resolution of T63L31 using the atmosphere-only GCM ECHAM5. These global climate model data have then been used to drive the regional climate model COSMO-CLM in horizontal resolution of 55km for the selected time slices.
The 200 year GCM time periods were analyzed to identify strong and weak phases of ISM activity with a duration of about 30 years. In each GCM time slice simulation one wet and one dry phase could be found. The results of the regional climate model provide a deeper insight into the spatial structure of these strong and weak phases of the ISM. The dry phases with the exception of the dry phase during Little Ice Age are characterized by a lower interannual variability compared to wet phases.
A further evaluation will focus on the occurrence of extreme events on intra-seasonal timescales, e.g. droughts and floods. Physical mechanisms leading to long lasting active and break spells as well as the transition between these phases during one summer monsoon season will be investigated.

Poster

## Monsoonal variability during the Holocene: An integrated data and modeling study

Eli Biton[2], ***Hezi Gildor[1]***, Gabriele Trommer[3], Michael Siccha[3], Michal Kucera[3], Marcel van der Meer[4], Stefan Schouten[4]

[1]Institute of Earth Sciences, Hebrew University of Jerusalem, Jerusalem, Israel, [2]Department of Environmental Sciences and Energy Research, Weizmann Institute of Science, Rehovot, Israel, [3]Institute of Geosciences, University of Tübingen, Tübingen, Germany, [4]Department of Marine Organic Biogeochemistry, NIOZ Royal Netherlands Institute for Sea Research, Den Burg, Netherlands

The Red Sea is connected to the Indian Ocean via a narrow and shallow strait. It is extremely sensitive to climatic changes, including sea-level variations and changes in atmospheric conditions, and therefore it is an ideal place to study climate variability. We use an ocean general circulation model in conjunction with proxy records to investigate regional climate changes during the Holocene and to propose a new proxy for the strength of the summer Monsoon.
Changes in the monsoon system influence the exchange flow through the Strait of Bab el Mandab, the circulation in the Red Sea, and its hydrography. Sea surface temperature reconstructed from proxy records and our ocean general circulation model results suggest prevailing humid conditions during early Holocene and arid conditions during late Holocene. The gradual decline in Red Sea temperature between these two time periods suggests a gradual decline in the summer Monsoon strength.
Monsoon-driven changes in the exchange flow through the Strait of Bab el Mandab affect the Crenarchaea population structure in the central and southern Red Sea, i.e. the relative contributions of open ocean and the hypothetical endemic or Northern Red Sea Crenarchaeota populations. Therefore, the molecular fossil distribution in the sediments of the central Red Sea compared with the northern Red Sea potentially provides an index for the summer monsoon strength during the Holocene.

Talk

## Monsoon Climate Sensitive Tree-Ring Chronologies of Teak (Tectona grandis L. F.) from central India and their teleconnection with ENSO

***Hemant Borgaonkar[1]***

[1]Indian Institute of Tropical Meteorology, Pune, India

The present knowledge of decadal to century scale variations in climate is based upon discontinuous and limited information beyond the observed meteorological data. The tree-ring chronologies, though shorter in palaeoclimatic time frame, are accurate and their time resolution is to a specific season and year. Studies based on teak (*Tectona grandis* L. F.) samples collected from tropical forest of central India indicate long tree-ring

data beyond 300 years in age with high sensitivity to environmental changes. Well-dated tree-ring chronologies covering a wide geographical area provide yearly proxy data for studies of climatic and hydrologic variations over both space and time. Tree-ring analysis of teak from tropical forest indicate high dendroclimatic potential of the species and can be used to reconstruct pre-monsoon and monsoon climate variability in the past.
In this paper we present a more than 300 years long tree-ring width index chronologies of Teak prepared from five forest sites of central India. Dendroclimatological investigation indicates significant positive relationship of tree-ring index series with Indian summer monsoon rainfall (ISMR) and related global parameters like Southern Oscillation Index (SOI). Frequency of occurrence of low tree growth index was significantly higher during the recorded deficient monsoon rainfall years. There strong positive relationship with PDSI also indicates high potential of tree-ring chronologies for monsoon drought reconstruction. Such monsoon climate sensitive teak tree-ring chronologies lead to their usefulness to understand the past vagaries of monsoon.

Talk

## Impact of insolation, fresh water fluxes and ice-sheet on Early Holocene monsoon characteristics

***Pascale Braconnot[1]***, Charline Marzin[2], Masa Kageyala[1], Anne-Marie Lézine[3]

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In the tropical regions, the early Holocene is well known for the increased water resources recorded from various climatic indicators, such as pollen and lakes, in regions affected by the Afro-Asian monsoon. It has been attributed to the increased summer insolation in the northern hemisphere that triggers the interhemispheric and the land-sea temperature contrast and thereby the monsoon flow. However other factors could have influenced the evolution of monsoons during this period and offset the impact of the insolation forcing. We consider the role of the remnant ice sheet over North America and Europe, and of an ice sheet melt water flux in the North Atlantic. Results of sensitivity experiments with the IPSL CM4 show that the melt water flux and the ice sheet induce a similar cooling of the North Atlantic associated to a southward shift of the ITCZ in the Atlantic and a reduction of the African monsoon. The two perturbations have different impact on the Asian sector. The Indian monsoon is weakened in the melt water flux experiment whereas the ice sheet induces a more complex response with the strongest effect on the East Asian monsoon. The mechanisms by which the different perturbations affect the African and Asian monsoon precipitation will be discussed considering changes in the ocean and atmospheric heat transport, energy budgets and teleconnections through atmospheric bridge. The results will also be discussed at the light of hydrological reconstruction in Africa and Arabia.

Poster

## Quantified paleo-seasonality of the West African Monsoon in Senegal

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Ecosystems and agriculture in the Sahel are strongly dependent on the seasonality of precipitation. Little is known, however, about the natural variability of this parameter and its sensitivity to global climate change. Here we present a method to reconstruct quantitatively the duration of the dry and rainy seasons based on the sclerochronology and oxygen stable isotopes of fossil mollusk shells from the hypersaline Saloum Delta, Senegal. We reconstructed a multidecadal record of the precipitation-evaporation budget and the monsoon seasonality using fossil shells from a stratified monumental shell middens continuously accumulated between A.D. 460 and 1090. The salinity of the Saloum Delta was significantly lower at that time. The inverse salinity gradient observed today in the Saloum estuary was likely not established yet, indicating a more positive precipitation-evaporation annual budget. No multidecadal drought similar to the event of the 20th century was detected in this ~600-years interval. The rainy season lasted ~5 months in average during this period while its duration is only ~3 months in the instrumental record. Annual evaporation was thus reduced and precipitation increased. Climatic processes responsible for this change may either be related to a latitudinal shift of the summer intertropical convergence zone, or involve additional rainfall events forced from the extratropics.

Talk

## What is the influence of Tibetan Plateau on the Asian summer monsoon? Barrier versus heating effect

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The Tibetan Plateau plays critically roles in the evolution and variability of the Asian monsoon system. In spite of advances in our understanding of this complex interaction, the effects of Tibetan Plateau on the Asian monsoon system remain hotly debated. Traditionally, The Tibetan Plateau is considered as a heating source, which drives the Asian summer monsoon system. A new hypothesis is recently proposed, suggesting that the Tibetan Plateau acts as a barrier posed by the mountains at the southern edge of the plateau, separating the moist warmer air over the South Asia from the dry colder air over the north Eurasia, such that the moist warmer air is favourable for deep convection.
To further study the influence of the Tibetan Plateau on the Asian summer monsoon, a set of four experiments is performed with a state-of-the-art fully coupled global model to test the responses of the Asian monsoon to

the total Tibetan Plateau uplift, the southern barrier, the sensible heating on the slope of the barrier. Based on these simulations, we find that the plateau affects the South Asian monsoon mainly through its southern flank, consistent with previous studies. However, our experiments show that the southern flank affects the South Asian monsoon by producing a concentrated "candle" heating on the southern edge of the plateau rather than by increasing deep convection to the south of the plateau. Our experiments reveal that this "candle" heating is mainly (about 55% of the total) driven by sensible heating on the south slope of the plateau. The source of the remaining (about 45% of the total) diabatic heating is further explored.
Although the main chunk of Tibetan Plateau (except the south barrier) has limited impacts on the South Asian monsoon, it significantly influences the East Asian monsoon. An eastward-extended rain belt is found over East Asia in the case when the main chunk of Tibetan Plateau is present. The mechanism of this eastward-extended rain belt requires further study. Our preliminary results indicate that the surface heating on the Tibetan Plateau may cause the eastward-extended rain belt.

Poster

## Intellectual Structure Of Monsoon Research- A Bibliometric Study

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Monsoon plays a very important role for shaping up national economies, particularly of India, and other countries of Indian subcontinent. The term was first used in English in British India (now India, Bangladesh and Pakistan) and neighboring countries to refer the big seasonal winds blowing from the Bay of Bengal and Arabian Sea in the southwest bringing heavy rainfall to the area. With the threat of climate change, research questions pertaining to monsoon have become diverse and complex. In this paper effort has been made to find out latest highlights in monsoon research. India being one of the significant leaders in monsoon research along with USA and China, its connectedness with other countries to address issues of common interest, will be examined. Role of other countries and organizations involved in monsoon research will be studied. Discussion on most-cited documents in this super specialty subject along with emerging research fronts will be presented.

Talk

## The role of Asian monsoon dynamics for Late Quaternary lake level changes at the north-eastern Tibetan Plateau

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The Tibetan Plateau provides water for billions of people and is rich in lakes. Its hydrological cycle is dominated by moisture supply from the Indian and East Asian monsoon systems. However, extent and timing of Late Quaternary peak monsoon intensities are still under debate. Often an asynchronous and complex picture is drawn, also for the representation of Holocene cold events and the Holocene climatic optimum.
Lake level changes are a critical aspect to understand past moisture distribution. Often they are reconstructed using stratigraphic variations in lacustrine sediment cores. Depending on the setting of the studied catchment, lake system response to monsoon variations can be biased by local non-climatic factors that complicate the interpretation of past sedimentary conditions. Many Tibetan lakes are located at active faults with intense morphotectonic dynamics that have to be considered prior to assess past climatic change.
We present a study from Lake Donggi Cona, Qinghai province, China. The currently open freshwater lake (area: 230 $km^2$, volume: 6.8 $km^3$, modern lake level: 4090 m a.s.l.) belongs to a pull-apart basin at the Kunlun fault and is influenced by monsoonal air masses at their modern northern boundary. Several former lake extents were mapped using geomorphologic and sedimentologic archives and methods. Grain size distributions of 5 high-stand sediment profiles in on-shore lake terraces were unmixed using EMMA (end-member modelling analysis) to decipher past sediment transport processes. Radiocarbon dating of more than 30 Radix shells and bulk lake sediment samples of high-stand profiles and off-shore sediment cores provide the time frame.
Three lake stands at 24, 39 and 57 m could be classified below the present lake level (p.l.l.), while four generations of lacustrine terraces at 16.7, 10.1, 6.1 and 3.5 m above p.l.l. were mapped at several locations on-shore. At ~20 cal ka BP, Lake Donggi Cona had only half of its present area and volume during the lowest dateable lake stand at -24 m. Throughout the Holocene, small-scale hydrological signals from on-shore lake high-stand sediments varied in concert with known Asian monsoon proxies, whereas off-shore sediment cores from the Donggi Cona and nearby lakes are generally of low resolution. Sub-catchment specific sediment fluctuations are superimposed on the rapid lake level rise since 11.5 cal ka BP. The lake reached its maximum volume (~12.3 $km^3$), when Indian monsoon intensities peaked at ~9.1 cal ka BP. A short-term lake level fall ~8.5 cal ka BP, inferred from cryogenic sediment distortions and deposition of floodplain sediments may represent the global centennial cooling that peaked in the 8.2k event. A second lake high-stand was reached around 7.5 cal ka BP. After its opening at 6.8 ka BP triggered rather by local tectonic and/or morphologic dynamics, the lake remained at a high level (+6.1 m). A transition to drier conditions and a reduction in lake volume to 7.9 $km^3$ coincides with the main decline in monsoon intensity ~4.5 cal ka BP, when high-stand sedimentation stopped. The final modification of the lake volume is related to construction of an artificial outlet in the 1970s, which nicely documents the increasing human influence on

the Tibetan ecosystem. Hence, most of the time Asian monsoon variations were the main driver of lake level variations, but local morphodynamics played a further important role.

Poster

## History of terrestrial precipitation in the Amazon basin (South America) during the last 240 ka

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With the Earth's largest rainforest and highest river flow, the Amazon basin plays a key role in the global hydrologic cycle. Over the last decades, there are signs of a changing water cycle in the eastern and southern regions of the basin linked to deforestation, land use and climate change. Anthropogenic impacts do not yet seem to surpass the magnitude of natural variability of the hydrologic cycle, but model projections suggest that the basin nears a tipping point. The lack of detailed information on past natural precipitation variations and the mechanisms behind them makes assessments of modern and future changes difficult. Of the small number of records documenting lowland South American paleoclimate, most are short (i.e. < 25 ka) or discontinuous.
Here we present a 240 ka history of precipitation changes in northern South America that resolves both orbital and millennial-scale variability. Located near Barbados, the marine sediment core GeoB3938-1 (12.26°N, 58.33°W, 1972 m water-depth) receives terrigenous material from nearby rivers. We analyzed the intensities of major elements every 1 cm by X-ray Fluorescence core scanning. We also measured the major element concentrations of 35 powdered bulk sediment samples. Using a log-ratio regression approach, we derived high-resolution calibrated proportions of the elements Ca, Fe, Al, Si, Ti and K. Calibrated data indicate that the terrigenous material at our core site mainly originates from the Orinoco and Amazon Rivers and that the input of Saharan dust blown across the Atlantic Ocean is negligible over the last 240 ka.
We applied endmember unmixing analyses to the calibrated elemental dataset and reconstructed past changes in the relative proportions of the marine, Amazon and Orinoco endmembers. The proportion of Amazon material (normalized to the sum of both terrigenous components, i.e. independent of marine variations) shows changes on two different time scales.
(1) During the last 240 ka, decreased (increased) proportions of Amazon material occur during periods of low (high) boreal summer insolation. A southerly position of the Intertropical Convergence Zone (ITCZ) and intensified trade winds during these periods, strengthen the North Equatorial Counter Current and North Brazil Current retroflection. This results in a reduced amount of Amazon water transported northwestwards by the North Brazil Current and hence decreased proportions of Amazon material at our study site.
(2) The relationship with insolation weakens during glacial times and is overprinted by millennial-scale variability. Increased input of Amazon material occurs during most of the Heinrich Stadials (HS) in the last 65 ka. This result supports wet conditions controlled by the North Atlantic cooling and southward shift of the ITCZ position, as documented by existing records from South America. The large decrease in Amazon material recorded at the study site during HS3, however, suggests a more complex spatial response of South American precipitation to HS climate change.

Poster

## Climate instability and monsoon variability during the past 45,000 years in NW China derived from desert lake records

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Hereby we intent to represent lake status records from Central Asian desert lakes indicating changes in water budgets that are strongly linked with global climate signatures. The interrelated processes of glacier dynamics, marine circulation pattern and monsoon variability during the Late Glacial cycle were the main triggers for the evolution of the desert lakes in north-western China in space and time.
Our lake status record derived from 15 lake status records, however, is closely related to changes in the regional precipitation pattern, while temperature variations may have played a minor role. Moisture availability was mainly controlled by two different air masses: the SE summer monsoon and the westerly winds. Despite their differences in water vapour sources and transport capacity, which might have influenced the effective moisture supply in different regions, our data imply that all investigated lakes responded synchronously in terms of water budget during the Last Glacial. The major reason for this synchronism is the fact that the lakes were connected with the glaciated mountain ranges, leading to sufficient meltwater supply that kept the lakes on high levels. This might be also the reason why the lakes did not dry up completely in periods of reduced water supply, when cold-dry climate conditions during the Last Glacial Maximum and during short-term events, such as the Heinrich events and the Younger Dryas spell prevailed. Phases of low lake status promoted the exposure of fine-grained lacustrine deposits now being deflated by wind erosion and re-deposited as loess. Grain size records from the Loess Plateau confirm the coherence of low lake status and enhanced loess mobilisation quite well.
Since the last termination the global interplay between glacier development and the monsoon/westerlies over Asia lost its major impact on the water budgets of the desert lakes. Owing to the fact that summer monsoon related moisture supply during the Holocene period could not affect all desert lakes synchronously, influences by local catchment characteristics have more frequently

overprinted regional climate signals. Despite the differences in lake status since the last 13 ka, however, major negative water budgets were still linked to global climate deteriorations around 8.6-8.0, 7.0-6.4, 4.8-4.4, 3.5-2.9 and 2.5-2.2 ka, documenting at least synchronization on a larger scale. Differences in the timing of dry events in northwestern China between the western and eastern part of the study area are due to the retarding influence of the summer monsoon and to important moisture control by the westwind system.
We conclude that lake development in arid China displays the influence of northern hemispheric circulation patterns much more significantly than any other factors such as tectonic events. Hence, the desert lakes are important archives with the potential to provide a valuable basis for the reconstruction of Asian monsoon system feedback mechanisms over China.

Talk

## History of the Indian Monsoon recorded in Andaman Sea sediments

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Over 3 billion people live in the area influenced by the Asian monsoon, the rains of which provide vital water resources while posing a risk to human life through flooding. Despite the importance to so many the monsoon is difficult to predict and model, making its future development in a changing global climate uncertain. To help improve models and predictions, histories of monsoon variability beyond the instrumental record are required. Many records of the East Asian monsoon have been generated from China and the South China Sea while the past variability of the Indian Monsoon is mostly known from records of monsoon wind strength over the Arabian Sea. This study uses a unique long sediment core obtained by the IODP vessel JOIDES Resolution in the Andaman Sea to examine the past variability of Indian Monsoon precipitation on the Indian sub-continent and directly over the ocean. Our multi-proxy approach will reveal changes in continental weathering, runoff and direct precipitation on orbital timescales for the last 2 million years, filling a fundamental gap in our understanding of the Indian Monsoon in the past. Here we present initial data examining variations on millennial timescales for the last glacial and deglaciation.
The monsoon related influx of freshwater to the Bay of Bengal and Andaman Sea leads to a low salinity surface layer and a strong stratification of the upper 200 meters. Ocean atlas data indicates this stratification is remarkably stable throughout the year while the salinity of the surface layer changes with the monsoon. A sediment trap study in the region suggests that the abundance of mixed layer dwelling planktonic foraminifera *G. ruber* and *G. sacculifer* are not biased towards a particular season. The thermocline dwelling *N. dutertrei* was also found throughout the year but exhibited a broad peak at the initiation and during the summer monsoon. Core top studies have suggested the abundance of *N. dutertrei* is directly related to the low surface salinities associated with the monsoon. We utilise these ecological preferences to investigate the freshwater induced stratification with *N. dutertrei* abundance data and paired Mg/Ca and $\delta^{18}O$ analyses of both *G. sacculifer* and *N. dutertrei* for the last glacial and deglaciation. Additionally, determining the Mg/Ca temperatures and $\delta^{18}O$ of seawater from many single shells of these surface and thermocline dwelling species potentially allows the predominant range of temperature, salinity and stratification conditions to be reconstructed for intervals in the past.

Poster

## Glacial terminations and periodicities for the last 800 kyr: Constraints from the bulk magnetic susceptibility record, the southeastern South China Sea

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The glacial cycle is often referred to as the 100 kyr cycle, but it is actually rather more irregular, saw-toothed and non-identical. Of particular is the timing of the glacial terminations as the ice sheet collapses are the fastest changes in the glacial cycle and the triggering mechanism of such collapses remain unknown. South China Sea (SCS) provides a platform to investigate a number of paleoclimate and paleoceanographic problems on orbital to millennial timescales mainly because of three factors: high sedimentation rates, good preservation of microfossils and the location of SCS as a connector between the Western Pacific Warm Pool and the SE Asian monsoon. Here we investigate the bulk magnetic susceptibility (MS) time series reconstructed from a 35.91 m long piston core MD97-2142 (12°41.33′N, 119°27.90′E; 1557 m water depth) raised from the southeastern SCS during the 1997 IMAGES III – IPHIS Cruise. Our bulk MS time series faithfully records the last seven glacial terminations (T1-T7) with distinctive behaviors of T4 and T6. Wavelet analysis of MS record exhibits statistically significant periodicity at 239 kyr, 142 kyr, 85 kyr, 45 kyr, 24 kyr and 13 kyr of eccentricity, obliquity and precession cycles. Furthermore, there is no 400 kyr periodicity in the bulk MS, but it can be by resolution of the data and after 450-500 kyr the spectral power decreases indicating that there are changes in the parameters of orbital eccentricity. Through cross spectral analysis of representative proxy records from the SCS, we will address the link among the global ice volume, monsoon and carbon dynamics and East Asian chemical weathering changes during the past seven glacial terminations.

Poster

## Variation in the Indian Summer Monsoon intensity during the Bølling-Ållerød and Holocene

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Variations in the Indian summer monsoon (ISM) intensity during the last 16.7 ka have been studied using organic carbon (Corg), $d^{15}N$ of sedimentary organic matter, $CaCO_3$, sediment texture, $d^{18}OC$ and Mg/Ca derived sea surface temperature, $d^{18}O$ of sea water and sea surface salinity, in a $^{14}C$-dated sediment core from the eastern Arabian Sea. The $d^{18}O$ in water and planktonic foraminifera shells off the central west coast of India may be controlled by the ISM intensity as this area receives high precipitation and land runoff. Also, the Corg and CaCO3 contents of sediments and $d^{15}N$ of sedimentary organic matter may be linked to ISM-induced productivity and denitrification. The results of the present study reveal that between 16 and 15.2 ka BP the ISM was weak with minor fluctuations and started intensifying around 15.2 ka BP, at the onset of the Bølling-Ållerød (B-A) event. The B-A event is characterized by higher water column denitrification rates comparable to the present day. The ISM signatures observed in the $d^{18}OC$ record of B-A event compare well with those from Timta cave of the western Himalayas and also the Asian summer monsoon signatures from the Hulu caves in China and warming signatures in Greenland Ice Sheet Project 2 (GISP2) suggesting atmospheric tele-connections through Intertropical Convergence Zone (ITCZ). The boundary between the Younger Dryas and the Holocene is discernible with small episodes of abrupt events of increased ISM intensity. This decrease in $d^{18}OC$ values at ~ 11.8 ka BP is contemporary with June solar insolation maximum at 30° north and the increase in methane in the GISP2 ice core supporting episodes of warmer climate and increase in ISM intensity. The ISM seems to have been most stable between 7 and 5.6 ka BP. The core exhibits periodicity of 500 that is comparable to the Atlantic water formation and the Chinese monsoon.

Poster

## Late-Pleistocene-Holocene basin filling by Himalayan sediments in Great Rann of Kachchh: A palaeoclimatic perspective

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The dried up sea floor of Arabian Sea forms the present day vast, saline, desertic flatland of around 45,000 sq. km area of Great Rann of Kachchh. The structurally controlled basin of Great Rann of Kachchh marks the site of extensive Holocene sedimentation that started as an early response to the monsoon strengthening during Late-Pleistocene. Cores raised from Dhordo and Banni plains suggests that the central rann started receiving sedimentation as early as ~17.9ka B.P. whereas, the marginal part of the rann i.e. Banni plain received sediments only from ~9.7ka B.P. The sediment grain size data and clay mineral ratio down core record from these two shallow cores (50m & 60m depth) indicates the continuous sedimentation throughout the Holocene times in low energy environment. The clay mineral analysis and geochemistry of the 53 sediment samples was attempted. The clay mineral studies shown Illite (53.94-72.04) and Chlorite (11.72-23.96) are dominant clay minerals in both of the studied cores whereas the Kaolinite (5.54-14.61) and Smectite (1.3-17.6) are present in relatively low amount. It is inferred that the major sediment flux was derived from the Himalayas as the clay mineralogical assemblage is similar to that of the sediments of Indus delta. The down core record of the clay mineral relative abundance and clay mineral ratios as climate sensitive proxies were used to decipher the palaeoclimatic conditions. $CaCO_3$, $C_{Org}$ and C/N ratio estimation was used to observe the continent-marine flux during the deposition of rann sediments. C/N ratio suggests the depositional conditions varied from continental-mixed marine and mixed-marine to marine dominated environments. The dominantly mixed-marine environment was punctuated by spells of abrupt increased continental flux that is also reflected in the clay mineral composition. Overall, the sediment flux into the basin appears to conform to the known palaeoclimatic changes since the LGM.

Poster

## Reconstruction of precipitation and primary productivity during Holocene using geochemical proxies from deep sea cores from the internal seas of the Philippines

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The Philippines is very much susceptible to changes in monsoonal cycles which greatly affect frequency and intensity of rainfall. These phenomena affect river discharge which in turn strongly influences primary productivity in the internal seas. Sediment cores from Sibuyan and Bohol Seas were analyzed using an XRF core scanner at 1 cm resolution. Ten AMS radiocarbon dates from picked foraminifera provide age control spanning the last ~10 ky BP. Ti, Al and Al/Ti show an increasing trend till 5kyBP then a decreasing trend to present. Zr/Ti, Y/Ni and loss on ignition-based % lithics show similar patterns. The pattern is consistent with insolation-driven precipitation; where increasing insolation is associated with increasing precipitation. Superimposed on the overall trend are cycles with periods of about 1000 to 2500 years which in turn are overprinted with century-scale cycles. Proxies

for primary productivity, Ba/Ti and Si/Ti, show coeval but opposing trends. Ba/Ti co-varies with Ca/Ti and organics while Si/Ti co-varies with Ti, Al and Al/Ti. Greater Si input associated with higher precipitation favored the diatoms but led to an overall decrease in primary productivity.

Poster

## High resolution Indian summer monsoon variability record during the last deglaciation

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We present high resolution record of the Indian Summer Monsoon (ISM) variability using oxygen isotopes from a speleothem from Valmiki Cave, in Southern India. The $\delta^{18}O$ record covers a time span of 1000 yrs (from 15,700 – 14,700 yr BP (before AD 1950)) with an average sampling resolution of 4.5 years. Significant changes in the ISM activity during the last deglaciation are observed as suggested by large variations in $\delta^{18}O$ of our record. Substantial depletion in $\delta^{18}O$ at 15,640, 15,595, 15,290, 15,105, 15,005, 14,940, 14,885, 14,795, 14,725 and 14,700 yr BP suggests intensification of ISM activity. Enriched $\delta^{18}O$ values at 15,535, 15,135 and 14,835 yr BP indicate extreme dry episodes. Synchronous variability in $\delta^{18}O$ of our record with Chinese cave records suggests a strong in-phase relationship between the onset of increasing ISM and East Asian Monsoon (EAM) during Termination I, at 14,835 and 14,700 yr BP. The variance of amplitude in VSPM4 $\delta^{18}O$ (>1.0‰) reveals significant multi-decadal ISM variability. Spectral analysis of VSPM4 $\delta^{18}O$ time series reveals periodicities of ~12 and 33 years (with 99% confidence level) suggesting a strong control of solar forcing and ocean-atmospheric circulation on ISM activity during the time interval.

Poster

## Simulation of the East Asian Summer Monsoon during the Last Millennium with the MPI Earth System Model

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The decadal-centennial variations of East Asian summer monsoon (EASM) and the associated rainfall change during the past millennium are simulated using the Earth system model developed at Max Planck Institute for Meteorology. The model was driven by up-to-date reconstructions of external forcing including the recent low-amplitude estimates of solar variations. Analysis of the simulations indicates that the EASM is generally strong during the Medieval Warm Period (MWP, AD 1000-1100) and weak during the Little Ice Age (LIA, AD 1600-1700). The monsoon rain-band exhibits a meridional tri-polar pattern during both epochs. Excessive (deficient) precipitation is found over North China (35°-42°N, 100°-120°E) but deficient (excessive) precipitation is seen along the Yangtze River valley (27°-34°N, 100°-120°E) during the MWP (LIA). Both similarities and disparities of the rainfall pattern between our model results and the proxy data have been compared, reconstructions from Chinese historical documents and some geological evidence support our results. The changes of the EASM circulation including the subtropical westerly jet stream in the upper troposphere and the western Pacific subtropical High (WPSH) in the middle and lower troposphere are consistent with the meridional shift of monsoon rain-belt during both epochs. The meridional monsoon circulation changes are accompanied with anomalous southerly (northerly) winds between 20° and 50°N during the MWP (LIA). The land-sea thermal contrast change caused by the effective radiative forcing lead to the MWP and LIA monsoon changes. The “warmer-land-colder-ocean” anomaly pattern during the MWP favors a stronger monsoon, while the “colder-land-warmer-ocean” anomaly pattern during the LIA favors a weaker monsoon.

Poster

## Do instrumental data co-vary with the paleoclimate proxy records of Southern India?

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Monsoon rainfall is the most important source of water for the global hydrological cycle that not only prevailing over the tropical region, but extending into higher latitudes. It is particularly important for tropical and sub-tropical regions, such as, Africa, Arabia, South Asia, South East Asia, Australia, etc. Semi-annual reversal of monsoon winds over the Southern Asia and surrounding the Northern Indian Ocean result in summer south-west monsoon (SWM) and winter north-east (NEM). The former in South Asia, particularly in India accounts about 80% of the annual rainfall and hence it is crucial for agriculture, water resource as well as for power generation. Meteorological data available over the past 140 and odd years suggest that the all-Indian summer monsoon rainfall did not vary beyond ± 30% from the long-term mean. The reasons behind the interannual variations explained to changes in regional/global atmospheric processes such as El Niño/ La Niña-Southern Oscillation (ENSO), North Atlantic Oscillation (NAO), Equatorial Indian Ocean Oscillation, etc. All these inferences drawn from very much limited meteorological data spanning little more than hundred years which are not sufficient for understanding long-term trends. Comparison of paleoclimate records with meteorological ones suggests though there is good

agreement between these two, however, the former records indicate that there were severe droughts/floods prior to weather monitoring. Even though paleoclimate records of Southern India are in consensus with those of global climate change, however, there were extreme events identified in between. Therefore, there is a need to establish a high resolution paleoclimate record in the high rainfall regions in the tropics as most of paleoclimate conclusions have been drawn from studies carried out in the border tropics and temperate climates.

Poster

## Holocene climatic variability in lake Sonkul sediments (Kirghizstan, central Tien Shan): a monsoon influence in western Central Asia?

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Western Central Asia, as a remote intracontinental setting located far from oceanic influences, is a key place for high-resolution paleoclimatic studies because different climate systems interact at decadal- to millennial timescales and control the regional climate variability. A multi-proxy study (pollen grains, palynofacies, and magnetic susceptibility) was conducted on Holocene sediments from the alpine lake Sonkul (3010 m, central Tien Shan, Kyrgyzstan). The combination of sediment core proxies allowed the reconstruction of palaeoenvironmental and palaeoclimatic changes through vegetation dynamics and lake level variations between 8400 and 2000 cal. BP. A high-resolution age model was built on Holocene sediments, constituting one of the most accurate chronology available in Central Tien Shan. A quantitative reconstruction of climatic parameters using the "Modern Analogue Vegetation types" (MAV) method was further carried out to establish the climate variability, and especially the humidity patterns in western Central Asia during the Holocene.
During the early- to mid-Holocene, the climate conditions evolved from a wet alpine meadow at ca. 8400 cal. BP to a warm steppe with semi-arid elements at 6000 cal. BP. The wettest conditions were most probably attained around 8200 cal. BP in central Tien Shan, and coincide with the short-lived and large-scale cooling event in the Northern Hemisphere. Conversely, the climate conditions drastically declined between 7000 and 6000 cal. BP, with warm and dry conditions associated to the lowest lake levels of lake Sonkul.
Between 6000 and 4300 cal. BP, the vegetation restored to a semi-wet high-alpine steppe/meadow suggesting moderately moist conditions in central Tien Shan linked to the predominant influence of the Westerlies over central Asia. This climatic shift occurring at ca. 6000 cal. BP is rather abrupt in lake Sonkul sediments, through a prominent change in the vegetation pattern. We suggest that the regional climate system evolve from one predominantly controlled by Asian summer monsoons and the weak influence of middle latitude Westerlies before 6000 BP, to one overwhelmingly controlled by the Westerlies during the mid- to late Holocene. Finally, between 4300 and 2000 cal. BP, the climate becomes persistently warm and semi-arid, as it is nowadays, associated to relatively high lake levels of lake Sonkul. Our results, which are regionally coherent in Central Asia, document a close link between vegetation dynamics, humidity conditions, millennial-scale variations in Holocene climate and North Atlantic and Asian monsoon climatic patterns during the Holocene.

Talk

## Long term Monsoon variability inferred from lake sediments on the Tibetan Plateau

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In this contribution we will present one of the longest continuous high-resolution environmental archives on the Tibetan Plateau. Lake sediments from Nam Co (Central Tibetan Plateau) date back to ~23 ka cal BP. During that period, a multi-proxy approach, reveals oscillations of different duration and magnitude. Sedimentation rates are highest around 21.2 ka cal BP (>5 mm/a) with rapidly decreasing values to <1 mm/a at ~20.5 ka cal BP and <0.5 mm/a after ~18.5 ka cal BP.A slight increase is observed between 13,2 and 11,3 ka cal BP. In the geochemical record (TIC, TOC, TN, TS, Ca, Mg, Sr, Al, Ti, Fe, Mn) the time span between ~23 and 13,8 ka cal BP is characterized by the lowest values of TOC and TN and only small variations of the other elements. This points to a slowly raising lake level of Nam Co with decreasing sediment transport to the coring location and a low bioproductivity. This is supported by subbottom profiling showing submerged beach remains up to 60 m below the present lake level. Marine records, originating from the Arabian Sea, give evidence for a first prominent post-glacial climate change in South-East Asia around 14.3 ka cal BP. Prior to this date, an intense moisture transport from the Arabian Sea to the Tibetan Plateau by monsoonal air masses seems to be unlikely. Therefore we assume that sedimentation rates and geochemical signatures from ~23 ka cal BP to ~13.8 ka cal BP reflect the input of melt water from glaciers caused by rising air temperatures after the LGM.
At ~13.8 ka cal BP the system seems to change. A sharp increase in TOC is accompanied by rising concentrations of TN and TS and a significant lowering of the TIC content indicating an increase in bioproductivity and a rising lake level leading to an incomplete mixing of the water body and lower ionic concentrations. A second sharp rise in TOC can be observed around 12.2 ka cal BP. In contrast to the ~13.8 ka cal BP event, levels of TN and TS remain low, leading to high TOC/TNmolar ratios (of up to 21) within this core section. An enhanced input of terrestrial organic matter at ~12.2 ka cal BP is a possible

explanation for these high values. During this period allochthonous input, represented by Al, Ti and K is slightly decreasing, most probable associated with the increasing lake level influencing the sediment transport to the coring location. After ~12.2 ka cal BP a lowering of the TOC can be observed, reaching lowest values around 11.4 ka cal BP indicating a drop in bioproductivity. Around 11 ka cal BP smaller peaks in K, Al, Ti and the Rb/Sr-ratio are visible pointing to a higher input of physically weathered material from the catchment. This might correspond to the Younger Dryas. From the Arabian Sea strong monsoonal pulses dated to 13.5 ka cal BP, 13.0 ka cal BP and 13.0 – 12.5 ka cal BP are reported. These are associated with an intensified moisture transport from the Arabian Sea to the Tibetan Plateau. The changes in lake Nam Co ~13,8 ka cal BP are therefore obviously directly related to the strengthening of the monsoon in the Arabian Sea, but the different pulses are not detected in the Nam Co record until now. An event corresponding to the Younger Dryas is not reported from these marine records

Talk

## A high-resolution record of West African Monsoon variability for the past 530,000 years from Lake Bosumtwi, southern Ghana

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The West African Monsoon (WAM) system is an important component of the global climate system. It is also the primary source of moisture for millions of people in sub-Saharan Africa. The region is prone to decadal to multi-decadal droughts and pluvials associated with slow changes in Atlantic sea surface temperatures (SSTs). The instrumental climate record is too short to understand natural variability in the WAM, let alone how it responds to large changes in global climate. Here we present the first, high-resolution terrestrial record of sub-Saharan paleohydrological variability for the past 530,000 years; a sediment geochemical record from Lake Bosumtwi in southern Ghana (6°30′ N, 1°25′ W) with an average temporal resolution of 40 years. The abundance of terrigenous elements in the sediment, as well as the mineralogy and isotope geochemistry of carbonates formed in the lake, are sensitive to changes in lake level, and reveal a dynamic history of hydrologic variability over the past 530 kyr. Hydrology in the region is driven by a complex interplay of orbital forcing and glacial-interglacial boundary conditions. The 400-kyr component of eccentricity drove a more arid background state at the lake between 300 and 100 ka, likely due to the amplification of precession and the redistribution of tropical moisture to more subtropical regions. On glacial-interglacial timescales, lake level displays a positive relationship with the 100-kyr component of eccentricity, such that interglacial periods are generally less arid than glacial periods, likely due to the influence of warmer north Atlantic SSTs during interglacial periods. Superimposed on the orbital-scale variability in the record are six multi-millennial scale intervals of extreme aridity recorded in the sediments during the past 530 ka, all during the eccentricity-high interval from 300-50 ka. These events are generally associated with deep glacial conditions and local summer insolation minima, and in two cases, were immediately preceded and followed by intervals of high lake level. The transitions, both into and out of the arid intervals, appear to be rapid, occurring on the order of centuries or less, although the underlying climate dynamics of these transitions remains uncertain.

Poster

## Increased transport of summer monsoon moisture to the Higher Himalaya in the early Holocene

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This study presents Holocene paleoclimate record from a shallow pond lake near Chandra Tal (CT), located in the rain shadow Chandra Valley of Higher Himalaya. The chronology of lake sediment profile has been constrained by using 9 AMS $^{14}C$ dates. The geochemical results of CT display a lower value of the Ti content during ~11 to 9 kilo years before the Present (ka BP) which increased abruptly at 9 ka BP and remained higher until 6 ka BP. A gradual drop in Ti content from 6 to 3 ka BP was observed that suddenly dropped exhibiting consistent lower values from 3 to 1.5 ka BP. The time period between 1.5 ka BP to the Recent displays moderately higher Ti content. On the other hand, Magnetic Susceptibility (MS) and Fe content display lower values during 9 to 6 ka that gradually increased from 6 ka to the Recent. We observed a strong positive correlation with our Ti and continental summer monsoon records of south China (Dongge Cave), Oman (Qunf Cave), and Arabian Sea Hole 723A. A similar type of correlation is also observed with MS of both CT and Huguang Maar Lake (China). These correlations allow us to infer that the Ti content of the CT is controlled by the summer monsoon precipitation while the concentration of MS and Fe is controlled by the atmospheric input by intensified dry winter winds from central Asian provenance during weak summer monsoon periods. Our finding suggests large scale heterogeneity in interannual pressure distribution in the monsoon regime of the Northern Hemisphere during extreme warm and cold events. The excessive cold dry winds during ~11 to 9 ka and 3 to 1.5 ka BP (extreme cold conditions) pushed the Intertropical Convergence Zone (ITCZ) to the south of the Himalaya. Conversely, the extreme warm conditions between 9 and 6 ka BP pushed the ITCZ north to Higher Himalaya that extended and increase the monsoon precipitation across the Higher Himalaya.

Poster

## Incrusions of shorther wetter phases of SW Monsoon in an overall dry middle to late Holocene palaeoenvironment of Pookode Lake, South India

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Pookode Lake, Kerala, South India, is a fresh water lake situated at an altitude of ~2000 masl which receives water predominantly from the southwest monsoon. A sediment core of its (125 cm long) was investigated for sediment texture, dating and geochemical composition. Radiocarbon dates range in age from the mid Holocene to Recent (6240 to 565 yrs BP). In this sediment core Medieval Warm Period (MWP) and the Little Ice Age (LIA) are represented. Sediment texture, CWI values supported by phytolith and pollen assemblages indicate that the warm and dry conditions dominated the period between 6200-420 yrs BP but was interrupted by short periods of intense wet phases during ~3900-~1900, ~1400-~760, and ~420-~140 yrs BP. The wet events resulted from the strengthening of south-west monsoon (SWM) and they caused rising water levels and brief expansion of the Pookode lake.

Poster

## Nd-Sr-Hf isotopes in fine detritus material in Red Sea cores as tracers of Sahara – Arabia dust storms and monsoonal rains during the past 140 ka

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The Red Sea (RS), situated between the Sahara and Arabia deserts, comprises a trap for fine detritus material (FDM) that was transported during the Quaternary time by wind and floods from the late Proterozoic terrains of the Arabian-Nubian Shield (ANS) and the early to late Proterozoic terrains of the Sahara shields. Thus, sediments that were deposited at the bottom of the RS provide valuable information on the atmospheric circulation in the low-to-mid latitude region. Here, we report on the grain size, mineralogy, chemical composition and Nd-Sr–Hf isotope ratios of FDM that were recovered from the drilled cores KL-23 and KL-11 situated in the northern tip and center of the Red Sea, respectively.
The isotopic ratios indicate that the FDM represent mixtures between Sahara type granitoids (eNd < -8 and $^{87}Sr/^{86}Sr > 0.711$) and basaltic-granitic material (eNd > -4 and $^{87}Sr/^{86}Sr < 0.709$). The KL-11 samples are closer to the basaltic composition indicating transport of FDM from the Ethiopian volcanic plateau, while KL-23 samples are closer to the Sahara granitic compositions. However, during the last interglacial (MIS5) there was a significant addition of granitic material from the neighboring terrains of the ANS to the two locations.
In terms of synoptic conditions it appears that during glacials FDM was blown from the Sahara deserts and the Eritrean plateau to the Red Sea under the effects of the westerlies, while during the last interglacial and possibly at the African wet period (AWP) monsoonal rains caused erosion and flooding at the ANS margins of the Red Sea increasing the contribution of granitic ANS material to the Red Sea floor.

Talk

## Can South-West monsoon intensification develop a reduced condition in the Bay of Bengal sediments?

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Monsoon precipitation plays an important role in the socio-economic and agriculture development in the Asian region. Therefore, it is important to understand the monsoon dynamics and its impact on the benthic biogeochemistry. The Bay of Bengal (BOB) receives large quantity of suspended particulate matter and fresh water discharge from the Himalayas and Indian peninsula by a number of major rivers like Ganges-Brahmaputra, Krishna, Godavari, Cauvery and Irrawadi-Salween. The northern BOB receives maximum lithogenic flux during south-west (SW) monsoon that coincides with maximum river discharge from Ganges-Brahmaputra, Krishna-Godavari. In the present study, an attempt has been made to understand the impact of intensified SW monsoonal precipitation on the behaviour of redox-sensitive elements in a sediment core.
Reconstruction of paleo-redox conditions in a radiocarbon ($^{14}C$) dated sediment core (SK-218/1), covering the past 45 ka (thousand calendar years), collected from the western Bay of Bengal (Lat: 14° 02′N; Long: 82° 00′E) at a water depth of 3307 m, has been made based on geochemical analysis of redox-sensitive elements. The high U/Th ratio, Mo enrichment, Mo/U enrichment factor ratio, negative Ce-anomaly and lower Mn/Al and Fe/Al ratio, are all indicative of prevalence of sulfidic conditions in the benthic environment from 15.2 to 4.5 ka, peaking around 9.5 ka. Another event of smaller intensity and duration appears to have occurred around 20.5 ka. At this time, the U enrichment factor (3.1) was close to the Fe (II) – Fe (III) redox boundary and Mo/U enrichment ratio was nearly half that of the seawater, suggesting the prevalence of suboxic conditions. The major event centering around 9.5 ka corresponds to the previously recorded Southwest Monsoon intensification in response to increase in northern hemisphere summer insulation. However, productivity proxies – organic carbon and

nitrogen contents – do not indicate marked increase in productivity at this time. It is proposed that as a result of large increase in lithogenic material supplied from land due to southwest monsoon intensification, which is evident by the very high concentrations of Al, Zr and Hf, the flux of fresh labile organic matter reaching the seafloor was higher, the degradation of which led to anoxia in the benthic environment. There is a strong positive correlation ($R^2$=0.97) between Mo and Zr suggesting a coupling between lithogenic flux supplied by the monsoon and development of reducing condition during intensified monsoon between 4.5ka to 15.2ka. Our results suggest that temporal variability of the ballasting effect of the terrestrially-derived material could play a key role in benthic biogeochemistry and ecology of the Bay of Bengal. On the contrary, there is no correlation between Mo and Zr ($R^2$=0.1) from 15.2ka to 45ka (except at 20.5ka) due to weaker monsoon during that period. Therefore, present data clearly shows that monsoon intensification can develop a reducing condition in the Bay of Bengal sediments.

Poster

## Sr isotope study of Kaveri river – a potential proxy to infer the paleo-intensities of SW and NE monsoon in south India

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Each major river has certain characteristic $^{87}Sr/^{86}Sr$ ratio that depends on the age and type of rocks exposed in the drainage basin. Weathering of older rocks with high Rb/Sr ratio will release Sr having high $^{87}Sr/^{86}Sr$ ratio, whereas weathering of rocks with low Rb/Sr ratios will yield low $^{87}Sr/^{86}Sr$ ratios in water. This study is focused on Kaveri river draining the Dharwar Craton (DC) and Southern Granulitic Terrain (SGT) of south India to find out Sr isotope signatures of the river, which experience tropical bimodal monsoonal climate. The Kaveri river was sampled during NE monsoon of the year 2005 and the begining of SW monsoon (pre-monsoon) of 2006. The dissolved major ions, trace elements and $^{87}Sr/^{86}Sr$ ratios of river waters were measured.
In the Kaveri, highest $^{87}Sr/^{86}Sr$ ratio (0.717931 ± 0.000008, 2Σ) of monsoon water samples was measured from the Hogainakal and among pre-monsoon samples it is from Krishna Raja Sagar Dam, near Mysore (0.720296 ± 0.000008). These samples represent water draining granitoid intrusives and gneisses, mafic rocks and minor carbonates exposed in the southwestern part of the Dharwar craton. Lowest $^{87}Sr/^{86}Sr$ ratio (0.710002 ± 0.000018) was measured on Bhavani which drains mainly granulitic terrain, consisting of felsic and mafic granulites, calc-gneisses and minor amount of marble. Among pre-monsoon samples, Nagavari river a tributary to Kaveri drains mostly epidote-hornblend gneiss, granulites and synite has a low ratio of 0.705285 ± 0.000010. Marudaiyar, another tributary to Kaveri drains Cretaceous formation of Trichinapally also shows lower ratio of 0.708921 ± 0.000010.
The river sample show a distinct collinear arrays when $^{87}Sr/^{86}Sr$ ratio plotted against Ca/Sr and Mg/Sr ratios, which could be a result of two component mixing. Based on the distribution of various rock types in the upper, middle and lower reaches of the rivers they could be grouped into two major end members. These are (a) granulites and gneisses of Southern Granulitic Terrain and (b) meta-volcanic rocks + carbonates + granite and granitic gneisses of south Dharwar caraton. Interestingly, the end member (a) predominates in lower and middle reaches and (b) is in the upper reaches. When SW monsoon is active upper reach of Kaveri receives high rainfall and result in high $^{87}Sr/^{86}Sr$ ratio in tributaries that increases the $^{87}Sr/^{86}Sr$ ratio of the main course. During strong NE monsoon lower and middle reaches of Kaveri receive heavy rainfall and weathering of granulites and gneisses of Southern Granulitic Terrain gives rise to lower $^{87}Sr/^{86}Sr$ ratio in the main course. The two distinct Sr isotope signature in the main course of Kaveri is observed in a year during SW and NE monsoon periods. Therefore, Sr isotopic study on suitable materials that grew in equilibrium with Kaveri river water, such as, authegenic minerals and carbonate shells, formed in flood plains or delta, can be used for assessment of the relative intensity of NE or SW monsoon during recent geological past.

Poster

## Hydrological changes in the Gulf of California during the past 6200 cal yr BP and their relationship with ITCZ and North American Monsoon variability

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The aim of this study is to investigate changes in precipitation patterns and variations in paleoproductivity in the tropical Pacific region associated with the North American Monsoon, ITCZ latitudinal migration and changes in insolation during the Middle and Late Holocene. Major and trace element records (Al, Ba, C, K, Si and Ti) and Zr/Al and Ba/Al ratios in a core from Alfonso Basin, southern Gulf of California, are used as proxies of terrigenous input and bio-productivity. Records reveal an increase in precipitation and low bio-productivity ca. 6200 to 3700 cal yr BP and from ca. 2700 to 2400 cal yr BP, associated with the strengthening of monsoonal precipitation and northward shift of the ITCZ mean position in the eastern tropical Pacific. Droughts intervals from ca. 2400 to 1700 cal yr BP, and between ca. 700 and 340 cal yr BP, are characterized by strong aeolian input and enhanced productivity, associated with diminution of the summer monsoonal precipitation and reduced insolation in the Northern Hemisphere and more southerly ITCZ position. Correlation of Alfonso Basin records with other records in the Gulf of California and the Pigmy and Cariaco basins provides support for the paleoclimatic reconstruction and constraints on NAM, ITCZ migration, and insolation-driven changes.

Poster

## Analysis of the South American Monsoon for the mid-Holocene considering the results of 7 different PMIP3-model outputs

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Here we present a comparison between a multiproxy data compilation and paleoclimate model simulations for eastern South America (i.e., 0°-40°S; 10°-60°W) during the mid-Holocene (7,000 – 5,000 years Before Present). To avoid model-specific biases we averaged the output from seven mid-Holocene simulated mean precipitation fields from the fifth phase of the Coupled Model Intercomparison Project (CMIP5) and third phase of Palaeoclimate Modeling Intercomparison Project (PMIP3). The model outputs analyzed correspond to the experiments of the IPSL-CM5 (Institut Pierre-Simon Laplace – Coupled Model version 5, France), MIROC-ESM (Model for Interdisciplinary Research on Climate – Earth System Model, Japan), NCAR-CCSM4 (National Center for Atmospheric Research Coupled Climate Model version 4, USA), CNRM-CM5 (Centre National de Recherches Météorologiques – Coupled Model version 5, France), FGOALS-s2 (Flexible Global Ocean-Atmosphere-Land System Model, China), HadGEM2-CC (Hadley Centre Global Environment Model version 2, Carbon Cycle configuration), and HadGEM2-ES (Hadley Centre Global Environment Model version 2, Earth System configuration). $CO_2$ values were the same for both mid-Holocene and Pre-industrial simulations for all models. Mid-Holocene annual precipitation anomalies were calculated by subtracting the pre-industrial values from the mid-Holocene annual climatology.
Results are compared with proxy data obtained from a compilation derived from 83 published studies, which includes pollen assemblages, stable isotope analyses in foraminifers and speleothems, soil geochemistry, lake sediments, physico-chemical soil analyses and relative abundance of species. Proxy data were semiqualitatively classified according to their age model and sampling resolution.
When compared to modern conditions proxy data point to a drier Southern Brazil and South Atlantic Convergence Zone (SACZ), but a wetter/similar to present Northeastern Brazil. This suggests a weaker South American Monsoon (SAM) during the mid-Holocene if compared to the modern strength of the SAM. The analyzed model simulations indicate a similar pattern, with a southward shift of the Intertropical Convergence Zone during mid-Holocene, related to a weaker South Atlantic Subtropical High, and negative annual precipitation anomalies over the SACZ area. Nevertheless, regional differences between the analyzed models were clearly detected. The model ensemble precipitation mean field show a good fit with the multiproxy compilation, whereas the best fit was provided by the FGOALS-s2 individual simulation.

Poster

## Stepwise strengthening of Indian Summer Monsoon in the Bay of Bengal during last Glacial-Interglacial: Possible North Atlantic Tele-connection

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$\delta^{18}O$ measurements in surface dwelling planktonic foraminifera (PF) Globigerinoides (Gs.) ruber from a sediment core from the central Bay of Bengal (BOB) has recorded a gradual depletion from ~ -1‰ during Last Glacial Maximum (LGM) to ~ -3‰ during mid-Holocene suggesting a strengthening of Indian Summer Monsoon (ISM) over the bay during last glacial - interglacial transition. However, this trend is punctuated by abrupt multi-centennial enrichment in the $\delta^{18}O$ values of the order of ~ 0.5 ‰. Age model of the core obtained from AMS $^{14}C$ dates in mixed planktonic foraminifera and in bulk sediment suggests that timing of these abrupt enrichments of the $\delta^{18}O$ values corresponds to the Heinrich (H1), Younger Dryas (YD) and 8.2 ka North Atlantic cold events centered at ~ 15.5 cal ka BP, 11.7 cal ka BP and 8 cal ka BP respectively. It is also observed that although there are episodes of significant changes in the sea surface temperature and salinity (as reflected in the periodical enrichment in the $\delta^{18}O$ values) between 19ka to 5ka, the abundance of the mixed layer PF - Gs. ruber and Gs. sacculifer - and upper thermocline dweller Neogloboquadrina dutertrei do not show much variation during this period indicating that the upper ocean stratification remained almost same in the bay after the major turnover at the end of LGM. This suggests that this periodical enrichment of $\delta^{18}O$ in the surface dwelling PF Gs. ruber is controlled primarily by the episodes of abrupt monsoon decline. The synchrony of cold events of NGIRP ice core and North Atlantic marine records with the central BOB core suggests the existence of a strong tele-connection between the North Atlantic and the monsoon variability as recorded in BOB sediments. We propose that northern hemispheric abrupt cold events like H1, YD and 8.2 ka recorded in the Greenland and the North Atlantic had played a vital role in modulating the ISM over the bay and thus giving rise to a stepwise strengthening of ISM during the last glacial-interglacial transition in the BOB.

Poster

## Reconstruction of late Quaternary climate changes as derived from a pollen record from Lahaul Himalaya, Himachal Pradesh, India

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The Himalaya and the Tibetan Plateau play a crucial role in driving changes in the distribution and intensity of the Indian Summer Monsoon (ISM) rain. Small scale variation in the distribution and intensity of the monsoon can have a pronounced effect on the hydrological and socio-economic conditions of the South Asian region. The Lahaul Himalaya is situated in the rain shadow zone immediately north of the east-west oriented Rohtang Range, which restrains the entry of the ISM. The weather record of the nearest station at Koksar (977 m altitude, 32.40°N and 77.20°E, WMO station # 42065.1) located at the base of the Rohtang Pass in the downstream area of Chandra River, reveals ~1000 mm annual precipitation mainly as winter snow. However, the occasional spill over of ISM during July to September contributes around 100 mm rainfall during the increased strength of ISM in northern India and significantly controls the subsistence of Chandra Tal meadow. Whereas, the major precipitation (>800 mm) as a winter snow, occurs due to Westerly disturbances during December to early March. The centennial to millennial scale climate records since the late Pleistocene peat deposit of Lahaul valley are significantly important for reconstruction of ISM variability in the NW Himalaya and understanding the spatio- temporal distribution of ISM in the South Asian region. Pollen record of an AMS radiocarbon dated lacustrine to peat sediment situated between the Chandra Lake and left bank of Chandra River in Lahaul, Himachal Pradesh provides an undisturbed and continuous account of vegetation vis-à-vis climate record which helps to understand ISM variability in centennial to millennial scale during the last ~13,000 cal yrs BP. On the basis of changes in relative proportion of the recovered pollen percentages and pollen concentrations derived from local, regional and extra-regional, the Chandra peat profile suggests numerous transitions of ISM from strong to weak, as well as three prominent warm and wet period and five major cold-dry events recorded during the last ~13,000 cal yrs BP.

Poster

## Regional monsoon dynamics from small but complex paleoclimate networks

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Understanding the timing, extent and mechanisms underlying climate transitions in the past is of great importance to assess future climate change. Paleoclimate research, both in modeling and in data analysis, has given important clues as to how the mean state of climate system parameters, like temperature or precipitation, has changed. The regional extent of these changes, and their relation to each other, remains more difficult to pinpoint, however, due to limited data availability and model restrictions.

Relevance of individual paleoclimate-proxy time series needs to be assessed by cross-checking with other datasets. However, visual comparison of climate-proxy time series is insufficient to robustly detect similarities, differences, lags or leads. Heterogeneous growth or accumulation rates often lead to irregular temporal sampling, even if only one dataset is concerned. Therefore, computing correlation values is difficult because standard methods require coeval observation times, and sampling-dependent bias effects may occur. Paleoclimate networks offer new tools to assess and visualize the spatial coherence of past climate variability as recorded in paleoclimate proxy data. The climate network approach is based on complex systems theory, where (here: Earth) system dynamics are extracted from observed time series and investigated in a spatio-temporal context. Paleoclimate networks are adapted to spatial and temporal inhomogeneous sampling. They are based on adapted linear and nonlinear association measures that are more efficient than interpolation-based measures in the presence of inter-sampling time variability. We show how time uncertainties can be incorporated in the analysis and to what extent causality or directionalities can be inferred.

We reconstruct Holocene Asian Summer monsoon dynamics from paleoclimate data and investigate spatial structures and dependences. We observe a strong influence of the Indian Summer Monsoon (ISM) on the East Asian Summer Monsoon (EASM) during the Medieval Warm Period. During the cold Little Ice Age, the ISM circulation seems to have been weaker and did not extend as far east into the EASM realm. The network structure we observe for the most recent period of warming potentially indicates an ongoing transition towards a stronger ISM penetration into China. We investigate ISM strength further back in time and evaluate how ISM-EASM interactions varied during the last deglaciation. The robustness of our results are evaluated using a semi-empirical dynamical fluid model.

Poster

## Holocene history of climate, vegetation and anthropogenic disturbance from core monsoon zone of central India as reflected in lacustrine sediments of Lonar Crater, Maharashtra

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To infer changes in monsoon activity during the Late Glacial and Holocene, sediments of Lonar Crater Lake are being intensively studied within the Indian-German research collaboration HIMPAC (Himalaya: Modern and Past Climates). Based on detailed palynological analysis, the lacustrine sequence of Lonar Lake provides one of very few comprehensive and well dated records of vegetation changes in the context of climate fluctuations and human activity during the last ca. 10.000 years in semi-arid central India. Lonar Crater is situated on the Deccan Plateau of Buldhana District, Maharashtra. The climate is driven by SW-Monsoon circulation, which brings rainfall between June and September. Modern vegetation of this area is of transitional character between thorn shrub and dry deciduous forests and is therefore assumed to be sensitive to changes in annual precipitation and length of the rainy season.
Results of pollen analysis indicate a steady decline of dry deciduous forests between ca. 9 and 6.5 kyr BP, while contemporaneously a rise in thorn shrub vegetation occurs. After ca. 6.5 kyr BP the amount of pollen from dry deciduous forests vegetation increases, likely as a result of moister climate conditions. Starting at ca. 4.7 kyr BP, a drastic increase in sedimentation rates as well as in the number of disturbance indicating plant pollen occurs which may result from anthropogenic activity inside Lonar Crater. The sharp rise in thorn shrub vegetation after ca. 3.8 kyr BP can also be attributed to human induced vegetation disturbance, while the gradual decline in arboreal pollen since ca. 2.7 kyr BP refers to both human activity and decreasing precipitation. Our observations on vegetation responses to climate fluctuations are widely in line with other terrestrial palaeoclimatic records from the zone of SW-Monsoon influence of S-Arabia and India.
The palynological investigations on the Holocene sediment cores are flanked by an intensive study on modern pollen-vegetation relationships in surface sediments of Lonar Lake. These results provide detailed insights into mechanisms of pollen transport in tropical lacustrine archives, as well as the representation of pollen assemblages in the lake sediments in comparison with the recently occurring dry deciduous forest vegetation inside Lonar Crater. Our findings illustrate challenges and limitations in the interpretation of fossil pollen spectra from tropical Asia, as well as their suitability for quantitative climate reconstructions.

Poster

## Millennial-scale proxy records of the North American Monsoon from the arid northern Mexico over the last glacial period and Holocene

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The summer precipitation occurring in the arid northern Mexico and southwestern USA is referred as the North American Monsoon (NAM). In the modern era, it contributes 70-80% of the annual rainfall of northern Mexico and 40-50% of precipitation at southwestern USA. We present two multi-proxy millennial-scale paleohydrological records from the arid Mexico as possible registers of summer precipitation over the last glacial period and Holocene, respectively. The variations in runoff are compared to paleo-records of winter precipitation, north Atlantic temperature, solar insolation, El Niño Southern Oscillation (ENSO) and latitudinal shift in the average position of Intertropical Convergence Zone (ITCZ) in order to validate them as proxies to understand the dynamics of summer precipitation and the possible teleconnections and forcing mechanisms. The lacustrine sediment sequence from the paleolake Babicora (29°N) represents the last 80 cal ka BP. Intervals of higher runoff are synchronous to the interstadials and generally more than average runoff occurred during the intervals of higher summer insolation. Higher and relatively stable runoff during 80-58 cal ka BP possibly represented the most humid period in the northern Mexico with the expansion of terrestrial plants occurring between 71 and 53 cal ka BP. Over the last 40 cal ka BP, high amplitude variations in runoff mirror a fluctuating NAM. The region remained dry both during the Last Glacial Maximum and Younger Dryas. Sediments from the paleolake Las Cruces (22°N) registered the summer rainfall over the Holocene. The runoff was higher during the early Holocene thermal maximum. Except for the humid event of 2 cal ka BP, the runoff was less than average over the last 5 cal ka BP. The Holocene paleohydrological conditions show teleconections with the latitudinal migration of ITCZ and varying amplitude and frequency of ENSO. The runoff was more during the periods of less frequent and weak ENSO. Increase in the aeolian activity over the last 2 cal ka BP corresponds to an interval of stronger and frequent El-Niño.

Talk

## Deglaciation in the tropical Indian Ocean driven by interplay between the regional monsoon and global teleconnections

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High resolution climate records of the ice age terminations from monsoon-dominated regions reveal the interplay of regional and global driving forces. Speleothem records from Chinese caves indicate that glacial terminations were interrupted by prominent weak monsoon intervals (WMI), lasting a few thousand years. Deglacial WMIs are interpreted as the result of cold temperature anomalies generated by sea ice feedbacks in the North Atlantic, most prominently during Heinrich Events. Recent modelling results suggest, however, that WMIs reflect changes in the intensity of the Indian rather than the East Asian monsoon. Here we use foraminiferal trace element (Mg/Ca and Ba/Ca) and stable isotope records from a sediment core off the Malabar coast in the southeastern Arabian Sea with centennial-scale resolution to test this hypothesis and to constrain the nature and timing of deglacial climate change in the tropical Indian Ocean. The Malabar records indicate that deglacial warming started at 18.6±0.6 kyr BP, within error of the onset of warming at other tropical sites as well as in Antarctica and the Southern Ocean and with a lead over atmospheric $CO_2$ of 1.0±0.6 kyr. The Malabar deglacial SST record is unique in character and different from other tropical climate records. Deglacial warming occurred in two steps separated by an interval of stable SST between 15.9 and 13.5 kyr BP. The Ba/Ca record, which is a measure of riverine runoff, indicates that the last ice age termination was marked by a prominent weak Indian Monsoon interval interrupted by an intense monsoon phase, as seen in speleothem records and predicted by modelling. The deglacial tropical monsoon intensification coincides with northern high latitude warming, suggesting dominant control of northern high latitude ice-sheets on tropical monsoon.

Talk

## Glacial to Holocene changes in African monsoon according to deuterium isotope signals from alkenones and n-alkanes

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Tropical African monsoon evolution is controlled at first order by insolation, but the timing and trends of paleo-records sensitive to precipitation substantially differ upon proxies and locations. This presentation will review the status of paleohydrological reconstructions based on the deuterium isotope signal on land-plant lipids in lacustrine and marine sediment cores around Africa, showing the influences of the ITCZ in central Africa and of the southwestern Indian Ocean moisture laden airflows over Southeast Africa. Furthermore, results for deuterium isotopes of alkenones from a sedimentary sequence of the Niger River are presented to re-evaluate past estimates for changes in West African Monsoon. Here, a smooth, long-term increase of about 10 permil was found between 10 and 3 kyr BP, followed by a rapid decrease of about 10 permil between 3 kyr BP and core top, with alkenone deuterium isotope values slightly lighter than during the early Holocene. Both, oxygen isotope estimates for seawater and alkenone deuterium isotopes suggest a late Holocene salinity decrease based on the modern relationship between salinity and isotopic composition of seawater. This result at first is in contradiction with the salinity record derived from a Ba/Ca record of planktonic foraminifera. However, using water isotopologues as described in Rohling (2007) and in LeGrande and Schmidt (2011) reconstructing paleosalinities from paired oxygen isotope estimates for seawater and alkenone deuterium isotopes yields a monotonous salinity increase over the last 7 ka; in much better agreement with the Ba/Ca record. Our approach also reveals that late Holocene isotopic trends in precipitation over central Africa were similar to oxygen isotope records measured on Chinese speleothems, strongly suggesting that fractionation processes affecting water vapour in monsoon regions over the last 2 millennia can have a significant impact on the isotopic signal.

Poster

## Fluctuations in the Indonesian-Australian Monsoon: New insights from the Flores stalagmite record.

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The extension of the Flores paleomonsoon record back past 50kyr reveals not only a new paleomonsoon record, but also new mechanisms on the influencing factors of the movement and strength of the Inter-Tropical Convergence Zone (ITCZ) and associated rainfall over the Indonesian maritime continent. Our new stable isotope record shows fluctuations in the intensity of the Flores paleomonsoon on multiple timescales: glacial/interglacial, orbital and millennial.
At both millennial and orbital timescales the new $\delta^{18}O$ record shows negative-correlation with the Chinese Hulu-Dongge speleothem record, detailing movement of the ITCZ. These latitudinal shifts show close correspondence with Heinrich Events and other Northern hemisphere

glacial fluctuations. Additionally, on longer timescales, precessional changes in solar insolation exert a strong control on $\delta^{18}O$. Other positive correlations between the two records highlight potential changes in the overall strength of the monsoon. Events that appear in only one record may be indicative of more local processes and/ or changes in source moisture composition, moisture trajectories or kinetics.
Often overlooked, the carbon isotope record ($\delta^{13}C$) provides a record of changes in the vegetation on Flores. i.e. The ecosystem response to the changing climatic signal seen in $\delta^{18}O$. Varying degrees of correspondence between the $\delta^{18}O$ and $\delta^{13}C$ reveals which $\delta^{18}O$ excursions are likely to be the true result of changing rainfall intensity, as well as highlighting potential leads and lags in the system.
Our results highlight the importance of regional context in interpreting stalagmite records. This is due to the complex interactions of multiple factors that all contribute towards the stable isotope signature in speleothems, which, in the tropics, are often simply interpreted as changes in rainfall intensity.

Poster

## Synchronous summer and winter monsoon breakdown in the Arabian Sea during glacial cold phases

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The impact of extreme conditions in the North Atlantic on the global climate system remains hotly debated. The seasonal change in winter and summer monsoonal airflow controls climate over large parts of Asia. Unraveling the close link between maximal stadial perturbations in seasonal monsoonal airflow over Asia and the massive ice surge (Heinrich) events seems key to understanding northern hemisphere teleconnections. Here we present a new high- resolution eastern Arabian Sea paleo-productivity record, documenting millennial scale winter monsoon intensity over the last 80 ka BP. This eastern Arabian Sea productivity pattern varies in concert with western and northern Arabian Sea productivity profiles influenced mainly by summer monsoon on a stadial-interstadial time scale. Prominent minima in paleoproductivity occurred in the eastern Arabian Sea, which are in phase with the North Atlantic Heinrich events, and with minima in the productivity record from the western Arabian Sea. Hence, entire Arabian Sea biological production factory appears switched off during stadials, paralleling northern hemisphere climate changes. Furthermore, in contrast to E-Asia where changes in summer and winter monsoon strength are inversely related at the millennial scale, the results from the W-Asian monsoon controlled climate in the Arabian Sea show a synchronous decline in both summer and winter monsoon strengths during the cold stadials. These findings imply that summer monsoonal change across glacial Asia at the millennial scale occurred synchronously, whereas winter monsoon change in the E and W-Asian monsoon areas was decoupled.

Poster

## Variability in the strength of Monsoonal winds in the Western Arabian Sea since the Last Glacial Maximum: Evidence from Planktic Foraminifera and Oxygen isotope records

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The Western Arabian Sea (WAS) responds to the southwest (SW) monsoon winds during summer seasons by upwelling of colder and nutrient rich waters which is reflected in planktic foraminiferal abundance record. During the winter season, WAS is affected by the Northeast (NE) monsoon wind. The cold NE monsoon winds causes sea surface cooling and convective overturning conditions (Bartolacci and Luther, 1999). The SW monsoonal upwelling and the NE monsoonal convective overturn cause significant increases in primary productivity and zooplankton productivity in the Indian Ocean. Based on relative abundance of depth stratified planktic foraminiferal assemblages and oxygen isotopic values, four intervals of increased Southwest Monsoon Mode (SWM) have been inferred. The first intensification (SWMI-I) occurred during ~19-18.4 Ka in a glacial background and is possibly an outcome of early deglacial melting and stepwise increase in its strength after LGM. The second such interval (SWMI-II) occurred around (~16 to 12 Ka) has been termed as post LGM strengthening of Summer Monsoon. The third intensification of the SW monsoon is recorded around ~10 Ka after gradual strengthening from the end of Younger Dryas cold episode termed here as post Younger Dryas intensification of Southwest Monsoon Mode SWMI-III. The last interval of intensification occurred around (~8.2-8.0 Ka) SWMI-IV. After attaining an early Holocene maximum, the SW monsoon attains moderate mode and stays more or less uniform during the rest of the Holocene. We have also observed the enhanced abundance of Northeast monsoon (NEM) indicator Planktic foraminiferal species (*Globigerinoides ruber*, Globigerinoides species and Neogloquadrina dutertrei) which suggests stronger of NEM winds during ~8.0 - 5.4 ky BP as compared to the present.

Poster

## Tropical Variations of the Global Monsoon Precipitation during Last Interglacial (Eemian)

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Monsoons, the most energetic tropical climate system, exert a great social and economic impact upon billions of people around the world. Investigation of past monsoon variability over past interglacials, in particular the last interglacial (LIG) or Marine Isotope Stage 5: MIS5, helps to understand better the present monsoon dynamics and mainly its future under global warming conditions. Here the climate and monsoon during MIS5 is simulated using both a climate model of intermediate complexity, LOVECLIM, and a couple atmosphere-ocean general circulation models, CCSM3 compared to Pre-Industrial (PI). The global monsoon precipitation is much larger in both CCSM3 and LOVECLIM. Both models depicts almost similar pattern for JJA (June to August) rainfall difference between MIS5 and PI (MIS5 minus PI) except over tropical central Pacific and equatorial Atlantic. Rainfall increased over central Africa and Saudi Arabia by 4 to 5 mm/day and over India, Tibet, southwestern China and over northern part of South America by 3 to 4 mm/day. A strong migration and intensification of Intertropical Convergence Zone (ITCZ) was observed in equatorial Africa with significant increase in precipitation over the Sahel and southern Sahara, and a less increase over tropical Africa South of 8°N. A major precipitation difference between the two models is found over tropical Indian Ocean, tropical central Pacific Ocean, tropical Atlantic Ocean and North America. The increase of the tropical global monsoon precipitation during the last interglacial is attributed to the increases of tropospheric wind, land-sea thermal contrast, moisture convergence and surface evaporation consistent with a La Niña-like configuration of the El Niño-Southern Oscillation (ENSO)patterns. The upper level tropical easterly jet (TEJ) was strong between 300 and 100 hPa in the simulation is in good agreement with the heavy rainfall over the tropical monsoon region, because the TEJ is closely linked to boreal summer monsoon rainfall in Africa and Asia through the meridional vertical circulation. We found that TEJ was stronger and shifted northward from its mean position during MIS5. Nonetheless, the Earth's climate for the last interglacial remains not fully resolved because the data is insufficient and mostly confined to the Northern Hemisphere and the interpretations are regionally biased. Hence, there is a need of additional data from the tropics and Southern Hemisphere that could increase our understanding of the past climate dynamics, by providing the necessary data for model validation.

Poster

## Holocene vegetation and climate dynamics in Northeast China inferred from palynological analyses of the Sihailongwan maar lake sediments

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The annually laminated sediments of the Sihailongwan Maar Lake, NE-China, enable detailed reconstructions of vegetation changes and related climate variations under precise time control over the past ca. 75 ka. The key geographical position of NE-China in the northern periphery of the East Asian Summer Monsoon (EASM) and near the centre of the Asian Winter Monsoon (AWM) close to the arid parts of northern China provides excellent opportunities for unravelling monsoon variations in the context of global climate changes. Here we present the high-resolution pollen record of the Holocene part of the Sihailongwan lacustrine sequence. As the forest vegetation of the study area was largely unaffected by human activity until the youngest past, the recorded pollen features can be directly interpreted as climate changes.

The present study indicates that dense and species-rich deciduous forests, predominantly consisting of thermophilous broadleaf taxa (*Ulmus, Fraxinus, Quercus* and *Juglans*), became established and widespread during the first millennium of the Holocene. The beginning of the Holocene climate optimum corresponds to a significant increase in the temperate oak forest at 9.7 ka BP as a result of an intensified EASM. A spread of walnut at about 7.7 ka BP marks the second half of the climate optimum as somewhat warmer. The Holocene climate optimum was interrupted by a two stepped cold reversal at around 8.0 ka BP, possibly reflecting the 8.2 ka cold event. Around 6.5 ka BP, the beginning increase of Pinus koraiensis suggests a trend towards cooler conditions, while the present forest composition begins to establish in the study region. At 3.5 ka BP, an increase of Betula and steppe elements indicates drier climate conditions due to a weakening of the summer monsoon. Cold tolerant conifers spread around 1.9 ka and 950 years BP.

Over-regional comparisons of the Holocene vegetation changes recorded in the Sihailongwan Lake sediments reveal that climate changes in NE-China correspond to both variations in the EASM and to climate variations in Arid Central Asia controlled by winter monsoon and westerlies. Whereas the vegetation development of the Sihailongwan shows no strong correlation with the EASM during the first half of the Holocene, Late Holocene periods of weak summer monsoon as recorded in the Dongge cave match with recurring phases of pine spreading. The crucial factor for the observed pattern could be a basic change of the correlation between summer and winter monsoon. The results underline the high potential of palynological contributions from well-dated archives without anthropogenic influences to spatio-temporal reconstructions of climate change.

Talk

## Novel precipitation isotope records address a long-standing debate about East Asian cave oxygen isotope records

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Chinese speleothem oxygen isotopes ($\delta^{18}O_{cave}$) are well-dated, high-resolution proxies for $\delta^{18}O$ of precipitation. Although $\delta^{18}O_{cave}$ is widely interpreted as a proxy for Asian Summer Monsoon (ASM) strength, less than 50% of annual precipitation in the cave region falls during the ASM season (June, July, August). Furthermore, the phasing of $\delta^{18}O_{cave}$ relative to orbital precession, an important driver of monsoon dynamics, is different than a suite of 18 independent summer monsoon records from throughout Asia. The interpretation of $\delta^{18}O_{cave}$ as a summer monsoon proxy has therefore been a subject of debate in recent years. To inform current interpretations of existing monsoon proxies and to improve our understanding of East Asian precipitation seasonality, we generate independent precipitation isotope records for southern and central China. We analyze leaf wax hydrogen isotopes ($\delta^2H_{wax}$) and surface temperature records at millennial-resolution from 50-350 ka, an interval during which $\delta^{18}O_{cave}$ contains the greatest variability at the precession band. $\delta^2H_{wax}$ reflects the $\delta^2H$ of precipitation that falls during the growing season, especially in regions with little groundwater input. At Weinan (34°24'N, 109°35'E), on the southern Chinese Loess Plateau, soils are well drained and plants grow during the warm summer season, with rainfall mainly from the ASM. $\delta^2H_{wax}$ at Weinan therefore records $\delta^2H$ of summer precipitation. Terrestrial leaf waxes at ODP Site 1146 in the northern South China Sea (19°27.40'N, 116°16.37'E) are derived from the Pearl River, which drains subtropical southeastern China, where plants grow year-round. $\delta^2H_{wax}$ at Site 1146 therefore reflects annually integrated precipitation isotopes, similar to $\delta^{18}O_{cave}$. We use a radiometric chronology independent of orbital tuning at Site 1146 and tune mean grain size at Weinan, which varies in phase with ice volume, to Site 1146 benthic foraminifera $\delta^{18}O$.
We use the modern spatial relationship between precipitation $\delta^2H$ and surface temperature to remove the effects of condensation temperature on $\delta^2H_{wax}$ at both study sites. The resulting $\delta^2H_{wax\text{-}T}$ records contain information regarding precipitation source area and transport distance, both important indicators of monsoon precipitation. These seasonally distinct $\delta^2H_{wax\text{-}T}$ records provide insight into current interpretations of existing $\delta^{18}O_{cave}$ and inform our understanding of precipitation seasonality in East Asia.

Poster

## First Sub-centennial to Centennial Scale SST Record from the Eastern Arabian Sea

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This study is the first attempt to reconstruct sub-centennial to centennial scale record of the paleoceanographic conditions i.e., sea surface temperature (SST) and sea surface salinity (SSS) from the eastern Arabian Sea since mid-Holocene. Eastern Arabian Sea records signatures of Indian Summer Monsoon (ISM) precipitation as significant changes in salinity occur due to orographic runoff along the south-western coast of India. Moreover, due to the oxygen minima zone (OMZ) in the Arabian Sea, minimal bioturbation occurs in coastal sediments accumulating rapidly, which therefore can provide good high-resolution records of past ISM precipitation changes. The sediment core used in this study, SN-6, was collected offshore Mangalore from OMZ from a water depth of 589 m (length: 36 cm; sampled at every cm). The core spans a period of 154 to 4772 yr BP (based on five AMS radiocarbon dates). The average sedimentation rate is 8.96 cm/Kyr while the average resolution is ~112 yrs/sample; the top 11 cm has a higher sedimentation rate of 16.2 cm/kyr i.e., a sub-centennial resolution of ~62 yrs per sample. The stable oxygen isotope content ($\delta^{18}O_c$) were determined on the planktic foraminifera *Globigerinoides ruber* while the past SST variations were determined using an independent parameter - Mg/Ca - in the same species. The salinity was obtained by deducting SST from the $\delta^{18}O_c$ using empirical equations. We find that the SST has varied from a maximum of 28°C to a minimum of 25.6°C in the eastern Arabian Sea - a variability of 2.4°C since mid-Holocene. The salinity varies from a maximum of 36.0 psu (arid) to a minimum of 34.6 psu (wet) - a range of 1.4 psu. Periods of lower SST were centred at 4400 yr BP, ~2800 yr BP, ~2450 yr BP, ~2100 yr BP, ~1500 yr BP. Thereafter, there was a 500 year long period of reducing SST from ~1300 yr BP to 800 yr BP followed by colder SST at ~650 yr BP, ~500 yr BP, and ~350 yr BP. Interestingly, all these periods of lower SST were accompanied by that of lower salinities indicating enhanced ISM precipitation. This correlation indicate that the moderate upwelling, also reported from the climatological data, along the south-western coast of India during the summer monsoon season brings colder water to surface. SST contribution to $\delta^{18}O_c$ is quite large and cannot be ignored even for a short duration of 5000 years. The link of ISM precipitation with solar variability on centennial timescales based on a few earlier studies is still speculative because the SST and salinity component are not resolved accurately. This study has generated centennial scale SST records from eastern Arabian Sea that would help to delineate the effect of temperature from the oxygen isotopic data that mars most of the high-resolution precipitation/climate reconstruction. Comparison of this salinity reconstruction with the Total Solar Irradiance (TSI) fluctuations reveals that ISM precipitation was weaker during periods of TSI minima including Maunder, Spörer, Wolf, and Oort minima.

Spectral analysis of the reconstructed salinity exhibits a periodicity of ~315 years - near to the Suess solar cycle of ~200 yrs.

Talk

## Assessing the severity of monsoon decline during Heinrich events

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Much of our current understanding about orbital- and millennial-scale monsoon variability comes from accurately dated and highly resolved $\delta^{18}O$ time series analyzed in stalagmites. The interpretation of $\delta^{18}O$ records of stalagmites is based on the assumption that the $\delta^{18}O$ record largely reflects shifts in $\delta^{18}O$ due to changes in the amount of precipitation (amount effect). Most recently, a modeling study questions this assumption and suggests, for example, that the $\delta^{18}O$ records in Chinese cave deposits do not reflect changes in East Asian monsoon intensity, but in non-local changes in the $\delta^{18}O$ of water vapor. Furthermore, the same modeling study that simulated Heinrich event-like conditions suggests that approximately 50% of the $\delta^{18}O$ enrichment, as recorded in a speleothem from northern India during the Younger Dryas, arises due to changes in seasonality of precipitation and other processes such as the origin of water vapor, changes that the water vapor underwent en route from the source to the site of precipitation, and a mixture of vapor originating from Arabian Sea and Bay of Bengal. We tested this model-based hypothesis by focusing on sediment sequences recovered off large river systems (Niger-Sanaga and Ganges-Brahmaputra rivers) that drain large part of the West African and Summer Indian Monsoon areas. We established time series of foraminiferal Ba/Ca-based, runoff-induced sea surface salinity changes that reflects variability of monsoon precipitation. We removed the temperature, sea level, and runoff-induced SSS components from the $\delta^{18}O$ record analyzed in *Globigerinoides ruber* and derive $\delta^{18}O_{residual}$. The reconstructed $\delta^{18}O_{residual}$ variability within the runoff-induced fresh water plumes reflects largely changes in $\delta^{18}O_{precipitation}$. Our findings indicate that millennial-scale changes in monsoon precipitation during the 75 kyr BP was linked to large-scale reorganization of atmospheric circulations that significantly affected the isotope signature of monsoon precipitation. Our $\delta^{18}O_{residual}$ time series suggest that weak monsoon precipitation during stadials and Heinrich events was accompanied by significant shifts in $\delta^{18}O$ of precipitation toward higher values. We conclude that reconstruction of monsoon variability during the last glacial based solely on $O\delta^{18}O_{calcite}$ most likely overestimate the severity of precipitation decline.

## OSM02: Regional Climate Variability Over the Last 2000 Years

Convenors: Joelle Gergis, Guillaume Leduc, Jürg Luterbacher, Steven Phipps

Talk

### Reconstruction of tropical ocean SST trends during the last millennium: Results from the PAGES/Ocean2K project

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As part of the greater PAGES2K project (http://www.pages.unibe.ch/workinggroups/2k-network), we compiled and analyzed highly-resolved (near annual to sub-annual) proxy records from throughout the global tropical oceans. The goal of this synthesis project is to contextualize the current anthropogenically-influenced sea surface temperature (SST) trends using a systematic analysis of published, publically-archived paleoclimate data. The high resolution tropical proxy data have good spatial coverage since ~1800 AD for all basins, while a more limited number of records allow for the SSTs reconstructions to be extended further back into the last millennium. Our analysis protocol applies a consistent binning of all proxy data onto April-May annual averages that limit splitting of the tropical interannual climate signals of the El Niño-Southern Oscillation, the Indian Ocean Dipole and the monsoon systems across adjacent calendar years. Using a composite-plus-scale (CPS) methodology, we group the data by ocean basin, weight each proxy's contribution to the reconstructions based on their correlation with basin-wide instrumental SSTs, then calibrate and validate the resulting proxy composite across the instrumental period. Uncertainty in the reconstructions arises from the sparseness of the observational network in the early part of the reconstruction, limited calibration and validation intervals, the possibility of nonstationarity in the climate and the proxy observations, and limited validation of secular trends and decadal timescale variations. The SST reconstructions reveal that most regions of the tropical oceans have undergone warming during the 20th century, consistent with the findings of the continental temperature syntheses under the PAGES2k project. We present results determining the initiation points for the recent warming trends in each ocean basin and examine sub-basin scale differences in the rate of temperature change and the magnitude of interannual and decadal variability. These differences may reflect the regional expression of both internally and externally-forced tropical marine climate variability in the paleoreconstructions.

Poster

### An Expanded Archive Facilitating Temperature Reconstructions of the Past Two Millennia from Paleo Proxies

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Regional (as opposed to global or single-site) reconstructions of temperature during the past two millennia derived from paleo proxies are valuable in elucidating many aspects of climate variability and change. Regional reconstructions reveal the exquisite sensitivity of the Arctic and the relative stability of the low latitudes. They additionally reveal decadal variability that appears regionally rather than globally, while over the past millennium they exhibit broad similarity at the multi-centennial scale. In support of an international working group of PAGES, the 2k Network, the World Data Center for Paleoclimatology (www.ncdc.noaa.gov/paleo) has assembled an extensive network of paleo proxy data and temperature reconstructions based on these data. Regions represented include the Arctic, Antarctica, Africa, Asia, Australasia, Europe and the Mediterranean, South America, North America, and Oceania. The archive contains both raw and reconstructed variables, and a future version is planned that will include age-depth information allowing age models to be revised. The archive will be expanded to include proxies related to precipitation and surface and 500 hPa geopotential, providing a state-of-the-art window on the near-past variability of climate and atmospheric circulation over the past two millennia.

Talk

### Covariability of precipitation and sea surface temperature changes in Northern Chilean Patagonia during the last 2000 years

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The climate of Chilean Patagonia is highly influenced by the Southern Westerlies, which control the intensity and latitudinal distribution of precipitation in the Southern Andes. In austral summer, the Westerly Wind Belt (WWB)

is restricted to the high latitudes (> 47°S). It expands northward in winter, which results in a strong seasonal signal in precipitation between ~47 and ~30°S. In addition, the area is characterized by a steep latitudinal Sea Surface Temperature (SST) gradient, which reflects the regional influence of the Antarctic Circumpolar Current (ACC). Here, we present a new precipitation proxy record from the Chilean fjords at 45°S, and we compare our results with regional SST records to assess the ocean-continent interactions in Chilean Patagonia during the last 2 millennia. Our precipitation record is based on a high-resolution geochemical analysis of a 2m long sediment core from Quitralco fjord (45°S). Our coring site is particularly sensitive to changes in river discharge, and therefore precipitation, since it is located in front of a small river that drains the Patagonian Andes (Rio Pelu). Our data demonstrates a significant increase in Fe/Al and Ti/Al between ~700 and ~50 cal. yr BP, which corresponds to a decrease in mean sediment grain-size from ~30 to ~20 um. This shift is interpreted as a decrease in the energy of river sediment discharge, which most likely reflects a decrease in seasonal floods. The comparison of our precipitation record with published SST records from the region demonstrates that lower (higher) SSTs are systematically coeval with a decrease (increase) in seasonal floods in the Patagonian Andes. The decrease in seasonal floods at 700-50 cal. yr BP corresponds to a SST decrease of ~1°C. We argue that the synchronicity of changes in precipitation and SST during the last two millennia was likely caused by concomitant migration of the zonal systems, i.e., the Southern Westerlies and the ACC.

Poster

## How subsurface temperature data may help to reconstruct past climate

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Borehole climatology is a useful tool to reconstruct the past climate changes on the time scale of several past millennia (in an ideal case of the whole Holocene). Surface soil temperature tracks the air temperature variations and due to thermal diffusivity of the near surface rocks these variations slowly penetrate downwards. Detailed temperature vs. depth profile can be then inverted into surface temperature vs. time record; deeper we go in depth, further in time the past climate can be assessed. We have analyzed some one hundred borehole T(z)-profiles on the territory of the Czech Republic to propose past climate scenario for the last two thousand years. Special attention was paid to the Medieval Climate Optimum, the Little Ice Age and especially to the following temperature recovery resulting in the Present Global Warming. To better understand the mechanism of the downward penetration of the surface climate signal, we are running a "geothermal observatory" by monitoring air, surface and soil temperatures within and below the near surface "active" layer, i.e. within the zone where temperature field is affected by surface annual cycle (uppermost 40-50 m). Results of almost 20 year-long observation experiment were completed with additional experimental data confirming the significant role of the surface (vegetation) cover as well as the effect of meteorological phenomena such as rain fall, snow cover, winter freezing and thawing. The major outcome of these studies is a certain possibility to quantitatively describe the present (climate) warming and eventually evaluate the potential man-made contribution to it.

Poster

## Results of Long-Term Temperature-Time Monitoring at the Geothermal Observatory Sporilov, Prague (The Czech Republic)

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Borehole-based geothermal observatory has been running at the Sporilov campus of the Institute of Geophysics in Prague since 1993. Borehole temperature-depth profiles contain climatic information related to surface ground temperature history. Observations of air and ground temperatures (in the 0 to 40 m depth section) were analyzed to understand the relationship between these two quantities and the mechanism of heat transport at the land-atmosphere boundary layer. The 19-year-long monitoring series provided a surprisingly small mean ground-air temperature offset of only 0.27 K with no clear annual course and offset value changing irregularly even on a day and night scale. Monitoring records were completed with detail studies of the effect of various surfaces on the downward penetration process and of the effect of snow cover, ground freezing and precipitation. Data series were further processed with the help of the Fast Fourier Transform and Recurrence Quantification Interval analysis to uncover the potential hidden periodicities in the noisy time series. The results show considerable similarity for all investigated depth levels; besides the characteristic pronounced annual wave all series contain 8-year and also 11-year periodicities. The site presents a typically urban environment, the gradual year-to-year increase of temperature below the "seasonal-variation zone" amounts to 0.03 K/yr, while another observational site in the rural environment Kocelovice (southern Bohemia) gave lower value of 0.02 K/yr.

Poster

## Last 2000 years environmental changes in Lake Pa Kho, Northeast Thailand

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Lake sediment and peat archives from Indochina provide important information regarding past changes in moisture availability and/or human impact, but have also shown to be problematic with respect to age control and their geographical coverage. Here we report a multi-proxy geochemical record (LOI, TOC, CNS elemental and isotopic data, and biogenic silica) from Lake Pa Kho in northeast Thailand, which is underpinned by 16 AMS $^{14}C$ ages. Changes in sediment stratigraphy, geochemistry and accumulation rate were used to reconstruct the paleoenvironmental response to monsoon variability and anthropogenic impact during the past 2000 years. From c. 250 B.C. to c. 500 A.D. Pa Kho was a shallow lake with relatively high productivity, which could signify a stronger summer monsoon. The lake transformed into a wetland/peatland with a dominance of higher plants around 500 A.D. The wetland/peatland phase between c. 500 and 850 A.D. suggests that effective moisture had decreased. The combined paleo-proxies (mix of aquatic and terrestrial organic material) show that the lake level increased again between c. 850 and 1400 A.D., which could be interpreted in terms of higher moisture availability. Depleted $\delta$13 C values in the sediments between c. 1450 and 1550 A.D. indicate a dominance of terrestrial organic material, which in turn could imply a lower lake level, the development of an extensive wetland/peatland and as such less effective moisture. This latter period coincides with an interval of monsoon drought shown by tree-ring studies and also compares well to the collapse of all major kingdoms in Southeast Asia. The wetland/peatland phase continued up to the present, although damming of the outlet during the past decade allowed the renewed establishment of a lake. The high pre-colonial era in Southeast Asia and intensification of agriculture started c. 1600 A.D. The two millennia record of Lake Pa Kho adds important paleoclimatic information for northeast Thailand. This allows discussing historical climates and cultivation in the region in greater detail.

Poster

## Tree-ring reconstructed boreal summer temperature anomalies for temperate East Asia since 800 C.E.

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We develop a summer temperature reconstruction for temperate East Asia based on a network of annual tree-ring chronologies covering the period 800-1989 C.E. The East Asia reconstruction is the regional average of 585 individual grid point summer temperature reconstructions produced using an ensemble version of point-by-point regression. Statistical calibration and validation tests indicate that the regional average possesses sufficient overall skill to allow it to be used to study the causes of temperature variability and change over the region. Substantial uncertainties remain, however, particularly at lower frequencies, thus requiring caution in the interpretation of this record. The reconstruction suggests a moderately warm early medieval epoch (ca. 850-1050 C.E.), followed by generally cooler 'Little Ice Age' conditions (ca. 1350-1880 C.E.) and 20th century warming up to the present time. Since 1990, average temperature has exceeded past warm epochs of comparable duration, although it is not statistically unprecedented. Superposed epoch analysis reveals a volcanic forcing signal in the East Asia summer temperature reconstruction, resulting in pulses of cooler summer conditions that may persist for several years.

Poster

## Relationship between sea ice variability and atmospheric circulation during the last millennium in Antarctic Peninsula

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Atmospheric circulation influences the seasonal sea ice duration in Antarctic Peninsula and plays a significant role on the heat budget in Antarctica. However, little is know about past regional variations of this important component of the earth climate system. In this study, we present two marine sediment core records covering the last millennium from key located in the eastern and the western sides of Antarctic Peninsula. We combined diatom assemblages and specific sea-ice biomarkers to document changes in sea ice, hydrology and primary productivity over the last ~700 years. Diatom assemblage and biomarker variations were coincident with Na+ concentration record in Siple Dome ice core suggesting that oceanic conditions variations, upper circumpolar deep water upwelling and Weddell Gyre intensity in west and east Antarctic Peninsula areas respectively, responded to the atmospheric circulation variability during the last millennium. For both regions, we identified a period of shorter seasonal sea ice cover and reduced primary productivity related to a strengthening of the Westerlies during the so-called Little Ice Age (LIA) period. A cooler interval, characterized by an increase of the sea ice seasonal duration, a stronger water column stratification and a higher productivity extending of the last two centuries as a response to a weakening of wind intensity has also been identified. We propose that the globally mild environmental conditions in both sides of the Antarctic Peninsula during the LIA resulted from a common atmospheric forcing such as the greater occurrence of positive SAM anomalies during that period.

Poster

## Two-thousand-year climate reconstruction of the Altai region with annual time resolution and the search of natural cycles with length from 3 to 1,000 years

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The purpose of the study is to find the natural cycles of different periodicity (from 3-10 years to several hundred years) in trace element composition and lithological properties of sediments lake Teletskoe (Altai region) in the time interval of the last two millennia.
Sediment cores up to 230 cm were selected in 2002, 2004 and 2010 using gravity tube in the deep basin (326 m) of the lake Teletskoye. There also were selected blocks of the upper layers of undisturbed sediment with box-corer. In the laboratory, the cores were cut into two halves. One part was used for the sampling with step of 5 mm. These samples were used for measure humidity, isotopic analysis, the determination of total carbon, loss of ignition, isotopic age determinations using $^{137}Cs$, $^{210}Pb$ and $^{14}C$. From the second half of the core samples were prepared for scanning microanalysis.
Scanning microanalysis using synchrotron radiation (μ-XRF) has been made on storage ring VEPP-3 in the Institute of Nuclear Physics SB RAS (Novosibirsk). Trace elements along the core was analyzed at excitation energies of 18 and 24 keV with step 100 microns. In each point was determined from 15 to 25 elements with a detection limit 0.5 ppm and X-ray density of the sample (XRD).
Time model was calculated according to the isotopic analyzes using $^{137}Cs$, $^{210}Pb$ and $^{14}C$.
For the analysis of non-stationary time process has been applied the empirical mode decomposition method with the application of the Hilbert-Huang conversion.
Were found natural cycles with periods: 3,5±0,3; 8,8±0,9; 18,8±2,0; 37,8±1,6; 86,0±10,2; 164±15; 346±30; 596±71; 993 years.

Talk

## Shifting Winds over the North Sea: How Anglo-Dutch documentary evidence enables the reconstruction of changes in prevailing wind during the Little Ice Age, 1630-1700

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Climatic reconstructions that record the regional chronologies of the Medieval Climatic Optimum and the Little Ice Age traditionally consider changes in average seasonal temperature or precipitation. Past fluctuations in these meteorological expressions are readily visible in proxy data available from natural archives, yet regional variability in prevailing wind intensity or direction are not easily reflected in, for example, tree rings or ice cores. This paper introduces previously unexamined Anglo-Dutch ship logbooks, weather diaries, accounts and correspondence as quantifiable sources useful for the reconstruction of changes in past wind intensity and direction. Using documentary evidence, the paper argues the late-seventeenth century transition to the cooler climate of the Maunder Minimum in the North Sea region was accompanied by a shift in the patterns of prevailing wind. While Anglo-Dutch observers described an abundance of westerlies in the middle of the seventeenth century, easterlies and high winds were recorded with greater frequency in subsequent decades.

Poster

## Garabashi glacier (Central Caucasus) mass balance reconstructions inferred from tree-rings

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Tree-ring data was successfully used for glacier mass balance change.The exploration whether tree-ring data can be effectually applied for the mass balance reconstruction in Caucasus was the main goal of this research. Tree-ring width and maximum density chronologies of pine (*Pinus sylvestris* L.) at seven high-elevation sites in Northern Caucasus were explored for this purpose. As well as in other places of the temperate zone tree- ring width has complex climate signal controlled both temperature and precipitation. Tree-ring maximum density in Caucasus has a clear climate response to summer temperatures and allowed the reconstruction of April-September temperatures since 1800s. Instrumental mass balance records of Garabashi glacier started at 1983s. It is well known that Caucasus glaciers intensively retreat in the last decades and according to instrumental data mass balance variations are mostly controlled by the ablation, i.e. summer temperature variations. Maximum density chronology has statistically significant correlation with mass balance due to summer temperature sensitivity and great input of ablation to total mass balance variations. To include in our reconstruction different climatically sensitive parameters, stepwise multiple regression model was used. The strongest relation ($r = 0.88$; $p < 0.05$) between 2 ring-width and 1 maximum density chronologies was identified. Cross-validation test ($r = 0.79$; $p < 0.05$) confirmed model adequacy and it allowed to reconstruct Garabashi glacier mass balance for 1800-2005. The reconstruction length threshold by Expressed Population Signal (>0.85) values counted for chronologies. Reconstructed and instrumental mass balance values coincide well except the most recent period in 2000s, when the reconstructed mass balance slightly underestimated the real values.

However even in this period it remained negative as well as the instrumental records. The bias can be explained by the weak sensitivity of the chronologies to winter precipitation (i.e. accumulation). The tree-ring based mass balance reconstruction was compared with one based on meteorological data (since 1905s). Both reconstructions have good interannual agreement ($r = 0.53$; $p<0.05$) particularly for the period between 1975 and 2005. According to the reconstruction two distinct periods of positive mass balance occurred in 1830s and 1860s. They agree well with early historical data and the tree-ring of moraines of Kashkatash glacier in Central Caucasus.

Poster

## Sea ice, biological production and nutrient cycling reconstructed at an unprecedented time resolution in the Adélie Basin, East Antarctica, for the last 2,000 years

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Antarctic sea ice impacts on the ocean-atmosphere heat and gas fluxes, the formation of deep and intermediate waters, the nutrient distribution and primary productivity, the so-called 'biological carbon pump', one of the most active in the global ocean. In this study, we explore the link between sea ice dynamic, biological production and nutrient cycling during the late Holocene (the last 2,000 yrs) in the AdÉlie Basin, East Antarctica, from the well-dated sediments of the Ocean Drilling Program (ODP) Site U1357. This archive, composed from ~32 meters of seasonal to annual laminated diatomaceous sequences, allows reconstructions at an unprecedented time resolution (5-10 yrs). Our study combines records of diatom census counts and diatom-specific biomarkers (a ratio (D/T) of di- and tri-unsaturated Highly Branched Isoprenoid lipids (HBI)) as indicators of sea ice and biological production changes, XRF data as markers for terrigenous inputs and bulk nitrogen isotopes (d15N) and d15N on chlorins as proxies for reconstructing nitrogen cycle.
The diatom and HBI records reveal five distinct periods. From 0 to 350 yrs AD, decreasing occurrences of sea ice-related diatom species (e.g. Fragilariopsis curta + F. cylindrus) together with low D/T values and increasing open ocean diatom species (large centrics, Chaetoceros Resting Spores (CRS)) document a progressive decline of sea ice presence during the year (> 9 months per year) with spring melting occurring earlier in the year and autumn sea ice formation appearing later. In contrast, between 350 and 750 yrs AD, high production of open ocean diatom species and low low D/T values and sea ice related species indicate a short duration of sea ice cover (< ~8 months per year). From 750 to 1400 yrs AD, a prolonged seasonal sea ice (> ~10 months per year) is illustrated by a pronounced increase of sea ice-associated diatom species and high D/T values. Between ~1400 and 1850 yrs AD, seasonal sea ice strongly declines (<~7 months per year) as a result of early spring melting (increasing CRS production) and late autumn waxing (high occurrences of Thalassiosira antarctica). Longer growing seasons promoted a substantial development of phytoplankton communities (especially large centric diatoms) that conducted to lower D/T values.
Consistent with diatom and HBI reconstructions, XRF data show higher Fe/Al and Zr/Al ratios values during inferred warmer periods and lower ratio values during inferred cooler and icier periods, thus supporting a strong impact of the sea ice seasonal cycle on glacial runoffs.
The link between sea ice conditions, biological production and nutrient cycling is still being explored and we will discuss its relationship by combining all the cited records cited above with the $d^{15}N$ records that we are currently generated.
Based on our results, we find that sea ice dynamic and associated diatom production in the AdÉlie Basin revealed an opposite climatic trend than that identified in the Northern Hemisphere for the last 2000 years. The 'Little Ice Age' (1400-1850 yrs AD) or the 'Dark Ages' (400-750 yrs AD) corresponded to warmer climate conditions in the AdÉlie Basin, while the 'Roman Warm Period' (0-350 yrs AD) or the 'Medieval Warm Period' (900-1200 yrs AD) were associated to colder conditions. We therefore emphasize that Northern and Southern Hemisphere climate evolved in anti-phase seesaw pattern during the late Holocene.

Poster

## Multi-annual variability of the Peruvian Oxygen Minimum Zone across the last millenium

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There is evidence that pelagic oxygen minimum zones (OMZ) have expanded and intensified for at least 50 years, probably as a response of global warming. However, it is essential to document the OMZ evolution beyond the historical record to better assess the relative contributions of natural and anthropogenic forcings. Such records from the Peruvian margin have been studied but only a few ones focus on both variability and mean state of nutrient cycle and upwelling intensity in the OMZ.
We here analyzed three trigger cores containing faintly laminated sediments from the Peruvian shelf, along a North-South transect, from 11°S to 15°S within the OMZ. Non-destructive measurements (X-ray radiography and X-ray fluorescence core-scanning) were first realized to better identify individual layers. A combination of $^{210}Pb$ based estimates of accumulation rates and $^{14}C$ analysis on calcitic foraminifera or organic matter will provide the age model for the cores. We analyzed diatom assemblages, bulk $\delta^{15}N$, total nitrogen, organic carbon and alkenone contents as well as alkenone-based sea surface

temperatures.
All three cores show three distinct periods that we attributed to the Medieval Warm Period (MWP), the beginning of the Little Ice Age (LIA) and the end of the LIA according to our preliminary time scale. Our record shows a very productive mean state during the MWP. High diatom abundances and very high relative abundances of upwelling-associated diatoms point at pervasive La Niña conditions. Such observations are in agreement with previous studies. The beginning of the LIA stands out with strong variability in all proxies that we attribute to enhanced ENSO activity. Low total diatom abundances indicate a less productive mean state closer to than during the MWP. Finally, total diatom abundances are low and mesotrophic diatom relative abundances are high during a period corresponding to the end of the LIA. These observations suggest that the OMZ was less intense that nowadays, which is in agreement with previous studies. Interestingly, diatom abundances and $\delta^{15}N$ show a positive correlation. Heavy sedimentary $\delta^{15}N$ within OMZ are generally interpreted as the result of an increase in subsurface denitrification, while high total diatom abundances as well as the occurrence of Chaetoceros resting spores during these periods of heavy $\delta^{15}N$ also suggest enhanced nutrient consumption in surface waters during these periods of heavy $\delta^{15}N$.

Poster

## Dendrochronological studies in Nepal: Current status and future prospects

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For to its diverse topography coupled with climatic variation and unique biodiversity, Nepal poses high potential for dendrochronological study. The first tree ring research in the country was carried out in 1970s, and shows a steady progress till date with only 53 tree ring studies reported that include published and unpublished research reports, thesis and journal articles. Studies have covered some 15 tree species such as Abies spectabilis, Betula utilis, Cedrus deodara, Juniperus spp, Picea smithiana, Pinus roxburghii, P. wallichiana and Tsuga dumosa. The most favored tree for the study has been Abies spectabilis and the most widely used parameter for analysis has been the ring width. The longest chronology for Nepal was build from Tsuga dumosa with 1,141 years that extended from 856 AD to 1996 AD. On climatic reconstruction, three studies were found that covered temperature from 1546 AD to 1991 AD. Interestingly a drought reconstruction of 223 years ranging 1778 AD to 2000 AD has also been reported. Past studies have covered areas like dendroclimatology, dendroecology, dendroarchaeology and stable isotopes in dendrochronology. By geographic coverage, 22 districts out of 75 in the country have been covered, and they are mostly from high altitudes. Recently, several new chronologies have been developed but with incomplete climatic reconstructions. Our recent dendroecological studies have revealed an upward shift of A. spectabilis at treeline as well as differential regeneration pattern of treeline forming species in east, central and western Nepal Himalaya. There exists a potential of application tree ring study in wider aspects including dendrohydrology, geomorphology and glaciology with large spatial coverage of the country. When analyzed by participation, 51% of the total studies till date were carried out by Nepali researchers, 28% by foreign researchers and 21% in joint endeavors. Hence, Nepal offers a great prospect for tree ring study specifically in context of climate change today.

Poster

## High altitude tree-ring chronology from Malari Glacier, western Himalaya, India, and its climatic implications

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Understanding of the natural variability of climate over millennium and longer is required to assess the effects of the recent global climate change. Knowledge of temperature and precipitation (rain, snow) variations over the Himalayan region is necessary for understanding climate variability before instrumental era. Tree-rings are known as excellent proxies for developing millennia long climate records. Himalayan pencil cedar (Cedrus deodara) is one of the conifer species showing distinct growth rings with high dendroclimatic potential for reconstructing past climatic records in the western Himalaya. For the present study, 24 tree-rings samples were collected from high altitude near glacier site of Malari region of Uttarakhand (30.05°N, 79.04°E) in the western Himalaya, India. Many tree-ring series are going back to more than 400 rings with the highest 527 rings. Most of the samples exhibit patches of narrow rings and their occurrence is coherent among the samples. Meteorological data of the Mukteshwar station which is comparatively closer to the tree-ring site have been used in response function analyses to understand the tree growth climate–relationship. It suggests that the summer as well as winter conditions influence the tree growth. Existence of resin rings mainly associated with the latewood growth is the common feature observed in the samples of the Malari. External conditions (e.g., heavy snow fall) influence the resin ring formation. These features might be related with the stress conditions caused by large amount of snow accumulation as this site remains covered by snow for about 6 months in a year. This chronology shows the similar warm and cool epochs as observed in the other conifer tree-ring chronologies from Kinnor and Gangotri regions of western Himalaya. Snow accumulation records of the Dasuopu ice core data are closely matching with warm and cold period in our present chronology. Such high altitude temperature sensitive tree-ring chronologies associated with of resin rings would be useful to map the glacier fluctuation in the past.

Solicited Talk

## Antarctic temperature changes during the last millennium: evaluation of simulations and reconstructions

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Temperature changes in Antarctica over the last millennium are investigated using proxy records, a set of simulations driven by natural and anthropogenic forcings and one simulation with data assimilation. Over Antarctica, a long term cooling trend in annual mean is simulated during the period 1000-1850. The main contributor to this cooling trend is the volcanic forcing, astronomical forcing playing a dominant role at seasonal timescale. Since 1850, all the models produce an Antarctic warming in response to the increase in greenhouse gas concentrations. We present a composite of Antarctic temperature, calculated by averaging seven temperature records derived from isotope measurements in ice cores. This simple approach is supported by the coherency displayed between model results at these data grid points and Antarctic mean temperature. The composite shows a cooling trend during the pre-industrial period consistent with model results. In both data and simulations, large regional variations are superimposed on this common signal, at decadal to centennial time scales. The model results appear spatially more consistent than ice core records. We conclude that more records are needed to resolve the complex spatial distribution of Antarctic temperature variations during the last millennium.

Poster

## Northern alpine ecosystems: Is temperature one climate factor, influencing to spruce and larch light-ring formation?

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Possibility to reveal the extreme environmental conditions, leading to the light ring formation in conifers, growing in the high mountain areas, can significantly enhance the dendroclimatic reconstructions. The air temperature is the main factor of the light ring formation in such ecosystems as forest-tundra and alpine forests which functioning is limited by temperature.
We have analyzed light-ring chronologies of Siberian spruce (*Picea obovata* Ledeb.) and Siberian larch (*Larix sibirica* Ledeb.), which were derived from 100 trees of each species growing in mixed sparse forest on the upper tree line at the Polar Ural Mountains (230 m a.s.l.)
We have used following meteorological observation rows from the Rai-Iz weather station (WMO code 23331, 890 m a.s.l., the observation period 1939-1997): maximum, minimum and average monthly temperature from October of previous year, monthly sum precipitation, cold period precipitation (October-March), dates of the growing season beginning and the number of sunshine hours. Additionally, 10 days mean summer precipitation with a lag of 5 days. Correlation, regression and factor (principal component method) analysis were done, to evaluate the meteorological factors.
Larch chronology is about 230 year length, 32 years were found in the 20th century. A 100 years spruce chronology was built, 34 light-ring years were identified.
Both species have high negative correlation coefficients with maximal June and August temperatures.
Minimal and mean June and August temperatures are characterized lower, but also significant negative correlation coefficients. Extra, significant negative correlations with June and August sunshine duration were revealed and a positive correlation with precipitation of the 1st August decade. Linear multiple regression model has significant coefficients only for June and August temperature and precipitation of the 1st August decade. The derived regression equations describe up to 60% of the variability of light ring chronologies (spruce $r^2 = 0.36$ and larch $r2 = 0.32$). The June and August sunshine duration, which characterize by significant correlation coefficients, slightly improves the proposed model. The factor analysis results have shown that the 1st factor (41% explained variance) is composed from the maximum June and August temperature, and the precipitation of the 1st August decade is the 2nd factor (27% variance).
Reconstruction of c climatic parameters using light rings chronologies derived from trees growing on the Polar Urals is difficult, due to multiple factors of the light-ring formations. Possible to reconstruct maximum temperature of extremely short growing seasons. Another possibility is to offer a hydrothermal coefficient describing conditions of the beginning and the end of growing seasons.

Poster

## Climatic and environmental changes in the Barents Sea during the last 2ka: Response to variations in the Atlantic water inflow and NAO index

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The Barents Sea is located on the trajectory of the warm and saline Atlantic water and NAO-related cyclones to the Arctic. Therefore, recent environmental changes in the basin are likely controlled by the modes of NAO variations. Abundant microfossils in the sediment cores from several fjords and deeps permit to reconstruct ocean conditions during the last 2 ka and to compare them with the available records of the NAO index and AMOC

variability. Herein we present the new benthic and planktic oxygen isotopes, microfossil and IRD data from the AMS-$^{14}$C dated sediment cores encompassing the last 2 ka from the Kvitøya-Erik Eriksen and Franz Victoria troughs in the northern part of the Barents Sea. The results led to revisit our previously published data on the Ingøydjupet Depression from the south-western Barents Sea and the Russkaya Gavan' Fjord, Novaya Zemlya. The water column in the northern troughs is characterized by Arctic water at the surface, Atlantic water at depth of about 100-200 m and strongly transformed local water below. The Ingøydjupet Depression is located on the major route of the North Cape Current flowing eastward into the Barents Sea. Atlantic water fills the water column from ~ 30 to 400 m. The sediment core from the 170-m deep Russkaya Gavan' Fjord documents changes in the Shokal'sky glacier meltwater load mainly depending on the cyclone-related winter precipitation.
In the Franz Victoria Trough, a strong stratification that characterized the water column during the Dark Ages gradually weakened during the Medieval Warming Period (MWP) while the temperature increased in the subsurface layer and particularly in the bottom-water layer. During the Little Ice Age (LIA) vertical mixing became more vigorous likely due to the decreased Atlantic water input into the trough, surface-water cooling and winter brines formation. Similarly, a weakening of the stratification during the LIA is suggested from the small benthic-planktic oxygen isotope gradients of the Kvitøya-Erik Eriksen core.
In the Ingøydjupet Depression, higher percent of benthic species Cassidulina teretis and low benthic-planktic oxygen isotope gradients during the MWP indicate increased Atlantic water input. The LIA is characterized by a subsurface water cooling from 12 to 9°C inferred from the planktic foraminiferal assemblages, raised oxygen isotope gradients and low abundance of C. teretis suggesting a reduced Atlantic water input.
The data from the Russkaya Gavan' Fjord document an abrupt two-fold increase in mass accumulation rates (MAR) of the bulk sediments and organic matter at the MWP/LIA boundary. Abundant microfossils indicate high bioproductivity. These findings are consistent with the increase in marine salt ions concentration in the GISP2 ice core during the early LIA, at about 1400 AD, pointing to strengthening of the Icelandic Low (Meeker and Mayewski, 2002) and corresponding increase in frequency of the winter cyclones. The dramatic decrease in MAR and microfossil abundance at ca. 1600 AD also corresponds to the switch from positive to generally negative winter NAO index which is demonstrated by the record of Trouet et al. (2009).

Poster

## $\delta^{13}$C and $\delta^{15}$N in Soledad Basin and Magdalena Margin of Baja California, Mexico for the last 2 ky

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The elemental ratio C/N have been used to estimate to global ocean like a $CO_2$ sink. The composition of sedimentary organic matter generates knowledge about carbon global cycle study. The southern of California current system have a intense costal upwelling this promotes a high primary productivity and a great amount of organic matter is settle. High oxygen consumption for the oxidation of organic matter generated by productivity, exceeding the oxygen supply, creates an oxygen minimum zone. This condition helps to conserve the organic matter exported, wich can be used to infer changes in productivity. In this study we used ratio C/N and stable isotope of carbon and nitrogen to estimate the source, composition and flux of organic matter from southern of California current for the last 2 ky. A multicore were collected of oxygen minimum zone of Soledad Basin and Magdalena margin, Mexico. The desnitrification showed the same variability on Medieval Warm Optimum (1.3 to 0.8 ky) for both sites but the level of desnitrification increased more rapidly in Magdalena margin during the Little Ice Age (1.7 to 1.4 ky) this suggest and increment on primary productivity and consequently a depletion of oxygen. The oceanographic characteristics for this area suggest that the primary source of organic matter was of marine origin.

Poster

## Paleorainfall variations in Southern India during the past 3154 years: Evidence from Pookot Lake record

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There are apprehensions about changing climate, particularly against the backdrop of global warming and extreme climatic events reported from many parts of the world. As India's agriculture and economy are strongly dependent on the summer monsoon, it is imperative to generate high-resolution paleorainfall records during the Late Holocene. Environmental magnetic analysis of two AMS C-14 dated sediment cores from Pookot Lake (Wayanad district, Kerala, Southern India), provide a continuous high-resolution record of monsoon for the past 3154 years. A range of magnetic parameters (Xlf, Xfd, Xarm, IRMs at different fields) were determined and interparametric ratios were calculated. A positive correlation was documented between magnetic parameters and Vythiri Station (near to the lake) rainfall data. There were significant variations in rainfall with periods of higher rainfall indicated by high magnetic susceptibility (Xlf) values and vice versa. The periods ~ 3154-2435, ~ 2189-2143, ~ 1486-1406, ~ 1069-715 and ~ 647-559 cal. years B.P. are characterized by relatively high rainfall whereas during the periods ~ 2435-2189, ~ 2143-1486, ~ 1406-1069, ~ 715-647 and ~ 559-350 cal.

years B.P. rainfall was relatively low. From 350 to 200 cal. years B.P., rainfall exhibited an increasing trend. From 200 cal. years B.P. to the present, it was steady albeit with high-amplitude fluctuations. It appears that monsoonal rainfall in the region is influenced by the Sun, with periods of higher sunspot activity and Total Solar Irradiance characterized by higher rainfall (= high XIf) and vice versa. On a longer time scale, insolation also seems to have had an influence on rainfall, with periods of high insolation typified by high rainfall (= high XIf) and vice versa. The rainfall in the region exhibits periodicities of 469 years, 209-134 years, 14.3 years, 10 years, 8.5 years, 8.1 years, 7.8 years, 21.6 years, 17.1 years and 11.5-11.9 years, many of which have a solar origin. This was substantiated by cross spectral analysis between XIf and Group sunspot numbers, annual sunspot numbers as well as reconstructed sunspot numbers. High coherencies are obtained for many of the afore-mentioned periods which are attributed to solar origin. The Pookot Lake XIf record has faithfully recorded the global climatic events like the Little Ice Age (LIA) and the Medieval Warm Period (MWP). Rainfall was relatively low during LIA (559-350 cal. years B.P.) and relatively high during MWP (1069-715 cal. years B.P.). This was further substantiated by wavelet analysis of the XIf data. But it was not consistently high during the entire span of MWP. LIA appears to have been short-lived in the region and its termination could have been anywhere in the range of 350-200 cal. years B.P. as rainfall exhibits an increasing trend during this period. The Pookot Lake XIf record exhibits similarities with other continental and marine palaeoclimatic records in the region.

Talk

## Data and model perspectives on the Indian Ocean Zonal Mode over the past millennium

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The Indian Ocean Zonal Mode (IOZM) is a coupled oceanic-atmospheric phenomenon that strongly impacts precipitation patterns in the Indian Ocean region. On interannual timescales, modern observations have linked the IOZM with variations in the Indian, Asian, and Australasian monsoons and with the El Niño Southern Oscillation (ENSO), although exact mechanisms remain unclear. On multi-decadal to orbital timescales, an "IOZM-like" pattern has often been invoked to explain spatial patterns in precipitation in East Africa, Indonesia, Australia, and India. However, the relevance of an IOZM-like mode to regional rainfall during the past millennium has yet to be confirmed from high-resolution proxy records, and the mechanisms linking the IOZM to monsoon and ENSO-like variations on paleoclimate timescales remain elusive.
The $\delta D$ and $\delta^{18}O$ of precipitation in East Africa and Indonesia have been shown to reflect the IOZM and other regional convective processes, suggesting that continental proxy reconstructions using stable H and O isotopes may track the IOZM. In this study, we assess the role of the IOZM in rainfall variations in the Indian Ocean region over the past millennium using (1) a synthesis of 1-2 kyr continental proxy reconstructions from East Africa and western Indonesia, and (2) an isotope-enabled atmospheric general circulation model experiment from 1870-2003 by the Stable Water Isotope INtercomparison Group (SWING). We present recent reconstructions from lake sediments based on the $\delta D$ of terrestrial plant wax compounds, which reflects the $\delta D$ of precipitation. Our data reveal an intensification of the Australasian monsoon over the past millennium, bringing progressively wetter conditions and D-depleted waxes to western Indonesia starting around 950 C.E. while overall wet conditions persisted in easternmost East Africa until the end of the 19th century. Superimposed on these long-term trends are a series of pronounced, multi-decadal to centennial scale isotopic excursions that appear zonally asymmetric and possibly "IOZM-like." The zonal asymmetry is most pronounced beginning around 1400 C.E., with the onset of Little Ice Age cool conditions recorded in sea surface temperature (SST) reconstructions from the Northern Hemisphere and the Indo-Pacific Warm Pool (IPWP). We interpret these results in light of the SWING experiment and of 20th century precipitation observations. We find that significant multi-decadal isotopic variability is associated with the IOZM in both East Africa and Indonesia; however, this relationship is non-stationary. Multi-decadal periods of weaker and stronger correlation between the IOZM and isotopes of precipitation are coherent across both sides of the Indian Ocean, suggesting that another process, possibly ENSO or connections to local and remote SSTs, may modulate the strength of the relationships between the IOZM, precipitation, and precipitation isotopes. We investigate potential mechanisms for these variations and use these findings to assess whether an IOZM-like mode may have been present during the Little Ice Age or other periods during the past millennium, and discuss the implications of our results for reconstructions and simulations of past and future climate.

Poster

## Unraveling the mysteries of chrysophyte resting stages – distribution of chrysophyte cysts in Finland

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Chrysophytes (classes Chrysophyceae, Synurophyceae) often dominate in the phytoplankton of oligotrophic alpine, arctic and subarctic lakes. All chrysophyte species produce siliceous resting stages (stomatocysts, statospores, cysts) as part of their life-cycle. Cysts ensure the survival of the chrysophyte population under unfavorable conditions. Chrysophyte cysts are considered to be good paleolimnological indicators because they are abundant and diverse in most Northern lakes and they preserve well in the sediment. Many chrysophyte taxa have fairly well defined environmental

optima and tolerances and they can therefore be used in paleoecological studies even with the cyst producing species name unknown. Chrysophytes distinct seasonality makes them suitable for creating seasonal inference models. Surface sediment calibration sets (training sets) for chrysophyte cysts have been developed for example in Central Europe and Canada but for the time being there is no reliable data about the cyst assemblages in Finland or Fennoscandia. Elsewhere chrysophyte cysts have been successfully linked with for example spring temperatures, pH and salinity.
The ultimate aim of this project is to create a temperature/length of ice-cover -transfer function for chrysophyte cysts in Finland in order to reconstruct past temperatures and ice cover times. Surface sediment samples were collected between 2007 and 2008 from 62 lakes around Finland. These lakes cover different types of catchment areas from the northern barren treeless tundra to boreal forest and rural areas in the south and span a large temperature gradient with mean July air temperature of 17.1°C in the south to 8.0°C in the north. So far over 13000 Scanning Electron Microscope (SEM) images have been taken and 180 taxa identified. However, almost half of the counted ca. 200 cysts/lake are still unidentified so the results of the multivariate analysis are relatively preliminary. A computer-aided SEM-analysis of Finnish chrysophyte cysts is being developed to classify the remaining unclassified cysts. Here, however, I'm going to present the preliminary results of the impact of several measured environmental variables on the distribution of chrysophyte cysts. Multivariate analysis results indicate that the most important factors affecting chrysophyte cyst assemblages in Finland are pH and altitude/air temperature. Hopefully further analysis will shed new light on how the cysts are linked to seasonal, mainly spring, temperatures. Since most paleobioindicators are linked with summer mean temperatures, chrysophyte cysts might create a more complete picture of the effects of climatic events during different seasons especially winter and spring. This new transfer function will be used to study the climatic history of annually laminated Lake Nautajärvi. The lake's responses to climatic forcing is expected to be seen in form of changes in the composition and diversity of chrysophyte species assemblages. This varved lake is an ideal paleoenvironmental archive due to its seasonal resolution and is being studied for its geophysical, geochemical and several different biological proxies.
As no previous cysts studies in this scale have been conducted in Finland thus far, this study also brings new information about the geographical distribution of different cyst morphotypes in Finland. The sediment material also contains several new previously undescribed cyst morphotypes.

Poster

## Climatic Fluctuations in the last ~2,000 years from Garhwal Himalaya (India) by using multi-proxy analyses

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Abstract: Our recent research on a 2.65m long lake sediment core from Badanital (Garhwal Himalaya) by using multi-proxy analyses reveals the high resolution climatic records in the last ~2,500 years. The major events during this period, e.g. Medieval Warming Period (MWP), Little Ice Age (LIA) and Modern warming have been captured. The proxies used were mineral magnetism, clay mineralogy, geochemical parameters and pollen analysis. The core is composed of almost homogeneous and massive mud, generally rich in organic content. The chronology of the core was based on the four AMS dates (including the topmost negative date which was considered as zero for calibration). Considering the prominent characteristics of various climatic zones, the accumulation rate is estimated as 1cm/11.7 yr from 2,540 to 620 yr BP, 1cm/2.75 yr from 620 to 530 yr BP and 1cm/7.9 yr from 530 yr BP onwards. The age depth modal of the profile reveals comparatively higher accumulation rate in the middle part of the core which may be a result of excess erosion in the lake catchment, triggered by a possible tectonic activity. In and around the study area, a number of geomorphological features, e.g., steep water falls, colluvial wedges and fans, large landslide debris and location of lakes on the mountainous tops add to the possibility of neotectonic activity by which the lakes may have been formed.
Our results indicate the wetter/moist conditions from ~2,550 to 1,730 yr BP-a period characterized by enhanced concentration of the magnetic minerals, higher organic content, high CIW (chemical intensity of weathering) and CIA (chemical intensity of alteration), lowered values of C/I (Chlorite/Illite) and good representation of the broad leaved vegetation. The Phosphorus and organic contents suggest that the lake was oligotrophic during this time. However, the upper part of this climatic zone (~1,730-740 yr BP), seems to represent an arid spell which has dominance of Pinus, increased values of Chenopodiaceae pollen, lesser concentration of magnetic minerals, reduced organic matter and low chemical weathering.
For the next two centuries (e.g., between 740 to 450 yr BP), the climatic conditions show improvement and amelioration with higher CIW, magnetic susceptibility, S-ratio and other magnetic parameters in addition to high organic content. However, a weak monsoonal pattern is observed from ~450 to 240 yr BP as we notice a decreasing trend in the amount of magnetic minerals, less chemical weathering, very low organic content and shallower lake level. This long event may be ascribed to the Little Ice Age (LIA) in the Garhwal Himalaya which as a whole was wetter but punctuated by dry spells.
The Post-LIA period (from ~240 yr BP onwards) is characterized by improved concentration of magnetic minerals, higher values of the Illite, Al, P, Ca and high chemical weathering with enhancement in broad leaved elements indicating the wetter climatic conditions. However, our results may be correlated well with those areas influenced by both Indian Summer Monsoon (ISM) and Westerlies but may be conflicting to those sites which are under the sole influence of the ISM. Therefore, the role of Westerlies in the palaeoclimatic history of the Indian Himalayan seems equally important.

Poster

## Isotope composition of the deep ice core from Elbrus Western plateau (the Caucasus)

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Here we present the first results of the isotope measurements of the 182 m ice core from the Western Elbrus plateau derived in 2009 by the specialists from the Institute of Geography, Russian Academy of Sciences (Moscow, Russia). It is believed that the core archives a unique regional paleoclimatic information for the last few hundred years.
The analyses of the ice core isotopic content are being carried out in Climate and Environment Research Laboratory, Arctic and Antarctic Research Institutes (Saint Petersburg, Russia). The deuterium ($\delta D$) and oxygen 18 ($\delta^{18}O$) concentrations have shown distinct seasonal fluctuations in the upper part of the core. Snow accumulation rate according to the isotope and density profiles is 1400 mm of w. e per year. Average values of $\delta D$ and $\delta^{18}O$ are -109,05‰ and -16.02‰ correspondingly. Relationship between two isotopes is $\delta D=7,9\ \delta O18+17,5$. We have compared isotope data with the surface air temperature in Mineralnye Vody situated in 120 km from the drilling place. This parameters are in close agreement with equation for deuterium y=3,4x-133,2 (R2=0,95).

Poster

## Lake Geneva sediments as archive for past environmental changes and human activity since the last 3000 years

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Lake sediments are excellent archives of past climate and environmental changes and record regional variations as well as rapid and extreme events.
Lake Geneva (Switzerland-France), the largest peri-alpine lake, with a maximal water depth of 309 m, is part of the Rhone river system and was formed during the Pleistocene by glacial erosion. Our study focuses on the deepest part of the lake basin, where sedimentation is mainly controlled by fluviatil input from the Rhone and Dranse rivers. These two river systems are sensitive to regional climate variations in the alpine realm and to human activity that affect the discharge regime and sediment input into the lake.
In Lake Geneva, high resolution seismic reflection profiles reveal two distinct units in the late Holocene sedimentation history. The first unit (Unit 1) consists of a succession of five large lens-shaped seismic sub-units, characterized by transparent/chaotic seismic facies with irregular lower boundaries, interpreted as mass-movement deposits. These sub-units interbed with parallel, continuous and strong amplitude reflections, interpreted as the 'background' lake sediment. The second unit (Unit 2) consists of 5 m of 'background' seismic facies with parallel geometry, varying at dm scale between chaotic/transparent and continuous, high amplitude reflections, which is interpreted as alternating turbidite and hemipelagic layers, respectively. Thus, deep Lake Geneva sediment is mainly composed of hemipelagic deposits intercalating with turbidite layers, which are interpreted as floods- and mass movement-related deposits.
Four 7- to 12-m long sediment cores were retrieved with a modified Kullenberg system from the deepest part of Lake Geneva. These cored sediment intervals cover the last 3000 years period, as dated with four Radiocarbon ages of plant remains. Major element composition analysis was performed with X-ray fluorescence using an Avaatech core scanner at cm resolution. Magnetic susceptibility and density were measured by Geotek Multisensor Core Logger at 0.5 cm resolution.
The resulting sediment record can be interpreted as proxy of clastic variations of the inflowing rivers and due to climate variations, such as the Medieval Warm Period (MWP) and the Little Ice Age (LIA), punctuated by extreme events such as floods. However, these signals are certainly also overprinted by human activity during the last 3000 years, and particularly during last centuries with river regulation and dam building on the Rhone river.
This project is financed by the Swiss National Foundation project nr. 200021-121666/1.

Talk

## On the role of sea ice at the onset of the Little Ice Age

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The transition from the Medieval Climate Anomaly (MCA) to the Little Ice Age (LIA) is believed to have been driven by an interplay of external forcing and internal variability. While the global signal seems to have been dominated by solar irradiance, the understanding of mechanisms shaping the climate on continental scale is less robust. A recent reconstruction proposes that a shift from a persistent positive to a more negative North Atlantic Oscillation (NAO), orchestrated by tropical sea surface temperatures and atmospheric teleconnection, dominated the North Atlantic-European region during the transition phase. There remain doubts with this particular reconstruction and new results from models and proxies suggest an alternative mechanism in which the atmosphere is not the leading component: forced by a sequence of volcanic eruptions and decreasing solar irradiance the Arctic sea ice expands substantially at the beginning of the LIA. The excess of sea ice is exported to the northern North Atlantic where it melts, thereby

weakening convection. As a consequence, northward heat transport is reduced, reinforcing the expanded sea ice cover and the cooling of the Northern Hemisphere. Using transient "all-forcing" simulations as well as sensitivity experiments with artificial sea ice growth, we are able to show that indeed many aspects of reconstructed temperature anomalies of the MCA-LIA transition can be explained by changes in sea ice and ocean heat transport. Artificial sea ice growth experiments in coupled models are a novelty, providing the opportunity to study dynamical changes in sea ice and heat transport after a perturbation. Preliminary results of these experiments point towards the Labrador and Barents Sea being key regions in a complex feedback loop that determines much of Europe's climate during the onset of the LIA. Support for this mechanism comes from proxies of Scandinavian land temperature, glaciers, and ocean heat transport.

Poster

## Climatic signal in tree-ring width chronologies of European Russia: Spatial change and perspectives for paleoclimatic reconstructions

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European part of Russia, especially its central part, is still poorly studied in terms of dendroclimatology. In this study we analyzed the climatic response of 55 tree-ring width chronologies of living pines (*Pinus sylvestris*), spruces (*Picea abies*, *Picea obovata*) and larches (*Larix sibirica*) in European Russia. For this analysis we used two periods (AD 1950-1990 and AD 1901-1990) and 20 different meteorological parameters calculated from the following archives: daily and monthly data from more than 150 meteorological stations, CRU TS 3.0 gridded data and 20th Century Reanalysis. Also we analyzed growth response to the main teleconnection indexes (NAO, EA, EAWR, SCAND, POLAR), Palmer Drought Severity Index and CPC Soil Moisture. Mapping the results of the analyses has allowed us to identify the most important climatic parameters which influence the radial growth of conifer trees in the northern and central parts of European Russia. It is obvious that all conifers growing to the north of 60°N react positively to summer temperature (minimum, maximum, mean temperatures of the warm season and individual months). To the south, at the latitude of 54°-56° N the signal is changing and the ring width depends on the combination of two parameters – warmth and humidity (drought index PDSI, precipitation, relative humidity of vegetation season). This border coincides with the modern border of broadleaved and boreal forests. Climatic parameters that form "pointer years" were also defined for all the chronologies of living trees. Currently we are in progress of constructing and updating six long chronologies that contain samples from archaeological and architectural wood. Two of them – "Vologda region" (60°N 39°E; 1085-2009 AD) and "Solovki islands" (65°N 36°E; 1187-2008 AD) chronologies – are already suitable for paleoclimatic analysis. "Solovki islands" chronology showed the highest correlations with the reconstruction of summer temperatures for Kola Peninsula and total solar irradiance reconstruction, while "Vologda region" chronology better correlates with the reconstruction of Northern Hemisphere annual temperature. Comparison of "pointer years" in the chronologies with historical data about extreme climatic events showed that 25% of all the events fall into "pointer years", and vice versa, 33% of negative pointer years fall into historical data. All these results demonstrate good paleoclimatic potential of tree ring width chronologies in European Russia.

Poster

## Landscape (Palaeo)limnology: A multi-lake approach to understanding climate change and human disturbance in south-eastern Australia over the last 500 years

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Sediments from a range of lakes across western Victoria provide an ideal set of temporal and spatial scales to study climate change and lake ecosystems. The ability to simultaneously understand time (e.g. long-term dynamics) and space (e.g. a number of lakes with differing characteristics across a landscape) is becoming increasingly important in (palaeo)limnological studies. This is a particularly pertinent approach when realising that not all lakes respond to external (e.g. climate) forcing in a similar way. Climate change has been shown, in the broadest sense, to manifest as general trends across regions and continents. Whilst this is only really apparent in long-term studies of lake sediments, they often overlook the dynamics controlling a lake's response. Climate and land-use change are external drivers of lake dynamics; however, changes across a region produce a variety of responses in lake ecosystems. This is primarily due to the way in which different ecosystems filter these signals and alter their expression. Understanding the temporal coherence of lakes at various spatial scales provides insight into the factors influencing lake dynamics.
To further investigate the environmental factors that might be driving changes in these lake ecosystems a set of predictor (e.g. ENSO, modelled rainfall/evaporation) and response (diatom taxa) variables were analysed over the last 500 years. With known human impacts occurring across many of these ecosystems since the 1850s, this research assesses when anthropogenic impact on lake ecosystems first becomes apparent in western Victoria, and whether human impact in lake catchments has affected the recent lake-climate relationship.

Poster

## Hydrological and Climatological Changes in the Trondheimsfjord/Norway during the late Holocene inferred from Benthic Stable Isotopes and Dinocyst Assemblages

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Fjords are semi-enclosed basins surrounded by continental bedrock and are characterized by high sedimentation rates of several mm/yr. The hydrology of Norwegian fjords is linked to the North Atlantic Current (NAC) and the Norwegian Coastal Current (NCC), two major northward flowing sea surface/intermediate depth currents. The comparison of instrumental records from the Norwegian Sea and the Trondheimsfjord suggests that changes of bottom water temperature and salinity in the fjord are related to the NAC variability. Variations in primary productivity and salinity of the surface and intermediate water masses as well as the sedimentary budget in the fjord are driven to a high extent by variabilities in river input and precipitation in the hinterland. We test the use of dinocyst assemblages and stable isotope ratios of benthic foraminifera as proxies of surface/intermediate and bottom water conditions in the Trondheimsfjord, respectively. The calibration of these two proxies against modern and recent (past 60 years) hydrological conditions is based on 60 surface sediment samples that are evenly distributed in the fjord and three multi-cores recovered from locations along the fjord's axis. The chronology of the multi-cores is based on $^{210}$Pb and $^{137}$Cs measurements. Regardless of the locations of the surface sediment samples with respect to the river mouths, the modern benthic $\delta^{18}$O ratios and dinocyst assemblages show continuous gradients from the fjord's entrance toward the innermost basin. Our multi-core time series suggest that the relative influence of the bottom water temperature and salinity on the oxygen isotope signature varies according to the distance of the core location to the fjord entrance and stratification patterns. The dinocyst assemblages clearly record changes of the surface water characteristics and nutrient delivery due to river input. Since the benthic $\delta^{13}$C ratios across the fjord vary according to the fjord's topography and the associated changes in flow speed of bottom waters (winnowing effect), we assume that temporal variations in the carbon isotope ratios at a given location are mainly recording changes in the flux of marine organic matter at the water-sediment interface as well as variable inputs of terrigenous organic matter through rivers. We use this information to reconstruct the paleohydrology and paleoenvironmental conditions in the Trondheimsfjord from a piston-core which covers the last 3175 years. This late Holocene record shows an abrupt shift from lighter to heavier $\delta^{18}$O ratios at 1200 years BP and high amplitude variations from 1000 to 2100 cal. yr BP. This variability is discussed in view of other evidences for changes in surface water physico-chemical and productivity changes as indicated by the down-core distribution of benthic $\delta^{13}$C ratios and dinocyst assemblages.

Poster

## A 576-year annual minimum temperature history for the source region of the Yangtze River

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Abstract: The Yangtze River is critical for the ecosystem around southern China. However, the source region of the river is experiencing ever-faster glacial retreat and land deterioration as a result of climate change. Hence, knowledge of the past climate variability in the region is urgently needed. Here we developed nearly a six-century long annual minimum temperature history based on a regional tree-ring width chronology of Juniperus tibetica Kom. at the high elevation sites of Yushu region, southern Qinghai Plateau. Correlation and response analysis indicated that prior year annual (January-December) minimum temperature was most responsible for the juniper radial growth in the study region. Tree growth-climate model accounted for 41.7% of the variance in actual temperature during their common period AD 1957-2010. Regional warm periods occurred during AD 1488-1513, 1516-1569, 1609-1625, 1723-1734, 1755-1817, 1828-1866, 1933-1950, 1984-1995 and 2001-2010, whereas cold intervals were identified during AD 1441-1487, 1570-1608, 1634-1676, 1686-1703, 1738-1754, 1873-1884, 1889-1900, 1911-1932 and 1951-1983, respectively. The low-frequency variability agreed well with other temperature reconstructions around the study region, suggesting that our reconstructed temperature was reliable and could be used in the evaluation of regional climate variability. This study gives a new perspective of the recent warming trend on a longer time scale context.

Poster

## 2k ice core records from the Weddell Sea region of Antarctica

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Joint UK-French drilling teams have recovered three ice cores to bedrock in the Weddell Sea region in recent years. Each of the ice cores spans the period from the last glacial to the present, and have high resolution climate records derived from the stable water isotopes measured along the cores. The cores were retrieved from sites around the Weddell Sea and Ronne Ice Shelf: James Ross Island to the north-west; Fletcher Promontory to the south west; Berkner Island to the south. Here I look at the regional climate of the past 2,000 years in detail, comparing between the sites, and contrasting with two cores spanning the same period from Dronning Maud Land, and assess any evidence for Antarctic analogues of the 'Little Ice Age' and 'Medieval Warm Periods'.

Poster

## Late Quaternary paleoceanography of the southwestern Indian Ocean

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Temporal variation in planktic foraminiferal abundance, stable isotopic ratio ($\delta^{18}O$) and trace metal ratio (Mg/Ca) of Globigerina bulloides have been used to infer Late Quaternary history of the southwestern Indian Ocean around Agulhas Retroflection Current. The high relative abundance of G. bulloides during marine isotopic stages 4 and 3, as compared to the early Holocene, is interpreted as the time of increased availability of nutrients as a result of enhanced upwelling. The seawater temperature as estimated from Mg/Ca composition of G. bulloides during this time interval was warmer than MIS 2 and comparable with early Holocene. The $\delta^{18}O$ G. bulloides during MIS5 through 3 was depleted than that during early Holocene, suggesting saltier condition during the last glacial period. The presence of warm and saltier water at the core site during the glacial period suggests increased transport of warm water by the Agulhas Retroflection Current. Just prior to last glacial maximum, a sharp increase in G. bulloides abundance coupled with equally significant increase in the relative abundance of warm water indicator Neogloboquadrina pachyderma dextral, suggests warm waters with high amount of nutrients. This increase in N. pachyderma dextral abundance is, however, not supported by G. bulloides Mg/Ca, suggesting that the warming was more pronounced in and most likely confined to the sub-surface waters, confirming the model studies wherein it is found that the non-breaking surface wave–induced mixing in the Southern Ocean can reduce sea surface temperature and increase subsurface temperature of the upper ocean. The last glacial maximum is marked by a significant drop in G. bulloides abundance, indicating decreased nutrient availability. The lowest Mg/Ca G. bulloides seawater temperature (6.5°C) during MIS 2 (at 21.2 kyr BP) was ~3°C cooler than that during the average early Holocene Mg/Ca SST (9.4 °C). The lowest LGM Mg/Ca SST, however, was ~8 °C lower than the average spring SST near the core-site, suggesting northward shift of subtropical front.

Talk

## Temperature and moisture variability across Africa during the last 2000 years

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A growing number of proxy, archaeological, historical and instrumental data sets are now available from continental Africa through which palaeoclimatic variability during the last 2000 years can be assessed. This paper, co-authored by members of the PAGES Africa2k Working Group, synthesises published material to produce a record of variations in temperature and available moisture for Africa as a whole during the Medieval Climate Anomaly (MCA), Little Ice Age (LIA) and the late 19th to early 21st centuries. Very few records are available through which to assess palaeotemperature variability. Warmer conditions during the MCA are evident at Lake Tanganyika, the Ethiopian Highlands and records from Cango Cave, Kuiseb River and Wonderkrater in southern Africa. Other records covering the MCA give ambiguous signals. Warming appears to have been greater during the early MCA in parts of southern Africa and later MCA in Namibia, Ethiopia and at Lake Tanganyika. LIA cooling is evident in Ethiopian and southern African pollen records and the Lake Malawi record, but there appears to have been limited temperature depression at Lake Tanganyika. A warming trend in mean annual temperatures is clearly evident from historical and instrumental data covering the late 19th to early 21st centuries.

The majority of African palaeoclimatic reconstructions focus upon moisture variability. Available high resolution records indicate that conditions during the MCA were far from uniform. However, some generalisations can be made. The MCA appears to have been wetter than today across the Sahel with humid conditions probably extending at least as far east as northern Chad. Regions immediately south were relatively arid, with a major low stand recorded at Lake Bosumtwi. Equatorial East Africa was also relatively dry, with reduced moisture availability evident from many lake records as far south as Lake Malawi. The general indication from southern Africa is of a wetter MCA. The climatic variability evident within high resolution records, together with an apparent antiphase relationship between some southern and equatorial African records, is discussed.

Few high resolution palaeomoisture records exist for the LIA. The record from Spitzkoppe in southern Africa indicates a short arid early LIA from AD 1450-1650. A similar pattern is observed at Lake Bosumtwi and Lake Naivasha, but not Lake Edward, which remained dry until AD 1750. At Lake Bosumtwi, Lake Naivasha and Spitzkoppe, the period from AD 1600-1700 is marked by a rapid shift toward wetter conditions. Drought conditions are evident between AD 1700-1725 at Lake Bosumtwi, Lake Naivasha and Lake Edward, but are less apparent at Spitzkoppe. All of these records indicate a period of relative aridity from ~AD 1800-1875.

Records from the last 200 years are remarkably similar across inter-tropical Africa. At Lake Bosumtwi, Lake Edward, Lake Naivasha and Spitzkoppe, the period of relative aridity from ~AD 1800-1875 is followed by wetter conditions from ~AD 1880-1930, a general drought from

~AD 1930-1950, and relatively humid conditions from ~AD 1950-1970. These broad patterns are backed up by annually resolved historical records and gauge data, suggestive of a pan-African response to a common forcing mechanism.

Talk

## Simulated and reconstructed Atlantic gyre circulation and its relationship with the North Atlantic Oscillation during the past 600 years

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Instrumental records, paleo data and climate modelling show that multidecadal variability is a dominant feature of North Atlantic climate variations in the recent past. In particular the dynamics of the North Atlantic subpolar gyre circulation and its interaction with the subtropical gyre circulation play a key role in controlling the water mass properties of the northward flowing Atlantic water. The Atlantic subpolar region has also been identified as a major hot spot in terms of potential decadal predictability. The governing mechanisms for longer-term variations in the Atlantic ocean gyre circulation are, however, not fully understood. In this study we use a long historical model simulation with the Bergen Climate Model for the last 600 years and new unique high-resolution reconstructions of northward flowing Atlantic water mass properties. The objective is to examine the potential relationship between Atlantic ocean circulation changes and large-scale atmospheric circulation patterns during recent centuries. In particular we will utilize proxy records from a core sitting just beneath at the inflowing warm Norwegian Atlantic Current. We hypothesize that $d^{13}C$ measurements of the spring-dwelling planktic foraminifer, G. bulloides, can be used as a tracer of water masses with more Atlantic subtropical origin. A model – proxy data comparison suggests a strong link between the reconstructed water mass properties in the Nordic Seas and the simulated Intergyre Gyre (IGG) circulation in the North Atlantic. When the IGG is strong in the model there is a northward extension of the subtropical gyre and warmer and more saline waters are advected into the Nordic Seas with a few years lag. The IGG is in turn strongly linked to the North Atlantic Oscillation, but with potential important interaction with the large-scale meridional overturning circulation. If the strong similarities between the Nordic Seas reconstruction and the simulated IGG reflect real changes in nature it would imply that natural forcings have been a major player in terms of decadal to multidecadal variations in Atlantic ocean circulation during the recent three centuries.

Poster

## Pluvials, Droughts, Energetics, and the Mongol Empire

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The success of the Mongol Empire, the largest contiguous land empire the world has ever known, is a historical enigma. At its peak in the late 13th century, the empire influenced areas from the Hungary to southern Asia and Persia. Powered by domesticated herbivores, the Mongol Empire grew at the expense of agriculturalists in Eastern Europe, Persia, and China. What environmental factors contributed to the rise of the Mongols? What factors influenced the disintegration of the empire by 1300 CE? Until now, little high resolution environmental data have been available to address these questions.

We use tree-ring records of past temperature and water to illuminate the role of energy and water in the evolution of the Mongol Empire. The study of energetics has long been applied to biological and ecological systems but has only recently become a theme in understanding modern coupled natural and human systems. Because water and energy are tightly linked in human and natural systems, studying their synergies and interactions make it possible to integrate knowledge across disciplines and human history, yielding important lessons for modern societies. We focus on the role of energy and water in the trajectory of an empire, including its rise, development, and demise. Our research is focused on the Orkhon Valley, seat of the Mongol Empire, where recent paleoenvironmental and archeological discoveries allow high-resolution reconstructions of past human and environmental conditions for the first time.

Our very preliminary tree-ring record of hydroclimate, from 980-2009 CE, indicates that the period 1207-1234 CE, the height of Chinggis Khaan's reign (aka Ghengis Khan), is one of the longest pluvials with the greatest departure from the long-term mean. Inferred temperature from a nearby millennium-long record from a subalpine forest indicates warm temperatures beginning in the early 1200's and ending with a plunge into cold temperatures in 1260. Abrupt cooling in central Mongolia at this time is consistent with a well-documented volcanic eruption that caused massive crop damage and famine throughout much of Europe. In Mongol history, this abrupt cooling also coincides with the move of the capital from Central Mongolia (Kharkhorin, aka Karakorum) to China (Beijing). In combination, these tree-ring records of water and temperature suggest that 1) the rise of the Mongol Empire occurred during an unusually prolonged period warm and wet climate and 2) the disintegration of the Empire occurred following a plunge into cold and drier conditions in Central Mongolia.

These results represent the first step of a larger project integrating physical science and history to understand the role of energy in the evolution of the Mongol Empire. Our next immediate step is to process samples collected in Summer 2012 to increase the replication of the preliminary record of hydroclimate prior to ca 1400 CE and

potentially add a second millennial-length record from the same site using a different tree species. In the future we will use data from historic documents, ecological modeling, tree rings, and sediment cores to investigate whether the expansion and contraction of the empire was related to moisture and temperature availability and thus, grassland productivity associated with climate change in the Orkhon Valley.

Talk

## Solar and volcanic forcing of the Southern Hemisphere climate over the past 1500 years

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The past 1500 years provides a valuable opportunity to study the role of external forcings in driving the global climate. Significant changes have taken place within the climate system over this period, and proxy data that records these changes covers a wide geographical area and has high temporal resolution. Natural and anthropogenic forcings are also reasonably well constrained. While previous detection and attribution studies have found a significant role of volcanic eruptions in driving the pre-industrial Northern Hemisphere climate, the drivers of the Southern Hemisphere climate are much less well understood.
Here, the CSIRO Mk3L climate system model is used to simulate the global climate of the past 1500 years. Different combinations of natural and anthropogenic forcings are applied, including changes in the Earth's orbital parameters, solar irradiance, volcanic emissions and anthropogenic greenhouse gases. The simulations are then compared with a multi-proxy reconstruction of Southern Hemisphere temperature. We find strong solar and volcanic influences on the Southern Hemisphere climate during the pre-industrial period, with the anthropogenic signal becoming increasingly dominant after 1850 CE. However, the results are sensitive to the specific reconstructions of solar and volcanic activity that are used to drive the model. The choice of volcanic reconstruction is particularly critical, and we find that the dating of major eruptions can impact significantly upon the agreement between the model and the proxy record. If we are to learn all that we can from the climate of recent millennia, a critical challenge is therefore to develop better reconstructions of past climatic forcings – particularly volcanic eruptions.

Poster

## Was the Medieval Warm Period Global? Evidences from the Gulf of Kachchh Coast, Western India

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Palaeoclimatic variability during the Late Holocene is still unclear and warrants an urgent attention of palaeoclimatologists. The period spanning the last 2 kyr is of vital importance, as it covers several abrupt changes in climatic systems in both hemispheres. There have been several studies pointing out the links between the North Atlantic and Indian Ocean climatic variability during the Holocene. Other factors which affect the climatic systems, namely solar forcing have also been documented for the past couple of millennia. However, efforts are under way to better understand the signatures of these recent events, factors affecting them, and proxy response to this climatic variability in different archives. With a hypothesis that the mudflats of Gulf of Kachchh (western India) can be used as potential high resolution archives for palaeoclimatic changes, we have studied a 2m sequence spanning between 1350 AD and 300 AD. We have employed geochemical, as well as magnetic parameters, which serve as direct proxies for changes in climate dynamics. Chronology has been ascertained using AMS $^{14}$C dating of bivalve shells. The variations in concentration of Al2O3, TiO2 coupled with Cr, Zr, Rb, Sr among others are primary indicators for changes in precipitation regime (i.e. monsoonal dynamics). Similarly magnetic parameters i.e., magnetic susceptibility, S-ratio and IRM, also provide robust information about changes in monsoonal system. Here we present evidence for enhanced precipitation during 750 AD – 1250 AD, which coincides with the medieval warm period (?) as reported in Greenland ice cores. All geochemical parameters representative of detrital flux show enhanced precipitation during this time period, whereas period from 750 AD to 625 AD shows relative weakening of climatic system reflected in terms of reduced flux of sediments (Cold Dark Age?). The bottommost part of sequence spanning from 315 AD to 625 AD shows again increased flux of detrital sediments (Late Roman Warm Period?). Owing to the robustness of our proxies and taking into account our chronological uncertainties the data support that these historical events are being recorded globally.

Poster

## Correlation between pollen spectra and vegetation of southwestern Madhya Pradesh, India

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We analysed pollen spectra constructed after the pollen analysis of 12 surface samples, collected 2 each from northern, southern, eastern and western flanks of Amjhera Swamp as well as 4 from the mixed tropical deciduous forests dominated by teak (Tectona grandis) in Hoshangabad District, southwestern Madhya Pradesh, India, to provide information on modern pollen rain in the area of investigation. The pollen assemblage demonstrates the dominance of arboreals (trees and shrubs) over the non-arboreals (herbs). Among the tree taxa, Madhuca indica is constantly represented in most of the samples which could be attributed to the good preservation of its pollen in the sediments coupled with its high pollen dispersal efficiency. Terminalia is also retrieved steadily. Besides, Adina cordifolia, Mitragyna parvifolia, Schleichera oleosa and Emblica officinalis are present in good number, but only in a few samples. Syzygium, Maytenus, Lagerstroemia, Lannea coromandelica, etc. are also intermittently recovered in almost all the samples, but in varying frequencies despite their frequent presence in the forest. This erratic display of all these taxa could be inferred to their low pollen productivity, since majority of the tropical trees portray a strong tendency of entomophily. Differential pollen production as well as microbial degradation of their pollen in the sediments cannot also be denied. The relatively meager representation of grasses, sedges, Malvaceae, Xanthium except. Tubuliflorae and culture pollen taxa such as Cheno/Am, Caryophyllaceae, Brassicaceae and Cannabis sativa are suggestive of poor herbaceous cover around the swamp and also in mixed tropical deciduous forest. However, the record of Cerealia and other culture pollen taxa stamps the proximity of cultivated land and human habitation in and around the investigation site. The abundance of trilete fern spore as well as Ceratopteris, monolete fern spore and trilete with perine, though in relatively low values envisages their origin from the local sources as ferns and their allies prefer damp and shaded situations for their profuse growth. This comparative data base on the modern pollen rain/vegetation relationships will serve as modern analogue for the proper delineation of different seral stages of vegetation of the study area and coeval change in climate during the Late Quaternary Period.

Poster

## Dust, sea salt and moisture source variability in central Draonning Maud Land, East Antarctica during the last millennium: Role of Southern Annular Mode and El-Niño-Southern Oscillation

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Southern Annular Mode (SAM) and the El Nino Southern Oscillation (ENSO) have been recognized as the primary drivers of climate variability in the Southern Hemisphere at interannual to decadal timescales. However, a critical requirement underlying the study of temporal variability of SAM and ENSO is the availability of highly resolved proxy records that go beyond the instrumental records. In this regard, Antarctic ice cores are excellent natural archive which provides high resolution, continuous records comparable to instrumental records and go beyond the instrumental records. In this study, an effort has been made to understand the role of SAM and ENSO in modulating Antarctic climate variability as a consequence of SAM-ENSO influence through the high resolution proxy records of sodium ($ssNa^{+}$ flux, a proxy for sea salt), calcium ($nss\text{-}Ca^{+2}$ flux, a proxy for dust) together with deuterium excess $d=\delta D-8*\delta^{18O}$ as a proxy for tracing variations in regional moisture sources, fluxes and transport pathways available from two ice cores IND-22/B4 and IND-25/B5 collected from central Draonning Maud Land (cDML), East Antarctica. The chronology established in this study for IND-22/B4 and IND-25/B5 core represent depositional history from ~1500 to 2000 and ~1900 to 2005 AD. In the present study, d-excess varied from –1.6 to 17.3‰ with an average value 8.0±4.5‰ in IND-22/B4 and –1.0 to 10.6‰ with an average value 4.3±3.8‰ in IND-25/B5 core; average value of d-excess in IND-22/B4 is double of IND-25/B5 core. The annual fluxes of $ssNa^{+}$ and $nss\text{-}Ca^{+2}$ have been estimated for the IND-25/B5 core based on their annual average concentration and accumulation rate. The annual fluxes of $nss\text{-}Ca^{2+}$ and $ssNa^{+}$ are highly variable; ranges from 6.3-118.7_$10^{3}$ μg $m^{-2}$ $a^{-1}$ with mean (26.3±17.4)_$10^{3}$ μg $m^{-2}$ $a^{-1}$ and (5.1-54.8)_$10^{3}$ μg $m^{-2}$ $a^{-1}$ with mean (21.2±11.2)_$10^{3}$ μg $m^{-2}$ $a^{-1}$ respectively. The d-excess profile in IND-25/B5 core shows dramatic shift during ~1940 and ~1980; the average value of d-excess~7‰ during 1905-1940 reduces to ~3‰ during 1940-1980. The $nss\text{-}Ca^{2+}$ and $ssNa^{+}$ fluxes also show significant increase during 1940-1980 which is consistent with the dramatic shift of d-excess. Such abrupt change in d-excess indicates reorganization of atmospheric circulation and changes in evaporation conditions in source regions. The higher values of $nss\text{-}Ca^{2+}$ and $ssNa^{+}$ fluxes during 1940-1980 indicate increase in sea ice production and dust flux respectively in cDML region. The increase in dust flux could be linked to the efficient transfer of dust from Patagonia, a potential region of dust source corroborated by backward wind trajectory analysis. The overall trend of d-excess is inversely proportional to SAM where as the $nss\text{-}Ca^{2+}$ and $ssNa^{+}$ trend are linearly proportional to SAM; dramatic shift of d-excess and large increase in ssNa and nss-Ca fluxes during 1940-1980 coincides with the negative shift of SAM. Therefore, the large variation in d-excess, $ssNa^{+}$ and $nss\text{-}Ca^{2+}$ is expected to be consequence of shifting moisture source regions, change in environmental conditions and atmospheric circulation during the periods of stronger ENSO and SAM teleconnections.

Poster

## Marine records of environmental change in the NE Atlantic (west coast of the Iberian Peninsula) over the past 150 years – a dinoflagellate cyst perspective

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The west coast of the Iberian Peninsula is part of the Canary upwelling system, one of the most productive marine areas worldwide. Here, wind-driven transport of nutrients from depth to the photic zone contributes largely to phytoplankton growth. Upwelling leads to mixing and nutrient-enrichment, favouring diatom blooms, while dinoflagellate blooms are typically restricted to warmer and more stratified waters, associated with upwelling-relaxation and other stratification-inducing processes.
We have studied the sedimentary record of dinoflagellate cysts from three areas along the west coast of the Iberian Peninsula. The aim of this study was to reconstruct past environmental changes and evaluate the relative contribution of climate variability and human impact in this area, which is influenced by both river input and coastal upwelling.
A major shift in the cyst assemblages was recorded off the Douro and Lis rivers after the 1940's. This shift included a marked increase in total cyst concentrations and Lingulodinium machaerophorum (accompanied by an increase in Operculodinium centrocarpum), previously proposed to indicate cultural eutrophication. However, this community change is also concomitant with a large excursion of the North Atlantic Oscillation (NAO) towards negative indices, unique in the context of the past ca. 150 years, which, among other effects, is related to increased river runoff. Contrary to the cyst signal registered in the two cores collected from the NW sector of the west Iberian shelf, the southernmost record shows an increase in Protoperidinioid cysts possibly related to an intensification of the upwelling.
This study indicates that the observed changes in the cyst-forming dinoflagellate community off west Iberia have been driven by regional climate variability, which exerts a large influence in water stability and nutrient availability by modulating river flow and upwelling in the area.

Poster

## Reconstructing the past millennium of hydrologic variability in the Western Tropical Pacific using the hydrogen isotopes of lipid biomarkers

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Global changes in precipitation patterns are potentially one of the most important impacts in a warming climate. Understanding the changes in spatial and temporal patterns of natural hydrologic variability over the past millennium is imperative to making accurate predictions of future changes in hydroclimate. In this study we present a proxy reconstruction of rainfall variability over the past millennium from a marine lake in Palau. Palau is located in the Western Pacific Warm Pool, which is a primary source of heat and moisture to the extratropics. Past changes in Palau's hydroclimate may indicate fundamental changes in El Niño-Southern Oscillation or shifts in the mean position of the Intertropical Convergence Zone. We use the novel proxy technique of compound-specific hydrogen isotope analysis to reconstruct rainfall in this study. This approach is based on the fact that the hydrogen isotopic ratio ($\delta$D) of membrane lipids of aquatic algae reflects the $\delta$D of lake surface water. The $\delta$D of the lake surface water, in turn, varies as a function of the amount of rainfall. We observe several large (ca. 40‰) shifts in the $\delta$D of dinosterol in Palau over the course of the past millennium. There is a shift to dryer conditions in Palau ca. 1600-1800 A.D., which is consistent with a southward shift in the mean position of the ITCZ observed in other records spanning the tropical Pacific Ocean during this period. Another shift to dry conditions occurs ca. 1350-1500 A.D. Both of these dry periods correspond to archeological evidence of abandonment of settlements and/or increased fortifications in Palau. Positive correlation with two additional records of hydroclimatic variability from the Indonesia indicate that the Palau $\delta$Ddinosterol record is representative of broad scale regional shifts in precipitation.

Poster

## Late-Holocene climate variability in southern New Zealand: A multi-proxy study of laminated lake sediments from Lake Ohau to reconstruct regional climate

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Driving this research is the need to improve our understanding of synoptic climate systems that influence climate in southern New Zealand and to document changes in the intensity of these systems beyond the historical record. Year-to-year variability in New Zealand's climate (e.g. temperature and precipitation) is influenced by climatological patterns originating in both the tropics (El-Niño-Southern Oscillation, Interdecadal Pacific Oscillation) and the Antarctic (Southern Annular

Mode). Currently, very few highly resolved climate reconstructions exist in mid-latitudes of the Southern Hemisphere. The identification of annually laminated sediments in Lake Ohau, Mackenzie Basin, New Zealand (44.234°S, 169.854°E) offers a unique opportunity to investigate changes in regional hydrology and climate, and by extension also explore connections to large-scale climate patterns. Importantly, Lake Ohau is situated east of and in the lee of the Southern Alps, rendering the region characteristically dry and sensitive to small fluctuations in precipitation and temperature.
Short cores (<6 meters) from Lake Ohau contain layered sedimentary couplets, which $^{137}$Cs and $^{210}$Pb analyses suggest represent annual accumulation of terrigenous sediment at an average rate of 0.5 cm $a^{-1}$. Core imaging (RGB, L*), density, and magnetic susceptibility data were acquired using a Geotek multi-sensor core logger. Presented here is an initial assessment of couplet characteristics based on thin-sections, grain size analysis, and the GeoTek output. Initial correlation with records of lake inflow (1924-2012), and local precipitation and temperature (1910-2012) will also be presented. These results will provide the foundation for reconstructing the longer ~1,200 year record. Future work may result in the collection of a 100+ m core, allowing for a highly resolved climate record dating to 17,000 years before present. Ultimately, this annually resolved late Holocene climate record from the Southern Hemisphere mid-latitudes will be critical for testing our understanding of the behavior of large-scale climate patterns and can be used to inform regional and global climate modeling studies.

Poster

## Climate change in south India during the past two centuries inferred from geothermal and meteorological observations

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Temperature-depth profiles measured in boreholes contain records of changes in surface ground temperature over the past several decades to a few centuries. Through the process of heat diffusion, the Earth acts as low pass filter and a recorder of past surface temperature variations. Borehole temperature-depth profiles thus serve not only to complement the meteorologic record of climate change, but also provide important constraints on temperature trends prior to the occurrence of a global instrumental meteorological record. We analyzed seventy-five borehole temperature-depth profiles in south India, located between 8° and 15° N to infer past changes in surface ground temperature. Solutions for a linear surface temperature change indicate average warming of about 0.9±0.3 °C over the past 127±25 years at the 95% level of confidence for the entire data set, albeit with considerable geographic variability. Some sites in a restricted region exhibit surface ground temperature cooling during the last 50 to 100 years while a number of other borehole sites show large surface warming amplitudes in the range 1-3 °C with onset times during the last few decades to less than a Century. Such rapid changes may represent effects of local land use changes superimposed on the long-term climate change. Monthly and annual temperature data have been compiled for 28 meteorological stations in south India. They yield an average warming trend of 0.6±0.2 °C/100 years over the period 1901-2006. Combined analysis of borehole temperatures and SAT data yields a long-term, pre-observational mean (baseline) temperature 0.6±0.1 °C lower than the 1961-1990 mean SAT. With an additional 0.35 °C of warming beyond the 1961-1990 mean, the total warming from the ca.1800 baseline is 0.95 °C. We therefore infer that significant warming took place prior to the establishment of widespread meteorological stations in southern India in about 1900 A.D. The present data set together with the set of 70 temperature profiles in India analyzed earlier constitute an extensive documentation of climatic warming for the low latitude region 0°-20° N that was previously under-sampled in global geothermal climate change studies.

Poster

## Variations in discharge from the Qilian mountains, northwest China, and its effect on the agricultural communities of the Heihe basin, over the last two millennia

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Over the last two millennia, agricultural land in the Hei river basin, northwest China, has been subjected to a series of significant droughts and flood events. These documented hydrological events were compared to estimates of fluvial and fluvioglacial discharge from the mountains. Areal extents of glaciers are important for validation as water mass remaining in mountain area, although glacier area occupied only about 1.5 % at present in this high mountain area. These glacier mass balance and discharge estimates, calculated using proxy data, appear reasonable, as the total maximum glacier area during the little ice age (LIA) was comparable to the maximum glacier area deduced from the positions of terminal moraines. The precise timing of the glacier area maximum during the LIA in the Qilian mountains is unknown. However, variations in the calculated glacier area suggest that glacier extent reached a maximum between 1520 and 1690 CE. A number of the historical drought events occurred during periods of reduced discharge from the mountains, and, conversely, flood events tended to coincide with an increase in discharge from glaciers. Historical documents record five multi-year droughts in the basin between 1200 and 2000 CE. The modelling of the fluctuating pattern of fluvial and fluvioglacial discharge implies that at least two drought events were anthropogenically driven. Furthermore the

reasons for the presence or absence of drought events are considered based on continuous discharge fluctuation and water demands of each ages, that can be estimated from analysing intermittent historical documents.

Poster

## The missing ocean - Generation of high resolution records of sea surface temperature for the Common Era

***Jeff Salacup***[1], Timothy Herbert[1], Warren Prell[1]

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Of the twelve high resolution compilations of climate composited to produce the IPCCs most current understanding of climate over the past 2000 years (the Common Era), three contain 'limited coverage' of the oceanic realm and the others contain 'none or very few'. This is due in large part to low sedimentation rates encountered in the open ocean which limit the resolution of an environmental reconstruction. Our understanding of the climate system over this period is therefore largely dependent on terrestrial data, and furthermore based primarily on tree rings. Given the importance of the ocean to both local and global heat budgets, a better understanding of the ocean's role in climate change over the Common Era is sorely lacking and inclusion of more marine based records into the IPCC composites should be of primary concern.
To that end we investigated the utility of the Uk'37 sea surface temperature (SST) proxy, based on organic compounds called alkenones produced by haptophyte algae, in a high sediment-rate archive, the estuary Narragansett Bay. We developed a new understanding of how the proxy is being produced in the water, and then recorded in the sediments, by producing a multi-year-long, monthly to sub-weekly resolved time-series of water column Uk'37. Comparison with instrumental SST suggests that while important and informative seasonal inconsistencies exist, especially during alkenone blooms, the integrated Uk'37 signal produced in the water column reflects mean annual instrumental SST, and also closely matches values seen in modern sediments.
A subset of samples were analyzed for haptophyte-specific 18S ribosomal RNA (rRNA) to understand the composition of the alkenone-producing community during times of instrumental-Uk'37 coherency and incoherency, alike. So far, the only alkenone-producing species detected in Narragansett Bay, E.huxleyi and G.oceanica - which dominate open-ocean production and form the foundation of the Uk'37-SST calibration – were detected in the high salinity lower-Bay during the spring bloom of 2010. A second 'brackish' alkenone-producing population is suspected on the basis of high contributions of the C37:4 alkenone in the low-salinity upper Bay.
We used our improved understanding of Uk'37 to generate three sediment core histories of local-to-regional climate change spanning the past ~1500 years. The average resolution of the records, sampled every two centimeters, is approximately decadal, an order of magnitude finer than even highly-resolved open-ocean reconstructions. The reconstructions show strong inter-core coherence of centennial-to-decadal variability, and structure consistent with the Medieval Warm Period, the Little Ice Age, and 20th century warming. This work supports the careful but expanded application of the Uk'37 SST proxy in other high-salinity estuaries in an effort to provide the scientific community (e.g. IPCC) with a more robust understanding of oceanic-climate dynamics and variability over the Common Era.

Poster

## Millennial-length drought reconstructions for southern and central Fennoscandia

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Tree-ring data from trees growing in environments where climate is the major growth-limiting factor can be used as a powerful tool for developing long-term, annually resolved series of past climate events, such as drought. While a large number of temperature sensitive tree-ring chronologies have been developed and used in temperature reconstructions throughout the northern high latitudes, comparatively few efforts have been made to provide tree-ring based moisture reconstructions for this region.
In this study we present the first gridded, annually resolved, drought reconstruction that cover most of the southern and central Fennsocandia. The reconstruction is based on a dense, newly sampled, network of tree-ring chronologies from the region, and the drought metric used is the global 0.5° x 0.5° Standardized Precipitation and Evapotranspiration Index (SPEI). The use of the newly developed "signal-free" approach in the standardization of the tree-ring data enabled a more extensive preservation of the long-timescale climate variability from tree rings, than would have been obtained by using conservative curve-fitting standardization methods. Point-by-point (PPR) local regression technique was used to calibrate tree-ring chronologies against the instrumental record of summer drought (June-July SPEI) and to develop up to millennial-long reconstructions for more than 1000 grid points throughout the region. Results showed that most of the grid point SPEI estimates passed the verification tests used, and that the spatial features of drought in the region have, in general, been recorded.

Poster

## Climatic response of tree-ring density parameters of conifers from western Himalaya, India: Implications in dendroclimatology

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The densitometric analysis of Himalayan conifers from four different sites indicates strong association of ring density parameters with regional climate. Minimum earlywood density and total ring width are major contributors to the tree growth-climate relationship. It also indicates that pre-monsoon (March-April-May) temperature has significant positive relationship with earlywood density and significant negative correlation with total ring width. In case of precipitation, earlywood density gives negative relationship and ring width gives positive relationship with pre-monsoon precipitation. Latewood density parameters do not show any coherent pattern of relationship with climate. A strong association of earlywood density and ring width parameters may be due to severe moisture stress conditions occurring during the early phase of growing season of the conifers over the region.
This clearly establishes the great performance of density parameters of Himalayan conifers in dendroclimatic studies and indicates that the use of earlywood density parameters jointly with ring width may provide a more robust picture of past climate over the entire western Himalaya than the available reconstructions obtained only with total ring width.

Poster

## Tree ring inferred seven century long Satluj river discharge records from the Indian Himalaya

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The water demand for irrigation, hydropower and other usages has been increased in the recent decades due to increasing population pressure. River discharge variability information in the past is of crucial importance for planning future and ongoing developmental activities. However, the available river discharge records are for very short span and restrict long-term understanding in the past. Here, trees growing in the river catchment area provide valuable archive to extend the river discharge records in the past.
A seven century long ring-width chronology was developed using together growth rings of chilgoza pine and Himalayan cedar tree cores collected from Satluj river catchment area at Purbani and its surroundings, Kinnaur, western Himalayan. Cross-correlation analysis among monthly Satluj River discharge data and ring-width indices revealed that previous year October to current year September river discharge have positive relationship with the tree growth. Strong positive relationship among tree rings and river discharge data in the month of previous year December to current year July was used in reconstruction of river discharge back to AD 1295. The reconstruction captured 37% variance explained in the calibration model (AD 1922-2004). This is first such report of river discharge reconstruction from the Indian region. The 50-year running mean period showed lowest river discharge period in the eighteenth century and highest in the nineteenth century over the last seven century.

Poster

## Do baobabs have annual tree rings for high-resolution palaeoclimatology? An approach using wood anatomy and stable isotopes.

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Reconstructing past climate variability contributes to a better understanding of the ancient environments and human-environmental interactions. Proxy data derived from high-resolution archives, such as tree rings, ice cores, speleothems, corals and laminated lake sediments can be used to evaluate climate models. However, it is often difficult to find such high-resolution climate archives in arid and semi-arid regions. Our current study aims to investigate the African baobab (Adansonia digitata). This tree species is widely distributed throughout semi-arid Africa and can reach ages of up to 2000 years, thus, having potential to be an important source of high-resolution palaeoclimatic information. So far it has not been reported that growth patterns of baobabs respond to climate variability at annual or seasonal resolution. In order to check this, increment cores from 16 selected baobab specimens from Kubu Island (20°53′ S, 25°49′ E) located in the Kalahari, Botswana, were collected in June 2011. The area records an annual average rainfall of about 415 mm. Kubu Island is granite pluton. Baobabs growing there do not have access to ground water, but rely on the highly variable atmospheric precipitation falling mainly from October to April. Up to 80 cm long wood core samples of 5 mm in diameter collected in the field were transported to Germany and kept moist and cool until they were analysed in the laboratory. To test the hypothesis of annual growth and presence of tree rings, photos were taken under UV-light and incremental wood anatomical structures (ring-width) were measured in radial direction with the help of the software WinDENDRO. The comparison of ring width and precipitation data allowed recognizing annual growth patterns. We tested these results by stable isotope analyses. We will present the $\delta^{13}C$- and $\delta^{18}O$-data and discuss the presence of annual

growth patterns in African baobabs and their potential for palaeoclimatological research.

Talk

## A 2000-yr European Summer Temperature Reconstruction from the PAGES 2k Regional Network and Comparisons to Millennium-Length Forced Model Simulations

***Jason Smerdon***[1], Johannes Werner[2], Ulf Buntgen[3], Fredrik Charpentier Ljungqvist[4], Jan Esper[5], Laura Fernandez-Donado[6], J. Fidel Gonzalez-Rouco[6], Juerg Luterbacher[2], Danny McCarroll[7], Sebastian Wagner[8], Eugene Wahl[9], Heinz Wanner[10], Eduardo Zorita[8]

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A new reconstruction of European summer (JJA) land temperatures is presented and compared to 37 forced transient simulations of the last millennium from coupled General Circulation Models (CGCMs). The reconstructions are derived from eleven annually resolved tree-ring and documentary records from ten European countries/regions, compiled as part of the Euro_Med working group contribution to the PAGES 2k Regional Network. Records were selected based upon their summer temperature signal, annual resolution, and time-continuous sampling. All tree-ring data were detrended using the Regional Curve Standardization (RCS) method to retain low-frequency variance in the resulting mean chronologies. A nested 'Composite-Plus-Scale (CPS)' mean temperature reconstruction extending from 138 B.C.E. to 2003 C.E. was derived using nine nests reflecting the availability of predictors back in time. Each nest was calculated using a weighted composite based on the correlation of each proxy with the CRUTEM4v mean European JJA land temperature (35°-70°N, 10°W-40°E). The CPS methodology was implemented using a sliding calibration period, initially extending from 1850-1953 C.E. and incrementing by one year until reaching the final period of 1900-2003 C.E. Within each calibration step, the 50 years excluded from calibration were used for validation. Validation statistics across all reconstruction ensemble members within each nest indicate skillful reconstructions (RE: 0.42-0.64; CE: 0.26-0.54) and are all above the maximum validation statistics achieved in an ensemble of red noise benchmarking experiments.
A gridded (5°x5°) European summer (JJA) temperature reconstruction back to 750 C.E. was derived using Bayesian inference together with a localized stochastic description of the underlying processes. Instrumental data are JJA means from the 5° European land grid cells in the CRUTEM4v dataset. Predictive experiments using the full proxy data were made, resulting in a multivariate distribution of temperature reconstructions from 750-2003 C.E. The mean of this distribution is the optimal estimate of the gridded JJA temperature anomalies and its width provides objective reconstruction uncertainties. The derived reconstruction is compared to withheld instrumental and proxy data to evaluate reconstruction skill on decadal-to-centennial time scales. A comparison between the mean Bayesian and CPS reconstructions indicates remarkable agreement, with a correlation during their period of overlap of 0.95.
In both the Bayesian and CPS reconstructions, warm periods during the 1st, 2nd, and 7th-12th centuries compare to similar warm summer temperatures during the mid 20th century, although the 2003 summer remains the warmest single summer over the duration of the reconstructions. A relative period of cold summer temperatures is also noted from the 14th-19th centuries, consistent with the expected timing of the Little Ice Age. Comparisons between the reconstructions and the 37-member ensemble of millennium-length forced transient simulations from CGCMs, including eleven simulations from the collection of CMIP5/PMIP3 last-millennium experiments, indicate good regional agreement between reconstructions and models. Based on the separation of simulations into strong or weak scaling of total solar irradiance (TSI) forcing over the last millennium, there is some evidence that there is better agreement with the ensemble using strong TSI as forcing.

Poster

## Sensitivity of the forest-grassland ecotone to historical rainfall variation in pristine open woodland savanna of equatorial East Africa

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Fossil pollen records provide key insight into the sensitivity of terrestrial ecosystems to climate change. However, tracing vegetation response to relatively modest historical climate fluctuation is often complicated by the overriding signature of anthropogenic disturbance on the landscape. As a result it is almost impossible to estimate the magnitude of climate change, e.g., moisture-balance variation, responsible for a specific change in pollen assemblage, and to translate pollen assemblage changes into reconstructions of past landscape-scale vegetation change. Here we use high-resolution pollen data from a ~250-year lake-sediment record in western Uganda (equatorial East Africa) to assess the sensitivity of natural vegetation in the ecotone between grassland and open woodland savanna to historical trends in annual rainfall on the order of 10% lasting for several decades. Specifically we trace regional vegetation response to two episodes of increased rainfall ~1865-1885 (modestly continuing until the 1920s) and 1962-1985. During these wetter episodes we find an immediate increase in pollen abundance from woodland shrubs Myrica, Rhus, Celtis, Macaranga and Alchornea, and herbs such as Asteraceae and Swertia usumbarensis-type. Conversely, herbs such as Commelina and Justicia expanded during the mid-20th century dry episode ~1920-1962. Increases in Acalypha and Phoenix reclinata-type, two woodland taxa with strong influence

on grass pollen percentage, are delayed on the order of 15 years, suggesting that this response represents a real but temporary expansion of woodland relative to grassland. Pollen from cultivated plants and exotic trees appears from the 1970s onwards, but the combined influence of this long-distance influx fails to mask regional vegetation response to natural rainfall variability.

Talk

## Mechanisms for European summer temperature response to solar forcing over the last millennium

***Didier Swingedouw***[1], Laurent Terray[2], Jérôme Servonnat[1], Joel Guiot[3]

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A simulation of the last millennium is compared to a recent spatio-temporal reconstruction of summer temperature over Europe. The focus is on the response to solar forcing over the pre-industrial era. Although the correlation between solar forcing and the reconstruction remains small, the spatial regression over solar forcing shows statistically significant regions. The meridional pattern of this regression is found to be similar in the model and in the reconstruction. This pattern exhibits a large warming over Northern and Mediterranean Europe and a lesser amplitude response over Central and Eastern Europe. The mechanisms explaining this pattern in the simulation are mainly related to evapotranspiration fluxes. It is shown that the evapotranspiration is larger in summer over Central and Eastern Europe when solar forcing increases, while it decreases over the Mediterranean area. The explanation for the evapotranspiration increase over Central and Eastern Europe is found in the increase of winter precipitation there, leading to a soil moisture increase in spring. As a consequence, the evapotranspiration is larger in summer, which leads to an increase in cloud cover over this region, reducing the surface shortwave flux there and leading to less warming. Over the Mediterranean area, the surface shortwave flux increases with solar forcing, the soil becomes dryer and the evapotranspiration is reduced in summer leading to a larger increase in temperature. This effect appears to be overestimated in the model as compared to the reconstruction. Finally, the warming of Northern Europe is related to the albedo feedback due to sea-ice cover retreat with increasing solar forcing.

Poster

## Multiproxy evidence of environmental changes during last 1800 years recorded in coastal peatland of Puck Lagoon (southern Baltic)

***Szymon Uscinowicz***[1], Wojciech Jeglinski[1], Grazyna Miotk-Szpiganowicz[1], Jacek Pawlyta[2], Natalia Piotrowska[2], Mariusz Galka[3], Malgorzata Witak[4]

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This study presents results of multiproxy investigation of palaeoenvironmental changes recorded in coastal peatland of Puck Lagoon (NW part of the Gulf of Gdańsk, southern Baltic). Proxies include $\delta^{13}C$ and $\delta^{18}O$ on bulk peat samples, palynology, macrofosils, diatoms and chemical composition. Chronology was established using 4 $^{14}C$ AMS dates and pollen spectrum, what showed that in 1.2 m peat profile are recorded the events that took place during last 1800 years. The samples for analyses were taken from sections of 5 cm, which according to age-depth model gives a resolution of approximately 100 years. Minima and maxima $\delta^{18}O$ well correlate with changes in solar activity that recognized, by e.g. Among other things, $\delta^{18}O$ maxima attributable to the Medieval Warm Period (ca. 800-1100 AD) are clearly separated by a minimum of covering a minimum of solar activity before the Oort minimum. Clearly indicated by $\delta^{18}O$ minimum is also a main phase of the Little Ice Age around 1650-1850 AD, which is the period fit well to Maunder and Dalton minima. Since the XIX century, there is an increase $\delta^{18}O$ values, which is consistent with the contemporary climate warming. The variations in the proxies are not always synchronous, suggesting different triggering factors. For example, in the analyzed core, there is no correlation between curves $\delta^{18}O$ and $\delta^{13}C$ demonstrated the relationship between water salinity and the $^{13}C/^{14}C$ isotope ratio in organic carbon in surface sediments of the Baltic. Therefore elevated values of $\delta^{13}C$ in peat may indicate rather increased salinity, increased water levels and more frequent and stronger storms, than temperatures oscillations. Rapid change of environment from freshwater into brackish, according to $\delta^{13}C$ and Ca/Mg ratio took place ca. 200-300 AD, what was related with first inflow of lagoonal water onto the peatland. The $\delta^{13}C$, diatoms, pollen, plant macrofossils and geochemical indicators points that frequent stormy periods occurred in years: 200-300 and 1300-1500 AD and since the beginning of the twentieth century. According to radiocarbon age of peat samples and its position in relation to present sea level, average water level in Puck Lagoon rose ca. 1.0-1.2 m during the last 1800 years. Bases on mentioned proxies it is highly probable that water level rise periodically.

Poster

## An updated pseudoproxy evaluation of four climate field reconstruction methods using improved emulations of real-world conditions

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Many studies have assessed the performance of different climate field reconstruction (CFR) techniques with

synthetic data in pseudoproxy experiments (PPEs), but these experiments have been idealized in their choice of spatiotemporal coverage and the adopted noise models in the pseudoproxy series.
Here we present a pseudoproxy network based on more realistic characteristics to better discriminate between CFR techniques. The network mimics the Mann et al. [2008] (hereinafter M08) proxy network and is constructed from the model output of the NCAR CCSM1.4 millennial simulation (850-1999 CE). We design the pseudoproxy network to reflect the loss of spatial sampling back in time in the M08 network and employ signal-to-noise (Gaussian white noise) ratios (SNRs) that are empirically derived from correlations between real-world proxies and the HadCRUT3v temperature field from 1850-1996 CE. This improved pseudoproxy framework is used to evaluate the spatiotemporal performance of four CFR techniques: (1) RegEM using truncated total least squares (hereinafter "TTLS") with fixed truncation, (2) EM using graphical model selection (GraphEM), (3) canonical correlation analysis (CCA) and (4) the Mann et al. [2009] (hereinafter M09) implementation of RegEM TTLS. Compared to previous PPEs using more idealized designs, the updated pseudoproxy framework presents a more stringent test for this collection of CFR methods.
The ensemble framework allows us to test the consistency of each method. CCA, TTLS and GraphEM all improve on the reconstruction of low-frequency variability compared to M09, but they all tend to underestimate it (as expected of regression-based methods). All methods tend to introduce warm biases, with TTLS the least biased of the four on the global mean. Preliminary results with idealized SNRs indicate that GraphEM best preserves spatial information, closely followed by CCA. Results with a realistic network are less interpretable, partly due to our design choices. In general, we find that networks comprising relatively few pseudoproxies with high SNR produce much better reconstructions than a large proxy network with low SNR, suggesting that this should be a guiding principle for designing real proxy networks. Contrary to expectations, the skill of our experiments varies substantially from century to century, even when proxy availability is time-invariant. We find that high-amplitude climate events, which have more coherent spatial expressions than other fluctuations, get more easily resolved by the proxy network. This suggests that reconstruction skill is not only affected by proxy availability and quality, but is also a function of the type and amplitude of climate variations (e.g. internally-generated vs. externally-forced variations).
Since a number of these results are model-dependent, they will be checked with additional GCM integrations from the PMIP3/CMIP5 archive. Despite the improvements noted above, all CFR methods still yield reconstructions with important spatial errors. Methodological refinements are needed to quantify and minimize the errors associated with each method.

Talk

## A 2000-year synthesis of marine-derived SST records: Results from the Ocean2k project

Working Group PAGES/Ocean 2k[1], ***Guillaume Leduc***[2]

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Using the PAGES Ocean2k project metadatabase (n = 309; http://www.pages-igbp.org/workinggroups/ocean2k/metadatabase), we have analyzed reconstructed sea surface temperatures (SSTs) from sediment-derived proxies (Mg/Ca, alkenones, TEX86, and faunal assemblages) at 200-year resolution. Over 75 volunteers constructed the paleodata metadatabase from which this work was developed, and about 25% of them actively contributed to the analysis reported here. We focused on the portion of the records meeting tight chronological control criteria and compiled the data into 200-year bins. The resulting SST sub-dataset is geographically sparse, but 34-60 records are represented within each 200-year bin. Analysis of multi-millennial AOGCM output suggests that the composite of this dataset on these timescales is sufficient to resolve the global mean ocean surface temperature.
Here we present a 'global' synthesis of the available data for the interval 0-1800 C.E., which we expect to be dominated by a combination of natural external climate forcing and internal ocean variability. We observe a statistically-significant cooling trend, which is qualitatively consistent with the SST cooling observed in realistically-forced AOGCM experiments, in which cooling partly arises from orbitally-induced variations in radiative flux. Superimposed on the overall cooling trend, the Little Ice Age is defined in these data as a statistically-significant cool period in the 200-year bins centered on 1500-1700 C.E., relative to conditions before and after. These results are apparently not sensitive to quality of chronological control, chronological resolution, seasonality in proxy signal-carrier, water depth of the sediment core, or type of proxy measurement, but are likely biased toward observations from the North Atlantic basin margins. Analysis of the time-changing overprint of natural and anthropogenically-forced SST change since 1800, which is resolved in available paleodata and consistent with robust features of AOGCM output, is the subject of ongoing synthesis and model-data intercomparison studies.

## OSM03: New Approaches to Data Assimilation and Data-Model Comparison

Convenors: Basil Davis, Daniel Ariztegui, Simon Brewer, Hugues Goosse

Poster

### Contrasting changes in vegetation and West African wind systems over the west African Sahel region during Heinrich Stadial 1

***Ilham Bouimetarhan[1]***, Matthias Prange[1], Enno Schefuß[2], Lydie Dupont[2], Jörg Lippold[3], Stefan Mulitza[2], Karin Zonneveld[1]

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Millennial-scale dry events in the Northern Hemisphere monsoon regions during the last glacial period are commonly attributed to southward shifts of the Intertropical Convergence Zone (ITCZ) associated with an intensification of the northeasterly (NE) trade wind system during intervals of reduced Atlantic meridional overturning circulation (AMOC). Through the use of high-resolution last deglaciation pollen records from the continental slope off Senegal, our data show that one of the longest and most extreme droughts in the western Sahel history, which occurred during the North Atlantic Heinrich Stadial 1 (HS1), displayed a succession of three major phases. These phases progressed from an interval of maximum pollen representation of Saharan elements between ~19 and 17.4 kyr BP indicating the onset of aridity and intensified NE trade winds, followed by a millennial interlude of reduced input of Saharan pollen and increased input of Sahelian pollen, to a final phase between ~16.2 and 15 kyr BP that was characterized by a second maximum of Saharan pollen abundances. This change in the pollen assemblage indicates a mid-HS1 interlude of NE trade wind relaxation, occurring between two distinct trade wind maxima, along with an intensified mid-tropospheric African Easterly Jet (AEJ) indicating a substantial change in West African atmospheric processes. The pollen data thus suggest that although the NE trades have weakened, the Sahel drought remained severe during this time interval. Therefore, a simple strengthening of trade winds and a southward shift of the West African monsoon trough alone cannot fully explain millennial-scale Sahel droughts during periods of AMOC weakening. Instead, we suggest that an intensification of the AEJ is needed to explain the persistence of the drought during HS1. Simulations with the Community Climate System Model indicate that an intensified AEJ during periods of reduced AMOC affected the North African climate by enhancing moisture divergence over the West African realm, thereby extending the Sahel drought for about 4000 years.

Poster

### Oceanographic data-model comparisons: What exactly are we doing? A late Miocene case study

***Catherine Bradshaw[1]***, Rachel Flecker[1], Daniel Lunt[1], Ana Christina Ravelo[2], Eirik Vinje Galaasen[3], Howard Spero[4]

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After 40 years of deep sea drilling, there now exists a wealth of oceanographic proxy data available for reconstructing past climates. However, whilst the data may offer the opportunity to reconstruct past climate states, only climate modelling offers the opportunity to test and fully understand the processes and boundary conditions that led to them. Fully coupled atmosphere-ocean GCMs are used to simulate past climates, and so comparisons between quantitative oceanographic proxy reconstructions and simulated ocean temperatures and salinities can be made.

In this study, we examine how these oceanographic data-model comparisons can be made, and the implications of some of the many uncertainties, from both data and model, on the results obtained. A case study of the late Miocene (11.61-5.33 Ma) is chosen for the data-model comparison, a period of major tectonic developments including the restriction of ocean gateways, the reduction in the size of the Paratethys Sea, and the uplift of the world's major mountain chains. This poorly studied past warm period is important because of the apparent disconnect between global temperatures and $CO_2$ concentrations, and therefore questions arising from the role of tectonic reorganisation in driving climate.

The oxygen isotope-enabled version of the fully coupled atmosphere-ocean-vegetation GCM HadCM3L-TRIFFID is used to simulate both the late Miocene climate and the potential modern climate. Comparison between the late Miocene and the potential modern climate simulations suggests significant differences in ocean dynamics in the past. It is vital to make meaningful data-model comparisons in order to evaluate that a model is correctly simulating past ocean dynamics before it is possible to examine the role of those tectonic changes in determining climate.

A database of >25,000 proxy records for the late Miocene has been compiled from the literature, the vast majority of which are $\delta^{18}$Oc foraminifera records, along with some 4,000 core-top proxy reconstructions. Data-data comparisons are made between the core-top and down-core measurements, and data-model comparisons between both the core-top measurements and the simulated modern climate, and the down-core measurements and the simulated late Miocene climate for both planktic and benthic realms. For planktic water depths, we examine the difference made to reconstructed depth habitats when the different $\delta^{18}$Oc-temperature calibration equations are considered, and how those depth calculations assuming equilibrium calcite precipitation compare to the reported depth habitat

preferences in the modern ocean. Also considered is the impact of both seasonal bias in flux and the uncertainty of depth habitat on the resulting data-model comparison. For some species this is significant, whilst less so for others. Finally, the impact of comparing the data to absolute depths in the model output versus comparing to the model-simulated structure of the ocean, e.g. mixed layer, thermocline etc, is demonstrated, indicating that for some regions, this can be very different.

Poster

## Exploring the causes of enhanced recent growth in high-elevation bristlecone pines using stable isotope dendroclimatology

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The Great Basin Bristlecone pine (pinus longeava) is one of the oldest known tree species in the world. Growing in the western United States, ring-width series from bristlecones provide a valuable high-resolution multi-millennial palaeoclimate resource. Researchers have reported a strong increase in growth rates of some tree-line bristlecones during the second half of the 20th century. This growth increase is not seen at lower elevations and is the subject of much controversy. It has been suggested that the enhanced growth may be the result of anthropogenic temperature increases, a $CO_2$ fertilization effect or fertilization from nitrogen pollution. Understanding the causes of this growth increase is important in using the high-elevation ring-width record as a proxy for temperature.
Cores were collected from a tree-line location known to exhibit enhanced growth and a lower-elevation control site on Sheep Mountain, California. Ring-width chronologies indicate that trees at the upper-site do indeed display the reported growth increase while trees at the lower site do not. Preliminary results are presented from several investigations carried out at both sites.
No significant difference in nitrogen supply between elevations was found for foliar material, associated vegetation types and soils. This was further investigated using nitrogen isotope time-series from tree-cores and foliar material. Stability in the oxygen isotope time-series from tree-cores has revealed no changes to the precipitation and humidity regime over recent decades. A possible $CO_2$ fertilization effect has been identified using carbon isotope records from tree-line cores.

Poster

## Megadroughts in Millennium-Length Forced and Control Simulations and their Comparison to the Proxy-derived North American Drought Atlas

Sloan Coats[1], ***Jason Smerdon***[1], Richard Seager[1], Benjamin Cook[2], J. Fidel Gonzalez-Rouco[3]

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Some of the starkest features of proxy-estimated hydroclimate variability in the North American Southwest (NASW; 125°W-105°W, 25°N-42.5°N) are the severe and multidecadal drought periods that have existed in the region. These so called megadroughts are a prominent and well-established feature of the NASW's hydroclimate history. Given the prominence of these features in our recent past, it is imperative to consider whether Atmosphere-Ocean General Circulation Models (AOGCMs) are capable of simulating these events and if such features of past hydroclimate change are forced or the product of internal variability. Simulated hydroclimate variability in millennium-length forced transient and control runs from the ECHO-G coupled AOGCM is analyzed and compared to reconstructed Palmer Drought Severity Index (PDSI) variability from the North American Drought Atlas (NADA). Megadroughts in the ECHO-G AOGCM are found to be similar in duration and magnitude to those estimated from the NADA. The droughts in the forced simulation are not, however, temporally synchronous with those in the paleoclimate record, nor are there significant differences between the megadrought features simulated in the forced and control runs. These results indicate that model-simulated megadroughts can result from internal variability of the modeled climate system, rather than as a response to changes in exogenous forcings. Although the ECHO-G AOGCM is capable of simulating megadroughts by means of persistent La-Nina-like conditions in the tropical Pacific, other mechanisms can produce similarly extreme NASW moisture anomalies in the model. In particular, the lack of low-frequency coherence between NASW soil moisture and various atmospheric or ocean modes during identified drought periods, suggests that stochastic atmospheric variability can contribute significantly to the occurrence of simulated megadroughts in the NASW by means of storm track displacement. These findings indicate that either an expanded paradigm is needed to understand the factors that generate multidecadal hydroclimate variability in the NASW or that AOGCMs may incorrectly simulate the strength and/or dynamics of the connection between hydroclimate variability in the NASW and the tropical Pacific. Using the ECHO-G results as a framework, we also present preliminary results for multi-model comparisons using the collection of last millennium simulations from the CMIP5/PMIP3 archive.

Poster

## Integrated climate-proxy modeling using the isotope-enabled SPEEDY-IER with a focus on tropical climate

***Sylvia Dee***[1], David Noone[2], Julien Emile-Geay[1], Nikolaus Buenning[1]

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Water isotope records lend insight into past climatic and hydroclimate conditions and can help identify the isotopic signature accompanying abrupt climate change events. Such signatures may be caused by changes in the hydrological cycle and the resulting variations in precipitation amount, evaporation, origin and composition, as well as changes in circulation. However, it is usually not possible to isolate the causes of isotopic excursions in proxy records without an isotope-enabled general circulation model (GCM). Currently, there are few efficient isotope-enabled models that are fit for tropical paleoclimate studies.

We address the need for a fast, realistic, isotope-enabled model suitable for paleoclimate integrations with the efficient atmospheric GCM, 'SPEEDY' (Simplified Parameterizations, primitivE-Equation Dynamics) (Molteni 2003). Our new model (SPEEDY-IER) provides physically-consistent realizations of tropical climate and isotopic excursions in proxies at a fraction of the computational cost of IPCC-class GCMs, and allows for long simulations comparable in scale to proxy archives. Isotopic physics have been incorporated into SPEEDY. Stable water isotopologues $H_2{}^{18}O$, HDO, and $H_2O$ are included as tracers and advected within all stages of the hydrologic cycle with appropriate equilibrium or kinetic fractionation during phase changes. Changes to SPEEDY-IER are carried out systematically, allowing us to quantify the influence of each physical process and yielding insight into the main causes of isotope variability. We investigate the effect of equilibrium and kinetic fractionation, advection, isotopic exchange during rainfall, and the addition of a 2-bucket soil moisture model on the modeled isotope values, comparing them to GNIP data and the SWING2 model database. Despite the atmospheric model's simplified physics, SPEEDY-IER captures the observed range of isotope variability. Modeled annual average values as reproduced by SPEEDY-IER are consistent within a ~3 permil range with GNIP and SWING2 values across the tropics and subtropics and within a ~5 permil range over the poles.

SPEEDY-IER is used to explore relationships between climate variability and proxy records. To further bridge the gap between coupled AGCMs and observational proxy archives, SPEEDY-IER is coupled to forward process models of coral aragonite and tropical tree-ring $\delta^{18}O$. This enables us to simulate the atmospheric response and subsequent isotopic signal induced by a range of tropical sea surface temperature anomalies (both idealized and realistic), and how this signal is expressed in the proxy records. Implications for climate reconstructions are then discussed.

Poster

## Reconstructions of the climate states over last centuries using particle filtering

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In contrast to meteorology, data assimilation in paleoclimatology is relatively new, but the interest in it is growing as it gives a more reliable state estimation of the past climate changes. Data assimilation enables reconstructions of the climate of past centuries to be consistent with the model physics and proxy data (indirect reconstructions based on tree rings, ice cores, sediments), and it assists in estimating uncertain model parameters, e.g., forcing estimations. But it is not straightforward to implement a data-assimilation method developed for weather forecasting for paleoclimatological applications, since the observations in paleoclimatology have a sparse spatial distribution, the time resolution of proxies becomes lower as the record goes further back in time, and there are non-climatic uncertainties associated with the reconstructions based on proxies. On the other hand, in paleoclimatology, a description of the state of the system does not need to be as detailed as in meteorology. In many cases, large-scale averages on seasonal to annual means give already very valuable information, while data assimilation for weather forecasting requires reconstructions every six hours at the scale of a few tenth of kilometers at most.

In order to test data assimilation approaches adapted to paleoclimatology, we conduct experiments with the three-dimensional Earth system model of intermediate complexity LOVECLIM using particle filtering to reconstruct past climate states over the last 150 years. LOVECLIM was chosen due to its computational costs, and particle filtering was chosen due to its simplicity of implementation and because it adequately handles nonlinearities. LOVECLIM consists of an atmospheric model, a sea-ice model, an ocean general circulation model, and a vegetation model. Using particle filtering, we assimilate surface temperature over southern hemisphere with assimilation period of three months.

We consider two particle filtering methods: sequential importance resampling and an extremely efficient particle filter. In sequential importance resampling, a set of particles, where a particle is a realization of the model with random perturbation of initial conditions, is integrated over a season. Then, when observations of sea surface temperature become available, the set is resampled according to an importance weight of each particle. This importance weight comes from computation of the likelihood of the state obtained by each particle. The extremely efficient particle filter used here is based on sequential importance resampling and nudging. In addition to the assimilation of surface temperature each three months, sea surface temperature is nudged every day through the fluxes coming from the atmosphere to the ocean such that it is slightly pulled towards the seasonal/monthly mean calculated from observations. This method was originally proposed for high-dimensional problems to take care of filter degeneracy. We, however, when using this method, pursue a different object–to accomplish a better reconstruction of the climate states.

We compare results of the simulations obtained using LOVECLIM only, LOVECLIM constrained by sequential importance resampling, and LOVECLIM constrained by the extremely efficient particle filter. In the last two simulations, surface temperature from a twin experiment is assimilated over southern hemisphere.

Poster

## Data assimilation of climate proxies in a set of 30 model simulations using the Ensemble Kalman Filter

***Jörg Franke[1,2]***, Jonas Bhend[3], Stefan Brönnimann[1,2]

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The assimilation of observational data in climate models allows for climate model simulations that are both consistent with observations of the past and with our understanding of the physics of the climate system as represented in the model used. Assimilation methods have been developed in the field of weather prediction to achieve the best possible initial conditions for the numerical models. Furthermore, data assimilation is used in so-called reanalysis projects which aim to produce climate simulation that agree with past observations an thus offer spatially comprehensive, temporally highly resolved, multivariate climate information. Conventional assimilation methods require a large amount of input data which limited their applications to the satellite era and some decades of intensive instrumental measurements before. The first reanalysis covering more than a century back in time has recently been accomplished with a comparatively small amount of sea level pressure data only. This became possible by applying a new technique, Ensemble Square Root Filtering. Based on this study we investigate the options of using Ensemble Square Root Filtering on even more sparse and noisy climate proxy data. In a first attempt we constrain an ensemble of 30 simulations from an atmosphere-only general circulation model (GCM) with 45 pseudo-proxy time series. After some methodological improvements, such as an introduction of a localisation scheme that prevents overcorrection in distant not deterministically correlated regions, we can improve the representation of surface quantities such as temperature. In Europe and other regions with a sufficient amount of input data, data assimilation leads to a considerable increase in reconstructions skill. Although we solely assimilate land-surface temperature, also precipitation as well as upper-air features such as the intensity of the stratospheric polar vortex or the strength of the northern subtropical jet can be improved. We will present the transition from pseudo proxies to instrumental data and finally real proxies.

Poster

## Stable Water Isotopes in a Coupled Atmosphere-Vegetation Model: Comparison of simulation results with observational and proxy data

***Barbara Haese[1]***, Martin Werner[1], Britta Beckmann[2], Gerrit Lohmann[1], Enno Schefuß[2]

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The aim of our project is to improve the understanding of the hydrological evolution of the North-West African monsoon system during the Holocene. Based on climate model simulations as well as proxy data we try to identify the most significant mechanisms, which force variations in the monsoon system. Special focus will be given to detailed analyses of coupled atmospheric-vegetation feedback processes. To reach this goal we use the land surface model ECHAM5-JSBACH enhanced by the stable water isotopes $H_2{}^{18}O$ and HDO (ECHAM5-JSBACH-wiso). To evaluate the simulated isotope values we use a first set of present-day simulations and compare these results with both observational data and proxy data over the last century from Africa. The model resolution varies between T31 (3.8° x 3.8°) and T63 (1.9° x 1.9°) at the spatial grid and vertically between 19 and 31 pressure levels. Furthermore, to get a more realistic performance we also perform an ERA40 nudged ECHAM5-JSBACH-wiso simulation over 50 years. These model results enable a simulation-based quantitative calibration of observed isotope variations with respect to changes of, e. g., local temperature and precipitation amount.
In order to investigate the North-West African monsoon system during the Mid-Holocene (6k) we carry out different paleoclimate simulations with varying boundary conditions. Furthermore we distinguish between prescribed and simulated past vegetation changes. We compare these new 6k model results with biomarker-based proxy data to improve our understanding of past hydrological changes in this region.

Talk

## Skill and reliability of climate model ensembles at the Last Glacial Maximum and mid-Holocene

***Julia Hargreaves[3]***, James Annan[3], Rumi Ohgaito[3], Andre Paul[1], Ayako Abe-Ouchi[2]

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Paleoclimate simulations provide us with an opportunity to critically confront and evaluate the performance of climate models in simulating the response of the climate system to changes in radiative forcing and other boundary conditions. Here we assess the ensembles from the Paleoclimate Model Inter- comparison Project against available data from the Last Glacial Maximum (LGM) and mid-Holocene intervals, using analogous methods to those used to regularly evaluate weather forecasting models. Our results are predominantly positive for the LGM, suggesting that as well as the global mean change, the models can reproduce the observed pattern of change on the broadest scales, such as the overall land-sea contrast and polar amplification, although the more detailed regional scale patterns of change remains elusive. We analyse the correlations between the spatial temperature and climate sensitivity in the model ensembles, and combining this with a recent reanalysis of the LGM temperature field, use two different methods to produce new estimates for the constraint of the LGM on

climate sensitivity. The predicted values are in line with other recent estimates on climate sensitivity, with best estimates close to 2.8C and 90% ranges of 1.2-4.1C and 1.6- 4.8C respectively.
The mid-Holocene climate forcing is regional and seasonal in nature and the global average change is very small. It is thus a stiffer test of the models' performance at finer resolution. The results of the analyses of the mid-Holocene ensemble are substantially negative. This further strengthens the finding for the LGM that regional scale climate changes are not well reproduced by the models. This does not necessarily mean that future regional prediction is also poor, as the root cause of the model-data mismatch at regional scales is unclear. The proxy calibration may be at fault, but alternatively, representation error in the data-model comparison is another possible cause, given the highly localized nature of paleoclimate measurements. Missing climate feedbacks in the models, particularly the terrestrial vegetation, are another potential source of error, which would have more worrying implications in terms of future prediction.

Poster

## The global ocean during the mid-Holocene: A multi-sensor sea surface temperature reconstruction (MARGO-6k) and evaluation of the CMIP5 mid-Holocene simulations

***Ines Hessler*[1,2]**, Sandy Harrison[1], Michal Kuchera[2], Stefan Mulitza[2], Claire Waelbroeck[3], data contributes MARGO-6k[4]

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The change in orbital configuration during the mid-Holocene caused changes in incoming solar radiation that affected the coupled ocean-atmosphere system and led to changes in seasonal climates. Simulations of the mid-Holocene climate, conducted as part of the Coupled Ocean-Atmosphere Comparison Project (CMIP5) show three large-scale temperature features in the ocean, namely: 1. high latitude warming in the Northern (NH) and Southern Hemispheres (SH), particularly during summer in the NH and during winter in the SH, 2. cooling in the SH tropics, especially during summer and 3. increased seasonality in the NH and decreased seasonality in the SH. These model signals need to be evaluated using palaeo-data. Unfortunately the only global synthesis of sea-surface temperature data (GHOST) contains relatively few data points, mostly confined to coastal regions. Although there are many individual records based on several different types of indicators.
Here we present a global mid-Holocene compilation of seasonal SSTs based on Mg/Ca, alkenones (expanded from the GHOST database) and census counts of planktonic foraminifera and dinoflagellate cysts. SST reconstructions from foraminifera and dinoflagellate assemblages are based on transfer function techniques. The foraminifera based reconstructions are newly calculated using a standardised transfer function scheme. We follow the MARGO-LGM protocol for quality control and uncertainty estimates of individual reconstructions. Comparisons between reconstructions using different sensors allow us to evaluate the overall reconstruction uncertainty. For comparison with model outputs, we pooled the available data and re-gridded them to a 2x2 degree grid (comparable with the grid size of individual models). These data are then compared to the model simulations of seasonal ocean climates to assess the realism of the simulated ocean changes and features. The outcomes of this study will shed light on the role of the ocean in mid-Holocene climate change.

Poster

## Modelling oxygen and deuterium isotopes over the last 120 ka in a fully-coupled atmosphere-ocean GCM

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With this work, we aim to address the question of whether or not oxygen isotope proxy-records can be used to constrain real world (climate) changes. In addition, we investigate the global-representativeness of existing oxygen isotope records and suggest key target locations for future coring expeditions that will yield maximum information on climate variability and its underlying mechanisms.
To do this, we ran a suite of fully coupled Atmosphere-Ocean General Circulation Model (AOGCM) simulations spanning the last 120 ka years at up to 1 ka temporal resolution. Building on the work of Singarayer and Valdes (2004), the transient simulations were run using the UK Met Office's HadCM3 and include oxygen ($\delta^{18}O$) and deuterium ($\delta D$) isotope enabled ocean model. They were forced with evolving ice-sheet extent, height and isostatic rebound (following the ICE-5G reconstruction; Peltier, 2004 and Peltier and Fairbanks, 2006), variability in Earth's orbit (following Berger and Loutre, 1991), changes in atmospheric trace gas concentration ($CO_2$, $CH_4$ and $N_2O$ from Vostok and EPICA ice cores; and idealised Heinrich Event iceberg discharges (following the timings of Hemming, 2004).
By directly comparing the evolution of simulated $\delta^{18}O$ and $\delta D$ to the ocean sediment- and ice-core records, we are able to evaluate the performance of our model and identify key areas (and time periods) of high variability and sensitivity to circulation changes. With a particular focus on the Last Deglaciation, we examine transitions in ocean circulation, presenting our findings on the relationship between $\delta^{18}O$, $\delta D$ and temperature. This allows us to investigate the stability of the (modelled) correlation through time and elucidate the key implications for atmospheric versus oceanic dynamics in the climate system.

Talk

## Lake Isotope – Climate Model comparisons: An iterative approach to improved palaeoclimate understanding?

***Matthew Jones***[1], Steven Phipps[2]

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Lake $\delta^{18}O$ records provide an important window into variability in hydroclimate on timescales longer than those available to us via instrumental records. Here we describe an approach for lake isotope data – climate model comparison, which could ultimately result in an iterative approach to a better understanding of both. With climate models increasingly becoming isotope enabled, understanding isotope palaeoarchive systematics is vital for fulfilling the potential for data model comparisons. An initial case study from Nar Golu, Turkey will be presented. Long term (>5 year) monitoring of lake systems allows the development of robust lake isotope models that explain the measured variability. These models can be used to model lake isotope variability in 2 temporal directions and allow comparison with isotope records from sedimentary archives and climate model output. Forward modelling of the Nar isotope system driven by climate model output, in this case from the CSIRO Mk3L climate system model, produces a pseudo-proxy record that can be compared to the lake isotope record over the last 1500 years. Inverse modelling using the lake isotope system model and the sedimentary $\delta^{18}O$ record can be used to compare with climate model output. These exercises will highlight the differences between the isotope data interpretation and the climate model output which can be investigated and iteratively reduced, improving performance of the model and our interpretation of lake isotope records.

Poster

## A simple approach to assessing the accuracy of age models from Holocene sediment cores

***Darrell Kaufman***[1], Nicholas Balascio[2], Nicholas McKay[1], Hanna Sundqvist[3]

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We have embarked on major systematic compilation of previously published Holocene proxy climate records from the Arctic, with the goal of reconstructing the spatial-temporal pattern of past climate changes. The focus is on well-dated, highly resolved, continuous records that extend to at least 6 ka, most of which are from sedimentary sequences sampled in cores from lakes and oceans. The database includes the original geochronological data for each record so that the accuracy of the underlying age models can be assessed uniformly. Determining the accuracy of age control for sedimentary sequences is difficult because it depends on many factors, some of which are difficult to quantify. Nevertheless, the geochronological accuracy of each time series must be assessed systematically to objectively screen the records to identify those that are appropriate to address a particular level of temporal inquiry. We have therefore devised a scoring scheme to rate the accuracy of age models that focuses on the most important factors that determine the overall accuracy. Because some of the detailed geochronology information from previous studies is no longer available, we rely on just the most basic and frequently published information. We focus on three characteristics of dated materials and their downcore trends to assess the overall geochronological accuracy: (1) The delineation of the downcore trend, which is quantified based on three attributes, namely: (a) the frequency of ages, (b) the regularity of their spacing, and (c) the uniformity of the sedimentation rate. (2) The quality of the dated materials, as determined by: (a) the proportion of outliers and downcore reversals, and (b) the type of materials analyzed and the extent to which their ages are verified by independent information as judged by a five-point scale for the entire sequence of ages. And (3) the overall uncertainty in the calibrated ages, which includes the analytical precision and the associated calibrated age ranges. Although our geochronological accuracy score is numerical, we recognize that judging the quality of material and weighting the various factors that influence accuracy can be subjective. We applied the scoring scheme to more than 110 different downcore age models and conducted sensitivity tests to assess the behavior of the score to a range of choices for the weighting factors. While no scoring scheme will be perfect, ours can be used to assign reasonable numerical ratings to the reliability of downcore age models based on a simple, reproducible, and customizable procedure that focuses on the most important factors that determine the overall geochronological accuracy.

Poster

## Biases in the diurnal temperature range in an ensemble of regional climate models and their possible causes

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The study examines how current regional climate models (RCMs) reproduce the diurnal temperature range (DTR) in their simulations of the recent climate over Central Europe. We evaluate 5 RCMs (HIRHAM, REMO, RACMO, RegCM, RCA) driven by two sorts of driving data: perfect boundary conditions (the ERA40 reanalysis, 1961–1990) and a global climate model (ECHAM5). The RCMs' performance is compared against the dataset gridded from a high-density stations network. We find that all RCMs underestimate DTR in all seasons, notwithstanding whether driven by ERA40 or ECHAM5. Underestimation is largest in summer and smallest in winter in most RCMs. The relationship of the models' errors to indices of atmospheric circulation and cloud cover is discussed to reveal possible causes of the biases. In all seasons

and all simulations driven by ERA40 and ECHAM5, underestimation of DTR is larger under anticyclonic circulation and becomes smaller or negligible for cyclonic circulation. In summer and transition seasons, underestimation tends to be largest for the southeast to south flow associated with warm advection, while in winter it does not depend on flow direction. We show that the biases in DTR, which seem common to all examined RCMs, are also related to cloud cover simulation. However, there is no general tendency to overestimate total cloud amount under anticyclonic conditions in the RCMs, which suggests the large negative bias in DTR for anticyclonic circulation cannot be explained by a bias in cloudiness. Errors in simulating heat and moisture fluxes between land surface and atmosphere probably contribute to the biases in DTR as well.

Poster

## How did the late-glacial no-analog plant communities in eastern North America arise? Testing competing hypotheses through model-data comparison

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Dynamic Global Vegetation Models (DGVMs) provide a mechanistic link between past environments and observed vegetation proxies (e.g. pollen), and can therefore be used to identify processes and mechanisms of past ecosystem changes. By comparing model simulations of past vegetation and actual fossil pollen records at 5 sites (Crystal Lake, IL, Appleman Lake, IN, Silver Lake, OH, Anderson Pond, TN, Cupola Pond, MO) in eastern North America, we tested competing hypotheses concerning the drivers of the no-analog plant communities during the last deglaciation.
We parameterized a DGVM, the Lund-Potsdam-Jena General Ecosystem Simulator (LPJ-GUESS) model, with selected key taxa from the late-glacial period using published data. We forced LPJ-GUESS with climate output from the SynTraCE-21 project (a transient climate simulation), downscaled to sites. Simulated plant biomass was converted into pollen composition (accounting for taxon-specific pollen productivity and dispersal ability) to compare with fossil pollen records.
Major competing hypotheses of the control of the no-analog plant communities include: (1) unique environmental conditions and gradients (e.g., different-from-modern temperature seasonality), (2) lower-than-present atmospheric $CO_2$ concentration, and (3) biotic top-down control. We designed simulation experiments of different environmental drivers and their combinations to evaluate the first two hypotheses.
The simulation results show that climate appears to be a major driver for the no-analog vegetation, giving rise to novel plant assemblages at multiple sites during the late-glacial period. Vegetation composition is also sensitive to inter-annual climate variability. Atmospheric $CO_2$ concentration had little effect on vegetation composition. The no-analog plant communities developed at different times at different sites, and with different plant composition. We are currently analyzing spatiotemporal patterns of the simulated no-analog vegetation.
Our study provides a general framework for testing ecological hypothesis over long time scales and similar applications. We acknowledge uncertainties arising from climate drivers, vegetation-model parameters, initial conditions, model process error, and other sources in our model-data comparison. Currently we are testing the relative importance of these sources of uncertainty by conducting (1) climate sensitivity runs, (2) ensemble runs to incorporate parameter uncertainties, (3) simulations with different initial conditions (states after the spin-up), and (4) simulations with other process-based vegetation models.

Poster

## Using data assimilation to estimate the consistency between different proxies and model results

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Multiple proxies and/or the results from climate models can be used to study past climate changes. When these sources of information are utilized together, the proxies often serve to validate the model results while the models aid analysing the processes responsible for the recorded changes. Proxy records and model results can also be combines through data assimilation to produce a reconstruction of the past climate changes that is consistent with a climate model and with the proxies. Additionally, data assimilation can help to understand if the hypotheses proposed to explain proxies variations are compatible between them and with the physics of a climatic model. This can contribute to improve the interpretation of the climatic records based on different archives and model-data comparisons. Here, this method is applied to the mid-Holocene climate using the LOVECLIM model and a dataset including 47 publicly available surface temperature proxies. This dataset is heterogeneous because the proxies come from different authors, different archives and are based on different methodologies and interpretations. When applying it in data assimilation experiments, the constraint is weak and the disagreement between the simulation with data assimilation and the proxies remains large. In other words, the simulation with data assimilation mainly highlights incompatibilities between the proxies and with the model physics rather than producing a shift of the model state in order to be in better agreement with the proxies. Our objective is then to document and understand the origin of these incompatibilities in order to find how improving the consistency between the interpretation of the various proxies and the model results.

Poster

## Model-data comparisons of Holocene treeline dynamics in Fennoscandia and European Russia

***Jesse Morris[1]***, Keyan Fang[1], Heikki Seppä[1], Sakari Salonen[1], Paul Miller[2], Hans Renssen[3]

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The northern high latitudes have warmed considerably in recent decades. One concern with increasing temperatures in this region is that conifer encroachment onto tundra will lower land surface albedo and provide a positive feedback to climate warming (i.e. Arctic amplification). We can look to the past to better understand this potential feedback mechanism. During the middle Holocene, the Arctic forest/tundra ecotone shifted northward of its historical location in response to insolation-driven climate warming. However, to what extent the middle Holocene warming was enhanced by lowering of Arctic surface albedo is not precisely known and requires quantitative evaluation. To address this uncertainty, we use the LPJ-GUESS model to simulate forest/tundra ecotone dynamics in northern Europe over the last 9,000 cal yr BP. Model simulations are compared with proxy-based Holocene treeline reconstructions. In general, the model output and proxy data are in agreement. Treeline advances northward during the warm middle Holocene and then retreats southward in response to cooling temperatures at 3,000 cal yr BP. One notable mismatch occurs in the Kanin Peninsula-region of Russia. Currently available proxy records in this region are sparse and this mismatch may be at least partly clarified with lake sediment cores collected from the Malozomelsk Tundra during summer 2012. This study provides estimates of net changes in land cover albedo, roughness, and radiative properties during the middle Holocene treeline advance. Exploring past forest/tundra ecotone dynamics in northern Europe will help resolve feedback uncertainties in high latitude landscapes elsewhere in the Northern Hemisphere.

Poster

## The importance of external forcing on the climate of the last millennium

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Reconstructions of past climate have shown substantial decadal and centennial scale climate variability in northern hemisphere temperature records, with relatively warm conditions during the 'Medieval Climate Anomaly' and a cold 'Little Ice Age'. Is this variability consistent with our understanding of the magnitude of climate variability and the causes of recent climate change? Here we use multi-model simulations of the last millennium together with a wide range of reconstructions of northern hemispheric temperature to separate climate variability from 850CE to 1950 into changes attributable to external forcing and those due to internal climate variability.
Our results show that external forcing contributed significantly to the long-term temperature variability irrespective of reconstruction used. The recent 50-year and 100-year trend is far outside the range of internal variability estimated from all reconstructions, confirming the highly unusual nature of the recent warming. Many reconstructions show a smaller forced response than the models, but this may be explained by non-linearities in the response of tree-ring proxies.
To estimate which forcings are contributing to this change we use an ensemble of simulations of the HadCM3 model with a combination of different forcings to derive the effect of each individual forcing. In combination with an ensemble of reconstructions which for the first time allows us to account for uncertainty in the reconstructions, we find that the two key drivers of pre-industrial temperature variability are changes in greenhouse gases and explosive volcanic activity and find no evidence of a large solar effect on mean annual northern hemisphere (NH) temperatures over the last millennium. In particular we find that the HadCM3 model response cannot be reconciled with recent estimates of very large solar forcing.

Poster

## Holocene thermal maximum in Europe: Data and model simulations

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The Holocene thermal maximum (HTM) is a relatively warm climatic phase between 11 and 5 ka BP and is of particular interest for climate change research because it represents the closest past analogue for the predicted warmer world. The HTM is commonly associated with the orbitally-forced summer insolation maximum, but proxy-based temperature reconstruction have suggested marked spatio-temporal complexity in the occurrence of the HTM in the northern hemisphere. Here were show that in northern Europe, North Atlantic and the Arctic Region, the proxy-based quantitative climate reconstructions and other palaeoclimatic proxy records demonstrate a distinct HTM with summer and annual mean temperatures generally 1.5-2.5°C higher than at present, but suggest that the warmest summer conditions took place after 8 ka, 2-3 ka later than the summer insolation peak. Climate model simulations driven by orbital and greenhouse gas forcings alone have not been able to capture this complexity in the timing of the HTM. However, these

simulations have not accounted for the fact that the deglaciation of the large icesheets in North America and Eurasia continued for several millennia after the Younger Dryas-Holocene transition. The Fennoscandian Icesheet persisted until 9 ka BP, and the last substantial remnants of the Laurentide Icesheet (LIS) vanished as late as 7 ka BP. Palaeoclimatic model simulations that, in addition to the orbital and greenhouse gas forcings, account for the influence of the early Holocene ice sheets on global climate mimic the proxy-based reconstructions and suggest that the HTM occurred 8-6 ka in the regions directly influenced by the LIS, in the North Atlantic and even in northern Europe. The data and simulations therefore show that the meltwater flux from the LIS and the high surface albedo of the ice sheets compensated for the strongest orbital forcing and caused the delayed warming near the LIS and in northern Europe. In southern Europe, the palaeoclimatic reconstructions and model simulations are less in accordance, with models suggesting markedly warmer early-Holocene than many reconstructions. We discuss the importance of model-data comparisons for understanding the forcings and feedback of past and future warm climates.

Poster

## Triple water vapor isotopic ($H_2^{18}O$, $HD^{16}O$, $H_2^{17}O$) measurements above the Greenland Ice Sheet and importance for interpretation of ice cores

***Hans Christian Steen-Larsen***[1], Renato Winkler[2], Frédéric Prié[2], Amaelle Landais[2], Valérie Masson-Delmotte[2], Camille Risi[3], Barbara Stenni[4]

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Water stable isotopes from ice cores provide highly resolved, well-dated climate information. The archived climate signal is however an integrated signal of the precipitation isotopic composition, which itself is controlled by variations in moisture origin and condensation history. Therefore, in order to correctly interpret ice core isotope records it is of great importance to understand the underlying physical processes of the atmospheric hydrological cycle.
Novel triple water stable isotope measurements ($H_2^{18}O$, $HD^{16}O$, $H_2^{17}O$) revealing both d-excess and $^{17}O$-excess have been carried out on both vapor and snow samples with the aim at improving our understanding of the atmospheric processes affecting ice core isotopic records. This has shed new light on both the super saturation during snow crystal formation and source region conditions. We have therefore for the last four summer seasons since 2009 measured the isotopic composition of the water vapor in continuous mode on top of the Greenland Ice Sheet as part of the NEEM deep ice core-drilling project.
By comparing the observed variability of the in-situ water vapor isotopic composition with general circulation models equipped with isotopic modules we have been able to both validate and point to weaknesses in the modeled isotopic values. We find that the general circulation model (LMDZiso) used here captures reasonably well both variations in absolute humidity and vapor isotope composition. However comparing the observed and modeled d-excess reveals very poor correlation. We understand this as indications for the general circulation model (LMDZiso) having a correct representation of the large-scale atmospheric circulation but having poor sub-grid physics performance especially related to the simulation of relative humidity in the Arctic Ocean boundary layer.
We use back trajectory analysis to relate the origin of the water vapor to its isotopic fingerprint, in particular for the d-excess and $^{17}O$-excess. This leads us to identify Arctic and North Atlantic origin respectively. By combining the d-excess and $^{17}O$-excess we are able to show the effect of multiple sources along the trajectory of the air masses. Using in-situ water vapor isotopic monitoring in the Arctic is shown to be important tools to enhance our understanding of physical processes in the atmosphere and to better evaluate the performance of general circulation models, which can be used to both understand paleo-climate variations and predict future climate.

Talk

## Assimilation of time-averaged pseudo and real proxies for climate reconstruction

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We address the climate reconstruction challenge with a novel ensemble-based filter that assimilates time-averaged observations. Unlike many other climate reconstruction techniques based on data assimilation (DA), our approach follows a standard mathematical framework familiar from weather forecasting, where a prior estimate is updated with information from observations. Here, the prior consists of a training dataset derived from either a model climatology or reanalysis data. We illustrate the utility of our approach by performing several pseudoproxy experiments (PPEs) and several real proxy-based reconstructions. The PPEs are compared against a conventional climate field reconstruction approach that uses Principal Component Analysis. The results reveal that both approaches reproduce global mean temperatures with similar skill, while DA also improves reconstructions around sparsely sampled pseudoproxy locations. Moreover, the DA technique is robust to changes in the prior and produces more consistent spatial reconstructions across different data types, including general circulation model output and reanalysis data. We will also present and discuss DA reconstructions based on weather station and isotope proxy data.

Poster

## Evaluation of historical climate simulation with High-resolution global atmospheric model

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Climate simulations with high-resolution (40-km mesh) atmospheric general circulation model (GCM) have been used for regional detail climate response to observed $CO_2$, sulfate and other greenhouse gas during the historical period. For this long-term climate simulation, we have adopted operational global numerical weather prediction model (GME) of German Weather Service (Deutscher Wetterdienst). It is based on uniform icosahedral-hexagonal grid so it has several advantages to simulate at high spatial resolution relative to spectral methods. So in this study, we have performed GME in high-resolution (40km) and 40 layers using AMIP observed sea surface temperature and sea ice concentration and have reproduced the global climate simulation for historical period (1979~2009). From the results in AGCM, we have analyzed the performance of simulating the past climate in global distribution with observed data like CPC Merged Analysis of precipitation (CMAP), Global Precipitation Climatology Project (GPCP), ERA40 reanalysis dataset. Although seasonal mean precipitation in JJA shows the tropical biases of the so-called double-ITCZ problem, it can reflect the trend of precipitation generally in DJF. And seasonal surface air temperature is also simulated well with the observation. Especially, it is able to capture accurately the response of regional climate changes, it can provide the detailed precipitation pattern for the estimation in the East Asia summer monsoon.

## OSM04: Climate Modes in the Past

Convenors: Ed Hathorne, Nerilie Abram, Manish Tiwari, Thomas Felis

Poster

### Climate variability and warming on the Antarctic Peninsula during the last millennium

***Nerilie Abram[1,2]***, Robert Mulvaney[1], Jack Triest[1,3], Eric Wolff[1], Sepp Kipfstuhl[4], Luke Trusel[5], Francoise Vimeux[6,7], Louise Fleet[1], Carol Arrowsmith[8]

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The Antarctic Peninsula has experienced rapid warming in recent decades, which has led to the collapse of ice shelves and the acceleration of glacial outflow. In this study we present reconstructions of temperature and melt history from a new, highly resolved ice core record from James Ross Island on the northeastern Antarctic Peninsula. We use the deuterium isotope proxy for mean annual temperature, in conjunction with similar records from previously published ice core records, determine the spatial features of climate variability and recent warming of the Antarctic Peninsula and West Antarctic Ice Sheet over the last 200 years. We also present a record based on visible melt layers in the James Ross Island ice core to examine the response of ice melt to changing temperatures on the Antarctic Peninsula over the last 1000 years. Our results demonstrate the role that strengthening of the Southern Annual Mode has played in recent warming of the northern Antarctic Peninsula and show that the El Nino-Southern Oscillation has had a persistent influence on driving interannual and interdecadal temperature variability in this region over the last millennium. Our results also point towards the non-linear relationship between temperature and melt intensity, with implications for future ice shelf and ice sheet stability in this region.

Talk

### Proxy and model evidence for ENSO-mediated coupled Pan-Pacific Drought and Pluvial Modes in North America and Asia

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A network of more than a thousand tree-ring chronologies across the Northern Hemisphere provides precisely dated annual resolution data on past droughts and pluvials spanning the last two thousand years (the Common Era). Hydroclimate reconstructions using these proxies consistently reveal epochs of anomalously dry and wet conditions of substantially greater magnitude and duration than those recorded over the last century of direct observations. Using networks of tree-ring chronologies from North America and Asia, we identify the extent and duration of these events, and link their spatiotemporal fingerprint to large-scale modes of ocean-atmosphere variability. In particular, Pan-Pacific drought and pluvial patterns are linked to interannual and decadal variability in the El Nino-Southern Oscillation, while proxy and climate model evidence show that periods of weak interannual variability in the tropical Pacific coincide with rare but severe periods of synchronous North American and Monsoon Asian 'megadrought' and reveal additional influences.

Poster

### SST and Salinity Variations Associated with ENSO and IOD: Records from Indonesian Corals

***Sri Yudawati Cahyarini[1]***, Intan Suci Nurhati[2], Miriam Pfeiffer[3], Jens Zinke[4], Mutiara Putri[5], Edvin Aldrian[6], Wolf-Chr. Dullo[7]

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The Indonesian maritime region is influenced by interannual climate variability – i.e. the El Niño-Southern Oscillation (ENSO) and the Indonesian Ocean Dipole (IOD), which modulates monsoonal seasonality in the region. These interannual climatic events cause rainfall anomalies that manifest as salinity variations across the Indonesian seas. However, long instrumental salinity record is rarely available; therefore coral-based salinity proxy records are invaluable to provide information on salinity variations across the archipelago. Coral oxygen isotopic ($d^{18}O$) composition is sensitive to changes in both sea-surface temperature (SST) and salinity. When paired with coral Sr/Ca (a SST proxy) and/or available instrumental SST datasets, coral $d^{18}O$ timeseries may be used to derive the $d^{18}O$ of seawater ($d^{18}Osw$) as a salinity proxy by removing the SST component from coral $d^{18}O$. In this study, the reconstructed $d^{18}Osw$-based salinity records from Indonesian corals (from west to east: Simelue, Mentawai, Seribu, Bunaken, Bali and Timor Islands) reveal varying signals of salinity that are associated with ENSO and IOD events. In the west, corals from Simelue at the northern Sumatra show strong monsoonal salinity variations but with no clear ENSO-IOD imprint; while a strong IOD

signal on salinity is evident in Mentawai in southwestern Sumatra. Corals from the central to eastern Indonesia (e. g. Bunaken, Bali and Timor) show stronger ENSO-IOD signals compared to the northern Sumatra corals. Seribu Islands' corals contain clear ENSO-IOD signatures, however with an opposing sign of those observed in the southwestern Sumatra (i.e. Mentawai). This study shows the varying salinity imprints of ENSO-IOD attributes across the Indonesian waters, consistent with analyses of a network of meteorological records from the archipelago that corroborate the spatially complex responses of salinity/rainfall associated with interannual Indo-Pacific climate variability. This stresses the importance of understanding robust climate imprints for conducting paleoclimate studies from any site and timescale in the Indonesian maritime region.

Talk

## Holocene history of ENSO in the Eastern Tropical Pacific reconstructed from Peruvian mollusk shells

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Reconstructing the past behaviour of the El Niño phenomenon and the Southern Oscillation (ENSO) requires seasonally resolved marine proxies from across the tropical Pacific. We present here a Holocene record based on monthly isotopic records of fossil mollusk shells from Peru. Shell samples from radiocarbon dated archaeological middens provided us with statistical estimates of the annual mean temperature, the mean amplitude of the temperature annual cycle, and the variance of this amplitude, which was shown to be an indicator of ENSO variance in the Niño1+2 region. Combining the results from several archaeological sites, a composite record was built to document millennial changes of ENSO-related variability in the Eastern Tropical Pacific. Uncertainties were estimated using Monte Carlo simulations. Although the proxy excludes extreme warm events, significant changes were observed through the Holocene. ENSO variance was lower than today during most of the Holocene. It was ~30% lower than today during the early Holocene, with a short period of higher activity recorded at ~9ka. The distribution shape of ENSO anomalies suggests that ENSO variance may have been shifted to the Eastern Tropical Pacific during the Early Holocene. The period of lowest activity appeared in the middle Holocene with a variance reduction of 40 to 60% compared to the modern variance. This period was also characterized by circulation changes in the Humboldt system and the highest intensity of coastal upwelling. From ~3ka, SSTs and ENSO anomaly distributions were similar to the modern conditions. Our results open a door on long-term variability of ENSO spatial modes, and bring new insights into the relationship between ENSO activity and the global climate.

Poster

## Low frequency variability of the Arctic Oscillation (AO) and ENSO during the Holocene recorded in the spatial pattern of Northern Hemisphere extra-tropical temperatures

***Basil Davis***[1], Achille Mauri[1], Jed Kaplan[1], Christoph Raible[2], Flavio Lehner[2]

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The Arctic Oscillation (AO) and ENSO account for much of the inter-annual to decadal variability of Northern Hemisphere temperatures. A wide variety of proxy-evidence also indicates that these same climate modes may vary over much longer Centennial to Millennial timescales, representing low frequency persistence of the same mode states shown in the high frequency domain. During the Holocene evidence indicates that the mid-Holocene was characterized by an atmospheric circulation comparable with a high index AO, while ENSO evolved from comparatively few El Niño events (La Niña conditions) in the early-mid Holocene, to an increasing frequency of El Niño events in the late Holocene. Importantly, climate models are generally unable to fully capture these changes in the low frequency variability of AO/ENSO but it remains uncertain whether this is due to a problem with climate models or with the interpretation of the proxy evidence. Here we use a new pollen-based gridded climate reconstruction for the North American and Eurasian continents for the last 12,000 years to investigate the low frequency variability of AO/ENSO based on the changing spatial pattern of temperature anomalies. Both the AO and ENSO have a large and regionally distinct impact on Northern Hemisphere temperatures, providing a spatial fingerprint that we use to compare the Holocene record with the spatial pattern of temperature anomalies associated with known AO/ENSO states over the last 100 years. This study provides an independent evaluation of Holocene AO/ENSO interpreted from other proxies, whilst also providing a basis for evaluating the role of the AO/ENSO in Holocene temperature change.

Talk

## Shifts in sea surface temperature on centennial to interannual timescales in the Gulf of Mexico since 1734 CE

***Kristine DeLong***[1], Christopher Maupin[2,3], Jennifer Flannery[4], Terrence Quinn[2,3], Ke Lin[5], Chuan-Chou Shen[5]

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The Gulf of Mexico is a major source of moisture for North America and is a source region for the Gulf Stream, which

transports ocean heat northward; therefore, temperature variations in the Gulf have the potential for wide impacts. Sea surface temperature (SST) variations on centennial to millennial time scales have been documented for this region using paleoceanographic proxies; however, records capable of resolving decadal to interannual variability are lacking. Here we present 275 years of monthly-resolved SST variations derived from records of strontium-to-calcium ratios (Sr/Ca) extracted from three Siderastrea siderea coral colonies within the Dry Tortugas National Park (24°42'N, 82°48'W) in the Gulf of Mexico. We find significant covariance between these records ($r \geq 0.90$, $p \leq 0.05$; monthly) and no significant difference in mean Sr/Ca on any time interval suggesting these corals are recording the same environmental signal. The cross-dated chronology, determined by counting annual bands and correlating Sr/Ca variations, agrees with four $^{230}$Th dates within $\pm 2\Sigma$ analytical precision. Calibration and verification of our compiled Sr/Ca record with local SST records reveals high agreement (Sr/Ca = –0.042 SST + 10.074, $R^2 = 0.96$; $\Sigma_{regression} = 0.70$°C, $1\Sigma$), similar to those reported for single coral records from this location. The average reconstructed SST during the Little Ice Age (LIA; 1734–1880 CE) is colder (–0.79°C) than that during the late twentieth century (1971–2000 CE) with larger decadal-scale variability (1 to 2.0°C) compared to similar scale variability in the twentieth century. The secular trend and decadal-scale variability in our reconstruction are broadly similar to an ~ decadally-resolved (~12 years/sample) Mg/Ca record from planktic foraminifer in the northern Gulf of Mexico, thus further confirming the reconstructed patterns of temperature variability in the Gulf of Mexico during the LIA.

Poster

## Sub-seasonally resolved coral records of northern Red Sea climate during the Holocene and the last interglacial

***Thomas Felis***[1], Norel Rimbu[2], Saber Al-Rousan[3], Henning Kuhnert[1], Martin Kölling[1], Gerrit Lohmann[2]

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The northern Red Sea represents a unique location where ocean currents transport warm tropical waters northward, enabling coral reef growth at unusually high latitudes of up to 29 degrees North. Moreover, one of the world's northernmost complexes of uplifted Pleistocene reef terraces can be found here at Aqaba (Jordan). We present sub-seasonally resolved reconstructions of northern Red Sea surface ocean conditions derived from annually banded Porites corals. The Sr/Ca and delta$^{18}$O variations in the aragonitic skeletons of our modern and fossil coral colonies provide proxy records of temperature, salinity and hydrologic balance at the sea surface during the last centuries and during time windows (40 to 100 years length) of the Holocene and the last interglacial period. Previous work has shown that seasonality and interannual to decadal climate variability in the northern Red Sea as documented in our coral records is strongly coupled to climate variations in the eastern Mediterranean, Middle East and Europe, reflecting the prominent role of atmospheric teleconnections of the Arctic Oscillation (AO)/ North Atlantic Oscillation (NAO) in controlling regional climate on these timescales.
New coral Sr/Ca data, in combination with delta$^{18}$O, reveal an abrupt regime shift toward fresher surface ocean conditions in northern Red Sea surface waters at the end of the Little Ice Age. Possible mechanisms include a re-organization of the Northern Hemisphere atmospheric circulation. Sr/Ca records from a large number of fossil corals indicate a trend of decreasing temperature seasonality over the last 6000 years toward present-day. Such a trend is expected in the higher latitudes of the Northern Hemisphere from insolation changes on orbital timescales. Coral delta$^{18}$O and Sr/Ca records suggest an increased seasonality in the hydrologic balance during time intervals around 4400, 4600 and 6000 years ago, which could result from both enhanced winter evaporation or increased summer precipitation, although the latter is rather unlikely in this arid region. We currently generate century-long delta$^{18}$O and Sr/Ca records from large fossil corals, in order to reconstruct northern Red Sea temperature, salinity and hydrologic balance at sub-seasonal resolution during time windows (up to 170 years length) of the last 2000 to 3000 years, and during shorter time windows of the last interglacial.

Poster

## The Holocene climatic fluctuations in the Ukrainian steppe based on multidisciplinary study of the banded deposits of the lake Saki (Crimea)

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The alternation of dry and wet periods in the Ukrainian steppe during the Holocene was crucial for the changes in economic and settlement patterns of the old societies, and, at present, the re-current droughts greatly impact the regional agriculture. The high resolution data on the Holocene climatic fluctuations are recorded in the sedimentary archive of the lake Saki. Its deposits show fine lamination: dark clay bands (the result of runoff during wet seasons) alternate with white salt layers (summer evaporites). The seasonal origin of the lamination is proved by comparison of pollen assemblages from individual black and white laminae with the seasonal distribution of modern pollen-fall over the lake. The first count of the annual bands (Shostakovich 1934) has shown that formation of the lake deposits started 5444 yr BP, and this is presently confirmed by $^{14}$C dates (5610-5340 cal yr BP). It has been shown (Shvets 1978) that the changes of varve thiknesses in the Saki record correlate fairy well with the runoff of the Dnieper River. Thus, the Saki sedimentary sequence reflects the past precipitation cycles in the main part of steppe belt

of Ukraine. The new study fulfilled within the research project "Palaeogeography and climate of the North Black Sea during the Holocene" includes varve counts, lithology, geochemistry, quartz micromorphoscopy, pollen and palaeomagnetic analyses. Paleosecular geomagnetic variations, together with $^{14}C$ AMS dates, have been also used in order to establish the chronology of the Saki sequence.
The cyclic alternation of warm and cool phases, as well as wet and dry phases during the last 5,500 years has been revealed. This is observed in the pollen diagrams and confirmed by lithology, magnetic mineralogy and distribution of aeolian quartz grains. The duration of a phase alters between 200 and 400 years. The warmest and wettest phase corresponds to the Late Atlantic optimum. The driest phase happened 4050-3750 cal yr BP. The coolest phases occurred ca 1700-1500 and 400-200 calendar yr BP. The correlation between temperature and moisture regime is not direct, but after 5,000 years, the majority of warm phases were drier than the cool phases. The climatic oscillations are seen through the progressive trend to an increase in climatic continentality from the Atlantic to the "Little Ice Age". The climatic phases are compared with the Black Sea level fluctuations revealed by marine geologists (Balabanov, 2007). In general, warm and cool phases coincide with high and low sea stands, respectively.
The climatic phases derived from the Saki record are compared with the changes of material cultures existed in the Ukrainian steppe. The increase in precipitation provided the best conditions for the sedentary economies which possessed elements of plant husbandry (the heyday of the Chalkolithic, the Catacomb, Timver-grave and Sabatinovka cultures of the Bronze Age, the Greek and Byzantine periods). During the dry phases, the ancient agrarian settlements were abandoned, and only nomadic groups exited in the steppe. Thus, the economic pattern in the drought-vulnarable steppe belt was strongly controlled by climatic variability. A strong human impact on the vegetation (pollen of Cerealia, segetative and ruderal weeds, and Juglans from the Greek settlements) appeared ca 750 cal yr BP, and, later on, it regularly increased during wet phases.

Poster

## Recent accumulation rate and impurity seasonality derived from NEEM firn cores

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Chemical ice core measurements reveal information related to climate and atmospheric processes. However, they often also contain noise introduced by glaciological processes, arising from the movement of surface snow by wind driven erosion and re-deposition.
To separate the climate signal from glaciological noise, five 12 m long shallow firn cores, arranged in a square of 10 m side length and one in the centre, have been drilled close to the NEEM camp in Greenland during the field season 2011. They have been analysed with a Continuous Flow Analysis (CFA) system in high depth resolution. Among others, calcium, sodium, ammonium, nitrate, electrolytic conductivity, dust particle numbers, and hydrogen peroxide have been measured. These data allow for a very precise dating using common peak patterns in all firn cores and assuming hydrogen peroxide maxima occurring at summer solstice and minima in midwinter. The time period from 2008 back to the year 1989 is covered by all five cores. A very good covariance of the measured concentrations is found between the five cores. For the mean accumulation rate in the time period between 2008 and 1989 we find 26 cm (water equivalent) $a^{-1}$.
Due to a lack of information, in many firn and ice core studies a constant intra-annual snow accumulation distribution is assumed. However, spares snow height measurements at NEEM and the nearby site "Humboldt" together with model results point to the fact that winter to summer accumulation ratio is about 1:2. Using such an accumulation distribution we can come up with improved constraints on the seasonality of the measured chemical species. Dust particle numbers and calcium concentration peak distinctively in February, shortly after sodium showing its maximum in December. On the other hand, peaks are less pronounced for nitrate with a maximum in April and ammonium with a broad maximum from May to July. Although there are multiple peaks within one year, ammonium shows a very distinctive decreasing flank in August.
In order to understand the seasonality of the measured aerosols monthly statistics of five days back-trajectories using the HYSPLIT model have been derived, providing information about the origins of the air masses which arrive at the NEEM camp. Together with the seasonal cycles of environmental boundary conditions (such as temperature/precipitation in potential source regions, sea ice extent) and the analysis of typical weather patterns, this helps to constrain potential source regions for the different aerosols.

Poster

## Developing South Atlantic Coral Paleoclimate Records from Rocas Atoll, Brazil

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Records describing Tropical Atlantic climate history tend to be located well north of the equator in the Caribbean Sea or on land bordering the Caribbean Sea while most studies of tropical Atlantic climate dynamics focus on the open ocean sector of the tropical Atlantic. Coral-based paleoclimate records have this Caribbean bias in part because the massive species most commonly used for paleoclimate reconstructions either do not extend their range to the southern hemisphere, or they do not grow large on South Atlantic reefs. We aim to remedy this spatial sampling bias by developing robust coral-based

paleoclimate records using the species Siderastrea stellata, one of the common massive reef building corals of the tropical South Atlantic.
The location we are targeting as a first priority is Rocas Atoll (3°52'S, 33°49'W), an uninhabited atoll approximately 300km offshore from Brazil. This exceptional site is isolated from human activity and its distance from the continental land mass ensures no terrestrial influence on the conditions of local reefs
Rocas Atoll's position in the western equatorial Atlantic, makes it ideal for exploring mechanisms and variability in the tropical Atlantic climate system. Sea surface temperature (SST) from our site is significantly correlated to SSTs in a broad swath of the tropical South Atlantic. Multi-century SST records from this site will provide a measure of the spatial extent of tropical Atlantic cooling during the Little Ice Age and hence testing the sensitivity of the tropical Atlantic ocean to radiative forcing. The study site is near the southern-most extent of the mean seasonal ITCZ migration route, making it ideally situated for a study of seawater $\delta^{18}O$ from paired coral Sr/Ca and $\delta^{18}O$ to record changes in the ITCZ. Movements of the Atlantic ITCZ cause drought and floods in the Nordeste region of Brazil. Combining a reconstruction of ITCZ movements over multiple centuries with the tropical South Atlantic SST record and existing tropical North Atlantic SST reconstructions will enable us to explore the roll of cross equatorial SST gradients in ITCZ movement on interannual to multidecadal timescales and test the interpretation of ITCZ-influenced paleoclimate records with terrestrial and Caribbean origins.
Here we report our initial findings including a calibration of the S. stellata paleothemometer and a field report for our National Geographic Society-funded expedition to Rocas Atoll. We conducted a replicated calibration experiment using 3 S. stellata corals collected February 10th, 2008 from Porites pool at Rocas Atoll (3°52'20"S 33°48' 17"W). Coral powders were drilled from each specimen at a rate of 0.5mm/sample (~6 samples/year) for ~20 years. Paired Sr/Ca and $\delta^{18}O$ were measured on each sample. One specimen was drilled at a rate of 0.25mm/sample, to explore the impact of the lower resolution sampling on the calibration. Furthermore, the impact of sampling resolution on the amplitude of the seasonal cycle and hence on the calibration was explored with a numerical model using satellite-based and gridded temperature data. The temporal decorrelation scale of the ocean drives the results, which indicate that some time averaging of coral skeletal material does not substantially reduce the seasonal cycle since the ocean temperatures usually do not change rapidly.

Poster

## Mid-Holocene regional reorganization of climate variability: Analyses of proxy data in the frequency domain

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Recurrent shifts in Holocene climate define the range of natural variability to which the signatures of human interference with the Earth system should be compared. Characterization of Holocene climate variability at the global scale becomes increasingly accessible due to a growing amount of paleoclimate records for the last 9000–11 000 yr. Here, we integrate 124 proxy time-series of different types (e.g., $\delta^{18}O$, lithic composition) and apply a modified Lomb–Scargle spectral analysis. After bootstrapping the data in moving time windows we observe an increased probability for generation or loss of periodic modes at the mid-Holocene. Spatial autocorrelation of spectral changes robustly reveals that this (in)activation of modes was organized in regional clusters of sub-continental size. Within these clusters, changes in spectral properties are unexpectedly homogeneous, despite different underlying climatological variables. Oscillations in the climate system were amplified especially at the upwelling areas and dampened in the North Atlantic. We cross- checked the spectral analysis by counting events in the time-series and tested against possible dating errors in individual records or against an overestimation of singular events. A combination of different mechanisms may have affected the coupling intensity between climate subsystems, turning these more or less prone to oscillations.

Poster

## The Summer North Atlantic Oscillation: Character and teleconnections over the last millennium

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The influence of the atmospheric circulation on climate over the North Atlantic region has been highlighted over the past few decades. The most important atmospheric phenomenon is the North Atlantic Oscillation (NAO). So far, most research regarding the NAO has focused on the winter season. Although it has long been recognised that NAO patterns exist outside winter, it was only recently that conclusive evidence of strong links of the NAO to climate variability over Europe, especially Northern Europe, also in summer was presented by Folland et al. (2009). The summer NAO (SNAO, which focuses on high summer, i.e. July-August) exerts a strong influence on rainfall, temperature, and cloudiness and is related to summer extremes, such as droughts and floods and related phenomena (e.g. forest fires), mainly in Europe but also elsewhere.
In its positive phase, the SNAO is associated with anticyclonic conditions over Northern Europe, yielding sunny, warm and dry conditions. Accordingly, the positive phase of the SNAO is related to summer droughts over Northern Europe, from the UK to Scandinavia in particular, and a northerly position of the main storm

track. In the negative SNAO phase, the storm track moves ~10 degrees (lat) further south, giving cloudy, wet and cooler conditions over the same region. This relationship is more or less the opposite for southern Europe, especially in the eastern Mediterranean. Moreover, it has been demonstrated that the SNAO is related through teleconnections with climate outside Europe e.g. eastern USA and East Asia, and there is strong evidence to indicate that the summer atmospheric circulation is related to global monsoon systems, especially the West African, e.g. the Sahel region. Thus, this weather pattern is associated with climate variability in both heavily populated, but also sensitive regions.
Presently, the longest reconstruction of the SNAO reaches 550 years back in time. This was used to examine long-term relationships between SNAO and European and Sahel drought, as well as teleconnections between a) northern and southern Europe and b) the SNAO and summer climate in East Asia. Here we present a new reconstruction of the SNAO, covering the last millennium. The long-term evolution of the SNAO is discussed, as well as its association with summer climate over Europe. Further, the stability of the teleconnections outside Europe evident from instrumental data is explored as well as possible forcing mechanisms of the SNAO, e.g. the Atlantic Multidecadal Oscillation (AMO), solar variability and Arctic sea-ice coverage.

Poster

## Mid- to Late Holocene temperature and salinity changes in the Southwestern Atlantic

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Most of the paleoclimatic reconstructions from SE South America point to Mid- and Late Holocene climatic changes derived from orbital timescale insolation changes. Other modes of climatic variability are commonly overlooked. Here we present the stacked record of two marine sedimentary records collected in the SE Brazilian continental margin that highlight millennial timescale changes in oceanographic conditions. We measured Mg/Ca ratios and stable oxygen and carbon composition from planktonic foraminifera (G.ruber (pink)), from cores collected in the middle shelf of the SE Brazilian continental margin. The SE Brazilian shelf is under high hydrodynamic conditions related to the meandering pattern and eddy formation corridor of the Brazil Current (BC) which leads to warm and oligotrophic waters. However, during summer, the balance between the BC strength and prevailing NE winds promote the penetration of the South Atlantic Central Water (SACW) into the shelf, enhancing primary productivity with the input of colder, less saline and nutrient-rich waters. Our data presents two negative temperature incursions between 5.5 and 4.5 kyr and from 2.8 kyr towards the Present, accompanied by lower salinities and enhancement primary productivity characteristic of SACW shelf penetration. We propose that these changes are a result of the strengthening of NE winds pattern as a consequence of stronger South Atlantic High system related to the occurrence of higher frequency and intensification of El-Niño like events throughout the Holocene.

Talk

## Regional differences in Indonesian rainfall and their relation to ENSO and IOD mode

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The Indo Pacific Warm Pool is a key evaporative site for the global hydrologic cycle. Modern observational data indicate that both the El Nino Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD) mode exert strong influences on rainfall patterns of Indonesia, and paleoclimate studies have revealed that these systems have varied considerably in the past. To what extent this has been reflected in long-term rainfall patterns in Indonesia, however, has not yet been demonstrated. We present a record of changes in the amount of rainfall over Northwest Sumatra throughout the past 24,000 based on the stable hydrogen and stable carbon isotopic composition (dD and $d^{13}C$, respectively) of terrestrial plant leaf waxes. We examine similarities and differences of our record with respect to paleohydrological reconstructions from Flores and Borneo, and discuss their link to changes in ENSO and IOD mode variability during the late Last Glacial and the Holocene.

Poster

## Coral Records of South China Sea Throughflow's Thermohaline Variations over the Last Century

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As the main conduit of oceanic mass and heat from the West Pacific Warm Pool to the Indian Ocean, the Indonesian Throughflow (ITF) influences Indo-Pacific climate variability. Recent modeling studies and oceanographic measurements however highlight the role of the South China Sea Throughflow (SCSTF), an oceanic current whose flow advects the less dense waters from the southern sector of the South China Sea into the ITF's main pathway during the NE monsoon – thereby slowing down the meridional velocity of the ITF. It is important

to understand the relationship between the interplay of these two ocean throughflows in the maritime region and the regional climate. However, long instrumental salinity record is not available to estimate changes in seawater density. Here, we present monthly-resolved coral oxygen isotopic ($\delta^{18}O$) and Sr/Ca records from the Natuna Islands (Indonesia) in the southern South China Sea over the last century (1923-2011). Coral $\delta^{18}O$ values are sensitive to changes in sea-surface temperature (SST) and the $\delta^{18}O$ of seawater ($\delta^{18}O_{sw}$). We derive sea-surface salinity proxy record by removing the SST component from our coral $\delta^{18}O$ using both coral-derived and instrumental SST data, and subsequently reconstruct past seawater density variations at Natuna. Our seawater sampling confirms the sensitivity of $\delta^{18}O_{sw}$ to salinity variability driven by monsoonal ocean circulation changes in the region. The prevailing SW monsoon winds deliver warmer and fresher waters to our site; whereas colder and more saline conditions during the following season enrich our coral $\delta^{18}O$ values meanwhile the warm and fresh water mass has departed southeastward to interact with the ITF. The monsoonal seasonality of coral $\delta^{18}O$ is modulated by interannual and decadal variability attributed to salinity variations. Natuna SST shows predominant monsoonal variability with a 0.7°C warming trend over the last century, whereas coral-derived salinity record has pronounced decadal variability that masks a moderate freshening trend. We observe a correlated pattern between low density Natuna waters and reduced ITF in the following season; with a long-term trend towards less dense waters in Natuna. High-resolution paleo-thermohaline records from Natuna may improve our understanding on the dynamical links between the Indo-Pacific climate modes (e.g. monsoon, ENSO, IOD) via the interplay of ocean throughflows in the maritime continent.

Poster

## Multi-proxy study of a Lake from mainland Gujarat: Understanding mid-late Holocene climatic fluctuations

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Reactivation along faults during early Holocene resulted in disruption of Orsang River and witnessed formation of several lakes and ponds in the areas occupied by it. Remote sensing data established the presence of palaeodrainages in the area between Dhadhar and Orsang river basins in the central part of Gujarat alluvial plains in the western India. The exposed sediment succession in the lakes and ponds showed thick fluvial sequence overlain by 4-5 m thick lacustrine clays. In order to determine the mid-Holocene climatic fluctuations, and its possible impact on the Harappan culture, multi-proxy studies involving palynology, phytolith, sedimentology, clay mineralogy, isotopes and magnetic mineralogy were carried out on one of the largest lake i.e. Wadhwana lake sediments which falls in the sub-humid climatic zone of mainland Gujarat. The 1.03m sediment profile of Wadhavana lake shows various paleoclimatic phases. A considerable wet phase has been deduced spanning ~6887-~5628 yrs BP based on high phytolith climatic index for cool climate, high kaolinite, high susceptibility values and predominance of moist evergreen pollen taxa. Prevalence of winter precipitation and cool and moist climatic conditions has been attributed to higher winter rainfall activity that correlates well with the lake records of Rajasthan. This indicates that winter precipitation activity was not only confined to eastern Rajasthan as reported earlier, was much more widespread in the larger parts of western India as well, and could have provided conditions ideal for the establishment of early Harappan agricultural base in the region. Change from wet evergreen palynofloral assemblage to moist deciduous and dominanace of smectite over kaolinite during ~5628-4824 yrs BP is indicative of gradual shift from wet climate to seasonally dry monsoonal climate. Appearance of deciduous genera like Madhuca, Terminalia, Mangifera, as well as large number of Ceralia pollen in this phase suggests increased anthropogenic activities as intensification in food production as a response to declining rainfall activity. The onset of aridity at 4800 yr BP in the present study correlates well with the lake records of Rajasthan as well as other regional records indicating mid-Holocene aridity 4800-~3500 yr BP was a synchronous event and was widespread in Indian continent. Changing rainfall conditions could be the cause of shifting pattern in the agricultural subsistence strategy and in turn could be the driving stimulus for the urbanization and deurbanization of Harappan culture.

Poster

## A 65 ka stalagmite paleoclimate record from northern Venezuela: A record of Caribbean climate change

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Three stalagmites collected from Cueva Zarraga in the Falcon Mountains of northwestern Venezuelan were analyzed to determine local paleoclimatic history and help examine climate change in the Caribbean. Stalagmites ages were determined by U/Th disequilibrium and show a nearly complete Holocene record for two stalagmites. A third stalagmite has a record of ~ 65 ka, but has a significant period of non-deposition lasting from the Last Glacial Maximum at 19,820 ± 149 cal yr BP to start of the Holocene at 10,408 ± 78 cal yr BP. A brief resumption of stalagmite growth at 15,409 ± 747 cal yr BP possibly represents the Bölling-Alleröd interstadial. Both carbon and oxygen isotopes preserve quasi-millennial oscillations and show a major depletion shift from the last glacial

period into the Holocene, suggesting warmer and wetter conditions during the Holocene. The preservation of quasi-millennial oscillations and of high frequency multi-decadal changes by the $\delta^{13}C$ indicates that the soil-vegetation-stalagmite system is acting as an amplifier of the climatic signal produced by climatic events and changes. While tempting to attribute $\delta^{13}C$ depletions to decrease of the C4 plant contribution, there is no evidence that the area experienced major vegetation changes. We attribute the $\delta^{13}C$ depletion to enhanced recycling of soil $CO_2$ resulting from canopy effects. The late Pleistocene record shows multiple short-term $\delta^{18}O$ enrichment events that likely correspond to Heinrich events 2 through 5. In the early Holocene, the $\delta^{18}O$ record shows a depletion trend from ~ 11,600, coming out of the Younger Dryas, to 8,000 cal yr BP before reaching the Holocene Thermal Maximum. A prominent $\delta^{18}O$ enrichment event is recorded in all the stalagmites that correspond to the 8200 cal yr BP event. Other short-term $\delta^{18}O$ enrichment events likely correspond to Bond events 1, 2, 5, and 6. The late Holocene record, like other Caribbean records, indicates that the climate system diverges from insolation and may represent an atmospheric rearrangement that resulted in ENSO increase instability or in reduced seasonal movement of the ITCZ.
Today, Cueva Zarraga is at the northern extent of the Inter-Tropical Convergence Zone (ITCZ) and has two rainy seasons. The cooler and drier conditions of the last glacial period suggest a southern displacement of the ITCZ also suggested by Brazilian speleothem records that show anticorrelative trends to Cueva Zarraga. The Cariaco Basin and Cueva Zarraga records show very similar trends, except the timing of the Holocene Thermal Maximum. The Cariaco Basin Ti concentration record suggests that the Holocene Thermal Maximum starts at ~10,000 cal yr BP, while the Cueva Zarraga record suggests a start ~2,000 cal yr BP later, suggesting there is a lag between the erosion leading to the increase in Ti delivery and isotopic composition of precipitation. The close proximity of Cueva Zarraga to Cariaco Basin may allow for a high resolution tropical terrestrial and oceanic climatic response comparison.

Talk

## The Tropical Pacific climate response to the changing forcing over the last glacial cycle

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The response of the tropical Pacific to orbital forcing is poorly understood. This is the result of the relative complexity of modelling the tropical climate which requires full complexity global models. Such full complexity models do not, however, lend themselves to long integrations over orbital time scales due to the vast computer resources needed. Studies have shown how the mean state and interannual variability of ENSO vary with changes in orbital forcing but the results are conflicting and the models used have serious short comings. We shall present results from a full complexity GCM, HadCM3, which contains all the processes that could change the mean state and interannual variability (ENSO) on long and short timescales and therefore overcomes the flaws in previous studies.

We shall show results from a suite of model simulations, run as a series of snapshots over the last 120 thousand years that not only vary the orbital forcing but also the greenhouse gas forcing and the presence of Northern Hemisphere ice sheets. These are varied in three sets of simulations that vary the orbital forcing alone, the orbital and greenhouse gas forcing and all the forcings together. With these three sets of experiments we can unravel how the tropical Pacific climate varies over the glacial cycle.

We shall show that changing the orbital forcing causes the annual mean temperature and ENSO to vary and both are paced on precessional timescales. Although this is in agreement with previous studies we do not find that the previously proposed mechanism is responsible for the change in the full complexity model. We find that the effect of greenhouse gases on the annual mean temperature dwarves the effect of orbital variations but that ENSO variability is unaffected by the mean state change, and is once again paced by the precessional cycle. The presence of ice sheets has little impact on the annual mean temperature in the tropics but causes a dramatic increase in the variability of ENSO.

Poster

## Relationship between the variations of the location of the ITCZ in the West Pacific and ENSO in different climatic contexts

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Improved understanding of the relationship between interannual variability and the mean climate state is an important issue for anticipating possible changes due to the current global warming. In the tropical Pacific, the interannual variability is mainly driven by the El Niño/ Southern Oscillation (ENSO). Its future evolution raises lots concerns given its strong economical and health consequences. We consider past simulations for mid Holocene, last glacial maximum, and future climate scenario were the carbon dioxide multiplied by four performed as part of the PMIP3/CMIP5 with the IPSL model to investigate the characteristics of ENSO in these different climate, as well as the relationship between the fluctuations of ENSO and the location of the South Pacific Convergence Zone (SPCZ). The results show that event though ENSO is a dominant component of the tropical variability in each simulation its characteristics are significantly modified depending on the climate context. The west Pacific is a region were differences between the climate periods are the largest, which can be related to changes in the intensity and the structures of the atmospheric cells – especially the Walker cell. The

changes in the mean state have also implications on the location of the SPCZ. However the teleconnections between the fluctuations of the SPCZ and the strength of El Niño events vary from one climate to the other in the IPSL simulations. This will also be investigated considering the ensemble PMIP3/CMIP5 simulations available for these three periods. Implications for model data comparison using coral data located in the west Pacific as proxy indicator for ENSO variability will also be discussed.

Poster

## High resolution climatic record from the Kumaun Himalaya: A speleothem study

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A high resolution record of climatic fluctuations of multi-annual to decadal scale high resolution stable isotope ($\delta^{18}O$) data is obtained from U/Th dated stalagmite from the Eastern Kumaun Himalaya. The $\delta^{18}O$ and $\delta^{13}C$ values varying between -4.31‰ to -7.61‰ and -3.44‰ to -9.1‰, respectively- this record suggests shifting of a warm period of the Medieval Warm Period (MWP) to a wet phase corresponding to the Little Ice Age (LIA) and a post-LIA drier phase. Speleothem record starts around 200 AD (1,800 yr BP) that shows evidence of wet conditions, which is succeeded by the reduced precipitation with a brief but prominent dry spell around AD 250-335. The large-amplitude variations in $\delta^{18}O$ between AD 335 and AD 535 point to a variable climate, with prominent phasess of weaker precipitation around Ad 430 and 460. The precipitation trend shows variations between AD 535 to 1200, indicating warm conditions during MWP and followed by variability in $\delta^{18}O$ between AD 1200 and AD 1320, suggesting climatic deterioration. A warm and wet phase during MWP and a wet phase during the LIA are indicated by the $\delta^{18}O$ values, which agree well with some of the earlier studies in similar latitudes. However, such trends from here do not correlate with the records, from the continental areas dominated by the Indian Monsoon. This may be due to the possible variations in precipitation patterns in both the areas as well as due to the shifting of the Inter Tropical Convergence Zone (ITCZ) and also due to the relative regional dominance of the Westerlies in the Himalayan region.

Poster

## Late Quaternary climatic signals from the Kumaun lesser Himalaya: Evidence from a fluvio-lacustrine deposit

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We are able to make a reconstruction of Quaternary climatic changes from the stable isotopic data ($\delta^{13}C$) obtained from a sedimentary profile of a fluvio-lacustrine basin fill near Dwarahat Village located in the Kumaun central Himalaya. The profile shows multiple phases of extreme events like LGM, Older Dryas (OD) and Younger Dryas (YD). The values of Carbon Isotopes vary from -23‰ to -14‰ marking the shifts in vegetation pattern through different stages. The lower part of the profile dated at 21197±329 yr BP is dominated by C3 vegetation, indicating warm and moist conditions. A gradual shift from C3 to C4 vegetation occurred around 20,000-18,000 yr BP, indicating cold and arid climate during LGM. The post LGM period was marked by an increasing trend in C3 plants which lasted for about 2000 years. Around 16000 yr BP, the C4 plants started to dominate, reflective of cold drier conditions, which correspond with general climatic conditions of Older Dryas. The values of $\delta^{13}C$ show a depleting trend after ~16,000 yr. BP. representing moderate to warm and moist conditions. The period of warm moist period is succeeded by arid conditions as evidenced by $\delta^{13}C$ value of -12‰. This shift from warm moist condition to an arid phase coincides with Younger Dryas ~11,000 yr BP. The upper part of the profile is dominated by an increasing trend of C3 vegetation, demonstrating the warm moist conditions towards the beginning of Holocene.

Poster

## New insights on last glacial ice-sheet dynamics and retreat deduced from Southeastern Weddell Sea sediment

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Ice-sheets are very sensible to climatic, especially temperature changes. In particular, the transition from the Last Glacial to the recent Interglacial is of main interest for scientists to predict future climate changes. The timing of the final East Antarctic Ice Sheet (EAIS) retreat at the end of the Last Glacial is still only partially understood. Deep-sea sediments from the Antarctic continental margin, SE Weddell Sea, can help to reconstruct glacial ice-sheet dynamics. The cores (e.g., PS1791-2, PS1795-2) originate from up to 300m high and up to 100 km long sediment ridges located on a terrace of the continental slope in 2500-3000 m water depth, with a channel running SE of each ridge. During the Last Glacial Maximum (LGM) when the grounded EAIS margin advanced to the shelf break, coastal polynyas formed, which were enhanced by intensified katabatic winds. This led to more sea-ice formation, which induced brine rejection. The produced dense, high salinity water masses sank down the continental slope, reworked sediments and drained as contour currents into the channels and deposited

material on the ridges. These sediments are fine-grained siliciclastic varves related to seasonal velocity changes of the contour current during the LGM. The silty layers are interpreted as overspill sediments, deposited on the ridges during glacial winter, because of intensified thermohaline convection, induced by enhanced sea-ice formation. Clayey layers were accumulated during reduced thermohaline convection in the glacial summer, due to less sea-ice formation. These sediment varves are interrupted by bioturbated sediments, which were deposited during open-water conditions with less thermohaline convection, requiring an ice-sheet retreat. We used the BMPix and PEAK tools for automated varve counting and to gain more information about the thickness differences between the individual varves and their deposition time frame. In addition to that spectral analysis on the thickness variability of the varves through time reveals that sunspot cycles, e.g., the Gleissberg cycle (period near 87 yrs), are preserved in the sediment. Furthermore, sediment component analysis, mainly to identify ash layers, and physical dating methods (e. g., AMS$^{14}$C, $^{40}$Ar/$^{39}$Ar on ashes) lead to the identification of chronostratigraphic marker horizons, which can help to correlate the sediment cores among each other and even with EDML ice core. This allows for a better understanding of the glacial ice-sheet dynamics during Marine Isotopic Stage 3. Also, the stratigraphic evidence from the sediment ridges can be used to evaluate the timing of the final ice-sheet retreat and potential asynchronies between the East and West Antarctic Ice Sheets.

Talk

## Historical mega-droughts in the medieval Levant and Nile Valley

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Climate models predict that subtropical regions will become more arid with the rise of atmospheric greenhouse gases and the associated "global warming", a prediction that will impact millions of people. This future is set in a backdrop of the paleohydrological history of these regions, which displays protracted warm and arid periods. Here, we focus on the time interval of the Medieval Climate Anomaly (MCA), which extended from the mid 10th to the early 14th centuries AD and was characterized by overall warmer global temperatures and arid conditions in the subtropics. This prolonged, multi-centennial epoch was perturbed by shorter climate cycles whose precise reconstruction and comparison with contemporaneous global climate archives is crucial for understanding mechanism of climate variability and change in the subtropical regions. The regional geological records are generally crude and imprecisely dated, lacking the details needed to accurately portray the patterns of sub-millennial fluctuations, and they also lack direct, contemporaneous information on climate-related societal impacts. We examine historical documentary evidence, which portrays a coherent pattern of medieval droughts in the subtropical Levant and Nile-Valley. Sever droughts occurred in the Levant between 1100 and 1250 AD following in the wake of a century of droughts in Nile-Valley. This time sequence is consistent with the anti-phase hydroclimate relationship between the east-African monsoon and Levant rainfall seen in the instrumental record of past century, confirming a ubiquitous pattern of multidecadal, subtropical hydroclimate variability that points at a link to the North Atlantic. Notably, this pattern is disrupted by abrupt aridity across the entire Afro-Asian subtropical belt at the beginning of the 14th century, which coincides with the Wolf solar minimum and the transition to the Little Ice Age.

Poster

## Indian Ocean dipole mode and its relation with the Indian summer monsoon variability at multi-centennial to millennial timescales

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One of the major modes of tropical climate variability is the Indian Ocean Dipole (IOD) that affects regions in and around Indian Ocean. The positive IOD mode events are tightly coupled with the strong zonal easterly wind anomalies that prevail over the weak annual westerly component. A few studies have reported multi-decadal variability in IOD mode – early decades (1880-1920) show dominance of negative phase while dominance of positive phase has been reported for later years (1960-2000) – based on recorded meteorological data spanning past ~150 years. As far as Indian summer monsoon (ISM) is concerned, short-term climatological studies have shown that positive IOD mode events tends to increase the ISM rainfall. But the full magnitude of IOD mode variability and its relationship with ISM at longer multi-centennial to millennial timescales cannot be grasped using such short time series data. To look in to this aspect, we analyzed the sediment core, BP 13/A (length: 590 cm; water-depth: 3700 m), from the southwestern tropical Indian Ocean (SWIO). This region is important as it is swept by south-easterly winds during summer, which are the main causal factor behind development of positive IOD mode events. Productivity in the region will increase during periods of stronger south-easterlies due to wind induced mixing/ moderate upwelling. We analyzed oxygen ($\delta^{18}$O) and carbon ($\delta^{13}$C) isotopic abundance of two depth-stratified species of planktic foraminifera namely Globigerinoides ruber and Globorotalia menardii. The core spans from ~45 Kyr BP to 187 Kyr BP - a period of ~140 Kyr that includes parts of Marine Isotope Stage (MIS) 3 to MIS 6. We find that the warmer periods (identified from $\delta^{18}$O values) were persistently characterized by stronger south-easterlies (inferred from higher $\delta^{13}$C values indicating enhanced productivity) implying increased positive IOD mode events at millennial timescales. Spectra of IOD events is dominated by precessional cycle indicating insolation changes due to the varying Sun-Earth geometry as the

major forcing factor on such long timescales. We compare our 140 Kyr long record with that of Indian Summer Monsoon (ISM) variability reconstructed by Clemens & Prell, 2003, Marine Geology 201, 35–51). We find that positive IOD modes were consistently accompanied by stronger ISM on millennial timescales possibly due to enhanced monsoonal-Hadley circulation and atmospheric instability due to higher SST in the SWIO as suggested by climatological studies. Coupled Atmosphere-Ocean General Circulation models (FOAM and NCAR-CCSM1) have suggested swing towards positive IOD mode during early to middle Holocene – a period characterized by higher warmth and stronger monsoon than present. Our result of increased positive IOD events during warmer periods corroborates it.

Poster

## Sub-centennial to centennial scale changes in productivity in the Eastern Arabian Sea: Implications to the Indian summer monsoon variability since mid-Holocene

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Previous millennial scale studies in the coastal eastern Arabian Sea have revealed that surface productivity is governed by the Indian summer monsoon (ISM) induced upwelling and/or influx of nutrients via surface run-off. But very little information, covering only past few hundred years, is available on centennial scale variability of productivity from this region. We present here a sub-centennial to centennial scale study using a sediment core, SN-6, from oxygen minimum zone (OMZ) of the Eastern Arabian Sea (EAS) (length: 36 cm; water depth: 589 m; sampled at every cm). The chronology of the core is based on five AMS radiocarbon dates at an average resolution of 9 cm; the top is dated to 216 ± 44 Ka (1$\Sigma$) while the full core spans the last ~4800 yr. The sedimentation rates observed for the top 11 cm is 16.2 cm/kyr yielding a sub-centennial scale resolution of ~62 yrs per sample while the average resolution is 127 yrs/ cm. Total Organic Carbon content (% TOC), and carbon isotopic abundance ($\delta^{13}C$) of sedimentary organic matter (SOM) were determined on acid-treated samples (1 N HCl using 'Rinse Method'). Since the core is from the OMZ therefore the affects of diagenesis and bioturbation are minimal. The OMZ leads to intense denitrification in the water column manifested in nitrogen isotopic abundance ($\delta^{15}N$) of SOM. We therefore also measured the $\delta^{15}N$, and Total Nitrogen (% N) throughout the core in untreated samples as studies have shown that acid pre-treatment may randomly alter the values. C/N ratios were calculated to look at the source of the organic matter. We find that C/N ratio varies from 12.7 to 16.1, which is indicative of marine organic matter (upwelling-induced) with some terrestrial influx via surface run-off during the ISM season due to its coastal location. The carbon isotopic composition corroborates it, which varies from -20 ‰ to -21 ‰ indicative of marine phytoplanktons and slight contribution from terrestrial organic matter ($C_3$ plants: -27 ‰). We find that the % TOC and % N contents vary from 4.7 to 7.5 % and from 0.5 to 0.3 % respectively. As evident from the % TOC, SOM is very well preserved at this location due to the overlying OMZ. Productivity proxies reveal that ISM intensity rises from the base of the record (4.8 Ka) till 4.2 Ka and decrease slightly thereafter till 3.6 Ka. Subsequently a sudden increase in its intensity is followed by a shift to lower productivity/ISM strength till 2.9 Ka. Then the ISM intensity exhibits an increasing trend till 0.7 Ka. Thereafter it declines slightly concurrent with the periods of TSI minima viz. Maunder, Spörer, and Wolf. This was a period when Europe was experiencing Little Ice Age. Interestingly this high-resolution study reveals that ISM also weakened during that time-period indicating a strong connection between the northern high-latitude and tropical climate system. Earlier studies from eastern Arabian Sea have found such a teleconnection on millennial to sub-Milankovitch timescales. But the present multi-proxy study implies that this teleconnection was active even on timescales as short as sub-centennial.

Poster

## Response of planktic foraminifera to oceanic environmental changes during cenomanian - Turonian transition in SE India

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The Cretaceous period had been significant in the geological history of India with major marine transgressions that left the marine sediments in parts of southeast India. The present investigation deals with the response of Planktic foraminifera to oceanic environmental changes during Cenomanian-Turonian Period in Southern India. The Middle Cenomanian to Early Turonian interval is traditionally characterized by four planktic foraminiferal biozones. These zones in the ascending order as follows: Thalmaninella reicheli Total Range Zone, Rotalipora cushmani Total Range Zone, Whiteinella archeocretacea Partial Range Zone, Helvetoglobotruncana helvetica Total Range Zone. They are based on the First Appearance Datum (FAD) and Last Appearance Datum (LAD) of marker species and their ranges. Rotalipora cushmani zone is characterized by a stepwise extinction of major species such as Thalmaninella appenninica, Thalmaninella greenhornensis, Thalmaninella reicheli and Rotalipora cushmani.

The results of our study confirm the Late Cenomanian Extinction Event is "Step wise" in the study area unlike it was sudden/ mass extinction in some regions in Europe and America. The planktic foraminifera are abundant and diversified, especially keeled species appear with complex tests, such as Thalmaninella appnninica, Thalmaninella greenhorensis, Thalmaninella reicheli. The globular morphotype Whiteinella spp. would indicate more or less oxygenated water mass near sea. Dicarinellids evolved and successfully adapted to the new conditions, and their competition probably hastened the demise of the rotaliporids. H. helvetica appeared only

when fully oligotropic and oxic conditions throughout the water column were restored. More oxygen in the sea – water column, linked to the transgressive pulse of Lower Turonian, lead to the restoration of bio-diversity with a re-development of new complex morphotypes of planktic foraminifera such as Marginotruncana and Helvetoglobtruncana helvetica. Eventually oxygenated environment were recovered from Helvetoglobtruncana helvetica zone mainly in shallow water. However, this biotic turnover is not a major mass extinction as most species survived in refugia (is a location of an isolated of a once more wide spreads species) and returned when the oceanic conditions improved.

## OSM05: Abrupt Changes and Extreme events - Assessment and Risks

Convenors: Ray Bradley, Pierre Francus, Manfred Mudelsee

Poster

### Abrupt climatic events in continental Europe during MIS 5 (Early-glacial / 112-70 ka): Highlighting a new reference record at Dolni Vestonice (Czech Republic)

***Pierre Antoine***[1], Denis-Didier Rousseau[2], Markus Fuchs[3], Sebastian Kreutzer[3], France Lagroix[4], Olivier Moine[1], Christine Hatte[5], Caroline Gauthier[5], Jirí Svoboda[6], Lenka Lisa[7]

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High-resolution multidisciplinary investigation of key European loess-palaeosols profiles have demonstrated that Last glacial loess sequences result from rapid and cyclic aeolian sedimentation which is reflected in variations of loess grain size indexes and correlated with Greenland ice-core dust records. This correlation suggests a global connection between North Atlantic and west-European air masses. During the Last glacial, the Early-glacial period (± MIS 5d to 5a between ~ 112 and 70 ka), is a key-period recording the complex transition between the Last Interglacial (Eemian) and the first evidences of periglacial conditions (Weichselian) occurring at about 65 ± 5 ka as indicated by the deposition of the first typical loess. This long (~ 30 ka) and complex period is characterised by the occurrence of rapid and cyclic climatic changes: seven stadial-interstadial cycles, including long (8-10 ka) and very short interstadial periods (1-2ka). During this time-span, a progressive shift from oceanic temperate conditions to continental steppic environments has been evidenced in a large number of European pedo-sedimentary sequences. This evolution, especially well recorded in humic soil complexes from European loess sequences, is characterised by a succession of steps, each registered as a distinct soil horizon, and indicating more and more continental environmental conditions (alternation of humic soil horizons / colluvial deposits and aeolian silt layers). In this context the famous Dolní Vestonice loess sequence, located in the Moravian region of the Czech Republic, exhibits an exceptionally well-preserved soil complex composed of three chernozem soil horizons, two intermediate colluvial-humic soil horizons and five aeolian silt layers (marker silts). This soil complex has been investigated and sampled by our team for continuous high-resolution record of grain-size, magnetic susceptibility and organic carbon $\delta^{13}C$ (as the whole 15 m thick Last Interglacial-glacial sequence). A new set of quartz OSL ages has provided, for the first time, a reliable and accurate chronology of the sequence's main pedosedimentary events. According to these new data and OSL dating results the Dolní Vestonice humic soil complex is, at present, the most complete record of environmental variations and dust deposition (dust storms) in the European loess belt for the Weichselian Early-glacial period spanning about 110 to 70 ka. These results allow to propose accurate and reliable correlations between the pedo-sedimentary sequence and various global palaeoclimatic records. OSL ages combined with sedimentological and palaeopedological observations lead to the conclusion that this soil complex registered all of the main climatic events expressed in the North GRIP record from Greenland Interstadials (GIS) 25 to 19.These new data clearly demonstrate that continental environments reacted very rapidly to the succession of short climatic events during this long and complex transition period of the weichselian Early-glacial.

Talk

### The Indian Monsoon anomaly at 4k; dynamical analogs and cultural implications

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Widespread evidence from a number of locations throughout the Northern Hemisphere indicates the presence of a spatially expansive climate anomaly at 4,100 years BP. The climate anomalies appear within dating uncertainty of a number of major cultural changes across North Africa, the Middle East and South Asia including the de-urbanization of the expansive Indus Valley and Harappan societies of India. While climate change has long been considered a plausible explanation for the cultural changes at this time, there has hitherto been no strong evidence of changes in Indian Monsoon precipitation during this period. Furthermore, significant reductions in the flow of the major rivers of the region associated with reduced winter snowpack, significantly predate the cultural changes and therefore cannot plausibly be causally related. In this paper, a new ultra-high resolution stalagmite record from Northeast India is presented that shows the Indian Summer Monsoon experienced an excursion at 4,100 years BP whose magnitude and duration exceeds anything experienced during the entire Holocene. We present this record and discuss caveats associated with quantitatively interpreting water isotope records from India. In order to forward an understanding of the dynamics that lead to the weakened monsoon during this period, we present satellite isotope retrievals and a series of water tagging experiments with a general circulation model during recent monsoon droughts. These two tools used in conjunction shed light on how the monsoon moisture budget shifts during droughts and how these changes become manifest in

regional isotope proxy records. The discussion of modern monsoon dynamics focuses on the large monsoon drought of 2009, which was the fifth largest of the instrumental period and one that serves as a powerful modern analog to the monsoon changes at 4,100 years BP.

Poster

## Analysis of tree-ring data of fir (Abies densa) in relation to climate vis-à-vis movement of Zemu glacier, Eastern Himalaya

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Glaciers in the Eastern Himalaya region provide water resource for the vast population of the mountains and surrounding lowland of Indian subcontinent. Their recent rapid melting is cause of much worried as it linked with the fate of these glaciers. We are much concern to know how they would respond with the global warming associated with erratic monsoon variability. We analyzed tree-ring data of fir (Abies densa) trees growing at the tree line zone close to snout of the Zemu glacier, North Sikkim of this region and established the relationship between tree growth, climate and glacier movements of this region. Analysis of tree growth climate (Response Function analysis) shows that temperature during pre monsoon (Feb-April) and late summer (June-September) have positive and negative role respectively with the tree growth of this region. Moreover, a negative relationship has also been recorded between tree growth and known record of glacier movements. We observe tree- ring width index are low during AD 1988-2000, the period of advancement of glaciers and higher during 1976-1978, 2001-2005, the periods with the rapid retreat of glacier. Based on these observations our tree-ring record of 250 yrs from this site provides new insight towards understanding the dynamic behavior of the monsoonal glacier in the Eastern Himalaya in relation to climate.

Poster

## Abrupt Climate Change- Past and Present and Future Meet

***Peter Carter[1]***

[1]Climate Emergency Institute

We present a simple approach to determining possible abrupt climate change in the present period using evidence from the past and future commitment today. From pale-climate evidence it has been determined that the rate of atmospheric carbon dioxide is unprecedented. Carbon dioxide is being added to the atmosphere 14000 times faster than natural processes can remove it. Carbon dioxide has contributed to at least 50% of global warming. The increase in radiative forcing of an atmospheric greenhouse gas correlates directly with its atmospheric concentration and is a far better indicator for abrupt change than global average temperature increase, because it is the heat energy in the entire climate system that lead to abrupt climate change. The only offset to this atmospheric greenhouse gas forcing is from fossil fuel air pollution aerosols. However, because of the definite zero carbon requirement to stabilize global temperature and climate, this hidden forcing will definitely be unmasked, and may be considerably greater than today's working estimate. From these well-established facts of the science we can conclude we are committed to abrupt climate change. This is further supported by the finding that atmospheric $CO_2$ is the highest in at least 15 million years and by a current acceleration in $CO_2$ emissions. What about the other greenhouse gases? Methane has contributed the most warming after carbon dioxide. At two and a half times its preindustrial level methane's atmospheric concentration has been assumed to be unprecedented. It is more than double its limit over the past 800,000 year ice core data with a rate of increase faster than carbon dioxide. Although methane only lasts in the atmosphere 12 years is in partly oxidized to carbon dioxide increasing the forcing of methane emissions. We conclude that atmospheric methane increases the commitment to abrupt climate change. The next factor in commitment to abrupt climate change is positive feedbacks. We know from the pale-climate record that natural warming tends to be abrupt and may be extremely abrupt. We know that the warming is driven by positive feedbacks, loss of ice sheet albedo, methane feedback and $CO_2$ feedback. The most sensitive of the gases for natural feedback, by orders of magnitude, is methane. Since 2007, methane having leveled off since 2000, is now on a fast sustained increase- due this time to feedback emissions. We conclude this methane feedback situation is established and it will increase with the future time and degree of warming, greatly increasing commitment to abrupt climate change. The Arctic summer sea ice is collapsing, which is a strong feedback to warming due to loss of albedo and latent heat of ice. This will greatly increase the rate of Arctic methane emissions as well as directly increasing global warming. Arctic sea ice collapse therefore increases commitment to abrupt climate change. Finally, even without the Arctic feedbacks, we are committed to an unavoidable increase in global warming that is 3°C by 2100 (research evidence is included in the paper). We conclude we are today committed to abrupt global climate change which is a planetary emergency situation.

Talk

## Extreme Events: Himalayan Floods

***Shipra Chaudhary[1,2]***, Y.P. Sundriyal[2], Navin Juyal[3], R. J. Wasson[4]

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Floods are caused by weather phenomena and events that deliver more precipitation to a drainage basin than can be readily absorbed or stored within the basin (USGS). In Himalayan region breaching of landslide lake is an unrecoverable natural calamity that creates great havoc downstream by generating floods, which flushes out everything on its way in just few minutes without warnings. One classic example of flood prediction and warning is exemplified from 1894 Gohna lake outbust, Alaknanda valley, Garhwal Himalaya. Gohna lake was formed in 1893 in Birahi ganga valley (Alaknanda tributary) due to a massive landslide, which first got breached in 1894. This lake was continuously monitored by an engineer of British India since its formation to breaching. Two days before its breaching the warning was sent to administration, as a result no life claimed although 10,000 cubic feet water was released, which lowered the level of the lake by 390 feet and completely washed out Srinagar township. The same lake busted fully in 1970 and due to lack of monitoring and awareness it became one of the most tragic event in the Alaknanda flood history.
The flood deposits of 1970 were traces throughout the Alaknanda valley by Wasson et al, (2008). Considering 1970 flood deposit as a marker, in the present study we have found eleven (11) flood units below the 1970 flood unit. This sequence of flood deposits can be used to establish a preliminary flood cycle in the valley. Although in the high gradient Himalayan river it is very difficult for the flood deposits to get preserved for several years, but the possibility of their preservation increases when they deposit in a low gradient tributary mouth.
The study area is located in Lesser Himalayan part of Alaknanada valley near Srinagar (78°41′01.14″E; 30°13′19.96″N). The deposits are preserved in a tributary mouth at 511 msl and 60 m inlandward. The bottom most deposit is dated as 597±71 yrs although the sequence is topped by 1970 flood deposit. Based on these ages it can be inferred that the valley experiences major flood once in every 50 yrs. Samples for OSL dating have been collected from each unit. Units can be differentiated on the basis of sharp upper and lower boundaries. Individual unit can be differentiated as fine sand or fine sandy clay in the upper few centimeters (the result of waning flood flows) overlying parallel laminated (upper flow regime), ripple laminated (lower flow regime), or massive fine to medium sand with some coarse sand (rapid deposition).
Obtained ages of individual flood unit and a hydraulic model will be discussed in the conference. In addition to this climatic changes in past 1000 years will be presented which will throw light on the relation of flood with climatic cycle.

Poster

## Abrupt changes in lake sediment properties are not always reflecting regional abrupt changes: Example from varved Lake Yoa, Northern Chad.

***Pierre Francus***[1], Hilde Eggermont[2], Dirk Verschuren[2], Stefan Kröpelin[3]

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Some indicators reflecting the evolution of the aquatic environment of this groundwater-fed lake display two main abrupt changes. First, quantitative salinity inferences based on fossil chironomid assemblages indicate a fresh-to-saline transition that occurred fairly abruptly between 4100 and 3400 cal BP. However, the timing of the fresh-to-saline transition in Lake Yoa is strongly influenced by the progressive decrease of massive groundwater inputs, and increase in salinity is most probably reflecting the threshold from an hydrologically open lake to a close system. Second, neoformed calcite forming the summer component of the varves abruptly disappears after 1050 cal BP. However, geochemical model predicts that the dilute fossil groundwater springing at Lake Yoa, assuming stable groundwater geochemistry through time, should evolve into a hypersaline brine depleted in Ca and Mg following their precipitation caused by continuously strong evaporation. On the other hand, other aquatic indicators and all terrestrial indicators of the environment all point to a progressive drying of the Sahara since 6100 cal BP. The pollen record showed a more progressive decrease of tropical tree species between ~5600 and 4300 years ago, and further gradual desiccation of the landscape until today's desert environment was formed 2700 years ago. The gradual decrease of clay content over the entire core and changes in clay composition indicate the progressive exhaustion of clays formed in Early Holocene soils of the surrounding landscape, as well as the transition from a humid towards a hyperarid landscape. There is also a simultaneous and steady increase of indicators of aeolian input, i.e., fine sand, reacting to the progressive loss of vegetation cover and thus to increasing material availability.

Poster

## 4100 years long tree-ring record of extreme temperature events in the Yamal Peninsula

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Extreme climatic events have a strong effect on the functioning and stability of ecosystems. The promising method of climatic extreme reconstruction in times before the advent of instrumental meteorological observations is the analysis of anomalous structures in tree rings.
At present, we have 7000 years long ring width chronology of *Larix sibirica* Ledeb. for the Yamal Peninsula. Samples from dead trees have been used to prolong chronology beyond the age of the oldest living trees (400-500 years old). Greatest proportion of these trees are made up of *Larix sibirica* Ledeb. (95%) and *Picea obovata* Ledeb. (4%). The collection of subfossil wood samples was carried out in the basins of small rivers that traverse the plain located between 67°00'and 67°50'N and 71°00'E. The determination of calendar dates of tree-ring formation was carried out by cross dating with preexisting

ring-with master chronology.
In contrast to ring width, growth anomalies are produced by very short-term events, and in some cases they occur within seasons that were not reconstructed as cold using ring-width data. Three types of micro anatomical traces of larch and spruce have been used for the reconstruction of such short extreme temperature events, namely, frost-damaged layer of cells (frost rings), thin-walled latewood cells ( light rings) and wood density fluctuations (false rings). To reveal the relationship between the formation of anomalous structures and climatic parameters, we used meteorological data obtained at the Salekhard station (1883-2000), which is located 150-200 km southwest of the research area. A typical frost ring in a coniferous species consist of underlignified, deformed tracheids, collapsed cells and abnormal tracheids. Frost rings appear in the period when the air temperatures drop to subzero values during cambial activity and xylem cell grows (in Yamal during 20 June to 20 July). 1.1% larch and 1.2% spruce tree-rings were damaged by frost.
Light rings contain thin-walled latewood cells. In the subarctic zone light rings may be formed as a consequence of cool and short summer, especially the second half of the summer (in Yamal low average temperature of July-August). 11% larch and 10% spruce tree-rings were light rings.
False rings are manifested in the appearance of a darker cell layer within a tree ring. Cells of this layer differ from neighboring cells in their shape, size and cell wall thickness. Such structures can appear when a long-term worsening of weather conditions during the growing season (at the northern forest boundary, an air temperature drop) is followed by their normalization. 0.35% larch and 0.12% spruce tree-rings were false rings.
In addition, we recorded the absence of individual tree rings. Missing rings indicate very low temperature of summer. 0.17% larch and 0.06% spruce tree-rings were missed.Thus, on basis of anomalous structures analysis we reconstructed cold summers, summer frosts and abrupt temperature declines during the second half of the growing season over the past 4100 years.
The most severe temperature events were in BC 2053, 1935, 1647, 1626, 1553, 1538, 1410, 1401, 982, 919, 883, 338, AD 143, 404, 543, 1209, 1440, 1453, 1466, 1481, 1601 and 1818. Comparison of our data with data from other regions of the world shows that there is agreement in the timing of many extreme temperature events. Most probably, these extremes have been caused by climatically effective explosive volcanic eruptions.

Poster
## Gravel beaches: Signals of changing

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Coastal erosion and collateral effects of thinning and landward migration of beaches and cliff retreat is of worldwide concern, especially in countries with low and sandy coastal borders. Global sea level rise scenarios reinforce this concern. Contributing to this awareness are climatic changes that, though controversial, have added to the most pessimistic forecasts for the near future, regarding sea level rise, intensification of tropical and extra-tropical cyclones, larger extreme waves and storm surges, among other events. These phenomena will vary considerably at regional and local scales, but the impacts are virtually certain to be overwhelmingly negative for human occupation of the shoreline.
Given the lack of simple relationships between sea-level rise and shoreline retreat, sediment budgetary changes are considered a useful tool to assess beach response to climate change. To undertake this, at the local scale, it is necessary to assess the human impacts, not only on coastal systems, but also on the associated river systems that influence the supply and transport of sediments to the coast (e.g. land use changes, forest fires, dams with retention reservoirs).
The Northwest coastal zone of Portugal despite exhibiting an erosion balance for decades) has shown a new phenomenon, since the end of 20th century. Between Lima and Cávado rivers, a progressive disappearance, from north to south, of sandy beaches and their replacement by gravel beaches has taken place very suddenly. However this phenomenon is not new, having occurred in the relatively recent past (before the Little Ice Age). This paper intends to identify the structure and status of new gravel beaches (former sandy beaches, that have lost all of their sand), which have become a progressive and dominant feature of the Northwest Portuguese coastal landscape, under the scenario of rising sea-level and sediment supply variation.
Relatively little research is undertaken concerning the relationship between gravel-based coastal systems (barriers) and the same forcing parameters. Worldwide, the understanding of the behaviour of gravel beaches is still very rudimentary compared to that of sandy beaches. Gravel systems are also threatened by sea-level rise, even under high accretion rates. The persistence of gravel and cobble-boulder beaches will also be influenced by storms, tectonic events and other factors that build and reshape these highly dynamic shorelines. This research intends to define: the mechanisms led to the sudden beach facies change; the destination of loss sands; the provenance of the large volume of gravels, cobbles and boulders; and the relationships between natural and human factors in that change. This work presents an integrated and multidisciplinary approach in order to assess the past and the forcing factors, the present and their mechanisms, the the future an the expected trends. The understanding of a poorly known coastal system as a whole, its evolution and recurrence, its value as a natural defence without costs, is fundamental for coastal zones where the human occupation has increased during the last decades, creating a source of concern, that laws and regulations did not attempted to prevent.

Talk
## The last rapid decline of lake levels on the Tibetan Plateau

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Hydrological processes on the Tibetan Plateau (TP) are directly influencing the lives of millions of people in adjacent regions since the TP feeds the seven major rivers of Asia providing freshwater to a large portion of the population. In addition to that, these rivers provide sediment for megadeltas which are home to millions of people. Climate Change has strongly affected and will further affect the progradation and retreat of these megadeltas fed by rivers originating from the TP.
Here we present indications for very rapid lake level declines which seem to have occurred rather simultaneously at various sites on the TP at ~2000 cal BP. These observations are probably linked to a shift in the precipitation regime and hence to a change in the monsoon system which in turn will influence the above mentioned water supply.
Evidence for this distinct shift is found in the Tangra Yumco (co=lake) basin on the central TP (31°15'N, 86°43'E). A 2-3 m thick carbonate layer which is associated with a lake level high-stand can be found in outcrops all around the lake. In a small remnant lake 150 m above the recent lake level the top of this respective facies is embraced by radiocarbon ages which due to a potential reservoir effect have to be considered as maximum ages of 2620 +155/-255 and 2190 +235/-255 cal BP. However, the lithological change to the stratigraphic unit above is closer to the younger age. In an outcrop ~25 m above the recent lake level of Tangra Yumco and therefore 125 m below the remnant lake the top of the carbonate layer is OSL dated to 2.3 +/- 0.2 ka which is in the same age range and can only be explained if the lake level fell very rapidly.
According to gravity cores recovered from the 230 m deep central basin of Tangra Yumco this rapid lake level decline caused a turbidite. Below this turbidite minerogenic input which is interpreted as fluvial input and hence a reaction to precipitation changes was rather high whereas above it is distinctively lower indicating drier conditions thereafter. The exact age of the turbidite is hard to determine but according to the event corrected chronology of this core it has an age of ~2100 cal BP.
A similar hydrologic shift is visible in sediments from Nam Co ~400 km east of Tangra Yumco. There it is expressed as a marked decrease in minerogenic input, too, a coarsening of grain sizes, and the occurrence of Monohydrocalcite, as well as a marked rise in the carbonate content pointing to much drier conditions. This shift occurs within two centimeters which corresponds to ~50 years in a section where no traces of a hiatus are detectable. Since radiocarbon dating of sediments on the TP is a very difficult issue chronologies of both records as well as the synchronicity of this event were checked using magnetostratigraphic techniques.
All this points to a major shift in monsoon intensity (drier conditions) at ~2000 cal BP detectable on a large part of the TP. Although, recent observations indicate a lake level rise in both mentioned lakes and hence more moisture a similar shift to drier conditions today would be harmful to large portions of the world population.

Poster

## Seasonal and centennial cycles of carbonate mineralisation during the past 2500 years from varved sediment in Lake Shira, South Siberia

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Meromictic Shira Lake is situated in semi-arid climatic region of South Siberia. It is closed plane – bottom basin 9,4x5,3 km$^2$ of brackish water (total salinity up to 19 g/l) inflowed by small Son river. Continental climate provides mean July temperature 18° and January -20°C. A long-term waterbody stratification with intra-annual chemocline depth from 11 to 16,2 m is observed as well as historically documented level oscillations up to 7 m. Age-depth model has been built by varves counting combined with $^{137}$Cs and $^{14}$C isotopic dating. Using a modern analytics - scanning X-ray fluorescence technique for sub-millimeter microstratigraphic study of varves allowed to connect geochemical oscillations of microelement content (Rb, Ti, Ca, Sr, Br, XRD) with environmental change.
Seasonal sedimentation in Shira Lake results in two contrast laminas within annual rhythms: black ones containing organic matter correspond with winter conditions (November- April), and white, organic free – with summer (May – October). Seasonal distribution of clastic (Rb, Ti, XRD), organic (Br) and chemical deposited (Ca, Sr) microelements is stable within individual layers. Sentennial periodicity of essential carbonate sedimentation is revealed by white intervals along the core, which are marked by Sr anomalies as well. The process was stipulated by drop in the lake level together with increase of water salinity. Such external environment are in accordance with the equilibrium physical-chemical conditions of the natural sediment – water system. Thermodynamic estimation of rock-water multisystem in conformity with local conditions and composition of source matter provided grounds for interpretation of measured geochemical parameters in sediments as environmental indicators like temperature, salinity, pH etc. For estimations we used: Source data - 1) rock-forming minerals in sediment, 2) chemical composition of dry sediment, 3) composition of pore water from the same sample of sediment, and 4) rock-water ratio. Instrument Software - "Selektor" for the Gibbs free energy minimization in multisystem, composed by main chemical elements: H, O, C, S, P, Si, Ti, Al, Fe, Mn, Ca, Mg, Na, K, Sr, etc., which occur in the chemical analyses of sediments. All known chemical molecules and ions, which have thermodynamic constants collected in the special

databases, serve for computing. Results - Content of solid mineral phases, dissolved ions and gases, water and gas (mas. %) as a function of outer (environmental) factors: temperature, salinity, pH, solid-water-gas ratio, partial pressure of gases ($O_2$, $CO_2$, $H_2S$...) and so on in condition of thermodynamic equilibrium.
Quantitative environmental reconstruction using multiple regression for precipitation calibrated by hydrometeorological time series year by year was curried out for the lake over the last 2500 years. Carbonate biochemical mineralization in Shira Lake showed not only seasonal but also centennial oscillations. So light carbonate Sr-enriched laminas were formed just after each cold season during meromictic (normal) state of lake. More thick light intervals corresponded to extremely low lake level periods of holomictic state were repeated every 450-550 yrs. Mineral composition for both conditions seems to be typical for similar carbonate bearing sediments, for example in Lake Van (Turkey), Telmen (Mongolia) and others.

Poster

## Millennial and orbital climate variability in West Antarctica

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Drilling of the West Antarctic Ice Sheet (WAIS) Divide ice core was completed this year, reaching a depth of 3400 m. Annual layers are detectable to at least ~30,000 years, and a preliminary timescale is in good agreement with Greenland ice core and speleothem timescales. We present the complete stable water isotope ($\delta D$, $\delta^{18}O$, $d_{excess}$) climate record from WAIS Divide with resolution better than 25 years per sample to 30 ka and better than 50 years per sample through the bottom of the core at 62 ka. Stable water isotopes are well-established proxies of past site temperature ($\delta^{18}O$, $\delta D$) and moisture source and transport ($d_{excess}$) changes. The WAIS Divide record represents the highest resolution climate record ever recovered form the Southern Hemisphere that spans the Last Glacial period and transition to the Holocene.
Deglacial warming at the West Antarctic site is shown to commence at least 1000 years earlier than previously recognized from Antarctic records. We use an objective statistical approach to identify periods of significant change in the $\delta^{18O}$ and dexcess records and highlight an apparent abrupt warming event near the beginning of Antarctic wide deglaciation. The Antarctic Cold Reversal is strongly expressed in the WAIS record and a pronounced increase in accumulation is observed near the end of the Younger Dryas (~11.7 ka). Antarctic Isotope Maximum (AIM) events, which have been related to the Northern Hemisphere (NH) Dansgaard-Oeschger (DO) events, are well resolved in the WAIS Divide record. In particular, the AIM 2 event is clearly expressed as in other Pacific and Atlantic sector cores but notably absent in Indo-Pacific cores, suggesting strong regional climate variability in Antarctica during the Last Glacial Maximum.
The $\delta^{18}O$ record and timescale reinforce the known out-of-phase relationship between Northern and Southern Hemisphere (SH) temperature during DO/AIM events, the "bi-polar seesaw" explained through ocean heat transport. In contrast, preliminary analysis of the $d_{excess}$ record suggests a different, more in-phase relationship with NH temperature and methane during some millennial scale climate events. A pronounced step-change in the WAIS dexcess record appears to be associated with the most recent abrupt NH event at 8.2 ka, though lagging by ~ a century. While the 8.2 ka event is absent or ambiguous in other Antarctic ice cores, the change in WAIS Divide dexcess is the most distinctive feature of the Holocene record. Similarities and differences to other Antarctic records are addressed.
The timing of changes in $d_{excess}$ may point to changes in atmospheric circulation or the meridional temperature gradient during rapid climate change events. One hypothesis is that changes in tropical climate may directly influence atmospheric circulation near West Antarctica through known atmospheric teleconnections in the Pacific. We explore these inter-hemispheric relationships through coupled global climate model experiments using CESM1 and ECHAM. We examine the influence of freshwater hosing events in the North Atlantic and in the Southern Ocean, for which there is emerging evidence of iceberg discharge during the deglacial transition.

Talk

## Regional reconstructions of the past extreme flood activity from Alpine lake sediments

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An increase of the intensity of hydrological extremes is expected with the global warming. However, the lack of observations of torrential events and measurements of precipitation at high elevation areas does not allow supporting this theory. Past extreme flood evolutions can be recorded in lake sediments and allow to explore the evolution of such events in response to past climatic changes. In this context, our work aimed at reconstructing the past evolution of flood frequency and intensity based on the study of sediment sequences of high elevation lakes of the French Alps, and focused over the last millennium which includes thermal-contrasted periods. Studied sites were selected along a north-south transect to investigate the regional variability of flood evolution. In addition, proglacial sites were preferred to minimize human disturbances on the erosion processes in the catchments.
Flood deposits are the most often characterized, in lake sediment, by a coarse base, an upward-fining trend and enrichment in detrital elements. High-resolution grain-size proxies of higher detrital inputs were hence assessed for an exhaustive identification of flood deposits based, on geochemical measurements obtained by X-ray florescence

core scanning. However, such graded deposits can also result from gravity processes. Spatial sedimentary investigation (multi-coring) was hence undertaken to identify graded deposits triggered by gravity processes. The flood intensity was indirectly assessed from the coarsest grain-size of each flood deposit. Some distinct dating methods ($^{210}$Pb, $^{137}$Cs, $^{14}$C, paleomagnetism, correlation with historic earthquakes and pollutions) were here used to reduce as much as possible age uncertainties on the age-depth relationships. Finally, the reliability of the flood records was checked from the comparison with local historic flood dates.
The two flood record for the Northern French Alps present strong similarities, supporting our reconstructions. In this region, floods are mostly triggered by localized summer convective events. Comparisons with paleohydrological and temperature reconstructions suggest that these extreme events are the result of complex, timescale-dependent interplays between the movement of air masses, which bring moisture to landmasses, and temperature conditions, which influence the stability of humid air masses on landmasses. In the Southern French Alps, floods are mostly triggered by autumnal meso-scale precipitations linked to the Mediterranean humid inflows and are thereby most straightly linked to atmospheric circulations. The flood record for the Southern French Alps shows a good agreement with short and long-term processes over the North Atlantic domain. Our results suggest that a generalised decrease of torrential flood frequency should occur all around the French Alps. But, an increase in flood intensity during the last century and past warm period in northern French Alps should increase flood hazard in this region.
Hence, our study shows that long-term reconstructions of regional flood patterns can be reliably undertaken. This approach could be now exported in other regions to improve the understanding of the climate-flood relations. However, a particular effort should also be now undertaken based on statistic and modelling approaches to confirm and quantify the climate-flood relations.

Poster

## Tree-ring-based long-term snowfall records for Western Himalaya, India

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Snowmelt water in cold-arid regions of the western Himalaya, contributing over ~70% of the annual precipitation is critical for the socioeconomic development of the region. However, our understanding of the natural variability in snow fall is limited largely due to the paucity of weather records from this region. High-resolution proxy records offer unique opportunity to extend the snowfall records back to past few centuries. However, among the plenitude of proxies the tree-rings overwhelm others due to precision in dating and calibration with the target variables viz., weather records. A network of tree-ring data from six ecologically homogeneous sites in Lahaul-Spiti, where tree growth is likely to be limited by soil moisture was developed. These chronologies showed strong similarity in year-to-year and significant correlation indicating the common climate forcing affecting growth. The calibration of chronologies with weather records available from neighbouring regions showed that the winter-spring season precipitation has dominant control on tree growth. As winter spring precipitation over the region largely falls in the form of snow, we calibrated our tree-ring data with the November-April snowfall records from Patseo, the station lying close to the tree-ring sampling locations in Lahaul-Spiti, Himachal Pradesh. The November-April snowfall reconstruction spanning over the past seven centuries (AD 1290-2008) was developed using linear regression model. The strength of the snowfall reconstruction was established using winter precipitation data of weather stations situated in similar climatic regimes. The reconstructed time series revealed inter-annual-decadal variability in snowfall and is related to the large-scale oceanic and atmospheric features. The reconstructed series has been used to understand the recurrence behaviour of extreme snowfall events and utility in developing appropriate climate change adaptive measures.

Talk

## A high resolution dust flux record of the last glacial period from northwestern Chinese Loess Plateau

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Aeolian dust plays an important role in Earth climate system. To better understand the historical role of dust in long-term climate change, it is essential to have accurate estimation of the flux and atmospheric transportation of dust in the past. The arid desert and Gobi of inner Asia is one of the most important global dust sources. The dust emitted from inner Asia is transported to both the Chinese Loess Plateau and northern polar region. Up to tenfold abrupt changes of dust flux over the northern polar ice sheet were recorded in the Greenland ice cores during the last glacial period in parallel with the Dansgaard-Oeschger abrupt climatic events. It is argued that the dust lofting associated with the abrupt gustiness changes is responsible for an order of dust flux changes on millennial scale. Although the dust of Greenland is mainly transported by the high altitude westerlies, the dust needs to be loaded into atmosphere by low altitude wind events, e.g., East Asia Winter Monsoon, which is responsible for the dust transportation of Chinese loess. Therefore, it is expected that a similar millennial pattern would be observed in the loess record. In this study, we examine changes in dust flux by studying a 35 m thick loess sequence from northwestern Chinese Loess Plateau. Chronology was established through optically stimulated luminescence dating of over 50 closely spaced samples. Severe age underestimation was encountered and a stepped irradiation approach was developed to circumvent the problem. In addition, the recently developed post-IR IRSL (Infrared stimulated

luminescence) protocol of feldspars was also applied to improve the accuracy of the luminescence ages. High resolution dust accumulation rate for the last glacial period in northwestern China is obtained and compared with the dust records of the Greenland ice cores. This allows us to investigate 1) whether similar millennial patterns in dust dynamics co-exist in high latitude and mid-latitude; 2) if there is any unknown mechanism in rain-out of dust responsible for the close relationship between the dustiness and the oxygen isotope records of the Greenland ice cores.

## OSM06: Past Changes in Fluvial Systems, Floodplains and Estuaries

Convenors: Thomas Hoffmann, Onkar S. Chauhan, Peter Gell, Rajiv Sinha

Talk

### Late Holocene Hypolimnetic Anoxia in Lake Victoria at Napoleon Gulf as inferred from Geochemical Proxies

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Lake Victoria has undergone major changes during the past three decades, 1960s to 1990s. Primary productivity of the lake appears to have risen to about 2 to 3-fold. A consequence of this increased phytobiomass production has been increased deoxygenation of the deep water. Sedimentary Fe/Mn and Total Nitrogen (TN) determined using XRF and CNS analysers respectively and AMS radiocarbon dating have provided evidence of hypolimnetic anoxia and eutrophication from nitrate input into Lake Victoria at Napoleon Gulf in Jinja for the last 4,186 years to present. The results showed that hypolimnetic anoxia at Napoleon Gulf has been relatively high ca. 4186 to 1684 yr. BP possibly due to natural causes and low between ca. 1684 to 1029 yr. BP. Anoxia drastically increased from ca. 1029 to 370 yr. BP with levels becoming relatively very high from ca. 370 yr. BP to present. This may be attributed to eutrophication from high input of nitrates possibly associated with increased anthropogenic activities towards the most recent years as there was a positive correlation between Fe/Mn and TN ($r = 0.616$, $p = 0.025$, $n = 13$) and high TN values towards the most recent years.

Poster

### Response and recovery from the effects of 100 years flood: Significance of long term slope-channel coupling in Damodar River, North-Eastern India

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Variability in the frequency and magnitude of floods is the main direct regulator that determines the response of river systems. This results from altered precipitation and runoff regimes, and it is coupled with variation in the input of sediments from channel-way and slope domains. Alluvial river systems can respond to flood-producing events differently by adjusting gross sediment throughput and geomorphological attributes, including channel dimensions, change rates and patterns. This may involve net changes in the form and quantity of valley sediment storage through channel aggradation or lateral dispersal, or channel incision. The idea of fluvial response is highlighted by M. G. Macklin, J. Lewin and J.C. Woodward's (2012) assertion that change may be propagated through entire fluvial systems in time, transforming floodplain 'fluvial style' or 'alluvial architecture ensemble', river long profiles and the extent of channel networks.

In this context, recorded flood chronologies from the Damodar River Basin (area=24,235 km$^2$) in North-East India are also manifested the major geomorphic changes in the main fluvial regime. Some of the largest floods since 20th century were recorded in 1913, 1935, 1941, 1958, 1959, 1978, 1995, 2000, 2006 and 2007. The September 1978 flood, with a combined inflow at Maithon and Panchet was recorded as 21,070 m$^3$/s, is significantly disastrous in recent century.The basin area (22°15'N-24°30'N latitude and 84°30'E-88°15'E longitude) of this river is a sub-basin and part of the Ganges river spreading over in the states of Jharkhand (3/4th of upper basin) and West Bengal (low-lying flood plains) which resembles a tadpole in shape with the head to the west. The river alternately flows through Archaean deposits in its upper reaches and alluvium soil in downstream along its 541 km long course. The Damodar river is entirely rainfed and the annual hydrographs available for some gauging sites on the downstream of the Damodar River display a simple hydrologic regime with only one pronounced maximum as common for most Indian rivers. The geomorphic changes, which were documented during floods, involved extensive planform changes and substantial sediment input to the stream systems. Analysis of the natural flood regime of the Damodar River at Rhondia is greatly assisted by a reasonably complete streamflow record beginning in 1933. The incidence of flooding prior to the instrumental record has been gathered from documentary evidence that covers most of the 300 years. The channels are responded in many reaches by switching to wide shallow unstable locally braided channels. Over the 100 years within the time of inter-event, there has been a partial recovery to channel geometries similar to the pre-flood conditions; however the degree of recovery contrasts between two neighbouring valleys. Flood sedimentation zones have largely stabilised and new single-thread channels have cut through most of the former braided reaches. In some places channel widths remain higher than the pre-flood values, and locale recovery had been modified by a lagged complex response.

The present work involves the assessment of the change in channel response and slight recovery within the low interim extreme events of Damodar River. The study also endeavours the evolutionary history of the channel planform especially in the perspective of depositional environment.

Poster

## Hydrological and Nutrient budget of Bhitarkanika Mangrove Estuary, East coast of India

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Mangroves are highly productive ecosystems that are periodically submerged with saline water of estuaries of tropical and subtropical regions. The important biogeochemical services of mangroves include the entrapment of sediments and pollutants, filtering of nutrients, remineralisation of organic and inorganic matter, and export of organic matter. In present study, the seasonal variation of water, salt and nutrient budgets of Bhitarkanika mangrove dominated estuary of Brahmani-Baitarani River system were assessed using Land Ocean Interaction in Coastal Zone (LOICZ) model. Surface water samples were analyzed for salinity, dissolved inorganic nitrogen (DIN) and dissolved inorganic phosphorus (DIP) concentration during pre-monsoon, monsoon and post monsoon seasons. The LOICZ nutrient budget estimated the residence time of mangrove water as 4 days, 1 day and 2 days for pre-monsoon, monsoon and post-monsoon seasons respectively. Such low residence time causes rapid nutrient transformation within the Bhitarkanika mangrove area. DIN and DIP budget revealed uptake of nutrients in the estuarine-mangrove region during pre-monsoon and post-monsoon seasons, while it export the nutrients during monsoon season. Net ecosystem metabolism (NEM) and Nfix–Denit indicate a heterotrophic metabolism of nitrogen in the estuarine-mangrove region, which is essentially controlled by denitrification process during pre-monsoon and post-monsoon seasons. On contrary, during monsoon, autotrophic metabolism was observed to be dominant with nitrogen fixation as process for availability of nitrogen within mangrove ecosystem.

Poster

## Rapid ecological changes following altered hydrological connectivities with the Yangtze River in Zhangdu Lake (China) over the past 200 years

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Altered hydrological connectivity between lakes and rivers may impose significant effect on lake ecosystems and this topic attracted much interest along with the increasing anthropogenic-induced hydrological regulation in recent decades. This work investigated the long-term (~200 years) ecological changes responded to altered connectivity between a shallow floodplain lake (Zhangdu Lake; area 35.2 km$^2$, mean depth 1.2 m) and the Yangtze River using high-resolution multi-proxy analysis (diatom, cladocera, testate amoebae, geochemistry, and grain size) of a $^{210}$Pb-dated sediment core. Palaeolimnological records revealed the lake has experienced three changes of the hydrological connectivity with Yangtze River, which matches well with the documentary records. Prior to 1954 (stage I), the lake connected naturally with the Yangtze River and a low-nutrient, relatively deep and disturbed lake condition was inferred based on the high abundance diatom species Cyclotella bodanica and oligotrophic testate amoeba species. With the impoundment by the dam between lake and the Yangtze River (from stage II), residence time of lake water became longer and hence decreased in clarity, which favours diatom species Aulacoseria granulata. Correspondingly, nutrient enriched gradually which indicated by the slightly increase of eutrophic diatom and testate amoeba, as well as significant higher concentration of LOI and sedimentary TP/TN. In recent 20 years (stage III), lake became much eutrophicated inferred from high percentages of eutrophic species (diatom: *Cyclotella meneghinena*, *A. alpigena*, *Nitzschia palea*, *Surirella minuta*; testate amoeba: *Difflugla smillon*, *Difflugla corona* et al.) and geochemical records including LOI, sedimentary TP/TN. Both palaeolimnological and documentary records revealed the rapid degrading ecological status of the lake since its disconnectivity with the Yangtze River. Consequently, reconnection with Yangtze River may be an effective manner to relief the stressed floodplain lakes.

Poster

## Sedimentary archives of wetland-river interactions: The lower Murray River, Australia

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The condition of floodplain lakes is dependent upon local impacts, but more importantly their interaction with the main river channel. This interaction changes over time with climate change and variability, but also direct impacts such as river regulation. The sediments of floodplain wetlands archive records of these interactions by preserving microfossil remains. These remains can be derived from within the wetland, or transported to the wetland via inflows from the main channel. As these records integrate conditions over several months or years, they generally reflect gradual changes over time, rather than of major events such as floods. Long records show that the planktonic diatom Aulacoseira granulata has dominated the river and its distributaries for over 5000 years. Variable connectivity is revealed by changes in the record of this species in wetland deposits. Abrupt changes occurred soon after river regulation with coincident increases in river plankton in wetlands across the basin, including the arrival of the marker species Aulacoseira subborealis. More recently the salt and nutrient tolerant Actinocyclus normannii has entered records across the basin. These basin-wide changes reveal a change to the

river flora itself suggesting widespread salinisation and eutrophication. Further, regulation has permanently inundated previously intermittent wetlands and accelerated sediment accumulation. The river continues to be an agent for accelerated wetland infilling.

Poster

## To study the chemical weathering and clay mineralogy of the sediments in Brahmaputra river and two of its tributaries to understand the carbon sequestration by weathering

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Rivers play an important role in earth surface processes by weathering and eroding the upper continental crust. In this study the CIA (chemical index of alteration) of the suspended particulate matter(SPM) and the fine grained floodplain sediments of the Brahmaputra and two of its tributaries were calculated. The chemical weathering of the north bank tributary was found to be more than the south bank tributary. The clay mineralogy of the sediments was studied using X-ray diffraction technique to study the organic matter sequestration and impact of sediment mineralogy on carbon sequestration by weathering.

Poster

## A Preliminary study on the removal of earth materials from the river basins in Sri Lanka

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Sri Lanka is an Island in the Indian Ocean. Physiographically Sri Lanka consists as a central mountainous mass or central highland surrounded by a low, flat plain on all sides and extending to the sea. The rivers beginning from the mountains and flowing to the sea from all the directions shows a radial drainage pattern. The separated materials or sediments due to weathering and erosion in Sri Lankan rocks are transported by these rivers and are deposited in the lower basins or joins with the sea sediments. This river sedimentation may be high in tropical countries because rock weathering is most intense in the humid region. Hence a study on the rock weathering, river sedimentation and landscape reduction in Sri Lanka is very important. The objective of this basic research is to find out the weight losses and the rate of landscape reduction due to the transportation of separated sediments by the rivers in Sri Lanka.
About 300 samples from 72 locations were used to find out the bulk density and porosity of fresh and weathered rocks. The results show the decrease of bulk density and the increase of porosity with the increase of weathering. The reduction of bulk density of rocks indicated that total loss of material is about 20% by weight. The total dissolved ions, total suspended materials and bed load in surface waters are a result of the chemical weathering (with some physical weathering) of rocks in the entire region of the river basin. The available data on the runoff of the total river basins in Sri Lanka and chemical analysis of river waters in different localities were collected from the various references. The calculation of total solids transported by the river waters of the entire country indicates the average rate of landscape reduction. It is about 44 mm per 1000 years period.

Poster

## River channel response to climate change and human impact: Case study of Russian plain

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Climate and land use change are among main drivers of river runoff and consequent river channel changes. River bed migration often lead to substantial economic losses due to bank erosion, destroy of buildings, bridges, pipeline river crossings etc., because bank retreat rate may be up to first tens of meters per year. For reliable prediction of river channel response to climate change and human forcing in coming decades we have to assess river channel change in the past. Traditionally they use fluvial landforms for this assessment. But historical maps could be more precise tool for short (decades – centuries) time spans.
We analyzed series of historical maps from XVIII-XX centuries, modern topographic maps, aerial and satellite imagery to estimate rates and trends of river channel migration in Northern (Vychegda, Severnaya Dvina rivers), Central (Moscow, Oka rivers) and Southern (Urup, Laba, Belaya rivers) parts of Russian plain. During periods when runoff was above mean in Russian plain we observed increase of vertical and horizontal channel deformation and meanders size.
We note that river sinuosity depends on local settings and river runoff, so in case of stable settings meander size is function of runoff. This relation is useful tool for reconstruction of river discharge and predict of future channel migration. For example, we determined that runoff of Severnaya Dvina river has been decreased since XVIII century up to 20-30%.
Water transfer from one catchment to another could lead to drastic runoff change comparable with millennia periods. Moscow river runoff increased two times since 1937 due to water transfer from the Volga catchment. Before present we observe rapid river channel adaptation to increased runoff: river banks are eroded, meanders size is enlarged and meanders shape is varied.
In the southern flank of Russian plain we observe very rapid (tens meters per year) change of channel location, braiding, change of main stream etc. caused by climate induced flash floods. This phenomena lead to dramatic destruction not just of pipelines bridges, roads but also settlements.

Poster

## A simulation of the Neolithic transition in the Indus valley

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The Indus Valley Civilization (IVC) was one of the first great civilizations in prehistory. This bronze age civilization flourished from the end of the fourth millennium BC. It disintegrated during the second millennium BC; despite much research effort, this decline is not well understood. Less research has been devoted to the emergence of the IVC, which shows continuous cultural precursors since at least the seventh millennium BC. To understand the decline, we believe it is necessary to investigate the rise of the IVC, i.e., the establishment of agriculture and livestock, dense populations and technological developments 7000--3000 BC. Although much archaeological information is available, our capability to investigate the system is hindered by poorly resolved chronology, and by a lack of field work in the intermediate areas between the Indus valley and Mesopotamia. We thus employ a complementary numerical simulation to develop a consistent picture of technology, agropastoralism and population developments in the IVC domain. Results from this Global Land Use and technological Evolution Simulator show that there is (1) fair agreement between the simulated timing of the agricultural transition and radiocarbon dates from early agricultural sites, but the transition is simulated first in India then Pakistan; (2) an independent agropastoralism developing on the Indian subcontinent; and (3) a positive relationship between archeological artifact richness and simulated population density which remains to be quantified.

Poster

## Submarine fill of a drowned large incised valley. The legacy of eustatic and climatic forcing

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Incised valley systems represent one of the most intriguing geological features on modern clastic continental margins. The study of the processes leading to valley incision and infill revealed, at both regional and global scales, the influence of tectonics, eustatism, and climate on evolution of fluvial landforms in coastal plains. Moreover, the sedimentary infill of lowstand incised valleys that formed during the last glacial-interglacial cycle may represent one of the best archive to investigate past environmental changes since glacial times. The Manfredonia Incised Valley (MIV) is a huge buried erosional feature identified on the Apulian shelf (western Adriatic margin, central Mediterranean Sea). The MIV records a single episode of incision, induced by the last glacial sea level fall that forced the rivers draining the southern Apennine to advance basinward, reaching their maximum extent at the peak of the Last Glacial Maximum. The valley was filled during a relatively short interval of about 10,000 yr during the Late Pleistocene-Holocene sea level rise and almost leveled-off at the time of maximum marine ingression, recording the short-term climatic fluctuations occurred during this interval. High-resolution chirp sonar profiles allow the reconstruction of the morphology of the incision (more than 60 km long, up to 7 km wide, sinuosity index 1.45), its correlation at regional scale, and the internal architecture of the sedimentary infill. The integration of seismic data with the sedimentary core record permits to better define facies associations, constraining the chronology of events, and reconstructing the climatic scenario. The accommodation space generated by the lowstand incision was exploited during the following interval of sea level rise by very high rates of sediment supply that allowed the preservation of up to 45 m of valley fill. Seismic profiles highlight stratal geometries that are consistent with a typical transgressive valley fill, including bay-head deltas, central basin and distal barrier-island deposits, organized in a backstepping configuration. The highest complexity of the valley fill is reached in the shallowest and most proximal area, where a subaqueous prograding wedge, more than 1.5 km long, formed during a period dominated by riverine input, connected to high precipitation rates, likely isochronous with the formation of Sapropel S1 in the Mediterranean region.

Poster

## Mid-Holocene environmental changes deduced from sedimentary records in the lower reaches of the Yeongsan River, Korea

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This study presents sedimentological observations and interpretations on two sedimentary core sections from the lower reaches of the Yeongsan River, the southwestern Korean Peninsula. Core JD-1 (11.88 m long) is located around the confluence point of the Yeongsan River and the Sampo tributary, and core MW-2 (9.05 m long) is on the main channel of the Yeongsan Estuary. Two cores provided evidence for dynamic coastal environmental changes in the area during the early to mid-Holocene. The first sea influences occurred at around -12~-14 m in elevation (about 8500 cal. yrBP). During the mid-Holocene, cores JD-1 and MW-2 showed finely laminated mud (6400-4700 cal. yrBP) and rhythmic sand-mud couplets (6200-5100 cal. yrBP), respectively. The most possible mechanism of lamination is that continuous deposition of clay is periodically enhanced by greater detrital input. This was attributed to intensified rainfall resulted in elevated stream-flow and increased transport of freshwater and sediment loads into the study area. Although the sea-level was estimated to be high enough to have a strong influence on the study area during the mid-Holocene, the sedimentary features suggested that riverine activity was

the dominating element controlling the sedimentation patterns. This might be related to the Holocene Climate Optimum, the period of high temperature and rainfall in the Korean Peninsula. Several previous work mainly based on pollen analysis reported the Holocene Climate Optimum corresponded to the period from 7000 to 5000 cal. yrBP. However, this study suggests that the increased rainfall period was from 6400-6200 to 5100-4700 cal. yrBP. The data were compared with previously reported high-resolution, monsoon-influenced records to elucidate the possible influence of regional climate changes and sea-level fluctuations in Korea. The findings reported in this study substantially improve our knowledge of the timing and severity of mid-Holocene environmental changes in the southwestern Korean Peninsula.

Talk

## Evidence for transformation of floodplain lake and wetland ecosystems at a regional scale due to agriculture and water resource development in south east Australia

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Australia is a dry, low relief, tectonically inactive continent and, as a result, freshwater habitat is relatively scarce. In this context, lowland floodplain rivers are disproportionately important ecologically. Not only do these rivers support freshwater ecosystems across vast areas, the productivity and biodiversity generated by these ecosystems within a severely water-limited landscape supports the terrestrial ecosystems of the broader landscape. Not surprisingly, humans make use of the water subsidy provided by floodplain rivers and have built a substantial agricultural economy based on these systems in south east Australia, notably within the Murray-Darling Basin (MDB), which takes up most of the interior of this region. The effects of agriculture and water resource development on the freshwater ecosystems of the MDB are widely held to have been substantial, but the precise nature and degree of changes is difficult to determine because agricultural developments began long before any systematic ecological study. Numerous palaeoecological studies of floodplain lakes and wetlands have been undertaken in order to establish long term ecological histories within these systems. Palaeoecological records support the notion that agriculture and water resource development have had a profound impact on individual sites. Nevertheless, it is difficult to establish cause-effect relationships because of the complex array of drivers that operate across multiple spatial and temporal scales to influence floodplain lake and wetland ecosystems and because of the complex sedimentary processes that influence the way in which ecosystem character is recorded in sediment sequences. In this context, there is a need to utilise replicate records in order to separate the broader 'signal' of regional-scale environmental change from the 'noise' of natural spatial and temporal variability.
This study is a systematic regional synthesis of palaeoecological records from floodplain lakes and wetlands in the southern MDB. Results indicate that agriculture and water resource development has resulted in an increase in the prevalence of systems dominated by planktonic production at the expense of macrophyte and periphytic production. This change is consistent with a system-wide decrease in photic depth relative to mean depth, which in turn may reflect reduced water clarity, increased depth or a combination of both. The recorded changes represent a substantial shift in ecosystem structure and function and a likely loss of bio and structural diversity.

Talk

## Channel forming discharge and longitudinal rivers profiles as drivers of landscape diversity in the Ganga plains

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The equilibrium state of a channel longitudinal profile controls the landscape of a river basin in a major way. A stable landscape is defined when the base profile coincides with the longitudinal graded profile of the river. Climatic and tectonic conditions set the 'base profile' of a drainage basin at a given time relative to a chrono-stratigraphic datum. Any change of climate and tectonic conditions define the energy gap (positive or negative) between the 'base profile' and the existing longitudinal profile. The energy gap created between these two actually promotes vertical aggradation or incision in a drainage basin. This paper attempts to analyse the relationship between channel-forming discharge variables and river longitudinal profile geometry of the rivers draining the western and eastern parts of the Ganga plains (WGP and EGP respectively) and relates this to landscape diversity. Our results show a significant correlation between these hydro-morphometric parameters for the WGP rivers which is in sharp contrast to the EGP rivers where such correlation is lacking. This suggests that the present channel flow in the EGP rivers does not perform significant geomorphic work for shaping river profile geometry. Based on the cross correlation between river discharge & profile geometry (stream concavity) parameters, we have attempted to determine the contrasting geomorphological evolution of these two adjacent alluvial plains and thus estimate their long term evolutionary pathways and drivers over the Late Quaternary period.
The rivers draining the WGP and EGP have produced contrasting landscapes. While the WGP rivers are characterized by incised valleys and narrow floodplains, the EGP rivers are mostly aggradational in nature and have produced large fans and extensive floodplains. The

geological records of EGP river deposits also show a continuous aggradation over the Late Quaternary, while the alluvial architecture of the WGP shows an alternation between valley incision and filling thereby generating multi-storied channel sands and intra-valley floodplain deposits. This cyclicity in stratigraphic architecture is interpreted as relative rise and lowering of channel longitudinal profile with respect to its base or equilibrium profile over the Late Quaternary. The rise and lowering of longitudinal profile have been controlled by the change of effective discharge along the river channel. High effective discharge during early Holocene could have caused lowering of longitudinal profile and low effective discharge during Late Holocene resulted in rise in longitudinal profile. High denudation rate (~4.3 mm/y) measured during early Holocene (10-7 ka) and low denudation rate (~0.7 mm/y) measured during Late Holocene strongly support the idea of high and low effective sediment transport.
Key words: longitudinal profile, effective discharge, incision-aggradation architecture

Poster

## Neogene Palynofloral evolution of Ramganga Basin, Uttarakhand, India

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The present paper focuses on the vegetational changes during the Neogene period in the Ramganga Basin of Uttarakhand. Palynofloral information has been derived from the Siwalik Group of rocks exposed in Tanakpur and its adjoining areas. The composition of assemblages is controlled by the changing patterns of climate, moisture flow and altitudinal disposition. Prior to Mid Miocene Himalayan orogeny the palynofloras largely contain subtropical to tropical plant taxa. The post- Himalayan uplift brought in several climatic, geographic and altitudinal changes which paved a way for the invasion of cold- loving plants. Several palynoassociations have been recognised in the Siwalik succession between 13 Ma to 5 Ma. The data has been interpreted and plotted against a chronostratigraphic control based on the magneto-stratigraphic study. A standard successional palynofloral model from Kalaunia River Section, Tanakpur has been prepared for comparative study. Progressive enrichment of Neogene palynofloras of Himalaya due to evolutionary changes and inflow /outflow of plant taxa from the adjoining areas is envisaged to have shaped the present day floras.

Poster

## The development of sand dunes around Lake Balkhash and Ili delta in Southeast Kazakhstan: the effects from hydrological environment changes and the Holocene Climate changes, in Central Eurasia

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1. Introduction
Lake Balkhash is known as endorheic basin and located in southeastern Kazakhstan, Central Eurasia. Ili River is the largest river flowing into L.Balkhash that has the source in western-Tienshan Mountains. Ili River forms Ili delta along the lowest reaches. The international joint team between Research Institute for Humanity and Nature, Japan and Kazakhstan Scientific Research Institute have researched about the environmental changes of L.Balkhash, Ili River drainage area and the effects for past human-activities during Holocene, providing the results on the Holocene climate changes on the basis of integrated analyses including sedimentological, geochemical and micro fossil analyses for the lake sediments focusing on the lake-level changes.
In this presentation, we focus on the sand sea known as Saryyesik Atyrau Desert around L.Balkhash and Ili delta. Ili River flows in the center of Saryyesik Atyrau Desert. Under the continental climate, arid and semi-arid zones dominate in this area. Sandy sediments from Ili River, and coastal zone of L.Balkhash are the main source of aeolian sand, along with surrounding desert area. We have a hypothesis that the sand dune formation and sand sea's activity of Saryyesik Atyrau Desert reflect environmental changes of L.Balkhash, Ili delta and the drainage area. These fundamental changes seem to be related to the global climate changes during Holocene. This study aims to clarify the relationship of environmental changes between sand sea and inland hydrological system.
2. Methods
To clarify the distribution and development of sand dunes, we analyzed high-resolution satellite images and DEM. Moreover, we had geomorphological survey (dune measurements, sampling of dune sediments including for OSL dating). And these results are compared with those of L.Balkhash and other fluvial sediments.
3. Result and discussions
From these analyses, the distributions of sand dunes are covering wide range of the desert, for example the abandoned meander, past-fluvial terraces of palaeo-Ili delta and sand sea. Therefore, the development of sand dunes is able to understand from the relationship between fluvial geomorphology. These sand dunes topography is mainly classified into three units, Dune I, II, and III. Dunes I and II are mega-linear dunes (Draa) in the Last Glacial period by OSL dating. Dune III is characterized by small-scale sand dunes covering on the middle terrace dominantly. OSL dating shows 4-5 ka, mid-Holocene. Those ages correspond to the lowest lake-level and dry climate phase of L.Balkhash. Recently, some palaeoclimatology studies show that Central Eurasia shifted to dry phase in mid-Holocene from humid phase of the Holocene Climatic Optimum. Under such arid climate conditions, the transport and accumulation of aeolian sand were activated along with the regression of L.Balkhash.

Poster

## Geochemistry of buried river sediment in Ghaggar plains, NW India: Inferences on Late Quaternary palaeoclimate

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The semi-arid Ghaggar plains in northwest India is presently drained by an ephemeral Ghaggar river that dries out near the margins of the Thar Desert. Based on resistivity surveys and drill cores, along a transect across the modern Ghaggar river near Kalibangan in Rajasthan, a recent study[1] has identified a large valley-fill complex buried beneath the Ghaggar plains. Luminescence dating suggests that the buried sediments represent fluvial aggradation spanned over MIS5/4 to MIS1. We present the geochemical record of the buried sediments to understand the processes that resulted in the observed compositional variations and in particular to interpret source characteristics, weathering and climate variability. Major element concentrations in the carbonate-free bulk sediments (40 samples in total) from two of the five cores range within that of the modern river surface sediments from the northwest draining through the Higher Himalaya viz. Indus and its tributaries, and Yamuna. Good positive linear correlation ($R^2$ >0.65) of $Al_2O_3$ (8.1-15 wt%) with $Fe_2O_3$ (1.3-6.8), $K_2O$ (1.6-3.9), MgO (0.6-3.3), and $TiO_2$ (0.3-0.8) and a negative correlation ($R^2$=0.87) with $SiO_2$ (58.3-84.5) are observed. The chemical index of alteration (CIA, molar ratio of 100_$Al_2O_3$/($Al_2O_3$+$K_2O$+$Na_2O$+CaO*), where CaO* is from silicate minerals only) varies in the range 47-68, with sediments within the top 10 meters having values > 60 suggesting relatively more intense chemical weathering relative to the deeper sediments. It can be inferred that continuous sediment deposition till MIS2 limited the alteration effect, while the limited channel activity thereafter allowed enhanced chemical weathering during mid-Holocene. The radiogenic Sr-Nd isotopic composition of one of the cores (16 samples) shows range of values ($^{87}Sr/^{86}Sr$: 0.7314-0.7783; εNd: -19.2 to -14) similar to that of silicate rocks from the hinterland Himalaya), and the down-core variation pattern is similar to that reported for the Ganga-Yamuna interfluve sediments belong to the same age. Deeper (and older) sediments deposited during MIS-4 (at 70 Ka) show high $^{87}Sr/^{86}Sr$ and low εNd suggesting an enhanced proportion of sediments from the Lesser Himalayan rocks (characterised by high $^{87}Sr/^{86}Sr$ and low εNd). This is attributed to the fact that during the cooler MIS-4, a large part of the Higher Himalaya was covered with ice, and therefore, its relative contribution decreased. Further, decreased monsoon activity during MIS-4 could have further reduced the erosion over the Higher Himalaya. Sediments deposited during the warmer MIS-3 (60 to 27 Ka) show distinctly less radiogenic Sr and more radiogenic Nd suggesting increased contribution from the Higher Himalayan rocks (characterised by low $^{87}Sr/^{86}Sr$ and high εNd) due to decrease in the glacial cover. These findings corroborate our earlier results from the Ganga plains[2] and suggest a strong climatic control on sediment provenance from the Himalaya.

Poster

## Stratigraphic response to Late Quaternary monsoonal fluctuations in a buried valley complex in Ghaggar plains, NW India

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The Ghaggar plains in NW India is presently devoid of any major surface drainage. However, a ~40 m thick buried valley fill exists beneath the plains as inferred from electrical resistivity mapping and validated by drilling and coring. The buried valley fill, along a transect near Kalibangan in Rajasthan, NW India, is ~12 to 15 km wide and ~35 to 45 m thick. We have used the drill core lithologs aided by optically stimulated luminescence chronology to reconstruct the alluvial stratigraphy of this buried valley fill that spans from marine isotope stage (MIS) -5/4 to MIS-1. Drill core lithology reveals that the ~30-35 m thick alluvial deposits overlie aeolian sands separated. Based on five drill cores penetrating down to a depth of ~40-45 m, four major stratigraphic units are identified. The lowermost unit is a ~ 2-3m thick (base not exposed) aeolian sand layer. A major discontinuity defined by an intermediate zone of calcrete bearing silty sand and fine sand layers separates this unit with the upper fluvial units. The fluvial succession starts with a 8-10 m thick coarse grey micaceous sand unit and is overlain by ~8-20 m thick unit of medium to fine grey micaceous sand occasionally inter-layered with yellow mud/silt. The upper 2-8 m of strata is made up of red brown very fine sand and silty clay. Stratigraphic reconstruction of the valley fills based on drill cores and OSL-based chronology allow us to identify four aggradational phases punctuated by three incision events. A major aggradation event during MIS 4 filled the valley with ~10 m thick succession of coarse grey micaceous sand. An incision event during early MIS 3 was followed by aggradation of medium to fine sand interlayered with floodplains sequences. This was followed by another incision event during late MIS 3 and aggradation of grey fine sand sequences during MIS 2. In MIS-1, Finally, the mid Holocene period (MIS 1) aggradation, preceded by incision during early Holocene, filled up the valley. This is also the period during which the modern Ghaggar river probably occupied the valley and provided continuity to the stratigraphic succession. Our records show that the main alluviation phases coincided with periods of weak or declining monsoon when low water-sediment ratio favoured aggradation. Our stratigraphic reconstruction matches quite well with the available basin fill history from NW Rajasthan. Further, the aggradational and incision events in the Ghaggar valley show good correlation with that in the Ganga valley, except for the prolonged channel activity in Ganga plains during MIS 5 which is not recorded in the study area.

Poster

## Sea level and coastal changes during the Holocene in the Cauvery River delta, southern India

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The results from the three sediment cores two from northeastern and one from southern coastal plain of the Cauvery River delta, taken one to two km inland, reveal the changes in coastal geomorphology and sea level during the Holocene. The radio carbon ages in the sediment core from Porayar located in the northern part of the delta, collected 2 km inland, suggests that the early Holocene sea level was at least at -11.4 m at ~9.3 cal ka BP as indicated by the presence of foraminifera and shells of brackish to saline water affinity at this depth. The rise in the sea level to -1.7 m at ~7.5 cal ka BP is indicated by presence of marine/brackish water shells in sediment core collected from Vadapadi, 2 km inland from the southern shoreline. At ~ 6 cal ka BP the marine/brackish water sequence is recorded in all the three cores but at different depths, ranging between -10.6 m in the northernmost core and -0.9 m in the southernmost core. The higher depth of sediment deposition in the northern part at ~6 cal ka BP and earlier, suggests that the Cauvery delta plain was deeper in this part in comparison to southern part at this time and the sea water influence extended at least up to 2 km inland from the present coastline. In the northern core from Porayar, the marine shells show their presence up to ~2.6 cal ka BP i.e. 0 m depth (2m below present ground surface) with respect to present sea level. This would suggest that during the pre-Holocene period the major distributary channels flowed towards northern delta plain in response to lower sea level during the LGM leading to greater erosion in this part. The coastal delta region changed into estuary and bay with rise in sea level during the Holocene before gradually getting filled and becoming part of delta plain.

Talk

## Exploring the Channel Connectivity Structure of the August 2008 Avulsion Belt of the Kosi River: Application to Flood Risk Assessment

***Rajiv Sinha***[1], Kumar Gaurav[1], Shashwat Chandra[1], Sampat Tandon[2]

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The August 2008 avulsion of the Kosi River resulted in a maximum eastward shift of 120 km and created an associated avulsion belt of 2722 km$^2$. Based on 2000 SRTM data and 2005 IRS 1C satellite image derived channel network (pre-avulsion), we use a topography driven connectivity model to simulate the path of the avulsion channels which corresponds to a large extent to the observed path in the post-avulsion period. We then use the same model to postulate the avulsive course of the river from another upstream point that has been categorized as vulnerable to avulsion. Our results demonstrate that this model has the potential to be a predictive tool for postulating the path of an avulsive channel. This analysis can therefore provide a priori information on the areas likely to be flooded following an embankment breach and can serve as a flood risk assessment tool.

Poster

## The rise and fall of palaeo-megalake Bungunnia and the birth of the Murray-Darling basin in southeastern Australia: New palaeomagnetic and cosmogenic nuclide constraints on rates of geomorphological change

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The Murray-Darling Basin (MDB) dominates the geomorphology of southeastern Australia and is the product of increasing aridity since the late Pliocene. From a geological perspective the landscape is relatively young. Agricultural pressures have aggravated demands on regional water supplies and there is a need to understand the sensitivity of this stressed fluvial system to climate change.

The majority of MDB's surface is an ancient lake bed and images from NASA's Shuttle Radar Topography Mission show that this palaeolake (Bungunnia) once covered more than 50,000 square km. Studies of the relatively thin, but regionally extensive, sedimentary facies that were formed during the lake's life have produced an intriguing story of the rise of the lake, its demise and subsequent transformation into the modern river system. The main depositional unit of Lake Bungunnia is the Blanchetown Clay, which reaches thicknesses of ca. 30 m in the depocentre between the South Australian border and Lake Victoria in New South Wales. Dating of the transitions between sedimentary facies has proved challenging due to the lack of fossils in the relatively saline environment. Results of low resolution palaeomagnetic studies of cliffs along the Murray River suggest that a distinct step to increased aridification, characterized by the aeolian silts of the Nampoo Member, took place during a period of reversed polarity that postdates a normal polarity subchron. These studies interpreted this subchron as Olduvai (1.95-1.78 Ma), which places the Nampoo Member to the beginning of the Pleistocene. However, it was not possible to extend the magnetostratigraphy into the normal Brunhes chron and the identification of Olduvai is debatable.

To improve the magnetostratigraphy and obtain independent age control we recovered two drill cores (DE1 & DE2) from the Devil's Elbow to a depth of c. 30 m, hence reaching the basal Chowilla Sand that marks the birth of the lake. Palaeomagnetic sampling was carried out on both cores at 10 cm intervals and we measured the concentration of $^{10}$Be atoms in the different facies. Opportunely, normal polarity sediments extend below the upper calcrete and suggest that we can identify the Brunhes/Matuyama boundary (0.78 Ma). In total, six polarity reversals are identified and these allow us to produce two alternative palaeomagnetic age models. Alternative 'A' extends to the Matuyama/Gauss boundary (2.58 Ma). If this alternative 'A' were true we would predict the $^{10}$Be concentration to be approximately twice as high at the top of the unaltered Blanchetown clay compared to the bottom because ca. 2 million years would have elapsed. Alternative 'B' extends to the top of the Olduvai subchron and indicates that the Jaramillo subchron (1.07-0.99 Ma) is represented by almost 9 metres of sediment and was previously misidentified as Olduvai. The concentration of $^{10}$Be atoms in the unaltered Blanchetown Clay is relatively stable, which suggests the same degree of radioactive decay. The $^{10}$Be data are, therefore, consistent with alternative 'B'. This interpretation requires a radical reassessment of the rates at which the MDB developed.

Poster

## Main stem- tributary sedimentation in response to flood events during last 1000 years in lower Narmada basin, India

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Variations in the hydro climatic conditions lead to change in magnitude and frequency of severe regional flooding events in the tributary as well as the main stream and the spatial and temporal response of both may be distinct. Tributary junctions are the major nodes of geomorphic and hydrological adjustments in a river system. Understanding this linkage is critical for improving flood-frequency forecasting and water resources management in a river basin. The present study aims to demarcate the flood events in the main stream Narmada and Karjan, one of its tributaries in response to the climatic events during last 1000 years. A depositional terrace ~8 m in thickness at the tributary junction provides scope to appreciate the activity of these channels in terms of flooding pattern and related sedimentation. Sediment analysis including the particle size, major and trace elements and radiocarbon dating has been carried out to discern the flood events of the main stream from the tributary. The impact of source area weathering, grain size selectivity of erosion and sedimentary processes are considered. An attempt has been made to characterize and fingerprint the flood sediments deposited by the backflooding of the Narmada and Karjan. The terrace comprises a gravel unit at the base and a finer facies unit overlying it. The sedimentary facies suggests that the terrace sequence initiated under a bar regime where Karjan River deposited its gravel bed load followed by overbank deposition. Shells from these gravel units have been dated to 1300 cal yrs BP at the base and 730 cal yrs BP at the top. Following this, 8 major flood events have been identified based on the grain size data, each showing distinct silt-clay couplets. The major oxide percentages have further enabled to differentiate the flood events in the Narmada. The results indicate higher concentration of Feo, MgO and $Al_2O_3$ in Karjan River sediments as compared to the Narmada whereas the Narmada sediments show higher percent of CaO. Three probable events of high magnitude flood in the Narmada River have been demarcated, the oldest in the sequence being 680 cal yrs BP. It can be inferred that the period from 1300–730 cal yr BP, synchronous with the Medieval Warm period, was a period of high activity when maximum bedload was carried by the Karjan River and deposited at the tributary mouth. The finer suspension load carried by the Narmada river was however, deposited further downstream as the Karjan offered no accomodation space for back flooding. Due to subsequent reduction in the precipitation and hence in the overall discharge post 730 cal yr BP (may be synchronous to the Little Ice Age), the high magnitude flood events in the Narmada backflooded the Karjan River resulting into the deposition of flood sediments at the tributary mouth.

Poster

## Fluvial response to 3-2 ka sea-level lowering: An example of the latest Pleistocene to Holocene incised-valley fills in the Tokyo Lowland, central Japan

***Susumu Tanabe***[1], Yoshiro Ishihara[2]

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Based on the age and depth of the Uppermost Alluvium (latest Pleistocene to Holocene incised-valley fills) in the coastal lowland of Japan, it has been believed that a small sea-level lowering called "Yayoi regression" occurred during 3–2 ka. But the occurrence of the "Yayoi regression" is not eustatic phenomenon. Sedimentary facies and radiocarbon dates in the Tokyo and Nakagawa Lowlands show (1) floodplain sediments of the Uppermost Alluvium distributes shallower than 1 m below present sea level, and (2) morphology of the fluvial channel sediments of the Uppermost Alluvium changes from sheet like (7–3 m below present sea level, 3–2 ka) to anastomosed (above 3 m below present sea level, 2–0 ka). A sheet-like sand body and an anastomosed sand body are, respectively typical in the lowstand and transgressive fluvial systems. Therefore, we conclude that the sea level was lower than present level during 3–2 ka, and it rose to the present level after 2 ka in the Tokyo and Nakagawa Lowlands.

Solicited Talk

## Deciphering landscape dynamics from the Late Quaternary stratigraphic records of the interfluves and valleys of the southern Ganga plains

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Gross linkages between tectonics and regional climate in the Himalayan orogen have been investigated by several workers over relatively longer time scale, and their influences on foreland basin sedimentation have been modeled for part of the Cenozoic. However, studies on the influence of Late Quaternary climatic shifts on the foreland basin sedimentation on shorter time scales ($10^3$ -$10^5$ years) have been limited. Therefore, to understand the role of Late quaternary climatic shifts on landscape dynamics and sedimentation, the interfluve and valley deposits of the southern Ganga plains have been examined.
The chronology of the sediment sequences has been developed from the cliff sections of the Belan (Deoghat), Yamna (Kalpi), Sengar (Mawar), and Ganga (Bithur) rivers as well as drill core samples from some parts of the Ganga valley.
Our data on physical stratigraphy and facies analysis revealed that the late Quaternary strata below the interfluves show a distinct architectural motif of discontinuity-bounded sequences. The intervenient interval between two discontinuities is marked by floodplain growth and sustained aggradation; discontinuities themselves are marked by low-relief surfaces implying degradation, ravine development, soil formation, and in places formation of lake and eolian deposits.
From this pattern of variations in alluvial stratigraphy we have inferred that in a large dispersal system, with well-developed floodplains, much of the floodplain was detached over extended periods of time. This reduced lateral connectivity resulted in a modified physical domain on the floodplains that increased local scale heterogeneity within them involving degradational processes, soil development and sedimentation in small lakes and ponds together with local eolian sediment transport.
A first order age correspondence of this river and floodplain dynamics interpretation with the Late Quaternary monsoonal variations has been noted. Further, two major excursions in the in $^{87}Sr/^{86}Sr$ and $\varepsilon Nd$ profiles at 20 ka and 70 ka in a sediment core from the interfluve near Bithur coincided with the precipitation minima and larger glacial cover in the Himalayan hinterland. Considering these factors, we suggest that the landscape dynamics on shorter time scales in this part of the Himalayan foreland has responded to Late Quaternary climatic shifts.

Poster

## Early diagenetic processes of clay matters in decadal time-scale in tropical coastline sediments – case study in Vietnam

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In recent decades, coastal zone are changing dramatically as a result of complex interactions between land – sea – mangrove biota – human activities. Imprints of these environmental variations recorded in clay minerals of sediment background were investigated based on XRD (e.g. XRD-peak aea, CSD) and TEM-EDX (frequency spectra of mixed layer series, particle morphology, crystallite structures and chemical structures) in order to reveal early diagenesis. In case study of coastal zone of Red River Delta, clay mineralogical composition is diverse with predominance of four mixed layers series: Illite - Smectite mixed layer, Diorthahedra Vermiculite - Smectite mixed layer (diVS-ml) (68 – 72% of total particle frequency in the fractions < 2μm), Chlorite - Smectite mixed layer and Kaolinite - Expandable mixed layer (KE-ml). Post-sedimentary geochemical-mineralogical alterations including three principal diagenetic processes: dissolution, smectitization and kaolinitization.
Dissolution process in the coastal alkaline condition is a function of diagenetic time, giving rise to decrease in full frequency spectra of clay phases in fractions < 2 μm. It can be intensified by intensive hydrodynamic process (e.g. surficial erosion in low tidal mudflat and shrimp pond profiles) and also in contact with acidic microenvironment (e.g. rhizosphere layer in mangrove forest profiles). In diVS-ml series, smectitic structure is more easily dissolved in comparison to dioctahedral vermiculitic structure, as a linkage higher octahedral substitution in chemical structures.
Smectitization of diVS-ml series is evidently in clay size matters of the studied profiles with the increase of expandable phase with depth, migration of frequency spectra from vermiculitic to montmorillonitic structures as well as morphological modification of particles. This alteration process can be intensified under intensive surficial dissolution as well as under influence of mangrove root in rhizosphere layer. The smectitization in diVS-ml structures occurs in group-wise layer by layer transforming mechanism. Each step is indicated by a gauss-like distribution of the octahedral layer charge. K seems to have a trigger function with commonly maximum occurrence in interlayers between two neighboured tetrahedral levels.
Kaolinitization of KE-ml series occur also as function of time, parallel to smectitization and dissolution processes. This alteration process can be intensified under intensive surficial dissolution as well as under influence of mangrove root in rhizosphere layer. When interlayer cations and tetrahedral layer of beidellitic component are released by dissolution process, attachment of hydroxyl group from sea water to the octahedral layer facilitates formation and growth of kaolinite patch. This solid transformation of KE-ml series is comparable to kaolinitization mechanism discussed by Dudek et al (2006).

Poster

## Fluvial packages as archives to the Late Quaternary climatic fluctuations in SW Saurashtra, western India

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Earth's history has witnessed several long term climatic fluctuations during the Late Quaternary period. There have been several studies documenting the variations in strength of Indian Summer Monsoon (ISM) from a variety of archives like marine, fluvial, lake, aeolian, and glacier environments. Here we present a study from the drylands of southwest Saurashtra, western India highlighting the role of Late Quaternary climatic fluctuations in shaping the landscape of the region. The fluvial sequences of southwest Saurashtra exhibit a variety of sedimentary facies like trough cross bedded gravels (Gt), planer cross bedded gravels (Gp), homogenous silty sand (Ss), planer cross bedded sand (Sp) and flood plain (Fl) which non-conformably overlies the basalts of the Deccan Trap Formation. These are found associated with the dominant aeolian sedimentation, much famous as the Miliolite Formation. The lateral and temporal variations in these sedimentary facies show the dominant role of climatic fluctuations in landscape evolution.

Poster

## Depositional Environment of intertidal Mudflat and Mangrove Environments with Time within a Tropical (Vaitarna) Estuary, West coast of India

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Intertidal mudflat and mangrove sediment cores collected towards the mouth of Vaitarna estuary were investigated for the distributions of sediment components, organic carbon and aluminium normalized metals (viz., Iron, Manganese, Copper, Zinc, Cobalt, Nickel and Lead). The variation in bulk sedimentary organic stable isotope ($\delta^{13}C$, $\delta^{15}N$) ratios along with elemental C:N ratio were also studied. A gradual change in depositional environment of mangrove core (core MG) from sand dominated to clay dominated in recent years is observed. While in mudflat core (core MF) data points were more spread out indicating varying hydrodynamic energy conditions. Aluminium normalized metals showed similarity in their distribution pattern. All the metals showed an increase towards the surface thus pointing towards anthropogenic addition in recent years in core MF. Further, similar distribution pattern of trace metals with Fe and Mn indicated co-precipitation of trace metals with Fe-Mn oxyhydroxides. The results of the bulk sedimentary organic stable $\delta^{13}C$ and $\delta^{15}N$ ratios supported by C:N ratio indicated change in the proportion of organic carbon sources with a gradual increase of marine influence to the Vaitarna estuary.

Solicited Talk

## Forests, large floods, and sediment transport

***Robert Wasson***[1]

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It is still commonly held that forests in catchments reduce the incidence of large floods by reducing runoff or by increasing erosion and subsequent sedimentation in channels thereby reducing channel capacity.Studies of modern hydrology show that forests do not reduce the incidence of large floods, but there is some evidence that removal of forests increases erosion and subsequent channel sedimentation. Given that these processes and responses operate over decades to centuries, longer temporal perspectives are required. Palaeoflood, vegetation, and land use inferences and reconstructions over the past 1000 years in North Australia and India are used to show that climate change is the principal control on the frequency of large floods, amplified by natural dam formation and bursts in the Himalaya.

Poster

## Fossil Diatoms as a flood indicator in a large shallow floodplain lake

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Longgan Lake is a typical large shallow lake with high coverage of aquatic plants in the middle and lower reaches of Yangtze River in China. Based on diatom analysis of a 50cm-long core taken in 2008, planktonic Aulacoseira granulate and epiphytic diatoms were dominant throughout the core. Ratios of planktonic and epiphytic diatoms exhibited 12 dramatic changes over the past 100 years and this may be related to flood events. On the one hand, given the relatively thick siliceous shell of Aulacoseira granulate, this species always grows in a strongly mixed and low light permeability water environment to maintain its photosynthesis. Once flood occurred, water mixing enhanced and opacity decreased, which was in favor of the growth of Aulacoseira granulate. On the other hand, in floodplain shallow lakes, flood is one of the main factors leading to sudden reduction in aquatic vegetation. Affected by floods, aquatic plants encountered great loss due to lacking of effective photosynthesis, physical injury, disease and predation. Epiphytic diatoms lost their host plants and thus resulted in abundance reduction. In order to reveal the relationship between diatom changes and flood occurrences, we used the ratio of planktonic and epiphytic diatoms to reconstruct flooding records in the past 100 years. Results show that the reconstructed flooding events matches well with the historical flooding records from 1900 to 1958AD. After 1958AD, the peaks

of ratio between planktonic diatom and epiphytic diatom were lower and most flood events were not reflected by the diatom record. It is speculated that the artificial control on water has weakened the impact of flood on lake ecosystem since 1958AD.

## OSM07: Sensitivity of the Cryosphere: Past and Future

Convenors: Olga Solomina, Anders Carlson

Poster

### Mountain glaciers reaction on the Holocene climate changes in Central Asia in contrast to glaciers behavior in mountain systems of continental edges

***Anna Agatova***[1], Roman Nepop[1], Andrey Nazarov[2], Ljubov' Orlova[1]

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This study investigates glacier dynamic and climatic variations in the south eastern part of the Russian Altai (SE Altai) during the last 7000 years. Recent glacier retreats and ice melting in moraines has led to exhumation of organic material allowing the possibility of radiocarbon dating. We report a numerous dataset for the vast but unified in neotectonic and climatic conditions mountain area. We have also analyzed and summarized all previously published radiocarbon dates for basing the glacier activity within SE Altai at the second half of the Holocene. Moreover we have made a correlation of dynamics of Central Asia glaciers with glaciers behavior within some other mountain systems of the Northern Hemisphere.

The collective evidence indicates that the early Holocene climate in SE Altai was warmer than at the present day. There were no traces of the late Würm (Sartan) glaciation within intermountain depressions and at the foots of framing ridges already in the beginning of the Holocene and by 7000 cal. years BP mountain glaciers at the heads of trough valleys were either completely decayed or reached only the modern extent. The second half of the Holocene (after 5000 years BP) is characterized by shorter glacier recessions and more prolonged and frequent advances compared to the first half. The Holocene glaciation in the SE Altai reached its maximum extent during the Akkem stage, most likely about 4900-4200 cal. years BP. This abrupt and most powerful glacier advance, which left moraines far downstream, was probably caused by the coincidence of extremes of temperature lowering and humidity increasing. Two other moraine complexes morphologically expressed in the topography indicate significantly smaller glacier advances and have been dated: 2300-1700 cal years BP (Historical stage); and the 13th - 19th centuries (LIA or Aktru stage). During the periods between expansions glaciers degraded to at least the modern state, and possibly even more. These degradations were accompanied by repeated forest regrowth in the presently glaciated area above the modern upper tree limit.

The major trend towards increasing glacier extent during each subsequent glacial stage after 6000 cal. years BP, culminating in the LIA, is generally accepted for some mountain systems of the Northern Hemisphere (European Alps, Scandinavia, Canadian Cordillera), however it is not confirmed for the SE Altai and some other mountain systems of the Central Asia (Pamiro-Alai, Tien Shan, Tibet). Our data argue for a hypothesis of periodic but successively less Holocene glacier expansion from about 5000 cal. years BP to the Little Ice Age. It is very likely that this is a common feature of glacier dynamics for some mountain systems of Central Asia. A decrease in the areas occupied by forest vegetation and the reduction in glacier size at each subsequent glacial stage expressed in the topography suggest an increasing moisture deficit during the second half of the Holocene in the central part of Eurasia continent. This conclusion is also supported by the absence of a reaction from the glaciers to the thermal minimum of the middle of 19th century. It can be seen that the role of aridity (as well as temperature) as climatic forcing factors in driving glaciation in the Altai Mountains, as well as in the whole Central Asia, cannot be overestimated.

Poster

### Glacier expansion during the Late Quaternary in the monsoon dominated Goriganga valley, Central Himalaya, India

***Sheikh Nawaz Ali***[1], Rabiul Biswas[1], Anil Shukla[1], Navin Juyal[1]

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The Himalaya and Tibetan plateau have considerable influence on global and regional climate and may have played key role in the onset of the Quaternary glaciation. The elevated topography paved the way for glaciers, and records of past glaciation that are preserved in the region which can be used to reconstruct the past climate variability. The limited chronometric studies in central Himalaya have suggested that Central Himalaya, glacier dynamic is intimately associated with the temporal changes of monsoon-driven moisture regime

In order to test the above hypothesis, we have used detailed field stratigraphy and optical chronology of the relict moraine succession in the upper Goriganga valley to ascertain the timing and magnitude of various glacial events. Based on the stratigraphic position of moraines, morphology and the degree of vegetation cover a total of four glacial events of decreasing magnitude have been identified and are termed as Stage-I (oldest and longest) to Stage-IV (youngest and smallest). Stage-I glaciations which is dominated by calc-silicate lithology is represented by the presence of 12.5 km long discontinuous diamictite ridge which terminates at Rilkot (~3177 m). The crystalline lithology dominated Stage-II glaciation is represented by relatively sharp crested lateral moraines that terminates around Martoli village (~3240 m). The Stage-III and IV glacial events lie proximal to the present day glacier and terminate at 3640 m and 3740 m respectively.

Stage-II moraines were found to contain ice contact sediment and have been dated to 22±1, 25±2, 22±2 and 21±2 respectively at different locations. These ages broadly correspond to the Last Glacial Maximum (LGM). This would imply that stratigraphically older Stage-I

glaciations pre dates the LGM whereas the Stage-III and IV have been attributed to Holocene.
Multiple ages corresponding to the LGM are obtained for the first time from the monsoon dominated Central Himalaya on moraines that show reasonable extent of valley glaciers during the LGM. Considering that the insolation driven southwest summer monsoon was weaker during the LGM, hence the only source of moisture could be the enhanced mid-latitude westerlies. Our observations are contrary to the suggestion that central Himalayan glaciers were less extensive during the LGM due to the weak summer monsoon. However, considering that the longest Stage-I glaciations pre date the LGM whereas the Stage-III and IV glaciations post date the LGM, our study suggests that the glacier expansion in the Central Himalaya was modulated by the changing intensities of both the summer monsoon and mid-latitude westerlies.

Poster

## Projected 21st Century Decline Snow Cover Overlying the Arctic Sea Ice and Implications for the Sea Ice and Arctic Climate in CESM/CCSM

***Benjamin Blazey***[1]

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In this study, we examine the causes of the projected decline in 21st century snow cover overlying the sea ice in the Arctic Ocean in a General Circulation Model (GCM). While this decline is observed in multiple Representative Concentration Pathway (RCP) scenarios, this study uses an ensemble of Community Earth System Model (CESM) / Community Climate System Model (CCSM) simulations for the high emissions RCP 8.5 scenario. Despite increases in total precipitation in the Arctic basin, the snow cover on the sea ice is projected to decrease year round over the course of the 21st century. While accelerated springtime melt is projected, the primary mechanism leading to this decline is the absence of autumn ice cover. As a result, early snow events are not accumulated, resulting in reduced snow cover year round. The decline of snow cover results enhances two competing mechanisms, which impact the energy balance of the Arctic sea ice. First, the reduced snow thickness during the winter months results in enhanced transport of energy through the sea ice, which enables increased winter ice growth. The annually averaged effect of this increased energy loss by the ice exceeds the globally averaged 8.5 W/m$^2$ increase prescribed for this scenario. However, the reduced snow results in earlier spring loss of the snow cover. This process produces a lower sea ice surface albedo, which results in increased short wave absorption. As a result, the loss of spring and summer snow cover results in an increased energy flux to this ice. The magnitude of these effects, while large, is very similar, indicating the need for a careful treatment of snow cover on sea ice in GCMs, including the validation of snow cover and a careful treatment of the effects of snow cover.

Poster

## Detailed reconstructions of fluctuations of seven glaciers during the "Little Ice Age" in the Northern Caucasus Russian Federation

***Irina Bushueva***[1]

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The main task of this work is the development of detailed reconstructions of mountain glaciers' fluctuations with precise spatial references in the Northern Caucasus and their analyses in terms of glacier length, area and volume changes. The studied glaciers (Alibek, Ullukam, Terskol, Kashkatash, Bezingi, Mijirgi, Tsey) are situated along the Bolshoy Caucasus Range from the very west (Teberda river basin) to the east (Tsey river basin). Basing on instrumental data (since the middle of 20th century), remote sensing images (CORONA, Geoeye, Cartosat, IRS, ASTER, etc.), aerial photos of 1950s-1980s, maps (since 1887), old photographs, as well as proxy data (historical descriptions, lichenometry, dendrochronology, $^{14}$C, $^{10}$Be), we reconstructed 15-20 positions of the glaciers tongues for each glacier and produced high resolution maps showing spatial variations of the glaciers since their maximum in the middle 17th or first half of 19th century. For Alibek glacier six former front positions and elevan moraines were photo-identified and dated. We obtained the carbon dating of intermorainal peat-bog (103%), moraine dating based on isotopes of $^{10}$Be (1900±12) and determined minimum age of most distant moraine according to dendrochronological analysis of trees (*Abies nordmanniana*), growing on its surface (more than 200 years,). At that time (1895) the glacier was 290 m longer than today, its surface was 0.31 km$^2$ larger (5.94 km$^2$ in 1895, 5.63 km$^2$ in 2008). We calculated glaciers' length and area changes, using different methods (GLIMS) and analyzed advantages and disadvantages of each method in case of their application for Caucasian glaciers. Based on our measurements we evaluated changes of equilibrium line altitude and volume. Volume changes have been reconstructed using the model offered by Lüthi et al. (2010). The results of this study are important for verification of other reconstructions with the lower spatial and temporal resolutions, they provide additional points for the growth curve of lichens in the Central Caucasus, which is poorly fixed at the moment, and are important contributions to the global paleoclimatic reconstructions, where Caucasus is strongly underrepresented.

Talk

## What paleo ice sheets can say about future sea-level rise

***Anders Carlson***[1]

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The retreat of Earth's remaining ice sheets in response to anthropogenic climate change represents the greatest uncertainty in projections of future sea-level rise. This uncertainty is often used as motivation to study paleo-ice

sheet behavior for a variety of time periods at varying time scales. In particular, past "warm" periods are targeted, such as the Medieval Warm Period, early Holocene, earlier interglacial periods like Marine Isotope Stages 5e and 11, the Pliocene and the Miocene, as they may provide paleo-analogues to Earth's future. Nevertheless, the applicability of a paleo-analogue can be questioned, because of a different dominant forcing mechanism other than atmospheric greenhouse gases (Quaternary periods), or a different time scale of response than a century to centuries (earlier interglacial periods and the Pliocene and Miocene). Here I will discuss the potential of ice-sheet paleo records to be utilized in projecting future sea-level rise. I will focus on the applicability of different time periods and time scales for addressing these two questions: How much will sea-level rise by the end of the century? and What is the longer-term response of Earth's remaining ice sheets to a different concentrations of atmospheric greenhouse gases?

Poster

## Glacial response to environmental change in the upper Ravi basin of North Western Himalaya

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The cryosphere (the subsystem of the Earth characterized by the presence of snow, ice, and permafrost) plays a vital and central role in changes occurring in the Earth's environment. As an integral part of cryosphere mountain glaciers constitute one of the most important components of the Earth's natural system. In order to make best use of recent technique of remote sensing and GIS with incorporating extensive field data, the present research examines the glacial response to environmental change in the Upper Ravi basin in terms of change in the length of glacier terminus, glacier geometry and its equilibrium line altitude (E.L.A) during the last five decades.
The study area consists of Quaternary-glaciated part of the upper Ravi basin in Himachal Pradesh, which consist mountain ranges between 1520 and 6013 m a.s.l. The study has found that glaciation appears to have the greatest influence on the topography in terms of its spatial influence, relief production and ability to modify the landscape. The study found the different glacier retreat rate at different time interval of 1963-1989, 1972-1989, 1989-2002 and 2002-2010 in the basin where from last ten years the retreat rate is minimum and most of index glaciers are in stagnate stage in terms of terminus fluctuation which made a positive correlation with the increased mean snow cover area (extracted from MODIS snow 8 day composite image) in the basin during this period.
In a nutshell, the study indicates retreat-advance-retreat state for the index glaciers in basin where the retreat rate during the decadal time decrease and from the last ten years its shows minimum whereas the mean retreat rate in the basin is also comparatively less than other glaciers in the Himachal Himalayas. Additionally, the study results from the basin suggest that the climate change is not an only relevant phenomenon for the glacier retreat and advance. These are regional rather than global and more specifically they are glacier-centric than regional: clearly controlled by their morphology and topography, and relationship with incoming solar radiation in the individual glacier basin of the upper Ravi basin as investigated during the present research.

Poster

## Impact of De-glaciation and snow cover changes on the local water balance and develop adaptation strategies in the upper Ravi basin of North Western Himalaya

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Amidst growing concerns over the melting of the Himalayas' snow and glaciers and its impact on the hydrological regime of the Himalaya river system, the present study strive to answer some of the questions related to the impact of glacial dynamics and snow cover changes on the water balance of the Ravi basin in North Western Himalayan and accordingly suggest the potential adaptation strategies for the sustainable management of water resources in this basin.
The study region is extensively glaciated. Mainly the glaciers and seasonal snow pack feed local rivers. The glacier dynamics and Snow cover changes has been achieved through the combined use of satellite imagery and digital elevation models using Landsat TM/ETM+, LISS-IV, ASTER and MODIS, for the past 40 years and the verification done by the field data. The snow cover analysis shows that during the summer months in the last ten years (2000-2010) the snow cover area increased. This trend makes a sign for the sustainable management of water resources in the basin since continuous depletion in the snow cover in summer season.
The output of the study further immensely helps to develop the potential adaptation strategies for the sustainable management of the water resources in the particular mountain basin.

Poster

## Late Weichselian glacial history of the southern Yermak Plateau

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High-resolution bathymetric and sub-bottom acoustic data as well as a sediment core from the southern part of Yermak Plateau have been studied to reconstruct the Late Weichselian glacial history. The core site is located near the present position of the Polar Front and in the

pathway of Svalbard Branch (SB) of the West Spitsbergen Current (WSC). Trend obtained from benthic foraminifera assemblages and statistical parameters suggests that this was a region of low sedimentation and high energy environment during the Holocene. Six radiocarbon ages and correlation with SPECMAP $0^{18}$ stack shows that the 3.69m long core extends from MIS 5 (or possibly earlier) to the Younger Dryas. Near the bottom of the core abundant benthic foraminifera *C. reniforme* and *I. norcrossi* indicates arctic conditions with presence of cooled Atlantic water. After the foram-rich section follows a zone which is mostly devoid of planktic foraminifera species and indicates polar conditions of MIS 4. Presence of the benthic foraminifera species *Buccella spp.* , along with *Elphidium spp. , I. norcrossi* indicates seasonal sea ice cover in early MIS 3. Open water conditions during late MIS3 is reflected by high concentration in planktonic foraminifera which corresponds to high productivity zones in the core. Dominance of the benthic *species C. neoteretis* and *I. norcrossi*, suggest Atlantic Water inflow and nutrient-rich bottom water. LGM starts with barren sections. Thereafter,co-occurrence of *C. reniforme , N. labradorica , Buccella spp.* indicates the return of polar conditions. *Elphidium spp.* , and *C. reniforme* indicate cooler water, variable salinity and *C. lobatulus , A. gallowayi* which are associated with stronger current regime dominates in the upper part of the core (75-0cm). This is interpreted as the transition zone from Younger Dryas to Holocene. Glacial geomorphology obtained from high-resolution bathymetry of this transition zone shows four sets of lineations, which resulted from different ice-grounding events. Lineations present above the core site are oriented SSE-NNW. At ~130-145cm a second strong reflector is observed in the seismic profile. It corresponds to dark sandy mud with high shear strength and few or no planktonic and benthic foraminifera between 25-23ka. This may be due to increased bottom current activity or re-advance of glaciation related to moisture supply from ice free condition that prevailed during the period of high productivity.

Talk

## Highly branched isoprenoid (HBI) biomarkers as a new Antarctic sea-ice proxy in deep ocean glacial age sediments

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Antarctic sea-ice plays a primary role in the climate system, potentially modulating interhemispheric millennial-scale climate change and deglacial warming. Recently, microfossil proxy data have provided important insights into this potential forcing. However, additional proxies for glacial sea-ice reconstructions are required, to support the microfossil data and to control for potential preservation issues. We considered highly branched isoprenoids (HBIs) as a sea-ice proxy, building on earlier studies in the Arctic and Antarctic. This study focused on measuring HBIs in glacial deposits in Southern Ocean deep ocean sediment cores. These deep ocean sites provided a study location away from the local sea-ice complexities associated with coastal and shallow water sites and allowed the comparison of HBIs during several phases of glacial sea-ice variability inferred from microfossils. Down-core profiles of di- and tri-unsaturated HBI isomers diene II and triene III were compared with diatom-based reconstructions of Antarctic sea-ice derived in three high-resolution sediment cores recovered from a transect across the Scotia Sea, Southwest Atlantic. High quality chronological control was achieved through a combination of abundance stratigraphy, relative geomagnetic palaeointensity data, and down-core magnetic susceptibility/ice core dust correlation. Positive correlations, observed between HBI diene II and sea-ice presence, and a strong coupling between HBI triene III and Marginal Ice Zone conditions indicated that the two HBIs are both closely related to sea-ice and sea-ice edge dynamics. Strong down-core correlations between the HBIs indicate coeval sedimentation related to the summer breakdown of sea-ice melt-induced stratification. Combined, the two HBIs and diatoms demonstrated their potential as proxies for permanent sea-ice cover and sea-ice seasonality, two parameters poorly resolved in current climate models. The sea-ice reconstructions presented confirmed that HBIs are a viable proxy for glacial Antarctic sea-ice and sea-ice dynamics back to at least ~60 ka.

Poster

## High-resolution reconstruction of southwest Atlantic sea-ice and its role in the carbon cycle during marine isotope stages 3 and 2

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Recent modeling suggests that changes in Southern Ocean sea-ice extent potentially regulated the exchange of $CO_2$ release between the ocean and atmosphere during glacials. Unfortunately, a lack of high-resolution sea-ice records from the Southern Ocean has prevented detailed testing of these model-based hypotheses with field data. Here we present high-resolution records of Southern Ocean sea-ice, for the period ~35–15 cal ka BP, derived from diatom assemblages measured in three glacial sediment cores forming an ~8˚ transect across the Scotia Sea, southwest Atlantic. Chronological control was achieved through a novel combination of diatom abundance stratigraphy, relative geomagnetic paleointensity data, and down-core magnetic susceptibility and ice core dust correlation. Results showed that the winter sea-ice edge reached its maximum northward extent of ~53˚S, at least 3˚ north of its modern limit, between ~25 and ~23.5 cal ka BP, predating the Last Glacial Maximum (LGM). Maximum northward expansion

of the summer sea-ice edge also pre-dated the LGM, advancing to at least 61˚S, and possibly as far north as 55˚S between ~31 and ~23.5 cal ka BP, a ~12˚ advance from its modern position. A clear shift in the seasonal sea-ice zone is evident following summer sea-ice edge retreat at ~23.5 cal ka BP, potentially related to austral insolation forcing. This resulted in an expanded seasonal sea-ice zone between ~22.5 cal ka BP and deglaciation. Our field data confirm that Southern Ocean sea-ice had the physical potential to influence the carbon cycle both as a physical barrier and more importantly through the suppression of vertical mixing and cycling of pre-formed nutrients. Our data indicates that Southern Ocean sea-ice was most effective as a physical barrier between ~31 and ~23.5 cal ka BP and as a mechanism capable of reducing vertical mixing between ~22.5 cal ka BP and deglaciation. However, poor correlations with atmospheric $CO_2$ variability recorded in ice cores, particularly the lack of a $CO_2$ response during a rapid sea-ice meltback event, recorded at our study sites at the same time as Antarctic Isotopic Maximum 2, suggest that Southern Ocean sea-ice in the Scotia Sea did not play a controlling role in atmospheric $CO_2$ variation during the glacial.

Poster

## Testing the GCM matrix method for indirectly coupling climate models to ice sheet models.

***Edward Gasson[1]***, Dan Lunt[1], Mark Siddall[1], David Pollard[2]

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The computational expense of running GCMs and the long response times of ice sheets presents a problem when modeling large ice sheet changes. Although a fully synchronous coupling between GCMs and ice sheet models is desirable, when performing long duration ($10^6$ – $10^7$ year) transient simulations of paleoclimates this is currently not feasible. This has led to the use of reduced or intermediate complexity climate models, climate parameterizations, asynchronously coupled GCMs and GCM lookup tables to provide a climate forcing to ice sheet models. Here we test the GCM matrix method against a suite of GCM simulations from the last interglacial period to present. We then apply this method to simulate the formation of the Antarctic ice sheet at the Eocene/Oligocene boundary. The computational efficiency of our method allows us to perform many sensitivity tests investigating the stability of the East Antarctic ice sheet.

Poster

## Holocene Climate in Western Mongolia from an Altai Ice Core

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During summer 2009 a 72 m surface-to-bedrock ice core was collected on Tsambagarav glacier in the Mongolian Altai (4'100 m asl, 48°39.338'N, 90°50.826'E). This for the region typical flat-top type glacier has ideal properties for preserving climate information: 1) Low ice temperatures from -14 to -12.5°C preventing post-depositional artifacts due to melt water percolation and 2) a flat bedrock topography at the drill site ensuring an undisturbed chronology. The upper two-thirds of the ice core contain 200 years of climate information with annual resolution, dated by three independent approaches, i.e. annual layer counting, identifying horizons, and $^{210}$Pb dating. The lower third was dated with a novel radiocarbon method, revealing strong thinning of the annual layers and a basal ice age of approximately 6'000 years before present (BP). We interpret the basal ice age as indicative of ice-free conditions at 4'100 m asl prior to 6'000 years BP. This age marks the onset of the Neoglaciation at the end of the Holocene Climate Optimum. Since most glaciers in the Mongolian Altai have comparable or lower elevation we conclude that they are not remnants of the Last Glacial Maximum but were formed during the second part of the Holocene. The ice core-derived accumulation suggests significant changes in the precipitation pattern of the last 6'000 years. During formation of the glacier wetter conditions than presently prevailed, followed by a long dry period from 5'000 years BP until 250 years ago.
To test whether the ice core stable isotope parameter $\delta^{18}O$ is suitable as temperature proxy a correlation analysis with instrumental data from Khovd weather station was performed. The highest correlation was obtained for the 5-year averaged $\delta^{18}O$ record and the months June-July-August. The reconstructed JJA temperatures from Tsambagarav show strong centennial fluctuations. The Little Ice Age cooling seems to be less pronounced compared to Mar-Nov ice core derived temperatures from the 350 km distant Belukha glacier in the Siberian Altai.

Poster

## Data-model comparison of the Late Weichselian Svalbard-Barents Sea ice sheet – for better constraints of postglacial isostatic uplift

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The deglaciation of the northwestern Barents Sea Ice sheet documented in terrestrial and marine records was reviewed recently. These data are implemented in a regional model described in Fjeldskaar et al. (Tectonics 1997) adjusted for the Svalbard region in order to search for uplift anomalies.
New cosmogenic nuclide (CN) ages from glacially transported boulders in interior areas of northern

Svalbard can be used to suggest a glacier surface lowering of conservatively estimated 100-200 m in inner parts of Svalbard from 25 ka until 17 ka. The grounded ice retreated with a time lag from the outer shelf throughout millennia 20.5-16 ka during Heinrich 1 and ice thinning persisted. The ice streams and ice shelves were located on the inner shelf around 17-15 ka. Between 15 and 14 ka a rapid collapse of the ice shelves is recorded in only a few centuries, based on overlapping deglaciation radiocarbon dates from the inner shelf and the inner fjord zones. This collapse predated the meltwater pulse 1a and we assume that a considerable contribution of 0.2 cm/yr$^{-1}$ to the sea level rise to the North Atlantic root in the disintegration of the western and northern Barents Sea Ice sheet.
We will present our effort to implement the new deglaciation dates in the postglacial isostatic adjustment (PGA) model. In general tectonic uplift models assume the post-glacial rebound is exclusively of glacial isostatic origin, but this is a questionable assumption. Fjeldskaaar et al. (Norsk Geologisk Vinterm 2011) found that areas where the measured present rate of uplift is greater than that predicted by regional glacial istostatic models and the difference is assumed to be a tectonic component.

Poster

## Cataloguing of glaciers of the river basins Koksu Aan Kyunes (Chinese part of Ile River basin) by materials of space monitoring

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Mountain areas are zone of runoff formation of the majority of the main rivers of the Central Asia. Results of researches do not leave doubts that the glaciation of the region starting from the middle of the last century is in degradation stage. In this connection, attempt of estimation of degradation of the glaciers located in rivers basins of Koksu and Kyunes (Chinese part of Ile river basin) from 1963 to 2011 is undertaken. The new catalogue of glaciers of the river basin Koksu is made on the basis of processing satellite images Landsat 7 ETM + and ASTER. Digitization of glaciers is made manually by raster bottom layer with application of various automatic methods of glaciers digitization. Besides mapping of glaciers boundaries also decoding of moraine complexes having distinct decoding signs (light tone of colouring, good expressiveness in relief) is made. Methodology of calculation of the volume of glaciers of continental glacial systems is made taking into account dependence between average thickness and glacier area.
In the basins of both rivers according to results of research there are 1045 glaciers. Decrease of the glaciers area depending on their morphological type and exposition is analyzed. Statistical analysis of the received data is carried out. By strong prevalence of number of the small glaciers, the overwhelming part of glacial resources is concentrated in valley glaciers. By considerable interbasins distinctions the glaciation of considered glacial systems is characterized by the general tendency and rates similar by size of degradation of the area of glaciers and ice resources.
The area of the open part of glaciers in the rivers basins of Koksu and Kyunes from 1962/63 to 2011 reduced for 27% and 41% accordingly. Rates of degradation of glaciation have made 0,56% and 0,85% a year by the area of the open part of glaciers and 0,81% and 0,99 % a year by ice volume accordingly.

Poster

## Change of glacial systems of Kazakhstan

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Modern condition of glacial systems of Kazakhstan is estimated by new Catalogues of glaciers made according to operative satellite survey for the last years. The main objects of glacial monitoring are the glacial systems of regional level (glaciation of Zailijskiy Alatau – northern peripheral ridge of Tien-Shan, Kazakh part of Dzhungarian Alatau and ridge Saur).
Because of changes of climatic conditions in all mountain glacial systems of Kazakhstan the reduction of the area of open part of glaciers, lowering of surface and as consequence reduction of volumes, disintegration of large glaciers into smaller parts is registered. At the same time, increase by the area and volume of moraine with the buried glacier ices which melting occurs much more slowly than at the open part of glaciers.
On northern slope of Zailijskiy Alatau in 2008 441 glacier, with the total area of open part 171,96 km$^2$ and volume of ice 6,90 km3, with the area of moraines 91,63 km$^2$ and volume of buried ice 1,72 km3 is registered. From 1955 to 2008 glaciation of northern slope of Zailijskiy Alatau reduced by the area for 116,60 km$^2$ (41 %), losing in the year 2,20 km$^2$ or 0,77 % of the area.
Within the Southern Dzhungaria as for 2000, 482 glaciers are registered. The total area of glaciation made 214,49 km$^2$ (area of open part made 130,80 km$^2$ and area of buried part made 83,69 km$^2$). The total ice volume made 6,56 km3, (volume of open part made 5,19 km3, ice volume under moraines taking into account degradation made 1,37 km3). In the whole for 44 years (1956-2000), the area of glaciation in Southern Zhetysuskiy Alatau decreased for 42 %, losing on the average 0,97% a year. For this period 59 glaciers with the total area of 5,4 km$^2$ have completely melted. By comparison of the total areas of glaciation for the years 1990 and 2000 calculated with identical degree of reliability we can see that the glaciation area has decreased for the 10 years for 22,7 km$^2$ (15 %), and degradation degree has made 1,5 % a year. According to preliminary estimations, for last decade (from 2000 to 2011) obvious slowdown of the rate of degradation of glaciation in comparison to the previous periods is observed (1,1 % a year).
Within the Kazakhstan part of ridge Saur the number of glaciers from 1960 to 2005 has increased from 18 to 31 not only due to detection of 8 glaciers which were not registered before, but also because of disintegration of larger glaciers. The total area of open part of glaciation

(without taking into account of 8 glaciers which were not registered before) was reduced for 2,516 km$^2$, that has made from the initial area 14,8 km$^2$ (about 17 %), the volume has decreased for 0,123 km3 (20 %). Speed of degradation of the area of glaciation during the years 1960-2005 has made 0,056 km$^2$/year (0,38 %/year), that practically corresponds to speed of degradation of glaciers of the Russian Altai.
Thus, average degradation of glaciation by our estimations is characteristic for Kazakhstan part of Tien-Shan, maximum – for southern parts of the mountains (Dzhungarian Alatau), minimum – for northern regions of Kazakhstan (Saur and Altai).

Talk

## Sensitivity of the Greenland ice sheet to the Holocene thermal maximum

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Geophysical modeling can be applied to constrain the past evolution of ice sheets and therefore provide insight to their response to past climate change. In this paper, we build on the results of a previous study in which a 3-D thermomechanical ice sheet model of the Greenland ice sheet (GrIS) was calibrated to observations of relative sea-level and ice extent from the last glacial maximum to present . While the Simpson et al. model provides a good fit to the majority of the data used in its construction, there are some significant misfits. In addition, the model fails to capture recent estimates of rapid and pronounced ice surface thinning derived from ice-core records. We focus on addressing the data-model misfits during the mid-to-late Holocene in an attempt to better constrain the model response to the Holocene thermal maximum (HTM). Given that present Greenland temperatures are approaching those experienced during the Holocene thermal maximum (HTM), the response of the GrIS to this past climate forcing is an analogue that can be used to inform and assess estimates of future mass balance changes. In our attempt to resolve the data-model misfits, we have carried out an in-depth model sensitivity analysis that considers uncertainty in both data and model constraints. For example, we considered new constraints on the positive degree day parameterisation of our surface mass balance model, as well as uncertainty in the amplitude of the temperature forcing during the HTM. Our results indicate that, while it is possible to resolve the majority of the data-model discrepancies, the existence of multiple plausible solutions renders it difficult to arrive at a tightly constrained volumetric contribution of the GrIS to sea-level in response to the HTM. We conclude by identifying the types and locations of new observational information that would be most effective in reducing this model non-uniqueness.

Talk

## Exploring the potential of sea salt as a proxy for sea ice extent on glacial-interglacial timescales

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Sea ice is both a reflection of, and a feedback on, the Earth's climate; it is also a source of chemically-reactive trace gases that profoundly affect polar atmospheric chemistry. A record of the extent and geographical distribution of sea ice, and their co-evolution with past climate, would therefore be highly valuable, and the hope is that one or more chemical proxies measurable in polar ice cores could contribute to this. Diatom assemblages in Antarctic marine sediment cores provide robust records of when transitions between permanent sea ice, seasonal sea ice and permanent open ocean occurred at specific sites. However, it remains difficult to piece together from these the polar-wide temporal evolution of sea ice, and it is here where ice-core records, for example of sea salt, could potentially provide complementary, regionally-integrated and long-term proxies for sea-ice extent. Besides uncertainties surrounding the sources of sea salt reaching ice-core sites (e.g. the relative importance of sea-ice related sources c.f. the open ocean), the influence that the climate has on the efficiency of sea-salt transport to these sites remains uncertain. Here, we present findings from a series of idealized model experiments aimed at quantifying the relative influences of sea-salt sources and transport on the flux of sea salt to Dome C, Antarctica, with a view to ultimately assessing the potential of sea salt (and methane sulfonic acid) to infer regionally-integrated records of sea-ice extent, here and at other ice-core sites, on a range of timescales up to glacial-interglacial.

Poster

## Inferring the Source Distribution of Meltwater Pulse 1A using Near- and Far-Field Data and Modelling Constraints

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Meltwater Pulse 1A (MWP-1A) was first identified in Barbados coral records as a large, rapid pulse in sea level that occurred during the last deglaciation. A recent interpretation of fossil corals in Tahiti constrains this event to have occurred between 14.65 and 14.31 ka BP. The amplitude of MWP-1A is uncertain, with site-specific values at Barbados, Sunda Shelf, and Tahiti falling in the range 12-22 m, or ~10-20% of the total sea level rise at these sites since the Last Glacial Maximum. While this range indicates that MWP-1A was one of the largest

melting events in recent geological history, its sources remain poorly known and the subject of intense debate. In particular, though early sea level fingerprinting studies suggest a significant Antarctic contribution, subsequent Antarctic deglaciation studies show that only a limited amount of ice came from the Antarctic at the time of MWP-1A.
In this study, we build on previous work that applied a sea-level fingerprinting technique to constrain the MWP-1A source distribution using data from Barbados and Sunda Shelf. We extend this analysis in several respects, by (1) considering data from an additional site: Tahiti; (2) including careful re-assessments of the MWP-1A amplitude and uncertainty at Barbados and Sunda Shelf (present study); (3) using more realistic melting scenarios for the Laurentide) and Antarctic, and (4) applying a statistical approach to map out the range of plausible meltwater sources. Preliminary results show that there exists a range of melting scenarios that are prescribed by recent near-field data and models in both the Northern Hemisphere and Antarctic that also satisfy the far-field sea level constraints at Barbados, Sunda Shelf, and Tahiti.

Talk

## Melting of Northern Greenland during the last interglacial

***Kerim Hestnes Nisancioglu*[1,2,3]**, Andreas Born[4,5]

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The Greenland ice sheet (GrIS) is losing mass at an increasing rate, making it the primary contributor to global eustatic sea level rise. Large melting areas and rapid thinning at its margins has raised concerns about its stability. However, it is conceivable that these observations represent the transient adjustment of the fastest reacting parts of the ice sheet, masking slower processes that dominate the long term fate of the GrIS and its contribution to sea level rise.
Using simulated climate data from the comprehensive coupled climate model IPSL CM4, we simulate the GrIS during the Eemian interglaciation with the three-dimensional ice sheet model SICOPOLIS. The Eemian is a period 126,000 years before present (126 ka) with Arctic temperatures comparable to projections for the end of this century. In our simulation, the northeastern part of the GrIS is unstable and retreats significantly, despite moderate melt rates. This result is found to be robust to perturbations within a wide parameter space of key parameters of the ice sheet model, the choice of initial ice temperature, and has been reproduced with climate forcing from a second coupled climate model, the CCSM3. It is shown that the northeast GrIS is the most vulnerable. Even a small increase in melt removes many years of ice accumulation, giving a large mass imbalance and triggering the strong ice- elevation feedback. Unlike the south and west, melting in the northeast is not compensated by high accumulation. The analogy with modern warming suggests that in coming decades, positive feedbacks could increase the rate of mass loss of the northeastern GrIS, exceeding the recent observed melt in the south.

Poster

## Glacier hazards caused by glacier shrinkage and climate change: Case study of Russian Caucasus

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Glacier hazards caused by climate change and consequent glacier shrinkage in the Caucasus, highly glaciated mountains with altitude up to 5642 m asl increase socio-economic stress in the region and result in numerous fatalities and economic losses. Glaciers in the Russian Caucasus have experienced an accelerating downwasting due to regional climate changes over the past decades. This trend could be explained by rapid (0.03°C per year) increase of summer air temperature. In the Central Caucasus temperature growth is partially compensated by increase of solid precipitation, but this tendency is not typical for Western and Eastern parts of the Greater Caucasus.
Such conditions have already resulted in predominantly negative glacier mass balance and consequent reduction of glacier covered area. Since 1968 representative for the Central Caucasus Djankuat Glacier has been lost more than 6 m w.e. Moderate ice loss was observed in 1968-1975, slowing down in 1976-1986, followed by positive mass balance in 1987-1997, and a subsequent dramatic ice loss until nowadays. This is also typical for Garabashi Glacier in the southern slope of Mt. Elbrus. Glaciers in the Western and Eastern parts of Russian Caucasus also demonstrate ice loss. Thus lead to accelerating termini retreat, say for Mt. Elbrus glaciations over the 1997-2007 it was twice and half faster than in 1957-1997. Glacier area shrinkage comes to -0.5% per year at Mt. Elbrus in 1997-2007 mostly through frontal retreat. On valley and cirque glaciers area shrinkage comes mostly through disappearing of ice apron. According to our assessments for some major river catchments, glaciers in the Russian Caucasus have been lost ca. 20% of area in last 40-50 years.
The observed and projected reduction in the extent of glacier ice has implications for various geomorphic processes, including accelerating glacier lake formation and expansion, glacier related debris flows, rockfalls and rock avalanches from bare slopes above glaciers etc.
We present case studies of some glacier hazards in the region, related to climate warming and glacier retreat, including GLOFs, debris flows and multi-stage hazards.
We conclude that glacier hazard increases in some valleys in the Caucasus, whereas in other valleys glacier hazard decreases or remains quasistable.

Poster

## Holocene Climate vis-à-vis Glacier history from Garhwal Himalaya: A Multiproxy approach

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Inferences based on pollen and other proxy data made from three sites at sub-alpine to alpine zones in the glaciated valleys of Gangotri and Dokriani at Uttarakhand and Sangla in Himachal Pradesh show a regional post glacial or Holocene climatic sequence vis-à-vis glacier history for the regions. Dokriani area shows a continuous cool and dry phase prior to 10,240 yr BP as indicated by the dominance of steppe elements and low negative $d^{13}C$ values (-180 to -200) suggestive of more $C_4$ taxa in the surrounding vegetation. This is also supplemented with the corresponding low Magnetic Susceptibility (clf) values. Cool-dry conditions are also noticed prior to the beginning of post-glacial period from Sangla valley as supported by the presence of frozen layer, the upper boundary of which is dated around 10,640 yr BP. This phase can well be correlated with the Younger Dryas event when glacier snout might have been at much lower altitudes than present. The onset of climatic amelioration is recorded in the region since around 10,240 yr BP as reflected by the decrease in $d^{13}C$ values that further declined to maximum negative (-280) indicating dominance of $C_3$ vegetation with high clf values around 9,227 yr BP. The pollen data also shows diversification of vegetation with taxa favorable to warm-moist climate when the Himalayan glaciers were under retreating condition with the migration of tree line to higher altitude. The early to mid Holocene part in the valleys is interrupted by short cool phases around 8,730; 7,600 and 6,200 yr BP as indicated by the increase in C4 taxa and decline in clf values. Pollen data from Sangla valley shows that since early to mid Holocene tree line was at lower altitude than its present day distribution. Accordingly, the glacier snout might also be at lower elevations but under retreating condition at various rates. The mid to late Holocene part is well reflected by the Gangotri and Sangla valleys that shows cool phase around 2,900 yr BP followed by warm conditions since 1,800 yrs BP till present, which is marked by the movement of tree line to higher elevations in this valley as indicated by the increase in pollen frequency of conifers and tree line forming taxa (Betula and Juniperus). Gangotri valley shows sharp increase of steppe elements around 1200 and 1400 AD indicating cool episode that can be correlated with the Little Ice Age signatures when the glacier might have shown stagnation or some advancement.

Poster

## Environmental records in permafrost of East Siberian Arctic during the MIS2 Stadial and the MIS3 Interstadial

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In East Siberian Arctic permafrost deposits is increasingly employed as an archive that preserves records of regional environmental history. Pollen records play a leading role among bioindicators because of the common presence of fossil pollen in Quaternary terrestrial periglacial and lacustrine sediments. One of the most promising study areas for collecting information that can be used to highlight the environmental history of West Beringia is Bol'shoy Lyakhovsky Island, located between the Laptev and the East Siberian seas. The southern coast of B.Lyakhovsky Island exposes permafrost outcrops that feature frozen sediments, ground ice, and fossil remains dating from the mid-Pleistocene.
During the MIS3 Interstadial, continuous Ice Complex development took place on B.Lyakhovsky Island. Pollen records of Kargin Interstadial reflect some amelioration of the harsh environmental conditions predominant during the previous interval. The studied record of a continuous permafrost sequence dated between > 55 and 27 kyr BP reflects the palaeoenvironmental history from the end of the MIS4 to the end of the MIS3. The combined data sets allow to differentiate the late Zyryan Stadial (>55 to 52 kyr BP) with a quickly developing polygon tundra; harsh cold and dry summers are reflected by sparse grass-sedge tundra-steppe and high amounts of redeposited conifers. During the early Kargin Interstadial (52-48.5 kyr BP) pollen record shows higher Artemisia percentages within a grass-sedge tundra-steppe vegetation that support dry conditions. The Kargin Interstadial optimum between 48.5 and 37 kyr BP promoted low-centered polygon tundra with shallow water in polygon centers. Moister conditions in the landscape than during the previous Zyryan Stadial are assumed while the general summer climate conditions likely remained dry, but slightly warmer as reflected by higher Salix abundances. Warmer summer air temperatures and moister condition on landscape scale during the MIS3 optimum are revealed mainly by Salix and green algae findings in the palynological tundra-steppe records. A cooling trend in summer air temperatures between 37 and 27 kyr BP can be deduced from disappearing Salix pollen.
Changes in the accumulation conditions are indicated at the end of the MIS3 in transition to the MIS2. The palynological complex (L7-07) dated to the early Sartan stadial reflects the existence of an impoverished variant of tundra steppe or cryophyte steppe vegetation. The dominance of graminoids, together with abundant Artemisia, and low percentages of Ericales (indicator of wet plant communities) in the pollen spectra point to rather dry climatic conditions. Evidence of an extremely cold climate is given by the dominance of Poaceae over Cyperaceae. The large amount of Caryophyllaceae, Brassicaceae, and Papaveraceae, which are arctic pioneer taxa characteristic of northernmost vascular plant communities in polar deserts, confirms this interpretation.

The temporal appearance of LGM conditions in East Siberian permafrost as represented by pollen and ground ice data differs somewhat within the region, but delineates a general trend to coldest and driest climate conditions between about 24 and 18 ka BP. Herb- and shrub-dominated Lateglacial vegetation is reflected in pollen data from Bol'shoy Lyakhovsky after the Sartan stadial. Betula sect. Nanae, B. sect. Albae, and Duschekia fruticosa pollen mirror warming climate conditions.

Talk

## Global and regional patterns in the Holocene glacier fluctuations records

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Reconstructions of glacier length variations provide important independent paleoclimatic information. The number of detailed chronologies of glacier variations based on cosmogenic isotopes ($^{10}$Be, $^{26}$Al, $^{36}$Cl ) surface exposure dating technique, tree-rings and lake sediments multi-proxy analyses increased dramatically in the last years and allowed much more precise interregional comparisons of chronologies and extent of former glaciers. In this review we analyze the glacier variations at the two time scales: the Holocene and the last 2 ka and a) assess the agreement between the results of different dating techniques in several key regions; b) compare the regional reconstructions of glacier variations with the climatic proxy reconstructions of temperature and precipitations in order to recognize the leading climatic forcings of glacier advances and retreats, c) present a new series of maps superposing the regional glacier advances at the temperature and precipitation spatial reconstructions of the last 2ka (100-years step) using as a background the maps from the Holocene Climate Atlas (www.oeschger.unibe.ch/research/projects/holocene_atlas/), d) update the regional glaciological information related to six specific cold events (8200, 6300, 4700, 2700, 1550 and 550 years BP); e) use principal component and cluster analyzes of Loss-on-Ignition, grain-size analysis, magnetic properties, and geochemical elements time series indicating the variations of glacier activity in the past to identify the global and regional patterns in variations of glacier sizes and Equilibrium Line Altitude over the Holocene and the last few millennia.

Poster

## Reconstruction of the past 2000 years of ocean and glacier variability in Sermilik Fjord, SE Greenland, based on sediment archives

Andreea Stoican[2], Camilla S. Andresen[1], Marit-Solveig Seidenkrantz[3], Kurt K. Kjaer[2], Antoon Kuijpers[1], Guillaume Massé[4], ***Kaarina Weckström[1]***

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Glaciomarine sediments represent valuable archives of climate and glacier variability in the arctic environment. Especially the fjords along Greenland's east coast represent a dynamic and complicated system, influenced by regional ocean circulation, local currents and by glacier terminations. Therefore, they represent appropriate locations for sedimentary core studies in order to detect the relative glacier and ocean variability.
The aim of this project is to reconstruct the past 2000 years of glacier and ocean variability in Sermilik fjord, SE Greenland, into which Helheim glacier terminates. This is done by analysing two sedimentary cores (ER11 and ER07) and hereby reconstruct fluctuations in marine-terminating outlet glacier dynamics (including iceberg and to a lesser extent meltwater production) and the interaction with oceanographic changes. The oceanographic variability is reconstructed on the basis of benthic and planktonic foraminiferal analysis and the content of the biomarker IP25 and these proxies are interpreted to reflect changes in the inflow of the warm Irminger Current and polar waters in association with the East Greenland Current. Interestingly, studies show that the onset of the Little Ice Age was characterised by intensified inflow of Irminger Current water masses to the Southeastern and Southwestern shelves of Greenland and that these may be associated with a contracted subpolar gyre. At the same time, the EGC Polar Water transport also intensified leading to a stratified water column on the shelf and this may have favoured entrainment of warm subsurface IC waters. Alternatively, the relatively warm rim of the eastern subpolar gyre may have promoted intense submarine melting of extended outlet glaciers at this time, producing enhanced melt water outflow which favoured estuarine circulation processes maintaining the inflow of IC water masses. Thus the aim of this study is to investigate in detail the circulation of these LIA warm waters from shelf into the fjords and in particular the glacier response/role. The results will provide valuable information for improving model studies of ocean-cryosphere interaction and prediction of future sea level changes.

Poster

## Reconstructing spatial and temporal patterns of former glaciation along the Tian Shan

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Testing and calibrating global climate models require well-constrained information on past climates of key regions around the world. Particularly important are transitional regions that provide a sensitive record of past climate change. Central Asia is an extreme continental location with glaciers and rivers that respond sensitively to temporal variations in the dominance of several major climate systems. As an international team initiative, we are reconstructing the glacial history of the Kyrgyz and Chinese Tian Shan, based on mapping and dating of key localities along the range. Remote-sensing-based geomorphological mapping, building on previous maps produced by Kyrgyz, Russian, Chinese and German scholars, is being augmented with field observations of glacial geomorphology and the maximum distribution of erratics. We are using cosmogenic nuclide (CN) $^{10}$Be dating of moraines and other landforms that constrain the former maximum extents of glaciers. Comparing consistently dated glacial histories along and across the range will allow us to examine potential shifts in the dominance patterns of climate systems over time in Central Asia. We are also comparing ages based on CN with optically stimulated luminescence (OSL) and electron spin resonance (ESR) dates. The final stage of this project will use intermediate complexity glacier flow models to examine paleoclimatic implications of the observed spatial and temporal patterns of glacier changes across Central Asia and eastern Tibet, focused in particular on the last glacial cycle.

Poster

## Evaluation of the sea ice proxy $IP_{25}$ against observational and diatom proxy data in the SW Labrador Sea

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The recent rapid decline in Arctic sea ice cover has increased the need to improve the accuracy of the sea ice components in climate models and to provide detailed long-term sea ice concentration records based on proxy data. Recently, the highly branched isoprenoid $IP_{25}$ has emerged as a potential sea ice specific proxy for past sea ice cover, found in marine sediments underlying seasonal sea ice. We tested the reliability of this biomarker against observational sea ice data (sea ice concentrations from the global HadISST1 database) and against a more established sea ice proxy (sea ice diatom abundance in sediments) in the South-West Labrador Sea. We further tested a novel index based on $IP_{25}$ and a phytoplankton biomarker, the $PIP_{25}$ index, in a new environmental setting at the southern margin of Arctic sea ice drift. Our two study sites are located North-East (NE) and South-East (SE) of Newfoundland where box cores covering the last ca. 100-150 years were collected. The results show an overall good agreement between the $IP_{25}$, sea ice diatom, and the observational HadISST1 data. $IP_{25}$ concentrations are clearly higher and sea ice diatoms more abundant NE of Newfoundland, where sea ice prevails 2-4 months per year compared to the generally ice free conditions SE of Newfoundland. The $IP_{25}$ fluxes NE of Newfoundland agree well with multi-decadal North Atlantic Oscillation (NAO) trends in the study area, which have in previous studies been shown to affect the climatic and sea ice conditions in the region. $IP_{25}$ appears to be a more sensitive indicator of sea ice variability in this setting compared to sea ice diatoms and proved to be a robust and reliable proxy for reconstructing low-frequency variability in past sea ice concentrations. The $PIP_{25}$ index results clearly differ from the observed sea ice data underlining that caution needs to be exercised when using the index in different environmental settings. We present a late-Holocene $IP_{25}$ record, showing increasing sea ice concentrations starting from ca. 1500 cal. yr BP, with clearly less sea ice during recent times.

## OSM08: Natural and Anthropogenic Transformation of Land Cover During the Holocene

Convenors: Carsten Lemmen, Marie-José Gaillard, Jed Kaplan, Anupama Krishnamurthy

Poster

### Holocene Vegetation changes in the Cauvery Floodplains, southern India: A case study

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Pollen analysis of a Quaternary sediment core from Cauvery floodplains, Southern India provides the history of vegetation of the area and its catchments for the past 8,500 years. The top part (3 to 560 cm) of a long core of depth ~55m recovered from Uthirangudi (10°39'17.7" N; 79°39'42.2" E) located in Thiruvarur district of Tamil Nadu was analyzed palynologically. Increase and decrease in the abundances of different pollen assemblages indicate that environmental conditions have fluctuated over time, favoring different plant species at different times in the past. From 500 to 390 cm, the core has yielded very less number of pollen or is barren. Between 8500 yr and 6500 yr (390–250 cm), forest species were dominating over the herbaceous grass species. A progressive expansion of deciduous woody species was noticed between 310 and 210 cm as revealed by Drypetes and Melastomataceae/ Combretaceae pollen types. In the upper part of the core, opening and disturbance markers are abundant with high percentage of Strobilanthes pollen type along with human impact markers; this is simultaneous with a decrease of dominant forest markers such as Melastomataceae/ Combretaceae, leading to the probable indirect inference of strong anthropogenic disturbances and clearings for possible agricultural activity during the mid-Holocene. Other chemical proxies are also being correlated to this pollen record of vegetation change to derive past climate fluctuations.

Poster

### Holocene vegetation estimates for selected regions in Bohemia (Czech Republic)

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We calculated vegetation estimates by model REVEALS (Regional Estimates of VEgetation Abundance from Large Sites) (Sugita, 2007) in six regions of Bohemia for whole Holocene. Fossil and modern pollen data originate from Czech Quaternary Palynological database (PALYCZ). Firstly, we recalibrated Pollen Productivity Estimates (PPEs) by REVEALS model. We compared present regional vegetation with REVEALS estimates using zero depths from same cores with the same model setting as for the fossil time windows. PPEs were selected and changed until REVEALS results matched present regional vegetation, which was compiled from CORINE land cover data, forest inventories and agricultural statistics. Fossil pollen sequences were split to time windows according to density of dating and resolution of the pollen record. The results substantially contribute to the long discussion about past human impact, the continuality of the open landscape and composition of natural vegetation in Bohemia. Vegetation development in selected regions corresponds to general ecological demands of taxa. Thus, differences between regions can be explained by altitude, soils and climate. Continual open landscape (>20%) on regional scale was revealed in Polabi lowland. It was dominated by Poaceae from the beginning of the Holocene until the Bronze age, when was replaced by Cerealia due to increasing human impact. In this cultural lowland, pine (ca. 15%) and oak (ca. 25%) have higher abundance. Regions with higher altitude keep forested areas (>90%) until Early Medieval ages. Fir and beech were dominants at this time. Additionally, mountainous regions host more than 20% spruce.

Poster

### A large-scale erosion anomaly (2nd c. BC- 4th c. AD) in NW Alps: A locally-defined onset of the Anthropocene?

***Fabien Arnaud***[1], Laurent Astrade[1], Manon Bajard[1], Jean-François Berger[2], Yves Billaud[3], Emmanuel Chapron[4], Christian Crouzet[5], Fernand David[6], Philip Deline[1], Elise Doyen[7], Charline Giguet-Covex[1], Jérémy Jacob[4], Melaine Le Roy[1], Laurent Millet[7], Jérôme Poulenard[1], Sidonie Révillon[1], Pierre-Jérôme Rey[1], Pierre Sabatier[1], Anaëlle Simonneau[4], Pierre Taberlet[8], Boris Vannière[7]

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The research program Pygmalion consisted in a 4-years long unprecedented scientific effort to investigate complex human-climate-environment interactions in Northern French Alps. Thanks to a wide geographic cover, it led to evidence an erosion anomaly that began in 200 BC, at the time of the Allobroges Gallic tribe, just prior their embedment into the Roman Empire and ended at the end of the Roman period (around 400 AD). Indeed during the whole Holocene period, a strong link has been evidenced between climate and erosion fluxes at a regional scale. This link was obviously broken at the end of Iron Age.

At that time, huge erosion fluxes were recorded from sedimentary records taken in lakes with small catchment areas, both in high and low elevation sites. Even regional detrital fluxes in Lake Bourget, representative of a 4000 km$^2$ catchment area, present an anomaly, whereas no glacier advance nor temperature drop were recorded in the area. Moreover paleovegetation and fire regime data point major changes in vegetation cover that pinpoints a drastic change in land-use practices at regional scale suggesting a reinforcement of pasturing activities. In Lake Anterne high-altitude (2060 m asl) catchment area, this is confirmed by DNA barcoding data acquired on from lake sediment evidencing the unprecedented intensive presence of both sheeps and cows as well as by the discovery of a ruined shepherd caban, the first occupation of which being dated 2$^{nd}$ c. BC. Finally, based on the measurement of molecular biomarker, we evidenced this period as peak in broomcorn millet cultivation around Lake Bourget and Lake Paladru.
Based on above-mentioned field evidences we argue that changes in land-use practices between 200 BC and 400 AD had such an important impact that it significantly affected the erosion budget at a regional scale. From our dataset covering the whole Holocene, this was the first time, in the considered area, that human activities became intensive enough to significantly alter an important geodynamic process such as erosion. Following various authors we hence wonder if this could not define a local onset of the Anthropocene period characterised by the emergence of humans as a major geologic agent.

Poster

## Early Neolithic diets at Baijia, Wei River valley, China: Stable carbon and nitrogen isotope analysis of human and faunal remains

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The first farmers of the Wei River valley belonged to the Laoguantai period (ca. 8500-7000 yr BP) and lived in small settlements that were sparsely distributed in the landscape. Understanding of Laoguantai farming practices is limited as only a small number of archaeological sites are known. Here we present stable carbon and nitrogen isotope values for faunal and human bone collagen from Baijia, a Laoguantai site in the Wei River valley of Shaanxi Province, China. Five of the collagen samples have been AMS $^{14}$C dated and have a calibrated age range of ca. 7659-7339 yr BP. Stable isotope results show millet and aquatic foods, such as fish and shellfish, being included in the human diet. Bovid samples, which are tentatively identified as water buffalo, have stable carbon isotope values reflecting some millet consumption. The question of whether these bovids were grazing on millet growing wild, or had diets directly influenced by humans, remains to be answered. Stable isotope results for a single pig reveal a markedly different diet, one dominated by $C_3$ plants which would have dominated natural vegetation of the region. Overall, stable isotope results conform to the current view of Laoguantai people being millet farmers with subsistence strategies that included hunted wild foods.

Poster

## Impact of monsoonal variation on vegetation and climate change as inferred from late Holocene sediment of Garbhanga reserve forest, Assam, north east India: A pollen based study

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Study of the Indian monsoonal activity is critical for understanding regional and global variability as it drives major changes of tropical Indian Ocean sector. These changes were accompanied by changes in rainfall over South Asia largely affecting the fluvial system and thus flora and fauna of the region. Here we present a late Holocene pollen record procured from a 2 m sedimentary profile dated back to 5800 years BP from Garbhanga reserve forest bordering India's Assam and Meghalaya states facing security threats from timber smugglers. In recent time it is estimated that in the last six years, around 40% of the forest's trees have been felled and large-scale timber smuggling is fast depleting the reserves and playing havoc with the ecosystem. Therefore, it is felt necessary to take immediate measure to restore the lost pristine environment. In the present study the pollen diagram has depicted existence of tropical mixed tree savannah during 5800 to 3400 years BP influenced by relatively less cool and humid climate. The vegetation scenario implies poor growth of woods probably due to harsh abiotic dynamics causing changes in hydrology (drainage patterns). Subsequently during 3400 to 1750 years BP the savannah has been replaced by invasion of mixed deciduous elements showing onset warm and humid climatic condition supported by the evidence of higher value of ferns and fungal remains. However, during 1750 to 680 years BP a steady increment of more important deciduous taxa was witnessed in the assemblage influenced by active SW monsoon under increased warm and humid climate. Acceleration in marshy/aquatic elements in this phase indicates vast swampy and wider lake conditions. Finally during 680 years BP onward the floristic have been drastically reduced influenced by climate change turned to warm and relatively drier probably attributable to weaker monsoon rainfall. Marshy/aquatic elements were also reasonably disappeared from the scenario; however, the human settlement was witnessed as evidenced by the higher frequency of cereals with other ruderals. Evidence of high value of Melastoma, Areca catechu and Mimosa pudica is suggestive of forest clearance during the phase. Intensity of monsoonal activity has been estimated using

pollen marker taxa during the period of deposition. Evidence of degraded pollen spores festooned with fungal remains suggest the initiation of biological degradation in sediment.

Poster

## Southern Westerlies postglacial dynamics at Central Chilean Patagonia (Río Cisnes valley, 44°S)

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Central Chilean Patagonia (44-49°S, South America) is a key area to reconstruct past Southern Westerlies (SW) dynamics through the last glacial-interglacial cycle since its position within their maximal zonal flow and the presence of appropriate terrestrial paleoclimate records. An interdisciplinary project including geomorphology, pollen and fire records since 19kyr BP has been carried out along the Río Cisnes valley (RCv, 44°S) to trace past environmental changes related to SW dynamics. The upper RCv was free of ice by 19kyr BP but the presence of a Late Glacial moraine in the middle RCv points out that the valley was under glacial influence until 13kyr BP. Major vegetation changes were recorded from the Late Glacial to the early Holocene when grass-shrub steppes were replaced by the Nothofagus forest-steppe ecotone in the upper RCv and the deciduous Nothofagus forest in the middle RCv. High fire frequencies associated to the Nothofagus forest development were recorded in RCv around 12.5-8.5kyr BP. A maximum development of the Nothofagus forests along the RCv was recorded during the mid-Holocene whereas high pollen assemblage variability and high fire occurrence characterized the late-Holocene. Climatic changes in RCv were mostly associated to past SW major changes previously recorded along Patagonia from the Late Glacial to the mid-Holocene. During the Late Holocene, a high record variability emerges throughout Central Chilean Patagonia probably related to (1) low magnitude SW changes probably associated to ENSO and/or SAM or (2) the complex relationships between vegetation, fire and human occupations during the last 3kyr.

Poster

## Late Holocene vegetation vis á vis climate dynamics from Hasila wetland, western Assam, Northeast India: Pollen and diatom record

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Pollen and diatom observation of a 1.5 m deep sedimentary profile cored from Hasila wetland of Goalpara District, western Assam, Northeast India has revealed climate vis-à-vis vegetation succession since Late Holocene supported by contemporary pollen/ vegetation relationship in and around the wetland which could be employed as background information for the palaeoclimate studies. Enrichment of tropical mixed deciduous forest elements like *Syzygium cumini, Shorea robusta, Dillenia pentagyna and Acacia catechu* along with fair value of planktonic diatoms indicate warm and humid climatic regime during 3,570-1,950 cal years BP. Subsequently during 1,950-570 cal years BP, increased warm and humid climatic regime persisted as evidenced by relative increment in proliferation of Sal and its associates indicating final settlement of tropical mixed deciduous forest. Consistent frequency of planktonic diatoms along with high percentage of *Impatiens* and *Myriophyllum* signify high monsoonal condition corresponding to that of Medieval Warm Period. The swamp level along with pastoral practice relatively improved during this phase, thus, attributable to increased SW monsoon. However, from 570 cal year BP onwards gradual deterioration of mixed deciduous forest occurred as evidenced by sudden decline in Sal and its associates along with relative increment in benthic diatom assemblage under warm and relatively drier climate. Drastic increment in *Melastoma*, *Ziziphus* and *Areca* implying forest clearance at this phase. The occurrence of degraded pollen-spore along with adequate fungal remains especially *Xylaria, Diplodia, Nigrospora, Cookeina* and *Microthyriaceous* fruiting body is suggestive of aerobic microbial digenesis of rich organic debris during sedimentation.

Talk

## Soil erosion processes and long-term human-environment-interactions in central Europe and SE-USA

***Markus Dotterweich[1]***

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This presentation will firstly review the current state of knowledge about the dynamics of past soil erosion and gullying in small catchments, the effects to adjacent fluvial systems, and possible feedback mechanisms to land-use changes over the last 7,000 years in central Europe. The discussed studies were conducted on hillslopes and gully systems in low mountain range areas. They are characterised by coupled slope–channel systems as well as uncoupled systems like closed depressions in Pleistocene lowlands, maars, lakes, and sunken areas. The studies show that sediment fluxes in small catchments are highly sensitive to local land-use changes, while river sediments show regional trends in land use and climate change. Peaks of soil erosion and gullying occurred during phases of rapid climate change.Extreme precipitation events in particular caused intensive runoff on slopes

used for agriculture. The most significant phases occurred in the first half of the 14th century and in the mid-18th to the early 19th century. Most of the gully systems in Europe today are a result of these catastrophic occurrences, which triggered land abandonment and influenced the ecosystem and the socio-economic situation. The results imply that a future increase in land-use intensity and extreme precipitation events as a result of climatic change might have severe consequences regarding soil erosion, flood risk, and ecological aspects.
The loess hills of Northern Mississippi, SE-USA were repeatedly exposed, eroded, and translocated via fluvial systems during the Holocene. Near Owl Creek Indian Mounds, a valley fill soil-sedimentation sequence documents the stages of natural and anthropogenic influences on the landscape, beginning in the Middle Archaic, around 7,000 BP. Intensive rainstorms and highly erodible material make the landscape in the uplands of North Mississippi extremely vulnerable to soil erosion. Traces of intensive soil erosion were found particularly in the period between the 12th and 16th century as a result of land clearings and intensive land use by the native Indians, which .had probably led to a decrease in soil fertility as well as crop yields. However, as white men arrived in this region during the early 19th century, they still found highly fertile soils. Subsequent deforestation and farming caused intensive erosion, and in a very short time nearly all of the soil was washed away and extensive gullying transformed the landscape into badlands. These long-term human environment interactions will be discussed in the light of resilience and vulnerability over the long duree.

Poster

## Grazing activities and vegetation history in the Pyrenees inferred from palaeoecological data

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In the Pyrenean mountains, the seasonal use of high altitude pastures is an essential component of the traditional agro-sylvo-pastoral system and short or long distance transhumances are strongly integrated into the socio-economical territory of mountain societies. Since the middle of the 60's the strong decrease in grazing pressure caused important transformations in highland zones such as abandonment or overexploitation according to the cases and the areas and threatens high mountain traditional cultural landscapes as well as biodiversity in alpine ecosystems. Since many years, several interdisciplinary projects involving palaeoecological and archaeological research performed all over the Pyrenean mountain aim to reconstruct the environmental history of these highlands zones and the impact of summer grazing on vegetation at high altitude in a long term perspective. Multi-proxy records (pollen, non-pollen palynomorphs and charcoal) and archaeological surveys show the first signals of small scale grazing activities at the end of the early Neolithic period. During Neolithic times the use of alpine pasture remains moderate and occasional while important changes occur during Bronze and Iron ages as suggested by deforestation, the increase of pollen grazing indicators and by numerous archaeological remains found at high altitude. The origin of such a change and the increase in grazing pressure can be correlated with the transformation in the agrarian system reflected by pollen and charcoal records from lower altitude. The Medieval period (ca. 8th and 10th centuries AD) is characterized by a second step of intensification in summer pasture exploitation that involves massive deforestation and forest reduction. The maximum pressure is reached during the 19th century with well documented case of overgrazing.

Talk

## From forest to farmland and moraine to meadow: Integrated modeling of Holocene land cover change

***Jed O. Kaplan***[1], Mirjam Pfeiffer[1], Kristen M. Krumhardt[1], Basil A. S. Davis[1], Marco Zanon[1], Pamela M. Collins[1], Achille Mauri[1]

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Did humans affect global climate over the before the Industrial Era? While this question is hotly debated, the co-evolution of humans and the natural environment over the last 11,700 years had an undisputed role in influencing the development and present state of terrestrial ecosystems, many of which are highly valued today as economic, cultural, and ecological resources. Yet we still have a very incomplete picture of human-environment interactions over the Holocene, both spatially and temporally. In order to address this problem, we combined a global dynamic vegetation model with a new model of preindustrial anthropogenic land cover change. We drive these integrated models with paleoclimate from GCM scenarios, a new synthesis of global demographic, technological, and economic development over preindustrial time, and a global database of historical urbanization covering the last 8000 years. We simulate land cover and land use change, fire, soil erosion, and emissions of $CO_2$ and methane ($CH_4$) from 11,700 years before present to AD 1850. We evaluate our simulations in part with a new set of continental-scale reconstructions of land cover based on records from the Global Pollen Database.
Our model results show that climate and tectonic change controlled global land cover in the early Holocene, e.g., shifts in forest biomes in northern continents show an expansion of temperate tree types far to the north of their present day limits, but that by the early Iron Age (1000 BC), humans in Europe, east Asia, and Mesoamerica had a larger influence than natural processes on the landscape. 3000 years before present, anthropogenic deforestation was widespread with most areas of temperate Europe and southwest Asia, east-central China, northern India, and Mesoamerica occupied by a matrix of natural vegetation, cropland and pastures. Burned area and emissions of $CO_2$ and $CH_4$ from wildfires declined slowly over the entire Holocene, as landscape fragmentation and changing agricultural practices led to decreases

in burned area. In contrast, soil erosion increased with increasing human pressure over the last 11 ka, except in areas where topsoils became exhausted, e.g., in the Andes and the eastern and southern Mediterranean. While we simulate fluctuations in human impact on the landscape, including periods of widespread land abandonment, e.g., during the Migration Period in Europe that following the end of the Western Roman Empire, approaching the Industrial Revolution nearly all of the landmasses of Europe and south and East Asia are dominated by anthropogenic activities. In contrast, the collapse of the aboriginal populations of the Americas following 15th century European contact leads to a period of ecosystem recovery. Our results highlight the importance of the long histories of both climate change and human demographic, economic, and technological history on the development of continental-scale landscapes. We emphasize the need for improved datasets that use archaeological data synthesis and build on recent theory of preindustrial economic and technological change. A large source of uncertainty in our results comes from assumptions we make about the rates and timing of technologically driven intensification of land use, and the importance of international trade for the subsistence of preindustrial societies.

Talk

## Holocene Vegetation and Climate history of Peninsular India from terrestrial archives: Problems and Prospects

***Anupama Krishnamurthy*[1]**, Prasad Srinivasan[1]

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This paper presents the current status of studies on Holocene cores and sections from terrestrial sites in Peninsular India, analyzes the problems faced in arriving at a synthesis, both spatial and temporal, at a regional scale and highlights some potential prospects for the future directions of such studies. Although the terrain presents one of the best places to study both natural and human induced changes in the land cover and the possibly associated climatic shifts, given the facts of the present diversity in climate (especially, the monsoon) and vegetation and also its long history of settlements by humans and their ancestors, palynology and paleoecology have been rendered difficult by the present day sub humid and semi arid conditions largely prevailing here (except in the higher elevations and areas such as the Western Ghats, directly under the influence of the south west monsoon). Poor preservation of proxy records, ambiguity of the chronology and its coarse resolution in most available studies are among the problems highlighted. On the brighter side, new approaches to site selection (a combination of rainfed irrigation reservoirs, river floodplain deposits, possible paleolakes and archaeological sites in the plains and peat deposits in the higher elevations) and the use of multiple proxies in tandem with the wealth of already systematically documented historical/archeological data in this region provide the main prospects for such synthesis. For example, recent studies of cores and sections from rainfed irrigation reservoirs (or tanks) located in different parts of south India, have dated them from around four centuries ago to nearly 2000 years ago and these cores show interesting vegetation shifts reflecting both climate and human impacts; spatially distributed in a cross section reflecting the region's present gradient of rainfall availability and the past history of settlements of humans and their ancestors, these cores offer the possibility of finer resolution studies that can help delineate natural and human impact markers. While it was possible to find that settled agricultural practice started to flourish, starting around 1200 AD and got firmly established around 1500 AD and also separate at least 3 wet periods, the most recent one from 1450 AD to the present, intervened by drier periods, from a multiple proxy record of one late Holocene core from a tank located in the heart of an agricultural landscape in southern Tamilnadu, the pollen record of another late Holocene core, dated to ~ 1660AD from a tank, located at the foothills of a forest in Central Andhra Pradesh, allowed the distinction of human impacts (at ~ 1770AD) and three separate climatic shifts, thus offering a greater resolution of the more recent climatic changes as well as anthropogenic influences. On the other hand, recently established chronologies of long cores from river deltas and floodplains show good preservation of much of the Holocene except the most recent (2000-2500 years ago): the abundance of tanks dotting the peninsular Indian landscape offers ideal complements to these longer, coarser resolution records.

Poster

## Palynological methods for land-cover reconstruction in semi-arid Peninsular India

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Arid and semi-arid lands occupy more than 50% of the land area of the Indian subcontinent, and are amongst the most human modified ecosystems. Understanding land-cover changes, especially during the Holocene, is of particular importance to understand ecosystem changes due to the prevailing global environmental changes and successive human occupation of much of this terrain. The combined use of palynological and quantitative methods including land-cover models can strengthen the interpretation and render further insights in to the drivers of vegetation change. Although some well-established methods for pollen-inferred quantitative reconstructions exist, these have not yet been applied to the Indian subcontinent and in particular, to south India. One of the requirements for such quantitative reconstructions is the measurement of PPEs for the Indian taxa, first estimates of which we hope to present for some of the relevant Peninsular Indian pollen taxa.

Poster

## Climate and Vegetation Dynamics in the Lake Victoria Region of East Africa during the Holocene: Evidence from Phytolith analysis

***Julius Lejju Bunny[1]***

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Analysis of microfossil phytoliths of a sediment core collected from Napoleon Gulf on Lake Victoria provides evidence of climate and vegetation dynamics in Lake Victoria region of East Africa, dating to the early Holocene. The records of microscopic phytoliths indicate moist and humid climatic conditions in the region from ca. 8030 yr. BP during which, environment in the lake catchments was characterized by forested vegetation, possibly comprising mixed medium altitude evergreen and semi-deciduous forest. Locally the lake catchment appears to have experienced relatively wet conditions during this period, influencing the development of sedges dominated by Cyperus papyrus in the lake catchments. Evidence of forest decline in the lake region occurred from ca. 2500 to ca. 2000 yr. BP, suggesting a period of reduced moisture conditions that are registered in the wider part of the region. This period was followed by a return to moist and humid environmental conditions in the lake region, resulting in progressive increase in forested environment from around ca. 2000 yr. BP, reaching a climax at ca. 450 yr. BP (cal 1407 – 1616 AD). This was briefly interrupted by a phase of forest decline at around ca. 110 yr. BP (cal 1677 – 1940 AD). This phase coincides with the period of relatively low moist environmental conditions recorded in the Nile river records cal 1560 -1640 AD and 1720 – 1870 AD and also reported in the oral rich traditions of East Africa.

Poster

## Integrated prehistory of people and environment: Linking the global scale to regional narratives

***Carsten Lemmen[1]***, Aurangzeb Khan[2,1], Kai W Wirtz[1], Detlef Gronenborn[3]

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The many regional transitions from foraging subsistence to agriculture and subsequent demographic transitions present one of the greatest revolutions in the interaction between people and their environment. Changes of subsistence have been associated with societal reorganization, with migration, and with conversion. Superimposed on the social sphere, the generally stable regional climates were intermittently punctuated by severe anomalies beyond the event horizon of cultural transmittance; these events exerted pressures on and provided new opportunities for society. We here present results from the Global Land Use and technological Evolution Simulator (GLUES)---a socio-technological numerical model which describes the evolution of demography and innovation in the biogeographical and sociocultural context for 685 country-size regions. We examine the global pattern of the emergence of agriculture with special consideration of the importance of climate anomalies in shaping this pattern. We then go on and compare the global picture to three regional narratives: (1) The timing lag and diffusion mechanism between the Linear Pottery and Funnelbeaker culture in northern Germany around 4200 BC; (2) the decline of the Indus valley civilization after 1900 BC; and (3) the long mixed subsistence evolution of Eastern North American woodland societies 1000 BC to 1000 AD.

Poster

## Towards an Earth System Model with Interactive Culture: Feedback effects between land use change and global climate change

***Carsten Lemmen[1]***, Kerstin Haberkorn[2]

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The emergence of agriculture-based societies from 10000 years ago transformed formerly natural landscapes into managed land. The many regional transitions lead to emissions of climate-relevant gases, changes in the soil-air moisture exchange and altered ground albedo, all of which may have given the Anthropocene an early start in the mid-Holocene. While paleoclimate and paleovegetation modeling have been successful in simulating past potential vegetation, and pollen have been extensively used to reconstruct past vegetation, both reconstructions cannot agree when the anthropogenic use and alteration of vegetation play a significant role. We (1) quantify with the Global Land Use and technological Evolution Simulator the impact of early population density, technological advance, and the change to farming subsistence on land use and land cover; we (2) report on the feedback effects of Holocene anthropogenic land surface changes represented in a global climate model of reduced complexity; and we (3) identify the positive feedback mechanisms in this Earth System Model with Interactive Culture.

Poster

## REVEALS-based reconstruction of regional vegetation and land cover for evaluation of a dynamic vegetation model along N-S and W-E transects in NW Europe

***Laurent Marquer[1]***, Marie-José Gaillard[1], Shinya Sugita[2], Anneli Poska[3], Anna-Kari Trondman[1], Florence Mazier[4], Anne Birgitte Nielsen[3], Ralph Fyfe[5], Bent Vad Odgaard[6], Teija Alenius[7], John Birks[8], Anne E. Bjune[8], Jörg Christiansen[9], Thomas Giesecke[9], Mihkel Kangur[2], Tiiu Koff[2], Malgorzata Latalowa[10], Jutta Lechterbeck[11], Heikki Seppä[7]

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The evaluations of regional climate models and dynamic vegetation models (DVG) using proxy records of past vegetation and climate change are needed to better understand land cover-climate feedbacks at the regional spatial scale and on long time scales. In the Swedish LANDCLIM project, the performance of LPJ-Guess in the past are evaluated by comparison with reconstructions of past vegetation cover using Holocene pollen records and the REVEALS model. We present in the Poster the complete Holocene (last 11,700 cal. yrs BP) REVEALS reconstructions for 18 target sites and for 36 grid cells along N-S and W-E transects in NW Europe. REVEALS estimates of plant cover were calculated for 25 plant taxa and 10 plant functional types (PFTs) for comparison with the LPJ Guess outputs. We also present the new approach that has been developed to evaluate the impacts of the differences between REVEALS estimates and LPJ Guess outputs on the understanding of Holocene vegetation dynamics.

Talk

## Human Impact on Vegetation and Soils in Northern Karnataka, India: Integrating Archaeological and Palaeoecological Data from the Last 5,000 Years

***Kathleen Morrison[1]***

[1]University of Chicago

In the semi-arid interior of northern Karnataka, India, humans have had a significant impact on regional vegetation and soils, especially since the beginning of agriculture around 3000 BCE. This record is not, however, one of continuously increasing anthropogenesis nor is it geographically uniform. Instead, landcover and landform changes are closely tied to the complex histories of settlement and land use in this region. This presentation integrates original archaeological, historical, geomorphological, and palynological data which provide a record of land use and landcover change over the last 4.3k years. These data suggest that periods of agricultural intensification, associated with large, permanent settlements, create the most significant vegetation changes, although industrial activity such as iron smelting, also plays an important role. Deurbanization is associated with forest regeneration, though new forests differed from their predecessors in species composition. The temporally episodic and spatially discrete nature of anthropogenic 'islands of intensification' in the dry interior of southern India thus suggest that at a regional scale, human impact on vegetation and soils has been variable, with some regions experiencing very severe human impacts prior to the industrial revolution. The notion of an Anthropocene, if at all useful, must account for these variable trajectories, taking into account the diverse histories of settlement and land use across the Holocene.

Poster

## Late Holocene variations from Lake Rutundu, mount Kenya

***Christine Omuombo[1]***, Daniel Olago[1], Stephen Rucina[2], David Williamson[3]

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Records of the mountainous records from the Kenyan highlands have been obtained from low-resolution sampling records with specific interest in the Quaternary climate changes. In this study, high resolution records from multi-proxy geochemical and palaeoecological account from Lake Rutundu located on the NE flank of Mt. Kenya at 3078masl was used to reconstruct changes in the environment. The analysis was carried out on a short sediment core of 1m that covers the late Holocene period from 2000yrs to present. Measurements of Stable carbon-isotope ratios, total organic carbon and sediment properties present a continuous palaeo-environmental change record. The pollen data show that grasses are major constituents of the late Holocene to modern day vegetation transition. This study offers new insights into processes that may have operated in the millennial scales during the late Holocene.

Talk

## Assessing the early Iron Age landscape and human activities in southern India: Phytolith and archaeological studies of a Megalithic burial site

***Premathilake Rathnasiri[1,2]***, Prasad Srinivasan[2], Anupama Krishnamurthy[2], Rajan K.[3], Yathees Kumar V.P.[3]

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Understanding the extent of human impact around burial sites is of particular significance in archaeology as it can be used to understand peripheral human activities in the vicinity of the site. Here we report the phytolith concentrations and morphotype assemblages in the Late Iron Age phase/early phase of Early Historic times burial site of Porunthal (77°28′38″E; 10°22′58″N) in Southern India to understand the landscape around the site. Phytolith evidence shows that Iron using communities were definitely engaged with agricultural economy as evidenced by the presence of phytolith from domesticated rice (Oryza sativa) and millet (Pannicum milliaceum). Paddy stored in four-legged jars kept in the grave have directly been dated to 490-450 BC using AMS radiocarbon

analysis, thus establishing a definite chronology for this site from physical evidence as well. The records also highlight (1) utilization of domesticated rice and millet in social context, (2) food processing, (3) different ritual connotations associated with rice and millets; (4) social differences between communities or at personal levels. The phytolith analyses evidence that the vegetation of the landscape appears to have been dominated by a mixture of $C_4$ and $C_3$ plants, and Palmae and herbaceous monocots such as Cyperaceae and Oryzoideae grasses which typically grow in wetlands and open habitats. Pollen and phytolith evidences from an excavated habitation site, closely linked to these burials, are also reported here.

Poster

## Holocene climate and environmental changes in the Horton Plains, Sri Lanka

***Rathnasiri Premathilake[1]***

[1]Postgraduate Institute of Archaeology, University of Kelaniya, Sri Lanka

An AMS-dated multiproxy montane rainforest records (pollen, spores, Sphagnum spp macrofossils and total organic carbon) reveals Holocene vegetation and climatic history in the Horton Plains, central Sri Lanka. The first part of the early Holocene (10,400-9,850 cal yrs BP), rainforest diversity abruptly increases with large climatic amelioration, with significant rise in South West Monsoon rains (SWM). This condition appears to be punctuated by two short-lived, moderately semi-arid conditions. The second part (9,850-8,800 cal yrs BP) is characterized by moderately semi-arid and humid conditions respectively. Soon after, the SWM rains downturn, and rainforest severely decline and aridity increase up to 3,400 yr BP. During the late Holocene, the conditions became more humid and strengthen the SWM rains again for large-scale reforestation, but the strengthening trend is interrupted by number of moderately semi-arid conditions. Broadly synchronous climatic records of the Horton Plains, Arabian Sea, Oman and India, west and east Africa, and the North Atlantic regions indicate two-way teleconnections between tropical Asian monsoon fluctuations and high latitude events. The above changes reflect vast spatial rearrangements in atmospheric circulation patterns, probably caused by forcing associated with coupled ocean-atmosphere-vegetation feedbacks.

Poster

## Human impact on lowland rainforest and early maritime dispersal of bananas: Evidence from Sri Lanka

***Rathnasiri Premathilake[1]***

[1]Postgraduate Institute of Archaeology, University of Kelaniya, Sri Lanka

Phytoliths recovered from the archaeological sequence at the FaHien Rockshelter show that wild bananas, which probably occurred as a truly natural element in disturbed lowland rainforest and edge habitats, from which they colonize broken ground in Sri Lanka, were used as early as 37,000 BC. It is suggested that, in the remote past, prehistoric people were responsible for keeping of the two wild banana species (Musa acuminata and Musa balbisiana) with an expansion of anthropogenic landscape. Phytoliths from domesticated bananas, dated to 4,044-4,245 BC, have been positively identified from an archaeological sequence in Sri Lanka for the first time. The occurrence of wild banana phytoliths continues, apparently virtually unchanged, after the introduction of forms comparable with domesticated types. This clearly indicates that movement of this important crop across the wet tropics of Island South East Asia and the Indian Ocean occurred well before 2,000 BC. This discovery shows that the engagement of prehistoric cultures with the management of starchy staples in the rainforests of Asia has been underestimated and should be the focus for future research.

Poster

## Deforesting Europe: Towards a pollen-based reconstruction of Holocene land cover change

***Neil Roberts[1]***, Jessie Woodbridge[1], Ralph Fyfe[1]

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European forests were established during the early Holocene and since this time the continent has been transformed into a mosaic of different land cover types, some of which are agricultural, others semi-natural. This project aims to investigate the nature of human-environment interactions throughout the Holocene in relation to the timing and characteristics of European-wide vegetation transitions. Pollen records of vegetation change, which provide information about land cover at a variety of temporal and spatial scales, have the potential to reconstruct European land cover over centennial to millennial timescales. Our research employs a pseudo-biomisation method in order to quantify past land cover. Within this method pollen taxa are assigned to one of a range of possible Land Cover Classes (LCC) based on modern community assemblages using the indicator species approach. For each pollen sample, a modified pollen sum is calculated based on the taxa assigned to each LCC. This approach has been tested in a pilot study, in which individual samples from 42 $^{14}$C-dated pollen records for Britain were placed into one of ten LCCs: three woodland classes (coniferous, deciduous, wet/carr), three open ground (pastoral/meadow, arable, heath) and four semi-open. These pollen-based results have been compared with $^{14}$C date probability density functions from archaeological sites, which have been inferred to indicate shifts in population density. The two independent sources show common trends and timing in terms of demographic and environmental change across Britain during the millennia prior to and after the appearance of the first Neolithic farming communities (9000-3400 Cal BP). They

confirm that forest clearance is clearly detectable as a driver of regional-scale, as well as local-scale, landscape change during the mid-Holocene. Our methodology is currently being validated and results calibrated at a Europe-wide scale by comparison of modern CORINE-derived land cover) with a large (~4000 site) data set of surface pollen assemblages. Pollen-based reconstructions can be used to test computer model estimates of land cover change, and have potential application to other regions in order to derive numerical estimates of when and where humans have deforested the Earth.

Poster

## Lonar Crater, central India: Pollen transport processes and pollen vegetation relationships in tropical dry deciduous forests as reflected in modern lake sediments and surface soils

***Martina Stebich***[1], Nils Riedel[1], Philip Menzel[2], Ambili Anoop[3], Sushma Prasad[3], Saswati Sarkar[4], Dirk Sachse[4], Martin Wiesner[2], Nathani Basavaiah[5]

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Investigations on modern pollen-vegetation relationships are an essential step in the interpretation of fossil pollen spectra. As part of ongoing research on Holocene lacustrine sediments from Lonar Lake, an extensive study on today's vegetation, modern pollen transport processes, and pollen-vegetation relationships have been carried out in tropical dry deciduous forest inside Lonar Crater. The current investigations on the Lonar Lake sediments are being conducted jointly by German and Indian scientists within the framework of the DFG funded HIMPAC (Himalayas: Modern and Past Climates) program, which aims to reconstruct Indian Monsoon climate on the basis of a multi-proxy and multi-archive approach. In the focus of these investigations are climatically sensitive regions of the Himalaya, eastern, and central India with the aim to unravel monsoon variability in the context of large-scale climate processes [e.g. El Niño-Southern Oscillation (ENSO), North Atlantic Oscillation (NAO), tropical mid-latitude interactions].
Due to the predominant zoophily of arboreal plant taxa in the vegetation of Lonar Crater, gravitational transport leads to a significant enrichment of pollen in surface soil. Therefore, pollen spectra from soil samples show a good representation of dominant arboreal taxa. Transport of arboreal pollen to the lake sediment is mostly restricted to surface and channel runoff, which is reflected in strong underrepresentation of arboreal pollen types in the modern lake sediments, as well as in very heterogeneous pollen spectra and concentrations in the studied lake sediment samples. Results of pollen analysis also well coincide with geochemistry and sedimentology of modern Lonar Lake sediments.
Due to the strong differences in the representation of most arboreal plants in the tested trapping media, it is questionable if modern pollen spectra from surface soils or pollen traps can be used as analogues for the interpretation or correction of fossil pollen assemblages from lacustrine archives in tropical vegetation of central India. These findings should be considered in the selection of approaches for quantitative climate reconstructions using fossil pollen spectra from tropical Asia.

Talk

## Land cover-climate interactions in NW Europe, 6000 BP and 200 BP – first results of the Swedish LANDCLIM project

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Terrestrial vegetation is an important part of the earth system that is influenced by, as well as affecting, climate through biogeochemical and biogeophysical feedbacks. Human-induced changes in land cover would have impacted climate. Hence, it is important to incorporate land-cover information in climate models for reliable predictions of future climate and related impacts. Previous attempts at describing past anthropogenic land-cover change (ALCC) based on the historical estimates of human populations and land suitability for agriculture and grazing are inconsistent for several key time periods of the past. Therefore, pollen-inferred quantitative reconstruction of land cover changes is important to evaluate ALCC scenarios and evaluate the past land cover-climate feedbacks over long temporal scales. The model-data comparison approach used in the Swedish project LANDCLIM (LAND cover – CLIMate interactions in NW Europe during the Holocene) comprises five steps: 1) reconstruct Holocene land cover using fossil pollen data and the REVEALS model, 2) compare the REVEALS reconstructions with ALCC scenarios and simulations of a dynamic vegetation model LPJ-GUESS, 3) use the alternative land-cover descriptions to simulate past climate with a regional climate model RCA3, 4) compare the RCA3 outputs with palaeoclimate proxies, and 5) evaluate land cover-climate feedbacks in the past for a better understanding of the effects of land-cover change on past climate, and implications for model predictions. The REVEALS reconstruction of ten plant functional types (PFTs) and three major land-cover types (LCTs) for five time-windows of the Holocene show that there are substantial differences between REVEALS estimates and pollen percentages in terms of land-cover change. Comparison of the REVEALS estimates of cereal and herbs % cover (PFTs agricultural land (AL) and grassland (GL)) with the deforested fractions of the ALCC scenarios suggests that REVEALS estimates are closest to the KK10 scenarios. First RCA3 simulations using the potential

vegetation (LPJ-GUESS simulations) and ALCC scenarios indicate that deforestation produce a negative feedback in winter of ca. >0-1.5°C colder, and a mixture of negative ca. (>0-1.5°C colder) and positive (ca. >0-1°C warmer) feedbacks depending on the area, in summer.

Poster

## Changes in Land-use and Land-cover from the Iron Age to Medieval period in the Central Eastern Tamil Nadu: A preliminary investigation

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The Central eastern Tamil Nadu covers the area of the Kaveri delta and the adjacent regions of Pudukkottai and Ariyalur regions. The proposed paper seeks to investigate the pattern of land-use and land-cover from the Iron Age to the Medieval period based on archaeological and epigraphical data. The Iron Age began in this region around 1000 BCE and continued till 300 BCE. The Historical period starts around 300 BCE and the period from 500 CE to 1300 CE is considered Medieval. This region witnessed human occupation right from the Late Pleistocene onwards. However, intensive human occupation and modification of land began only from around 1000 BCE. Land was put to use for different activities such as pastoralism, dry cultivation and wet cultivation. Tamil texts mention about clearing of forests in the Kaveri delta. Digging of canals, construction of tanks, strengthening of river banks, de-silting of tanks are referred to in the literature and inscriptions. Analysis of texts and archaeological evidence related to settlements and their spatio-temporal change in relations to landcover are presented in this paper.

Poster

## Exploring the spatio-temporal archaeological and landscape dynamics of early farming communities using Bayesian approaches

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Archaeology has much to contribute to our understanding of the development of the cultural landscape and changing land cover over the course of the Holocene. Until recently, there has been relatively little attempt to examine the archaeological record in tandem with the palaeoecological record on a temporal and spatial scale that allows the exploration of the large-scale effects of archaeological activities on land cover changes. This is partially as archaeologists and palaeoecologists tend to work at different spatial and temporal scales. Recently there have been important developments in this respect and an enhanced appreciation by archaeologists of the need to create synthetic narratives of the archaeological record that are at the spatial and temporal scales necessary to address questions of land cover change. Improved understanding and new approaches to chronology, especially Bayesian approaches, have been critical in this respect, allowing the tempo and pace of change of the archaeological and palaeoecological record to be assessed on a common time-scale. Such long-term perspectives allow a more nuanced understanding of the human-environment relationship and the adaptability and resilience of communities to outside stimuli that can often be surprising and unexpected.
Often, these run contrary to progressive evolutionary expectations that may be implicit in some land cover change models. New approaches also offer significant insights into our understanding of issues such as intensity of agricultural usage, practice and change over long time scales; these have important implications for our understanding of the Holocene carbon cycle.
We explore some of these issues by drawing upon a multidisciplinary research project that has integrated archaeological and palaeoecological datasets to examine spatio-temporal aspects and nature of Neolithic farming in Ireland and further afield. Pollen-based modeling has facilitated a comparison between land cover changes with the archaeological record. Bayesian analyses of palaeoenvironmental and archaeological $^{14}C$ data have allowed us to examine linkages between environment, climate, farming and settlement within a much stronger chronological framework, allowing us to explore the temporal and spatial character of this highly resolved dataset.

## OSM09: Climate Impact on Human Evolution and Civilizations

Convenors: Mark Maslin, Dhananjay A. Sant, Martin Ziegler

Poster

### Correlation between the climatic and geological events and changing of archaeological cultures in SE Altai (Russia) during the Late Holocene

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At present time, the issue of chronology of the archaeological cultures in Russian Altai (Southern Siberia, Russia) is still debated. Peoples settled this area from the beginning of the 1st millennium BC can be regarded as nomads of arid piedmonts and mountains of temperate zone. However, both the names of cultures and the periods of their existence are debated. Climatic reconstructions within Russian Altai in Holocene also vary considerably. This complicates the correlation between geological/geomorphological events and changing of archaeological cultures. By now, there are just single attempts to provide such correlation.
This study focuses on investigating of climate changes, estimating of paleoseismicity, catastrophic outbursts of landslide dammed lakes and their correlation with the changing of archaeological cultures within SE part of Russian Altai during last 3 ka. This time period covers the life span of Siberian Scythians, Hun-Sarmatians and Turks. Paleoclimatic reconstructions and estimating of paleoseismicity are based on absolute dating (using radiocarbon and dendrochronological methods) of landslides, fossil soils, moraines, lacustrine sediments, as well as archaeological sites located within Kurai-Chuya system of intermountain depressions and framing ridges. Recent glacier retreats and ice degradation in moraines lead to exhumation of organic material which makes possible the radiocarbon dating. Newly obtained a numerous set of radiocarbon dates together with previously published data has been used for basing the glacier activity at the second half of the Holocene.
Data provided by archaeological sites of Scythian, Hun-Sarmatian and Turk epochs have been used for reconstruction of landscape prevailing at the time of these internments. Existence of landslide dammed lake and water discharge define altitudes of sites of each archaeologycal culture in Chuya basin. On the other hand, absolute dating of archaeological sites allows estimating the time of lake lowering events and its final outburst.
A continuous 2367-years absolute tree-ring chronology "Mongun" developed for Tuva (the region adjacent to Altai) has enabled using dendrochronology for absolute dating of seismically triggered landslides. Both dead and living trees on landslide bodies have been analyzed. The date of previously unknown earthquake, which occurred in SE Altai during medieval times, has been obtained using dendrochronological analysis of tree injuries and independently verified by radiocarbon dating of seismically cut fossil soil overlapped by that undistorted. In general, suggested chronology of the most important climatic and seismic events which caused glaciers expansion, outbursts of landslide dammed lakes and seismically induced slope processes with disastrous effects may provide insights for pattern of changes in archaeological cultures and migrations of nomadic population inhabited the south-eastern part of the Altai Mountains during the Late Holocene.

Poster

### Regional integration of lake sediment and archaeological archives: Holocene climate variability and socio-evolutionary pathways in Cappadocia, central Anatolia

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Collaborative studies between Quaternary scientists and archaeologists increasingly provide new and informative discussions about the nature and timing of cultural change and links with variation in the natural world (particularly climate). In the Eastern Mediterranean region, human occupation has been extensive throughout the Holocene period and climatic change has repeatedly been acknowledged in the area as a fundamental component in the rise and fall of these cultures; commonly linking climate perturbations to societal collapse. The contemporaneity of changes in culture and climate however has been poorly demonstrated and palaeo-climate records have often been collected from regions distant from the human record.
Varved sediment data collected from Nar crater-lake and archaeological archives from the same region, Cappadocia (Turkey) allow these chronological discrepancies and problems with spatially variable data sets to be addressed. Recovery of an annually laminated sequence from Nar Lake provides a fine temporal detail and a well dated record of Holocene climate variability which is highly suited for studies into human/climate relationships. Variations in the frequency and amplitude of Holocene climate are demonstrated from differences in the chemical composition of varve deposits from ITRAX XRF core scanning and other sedimentary techniques. The detail of these temporally constrained records are correlated alongside settlement histories and culture change profiles to 1) gauge their development side by side; 2) investigate the sensitivity or resilience of past people to unstable climates; 3) identify when cultures were ill-prepared and fail to initiate effective management strategies during times of stress and vulnerability created by climate variability.
ITRAX scans document a shift from a predominately stable system (high authigenic Ca & Sr) to one exhibiting much higher annual variability, including clastic in-wash events, characterised by peaks in Fe, Ti, Si, K and Rb.

These high detrital components indicate strong erosion input into the lake which is related, in part, to the impact of increasing human occupation and catchment use. Increased catchment sediment supply is particularly prevalent between 8800-7840 varve years (vy) B.P. and 2600-0 vy B.P. Both periods coincide with the growth of Neolithic populations and the development of obsidian 'factories' on near-by Nenezi Dag, and the establishment of Phrygian, Persian, Hellenistic-Roman, and Byzantine rule respectively. The former may also have been influenced by volcanic activity. Less variable conditions and reduced detrital input between 7840 and ~6200 vy B.P. occurred during times when archaeological survey data suggests less intensive human occupation of central Anatolia. The Nar lake geochemical record thus records both natural (e.g. climatic) and human-induced processes, with the balance between them changing over time.

Poster

## Dating the earliest human occupation of Western Europe: New evidences from the fluvial terraces system of the Somme basin (North France)

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Dating the earliest human occupation of Western Europe and reconstructing its relations with climatic and environmental constrains is becoming a central question, especially with the discovery of Palaeolithic artefacts allocated to the Early Pleistocene in south-east Britain and in Central France. In this context, the Quaternary sequences of the Somme basin, where is located Saint-Acheul, the type-site of the Acheulean, is a key location. Research undertaken for more than 15 years on both fluvial and loess sequences of the Somme basin and on the main river valleys of Northern France (Seine and Yonne) provide a unique dataset for the study of the relations between human occupations and environmental variations.
Studies have been based on an interdisciplinary approach combining stratigraphy, sedimentology, palaeontology and geochronology using the following methods: U-series, ESR, OSL, and ESR/U-series. Meanwhile, the palaeoenvironmental interpretation of Pleistocene sequences containing Palaeolithic levels has been refined with several biological proxies (molluscs, beetles, mammals, pollen, plant remains) and sedimentological data (grain size, geochemistry, magnetic susceptibility, palaeopedology, micromorphology) obtained on both loess and fluvial sequences. Moreover the investigations lead on the bottom valley fluvial sequence (Lateglacial and Holocene) allowed to the elaboration of a model concerning the response of the Somme fluvial system to climatic changes for the last Myrs. Our data have highlighted the impact of the 100 kyr cycles on terraces formation since ± 1Myr, and the fluvial terraces system of the Somme basin has become a reference model for the study of the response of fluvial systems to Milankovich cycles in areas characterised by slow continuous uplift.
Compilation of the whole results from modern archaeological excavations within this chronoclimatic reference system of Northern France shows that human occupation of this area has been discontinuous and highly influenced by climatic and environmental factors. Indeed human occupations are quite systematically related to full interglacial or to transitional climatic contexts (Early or late glacial), as it is demonstrated from a large number of sites for the Last climatic cycle (Eemian-Weichselian). In the Seine basin, the oldest in-situ Acheulean archaeological level has been evidenced within a tufa sequence dated from MIS 11 (La Celle) but older sites including Acheulean handaxes are known in the middle terraces (early MIS 14?). In the Somme terraces system in situ Acheulean settlements where dated to early MIS 12 at ± 450 ka in the 1990s, but new field discoveries allowed to push significantly the age of the oldest human occupation during the Early middle Pleistocene. The first one discovered in 2009 in Amiens was recently dated at ± 550 ka using ESR and terrace stratigraphy (early MIS 13). The newest findings have been done in 2011 in Abbeville, where evidence of human occupation occurs in calcareous fluvial deposits of the "High terrace" (+ 40 m relative height above the modern valley bedrock). According to terrace stratigraphy, ESR dating (quartz) and large mammal assemblages, these artefacts can be dated from 600 to 670 ka. They are contemporaneous of the site of Mauer, the type-site of Homo heidelbergensis.

Talk

## Central American rainfall changes over the past 2 ka and implications on the Classic Maya society

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We discuss the role of rainfall variability on the fate of the Classic Period Maya civilization on the base of new high-

resolution speleothem data from Yok Balum Cave, Belize. The precisely U-series-dated sub-annual stable isotope-based climate record from stalagmite YOK-I is comparable with historical records for the past 2000 years. The YOK-I $\delta^{18}O$ and $\delta^{13}C$ both record hydrological conditions above the cave, variations of which are linked to mean ITCZ position. More negative stable isotope values are interpreted as reflecting wet, less negative values drier conditions.
We observe a significant relation between the oxygen and carbon isotope records and northern hemisphere temperature and NAO reconstructions. We argue that the YOK-I record reflects the influence of the NAO on the wet season length. The NAO, affecting summer rainy season length by repositioning the Bermuda-Azores High (BAH) likely governs moisture transport from the Atlantic to Belize. NAO+ produces a strong BAH extending far to the southwest, thus displacing the trade winds and carrying moisture to Belize. Positive $\delta^{13}C$ excursions correlate with NAO- conditions recorded in a Scottish stalagmite, while negative excursions are predominantly related to NAO+ conditions. The observed correlation indicates that a significant amount of rainfall variability is related to the NAO and supports our hypothesis that the NAO strongly influences drought/rainfall conditions in the tropical Maya lowlands via its influence on ITCZ position.
Comparison of paleoclimatic and archaeological records implicates climate change as a significant factor in the florescence and disintegration of Classic Maya civilization. Gradual rainfall reduction resulted in drying after AD 660, culminating in multi-decadal droughts at AD 820-870, and especially AD 1000-1100. We propose a two-stage collapse beginning with balkanization of polities, increased warfare, and ultimate disintegration of Maya centers between AD 660-900 related to diminishing rainfall, followed by population collapse driven by extreme drought that peaked between AD 1000-1100.

Poster

## Megalake Chad occurrences in the Pliocene: An insight into early hominid environment

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The occurrence of large lakes episodes in the Chad basin during the Mio-Pliocene has been demonstrated through the analysis of sedimentary deposits located in the presently arid area of the Djurab desert. There, the Mission PalÉo-Franco Tchadienne (MPFT) identified four main paleontological sites, ranging from 7 to 3 Ma. All of them are extremely rich in vertebrate fauna remains and in two of them, remains of early hominids have been collected. Australopithecus barhelghazali, the first australopithecine ever found out of the classical hominid sites, is associated to fauna assemblages showing the presence of a mosaic landscape typical of a perilacustrine area, and habitats from wooded savanna to open grassland. Sahelanthropus tchadensis, the earliest known hominid, was found in comparable perilacustrine environment.
It is worth noticing that these four major continental vertebrate sites are always associated to large lake episodes. This suggests that there is a strong link between large lake episodes (megalakes) and fauna dispersal/presence of early hominids. This link highlights the need for a comprehensive understanding of the rise, culmination and demise of megalakes in the Chad basin during the Neogene.
From 7 to 3 Ma, the climate was globally warmer than present, and the Hadley circulation might have been slowed, leading to a poleward shift of the Inter Tropical Convergence Zone during the whole Pliocene interval. Insolation changes related to the 23 kyr precession cycles might have also played a role on the monsoon, providing a sufficient amount of water to fill in the vast endorheic region of Chad basin.
In order to better characterize the forcings leading to these Mega-lake Chad occurrences during the late Cenozoic, we use a coupled ocean atmosphere climate model forced with four different orbital configurations and mid-Pliocene boundary conditions. The four orbital configurations, all around 3 Ma, correspond to 1/ maximum insolation at 30°N during summer solstice (precession maximum); 2/ minimum insolation at 30°N during summer solstice (precession minimum); 3/ maximum insolation at 30°N during autumn equinox; 4/ minimum insolation at 30°N during autumn equinox. The simulated climates are then used to force the river routing model HYDRA, which calculates the water balance, river discharge and potential lake areas. Related vegetation changes are also investigated and compared to fauna assemblages. Lake Chad extent and vegetation changes will also be compared to the mid-Holocene.
Thanks to this study, we will be able to determine favorable/unfavorable conditions for megalake Chad occurrences during the Pliocene and the associated changes in vegetation, bringing insights to the possibility for early hominids populations to live in this region throughout the Mio-Pliocene period.

Poster

## Impacts of climate variability and Maya settlement on Laguna Tuspán (Petén, Guatemala) during the past 5000 years

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Even though several studies prove the occurrence of severe droughts between 800 and 900 AD, some studies have demonstrated that the reduction of rainfall was not the only cause of the collapse of Maya civilization at

that time. There is some evidence that the Mayas caused deforestation, which potentially changed the properties of soils (composition, sensitivity to erosion). In this case, human activities would have increased the vulnerability of their cultures to natural phenomena. Droughts, combined to a long-term decreasing productivity of fields, would have led the Mayas to migrate.
Here we present a multi-proxy study of lacustrine sediments from laguna Tuspan, near the Maya city of La Joyanca (PetÉn), designed to test the relative impact of climate variability and human activities on the environment. Results on the clay composition clearly show environmental changes in the drainage basin of the lake around 3000 BP (950 BC), when the La Joyanca plateau is first inhabited by the Mayas. Before human settlement around the lake, the ostracod abundance decreases while the percentage of organic matter increases during humid periods. Such variability decreases in amplitude around 4000 BP, when the Caribbean zone gets drier. Halloysite is the main clay across the whole period preceding the arrival of the Mayas, which proves the formation of stable soils due to a dense forest cover.
After 3000 BP, none of our proxies follows the drying trend that is observed in the rest of the Caribbean zone. Interstratified smectite-chlorite are the main component of the clay fraction, which reveals increasing erosion of the substratum. Litter thickness and forest density are much reduced, which enhances the destabilization of soils under humid conditions. The lake receives much more detritic particles than before, especially during the deposition of Maya clays.
This study clearly indicates that the Mayas changed their environment even before they built cities. Erosion was enhanced by deforestation and land-use but its intensity does not depend on human density.

Poster

## Extreme Weather, Famine, Dynasty Revolution, and the Possible Connection to Volcanic Activities over the Past 1500 years in China

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Explosive volcanic eruptions have long been recognized as a possible natural cause of past climate variations. Besides producing summer cooling, most volcanic eruptions also dynamically induce warming over northern hemisphere continents for couple winters following the eruptions. Cold summers reduce the crop production while warmer winters enable insects to survive the cold seasons, causing famines and other social unrest. Using an ice-core-based volcanic index, tree-ring based temperature reconstruction, and historical records from China this work examined the possible connection between extreme weather, famine, dynasty revolution in China, and volcanism over the past 1500 years. Complied historical documents provided rich records of the wide spread severe weather and crop failure after the 1640, 1809 and 1815 A.D.eruptions. On the other hand, every dynasty replacement (for example, from Beisong to Yuan Dynasty in 1260 A.D. and from Ming to Qing Dynasty between 1636-1644 A.D.) during the past one and half millennium lies in or close to a year with moderate to large eruption. The repeated coincidences suggest that the extreme weather caused by volcanic eruption maybe one of the reasons for the social revolution in China and probably other parts of the world. The proposed connection between past volcanism and social revolution may also explain the lack of historical documents of abnormal climate response after certain big eruptions such as the 1259 A. D. Unknown event.

Poster

## Assessing impacts of climate variability on the demography of pre-Hispanic societies from the Atacama Desert over the past three millennia

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Multiple paleoclimate reconstructions reveal that the hyperarid Atacama Desert has experienced important hydroclimate variations on centennial and millennial timescales over the past 18,000 years. These past hydroclimate anomalies are known to have affected significantly regional hydrological patterns and distribution of terrestrial biota. The relationship between such paleoclimate events and population dynamic of pre-Hispanic societies that inhabited the driest desert on Earth, however, remains unclear. Here, we tackle this issue by reconstructing the long-term population history for the Atacama Desert (16°-24°S) over the past 3,000 years. Specifically, we evaluate changes in population size by examining the summed probability distribution of 334 calibrated $^{14}C$ dates from 123 archeological sites across the interior of the Atacama (>900 masl). Our results point to important centennial-scale variations in demographic patterns for agricultural societies from the Atacama throughout the late Holocene. The resulting curve indicates that population started to increase gradually at 3.0 ka and then stabilize at relatively high level between ~2.8 and 2.3 ka. A strong decline in population size is evident between 2.3 and 1.4 ka. Population recovered again by 1.4 ka and peaked at 1.05-0.5 ka. Thereafter, demographic levels decrease sharply. Overall, these demographic changes in the Atacama Desert occurred at the same times as the major late Holocene paleoclimate changes of that region. Actually, increased population levels by 1.05-0.5 ka are coeval with a prominent positive hydroclimate anomaly detected regionally during the so-called Medieval Climate Anomaly (MCA). Conversely, the sustained decline after 0.5 ka coincide with a protracted negative hydroclimate anomaly during the Little Ice Age (LIA). Our findings indicate that pre-Hipanic agrarian populations from the hyperarid Atacama Desert were sensitive to Late Holocene hydroclimate variability. Moreover, the observed relationship between paleoclimate and long-term population trends over the

past 3,000 years, suggest that regional hydroclimate was a first-order factor for the past demographic structure of these societies.

Poster

## History of climate: 2000 Leagues overseas

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The history of climate is treated amusingly as an occupation for the retired, according to its creator Emmanuel Le Roy Ladurie (2009) in a long interview included in number 4 of "Ethnologie Française" devoted to the close relations between meteorology, climate and societies. Le Roy Ladurie was not brought up in the French tradition with French historians but outside of France with a wide intellectual lineage in Belgium, Central Europe, Italy, Latin America where many have been profoundly influenced by his publications and teaching.
However the impact of the progress in "L'histoire du climat depuis l'an mil" has been like a thunderclap on European climatology because this publication of 1967 shows clearly that climate has not been a terrestrial constant (apart from changes on a geological scale brought about in the Holocene by the disappearance of the Ice Age about 12 000 years ago and since the great Saharan Pluvial period) but that it varied more or less on an annual, decennial, secular or pluri-secular scale. This new paradigm goes hand in hand for scientists with the following great discovery: humans, after suffering continually climatic hazards were now able to have a strong effect on the geosphere and the biosphere by a perceptible increase in carbon dioxide - a fact that was accepted at the international level following measurements made in 1957-58 on the side of a volcano in Hawaii during the International Geophysical Year (IGY). We shall follow this journey, initiated by Le Roy Ladurie in Europe, by a trip around the world so as to try to demonstrate why and how historians can Poster about climate.

Poster

## Mineral Magnetic studies to indicate Paleo-anthropogenic loading of particulate matters in the Mumbai and Delhi metropolitan regions

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Surface loading of anthropogenic dust and aerosol particulate matters plays significant role in deterioration of the natural condition of soil, wind and water in the urban and industrialized areas. It is essential to know the extent of anthropogenic particulate loading and their seasonal dumping to envisage its long term residence effect in the urban soils. By presenting a first order linkage between ferrimagnetisms and heavy metal concentration in the soils of Delhi and Mumbai Metropolitan Regions (DMR & MMR), we identify the areas of dispersal, redistribution and seasonal dumping of the particulate matters by systematic spatial sampling in these regions. Further a historical data was generated by sediment cores samples from the soil profiles, flood plains, lakes and creek. The comparative mineral magnetic studies decipher the highest loading in the top soils as compared to the seasonal dumping in depressions like lake and floodplains. This indicates the topsoils as the best absorbents (and adsorbents) for the heavy metal loading playing a significant role in effective seasonal dumping as well as redistribution of the heavy metal load. The results suggests that the depths of enrichment of topsoils is largely independent of the bedrock-soils composition which is proven by the contrasting set up of ferrimagnetically reach MMR and that of ferrimagnetically poor DMR region. We further compare the role of geomorphology, wind circulation and surface water run-off as some of the most important factors of redistribution and dumping of anthropogenically loaded soils and therefore needs special attention.

Poster

## Regime shifts in past ecosystems of maar lakes: Lessons for building ecological resilience to future climate change

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Although freshwater lakes make up a small proportion of the Earth's surface, they act as sentinels of global climate change by providing signals of regime shift and adaptability of past ecosystems for environmental change. In particular maar lakes archive high-resolution biological and chemical proxies that are becoming increasingly valuable for unravelling the impacts of climate change and understanding ecological adaptation to change. To extend this understanding to global scale, we studied two maar lakes, Lake Schalkenmehren maar (SMM), Germany and Lake Onepoto maar (ONM) in northern New Zealand. Both maar lakes were formed by phreatomagmatic explosions and have been infilled by sediments spanning at least the last glacial period. The response of these maar lakes to global climate change is astonishingly synchronous. Biological and chemical proxies for environmental change retrieved from maar lake sediment cores indicate that the lake ecosystems and biodiversity switched to different regime following the end of the Last Glacial Maximum c. 18 kyr BP. Although the ability of the cold preferring taxa such as cladoceran

zooplankton to adapt to change generally declined during the postglacial warm period, some species were able to show their ability to colonize the new habitats. Adaptability of cladocerans to change increased further following the smaller climatic oscillations such as the 8.2 ka Event in Lake SMM and the Antarctic Cold Reversal in Lake ONM. However, unlike at Lake ONM, where the human influence is recent, and resilience of the Lake SMM ecosystem to climate change declined significantly once the widespread human disturbances began in Roman time leading to a poorly functioning lake ecosystem and biodiversity. We argue that compared to natural climate variability, the human disturbances have greater impacts on social and ecological system (SES) of the maar lakes. However, lessons of ecological adaptations following the disturbances can have profound implications for future ecosystems management and building ecological resilience in maar lakes.

Poster

## Palaeoenvironments of the Olorgesailie Basin during Mid-Late Pleistocene inferred from Phytolith analyses

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Olorgesailie basin is an important prehistoric locus and holds a prominent place in African Quaternary research. It is located in the southern Kenya rift system (1°35'S and 36°27'E) with numerous archaeological findings of the Early and Middle Stone Age, and more importantly, hominin cranium associated with the Acheulean hand-axes. Evidence of past vegetation has hitherto been scarce hence, phytolith analysis is used to reconstruct the vegetation history and understand hominin habitat during mid-late Pleistocene (~746-64ka).
Modern phytolith analogue are used to interpret the fossil assemblage. Correspondence analysis distinguished vegetation components according to moisture gradient while Cluster analysis identified unique morphotypes that were taxonomically affiliated to their parent plant species. Based on fossil phytolith data, vegetation cover of the Olorgesailie basin was predominated with tall moisture loving grasses belonging to C3 Arundinoideae and C4 Panicoideae subfamilies. High elevation C3 Pooideae grasses though rare were significantly present while short arid grasses; C4 Chloridoideae and Aristidoideae subfamilies were much less compared to present. In addition, grass short phytolith indices suggested warmer and moister climates prevailed on the basin during Pleistocene than present.
Fossil data from three Localities suggested vegetation heterogeneity existed across the paleolandscape, including riverine, wooded and grassy habitats. Such habitats offered variety of resources to the early hominins. Series of radiometric dates on geological markers (tuff and pumice) bracketing the palaeosols are used for paleoenvironments reconstruction. However, provision of absolute dates from the palaeosol for future research would give clearer picture on vegetation changes and climatic signals.

Talk

## Integration of regionally resolved decline models for the Indus Valley Culture

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The causes for the 600 year long decline of the Bronze Age Indus Valley Culture (IVC) in the 2nd millennium BC are heavily debated. Monocausal theories like aridity, floods, invasion and river course shifting were used to explain the demise of various cultural traits, foremost urbanization. Are explanations required that involve synergies between different factors and regional sub-domains to understand deurbanization and associated technology loss? We believe they are, and introduce four spatial subdomains of the IVC, where decline is dominated by different actors. The Punjab (Northwest) went through a regime change by elite dynamics, Sindh (Southwest) experienced extreme floods, the Thar Desert (East) faced drying of the Ghaggar Hakra river, whereas Gujarat (South) went through economic collapse. We reconstruct the regionally resolved decline factors to assess their synergistic effects for the entire IVC domain. The resolution of inter-regional dependencies suggests reduced resilience of urban centers throughout the IVC. This low resilience in combination with environmental disruptions ultimately led to a regionalization.

Poster

## On the sensitivity of the simulated European Neolithic transition to climate extremes

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Was the spread of agropastoralism from the Fertile Crescent throughout Europe influenced by extreme climate events, or was it independent of climate? We here generate idealized climate events using palaeoclimate records. In a mathematical model of regional sociocultural development, these events disturb the subsistence base of simulated forager and farmer societies. We evaluate the regional simulated transition timings and durations against a published large set of radiocarbon dates for western Eurasia; the model is able to realistically hindcast much of the inhomogeneous space-time evolution of regional Neolithic transitions. Our study shows that the consideration of climate events improves the simulation of typical lags between cultural complexes, but that the overall difference to a model without climate events is not significant. Climate events may not have been as

important for early sociocultural dynamics as endogenous factors.

Poster

## Modeling and simulation of Holocene hunter-gatherer and agro-pastoral groups to explore the role of climate in population behaviour

***Marco Madella[1]***, Andrea Balbo[1], Carla Lancelotti[1], Bernardo Rondelli[1], Xavi Rubio[2], Alexis Torrano[2], Matthieu Salpeteur[3], Victoria Reyes-Garcia[3], P. Ajithprasad[4], Andreas Angourakis[5]

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The role of climate and social changes in the rise and fall of past civilizations as well as in fundamental changes in human societies (e.g. the move from hunting and gathering to agriculture) has been a focal discussion point in the social and environmental sciences over the last couple of decades. It is clear that the complex socio-ecological systems that result from the interplay of human populations and their environments are defined by overall climatic cycles. However, it is currently difficult to clearly understand social resilience over centennial and/or millennial scale and to untangle the chain of action/reaction between climate and populations. To approach this problem in a novel and experimental way we are applying Agent-Base Model simulation of hunter-gatherers and agro-pastoral groups to explore population dynamics such as behavioural change and resilience. Our simulation is inspired by realistic scenarios and calibrated with real world data from prehistoric, Holocene hunter-gatherers and Chalcolithic groups of North Gujarat (India).

Talk

## Early human speciation, migration and brain expansion driven by African climate pulses

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Early human evolution is characterised by pulsed speciation and migration events that cannot be explained fully by global or continental paleoclimate records. We propose that ephemeral East African Rift System (EARS) lakes are a proxy for regional paleoclimate conditions. The presence of these lakes is associated with low levels of dust deposition and periods of rapid climate turnover in both West African and Mediterranean, but not with long-term global trends evidenced by stacked benthic foraminifera oxygen isotope records. We show statistically that speciation and migration events in African hominins are temporally associated with regional climate pulses evinced by the lakes. Hominin expansion and diversification are associated with periods of productivity during periods of wet and variable climate characterised by the appearance of deep EARS lakes. Around 1.9 Ma was the most profound period for hominin evolution; it was associated with the highest recorded diversity of hominin species ever, the appearance Homo and major migration events out of East Africa and into Eurasia. During this period, ephemeral deep-freshwater lakes appeared along the whole length of the EARS, fundamentally changing the local environment. In contrast, after this major step brain size increases in African hominins are associated with very dry periods with no lakes. Plio-Pleistocene East African climate pulses are, therefore, fundamental to hominin speciation, encephalisation and migration.

Talk

## Variable Impact of climate change on populations of archaic humans and modern humans inferred from archaeological evidence

***Sheila Mishra[1]***, Navin Chauhan [2], Ashok Singhvi[2]

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During the Late Middle Pleistocene (MIS 5/6) humans were a very widely dispersed species broken up into distinctive "populations", including at least Modern Humans, Neanderthals and Denisovians. It is likely that additional archaic populations occurred in Africa, China and the Indian Subcontinent.
Modern Humans and Indian Archaics, in contrast to other populations such as Neanderthals and Denisovians shared an adaptation to tropical environments, thus competition between them would have been intense. . It now seems likely that during MIS 5 modern humans were present not only in the Middle East but also Arabia, SE Asia and China. There is no evidence for modern humans in India during MIS 5, and the archaeological evidence indicates strong continuity during MIS 5 times to the preceding Acheulian. We suggest that during MIS 5 times, modern humans did not expand into the Indian subcontinent as conditions favourable for range expansion of modern humans were also favourable for Indian. During MIS 4 times however when archaicssuch as the Neanderthals re-occupied areas like the Middle East, and the Sahara desert became uninhabited, we see a dramatic change in the archaeological record in the Indian Subcontinent with the appearance of microblade technology which can be associated with modern humans due to its continuity upto the Iron Age. Modern Humans therefore appear to have replaced Indian archaic during a time unfavourable to both when modern humans disappeared from many previously occupied areas such as the Middle East. The re-expansion of modern humans during MIS 3 times may have the Indian subcontinent as the ultimate source.

Poster

## Human responses to monsoon variability in South East Asia: Cambodian pre-Angkor and Angkor periods

***Naoko Nagumo[1]***, Toshihiko Sugai[1], Sumiko Kubo[2]

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Cambodian pre-Angkor and Angkor societies are known by remarkable brick and stone monuments, widely developed in monsoon-affected Indochina. Cultural activities in monsoon region are principally supported by abundant precipitation, and water availability is a key factor for perpetuating human society. During Holocene, Indochina region has experienced summer monsoon seasonality and multi-decadal variability, which controlled water availability and contributed to the major cultural events of pre-Angkor and Angkor societies. After the establishment of Isanapura, the pre-Angkor capital in the early 7th century, the monsoon intensity declined and consequently prompted abandonment of the city and relocation to the Angkor region, whereas the drought conditions resulting from the decreased monsoon intensity enhanced baray (reservoir) construction and water imbalance was rectified during the Angkor period. In contrast, a strengthened summer monsoon was coincident with the period of flourishing of Angkor society from the 10th century onward. Pre-Angkor Isanapura was highly dependent on the river and tried to use water resources efficiently, whereas the Angkor dynasty without large rivers tried to manage water imbalances and increase its water resources by hydraulic construction to sustain prosperity. It is reasonable to understand barays were constructed as a part of water management system, and also represents an abandonment of river-dependent governance and a shift to a new state of control of water resources.

Poster

## Recent climate change in West Africa and adaptation strategies proposed by rural population

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Climate in Sahel region of West Africa is of crucial importance for the mainly rural population, (83% of the agriculture is rain fed). The main objective of this work is to understand farmers' perception of climate change and their adaptation strategies. By interviewing 2459 farmers on their perceptions of climate change over the past 30 years, and compare it to historical climate data (rare in this part of the world compared to other regions), we show that peasants have a rather good perception of past climate variability. A designed methodology offers the opportunity understand their vulnerability and to propose adaptation solution. Climate risks are classified and both temperature increase and precipitation variability are classified over the whole study sites as the first major risks, even if risks related to precipitation patterns (such as drought, shortening of the crop season etc are noted as more important overall).
This work is done by a compilation of 2459 interviews, done by 14 master students of the Regional Center AGRHYMET in Niamey, Niger, a technical institution of the Permanent Interstate Committee for drought control in Sahel and spans 10 countries over West Africa (Benin, Burkina Faso, Cape Verde, Chad, Guinea, Mali, Mauritania, Niger, Senegal, Togo). This study is one of the first one based on such a large number of people interviewed, the variety of localities (agro-ecological and socio economic differences between, for example herders form Niger to agriculture form Togo), which is, at the end, targeted to concrete propositions of operational projects to be achieved by field actors e.g. Mainstreaming Climate Change in the Communal Investment Plan of Diofior (Senegal), or Adaptation and restocking poultry flock in Tondikiwindi municipality (Niger).

Talk

## Late Pleistocene to Holocene climate and seasonality in North Africa from $\delta^{18}O$, $\delta^{13}C$ and Mg/Ca analysis of marine and terrestrial mollusc shells (Haua Fteah, Libya)

***Amy Prendergast[1]***, Rhiannon Stevens[2], Tamsin O'Connell[2], Chris Hunt[3], Graeme Barker[2]

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The Haua Fteah cave in Libya contains one of the longest and most complete sequences of human occupation in North Africa. This rich archaeological assemblage occurs in tandem with abundant material for paleoenvironmental reconstruction. In this study, stable isotope and element ratio analyses of the archaeological mollusc assemblage from the Haua Fteah have allowed the reconstruction of paired marine and terrestrial climate records that extend from c.120,000 to c.5000 years ago. These analyses have been interpreted with reference to analogue studies on modern marine and terrestrial molluscs from Libya. In the marine topshell Osilinus turbinatus, $\delta^{18}O$ and Mg/Ca ratios record fluctuations in sea surface temperature. In the terrestrial mollusc Helix melanostoma, $\delta^{18}O$ varies according to the water ingested by the animal as the shell grows, which in turn is linked to water and air temperature at the moment of precipitation whilst $\delta^{13}C$ provides a proxy for palaeovegetation patterns and water stress. Intrashell stable isotope series from these shells record snapshots of sub-seasonal climatic variations covering rapid and profound climatic fluctuations from MIS 5 to MIS 1. This high-resolution climatic framework coupled with the well-dated record of cultural change, allows an examination of human-environment interactions during critical periods of late Pleistocene to Holocene climate change in a region of North Africa with comparatively few climate records.

Poster

## Peat in the desert: A local environmental history for the Holocene in semi-arid Jordan, and its comparison to the evolution of societies

***Claire Rambeau***[1]

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The Southern Levant (roughly corresponding to modern Jordan, Israel and Palestine) is a key region to understand past interactions between human communities and their environments. This region is part of the 'Fertile Crescent', where agriculture first developed, around the beginning of the Holocene. Since then, human impact on surrounding landscapes has steadily increased, which renders the causes of environmental change (climate- or human-induced) more and more difficult to unravel when we progress towards the present. However, if one wants to compare climate fluctuations with the evolution of human communities, and determine the role of such changes in major societal developments, one needs a good assessment of climate evolution - progressive or abrupt - throughout the Holocene, within an accurate chronological framework. Such an assessment is particularly difficult to achieve in the most arid regions of the Southern Levant, where archives of climate or environmental change are usually badly preserved and difficult to date. However, the potential of the arid environments of the Southern Levant to harbour records of Holocene past climate change is far from being exploited to its full extend.
The unique discovery of Holocene organic, peat-like deposits in the rain-shadowed Dead Sea area allows studying past climate change at the local scale for arid Southern Levant. This will be achieved primarily through pollen analyses, but ultimately through a multi-proxy approach, including charcoal for the occurrence of fires, spores and fungi (potential indicators of past grazing activities), and detrital content (enhanced erosion), at a high-resolution constrained by radiocarbon dating. This contribution will present the first results of this multi-proxy approach applied to thick and well-preserved organic sequences obtained from the mountain slopes east of the Dead Sea in February 2012. Such local-scale, continuous records are crucial for an in-depth evaluation of potential relationships between climate and cultural development, including settlement history, the development of agriculture, and the evolution of water management practices, especially in Levantine desertic and semi-desertic environments.

Talk

## Medieval climate change and the end of the Norse settlements in Greenland

***Sofia Ribeiro***[1], Antoon Kuijpers[1], Marit-Solveig Seidenkrantz[2], Naja Mikkelsen[1]

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The response of modern society to future climate scenarios is greatly dependent on our knowledge of past human societies, and how these may have been affected by climate change.
The fate of human settlements in the Arctic region is particularly interesting in this respect, because the effects of climate change are amplified in the Arctic, and survival is tightly connected to adapting to extreme environmental conditions.
Greenland has a rich and dynamic history with multiple episodes of human migration during the past few millennia. In the late 10th century, Greenland was settled from Iceland by the Norse (at c. AD 985). The Norse occupied sheltered inner fjord areas, where they sustained communities based on farming, pastoral activities and hunting. They established two main settlements: the Western Settlement (in the region of present-day Nuuk) and the Eastern Settlement (in southernmost west Greenland). The Western Settlement was abandoned c. AD 1350 and the larger Eastern Settlement after c. AD 1400.
A wide range of data from historical, archaeological, and climate studies indicate that environmental deterioration and climate change played an important role in the demise of the Greenland Norse settlements.
We will present an overview of the impact of climate change on the two main settlements of the Greenland Norse, based on evidence from several marine records collected in offshore and fjord areas from the vicinity of the Western and Eastern Settlements, as well as a high-resolution record from Disko Bay, where the main Norse hunting grounds were located.

Poster

## Climate change and the Plague of Justinian

***Neil Roberts***[1], Matthew Jones[2], Warren Eastwood[3], Jessie Woodbridge[1], Samantha Allcock[1], Jonathan Dean[2]

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The Plague of Justinian was a pandemic that struck the Byzantine Empire in AD 541–542. It affected much of west and south Asia, North Africa and Europe and recurred periodically until AD ~750, leading to the premature death of up to a quarter of the human population in this region. Its likely cause was bubonic plague - which later caused the Medieval Black Death - and its epidemiology is complex and multi-causal, perhaps including climate change. Human plague is caused by fleas infected with the bacterium Yersinia pestis, which in turn are carried by rodent hosts. Modern studies show that wetter climatic conditions can lead to increased host and flea populations and heightened plague risk.
Stathakopoulos (2004) used documentary sources to compile a detailed record of epidemics, famines and extreme weather events in the eastern and central Mediterranean between AD 284 and 750. Independently, Nar lake provides an exceptionally well-dated proxy record of climate and land use since AD280 from central Anatolia, then in the agrarian heartland of the Byzantine

Empire. Decadal or better dating precision is possible due to its annually-varved lake sediment record. Analysis of $\delta^{18}O$ (3-5 yr interval), diatom-inferred salinity (10 yr) and Itrax-derived elemental chemistry (sub-annual sampling) shows that the largest dry-to-wet climatic shift of the last 1,720 years occurred during the 6th century AD, centred on 530-560 AD, and led to conditions conducive to the rapid spread of plague. We use pollen analysis to test if there was a fall in the proportion of cultivated tree crops and cereals after the onset of the plague, linked to reduced agricultural activity and rural de-population. Inferred climate remained humid until AD 750, after which a return to drier conditions lowered the plague risk.
These results contribute to wider debates about the role of climate change in past and possible future plague activity.

Poster

## The effect of late Holocene precipitation changes on natural resources and human society in northern Europe

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Stable isotope records from high-latitude European lakes reveal common responses to precipitation forcing over the past 5000 years indicating that changes were the result of significant regional shifts in atmospheric circulation. We show that abrupt changes in the seasonality of precipitation occurred, some of which have influenced human society significantly. A major increase in winter precipitation occurred after 4200 cal yr BP which prolonged the snowmelt period and shortened the vegetation period. Together with a minor lowering of temperature, this change had a significant effect on natural resources and on human society in northern Sweden. Several European famines occurred during the last Millennium. Tree-ring based temperature reconstructions show that some of these famines coincided with low, but not unusually low, growing season temperatures. We infer increased summer wetness and a dominance of North Atlantic derived precipitation in northern Sweden for these periods, indicating that shifts in precipitation strongly influenced human society at these times. The recurrence of the recorded changes would greatly affect future regional climate conditions in the North Atlantic region.

Poster

## Evidence of Human-Animal-Climate interaction in lower reaches of Narmada Valley, Western India

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Recent explorations along the lower reaches of Narmada River in Western India revealed interesting evidence regarding association of microliths with vertebrate fossils within the gravel lenses. These gravels occur as intercalated lenses within sand and silt facies. The gravel lenses form a part of a regional landform referred to as 'palaeo-bank', which comprises of Tertiary rocks towards eastern margin followed by gravel-sand-silt sequence in the middle reaches. On its further west, there occurs sandy-muddy facies. The palaeo-bank is of a regional significance that extends for almost sixty kilo meters laterally along the southern bank. The palaeo-bank is tentatively datable to the end phase of last glacial. The archaeological artefacts recovered from here included geometric and non-geometric tools, scrapers and cores. The vertebrate fragments included cattle bones, jaw fragments and tooth; fragments of elephant tusk; and fragments of rhino bones. The presence of these vertebrate remains along with microliths indicates that a congenial environment was available in the lower Narmada Valley. The gravel lenses as lobes and insitu artefacts together with the vertebrate remains suggest a wetter climate.

Poster

## Examining the relationships between Holocene climate change, hydrology and human society in Ireland

***Philip Stastney[1]***

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This Poster will summarise the aims, objectives and findings of ongoing doctoral research investigating the complex interactions between peatland hydrology, climate and human societies. Using a combination of testate amoebae and humification analyses, in conjunction with AMS radiocarbon dating, the bog surface wetness of several raised bogs across central Ireland has been reconstructed. The hydrology and ecology of these wetlands are intimately linked both to global climatic variation during the Holocene and to the experience of the societies that lived around them. Whilst the forcing effects of climate on the hydrology of raised bogs has been a focus of previous research, this project will focus directly on the interactions between human societies and the climate as experienced through changes in environmental conditions. Assumptions of simplistic linear relationships between climate change and societal transitions have been shown to be inadequate and naïve; however, some well recognised climatic fluctuations appear to be broadly synchronous with gross changes in material culture: for

example the '2.8kyr event' around the Late Bronze Age-Iron Age transition. Through the construction of detailed, high-resolution records, this project examines the ways in which changes in local environments as a contingent (as opposed to deterministic) part of the human experience can be useful in interpreting changes in the archaeological record. Data from a number of sites indicate that construction of timber structures in wetlands was notably intense during the late Bronze Age, at around the same time reconstructed water tables show marked variability. A simple correlation between dry bog surface conditions and increased human activity on the bogs does not appear to be tenable. More detailed and plausible hypotheses concerning human response to changing environmental conditions are being developed by examining inter- and intra-site variability of the climate signal, investigating which variables of climate are driving the proxy record, and by carrying out more detailed analysis of the archaeological record.

Poster

## The impact of environmental change on past human societies in the Central Peloponnese (Greece)

***Ingmar Unkel***[1], Helmut Brückner[4], Walter Dörfler[1], Timothy Filley[6], Jeannette Forsén[5], Christian Heymann[1], Haydn Murray[3], Oliver Nelle[1], Arndt Schimmelmann[3], Christine Shriner[3], Helen Zagana[2]

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Sediment cores from inland lakes typically express a more constant sedimentation rate and thus provide a more continuous palaeoenvironmental archive than alluvial or near-coastal sediment archives. The central Peloponnese has been lacking detailed palaeoenvi¬ronmental reconstructions, although a direct comparison of sedimentary and other geoarchives of climate and environmental changes against the rich archaeological and historical records of ancient Greek societies may shed new light on human-environmental interactions.
In 2010 we recovered four sediment cores from a former lake bed in the valley of Asea near Tripolis. Especially the 8 m long core Asea-1, covering the entire Holocene, has the potential to provide a detailed palaeoenvironmental reconstruction. In the same year, we also retrieved a 15.5 m long core (STY-1) at the center of Lake Stymphalia, the only remaining natural lake on the central Peloponnese and only 30 km west of the ancient city of Mycene.
Our initial work focuses on sedimentological and geochemical proxies of the last 8 ka. High-resolution AMS-$^{14}$C dating and Bayesian age-depth-modeling was used to establish time series of climatic and environmental variables. We attempt to correlate our records from the Peloponnese with (1) other Mediterranean and global patterns of Holocene climate change, and (2) with archaeological and historical information for this region. While there is a profound archaeological record of cultural changes in mainland Greece covering the last 4200 years BP (back to ca. 2200 cal BC), there is still a lack in linking this record with natural archives recording climatic and environmental changes, which might have influenced the cultural development. Going into more detail, we focus on the balance between sustainability and exploitation, trying to answer questions like: How did the different ancient cultures manage their water resources? How sustainable was their agricultural land use?
So far, our geochemical analyses of sediments from Lake Stymphalia have shown that the water supply in the region fluctuated over time in response to changing climate. The Rb/Sr ratio as a proxy for changes between dry/warm and wet/cold conditions indicates pronounced wet phases around 6800, 4000–3700, 3500–3000 and 500–200 cal BP, partially corresponding to known phases of rapid climate change. The geochemical data mentioned here are the starting point for a more detailed and comprehensive environmental reconstruction of the central Peloponnese.

Poster

## Development of modern human behaviour linked to rapid climate change

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The development of modernity in human populations in Africa has been linked to pulsed phases of technological and behavioral innovation within the Middle Stone Age (MSA) of South Africa, which are associated with early evidence for symbolic behaviour, personal ornaments, complex tools and sophisticated hunting techniques. However, the trigger for these intermittent and sometimes very short-lived (<1000 years) pulses of technological innovation is an enigma, as is the reason for sudden abandonments of occupational sites and reoccupation thousands of years later. Here we show that, contrary to some previous studies, these intervals of innovation were tightly linked to local climatic ameliorations. We demonstrate that major MSA innovational pulses occurred at times when South African climate changed rapidly towards humid conditions while northern sub-Saharan Africa experienced widespread 'megadroughts' as the Northern Hemisphere entered phases of extreme cooling. These millennial-scale teleconnections result from a southward shift in the austral summer position of the Intertropical Convergence Zone (ITCZ) in combination with warmer conditions in the Agulhas current regime during North Atlantic cold events. Humid pulses in South Africa contributed to the creation of a refugium with favorable environmental conditions. This strongly implies that innovational pulses of early modern human

behaviour were climatically forced, linked to the adoption of new refugia. These required adaptive change, but also subsequently provided favourable conditions for population growth, supporting models linking such pulses with changes in demography.

## OSM10: Sea Level Change and the Coastal Zone: Threats for Human Societies

Convenors: Anne de Vernal, Yusuke Yokoyama, Benjamin P. Horton, Adam D. Switzer

Poster

### Diversity of mangrove plants in relation to palaeoenvironment during Quaternary Period in Bengal Basin

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Peat samples were collected and palynologically investigated from Rajarhat area, N-24Paraganas, 20 km North East of the great city Kolkata where work was done in connection with the building construction. The pollen analytical investigation of the peat samples reflected the existence of large number of mangroves plants ,some fresh water elements and ferns from a peat band located at the depth of about 535.5 cm to 614.5 cm below the surface. The present investigation reveals the age of the peat layers ranging from 4690 to 5060 YBP, confirming the Quaternary age of the deposits. The dominant pollen grains recorded from the samples were *Heritiera, Excoecaria, Rhizophora, Sonneratia, Avicennia, Bruguiera, Nipa, Barringtonia, Suaeda, Phoenix paludosa* and large number of fern spores including *Acrostichum* and grass pollen grains, reflected a diversity of mangrove vegetation in the peat bands. The variability of the vegetation in the peat bands from bottom to top shows the change of monsoon months during Quaternary Period in Bengal Basin. They also reflect the swampy halophytic vegetation, to some extent comparable to the present day vegetation of the Sunderbans where the diversity of vegetation is also noticed. The Sunderban mangroves in India are spread over 4266.6 $km^2$ of the estuarine tracts of the Ganga-Brahmaputra system on the northern parts of the 24 Paraganas district (North and South ) in West Bengal. There are also changes in shape and size of the tidal creeks, coastal wet lands and low lands through space and time. The present study reflected the specific geomorphologic changes supposed to affect the existing vegetational assemblages during Quaternary Period in Bengal Basin.

Poster

### Effects of sea level changes and tectonics on scalping the Late Quaternary deposits along the Southern Saurashtra coast, Western India

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Quaternary deposits of biogenic origin are exposed all along the western and southeastern Saurashtra coast of Western India. Stratigraphically these biogenic deposits which are called miliolites, rest unconformably on the Deccan Traps, Limestone beds of Gaj formation,, fluvial gravels as well as on clays separated in age from Late Cretaceous to Holocene. They occur as coastal beach dune complexes, various types of dunes as well as valley fill sheet deposits all along the Saurashtra coastline. Along the southern coastline miliolitic ridges are seen as coastal cliffs, stacks, rocky islands and shore platforms. Inland and along the coast these miliolites are deposited varying in form from scattered parabolic dunes, transverse and longitudinal dunes to barchans and sheets and also as reworked valley fill deposits. A detailed study of the lithostratigraphic sequences has been carried out by understanding the vertical facies changes and their lateral variations. The lithostratigraphic studies of the exposed sediments have revealed Basaltic basement followed by tertiary deposits. This is overlain by vertically stacked fluvial sediments comprising of gravels, paleosols, sands and silts and on the top rests miliolitic deposits of various generations. The lateral facies variation and the occurrence of miliolites suggest at least two major transgressive phases and a regressive phase. The last interglacial high sea stand is preserved as abraded platforms. Their present occurrence at around 20 m implies a significant tectonic component which has been worked out to be ~10m based on the notch morphology between Babarkot and Diu. During the Last Interglacial sea level high, Diu, Rohisa and Jafrabad were submerged bars. This is followed by regression of sea during Last Glacial Maximum (LGM) and lead to an exposure of the shelf by upto 100m. This is evident by the presence of barchans having an orientation opposite to the present day wind conditions suggesting North-Western winds which were prevalent during LGM. Following this sea transgressed again during the Holocene but was limited to the filling of the lagoons. During this period also the coastal Saurashtra witnessed tectonic instability.

Poster

### Deciphering natural trends from anthropogenically induced changes in coastal areas: Example of the hypoxia in the Lower Estuary of St. Lawrence, eastern Canada

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The coastal areas are experiencing important changes that are related to both natural variations and human activities. In order to forecast the evolution of coastal environments with the objective to develop remediation plans and/or adaptation strategy, the driving factors have to be considered and their respective impact have to be quantified. In the Estuary of St. Lawrence, for example, the development of hypoxia that affects the fauna of bottom waters seems to be dependent upon a number of factors, which include eutrophication and carbon fluxes, the warming of the water masses , and large

scale ocean circulation patterns in the western North Atlantic. Eutrophication is in part due to nutrient release in the St. Lawrence, which could be regulated, but can be also linked to the upwelling intensity at the head of the Laurentian Channel. Moreover, the characteristics of bottom waters is dependent upon the properties and relative contributions of the North Atlantic and Labrador Sea waters that mix, prior to entering into the Laurentian Channel through Cabot Strait.
Recent studies from sedimentary cores collected in the Laurentian Channel tend to demonstrate important changes in bottom water properties over the last century accompanied by a warming close to 2°C, which can be due to enhanced contribution of North Atlantic water relative to Labrador Sea water. Such a change apparently played a role in the trend towards hypoxia, because North Atlantic water are depleted in dissolved oxygen as compared to the Labrador Sea Water and because higher temperatures result in increased organic matter respiration rates and oxygen consumption. In such a context, it appears relevant to evaluate the natural variability of the ocean circulation that controls the mixing of North Atlantic and Labrador Sea water masses along the eastern Canadian margins and may also influence the water current speed in the Laurentian Channel, which in turn affects remineralisation and upwelling intensity at the head of the Channel. The postglacial records from the Estuary and Gulf of St. Lawrence illustrate a millennial pacing of the upwelling intensity and bottom water temperatures, which suggest that large scale ocean circulation exerts a determinant role on environmental conditions and might buffer or intensified their sensitivity to the anthropogenic stress.

Poster

## Chemical Fractionation of Metals in Sediment cores of Intertidal regions along Ulhas Estuary, Mumbai, India

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In order to predict the mobility, bioavailability and potential toxicity of metals it is necessary to distinguish and quantify the different forms of metals in sediments. This can be achieved by Speciation analysis. Previous studies carried out in Ulhas estuary, located in Mumbai, India, have shown presence of sediment pollution. However, no study has focused on sediment metal fractionation of the aquatic system. Therefore, speciation study was carried out along the intertidal regions of the estuary. Three mudflat cores of the estuarine region, i.e. near the estuary mouth (UI), the lower estuary (UV) and the upper estuary (UIV) were sampled and analysed for metals (Fe, Mn, Cu, Pb, Co, Zn and Cr) in the bulk as well as in the different fractions of the sediment. The results indicate that the upstream region (core UIV) of the estuary, representing the combined effect of the lithology, land use patterns and soil conditions, show higher values of metals in the exchangeable (F1), carbonate (F2) and Fe-Mn oxide (F3) fractions as compared to the downstream regions of the estuary. This observation suggests that supply of metals in the estuarine system via the sediment dissolution and soil erosion has been a significant factor which has been increasing in recent times. Also, from the bottom to the surface, the metal concentration is found to increase, except for upper few layers of some of the cores. This may be due to the post diagenetic disturbances taking place in this region like dredging, resuspension, etc. Based on correlation analysis in each of the cores, distinct associations among the different elements and sediment components (sand, silt, clay, organic matter) are not observed. This may be attributed to frequent sediment resuspension caused by dredging activities, which strongly disturbs the spatial distribution of heavy metals in sediments. Eco-toxicological effects of heavy metal contaminations in sediments were determined using Sediment Quality Guidelines (SQGs). The bio-available fractions of Cu, Pb, Zn and Cr in all the cores of the estuary are below Threshold Effect Level (TEL), Probable Effect Level (PEL), Effects Range-low (ERL) and Effects Range-Median (ERM) values indicating low risk of adverse effects on organisms. Further, the Risk Assessment Code (RAC) was used to assess environmental risks and estimate the possible damage to benthic organisms. Fe, Cu, Co, Zn and Cr project low risk; Mn and Pb show low to medium risk. Although metal concentrations in the bio-available fractions are low in the estuary, contaminated sediments at relatively shallow depths in estuary experiencing erosion, may present considerable risk to sediment dwelling biota.

Poster

## Identification of Tsunami deposits and their impact on coastal zones: A study case of the Boca do Rio estuary (Algarve, Portugal)

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Tsunamis are unforeseeable phenomena and therefore one of the most devastating natural disasters in terms of human and economic losses. Their impact on coastal and nearshore zones is substantial and needs to be accurately evaluated to improve their prevention and management. In the last decades, numerous investigations focused on the identification of paleotsunamis in order to evaluate their frequency in the geological record. However, because storm- and tsunami-deposits are generated by similar depositional mechanisms, their discrimination using classic sedimentological methods is an elusive prospect. A promising approach is to couple classic geological criteria with geophysical and geochemical proxies to search for new benchmarks of tsunami deposits and to integrate them into a multi-disciplinary study. To test our method, we investigate the 1755 Lisbon tsunami

deposit from the Boca do Rio estuary and other Tsunami-induced deposits from Algarve (Portugal). First results show that, Sr and Ca are enriched in the tsunami layer probably linked to the presence of shelled organism. Contrarily, others marine seawater indicators, such as Ba and Br, which are usually more concentrated in brackish than in fresh water, and heavy minerals, which are generally used as high energy event indicators, are depleted in the Tsunami deposit. Very low magnetic susceptibility values for the Tsunami deposit also indicate a dilution of iron oxides, reworked from the estuarine clays, within the huge volumes of quartz and carbonate (i.e. diamagnetic), issued from the abrasion of the littoral sandy dune and the surrounding carbonated cliffs. Diffusive Reflective Spectrophotometry analyses show significant changes in the siliciclastic fraction below and above the tsunami layer. These colour variations are linked to the deposition of finer siliciclastic particles after the tsunami. Our data show that the material brought by the Tsunami is proximal, i.e. littoral, and not marine as usually thought. Our study also suggests that the 1755 Tsunami affected the geomorphology of the estuary, and therefore the sedimentation, inducing mis-interpretations of the geological record regarding local sea level changes and coastal evolution history. These results provide new benchmarks for the identification of tsunami-induced deposit and for the evaluation of their impact on the coastal zone.
Keywords: rock magnetism, tsunami deposit, estuary, natural hazards.

Talk

## Erosion of Arctic permafrost coasts and mobilization of dissolved organic carbon (DOC) from ground ice

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Arctic permafrost coasts make up ~34% of the world's coastline (ca. 400,000 km) and are often made of ice-rich unconsolidated sediments. This makes them highly susceptible to coastal erosion, and it is likely that large quantities of carbon are released, because permafrost soils are considered to hold approximately 50% of the global soil organic carbon pool. Current estimates of the carbon released by coastal erosion focus solely on particulate organic carbon (POC). Dissolved organic carbon (DOC) is generally not included in these calculations, because estimations of DOC contents in ground ice, which is overwhelmingly present along Arctic coasts, do not exist. In some cases, ground ice occupies as much as 90% of coastal bluffs with 40 m in height, where the coastline erodes at rates approaching 10 m/yr at its maximum. Here, we report DOC contents from different ground ice types throughout the Arctic. We put them into context of Arctic organic carbon pools and fluxes, and evaluate their contribution to the Arctic carbon budget against the background of increasing permafrost degradation and enhancing coastal erosion in the future. For example, even conservative numbers for the background parameters (coast length, erosion rate, cliff height, ground ice content) lead to a first estimation of DOC flux derived from ice wedges of 0.29 Gg/yr. This number is expected to increase significantly if the whole Arctic permafrost coastline was classified, if other ground ice types were incorporated, and if the DOC concentrations were weighted and upscaled for different terrain units (e.g. carbon-rich and ice-rich Pleistocene uplands).
Although these numbers might be still small compared to the POC stocks in peat and mineral soils, DOC is chemically labile and may directly enter local food webs of the near-shore zone. Moreover, due to its lability, DOC is quickly mineralized and returned to the atmosphere when released due to permafrost degradation.
Robust estimations of how much organic carbon is potentially released from permafrost are crucial for predicting the strength and timing of carbon-cycle feedback mechanisms in the Arctic. This approach shall lead to an improved understanding of how important permafrost thaw in general and the erosion of permafrost coasts in particular are for the climate development this century and beyond. This is especially important in the Arctic before the background of expected rising air and sea surface temperatures, prolongation of the open-water season, increasing storm frequency and accelerating eustatic sea level rise.

Poster

## Anthropogenic impact in coastal Baltic Sea over the last 2000 years using biological proxies

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Baltic Sea is one of the most intensely studied coastal marine systems in the world. The environmental problems related human-induced eutrophication and anoxic bottom waters are of prime concern. But still there are a number of unanswered questions: for instance for how long and to what extent has the human activity affected the Baltic Sea. In our project we aim to develop and refine biological proxy variables in the marine sediment record over a span of last 2000 years. We present data from two stations along the Swedish Baltic coast. Two long cores (~ 5.2m) have been sampled and employing XRF scanning, and a range of biological proxy variables, such as dinoflagellate cysts, testate amoebas (thecamoebians), ciliates (tintinnids), together with bottom-dwelling (benthic) foraminifera. The XRF results show a high proportion of Bromine in organic rich intervals that may be related to marine organic matter. The micropalaeontological analyses indicate a very poor population of benthic foraminifera with very few agglutinated form such as Miliammina fusca, no calcite adult species but relative moderate proportion of unidentified juvenile forms. The preliminary investigation also reveals a large and diverse abundance of tintinnids, which can be related

to environmental settings with high content of organic matter.

Poster

## Late Holocene environmental change inferred from coastal lake and estuarine sediments in the Wilderness area, southern Cape, South Africa

***Torsten Haberzettl***[1], Roland Mäusbacher[1], Bastian Reinwarth[1], Siegfried Clausnitzer[1], Sarah Franz[1], Kelly Kirsten[2], Jussi Baade[1], Thomas Kasper[1], Lynne Quick[2], Gerhard Daut[1], Michael Meadows[2]

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The southern Cape coast between George and Knysna provides a unique combination of climatic and geomorphic properties: the coastal plain is composed of alternating sub parallel dune cordons and depressions holding wetlands, lakes and estuaries which temporarily are cut off from the Indian Ocean by sand bars. Year-round rainfall supports afromontane forests with intermediate fynbos patches. Seasonal rainfall and vegetation patterns are supposed to be sensitive against climate fluctuations, but paleoecological evidence is presently limited. A sediment reconnaissance survey at various sites was conducted in 2010. Based on data from hydroacoustic measurements short gravity cores SWART 10.1 (1.00 m) and EV 10.1 (0.65 m) were recovered from an estuary and a brackish coastal lake called Swartvlei and Eilandvlei. Sedimentological and geochemical properties as well as variations in the diatom assemblage were investigated in order to infer past environmental change. Due to the lack of dateable macro remains, radiocarbon dating was carried out on the organic fraction of bulk samples. Radiocarbon ages of SWART 10.1 were corrected prior to calibration, since dating of surface sample implied a reservoir effect of ~180 yr. Reservoir corrected chronologies give and age of ~AD 1350 for EV 10.1 and ~AD 600 for SWART 10.1. Results point to variable sedimentation rates throughout the last centuries with long-term averages of 0.7 mm/yr (SWART 10.1) and 1 mm/yr (EV 10.1). Variations in density and grain size distribution which were analysed in 1-cm-intervals are likely caused by variable runoff and sediment flux from the catchments. Correlation webs in addition to principal component analyses indicate that certain elements can be used to track changes in past sedimentation regimes: Al, Zr, Ba and K concentrations mainly reflect minerogenic input, whereas B, C, Ca and Sr can be attributed to autochthonous sediment production or marine influences. Moreover, geo-pedological conditions in the catchment suggest that clay and fine silt predominantly originate from weathered top soils. A synopsis of geochemical and sedimentological results points to an increase of minerogenic sediment proportions starting at ~AD 1400 and therefore approximately 375 years prior to the advent of European forestry in this region. It is hypothesized that reduced summer precipitation during the northern hemisphere Little Ice Age period affected vegetation patterns and consequently altered hydrology and sediment flux. Enhanced sedimentation rates and distinct changes of grain sizes and geochemistry of both records presumably correspond to accelerated soil erosion in the catchment following the conversion from natural vegetation to agricultural and forestry land in the 19th century. Rising C, N and P concentrations towards the top of EV 10.1 possibly indicate that increasing sediment and nutrient flux into Eilandvlei results in enhanced burial of organic matter. Artificial opening of estuary mouths connecting the lakes with the Indian Ocean, water abstraction from tributaries in addition to landscape modifications might have changed water salinity leading to growing diatom species diversity. Further investigations as for example pollen analysis will scrutinize these interpretations.

Solicited Talk

## Anthropocene changes in particulate and dissolved fluxes from major rivers and their impact on coastal processes: Methodological issues

***Claude Hillaire-Marcel***[1]

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Since the late 1990s, cooperative studies on large river systems of Canada (St. Lawrence, Mackenzie, Great Whale River, Nelson River, Koksoak, La Grande...) have led to conclude that particulate and dissolved fluxes from most of these rivers were strongly modified by direct or indirect anthropogenically-driven processes (damming, land management, agricultural practices, industrial/mining activity, climatic changes...). If this is the case at the scale of the little-populated Canadian sub-continent, then other large river systems from lower latitudes are likely to be more drastically modified by similar processes. On one hand, naturally-controlled (i.e., pre-anthropogenically modified) fluxes are difficult to assess, thus leading to uncertainties in estimating rates of change. On another hand, the impact of such changes on coastal processes is still poorly documented. Aside direct influence on the estuarine and near shore productivity and ecology, sediment accretion processes along shorelines and the nearshore environment, as well as larger scale sediment loading rates, may be impacted by such changes. Time series of particulate and dissolved fluxes from major river systems are rare. The seasonal patterns are rarely well recorded, often for logistical reasons. This has led to the setting, under the umbrella of the IAEA, of a working group on Large River Systems. Plans are to complement water and particulate flux records by a large array of chemical and isotopic measurements in order to couple information on changes in hydrological regime (stable water isotopes), carbon and nitrogen fluxes and cycling, erosion (radiogenic isotopes, Li isotopes...), with constrains on residence times of particulate and dissolved compounds using radioactive isotopes. Access to time series from pre-anthropogenic state to the present one, will often require linkages with proxies from sedimentological records in estuarine and near-shore

deposits. A few examples with specific methodological issues will be presented.

Poster

## Postglacial-Holocene relative sea level data from the White Sea Coast, Russia

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Precise relative sea level (RSL) data are important for inferring regional ice sheet histories and postglacial paleogeography of region. The Kandalaksha Bay coasts of the inland White Sea are a relatively new region where RLS curve were constructed for six localities. The so-called isolation basin method has been used for reconstructing former sea-level changes. The examined localities are situated in front of, or behind the moraines with YD age (Salpausselkä I - Rugosero stage). Our results have shown that during the Alleröd White Sea depression was isolated from the Ocean, there existed Belomorian Ice Lake. The first sea inflow into depression is dated by 11230±340 yrs BP (13 150 cal yrs BP). After the first emergence following deglaciation, the relative sea level rose by 11-30 m in various areas of western White Sea coast and culminated late in the YD. Shortly after the YD/Holocene boundary, the sea level fell abruptly by 42 m after which there has been a gradually slowing regression of c. 2.5-0.5 m/100 years up to the present time. There is no evidence of halts in the regression but the low rate of regression (c. 0.4 m/100 yrs) and even stillstand around 6000 BP correlate with the Tapes (Holocene maximum) transgression on Barents Sea coast. An abrupt fall (4 and 10 m) is observed on RSL curves of two localities shortly after Tapes transgression. We concluded that this phenomenon was caused by the tectonic forces of the reactivated Precambrian Kandalaksha graben.

Poster

## Postglacial RSL changes of White Sea according the lithological and micro-paleontological data (Kandalaksha Bay, NW Russia)

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The bottom sediments in lake depressions on coastal areas of the Kandalaksha Bay of White Sea have been studied to identify the local features of postglacial marine regression caused by glacioisostasy uplift. From lithological and $C^{14}$ data RSL curves were reconstructed and glacioisostasy uplift was established. The velocities of glacioisostasy uplift were 40-50 mm/yr on the northern Kahdalaksha Bay coast and 40-70 mm/yr on the southern one in 10000 – 9000 $C^{14}$ yr BP, and 20 mm/yr on the head of the Kandalaksha Bay and ~10 mm/yr on the both coasts in 9000-3000 $C^{14}$ yr BP and ~5 mm/yr everywhere here during the last 3000 years.
RSL changes are reflected not only in the sedimentology successions but in the features of spore-pollen spectra. Poaceae and Cyperaceae pollen peaks along with the dying-out of Aster-type and Plantago pollen indicate the marine regression and the abjuction of the lake basins from the sea on the coastal areas. Because of later marine regression and appeared new ecotopes on the coasts the spore-pollen spectra are characterized by arborescent pollen with dominated Pinus or Picea. A low amplitude marine transgression and raised base level of erosion and humid climate were indicated by pollen spectrum with one more Poaceae pollen peak and dominated Betula sect. Albae.
The RSL curves and the sporo-pollen diagrams from sample cores of bottom sediments, and initial lithological data will be presented.

Poster

## Tectonic geomorphology of the Holocene marginal marine basin of the Great Rann of Kachchh, Western India: Implication for pattern of emergence during historical times

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Based on its peculiar geomorphic characteristics, archaeological evidence and historical records, it is generally agreed that the Great Rann marks the site of an ancient gulf connected to the Arabian Sea in the west. Historical accounts also suggest that there was a navigable sea belonging to archaeological sites of Harrappan civilization including port town of Dholavira. The major factor responsible for the unique present day environmental conditions of the rann surface is its periodic submergence by sea water and monsoon precipitation. The flat rann surface and the negligible gradient allows extensive inundation by sea water from the Arabian sea in the west and by river waters from the north east and south during the monsoon season (Roy and Merh, 1981).The inundation periods are separated by relative long periods of dry and hot saline wasteland conditions during the summer season. Overall, the alternate wet and dry condition in the Great Rann of Kachchh has resulted in a unique and hostile terrain whose environmental condition fluctuates between extremes. The major geomorphic components of the Great Rann are the almost flat and gradientless surface, hereafter described as the rann surface, several islands (locally called 'bet') of different shapes and sizes and the roughly E-W trending Allahbund scarp Based on the present day submergence pattern and surficial characteristics, the Great Rann of Kachchh has been geomorphologically divisible into four units- the Banni plain, Supra tidal salt flat, Inland saline flat and the Bet zone. Owing to very small variation in elevation and imperceptible gradient, the boundaries between the

various divisions are gradational. The northern part of the Great Rann witnessed drastic geomorphological changes after the 1819 Allahbund earthquake and subsequent flooding events of the now defunct distributary of Indus River that flowed into this region joined Kori creek in the south before the earthquake. Historical documents suggest that the earthquake produced a distinct fault scarp that uplifted the northern part of the Great Rann which corresponds with the present day Bet zone. The scarp trends in roughly E-W direction and laterally extends for about 90 kms. Overall, the Allahbund scarp all along its length appears as a highly degraded erosional scarp that exposes raised rann sediments in the vertical cliff sections. The geomorphic framework is strongly controlled by the tectonic framework including the subsurface structural features. The close association of these units with faults suggests differential tectonic activity along subsurface faults within the Great Rann basin may have played a major role in the emergence of various morphologic units at different times. We infer that the emergence of the rann surface may have occurred gradually in the historic past which led to the formation of the distinct morphologic units viz. the Banni plain, the Bet zone and the Linear Trench zone. Based on elevation and present day submergence characteristics, the Banni plain appears to have been the first to emerge followed by the Bet zone and the Supratidal salt flat which still gets submerged by marine waters regularly.

Talk

## The probable drivers of contemporary effective sea level rise rate in southwest Bangladesh

John Pethick[1], ***Julian Orford[2]***

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Both Bangladesh and the West Bengal Sundarbans have over the 20th century used polders or embankments to protect subsistence agriculture on those tidal islands to the west of the main Gangetic delta depositional centers. There is some limited evidence for the impact polders have on associated palaeo-deltaic estuary dynamics and sedimentation. This paper gives an example of a more direct association between sea level, tidal regime and polderisation. Evidence is presented from estuarine tide gauges located along the Pussar estuary in the Bangladesh Sundarbans, of an effective relative sea level rise substantially in excess of the generally accepted RSL rates from altimetry as well as from previous tide gauge analyses. It is proposed that this difference arises from the use of relative mean sea level (RMSL) to characterise the present and future coastal flood hazard. We consider that RMSL can be misleading in estuaries in which extreme water elevations and tidal range is changing. Three tide gauges, one located in the uninhabited mangrove forested area, the others in the densely populated polder zone, show rates of increase in RMSL ranging from 3.3 mm a-1 to 7.65 mm/yr during the late 20th and early 21st centuries However, these trends in RMSL disguise the fact that high water levels are increasing at an average rate of 18 mm/yr in the polder zone, with a maximum rate of 22 mm/yr. In an area experiencing extreme water level amplification, we suggest that the use of trends in high water maxima or 'Effective Sea Level Rise' (ESLR) is adopted as a more strategic parameter to characterise the flooding hazard. The rate of increase in ESLR is shown to be due to a combination of deltaic subsidence, including sediment compaction, and eustatic sea level rise, but principally as a result of increased tidal range in channels recently constricted by embankments. The increases in ESLR have been partially offset by decadal decreases in fresh water discharge in those estuaries connected to the Ganges. If the observed rate of increase in ESLR continues and is added to the range of predicted values due to global warming in the 21st century, then total effective sea level rise by 2100 within the polder zone of SW Bangladesh could range from 2.42 m to 3.92 m with catastrophic impacts on these low lying delta areas which have a population in excess of 3 million.

Talk

## Using sea-level proxy data to constrain future sea-level rise

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Considerable progress has been made in recent years in reconstructing sea-level variations over past millennia. This information about past sea level should be useful in constraining the future response of sea-level to global warming. However, it is not straight-forward how this can be achieved. We will discuss the semi-empirical approach to projecting sea level, its robustness and validation issues, and the role that paleo-climatic data can play in constraining the parameters for future sea-level rise. We show that proxy data are critical for constraining multi-century projections of sea-level rise like those of Schaeffer et al. 2012.

Poster

## Analysis of Mangroves vegetation history from Kanjani (Kerala), the South West coast of India

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The present study aims at reconstructing the past history of mangrove vegetation vis a vis climate change along the south west coast of India. Sub-surface sediments collected from the Kanjani area of Thrissur district, Kerala were analyzed for the pollen and diatom studies. This study shows phases of dominance of core mangrove over mangrove associates during a time span of ranging from 6380yrs BP to 1140 yrs BP. The study reveals that around 3280±100 yrs BP the environmental conditions were not favorable for the growth of mangroves in and around the study site as evident from the absence of core mangroves taxa and presence of mainly the pollen grains of Poaceae, Palmae, Cyperaceae. This is also

supported by the presence of phytoliths of only Poaceae, Cyperaceae and Palmae. Even the number of diatoms taxa was either very low or absent. Subsequently, during 3280 yrs BP to 6330 yrs BP environmental conditions became favourable for the existence of mangrove vegetation in the vicinity of the lake. Apparently, several species of Rhizophora viz. R.mucronata, R.apiculata, R.lamarckii, Avicennia marina, Ceriops decandra, Ceriops tagal, Bruguiera ,Kandelia, Excoecaria were well represented in this region. The mangrove spikes at this time perhaps represent a transgressive phase under warm-moist climate. A good number of diatom taxa both penate and centric viz. Navicula, Nitzschia, Eunotia, Tabularia, Coccconeis, Aulacoseira, Meliosira, Thalassiosira etc have also been recorded representing brakish water conditions that favours the growth of mangroves. Subsequently for a brief phase 1140 ±440 yr BP was not favourable for the development of mangroves. The presence of good number of diatoms taxa like Navicula, Eunitia, Aulacoseira, Meliosira representing the fresh water ,oligotrophic environmental conditions at the site during this time frame .Some mangrove taxa viz. Rhizophora, Avicennia, Ceriops and others were either decreased or even disappeared. Decline of mangroves and the rapid expansion of Cheno/Ams and other species indicated lowered sea level besides decrease in precipitation. Around 2,203 yrs B.P., the deterioration of mangroves took place as a result of change in climate towards more aridity, relative sea-level fall, which was further accelerated by anthropogenic activities. The present study reveals the existence of mangroves in the area in the recent past and such investigations would also be helpful in the regeneration and restoration of mangroves around the Chilka Lagoon.

Poster

## Mangrove and coastal environment changes during the Holocene in the Mahanadi Delta, India

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Mangrove vegetation is an important component of the coastal ecosystem. The palynological studies of mangrove sediments reveal not only the past extent of mangroves but also changes of environmental conditions over time, hence they form very good archives for paleoclimatic records. The Chilka Lagoon is the largest open lagoon of Asia, declared as a Ramsar site under the convention on “Wetlands of International Importance”. The pollen records and radiocarbon dates obtained from two sediment cores of the Chilka Lagoon, Mahanadi Delta, were used for reconstructing the history of mangroves in relation to climatic changes and relative sea-level fluctuations during the Holocene. Pollen and chrono-stratigraphic data indicate that diversification of mangroves at the study site took place between 8,842 to 5,134 yrs B.P. This development of mangrove dominated vegetation was due to sea-level rise followed by stabilization of marine-freshwater environment, which provided conducive environment for the optimum development of mangrove forests. After 5,134 yrs B.P., the rich mangrove vegetation started deteriorating as indicated by the poor frequencies of core mangrove pollen, probably due to changes in sea-level. An intertidal environment reappeared for a short span of time around 2,526 to 2,203 yrs B.P., resulting in the rejuvenation of the mangroves due to relative rise in sea-level, balanced influx of fresh water and warm and moist conditions.

Poster

## Persistent non-solar forcing of Holocene storm dynamics in coastal sedimentary archives

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Most of the world’s sandy shorelines have retreated during the past century and, if sea-level rise is an underlying cause, climate-related ocean-atmosphere oscillations significantly contribute to coastal changes1. Extreme sea-level rise events, arising from changes in storm dynamics, are of widespread concern since coasts are highly vulnerable to extreme storm surges. The most recent reviews support the view that both tropical and extra-tropical (i.e. mid-latitude) storm activity has increased and this will continue if global warming remains unabated2. The lack of long-term instrumental and proxy data, however, hampers a thorough exploration of the mechanisms linking past storminess maxima and ocean-atmosphere dynamics. Recent works3 have highlighted the crucial need in obtaining tighter constraints on future ocean circulation for a better forecasting of the North Atlantic storm track. Disentangling the role of the ocean and the solar activity forcing in triggering climate signals is therefore crucial to understand forcing mechanisms on long timescales including how such forcings are translated into regional climate variability. Here we present a series of records from high-energy estuarine and other coastal systems from Northern Europe, and report evidence for five distinct Holocene Storm Periods (HSP) of enhanced storminess during the last 6,500 years. The HSP occur periodically with a ~1,500-year frequency, and closely fit with Holocene cold and windy periods during the last 6,500 years4–7. For Northern Europe, we show that millennial-scale storm extremes are phase-locked with the internal oceanic frequency of the North Atlantic (~1,500 years), whilst no consistent correlation emerges from solar power spectrum maxima. The close but striking correspondence between HSP and the internal oceanic frequency of the North Atlantic indicate that the pervasive ~1,500-year increased storminess is therefore anchored

in coupled ocean–atmosphere dynamics, but discredits solar activity changes as a primary forcing mechanism of millennial-scale variability in storminess. The data also demonstrate that recent increases in storm activity1,2 are not in-phase with coupled ocean-atmosphere forcings.

Talk

## What can we learn from recent catastrophic coastal events in Vietnam, India, Philippines and Thailand?

***Adam Switzer[1,2]***, Christos Gouramanis[1], Ying Sin Lee[1,2], Charles Bristow[3], Charles Rubin[2], Kruawun Jankaew[4], S. Srinivasalu[5], Lam Dinh Doan[6], Fernando Siringan[7], Que Dinh Hoang[8]

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This presentation summarises early results from recent collaborative work on the coasts of India, Vietnam, Philippines and Thailand. The investigation of a variety of coastal settings has allowed the direct comparison between the impacts of recent tsunamis and storms on these coasts. The sedimentary and geomorphological features found in coastal environments at these sites allowed the study of event dynamics along with an examination of the post-event recovery. The investigations also examined the modification of sedimentary deposits and geomorphological features (erosional scours and transported clasts) in the different coastal settings. This work has furthered the comparative study of the impacts of storms and tsunamis and highlighted areas where sedimentary signatures of storms and tsunamis are most likely to be preserved and some of the processes that are most likely to destroy them. In India and Thailand we also located areas that allowed for a direct comparison between storm and tsunami deposits. Such work provides important modern analogs for the study of prehistoric deposits and features found in the landscape in tropical Asia.

Talk

## Uncertainty on future sea level rise - implications for planning and the role of scientist qua advisor

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Future sea level rise presents planners in costal zones with a new and difficult situation. There are large uncertainties in current projections of future sea level rise and many different methods are used (e.g., based on climate- and ice-sheet models, expert assessments of ice sheets and glaciers, semi-empirical models & paleo analogs). To this must be added the potential for rapid changes that could be initiated in the near future. These include "tipping points", such as a rapid collapse of the West Antarctic Ice Sheet or changes in ocean currents. In addition there is the risk of surprises, such as non-linear responses and new phenomena.
Planners in costal zones must deal with this situation today, but even more so in the foreseeable future. It is likely that there will remain considerable uncertainty in sea level projections, multiple methods and models, and difficulties in interpreting signals that could indicate tipping points and novel phenomena.
This paper discusses the implications of the above for planning. One consequence is that simple "predict-then act" and optimizing approaches becomes more risky. Instead other approaches need to be employed that better can deal with uncertainty in impacts and vulnerability. A review of the methods that been proposed is given, including those that focus on "robustness", "resilience" or "flexibility".
The paper then examines how new scientific studies and results best can be used to inform planning in light of the situation described above. Does it mean any new requirements on "providers" of scientific information to policy-makers and stakeholders? In particular, the role of the scientist qua advisor will be analyzed, based on recent developments in the philosophy of science on the role of values in science and policy.

Poster

## Holocene sea-level change in Sri Lanka and melting history of Antarctic ice sheet

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Mid to Late Holocene sea-level change can be used for evaluating long-term stability of the Antarctic ice sheet since the most of the Northern hemisphere major ice sheets disappeared by approximately 8,000 years ago. Ongoing global warming may trigger disintegration of this ice sheet, with collapse of the West Antarctic Ice Sheet alone potentially producing a more than 3 to 4 m global sea-level rise. Relative sea level records from sites far away from former ice sheet regions (far-field) provide information on total volume of the ocean mass change, which can be interpreted as global ice volume change. Here we report Holocene sea- level records from Sri Lanka compared with glacio-hydro-isostatic modeling to better understand the melting history of Antarctic ice sheet during the Holocene.

Poster

## Holocene evolution of Qing'ao embayment, Southern China

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The Holocene evolution of the Qing'ao embayment, Nan'ao Island, southern China, is a result of the interaction of tectonic activity, climate variation and the sea level change. Understanding the evolution history of Qing'ao embayment during the Holocene will help improve our understanding on these driving mechanisms in this area. To reconstruct the Holocene evolution history of Qing'ao embayment, this study analyzed the grain size and loss on ignition (LOI) on modern and core samples. A modern-day analogue of the grain size was developed based on a total of 68 modern samples ranging from the sand dune seawards to the offshore area. The results of these modern samples suggest that dune sand (mean size of ~2.33Phi) are slightly finer than beach sand (mean size of 2.13Phi), and the onshore sediment (both dune sand and beach sand) is much coarser than offshore sediment (mean size of 5.90Phi). LOI of modern samples was not analyzed. This modern analogue is then applied to 8 cores from the Qing'ao embayment. A chronological framework obtained from 11 radiocarbon samples suggests that the Qing'ao embayment started to accept deposition since early Holocene, ~8400 cal. yr. BP. Based on sedimentary lithology, grain size analysis and LOI results from 8 percussion cores, three main phases of Holocene evolution were identified in Qing'Ao embayment. A basin wide shell-rich clayey sheet forms the early Holocene facies (~8400-6000 cal. yr. BP) and overlies the bedrock. This facies records an initial sedimentation phase associated with the early Holocene transgression into the embayment. The basal facies grades upward to a mixed sandy coastal system lasting from ~6000-1500 cal. yr. BP that appears coincident with falling regional sea levels, a period of coastal dune building recorded as yet undated massive sands that are found in the upper fill. Toward the end of the coastal phase it is apparent that dune migration has restricted the lagoon entrance and that this was contemporaneous with the final stages of infilling of the lagoon. The final phase of sedimentation is recorded as a thin terrestrial sequence dominated by fluvial floodplain facies that covers the last ~1500 cal. yr. BP and is topped by soils that also record the enhanced anthropogenic modification over the last 1500 years. Results suggest that sea level is the main driving mechanism for evolution of the Qing'ao embayment, as climate change during the Holocene in this region is relatively insignificant. However, as this area is reported to be tectonically active, impact of the tectonic movement on the evolution of Qing'ao embayment still requires further investigation.

Poster

## Assessment of the Possible Impact of Climate Change on Fresh Water – Saline Water Interaction in the Coastal Aquifers of Bangladesh due to Sea-level Rise

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Groundwater is the major source of fresh water across much of the world but there has been very little study on the potential effects of climate change on this resource. Climate change addresses changes in a number of components of the hydrological cycle includes increasing global average air and ocean temperatures, widespread melting of snow and ice, rising sea level, changing precipitation patterns and intensity, increasing atmospheric water vapour, increasing evaporation, and changes in soil moisture and runoff and all of these have link with groundwater storage and quality. Rising levels of greenhouse gases are likely to increase the global average surface temperature by 1.5-4.5°C over the next 100 years, raise sea-levels and reduce soil moisture. The amount of water stored in the soil is fundamentally important to agriculture and has influence on the rate of actual evaporation, groundwater recharge, and generation of runoff. Rising sea levels would cause the tidal saltwater wedge to intrude further upstream in rivers, with resulting changes in salinity affecting coastal aquifers. However, to face the challenges in adaptation with the climate change impacts to know the real evidences of changes in the events of hydrologic cycle is very important. Because of its low-lying topography, Bangladesh is expected to be more vulnerable regarding climate change issues. In Bangladesh, about 98% of drinking water supply and 80% of irrigation water is being provided by groundwater. In the coastal areas where availability of fresh and safe water is a big problem due to arsenic contamination and saline water intrusion in upper aquifers, assessment of probable impact of sea-level rise on deep fresh water is utmost important. Considering importance of groundwater use, a network for monitoring hydrological and hydrogeological data had been established mainly to facilitate sustainable management of overall water resources of the country. The necessity is to upgrade, strengthening and expand of monitoring technologies for tracking changes in the system due to climate change. This paper focuses on the impact of climate change on the fresh water – saline water interaction in the coastal aquifers of Bangladesh considering anticipated sea-level rise and to develop and design of monitoring network to evaluate, identify and monitor the obvious changes expected from climate variables in coastal areas.

## OSM11: Biodiversity and Refugia - Lessons Learned from the Past

Convenors: Sheri Fritz, Surangi Punyasena, Kathy Willis

Talk

### Non-linear responses of vegetation to orbital forcing across the temperate to tropical transition in South America

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Ecologists have sought explanations for the biological richness of tropical forests since the Linnean era of biological exploration. Many explanations centred around the presumed stability of tropical systems, in contrast to the shorter-lived ecosytems of higher latitudes. Haffer's Pleistocene refugia hypothesis proposed that Holocene Amazonian forests were a recent formation from a largely savanna Neotropics during the time of the Last Glacial Maximum (LGM). Recent palaeoecological effort has established that the Amazon basin was fully forested throughout Pleistocene climatic oscillations, albeit with changing composition. However, these palaeoecological investigations, and climate modelling for the Neotropics, indicate that temperatures may have been up to 5C lower at LGM, but regionally variable, and there is greater uncertainty about patterns of precipitation. These conclusions open the possibility that the range of climatic variation in the Neotropics, much less than at higher latitudes, may even approach what might be described as 'stability' over longer periods. Nevertheless, these small climate changes lead to vegetation changes that are substantial in terms of community re-organization, but may be of limited geographical extent, indicating that the vegetation-climate relationship is non-linear, and possibly strongly so. A number of questions then arise, including (i) what are the geographic limits of this region of relative 'stability', (ii) what happens at the transition to higher latitude regions of relative 'instability', (iii) what are the limits of predictability for community response to climate change, and (iv) what are the consequences for the evolution of flora and vegetation?

Poster

### Resilience of an ancient tropical forest landscape to 7500 years of environmental change in the Western Ghats, India

Shonil Bhagwat[1], ***Sandra Nogue***[2], Kathy Willis[2]

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There is growing recognition that the fate of the world's terrestrial biodiversity depends on the management of human-dominated tropical forest landscapes. While global environmental change is transforming the ecology of tropical forests, a number of studies have also demonstrated that tropical forests are able to recover following disturbance. But are tropical forests resilient to environmental and anthropogenic disturbances over timescales of centuries or millennia? Here we examine the relationship between vegetation cover and variation in monsoon rainfall, soil erosion, and fire over 7500 years in an ancient tropical landscape in the Western Ghats of India. We collected two overlapping sediment sequences at one study site and analysed them with palaeoecological techniques to reconstruct vegetation cover. Results suggest that climate and land-use changes might have had synergistic effects on this forested landscape, although the relationship between these factors and vegetation cover has varied over time. Results also indicate that the weakening of monsoon around 5750 BP might have caused a threshold event altering this landscape to a low tree-cover state. Although anthropogenic fire has maintained this landscape in low tree cover state from 3500 BP, this degraded tree–grassland mosaic has remained relatively resilient to fluctuations in environmental and anthropogenic factors. Tree taxa present throughout the sequence have lighter seeds than those absent in parts of the sequence, suggesting that dispersal mode might be an important factor in their persistence. Despite maintaining a degraded and fragmented forest mosaic, however, this landscape has supported populations of heavy-seeded trees and a probable refuge to their dispersal agents. We suggest that retaining tree cover on this landscape, even if fragmented, is key to maintaining its ecological resilience to environmental and anthropogenic disturbance.

Talk

### Glacial refugia of Cedrus atlantica in Morocco: New records bring new interpretations

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Data from lakes Tigalmamine and Sidi Ali from the Middle Atlas, Morocco, showed that Cedrus atlantica appeared roughly after 7000 years BP. One hypothesis was that the temperature of the coldest month was too high during the early Holocene, which had "prevented" the expansion of cedar. But these surveys covered only the Holocene. A new sequence obtained in the lake Ifrah, Middle Atlas, allowed to investigate both the last glacial period and the early Holocene. Its pollen content clearly showed that the cedar was present throughout the glacial period but had in fact decreased during the early Holocene. A quantified reconstruction of the winter temperature confirmed the

earlier observations from the other records.
Parallel to these paleoenvironmental data, a genetic study of several populations of cedar in the Rif, in the Middle and the High Atlas suggests that there is significant weak genetic structuring and without clear spatial pattern. In other words, the cedars did not propagate from a specific area or originated from a common population or ancestor, but they rather probably continued to exist in the form of fragmented populations in different mountain areas at least since the last glacial period.
In 2011, we collected a new coring in the Middle Atlas, which covers more than 20,000 years continuously according to the ten $^{14}C$ dates that we have obtained. We analyzed the pollen content and 21 geochemical elements (XRF) and particle size of the record. This survey indicates that the cedar has existed continuously in the study area during the last glacial period and even during the early Holocene. Without interruption.
These new data suggest that several glacial refugia for cedar have existed at least in the Middle Atlas and these refugia remained separated due to the mountainous landscape which prevented or limited the gene flow between the isolated populations. A synthetic view of these long lasting refugia in the Middle Atlas will be presented at the workshop.

Poster

## Biodiversity and land cover change in Europe over the Holocene: A functional approach based on pollen data

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The natural landscapes of Europe today are the product of climate changes and the impact of human activities over the Holocene. The importance of humans in millennial-scale landscape change continues to be debated after nearly a century of research. Here we show quantitatively, using a series of novel analyses of the European Pollen Database, that variations in natural vegetation are limited to northern Europe while more large scale land cover change appears synchronous with known developments in human history. Functional biodiversity increases over the last 12ka, with fastest change in recent millennia, suggesting that anthropogenic fragmentation of landscapes was important.
Using more sites and stricter quality control than any previous study, we first converted raw pollen counts to plant functional type scores and then use a novel technique to interpolate those plant functional scores in time and space across Europe. The interpolated plant functional type (PFT) scores then form the basis of four analyses:
1. Calculated Squared Chord Distance from present shows that the European plant functional landscape of the early Holocene was quite different from present, but became more similar to present conditions at an increasing rate, crossing the modern analog threshold on average around 5,000 cal yr BP.
2. Biome reconstructions suggest that this Holocene vegetation change is not likely due to climate alone, as the distribution of different biomes changes minimally outside of Fennoscandia, which experienced large temperature changes over the Holocene due to orbital forcing.
3. Arboreal : non-arboreal PFT ratios start low in the early Holocene, reach a maximum in the mid-Holocene, and decline towards the present.
4. Calculations of the diversity of functional types present in the landscape show a steady increase in overall plant functional diversity, with a strong south-north gradient, with the north having lower functional diversity.
The biome reconstructions suggest that the late-Holocene decrease in prevalence of arboreal functional types and the increase in plant functional diversity was not driven by secular climate change. Human activities, including the spread of the Neolithic and the onset of the Iron Age, are concurrent with the changes we observe in the pollen record and could have been sufficiently persistent and widespread sources of disturbance to effect such changes in the European landscape. We conclude that the European "cultural" vegetated landscape dates to roughly the mid-Holocene, when human populations and activities became sufficiently intensive and prevalent to influence the vegetation in ways detectable at the continental, millennial, and plant functional type scales.

Poster

## Development and application of Australian lacustrine ostracod-based transfer functions

***Chris Gouramanis[1]***, Stuart Halse[2], Patrick De Deckker[3], Daniel Wilkins[4]

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Transfer functions are a commonly used technique for deciphering changes in palaeoenvironmental variables from fossil sequences. The technique is derived from the knowledge that an extant species is adapted to the characteristics of the environments in which it lives. Thus, finding this species within a fossil record implies that similar environmental conditions existed at this time. This can be further refined if a number of fossil species are present with known overlapping environmental tolerances. Environmental change can be deciphered from the fossil record where faunal variability is recorded.
Here we present the development and calibration of a salinity-based transfer function using extant ostracod species from athalassic waterbodies in Australia, and its application to a Holocene fossil ostracod sequence recovered from Rottnest Island, Western Australia.
Over 120 ostracod species and water chemistry data from over 1500 sites were collated from published and unpublished records from across Australia. The Non-metric Multidimensional Scaling (NMDS) technique was employed to examine the environmental variables of significance, and the principle axis of variation in Australian ostracod species distributions is salinity.
From this training dataset, we then applied the Modern

Analogue Technique (MAT) to a 7.4 ka fossil ostracod sequence from Barker Swamp on Rottnest Island, Western Australia. It is clear from the reconstruction that significant variations in salinity have occurred through time and that these variations coincide with other proxy records from the same swamp.

Poster

## Interglacial variability from the Middle Pleistocene up to the Holocene after molluscan assemblages and geochemical records from NW European tufa sequences

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Calcareous tufas provide rich and diversified malacological assemblages that witness forest development during full temperate climatic Quaternary episodes. Because mollusc identification reaches specific level, this group provides a mean to evaluate palaeobiodiversity evolution throughout Quaternary climatic cycles. However lithological homogeneity is important to preserve in order to avoid discrepancies linked to lateral variations, as distribution of molluscs is strongly dependant on local environments.
Recent investigations on calcareous tufas in Northern France have led to reconstruct forest recolonization after molluscan successions for several interglacial periods from the Middle Pleistocene up to the Holocene. Each temperate episode appears characterized by specific occurrences of land snails today extinct or out of their modern geographical range. Detailed Pleistocene malacological successions have been described from two thick tufa sequences respectively dated of MIS 11 and MIS 5e. On both sites occurrence of forest species are organised in successive "waves" related to species geographical ranges that give clues on refugia and patterns of biodiversity during Pleistocene times. Earliest forest species at the beginning of Interglacial periods are North and West European. Central and Eastern immigrants arrive just before and during interglacial optima while South European species are the last to reach the area during the warmest phase.
Comparisons of malacological successions from MIS 11, MIS 5e and MIS 1 interglacials provide means of climatic evolution for these different temperate episodes. They emphasize strong similarities between Pleistocene and Holocene malacological cycles suggesting close timings of vegetation recolonization. Tufa calcite $\delta^{18}O$ and $\delta^{13}C$ are known since the 80s to be important palaeoclimatic proxies for the Holocene and we recently have shown their suitability in Pleistocene deposits. Geochemical data have been compared with malacological record and exhibit good correlation of palaeoclimatic and palaeoenvironmental reconstructions.
In Western Europe numerous fossiliferous tufas dated from the second part of the Middle Pleistocene (MIS 11) up to the Holocene are known. Although all interglacial periods are not represented by a similar number of sites, available data appear consistent enough to offer a first attempt of comparison between forest communities and their evolution during different interglacial periods at a European scale. Data have been recovered from British Isles, Germany, Luxembourg and Northern France in similar morphostratigraphical conditions. Global number of species and evolution of shade loving land snails show a trend to a decrease diversity of forest habitats from the mid part of the Middle Pleistocene until now. Geographical distribution of species through time allows to distinguish two faunistic areas designated as the Eastern and the Atlantic domains. When compared independently malacological data of each domain produce similar results and emphasize a dramatic separation of Holocene sites from Pleistocene interglacial sequences. This strong difference in forest malacological assemblages appears independent from human impact and suggests a climatic origin to this discrepancy. This conclusion is strenghtened by geochemical data. The $\delta^{13}C$ values record climatic conditions significantly wetter during MIS 11 and MIS 5e optima compared to the Holocene warmest episode.

Poster

## Genetic differentiation in the Patagonian-fueguian rodents Abrothrix olivaceus and A. longipilis (Rodentia: Cricetidae) associated to the major Pleistocene-Holocene climatic changes: Using molecular data to the global changing assessment

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The biogeographic consequences of climate change have attracted considerable attention. Particularly, the "refugial debate" centers on the possible retraction of habitats to limited areas that might have functioned as refuges for many related species, especially during glaciations of the Quaternary. One prediction of such scenarios is that populations must have experienced substantial growth accompanying climatic amelioration and the occupation of newly expanded habitats. An increasing number of phylogeographical studies in Patagonia have laid a framework for testing hypotheses concerning the impact of shifting environmental conditions on changes in the distributional ranges of the species, particularly for small mammals. Many specialists' rodent species might allow us to know how the climatic changes have limited the contraction and expansion of their populations. Assessing the phylogeographic patterns on rodent's species, I show how the response to dramatic fluctuations in climate during the late Pleistocene-Holocene has direct implications for predicting the impact of current climate change. In order to overcome this goal I combined information derived from genetic markers and demographic studies of two species of sigmodontine Patagonian rodents, Abrothrix olivaceus and Abrothrix longipilis, which have highly extended distributional ranges into Patagonia. We used nuclear DNA sequence data of the entire intron-7 of β-fibrinogen (FGB-680bp), a

partial fragment of the intron-2 of alcohol dehydrogenase (ADH1-630bp), and the entire intron of T-Complex Protein (TCP10-800bp) of 130 individuals of each species from 15-20 different populations distributed across four Argentinean provinces and two Chilean regions in Patagonia. Our goal is to supplement inferences based on mtDNA to interpret the patterns of genetic structure of these species and understand the role of glacial cycles in shaping geographical genetic variation. Our main finding is that phylogeographic genetic subdivision in A. olivaceus is weaker than in A. longipilis, which shows a stronger phylogeographical signal, most probably in agreement with the hypothesis of differentiation in isolation during Pleistocene-Holocene climatic events. While A. longipilis seems to be at equilibrium between mutation and genetic drift, A. olivaceus seems to have suffered recent historical population range expansions. All intron data supported the idea of two sites as centers of population range expansions for A. olivaceus. On the other hand, A. longipilis showed distinctive ecological characteristics that appear to have limited reductions of their populations at glacial times, possibly because of its association with the Patagonian steppe (which may have expanded at glacial phases, as a result of changes in sea level). I address the value of linking population genetic inferences in these high-latitude rodent's species with the main climatic changes observed during the Pleistocene-Holocene in Patagonia.

Talk

## Using elevational gradients to discuss the origin of the highly biodiverse neotropical table mountains of northern South America

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Why endemic species occur where they do is still a matter of controversy and of global interest. What is widely accepted is that islands and mountaintops often contain a high concentration of endemic species. The Neotropical table mountains (tepuis) of the discontinuous biogeographic province of Pantepui (Venezuela) are not an exception, harbouring a unique and highly specialized variety of species. The origin of such high levels of biodiversity and endemism is still debated. Recent palaeoecological and phylogeographical data have challenged the vicariant Lost World Hypothesis which proposed an uninterrupted long-term isolation of species growing on the flat summits since the formation of the tepuis (Cretaceous: 80-100 Myr) as the most probable explanation for the high degree of endemism. In contrast, palaeocological results suggest an important role of the Pleistocene glacial cycles in shaping the current biodiversity pattern atop the tepuis. This implies a dynamic process of past isolation combined with intermittent mixing between highlands and lowlands species. Based on this framework, we have used elevation gradients to contribute to this debate. Our results show different elevation patterns between Single-tepui, Pantepui (regional) endemics, and non-endemics. We found that Pantepui endemics richness display a hump-shaped curve. Single-tepui endemics increase with elevation, whereas non-endemics decrease with elevation. Thus, these patterns suggest that isolation due to elevation alone is not likely to drive the elevation patterns described here. Conversely, it highlights that available area, mid domain effect, isolation and downward migrations due to Quaternary climatic changes together with habitat diversity have played an important role in shaping the current vegetation diversity and endemism atop the tepuis.

Poster

## Late Quaternary palaeoenvironments of the southern Cape, South Africa: Palynological evidence from three coastal wetlands

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Despite recent advances in palaeoenvironmental research in southern Africa, the late Quaternary palaeoenvironmental history of the region remains incomplete. The southern Cape is a key focus area within this region as it falls within the Fynbos Biome, a global biodiversity hotspot, encompassing a mosaic of afrotemperate forest, thicket and various fynbos communities and is therefore of great botanical importance. As this area includes the transition from southern Africa's winter rainfall zone to the year-round rainfall zone, it is also important from a palaeoclimatic perspective.
Palynological records have been generated from three sediment cores from wetlands along the southern Cape coast. The records from vleis at Pearly Beach and Rietvlei, near Still Bay, provide information from much of the last ~25 and ~33 cal kyr BP respectively. Assessed in conjunction with plant biomarker, sedimentological, geochemical and charcoal data, these pollen sequences indicate distinct changes in late Pleistocene and Holocene palaeoenvironments.
Further to the east is Vankervelsvlei, a small ombrotrophic depression near the town of Knysna. It is an example of a schwingmoor or floating bog, a geomorphological feature that is rarely found in the southern hemisphere. The site is situated in the year-round rainfall zone and is located at the ecotone between the Fynbos and Afrotemperate Forest biomes. An organic-rich sediment core has yielded a near-basal OSL age of c.120 ka. Despite the temporally discontinuous nature of this sequence, the pollen record exhibits marked changes in forest and fynbos taxa, with changes especially evident during the Last Interglacial.

This study provides important insights into the palaeoecology of lowland fynbos and reveals a uniquely extensive palynological record for the Knysna afrotemperate region.

Poster

## The response of planctic foraminifera to oceanic environmental changes during cenomanian-turonian transition of Karai Shale, Uttattur group, southern India

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The Cretaceous period is quite significant in the geological history of India as it heralded the marine transgression. The Cretaceous rapidly evolving planktons have been great stratigraphic value throughout the world. The present investigation deals with the response of Planktic foraminifera to oceanic environmental changes during Cenomanian-Turonian of the Karai – Kulakkalnattam Traverse, Uttattur Group, East coast of India. For this study one hundred ninety five sediment samples were systematically collected from the Karai-Kulakkanatham traverse. Eleven species of planktic foraminifera were identified and studied. The Middle Cenomanian to Early Turonian interval is traditionally characterized by four planktic foraminiferal biozones. These zones in the ascending order as follows: Thalmaninella reicheli Total Range Zone, Rotalipora cushmani Total Range Zone, Whiteinella archeocretacea Partial Range Zone, Helvetoglobotruncana helvetica Total Range Zone. These biozones have provided useful age control worldwide. They are based on the First Appearance Datum (FAD) and Last Appearance Datum (LAD) of marker species and their ranges.

Rotalipora cushmani zone is characterized by a stepwise extinction of major species such as Thalmaninella appenninica, Thalmaninella greenhornensis, Thalmaninella reicheli and Rotalipora cushmani. The results of our study confirm the Late Cenomanian Extinction Event is "Step wise" in the study area. The planktic foraminifera are abundant and diversified, especially keeled species appear with complex tests, such as Thalmaninella appnninica, Thalmaninella greenhorensis, Thalmaninella reicheli.

The globular morphotype Whiteinella spp. would indicate more or less oxygenated water mass near sea. Dicarinellids evolved and successfully adapted to the new conditions, and their competition probably hastened the demise of the rotaliporids.

H. helvetica appeared only when fully oligotropic and oxic conditions throughout the water column were restored. More oxygen in the sea – water column, linked to the transgressive pulse of Lower Turonian, lead to the restoration of bio-diversity with a re-development of new complex morphotypes of planktic foraminifera such as Marginotruncana and Helvetoglobtruncana helvetica. Eventually oxygenated environment were recovered from Helvetoglobtruncana helvetica zone mainly in shallow water.

They respond strongly to changes by species extinctions, evolutionary diversification, morphological adaptations, prolonged absence of species and changes in the relative abundance of species populations. However, this biotic turnover is not a major mass extinction as most species survived in refugia (is a location of an isolated of a once more wide spreads species) and returned when conditions improved.

Poster

## Marine and terrestrial response of the Black Sea/Northern Anatolia region to rapid climatic variability during the marine isotope stage 3

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Recent studies on SE Black Sea sediments demonstrate a powerful potential of these archives for palaeoenvironmental and palaeoclimatic reconstructions in Northern Anatolia and the Black Sea region during the last two interglacials and Terminations I and II. Here we present the first high-resolution pollen and dinoflagellate cysts (dinocyst) records from the SE Black Sea core 25-GC1, covering the marine isotope stage (MIS) 3. In comparison to oxygen isotopes and ice-rafted debris (IRD) records from the same archive provides a better understanding of the environmental dynamics in Northern Anatolia/Black Sea region. Age-control of the time series is based on radiocarbon and tephra dates with additional tuning of the proxy records to the GICC05 time scale of the North Greenland Ice Core Project oxygen isotopes.

During the MIS 3, general cold/arid conditions in Northern Anatolia are indicated by our pollen records. The pollen spectra are dominated by *Artemisia*, Chenopodiaceae and Poaceae, suggesting dominance of steppe vegetation in Northern Anatolia. Relatively low arboreal pollen percentages reveal arid conditions during this time, whilst stable occurrence of *Fagus, Carpinus betulus, Ostrya*-type, *Tilia, Corylus* etc. indicate the existence of small euxinian forest refugia on the adjacent land. In the Black Sea, dinocysts assemblages consist of two dominant species *Pyxidinopsis psilata* and *Spiniferites cruciformis*, indicating sea-surface salinity from 0 to 12. For SSS ~12 speak occasional appearance of *Lingulodinium machaerophorum* and *Operculodinium centrocarpum* during ~63-25 ka BP. However, stable increase in concentration of freshwater algae *Pediastrum* and Botryococcus indicates stable freshening of surface layer of the Black Sea from 63 ka towards 25 ka BP.

High-resolution records from 25-GC1 demonstrate unstable climate conditions during the MIS 3, characterized by general cool/arid conditions with several alternating warm and cold intervals. These oscillations, known as Dansgaard-Oeschger events (D/O), are clearly reflected by e.g. oxygen isotopes, dinocysts concentrations, pollen, and IRD. Warm D/O interstadials are indicated by high dinocyst concentrations revealing enhanced primary productivity in the Black Sea. Increases in pine and oak pollen percentages during the interstadials

suggest an increased temperature and/or precipitation on land. Interestingly, pollen of euxinian vegetation do not increase during the interstadials, what is likely explained by too cold and dry conditions and/or too short time for spreading of euxinian vegetation. D/O stadials are characterized by low dinocyst concentrations and high percentages of steppe pollen (Artemisia, Chenopodiaceae, Poaceae). Higher percentages of spores of mycorrhizal fungi Glomus also indicate increased soil erosion on land during these intervals. Extreme winter cooling during stadials is indicated by the high amount of IRD, transported by coastal ice to the core site. Based on our records from 25-GC1, impacts of Heinrich events in Northern Anatolia/Black Sea region were similar to those associated with other D/O stadials.
In general, multi-proxy analysis on core 25-GC1 demonstrate a high sensitivity and clear response of marine and terrestrial ecosystems of Northern Anatolia/ Black Sea region to abrupt climate changes in Northern hemisphere during MIS 3.

Poster

## Eastern Andean Patagonia (40°-51°S) vegetation and climate variability during the Holocene related to southern westerlies fluctuations and recent human interactions. Impacts on Patagonian forests and steppe plants communities

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The integration of eastern Andes Patagonian peat, lake and caves records offer the opportunity to get a better understanding of different plant communities' response to environmental challenges at different scales. The selected fossil records implied in this study are located between 40-43°S in western (NWP), central (NCP) and northeastern of Patagonia (NEP) and between 49°-51°S in western (SWP) and southcentral (SCP) of Patagonia. Since the early Holocene northern and southern records shows similar patterns, displacing forest and grass steppe communities eastwards and showing high fire activity. This vegetation shifts may have been forced by weaker westerlies allowing humid air masses to reach eastward. During the middle Holocene WNP registered short humid periods inferred by eastern expansion of the forest communities and low fire activity meanwhile in NCP and NEP xeric steppe communities dominate with low fire activity suggesting arid conditions by an intensification of westerly belt. This westerlies behavior is inferred in SWP by the development of dense forest and arid shrubs steppes and low fire activity. Between 3000-2000yrs BP, north and south steppe reconstructions suggest wetter conditions possibly associated to an equatorial displacement and weakening of the westerly belt. Since the 2000 to 500yrs BP there is a similar trend from wetter to arid conditions inferred by northern and southern steppe sequences. After the Medieval Climatic Anomaly (last 500yrs BP) the NEP shows palynological and charcoal evidences of wetter conditions than the previous period meanwhile the SWP presents short periods of wetter conditions inferred also by glaciological records. Patagonia steppe fire dynamic have been related with climate- shrub/grass abundance meanwhile forest fire dynamic and diversity have been link with climate- tree-shrub-grass abundance during the Holocene. Since the 1900s European settlement has modified forest and steppe ecosystems through fire setting and the introduction of exotic plant species and cattle.

Poster

## Late-Holocene climate and environmental history in the Lake Victoria basin: A sediment-based evidence from pollen, charcoal, $\delta^{13}C$ isotope, spores and blue-green algae

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The evidence of vegetation histories in the form of ecological and ecosystem responses to climate changes in the past, have been increasingly influenced by human activity during Late-Holocene period, and thus become increasingly difficult to isolate from anthropogenic signals in the sedimentary records. It becomes even more difficult if a single proxy is employed in such a reconstruction. We used evidence from pollen, charcoal, $\delta^{13}C$ isotope, spores and Pediastrum species from LVNG2 and KAG2 cores to trace Late-Holocene climate and environmental history in Lake Victoria basin. We investigated extent of vegetation changes and main drivers for the changes, climatic variations and link with palaeo-lake level dynamics. AMS $^{14}C$ dates provided chronological ages for the cores. Results provide a reconstructed historical perspective on Late-Holocene vegetation dynamics and climatic variability; and permit to trace, a semi-quantitative depth and/ or surface-area inference of palaeo-lake levels of the lake from ca. 4180 yr. BP to present only. Pollen and charcoal records infer mixture of both dry and humid climatic conditions between ca. 4186 ± 40 and 1830 ± 40 yr. BP. A closed vegetation cover was re-established in the lake's basin towards ca. 1320 ± 40 yr. BP and ca. 1247 to 190 ± 40 yr. BP, becoming more humid with dense forest cover at ca. 458 ± 40 yr. BP. However, from ca. 190 ± 40 to 70 ± 40 yr. BP, $\delta^{13}C$ values, indicate drastic vegetation changes, from a C3-type to a C4-type, presumably as a result of human-induced forest disturbance.

Poster

## Using the fossil record to reassess the functioning of the southern Levant as a biodiversity pool during European glaciations

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Refugia models suggest that relatively warm southern areas of Europe and the Mediterranean would have preserved biodiversity during cold and dry glacial periods and functioned as a reservoir for northern parts of the continent with more extreme glacial conditions. These models are typically based on data from DNA of modern plant and animal species and phylogeographic reconstructions. Data from the fossil record has rarely been used to test independently assumptions regarding the existence of specific refuge areas, however. The southern Levant in the eastern Mediterranean has been suggested as one of these refuge areas and is a modern biodiversity hotspot. Biodiversity has been identified as an important indicator of refugeal dynamics, although, it is unclear whether the implied biogeographic isolation associated with most refugia models ever existed in the southern Levant which was always a major biogeographic crossroad. There is some evidence which suggests that during the last glacial period in Oxygen Isotope Stage 4 (70-40 ka BP), for example, this region harbored species of small mammals as well as Neanderthal populations which previously had more northern limits of distribution. To assess the hypothesis that the southern Levant functioned as a refuge area similar to the peninsulas of southern Europe, we examine whether changes in taxonomic composition in the long and fairly detailed fossil record of the region were accompanied by significant changes in taxonomic diversity or rather remained stable in its biodiversity levels throughout long periods of time. We employ data from records of vegetation (pollen) and small and large mammalian remains covering the Middle-Upper Pleistocene and the Holocene periods. Our analysis looks at taxonomic richness through time and tests correlations with the record of global climate fluctuations. In addition, we also consider the impact of other factors related to the complex origins of Levantine biota including interactions with surrounding desert environments.

Poster

## Reviewing Late Quaternary Megafaunal Extinction: The case-study of Sri Lanka

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Late Quaternary megafaunal extinction, mostly of mammals, significantly reduced global biological diversity. Extinctions in some regions are well documented, and data are available for sufficient numbers of extinct species and living relatives to make comparisons. Two main theories for the cause of these extinctions are interaction of humans with megafauna, environmental/climate changes, or both. Salient data include biological characteristics of species, models of 'overkill', chronological comparisons, and so on.
The taxonomy of extinct Quaternary mammals and their present relatives has been described for the Indian subcontinent. But for Sri Lanka less is known. New palaeontological work needs to focus on glacial & interstadial fluctuations, and the significance of the Sri Lankan landmass as a Pleistocene habitat. Deraniyagala and others (1958) identified nineteen fossil mammalian species belonged to seven Orders and eleven Families from Sri Lanka, most probably belonging to the Quaternary period. Since then there has been no significant progress in the field, until a couple of recent initiatives.
The study considered body sizes of living and extinct Quaternary extinct species. Among the present mammalian species are identified: small-sized 62 (12 families), medium-sized 21 (10 families), large-sized 7 (6 families) and mega-sized 1 (1 family). This reflects the strongly decreasing number of species with increasing body size, but the number of families does not decreasing as much as number of species.
Quaternary species of Sri Lanka are mainly from two contexts: Ratnapura alluvial sediments, and cave/rock shelter excavations. They can be classified into a Pre-Mesolithic Pleistocene Fauna (PMPF), probably belonging to the Paleolithic culture (before 40,000 BP), and a Mesolithic Late-Pleistocene Fauna (MLPF) (after 40,000 BP). Most of the Quaternary megafauna belonging to PMPF are already extinct in Sri Lanka, especially three elephant species (phylogeny yet to be confirmed), two rhinoceros species, one hippopotamus and one lion/tiger species. Of this fauna only one species of elephant has been able to survive up to now (Elephas maximus maximus). The results show that more than 75% of the Quaternary megafauna of Sri Lanka is extinct. Environmental, climate change and catastrophic scenarios contributed to the megafaunal extinction, together with the possible impact of early man. The stratigraphy of finds, and stone tool technology, are included in the study.

## OSM12: Climate change: Physical forcings and biogeochemical feedbacks

Convenors: Jennifer Marlon, James Levine, Jérôme Chappellaz, Bärbel Hönisch

Poster

### A multiproxy examination of the toarcian oceanic anoxic event, Arroyo Lapa, (north and south) Neuquen Basin, Argentina

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The Toarcian, Early Jurassic, Oceanic Anoxic Event (T-OAE: ~183 Ma) was characterized by globally synchronous deposition of sediments rich in organic carbon (black shales), and is associated with an abrupt negative carbon isotope excursion, disrupting a positive carbon-isotope excursion during the tenuicostatum–serpentinum ammonite Zone boundary. These disturbances are recorded in bulk sedimentary organic matter, carbonate and fossil wood, the latter recording the isotopic composition of the atmosphere. The T-OAE has been extensively studied in Northern and Southern Europe and new studies from the southern hemisphere have provided chemostratigraphic evidence for the global imprint of the event. Here we present new geochemical data from the NeuquÉn Basin, Argentina: bulk-sediment $\delta^{13}C$ values fall to -32.5‰ and $\delta^{13}C$ values from fossil wood fall to -30.7 ‰, isotopic ratios that are comparable to those identified in Europe for the T-OAE. Hydrogen Index (HI) data for the T-OAE in Argentina give values ranging from 12 to 425 mg HC/ g TOC, indicating a mixture of terrestrial and marine organic components. Pristane/Phytane ratios and pyrite framboid distribution data indicative of anoxic conditions occur at some levels, and new $\delta^{98/95}Mo$ data, with values ranging from ~ -0.2 to 0.78 ‰, which contrast with previously published molybdenum-isotope values from T-OAE black shales of northern Europe.

Poster

### A multidisciplinary laboratory study using iron oxide 'markers' from modern drylands dust towards adapting this methodology for characterizing Quaternary dust, their source areas and transport paths

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We can better understand the effects of mineral dust on Quaternary atmospheres and ecosystems (both terrestrial and marine) by comprehending the compositions of contemporary mineral dusts associated with major dust-source areas in global drylands. Of special interest are the ferric oxide minerals that have extraordinary influence on the Earth System, disproportionate with their abundances of typically just a few weight per cent in common (but not all) desert dust. Properties of these oxide minerals have critical effect on radiative forcing of the atmosphere and snow cover, today as in the past. Moreover, solubility of ferric oxides in sea water is an important influence on modern marine productivity and similarly influenced past productivity.
Our approach uses modern dust-source sediments on the southern Colorado Plateau (USA) that lack significant concentrations of anthropogenic matter, as well as dust from these sources that is deposited on mountain snow cover about 200-500 km to the northeast. Accelerated melting of this snow cover, which is a critical source of water for the arid southwestern U.S., is strongly linked to radiative properties of the dust that diminish snow-cover albedo. To evaluate the mineralogic causes for dust-radiative properties, we have determined the types, amounts, and sizes of ferric oxide minerals in these sediments through the complementary methods of rock magnetism, Mössbauer spectroscopy, and reflectance spectroscopy. Outcomes from these approaches include the important, quantitative distinction between hematite and goethite, which have different optical properties. Dust-source sediments weathered from red, Paleozoic and early Mesozoic sedimentary rocks contain exclusively nano- and microcrystalline hematite, whereas sediments weathered from grey, Cretaceous sedimentary rocks contain exclusively goethite, at least some of it nanophase. In these samples, higher amounts of ferric oxide are associated with higher absorption of solar radiation determined from reflectance parameters. Commonly, dust from both kinds of sources mix during atmospheric transport, so that dust in snow cover typically contains both nanohematite and nanogoethite in amounts that vary, depending probably on source-area conditions and on wind direction during dust storms. Results from Mössbauer spectroscopy, combined with chemical analysis for total iron, measure the concentrations of both hematite and goethite in the same sample. The partition between hematite and goethite is important to know to improve models for the radiative effects of ferric oxide minerals in mineral dust aerosols. Our results are applicable to understanding the radiative influences of mineral dust on atmospheric dynamics today and in the past.

Talk

## The role of dust in glacial-interglacial cycles

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The interaction between dust and climate is far from being fully understood, with changes in climate affecting the amount of dust in the atmosphere, and conversely high concentrations of dust having potential climatic implications. Possible radiative and microphysical effects of atmospheric dust include: (1) the aerosol direct radiative effect (an increase in aerosol optical depth decreases the flux of solar radiation to the surface of the Earth), (2) the effect of contaminants on snow and ice albedo, and (3) the aerosol indirect and semi-direct effects on clouds, whereby aerosol particles change the reflection and absorption properties of clouds by altering their microphysical properties.
We investigate the possible climatic effects due to variations in dust flux during the last six glacial cycles (575–0 ka before present (BP)). While most past studies investigated the role of dust in equilibrium or in relatively short transient experiments, we conduct million-year simulations using a two-dimensional model.
We demonstrate that dust likely took part in shaping the structure of glacial cycles (emphasizing the temporal asymmetry of the glacial cycles) and in determining glacial–interglacial temperature differences. Moreover, by considering time-dependent dust load in our model varies the timing of the Last Glacial Maximum (LGM) by an order of a few ka.

Poster

## Synchronous variations in terrigenous flux to the Bay of Bengal and solar insolation: Implications to solar forcing on monsoon system

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The monsoon system of the Indian Ocean as a whole is one of the major atmospheric components of the tropical climate patterns where there are large seasonal variations with intensive rainfall during summer. The physical, biological and chemical environment of the Bay of Bengal is closely linked to the variation in the summer and winter monsoon systems of the Indian subcontinent. The monsoonal cycle dominates the fluvial runoff of one of the world's largest rivers systems viz. the Ganga and Brahmaputra system, which drains most of the Himalayas and the northern Indian subcontinent. Three major climatic excursions as recorded in the sediment cores from the Bay of Bengal suggests enhanced monsoon during MIS–3 (between 50 kyr and 30 kyr), a weakening of the monsoon around LGM (dated to 20 kyr) and a post glacial strengthening of the monsoon (after 20 kyr and 10 kyr). Within these periods, low frequency and low amplitude fluctuations have been recorded. It has been demonstrated that periods of winter rainfall are associated with low $^{87}Sr/^{86}Sr$ ratio and high $\varepsilon^{Nd}$ and vice versa. Synchronous variation in solar insolation, mean effectve moisture and $^{87Sr}/^{86}Sr$ in the core 4032 is noticed. The dry period corresponds to low $^{87}Sr/^{86}Sr$ is indicative of low detrital discharge from the G-B River system, which coincides with low solar insolation.
The Earth's climate system is highly sensitive to extremely weak perturbations in the Sun's energy output on the centennial to millennial time scales. The insolation forcing in the low latitudes directly controls atmospheric processes in the African, Indian and Asian Monsoon, responsible for huge amount of trans–equatorial water vapour and therefore latent heat transport. To ascertain the forcing factors responsible for the cyclic fluctuations in the lithogenic and biogenic proxies in sediment cores from the Bay of Bengal, spectral analysis was performed. The spectral analysis of the detrital, productivity and redox sensitive proxies shows dominant periodicities of 2.4, 2.7 and 3.7 kyr known to be of solar origin. The synchronous retrieval of various periodicities indicates solar forcing of climate and its variations in the Bay of Bengal with these cycles.

Poster

## Reconstruction of the Late Quaternary climatic change from glaciogenic varve deposits in Lahaul and Spiti, N-W Himalaya

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The study deals with the preliminary observations on the Late Quaternary deposits of Lahaul and Spiti, N-W Himalaya and their Palaeoclimatic significance. The study area centred on "77° 27' E; 32° 48' N" and located about 65 km from north-west of Manali. It is situated in a transition zone for influence of Indian Summer Monsoon (ISM) system. It receives 75% of the precipitation due to westerlies. Two laminated profiles have been studied from Yunam Basin, situated near Kilang Sarai and Bharatpur area. The Yunam Basin is laterally extended 11 km from Kilang Sarai to Bharatpur. The four levels of soft sedimentary structures are identified in Kilang Sarai profile which indicates the past tectonic effects. The present study summarize the late Quaternary climate change of the region based on multi-proxy analysis such as lithological details, $^{14}C$ chronology, $\delta^{13}C$, clay mineralogy, geochemical analysis, total organic carbon (TOC), loss on ignition (LOI), and mineral magnetism. The 8 meter thick Kilang Sarai profile ascertain the age of 25.3 ka BP by radiocarbon. The soft sediment deformation structures from four prominent horizons, approximately ca. 25.3-24.8 ka BP, ca. 20.8-19.5 ka BP, ca. 18.0-17.5 Ka BP, and ca. 12.5-12.0 ka BP have evident in the Yunam Basin. The present study documents few abrupt climatic events, such as Older Dryas, Younger Dryas, and cooling event 8.2 ka.

Poster

## Precession forcing of fire activity in subtropical southern Africa over the past 170,000 years

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Subtropical southern Africa is dominated today by grass fires that are controlled by marked rainfall seasonality. This seasonality consists of wet austral summers during which fuel accumulates, and dry winters that increase fuel flammability. Under global warming scenarios, fire is projected to intensify in this region due to an increase in temperature and winter dryness. However, the strong dependence of fire on fuel build-up, and thus precipitation, greatly increases the uncertainty of such projections. To address the question of whether fire increases in the subtropics of southern Africa during periods of global warming, a continuous record of biomass burning covering several past warm periods is needed from the region. Here, we show that precession-driven rainfall seasonality is likely the main driver of fire activity over the last two climatic cycles in southern Africa. Our results are based on a reconstruction of biomass burning changes from a marine sediment core off Namibia between 170,000-30,000 years ago. During periods of precession maxima and high northern-hemisphere ice volume, fire activity increased in southern Africa. This pattern is attributed to an increase in summer rainfall and fuel accumulation led by a shift of the Intertropical Convergence Zone poleward. If correct, a decline in wildfires over the forthcoming millennia would be expected, owing to the ongoing decrease in the precession index and resulting increase in summer dryness. In addition to the natural trend, human-induced landscape fragmentation would accelerate fire reduction.

Poster

## Holocene carbon fluxes in the tropical peatlands of Southeast Asia: The contrasting roles of changing sea-level and climate

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Tropical wetlands play a significant role in the global carbon cycle because they are believed to represent one of the largest natural sources of atmospheric methane. Tropical wetlands also comprise an important terrestrial carbon reservoir sequestering a large mass of atmospheric carbon dioxide in their organic soils. Changes in the extent of these wetlands have been invoked to explain Pleistocene and Holocene fluctuations in atmospheric $CH_4$ and $CO_2$ concentrations. However, the timing of tropical wetland initiation and its spatial expansion during the Late Quaternary have not been quantified based on stratigraphic evidence. Here we provide the first estimates of the Holocene spatio-temporal expansion of peatlands in Southeast Asia – one of the largest tropical wetland regions – using new and available radiocarbon-dated peat profiles. We also establish the temporal sequence of peatland initiation for Peninsular Malaysia, Sumatra and Borneo based on a collation of basal dates including newly dated cores from our field site in Borneo. In addition, we reconstruct Holocene rates of carbon sequestration and methane fluxes for this region. After deglaciation, the first peatlands of Southeast Asia formed in southern Borneo driven by the intensification of the Asian monsoon and by rapid flooding of the Sunda Shelf. However, this peatland region was too small to explain the abrupt increase of atmospheric $CH_4$ that occurred at the onset of the Holocene. Other tropical wetland sources most likely in northern Africa and continental southern Asia likely contributed to this rise in $CH_4$. The slower rate of sea-level rise after 8000 BP appears to have driven the formation of peatlands in the coastal areas of maritime Southeast Asia. The maximum rate of peatland initiation in Southeast Asia occurred between 6000 and 5000 BP when sea-level on the Sunda Shelf reached its Holocene highstand and Borneo experienced its wettest climatic phase. Significantly, this peak in peatland formation occurred nearly synchronously with the Holocene minimum in atmospheric $CH_4$ concentrations, implying that Southeast Asian peatlands were not an important $CH_4$ source at this time. Falling sea-levels after 5000 BP allowed for constant spread of coastal peatlands onto newly exposed land. These peatlands show the highest long-term rates of carbon accumulation of over 70 g C $m^2$ $yr^{-1}$. Over 15 million ha of peatland formed in Peninsular Malaysia, Sumatra and Borneo over the Holocene and peat carbon sequestration of this region approached ca. 9 Tg C $yr^{-1}$ by ~1000 BP. However, higher El Niño frequency and intensity during the past 4000 years substantially affected the peatlands of southern Borneo, which largely stopped sequestering carbon in response to higher drought stress. The areal expansion of peatlands during the Late Holocene contributed to the observed constant increase in atmospheric $CH_4$ concentrations over the last 3000 years, but was too small to account for the overall rise of ca. 100 ppbv $CH_4$ from Mid-Holocene to pre-industrial concentrations. Therefore, sea-level changes evidently exert greater control on changes in $CH_4$ emissions from Southeast Asian peatlands than does the often-inferred changes in precipitation related to Holocene shifts in the mean position of the Intertropical Convergence Zone.

Poster

## Biogeochemical constraints from carbon monoxide measured in firn air and ice cores

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Carbon monoxide (CO) is the main sink for hydroxyl radicals (OH) in the troposphere. Consequently, changes in atmospheric levels of CO can considerably perturb the oxidizing capacity of the atmosphere, and affect mixing ratios of a host of constituents that are oxidized by OH, including methane. In addition natural CO variations (and changes in its stable isotopic composition) are expected to be a good tracer of changes in biomass burning emissions. Investigation of the past mixing ratios of carbon monoxide is thus a promising approach to reduce uncertainty related to the past oxidative capacity of the atmosphere and the past biogeochemical cycle of methane. However, since the 1990s only few CO records have been obtained from ice cores through discrete sampling analysis. These data are not sufficient for a quantitative understanding of the past evolution of atmospheric CO above Antarctica and Greenland, notably due to the existence of artifacts in Greenland ice.
New methods are required to reconstruct from ice cores with unsurpassed accuracy and resolution CO mixing ratios during the past. Such new method has recently provided the combined history of CO and its stable isotopic ratios during the last 650 years over Antarctica, and during the last 60 years from Greenland firn air. Recent developments in optical spectrometry (Optical Feedback Cavity Enhanced Absorption Spectrometry, OFCEAS) allow us now to measure CO concentrations directly on the drill site or in the laboratory when combined with continuous flow analysis (CFA) systems. Coupling of our OFCEAS spectrometer with the CFA melter operated at DRI (Reno, USA) provided the first continuous CO measurements along the NEEM (Greenland) core covering the last 2000 years with an unprecedented resolution. The same spectrometer was also deployed on the blue ice field of Taylor Glacier (Antarctica, austral summer 2011) to evaluate if an atmospheric record of CO was preserved at this site where horizontal ice coring can provide tons of ice –including from the last deglaciation.

Talk

## New $CO_2$ and $\delta^{13}CO_2$ ice core records on carbon cycle changes during the last glacial cycle

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Latest improvements in high-precision and high-resolution $CO_2$ ice core records and its carbon isotopic signature allow for new insights into past carbon cycle changes. Our new $\delta^{13}CO_2$ records from the EPICA Dome C and Talos Dome ice cores over the last and penultimate transition point to the same processes being responsible for the observed 100 ppmv increase in $CO_2$ during both deglaciations. However, the contribution of individual carbon cycle processes to the overall change and their phasing may be different.
The major player appears to be the upwelling of old, carbon enriched water in the Southern Ocean which leads to a depletion in atmospheric $\delta^{13}CO_2$ early during the deglaciation, although the imprint of such a well defined old water mass has been elusive in marine records. Also a decrease in iron fertilization concurrent with the decrease in mineral dust deposition in the Southern Ocean region may contribute to the early depletion but according to models is quantitatively only of secondary importance. Later during the transition, the growth of the terrestrial biosphere and the consecutive carbonate compensation effect control the $\delta^{13}CO_2$ and $CO_2$ evolution into and during the subsequent interglacials. The end of the penultimate interglacial is characterized by a cooling likely accompanied by a release of isotopically light terrestrial carbon into the ocean/atmosphere system, which may explain the enigmatic lag of the $CO_2$ decline to Antarctic temperature by a few thousand years.
A strong effect of different ocean hydrography and modes of the Atlantic Meridional Overturning Circulation (AMOC) is also evidenced in high-resolution $CO_2$ records from the Talos Dome and EPICA Dronning Maud Land ice cores during MIS3 and 5. The interglacial overturning mode in the Atlantic leads to overall about 30 ppmv higher $CO_2$ concentrations during MIS5.1-5.4 compared to MIS3. Moreover, during the mode switches of the AMOC connected to Dansgaard Oeschger events, also the carbon storage in the deep ocean is altered leading to millennial $CO_2$ changes in parallel to the Antarctic Isotope Maxima. Our high resolution $CO_2$ measurements over these events show that $CO_2$ concentrations peak several centuries after the onset of a Dansgaard Oeschger event during MIS3, while they are essentially synchronous in MIS 5. We attribute this to the upwelling of old, carbon enriched water from the deep Atlantic during MIS3, which is absent during MIS5.

Talk

## Were glacial-interglacial changes in the biological pump driven primarily by the marine ecosystem response to ocean temperature and iron fertilization?

***Eric Galbraith***[1]

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Changes in ocean circulation have widely been invoked as the cause of the strengthening and weakening of the ocean's biological pump over glacial cycles of the

Quaternary. I will discuss an alternative hypothesis, according to which changes in circulation played a negligible role. According to this view, the effects of temperature and iron supply on the marine ecosystem dominated at the glacial-interglacial timescale, while the effect of changes in ocean circulation is relegated to millennial variability of the biological pump, superimposed on the larger glacial-interglacial cycles. These arguments are motivated by a new statistical analysis of globally-distributed proxy records for the marine nitrogen and oxygen cycles over the last deglaciation, that show a clear partitioning between the glacial-interglacial change and the millennial-timescale changes. New simulations with an ocean-ecosystem model will also be presented, illustrating that iron fertilization and temperature-dependent remineralization may have been sufficient to explain both the oxygen and nitrogen observations, as well as the changes in ocean carbon storage required to explain the glacial-interglacial variations. This suggestion will be compared with carbon isotopic evidence that has often been interpreted as indicating glacial-interglacial changes in ocean circulation.

Poster

## The lightning-biota climatic feedback

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We investigate the "lightning–biota climatic feedback" which involves an increase in deposition of lightning-produced nitrogen compounds into ecosystems as a response to a global temperature rise. This increases primary production on both land and ocean, which reduces atmospheric carbon dioxide ($CO_2$), and consequently global temperature in return. Large uncertainties in numerous processes and parameters in this feedback exist and therefore its importance is unclear. This feedback is investigated using a conceptual dynamical model, including assessing its role in counteracting anthropogenic-induced warming by reducing the rate of accumulation and concentration of atmospheric $CO_2$. Overall, our study suggests that this feedback is of mild strength in the climate system, but raises the intriguing possibility that it should be considered in long-term climate simulations.

Talk

## High resolution characterization of the Indian monsoon over the last glacial period from Bitoo Cave, northern India

***Gayatri Kathayat***[1], Hai Cheng[2], Ashish Sinha[3], R. L. Edwards[2]

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The Indian summer monsoon (ISM) is one of largest components of the global climate system, transporting large amounts of moisture and heat northward across the Indian Ocean into India, southeastern China, and as far as northeastern China and Japan. Thus far, the longer-term climate history of the ISM has been primarily inferred from either coarsely resolved Arabian Sea sediments or from speleothem records from marginal locations in Arabian Peninsula. Here we present new high-resolution and absolute-dated $d^{18}O$ records from Bitoo Cave (30047'25"N, 77076'35"E, and ca. 3000 msl) that characterize the detail monsoon variability during the last glacial period. The Bitto cave is located on the southern slope of northwestern Himalayas with about 80 % of annual precipitation falling between June and September. Several lines of evidences, including modern observation and model simulation, show that the $d^{18}O$ of precipitation in this region is primarily inversely correlated with the overall ISM intensity.
The Bitoo Cave $d^{18}O$ records are characterized by large amplitude fluctuations over the last glacial period on both orbital (~ 80) and millennial timescales (~ 2-30). The orbital variation broadly tracks Northern Hemisphere (NH) summer insolation without notable temporal lags, consistent with the East Asian monsoon (EAM) variability as documented from Chinese speleothem records. This observation strongly supports the notion that on orbital time scale, changes in ISM and EAM are predominantly driven by NH summer insolation. In particular, the Bitoo Cave record provides evidence for a relatively strong ISM period between 60 and 30 ka ago (MIS 3) - a time of larger global ice volume. This scenario is also consistent with the stronger EAM during this period as inferred from Hulu and Dongge cave records from China and with a number of simulation studies that indicate that increased summer solar radiation appears to be most effective in strengthening monsoons. Superimposed on the orbital scale variability, the Bitto speleothem records are also characterized by a series of millennial-length events that can be one-to-one correlated within age uncertainties to Greenland Interstadials 1 to 25 (or Chinese Interstadials A.1 to A.25) and Heinrich events 1 to 6, thus demonstrating a strong link between NH high latitude climate and low latitude monsoonal climate. A detailed comparison of the Bitoo records with Southern Hemisphere high-latitude temperature changes, documented by both sea surface temperature (SST) and Antarctic ice core records, does not appear to confirm a dominant role of Southern Hemisphere impact on the ISM through the increased cross-equatorial pressure gradient.

Poster

## Effect of climate change on agriculture and health in India

***Rabindra Kumar***[1], J. Nagendra Babu[2]

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The climate of India defies easy generalization, comprising a wide range of weather conditions across a large geographic scale and varied topography. Analyzed according to the Koppen system, India hosts six major climatic subtypes, ranging from desert in the west, to alpine tundra and glaciers in the north, to humid tropical regions supporting rain forests in the southwest and the island territories. Observations over India show that the mean annual surface air temperature has increased by 0.4-0.6°C in the last 100 years. Variation in season effected by national climate processes and phenomena such as EL-Nino / Southern Oscillations as well as to the effects of a warming climate that has a significant anthropogenic component, results in many weather and climate related disaster each year. Three main 'categories' of impacts are those on agriculture, sea level rise leading to submergence of coastal areas, as well as increased frequency of extreme events. Each of these is pose serious threats to India. From India's point of view, a 2°C increase would be clearly intolerable. Other developing countries may be even more vulnerable (possibly Bangladesh or Small Island States). Climate change impacts increased risk of elevated water tables, higher relative humidity, flooding and prolonged periods of rainfall. Flooding increases risks from pests e.g. rats and biting insects, problems of refuse storage. Climate change has also effect food system and the food have to adverse impact on human health by production of vegetables, fruits, and other grains which utilized by the human beings. Increasing temperatures combine with air pollution to increase ground level ozone, causing morbidity from respiratory disease. India will have to invest in future heavily in science and technology to reduce or minimize the threat or effect of climate change on agriculture and health for betterment of not only human beings also for living beings.

Poster

## Seasonal variability of atmospheric aerosol over the North Indian region during 2010

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The Indo-Gangetic basin (IGB) extends 2000 km in length along NW–SE and has 400 km width, in the north the basin is bounded by towering Himalaya. High aerosol optical depth (AOD) is observed over the IGB throughout the year. The Himalaya restricts the transport of aerosols across Tibet and China. We have used ground based Kanpur Aerosol Robotic Network (AERONET) stations and Multiangle Imaging SpectroRadiometer (MISR) and Moderate Resolution Imaging Spectroradiometer (MODIS) Terra level-3 AOD products for the year 2010 to study the variability of aerosol over the Indo-Gangetic (IG) plains. An increase in both satellite-derived as well as ground observed aerosol loading during 2010 has been found over major city located in the IG plain. The correlation analysis between AERONET - MISR and AERONET - MODIS has been done. The AOD estimation using MISR is found to be close to AERONET data during summer and monsoon seasons, in contrast MODIS estimation is better during winter season.

Poster

## Plio-Pleistocene evolution of nutrient cycling in the Benguela upwelling system: A chlorin-specific $\delta^{15}N$ approach

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The Plio-Pleistocene climate evolution was marked by a transition from stable and warm conditions during the Pliocene toward colder conditions associated with the onset of pronounced glacial-interglacial cycles. In the Benguela Upwelling System (BUS), the onset of the Plio-Pleistocene cooling co-occurred with extremely high accumulation rates of diatoms and biogenic opal, indicative of very high primary productivity during this time interval. As bulk $\delta^{15}N$ values were relatively low, ranging from 1 to 3‰ at this time, it is difficult to fully understand pathways of nutrient supply to sustain such high productivity. In order to better assess the BUS nitrogen cycling, we measured the $\delta^{15}N$ on chlorins that we compared with the sedimentary $\delta^{15}N$.
We have purified a suite of chlorophyl-derived chlorins (phaeophytin a , pyrophaeophytin a, sterylchlorin esters, and chlorophyllone a) extracted from ODP Site 1082 (northern BUS) by HPLC and measured their $\delta^{15}N$ with an ultra-sensitive elemental analyzer/isotope ratio mass spectrometer. We find that chlorin-specific $\delta^{15}N$ are depleted by ~2 to 5‰ as compared to the bulk $\delta^{15}N$ values, reflecting the effect of the isotopic fractionation occurring during biosynthetic partitioning of nitrogen within microalgae. This difference in $\delta^{15}N$ values between chlorins and bulk sediment however tends to decrease with age, indicating that other processes than nutrient cycling within the water column and/or sediment may have modified the isotopic signature of bulk sediment and/or of chlorins. We also detect more variability in chlorin $\delta^{15}N$ as compared to the $\delta^{15}N$ measured on bulk sediment, as already reported from other environmental settings. Overall, the chlorin-specific $\delta^{15}N$ values suggest little or no long-term changes in $\delta^{15}N$ associated with the Plio-Pleistocene climate transition.
It has been demonstrated that within particular sedimentary environments associated with high organic matter content such as in sapropel layers and black shales deposited during Oceanic Anoxic Events the bulk $\delta^{15}N$ signal can be significantly altered or hampered by diagenetic or heterotrophic processes. Therefore, if only the chlorin $\delta^{15}N$ is considered, it suggests that the mode of nutrient cycling in the BUS has experienced only little changes at the million-year timescale. Overall, the chlorin $\delta^{15}N$ values of ~0.5‰ (+/- 1.5‰) lead us to estimate an isotopic composition of the marine phytoplankton of ~6‰ if the isotopic integrity of the chlorin $\delta^{15}N$ remained unchanged over the last 3.5 Ma. Implications on the BUS

nutrient cycling through the Pliocene-Pleistocene time interval will be discussed.

Poster

## Effects of Large Volcanic Eruptions on Global Summer Climate and East Asian Monsoon Changes during the Last Millennium: Analysis of MPI-ESM simulations

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Responses of summer temperature and precipitation to large volcanic eruptions are analyzed by using the millennial simulations with the Earth system model developed at Max Planck Institute for Meteorology. The model was driven by up-to-date reconstructions of external forcing including the nature (solar and volcanic forcing) and anthropogenic forcing (land-cover change, greenhouse gases). Cool anomalies after the large volcanic eruptions are seen nearly in global scale. The cooling in the northern hemisphere is stronger than that in the southern hemisphere and is stronger over the continent region than that over the ocean. The precipitation generally decreases in the tropical and subtropical regions in the first summer after the large volcanic eruptions. The cooling with amplitudes up to -0.4°C is also seen over China. The East Asian continent is dominated by northerly wind anomalies and the corresponding summer rainfall exhibits a coherent reduction over the entire East China. The tropospheric mean temperature anomalies indicate that there is a coherent cooling over East Asian continent and the tropical ocean after the large volcanic eruptions. The cooling over the middle-high latitudes of the East Asian continent is stronger than that over the tropical ocean. This temperature anomaly pattern suggests a reduced land-sea thermal contrast and favors a weaker East Asian summer monsoon circulation. The analysis of the radiative fluxes at the top of the atmosphere (TOA) suggests that the reductions in the shortwave radiation after the large volcanic eruptions are nearly twice as large as the reduction in emitted longwave radiation, a net loss of radiative energy that cools the surface and lower troposphere.

Poster

## Tracking carbon dynamics and climate forcing through Holocene peatland development by combining palaeoecological information and modern carbon flux measurements

***Paul Mathijssen***[1], Minna Väliranta[1], Eerika Niemelä[1], Annalea Lohila[2], Juha-Pekka Tuovinen[2]

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High latitude peatlands act as a huge reservoir of carbon, containing ca. 475 Pg of organic carbon. Pristine mires are generally regarded as long-term sinks for atmospheric carbon, because of the slow decomposition rate of organic matter under water-logged conditions. However, due to anaerobic decomposition processes, these ecosystems release methane ($CH_4$) to the atmosphere. Seen over a 100-year period, $CH_4$ has an atmospheric warming effect 25 times larger than that of carbon dioxide ($CO_2$). In order to better understand the role of northern mires in future global carbon budget, it is important to understand past mechanisms: how different types of mires have responded to climate changes before. Predictive models need profound background data and relevant parameters. In terms of modeling the climate-biosphere interactions, peatlands have proved to be a complicated environment where autogenic and allogenic forcing factors operate in tandem. Palaeoecological approach may provide means to understand past, present and future peatland dynamics and subsequent changes in carbon accumulation and emission patterns. In this project, by taking into account vertical and horizontal growth patterns, we establish robust three-dimensional chronologies for four peatlands in Finland to quantify carbon accumulations. Our ultimate aim is to produce Holocene-scale radiative forcing reconstructions by using the established relationships between the wetland type, vegetation composition and greenhouse gas fluxes and an existing radiative forcing model.
The first radiative forcing reconstruction experiment performed in a northern Finnish aapa mire showed that ca. 2000 years after the mire initiation the radiative forcing pattern changed from positive to negative. The result suggests that despite relatively high methane emissions minerotrophic fens can act as a climate cooling agent if the examination time-window covers the whole Holocene.

Poster

## The late Pleistocene-Holocene climatic transition record in the alluvial sequences of central Argentina (33-38°S)

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Alluvial records of central Argentina (33-38°S) have been the focus of detailed sedimentological, stratigraphical and geochronological studies along a west-east climatic transect encompassing the Andean piedmont, the central Pampas and the eastern Pampas of Buenos Aires province, from arid (200 mm/yr mean annual rainfall) to humid (900 mm/yr mean annual rainfall) dominant climatic conditions. The results obtained permitted to infer paleoenvironmental conditions during the late Pleistocene -Holocene climatic transition.
At the Andean piedmont between 33-34ºS, located in the South American Arid Diagonal, the Late Pleistocene -Holocene alluvial record is composed of sandy and silty deposits accumulated by braided streams in alluvial

fan environments punctuated by episodes of volcanic eruptions and the formation of limnic levels. Aeolian process dominated the piedmont during the Last Glacial Maximum and the Late Glacial contributing with fine sediments. A soil stability interval followed documented by a conspicuous paleosoil (12-10 cal yrs BP) developed in a floodplain environment. The early Holocene alluvial deposits record a higher frequency of flooding events and the development of relative more abundant limnic levels reflecting higher organic production in the alluvial environments or higher organic matter inputs to them. The late Pleistocene -Holocene transition in the central Pampas and the eastern Pampas of Buenos Aries province is also recorded by sandy silt fluvial facies with paleosoil developed on top. In the central Pampas this paleosoil was dated in 11.601-12249 and 11.592-12.400 cal yrs BP. Paludal-like aggradation dominated during the early Holocene.
Although analyzed alluvial sequences are located in a west-east climatic transect, they show a quasi synchronic behavior during the late Pleistocene -Holocene climatic transition. Paleosoil development indicates a climatic amelioration after arid-cold Late Glacial Maximum and Late Glacial conditions; in turns early Holocene records greater vegetation productivity in the fluvial basins. The conditions reflected across the west-east transect during the early Holocene -Andean piedmont more frequent flooding events and paludal-like environments of the Pampas- might have been linked with summer rains influenced by the South Atlantic anticyclonic center favoured by a southward displacement of the South Pacific anticyclonic center as it has been suggested by many authors.

Poster

## Variations in planktonic foraminifera shell calcification in the eastern Arabian Sea during the Holocene

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One third of the excess atmospheric $CO_2$ is absorbed by the ocean and causes an increase in $[H^+]$ which leads to a lowered pH, and a decrease in $CO_3^=$. The surface water $CO_3^=$ decrease leads to a reduction in shell calcification and in turn surface water $CO_3^=$ has been estimated by using shell weights of planktonic foraminifera. A few studies also opined that shell calcification depends on various other environmental conditions and that, factors controlling shell calcification may vary from species to species as well as depend on the environments wherein they grow.
The eastern Arabian Sea is devoid of seasonal upwelling unlike the western Arabian Sea. Therefore we can expect that this region is in equilibrium with the atmospheric $CO_2$. The study utilizes a sediment core (AAS 9/19) recovered from eastern Arabian Sea (off Goa: 14° 30.115'N; 73° 08.515'E). The core was recovered from the Oxygen Minimum Zone (OMZ) at a water depth of 367 mts. The core is dated to 12.5 Cal Kyrs BP. We use the shell weights of two planktonic foraminifera species *G. ruber* and *G. bulloides* to understand whether shell calcification is controlled by $CO_3^=$ and hence atmospheric $CO_2$.
The shell weights of *G. ruber* and *G. bulloides* are seen to decrease from 12.5 kyrs to present. *G. ruber* shell weights varied from 13.5 μg to 19.5 μg and maximum shell weights of 19.55 μg were observed at 12.35 kyrs. The shell weights of *G.bulloides* varied from 9.7 μg to 18 μg. The maximum shell weight of *G.bulloides* was noted to be 18 μg, which correspond to an age of 12.15 kyrs. The average shell weights of G.bulloides and G.ruber are 13.9μg and 15.8μg respectively. In terms of shell calcification, the two species in the present study behave in an almost similar manner for the past 12.5 kyrs suggesting common controlling factors. We have compared atmospheric $CO_2$ obtained from the Taylor Dome ice core, with shell weights of *G. ruber* and *G. bulloides*. The $CO_2$ measured from the Taylor Dome core shows an increase from the beginning of the Holocene to present and the variations are within the range of 251 to 281 ppmv for the past 12.5 kyrs. The comparison between shell weights and atmospheric $CO_2$data shows a strikingly similar trend. The minimum in atmospheric $CO_2$ seen at around 12 to 12.5 kyr is also well recorded in the shell weight data where highest shell weights were recorded. Further, for a change of 30 ppmv in atmospheric $CO_2$ during the course of Holocene there is a change of 6μg in shell weights of G. ruber and 8μg in shell weights of *G. bulloides*. Though many other factors as mentioned above could influence shell calcification the present study shows that there is a possible control of atmospheric $CO_2$ over it in the eastern Arabian Sea.

Poster

## Diatom based sea-ice reconstruction over the past 95,000 years in the Indian Ocean sector of Southern Ocean

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A detailed investigation of the marine core SK 200/22a was undertaken to display the migration of Antarctic sea-ice extent in the Indian sector of Southern Ocean over the past 95,000 years. The core retrieved from sea-ice free zone near the Sub-Antarctic front (SAF) region of the Indian Ocean sector of Southern Ocean revealed ≥ 3% of the seasonal winter sea-ice indicator Fragilariopsis curta in the fossilized diatom assemblages. Additionally, the Eucampia Index showed similar temporal variations in the winter sea-ice extent. The temporal distribution of these sea-ice proxies at the core site indicate that the equatorward extent of Antarctic winter sea-ice significantly enhanced during the marine isotopic stages (MIS) 2, MIS4 as well as the late MIS 3. Comparison with the ice rafted debris (IRD) record reveals that the major IRD events within the MIS 2 and MIS4 significantly lagged the seasonal winter sea ice extent, with enhanced ice rafting occurring at the terminations of sea- ice extent. Our

study suggests that during glacial intervals, the Antarctic winter sea-ice was extended till the present sea-ice free SAF zone of the Indian sector of Southern Ocean, and subsequently retreated with the onset of inter-glacial period. The observed lag between the sea ice extent and IRD events at the core site also support that while the IRD records were dominantly controlled by the ice sheet dynamics and ocean currents, the deglacial sea surface warming seems to have influenced the equatorward extent of seasonal sea-ice.

Poster

## High-resolution multi-proxy climatic reconstruction off Myanmar suggestive of climatic modulations due to solar forcing during the past ~489 years

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A 1.78 m long sediment core was obtained at 37 m water depth on the Ayeyarwaddy Delta front, off Myanmar during the Indo-Myanmar Joint Oceanographic studies in the year 2002. The data set generated offers a resolution of ~4 years since 1513 to 1676 AD and since then ~8 years resolution unto Present. Detailed foraminiferal investigations were carried out on this core. The abundance as well as reproductive behaviour of a particular benthic foraminiferal species, Asterorotalia trispinosa indicate two significant climatic conditions in the study area since 1513 AD; a dry climate prior to 1650 AD and warm and wet climate since 1650 to present. Since 1650, 3 major freshwater pulses are recorded in the core at 1675, 1750 and 1850 AD. The oxygen isotopic ratios, Mg/Ca and Sr/Ca values as well as the pteropod and testate amoeba abundances also support these inferences. Major freshwater pulses reflected within the core at ~1675, 1765 and 1850 AD occur at an interval of 90 and 85 years respectively. However, the data set also shows several smaller fluctuations, especially in the older part of the core. The downcore data for Mean Proloculus Size (MPS) indicative of the sensitive reproductive behaviour in foraminifera was analyzed to identify cyclicity in events using the software Redfit 3.8. The MPS data revealed a ~93-year clyclicity at a 90% level of reliability. 90-year cycles are well within the purview of the Gleissberg Cycle. Variations in the radius of the sun are believed to modulate these cycles at a periodicity of 80 (±10) years vis. the 'Gleissberg Cycle'. Thus, the events seen in the core could be suggestive of solar forcing. Such 90-year cyclicities have been well documented in high-resolution climatic records, especially in those representing the past 500 years.

The records in the core under study seem to account for the period of cooling called the Little Ice Age i.e. ~16th to the mid 19th century. It is worth exploring if this phenomenon affected the present study area in any way. Though there is no agreed consensus on an agreed date of its beginning, it is believed that it ended at ~1850 AD after which warming began. It is also agreed that there were three sunspot minima beginning at ~1650, 1770 and 1850 AD, each separated by slight warming intervals. The three fresh water pulses recorded at ~1675, 1765 and 1950 AD in the current data set data collected on the shelf off Myanmar seem to be in response to warming events associated with the Little Ice Age.

There is much speculation over the causes of the significant climatic fluctuations within the past 500 years (increased volcanic activity, sunspot activity, ENSO and change in ocean circulation patterns, etc). Researchers trying to understand the climate dynamics within this period stress upon the need for reporting high resolution and calibrated proxy records from different parts of the globe. The present work is an attempt to report such data and comparable global phenomena and ascertain the causes of these high amplitude climatic events reported here.

Talk

## Silicon and carbon isotope reconstructions of Holocene productivity of the sea ice zone of the Southern Ocean (east Antarctica)

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High latitudes are particularly interesting locations to study climate variability, as changes are amplified compared to low latitude environments. This is very much the case for east Antarctica, highlighting its potential for reconstructing Holocene environmental change. Coastal and continental shelf zones are among the most productive ecological provinces of the Southern Ocean and account for c. 76% and 3.5% of the total primary productivity of the marginal ice zone and southern ocean respectively . Diatoms account for a large proportion of primary productivity in these regions, therefore dominating the biogeochemical cycling of silicon, strongly influencing the biogeochemical cycles of other macro-nutrients (e.g. nitrogen and phosphorous). The information provided by stable isotope analyses of biogenic silica (e.g. $\delta^{30}Si_{diat}$ and $\delta^{13}C_{diat}$) on nutrient utilisation and export production provides an important link in understanding the role of the siliceous biological pump in transferring carbon into the deep ocean and regulating atmospheric concentrations of $CO_2$ over glacial-interglacial cycles.

Piston core MD03-2601 was recovered in 2003 off the coast of Adélie Land, east Antarctica (66°03.07'S, 138°33.43'E, 746 m water depth). $\delta^{30}Si_{diat}$ and $\delta^{13}C_{diat}$ were conducted on a total of 58 and 117 samples respectively at regular intervals across a total 4000 cm (c. 1000-11,000 years BP) of the core to reconstruct diatom utilisation

changes. Samples were cleaned using multiple stages of heavy density separation and stages of organic digestion. Contamination of samples was minimal (e.g. <1% Al), preservation of diatoms good throughout and reproducibility was 0.12‰ and 0.17‰ for both $\delta^{30}Si_{diat}$ and $\delta^{13}C_{diat}$ respectively.
Low productivity is seen at the start of the record after c. 11,000 years BP and after c. 8000 years BP values of $\delta^{13}C_{diat}$ and $\delta^{30}Si_{diat}$ show an increasing trend. This is concomitant with increased abundances of more heavily silicified summer diatom species, predominantly Fragilariopsis kerguelensis as well as increased Si:Corg and Si:Norg ratios. Data reflects greater productivity and a prolonged growing season associated with the Holocene Hypsithermal period. Main trends in the percentage abundance of the summer diatom group show a decline after c. 4000 years BP and a change to the dominance of spring diatom assemblages (e.g. *Fragilariopsis curta*) is seen, reflecting prolonged sea ice cover and shorter growing seasons [5]. At this time a decoupling trend is seen between productivity indicators (Si and C isotopes) and Si:Corg and Si:Norg ratios decline. Increased Fe fluxes are also documented in sediments after this time. The authors discuss the complex role of Fe addition after this time and variations in climate, sea-ice cover and upwelling at the site in order to understand these differing trends.

Poster

## First results of the paleolimnological research in Tundra polygons (the project POLYGON)

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A joint German-Russian project (Polygons in tundra wetlands: state and dynamics under climate variability in Polar Regions) started in 2010. The first part of field research during the 2011 field campaign in the lower Indigirka River (70°N, 147°E) and the lower (68°N; 161°E). After one month of field work the author has completed sediment samples from typical polygonal ponds on different evolution levels. Eight polygonal ponds and three thermokarst lakes were drilled. Total number of samples is 170.
The first task was to capture a certain number of sedimental samples. The analysis of potential indicator organisms in ponds and cryosols in a wider area and the monitoring of species dynamics in ponds at selected locations was completed by further on-site measurements (e.g. temperature, pH, conductivity, acidity, alkalinity, oxygen) and hydrochemical (major ion concentrations), sedimentological (CNS, grain size) and stable isotope lab analyses ($\delta$D, $\delta^{18}$O, $\delta^{13}$C) in order to record the life conditions of indicator species during the open water period. These analyses were performed by the involved institutions in Germany.
The morphometric description (size, depth, bathymetry, type) of the polygons aims to establish the relationships of these parameters with precipitation and permafrost dynamics during summer.
Simple, but stable sensors connected with long-term data loggers (one year records) were installed in selected polygon ponds in the Chokurdakh and the Chersky study areas. These instruments have to be extra purchased by this project. Physico-chemical field data from the study sites was compared and correlated with climate data of the respective climate stations (e.g. air temperature, precipitation, radiation). Summer precipitation was quantified and sampled since it is – next to ice melting - the main source of water in polygon ponds during summer, determining their hydrochemical and stable isotope properties.
Compilation of sedimental samples gave data about polygonal ponds with different evolution levels and age. Ponds aggregated to two kinds:
First ponds have a good well-marked wall borderline. They are ponds with flat ground and no deep water level. Another pond group is classified by rotted walls, high water level and the absence of the most part of sediment accumulation. It means that degradation processes of polygonal pond flowing fast enough on this allas territory. Radiocarbon dating will approve time line of evolution ponds from regular-shaped structure to deep water-filled frost crack.
Based on the experience from the fieldwork in 2011 in the Indigirka lowland, the expedition continues in 2012 in the lower Kolyma River region.

Poster

## Accelerator Mass Spectrometry: Revealing subtle signals in ice sheets

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Accelerator Mass Spectrometry (AMS) determines the ratio of a rare isotope, normally radioactive and of intermediate half-life, to a stable isotope. AMS permits the detection of individual atoms in a sample and so is an inherently sensitive analytical technique. A well-known example is radiocarbon dating ($^{14}C$, $t_{1/2}$ = 5730 a), where measurement of the $^{14}C/^{12}C$ ratio permits determination of the age of an artifact. Such AMS measurements can be performed rapidly (~ 20 min), at good precision (~ 0.3 ‰), with high sensitivity (< $10^{-15}$) and on very small samples (as little a few μg of carbon). Radiometric measurements, by contrast, require much larger sample masses and much longer measurement times in order to obtain good precision. Besides its use as a chronometer, $^{14}C$ is increasingly used as a tracer in geophysical studies as the amount of carbon required for a measurement has decreased.
At ANSTO we routinely measure $^{14}C$, $^{10}Be$, $^{26}Al$ and the Actinides by AMS and in 2010 we added $^{7}Be$ to the list. Here I give some examples from the ice sheets in Greenland and Antarctica of palaeoclimate research I have been involved in. In each case AMS has provided the unique key to unlock these important climate archives. I will discuss $^{14}C$ studies of atmospheric gases from firn air and ice core bubbles, with the objective of learning

more about the natural and anthropogenic sources of the important greenhouse gas methane. Additionally, I will discuss studies of the beryllium isotopes, $^{7}Be$ ($t_{1/2}$ = 53 d) and $^{10}Be$ ($t_{1/2}$ = 1.4 _ $10^{6}$ a) in snow and ice, with the objective of improving the use of $^{10}Be$ as a proxy for Solar variability.

Talk

## Continental-scale temperature variability over the Common Era

***Chris Turney***[1], Members PAGES 2K[2]

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Past climate variability provides a baseline against which to compare present and future changes. To coordinate the integration of new and existing data of all proxy types, Past Global Changes (PAGES), a core project of the International Geosphere-Biosphere Programme, developed the 2k Network, with the goal of generating a global array of regional syntheses of climate variability for the last 2000 years. The 2k Network is coordinated with the NOAA World Data Center for Paleoclimatology to maintain a benchmark database of high-resolution proxy climate records for the past two millennia. Here we present a major new synthesis of seven continental-scale temperature reconstructions to elucidate the global pattern of variations and their association with climate-forcing mechanisms over this common period. Reconstructed temperatures in all regions show an overall long-term cooling trend until around 1900 C.E., followed by strong warming during the 20th century. Solar and volcanic impacts do not induce globally consistent decadal shifts, although they do increase the probability of cooling or warming at the continental scale. The majority of extremely cold and warm decades in the regional reconstructions cannot be explained by changes in volcanic activity or solar forcing indicating that, prior to recent anthropogenic forcing, unforced internal variability of the climate system was the dominant control on these timescales.

Poster

## Late Glacial-Holocene Elemental and Stable Isotope Records from the Southeastern Arabian Sea

***Yoganandan Veeran***[1], Selvaraj Kandasamy[2], S.J Kao[3], Ravi Prasad G. V[4], Koushik Dutta[4], Krishnaiah C[6], Gangadhara Bhat H[7]

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It is known that high to moderate water column productivity, low to moderate oxygen levels in intermediate waters, and high accumulation rate of organic matter in the southeastern Arabian Sea (SEAS) together make this region as one of the important oceanic centers to investigate the past climate and oceanographic changes, including denitrification process. Here we report high resolution elemental (C and N) and stable isotope ($\delta^{13}C$ and $\delta^{15}N$) data from a sediment core SK–215/5 collected at water depths of 460 m during 215thCruise of ORV Sagar Kanya. A 4.2 m-long sediment core covers the sedimentation and climate history of Late Glacial-Holocene intervals. High C/N ratio but low $\delta^{13}C$ and $\delta^{15}N$ values in sediments between ~13.5 and 11.5 kyr BP indicate a considerable amount of terrigenous input when $\delta^{15}N$ values (~5–6‰) suggest low denitrification during the Late Glacial period. Distinct decrease of C/N ratio but increase of $\delta^{13}C$ and $\delta^{15}$ N values from 11.5 to ~8 kyr BP indicate increased productivity and denitrification during the early Holocene, consistent with intensified SW monsoon and associated upwelling in the Arabian Sea. Gradual decrease of $\delta^{13}C$ since early Holocene to the Present suggests an increased marine productivity as $\delta^{13}C$ values move from lighter to heavier values towards the late Holocene. This is consistent with C/N ratio, which shows a long-term decreasing trend during the Holocene, suggesting an increased marine productivity but decreased terrestrial input since 8 kyr BP. This study provides a high resolution $\delta^{15}N$ record from the SEAS for the Late Glacial-Holocene interval.

Poster

## How can ice cores constrain our knowledge of the likelihood of damaging solar flare events?

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Solar flares are sometimes associated with the appearance at Earth of solar energetic particles (SEPs). Since large flares can cause severe disruption to communications, power and satellite systems, there is a strong driver to learn about the frequency of events of different magnitudes. For many years now, there has been a belief in solar-terrestrial physics communities that SEP events leave a signature of nitrate spikes in polar ice

that can be used to diagnose their past occurrence. The ice core and atmospheric chemistry communities have been equally convinced that such spikes are not due to SEPs. The previous work was mainly based on a single ice core, and the advent of continuous high-resolution ice core analytical techniques means that there are now numerous datasets available to test the idea. Here we show that the most famous solar flare event in history, the 1859 Carrington event, is not observed as a nitrate spike in most polar ice cores. Furthermore we confirm that most nitrate spikes are accompanied by other chemistry that fingerprints them as the result of biomass burning events. This negative result seems to close the argument but enhances the need to search for other diagnostics of SEPs. The most attractive is $^{10}$Be, also in ice cores. $^{10}$Be is produced by cosmic rays in the atmosphere. SEPs should certainly enhance $^{10}$Be in the atmosphere, but only large events would take the (typically) annually-resolved signal above the background level, and we will discuss the likely thresholds that could be observed in ice core records. Through painstaking collection of such records covering as many years as possible and in several cores (to negate local depositional noise) it should be possible to constrain the likelihood of particularly large events.

## OSM13: Past Warm Periods Informing the Anthropocene

Convenors: Stijn De Schepper, Bjørg Risebrobakken, Bette Otto-Bliesner, Stéphanie Desprat

Poster

### Surface ocean conditions in the eastern Nordic Seas during the Pliocene

***Carin Andersson*[1,2]**, Bjørg Risebrobakken[1,2], Erin McClymont[3], Lisbeth Jensen[4]

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The Pliocene, in particular the mid-Pliocene, is the most recent period of past global warmth and has an important role in the evaluation of projections for future global warmth. The PRISM data set provides valuable data that describes global temperatures during this period of global warmth. However, some areas, such as the Nordic Seas, have relatively low data coverage with hampers our ability to constrain Pliocene temperatures. Here, we present preliminary data of surface ocean conditions for the eastern Nordic Seas, an area that previously has been "an empty spot on the map". We look at Ocean Drilling Program Site 642 in the eastern Norwegian Sea (67°13.5´N, 2°55.7´E, 1286 m water depth). It is situated beneath the inflowing of warm Atlantic water masses into the Nordic Seas. Sea-surface conditions are reconstructed from stable oxygen isotope analysis and faunal assemblage counts of planktic foraminifera in addition to analysis alkenone paleothermometry. Pliocene ea-surface temperature estimates based on planktic foraminifera are challenging based on the presence of extinct species. However, assumptions can be made about the environmental preferences of these species and temperature estimates calculated. Or data from Site 642 so far show that the very sea-surface, reconstructed from alkenone data, is generally warmer than corresponding Holocene data. The more sub-surface conditions, as depicted from planktic foraminifers show more variability throughout the Pliocene. The foraminiferal faunal data indicate a warm period, but also highly variably value for the PRISM interval. We cannot document a large warm mid-Piacenzian sea-surface temperature anomaly for the eastern Norwegian Sea based on the data we got from Site 642 so far. This contradicts what would be expected from previous finding of polar amplification of mid-Pliocene warmth.

Talk

### About the difficulty to find a Pleistocene analogue to the Holocene and Anthropocene

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To understand better our current interglacial and its future, we have investigated the response of the climate system to insolation and GHG at the peaks of the interglacials over the past 800,000 years using both LOVECLIM and CCSM3. If we identify these peaks with NH summer at perihelion, MIS-1, MIS-11 and MIS-19 show a pretty similar latitudinal and seasonal distribution of the incoming solar radiation. When compared to the average of the last 9 interglacials, they are under-insolated over the whole globe during boreal summer and are over-insolated during boreal winter with a maximum at the South Pole. This insolation distribution leads to a cooling over all the continents in boreal summer and to a warming over the whole Earth, except the Arctic, in boreal winter. A warming over the Southern Ocean in austral winter occurs during MIS-1 and MIS-19 due to the summer remnant effect of insolation. However, this does not happen in MIS11 because the large global cooling during this season is dominating the remnant effect of the austral summer. This leads to MIS-11 being a cool insolation-induced interglacials and thus not as good an analogue of MIS-1 as MIS-19, at least as far as insolation is concerned. The $CO_2$e of MIS-1 and MIS-19 is also practically the same (265 ppmv) but is larger for MIS-11 (286 ppmv). This pretty low value for MIS-1 and MIS-19 cools the Earth, reinforcing the insolation-induced cooling during boreal summer and moderating the warming during boreal winter. The reverse happens for MIS-11 for which its higher value allows it to be finally classified among the warm interglacials. The best analogue to MIS-1 depends therefore upon the criteria used to select such an analogue.

If we look now for analogues of the whole Holocene and its future, it must be stressed that the next minimum of eccentricity at the 400-ka time scale is approaching. With this and a $CO_2$ concentration at the interglacial level, and even larger under human influence, our interglacial was predicted to be exceptionally long. The same happened during MIS-11, its long duration having been confirmed by the EPICA record. According to the sensitivity experiments of Berger et al. (1999), moderate values of $CO_2$ sustained for sufficiently long might have led to an interglacial MIS-19 even much longer than MIS-11 and MIS-1.

The interglacials MIS-9 and MIS-5 are the warmest over the last 800 ka and, as such, are considered as analogues for our $CO_2$-induced future warm interglacial, although their astronomical forcings are largely different from MIS-1 and its future. MIS-9 is the warmest and MIS-5, which is generally assumed to be a good analogue for the future warmth of our interglacial, is slightly warmer than the simulated present-day climate. During boreal winter, both MIS-5 and MIS-9 are cooler than the climate of a $2xCO_2$ atmospheric concentration simulated under Pre-Industrial conditions all over the Earth, especially over the continents. During boreal summer, they are much warmer over the continents, but remain cooler over the oceans.

This shows the importance of the insolation which is much larger at MIS-5 and MIS-9 (even at MIS-11 and MIS-19) with boreal summer occurring at perihelion than in the future with boreal summer occurring at aphelion.

Talk

## The relative roles of $CO_2$, palaeogeography and vegetation in determining late Miocene climate: Results from a terrestrial model-data comparison

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The impact of rising $CO_2$ is the biggest uncertainty on the future climate of the Anthropocene. Late Miocene paleo-$CO_2$ reconstructions are similar to the present level, yet the paleorecord suggests a much warmer and wetter world than today. If past warm climates can be used to infer anything for potential future climate changes, it is important to separate out understanding of climate dynamics due to $CO_2$ forcing from the effects of paleogeography (continental positions, ocean gateways and ice extents) and vegetation. This study focuses on determining the relative roles of $CO_2$ forcing, palaeogeography and vegetation in driving late Miocene climate through comprehensive model-data comparisons. We provide insight into the role of $CO_2$ in a past warm climate, and the role of vegetation changes as a feedback mechanism.
Three potential late Miocene climates have been simulated using the fully coupled atmosphere-ocean-vegetation GCM model HadCM3L-TRIFFID. All of the paleosimulations assume an identical paleogeography appropriate for the late Miocene, but use three different $CO_2$ concentrations: 180ppm, 280ppm, 400ppm. The 280ppm late Miocene simulation is compared to a modern simulation with the same preindustrial level of $CO_2$ to investigate the potential role of paleogeography. The late Miocene climate simulations are compared to investigate the role of $CO_2$. The vegetation GCM component is used to predict vegetation distributions in equilibrium with the prescribed geographic configuration and $CO_2$ concentration of each simulation. Subsequently, the vegetation distribution is fixed to that predicted in equilibrium with a higher or lower $CO_2$ concentration than the level prescribed in the simulations (e.g. the vegetation distribution in the 400ppm $CO_2$ scenario is prescribed with the model-predicted vegetation distribution for the 280ppm equilibrium climate scenario) and so we are able to separate the relative roles of $CO_2$ forcing and vegetation feedbacks on the late Miocene climate.
A database containing 1030 terrestrial proxy annual and seasonal reconstructions for the late Miocene has been compiled from the literature. Quantitative comparisons have been made of these data and the model simulations, and a qualitative comparison with published biome data has also been made. The results indicate that:
1. In the Northern Hemisphere, the vegetation changes driven by increasing $CO_2$ from 280 to 400 ppm causes warming that is equal in magnitude to the warming associated solely with increasing $CO_2$. However, these contributions do not add linearly.
2. Both atmospheric $CO_2$ and paleogeography contribute to the proxy-derived precipitation differences between the late Miocene and modern. However, these contributions do not add linearly.
3. The proxy-derived temperature differences between the late Miocene and modern can only begin to be accounted for if we assume a paleo-$CO_2$ concentration towards the higher end of the range of estimates.

Poster

## Modeled variability of land vegetation and carbon during the Holocene

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During warmer interglacials, major shifts within the vegetation cover took place. For example, the boreal tree line was shifted further north and the Sahara was on average greener than today due to an amplified monsoon system. These orbit-driven features are well known for the Holocene and are much more pronounced during MIS5e. In addition, there is an additional man-made forcing by land use during the last millennia.
From a paleo perspective, it is crucial to constrain these vegetation dynamics to understand the variability in carbon cycle. Carbon storage and vegetation cover are simulated by the land component JSBACH of the Max-Planck Earth System Model (MPI-ESM). The model comprises a module for dynamical vegetation and disturbances by wind and fire and can be driven by climate parameters out of observations, reconstructions, or directly coupled to ESMs of full or intermediate complexity.
We will present a model study focusing on vegetation dynamics and carbon storage on land during warm climates (primarily Holocene) and their variability. Using a factor separation method, an ensemble of transient simulations including / excluding (i) different land use changes, (ii) orbit forcing, and (iii) peat accumulation will be analyzed to disentangle the overall change in the land carbon by including all drivers. For this analysis, JSBACH is coupled to the Earth system model of intermediate complexity CLIMBER2 as this gives a reasonable timeframe for the ensemble of these 8000yrs spanning transient experiments.

Poster

## How to glaciate the Northern Hemisphere in a globally warm world?

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The early Late Pliocene (ca. 3.6–3.0 Ma) world is characterised by a stable global climate that was about 2-3˚C warmer than present and with atmospheric carbon dioxide concentrations comparable to today. It has therefore been considered as a good analogue for future climate conditions on Earth. Notwithstanding the warm climate, a major glaciation within marine isotope stage (MIS) M2 occurred between 3.305 and 3.285 Ma. The processes behind this "failed attempt at intensification of the Northern Hemisphere glaciation" are unknown. We investigated the role of North Atlantic surface ocean circulation in the processes leading to MIS M2.
We used high-resolution geochemical proxy records for sea-surface temperature (Mg/Ca of different planktonic foraminifers, alkenones) and also analysed dinoflagellate cyst assemblages to reconstruct the surface circulation in the North Atlantic. Five ocean drilling sites were selected along a transect from the Caribbean to the eastern North Atlantic. These sites allowed us to reconstruct variations in the Central American Seaway throughflow and the Gulf Stream/North Atlantic Current system – a current system that transports warm surface waters to higher latitudes and influences present-day climate in northwestern Europe.
Our results demonstrate that a weakening and southward shift of the North Atlantic Current resulted in reduced northward heat transport and cooling of the high latitude oceans prior to and during MIS M2. We argue that this was a crucial prerequisite for the expansion of the Greenland ice sheet during MIS M2. We link the changes in the North Atlantic surface circulation to variations in Pacific to Atlantic throughflow via the Central American Seaway.

Talk

## Pliocene Marine Isotope Stage (MIS) M2: Caused by a hiccup in the closure of the Panamanian Gateway.

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The mid-Piacenzian was an episode of prolonged global warmth and intense thermohaline circulation, interrupted briefly at ca. 3.30 Ma by a global cooling event corresponding to Marine Isotope Stage (MIS) M2. This glaciation has been regarded as a failed attempt to attain the ice-house world of the later Pliocene, which is characterized by extensive Northern Hemisphere glaciation and often associated with the complex closure of the Panamanian Gateway. Here, we focus on the Panamanian Gateway and present ongoing work from the east Pacific (Site 1241) and the Caribbean (Site 999). Both sides are part of a transect of high-resolution records from six (I)ODP/DSDP sites covering the Gulf Stream (Site 603), subtropical gyre (Site U1313), and the North Atlantic Current (NAC; Sites 610 and U1308). The aim is to reconstruct at high resolution the sequence of events leading into MIS M2 and through the following deglaciation into the mid-Piacenzian Warm Period, (PRISM-interval), with a focus on the Panamanian Gateway. We will address the following two questions; 1) how did water column stratification in the Caribbean change around MIS M2; and 2) can a possible, temporary closure of the Panamanian Gateway be determined using dinoflagellate cyst assemblages?
We have used a multi-proxy approach to reconstruct changes in sea water temperature (SWT), relative sea surface salinity (SSS), and overall water mass characteristics in the Caribbean (Site 999) and east Pacific (Site 1241). To reconstruct changes in SWT we used Mg/Ca on Globigerinoides sacculifer (mixed layer) and Neogloboquadrina dutertrei (thermocline). Changes in relative salinity ($\delta^{18}O_{water}$) were determined by combining stable oxygen isotopes of the planktonic foraminifer species with the reconstructed temperatures. Dinoflagellate cyst assemblages, stable carbon isotopes, and sand fraction are used to reconstruct changes in water mass characteristics not only related to temperature and/or salinity. Benthic $\delta^{18}O$ records were used to tune the age models from each site the LR04 global benthic $\delta^{18}O$ stack. Results show that the major changes at east Pacific Site 1241 followed the global pattern of glacial-interglacial variability with lowest temperatures reached during MIS M2. However, at Caribbean Site 999, a major water-mass change already began during interglacial MIS M1 when SWT decreased, sand fraction reached its lowest content and the dinoflagellate cyst assemblage characterized by a heterotrophic flora revealed the inflow of colder, high-productivity water from the east Pacific during the sea level highstand. Model studies have shown that such an inflow of colder waters into the Caribbean leads to a slowdown of the Gulfstream and NAC. This will have triggered changes in the North Atlantic just before MIS M2 needed for the build-up of an ice-sheet on Greenland. With increasing global ice volume, sea level dropped and eventually led to the glacial closure of the Panamanian Gateway, which in turn allowed the Caribbean Warm Pool (CWP) to expand causing SWT at Site 999 to start increasing during maximum ice volume. Hence, the intense glaciation of MIS M2 came to an end, Earth's climate transitioned into the mid-Plicenzian warm period, and the ice-house world of the latest Pliocene was delayed by nearly half a million years.

Poster

## Interglacial vegetation dynamics revealed from land-cover estimates and potential disturbance factors

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Past interglacials are warm periods characterized by a relatively long stable climate enabling development of temperate forest vegetation in northern latitudes. This type of vegetation, however, cannot maintain itself over millennia, and after a maximum in the interglacial optimum its productivity slowly decreases under deteriorating conditions. The reasons of such changes are not yet fully understood, but most probably are result of changing nutrient availability in soil. Climate might also play a role with greater significance towards the ends of warm periods where even major climatic oscillations might occur. Understanding past vegetation dynamics during these warm periods, the role of internal processes, disturbances and climate, may be of great significance for the present interglacial and future climate change (warming or cooling).
Here we use both published and new terrestrial interglacial records in northern Europe in order to track vegetation changes. For detecting vegetation change we use a novel quantitative vegetation reconstruction approach enabling translation of pollen signal into regional vegetation proportions. We further use these to investigate on total forest cover, changing soil conditions, and vegetation rate of change to detect possible climatic disturbance. We also attempt to detect other disturbance factors during some of the warm periods based on several non-pollen palynomorphs such as charcoal for fire and fungal spores for herbivores.
Although warm periods differ in species composition, their vegetation changes show a consistent pattern in initially rising productivity and forest cover followed by their long and slow decrease. Comparison of Eemian vegetation rate of change over the northern-European continent suggests that no abrupt shifts occurred regionally during the warm stage and some major shift are rather attributed to local events. Climate therefore played only a minor role in vegetation change and it only became important with a major cooling by the new glacial inception. Two new interglacial records including charcoal and fungal spores bring new insights into fire dynamics and potential impact of large herbivores on vegetation. Fires seemed to play minor role during interglacial optima when forests were dense, but fire frequencies increased towards the end of interglacials accompanied by coniferous vegetation probably maintaining the vegetation openness. Detecting presence of large herbivores from occurrence of fungal spores is still questionable as it probably has only very limited local signal and no high frequencies of any were recorded.
We conclude that vegetation in later parts of warm stages was mainly driven by processes of soil development (mainly impoverishment) and as such was more sensitive to fires. Such irreversible changes when speeded up by anthropogenic impact might bring more risks for future abrupt events.

Poster

## Can variations in orbital and greenhouse gas forcing explain the North Atlantic sea-surface temperature evolution during the Last Interglacial?

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The Last Interglacial (LIG, 130,000 to 115,000 years ago) is a period characterized by warm boreal summers and sea level several meters higher than today due to reduced ice sheets. It is considered an analogue for the response of the current land based ice sheets to a future climate warming.
Here we present results from time slice simulations covering the LIG using the Norwegian Earth System Model (NorESM-L). The model is forced by orbital configurations representing different stages of the LIG, combined with either pre-industrial or LIG levels of atmospheric greenhouse gases.
In the Northern Hemisphere, our results show a strong seasonal cycle in the early LIG reducing to a weak seasonal cycle in the late LIG, closely following the orbital evolution. A reduction in greenhouse gasses, as is the case in the early LIG, causes a season- independent, global cooling.
We furthermore compare our model results to sea-surface temperature records derived from North Atlantic sediment cores. The simulated LIG summer sea-surface temperature evolution, when combining orbital and greenhouse gas forcing, corresponds well to the general temperature trends found in the sediment records. The reduced greenhouse gas concentrations at 130,000 years ago, and its associated colder temperatures, are essential for establishing the relatively low temperatures in the early LIG.

Poster

## Modelling the influence of evolving vegetation on past greenhouse climates

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The warmest climates of the past 65 million years occurred during the early Eocene (56-48 Ma)- Atmospheric $CO_2$ levels for this time period have a large uncertainty associated with them, but were possibly as high as 2000 to 3000 ppm. Current modeling efforts have had great difficulty in replicating the shallow latitudinal temperature gradient indicated by proxy data for this time period. This

is partly due to the fact that the specific mechanisms that cause this shallow temperature gradient are unknown or not fully understood so cannot be accounted for. Another contributing factor could be that not all climate feedbacks are included in these models. Vegetation feedbacks have been shown to be especially important so by including a more accurate representation of vegetation in the climate model, the model-data discrepancies may be reduced.
A fully coupled atmosphere-ocean GCM, HadCM3L, coupled to a dynamic global vegetation model (TRIFFID), was used to simulate Eocene climate at $CO_2$ concentrations of 560ppm and 1020ppm. This allows simulations with vegetation-climate interactions to be compared to simulations with static vegetation, but also to see how predicted vegetation changes with atmospheric $CO_2$. The effects of removing $C_4$ grasses from the dynamic vegetation model were also investigated, as they did not evolve until the Oligocene. This had an important effect on the coverage of other PFTs and therefore the climate.
The global mean annual temperature was higher when interactive vegetation was present compared to the simulations with static vegetation, increasing from 17.7 degrees C to 18.4 degrees C at 560ppm and 21.7 degrees C to 23.3 degrees C at 1020ppm. The latitudinal temperature gradient also became shallower, making it more consistent with proxy data. Climate sensitivity is higher with dynamic vegetation, so temperatures consistent with data can be reached at lower (and more plausible) $CO_2$ levels than some previous studies. Vegetation cover predicted by TRIFFID matches reasonably well with fossil evidence, especially at higher atmospheric $CO_2$. For example, TRIFFID predicts broadleaf trees growing on most of Antarctica, which is in agreement with fossils found on Antarctica.
These results demonstrate that by including a dynamic vegetation component in climate simulations, the discrepancy between model results and data can be reduced. In addition, although TRIFFID was designed for modern day vegetation, it can still produce a reasonable representation of vegetation in paleoclimate simulations.

Poster

## The Miocene Mi-events: New paleobiological and paleotemperature data from Porcupine Basin, SW Ireland

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The Miocene is a geological period during which the climate toppled globally, and is pivotal in the comprehension of the Cenozoic climate evolution. A warm phase was established during the later part of the Oligocene and resulted in the waning of the Antarctic ice sheets and a global increase of bottom water temperatures. The warming phase culminated in the Middle Miocene Climatic Optimum (MMCO) between 17 and 14.5 Ma, and this period is considered to have been the warmest interval during the last 34 Ma. However, the climate during Miocene times was anything but uniform, and was punctuated by several short-lived cooling events of differing intensity, the Mi-isotope zones or Mi-events. Several causal mechanisms for the Middle Miocene climate transition have been advanced (large-scale change in oceanic circulation induced by opening or closing of oceanic gateways or changing atmospheric circulation; massive burial of organic carbon in the marine realm leading to a drawdown of atmospheric $pCO_2$, impairing the greenhouse capacity and resulted in global cooling – the Monterey hypothesis). Although various proxies of paleoatmospheric $CO_2$ show different results, the most recent Miocene data point to a stepwise lowering of $CO_2$ levels in conjunction with Mi-events. Amplitude variation of eccentricity and obliquity is now regarded as a major driving force behind the Neogene climatic variations.
For this reason we want to examine the role of the Gulf Stream in the cooling and subsequent warming of the Mi-events, since it is a possible mechanism to amplify regional changes in Northwestern Europe. IODP Leg 307 recovered a fairly continuous Lower and Middle Miocene sequence in the Porcupine Basin, offshore southwestern Ireland.
The Middle Miocene sequence from core 1318B was examined with a very high resolution for organic-walled palynomorphs (mainly organic-walled dinoflagellate cysts, acritarchs, some pollen) and organic molecules for paleothermometry (e.g. $TEX_{86}$ and $U^{K'}_{37}$). With these proxies the development of the Mi-3 and Mi-4 events are reconstructed on high resolution, by assessing e.g. temperature, sea level, thermocline depth and productivity. First results indicate a pronounced cooling as recorded simultaneously in $TEX_{86}$, $U^{K'}_{37}$ and dinoflagellate cyst assemblages during Mi-4. The $TEX_{86}$ record indicates a cooling of surface waters of as much as 4°C. This cooling is similar to sea surface temperature cooling at the Eocene/Oligocene transition, when the buildup of the East-Antarctic ice was initiated. On top of the Mi-4 shift dinoflagellate cyst assemblages show a clear 100-kyr eccentricity signal in temperature, productivity and sea level. This feature might be useful to correlate the Porucpine Basin, that lacks stable isotope data, with other high-resolution records. The presented results will focus in detail on the phasing and rates of change in the reconstructed Mi-events.

Poster

## New insights into the Holocene Thermal Maximum: Feedback and triggering mechanisms

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The Holocene Thermal Maximum (HTM) is considered as a period of relatively warm climate which characterized the Northern Hemisphere between ca. 9.0 and 5.0 ka.

This climate anomaly has been primarily attributed to a summer insolation maximum associated with the Earth's precessional cycle. However, proxy-based reconstructions from the regions bordering the North Atlantic show substantial differences in the spatial extent and magnitude of the warming, suggesting the involvement of hitherto unresolved forcing and feedback mechanisms. By comparing ice-core, marine and terrestrial paleoclimate records, we explore a potential linkage between the HTM in northwestern Europe and low-latitude atmospheric circulation dynamics. Specifically, we discuss the role of mid-Holocene sea-continent feedback processes related to changes in the poleward heat transport by the North Atlantic atmospheric system. Data comparison also indicates a coupling between the termination of the "8.2 ka cold event" and the onset of the HTM, providing new insights into the potential long-term forcing mechanisms underlying abrupt climate fluctuations.

Poster

## Investigating the Uncertainty in the HadCM3 Model using a Perturbed Physics Ensemble in a Warmer World Palaeoclimatic Setting

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The Quantifying Uncertainty in Model Predictions for the Pliocene (Plio-QUMP) project runs a Perturbed Physics Ensemble (PPE) for the mid-Pliocene Warm Period (mPWP – 3.3 to 3.0 Ma BP). The mPWP is a warmer than modern climate making it useful for investigating the uncertainty within the UK Met Office atmosphere-ocean general circulation model, HadCM3 caused by parameterisations of physical processes in the atmospheric component of the model.
Following the methodology of the UK Met Office 'QUMP' project, an initial ensemble investigation was carried out investigating three versions of HadCM3 with high, low and standard Charney sensitivity. The results from these simulations showed that there was potential for a better fit in data-model comparisons (DMCs) using different versions of the model based on perturbations to parameters. Compared to the standard version of HadCM3, the high sensitivity simulation produced an improved DMC to the Pliocene Research Interpretations and Synoptic Mapping (PRISM) groups Mean Annual Sea Surface Temperature (MASST) dataset, but produced a weaker DMC when compared to vegetation data.
The next development for the project was to run two 17 member ensembles covering a range of Charney sensitivities (from 2.19°C to 7.1°C for a doubling of $CO_2$), the first using the PRISM2 boundary conditions and the second using the PRISM3D boundary conditions. A sub-ensemble has also been produced using different ranges of $CO_2$ which are plausible for this period in the Pliocene. These ensembles have produced a range of results investigating the uncertainty from parameterisations and Pliocene boundary conditions as both of these provide uncertainty to the modelling uncertainty for mPWP climate reconstructions. Model performance (within ensembles) is judged using IMCs and DMCs (using the PRISM surface air temperature (from vegetation), sea surface temperature data and biome reconstructions) to rank ensemble members performance.
The results suggest that Charney sensitivity at the higher end of the IPCC range of 2°C to 4.5°C is required for the HadCM3 model to produce a stronger reconstruction of mPWP climate, which could have an implication for our projections of future climate change using models with lower Charney sensitivity values. The best performing ensemble members (in comparison with the Palaeo-data) have climate sensitivities of 4.54°C (M), 4.62°C (N), 4.88°C (L), 5.40°C (P) & 7.11°C (Q). Q has been shown in previous work to be too hot especially into lower latitude continental regions, but M, N, L and P are all good simulations improving the DMC in the higher latitudes without causing an overheating in the tropics in comparison to the SST data. Results will also be presented showing the performance of the ensemble members against terrestrial SAT data from vegetation and from using the BIOME4 equilibrium vegetation model to reconstruct biomes from the ensemble members.

Poster

## Characterizing conditions of the Nordic Seas water column through the Pliocene

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The Nordic Seas is one of the world's ocean areas with least data available to constrain Pliocene temperatures. Nevertheless, the Nordic Seas is considered to be the hot spot of the worlds oceans in terms of temperature anomalies between the Pliocene and preindustrial times. In this study a multi proxy approach is used to characterize the conditions of the Pliocene water column of the Nordic Seas. The study site is ODP Site 642B, located in the eastern Nordic Seas (67°13.5´N, 2°55.7´E, 1286 m water depth), a site presently under influence of the warm Norwegian Atlantic Current.
Temperature estimates based on alkenone indicate 1-2°C warmer SSTs compared to the Holocene, probably reflecting the effect of higher radiation on summer mixed layer temperatures. In contrast to the slight warming recorded by the alkenones, planktic oxygen isotopes document colder (and/or saltier) conditions than through the Holocene. Temperature estimates based on relative abundance of planktic foraminifera supports an interpretation of colder subsurface conditions, as indicated by the oxygen isotopes. Hence, the results from ODP Site 642B shows that the eastern Nordic Seas was less warm than previously suggested. Benthic isotopes

record saltier (and/or colder) bottom water than what is seen for the Holocene in the same area. Together, the planktic and benthic oxygen isotopes show that stratification and density structure of the water column was different during the Pliocene. The planktic carbon isotope record document a well ventilated upper water column, with the exception of the period ca. 4-3.7 Ma BP when the ocean atmosphere gas exchange was hindered by a fresh water lid. Even though the upper part of the water column was well ventilated, the benthic carbon isotopes document that the bottom water was less well ventilated during the Pliocene than through the Holocene, implying that no strong deep convection took place. Our results that the ocean circulation and northern limb of the AMOC may operate differently from today under climate boundary conditions close to modern.

Poster

## Understanding the range of climates that can be simulated by perturbing uncertain climate parameters within their range of uncertainty for the early Eocene warm paleoclimate

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Geological proxy data for the early Eocene, ~55 million years ago (Ma), indicates extensive global warmth with reduced seasonality in both the Polar Regions and continental interiors. Estimates of $CO_2$ levels during the early Eocene are on par with those predicted in the near future and thus the early Eocene has become an increasingly relevant area of palaeoclimate research. However, the modern generation of climate models has not satisfactorily replicated the temperature distribution inferred from the geological proxy data. This significant discrepancy between proxy data and climate models has highlighted short-comings in both the models and the proxy data. Reducing this model-data mismatch will improve our understanding of processes important in warm climates.
Our work investigates the role of climate model uncertainty in this problem. We aim to answer the question, 'are modern climate models capable of simulating the temperature distribution inferred from early Eocene proxy data?' We attempt to answer this question by perturbing a set of 10 uncertain parameters within our climate model FAMOUS (Fast Met Office/UK Universities Simulator).
We perturb the uncertain parameters simultaneously, in order to maximise the parameter space covered, and independently, to understand the specific impacts on climate. We use 560 ppm $CO_2$ in all our simulations which is at the lower estimate of early Eocene $CO_2$ concentrations. We compare our results to published proxy data.
From over 100 initial simulations only 17 simulations are successful. Of these 17, 2 different parameter sets produce promising early Eocene climates which match the proxy data well (and have negligible sea ice, warm Polar Regions and a reduced pole to equator gradient). Both simulations converge to a similar climate which is distinct from the remaining simulations and show similarities in seasonal cloud cover and similar behaviour in oceanic and atmospheric circulation.
Our results indicate that within the bounds of uncertain parameter values, it is possible to improve early Eocene climates with FAMOUS. Changes in the physical properties and behaviour of clouds are similar in all 3 simulations which match the proxy data well. This emphasises the importance of clouds in warm climates. There are compelling arguments for different cloud behaviour and properties in the past and these results may be applicable to other palaeoclimates.

Poster

## Evaluation of the ratio of natural and anthropogenic forcing in the regression of the Aral sea during the Medieval Warm Period

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The present communication is based on the quantitative analysis of the structure and development of the Medieval urbanization of the Syrdarya and Northern Tienshan regions; and proceeds analyzing the possible environmental impact of such a huge urban complex. Medieval anthropogenic impact could have happened in 2 detectable forms: disturbances of the relief and soils of irrigated areas, and non sustainable water use. Both impacts have been documented: the first in the history of the irrigation schemes of the Otrar oasis, the second as largely responsible of the regression of the Aral sea of the Medieval Warm Period (XII-XIII centuries AD).
Particularly significant as historical example of coupled action of natural and anthropogenic forcing is the case of the medieval regression of the Aral. Witness of the establishment of a warm dry climate, of low water levels, and of relevant amounts of anthropogenic water subtraction from the Aral tributaries is provided by paleoclimatic and geoarcheological studies.
The establishment in Central Asia of a warm dry period between the VIII and the XIII centuries AD is confirmed by palynological studies and by the results of the recent coring of the Balkhash lake in the context of the cooperation project between RIHN (Japan) and the Laboratory of Geoarchaeology (Kazakhstan).
A small urban center (Kerderi) surrounded by simple irrigation schemes has been detected on the Aral shore at +31 m asl, pointing without doubt to a strong regression, which is paralleled by a similar synchronous regression of the Balkhash lake.
Where the medieval regression of the Balkhash is largely attributable to just natural climatic changes, the medieval regression of the Aral must be partly attributed to the consistent urbanization of the middle and low Syrdarya and Amudarya rivers, a factor that up to now has been ignored by the studies of the historical behavior of Aral sea and that has been surely enhanced as a positive feedback under the establishment of a warm phase. The coefficient of water use per hectare of urban structure has been calculated for the Otrar oasis during the X AD and,

when extrapolated to the entire Syrdarya and Amudarya urban complexes, allows the estimation of the yearly amount of water diversion from the Aral for irrigation needs. Supposing a climate similar to the present one, the hydrological model suggests that such medieval anthropogenic subtraction will be equivalent to the 51% of the river stocks, i.e. to the 63% of the modern subtraction, and would be responsible for the 60% of the medieval regression of the Aral sea (with the remaining 40% being attributable to the dry climatic phase).

Poster

## Refined $pCO_2$ reconstruction in Pliocene warmth

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Atmospheric $CO_2$ has been a primary driver of global temperature change. The current increase in the atmospheric concentration of the greenhouse gas carbon dioxide, from 280 ppm in pre-industrial times to >380 ppm today, is unprecedented in recent Earth history, with present levels exceeding the natural range of at least the last 800 kyr. Understanding the relationship between $pCO_2$ and climate is therefore central for the accurate prediction of future climate change. Past responses to $pCO_2$ change are important components in resolving these relationships. Also a future climate can be estimated from an understanding of ancient climate change if we obtain reliable information on past concentrations of $CO_2$ in the atmosphere from geological record. Therefore, it is important to work on refining the $CO_2$ proxy. Recent $pCO_2$ estimates based on alkenone carbon isotope method show that $pCO_2$ level (330-400 ppm) in mid Pliocene warm period (4.5-3 Ma), the most recent period of sustained global warmth is slightly warmer than preindustrial level (280 ppm), suggesting high earth system sensitivity in the Pliocene warmth. However, the alkenone method for $pCO_2$ reconstruction relies on several assumptions, which is sensitive to regional oceanographic settings. This uncertainty results in large differences in $CO_2$ estimates from site to site. In this study, we attempt to refine the alkenone $pCO_2$ method and reevaluate $pCO_2$ estimate in Pliocene.

Poster

## A comparative study of large scale atmospheric circulation in the context of future scenario (RCP4.5) and past warm climate (mid-Pliocene)

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The Pliocene climate simulations (3.3~3.0Ma) are often considered as the last warm period with close enough geographic configurations to the present one and atmospheric $CO_2$ concentration (405±50ppm ) higher than the modern level. It is therefore suggested that the warm Pliocene climate may provide plausible comparative scenario for investigating the future climate warming. RCP4.5 scenario is indeed one of the current available future projections selected for comparison with past warm mid-Pliocene climate.
In a first step, both the mid-Pliocene simulation and future projection are compared to the pre-industrial simulation (control run) to better point out whether the mid-Pliocene provides a potential comparative "analogue" for future climate warming. Global annual mean surface air temperature is 15.2°C in the mid-Pliocene (2.07°C warmer than control run), whereas the future projected is 16.0°C (2.87°C higher than the pre-industrial run). Global averaged annual mean surface temperature in RCP4.5 scenario is 0.8°C warmer than that in the warm mid-Pliocene climate due to $CO_2$ concentration difference (140ppm). Surface air temperature in the RCP4.5 scenario compared to mid-Pliocene increases over most areas with stronger warming at higher latitudes and weaker increasing in the subtropics. Excessive precipitations in RCP4.5 scenario relative to the mid-Pliocene are found in the tropics and higher latitudes and negative values occur in the subtropics.
Changes in the large scale circulation could explain the different behavior between the mid-Pliocene and RCP4.5. Simulated Hadley circulation in the future projection is shown to be significantly shifted poleward in comparison with the mid-Pliocene. This expansion area implies the poleward shift of the subtropical subsidence, leading to poleward shifts of the subtropical dry zone. Meanwhile, by comparing the RCP4.5 with the mid-Pliocene, the upward branch of Walker circulation shifts eastward significantly and anomalous sinking motion dominates in the northeast Pacific, leading to an eastward shift of the excessive rainfall and reversely decrease rainfall occurring in the northeast Pacific.
In the present study, we demonstrated that Hadley and Walker cell response to the past and future non-uniform warming may explain major differences of the temperature and precipitation pattern between RCP4.5 and mid-Pliocene simulation. Our conclusion is that, whereas it is often argued that mid-Pliocene could be an analogue for future climate, we demonstrate that there are substantial differences, produced by atmospheric response to the past and future non-uniform warming.

Poster

## Multiple drivers of long-term hypoxia in the Baltic Sea: A pilot biomarker study

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Hypoxia, defined as < 2mg/l dissolved oxygen, in marine environments has developed to a globally significant problem with over 400 reported sites suffering from its harmful effects on life (Diaz & Rosenberg, 2008). Today, the hypoxia induced by anthropogenic nutrient loading is responsible for one of the most negative effects on the health of the Baltic Sea. Sediment sequences reveal that intermittent hypoxia has occurred in the Baltic Seas's deeper depressions since c. 8000 cal. yrs. BP overlapping the Holocene Thermal Maximum (HTM) the Medieval Warm Period (MWP) and the observed warming that has occurred during most of the last c. 100 years. Recently, Kabel et al. (2012) showed that there is a close relationship between sea surface temperatures and the deep-water oxygenation in the Baltic Sea over the last 1000 years. Thus, it can be argued that global warming with increasing temperature may lead to further ecosystem deterioration. However, hypoxia during the last two millennia can also be linked to population expansions and large land-use changes that occurred in vast areas of the Baltic Sea watershed. It may therefore be hypothesised that changes in the marine environment during this time period were caused by a combination of climate and anthropogenic forcing. However, the relative importance of these two forcing mechanisms is unresolved, which restricts predictions about the Baltic Sea ecosystem response to future changes in climate and nutrient loads. Unravelling the environmental conditions that have caused long-term hypoxia in the Baltic Sea would be an important step forward.

Organic carbon compounds (or biomarkers) in sediments have been widely used as proxies to estimate changes in past environmental conditions, both climate and human induced. Here, we present preliminary results of biomarker assemblages and concentration analyses performed on two long sediment sequences in the Baltic Sea. Records of high molecule weight (HMW) n-alkanes and low molecule weight (LMW) n-alkanes demonstrate high productivity during periods of hypoxia spanning the HTM and MWP, with maximum algae and aquatic macrophyte productivity, and terrestrial organic inputs during the MWP. Dinosterol, which is associated with dinoflagellates, provides a measure of planktonic abundance, shows similar trend with high concentration during the hypoxic periods and maximum abundance during the MWP. Concentrations of Diols (Eustigmathophyte Algae) closely follow the concentration of Dinosterol, which suggests that large amounts of algae were associated with hypoxia periods, particularly during the MWP. n-alkane average chain length (ACL) values (indicator of aridity) and LDI (long chain idol index; a novel proxy for sea surface temperature) suggest that more arid conditions and maximum Holocene sea surface temperatures prevailed during the HTM. This study indicates that the hypoxia of the MWP was driven by a combination of the relatively warmer climate and increased loadings of nutrients caused by human activity. Temperature, therefore, is not the single driver of long-term hypoxia in the Baltic Sea; nutrient loadings and other factors, such as freshwater inflow, also play important roles.

## OSM14: Natural and Human Effects on Ecosystem Processes

Convenors: Janet Wilmshurst, Amalava Bhattacharyya, Mukund Kajale

Poster

### Late Quaternary environmental change at Lake McKenzie, in subtropical eastern Australia: evidence from sedimentary carbon, nitrogen and biomarkers

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Fraser Island is part of a large sand mass that extends along the subtropical coastline of south-eastern Queensland. The island is a World Heritage site, listed for its unique natural environment that includes numerous perched oligotrophic dune lakes and a diverse suite of coastal and subtropical vegetation communities. Here we present geochemical and microfossil information for a sediment core collected from Lake McKenzie, in the island's centre. AMS $^{14}C$ and $^{210}Pb$ dating has been conducted and indicates a basal age of ca. 37,000 cal. BP. A hiatus in the sedimentary record is apparent at around 25 cm depth and spans the time period from ca. 18,280 to 13,990 cal yr BP. Elemental and stable isotope measurements of carbon and nitrogen in bulk organic matter, along with biomarker and compound specific carbon isotope analyses, show a clear shift in lake conditions appearing with the re-commencement of sediment accumulation following this hiatus. A marked decline in the abundance of microfossils of the green colonial algae *Botryococcus*, coincides with a distinct change in composition of *Botryococcus* derived lipids and a shift to more negative $\delta^{13}C$ values of long chain odd n-alkane compounds. An increase in lake size around 13,990 cal yr BP is suggested by the recommencement of sediment accumulation at the site, and is presumably in response to increased effective precipitation. The lake McKenzie record provides a long-term perspective on changing environmental conditions in central Fraser Island.

Poster

### Diatoms as Environmental Indicators to Infer Past Conditions in Relation to Acidity (Humedal de Batuco, Regíon Metropolitana, Chile Central)

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Diatoms are the most common and diverse group of algae in wetlands, however the strong influence of acidity on distribution of diatom taxa has rarely been studied in Central Chile. Humedal de Batuco (33°12,152'S, 70°49,490'W) is a coastal wetland and has great relevance due to the landscape gradients that occur associated to disturbances of the coupled ocean-atmosphere system of the tropical Pacific. We use diatoms as bioproxies to infer past environmental conditions. In 2008 (under the multiproxy approach of LINCGLOBAL) a shortcore was obtained with a gravity corer: BAT1 (length 35 cm, 0.3 m depth). BAT1 (AMS date of 200±50$^{14}C$ yrs BP) was opened, photographed, described sedimentologically and volumetrically subsampled every 5 cm. Aliquots were taken for diatomic analysis, processed according to standard methods for diatoms, permanent slides mounted and the first 5 cm were observed under an optical microscope, understanding that the surface sediments represent an integrated sample of the diatoms of the wetland, both spatially and temporally. We identified 29 species belonging to Bacillariophyceae and calculated the generic relative abundance: Actinocyclus (1; 7,8%), Anomoeoneis (2; 3,9%), Aulacoseira (1; 2%), Cocconeis (1; 2%), Craticula (1; 3,9%), Cyclotella (2; 9,8%), Cymatopleura (1; 2%), Encyonema (1; 2%), Epithemia (1; 2%), Eunotia (4; 17,6%), Gomphonema (3; 5,9%), Navicula (4; 15,7%), Nitzschia (4; 11,8%), Pinnularia (1; 2%), Tabellaria (1; 2%) and Tryblionella (1; 7,8%). These results, based on presence-absence of species and generic relative abundance variations would indicate conditions of oscillating pH between alkaline and acidic in recent times.

Poster

### Mapping biomes of India using Holdridge Life Zone Model – identifying footprints of climate change

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The primary aim of the study is generation of a biome map of India using the Holdridge life zone (HLZ) model. According to the HLZ model, natural vegetation of an area could be objectively determined by the local climate. Using this conceptual framework of HLZ model, minimum distance classifier and climatic datasets, the distribution of potential biomes was assessed. The study identifies nineteen (19) potential Holdridge life zones; seven (7) biomes and nineteen (19) sub-biomes in the Indian subcontinent. In order to verify the biome mapping precision, actual vegetation cover type map derived from IRS Wide Field Sensor (WiFS) data has been used to calculate the accuracy. The overall accuracy and kappa coefficient come out to be 82.7% and 0.75, respectively.
Climate change has become a familiar concept as some

of its intense impacts are being increasingly recognized. Since the HLZ model uses climate parameters only; it can help predict potential biome redistribution. In this study, modeling was carried out on entire region of India using various combinations. First, the current (present) climate data was used to generate a primary biome map of India. Second, predictive modeling was carried out using different assumptions of changes in temperature and precipitation; and third, the IPCC predicted climate simulations was also used to test the similarity between the results. When the geographic shifts in ranges are considered, the results suggest Tropical Desert (Plains), Tropical Desert Scrub (Lower Montane), Tropical Very Dry Forest (Plains), Tropical Dry Forest (Plains), Tropical Dry Forest (Lower Montane), Tropical Moist Forest (Lower Montane), and Tropical Wet Forest (Lower Montane) being most susceptible to changes in the percentage of area cover under climate change for different years for emission scenarios and the various modeled climate change regimes. Such estimates are very important for the detection and assessment of regional impacts of climate change so that better management and conservation strategies can be adopted for the biodiversity and forest dependent community.

Poster

## Foliar and total soil $\delta^{15}N$ as a proxy for precipitation in the Atacama Desert

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Precipitation is an important control of the nitrogen cycle and known to affect the isotopic nitrogen signal ($\delta^{15}N$) of total soil N and leaves. In general, soil and foliar $\delta^{15}N$ decreases with increasing mean annual rainfall across diverse ecosystems. Such changes in the N cycle would be important to detect in paleoecological records, especially in arid regions where rainfall is a limiting factor for biological activity. Here, we present a modern analog study of the $\delta^{15}N$ signal along an environmental gradient in the Atacama Desert of northern Chile.
We performed vegetation and soils surveys along a 2000 m altitudinal gradient in the western Andean slope adjacent to the Atacama Desert. Rainfall increases by an order of magnitude along this gradient. We sampled 22 sites, starting at 4500 m (mean annual precipitation (MAP) = 160 mm/yr) and ending at 2500 m (MAP < 10 mm/yr). We analyzed the N content and $\delta^{15}N$ of 28 soil samples and foliar $\delta^{15}N$ of 50 specimens from widespread Andean-Atacama species (Baccharis tola, Jarava frigida, Opuntia camachoi, Parastrephia quadrangularis and Atriplex imbricata). We also compared the signal of two different seasons (after and before the rainfall season in summer). Our results show no relation between total soil N (mg/kg) and MAP ($R^2$= 0.03, p>0.05). In contrast, there is a significant negative correlation between mean soil $\delta$15N and MAP ($R^2$= 0.77, p < 0.01). This soil $\delta^{15}N$ signal is persistent across the wet and dry seasons. Although foliar $\delta^{15}N$ for individual species shows no correlation with MAP, mean foliar $\delta^{15}N$ per site shows a significant positive correlation ($R^2$= 0.52, p < 0.01). Thus despite the elevated intra-site variation observed for the foliar $\delta^{15}N$ values, a large part of this variation can be explained by which species and season were analyzed.
Before we consider the paleoclimatic potential of foliar $\delta^{15}N$ as a precipitation proxy in the Atacama, two aspects need to be addressed. First, mean soil $\delta^{15}N$ is correlated with MAP as expected, but other processes could change the isotopic soil signal (e.g. age and depth) and should be considered before using it as a precipitation proxy. Second, mean foliar $\delta^{15}N$ per site shows an important correlation with precipitation but individual species tend to be much more variable. Finally, the challenge remains of finding suitable integrators of foliar $\delta^{15}N$ in the paleoecological record. Fossil herbivore dung and urine $\delta^{15}N$ preserved in caves and in rodent middens hold much promise in this regard.

Poster

## Treeline dynamics at high mountain of Manaslu Conservation Area, Central Nepal: Climate change or land use is the main driver?

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Treeline shifting in tandem with climate change is widely observed phenomenon in various parts of the world. With an array of different habitats and graded climatic zones, Nepal's high mountains provide a great potential in multidimensional tree ring research. This dendroecological study was carried out at the treeline ecotone (3,750m - 4,003m asl) in Kalchuman Lake (Kal Tal) area of Manaslu Conservation Area in Central Nepal Himalaya with an aim to assess the impact of climate (environmental) change at treeline and its dynamics. Two rectangular vertical belt transect plots (20m x 250m) were marked out covering treeline as well as species limit. With ecological mapping of all individuals, tree-cores were collected from two dominant tree species of the area: Abies spectabilis (D. Don) Mirb and Betula utilis D. Don. Stand character and age distribution testified B. utilis more matured with maximum age of 300yrs compared to A. spectabilis (max. 160yrs). With younger plants (<50yrs) accounting for an overwhelming 89% of population, A. spectabilis has a substantially high recruitment rate. Population age structure along an elevational gradient revealed that the species has been shifting upward in recent decades at a rate of 2.61m per year. However, the upper distribution limit of B. utilis was stagnant in the past few decades having only13% of its population <50yrs old, and small number of seedlings and saplings in both transects. Temporal pattern of growth in A. spectabilis significantly negatively correlated with mean monthly temperature of July-August of current year and September of previous year although we also noticed that there was a tendency for positive relationship of growth with previous November through current March temperature. However, regeneration of A. spectabilis was positively related with May-Aug precipitation and Jan-

Apr temperature of current year. Population demography indicates that the two most dominant tree species of treeline ecotone community have species specific response to climate change with much wider differences anticipated in the population status of the species as climate continues to change throughout the century. Further detail study is required to quantify the role of climate change and land use on the treeline dynamics of the Nepal Himalaya.

Poster

## Monsoon variability and carbon sequestration dynamics: Evidence from tree-rings

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Climatic variables are known to affect the growth in trees. Tree rings produced as a result of annual growth is a best proxy to measure the influence of climate on growth. Several studies have established relationship between annual rainfall and growth by examining tree rings. We are presenting dynamics in carbon stock and rate of assimilation of carbon in peninsular India by examining the growth rings of Teak (Tectona grandis, L.f.). Teak is one of the dominant trees in the dry and moist deciduous forests of peninsular India. The dendro-climatic potential of teak is well established.
The anthropogenic activities have led to increase in the concentration of $CO_2$ in the atmosphere. Various biomes across the globe have responded to the elevated levels of $CO_2$ differently. Trees have responded to the inter-annual variability in monsoon through changes in mortality, recruitment or growth. We have exploited the growth response of trees to the inter-annual variability in monsoon to understand the carbon sequestration.
We have used the tree rings of teak from peninsular India to understand carbon dynamics over several years. We ask specifically how the monsoon variability affects the carbon stocks. We have employed allometric equations to estimate the biomass and carbon stocks. We analyzed the changes in the carbon stock and related that changes to amount of rainfall received. We further discuss the impact and significance of monsoon variability in Carbon dynamics. We also discuss the larger implications of climate change on forest systems of peninsular India and importance of dendrochronology in understanding dynamics of Carbon sequestration

Poster

## Permafrost melting and ecotoxicological consequences in a periglacial lake in the Eastern Alps: Answers from the past and present

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Understanding how climate change influences mountain lakes both directly and indirectly by modifying catchment processes is central to ongoing and future research. Special emphasis is now placed on problems associated with the interactions between climate change, the melting mountain permafrost, enhanced pollutant release, and ecosystem health. Our study aims to contribute to the current understanding of the linkages between warming-related processes of excessive metal release from melting rock glaciers and potential ecotoxicological risks in high-alpine lakes. Here, we report the initial results from our ongoing research on lakes situated in a periglacial environment in the Öztal Alps, Central Eastern Alps, Italy. The focus of the research is the assessment of ecotoxicological effects of trace metal inputs from an active rock glacier on the present-day ecosystem of Rasass See, a remote high-alpine lake (2680 m a.s.l.), and the reconstruction of changes in the ecotoxicological state of the lake during the Holocene caused by warming-related increases in discharge of metals from the rock glacier. In order to assess the current ecological status of this lake, where levels of nickel in water exceed its limit for drinking water by one order of magnitude, concentrations of trace elements were measured in the surface sediments and tissues of aquatic macrophytes and invertebrates. The measured values were used to assess the biomagnification factor of trace metals through the benthic food chain in the lake and to compare it with values measured in reference lakes without rock glaciers in their catchment. Frequency and severity of morphological deformities in chironomid larvae (Diptera: Chironomidae) from the lake were comparable with those recorded in lakes polluted by agricultural and industrial chemicals. The incidence of morphological deformities in living chironomid larvae is reflected well in their subfossil assemblages that yield a robust basis to reconstruct changes in the frequency of deformities and periods of critical ecotoxicological situations in the past.

Poster

## Late Holocene biological assemblages of Mansar Lake (District Nagpur, Maharashtra, India) in the context of Palaeoecology and neo-ecosystem dynamics

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Studies on ecosystem dynamics deal with the contemporary environmental processes operating in a given geographical region representing complex systemic interactions amongst landscape, topography, flora, fauna, climate, human interference, soil-cover, geological formations, etc. Palaeoecology, on the other hand, deals with the historical processes through multi-disciplinary studies involving palaeobiological, archaeological, physic-

chemical an absolute dating of sediments. Later phases of late Holocene deposits provide a meeting hub for palaeoecological and neo-ecological studies as both the disciplines can potentially facilitate insights for "cause and effect" relationship, useful for seeking sustainable environmental applications for societal utility.
The paper deals with a multi-proxy palaeoecological study on a late Holocene biological assemblages from Lake Mansar (21 20E:79 20N) situated in Nagpur district of Maharashtra State, India. This shallow freshwater lake site is formed by impounding the rivulet during early Historical period. It falls under hot tropical, sub-humid eco-climatic zone of erstwhile central province of India receiving annual average rainfall varying from c. 1000 to 1250 mm. The major amount of precipitation results from southwest monsoon, from mid-June to mid-September and minor amount during winter season from the retreating monsoon. The lake lies at the base of a well excavated. Historical hilltop settlement of Mansar exhibiting three cultural phases of occupation and construction activities from c. 200 B.C. to 700 A.D.; namely Period I (c. 200 B.C.-200 A.D.), Period II (c. 250 -500 A.D.) and Period III (c. 500-700 A.D.). There is a also an epigraphical and architectural evidence for bunding of rivulet (nullah) during Early Historic period (Personal communication: Joshi and Sharma). The archaeological excavations were carried out by J.P. Joshi and A.K. Sharma at the hilltop settlement (about 10 to 20 m above lake level) while the palaeocological excavations (trenching) were carried out by our team (under the Research Project to 1st author by Deccan College) in the foot-hill lake of Mansar to understand mutual interactions and climatic fluctuations, if any, during the immediate past. Bio-geolological variations of the lake during last circa two thousand years indicate hydrological change which could have been partly due to man-made activities as also natural environmental changes and discerning the two types of changes is difficult at this stage.
Thus, our multidisciplinary studies involving litho-stratigraphical, pollen analytical, radiocarbon, palaeontological, phytogeographical, neo-ecological approaches are being integrated for holistic unraveling of palaeoenvironmental changes of sub-recent biological diversity prevailing in the region. The vegetation and agricultural-botanical study of the hill-slopes and adjacent low-lying valley strips (mainly carried out by the first author during his initial research career around sub-humid hilly terrains around Pune and during later years, the second author participated in field visit) with respect to hill slope soils under semi-humid to sub-humid climatic regime with basaltic terrain of western India could possibly suggest comparable ecosystemic parallel for understanding relevance of the 'palaeo' processes during sub-modern period contemporary society.

Talk

## Regional-scale dynamics in humid, late Holocene broadleaf forests

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In humid, broadleaf-dominated forests where the prevailing disturbance regime is perceived as gap dynamics, paleoecological evidence shows regional-scale changes in disturbance regimes and forested ecosystems in association with climatic variation. Yet, there is little evidence of regional-scale disturbance linked with specific climatic triggers in extant forests. We use 76 tree-ring collections covering 840,000 km$^2$ and 5.3k tree recruitment dates spanning 1.4 million km$^2$ of the eastern United States to investigate the potential for regional-scale dynamics in late-Holocene forests through time. Specifically, we test a null hypothesis of gap dynamics in which disturbance and tree recruitment would resemble a white-noise process: forest dynamics would not be regionally synchronous and time-series of disturbance and recruitment would not deviate significantly above the long-term background rate. Importantly, we find that both time-series of forest dynamics reflect the annual, stochastic patterns of gap-dynamic processes expected in closed-canopy forests. However, both series also reveal the occurrence of regional-scale dynamics that are outside the envelope of gap-dynamic processes. Growth-release analysis of the 76 populations indicates severe canopy disturbance over 42,800 km$^2$ from 1775-1780 peaking in 1776. The 1776 event is nearly seven sigmas above the 1685-1880 mean rate of disturbance. We also find that during years and periods of elevated disturbance, canopy disturbance is often more severe and occurs at broader spatial scales than the long-term mean. Climate plays a critical role in these dynamics as years of elevated disturbance are significantly associated with prior drought. Particularly, the 1775-1780 event was preceded by repeated drought as well as an extensive, severe frost event in 1774. A pulse of tree recruitment, composed of 34 different species, occurs over much of the eastern US during the late-1600s. According to multiple geologic and tree-ring based estimates of hydroclimate, a dry and highly variable climate precedes and occurs during this recruitment event.
These two large, biodiverse, and geographically widespread data sets indicate that "white-noise" processes are not the sole drivers of forest dynamics in a humid, broadleaf-dominated region. Rare and intense events occurring 230-360 years ago are still influencing today's old-growth forests across much of temperate eastern North America. In fact, the time-series of canopy disturbance is so poorly described by a Gaussian distribution that it can be considered 'heavy tailed' or a 'Black Swan' event, an event that can alter ecosystem trajectory. Similarly, the late-1600s recruitment event is of a scale and intensity that has not been previously described in extant forests of the eastern US. While it is well known that historical events resonate through the structure and dynamics of forested ecosystems for centuries, events from centuries ago have been uncovered for the first time at annual resolution that are still reverberating in today's broadleaf forest. Given evidence of two Black Swan events and drought-driven disturbance, our results provide mechanisms of how climatic events can shape broadleaf forests for centuries. These insights

are critical given the potential for more frequent extreme climatic events and rapid, regional-scale forest turnover with future climate change.

Poster

## Geochemical signals of organic matter in sediments of Pichavaram mangrove-estuarine complex, Southeastern coast of India: Implications of anthropogenic influence

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Sediment constitutes an essential compartment of an ecosystem where products from natural processes and anthropogenic influence accumulate with time. These sediment act as an archive for different environmental conditions, which leave geochemical signals in sediment that can be used to interpret both contemporary and paleoenvironmental histories. Organic matter (OM) preserved in sediment represent a unique reservoir of information about the biogeochemical processes in the geological past, and how these processes responded to environmental changes. The objective of the study was 1) to assess the geochemical signals through characteristics of organic matter from the Pichavaram mangrove-estuarine complex and 2) examine polycyclic aromatic hydrocarbons (PAHs) as biomarker for degree of hydrocarbon contamination. Five sediment cores were collected from different locations of the Pichavaram mangrove-estuarine complex. Each of these locations exhibited distinct characteristics with respect to vegetation cover, land-use pattern, and anthropogenic influence. Sediment cores were dated using lead-210 chronology and subsequently analysed for grain-size composition, pore water salinity, dissolved organic C (DOC), loss-on-ignition (LOI), elemental ratios (C/N and H/C), pigments (Chl a, Chl b, and total carotenoids) and polycyclic aromatic hydrocarbons (PAHs). Our results showed relatively high concentrations of pore-water DOC (32 ± 14 mg/L) and low salinity levels (50 ± 5.5‰) in locations from mangrove areas than estuarine areas. Likewise, LOI, organic C and N, and pigment concentrations were also higher in mangroves than estuarine areas. Source apportionment studies revealed that OM was mainly derived from upstream terrestrial matter and/or mangrove litter, and marine OM. The bulk parameters of organic matter indicated that the Vellar and Coleroon Estuaries are more affected by anthropogenic processes than mangrove forests. The source and vertical distribution showed an increased up-core in PAH flux in sediments which coincide with rapid urbanization since the 1970s. The flux showed a decrease in recent years (since 1990), which coincide with less riverine discharge to mangrove-estuarine complex. The low concentration of high molecular weight (HMW) PAHs in older sediments specified the direct impact of increasing anthropogenic activities in the area. Diagnostic PAH ratios showed that most PAHs in the sediments are derived from petrogenic sources, with a limited input from pyrogenic processes involved with combustion of firewood and lignite. In both estuarine and mangrove sediments, the sediment toxicity values remained far below the effect range low (ERL) and effect range medium (ERM) limits for LMW and HMW PAHs. Thus, despite the fact that PAH concentration increased, these compounds do not represent an immediate ecological hazard.

Poster

## Holocene environmental variability – a high-resolution study from northeast Finland

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Environmental variability during the Holocene is, though not as pronounced as during glacial periods, commonly acknowledged to have been of considerable significance both to the flora/fauna and to human civilization. An exceptionally long lake sediment core retrieved from Lake Loitsana, northeastern Finland, allows for environmental reconstructions to be conducted with a decadal resolution. Our study covers the entire Holocene but with emphasis on mid to early Holocene; the aim is to quantify July temperatures and reconstruct environmental conditions such as catchment erosion, trophic status and vegetation development directly after the deglaciation and throughout the Holocene. Furthermore, the timing and magnitude of the Holocene thermal maximum (HTM); a warming which is mostly pronounced in the Northern Hemisphere and with summer temperatures 1-2°C higher than today, has been assessed. The methods used in this study include biogeochemical data (loss on ignition and C/N measurements), macrofossil analysis, diatom analysis, chironomid analysis, lithological characteristics and AMS $^{14}$C dating. A radiocarbon date on tree Betula seeds indicates that the area was deglaciated prior to 10 700 cal. yrs. BP and preliminary plant macrofossil and chironomid results suggest that a peak in temperature occurred already during early Holocene; a time when summer insolation was at its highest. Aquatic macrofossil taxa, i.e. *Glyceria lithuanica*, indicate mean July temperature of minimum 15°C at 10 700 cal. yrs. BP which is 2°C higher than present day climate. Diatom assemblages indicate changes in water depth as well as trophic state. The vegetation immediately after deglaciation in the Early Holocene appears to have responded rapidly to the summer insolation peak after the influence of the ice-sheet was diminished. The reconstructed timing of the HTM is inconsistent with quantitative pollen-based temperature reconstructions.

Poster

## Mid to Late Holocene climatic history of rangelands from Spiti Valley, Trans-Himalayas

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The arid landscapes of Trans-Himalayas covers the high altitude region of the Tibetan Plateau and its marginal mountains spread over 2.6 million sq km in the rain shadow of the greater Himalayas. These arid landscapes cover vast stretches of rangeland ecosystems, dominated by graminoid biomass. Being least productive ecosystems on earth, they have a unique assemblage of wild life populations. The region is one among the few places on earth that continues to support Pleistocene period large wild herbivores. The Pastoral activity in the rangelands dates back to several millennia with domestic ungulates sharing forage resources with wild herbivores. Competitive effects of resource overlap between livestock grazing on wild ungulates and hunting have resulted in local extinctions and overall decline in the population of wild herbivores from the region. A history of intensive livestock grazing, however, has led to local extinctions of wild herbivores from several regions. We have set out to understand the history of climatic and anthropogenic impacts on rangeland vegetation in order facilitate restoration and re-wilding. Given the importance of the rangelands in the Trans-Himalayans, our understanding of past vegetation composition which presumably supported a greater diversity of wild herbivores is limited.
Against this background, to understand past vegetation and species extinctions brought about by climatic changes in the region, we have collected 2 sediment cores from swamps in Kibber Plateau, Spiti Valley. We are using multi proxies such as, pollen, fungal spores, charcoal and geochemical evidence (C/N, %C, %N and $\delta^{13}C$) to reconstruct the historical events. Our initial results from geochemical proxies are presented here. The $^{14}C$ age of the two cores cover a period of 6.3 kyr BP(core-1) and 5.9 kyr BP (core-2). $\delta^{13}C$ from Core-1 has values ranging between -29.09‰ to -16.62‰ and core-2 between -22.38‰ to -10.79‰. Total organic carbon from the two cores vary between a high of 14.7% and 7.67% and a low of 1.04% and 2.85% along with nitrogen values between 0.85% to 0.13% and 0.38% to 0.11% respectively. Variations in C/N ratio from core-1 is between 17.86 to 6.38 and Core-2 is 32.48 and 15.38. C/N ratios and low values of $\delta^{13}C$ from core-1 when compared to Core-2 suggests that the proportion of organic carbon is more from planktonic source than from the terrestrial plants. The variation in $\delta^{13}C$ of core-1 with corresponding C/N ratio reflects predominance of $C_3$ type when compared to core-2 having $C_4$ type of vegetation. Around 6 kyr to 5 kyr BP, Core-1 shows no significant correlation with %C and C/N, suggesting the organic carbon source from the swamp itself and shows low value of $\delta^{13}C$ (-24.60‰). However, Core-2 showed significant correlation with high value of $\delta^{13}C$(-19.16‰) during this period. Between 4kyr to 2kyr BP a positive trend is seen in core-1 with C/N and %C, and $\delta^{13}C$ varies between -4‰ to -2‰ with a mean of -20‰. Core-2 had no correlation between C/N and %C and $\delta^{13}C$ fluctuating between -4‰ to -2‰ with a mean of -17‰ is observed. This reflects predominance of $C_4$type with drier conditions during this period. Climatic signals inferred from two cores through $\delta^{13}C$ is associated with $C_3$-$C_4$ transition in vegetation alternating with wet and dry phases since 6 kyr BP.

Talk

## Long-term perspectives on landscape structure, ecological change and biodiversity during the Quaternary; comparisons between NW European Pleistocene fossil beetle assemblages

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Climate has been in continual flux over the Quaternary, and is directly or indirectly the primary determinant of the distribution of most insect species. The story of European Pleistocene beetles has been one of local extinction and invasion in response to climate and latterly, human impact. While many species have clearly changed their ranges compared to their modern distributions, none seem to have become globally extinct – at least in temperate latitudes - something that at first seems counter-intuitive in view of the perturbations of Pleistocene climatic events. Perhaps one of the striking aspects of these patterns concerns the similarity of the NW European fauna in the different warm and cool periods. The re-expansion of thermophilous species seen at the end of the last glaciation and in the early Holocene is no more than a coming together of a species configuration that have occurred many times previously, although each interglacial appears to have had its own novelties. How similar or dissimilar where assemblages between different warm stages? Why are some periods very similar, others far less so? One might expect ecological configurations to have become increasingly dissimilar, the further back one goes in time. However, this is far from the case. What drives these communities? There are in excess of 100 published interglacial and interstadial sub-fossil beetle assemblages (excluding the late glacial interstadial) from the British Isles alone. These assemblages contain detailed species-level data, thereby offering the opportunity to examine long-term species and ecological trends against a changing climate story. We have examined these assemblages to investigate what drives faunal configurations; in particular, we assess the varying role of magafaunal herbivory and disturbance in creating novel communities and associated landscape spatial heterogeneity. Herbivory in particular appears to have had important, differing ecological repercussions during warm stages within invertebrate and plant groups, with associated implications for ecosystem processes and function. Here, we focus on changing ecological groupings of dung beetles, sand & gravel indicators, wood/tree and open/meadow species and present analyses from a range

of sites dated to MIS stages 5e, 7, 9, 11 and several early Middle Pleistocene sites and compare results with the Holocene record. We examine three interlinked questions:
(1) Did landscape spatial heterogeity change over the different stages studied and did this affect biodiversity in different ecological groups?
(2) What was the role of disturbance and herbivory in these periods and how do these compare with the present interglacial? Did they play an important role in biodiversity?
(3) How did biodiversity in the ecological groups examined change over the periods represented by the study sites?
Methodologically, this work also prompts difficult questions such as appropriate measures of past biodiversity and whether modern rarity categories are appropriate for the study of past species.

Talk

## Assessing the importance of climate and human activity on past and present fire dynamics

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In a world where biomass burning is steadily increasing, understanding fire's linkages to climate and human activity becomes increasingly important. Reconstructions of past fire provide a critical source of information to assess the role of climate and land-use change in altering fire regimes. A variety of paleofire proxy data (e.g., satellite, historical, tree rings, lake sediments, ice cores) is now available, and scientists within these communities have been actively engaged in data synthesis and database development. The Global Palaeofire Working Group, for example, has published important papers describing past trends in biomass burning at regional to global scales. These syntheses generally point to temperature as the primary driver of biomass burning, outweighing the influence of humans until (possibly) recently. In contrast, studies at finer scales highlight the importance of prehistoric humans in altering natural fire regimes by changing the frequency and timing of ignitions and modifying fuels. In between global and local-scale reconstructions lies the scale where human and climate probably interacted to shape fire regimes. Three examples from temperate forest ecosystems illustrate fire's long-term role in shaping ecosystem dynamics and the opportunities for paleodata to inform fire management: (1) In the western US, charcoal data disclose the time since last fire and the long-term trajectories in fire area and frequency that relate to changes in climate and vegetation. Fire histories show considerable spatial variation as a result of sharply defined climate and fuel boundaries in a heterogeneous region, and the signature of anthropogenic burning is less clear. Understanding climate-fire-ecosystem links in the western US helps determine which ecosystem types and fire regimes are most altered by 20th century fire suppression and land-use change and which are most likely to burn in the future. (2) In northwestern Patagonia, the position of the forest-steppe ecotone is governed by climate change along a steep environmental gradient. Holocene charcoal records suggest that nonclimatic (human) drivers altered fire activity at a subregional scale and the resulting fire-fuel feedbacks shifted vegetation between forest and grassland stable states. Understanding the sensitivity of this ecotone to fire helps target areas of highest priority for fire management. (3) In New Zealand, prehistoric fires were rare prior to the arrival of Maori, ~700 years ago, and widespread use of fire during an initial burning period permanently transformed the natural vegetation. Return to pre-Maori forests would require almost full-fire suppression to convert the vegetation to less flammable, late-successional types. In summary, paleofire data provide unique insights about the dynamics that link fire, climate, fuel, and people across temporal and spatial scales and our best source of information for assessing the resilience of forest ecosystems to climate change, the rate and trajectory of recovery following disturbance, and the role of human activity in modifying fire regimes. The challenge for paleofire researchers is to make such data relevant and meaningful to land managers addressing the consequences of altered fire regimes in the face of current climate and land-use change.

## OSM15: The Role of Ocean Circulation in Climate Dynamics

Convenors: Frank Lamy, Jörg Lippold, A. D. Singh, Devesh K Sinha

Poster

### Sub-centennial Holocene fluctuations of Atlantic water inflow and sea ice distribution in the western Barents Sea, European Arctic

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The North Atlantic Current (NAC) brings warm and saline water into the Arctic: this inflow is balanced by the outflow of cold surface water and by the formation of deep water to the south, which is part of the Atlantic Meridional Overturning Circulation (AMOC). Changes of the AMOC can greatly affect the global ocean circulation and climate, especially at high latitudes where the inflow of warm water, heat exchange and its effect on sea ice formation is essential for environment and society. Hence, it is crucial to establish the natural range of oceanographic fluctuations within this area. Here we investigate a continuous high resolution record from the Kveithola Through, western Barents Sea, in order to elucidate the past variability of the Atlantic Water flow and sea ice distribution throughout the Holocene.
The age model is based on nine AMS $C^{14}$ dates, and shows sediment accumulation rates up to 0.034 mm/yr, enabling a sub-centennial resolution. Planktic foraminifera and stable isotopes were analysed. In addition, the sea ice biomarker $IP_{25}$ is measured in order to establish a reconstruction of temporal changes in sea ice cover. Finally, Mg/Ca ratios will be presented in order to further quantify the surface water mass properties as SST and SSS.
The planktic foraminiferal stable isotopes show warming at ca. 10 000 cal yr BP followed by a cooling from ca. 8 000 cal yr BP until present day conditions. This long-term cooling correlates to the decreasing June insolation at 70° N following the orbital forcing. The planktic foraminiferal fauna has two dominating species: the polar N. pachyderma (sin) and the sub-polar T. quinqueloba. The early Holocene is dominated by N. pachyderma (sin), while throughout the mid and late Holocene T. quinqueloba dominates the fauna with values up to 75% possibly reflecting a high nutrient availability close the sea ice margin. The sea ice indicator $IP_{25}$ shows that the core site is influenced by sea ice in the early Holocene. From ca. 8 500 to 2 500 cal yr BP the sea ice gradually decreases. After this time the $IP_{25}$ record increases suggest a returned appearance of sea ice although in a smaller extent than during the early Holocene.

Talk

### Influence of the tropical hydrologic cycle on Atlantic meridional overturning at the end of the last interglacial

***Benjamin Blazey***[1], Matthias Prange[1], Andrè Paul[1], Aline Govin[1]

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In this study, we examine the state of the Atlantic thermohaline circulation at the end of the last interglacial (129ka to 116 ka). More specifically, we consider the effect of tropical precipitation changes on modulating the salinity of the North Atlantic, and the persistence of the thermohaline circulation during the formation of continental Northern Hemisphere ice sheets. We utilize a combination of tropical precipitation reconstructions and modeling scenarios to investigate the teleconnection between the tropics and North Atlantic. The tropical rainfall records derive from marine sediment core transects from the South American and African margins in the tropical Atlantic. The rainfall reconstructions are translated into forcing fields for general circulation model experiments using the Community Climate System Model (CCSM). In this study, we report the results of two primary sets of model experiments. In the first we compare paleoclimate simulations of the last interglacial using CCSM to the sediment core based reconstructions. Second, we report the results of an ensemble of sensitivity experiments in which we investigate the role of modeled and reconstructed tropical precipitation changes on the North Atlantic salinity and deep water formation. More specifically, we report how modifications to the precipitation the ocean receives in the tropics propagate to the North Atlantic and in turn impact the deep water formation. The work will continue with an investigation of the role a persistent thermohaline circulation has on the formation of Northern Hemisphere ice sheets.

Poster

### Location of the Marine ITCZ in the Atlantic Ocean over the last 30 ka

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The Atlantic Intertropical Convergence Zone (ITCZ) is a major atmospheric feature of the tropical ocean driving wet and dry seasons for many countries in South America and Africa. Understanding past shift of the mean position of the ITCZ in response to high latitude conditions and isolation forcings is crucial to forecast future climate in a shrinking polar ice world. A number of terrestrial and coastal records have already shown large displacements of the ITCZ with changing climate but these records bear the influence of land-driven ITCZ displacement. Over continental areas seasonal displacements of the ITCZ are very large, on the contrary, the ITCZ over the Ocean

has a much reduce seasonal shift, its mean position in the Atlantic Ocean is located at 5˚N. In this work, we reconstructed the location of the marine ITCZ in the Atlantic Ocean and study its variability over the last 30 ka. We used a series of 15 sediment cores located along the mid-Atlantic from 26˚N to 17˚S. We measured the stable oxygen isotope and Mg/Ca composition of the foraminifer G. ruber and calculated thermal and salinity gradients change at millennial resolution over the transect. Our reconstruction shows large changes of the salinity minimum and temperature maximum bands both in their latitudinal positions and intensities.

Poster

## Eastern South Pacific water mass geometry during the last glacial-interglacial transition

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The eastern South Pacific is characterized today by a complex thermocline structure where large salinity and oxygen changes as a function of depth coexist. Surface waters from tropical origin float on top of subantarctic fresher water (the so-called 'shallow salinity minimum of the eastern south Pacific'), which in turn, flow above low oxygen and high nutrient equatorial subsurface waters and deeper, recently ventilated Antarctic Intermediate waters. Little is known however about the water mass geometry changes that could have occurred during the last glacial maximum boundary conditions (about 20,000 years before the present), despite this information being critical for the assessment of potential mechanisms that have been proposed as explanations for the deglacial onset of low oxygen conditions in the area and the atmospheric $CO_2$ increase during the same time.
Here we present benthic and planktonic foraminifera stable isotope and radiocarbon data from a set of sediment cores from the Chilean continental margin covering a large -yet still limited- geographical area and depth range. Sedimentations rates were relatively high (>10 cm/kyr) precluding major caveats from bioturbation in all of our archives. The distribution of $\delta^{13}C$ of $\Sigma CO_2$ shows the presence of a very depleted ($\delta^{13}C$ < -1‰ V-PDB) water mass overlaying more recently ventilated waters at intermediate depths as indicated by thermocline foraminifer dwellers being more depleted in $^{13}C$ than the benthic species. The origin of this depleted end-member is probably upwelling from the Southern Ocean as expressed by the radiocarbon content and the large reservoir effect associated with the last glacial maximum and the beginning of the deglaciation along the margin. Our data suggest that the Tropical waters that today bath the lower latitude cores was displaced by surface waters of southern origin and therefore in line with the evidence of a latitudinal shift of the frontal systems.

Poster

## Reconstructing Plio-Pleistocene Intermediate Water Temperatures Using Mg/Ca of Infaunal Foraminifera (Uvigerina peregrina)

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The reconstruction of past surface, intermediate and deep-water temperatures is critical for our understanding of feedbacks within the ocean-climate system. Proxies for determining the paleotemperature of interior water masses have many caveats including the 'Carbonate Ion Effect' on the Magnesium to Calcium ratio (Mg/Ca) of benthic foraminifera. Recent studies have demonstrated that the shallow-infaunal species, Uvigerina peregrina, co-precipitates Mg independent of carbonate saturation state, affording the use of $Mg/Ca_{Uvigerina}$ for Quaternary paleotemperature reconstructions.
Herein, we present the first record of intermediate water temperatures for critical time-periods during the Pliocene and Pleistocene, including the Mid-Pleistocene Transition (MPT), from a sediment core in the Southwest Pacific (DSDP site 593; 40°30'S, 167°41'E, 1068m water depth), within the core of modern Antarctic Intermediate Water (AAIW). By comparing $Mg/Ca_{Uvigerina}$, $Mg/Ca_{Cibicidoides}$, and $\delta^{18}O_{Cibicidoides}$, a multi-proxy approach helps to further demonstrate the utility of Mg/CaUvigerina as a paleotemperature proxy, without effects of carbonate ion. We then examine the changing structure of the interior Southern Ocean through the Plio-Pleistocene by comparing our new intermediate-water paleotemperature estimates with sea surface paleotemperature estimates generated using the alkenone-derived $U^{K}_{37}$' index from the same site, as well as deep-water paleotemperature estimates from a proximal site, ODP site 1123 (3290m water depth). Intermediate water temperature reconstruction is particularly important since intermediate waters, including AAIW, are proposed to be a main driver in high-low latitude teleconnections. However, quantitative information about how intermediate waters evolved through the Plio-Pleistocene remains scarce. The production strength and depth of intermediate water formation in the Southern Ocean is directly tied to the location of the Sub-Antarctic Front (SAF). DSDP site 593 lies just north of the modern SAF, and its location is presumed to oscillate between north and south of the front according to the orbitally-timed latitudinal migration of the SAF. Consideration of changes to the SAF is made possible through comparison of Southwest Pacific sea surface temperature record with a high-resolution sea surface temperature record from the South Atlantic (ODP site 1087; 31°28'S, 15°19'E, 1374m water depth), which also lies just north of the modern SAF.

Poster

## Holocene Atlantic bottom water inflow at the western Barents Sea margin, European Arctic

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The northward flow of warm and saline Atlantic Water forms an integral part of the Atlantic meridional overturning circulation (AMOC). Variability in the AMOC can affect the convective formation of deep water in the Nordic Seas and thereby the global ocean circulation. Additionally, variations in the inflow of Atlantic Water govern the ecological conditions at higher latitudes. Hence, it is crucial to establish the natural range of oceanographic fluctuations.
Here we investigate a high resolution record from the western Barents Sea margin to elucidate any changes in the flow of Atlantic Water into the Arctic Ocean during the Holocene. Benthic foraminiferal assemblages and $\delta^{18}O$ values (*Cassidulina neoteretis*) indicate rapid bottom water warming at the start of the Holocene with a replacement of the cold water species *E. excavatum f. clavata* by species such as *C. neoteretis and Cassidulina reniforme*, associated with cooled Atlantic Water. From ca. ± 10.000 to 2.000 cal. yr. BP. the foraminiferal assemblage indicates stable conditions while the $\delta^{18}O$ record shows a cooling trend that can be correlated with summer insolation at this latitude following orbital forcing. The bottom water properties will furthermore be investigated using Mg/Ca ratios measured on *C. neoteretis*. Opposite to the stable foraminiferal assemblages, there are two large lithological changes. Around 8000 and 1500 cal. yr. BP. both the grain size and the foraminiferal productivity increase, indicating an increase in bottom current strength and more favorable living conditions. This change probably represents an amplified, regional, inflow of Atlantic Water into the Barents Sea.

Poster

## Suborbital ice-sheets variability in the subpolar North Atlantic during the Early and Mid-Pleistocene (MIS 31–19) as a response of low-latitude forcing

***Iván Hernández-Almeida***[1], Francisco Javier Sierro[2], Isabel Cacho[3], José Abel Flores[2]

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A new high-resolution planktonic and benthic $\delta^{18}O$ time series, faunal-based sea surface temperature (SST) reconstructions and ice-rafted debris (IRD) records from the Integrated Ocean Drilling Project (IODP) Site U1314 (56.36°N, 27.88°W), in the subpolar North Atlantic, were examined to investigate orbital and suborbital climate, ocean hydrogaphy and ice-sheet dynamics during the Early and Mid-Pleistocene, from Marine Isotope Stage (MIS) 31 to MIS 19 (1069–779 ka). Benthic and planktonic oxygen isotopes, IRD and SST show a different pattern before and after MIS 25 related to the transition between 41-ka and 100-ka glacial-interglacial cycles which occurred during the Mid-Pleistocene Transition. Beside the glacial-interglacial (G-IG) variability and the large increase in Northern Hemisphere ice-volume, linked to the cyclicity change, we observe a persistent suborbital climate fluctuations, starting with an abrupt warming event that is followed by gradual and progressive cooling to culminate with an event of iceberg discharge at the time of maximum cooling or the ensuing prominent warming. Negative excursions in the benthic $\delta^{18}O$ time series observed at the times of IRD events may be related to glacio-eustatic changes due to ice-sheets retreats and/or to changes in deep hydrography. Time series analysis on surface water proxies (IRD, SST and planktonic $\delta^{18}O$) of the interval between MIS 31 to MIS 26 shows that the timing of these millennial-scale climate changes are related to half-precessional (10-ka) components of the insolation forcing, which are interpreted as cross-equatorial heat transport toward high latitudes during both equinox insolation maxima at the equator. These observations support the hypothesis that during the Early and Mid-Pleistocene, changes in low-latitude insolation forced suborbital climate variability at higher latitudes in the North Atlantic before the establishment of high-amplitude 100-ka glacial cycles from the Late Pleistocene.

Talk

## Mid-Holocene amplification of century scale climate variability - potential interhemispheric linkages

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Many high latutude paleoclimatic archives in both Hemispheres document an increase in the amplitude of climate variability and an emergence of stronger century scale (and sometimes longer) variability between approximately 5 and 4 ka. In the North Atlantic/Nordic Seas this change is accompanied by more widespread sea-ice cover, changes in the northward ocean heat flux and related parameters of the meridional overturning circulation. Accompanying these changes are growing glacier size in Scandinavia and the Alps, and a marked shift in wintertime atmospheric circulation over Northern Europe, with stronger influence of northerly winds in the winter season, as derived both from glacier records and lake records. In the Southern hemisphere several records point to marked changes in Southern Ocean frontal movements and dynamics related both to changes in the westerlies and ENSO-related influence of tropical waters at SH mid-latitudes. We here identify the characteristics of this marked shift in Holocene dynamics and explore the emergence and phasing of the changes both between paleoclimatic archives and spatially in terms of their interhemispheric phasing. The question of the degree to which the changes are synchronous or reflect a see-saw pattern between the hemispheres is explored via data analyses and data-model integration utilising output from the PMIP3/CMIP5 model experiments.

Poster

## Antarctic linkages to the deep water flow variability during the past 95000 years in the Indian sector of the Southern Ocean

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Palaeoceanographic reconstruction based on high-resolution benthic (*Cibicidoides wuellerstorfi*) stable isotope, mean sortable silt (SΣ) and magnetic grain size records in a sediment core (SK200/22a) from the Sub-Antarctic regime of the Indian sector of Southern Ocean depict the variations in global influence of Circumpolar Deep Water (CDW) and the southward spreading of the North Atlantic Deep Water (NADW). Interestingly, the marine isotopic stage (MIS) 1 and MIS2 are characterized by near constant variations in SΣ values, negating any significant changes in the flow during these periods. The MIS 2 - MIS 5 periods were characterized by a general increase in SΣ value with specific increases at around 91-88 kaBP, 80-78 ka BP, 73-72 kaBP, 56-52 kaBP and between 40-37 kaBP, supporting a strengthening of bottom-current activity that triggered winnowing at these periods. The SΣ records are supported by the low $\delta^{13}C$ values of *C. wuellerstorfi* during the glacials and some parts of MIS3 and MIS 5, confirming older nutrient-rich and poorly ventilated southern sourced deep waters at these periods. The core site is within the influence of ACC-CDW current, where it merges with NADW, apparently restricting the southward transport of northern source deep waters during these periods. The termination I is marked by decrease in flow speed and an increase in the *C. wuellerstorfi* $\delta^{13}C$ values. Comparison of SΣ and *C. wuellerstorfi* $\delta^{13}C$ record with the Antarctic ice core records reveal that pulses of reduced bottom water flow of CDW/NADW are synchronous with the Antarctic warming Events (A1-A7). Accordingly, the Antarctic warming events are co-eval with a weaker bottom flow that transported finer magnetic grain size, which seem to be particularly sensitive to fluctuations of the CDW/NADW variations. The decreased flow speed during the Antarctic warm events may be due to the lower production rate of southern-sourced water or reduced density, leading to reduced geostrophic flow. During the cold phases of the Antarctic climate, enhanced southern westerly wind transport caused increased sea-ice export leading to increase in density of southern-sourced water, supporting a direct Antarctic linkage on the past changes in deep flow vigour in the study region.

Talk

## Increase proportion of Antarctic Intermediate Water off northern Chile (27°S) in glacial periods over the past million years

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While in the past the variability in the production of North Atlantic Deep Water was seen as the major trigger of rapid ocean circulation and climate change, processes occurring in the tropics as well as at high austral latitudes are now viewed as equally important. In addition, efforts are made towards the understanding of the role of intermediate water−mass changes in the global ocean circulation and climate. Among the intermediate water masses, Antarctic Intermediate Water (AAIW) is of particular importance. Of all it has the largest extension, forming at the Antarctic Convergence Zone and spreading as far north as 20°N. Moreover, AAIW plays an important role in the oceanic sinking of $CO_2$ and in rapid global−scale oceanic overturning processes. Besides, it provides a link transporting signals resulting from processes occurring at high austral latitudes to the rest of the oceans through the so−called ′ocean tunnel′. However, at present, few paleoceanographic reconstructions of the characteristics, strength and variability of intermediate waters on glacial−interglacial time scales exist, partially due to the lack of long, high−resolution sediment sequences at intermediate depths. With this contribution we aid to fill in this gap and increase our knowledge about changes in the distribution of the AAIW.
Here we present benthic stable isotope data from the long sediment core GeoB15016 (56 meters composite depth). GeoB15016 was recovered with the sea floor drill rig MARUM−MeBo at 956 m water depth, off northern Chile (27°29,48´S, 71°07,58´W). The sediments at this site presently are deposited at the lower boundary between AAIW and Pacific Deep Water (PDW), allowing long−term paleoceanographic reconstructions (orbital to sub−orbital time scales) in an area sensitive to AAIW variability.
The GeoB15016 composite record covers the time interval from 965 to 80 ka. In this interval, the benthic $\delta^{18}O$ and $\delta^{13}C$ records display orbital modulation. The benthic $\delta^{13}C$ record reveals a strong influence of PDW during interglacial periods (MIS 25 to 5) at the study site. This is indicated by the overlap in $\delta^{13}C$ values between our intermediate−depth site and deeper records in both the SE and equatorial Pacific. During glacial periods (MIS 26 to 6) the $\delta^{13}C$ records diverge, with the Geo15016 intermediate water record displaying higher $\delta^{13}C$ values. This suggests i) a shift in the mixing ratio between AAIW and PDW, with stronger influence of the more $\delta^{13}C$−enriched AAIW during glacials; or ii) changes in the properties of either water mass between glacial to interglacial conditions; or iii) a combination of both. A shift in water−mass mixing ratio could be related to a lowering of the boundary between AAIW and PDW due to global sea level change, but also to an increased production of the glacial equivalent of AAIW. We favour and discuss in our presentation the last option.

Poster

## Cold-water corals of the West: North Carolina contribute to a North Atlantic basin study

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The climate variability recorded for the last million years – and namely glacial-interglacial cycles – has been linked to reorganisations of the North Atlantic thermohaline circulation and water mass distribution. Recently, aragonite-forming cold-water corals (CWC) have become key archives to unravel intermediate water-mass history. Changes on the CWC distribution through time can reveal important insights into the oceanographic conditions that favour coral growth. Moreover, CWC can be accurately dated by means of mass spectrometric U-series dating, thus providing unique records of ocean circulation for the last ~300 kyrs.

Previous studies in the northeastern Atlantic observed a glacial-interglacial see-saw pattern of the CWC distribution: abundant coral growth occurred north of 50°N during interglacial periods (MIS1, 5 and 7); and south of 37°N during glacial periods (MIS2, 3, 4 and 6). Variations in the strength and flow path of the Mediterranean Outflow Water have been suggested to influence this pattern in the north. Oligotrophic conditions, weak tidal currents and changes in water mass density might have caused the CWC demise during warm climate stages in the Gulf of Cadiz and along the Moroccan margin.

While aiming to study CWC development at a basin-scale and its relation to the North Atlantic climatic cycles, we need to know how CWC distribution changed along the northwestern margin of the Atlantic. Here, we present fifteen ages of the CWC Lophelia pertusa sampled from mound structures at 320-500m water depth off Cape Lookout (Blake Plateau) on the North Carolina margin (34°N). Coral (on-mound) and sediment (off-mound) samples, obtained with box- and piston-corers, were used in this study. Uranium-series dating of fossil coral fragments was conducted using MC-ICPMS technology at LSCE (Gif-sur-Yvette). The chronology of one off-mound sediment core was further investigated through AMS-$^{14}$C dating (on planktonic foraminifera).

Our coral samples revealed interglacial ages, from Late- to Mid-Holocene and early Eemian (present and last interglacial, respectively). Hence, we found first evidence that CWC grew during interglacials in the temperate West Atlantic; while in the temperate East Atlantic little CWC development was reported during these warm periods. The temporal distribution of CWC off North Carolina resembles the pattern found much further north in the Eastern Atlantic. It is likely that the Gulf Stream glacial-interglacial cyclicity is somehow related to CWC development in the North Carolina margin.

Talk

## Stability of the thermohaline circulation during MIS3 in a comprehensive climate model: Towards a dynamical understanding of Dansgaard-Oeschger events

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Marine Isotope Stage 3 (MIS3) was a period of pronounced millennial-scale climate variability, associated with the most regular occurrence of Dansgaard-Oeschger (DO) events. The origin of DO events remains controversial, but there is strong evidence that variations in the strength of the Atlantic meridional overturning circulation (AMOC) were involved. A widely held view of DO dynamics involves switches between two states of different AMOC strength and many conceptual models have been suggested to explain the millennial-scale climate oscillations based on this concept of oceanic bi-stability. So far, however, no attempts have been made to systematically examine the stability properties of the AMOC in comprehensive coupled climate models under MIS3 boundary conditions. Here, we present results from a series of equilibrium water-hosing experiments using the Community Climate System Model version 3 (CCSM3, including a dynamic vegetation module) forced with MIS3 (38 ka before present) boundary conditions and North Atlantic freshwater perturbations ranging from 0.005 to 0.2 Sv. Without freshwater perturbation, the model simulates an equilibrium North Atlantic overturning-maximum of 17 Sv under MIS3 boundary conditions, which is 3 Sv stronger than in the pre-industrial control run. The southward flow of North Atlantic deepwater occurs at shallower levels in the MIS3 run than under modern conditions. We interpret this configuration as MIS3 interstadial state. This state is remarkably unstable with respect to minor North Atlantic freshwater perturbations, dropping to 10 Sv in response to a weak 0.02 Sv freshwater hosing. The associated reduction in oceanic heat transport leads to a pronounced interhemispheric seesaw pattern in surface temperature with a cooling over central Greenland of approximately 10 K and a warming of 0.5-1.5 K over Antarctica, consistent with the transition to a stadial climate state. For perturbations above 0.02 Sv, the AMOC shows an almost linear response to increasing freshwater forcing. Upon removal of the freshwater perturbation, the AMOC recovers, indicating the absence of multiple equilibrium states. In summary, our hosing experiments reveal a dramatic DO-type global climate shift associated with a non-catastrophic threshold for North Atlantic freshwater perturbations varying between 0.01 and 0.02 Sv. Thus, according to our model results, minor perturbations in the hydrologic cycle (e.g. related to ice-sheet processes) could have triggered substantial global DO climate transitions. Mono-stability of the ocean circulation in the coupled climate model implies that the atmosphere-ocean system alone was unable to produce multiple equilibria, such that other components of the climate system (e.g. continental ice-sheets) were probably involved.

Poster

## Mo isotopes in tropical estuaries: Implication to paleo-redox proxy

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Molybdenum isotope composition has been emerged as an important proxy to determine paleo-redox conditions of ocean throughout Earth's history. The quantitative interpretation of Mo isotope records in terms of redox conditions of ancient oceans critically depends on the Mo inputs and their isotope compositions entering the oceans. However, the inputs are poorly constrained. Mo enters the oceans predominantly via rivers. However, behavior of Mo in the estuaries and its associated isotopic fractionation is not resolved. Therefore, it is important to identify the processes responsible for Mo removal and its associated Mo isotope fractionation in the estuaries. Dissolved Mo isotopes ($\delta^{98}$Mo) were measured in five estuaries of India to understand its behaviour in the tropical estuaries. Systematic studies were carried out in the major estuaries viz. the Narmada, Tapi and the Mandovi estuaries lying in the Arabian Sea and the Hooghly in the Bay of Bengal. $\delta^{98}$Mo in all the estuaries analysed in this study is highly variable; ranges from 0.37 to 2.57‰. Dissolved $\delta^{98}$Mo shows conservative mixing in the Narmada estuary. In contrast, it shows non-conservative behavior with depleted $\delta^{98}$Mo in the Tapi Mandovi and the Hooghly estuaries. Depleted Mo isotope composition along with Mo loss reported earlier in the Mondovi and the Hooghly indicate its suboxic removal where heavier isotope is being lost preferentially to the pore water. Mo sinks and associated isotope fractionation during its removal in all major global estuaries need to be considered while using Mo isotope composition to study paleo-redox condition of the global ocean.

Talk

## Millennial scale variability in the upstream Agulhas Current

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Substantial evidence suggests that the transport of thermocline and intermediate water between the Indian and Atlantic, the so called 'Agulhas Leakage (AL)', may impact the vigour of the Atlantic Meridional Overturning Circulation (AMOC) and thus be an important climate driver on various timescales. The leakage occurs through 'direct' leakage and through ring shedding events of the Agulhas Current (AC) at its retroflection off the southern tip of Africa. While satellite altimetry data has shown a clear connection between the variation in the upstream Agulhas and the subsequent behaviour of the retroflection and ring formation, most palaeoclimate studies aimed at the reconstruction of AL within the South Atlantic. Based on these reconstructions it has been suggested that an increased Leakage during deglaciations may effectively regulate the buoyancy of the (South) Atlantic Ocean hence impacting the strength of the AMOC.
Here we present a high–resolution multi-proxy record from a marine sediment core located in the main upstream flow of the Agulhas Current, offshore Eastern Cape Province, that shows considerable variability in upper ocean temperatures, salinity and foraminiferal marker assemblages characteristic of AL (the so called 'Agulhas Leakage Fauna') on glacial-interglacial and millennial timescales. We find that warmer surface and sub-surface water temperatures during the Holocene, MIS 3 and 5 are associated with an increased abundance of subtropical planktonic foraminiferal marker species, whereas colder surface water conditions during the LGM and MIS 4 coincide with higher abundances of Globorotalia inflata and Neogloboquadrina pachyderma (dex.) species. The occurrence of these transitional species in the AC during Southern Hemisphere cold intervals, when other evidence shows the Southern Ocean frontal system was shifted several degrees northward compared to today suggest that a stronger and/or reorganised Agulhas Return Current Circulation likely had a significant impact on the upper water column properties of the AC itself.
We suggest this upstream AC variability is strongly linked to changes in the strength of the southwest Indian Ocean subtropical gyre (STG) and modification of the Agulhas Return Current circulation. Our study is in agreement with numerical model simulations, which demonstrate that the vigour of the STG is modified by intensified and/or shifted Southern Hemisphere westerlies leading to a modification of upstream Agulhas Current. These data highlight the need for estimates of past AL based on reconstructions close to the western tip of the Agulhas Retroflection to consider temperature/salinity shifts of the Agulhas Current.

Poster

## Evolution of the Mediterranean Outflow Water and its oceanographic - climatic implications: Preliminary Results of IODP Expedition 339 in the Gulf of Cadiz and west off Portugal

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The Northeast Atlantic is a critical region to understanding the evolution of the Mediterranean Outflow Water (MOW) and its impact on the Thermohaline Circulation (THC) and the global climate. During the recent expedition of the IODP(Expedition 339), the Gulf of Cadiz was targeted for drilling as a key location for the investigation of

MOW through the Gibraltar Gateway and its influence on global circulation and climate.It is also a prime area for understanding the effects of tectonic activity on evolution of the Gibraltar Gateway. This expedition drilled 5 sites in the Gulf of Cadiz and 2 off the west Iberian margin, and recovered 5.5 km of core with an average recovery of 86.4%. We present in this work the preliminary results of the studies carried out onboard the drilling RV Joides Resolution during the expedition.
We penetrated into the Miocene at two different sites and established a strong signal of MOW in the sedimentary record of the Gulf of Cadiz following opening of the Gibraltar Gateway. Preliminary results show contourite deposition from 4.2-4.5 Ma, although subsequent research will establish whether this dates from the first onset of MOW. The Pliocene succession, penetrated at four sites, shows low bottom current activity linked with a weak MOW. Significant widespread unconformities, present in all sites but with hiatuses of variable duration, are interpreted as a signal of intensified MOW, coupled with flow confinement. The Quaternary succession shows a dominant phase of contourite drift development, with two major periods of MOW intensification separated by a widespread unconformity. Following this, the final phase of drift evolution established the present contourite depositional and erosive features.
There is a significant climate control on the MOW evolution and bottom-current activity. However, from the closure of the Atlantic-Mediterranean gateways in Spain and Morocco just over 6 Ma and the opening of the Gibraltar Gateway at 5.3 Ma, there has been an even stronger tectonic control on margin development, downslope sediment transport and contourite drift evolution. Based on the timing of events recorded in the sedimentary record, we propose a long-term tectonic pulsing in the region, linked with lithospheric and asthenosphere activity.Preliminary work has also shown a remarkable record of orbital-scale variation in bulk sediment properties of contourites at several of the drift sites and a good correlation between all sites. The climate control on contourite sedimentation is clearly significant at this scale; further work will determine the nature of controls at the millennial scale.
[5]IODP Expedition 339 Scientists: Acton, G., Bahr, A., Balestra, B., Ducassou. E., Flood, R., Flores, J-A.,Furota, S., Grunert, P., Hodell, D., Jimenez-Espejo, F., Kim, J. K., Krissek, L., Kuroda, J., Li, B., Llave, E., Lofi, J., Lourens, L., Miller, M., Nanayama, F., Nishida, N., Richter, C., Roque, C., Sanchez Goñi, M., Sierro Sanchez, F., Sloss, C., Takashimizu, Y., Tzanova, A., Voelker, A., Williams, T., Xuan, C.

Poster

## Late Neogene planktic foraminiferal events of ODP Site 762B, Exmouth Plateau, eastern Indian Ocean: Regional Diachrony and evidence of late Pliocene Ocean Circulation Changes

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Sequential order of Late Neogene planktic foraminiferal events have been determined at the ODP Hole 762 B situated on the Exmouth Plateau in Eastern Indian Ocean. The site is under the influence of warm Leeuwin Current from the north and cold west Australian Current from the south and records a mixture of tropical (mostly Globigerinoides group) and temperate (Globoconnela group) planktic foraminiferal species. The planktic foraminiferal biostratigraphy was integrated with the available magnetostratigraphy which yielded numerical age estimate for 32 planktic foraminiferal events. Simultaneously we have also carried out planktic foraminiferal census counting to compare the faunal trends of upwelling indicator species and mixed layer species. Our result shows a major faunal turnover during Late Pliocene, between 3.58 Ma to 2.39 Ma when about 20 planktic foraminiferal events (FOs and LOs) have been recorded. This interval closely corresponds to entire duration of Chron C2 An. We also compared the results with a closely situated ODP Hole 763A (Sinha and Singh 2008), towards south of Hole 762B, and find that most of the events are synchronous while few are diachronous also. The observed diachrony has been attributed to the changing strength of Leeuwin and West Australian Currents in response to Late Pliocene climatic fluctuations. During this interval we also observe a significant declining trend in the Mixed layer Group and increasing trend in the Upwelling indicator groups. We attribute the Late Pliocene faunal turover to diminishing strength of the warm Leeuwin Current and more influence of cold west Australian Current in the eastern Indian Ocean and suggest that it might be related to the Northern hemisphere glaciation combined with Early Pliocene closing of the Indonesian Seaway.

Poster

## Meeting the challenge of global high resolution paleoclimate modelling.

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Given the dominant role of the Ocean in Earth's energy budget, large-scale paleoclimate events are often hypothetically linked to changes in the global ocean circulation. In turn, General Circulation Models (GCMs) have been widely used to evaluate the Ocean's ability to drive and respond to paleoclimate change. However, to date almost all paleoclimate GCM simulations are limited to coarse resolution models that fail to resolve mesoscale features that are known to dominate the oceanic kinetic energy budget. Inaccuracies in the representation of mesoscale ocean features, such as coastal boundary currents and eddies, can severely limit a GCMs ability to simulate the ocean circulation and it's related climate feedbacks. This study will outline both the need for high resolution paleoclimate simulations and the physical challenges associated with it. In particular, we address the following: Where and why are mesoscale ocean features important for the modeling of paleoclimate events? How strongly does model resolution influence the deep and near surface ocean circulation? What are some of

the implications of high resolution ocean modeling for biogeochemistry cycles? How is Access-OEP being used to meet the challenge of high resolution paleoclimate modeling?

Poster

## Oxygen Isotope–Salinity Relationship for Paleosalinity estimation in distinct water masses of Indian & Southern Ocean

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Present interest is to accurately quantify past salinity using the oxygen isotopic abundance ($\delta^{18}O$) of carbonates to understand the climatic variability of a region. Accurate reconstruction of past regional oceanic conditions requires precise oxygen isotope-salinity relationship ($\delta^{18}O$-SSS) of the specific area under the study. In this study, we present the $\delta^{18}O$-SSS relationship of surface sea water along a transect from the west coast of India to Antarctica at every degree latitude. We identify five distinct water masses based on $\delta^{18}O$ & salinity data. Previous studies have used data from the whole of Indian Ocean or Southern ocean to obtain $\delta^{18}O$-SSS relationship. But we are able to obtain more representative $\delta^{18}O$-SSS relationship as we have segregated the data pertaining to different water masses. Additionally, to account for temporal variability in $\delta^{18}O$-SSS relationship, we have plotted our data along with that of the previous studies corresponding to the water masses identified in the present study. We observed the presence of Subtropical Front and Polar Front at 44°S and 56°S respectively. The present dataset offers to bridge the existing gap in the present global grid of the $\delta^{18}O$ dataset. The relation thus obtained can be used to reconstruct paleo-salinity in the study region as it provides a more accurate relation between $\delta^{18}O$ and SSS. It would further help to understand the different hydrological process active in the two oceans viz. Indian and Southern ocean.

Poster

## Oceanographic and climate variability in the Bay of Bengal over the last 60 kyr BP: Foraminiferal evidences

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A gravity core (SK-218) raised from 3307 m water depth in the western Bay of Bengal (14°02'06" lat; 82°00'12" long) was investigated to construct various foraminiferal (planktic and benthic) proxy records for the last 60 kyr BP. The age model of the core is based on 8 AMS $^{14}C$ dates integrated with the oxygen isotope stratigraphy. High-resolution foraminiferal census data demonstrate major changes in assemblages at orbital to sub-orbital scales. Changes in the upper water column structure (temperature gradient, mixed layer vs thermocline depth and nutrient level) linked with fluctuations in the strength of the monsoonal climate are deduced by temporal variations of planktic foraminiferal proxy records. Record of the abundance pattern of mixed layer eutrophic species indicates that the paleo-productivity conditions at the core site are primarily controlled by the winter monsoon winds. Furthermore, the faunal evidences suggest that productivity was higher during the last glacial period as compared to the Holocene, but declined repeatedly at the millennial scale. Benthic foraminiferal assemblages were studied mainly for the temporal changes in the microhabitat categories (epifauna vs infauna), which are known to be linked with ocean bottom oxygen condition and organic carbon flux. The microhabitat patterns reveal that dissolved oxygen level of underlying waters in the western Bay of Bengal has considerably varied in the past at the millennial scale. The intervals of high abundances of epifaunal taxa and corresponding low abundances of infaunal species are indicative of oxic conditions. A coupling/decoupling between bottom oxygen condition and surface primary productivity and its global climatic implications are discussed.

Talk

## Reduced flow of North Atlantic Deep Water into the Arabian Sea during Last Glacial Maxima: Evidence from $^{187}Os/^{188}Os$ of the Arabian Seawater

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Records of Os isotope composition of the Arabian seawater since last 40 ka archived in two sediment cores taken from Arabian were tracked. The results display significant variation in $^{187}Os/^{188}Os$ of the Arabian Sea during last 40 ka. The $^{187}Os/^{188}Os$ of seawater in the most recent sample has a value of 1.04 ± 0.01, close to the Os isotopic composition of present day seawater (1.06 ± 0.01). The Os isotopic composition of the Arabian seawater varies in phase with that of the global ocean since last 40 ka except during the Last Glacial Maxima (LGM). During LGM, however, $^{187}Os/^{188}Os$ deviates from the trend set by the global ocean and shows an excursion towards higher 187Os/188Os. In addition, Os concentrations of the leachable fraction and Re contents of bulk sediments from the Arabian Sea are higher during the LGM. Higher concentrations of Re and Os in the sediments deposited during LGM indicate higher degree of anoxicity at the sediment water interface during LGM. This could be due to reduction in the oxygen content in the bottom water during LGM. Lower oxygen content in the bottom water of the Arabian Sea could have been caused by the reduced transport of polar waters (North Atlantic Deep water, NADW) into the Arabian Sea. Deviation of Os isotope composition of Arabian Seawater from the global oceanic trend and higher bottom anoxicity during LGM, thus, indicate the reduced supply of NADW to the Arabian Sea

during LGM, resulting in partial isolation of the Arabian Sea from rest of the oceans during the LGM.

Poster

## Seasonality reconciles the discrepancies of sea surface temperature evolution in the Indian Ocean during the last deglaciation

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Different proxies for sea surface temperature (SST) often exhibit divergent trends in tropical regions at times of terminations. In this study we report new SST records reconstructed from two commonly used paleothermometers (namely the foraminifera G. ruber Mg/Ca and the alkenone unsaturation index) from a marine sediment core collected in the southwestern tropical Indian Ocean encompassing the last 37,000 years. Our results show that SSTs derived from the alkenone unsaturation index ($U^{K'}_{37}$) are consistently warmer than those derived from Mg/Ca by 2-3 °C throughout the core. In addition, the initial timing for the deglacial warming derived from $U^{K'}_{37}$ SSTs started ~15.6 ka, which is in phase with temperature stack records from Northern Hemisphere that is marked by the Bölling-Alleröd temperature rise. In contrast, Mg/Ca SSTs deglacial warming led the $U^{K'}_{37}$ SST rise by 2.5 ka, and is in phase with timing from stacked temperature records from Southern Hemisphere. Moreover, the gradual decrease in $\delta^{18}O$ record derived from G. ruber in the same core is concomitant with deglacial warming trend observed in Mg/Ca SST record. We interpret the SST records of alkenones and Mg/Ca as being skewed toward contrasting seasons, with the $U^{K'}_{37}$ likely recording summer temperatures whereas the Mg/Ca SSTs recording winter temperature. Our interpretation implies that the warm season SSTs were primarily influenced by northeasterly winds transporting heat from the northern tropical Indian Ocean across the equator during austral summer. The deglacial warming trend was likely mediated by changes in the Atlantic Meridional Overturning Circulation (AMOC) at the onset of the deglaciation, as the alkenone-based SST record clearly mimics the deglacial SST trend recorded in the North Atlantic region for the earlier part of the termination. On the other hand, the glacial to interglacial SST pattern recorded by G. ruber Mg/Ca indicates that cold season SSTs were likely mediated by climate changes occurring in the southern hemisphere, as it closely tracks the Antarctic timing of deglaciation. Such interpretation describing contrasting SST features induced by seasonally-skewed paleothermometers is also apparent in the seasonal SST trends modeled by AOGCMs, and might explain similar proxy mismatches observed in other tropical regions at the onset of the last termination.

Poster

## Control of the Northern Hemisphere Ice Sheets on Glacial Climate Stability

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Glacial/interglacial cycle was marked by abrupt climate shifts of which mechanisms are generally interpreted by the bifurcation theory associated with hydrological variation in the Atlantic basin. However, the limited knowledge about hydrological change during glacial/interglacial cycles still hampers our further insight about its underlying mechanism that is supposed to be related to freshwater perturbations into the earth system in previous model studies. Here we employ a fully coupled earth system model to investigate the role played by the continental ice sheets in the Northern Hemisphere (incl. Laurentide ice sheet, Greenland ice sheet and Fennoscandian ice sheet) on abrupt climate shifts during glacial periods. We found that the sudden transition from the stadial/interstadial Atlantic meridional overturning circulation (AMOC) to the interstadial/stadial AMOC occurs when we gradually increase/decrease the ice sheets from its present-day (PD)/ Last Glacial Maximum (LGM) level to the LGM/PD level. In terms of the hydrological cycle in the Atlantic basin, the glacial climate is bistable/monostable as the ice sheets are close to/far from the threshold. Furthermore, varying greenhouse gas concentrations is able to trigger the transition from stadials to interstadials as the system approaches to the threshold. These results are related to the variation of surface wind fields associated with the elevation of ice sheets and the corresponding adjustment of the local air-sea interaction over the Northeast Atlantic, which improves our understanding about abrupt events without freshwater control. Our study suggests that the fluctuation of ice sheets during glacial periods modifies the stability of glacial climate by varying the surface energy budget and developing the local positive ocean-sea ice-atmosphere feedback over the high latitudes of North Atlatnic, which provides possibility for the variation of natural forcing to trigger the abrupt climate changes during glacial/interglacial cycles.

## OSM16: Open Session on Latest Highlights in Paleoscience

Convenors: Hubertus Fischer, Denis-Didier Rousseau, Liping Zhou

Poster

### Chronology of deposition of coastal Red dunes (Teri sands) in South India and its palaeoenvironmental implications

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Red sand dunes occur in the coastal plains of Tamil Nadu in the south coast of India between the co-ordinates of 8°00′ to 9°30′ N; 77°18′ to 79°00′ E. While most of the dunes in east and west coast of India are white and show much younger age of deposition (middle to late Holocene), the red dune sands found to have deposited since Late Pleistocene. Sections were excavated (5-12m) reaching up to the palaeo-surface as a part of a detailed investigation and samples were collected for optically stimulated luminescence dating, geochemistry, grain size and magnetic susceptibility measurements. The objectives of this study were, i) to find the onset of dune accumulation using OSL dating ii) dosimetric aspects of dune reddening and iii) changes in weathering index and geochemical proxies to constrain the humid intervals. Two representative sections (Muttom; 8°07′56″ N; 77°19′84″E and Kachanavilai, KCV-1; 8°33′51.9N; 78°00′43.0″E) from different morphological settings from east and west coast will be presented. At Muttom a 12m section comprised of partly consolidated sand at the base transiting to thin (~1m) loose sand at the top were studied. The dunes on this elevated promontory overlooking to the low lying coastal plain has the potential to preserve multiple periods of stacked records as the wind is flowing from a high energy environment to declining environment. The contact zone with bedrock over which the sand was deposited was highly weathered and deep gullies were formed in the dunes. OSL ages for the upper 5m of the section indicated sand aggradations between 18 ka to 9 ka and the loose aeolian unit at the top had an age of 0.7± 0.1ka. Bleaching experiments were carried out to check the pretext of attenuation of light due to the red coating on the sand grains, leads to incomplete bleaching of re-worked sands, on the loose, un-consolidated upper part of the deposits. It was observed that the sun lamp could bleach the luminescence signals to a near background level with in 10m of exposure on non-treated sample. The OSL ages of the upper part of the samples in Muttom section corresponds with periods of gradual strengthening of monsoon with intermittent dry intervals. This shows that the dune record preserved here is representative of a transition period from highly active dune to dormant, where the wind was still active and enhanced moisture from SW monsoon on the sand helped in weathering and soil formation led to vegetation growth and stability.
Sections at KCV-1 represents a relict surface with a ~4m thick sand resting on the underlying lateritic bedrock. The upper part of the section comprised of indurated red sand with nodular calcrete and topographically, it occurs as a relict mount. The preliminary ages (9-6 ka and 4-3 ka) for the upper part of the sands in the area indicates that the area had abundant sand through out the Holocene possibly from both the fluvial and littoral sources. OSL ages, grain size, geochemistry and magnetic susceptibility results of these sections will be presented

Talk

### A global reconstruction of temperature changes at the Last Glacial Maximum

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The Last Glacial Maximum (LGM, 19-23ka BP) represents the most recent interval when the global climate was substantially different to the present, and as such provides us with a key target in testing the response of climate models to large changes in radiative forcing. There is, however, significant disagreement even in such first-order diagnostics as the global mean temperature at that time, with estimates ranging from as much as 6°C to as little as 3°C colder than the pre-industrial climate, and this uncertainty limits our ability to critically assess climate model performance. Some recent comprehensive syntheses of proxy data both on land and ocean have provided a new opportunity for an improved assessment of the climatic state of the LGM. Here we combine these proxy data with the Paleoclimate Modelling Inter-Comparison Project ensemble of structurally diverse state of the art climate models to generate a spatially complete reconstruction of surface air (and sea surface) temperatures. Our reconstruction is significantly different to and more accurate than previous approaches and we obtain an estimated global mean cooling of 4.0 +/- 0.8°C (95% CI).

Poster

### Dynamics of a Snowball Ocean

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Neoproterozoic Snowball Earth events (~710 and ~635 Ma million years ago) challenge our understanding of the climate system and are an important test of our climate models. Snowball ocean circulation and mixing processes set melting/ freezing rates that determine ice thickness, influencing the survival of photosynthetic life, and are important for the interpretation of geochemical observations. We study, for the first time, the coupled dynamics of the ocean and a global, thick, ice cover. We find that ocean circulation can be energetic, strongly time-dependent, characterized by large equatorial meridional overturning circulation, zonal jets and convective mixing, rather than uniform and sluggish as often thought. Melting rates near continents may be ten times larger than previously estimated, possibly shedding new light on the survival of photosynthetic life during Snowball events.

Poster

## U-Pb age model for an Early Pleistocene stalagmite from Corchia Cave (Italy)

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Speleothems are well-established archives of palaeoenvironmental change. The proxy data that underpin their utility in this regard are numerous and derived from the study of the physical (growth rate and growth intervals, petrography) and chemical (stable isotopes, trace elements, fluid inclusions) properties of speleothem calcite. The major strength of speleothems when compared to other palaeoclimate archives, however, is that they can be accurately and precisely dated using the U-series decay scheme, allowing palaeoclimate series to be fixed in absolute time.
Virtually all speleothem-based palaeoclimate studies up until now have been confined to the Middle to Late Quaternary period because of the time constraints imposed by the practical upper limit of the U-Th dating method, i.e.~500 ka. Although recent advances in U-series isotopic measurements continue to push this boundary, the age of many speleothems clearly exceeds the U-Th limit. The possibility of probing the many important but unanswered questions in palaeoclimatology (and other fields, such as palaeoanthropology) using such older speleothems has traditionally been considered rather remote. However, the recent refinement of the U-Pb dating method for speleothems has opened up new research opportunities in this field. An important goal in this new frontier is to produce palaeoclimate records underpinned by accurate, robust age models and minimised age uncertainties, which together will increase the range of palaeoclimate questions that can be addressed by the speleothem community.
Here we present the first high-resolution U-Pb chronology of a single speleothem. Our main goal was to investigate the level of age-model precision that is achievable by applying high-resolution U-Pb dating comparable to that performed in studies of younger (U-Th dated) speleothems.The stalagmite (CC8) comes from Corchia Cave in Italy. Speleothems from this cave have already yielded useful palaeoclimate information for the latter part of the Quaternary. Their characteristics, such as high concentrations of uranium, low concentrations of common lead and thorium, and relatively well-constrained initial uranium-series disequilibria make them ideal candidates for successful U-Pb dating.
The stalagmite grew during the Middle Pleistocene Transition, an interval during which the period of glacial-interglacial cycles apparently shifted from 40,000 yr to 100,000 yr cycles. We focused largely on the periods encompassing three glacial terminations (TX, XI and XII). Using a combination of Tera-Wasserburg isochron and common-Pb-corrected age approaches, coupled with Bayesian Monte Carlo age modelling, our results show that 95% age-model uncertainties of a few thousand years are possible. Such levels of age-model uncertainties imply that palaeoclimate time series derived from speleothems of this age can be used to test hypotheses of orbital forcing.

Poster

## Norwegian Research School in Climate Dynamics (ResClim)

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Northwest Europe owes its mild climate to the northward transports of heat associated with the North Atlantic storm tracks and the North Atlantic Currents. Further, it is characterized by strong annual and decadal variability, making it particularly challenging to separate anthropogenic climate changes from natural variability. Particularly strong changes in our local climate have been observed for the last couple of decades. At present we do not know to which extent this is related to anthropogenic forcing, or if the next decades will show further amplification or a return to more normal conditions. Yet the success of all future political measures will strongly depend on the right input data from the climate community, making it more than ever before important to train future generations in the complex dynamics of the climate system. Related to this complexity is the need for collaboration between scientists of various skills, whether they have their expertise in the atmosphere, ocean, sea ice, biogeochemical cycling, or in climate modelling, and a need for scientists to be able to communicate to non-scientist to a much larger extent than before. Hence the Norwegian Research School in Climate Dynamics (ResClim) was officially launched on March 13, 2009 by the rector of the University of Bergen.
Here, we would like to present an overview of the organization, its aim and objectives. ResClim is a project with 10 national partners and 7 international collaborators and is lead from the Geophysical Institute at the University of Bergen, Norway. The aim of the school is to give PhD candidates in-depth knowledge in their specific

study field within climate research, trans-disciplinary knowledge in the dynamics of the entire climate system, insight into the political and societal impacts of climate change, and the necessary skills to play an active role in appropriately predicting, mitigating, and adapting to climatic and environmental change. As the school's participants encompass different disciplinary backgrounds and cultures with varying degrees of experience, ResClim provides a range of unique activities that students can integrate into their own training programme so as to accommodate specific requirements with personal interests. The activities include all kinds of courses such as intensive courses, specialized workshops, specialized and/or more generalized summer schools, outreach activities; an annual short symposium on climate change as well as an annual all-staff meeting. Finally, ResClim also provides financial support for shorter research stays and research facilities.

Poster

## Testing the tree-ring parameter Blue Intensity, a new inexpensive path towards robust low-frequency reconstructions of late Holocene summer temperatures?

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Trees growing in the outskirts of their ecological niche, where climate conditions prevent further expansion, usually exhibit growth patterns dominated by variations in climate. Tree-rings from trees in such areas acquire similar annually resolved growth patterns. By piecing the climate induced fingerprints of living trees, where every ring is absolutely dated in time, with the similar fingerprint in dead-wood, tree-ring records can reach quite far back in time, at best >7000 years in Fennoscandian forests. In reconstructing climate variability of the late Holocene, especially the last thousand years, the most favored proxy has been tree-ring data. On annual scale the skill of tree-rings as climate proxy is undisputed. The debate about tree-rings' as climate proxy regards its capacity to provide information about how paleoclimate has varied over centuries and over millennia.
The tree-ring parameter maximum density (MXD) has proved competent to provide growing season temperature reconstructions with skill both on annual and multicentennial scale. MXD analyzed with x-ray densitometry, measures how dense the annual late wood is. In regions where growth is limited by growing season temperature, a denser late wood means warmer summers. MXD often yields superior signal strength compared to the more inexpensive tree-ring width (TRW) parameter. But studies have also shown that numerous chronologies (TRW or MXD) over larger areas are superior to single chronologies, and give more robust climate reconstructions.
A more inexpensive alternative to MXD is Blue Intensity (BI). With BI the wood pieces are scanned and the blue light reflectance is measured, presumably related to amount of lignin in the wood. Low blue light reflectance values are associated with dense wood. The parameter minimum blue intensity and MXD have roughly an inverse relationship. The BI method has been shown to provide equivalent annual scale information to those produced with x-ray densitometry. However the quality of the multicentennial scale information has yet to be investigated.
Here we present a new, well replicated, millennium long Scots pine (Pinus Sylvestris) chronology from northern fennoscandia. Both MXD and BI measurements were undertaken from the same cores to evaluate BI as a new way of providing high quality multicentennial paleoclimate information. The climate response of each chronology will be investigated, and compared. If the year-to-year variability in both records is driven by the same climate forcing, it is safe to assume that the low-frequency variability should in fact also be similar for both proxies. Furthermore, both chronologies will be compared to existing long MXD chronologies from the Fennoscandian region to make sure that robust results are achieved.
Preliminary results show that careful removal of movable compounds in the wood and thorough preparation of the sample surface before scanning is critical to retain un-biased climate-related low-frequency variation. Furthermore, preliminary analyses show that if these criteria are met, BI cannot be separated in skill ($p<0.05$) from MXD, to reconstruct multi-centennial scale Fennoscandian summer temperatures, and probably elsewhere too. Implications from these results yield that, with BI, paleoclimate information for the last thousand years can be made more robust with less money.

Poster

## You are what you eat: Differences in the chemical composition of organic-walled dinoflagellate resting cysts and its implications for preservation

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Organic matter-based paleoproxies are important tools for our understanding of past climate changes and the global carbon cycle. As such, they represent important links between organisms, the environment, and the sedimentary record. However, many organic matter-based proxies suffer from selective preservation, so that the sedimentary record can be thought of as incomplete. The factors responsible for selective preservation are only partially understood, specifically in regards to some of the organic microfossil groups, such as the resting cysts of dinoflagellates (dinocysts). Very little is known regarding

the chemical structure of dinocysts, in particular, the compounds comprising the dinocyst macromolecule, called dinosporin. However, it is thought that differences in its composition may explain why some species are better preserved in the sedimentary record. Therefore, a more precise understanding of dinosporin chemistry can provide new information regarding the preservation of dinocysts and organic matter in general, which, in turn, will allow for more accurate interpretations of the signals derived from the sediment record. In this study, we analyzed the cyst wall chemistry of various extant dinoflagellate lineages using micro-Fourier transform infrared spectroscopy (FTIR). Based on the presence of characteristic functional groups, two inherently different dinosporin compositions are suggested, which roughly correspond to the dinocysts produced by either photoautotrophic or heterotrophic dinoflagellates. Both dinocyst wall chemistries exhibit a carbohydrate-based composition, but the autotrophic dinosporin appears more similar to a cellulose-like glucan, while the heterotrophic dinosporin is suggestive of a chitin-like glycan. The variations likely reflect the different life strategies of these two cyst-producing dinoflagellate groups, something that could be developed as a paleoecological proxy by inferring the past nutritional strategies of extinct taxa. These results constitute the first demonstration of differences in dinosporin composition between these dinoflagellate groups and provide evidence that differences in preservation potential may be related to dinocyst wall chemistry.

Poster

## Climate controlled size variability of diatom Fragilariopsis kerguelensis in the Southern Ocean

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*Fragilariopsis kerguelensis* is the most abundant open ocean diatom species in Southern Ocean sediments and its valve area has recently been used to infer glacial-interglacial paleoceanographic conditions. Studies from the Atlantic sector of the Southern Ocean demonstrated larger size of *F. kerguelensis* during the last glacial compared to interglacial, possibly in relation to greater availability of iron (through wider sea ice coverage and higher eolian dust input). We present here a study on average valve area of *F. kerguelensis* conducted in three sediment cores covering the last ~42 ka BP from different zones of the Southern Ocean. Our records confirm previous results from the Atlantic sector, but highlight a different pattern from the Indian sector where largest valves of *F. kerguelensis* are encountered during the Holocene. Diatom size variations in the Atlantic sector are in phase with records of opal burial while diatom size variations in the Indian sector are at odds with records of opal burial. Variations in circum-polar upwelling were suggested as the main controlling factor of opal production during the last 20,000 years. We however show here that different processes may have triggered changes in diatom size and opal export in the two sectors of the Southern Ocean. We here hypothesize that high nutrient input from the Antarctic Peninsula during the last deglaciation may have exerted a stronger control on diatom size and opal export in the Atlantic sector of the Southern Ocean than inferred changes in the circum-polar upwelling.

Poster

## DNA barcoding from lake sediments: An unprecedented "deep" view of past vegetation dynamics and human land-use

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We present the transposition of an innovative ecological tool, DNA barcoding, to paleosciences in the aim of reconstructing past vegetation dynamics and human land-use in relation with the evolution of erosion patterns in Alpine areas. DNA barcoding was applied on extra-cellular DNA from mammals (mitochondrial DNA) and plants (chloroplast DNA), which are preserved in lake sediments This method consists in four steps: (i) DNA extraction (ii) amplification with selected primer pairs of short-enough regions to allow the amplification of degraded DNA (iii) DNA sequencing and (iv) comparison of DNA barcodes to a reference database. This last step permits to establish the relative abundance of of taxa at least at family level and sometimes up to genus or species level.
The Holocene sediment core of Lake Anterne (2063 m asl, NW French Alps) was chosen because soil and erosion histories were already known. Moreover, palynological and archaeological data are available from the catchment and around. Samples corresponding to periods of major environmental changes (from 10,000 cal. BP to 1975 AD) were selected for this preliminary test.
Our data highlight the early expansion of plants during the Early Holocene (10–7 ka cal. BP), leading to the soil development which was previously evidenced from abiotic records. The succession of pioneering plants, including both arboreal and herbaceous ones, is hence recorded at the genus to species level.
Subsequently, a precise picture of the forested ecosystem corresponding to a maximum in soil development (7-5 ka cal. BP) is obtained. The development of Pinus is then accompanied by a typical succession of non-lignous species (e.g. Achillae sp., typical of mountainous forests with developed soils).
These species almost disappear around 3.4 ka cal. BP, indicating a major landscape opening, also marked by the appearance of Alnus genus. At the same time, Plantago genus appears, highly suggesting that grazing activities were responsible of a dramatic ecological change. However sheep and cow DNA are only found

during the Iron Age (2.3 ka cal. BP) and Antiquity (2 ka cal. BP) suggesting the pastoral load then reached a specific threshold in response to changes in agro-pastoral practices.
The Dark Age (500-1000 AD) is marked by the regression of all vegetal and animal agro-pastoral indices. A last major period of intense human land-use is then recorded from 1000 to 1900 AD. The unprecedented occurrence of Alpine plants (e.g. Ranunculus glacialis) suggests the Little Ice Age cold spell could have been the most intense of the whole Holocene. However, during this period grazing activities never stopped and on the contrary reached a maximum. It differs from the Antiquity by the sole presence of cow DNA, in accordance with historic information pointing the preponderance of cow breeding – dedicated to "Gruyere-like" big cheese making for exportation - in NW Alps since the 14th century AD.
With this rather simple low resolution investigation, we hence demonstrate DNA barcoding is a powerful tool to get an unprecedented precise picture of past ecosystems. In this, it presents a huge potential to discuss complex dynamic trajectories involving both human- and non-human-triggered pressures. Its development in next years should hence be an important advance for paleosciences.

Poster

## Nonlinear Method for Climate Field Reconstruction

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All currently used multiproxy climate field reconstruction methods assume that each proxy record is linearly related to the target climate parameter to be reconstructed. An example is shown where a seemingly linear relation is actually nonlinear and the existing methods fail to adequately reconstruct the target climate parameter. A novel climate field reconstruction method is presented that only assumes these relations to be monotonic, i.e., only the direction of change of the values in a proxy record matters. Consequently, the proxy records need not be standardized. Furthermore, the records are used in their original resolution, removing the need to interpolate and otherwise concern about missing data.

Talk

## A unique long proxy record from Sokli in the central area of Fennoscandian glaciations drastically changes classic concepts of glaciations, vegetation and climate in N Europe during the Late Pleistocene.

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A long sediment sequence covering the last ca. 140 kyr has been recovered from Sokli (N Finland) situated in the central area of Fennoscandian glaciations (N Europe). Recent studies on sediments of Weichselian age (11-110 kyr ago) show the enormous potential of the Sokli sediments in providing detailed proxy-based climate data for high-latitude Europe. Adapting new, state-of-the-art methods in climate reconstructions in close collaboration with world leading experts have so far produced temperature records for the time-slices around 50 kyr BP (early MIS 3) and 95-110 kyr BP (MIS 5c-d). Climate parameters are inferred from fossil assemblages of pollen, macrofossils of plants, chironomids (aquatic insects) and diatoms, which are found abundantly in the non-glacial sediment intercalations in the Sokli sequence. The fossil assemblages also allow detailed reconstructions of former changes in vegetation and depositional environments. Similar studies are in progress on thick (nearly 10 m thick) lacustrine deposits of Eemian (MIS 5e) and Holocene age in the Sokli sequence. Results from the Sokli studies have been surprising in various ways, drastically changing the classic concepts of glaciations, vegetation and climate in northern Europe during the Late Pleistocene, which are based on the long-distance correlation of generally poorly-dated and highly-fragmented stratigraphic evidence. The Sokli data reveals a highly dynamic Fennoscandian Ice Sheet with ice-free conditions at Sokli and present-day summer temperature during MIS 3, i.e. when major part of Fennoscandia was previously thought to have been glaciated. In contrast to earlier reconstructions showing ice-cover and presence of tundra vegetation over N Finland during MIS 5d respectively MIS 5c, the Sokli sediments record highly continental climate conditions for MIS 5d, with steppe-tundra vegetation and a braided river pattern, and a lush boreal forest for MIS 5c with summer temperatures several degrees higher today. Sokli can be regarded as a hotspot for climate model validations. It also allows the extension of transect studies into high-latitude Europe. The Sokli data shows that results from earlier transect studies, which used the low-quality data from Fennoscandia, can be regarded as highly questionable. This presentation will give an overview of the Sokli proxy data. It also gives an overview of a recent compilation on the Late Pleistocene in central and northern Europe in which the Early Weichselian is suggested to be included in a last interglacial complex (comprising entire MIS 5) similar as in the deep-sea stratigraphy.

Poster

## Intercontinental Ash: The correlation of the Alaskan White River Ash to the European AD 860B tephra

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The presence of a volcanic ash (tephra) across a landscape provides a valuable isochronous marker horizon in diverse depositional settings. The correlation of widely distributed tephra beds has been identified by several large-scale, multidisciplinary projects (e.g. INTIMATE, RESET, PRECIP) as the only method that can decipher timing of rapid climate change events with shifts in, for example, archaeological, faunal and floral records. Here we present the correlation of the Alaskan White River Ash, eastern lobe (WRE), to the AD 860B tephra, first identified in Ireland, via major-element geochemistry and coincident age-determinations. WRE is present across the North American continent and in northeast Pacific marine cores. AD 860B has been located across northern Europe and in NGRIP, but a source was never determined until now. The correlation of these two tephra beds illustrates the viability of ultra-distal correlations, and the comparison of the diverse archives in which the tephra are found. Additionally, multiple Alaskan tephra beds produced by eruptions as large, or larger, than that which produced WRE, offer the possibility of additional North American tephra beds being present at an intercontinental scale. Many of these beds are beyond radiocarbon in age, such as the Old Crow tephra (124 ± 10 ka), an important marine isotope stage 5e marker horizon, presenting opportunities for correlations well into the Pleistocene.

Poster

## Evidence of a wetter LIA (Little Ice Age) in the Indian Himalaya, India: Evidence from a ca. 400 yr. old stalagmite record

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We present the first mineralogical as well as stable isotope ($\delta^{18}O$ and $\delta^{13}C$) data of a ~400 years (1590 to 2006 AD) long annual to decadal speleothem record collected from the Indian Lesser Himalaya. The stalagmite is composed of the primary aragonite. The SEM results of the stalagmite show that the compact sub-layer is composed of elongated columnar aragonites with a general longitudinal orientation (parallel to the vertical growth axis) and the coalescence of the aragonite crystals is well developed, leaving few inter-crystalline voids. In other words, the compact sub-layer may have formed in quasi-equilibrium conditions and provide the main carrier of climate proxies. The porous sub-layer is made up of needles, drusy and fibrous aragonites intersecting each other. And accordingly, the coalescence is low, with many inter-crystalline voids, which looks like the short hiatus between two adjacent compact sub-layers. Therefore, we infer that the growth of alternation of compact/porous sub-layer may not be successive and they may have formed in different seasons.
The chronology of ca. 12cm long stalagmite is based on six U/Th dates. The isotopic data show a variation of -2.7 to -5.9‰ in $\delta^{18}O$ and -5.3 to -8.8‰ in $\delta^{13}C$. The isotopic analyses indicate that the climate during this period can be divided into two stages: a wet phase during the Little Ice Age (LIA) (1590—1850 AD) and comparatively dry phase during the post-LIA after 1850 AD. However, the record also documents the minor dry events during the LIA and a wet episode after the LIA. This inference seems to be consistent with some previous studies in the areas influenced by the Westerlies but appears to be conflicting to the regions, dominated by the Indian Summer Monsoon (ISM). This may be due to the possible changes in the strength of Westerlies in the study area and added by negative anomaly of North Atlantic Oscillation (NAO) during the LIA.
We suggest that the hydrological conditions during the LIA may have varied significantly under various precipitation regimes as well as in different latitudes. We also propose that during the LIA, the Lesser Himalaya and the nearby regions were humid, whereas the areas under the sole influence of the ISM were dry. We believe that the enhanced Westerlies may have produced higher than normal precipitation during this period in the north India. The temperatures of the Northern hemisphere, China and Central Asia as reconstructed by a variety of proxies at a multi-centennial scale clearly show that the wet climate is associated with the low temperatures, a conclusion achieved in the present study. However, we suggest that the studies from additional sites are required to document the temporal patterns of precipitation from various rainfall regimes in the Indian Himalaya. We also advocate that in addition to the isotopes, it is equally important to carry out the mineralogy and structure of laminae of the stalagmites for better elucidation of the palaeoclimatic changes.

Poster

## Changes in sea level on the coast of São Paulo during the Holocene and landslides in the Serra do Mar – Brazil

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The northern coast of São Paulo presents an escarpment altimetry extent 900 meters, with rainfall of 2.500mm at its base and up to 4.000mm in its higher portions. These slopes have declivity greater than 80%, with very common landslides. Despite high declivity, soils are deep, with more than 5 meters in thickness.
Landslides are inherent in this region, propitiated by intense rains, simultaneously associated to the other events occurred in geological time, as the successive marine ingressions and regresses in the Quaternary period. As a consequence of these events, there is a load of sediments situated on Ubatuba Coastal Plain, which is classified as "pocket beach", a small zone of deposits, separated by advances of Precambrian Basement, making the area of discontinuous sedimentation.

This work has the objective to identify areas of marine deposits, submerged in the last marine ingression (occurred about five thousand years ago) with an elevation of about five meters related to the actual and the relation with the gravitational deposits of the escarpment situated over the sedimentary plain. According to this event, it makes necessary the comprehension of geology, geomorphology, pedology, climatology, covered vegetation and occupation of the ground.
It was verified the evolutions of marine levels along the Holocene, as well as the typology and morphology of its sedimentation. It was simultaneously verified the occurrence of landslides, so that it became possible the understanding the occurrence of the last event in this place, besides the observation of the low areas, verifying the characteristics of the deposits and its evolution in the geomorphological dynamics of the place. Thus, the risks to the occupation of the area are very relevant, especially in rugged areas, close to hills and rivers.
The region shown to be extremely susceptible to any major rainfall event and also to small changes in sea level, because most of the cities are at elevations below 3 meters high.

Poster

## Greenhouse effect of Upper Cretaceous - analysis by paleosols of Marilia Formation/ Bauru Group/Brazil

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The climate of the Cretaceous is usually characterized by warmer and drier conditions. It is estimated that the global surface temperature during the Cretaceous was approximately 5.5°C higher than at present and the concentration of carbon dioxide, about 4000 ppm in the middle Cretaceous, which means a value of 4 to 6 times larger than the current. The soils are good indicators of climatic conditions, so the paleosols of the period can be used for paleoclimatic reconstructions.
Marilia Formation (Upper Cretaceous) top unit of Bauru Group, Paraná Basin, occurs in the states of São Paulo, Minas Gerais, Goiás and Mato Grosso do Sul. This unit consists of sandstones with grain size ranging from fine to coarse conglomerates, with angular grains and content matrix variable. One of the main features of the Marilia Formation is the high content of carbonate cement ($CaCO_3$).
The literature has indicated the presence of paleosols in this formation since the 1970s and this study aimed to characterize different types of paleosols that occur in this formation in Estado de São Paulo. The procedures were the description field of the profiles, chemical analysis with fluorescence spectrometry of X-ray and description of thin sections.
Marilia Formation presents paleosols very well preserved, having been described soils without diagnostic B horizon, vertic properties, hydromorphic soils, soil with textural contrast, soil with oxidic horizons and more commonly soils with high concentration of $CaCO_3$, featuring calcretes with different degrees of development.
The soils indicate clearly that developed under conditions predominantly arid and semi-arid, with occasional streams of water that filled depressions, agreeing with the interpretations of the environments of deposition resulting from sedimentological studies, however this study enabled the identification and detailed especially succession of drought and humidity conditions during the deposition of sediments of Marilia Formation.
The soils that do not have diagnostics horizons B show marks roots absence of sedimentary layering and abundance of easily weathered minerals, indicating a trend in very dry conditions, since the interval deposition was apparently long. The vertic and hydromorphic soils are indicative of lower positions on the landscape, associated with depressed areas and concentrated water during certain period of the year, and the presence hydromorphics indicates humid conditions most of the year. The presence of oxidic soils indicate humid tropical conditions.
Thus, despite the prevailing drought conditions, certain positions of the landscape could provide water for long periods. Soils with high concentrations of carbonate indicate that the landscape went through periods of significant geomorphological stability without erosive and depositional processes, since these are soils that require thousands of years to fully develop under semi-arid conditions. The profiles of paleosols not indicate drought conditions are those with high textural contrast and oxidic horizons. Its occurrence in sedimentary sequences is relatively rare, but indicate a high geomorphological and climatic stability. Thus, the Upper Cretaceous greenhouse promoted in the area, semi-arid conditions prevalent and rare humid tropical conditions.

Talk

## Millennial and sub-millennial scale variations in rainfall revealed by chinchilla rat (Abrocoma) middens over the last 16,400 years in the central Atacama Desert (22-24°S)

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Many records of past variations in rainfall in the tropics and subtropics during the late Quaternary, often derived from variations in lake levels or speleothems, are often subject to complex variations in many other variables aside from precipitation. These shortcomings rarely allow for the conversion of a given proxy into a direct amount of precipitation. Here, we present a new record based on the response of rodent body size to biological productivity driven by past rainfall events in the Atacama Desert of northern Chile. Ashy chinchilla rats (Abrocoma cinerea) are widespread here and build large accumulations of feces, plant remains and bones all encased in a crystallized urine matrix. Fecal pellet diameters in modern middens evince a strong positive correlation ($R^2$= 0.856, $p < 0.001$) with mean annual precipitation (MAP) over 7° of latitude

which we use to estimate past MAP anomalies from fossil pellets. Over 80 individually $^{14}$C-dated A. cinerea middens were collected from the central Atacama desert between 2350-3400 m asl and spanning the last 16,400 yrs. Periods of increased variability with large positive anomalies occur between 13.3 – 9.6 and 3.5 ka BP to the present. Wetter periods were interrupted by a dry phase between 9.6-4.0 ka BP with large positive anomalies at 9.3 – 8.9, 7.6, 6.8 and 5.2 ka BP. Major positive anomalies also occur at 2.4, 1.0 and 0.17 ka BP. Our results demonstrate that despite the unknown duration of a depositional episode (on the order of $10^0$ -$10^2$ yrs) represented by a single midden, these can be collated together into a single quantifiable, detailed record of past climate change. Such records hold much promise for unraveling past rainfall changes in the arid regions of South America.

Poster

## The ice core record of atmospheric methane: Chemistry-climate interactions on tens to thousands of years

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The concentration of atmospheric methane trapped in Antarctic ice, [$CH_4$], shows large variations over the last 800,000 years that appear to track changes in temperature ($\delta$D) on orbital timescales. As methane is a potent greenhouse gas and influences the tropospheric oxidizing capacity, it straddles issues of chemistry and climate, and attempts to explain past changes in its budget test our understanding of the Earth system. Amongst the most striking natural features of this record are: the differences in [$CH_4$] between glacial and interglacial periods, for instance rising from around 360 ppbv at the Last Glacial Maximum (LGM; 21,000 years ago) to about 700 ppbv in the pre-industrial era (PI; 200 years ago); and the rapid rises of 100-200 ppbv, from a baseline of 360-460 ppbv, in response to northern-hemisphere warmings during the last glacial period (21,000-110,000 years ago) at the beginning of Dansgaard-Oeschger (D-O) events. Here, we present 'highlights' from a series of model studies aimed at better understanding the changes in the methane budget responsible for these features. Our main conclusion is that the rises in [$CH_4$], both between the LGM and the PI, and at the beginning of D-O events, were likely almost entirely source-driven, with the main factors affecting the oxidizing capacity—changes in air temperatures and emissions of non-methane volatile organic compounds from vegetation—having substantial, but roughly equal and opposite, effects.

Poster

## Chironomid-temperature and pollen-precipitation quantitative reconstructions at Laguna Potrok Aike (51º58´S 70º23´W), in Southern Patagonia

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The present climate of the southern tip of South America is mainly influenced by the Southern Hemisphere westerly winds (SWW) and the topography of the land mass. Winds, together with topography, mainly affect precipitation and air temperature.
Here we combined a pollen-based quantitative precipitation reconstruction and a chironomid-based quantitative temperature reconstruction of Laguna Potrok Aike (LPA) located in the southern Patagonian steppe to evaluate fluctuations in temperature and precipitation associated with changes in the westerly airflow.
For the pollen-precipitation reconstruction, a WAPLS-C2 model was chosen using 97 samples from the Patagonian steppe. With the same algorithm a 63-lake chironomid transfer function was build up using mean annual temperature as the most important factor explaining chironomid distribution.
At LPA, pollen results inferred low precipitation during the Lateglacial/Glacial, increasing and remaining high towards the Holocene. This model together with Ca analysis performed on the sediment cores of LPA suggested dry periods between 4,600-3,800 cal yrs BP and between 8,700-7,200 cal yrs BP. During these periods, the chironomid temperatures were the warmest inferred.
The chironomid model shows colder-than-average temperatures during the Lateglacial-glacial and ACR. These general patterns corresponded well to the temperature patterns observed in Antarctica with drier and colder climate during the Lateglacial-glacial period.
Pollen reconstruction suggests that during the Lateglacial-glacial, precipitation was linked to temperature patterns whereas, during Holocene times, SWW influence was the main force driving the amount of yearly precipitation over the southern South American continent.

Talk

## Is the current rapid warming of the Antarctic Peninsula unprecedented?

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The Antarctic Peninsula is at present one of the most rapidly warming regions on Earth, with historical observations from meteorological stations in this region documenting warming equivalent to around 3.5°C per

century. During recent decades, a series of ice shelves stretching from Prince Gustav Channel to the Larsen B ice shelf on the north-eastern Antarctic Peninsula have been lost, causing an acceleration of the feeder glaciers that drain ice from the Antarctic Peninsula. However, marine sediment records taken from the areas where ice shelves have been lost suggest that the ice shelves were also absent during the middle of the Holocene, presumably then reforming before being lost again recently.
The paradox between modern observations of rapid climate change and retreat of ice shelves and yet an apparent absence of ice shelves only a few thousand years before today cries out for a local palaeoclimate record. This was achieved in 2008 by a joint UK-French team who recovered an ice core to bedrock, from James Ross Island, situated at the north of the Antarctic Peninsula, close to the area where ice shelves have retreated. The 364m long core spans the period from the glacial through to the present. Our temperature estimates, based on the record of deuterium isotope variations in the core, show that the Antarctic Peninsula experienced an early-Holocene climate optimum followed by stable temperatures, from about 9,200 to 2,500 years ago, that were similar to modern-day levels. We find that the late Holocene development of ice shelves near James Ross Island was coincident with pronounced cooling from 2,500 to 600 years ago. This cooling was part of a millennial-scale climate excursion with opposing anomalies on the eastern and western sides of the Antarctic Peninsula. Warming of the north-eastern Antarctic Peninsula began around 600 years ago, with the rate becoming more rapid during the 20th century. We compare the recent climate history with earlier sections of the James Ross record in order to assess whether the recent warming is indeed unprecedented.

Poster

## Unraveling groundwater and surface water interaction in Central Kenya Rift lakes: Implications for Paleohydrology

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Groundwater is increasingly becoming an important resource for rural communities especially in arid and semiarid regions. Knowledge of the occurrence and state of this resource is important for sustainable management. For along time groundwater and surface water budget estimations and response to climate changes have been treated separately. However, aquifers surrounding lakes can modify how lake levels and solute balance respond to climate changes. Understanding ground and surface water connection is important to reconstruct paleohydrologic conditions and inform on future changes linked with climate changes.
Lakes in the East Africa Rift have been intensively studied to better understand the influence of climate change on hydrological systems. The exceptional sensitivity of these rift lakes, however, is both a challenge and an opportunity when trying to reconstruct past climate changes from changes in the hydrological budget of lake basins on timescales of 100 to 104 years. The regional comparisons of these studies results however, are riddled with heterogeneity of response in magnitude and time within the region. Groundwater is an important component in the hydrology of these closed lakes and has not been considered much in the Paleo-hydrologic reconstructions. In this study, we reconstruct groundwater dynamics since the Holocene within the Central Kenya rift basins of lakes Naivasha and Nakuru by combining tracer methods of chemical, isotopic and noble gasses approaches (Major Anions and Cations, $^{3}H$-$^{3}He$, 4He, $^{14}C$) with a simple numerical model using a linear decay approach. Water samples from wells, springs and lake in the catchment are analysed to determine the flow, age and origin of the groundwater in the study area. Paleoclimatic parameters such as airmass origins and rainfall intensity can be deduced from these.
The study is on-going and we plan to present the reconstruction of the recorded climate history, groundwater flow pathways and connectivity to the lakes additionally modern recharge rates and flow paths in the unsaturated zone. Further we'll attempt to provide important quantitative I foundations for sustainable management of these resources

Poster

## Species distribution and oxygen isotope composition in modern planktic foraminifers in the Fram Strait (Arctic Ocean)

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Isotopic analyses and abundances of fossil foraminifera are common tools for paleoceanographic reconstructions. Oxygen isotopic ($d^{18}O$) records of sediment cores provide information about variations in sea surface temperatures and salinities in the past, while the ratio between the abundances of different planktic foraminifer species refer to the hydrographic regime, e.g., distribution of water masses, water temperatures and the position of the summer sea ice margin. However, for a correct interpretation of the fossil data it is important to improve our understanding of the correlation between recent oceanic variability and the distribution/composition of shells of living foraminifera. For this purpose, water samples and planktic foramifers from plankton tows were studied along a transect across the Fram Strait (Arctic Ocean, 78°50'N, 5°W-8°E). Five depth intervals were sampled vertically between 500 m water depth and the sea surface by using a large-diameter multinet at 10 stations. This area is characterized by high oceanographic variability. In the western Fram Strait, the water column is strongly stratified, with cold, low-saline Arctic outflow waters of the East Greenland Current (EGC) in the upper 200 m and warmer, saline waters of Atlantic origin underneath. In the east the West Spitsbergen Current (WSC) carries Atlantic Water northwards, with a thin

mixed layer on top. In the cold polar water masses of the EGC the polar species Neogloboquadrina pachyderma (sin.) clearly dominates the total assemblage, while the warm Atlantic water of the WSC yields higher abundances of Turborotalita quinqueloba. The multinet sampling results are also compared to the planktic foraminifer assemblages in sediment surface samples to investigate how well the planktic species distribution at the sea floor reflects the surface-near environments. The d$^{18}$O values of the shells are compared to those from the water column. Results hold important information on preferred calcification depths of the foraminifers, which are variable in the different hydrographic regimes in the Fram Strait.

Poster

## Multiproxy study of a Tertiary sedimentary section along Madhwali Nadi, western Kutch, Gujarat: Implications on Palaeoenvironment and Age

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Kutch basin in the western margin of India is well preserved by the Tertiary sequences ranging from Palaeocene to Pliocene and has experienced several episodes of successive tectonic activities and upheavals throughout the Cenozoic thus evolving a youthful topographyi. Since decades these Tertiary sequences are being studied for their faunal, floral and palynofloral assemblages with emphasis on the ecology, environment and age of the formations during that period. But still these vast deposits need much attention in terms of high resolution biostratgraphy and palaeoclimatic studies using various proxies.
In this regard around 35 feet exposed section along the Madhwali Nadi near the Matanomadh village, western Kutch, Gujarat, has been analysed palynologicaly for its palaeoecology, depositional environment and age. The study is also supported by the environmental magnetic properties which is the first ever attempt for the Tertiary deposits. The magnetic susceptibility (clf) values corresponds well with lithology of the section with light to dark brown ferruginous claystone at the lower part where the clf values are high followed by decline in the values corresponding to black carbonaceous clay, fine to gritty sandstone, white and purple clay topped by soil. The higher clf values at the lower portion might be due to oxidizing conditions. Palynologicaly the upper part of the section has yielded good amount of spores-pollen with diversified taxa and dinoflagellate cysts as compared to lower part. The presence of the pollen of gymnosperm Podocarpaceae (Podocarpidites sp) and angiosperms viz. Poacea (Graminidites sp), Arecaceae (Palmidites sp) etc. along with pteridophytic spores and fungal bodies indicates the humid tropical climate. The absence of dinoflagellate cysts in the lower part of the section and their appearance along with the spores and pollen in upper portion of the section may indicate lagoonal to inner shelf depositional environment with the transgression of the sea. The age of the section is suggested since Late Eocene to Oligocene based on the presence of Striatriletes sp (Pteridophyte), Graminidites sp and pollen grains with syncolpate morphology.

Poster

## A brief history of climate – the northern seas from Last Glacial Maximum to global warming

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The Atlantic Ocean's thermohaline circulation carries Tropical heat and salt to the high northern latitudes. The relatively warm Atlantic water progressively gives up its excess heat en route to the Arctic, and thus moderates regional climate. This interaction between a variable ocean circulation and climate is therefore central to the current understanding of past, present, and projected future regional climate change. The present study assesses the "mode of operation" of the northern seas – in particular that of the Norwegian Atlantic Current's extension toward the Arctic – and its relation to regional coastal climate from the termination of the Last Glacial Maximum to the end of the 21st century. We first present a new synthesis of reconstructed, instrumental, and projected ocean and terrestrial temperatures covering the region and full time span in question. The synthesis constitutes the reference climate to be related to ocean circulation. There appear to be two robust and general features of the reconstructed climate: 1) the anomalously warm sea surface temperatures reflect terrestrial temperatures, whereas 2) the bulk temperature of Atlantic-derived waters is persistently anti-correlated, and thus anomalously cold. The former is consistent with the general understanding of a temperature development through the Holocene reflecting changing solar insolation, whereas the latter is rooted in ocean circulation. We suggest a simple, but consistent framework where the apparently contradicting marine reconstructions are reconciled. In this framework, it is the temperature and strength of the Norwegian Atlantic Current that separately constrain reconstructed bulk temperatures. This is consistent with present climate in the sense that northern heat loss primarily resides with the ocean, whereas projections of future climate suggest the warming atmosphere to be the main constraint.

Poster

## Biomarkers – a new potential method to study highly humified peat components?

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Acute and contemporary questions related to human-induced changes in climate have emphasized the importance of peatland research because peatlands store large quantities of carbon. Historically, pristine mires have been long-term sinks for atmospheric carbon because of a slow decomposition rate of the organic matter once below the water table. However, the net carbon balance of mires is highly sensitive and reflects changes in moisture conditions and consequent changes in vegetation assemblages. Historical variations in climate and hydrology are recorded in peat layers as alteration in the assemblages of different biological organisms. Past vegetation assemblages are in a key role when reconstructing the past moisture conditions that control peatland carbon dynamics. In order to evaluate the role of northern peatlands as carbon sinks or sources in changing future climate, it is important to understand the past mechanisms: how mires have earlier responded to climate forcing. An especially useful proxy method to reconstruct past environmental changes is the plant macrofossil method.
Large parts of northern peatlands are fens, where, as a result of fast surface decay, major parts of the peat below the surface layer is highly humified. Bog peats, in turn, usually contain relatively well preserved plant material for palaeoecological examination, but highly humified layers can also be found underneath the top layers of bog peats. A high degree of humification constrains palaeo-botanical and -climatical studies because reliable identification of different fossil vegetation components is difficult. Previous work has shown that plant biomarkers (compounds that can be linked to specific plant types) can be successfully applied to identify modern and fossil plant groups from less-humified bog peat.
We applied selected organic geochemistry methods to fen plant species to investigate the potential for biomarkers to characterise different fen plants. We focused on plant types that would give insight into major palaeoecological challenges (e.g. Sphagnum subsecundum, Warnstorfia exannulata, Carex livida). We studied differences between species and plant groups by comparing n-alkane distributions, n-alcohols, n-alkane ratios and sterol distributions and concentrations of living plants. We found that when n-alkanes, n-alkane ratios and sterols of sampled plants were compared together with redundancy analysis mosses, above-ground and below-ground plant parts can be separated from each other as groups. To test this proxy in palaeo-environment we analyzed both macrofossils and biomarkers from two peat cores from Northern Finland (64°45´N, 24°42´E). In this study we are concentrating to the shift between bog and fen stage on the studied cores. Because the identification of plant macrofossils in highly decomposed environments is challenged, our aim is to study if by applying selected organic geochemical analyses, biomarker proxies, we can gain more information from peat archive around this not so well know part of peatland succession history.

Poster

## Coralline algal and larger benthic foraminiferal facies in an Upper Palaeocene shallow water, reefal carbonate platform (Meghalaya, North-Eastern India): Exploring the palaeoenvironmental implications

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Facies analysis of Thanetian shallow-water carbonate successions in the outcrops near Jowai (Meghalaya, north-eastern India) and the subsequent integration of palaeoecological data have been applied to produce a detailed palaeoenvironmental model. The facies distribution and the processes, which controlled the coralline algal and larger benthic foraminiferal assemblages in the studied Thanetian reefal carbonate platform, are discussed in detail.
Coralline red algae and larger benthic foraminifera are highly abundant and well diversified in the well exposed carbonate deposits of the Thanetian age Lakadong Limestone Formation. Detailed microfacies analysis led to the recognition of eight microfacies types on the basis of lithological characteristics, faunal content and sedimentary structures, indicating that the Upper Palaeocene sequence was deposited in a complete marine environment ranging from near shore, warm shallow inner to middle neritic environments with development of reefal facies. The coralline algae are represented by both non-geniculates (Lithothamnion, Mesophyllum, Lithoporella, Spongites and Sporolithon) and geniculates (Corallina). Similarly, Miscellanea, Ranikothalia, Nummulites, Assilina, Alveolina and Discocyclina are the major larger benthic foraminifera. The distinctive characteristics of the palaeoecological gradient are an increase in the dominance of melobesioids, a thinning of the encrusting corallines and a flattening of the larger benthic foraminiferal shells.

Talk

## Mid-Brunhes shift in continental weathering intensity and its feedback with atmospheric $CO_2$: Insights from a new ice core proxy

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The analysis of $CO_2$ and its stable carbon isotopes from ice cores reveal large changes of atmospheric $CO_2$ which are closely related to a reorganisation of the ocean circulation, marine biologic processes and minor contributions in the terrestrial carbon storage. These components dominate the large $CO_2$ amplitudes during glacial/interglacial terminations. Yet, on orbital time scales, $CO_2$ is also modulated by the alkalinity of the ocean. The net alkalinity influx to the ocean is driven by silicate weathering drawing down atmospheric $CO_2$. Conversely, alkalinity is lost during coral reef growth and when $CaCO_3$ is buried in marine sediments. On orbital time scales, these fluxes are assumed to be almost balanced as atmospheric $CO_2$ feed back on the weathering rates providing a negative feedback loop.
Besides these basic concepts, little is known about the magnitude of weathering rate fluctuations on orbital scales. To date, proxies from marine sediments and Fe-Mn crusts do not quantify the total weathering fluxes to the ocean but only indicate that the style of weathering has changed. Here, we use a novel approach using the pptv-level trace gas $CF_4$, which can be analysed in air trapped in ice cores. $C_{F4}$ is a trace gas in granites, and during weathering $CF_4$ escapes into the atmosphere. In preindustrial times, weathering of granitic rocks was the only natural source of $CF_4$. Because $CF_4$ is inert to destruction processes in the lower atmosphere, its only sink is destruction by UV radiation in the mesosphere and above. This chemical inertness is responsible for an exceptionally long atmospheric lifetime of estimated 50 kyr to 400 kyr.
We developed a system to precisely measure the trace amounts of $CF_4$ found in the past atmosphere. During the last 800 kyr, the atmospheric $CF_4$ varied in a narrow band between 31 ppt and 35 ppt, only 10-15 % variability, providing a first estimate of the long-term weathering rate fluctuations. On closer inspection, our $CF_4$ record, however, shows a pronounced shift toward higher $CF_4$ levels after 430 kyr (the Mid-Brunhes Event). With the beginning of Marine Isotope stage 11, we find a steep rise in $CF_4$ that probably relates to intense weathering during the first interglacial, where $CO_2$ reached 280 ppm and sea level may have been even higher than today. Further, $CF_4$ concentrations, thus weathering, increases during interglacials and falls during glacials lending support to a strong positive coupling of weathering rates during warmer climate conditions at high $CO_2$ levels.

Poster

## Abrupt climate change during the last glacial cycle on the Qinghai-Tibetan Plateau reconstructed using multiple organic geochemical proxies from Lake Qinghai, China

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Lake Qinghai (37°N, 100°E, 3200 m above sea level) is a large closed-basin lake on the Qinghai-Tibetan Plateau. The lake and its catchment are situated within the modern transition between desert (<200 mm precipitation/yr) to the northwest and grassland (>400 mm precipitation/yr) to the southeast. Lake Qinghai is therefore sensitive to climate change that drives shifts in these boundaries. Today, the Qinghai-Tibetan Plateau is characterized by strong seasonality, with cold, dry winters and warm, wet summers. Precipitation isotopes ($\delta^2H$ and $\delta^{18}O$) in this region also contain distinct seasonal signatures with a strong temperature influence ($\delta^2H$ vs. T, r = 0.98): isotopes are most depleted in the winter and most enriched in the summer. Airmass source and travel distance also likely influences the precipitation isotopes.
Paleoclimate records elucidate the mechanisms that drive climate change and provide validation for climate models, but there are few continuous records that span the last glacial cycle in this region. Here, we use two sediment cores from Lake Qinghai, one spanning 30 thousand years (kyr) and one spanning 13 kyr, to reconstruct past precipitation and temperature changes in this region. We measure multiple organic geochemical proxies preserved in Lake Qinghai sediments, including hydrogen and carbon isotope ratios of leaf waxes ($\delta^2H_{wax}$ and $\delta^{13}C_{wax}$, respectively), leaf wax abundance and distribution, and alkenone distribution.
The most depleted $\delta^2H_{wax}$ values occur during the last glacial interval, suggesting low temperatures and/or a dominant influence of westerly winds. A prominent interval of $\delta^2H_{wax}$ enrichment occurs during Heinrich Event 1, indicating dry conditions over the Qinghai-Tibetan Plateau. $\delta^{13}C_{wax}$ also exhibits enrichment during Heinrich Event 1, likely due to changes in the dominant plant type; $C_3$ plants dominate the Qinghai catchment today, but $C_4$ plants are dominant in biomes at only a few hundred meters lower elevation. Leaf wax hydrogen and carbon isotopes did not respond as dramatically to Heinrich Event 2 or the Younger Dryas, indicating that the spatial expression of these events is heterogeneous. $\delta^2H_{wax}$ from the two sediment cores show consistent changes during the Holocene, with a rapid 20‰ shift to more enriched values 3 kyr ago.
Alkenone distributions are also reproducible between the two cores, with $U^K_{37}$ ratios declining from early Holocene to present, interrupted by intervals of lower $U^K_{37}$ around 8 and 4 ka. The Younger Dryas and Heinrich Event 1 contain low $U^K37$ ratios, suggesting cold conditions. Due to low within-lake primary productivity, alkenones are absent from the record before 17 kyr. Leaf wax abundance and distributions also show strong responses to Heinrich events 1 and 2, as well as to Holocene climate change. Our results indicate that climate on the Qinghai-Tibetan Plateau is sensitive to North Atlantic processes, with AMOC weakening resulting in substantially dryer and colder conditions. Climate in these two regions is likely teleconnected via the winter westerly winds. Different seasonal expressions of the different abrupt events may explain why some abrupt events are more prominent than others on the Qinghai-Tibetan Plateau.

Poster

## Modelling the Bolling-Allerod rapid warming event.

***Paul Valdes***[1], Peter Hopcroft[1]

[1]School of Geographical Sciences, University of Bristol

The Bolling-Allerod represents one of the most rapid warming events in recent Earth history, yet we have a relatively poor understanding of the mechanisms and processes responsible. We present a new modelling study (using the FAMOUS model which is a low resolution version of the Hadley centre climate model, HadCM3) which examines the stability of the coupled atmosphere-ocean system to changes in fresh water input and other forcings. We find that the standard configuration of the model is too stable and cannot reproduce a realistic Bolling-Allerod warming. Further investigation examines the sensitivity of the results to model internal parameters, and identifies a configuration that better simulates the transition. We compare the results to data and find that the physical response is reasonable, but that the biogeochemical response (specifically changes in methane emissions) are too small.

Poster

## Reconstructing peatland water tables using transfer functions for plant macrofossils and testate amoebae: A methodological comparison

***Minna Väliranta***[1], Antony Blundell[2], Dan Charman[3], Edgar Karofeld[4], Atte Korhola[1], Ülle Sillasoo[5], Eeva-Stiina Tuittila[6]

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Plant macrofossils and testate amoebae are commonly used proxies to reconstruct past changes in peatland surface moisture conditions, but there are no comparisons between quantitative reconstructions based on both techniques. We compared two high-resolution late-Holocene quantitative water table reconstructions based on transfer functions for plant macrofossils and testate amoebae from two boreal peatlands in Finland and Estonia. The reconstructed water table variation patterns during the last ca. 5000 years are almost identical in directions for both proxies. However, both bog records contain one incoherent period when the two proxies indicate differing hydrological conditions. In both cases, the testate amoebae reconstruction shows wetter than the average conditions, whereas the plant-based reconstruction indicates drier than the average conditions. Divergences between the proxy records emphasize the fact that single-proxy reconstructions are subject to larger uncertainties than those based on two or more methods.

Talk

## Antarctic deglaciation rewritten – highly dynamic ice-sheet disintegration during meltwater pulses and contribution to sea-level rise

***Michael E. Weber***[1], Peter U. Clark[2], Rupert Gladstone[3], Axel Timmermann[4], Gerrit Lohmann[5], Gerhard Kuhn[5], Daniela Sprenk[1]

[1]Institute of Geology and Mineralogy, University of Cologne, Cologne, Germany, [2]College of Earth, Ocean, and Atmospheric Sciences, Oregon State University, Corvallis, Oregon, USA, [3]Arctic Centre, University of Lapland, Rovaniemi, Finland, [4]International Pacific Research Center, School of Ocean and Earth Sciences and Technology, University of Hawaii at Manoa, Honolulu, Hawaii, USA, [5]Alfred-Wegener-Institute for Polar and Marine Research, Bremerhaven, Germany

Reconstruction of the last global sea level rise faces uncertainties because only a few robust data evidences are available for Antarctic ice sheets. Deglacial dynamics have mostly been inferred from shallow-water cores on the shelf, where decisive changes are either erased by grounding ice or occur in condensed, lithologically complex successions with partially reversed and generally unreliable $^{14}C$ ages. Modeling studies reconstruct a late ice-sheet retreat starting around 12 ka BP and ending around 7 ka BP with a large impact of an unstable West Antarctic Ice Sheet (WAIS) and a small impact of a stable East Antarctic Ice Sheet (EAIS). However, new findings from deepwater cores the Scotia Sea challenge these reconstructions and call for a principal revision of the Antarctic deglacial history with an impact on projections on future sea-level rise as well.
Two deep-sea sediment sites from the central Scotia Sea are located in the center of the "iceberg alley", where 90 % of all Antarctic icebergs route through. Accordingly, this is a representative location to reconstruct the entire Antarctic ice-sheet disintegration during the last deglaciation. Sites MD07-3134 and MD07-3133 have well constrained age models circumventing the problems associated with $^{14}C$ dating. These sites document four phases of enhanced iceberg activity as indicated by the amount of small ice-rafted debris (IRD). We dubbed them Antarctic Ice Sheet Disintegration (AID) phases 1 to 4. They occurred 20 – 19, 17 – 16, 14 – 13, and 12 – 11 ka and contain peak IRD fluxes during all times of major meltwater pulses (mwp). Stacked IRD fluxes indicate that accelerated Antarctic deglaciation commenced at 17.5 ka and concluded at 9 ka.
Ice-sheet retreat signals detected in the Weddell Sea at 19 ka and 16 ka are recorded as IRD peaks in the Scotia Sea during AID 1 and 2. Also, there is a clear IRD peak during mwp1b at 11.3 ka. However, the highest IRD flux is recorded during AID 3 with a distinct peak at 14.76 – 14.4 ka, which is consistent with the recent dating of mwp1a at 14.65 – 14.31 ka, both in terms of timing and duration (340 years in the Scotia Sea versus 360 years at Tahiti). Accordingly, we found the first sustained data evidence for a significant contribution of the Antarctic ice sheets to mwp1a, with up to 7 times the iceberg flux relative to the

Holocene steady-state average. Modeling studies indicate that a mainly southern-sourced mwp1a is consistent with the observed cooling of the Southern Hemisphere, the expansion of Antarctic sea ice, and the establishment of the Antarctic Cold Reversal thereafter.
The new integrative ice-sheet disintegration record shows previously unrecognized, highly dynamic ice sheets and clear responses to all meltwater pulses that question the presumed stability of Antarctic Ice Sheets and minor contribution to the last sea-level rise. It will hence also lead to a revision of projections for future sea-level rise.

Poster

## On the existence and the origin of the mid-Brunhes Event

***Qiuzhen Yin***[1], Andre Berger[1]

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The individual contributions of insolation and $CO_2$ to the interglacial climates of the past 800,000 years were quantified through simulations with an Earth system model of intermediate complexity LOVECLIM and using the factor separation technique. Here a special emphasis is made on understanding the origin of the change around 430,000 years ago in the magnitude of the interglacial peaks recorded in the marine sediments and in the Antarctica ice cores (the so called mid-Brunhes event: MBE). Our simulations show that $CO_2$ plays a dominant role in the variations of the annual mean temperature of both the Global mean and the southern high latitudes, whereas, insolation plays a dominant role on the variations of monsoon precipitation, of vegetation and of the northern high latitude temperature and sea ice. As far as the surface climate is concerned, MBE appears mainly in the variables dominated by $CO_2$ (as expected). It is not as clear in the variables which are dominated by insolation. This explains the absence of MBE in many regional records especially from the land and from the northern hemisphere. However, the oceanic response to insolation is more complex depending significantly on the interactions between the atmosphere and the ocean. Insolation alone can induce a MBE in some oceanic processes which are critical for the carbon cycle. This is expected to contribute to the understanding of the origin of the MBE in the atmospheric $CO_2$ concentration.

## Presenting Author Index

# MEETING PROGRAM

**TUESDAY, 12 FEBRUARY**

| | |
|---|---|
| 18:30 | Ice breaker and Registration |

**WEDNESDAY, 13 FEBRUARY**

| | |
|---|---|
| 09:00-10:00 | Welcome |
| 10:00-10:30 | Plenary Talk: A. Singhvi - Land-sea correlation: Pitfalls and remedies |
| | Coffee Break |
| 11:00-12:30 | Oral Sessions OSM01 (Part 1) and OSM03/OSM13 |
| | Lunch |
| 14:00-15:30 | Oral Sessions OSM01 (Part 2) and OSM16 |
| | Coffee Break |
| 16:00-18:00 | Poster Sessions OSM01, OSM03, OSM13 and OSM16 |
| 18:30 | PAGES Soccer Cup |

**THURSDAY, 14 FEBRUARY**

| | |
|---|---|
| 09:00-09:30 | Plenary Talk: D. Sauchyn - Extending baseline hydrology from decades to centuries |
| 09:30-10:00 | Plenary Talk: A. Kulkarni - State of the Himalayan cryosphere |
| 10:00-10:30 | Plenary Talk: J. Syvitski - Rivers and deltas in the Anthropocene |
| | Coffee Break |
| 11:00-12:30 | Oral Sessions OSM12 and OSM11/OSM14 |
| | Lunch |
| 14:00-15:30 | Oral Sessions OSM07 and OSM08 |
| | Coffee Break |
| 16:00-18:00 | Poster Sessions OSM07, OSM08, OSM11, OSM12 and OSM14 |
| 19:00 | Public Lecture: R.K. Pachauri - Climate Change and implications for global society |

**FRIDAY, 15 FEBRUARY**

| | |
|---|---|
| 09:00-09:30 | Plenary Talk: J.E. Tierney - Indo-Pacific climate during the Common Era |
| 09:30-10:00 | Plenary Talk: M. Claussen - Tipping points in biogeophysics |
| 10:00-10:30 | Plenary Talk: M. Visbeck - Ocean circulation |
| | Coffee Break |
| 11:00-12:30 | Oral Sessions OSM02 (Part 1) and OSM06 |
| | Lunch |
| 14:00-15:30 | Oral Sessions OSM02 (Part 2) and OSM15 |
| | Coffee Break |
| 16:00-18:00 | Poster Sessions OSM02, OSM06 and OSM15 |
| 19:00-22:00 | Conference dinner |

**SATURDAY, 16 FEBRUARY**

| | |
|---|---|
| 09:00-10:30 | Oral Sessions OSM04 and OSM09 |
| | Coffee Break |
| 11:00-12:30 | Poster Sessions OSM04, OSM05. OSM09 and OSM10 |
| | Lunch |
| 14:00-15:30 | Oral Sessions OSM05 and OSM10 |
| | Coffee Break |
| 16:00-16:30 | Plenary Talk: M. Jones - Food economics in (pre-)historical times |
| 16:30-17:00 | Plenary Talk: K. Willis - Climate change and biodiversity |
| 17:00-17:45 | Panel Discussion - Future Earth |
| 17:45-18:00 | Closing |

**SUNDAY, 17 FEBRUARY**

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|---|---|
| | Field Trips |

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