PROGRAM AND ABSTRACTS

PAGES AGADIR 2022

6th Open Science Meeting

"Learning from the past for a sustainable future"

16 - 20 May 2022

PAGES
PAST GLOBAL CHANGES

Learning from the past for a sustainable future

PAGES AGADIR 2022

6th Open Science Meeting

Contents:

Welcome on behalf of the LOC

Welcome to PAGES Agadir 2022!

Dear delegates,

Originally, the PAGES 6th OSM Congress was scheduled for May 2021. The year before the Congress, in 2020, we were still in a state of great uncertainty about global health issues. Our enthusiasm over the past two years to organize a face-to-face congress in the beautiful city of Agadir, Morocco, was inversely related to the successive waves of COVID.

We postponed the date of the 6th OSM to a year after the original date and decided in March 2021 to organize it online only. This decision was frustrating because we had sought and organized some very welcoming venues for both the YSM and the OSM in Agadir, and we wanted this first PAGES congress on African soil to be a new scientific and human adventure for our scientific community.

Morocco is geographically so close to Europe and at the same time in Africa, from where most African, European and American capitals are served by frequent flights. We hope that our desire to have scientists from different continents come together in one African country will be reflected in this online congress.

For this online version of the 6th OSM, we have chosen a professional streaming platform that we hope will facilitate access to the numerous lectures and poster sessions for all congress participants around the world, and that the contacts and exchanges between delegates will be of high quality.

We wish you all an excellent and productive 6th OSM.

The Local Organizing Committee

Welcome on behalf of PAGES

Dear participants,

On behalf of Past Global Changes (PAGES), we are pleased to welcome you to the 6th PAGES Open Science Meeting, held online from 16 to 20 May 2022.

The Open Science Meeting is designed to be an international and multi-disciplinary platform, bringing together the scientific community from around the world to share the latest research results on past global changes. Building on the success of previous meetings, we look forward to discussing the role of paleoscience in the years to come with you.

The IPCC Working Group II Sixth Assessment Report (AR6) begins with the sentence "This report recognizes the interdependence of climate, ecosystems and biodiversity, and human societies". The PAGES scientific community investigates such interdependences in the past to better assess the processes and mechanisms controlling Earth system dynamics under global change conditions. Dedicated scientists from different backgrounds come together to build a representative landscape of the past. Of course, as scientists, we are driven by curiosity and "love" our science. But there is more: the outcome of our research should improve future climate and environment projections and inform strategies for a more sustainable future.

In 2021, PAGES celebrated its 30th anniversary, and we are excited to share some of the latest milestones with you:

PAGES currently has about 20 active working groups, bringing together paleoscientists from around the globe to tackle specific questions. Their findings are used in international frameworks providing the solid scientific evidence for making sound decisions.

Recognizing the importance of making data available for the larger community, PAGES set up a new Data Stewardship Scholarship to help the working groups manage their data.

PAGES has always given a specific focus on early career scientists and scientists from low- and middle-income countries. Following the last Open Science Meeting, PAGES established an early-career network and a new Mobility Research Fellowships for African and for South American early-career scientists.

We have launched a new outreach initiative, Past Global Changes Horizons. It is a magazine designed for teenagers and young adults who are interested in learning more about paleoscience, past global changes, and science in general.

Unfortunately, we can't celebrate this anniversary together in person as the unpredictability of the pandemic has forced the organizers to run this meeting online. Nevertheless, I'm confident that this format will lead to a successful meeting full of fruitful scientific exchanges and discussions.

In this spirit, I wish us all a stimulating and productive meeting!

Marie-France Loutre, Sarah Eggleston, Leigh Martens Winiger, Basil Davis

PAGES IPO

Willy Tinner and Zhimin Jian

PAGES co-chairs

Acknowledgements: OSM supporters

Académie suisse des sciences naturelles
(SCNAT)
https://scnat.ch/de

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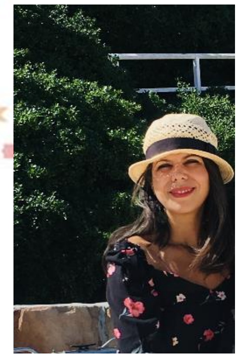
https://english.cas.cn/

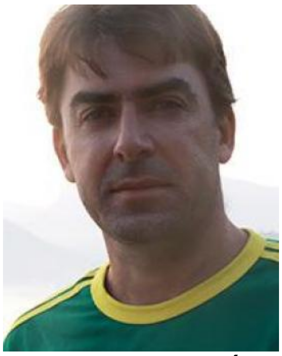
Université de Berne
https://www.unibe.ch/

Acknowledgements: OSM Committees and Organizers

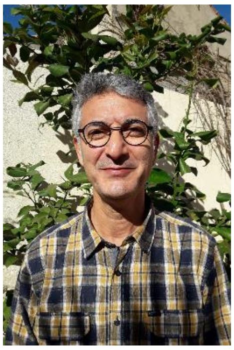
e-Organizing Committee



Ilham BOUIMETARHAN, Professor of Marine Geosciences, UIZ, Agadir. Morocco



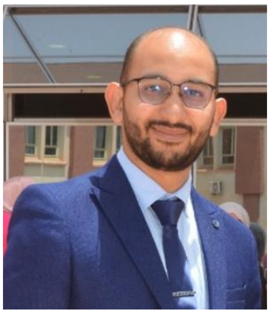
Matthieu CARRÉ, Paleoclimatologist, LOCEAN, France



Rachid CHEDDAD, Palaeoecologist, ISEM, CNRS, Montpellier, France

Hanane REDDAD, Professeur, USMS, Beni Mellal, Morocco

Asmae BAQLOUL, UIZ/USMS, Morocco (PhD, ECR)



Abdelmoula ABOUHILAL, UMSM, Beni Mellal, Morocco

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- Katrin MEISSNER, University of New South Wales, Australia
- Abdelfettah SIFEDDINE, IRD, France/UIZ, Morocco

Meeting programme

Monday, 16 May	
7:30-08:00	**Opening Ceremony**
08:00-10:00	**Block 1-Oral Sessions: OSM02 (part 1), OSM36 (part 1), OSM19, OSM05 (part 1)**
10:00-10:30	**Plenary session 1:** R. Cheddadi-Glacial refugia and future microrefugia: an effective plan to save plant species?
10 :30-11:00	Break
11:00-12:00	Lightning talk session 1
12:00-14:00	E-poster session 1: OSM02 (part 1), OSM19, OSM05
14:00-15:00	OSM Townhall-Inclusivity roundtable
15 :00-16:00	Break
16:00-18:00	**Block 2-Oral Sessions: OSM02 (part 2), OSM36 (part 2), OSM11, OSM14, OSM06**
18:00-18:30	**Plenary session 2:** J-J. Hublin-The origin of Homo sapiens: a North African perspective
19:00-20:00	Lightning talk session 2
20 :00-20:30	Break
20:30-22:30	E-poster session 2: OSM02 (part 2), OSM11, OSM14, OSM06

Tuesday, 17 May	
08:00-10:00	**Block 3-Oral Sessions: OSM05 (part 2), OSM15, OSM13 (part 1), OSM26 (part 1), OSM37**
10:00-10:30	**Plenary session 3:** H. Cheng-High and low latitude climate interactions at multiple timescales
10 :30-11:00	Break
11:00-12:00	Lightning talk session 3
12:00-14:00	E-poster session 3: OSM15, OSM13 (part 1), OSM26 (part 1), OSM37
14:00-15:00	OSM Townhall PAGES-Ocean KAN
15 :00-16:00	Break
16:00-18:00	**Block 4-Oral Sessions: OSM33, OSM13 (part 2), OSM26 (part 2), OSM03**
18:00-18:30	**Plenary session 4**: T. Lenton-Learning from past climate tipping points to avoid future ones
19:00-20:00	Lightning talk session 4
20 :00-20:30	Break
20:30-22:30	E-poster session 4: OSM33, OSM13 (part 2), OSM26 (part 2), OSM03

Wednesday, 18 May	
08:00-10:00	**Block 5-Oral Sessions: OSM 27, OSM18 (part 1), OSM30 (part 1), OSM25**
10:00-10:30	**Plenary session 5:** P. Braconnot-Thoughts on the role of paleoclimate model-data comparisons in assessing climate projection levels of confidence
10 :30-11:00	Break
11:00-12:00	Lightning talk session 5
12:00-14:00	E-poster session 5: OSM27, OSM18 (part 1), OSM30 (part 1), OSM25
14:00-15:00	OSM Townhall- Expand the reach of your science: Archiving your data in community repositories
15 :00-16:00	Break
16:00-18:00	**Block 6-Oral Sessions: OSM12 (part 1), OSM18 (part 2), OSM30 (part 2), OSM39, OSM25, OSM13 (part 3)**
18:00-18:30	**Plenary session 6:** Y. Maezumi-Legacies from the past as lessons for the future
18 :30-19:00	Break
19:00-20:30	Conference dinner-cooking session with our local master chef

Thursday, 19 May	
08:00-10:00	**Block 7-Oral Sessions: OSM 34, OSM42 (part 1), OSM28 (part 1), OSM17**
10:00-10:30	**Plenary session 7:** P. Srivastava-Flood history of the Himalaya: A geologist's perspective
10 :30-11:00	Break
11:00-12:00	PAGES e-soccer Cup
12 :00-16:00	Break
16:00-18:00	**Block 8-Oral Sessions: OSM12 (part 2), OSM42 (part 2), OSM28 (part 2), OSM07**
18:00-18:30	**Plenary session 8:** M.E. Ferrero-Dendrochronology and climate in the tropical Andes and lower lands: What we know and what to expect
19:00-20:00	Lightning talk session 6
20 :00-20:30	Break
20:30-22:30	E-poster session 6: OSM18 (part 2), OSM30, OSM39, OSM28 (part 2), OSM42 (part 2), OSM20, OSM22

Friday, 20 May	
08:00-10:00	**Block 9-Oral Sessions: OSM01, OSM16 (part 1), OSM24 (part 1), OSM41**
10:00-10:30	**Plenary session 9:** L. Gillson-A past-present-future perspective on using paleoecology to conserve African ecosystems
10 :30-11:00	Break
11:00-12:00	Lightning talk session 7
12:00-14:00	E-poster session 7: OSM01, OSM24, OSM41
14:00-15:00	OSM Townhall-PAGES 2k Network
15 :00-16:00	Break
16:00-18:00	**Block 10-Oral Sessions: OSM38, OSM20, OSM16 (part 2), OSM24 (part 2), OSM22, OSM42 (part 3)**
18:00-18:30	**Closing Ceremony**

General Information and Social Activities

Held every four years, PAGES' Open Science Meeting (OSM) and Young Scientists' Meeting (YSM) provide an invaluable opportunity to bring the global paleoenvironmental change community together from around the world. The theme of the 6th PAGES OSM is Learning from the past for a sustainable future. It reflects the growing awareness amongst scientists and social stakeholders of the threat climate change represents to health, agriculture, peace, security, and prosperity. Evidence of the occurrence of an adaptation to past global changes is the basis on which the future sustainability of societies can be built. The 6th PAGES OSM will particularly focus on the impact of climate change on humans and the environment, via factors such as demography, economy and energy. These questions will require a transdisciplinary approach and working closely with humanities and social scientists toward sustainable development. For the first time, the OSM/YSM will fully integrate social science partners to promote transdisciplinary approaches that support decision-makers and societal changes at all scales and in different contexts, especially for developing countries, and in focusing on three research themes - Dynamic Planet, Global Sustainable Development, and Transformations to Sustainability. At the local and regional levels, this conference will additionally provide an opportunity to integrate more African scientists into the PAGES community, strengthen South-South partnerships between African, Middle Eastern and South American scientists, examine the impact of climate change on Morocco's natural resources, and to showcase how Morocco, with significant renewable energy potential, is contributing toward carbon neutrality.

Social program

Conference dinner

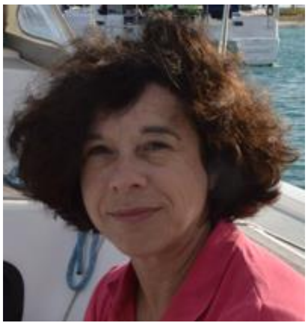
The PAGES 6th OSM Conference dinner will be held online this time. A cooking session of 1.5 hours will be conducted by our local Master Chef guiding us on how to prepare a delicious Moroccan menu. We will then take a break to enjoy our freshly cooked authentic Moroccan food with wine or beer or water or Moroccan mint tea. Participants are invited to share pictures and post them on social media using the tag #PAGESOSM.

A booklet with information about the Menu of the Day will be available on the digital conference venue. We recommend that you prepare ahead of time all the ingredients and the cooking utilities needed for the cooking session, along with a happy spirit and your choice of wine, beer, water, or tea.

The PAGES soccer game

The traditional PAGES soccer competition pitting proxy scientists against modelers will be organized online. If you are interested, please contact the local organizers at PAGES2021@uiz.ac.ma with your full name and preferred team.

Plenary speakers



Pascale Braconnot, Lab. des Sciences du Climat et de l'Environnement, CEA-CNRS, Gif-Sur-Yvette, France.

Thoughts on the role of paleoclimate model-data comparisons in assessing climate projection levels of confidence

The Paleoclimate Modelling Intercomparison Project (PMIP) was launched 30 years ago, with the aim to understand the climate response to various external forcings and to assess the ability of state-of-the-art climate models to represent climate states different from the modern one. Since the beginning, this project was endorsed by PAGES and WCRP, and has fostered paleoclimate reconstructions from different paleoclimate archives and model-data comparisons for key periods in the past. Paleoclimate simulations are now recognized as essential steps in the overall assessment of the realisms and progresses of climate models used for future climate projections. They offer a unique way to test model performances over a wide range of climate situations that have similar magnitude than the one expected in the future.

This presentation will address several aspects of model-data comparisons, and of the evolution of the underlying scientific questions. Models have evolved from only including atmospheric components to fully coupled Earth system models that account for the interplay between atmosphere, land ocean, and ice through the energy and water cycle, as well as the coupling between these cycles and the carbon cycle. New possibilities are offered by forward modeling of the way paleoclimate archives record environmental changes, new paleoclimate indicators, or statistical methods. They open method questions and new challenges to tell if model content in terms of physics and biogeochemisty is sufficient to represent different climate states and the transitions between them. Examples will consider climate sensitivity, the water cycle, and interannual to centennial variability to illustrate different levels of model evaluation – from process understanding, to full benchmarking considering the different sources of uncertainties in model and climate reconstructions. They will also be used to question how to further provide more direct constraints on the quality of climate projections.

About the speaker:

Pascale Braconnot is a former member of the PAGES Scientific Steering Committee, and a climate modeling specialist. She is now a member of the WCRP Joint Scientific Committee. Her scientific activities range from coupled ocean-atmosphere model development with a focus on air-sea coupling, to the use of coupled Earth system models in different climatic contexts. Her main scientific interests are the role of insolation, ocean feedbacks, and the hydrological cycle and its variability in past and future climate changes. She has been the PMIP coordinator since 2001 and has contributed to or led several multi-disciplinary projects to understand past or future environmental changes. In 2009, she was awarded the EGU Milankovic Medal for her work on past monsoons and analyses of ocean and vegetation feedbacks. She was a Lead Author of the IPCC AR4 and AR5 and Review Editor for Chapter 8 on the water cycle in the IPCC AR6 report.

Rachid Cheddadi, CNRS, University of Montpellier, France.

Glacial refugia and future microrefugia: an effective plan to save plant species?

In Europe and North America, plant species survived the last glacial period in refugial areas that provided them with a suitable climate that differed from the global climate until the Holocene warming. Today, long-lived plant species are threatened by global warming, and even if the rate of migration or dispersal of some species can follow the velocity of climate change, there are many barriers that prevent them from adapting their range, which in may lead to their extinction. One of the ways to protect these plant species from a potential extinction is to assess the ability of some of their populations to survive locally and determine if the areas where they occur today are suitable as future microrefugia to accommodate them in the long term, as was the case during the unfavorable last ice age. Defining tandems of suitable microrefugia and populations requires historical data on past changes in the species' range, its resilience, its genetic adaptability, the topography of the landscape, and a prediction of future climate.

In this talk, I will summarize what fossil data collected in Morocco over the past 30 years or more have revealed about past vegetation and climate change since the last ice age, and link this to an extended genetic study of an endemic and endangered mountain tree species to show that microrefugia may be an effective option for protecting species from ongoing global warming.

About the speaker:

Rachid Cheddadi is research director at the CNRS, University of Montpellier, France. His research topics include paleoecology, paleobiogeography, and quantitative past climate reconstructions from fossil pollen records. He has studied the role of glacial refugia and postglacial recolonization processes in the distribution of modern plant species, and how these past changes may help to manage future threats to plant species. His longstanding collaborations with vegetation modelers and geneticists have led him into the field of protecting endangered mountain tree species in Morocco and Lebanon and prioritizing effective protected areas in the face of ongoing climate change.

Hai Cheng, School of Human Settlement and Civil Engineering, Xi'an Jiaotong University, Xi'an, China.

High and low latitude climate interactions at multiple timescales

Earth's natural climate system varies persistently at multiple timescales with different dynamics. While we outline a sustainable future for a climate context, detailed case studies of past climate variations on various timescales are important, which however, haven't yet been fully developed. In the last two decades, significant advances in understanding the climatic controls on d^{18}O in atmosphere and cave environment together with landmark developments in U-Th dating techniques have propelled speleothems to the forefront of paleoclimatology and substantially improved our view of our planetary climate system on a wide range of timescales. I will present here speleothem data across multiple timescales, providing detailed case study in the context of high and low latitude climate interactions. On orbital-scale, a set of cave d^{18}O records from different climate domains suggest that precession-induced changes in summer insolation in producing distinct climate variability in the ice-sheet proximal and distant regions via the (delayed) ice-volume forcing and in-phase CO_2 feedback/forcing, and the direct summer insolation forcing and CH_4 feedback in driving the climate variability at low-latitude monsoon regimes. On millennial-scale, we used a combination of well-dated speleothem and ice core records to pinpoint the timings of the Younger Dryas event onsets and terminations in various climatic domains around the world. We show that the event occurred first at high northern latitudes then propagated southward into the tropical monsoons belt within a few decades, eventually reaching Antarctica before reversing the course to its eventual termination. It appears that changes in Antarctic and/or low-latitude hydroclimate might have served as precursors of the YD termination or Holocene onset. On centennial-decadal scales, new high-resolution record of the 8.2 kyr event from the Southern Indian Ocean reinforce the double peak structure centered at ~8.2 and 8.1 kyr BP, withstanding the interhemispheric anti-phased relationship. Importantly, the significance of the 8.1 kyr BP peak is prominent in Southern than Northern Hemisphere proxy records, likely implying a different mechanism. There is a large array of hydroclimate events worldwide around 4.2-3.9 kyr BP, the so-called '4.2 kyr event'. These events are not representative of one synchronous event globally, and it remains unclear whether the events are indeed a manifestation of one time-transgressive event in different geographical regions. I will conclude by briefly presenting the annual resolution speleothem record across the 'Chongzhen Drought' event (~1637–1644 CE) and its wide social-economic impacts. The case studies are fundamental for gaining insights into the inner workings of the earth's climate system for a sustainable future.

About the speaker:

Hai Cheng has been a professor at the Xi'an Jiaotong University since 2010. He received his PhD in geochemistry in 1988 from Nanjing University. He joined the Institute of Geology at the Chinese Academy of Sciences in 1988 and was a Senior Research Scientist at the University of Minnesota from 1993 to 2010. Hai Cheng has received many honors and awards, including appointment as a Geochemical Fellow of the Geochemical Society and European Association of Geochemistry (2015), AGU Fellow (2017), and the AGU Emiliani Lecturer (2019). He has been at the leading edge in developing U-series dating techniques and provided innumerable U-Th dates for collaborators who have made discoveries about paleoclimatic change worldwide. He played a world-leading role in paleoclimate studies of global speleothems, including the longest East Asian (640 kyr) and Indian (280 kyr) monsoon records, the longest Westerly climate records from central Asia (500 kyr) and North America (335 kyr), and the longest record from the Amazon Basin (250 kyr).

María Eugenia Ferrero, Instituto Argentino Nivologia, Glaciología y Ciencias Ambientales (IANIGLA), CCT-CONICET, Argentina.

Dendrochronology and climate in the tropical Andes and lower lands: What we know and what to expect

All Andean populations depend almost exclusively on rainwater for domestic use, irrigation and agricultural activities. Since these activities are directly affected by climatic conditions (high social vulnerability), it is essential to know the changes and trends in rainfall. The presence of the Andes and altitudinal gradients create very marked differences in hydroclimatic patterns; instrumental records help to understand spatial patterns but are very limited to understand long-term variability. In this case, dendrochronology allows for the development of high-resolution paleoclimatic reconstructions.

It is well known that developing ring-width chronologies in the tropics is challenging, both because of the enormous species diversity and variability of environments, as well as the forest and land use processes occurring in different regions. In tropical South America, a network of dendrochronological archives constructed from different species has been developing and growing over the last 15 years. These paleorecords are helping us to understand how climate (particularly precipitation) operates in different environments and on different timescales.

In this talk I will present advances in tropical dendrochronology, with emphasis on the Andes and adjacent lowland regions, the hydroclimatic reconstructions developed to date in different biomes and how these records are helping us to understand large-scale forcings, long-term trends and how precipitation is behaving in recent years in the South American tropics.

About the speaker:

Dr. Eugenia Ferrero is a researcher at the Institute of Nivology, Glaciology and Environmental Sciences (IANIGLA, CONICET) in Mendoza, Argentina. Her research focuses on hydroclimatic reconstructions along tropical and subtropical environments in South America based on tree-ring records. Her work includes the study of instrumental data variability, and the impacts of climate on ecosystems long-term responses.

Lindsey Gillson, Dept of Biological Sciences, University of Cape Town, Rondebosch, South Africa.

A past-present-future perspective on using paleoecology to conserve African ecosystems

Africa has a wealth of biodiversity, and a long history of customary management, alongside a large rural population that is directly dependent on ecosystem services and rapidly changing socio-economic contexts. These circumstances demand sustainable strategies that balance development and conservation for the future. Conservation of biodiversity and social-ecological systems therefore requires a past-present-future perspective that includes local knowledge as well as an awareness of future resilience and adaptability.

One of the main challenges in conservation management in Africa is to conserve biodiversity and enhance livelihoods. Central to this is knowledge of the historical range of variability in key ecological parameters such as tree density, fire regimes, and herbivore density, which were disrupted on much of the continent during the 18th and 19th centuries. Paleoecology offers a potentially valuable role in reviewing and assessing the range of these variabilities on scales of centuries to millennia. Specifically:

• Reconstructing vegetation change using fossil pollen provides insights into how landscapes looked before the intensive management that began in the 19th century.

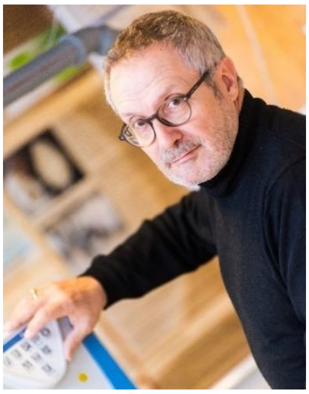
• Analysis of charcoal can help to reconstruct fire regimes prior to policies of fire suppression and prescribed burning.

• Analysis of coprophilous spores can be used to address important conservation questions regarding the abundance and management of herbivores, both wild and domestic.
• Phytoliths, diatoms, and other climate-related proxies can help us to gain an understanding of how ecosystems responded under warmer/drier climates.

Application of such data in real-world conservation contexts requires good calibration against modern analogues that can convert paleo proxies to indicators that are useful and understandable to managers and other stakeholders. Furthermore, modeling tools can facilitate stakeholder engagement by incorporating local knowledge of ecosystem dynamics. This enables stakeholders to explore the effects of different future climate and land-use scenarios on land cover and ecosystem services, improving inclusivity of conservation in the process.

About the speaker:

Lindsey Gillson is Professor at the Plant Conservation Unit, University of Cape Town, South Africa. Her interests include landscape ecology, theoretical ecology, conservation biology and applied paleoecology. Her research focusses on long-term ecosystem dynamics, and the implications for conservation, sustainability, and ecosystem services. She has a focus on African ecosystems, *especially savannas, and is interested in multidisciplinary studies of these complex socio-ecological systems. She is currently leading extensive projects on various ecosystems in southern Africa and Madagascar.*



Jean-Jacques Hublin, Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany.

The origin of *Homo sapiens*: a North African perspective

Both genetic data of extant humans and fossil remains point to an African origin of our species. For a long time, the oldest securely dated specimens of *Homo sapiens* fossils have only been known from sites in East Africa. According to the so-called "Garden of Eden" model, all humans living today were believed to descend from a small population that lived in East Africa around 200 thousand years ago. In this region, humans anatomically close to modern humans would have appeared quite rapidly around this date. However, the discoveries made at the Jebel Irhoud site (Morocco) have seriously challenged this model. In this cave site, deposits dated to about 300 thousand years ago yielded primitive forms of *Homo sapiens* associated with stone tools assemblages from the early Middle Stone Age. Not only did this discovery extend the antiquity of our species, but it also demonstrated that over a long period of time *Homo sapiens* evolved rather gradually. It led to the rise of a new model for *Homo sapiens* origin involving the entire African continent. During the late Middle and early Late Pleistocene, "Green Sahara" climatic episodes facilitated the spread of African populations to the Near-East and their contacts with Eurasian Neandertals. During this period, archeological evidence documents the increasing technical and social complexity of Middle Stone Age African groups. It is highly likely that these changes triggered the subsequent expansion of *Homo sapiens* into the colder mid-latitude environments of Eurasia and the subsequent replacement or absorption of local archaic hominins.

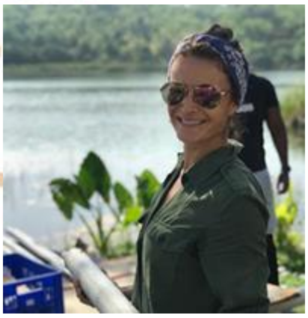
Timothy Lenton, University of Exeter, Exeter, UK.

Learning from past climate tipping points to avoid future ones

Tipping points exist in social, ecological and climate systems and those systems are increasingly causally intertwined in the Anthropocene. Climate change and biosphere degradation have advanced to the point where we are already triggering damaging environmental tipping points, and to avoid worse ones ahead will require finding and triggering positive tipping points towards sustainability in coupled social, ecological and technological systems. To help with that Tim will outline how tipping points can occur in continuous dynamical systems and in networks, the causal interactions that can occur between tipping events across different types and scales of system – including the conditions required to trigger tipping cascades, the potential for early warning signals of tipping points, and how they could inform deliberate tipping of positive change. In particular, the same methods that can provide early warning of damaging environmental tipping points can be used to detect when a socio-technical or socio-ecological system is most sensitive to being deliberately tipped in a desirable direction. Tim will provide some example targets for such deliberate tipping of positive change.

About the speaker:

Tim Lenton is Director of the Global Systems Institute and Chair in Climate Change and Earth System Science at the University of Exeter. He has over 20 years of research experience in studying the Earth as a system, and developing and using models to understand its behaviour. He is particularly interested in how life has reshaped the planet in the past, and what lessons we can *draw from this as we proceed to reshape the planet now. His accolades include the Times Higher Education Award for Research Project of the Year 2008; the Royal Society of London William Smith Fund, 2008; the Royal Society Wolfson Research Merit Award, 2013. He is a Turing Fellow and a Fellow of the Linnean Society, the Geological Society and the Society of Biology.*



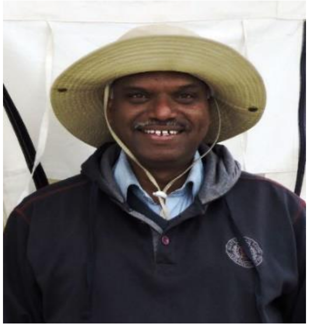
Yoshi Maezumi, University of California, Davis, USA.

Legacies from the past as lessons for the future

Increasing evidence suggests past human-environment interactions have a lasting legacy on modern ecosystems. Many advancements made in understanding long-term human drivers of ecological change have come from interdisciplinary studies integrating fields such as archaeology, palaeoecology, palaeoclimatology, soil science, and botanical inventories. This talk will highlight multiproxy case studies of long-term climate-human-fire interactions in the Brazilian and Bolivian Amazon. These data indicate indigenous populations employed diverse subsistence strategies that combined polyculture, including the cultivation of maize (corn), Ipomoea (sweet potato), Maniot (manioc), and Cucurbita (squash), and agroforestry through the enrichment of forests with edible tree species. Soil amelioration techniques were evident with the development of Amazonia Dark Earth (ADE) soils in residential areas that were later exploited to increase subsistence yields and maximized subsistence diversity without large-scale land clearance. These data provide evidence of resource diversification, improved food security, and sustainable anthropogenic landscapes through periods of increased climate variability, expanding indigenous populations, and increased social conflict in the late Holocene (~4000 to 500 cal yr BP). Existing research from remote sensing data indicate that modern ADE forests have lower canopy moisture, increased drought susceptibility, and greater flammability – indicating past indigenous land use has an enduring legacy on modern ADE forests. These various lines of research provide comprehensive examples of millennial-scale Anthropogenic landscapes that can inform forest and fire management for sustainable futures of Amazon ecosystems in the 21st century.

About the speaker:

Dr S. Yoshi Maezumi is a Paleoecologist and National Geographic Explorer specializing in past human-environment interactions. Her research integrates a background in Anthropology, Analytical Archaeology, and Physical Geography. Following completion of her doctorate in Paleoecology, she held a three-year post-doctoral fellowship at the University of Exeter, UK, developing a methodology integrating palaeoecology, archaeology, archeobotany, and paleoclimatology to examine human-environment interactions in the Amazon. In 2018 Maezumi held a one-year lectureship position teaching Climate Change in the Tropics in the Department of Geography and Geology at the University of the West Indies, Jamaica. She then completed a two-year Marie Curie Research Fellowship at the University of Amsterdam where she examined past natural and human drivers of fire in the Amazon Rainforest Ecotones. She is currently a post-doctoral researcher in fire and vegetation ecology at the University of California, Davis. Her research contributes to our understanding of human legacies in modern ecosystems and has been published in Science, Nature Plants, Nature Ecology and Evolution*, and* Scientific Reports.



Pradeep Srivastava, Indian Institute of Technology and Wadia Institute of Himalayan Geology, India.

Flood history of the Himalaya: A geologist's perspective

Rivers that drain the Himalaya experience frequent floods leading to large-scale sediment erosion, and landscape changes in the mountains and its foreland. Such natural changes at an interface with society are disastrous accounting to severe losses in terms of economy and lives. The volatility of these extreme events increases as the climate warms and in order to prepare better predictive models the long-term records of flood (1) frequency, (2) forcing factors, and (3) sediment/water routing of these events are needed as the century-long instrumental records that currently exist are not enough.

Slack Water Deposits (SWDs) are the sedimentary archives that occur along the rivers at the specific geomorphic locations represent the past floods. When chronologically constrained, SWDs have potential to extend flood records deeper in time. In this context, the Indus and the Brahmaputra rivers that cover the full climate and tectonic spectrum of Himalaya were explored, dated, and studied for their sediment provenance. In this talk, we will discuss the results obtained on these studies and attempt to answer: (1) Why are the floods in the Indus and the Brahmaputra an order of magnitude different in terms of discharge they bring? (2) Where do they erode the most and what Geology explains it? (3) What are timescales and driving factors of these floods in Himalaya?

About the speaker:

Dr. Pradeep Srivastava is a faculty in the Department of Earth Sciences, Indian Institute of Technology-Roorkee, INDIA. Dr. Srivastava is trained fluvial sedimentologist, geomorphologist and luminescence dating person. He applies his knowledge to understand the evolution of thrust and fold belts and riverine responses to climate change across Quaternary timescales. Dr. Srivastava has worked extensively on exploring paleoflood records across the Himalaya. He has 25 years of working and publishing experience in Himalaya, Ganga Foreland, Namib deserts, and southeastern America.

OSM01: Quaternary paleoenvironments of southern Africa

Co-conveners: Lynne Quick and Manuel Chevalier

Oral

Long-term relationships between land-use, erosion and vegetation at a mountain site of the Cape Floral Kingdom Hotspot (South Africa). Implications for its conservation and management.

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Abstract :

The Cape Floristic Region (CFR) extends over the SW corner of South Africa. Here, over 9,000 species of plants occur in a series of biomes, namely the Fynbos (Mediterranean Shrubland), Renosterveld (unpalatable Asteraceae scrub) and the Succulent Karoo (a succulent shrub dominated scrub). These landscapes provide an array of ecosystem services, such as water provisioning, erosion retention and grazing, as well as biodiversity and nature tourism. These biomes represent global conservation priorities due to their richness but also because their original extent has been modified, transformed by agriculture or otherwise degraded by land use and alien species. Some land use changes, such as the abrupt transition between extensive grazing and intensive cultivation establishing after Dutch colonization in the 17th century have left a long-lasting imprint on the vegetation of the CFR. In the last decades, however, biological conservation has emerged as a new management goal and one which sustains many livelihoods.

Several conservation concerns are pervasive in the CFR, namely, (i) the origin of the current vegetation landscape, including the effects of secular intensive farming, (ii) the long-term drivers that control the internal and boundary dynamics of the biome in such a drought sensitive area, (iii) the relationship between vegetation and land use iv) the effect of changing land cover on erosion and water retention in the landscape.

Here we present the results of a palaeoecological study of a ~1000 year old sediment core from a small wetland (Erica Kuil) in the Drie Kuilen Nature Reserve (Western Cape pr. Montagu). This is a mountain site, at the ecotone between the three biomes mentioned above. The fine level of taphonomic (separating reworked from non-reworked pollen grains) and taxonomic pollen identification detail allows for local, conservation-applicable conclusions to be drawn.

Results point to high-local dynamism within and among biomes where the present landscape is the result of recent grazing impacts and management. This also suggests that soil development is key for the resilience of vegetation whereas erosive events can have major impacts in biome shifts and wetland development. Conservation interventions should focus on the management of grazing and their potential impacts on erosion and the wider geomorphological dynamics of the reserve.

Keywords : South Africa, vegetation, conservation, fynbos, palaeoenvirnoments, fire, land use

Using pedogenic weathering timescales as a Quaternary paleoclimate proxy.

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Abstract :

The progressive aridification of southern Africa's paleoclimate since the Plio-Pleistocene is generally accepted (e.g., Vrba, 1995; de Menocal, 2004). However, records that help constrain southern Africa's climate variability during the Quaternary Period are still insufficient (e.g., Chase, 2021). Most of southern Africa's Quaternary paleoclimate records come from localised fossil sites or from ocean-derived records such as marine cores or benthic organisms. Geomorphic landscapes and deposits such as soils can be used to provide local, regional or continental paleoclimate proxy records based on their weathering geochronology over the 10^4 to 10^6 years' timescales. In this study, we examined the

extent of chemical weathering in soils from the Graskop area near the edge of the eastern Great Escarpment, South Africa. We then used the uranium-thorium-helium ((U,Th)-He) dating method to determine the dates associated with the weathering and pedogenesis there. We found that the soils were mainly composed of quartz, kaolinite and ferromanganese-oxides. The bulk chemistry of these soils, depleted in silica and base cations whereas enriched in Al and ferromanganese-oxides, suggested that the soils were formed by ferrallitization during hot humid climate (Duchaufour, 1998). The (U,Th)-He ages of goethite concretions in these soils range from 0.85 Ma to 1.05 Ma, and they date the last period of intensive chemical weathering on the eastern escarpment (Makhubela et al., 2021). This period is consistent with the 1.5 Ma to 1.0 Ma wet period in southeastern Africa shown by the high resolution hydroclimatic reconstruction of the Limpopo Catchment (Caley et al., 2018). Further, this period coincides with the Mid-Pleistocene Transition, which supports the termination of intense chemical weathering in this area during the change in climate from humid to more arid conditions on the southern African subcontinent. Our results suggest that weathering geochronology of geomorphic landscapes and deposits across southern Africa can offer a direct paleoclimate proxy that is either local, regional or continental and useful for constraining paleoclimatic reconstruction of the Quaternary Period.

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Keywords : Quaternary, Paleoclimate, Mid-Pleistocene Transition, Weathering geochronology, ferrallitization

An abrupt temperature and hydroclimate transition in eastern Africa during Termination V (~430 ka).

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Abstract :

Africa's climate became progressively drier and more variable in the last few million years (e.g., deMenocal, 2004). Of particular interest, is a shift to drier and more variable conditions in the Olorgesailie Formation (Kenya) between 500 and 300 thousand years ago (ka) in which Potts et al. (2018) observed a turnover of ~85% of large-body mammalian fauna to smaller-body related taxa, suggesting that the shift was an evolutionary response to better adapt to the changing climate. However, a hiatus in the Olorgesailie record means that the cause of this faunal shift is still an outstanding question. Here, we analyze Lake Malawi drill core MAL 05–1 (~11ºS, 34ºE) to investigate if a specific climatic event stands out as a possible driver of the dramatic change observed in the East African mammal community. We use organic geochemical proxies including branched glycerol diaklyl glycerol tetraethers (GDGTs), leaf wax carbon and deuterium isotopic records to develop high-resolution temperature, vegetation, and precipitation records, respectively, between 600 and 200 ka. Results show a dramatic and abrupt temperature increase of ~6°C occurring in less than 3000 years during Glacial Termination V, which is the Marine Isotope Stage (MIS) 12 to MIS 11 transition at ~430 ka. Notably, this deglacial

warming coincides with enriched leaf wax deuterium isotopic values suggesting a shift to more arid conditions in interglacial MIS 11 than in glacial MIS 12. Results also show another abrupt warming period in which temperature increased ~9°C around MIS 7 (~240 ka). We propose that the major warming and drying during Termination V in East Africa represents a significant abrupt change in the climate of eastern Africa and was a likely driver of the major faunal turnover noted in the Olorgesailie Basin.

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Keywords : Lake Malawi, GDGTs, leaf wax, faunal turnover

Holocene vegetation and fire dynamics in Mozambique's miombo woodland zone.

James Palmer [1], Simon Connor [1], Mussa Raja [2,4], Jonathan Haws [3,4], Nuno Bicho [4] and Ana Gomes [4]

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Abstract :

Southern Africa harbours globally significant biodiversity and ecosystems that have developed in close association with humans over many thousands of years. Miombo woodlands are distributed across southern and central Africa and provide important ecosystem services for the communities that live among them. One of the main threats to the ecological functioning of miombo woodlands is fire regime change, which is linked to land-use and climate change. It is critical to understand fire's long-term impacts on miombo woodlands to predict how fire regime changes are likely to impact on Africa's biodiversity in the future. This study aimed to reconstruct the fire history of dry miombo woodlands in Mozambique. We used a sediment sequence from a coastal lake to provide a continuous record of environmental change. We sampled sedimentary charcoal particles at high temporal resolution (approx. every 20 years) and classified them according to morphological characteristics. We then compared charcoal data to palaeoecological proxies in the same radiocarbon-dated sequence. The results indicate strong links between Holocene vegetation and fire dynamics. Large, infrequent fires are implicated in a major deforestation event approx.1300 cal. yr BP and the charcoal data provide evidence of a shift to a higher frequency fire regime in the last 500 years. We interpret these changes in the light of archaeological and palaeohydrological records from the miombo woodland zone.

Keywords : palaeoecology, fire history, charcoal analysis, Holocene, Inhambane

Quantitative climate reconstructions for the Drakensberg-Maloti region using a new synthesis of pollen records.

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Abstract :

The Drakensberg-Maloti has been a region of great hydrological importance for thousands of years, captured in the archaeological record as a region of refuge under dry conditions for humans and many other species. This is due in large part to its high amounts of orographically induced rainfall, which mean that the area lends itself well to the preservation of multiple proxies in the many wetlands. This is an incredibly valuable resource for palaeoecological studies in the generally dry southern Africa. However, there have been few quantitative palaeoclimatic studies taking advantage of this, and none using multiple sites

within the Drakensberg-Maloti region. This study represents the first attempt at such a regional synthesis. We utilised all published pollen records from the area to produce a dataset from which the standard Modern Analogue Technique was performed to reconstruct mean temperature of the warmest month, mean annual precipitation, mean winter precipitation and an annual climatic moisture index for the past 8 000 years. The moisture index showed a very low amount of variation, most likely due to the low amount of variation in the modern climate data associated with the sites in the modern calibration dataset, being so near the saturation point of this index. We found evidence for a cool, wet period at around 2 000 years ago, a period that has been identified in records from across South Africa as a Neoglacial, and which is consistent with diatom and sedimentary records from the Drakensberg-Maloti. We also highlight the importance of having an extensive modern calibration dataset for this type of study as one of our sites exhibited evidence of having no viable analogues throughout the record. All other sites display the same general climatic trends over the past 8 000 years, supporting the use of the Modern Analogue Technique on pollen records from Southern Africa. More quantitative studies from this region will greatly aid our understanding of the climate system as a whole and the conditions we are likely to face in the future.

Keywords : palaeoenvironment, quantitative reconstructions, pollen, Southern Africa, late Quaternary.

High-Resolution Mid-to-Late Holocene Fire-Climate Links in the Hyper Biodiverse Fynbos, South Africa.

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Abstract :

In South Africa's Cape Floristic Region (CFR), fire is necessary for the development and health of the highly biodiverse and disturbance-adapted fynbos biome. Yet, fire history and the ecological responses to fire over time remain poorly understood. In this research, we use sedimentary charcoal influx (# of particles/cm2/year) at exceptionally high continuous-resolution averaging two-year timesteps between samples to reconstruct mid-Holocene burning activity at a southern coast fynbos-afrotemperate forest ecotone site, Eilandvlei. Our resolution allows us to address fire over millennia on ecological timescales and to calibrate long-term fire history against recent fire observations from near-surface sediments and satellite records. Here, we explore how fire frequency and magnitude vary with local, regional, and global changes in climate, and investigate the degree to which in-lab experimental burning of known CFR vegetation can inform a fynbos-specific charcoal morphotype key. We expect that the fire regime at Eilandvlei will change in response to large-scale climate drivers such as shifts in the Westerlies and associated moisture availability, and to regional- and local-scale changes in sea level and vegetation. We further expect that experimentally produced charcoal morphotypes will assist in the interpretation of vegetation dynamics and ecological responses to fire in the fynbos. Results highlight short-term events, such as peaks in influx, interpreted as significant fire events and reveal long-term trends in the frequency of fire in the fynbos. Past changes in climate have likely altered fire regimes beyond the range of variability observed today, which has been estimated to average 10-13 years between fires during the late 20th century. This data is provocative and suggests fynbos fire regimes are more dynamic than once believed and points to the critical importance of exploring fire history at this high-resolution to understand how climate and human impacts may have shaped disturbance in the fynbos. This work is critically needed for

conserving and maintaining the fynbos as a biodiversity hotspot of global significance.

Keywords : Fire, Fynbos, Charcoal, Eilandvlei, Climate

Consistent coastal versus inland hydroclimatic contrasts in South Africa with increasing glacial conditions during MIS 5-4 revealed by data-model comparison.

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Abstract :

It has been demonstrated that hydroclimatic anomalies existed in the Holocene between near-coastal environments and those in the adjacent South African interior. To explain such spatial patterns the Agulhas Current and its highly localized influence on near-coastal environmental conditions has been suggested. However, the limitations in the data and model set ups available do not allow for a detailed examination. Here, we present results from a combined data-high resolution modelling study focussing on the transition from MIS 5 to MIS 4 in South Africa which reveals similar coastal versus inland gradients.

We present results from downscaling simulations performed for southern Africa, with a high resolution (12 km) regional climate model (WRF), forced by a global earth system model (NorESM). We focus on two time slices, 82 ka BP (MIS5) and 70 ka BP (onset MIS4), when orbital parameters and global sea level were markedly different from each other. Changes from 82 to 70 ka BP are generally in line with orbital forcing; indicating, for example, a widespread and significant (> 40%) increase in summer precipitation over inland southern Africa (south of 15 S) due to higher insolation at 70 ka BP compared to 82 ka BP. In contrast, the western and southern Cape coasts became drier at 70 ka BP, owing in part to a 40 m lower sea level, as the coastline shifted and the paleo-Agulhas plain got exposed. An additional factor driving the coastal aridity in the model derives from a cooling in the Agulhas Current from 82 to 70 ka BP.

We combine these sensitivity experiment with paleo-proxy observations representing coastal and interior hydroclimate conditions derived from i) archaeological cave soil deposits and ii) offshore marine sediment cores, respectively. A suit of marine sediment cores along the SE African margin show, based on their variability in the terrestrial components that reached the core sites, that South African climate was strongly modulated by orbital (precession) forcing. As the river catchments sourcing the material to the SW Indian Ocean lay inland the pattern recorded by the marine cores is in-line with the model simulating increased interior precipitation with increasing precession. Conversely, existing, and new hydroclimate reconstruction from Diepkloof Rock Shelter and Blombos Cave based on δDwax timeseries suggests shifts in coastal hydroclimate, from MIS 5 towards MIS 4 that can be interpreted as a shift towards increasing aridity in line with the model results.

Our study demonstrates the need for local-scale representation in climate modelling and the benefit of integrating multi-archive, multiproxy regional to wider far-field environmental information.

Keywords : South African hydroclimate, precession, data-model comparison, Agulhas Current

Reconstructing Late Quaternary Environmental and Climate Dynamics Using Palaeolake Sediments from Etosha Pan, Namibia

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Abstract :

Dry lakes in southern Africa have proved to be significant archives of palaeoenvironmental and palaeoclimatic data using palaeoecological proxies such as pollen (Nash et al. 2006) and geochemistry (Eckardt et al. 2008). Etosha, in northwest Namibia, is one of the largest dry lake basins in Africa but there remains a fundamental debate about its palaeoenvironmental context. Rust (1984) and Miller (2008) hypothesised that the Etosha basin is not a former lake at all but instead developed as a pan from long-term aeolian deflation that began in the Miocene and has remained as one since. Others, including Schwarz (1920) and Hipondoka et al. (2014) have proposed a more complex history in essence that Etosha was formerly a large lake system that has recorded fluctuating levels in relation to regional climate changes. This project aims to significantly advance the palaeoenvironmental evidence base for Etosha by generating new data from basin floor sediments to investigate 1) the age and mode of basin development and 2) responses to hydroclimate changes in the Late Quaternary. Recent studies by Brook et al. (2007) and Hipondoka et al. (2014) have used shoreline/lunette dune records from Etosha to demonstrate Late Quaternary hydrological dynamism in the pan. The nature of sediment accumulation at the basin margins is however contested, while the temporal resolution of existing data remains too coarse to test climate model (e.g. PMIP) driven hypotheses of past hydroclimate changes in the system. There is still, therefore, no clear understanding of the long-term hydroclimate controls of the Etosha system and, to date, basin floor sediments have never been investigated for their potential to provide robust data to address questions of basin origin or hydroclimate responses.

This project will therefore investigate, for the first time, sediments from the basin floor system through a multiple-proxy approach to test hypotheses about pan genesis, chronology, hydrology and to improve understanding of southern Africa's complex regional climate system during the Late Quaternary. Samples from a series of pits and three sediment cores from the pan floor will be subject to a range of analyses to determine the age and environmental contexts of deposition. Chronological control will use both radiocarbon and Optically Stimulated Luminescence (OSL) dating. Laser grain size analyses from downcore subsamples, along with geochemical data from Itrax XRF scanning and ICP-MS will facilitate the identification of major changes in sedimentary patterns that may be related to hydrological changes. These data will be used with existing climate model outputs to improve understanding of the supra-regional climate system.

Keywords : Drylands, Palaeolakes, Playas, Salt pans, Palaeoclimate

Poster

A new, user-friendly and ecologically relevant pollen type classification for the Southern African Asteraceae

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Abstract :

The Asteraceae are the most diverse angiosperm family in Southern Africa, representing an essential component of several biomes, such as the Fynbos, Renosterveld, and Succulent and Nama Karoo. The historical importance of the Asteraceae in these biomes is supported by a wealth of palaeoecological, mainly palynological literature.

However, the long-term ecological role and dynamics of the Asteraceae in South African landscapes is far from understood even when the Asteraceae dominate pollen assemblages. This is because fine-scale pollen identification below family level is seldom attempted, and instead, morphologically descriptive groupings, such as "Asteraceae undifferentiated" or "Long spine/short spine Asteraceae", or "Asteraceae medium" are commonly found in the palaeopalynological datasets. These morphological groups or "pollen types" include hundreds of species of different taxonomical and ecological ascriptions, and therefore are uninformative from an applied point of view. To date, this limitation has precluded the full understanding of the long-term dynamics of this essential component of the South African vegetation. Here I proposethat a pollen type

classification for a comprehensive, ecologically relevant and user-friendly identification of the South African Asteraceae is feasible to improve the resolution of asteraceous pollen identification in South Africa and assist in ecological interpretation of this diverse family.

The asteraceous pollen grains are typically 3-colporate, echinate or, sometimes, lophate. This pollen type calssification proposal is based mainly on qualitative (echinate vs. lophate) and discrete characters (number of spines) and it is supported by the most recent phylogenetical hypotheses for the Asteraceae. To a great extent, a tribal/infratribal classification of the pollen grains is feasible, and identification of groups of especies of karroid, renosterveld or fynbos affinities can be achieved. In turn, phylogenetical clades have been found to be ecologically meaningful in the assemblage of the different Southern African biomes, and thus this classification is applicable to palaeo- and ecological research. Additionally, this classification is relevant to any ongoing melissopalynological (honey), aerobiological (allergy) and forensic research to which fine resolution pollen identification is basic.

Keywords : Asteraceae, Compositae, Pollen, Taxonomy, Palaeoenvironments

Middle MIS 3 multi-proxy study of a speleothem from Bloukrantz cave, South Africa

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Abstract :

Current archeological evidences highlight the 100-50 ka period as being a watershed for human cognitive, technological and social development in Africa. High-resolution climatic and environmental records are needed to provide context for the behavioral evolution of early Homo sapiens. Here we present trace element and stable isotope data along with temperature reconstructions from both fluid inclusion microthermometry and fluid inclusion water isotopes from a speleothem (BL3) collected in Bloukrantz Cave, in the De Hoop Nature Reserve situated on the southern Cape coast of South Africa.

BL3 grew from 48.3 to 45.2 ka and from 7.6 to 1.6 ka. Here we focus mainly on the older part of BL3 (during Marine Isotope Stage -MIS 3), where both δ18Oc and δ 13Cc vary strongly, and covary with Sr/Ca. This correlation suggests that the control on the proxies originates from internal cave processes such as Prior Calcite Precipitation, which could be related to precipitation amount. The hydroclimate indicators furthermore suggest a shift towards overall drier conditions after 46 ka, coincident with cooling in Antarctica.

The temperature reconstructions show good agreement between both methods and display little variation throughout the record, with reconstructed temperatures close to the present-day cave temperature of 17.5 deg C. Overall, the BL3 record thus suggests stable temperature from 48.3 to 45.2 ka whereas precipitation was variable with marked drier episodes on sub-millennial timescales. Future studies will extend the record back in time to investigate whether this type of hydroclimate variability might have affected the early humans in the region.

Keywords : South Africa; Speleothems; Paleoclimate

Investigating sediments supplying the Southeast African Margin: a multiproxy study.

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Abstract :

Evidence of early technological and cultural behaviours of anatomically modern humans during the Middle Stone Age (MSA), 100-50 ka BP is apparent in archaeological sites in the southern Cape region of South Africa. It has been widely speculated that this cultural development was facilitated by specific environmental and climatic conditions in the region; particularly at the dynamic land-ocean interface. However, there is a lack of terrestrial palaeo-environmental and climatic records in South Africa which constrain testing these hypotheses. High accumulation rates along the Southeast African continental margin provide high resolution, continuous archives of both terrestrial and marine settings.

Here we utilise marine sediment core MD20-3591 (36° 43.707 S; 22° 9.151 E, water depth 2464m), located ~150km offshore at the continental slope off South Africa. This core site records both marine hydrographic (Agulhas Current) and terrestrial hydrological variability, receiving a significant amount of terrigenous material delivered from the African continent via riverine discharge, filling a key spatial and temporal data gap in this region by spanning the past ~450 ka, with an average sedimentation rate of 17 cm/kyr.

To decipher the variability of the terrestrial sediment input from the southern Cape rivers and more distal riverine sources, we systematically collected river sediments from drainage basins between Durban and Cape Town to gain a broad spatial coverage of the radiogenic isotope catchment fingerprints (neodymium and strontium isotopes and clay mineralogy). We targeted the finer <2µm fraction of lithogenic sediments as they are transported over longer distances as well as the coarser <32µm fraction which may represent a more local transport pathway.

Utilising MD20-3591, we present preliminary bulk sediment chemistry (XRF), oxygen isotope and grain size data spanning the past 450 ka to reconstruct transport history and characterise sediment source regions for this site. These multiproxy records will be augmented by additional radiogenic isotope reconstructions to further allow us to explore the variability of regional hydroclimate in relation to the archaeological record during the MSA interval.

Keywords : Provenance, South African Rivers, Source Regions

Vegetation succession in the Middle Stone Age at three sites from ~ 250 000 to ~ 35 000 years ago.

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Abstract :

The woody taxa in archaeological charcoal representing vegetation at Sibudu ~77-49ka, Rose Cottage Cave ~96-35ka and Border Cave ~250-43ka were researched by means of anthracology. Plant communities were compared in terms of site altitude and proximity to the coastline, spanning Marine Isotope, MIS7-2 during Interglacial warming, MIS5 and Glacial cooling, MIS4-3 periods. Charcoal was identified from the archaeological sequence at three sites, to describe the transitions of plant communities over time and determine vegetation succession. Layers from Sibudu and Rose Cottage Cave were analyzed in addition to Members of Brown Sand (BS) and White Ash (WA) Border Cave long sequence. Anthracology records anatomical features of charcoal by means of reflected light microscopy and digital photography. The IAWA, International Association of Wood Anatomy code is used to describe anatomical features. The identifications are made in comparison with the InsideWood online database and modern wood charcoal reference collections. Sibudu anthracology previously suggested that evergreen forest <60ka, was followed by woodland ~58ka, then by bushveld ~49ka. Woody taxa from evergreen forest and savanna or cliff scrub vegetation communities implied a

mosaic of habitats. From the new charcoal analysis, during the Glacial cooling MIS4 conditions of ~77-65ka, the deciduous genera and taxa diversity increased, suggesting an expansion of forest and forest margins. Previous studies revealed a vegetation mosaic at MIS3 ~58ka which differed from the coastal forest and savanna near Sibudu and conditions were colder and drier than today, the mosaic vegetation communities suggest a warmer and drier environment than preceding periods. In conclusion, the vegetation profile at Sibudu described a mosaic of vegetation communities which included evergreen forest and patches of open savanna. Rose Cottage Cave, interglacial and glacial phases encouraged relatively frost-tender plants in the ~96-75 ka interglacial warming period and "Protea" and "Erica" in the vegetation during the Rose Cottage glacial cooling post-75 ka occupations. Vegetation from relatively warm MIS5 seems more diverse than the later vegetation of MIS 4-3. In conclusion, vegetation patterns seem to respond to the Interglacial MIS5 warming and Glacial MIS4/3 cooling periods. Border Cave woodland existed from a dry environment before approximately ~150 ka when micromammals from the palaeofaunal record included taxa that prefer a drier environment than today. A bushveld vegetation community is implied before 100,000 years ago. Bushveld genera are more strongly represented than forest in the Members except for Member 4WA (~115ka). Differences exist between deciduous and evergreen vegetation. The vegetation does not suggest much change over a long period of time, thus Lebombo Bushveld and Summit Sourveld probably persisted throughout the sequence. Anthracology provides a profile of palaeo-vegetation through time at three sites since ~250ka.

Keywords : Anthracology, Palaeobotany, Middle Stone Age

Seeking seasonality in serial sampled equid teeth from late Middle Stone Age levels at Sehonghong Rockshelter, highland Lesotho

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Abstract :

Seasonal cycles are fundamental to hunter-gatherer decision making and land-use, and developing methods to detect them archaeologically is critical to accessing pasts at the scale of lived experience. But seasonality is an elusive climatic parameter. The isotopic analysis of faunal tooth enamel provides an archive of dietary and environmental conditions ranging from daily/weekly increments to months or years. However, systematic assessments of environmental and resource variability demands standardized sampling procedures that use detailed histological sections to guide isotopic sampling. Tooth histology and enamel growth patterns and rates must be linked to the location of isotopic samples, so that the time of enamel mineralization is well constrained relative to other samples from the tooth and within the life history of the individual. This study applies a method for interpreting intra-tooth isotopic variability as a proxy of past seasonality to equid teeth from the final Middle Stone Age (MSA) levels at Sehonghong Rockshelter, highland Lesotho. The method was developed by using a model of equid tooth mineralization to analyze the serial enamel isotopic composition of modern assemblage of zebra and corresponding results with contemporaneous precipitation data from Ol Pejeta Conservancy, Kenya. Sehonghong equid enamel was serial sampled for oxygen (d18O), carbon (d13C) and strontium (87Sr/86Sr) isotopes to obtain a comprehensive picture of annual migratory behavior and associated seasonal hunting practices of afromontane foragers during the final MSA.

Keywords : Tooth enamel, stable isotopes, microsampling, seasonality, migration

Late Quaternary palynological Studies at Lake St Lucia, KwaZulu-Natal.

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Abstract :

Palynological studies were done on lacustrine sediments deposited during the last ~7000 yrs. BP in Mkhuze Swamp, which drains into the most northern part of Lake St Lucia located in the Indian Ocean Coastal Belt Biome of KwaZulu-Natal, eastern South Africa. The aim was to reconstruct the past vegetation and to infer past climate fluctuations as well as human disturbances to complement growing evidence from other disciplines about these questions in the area. Palynological results shows a dominance of Podocarpus (yellowwood tree), other forest elements, marine indicators as well as Chenopodiaceae/Amaranthaceae accompanied by a decline in fungal spores between 7000yrs BP and 3500yrs BP indicating a mesic forested environment with marine influence leading to an increase of the water table along the coast. Regionally, pollen records in Lake Eteza shows similar vegetation change during that period. A peak of Fungal spores and grasses with a corresponding decline in Podocarpus and other forest elements and the disappearance of marine elements between 3500yrs BP and 2300yrs BP, signals a drop in water table probably due to evaporation, which was due to an increase in temperature. During the last 1000yrs pollen of Podocarpus decreased and a peak of pollen of the woodland tree Spirostachys (tamboti), together with strong Chenopodiaceae/Amaranthaceae presence and the appearance of marine elements (scolecodonts and foramenifera linings) suggest a change from a forested environment to an open woodland vegetation and an increase in the salinity of the swamp. Similar pollen fluctuations are found in Lake Eteza and Sibaya. The presence of Pinus pollen at the top of the profile suggests the onset of European settlement which were introducing pines for timber production. Regional pollen records in the last ~7000 yrs. BP shows a general trend from a mesic forested environment towards an open woodland environment.

Keywords : Palynology, Late Quaternary, Indian Ocean Coastal Belt Biome(IOCB), Vegetation history, Human Impact

MODERN POLLEN-VEGETATION RELATIONSHIPS IN NORTHEASTERN SOUTH AFRICA.

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Abstract :

Fossil pollen and spores are widely utilized proxies for the reconstruction of past vegetation, climate change, and human impact on decadal and millennial timescales. However, differential pollen preservation, production, dispersal, and depositional environments limit or enhance their recovery and interpretation. Thus, to improve the interpretation of fossil pollen spectra and the reconstruction of past vegetation changes, it is essential to understand the relationships between the modern pollen assemblage and contemporary source vegetation of a study area. For southern Africa, only little is known regarding pollen-vegetation relationships. In this preliminary study, palynological studies were carried out on six surface sediment samples alongside the botanical survey of five vegetation sample plots at Gustav Klingbiel Nature Reserve, Mpumalanga province in northeastern South Africa to explore modern pollen-vegetation relationships. In addition, multivariate Correspondence Analysis (CA) was conducted to examine whether the vegetation types are distinguished by the modern pollen assemblage.

A minimum of 250 terrestrial pollen grains was counted per sample. GK 1 (Fen vegetation) was characterized by the presence of Phragmites and other grasses, Typha, Sparganiaceae, and Cyperaceae. GK 2 (grass patches within thickets) was characterized by grasses (Poaceae >25), Asteraceae, Tubuliflorae, Vachellia, and Acanthaceae. GK 3.1 (Forest vegetation) was characterized by the dominance of Euclea, Searsia, and Diospyros. GK 3.2 (Fen vegetation close to a Gunnera plant) was characterized by

Phragmites, Cyperaceae Sparganiaceae, grasses (Poaceae >25), Anthospermum, Amaranthaceae with a slight occurrence of Typha and Gunnera. GK 4 (Fen and Forest margins) was characterized by the mosaic of Searsia, Anthospermum, Vachellia, Acanthaceae, Combretaceae, Asteraceae, Diospyros, Phragmites, and Cyperaceae. GK 5 (Riparian vegetation) was characterized by Poaceae, Cyperaceae, Phragmites, Dais sp, Vachellia, Pteridium, and Glomus.

The modern pollen data show that vegetation can be relatively well represented by surface pollen assemblages although Pinus (pine tree), a neophyte planted since the last c. 250 years for timber production, was overrepresented in the samples across the vegetation plots except in the forests. This is possibly due to its high pollen productivity and dispersal efficiency by the wind. The study indicates that pollen data provides a reliable basis for vegetation and palaeoecological reconstructions within the Mpumalanga region despite the limitations inherent in palynological studies.

Furthermore, extensive studies are needed to investigate pollen-vegetation relationships within the southern African vegetation with its 9 climatically and floristically highly diverse biomes further.

Keywords : Palynology, Modern surface samples, Botanical survey, Pollen-vegetation relationships, northeastern South Africa

OSM02: The last interglacial

Co-conveners: Eric Wolff, Laurie Menviel, Natasha Barlow, Chronis Tzedakis and Alessio Rovere

Oral

Extensive evidence for the Last Interglacial analog of the 8.2-ka event.

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Abstract :

A glacial lake outburst flood or accelerated ice sheet melting some 8,200 years ago (8.2 ka) caused the largest abrupt climate change event during the Holocene. It has been proposed that this 8.2-ka event has an analog during the Last Interglacial. Here, we characterize in detail the provenance, timing, and delivery mechanism of a layer of red sediments deposited across much of the Northwest Atlantic at about 125 ka. Our observations provide strong support for the occurrence of a Last Interglacial event that was analogous to the 8.2-ka event in all three aspects, and likely surpassed it in magnitude. The freshwater discharge associated with the Analog Event may explain a series of abrupt global changes, including a reduction of the North Atlantic Deep Water and reinvigoration of the Antarctic Bottom Water. Our findings suggest that the mechanism that triggered the Analog Event may be an integral part of the deglacial sequence of events, during which the final collapse of the contiguous Laurentide Ice Sheet (LIS) takes place 3.5 – 4 kyr after full interglacial temperature is reached in the middle and high northern latitudes.

Keywords : 8.2-ka event, North Atlantic, Last Interglacial, Ice dam collapse, Red layer

Post-Eemian paleo-environmental analysis in the southern North Sea.

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Abstract :

The Early Weichselian (MIS5d-a, 115-71 ka) is characterized by relatively rapid climatic changes, with cool stadials (Herning, MIS5d and Rederstall, MIS5b) and temperate interstadials (Brørup, MIS5c and Odderade, MIS5a). Mean annual air temperature differed by about 6°C between these cool and temperate phases in north-western Europe, while Northern Hemisphere ice sheet extent was limited. This situation is very different from terminations (such as the start of the Eemian), when climate warmed after peak glacial conditions with extensive ice sheets. As the best preserved post-highstand period, the Early Weichselian is critical for understanding climate change at the end of an interglacial, and could provide us with insights for the (near) future. Currently, there is limited knowledge on the magnitudes and rates of climatic changes and associated sea-level and landscape responses during this time interval for the North Sea region. For this purpose, the Late Eemian to Early Weichselian Brown Bank Member, a widespread and easily recognizable clay-rich unit in the North Sea, is being analyzed using a variety of methods.

Here I will present the first high resolution multiproxy study of two vibrocores from the Brown Bank area, a tidal ridge in the Dutch North Sea. Data from organic content (LOI), luminescence dating (OSL), elemental composition (XRF), pollen, diatoms, mollusks, lipid biomarkers (plant wax n-alkanes and membrane lipids; GDGTs) were combined with seismic interpretations for unique post-Eemian environmental reconstructions of the southern North Sea. Preliminary dating results and pollen stratigraphy suggest a depositional age of ~75 ka (MIS5a; Odderade interstadial) of these sediments. The first branched GDGT-based local annual air temperature estimates for MIS5a indicate that this region was approximately 5°C cooler than today. This compares to the pollen data, which indicate there were forests in the hinterland dominated by Pine and Birch, with only some thermophilous trees. Herbs, grasses and heathland were also present. Sea level must have been high enough to allow marine conditions, but fine-grained terrestrial input to the system was very high, indicating that a river

mouth was nearby. It is likely that a large part of the southern North Sea was a low energy pro-deltaic region of the Rhine-Meuse system. The new insights from our unique dataset can help to understand landscape development during a relatively warm phase in the Early Weichselian southern North Sea. The next step will be to combine seismic interpretations with high-resolution records from different sites, to enable us to make a unique, integrated reconstruction of post-highstand landscape development.

Keywords : Paleo-environment, multi-proxy, Early Weichselian, North Sea

Weakened Indian Summer Monsoon rainfall during the Last Interglacial

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Abstract :

Solar insolation is regarded the dominant control of glacial-interglacial monsoon variability but solar modulation of monsoon intensity during warm interglacial periods is so far largely unexplored. Understanding and addressing how the monsoon will respond to global warming scenarios is crucial for the food security and socioeconomic well-being of 40 % of the world's population. In this study, we compared the intensity of the Indian Summer Monsoon (ISM), one of the world's most sensitive weather systems, during the two most recent interglacial periods, the Holocene (11.6 ka BP to present) and the Last Interglacial (130 to 115 ka BP). Although these two interglacial periods underwent comparable changes in orbital configurations, ISM intensity is commonly assumed to have been higher during the Last Interglacial because of higher boreal summer insolation during this period, but qualitative proxy evidence for this assumption is so far lacking. By analyzing the stable hydrogen (dD) and carbon isotope (d13C) composition of terrestrial biomarkers in a marine sediment core from the northern Bay of Bengal, we provide proxy records of ISM rainfall and vegetation changes in the Ganges-Brahmaputra-Meghna river catchment for the Holocene and the Last Interglacial at sub-millennial-scale. We find that ISM intensity, inferred from both terrestrial biomarker dD and sea water salinity in the northern Bay of Bengal, was lower during the Last Interglacial – despite higher summer insolation and greenhouse gas concentration – than during the Holocene. Our findings challenge assumptions from climate model simulations that summer insolation exerts a primary control on ISM variability. Consistent with modern observations, we argue that lower ISM intensity during the Last Interglacial was caused by sustained high sea surface temperatures in the equatorial and tropical Indian Ocean, which may have increased convection above the ocean but consequently decreased convection above the continental land mass. Our finding of weakened ISM intensity in South Asia during the Last Interglacial compared to that during the Holocene highlights the need to re-evaluate the effect of insolation forcing on monsoonal rainfall intensity in fully coupled ocean-atmosphere climate models.

Keywords : paleoclimate, South Asia, sea surface temperature, sedimentary leaf wax, compound specific isotopes

A synthesis of last interglacial marine sites in the glaciated Northern Hemisphere.

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Abstract :

The last interglacial (LIG; 130 and 115 ka) is a useful analogue for understanding the sensitivity of the Earth System to future change because global sea levels were 5 to 10 m higher than present day and some regions of the Northern Hemisphere were 5°C warmer. Here, we present a database of marine sites constrained to the LIG from the glaciated region of the Northern Hemisphere. These sites are critical for constraining LIG global sea level as well as inferring the relative size of MIS 6 ice sheets and isostatic uplift. We describe 82 LIG sites from Russia, northern Europe, Greenland and North America from a variety of settings, including boreholes, riverbank exposures and coastal cliffs. These sites were constrained to the LIG using variety of chronological approaches, including radiometric methods (radiocarbon, U-Series dating, K-Ar dating), non-radiometric methods (amino acid dating, luminescence methods, and electron spin resonance, tephrochronology). Stratigraphic and palaeoenvironmental approaches were also commonly employed to assign a LIG age. We rank each site according to (i) quality of sea level measurement, and (ii) confidence in the LIG age assignment. Overall, LIG marine sediments are found in a wide variety of settings in northern Europe and Russia; however, they are relatively rare in North America. Many of the LIG sites document sea level regression, which is influenced by glacial isostatic adjustment, and some also document regrowth of continental ice and/or the increased influence of the global sea level signal. Obtaining precise chronological constraints (ie. MIS 5e, if radiometric data permit) remains one of the most significant challenges for LIG deposits in the glaciated region. Our work is a contribution to the World Atlas of Last Interglacial Shorelines (WALIS), which is a standardized database to archive sea level sites constrained to the LIG.

Keywords : sea level, last interglacial, database

East Asian climate response to insolation, CO2 and ice sheets during MIS-5 and indication for the future.

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Abstract :

Marine Isotope Stage (MIS) 5, between about 130 and 70 ka BP, characterized by climate oscillations consisting of three interstadials and two stadials. In this study, two sets of snapshot simulations by a step of 2 ka covering the whole MIS-5 period are performed with the model HadCM3 to investigate the relative impacts of insolation, CO2 and Northern Hemisphere ice sheets on the spatial and temporal variations of the East Asian climate, including the East Asian summer monsoon (EASM). Results show that precession plays a dominant role in the simulated summer precipitation, temperature and the EASM index. Within the range of CO2 variability during MIS-5, the change of CO2 causes similar degree of warming effect but much lower degree of humidifying effect compared to insolation. Insolation and CO2 affect the summer precipitation mainly through dynamic and thermodynamic processes, respectively. Our results also show that the influence of ice sheets on temperature and precipitation is less important than the effect of insolation and it varies from regions and in time. The effect of ice sheets depends on background insolation and also the location, height and area of the ice sheets. The simulated spatial-temporal variations of the EASM climate are compared with proxy records and the mechanisms involved are investigated. The simulated MIS-5 climate is also compared with the present and the future to investigate to which degree it can be considered as an analogue for the future in terms of East Asian climate.

Keywords : East Asian summer monsoon, paleoclimate modelling, insolation, CO2, ice sheets

Astronomically-induced abrupt cooling at the end of the last interglacial

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Abstract :

Paleoclimate records show that the end of the last interglacial (MIS-5e) was marked by abrupt cooling events and other abrupt climate changes such as abrupt weakening of the Asia summer monsoon. Strong abrupt cooling occurring when the climate was still in a warm condition is puzzling and its cause remains uncertain. Our LOVECLIM1.3 transient simulations covering the period 133ka-111ka show that there exists a threshold in the astronomically-induced slow variation of insolation below which abrupt changes at the end of MIS-5e occur. When the summer insolation in the Northern Hemisphere (NH) high latitudes decreases to a critical value, it triggers a strong, abrupt weakening of the Atlantic meridional overturning circulation (AMOC) and a strong cooling in the NH followed by high-amplitude variations. The mechanism involves sea ice feedbacks in the Northern Nordic Sea and the Labrador Sea. Similar abrupt oscillations happen in the simulated temperature, precipitation and vegetation from low to high latitudes as well as in the NH snow and sea ice. Taking into account age uncertainty in the proxy records, the timing of the abrupt cooling in our model (119.8ka) corresponds well with the timing of abrupt changes observed in many marine and terrestrial records, such as the Greenland ice core records, various marine records in the North Atlantic, the Chinese speleothem and loess records and some lacustrine records in low and high latitudes. Our simulations for the other interglacials of the past 800ka show that the insolation threshold occurred also at the end of other interglacials, suggesting its fundamental role in terminating the warm condition of the interglacials.

Keywords : Interglacials, Abrupt changes, Astronomical forcing, AMOC, Paleoclimate modelling

East Antarctic warming triggered by West Antarctic ice loss during the Last Interglacial

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Abstract :

During the last interglacial (LIG) (129-116 thousand years before present), annual mean sea-surface temperature was 0.5 degrees C higher than pre-industrial (PI) and global mean sea level was 1-9 m above PI levels, with an Antarctic ice sheet contribution of 1-7 m sea level equivalent (SLE). Coupled climate model simulations of the LIG typically use prescribed modern ice sheets, and lack dynamic feedbacks associated with melting of the Antarctic ice sheet. Here, we assess the climatic impact of a partial melting of the West Antarctic ice sheet, both from directly removing parts of the ice sheet, and from enhanced meltwater input around the Antarctic coast at the LIG. We find that partial ice sheet removal induces a surface warming over East Antarctica of 3-4 degrees C, as well as a summer sea surface temperature (SST) increase in the Weddell and Ross Seas by up to 2 degrees C, which could induce a further disintegration of the Antarctic ice-sheet. While the meltwater perturbation causes a high latitude surface cooling, it also leads to a subsurface (0-500 m) ocean temperature increase of up to 2 degrees C in the Ross Sea. We find that combining a partial removal of the WAIS, with the impact of enhanced meltwater input could further destabilise the Antarctic ice-sheet through an increase in surface air and subsurface ocean temperatures.

Keywords : West Antarctic ice sheet, coupled climate modelling, meltwater, Southern Ocean

Global temperature and hydroclimate in warmer climates of the past and future: the Last Interglacial versus greenhouse scenarios

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Abstract :

History does not repeat itself; nor does climate. But history often rhymes; and maybe so does climate. The study of the Last Interglacial (LIG; ca. 125,000 years ago) is frequently motivated also by presenting it as a possible partial analog to a future warmer climate forced by enhanced greenhouse effect. Still, a rigorous assessment of similarities and differences between what we have reconstructed of the LIG (with models and proxies) and what we expect for the future has not been carried out. As a consequence, the concept of 'partial analog' remains vague and we do not know how much we can use this past climate to learn about ongoing climatic changes. Here we address the question: for which scenario, time horizon, regions and season is the climate of the LIG a useful analogue of the future? We use the results of 13 climate models that performed the harmonized experiments of PMIP4 (lig127k) and CMIP6 (scenarioMIP), and present a comparison of hemispheric temperature and precipitation between the LIG and SSP scenarios of the future. We also propose two independent assessments of models performance, by comparing their temperature and precipitation to climate reanalysis of the last decades and to proxies of the LIG. Insights gained from this comparison can inform studies in disciplines beyond climate studies, such as hydrology and ecology.

Keywords : Climate models, paleoclimate, climate scenarios, future analog

Initial constraints on the rate and magnitude of Last Interglacial sea-level change in Northwest Europe.

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Abstract :

The past instability of the West Antarctic ice sheet, and its potential contribution to global and regional sea level during periods of warmer climate, is poorly constrained. Past interglacials provide opportunities to study the sea-level response to ice-sheet retreat, in turn helping to refine our projections of future change. Here, we present results from the ERC-funded RISeR project which seeks to exploit the sea-level fingerprint of the Antarctic ice sheet during the Last Interglacial (LIG), to determine the magnitude and rate of sea-level rise from ice-sheet melt at a time when polar temperatures were broadly analogous to future projections. We combine new palaeolandscape reconstructions, derived from offshore seismic reflection data, with detailed sedimentological and geochronological analysis of five new boreholes collected from the southern North Sea, alongside state-of-the-art ice sheet and glacial isostatic adjustment modelling. In doing so, we aim to constrain Antarctic ice sheet contribution to regional LIG sea-level highstands. Our new constraints will provide the first insights into the rate of sea-level rise, and thus ice-sheet retreat, during the LIG to better inform long-term high-risk, low-probability sea-level projections.

Keywords : Sea level, Last Interglacial, North Sea, Eemian, GIA

Did the Ronne Ice Shelf and West Antarctic Ice Sheet retreat in the last interglacial?

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Abstract :

There is intense interest in the future stability of the West Antarctic Ice Sheet (WAIS). Models range widely in their predictions and in the physics they include. Because the timescales for ice sheets are long, our best hope of constraining the solutions is to look at the past behaviour of WAIS. The last interglacial (LIG) is a particularly important time because Antarctic temperature was higher than present and some models predict the complete loss of WAIS and of the large ice shelves adjacent to it.

Within the WACSWAIN (WArm Climate Stability of the West Antarctic ice sheet in the last INterglacial) project, in 2019 we retrieved a 651 metre ice core to the bed of Skytrain Ice Rise. This ice rise is adjacent to the Ronne Ice shelf and the WAIS, but is expected to have maintained an independent ice flow because of the protection afforded by the Ellsworth Mountains. The ice core has been processed and analysed continuously for a range of analytes, including water isotopes, methane and major chemistry.

Our analyses show that the core is continuous through the last glacial period, and most of the last interglacial. Folds occur near the base, in the ice at the older end of the LIG, so that although older ice may be present, we can only interpret the core to 125 ka.

In the LIG, the record of marine ions in the ice suggest that the Ronne Ice Shelf was present at least from 125 ka onwards. This rules out occurrence of some of the more extreme retreats of WAIS that would have led to seaways between the Weddell, Amundsen and Ross Seas. We see somewhat higher water isotope ratios in the LIG than the Holocene, possibly consistent with some drawdown of WAIS in sectors other than the Weddell region.

Keywords : ice core, last interglacial, antarctic, ice sheet, ice shelf

Patterns of winter climate change in northern and southern Europe over the Last Interglacial.

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Abstract :

The Last Interglacial (LIG; 115-130 ka) is an important test bed for climate science as a realized case of significantly higher than preindustrial global temperatures. However, the regional climate patterns of the LIG remain poorly resolved, and especially so for winters, affected by a suite of strong feedbacks such as changes in ice cover in the high latitudes.

To resolve LIG climate patterns over Europe we prepared palaeotemperature reconstructions from a series of pollen sequences spanning the Atlantic seaboard of Europe from southern Iberia to the Arctic. Our reconstructions employ an ensemble of pollen–climate calibration models, including classical micro-palaeontological transfer functions (e.g., weighted averaging), the modern-analogue technique, and machine-learning approaches (random forest, boosted regression tree). In the Arctic, we rely on the high-resolution Sokli site of northern Finland, where the plant-ecological patterns allow the reconstruction of both January and July temperature (Tjan, Tjul). In southwest Europe, we use three marine pollen sequences. Galician margin (MD99-2331) and the Bay of Biscay (MD04-2845) sequences, located adjacent to the temperate forest primarily influenced by winter temperature, were used to prepare quantitative Tjan reconstructions. At the southwest Iberian margin site MD95-2042, located in the Mediterranean climate zone, we used the pollen sums of Mediterranean forest taxa and of semiarid taxa as qualitative proxies for winter precipitation.

Our reconstructions reveal contrasting winter climate trends between northern and southern Europe over the LIG. At Sokli, Tjul and Tjan closely follow the insolation trends, with a falling trend in Tjul but a strong rise of Tjan towards the late LIG, likely also reflecting the influence of the vigorous overturning circulation and warm Nordic seas in the late LIG suggested by marine proxy data. In contrast, the southern European reconstructions show a large reduction (up to 10°C) in Tjan over the LIG, coupled with a reduction in winter precipitation indicated by a fall in Mediterranean forest pollen and a rise in semiarid pollen. Importantly, while earlier transient climate modelling of the LIG was unable to robustly establish a timing for the Tjan peak in northern Europe, in southern Europe our reconstructed timing of the Tjan maximum (ca. 130–125 ka) contradicts the timing modelled for this region (120–119 ka), and runs counter to the insolation and oceanic forcing, and would thus need an additional explanatory factor.

To explore the possible causes of these latitudinal winter climate trends, we compared our reconstructions to climate model simulations (Community Climate System Model, version 3) for 130 and 120 ka. The simulations suggest a shift in winter circulation from 130 to 120 ka akin to a positive mode of the North Atlantic Oscillation, with a steeper, north–south sea-level pressure gradient and stronger zonal winds over most of northwest Europe. However, the modelled Tjan changes are muted compared to our data, within 0.5°C at the southwest European data sites. By contrast, the simulations show a latitudinal belt of strongly reduced winter precipitation over the Mediterranean at 120 ka compared to 130 ka, consistent with our moisture reconstructions.

Keywords : Last Interglacial, Europe, palaeoclimate, winter, North Atlantic Oscillation

Understanding ice sheet evolution leading up to the Last Interglacial using a coupled climate-ice sheet model.

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Abstract :

Evidence has suggested that the Last Interglacial (LIG, ~129-116ka) was one of the warmest interglacials of the last 800,000 years, with high latitude temperatures at least 1-2°C higher than today. With this warming being analogous to what is expected to occur due to polar amplification under climate change, it is important to understand the sources and mechanisms responsible for LIG sea levels being ~6-9m higher than present day.

Due to the transient nature of the earth system, sea levels during the LIG were still responding to changes in the ice sheets that occurred during the Penultimate Deglaciation (PDG, ~140-129ka). Yet, little is known about the evolution of the climate and ice sheets during the PDG, due to most geological evidence being destroyed by the more recent glacial advance. Nonetheless, available evidence has shown that the PDG differed to the Last Deglaciation (~21-9ka) in terms of the pace and magnitude of climate and sea level change and the timing of abrupt millennial-scale changes. Numerical modelling of the climate and ice sheets during the penultimate glacial cycle could be key to understanding the mechanisms underpinning these changes and thus achieving detailed knowledge of LIG climate, ice sheet and sea level change.

Here we present coupled climate-ice sheet simulations performed with the FAMOUS general circulation model and the Glimmer-CISM ice sheet model (FAMOUS-ice). The simulations follow the PMIP4 protocol for the Penultimate Deglaciation (Menviel et al., 2019), which includes time-varying changes in orbital forcing and GHG concentrations, and provides an initial condition for ice sheet geometry. We examine the important feedbacks between climate and ice sheet dynamics during the penultimate glacial cycle, simulate ice sheet evolution, and better understand contributions to LIG sea level. We also show the wider climate impacts of uncertainty in the ice sheet configuration by using alternative reconstructions more consistent with Penultimate Glacial Maximum sea level (~140ka) and empirical constraints.

Keywords : Last Interglacial, Penultimate Deglaciation, ice sheets, numerical modelling

Investigating climate variability during the Last Interglacial: Combined pollen and stable isotope analyses from the Fucino Basin, Central Italy.

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Abstract :

Environmental reconstructions of the Last Interglacial (LIG, 129-116 ka) can provide insights into natural climate variability under conditions of excess warmth. The LIG was characterised by a global mean temperature ~1˚C warmer than the pre-industrial era, pronounced Arctic warming, and elevated sea level (~6-9 m above present).The response of the climate system to a warmer background state can be explored through regional vegetation dynamics using combined pollen and stable isotope analyses. However, a lack of high-resolution palaeoclimatic archives employing a precise, independent, and robust chronological framework remains a primary limitation in investigating LIG climate variability and relating it to changes in other records.

Here, we present detailed palynological and isotope analyses of a thick lacustrine sedimentary sequence retrieved from the Fucino Basin, central Italy, covering the period from 139 to 107 ka. This key archive benefits from being very highly resolved with an independent chronology based on direct 40Ar/39Ar dating and geochemical

fingerprinting of several tephra layers. Pollen analysis was undertaken at 4 cm intervals representing a sampling resolution of ~80-100 years, while stable isotopic analyses (δ18O and δ13C) were undertaken on lake carbonates every ~8 cm with an average resolution of ~180 years.

The detailed pollen sequence captures a vegetation succession reflecting several climatic phases throughout the LIG at the Fucino Basin. Interrupting this succession are a series of centennial- to millennial-scale contractions in temperate vegetation. The comparison with δ18O records, from both the Fucino Basin and an Italian stalagmite (Corchia Cave), suggests a strong hydrological contrast between summer evaporation and winter precipitation during the early LIG maximum (~129-127 ka). Further δ18O-inferred changes in temperature and moisture availability are observed throughout the LIG at Fucino Basin and are concurrent with variations in forest composition and cover, as well as fluctuations in terrestrial and aquatic productivity recorded by δ13C.

Keywords : Climate variability, Last Interglacial, pollen, isotopes, tephrochronology

Labrador Sea paleoceanography and paleodiversity across the Last Interglacial.

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Abstract :

We have combined traditional paleoceanographic proxies with a paleogenomics approach to assess how the surface ocean conditions, especially sea ice cover, and paleodiversity evolved in the Labrador Sea across the late Marine Isotope Stage (MIS) 6 to 5d. This region is in a key location of the subpolar gyre, and receives cold, fresh Arctic water and sea ice via the East Greenland Current, and warm Atlantic water via the Irminger Current. We investigated stable isotopes, palynology, biomarkers and sedimentary ancient DNA in Last Interglacial sediments recovered with a piston corer from the Eirik Drift. In the sediment core, MIS 5e was identified via benthic and planktic foraminifer oxygen isotope records, and characteristic lithological features (i.e. the “red layer”). Sea ice biomarkers and palynology provide solid evidence for a likely permanent sea ice cover during MIS 6. The transition to MIS 5e is characterized by a seasonal sea ice cover, before sea ice free, open ocean conditions occur in MIS 5e. MIS 5d sees the return of seasonal sea ice conditions in the Labrador Sea. Across this interval we also investigated eukaryotic communities using sedimentary ancient DNA metabarcoding (V7 SSU rRNA). These results indicated substantial changes in paleodiversity across the different sea ice regimes associated with the climate transitions, but also within the Last Interglacial.

Keywords : multiproxy, paleogenomics, Last Interglacial, Labrador Sea, sea ice

Introducing Version 1.0 of WALIS, the World Atlas of Last Interglacial Shorelines.

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Abstract :

We present Version 1.0 of the World Atlas of Last Interglacial Shorelines (WALIS), a global database containing sea-level proxies and samples dated to Marine Isotope Stage 5 (~70 to 130 ka). The database was built through manuscripts and associated datasets compiled in a Special Issue in the journal Earth System Science Data (https://essd.copernicus.org/articles/special_issue1055.html). We collated the single contributions (archived in Zenodo at this link: https://zenodo.org/communities/walis_database/) into an open-access standalone database. This database release includes a documentation, also available as a Read-The-Docs website, describing the database fields. We also prepared scripts that allow to download, analyze, and visualize WALIS data. Version 1.0 of the database contains 4538 sea-level index points and 4270 dated samples connected with several tables containing relevant metadata (e.g., elevation measurement techniques, sea-level datums, and literature references).

Keywords : Last Interglacial, sea level proxies, database

Orbital to millennial scale variation of the speleothem δ18O during the Marine Isotope Stages 5 to 3 in southeast Chinese Loess Plateau and its climatic and environmental implications.

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Abstract :

The Chinese Loess Plateau is located in northern China, where the East Asian monsoon dominates the local climate and environment. Speleothem records from this region are crucial to fully understand the variability of the East Asian summer monsoon (EASM) and reconcile the disparity between loess records and speleothem δ18O records of EASM. Here, we present an absolutely-dated stalagmite isotope record spanning most of Marine Isotope Stage (MIS) 5 to MIS 3 from Xiaotian Cave, southeast of the Chinese Loess Plateau. The Xiaotian Cave speleothem δ18O record is dominated by precessional variations and punctuated by notable millennial-scale oscillations, coincident with other Chinese speleothem δ18O records within quoted errors, confirming that the loess summer monsoon records (e.g., magnetic susceptibility) and speleothem δ18O records might document the different aspects of the East Asian summer monsoon. Similar to other speleothem δ18O records from regions affected by EASM, the δ18O values of Xiaotian Cave during the MIS 5e were the same as or even heavier (e.g., Sanbao Cave) than those during the MIS 5c and 5a. This unparalleled response of speleothem δ18O to the insolation during the MIS 5 was likely caused by the unchanged or even increased contribution of 18O enriched moisture from the South China Sea and North Pacific, implying that an El Niño-like state existed during the MIS 5e. Our record also indicates that Xiaotian Cave speleothem calcite δ18O values increased abruptly at ~121.7 kyr BP, consistent with the previously reported Chinese δ18O records, demonstrating an abrupt weakening of the Asian summer monsoon at the transition from MIS 5e to MIS 5d. This abrupt change of speleothem δ18O values suggests a regime shift in atmospheric circulations or hydroclimate conditions in the Asian monsoon systems. We hypothesize that sea surface cooling in the tropical Indian and Pacific Ocean reached to a threshold, which resulted in an abrupt shift in precipitation δ18O either through the weakened convection over the tropical ocean or through the abrupt shifts in moisture transports and cycling of tropical moisture sources for the Asian summer monsoon. Xiaotian Cave speleothem calcite δ18O record shows centennial time-scale variability and an amplitude of ~3‰ within MIS 5e. These changes are similar to variations recorded by the δ18O record from Tianmen

Cave in the south central Tibetan Plateau and Shangxiaofeng Cave in Shandong Province, northern China, suggesting a heightened sensitivity of precipitation δ18O to climate changes at the marginal zone of the Asian summer monsoon during the warm and humid MIS 5e interglacial. Climatic oscillations during MIS 5e would seem to be comparable to those typical of the Holocene, featuring with unstable climate conditions. However, compare to the climate variations during the glacial (cold period), the climate was relatively more stable during the interglacial (warm period) on millennial to centennial timescales.

Keywords : stalagmite, stable isotope, Chinese Loess Plateau, last interglacial, abrupt change, tropical Pacific Ocean, sea surface temperature

Poster

Penultimate glacial-to-interglacial transition in the western equatorial Atlantic Ocean.

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Abstract :

The Atlantic meridional overturning circulation (AMOC) greatly influences global climate. Considering the possibility of a substantial reduction in AMOC strength by the end of the century due to ongoing climate change, AMOC-related studies became a topic of key importance. A weak AMOC would cause major changes in cross-equatorial heat transport within the upper Atlantic Ocean. Since the western equatorial Atlantic is the bottleneck for the northward return flow of the AMOC, a better understanding of changes in its upper water column during AMOC reorganizations on different time scales is required. Former glacial-to-interglacial transitions are particularly suited for this purpose, since they were marked by prominent changes in AMOC strength. Glacial-to-interglacial transitions are not only periods of major changes in the strength of the AMOC but also periods of striking increases in greenhouse gases and relative sea level. Here we assess changes in the western equatorial Atlantic upper water column structure during the penultimate glacial-to-interglacial transition. We show new results from marine sediment core CDH-89, collected from the western equatorial Atlantic (ca. 1°S), based on planktonic foraminifera oxygen isotopic composition from the mixed layer (Globigerinoides ruber white) and seasonal thermocline (Neogloboquadrina dutertrei). Our new data indicate increased upper water column stratification during abrupt millennial scale events of reduced AMOC strength related to a shoaling of the western equatorial Atlantic thermocline. This shoaling is linked to the east-west reduced transport of warm waters as a consequence of the weakening of the southeast trade winds. Our study subsidizes the debate of possible impacts that future changes in AMOC strength may have over the western equatorial Atlantic and ultimately over upper ocean heat transport in the Atlantic.

Keywords : Atlantic meridional overturning circulation, western equatorial Atlantic, foraminifera, oxygen isotopic composition

Last Interglacial (LIG) sea level proxies in Israel and Cyprus.

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Abstract :

Raised beaches in Israel and Cyprus have been subject to research since the early 20th century. The long and strong signal of the last interglacial together with the appearance of “Senegalese” fauna in the Mediterranean have contributed to

the existence of well-preserved and easily identified features on the semi-arid coastal landscape of Israel and Cyprus. The features include marine terrace deposits, often containing Middle Paleolithic anthropogenic remains, and marine abrasion notches. In places, the deposits present sequences of a basal conglomerate topped by poorly sorted shallow marine sediments, beach conglomerates and a stratified aeolian part. More than 60 relative sea level datapoints from Israel and Cyprus have been uploaded to the WALIS database.The data include sea-level and age indicators of variable quality, like warm Senegalese fauna, especially Strombus Bubonius, U-series dates on Cladocora caespitosa corals, but also ESR dates on mollusk shells, providing opportunity for mapping the LIG palaeo coastlines. This palaeo-sea level (reaching a height of ~39m in W Cyprus) suggests a predominately uplifting coastal zone in most sectors of Cyprus, in contrast to elevations up to ~6 to ~8m in the more stable coastal zones in Israel and sectors of Cyprus.

Keywords : Cyprus, Israel, LIG, MIS5e, Mediterranean

Last Interglacial subsurface warming on the Antarctic shelf triggered by reduced deep-ocean convection.

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Abstract :

The global mean sea-level was likely ~3-6 m higher at the Last Interglacial (LIG) compared to pre-industrial (PI), with an Antarctic contribution estimated at 3 to 5 m sea-level equivalent. Antarctic ice-sheet modelling studies suggest that such an ice-mass loss from Antarctica requires a subsurface warming on the Antarctic shelf of ~3 ∘ C compared to PI. Here we show that such a subsurface warming is simulated in an equilibrium experiment of the LIG performed with a comprehensive Earth System Model. Reduced deep-ocean convection in the Weddell and Ross Seas, arising from reduced sea-ice cover, are the primary drivers of this subsurface warming, reaching +2.4 ∘ C at 430 m depth. The associated changes in meridional density gradients and surface winds lead to a weakened Antarctic Circumpolar Current but strengthened Antarctic Slope Current, which further impact subsurface temperatures around both East and West Antarctica, with a maximum warming of +3.1 ∘ C at 125 m depth on the East Antarctic shelf. Higher SST and reduced sea-ice formation in the Southern Ocean thus increase ocean stratification and lead to a subsurface warming on the Antarctic shelf, with the potential to trigger ice-mass loss from the Antarctic ice-sheet.

Keywords : Last Interglacial, Antarctic subsurface warming, AIS, PMIP4

Surface temperature at Dome Fuji during the last interglacial period

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Abstract :

The last interglacial period (LIG, Marine Isotope Stage 5e) attracts much attention as a potential future analogue for an anthropogenically warming world. According to various paleoclimatic reconstructions, the LIG was warmer than the pre-industrial late Holocene, and the global sea level was higher than today by about 5 to 9 m (contributions from both Greenland and Antarctic ice sheets; IPCC SROCC, 2019). However, the LIG temperatures on the polar ice sheets are not well constrained. The LIG surface temperatures on the East Antarctic plateau estimated from oxygen and hydrogen

isotopic ratios in ice cores are ~4 – 6 K higher than pre-industrial, which are broadly consistent with modern spatial relationship between the surface temperature and isotopic ratio (e.g., Jouzel et al., 2007; Sime et al., 2009; Masson-Delmotte et al., 2010; Uemura et al., 2012; 2018). However, determining the temperature-isotope relationship is indeed complex, thus independent surface temperature estimates are highly desired (Buizert et al., 2021).

Recently, a new method to estimate the past surface temperature has been developed (Buizert et al., 2021), in which the age difference between air and ice (Δage) and δ15N of N2 in ice cores are inverted with a firn densification-heat transport model to reconstruct the surface temperature and accumulation rate. Buizert et al. (2021) estimated that the amplitude of surface temperature change in East Antarctic inland between the last glacial maximum (LGM) and pre-industrial is around 4 K, which is about half as the estimates from water isotopes (e.g., Jouzsel et al., 2007; Uemura et al., 2018), with a possibility of an altered temperature inversion during the LGM to reconcile the new estimate with previous isotope-based estimates. .

In this study, we used published δ15N and δO2/N2 data (Oyabu et al., 2021) and new CH4 concentration data from the Dome Fuji (DF) ice core around the LIG, and applied the inversion method of Buizert et al. (2021) to estimate the surface temperature at about the peak of LIG warmth (~129 kyr BP). The analytical precisions of DF gas data are 0.005 ‰ for δ15N, 0.1 ‰ for δO2/N2, and 3 ppb for CH4, and the typical time resolution is ~500 years. The inversion method with the firn densification model requires an ice age scale, Δage and δ15N. The ice age scale was constructed using a Bayesian dating tool (Paleochrono, Parrenin et al., 2021) with various types of age markers including the new δO2/N2 tie points. Preliminary Δage around the LIG was estimated by assuming synchroneity (bipolar seesaw) between the peak of δ18O and abrupt CH4 increase at the end of Termination II, and by converting the depth difference between gas and ice depths (Δdepth) to Δage using the ice age scale. The uncertainties of the ice age and Δage around the LIG are estimated to be ~1000 and ~800 years, respectively (2σ). Our preliminary result shows that the LIG surface temperature at DF was ~2 K higher than preindustrial, which is lower than the estimates from water isotopes.

Keywords : Antarctica, last interglacial, temperature, Dome Fuji

Testing the potential of phytolith analysis for improving paleoenvironmental reconstructions: El Cañizar de Villarquemado lacustrine sequence, NE Iberia.

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Abstract :

The last interglacial-glacial (LIG) is a critical period to understand the sensitivity of vegetation to abrupt climatic changes—especially concerning the global warming associated to some of the MIS5 episodes. The LIG is, unlike the present, a period where regional environmental change cannot be attributed to human agency. It is often used as an analogue to the current global warming and great efforts have been recently carried out for improving long-term paleoenvironmental reconstructions of the LIG, especially, at the Mediterranean basin scale and at the warmest stages, such as MIS5e.

Although the MIS5e is often considered a period of warmer and wetter climate, it does not always show synchronous climatic events

across regions, and, indeed, the nature of some climate drivers greatly differs between the Northeast of the Iberian Peninsula and the rest of Europe. All these characteristics can be explored with El Cañizar de Villarquemado sequence, the best accurately dated Iberian continental lacustrine record spanning up to the last interglacial. Previous studies on this sequence have described the depositional and paleohydrological evolution using sedimentology and geochemistry analyses and vegetation history using pollen. Fossil pollen is the main proxy for detecting plant cover changes as it is a powerful tool to approximate the response of vegetation to disturbances or the ecosystem's long-term assembly. However, palynology presents several, well-known drawbacks, such as its lack of taxonomical resolution in some plant families.

Phytoliths have been scarcely used in lacustrine sedimentary records in Europe, but they have proved to be very useful palaeoecologically in archaeological sites and different tropical lacustrine contexts around the globe. The Villarquemado palynological sequence offers a unique opportunity as it is characterized by high percentages of grasses especially during MIS5 but intermittently through the whole record. In the on-going study we aim to improve the taxonomic resolution of the Poaceae group by using phytolith analysis. We presume that a sensible amount of those grasses might be reeds (Phragmites spp.) and therefore linked to local condition variability and not necessarily to orbitally-led climate fluctuations. Cañizar means indeed reed community (thus, referring its abundance in the current place name) and previous sedaDNA metabarcoding analysis identified its presence at 14.4 ka BP. In addition, Poaceae present some antiphase evolution with Chenopodiaceae and similar trends to other aquatics and hygrophytes, in line with the alternation of the different sedimentary facies.

Phytoliths analyses in El Cañizar de Villarquemado sequence could fulfill two main objectives:

1) Obtaining a better resolution in the identification of Poaceae throughout the entire sequence. In this way, we intend to determine more precisely the vegetation inside and around the lake in different periods.

2) Testing the hypothesis that an important component in the Poaceae group during the LIG period is formed by reeds.

Keywords : Phytoliths, Paleolimnology, MIS5, Paleobotany, Environmental history

THE LAST TWO INTERGLACIALS IN AN EXPANDED BIOLOGICAL PROXY RECORD FROM THE COASTAL NORTHERN ADRIATIC (ISTRIA, CROATIA)

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Abstract :

Investigating forest successions from biological proxies in high resolution sedimentary records allows to reconstruct the climatic structure of interglacials. Here we present the first detailed centennial record of vegetation change for the Last Interglacial (LIG; i.e. MIS 5.5) and the Holocene in the northern Adriatic basin. Numerical techniques (MAT, WA-PLS, fxTWA-PLS) were applied on selected intervals of the fossil pollen record to obtain quantitative reconstructions of those climate parameters accounting for most part of the variance in the calibration set. We compared the obtained time series of climate parameters during the LIG and the Holocene from the same stratigraphic archive, to disentangle the differences in the fine climate structure between the last two interglacials.

Site and stratigraphy - The Istria Peninsula is located in the northern-eastern corner of the Adriatic Sea and it's dissected by deep karst valleys that during the marine high-stands have been transformed in rias. Part of these karst canyons was infilled by long amphibious sedimentary records, yet largely unexplored, and the valley of Mirna River represents the

largest and thickest one. The infill was successfully cored providing a 120 m long record (MIR1) of sedimentary environments, ranging from marine shelf to lagoonal to alluvial plain. The most complete transgression sequence, from 74 to 45 m depth, proved to contain an expanded record of the LIG with an exceptional potential of co-registered continental and marine biological proxies. So far, we analysed in detail microbotanical and sedimentary proxies. Interestingly, charcoal peaks mark fire events affecting plant communities developed on the limestone cliffs facing the coring site. The Last Glacial is almost missing due to the low-stand erosional phase, but the uppermost 32 m record the Holocene transgression.

Termination II is represented by a vegetation dynamic from semi-desert and steppe to mixed deciduous-conifer forests. Indeed, high pollen percentages of Pinus sp. and of xerophytic taxa (Artemisia, Juniperus, Chenopodiaceae) are followed by a sharp expansion of temperate forest pollen taxa and the development of a typical southern European LIG forest succession, clustered into two main zones. The lower one displays the maximum abundance of dry temperate broad-leaved trees (mainly Quercus robur-type), gradually replaced by moisture-demanding broad-leaved species (e.g., Carpinus betulus and Ulmus). A moderate expansion of evergreen Mediterranean sclerophylls (evergreen oaks and Oleaceae) is co-recorded in this upper main zone. These Mediterranean communities likely developed in the dry extreme of the edaphic gradient connecting the moist alluvial lowland to the dry cliffs.

Termination I is mostly not recorded. The hiatus is terminated by transgressional lagoonal facies dated to 10.4 ka, covered by a continuous expanded marine Early to Middle Holocene record and topped by the Late-Holocene coastal plain. Overall, the Holocene pollen record exhibits high percentages of deciduous oaks, evergreen oaks and Fagus, suggesting significant moisture availability and the return of Mediterranean elements after the Last Glacial.

Keywords : Last Interglacial; Vegetation dynamics; Multiproxy record; Paleoclimate; Transfer functions

Helicosphaera carteri resilience under different CO2 levels: living and fossil remains as a tool for studying past (MIS5) and future climate scenarios.

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Abstract :

The increase of anthropogenic CO2 emissions, and the consequent effects on climate, pressure the scientific community to provide solutions toward a rapid carbon neutralization. Marine phytoplankton can adsorb significant amounts of CO2, as it consumes as much CO2 as land plants despite constituting only 1% of the biomass on our Planet. Coccolithophores, a group of calcifying marine phytoplankton, takes part in the biogeochemical cycle consuming CO2 through photosynthesis (biological pump) and through the storage of microbiota-derived carbonates into the deep-sea sediments (carbonate pump). The study of coccolithophores in the geological records combined with lab experiments mimicking past and future scenarios is pivotal for understanding their response to climate changes together with their potential in CO2atm buffering.

Along the geological records, we selected a time interval spanning across Marine Isotope Stage (MIS) 5 to better monitor the Last Interglacial (LIG), which is considered as a good analogue for the modern warming. The microfossil content was analyzed in two deep-sea cores: the ODP Site 1209 (NW Pacific) and the IMAGES Core MD 97-2114 (SW Pacific). The results from the fossil records were compared with experimental cultures of a highly calcified species, Helicosphaera carteri, cultivated in photobioreactors under CO2-controlled levels of 290, 425, and 700 ppm mimicking the MIS5 and two of the best- and worse-case scenarios predicted by the Intergovernmental Panel on Climate Change (IPCC-2014), respectively.

Fossil assemblage analyses confirm that coccolithophores contributed significantly to the ocean carbon cycle through the biological

and carbonate pumps during MIS5, constituting up to 40-50% of the carbonate stocked into the sediments at the studied sites. In both oceanic sectors, we recorded higher coccolith carbonate fluxes at the start of MIS5, and thus coccolithophores' production may have acted as a positive feedback on CO2atm. Instead, higher carbonate dissolution episodes generating negative feedback on CO2atm occurred during glacial inception of MIS4 and interglacial at Site 1209, and during MIS4 in the southern site due to the stronger intensity of the corrosive Deep Western Boundary Current. At the beginning of MIS5e, the warmest substage of MIS5, the species H. carteri recorded at both sites an intense peak in abundance and CaCO3 production as well. This peculiar distribution confirms this substage as the warmest of the MIS5. It also documents the primary contribution of this species to the CaCO3 accumulation at the studied sites.

Preliminary culture-derived data reveal the H. carteri resilience toward CO2, showing bigger and well-preserved coccosphere at higher CO2 concentrations. The growth rate was lower at 290 ppm (0.35d-1) than at 425-700ppm (0.46d-1), suggesting an increased capacity of H. carteri to enhance its reproduction rate and CaCO3 production during higher CO2 levels. Culture and fossil data suggest that this specific species, as well as the group of coccolithophores, may play an important, but shifting role in carbon sequestration in a warmer world. These data show the importance of combining paleontological and culture-derived data to improve the accuracy of the predictions on coccolithophores' role within the carbon cycle.

"This research was funded through MUR for ECORD-IODP Italia"

Keywords : Helicosphaera carteri, MIS 5, IPCC scenarios, CO2-controlled cultures, coccolithophore microfossils

Marine Isotope Stage 5e: A new view from the Brazil Margin

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Abstract :

The last interglaciation (LIG) was characterized by stronger boreal summertime insolation, overall warming of the northern hemisphere, and global mean sea level several meters higher than today (Otto-Bliesner et al., 2021; Dutton et al., 2015). Higher LIG sea levels may be due to weakening of the Atlantic Meridional Overturning Circulation (AMOC), ice shelf collapse, and retreat of continental ice sheets (Clark et al., 2020). Reconstructions of LIG oceanic circulation are limited, however, making it difficult to understand the temporal and spatial scope of AMOC weakening. Here we present new stable isotope and carbonate ion reconstructions for the Brazil Margin spanning the last glacial cycle. Vertical profiles of benthic d18O imply the boundary between northern and southern sourced water during Marine Isotope Stage (MIS) 5e was ~500 m shallower than MIS 1. Profiles of d13C results indicate the entire water column at the Brazil Margin was isotopically lighter during MIS 5e, pointing to input of 13C-depleted carbon from an external reservoir. Additionally, time series of d13C and [CO32-] from mid-depth (1500-2500 m) sites reveal evidence for AMOC weakening during the MIS 6/5e transition. We will also compare the Brazil Margin results to other reconstructions from the Atlantic basin and discuss common patterns, discrepancies, and key areas for improvement.

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Keywords : last interglacial, stable isotopes, AMOC

Last Interglacial record of Dead Sea temperature and hydrology: evidence for orbital-scale North Atlantic Oscillation

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Abstract :

The North Atlantic Oscillation (NAO) is currently the main mode of atmospheric variability in the extratropical Northern Hemisphere. It dictates rainfall and air temperature variability from eastern North America to Siberia and from the Arctic to North Africa, especially during boreal winter. Whether or not the average NAO index may have shifted in the past is much debated, which calls for proxy-based reconstructions of air temperature and rainfall. Here, we use a new method, Brillouin spectroscopy on halite fluid inclusions, to reconstruct the Dead Sea deep layer temperature and hydrology throughout the Last Interglacial (LIG, ~130-115 ka BP). We identify two regimes for the temperature: (i) from 130.5 to 120.8 ka BP, temperatures were consistently lower than modern ones by ~2 °C; and (ii) from 120.2 to 117.2 ka BP, temperatures were still cold but much more variable. We reconstruct a ~100 m lake level drop from 130.5 to 116.7 ka BP, which we primarily ascribe to a ~65% reduction of freshwater discharge from the main tributary, the Jordan River. Using climate data from the recent decades, and the NAO index calculated as the sea-level pressure difference between Gibraltar and Iceland, we show that the temperature of the Dead Sea deep layer records interannual fluctuations of winter air temperature, which is itself anti-correlated with the NAO index. We further demonstrate that rainfall in the Jordan River catchment is a decreasing function of the NAO index. In light of our analysis of modern climate data, the reconstructed cold and dry conditions in the Dead Sea area are consistent with previous transient simulations which found that the winter NAO index was considerably above the modern mean during most of the LIG, due to orbital forcing. This adds to an array of evidence from other Eurasian sites.

Keywords : Dead Sea, Last Interglacial, halite fluid inclusions, Brillouin spectroscopy, paleotemperature, Jordan River discharge, North Atlantic Oscillation

Abrupt vegetation transformation during the last deglacial period in southern Yunnan

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Abstract :

The magnitude and pace of anthropogenic climate change are increasing the likelihood of abrupt changes in terrestrial ecosystems worldwide. But the impacts of global climate change on terrestrial ecosystems are imperfectly constrained by ecosystem models and direct observations. Identification of ecosystem turnover in the palaeovegetation record is with great importance for understanding the survivability and resilience of ecosystems to climate change and abrupt disturbances. However, our current knowledge of vegetation responding to environmental change is still insufficient.

Here, we conducted pollen analysis in Yilong Lake for the last 27,000 years. Abrupt vegetation transformation was recognized around 12.75 cal ka BP, by using CONISS cluster and structural change analyses. Pollen taxa were dominated by tree species of Pinus and deciduous Quercus before 12.75 cal. yr BP, but evergreen Quercus after. The biome shifted correspondingly from temperate deciduous forest to warm-temperate evergreen forest. This rapid vegetation turnover was probably relating to deglacial warming, since the temperature plays one of the most important climatic variables on the distributions of deciduous and evergreen forests. This assumption was backed up by regional climate

reconstructions with rapid warming signal during 13-12 cal ka BP. The short-term climate warming around 13 cal ka BP was accompanied by weaken Asian Summer Monsoon (ASM) as well as increased fire frequency in Yunnan. Weakened ASM would cause serious seasonal aridity, and aridity in warming climate promoted the fire occurrence. The abrupt vegetation turnover in Yilong Lake should be attributed to aridity and fire which caused tree mortality and accelerate the vegetation turnover under short-term warm conditions.

Considering the strong disturbance from human activities and increasing frequency of aridity, the southern Yunnan region is at high risk for vegetation turnover now. And the situation may be worse in the near future under high-emission scenarios.

Keywords : vegetation turnover, climate warming, Last deglacial, Yunnan

WAVELET ANALYSIS BETWEEN GEOMAGNETIC FIELD, CLIMATE, AND ORBITAL PARAMETERS: MAIN CHANGES IN THE MIS 5.

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Abstract :

During the last decades, the interrelationships between geomagnetic field (GF) variations, paleoclimates, and Milankovitch cycles were the subject of numerous research studies. The GF could have acted as a paleoclimate forcing, interacting with the cyclicity of the orbital parameters.

In this contribution, we evaluated the relationship between the GF variations, ocean paleotemperatures, orbital parameters, and an insolation forcing, covering the last 500 kyr using wavelets, cross wavelets, and multiple cross wavelets. The new multiple cross wavelet algorithms (Velasco Herrera et al. 2017) allowed the analysis of more than two-time series and know their relative phase relationships. The results of the wavelet analysis showed the eccentricity as the main forcing for the GF relative paleointensity (RPI) and the paleotemperatures time series. These results could suggest that the GF variations influenced the climate, or the same orbital forcing could have influenced both GF and climate. The results of the multiple cross wavelet analysis between RPI and the orbital parameters showed the precession as the main periodicity (~23 kyr) with higher spectral power when the eccentricity is maxima. Thus, we noted that the eccentricity modulated the GF behavior, and the precession could have been related to some short-term GF variations, being both precursors of GF changes.

During Marine Isotope Stage (MIS) 5, the GF could have played an important role as an indirect climate forcing. During this period, two GF reversals (Blake at ~120 kyr, and post-Blake at ~100 kyr) could have been associated with relative climate cooling after the Last Interglacial climax (MIS 5e). The GF reversals could have been precursor forcings creating positive synergy with the insolation changes. The Blake event promoted the end of MIS 5e and the beginning of the relatively colder MIS 5d, and the post-Blake event occurred at the end of MIS 5c and could have contributed to the beginning of the relatively colder MIS 5b. Thus, during these GF reversals, the conjunction of the absence or weakening of magnetic shielding and downward insolation, both forced by the orbital cyclicity, could have relatively cooled the planet.

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Keywords : Wavelet, periodicities, geomagnetic field, orbital forcing, MIS 5

Soils in the bipartite sediments within the Moscow (Late Saalian) Glacial Limits of the Russian Plain as a proxy for environmental trends of the last glacial-interglacial cycle.

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Abstract :

Soils respond to environmental changes and keep the records of any external impact in a wide set of pedofeatures, which can persist in soil profiles from several months to hundreds of thousands of years. This property of soils can be used to analyze paleoenvironment transformation during actively changing climate.

Within the territory covered by the MIS6 glacier on the Russian Plain, the investigations of the paleoenvironmental conditions are commonly done by studying the soils buried in the slope pedosedimentary sequences. However, such buried soils commonly lack sufficient spatial resolution because they usually develop as hydromorphic soils and cannot directly represent the factors of soil evolution on the uplands.

At the same time, it has been recently established that soils on the uplands, developed in bipartite sediments (a sandy cover layer on top of the glacial till), are polygenetic and not only reflect the modern climate conditions but also exhibit relic features acquired during several stages of pedogenesis and cryogenesis within the last interglacial-glacial cycle.

Retisols represent the most common soil profile formed in the bipartite sediments within the Russian Plain. We subjected these soils to detailed morphology, micromorphology, microtomography, clay mineralogy analysis, AMS and OSL dating, and confirmed the presence of polygenetic modern and relic features. The mantling layering of the bipartite sediments was verified by GPR, showing no signs of renovation or erosion of the underlying glacial till, which indicates the stability of uplands since the Middle Pleistocene. Thus, bipartite sediments have been subjected to pedogenesis starting from the late Moscow time (MIS6) until now.

Within the cover layer, pedogenesis resulted in a set of embedded soil profiles, formed in balance with the modern environment. In the glacial till pedogenesis was mostly exhibited on the ped faces as a set of multi-layered clay and clay-humus coatings. Based on the AMS dating of the clay infilling, we argue that clay illuviation has started during the Mikulino MIS5e and continued through the Holocene. Glacial till also keeps the cryogenic features of Valdai (MIS4/MIS2) time.

Besides, we revealed that soils keep the following features connected to:

1) the time of extensive deglaciation (Late Moscow time, MIS6 – MIS5 transition): a cover layer of the glaciofluvial genesis, as supported by new OSL dates, micromorphological and mineralogical data;

2) glacial formation of the parent material: a) features inherited from the material mobilized by the glacier such as red-brown colour, high weathered matrix; b) features resulting from sediment transport with the glacier such as over-consolidated matrix, sand infilling of glacial cavities and streaks.

Altogether, we confirmed studied Retisol profiles in bipartite sediments have been forming during the last glacial-interglacial cycle and Holocene. Thus, these soils should be considered as surface paleosols with the palimpsest type of soil memory, and a set of clay coatings could be studied as a potential source of evidence of past climate changes, reflecting environmental evolution during the last interglacial-glacial cycle and the Holocene.

Keywords : Surface paleosols, AMS dating, OSL dating, soil evolution

Late Pleistocene sea-level indicators in west Luzon, Philippines

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Abstract :

Using the framework of the World Atlas of Last Interglacial Shorelines (WALIS), we produced a standardized database of Last Interglacial (LIG) sea-level indicators in Southeast Asia after reviewing available studies on relative sea-level (RSL) proxies such as coral reef terraces and tidal notches in the Philippines; Sulawesi; and Sumba, Timor, and Alor regions. In total, we reviewed 43 unique RSL proxies in the region and highlighted sites for future studies. Following this work, we revisited a site in west Luzon, Philippines where LIG coral reef terraces were previously reported. Based on previous literature, a sequence of coral reef terraces (possibly LIG) is cut onto the Plio-Pleistocene Bolinao Limestone, the youngest formational unit in western Pangasinan. Rising to about 14 meters above mean sea level (m amsl) along the coast of western Pangasinan are previously dated Holocene coral reef terraces. In this paper, we present new geomorphic and stratigraphic data on the fossil coral reef terraces in Pangasinan, west Luzon which adds to the limited sea-level indicators in the region. While additional data is needed to shed more light on the RSL changes in the region, our work proves to be more challenging due to the difficulties of doing field surveys during a global pandemic. Nonetheless, we hope that data from this research will help us further understand the different drivers of past sea-level changes in SE Asia providing necessary geologic baseline data for projections of sea-level change in the future.

Keywords : LIG, coral reef terraces

Mean Ocean Temperature (MOT) during MIS5-6 Based on Noble Gas Ratios in the EDC Ice Core.

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Abstract :

The Last Interglacial (LIG) is one of the warmest climatic periods of the past 800kyr, during which high-latitude sea surface temperatures as well as Antarctic and Greenland surface temperatures, and global surface temperature in general, were higher than today. Although substantial differences in greenhouse gas concentrations and orbital parameters exist, the LIG is considered a potential analogue for certain aspects of near-future anthropogenic warming. The factors that contributed to an elevated LIG sea level of 6-9m with respect to today and the mass-loss from polar ice sheets implied therefrom are of particular interest. Ocean warming is expected to be one of the main contributors to sea level rise as it has the potential to affect sea level both directly, through thermal expansion, as well as indirectly, as a warmer ocean may lead to sub-shelf melting, leading to a destabilization of polar ice sheets and subsequent mass-loss.

Ratios of noble gases and molecular nitrogen trapped in polar ice cores can be used as a proxy for past MOT. Since noble gases are inert, their past atmospheric abundances on glacial-interglacial time scale are solely dependent on their well understood temperature-dependent physical solubilities in ocean water. As the atmosphere is well-mixed, a single ice core sample is sufficient to obtain a snapshot of the global ocean's noble gas content, and, thus, through the temperature-dependent solubilities, its heat content. Thanks to high precision mass spectrometry measurements, the 1σ uncertainty of recent MOT reconstructions is on the order of 0.4°C. As the ocean is Earth's dominant energy reservoir on a glacial-interglacial time scale, which is only rivalled by the latent heat changes connected to the waxing and waning of ice sheets, ocean heat content is an important metric in itself as a proxy for Earth's energy imbalance. As a consequence, MOT has proven to be a powerful proxy for the past climate.

Here, we present some preliminary MOT data for the MIS6-5 period based on noble gas ratios in the EDC ice core. Expanding on the recently

published Taylor glacier LIG MOT record, our dataset covers the entire Transition II and extends well into the penultimate glacial period. With this dataset, we aim to obtain a more comprehensive picture of MOT variations during the penultimate glacial-interglacial transition, and thus the state of Earth's energy imbalance as well as the role of ocean warming on sea level during Transition II and the LIG. As changes in the Atlantic Meridional Overturning Circulation (AMOC) are expected to lead to net changes in total ocean heat content, we also hope to gain more information on the role of AMOC during Transition II (and glacial terminations in general).

Keywords : MOT, AMOC, LIG, MIS6-5, EDC

Variations in calcareous nannoplankton assemblages and productivity during the Marine Isotope Stage 5 in South China Sea (IODP Site U1501).

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Abstract :

The Marine Isotope Stage (MIS) 5 (130-70 kyr) was the last major interglacial interval of the Earth's history [1] and it is considered as a good analogue of the current situation because of its high sea levels and temperatures, its reduced ice sheets [2], and an atmospheric CO2 concentration of 290ppm, which correspond to pre-industrial levels. Hence, its comparison with the current situation could be helpful to predict the future developments, to discriminate the anthropogenic impact with respect to the natural system and understand the effects of related-environmental changes on biota.

A good tool to investigate past marine ecosystem dynamics, to reconstruct the past environmental conditions and to study their effects on calcifying primary producers, is represented by coccolithophores. Coccolithophores are single-celled eukaryotic algae able to produce coccoliths, calcite plates which cover the organism forming the coccosphere. Their fossil counterpart is represented by calcareous nannofossils.

In this project, deep-sea sediments spanning a time interval from MIS 6 and 4 and collected from Site IODP U1501 (South China Sea) were analysed to deepen the coccolithophore responses during the MIS 5.

High-resolution analyses on calcareous nannofossil assemblages (with particular attention on the species Helicosphaera carteri) have been conducted on 50 samples, to reconstruct the Late Pleistocene palaeoecological and paleoenvironmental conditions. Data of coccolith carbonate production, paleoproductivity (N ratio) and carbon dissolution (dissolution index CEX) were collected and used to reconstruct the carbon and carbonate pump efficiency during the MIS 5.

The calcareous nannofossil assemblages from the South China Sea are well preserved and diverse; however, Florisphaera profunda, whose presence is linked to water stratification, is dominant. Its fluctuations in abundance seem to be related to variations in intensity of Asian monsoon.

Variations in sea surface temperatures and nutrient availability are reflected by fluctuations of different taxa (e.g. small Gephyrocapsa oceanica, Calcidiscus leptoporus) through the succession.

Helicosphaera carteri, despite being a minor component of the assemblage, shows an increase during the MIS 5e, which confirms its preferences for warm water conditions.

Additional specific morphometric analyses have been conducted on coccoliths of this species and the collected data have been used to determine its responses under past global warming conditions (e.g. increase/decrease in calcification).

Based on our evidence, the conditions during MIS 5e resulted in an increase in total coccolith absolute abundance and a shift to more heavily calcified species, resulting in increased $CaCO_3$ export, an acceleration of the biological and counter carbon pumps and therefore increased sequestration of carbon in the deep sea.

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Keywords : MIS 5, South China Sea, coccolithophores, Late Pleistocene

OSM03: New developments in speleothem paleoclimate and paleoenvironmental science

Co-conveners: Andrea Columbu, Franziska Lechleitner, Laia Comas-Bru, Yassine Ait Brahim and Yuval Burstyn

Oral

The decomposition of speleothems into subharmonic modes, a new approach to quantify changes in the past climate.

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Abstract :

Recent work has highlighted the crucial role of ocean Rossby waves in the evolution of past climate [1]. On the scale of several decades, even several millennia, the climate system responds resonantly to the solar and orbital forcing. This is attributed to the Rossby waves of long period winding around the 5 subtropical gyres. Resonances occur according to the natural periods of these "Gyral Rossby Waves" (GRWs) in subharmonic modes: 15 modes have been identified with periods ranging from 64 years to 2.36 Ma. The methodological approach presented in this communication is based on the stable oxygen isotopic compositions of speleothems, which consists in estimating the wavelet power of dated series of stable oxygen isotopic composition (δ18O) in speleothems within period bands representative of subharmonic modes. This has the advantage of increasing the degree of reliability of the information contained in the speleothem, i.e., the extent to which it widely affects the observed variations in calcite δ18O composition related to rain or to changes in the functioning of the karst system and its epikarst. In this way, precise regionalization, and reconstruction of the evolution of long-term rainfall oscillation can be achieved where the speleothems have sufficient spatial density. This method is applied to the migration of the summer intertropical convergence zone (ITCZ) during the Holocene, as well as to the evolution of the intensity of ENSO [2].

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Keywords : Speleothems; Ocean Rossby Waves; Climate variability; Holocene

Unlocking the Secrets Held by Organic Carbon Deposited within Speleothems: A Test Case in Northwestern Madagascar.

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Abstract :

Speleothems are hallmarks of paleoclimate research as they are easily dated (e.g., U/Th) and obtaining high-resolution data such as oxygen and carbon isotopesδ18O and δ13C using traditional IRMS techniques is straightforward. However, many speleothem records only focus on δ18O to infer changes to precipitation, as multiple complex factors can influence the δ13C signal including karst dynamics, soil processes, and overriding vegetation changes. Instead of trying to untangle the processes affecting the inorganic carbon, here we aim to gain additional paleoenvironmental data from the organic carbon deposited on the speleothem's surface. Using organic geochemical proxies that are traditionally applied to sediments, we can gain information about overriding plant types using plant waxes (e.g, n-alkane ratios), and fire/combustion history using polycyclic aromatic hydrocarbons (PAHs). To tease out what, if any, portion of the inorganic carbon isotope signal is contributed by changes in the dominant plant type, we use the carbon isotopes of plant waxes, including: n-alkanes and fatty acid methyl esters (FAMEs). Our locality to test

these proxies is the well-studied Anjohibe in northwestern Madagascar, where the inorganic carbon isotope record is well-understood. At least 10 records exist from this cave and the nearby Anjokipoty. Generally, all records show an enrichment of ~ 8-10 per mil in inorganic carbon isotopes between about 0.6-1.5 ka. Evidence from nearby Lake Mitsinjo (charcoal, pollen) and archeological sites suggests this abrupt enrichment is due to vegetation loss and change from a C3 to a C4 dominated landscape in response to a shift from human economies based on foraging and hunting to agropastoralism and controlled burns or "Tavy", a practice to promote the growth of certain grasses. In order to apply organic geochemistry techniques to speleothems and test this hypothesis, we first test different cleaning protocols to remove surface organic molecule contaminants. Our results suggest that higher yields of sample organic molecules is achieved through polishing off the outer surface of the speleothem as opposed to cleaning the surface via sonicating the whole sample. Preliminary biomarker results from Anjohibe indicate the presence of long-chain n-alkanes (C27, C29, C31) from trees, herbs and grasses, and a carbon preference index value close to, but above 1, possibly due to the dominance of Poaceae (e.g. cereals and pasture grasses) on the modern landscape. PAHs are present but further testing is required to determine their source. This study sheds light on how organic geochemical proxies may be used to enrich traditional inorganic speleothem records.

Keywords : speleothems, organic geochemistry, carbon isotopes

SISAL speleothem database - link to modern monitoring data, trace element proxies and increased accessibility.

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Abstract :

Speleothem (cave carbonate) archives are widely distributed in terrestrial regions around the world, and provide high-resolution records of past changes in climate and environment, encoded in oxygen and carbon isotopes. The SISALv2 database, created by the PAGES-SISAL Phase 1 Working Group, provided 700 speleothem records from 293 cave sites, 500 of which have standardized chronologies. The database provided increased access to records, and has enabled regional-to-global scale analysis of climatic patterns using a variety of approaches.

The PAGES-SISAL Phase 2 Working Group continues to build on these previous efforts and is focusing on the following objectives: (i) exploring ways to synthesise modern cave monitoring data to provide robust modern baselines and improve proxy interpretations, (ii) adding trace element proxies of Mg, Sr, Ba, U, and Sr isotopes to the SISAL database to increase our understanding of regional climatic and environmental variability, (iii) a database update to incorporate ~100 newly identified speleothem datasets, (iv) providing a javascript web app with a user-friendly GUI to increase SISAL data accessibility.

Here, we present preliminary information on available cave monitoring metadata synthesized from the Cave Monitoring Database (product of a Cave Monitoring workshop in Innsbruck, Austria) and published speleothem trace element records. We highlight regions where overlapping stable isotope, trace element and monitoring datasets are available, and

identify gaps. We show proposed database structures for cave monitoring and speleothem trace element data, linking them to the speleothem entities in the existing SISAL database with persistent identifiers, and introduce the Beta version of the SISAL GUI. We briefly present a synopsis of the SISAL-community level discussions on best practices for reporting trace element data, and reducing data measured with high resolution laser ablation methods.

We welcome feedback on PAGES-SISAL Phase 2 activities, and encourage participation and collaboration from interested researchers in different stages of their academic career and working in different geographical regions and allied disciplines.

Keywords : speleothem, SISAL, database, model, paleoclimate

Asynchronous suborbital fluctuations in Asian speleothems and their climatic implications.

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Abstract :

Oxygen isotopes records from speleothem archives are a tool of choice to track the evolution of the Asian Monsoon. Their precise chronologies have been used to pinpoint abrupt events, notably the onset of the proposed Meghalayan age (4.2 ky BP to present). This ``4.2ka event'' coincides with an isotopic excursion in a speleothem record from Mawmluh cave, India, and has been linked to several civilization collapses throughout Asia, though controversy surrounds their causes and detailed timing. Here we use 11 well-dated speleothem oxygen isotope records from the SISAL v2 database to investigate the regional coherency of rapid (centennial-millennial) shifts in Asian paleohydrology over the Holocene. Several complementary methods fail to detect spatially coherent variability at these time scales, either because none exists, or because, as numerical simulations suggest, any such shift may be obscured by heterogenous soil, vegetation, and karst processes. Given the small amplitude of sub-orbital isotopic excursions in speleothems, this result questions their use in defining regional- or global-scale events until regionally coherent excursions can be reliably detected and reproduced within age uncertainties. This result has critical implications for the definition (or rather, the existence) of a Meghalayan age.

Keywords : speleothem, spatial, coherency, Meghalayan

Sub-millennial scale climate variability during the early last glacial period recorded in French speleothems

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Abstract :

The last glacial period is characterised by millennial-scale climate variability, known as Dansgaard-Oeschger events, that are clearly recorded in ice-cores from Greenland, and many

marine and terrestrial records spanning a range of climate zones. The Greenland ice-cores also record sub-millennial scale climate variability, in the form of short-lived warming events preceding the main interstadial (precursor events), warming events at the end of interstadials (rebound events) and cooling episodes during interstadials (Capron et al. 2010). Such sub-millennial variability is particularly pronounced during the early last glacial period. These sub-millennial events are less well studied than the canonical Dansgaard-Oeschger events, as relatively few records have sufficient temporal resolution to resolve them.

This study presents five new speleothem palaeoclimate records from Saint-Marcel and Orgnac Caves in Ardèche, south-east France, collectively covering the period from 127 to 87 kyr BP. The replicated d18O and d13C time series provide a comprehensive record of millennial and sub-millennial scale climate variability, which mirrors events observed in the Greenland ice-core record, suggesting a strong climate coupling between south-east France and Greenland. Interstadial periods are interpreted to be associated with an abrupt increase in soil and vegetation activity, reflecting an increase in temperature, and an increase in the dominance of precipitation from the Atlantic. Variation in Mg/Ca, Sr/Ca and (234U/238U)0 is also observed across the main stadial-interstadial transitions, the interpretation of which is explored. The multi-proxy record provided by the d18O and d13C enables changes in different components of the climate system to be interrogated over sub-millennial events. It is found that changes in temperature and precipitation in Ardèche decoupled over a number of the sub-millennial events. This suggests that these short-lived events are in some ways distinctly different to the more prominent millennial-scale climate events. A stacked chronology was produced, based on 130 individual uranium-thorium ages, that provides a well constrained and continuous chronology of the early last glacial period. Comparison is made between the timing of the onset of interstadial events in the Ardèche speleothem records, the GICC05modelext chronology (Rasmussen et al. 2014) and the SIOC19 ages (based on a compilation of speleothem records) (Corrick et al. 2020), which shows good agreement between the chronologies.

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Keywords : Stalagmite, speleothem, last glacial period, Dansgaard-Oeschger events

Marine isotope stage 4 changes in hydroclimate of southern Portugal

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Abstract :

Marine isotope stage (MIS) 4 spanned ~ 71 - 57 ka and was one of the coldest segments of the last glacial in Europe. Speleothems can provide seasonal to decadal environmental data on vegetation and hydroclimate variability, and in this study, we prevent stable carbon and oxygen isotopes and elemental compositions of a stalagmite collected in southern Portugal (Companheira cave) that grew from ~ 69 – 64 ka, coeval with Greenland stadial 19.1. The data,

combined with regional records in Portugal, Spain, and France reveals a large latitudinal moisture gradient, with drier conditions in the north and wetter conditions to the south. As stalagmite growth ceased at Greenland interstadial 18 and did not restart during Heinrich stadial 6, this suggests that dry and cold conditions dominated this region of Europe. The implications of these results will be discussed in the context of terrestrial and marine climatic boundary conditions.

Keywords : paleoclimate, speleothems, Pleistocene, hydroclimate, Portugal

Behavior of the Azores High from 1200 Years of Proxy Records and Climate Model Simulations.

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Abstract :

The Azores High (AH), a subtropical ridge in the atmosphere over the North Atlantic comprising one node of the North Atlantic Oscillation (NAO) system, has a dominant influence on the weather and climate of the Iberian Peninsula and northwest Africa. The behavior of the entire NAO system over the last millennium has been the subject of much debate in both proxy- and model-based studies. Many studies have focused on the behavior of the entire NAO system, but we focus solely on the behavior of the AH due to its proximity to this region. Other proxies from this region, mainly from Spain and Morocco, have provided details about atmospheric dynamics yet spatiotemporal gaps remain. In this study, we present a continuous, sub-decadally-resolved composite stalagmite carbon isotopic record from three partially overlapping stalagmites from Buraca Gloriosa (BG) cave, western Portugal, situated within the center of the AH, that preserves evidence of regional hydroclimate variability from approximately 800 CE to the present. This composite record, developed from U-Th dating and laminae counting paired with carbon isotopes, primarily reflects effective moisture in western Portugal. Given the close pairing of AH behavior (intensity, size, and location) and moisture transport in this region, the BG composite record allows for a thorough analysis of AH behavior over time. Multidecadal to centennial scale variability in the BG record and state-of-the-art last millennium climate model simulations show considerable coherence with precipitation-sensitive records from Spain and Morocco that, like BG, are strongly influenced by the intensity, size, and location of the AH. Synthesis of model output and proxy data suggests that western Portugal was persistently dry during much of the Medieval Climate Anomaly (MCA; ~850-1250 CE) and Modern era (1850 CE-present) and experienced wetter conditions during Little Ice Age (LIA; ~1400-1850 CE). Even considering age uncertainties from the Iberian Peninsula and northwest Africa proxy records, the apparent timing in the transition from a relatively dry MCA to a wetter LIA is spatially variable across this region, likely due to the non-stationary behavior of the AH system.

Keywords : stalagmite, Azores High, hydroclimate, Last Millennium Ensemble, paleoclimate

A comparative approach between tufa and speleothem records in a climatic key region (Northwest Africa) over the last 5000 years.

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Abstract :

Tufa and speleothem growths are both the response to the rate of carbonaceous bedrock weathering, which is influenced by the vegetation development (and hence the humidity). To investigate the interdependency

of these two carbonate archives, a new record of tufa from Northwest Africa has been studied using thorough sedimentologic and stratigraphic analyses complemented with a multiproxy approach and radiocarbon dating. The result revealed a high correlation between the inferred humidity reconstructed from regional speleothem-derived isotopic curves, and our reconstructed depositional paleoenvironments during the last 5000 years. On a multi-millennial time-scale, the sedimentologic and stratigraphic insights depict a general trend of the deposition of lacustrine or palustrine sedimentary facies and the creation of the accommodation space with the reconstructed long-lived variation of the NAO-like pattern from regional speleothem-derived data. On the other hand, it has been shown that abrupt climate changes (Bond Events), highlighted by regional speleothem-derived isotopic curves, would have coincided with calcite bio-precipitation interruptions and the deposition and preservation of organic-rich facies. The occurrence of this organic-rich facies is frequent over the last ca. 2000 cal a BP, which might imply solar forcing on a multi-centennial scale, as shown from speleothem data of nearby sites. It is suggested that the strong expression of this assumed solar imprint in the tufa deposits after 2000 cal a BP and not before might be related to the background reduction of the insolation on the northern hemisphere, which would have increased the sensitivity of tufa with respect to solar minima peaks during this time-lapse.

Our data demonstrate the response of tufa and speleothem growth to regional climatic fluctuation during the last 5000 years BP. As such, combining these two carbonate archives in a holistic and comprehensive study including isotopic geochemical, sedimentologic, and stratigraphic approach is recommended to better understand the relation between the forcing mechanisms (e.g., climate change) and the response observed and inferred from these natural archives.

Keywords : Tufa, speleothem, climate change

Poster

Loess deposits in southern Tajikistan (Central Asia): Magnetic properties and paleoclimate

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Abstract :

The continental accumulation of dust during the Quaternary led to the formation of widespread loess deposits in southern Tajikistan. In this area, the accumulation of loess is commonly associated with the occurrence of dust storms and the widespread distribution of loess provides evidence of dust storms becoming more frequent in arid Central Asia at least since the Early Pleistocene. Southern Tajikistan represents one of the largest loess deposits in Central Asia. We conducted a thorough study on the magnetostratigraphy, grain size, and magnetic susceptibility

of the Chashmanigar section to reconstruct the stratigraphy of loess deposits and paleoclimate of Tajikistan.

Based on our new data, the lower boundary of the basal ages of the Olduvai and Reunion subchrons were established for the studied Chashmanigar section. Rock magnetic analyses showed that the predominant ferrimagnetic minerals are large pseudo-single domain grains of magnetite, including limited maghemite. Standard

demagnetization techniques yielded a characteristic component of natural remanent magnetization, which was used to obtain well-defined magnetostratigraphy. In southern Tajikistan, paleosols consistently exhibit finer grain size distribution and higher magnetic susceptibility than loess horizons, suggesting that the environment of the Chashmanigar section was colder, drier, and dustier during glacial periods than during interglacial periods.

Through correlation with astronomically tuned oxygen isotope records, sophisticated dating of the loess-paleosol sequence at Chashmanigar could be achieved, and the global significance of the recorded paleoclimatic variations could be revealed. The resulting grain size, magnetic

susceptibility, and correlation with astronomically

tuned oxygen isotope clearly provides information about the climatic pattern during the Early Pleistocene.

Keywords : Loess, Paleomagnetism, Pleistocene, Paleoclimate, Tajikistan, Central Asia

Detecting a distant volcanic eruption in speleothems using synchrotron micro x-ray spectroscopy?

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Abstract :

The detection of volcanic events in speleothem time series has much potential to improve our understanding of past occurrences of volcanic events and their impacts on climate. Previous studies have mainly focused on the identification of historical eruptions in annually resolved speleothems(1–3). In this study we aim to identify, for the first time, a prehistoric large volcanic eruption in speleothems that are over 9000 km distant from the eruption center.

We include three speleothems from two caves at Pinnacle Point on the South African south coast that have been dated by uranium series dating to between ~95 and ~60 ka. The region has an oceanic climate with small variations of temperature and rainfall amounts between seasons. Modelling of last glacial conditions suggests muted variability of temperature and rainfall amounts on glacial-interglacial timescales(4). This muted nature of glacial-interglacial variability might improve the chances of detection of a volcanic signal in these records.

Cryptotephra of the younger Toba tuff have been identified in open air and rock shelter sediments within a few km radius around the cave sites hosting the speleothems(5), however, it is unlikely that ash fallout was sufficient to affect the trace element composition of the speleothems. We therefore focus on identifying peaks of trace elements that could be associated with volcanic aerosols, namely sulfur and bromine. Sulfur peaks dating to the time of the Toba eruption have been identified in ice cores from both hemispheres(6,7) supporting the large amount and global distribution of the sulfur aerosols from the eruption. Large amounts of halogens have also been inferred for the eruption(8). We use synchrotron powered micro x-ray fluorescence at two different energy levels (3keV and 14 keV) to map the distribution of the trace elements in the speleothem carbonate.

The results of our analyses show that sulfur is enriched in layers that overlap within error with the younger Toba eruption, however, the sulfur increases are more temporally spread out than the increases in the ice core records. This observation may reflect recycling of sulfur in the soils and vegetation which complicate the identification of volcanic events even of the magnitude of the younger Toba eruption (M>8.0) in speleothems located far from the volcanic center. Bromine distributions in the samples appear even more complex, with higher values often occurring in sections of the sample that are older than the younger Toba eruption.

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Keywords : speleothems, synchrotron analyses, South Africa, sulfur, trace elements

OSM05: From the LGM to the Anthropocene: Environmental changes driven by climatic variability, sea-level fluctuations and human activities in East Asia

Co-conveners: Steve Pratte, Lydia Mackenzie, John Dodson and Fang Gu

Oral

Climate change and human impact- a view from central China.

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Abstract :

The mountains of central China support great plant biodiversity and a range of vegetation types from broad-leaved evergreen, deciduous and cool temperate conifer forests, with subalpine shrublands and grasslands at high elevations. Today the regional climate is driven by the East Asian Monsoon system. The few records that extend over the last 40,000 years reveal the presence of warm temperate forests at MIS 3, and at LGM forests survived the coldest period with some warm elements in-situ. This shows that even with lowered sea-level the East Asian Monsoon was active across the region bringing moisture and some warmth to central China. The modern patterns of vegetation became established in the early Holocene and human impact becomes evident in the late Holocene. There is some uncertainty about the late expansion of conifers and whether this is a result of cooling and/or human impact. One record from upland Chongqing is apparently free of any significant human impact which allows an analysis of vegetation changes due to natural environmental variability and the absence of fire.

Keywords : Central China, climate change, human impact, East Asian Monsoon

brGDGT and pollen-based Holocene temperature reconstruction from the Olgi Lake in the Tarvagatai Mountains (north-central Mongolia).

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Abstract :

Understanding the complex mechanisms that govern the short and long-term development of Holocene ecosystems requires the multi-proxy study of lake sediment or peat archives, for example. Factors such as climate variability can thus be determined, but also other factors influencing these ecosystems such as vegetation, disturbances (fires, storms, insect pests), as well as human impact. The objective of this presentation is to show new reconstructed Holocene (9500 ka – present) temperatures in the North-central region of Mongolia, in the Tarvagatai mountains, using two independent methods: transfer functions from pollen grains and from brGDGTs ratios. We aim to compare the results of these climatic reconstructions with each other, but also to analyze them with regard to the reconstruction of vegetation, fire dynamics and environmental changes, carried out by Unkelbach et al. in 2021. The temperatures obtained from the analysis of brGDGTs (calculated from the calibration of De Jonge et al., 2014) show a warm start to the Holocene (4.1 - 5°C), between 9500 and 8600 cal. yr BP. After an abrupt decrease in temperatures of 3 °C to 8500 cal. yr BP, temperature remain stable until the mid-Holocene, to 5500 cal. yr BP, where a warm period of 1000 years is observed. From 4500 to 500 cal. yr BP, a gradual and continuous decrease in temperatures (down to -2.7°C) took place. This agrees with the climatic indications given by the vegetation and the results obtained by the WAPLS transfer function from pollen grains.

Keywords : GDGTs, pollen, Mongolia, Holocene, transfer functions

MID TO LATE HOLOCENE SEA-LEVEL CHANGES IN SOUTHWEST COAST SRI LANKA: APPLIED COASTAL

MANAGEMENT STRATEGIES FOR FUTURE SEA-LEVEL TREND.

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Abstract :

The tectonically stable Sri Lanka is an ideal location for studying past sea-level changes during the Holocene. Sea-level changes imprinted signatures in terrestrial environments. In this study, the author considered the peat swamps, estuaries, submerged corals and inland corals for studying relative sea-level in the central Indian Ocean. In addition, sedimentological and geochemical characteristics were examined to understand coastal geomorphology in relation to past sea-level changes. In detail, bulk elemental and molecular compositions were identified using C, N, S elemental analysis and gas chromatography-mass spectrometry, respectively. 14C dating of shells, wood and bulk organic matter was used to identify chronological events in the sedimentary successions. This study shows two major chrono-stratigraphic divisions (i.e., from ca. 7.5 ky B.P. to 2.5 ky B.P. and from ca. 2.5 ky B.P. to the Recent). The lower sedimentary succession indicates deposition of marine-terrestrial organic matter under oxygen-poor/anoxic conditions during mid-Holocene sea-level highstands. The mid-Holocene regression mainly changed geomorphology of the southwest coast of Sri Lanka from opened to a semi-enclosed and/or closed settings. Therefore, this major geomorphological change at ca. 2.5 ky B.P. was marked by enhancement of total organic carbon contents (nutrients) and accumulation of reworked terrestrial organic matter in the aquatic systems. Biomarker studies reveal that a gradual climatic transition from wetter to dryer since the middle Holocene based on n-C29/n-Call and n-C37/n-Call alkane proxies. In contrast, geomorphological observations suggest two main sedimentary facies in the southwest coast of Sri Lanka. In detail, the lower sedimentary succession (Facies 2) was characterized by expansion of beach ridges and headlands during the mid-Holocene highstands. The upper sedimentary succession (Facies 1) was characterized by semi-closed or closed brackish to terrestrial systems after the mid-Holocene highstands. Ongoing investigations identified submerged and 2-3 km distance inland coral deposits in the southwest coast of Sri Lanka. These coral deposits are clearly stood above present mean sea-level and thus strong indication for about 2-3 m height paleo sea-level highstands.

In the second part, an attempt is given to understand current coastal geomorphological changes such as coastal erosion and related various coastal hazards (e.g., damages on infrastructures and coastal wetland ecosystems) that negatively affect the economy of Sri Lanka. Several coastal engineering plans have been recently started in the country such as the Colombo Harbor Expansion Project. The inadequate monitoring program and coastal management strategies have been made a direct impact on coastal zone in Sri Lanka. Therefore, in this ongoing project, the author attempts to estimate sea-level changes using tide gauge measurements in the central Indian Ocean. In addition, Light Detection and Ranging (LiDAR) method will be used to predict sea-level inundation of the lowland area of the coastal region and to create hazard assessment maps.

Keywords : carbon sequestration, Holocene, sea-level change, paleoclimate, summer monsoon

Strong human disturbance to vegetation in the southeast mountainous region of China during the last Millennium.

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Abstract :

The lower Yangtze reaches holds a long history of human occupation and rice cultivation, but our understanding of human activities in the mountainous region south of the lower Yangtze is still limited. In this study, we present a high-resolution vegetation record spanning past 2,900 years from an alpine lake in southern Zhejiang by analyzing loss-on-ignition, pollen, charcoal, and non-pollen-palynomorphs from a sediment core retrieved recently. Combining

historical records, our result suggests primitive conditions prevailed in the study region before 846 CE, which was covered by dense broadleaved forests dominated by evergreen Cyclobalanopsis/Quercus. Exploitation into the mountains has been hindered by rugged relief, closed forests, and lack of suitable land for farming. Between 846 CE and 1176 CE, the slight decrease of evergreen trees, small rises in cereals and the ruderal herb Artemisia, and more frequent fire events pointed to small-scale agricultural practices related to an increased population. Since the Tang Dynasty (618–907 CE), the economic center of China started shifting to the lower Yangtze reaches, which absorbed influx of war refugees from the north especially during the Song Dynasty (960–1279 CE). From 1176 CE, abrupt cereal expansion coincided with the sharply declined evergreen broadleaved trees and the peaking fire frequency, closely linking slash-and burn cereal cultivation with deforestation. These changes were accompanied by the remarkable spread of pioneer secondary plants such as Pinus, Artemisia, and Dicranopteris-type ferns, which are typical indicators for human-induced landscape opening in the mountains of subtropical southeast China. It is probable the population boom spread to the mountains and intensive agricultural activities took place by involving terraced fields. Additionally, the coeval mining, smelting, and porcelain production in the mountains enlarged the scale of deforestation. Our study provides valuable information for landscape management and biodiversity conservation in the mountainous hinterland of subtropical southeast China.

Keywords : Pollen, Subtropical mountains, Human activity, Rice cultivation, Song Dynasty

Late Holocene Climate variability from Ladakh Himalaya and its teleconnections

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Abstract :

Paleoweathering and source reconstruction from Shakti sedimentary profile of the Ladakh in Northwestern Himalayas, India. It was carried out by using a representative sediment core and was measured for the proxies such as biomarker (n-alkane), major, trace elements and magnetic susceptibility over the last ~3200 yr. The study identifies the distinct phases of temporal changes with increased Indian Summer Monsoon (ISM), weathering/erosional activities and the organic matter source. It is a study attempting to understand the sources of sediment, their preservation and forcing factors role in climate change in the Northwest Himalayan regions. The chronology of the core was constrained using AMS14C dating techniques. During period ~3230-3060 cal yr BP; ~2850-2550 cal yr BP; ~2550-1980 cal yr BP which suggested a consistent increase in Terrestrial Ratio /Aquatic Ratio (TAR) value. This reveals that long chain n-alkanes (C27-C33) indicate a source of terrestrial with increased surface runoff. The low detrital inputs and weathering with an average CPI and ACL ratio show a short chain n-alkanes (≤C21) causing algae and photosynthetic bacteria during the period, ~3130-3060 cal yr BP; ~3060-2850 cal yr BP; ~1470-1050 cal yr BP; ~1050-742 cal yr BP. However, during the phase ~1980-1470 cal yr BP experienced less erosional activity and was supported by moderate long chain n-alkanes (C27-C23). The available records of precipitation change and Total Solar Irradiance (TSI) for the late Holocene and the Northern hemisphere (NH) and the associated co-variance for the past 2ka suggested solar insolation as the main forcing mechanism of ISM variability. The ancient Vedic was established and agriculture flourished as a of strengthened ISM precipitation.

Keywords : Paleo weathering, n-alkane, organic matter source, geochemistry

Eolian dust in NE China since the Late Holocene: Monsoon driven or human induced?

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Abstract :

The East Asian summer monsoon (EASM), an important component of the global climate, controls rainfalls in China and impacts the lives of billions of people. The drylands of northern China, at the margin of the EASM, are sensitive to changes in EASM rainfall. Northern China has a long history of human occupation being one of the most densely populated areas. Human activities (landscape modification) and climatic (moisture, wind strength) changes in the region affect surface processes resulting in broader changes in dust emission and deposition. Dust deposition rates and provenance were determined using Sr-Nd isotopes and rare earth elements in dust from a peatland in NE China. The dune fields of northeastern China were identified as the main source of particles. Dust fluxes show a sharp increase starting at 5.8-4.0 ka cal BP, coeval with a decrease in monsoonal rainfall and general aridification of northern China. Since 2.0 ka cal BP, changes in dust deposition are more frequent and do not follow the EASM as closely. A review of dust records downwind of Eastern China drylands and of human occupation at the drylands' margin suggests increased dust deposition during peaks in human activities. Whether those changes are directly linked or also related to variations in EASM rainfall is still unclear and need to be further investigated. Our results show that the dune fields of Inner Mongolia should be a primary area of focus to investigate the interactions between the East Asian monsoon, population changes and environmental changes in Eastern China.

Keywords : eolian dust, geochemistry, peatlands, northeast China

Last Glacial Maximum to Holocene palaeoenvironmental records retrieved using lacustrine archives from the Kashmir valley, western Himalayas.

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Abstract :

The Last Glacial Maximum (LGM; ~25000 yr BP) was the most recent stage of the Last Glacial Period, during which ice sheets were at their greatest extent. While, the Holocene Epoch started at around 11700 yr BP marking the end of the Pleistocene Epoch. This phase witnessed climate shift from extreme cold LGM to warm interglacial, and it significantly influenced the geomorphology of the surface and evolution the flora and fauna on it. The Holocene Epoch was characterized by commencement of noticeable rapid deglaciation. However, cyclic dry/cold climate events tentatively linked to climate fluctuations due to North Atlantic ice rafting, known as Bond events have also been reported in Northern hemisphere during this Epoch. In this work we will presents results from multiple sediment cores and sediment trench from lakes to understand evolution of the Last Glacial Maximum (LGM) to Holocene paleoclimate in western Himalayan region that is reportedly influenced by both mid-latitude westerlies and Indian summer monsoon (ISM). The chronology was generated using AMS 14C dating. The results revealed relatively cold/dry climate from 29000 yr BP to 20000 yr BP, that peaked at around 26000 to 24000 yr BP (LGM stage). The proxy records revealed continuous climatic amelioration from to 20000 yr BP to 12000 yr BP. The multi-proxy analysis on the Holocene sedimentation revealed phases of dry/cold climate from 10,800 to 10,200 yr BP, 8700 to 7700 yr BP, 6200 to 5700 yr BP, 4600 to 3750 yr BP, 3100 to 2250 yr BP and 500 to 350 yr BP during the Holocene. The sediment chemical signatures reveal strong anthropogenic influence due to forest land clearing and agriculture extension during last 2000 years and similar observation were also revealed from the black carbon (BC) concentration data from the lake sediments. Our observations reveal that the region has been profoundly influenced by westerly disturbance during the entire Holocene.

Keywords : Last Glacial Maximum, Holocene, Palaeoclimate, Limnology, Radiocarbon dating

Long term vegetation dynamics and its responses to the past monsoon climate and sea-level change in East Asia.

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Abstract :

Past vegetation is considered to be one of the most reliable evidence for recovering paleoclimate changes in palynological studies because it is sensitive to temperature and precipitation during the growing processes. The monsoon played an important role in the high vegetation diversity in East Asia by providing humid air masses from the adjacent seas and the Pacific Ocean. However, questions remain unanswered about how the past sea level and the intensity of monsoon climate have changed over time.

The factors with distinct different distribution zones of vegetation communities, high diversity among vegetation types, and unique topography with low altitude coastal plains all place this area as a favorable region for studying the monsoon climate in eastern Asia. Therefore, in this study, the existed paleoclimate records from northern to South Asia will be reevaluated for a comprehensive understanding of the long-term vegetation dynamics and its response to past monsoonal climate and sea-level changes in East Asia.

Keywords : Vegetation; East Asia Monsoon; Sea-level changes

Forest dynamics and land-use history in the highland of Sumatra since AD 200: palaeoecological evidence from Danau Kecil in the Kerinci Seblat National Park.

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Abstract :

Understanding the vegetation dynamics and agroforestry history can provide insight into sustainable forest management, local livelihoods, and biodiversity conservation. This study aims to provide an understanding of forest dynamics and land-use history in the highland of Sumatra for the last 1800 years. Palaeoecology is a helpful tool to reveal the history of vegetation and forest transformation. In our study, pollen and spores, non-pollen palynomorphs of glomus spore, macro-charcoal and XRF scanning analyses were carried out on a sediment core collected from the central lake of Danau Kecil in the submountainous area of the Kecinci Seblat National Park in Sumatra, Indonesia. The palaeoecological results reveal the evidence of forest transformation from initial shifting cultivation to permanent agroforestry system with persistent human-opening forest activities for the last 1800 years (since AD 200). Our results show three main phases of tropical forest transformation exhibited human-induced activities. The initial human activities in the forest were demonstrated by the dominant regrowth pioneering trees Trema and Macaranga along with initial Dipterocarpaceae agroforestry since AD 200 followed by Arenga cultivation in AD 400. Since AD 500, the agroforestry system with forest-like gardening practices integrating natural forest has been established by the presence of Dipterocarpaceae, Arenga and reintroducing substantial timbers such as Lithocarpus/Castanopsis and Bischofia. Later, since the mid-18th century (AD 1760), the permanent agroforestry has been dominated by the expansion of Diptercarps agroforestry (e.g Shorea javanica) for its resins together with some cash crops such as Sugar Palm (Arenga).

Keywords : Late Holocene, Land-use, Shifting cultivation, Agroforestry, Indonesia

Relationship Between C4 Biomass and C4 Agriculture During the Holocene and its Implications for Millet Domestication in Northeast China.

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Abstract :

The origin of C4 agriculture in China, foxtail millet (Setaria italica) and common millet (Panicum miliaceum), remains unclear. Here we

conducted a comprehensive geochemical study of the archeological site of Chahai in Northeastern (NE) China and deduced that higher C4 biomass in the cultural layers was mainly caused by agricultural practices and other human activities. To evaluate the anthropogenic factors involved in millet domestication, we produced a time series of contour maps of C4 biomass for North China since 14 ka and integrated archaeological data. Results show that the origin and development of millet agriculture was nearly synchronous~ with the increase in C4 biomass in the early-mid Holocene, but the synchrony was decoupled at 4 ka when millet cultivation was established in NE China. Our findings suggest that both human management (possibly cultivation) of C4 plants, and an environmental background of high C4 biomass drove the origin of millet agriculture.

Keywords : C4 agriculture, human activities, Holocene

Poster

Holocene lake level, vegetation, and climate at the East Asian summer monsoon margin: records from Chagan Nur and Lake Wulanhushao, Inner Mongolia

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Abstract :

Understanding the impact of Holocene climate variations in arid northern China provides an important basis for a better prediction of future water availability in this region. In this study, we present paleoenvironment data from Chagan Nur and Lake Wulanhushao (Chen et al., 2021; Li et al., 2020), both located in Inner Mongolia at the East Asian summer monsoon (EASM) margin, to provide new insights into the pattern and mechanisms of EASM change during the Holocene.

Optically Stimulated Luminescence dating and elevation measurements on the paleoshoreline outcrop sections provide an estimation of Holocene lake-level changes of Chagan Nur and Lake Wulanhushao. From both lakes, sediment cores retrieved were radiometrically dated and carefully analyzed involving multi-proxies of XRF, grain size, loss-on-ignition, and pollen. These results yield a comprehensive and high-resolution record of the paleoenvironment at the EASM margin.

Remarkably higher lake level comparing present occurred during the early-middle Holocene, followed by lake-level drops since mid-late Holocene. The maximal arboreal expansion identified from pollen data suggests optimal climate conditions between 9 and 6 cal ka BP., which lagged ~ 1.5–3 ka behind the start of lake-level rise. Pollen-based quantitative precipitation reconstruction from Chagan Nur shows a maximum precipitation 30–50 % higher than present at 8–6 ka. After then, aridification in the region was evidenced by the declined trees and the increase of desert components. The lag between EASM precipitation rise and northern Hemisphere solar insolation shift indicates that variation in EASM intensity did not respond directly to northern Hemisphere summer insolation, but rather was likely modulated by high latitude forcing of ice volume and greenhouse gases.

Reference:

Chen, C., Tao, S., Zhao, W., Jin, M., Wang, Z., Li, H., Ren, H., Li, G. (2021): Holocene lake level, vegetation, and climate at the East Asian summer monsoon margin: A record from the Lake Wulanhushao basin, southern Inner Mongolia. Palaeogeography, Palaeoclimatology, Palaeoecology, 561: 110051

Li, G.Q., Wang, Z., Zhao, W.W., Jin, M., Wang, X.Y., Tao, S.X., Chen, C.Z., Cao, X.Y., Zhang, Y.N., Yang, H., Madsen, D. (2020): Quantitative precipitation reconstructions from Chagan Nur revealed lag response of East Asian summer monsoon precipitation to summer insolation during the Holocene in arid northern China. Quaternary Science Reviews, 236: 106365.

Keywords : Asian monsoon, Climate optimum, Lake level change, Pollen, Luminescence dating

Pollen distribution of surface sediments from the Liaodong Bay, China: Insights into pollen provenance, transport, deposition, and coastal-shelf paleoenvironment

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Abstract :

To elucidate the mechanisms responsible for pollen and spore transportation and deposition in the Liaodong Bay, China, 164 surface sediment samples, and 39 analogous surface alluvium samples from its five inflowing rivers were collected for palynological analysis. The results show that pollen and spore assemblages in surface sediments are well correlated to regional vegetation distribution, and the variations of pollen assemblage in different parts of Liaodong Bay reflected local vegetation changes along the coast. High pollen concentrations are mainly distributed in the estuaries of inflowing rivers, coastal waters and sea muddy areas. The pollen assemblage characteristics of alluvial samples are similar to those from coastal waters with water depths <8.5 m. Samples from the alluviumand surface sediments of coastalwaters were dominated by herbaceous pollen taxa. Herbaceous pollen percentages and concentrations decreased as the water depth increased, indicating that pollen and spores in the coastal waters of Liaodong Bay are mainly carried by the inflowing rivers. However, pollen assemblages for samples with water depth >8.5 m are significantly different from those of the alluvium. In samples taken below a depth of 8.5 m, the arboreal pollen is dominated by airborne Pinus, and there is a high number of the waterborne Selaginella fern spores, both of which are sourced from a wider region. In the Liaodong Bay, both wind and ocean current transportation determines the pollen distribution patterns in deeper waters, while fluvial and longshore current transportation determines the pollen assemblages found in shallow waters. The dispersal characteristics of pollen assemblages between the land and the sea in Liaodong Bay provide a theoretical basis for the interpretation of fossil pollen assemblages and past sea level changes.

Based on the above studies, we selected a well dated sediment core from Liaohe delta of northeast (NE) China to reconstruct the regional vegetation, and to verify the response of the coastal ecosystem to regional climatic changes and the past sea-level fluctuations during the Holocene. The pollen record of core suggest that during early Holocene, the regional vegetation in the plain was meadow-dominated by Artemisia. And forest with cool-temperate conifers and temperate broad-leaved trees were present in the nearby hills, which is coincident with the gradually climate warming and delta transgression. From mid-Holocene to early late Holocene, meadow vegetation with Artemisia were relatively stable, while the forest vegetation with broadleaved trees reached to the maximum expansion in the nearby hills. The large expansion of broadleaved trees indicate a warm and humid regional environmental conditions and this is coincidence with the relative high regional sea level stand during this period. Since ca. 1470 cal yr BP, with the continuous delta progradation, a large coastal region was colonized by Suaeda spp., which suggests that the formation of unique red beach wetlands along the coastal region of the Liaohe Delta. By comparison with previous multi-proxy records together with the surface sediment record from Liaodong Bay, it is suggested that the Holocene vegetation changes of the Liaohe Delta are mainly driven by the climate change and regional sea level oscillation.

Keywords : Liaodong Bay, Pollen and spores, Provenance, Red beach wetlands, Sea level oscillation

Pollen Record of Early to Mid-Holocene Vegetation and Climate Dynamics on the Eastern Coast of the Yellow Sea, South Korea.

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Abstract :

To understand the early to mid-Holocene vegetation and climate dynamics on the eastern coast of the Yellow Sea, we obtained a sedimentary core with high-resolution AMS 14C data from the Gunsan coast in South Korea. The palynological analysis demonstrated that the riverine wetland meadow from 12.1-9.8 cal kyr BP changed to temperate deciduous broad-leaved forest in 9.8-2.8 cal kyr BP. Additionally, the cold climate from 12.1-9.8 cal kyr BP became warmer from 8.5-7.3 cal kyr BP. This was followed by another relatively cold period from 7.3-2.8 cal kyr BP. The temperature change was mainly in response to solar factors. However, there are two relatively humid periods from 12.1-9.8 cal kyr BP and 8.5-7.3 cal kyr BP, which arose for different reasons. The earlier humid period resulted from strong westerlies and a rapidly rising sea level. The later humid period was produced mainly by the strong East Asian summer monsoon and may also be linked to La Niña-like activity. The cold "Younger Dryas" event from 12.0-11.4 cal kyr BP recorded in this study may have been produced by a North Atlantic meltwater pulse. This would have reduced temperatures that were already low due to weak insolation, and the strong winter monsoons would have increased the precipitation.

Keywords : Climate change, pollen, vegetation, Yellow Sea, 'Younger Dryas'event

OSM06: Sedimentary varves: High-resolution archives of past climate and environmental change

Co-conveners: Celia Martin Puertas, Bernd Zolitschka and Adrian Palmer

Oral

Causes and impacts of the first global pandemic: high-resolution analysis of lake varves from central Anatolia reveals the climate and environment of the Plague of Justinian

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Abstract :

Annually laminated sediment archives offer unique insights into the timing and duration of past environmental changes and can be used to study a wide array of research problems. One such event concerns the Justinianic Plague (JP) that struck the Byzantine Empire in 541–542 CE and recurred periodically until ~750 CE. There is on-going debate about the causes and societal consequences of this, the world's first historically recorded pandemic (Sarris 2021). The initial plague outbreak occurred following one of the coldest decades of the last two millennia, while contemporary historians, e.g., Prokopios, describe a dimming of the sun for over a year. Did climatic disturbance therefore play a role in triggering or amplifying the spread of plague? There is also uncertainty and disagreement concerning its impact on mortality and human demography. It was widely believed that the JP led to the death of up to 25% of the population in the Eastern Mediterranean, and some historians (e.g., Harper 2017) see it as marking the transition from antiquity to early middle ages. Mordechai et al. (2019) offer an alternative, minimalist view. One line of evidence they use comes from fossil pollen data, which reflect land-cover change and do not show a detectable decline in rural agriculture during the 6th century CE. However, most East Mediterranean pollen records have imprecise chronologies and only centennial sampling resolution for the first millennium CE.

Nar Gölü, a >20 m deep monomictic maar lake in Cappadocia, central Anatolia, has a continuously laminated sediment record extending back more than 2600 years. Lake monitoring and radioisotope dating has shown these laminations to be annual (Dean et al. 2015). Initial analysis of sediment cores included stable isotopes (5 varve-year (VY) sampling for the JP), pollen and diatoms (both 20 VY-sample resolution). δ18O data indicated a major dry-to-wet climate shift during the 6th century (Jones et al. 2006), while the pollen record did not show a sustained or substantial decline in cultivation of cereals and tree crops in the decades following the JP (England et al. 2008). Here we report new, higher resolution, multi-proxy analytical results from Nar Gölü based on parallel cores with an independent varve chronology spanning the time period prior to, during, and after the initial plague outbreak. They include replicate stable isotope and pollen analyses (3 VY-sample resolution), elemental chemistry from ITRAX core scanning and thin-section analysis (both sub-annual resolution). These allow us to test the potential role of changes in climate as a causal agent, and land cover as a proxy for impact on rural economy and demography at the time of the first plague pandemic, in a region that lay at the heart of Justinian's Byzantine empire.

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Keywords : Justinianic Plague, Mediterranean, Anatolia, lake varves, pandemic

Into the mega-monsoon: yearly flood dynamics of the Nile River during the last African Humid Period

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Abstract :

Seasonal floods are life-supporting events in the Nile Valley and have been crucial to the development of complex societies. Past and present populations depend on their occurrence but the alteration of fluvial dynamics under climate change remains elusive. In this presentation, we will explore the changes in flood dynamics of the Nile River during a period of high monsoon activity known as the African Humid Period (during the early Holocene). Using a unique sediment core from the Nile deep-sea fan that contain well-preserved marine varves (i.e., annual layers), we were able to track the changes in flood dynamics at annual resolution between 9.5 and 7.5 ka BP. This remarkable 1500 yr-long annual flood record from the Nile River allows us to investigate fluvial regimes under high rainfall intensity and determine the main climatic forcing driving flood dynamics.

Microfacies analysis and elemental micro-XRF scanning indicate that couplets of alternating dark- and light-coloured layers represent seasonal deposits of Nile discharge and marine hemipelagic sedimentation, respectively. The excellent match between layer thicknesses expressed as accumulation rates and the probability distribution of radiocarbon ages confirms the presence of varves in our core. In addition, a Bayesian age model provides us with a very precise age determination with errors well below 100 yrs throughout the record. Varve thicknesses vary drastically through time between 0.3 and 13 mm with significant changes at 8.2, 8.9 and 8.7 ka BP occurring within a few decades. These variations suggest large modifications in the erosional regime of the Nile, leading to the deposition of variable amounts of sediments on the margin. Thicker flood layers between 9.5 and 8.7 ka BP are characterized by a strong Blue Nile isotopic signature and are proposed to represent large flood events related to more frequent or longer episodes of heavy rainfall in Ethiopia. Comparable to the historical records of past Nile flow from Nilometer readings both in length and temporal resolution, our new record enables us to explore the embedded climatic forcing. Accurate time-series analyses demonstrate the persistence of Pacific (El Niño-Southern Oscillation) and Atlantic (North Atlantic Oscillation) climatic forcing on flood dynamics during the mega-monsoon interval.

Keywords : Nile River, African Humid Period, Varves, Floods

Holocene spring and summer temperature variability inferred from Ca/Ti ratios, Lake Żabińskie, Poland.

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Abstract :

Quantitative paleoclimate reconstructions are essential for assessing the magnitude of forced and unforced climate variability at scales from decades to millennia. Extensive efforts in recent years have established global scale compilations of temperature records spanning the common era [1] and the Holocene [2]. Yet, high-resolution (annual to decadal) climate reconstructions that extend beyond the past 1-2 millennia are still rare. Varved lake sediments and high-resolution core-scanning techniques offer the potential to produce paleoclimate data with annual to sub-decadal resolution and sufficient chronological precision to assess decadal-scale variability over multi-millennial timespans. Here, we present a reconstruction of spring and summer temperatures from the varved sediments of Lake Żabińskie, NE Poland. Elemental ratios of Ca and Ti (determined by X-ray fluorescence core-scanning) track autochthonous calcite precipitation, which has been shown to be driven by warm-season temperatures [3]. We calibrate the Ca/Ti data to

a 240-year instrumental monthly mean temperature record from Warsaw, Poland and find statistically significant correlations between the instrumental and proxy data. This calibration is then applied to the 10,700 year record of Lake Żabińskie. The resulting spring and summer temperature reconstruction shows similar millennial-scale trends compared to other Holocene length temperature reconstructions from central and northern Europe and the Northern Hemisphere. Ongoing work will investigate modes of variability and short-lived climatic perturbations recorded in this high-resolution reconstruction.

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Keywords : Holocene, paleotemperature, varves, element geochemistry, calibration-in-time

The hydrological and climatic significance of laminated sediments at the Dead Sea Basin: new evidence

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Abstract :

The Dead Sea Basin laminated sediments often consist of mm-scale alternating detrital and authigenic carbonate (aragonite) laminae, including major parts of the Dead Sea Deep Drill¬ing Project (DSDDP) cores that cover the last ~250,000 years. Previous studies assumed these laminae were varves; detritus deposition during the winter and chemical aragonite in the summer. Our study examined the seasonal deposition of detrital and aragonite couplets using pollen and sedimentological analyses, which were complemented by the examination of contemporary flashfloods using geochemical sampling and satellite remote sensing analysis. It was concluded that the laminated sequences represent an even more detailed record controlled by the local to regional hydrology and meteorology at the scale of instantaneous short-lived events.

In my talk I will introduce the Dead Sea Basin record, its use for paleoclimate and paleogeographic reconstruction and discuss the role of desert storms, dust, and flashloods in the accumulation of one of the most detailed records used for Quaternary climate reconstruction.

Keywords : Laminated sediments, Aragonite, Air-borne pollen, Flashfloods, Dust storms

Varve seasonality changes in response to orbital forcing through the Holocene.

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Abstract :

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Proxy-based climate record could be affected by seasonal bias, which could prevent from robust reconstructions through time. Varved sediments provide highly-resolved records that allows identifying seasonality changes in the lake response to environmental and climate conditions. Diss Mere (52° 22’N, 1° 6’E; 29m a.s.l) is one of the few lakes in the world that presents a continuous varved record for most of the Holocene. Human impact did not have a significant impact on the landscape around the catchment until the Iron Age, when varves stop

preserving, which makes Diss Mere an ideal site to evaluate the lake response to natural climate variability during the present interglacial period. Varves are well-preserved from 2100 to 10,300 cal a BP and the record is linked to a very robust chronology with a maximum absolute uncertainty of ± 55 years at the beginning of the Holocene. The varves consist of a pale lamina made of authigenic calcite crystals, and a dark lamina composed of, primarily, crysophyceae cyst, planktonic centric diatoms with a main bloom in autumn, filaments of organic matter and micrite. According to the phenologic characteristics of the varves, the pale calcite layer is deposited in the summer (May-August) and the dark organic layer represents sedimentation from the late summer to the late spring (September-April), when the water column is mixed. The varve structure, thus, distinguishes between limnological summer (lake stratification) linked to an increased temperature gradient and winter (lake mixing) associated with intensified windy conditions. Here we evaluate the varve thickness record and the contribution of the winter and summer sub-layers to the annual signal as an indicator of change in the seasonal lake response to climate conditions. Our results show that interannual varve thickness variability is driven by the winter layer in both the early Holocene (prior to 8.2 cal ka BP) and late Holocene (after 3.5 cal ka BP) and by the summer layer during the Holocene Thermal Maximum (HTM, 3.5 -8.2 cal ka BP). This long-term shifting seasonal signal in the annual varve thickness record coincides with the tripartite subdivision of the Holocene, which represents different background climate conditions under different orbital settings.

Keywords : varve seasonality, Holocene

Transfer of the varve chronology from 1999 to a new sediment record from Holzmaar (West-Eifel Volcanic Field, Germany) and integration of Bayesian age-depth modeling.

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Abstract :

Lacustrine sediment records are valuable archives to reconstruct anthropogenic influences and climate change beyond historic and instrumental data. However, only sediment analyses relying on accurate age control enable comparison of reconstructed environmental conditions on regional to global scales, e.g. for the detection of large-scale climatic patterns. A robust chronology is usually obtained by radiometric dating, well-known event layers (tephra), historic data (e.g., flood events) or varve counting or a combination of these methods. Especially varved sediment sequences, which are rhythmic seasonal laminations that can be distinguished and counted like tree rings if optimal conditions for preservation exist, result in most accurate and continuous calendar-year chronologies.

In 2019, Holzmaar was revisited and sediment cores from this varved sediment archive were recovered providing the new and 15 m long composite profile HZM19. Here, we present the master chronology VT-22 for HZM19 combining the previous varve chronology (VT-99) with radiometric data (C-14, Pb-210, Cs-137) obtained through Bayesian age-depth modeling (Blaauw and Christen, 2011). VT-22 consists of four different sections, where age calculations are based on interpolation of 41 predefined marker layers and their corresponding VT-99 ages and errors (Zolitschka et al., 2000) for the depth intervals 0 - 5.98 m (including Pb-210 and Cs-137 analyses) and 6.70 - 9.90 m and on Bayesian age-depth modeling of 34 C-14 dates (Hajdas et al., 2000) for the depth intervals 5.98 – 6.70 m and 9.90 - 14.60 m (including the isochrone of the Laacher See Tephra). In total, the chronology covers the age range from -67 ±1 to 16,128 ±417 yr cal. BP with maximum, mean and median errors of 417, 203 and 176 years, respectively.

This integrated approach makes best use of the accurate and multiple counted VT-99 for the sediment sequence of Holzmaar. We see, on the one hand, an advantage over only using radiometric dates for age-depth modeling, as dating density is thus considerably increased for major parts of the record. On the other hand, parts of the VT-99 varve chronology with reported higher counting uncertainties due to exceptionally thin varves or missing sediment are improved by the Bacon age-depth modeling.

Optimizing the Holzmaar chronology for application to HZM19 is the first step in order to provide a precise and robust age-depth model for upcoming and highest resolution multi-proxy investigations to unveil all the environmental details recorded by this varved sediment archive.

Keywords : Holzmaar, Bacon, Bayesian age-depth modeling, varve chronology

Calcite varve formation processes in Diss Mere, a lake in the UK: insights from lake monitoring.

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Abstract :

Diss Mere (UK) preserved varved sediments between 10,300 to 2,100 cal BP. The varves consist of an authigenic calcite lamina and a darker organic lamina consisting of crysophyceae cysts, centric diatoms and organic matter. Here we present a comprehensive lake monitoring study to observe whether Diss Mere is currently forming varves today, and if so, what the main limnological processes associated with the varve structure are.

The monitoring set-up includes two sediment traps placed in the epi- and hypolimnion, which were emptied on a near-monthly basis between April 2018 and November 2021. Physico-chemical profiles of the lake water were also recorded to explain internal lake variability, and drivers of sediment deposition and preservation.

Our results show that the current lake is monomictic and the trapped material records the same seasonality to that recorded in the Holocene varves. However, we find that Diss Mere is not currently preserving these varves because anoxic bottom waters are not consistent enough to preserve the seasonal laminations likely due to the insufficient water depth. We observed evidence of interannual variability in the calcite precipitation, with some years precipitating twice in both the mid and late summer/early autumn. The mid-summer events occur at maximum summer air temperatures and produce larger, coarser grains. We attribute the latter event to an increase in organic productivity due to an extra nutrient input from the lake bottom at the beginning of the lake turnover. The calcite grains are much smaller here, and are bound to organic matter. We conclude that despite this additional precipitation event during some years, it does not implicate the counting or interpretation of varves in the Holocene sediments as the phenology of the laminations follow the same cycle with summer calcite being capped with a crysophiceae cyst layer representing the end of the summer followed by a diatom bloom and organic layer deposited during the autumn and winter.

Keywords : calcite varves, lake monitoring

Poster

Layer counting of the bottom sediments of the lake Kucherla (Altai, Russia).

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Abstract :

The paper presents a study of modern sediments of Lake Kucherla, which is located at the foot of the Katunsky ridge (49.87,86.41) at an altitude of 1790 meters above sea level. The lake has a size of 4.5 km x 0.7 km, is located in a remote area and is subject to minimal anthropogenic impact. Sediment core (112 cm) was obtained in March 2018 with a gravity tube in the deepest part of the lake (45 m). During sampling, the preservation of the upper (weakly consolidated) part of the sediment was especially controlled. The core was delivered to the laboratory of the Institute of Geology and Mineralogy SB RAS (Novosibirsk) in an upright position. Under laboratory conditions, the core was opened along the sampling axis. Layers 0.5–4 mm thick were found in the upper part of the core.

Using gamma-ray spectrometry, the activity distribution of Cs-137 and Pb-210 isotopes was obtained for the upper interval 0-200 mm. Visual layers were counted from photographs of

wet core and optical sections, and an age model was built in the range of 0–200 mm. The general agreement of the calculation results, and their correspondence to the position of the Cs-137 layer, confirms the assumption about the annual nature of the released layers. The maximum discrepancy in the dating of the layer with the maximum Cs-137 activity (1962) at a depth of 165 mm is ±4 years, from 1957 to 1965. The error estimate in calculating the layers is ~ 7%. At the same time, the average value of the dating by counting the layers is in good agreement with the isotope dating.

Synchrotron micro-XRF scanning of optical thin sections with a spatial resolution of 0.1 mm was carried out with the simultaneous determination of more than 20 rock-forming and trace elements. Comparison of analytical data with photographs of thin sections showed the possibility of distinguishing the boundaries of layers by geochemical indicators (Rb/Sr ratio).

The reported study is funded by RFBR (grant № 19-05-50046).

Keywords : varve, lake sediments, chronology, isotope studies

A 16,000-year multiproxy record from the varved sediment archive of Holzmaar, Germany;

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Abstract :

Paleoclimatic reconstructions help to understand how ecosystems change through space and time. In this respect, environmental archives with annually laminated (varved) sediments are favoured on continents since they permit a calendar-year chronology and allow calculation of precise sediment accumulation rates. Diatoms are one of the most widely used biological proxy for lake records with their species composition being related to climate variability and anthropogenic impact. In this study, we present multiproxy analyses of a new composite record (HZM19) with annually laminated sediments from Holzmaar (West-Eifel Volcanic Field, Germany) for the last 16,000 years. In addition to diatoms, we analysed physical (magnetic susceptibility) and geochemical proxies (biogenic silica, elemental composition) to assess the main trends of paleoenvironmental change with a centennial resolution for the 14 m-long composite record. A total of 148 diatom species were identified and 23 of them are present with >5% of relative abundance (10 planktonic and 13 epiphytic or benthic species). Magnetic susceptibility shows relatively stable values along most of the record except for higher values during the Pleniglacial, for the volcanic ash layer of the Laacher See Tephra at 13,000 cal BP and since the Iron Age. Ca/Ti ratios are very low during the Pleniglacial, highest during the Lateglacial and decrease throughout the Holocene. TOC/TN ratios fluctuate on a relatively low-level suggesting dominance of autochthonous lacustrine productivity. Biogenic silica values are low, except for the Pleniglacial/Lateglacial transition and for the Late Holocene, then influenced by intensified cultural eutrophication. The presented record is the first continuous diatom stratigraphy for Holzmaar covering the time since the Pleniglacial supported by physical and chemical parameters. The patterns of the diatom assemblages allow us to infer the trophic history of Holzmaar. There is a distinct variation at the Pleistocene/Lateglacial transition, characterized by a replacement of Staurosira construens with Stephanodiscus minutulus, increase of Ca/Ti, TOC/TN ratios and biogenic silica, together suggesting an increase in lacustrine productivity and a shift of the lake´s trophic status from oligotrophic to mesotrophic. These conditions remain during the Bölling/Alleröd interstadial and notably change during the Younger Dryas stadial, when epiphytic and benthic species, such as small fragilarioids, regain importance suggesting a cooler and drier period. The Postglacial is dominated mainly by planktonic species: Nitzschia paleacea dominated since 9000 cal BP and together with an increase of TOC/TN and TS suggest lake eutrophication with periodic anoxia (Holocene Climatic Optimum). After 4200 cal BP, Lindavia radiosa and Pantocsekiella comensis are dominant suggesting warmer conditions (especially during the Medieval Climate Anomaly) but also cultural eutrophication. Moreover, the appearance of Aulacoseira subarctica is related to a cold and wet period during the Little Ice Age. Aside from environmental changes, our

multiproxy analyses also track human impact since the Middle Holocene. Future studies will utilize this multiproxy approach to investigate specific time windows with high temporal resolution to better understand short-term variabilities of lacustrine systems in response to past changes in aquatic ecosystems and their catchment areas for an improved assessment of future developments.

Keywords : Pleniglacial, Lateglacial, Holocene, lacustrine sediments, diatoms

Ecological responses to environmental changes revealed from a varved sequence of Lake Lubińskie (western Poland).

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Abstract :

Landscape and ecosystem transformations depend on combined climatic forcing and human activity. The timing of changes can provide crucial information about the underlying mechanisms. One of the processes that reflects the sensitivity of lakes to environmental and climatic changes is eutrophication, which has serious consequences on both aquatic life and human health. The Holocene natural eutrophication has been overprinted by the human impact due to agriculture, livestock breeding and related deforestation, followed by soil erosion, rapid urbanization and sewage disposal, which lead to the degradation of water quality. As these processes are expected to be more intense with the population growth, it is crucial to understand the drivers, magnitude and directions of changes in ecosystem structures over long timescales.

This study presents a 2,500 year-long chronology and paleoenvironmental proxy record from Lake Lubińskie located in western Poland in order to explore long-term ecosystem dynamics and responses to environmental changes. We use various dating techniques including varve microfacies analysis and varve counting, radiometric measurements (C-14, Cs-137, and Pb-210), and age-depth modelling. Furthermore, we investigate the changes in diatom assemblages and pollen spectra and combine them with µXRF scanning and elemental analysis.

The preliminary results show that up to the 4th-5th century the human impact on the landscape was negligible. It was followed by a gradual increase of anthropogenic indicators towards the top of the profile. Around the beginning of the 9th century, there was a rapid increase in varve thickness accompanied by changes in varve composition, rapid shifts of diatom assemblage and vegetation cover around the lake. In contrast, the geochemical changes were gradual and lasted a few decades. We hypothesize that the major changes were triggered mainly by human activity in the area as they coincidence with the development of the society and the Emergence of the Polish State between the 9th and 10th centuries. Since then, there was a continuous human presence in the lake vicinity. The intensified deforestations in the area were most likely caused by the Order of St. John of Jerusalem, Knights Hospitaller, who arrived in the area in the 12th century. Their presence and activity caused increased erosion and fostered eutrophication of the water body. After a peak in cultivated plant taxa in the first half of the 20th century, there was a significant decrease in agricultural activity which resulted in reforestation and a decrease in the hypereutrophic species of diatoms. This was related to the destructive influence of World War II on local agriculture and the introduction of new agrarian techniques.

Keywords : eutrophication, human activity, XRF, varves, Poland

Laminate sediments from the Al-Azraq Basin, Jordan: A reflection on regional climate perspectives.

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Abstract :

The micro-scale analyses of cored sediments from the Al-Azraq basin Jordan demonstrate laminated sediments beyond the Dead Sea basin. The Dead Sea basin laminated sediments, long recognized as varved deposits or seasonal couplets forming annual deposition, are currently under reevaluation. Micro-facies of an ICDP-DSDDP long core from the central basin identifies sequences of varved deposits extending over the last ~220,000 years. Recent assessment of the sediments along the margins are the basis for reevaluation of the varve designation of the Dead Sea laminated sediments. The Al-Azraq, located 90 miles east of the Dead Sea and separated by the Jordan Plateau into an eastern drainage reveal laminated sediments beyond the Dead Sea basin. The Al-Azraq is a low lying, endorheic basin draining an area of approximately 12,700 km2 of the interior desert extending from Syria to Saudi Arabia. The basin, formed by the Hamza Graben, is a rare and deep sediment archive. The research uses multiple environmental proxies to characterize the laminated sediments. XRF identifies millimeter rhythmites of alternating terrestrial material and Ca evaporite demonstrating different depositional processes and accompanying changes in moisture flux. XRD identifies the Ca as predominantly gypsum and halite, with minor dolomite. There is a lack of aragonite. SEM scans identify seasonal diatoms, Stephanodiscus sp. and Aulacoseira lirata, and EDS demonstrate an encrusting evaporite matrix. Seasonal diatoms are in situ indicators of fine resolution climate cycles. Results reveal rhythmite sediments composed of evaporite-clastic and evaporite-diatom sequences of potentially seasonal origin. Multiple paleoenvironments are evident with differing sedimentation above and below laminated rhythmite sediments. Al-Azraq rhythmites are similar to regional occurrences from west of the Nile to the Dead Sea to the Jordan Plateau, reflecting detailed regional climate processes and patterns.

Keywords : laminated sediments, geochemistry, diatoms, Paleoclimate reconstruction, Eastern Mediterranean

Exploring resilience and vulnerability of Mediterranean ecosystems using annually laminated sediments from Lago Grande di Monticchio (Southern Italy)

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Abstract :

Climatic and societal changes are expected to tremendously impact ecosystems. To reduce risks, we need to better understand the associated (transient) environmental and ecological processes in time. More specifically, we need to disentangle the roles of climatic and societal change on vegetation, biodiversity, land use, and fire dynamics and to assess potential linkages between the driving forces. This understanding will also allow us to better assess the resilience and vulnerability of Mediterranean ecosystems, which are the hotspot of European biodiversity. Within this project, we tackle these issues for southern Italy using sedimentary archives which allow to go beyond the temporal scope of present-day observational experiments. We study Lago Grande di Monticchio (Basilicata) to reconstruct the Holocene ecosystem dynamics at decadal scales. The annually laminated sediment allows a record of high precision and high taxonomic and temporal resolution by e.g. constant year sampling and wiggle-matched chronologies. Lago di Monticchio is one of the few study sites in Europe which allows the study of millennial-scale land use and climate interactions on the basis of annually laminated sediments. We focus on the time from the Neolithic onwards, the time where human populations became sedentary, developed agriculture, and thus significantly assessed natural ecosystems for the first time. Here, we will present our ongoing and future work. We start with the investigation

of the cores retrieved in June 2021, with emphasis on the understanding of the varve structure and varve years, applying biogeochemical and chronological approaches such as XRF, micro-XRF, pigments as well as radiocarbon dating, and wiggle-matching. The sediment analyses and the chronology will allow subsampling at constant time intervals (c. 10 years; following Rey et al. (2019: Radiocarbon Wiggle Matching on Laminated Sediments Delivers High-Precision Chronologies. In Radiocarbon 61 (1), pp. 265–285). Plant macrofossils, macroscopic charcoal (> 600 µm), pollen, spores, stomata, microscopic charcoal (> 10 and < 500 µm) and other non-pollen palynomorphs (NPP) will allow the reconstruction of vegetation, land use and fire dynamics at local to regional scales. Numerical analyses will be used to detect past influences and response lags of vegetation to human impact, fire disturbance, and environmental changes (e.g. climate, soil erosion). Furthermore, we will consider historical and archaeological sources on man-made developments in agriculture, forestry, industry, or mobility to assess their effects on land use and vegetation change. Conclusively, this study will provide mechanistic insights into causes, consequences, leads, and lags of climate, vegetation, biodiversity, land use, and fire dynamics to better asses the resilience and vulnerability of Mediterranean ecosystems.

Keywords : paleoecology, human impact, climate impact, vegetation dynamics, varves

Temperature reconstruction highlights the multi-decadal solar forcing on middle Tibetan Plateau.

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Abstract :

Observations show that the Tibetan Plateau (TP) underwent a rapid warming trend during the past several decades, but it is unclear whether this trend was due to natural variations or human activities. We provided a mean annual temperature (MAT) record since 1534 CE based on lacustrine varve thickness from the middle TP. With robust chronology, two warm episodes around 1600-1620 CE and 1770-1790 CE were consistent to solar activity maximums, suggesting that exceptional warming episodes on middle TP can be attributed mainly to natural-influenced solar radiation before 1800 CE when anthropogenic GHGs emission was low. The recent warming signals on middle TP appeared after 1875 CE, slightly earlier than the increased temperature from extra-tropical Northern Hemisphere. Comparison between model-based MAT results and our record yield significant correlations after 1800 CE, while obvious inconsistencies before 1800 CE. Recent warming trend was also significantly correlated to solar activities as well as to GHGs. These results provide compelling evidence of the solar forcing on plateau climate change over decadal to multi-decadal scales. We therefore suggest more efforts on understanding the effect of natural forcings on plateau's climate change.

Keywords : Tibetan Plateau, climate change, solar forcing, varve, mean annual temperature

Paleoproductivity changes in the southeastern Arabian Sea over the last ~14,400 years.

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Abstract :

Reconstruction of past productivity changes in the marginal seas is crucial to understand the role of ocean productivity in altering the atmospheric carbon dioxide on millennial timescale. Here we measure sedimentary biogenic components such as organic carbon (OC) and calcium carbonate (CaCO3) and their mass accumulation and burial rates using a 4.82 m long sediment core from the southeastern Arabian Sea (SEAS) and estimate paleoproductivity to understand climate-productivity link during the late glacial to Holocene interval (ca. 14.4 thousand year BP). Results indicate high productivity during the Bolling-Allerod (B/A) event, a step-wise decreased productivity during the Younger

Dryas (YD) cold period, the lowest productivity during the early Holocene and increased and stabilized productivity during the mid- and late Holocene intervals. These productivity variations seem to be driven by the Indian summer monsoon induced varying strengths of upwelling in the study area and therefore monsoon winds play a key role on millennial scale productivity changes in the SEAS. Furthermore, a synthesis of selected paleoproductivity records from the entire Arabian Sea reveals a regional similarity of productivity on millennial timescale, suggesting a strong role of Indian summer monsoon winds in driving basin-scale productivity changes in the Arabian Sea.

Keywords : Paleoproductivity, organic carbon, calcium carbonate, Indian summer monsoon, SEAS

OSM07: Charting future pathways to sustainability using concepts of resilience and adaptation

Co-conveners: Lindsey Gillson, Estelle Razanatsoa and Rob Marchant

Oral

crestr An R package to perform probabilistic climate reconstructions using fossil proxies

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Abstract :

Statistical climate reconstruction techniques are fundamental tools to study past climate variability from fossil proxy data. In particular, the methods based on probability density functions (or PDFs) have the potential to be used in various environments and with different climate proxies because they rely on elementary calibration data (i.e. modern geolocalised presence data). However, the access and curation of these calibration data, as well as the complexity of interpreting probabilistic results, often limit their use in palaeoclimatological studies. I introduce a new R package (crestr) to apply the CREST method (Climate REconstruction SofTware) on diverse palaeoecological datasets and address these problems. crestr includes a globally curated calibration dataset for six common climate proxies (i.e. plants, beetles, chironomids, rodents, foraminifera, and dinoflagellate cysts) associated with an extensive range of climate variables that enables its use in most terrestrial and marine environments. Private data collections can also be used instead of, or in combination with, the provided calibration dataset. The package includes a suite of graphical diagnostic tools to represent the data at each step of the reconstruction process and provide insights into the effect of the different modelling assumptions and external factors that underlie a reconstruction. With this R package, the CREST method can now be used in a scriptable environment, thus simplifying its use and integration in existing workflows. It is hoped that crestr will contribute to producing the much-needed quantified records from the many regions where climate reconstructions are currently lacking, despite the availability of suitable fossil records. The use of the package will be illustrated with a recent application to produce a 790,000 year long mean annual temperature reconstruction based on a pollen record from southeastern Africa.

Keywords : climate reconstruction, R package, CREST, Africa, pollen

Climate-driven Mediterranean fire hazard assessments for 2020–2100 on the light of past millennial variability

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Abstract :

In the Mediterranean basin, Corsica (French island) harbours among the best-preserved Mediterranean forest ecosystems. However, its high biodiversity could be threatened by the climate and disturbance-regime changes due to the global warming. This study aims (i) to estimate the future climate-related fire hazard in Corsica for the current century (2020–2100) based on two RCP scenarios (RCP4.5 and RCP8.5) and (ii) to compare the predicted trends with the entire Holocene period for which fire hazard has previously been assessed. An ensemble of future climate simulations from two IPCC RCP scenarios has been used to compute the Monthly Drought Code (MDC) and

the Fire Season Length (FSL) and to assess the level of fire hazard. Here, we show that the MDC and the FSL would both strongly increase over the next decades due to the combined effect of temperature increase and precipitation decrease in the Corsica region. Moreover, the maximum Holocene FLS (7000 to 9000 years ago) will be reached (and even exceeded depending upon the scenario) after 2040. For the first time in the Holocene, we may be confronted to an increase in the number of fire-prone months driven by climate combined with many human-caused ignitions. This combination should increase the burned area from 15 to 140% according to scenarios. For the next 30 years, the game seems to be already played as both RCP scenarios resulted in similar increase in fire hazard in terms of drought and duration. It is thus mandatory to reconsider fire-management and fire-prevention policy to mitigate the future fire risk and its catastrophic consequences for ecosystems, population, and economy.

Keywords : Palaeofires, Fire season, Monthly Drought Code (MDC), Modelling, Holocene, Anthropocene

Reinstating variability to recover biodiversity in floodplain wetlands - the Murray-Darling Basin.

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Abstract :

The rivers of the Murray Darling Basin are flow-stressed on account of high levels of abstraction for irrigation agriculture and a drying climate. In response the Australian government is implementing a basin-wide water recovery program to enable environmental flows. Many floodplain wetlands lie close to the main rivers and are influenced by the regulation of water levels brought on by the commissioning of impoundments in the early 20th century. A network of short cores across more than 60 sites reveals that most were likely seasonal or intermittent before regulation. The shift from variable water levels to semi-permanent was followed by rapid sedimentation, a switch from benthic and epiphytic, to planktonic diatoms and the replacement of submerged plants with floating and emergent. This has coincided with widespread declines in small-bodied native fish which are now considered vulnerable to predation. While many wetlands are predominantly dry and would benefit from managed watering, a large number are impacted by the shift to stable water levels which has precluded the resetting of aquatic plant communities. The recovery of past biodiversity may rely on the return to variable water levels, and so both the wetting, and the drying, of wetlands.

Keywords : wetlands, environmental flows, wetting-drying regime, diatoms, native fish

Quantifying resilience of socio-ecological systems through dynamic Bayesian networks: An application to high Andean Ecosystems in Colombia.

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Abstract :

Quantifying resilience of socio-ecological systems (SES) can be invaluable to delineate management strategies of natural resources and aid the resolution of socio-environmental conflicts. However, resilience is difficult to quantify and the factors contributing to it are often unknown in SES. We provide a theoretical and conceptual framework to quantify resilience in a long-term context. Our approach uses elements from interdisciplinarity and network perspectives to establish links and causalities between social and palaeoecological components and resilience attributes of SES. The evaluation and modeling of SES structure and function are established from the analysis of dynamic Bayesian networks (DBN). An advantage of DBN models is that they allow quantifying resilience through probabilities, but also offer a platform of interdisciplinary dialogue and an adaptive framework to address questions on ecosystem monitoring and management. The proposed DBN is then tested in Monquentiva, a SES located in the high Andes

of Colombia. We determined historical socio-ecological resilience from palaeoecological evidence (i.e. palynological diversity, forest cover, fires, and precipitation) and social factors (i.e. governance, social organization, and connectivity) between 1920 and 2019. We find that the transformation processes in Monquentiva are mainly related to social change (e.g. high social organization) and have resulted in increased ecological diversity and SES resilience between 1980 and 2019. Differently, the absence of social organization has been related to low diversity and poor socio-ecological resilience between 1920 and 1980. The ability to predict the SES response over time and under cumulative, non-linear interactions across a complex ecosystem highlights the utility of DBNs for decision support and environmental management. We conclude with a series of management and policy-relevant applications of the DBN approach for resilience assessment.

Keywords : Dynamic Bayesian Networks, Functionality, Interdisciplinarity, Participatory approach, Resilience modeling, Socio-ecological systems, Disturbance

The whole is not the sum of the parts: building a synthesis database of past human-environmental systems in the Global South (pSESYNTH Project).

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Abstract :

While the theoretical basis for fruitful interdisciplinary studies in paleosciences has already been identified, less efforts have been made in finding feasible strategies to put them into practice using inclusive and democratic approaches. This applies to the Global South, the regions of Latin America and the Caribbean, Africa, Asia, and Oceania, which have been historically marginalized from scientific collaborations. Despite its diverse landscapes and socio-economic histories – and regardless the growing number of early-career scientists (ECRs) emerging from these regions – the study of past socio-environmental systems in the Global South is clearly underrepresented and understudied as compared to other more developed regions of the world. Moreover, one of the greatest challenges in paleosciences is to access data repositories of time series of comparable temporal and spatial resolution. Overlooking interdisciplinary and inter-cultural approaches can therefore lead to a biased understanding of long-term human-environmental dynamics, and ultimately mislead our responses to pressing environmental issues in the Global South that primarily include developing tropical countries.

Stemmed from the organization of the PAGES-INQUA ECR workshop "Past Socio-Environmental Systems", a newly minted INQUA funded project, pSESYNTH, has the overarching objective to build the first-ever multi-disciplinary database of past socio-environmental systems from the Global South. A team of more than 20 ECRs from 8 different countries with diverse expertise including paleoecology, paleoclimatology, archeology, and data science will discuss how best paleo-datasets from the respective regions can be consolidated so that they can act as practical analogs of present and project future trends. Through developing integrative methodologies for region-specific multi-proxy comparison leading to a relational and visual open-access database, pSESYNTH participants will test the key hypothesis i.e. whether or not cultural "stress" of ecosystems is widespread across the Global South. The specific aims of pSESYNTH are to cross-fertilize knowledge among each other's approaches and to synthesize results to launch an open-to-all database from the perspective of interdisciplinary questions. The project's core mission is to foster new, long-lasting research collaborations among the next-generation leaders in the field, hailing from the respective Global South regions. In this presentation, we will introduce the development and implementation and the first products of pSESYNTH project.

Keywords : Global South, human-environment relationships, open-data, database, time series, quantitative models

Endurability and transformability: what we can learn from societal resilience in society from sub-Saharan Africa.

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Abstract :

A wide diversity of fields has since the 1970s explored and developed methodologies and concept to explore resilience over multiple and temporal scales. There are some good examples of interdisciplinary studies which has explored societal-ecological resilience in historical societies (combining archaeology, paleoecology and current understanding of resilience and adaptability. In this paper I try to extract some of the lessons to be learnt from these studies in terms of the organisation of resilience, eg. what strategies, forms of social organisations and its combinations has been conducive to a high degree of adaptability and capacity for resilience. The presentation starts from exploring the concept of “heterarchy” (cf Carole Crumley) and attempts to combine the Sustainable Livelihood studies concepts with resilience thinking, tracing forms of vulnerability, endurability and transformability using historic and contemporary examples from sub-Saharan Africa. I also discuss possible approaches and collaborations for further research and for a better integration with landscape planning.

Keywords : Transformability, Endurability, Resilience, Livelihood, Heterarchy, Archaeology, Historical Ecology

Holocene vegetation and fire history in the Central Highlands of Madagascar and its conservation implication

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Abstract :

Madagascar, a biodiversity-rich country, presents a high level of human dependence on ecosystems. Currently, a rapid increase of anthropogenic activities, for instance through increasing deforestation, is recorded on the island and this threatened Malagasy ecosystems. Accordingly, reforestation program is intensified, and local fire use is banned on the island. However, the nature and dynamism of these ecosystems over time are still misunderstood leading to misinterpretation and therefore non-sustainable conservation strategies for the biodiversity conservation of the island. There is concern that afforestation projects are taking place on some areas of suggested ancient open ecosystems using mostly exotic species which further threatens biodiversity and ecosystem services. A full understanding of landscape history is essential to the success of conservation strategies on the island particularly in the region presenting rapid population growth and high deforestation rate such as in the Central Highlands of Madagascar region. This research aims to understand long-term analysis of vegetation history and fire regimes at two local sites in the region. Our results demonstrated that the landscape has a different history in terms of forest abundance and presented both some abundance of open vegetation prior to human presence. Yet, an expansion of the grassland ecosystem with high fire activities at both sites coincided with human presence and activities in the last millennium. Consequently, consideration should be made in terms of the natural presence of open and mosaic ecosystems in the region, but also fire bans and tree plantations to allow them to accommodate the human needs and the biodiversity conservation in the region.

Keywords : Madagascar, Holocene, forest, grassland, fire

OSM11: Tropical and subtropical interhemispheric teleconnections during the last 2000 years: A transatlantic approach

Co-conveners: Abdelfettah Sifeddine, Lhoussaine Bouchaou, Heitor Evangelista, Evens Emmanuel and Juan Pablo Bernal

Oral

Holocene contraction of the Intertropical Convergence Zone over northeastern South America.

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Abstract :

Modern precipitation over northeastern (NE) South America is strongly controlled by the seasonal meridional migration of the Intertropical Convergence Zone (ITCZ). Ample evidence from the Northern Hemisphere suggests a mid- to late Holocene southward migration of the ITCZ. One such shift would be expected to increase precipitation over semi-arid northern NE Brazil (Southern Hemisphere). However, the most meaningful precipitation record from northern NE Brazil shows a drying trend throughout the Holocene. Here we address this issue presenting a high temporal resolution reconstruction of precipitation over northern NE Brazil based on data from a marine sediment core, together with analyses of mid- and late Holocene simulations performed with a fully coupled climate model. We reconstructed changes in precipitation through three independent approaches: (i) bulk sediment ln(Fe/Ca) and ln(Ti/Ca) values; (ii) mass accumulation rate of the siliciclastic fraction; and (iii) stable hydrogen isotopic composition of long-chain n-alkanes. A mechanistic understanding of the reconstructed changes from our core and other NE South American ITCZ-related high temporal resolution records was attained by specific analyses of FGOALS-s2 climate model simulations. Both, our reconstruction and the climate model simulations show a decrease in precipitation over northern NE Brazil from the mid- to the late Holocene. The model outputs further indicate a latitudinal contraction of the seasonal migration range of the ITCZ that, together with an intensification of the regional Walker circulation, were responsible for the mid- to late Holocene changes in precipitation over NE South America. Our results reconcile apparently conflicting precipitation records and climate mechanisms used to explain changes in precipitation over NE South America, challenging the hypothesis of a global southward migration of the ITCZ through the Holocene.

Keywords : Precipitation, Intertropical Convergence Zone, Holocene, South America, Organic and Inorganic Geochemistry

Exploring the drivers and teleconnections of late-Holocene precipitation anomalies in the Altiplano, South America: Paleoclimate records and modern climate analysis.

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Abstract :

By documenting extended records of atmospheric variability, paleoclimate

reconstructions provide long-term climate information critical to evaluate forcing mechanisms and the extent to which current drivers will influence future trends.

The southern portion of the Altiplano (18-25°S) is a unique region in South America due to its pronounced seasonality where up to 90% of annual precipitation falls during the austral summer months (DJF). The scant rainfall that reaches this arid region in summertime represents the southwestern margins of the South American Summer Monsoon (SASM), which transports Atlantic moisture from the interior of the continent up to the high Andes. Inter-summer precipitation variability in the southern Altiplano results from complex dynamics in the low- and high-troposphere, further modulated by the equatorial Pacific through the inter-annual El Niño Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO); as well as by changes in Atlantic SSTs. While tree-ring chronologies have revealed the impact of these drivers from inter-annual to multi-decadal timescales, their influence over longer scales (i.e., centennial and beyond) is still largely unknown.

We explore changes in summer precipitation at centennial timescales in the southern Altiplano during the last 2500 years using pollen-climate reconstructions from lake sequences and fossil rodent middens. The tight rainfall-vegetation relationship in this region is used to uncover intervals of increased and reduced precipitation based on changes in key pollen indicators. We further compare our reconstructions with proxy records from the Altiplano, the tropical Andes and the equatorial Pacific in order to evaluate potential drivers and long-term teleconnections. In addition, we explored potential mechanisms of past precipitation change by analysing the regional atmospheric circulation during anomalous wet and dry summers that occurred over the last decades.

Our pollen-climate reconstructions identify at least 3 multi-centennial wet/dry anomalies in the southern Altiplano in the last 2500 years: An intervals of enhanced precipitation between ~2300-1900 BP (BP; taken as Common Era 1950), reduced rainfall between ~930-550 BP, and wetter and more variable conditions afterwards. Our comparison with other precipitation proxies from South America suggest that a teleconnection with the tropical Pacific akin to modern ENSO could have been dominant over the last millennia. However, such tropical teleconnection fails to explain the younger multi-centennial anomaly detected in our records, suggesting that other non-tropical teleconnections could have also played a significant role over the recent past. Key features of the atmospheric circulation during present-day anomalous summer seasons suggest that past precipitation anomalies might have resulted from switches in the upper-level zonal circulation above the Altiplano, El Niño/La Niña-like variability, latitudinal shifts in the in the South Atlantic Convergence Zone (SACZ), changes in Atlantic SSTs and/or the intrusion of extra-tropical Atlantic moisture.

Our results highlight that the Altiplano experienced significant changes in precipitation during the most recent millennium. Furthermore, our work demonstrates that past precipitation records are critical to improve our understanding of the causes and mechanisms of precipitation change in these regions, as well as to evaluate whether the drivers of modern precipitation could also influence future trends.

Keywords : Paleoclimate, ENSO, South America, Precipitation, Andes, Atlantic, Telecconnections

Coastal wetland responses to a century of Climate Change in Northern Saharan Environment

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Abstract :

The most important transition environments between terrestrial and marine ecosystems are coastal vegetated wetlands. Complex interactions among stressors and autochthonous and allochthonous material fluxes from land, ocean, and atmosphere control the ecosystem's evolution. Mangroves and saltmarshes contribute to coastal economies regarding ecosystem services (flood and erosion protection, "blue carbon burial", fishery, tourism...). In arid areas, where resources are scarce, coastal wetlands contribute to the sustenance of local population and biota. Apart from the common vulnerabilities that coastal wetlands surfer (sea-level rise, anthropogenic action, storms…), these environments also deal with the pressure of the surroundings dryness and drought regime. Coastal wetlands are sensitive to changes occurring at the coastline, therefore, it is critically important to determine region-specific expected future changes once wetlands are diverse environments with specificities and different vulnerabilities to climate change. The Khnifiss Lagoon is the only example of a continental-marine environment in the Moroccan Sahara, supporting the local population — fishery, grazing, and tourism — and the local biodiversity, including endemic species and a significant amount of intercontinental migratory birds. Our objective was to comprehend the regional impacts of climate change on coastal ecosystems in North Africa during the recent past and their relationship with the climate variability modes such as the North Atlantic Oscillation (NAO). By analyzing the ecosystem's response and tendencies, we aimed to contribute to predicting possible future impacts and planning adaptation and mitigation strategies. We have applied a combined approach using remote sensing techniques and environmental reconstructions based on high-resolution analysis of sediment cores for a complete overview of the changes that occurred during the last ~100 years. Remote sensing highlighted changes to the lagoon inlet, accompanied by a greater meandering character of the tidal channels. As a response, the sediment cores have recorded a predominant vegetation substitution due to changes in the tidal limit, and an increase in organic carbon accumulation was observed. The tidal vegetation distribution follows a zoning pattern linked to the plants' tolerance to flooding and salinity. Although tidal flats are highly dynamic environments, in a possible future scenario of tidal line displacement, it is expected that there will be a loss of the upper marsh vegetation due to the insertion in a desert climate. For the current climatology, during positive phases of the NAO, winds reaching the coast strengthen in an east-to-west direction. In the Khnifiss Lagoon, whose inlet is dominated by the ebb tide, the intensity and direction of the winds on the coast at surface level modifies its connection to the ocean by increasing sediment transport toward the interior of the lagoon. Carbon accumulation rate estimations revealed an increasing tendency and high values, up to 88.65 g C m^{-2} yr^{-1}, were observed in the most recent sediment layers, indicating the Lagoon's great potential as a carbon burial ecosystem. The rare wetlands at Northern Sahara are key environments related to natural services sustainability. We demonstrated that the regional wind structure, driven by known climate changes, can profoundly impact the lagoon hydrodynamics and biogeochemical cycles.

Keywords : Sahara desert, Khnifiss Lagoon, Coastal impacts, Geochemistry, Remote sensing

Sahara as Amazon's main fertilizer: not that much! Exploring mineral dust sources for the Amazon Basin since the mid-Holocene.

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Abstract :

Today satellite images allow us to recognize the great amplitude of Sahara dust reaching the Amazon Basin, expected to be around 50 Tg/yr. Many authors deduce that such amounts may carry (micro)nutrients that could act as "fertilizers" for the rainforest, with an important contribution to its expansion during the Holocene. However, considering different atmospheric transport conditions, different aridity levels in South America and Africa, and active volcanism, it is not clear if the same pathways for dust have occurred throughout this Epoch. To investigate the Sahara dust's effectiveness and its geographic range through time, we have analyzed a sediment core (~7.5 kyr B.P.) at one of the most remote sites in Central-Western Amazon (Pata Lake), aiming to detect if a persistent Saharan dust signal does exist. We based our work on the 87Sr/86Sr and 143Nd/144Nd isotope ratios as fingerprints of dust provenience. Our results and interpretations, contrarily to the modern scenario, showed that along the mid-to-late Holocene, dust reaching this part of the Amazon basin had diverse sources regions accounting with contributions from the Andean region, the Northern and Southern Africa, and probably some volcanic activity. Our results suggest that Sahara's dust impact cannot be generalized as the main source of dust for the totality of the Amazon rainforest.

Keywords : dust provenance, Sr-Nd isotopes, Holocene, Amazon, Sahara dust

Centennial-scale SST variability in the southeastern Caribbean Sea linked to regional hydroclimate changes during the Common Era.

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Abstract :

The Common Era (CE, past 2,000 years) is characterized by several warm and cold climate epochs, such as the Medieval Climate Anomaly (MCA, 950–1250 CE) and the Little Ice Age (LIA, circa 1300-1850 CE). To improve our understanding of centennial climate variability, we generated a multi-proxy dataset using a box core from the southeastern Caribbean Sea, an underexplored yet a key region that directly responds to the North Atlantic sea surface temperature (SST) anomalies. Our Mg/Ca-based SST reconstruction reveals a major ~1.5 °C cooling from 1100 to 1600 CE that is linked with the transition from the MCA to the LIA. In addition, this time interval is associated with a decline in proportions of planktic foraminifera species characteristic of high riverine nutrient supply, implying reduction in the nutrient-rich Orinoco freshwater outflows and thus reduced rainfall over northern South America. Our results further suggest coldest SST in the SE Caribbean roughly between 1400 and 1600 CE, whereas the later LIA period, between 1600 and 1800 CE, is associated with warmer ocean temperatures. The inferred centennial SST variability contrasts with the interpretations derived from the Cariaco sediments and Caribbean corals, included in the current PAGES 2k global temperature database, but agrees with the estimations based on marine sediments from the Gulf of Mexico. Comparing our reconstruction with SST anomalies in the High-

Arctic further suggests coherence in climate variations during the MCA-LIA period pointing to a tropical-extratropical climatic teleconnection on centennial timescales.

Keywords : Common Era, SST, Caribbean Sea, Little Ice Age

Poster

Hadley Cell Variability during the Last Millenium in the CMIP6 models.

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Abstract :

Human activities are highly dependent on climatic conditions. Rainfall is crucial for agriculture and availability of water resources. Nonetheless, extreme rainfall events, as well as prolonged periods with little or no rainfall, may have deep economic and societal impacts and lead to the loss of lives. In the Tropics, the Hadley Cell plays a key role in controlling precipitation patterns, since it is related to the position of the ITCZ, which is also a main component of the South America Monsoon System (SAMS). The position of the ITCZ over the ocean is locked to the sea surface temperature patterns and the net northward heat transport in the Atlantic ocean, by the meridional overturning circulation (AMOC), and atmospheric redistribution of this heat leads the average ITCZ position to be displaced north of the equator. Therefore, changes in surface temperature patterns in the tropical region may impact precipitation in the surrounding continents, via their influence on the Hadley Cell and the monsoon system. Several studies have documented a poleward expansion of the Hadley Cell over the historical period and a shift in the position of its subsiding branches and the expansion of the subtropical dry zones. This widening has largely been attributed to anthropogenic forcing, such as greenhouse gases (GHG) and stratospheric ozone depletion. However, the large natural variability at play makes it harder to effectively detect externally forced trends. Therefore, understanding the natural variability of the Hadley Cell extent without the influence of anthropogenic is key. In this study we aim to investigate the variability of the Hadley Cell in connection with the Tropical Atlantic modes of sea surface temperature variability during the Last Millennium. We will rely on the simulations of the Last Millennium provided by the Paleoclimate Modeling Intercomparison Project (PMIP4) contribution to the Climate Model Intercomparison Project phase 6 (CMIP6).

Keywords : Hadley Cell, CMIP6, Tropical Atlantic Variability, ITCZ

OSM12: Volcanic impacts on climate and society

Co-conveners: Matthew Toohey, Kevin Anchukaitis, Allegra LeGrande, Francis Ludlow, Michael Sigl and Celine Vidal

Oral

Mid to Late Holocene East Antarctic ice-core tephrochronology: Implications for reconstructing volcanic eruptions and their impacts over the last 5,500 years

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Abstract :

Ice cores are powerful archives for reconstructing volcanism and developing tephrochronological frameworks, as they can preserve both the soluble, i.e. aerosols, and non-soluble, i.e. tephra, products of volcanic eruptions. In addition, and particularly over Holocene timescales, high-precision annually resolved chronologies have been developed for these records and permit ages to be assigned to eruptions. The identification of tephra in ice cores in direct association with chemical indicators of volcanism, such as sulphate, can significantly enhance volcanic reconstructions as tephra can be linked to an eruptive source. Such source attributions can provide information on the location of the eruptions, the magnitude of aerosol emissions at the source and help assess any climatic impact. In addition, they can aid the reconstruction of volcanic histories and the assessment of future hazard risk.

The tephra record for the interior of East Antarctica over the last 5,500 years is potentially underexploited as a prior focus on visible horizons and exploring the deep ice cores that cover longer time spans has resulted in only one horizon, dated to ~3.5 ka BP, being identified in these records. Here we discuss ongoing tephrochronological investigations of two ice-cores, B53 and B54, retrieved from the interior of the East Antarctic Plateau. High-resolution, sub-annual chemical records have been measured from both cores using a continuous melter system. These data were used to develop a sampling strategy to identify cryptotephra horizons with ice-core sections containing coeval peaks in fine insoluble particles and non-sea-salt sulphur targeted and >50 events were directly sampled. This approach recently has been used to identify cryptotephras in both Greenland and Antarctic ice cores. When glass tephra shards were identified thin sections were created and individual glass shards were geochemically analysed using electron-probe microanalysis to help identify their volcanic source and permit correlations between records.

Thus far, more than 10 cryptotephra horizons have been identified and linked to regional sources such as the South Sandwich and South Shetland Islands and the ~3.5 ka BP event has been traced in both cores as a visible layer. More detailed investigations are being conducted on samples from specific volcanic signals of interest that may derive from eruptions of ultra-distal volcanic sources. Such eruptions could have deposited very small glass tephra shards over Antarctica, which poses significant analytical challenges and necessitates the use of innovative approaches for tephra identification and geochemical analysis.

Keywords : Tephrochronology, cryptotephra, Antarctic, ice cores, volcanic history

Effects of volcanic eruptions on on-going multi-year western Mediterranean droughts.

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Abstract :

Many proxy records have shown the occurrence of persistent droughts during the Common Era in the Mediterranean region, indicating that multi-year-long droughts are recurrent climatic features of the region. Some persistent dry events have also been detected during the period of frequent volcanic eruptions, for instance, the Little Ice Age (approximately 1300 – 1850 CE). However, up to date, little is known about the impacts of volcanic eruptions on on-going dry events over the region. Understanding of how external forcing, particularly the volcanic forcing, may impact regional droughts needs to be better examined in order to portray a complete description of the mechanisms of droughts. More understanding of droughts is especially valuable for the Mediterranean region since the drought risk over the region is projected to increase due to anthropogenic climate change.

Here, we investigate the effects of volcanic eruptions on on-going multi-year western Mediterranean (32° – 42°N, 10°W – 22°E) droughts using the Community Earth System Model 1.2.2 (CESM). For the analysis, simulations for the late Holocene (1501 BCE – 600 CE) and the Last Millennium (850 – 1849 CE) have been used. In addition, several sensitivity tests with prescribed volcanic eruptions of different magnitudes have been performed. Droughts are quantified through the annual mean of the upper 30 cm soil moisture anomalies. Drought periods that overlap with eruptions (eruption-drought type) are compared to the drought periods without overlapped eruptions (non-eruption-drought type).

Our result shows that the maximum duration of the eruption-droughts with large eruptions (with the values of the Volcanic Sulfate Stratospheric Injection of more than the 1991 Pinatubo eruption) is 4 years, which is significantly lower than the maximum duration of the non-eruption-droughts, which is 11 years. Moreover, it is found that large eruptions occur mostly during the last year of droughts. These findings imply that large eruptions can terminate long-lasting western Mediterranean droughts shortening the duration of the events. Mean circulation and temperature during the initiation years and transition years of droughts are similar between the eruption- and non-eruption-drought types. However, the climate conditions over Europe during the termination years differ between the two drought types. While a slight warm condition dominates over Europe during the termination years of the non-eruption-droughts, an opposite cool condition occurs during the eruption-droughts. The most notable differences in the circulation pattern between the two drought types are found in the summer, indicating that the termination of droughts is initiated in this season. This discrepancy in the climate conditions indicates that the drivers of the termination of droughts between the two drought types are different. For the non-eruption-droughts, the drivers of the termination are clearly associated with volcanic eruption-induced changes in the atmospheric circulation and temperature.

Keywords : volcanic forcing, droughts, Mediterranean region, climate circulation, extreme events

Did Volcanic Cooling Bring About the Fall of the Kingdom of Israel c.720 BCE?

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Abstract :

The idea that warfare increases when societies are subject to stress from climate extremes is plausible and yet has not been definitively established. Were it to be so, then the possibility of outbreaks of warfare, particularly between nations capable of bringing about unprecedented levels of destruction, would be one of the greatest risks for those living in an age of extreme climate events. As a contribution to the contention that there is a connection between extreme climate events and outbreaks of warfare, this paper offers a case study of the fall of the Kingdom of Israel c. 720 BCE with the conquest of the city of Samaria by Assyria. Because of the religious significance of the event, the defeat of the ancient Kingdom of Israel has been a subject of considerable study, despite the paucity of the sources. Until now, there has been no exploration of the role of

climate extremes in the events of the period, other than to reject the idea that climate had any impact on the issue, as one scholar has written: 'no specific impulses from a (sudden) change in climate would have influenced the course of events leading to the end of the kingdom.'

This paper will draw on recent ice-core data to connect the fact that there was a very significant volcanic eruption in 723 BCE with the political and military events of the years immediately following. It will argue that a severe drop in temperature had a powerful impact on societies with relatively frail resilience to such shocks and that the stress created by the volcanic climate event had a profound effect on the decision makers of the era, with disastrous consequences in the case of the Kingdom of Israel.

Keywords : Volcanic cooling, Israel, Assyria, Hoshea, Sargon II

Multi-method, multi-proxy reconstructions of the Pacific Walker Circulation over the past 800 years.

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Abstract :

The Pacific Walker circulation (PWC) affects weather and climate far beyond the tropical Pacific. The PWC is also an important component of the El Niño-Southern Oscillation (ENSO) and its global teleconnections. Understanding drivers of PWC variability is important for understanding impacts of future climate change, but neither the response of the PWC to external forcings nor its natural internal variability are well understood.

There is a strong PWC imprint in spatio-temporal variability in modern global precipitation δ18O (Falster et al., 2021). That imprint allows us to use proxy records for past meteoric water δ18O/δ2H to reconstruct PWC variability back beyond the instrumental era. We applied several statistical methods to reconstruct the PWC at annual resolution from 1200-2000 CE, using records from the Iso2k database (Konecky et al. 2020). Validation tests demonstrate that our suite of statistical methods—incorporating different subsets of the available data and explicitly accounting for chronological uncertainty—produce reconstructions that accurately capture instrumental-era PWC variability and are internally consistent.

We used these reconstructions to assess PWC variability on various time scales, as well as comparing our findings with climate model simulations, and assessing the PWC response to volcanic eruptions. Preliminary findings suggest that large volcanic eruptions drive an El Niño-like atmospheric response (weaker PWC) in the year following the eruption.

Falster, G., et al. 2021. “Imprint of the Pacific Walker Circulation in global precipitation δ18O”. Journal of Climate.

Konecky, B., et al. 2020. “The Iso2k Database: A Global Compilation of Paleo-δ18O and δ2H

Records to Aid Understanding of Common Era Climate.” ESSD.

Keywords : Pacific Walker circulation, last millennium, superposed epoch analysis, water isotopes

Modelling volcanically induced climatic perturbations in order to better understand vulnerability and resilience of Palaeolithic forager communities at the end of the Pleistocene in Europe.

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Abstract :

Climate and human populations can be said to make up a complex socio-ecological system with many possibilities for one component to impact

another. Today's anthropogenic global warming is a clear and present example, yet climate-society interactions are not limited to the Anthropocene. The deep past offers a veritable laboratory of cases where climatic perturbations – at times caused or exacerbated by volcanic eruptions – have impacted human communities. The very end of the Pleistocene is one such period where ice-core analyses suggest a suite of major eruptions occurred in short succession (Abbott, et al. 2021), one which was the Laacher See Eruption (LSE) that occurred around 13,000 BP (Reinig, et al. 2021). This eruption, in particular, may have impacted contemporaneous ecosystem services and human demography via tephra-mediated hazards as well as its impact on climate. The archaeological record as well as paleoenvironmental proxies suggest regionally varying responses, however, and the relative contribution of different impact mechanism remains contentious (Riede 2017). We here investigated the short-term (annual>decadal) climatic legacy of the LSE using an ensemble of MPI-ESM simulations with newly available estimates of the LSEs sulphur burden (Abbott, et al. 2021). We also investigated the longer-term (decadal>centennial) climatic legacy of the suite of eruption occurring around 13,000 BP. The impact of the LSE on relevant climatic variables is analysed for four regions – Southern Scandinavia, Central Europe, Western Europe, and the Alpine foreland, and in comparison with the archaeological record. All locations exhibit clear shifts in climatic conditions, albeit with transient signatures. These downturns in temperature may have translated into similarly transient population declines, which in combination with the tephra fallout may also have led to more long-lasting cultural changes in some regions the root causes of which must be sought in the pre-existing vulnerabilities of these contemporaneous populations.

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Keywords : Volcanoes, Hunter-gatherer, Climate forcing

Insights into volcano-climate impacts between 750 and 770 CE using the Greenland ice core records.

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Abstract :

Icelandic eruptions can have significant impacts on the North Atlantic and European climate system, resulting in widespread cooling at earth's surface. Owing to the proximity of Iceland to Greenland and high frequency of Icelandic eruptions, fallout from these events (volcanic ash and sulphate aerosols) may be preserved in the ice core records (Abbott and Davies, 2012). The high-resolution and independent chronologies of these archives can facilitate the robust reconstruction of past eruptions.

Preliminary analysis of several Greenland ice cores (TUNU2013, B19, NGRIP, NEEM, EGRIP, and RECAP) has revealed a prolonged period of elevated background sulphur emissions between 750 and 770 CE. Several cold years throughout this period of elevated sulphur are recorded in historical documents (Newfield, 2013) and by several European paleoenvironmental archives such as Speleothem (Affolter et al 2019; Fohlmeister et al 2012) and tree-ring records (Büntgen et al 2011; Esper et al 2012, 2020). However, uncertainty remains regarding the overall nature of this sulphur producing event, thereby hindering robust climate reconstructions. Mainly, was it the product of one eruption, or several consecutive eruptions? Which volcanic centre(s) were responsible for this event? What was the overall magnitude and duration of the sulphur producing event(s)?

Here we present the preliminary results of a multi-parameter approach applied across several Greenland ice cores to constrain the overall nature of this sulphur producing event. (1) synchronisation of records on a common timescale to constrain the total duration of this event, (2) targeted sampling for cryptotephra geochemical analysis to pinpoint the source volcano through correlation with proximal material, and (3) high-resolution sulphur isotope analysis to determine the magnitude of the eruption (tropospheric or stratospheric).

The application of the above methods has ultimately provided the necessary information to robustly assess the climatic impacts of this period of elevated background sulphur on the North Atlantic and European regions.

Keywords : Tephrochronology, Ice cores, Palaeoclimate, Volcanoes, Holocene

Do volcanoes influence ENSO? A re-appraisal with paleoclimate data assimilation.

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Abstract :

The potential for explosive volcanism to affect the El Niño-Southern Oscillation (ENSO) has been debated since the 1980s. Several observational studies, based largely on tree-ring proxies, have since found support for a positive ENSO phase in the year following large eruptions. In contrast, recent coral data from the heart of the tropical Pacific suggest no uniform ENSO response to explosive volcanism over the last millennium. Here we leverage paleoclimate data assimilation to integrate both tree-ring and coral proxies into a reconstruction of ENSO state, and re-appraise this relationship. We find only a weak statistical association between volcanism and ENSO, and identify the selection of volcanic events as a key variable to the conclusion. We discuss the difficulties of conclusively establishing a volcanic influence on ENSO by empirical means, given the myriad factors affecting the response, including the spatiotemporal details of the forcing and ENSO phase preconditioning.

Keywords : ENSO, volcanism, assimilation, corals, tree-rings

Tropical ocean responses to large volcanic eruptions during the last millennium.

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Abstract :

Volcanic eruptions are known to have strongly forced natural climate variability during the last millennium. Large eruptions caused air and ocean surface temperatures to decrease for up to a decade, and potentially also forced multidecadal variability and the long-term cooling of climate prior to the onset of human-caused climate warming. Climate model simulations also suggest an increase in the likelihood of El Niño and positive Indian Ocean Dipole events in the years following an eruption, however even small chronological errors preclude directly testing this in palaeoclimate data. Here we use the unambiguous δ13C signatures of the three largest eruptions of the last millennium recorded within precisely dated and monthly resolved fossil coral records from the equatorial eastern Indian Ocean to assess the seasonal timing of these past eruptions and their impacts on tropical climate. The seasonal timing of the 1452 Kuwae/unknown eruption was similar to the April 1815 eruption of Tambora, while the 1257 Samalas eruption most likely occurred around October. Coral δ18O data from the eastern Indian Ocean and central Pacific indicate that El Niño events followed in the year after the Tambora and Kuwae eruptions, however the eruption seasonal timing and a pre-eruption El Niño state may have precluded a response to the extreme Samalas eruption. The lack of a positive IOD response in the eastern Indian Ocean following each of the three largest volcanic eruptions of the last millennium further suggests that volcanic forcing is unlikely to generate a direct response on the IOD.

Keywords : volcanic eruptions, ENSO, Indian Ocean Dipole

Volcanism and human resilience during the Late Mesolithic in the Iberian Peninsula. New results from the La Garrotxa Volcanic Field (Girona, NE Iberia).

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Abstract :

Past human communities in volcanic areas have been repeatedly threatened by eruptive activity and subjected to short-term catastrophic events leading to major landscape changes. However, it becomes crucial to consider the socio-ecological characteristics of the affected societies, since vulnerability or resilience of human societies relies on different aspects, involving the settlement patterns, demography and socio-political and economic organization. In this work, we present new and high-resolution multi-proxy records (sedimentology, XRF geochemistry, ostracods, charophyte gyrogonites, diatoms, pollen, sedimentary charcoal, and plant macrofossils) from the Vall

d'en Bas valley (La Garrotxa, NE Iberia) to investigate how Mesolithic hunter-gatherer communities were constrained by and adapted to paleoenvironmental changes. Prior work showed that the valley hosts an infilled paleo-basin that was formed by successive lava flows from the La Garrotxa Volcanic Field, which dammed the Fluvià river. As the last large lava flows were likely associated with the most recent eruptions from the Puig Jordà (17,000 BP) and the Croscat volcanoes (15,710-13,160 cal BP), the basin includes an undisturbed sequence of sediments that were deposited during the Late Pleistocene-Holocene transition.

This interdisciplinary research enabled both the identification and age assessment of previously unknown Late Glacial and Early Holocene volcanic eruptions in the area of La Garrotxa Volcanic Field. Moreover, we identified major paleoenvironmental changes that were triggered by the eruptions, including fire episodes and disturbances on vegetation, hydrology and limnological conditions. By linking these records with the regional archaeological context, we observe the resilience of last hunter-gatherer communities at an extra-local scale, with several occupations in nearby sites (e.g. Bauma del Serrat del Pont (9,400-8,000 cal BP)) that is coetaneous with the most recent eruptive episodes in the La Garrotxa Volcanic Field.

Keywords : La Garrotxa Volcanic Field, Iberian Peninsula, Holocene, Mesolithic, palaeoenvironmental impacts of volcanism

Climatic, weather and socio-economic conditions corresponding with the mid-17th century eruption cluster

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Abstract :

The mid-17th century is characterized by a cluster of explosive volcanic eruptions in the 1630s and 1640s, deteriorating climatic conditions culminating in the Maunder Minimum as well as political instability and famine in regions of Western and Northern Europe as well as China and Japan. This contribution investigates the sources of the eruptions of the 1630s and 1640s and their possible impact on contemporary climate using ice-core, tree-ring and historical evidence, but will also look into the socio-political context in which they occurred and the human responses they may have triggered. Three distinct sulfur peaks are found in the Greenland ice core record in 1637, 1641-42 and 1646. In Antarctica, only one unambiguous sulfate spike is recorded, peaking in 1642. The resulting bipolar sulfur peak in 1641-1642 can likely be ascribed to the eruption of Mount Parker (6°N, Philippines) on December 26, 1640, but sulfate emitted from Koma-ga-take (42°N, Japan) volcano on July 31, 1641, has potentially also contributed to the sulphate concentrations observed in Greenland at this time. The smaller peaks in 1637 and 1646 can be potentially attributed to the eruptions of Hekla (63°N, Iceland) and Shiveluch (56°N, Russia), respectively. To date, however, none of the candidate volcanoes for the mid-17th century sulphate peaks have been confirmed with tephra preserved in ice cores. Tree-ring and written sources point to severe and cold conditions in the late 1630s and early 1640s in various parts of Europe, and to poor harvests. Yet the early 17th century was also characterized by widespread warfare across Europe – and in particular the Thirty Years' War (1618–1648), rendering any attribution of socio-economic crisis to volcanism challenging. In China and Japan, historical sources point to extreme droughts and famines starting in the late 1630s, and thus preceding the eruptions by some years. The case of the eruption cluster in the late 1630s and early 1640s and the climatic and societal conditions recorded in its aftermath thus offer a textbook example of difficulties in (i) unambiguously distinguishing

volcanically induced cooling, wetting or drying from natural climate variability, and (ii) attributing political instability, harvest failure and famines solely to volcanic climatic impacts. This example shows that the impacts of past volcanism must always be studied within the contemporary socio-economic contexts, but that it is also time to most past reductive framings and sometimes reactionary oppositional stances in which climate (and environment more broadly) either is or is not deemed an important contributor to major historical events.

Keywords : volcanic eruption, cooling, climate, Thirty Years' War, resilience.

Tropical Atlantic variability after large volcanic eruptions during the Last Millennium.

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Abstract :

Volcanism is one of the main forcings driving the climate variability over the pre-industrial millennium (850 to 1849 CE). This period is vastly studied with respect to the responses to natural forcing, given the similarity of the climate background with present-day conditions. Large volcanic eruptions affect the global climate through changes in atmospheric and ocean circulation. Understanding their influence on the dynamics of Tropical Atlantic Ocean is of great scientific and social importance considering the strong links between this ocean with the precipitation pattern of the surrounding continents (i.e. North Brazil rainfall). The dynamics of Tropical Atlantic air-sea interactions are dominated by the Bjerknes Feedback. Tropical-extratropical exchanges and the wind pattern also play a role in Tropical Atlantic sea surface temperature variability, via changes in upwelling regions and tilting of the thermocline depth. In this study, we aim at identifying how large volcanic eruptions of the Last Millennium change the ocean-atmosphere interaction in the Equatorial-Tropical Atlantic, considering the components of the Bjerknes Feedback. For that, we rely on results from the Last Millennium period from the Paleoclimate Modeling Intercomparison Project (PMIP4) contribution to Climate Model Intercomparison Project CMIP6.

Keywords : volcanism, Tropical Atlantic, Bjerknes Feedback

Sahel droughts induced by large volcanic eruptions over the last millennium in PMIP4/past1000 simulations.

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Abstract :

The Sahel region is extremely sensible to alterations in its characteristic precipitation regime, associated with the West African Monsoon (WAM). In fact, the WAM presents strong variability at several timescales associated with variations in the sea surface temperature. Such changes have focused the attention of many works that mainly attribute them to internal variability amplified by external forcings, such as the emerging increase of greenhouse gases concentration and alterations in land use. However, the impact of large volcanic eruptions has been just tentatively addressed. This work aims at shedding more light on the influence of large volcanic eruptions on Sahel rainfall relying on PMIP4/past1000 multi-model simulations, covering the last millennium. A classification of volcanic eruptions in the last millennium, reveals different WAM responses according to the meridional symmetry of the radiative forcing. In addition, we add evidence of a role of high volcanic activity in multi-decadal Sahel droughts.

Keywords : Volcanic forcing, PMIP4/past1000, Sahel drought

The Interplay between Volcanic and Solar Cooling in the Early 19th Century

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Abstract :

Volcanic eruptions and reduced solar irradiance can individually cool the globe directly through the reduction of surface incoming radiation. In addition, the cooling may be enhanced at high northern latitudes indirectly through local feedbacks and dynamical processes. However, the interplay between solar- and volcano-induced cooling has hardly been studied and the Arctic amplification (AA) contribution to the cooling remains unclear. In this study, we focus on the early 19th century (1791-1830) when strong tropical volcanic events (the 1809 unidentified eruption and the 1815 Tambora eruption) and a solar minimum (Dalton minimum from 1790-1830) coincide. We simulate the climate of this period using the Max Planck Institute Earth System Model (MPI-ESM1-2-LR). We found that volcano- and solar-induced cooling is additive in general, regardless of combining or separating the forcing agents. The solar-induced surface cooling does not temporally follow the strength of the prescribed forcing but, instead, is partly controlled by the Arctic sea-ice extent resulting in a stable ~0.1K surface cooling throughout the period. The short-term volcanic cooling is strongly linked to the direct volcanic aerosol radiative forcing, whereas the post-volcanic decadal scale cooling is also controlled by ocean circulation changes related to Arctic sea-ice increases. AA exists in both solar and volcanic cooling. The AA from solar forcing is stronger with larger ensemble spread, while the volcano-induced AA is weaker with smaller ensemble spread . The distinct AA contributions of individual processes/feedbacks to the short-term and the decadal-scale post-volcanic cooling will also be discussed.

Keywords : Early 19th Century, Volcano, Solar Irradiance, Internal Variability, Arctic Amplification

Estimation of Stratospheric Aerosol Optical Depth from Astronomical Observatories.

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Abstract :

Stratospheric Aerosol Optical Depth (SAOD) data is obtained for the period 1955-present based on measurements of starlight intensity by ground-based astronomical equipment as the star rises or sets in the sky. These measurements of intensity at different stellar zenith angles allow for the calculation of optical depth, a quantity measuring of how much starlight is extinguished by the atmosphere for a given time and location. This data presents an exciting opportunity to supplement measurements of SAOD in periods where satellite data is either sparse or non-existent. The use of astronomical observations to reconstruct SAOD was pioneered by Richard Stothers, who in 2001 published hemispheric annual means for SAOD using astronomy data from 1961-1979. This reconstruction is still a component of SAOD reconstructions used in climate modeling today. This period, referred to here as the Stothers period, fills a gap between SAOD reconstructions using ice cores and satellite instruments (1979-present). Stothers claimed that the astronomy data is the most accurate source of SAOD information in this period. However, this claim has yet to be substantiated as no quantified values of uncertainty were presented and no comparisons to other methods were made. Therefore, it is not currently clear how accurately the astronomy data represents the true SAOD in the Stothers period. To establish uncertainty in this period, a comprehensive literature search for was done for astronomical optical depth measurements in the modern period. 5 observing sites with long term time series data were chosen. These sites include Canary Islands, Cerro Tololo, Flagstaff, Washington Camp, and San Pedro Martir. The Stothers method was applied to measurements at these sites past 1979 to deduce SAOD from astronomical data in the modern period. The GloSSAC stratospheric aerosol reconstruction, based primarily on satellite data is taken to be

the true value of SAOD and the error in the astronomy data is obtained by considering the difference between the measurements. Using this method, a value for mean percent error of approximately 36% was found for annual means of SAOD obtained from astronomical measurements. This error estimate can be used to impose constraints on values of SAOD obtained from astronomical data in the pre-satellite era and will inform more robust quantification of the effect of volcanic eruptions on 20th century global mean temperature variability.

Keywords : aerosol, optical, stratospheric, estimation, astronomy

Deconstructing the Big Ones: what more can tephra can tell us about volcanic eruptions with the greatest climatic and societal impacts.

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Abstract :

Polar ice core records play an integral role in the recognition of past volcanism and its impacts on climate, and by extension, society (Sigl et al. 2015). The ice cores capture evidence for eruptions through both their chemical and particulate record. By establishing the source of a volcanic signal in the ice, co-registered volcanic ash (fine-grained tephra) enables a more refined estimation of climate forcing potential. In the last decade, tephra studies on Late Holocene Greenland ice cores have demonstrated that extra-tropical eruptions can have significant climate impacts (Sigl et al. 2015; McConnell et al. 2020), but that not all large eruptions necessarily do (Sun et al. 2014; Smith et al. 2020; Mackay et al. 2021; Plunkett et al. 2022), overturning widely-held views that large or tropical eruptions pose the greatest threat to the climate system. Although it is now recognised that other factors – for instance, sulphate and other emissions, aerosol particle size, plume dynamics and season – are also influential in determining volcano-climate interactions (Marshall et al. 2019; 2020; Clyne et al. 2021; Staunton-Sykes et al. 2021), we examine whether it is possible to identify commonalities between the most climatically effective eruptions of the last two millennia that would further our understanding of volcanic forcing. We focus on sulphate signals in Greenland ice cores whose sources have been verified through associated tephra. We consider the source regions, eruption styles, and magma type that we infer from the glass shard geochemistry and morphology, as well as eruption's measure on the Volcanic Explosivity Index (VEI) where known. While the Greenland tephra data are unsurprisingly biased towards Northern Hemisphere sources, our initial results suggest that eruption location and magnitude are poor determinants of climate response. Instead, climatically effective eruptions tend to be associated with tephra indicative of mafic to intermediate magma, phreatomagmatic processes, and/or multiple eruptions. Our findings imply that eruption type and style influence the volcano-climate response to a greater degree than VEI, with potential significance for understanding the likely recurrence intervals of eruptions capable of adversely impacting society.

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Keywords : Cryptotephra, ash shard geochemistry, ash shard morphology, volcanic forcing, Greenland ice cores

The Unidentified ~1809 Volcanic Event: Evidence from Tree Rings and Historical Data.

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Abstract :

The early 1800s was one of the coldest periods of the Little Ice Age, and has been associated with two major volcanic events. While there is considerable evidence for the 1815 Tambora, Indonesia eruption from proxy, instrumental, and historical data, relatively little information is available regarding cooling following the so-called "unidentified" eruption of ~1809, first identified in polar ice core records. Here we describe the climatic and historical impacts of the 1809 episode on conditions over northwestern North America using a tree-ring data network of Blue Intensity and other tree-ring parameters, along with other proxy and historical records. This evidence reveals a particularly strong cooling response in the vicinity of the Gulf of Alaska, Wrangell St. Elias Mountains, and the Yukon and adjacent Canada, which could suggest, among other possibilities, a link to tropical volcanic forcing and a subsequent shift in atmosphere-ocean circulation dynamics.

Keywords : volcanic cooling, tree rings

OSM13: Climate variability across scales and climate states

Co-conveners: Raphaël Hébert, Thomas Laepple, Kira Rehfeld, Tine Nilsen, Mathieu Casado, Shaun Lovejoy, Christian Franzke and Reik Donner

Oral

Analysis of Rainfall Dynamics in Conakry, Republic of Guinea.

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Abstract :

Observed rainfall data of the National Meteorological Service of Guinea (NMS) exhibit that synoptic station usually records the largest rainfall amount in Guinea. Only few studies have been done on this rainfall peak observed in Conakry. This work better analyses the atmospheric dynamics leading to rainfall particularity. Using NMS data from 1981 to 2010, the monthly contribution and mean seasonal cycle of each station has been done. These findings of the study show that between July and August (rainfall season peak), the coastline particularly Conakry records the largest amount of rainfall. Using Era Interim data for the common period (1981-2010), we also investigate the rainfall dynamics in the lower level (1000 hPa - 850 hPa) from precipitable water, divergence, and moisture flow transport. There is a west and southwest moisture flow transport explained by a strong moisture convergence in the coastal region (Lower-Guinea). Furthermore, values of precipitable water in the same region are found, in agreement with the high moisture flow transport gradient. These incoming flow (west and south-west) undergo a return by blocking's Kakoulima range (foehn effect) and Fouta Djallon massif to initiate convection clouds on the Guinean coast. These processes enhance a convergence of moisture associated with orographic origin convection. This has an important effect by increasing the rainfall amount in Conakry.

Keywords : Conakry, Guinea, Maximum Rainfall, Precipitable Water, Divergence, Moisture Flo

Understanding the hypothesis "a warmer climate is a wetter climate"; the spatio-temporal evaluation.

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Abstract :

As the climate warms, the hydrological cycle is expected to intensify. Also, in response to climate warming, hydrologic sensitivity is a major concern for the coming decades. Here, we aim to understand the relationship between hydroclimate and temperature variability during the past. The periods selected for investigation are the Mid-Miocene Climate Optimum (MMCO), the Eemian Interglacial (EI) Stage, the Last Glacial Maximum, the Heinrich and Dansgaard–Oeschger Events, the Bølling-Allerød, the Younger Dryas, the 8.2 ka event, the Medieval Climate Anomaly, and the Little Ice Age. In general, the proxy records suggest that the hydrological cycle is intensified under warmer climate conditions and weakened over colder periods. However, the spatial signals are not uniform worldwide. For instance, during the MMCO and EI, the global temperature was higher than the pre-industrial time; some regions were wetter, (northern Eurasia and Sahara Arabian desert), while others were more arid (Argentina, Bolivia, and Africa). Therefore, the hypothesis "a warmer climate is a wetter climate" could be considered as a simplified pattern of regional changes as a result of global warming. The reason is that the water cycle response is spatiotemporally not similar. Due to its wide distribution, hydroclimate variability is

difficult to quantify on a regional, continental, and global scale. In this context, investigation of paleo-hydroclimatic changes, specifically during the warm periods, could provide relevant insights into the present and future climate.

Keywords : Water cycle intensification, paleoclimate, global warming

Internal climate variability and inter-regional temperature correlations during the past 2000 years.

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Abstract :

Based on the combination of temperature reconstructions and transient climate model simulations covering the past 2000 years, the PAGES-2k PMIP3 group (2015) found that climate model show stronger temperature covariance across continental regions compared to the reconstructions. One of the proposed causes is a lack of centennial-scale internal climate variability in climate models, with the idea in mind that more internal climate variability could add random noise to the system and therewith lowers inter-continental temperature covariance.

We will show the analysis of multiple sources of information on past 2k temperature variability: i) a new perturbed-parameter ensemble transient climate simulations with the iLOVECLIM model containing various levels of AMOC-related internal climate variability; ii) the global temperature reconstructions by Neukom et al. (2019); and iii) the Ocean2k SST synthesis by McGregor et al. (2015). We investigate the inter-continental temperature covariance structure across these data-sets and potential land-ocean differences in the characteristics of temperature variability. The perturbed-parameter ensemble allows us to elucidate the role of internal climate variability over the past 2000 years and if increased AMOC-related internal climate variability in a climate model indeed brings model and data in better agreement.

Keywords : Climate variability; Climate modelling; Climate reconstructions

A southern Portuguese margin perspective of Marine Isotope Stage 47 – a very warm interglacial in the 41 kyr world.

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Abstract :

In order to understand interglacial climate variability we also need to study interglacial periods prior to the Mid-Pleistocene Transition, i.e. within the 41 kyr world. Early Pleistocene interglacial periods, in particular from the interval directly preceding the onset of the Mid-Pleistocene Transition, provide ideal study cases since interglacial atmospheric carbon dioxide levels during that period appear to have been similar to or only slightly higher than during the warmest interglacials of the last 800 ka. Here we present the first results from a high-resolution, multi-proxy study of interglacial Marine Isotope Stage (MIS) 47 (1424-1452 ka) at IODP Site U1387 (36°48´N 7°43´W), drilled into the Faro Drift on the southern Portuguese margin at 559 m water depth. Nowadays, surface waters near Site U1387 originate from the subtropical gyre, whereas the intermediate-depth Mediterranean Outflow Water (MOW) is encountered at the seafloor. For our study, we use the stable isotope data of planktonic foraminifera species G. bulloides and G. ruber white and benthic foraminifera species P. ariminensis and C. pachyderma, biomarker-

derived sea-surface temperatures (SST), the weight percentage of the sand fraction, and microfossil evidence.

Following a rapid transition, interglacial conditions were quickly established in the surface waters with SST often exceeding 24°C throughout much of MIS 47. Those are the warmest SST so far observed for the Pleistocene at that location, being more than three degrees warmer than modern SST. The common occurrence of tropical species in the planktonic foraminifera fauna (e.g., Sp. dehiscens, G. crassaformis) and the abundance of warm water taxa in the coccolithophore flora hint to a persistent contribution of tropical waters to the surface waters and thus probably the northward expansion and/or intensification of the North Atlantic's subtropical gyre. The MOW, on the other hand, experienced an extended period of poor ventilation, most likely associated with low oxygen levels, as indicated by the extremely low benthic carbon isotope values and the occurrence of gypsum crystals in the sediments that formed when the pyrite in the sediments was oxidized after the cores were opened. Following evidence from younger interglacials, this MOW signal should be linked to reduced ventilation and overturning in the Mediterranean Sea as consequence of increased freshwater input caused by an intensified North African monsoon. The benthic δ18O record of MIS 47 indicates a three phased interglacial period with a minimum separating two maxima. On a subtle level, this phasing might also exist in the surface water records. This and potential causes need to be explored further in the future, when all high-resolution data is available. Overall, the Site U1387 records confirm MIS 47 as a "super"-interglacial, much more so than MIS 31, on the southern Portuguese margin. Insights from this warm interglacial and associated oceanographic conditions and changes in the planktonic and benthic microfossil floras and faunas might provide hints on how future warming in those waters could impact the regional ecosystems.

Keywords : Interglacial, Marine Isotope Stage 41, 41 ky world, SST

Insolation and CO2 induced variations in the sea ice of the last nine interglacials and their comparison with the future.

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Abstract :

Understanding the sea ice variability and the mechanisms involved during warm periods of the Earth is essential for a better understanding of the sea ice changes at the present and in the future. Based on simulations with the model LOVECLIM, this study investigates the sea ice variations during the last nine interglacials and focuses on the inter-comparison between interglacials as well as their differences from the present and future. Our results show that, for the double CO2 experiment and the Shared Socioeconomic Pathway (SSP)1-2.6, SSP2-4.5 and SSP5-8.5 scenario experiments, the global, Arctic and Southern Ocean sea ice areas simulated by LOVECLIM all fall in the range of the multi-model results from CMIP6. In addition, the results show that the annual mean Arctic sea ice variation is primarily controlled by local summer insolation, while the annual mean Southern Ocean sea ice variation is more influenced by the CO2 concentration but the effect of local summer insolation can't be ignored. The lowest Arctic sea ice area results from the highest summer insolation at MIS-15, and the lowest Southern Ocean sea ice area at MIS-9 is explained by the highest CO2 concentration and moderate local summer insolation. As compared to the present, the last nine interglacials all have much less sea ice in the Arctic annually and seasonally due to high summer insolation. They also have much less Arctic sea ice in summer than the double CO2 experiment, which makes to some degree the interglacials possible analogues for the future in terms of the changes of sea ice. However, compared to the double CO2 experiment, the interglacials all have much more sea ice in the Southern Ocean due to their much lower CO2 concentration, which suggests the inappropriateness of considering the interglacials as analogues for the future in the

Southern Ocean. Our results suggest that in the search for potential analogues of the present and future climate, the seasonal and regional climate variations should be considered.

Keywords : Sea ice, Interglacials, Insolation, CO2, Paleoclimate modeling

Unraveling forced responses of extreme El Niño variability over the Holocene.

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Abstract :

Uncertainty surrounding the future response of El Niño-Southern Oscillation (ENSO) variability to anthropogenic warming necessitates the study of past ENSO sensitivity to substantial climate forcings over geological history. Here we focus on the Holocene epoch and show that ENSO amplitude and frequency intensified over this period, driven by an increase in extreme El Niño events. Our study combines new climate model simulations, advances in coral proxy system modeling, and coral proxy data from the central tropical Pacific. Although the model and corals diverge regarding the exact magnitude of change, both indicate that modern ENSO variance eclipsed paleo-estimates over the Holocene, albeit against the backdrop of wide-ranging natural variability. Towards further constraining paleo-ENSO, our work underscores the need for multi-model investigations of additional Holocene intervals alongside more coral data from periods with larger climate forcing. Our findings implicate extreme El Niño events as an important rectifier of mean ENSO intensity.

Keywords : ENSO, paleoclimate, climate models, corals

RAPID OCEANOGRAPHIC VARIABILITY RECORDED FROM THE SW IBERIAN MARGIN (IODP SITE U1385) ACROSS THE LAST THREE TERMINATIONS USING PLANKTIC FORAMINIFERA.

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Abstract :

The SW Iberian Margin is a crucial location to understand the paleoclimatic fluctuations over orbital and millennial time scales. It has been demonstrated that this region archives the signals of both the polar climate systems (Antarctica and Greenland) and the tropics. In addition, it is situated at the northern edge of the Canary eastern boundary upwelling system and the southernmost limit of the ice rafted debris (IRD) belt, thus, preserving signals of both the North Atlantic atmospheric and mid-latitude hydrographic systems. Finally, its proximity to the continental margin makes it suitable for correlating the terrestrial and oceanic records as well as highlighting the role of European Ice Sheet Complexes during the stadials. Therefore, Iberian margin represents a benchmark region to investigate the Quaternary climatic variability and to assess the possible links triggering these fluctuations.

Here, we present planktic foraminiferal assemblage records along with Artificial Neural Network derived sea surface temperatures (SST) to reconstruct the paleoceanographic changes that occurred during the last three terminations (T I, T II and T III) and the ensuing interglacials at high resolutions from the IODP Site U1385. We used relative abundances of ecologically sensitive species to infer past meridional oscillations of polar/subpolar front (% Neogloboquadrina pachyderma and % Turborotalita quinqueloba), Azores front (% warm water species/group) and paleoproductivity variations (% Globigerina bulloides + Globigerinita glutinata) related to the seasonal atmospheric wind strength. Our records reveal similar events (stadial/interstadial) during the T I & T III although their sequence, durations and SST

gradients were considerably different. However, T II was analogous to T I in terms of duration (~6 kyr) and SST gradient (>2 °C/kyr) meanwhile T III lasted much longer (~10 kyr) with a more gentle SST gradient (<1 °C/kyr). Terminal stadials showed a complex response with a brief warm event of amplitude ~ +4 °C within its cold progression. Further, Heinrich 1 was the coldest stadial at the core location with a more southward displacement of the polar front as compared to other stadials recorded in this study. Comparison of the interglacials (Holocene, MIS 5e & MIS 7e) in terms of SST and productivity fluctuations, showed a very similar response with a productivity decrease during the early and late stages while a maximum during the middle stage. We also record multiple lower amplitude (2-4 °C) fluctuations interrupting the three interglacials along with a cooling trend during the late stages. In addition, Azores front showed drastic fluctuations during the terminations with southward and northward shifts during the stadials and interstadials respectively. Throughout the interglacials, Azores front showed a northward shift although brief southward displacements were also evident.

Keywords : Planktic foraminifera, Northeast Atlantic Ocean, Holocene, MIS 5e, MIS 7e, Termination, Heinrich stadials

Multiscale fractal dimension analysis of a reduced order model of coupled ocean-atmosphere dynamics.

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Abstract :

Atmosphere and ocean dynamics display many complex features and are characterized by a wide variety of processes and couplings across different timescales. Here we demonstrate the application of Multivariate Empirical Mode Decomposition (MEMD) to investigate the multivariate and multiscale properties of a reduced order model of the ocean-atmosphere coupled dynamics. MEMD provides a decomposition of the original multivariate time series into a series of oscillating patterns with time-dependent amplitude and phase by exploiting the local features of the data and without any a priori assumptions on the decomposition basis. Moreover, each oscillating pattern, usually named Multivariate Intrinsic Mode Function (MIMF), represents a local source of information that can be used to explore the behavior of fractal features at different scales by defining a sort of multiscale/multivariate generalized fractal dimensions. With these two approaches, we show that the ocean- atmosphere dynamics presents a rich variety of features, with different multifractal properties for the ocean and the atmosphere at different timescales. For weak ocean–atmosphere coupling, the resulting dimensions of the two model components are very different, while for strong coupling for which coupled modes develop, the scaling properties are more similar especially at longer time scales. The latter result reflects the presence of a coherent coupled dynamics. Finally, we also compare our model results with those obtained from reanalysis data demonstrating that the latter exhibit a similar qualitative behavior in terms of multiscale dimensions and the existence of a scale-dependency of topological and geometric features for different regions, being related to the different drivers and processes occurring at different timescales in the coupled atmosphere-ocean system. Our approach can therefore be used to diagnose the strength of coupling in real applications.

Keywords : Ocean-Atmosphere, Fractals, Multiscale, Multivariate Empirical Mode Decomposition

A hypothesis test on the nature of Holocene climate variability - A case study on replicated marine sediment records.

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Abstract :

To describe earth's former and predict its expected future climate in a general way, we need to understand at least two basic characteristics of the distribution of earth's temperature, its mean state and its temporal and spatial variance. While there is some confidence in projections of the mean state, earth system models (ESMs) models are suspected to underestimate natural climate variability on longer time scales, as they are developed and evaluated mainly on observational data that only cover a short time period. At low frequencies they show up to two orders of magnitude less temperature variability than data from proxy archives.

However, while climate proxies, such as oxygen isotopes from foraminifera retrieved from marine sediments, provide long records, they are sparse in time and space and contain additional non-climate components such as measurement error. A fundamental criticism of proxy data is that correlation between even nearby records is low and therefore they cannot represent the shared climate signal between the two locations.

So how to decide whether climate models simulate enough variability at long timescales? We here suggest a new evaluation method for existing climate models. The idea is to combine proxy data, proxy understanding and climate models in such a way that we can derive a plausibility check on the ability of the climate models to reproduce natural climate variability. Considering the high noise levels that we find, what if the proxy records don't replicate well but still replicate too well enough to have come from a relatively low-variability climate like the climate models?

This is the question we answer in this combined data analysis and simulation study. We do this by developing a hypothesis test where transient ESM simulation TraCE21k forms the null hypothesis on the nature of climate variability. Our proxy data base are multiple and high-resolution Holocene oxygen isotopes and Mg/Ca records from marine sediment cores from the Eastern tropical Indian Ocean - a region with a strong variability mismatch between proxy data and climate model simulations.

The result of the hypothesis test is that, based on the correlation we find in our records, we have to reject the null hypothesis. That means the possibility that the climate signal that was imprinted in our records was generated by a climate system with TraCE21k-like variability characteristics is very unlikely. We therefore reject the hypothesis that TraCE21k reproduces the climate variability characteristics.

We will expand the analysis on different simulations of last generation of ESMs to see if they perform better.

Keywords : hypothesis testing, Holocene, temperature variability, model-data comparison

Advances in reconstructing sea ice variability in the subpolar North Atlantic during the Glacial-Holocene transition.

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Abstract :

Bromine enrichment (Brenr) in polar ice cores is suggested to be a sea ice tracer while iodine atmospheric concentration generally responds to climate fluctuations as an interplay between sea ice variability and biological productivity in the oceans. To address the need to contextualize recent Arctic sea ice decline and improve performance of climate predictions, several efforts have been made in reconstructing past sea ice conditions. The Glacial-Holocene transition is a perfect context for understanding how the Arctic ocean responded to abrupt climate changes. We present the highest to-date resolution of iodine and bromine enrichment (Brenr) measured in the EGRIP ice core in Northeastern Greenland for the period 9000 – 15700 years b2k, covering the Last Glacial Termination and Early Holocene. By comparing our records with halogens measured in Arctic deep ice (NEEM and RECAP) and sediment core proxies, and given the high-resolution of our measurements, we move a step forward in understanding ocean conditions variability in the subpolar North Atlantic.

We find low and highly variable levels of Brenr during the colder periods of the Last Glacial Termination, likely suggesting that the subpolar North Atlantic was covered by extensive multi-year sea ice, while high levels of iodine flux are probably connected with strong uptake of gas-phase iodine on dust and sea salt aerosols. After the climatic transition, increasing EGRIP Brenr and iodine fluxes are likely to be representative of the climate amelioration of the Early Holocene, with progressively higher fraction of first-year sea ice especially in the Fram Strait and Labrador Seas, stronger Atlantic water inflow and primary productivity.

Keywords : Ice cores, bromine enrichment, iodine, sea ice, Glacial-Holocene transition

Forcing of the Holocene hydro-climatic variability at the North African desert margin inferred from multi-proxy frequency analyses: Lake Sidi Ali, Morocco

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Abstract :

The North African desert margin is considered one of the areas most sensitive to future climate changes. Improved knowledge about Holocene climatic variability and environmental responses on millennial to centennial scale will help to refine scenarios related to future climate changes. During the last two decades, the recovery and compilation of Holocene and Last Glacial records from the subtropical North Atlantic and the Mediterranean realms have improved our knowledge about the millennial-scale variability of the Western Mediterranean palaeoclimate and the Saharan dust cycle. However, the forcing mechanisms remain poorly known. Due to the distinctive timescales of fluctuating behaviour of different forcing

mechanisms, spectral analyses can be a powerful tool to help identify the influence of different drivers such as oceanic and solar variability.To detect periodicities in Holocene climatic variability and geomorphological processes, we use a Holocene sediment record from Lake Sidi Ali in the sub-humid Middle Atlas with a precise 210Pb and pollen-based 14C chronology. In order to distinguish between internal (e.g. chemical precipitation) and external (e.g. detrital input) lake processes, which both might be driven by varying hydro-climate, we use a high resolution XRF-scanning record with a stationary XRF data set for calibration. RedFit and Wavelet time-series analyses reveal distinct periodicities of millennial to centennial scale. Based on a correlation analysis of extracted, highly significant, frequency-analysis spectra, we identified three RedFit Proxy Groups (RPGs) in the XRF data with distinct periodicities. The comparison of our XRF data with existing proxy interpretations show, that the use of universal palaeoenvironmental interpretations is inappropriate. In the next step, we integrated environmental and climatic proxies from the same core (Cedrus atlantica pollen abundance, magnetic susceptibility, $\delta^{18}O$ and $\delta^{13}C$ values of ostracod shells, grain-size endmembers and total organic carbon) using their wavelet domain to improve the interpretation capacity. Finally, we identified two main forcing mechanisms that influence 1) the hydrological regime, and 2) the lake productivity and catchment-erosion dynamics. As the hydrological regime is supposed to be controlled mainly by winter-rain variations, we discuss evaporation-related proxies (Ca, Sr, Ca/Ti, Sr/Ti, etc.) as driven by North Atlantic and solar forcing (2 ky and 1 ky periodicities). In contrast, the lake productivity is likely driven by summer temperature variations.

Keywords : Spectral analysis, XRF, Multi-Proxy, Holocene

Scaling interactions of macroevolution and the megaclimate – searching for temporal domains of the Court Jester and the Red Queen.

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Abstract :

Evolutionary dynamics are determined by a hierarchical interaction of many internal (biotic) and external (abiotic) driving mechanisms working over a wide range of time scales. Here we present the results of Haar fluctuation analysis of sample-standardized marine animal diversity, origination and extinction rate estimates and compare them to the surface sea water temperature changes through the Phanerozoic eon. The temperatures on time scales longer than approximately 1 Myrs exhibit positive scaling exponents, thus showing unstable, “wandering” behaviour with no signs of regulation. The extinction and origination rates, on the other hand exhibit negative scaling exponents, which implies a tendency for long term stabilization. The marine genus level diversity, interestingly, reveals two scaling regimes – the positive exponent scaling up to the critical time scale of 40 Myrs, and negative exponent scaling at longer time scales. The diversity scales similarly to megaclimate paleotemperatures at shorter time scales, and shows larger and large fluctuations with time scale. At the time scales longer than 40 Myrs the extinction rates start to increasingly negatively correlate with the diversity – this shows an onset of their diversity density dependence and therefore their coordinated regulation.

We interpret this transition in diversity fluctuations as a result of a crossover between two diversity affecting factors – positively scaling and destabilizing megaclimate (Court Jester regime) which influence is overwhelmed at time scales > 40 Myrs by another scaling process of biotic regulation by means of completion (Red Queen regime). The transition time scale most probably related to a characteristic time for a global biotic homogenization, which effectively works as a global coordinating factor for the evolution of the biosphere.

Keywords : Scaling, Megaclimate, Macroevolution, Red Queen, Court Jester

A new approach to Climate modelling: the Fractional Energy Balance Equation.

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Abstract :

At present, the dominant – and often unique - approach to modelling past, present and future climates are GCM's. These are essentially weather models coupled to ocean models and pushed way beyond their deterministic predictability limits. The philosophy is a deterministic, mechanistic one that attempts to include as many processes and fluid structures as is computationally feasible. Even though one is typically interested in decadal averages, structures whose lifetimes are ≈100,000 times shorter (hours) are modelled explicitly and then averaged out. While acknowledging that almost all the details currently modelled are irrelevant, it is nonetheless hoped that chasing the details even further down to sub-hourly structures ("cloud resolving models") will lead to improved realism.

I argue that since only the statistics of the details are relevant, climate models should be explicitly and fundamentally stochastic, it should be directly built at scales longer than weather scales – in the macroweather regime (i.e. with smallest scale ≈ 10 days). By combining two symmetries of the governing equations - scaling and energy balance, we derive the Fractional Energy Balance Equation (FEBE). A special (long memory) case is the Half – order Energy Balance Equation (HEBE) that follows by using the correct radiative-conduction boundary conditions in Budyko-Sellers energy balance models. The FEBE is then a generalization of the HEBE. At the moment, the FEBE is more skillful for monthly, seasonal, annual temperature forecasts and yields projections throughout the 21st century that have much lower uncertainty than current (CMIP6) GCM's.

In this presentation, we review the FEBE and show how it can be used to model and understand past climates, including the broad scaling character of the 100ky glacial-interglacial transitions.

Keywords : climate models, past climates, future climates, climate projections

Climate and anthropogenic impact on vegetation of the southern Central Mediterranean from Siculo- Tunisian Strait during the last 5 kyr.

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Abstract :

According The IPCC (2014) record, the Mediterranean will be one of the most regions affected by future climate change. Despite a large number of studies, the long-term and millennial to centennial-scale climatic variability in the Mediterranean region during the last Holocene is still debated, including in the southern Central Mediterranean.

Palynological studies represent an important tool to reconstruct the continental environments history through the time in particular the vegetation changes and the climate variation as well as elucidating questions related to paleoclimates and paleoecology (Ybert et al. 1992, Salgado-Labouriau 2001).

In order to provide high-resolution analyses of past vegetation changes, we present a high-resolution paleoclimatic and paleoenvironmental reconstruction of the last five millennia from a shallow water marine sedimentary record (Record 13-53) from the Southern central Mediterranean Sea (Siculo-Tunisian Strait) using pollen and geochemical analysis. The pollen data from the REC13-53 marine core have made it possible to reconstruct the changes in Tunisian vegetation, and more generally in North Africa, during the last 4500 years. Pollen data from the sediment core Record 13-53 allowed to reconstruct the changes in Tunisian vegetation, and more generally in North Africa, during the Upper Holocene. Our data show that the climate fluctuations at centennial scale recorded in the Siculo-Tunisian Strait during the last 4500 years are also observed in Northern Tunisia and throughout Central Mediterranean. our pollen records permits to identify 3 episodes of forest reduction, probably associated with a decrease in winter precipitation. These arid events

coincide with rapid cold North Atlantic climatic events 4.2, 1.3 and 0.4, respectively (Bond et al., 1997; 2001) resulting in an opening of vegetation. This opening of the forest favors the development of herbaceous plants, in particular the increase of Cichorioideae. At the same time, we demonstrate that the effect of anthropization has been revealed in the pollen spectra through the intensification of land use and deforestation. This anthropization has resulted in episodes of intensification of agricultural and / or pastoral activities. We found that the impact was reinforced from the third millennium BC, where the development of olive growing and several other taxa related to agriculture testifies the accentuation of colonization human populations in North Africa during Classical Antiquity. The anthropogenic impact continues and intensifies through increased pastoral activities, particularly during the MCA period as evidenced by high levels of Artemisia in the pollen spectra.

The climatic episodes identified during the historic period indicate a clear correspondence between phases with a negative (positive) NAO index and forest declines (increases) corresponding to a decrease in winter precipitation in the southern Mediterranean. This suggests that in this region negative NAO conditions are associated with dry events and vice versa.

Keywords : high-resolution analyses, past vegetation changes, climatic changes, Siculo-Tunisian Strait, Record 13-53 marine core, late Holocene

Post-LGM Caspian Sea paleogeography in the prospect of stable oxygen record.

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Abstract :

The Caspian Sea (CS) is highly variable on spatial and temporal scales, fluctuating substantially in the geological and historical past. After more than a century of research, there is not yet a full understanding of the amount and causes of the sea-level fluctuations and the dynamics of the Sea. Instrumental observations for the CS level (CSL) and hydrometeorological parameters cover only the last 150 years. The rare studies available so far on the CSL during the Late Pleistocene and Holocene have been made on coastal sections or in the shallow northern basin and suffer from deposition hiatuses during lowstand periods and sedimentation starvation. The correlation of paleogeographic events within the region is as important as a comprehensive consideration of the history of the development of the CS against the background of global climate changes. Here we use our δ18O records from the North basin together with available stable oxygen data on the continual sequence of deep-sea cores and on Kara-Bogaz-Gol Gulf, The Black Sea, nearby lakes, and caves to complete palaeogeographical reconstruction of the CS.

According to our results, CSL oscillations occur as a response to climatic changes among numerous probable causes. Alternations of climate cooling and warming led to changes in the isotopic composition of the atmospheric precipitation supplying water to the continental water bodies and catchment basins of river systems. Fluvial influx to the CS, hydrometeorological conditions over the sea is the main factors that control the seawater characteristics and thus its level fluctuations. During transgressions, the rivers carried the water of melting glaciers into the sea, which had a light isotopic composition; during regressions, the Caspian Sea water got heavier. Transgressions are usually accompanied by the freshening of water masses and cold climate while regressions primarily correspond to increased salinities and warm climate.

Oxygen isotope data allow us to correlate the transgressive-regressive events in the region with glacial-interglacial rhythm in the Russian Plain and global climate changes. We distinguish several evolution stages for the region:

1. The Last Ice Sheet degradation. A series of step-like environmental shifts may match the sequence of abrupt cooling/warming events recorded in different paleoarchives (like the Greenland ice cores).

1.1. Values of δ18O are higher for the 19-16 ka period. A similar trend is observed in data from the lakes nearby.

1.2. Complex internal dynamics: two distinct peaks in higher isotope composition during Bølling–Allerød warming and lower δ18O values during the stadials (change to glacial conditions at the onset of the Younger Dryas). CSL change is presumably a result of shifts in both temperature and precipitation. The isotopic characteristics change in a different way along the sections in the southern and middle CS.

2. Sharp warming at the beginning of the Holocene. Stable-isotope data show significant shifts in lake-water balance represented by an abrupt increase of isotope ratio.

3. The climatic changes of the second part of the Holocene reflected differently in various cores: staggered weighting/stabilization and increase of isotope values.

The research was funded by RFBR project № 20-35-90020/20.

Keywords : stable oxygen isotopes, sea-level changes, inland sea, correlation

Disentangling Internal and External Contribution to Atlantic Multidecadal Variability over Past Millennium.

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Abstract :

The Atlantic Multidecadal Variability (AMV) modulates the North Atlantic surface ocean variability and affects decadal climate evolution up to the global scale; however, the underlying mechanisms of the AMV remains debated. We use a multi-model ensemble of transient past-millennium and unperturbed preindustrial control simulations contributing to the Paleoclimate Modelling Intercomparison Project - Phase 4 (PMIP4) to decompose the AMV signal into its internal and external components. The internal component of AMV exhibits no robust behavior across simulations during periods of major forcing such as strong volcanic eruptions, whereas the externally-forced component of AMV responds to volcanic eruptions with an immediate radiative cooling followed, in some simulations, by a sequence of damped multidecadal oscillations. This indicates that the intrinsic mechanism underlying the AMV is distinguishable from its response to external forcing. The internal component of AMV is tightly connected with the Atlantic meridional overturning circulation (AMOC) and controls the variations of AMV. The external component of AMV explains about 25% of the variance in the past millennium simulations, though less-consistency is found between models. Our results further indicate that the spatial imprint of external volcanic forcing on North Atlantic sea-surface temperatures differs from the surface pattern of the internal AMV contributing to the lack of robustness for the AMV pattern.

Keywords : Atlantic Multidecadal Variability, Internal variablity, past2k, past1000, Volcano

The role of the external forcing for centennial climate variability.

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Abstract :

Knowledge of the amplitude and causes of surface temperature variability is essential for attributing and predicting temperature changes. Instrumental temperature records are too short to reliably determine surface temperature variability on multidecadal and centennial time-scales. Unfortunately, variability estimates using proxy data and climate model simulations do not agree in magnitude, with simulations showing substantially smaller variability.

Here we show that two transient Holocene climate simulations - performed with the same climate model - differ significantly in terms of the amplitude of temperature variability on long time-scales. The difference in the centennial variability between the two integrations is due to the external forcing. While both simulations are driven with orbital and greenhouse gas forcing, one simulation is additionally forced by

stratospheric volcanic aerosol distribution and spectral variations of solar irradiance. Our results provide an indication of possible causes for the amplitude differences between proxy and model based temperature variability on long time scales.

Keywords : climate variability, volcanic forcing, transient simulation

Southern Hemisphere high-latitude controls on AMOC deep-water circulation sustaining the MBT.

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Abstract :

The climate system experienced several periodic oscillations over the last ca. 800 ka known as glacial-interglacial (G-IG) cycles. Disruptions of the global carbon cycle were evident on this time scale, promoting fluctuations in the atmospheric CO2 concentration leading to global climate variability. In the more recent interglacials, both Antarctic temperatures and atmospheric CO2 concentrations are significantly higher than in the previous "lukewarm interglacials" (ca. 800 – 430 ka) before the Mid-Brunhes Transition (MBT). Changes in the Atlantic Meridional Overturning Circulation (AMOC) and deep-water formation rate around Antarctica have been invoked to explain a 30 ppm increase in the atmospheric CO2 during post-MBT interglacial periods. Deep-water variability is tightly coupled to the ventilation of CO2 in the Southern Ocean by atmospheric and oceanic connections, contributing to carbon storage in the deep ocean and the atmospheric CO2. Here, we present a new 770 ka benthic foraminifera δ13C record from sediment core GL-854 retrieved from the western South Atlantic (WSA) at 2200 m water depth. We compare our record with published δ13C data from the eastern South Atlantic margin to investigate the zonal gradient variability of the North Atlantic Deep Water (NADW) in the deep South Atlantic basin. WSA δ13C variability and absolute values strongly mimic the North Atlantic mid-depth record at the NADW formation region. This similarity is interpreted as NADW preferentially carrying a modified signal through the deep western boundary current towards the WSA (rather than towards the eastern margin) after the MBT. The δ13C gradient based on the difference between benthic foraminifera C. wuellerstorfi from both margins (Δδ13Cw-e) gradually increases after a transitional period between ca. 400 ka to 300 ka towards the Holocene. We suggest that the mechanism behind this long-term increasing trend on the Δδ13Cw-e record post-MBT is the result of enhanced production of North Component Water due to Agulhas Leakage intensification driven by reduced sea-ice extent after the MBT. Furthermore, reduced sea-ice extent decreases the Antarctic Bottom Water density and formation in the Southern Ocean, contributing to the deepening of the AMOC during post-MBT interglacial periods. Our interpretation proposes a framework connecting sea-ice and ocean-atmosphere dynamics to deep-water geometry within the South Atlantic basin, which ultimately contributed to the climate change observed across the MBT.

Keywords : Mid-Brunhes Transition, Southern Ocean, Stable carbon isotopes, long-term benthic δ13C variability, Atlantic Meridional Overturning Circulation

Contrasting Climatic Conditions and Internal Dynamics of the Mediterranean Sea

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Abstract :

The variability of the Mediterranean Sea circulation during the instrumental period has been attributed to both atmospheric forcing and internal dynamics, based on observational and modelling analyses. The present study examines

the inherent variability of the Mediterranean Sea circulation under different climatic extreme conditions, I.e. cold and dry conditions referring to the Younger Dryas event and warm and wet conditions referring to the S1a sapropel deposition interval. The instrumental variability is examined as well, as a reference period. Corresponding to the above climatic conditions, three 1000-year-long simulations forced by perpetual-year atmospheric forcing were performed in order to reveal the inherent interdecadal and intercentennial variability of the basin. Model-depended diagnosed fluxes were estimated and used to account for the absence of climatological relaxation and data assimilation. EOF and spectral analysis was applied to the density, salinity, and temperature fields for each experiment. Diverse climatic conditions alter the Mediterranean function from concentration (reference and Younger Dryas-like experiment) to estuarine (S1a sapropel deposition- like experiment). In all experiments, the basin exhibits inherent interannual, interdecennial and/or intercentennial variability throughout the water column. Inherent decennial variability dominates in both the Gibraltar and Sicily Straits, for all experiments. The spatiotemporal characteristics of internal mechanisms revealed between different sites of the basin and the contribution of salinity and temperature variability to the thermohaline oscillations for each experiment are discussed.

Keywords : Mediterranean Sea, inherent variability, Younger Dryas, S1a sapropel

Characterizing climate nonstationarities in response to forcing across the CESM1 Large Ensemble, Last Millennium Ensemble, and observational products.

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Abstract :

Understanding the time evolution of climate statistics and extremes under forced and internal climate variability is important for understanding past and future changes in climate variability. Although past work has examined the evolution of individual climate 'modes' in response to forcing, we do not yet have a comprehensive understanding of expected changes in climate covariance relationships. This work uses output from the NCAR CESM1 Large Ensemble, Last Millennium Ensemble, and Single Forcing Ensembles to quantify and characterize changes in the spatial covariance of surface air temperature. We find that changes in covariances computed across ensemble members through time (diagnosed as a time series of Kullback-Leibler divergences and covariance Frobenius norms of forced simulations relative to controls) reflect time series of external forcing and exceed background levels of nonstationarity diagnosed from control simulations. Eigenvector decompositions of covariance differences allow us to isolate dominant patterns of variability change. Finally, we compare model-based results to available observation-based reanalyses and gridded instrumental products and suggest that model representations are consistent with (sparse) available data. These tools and analyses provide a general basis for comparison among large ensembles from different models.

Keywords : Climate variability, large ensembles, pattern analysis, model-data comparisons

Poster

Climate and anthropogenic impact on vegetation of the southern Central Mediterranean from Siculo- Tunisian Strait during the last 5 kyr.

Emna GACEUR

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Abstract :

According The IPCC (2014) record, the Mediterranean will be one of the most regions affected by future climate change. Despite a large number of studies, the long-term and millennial to centennial-scale climatic variability in the Mediterranean region during the last Holocene is still debated, including in the southern Central Mediterranean.

Palynological studies represent an important tool to reconstruct the continental environments history through the time in

particular the vegetation changes and the climate variation as well as elucidating questions related to paleoclimates and paleoecology (Ybert et al. 1992, Salgado-Labouriau 2001).

In order to provide high-resolution analyses of past vegetation changes, we present a high-resolution paleoclimatic and paleoenvironmental reconstruction of the last five millennia from a shallow water marine sedimentary record (Record 13-53) from the Southern central Mediterranean Sea (Siculo-Tunisian Strait) using pollen and geochemical analysis. The pollen data from the REC13-53 marine core have made it possible to reconstruct the changes in Tunisian vegetation, and more generally in North Africa, during the last 4500 years. Pollen data from the sediment core Record 13-53 allowed to reconstruct the changes in Tunisian vegetation, and more generally in North Africa, during the Upper Holocene. Our data show that the climate fluctuations at centennial scale recorded in the Siculo-Tunisian Strait during the last 4500 years are also observed in Northern Tunisia and throughout Central Mediterranean. our pollen records permits to identify 3 episodes of forest reduction, probably associated with a decrease in winter precipitation. These arid events coincide with rapid cold North Atlantic climatic events 4.2, 1.3 and 0.4, respectively (Bond et al., 1997; 2001) resulting in an opening of vegetation. This opening of the forest favors the development of herbaceous plants, in particular the increase of Cichorioideae. At the same time, we demonstrate that the effect of anthropization has been revealed in the pollen spectra through the intensification of land use and deforestation. This anthropization has resulted in episodes of intensification of agricultural and / or pastoral activities. We found that the impact was reinforced from the third millennium BC, where the development of olive growing and several other taxa related to agriculture testifies the accentuation of colonization human populations in North Africa during Classical Antiquity. The anthropogenic impact continues and intensifies through increased pastoral activities, particularly during the MCA period as evidenced by high levels of Artemisia in the pollen spectra.

The climatic episodes identified during the historic period indicate a clear correspondence between phases with a negative (positive) NAO index and forest declines (increases) corresponding to a decrease in winter precipitation in the southern Mediterranean. This suggests that in this region negative NAO conditions are associated with dry events and vice versa.

Keywords : high-resolution analyses, past vegetation changes, climatic changes, Siculo-Tunisian Strait, Record 13-53 marine core, late Holocene

Planktic foraminiferal biozones and biochronological events in the Mediterranean Sea since the Late Glacial period.

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Abstract :

Quantitative and Qualitative analyses of planktonic foraminifera fauna, past sea surface temperatures (SSTs), oxygen isotope (O2) and radiocarbon dating have been generated in the Mediterranean Sea in order to reconstruct a biochronological record covering the period extending to the Late-Glacial. The current study is based on micropaleontological and isotopic analyses performed along three well-dated deep-sea cores: REC13-53, KET80-19 and MD84-641 recovered in the Siculo-Tunisian Strait, Tyrrhenian Sea and Levantine Basin, respectively. The quantitative distributional patterns of planktonic foraminifera allowed to identify seven biozones based on the appearance and/or disappearance of the main specific taxa or by their noticeable abundance peaks. Planktonic abundance records display that the major changes in planktonic foraminiferal assemblages have a similar pattern largely in the central and western basins. In particular, four bio-events were identified. They can be used to establish or/or to improve the chronology of Mediterranean deep-sea cores.

Noticeable changes in seasonality, through the sea-surface temperature (SSTs) difference between winter and summer were observed during the last 24 kyr, and the lowest values are obtained during the cold periods synchronous to the Heinrich event (H1) and the Younger Dryas (YD). By contrast, the warm intervals of

the Bolling/Allerod and the Holocene were rather characterized by a seasonality similar to the present.

Moreover, the comparison of our foraminiferal records and sea surface temperature (SSTs) estimates with those of NGRIP ice-core shows a large similarity between the global climate and the Mediterranean hydrology. This indicates that the main climate changes reported in the North Atlantic are globally synchronous with those observed in the Mediterranean region.

Keywords : bio-events, Late Glacial, carbon 14, seasonality, biozones

Dynamics of seasonal patterns in proxy and meteorological records of the Elbrus region derived from functional data clustering.

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Abstract :

In the last decade, new paleoclimate archives were obtained in the Elbrus region (Central Caucasus), including ice cores of the Western plateau of Elbrus, bottom sediments of the lakes Karakel, Donguz-Orun, and Khuko.

In this work, cluster analysis was first applied to investigate several synchronous time series characterizing the dynamics of the natural environment in the Central Caucasus during the period of meteorological observations in the region (1926–2010): titanium concentrations in varved (annually laminated) bottom sediments of proglacial Lake Donguz-Orun; an oxygen-18 isotope record in an ice core from Mt. Elbrus; temperature and precipitation observations from two local meteorological stations. As the result of clustering procedure, each time series is divided into intervals corresponding to different clusters. We applied a recently developed nonparametric method of clustering functional data, the Bagging Voronoi K-Medoid Alignment (BVKMA), which simultaneously clusters and aligns by phase the data elements (annual curves), using the information about the dependence (sequence) of these curves. A specific feature of this approach is that splitting annual data into clusters is based on the shape of intra-annual variations of the parameter under investigation. The study is aimed to determine whether the instrumental period could be reasonably divided (clustered) into several sub-periods on the base of different climate and proxy time series; to examine the resulting borders of the clusters; to study typical patterns of intra-annual variations of the data series.

The results of clustering suggest that the precipitation and to a lesser degree titanium decadal-scale data may be reasonably grouped, while the temperature and oxygen-18 series are too short to form meaningful clusters; the intercluster boundaries show a notable degree of coherence between temperature and oxygen-18 data, and less between titanium and oxygen-18 as well as for precipitation series from different locations; the annual curves for titanium and partially precipitation data reveal much more pronounced intercluster variability than the ones for temperature and oxygen-18 data. Our results demonstrate that for parameters with relatively stable intra-annual patterns of variability (like temperature) the usual length of instrumental period may be not enough for its reasonable division into sub-periods, while highly variable parameters (like precipitation) may be reasonably clustered even inside several decades.

The ice core data analysis was fulfilled with the support of RSF project No. 17-17-01270-П.

Keywords : Central Caucasus, lake sediments, ice cores, clustering, functional data

Synchrony and asynchrony in the δ15N of organic matter in the Tropical Northeast Pacific over the last 1200 years.

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Abstract :

The oxygen minimum zone has received particular attention due to its possible expansion associated with global warming. Several oceanographic mechanisms could explain the variability of δ15N in organic matter

as an indicator of denitrification of the water column in the Pacific Ocean. Our objective was to infer local or remote forcing mechanisms that lead to the strengthening or weakening of the OMZ in the Eastern Tropical North Pacific. A 42 cm sediment core was recovered at 680 m of depth in the Magdalena margin and sectioned every 1 cm for the analysis of stable isotopes nitrogen.The desynchronization of δ15N between the Pescadero and Magdalena margins with respect to the Santa Barbara basin confirms a decrease in denitrification in the Mexican Pacific. The δ15N in the Magdalena margin and the Santa Barbara basin indicated a reduction in denitrification, which was not observed in the Pescadero margin. This suggests an intense advection of dissolved oxygen from tropical waters during the LIA. While exported productivity maintained a high oxygen demand, denitrification conditions persisted over the same period in the Pescadero margin.

Keywords : oxygen minimum zone, nitrogen stable isotopes, Magdalena margin, exported productivity

Assessment of summer macrocirculation processes over Europe in the 18-20 centuries.

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Abstract :

The regional atmospheric circulation at the synoptic scales is the main factor defined the weather. The prolonged prevail of zonal or meridional component of the atmospheric flows in the region usually accompanied by various anomalies in the temperature and precipitation regimes as well as different weather extremes (drought, heavy rains, heat or cold waves etc.).

The features of the atmospheric circulation over Europe in the 18-20th centuries were defined using the general atmospheric macrocirculation index introduced by A.L. Katz (1960).

The Katz index (Io) is determined as the ratio of the zonal (Iz) and meridional (Im) pressure gradients (Io = Im / Iz) corresponding to the intensity of zonal and meridional flows. Large Katz indices (> 0.75) often correspond to the development of extensive stationary or blocking anticyclones in the atmosphere of the region. Therefore, if the mean monthly pressure field is characterized by a large Io index, this indicates a high frequency of stationary atmospheric processes, which in summer lead to drought in some regions and floods in others.

The reconstructions of gridded monthly sea level pressure (SLP) fields from 1700 to 1999 for the European region (5°E to 40°E; 40°N to 70°N) were used. These fields has been developed by Luterbacher et al. (2002) using principal component regression analysis based on the combination of early instrumental station series and documentary proxy data from Eurasian sites.

An analysis of the Katz indices showed that the zonal type of macrocirculation prevailed over Europe in all years, but during the summer its frequency was different. In June, in the 18th and 20th centuries, the frequency of occurrence of zonal macrocirculation was 96-97 % of cases, in the 19th century it was less - 91 % of cases. Meridional type of macrocirculation, respectively, accounted for 3-9 % of cases. In July, the frequency of zonal processes decreased to 66-68 % in all centuries, and meridional processes were observed in 32-34 % of cases. In August, the frequency of zonal circulation increases again, however, if in the 18-19th century the frequency of zonal processes was 92-95 %, then in the 20th century their number decreased to 83 % with a simultaneous increase of meridional processes.

Analysis of the time series of the Katz index showed that, in general, there are small interannual fluctuations in the index values, but in each century periods with a relatively high or low index during two or even three summer months can be distinguished.

Keywords : Katz index, atmospheric circulation, sea level pressure

Multi-proxy temperature reconstruction and paleoenvironmental conditions during the Late Glacial and Early Holocene in the Černé lake, Central Europe.

Amanda Mateo Beneito [(1)], Gabriela Florescu [(2)], Iuliana Vasiliev [(3)], Richard Chiverrell [(4)], Oliver Heiri [(5)], Jolana Tátosová [(1)] and Petr Kuneš [(1)]

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Abstract :

Multi-proxy climate reconstructions are still scarce, yet they can provide better insights into the past environmental conditions. An accurate long-term perspective of the climate is essential to understand vegetation development and assess how forest reacts to climate and disturbance regimes changes. This research aims to test paleoclimatic reconstructions obtained from different proxies to discern the climatic signal and evaluate their strengths and weaknesses. Furthermore, we analyzed the climatic signal and the vegetation development to determine the main drivers for vegetation changes. For that purpose, we performed a chironomids-based reconstruction for July air temperature and an iso-GDGTs mean annual temperature reconstruction during the Late Glacial and Early Holocene (13,500-7,690 cal yr BP) at Černé jezero lake (1008 m. a. s. l.), in Šumava Mountains, Central Europe. Other proxies, such as pollen and geochemistry estimated past environmental conditions such as the vegetation dynamics, the variability of erosion (Rb), and the sources of organic matter (C/N ratio and d13C). Both temperature reconstructions showed similarities during the main cooling and warming transitions, but different responses were found in other climatic events. Iso-GDGTs appeared to react to changes in organic carbon sources, producing a shift in the bacterial community and increased methanogenic activity, which likely altered the climatic signal. Those anoxic episodes in the lake might be caused by an increasing input of nutrients from the catchment, related to the development of the vegetation at the beginning of the Holocene. This increment of nutrients to the lake also affected the chironomid community, with a fast increment in their abundance and the development of the littoral species community. Providing the first multi-proxy paleoclimatic reconstruction we conclude that the temperature fluctuations were the main driver for vegetation development in the montane forest zone in Bohemian-Bavarian Forest. Our study helps to better understand the climate-vegetation-environmental feedbacks during the Late Glacial and Early Holocene in Central Europe.

Keywords : Palaeoclimate, chironomids, biomarkers, iso-GDGT, Late Glacial, Central Europe

One way to interpret decadal and secular climate variability.

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Abstract :

Data sets of measurements and paleo reconstructions demonstrate that there are a lot of natural systems undergo significant multiscale variations. Their typical feature is the red noise-like behavior. The first example is the observed inter-annual changes in the length of the glaciers. They can be explained as a result of the accumulation of anomalies of the heat fluxes and water flows, creating slowly evolution of the glacier. The second example is the Caspian Sea (CS): observed changes of CS sea level represent a form of non-linear "self-induced" behavior due to short-term river runoff and evaporation variations. The third example is the inter-annual variability of the Earth's rotation rate due to the short-term dynamics of the planetary atmospheric circulation. Averaging over the spatial coordinates of the reduced equations of hydrodynamics taking into account rotation rate of the Earth allows one to proceed to the determination of the relationship between circulation anomalies and rotation rate anomalies. Other examples are sea surface temperature and salinity variations, global climate changes, soil moisture variations, etc.

In all cases, in spite the fact that the initial models of dynamics are deterministically based on the physical laws of conservation (mass or angular momentum), the models of change can be interpreted as stochastic. The key role in the dynamics of such models belongs to interacting fast and slow elements. Such models are described by the Langevin equation (or generalized Langevin equation) or the Fokker–Planck equation, the solution of which allows calculation of a probability distribution function for variations. From this position, we can interpret the continuous spectrum of decadal

and secular climate fluctuations in terms of Brownian (classical or fractal) motion.

Keywords : Variability of glaciers, variability of the Caspian Sea, Earth's rotation rate anomalies, sea surface temperature, salinity variations, global climate changes, soil moisture variations, Brownian motion

A Global Assessment of Heatwaves since 1850 in different datasets.

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Abstract :

Over the past century there was a significant increase in heatwaves in several regions around the globe. This increase is projected to continue with ongoing global warming and forms a serious risk for various ecosystems as well as human health. Changes in the occurrence and the characteristics of heatwaves since the middle of the 20th century are extensively studied in observational datasets and model simulations. However, there is a research gap concerning preindustrial (1850-1900) heatwaves and heatwaves in the early 20th century and their relation to forcings and large-scale variability modes.

In this study we analyse the occurrence of heatwaves and the spatial and temporal distribution of different heatwave characteristics since 1850 using different observational datasets (20CRv3 reanalysis, EUSTACE gridded temperature, HadEX3 and station data) and a 36-member ensemble of atmospheric model simulations. We compare preindustrial heatwaves to recent and projected heatwaves and analyse how global or local heatwave hotspots change over time.

We use a new approach, a 30-year running baseline climatology, which allows us to analyse heatwave characteristics across different centuries. Our analysis shows that the different observational datasets show a comparable distribution of heatwave characteristics. Furthermore, the atmospheric model based on observed volcanic forcings can also be used to analyse preindustrial and early 20th century heatwaves. The agreement of the model simulations with the observational datasets allows to use the atmospheric model to analyse earlier preindustrial time periods that are not covered by observations. With our ongoing analysis of preindustrial heatwaves, we consequently contribute to a better understanding of past climate extremes.

Keywords : Heatwaves, Extreme Events, Climate Modelling

Sampling rate-corrected time series analysis of irregularly sampled palaeoclimate proxy records.

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Abstract :

Irregular sampling remains a challenge in the analysis of time series from different palaeoclimate archives. Aside from rendering most standard time series analysis methods inapplicable, changes in the sampling rate of a record entail significant biases that can not be corrected by basic pre-processing procedures such as linear interpolation. Yet, sampling rates frequently show non-stationary characteristics, e.g. for speleothems, as they are coupled to environmental parameters via their growth rate.

Consequently, methods that account for continuous and abrupt changes of sampling resolution without introducing additional biases are required. In several applications, the edit–distance has proven to be an effective metric to quantitatively compare time series segments of unequal length by computing the cost of transforming one segment into the other. We demonstrate that transformation costs generally exhibit a non-trivial relationship with local sampling rate. If the sampling rate undergoes significant variations, this dependence rules out an unbiased comparison

between different time episodes. We study the impact of this effect on recurrence quantification analysis, a framework that is well-suited for identifying regime shifts in nonlinear time series. A constrained randomization procedure is proposed as a bias correction for recurrence quantification analysis.

We demonstrate the effectiveness of the proposed approach in the analysis of an irregularly sampled speleothem proxy record with seasonal laminae from Niue island in the central tropical Pacific. Application of the proposed correction scheme identifies a spurious transition that is solely imposed by an abrupt shift in sampling rate and uncovers periods of reduced seasonal rainfall predictability associated with enhanced ENSO and tropical cyclone activity.

Keywords : speleothem, irregular sampling, nonlinear time series analysis, recurrence plot, non-stationarity

American Monsoon System variations during the Holocene.

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Abstract :

During the Holocene (11.7 ka B. P. – present), there were climate changes on a global scale that had as main drivers changes in insolation related to the Earth's orbital variations and solar variability. Along this period, there was an increase in insolation in the Northern Hemisphere during the Early and Middle Holocene, with a decrease throughout the Late Holocene, with an opposite trend being observed in the Southern Hemisphere, which promoted a redistribution of energy. Changes in the energy budget impact the transport of water vapor in the atmosphere, and may result in variations in precipitation regimes, such as the American Monsoon System (AMS). The AMS can be interpreted as being composed of two axes of the same cycle, which are the North America Monsoon System (NAMS) and South America Monsoon System (SAMS). This system is responsible for a significant part of the precipitation in the Tropical Americas. In South America (SA), SAMS is characterized by intense rainfall over central Brazil, with rainfall concentrated in the southern summer months, in a region that is connected to the Intertropical Convergence Zone (ZCIT) of the Atlantic to Northeast Brazil. Thus, it is important to understand how changes in insolation modulated the AMS variability along the Holocene. Here we will present a compilation of paleodata in the AMS domain for precipitation proxies along the Holocene. Some criteria for selecting the paleorecords are the spatial domain, defined based on characteristics of the AMS (40°N - 40°S; 120°W - 30°W), studies with two or more proxies, and calibrated. Finally, we will compare the paleodata compilation with results derived from the TraCE-21 ka simulation for the last 11,000 years to investigate physical mechanisms associated with climate variability.

Keywords : AMS, Holocene, multiproxy compilation, TraCE-21, climate variability

Multiple effects of archive and proxy type on the dynamical characteristics of paleoclimate proxies and climate variability derived therefrom.

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Abstract :

It is a well established fact that paleoclimate proxies do not present linear transformations of past climate variability, but record information on a multivariate climate state in terms of a time, state and likely also time-scale dependent nonlinear filter that depends ultimately on the type of considered archive and proxy. During the past years, this complex climate-proxy relationship has attracted considerable interest in the community aiming at developing sophisticated proxy forward models to account for the corresponding effects. Nonetheless, the fact that proxy variability does not necessarily equal the variability of the supposedly underlying variable has been gently ignored in many previous studies.

In my presentation, I will discuss some implications of this empirical fact from a complex system perspective by focusing on a suite of selected nonlinear time series characteristics of different types of proxies. The obtained results demonstrate that the interpretation of the dynamical characteristics of reconstructed climate variability needs to account not only for the scaling properties of the studied proxy, its “noise” content and potential artifacts arising from chronological uncertainty and interpolation. In addition, the representativeness of the considered archive and proxy type for the desired climate variable of interest plays a crucial role for obtaining reliable information on nonlinear variability properties from proxies. I will present some recent findings suggesting that this property can be ultimately characterized by the associated observability of the available proxy time series, and that different widely used types of archives are associated with different levels of observability. This modern nonlinear variability perspective may have considerable implications for the interpretation of proxy variability and the choice of advanced (e.g., machine learning based) methodologies for developing future improved, fully-empirical data-driven proxy forward models.

Keywords : Proxy variability, nonlinear dynamics, observability

Tropical Atlantic stratification response to late Quaternary precessional forcing.

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Abstract :

The upper ocean circulation in the western tropical Atlantic (WTA) is responsible for the northward crossequatorial heat transport as part of the Atlantic Meridional Overturning Circulation (AMOC). This crossequatorial transport is influenced by the thermocline circulation and stratification. Although seasonal thermocline stratification in the WTA is precession-driven, the existence of an orbital pacemaker of changes in the entire WTA upper ocean stratification, which comprises the main thermocline, remains elusive. Here, we present a 300 ka-long record of the WTA upper ocean stratification and main thermocline temperature based on oxygen isotopes (δ18O) and Mg/Ca of planktonic foraminifera. Our Δδ18O record between Globigerinoides ruber and Globorotalia truncatulinoides, representing upper ocean stratification, shows a robust precession pacing, where strong stratification was linked to high summer insolation in the Northern Hemisphere (precession minima). Mg/Ca-based temperatures support that stratification is dominated by changes in thermocline temperature. We present a new mechanism to explain changes in WTA stratification, where during the Northern Hemisphere summer insolation maxima, the Intertropical Convergence Zone shifts northward, developing a negative wind stress curl anomaly in the tropical Atlantic. This, in turn, pulls the main thermocline up and pushes the South Atlantic Subtropical Gyre southwards, increasing the stratification to the north of the gyre. This mechanism is supported by experiments performed with the Community Earth System Model (CESM1.2). Finally, we hypothesize that the precession-driven WTA stratification may affect the cross-equatorial flow into the North Atlantic.

Keywords : western tropical Atlantic stratification, precession, ITCZ, South Atlantic Subtropical Gyre

WAVELET ANALYSIS IN ROCK MAGNETIC PROPERTIES IN HOLOCENE AEOLIAN SEDIMENTS OF ARTURO DUNE, TIERRA DEL FUEGO, ARGENTINA.

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Abstract :

We performed a wavelet analysis in time series of magnetic properties obtained from a 19 m-thick profile of Arturo Dune, in the northern region of Isla Grande of Tierra del Fuego, Argentina (53° 43' 28'' S, 68° 18' 51'' W). The profile comprises a succession of aeolian units interdigitated with paleosoil levels.

Considering the 14C datings from organic matter in the paleosoil levels presented by Coronato et al. (2021), an age model was created taking a continuous sedimentation rate to date the aeolian deposits. According to this model, the profile was developed along the Holocene, covering an age range from 832 to 12086 years BP.

The results include different magnetic properties and ratios, such as coercive force (Hc), saturation magnetization (Ms), low-frequency (470 Hz) magnetic susceptibilities (kLF), anhysteretic remanent magnetization (ARM), among others, measured in aeolian sediment samples. These properties and ratios are widely used to study magnetic mineralogy, concentration, and magnetic grain size in sediment samples. Rock magnetic results indicate stable magnetic mineralogy in the aeolian deposits (magnetite or titanomagnetite, with low content of Ti), showing that the variations in the concentration and magnetic grain size parameters could be related to wind variations.

The wavelet analysis has been relevant to distinguishing common and consistent periodicities in time series. Velasco Herrera et al. (2017) created a new algorithm to analyze spectral covariance for multiple-time series that can be applied to geophysical records. The statistical analysis of the magnetic parameters in the profile could indirectly indicate any prevailing periodicity of the wind variations over time recorded in the deposit. The results obtained through the wavelet and multiple cross wavelet analyses of the magnetic parameters suggested a periodicity of around 2800 years. By adding the South Atlantic Ocean paleotemperatures in the analysis, a periodicity of about 3000 years was obtained.

The results that emerge from this wavelet analysis are similar to recurrent cycles that appear in other wavelet analyses of different records that identify fundamental solar modes (Soon et al. 2014). However, they are not conclusive about the sun-climate relationship on a series of millennial suborbital time scales, and more studies should be performed.

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Keywords : Dune, Magnetic Properties, Periodicity, Holocene, Tierra del Fuego.

PERIODICITIES OF THE GEOMAGNETIC FIELD DURING THE HOLOCENE. POSSIBLE FORCINGS

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Abstract :

Several studies in different records show that paleoclimate variations during the late Cenozoic would have been moderated mainly by changes in insolation through orbital cyclicality. In the last decades, the analysis of the mechanisms and possible periodicities of the geomagnetic field (GF) variations has aroused interest in climate forcing studies. Numerous authors have made different proposals on the relationship between GF variations and orbital cycles. However, the link between orbital frequencies and GF-related processes is still under debate. Moreover, studying this connection in the Holocene acquires significance due to the remarkable weakening trend of the GF intensity, at least during the last 500 years.

To estimate that relationship, we performed a wavelet analysis (Velasco Herrera et al. 2017) on time series of GF paleosecular variations (Declination, Inclination, and relative paleointensity, RPI) from the best South American lacustrine records (Patagonia, Argentina). The records involved sediment cores, that cover the entire Holocene, from three Patagonian lakes: El Trébol (41°04′S, 71°29′W), Escondido (41°S, 71°30W), and Potrok Aike (51°58′S, 70°23′W).

We analyzed the coherence of the oscillations registered in the magnetic records, using wavelet, cross wavelet, and a new methodology based on multiple cross wavelets to determine the possible existence of some typical common patterns in the time series involved.

The multiple cross wavelet analysis performed on the magnetic data from the three lakes showed variations with periodicities around 1500 and 3000 years.

We also performed a wavelet analysis on a benthic isotopic record (δ18O) since it is a time series representing the paleotemperatures of the South Atlantic Ocean (Waelbroeck et al. 2011, core MD07-3076Q, 44°09.19′S, 14°13.70′W). Periodicities close to 1500 and 3000 years were also recorded in this paleoclimate proxy. The results obtained would indicate similar rhythmicity and certainty in the variations on the Holocene climate and GF.

Therefore, we speculated that the GF could act as one of the climatic forcings, or that GF and climate would oscillate together due to the influence of the same forcing external to the planet. As it is a complex system and according to our results, we suggest that external forcings could promote the variations of the GF and climate during the Holocene.

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Keywords : Periodicities, wavelet, geomagnetic field, Holocene, patagonian lakes.

OSM14: Past extremes and risks assessment: Linking the instrumental and the paleo record

Co-conveners: Blas Valero-Garcés, Bruno Wilhelm, Hugues Goosse, Boris Vannière and Chantal Camenisch

Oral

Rainfall Rescue: extending instrumental rainfall reconstructions backwards into the 18th century over the British and Irish Isles.

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Abstract :

Recovering additional historical weather observations from known archival sources will improve understanding of how the climate is changing and enable detailed examination of extreme events within the historical record.

More than 16,000 volunteer citizen scientists completed the transcription of more than 5 million hand-written monthly rainfall measurements taken across the UK and Ireland between 1677 and 1960 using the RainfallRescue.org website. These observations have now been quality-controlled and made openly available. Only a small fraction of these observations were previously digitally available for climate scientists to analyse.

These new instrumental observations allow the extension of high-resolution gridded rainfall reconstructions over the entire UK back to at least 1836 and, for some regions, until the late 1700s. These long reconstructions help link the instrumental and paleo records and also allow a more detailed examination of notable extreme events, including: (1) floods such as September 1774, which remains the wettest month on record for Oxford, and (2) sequences of dry winters which could cause water shortages if they were to occur today. The rainfall reconstructions are also compared with the 20th Century Reanalysis, which produces an entirely independent estimate of variations and long-term trends in rainfall, with excellent agreement.

Keywords : rainfall, reconstruction, flood, drought, citizen science

A 211-year moisture reconstruction in southern Quebec based on snowpack-sensitive trees.

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Abstract :

We present a 211-year tree-ring-based reconstruction of the annual mean flow of the Sainte Anne River, Gaspésie, Québec, Canada. The river traverses through the interior of the Gaspé Peninsula where the instrumental hydrological and climatic records are particularly short. This is the first streamflow/soil moisture reconstruction between the Hudson River and north-central Québec, filling a substantial geographical gap along the eastern North American margin, and adding to theonly three existing river reconstructions of the Atlantic coast. Our skillful nested reconstruction (maximum R2 = 0.61, maximum RE = 0.36) is based upon eight site chronologies from locations where high snowpack limits the length of the growing season and the energy available to trees. Although energy-limited tree-ring chronologies are well-known in western North America, we find the first energy-limited snow proxy sites in eastern North America, in this region noted for its high snowfall. We found sustained periods of low flows and high flows not captured in the relatively short instrumental record. This Gaspésie reconstruction shows drought and pluvial synchronicities in common with multi-centennial-length river/soil moisture reconstructions from along the Atlantic Seaboard from New York, Delaware and Maryland, as well as with net basin water supply reconstructions from much closer north-central Québec. The Sainte Anne River is an important

salmon fishing river located in the Parc national de la Gaspésie (PNG). The PNG is the last refuge south of the St. Lawrence River of the once-common woodland caribou, and the troop in the PNG are critically endangered. Hence, our reconstruction is of interest to wildlife and fisheries managers.

Keywords : tree-ring-based river reconstruction; southern Québec; droughts; pluvials; energy-limited tree-ring chronologies; April 1 SWE

The Link Between Southern Portuguese Climate and the East Atlantic Mode from Highly Resolved Speleothem Records.

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Abstract :

Climate in the Iberian Peninsula is impacted by both internal and external climate modes, which are expected to shift in position and intensity due to anthropogenic climate change. Examples of such modes include the North Atlantic Oscillation (NAO) and the East Atlantic mode (EA). Changes in the behavior in these regional climate modes could significantly alter water availability in the Iberian Peninsula, a region identified by model projections as particularly sensitive to future warming scenarios. There has been extensive research and paleoclimate reconstructions of the NAO and its impacts on Iberian climate. However, to date few paleoclimate records have been developed to evaluate the behavior of the EA over the late Holocene and into the present. The development of highly resolved regional paleoclimate records from Iberia is critical for improving the predictive capability of regional climate models under future warming scenarios and to determine the extent to which different teleconnection patterns are influencing climate. Here we present a near annually resolved stable carbon isotope (δ13C) and oxygen (δ18O) isotope time-series from three stalagmites from the Algarve region of southern Portugal from two caves within 2.3 km of each other. The southern coast of Portugal offers an ideal location to study the behavior of the EA due to the modulation of storm tracks coming across the North Atlantic Ocean into Iberia associated with the EA. U/Th dating indicates that our composite record spans the last millennia continuously through 2018 CE. Two stalagmites (GIA-19-1 and C-18-1) stopped growing around 1600 CE, during a dry interval, and sample GIA-19-2 grew continuously since the 15th century. GIA-19-2, with sub-annual resolution, is compared to modern instrumental records to evaluate the influence of specific environmental controls, including temperature and precipitation amounts. Isotope data from all three stalagmites exhibit substantial multidecadal variability indicating relatively wet and dry intervals. Based on our initial results, it is likely that both temperature and precipitation amount effects are the dominant controls on isotopic variability in these stalagmites. Comparison of the GIA-19-2 oxygen isotope time-series with the instrumental index (1950 to present) and reconstructed index (1650 CE to present) of the EA mode shows strong coherence with both index records. Hence, multidecadal variability observed in our stalagmite isotope time series may provide insight into the historical behavior of the EA mode and its resulting impacts on southern Portuguese climate.

Keywords : Paleoclimate, stable isotopes, stalagmites

Extreme weather events recorded by daily to hourly resolution biogeochemical proxies of marine giant clam shells.

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Abstract :

Paleoclimate research offers an overview of Earth's climate change over the past 65 million years or longer, but our knowledge of paleoweather (i.e., extreme weather events occurring in days or even hours and minutes) is almost absent because current paleoclimatic reconstructions rarely provide information with temporal resolutions shorter than a month. Recently, our studies found that the Giant Clam shells from tropical western Pacific have clear daily growth bands and can provide daily to hourly resolution biogeochemical proxies records, including daily growth rate, hourly elements/Ca ratios, and fluorescence intensity. These ultra-high resolution proxies can clearly record the activities of past extreme weather events, for example, tropical cyclones during the summer-autumn and cold surges during the winter, indicating that Giant Clam shells have the potential to be used as an unprecedented archives for paleoweather reconstructions. The fossil shells living in different geological times can be built as a Geological Weather Station network to lengthen the modern instrumental data and investigate the weather-timescale extreme events under various climate conditions.

Keywords : Tridacna shell, daily growth bands, ultra-high resolution, biogeochemical proxies, weather-timescale extreme events

East Asian summer monsoon over the past millennium

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Abstract :

The East Asian summer monsoon determines the summer precipitation pattern in East Asia, home to approximately one-quarter of the world's population, and its variability is thus of broad interest for both the scientific community and the general public. However, it is difficult to reconstruct the EASM strength for eastern China over the past millennium using the precipitation-sensitive proxy evidences because the relationship between monsoon strength and precipitation intensity in China can be complex and vary between regions. Here, we reconstructed a wind-based EASM index over the past millennium. The reconstructed EASM index represents the simultaneous changes of the Meiyu precipitation and the southwesterly wind anomalies in East China, and is also significantly related to the first leading mode of the summer precipitation in China. Based on the reconstructed EASM index, we find that the EASM variability is primarily correlated with the Indo-Pacific Tripole (IPT) mode of the summer tropical sea surface temperature anomalies.

Keywords : East Asian summer monsoon, Tree ring, Speleothem, Historical document, Past millennium

Dendrogeomorphology of the avulsion event on the Pedregoso Creek alluvial fan (Argentina, Puelo Lake) triggered by the historic 1960 earthquake.

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Abstract :

The most intense earthquake worldwide ever measured occurred in Valdivia, Chile, in May 1960. Its occurrence resulted in ecosystem's impacts on the Argentine Andean region in northwest Patagonia during and after the event.

A known case is the Tsunami in Lake Nahuel Huapi that destroyed the Bariloche port. On the other hand, less is known about the Pedregoso Creek (PC) flood in the north bayhead of the Puelo Lake. Historical local farmers who used to cross the PC recall that after the quake, small natural water bodies placed in the middle basin got undammed leading to a big flood in the lower basin. As a result, a channel avulsión took place in the PC alluvial fan and the location of its rivermouth changed drastically. Nowadays, the flood and the avulsion event is still recognizable in the alluvial fan due to a lower forest density that had slowly reestablished on the paleochannel sector. With this framework, we are conducting dendrogeomorphological studies in the alluvial fan in order to characterize the event, explore other conditions present during 1960th (e.g. above average annual precipitation) and analyze the channel's subsequent migration dynamics. For this purpose, we estimated forest density (tree/ha) and took increment core samples at multiple sampling points (distanciated 50 m) along three arcuate transects that radially dissect all the Predregoso alluvial fan. After the land survey, we zonificated the alluvial fan in six different sectors. The sectors were characterized by the forest maximum density value and the minimum potential tree establishment date of the last fluvial activity (oldest dated tree established), as follow: 1) the active PC channel with no trees; 2) a fluvial semi-active sector with 152 trees per ha and a minimal establishment date of 1987; 3) a fluvial inactive zone with 962 trees per ha and an establishment date of 1967; 4) the paleochannel sector, active before the earthquake and the flood events, with 337 trees per ha and an establishment date of 1973; 5) a paleochannel middle fluvial bar sector, with 429 trees per ha and an establishment date of 1963, and finally; 6) an undisturbed forest sector with 1975 trees per ha and an establishment date of 1832. These results, with no intermediate dated sector between the undisturbed (1832) and the paleochannel (1963) sectors, may preliminary suggest that the avulsión event was unique over the last two centuries. The younger sectors (2 and 3) are reflecting a gradual channel migration to the north side of the alluvial fan after the avulsion. Future work will continue surveying higher areas of the basin looking for lost small water bodies (damms), directed dendrogeomophological sampling to reinforce the dating of the avulsion event and, lastly, analyzing instrumental climatic data to establish whether the earthquake took place on a wet year resulting in an increased level of the Puelo Lake.

Keywords : Patagonia, Andean Range, fluvial dendrogeomorphology, channel, flood

Analysis of the last 75 years of floods in a high-resolution sedimentary record from the Tschingelsee (Swiss Alps).

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Abstract :

Linking instrumental records with paleorecords such as lake and fluvial sediments can be a difficult task. For the calibration and correlation of different time series it is necessary to achive high resolution sedimentary records with a robust geochronological model within comparable physiographic boundary conditions. Furthermore, there may exist differences between the temporal resolution of different types of records, and frequently, instrumental data are limited to a period no longer than 100 years, whereas the paleorecords usually exceed by far this time period.

In this work, we present the sedimentary and geochemical record of the Tschingelsee lake, located in the Bernese Oberland (46°33.170'N; 7°44.661'E). The lake was formed after a debris flow event, that occurred during the night of August 18 to 19 of 1972, which dammed the river outlet and contributed to the flooding of most of the Tschingel valley floor. After the lake formation, a river delta was growing on the upper part of the valley and currently the lake is almost completely covered by sediments. The excellent location of this lake, placed close to the Kiental meteorological station, and the exceptional high-resolution sedimentary records, which include varve-like layers, are favourable factors that contribute to a close correlation of the hydrological events between sedimentary and instrumental records.

The results from this work include a sedimentary analysis of a 4 meters long core, which presents facies of different granulometry (from gravels to clays) and covers a narrow time period of approximatly 75 years. The geochronology was not based on absolute dating techniques but rather on the geomorphological interpretation of the depositional conditions of sedimentary facies, correlated with the geomorphological information retrieved from several historical aerial photographs and topographical maps. The survey of these cartographic data also contributed to resolution precise reconstruction of the paleographic evolution of the lake and the river delta over the last 50 years.

The daily-monthly instrumental record allowed a correlation between high magnitude precipitation events and flood layers identified in the lake and fluvial sediments over the last 100 years. Two large magnitude historical flood events were identified in the Tschingelsee sedimentary core by coarse-grained flood layers (medium and fine gravel). The first flood layer could be associated with thunderstorms that occurred between the 28th and 30th of July of 1948, that activated the Gwindlibach stream. The second flood layer is associated with storms from the 18th of August of 1972, which triggered the debris flow. In both cases, the rainfall recorded by the Kiental meteorological station does not show especially high precipitation values. Therfore, other keyfactors such as slope inestability due to environmental changes, the permafrost degradation and the progressive input of clasts in the headwater catchment and channel, snowmelt etc. can be important variables for crossing the threshold of erosion, catchment connectivity and the generation of debris flows. In contrast, large rainfall events that affected many regions of Switzerland, such as the flood events from August 1978, August 2005, or July 2014 may correspond to flood layers of fine sand texture.

Keywords : Sedimentary record, Swiss Alps, debris flow, historical events, rainfall record

OSM15: Art and science in a changing planet: A past global perspective

Co-conveners: Graciela Gil-Romera, Alejandra Vicente de Vera and Vojtech Abraham

Oral

New ways of visualising palaeoenvironmental data.

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Abstract :

We are developing a method to visually express the responses by the ancient Maya population to climate change through cutting edge digital art technologies. It is believed that the ancient Maya adapted to their changing environment in different ways, and that they ultimately abandoned some of their cities in response to a devastating drought around 730-900 CE. This pilot project aims to convert geochemical data into a high fidelity visualisation using 'game engine' technology to represent the changing population, vegetation and climate of the ancient Maya population over 3300 years based on geochemical analyses of lipids extracted from sediments in a cenote located adjacent to the ancient lowland Maya population centre of Itzan in the southwest Maya lowlands in Guatemala. The site of Itzan has been mapped with elevation data and archaeological findings. We will use this map alongside images of this site to meticulously re-create the environment digitally. Using real-time computer graphics technology found in 'game engines' we will be able to simulate the shifting climate patterns extrapolated from the collected data. The project moves beyond conventional data visualisation to create an affectual experience that enables new ways for spectators to engage with complex patterns found in scientific data. The primary way the work will be exhibited is as a large-scale projected installation. The image will provide a window into a new imagined environment at a large scale.

Keywords : art, communication, visualisation, geochemistry, palaeoenvironment

Music of a Changing Planet: data musicalization and its potential for Earth Sciences outreach and education.

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Abstract :

Music is one of the most direct and powerful means of expression to humans, being able to convey complex messages and emotions to a wide variety of collectives. Data musicalization or sonification offers the opportunity to transform complex datasets into musical sounds, allowing scientists to communicate their findings in creative ways. In this presentation I show the potential of data musicalization within the Earth Sciences using the free web-based software 'musicalgorithms'. I present an overview on the methodological choices available to convert long-term environmental data into music, and test their potential to produce a range of sound experiences using isotopic, palynological and atmospheric composition datasets. Finally, I reflect on the advantages and limitations of these tools in science outreach and educational activities.

Keywords : Data musicalization, sonification, science outreach, Earth Sciences

2A Earth Core: The Hominin Project: an art and science collaboration.

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Abstract :

The exhibition, 2A Earth Core The Hominin Project at Aberystwyth Arts Centre in 2017, marked the culmination of an art-science project focused on climate change. The collaboration brought together an artist undertaking a practice-based PhD at

Aberystwyth University and the Hominin Sites and Paleolakes Drilling Project (HSPDP), an international scientific collaboration researching the relationship between climate and human evolution. This presentation relates the experiences of the collaborative enterprise from the perspectives of the artist and a lead scientist in the research cluster, thereby providing insight from both disciplinary fields. This leads to an examination of the creative strategies that were used in translating the data, images and ideas from the science into exhibition content.

The theoretical background to the project lies in the contrasting opinions that have emerged in recent decades regarding the value of collaboration between the arts and the sciences. Some commentators argue that the fundamental differences between art and science make interdisciplinary practice untenable, while others suggest that many potential benefits are achievable through dialogue and mutual work in areas of shared interest. Here, we examine this potential and offer some newly identified approaches to collaboration within the art-science and climate change discourse.

As background, the presentation includes information on the initial stages of the collaboration. In 2014 the artist traveled with the HSPDP team to the dried lake basin of Chew Bahir, southern Ethiopia, regarded as a significant region for early hominin evolution; the experience of the landscape seen from an artistic perspective is discussed. As observer, the artist was able to gain insight into the field research, which involved drilling nearly 300 m of sediment cores, later shown to record climate change of the last 600,000 years.

The collaborative relationship enabled a number of works to be developed, bringing together the knowledge and insight of both the artist and the science team. The exhibition contained two principal works: 2A (2017) is a film in which hundreds of high-resolution images of the sediment cores were sequenced into a 24-hour film. 2B (2017) is an installation made of mud from the bottom of the drill hole which, when re-hydrated and then allowed to dry, created an experimental version of the ancient playa lake surface. The original exhibition has now, in 2021, been developed into a virtual exhibition space which allows visitors to navigate both the art gallery and a dedicated science area.

The presentation concludes with a commentary on collaboration across art and science, and on the rationale for the curation of the exhibition as a hybrid space, an innovative combination of material that included art, documentary interviews with science researchers and science artifacts. In offering fresh approaches to collaboration, the presentation argues for the crucial role that art can play in enabling audiences to encounter larger narratives of humanity's relationship with a changing climate.

Keywords : art, science, collaboration, interdisciplinary, hominin

Sky Islands: a past time travel at the Andes mountains.

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Abstract :

"Sky Islands: a past time travel in the Andes mountains" is a short film based on the scientific publication "The flickering connectivity system of the northern Andean páramos"[1] which was selected for a special virtual issue in the Journal of Biogeography (July 2021) as one of the highest citation rates of papers published since 2009. This film used digital art, photography, 3D animation, and scientific data visualization to understand how the high-altitude ecosystems of the Northern Andes, the páramos, evolved in time and space. It displays how the shifting elevational distributions of the páramos were caused by changing temperature conditions driven by long-term climate fluctuations and how speciation could have increased

exponentially under these dynamic conditions. Additionally, it provides key insights in how the present-day biodiversity, which was built up during several million years, is deteriorating in just a few decades of devastating human activity. The film has now been shown at different public events, is available in Youtube ([2] over 7,500 views since 07-2018) and has been the official selection of international environmental film festivals, winning several awards in addition. The results of this outreach approach have had a significant impact in various ways. First of all, decades of knowledge on the evolution in Andean ecosystems has been integrated, providing a much-needed interface for multi-disciplinary research between paleoecology, phylogeography of plants, and pollen-based reconstructions of paleoclimate. Secondly, strong information graphics trigger new initiatives in mountain research globally, elucidating the origin of biodiversity in an unprecedented manner. Thirdly, science visualization is increasingly being considered as a vital tool in communicating key scientific development. In addition, it helps students to better understand the history of the páramos, and high mountain ecosystems in general. Finally, the visualization is relevant for a large public including scientists and universities, filmmakers, new media artists, schools, policymakers and governments, stimulating outreach to the community also through the use of social media tools [4,5,6]. In this talk, we will elaborate further on the process of making a scientific film from a scientific publication, and the challenges of “translating” a scientific story into a work of public outreach and art.

References

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[2] https://www.youtube.com/watch?v=-Wcp18vBDK4

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[4] https://www.instagram.com/skyislandsandes/

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Keywords : Short film, science-based story telling, Andes, 3-D animation, landscape photography, Outreach

Film festivals as venue for science and environmental outreach and communication.

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Abstract :

Nowadays, there are several venues available for science communication not only for scientists but also for wide public outreach. About 150 Environmental and Science Film Festivals are open every year globally and they are distributed through platforms like FilmFreeway [1], Festhome [2], or by own platforms. These festivals are released in the hopes of shedding light on what can be done to raise awareness on the current environmental crisis and to help save the planet from the negative consequences of unsustainable use of natural resources. They present movies on sustainability, ecology, conservation, wildlife, climate change, medicine, physics and other related topics. Meanwhile, they also seek to challenge and strengthen the role of science in the current discourse on the environmental crisis (by providing a forum for adventurous interdisciplinary projects). They also provide a platform to make scientific findings accessible and entertaining to a broad audience, while demonstrating that science can be fun. In the search of awakening curiosity and transmitting passion for science, these festivals promote constructive dialogue between filmmakers, scientists, environmentalists, and society about global and essential challenges that we are facing as human beings.

"Sky Islands: a past time travel in the Andes mountains" [3,4,5] is a short film based on the scientific publication "The flickering connectivity system of the northern Andean páramos"[6]. This film is using digital art, photography, 3D animation, and scientific data visualization to understand how the high-altitude ecosystems of the Northern Andes, the páramos, evolved in time and space. A first version was displayed at several venues in the Netherlands: KINO Cinema Rotterdam, Willem de Kooning Academy, the Royal Netherlands Academy of Science, and Science Park Amsterdam. Since its first version launch on YouTube [7] (July/2018) it has attracted over 7,500 views. As a result of this success, we created a new version in English and in Spanish for Environmental and Science Film Festivals. Premiered in 2020, the film became an official selection for international Festivals around the globe. The Spanish version was nominated for 3 festivals in Colombia and 1 in Ecuador, while the English version has been displayed at 8 festivals in Brazil, Angola, Burkina Faso, Ethiopia, Kenya, Malaysia, Namibia, Philippines, Rwanda, South Africa, Australia, USA, Croatia and Hungary. Finally, it won awards of Honorable Mention, Best Sciences Life Documentary, Excellence and Pantalla Verde, a digital platform in Latin America for environmental cinema [8]. Targeting a wider public but also stimulating conversation about science and environment on film, we aimed to create innovative and different outreach approach for institutes studying biodiversity in general, to stimulate conversation about science through the use of new media and film for general public divulgation. In this talk, we will elaborate further on the process of making a scientific film for festivals, submitting and joining environmental and science film festivals around the world.

References

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[5] https://www.facebook.com/SkyIslandsAndesMountains

[6] Flantua et al. 2019. The flickering connectivity system of the northern Andean páramos. JBI 46(8), 1808-1825. https://onlinelibrary.wiley.com/doi/epdf/10.1111/jbi.13607

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Keywords : Environmental Film Festivals, 3D Animation, global outreach, multi-language, cinema

OSM16: Towards an improved understanding of past flood variability and examples on how such data can have a bearing on present and future flood risk management

Co-conveners: Juan Antonio Ballesteros Canovas, Øyvind Paasche, Lothar Schulte, Eivind Wilhelm Nagel Støren, Mehmet Salih Bayraktutan and Bruno Wilhelm

Oral

Impact of warmer climate periods on flood hazard in the European Alps.

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Abstract :

Flooding is a pervasive natural hazard and climate change will likely exacerbate risks around the world. Mountainous areas, like the densely populated European Alps, are of particular concern as topography and atmospheric conditions can result in large and sudden floods and because they are experiencing a high warming rate, which is likely leading to more heavy rainfall events.

Here, we compile 33 paleoflood records to test the impact that these climatic trends might have on flood frequency and magnitude in the European Alps. The paleoflood records are provided from lake sediments, guarantying the record continuity over long time periods. The dataset passed a screening procedure of hydrological, sedimentary and geochronological controls resulting in a final selection of 27 records that continuously span the last 150 to 10000 years, thereby documenting a total of 7792 floods. We perform three analyses with this dataset:

(i) we determined changes in the occurrence of large (≥10 years) floods during past cooler and warmer subperiods, analogous to the methods used by climate projections under future warmer conditions,

(ii) we analyzed the trends in the occurrence of large (≥10 years) floods during periods of warming and cooling, following trend analysis techniques that are based on modern discharge data and,

(iii) we determined changes in the occurrence of extreme (≥100 years) floods during past cooler and warmer subperiods.

From these analyses, we demonstrate that a warming of +0.5 to +1.2°C led to a 25-50% decrease in the frequency of large (≥10 year return period) floods. This decreasing trend is not observed in records covering less than 200 years (i.e. maximum time period of instrumental series) but it is persistent in those ranging from 200 to 9000 years. In contrast to large floods, we show that the occurrence of extreme (> 100-year return period) floods may increase with a similar degree of warming in some small alpine catchments. This may be due to the intensification of extreme rainfall events locally, together with warmer temperature. Our results show that continuous paleoflood

records can be used to disentangle complex climate-flooding relationships and assist in improving our knowledge in flood risk assessment at regional scales.

Keywords : Flood frequency, flood magnitude, risk assessment, European Alps, paleo timescales

Lessons from the Ahrtal Flood 2021 and the Disregard of the Historical Dimension.

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Abstract :

The extreme rainfall leading to an „unexpected“ severe flash flood caused numerous deaths, massive damages and ecological disasters in the Ahrtal, Germany during July 2021.

The overall discussion about the enormous damage focused on errors in the warning chains and in disaster management, as well as the disregard of forecasts and the induvidual misconduct and a general lack of preparedness. Furthermore, reference was made to the misjudgements resulting from the evaluation of official hazard and flood risk maps. These are regularly calculated from instrumental tide gauge data since the 1940s and provide data for HQ10, HQ50, HQ100 and HQextreme. The calculated values were exceeded by far during the event. In this context, it also became clear that historical floods such as the events of 1910 and 1804, which had a similar dimension, were not taken into account.

In the 19th century alone, a total of 17 damaging flood events have been recorded for the Ahr valley, most of which occurred in the summer half-year, similar to 2021.

In the presentation, the historical events concerning the Ahr valley and the area of the Eifel are analyzed and related to the current flood disaster. In addition to measurement series, written documents are also evaluated using Natural Language Processing methods.

The talk provides arguments and examples of how historical events contribute to a better awareness and especially to a more valid assessment of extreme flood risks.

It also shows that the exclusive reliance on comparatively short modern instrument measurement series tends to underestimate extremes and thus to misjudge the flood risk and to suggest false security.

Keywords : flood extreme, Ahrvalley, risk analysis, historical documents, NLP

The rhythm of the river: a CPDF of Lower Meuse river deposits.

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Abstract :

Over the last decades the Lower Meuse River (the Netherlands) has been the focus of a growing number of earth-scientific and (geo)archaeological studies. Targeted case studies have laid the groundwork for a broad understanding of fluvial responses during glacial-interglacial cycles and climatic anomalies such as the Younger Dryas. The Lower Meuse has also been a hotspot for geoarchaeological studies, as the catchment was home to the early agriculturalists, and it was an intensively cultivated area afterwards, particularly during the Iron Age and Roman Periods. Studies from both fields of research have caused a steady growth in the data set of dating information derived from the fluvial environment, often from well-studied local settings that are supported with detailed sedimentary and palynological information. In the current study we performed a Cumulative Probability Density Function (CPDF) on the currently available data set of c. 250 radiocarbon and OSL (Optically Stimulated Luminescence) dates that were collected within a fluvial context. The CDPF is a broad regional reflection of the changes that occurred in the fluvial system in the last c. 15,000 years, forming the ensemble overview or 'memory' of the fluvial archive, which is often not fully recorded or preserved at a single site of investigation.

A first analysis of the CPDF suggests that the clustering of dated deposits relates to three

main factors; (i) changes in river channel planform during the Late Glacial and early Holocene period, (ii) repetitive phasing of the Lower Meuse flooding regime and the occurrence of anomalous extreme flood events during the Holocene, and (iii) human influence. The results demonstrate that after an initial period of high fluvial activity that ended in the early Holocene, the Lower Meuse became a relatively stable system with limited changes apart from periodic multi-centennial oscillations in flood occurrence. Fluvial activity progressively increased in the last c. 4,000 years, and peaked during Medieval times, in line with increasing human settlement in the region. Although human influence became the driving force for changes in the fluvial setting, persistent climate-driven variations remained. Hence, there seems to be a natural climate-driven rhythm of the river that modulates flood activity and that may be important baseline information for present and future flood risk assessments.

Keywords : Holocene, flood regime, Meuse, alluvial valley, non-stationarity

Looking at long-term debris flow activity in the Japanese Alps.

Juan Ballesteros Canovas [(1)], Ryoko Nishii [(2)], Yoshihiko Kariya [(3)], Fumitoshi Imaizumi [(4)], Norikazu Matsuoka [(5)] and Markus Stoffel [(6)]

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Abstract :

Debris flow is one of the most common hydrogeomorphic hazards in mountain streams, causing large damage and losses owing to the large and quick sediment transport capacity. In Japan, these extreme events are particularly enhanced by rugged topography, specific geological conditions, and the frequent passage of tropical storms. Yet, monitoring such extreme events is difficult since the initiation zones are generally located in the upper mountain catchments. As a consequence, there is a lack of long-term observations of debris flow activity. Here we use tree-ring records to reconstruct debris flow activity in two neighboring yet contrasting -small (1.4 km2)/large (11.8 km2)- catchments in the Japanese Alps and identify potential linkages with the typhon activity over the last two centuries. More than 200 affected trees were sampled at the level of the debris-flow fans of two right-bank tributaries of the Azusa River. Debris flow dating was based on the analyses of growth disturbances, but also on the spatial location of each tree. Dated debris-flow events were later correlated with local rainfall data and the historical tropical storm and typhoon tracks affecting the study area. We identified 38 and 24 debris-flow events for the period 1800-2018, in the large and small catchment, respectively. Overall, we also observe an intensification of debris-flow activity during the 1960s and recently since the 2000s (~ 0.6 events x year-1). The long-term debris-flow variability correlates with averaged sea surface temperatures in the Pacific Ocean from May to November. Since 1956, dated debris flows also correlate well with the passage of historical typhoons. In particular, we observe 14 matches with extratropical cyclones, 11 matches with severe tropical storms, 9 matches with tropical depressions and 7 typhoons, as the recent cases of Sinlaku (September 2008) and Halong (July 2014). Our analysis is a successful case of the use of tree-ring records to decipher past debris-flow activity in Japan, pointing to an enhanced debris-flow activity associated to an increment of typhoon activity during warmer period of the Pacific Ocean.

Keywords : Debris flow, Tree-rings, Typhoons, Japan

The disastrous River Ahr flood of July 2021 - Learning from the past to prepare for the future.

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Abstract :

The devastating flood that occurred July 2021 in the River Ahr valley (Germany) caused major damage and the death of 134 people. The flood

also destroyed the gauges alongside the river. Therefore highwater stages and discharges could not be recorded directly. However it was clearly the highest magnitude since gauge-installation.

Considering historical preinstrumental period, single flood events (particularly July 1804 and June 1910) occurred that were documented in written sources, flood marks on buildings and also photographs (1910). In addition with further historical documents (old maps, paintings) it was possible to reconstruct highwater stages and the historical conditions. Based on these reconstructions an estimation of mean flow velocity and discharge was possible with a calculated peak discharge of 1.200 m^3/s in 1804 which exceeds the largest directly measured discharge to date (236 m^3/s on June 2016 at the Altenahr gauge), by a multiple.

Based on the methodical approach used for the quantitative reconstruction of historical flood-discharges, the peak discharge of the recent flood of July 2021 is quantified also. This is done by evaluating and measuring water stage indicators and the topography by field study as a first approach and by analysing remote sensing data as an alternate approach. The calculated peak discharge of the 2021-flood was between 1.000 and 1.200 m^3/s, thus a similar magnitude as the flood in 1804. The example underlines the importance of historical data as additional input to flood risk analysis and applied flood protection.

Keywords : Flood, extreme event, discharge estimation, Ahr, historical floods

Analysis of an extreme hydrological event in a semi-arid region. The case of the 2012 flood in the Antas River, Spain.

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Abstract :

This work presents the results of the analysis of a severe flood event that occurred on the 28th of September of 2012, in the southeast of the Iberian Peninsula. This extreme event affected several catchments from this region and the settlements near the Antas, Aguas and Almanzora rivers where amongst the most impacted areas, regarding the amount of economic losses. The southeast of Spain is characterized by having an arid/semi-arid precipitation regime, with 200-250 mm of rainfall per year, but in this flood event the rainfall registered in some meteorological stations exceeded the annual precipitation in just a few hours. Despite the amount of information from this flood event that was subsequently generated in the media, both in written and in audiovisual sources, at a scientific level there are still some questions to delve into, especially regarding the hydraulic characteristics of the flood and the recurrence period of this event. This study focuses on the lower catchment of the Antas River and performs a characterization of the flood event and a reconstruction of the flood area by means of a hydraulic modeling. This catchment has no meteorological or hydrological measuring stations, therefore, it was a challenge to analyze the event and to perform a reconstruction of the flood area. The analysis that has been carried out has been developed in three stages. Firstly, we performed a characterization of the event, which included an analysis of the triggers and consequences of the 2012 flood. In this stage we analyzed the synoptic situation and the characteristics of the rainfall that caused the flood event. Secondly, the magnitude of the flood was compared with other historical floods that had affected the Antas catchment and the recurrence period of the 2012 event was established. Finally, a flood area was reconstructed by means of a hydraulic model and the results were compared and validated with floodmarks and primary and secondary documental sources. The results of this study show that the 2012 flood was an extraordinary event with an estimated return period of 100 years. The comparison with similar flood events from the past shows that the damages of the 2012 flood were more severe and caused substantially higher economic losses. This is mainly attributed to considerable land use changes in the past decades, especially due to an increase of touristic and intensive agricultural activities.

Keywords : Floods, Hydraulic Model, HEC-RAS, Flood reconstruction; Land use changes

Pattern of severe alpine floods of the last 540 years reconstructed from temporal-spatial analysis of natural and documentary archives.

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Abstract :

The change of policy towards integrated management of floodplains for disaster risk reduction and to achieve greater resilience of social and ecological systems requires innovative methodologies for an efficient application of measures. For this reason, it is urgent to develop a holistic vision of historical hydrological events to understand fluvial and environmental dynamics in flood areas under the effect of Climate Change.

Under the umbrella of Work package 2 of the PAGES Flood Working Group an innovative multidisciplinary methodology was designed that integrates multi-archive datasets from floodplain and lake sediments, tree rings, lichens, historical documentary evidence, hydraulic infrastructure, and archaeological sites to perform robust centennial-long reference flood records for the Bernese Swiss Alps (Schulte et al., 2019). Here we present how this methodology was systematically applied to the 17 severest floods from 1480 to 2011 to investigate the relation between the temporal-spatial pattern of paleofloods and atmospheric dynamics.

The paleoflood maps of the Bernese Alps show the following spatial patterns: i) all catchments (1480, 1831, 1851, 1977, 2005, and 2011) ii) western catchments (1575, 1651, 1711, and 1852); iii) northern catchments (1511 and 1566), iv) eastern catchments (1762) and v) local catchment flooding (1678, 1791, 1873 and 1933).

According to the sequences of atmospheric dynamics generated from reconstructions (20th Century Reanalysis Project, 1836-2011) and paleoclimatic models (Last Millennium Ensemble Project, 1480-1836) different climatic patterns of flood episodes were classified: atlantic Mediterranean (1480), Mediterranean (1511, 1575, 1651, 1762, 1791, 1933, 2005), Mediterranean winter (-NAO; 1678, 1711), Central European (1566), mediterranean Atlantic (1831, 1852, 1973, 2011) and Atlantic-Mediterranean (1851, 1977).

Multivariable Analyses were performed to investigate regional flood forcing and types. Flood type 1 (1831, 1851, 1852) are large late summer floods caused by persistent, heavy rainfall and snowmelt and result from southern airflow and positive mode of the Summer North Atlantic Oscillation. Although floods occurred in years with warm-moist spring and cool-dry summer they coincide with the final cool climate pulse of the Little Ice Age and maximum glacier advances.

The large to moderate Type 2 floods (1480, 1977) affected all catchments, with a strong erosion signal in the watersheds of the high-elevation lakes. The floods were triggered by persistent and heavy precipitation of Atlantic origin following a cool spring and summer. However, they occurred during warmer climatic periods with small glaciers.

The moderate (1575, 1791, 1873, 1933) to severe floods (2005) of type 3 were caused mostly by thunderstorms, or persistent rainfall (2005) and snowmelt associated with Mediterranean air masses during years of warm-dry spring and summer and correspond with periods of increased solar activity.

Finally, Type 4 is characterized by greater diversity. Although the floods of 1566, 1651, 1711, 1762, and 1791 occurred in all seasons, they were caused by Mediterranean air masses that produced thunderstorms and persistent rainfall. Significant snowmelt and runoff from large glaciers were recorded during some floods.

Based on this systematic cataloging, a 4D flood model should provide unique insights into flood generation in high mountains.

Keywords : Paleofloods, multi-archive datasets, historical flood pattern, atmospheric dynamics, temporal-spatial integration

Extraordinary floods and climatic variability in southern New Zealand from 1862 to 2020.

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Abstract :

This study aims to undertake the spatial-temporal reconstruction and climatic characterization of floods in the southern regions of New Zealand from 1862 to 2020. Three regional synthetic flood database has been created for West Coast, Otago, and Southland from the data provided by the online application of the New Zealand Historic Weather Events Catalogue of the National Institute of Water and Atmospheric Research (NIWA), as well as a study on climate variability leading to extreme hydrological events. We attempt to characterize flooding behavior, determine weather patterns, understand the impact of climate change and assess the vulnerability of the local population to flooding. In addition, we try to understand the mechanisms of atmospheric linkages in the Southern Hemisphere. The West Coast has a very high relief with short rivers and steep slopes, whereas on the other side of the Southern Alps the catchments have gentler slopes with long rivers and lower ridges. This division influences the regional climate and therefore affects directly flooding and impacts. The approach of this research allowed us to: reconstruct time series of intensity and geographic impact of extreme hydrological events; discover the most severe years and periods of maximum flood intensity; learn about the longest-lasting flood episodes and the main causes; asses the average return period of the magnitude 1-4 events; demonstrate the difficulties to reconstruct historical flood series from the number of fatalities and economic damage; investigate the causes of the reduction in the degree of impact; analyze the validity of civil defense warnings; and finally, relate the flood series to the Southern Annular Mode and Southern Oscillation Index teleconnections.

Keywords : Historical floods, Southern Annular Mode, Southern Oscillation Index, Southern Alps, New Zealand

The risk of marine flooding along the Mohammedia coastline (Morocco).

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Abstract :

Several scientific studies, including the IPCC's, support the progression of global warming, which is accompanied by rising sea levels and increasing the energy and frequency of marine storms. The climate forcing models stress the possibility of sea level rise, which might exceed the coast by 1 m by 2100 in the most severe scenarios. Coastal flooding is expected to grow as a result of the combination of sea level rise and changes in extreme weather events such as increasing wave energy, winds and surges. This

trend has the potential to have a major influence on coastal cities.

The research seeks to analyze the danger of flooding along Mohammedia's coast (Moroccan Atlantic), which consists of sandy and rocky beaches that are locally strengthened by maritime infrastructure (port of Mohammedia). To establish the geographical extent of exceptional sea levels, this work employs a technique based on their spatiotemporal projection on a digital elevation model (DEM). This makes it easier to study their influence.

Using IPCC forecasts, maximum and extreme sea levels were computed for present and future (2100) time circumstances (RCP8.5). The characterisation of the tidal components (astronomical amplitude and surge), the computation of the run-up, and their statistical modeling according to the generalized extreme value theory are all used in the calculation of these levels (GEV). The physical qualities of the shoreline are also taken into account while estimating the run-up parameter (in particular the variation of beach slopes).

The findings reveal that Mohammedia's shoreline is poorly protected from coastal flooding during powerful storms. The most susceptible sites are those near the mouth of Oued El Maleh and Miramar's backshore sections, as well as the refinery's location. The extension of potentially floodable areas would include areas of 10949.8 km2 and 12082 km2, respectively, with a continental width of submersion between 2062 m and 2136 m, according to projections of sea levels for present temporal circumstances and at the horizon 2100.

Because of the importance of areas that may be submerged now and in the future due to sea level variations during severe storm events, managers of the Mohammedia coastline must develop a protection and adaptation policy now in order to ensure the physical and socioeconomic sustainability of this densely populated area.

Keywords : Submerged, Mohammadia, IPCC (RCP 8.5), GEV.

Paleoflood records of Western Himalaya, flood genesis and human remains.

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Abstract :

Floods have been highly variable on the basis of magnitude duration and extent. They can also be differentiated by their causes and origin. Their location, geology, physiographic and meteorological conditions can influence the outcome of riverine floods. In the geologic past, floods have taken an important role as after the Last Glacial Maximum (LGM), several catastrophic floods occurred globally most of which were originated from the melting of several ice sheets and rise in temperature. The discharges that quantify the magnitude and the recurrences were known to be quite different compared with the present counterparts. Floods with discharge higher than a million cubic meters per second known as megafloods were documented globally in this time frame. The Himalaya is also known to host priceless records of past floods in the form of sedimentary archives. This paper deals with the exploration of such archives as a typical fluvial deposit knows slack water deposits (SWDs). SWDs are composed of stacks of sand-silt couplets deposited instantaneously during high flooding events in areas where a sharp reduction of flow velocity is encountered by local obstructions. These events were constrained by Optically Stimulated Luminescence (OSL) and AMS 14C. In the overall scenario, the data suggest the occurrence of large floods during phases of strengthened ISM when with increased penetration of monsoon. We also have explored detrital zircon U-Pb ages of flood sediments of Ladakh indicating the role of river flow direction in determining the flood sediment transportation. Into the bargain, as the presence of past human remains has been discovered and constrained by sufficient chronologies to be Holocene, their further extraction of genetic remains would uncover a previously unknown

of prehistoric human migration and settlement patterns at Ladakh.

Keywords : Paleoflood, Ladakh, OSL, Slack Water Deposits

The temporal context of glacial lake outburst floods in Russian Altai – current state of research and future prospects.

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Abstract :

The Russian Altai, mountains of southern Siberia, is one of the regions where extensive ice-dammed lakes were formed repeatedly in intermountain depressions during the Pleistocene glaciations. Degradation of ice dams led to cataclysmic draining of these lakes. The estimated magnitudes of palaeofloods from the Kuray-Chuya system of basins are considered to be among the largest known terrestrial fresh water discharges on Earth. Significant landscape transformation took place as a result of such flood events among which are high-elevation lake strandlines, giant gravel dunes, lacustrine bars, overflow channels, specific erosional features and outwash deposits.

Today the Pleistocene ice-dammed lakes within the Chuya-Kuray system of basins and their cataclysmic drainage into the Arctic Ocean along the Ob river are among the most intensively studied of such phenomena in Central Asia. Nevertheless, the chronology of the Pleistocene Altai glaciations, as well as the chronology of associated ice-dammed lakes and their cataclysmic draining are highly debatable. Among unsolved problems is the timing of the largest ice-dammed lakes, as well as the last lakes, which contribute to the cataclysmic outburst floods. Final drying of the high-mountain depressions of the Russian Altai gave rise to the evolution of post-glacial landscapes and formation of the modern hydrological network.

Pronounced methodological and technological progress in dating techniques have improved knowledge of the temporal dynamics of these events. It has led to expanding of new data set, but at the same time, it also increased the uncertainty due to an increasing number of contradictory data. This circumstance raises a question of more detailed studying the dated material and conducting multidisciplinary studies to provide a mutual control and verification of the obtained results.

This paper presents the results from geomorphological, sedimentological and geochronological analyses, together with micropaleontological and mineralogical characteristics of deposits of different genesis in more than 15 locations starting from the upper (peripheral) part of the Chuya basin down to the middle part of the Katun river. About 30 new OSL and radiocarbon dates together with the previously published ones specify the chronological benchmarks of major GLOF and associated events in the region and outline the context of further researches.

The age of the most ancient glaciolacustrine sediments is limited to 170 ka. Landforms associated with the largest ice-dammed lakes in Chuya basin are predated by 85-80 ka. The last outburst floods in Chuya basin took place later than 37 ka, and the last ice-dammed lakes in Kurai basin were drained about 19-16 ka. Available radiocarbon and luminescence ages for Katun terraces (associated with GLOF) form two non-overlapping clusters - older than 90-75 ka and 35-12 ka. This may be due to methodological difficulties in numerical dating, and/or by still insufficient geological knowledge about effects of ancient megafloods.

Study was supported by Russian Science Foundation (grant 22-27-00447).

Keywords : ice-dammed lakes, outburst floods, Russian Altai

Climate-driven alluvial fan history and a record historical flood in western Washington.

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Abstract :

Alluvial fan development on Holocene time scales integrates many processes which are often masked by incomplete fan history. We used a sediment record from a lake bordering an alluvial fan to provide a continuous 6100-year record of flooding in western Washington. The river is currently constrained to a fanhead trench which carries high sediment loads into a broad glacial valley. A hydraulic model indicates the channel capacity must decrease 80% for typical floods to reach the fan surface and lake. The sediment record shows that fan-building overbank flows were very frequent during multi-centennial periods during dry periods when the river was aggraded, while during cool and wet periods it was entrenched, a pattern shown for semi-arid areas but not previously in forested landscapes. This long-term pattern was punctuated by three forms of extreme events. First, the only flood at our site in the last 900 years was an atmospheric-river event in 1867, dated by annually laminated sediments and supported by historical records as one of the largest in the last 150 years. Second, forest fires precede periods of flooding, suggesting postfire erosion aggraded the river channel. Third, a turbidite, coeval with a previously dated Seattle Fault Zone earthquake ca. 1040 years BP, is consistent with coseismic landslides aggrading the channel for decades. Overall, the record is consistent with centennial and millennial-scale climate change, and extreme events, driving channel morphology and contributing to flood hazard.

Flood hazard changes from both changes in peak streamflow and in channel capacity. Our unique 6100-year record of flooding onto an alluvial fan shows decadal to centennial periods of regular overbank floods occurred during dry periods, following forest fires, and after a large earthquake, when sediment supply outpaced sediment export. Combined with historical climate data, our record also identified a flood that dates to an extreme atmospheric river event in 1867. Dynamic river channels, driven by decadal-scale climate and extreme events, complicates the relationship between climate change and flood hazard in western Washington.

Keywords : paleofloods, alluvial fan, wildfire, sedimentation

Holocene chronology of the climatically driven Ureg-Nur lake level transformation, Inland Drainage Basin of Mongolia.

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Abstract :

One of the sections of the global watershed between the basin of the Arctic Ocean and the Inner Basin of Mongolia, which belongs to the drainless basins of Central Asia, is located in the mountains of Altai and Tuva, Russia. The position of the Dzhulukul neotectonic depression on this watershed largely determined the direction of the Pleistocene and the early Holocene melt water runoff from the glaciers, as well as from glacier- and moraine-dammed lakes. The direction of this waterflow during different periods was also controlled by development and degradation of large glaciers that occupied framing ridges.

The Ureg-Nur lake, located in neighboring areas of Mongolia, is one of the two large lakes, which received the water runoff from the Dzhulukul ice reservoir and melt water from mountain glaciers around it. The Kargy river flows into the Ureg-Nur lake. It originates in the Shapshal ridge and receives tributaries, which drains the slopes of the Shapshal and Mongun-Taiga ridges. The last one is the center of modern glaciation in the region.

At the stage of the Dzhulukul ice sheet development and early stages of its degradation the Kargy river received meltwater from these glaciers. Later, in the course of further deglaciation, water runoff from glaciers and from arise Dzhulukul lake (which was glacier-dammed at that time), started to flow in

opposite direction into Teletskoye Lake, i.e. into the Arctic Ocean basin.

In contrast to the Achit-Nur lake, which is transitional reservoir on the way to the Great Lakes Basin, the Ureg-Nur lake occupies a closed tectonic depression. It allows analyzing the position of lake shorelines to reconstruct the changes in the intensity and direction of river runoff.

This paper presents the results of field researches of lake shorelines accompanied by interpretation of space images and investigations of paleo- Ureg-Nur lacustrine deposits in more than 10 locations. 8 OSL and 1radiocarbon dates give chronological benchmarks of the Holocene lake level changes. The highest level was recorded at 1480 m a.s.l., which is 55 m higher than the modern one (about 1425 m a.s.l.).

Not so strong change in the lake area (in comparison with the nearest Achit-Nur lake) is stipulated by quite steep slopes of the tectonic basin. The wave-cut level of 1457 m a.s.l. is well expressed in topography, and indicates a prolonged balance between water inflow and evaporation during its formation. The dating results showed that the lake was the largest in size at the beginning of the Holocene, which may be due to the inertia of the degradation of the Dzhulukul ice reservoir. The Ureg-Nur water edge decreased practically to its current level no later than 5-3 ka – khereksur (Late Bronze - Early Iron Ages) and Pazyryk burial mounds (Early Iron Age) were erected on the surface of low terraces.

Study was supported by Russian Science Foundation (grant 22-27-00447).

Keywords : Inland Drainage Basin of Mongolia, Altai mountains, lake level fluctuation, Holocene

Assesing flood frequency with botanical evidence: a case study from the Asco valley, Corsica, France.

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Abstract :

Flood risk assessment and management typically rely on a flood frequency analysis (FFA), such that land-use planning and countermeasures can be designed for an expected discharge at a given location and a given return period. In mountain rivers, instrumental records are scarce and limited to short periods of the past. On vegetated embankments, floods can affect trees and leave injuries on their stems. Such botanical evidence is a valuable source of information to reconstruct past flood events over longer timescales and with annual resolution. For more than a decade now, the height of scars and the amount of tilting of stems have been used extensively as paleoflood indicators (PSI) to estimate flood magnitudes. In this study, we aim to expand the use of position of sampled trees combined with scar height to estimate past flood magnitude. To this end, we sampled 66 stems and 29 roots from Corsican black pines (Pinus nigra subsp. laricio) growing on the banks of the Asco river, Corsica and reconstruct 34 floods covering the period 1723–2020. We then combined tree position and scar height to model past events with a two-dimensional hydraulic modelling computed over a 1-m resolved topography. This combination allowed estimation of magnitudes for each of the reconstructed floods. Overall, our results highlight an increased flood activity between 1723 and 1786 and since 1905. At the opposite, less-than average flood activity occurred from 1804 to 1890. Based on these estimations we finally conducted a flood frequency analysis and show that the inclusion of both scars height and tree position allows more accurate estimates of future flood magnitudes.

Keywords : Flood frequency analysis;Tree ring;flood magnitude;flood frequency;Corsica

Resilience to future floods through flood memory approach: an example from West Bengal, India

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Abstract :

In the last two decades, considering the catastrophic flooding episodes worldwide, there is a gradual shift in the focus of mitigation approaches from 'flood management' (fight against the floods) to 'flood resilience' (living with the floods). Today, the core of flood risk management policies lies on the socio-ecological approach, that includes an operative involvement from the local community based on their experiences on the past flood episodes. Perhaps, the instances of taking this indigenous knowledge into account of flood mitigation planning is not very popular or frequently exemplified, where this could be the most dynamic tool for living with flood scenario. On this background, the present work aims to inspect the ways and approaches through which a local community memorizes the fury of floods, how this information can be put in a quantitative way and can be useful for avoiding future flood consequences in the state of West Bengal. In India, this state has been chosen for our flood memory research as floods has been intensely mediated through print newspaper, magazine, painting, and reports here. The present work considered the interdisciplinary methods of memory work, e.g., archival research, oral history interviewing, site-specific folklores and mythological stories, campaigns and exhibitions, and exploration of flood markers. A digital questionnaire-based survey is also conducted in the most flood-suffering wards (an administrative division) of Kolkata Municipal Corporation area in West Bengal and upon receiving the reactions, a Flood History Volatility Scale has been devised to test the strength of individual's flood memory based on some climatic and socio-cultural criteria. Perceiving the importance of community knowledge during the survey, a comprehensive flood risk management approach has been drawn up as a drive for flood risk reduction.

Keywords : Resilience, flood memory, archives, scale of volatility, risk management

Dendrogeomorphological variability of the Eistlenbach, Tschingelsee and Spreitlouwi alluvial fans, Bernese Alps

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Abstract :

Natural disasters leave their footprint on geomorphological landforms, affecting both the natural landscape and, in many cases, human settlements. Mountain regions such as the Swiss Alps are frequently affected by hydrological extreme events and, therefore, time series are important for risk assessment. Although historical evidence in small alpine catchments is rare, in the study area multiple events can be assessed from maps (since the first half of the 19th century), aerial photography (since the '20s of the 20th century), and historical photography and paintings (since '20 of the 20th century). Because the forest cover of alluvial fan also suffers the impact of flash floods and debris flows leaving evidence of impacts or changing tree-ring growth, the spatiotemporal reconstruction of extreme events can also be performed by dendrogeomorphology. The combination of dendrochronological data, historical cartography, and aerial images provides information about those small and large changes in landforms and land cover in the catchments, and it also allows us to distinguish between overflows of the fluvial channels and other natural phenomena or anthropogenic activities.

Dendrochronological samples from Picea abies trees were collected from three study areas, the Eistlenbach, Tschingelsee, and Spreitlouwi

basins, in the Bernese Oberland (Switzerland) in order to compare the historical flood series. At each site, a reference chronology was built to assess a correct dating of the samples; dendrogeomorphological analysis was performed to obtain disturbance evidence from tree rings; and finally, an estimation of tree age was calculated to date a minimum age of post-event surfaces.

In the case of the Eistlenbach and Tschingelsee catchments, two major floods completely changed the geomorphology of the alluvial fans, as was the case in 1949 in the former, where the flow path changed, and in 1972 in the latter, which dammed the main river of the Gornerewasser basin. In either case, part of the forest was razed, thus the tree ages date approximately the start of the recolonization. Additionally, in Tschingelsee the tree rings corresponding to 1937 and 1983 show many strong signals, which could have been caused by overflows in 1936 and 1982.

In the case of the Spreitlouwi fan, dendrogeomorphological evidence supplies the information obtained from aerial photographs showing patches of destroyed woodland. Trees which resisted the event showed disturbance evidence which could be dated and related to the Vivian storm, in February 1990.

The analysis of tree rings can reaffirm previously known information and provide new details, as in the rings corresponding to 1940 and 1981, with characteristic features in most of the trees from the different basins, which could be due to climatic conditions rather than to natural hazards.

Keywords : tree rings, dendrogeomorphology, floods, debris flows, Swiss Alps

OSM17: Dendrochronology: A flashlight into an elusive past and a tool for an uncertain future

Co-conveners: Aster Gebrekirstos, Shawn Marshall, Rob Marchant, Mark Bryan and Carolina Adler

Oral

Climate-growth relationships of the most dominant agroforestry parkland tree species (Vitellaria paradoxa C. F. Gaertner) in the Sahel of West Africa.

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Abstract :

Shea tree (Vitellaria paradoxa C. F. Gaertner) is an indigenous species endemic to the African savannas. It's the commonest species of agroforestry parklands found in semi-arid regions of West Africa. This species plays an important role in farmer's mitigation and adaptation strategies to climate change through its ecosystem services (oil, food, wood, fodder, medicine, skin ointment, carbon sequestration, micro-climate, less evaporation and more soil moisture, reduced soil temperature, etc.). Unfortunately, the species is declining in the Sahel including southern Mali because of its sensitiveness to recurrent drought induced by climate change. Understanding the underlining processes of such decline requires the knowledge of the impact of environmental factors for which dendrochronological approaches is used. Therefore, our study aimed to assessing the growth dynamics and response to climate change of V. paradoxa in Southern Mali. Twenty stem disks were collected from three land-use types (parklands, fallows and protected areas) in Koutiala and Yanfolila districts. A standard dendrochronological approach was applied on the sample in the laboratory to estimate the growth dynamics. The climate-growth relationships were investigated through multiple regression analysis between tree-ring index and climatic factors (rainfall and temperature). The results showed that V. paradoxa forms distinct growth ring boundaries despite most of the disks from parklands did not successfully cross-date due to management practices like pruning. The mean annual radial growth ring width of V. paradoxa ranged from 2.10 to 2.60 mm and 2.50 to 3.25 mm in Koutiala and Yanfolila, respectively. The ring width index (standard chronologies) showed a significant relationship with rainfall amounts in Koutiala ($r2 = 0.50$, $n = 45$ years, $p < 0.01$) and Yanfolila ($r2 = 0.66$, $n = 31$ years, $p < 0.01$). However, no significant correlation was found for temperature either in Koutiala ($r2 = -0.20$, $n = 31$ years, $p > 0.05$) or in Yanfolila ($r2 = 0.1$, $n = 31$ years, $p > 0.05$). These results suggest that climate change could affect the growth of V. paradoxa in southern Mali. In addition, the significant relationship with rainfall events indicates the potential of dendrochronology to reconstruct past climate events in Mali.

Keywords : Annual radial growth, Climate change, Dendrochronology, Southern Mali, Vitellaria paradoxa

Dendrochronological dating of wildfires in Mordovski Nature Reserve (Central Russia).

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Abstract :

Mordovski reserve is situated in nemoral forest zone, though it is dominated by pine forests, vulnerable to wildfires, due to the sandy substrate of alluvial and fluvioglacial terrain. Massive fires were recorded in the reserve in 1938, 1972, 1991, 1992, 2010 и 2021 years. To lengthen the fire history and to record local minor fires, in 2020 we started collecting dendrochronological material to cover the whole territory of the reserve. We cut cross

sections of fire-scarred fallen pines and sample live trees with a Pressler increment borer for further cross dating of the dead wood. In those places where we can't find fallen trees, we sample fire-scarred trees with the borer. At the moment, 158 tree-ring chronologies are built (65 based on cores and 93 on cross sections) and 78 fire dates are obtained. The average age of the sampled trees is 130 years, the maximum is 231 years. The largest number of fires recorded by one tree is 8. The years of fire detected on three or more samples are: 1888-1889, 1906-1907, 1938, 1943, 1977-1978. It's interesting that we didn't come across a tree with the scars from 1972 or 2010, the years of largest fires in the region.

Cross correlation analysis of ring-width index series from individual trees identified two clusters where the cross-date index (CDI offered by TSAP-Win software) increased to 50-80 between trees in a cluster and fell to 20-30 between trees from different clusters. Quite clearly, these clusters correspond to two types of habitats. The first belongs to well drained sandy and sandy-loam plains with pine and spruce-pine forest with sparse underwood vegetation; the second belongs to relatively wet sandy plains with shallow bed of moraine loams with spruce-pine forest with an admixture of maple, linden and oak and dense underwood vegetation.

Multiple regression analysis was used to examine the contribution of climate to ring index variation in two chronologies built for each cluster. Both chronologies show a high association with winter and spring precipitation and temperature difference between July and January. The regression equations describe the radial growth with medium accuracy (R2 0.42 and 0.58), though with a low error probability (p-value<10-6), this may be interpreted as an undoubted but not absolute influence of climate. The high difference between regression line and actual chronology could be a marker of an extreme event, including fire. For example, the tree ring decline in 1981 contradicts climatic factors, however, our study revealed a fire in 1980 from one sample. This date needs to be corroborated by additional material, but a connection is highly likely.

The research was supported by RFBR, project No 20-05-00234.

Keywords : nemoral forest zone, fire-scarred pines, cross-dating, regression analysis, habitat

Multi-parameter temperature reconstruction of the past 400 years for the Carpathian Mountains from tree rings.

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Abstract :

Instrumental data derived from meteorological stations provide a relatively reliable record of climate variability for most parts of Europe for the last century. Efforts have been made to extend these records further back in time using a range of proxy-based climate reconstructions. Nevertheless, some parts of central and eastern Europe still remain underrepresented, leading to gaps in high-resolution climatic information even in recent centuries. Additionally, the generally weak climatic sensitivity of available proxy records reflects limitations in data quality and is linked to large uncertainties. Within the scope of the REPLICATE project, we aim to address this deficiency by utilizing various tree-ring parameters from temperature-sensitive Norway spruce (Picea abies) from the Carpathian Mountains. Based on a collection of over 18 000 high-elevation Norway spruce tree ring samples from 37 treeline or near-treeline sites, robust chronologies covering 300-400 years have been developed for each location. These chronologies, broadly grouped into four

sub-regions (i.e., northern Slovakia, western Ukraine, northern and central Romania), will be used to develop a set of temperature reconstructions throughout the region. By doing so, we will contribute to filling in the spatial paleoclimatic and data quality gap in central-eastern Europe. To improve the climatic signal, we utilized a combination of tree ring width (TRW) series corrected for non-climatic (disturbance) trends and blue intensity (BI) series derived from a subset of scanned sample images as a surrogate for maximum latewood density. We have also developed a novel tree-ring parameter similar to BI based on high-resolution reflected light microscope images of the tree sample surface – termed surface intensity (SI) – which accounts for resolution and color bias limitations commonly encountered in BI datasets. Additionally, traditional thin section-based quantitative wood anatomy (QWA) parameters and their reflected light surface imaging-based counterparts (sQWA) were also included. Integrating this range of tree-ring parameters in a complementary fashion helps isolate, optimize, and extract stronger climatic signals by accounting for and minimizing a range of parameter-specific limitations and biases, yielding improved calibration with a more accurate representation of low-frequency climatic trends and high-frequency extremes. From these multi-parameter tree-ring chronologies, annually resolved, robust, high-quality summer temperature reconstructions extending to the early to mid-17th century are under development for the Carpathian mountain range. Initial results indicate that the reconstructions based on this multi-parameter approach can produce paleoclimatic records with reduced uncertainty that explain between 50% and 60% of the regional temperature variability. These reconstructions will contribute to a more highly-resolved temperature dataset in a part of Europe with considerable research potential, resulting in an improved spatial representation of past European temperature fluctuations. This will also provide a reliable historical context to evaluate return periods and magnitudes of temperature extremes, and contribute to assessing potential future socio-economic impacts of climate change (e.g., on agriculture) and developing possible mitigation solutions.

Keywords : paleoclimatological reconstruction, multi-parameter analysis, high-resolution imaging, non-climatic biases, Norway spruce

High-resolution wood surface imaging for dendrochronology: towards the development of unbiased reflected light timeseries.

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Abstract :

Climate change is a global-scale issue of societal, economic, and political importance and so understanding the climate of the present within the context of past climate variability is of vital importance. Dendroclimatic reconstructions play a key role in contextualizing recent climate change by improving our understanding of historical climate conditions. The climatically-sensitive blue intensity (BI) tree-ring parameter is gaining prominence as a more affordable and accessible alternative to traditional X-ray densitometry. Yet the accurate representation of low-frequency trends and high-frequency extremes using scanner-based BI remains a challenge due to color-related biases and resolution limitations. As part of the REPLICATE project, which aims to develop a set of robust multi-parameter temperature reconstructions from Carpathian Norway spruce (Picea abies) tree rings, methodological advances in sample surface preparation, imaging and measurement techniques have produced series analogous to BI from ultra-high resolution (~74 700 true dpi) images. Series from these microscope-based reflected light images of the tree-ring sample surface, termed surface intensity (SI), represent

the binary (black-white) segmentation of wood anatomical structure, which approximates anatomical density. By eliminating color altogether and using a high-resolution system, the most substantial drawbacks of scanner BI (i.e., discoloration and resolution biases) are bypassed and hence climate signal optimization is achieved by more accurately representing low-frequency climatic trends and high-frequency extremes. A comparison of SI chronologies with a multi-parameter tree-ring dataset from a large-scale parameter assessment study by Björklund et al. (2019) showed that this novel SI parameter can outperform its BI couterpart in terms of common signal (interseries correlation) and climate signal strength, and that it is on par with the best-performing X-ray densitometric chronologies. However, existing programs are not currently designed to effectively capture SI measurements and so additional development of measurement software is required to unlock the full potential of this new parameter. Continued improvement of high-resolution imaging techniques will aid the attainment of unbiased long tree-ring chronologies by overcoming color biases and resolution issues, but also holds promise for the development of surface quantitative wood anatomy (sQWA) datasets from reflected light images of samples. These improvements will therefore not only lead to more accurate dendrochronological paleoclimatic records and climate reconstructions but will also find future application in a broad range of dendrochronological contexts.

Keywords : high-resolution imaging, reflected light microscopy, blue intensity color biases, climatic signals, tree rings

Aquatic and terrestrial primary production under climate warming conditions in a low atmospheric nitrogen deposition site in southern central Siberian mountains.

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Abstract :

The effects of global warming on ecosystems are usually masked by other global, regional and local interacting factors, such as atmospheric nitrogen deposition. In order to avoid the interaction between these two global ecology processes, we selected a study site with relatively high warming but minimal atmospheric nitrogen deposition rates: the Ergaki Natural Park in the Sayan mountains, southern central Siberia. This study assesses the last century history of climatic and nutrient controls of primary production in three mountain lakes phytoplankton and Pinus sibirica growing nearby the lakes by using paleolimnological and dendrochronological approaches.

Low atmospheric nitrogen deposition in the region was confirmed by atmospheric deposition measurements (less than 119 ± 71 mg NO3-N m−2 yr−1) and records of nitrogen and d15N in lake sediments. Besides that, we detected two dramatic events of terrestrial material input in two of the lakes during the last century (at 1920-46 and 1978-80), whose origin is not clear yet (avalanches, wildfires, etc.).

Phytoplankton in the studied lakes was not clearly nitrogen-limited, as expected, but in a regime that repeatedly shifted between nitrogen and phosphorus limitation. Temperature increase could not raise up phytoplankton primary production, but it allowed eutrophication to occur if an extra nutrient load was locally added to a particular lake. As for Siberian pines, radial growth clearly increased during warmer years, whereas it decreased in the case of humid winters that would likely entail delayed snowmelt and shorter vegetative seasons. Water availability was also a limiting factor, especially in one of the

three sites. Finally, potassium was a limiting factor, whereas phosphorus did not.

In conclusion, the lack of significant atmospheric nutrient deposition resulted in a variable nutrient limitation regime in lakes and primary production in contiguous aquatic and terrestrial ecosystems were ruled by clearly different combinations of climatic and nutrient factors despite the important nutrient fluxes from terrestrial to aquatic environments.

This work was funded by the Russian Foundation of Basic Research grant number 20-04-00960 and the Ministry of Science and Higher Education of the Russian Federation grant number FSRZ-2020-0014.

Keywords : Siberia, Sayan mountains, atmospheric nitrogen deposition, climate warming, lake paleolimnology, Pinus sibirica, dendrochronology, pigments, nutrient limitation

Partial least squares regression for dendroclimatic reconstructions: new perspectives.

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Abstract :

Statistical reconstruction approaches, such as scaling and regression, are widely used in dendroclimatology. Principal component regression (PCR) is probably the most widespread reconstruction method, being used in drought atlases all over the world. Another multiple linear regression method - partial least squares regression (PLSR), is less commonly used in dendroclimatological studies. It originated from social sciences but found its broad application mainly in chemometrics. A principal difference between PLSR and PCR is that when constructing latent variables (which in the case of PCR are called principal components) from the initial predictors, the latter method maximizes the explained variance in the set of the predictors, while the former method maximizes the explained variance in the dependent variable.

Here we studied two dendrochronological datasets from different regions: 63 chronologies from Tierra del Fuego (Southernmost South America) and 40 chronologies from European part of Russia. The target variables were austral summer temperature and summer scPDSI respectively. We showed that PLSR has improved performance over principal PCR in the case of multiple tree-ring predictors. Additionally, PLSR showed signs of better extraction of climatic signal from large datasets of tree-ring predictors. According to these results, PLSR may be a preferable method over PCR for the use in automated tree-ring based reconstruction approaches, akin widely used point-by-point regression.

Keywords : partial least squares regression, principal component regression, dendroclimatology, statistical methods

Tree-ring anatomy and climate models agree – recent warming unprecedented in the past millennium.

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Abstract :

Climate reconstructions from proxy archives and climate models form the basis of understanding past climate variations, where the reliability of future model simulations is strengthened if they are in broad agreement. Tree-ring data has mainly driven the explosion in studies characterizing temperature change of the Common Era but face various critiques – not being able to capture long term climatic trends, for portraying too much climate variability on decadal to centennial time-scales, or for rapidly fading in quality and replication back in time. These and other shortcomings limit tree-ring data to reliably and consistently capture the full range of natural and anthropogenic

temperature variations, and hampers model/proxy compatibility.

Here we present innovative proxy evidence from tree-ring anatomy that mitigate many of these issues. The ensemble average of anatomical features of latewood tissue from Fennoscandian Pinus sylvestris trees explains >70% of the variance in local to regional warm season temperatures, captures the full variability of both hot and cold extremes and exhibit rapid recovery from devastating weather events and thus very little biological memory. The new temperature reconstruction reveal that the last hundred years were significantly warmer than any other century during the past 1169 years, in contrast to earlier attempts using state-of-the-art tree-ring density data, but in agreement with a geographically corresponding CMIP5/PMIP3 model ensemble. The subdued context preceding the dramatic recent warming emphasizes how extreme the 2018 heat wave was in the region, and how commonplace such agricultural and health related stress likely will become in the immediate future, regardless of emission scenario.

Keywords : Dendroanatomy, CMIP5, PMIP3, temperature reconstruction

Carbon isotope analysis in baobabs rings provides an insight into the past and future of the southwest Madagascar.

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Abstract :

Assessing the risks and likely trajectories of future climate change requires an understanding of rainfall drivers over time but such analysis could only be done through highly resolved climate records. Despite the development of methodologies to develop climate reconstructions using proxies, dendroclimatology is very limited in tropical regions, particularly in Africa. We measured the variation in the carbon isotope composition of baobab (Adansonia spp.) rings which reflect rainfall in southwest Madagascar which will ultimately help to understand the climate systems in Southern Africa. Despite the challenges related to the validation of the chronology, the records cover a few centuries showing a higher variability in rainfall amount at a centennial scale. The preliminary results found that the duration of wetter periods decreased over time with the wettest periods between AD 1350 – 1450, after the onset of the Little Ice Age, while the driest period occurred between AD 1600 – 1750, during the Maunder Minimum. Wetter periods are regulated by the movement and migration of easterly winds linked to the Intertropical Convergence Zone, while dry periods are influenced by the effect of the Pacific Decadal Oscillation linked to the El Niño Southern Oscillation and the sea surface temperature variation in the Southwestern Indian Ocean. In more recent years, the combined effect of sea surface temperature and land-use change have affected the rainfall in the region. This evidence provides a new understanding of rainfall across southern Africa and the interaction of global forcing with regional factors thereby assisting with future projections and downscaling. This information will be essential in assessing likely scenarios of resilience, the vulnerability of social-ecological systems in Madagascar, and potentially inform more sustainable management of the island's biodiversity for its population.

Keywords : Carbon isotope, baobab rings, rainfall reconstruction, southwest Madagascar

Poster

Climate-growth relationships of two valuable Anacardiaceae species in Burkina Faso, West Africa.

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Abstract :

West African trees strongly contribute to livelihood supports and climate change mitigation through carbon sequestration. Yet, current anthropogenic pressures and climate change threaten the populations of socio-economically and ecologically important tree species, thereby, affecting negatively ecosystem dynamics, functioning and services. Assessing tree growth dynamics in such context is mandatory for understanding ecosystem responses to climate change, a prerequisite for forest resource management and sustainable utilization. This study used tree ring records to assess the impacts of climate variability on tree growth of two deciduous anacardiaceae species with high socio-economic significance in West Africa. The study species were Lannea microcarpa (Engl. & K.Krause) and Sclerocarya birrea (A.Rich.) Hochst commonly known as African grape and marula tree, respectively. Both species occur in the semi-arid areas of West Africa and have a valuable socio-economic importance through their edible fruits.

Methods A total of eight (8) stem discs, four (4) discs per species, were collected from died trees of both species in a communal reserve belonging to the Sudano-sahelian climatic zone in Eastern Burkina Faso. Standard dendrochronological methods were used to process wood samples and measure ring-widths. Cross-dating of ring series was performed within tree and between species, and the mean curves of best cross-dated series were used to build mixed-species chronology. To analyze climate-growth relationships, Pearson correlation tests were performed using ring width index and climate data.

Results and Discussion Both L. microcarpa and S. birrea showed distinct growth rings demarcated by thick marginal parenchyma bands. Cross-dating was successful within disc and within species. Seven out of eight trees successfully cross-dated between species (87.5%) spanning 1991–2020. The mean GLK and T-value of the chronology were 86.83 ± 8.765 and 3.758 ± 1.645, respectively. The mean growth rates of L. microcarpa (2.897 ± 1.076 mm. year−1) and S. birrea (2.386 ± 0.068 mm. year−1) were not statistically different (p-value > 0.05). Wood density ranged between 0.772 ± 0.032 g.cm−3 (L. microcarpa) and 0.797 ± 0.003 g.cm−3 (S. birrea). Pearson correlation tests showed that residual ring width index positively correlated with total annual precipitation (r = 0.719; p-value = 7.458e-6) and mean seasonal precipitation (r = 0.478; p-value = 0.007). Yet, no significant correlation was found ring width index and temperature. These finding support that rainfall controls tree radial growth of L. microcarpa and S. birrea in the study area.

Conclusion This study demonstrated that L. microcarpa and S. birrea respond to rainfall variability in West African region. Therefore, these species present high potential for dendroclimatic studies. The short time span was due to the sampling of smaller trees. Accordingly, sampling of big trees of both species may enable long-term climate reconstruction for West Africa.

Keywords : Valuable species; Tree growth; Climate variability; Sudanian region; West Africa

Applying charcoals from iron smelting furnaces for dendrochronological investigations in Russian Altai.

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Abstract :

The presented study is aimed on solving one of the main fundamental problems of historically oriented sciences (geology, paleogeography, paleoclimatology, archeology etc.) - the development of new and improvement of already known methods of numerical dating of natural and archaeological events. Within the framework of this problem we focused on the one of the most precise - with an accuracy of a

year and even a season - dendrochronological method.

In natural and in archaeological sciences there is a problem of dating past events, which duration is obviously much shorter than the accuracy of applied geochronological methods. In some cases, such problems can be solved by applying dendrochronology. This technique is based on studying of tree rings: both from cores from living trees and cuts from fossil or paleotrees. In our study we have expanded the limits of dendrochronological approach by involving charcoals as dating material.

The southeastern part of Russian Altai (SE Altai), examined in this study hosts an extraordinary number of archaeological sites, which vary from the Late Paleolithic time to the Turk khaganates and Mongol empire. The arid climate, widespread permafrost and low population density support good preservation of ancient monuments and offer a unique opportunity to study the rich historical heritage of the region. SE Altai is an area of ancient bronze and ferrous metallurgy and pottery production, that determined the large amount of ancient iron smelting furnaces in the region. This fact stipulated the presence of the large amount of charcoals of similar age, that support the success of dendrochronological dating.

During the long-term geological, geomorphological and geoarchaeological investigations more than hundred fragments of charcoals were collected. Sample preparation procedures were developed to have an opportunity involving them into dendrochronological dating.

Generally, 3 long regional tree-ring chronologies (TRC) were built: first one - 162 years long (1353 measured tree rings, 12 individual series with an average length 112 years); second - 293 years long (952 measured tree rings, 11 individual series with an average length 86 years); third - 176 years long (582 measured tree rings, 6 individual series with an average length 97 years).

Further perspectives we associate with the assignment of the developed TRC with the calendar time scale applying absolute regional tree ring chronologies and/or the AMS 14C dating with further applying “wiggle matching" procedure. Until now, charcoals have not been used for constructing long tree-ring chronologies.

Dendrochronological dating on charcoals, besides the evident methodological aspect, will make it possible to solve various problems of regional paleogeography, paleoecology, paleoclimatology, archeology, in particular, to clarify time periods of forest development in now forestless areas in the highlands of Russian Altai; to establish the time and reasons for deforestation of the region; to specify the time of operation of iron smelting furnaces in one of the most ancient metallurgical centers of Asia; to date the change in technology associated with the migration of nomads and shifting of archaeological cultures, etc.

Study was supported by Russian Science Foundation (grant 22-27-00454).

Keywords : tree-ring chronologies, charcoals, Russian Altai

Dendroclimatological studies in Solovki Islands.

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Abstract :

Solovki Islands (65°05′ N, 35°53′ E) is the place where dendroclimatology studies successfully applied because of its natural isolation where natural undisturbed forest is still exist, and long land development history that has started since the first monks settled in 16th century. Tree-ring network contains three types of wood: living conifers, architectural and driftwood. Annual tree-ring widths were measured for 420 samples, seasonwood widths were measured for 45 series and blue intensity were obtained for 350 samples. Such vast material measured for different species growing in different local conditions (from sea terraces to uphills) allowed us to identify climate response function in high detail. It was found that the limiting factor of growth of pine and spruce is different. Pine growth highly depends on local conditions, while spruce has a strong and temporally stable response to June temperature variations (R = 0.57). This signal is also spatially stable and

contained in all 13 local spruce chronologies developed for trees growing in different landscapes. Latewood width measured for pine showed dependence with precipitation in current July. Delta Blue Intensity (dBI) showed higher correlation with summer temperatures compared with widths-related parameters. In both conifers climate signal is spatially and temporally stable: all trees shows the same sensitivity regardless of its location and signal strength doesn't fall during the last 116 years. High sensitivity of dBI in conifers became a reason of successful cross-dating of driftwood. When dBI is used for dross-dating, coefficients of correlation are much higher compared to TRW.

As a result dBI was chosen as the parameter for climate reconstruction. Final dBI chronology consists of 300 samples in total and covers the period of 888-2016 CE. EPS exceeds the value of 0.85 starting from 1347s. Correlation of dBI chronology with summer temperatures achieved $r = 0.75$ ($p < 0.01$) and is stable over the last 116 years of period of calibration.

This research was funded by the Russian Science Foundation project no. 17-77-20123.

Keywords : climate reconstruction, Solovki Islands, conifers, Blue Intensity, tree-ring width, climate signal

Millennium length tree-ring anatomy from the iconic Yamal chronology.

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Abstract :

Tree-rings form the backbone in many Northern Hemisphere temperature reconstruction of the past millennium. A select few sites are nearly always included due to their length, skill and strategic location. The Yamal chronology from northern Russia is one of the most prominent examples, currently extending almost 9000 years back in time. Ring widths from this site have been repeatedly measured over decades and featured in numerous reconstructions and methods development articles. The most widespread tree species in the collections of subfossil wood samples is Siberian larch (Larix sibirica Ledeb.). Now the time has come to analyze a subset of these trees for quantitative wood anatomy to explore if it is possible to add a new set of skillful predictors and further strengthen temperature reconstructions from this region. Here we present the process of developing a >1000 years long dataset of tree-ring anatomy using methods largely developed or refined over the last decade at WSL Switzerland. The dataset will include >10 million analyzed cells feeding information to dozens of annualized parameters. The hope is that we will uncover temperature signals which at least in part are separated in seasonality from the one of ring width, and that statistical properties such as autocorrelation describing the biological memory of the formed wood tissue will behave similarly to instrumental observation, and in extension give a more precise representation of volcanic cooling events.

Keywords : Quantitative wood anatomy, Yamal Russia, Temperature reconstruction

OSM18: Using high-resolution marine archives to investigate marine climate, marine environment, and maritime societies through the Holocene

Co-conveners: Stella Alexandroff, Carin Andersson, Meghan Burchell, Paul Butler and Tamara Trofimova

Oral

Precise sea ice cover reconstruction with dendrochronology cross-dating methods applied to of Arctic coralline red algae Clathromorphum compactum

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Abstract :

Clathromorphum compactum is a coralline red algae species currently being developed as a marine sea ice cover proxy for arctic regions. It is a photosynthetic calcifying alga that produces annual growth increments in its calcium carbonate skeleton which can yield environmental data on a multi-centennial timescale. Previous research suggested that Clathromorphum compactum growth and magnesium-calcium ratios (Mg/Ca) are controlled significantly by sea ice cover (sunlight inhibitor) in regions with more than 7-months sea ice cover. However, studies that include multiple algal samples have demonstrated poor inter-sample replicability. This study applies dendrochronology cross-dating methods aimed at accurately dating algal growth increments to improve reliability of chronologies and produce well-dated proxy sea ice cover timeseries. We present the results of our proof-of-concept study of 3 samples from Lancaster Sound, Nunavut, Canada, showing how cross-dating offers useful tools to improve inter-sample correlation and provides statistics to assess the replicability of data between samples. The study site has already been proven to produce strong correlations with short-term satellite sea ice concentrations, though less than perfect inter-sample correlations and expressed population signal (EPS). We first used traditional age model construction methods to establish significant correlations between multiple measurements from the same sample. We then cross-dated samples and used COFECHA software to help flag problematic correlations of segments of age models. COFECHA also provided valuable statistics to assess the strength of the match between sample age models. Pointer years identified by very small increments or very large increments and/or abnormally high or low Mg/Ca ratios were used to tie sample sections together. We also detrended timeseries and isolated low-frequency year-to-year variability. Results show that inter-series correlations between samples significantly improve with the use of cross-dating methods. Master cross-dated algal growth increment width time-series were also compared to short and long-term regional sea ice chronologies and Arctic Oscillation and North Atlantic Oscillation records to assess the strength of sea ice reconstructions. The results suggest that non-cross-dated samples likely include dating errors and that cross-dated chronologies provide more reliable reconstructed sea ice cover data.

Keywords : Coralline red algae; dendrochronology; cross-dating; trace elements; growth increments; sea ice proxy; Arctic

Monthly resolved coral barium isotopes record increased riverine inputs during the South Asian summer monsoon.

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Abstract :

We present a monthly resolved stable Ba isotope record (δ138Bacoral) of a young fossil coral (Porites) from the eastern side of the Andaman Islands (NE Indian Ocean), which grew prior to the 19th century. This δ138Bacoral record complements 19-years of monthly resolved Ba/Cacoral, Sr/Cacoral, U/Cacoral, δ18Ocoral and δ13Ccoral data from the same colony that can serve as a baseline of environmental variability before the industrialised era. The δ138Bacoral record exhibits small but significant seasonal variability ranging from 0.16 ± 0.03‰ to 0.27 ± 0.03‰ over two continuous annual cycles. The δ138Bacoral signature is generally light during the South Asian summer monsoon (SAM, June-September) and post-SAM seasons (October-January), which are characterised by high Ba/Cacoral and more depleted δ18OSW values. We suggest that Ba desorption from suspended fluvial sediments followed by lateral advection are the main causes of the light δ138Bacoral and elevated Ba/Cacoral values during the SAM and post-SAM seasons. However, this promising Ba proxy behaviour is offset by pronounced spikes of light δ138Bacoral and high Ba/Cacoral observed during the pre-SAM season (February-May) throughout the 19-year record. Possible explanations for these spikes observed during dry seasons are (1) incorporation of barite formed as a consequence of phytoplankton blooms or (2) Ba release from sediments trapped by local fringing mangroves. Surface seawater from the coral site sampled over an annual cycle exhibits a wide range of dissolved δ138BaSW and [Ba]SW values, with significantly light δ138BaSW of 0.29 ± 0.04‰ and high [Ba]SW of 66.03 nmol/kg during the SAM, which is broadly consistent with the coral skeletal signals. Our results establish a clear link between monsoon-driven freshening events and Ba isotope variability of surface waters and assess the utility of coral skeletal Ba isotopes to trace riverine inputs to tropical coastal oceans.

Keywords : stable barium isotopes, coral proxy records, riverine inputs, the South Asian summer monsoon

A 23.7-year long daily growth rate record of a modern giant clam shell from South China Sea and its potential in high-resolution paleoclimate reconstruction.

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Abstract :

Tridacna spp. usually have annual and even daily growth bands, and thus provide great potential to be the high-resolution recorders of past climate and environmental changes of the ocean. However, current studies mainly focus on the geochemical records of Tridacna shells, the environmental and climatic implications of long time sequenced daily growth increments are relatively unexplored. In this study, based on the confocal microscopic line-scanning imaging, a 23.7-year long (from 5 June 1989 to 21 February 2013) daily growth rate (DGR) record of Tridacna gigas shell MD3 from southern South China Sea was established and its climatic implication was investigated. On seasonal scale, significant positive correlation was found between the DGR and sea surface temperature (SST). The main growing season of T. gigas MD3 was from March to August, when sufficient sunlight and warmer SST prevailed. While high rainfall (low sunlight) from September to December and low SST from December to March hindered the growth of the shell in autumn and winter. On an inter-annual scale, the DGR of the shell varied periodically on timescales of 2–3 years and 4–5 years, which possibly represented the impacts of the

Tropospheric Biennial Oscillation and El Niño-Southern Oscillation activities respectively. Our result suggested that the daily growth lines of T. gigas can establish an extraordinarily high-resolution chronology and have high potential to explore daily to inter-annual paleoenvironmental changes in tropical ocean. Compared with the paleoclimate reconstructions of geochemical approaches, this method has the advantages of low cost and short experimental time.

Keywords : Tridacna shell, Daily growth rate, Seasonal growth, Inter-annual oscillation, South China Sea

Dual Bivalve Analysis of Shellfishing and Palaeotemperature in Powell River, British Columbia (2682 cal. BP).

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Abstract :

Single-species analysis is a common practice in archaeological shell midden studies where there is a single, dominant species at the site. On the Pacific Northwest Coast, the most commonly studied species is Saxidomus gigantea, but Leukoma staminea, Tresus capax, cockles, barnacles, mussels, and whelks are present as well, although not as abundant. Shell midden sites from Powell River, British Columbia, contain an abundance of both S. gigantea and L. staminea. Using high-resolution stable oxygen isotope sclerochronological analysis (δ18O), we conducted a dual proxy analysis of S. gigantea and L. staminea to examine variation in δ18O, season of collection, and harvest pressure between the two species. Specimens were collected from six different archaeological shell midden sites ca. 2682-797 cal. BP from Powell River, British Columbia, in the traditional territory of the Tla'amin First Nation. Results show that S. gigantea had a δ18O range of -7.01‰ to -1.38‰, whereas L. staminea had a range from -5.83‰ to -1.2‰. This suggests that S. gigantea captures a greater environmental range and thus is potentially more sensitive to changes in its environment. Both species showed fluctuations on a seasonal basis, but there is a difference of 3.76‰ captured between the species. When converted using the Böhm et al. (2000) palaeotemperature equation, the sea surface temperature (SST) ranged from 6.1 32.0°C for S. gigantea and 5.3-26.7oC ∓ 0.62 oC for L. staminea. Measured sea surface temperature from local lighthouses recorded T between 5.7-20.4oC, suggesting an over-estimation of SST by 11.6 oC, indicating that the location is highly influenced by salinity. When the data from the two separate clam species are analyzed, a more nuanced interpretation of harvesting practices can be developed. Seasonally, S. gigantea was harvested only in spring, whereas L. staminea was collected in spring, summer, and autumn. Although seasonally the shells were collected at different times of the year, both species were harvested with the same levels of intensity. This suggests that S. gigantea is harvested very intensively in the spring, whereas L. staminea would have been harvested regularly throughout the year. When the data from both species is taken as a whole, the overall image of past climatic conditions and cultural practices is more refined.

Keywords : Sclerochronology, Palaeotemperature, Seasonality, Shellfish Harvest Intensity, Shell Midden, Archaeology

Corals record deforestation in Malaysian Borneo through enhanced sedimentation.

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Abstract :

Industrial-scale deforestation in Malaysian Borneo has heavily impacted terrestrial ecosystems since the 1970s (Gaveau et al., 2016). Biodiversity loss as well as land erosion are only two of the many consequences forest clearance has had for the last 50 years. Deforestation has created erosion hotspots and

models estimated it to be responsible for the loss of 28 t h-1 year-1 of soil in 2017 in Malaysian Borneo (Vijith et al., 2017). However, these estimates heavily rely on the accuracy of satellite and topographic data as well as soil maps, which make them very limited in time by the availability of observational data.

In this study we circumvent the issue of data scarcity and use the skeletal barium to calcium ratio (Ba/Ca) in massive Porites spp. corals off the coast of Miri in Malaysian Borneo as a proxy for river discharge and land erosion. This non-quantitative record allows us to uncover past variations and thus compare soil loss from the beginning of industrial-scale deforestation to the present thanks to the creation of two composites based on five different cores.

Results show a significant Ba/Ca increase across the two composite records concurrent with river discharge from 1990 to 2015. The similar slopes between records and river discharge are indicative of the ability of coral Ba/Ca ratios to accurately record sediment input in the marine environment through river discharge in coastal environments close to river mouths.

Findings highlight the steady rise of land erosion and soil loss through time and showcases the need for new deforestation regulations to limit the human impact on both terrestrial and marine ecosystems. More importantly, this study marks the need to access proxy records that go further back in time before industrial-scale deforestation to establish a baseline value of land erosion that can be used to assess the current and possible future trends of sediment input into marine environment and how both are influenced by deforestation and land use.

Keywords : Coral, proxy, land use, Southeast Asia

Unlocking Western Tropical Indian Ocean temperature and hydroclimate back to the Little Ice Age, reconstructed from coral geochemistry.

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Abstract :

Indian Ocean sea surface temperatures (SST) have a profound influence on precipitation over the tropics and Indian Monsoon regions. Sea surface salinity (SSS) reflects the near surface evaporation-precipitation (E-P) balance and its seasonal and interannual variabilities were found to be majorly impacted by monsoonal precipitations and the Indian Ocean Dipole (IOD) (Vinayachandran and Nanjundiah, 2009; Grunseich et al., 2011). Furthermore, teleconnections between Indian Ocean Monsoon system and El Niño–Southern Oscillation (ENSO) have been reported in many studies (e.g.: Cai et al., 2011; Achuthavarier et al., 2012). Further global warming is thought to increase the probabilities of extreme weather conditions, which can exert great economic and social impacts. Advanced knowledge of past SST and hydroclimate variability over the Indian Ocean is therefore crucial for characterizing natural climate variabilities and recognizing anthropogenic impacts, which can help yield more reliable predictions for future climate.

Coral cores are of vital importance to reconstructions for site-specific variability in SST, SSS, ocean advection and the hydrological balance, providing insights into past climate change in the tropical oceans (Grove et al., 2013). Here we present first data for multi-site temperature and hydroclimate reconstructions based on coral geochemistry from north and northeast Madagascar with bimonthly to monthly temporal resolution, dating back to early 20th century. Coral record of skeleton oxygen stable isotope (d18O) is coupled with Sr/Ca (U/Ca) ratios to reconstruct past variations in seawater d18O (hydrology) by subtracting the thermal component of d18O based on the Sr/Ca (U/Ca) - SST estimates (Zinke et al., 2008). We aim to assess natural changes in the teleconnectivity of the western Indian Ocean for both SST and SSS with the tropical eastern Indian Ocean and the Pacific. Evolution of land-ocean climate teleconnections will be assessed by comparing our data to terrestrial climate archives and instrumental climate data from Sub-Saharan Africa and Madagascar.

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Keywords : Western Indian Ocean, Coral d18O, Coral Sr/Ca, El Nino-Southern Oscillation, SST

Development of the Nile Littoral Cell since 8 kyr BP.

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Abstract :

The depositional history of the Nile Littoral Cell (NLC) in the past 8.2 kyr was reconstructed from two radiocarbon-dated cores retrieved down-flow the Nile Delta at the southeastern Mediterranean-Levantine continental shelf. The two cores are located ~80 km apart at the inner shelf off-shore Israel: core V115 at a southern proximal site and core V101 at a northern distal site. Grain-size distribution, chemical composition, and eNd and 87Sr/86Sr isotope ratios and marine derived variables such as carbonate content, total organic carbon and its 13C composition record the temporal and spatial variations in transport processes and sediment provenance.

From ~8.2 to ~5.5 ka BP the record is dominated by coarse quartz sands from the Nile Delta front that were recycled along the NLC due to shelf transgression along with the post glacial sea level rise. Oligotrophic conditions prevailed in the inner shelf, and the relatively high carbonate content reflects the decrease in Nilotic fine particles due to increased vegetation and decrease in surface erosion related to the African Humid Period (AHP) wetter conditions. The chemical and isotope signature of the fine fractions indicates mostly remobilization of dust-driven surface cover soils from the surrounding lands that originated from the granitoid terrains of the Sahara-Arabia deserts.

Sea level stabilization, termination of the AHP at ~ 5.5 ka BP and the partial drying of the Ethiopian Highlands resulted in the increase of fine sediments with a basaltic signature. After ~5.5 ka BP, fine sediments were supplied seasonally by the Nile, creating a distinct mud belt along the Israeli coast and Nile Delta at water depth exceeding ~35 m. Occasional sediment coarsening in the distal NLC likely reflects periodical decrease in Nile floods discharge or contribution from shallower water depth due to increased storminess. With the continuation of the regional aridification and decreasing intensity of the Nile River flow during the last 2 kyr, higher contribution of surface cover particles from the nearby lands was recorded in the distal northern site, while the southern site continued to be affected mostly by the Nilotic contribution.

A distinct increase in grain size and carbonate content, and decrease in TOC content and d13Corg values at the topmost part of the sedimentary record represent the Nile River damming during the modern period, which resulted in halting of the Nile fine suspension and lead to ultra-oligotrophic conditions in the Levantine basin.

Keywords : Nile River, East Mediterranean, Desert dust, Loessian soils, African Humid

Period, Holocene aridification, hydro-climatic conditions, 87Sr/86Sr- eNd isotopes, sea level transgression.

PhD candidate

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Abstract :

Fossil reef records can provide extremely valuable information about conditions (physically, environmentally, and biologically) past reefs had to grow in and about the resilience of certain communities. This information is crucial for researchers to understand how and in which terms reefs can survive future disasters. Located at the northern end of the Gulf of Aqaba (GoA), the fringing reefs of Eilat are spatially restrictive but nonetheless significant as they represent the northernmost extent of coral reefs along the 2000 km Red Sea inlet. It is unknown when these coral reefs were first established as the Red Sea is considered to have been too saline to support coral habitats during the last glacial maximum (LGM). Here, we set out to reconstruct the paleoecology and growth history of this unique coral reef environment in order to better understand the rate of Red Sea coral recolonization following the termination of the LGM, how the coral community has changed over the years and how changes in climate during the Holocene and Anthropocene may have impacted coral growth and development at this site. Following a drilling campaign in the Eilat Nature Reserve, seven reef cores were recovered from backreef, forereef, and flatreef environments. The lithology of the cores was described and pristine coral fragments were collected throughout five select cores and used to establish a 14C and U-Th-based chronology. In each of the cores, we report the community structure of corals, CaCO3 content, grain size distributions, and the δ18O and δ13C of the coral fragments. Results indicate that the Eilat coral reefs existed for at least ~6,600 years and had continued growing over ~2000 years. Hiatus- a period where no coral evidence could be found, is clearly seen in all reef areas between ~4500-1000 ya BP (years ago before present) and probably attributed to sea level, tectonic faults, or both. The re-initiation of the reef ~1000 ya is striking and proves the Eilat's reef can survive such catastrophic demise. Reviewing all global hiatus sites contributed to the presumption that a global phenomenon may be responsible for reef shutdown in distinct and remote environments.

Keywords : GoA, Reef cores, Paleo-environment, Sea level

Dissolved heavy metal incorporation into the skeleton of Porites corals based on multi-element culturing experiments.

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Abstract :

Coral reefs house an extraordinary biodiversity and provide fish, a tourist attraction and natural shoreline protection and are therefore vitally important for society. Anthropogenic influences like ship traffic, agriculture, urban runoff or mining have increased the level of dissolved heavy metals in some tropical near-shore environments threatening reef ecosystems. Monitoring of the ecosystem status by using chemical tracers in sessile organisms has become increasingly important for reef risk assessment and environmental management. The skeleton of stony corals like Porites species provide a high-resolution geochemical archive for the recent and historical heavy metal concentration in ambient seawater, yet there are little calibration data directly comparing metal concentrations in water and coral skeletons. To address this, culturing experiments exposing Porites lobata and Porites lichen colonies to a mixture of dissolved chromium (Cr), manganese (Mn), nickel (Ni), zinc (Zn), silver (Ag), cadmium (Cd), mercury (Hg) and lead (Pb) over a wide concentration

range have been performed. Water samples were taken frequently to monitor expected changes in the heavy metal concentration due to adsorption. The concentrations of some metals declined as anticipated but stabilised a few days after the input of the high metal stock solution. Laser ablation ICP-MS measurements of the coral aragonite revealed metal concentrations that were positively correlated with Cr, Mn, Ni, Zn, Ag, Cd and Pb concentrations in the culturing medium. Cu and Sn showed no variance as the variation in the concentration of these metals in the experimental seawater was minimal. Hg did not exhibit any clear trend, even though the Hg concentration in seawater varied by a factor > 5 between phases. The calibrations and calculated partition coefficients for some metals enable a reconstruction of the heavy metal concentration in seawater for ecosystem monitoring and potentially century long records revealing baseline values before large-scale human disturbance.

Keywords : seawater heavy metal pollution, Porites coral

200 year high resolution proxy record from NW Australian corals capturing Indo-Pacific hydroclimate variability.

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Abstract :

Geochemical proxy records from stony corals provide a useful, high resolution archive of past climatic conditions. In the tropical oceans, which are critical sources of heat and moisture for the global climate system, these records are particularly crucial since instrumental data are often short and spatially scarce.

Here, we present a coral-based hydroclimate reconstruction of the past 200 years from the Indonesian Throughflow (ITF) outflow region into the south-eastern Indian Ocean along the North West Shelf of Australia, a key region for Indo-Pacific climate connectivity. Our objective was to assess the role of tropical Pacific forcing on Indo-Pacific sea surface temperature (SST) and salinity exchange through the El Niño-Southern Oscillation (ENSO) in concert with Indian Ocean Dipole (IOD) events. Paired Sr/Ca and δ18O analyses from modern Porites sp. corals from Browse Island enabled the reconstruction of both SSTs and the oxygen isotopic composition of the seawater (δ18Osw). We have carried out a replication study of cores from two coral colonies from different locations around the island, covering the satellite based instrumental data period back to 1982. Through the calibration and comparison with instrumental and modelled data, we demonstrate that reliable climate records can be generated from the Browse Island coral cores, indicating the expansion of the Indo-Pacific warm pool into the Indian Ocean, as well as correlation of the coral proxies with large scale interannual variability. Our long core coral record shows good agreement with the instrumental data until approx. the 1950s. Prior to that, we have identified decades where instrumental observations diverge from the coral-based reconstructions. These periods include the World War II period, known for biases in ship-of-opportunity SST records. A preliminary comparison to an ITF transport time series revealed excellent agreement. While the imprint of the IOD seems to be rather reflected in sea surface temperature anomalies in the region, the influence of ENSO is recorded in hydrological anomalies because of changes in ocean advection, e.g. Indonesian Throughflow dynamics, and/or precipitation.

Our long, highly resolved proxy record presented here will enhance our understanding of climatic and oceanographic processes in a globally important ocean gateway, far beyond the current observational capacities, thereby critically informing decision makers on the role of the Australian shelf in regulating regional climate (Australia, Maritime Continent, Western Pacific) and further afield (elsewhere in Asia, Africa and western Indian Ocean).

Keywords : corals, sst, salinity, ENSO, IOD

Warming the cockles of El Niño's heart: Tracking ENSO in Trachycardium procerum from coastal Peru

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Abstract :

Because of the substantial and widespread impacts of El Nino Southern Oscillation (ENSO) events on global climate and the associated influences on societal and economic conditions, characterizing the frequency, magnitude, and types of ENSO events (so-called flavors) during the Holocene is of great interest. Archaeological evidence is essential for understanding the role of humans and climate throughout space and time, and the Peruvian coast is both a core region for ENSO and one of the world centers for the prehistoric development of complex societies. Developing accurate climate proxies using archaeological remains often relies on ground truthing such records. In this study, we collected live caught mollusks (T. procerum) from coastal Peru in 2017, 2019, and 2021 to evaluate how faithfully these archives record ENSO events in their shells. High resolution (daily to weekly) oxygen isotopes reveal baseline variability during normal, El Nino, and La Nina conditions related to sea surface temperature conditions that are statistically unique. Based on this result, it is likely that shells of this species from the archaeological setting in coastal Peru can provide a time history of ENSO conditions. Future work is required to confirm our preliminary results suggesting that the geochemistry in these shells can determine the different types of ENSO events.

Keywords : ENSO, El Nino, La Nina, mollusks, sclerochronology

Developing multi-centennial shell-based records from the Mid-Atlantic region

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Abstract :

Warming in the North Atlantic Ocean has been heterogeneous in recent decades, with locations along the eastern United States seaboard (northwestern Atlantic) seeing some of the largest and fastest warming in the last 100 years. In order to provide a longer temporal context for these changes, we are in the process of developing several master shell growth chronologies and associated geochemical records from the Mid-Atlantic coast using the shells of the long-lived marine bivalve Arctica islandica. Based on the shell collection locations (shelf regions off Ocean City, Maryland in ~ 61 m water depth and Long Island, New York in ~47 m water depth) and shell geochemistry measurements, we will be able to better ascertain hydrographic spatial and temporal variability of subtropical Atlantic water moving northward through time. These findings will be integrated with similar sclerochronology datasets previously published from the Gulf of Maine region and several others from the Mid-Atlantic region that are currently being constructed. Collectively, this network of sclerochronology records will allow us to better characterize changes in the northwestern Atlantic and provide hydrographic insights beyond the relatively short instrumental record and evaluate potential dynamical forcings through time.

Keywords : sclerochronology, mollusks, North Atlantic Ocean, climate, ocean

Oyster Middens of Hogg Island, Prince Edward Island, Canada: 2000 years of human-environmental interactions.

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Abstract :

The eastern oyster (Crassostrea virginica, Gmelin, 1791) has been previously analyzed in archaeological shell middens from Europe and the United States of America (USA), but has not been analyzed in archaeological contexts from Atlantic Canada. This research tests the feasibility of using the eastern oyster from the North Atlantic waters of Canada to interpret past human-environmental interactions. Oysters are abundant in the Maritime Provinces, and their importance as an economic resource has gained momentum in recent years, with multiple aquaculture projects being established in Prince Edward Island (PEI) and Nova Scotia. The Mi'kmaq, the Indigenous population of the region have expressed concerns for the conservation of oyster stocks within their traditional territories and have long-standing traditions of strategic harvesting to protect this resource: "Netukulimk, take only what you need". However, very little is known about the historic and archaeological practices of oyster harvesting in Atlantic Canada. Sclerochronological analysis of thin-sectioned oysters has revealed seasonal patterns of harvesting from Danish 'kitchenmiddens' during the late Neolithic period. Along the eastern coast of the USA, archaeological analysis of oyster isotope profiles yielded past environmental SST reconstruction for the Chesapeake Bay during the Pleistocene (250-400ka).

The Mi'kmaq have harvested oysters on the Atlantic coast of eastern North America for nearly 10,000 years, and the valves are preserved within the archaeological shell middens throughout the Maritime Provinces. The archaeological site, Pitawelkek (CdCw-5), is a 2000-year-old shell midden site on Hog Island, PEI, in Malpeque Bay's northeast edge that is now threatened by coastal erosion. Live-collected C. virginica valves were analyzed to understand variation in growth patterns and to establish baseline data of modern environmental conditions, specifically sea surface temperatures (SST). Future work will use stable oxygen isotope analysis, Fourier transform infrared spectroscopy (FTIR), and radiocarbon dating to reconstruct SST and the season of shellfish collection over time. Examining oyster's growth and chemistry from modern and archaeological contexts from PEI will provide a new environmental and cultural context to understand the significance of oysters in Mi'kmaw subsistence. Further, the combination of Indigenous knowledge with sclerochronology will provide a better understanding of Atlantic waterways and their environmental conditions.

Keywords : Sclerochronology, Bivalves, Paleoclimate, Archaeology, Subsistance

The El Niño-Southern Oscillation and its impacts on coastal Peruvian settlements ~2.4 ka: perspectives from two short-lived bivalve species

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Abstract :

El Niño-Southern Oscillation (ENSO) variability has impacted human societies along the western coastline of South America throughout the Holocene. However, paleoclimate evidence of these events is often derived from natural archives (i.e., marine sediment cores, ice cores, scleractinian corals) located far from human settlements. Short-lived (<5 years) bivalves (SLB) collected from archaeological deposits have emerged as a proxy for ENSO variability using a method related to individual foraminifer analysis (IFA) that directly reflect the impacts of ENSO on human societies in prehistory. Donax obesulus and Mesodesma donacium are two short-lived bivalve species that represent complementary temperature tolerances and were widely consumed in Peruvian prehistory, making them useful for reconstructing ENSO variability during key intervals of societal and climate change. Though M. donacium records have been used to reconstruct ENSO throughout the Holocene, D. obesulus shell oxygen isotope

(δ18O) profiles represent a novel paleoclimate archive with no previously published reconstructions. We subsampled individuals of D. obesulus (n = 12, average lifespan 1.8 years) and M. donacium (n = 10, average lifespan 3 years) from the site of Caylán (~2.6–2.2 ka) in the Nepeña Valley, Peru (~9.1°S, ~78.6°W) for δ18O at approximately monthly resolution. The variance of the annual range of δ18O (δ18Omax – δ18Omin) in both species reflects the variance of the annual range of sea surface temperature, which is driven by the relative frequency and strength of ENSO events. Using these two thermally complementary species, we can improve ENSO reconstructions by capturing both strong El Niño and La Niña events and fill in temporal and spatial gaps where both species were not available.

The relative variance of the annual range of δ18O in both species was similar to that of the last ~100 years during the occupation of Caylán (Modern = 1.0 ± 0.22; Caylán D. obesulus = 0.98 ± 0.33, M. donacium = 0.87 ± 0.26). Reconstructions using M. donacium alone did not include this interval, and lack data from the north-central coast of Peru where Caylán is located. Alongside a similar relative variance, we also found that mean annual SST was ~1 °C lower than modern (~0.8 °C in D. obesulus and ~1.6 °C in M. donacium), indicating a cooler background climate. Variance is increased compared to M. donacium based records from ~3 ka, and principal components analysis (PCA) of our data indicates that this increase is driven by strong El Niño events similar to those of the last 40 years. During the same two intervals (~3 ka and ~2.4 ka) archaeological data from the Nepeña Valley indicate a shift from publicly oriented monumental religious sites located in proximity to the Nepeña River to densely packed, proto-urban, privately oriented residential centers located away from the river flood plain at higher elevations. We suggest that these shifts in settlement pattern and organization do not reflect catastrophic ENSO events driving human migration away from the flood plain but rather increased ENSO variability widening ecological niches, including forests, wetlands, and arable land, useful to human populations undergoing simultaneous cultural changes.

Keywords : Sclerochronology, Archaeology, Stable Isotopes, Bivalves, Human-Environment Interactions

Pseudo-proxy assessment for extracting coral climate histories across the tropical oceans.

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Abstract :

Corals preserve detailed, high-fidelity histories of past climate variability and change across the tropical oceans. Paired records of Sr/Ca and oxygen isotope ratios from corals present the potential to extract histories of sea surface temperature (SST) and hydrological change that would be invaluable for improving the quality and length of observational SST and rainfall products that are a foundation for climate research. Individual studies have not yet identified a common, best-practice approach to quantifying the climate signals preserved within coral geochemical records that is necessary to draw rigorous information from these proxies. In this study we use a pseudo-proxy approach to assess the influence of coral skeletal growth, site location, record length, sampling method and calibration method in quantifying climate information from coral records. We then apply these insights across the newly developed CoralHydro2k database (Walters et al., 2022) to assess if these influences can reconcile published calibration variability of coral records. This work will provide a best-practice foundation for development of SST and hydroclimate histories through the CoralHydro2k community research project.

Keywords : corals, SST, hydroclimate, pseudo-proxies, calibration

Constraining sea-ice anomalies in the Little Ice Age using high-resolution marine archives and documentary historical records from the northern North Atlantic.

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Abstract :

The Great Salinity Anomaly (GSA) of the 1960s-1970s resulted from an abrupt increase in the export of Arctic sea ice that was transported southward along the East Greenland Current. The East Iceland Current was transformed into an ice-laden polar current, bringing sea ice to Iceland and polar waters near the Faroe Islands. There are indications of an even larger GSA-like event in the 1880s, based on fragmentary hydrographic measurements and historical data. However, this has never been constrained or explained, nor have earlier occurrences in the Little Ice Age that may be apparent from historical data and high-resolution marine proxy data. Here we investigate sea-ice variations since 1600 CE using high-resolution marine archives (e.g., marine sediments and sclerochronological bivalve mollusc shells) and documentary historical and instrumental records. The emphasis is on discovering and constraining so-called Great Sea Ice Anomalies using the combined evidence from different archives. Using indications of Arctic Ocean origin sea ice from high-resolution marine sediment records from Fram Strait, the east Greenland shelf and the north Iceland shelf, we target the periods around 1600, the late 1600s, the 1750s, around 1800 and the 1880s. These cases are then examined further using recently published data on stable oxygen isotopes from shells of the bivalve Arctica islandica from north Iceland and the Faroe Islands, combined with documentary historical records of sea-ice incidence off the coasts of Iceland, and other historical data and long oceanographic records from Iceland and the Faroe Islands.

Keywords : sea ice, historical data, Iceland, Faroe Islands

Poster

Elemental cycles in the coralline alga Neogoniolithon mamillosum as a recorder of temperature variability in the Mediterranean Sea.

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Abstract :

Coralline algae play important ecological roles throughout the photic zones of the world's oceans. Recent studies have shown that attached-living coralline algae can contain records of past climate variability. So far, algal-based paleo-reconstructions are mainly available from mid- to high-latitudes, while in low latitude and temperate regions only few examples exist. Here, we investigate samples from the attached-living encrusting coralline algal species Neogoniolithon mamillosum from a temperate site in the Mediterranean Sea to assess its potential as an environmental recorder. The specimens were collected at different water depths (20 and 40 m) in Columbretes Islands (Spain). Sclerochronological analysis of sectioned samples revealed seasonal growth patterns. In addition, Mg/Ca, Li/Ca, and Ba/Ca ratios were measured in the algal skeletons using laser ablation inductively coupled mass spectrometry (LA-ICP-MS) in ultra-high resolution. Elemental ratios analyzed in Neogoniolithon mamillosum were compared to in situ water temperatures measured at the water depth of sample collection (available since 2007 in an hourly resolution). Our results show significant

positive relationships between algal Mg/Ca as well as Li/Ca ratios and in situ measured temperature data. Mg/Ca exhibits the highest correlation with temperature (R=0.55), followed by Li/Ca (R=0.46; all records: 2012-2017 time period, monthly sample means, $p<0.01$). Ba/Ca ratios shows no significant correlation to temperature and may be influenced by other factors. We report a mean vertical extension rate of 1.1 mm/year based on averaging of two laser transects on the 40 m water depth specimen, representing the first growth rate measurement for this species. Our results suggest further potential of this species for climate reconstructions in temperate regions as Neogoniolithon mamillosum is not only widely distributed in the Mediterranean, but also one of the few species that may be used as a temperature archive for mesophotic coralligenous assemblages that are strongly affected by the recent anthropogenic temperature rise. Further calibration studies are needed to test the element-temperature relationships on samples with longer growth records and in different settings and water depths.

Keywords : coralline algae, laser, Mg/Ca, Neogoniolithon, growth

Oxygen isotope temperature calibrations for modern Tridacna shells in western Pacific.

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Abstract :

The oxygen isotope ratio of carbonate in Tridacna shell (δ18Oshell) is assumed to be precipitated in isotopic equilibrium with surrounding seawater, and thus reflects a combination of the sea surface temperature (SST) and the δ18O of seawater (δ18OSW). Accordingly, Tridacna δ18Oshell has been widely used for high-resolution paleoclimate reconstructions. However, the influences of interspecific differences, spatial heterogeneity, as well as the "growth effect" on the δ18Oshell-SST relationship have not been fully tested. Here, we present a monthly resolved δ18Oshell record of a Tridacna squamosa specimen from Yagong Island, South China Sea (SCS). Our results suggested that the monthly resolved δ18Oshell from northern SCS was dominated by the seasonal SST variations, which was highly correlated with measured SST after excluding the influence of δ18OSW. Then, the SST = f(δ18Oshell-δ18OSW) equations of all published monthly δ18Oshell records of modern Tridacna from the Indo-Pacific were collected. The resulting investigation revealed that similar SST = f(δ18Oshell-δ18OSW) equations for each shell, indicating the minor influences of spatial heterogeneity and interspecific differences. The average equation for Tridacna (Tridacna gigas, Tridacna derasa, Tridacna squamosa, Tridacna maxima and Hippopus hippopus) was SST = -3.56 ± 1.26 (δ18Oshell-δ18Osw) + 22.44 ± 2.77 (-0.28 ± 0.08 ‰°C-1, VPDB) (2σ), which was close to the equations set up for other mollusks (without Tridacna) and inorganic aragonite. Finally, although the growth rates varied greatly among Tridacna specimens and within different growth stages of each specimen, we did not find a significant influence of the growth rates on SST = f(δ18Oshell-δ18OSW) equations, indicating that the "growth effect" might have at best a slight impact on the δ18Oshell of Tridacna.

Keywords : Tridacna, δ18O, SST, growth effect, western Pacific

Coral evidence for the underestimate of the 20th century warming in the Eastern Pacific cold tongue

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Abstract :

Sea surface temperature (SST) changes in the eastern Pacific cold tongue (EPCT) are of great importance for understanding global climate. However, observations and models show large uncertainties for the 20th century EPCT SST changes due to the limited length of reliable observations. Here we synthesize four coral Sr/Ca-SST records from the tropical central-eastern Pacific and develop a seasonally-resolved Cold Tongue Index (CTI) reconstruction for the period 1887–1997 A.D. Our coral-based CTI reconstruction (CTIcoral) is well validated with instrumental data from 1960 A.D., and thus provides a reliable evaluation of the 20th century EPCT SST changes. The CTIcoral record, together with the low-resolution SST reconstructions, show a rapid 20th century warming trend of the EPCT due to the rising greenhouse gases forcing, indicating an underestimate of the warming trends in the instrumental CTI. We find that the decadal warming of the EPCT SST is associated with strong volcanic eruptions, particularly for the post-1960 period when volcanic eruptions were persistent and frequent. The robust CTI-volcanism relationship implies that the early 21st century EPCT cooling is partly driven by reduced volcanic forcing.

Keywords : coral Sr/Ca, Eastern Pacific cold tongue, 20th century warming, volcanic forcing, early 21st century cooling

Sclerochronological signatures of giant clam shells from turbid coral reefs

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Abstract :

The Coral Triangle comprises the most biodiverse marine ecosystems on the planet. Yet, this high diversity is increasingly threatened by unprecedented environmental change and large-scale bleaching. Given that high temperatures and light together cause bleaching, shallow-turbid mesophotic coral reefs may be more resilient to thermal stress and act as potential ecological refugia. Aside from corals, it is crucial to investigate other key reef builder responses to these environments to better understand their capabilities. Here, we investigate how giant clams — a bivalve subfamily known to form continuous daily growth lines — respond to a mosaic of turbid reefs in Darvel Bay (Sabah, Malaysia). We apply a sclerochronological approach to fourteen modern shells combining petrography and scanning electron microscopy (SEM) to develop growth chronologies at daily resolutions. We

find combining methods gives the best results due to differences between visual identification of growth increments in some sections. Preliminary comparisons between habitats show growth rates lack seasonal structure in turbid reefs but not in clear water environments. Annual and seasonal growth in turbid reefs (i.e. proximal to river mouth) is likely controlled by different environmental variables (i.e. Kd490 and chlorophyll-a) compared to that of clearer waters (i.e. SST, cloud cover and rainfall). These findings suggest that the heterotrophic nature of Tridacna squamosa might impact its growth between turbid and clear reefs and biomineralization responses are modified between diverse reef sites. However, further work looking at daily variations in growth will help us understand the complex mix of forcings influencing growth on multiple time scales.

Keywords : Coral Triangle, Shell growth, Turbid reefs, Sclerochronology, Tridacna, Reef conservation

Marine bivalves from northern Norway record persistent multidecadal climate variability at high latitudes.

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Abstract :

Atlantic Multidecadal Variability (AMV) is a feature of the North Atlantic marine system describing the 60-85 year oscillation between relatively warm and cool sea surface temperature across the North Atlantic Ocean. Evidence for the persistence of this mode in previous centuries is limited due to a lack of available marine-based proxy records of sufficient resolution and geographic diversity. Here, we present absolutely-dated, multi-century records of Arctica islandica shell growth (1449-2014 CE; 564 years) and oxygen isotope ratios (1539-2014 CE; 476 years) from Ingøya, Norway (71°N). A temperature reconstruction from the oxygen isotope data suggests an increase of at least 2°C from the mid-18th century to early 21st century. Spectral characteristics of the shell-based records indicate multidecadal periodicity of Southern Barents Sea sea surface temperature has persisted for at least the past five centuries. Comparisons between the shell-based records and nearby tree-ring reconstructions of summer air temperature reveal close coupling between marine and atmospheric dynamics since the 16th century. These results enable insight into long-term dynamics of AMV, the magnitude of temperature change near the gateway to the Arctic, and Arctic-Atlantic marine and terrestrial coupling through time. The results highlight the potential to strengthen regional marine climate syntheses using shell-based records.

Keywords : Arctica islandica, Atlantic Multidecadal Variability, Oxygen Isotopes, Shell Growth Chronology

Building extensive high-resolution sclerochronological archives using Laser Induced Breakdown Spectroscopy (LIBS) and rapid elemental mapping.

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Abstract :

This talk will outline how we can expand the number of mollusc shell records to gain a more robust way of identifying and quantifying the

immediate impact of climatic events on societies of the past.

Advances in data acquisition regarding speed and resolution promise improved access to this high-resolution climate archive, and thus an improved interdisciplinary perspective on the underlying mechanisms and dynamics of human-environment interaction. We are employing an innovative way of acquiring sea surface temperature (SST) data using a combined approach of stable oxygen isotopes (δ18O) and LIBS-screening, resulting in a lower quantity of δ18O values required per shell and, as a result, a higher quantity of sampled shells. Our improved data acquisition process enables us to use a high resolution (i.e. +1000 data points per shell record within a few minutes) as well as a high sample quantity (100s of shells) approach, that provides extensive coverage across entire site stratigraphies and more robust interpretations that less affected by interspecimen specimen variability.

By sourcing our climate data from shell remains found in archaeological layers, we are able to directly compare archaeological information of that layer with the individual climate records, side-stepping the need of radiocarbon-dating either dataset extensively and instead using the shared stratigraphic position to infer temporal concurrence.

Keywords : Sclerochronology, Archaeology, Molluscs, LIBS, Sea Surface Temperature

Reconstructing Holocene changes in growth rates of Adriatic gobies using coupled radiocarbon dating and sclerochronological analyses of fossil otoliths.

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Abstract :

Climate warming is expected to lead to a reduction in the body size of marine organisms, a trend already observed in commercial fishes, but the effects of temperature rise on size distribution in exploited populations are difficult to separate from the impact of overfishing and other anthropogenic stressors. We aim to test the hypothesis that fish growth rates dropped during the late Holocene and Anthropocene in the northern Adriatic Sea due to environmental perturbations caused by climate warming. We perform sclerochronological analysis on radiocarbon-dated otoliths of non-commercial, demersal gobies sampled from a sediment core taken off Piran (Slovenia) to quantify changes in body size and growth parameters throughout the Holocene. Otoliths are the aragonitic structures of the fish inner ear with species-specific morphology, and thanks to their incremental growth, they serve as unique environmental and life-history archive. Moreover, otolith size correlates with fish size. We use otoliths cut in half to perform both sclerochronology and radiocarbon dating, obtaining a high-resolution time series of changes in fish body size, growth dynamics and life history parameters. We employ backscatter electron (BSE) imaging and energy-dispersive X-ray spectroscopy (EDX) to identify growth dynamics, as well as to correlate their growth with climatic parameters. The reconstructed changes in size and growth rates of very common, non-commercial fish species over the last 7,000 years, can serve as an ecological baseline for evaluating the magnitude of ongoing and future shifts in fish populations in response to global warming.

Keywords : otoliths, sclerochronology, climate change; body size changes

Barium/Calcium Ratios in Eastern Oysters (Crassostrea virginica) as a Potential Environmental Proxy: Examining the Effects of Anthropogenic Freshwater Flooding on Development and Mortality of Oysters in the Pontchartrain Basin.

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Abstract :

Louisiana's oystermen have long protested planned freshwater diversions and extended spillway openings as deleterious anthropogenic disruptions of reef ecology that stimulate oyster mass mortality. However, other evidence

indicates that the impact of freshwater flooding on oyster reef health is minimal, posing little threat to oyster fishery vitality. The trace element ratio Ba/Ca has been investigated as a proxy for salinity and other environmental signals (nutrient cycling, upwelling) in some estuarine bivalves, but is yet to have been explored in oysters.

We examine whether eastern oysters (Crassostrea virginica) archive freshwater flooding-induced shifts in salinity or other environmental signals within their internal growth increments by analyzing Ba/Ca signatures in oyster valves live-collected from the southern shore of Lake Borgne along Louisiana's Pontchartrain Estuary. These oysters survived the extended Bonnet Carré Spillway openings in February and May of 2019, and thus experienced acute freshwater shock. We expect that Ba/Ca ratios will correlate with spillway openings via reduced salinity or increased nutrient input.

Our results could provide a new tool for monitoring the impacts of anthropogenic stressors on economically vital coastal resources, thus informing oyster fishery management and river infrastructure planning and operation. Such improved understanding of freshwater flooding's impact on oyster development and survivability could aid oystermen and coastal engineers in reconciling the dual imperatives of safeguarding the integrity of Louisiana's foodways and coastline.

Furthermore, this project has the potential to inform and extend ambient climate data into the past via examining archaeological oyster specimens to investigate historic oyster population flood responses. Such improved understanding of past climate variability holds potential to promote knowledge of the interplay of systems such as salinity, coastal foodways, and flooding, thus improving reconstructions of past flood events along the Mississippi Delta and contributing to an enriched and expanded chronology of the dynamic evolution of Louisiana's landscape.

Keywords : schlerochronology, biomonitoring, trace elements, biogeochemistry, coastal ecology, oysters

Decadal patterns of variability from a sclerochronological network

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Abstract :

Bivalve shells of long-lived specimens serve as interesting climate archives to improve our understanding of the upper ocean layer, in particular climate drivers that influence the marine environment. Master shell growth chronologies on multi-centennial time-scales exist, but most available sclerochronologies are limited to several decades. Here we compiled open-source annually-resolved master shell chronologies longer than 100 years (i.e., 8 chronologies) from different locations in the North Atlantic sector (above 40 °N) to investigate common climate drivers acting upon the shell growth signal at large-scale. To retrieve the common shell growth signal, we performed a principle component analysis (PCA) for the common period 1888-1992, and then compared the leading principle components with various climate fields and indices. Our results suggest that each chronology might be prone to local influences in the high-frequency domain, showing little coherence with the sea-surface temperature (SST) fields, but the signal strengthens on decadal time-scales once the chronologies are low-pass filtered. The first principle component explains ~28 % of variability and relates to large-scale oceanographic patterns, indicating a predominant Pacific decadal influence (e.g., Interdecadal Pacific Oscillation and Pacific Decadal Oscillation), and a strong connection with the SSTs on the path of the Gulf Stream in the Atlantic. Preliminary results also suggest that the first leading principle component relates to tropical anomalies in the Caribbean regions as inferred from coral networks. The second mode of variability is concentrated on the entire Atlantic Ocean, exhibiting a strong extratropical dipole associated with the Atlantic Multidecadal Oscillation. The results of this work are highly relevant for understanding decadal air-sea interactions and sources of variability across the upper ocean. Forthcoming analyses with a climate model could support the

observed decadal pattern and its stability on longer time-scales.

Keywords : bivalve shells, SST, decadal variability, IPO, PDO, AMO

Documenting Environmental and Oceanic Variability in the Down East Coastal Region of the Gulf of Maine using the long-lived bivalve Arctica islandica.

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Abstract :

The Gulf of Maine (GoM) is currently undergoing rapid environmental and ecological changes and this system is projected to become increasingly stressed in the coming decades. Thus understanding past spatial and temporal conditions of this region is key to understanding how future environmental changes and extreme events may impact fisheries and ecosystem dynamics in the GoM. Changes in the physical and chemical variations in the shells of mollusks can be used as a powerful proxy for studying past climates and environments. In this study, we used the growth and geochemistry signatures in the long-lived marine bivalve Arctica islandica collected from the Down East coastal region in the Gulf of Maine (Jonesport, ME) to evaluate past climatic and hydrographic variability in the northwestern North Atlantic Ocean. The recent collection of shells extends a previously developed master shell growth chronology by 11 years and now spans from 1954 to 2020 CE. Based on visual crossdating techniques, shell growth variability is highly coherent among the population indicating that environmental conditions are driving growth. Variability in annually resolved shell growth increments and stable oxygen isotope values are largely related to sea surface temperatures (SSTs) and water mass properties of the Eastern Maine Coastal Current. This master shell growth chronology and annually-resolved isotope series will fill data gaps prior to instrumental records and allow us to better understand the spatial oceanographic variability in the GoM.

Keywords : sclerochronology, paleoclimatology, environmental variability, proxy, isotopes

Holocene paleoclimate of McMurdo Sound, Antarctica reconstructed from growth striations and d^{13}C, d^{18}O, and d15N values in shells of the Antarctic scallop Adamussium colbecki.

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Abstract :

Fluctuations in sea ice cover are major factors driving climate change and are a substantial component of the global climate feedback loop. Antarctica currently lacks notable proxy records of sea ice state; bivalves archive environmental conditions and can be studied to track changes in sea ice cover through time. Adamussium colbecki is a large sea scallop with a circum-Antarctic distribution and an abundant fossil record throughout the Holocene. Our group's prior work showed that carbon (d13Cs) and nitrogen (d15NCBOM) isotopes in modern scallop shells record seasonal variation in sea ice state over time when paired with growth markers called striae. We also found that sea ice cover is recorded by low d13Cs values in narrow striae while ice-free conditions are recorded by high d13Cs values in wide striae. Nitrogen isotopes of carbonate bound organic material also recorded sea ice state, with ice-free conditions recorded by lower values. Here we apply these paleoclimate proxies by analyzing A. colbecki subfossil shells collected from terraces along Explorers Cove (EC) and Bay of Sails (BOS), western McMurdo Sound, Antarctica which grew between 1,000 and 6,000 years ago (based on 14C ages). Today, these two sites have contrasting sea ice states: persistent (multiannual) sea ice at EC and annual sea ice (that melts out every year) at BOS. Two adult fossil shells collected at EC and four fossil shells (including one juvenile) collected at BOS were serially sampled for d13C, d18O, and d15N from the growing shell margin to the umbo. Imaging of striae allowed for d13Cs

and d18Os values to be paired with summer (wide striae) and winter (narrow striae) scallop growth; d15NCBOM required larger sample size, so were not seasonally paired. Seawater temperature proxy records suggest warmer conditions 2,000-5,000 ybp, so we expect variable d13Cs values recording annual sea ice in shells from both sites.

Fossil BOS and EC d13Cs means are not statistically different between wide and narrow striae groups, indicating multiannual sea ice may have been present at both sites 1,000-6,000 years ago. Fossil d18Os means are statistically higher than modern d18Os values at both BOS and EC, which would indicate similar conditions at both sites while the scallops were alive. The 0.24‰ difference (t-test $p<0.0001$) may mean water temperatures were ~1ºC colder, there was decreased meltwater input, or a combination of these factors are represented in the fossil shells. However, these colder temperatures are not consistent with estimated warmer temperatures 2-6,000 years ago (Braddock et al., 2014) and may imply intervals of cold and warm conditions. The wide spread of fossil BOS d13Cs values may be a time averaged result of multiple sea ice conditions at BOS. d15NCBOM data are forthcoming. Serial sampling of modern and fossil shells of A. colbecki allow comparisons of wide (summer) and narrow (winter) striae with stable carbon and oxygen isotopes to provide high resolution proxies for sea ice persistence and temperature to understand Antarctica's sea ice history.

Keywords : Antarctica, sclerochronology, nitrogen, carbon, isotope

Future research priorities in sclerochronological studies on past global changes: Findings from a community-based survey.

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Abstract :

Sclerochronology is the study of changes in physical and chemical properties of accretionary hard tissues of organisms through time, and provides a powerful tool to investigate past global changes. Given the broad applicability to solve questions across different research disciplines, the field is continuously developing, with the number of archives and applications fast increasing. To facilitate a discussion on which fundamental questions and applications we should prioritise as a scientific community, we conducted a horizon-scanning survey via online questionnaires. After an initial round of the community survey, with feedback from an expert panel chosen for experience in the research field and geographic diversity, a list of 130 research questions was prepared. Through a follow-on survey, these 130 questions were ranked to identify the top 50 priority research questions and applications that should be prioritised in the near future. In the presentation of our results, we included eight additional questions that did not rank in the top 50, but were considered by the expert panel to be especially novel or potentially ground-breaking. Here, we highlight the research priorities chosen by the community and expert panel related to the study of past marine climate, ocean variability, and human-environmental interactions in particular. We focus on the opportunity for transdisciplinary collaboration, discuss the potential to bridge our current gaps in knowledge, and how the results of this survey can function as a roadmap for future research. Diversity and biases among survey participants are briefly discussed. With this submission, we not only want to share our findings, but we invite further input from colleagues from all relevant research disciplines as we hope to continue the conversation on what the most pressing questions are, and how we can work better together to solve them.

Keywords : Sclerochronology, proxy system science, climate change, community survey, horizon scanning

Species specific Sr/Ca-$\delta^{18}O$ relationships for three Tridacnidae species from the northern South China Sea.

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Abstract :

Skeletal remains of marine bivalves, Tridacna spp., can provide multi-proxy records of environmental variables. Sr/Ca ratio, which has been widely used in corals as a paleo-temperature proxy, has also been explored in Tridacna spp. shells in recent decades, but some controversies remain, especially regarding the different Sr/Ca-SST relationships across Tridacnidae species. In this study, ten specimens of three different species (Tridacna gigas, Tridacna squamosa and Tridacna derasa) were collected from the northern South China Sea and the monthly resolution Sr/Ca and δ18O ratios were investigated. Almost all high-resolution Sr/Ca profiles, determined by ICP-OES (Inductively Coupled Plasma Optical Emission Spectrometer), show pronounced annual cycles and are significantly correlated with paired δ18O value. However, Sr/Ca ratios of T. gigas are positively correlated with paired δ18O values, suggesting a negative correlation between T. gigas Sr/Ca and in-situ SST, while Sr/Ca ratios of T. derasa and T. squamosa are negatively correlated with paired δ18O, suggesting a positive correlation between SST and Sr/Ca in T. derasa and T. squamosa. These interspecies differences highlight the necessity of species identification before using Tridacnidae Sr/Ca ratios in paleoclimate reconstructions. Although the Sr/Ca-δ18O relationship has obvious interspecies differences, the clear annual cycles in all these specimens indicate that the Sr/Ca ratios of Tridacna spp. may have the potential to be used in reconstructing the past climate seasonality, ENSO variability and so on.

Keywords : Tridacna spp., Sr/Ca, δ18O, SST, seasonality

SEACHANGE: Quantifying the impact of major cultural transitions on marine ecosystem functioning and biodiversity.

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Abstract :

Change in the marine environment is, as far as human society is concerned, characteristically cryptic, occurring out of sight beneath the ocean surface. Even in the present day, when we have detailed measurements of many marine properties, we are hampered in our understanding by the shifting baseline and by our lack of direct knowledge of conditions and rates of change in the past. For periods before instrumental records became available, the impact of human cultural activity on marine ecosystems and the marine environment is largely unknown.

The SEACHANGE project aims to tackle this knowledge gap by applying novel geochemical and genetic techniques to high resolution marine proxy archives with the aim of identifying indications of the impacts of human cultural changes, focusing on five periods of major cultural transition during the Holocene:

(a) The Mesolithic to Neolithic transition around the North Sea (~6ka BP);

(b) The impact of aboriginal culture and the colonial transition in Australia between ~6ka BP and the present day;

(c) The Viking settlement of Iceland in 874 CE and the phases of intensification of fishing around Iceland up to the present day;

(d) The transition to industrial fishing in the North Sea from 1000 CE to 1800 CE;

(e) The onset and cessation of whaling in Antarctica in the first half of the 20th century.

SEACHANGE is a transdisciplinary project which will crossfertilize several diverse research fields including marine ecology, marine geology, geochemistry, molecular biology (metagenomics), historical ecology, archaeology and anthropology.

SEACHANGE is an ERC (European Research Council) Synergy grant which started in October 2020. The first major sample collection cruise in the North Atlantic took place in April and May this year.

Keywords : Cultural transition, shifting baseline, marine ecosystem, Holocene, fisheries

Using giant clam shell geochemistry to understand past environmental change and human-environment interaction in the South Pacific.

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Abstract :

Climate change has been of consistent and considerable concern for the past decades. Paleoenvironmental proxies can reconstruct past environmental conditions and provide critical baselines for understanding the climate system. This in turn, can enable us to better adapt to current and future climate changes.

Giant clams (Tridacnidae spp.) have great potential as a novel and reliable high-resolution paleoenvironmental proxy. Both the isotopic and trace element composition of the giant clam shells are affected by the surrounding seawater. Therefore, by analysing the geochemical composition of giant clam shells, we can faithfully reconstruct paleoclimate records, including sea surface temperature (SST), sea surface salinity (SSS), dissolved inorganic carbon (DIC), daily light cycles, rainfall, river input, marine primary productivity and extreme weather events.

Giant clams have a widespread distribution in the subtropical-tropical Pacific region. Compared with other archives, giant clams have advantages including high growth rate, clear increment bands and long lifespans (up to 100 years), enabling long continuous reconstructions. The clear annual and daily shell increment bands can provide monthly, and even daily paleoenvironmental reconstruction resolution and have the potential for hourly ultra-high resolution.

In this ongoing research project, I am using multiple traditional and novel techniques, including LSCM, XRF, IRMS, ICP-AES and LA-ICP-MS, to investigate the relationship between giant clam shell's growth patterns, geochemical compositions ($\delta13C$, $\delta18O$, Sr/Ca, Mg/Ca, Ba/Ca, Fe/Ca) and surrounding seawater parameters in the Great Barrier Reef. The $\delta18O$ results show the studied shell records 24~26 years parameter records and have a very fast growth speed during their juvenile period and a growth speed is going to slower with age increasing. The temperature range reconstructed by the $\delta18O$ value is between 24°C to 30°C, which is exactly the same as the instrumental records in the GBR. More geochemical analyses will be conducted in the recent two months and the results will come out before May. A tank experiment will also be included to investigate a more specific relationship between surrounding environmental parameters and shell compositions in this research project.

This project will ultimately provide calibrated proxies for ultra-high-resolution reconstructions of Great Barrier Reef Holocene environmental change as a baseline for understanding the long-term social-ecological system and providing data for the future management of the reef.

Keywords : Sclerochronology; Geochemistry; Giant Clam ; Great Barrier Reef

Coralline algal records of past ocean and sea-ice variability in northern Svalbard.

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Abstract :

An accelerated decline in Arctic sea-ice cover is one of the most prominent indicators of ongoing

climate change. Although the recent loss of Arctic sea ice is well-documented, the long-term, multidecadal, sea-ice variability is poorly understood due to short instrumental and satellite records. High-resolution proxy data enabling reconstructions beyond the brief history of observations are, therefore, needed to put recent changes into perspective.

Recent studies demonstrated the high potential of the long-lived crustose coralline algae Clathromorpum compactum as a multiproxy archive for reconstructions of Arctic climate and sea-ice variability for several centuries in the past. It has been shown that growth rates and Mg/Ca ratios in algal thalli are dependent on the light availability and temperature at the shallow seafloor habitats, related to the duration of the seasonal sea-ice cover. By analyzing annual growth increments and geochemistry, precise calendar dating of algal hard tissue can be archived, enabling high-resolution reconstructions.

Here, we present the first results of a study of C. compactum collected off the coast of northern Svalbard (80°28 N, 19°54E). This is a key location for reconstructions of past ocean and sea-ice variability due to presence of seasonal sea ice at this site today and the oceanographic influence of warm Atlantic water via West Spitsbergen Current, which plays a major role in shaping ice conditions in the region. The aim of this study is to develop and evaluate a multiproxy approach based on coralline algae growth and Mg/Ca records to reconstruct past sea-ice conditions. Using Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) and sclerochronological analysis, we examine the growth and trace element composition of three C. compactum specimens. The results yielded continuous records for up to ca. 270 years (1741-2019 CE). We compare combined algal proxy records with observational time series and available proxy data to test their application for reconstructions of past marine climate and sea ice conditions in the area.

Keywords : coralline algae, Mg/Ca, sea ice, Svalbard

Shape, growth and individual variability: three inseparable components of shell sclerochronology.

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Abstract :

The future of shell sclerochronology depends on strengthening the fundamentals of how incremental growth records are measured, analysed and modelled. Unlike dendrochronology, where raw data are made available and shared, shell sclerochronology has yet to developed an open, data-sharing framework. This impedes the ability of theoreticians to test statistical and mathematical approaches that will allow sclerochronological data to be integrated into a quantitative framework. Among these challenges are how to compare and scale growth records observed on small numbers of individuals to local, regional and global scales. This is not a question of more data, but more integration.

We have now merged sclerochronology and morphodynamics within a single stochastic framework based on modelling shell growth and identifying changes due to the variations of the environment. This approach formalises the notion of growth trajectory and allows filtering out high variability by integrating the growth over the shell surface.

This tool is providing new information about growth processes. We have begun re-analysing growth increment data from a single species dataset of more than 650 shells to compare the observed growth with modelled growth from 3D dimensional representations and the environmental dynamics observed in the same system. Our aim is to provide : new insights into how well increment growth records represent ecological dynamics, and encourage emergence of an open basis of comparison between systems through sharing of virtual shell representations.

Keywords : shell morphodynamics, sclerochronology, modelling, marine ecology, trend reconstruction

Key Temperature Differences between the Northern and Southern Gulf of Mexico since 1800 CE Revealed by Siderastrea siderea Coral Sr/Ca Reconstructions

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Abstract :

The Gulf of Mexico supplies water to the air over Central and North America, which is influenced by sea surface temperature. Understanding the how predicted temperature change in this region will change water levels in the air is critical. One way to understand such changes is by reconstructing past sea surface temperature (SST). Coral skeletons act as skeletal diaries preserving such records. Here we examine two massive records of SST from the chemistry of corals from the northern (Flower Garden Banks) and southern (Dry Tortugas) Gulf of Mexico. We find that the northern Gulf (FGB) has a wider range in seasonal SST and overall cooler SST compared to the southern Gulf (DRTO). FGB also has colder winter SST and DRTO has warmer summer SST, except for ~11 years when FGB summer SST surpasses DRTO. In FGB, winter SST decreases from ~1870–1905 and increases from ~1910 to 2005 whereas DRTO has no significant changes in winter SST for the entire reconstruction. No trends are observed in annual and summer SST in both FGB and DRTO from ~1870–2005. In addition, a ~10-year cooling event is observed in FBG coincident with the Southern Plain Dust Bowl beginning in 1930.

Keywords : Coral, Sr/Ca, Gulf of Mexico, SST, Siderastrea siderea

OSM19: Understanding Past Hydrological Changes in Africa since the Last Glacial Maximum

Co-conveners: Ilham Bouimetarhan, Rachid Cheddadi and Enno Schefuss

Oral

Palaeohydrological changes recorded from a small Moroccan Middle Atlas pond during the last 6,000 cal. yr BP: a multi-proxy study.

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Abstract :

The perennial and seasonal wetland diversity of the Moroccan Middle Atlas region provides a valuable "test-bed" for understanding the response of different hydrosystems to climatic variations. A multiproxy study, based on sedimentological descriptions, together with mineralogy, carbonate content, XRF core scanning and biological proxies supported by AMS 14C dates, were applied to the 3-m-long core extracted from "Flowers Marsh", a small Middle Atlas pond. This approach provides evidence for a continuous paleohydrological and paleoenvironmental record during the Mid- to Late Holocene. The investigated aquatic system evolved from a dry or very shallow waterbody towards a system with a progressively rising water level. The dominance of the detrital fraction with poor preservation of bioindicators and eroded pollen, indicate the existence of an ephemeral waterbody from 6,000 cal. yr BP until a transitional phase characterized by new sedimentological facies and the appearance of ostracods around 2,300 cal. yr BP. This transition, ending at 2,000 cal. yr BP, is interpreted as a flooding phase leading to an ephemeral lake. It is certainly fed by the excess water from the nearby Aguelmam Azigza Lake during its high-level period. Afterwards, enhanced organic matter deposition and the appearance of well-preserved diatoms until 1,400 cal. yr BP corroborate a high water-level trend. Endogenic carbonate to detrital fraction ratios indicate fluctuating, but generally shallow, water levels from 1,400 cal. yr BP until 650 cal. yr BP when a relatively rapid rise in water level occurred. Flowers Marsh data are, generally, consistent with most of the existing regional records. The highstand period recorded between 2,000 and 1,400 cal. yr is a common feature extending to more distant sites from the northern Mediterranean. It corresponds to the wetter Iberian-Roman period. Fluctuating shallow water levels recorded since 1,400 cal. yr BP to now could be linked to drier/wetter phases associated with the Medieval Climate Anomaly and the Little Ice Age (650-150 cal. yr BP) respectively, in the western Mediterranean realm. The present study demonstrates the ability of Flowers Marsh to record valuable palaeohydrological changes since the Mid-Holocene and confirms the high sensitivity of Middle Atlas hydrosystems to climatic changes.

Keywords : Middle Atlas, Palaeohydrology, Mid- to Late Holocene, Lacustrine sediment, Climatic changes.

Middle to Late Holocene paleoenvironmental evolution of the Tahaddart lower estuary (NW of Morocco)

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Abstract :

A multiproxy approach, combining sedimentological, geochemical and microfaunal (benthic foraminifera content) analysis, was performed on four sediments cores collected from the Tahaddart lower estuary (NW of Morocco) to reconstruct its middle to late Holocene paleoenvironmental evolution. This reconstruction is based on a chronological framework provided by 210Pbex, 137Cs and 14C measurements. The main results showed general upward fining sequences, with three major sedimentary phases, which correspond to different depositional environments. Before ~6800 cal BP (phase I), the sedimentation was dominated by coarse fluvial sediments, indicating that the Holocene marine transgression did not reach yet the Tahaddart estuary. The latter was in the form of a valley, deeply incised by the two rivers, Hachef and Mharhar. The Holocene transgression, which began about 14,000 years ago, inundated the Tahaddart estuary around 6800 cal BP and transformed it into a bay, partially separated from the Atlantic Ocean with a Pleistocene coastal dune. Between ~6800 and ~625 cal BP (phase II), as a result of a general stabilization of the mean sea level, the accommodation space created by the transgression was filled progressively by sediment input by both river and marine processes. The coring site, situated in the coastal part of the bay, was dominated by marine sandy sediments with shell debris, characterized by a high concentration of Ca, Sr and Zr, and by a high abundance of marine benthic foraminifera with the species Ammonia beccarii, Elphidium crispum, Quinqueloculina sp. and Bulimina sp. During the same phase, the two rivers, Hachef and Mharhar, has gradually prograded inside the bay in the form of bayhead deltas. The latter has reached the Tahaddart lower estuary around 625 cal BP (phase III) and covered the marine sediments with fluvial ones, marked by a high concentration of Rb and by a high abundance of brackish foraminiferal species, such as Ammonia tepida, Haynesina germanica, Trochammina inflata and Entzia macrescens. This last sedimentary phase represents the final filling of what is left from the former bay.

Keywords : Paleoenvironment, Holocene, Tahaddart lower estuary, Morocco

Effects of Climate and land-use on hydrological and vegetation signals during the last three millennia in southwestern Morocco

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Abstract :

The southwest of Morocco is considered to be an area of refuge within the Mediterranean region, hosting the endemic tropical Argan tree. This region is presently subject to severe droughts, desertification, and land degradation, and likely facing increased climate variability and socio-economic stress in the future. Here, we use the stable hydrogen and carbon isotope composition (δD and δ13C) of plant-waxes in a high-resolution marine sediment core (GeoB8601-3) collected off Cape Ghir in southwestern Morocco, in combination with published data on pollen and XRF element ratios from the same archive. We aim to reconstruct the hydroclimate and vegetation history during the last 3000 years. Stable carbon isotope compositions of leaf waxes (δ13Cwax) show that natural vegetation in southwestern Morocco consists of C3 plants. Minor variations in δ13Cwax were positively correlated to changes in stable hydrogen isotope compositions of leaf waxes (δDwax) before 700 CE. Changes in rainfall amounts and water use efficiency indicate a clear vegetation response to precipitation changes and thus to climate

forcing. After 700 CE, δDwax and δ13Cwax became de-coupled suggesting that the plant wax discharge and their isotope signals were no longer solely controlled by climate; the waxes likely mainly originate from the lowlands and carry an enriched (dry) δD signal but a depleted 13C signature. The depletion of δ13Cwax correlates with the increase of Argan pollen concentration in the record. The period between ~700 and 900 CE coincides with the Arabization of Morocco which had an impact on the demographic composition of the country leading to new agricultural habits and, as a result, on the land-use triggering a higher erosion of lowland material by the Souss River.

Keywords : Argan tree, carbon isotopes, climate change, human land-use, Hydrogen isotopes, southwestern Morocco

A predominantly tropical influence on late-Holocene hydroclimate variation in the hyper-arid central Sahara.

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Abstract :

The climate history of the Sahara desert during recent millennia is obscured by the near-absence of natural climate archives, hampering insight in the relative importance of southerly (tropical) and northerly (mid-latitude) weather systems at sub-millennial time scales. A new lake-sediment record from Ounianga Serir oasis in northern Chad, spanning the Late Holocene without interruption, confirms that immediately prior to ca 4200 years ago the Sahara experienced an episode of hyper-aridity even more extreme than today's desert climate. Due to continuous inflow of fossil groundwater, the hypersaline terminal lake which formed afterwards has never desiccated until today, yet its water balance was sensitive to temporal variation in local rainfall and lake-surface evaporation. Our in-lake geochemical proxies show that during the last 3000 years, century-scale hydroclimate variation in the central Sahara primarily tracked the intensity of the tropical West African monsoon, modulated at shorter times scales by weather patterns linked to shifts in mid-latitude Atlantic Ocean circulation.

Keywords : Late-Holocene, Sahara, North Africa, hydroclimate, 4.2 ka event

Late Quaternary aeolian-fluvial paleoenvironmental archives in the Sinai-Negev erg margins.

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Abstract :

Aeolian-Fluvial (A-F) processes formed vast and flat landscapes along many dunefield margins during the late Quaternary. The mechanisms and deposits of such processes and the hydrological response are not fully understood. At the northwestern Negev (Israel) dunefield margins, at the eastern edge of the Nilotic-sourced Sinai-Negev erg, a 120 m long and 7 m high, wadi bank exposure reveals a unique perseverance of aeolian sand and truncated dune units overlapped by fine-grained sediments. Chrono-stratigraphic analysis by relative (Portable OSL) and absolute luminescence (OSL), radiocarbon and archaeological dating of this A-F sequence, demonstrate a series of sand incursions into a medium-sized (64 km2) fluvial system, mainly between the Last Glacial Maximum until the Younger Dryas, resulting in a fluvial sediments deposition which lasted until the mid-Holocene.

These fine-grained fluvial sediments were deposited in standing or low energy impounded water bodies by nearby dune-damming and include: (a) couplets deposited in an ever-emptying waterbody, impounded by a dune-dam. (b) massive fine-grained deposits of suspended sediments in the deepest part of the water body (c) Fining upward deposits with fine laminas forming couplets. These sediments formed expanse, flat and alluvial dunefield margin landscapes. The water bodies in this arid region attracted hunter-gatherers represented by prehistoric settlements.

This palaeo-fluvial archive reflects successive and amplified late Pleistocene sediment aggradation during a time window of higher loess sediment availability in the fluvial system, when the vegetated linear dunes that formed the dune dams, were stable. The aeolian domination of the dunes persisted during early Holocene climatic changes and generated a lagged fluvial response until dune dams were breached and the flat alluvial landscape was consequently fluvially incised.

Keywords : Aeolian-Fluvial processes; Dunefield margins; Dune-damming; Landscape evolution; Chrono-stratigraphic analysis

Evidence for anthropogenic, climatic and oceanographic variability off southwestern Morocco during the last three millennia.

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Abstract :

In order to obtain a better knowledge of oceanic changes in the Canary Upwelling region during the Late Holocene, marine surface samples and two sediment cores retrieved off southwestern Morocco, GeoB8601–3 and GeoB4223–1, were investigated for organic-walled dinoflagellate cysts (dinocysts).

Firstly, a compilation of modern dinocyst distribution from marine surface sediments off southwestern Morocco has been conducted to better calibrate and interpret the marine dinocyst paleorecords in the region. The record off Cape Ghir is characterized by high percentages of L. macherophorum as well as cysts of Polykrikos species, while the record off Cape Yubi is still dominated by L. macherophorum but with much higher percentages of protoperidinioid cysts and Echinidinium spp. in comparison to the region off Cape Ghir. Secondly, the modern dinocyst distribution was used to interpret Late Holocene dinocyst records from two marine sediment cores retrieved off southwestern Morocco. The dinocyst results are well supported by previous palaeovegetation and palaeoenvironmental reconstructions using pollen, geochemical data, and stable hydrogen and carbon isotope composition (δ2H and δ13C) of plant waxes from the same core. The dinocyst results show upwelling conditions with high seasonality prior to 750 BCE with longer upwelling season between 750 BCE and 950 CE, corresponding with high relative abundance of Pinus pollen, higher fire frequency, high values of Ti/Al and lower values of Fe/Ca suggesting rather arid conditions associated with increased northeast trade winds. After 950 CE, a strong increase of L. machaerophorum and Gymnodinium species accompanied with a decline of Pinus pollen abundance and Ti/Al ratio, a strong increase of Fe/Ca ratio and increase of Argania spinosa pollen abundance indicate high fluvial input probably due to a combination of climate and anthropogenic impacts.

In conclusion, the oceanic conditions during the Late Holocene in the study are influenced by upwelling and fluvial input affected by the NE trade winds and human activities.

Keywords : Dinoflagellate cysts, Upwelling, Fluvial input, Late Holocene

Sub-decadal scale environmental responses to hydro-climatic changes in the Middle Atlas Mountains, Morocco – learning from historical archives and a high-resolution multi-proxy lake sediment record.

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Abstract :

The Western Mediterranean region including the North African desert margin faces major environmental challenges in the context of global climate change in terms of rising temperatures, a higher recurrence of drought events and a decrease in annual precipitation. Additionally, human activities have significantly altered the montane landscape over the past century through deforestation and agricultural practices. As a condition to state further prospects, it is crucial to comprehend past and present hydro-climatic patterns and their geo-ecological impact. The Moroccan Middle Atlas is considered a transition zone between the Atlantic, Mediterranean and Saharan air masses, and is therefore of unprecedented interest in order to comprehend regional climate variability and to assess emerging hydrological, geomorphological and ecological impacts. Despite the growing number of limnological studies from the Middle Atlas, there still is a strong need for coupling palaeolimnological results at the sub-recent time scale with historical cartographic information, meteorological data and underlying climatic forcing. Lake Sidi Ali (33°03' N, 5°00' W, 2080 m a.s.l.) provides a unique archive for understanding environmental changes throughout the 20th century. At least during the past 100 years, the lake has experienced at least three significant lake-level changes in the order of several meters. We were able to reconstruct and quantify these alternations with the help of historical sources, topographic maps and satellite imagery. In addition, we implemented a multi-proxy analytical approach on a 145-cm long sediment record, including pollen, δ18O and δ13C analysis of ostracod shells and CNS elemental analysis. A reliable age model based on 25 210Pb measurements and one radiocarbon dated cedar needle enables the correlation of sediment geochemical variations to lake-level changes. We examined meteorological precipitation and temperature data to evaluate their influence on these fluctuations. Furthermore, we have indications for a temporal coupling of Atlantic climate patterns (North Atlantic Oscillation, NAO; Atlantic Multidecadal Oscillation, AMO) with Sidi Ali's lake-level variations and we provide a more detailed insight into the responsiveness of local vegetation to the climatic and anthropogenic changes of recent decades. This study will thus help to better elucidate the interactions of lake hydrology and vegetation response to future environmental change.

Keywords : Middle Atlas, lake level, environmental change, historic archives, vegetation response

Spatiotemporal variations in precipitation isotopes and hydroclimate across Africa since the Last Glacial Maximum: a data-model synthesis.

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Abstract :

African hydroclimate changed considerably since the Last Glacial Maximum (LGM), but the climatic processes that controlled these changes remain poorly understood. Proxy reconstructions of African hydroclimate based on precipitation isotopes provide an important method to assess changes in rainfall and atmospheric circulation under different boundary conditions in the past, and to test and improve climate-model predictions. However, it can be difficult to constrain the processes governing precipitation isotope variations and the underlying forcings. Therefore, we synthesized existing LGM-to-present records of the hydrogen isotopic composition of precipitation (dD) from Africa and compared them to simulations of climate and precipitation dD from the isotope-enabled Transient Climate Evolution (iTRACE) model. Initial results indicate relatively good proxy-model agreement between observed and simulated dD and precipitation. The simulations and proxies document a dry, D-enriched LGM, relative to a wetter, more D-depleted early Holocene. This deglacial transition is punctuated by drier, more D-enriched conditions during Heinrich Stadial 1 and the Younger Dryas. Although the causes of these shifts vary regionally, atmospheric greenhouse gas concentrations and meltwater forcing explain much of the simulated shift in deglacial climate and dD. Despite the overall consistency between the model results and the proxy records, a notable discrepancy is increased LGM D-depletion in the model compared to the proxies. Future work will explore other components in the model such as temperature and wind to assess the potential influence of these factors on African hydroclimate and hydrogen isotopes over this time.

Keywords : Hydroclimate, precipitation isotopes, Africa, Last Glacial Maximum, climate models

Poster

Comparison of abundance and distributions of elements and plant waxes in terrestrial and marine deposits of southern Morocco.

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Abstract :

Terrigenous materials are delivered to the oceans via fluvial and eolian pathways; the interpretation of terrigenous signals in marine sediments needs an accurate understanding of initial source regions for different terrestrial components, as well as of their pathways up from the continent to the ocean. This work aims to conduct a comprehensive source-to-sink comparison of geochemical elements and plant-wax-lipids from surface terrestrial and marine samples in southern Morocco along the Atlantic coast and within the major southern river catchments. We intend to understand how comparable the distribution of elements and elemental ratios as well as plant waxes in terrestrial and marine samples is to assess their origin and transport mechanisms. We find a high concentration of terrigenous elements (Fe, Al, Si, Ti, K) and low concentrations of calcium (Ca) in the continental samples, and the opposite for marine sediments. In marine sediments, the variability of the Ca content is attributed mainly to biogenic origin and to lithic

particles. Elemental ratios including Ca (e.g., Fe/Ca and Ti/Ca) are sensitive to dilution effects (enhanced biological productivity, carbonate dissolution). Moreover, lower plant-wax concentrations in marine sediments compared with continental sediments, indicate a considerable degree of degradation in marine sediments. Fe/K ratios provide another line of evidence that the sediment composition is sensitive to weathering conditions in the study area. Most terrestrial input into the ocean is mainly controlled by physical erosion. Ti/Al ratios used as a proxy for aeolian input, confirm that sediments from the Draa basin are mainly transported via fluvial input whereas sediments from Souss and Tensift basins are transported by winds. In addition to that, minimum values recorded by CPI in the Draa basin; confirmed also by the lowest value of ACL and the low concentration of alkane in the Draa basin. Since the terrigenous fraction in southern Morocco is considered to be generally aeolian in origin, the concentrations of marine sedimentary plant waxes are likely more influenced by wind strength than changes in the extent of the vegetation cover.

Keywords : Surface sediments, terrigenous input, major elements, plant waxes, southern Morocco

Dust provenance analyses show changes in air-masses circulation over the North African desert margin during the Holocene.

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Abstract :

The North African desert margin is one of the areas most sensitive to ongoing climate change. Indeed, the area has recorded one of the largest temperature increases (> 2°C) between 1901 and 2012. In addition, models, coupled to historical data, forecast an increase in heat peaks and a reduction in rainfall leading to hyper aridity by 2100. Improving the scenarios of future climate evolution requires a state-of-the-art understanding of the response of natural systems to abrupt climate changes that occurred prior to the industrial era. In this regard, climate archives with high temporal resolution such as lake sediments are of prime importance for our understanding of the mechanisms that govern abrupt climate transitions in the climate system. Across the North African desert margin, variation in past hydro-climatic conditions is notably affected by changes in the air mass trajectories, whose temporal dynamics can be reconstructed using mineral aerosol (dust) provenance analysis. Indeed, the different sources of dust contributing to a given area are usually characterized by specific isotopic signatures in neodymium (Nd), strontium (Sr) and lead (Pb) notably depending on the age and conditions of geological formations.

In this study, we measured the Nd and Sr isotopic compositions in the "dust" fraction extracted from a sediment core of lake Sidi Ali, Middle Atlas, Morocco. There are coherent changes in the Sr and Nd isotopic compositions during the Holocene that we interpret as variations in the dust provenance. In particular, there is a pronounced decrease (increase) in the Nd (Sr) isotopic ratio around the 8.2 ka-climate anomaly likely reflecting a change in dust origin. Based on these preliminary results, Chad and/or Senegal could be the main contributors amongst the distal potential dust source areas while local contributions from Morocco could also occur. These results suggest that the sediment record from lake Sidi Ali is suitable for deciphering between major dust sources and for providing a high time-resolution in the air masses circulation changes along the North

African desert margin during the Holocene. We will increase the temporal resolution of our current isotopic record with a focus on the Mid-Holocene Saharan aridification and measure the Pb isotopic compositions to complement the Nd and Sr isotopic records.

Keywords : Dust, radiogenic isotopes, winds, Sahara, geochemistry

Locating North African microrefugia for mountain tree species from landscape ruggedness and fossil records.

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Abstract :

In order to optimize conservation policies for endangered plant species in North Africa and minimize the investment of the public resources we explore the capacity of a mountain plant species to persist locally in restricted natural areas. Palaeoecological studies have shown that plant species survived major global climate changes within refugia which offered suitable condition for their long term persistence. Our study aims at identifying potential mountains areas which may play the role of modern microrefugia for preserving locally endangered plant species. We analysed the mountain ruggedness of an area in the North-East of the Middle Atlas mountains where a population of an endangered plant species, Cedrus atlantica, is isolated today around lake Tameda. In addition, we collected a sediment core in the lake to investigate the recent history of the species with the local environmental changes. We compared the terrain and fossil analyses with an area in the Rif mountains where the terrain rugosity is lighter than in the Middle Atlas and where Atlas cedar populations occur as well. Our results show that the Atlas cedar is better preserved in terrains with high rugosity because they offer a wider panel of suitable microclimates for the species persistence and they restrict the number of inhabitants as well which, de facto, reduces the anthropogenic disturbances. We have carried out this analysis at a very small scale (less than 40km^2). A more exhaustive analysis of the terrain rugosity over the Atlas and Rif mountains, combined with historical data, will help to identify more suitable refugial areas for preserving the species at a larger scale. Protecting these refugial areas over decades from any anthropogenic activity should be possible at a minimal cost and would represent an immediate response to the ongoing climate change for preserving endangered species.

Keywords : Microrefugia, Holocene, Morocco, Mountain species, Atlas cedar, Conservation

OSM20: Societal risk arising from global change: Past, present, future

Co-conveners: Michael Evans, Blas Valero-Garcés, Felix Riede, Markus Reichstein and Marie-France Loutre

Oral

Linked molecular and isotopic indicators of fire history, population, vegetation and climate change in the Maya lowlands.

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Abstract :

Understanding past societal responses to climate change requires proxy indicators of human population, climate and land-use change. We apply a range of proxies to a lake sediment core from Laguna Itzan, a cenote adjacent to the ancient Maya population centre of Itzan, in order to examine the response of the lowland Maya to climatic and environmental change, which remains poorly understood. By combining molecular proxies for population (faecal stanols) and biomass burning (polycyclic aromatic hydrocarbons or PAHs) with isotopic analyses of plant wax n-alkanes as proxies for vegetation change (δ13C) and palaeohydrology (δ2H), we show the complex interplay of environmental and societal changes over 3300 years.

Faecal stanols suggest at least three periods of significant population decline associated with precipitation change, including between 3300 and 2900 cal yr BP and 1860-1670 cal yr BP, as well as the widely documented Terminal Classic drought (1220-1050 cal yr BP). The use of PAHs provides a record of fire history from both hearths as well as from vegetation burning associated with hypothesised slash and burn land clearance, or swidden, agriculture. Fire history can be linked with records of vegetation change inferred by δ13C of n-alkanes, which fluctuate between more negative values associated with forest (C3) vegetation and more positive values associated with maize (C4) agriculture. Our data indicate that human population dynamics and patterns of land clearance for agriculture varied substantially throughout the sediment core record, and that palaeoclimatic change may have largely driven these patterns.

Keywords : biogeochemistry, climate change, palaeoclimate, palaeodemography, fire

Risk of marine submersion in the bay of Agadir (Morocco).

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Abstract :

The global warming that results from the meteorological-oceanic perturbations translates, among other things, in the rise of the sea level and the increase of the energy of marine storms as well as their frequency. The IPCC predictions highlight the probability of sea-level rise, even exceeding 1m by 2100 for the most pessimistic scenarios (i.e., RCP8.5). As a result, coastal flooding episodes will increase. These occur during events that simultaneously combine strong swells, spring tides, low pressure conditions and abnormally high surges. This behavior can seriously affect urban spaces along the sea.

This study concentrates on the assessment of the risk of marine submersion in the bay of Agadir (Moroccan Central Atlantic), consisting of sandy beaches bordered by a tourist and commercial district of high added value. It is also developed in its northern part by the implementation of the large port complex of Agadir. The approach adopted is based on the estimation of extreme sea levels using the NWWII model (swells and winds), the SWAN wave propagation model, and the statistical analysis of extremums (GEV model). The results obtained are mapped to determine the spatial extent on a high-resolution Digital Terrain Model, established on the basis of recent topo-bathymetric data produced by the

administrative services of the Region, completed by GEBCO data.

For current conditions, the results of the study show the vulnerability of the southern part of the bay in contrast to the northern part which is less vulnerable because of its bay-shape and also because of the protection to the north offered by the harbor dikes. For future conditions, especially in 2100, estimates predict the submersion of the whole bay, threatening the infrastructures of the first line of the building facing the sea. This calls, from now, the managers of this coast to prepare a protection strategy against this risk.

Keywords : Bay of Agadir, marine submersion, NWWIII, SWAN, GEV.

Economic Damages from Weather and Climate Extremes.

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Abstract :

An important aspect of modeling the coupled human–Earth system is how weather and climate affects the economy. In particular, extreme weather and climate events can cause significant economic damages. Hence, there is a need to better understand the relationship between economic damages and extreme weather and climate events. Here, we analyze economic damage data using regression and probabilistic methods. We provide evidence for upward trends for inflation adjusted damages caused by extreme weather and climate events, while damages normalized by wealth have downward trends. We also find that relative to its wealth, Europe is the most affected continent followed by North America and Asia. We also identify covariates which affect economic damages. Multivariate regression models using either socio-economic or climate covariates explain only small amounts of the damage variation while the probabilistic Generalized Pareto Distribution (GPD) model with covariates fits the damage data well. This suggests that economic damages due to weather and climate extreme events should be modeled using probabilistic methods. Using non-stationary GPD models, we find that mainly population is a significant covariate while also Gross Domestic Product (GDP), global mean surface temperature and modes of climate variability are significant covariates too.

Keywords : Economic damages, Extremes, Extreme Value Statistics, Non-Stationarity, Trends

Holocene environmental and hydrological changes in sub-millennial-scale from southwest Mexico and associated climatic forcing.

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Abstract :

Radiocarbon-dated deposits from the Lake Coatetelco, located at south of the Trans-Mexican Volcanic Belt and near the archaeological sites of Coatetelco and Xochicalco, helped to extend the environmental and hydrological changes occurred in the southwest Mexico prior to the human occupations of the Pre-Classic Period of the Mesoamerican cultures and evaluated the variations over the Holocene (11.5-2 cal ka BP) with respect to orbital to sub-millennial-scale changes in insolation, latitudinal shifts in ITCZ, frequency of ENSO as well as the events of abrupt advection of cooler water into the North Atlantic in sub-millennial-scale. Proxy registers based on major element oxides in inorganic fraction, and δ13Corg and C/N ratio in bulk organic reconstructed the dynamics of erosion,

water column salinity, sediment-water interactions, and provenance of organics. Summer insolation modulated mean position of the ITCZ was the dominant forcing between ~11.5-4.2 cal ka BP and sub-millennial-scale ENSO dominated during ~4.2-2.1 cal ka BP. After a drier ~11.5-11.2 cal ka BP, the enhanced erosion transported moderate-to-extremely altered sediments to the basin with mainly autochthonous organic matter during the wetter ~11.2-6 cal ka BP. Contribution of C4 plants increased during the drier ~6-4.2 cal ka BP and this prolonged drought could be forced by advection of cooler water into the North Atlantic as well as seasonal insolation. Hydroclimate remained unstable as the first Olmec settlements commenced in this region as the ENSO related short-lived storms interrupted an overall arid condition after ~4.2 cal ka BP. Dissimilarity between this sediment record and speleothems from this region over the late Holocene might be reflecting different sensibilities of both the paleoclimate registers to seasonal-and-annual precipitations. The possible coincidence between drier events over the early and middle Holocene and influx of freshwater into the Atlantic Ocean can be better evaluated from sedimentary deposits with more robust age model and high-resolution proxy data.

Keywords : Paleohydrology, Paleoenvironment. Holocene, Mesoamerica, Climatic forcing

Poster

Paleo-construction of the Moroccan Atlantic coast

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Abstract :

Several studies around the world attempt to provide an integrated analysis of the response of ancient environments to recent climate change. The paleo-environmental archives such as marine sediments preserve records of past environmental changes. On the Moroccan continental shelf, the Quaternary sedimentary sequences are the only possibility to better understand the natural envelope of climate variation. These series have continuously trapped the environmental evolutionary history of the region that hosts them.

The Moroccan Atlantic coast is located between latitudes 36°N (Cape Spartel) and 21°N (Cape Blanc) and extends for about 3000 km from the Strait of Gibraltar in the north to the border with Mauritania in the south, it is oriented northeast - southwest.

This research focuses on the study of such series, proposing an integrated analysis of the response of Moroccan paleo-environments to recent climatic changes along an ocean-continent continuum.

To achieve this goal, a mission aboard the scientific vessel "Dr. Fridtjof Nansen, EAF-Nansen Programme/FAO" was carried out to collect a series of undisturbed sediment cores from strategic sites in the Moroccan Atlantic coast, using the preserved signatures through specific analyses to reconstruct the paleoclimate and the postglacial and Holocene evolution and functioning of the coastal and neritic system, and the historical reconstruction of low-oxygen events at selected sites in southern Morocco.

Four sediment cores were taken during the mission and several radials perpendicular to the Moroccan coast for the sampling network of the superficial sediment, of which several stations were sampled. In the laboratory, the sediments were analyzed with different methods; sedimentological, mineralogical and geochemical characteristics (granulometric analyses, radionuclides (Pb, Cs), foraminifera, heavy metals, organic matter, DRX, FRX....).

The preliminary results show significant variation in the geochemical composition of the sediments along the core. Currently, we are in the process of confirming the age of the sediments and its relationship with climate change in the Atlantic Ocean.

Keywords : Paleo environment, Moroccan Platform, Sedimentary core, Paleoclimate

Palaeoecological investigations on environmental impact of Iron Ages societies in mid-Kama region (Russia).

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Abstract :

The mid-Kama region is a unique territory uniting Europe and Asia by cultural, ethnic and economic relations throughout history. While its settlement history goes back to the Paleolithic, a significant increase in number of settlements occurred during the Early Iron Age (EIA). The subsistence economy of EIA populations and their impact on the environment raise many questions. Archaeologists suggest two hypotheses explaining the development here: (i) amelioration of environmental conditions within the Roman climatic optimum led to a rapid development of the economy and population of the EIA cultures in the mid-Kama region after the 3rd century BCE leading to a transformation of the Ananyino to Glyadenovo culture; (ii) climate cooling starting in the 4th-5th century AD led to a lower biological productivity, provoking competition for meadows and arable land and finally an exodus from the territory of the mid-Kama, leading to the appearance of two new cultures of Middle Ages: Lomovatovo and Nevolino. Our project "Plant and land use of Early Iron Age societies in the boreal zone of the mid-Kama region and its environmental impact" aims to investigate these questions by palaeoecological and archaeobotanical investigations and quantitative reconstructions. Here we present the first results of the studies on the core Shabunichi-I from the Paltinskoe peatland. It is located within the fluvial terrace of the Kama river close to the numerous EIA settlements. The multi-proxy study includes pollen, non-pollen palynomorphs, micro- and macrocharcoal, loss-on-ignition with AMS radiocarbon datings. We will provide important insights on vegetation, environment and land-use history of the mid-Kama region during the Holocene.

Keywords : Pollen, Non-pollen palynomorphs, palaeoenvironmental reconstruction, human impact, Early Iron Age, Kama

Past, present and future societal risk arising from global change: a collaborative approach.

Michael Neil Evans [(1)], Felix Riede [(2)], Blas Valero-Garcés [(3)], Cornelia B Krug [(4)], Markus Reichstein [(5)] and Marie-France Loutre [(6)]

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Abstract :

As global change accelerates, the risk of low probability but extreme cost/benefit events may be changing. At the same time, growing at-risk infrastructure and population are exacerbating the threat they pose to lives and livelihoods. Research on past climate and environmental change has produced a rich spectrum of data and model results that provide a multivariate and long-term perspective needed to understand climate variability and its varied impacts on past human societies and the environment. While it is clear that this picture has relevance to understanding future risk, information from (paleo)environmental research is not often integrated into risk modeling used on a practical level by insurers or municipalities, and (paleo)climate and -environmental research is not often designed with this aim in mind. We here envision a partnership between natural scientists, social scientists, risk modelers, and managers to improve the estimates of risks associated with

climate change by incorporating insights from earth system observations, modeling of natural and social systems, risk modeling and management, and risk exposure reduction practice. This work is necessary to address the impacts of changes in the probabilities of extreme storm, fire, drought, flood and ecosystem stress events, and tipping points between mean states. These impact assessments might in turn inform financial exposure estimates and municipal planning, and explore ways in which people and organizations might modify their behavior in response to changes in risk perception, not least across temporal horizons beyond electoral cycles and prevalent medium-term scenarios (i.e. beyond 2100). We illustrate a collaborative framework for doing so, using an idealized but nonlinear and coupled natural, socioeconomic and risk model.

Keywords : climate change, societal risk, modeling, observations

OSM22: Historical climate reconstruction and impacts utilizing written records

Co-conveners: Sam White, Qing Pei, Heli Huhtamaa and Oliver Wetter

Oral

A Decade of Cold Eurasian Winters in the Early 19th Century.

Stefan Brönnimann, Angela-Maria Burgdorf, Lukas Reichen, Jörg Franke, Ralf Hand, Veronika Valler, Eric Samakinwa, Yuri Brugnara and This Rutishauser

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Abstract :

Annual-to-decadal variability in northern midlatitude temperature is mostly dominated by the cold season. However, climate field reconstructions, which are essential for understanding the underlying mechanisms, are often based on tree rings that represent the growing season, with limited insights on cold season effects. Here we present extended cold-season (October-to-May average) temperature field reconstructions for the northern midlatitudes for 1701-1905 based entirely on phenological data. They consist primarily of freezing and thawing dates of rivers together with few early-spring plant observations and cover a large area of the northern midlatitudes. Reconstructions show that temperatures of the northern midlatitude land areas exceeded the variability range of the 18th and 19th centuries by the 1940s, to which recent warming has added another 1.5 °C. We also find 5-10 year long sequences of cold northern midlatitude winters. The most prominent example lasted from 1808/9 to 1815/6. Two volcanic eruptions (1808/9 and 1815) caused cooling as a direct effect. The years between the eruptions were characterized by weak southwesterly atmospheric flow over the Atlantic-European sector in early winter leading to low Eurasian temperatures, which persisted into spring

Keywords : phenological data, reconstruction, Bayesian approaches

Droughts in Mozambique and Angola since 1550.

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Abstract :

In southern Africa, documentary-based climate reconstruction has extended our knowledge of seasonal rainfall variability – and especially drought events – back to the early decades of the nineteenth century. To date, however, climatic information within early colonial documentary records dating from the sixteenth century onwards has rarely been employed in systematic reconstructions, meaning that understanding of hydroclimate extremes during the Little Ice Age 'main phase' in the region remains limited. Using written records from sources of Portuguese, Dutch and British origin, this presentation introduces a new chronology of (multi-)seasonal dry and wet events for Mozambique covering the period 1550-1830 CE, and re-examines a similar chronology for Angola covering the same period.

The presentation has four components. First, the nature of the early colonial records is examined and compared to documentary materials used in rainfall reconstructions for more recent centuries, with particular reference to methodological considerations that emerge from differences in the characteristics of source material. Second, the two chronologies are presented, with focus given to the timing and frequency of multi-year droughts. The chronologies are also cross-compared for issues common to documentary reconstruction in the tropics and subtropics, such as the under-representation of wet events. Third, both chronologies are compared to available palaeoclimate reconstructions in the study regions and examined for patterns of consistency and disagreement, with possible reasons suggested for periods where correspondence is limited. Fourth, the long-term relationship between southeast African droughts the El Niño Southern Oscillation in examined.

Overall, the paper concludes that early colonial documentary sources are important in understanding the deeper history of climatic extremes in sub-equatorial Africa, especially

when used alongside palaeoclimate records. However, critical attention must be given to the social context behind the recording of hydroclimate extremes given the 'outsider' origin of the sources, as well as changing economic imperatives and environmental knowledges over the long time period under examination.

Keywords : Drought, southern Africa, rainfall variability, Little Ice Age, documentary reconstruction

Analysis of the correlation between climate and historical extreme flood events in the southeastern Iberian Peninsula: The case of the Andarax River.

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Abstract :

Extreme flood events have affected human settlements in several ways throughout history. Establishing historical flood series, from the beginning of local written records to the present, helps to elucidate the mechanism of natural hydrological processes and their sociocultural impact on populations. Primary written sources, such as municipal proceedings, ecclesiastical archives and historical chronicles, are used to identify extreme events. Based on the information obtained from these sources and their qualitative classification, estimates of the size of the damage as well as its distribution can be made and a century-long intensity index can be reconstructed.

Obtaining a lower or higher proportion of writings on floods during historical periods may be due to anthropic factors (e.g. precision and frequency of accounting; administrative structure and actions; damage due to political instability and military action), but also to damage or destruction of archives by natural hazards such as floods, earthquakes or fires.

This study is focused on the search and subsequent analysis of primary and secondary sources of Andarax River floods. The Andarax river is located in the province of Almería (Spain), one of the driest regions of Europe. The catchment of the river is 2600 km2 large and drains the Sierra Nevada, Sierra Filabres and Alpujarras to the Mediterranean Sea where the city of Almería is located. El río Andarax es uno de los pocos ríos que quedan por analizar a nivel histórico en la vertiente mediterránea de la Península Ibérica, es por ello que ha sido todo un reto analizar la serie histórica de inundaciones extremas del río Andarax.

Five historical archives from four different towns and cities were analyzed. Another two historical archives, in Gérgal and Tabernas towns also were visited, but in these cases, the buildings had been destroyed in the past because a flood event in 1989 the first and because a fire in 1915 the second. The prevailing atmospheric situation when extreme events occur is with a south-southwest flow and a low pressure in the Gulf of Cadiz. In this way, it can be seen how there is a direct correlation between these synoptic situations, specifically with negative NAO and floods. On the other hand, it is also observed that there is a correlation between historical climate patterns, during colder and more humid periods there is a greater number of extraordinary events 17th Century and the end of 19th Century, as well as in warmer and drier periods, fewer, the beginning 15th Century and the beginning of 20th Century. Finally, the correlation between climatic patterns and the existence of extreme events loses correlation in the last 50 years.

The break in the correlation between floods and climate may be due to changes in land use that have occurred in the lower basin of the Andarax River and also to the sealing of soils in large areas of the flood plain, another anthropic action have been the channeling of various ramblas that cross the city of Almería, as well as in the final stretch of the Andarax river.

Keywords : Historical floods, historical climate reconstruction, hydrology, natural hazards

250 years of daily weather: a reconstruction of temperature and precipitation in Switzerland since the late 18th century.

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Abstract :

Numerous historical sources report on hazardous past climate and weather events that had considerable impacts on society. Studying for example mechanisms of such events is however hampered by a lack of spatial weather information. Gridded high-resolution daily data sets mostly cover the past few decades. For Switzerland, Pfister et al. (2019) reconstructed daily fields of precipitation and temperature back to 1864, but the century before this year would be particularly relevant to study the transition from the Little Ice Age climate to the Anthropocene and to analyze the anomalous, volcanically-perturbed climate in the early 19th century and late 18th century.

Here we present a daily high-resolution (1x1 km2) reconstruction of temperature and precipitation fields for Switzerland for the years 1763 to 1960 using the analog resampling method (ARM). Combined with the present-day meteorological fields, this gives a 250-year record. The ARM samples temperature and precipitation fields for the historical period from the most similar days in a reference period. These most similar days are selected based on the smallest distance calculated between the observational data in the historical period and the reference period. As observational data, we use temperature, pressure, and precipitation. Because precipitation measurements are very scarce in the 18th and 19th century, we include precipitation occurrence in our analog selection transcribed from weather notes. The resampled fields for temperature are then further improved by assimilating historical temperature measurements.

Despite the much scarcer data availability in the period before 1864, evaluation results are promising for the temperature reconstruction with correlation values of on average 0.9 and root mean square errors of on average 1.8°C. For precipitation, the evaluation results are less promising with correlation values of on average 0.7 and root mean square errors of on average 5 mm. Due to its high spatial variability and the small number of records in the historical period, precipitation is more difficult to reconstruct. However, the addition of the few available records of precipitation occurrence transcribed from weather notes proves useful and shows that the arduous task of digitizing such data is worthwhile.

Based on two case studies, we show that with the here presented dataset it is now possible to analyze historical weather and climate events in their spatial extent. In addition, the daily high-resolution dataset could be a useful basis for reconciling available written records.

Keywords : weather reconstruction, analog method, early-instrumental period

The REACHES high-resolution gridded temperature and humidity index datasets 1368-1911 in eastern China.

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Abstract :

The REACHES (Reconstructing East Asian Climate Historical Encoded Series) database was constructed building on the weather and climate related information retrieved from documentary records in the Chinese history. The original data in the REACHES was the records collected in A Compendium of Chinese Meteorological Records in the Last 3,000 Years (Zhang eds., 2003, 2014). The records in the Compendium have been systematically digitized into the REACHES, accessible at the NOAA data center (Wang et al., 2018). A standard historical climatological approach was adopted transforming descriptive narratives into four-point and five-point-scale temperature and humidity indices for reconstructing past climate 1368-1911 in eastern Monsoonal China. Calibration and validation of the annually resolved and

summer- and winter-half-year series have been made through comparing the series of the overlap periods and their data structure with early instrumental data in Beijing (1841-1911), Shanghai (1873-1911) and Hong Kong (1853-1911) all retrieved from Global Historical Climatology Network (GHCNm v4).

This study further reports the interpolation methods used to produce gridded climate index data based on the progress of the REACHES to improve paleoclimate data coverage in east Asia and facilitate its scientific application. A fundamental challenge to this work is the large number of missing data in the overall 1,692 sites covering the database. The problem which derived from the Chinese tradition to record abnormality (i.e., unusual or extreme events) rather than daily weather conditions has resulted in a notable bias in uneven data distribution in space and time (e.g., discontinuity of records in each site). To resolve the problem, we tested two hypotheses to fill the missing data gap: (1) assuming no record representing normal condition (mean state), and (2) assuming a man-made deficiency in recording or reserving records. Several multivariate interpolation methods were performed including inverse distance weighting, ordinary kriging, and simple kriging methods, along with the method to assign mean index value to the missing data points. Validation was made through comparing the interpolation results with the Climatic Research Unit gridded Time Series (CRUTS v4) temperature and precipitation detrend data 1901-2018 for the same spatial domain as REACHES. The similarity of the five leading modes of the Empirical Orthogonal Function (EOF) with shifting phases across CRUTS and REACHES suggests reliability of the reconstructed data and monsoonal climate variability in the last five hundred years.

Keywords : high-resolution gridded data, documentary records, temperature index, humidity index, east Asia

Poster

Usefulness of the local press as a weather research tool: the Semanario Sóller as an example in the final decades of the 19th century in Mallorca.

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Abstract :

Daily weather observations started to be recorded in Mallorca during the mid-19th century but the stations were scarce and a lot of information is missing, as records are lost. Meanwhile, in some towns of the island appeared a local press, usually weekly newspapers that included weather information. An example of such press is the Semanario Sóller, which was published once a week since 1885. Sóller is a town located in northwestern Mallorca, with a commercial bourgeoisie that had important relationships with Catalonia and the south of France. The writers of the paper decided that including weather news was interesting for their foreign readers as well as a necessity to explain negative conditions that could affect the agricultural-based economy of the town.

A section of the newspaper included information about climate and weather characteristics, from droughts to heavy rainfall and from strong winter cold to scorching summer heat. A recompilation of this information can describe how was the weather during a time when no climatic data was recorded and can improve our knowledge in an area of the Mediterranean, which is nowadays defined as a climate change hotspot.

Keywords : local press, weather observations, Mallorca, historical climate

Past Climate Variations in Early Instrumental Data.

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Abstract :

There is a growing need for past weather and climate data to support science and decision-making. This paper describes the compilation and the construction of a global multivariable (air temperature, pressure, precipitation sum, number of precipitation days) monthly instrumental climate database that encompasses a substantial body of the known early instrumental time series. The dataset

contains series compiled from existing databases that start before 1890 (though continuing to the present) as well as a large amount of newly rescued data. All series underwent a quality control procedure and subdaily series were processed to monthly mean values. An inventory was compiled, and the geographical coordinates were combined with correlation between records to deduplicate the collection. The data are provided in a common format accompanied by the inventory. The collection totals 27905 meteorological records in 118 countries. The data can be used for climate reconstructions and analyses. It is the most comprehensive global monthly climate data set for the preindustrial period.

Keywords : Paleoclimatology, early instrumental data, time series, quality control, deduplication

OSM24: Regional synthesis of environment-climate-human interactions during the past 2000 years

Co-conveners: Ilham Bouimetarhan, Yahia El Khalki, Martin Koelling, Mustapha Namous, Maurice Taeib, Joan Estrany and Hanane Reddad

Oral

Distribution of modern pollen and its transport from the continent to the ocean in southern Morocco.

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Abstract :

The modern pollen relationship with vegetation features and key environmental factors, constitute an essential step in studies about environmental history and recording natural environmental changes. The aims of this study are to investigate the modern distribution of pollen in southern Morocco, as well as its relationship with the environmental gradient, in order to interpret the origin of marine pollen taxa and the conditions that control their transport from the continent to the ocean. The results provide more insights into the distribution of pollen according to their mode of transport and their contribution to marine sediments. As well as the climate variability and anthropogenic impact have a significant influence on the sus-mentioned distribution. Moreover, the particular distributional patterns of the regional vegetation enable them to be very susceptible to long-distance wind and water transport. The distribution of pollen in southern Morocco and their transport are controlled by surface flow, as well as the NE trade winds. To understand the different transport processes, we used Fe/Ca ratio as an indicator of fluvial input, and the Ti/Al ratio as an indicator of wind input. It is observed that the latter is the most dominant because of the arid climate in southern Morocco, where the rivers have a temporary regime and only reach the Atlantic Ocean during exceptionally rainy periods. These reports show high values in the Tensift and Souss-Massa Basins with regard to the Drâa Basin, in parallel with the increase of Chenopodiaceae, Asteroideae, Cichorioideae, Poaceae, Olea/Phillyrea and Cyperaceae pollen values indicating the dominance of transport by the trade winds. Finally, the transportation of pollen from the continent to the ocean is done by the main wind systems in the region which are the NE trade winds, and by the rivers of the Basins, especially the occasional and exceptional events during winter.

Keywords : Distribution of pollen, Climate condition, Fluvial input, Wind input, Southwestern Morocco

Tropical lake ecosystems in the Anthropocene: Twin lakes from western Uganda.

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Abstract :

Tropical freshwater lakes are critical natural ecosystems of global importance. In western Uganda, crater lakes and their catchments provide vital ecosystem services (e.g. drinking water, aquaculture and ecotourism) to some of Earth's poorest and fastest growing human populations. Additionally, these crater lakes and their typically steep-sided catchments (often retaining fragments of original forest) are biodiversity hotspots in landscapes that have often been extensively modified by human activity. However, these ecosystems and the key services they provide are under increasing threat due to a changing climate and the impact of human activities. Direct anthropogenic impacts from local communities include rapid change in many crater lake catchments as a result of clearance and land use alteration, while

indirect anthropogenic impacts (local but also globally) and climatic change (e.g. an increase of temperature with 0.28°C per decade) has also led to alterations in crater lake ecosystems. Both climatic and anthropogenic impacts, of the past and present, on these vulnerable ecosystems are largely unknown.

Previous palaeoecological research carried out across eastern Africa has mainly focused on the larger lakes, such as Lake Victoria and Lake Tanganyika, and long-term changes in climate as recorded in their lake sediments. Little attention has been given to the more recent changes in ecosystem function driven by climate and/or humans, or on smaller, regional ecosystems. Besides focussing on larger lakes and longer timescales, tropical lakes are largely understudied compared to lakes in temperate regions. To fill in these gaps, this paper targets two adjacent lakes, Lake Katinda and Lake Mirambi, both with (heavily) impacted catchments.

Sediment cores from both lakes (spanning the last c. 50-150 years) were analysed for sedimentary diatoms to study the impact of human activity on the ecological functioning of these lake systems and try and disentangle natural from anthropogenic drivers. Both cores were dated using Pb-210 and diatom analysis was undertaken at high temporal–resolution (sub-decadal).

The diatom results demonstrate that both crater lakes are sensitive to climatic changes in the recent past, with increasing and decreasing lake level (and diatom-inferred salinity) due to a wetter or drier climate respectively. Lake Katinda shows a shift in the diatom assemblages which could indicate a human induced disturbance in the catchment area. Changes in the diatom composition of Lake Mirambi, however, occur earlier and have a different origin compared to Lake Katinda. Both lakes and their catchments have been heavily impacted by humans over the past decades, and their sediment records reveal major disturbances compared to other lakes in the same region with more "pristine" catchments. Disturbance in recent decades seem to be linked to a fluctuation in sediment influx attributed to land use change (catchment deforestation and agriculture under growing population pressure). Understanding past anthropogenic and climatic influences on these ecosystems can act as a guide to their future resilience under increasing environmental change and help sustainable management of vital ecosystem services these natural resources provide for local populations.

Keywords : Diatoms, Uganda, the Anthropocene, twin lakes

Human and climate impacts on crater lake hydrology in western Uganda over the past c. 1000 years.

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Abstract :

A group of >80 crater lakes located in western Uganda provide important water resources and opportunities for aquaculture and tourism to rural communities, as well as wider ecosystem services. The lakes and their surrounding ecosystems are subject to multiple pressures including catchment clearance (to make room for plantations and subsistence agriculture) and climate change, the impacts of which are exacerbated by the region's low levels of water infrastructure and high population growth rates.

Understanding how the lakes and their hydrology have responded to past environmental and climatic change is key to informing their future sustainable management; while previous work on the lakes has focused on changes in past water quality, changes in lake hydrology remain poorly understood. We present new high-resolution sediment core multi-proxy records, including authigenic carbonate $\delta^{18}O$ and $\delta^{13}C$, XRF, and physical proxies from four lakes located across the Bunyaraguru and Kasenda crater lake clusters which have been subjected to varying degrees of catchment-scale human impact. Using a paired lake approach in two crater lake clusters, alongside existing data from sediment cores spanning longer timescales, allows us to infer a regional history of hydrological change

across the region over the past c. 1,000 years, and infer the multiple interacting drivers responsible.

Keywords : palaeolimnology; multi-proxy; hydrology; human impact

Bioindicators Monitoring using Soil & Plant Sediments to Measure Environmental Impacts In the Research Oak Forest of Ilam, Iran

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Abstract :

The dust cycle, which consists of mineral dust emission, transport, deposition and stabilisation, has multiple interactions with many climate processes and biogeochemical cycles.The purpose of this study was to advance understanding of the characteristics of bioindicators using soil & plant sediments and the potential of environmental impacts in a research forest of Ilam, in the west corner of Iran.The study was also conducted to assess the nature of the dust in terms of the presence of heavy metals and how important elements in the soil and leaves of oak trees change. Accordingly, soil, leaves and branches samples of Oak species (Quercus Brantii) were randomly collected from the study area over a two-years period.Therefore, the place of bio-tracking was the Research Oak Forest of Ilam, and the type of bioindicators was oak leaves, branches and sediments of trees base soil. The time of bio-tracking was 2013 and 2014. In conducting this research, the beginning of the first shift sampling coincided with April (the beginning of the growing season) and the last shift of the sampling coincided with the end of September (the end of the growing season). In second stage, the available concentrations of four elements (lead, zinc, nickel and cadmium) in the soil, branches and leaves of the oak tree sampled from collected from the Research Oak Forest of Ilam, in two consecutive years and during eight repetitions. Then after preparation process, in the laboratory, samples measured by ICP device.During the four sampling, the results indicated that, over time, the amount of elements except zinc increased in the soil samples under the canopy of oak trees. All four elements absorbed by leaves of trees increased during the early spring until late summer, and their difference was significant at 5% level.This study demonstrated that the heavy metals include Zinc, Nickel, Cadmium and Lead have been absorbed mainly by oak leaves and roots in Ilam oak research forest in some cross-sectional studies during two consecutive years (2013 and 2014).The study also found that dust storms have been able to reduce the resistance of oak trees to decay, along with other stressors such as climate change, drought, pest infestation, grazing and other cases.

Keywords : Biomonitoring, Dust, Ilam, Heavy metals, Oak dicline.

The voyage of Humans in the South Pacific: the view from Lake Lanotō, Sāmoa

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Abstract :

Archaeological data suggests that humans commenced inhabiting the remote islands in the South Pacific around 3000 yr BP. Human occupation brought tremendous modifications to these small islands: clearing forests through burning, introduction of new flora and fauna, horticulture practices and the like. These practices were either drastic or gradual in some

areas in the region, and may have been related to patterns of climate change. To better understand the peopling of this area, a 4.75 m composite sediment core, encompassing the period of human settlement, was retrieved from Lake Lanotō, Sāmoa. A multi-proxy approach, including micro-XRF scanning of the cores, grain size distribution, organic carbon content and molecular biomarkers from human and plant remains engraved in the sediment, is used to reconstruct past environmental changes. Combining these biomarker and elemental proxies will help us advance our knowledge on the timing of human expansion in Sāmoa, and in the South Pacific region. The generated data will shed valuable light on Pacific prehistory and complement the knowledge gained from archaeological data.

Keywords : South Pacific, XRF, biomarker, multiproxy, grain size

The peopling of mangroves in Senegal in the late Holocene: relationship with climate and political changes in West Africa.

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Abstract :

We present a reconstruction of human demography and shell fishing activity in the Sine-Saloum mangrove Delta (Senegal) in the Late Holocene using the summed probability density (SPD) of radiocarbon dates in archaeological shell middens. We explore how this local history relates to the climatic and political history of West Africa. We find that traces of human presence were scarce from 6000 to 2000 yr BP, partly because the geomorphology of the estuary was less favourable to human settlements at that time. A specialized shell fishing population migrated massively to the Sine-Saloum around 2000 yr BP, at the end of the aridification trend that followed the African humid period. This population, likely coming from the northern coast in search of land and resources, fleeing the Saharan desertification and the subsequent warfare, found refuge in the coastal mangroves and reached a maximum activity at about 1700 yr BP. This period corresponds to the beginning of trans-Saharan trade, and to a political complexification that would give rise to the Ghana empire. The incoming migration may have occurred in two waves as suggested by two peaks in the SPD curve at 200-400 CE and 600-800 CE and by cultural differences within the Delta. Most sites in the Sine-Saloum islands were abandoned in the 14th century, before the arrival of Europeans, possibly because intensive shell fishing was not sustainable anymore, or because of the regional political destabilization associated to the fall of the Ghana empire and the beginning of the Mali empire. Shortly after, in agreement with oral traditions, a new population lead by the Manding Guelwars, moved to the Sine Saloum after a military defeat and founded the modern towns. They had a reduced shellfishing activity compared to previous inhabitants, possibly because activities were more oriented to the new trade with Europeans or to a prosperous agriculture in more humid climatic conditions that prevailed from 1500 to 1800 CE.

Keywords : Sahel, Climate change, shell middens, radiocarbon, mangroves, human migrations

Using Palaeoecology to Determine the Effects of Recent Human Impacts on a Shallow Lake in Madagascar.

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Abstract :

Lake Sofia is a large shallow lake in Northwest Madagascar. Much of its surrounding Cyperus marsh remains intact, and it was identified as the most suitable site for the reintroduction of the Madagascar Pochard. Widely reported as the world's rarest duck, this species of diving duck feeds on invertebrates in the lake sediment, however, there are multiple human pressures impacting the lake and macroinvertebrate density remains low. There are few submerged or floating macrophytes and the water is turbid. Farming occurs in the catchment where synthetic pesticides are thought to have been used since the year 2000. There is a tilapia fishery in the lake and it is thought these fish were introduced in the 1980s. The land-use changes in the catchment occurred much earlier, indicated by aerial photographs from the 1960s that show a similar distribution of land use to the present day. This temporal separation of pressures allows us to disentangle their effects using the sediment record. A wide-diameter sediment core was taken from the lake and successfully dated using Lead-210 analysis. The macrofossil and geochemical records suggest that a state shift has occurred in the lake at a depth of around 45 cm. The earliest Lead-210 date is 1898, at a depth of 39.5 cm, meaning this change occurred prior to tilapia introduction or pesticide use. It appears the lake used to be clear and dominated by submerged Charophytes, indicated by an abundance of two types of Charophyte oospore in sediments below this depth. There is also a greater abundance and diversity of macroinvertebrate remains in this period. Above 45 cm, there is a sudden reduction in the number of charophyte and invertebrate remains, except for Chaoborus mandibles, which appear suddenly in the record. This genus is commonly associated with a state shift and at the same time, the number of Water lily (Nymphaea stellata) seeds and Bryozoan (Plumatella spp.) statoblasts gradually decline. This trend of sudden change around 45 cm is also reflected in the geochemical indicators, with a peak or trough in Loss on Ignition/Mercury/XRF data and an increase in erosional indicators. This could be as a result of land-use change, which may have been responsible for the state shift. Macrocharcoal data will provide further evidence by indicating the onset of agropastoral burning in the area. These findings will be used to inform lake restoration work being done by the Wildfowl and Wetlands Trust. It appears that land use management may be vital for restoring the lake, but it is unclear whether this can return the lake to a clear and macrophyte-dominated state while the additional, more recent pressures, of synthetic pesticide use and the currently unmanaged introduced tilapia fishery persist.

Keywords : palaeolimnology, lake, conservation, restoration

Environmental evidence of metal smelting activities before, during, and post Roman period in the Carpathian borderlands

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Abstract :

Mining activities in the Carpathians reached maximum intensity during the Roman rule, with Roman Dacia (106-275 AD) hosting some of the largest underground mining operations in Europe during Late Antiquity. It is very likely that massive mining during the Roman and Medieval periods removed earlier field traces but here we discuss peat geochemical data that can verify the extent of metal processing before - during - after the Roman period. Indeed, the impressive amounts of gold and silver stated in ancient sources as war trophy from the Dacian Wars (101-106 AD) imply significant pre-Roman mining in Dacia. Chance discoveries of Bronze Age mining tools within deep-seated mines, and especially radiocarbon dating of timber remains found along ancient mining shafts at Rosia Montana produced some

verifiable evidence of pre-Roman mining of endogenous ores. Using high-resolution geochemical analyses of several peat profiles from the Apuseni Mountains, including two records from within the Rosia Montana area, we provide a detailed chronology of human activities and mining in one of Europe's oldest mining fields. The Pb isotopes on bulk peat suggest that by 300 BCE exploitation of the Neogene Au-Ag ores within the Apuseni produced a strong environmental pollution signal. Interestingly, the Pb curve as well as the Pb isotopes data suggest that mining activities at Rosia Montana did not cease following the Roman withdrawal from the area, despite that fact that Late Roman times in SE Europe have been marked by significant movements of peoples that triggered severe socio-economic disruptions. Instead, our data indicates that the Pb curve closely match a significant drop following the collapse of Roman authority north of Danube, but then diminished progressively with Pb data still indicating the Apuseni ore fields contributed for several centuries. By 700 CE however, the Pb isotope suggest that the pollution budget reflects only long-distance input of atmospheric metals originating from the Balkans.

The extent of mining during early medieval times particularly in central-eastern Europe is not well assessed. The generally held view, concurrent with developments in western Europe is that increased social disorganization and technological decline after the fall of Roman Imperial authority resulted in a collapse of continent-wide metal market and mining activities, which would recover only by 11-12th centuries CE. We document the existence of strong regional differences in the magnitude of past pollution before - during – after the Roman Period in central-eastern Europe, as well as temporal and spatial shifts in past emission sources that denote regional shifts in mining, metal production and consumption that require further investigations. Thus, a key finding from our analysis is that prevailing views on past European pollution during the Roman period are incomplete without closely considering past developments over the Balkans whose long-term and significant metal pollution output could potentially be traced at times even to the Greenland ice

Keywords : pollution, metal use, human impact, peat bogs

Paleoenvironmental changes in the lowlands of Transylvania (Central Eastern Europe) during the Late Holocene.

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Abstract :

To better understand the spatial and temporal transformation of the landscapes of the lowlands of Central-Eastern Europe by humans, and facilitate mitigation of potential future risks emerging from environmental degradation, century to millennium-scale records of environmental change are necessary. However, the dry climatic characteristics of this region limit the occurrence of suitable palaeoarchives such are peat and lake sediments. Significantly, despite the key role of these areas as populational and agricultural hotspots, very little is presently known about their past environment.

Here we present a 4000 year long, high-resolution record of the palaeoenvironmental changes documented in a7m-long sediment core from Taga Lake in the lowlands of Transylvania (Romania, Central Eastern Europe). We measured the sedimentological and geochemical properties to derive an erosion history of the catchment, while macroscopic charcoal, pollen and published archaeological information were used to identify anthropogenic disturbances at a local to extra-local scale.

Our results indicate that the lake-catchment system underwent two major changes in environmental conditions, around 3500 and 1100 years ago respectively. The most prominent change occurred around 1100 cal yr BP, when the physical and geochemical properties of sediments indicate an accelerated

increase in sedimentation rate and catchment erosion, pointing towards slope instability. Mineral magnetic properties further indicates a change in sediment sources from eroded topsoil, which predominated between 3500-1100 cal yr BP, to deeper soil layers, remain dominant over the last 1100 years. This change at 1100 cal yr BP corresponded to a marked increase in regional landscape openness and a reduction to minimum in biomass burning, as inferred from pollen and charcoal records, paralleled to an expansion of evidence for human settlements in the area. The 4000-yearlong sedimentary record of Taga Lake contributes to an understanding of palaeoenvironmental changes in relation to human impact during the Late Holocene in the lowlands of Transylvania and highlights the importance of the lake sediments in environmental and climatic reconstructions.

Acknowledgement: This work was supported by the Romanian National Authority for Scientific Research, UEFISCDI, PN-III-P1-1.1-TE-2019-1628.

Keywords : palaeoenvironmental changes, Taga lake, lowlands, Transylvania, Late Holocene

Past human-ecosystem dynamics in Vanuatu

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Abstract :

Small islands, where resources are scarce and space is by definition limited, are paradigmatic cases of anthropogenic impacts on ecosystems. Archeological studies show that human settlements in remote oceanic islands came along with major landscape modifications. How ecosystems responded to these changes is an open question. Reconstructing past environmental changes in recently colonized ecosystems such as the Island of Espiritu Santo, Vanuatu, can help understand the ecosystem responses to different degrees of anthropogenic modifications. Here we present sedimentological records spanning the last millennium. We combine geochemical tools based on fossil molecules of known origin with sedimentological and paleoecological methods. A high-resolution chronology from radiocarbon-dated terrestrial macrofossils allows for a detailed environmental reconstruction. The presence of coprostanol, a fecal biomarker, and charcoal in the cores provide signals of human presence dating back 1000 years. The presence of charcoal at the bottom of the lakes suggests that fires were used to clear the land for the establishment of agriculture, which is still a common practice in the area. Palmitone, a unique biomarker for taro, the main staple crop in the area, found downcore further confirms this hypothesis. Proxies such as grain size, total organic carbon, and biogenic silica are indicating past erosive events and changes in lake productivity, possible consequences of human activities in the area. The n-alkanes biomarkers together with the pollen record show changes in both aquatic and terrestrial vegetation. Altogether, these past changes can be linked with the tight interplay between humans and the surrounding environment in shaping the ecosystem as we see it today.

Keywords : human impact, islands, multi-proxy, sediment cores

Poster

Climate Change risks modeling

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Abstract :

That is obvious that Climate change is driving fundamental changes to the planet with adverse impacts on human livelihoods and well-being, putting development gains at risk already today on Nature and Eco-Systems. Precisely how climate change will play across regions and over time remains uncertain, but this is not an excuse to delay action. This report explores the uncertainties associated with climate risks and analyses the policy, financial and technological approaches needed to reduce and manage the risks of losses and damages from climate change, drawing on experiences from around the world. Mitigation and Adaptation of Climate Change ambition in Georgia require more than an assessment of emission reduction targets. It needs an assessment of underlying processes needed to increase sectoral climate change adaptation and modeling of Climate Change risks (flooding, soils erosion, droughts and etc). The Digital modeling (ArcGIS and Python) will present the best less risky scenarios of Climate Change on Rural and Urban infrastructure, eco-stsmes and human safety.

Keywords : Climate Change, Mitigation, Adaptation, Georgia, Modeling, ArcGIS

OSM25: Tipping points in the Earth system: Can the past inform us about the future?

Co-conveners: Edward Brook and Paul Valdes

Oral

Converging constraints on the glacial Atlantic overturning circulation from multiple proxies.

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Abstract :

The Atlantic overturning circulation plays a critical role in inter-hemispheric transport of heat, carbon, and nutrients, and its potential collapse under anthropogenic forcing is thought to be a major tipping point in the climate system. As such, painstaking efforts have been dedicated to a better understanding of the Atlantic circulation's past variability and mean-state under different boundary conditions. Yet, despite decades of research many uncertainties remain regarding the state of the ocean circulation over the past 20,000 years, during which Earth's climate was propelled out of the last ice age. Here, we employed the Bern3D intermediate complexity model, which is equipped with all major water mass tracers (Δ14C, δ13C, δ18O, εNd, Pa/Th, nutrients, and temperature), to search for converging constraints on the often conflicting interpretations of paleo-reconstructions from individual proxies focusing on the Last Glacial Maximum (LGM). By varying formation rates of northern- and southern-sourced waters we explore a wide range of circulation states and test their ability to reproduce the spatial patterns of newly compiled proxy data of the LGM. Generally, we find that late-Holocene to LGM anomalies give more consistent pictures of proxy distributions than absolute values, since systematic biases, that plague some of the proxies, cancel out. This has the additional advantage that also systematic model biases are minimized. Considering this, we find that the previously opposing neodymium and stable carbon isotope-based interpretations of the glacial water mass structure can be reconciled when non-conservative effects are appropriately taken into account. Furthermore, combining the information from all proxies indicates some shoaling of glacial northern-sourced water, yet not to the same extent as previous studies suggested.

Keywords : Modelling, Ocean, Atlantic, Proxies, Isotopes

Dichotomy between freshwater and heat flux effects on oceanic conveyor belt stability and global climate.

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Abstract :

The Atlantic meridional overturning circulation (AMOC, or oceanic conveyor belt) is an important global scale oceanic circulation and changes in AMOC may be responsible for past abrupt climate change events. Here, by using two versions of a coupled climate model, we show that the AMOC's stability depends not only on the background climate, but also on the type of primary external forcing: freshwater vs. greenhouse gases (GHGs). When freshwater forcing is dominant, AMOC hysteresis such as a sudden collapse/reactivation of AMOC become possible only under simulated glacial conditions. Whereas, under present day/future conditions, either freshwater or GHGs forcing could collapse AMOC but only GHG forcing produced a bi-stable equilibrium state equatable with abrupt climate change. Our results demonstrate that the Bering Strait status (open vs. closed) may facilitate or prohibit the existence of AMOC hysteresis irrespective to the background climate conditions, but respective to primary forcing (freshwater vs. GHGs). Our

results further suggest that with a collapsed AMOC, the surface temperature, precipitation, evaporation and cloudiness decrease in Northern Hemisphere, but increase in Southern Hemisphere with a net reduction globally with freshwater forcing alone. Under GHG forcing alone, the changes of these variables generally agree with those under freshwater forcing alone, and the differences show up mainly in the Polar Regions in association to the feedbacks due to the amplified warming there.

Keywords : AMOC, abrupt climate change, global climate change

Changing positive to negative temperature-moisture relationship at the start of the Holocene predicts future drying of East Africa.

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Abstract :

Characterized by national economies which rely heavily on crop agriculture and highly variable annual rainfall from year-to-year, East Africa is endemically vulnerable to water scarcity. Whereas future climate projections for the region predict increased rainfall during the 21st century as global temperatures continue to rise, meteorological observations record a trend towards drier conditions in the recent decades. Paleoclimate reconstructions have a clear role to play in understanding the stability of the relationship between temperature and moisture balance across a large range of climate states and in elucidating how this may develop over the next decades to centuries. However, there is generally a shortage of climate proxy records from continental low-latitude settings which are both long and detailed. We analysed glycerol dialkyl glycerol tetraethers (GDGTs) in the continuous and depositionally uniform sediment record of Lake Chala (Kenya/Tanzania) to provide the first paired temperature and hydroclimate reconstruction from equatorial East Africa spanning Marine Isotope Stages (MIS) 4 through 1. Our record shows that the Heinrich-1 megadrought period (~18,000-15,000 years ago) was both the driest and coolest episode in the last 75,000 years. Contrary to most low-latitude regions worldwide, the Last Glacial Maximum was fairly wet by comparison, continuing the wet conditions which prevailed through most of MIS4 and MIS3. Temperature and moisture balance in easternmost Africa both responded strongly to orbital precession but also show a significant obliquity signature. Moisture balance also shows the so-called half-precessional cycle (~10,500 year), typical of regions in the heart of the tropics, where the sun passes overhead during both the vernal and autumn equinoxes. Positive correlation between continental moisture balance and temperature during glacial time (MIS4-MIS2) implies that intermittent drought was caused by weakened monsoon rainfall. Overall, the glacial-era monsoon remained strong, due to only modestly lower temperature at sea level compared to today. During the Holocene (MIS1), however, continental moisture balance was inversely related to temperature, indicating that enhanced evaporation at high interglacial temperatures partly counteracted increased monsoon rainfall. Our results imply that under future conditions of anthropogenically increasing greenhouse-gas concentrations and temperature, equatorial East Africa is likely to experience increased water-resource scarcity notwithstanding IPCC projections of increasing rainfall.

Keywords : East Africa, lake, paleoclimate, GDGTs

Dansgaard-Oeschger events in climate models: Review and baseline MIS3 protocol.

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Abstract :

Frequent well documented Dansgaard-Oeschger (D-O) events occurred throughout the Marine Isotope Stage 3 (MIS3; appproximately 25 – 60 ka) period. The climate modelling community has not been able up to now to answer the question: Are our climate models too stable to simulate D-O events? To address this, this study lays the ground-work for a MIS3 D-O protocol for CMIP-class models. We review: necessary D-O definitions; current progress on simulating D-O events in IPCC-class models (processes and published examples); and consider evidence of boundary conditions under which D-O events occur. We find that no model exhibits D-O like behaviour under pre-industrial conditions. Some, but not all, models exhibit D-O like oscillations under MIS3 and/or Last Glacial Maximum (21 ka) conditions. Greenhouse gases and ice-sheet configurations are crucial, whereas the effect of orbital parameters is small. However most modelling groups have not run simulations of long enough duration to be sure which models do capture D-O like behaviour, under either MIS3 or LGM states. We propose a MIS3 baseline protocol centered at 38 ky (40 to 35 ky) period, which (1) shows a regular sequence of D-O events, and (2) features the intermediate ice-sheet configuration and cool MIS3 greenhouse gas values which our review suggests are most conducive to D-O like behaviour in models. The protocol also covers insolation, and freshwater forcing. Alongside this baseline, previous work suggests that a kicked Heinrich meltwater baseline variant may also be helpful in preconditioning a state in models which is conducive to D-O events. This review and protocol help unify the work of multiple model groups when investigating MIS3 D-O oscillations under a common framework.

Keywords : Dansgaard-Oeschger, MIS3, Tipping points

Learning from past climate tipping points to avoid future ones

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Abstract :

Tipping points exist in social, ecological and climate systems and those systems are increasingly causally intertwined in the Anthropocene. Climate change and biosphere degradation have advanced to the point where we are already triggering damaging environmental tipping points, and to avoid worse ones ahead will require finding and triggering positive tipping points towards sustainability in coupled social, ecological and technological systems. To help with that I will outline how tipping points can occur in continuous dynamical systems and in networks, the causal interactions that can occur between tipping events across different types and scales of system – including the conditions required to trigger tipping cascades, the potential for early warning signals of tipping points, and how they could inform deliberate tipping of positive change. In particular, the same methods that can provide early warning of damaging environmental tipping points can be used to detect when a socio-technical or socio-ecological system is most sensitive to being deliberately tipped in a desirable direction. Some example targets for such deliberate tipping of positive change will be provided.

Keywords : Climate tipping point Earth systems

Tipping points in the 620 kyr proxy record from Chew Bahir, S Ethiopia.

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Abstract :

We have used a change point analysis (CPA) and a recurrence plot/recurrence quantification analysis (RP/RQA) on a 300 m / 620 kyr lake-sediment record from the Chew Bahir basin in the southern Ethiopian Rift to determine the amplitude and duration of past climate transitions. In this record, there are numerous transitions from wet to dry conditions, as well as from dry to wet, which show the typical characteristics of a tipping point, where the change is always faster than the forcing and the actual transition is preceded by possible precursor events. One of the most interesting transitions examined with the CPA and RP/RQA was the termination of the African Humid period (15–5 kyr BP). The rapid (~880 yr) change of climate in response to a relatively modest change in orbital forcing appears to be typical of tipping points in complex systems such as the Chew Bahir basin. If this is the case then 14 dry events at the end of the AHP at 5.5 kyr BP, each of them 20–80 yrs long and recurring every 160±40 yrs as documented in the Chew Bahir cores could represent precursors of an imminent tipping point which, if properly interpreted, would allow predictions to be made of future climate change in the Chew Bahir basin. Compared to the low-frequency cyclicity of climate variability before and after the termination of the AHP, this type of cyclicity occurs on time scales equivalent to a few human generations. In other words, it is very likely (albeit speculative) that people were conscious of these changes and adapted their lifestyles to the consequent changes in water and food availability. A deeper analysis of our data is however required to understand whether the wet-dry climate transition in the area was due to a saddle-node bifurcation in the structural stability of the climate, or whether it was induced by a stochastic fluctuation.

Keywords : Africa, Green Sahara, Time-Series Analysis, Climate Change, Feedback

Decadal-scale onset and termination of Antarctic ice-mass loss during the last deglaciation.

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Abstract :

Emerging ice-sheet modeling suggests once initiated, retreat of the Antarctic Ice Sheet (AIS) can continue for centuries. Unfortunately, the short observational record cannot resolve the tipping points, rate of change, and timescale of responses. Iceberg-rafted debris data from Iceberg Alley identify eight retreat phases after the Last Glacial Maximum that each destabilized the AIS within a decade, contributing to global sea-level rise for centuries to a millennium, which subsequently re-stabilized equally rapidly. This dynamic response of the AIS is supported by (i) a West Antarctic blue ice record of ice-elevation drawdown >600 m during three such retreat events related to globally recognized deglacial meltwater pulses, (ii) step-wise retreat up to 400 km across the Ross Sea shelf, (iii) independent ice sheet modeling, and (iv) tipping point analysis. Our findings are consistent with a growing body of evidence suggesting the recent acceleration of AIS mass loss may mark the beginning of a prolonged period of ice sheet retreat and substantial global sea level rise.

Keywords : Antarctic Ice Sheet, glacial termination, tipping points, sea-level rise, ibeberg-rafted debris

Persistent Iceland-Scotland Overflow Water formation during MIS 11

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Abstract :

The Atlantic thermohaline circulation is one of the tipping elements in the climate system of the Earth [1] and it remains debated whether future changing boundary conditions, especially freshwater input in the North Atlantic, may influence the deep water formation. Deep convection in the Nordic Seas leads to the formation of Iceland-Scotland Overflow Water (ISOW) which is an essential part of the lower limb of the Atlantic Meridional Overturning

Circulation (AMOC). However, surface conditions in the Nordic Seas were unlikely always favorable for the formation of deep water in the past.

During Marine Isotope Stage (MIS) 11 a strong and active AMOC [e.g. 2] was reconstructed, which also contributed to the mass loss of the Greenland Ice Sheet [3]. However, cold and fresh surface conditions prevailed in the central Nordic Seas [4] which have been ascribed to freshwater input from the higher latitudes [5]. Thus, the question arises whether and where deep water formation took place in the Nordic Seas.

Here, we reconstruct authigenic neodymium isotopes extracted from deep sea sediment from the Gardar Drift from 470 to 374 ka. IODP Site U1304 is located directly in the modern flow path of ISOW and should therefore sensitively track changes of this water mass in the past. Today, it is characterized by a strongly radiogenic neodymium isotopic composition, which markedly differs from other North Atlantic water masses.

Starting right at the onset and for the full length of the interglacial MIS 11c, a radiogenic Nd isotopic composition is switched on and prevailed indicating the presence of ISOW at the core site. More unradiogenic conditions indicate the return to glacial like conditions during a short event in MIS 11b. However, during MIS 11a the radiogenic values point again to a persistent presence of ISOW.

Thus, although the boundary conditions in terms of freshwater fluxes and sea level were significantly differing in the central Nordic Seas, the deep water formation presumably happened in the southern part of the Nordic Seas. This led to the active formation of ISOW, which in turn helped drive the active and strong AMOC during MIS 11.

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[2] Dickson et al. (2009), Nat. Geosci. 2: 428-433.

[3] Rachmayani et al. (2017), Paleoceanography 32: 1089-1101.

[4] Kandiano et al. (2016), GRL 43: 10929-10937.

[5] Doherty and Thibodeau (2018), Front. Mar. Sci. 5: 251.

Keywords : AMOC, neodymium isotopes, MIS 11, ISOW

Evidence for centennial-scale Mid-Holocene episodes of hypolimnetic anoxia in a high-altitude lake system from central Tian Shan (Kyrgyzstan).

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Abstract :

Few sedimentary archives of lake meromixis are available in palaeolimnological records, because longterm observations are limited in time and indisputable sediment proxies of hypolimnetic anoxia are still scarce. Here we use visible and near infrared (VNIR), and short-wave infra-red (SWIR) hyperspectral imaging combined with geochemical analyses to reconstruct lake stratification history, redox status and mixing conditions in the water column of Lake Son Kol (Kyrgyzstan) in Central Tian Shan during the last 8500 years. In particular, the detection of Bacteriopheophytin a (Bphe a), a pigment produced by anoxygenic phototrophic bacteria at the chemocline of meromictic lakes, emphasizes episodes of multidecadal to centennial hypolimnetic anoxia in Lake Son Kol. Phases of hypolimnetic anoxia are inferred from the deposition of dark organic sediments within a stratified lake system, which occurred during periods of increased snowmelt (and solid winter precipitation) and warmer spring/summer temperatures that promoted floods and the export of terrestrial material from the catchment. Prolonged euxinic conditions in bottom waters (involving the development of a stable chemocline) are

reported around 8500, 8400, 8200-7800, 7700-7500, 7300-7000, 6500-6100, 6000-5700 and 5500-5250 cal yr BP. At ca. 5250 cal yr BP, the chemocline abruptly vanished as Lake Son Kol tipped into a regime with predominantly cooler and well-mixed conditions (predominance of oxygenic phototrophs), coeval with higher lake levels. The disappearance of hypolimnetic anoxia in Lake Son Kol coincides with strengthened wind conditions that imply enhanced lake overturning and upward mixing of nutrients in the water column. This study reveals the strong potential of hyperspectral imaging, in combination with more classical palaeolimnological approaches, to reconstruct the lake trophic and mixing history and explore the controlling mechanisms at work on decadal to centennial timescales. Our results outline how abrupt ecosystem changes may occur even in the absence of anthropogenic climate change.

Keywords : Hyperspectral imaging, Paleolimnology, Lake stratification, Hypolimnetic anoxia, Central Asia

Simulated response of marine ecosystems to Last Glacial Maximum boundary conditions.

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Abstract :

Through uptake of dissolved inorganic carbon in the ocean mixed layer, marine phytoplankton exert a significant control on the oceanic carbon distribution, and thus play a key role in influencing the atmospheric carbon dioxide (CO_2) concentration on centennial to millennial timescales. Previous research has hypothesised that higher aeolian iron input to the Southern Ocean during glacial times would have contributed to the atmospheric CO_2 decrease.

In this study we investigate the response of Southern Ocean marine ecosystems to enhanced aeolian iron input under Last Glacial Maximum (LGM) boundary conditions. We use a newly developed complex ecosystem model, which incorporates four distinct major plankton types with explicit prognostic equations for silicifiers and calcifiers. Under LGM conditions but without enhanced aeolian iron, increased sea-ice cover and lower surface nutrient concentrations lead to 2% decrease in export production in the Southern Ocean compared to pre-industrial (PI). A 78% increase in the aeolian iron flux into the Southern Ocean using the LGM dust flux from Lambert et al., 2015 along with a weaker Antarctic Bottom Water formation in the Weddell Sea increases the Southern Ocean EP by 4.4% compared to PI through an increase in diatom abundance within the seasonal sea-ice edge and an increase in coccolithophore abundance north of the winter sea-ice edge in the Atlantic sector.

Keywords : Marine ecosystems, Last Glacial Maximum, Iron fertilisation, carbon cycle

Role of polar stratospheric clouds in Arctic amplification.

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Abstract :

General circulation models are unable to reproduce the full magnitude of Arctic warming during past warm climates, such as the early Cretaceous and Paleogene periods. This suggests that certain physical processes responsible for Arctic warming might be missing in these models. Previous studies hypothesized that a large increase in wintertime Arctic polar stratospheric clouds might have played an important role in Arctic amplification. Massive methane emissions during the Eocene may have increased stratospheric water vapour, providing favourable conditions for polar stratospheric clouds, which in turn may have warmed the surface through an increase in downwelling longwave radiation. We revisit this hypothesis with a set of greenhouse gas sensitivity experiments in the presence of a strong polar-amplified surface ocean warming using a fully interactive chemistry-climate model and present day topography. We find that the Brewer-Dobson Circulation weakens with increased polar amplification but strengthens with an overall increase in global mean

temperature or greenhouse gas concentrations. However, radiative cooling due to greenhouse gases dominates over dynamic heating associated with the Brewer-Dobson Circulation. Increases in methane concentration monotonically increase stratospheric water vapor concentration, thereby increasing Arctic polar stratospheric cloud cover following a power law with respect to relative humidity. We find a large increase in outgoing longwave radiation in response to the polar-amplified warming that gradually reduces with increasing methane concentrations at fixed surface warming. In our highest methane experiments, 40% of this reduction is caused by polar stratospheric clouds with the rest caused by the increased greenhouse effect from methane, water vapor and tropospheric clouds. However, the radiative effects of polar stratospheric clouds in our idealized experiments are too small to contribute significantly to Arctic warming. A very different topography during the Eocene might have impacted the Brewer-Dobson Circulation thereby influencing polar stratospheric clouds. We therefore integrate another set of experiments using Eocene topography. We find that the Eocene topography reduces the strength of the Brewer-Dobson Circulation independent of the global mean temperature or greenhouse gases, thereby strengthening the Arctic vortex and promoting polar stratospheric clouds.

Keywords : Stratospheric circulation, Chemistry-climate models, cloud radiative effect, methane, greenhouse gases

Regulation of atmospheric CO_2 by sea iron solubility impacts during the Last Glacial Maximum and Holocene in an Earth system model.

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Abstract :

Ice and sediment cores have provided important information about the natural variability of atmospheric CO2, which has ranged between 180-280 ppm during glacial and interglacial periods, respectively. The ocean has been one of the main reservoirs, and in particular, recent studies have shown that the biological pump would be responsible for at least a quarter of this difference. In addition, one of the responsible for the variation in CO2 concentration is the iron supply to the surface ocean. As a result, an increase in wind dust fluxes during cold periods, such as the Last Glacial Maximum (LGM, 26 -19 ky BP), promotes significant biogeochemical activity by altering primary production and affecting the export and sequestration of carbon. Although the entire ocean is concerned, in certain areas, such as the High Nutrient Low Chlorophyll (HNLC) regions, phytoplankton production is more sensitive to the availability of iron. However, both the deposition of the dust and the solubilization of the iron transported by the dust particles are not homogeneous between basins, affecting the biological uptake of CO2.

Here, we used a carbon-centric Earth System Model of Intermediate Complexity, cGENIE, to quantify the effect of iron solubility in the biological pump, i.e. the difference between 80 and 100 ppm of atmospheric CO2 under different Earth's conditions. We worked with empirical data, and CMIP5 model simulations surface dust flux reconstructions for LGM and Holocene (12-8 ky BP) climatic conditions for this research. Since the solubility of iron is not well known both today and during the past, different solubility fields were created, and four levels of iron dissolution were tested at the global and regional levels to establish the main zones and conditions linked to the drawdown CO2.

Keywords : glacial and interglacial; biological pump; primary production; iron solubility; dust fluxes

OSM26: Past climates in our changing mountains: Contributions from the paleoscience community

Co-conveners: Elisa Palazzi, Bryan Mark, Aster Gebrekirstos, Shawn Marshall, Rob Marchant, James Thornton and Carolina Adler

Oral

Delta blue intensity chronologies of yellow pines (Pinus jeffreyi and P. ponderosa) in the Tahoe Basin of the Sierra Nevada, USA

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Abstract :

Advances in tree-ring analysis have demonstrated the usefulness of adding reflected light in the blue channel of RGB 8-bit digital images as a climate proxy. We tested the feasibility of using this new dendrochronological parameter by developing delta-blue chronologies from yellow pines (Pinus jeffreyi and P. ponderosa) sampled at five sites within the Tahoe Basin of the Sierra Nevada, at the boundary between California and Nevada in western North America. Dominant trees were selected to represent a range of stand conditions, from "sensitive" (low density with limited understory, sloping terrain with shallow soil, single dominant species) to "complacent" (deeper soils, higher density with dense understory, a few dominant species). Increment cores were mounted and mechanically sanded, then left in pure acetone at room temperature for 72 hours, and finally polished by hand. Images were obtained with a resolution of 2400 dpi using an Epson Expression 12000XL-GA as hardware, and Silverfast 8.8 as software. Color calibration was performed using IT8.7/2 reflective targets from LaserSoft Imaging. Delta-blue values, which are based on the difference between earlywood and latewood blue intensity, were computed using Coorecorder/Cdendro v. 9.6. Time series were combined together by site, and the delta-blue chronologies were then compared to chronologies of earlywood and latewood width. Climate signals in all these tree-ring chronologies were identified using bootstrapped correlation and response functions with monthly total precipitation and mean air temperature. The outcome of this study, which is currently ongoing, is expected to shed new light on the potential of reflected blue light as a tree-ring proxy for conifer species of the western US, particularly when samples are obtained from forest interior sites in mountain environments.

Keywords : Tree rings, Dendroecology, Sierra Nevada, Forest growth, Climate change

Climate controls on tufa deposition over the last 5000 years: A case study from Northwest Africa.

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Abstract :

The occurrence and rate of tufa deposition are controlled by a large number of external and internal factors, including climate which often represents the main allocyclic factor. In this study, the first of its kind in the Middle Atlas (Northern Morocco), we test the dependency between climate factor and Holocene tufa deposits in basin-like settings that involve enlarged barrage and extensive dammed area using sedimentologic and stratigraphic analyses complemented with a paleoclimate multi-proxy approach and radiocarbon dating. The sedimentologic and stratigraphic analyses revealed a remarkable change in the vertical stacking pattern within the main barrage-cascade: higher (lower) Aggradation/Progradation ratio between ca. 4 and ca. 2.7 cal kyr B.P. (between ca. 2.7 and ca. 0.35 cal kyr B.P.), which would have conditioned a transgressive (highstand) interval “basinward”. This shift is modulated by changes in precipitation and summer insolation, which is consistent with the petrographic analysis of the laminated microbialites (oncoids and stromatolites).

The previously reported arid and cold period of the Mid-Holocene Transition (between 6 and 5 cal kyr B.P.) is recorded in the sedimentary deposits and demonstrates landscape

instability. The North Atlantic high-latitude cooling events between 4.6 and 2.7 cal kyr B.P. (Bond events 2 and 3) resulted in the interruption of (bio-) calcification and the development of fen and sapropel (organic-rich facies) layers, respectively. The 4.2 ka event, might have coincided herein with a fifth-order bounding surface delineating the two depositional sequences recognized on the “basin-scale”. A multi-centennial timescale period with climate optimum conditions coinciding with enhanced calcite precipitation at the downstream-facing of the main barrage (buttress development), and centred at ca. 2 cal kyr B.P. may coincide with the Roman-Iberian Climate Optimum. A recurrent occurrence with a high frequency of sub-humid marshy conditions underscored the upper part of the highstand interval which may reflect solar imprints, as already reported in previous studies in the region.

Keywords : Tufa, Holocene, Bond Event, Middle Atlas, Morocco

Changing natural conditions and their impact on Mt Śnieżnica landscape, Outer Western Carpathians.

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Abstract :

In the present study, we analyzed a 4.4-m deep core excavated from the peat bog formed within the landslide body on the northern side of Mt. Śnieżnica in the Wyspowy Beskidy Mountains, the Outer Western Carpathians, southern Poland. In total, we analyzed 405 samples in terms of 29 geochemical components (e.g., N, C, S, and TOC) and physical properties, that is, particle-size distribution, loss on ignition (LOI), and microcharcoal content. Additionally, to establish geochronology, we dated 27 samples of different biological materials using the Accelerator Mass Spectrometry (AMS) radiocarbon method. A detailed examination of plant macrodetritus and wood anatomy supported our interpretation based on the geochemical data. The Mt. Śnieżnica landslide formed ca. 14,000 cal BP in the first phase of the Allerød Interstadial. For almost 9000 years, there were no appropriate terrain conditions for the long-term accumulation of organo-mineral materials. At ca. 4400 cal BP, peat accumulation commenced. The beginning of peat accumulation correlates with the global 4.2 Bond event of cold climate conditions. After ca. 1400 cal BP, the core sediments were dominated by limnetic mud, suggesting aquatic conditions in the peat bog. This sudden shift in the characteristic of sedimentation is loosely linked to the boundary between the Subboreal and Subatlantic phases (ca. 2500 cal BP). The apparent dichotomy of the depositional record agrees with the reconstructed climatic conditions during the second part of the Holocene. Up to 3000 cal BP, the regional climate was warm and humid, which allowed fast biomass production and hillslope stabilization by trees. Forest fires occurred only in the beginning and end of this period (4400-3000 cal BP). After 3000 cal BP, the regional climate became cool and dry. In this period, we found evidence of intensified erosion, but it was unrelated to forest fire activity.

Keywords : landslide, peat bog, geochemistry, radiocarbon dating, Holocene, Bond event, erosion

Long-term vegetation dynamics in Cofre de Perote volcano (east of Trans Mexican Volcanic Belt) between 10.3 and 4.9 cal. kyr BP.

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Abstract :

The Trans-Mexican Volcanic Belt (TMVB) has presented complex geological, climatic, and biogeographic processes favouring high diversity of vegetation types. In addition, climate variability has had a crucial role during the Quaternary in determining the composition and distribution of plant communities. Most of the long-term research in TMVB has focused on low and middle elevations sites, whereas knowledge about the deglacial history of high elevation environments remains limited. Here, we present a palaeoecological reconstruction that provides information about vegetation changes in a highland site during the Holocene onset in the east part of the TMVB. The sedimentary sequence was obtained from a peatland in La Teta Valley (3770 m a.s.l), in Cofre de Perote volcano. Changes in the pollen record from 10.3 to 4.9 cal. kyr BP are described in four significant pollen zones i) Between 10.3 and 10 cal. kyr BP, low pollen values suggests some poor preservation conditions in the depositional environment. ii) From 10 to 9.7 cal. kyr BP, pollen of Picea and taxa related to the Cloud Forest and Oak Forest are present with low percentages. Micro and macro-charcoal particles are presented with low concentrations. iii) Between 9.3 and 7.8 cal. kyr BP two abrupt increases in Poaceae percentages are shown. Micro-charcoal particles have high concentrations during the entire interval, while macro-charcoal shows a peak around 9.3 cal. kyr BP. An increase of Cyperaceae and a rise of Isöetes could mark a change in the local conditions of the peatland.; and iv) The final interval, from 7.4 to 4.9 cal. kyr BP, is characterised by the presence of taxa related to Coniferous Forest and Alpine grassland. Micro and macro-charcoal particles present high concentrations, mainly between 5.3 and 4.9 cal. kyr BP. The shifts observed in the pollen assemblage could respond to changes in the depositional environment and the regional climate variability. The presence of Picea in la Teta Valley (around 19°N) until 9 cal. kyr BP is noteworthy because its current distribution is restricted to the northern part of Mexico in the Sierra Madre Oriental and the Sierra Madre Occidental between 23 and 28° N. Species of this genus are endangered and endemic to Mexico. The results suggest that Cofre de Perote volcano could be considered a microrefugia during the deglaciation process. In this sense, studying the environmental conditions and the long-term vegetation dynamics in the east of TMVB are essential for developing conservation strategies for Coniferous Forests and species of Picea in Mexico for facing the ongoing climate change.

This research was possible thanks to economic support from PAPIIT projects (IN109216 and IN114019) and the CONACyT grant (CVU 659880).

Keywords : Tropical mountains, Microrefugia, Picea, Deglaciation, treeline

Vegetation history of the Gamo Highlands in the southern Ethiopian rift valley: palynological results from the wetlands Gelba and Chencha.

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Abstract :

Palaeoecological records in Ethiopia are sparse, with some studies only detecting human impact in the last hundreds years, while other records point to millennia of ongoing human impact on the Ethiopian landscape. The timing of the onset of human environmental impact remains therefore debated, with a resulting uncertainty about the origins of the current ubiquitous degraded landforms in the Ethiopian highlands and the relative contribution of climate and human activities on landscape evolution. Ethiopia's steep topography also leads to an altitudinal zonation of the vegetation from bushland, thicket and wooded grasslands in the rift valley over Afromontane forests at mid altitudes to Afroalpine vegetation at high altitudes. In this study, sites from different elevations were selected for a multiproxy palaeoecological analysis to better understand the vegetation changes through time and space. The study area are the Gamo Highlands in the southern Ethiopian rift valley, situated west of the major rift lakes Abaya and Chamo. Two palaeoecological records will be presented here: The first site is the wetland Gelba situated at 2300 m asl, the second site is a wetland close to the town of Chencha at 3000 m asl. Both records consist of peat sediment dating back to 18 cal. ka BP and 3 cal. ka BP respectively. Here we will focus on the pollen analysis performed

on both peat cores, complemented by charcoal and NPP data. Our aim is to reconstruct the Holocene vegetation history in the Gamo Highlands and identify the onset of human impact on the vegetation. By comparing the palaeoecological records to archeological and climatic data, we identify the role of humans and climate on the vegetation development in the study area.

Keywords : Pollen, Vegetation reconstruction, Africa, Ethiopia

First palaeoecological insights into long-term montane forest change in São Tomé island, the Gulf of Guinea.

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Abstract :

São Tomé is an 854 km^2 tropical island in the Gulf of Guinea (central Africa) that holds remarkable numbers of endemic species. It is thought that native plant populations have been heavily impacted since human arrival (AD 1470) due to the development of plantation economies and the introduction of land mammals (e.g. livestock) and plant species, but a long-term perspective on how endemic-rich forests have responded to these drivers of change remains lacking. Our research provides the first insights into montane forest natural variability during the Holocene, indentifying human disturbances through multiple palaeoecological methods. Preliminary palynological results are based on lake sediments from Lagoa Amélia, and possible thanks to the on-going creation of a site-specific pollen reference collection. Together with charcoal and sedimentological data they suggest significant changes in forest species composition and fire-regimes throughout the Holocene. We outline future perspectives to reconstruct human influence on the Gulf of Guinea islands, including multi-proxy analysis of terrestrial deposits obtained from São Tomé´s volcanic calderas and Principe's soil sequences.

Keywords : Paleoecology, Human impacts, Montane forest, Gulf of Guinea Islands

First 10Be chronology of Late Holocene moraines of Maly and Bolshoy Aktru Glaciers, Russian Altay.

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Abstract :

Altay region is located in the center of Eurasia and understanding its climate changes in comparison to those from Europe is important in order to assess continental scale climatic processes. A number of informative Holocene paleoclimatic proxies exists in Altay (ice cores, lake sediments, tree-rings, pollen analyses) including those that are addressing glacier history (e.g. Agatova, et al., 2012, 2022). According to these 14C and dendrochronological dating, the Atay glaciers advanced up to their LIA maximum extent first at 2.3-1.7ka, then during the 12th century.

Here, we present 28 new 10Be cosmic-ray exposure ages (CRE) from moraine boulder and roche moutonnee samples collected in Aktru valley (North Chuya Range) in 2020. The Maly

and Bolshoy Aktru glacier chronologies provide a new detailed picture of the Late Holocene glacier variations, that differs substantially from the earlier reconstructions.

The 10Be CRE ages show that Aktru glaciers repeatedly advanced outside the LIA moraine extent during the Late Holocene. The oldest advances identified in Aktru valley at 4.7-4.0, 3.6-3.2 and 2.8 ka are in agreement with the significant cooling recorded in Belukha ice core from 4 to 2.6 ka, that occurred after the Holocene Climatic Optimum. The following period (1.7 – 1.5 ka) is characterized in the temperature sensitive tree-ring chronologies as the "Roman time" warming, that is almost equal to the modern warming. In our dataset, we precisely notice an absence of moraine deposition, dated from this period of time. After this warm interval, a lateral moraine of the investigated Aktru Glaciers is dated to 1.3 ka and roughly corresponds to the "Late Antique Little Ice Age (LALIA)" cooling suggested by Buentgen et al. (2015) for the Alps and Altay at 536-660 AD. This is the first time that an advance or stillstand corresponding to this cold event is identified in Altay. Based on tree-ring records, Buentgen et al. (2015) suggested that this cooling "exceeded the Little Ice Age (LIA) in severity". Here the 1.3 ka Aktru moraine suggests a rather similar extent as the LIA maximum advance. Then occurred the Medieval Warm Period between ~1100 to ~640 AD (Aizen et al., 2016), which coincides to a CRE age gap identified in our dataset. Lastly, a minimum of four periods of glacier advances is documented from moraines of both glaciers at ~1350 AD, 1600-1650 AD, 1750 AD and 1870 AD. These successive glacier advances occurred during the LIA that locally begun at 1100–1150 AD as recorded in Belukha ice core (Aizen et al., 2016) and by spore-pollen data (Rudaya et al., 2016). Most of these Late Holocene glacier advances evidenced here at 4.4-4.2, 3.8-3.4, 3.3-2.8, 2.6, 2.3-2.1, 1.5-1.4, 1.2-1.0, 0.7-0.5 ka BP are consistent with glacier records from other mid latitude mountain regions of the Northern Hemisphere (Solomina et al., 2015).

Finally, apparent 10Be ages from samples collected on roches moutonnees at the ice front of Bolshoy Aktru Glacier reveal isotopic inheritance and suggest that the glacier was probably smaller during the mid-Holcoene than in early 21st century.

Keywords : glaciers Holocene cosmogenic dating Altai

Following the footsteps of the Ésera glacier (Central Pyrenees) during the last glacial cycle.

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Abstract :

The Ésera valley (Central Pyrenees) is one of the few in the Pyrenees with still receding glaciers and active periglacial processes in the headwaters, both affected by global warming. In this work, we investigate the Ésera glacier response to climate fluctuations during the last glacial cycle to provide a comparison with a current rapid decrease in glacier ice in the mountains.

We have analyzed the sedimentary record from Pllan d'Están, a paleolake located at 1,840 m asl in the Ésera valley in an over excavated basin that collected the water and sediments from the melting glaciers since it was formed 40 ka ago. We have obtained two parallel 6 m long cores using a vibracorer, and built a master sequence. Pllan d'Están depth-age model is based on 30 AMS dates with a basal date around 40 ka cal BP. We have analyzed several proxies to reconstruct past depositional, hydrological and climatic variations: sedimentary facies analyses to identify the main depositional environments; x-ray fluorescence to geochemically characterise the sediments, diatom composition to understand lake level fluctuations and pollen to reconstruct the plant community variations.

The preliminary interpretations of these proxies indicate that the Ésera glacier had already retreated from the Plan d'Están areas at 40 ka BP. The basal sediments are carbonate-rich, suggesting a dominant local source from the nearby limestone outcrops. The further retreat of the Ésera glacier allowed the

development of a proglacial lake characterized by deposition of millimetric-thick laminae, alternating darker grey, carbonate-rich laminas with lighter grey, carbonate-poor ones. At 35 ka cal yr BP, sedimentation became dominantly siliciclastic and banded, suggesting that the glacier had retreated higher up in the Ésera valley, only composed by granitic rocks. Up to 12 ka cal yr BP, changes in sedimentation rate, grain-size variability and some geochemical proxies (Rb/Zr) reflect the response of the glacier to climate with higher grain size and sediment fluxes during warmer phases associated to stronger meltwater flows and/or more intense precipitation. The sedimentation rate decreased between 35 and 25 ka cal yr BP and increased afterwards, pointing to changes in the intensity of erosion and transport processes, likely associated to the transition from very cold and dry conditions to a more humid climate.

The onset of the Holocene is characterized by a rapid transition to a lacustrine environment dominated by more organic deposition, with great variability of diatom assemblages, as pollen contents indicates a less harsh climate. At around 7000 years ago the shallow and permanent Pllan d'Están lake became an ephemeral lake/wetland, likely as a result of infilling of the accommodation space in the basin, and also paleohydrological and/or geomorphological changes.

The environmental evolution of Pllan d'Están Lake underlines the highly sensitive response of geomorphological features of the Ésera valley and associated hydrological and depositional features to climate changes during the last deglaciation. Our results are critical to produce and test robust models of future hydrological changes, essential to manage natural resources in the one of the southernmost mountain ranges in Europe.

Keywords : Paleoclimate, Pyrenees, Last Glacial Cycle, Cores

Conifer population dynamics during the Younger Dryas–Early Holocene transition in the southern Swiss Alps: combining paleoecological and paleogenetic approaches.

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Abstract :

Mountain trees are currently exposed to rapid climate change and are thus under strong environmental pressure that drives a response of upslope shifting of their ranges. Such range shifts are predicted to lead to a decrease in genetic diversity due to genetic drift along the colonization front. However, high levels of genetic diversity are a prerequisite for population persistence. Predicting and anticipating the effect that the current climate warming will have on populations and species requires a long-term perspective of past ecosystem dynamics. Natural archives, such as lake sediments, can conserve plant remains for millennia and have been regularly used in paleoecology to reconstruct vegetation dynamics based on pollen and plant macrofossil analysis. Recent advances in molecular techniques allow the analysis of ancient DNA (aDNA) still present in macrofossils, providing insights into demographic processes and their genetic consequence across several hundreds to thousands of years. However, due to technical difficulties, only a few studies have successfully exploited aDNA from plant macrofossils to answer research questions focusing on past population genetic processes.

In this study, we aim to investigate the impact of rapid temperature increase of 2-4 °C during the Younger Dryas (ca. 12,900-11,700 cal yr BP) – Early Holocene (ca. 11,700-10,700 cal yr BP) transition on conifer populations and their genetic trajectories in the southern Swiss Alps. To do so, we analyze two study sites located at different elevations: the mire Gola di Lago (972 m a.s.l.) and Lago del Starlarèsc (1975 m a.s.l.). We combine pollen, plant macrofossil, and microcharcoal analysis as proxies for vegetation dynamics with aDNA analysis from selected needles as indicators of past demogenetic changes. The pollen and plant macrofossil analysis reveals that during the Younger Dryas,

Larix decidua was locally present at Gola di Lago, but not at Starlarèsc. With the temperature increase of the Early Holocene, L. decidua moved to higher elevations, colonizing and expanding around Starlarèsc. However, L. decidua also persisted in the lowlands for another millennium. The preliminary genetic analyses indicate different degrees of DNA preservation in the L. decidua needles from the two sites, getting a higher coverage and endogenous content in the needles from Starlarèsc. We could also detect the signs of chemical damage (cytosine deamination), indicating that the DNA we isolated is ancient. Ongoing genetic analyses will enable us to understand i) the extent to which the L. decidua population decline at Gola di Lago led to a reduction in the genetic diversity, and, ii) how fast genetic diversity of L. decidua recovered from founder effects at Lago del Starlarèsc.

This work will provide valuable information on genetic changes in tree populations under climate change conditions and will help developing guidelines for managing future mountain forests.

Keywords : Lake sediments, plant macrofossils, pollen, ancient DNA, southern Alps

Disentangling drivers of environmental change in Alpine Australia: A multi-proxy paleolimnological approach to understanding climate- and anthropogenic-driven change in the Holocene.

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Abstract :

Disentangling the effects of climate change and anthropogenic activities on the environment is a significant challenge in palaeoenvironmental research. Natural archives of environmental change including tree rings, ice cores, and lake sediments can complement archaeological studies and record how humans have altered the environment through time. Paleolimnological studies which incorporate a range of chemical, physical and biological proxies can be used to infer past environmental change and understand anthropogenic impacts on the environment.

Here we present pollen and charcoal data, µXRF results, and physical proxies from Lake Cootaptamba (2048 m elevation) to reconstruct environmental evolution in the alpine region of southeastern Australia since the late Holocene. Charcoal data from multiple sites show a peak in local and regional fire activity occurred between 8-5ka yr BP. At the same time, multiple pollen records from sites above 1000 m elevation found an increase in both rainforest and wet sclerophyll vegetation types in the wider region. The high pollen concentration and µXRF results from the Lake Cootaptamba core indicate a period of increased organic deposition. Together these results suggest that an increase in the Southern hemisphere westerly wind-derived precipitation in the mid-Holocene allowed vegetation to expand in the alpine zone, causing biomass burning to increase in the alpine region. By 5ka yr BP the climate regime in southeastern Australia transitioned to one dominated by the El Niño Southern Oscillation, with variable precipitation leading to regional vegetation change and a fire regime limited by biomass availability. Finally, the paleolimnological results are compared to the Australian archaeological database to identify the impact of human occupation and land use. Our study finds that in the last 2ka yr BP increased erosion and changing fire regimes correspond with the increased occupation of the alpine zone. This work demonstrates how multi-proxy paleolimnological studies can uncover human traces and disentangle natural and anthropogenic drivers of change during the Holocene.

Keywords : pollen, charcoal, climate, alpine, Australia

When fires rage in grasslands and there's limited sedimentary charcoal: a multipolar interpretation of charcoal records from the Drakensberg Mountain range, South Africa.

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Abstract :

The value of fire in fragile mountain grasslands that provide varied ecosystem services is under review for it influences competing biodiversity protection and nature-based carbon storage goals. Fires are considered natural in some grasslands because of elevation and unique biodiversity favoring high light environments and fire-tolerance traits. However, in derived and secondary grasslands, fires and fire-dependent vegetation are legacies of anthropogenic land use that degraded forests and savannas. This origins problem has implications on the future conservation and resilience of mountain grasslands. Sedimentary palaeoecological records including charcoal have provided crucial insights into the role and value of fires in shaping ecosystem dynamics over long-time scales. Yet, interpreting or synthesizing long-term sedimentary records to discover emergent fire patterns is challenging when charcoal abundances are low in flammable ecosystems. Mountain ecosystems present another obstacle because of spatiotemporal heterogeneity resulting in unique biodiversity and fire histories. Here we consider the situation when sedimentary charcoal is unexpectedly low by comparing performance and researchers' consistency in applying three interpretative models: resource use, trait-based, and climate-vegetation. We qualitatively and quantitatively analyze 12 palaeoecological records from the Drakensberg Mountain range (South Africa) spanning an elevation gradient from 900-2130 m.a.s.l. and extending to the last 28 000 years.

Keywords : fire; grassland; mountain ecosystems; conservation; Drakensberg Mountain range

The value of the Neotoma Palaeoecology Database to unfold effects of disturbances and environmental changes on mountain ecosystems

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Abstract :

Mountain ecosystems provide important ecosystem services for both upstream communities and downstream users. Thus, it is crucial to assess the impacts of disturbances and environmental changes to provide baselines for management strategies and science-based scenarios of future development with changing climate. However, understanding natural ecological processes remains a challenge as processes often play out over long time scales (centuries, millennia), particularly when long-lived species such as trees are involved.

Paleoecological proxies (e.g. fossil pollen, plant macrofossils, charcoal, and phytoliths), are a crucial tool for documenting the vegetation dynamics over such ecologically relevant time scales. Records covering thousands of years can unfold land-use histories and ecosystem responses to disturbances (e.g. fires) and rapid past environmental changes. Moreover, while the steep environmental gradients in mountain areas and resulting high landscape diversity often allow species to track their climate space and survive climate change, the changing connectivity of mountain ecosystems on glacial interglacial fluctuations may even drive speciation. What emerges from these records is that current mountain ecosystems often carry legacy effects arising from complex interactions between natural and human disturbances. Such knowledge is crucial for defining stewardship objectives for mountain landscapes, guided by inter-disciplinary understanding of natural and anthropogenic drivers and response mechanisms.

The Neotoma Paleoecology Database (https://www.neotomadb.org/) provides the

infrastructure to store and analyse different proxies of past environmental change together. The large number of available records documents past environmental change in many mountain regions of the world and provide staring points for new research and hypothesis development. The functionality to connect analysis runs in R or Python directly to the data held in the database makes it also an ideal tool for collaborative work supporting ongoing research. In this contribution we aim at providing a broad overview of this online hub for paleoenvironmental data and illustrate the potential of paleoecological records to improve the understanding of mountain processes with several case studies.

Keywords : mountain ecosystems, vegetation responses, legacy effects, paleoecology, neotoma database

The REPLIM Network: integrating lake monitoring and paleolimnological analyses to improve our understanding of past global changes in the Pyrenees.

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Abstract :

The REPLIM network was established through a POCTEFA-EU funded project in 2017 with the main aim of monitoring lakes and peatlands in the Pyrenean Mountains and serve as an observatory of the impacts of climate change and human activities on high mountain ecosystems (http://www.ipe.csic.es/proyecto-replim). The REPLIM network includes a number of representative lake systems in the Pyrenees where annual sediment and water surveys are conducted and temperature is measured hourly at several depths with data loggers. The information of each node is summarized in the Pyrenean Observatory of Climate Change (OPCC) geoportal (https://opcc-ctp.org/es/geoportal). The depositional evolution of the selected lakes during the last 2 millennia has been reconstructed with multiproxy paleolimnological analyses based on short cores dated with ^{210}Pb, ^{137}Cs and ^{14}C.

This combined approach has allowed us to identify trends at different temporal scales. In this contribution we summarized the results from the sites located in the southern central Pyrenees. The REPLIM sediment sequences from these locations show rapid and abrupt limnological changes at the end of the Little Ice Age (LIA) (ca. 1850 CE) and since the mid to late 20th century, correlating with the warming post LIA and the onset of the recent temperature increase (0.2oC/decade since 1950). Interestingly, changes during warmer periods (Medieval Climate Anomaly, Roman Period) are less pronounced in these high altitude lakes compared to those during cold phases. The temperature measurements during the last few years already show changes in the thermal regimes with an increasing trend in surface water temperature, greater in summer and especially in autumn, and shorter ice-covered periods, in both cases paralleling air temperature patterns. This seasonal shift could have contributed to the documented changes in the diatom communities, favoring species of planktonic diatoms of shorter life span that bloom during the fall. The increasing temperature trend and the decreasing length of the ice-covered period in the lakes and snow accumulation in the watersheds may cause drastic changes in the seasonal thermal regime of some lakes. We expect that deeper lakes with a larger thermal inertia will respond more slowly to new physical (temperature and density gradients), chemical (salinity alkalinity, pH, nutrients) and biological (primary productivity, composition communities) conditions.

The available time series are not long enough to identify trends in measured variables, but they serve to define the baseline characteristics of these ecosystems in terms of sediment, water and biota composition and water temperature changes. The possible accelerating effects of the synergies between climate (increasing temperature, changes in wind dynamics) and global change processes (higher nutrient input) remain uncertain. The observed rapid changes during the last decades and the measured shifts in thermal regimes could serve as analogues for lake impacts during past warmer periods and help to better calibrate lakes proxies for temperature. However, future scenarios of limnological change (hydrology, ice cover and

water temperature) could exceed the prior Holocene range.

Keywords : Paleolimnology, Thermal Regime, Global Change, Global Warming, Pyrenees

Late Quaternary Glacial History and Climatic Reconstrution in Zemu Valley, Sikkim Himalaya, India.

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Abstract :

Glaciers provide huge repository of landforms that can be used as proxy data source to assess magnitude and frequency of processes over time and space. Zemu glacier (27°45'58.62"N, 88°22'45.95"E), one of the largest (26km) in Eastern Himalaya, descents from the eastern slopes of Kanchenjunga in Sikkim Himalaya region. Climate is dominated by SW monsoon, followed by the winter rain from the South China Sea as well as the Mediterranean Westerly which influences the behavior of glaciers in the region. In such geo-climatic settings, smaller changes in climate will be reflected in the behavior of the glaciers in the region. The sequence of moraines provides a fair opportunity to reconstruct the glacial history and paleoclimate since the Last Glacial Maximum in the region. Several field studies with hand-handled GPS and remote sensed data along with 3D view of Google Earth have been helpful to understand the geomorphology of the area. Toe to Headwall Altitude Ratio (THAR), Toe-to-Summit Altitude Method (TSAM), and Maximum Elevation of Lateral Moraines (MELM) methods have been used to calculate ELAs to assess the magnitudes of glacial changes over time. OSL dating has been used to assess the timing of LGM. Whereas, relative timings of the glacial advances have been estimated on the basis of ELA Change, distance of moraines from the present snout, and their comparison with the established chronology of glacial landforms in the neighboring areas of Bhutan and South-eastern Tibet. Based on the assemblage of landforms, four stages of glacial advance have been identified in the region during the late quaternary period. These glacial stages are Zemu I, Zemu II, Zemu III and Zemu IV in Zemu valley.

The first glacial stage (Zemu I) in the study area belongs to the period of global Last Glacial Maximum (LGM) and dated ~18.276 ±589 ka with a change of -445.17 m -2.89 oC in ELAs and temperature, respectively. The second glacial stage, Zemu II seems to occur during the Younger Dryas when ELA recorded a depression of -118.51 m with a temperature drop of -0.77 oC. The third glacial Stage (Zemu III) probably belongs to the late Holocene when ELA and temperature dropped by -71.84 m and -0.46 oC, respectively. The fourth glacial advance (Zemu IV) possibly occurred in the Little Ice Age (LIA) with an ELA depression of -12.84 m reflecting a change of -0.08 oC in temperature. The glacial stages in the study area are synchronous with the glaciations in the neighboring regions of Thangu valley in north Sikkim, Bhutan, and eastern Himalaya syntax.

Keywords : Qaternary, Glacial, Climate, Paleo-Reconstruction, Himalaya

Hydroclimate variability and an increase in severe droughts in recent decades revealed by a two-century precipitation record from the tropical Andes of Peru.

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Abstract :

The Amazon basin plays an important role in the dynamics of the South American summer (SAMS). Almost half of the tributary rivers of the Amazon originate in the tropical Andes, which form a topographic barrier that produces a strong gradient in precipitation. Complete instrumental data and good representation of rainfall over the tropical Andes is available from 1979, but longer records are needed to understand precipitation variability and summer monsoon dynamics at various scales. In this sense, we developed the first annually-resolved precipitation reconstruction for the tropical Andes of Peru, based on tree-ring chronologies of Cedrela and Juglans species.

The annual reconstruction (November to October) extends the short instrumental records back to 1817, and explains 68% of the total variance precipitation over the calibration period (1979-2007). An increase in the frequency occurrence of severe dry events (10th percentile) have been recorded for the last four decades in tropical Andean forests, in agreement with other paleoclimatic records in the region. The reconstruction also reveals the well-documented influence of ENSO on rainfall at interannual scales (~19% of total variance), and significant multidecadal variability of about 40 years (~13% of rainfall variability) related to the Atlantic Multidecadal Oscillation (AMO). Both oscillatory modes can explain dry and humid periods observed within the reconstruction and are likely associated with the negative trends of rainfall in the short instrumental records and the increased drought recurrence in recent decades.

Our results highlight that montane tropical tree rings and high-resolution precipitation reconstruction can characterize and contribute to the interpretation of the interannual to multidecadal variability and identify remote forcings in the hydroclimate over the Andes and tropics of South America.

Keywords : Dendrochronology; Tropical montane forests; Peruvian Amazon upper-basin; Extreme events; South America

Fluctuations of Akkem, Korumdu and Gebler glaciers (Russian Altai) in the Little Ice Age.

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Abstract :

Variations of Akkem (Rodzevicha) and Gebler glaciers (Belukha Mt.) and Korumdu glacier (Northern Chuisky Range) were reconstructed based on satellite and aerial images, repeated photographs, historical descriptions, dendrochronological, and lichenometric data. We identified the positions of Korumdu and Akkem Glacier fronts in 2021, 2018, 2015, 2012, 1980, 1970, 1952 and the location of seven moraines for each glacier. Gebler Glacier was the first one visited by a scientific expedition in Altai in 1835 (Gebler, 1935). 13 positions of the front (2019, 1989, 1985, 1980, 1970, 1960, 1952, 1937, 1933, 1926, 1911, 1895, 1835) and respective elevations of the equilibrium line altitude were identified. The moraines marked the Gebler Glacier advances in the mid 1980s, mid 1940s, in 1930s and in 1910s. According to the earliest image of the glacier, in 1870 it was retreating at that time (Poltoratskaya, 1879). Gebler (1835) described a fresh-looking moraine that was a few steps away from the glacier front and another one, more ancient, “covered with lichens” that was about 40 m away from the young moraine. The lichens Rhizocarpon geographicum sensu lato at the old moraine reached 40-50 mm. In 1897 Sapozhnikov calculated the number of very narrow annual rings (130 rings) at the crosscut of an Abies sibirica tree growing on the old moraine. Thus, the minimum age of the moraine is AD 1767. Based on tree-ring limiting dates Korumdu and Akkem glaciers reached their maximum extent about 200 years ago. These surfaces support the lichens Rhizocarpon geographicum sensu lato as large as 33-40 mm in diameter. The largest LIA advances (18th to early 19th centuries) predate the coldest period in the past millennium identified by tree-ring chronologies sensitive to summer temperature that underlines the role of winter precipitation in the mass balance of Altai glaciers. At Akkem valley a moraine older than the end of 17th century is also identified below the 18-19th

century maximum. In Korumdu and Aktru valleys the 14C dates of fossil wood in the moraines indicate the advances of equal magnitude in 15-17th centuries (Ivanovsky, Panychev, 1978). The first 10Be CRE dates from the moraines of Aktru glaciers reported by Jomelli et al. (2022) generally confirm these reconstructions, but provide more detailed picture of Late Holocene glacier fluctuations in Altai. From the LIA maximum the studied glaciers retreated up to 2 km in length, lost up to 2 km2 in area and their fronts raised up to 270 m in elevation.

We thank Russian Science Foundation (Project No. 19-17-00179) for support.

Keywords : Glaciers, Altai, Little Ice Age, remote sensing, dendrochronology

Poster

Unprecedented recent regional increase in Carbon and Lithogenic fluxes in high altitude Pyrenean lakes

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Abstract :

We use a W-E transect of short sediment cores from six high altitude lakes (1870-2630 m asl) in the western and central Pyrenees to reconstruct the organic and lithogenic fluxes during the last two millennia. Prior to the mid 1950s CE, most lakes show relatively higher organic carbon fluxes (OC) during warmer phases and higher lithogenic fluxes (Lflux) during colder periods. Rapid transitions in lithogenic and OC fluxes occurred at the onset (ca. 1200 CE), mid (ca. 1600 CE) and end (ca. 1850 CE) of the Little Ice Age (LIA) and at the onset of the Great Acceleration (GA) (ca. 1950 CE). In all sites OCflux are higher since 1950 and geochemical (lower δ13C and C/N, higher biogenic silica) and biological (diatom assemblages, chlorophyll) parameters suggest an increase in algal productivity, likely favored by warmer temperatures and higher nutrient deposition. The Lflux started to increase since late Medieval times, but particularly since the onset of the industrial revolution (IR) and even more after mid 20th century. Recent Lflux increase could be related to higher erodibility by rainfall and run-off during the longer snow-free period in the Pyrenees. Both Lflux and OCflux show recent unprecedented trends demonstrating the impact of the Great Acceleration in the ecological status and the hydrological cycle in high altitude watersheds.

Keywords : Limnology, Anthropocene, Carbon fluxes, Sediment fluxes, Pyrenean lakes

Pedogenic traits in paleosols help the Quaternary paleoclimate reconstruction in the SW Italian Alps.

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Abstract :

Few sites in the Alps (and in other mid-latitude mountain ranges) are characterized by soils developed for periods longer than the Holocene, as Pleistocene glaciations and the associated erosive processes erased most of the previously existing soils. In these sites, polygenetic paleosols preserve indicators of very different environmental conditions, ranging from warm interglacial pedogenesis to intense cryoturbation during glacial periods.

We described and sampled soils on stable surfaces in the Upper Tanaro valley, an unglaciated area in the Ligurian Alps (Southwestern Piemonte, Italy). The sampling sites were between 600 to 1600 m of altitude, under present day montane vegetation on quartzitic and dolomitic substrates.

The surface morphology is characterized by large-scale fossil periglacial patterned ground, such as coarse stone circles on flat surfaces, or stone stripes and solifluction/gelifluction lobes on steeper slopes. The soils preserved in such

relict Quaternary periglacial landforms normally showed stratification of different layers (units), separated by structural discontinuities, evidencing different depositional settings and different pedogenic development degree. Soil wedge casts, involutions, diapiric intrusions, strong cryogenic granulometric sorting and deep organic-matter rich layers characterized some layers in the observed soils. Compact and dense layers with strong platy/lenticular structural aggregation, sometimes associated with redoximorphic Fe oxide cementation (plinthic or placic horizons), were often observed along structural discontinuities.

Thus, geomorphology and soil properties evidence the widespread presence of permafrost during cold Pleistocene phases, with different active layer thicknesses (60-120 cm) in different climatic phases.

Some other deep layers, though, show up to four phases of intense pedogenesis, characteristic of climates even warmer and more humid than the Holocene.

The different layers in the studied soils represent excellent pedo-signatures of different specific past climatic/environmental conditions, as a response of different lithologies to specific soil-forming environments, which range from warm and humid climates typical of red Luvisols and Nitisols, to cool and wet climates leading to the formation of Podzols with placic or ortstein horizons, to extremely cold and dry ones characterizing permafrost sites and often associated with fragipan formation, to warm and dry leading to the cementation of petrocalcic horizons. The precise dating and interpretation of these soils are intriguing.

Keywords : Paleosols, Podzols, Calcisols, Solifluction, Interglacial

Hidden paleosols inside periglacial blockfields can provide paleoenvironmental data in high-elevation Alpine areas.

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Abstract :

Pleistocene glaciations and erosion-related processes erased most of the pre-existing landforms and soils in alpine areas, making paleoenvironmental reconstructions challenging in high-elevation landscapes. Nevertheless, some high-elevation, non-glacial areas remained protected from erosion during Pleistocene glaciations, either because unglaciated or because under cold-based, non-erosive glaciers. In the framework of climate change research, soils preserved in these non-glacial surfaces may provide excellent paleoenvironmental information, thus representing a powerful tool for paleoclimate reconstructions.

This study was performed in the periglacial Stolenberg Plateau (LTER site Istituto Mosso), located on the watershed between Valsesia and Lys Valley, on the southern slope of the Monte Rosa Massif (Western Italian Alps, elevation: 3030 m a.s.l.). The plateau is covered by thick active blockfields and blockstreams, with a <3-5% plant cover. Inside these periglacial features, the soils were unexpectedly well-developed, hidden under the surface stone layer: 30-60 cm thick umbric horizons were observed, under which discontinuous cambic Bw ones were developed. In contrast, the surrounding snowbed or alpine grassland communities (Salicetum herbaceae or Caricetum curvulae) were characterized by Regosols or Cambisols with 10-15 cm thick A horizons and weak signs of cryoturbation.

Despite the sparce plant cover, the organic carbon (C) stocks were surprisingly high (up to >5 kg*m-2), comparable to vegetated and even forest soils at lower elevation. Geophysical investigations showed that these “hidden” soils are widespread on the plateau, with a 30-90 cm thickness.

Radiocarbon dating (14C) indicated that these soils are old, apparently originated during the different warming phases/interstadials occurred between the end of Last Glacial Maximum (LGM) and the end of the Holocene Climatic Optimum. The age of the oldest sample was outstanding (22-21 ka cal. BP, obtained from two independent and blind datings performed in different moments), while other samples were dated ca. 17.5, 13, 8.5, 6.5, 5.7 ka cal. BP; the youngest age was 4.4-4.1 ka cal. BP.

The stabilized, mineral-associated organic matter (MOM) represented a large quantity, increasing with age from 90 to 97% of the total soil OM. Such fraction showed dominance of lipid and waxes, followed by cellulose and hemicellulose and no chemical differences were observed related to sample age. Otherwise, the younger Light Fraction (free and occluded particled OM) showed variations with depth, with dominance of cellulose and hemicellulose, than deeper ones, which were dominated by paraffinic compounds. The organic matter composition indicates its origin from vegetation, although with a high degree of decomposition.

The results, including age, geomorphological framework, pedogenic characteristics, and organic matter properties and composition, suggest that the plateau was a Nunatak, which acted as a refugium for alpine vegetation during the last glacial pulses, serving as a hot-spot for the rapid reoccupation of deglaciated high-elevation landscapes. The oldest samples also suggest that summer temperatures were already compatible with vegetation growth, able to accumulate organic carbon in the soil even right after the LGM.

Keywords : Paleosols, blockfield, periglacial, organic matter, LGM

Vegetation history and Indian summer monsoon variability during the past ~6000 years based on pollen record from Garhwal Himalaya (India).

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Abstract :

The Indian summer monsoon (ISM) variability on an interannual to interdecadal time scale affects the lives of millions of people in the Indian subcontinent. The ISM strength has fluctuated significantly during the Holocene, including the last 6000 years when the boundary conditions of the climate system did not change significantly. The ISM variability during the past ~6000 years have also affected past civilizations and kingdoms as agriculture has been a major source of economy in modern as well as in ancient India. In order to reconstruct the centennial to millennial scale ISM variability, we present a high-resolution pollen record for the past ~6000 years from Bednikund lake, located in an alpine meadow of the Pindar basin, Central Himalaya. The gradual increasing trends in arboreal taxa, e.g., conifers, Betula, Alnus, and Quercus, indicated a transition from extremely dry to wet conditions during ~5930-3725 cal yr BP. An overall expansion of grassland vegetation along with a decline in tree cover during ~3725-3380 cal yr BP period suggested a relatively drier climate. High pollen influx values and increased arboreal taxa along with marshy taxa (e.g., Cyperaceae and Polygonaceae) indicated a strengthened ISM during~3380-1865 cal yr BP with an intermittent short and abrupt dry period during ~2830-2600 cal yr BP. A decrease in arboreal taxa, tree line taxa, as well as alpine grassland vegetation suggested scarce vegetation cover under adverse climate conditions due to ISM weakening between ~1860 and 1050 cal yr BP period. Vegetation restoration suggested enhanced ISM rainfall during ~1050-790 cal yr BP (Medieval Climate Anomaly). Increased thermophillous broad leaved taxa such as Alnus, Juglans, and Betula, as well as desert-steppe taxa e.g., Chenopodiaceae, and decreased marshy taxa and ferns, indicated that warm and dry climate conditions had prevailed during ~500-335 cal yr BP (Little Ice Age).

Keywords : Palynology, Paleoclimate, Indian summer monsoon, Middle Holocene.

A multiproxy reconstruction of Holocene climate and land-use impacts on vegetation dynamics in the Eastern Swiss Alps.

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Abstract :

Mountain vegetation is particularly affected by climate change. With rising temperatures, plant

populations are either forced to shift their range upslope to more suitable areas, adapt to changing conditions or suffer decline. Despite the growth of monitoring programs assessing the impacts of current global change on alpine ecosystems, there is still an insufficient use of long-term studies in conservation biology to understand ecosystem responses on long timescales. Paleoecology has made important contributions to the reconstruction of past climate-driven vegetation changes based on the study of biotic proxies such as pollen and macrofossils preserved in lake sediments.

The last climate change of a similar magnitude and rate as projected for this century occurred during the transition between the last Ice Age and the Holocene interglacial (ca. 11,700 years ago), when temperatures rapidly increased by 2-4 °C within less than a century. Studying this time period can provide new insights into vegetation changes resulting from climatic drivers. Understanding the response of vegetation to rapid temperature increase and human impact is a fundamental prerequisite to produce accurate and reliable predictions of future mountain vegetation and mitigate climate change impacts. The overarching goal of this large-scale, multiproxy study is to better understand past vegetation dynamics and the impact of future climate change on plants at multiple scales; from the genetic to the community level.

We present ongoing work on macrofossil and pollen analysis from the Lai da Vons sedimentary record (1991 m a.s.l), an alpine lake situated at the treeline ecotone in Eastern Switzerland. Our results indicate that the first trees could have already established 13,500 years ago, in response to rising temperatures. Closed forests dominated by conifers like Pinus cembra and Larix decidua expanded during the Early Holocene, when summer temperatures were even warmer than today. However, from 6,500 years cal. BP onwards, increasing human impact led to an opening of the landscape, with more shrubs and herbs and a more diverse species composition.

In a next step, we will use novel molecular methods in order to track adaptive and neutral genetic diversity of conifers through the Holocene by analyzing ancient DNA from subfossil conifer needles. The combination of these well-established palaeoecological methods with novel molecular techniques to understand vegetation changes to climate variations can be insightful for future forest management and conservation in the Alps.

Keywords : Climate change, vegetation dynamics, palaeoecology, treeline, palaeogenetics

Tracing human impacts from a multi-proxy perspective in the Central Pyrenees: the Tramacastilla lacustrine sequence

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Abstract :

Earth is perpetually changing but current Global Change is proving to be unprecedented in several aspects. Surface processes, biological dynamics and socio-economic evolution are showing Earth's vulnerability to both climate and environmental changes, particularly in key sensitive areas such as high mountain regions. Thus, inferring the impact of current and past global changes is one of the major milestones considered by Sustainable Development Goals (SDGs) defined by the United Nations. In this sense, tracing early human impacts in mountain environments, but more importantly, when they started to be the primary forcing of landscape change is a key question. Answering this is challenging as understanding climate-human interactions is a complex, but essential, task in our society to adapt and mitigate future climate scenarios.

This work is focused on the identification and characterization of paleoclimatic and anthropogenic indicators in the Central Pyrenees, an Iberian region which has been demonstrated as very sensitive to past climate changes and with a long record of human occupation. Despite many paleoenvironmental studies available from this region, consensus

doesn't exist and data are insufficient to define when, how and where humans started to significantly modify the landscape through deforestation, early crops or incipient grazing activities, especially in high altitude areas.

Traditionally, records recovering the onset of the Neolithic are characterized by decreasing arboreal pollen abundances and interpreted as human deforestation. The isolated presence of some plant taxa, that are not unequivocally associated with agriculture or pasture lands, have been also used as anthropogenic indicators. Indeed, some recent literature is focused on identifying the earliest origin of the "cultural landscapes", in the Pyrenees at high altitudes, where intense and permanent human impact occurred later (since the Middle Ages). This is creating a vivid debate as the evidences for the whole region is heavily biased toward the eastern Pyrenees but no equivalent indicators have been found in the Central Pyrenees until now.

This work, through the re-study of a new sediment core from Tramacastilla Lake (42°43'35"N, 0°22'04"W, 1682 m.a.s.l.) aims to: 1) reconstruct climate and environmental variability using traditional indicators such as geochemistry and pollen variability; and 2) use sedimentary ancient DNA (sedaDNA) as an indicator of human impact, in a chronologically accurate and unambiguously fashion, and the presence of plants and animals associated with human activities.

In this contribution we present preliminary data and our new chronological model, built using Bayesian statistics based on 29 AMS radiocarbon dates of a ca. 20ka BP record.

SedaDNA, which provides a higher taxonomic resolution than pollen analyses, will allow for more precise identifications, more accurate results and may inform about the past ecological dynamics of plant and non-plant taxa.

With this strategy, we want to reconstruct human-landscape use from the onset of Neolithization (or even earlier) in the Central Pyrenees. Our results could also help in the design of conservation strategies that integrate the traditional management of landscapes in the mountains.

Keywords : sedimentary ancient DNA, pollen, vegetation reconstruction, Holocene, paleolimnology

Development of lakes in recent de-glaciated areas in the central Pyrenees: the Arrablo Lake (Ordesa- Monte Perdido National Park)

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Abstract :

During the Quaternary glacial and interglacial periods, mountain glaciers have advanced and retreated following climate fluctuations. Nowadays, humans have the ability to influence the climate system, a phenomenon that has led to an increase in the average temperature in the last few decades. Glaciers are one of the key indicators of global climate change and during the last decades, increasing temperatures due to global warming have greatly affected mountain areas all over the world and in particular glacial dynamics and cryospheric processes.

In the Pyrenees, where the largest glaciers of southern Europe are found, the glaciers retreat has been documented since the second half of the 20th century. Many of these glaciers eventually disappear, forming small high-altitude lakes throughout the Pyrenees.

This paper aims to identify and characterise the appearance of new high mountain lakes in the few areas with still active glaciers. In order to understand the changes in the limnological processes in these new lakes and its relationship with climate, we have chosen as a case study the lake known as Arrablo (2964 masl) in the Ordesa – Monte Perdido National Park that was formed in the late 1980s. The evolution of the lake has been described using remote observation systems, for which aerial images are available since 1956 and remote sensing techniques with images available since the end of the 1980s. In addition to this, a field campaign carried out in October 2021 included a bathymetric survey, the installation of two thermistors on the surface and at a depth of 3.5 metres, water sampling and the recovery of a transect of gravity cores. The chemical composition of the water preliminary analysis shows that the lake waters have very low conductivity and alkaline pH.

Interpretation by aerial imagery suggests that the generation of Arrablo lake occurred at some point between 1980 and 1990. One of the cores (ARB21-1B-1G, 22 cm long) has been selected for multiproxy analyses including magnetic susceptibility, sedimentary features and geochemical composition using an XRF scanner. Dating, isotopic and diatom analyses are in progress. The sedimentary sequence is composed of massive silty sediments at the base and laminated facies at the top with higher content of organic matter. This major change is likely indicative of the transition from a permanent ice - covered lake to a few months ice-free period and likely corresponds to the late 1980s when the new lake was reported. These preliminary results suggest that the lake basin was created long before it was detected by aerial photos and hikers, and there was a prior lake phase under permanent ice. Laminated facies likely reflect annual changes brought by increased runoff and sediment delivery and primary productivity during the ice-free period.

Combining monitoring of biological, geochemical and water properties of the new lakes, with paleolimnological studies and regional and local instrumental records of climate variables will help to understand the effects of current global change in these vulnerable alpine ecosystems and to improve our reconstructions of past environmental – climate synergies.

Keywords : paleolimnology, remote sensing, global change

Glacier dynamics and climatic variability since Last glacial Maximum in the Changme Khangpu valley, Eastern Himalayas, INDIA

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Abstract :

The glaciated Changme Khangpu basin (CKB) is the easternmost glacier bearing basin of the Upper Tista Basin, a part of the Eastern Himalayas. CKB covering an area of 767.8 km2, constitutes an important region in the Eastern Himalayas to assess the glacier variability over geological time. Climatically, this part of the Himalayas is mainly controlled by the Indian Summer Monsoon (ISM). To reach the objective, the study has opted for geomorphic feature analysis, sedimentological analysis, and associated with geochronological methods to place the glacier variability over the time frame.

The four sets of well-preserved moraines depicted four advances of this glacier. Due to the erosion of the Phase-I moraine, this study only provides the data on the palaeoclimate since the Phase-II glacier advances. The Phase-II glacier advance obstructed the ablation valley water and formed the ablation valley lake around 32 ka calBP. Over time with the recession of this glacier, the water has been breached that left the sedimentary archive. The geochemical study and geochronological study from this sedimentary archive help to reconstruct the palaeoclimate in this valley. The Schmidt Hammer Rebound values have been proved to be useful to date (relative dating) the remaining three advances of this glacier.

Keywords : Changme Khangpu glacier (Sikkim); Eastern Himalayas; Last Glacial Maximum; Palaeoclimate; Glacier geomorphology.

Temperature, Rainfall, and Fire in the Alpine Zone of the Rwenzori Mountains, Uganda-D.R.C.

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Abstract :

High-elevation tropical regions are believed to be some of the most sensitive to climate change. In Africa, the effects of climate warming are already detectable as mountain glaciers have significantly retreated in the past few decades. In addition to glacial retreat, recent incidences of drought, fire, and flooding suggest that

climate warming may already have begun to impact a variety of ecosystem processes and services; however, the short duration of observational records limits our ability to test whether these changes result from shifts in precipitation, temperature, or human activities. The Rwenzori Mountains, located on the border between Uganda and the Democratic Republic of the Congo, is one such region. Recent large-scale fires in the alpine zone undercut assumptions that fires were impossible in the cold, moist highest elevations. To put these recent climatic and environmental changes into context, we use paleoclimate and fire proxies (GDGTs, leaf wax isotopes, and charcoal) to reconstruct climate during the most recent deglaciation and Holocene in the Rwenzori Mountains. Here, we present sediment core biomarker and isotope records from two different high-elevation lakes in the Rwenzori's: Lake Africa (3895 m asl) and Lake Kopello (4017 m asl). These records serve to improve our understanding of Afroalpine climate-ecosystem dynamics and evaluate how high-elevation tropical regions may respond to anthropogenic warming.

Keywords : organic geochemistry, leaf wax, GDGT, fire, East Africa

A regional late-Quaternary pollen dataset of the Tibetan Plateau and its surrounding area.

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Abstract :

The fossil pollen record of the Tibetan Plateau and its surrounding areas (162 sites) were derived from previous collections and the new collection. 77% sites have more than three radiocarbon dating data. Lake sediment (94 sites), alluvial/fluvial core or profile (28) and peat core (21) account for 88.3% of samples. All pollen taxa were homogenized according to the digital floras of China and took the new taxonomy system of APG IV into account. Pollen percentages were re-calculated based on the total number of terrestrial pollen grains, excluding aquatic pollen and spores from ferns and algae, but including Cyperaceae. The age-depth models were re-established based on the common-used "Bacon" method and the IntCal13 radiocarbon calibration curve for calibrating original radiocarbon dating data, in order to obtain unified and comparable chronologies for all pollen records. Thus, all pollen data have reasonably high resolutions and robust chronologies.

Keywords : Fossil pollen, late Quaternary, Tibetan Plateau, pollen dataset

Evidence of acid rock drainage in cores from Laguna Shallap, tropical Andes, Peru.

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Abstract :

Initial results from four short sediment cores at Laguna Shallap, Cordillera Blanca, Ancash, Peru, show evidence of acid rock drainage's initiation. Sedimentological, siliceous microfossils, and elemental analysis indicate the change from shallow freshwater to shallow acidic waters. The sudden increase, above background levels, in elemental S, Fe, and Pb, associated with traces of the diatom Eunotia, an acidobiontic genus, favors the hypothesis that acid waters in this place of the Central Andes lixiviates metals towards surficial waters, most probably by the denudation, exposure, and weathering of sulfite ores due to glaciar melting. Physical sediment indicators are strong color changes from bottom dark gray to upper reddish-yellow sediments and from bottom laminated to upper disturbed, massive, dropstones sediments along the lacustrine cores. Current deglaciation rates will increase acid waters in the Cordillera Blanca in the next several decades, having great negative effects into the composition, function, and integrity of several mountain ecosystems as well as the drinking water and livelihood of Andean populations.

Keywords : Shallap Lake, acid rock drainage, sediment cores, elemental analysis, diatoms

Integrating paleolimnology and monitoring to understand current lake dynamics and future challenges: Lake Montmalus, central Pyrenees.

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Abstract :

High mountain lakes are especially sensitive to the effects of climatic fluctuations and anthropogenic impacts. The REPLIM initiative was launched in 2017 as a monitoring network in lakes and peat bogs in the Pyrenees including Spain, France and Andorra sites and aimed to characterize the impact of climate change in these high mountain ecosystems, both at a local and regional scale.

Montmalús lake, located 2433 m a.s.l. is one of the REPLIM sites located in the Principality of Andorra. The monitoring in Montmalús has included hourly temperature measurement at several depths along the water column, the annual collection and later analysis of the sediments using a sediment trap and the annual characterization of the physicochemical properties of its waters. This monitoring, combined with data obtained from nearby meteorological stations allows us to identify variations in parameters as the temperature of the deep waters, the duration of the ice cover or the duration of the mixing period of the lake water.

As part of a combined strategy including monitoring and paleolimnological studies,, the lake history during the last few millennia was reconstructed based on sedimentary facies, chemical (main and trace element) analyses and δ13C and δ15N of bulk organic matter and a robust age model based on 210Pb, 137Cs and 14C dating for the last 4000 years.

The results of this study show significant fluctuations in lacustrine dynamics, among which stand out a decrease of sediment delivery to the lake during the Medieval Climate Anomaly and the first half of the Little Ice Age, and periods of greater organic productivity during warmer phases and also larger heavy metal accumulation intervals (Roman mining and metallurgic activity from -500 to 400 years CE,). However, none of these limnological changes are comparable to the ones registered in the last few decades, which show a much larger decrease in detrital inputs and in exogenous organic material contributions. Heavy metal accumulation during the last decades show a decrease in the accumulation of elements like Pb (banned of Pb-fuels), but also, noticeable peaks in As,, likely reflecting industrial pollution.

The integration of both the monitoring surveys and the sedimentary record highlights the synergetic effects produced by the current climate and human impacts in the Pyrenean high mountain lakes.

Keywords : Pyrenees, Late Holocene, High Mountain Lake, Geochemestry, Global Change

OSM27: Variation and responses in fire regime behavior over time and space

Co-conveners: Carole Adolf, Kendrick Brown, Daniele Colombaroli, Elisabeth Dietze, Katarzyna Marcisz and Boris Vannière

Oral

Long-term fire dynamics mediated by herds, biomass and conflicts in Central Iberia.

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Abstract :

Fire has been identified as one of the major hazards of current global change, while it is as well one of the most powerful and transformative Earth processes. Fire-preventing policies are, sometimes, short-sighted in their spatio-temporal approach, as burning is often described as a feature to be avoided without any assessment of the long-term effect of fire on ecosystems. However, such an approach is related to prevent major effects in human populations as the forest-urban boundaries are progressively vanishing. Hence, producing coherent environmental policies regarding fire impacts necessarily implies a wide spatio-temporal perspective. In this study we present a lake sequence, La Parra, in a mid-montane location at the Iberian range, which records the last 1600 years with an extraordinary resolution (ca. 4 yrs/cm). The region holds the densest pine forests (Pinus nigra and Pinus pinaster) while being the least populated of the whole of Spain and, therefore, critically endangered by fire occurrence.

We performed a multiproxy analysis (XRF geochemistry, fossil pollen, spores and charcoal particles) reconstructing sedimentary and depositional environments, plant cover, fire and human activities changes from 300 to 2016 CE. In addition, we are starting a pilot study to compare current fire activity with that of the past, through the use of charcoal particles from short cores taken after high intensity experimental fires in the nearby region.

Three major fire scenarios have been evidenced in the sequence, related to well-recognized climate phases, the main historical events, agropastoral activities or the lack of them:

1) Very intense fire activity (700 to 1100 CE) occurring under two clear circumstances: expanding forests after land abandonment and increasing temperatures. This was the case during the transition from the Visigothic population to the Muslim expansion (600 to 800 CE), when a no-man land is described in La Parra region, under a warm scenario.

2) Medium-low fire activity (1100 to 1500 CE) occurred probably driven by one of the most important landscape transformations of the Middle Ages in Iberia: “La Mesta”. This was a powerful, herding institution in charge of regulating the seasonal grazing areas across the country. In the vicinity of La Parra, nearly 600k sheep crossed the area twice per year over centuries. Indeed, La Parra shows high amounts of different, obligate coprophilous fungi and a variety of adventives and ruderal plants, while there is relatively heterogeneous plant community. The burning activity promoted by herders probably sustained a mosaic landscape preventing large blazes to happen.

3) Very low fire activity (1500 to 2016 CE) is related to an expanding forest with reduced human activity, as deduced from the lack of palynological human indicators. This scenario partially concurs with the LIA that likely favored the expansion of black pines as temperature decreased, reducing also the fire risk.

Our results reproduce analogue scenarios to those of the current-day conditions, and most important, produce robust data, as the relevance of agropastoral activities sustained in long-term scales, that can be used by forestry managers for a more integrative conservation of the forests in Mediterranean Iberia.

Keywords : Mediterranean, charcoal, pastoralism, land abandonement, fire policies

Could fewer trees lead to more severe wildfires? Evidence from Holocene fire-vegetation dynamics at Lake Satagay, Central Yakutia, Siberia.

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Abstract :

Last year set new records for wildfire extent in the Republic of Sakha (Yakutia) in eastern Siberia, Russia. Wildfire seasons in this unique region, characterized by its deciduous boreal forest and permafrost landforms, are becoming more intense. Some fires are threatening local communities, while smoke covers vast stretches of land every summer, posing health risks to people even in the distance. At the same time, the larch trees of the eastern Siberian boreal forest stabilize the permafrost soils below as guardians of a continental-scale storage of terrestrial carbon. It is still largely unknown how the current trend of wildfire intensification will develop in the future, and how it will modify the structure of the boreal forests within the next decades to centuries. However, even though needed for a well-founded evaluation of long-term impacts of changing fire regimes, data on past trends of wildfire activity and its relationships to vegetation still remains scarce in eastern Siberia.

Here, we present a new reconstruction of boreal fire and vegetation dynamics, spanning the last ca. 10.8 ka. Continuously analyzed macroscopic charcoal particles, a REVEALS-transformed pollen record, and terrestrial plant ancient DNA from a sediment core from Lake Satagay (N 63.078, E 117.998) give insight into long-term trends and relationships between changes in fire regime and vegetation composition and coverage. The data indicates that modern larch-dominated forests co-exist with a lower severity fire regime since 4000 BP, whereas early Holocene open larch-birch woodlands enabled increased charcoal accumulation and thus supported a higher severity fire regime. Considering the expected increase in tree mortality caused by wildfires, droughts and insect damage, potentially thinning out currently denser tree stands, this fire-vegetation relationship may point towards an upcoming positive feedback on intensifying fire regimes.

Keywords : fire, boreal forest, charcoal, pollen, siberia

Climate changes and fire history in Central Siberia during the last 3400 years.

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Abstract :

Recent climate change in Siberia is increasing the probability of dangerous forest fires. The development of effective measures to mitigate and prevent fires is impossible without an understanding of long-term fire dynamics. This paper presents the first multi-site palaeo-fire reconstruction based on macroscopic charcoal data from peat and lake sediment cores located in different landscapes across the permafrost area of Central Siberia. The obtained results show similar temporal patterns of charcoal accumulation rates in the cores under study, and near synchronous changes in fire regimes. The paleo-fire record revealed moderate biomass burning between 3.4 and 2.6 ka BP, followed by the period of lower burning occurring from 2.6 to 1.7 ka BP that coincided with regional climate cooling and moistening. Minimal fire activity was also observed during the Little Ice Age (0.7 – 0.25 ka BP). Fire frequencies increased during the interval from 1.7 to 0.7 ka BP and appears to be partly synchronous with climate warming during the Medieval Climate Anomaly. Regional reconstructions of long-term fire history show that recent fires are unprecedented during the late Holocene, with modern high biomass

burning lying outside millennial and centennial variability of the last 3400 years.

The studies were supported by Russian Science Foundation, project 20-17-00043.

Keywords : fire frequencies, fire regime, fire return interval, biomass burning, macroscopic charcoal, paleo-fire reconstruction, Putorana Plateau, Central Siberian Plateau

Dynamics of forest fires in the western part of the Putorana plateau (Northern Siberia) last 1300 years.

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Abstract :

In the context of modern climate change in the Arctic region, the study of past environmental changes is becoming increasingly important. This study aimed to the reconstruction of forest fire history determined by climate and anthropogenic factors for the Western part of the Putorana plateau (Northern Siberia). The study is based on sampling data from one peat bog and two lake sediments. Macrocharcoal particles (size >125 µm) were analysed to reconstruct fire history. Pollen analysis was used for reconstruction of the climate, human and forest fires impact on the vegetation cover of this territory in the past.

We highlight 3 stages of forest fire frequency. The first stage from 1300 cal. year BP to ~900 cal. year BP characterized by high CHAR-index and an abundance of local fire episodes (up to 6 episodes, i.e. about the fire returned interval is approximately 65 years). Pollen analysis indicates for this period of warmer climatic conditions (Medieval Climate Optimum). Indicators of fire activity (Onagraceae, Gelasinospora) is found in pollen spectra. The middle part of the peat column dated ~900–100 cal. year BP has significant decrease in forest fire activity. This period corresponds to the Little Ice Age and according to pollen analysis is characterized by the predominance of sparse larch forests and treeless areas. The last stage (from ~100 cal. year BP to the nowadays) has only one fire peak with high CHAR-index in each site. We suppose that relatively high CHAR for last ~100 years caused by the modern climate changes and active anthropogenic influence, which began in this region only in the 20th century because this area is remote and difficult to access.

This study was supported by a grant of the Russian Science Foundation (20-17-00043).

Keywords : forest fire, fire frequencies, fire return interval, macrocharcoal analysis, biomass burning, pollen analysis, Northern Siberia, Putorana Plateau

Development of high diversity beech forest in the eastern Carpathians.

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Abstract :

Over the past decades, a surge in the number of large and uncontrolled wildfires has occurred on all terrestrial ecosystems. Global warming may amplify this trend and threaten most ecosystems worldwide for decades. These alterations of fire regimes will affect fire-prone ecosystems and forest ecosystems that have not historically experienced fires, such as European beech forests. These deciduous forests are characterized by high plant diversity, and understanding their formation and decline is

crucial to anticipate possible changes in these ecosystems in the ongoing global warming. In this context, this study aims to understand how these forests have expanded in Europe and the main factors explaining their high biodiversity. We applied a multi-proxy approach on a peat sediment core in the Eastern Carpathians, Slovakia (macrocharcoal, pollen, macrofossils) to fill this knowledge gap. Estimated palynological richness and charcoal analysis showed that low diversity spruce forests were dominant until 5200 cal. BP during a fire-prone period mainly due to climatic conditions. The establishment of late-successional, shade-tolerant beech (Fagus sylvatica) was facilitated by fire disturbances, but its expansion coincided wit absence of fire events from 3900 cal. BP. The palynological richness has increased during the spruce–beech forest transition, highlighting the importance of beech forests in maintaining plant biodiversity. However, the stronger increase of the richness is synchronous with the increase in human activities around 2000 cal. BP, and then 350 cal. BP. Low-frequency fire and extensive human impact could play an important role in maintaining high diversity beech forests in the future.

Keywords : Fire, Paleoecology, Carpathians, biodiversity, charcoals, pollen, marcofossils, human impact

Response of Arctic tundra fires to glacial-interglacial environmental variability inferred from molecular proxies at Lake El'gygytgyn, Far East Russia.

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Abstract :

The recent increase in Arctic tundra fire activity is impacting global air quality and human activities, accelerating ecological changes, and importantly, releasing large amounts of permafrost soil carbon into the atmosphere as carbon dioxide. As such, understanding the environmental controls of tundra fires is essential for predicting future climate feedbacks from burning. The frequency and severity of tundra wildfires are generally affected by aridity, lightening frequency, and vegetation assemblages. For example, the Last Glacial Maximum was cold and dry in parts of the Arctic, and wildfires were more common than during the relatively warm and moist Holocene. Contrastingly, current warming and increasing effective moisture appear to be moving the Arctic into a more fire-prone climatic state. Paleoclimate records of past warm periods are needed to elucidate if future climate change will ultimately suppress or stoke tundra fire activity.

Here, we investigate molecular proxies of fire and climate across Marine Isotope Stages (MIS) 20-22 (860-720 ka) in the Lake El'gygytgyn drillcore from NE Russia. We reconstruct fire activity using a combination of polycyclic aromatic hydrocarbons (PAHs) and monosaccharide anhydrides (MAs). Temperatures are reconstructed using the MBT'5ME index, based on branched glycerol dialkyl glycerol tetraethers. Vegetation change is inferred from leaf wax n-alkanes and pollen assemblages.

We find that MIS 20-22 experienced large climatic and vegetation shifts at Lake El'gygytgyn. Interglacial stage MIS 21 is 4-6 °C warmer than the preceding and following glacial periods. Tundra and cold steppe biomes characterize the study interval, but there are periods with elevated deciduous and coniferous tree species as well. We use the PAH and MA ratios to determine fire biomarker source regions and source fuel types across this glacial-interglacial cycle and further discuss how the wildfire proxies vary in response to environmental change.

Keywords : Arctic, Paleofire, Polycyclic Aromatic Hydrocarbons, Levoglucosan, Glycerol Dialkyl Glycerol Tetraethers

The shaping of Late Holocene fire regimes in mid elevation mountains: a peat-based multiproxy study in the Romanian Carpathians.

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Abstract :

A longer-term perspective on fire regime and fire impacts on local environments can contribute to sustainable ecosystem management and biodiversity conservation. Anthropogenic activities such as changes in land-use, forest clearance and mining, superimposed on climate change, may induce changes in fire regime and increase wildfire risk, thus threatening sensitive landscapes. The Romanian Carpathians are among the richest biogeographical regions in terms of biodiversity indicators and home to the largest remaining old-growth forests in Europe. Regionally, there are few long-term fire regime reconstructions, all located in the higher elevation mountain groups, hence, little is known about fire history at mid elevation. Here we reconstruct the late Holocene fire regime and the relationship with anthropogenic disturbance in a raised bog located in the Lăpuș Mountains, Northern Romanian Carpathians. We used sedimentary macroscopic charcoal abundance and the morphological characteristics of charred particles to reconstruct fire regime and determine the types of material burnt (wood, grass, forbs). Human impacts from historical mining and local soil and bedrock erosion were also reconstructed based on elemental geochemistry, magnetic mineral properties and particle size analysis. Published palynological and archaeological information was used to derive local to regional vegetation dynamics, particularly the spread of grazed and cultivated areas and settlements. Our results show that fire was variable over the last 3000 years, with moderate burning between 3000-2200 cal. yr BP and lower fire activity between 2200-600 cal. yr BP; the peak fire episode occurred around 500-400 years ago. Increases in fire were generally accompanied by episodes of increased landscape openness and extension of pastoral activities, except for the last 600 years, when maximum concentrations in heavy metals indicate an intensification of mining activities in the region. We found a mean fire return interval of 270 years for last 3000 years, with a minimum of 200 years/fire episode between 3000-2200 cal. yr BP and an increase to a 300-350 years/fire episode towards the present. Peak magnitude in the last 600 years was unprecedented throughout the entire record. The temporal variation in fire regime may also reflect climate changes (as shown by published regional palaeoclimate reconstructions) with, for example, warmer and drier condition between 3000-2200 cal. yr BP, followed by lower fire with moister conditions between 2200-600 cal. yr BP. The peak burning at 500-400 cal. yr BP, overlapped the cold and moist Little Ice Age period, suggesting that anthropogenic drivers became more important than climate in shaping fire regime over the last centuries. This study provides the first long-term, mid elevation fire regime reconstruction in NW Romania and adds a valuable perspective on the extent of human impact on the landscape.

Acknowledgement: This work was supported by the Romanian National Authority for Scientific Research, UEFISCDI (grant no. PN-III-P1-1.1-TE-2019-1628) and the "DECIDE-Development through entrepreneurial education and innovative doctoral and postdoctoral research", project code POCU/380/6/13/125031, project co-financed from the European Social Fund through the 2014–2020 Operational Program Human Capital.

Keywords : charcoal, fire regime, anthropogenic activities, Lăpuș Mountains, late Holocene.

Fire regime in Eurasian boreal forest

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Abstract :

Boreal forests contain ~30% of the world's forested area and ~65% of the world's forest carbon stocks. Eurasian boreal forest composition is not spatially homogeneous, and the dominant tree species in Europe is distinctly different from Siberia. Wildfire is the most common type of disturbance in boreal forests, however, its impact is strongly dependent on the fire regime (frequency, intensity, extent, etc). High-intensity crown fires alter species composition for an extended period, whereas surface fires do not typically trigger stand-scale forest replacement. Considerable efforts have been made in recent years to fill some of the

geographical gaps in past changes in wildfire regimes and on the analytical approaches to distinguish changes in fire frequency and intensity. However, our understanding of the fire regimes in the Eurasian boreal region, particularly in Siberia is still limited. Here I present selected macro-charcoal records from boreal Eurasia (Siberia and Europe, including some mountain sites) to document past changes in wildfire regimes and the timing of the major shifts in fire regime during the Holocene. The combination of pollen-based vegetation composition with information on fire-related functional traits of key boreal tree species was used to understand the fire-vegetation feedback. Results also provide estimates of ranges fire frequency and severity of key Eurasian boreal taxa and the most common plant functional traits that influence resistance to fire and post-fire recovery potential. The insights will improve our understanding of how Eurasian fire regimes might respond to future climate changes and evaluate the potential of boreal forests to adapt to new fire regimes.

Keywords : fire frequency, vegetation traits, taiga

Poster

Black carbon emissions from low-latitude lake sediments in the Southern hemisphere to quantify sources for Antarctic ice core records.

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Abstract :

Refractory black carbon (rBC) aerosols emitted from biomass and fossil fuel burning contribute to radiative forcing of climate. Understanding long-term rBC dynamics is crucial to quantify how humans have modified natural burning regimes and to disentangle biomass and fossil-fuel burning sources during the Industrial Era of the past 150 years. For example, previous charcoal-based studies from New Zealand lakes suggest a strong increase in local fire activity after the arrival of the Polynesian Māori (1200-1300 CE) that potentially resulted in increased rBC aerosols over vast areas in the Southern Hemisphere. Existing rBC records, however, are limited to remote ice core sites far from potential emission sources. This hampers linking rBC records to local lake sediment records from charcoal analyses. Directly measuring rBC near the sources in lake sediments may provide an important link between source emissions and the observed rBC deposition on the Antarctic ice sheet.

We developed rBC records from eight lakes across New Zealand, Tasmania, South Africa, and Patagonia using a recently developed, incandescence-based method for efficient and accurate rBC measurements in lake sediments. Our data suggest that rBC in Southern hemisphere lake sediments is spatially variable. While the rBC record from the most sheltered mountain site, Horsehsoe Lake on New Zealand's South Island, shows striking similarities during the past millennium with previous macroscopic charcoal, other sites that are more exposed show less similarity between rBC and charcoal trends. We hypothesize that rBC in more exposed lakes may include sources from distant regions in addition to local rBC. Such distal burning emissions are not captured in the larger charcoal fraction. Our rBC dataset from the Southern hemisphere may provide quantification of a key emission source for rBC deposition variability on the Antarctic ice sheet and a direct link between rBC source emissions and rBC records in remote polar ice archives. Moreover, we close a geographic gap of past Southern Hemisphere mid-latitude rBC emissions that may improve climate and fire models, and ultimately inform policy decisions.

Keywords : refractory black carbon, lake sediments, fire history, Southern hemisphere, fire emissions

Dynamics of the Forest Fynbos Ecotone at Orange Kloof Table Mountain National Park, South Africa.

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Abstract :

In recent decades, Afrotemperate forest has expanded in the Cape Peninsula. This expansion might reflect a recovery from past forest clearance in the 19th Century, or a more unprecedented side effect as a result of fire suppression in the 20th Century. Fire is crucial in determining the modern ecotone boundaries of the alternate stable states of forest and fynbos.

To determine the relationships between forest and fynbos and the key drivers of these alternate stable states, paleoecological techniques such as pollen, non-pollen palynomorphs, charcoal, stable isotopes ratios (δ15N; δ13C) and trace elements (XRF) were analysed form Late Holocene sediments extracted from Orange Kloof in the Table Mountain National Park.

Results clearly illustrate that forest - fynbos dynamics prior to the European settlement were controlled by the interplay between external and internal divers. An internal reorganization from an asteraceous fynbos to an ericaceous fynbos occurred at around 150 CE driven by increased water availability and fire activity allowing fynbos to persist despite climatic change. However, around 100 years later at around 250 CE there was a regime shift towards increased dominance of the forest alternative stable state, probably driven by increasing wetter conditions. Following European settlement (1652 CE), forest-fynbos dynamics were decoupled from climatic changes suggesting increased human influence.

The investigation shows that modern forest expansion is coupled to fire suppression and recovery of past forest clearance.

However, past changes in forest extent were related to fire vegetation climate feedbacks. The results suggest that continued fire suppression will facilitate forest expansion at the expense of mega-diverse fynbos vegetation. However, this could be balanced by a drying climate and more intense fires. In either case, there are implications for fire management that will have both social and ecological dimensions. Paleoecological data can assist in navigating this complexity.

Keywords : Cape Peninsula, Late Holocene, alternate stable states, fynbos, Afrotemperate forest, fire vegetation climate feedbacks, ecosystem management

OSM28: Regional and transregional climate variability over the last 2000 years

Co-conveners: Nerilie Abram, Bronwen Konecky, Steven Phipps, Hans Linderholm, Helen McGregor and Anais Orsi

Oral

Contribution of Southern Ocean dynamics, climate variability and land-use to changes in atmospheric CO2 concentration over the past two millennia.

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Abstract :

The fluctuations of atmospheric CO2 concentrations over the preindustrial Common Era are generally attributed to changes in land carbon storage, caused primarily by changes in surface air temperature but also by changes in land use. This dominant influence of the land carbon cycle is consistent with the negative correlation between atmospheric CO2 concentrations and d13CO2 variations recorded in ice cores. By performing an ensemble of sensitivity experiments with the LOVECLIM model, we confirm the potentially large role that temperature changes have on the land carbon cycle. However, this process alone cannot explain the magnitude of the reconstructed atmospheric CO2 and d13CO2 variations. In particular, even when the model is constrained to follow reconstructed temperature changes by data assimilation, and when applying relatively large values of the climate-carbon feedback parameter, it can only explain about 50% of the atmospheric CO2 decrease between the 12th and the 17th century. We find that land use changes are likely responsible for most of the observed long term atmospheric CO2 trend over the first millennium of the Common Era, and for up to 30 % of the decrease observed after 1600 CE. In addition, in our experiments, changes in southern hemisphere westerly winds induce slightly smaller changes in atmospheric CO2 concentrations than those associated with land use change, and variations in d13CO2 of the same order of magnitude as the observed ones. Combining the effects of changes in temperature, land use and winds over the Southern Ocean provides a reasonable agreement with reconstructions for atmospheric CO2 concentrations and d13CO2, especially for the low CO2 values observed during the 17th century. This underlines the important contribution of both land and ocean carbon processes. Nevertheless, some uncertainties remain on the origin of the relatively high CO2 concentrations reconstructed during the 11th and 16th centuries.

Keywords : carbon cycle, Southern Ocean, CO2, modelling, data assimilation

Process-based Estimate of Global-mean Sea-level Changes in the Common Era.

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Abstract :

Though the global-mean sea level (GMSL) rose steadily over the 20th century with a positive contribution from major sources, driving processes of GMSL changes during the pre-industrial common era (PCE; 1 – 1850 CE) are largely unknown. Here, the contributions of

glacier and ice -sheet mass variations and ocean thermal expansion to GMSL in the common era (1 – 2000 CE) are estimated based on simulations with different physical models. Although the 20th-century global mean thermosteric sea level (GTSL) is mainly associated with temperature variations in the upper 700 meters (86% in reconstruction and 74±8% in model), GTSL in the PCE is equally controlled by temperature changes below 700 meters. GTSL does not vary more than ± 2 cm during the PCE. GMSL contribution from the Antarctic and Greenland ice sheets tend to cancel each other, at least over the last millennium, owing to their differing response to atmospheric conditions. However, the uncertainties of sea-level contribution from land-ice mass variations are large, especially over the first millennium. Despite underestimating the 20th-century model GMSL, there is a general agreement between the model and reconstructed GMSL in the CE. Although the uncertainties remain large over the first millennium, model simulations point to glaciers as the largest source of GMSL changes during the PCE.

Keywords : GMSL, ocean thermal expansion, land-ice melting, climate variability

The Modern Era Reanalysis - ModE-RA.

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Abstract :

We present the multivariate and monthly resolved Modern Era Reanalysis (ModE-RA) for the past six centuries. This data set combines our understanding of physics coming from an ensemble of atmospheric model simulations with all available direct and indirect climate observations of monthly to annual resolution. We created a 36-member atmospheric model simulation ensemble driven by an ensemble of possible external forcings and an ensemble of new sea surface temperature reconstructions to cover the full range of possible past variability, which is in agreement with forcings and boundary conditions. After the entire simulations were generated, we assimilated multiple data sources into the existing transient simulations using an offline Kalman filtering technique. Direct observations included thousands of existing and newly digitised temperature, precipitation, wet days, and pressure time series, including measurements made on ships over the ocean and in harbours. Earliest instrumental station data go back to the year 1658. Additionally, we collected and digitised climate information from historical documents, including phenological data. These are especially valuable for the autumn, winter and spring season. Finally, we assimilate annually resolved climate proxies. The vast majority are tree-ring observations, which represent growing season land climate conditions. However, we use few additional proxies in otherwise data sparse regions, like coral data in the tropical oceans or ice data at high latitudes. This new paleo-reanalysis offers especially insides into interannual to multidecadal variability such as phases of accelerated warming, monsoon strength or subtropical droughts as well as rare events such as volcanic eruptions.

Keywords : Global, Climate, Reconstruction, Reanalysis

Announcing Phase 4 of PAGES 2k: Hydroclimate of the Common Era.

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Abstract :

Understanding the climate of the past two millennia (2k) remains vital for developing our wider comprehension of the climate system, including the nature and scale of recent and future anthropogenic change. Phase 4 of the PAGES 2k network will build on previous phases and take us to a new level of understanding and science-policy integration.

During previous phases, PAGES 2k members compiled global networks of proxy measurements, extending records beyond the instrumental period by more than an order of magnitude, reconstructing past climate and developing new knowledge of past variability and processes. Through data-model integration with state-of-the-art Earth systems models, proxy system modelling and data assimilation, we took key steps towards a more comprehensive understanding of climate dynamics.

Phase 4 will take us even further, challenging our community to turn its focus primarily towards the hydroclimate of the Common Era: performing new reconstructions and improving the interoperability, extent and scope of our data and model products. In doing so, we also seek to facilitate the translation of our science into evidence-based policy outcomes. Our overarching aim is to reconstruct hydroclimate variability over the Common Era from local to global spatial scales, at sub-annual to multi-centennial time scales. We propose to achieve this through new community led data curation efforts and the development of new data-driven tools and practices to maximise the interoperability of convenient, efficient and widespread model/data products. We will aim for a process-level understanding of past hydroclimate events and variability by evaluating and constraining Earth system models and through data assimilation.

Our coordination team places a strong emphasis on respect and inclusion, aiming to foster a diverse and equitable community. Through a 'hub and spoke' structure, our team will provide a facilitation, coordination and support role (the hub) for Pages 2k working groups (the spokes). We are actively seeking participation of those engaging in climate policy and climate services. Welcome to Phase 4! We warmly invite your collaborations and contributions.

Keywords : Hydroclimate, Common Era, Interoperability

A large-scale approach on (sub-)Arctic organic matter input to lacustrine environments over the Common Era.

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Abstract :

The centennial-scale variability of the Common Era's (CE; past 2000 years) climate affected the organic matter (OM) cycle. Lakes act as important sinks of both aquatic and terrestrial OM. Although they cover only a small fraction of the Earth's surface area, they are widespread in boreal and Arctic landscapes. However, climatic changes and their impacts on OM cycling observed in lake records may not be synchronous within the Northern Hemisphere. Therefore, our goal was to understand the evolution of OM input to lacustrine environments on a large spatial scale. We analysed 108 lake records to reconstruct the last 2000 years of OM input to lakes from high latitudes (> 55° N). The total OM input was inferred from data of organic matter, total organic carbon, biogenic silica, chlorophyll-a and diatom valve concentrations. The aquatic OM input was estimated based on the last three parameters. All records covered at least 80% of the CE and presented resolution higher than 100 years. In addition, we analysed several

environmental parameters like lake size, distance to the coastline and vegetation type to assess whether they influenced how OM input varied over time. Overall, the records presented an increase in the OM input in the last 200 years, which could be attributed to the expansion of human occupation in these regions or to anthropogenically induced climatic changes. The most common pattern, represented in 60 % of all records, indicates an increase in the OM input, especially after 1000 CE. While the aquatic OM records exhibit clearer evidence of the Medieval Warm Period, the total OM records did not display the same pattern. Because the total OM data also incorporates terrestrial material, this dissimilarity suggests that the warmer climate may have promoted aquatic productivity but not the fluvial input into these lakes. When the environmental parameters were analysed, only the total OM data presented statistically significant results. Lakes located far from the coast predominantly showed an increasing trend of OM input over the CE. Because this was not observed for the aquatic OM data, it suggests that the distance to the coastline only affects the terrestrial portion of the OM.

Keywords : lake records, meta-analysis, aquatic production, fluvial input

Volcanism and Climate during the Common Era and beyond

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Abstract :

Here we present a comprehensive review and new insights from polar ice-core arrays on explosive volcanism and its effect on climate over the Common Era, Holocene and Late Glacial. We demonstrate how we can combine high-resolution records of sulfur and its isotopic (33S, 34S) composition with targeted cryptotephra analyses to infer critical information on eruption source parameters (i.e. location, sulfur mass injection, plume height) which ultimately determine the climate impact potential of past volcanic eruptions. We will discuss the implications of recent cryptotephra analyses for existing reconstructions of volcanic forcing as prescribed in PMIP3 and PMIP4 model simulations. Specifically, we discuss the attribution and timing of volcanic eruptions detected in ice cores in the 15th, 5-6th and 1st centuries, including insights on the "mystery dust veil" in 536 CE, the Tierra Blanca Joven eruption of Ilopango, El Salvador and the historic eruption of Vesuvius, Italy in 79 CE. In the framework of the PAGES CLIVASH2k project we use the accurately dated WD2014 chronology from the WAIS Divide ice core (WDC) to synchronize a large number of ice cores from Antarctica. Thereby we correct a long standing dating bias inherent in many regional and global multi-proxy climate reconstructions and data assimilations (e.g. PAGES2k, PAGES-Iso2k, PHYDA). Finally, we present a new reconstruction of volcanic sulfur injection and radiative aerosol forcing for the Holocene (HolVol1.0) and the Allerød/Younger Dryas transition based on bipolar ice-core stacks and discuss to what extent the eruptions of Laacher See (dated 13,006 ± 9 years BP, Germany) and Thera (Greece) may have influenced climate.

Keywords : volcanic eruptions, tephra, chronology, Greenland, Antarctica

A high resolution climate reconstruction during the late phase of the Little Ice Age in the Gulf of Taranto, central Mediterranean Sea, based on organic-walled dinoflagellate cysts

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Abstract :

For the time interval of the Little Ice Age (AD 1400-1860) the underlying climate mechanisms are still poorly understood. The limited number of marine climate archives with a temporal resolution that i(rd"H s high enough to allow the detection of climate fluctuations in high frequency domains contributes to this situation. To obtain insight into the patterns and potential forcing of climate variability during the later phase of the Little Ice Age from 1700-1800 AD the association of marine organic-walled dinoflagellate cysts of the sediment core DP30PC from the Gulf of Taranto was analyzed with a temporal resolution of around 3 years. The reconstructed sea surface temperatures, based on the ratio of warm water species to cold water species, show from 1748-1755 AD a significant temperature decrease with otherwise relatively stable temperatures from 1700-1788, followed by a decreasing temperature trend from 1788-1799. A mostly synchronous relationship between the accumulation rates of the nutrient sensitive dinoflagellate cysts and the Adriatic Surface Water (ASW) species indicates that the trophic state of the upper water column is largely dependent on river input of northern and eastern Italian rivers, which in turn is a function of precipitation. Dust from the Sahara and the input of volcanic ashes may also be a secondary source of nutrients and trace elements. The accumulation rates of the ASW indicator species Lingulodinium machaerophorum and Pseudoschizaea point to varying amounts of precipitation during the investigated time interval from 1700-1800 AD, with two drier periods from 1743-1753 AD and 1776 AD onwards. Simultaneous cyclicities of 5.6-7 and 11 years could be detected in the reconstructed variations of the sea surface temperatures and river discharge indicating an influence of the North Atlantic Oscillation. Beside an 11-year cyclicity in the fluctuations of the surface water temperatures a correlation with the number of sunspots is observed, whereby the decreasing temperature trend coincides with the onset of the Dalton Minimum, a phase of reduced solar activity. The presence of an 11-year cycle in the reconstructed fluctuations in precipitation suggests that the solar variability might be an important forcing factor not only of the temperature, but also of the North Atlantic Oscillation, highlighting the importance of high resolution records to study regional climate variations and their underlying forcing mechanisms. Due to the correlation between temperature variations and the timing of major volcanic eruptions at some points in time, it is possible that volcanic activity might be an additional, though probably rather minor, climatic driver in the study region compared to solar activity and the North Atlantic Oscillation.

Keywords : Climate, Little Ice Age, dinoflagellate cysts, temperature, river discharge

Tropical Rainfall Belt trends and variability across the Southeast Tropical Indian Ocean over the last 200 years

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Abstract :

Changes in the position and width of the Intertropical Convergence Zone (ITCZ) are important as they are often associated with shifts of the subtropical dry zones and can have major impacts on rainfall. Since 1980, the ITCZ has exhibited widening, however, the majority of studies focus on indices which reflect the zonal mean and do not account for regional

variability. The ITCZ exhibits strong interannual variability across the Southeast Tropical Indian Ocean (SETIO) with associated shifts in subtropical dry zones and rainfall across Australia. Despite the influence on Australian rainfall, long-term characteristics of the ITCZ in this region are poorly defined and little is known prior to 1980.

Here, we identify characteristics of the ITCZ in the SETIO regions to describe variability through the instrumental period (1979-2020). Using an identification and characterisation method, which was applied to the European Centre for Medium-range Weather Forecasts Reanalysis 5 (ERA5), Global Precipitation Climatology Project (GPCP) and CPC Merged Analysis of Precipitation (CMAP) datasets, we have created a 41- year ITCZ climatology of the region. This method generated indices of the width, location, rainfall intensity, and both the southern and northern convection boundaries of the ITCZ. These were then utilised to assess trends and variability of the climate belts around Australia over the instrumental period. These new insights into trends and variability of the ITCZ will be used alongside a suite of coral paleoclimate records from the tropical southeastern Indian Ocean to develop a long-term understanding of tropical rainfall belt characteristics and its links to natural and human-caused climatic changes.

Keywords : Coral; Tropical Rainfall; SST

Summer temperature changes in Tierra del Fuego since AD 1765: atmospheric drivers and tree-ring reconstruction from the southernmost forests of the world.

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Abstract :

Proxy climate records, such as those derived from tree rings, are necessary to extend relatively short instrumental meteorological observations into the past. Tierra del Fuego is the most austral territory with forests in the world, situated close to the Antarctic Peninsula, which makes this region especially interesting for paleoclimatic research. However, high-quality, high-resolution summer temperature reconstruction are lacking in the region. In this study we used 63 tree-ring width chronologies of Nothofagus pumilio and Nothofagus betuloides and partial least squares regression (PLSR) to produce annually resolved December-to-February temperature reconstruction since AD 1765 which explains 37-50% of instrumental temperature variability. We also found that observed summer temperature variability in Tierra del Fuego is primarily driven by the fluctuations of atmospheric pressure systems both in the South Atlantic and South Pacific, while it is insignificantly correlated to major hemispheric modes: ENSO and SAM. This fact makes our reconstruction important for climate modelling experiments, as it represents specific regional variability. Our reconstruction can be used for direct comparison with model outputs to better understand model limitations or to tune a model or contribute to larger scale reconstructions based on paleoclimatic data assimilation.

Keywords : Southern hemisphere, Nothofagus pumilio, Nothofagus betuloides, dendroclimatology, Southern Atlantic

Large ensemble particle filter for proxy-based spatial reconstructions of the last 2000-years climate variability.

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Abstract :

Proxy records (corals, tree rings, speleotheme, etc.) documenting the last 2000 years (2K) provide evidences for the wide range of natural variability not captured by recent direct observations. Assessing climate models ability to reproduce such natural variations is crucial to understand climate sensitivity and impacts of future climate change. The length of record is relatively short for investigating slow climate features, especially when considering coupled ocean-atmosphere variability. In order to extend the information contained in regional proxies, additional information is needed to create a climate field reconstruction. Paleoclimate data assimilation offers a powerful way to extend the instrumental period and better characterize the decadal to secular natural variability by optimally combining the physics described by climate models with information from available observations while taking into account their uncertainties. The climate reconstructions include robust uncertainty quantification and a set of physically consistent spatial fields useful for dynamical inquiry beyond what is feasible from proxies or climate models alone. Here we present a new Proxy Data Assimilation method based on a sequential importance resampling particle filter (PF-SIR) that uses a GCMs emulator providing dynamical memory and improving the reconstruction of low-frequency climate variability. We use these new results to explore low-frequency aspects of main coupled variability modes and provide some constrains on climate model simulations for the last millennium.

Keywords : Paleoclimate data assimilation, Large ensemble particle filter, climate variability, climate reconstruction over the last millennium

East Antarctic temperature variability over the past 2000 years from the Aurora Basin North ice core.

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Abstract :

Temperature is one of the most important parameters of the climate system. In order to understand climate variability beyond the observations on the recent period, natural archives such as ice cores have been investigated. Here we use two different methods to reconstruct temperatures from the Aurora Basin North ice core on the East Antarctic Plateau during the past 2000 years: water stable isotopes (δ18O) and inert gases stable isotopes (δ15Nexcess) coupled to borehole temperature. While the temperature reconstructed from water isotopes shows no significant trend, the gas-based temperature reconstruction is marked by a warming trend from a cold phase spanning from 1000 to 1400 C.E. The observed discrepancy could result from the sporadic nature of precipitation events, during which the water stable isotopes signal is acquired. On average, we expect that the temperature was colder during the medieval period, which coincides with a positive SAM phase. The warming of continental Wilkes Land over the last Millenia also supports a trend towards anticyclonic wind anomalies in the Ross Sea (Pacific South American mode 2), consistently with other studies. The diversification of temperature proxies will help understand the teleconnections between Antarctic continent and other regions of the southern hemisphere.

Keywords : Antarctica, temperature, isotope, atmosphere

North Atlantic Oscillation and Jet Stream Impacts on Water Isotope Proxies from the Iso2k Database.

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Abstract :

Climate variability in the Atlantic region has implications for socio-economically relevant weather and climate extremes in North America and Europe. Characterizing the natural range of variability is also critical for the evaluation of anthropogenic changes. Natural archives that record the stable oxygen (δ18O) or hydrogen (δ2H) isotopic compositions of environmental waters (hereafter "water isotopes") integrate hydroclimatic information from a range of spatial scales. These data are therefore uniquely valuable for characterizing large scale climate variability on decadal to multi-decadal timescales. Here we present analyses of climate variability across the Atlantic region recorded by water isotope proxies from the PAGES Iso2k database (Konecky et al., 2020, ESSD). We focus on the instrumental era (~1880-2000 CE) to compare proxy data with observations and climate model output. These comparisons allow us to evaluate the sensitivity of water isotope proxies to precipitation amount, temperature, and atmospheric circulation. We filtered records for annual or better resolution and at least 66% data coverage between 1880 and 2000 CE. This resulted in ~80 proxy records in the circum-Atlantic region including glacier ice, corals, tree ring cellulose, and speleothems. We applied principal components analyses and a composite-plus-scale (CPS) reconstruction to evaluate the expression of the North Atlantic Oscillation (NAO) and the North Atlantic jet stream (NAJ) over the 20th century. The CPS reconstruction provided evidence of NAO influence beyond that which could be expected from white or red noise, and primary modes of variability were consistent with recent reconstructions of the NAJ defined as the first principal component of zonal mean zonal winds over the North Atlantic (Osman et al., 2021). Comparisons with gridded reanalysis products from the NOAA 20th Century Reanalysis Project showed that the first principal component of circum-Atlantic water isotope proxies was correlated with surface air temperature, sea level pressure, near-surface winds, and precipitation amount across the entire Northern Hemisphere Atlantic region. We compared these correlation structures with simulations from the isotope-enabled Last Millennium Ensemble (iLME) of the Community Earth System Model (CESM) to evaluate the relationships between the NAJ and δ18O in precipitation. Our results suggest water isotopes in modern precipitation and in proxies from the circum-Atlantic region track the NAO and NAJ through the influence of moisture transport history and precipitation amount. These complex and often competing influences help explain disagreements between previously published NAO reconstructions by highlighting gaps in temperature and precipitation correlations with the NAO and NAJ that may go undetected without the use of water isotope proxies. Our results therefore lay a strong foundation for reconstructions of North Atlantic climate that capture decadal to multi-decadal variability by applying regional to hemispheric collections of water isotope proxy records like the Iso2k database.

Keywords : Iso2k Database, Water Isotopes, North Atlantic Oscillation, Jet Stream

Paleo-productivity changes and Indian Summer Monsoon variability during the Little Ice Age (LIA); Inferences from the Bay of Bengal sediments.

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Abstract :

Little Ice Age (LIA) refers to the most recent period of advanced mountain glaciers during the sixteenth and seventeenth centuries. Recent paleoclimate investigations have targeted the reconstruction of Indian Summer Monsoon (ISM) variability from the north-eastern Indian Ocean to investigate long-term ISM evolution. ISM plays a significant role in the agrarian-based life of nearly two billion people in the Indian subcontinent by contributing over 80 % of annual rainfall and affecting most South Asian countries. Direct rainfall and river runoff into the Bay of Bengal during ISM is a characteristic feature of the bay. Recently, more attention was given to ISM variability during the Holocene Epoch (~11,700 cal yr B.P. to Present) and there is a pressing need to characterize its behaviour better to anticipate future changes. Here, we present the downcore variations in the relative abundance of planktonic foraminiferal species for the LIA and Modern Warming (MW) from

the western Bay of Bengal core SSK50/GC-04 (18.0222°N, 84.3667°E; water depth: 1277 m). The average relative abundance of the low salinity species N. dutertrei for the core SSK50/GC-04 was 20 %. The peak (high) abundance (38 %) was observed at AD 1502 and low abundance (7 %) was observed at around AD 1553. Overall, the abundance of N. dutertrei was not showing much fluctuations within the LIA and MW. On the contrary, the abundance of the productivity (fertile) species shows significant variations within the LIA. Higher abundance of the productivity species viz., G. bulloides, G. glutinata and G. falconensis was observed from AD 1400 to AD 1600. A similar higher abundance was observed with the s.l. morphotype of the mixed layer species, G. ruber. This indicates a well-ventilated seawater column with reference to a reduced freshwater input linked with weak ISM. However, there is a decreasing trend in the abundance of the above productivity species from AD 1600 onwards, which is coinciding with the low abundance of G. ruber s.l. (AD 1600 to AD 1800). This indicates a strongly stratified water column resulting from high river runoff and enhanced ISM. Even though the ISM was weak during LIA, the present study shows alternate strong and weak phases of ISM from LIA to the Present.

Keywords : Little Ice Age, Indian Summer Monsoon, Productivity, Planktonic foraminifera, Bay of Bengal

What climate characterised the Mediterranean during the past two millennia (2k)?

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Abstract :

A Mediterranean composite of peer-reviewed and publicly available marine reconstructions (marine sediments, corals) is compared with a stack of terrestrial records (stalagmites, lake sediments, tree rings) to detect climate modes of temperature and hydroclimate variability in the region over the past 2000 years. We base this on chronologically controlled time series gathered in FAIR databases (Luterbacher et al 2012, ELSEVIER; Roberts et al 2012, GPC; PAGES 2k consortium, 2013, NATURE GEO; Cook et al., 2015, SCIENCE; PAGES 2k consortium, 2017, SCI DATA; Labuhn et al 2018, LAA; Finné et al., 2019, THE HOLOCENE), and select those that cover most or the full period, to minimise statistical distortion. We focus on multi-decadal to centennial climate variability vis-à-vis possible external and internal forces taken into consideration in palaeoclimate simulations (PAGES 2k consortium, 2019, NATURE GEO). Results are evaluated comparing similarly analysed teleconnection patterns relevant to Mediterranean climate variability (e.g. AMO, NAO, EA, MOi, WR, IOD and ENSO; Josey et al., 2011, JGR; Redolat et al., 2019, TAC; Hernandez et al., 2020, ESR).

Prior to ca. 850 CE, the scarcity of measurements prevents us from making detailed inferences about climatic changes, though a large directional switch from dry-to-wet or vice-versa seems to take place during the early 6th century CE (Labuhn et al 2018, LAA). From ca. 850 to 1850 CE, both marine and terrestrial signals present common significant overall cooling trends, with anomalous cold temperatures registered during the Little Ice Age (LIA; between the 14th and 19th centuries

CE; McGregor et al., 2015, NATURE GEO). Ensembles of forcing simulations suggest that the LIA was regionally initiated asynchronously, arising from increased frequency of globally sustained volcanism and/or land use change (Neukom et al., 2019, NATURE).

In the Mediterranean, a climatic northwest-southeast winter seesaw matches a flip in proxies around the time of the onset of the LIA cooling, when models indicate an initial role by driving Arctic ice-rich waters into subpolar latitudes, which weakened the North Atlantic circulation, particularly persistent throughout the 16th–18th centuries (Slawinska & Robock, 2018, JC; Moreno-Chamarro et al., 2017, SCI REP). The LIA had strong impacts across different spatiotemporal scales and requires an interdisciplinary framework for uncovering climate–society interactions (Degroot et al., 2021, NATURE). Within the LIA, a reminder of an east-west patterning, more akin to the East Atlantic/West Russia mode, is linked with unprecedented cells of Mediterranean water downwelling formed in the Aegean and temperature and precipitation anomalies (Incarbona et al., 2016, SCI REP; Gogou et al., 2016, QSR). The timing of anthropogenic warming is identified around the mid-19th century for tropical latitudes and northern land masses (Abram et al., 2016, NATURE). Preliminary sensitivity tests suggest that the 20th century warming amplitude in the Mediterranean is more pronounced as more southern-eastern and/or terrestrial records are taken into consideration, whereas inclusion of northern-western and/or marine upwelling locations attenuates it.

Keywords : surface temperatures, hydroclimate, Mediterranean, climate forcing, Common Era

Poster

Coeval Drying Across the Central Tropical Pacific Over the Last Millennium

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Abstract :

Tropical Pacific climate phenomena, such as the El Niño Southern Oscillation (ENSO) and the Intertropical Convergence Zone (ITCZ), are major components of the global climate system. Due to the short and sparse observational record from the tropical Pacific, paleoclimate archives are necessary to understand the full range of climate variability in this region. Lake sediment records are particularly advantageous for assessing decadal- to centennial-scale terrestrial climate variability as they are typically continuous with high temporal resolution. To date there are only two lake sediment records from the central tropical Pacific, a key ENSO 'center of action' where precipitation is also highly sensitive to movements of the ITCZ. Here we use a lake sediment record from Kiritimati (2°N, 157°W), to quantitatively reconstruct changes in lake water chemistry and infer climate over the last millennium.

This work builds upon a previous study of lake sediment collected from Lake 30, a brackish lake on Kiritimati. Previous work used qualitative records of sediment mineralogy to assess hydroclimatic changes over the last millennium. Here we present a quantitative assessment of lake salinity using bulk hydrogen isotope values of total lipid extracts (δ2HTLE) measured at decadal resolution over the last millennium. This record was compared to new records of sediment mineralogy (S/Ca), carbonate δ18O, and carbonate δ13C to produce a more robust estimation of last millennium moisture balance changes. We also used the hydrogen isotopes of compound specific lipid biomarkers to broadly assess community metabolism shifts. These new hydroclimate records reveal a brackish lake system from 700-960 CE, a period of increased salinity from 960-1030 CE, a predominately hypersaline system from 1030-1370 CE, and a brackish lake in the modern (1970-2014 CE). Additionally, the updated age model revealed a previously unknown hiatus spanning from 1370-1970 CE. Increases in salinity are likely due to increased aridity, suggesting arid conditions beginning in 960 and likely continuing through the hiatus. Compound specific biomarker data indicates

shifts in primary organism metabolism from a photoautotrophic/chemoautotrophic environment in the past to a heterotrophic/photoautotrophic environment in the modern.

Comparison of δ2HTLE /salinity reconstructions from Kiritimati and nearby, but more northerly, Washington Island shows a similar pattern of increasing aridity followed by wetter conditions in the modern. Washington Island lake sediments are hypersaline from 1050-1650 CE with a sharp increase in salinity at 1420 CE. This increased salinity coincides with the start of the hiatus on Kiritimati, suggesting the hiatus is due to arid conditions facilitating complete evaporation of the lake. Multiple studies have suggested that increased aridity on Washington Island is due to a southerly migration of the ITCZ, which would produce additional rainfall on Kiritimati. New Kiritimati hydroclimate records revealing persistent aridity over the last millennium do not support this hypothesis. Instead, coherent changes in hydroclimate across the central Pacific leads us to conclude that past precipitation patterns are instead likely caused by changes in ENSO variability, filtered to lower-frequencies in the lake record, or lower-frequency variability in Pacific Walker Circulation strength.

Keywords : hydroclimate, environmental isotopes, paleolimnology

Closing in on a unified global ice-core chronology by merging cosmogenic radionuclides, sulfur isotopes, cryptotephra and tree-rings. Chances and limitations.

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Abstract :

To correctly quantify and attribute past climate variability on inter-annual to multi-decadal timescales, precise and accurate chronologies of the underlying proxies are a prerequisite. Ultra-long tree-ring chronologies provide annual dating precision over large parts of the Holocene and form the backbone of the radiocarbon (14C) calibration curve used to date many other climate proxy records. The dating precision of proxy records based on U/Th dating (e.g. speleothems) has become much higher in the last decades. With the WD2014 chronology from the WAIS Divide ice core (WDC) an accurate layer-counted chronology exists for Antarctica which is used to synchronize deep ice cores from Antarctica (e.g. EDML, EDC, TALDICE, SPC14, RICE, Dome Fuji). This allows us to analyze spatial climate response in Antarctica during global climate transitions. Using cosmogenic radionuclides in tree rings (14C) and in ice cores (e.g., 10Be), an age bias towards too old ages was identified during most of the Holocene for ice cores from Greenland dated in the GICC05 chronology framework. Here we use four sources of evidence to assess and improve the dating of ice-core chronologies over the Holocene: (1) Annual-to sub-decadal resolution 10Be ice-core data and annual tree-ring 14C analyses to identify extreme solar proton event (e.g. in 774, 993 CE) and changes in galactic cosmic rays modulated by solar activity; (2) sulfur isotopes to identify major stratospheric eruptions with

global sulfur distribution; (3) single-shard electron microprobe analyses on cryptotephra shards to identify volcanic source volcanoes and (4) tree-ring width and frost-ring data to identify the timing of cooling anomalies following major stratospheric eruptions. Merging these lines of evidence allows us to synchronize and constrain the dating of ice cores from both Greenland and Antarctica with dating uncertainties of less than ±1 to 10 years.

Keywords : chronology, Greenland, Antarctica, volcanic eruptions, Holocene

Investigating the sensitivity of Ugandan crater lakes to drivers of (hydro)climatic change in the Common Era using an isotope mass balance approach.

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Abstract :

Located in a region with low levels of water infrastructure and high population growth, the crater lakes of western Uganda provide important water resource and ecosystem services to local rural communities but face increasing pressure from catchment-scale human impacts (namely the removal and conversion of natural vegetation for plantations and subsistence agriculture) and climate change. Understanding and quantifying how these systems have responded to past changes in (hydro)climate is important for informing the lakes' future sustainable management.

In the absence of long-term climate, hydroclimate, and groundwater monitoring in the region, the carbonate $\delta^{18}O$ composition of lake sediments from Lakes Kasenda and Nyungu record significant fluctuations in water balance over the past couple of hundred years. Through the development of isotope mass balance models, a type of proxy-system model, we investigate the magnitude of (hydro)climate drivers responsible for the perturbations in sediment carbonate $\delta^{18}O$ composition records from the region over the past 1,000 years.

Keywords : hydroclimate, water isotopes, proxy-system model, tropical climate

Synchronous natural climate cycles within the past ~3ka observed in six temperature proxies from the poles, central Europe, east Asia and North America

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Abstract :

Four proxy temperature data sets previously analyzed (Asten et al., AGU 2020) from a European Alps glacier (Great Aletsch), an All-China compilation, an Arctic sea ice proxy IP25 from the north Iceland Shelf, and the Ludecke-Weiss G7 global proxy are herein supplemented with two further data sets from the mid-Mississippi basin, and from dated remains of penguin colonies from Cape Irizar, Ross Sea, Antarctica. The combination of these six data sets provides three from mid-latitudes (Europe, China, N America), plus the LW global dataset, together with both a high resolution IP25 set (resolves 60 year periods from 1500CE) and a low-resolution record resolving ~200 year periods from 4000 BCE. The first four proxies (limited to the N Hemisphere) show strong synchronicity with correlation coefficients > 0.7 for the past 500 years, and coefficients in ranges of 0.5 to 0.7 for the past 1200 years. The fifth proxy from the Mississippi Basin shows a strong temperature peak ~1.5x amplitude of the corresponding elevated temperatures in the all-China set associated with the Medieval Warm period (MWP). However, the Mississippi peak

appears delayed by ~150 years relative to that for the first four proxies. The sixth proxy using the Cape Irizar penguin remains shows clear colony abandonments at the commencement of the cold pessimum 700-500 BCE, at the cold Early Medieval Pessimum (EMP) 450-750CE, and at commencement of the LIA ~1300CE. Re-establishment of the colony associated with warming is evident at the end of the EMP and beginning of the MWP ~900CE. These events are clearly global, seen in all six proxies during the Common Era (with an apparent time shift for the Mississippi). These events are also evident on the Alps glacier and the low-resolution Arctic sea ice IP25 proxies for 3ka-2ka. The similarities between proxies 1-4 is supported by spectral analysis showing dominant peaks at periods 180, 500 and ~1000 years. In addition the Alps and China proxies show a common spectral peak at a 240 year period. The Mississippi Basin proxy does not support spectral analysis but its broad temperature maximum during the MWP is consistent with the 1000 year cycle (Roman warming, MWP, Recent) seen in Alps, China, and the global G7 proxies. The high level of synchronicity between these six proxies together with the widely divergent global spread of the source regions, strengthens the case for existence of global cycles of climate change with periods in the centennial to millennial range.

Keywords : global temperature proxies, natural cycles of climate change, Mississippi basin, IP25 proxy, Ross sea penguin colony

What can be learned from marine archives about the current warming in the Mediterranean Sea?

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Abstract :

The Ocean2k SST synthesis of McGregor et al. (2015) demonstrated a global long-term cooling over the Common Era (between 800-1800 CE) attributable to volcanism. This compilation includes only four SST records from the Mediterranean Sea due to the scarcity of high-resolution records at that time. Here, I present a synthesis of 23 high-resolution SST records (mainly based on alkenone paleothermometry) covering part or the entire Common Era. The records, distributed across seven sub-basins of the Mediterranean (i.e. Alboran, Balearic Sea, Gulf of Lion, South Adriatic Sea, Siculo-Tunisian Strait, Aegean Sea and Levantine Basin), are used to generate a SST composite for each sub-basin and for the entire Mediterranean as follows: each time-series is averaged into 200 yr bins before 1900 CE and into 25 yr bins after. Then each averaged record is standardized and a single sub-basin composite is produced by averaging all records of each sub-basin. The Mediterranean composite is calculated by averaging all sub-basin composites. The Common Era is subdivided into five historical periods, i.e. Roman Warm Period (RWP), Dark Ages Cold Period (DACP), Medieval Climate Anomaly (MCA), Little Ice Age (LIA) and Industrial Era (IE).

The synthesis highlights that only four sub-basins (Alboran, Balearic Sea, Siculo-Tunisian Strait and Levantine Basin) show cooling between 800-1800 CE while others (Gulf of Lion, South Adriatic and Aegean seas) indicate warming trend. The composite of the entire Mediterranean shows a small cooling trend of less than 0.5 s.d. units. This synthesis also shows a strong heterogeneity between sub-basins. The most outstanding feature is the East-West SST dipole during the MCA, similar to the spatial pattern of positive North Atlantic Oscillation and East-Atlantic/West Russia modes of climate variability. Almost all sub-basins indicate cold conditions during the LIA (mostly pronounced after 1500 CE) that are spatially coherent with prevailing negative East Atlantic pattern. Over the Industrial Era, four of the seven composites (Alboran, Gulf of Lion, Aegean Sea and Levantine Basin) are in good agreement with instrumental data and show mean SST values that exceed the MCA and RWP means. The highest warming trends (1.5-2 °C) are recorded in three Mediterranean convection regions (Gulf of Lion, Aegean Sea and Levantine Basin), probably reflecting a reduction of dense water formation. The later finding is expected to have consequences on primary production. Reduction of vertical mixing in winter will decrease the renewal of nutrients of the surface water sustaining spring algal production.

Keywords : Mediterranean, SSTs, Common Era, modes of climate variability, convection, primary production

The "Modern Era Reanalysis" data assimilation system.

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Abstract :

We present in detail the data assimilation framework used to generate the Modern Era Reanalysis (ModE-RA). We implemented an ensemble-based Kalman filter approach to assimilate different types of observations (instrumental measurements, documentary data and proxy records) into an ensemble of atmospheric model simulations (ModE-Sim) covering the period from 1421 to 2009.

Before incorporating the observations with monthly, subannual and annual temporal resolution into the existing model simulations several preprocessing steps were performed such as transforming observation to anomalies, quality check, calculation of the forward operators all documented in an input file.

Innovations in the assimilation were applied such as localization in space and time and adding a climatological part to the transient simulations to estimate the background-error covariance matrix. The observations are assimilated over three cycles based on their length. This way short instrumental records, will be assimilated into an already update state after an additional debiasing step.

We show some results of a set of sensitivity experiments.

Keywords : climate reconstruction, data assimilation

OSM30: Hydrology of arid regions

Co-conveners: Hind Cherkaoui Dekkaki, Abderrahim El Achheb, Bouabid El Mansouri, Fouad Amraoui, Lahoucine Hanich, Mohamed Hilali, Younes Fakir, Nour-Eddine Laftouhi, Abdenbi El Mandour, Jamal Eddine Stitou El Messari, Tarik Ghodbani, Younes Hamed, Ahmed Gaber, Souad Haida, Lahcen Benaabidate, Youssef Brouziyne, Abdelkader El Garouani and Hassan Tabyaoui

Oral

Dynamic interplay between local land use/land cover change and regional climate change: Implications on hydrology.

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Abstract :

The fact that Ethiopia's relatively abundant water resources have played minimal role in the development of the nation's economy altered the government to place priority on water resources development. However, the relevance of water to promote sustainable agriculture, urban and rural developments highly rely on the sustainability of water resources. Recognizing the dynamic interplay between land use/land cover (LULC) and climate to manage water resource requires understanding how LULC drives climate change and how climate affects LULC. Hence, this study was aimed at evaluating the dynamic interplay between LULC and climate change in Finchaa catchment, Upper Blue Nile basin. The separate and combined effects of LULC and climate change on regional hydrology was examined with Soil and Water Assessment tool. The increase in farm land and deforestation in the catchment was manifested by the rapid increase in population. The increase in population resulted in increased deforestation through expansion of cultivated land and increase in fuel wood and wood products accelerating climate change effects. In areas like Finchaa, where household energy needs are entirely dependent on forest resources, deforestation is likely to continue causing serious climate change problems. Evaluation of climate change revealed increase in temperature and decrease in precipitation. The combined impacts of LULC and climate change shows, climate change is dominant over the impacts of LULC on a regional hydrology. The decrease in precipitation and increase in temperature under the LULC revealed a decrease in runoff, aquifer recharge and water yield. However, the decrease in surface runoff and water yield by climate change was reduced by the effects of LULC in the catchment. Overall, understanding the interactions between LULC and climate with their combined effect is a prerequisite to plan and manage the environment, water resource and ecosystem appropriately in the face of future changes.

Keywords : LULC, Climate change, regional hydrology, SWAT

Assessing groundwater salinization under global changes, using hydrochemistry and multivariate statistics techniques : Case from Moroccan coastal aquifers

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Abstract :

Morocco is one of the semi-arid countries that suffer from groundwater quality degradation mainly in coastal zones, due to several factors: high population density, steady socio-economic development, groundwater over-exploitation, and climate change. In this work, a hydro-chemical database of thirteen aquifers have been gathered and processed by statistical and graphical methods. Our aims were to provide an overview of the current state of water quality in Moroccan coastal aquifers and to identify the dominant hydro-chemical processes. Results showed that the mineralization of groundwater in the coastal aquifers is due to different sources and processes. However, marine intrusion and water-rock interaction were the most dominant origins. Multivariate statistical analyses indicated that the aquifers have different degrees of mineralization. The aquifers of Foum El Oued, Bouareg are the most mineralized, those of Dakhla, Agadir, Essaouira, Sidi Abed-Ouled Ghanem, Bokkoya, Ghis-Nekor are considered as moderately mineralized, and the aquifers of Martil-Alila, Mnarsa, Chaouia, Oualidia, and Chtouka-Massa are with low mineralization incidence. In order to control the consequence of groundwater pollution and to ensure water availability for future generations in these critical environments, several management plans are proposed. These results will be helpful for decision-makers to preserve water resources in coastal areas under global changes.

Keywords : Coastal aquifer, Groundwater, Marine intrusion, global changes, Morocco.

Effects of Irregular water extraction on Hydrology of arid regions in Miqan sub-basin, Iran

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Abstract :

Miqan wetland is a natural hole between the Zagros Mountains and Central Iran. This lagoon is located in the heart of Markazi province of Iran. The basin has an area of about 5514 square kilometers with an average annual precipitation of about 290 mm. The width of the Miqan Desert in Arak has increased by several times over the past decades, leaving the surrounding agricultural lands in a state of disrepair and becoming a natural problem in the central province. Miqan Plume is the main source and location of important groundwater storage in Arak plain due to its permeability. In this study, monthly data of synoptic station of Iran and corresponding hydrometric data for the period 1940-2005 are based on the calculations of the present study. In the research method, with the selection of ten aqueducts in the area of Miqan basin and with homogeneous geographical distribution, the quantitative changes of aqueduct water during the periods of dehydration and flooding were investigated. Time series variations of the mean discharge and discharge data from the aqueduct were collected and adjusted. Then, using statistical-graphical methods, the trends of monthly seasonal and annual changes in groundwater level were compared. Geographic information system software is used to evaluate the spatial and temporal changes in groundwater level. The results of this study indicate that the groundwater level in Arak aquifers has declined to -28.50 million cubic meters in recent years. The obtained results were sufficient to judge the relationship between rainfall variations and depletion of surface and groundwater resources in the Arak Mighan basin. The results show different fluctuations in different seasons of the year. Evaporation and precipitation fluctuations have caused a significant change in aquifer alignment. In the wet seasons, as the runoff flows, toward the center of the desert, the groundwater level rises rapidly and the lake and surrounding area become swampy. In dry seasons with high evapotranspiration and utilization of groundwater by agricultural wells, saline water moves from the center of the desert around the desert to compensate for the impact that has caused the salinization of agricultural lands. Inlet waters, which are due to the salinity of the deserts around the salt saturation, evaporate rapidly and leave their salt in the lake as the temperature rises in the dry season. The results of this study showed that sub-basin of

Miqan Arak is exposed to desertification due to climatic anomalies and consequences of depletion of groundwater resources. It is understood that if runoff is delayed in the wet season and untreated groundwater harvesting is not inhibited, the groundwater level will be more volatile and consequently the salinity of the soil will increase with surface salinity.

Keywords : Arid regions, Aquifers, Groundwater, Hydrometric data, Miqan.

THE DYNAMICS OF RUNOFF OF AGHSTEV RIVER IN THE CONDITIONS OF CLIMATE CHANGE IN THE TERRITORY OF THE REPUBLIC OF ARMENIA

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Abstract :

Aghstev is a right side tributary of Kura. The length of river is 133 km, the surface of catchment basin is 2589 km2 (in the Republic of Armenia 81 km and 1730 km2 accordingly). Taking a count the role and significance of Aghstev, it have to study, estimate and forecast the annual runoff in the conditions of global climate change. In this work have been solved the following tasks: to study and analyze main physics- geographical factors, which determine the annual runoff, collect, work out and estimate meteorological and hydrological elements of river basin, to forecast the annual runoff in the conditions of global climate change.

For estimation of regularities of space-temporal changes of river runoff and study, analyze, forecast it have been used mathematic-statistic, analyze and synthesis, analogy, geography, interpolation and other methods. For estimation or forecast the influence of climate change is necessary to know about quantitative climatic changes, which will be in future. But for forecast of future climate there are not reliable methods yet. Instead of them are being chosen some climatic scenarios of future climate. The changes of annual runoff of Aghstev have been estimated for three scenarios of climate change: 1) , 2) , 3) .

So, possible vulnerability of runoff in basin is more close to 2-nd scenario. In case of keeping of nowdays tendency of change of air temperature and atmospheric precipitition is possible increasing of annual runoff of river even up to 15-25 %, in period of 2030-2070, unlike of other areas of republic. In means, the climate change not only negative, but also possitive influence can be have on river runoff.

Keywords : Dynamics, runoff, climate change, Aghstev

Hydrogeochemical characteristics and water quality assessment of groundwater in the arid Zenaga plain (Central Anti-Atlas, Morocco)

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Abstract :

Groundwater is the primary source to meet drinking and agricultural need for the most local population in the arid Zenga plain. In order to identify the main process controlling the groundwater chemistry, 23 groundwater samples including wells and boreholes collected from different locations across the plain were caried out. Besides, Sodium absorption ratio (SAR) and water quality index (WQI) were integrated also to assess water quality. The results show that mineralisation vary with depth and the ions concentrations follows the order Ca^{2+}>Na^{+} >Mg^{2+} >K^{+}, and HCO_3^{-}> Cl^{-}>SO_4^{2-}> NO_3^{-} for cations and anions, respectively. The chemical relationships of these ions in Piper diagram identify Ca-Mg-HCO_3 as the most prevalent water type. The groundwater chemistry is dominated by silicate weathering, cation exchange and carbonate dissolution. Water quality assessment indicate that the majority of water samples are good to permissible for irrigation and poor to good for

drinking purposes. In some areas, nitrate contents imply anthropogenic contamination derived especially from traditional septic tanks. The results of this studies can be used by the decision-makers and stakeholders to better conduct sustainable water resources management in this arid-area.

Keywords : Hydrogeochemistry, Zenaga plain, arid environment, water quality assessment

The effect of climate change on soil sensitivity erosion in a semi-arid environment

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Abstract :

Soil erosion is a complicated issue that is accelerating as a result of climate change. This has a detrimental influence on natural resources, human well-being, and national economy. According to the Global Climate Index, semi-arid territories are the most affected by climate change and have the worst soil resource degradation.

The goal of this research is to analyse and forecast soil erosion risk by incorporating a range of multi-criteria and artificial intelligence methodologies. In this regard, 11 factors were investigated, with 200 inventory points, 80% of which are used for model learning and 20% for result validation. The statistical approaches AHP (hierarchical process analysis) and RF (random forest) are used to calculate the weights assigned to the factors involved in the phenomena. The susceptibility of soil erosion has been anticipated to last until 2040. Thus, two sets of models have been developed named MCDM-WoE-AHP and WoE-RF.

The findings of the two models demonstrated a migration of soil erosion vulnerability towards highlands, with a positive correlation with the spatiotemporal evolution of precipitation from 1989 to 2040. The analysis of the evolution of soil temperature and vegetation cover also indicates agreement with the obtained results. The ROC-AUC approach was used to validate these results, with AUC=0.872 and 0.747 for the MCDM-WoE-AHP and WoE-RF models, respectively.

Keywords : Climate change, Water erosion, Statistical methods, Machine Learning, Vulnerability

Groundwater potential mapping in a fractured arid zone using Frequency Ratio and Shannon’s Entropy models (Case of the Ameln Basin, Kerdous Inlier, Western Anti-Atlas, Morocco)

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Abstract :

The study focused on groundwater potential mapping in a fractured aquifer basin (Ameln basin in the western Anti-Atlas Mountains of Morocco), using Frequency Ratio (FR) and Shannon's entropy (SE) models. The main goal is to predict the suitable boreholes zones for water exploitation, in order to meet the increasing demand on this resource, especially, in rural zones. Fifteen factors influencing

groundwater were considered in this study; including degree of slope, slope aspect, elevation, topographic moisture index (TWI), slope length (LS), topographic position index (TPI), plane curvature, profile curvature, drainage density, lineament density, distance to rivers and fault network, Normalized difference vegetation index (NDVI), Land surface temperature (LST) and lithology. In addition, the water flow of 49 boreholes over the study area were used to evaluate the predictive capacity of each model. The results show that the percentage of the positive water points are concordant to the most productive areas (high water flow) (42.86% and 30.61% for FR model and SE model, respectively). In contrary, the low water flows are concordant to the unfavorable predicted areas (4.08% for FR model and 6.12% for SE model). The results highlight the performance of both used models in mapping groundwater potential areas in fractured semi-arid zone, preferring the FR model. In addition, the obtained groundwater potential maps can help planners and engineers in future groundwater development plans and land use planning.

Keywords : Kerdous Inlier, Tafraout region, Ameln basin, Frequency ratio, Shannon's entropy, GIS

Characterization of the meteorological drought in the Ziz watershed

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Abstract :

This study was conducted to assess the drought in the Ziz watershed located in the South East of Morocco. Four meteorological indices; RAI (Rainfall Anomaly Index), PNI (Percent of Normal Index), SPI (Standardized Precipitation Index), ZSI (Z-Score Index) were applied. These indices are based on rainfall data series from four stations over a time scale of 37 years (starting from 1983), taking into account the ability of each index to detect drought as well as the relation that links these indices. The results indicate that the Ziz watershed has experienced several drought periods with their different classifications, it is also noted that the years 1986 and 2001 were dry to extremely dry in all stations of the watershed. The results highlight a strong correlation between the four indices (r ≥ 0.967). However, the ZSI and PNI reveal the most remarkable relation with a correlation coefficient r =1. In terms of drought detection, RAI and PNI have shown the best performance.

Keywords : Meteorological drought, degree of dryness, watershed Ziz, Morocco

Estimation of rainfall inputs feeding the Liassic aquifer of the Fez-Taza corridor, Morocco.

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Abstract :

The main aquifer of the Fez-Taza corridor circulates in the limestone and dolomites formations of the Lower and Middle Lias that outcrop in the southern and southeastern part of the study area. It receives a significant amount of water from rainfall flows from the Middle Atlas Mountains to the Fez-Taza corridor. The presence of a large hydrographic network in the upstream part of the Fez-Taza corridor promotes groundwater recharge by effective infiltration of rainfall inputs in areas with high rock permeability. There are two lateral recharge systems, the first superficial via outcrops of Lias limestone and dolomites and the second via faults affecting the Lias geological formations.

In addition, the main rivers in the study area are the Sebou river, the Inaouene river and the Bouhlou river. These rivers follow substantially South-North, SE-NW, ENE-WSW, ESE-WNW directions and represent tributaries of the main river of Sebou which drains a large watershed

towards its outlet located at the level of Kenitra city.

In this work, we will use the rainfall, hydrological, hydrogeological and geological data available in the study area to carry out an evaluation study of the recharge of the liasic aquifer of the Fez-Taza corridor. For this, the confrontation of all the available data will bring out a water balance making it possible to determine the water reserve that infiltrates in the aquifer of the Middle and Lower Lias of the Fez-Taza Corridor.

Keywords : Effective infiltration, Fez-Taza corridor, Liassic aquifer, water balance, water reserve.

Evaluation of the GPM-IMERG rainfall estimates at multiple spatial scales: The case study of the Tensift watershed, Morocco.

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Abstract :

Precipitation is an important input for hydrological modeling and water resources management, especially in arid areas where data are scarce. The objective of this study is to evaluate the accuracy of Integrated Multi-Satellite Retrievals for Global Precipitation Measurement (GPM-IMERG) rainfall data, on five rainfall stations in the Tensift watershed, namely Sidi Rahal, Marrakech, Abadla, Chichaoua and Talmest. The period considered for the evaluation is from 2001 to 2017. This evaluation is performed on the basis of seven statistical indices: Relative Bias (RBIAS), Root Mean Square Error (RMSE), Mean Error (ME), Mean Absolute Error (MAE), Correlation Coefficient (CC), Probability of Detection (POD) and False Alarm Rate (FAR). The results reveal that: (1) the GPM Final product showed a slight overestimation of the mean bias of 28.26%; and the GPM Early showed an overestimation of 57.97% for the entire basin. At the spatial scale of the grid (0.1°×0.1°), these mean biases become 21.49% and 27.51%, respectively, compared to the ground measurements; and (2) a slight improvement in the correlation coefficients has been observed between the gauged data and the GPM satellite products by changing the spatial reference (from 0.55 for the basin to 0.59 for the grid, using GPM Final, and from 0.45 for the basin to 0.50 for the grid, using GPM Early). Moreover, these correlation coefficients become more satisfactory at monthly and annual time steps. The POD and FAR results of the GPM Early and Final data showed very good performance at the grid scale, while these results become less satisfactory at the basin scale. Finally, overall, the accuracy of precipitation detection by GPM Final products is higher, allowing better use of these corrected products for water resource estimation.

Keywords : GPM, IMERG, Precipitation, Evaluation, Morocco.

Apport de la fracturation, de l'isoopie et l'hydrochimie à l'étude du massif calcaire de Haouz (Nord du Maroc).

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Abstract :

Le massif karstique du Haouz fait partie de la chaîne de montagnes du Rif, située dans les provinces de Tétouan, Fahs Anjra et Sebta (nord du Maroc). Les roches carbonatées affleurent en plusieurs reliefs abrupts avec de hauts sommets forment des aquifères individualisés.

Ce massif est orienté selon un axe majeur N-S, mesurant environ 30 km de long et 4 km de large. De nombreux cours d'eau, tels que le Martil, le Smir et le Negro, coulent de ce massif. La majeure partie de ces aquifères sont encore en régime naturel ; aucun pompage n'est effectué. Cependant, les prélèvements les plus importants sont ceux effectués dans la partie nord pour l'alimentation de la ville de Sebta et dans la partie sud où les rejets alimentent un réseau de distribution d'eau potable de l'ancienne médina de Tétouan appelé " skundo ". Il est à noter que certaines sources sont utilisées pour alimenter les villages ruraux. Dans Le cadre de ce travail, une contribution à la connaissance du fonctionnement de ces

aquifères karstiques est effectuée sur la base d'une étude de fracturation, d'hydrogéochimie et d'isotopie.

Les sources qu'émergent sont en relation avec le système de faille qu'affectent les formations calcaires et qui les mettent en contact direct avec les formations imperméables (à l'est et à ouest). Des caractéristiques hydrogéologiques, hydrochimiques et des altitudes moyennes de recharge ont été déterminées. En plus, le comportement des sources et la diversité hydrochimique observée sont liés à la lithologie des aquifères (roches calcaires, dolomitiques et évaporitiques) et au fonctionnement hydrodynamiques des sources.

Mots clef : Aquifère karstique, facturation, isotopie et hydrochimie

Keywords : Aquifère karstique, facturation, isotopie et hydrochimie

Comparison of three hydrological platforms to assess rainfall-runoff in the Mediterranean watershed in Morocco (North Africa)

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Abstract :

The Mediterranean sub-humid regions are generally affected by flooding phenomena, especially in the North of Morocco, which is the subject of this study; in this context better management of the state of water resources is proving important, through the development of hydrological modelling more precisely in the Oued Laou watershed (OLW) (940 km^2). A multitude of hydrological models are available to perform very efficient modelling, in this perspective, a comparative approach has been adopted through the implementation of three models with different characteristics using a continuous modelling approach. Daily rainfall data for 4 years (2004–2008) were used for calibration and 3 years (2009–2011) to validate the three models. The multi-criteria model comparison shows that all three models are capable to reproduce the observed flows. The SWAT model performs well over both periods, with an improvement in validation. A good agreement can be observed in the HEC-HMS model outputs, with a stable R^2 = 0.82 during the two simulation periods. The ATHYS model shows an R^2 = 0.68 during the calibration and show a decrease of 0.02 towards the validation period, the other performance criteria confirm these findings. Results indicate that land use and soil parameters have a real influence on the hydrological simulations. The CN2 parameter is approximately equal in the SWAT, HEC-HMS and ATHYS models respectively. These results suggest that distributed models are particularly suitable for the complex watershed due to its physical heterogeneity. Generally, the integration of these models may be suitable for water resources assessment.

Keywords : ATHYS, SWAT, HEC-HMS, Oued Laou watershed, Morocco.

Poster

Analysis of rainfall variability and its relationship with climate change: case study of the Merguellil Watershed, Central Tunisia.

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Abstract :

This study aims at examining a 36 years long rainfall record from Merguellil watershed (Central Tunisia) and identifying its relationship with climate change at regional scale. The adopted methodology is based on the use of Continuous Wavelet Transform (CWT) spectral analysis, permitting the characterization of rainfall regime and the identification of the main variability modes. Moreover, Wavelet Coherence (WC) analysis

was also applied to determine potential relationships between rainfall variability and indexes of the main modes of climate variability affecting the Mediterranean region, i.e. the North Atlantic Oscillation (NAO), the Mediterranean Oscillations (MO), The El Niño Southern Oscillation (ENSO), the East Atlantic pattern (EA),the East Atlantic – Western Russia pattern (EA-WR) and West Mediterranean Oscillation (WeMO). Application of CWT for mean monthly precipitation over the 36 years, for 13 rainfall stations spread over the study basin, allowed distinction between three different families of wavelet spectra. Each family shows common variability modes. The detailed analysis of CWT specific to each family reveals that energy of variance and the wavelength of variability of precipitation increase from upstream to downstream of the study catchment. Examination of the coherence spectra showed a strong relationship between the annual variability of precipitation and the WeMO, the EA and the EA-WR indexes with coefficients of 75%, 75% and 78%, respectively.

Keywords : Continuous Wavelet Transform, Wavelet Coherence, Climatic changes indices, Merguellil Watershed, semi-arid Central Tunisia
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Runoff assessment using SCS-CN Method and GIS in Arid areas: case study from the Toudgha Watershed-Morocco

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Abstract :

Runoff estimation is appointed as a crucial hydrologic analysis, further it is of paramount importance in the water development planning. Nevertheless, the data availability represents a serious challenge to decision makers, particularly in financially stressed areas. This research is simultaneously aimed to map the curve number of the Toudgha watershed (Southeastern Morocco) and to estimate the spatial distribution of its runoff quantities, applying the Soil Conservation Service Curve Number method, and using geographic information system and remotely sensed data. The results reveal that, the study area include four Hydrologic Soil Groups; A, B, C and D covers 55.78%, 6.5%, 32.74% and 1.97% of the total surface area, respectively. In addition, the Land Use and Land Cover classification distinguishes seven categories among which the wasteland covers 94%. Therefore, the Curve Number in normal condition of the Toudgha watershed is ranged between 53 and 100. Furthermore, the runoff was estimated and evaluated for normal, dry and humid conditions using linear regression analysis with rainfall and runoff measured during 59 years. The finding results present the performance of runoff estimated for dry conditions that showed a correlation coefficient of 0,97 and Nash-Sutcliffe efficiency of 0,91.

Keywords : Runoff estimation; Curve Number; GIS; Toudgha watershed.

A Phytolith Supported Biosphere-Hydrosphere Predictive Model for Southern Ethiopia: Insights into Paleoenvironmental Changes and Human Landscape Preferences since the Last Glacial Maximum.

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Abstract :

Southern Ethiopia has undergone tremendous climatic changes, from dry and relatively cold during the Last Glacial Maximum (LGM, 25–18 ka) to the African Humid Period (AHP, 15–5 ka), and back to present-day dry conditions. As a contribution to better understand the effects of climate change on vegetation and lakes, we here present a Predictive Vegetation Model that is linked with a Lake Balance Model and available vegetation-proxy records from southern Ethiopia including a new phytolith record from the Chew Bahir basin. We constructed a detailed paleo-landcover map of southern Ethiopia during the LGM, AHP (with and without influence of the Congo Air Boundary) and the modern-day potential natural landcover. Compared to today, we observe a 15–20% reduction in moisture availability during the LGM with widespread open landscapes and only few remaining forest refugia. We identify 25–40% increased moisture availability during the AHP with prevailing forests in the mid-altitudes. In comparison with existing archaeological records, we find that human occupations tend to correspond with open landscapes during the late Pleistocene and Holocene in southern Ethiopia. Furthermore, we see indications that modern anthropogenic landcover change has affected the water balance.

Keywords : Chew Bahir, Ethiopia, Predictive Modelling, Boosted Regression Trees, Biosphere-Hydrosphere-Interaction

The impact of climate change on the groundwater resources of the Sais deep aquifer (middle atlas, Morocco).

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Abstract :

The Liassic deep aquifer of the Saïs plain (2,100 km2 – The Middle Atlas of Morocco) is one of the largest freshwater reservoirs in Morocco. For many decades, this aquifer has been overexploited to satisfy the ever-increasing water needs of the local population, particularly for agriculture (irrigation of more than 40,000 ha), the drinking water supply of the two large cities of Meknes-Fez (4 million inhabitants), and the centers of the region...

Currently, this resource is seriously threatened by the combined effect of overexploitation and the recurrence of dry years. This is reflected in the field by a sharp drop in the level of the water table, a reduction in the pressure of artesian aquifer, and a drop in the flow rates of emergences.

To this end, based on the use of Geographic Information System (GIS) tools and remote sensing, this work aims to improve knowledge concerning the water resources state of the Sais deep aquifer system in a context of climate change tending towards aridity in the region. This approach has made it possible to draw up a certain number of structural and hydrodynamic maps, which provide an insight into the aquifer geometry, and the flow patterns of the water table.

The application of this approach is essential to move towards modeling the Saïs deep aquifer, to have a water resource management tool capable of simulating different trend or vision scenarios, based on the supply of surface water for irrigation or on artificial recharge

Keywords : Sais Plain, GIS, climate change, hydrodynamic modelling, deep groundwater

Diagnosis of the physico-chemical and bacteriological quality of the preurban streams of Casablanca: case of the Merzeg wadi

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Abstract :

The Merzeg wadi is a temporary coastal stream of about 29 km, located in the Casablanca-Settat Region. The high urbanisation and the multiplication of industrial activities around the Merzeg wadi have strongly contributed to the deterioration of its quality. It currently receives wastewater from the Berrechid and Had Soualem treatment plants as well as effluent

from the Had Soualem industrial area. This pollution causes nuisances that affect the quality of life of citizens and compromise the ecosystem functions of this waterway.

This work aims to map pollution sources and characterize it at the Merzeg wadi in order to establish the causal link between the identified pollutants and the different sources of pollution. Annual analytical campaigns that include the following parameters: T°, pH, Conductivity, BOD5, COD, MES, DO, NTK, TP, TC, FC, FS; were conducted between 2014 and 2020 to determine physico-chemical and bacteriological water quality in different stations along this hydrosystem. It emerges that the quality of the water of the Merzeg wadi pleads for the nonconformity of the water to be used directly in different usage because they greatly exceed the thresholds relating to surface water quality.

Keywords : Merzeg wadi, pollution, quality.

Characterization of interactions between groundwater and surface water in High Moulouya (MOROCCO)

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Abstract :

Absract : Interactions between groundwater and surface water are complicated. they are based on the hydrogeochemical, hydrogeological, hydrological, geological, geophysical and climatological study, To fully understand and quantify the processes of interaction and exchange between groundwater and surface water. There are several methods needed for parameter estimation and process identification in aquifers and surface waters (precipitation, lake and rivers). The majority of groundwater aquifers in the High Moulouya are fed by precipitation that infiltrates the recharge areas located at the top of the aquifers, which is the High Atlas and Middle Atlas.

Keywords : Groundwater, interactions, surface water, High Moulouya

OSM33: Quantifying and predicting terrestrial ecosystem responses to changing climates and land use

Co-conveners: Ann Raiho, Andria Dawson and Jack Williams

Oral

Human land use drove rapid changes in global rainforests during the last 12,000 years

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Abstract :

The global rainforests, a major terrestrial carbon sink and biodiversity host, are rapidly shrinking due to deleterious human impact. The knowledge of long-term rainforest response to disturbance, especially human influence, is key to developing effect framework for long-term management and conservation goals. We conduct a rate-of-change (RoC) analysis using 224 fossil pollen records covering different rainforest zones globally, to reconstruct the pace of vegetation compositional change in global rainforests during the last 12,000 years. RoC results were compared with past changes in climate and record of human land-use intensification. Intensive agricultural practices were found to be the major driver of accelerated rainforest changes within the last 12,000 years and tropical rainforests were the most impacted. Effective management of human influence in global rainforests is recommended to promote rainforest health and biodiversity into the uncertain future, especially in South American and central African tropical rainforests.

Keywords : Rainforests, ecosystem management, human land use, global biodiversity, rainforest turnover

Holocene fire, vegetation change, and ecological novelty in the high Colombian Cordillera Oriental

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Abstract :

Abrupt climate changes and the increasing presence of humans define the Holocene Epoch (11.6 ka BP to present), thus encompassing the most recent and abrupt environmental changes that any biological system has had to face. Understanding how biodiversity copes with extrinsic factors requires determining the effects of varying climatic conditions, disturbance regime shifts and increasing anthropogenic impacts. Despite being one centre for biodiversity, how tropical ecosystems respond to those environmental stressors remains an open question. Here we present pollen and charcoal time-series data from the eastern flank of the Colombian Cordillera Oriental (CCO) at 3000 masl to document relationships between climate, vegetation and fire through the Holocene.

We found compositional transitions at 8.7, 6.1 and 4.2 ka BP resulting from the interplay of climate, fire and human occupation. Páramo vegetation was gradually replaced by Subpáramo's from 8.7 ka BP due to a rising temperature. Mid-Holocene drier and warmer conditions favoured fire activity, which coincided with abrupt changes in vegetation at ca. 6.8 ka BP. Fire occurrence increased sharply throughout the last four millennia, with synchronous changes in vegetation at 3.8 ka BP and the establishment of novel communities composed of a mosaic of Subpáramo, Páramo and High Andean Forest vegetation. This shift in fire activity was likely associated with more severe ENSO events and subsequently intensified by human activities after 3.8 ka BP. Although high climatic responsiveness explains most changes in the eastern flank of the CCO vegetation through the Holocene, our study gives insights into the relevance of fire events,

uneven climatic variables distribution and human intervention to the composition of the vegetation we see today.

Keywords : Andes, Holocene, Paleoecology, Ecological novelty, Fire, Charcoal, Pollen

Simulating past and future vegetation dynamics and fire activity in Sardinia, Italy.

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Abstract :

Climate projections indicate that the Mediterranean Basin will be particularly affected by ongoing and future climate change. Rising temperatures and drier conditions are expected to lead to a drastic increase in fire frequency and severity. This is further exacerbated by human impact since millennia that has completely transformed the natural landscape from closed forests or woodlands to more fire-prone shrubland or even highly flammable pine or eucalypt plantations in the recent past. Paleoecological records in combination with process-based vegetation models can help to identify natural vegetation types and assess their suitability to mitigate climate change impacts on ecosystem services in the future. However, this approach has not been applied to Mediterranean islands that show distinct Holocene vegetation trajectories, most likely due to biogeographic legacy effects. In Sardinia and Corsica, for example, the Early Holocene vegetation is dominated by Erica arborea and Erica scoparia, fire-adapted trees or tall shrubs that play only a minor role on the mainland or other islands. It is unclear if such natural, but highly flammable vegetation types could reemerge in a hotter and drier future.

Here, we use a landscape-scale, dynamic vegetation model (LandClim) to simulate Holocene vegetation dynamics at three sites in Sardinia under different climate and disturbance scenarios. We compare model output with paleoecological data to disentangle climatic and anthropogenic drivers of vegetation dynamics. We are particularly interested if the dominance of Ericaceae in the Early Holocene can be explained by climatic factors alone or could be attributed to biogeographic legacy effects. We also check if LandClim is sensitive enough to accurately simulate regional differences in vegetation at the three sites that span a gradient across the island. Finally, we apply LandClim to simulate future vegetation dynamics and fire activity under different climate projections and disturbance scenarios. Our results will help ecosystem managers and policy makers to decide on management strategies and maintain important ecosystem services for future generations.

Keywords : paleoecology, dynamic vegetation model, Holocene, model-data comparison, climate change

Brazilian biomes distribution: Past and future.

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Abstract :

The Last Glacial Maximum (LGM, 26.5–19 ka) was marked by atmospheric cooling, in contrast to the current warming climate, which will probably continue in the coming decades, according to climate models projections. The LGM to pre-industrial transition provides an opportunity to test the vegetation response to a very large temperature change that can then be applied to project pre-industrial to end-of-century changes. In order to explore the changes in Brazilian biomes due to temperature change, we projected potential vegetation for both past and future scenarios. We compared biome projections with a compilation of 149 published LGM reconstructions of climate and vegetation within Brazil and adjacent areas. In addition, we evaluated the particular effects that changes in precipitation, temperature and CO2 had on vegetation by performing sensitivity experiments. Our results suggest that biomes in the western and central portions of the Amazon forest remained largely unchanged during the LGM mainly due to negative temperature anomalies, while a decrease in past precipitation was responsible for the shift from tropical evergreen forest to tropical seasonal forest in the eastern portion of the Amazon. These results are consistent with proxy reconstructions. LGM model projections and proxy reconstructions suggest expansion of grassland in the southern Brazilian highlands. Under future warming scenarios, biome changes are mostly forced by decreasing precipitation and increasing temperatures, which counteract potential biomass gain from the positive CO2 fertilization effect. Under future warming, our simulations show an expansion of Savanna/Cerrado and a reduction of tropical seasonal forest and Caatinga, with potential large impacts over biodiversity and regional climate.

Keywords : Last Glacial Maximum; Simulations; Biomes; Future scenario; Palaeorecords

Pollen-based reconstruction reveals the long-term impacts of the onset of agriculture on plant functional trait composition

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Abstract :

In the past two decades, plant functional traits have become an important tool in ecology and biogeography for the study of consequences of changing plant composition on ecosystem functioning and the effect of environment factors on plant composition. Recently, considerable interest in the trait-based approach has arisen in palaeoecology as well. Applying the trait-based approach could offer a new way of interpreting pollen data, but the intricacies of using this method in palaeoecology are underexplored. Here we test the validity of the use of pollen records for plant functional composition reconstruction using modern pollen samples. Using a Bayesian approach for reconstructing plant trait composition from pollen records, we provide a robust method that can account for trait variability within pollen types. We apply this method to assess changes in plant functional composition over 10 000 years for 79 European sites with an agricultural history. We evaluate how agriculture and climate affect plant functional composition. We reveal selection of common traits across agricultural landscapes, with resource-acquisitive communities of low stature and seed mass dominating after the arrival of agriculture. Understanding these selection processes and trade-offs between traits will advance our understanding of the legacy of human impact on ecosystems functions.

Keywords : Plant functional traits, Holocene, Early agriculture, Pollen data, Climate

Quantifying rates of vegetation change of the last 18,000 years.

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Abstract :

Assessing the biodiversity consequences of climate change ideally draws from different lines of evidence to understand the degree, rate, and nature of ecological responses in comparison with historical records before human interference. Fossil pollen records can provide detailed insights into ecosystem responses to past natural and anthropogenic

drivers of change during thousands of years. Here, we explore global rates of vegetation change during the last 18,000 years, based on an unprecedented global collection of over 1100 fossil pollen records from the community curated Neotoma Paleoecology Database. The analysis includes new sites added from tropical regions to have global coverage and uses a new statistical method for detecting rates of change. First, we show that late Holocene rates of vegetation change lack any precedent over the last 18,000 years, with respect to magnitude and global scope. This finding is remarkable given the large climate-driven vegetation changes associated with the end of the last glacial period. Second, biodiversity dynamics during the Anthropocene is a major topic of interest, with several papers demonstrating globally enhanced rates of local turnover during the 20th and 21st centuries. Here we show that this acceleration in rates of change began millennia ago (4.6 to 3.1 ka) for terrestrial communities, suggesting that the acceleration in turnover over the last two centuries is the tip of a deeper trend. Finally, we show how the spatiotemporal patterns of vegetation change are consistent with known climatic forcings and land-use use history, but that there are continental differences in terms of the timing of the vegetation change acceleration. Our work contributes to the pilling collection of evidence showing the global and long-term anthropogenic effects on ecosystems but also emphasises the need for further collaborations between ecologists, paleoecologists, and archaeologists to understand the deeper origins of the current Anthropocene.

Keywords : palaeoecology, biodiversity, vegetation turnover, rate-of-change, fossil pollen

Exploring land-use impacts on plant and insect diversity and the emergence of ecosystem novelty through synthesis of palaeoecological datasets from across the British Isles.

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Abstract :

Land-use change plays an important role in shaping plant and insect diversity. Great Britain provides an ideal case study to investigate patterns of long-term vegetation and insect diversity change due to the existence of spatially and temporally extensive environmental archives, and a long history of landscape transformation through agrarian change. Using fossil pollen, insect, archaeo-demographic, archaeobotanical and modern landscape datasets covering Britain, shifts towards ecosystem novelty are identified in the form of non-analogue species assemblages. The results reveal that trends in diversity and ecological novelty are associated with the scale of crop production, the range of crops grown, and reflect changing population levels. Modern landscapes with higher agricultural suitability are unlikely to have pollen analogues beyond the last 1000 years, whilst those in areas less suited to agriculture and on more variable topography are more likely to have analogues older than 1000 years. This demonstrates the role of agriculture in the emergence of novel ecosystems. The Anthropocene only sees major shifts in novelty in a low number of pollen sites suggesting that novel ecosystems emerged over a longer time period resulting from the cumulative impacts of land-use change.

Keywords : land-use; biodiversity; plants; insects; vegetation; ecosystems

Poster

Bark beetle outbreaks and fire: recorded disturbance events and land-use change from Central Europe.

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Abstract :

Natural disturbances have increased in both frequency and magnitude in the last decades. In Central Europe, bark beetle outbreaks occur often after large windstorms. As current climate change amplifies the frequency of both windstorms and droughts, bark beetle outbreaks in conifer plantations and nature parks throughout Central Europe have become more frequent and long-lasting. Our study provides an insight from the Tatra Mountains (Slovakia), a region which presumably has been largely untouched by extensive human activities until the second half of the 19th century. A 1000-year record of abundant bark beetle fossils, charcoal and pollen was explored for correlations between the vegetation changes and disturbance events such as fire and bark beetle outbreaks. Statistical analysis shows that bark beetle fossils and charcoal densities are positively correlated in the record, confirming the role of bark beetles as natural disturbance agent in this region. Further comparison to the pollen record shows the introduction of nearby human occupation from ~AD 1250 and their possible impact, in different phases, on the surrounding landscape.

Keywords : Natural disturbances; Bark beetles; fire; land-use change; Central Europe

Calibration of the relationship between stable carbon isotopes in leave waxes and osmotic stress in recent and Cretaceous coastal ecosystems.

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Abstract :

The stable carbon isotopes (δ13C) from plant material are nowadays commonly used by biologists, environmental scientists, and paleontologist for research of recent and past concentrations of CO2 or temperature reconstruction. Plant leave waxes are composed partly from n-alkanes which are one of the most stable compounds. These compounds have high potential to be preserved even in the fossil record and thus, they archive δ13C signature from the time when the plant was growing. However, there are several factors which do affect the δ13C signature of plants. Even though we know that δ13C in plants is affected by concentrations of CO2 or stressors such as salinity or drought, there are a very few studies investigating the systematic shift in δ13C caused by these stressors. This study aims to build a δ13C calibration set across a salinity and drought gradient to see the response of δ13C in n-alkanes of various plant species on stresses. Further, we investigate the δ13C of fossil plants from the Bohemian Cretaceous Basin where five sedimentary units represent different environmental settings covering different levels of salinity or drought stress. We extracted and analyzed n-alkanes for their δ13C from recent and fossil leaves collected along salinity gradient in costal ecosystems – British saltmarshes, New Zealandian saltmarshes invaded by mangroves and in the Late Cetaceous, Cenomanian Peruc-Korycany Formation of the Bohemian Cretaceous Basin. We observed a relationship between salinity and δ13C in n-alkanes. Thus, when combining the recent and fossil data, we were able to reconstruct the vegetation distribution and identify stressed fossil plants throughout several sedimentary units covering the late Cretaceous in Bohemian Cretaceous Basin. This study sets up a proxy for salinity and drought identification in fossil record, which is based on recent and fossil calibration set.

Keywords : carbon, isotope, leave wax, n-alkanes, osmotic stress

Stable isotopic (δ13C and δ18O) analysis of late Miocene Siwalik herbivores from Kangra valley, Himachal Pradesh, India: implication for Palaeoecology and Palaeoclimate.

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Abstract :

Fossil tooth enamel is one of the robust geological archives which retain and reveal the ecological shift and climatic conditions in the form of stable carbon and oxygen isotopic records. Stable carbon isotope from mammalian dental enamel gives the evidence of dietary habitat whereas stable oxygen isotope reflects temperature and precipitation. For the reconstruction of the paleoecology and paleoclimate of the late Miocene of Nurpur, five mammalian dental enamel belonging to equids, suids, tragulids, giraffids, and bovids have been analyzed for the stable carbon (δ13C) and oxygen (δ18O) isotopes including seventy-five serial samples from different tooth positions (Premolar and Molar). The δ13Cenamel values of five herbivore fossil mammals are -11.29 ±0.63, -12.01 ±0.47, -12.97 ±1.11, -13.30 ±0.71, and -12.68 ±0.49‰, respectively and the mean value is -12.2 ±1.09. This indicates that the mammals were mainly C3 diet from close canopy forest to woodland, whereas the very less abundance of C4 grasses (up to 17%) was also noticed in their diet. The δ18Oenamel mean value -7.81 ±1.92‰ VPDB, with an average oxygen isotope ratio -8.85 ±1.71, -10.65 ±0.23, -8.26 ±1.92, -5.83 ±0.85 and -7.86 ±0.62‰ respectively suggest humid/wet climatic conditions. The equid Cromohipparian theobaldi (δ13C value: -11.29 ±0.63 and δ18O value: -8.85 ±1.71) and the suid Tetraconodon minor (δ13C value: -12.97 ±1.11 and δ18O value: -10.65 ±0.23) were likely lived in a wet woodland environment. Whereas the tragulid Darcotherium majus (δ13C value: -13.30 ±0.71 and δ18O value: -8.26 ±1.92), giraffids Hydasptherium megacephalum (δ13C value: -13.30 ±0.71 and δ18O value: -5.83 ±0.85) and bovids Protragocerus gluten (δ13C value-12.68 ±0.49‰, δ18O value -7.86 ±0.62‰) were lived wet to intermediate close forest/forest environments. Overall, the present stable isotopic data on herbivore mammals represent forested and woodland environments with patchy grassland and water likely to be derived from local sources such as ponds or streams.

Keywords : Stable isotope; Mammals; Late Miocene, Paleodiet; Nurpur; India

Insights into the resilience of Neolithic forests under climate change and land use in Northern Greece.

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Abstract :

Around 9,000-8,500 cal. BP agriculture was first introduced to Northern Greece from Western Asia, starting the European neolithisation process. This cultural shift led to the arrival of new crops and livestock and changed the natural biomes and environments of Europe forever. Early farming societies developed new land use practices, which had an impact on the vegetation and on fire regimes. However, the exact nature and timing of these early farming practices is still unknown. At the same time, these early farming societies were dependent on their natural environment and their practices had to be adapted to changes in climate and vegetation. This relationship between Neolithisation, vegetation and climate is complex and still not well understood. Continuous and high-resolution multi-proxy time series of past vegetation dynamics and fire histories are needed to understand the long-term relationships between Neolithic people and their environment.

We analysed lake sediments from Limni Zazari, to study the interactions between climate, land use, fire and vegetation. Limni Zazari is a small lake located in the 'Four Lakes District' in Northern Greece and multiple Neolithic settlements were excavated around the lake. Here, we present a novel continuous and high-resolution vegetation- and fire history record spanning the Late Mesolithic and the Neolithic (ca. 10,000—5,000 cal. BP), reconstructed by using pollen, spores and microscopic charcoal.

During the Mesolithic, the area around Limni Zazari was covered by mixed deciduous oak forests interspersed with open grassland communities. Preliminary results show that the first Cerealia-type pollen grains occur around 9,500 cal. BP, but it seems these early traces of agriculture were unconnected to a significant impact on the vegetation. Such early evidence may fall into a transition phase between the Mesolithic and the Neolithic, the so-called aceramic Neolithic. The first noticeable decline in forest vegetation occurred around 8,600 cal. BP, but it is unclear if it resulted from land use alone or combined effects of climate change and early agriculture. After the establishment of several Neolithic settlements around 7,500 cal. BP, regular disturbances of the forest vegetation occurred. Even though forests recovered quickly from these disturbances, they likely led to changes in the forest composition. The presence of both Hordeum-type and Triticum-type pollen during the Neolithic suggest that people grew crops like barley, einkorn and emmer close to Limni Zazari.

Our study describes vegetation dynamics in response to climate change and oldest European farming disturbances of primeval forests. The results will lead to a better understanding of the complex interactions between climate, vegetation and human societies and may help our society to develop sustainable ecosystem management practices and prepare us for a future under global change conditions.

Keywords : vegetation history, land use, climate, Neolithic, Greece.

Exploring timing and patterns of resilience in a prehistoric mixed beech-oak forest at the transition from natural to disturbed vegetation using a high-resolution sedimentary record from Lago di Mezzano, central Italy.

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Abstract :

Climate change and alterations in land use are strongly impacting ecosystems. Understanding past ecological responses to climate variability and human pressure is key to improve our ability to predict future ecosystem dynamics. The motivation of our study is to reconstruct decadal-scale vegetation and fire history dynamics at Lago di Mezzano for a better understanding of the linkages between climate, land use, fire and vegetation communities in central Italy during the Mesolithic/Neolithic transition and to assess the resilience, vulnerability and adjustment capacity of Mediterranean plant communities and species. Previous palaeoecological studies have been carried out at many sites in Europe, however, the chronologies generally have wide uncertainties, usually >100 to 200 years. This lack of chronological precision impedes detailed comparisons with precisely dated independent records such as dendro-chronologically dated archaeological findings (e.g. prehistorical settlements, tools, tombs), historic events or palaeoclimatic data. Well-preserved annually laminated sediments that cover a long time span are very rare but offer the unique opportunity to reconstruct Holocene vegetation, biodiversity, land use, and fire dynamics with the highest possible chronological resolution and precision, especially when combined with Accelerator Mass Spectrometry (AMS) radiocarbon dating of short-lived terrestrial plant macrofossils and wiggle-matching approaches.

Here, we focus on the study of laminated Mid Holocene sediments collected from Lago di Mezzano (a maar lake located at 452 m a.s.l. in central Italy), aspiring to reach precisions comparable to those of tree ring chronologies. Results of high resolution palaeoecological (pollen, spores, microscopic charcoal, macrofossils) and palaeoenvironmental analyses (element geochemistry and photopigment abundance) are presented and compared with those from other lakes on the Swiss Plateau and in southern Switzerland, which are the only other sites providing comparable chronological precisions and resolutions in Europe. In this way we aim to assess causes and effects of past environmental, ecological, and societal change during the period ca. 8,500-5,000 cal. BP when societies changed from collection (Mesolithic) to production economy (Neolithic).

A closed, nearly undisturbed mixed beech-oak forest dominated the landscape around Lago di Mezzano during the Mesolithic and Neolithic until about 7,500 cal. BP. Subsequently, forest markedly declined in conjunction with increasing fires and agro-pastoral activities (e.g. increasing Cerealia-type, Plantago lanceolata-type and Urtica pollen grains). Land use phases at Lago di Mezzano repeatedly occurred at about 7,500 cal. BP, 6,850 cal. BP, 6,400 cal. BP, 5,700 cal. BP and 5,200 cal. BP, always followed by a recovery of the forest structure, although vegetation composition varied, suggesting a certain resilience of forest species and communities to first human impact (as reconstructed here for 3500 years). The comparison with high precision palaeoecological records from the Swiss Plateau and southern Switzerland suggests synchronous land use pulses across the two distant European regions, most likely controlled by climate change. Our outcomes are not only of palaeoecological and archaeological interest, ultimately they may also contribute to better projections of ecosystem dynamics under global change conditions, providing novel insights into biodiversity conservation and ecosystem management.

Keywords : Palaeoecology, climate change, land use, forest resilience, high-resolution analyses

OSM34: Cryosphere change impacts on arctic coastal environments and ecosystems during the Holocene

Co-conveners: Maija Heikkilä, Rebecca Jackson, Mimmi Oksman, Anna Pieńkowski, Sofia Ribeiro and Kaarina Weckström

Oral

Impacts of southwest Greenland freshwater runoff on fjord productivity since the late 19th century.

Mimmi Oksman [(1)], Anna Kvorning [(1)], Signe Larsen [(1)], Kristian Kjeldsen [(1)], Kenneth Mankoff [(1)], William Colgan [(1)], Thorbjørn Andersen [(2)], Niels Nørgaard-Pedersen [(1)], Marit-Solveig Seidenkrantz [(3)], Naja Mikkelsen [(1)] and Sofia Ribeiro [(1)]

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Abstract :

Climate change has increased freshwater runoff from the Greenland Ice Sheet during the last decades and freshwater input to coastal areas is expected to increase in the future (Fettweis et al., 2013). Freshwater discharge modulates the physico-chemical properties and nutrient dynamics of the water column, and directly impacts primary production, which is essential for socio-economic activities such as fisheries (Hopwood et al., 2020). Freshwater impacts on fjord productivity have been monitored by the Greenland Ecosystem Monitoring programme over the last two decades (Meire et al., 2017). However, long-term records of primary productivity changes are needed to define the natural baseline and variability beyond the accelerated climate change and for setting the recent changes into a wider context.

Here, we used a multiproxy approach (diatom assemblages and fluxes, total organic carbon, total nitrogen, C/N-ratios, biogenic silica, δ13C, δ15N, grain-size distribution) on four marine sediment cores from Nuup Kangerlua fjord to obtain long-term records of primary productivity. To evaluate the impacts of meltwater, we produced basin-wide estimates of freshwater runoff using MAR-regional climate model output and compared our unique dataset with changes in the glacier frontline position and historical air- and sea-surface temperature records.

We find that marine primary productivity in Nuup Kangerlua is higher today than any other time during the 20th century and is in line with the highest freshwater runoff volumes observed. Our record shows that an abrupt increase in marine productivity in the glacial-proximal area of the fjord occurred in the mid-1990´s, due to increased freshwater runoff. Changes in the diatom record suggest that freshwater runoff modulates the species assemblage and the dynamics and magnitude of the diatom spring bloom having influence on the atmospheric CO2 uptake. The impacts of freshwater runoff are most notable in the glacier-proximal area, however, we discuss also possible implications in the glacial-distal side branch of the fjord.

Keywords : Marine productivity, fjord, cryosphere, diatoms, sediment

A Holocene multiproxy record of environmental change in Nuup Kangerlua, the largest fjord in west Greenland.

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Abstract :

We present the first multi-proxy record of environmental changes covering the last ca. 10 000 years (based on a preliminary age-model) from Nuup Kangerlua, a fjord system influenced by both marine-terminating and land-terminating glaciers by Nuuk, Greenland's capital. This was done to gain a better understanding of how the changing cryosphere impacts this coastal marine ecosystem. Climate change is leading to a severe warming of the Arctic region. Sea-ice is rapidly decreasing, and

the Greenland ice sheet is discharging ca. 1000 Gt of freshwater to the coastal areas every year. Consequently, the physical and chemical properties of the water column are changing affecting the structure and functioning of marine ecosystems. Primary producers - such as diatoms and dinoflagellates - are found at the base of the marine food web, making them important to all higher trophic levels. To understand the current cryosphere changes and its impact on, e.g., marine productivity there is a need to place them in a larger context to separate human-driven versus natural changes. This can be achieved with long-term sedimentary records which archive information about past environmental changes. In this study, we analyzed dinoflagellate cyst assemblages alongside grain-size distribution, and biogeochemical indicators (total organic carbon (TOC), nitrogen (TN), calcium carbonate (CaCO3), stable isotopes (13C and 15N), and biogenic silica (BSi)). Our multiproxy record captures significant environmental changes throughout the Holocene. Dinoflagellate cyst concentrations varied from 1834 to 95483 and a total of 19 cyst taxa were identified. The bottom part of the core shows low cyst concentrations and is dominated by cold-water heterotrophic species related to sea-ice cover (e.g., Islandinium minutum, Islandinium? cezare spp., Echinidinium karaense and Brigantedinium spp.). This finding is compared with already existing data on local ice-sheet variations suggesting a re-advance of the Greenland Ice Sheet at 8.2k years BP and 9.3k years BP. In the middle part of the record there is a change in species composition, with the appearance of autotrophic species that overall indicate warmer sea-

surface waters (e.g., Pentapharsodinium dalei, Operculodinium centrocarpum, Nematosphaeropsis labyrinthus, Spiniferites elongatus and Spiniferites ramosus). In the uppermost part of the record cf. Biecheleria appears for the first time and the genus Halodinium increases which suggest sea-surface freshening as a result of increased glacial discharge to Nuup Kangerlua.

Keywords : Climate change, cryosphere, primary production, dinoflagellate cysts, marine sediments

Marine conditions and development of the Sirius Water polynya on the North-East Greenland shelf during the Younger Dryas-Holocene

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Abstract :

Polynyas are areas of persistent open water in the otherwise sea ice dominated marine environments, and several form in the Arctic region. At least three polynyas, which are considered hotspots of marine production, recurrently form at the confluence between the cryosphere (e.g., sea or land-fast ice) and marine realm on the shelves surrounding Greenland. Archeological evidence suggests the presence of a marine ecosystem supporting human settlements around 74°N off the North-East Greenland coast as early as 4.5 ka BP, the modern-day site of the Sirius Water polynya (SIW). The Holocene history of the SIW from a marine perspective however, remains largely unknown. Using a multi-proxy approach applied to a high-resolution marine sediment core from the modern-day SIW, we reconstruct the evolution of and interaction between the cryosphere and oceanic conditions over the Younger Dryas-Holocene transition. Our reconstructions indicate extensive Atlantic water influence and strong stratification during the Younger Dryas and locally-derived terrestrial organic matter suggests a nearby retreating ice shelf from 12.2 – 11.7 ka BP. After the establishment of the East Greenland Current in the early Holocene, recurrent open water and enhanced productivity suggest the potential onset of SIW formation as early as 10 ka BP. A combination of ongoing atmospheric warming and the retreat of the Greenland Ice Sheet on land likely provided the preconditions for SIW formation from ca. 10 ka BP.

Keywords : Holocene, Younger Dryas, Paleoceanography, North-East Greenland, Sirius Water Polynya

Biogenic sea-ice proxies in ice, water column and sediment over spring melt in a Hudson Bay archipelago.

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Abstract :

Sea ice is a major controller of the global climate system. The striking loss in Arctic seasonal sea-ice cover over the past four decades influences both marine and terrestrial ecosystems, yet the linkages of sea-ice variability, climate and ecosystem impacts are not well understood. Geological records of past sea-ice change can help understand these dynamics and predict future changes and impacts. Multiple biogenic proxies derived from protists associated with sea ice and preserved in marine sediment archives provide excellent tools for past sea-ice reconstruction. However, the sources, production and vertical transport of these proxies remain poorly understood, which hinders their use in the reconstruction of past sea-ice cover and environments.

Here we present a time-series study on vertical export of common biogenic sea-ice proxies: diatoms, dinoflagellate cysts and highly branched isoprenoid lipids (HBIs), supplemented by pigment and organic geochemical data. The samples from sea ice, underlying water column, vertical sediment flux to sediment traps, and the surface sediment were collected over a field campaign in spring–summer 2019 in the Belcher Islands Archipelago, Hudson Bay. The aim was to investigate which ice-associated species and HBI biomarkers inhabit the ice matrix and the underlying water column, how they are exported to the sediment and how they compare with the species and biomarkers found in the surface sediment. The results demonstrate that diatoms dominate over the sampling period in ice, water column and vertical export, while dinoflagellates and their cysts are virtually absent. In the surface sediment, late-blooming centric species dominate over the spring-to-summer diatom communities, while dinoflagellate cyst communities consist of typical (sub)Arctic species, indicating that dinoflagellates producing the cysts used for sea-ice reconstruction are produced later in the season. HBIs typical for sea-ice (IP25, IPSO25) and open-water conditions (HBI III and HBI IV) were present in all habitats, but surprisingly, HBI IV was the dominant type in ice samples. Diatom communities were most diverse within the sea ice, sharing some species with concurrent water column samples but differing markedly from the sediment trap and surface sediment diatom communities. In sediment archives, the comparably small biomass of sea-ice diatom blooms may be masked by the large diatom biomass delivered by ice-edge and open water blooms. We highlight the importance of a multiproxy approach when reconstructing past sea ice environments, as well as the need to enhance our understanding on the sources and behavior of the proxies we use in different environments.

Keywords : Sea ice proxy, diatom, dinoflagellate cyst, HBIs, Hudson Bay

Biomarker characterization of the North Water Polynya, Baffin Bay: Modern and Holocene perspectives.

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Abstract :

The North Water Polynya (NOW, Greenlandic Inuit: Pikialasorsuaq), Baffin Bay, is the largest polynya and one of the most productive regions in the Arctic. This area of thin to absent sea ice is a critical moisture source for local ice sheet sustenance and coupled with the inflow of nutrient-rich Arctic and Atlantic Water, supports a diverse community of Arctic fauna and indigenous people. However, as anthropogenic warming continues, formation of the ice arches in Nares Strait that block ice flow from the Arctic Ocean are forming less reliably, jeopardizing the formation of the NOW with uncertain consequences for the local cryosphere and biosphere. Looking to the past, previous studies suggest that the NOW developed following sea ice changes in Nares Strait associated with Late Holocene cooling. However, only a few paleoceanographic records exist from in and around the NOW, and scarcity of more diagnostic biological records for the NOW's associated high pelagic productivity, hinder a more complete picture. In this study, we aim to characterize and trace the spatiotemporal history of the NOW via the analysis of surface and downcore marine sediment samples that encompass its modern limits. Our toolkit relies on a variety of lipid biomarkers, including algal highly-branched isoprenoids and sterols for sea ice extent and pelagic productivity, and archaeal GDGTs for ocean temperature, as well as modern instrumental datasets. In terms of the surface sediment samples, our modern proxy calibrations enable us to identify a variety of sterols as key biomarkers to trace the presence/absence of polynya conditions, which are supported by the additional lipid classes to characterize associated environmental factors such as sea ice and ocean temperature. In our downcore records, we take advantage of our modern calibrations and compare the same lipid biomarker analyses with radiocarbon-dated records of sediment lithology and foraminifera stratigraphy that define Holocene paleoceanographic conditions related to deglaciation and Arctic Water throughflow. While these biomarker analyses are currently underway, we ultimately aim to contribute to the community's growing knowledge of past NOW dynamics by improving the spatial resolution of the NOW's past presence/absence and identifying the key mechanisms behind these changes.

Keywords : Polynya, Holocene, marine sediment, biomarkers

Using sedimentary ancient DNA to reconstruct the impact of Holocene environmental change on Arctic ecosystems

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Abstract :

Arctic ecosystems are highly sensitive to climate change and are currently being altered by increasing water temperatures and changes in sea ice conditions. These rapid changes will inevitably have profound effects on biodiversity and productivity. In order to understand the ongoing impact of climate warming on Arctic ecosystems, it is essential to assess the response of biodiversity to past changes in environmental conditions. To date, such paleodiversity studies are limited to groups of organisms that can be found as (micro)fossils in the sediment record. This leaves a very incomplete picture of the entire Arctic ecosystem.

Within a Norwegian-Polish collaborative project (NEEDED, Nordic Seas Sedimentary

Ancient DNA) we now aim to establish sedimentary ancient DNA sequencing as a new tool for reconstructing past changes in entire marine communities. The project focuses on the continental shelf in the Nordic Seas, near Svalbard, Eastern Greenland and Bear Island, and aims to reconstruct environmental and biodiversity changes throughout the Holocene.

Here, we present the first, preliminary metabarcoding results from a Holocene sediment record from the Hinlopen Strait, northern Svalbard. We extracted ancient DNA and trace a wide range of eukaryotic taxa through time to estimate past changes in diversity and productivity. These paleogenomic data will be compared to other proxies, changes in sea ice cover and water temperature.

This work is supported by the Norwegian Financial Mechanism for 2014-2021, project no 2019/34/H/ST10/00682.

Keywords : ancient DNA, Arctic, biodiversity, Holocene

Reconstructing the history of meltwater inputs into the Canadian Arctic Archipelago and Hudson Strait.

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Abstract :

The ultimate retreat of the Innuitian and Greenland Ice sheets from the straits of the Canadian Arctic Archipelago (CAA) led to the opening of the Nares Strait an important connection between the Arctic and the North Atlantic Oceans and the inception of the modern day ocean circulation in the Labrador Sea during the Holocene. Holocene meltwater discharges and their influence on climate variability could help better understand the effects of modern day ice sheet melting. Better understanding how meltwater injections into the key regions of deep-water formation influenced the North Atlantic Ocean circulation can provide crucial information for the future climate change predictions. In this study we investigate the input of terrigenous signals into Labrador Sea Water based on the radiogenic Nd isotope signatures (εNd) and Rare Earth Element (REE) patterns of bulk sediment leachates and the residual detrital silicates from three sediment records from the Lancaster Sound, the Nares Strait and the Hudson Strait, spanning the Holocene.

The records from the Lancaster Sound and the Nares Strait show overall relatively narrow range of εNd signatures over the Holocene with one exceptions, whereas the Hudson Strait record is more variable. An unradiogenic excursion (εNd ~ -28.2) recorded around 8.4 ka in the detrital silicates of the Hudson strait sediments is most likely associated with the Hudson Bay Saddle collapse (Lochte et al., 2018). A distinct decrease in εNd radiogenic signatures in Nares Strait sediments was recorded between 9 ka and 8.2 ka, in both leachates (εNd ~ - 22.5) and detrital silicates (εNd ~ -25.8). This unradiogenic excursion could reflect the retreat of the Greenland Ice Sheet from Kennedy Channel and the final transition to an open connection between the Arctic Ocean and Baffin Bay that may have led to the retroflection and intensification of the West Greenland Current at a similar time (e.g. Lochte et al., 2019). During the middle and late Holocene the Nares Strait εNd signatures get progressively more radiogenic (εNd ~ -15.5, bulk leach) and stay invariable over this time period, suggesting no major meltwater inputs or changes in sediment supply via this route. At Lancaster Sound the early to middle Holocene εNd signatures show a close range of values ranging between -18 and -19 (bulk leach), followed by a small unradiogenic excursion at the end of the Holocene (εNd ~ -19.6, bulk leach), suggesting either potential increase of unradiogenic input from the continent or decrease in radiogenic Pacific inflow. The Hudson Strait sediment record shows large variability in its signatures over the course of the entire Holocene, suggesting multiple meltwater input events tied to demise of the land-based portion of the Laurentide ice sheet.

Keywords : Holocene, Nares Strait, Lancaster sound, Hudson Strait, Neodymium isotopes, Innuitian Ice Sheet, Laurentide Ice Sheet

Tracing sea ice: protist DNA in marine sediment records from the Northeast Greenland Shelf.

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Abstract :

Sea ice is declining at an unprecedented pace and within decades the Arctic will transition into a seasonally sea-ice free regime. Today, much of our knowledge of past sea-ice extent derives from a relatively few microfossil and biogeochemical tracers, which all have their have limitations. Recent advantages using sedimentary ancient DNA provide a broader view into past biodiversity and offer the potential to develop new proxies. However, little is known about how well past protist communities are represented in marine sediments. Here, we present results from a study applying a combination of modern and ancient DNA methods to material collected along the Northeast Greenland Shelf. We characterized genetic material from surface sediment and in a dated sediment core, by targeting the hyper-variable V4 region of the 18S rRNA, with focus on protist groups. We further quantified amplicons from the sympagic dinoflagellate Polarella glacialis, using a single-species targeted digital droplet PCR approach.

Keywords : Sea ice, Protists, Proxies, Sedimentary ancient DNA, Metabarcoding, Polarella glacialis, Northeast Greenland Shelf

Poster

Diatom and dinoflagellate cyst succession over four annual cycles in a high Arctic fjord, Northeast Greenland

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Abstract :

Arctic coastal environments are rapidly transforming due to climate change impacts on land and in the ocean. To predict future cryosphere change and its impacts, it is essential to understand ecosystem responses beyond the instrumental era. Arctic marine sediments are rich in microfossils, in particular diatoms and dinoflagellate resting stages (cysts), which originate from the sea-ice matrix, pelagic ice-edge and open-water environments. These microfossils have been abundantly used for both quantitative and qualitative reconstructions of past ocean conditions. Our understanding of microfossil species' ecologies is predominantly based on the spatial distribution of each species in surface sediments in relation to modern surface ocean conditions across the Northern Hemisphere. However, we know little of their physical (ice, water) habitats and seasonal ecologies of over the annual sea-ice cycle.

We will present the diatom and dinoflagellate cyst succession at 1 to 12 week intervals over four years (2013-2015 and 2016-2018) in the seasonally ice-covered Young Sound fjord in Northeast Greenland. An automated sequencing sediment trap was installed close to the sea floor at a 37 -m water depth. Sediment samples are currently analysed for diatom and dinoflagellate cyst species with special interest in seasonal changes with respect to the sea-ice cycle. Our objective is to increase the knowledge of seasonal ecologies of diatom and dinoflagellate cyst species and thus improve the potential of and note possible limitations to qualitative and quantitative environmental reconstructions based on these microfossils.

Keywords : Dinoflagellate cysts, diatoms, Arctic coastal environments, sea ice

Late Holocene vegetation changes in the Zackenberg area, NE Greenland: the lake Lomsø record.

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Abstract :

The Arctic is highly vulnerable to the current increase in temperature due to anthropogenic emissions of greenhouse gases, something that has inspired researchers to study the relationship between vegetation cover and climate to understand the stability of Arctic ecosystems and biodiversity (Coyne & Kelley, 1974; Oberbauer et al., 1996; among others). Due to the variety of physiological responses of Arctic plants related to changes in climatic conditions, the impact of increased temperatures is expected to cause different responses in plant communities, which could be manifested through short-and long-term changes in the community structure and in the distribution ranges of the species (Oberbauer et al., 1996; Grogan & Chapin, 2000; Elberling et al., 2008).

Although various factors such as the conditions of the Greenland Ice Sheet, cloud cover, and volcanism in adjacent regions do influence the climate of the island at various time scales, the North Atlantic Oscillation/Arctic Oscillation (NAO/AO) and the extent of sea ice has a determining role on the climatic conditions in the coastal regions of NE Greenland in general and Zackenberg in particular (Hinkler et al., 2008). The NAO, which is directly related to the AO, is the most important climate mode in the Northern Hemisphere and explains the largest percentage of the interannual variability of atmospheric circulation and climatic conditions in the middle and high latitudes of the North Atlantic, differentiating its effects over North America/Greenland and Europe (Hurrell et al., 2003; Stendel et al., 2008). Although it is proposed that the relationship between the NAO and climatic conditions at Zackenberg are not linearly related (because the East Greenland margin lies right on the border between the two regions mainly affected by the NAO), there are studies who state that the interannual variation of snow cover in Zackenberg is strongly controlled by the NAO and that the influence of this climate mode on plant species in the region is evident (Forchhammer et al., 2008; Hansen et al., 2008; Hinkler et al., 2008; Stendel et al., 2008).

The Lomsø sedimentary lake record (core LOM18_02; 31,5 cm long; 4581 cal years BP) shows very low pollen concentration, especially in the lower sandy part of the record, so the palynological analysis was performed on the upper part of the core, one sample per cm (n=17). The palynological record ranges from 2200 cal yr BP to the present and shows three different pollen zones: LOM-Ia (2200 – 1450 cal yr BP), LOM-Ib (1450 – 500 cal yr BP) and LOM-II (500 cal yr BP – present) whose boundaries are marked by a sharp decrease of woody plants. All the zones are mostly herbaceous, dominated by Luzula/Juncus on every sample, showing a predominantly swampy environment surrounding the lake throughout the entire record.

Our results show than despite the vulnerability of Arctic ecosystems to climate change, the area near lake Lomsø has remained kind of stable, but we interpret that as a result of the over-representation of swampy pollen types (Luzula/Juncus) that lead changes in other taxa concentrations to be barely noticeable.

Keywords : Palynology, Climate Quantitative Reconstruction, Northeast Greenland, North Atlantic Oscillation/Arctic Oscillation, Late Holocene

OSM36: Quaternary climate change and human evolution in Africa

Co-conveners: Asfawossen Asrat, Andy Cohen, Verena Foerster, Henry Lamb, Frank Schaebitz and Martin Trauth

Oral

Vegetation and hydroclimate variability in tropical north Africa during the Pliocene-Pleistocene.

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Abstract :

The Plio-Pleistocene climate of continental Africa is of much interest as a number of key transitions in hominin evolution occurred during the past ~5 Ma (e.g., Maslin et al., 2014). Hominin speciation, extinction and migration events have been linked to changes in global or regional climate but currently our understanding of these relationships is limited by the fact that there are relatively few continuous Plio-Pleistocene paleoclimate records from the African continent (e.g., Cohen et al., 2016). Numerous outstanding questions also exist with respect to mechanisms driving African climate variability. For example, the role of high- versus low-latitude processes in driving changes in precipitation are debated. Marine dust flux records from subtropical West Africa have provided important information on Plio-Pleistocene hydroclimate fluctuations as dust concentrations are tied to precipitation (e.g., deMenocol, 1995). However, interpretation of dust flux records is not always straightforward because dust production tends to indicate transitions from relatively wet climate to arid/hyperarid conditions rather than representing a pure signal of continental aridity (Goudie and Middleton, 2001; Prospero and Carlson, 1972). To address this issue and to provide a continuous Plio-Pleistocene continental paleoclimate record from tropical North Africa, here we generate new multi-proxy organic geochemical records from ODP Site 660 (10 degrees N) in the tropical Eastern Atlantic spanning the past ~4.1 Ma. Situated beneath the path of the African Easterly Jet, Site 660 receives ample dust from the Sahara/Sahel region of central North Africa. We use plant wax deuterium isotopes, a proxy for rainfall amount in the tropics, to examine Plio-Pleistocene hydroclimate variability. Plant wax carbon isotopes are used to examine shifts in C3 versus C4 vegetation. Additionally, we reconstruct sea surface temperature (SST) by examining alkenones (the Uk'37 index) and isoprenoid glycerol dialkyl glycerol tetraethers (TEX86). Our new records reveal that dynamic vegetation and hydroclimate shifts occurred in central North Africa throughout the Pliocene and Pleistocene. Marine Isotope Stage (MIS) M2 at ~3.3. Ma, which is recognized as a brief but intense glaciation that interrupted mid-Pliocene warmth, stands out in nearly all proxy records while pronounced glacial-interglacial variability characterizes the Pleistocene portion of the record. An interesting result is that highly variable conditions are noted throughout the Pliocene, especially in the isotopic records. Although analyses are still in progress, thus far the largest shift in the deuterium isotope record occurs in the early to Mid-Pliocene

Keywords : Africa, hydroclimate, biomarker, SST, plant wax

Climate change shapes 50,000-year-old social network in Africa.

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Abstract :

Africa has undergone multiple dramatic hydroclimate reorganizations over the past 50,000 years, altering the distribution of plants and animals across the landscape, which in turn could have affected human behavior. However, it remains largely unexplored how these drastic hydroclimate changes affected ancient human behavior. To examine this, we used both paleoclimate data and archaeological ostrich eggshell beads (OES) from eastern and southern Africa to examine how human social dynamics shifted in response to climatic change. OES beads are tiny artifacts found throughout Africa in the last 50,000 years. They carry information about social networks because neighboring groups are likely to share similar bead styles. By

examining the changes of OES styles, we can learn about human social responses to climate change in the past. Our study shows clear evidence of cultural connections between eastern and southern Africa during a wet period in eastern Africa from 50,000 to 33,000 years ago (ka). The generally wetter conditions in eastern Africa seem to have facilitated larger group sizes with more extensive inter-group social contact. However, after 33ka, we saw an extended period of disruption in the social connections between eastern and southern population that lasts until the pastoralists enter southern African at 2 ka. The abrupt social disruption at 33 ka corresponds to the drastic hydroclimate change in Africa due to the southward migration of Intertropical Convergence zone to 10-20S. As a result, eastern Africa became drier due to decreased rainfall, while the Zambezi River Catchment—the large area connecting eastern and southern Africa—received higher precipitation and periodically flooded. This flooding of the Zambezi may have created a geographic barrier between the two regions, blocking the connection between east and south. While the eastern African bead tradition continues unchanged, southern populations appear to shift social strategies, and bead use becomes scarce. Our work demonstrates a strong link between climate change and social behavior among ancient populations.

Keywords : Paleclimate, Human behavior, Human social network, southern and eastern Africa, Ostrich egg shell beads

Northern Hemisphere Glaciation, African Climate and Human Evolution.

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Abstract :

The hypothesis of a connection between the onset (or intensification) of Northern Hemisphere Glaciation, the stepwise increase in African aridity (and climate variability), and an important mammalian (including hominin) species turnover is a textbook example of the initiation of a scientific idea and its propagation in science. It is, however, also an example of the persistent popularity of a hypothesis despite mounting evidence against it. A critical review of key publications on the topic and statistical re-analysis of key records of global ice volume and African climate leads to three conclusions: (1) The Northern Hemisphere Glaciation was a gradual process occurring between ~3.5–2.5 Ma, not a single event at ~2.8 Ma or at any other time. (2) A consistent stepwise (+/−0.2 Ma) transition toward greater aridity in Africa at ~2.8 Ma does not exist; instead, there are regionally different, gradual transitions partly in connection with the intensification of the Northern Hemisphere Glaciation, but above all with the establishment of the tropical Walker Circulation after ~2 Ma. (3) Mammalian (including hominin) species turnovers at this time also appear to have been gradual, rather than stepwise.

Keywords : Africa, Human Evolution, Northern Ice Sheets, Species Turnover

Hydroclimate changes in eastern Africa over the past 200,000 years may have influenced early human dispersal

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Abstract :

Reconstructions of climatic and environmental conditions can contribute to our understanding of key factors driving late Pleistocene human dispersal within and beyond Africa. We present here the uppermost part of the multi-proxy paleoclimate record from Chew Bahir, covering the last 200,000 years in the southern Ethiopian Rift. Our record reveals two modes of climate change, both associated temporally and regionally with specific human behaviours. The first is a long-term trend towards greater aridity between 200,000 and 60,000 years ago, modulated by precession-driven wet-dry cycles. Here, favourable wetter environmental conditions may have facilitated long-range human expansion into new territory, while less favourable dry periods may have led to spatial constriction and isolation of local human populations. The second mode of climate change observed after 60,000 years ago has similarities to millennial to centennial-scale Dansgaard-Oeschger cycles and Heinrich events. We hypothesize that human populations responded to these relatively abrupt climate fluctuations by selectively shifting between montane and lowland habitats.

Keywords : Paleoclimate, Human dispersal, Late Pleistocene

A spatiotemporally explicit paleoenvironmental framework for the Middle Stone Age of eastern Africa.

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Abstract :

Eastern Africa has played a prominent role in debates about human evolution and dispersal due to the presence of rich archaeological, palaeoanthropological and palaeoenvironmental records. However, substantial disconnects occur between the spatial and temporal resolutions of these data that complicate their integration. Here, we apply high-resolution climatic simulations of two key parameters, mean annual temperature and precipitation, and a biome model, to produce a highly refined characterisation of the environments inhabited during the eastern African Middle Stone Age. Occupations are typically found in sub-humid climates and landscapes dominated by or including tropical xerophytic shrubland. Marked expansions from these core landscapes include movement into hotter, low-altitude landscapes in Marine Isotope Stage 5 and cooler, high-altitude landscapes in Marine Isotope Stage 3, with the recurrent and preferential inhabitation of ecotones between open and forested habitats. Through our use of high-resolution climate models, we demonstrate a significant independent relationship between past precipitation and patterns of Middle Stone Age stone tool use overlooked by previous studies. Engagement with these models not only enables spatiotemporally explicit examination of climatic variability across Middle Stone Age assemblages in eastern Africa but enables clearer characterisation of the habitats early

human populations were adapted to, and how they changed through time.

Keywords : Middle Stone Age, Eastern Africa, palaeoclimate, climate simulations

Deciphering environmental thresholds in the habitat of early humans: a new 620,000-year mineralogical proxy record from Chew Bahir in southern Ethiopia.

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Abstract :

As a contribution towards a regional environmental context of human-climate interactions, the Chew Bahir Drilling Project, part of the Hominin Sites and Paleolakes Drilling Project (HSPDP), recovered ~280-m long cores of sedimentary strata from the Chew Bahir basin in southern Ethiopia. The drill site is situated near key archaeological and paleoanthropological sites, such as Omo 1 and 2.

These cores reveal a 620,000-year-long mineralogical record that provides a valuable opportunity to decipher environmental extremes and hydrological threshold conditions. The degree of authigenic mineral alteration is indicative of wet, dry and especially hyper-arid climate intervals. Our results show that the most extreme evaporative phases are represented by authigenic mineral assemblages including Mg-enriched clays, low-temperature authigenic illite and euhedral analcime. We combine the mineralogical profile with hyperspectral analysis to more finely differentiate levels of aridity. The oscillations between pronounced hydroclimatic conditions have important implications for transforming the habitats of human populations The time interval described by the core data encompasses several key hominin evolutionary benchmarks, including the transition to the Middle Stone Age, and the origin and dispersal of modern Homo sapiens.

Keywords : Chew Bahir, Ethiopia, hydrochemistry, authigenic minerals

The Great Lakes of Turkana – a Novel Perspective on the African Humid Period

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Abstract :

The region in the surrounding of Lake Turkana in northern Kenya and southern Ethiopia is famous for its fossil richness including key sites for human evolution studies. Modern Lake

Turkana is the last of numerous mega-lakes, that has persisted to dry up completely at the end of the last African Humid Period (AHP, 15 – 5 ka). The adjacent paleo-lakes Suguta (2,000 km^2) and Chew Bahir (2,500 km^2), which are desiccated today, have formed together with paleo-Lake Turkana (20,000 km^2) a N-S oriented mega-lake during the AHP that has being separated only by small morphological Barriers. While Turkana, Suguta and Chew Bahir have been part of intensive research during the past decades, paleo-lake Chalbi with up to 10,000 km^2 in size, just 10 km east of Lake Turkana was out of sight for most archaeologists and geoscientist. Here we present the first attempts for enhancing our understanding of the paleoenvironmental consequences of paleo-lake Chalbi close to one of the key regions in human evolution.

Keywords : Lakes, African Humid Period, Turkana, Eastern Africa

Tropical East Africa became wetter at 3 Ma: A compound-specific leaf wax biomarker record from the Baringo-Tugen Hills-Barsemoi Basin, Kenya.

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Abstract :

The Plio-Pleistocene (0-5 million years before present (Ma)) witnessed high-latitude cooling, the intensification of northern hemisphere glaciation (iNHG), the development of zonal sea surface temperature (SST) gradients in the tropics, and shifts in the frequency and amplitude of glacial-interglacial cycles. Although global trends are well-characterized in marine records, the dearth of continental cores hampers our understanding of terrestrial hydroclimatic changes during this time. Hominid fossil-rich East African strata are of particular interest, as paired geochemical-sedimentological and anthropological analyses can elucidate the environmental context of early hominin evolution.

The Hominin Sites and Paleolakes Drilling Project recovered a near-continuous core from a ~3.3–2.6 Ma section of the Baringo-Tugen Hills-Barsemoi (BTB) Basin, spanning iNHG, the intensification of 41,000-year (41-kyr) glacial-interglacial cycles, and key developments in Australopithecine and Homo lineages. Previous sedimentological, paleontological, and phytolith-based proxies from the BTB core suggest a shift to deeper-lake but more variable conditions around 3.04 Ma. These data could indicate a generally wetter and more variable climate, in contrast to evidence for Plio-Pleistocene drying elsewhere in Africa, but these proxies may also be affected by local geomorphic change in the BTB area.

Here, we present a new record of n-alkane-specific leaf wax hydrogen (δ2Hwax) and carbon (δ13Cwax) isotopes, proxies for precipitation amount and vegetation type, respectively, measured at suborbital resolution (~2 kyr). δ2Hwax values record large-scale changes in atmospheric circulation, providing regional context for basin-scale records. In accordance with prior work, our data show a sudden shift to wetter, more variable conditions between 3 and 3.1 Ma, suggesting that changes in BTB hydrology were symptomatic of broader rainfall patterns. Enhanced rainfall during global cooling is contrary to thermodynamic expectations and drying observed elsewhere (North Africa, in particular). However, δ2Hwax values closely correspond to the Indian Ocean west-east SST gradient, suggesting that fluctuations in Indian Ocean zonal (Walker) circulation are the primary control on East African rainfall during this time. Hemispherically synchronous high-latitude cooling around 3 Ma may also influence the observed depletion in δ2Hwax values, as bipolar cooling would compress the Intertropical Convergence Zone equatorward, increasing precipitation in equatorial Africa and the BTB Basin while favoring drying over the subtropics.

Although our understanding of Plio-Pleistocene African climate is far from complete, this new evidence suggests that continental paleoenvironmental conditions were more spatially variable than previously thought. These heterogenous landscapes may have promoted diversification and dispersal during a key period in hominin evolution.

Keywords : isotope geochemistry, biomarkers, paleoclimate, East Africa

Explosive eruptions, tephrochronology and Homo sapiens in the Ethiopian Rift.

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Abstract :

Efforts to date the oldest anatomically modern human fossils in eastern Africa, from Omo-Kibish and Herto in Ethiopia, have drawn on a variety of chronometric evidence, including 40Ar/39Ar ages of stratigraphically associated tuffs. The ages that are generally reported for these fossils are around 197 ka for Omo I, and around 160–155 ka for Herto. However, the stratigraphic relationships and tephra correlations that underpin these estimates have been challenged. Here we report geochemical analyses that link tuffs from the Omo-Kibish and Konso Formations with major eruptions of Corbetti and Shala volcanoes in the Main Ethiopian Rift, between ca. 233 and 150 ka. Notably, we link the Kamoya's Hominid Site (KHS) Tuff, which overlies the member of the Omo-Kibish Formation that contains Omo I, with an eruption of Shala volcano at 233 ± 22 ka, therefore providing a new minimum age for the Omo I fossil. Contrary to previous arguments, we also show that the KHS Tuff does not correlate with another widespread tephra layer, the Waidedo Vitric Tuff, and therefore cannot anchor a minimum age for the Herto fossils. Shifting the age of the oldest known Homo sapiens in eastern Africa to before ~200 ka is consistent with independent evidence for the greater antiquity of the modern human lineage.

Keywords : Ethiopia, volcanic eruption, Homo sapiens, ignimbrite, tephrostratigraphy, Ar/Ar dating

Paleoenvironmental reconstruction in East Africa at a critical period of hominin dispersion out-of-Africa (150-80 kyr).

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Abstract :

Climate may have played a critical role in early hominin evolution and dispersion, with rapid changes from humid to hyper-arid observed in East African palaeoclimate records. Many studies show linkages between these climate changes and hominin speciation and dispersion; however, few of them have focused on annual to decadal climate variability. This new study

presents paleoenvironmental records (diatom assemblages and oxygen isotopes in diatom biogenic silica, d18Odiatom) from the Ol Njorowa Gorge in Kenya. The study site is located west of the African Rift Valley, from where important hominin dispersals are believed to have taken place. The study site preserves a stratigraphic record of interbedded diatomite beds spanning a key period of theorised hominin dispersals; 150,000 to 80,000 years ago. In this study, diatom assemblages and d18Odiatom records are used to understand past changes in moisture and precipitation patterns over East Africa as well as changes in lake water chemistry. d18Odiatom has been used in both lacustrine and oceanic settings since the early 2000s. It is however an under-utilised proxy that holds great potential, especially for diatomites from exposed lake beds where carbonate material is scarce or inexistant. The study also uses high resolution scanning XRF data from diatomite blocks to develop an age model for the diatomite beds at an annual timescale.

Keywords : Paleoenvironmental reconstructions, diatom assemblages, oxygen isotopes, East Africa, hominin dispersion

OSM37: Peatland ecosystem functioning and ecosystem services: How paleoscience and management can feed back to each other

Co-conveners: Morag Angus, Sakonvan Chawchai, Minna Väliranta and Angela Gallego-Sala

Oral

Prescribed burning of peatland vegetation: assessing the role of charcoal in carbon accumulation rates.

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Abstract :

Recent work across multiple ecosystems has found that the prescribed burning of vegetation can prevent severe wildfire impacts, such as the combustion of organic soil carbon. Northern peatlands store vast amounts of carbon in the soil. These large carbon stocks are protected by high water tables, which makes them vulnerable to climate change and the associated increases in droughts and extreme temperatures. Prescribed vegetation burning can be a valuable tool to enhance habitat diversity and mitigate against wildfire impacts within northern peatlands and is practised in many parts of the world. However, in the UK, prescribed burning on heather-dominated peatlands is widely considered to have detrimental impacts, despite the evidence for its effects being both limited and inconclusive. Notably, no study to date has assessed the carbon balance (burn emissions, vegetation uptake during regrowth to maturity, charcoal gains) over an entire management cycle (~20-30 years). Whilst burning vegetation releases considerable amounts of carbon in the short-term (via combustion), subsequent vegetation regrowth and the addition of recalcitrant carbon (charcoal) could potentially outweigh these initial losses. Moreover, alternative management practices might result in unintended consequences, such as an increased risk of wildfire carbon losses due to fuel (biomass) buildup under a no management scenario or long-term carbon losses from brash decomposition under a mowing scenario.

Two recent UK peat core studies have highlighted net carbon accumulation can occur over multiple prescribed burning cycles within heather-dominated peatlands. These studies have been criticised for claiming to show a net carbon budget gain. Crucially, this criticism is not valid as the studies in question only discuss net carbon accumulation, which is entirely different from a net carbon balance (as pointed out in one of the studies). It is important to understand the difference between the two assessments and clarify the value and limitations of peat core carbon assessments. The main criticism stems from the potential of drainage to cause carbon loss from deeper (basal) peat layers, which is not assessed during peat core analysis. A key message is that it is crucial to separate drainage induced carbon storage impacts from any potential prescribed burning impacts. Worryingly, such confounding is prevalent within the UK prescribed burning evidence base, which may explain why many studies conclude that prescribed vegetation burning damages peatlands.

This talk will (1) present recent peat core findings, (2) discuss the criticisms of these findings by highlighting the importance of focusing on the stated study aims, presented data and outlined caveats, and (3) provide additional carbon flux data and carbon budgets. We will also explore the need to consider the confounding impact of drainage and the potential importance and limitations of peat carbon data. The talk will conclude by considering how carbon accumulation rates obtained from peat cores and carbon budget estimates based on carbon fluxes can be used to inform an evidence-based discussion about future management options within heather-dominated peatlands.

Keywords : Peatlands, fire, management, carbon, charcoal

Influence of melioration, peat exploitation and introduction of pine plantations (Pinus sylvestris) on the ecosystem of the Bagno Chlebowo.

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Abstract :

Peatlands serve many important functions in the environment. One of them is storing of carbon, therefore peatlands have a significant impact on climate change. Moreover, they are mainstays of biotic diversity and are responsible for capturing nitrogen and phosphorus compounds from water and its retention. Peat is a source of information incl. changes in vegetation, water conditions, carbon accumulation and fire activity. Unfortunately, peatlands are subject to progressive degradation as a result of changes in hydrological conditions (mainly as a result of melioration) and their exploitation for peat. This leads to the release of macronutrients stored in the peat into the waters and decreasing role of peatlands in biodiversity protection and water retention. In addition, when the peatland is drained, carbon dioxide (CO2) is released, which contributes to the increased greenhouse effect. Many peatlands in Poland are located in forests, which in the last 250 years have been transformed into pine monocultures. This way of forest managing makes them less resistant to different types of disturbances i.e. fires, strong winds or insect outbreaks.

During the PAGES OSM meeting I will present preliminary results of my ongoing project, which aims to investigate the effects of melioration, peat exploitation and introduction of pine plantations (Pinus sylvestris) to the ecosystem of the Bagno Chlebowo located in Noteć Forest, Poland. Changes in hydrological conditions were estimated on the basis of the analysis of testate amoebae which, due to their high sensitivity to water level changes are appropriate bioindicators.

The obtained results deepen the knowledge of how significant changes in forest management and the conducted operations affect the peatland ecosystem. Moreover, these results contribute to a better understanding of the functioning of peatlands that are highly influenced by human pressure and climate change. In addition, this is the first study documenting the transition from natural forests to artificial monocultures on the Bagno Chlebowo.

Keywords : peat exploitation, peatlands, pine plantations, paleoecology, forest management

Palaeoecological reconstruction of permafrost degradation in NW Siberia – a multiproxy approach.

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Abstract :

Instrumental climate data show that Siberia is warming faster than other parts of the Earth and future predictions reveal a steady rise in air temperature. Warming contributes to heatwaves, droughts, and massive wildfires. Rising air temperatures accelerate permafrost thaw causing irreversible changes in the ecosystems of northern peatlands. However, the process of the Siberia permafrost thawing, and its long-term consequences is still poorly explored. In NW Siberia, the relevant archives of environmental history are peatlands. Therefore, the main aim of this project is to investigate the past climate variability, history of permafrost thaw, and environmental feedbacks in NW Siberia over the last 2000 years based on peat cores and surface samples. We plan to apply a multi-proxy approach with high-resolution sampling (1 cm) using four peat monoliths from the Khanymey region. We will apply testate amoebae analysis to reconstruct water table

changes, plant macrofossils and pollen analysis to trace transformation in local and regional vegetation as well as charcoal analysis to reconstruct fire regime shifts. The high-resolution chronology will be based on radiocarbon dating. To identify sedimentological and geochemical changes, a non-destructive XRF analysis will be performed. Moreover, based on 76 surface samples collected in the same area, the new local transfer function (relationship between testate amoebae communities and the water table depth) for these peatlands will be constructed. Our study will help to create a synthesis of patterns, relationships and feedbacks caused by climatic shifts causing permafrost degradation in the region.

This research was funded in the framework of the National Science Centre (grant no. 2019/35/O/ST10/02903) and INTERACT No. 730938 – PeatHOT project.

Keywords : permafrost, peatlands, Siberia, testate amoebae

Modelling alluvial peatland development at Holocene timescales.

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Abstract :

It is well established that the rates of carbon accumulation are higher for short-term measurements in active peatlands, compared to the long-term carbon accumulation rates found in for example paleoecology studies. When selecting effective measures or management options focussed on sustaining or increasing the rates of peat growth and hence carbon storage, a proper understanding of the factors controlling carbon dynamics in peatlands at longer timescales is imperative. Multiple peatland models have been constructed to simulate peatland dynamics at longer timescales and such models can be a very useful tool to study the interactions between peatland development at centennial to millennial timescales and environmental conditions and management actions. While most of these models make the assumption that peat forms in a geomorphically stable environment, this assumption cannot be always be made for river floodplains. For example, many river valleys in temperate Europe have experienced phases of active peat growth during the Holocene, influenced by the geomorphic dynamics of the local river network and the associated sediment dynamics. Even more, many restoration schemes for alluvial environments are accompanied by allowing the channels to move more freely, including more natural channel behaviour and increased meandering. As the effects of these geomorphic dynamics are currently missing in the available models, a proper assessment of the relationship between long-term peatland development and river network dynamics remains difficult.

In this study, we constructed a new peatland modelling tool, specifically developed for floodplain settings, by coupling a modified version of an existing peatland model (Digibog 1D) with a river basin water balance model (STREAM). By combining the model with pollen-based climate and land cover reconstructions and stratigraphic cross-sections of the Holocene floodplains deposits, a detailed simulation of the alluvial peatland evolution can be made for several case-studies. This modelling framework allows to study the effect of changes in river network properties and river discharge on alluvial peat growth and the associated carbon dynamics. The model was applied to two contrasting case-studies: lowland river basins in the European loess belt (Dijle river basin) and sand belt (Grote Nete river basin). Peatland development was simulated over the entire Holocene period with an annual resolution under a variety of land cover and climate scenarios, as well as different channel properties (channel slope, roughness, channel dimensions and number of channels). The simulation results indicate that variations in discharge as a result of land cover and climatic changes have a limited effect on alluvial peat growth as discharge differences mostly impact the magnitude of peak events. The local river network configuration (position of the channels, relative to the peat surface and the number of channels) on the other hand have a strong effect on the resultant peat thickness, with a threefold increase in peat thickness for a fourfold reduction in the number of channels in the floodplain. These results indicate that measures impacting the river network configuration such as raising the river bed and reducing the number of channels can be

effective management strategies to promote alluvial peat growth.

Keywords : Holocene, peatland modelling, river floodplains, peatland management

Nineteenth century agricultural 'improvements' transformed moorland vegetation.

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Abstract :

Upland peatlands are nationally and internationally important habitats. They can provide a range of ecosystem services, including climate change mitigation, water supply and cultural services (e.g. recreation, archaeological preservation). Vegetation and ecological functioning are essential components in providing these services, but many peatlands are considered ecologically degraded as a result of human activities (e.g. burning, peat-cutting, drainage).

On Exmoor (South West England), reversing the effects of historical drainage (and other interventions) is often the focus of restoration activities. The nineteenth century was a period of enclosure and extensive landscape-scale drainage on Exmoor, which began with the sale of the Royal Forest area (c. 60 km2) to the Knight family in 1818. This was part of a drive towards the agricultural 'improvement' of the moor: a practice that encompassed economic, cultural and philosophical ideas. Understanding the effects of these historical 'improvement' schemes on vegetation and ecological functioning is important for informing restoration activities. To develop this understanding, long-term ecological context is essential, and this is being developed through a combination of palaeoecological (pollen, coprophilous fungi, microcharcoal, etc) and historical (archival research) analyses.

Multivariate and regression analyses indicate that the nineteenth century was a notable period of ecological change on Exmoor. Changes in land management associated with nineteenth century agricultural 'improvement' (e.g. peatland drainage, increased grazing intensity, increased burning intensity) may have rapidly altered moorland ecosystems on Exmoor, leading to less diverse, more monocot-dominated vegetation. However, the precise nature of changes in management, and their ecological effects, were spatially and temporally non-uniform. They also occurred in the context of more gradual, centennial-scale ecological processes, including non-linear, long-term declines in Sphagnum. There is no evidence for stable, pre-disturbance ecological baselines.

Keywords : Interdisciplinary, Restoration, Pollen, Coprophilous fungi, Microcharcoal

Repeated boreal permafrost peatland fires in Western Canada – implications for peatland ecosystem carbon functioning.

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Abstract :

Wildfires have a crucial role in northern boreal peatland ecosystems as a driver of ecosystem functioning affecting factors such as vegetation composition and biomass, peat accumulation patterns and soil carbon (C) stocks. These northern permafrost peatland ecosystems are under pressure due to the warming climate conditions and increasing anthropogenic impact. The frequency and severity of wildfires

is predicted to increase in the future and therefore knowledge of the long-term natural fire dynamics and its effects on the peatland ecosystem functioning could provide significant information for peatland management in changing environmental conditions.

To investigate the effect of long-term fire dynamics on vegetation succession on northern boreal peatlands we analyzed macroscopic charcoal and plant remains from five boreal peatland sites in western boreal Canada over the last 1500 years. To assess the changes in long-term carbon storage we analyzed carbon and nitrogen accumulation rates from one of the sites during last millennia. To examine the overall trend in peatland fires in our study region all macroscopic charcoal records were pooled together and 100 year moving average was calculated.

In general, all studied sites demonstrate repeated fires during last 1500 years suggesting that fires have been integral part of the peatland ecosystems in Western Canada. When all charcoal records are considered, highest abundance of charcoal occurs during the period from 1300 EC to1600 EC after which there is indication of decreasing fire activity during last centuries. The clear increase in the abundance of Sphagnum after fire periods suggest relatively rapid recovery of the mire ecosystem after fires. The regeneration of the pre-fire vegetation composition in long-term perspective suggests that natural fire regime may not have negative effect on carbon storage and peatlands could remain as carbon sinks, if left in natural succession after fire.

Our results demonstrate that in natural conditions peatlands are resilient ecosystems and in long-term perspective can maintain their role as diverse habitats and carbon storage. Therefore, in the future we should strive to preserve northern peatland ecosystems, and the knowledge of long-term ecosystem dynamics, such as past disturbances and vegetation composition and succession, obtained from paleorecords should be acknowledged in the peatland management plans.

Keywords : Boreal peatlands, fire, carbon storage, charcoal, plant macrofossils

Fire in tropical peatlands during the last 2000 years

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Abstract :

In tropical peatland soils, carbon has been slowly accumulating over millennia under anaerobic conditions, preserving palaeoenvironmental records which can be used to reconstruct past climate and human impact. Destabilised peatlands with reduced hydrological conditions are at increased risk from fire, and are highly vulnerable carbon-dense ecosystems that can shift rapidly from being carbon sinks to carbon sources. However, we have little knowledge about the fire history of peatlands, especially for those located in tropical regions. Here, we compile 76 charcoal records across the tropical region in order to examine the temporal and spatial variability of fire regimes over the past 2 ka. To better understand the linkages between fire regimes and climate at a regional scale, as well as human influence on fire, the whole tropical region was divided into three sub-regions: the Neotropics, Africa, and Australasia. We applied two different transformation methods (z-score and proportional relative scaling) to the raw

charcoal data to better describe fire patterns, and the two methods agreed well in terms of general trends over the last two millennia. Preliminary results suggest that the Australasian region experienced the clearest increase in fire regime during the last 100 years among the three regions, while the other regions present a more mixed signal. During the last 2000 years, the composite charcoal records for the Neotropics and Australasian region show an opposing trend.

Keywords : peatland, fire, charcoal record, Holocene

Poster

11500 years in 12 metres – palaeohydrology and volcanic dust in the stable growing Sphagnum peatland in CE Europe.

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Abstract :

The Linje peatland is located in northern Poland, near the city of Bydgoszcz. It is a particularly valuable and unique site for palaeoecological studies as it contains an uninterrupted peat core that is 11,500 years old. It is the only investigated site from Poland, where the existence of a stable peat bog was confirmed for such a long time. Palaeohydrological analysis was performed using testate amoebae at 5 cm resolution. The dominant species in most of the samples along the timescale that begins ca 9540 years BCE were Amphitrema flavum and Hyalosphenia papilio, which indicate moist conditions with an average depth to the water table – 7.6 cm. Date ca 1740 yrs CE is a threshold when species such as Arcella discoides, Assulina muscorum, Cyclopyxis arcelloides, Nebela militaris, Nebela tincta and Trigonopyxis arcula, Assulina muscorum, Assulina seminulum and Heleopera petricola dominate, which represent a drop in the average depth to the water table to 21.6 cm.

Simultaneously, the search for cryptotephra (volcanic glass shards) has been undertaken, whichwas intended as a supplementary radiocarbon dating method. The knowledge of the presence of cryptotephra populations allows the construction of a robust chronological framework and events stratigraphy of the peat bog. The whole core was divided into 10 cm monoliths, which were burned, and the remaining material was sieved, density separated and searched for volcanic glass shards. The cryptotephra particles have been identified, however in very small concentrations at depth 60-70 and 410-420 cm. Detailed screening for cryptotephra, undertaken at these depths with 1 cm resolution allowed to identify only a few glass shards at depths of 62- 63 (3985 +/- 40 cal. BP), 65-66, 412-413 (1140 +/- 30 cal. PB) and 418-419 cm. Their concentration was too small to allow for the extraction of the material for further geochemical analyses, however further tests of recovery of the volcanic glass shards from the peat are ongoing.

These preliminary results will soon be enriched with information on pollen, plant macrofossils and microphenology based on the subfossil dwarf birch leaves. The palaeobotanical record will help to reconstruct the dynamics of the past vegetation composition and changes in the length of the growing season. The knowledge gained from the palaeohydrological is expected to provide a better understanding of long-term changes in the peatland ecosystem that cover the entire Holocene period.

The research on cryptotephra was supported by National Science Centre (Poland) grant nr 2019/03/X/ST10/00488

Keywords : peatland, paleoecology, testate amoebae, cryptotephra

OSM38: Ice-sheet variability and behavior through the lens of geologic data and numerical modeling

Co-conveners: Aaron M. Barth, Paul Dunlop, Josh K. Cuzzone, Shaun A. Marcott and Petra Langebroek

Oral

Net effect of ice-sheet-atmosphere interactions reduces simulated transient Miocene Antarctic ice sheet variability.

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Abstract :

Benthic δ18O levels vary strongly during the warmer-than-modern early- and mid-Miocene (23 to 14 Myr ago), suggesting a dynamic Antarctic ice sheet (AIS). So far, however, realistic simulations of the Miocene AIS have been limited to equilibrium states under different CO2 levels and orbital settings. Earlier transient simulations lacked ice-sheet-atmosphere interactions, and used a present-day rather than Miocene Antarctic bedrock topography. Here, we quantify the effect of ice-sheet-atmosphere interactions, running IMAU-ICE using climate forcing from Miocene simulations by the general circulation model GENESIS. Utilising a recently developed matrix interpolation method enables us to interpolate the climate forcing based on CO2 levels (between 280 and 840 ppm) as well as varying ice sheet configurations (between no ice and a large East Antarctic ice sheet). We furthermore implement recent reconstructions of Miocene Antarctic bedrock topography. We find that the positive albedo-temperature feedback, partly compensated by a negative feedback between ice volume and precipitation, increases hysteresis in the relation between CO2 and ice volume. Together, these ice-sheet-atmosphere interactions decrease the amplitude of Miocene AIS variability in idealised transient simulations. Forced by quasi-orbital 40-kyr forcing CO2 cycles, the ice volume variability reduces by 21% when ice-sheet-atmosphere interactions are included, compared to when forcing variability is only based on CO2 changes. Thereby, these interactions also diminish the contribution of AIS variability to benthic δ18O fluctuations. Evolving bedrock topography during the early- and mid-Miocene reduces ice volume variability by 10%, under equal 40-kyr cycles of atmosphere and ocean forcing.

Keywords : Antarctica, Miocene, ice sheet, CO_2, paleoclimate

Using Parametrically and Temporally Varied Ensembles to Reconstruct the Greenland Ice Sheet of MIS-11.

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Abstract :

Reconstructing the evolution of the Greenland ice sheet (GrIS) prior to the Last Interglacial (ca. 130-115 kya) remains challenging owing to the limited availability of records that can offer constraints on ice extent. However, sea-level reconstructions, paleo-temperature records, and pollen deposits on Greenland considered to be local in origin all indicate a warm period of substantial length during the Marine Isotope Stage 11 interglacial, one that possibly produced the most extensive melt of the GrIS in the last 800 kyr. In this study, we examine constraints on GrIS melt during the MIS-11 interglacial by extracting climate forcing from several time-slice simulations of the CESM climate model to drive the advanced Glacial Systems Model (GSM). To address GSM parametric uncertainty, we use a high variance posterior distribution of ice-sheet ensemble parameter vectors from an approximate Bayesian calibration of the GSM for the last glacial cycle of the GrIS. We also examine the temporal uncertainties that arise from both the relatively low temporal resolution of constraining proxy records (O~1000 years) and

the initial state of the ice sheet. This is done by utilizing various ice topologies from calibrated simulations of the last deglaciation as the initial conditions, varying the corresponding initialization time across a window in the early stages of interglacial conditions in MIS-11. Thus, we attempt to account for the considerable uncertainties in ice topology, thermal profiles, etc. during the early phase of deglaciation in MIS-11 by capturing the probable range of initial states. We will present analyses demonstrating the sensitivity of the overall magnitude of melt of the GrIS, and its topographic arrangement during this period, with regard to both the initial conditions and choice of ice-sheet model parameters.

Keywords : interglacial climate, MIS-11, ice-sheet modeling, CESM

Patagonian Ice Sheet reconstruction through the Marine Isotope Stages 3 and 2 using numerical modeling and geological constraints.

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Abstract :

The Patagonian Ice Sheet (PIS) covered the central chain of the Andes between 38°S to 55°S during the Last Glacial Maximum (LGM, 23,000 to 19,000 years ago). While its western margin reached the Pacific Ocean, the easternmost sectors of the PIS were characterized by terrestrial lobes. Paleoclimatic evidence suggests that maximum ice sheet expansions in the Southern and Northern Hemisphere were not synchronized. However, large uncertainties still exist in the timing of the onset glaciation as well as its major drivers. Ice sheet modeling combined with glacial geochronology and paleoclimate reconstructions can provide information on the PIS geometry, ice volume and its contribution to the sea level during the LGM. It can also help to test different paleoclimate scenarios and identify climate models that capture regional climate responses to the global change in a realistic manner.

We present an ensemble of steady state and transient numerical simulations of the PIS that have been carried out to provide information on its thickness and extent at the LGM and through the Marine Isotope Stage (MIS) 3 and MIS 2. Our aim is to determine the range of climate conditions that matches the field-derived ice sheet geometries and the timing of local deglaciation, while bracketing the spread in possible ice volumes and sea level contributions originating from uncertainties in the internal parameters and external forcings. The model ensemble makes use of the new version of the ice sheet model SICOPOLIS forced by a combination of present-day atmospheric conditions from the ERA5 reanalysis and outputs from the Paleoclimate Modeling Intercomparison Project (PMIP) and new Community Earth System Model (CESM) experiments. Our results indicate that the regional climate conditions required to reproduce a realistic growth and demise of the PIS through the Late Quaternary are not captured by current coarse-resolution global climate models, implying a need for high spatial-resolution regional modeling. Our results also suggest that in order to realistically simulate the evolution of the PIS in agreement with geological archives, the MIS 3 should have witnessed colder regional temperatures in and around Patagonia.

Keywords : Ice-Sheet, Patagonia, Numerical Modeling, Last Glacial Maximum

Ocean temperature forcing in glacial-interglacial Antarctic Ice Sheet simulations.

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Abstract :

Ice shelf basal melt accounts for about half the present-day ice loss from the Antarctic Ice Sheet, and is important for both ice sheet mass balance and as a source of fresh water into the Southern Ocean. In Antarctic Ice Sheet simulations over Quaternary glacial cycle time scales, neither basal melt rate nor its principal oceanographic controls (temperature and salinity of waters adjacent to ice shelves) can be reconstructed directly from proxy records. Strong ice-ocean-atmosphere interactions suggest a coupled ice-ocean-atmosphere modelling approach is most appropriate for calculating basal melting, but the computational demands are prohibitively expensive except at short time scales. Stand-alone ice sheet simulations can cover much longer time scales at reasonable resolution, but then require an ocean forcing that is parameterised indirectly from alternative proxy records, or interpolated/extrapolated between/beyond simulated ocean states. Here we compare the strengths and weaknesses of three methods for establishing an ocean temperature forcing: (i) proxy reconstructions of North Atlantic or circumpolar deep water temperatures north of 43°S; (ii) an ice sheet air temperature reconstruction, damped and lagged by a linear response function; and (iii) a glacial index method which interpolates between CMIP6 lig127k (interglacial) and lgm (glacial) end-member ocean states. We find considerable differences in the rates and magnitudes of the Antarctic Ice Sheet contribution to past sea-level changes when applying the three methods in simulations over the last two glacial cycles. Geological evidence provides some guidance on which modelling choices are most appropriate. However, the ocean temperature forcing remains as an important but poorly-constrained boundary condition, whether investigating past warm climates or using long simulations as a spin-up for future projections.

Keywords : Antarctica, ice sheet, ice shelf, interglacial, Southern Ocean

OSM39: Obliquity vs precession: How long exactly is a 100-ka cycle and does it even exist?

Co-conveners: Martin Kölling, Mark Maslin and Lennert Stap

Oral

Precession at least as important as obliquity in pacing Late Pleistocene glacial terminations.

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Abstract :

The mechanism responsible for ~100-kyr cyclicity in Late Pleistocene glaciations is one of the most enduring questions in paleoclimate. Recent studies (Huybers, 2011; Tzedakis et al., 2017; Bajo et al., 2020) have identified that both obliquity and precession forcing affect the timing of Late Pleistocene glacial cycles and often suggest that obliquity is more fundamental to 100-kyr pacing than precession. In contrast, Raymo (1997) and Lisiecki (2010) proposed that 100-kyr cycles were paced by the amplitude modulation of precession. Distinguishing whether one orbital cycle is more important than the other depends on both age model accuracy and the metric used to measure orbital influence. Because precession is the shorter cycle, its apparent influence is disproportionately diminished by age model uncertainties and noise in climate proxy records.

We investigate the roles of precession and obliquity in triggering terminations by measuring the orbital phases associated with termination onset in North Atlantic benthic δ18O records. Non-orbitally tuned ages are generated by correlating North Atlantic ice-rafted debris (IRD) peaks to well-dated weak monsoon intervals (WMI) in Chinese speleothems (Cheng et al., 2016). Multiproxy probabilistic stacking software, called BIGMACS (Lee and Rand et al., in prep), is used to generate a 650-kyr stack of eight North Atlantic benthic δ18O records, enhancing the signal-to-noise ratio of the proxy signal. Multiple sources of uncertainty impact the age estimates of the stack, including IRD-WMI tie point identification, speleothem age uncertainty estimated by StalAge (Scholz and Hoffman, 2011), and benthic δ18O alignment during stack construction. Including all sources of uncertainty, the average standard deviation for the age of identified termination events is 3.9 kyr. Using these non-orbitally tuned termination ages, the durations of the last six glacial cycles vary from 91 to 117 kyr, with a mean of 102 kyr.

The effects of precession and obliquity on termination timing are evaluated using the Rayleigh's R statistic for the orbital phases of terminations, as in Huybers and Wunsch (2005). The obliquity and precession phases at the start of the seven most recent glacial terminations, as well as two termination-like events (TIIIa and TVIIa), generate Rayleigh's R values of 0.71 for precession and 0.66 for obliquity, both of which exceed the critical threshold for statistical significance. Given that precession has a slightly higher R value than obliquity, precession appears at least as important as obliquity in triggering glacial terminations. When considering the larger effects of age uncertainty on phase estimates for shorter cycles, precession likely has a stronger influence than obliquity. Thus, we conclude that the onset of glacial terminations corresponds most strongly with changes in precession, and secondly with increasing or above average obliquity.

Keywords : precession, obliquity, glacial terminations, 100 kyr cycles, Late Pleistocene

Links between orbital eccentricity and Late Pleistocene 100-kyr glacial cycles.

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Abstract :

Spectral analysis easily identifies responses to obliquity and precession in Late Pleistocene climate proxy records, but the climatic effects of orbital eccentricity are more difficult to assess. Although Late Pleistocene climate variability is

dominated by ~100-kyr power, the 100-kyr eccentricity cycle produces negligible 100-kyr power in seasonal or mean annual insolation. One way in which eccentricity may affect glacial cyclicity is through nonlinear climate responses to amplitude modulation of the precession index. Alternatively, several recent studies have argued that Late Pleistocene glacial cycles are more fundamentally driven by obliquity, with glacial terminations triggered every two or three obliquity cycles.

A link between eccentricity and the 100,000-yr glacial cycles has been established using cross-wavelet phase analysis of orbital eccentricity and benthic d18O records (Lisiecki, 2010). This method demonstrates that the eccentricity phase of 100-kyr glacial cycles has been stable since 1.2 Myr ago. The Rayleigh's R statistic for these phase results is sufficiently high to reject the null hypothesis that 100-kyr glacial cyclicity is independent of eccentricity. Because ~100-kyr power in the climate is phase locked to orbital eccentricity, Late Pleistocene glacial cycles can reasonably be described as "100-kyr cycles." However, the precise timing of the transition between glacial and interglacial states within each eccentricity cycle is also sensitive to the phases of obliquity and precession forcing.

Neither glacial cycle lengths nor termination timing suggest that obliquity has a more fundamental influence on Late Pleistocene glacial cycles than eccentricity or precession. First, eccentricity apparently determines whether terminations are separated by two or three obliquity cycles such that glacial cycles remain phase locked to eccentricity. Second, new non-orbitally tunes age estimates for the last seven glacial terminations range in obliquity phase by approximately 180 degrees. The obliquity phase of these terminations varies slightly more than their eccentricity and precession phases. Thus, we advocate for a holistic view in which glacial cycles are affected by all three orbital parameters. A more nuanced understanding of the ways each orbital parameter influences glacial cycles might be achieved by (1) comparing distribution of spectral power in each orbital band for different parts of the climate system and (2) identifying models that accurately simulate the substage variability of Late Pleistocene glacial cycles.

Keywords : Pleistocene, glacial cycles, orbital forcing, eccentricity, benthic d18O

On the Cause of the Mid-Pleistocene Transition.

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Abstract :

The Mid-Pleistocene Transition (MPT), where the Pleistocene glacial cycles changed from 41 to ~100 kyr periodicity, is one of the most intriguing unsolved issues in the field of paleoclimatology. Over the course of over four decades of research, several different physical mechanisms have been proposed to explain the MPT, involving non-linear feedbacks between ice sheets and the global climate, the solid Earth, ocean circulation, and the carbon cycle. Here, we review these different mechanisms, comparing how each of them relates to the others, and to the currently available observational evidence. Based on this discussion, we identify the most important gaps in our current understanding of the

MPT. We discuss how new model experiments, which focus on the quantitative differences between the different physical mechanisms, could help fill these gaps. The results of those experiments could help interpret available proxy evidence, as well as new evidence that is expected to become available.

Keywords : Mid-Pleistocene Transition, Milankovic, glacial cycles, climate feedbacks

"100ka" cycles as phases with increasing numbers of failed interglacials.

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Abstract :

We suggest interpreting post MPT quasi 100ka cyclicity as - mostly obliquity driven - phases with increasing numbers of failed interglacials. The focus is on mechanisms, that occur during glacials and that might control, whether a

subsequent insolation peak leads to a full interglacial or not.

Sulfide oxidation controlled carbon release (SOCCaR) on shelves exposed at low sea levels has been suggested as such a mechanism. While the effect of SOCCaR alone is likely too small to be the sole driver, there should be a similar negative feedback of organic matter oxidation in upper shelf sediments exposed during glacials (just like the currently discussed positive feedback of organic substance exposed by thawing permafrost).

Assuming the shelf inventories of pyrite and organic substance decomposable by exposure to atmospheric oxygen are limited, and the loss on exposed shelves during glacials is greater than the recharge during interglacials, that reservoir is shrinking over time.

The MPT might simply be the phase, when the size of this resevoir fell below a threshold magnitude. With the negative feedback missing during the glacial, the system fails to recover to a fully interglacial state. Only when the system gets even colder in the next low-insolation period and the sea levels get lower, deeper untouched parts of the shelf reservoir get exposed to the atmosphere and the positive feedback becomes active as befort the MPT allowing for a full interglacial recovery.

Following this theory, a stepwise increase in the length of glacial cycles is expected.

Keywords : 100 ka cycle, obliquity, failed interglacial, sulfide oxidation, shrinking reservoir

Poster

Half-precession signals in marine an terrestrial records – connecting IODP/ICDP sites from the equatorial Atlantic to Greenland.

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Abstract :

The characteristics of half-precession (HP) cycles (~9,000 - 12,000 years) is still poorly understood, despite their appearance in numerous records. We analyse HP signals in a variety of different marine and terrestrial proxy records from Europe and the Atlantic Ocean, investigate the temporal evolution of the HP signal from the early/middle Pleistocene to the present, and evaluate the potential of the HP to reflect the connectivity of climate systems over time.

We apply filters on the datasets that remove the classical orbital cycles (eccentricity, obliquity, precession) and high frequency signals, and to focus on the bandwidth of HP signals. Wavelet annalysis and correlation techniques are used to study the evolution of specific frequencies through the different records.

In addition to a connection of HP cycles with interglacials, we observe a more pronounced HP signal in the younger part of several proxy records. Besides, we observe a trend of more pronounced HP signals in records which are closer to the African continent compared to high latitude records. This is in agreement with the assumption that HP is an equatorial signal and can be transmitted northward via various pathways. The appearance of HP signals in mid- and high-latitude records may thus be an indicator for the intensity of the transporting mechanisms. We suggest that the African Monsoon plays a major role in this context, as its magnitude directly influences the climate systems of the Mediterranean and Southern Europe. The consequential next step is to investigate the alleged origin of the HP signal at the equator and to test records from low latitudes specifically for HP. In order to better understand the African climate variability, both equatorial marine and terrestrial records will be examined with respect to HP.

Keywords : Half-precession, IODP/ICDP, African Monsoon

OSM41: Towards a global past human land-use and land-cover synthesis over the Holocene

Co-conveners: Nicki Whitehouse, Kathy Morrison, Marco Madella, Anupama Krishnamurthy and Andria Dawson

Oral

Holocene vegetation history of the Pontic Steppe in southern Ukraine under changing land use and climate.

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Abstract :

Humans drastically increased their impact on vegetation when they changed from nomadic hunter and gatherers to sedentary farmers at the Mesolithic–Neolithic transition. In Europe, this so-called "Neolithisation" started more than 8000 years ago and had a big impact on the environment and the biosphere, e.g. through the introduction, propagation, reduction or extirpation of species as well as through increased erosion, fire, and eutrophication. Disentangling the ecological legacy of prehistoric land use from the natural climate-driven trajectories is important for correct assessments of future European ecosystem dynamics.

Holocene vegetation history of most of Europe's vegetation types has been studied for decades. However, there is little information available of Holocene vegetation changes related to climate and human impact in Eastern Europe, and even less concerning the Pontic steppe region. As a matter of fact, the complete lack of high-resolution studies and the usually poorly constrained chronologies so far prevented assigning vegetation shifts to specific climatic events detected in independent reconstructions or to archaeological findings.

Here, we present a novel palaeoecological record (pollen and charcoal), from the Kardashinski swamp in southern Ukraine, including two high-resolution sections (contiguous sampling), to contribute to filling the knowledge gaps in the vegetation history of this region. A robust and detailed chronology based on 15 AMS radiocarbon dates on terrestrial plant macrofossils allows assigning precise ages to the main vegetation changes reconstructed from the pollen record. Our results show that throughout the past 8200 years, the steppe was always the dominant vegetation. However, pollen data also suggest the presence of broad-leaved tree stands in the floodplain of the Dnieper from c. 8000 cal BP until c. 6100 cal BP, when they declined massively. Possibly, this decline was caused by a climatic change towards more arid conditions, recognized in other, pollen-independent paleoclimatic studies. The influence of humans on vegetation was initially very small and increased only in the last c. 2400 years.

Keywords : Palaeoecology, vegetation dynamics, human impact, pollen analysis

Reconstructing the Holocene land cover evolution of NE Belgium: an evaluation of population-based and pollen-based approaches in contrasting settings.

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Abstract :

Several methods to reconstruct past land cover are available which can be roughly divided into population-based and pollen-based approaches. The two most widely used population-based scenarios – KK10 and HYDE – do not agree on the timing and scale of anthropogenic land cover change (ALCC) throughout the Holocene. By performing pollen-based reconstructions of past land cover and comparing them with the ALCC scenarios, the accuracy of these models could be further improved. The most widely applied pollen-based approach is the Landscape Reconstruction Algorithm submodel REVEALS, yet it requires some parameters that are not

always available. In that case, non-metric multidimensional scaling (NMDS) of pollen data could be useful to provide insights in vegetation changes related to human impact.

REVEALS and NMDS were applied to a database containing all suitable pollen sequences for NE Belgium to obtain the first regional (semi-)quantitative estimates of landscape openness for this area. The pollen records were obtained from multiple alluvial floodplains located in contrasting settings: the central Belgian loess belt and the sandy Campine region. From the Neolithic period onwards, deforestation is detected in both regions, although the loess belt underwent a more rapid and severe land cover change characterized by a transformation from forest to cropland. The REVEALS and NMDS outcomes are not corresponding very well for the sandy region, which can be explained by the fact that its prevailing transformation from forest to pasture is less detectable using NMDS than REVEALS. On the other hand, the outcomes for the loess belt are so similar that NMDS could serve as an alternative for REVEALS to detect land cover changes. Moreover, the NMDS analysis seems to detect the first phase of land cover change in the loess belt better than the REVEALS-based land cover reconstructions, which might help to pinpoint the onset of significant human impact on the landscape more precisely.

Comparison of the ALCC scenarios with a historical land cover map and the obtained REVEALS-based land cover reconstructions indicates a consistent underestimation of landscape openness in NE Belgium – with increasing magnitude in the past – by the HYDE scenario. The discrepancy between the KK10 and REVEALS outcomes is initially large but this relationship improves towards the most recent millennia. However, while the historical land cover maps and pollen-based reconstructions indicate quite some variability between the catchments located within the loess belt, this variability is reflected by neither of the ALCC scenarios. At the moment, none of the two ALCC scenarios does take into account historical, archaeological and palaeoecological data that could indicate from when on and to what extent the potential for agriculture in a particular area was used. Including pollen data obtained from alluvial sites could not only improve the spatial coverage and accuracy of pollen-based land cover reconstructions but also improve our understanding of human transformation of the landscape, given that alluvial sites often experienced early anthropogenic impact.

Keywords : pollen, REVEALS model, NMDS, anthropogenic land cover change, alluvial floodplains

Uncovering regional land-cover changes in Australia using pollen-based models.

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Abstract :

During the late Quaternary, two main phases of human-driven landscape transformation occurred across the Australian continent: the earliest relating to the arrival of Aboriginal people (between 70,000 and 50,000 years ago) and the latest resulting from the British invasion (post 1788 AD). Debates exist about the land use modifications brought by Australian Aborigines and British colonials, and their effects on landscapes and biodiversity. Many of these revolve around the degree to which the nature and degree of Aboriginal cultural burning was used to rejuvenate patches of land and preserve treeless vegetation for game and cultural purposes and the different fire regimes and

landscape management implemented by the British across the continent.

The quantification of past land cover is needed to inform such debates. Pollen is the key proxy to track past vegetation changes, but pollen spectra suffer from some important biases relating largely to taphonomy, pollen productivity and dispersal capability. Many pollen records are dominated by pollen from a few high pollen-producing plant taxa, which mask the less productive taxa. In effect, there is a non-linear relationship between pollen percentages and plant cover. Estimating past vegetation cover from sedimentary pollen composition requires correction for productivity and dispersal biases using empirical-based models of the pollen-vegetation relationship. Such models for quantitative vegetation reconstruction (e.g. REVEALS) have so far been mostly applied in the Northern Hemisphere over the last 15 years - here we present recent applications of this methodology to Australia. We show the quantification of land cover changes through pre- and post- British invasion on multiple records (n=160) across the southeastern component of the continent. This represents the first regional application of REVEALS within Australia.

We provide the first empirical evidence that the regional landscape before British invasion (up to 1,000 years ago) was a cultural landscape with limited tree cover as maintained by Aboriginal people through cultural burning. After colonial settlement in 1788, cultural burning was suppressed in much of the country. Historical descriptions of southeast Australian vegetation suggest vegetation thickening in some of today's worst fire-affected zones since the cessation of Indigenous landscape management. Focusing on this transition, we quantified the regional effects on land-cover change, including woody fuel abundance and connectivity. We found that the southeastern Australian forests and woodlands have experienced increases in woody biomass in the last ca. 200 years. Our findings suggest that the removal of Indigenous vegetation management has altered woodland fuel structure and that much of the region was predominantly open before colonial invasion. These data contribute to an emerging pattern of widespread fire-regime disruption and forest fuel accumulation following European colonization across the globe. When combined with climate change impacts on fire weather and drought, it is shown that non-Indigenous fire management practices have played an important role preconditioning already fire-prone regions for unprecedented wildfires. Our deep-time data reaffirm Indigenous narratives about cultural burning, highlighting the need to embed these practices into wildfire management.

Keywords : pollen, REVEALS, Australia, cultural landscapes, wildfires

Chemical fingerprinting of grass pollen: a tool for wild and domesticated species discrimination?

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Abstract :

Numerous pollen records that document the vegetation history through the Holocene exist; and they have been widely used to describe land-use changes during human history. However, when it comes to cereal cultivation, pollen is an underdeveloped archive due to the challenges of classifying Poaceae pollen based on their morphology (Fægri et al. 1989, Schüler, and Behling 2011). Recent studies have successfully classified modern Poaceae pollen grains using their 'chemical fingerprint' obtained by Fourier Transform Infrared (FTIR) spectroscopy (Jardine et al. 2019, Julier et al. 2016, Diehn 2020) and our research intends to use this approach to overcome such classification difficulties.

Both untreated and acetolysed pollen grains were used in our study of 18 common wild grasses and cultivated cereal species. The chemical fingerprints of the wild and domesticated Poaceae species were used as a reference library to train supervised classification algorithms and evaluate the accuracy of their predictions. For these models spectra from pollen populations and single pollen grains were used. Models with spectra from pollen populations achieved 80%

classification success, while single grain models recorded maximum classification success of 70%. The aim of this study is to then use these models to classify fossil pollen. With this contribution I will outline the potentials of the 'chemical fingerprint' for pollen identifications of wild and domesticated grass species as well as the challenges of using this method on fossil pollen records.

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Keywords : chemical fingerprint, FTIR, Poaceae pollen, species classification, cereal cultivation

Postglacial changes of the East-European forest-steppe

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Abstract :

While many studies have documented changes of the northern latitudinal forest limit in Europe and its drivers, little is known about the southern latitudinal limit of the forest towards the steppe in eastern Europe. The region is characterized by fertile chernozem soils, and consequently anthropogenically changed, with more than 80 % of the area used as cropland. Therefore, it is hard to estimate the natural extension of the forest-steppe zone and to predict the response of the ecosystems to the global warming in the future. For sustainable management strategies, nature conservation and land use should be based on the knowledge of the natural vegetation of the area, which can be obtained by palaeoecological studies. Due to lack of archives in the East European forest-steppe, palaeoecological data are very sparse. In order to close this gap, several peat cores were obtained in a north-south gradient across the forest-steppe the Kursk (Russia) and Kharkov (Ukraine) regions. Multi-proxy studies including palynology, macro-charcoals, loss-on-ignition and botanical macroremain analysis were carried out on these cores. The records show distinct vegetation and environmental changes related to climate change and/or human activities. Combining all available records, we reconstruct the forest cover using the modern analogue technique and evaluate possible shifts in the forest limit and the character of the ecotone since the postglacial. With the use of transfer functions we explore potential climate forcing that may have changed the vegetation in the ecotone during the postglacial.

Keywords : Palynology, Holocene, vegetation history, transfer function

A late-Quaternary sedimentary pollen dataset of China

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Abstract :

Sedimentary pollen records provide highly creditable proxy allowing us to know the past environments. Especially the pollen database, extending the study regions into continental and even global scales and promoting the quantitatively reconstructions, is of great significance on investigating paleovegetation

dynamics on large spatial and temporal scales and understanding the responses of vegetation to natural and anthropogenic disturbances. Here, we describe a pollen dataset in China comprising 941 pollen taxa from 383 sedimentary pollen sampling sites by sorting out the original or digitized late-Quaternary pollen data records from published or unpublished Chinese literatures. Location and sampling information are also collected including site names, latitude, longitude and altitude of sampling sites, sample types, data types, references, etc. The dataset comprising 117 raw pollen records (46.2%) and 206 digitized pollen records (53.8%), is mainly from lake core (120 sites), peat profile (43 sites), lake profile (31 sites), and fluvial profile (30 sites). The dataset is valuable for synthesis studies such as taxa dispersal and vegetation dynamics, as well as their responding to climate and human disturbance in China and eastern Asia.

Keywords : China, pollen database, sedimentary pollen, late-Quaternary

Holocene vegetation, fire, and land-use history in Northern Greece: the Limni Vegoritida record revisited.

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Abstract :

For decades, palaeoecologists and palaeoclimatologists have extensively investigated the unique long sedimentary records of Northern Greece and the southern Balkans to reconstruct climate and vegetation change on orbital timescales. Despite several valuable Holocene palaeoecological sequences from this region, new higher-resolution sequences with better constrained chronologies can shed new light into specific questions of the vegetation history of the southern Balkans that remain unsolved. In this communication, we present the results of a new palaeoecological study conducted on the sedimentary record of Limni Vegoritida (Northern Greece), forty years after the publication of the pioneer work by Bottema (1982). In 2016, we cored the small basin of this lake, retrieving a sedimentary sequence c. 840-cm long. The chronology is based on AMS radiocarbon dating of short-lived terrestrial plant macrofossils. We have analysed pollen, microscopic charcoal, and spores of coprophilous fungi in 94 samples to reconstruct vegetation, fire, and land-use history during the Holocene. Our results show that deciduous Quercus and Pinus forests dominated the regional vegetation from c. 9000 to 8200 cal. BP, with a notable representation of Juniperus and certain presence of Abies during this period. Between c. 8200 and 7000 cal. BP, a remarkable episode of forest opening occurred affecting mainly deciduous Quercus, alongside the expansion of steppe-like open vegetation (Artemisia, Chenopodiaceae, Polygonum aviculare type) with Juniperus. The synchronicity of this episode with the 8.2 ka BP cooling event suggests climatic forcing. However, the finding of Cerealia type pollen and the establishment of the first Neolithic villages in the area call for further scrutiny. At c. 7000 cal. BP, mainly Pinus but also deciduous Quercus forests recovered, Ostrya/Carpinus orientalis expanded, and Fagus established, indicating that regional forest ecosystems were rather resilient to moderate disturbance. These forests dominated until c. 2300 cal. BP, when an abrupt demise of Pinus forests occurred, probably caused by increased burning to promote pastoral and agricultural farming (as evidenced by substantial rises in Sporormiella, Cerealia type, Secale, Plantago lanceolata type, Polygonum aviculare type, and Pteridium). This deforestation episode was followed by partial forest recovery (deciduous Quercus, Pinus, Fagus) that ended abruptly c. 1000 years ago, when the currently dominant open vegetation of agricultural fields, orchards, and steppe-like grasslands with Juniperus began to establish. These results underline the existence of thresholds concerning disturbance beyond which forests cannot recover any longer. Further, our study highlight the importance of the knowledge about the history of a landscape

to properly understand its current situation and its potential future development.

Keywords : forest resilience, human impact, Neolithic, palaeoecology, pollen analysis

Poster

Groundwater-fed Plot-and-Berm agroecosystems in aeolian sand hinterlands around the Mediterranean basin since medieval times: Regional agricultural connectivity in a stable late Holocene climate

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Abstract :

Overcoming the agricultural liabilities of loose sand remains a challenge for increasing global food production. Several historical societies have attempted agriculture in dunefields but these efforts are poorly recognized. Here we summarize the climatic implications of five years of geoarchaeological research of what we have coined “Plot-and-Berm” (P&B) agroecosystems.

The P&B agroecosystems of the Israeli coast consist of sophisticated agricultural utilization of a high groundwater table within loose, aeolian sand in agricultural hinterlands. Polygonal-shaped agricultural plots of several hectares were dug in the sand and bordered between 4-6 m high berms. The berms consist of sand mixed with refuse, coated with a 0.3-1 m thick anthropogenic sandy refuse unit to protect them from fluvial and aeolian erosion. Refuse and organic material enriched the plot sand, creating grey anthrosols. The anthrosols are located 1-2 m above the local groundwater table that enable easy manual access to the water for crop roots and/or human water extraction. OSL ages and artifacts suggest that the agroecosystems were developed and existed in Early Islamic (9th-early 12th centuries A.D.) times and were abandoned several decades after the Crusader occupation. Some were partially covered by dunes with time. The agroecosystem south of ancient Caesarea remarkingbly remained fully preserved until the mid-20th century. Portable OSL and OSL-dating of the various archaeological elements and sand accumulation rates, suggests that since medieval times the climate and shoreline dynamics have not undergone significant fluctuations. Woody root remains or fills were not observed in the plot anthrosols suggesting that seasonal crops were harvested.

Active P&B agroecosystems appear intermittently around the Mediterranean basin, Iberia and the Middle East. Some historically date to the Middle Ages, while the modern agroecosystems may be an inherited or revived manifestation of the hypothesized original Early Islamic effort as revealed in the Israeli coast. Such biocultural knowledge of historical land-use and regional agricultural connectivity may have been slowly transmitted across populations, generally along the track of the Moslem conquest. Its remaining modern status appear to altogether reflect a stable late Holocene climate, now challenged by modern environmental inflictions.

Keywords : aeolian, land-cover, agroecosystem, Mediterranean basin, late Holocene climate, geoarchaeology, anthrosols

OSM42: Open session on past global changes

Co-conveners: Sarah Eggleston, Marie-France Loutre, Michael Evans, Willy Tinner, Ilham Bouimetarhan, Lhoussaine Bouchaou and Rachid Cheddadi

Oral

Changes in mesopelagic fish body size during glacial–interglacial transitions.

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Abstract :

Mesopelagic fishes are an important element of marine food webs and major contributors to the biological carbon pump. However, their response to future climate change scenarios remains unknown. In order to investigate the impact of climate warming on mesopelagic fish size, we target here the MIS 20–18 glacial–interglacial–glacial transition of the Middle Pleistocene, ~750 ka ago, which included a 4ºC increase of global seawater temperature. Although lanternfishes, which are the most abundant group of mesopelagic fishes, exhibited an overall decrease in median size from the MIS 20 glacial to the MIS 19 interglacial, the trends of the individual species differed. Our findings reveal species-specific size shifts during warming in the geological past. Nevertheless, the mesopelagic fishes decrease in size with warming, on the community level, suggests downgrading of the marine food-web structure and a reduction in carbon sequestration during the MIS 19 interglacial.

Keywords : otoliths, Pleistocene, Mediterranean

El Niño diversity during the Holocene in relation to mean state changes

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Abstract :

A consensus has not yet been reached when it comes to the long-term changes in ENSO diversity. Indeed, for models that simulate larger warming in the East Pacific, some studies show an increase of Eastern Pacific (EP) events, and a decrease in Central Pacific (CP) events, or the opposite. Similar apparent contradictions also emerge from analyses of the changes in EP versus CP El-Niño events in the Holocene. In this study, we consider the Holocene period as a means to study long-term El Niño variability in a context relatively close to the present. Indeed, the Holocene period allows studying the changes related to the long-term trend induced by the long-term evolution of the Earth's orbit and seasonal evolution induced by the orbital forcing. We use two 6,000-year-long transient simulations of the IPSL model and two different indicators to characterize El Niño events.

This study shows that we can have opposite results on the behaviour of EP and CP events depending on the type of indicator used to characterize El Niño. We will discuss the reasons for these contrasting results, as seen in two previous studies. Moreover, we will test the extent to which the types of events are induced by changes in the tropical Pacific's thermocline.

Keywords : El Niño diversity, Holocene, Transient simulations

Constraining paleo sea-level through inversion of marine terrace morphology.

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Abstract :

Quantifying paleo sea-level variations is of fundamental importance to understand the complex relations between paleo-climate, -ice-sheets and geodynamics, yet uncertainties prior to the Holocene currently span several tens of meters. The world's coastlines present an enormous geomorphologic dataset of relative sea-level changes, and recent studies have showed how they can be used within forward landscape evolution models. We take a next step, and apply a Bayesian approach to invert the geometry of marine terrace sequences to paleo sea-level. Using a Markov chain Monte Carlo sampling method, we test our model on both synthetic profiles and observed marine terrace sequences from Santa Cruz (Ca, US) and Greece. The synthetic profiles – with known input parameters – show that there are optimal values for uplift rate and erosion rate to obtain a well-constrained inversion. Both the inversion of synthetic profiles and real sequences show how sea-level peaks are easier to constrain than sea-level troughs, but that also solutions for peaks tend to be non-unique. Synthetic profiles and profiles from several sites in Greece both show how inverting multiple profiles from a sequence can lead to a narrower range of possible paleo sea-level, especially for sea-level troughs. This last result emphasizes the potential of inverting coastal morphology, suggesting that joint inversion of globally distributed marine terrace profiles may eventually catalyse a better understanding of local/global paleo sea-level and glacio-isostatic adjustments.

Keywords : sea-level, marine terraces, inversion, landscape evolution modeling

Is the Last Glacial Maximum a weak emergent constraint on climate sensitivity?

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Abstract :

The use of paleoclimates to constrain the equilibrium climate sensitivity (ECS) has seen a growing interest. In particular, the Last Glacial Maximum (LGM) and the mid-Pliocene Warm Period have been used in emergent constraint approaches using simulations from the Paleoclimate Modelling Intercomparison Project (PMIP). Despite lower uncertainties regarding geological proxy data for the LGM in comparison with the Pliocene, the robustness of the emergent constraint between LGM temperature and ECS is weaker at both global and regional scales. Here, we investigate the climate of the LGM in models through different PMIP generations, and how various factors contribute to the spread of the model ensemble. Certain factors have large impact on an emergent constraint, such as state-dependency in climate feedbacks or model-dependency on ice sheet forcing. Other factors, such as models being out of energetic balance and sea-surface temperature not responding below -1.8°C in polar regions have a restricted influence. We quantify some of the contributions and show they mostly have extratropical origins, which contribute to a weak global constraint, and remotely impact tropical temperatures. Statistically, PMIP model generations do not differ substantially, unlike what has been previously suggested. Furthermore, we find that the lack of high or low ECS models in the ensembles critically limits the strength and reliability of the emergent constraints.

Keywords : climate sensitivity, emergent constraint, last glacial maximum, climate feedbacks

Development of physicochemical and spectroscopic methods to characterize the in-situ chemical speciation of the inorganic contaminants & Innovative

Technologies for Remediation of Water & Environmental Pollution By Catalytic Oxidants.

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Abstract :

In the present investigations the efforts are focused to develop physicochemical and spectroscopic methods to characterize the in-situ chemical speciation of the inorganic contaminants and develop technologies for remediation of water & environmental pollution by catalytic oxidants. Also, to discuss strategies to control Water & Environmental pollution resulting due to toxin, toxic gases, GHG (Green House Gases), by making use of Catalytic oxides of first row transition metal oxides.

Next, to control Global Warming and save marine life (Under Water) by inhibiting the and remediation of Water treatment process by making use of catalytic oxidants.

The oxidation process would be employed to treat Groundwater contaminants by making use of the chemical oxidant s viz. hydrogen peroxide, persulfate, permanganate & ozone. These oxidants have been able to cause the rapid and complete chemical destruction of many toxic organic chemicals; other organics are amenable to partial degradation as an aid to subsequent bioremediation.

Its presumed that catalytic oxides of first row transition metal oxides e. g. Cobalt oxide should optimize the process of subsurface remediation and above-ground water treatment systems depending on a variety of site-specific conditions e. g. reaction rate kinetics.

Also, to correlate Physio-chemical properties of these catalytic oxidants involving chemical oxidation be applied in subsurface systems and in above ground water treatment systems involving chemical oxidation regeneration of Granular Activated Carbon (GAC).

Water gets polluted due to toxin & toxic gases. There are generally four types of toxic entities; chemical, biological, physical and radiation in order to control marine environmental pollution, subsurface systems and in above ground water treatment systems.

The present investigations are also focused to develop innovative methods to entrap toxins , Chemical toxicants include inorganic substances such as, lead, mercury, hydrofluoric acid, and chlorine gas, and organic compounds such as methyl alcohol, by developing High Affinity Toxin Receptors (HART) & convert GHG (Methane, CO_2,) to ethanol by catalytic processes and develop hybrid fuels like bio-ethanol and bio-diesel and go for electricity from biomass.

Next, to evaluate correlation of chemical oxidants with chemical species associated with soil and aquifer materials, and with target and non-target contaminants during water treatment processes.

Finally, efforts have been made to develop Correlational Predictive Model of Chemical Reaction Kinetics (MCRK) in order to investigate process fundamentals & assess contaminant transformation.

Keywords : High Affinity Toxin Receptors (HART), Granular Activated Carbon (GAC), reaction rate kinetics, catalytic oxides, Global Warming, water & environmental pollution, Model of Chemical Reaction Kine

Relationships Between Climate and Species Traits in Holocene Forests Along an Elevation Gradient in Pacific Canada.

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Abstract :

Projected changes in climate are expected to shift the ranges of many tree species poleward and to higher elevations. Here, we examine past changes in forest composition in Pacific Canada using a paleoecological approach and investigate the role of past changes in climate and differences in species traits in changing forest compositions. We combine fossil pollen records from low, middle and high elevations along a 1400-m elevation gradient on Vancouver Island in coastal British Columbia, Canada to assess sorting of dominant woody

plant taxa and their life history and stress tolerance traits. On a regional scale, forests have been dominated by conifers for the last 14,000 years, starting with Pinus contorta in the cool late-glacial interval, Pseudotsuga menziesii in the warm and dry early Holocene, and Tsuga heterophylla and Tsuga mertensiana in the warm and wet mid- to late Holocene. Multivariate time series confirm elevational sorting of woody plant taxa through time with the modern elevational zonation of tree taxa established by 6000 cal yr BP. Some taxa have consistently occupied low and middle elevations (P. menziesii, Alnus rubra) or high elevations (T. mertensiana), whereas other taxa (P. contorta, T. heterophylla) have occurred at a wider range of elevations. Three-table statistical techniques reveal significant relationships among forest composition, independent paleoclimate records, and species traits. Tree species with similar traits tend to be most abundant at similar times and those that are functionally dissimilar are separated in time. For example, species with 'fast' life history strategies (e.g., P. contorta, Alnus viridis) are most abundant in late-glacial plant communities, while those with 'slow' life history strategies (e.g., T. heterophylla, T. mertensiana) are most abundant in mid-late Holocene forests. Within those time periods, sorting by elevation is governed most strongly by differences in ecological performance and stress tolerance traits. This research highlights that not only are species sorted through time as environmental changes occur but that species traits are also sorted on long timescales. Turnover in forest composition is driven primarily by changes in climate, which acts as a filter on species traits to direct changes in forest dynamics.

Keywords : pollen analysis, woody plants, trait-environment relationships, multivariate time series

GDGTs and n-alkane isotope compositions in modern fluvial sediments of the Amazon River Basin: Insights for paleoenvironmental reconstructions.

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Abstract :

Continental paleoenvironmental reconstructions based on marine sediments rely on indirect proxy information from land-borne sediments transported to the oceans. Thus, understanding how continental environmental signals are recorded and transported offer valuable insights for interpreting marine sedimentary records. By analyzing stable carbon and hydrogen isotope compositions of long-chain n-alkanes and the relative distribution of glycerol dialkyl glycerol tetraethers (GDGTs) from Amazonian modern fluvial sediments we provide an important dataset for interpreting marine records under the influence of the Amazon River. Our sample set shows that the fractional abundances of GDGTs differ between clearwater (e.g. Xingu and Tapajós), whitewater (e.g. Solimões and Madeira) and blackwater (e.g. Negro) Amazonian tributaries. GDGT distributions also vary in the Amazon River mainstem towards its mouth. Gradual changes in isoprenoid GDGTs and in 5- and 6- methyl branched GDGT ratios suggest that values from the western portion of the basin are more in line with a dominant soil source, while compositions in the eastern portion seem to have an important riverine component. Branched GDGT distributions change towards the Amazon River mouth and indicate that organic matter dilution or replacement may hamper the application of generalist models and calibrations for reconstructing past continental temperatures and soil pH in large tropical river basins. By comparing the obtained isotope signatures with literature data, we propose that long-chain n-alkanes sourced from the easternmost Amazonian lowlands may dominate the signals

delivered by the Amazon River to the Atlantic Ocean. Within the Xingu River, a large tributary in eastern Amazonia, seasonal changes also seem to play an important role in biomarker signatures. Both GDGT and long-chain n-alkane distributions point to a dominant soil source of organic matter during the high-water season and significant aquatic production during the low-water season. Hence, we recommend future studies to carefully consider seasonality and the disproportionate contribution of proximal sources when interpreting marine records under the influence of the Amazon River.

Keywords : Amazon, Stable Isotopes, GDGTs, Organic Geochemistry

Exploring the combination of sedimentary lipid biomarkers and novel hyperspectral imaging techniques: A Holocene-length multiproxy reconstruction from Lake 578, Southern Greenland.

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Abstract :

The deglaciated "transition" zone between the Greenland ice sheet and the coast is still understudied, despite a remarkable range of climate reconstructions from ice cores and marine sediments. Chronologically well-constrained climate reconstructions from lake sediments can contribute to the understanding of climate variability in these regions and further help elucidate Greenland's past climate variability. However, little is known about how lake systems in these regions responded to the local climate variability and how they have evolved over the Holocene. For example, ice cover extent and duration can impact lake mixing regimes and suppress holomictic events leading to stratification and anoxia in the hypolimnion. Meromictic conditions further hamper the resuspension and recycling of nutrients deposited in the sediments to the upper (productive) water layers. Combined with reduced light conditions (ice and snow cover) and colder water temperatures, this can limit lacustrine primary productivity during periods of extended ice-cover.

In this project, we present a Holocene-length multiproxy reconstruction based on lake sediments from postglacial Lake 578 from southern Greenland to investigate the above-mentioned processes. We gained unique insights into Lake 578's ontogeny combining branched glycerol dialkyl glycerol tetraethers (brGDGTs), used as temperature and anoxia proxies, with hyperspectral imaging (HSI) derived productivity and anoxia histories as well as µXRF analyses. We applied a recently published site-specific in-situ temperature calibration to convert the brGDGT signal into quantitative summer mean water temperature (SMWT). The application of a multi-site pigment calibration (green pigments and bacterio-pheophytins) on the HSI data allowed us to calculate pigment concentrations and depositional rates. The irregularly spaced time series were subjected to generalized additive models to detect periods of significant change in Lake 578's history (e.g., anthropogenic effects).

The lowest observed productivity combined with peak values in anoxia-proxies and the lowest SMWT during the early Holocene suggest an extensively stratified water column representing a proglacial system. Thereafter, the sediments are organically enriched showing that the lacustrine background sedimentation became more important. Indeed, higher reconstructed SMWT, and a decrease in anoxia-proxies indicate that the lake transformed into a postglacial system with less extensive ice cover. Fine laminations observed at the beginning of this sequence start to fade, pointing towards a better mixed lake system with more pronounced nutrient cycling. The Holocene thermal maximum is observed between 6k–3k cal yr BP coinciding with a well-mixed water column, and a decrease in productivity suggesting that productivity was nutrient-limited. After 3k cal yr BP, the occurrence of fine laminations in the sediment highlights a period of reduced holomictic events and thus more extensive ice cover, aligning with a decrease in SMWT. An abrupt increase in productivity and anoxia observed at ~1.4 k cal yr BP could be due to a lake-level increase that submerged nutrient-rich soils adjacent to the lake. The

generalized additive models reveal that productivity, anoxia, and mass accumulation rates were slightly higher during the Norse settlement period and that the productivity shows a significant increase during the most recent century, coinciding with the onset of sheep farming.

Keywords : Greenland, Lake sediments, Holocene, Molecular paleoclimatology, Hyperspectral imaging

The timing and ecological consequences of Pleistocene megafaunal collapse in the eastern Andes of Colombia.

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Abstract :

The timing and consequences of the functional extinction of Pleistocene megafauna remains debated and geographically concentrated across the continents. A major challenge that is intensified by the limited validity in using a range of fungi spores as a proxy for their demise. We present the first multi-proxy palaeoecological record from the high Andean forests of Colombia that looks to determine the timing of Pleistocene megafaunal decline and its ecological consequences. We quantify Sporormiella, alongside other coprophilous and semi-coprophilous spores, to reconstruct megafaunal abundance across the late Pleistocene and into the Holocene. Fossilised pollen and charcoal data are used to examine the possible effects extinction had on the Monquentiva ecosystem during a period of major climatic oscillations and human expansion. Enhanced by the incorporation of additional dung fungal spores (including Arnium imitans and Sordaria), Monquentiva recorded an absence of Sporormiella and all other key (coprophilous/semi-coprophilous) spores from ~22,900 yr BP. We infer the first of a two-wave decline in megafaunal populations at ~22,900 yr BP; with the local functional extinction of most species occurring by ~11,684 yr BP. Megafauna decline in the Colombian Andes corresponded with warm, wet interstadials and observed some of the ecological consequences attributed to extinction. The functional collapse of megafaunal populations in the early Holocene coincided with novel plant communities, increases in palatable and woody plants and increased fire activity. The data revealed that a synergy between climatic oscillations and Monquentiva's megafaunal population collapse triggered habitat-specific ecological repercussions surrounding the site.

Keywords : Megafauna; Functional extinction; Sporormiella; Coprophilous fungal spores; Novel plant communities; Palaeoecology, Charcoal

Geographic distribution and parameters influencing the presence of lacustrine alkenones.

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Abstract :

Understanding and predicting short-term and long-term changes in temperature is crucial for informing climate adaptation and management strategies in the coming decades to centuries. Quantitative temperature records from the past are needed to improve our understanding of climate mechanisms and test model predictions of future climate changes. The few existing tools to reconstruct past temperatures on the continents mainly provide mean annual or warm season temperatures, limiting our understanding of climate variability during the transitional seasons and winter. In this project, we are currently surveying lakes in several parts of the world for a promising sedimentary paleothermometer, the lacustrine alkenone biomarker. Alkenones are temperature-

sensitive lipids produced by Isochrysidales algae, which have been used for decades to reconstruct quantitative changes in sea-surface temperatures. Increased reporting of alkenones in both saline and freshwater lakes worldwide suggests that there is great potential for alkenone-based paleotemperature reconstructions in lacustrine settings. In particular, recent work has identified a group of lacustrine alkenone producers that bloom during the spring season and produce alkenones that are well correlated with changes in winter-spring temperatures. Winter-spring temperatures are crucial for understanding lacustrine ecosystems as they control how long lakes remain frozen and how rapidly they warm up during the spring season. Our goal is to extend the number of lakes investigated for lacustrine alkenones in particular in the Southern hemisphere. This study will contribute to refine the geographic area of distribution of lacustrine alkenones and to understand the parameters that influence their presence in lakes. It will be a first step to guide future studies on lacustrine alkenones and to develop local calibrations to reconstruct winter-spring lake temperature in the past.

Keywords : Lacustrine alkenones; quantitative paleoclimate reconstructions; seasonal temperature; Southern hemisphere; Northern hemisphere

Land-sea correlations during Late-Pleistocene abrupt climate changes in the of Cariaco Basin.

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Abstract :

We present a high-resolution dataset of pollen, spores and dinoflagellate from the Cariaco Basin, Venezuela, from 24,000 to 12,000 cal. yr. BP. The core MD03-2619 was analysed capturing abrupt climate events including Heinrich Stadial 1 and the Bølling/Allerød warming. By studying pollen and dinoflagellates from the same sediment samples, we establish correlations in oceanic and terrestrial conditions in the tropical Atlantic.

During the Post Last Glacial Maximum terrestrial and marine palynomorphs have high concentrations and correlate with a northerly position of the intertropical convergence zone. Evergreen forests and seasonally dry tropical forests dominate the vegetation, though a short-term cooling and drying period results in exposure of the Unare Platform and colonisation by Amaranthaceae and Cyperaceae. Upwelling intensity is at its lowest and increases gradually over time but is interrupted by periods of stagnation where autotrophic dinoflagellates increase in abundance.

The Heinrich Stadial 1 is characterised by a significant drop in pollen and dinoflagellate concentrations, indicating reduced continental run-off and a southward migration of the intertropical convergence zone. A lowered sea level exposes the Unare Platform, which is colonised by Amaranthaceae due to high salinity conditions, before rising sea level allows for colonisation by Cyperaceae. Montane pollen taxa show a relative increase, representing downslope migration of montane forests and cooling over land. In the Cariaco Basin, upwelling intensity increases, but dinoflagellates concentration declines, as primary production is dominated by cyanobacteria and coccolithophores.

The Bølling/Allerød warming phase shows pollen, spore and dinoflagellate numbers increasing to pre-Heinrich Stadial conditions. Rising sea levels floods the Unare Platform, causing the decline of Amaranthaceae and development of mangrove forests. Seasonally dry tropical forests and evergreen forests expand with increased precipitation over land and a northward movement of the ITCZ. Seasonally dry tropical forests become more extensive with strong increases in taxa such as Bursera and Croton. Increased montane taxa indicate upslope migration associated with warmer conditions. In the oceans, upwelling intensity decreases and heterotrophic dinoflagellates increase in abundance. Several short oceanic incursions occur, causing a dominance of autotrophic dinoflagellates.

Keywords : pollen, Pleistocene, dinoflagellates, Cariaco, Venezuela

Temporal resolution of multi-taxic fossil assemblages: challenges and opportunities for conservation paleobiology of continental shelf ecosystems.

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Abstract :

Continental shelf sediments are a rich source of data on biotic responses to long-term climate and sea-level changes, but extensive time averaging of fossil assemblages – mixing of remains of organisms that lived at different times in a single sedimentary layer – might compromise interpretation of paleoecological and paleoenvironmental signals. Taxonomic differences in susceptibility to postmortem destruction are expected to produce offsets in radiocarbon ages between species co-occurring in a given stratigraphic horizon. However, the importance of this effect is difficult to assess due to a lack of direct estimates of time averaging for many higher taxa.

Here, we compare radiocarbon ages across five major marine phyla, whose skeletal remains are preserved together in a sediment core from the northern Adriatic shelf. We dated individual foraminiferal tests, bivalve shells, tests and isolated plates of irregular and regular echinoids, crab claws and fish otoliths. In spite of different skeletal durability, mineralogy and life habit, all taxa showed similar, millennial-scale time averaging varying from ~1800 to ~3600 yrs (interquartile age ranges). Thus, just like macrofossil assemblages, benthic foraminifera from shallow shelf settings can be time-averaged over thousands of years, which may limit their utility as high-resolution environmental proxies. Moreover, even though the studied taxa showed similar extent of temporal mixing, their median ages differed by up to ~3700 yrs.

Our results suggest that skeletal accumulations of taxa characterized by different durability can represent paleoecological archives of comparable temporal resolution. However, centennial- to millennial-scale age offsets between co-occurring species, frequently reported from Holocene fossil assemblages on continental shelves, can severely complicate interspecific analyses. Consequently, high-resolution age models based on dating of a single taxon may not be directly applicable to other members of the fossil assemblage or to geochemical proxy records based on their biomineralized hardparts. Nevertheless, these limitations can be circumvented by direct age dating of large numbers of fossil specimens, made feasible by recent advances in radiocarbon methods.

Keywords : temporal resolution, time averaging, radiocarbon dating, paleoecology

Past summer sea-ice dynamics and ecosystem changes in the Weddell Sea recovered from novel snow petrel stomach-oil deposits.

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Abstract :

The physical and chemical feedbacks facilitated by the extent and properties of Antarctic summer sea-ice are vital for moderating Earths' climate as well as laying the foundation for the rich primary productivity in the Southern Ocean. However, lack of high confidence summer sea ice projections limits our understanding of how the summer sea-ice will be affected by future and current climate change. Development of new paleo archives suitable for summer sea ice reconstructions is therefore crucial in the goal towards understanding the future of Antarctic sea ice. Here, we present a novel archive for past summer sea ice and ecosystems from the well-preserved, regurgitated stomach oil of a sea-ice associated seabird, the snow petrel (Pagodroma nivea). We analysed deposits collected from

nunataks in Untersee Oasis, Dronning Maud Land, which record sea ice conditions within the snow petrel foraging range (the southeast Weddell Sea). We use a multi-proxy approach, combining elemental and fatty acid distributions of the deposits to reconstruct varying inputs of krill and other prey to the snow petrel diet through time. We infer that these changes in diet reflect changes in sea-ice conditions, influencing prey distributions or access to foraging grounds. Our results provide a new perspective on changing sea ice-environments close to the Antarctic continent through the last glacial cycle and confirm the stomach oil deposits as a valuable new archive for exploring the coupled relationship between ecosystems and past summer sea ice dynamics through time.

Keywords : Antarctic summer sea ice, snow petrel stomach oil, southern ocean sea ice ecosystems

Absolute dating of deep ice cores with 40Ar and 81Kr

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Abstract :

In the search for very old ice, finding the age of the ice is a key parameter necessary for its interpretation. Most ice core dating methods are based on chronological markers that require the ice to be in stratigraphic order. However, the oldest ice is likely to be found at the bottom of ice sheets, where the stratigraphy is disturbed, or in ablation areas, where the classical methods cannot be used. Absolute dating techniques have recently been developed to provide new constraints on the age of old ice, but their development in the context of ice cores is limited by the large sample size required. Here, we review the performances of two complementary methods: 81Kr and 40Ar on the bottom of the TALDICE and Dome C ice cores. We describe the recent analytical developments that have allowed for a dramatic reduction in the sample size requirement, and discuss the implications for the optimal use of precious ice to date the bottom of ice cores.

Keywords : ice core, absolute dating, oldest ice

Ground-penetrating radar data as a method to quantify the spatial representativeness of ice core surface mass balance records in Antarctica.

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Abstract :

Shallow ice cores provide invaluable records of surface mass balance (SMB) over annual to multi-decadal timescales. Their high temporal resolution is counter balanced however by their low spatial resolution, essentially representing a local measurement of SMB with their spatial footprint on the order of cm2. This implies that post depositional processes, such as wind-driven erosion and redistribution, can change an ice core's initial snowfall record. Because ice cores are single point measurements, it is difficult to assess whether the SMB reconstructed from the ice core record is pristine or has been affected somehow. Ice core SMB records are used to evaluate climate

models "as-is" at present as there are not enough ice core records to assess their "representativeness" of the area where they have been drilled.

This is where ground-penetrating radar (GPR) data can be useful. By tracing isochronal surfaces in the firn/ice and dating them using co-located ice core records, GPR data can be used to obtain a spatially extensive SMB record. GPR-derived SMB records have a lower spatial resolution (generally multi-annual to decadal) than ice core SMB records but they cover a much larger area at a high spatial resolution (along-track in particular). By comparing the radar-derived and ice core SMB records for the same area, we can quantify the surface area that the ice core is representative of, in terms of mean SMB as well as temporal variability, on historical timescales. We examine two contrasting regions of the Antarctic Ice Sheet: the ice rises of the Princess Ragnhild Coast where SMB is high and spatially highly variable and the interior of the West Antarctic Ice Sheet where SMB is spatially more uniform. We examine whether the type of regional SMB regime determines the spatial representativeness of the ice core records locally.

Keywords : Antarctica, ground-penetrating radar, ice cores, surface mass balance

Modern Pollen Dataset of China.

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Abstract :

Modern pollen samples own the essential information for interpreting and understanding the Quaternary pollen records, which in turn provide one of the most important sources of information on paleovegetation dynamics, paleoclimate changes and paleobiogeochemical cycles from site to regional and global scales. In the last decade or so, we collected and sorted out pollen data from published and unpublished Chinese literatures between 1960 and 2020 and established a modern pollen dataset. All taxa data had been taxonomically harmonized and a variety of quality control were applied. The metadata of this dataset includes sample numbers, sampling locations (latitude, longitude and altitude of sampling sites), sample types, data sources, data types, surrounding vegetation, references, and pollen taxa, their compositions as well. This dataset consists of 772 pollen taxa from 4497 modern pollen sampling sites, including 660 published data from the Chinese Quaternary Pollen Database, 1763 from early published data and 2074 from recently collected data. The samples were mainly from surface soils (3332 sites), together with moss, surface sediments of lakes and the ocean. The sampling sites were widely scattered around China representing different geographical regions and vegetation types: 24.91% in the temperate desert region, 24.02% in the subtropical evergreen broad-leaved forest region, followed by the temperate grassland region (16.14%) and alpine vegetation region of Qinghai-Tibet Plateau (15.83%). The data can be divided into the raw data (58%) and numerical data (42%) according to their sources, and grain count (59%) and pollen percentage (41%) by data type as well. The database constructed from the samples over China during the past half-century+ period, though far from complete, is good representation of most of the areas in China, and can be effectively used as modern verification in the reconstruction of past vegetation and climate.

Keywords : China, pollen dataset, surface pollen, modern vegetation

Severe cooling of the Atlantic thermocline during the last glacial.

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Abstract :

The mean cooling of the global ocean during the Last Glacial Maximum (LGM) was recently estimated to 2.6°C using noble gases trapped in ice cores (1). The ocean, however, is highly heterogeneous with respect to its internal temperature varying both in latitude and water depth. While temperature changes in the deep ocean are small at about 2 - 3 °C (1,2), the upper ocean is more dynamic. Regional temperature anomalies of up to 7°C are predicted during the LGM compared to modern interior ocean temperature by global ocean circulation models (3). Due to the temperature drop to near freezing conditions and the global increase in salinity from ice sheet growth, the oceans' deep interior became strongly haline stratified (2). Temperatures of the glacial ocean thermocline are, however, less well constrained.

Here, thermocline temperature reconstructions since the last glacial based on the Li/Mg ratio in cold-water coral skeletons are presented. The coral samples, collected from 300 - 1200 m water depths from different sites in the Atlantic (43°N to 25°S), reveal synchronous 5 - 7°C cooling during the last glacial period compared to today, as well as a dramatic shoaling of the thermocline. At the end of the LGM, warming of the upper thermocline ocean occurred early in the southern hemisphere followed by a fluctuating warming and thermocline deepening in the northern Hemisphere. This supports the oceanic climate seesaw proposed by Stocker and Johnson in 2003 (4). We thus propose dramatic changes in the export of polar waters towards the Equator and an enhanced subsurface ocean stratification leading to a mostly polar Atlantic with a shallow permanent thermocline during the glacial.

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Keywords : cold-water corals, glacial thermocline, Li/Mg temperatures

Regional pteropod preservation records from the Indian Ocean: An overview.

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Abstract :

The temporal variations in the shell numbers and post-mortem shell conditions of pteropods within the marine sediments are an excellent proxy for paleoceanographic and paleoclimatic studies. These organisms contribute 10 to 12 % of the total $CaCO_3$ produced in the ocean. Despite their small size, pteropods are astoundingly useful to geologists, paleoclimatologists and paleobiologists because of their sensitivity to ocean acidification and ability to record past oceanic conditions. In order to attain the longer record and to understand the preservation pattern of pteropods, we have analysed several cores collected from different parts of the Indian Ocean, i.e., IODP 359 Site U1467 (water depth of 487m) and U1468 (521m) (collectively date back to ~24 Ma), NGHP-17 (wd of 1325m) (~12.3 Ma) and SK343/GC01 (wd of 1340m) (~50 ka). The pteropod abundance study indicates that though these microorganisms have been known to occur from the Cretaceous, their fossil records only extend to late Quaternary sediments that date back to 1.5 Ma. The pteropods assemblage data combined with the results of carbonate dissolution signals (Limacina Dissolution Index, Fragmentation Ratio and average shell size of Heliconoides inflatus), suggests that the variability in carbonate chemistry, stratification of the water

column, seasonality, ventilation and productivity are the main controlling factors for the pteropod preservation in the Indian Ocean. The pteropod preservation record agrees with the preservation records from the Pacific Ocean, where better preservation is seen during glacial periods and cold stadials due to the fall in ACD and biogenic productivity, well-ventilated water column, and highly oxygenated bottom waters. In the last glacial cycle, the highest abundance in pteropods was observed during the deglacial period (18-15 ka) and poor preservation during Holocene. However, it is interesting to report high abundances/preservation of pteropods during the Eemian interglacial, which is analogous to the Holocene. The offsets in the preservation spikes from different physiographic domains of the Indian Ocean is believed to be due to the lag in the oceanic circulation and local climatic variability. The results demonstrate that the ability to calcify and maintain the shells of late Pleistocene pteropods was severely affected by the surface water carbonate chemistry.

Keywords : Pteropods, Aragonite preservation, Indian Ocean, IODP, Dissolution.

Sea surface temperature and productivity gradients across the eastern equatorial Pacific during the Pliocene.

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Abstract :

The mid-Pliocene Warm Period (3.3-3.0 Ma) is an ideal reference period for investigating potential climate change by the end of the 21st century. Differences in the geological boundary conditions during the Pliocene likely influenced patterns of sea surface temperature (SST) and productivity observed in the tropical Pacific Ocean where El Niño Southern Oscillation controls modern climate variability. Upwelled cool nutrient-rich Equatorial Undercurrent waters are responsible for the strong gradients in SST, surface productivity, and nutrient utilization that characterize the modern eastern equatorial Pacific (EEP). Easterly wind intensity and temperatures at the base of the mixed layer control SST gradients, while wind-driven upwelling and subsurface nutrient content dictate productivity gradients. However, the strength of these gradients is uncertain during the warmer and wetter Pliocene. We present new Pliocene alkenone paleotemperature and organic biomarker productivity records from Ocean Drilling Program (ODP) cores that span an east-west transect across the modern EEP upwelling zone. Additionally, we present new estimates of sediment composition calculated from calibrated X-ray fluorescence (XRF) elemental concentrations and fluxes along the same transect. The temperature and productivity records suggest climate variability on glacial-interglacial scales over the late Pliocene. The SST gradient between ~90°W and ~110°W was reduced to 0.2°C in the late Pliocene, compared to the >2.0°C gradient observed today. Contrary to modern El Niño SST and productivity patterns across the equatorial Pacific, there was no reduction in surface productivity based on alkenone C37 total and XRF fluxes, despite the diminished SST gradient measured across the Pliocene EEP. Biogenic opal average mass accumulation rates were up to seven times higher in the easternmost site (~90°W) than in the western EEP sites while lower CaCO3 accumulation was most pronounced in the westernmost site (~120°W). SST and productivity proxies show stronger spectral sensitivity to the high latitude influence of obliquity in the easternmost site, while the signal is weaker in western sites. The high biogenic opal composition in the eastern EEP suggests that upwelling velocity was not greatly diminished, and more nutrient-rich waters may have upwelled during the Pliocene relative to today. Therefore, reductions in the SST gradient suggest warmer waters at the base of the mixed layer upwelled in the Pliocene EEP, rather than diminished wind strength or upwelling intensity.

Keywords : paleoceanography, Pliocene, alkenones, biogenic opal, carbonate

Poster

Different patterns and origins between northwestern and southeastern Tibetan ice core glaciochemical records over the past century.

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Abstract :

Atmospheric circulation systems differ between the northern and southern Tibetan Plateau (TP) and are characterized by prevailing westerly winds and the Indian monsoon, respectively. This leads to spatial differences between glaciochemical records in the northwestern and southeastern TP. We compared the spatial differences in major soluble ion concentrations (Ca2+, SO42−, NO3−, NH4+, Cl−, Na+, K+, and Mg2+) during the last century in the Aru (northwestern TP) and East Rongbuk (ER; southeastern TP) ice cores. Ca2+ exhibited the largest difference between the ice cores (2371 ppb in the Aru ice core and 65 ppb in the ER ice core), indicating that crustal processes were more dominant in the Aru ice core. NH4+ accounted for 17% of the total ion concentration in the ER ice core but only 3% in the Aru ice core, which may be related to the Indian monsoon traveling over NH3 emission zones in southern Asia. The major soluble ion concentrations exhibited decreasing trends in the Aru ice core but increasing trends in the ER ice core ($P < 0.01$). Empirical orthogonal function and backward trajectory analyses indicated that the major soluble ions in the Aru ice core originated from crustal sources in central Asia; those in the ER ice core had crustal, anthropogenic, and oceanic sources from southern Asia. The results from the Aru ice core suggest that dust events and enhanced prevailing westerly winds promoted the deposition of dust aerosols from the Taklamakan Desert and arid and semi-arid regions of central Asia. Contrastingly, the results from the ER ice core suggest that the Indian monsoon transported crustal and anthropogenic sources from southern Asia and oceanic sources from the Bay of Bengal and Arabian Sea. This study contributes to the comprehensive understanding of the differences in glaciochemical records and their causes between the northwestern and southeastern TP.

Keywords : Aru ice core, East Rongbuk ice core, Tibetan Plateau, Major soluble ions, Crustal sources, Anthropogenic sources

Ten simple tips for publishing your research outside of the prefix "paleo".

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Abstract :

The prefix "paleo" in research may introduce difficulties to reach interdisciplinary audiences when publishing scientific articles. Other factors such as the use of unfamiliar methodology or jargon, as well as the wide range of disciplines that paleo-research connects with (e.g., geologists, ecologists, oceanographers), also can obstruct scientific cross-fertilization among disciplines that work with the vector of time in their approach. Therefore, publishing your research in journals outside of the prefix "paleo" requires special strategies and can be very challenging, especially for early-career researchers. This poster presents the results from a community-based effort to gather the ten most important tips or rules to successfully publish your research in journals outside your research field. More than 40 colleagues, from different fields and career stages, contributed to our 'ten tips'.

Keywords : Publishing strategies; ten simple tips; early-career researchers; community-based

Diverse response of global climate and vegetation to astronomical forcing and CO2 during MIS-11 and MIS-13.

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Abstract :

Paleoclimate and paleovegetation reconstructions and simulations of the past interglacials has been paid significant attention, as it facilitates the prediction of future climate changes, especially in a warming world. However, understanding the mechanisms of how astronomical forcing and CO2 influence global climate and vegetation pattern remains challenging. Given the distinct differences in orbital configurations and climate/vegetation variations between MIS-11 and MIS-13, we performed two sets of transient simulations using LOVECLIM 1.3, one driven by insolation change only, and another one by changes in both insolation and CO2. These simulations offer us a good opportunity to investigate the relative effect of astronomical forcing and CO2 on global and regional vegetation changes. Our results show that the effects of precession and obliquity on vegetation depend strongly on regions, and the simulated results are in good agreement with vegetation reconstructions at key regions. The vegetation response differs widely between MIS-11and MIS-13, which is mainly caused by the difference in their astronomical configurations, and the difference in CO2 concentration between these two interglacials plays minor role. In addition to the effect of precession and obliquity, our simulations are also able to capture the half precession signal (~ 10 ka) in the climate and vegetation changes in the tropical regions in response to the tropical insolation.

Keywords : Interglacials, paleoclimate modelling, precession, obliquity, vegetation

Exported organic carbon control over particle reactive element cycling during millennial-scale Holocene climate variability.

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Abstract :

The particulate organic carbon exported through the water column may control the distribution of particle reactive trace elements in the ocean, in particular the fractionation of rare earth elements (REE). This raises the possibility that carbon and REE cycles are closely related, opening the possibility of using REE as proxies for carbon sequestration in the ocean. Here we investigate Holocene climate forced export of particulate organic carbon using a benthic foraminiferal productivity record and compare this to REE patterns measured on foraminifera authigenic oxides from a sediment core collected at the continental shelf of the western South Atlantic. The high temporal resolution record of the biological productivity proxy Benthic Foraminiferal Accumulation Rate (BFAR) was obtained from a western South Atlantic shelf site sensitive to Brazil Current-driven upwelling. The comparison of biological records to REE patterns from authigenic oxides shows a strong relationship between higher biological productivity and stronger particle reactive element cycling (i.e. REE cycling) during rapid climate change events. Our cerium anomaly, the ratio between heavy and light REE, and BFAR records are coherent with increased particulate organic carbon scavenging of REE followed by its export to the seafloor during times of high primary productivity. Taken together, BFAR and REE patterns can be used as a proxy to reconstruct carbon sequestration. This is the first evidence that authigenic oxides archive past changes in shallow depths REE cycling controlled by the exported organic carbon. In addition, our data suggest that Brazil Current-driven upwelling varies on millennial timescale synchronously with changes in continental precipitation as registered in speleothem records from central-eastern Brazil. We interpret this correspondence as indicating that the NE wind pattern controlled changes in (i) Brazil Current-driven upwelling, (ii) marine biological productivity, (iii) organic carbon export, as well as (iv) continental rainfall related to the South American Monsoon System

strength. In addition, a strong link between our Southern Hemisphere records and North Atlantic sea-surface temperature reconstructions suggests a common interhemispheric mechanism operating via atmospheric and oceanic changes associated with the Intertropical Convergence Zone. Our data show that the western South Atlantic and eastern South America respond to millennial timescale North Atlantic temperature swings. Further, shallow marine depths appear to be a dynamic part of the marine carbon sequestration system and are tightly coupled with regional and global rapid climate change.

Keywords : rare earth elements, scavenging, carbon sequestration, South Atlantic

Coccolith Size variations of Calcidiscus leptoporus yield insights into palaeoecological preferences in the southwestern Atlantic during the last 135 kyr.

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Abstract :

Coccolithophores studies are essential since they constitute one of the main primary producers in the open ocean and play an important role in the organic carbon and carbonate pump. The use of coccolithophores assemblages is common in paleoceanographic studies, but the results can be limited due to the dissolution of their coccoliths in the water column and sediment. To minimize such limitations, we performed a morphometric study of a dissolution resistant species, Calcidiscus leptoporus, and assessed its paleoecological interpretation during the last 135 kyr in the South Atlantic. The species C. leptoporus presents differences in morphology and size, generally divided into three morphotypes: Small (<5 µm), Intermediate (5-8 µm) and Large (> 8 µm). In order to understand the dynamics of C. leptoporus morphotypes, this work aims to compare the morphometric data with productivity and sea surface temperature data. Measurements of 50 coccoliths were carried out in 42 samples of sediment core GL-1090, collected at a depth of 2,225 m from the southeastern Brazilian continental slope, covering the period of the last 135 kyr. Relative abundances were calculated and show maximum values of the large morphotype during Marine Isotope Stage (MIS) 5e and MIS 4, while the small morphotype exhibited lower values during the same period. In contrast, intermediate sized C. leptoporus dominated the studied time interval, exhibiting abundances higher than 40%, and thus, a wide tolerance to different environmental conditions. Statistical analyses are being done to test and confirm the small morphotype is correlated with productivity, showing a preference for warmer and nutrient-enriched waters. Moreover, the large morphotype reveals affinity with nutrients availability and cold waters. During MIS 4 dissolution, which probably contributed to the decrease of smaller and more sensitive species such as Emiliania huxleyi and Gephyrocapsa spp.,

might have also influenced the small C. leptoporus relative abundances and thus allowed higher abundances of dissolution-resistant specimens like its large morphotype and Florisphaera profunda. It is necessary to perform more morphometric analyses of C. leptoporus in sediment cores from the southeastern Atlantic, as well as in modern plankton samples, to obtain more reliable information and confirm specific regional ecological tolerances, as potential information for paleoceanographic reconstructions.

Keywords : Calcidiscus leptoporus; morphometry; coccoliths; coccolithophores.

Reconstruction of the Holocene temperature and productivity variability at the Portuguese margin.

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Abstract :

The current interglacial period, the Holocene, covering the last ~11.5 ky, is generally characterized by warm sea surface temperatures (SSTs), high atmospheric CO_2 levels, and low ocean productivity in some regions. However, previous studies showed that the oceanographic conditions across the Holocene are highly variable.

The Portuguese margin, located on the Eastern part of the North Atlantic, is at present, characterized by seasonal coastal upwelling, creating favorable conditions of cold waters and high primary productivity during spring-summer.

Considering that the planktonic foraminifera (PF) fauna is affected by water temperature and food availability, this study reconstructs the Portuguese margin summer temperature and export productivity (Pexp) across the Holocene, using the PF fauna and the SIMMAX transfer function, at two sites under different oceanographic conditions: Shak-03-6K (37⁰42.45'N, 10⁰29.542'W, 3735m) on the Sines margin and MD03-2699 (39°02.20′N, 10°39.63′W, 1895m) on the Estremadura spur.

In the Holocene, an estimated average summer SST of 18.9 °C and Pexp of 76.1 gC/m2/yr was registered in Estremadura, while at Sines core the average SST was 21.2 °C and Pexp 55.2 gC/m2/yr. Temporal variation reveals an early Holocene of warm SSTs (above 20 °C) and increased Pexp (above 75 gC/m2/yr) at both sites, followed by a cold event (starting at 10.5 ky), marked by abrupt drops in SST (13 ºC) and PExp (20 gC/m2/yr) at the Estremadura site, while at the Sines site the cooling was minor (2 ºC) but the Pexp drop (35 gC/m2/yr) was greater. Two additional cold and low productivity events occurred during the Holocene Thermal Optimum (HTO, from 9.5 to 5.5 ky) at the Estremadura Site, at 8.2 ky (~16 °C, ~65 gC/m2/yr) and 5.2 ky (17.5 ºC, ~65 gC/m2/yr). These short cold events are well marked in the North Atlantic possibly caused by freshwater input from the melting Laurentide ice sheet.

During these cold events, at our sites, increased relative abundance of polar and subpolar species (N. pachyderma and T. quinqueloba). Without considering these short cold periods, both sites have recorded an increase in subtropical and tropical species.

During the Late Holocene (~4.2 ky to present), the SSTs at both sites remained constantly warm, with a high abundance of G. bulloides at the transition of HTO and this period. However, Pexp at the Estremadura site was relativity higher than at the Sines site (~20 gC/m2/yr difference). A feature that, most probably reflects enhanced upwelling influence, mainly at the Estremadura site.

The Estremadura site is under a stronger influence of upwelling events and riverine nutrient supply from the Tagus River. Furthermore, being in the limit between subtropical and transitional surface and subsurface waters it also receives occasional incursions of cold nutrient-richer waters from the North.

Keywords : Planktonic foraminifera, Portuguese margin, Holocene, Sea surface temperature, Export productivity

Sulfur isotope ratio of sulfate aerosols in an Antarctic Dome Fuji ice core during the last glacial period: a potential contribution from the Atacama Desert.

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Abstract :

The flux of sulfate onto the ice in Antarctica has remained relatively stable over glacial-interglacial cycles. However, the mechanism behind the stable flux is controversial because of a lack of evidence for changes in multiple source emissions. To provide a new constraint on the interpretation of sulfate aerosols, we measured a new sulfur isotopic (34S) record in the Antarctic Dome Fuji ice core.

During the Last Glacial Maximum (LGM), the sulfur isotope ratio was depleted compared to that during the Holocene and was negatively correlated with terrestrial contributions. This result supports the hypothesis of increased terrestrial sulfate during the LGM but does not favor the constant marine biogenic sulfate hypothesis.

Further, we complied sulfur isotope values in potential gypsum sources to explore potential source areas (PSAs). The sulfur isotope value of the terrestrial endmember suggests that the PSAs for the DF sulfate during the LGM is characterized by low sulfur isotope value and a high SO42-/Ca2+ ratio. A potential source area for such DF ice core data is the high-altitude region of the Atacama Desert, which is consistent with such unique sulfur isotope value and a high SO42-/Ca2+ ratio. We cannot rule out contributions from other areas because of the limited geochemical data in source regions. For example, geochemical data suggest that the Puna-Altiplano Plateau is another important PSA for dust.

These results demonstrate that the estimation of changes in sources of sulfate significantly affects the interpretation of the relationship between climate and sulfate flux records in ice cores. Therefore, the contribution of soluble salts in deserts should be considered when interpreting ion data in Antarctic cores during the LGM.

Keywords : Sulfate, sulfur isotope, LGM, Dome Fuji, Atacama Desert

Marine record of monsoon-related changes in the Bay of Bengal.

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Abstract :

The climate of the earth is intimately connected to the ocean through the atmosphere which serves as a common canopy for both, thus transferring enormous quantities of water vapor, energy, and momentum from sea to land. Extensive studies have been undertaken jointly by climatologists and oceanographers on the air-sea interaction with a view to improve our understanding of the global climatic evolution and event to make short-term weather forecasts. Such studies will ultimately enable scientists to infer climatic changes over longer periods.

So, for studying past climate the ocean floors provide largely undisturbed, continuous, high-quality sediment archives that carry information of the past changes in physical, chemical, and biological conditions of the oceans. Various biological (micropaleontological), geochemical and sedimentological parameters/indicators are employed in the paleoceanographic and paleoclimatic reconstructions. Marine micropaleontologist investigates biotic remains (microfossils) preserved in the ocean sedimentary records.

Therefore, the present study is an attempt in this direction employing high-resolution foraminiferal records to understand the late Quaternary oceanographic and monsoon climatic changes in the Bay of Bengal (14002’06” lat., 82000’12” long.) at 3307 m water depth during the last 45 ka.

The strong stratification of the upper water column in the Bay of Bengal makes it today a biologically low productive area. High precipitation during the summer monsoon and associated discharge into the Bay results from a pronounced stratification of surface waters. Thus, paleo-productivity records from this region would provide ample information about the intensity of SW summer monsoon and associated surface hydrographic conditions. As planktic foraminifera are sensitive to variations in temperature, salinity, and nutrient conditions, they are the best proxy to reconstruct past sea surface hydrography. Temporal variations of planktic foraminiferal assemblages have been used to infer the Late-glacial- Holocene productivity history of the Bay of Bengal and its relation to summer monsoon-induced precipitation/fluvial discharge.

Keywords : foraminifera, Climate Change, Quaternary, Bay of Bengal

Climate synchronicity in Tasmanian terrestrial and aquatic ecosystem over the Holocene.

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Abstract :

Climate is the most important driver of aquatic ecosystem change, effecting changes to nutrient status, productivity, and ecosystem health and function. Aquatic ecosystems are affected by two climatic forces energy and mass. Energy encompasses the direct climate influences of heat, wind, and irradiance. Whereas mass fluxes are the indirect climate influences of energy on the terrestrial environment, catchment, and aquatic ecosystem through avenues of changing vegetation, soil development, and catchment dynamics that alter aquatic ecosystems. While there is a greater understanding of climate impacts on freshwater systems, and a growing understanding of the complex indirect relationships climate has on these environments; the patterns related to energy and mass on longer timescales and larger spatial scales are not particularly well-known. Therefore, we plan to explore the influences of energy and mass flux on aquatic ecosystem change in western Tasmania, by understanding the synchronicity and coherence of aquatic ecosystem response to changing climate across over the Holocene. Tasmanian freshwater systems show tight coupling to the terrestrial environment with changing climate over the Holocene. Climate related shifts in fire regimes, vegetation, and catchment dynamics indirectly drive aquatic ecosystem change including changes in species assemblage, pH, nutrient status, and light availability. While there is evidence of both energy and mass climate influences on the terrestrial and aquatic ecosystem of Tasmania, the timing (synchronicity) and consistency (coherence) in these responses have not been evaluated on a regional scale. Using five multiproxy lake records from western Tasmania of pollen, charcoal, aquatic remains, geochemical signatures and generalise additive modelling we aim to answer the following questions:

Q1- Are Tasmanian terrestrial and aquatic environments responding synchronously or asynchronously to Holocene climate?

Q2- Do terrestrial and aquatic ecosystems show consistent patterns (coherence) of direct and indirect responses to climate over the Holocene?

We expect there to be a high level of coherence and synchronicity between sites across western Tasmania due to the strong relationship between terrestrial environment change and climate, and the reliance of the aquatic ecosystem on the terrestrial environment (mass influences). These findings will inform us how aquatic systems across Tasmania as a whole respond to climate and if future shifts in climate will have regional impacts on the terrestrial ecosystems and/or the aquatic environment. The outcomes of this work will help stakeholders understand and predict expected changes in aquatic and terrestrial ecosystems of Tasmania under ever changing climate.

Keywords : generalised additive models, palaeoecology, Tasmania, climate, Holocene

Rare earth elements/Ca ratios in planktonic foraminifera as potential productivity proxies: The NW Iberia case study.

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Abstract :

Rare earth elements (REEs) in planktonic foraminifera have been recognized for reflecting water mass characteristics and for their potential use as paleoceanographic proxies for sea surface biologic productivity and for water mass tracing. However, these proxies are complex and poorly understood, especially in productive coastal upwelling areas, where living planktonic foraminifera may respond to several environmental variables, and where high carbonate dissolution occurs in the sediments underlying these regions. This work reports the first data on REEs (La, Ce, Nd)/Ca ratio in planktonic foraminifera species and investigates their use as possible proxies for primary production in the upper water column off the NW Iberian upwelling system using the

three most abundant species in the region (Globigerina bulloides, Neogloboquadrina incompta, Globorotalia inflata). The REEs/Ca of these species, of different depth habitats, seasonal abundances, and link to specific regional hydrographic conditions, were compared with the total organic carbon and traditional foraminifera productivity proxies measured on the same surface samples (Cd/Ca, Ba/Ca, δ13C, fauna). Our preliminary results show that G. bulloides, a species related to intense and persistent upwelling, records the highest REEs/Ca ratios studied and positive correlation to other productivity proxies, except for total organic carbon. G. bulloides Ce/Ca coincides with its highest relative abundance and area of more vigorous upwelling close to the coast. The La/Ca and Nd/Ca ratios from N. Incompta, a species related to less intense upwelling conditions and less nutrients, reveal a relationship to Cd/Ca, an established nutrients proxy. While G. inflata, a no-upwelling species, exhibit the lowest values of REEs/Ca and no correlation with any other productivity proxies. REEs/Ca measured in different species of planktonic foraminifera seem to reflect the nutrient input by coastal upwelling and, consequently, biological primary production, corroborating the more traditional productivity proxies.

Keywords : REE, planktonic foraminifera, productivity, upwelling

Reconstructing Holocene climate dynamics in Northern Greece using biomarker proxies in lake sediments.

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Abstract :

More than 8000 years ago, early human societies began practicing farming in Europe, marking the transition between the Mesolithic and Neolithic. Archeological evidence suggests that agrarian Anatolian populations spread over the Aegean Sea to an area encompassing Northern Greece and the Southern Balkans. From there, the neolithization process continued to spread gradually all over Europe. Although this transition is relatively well studied, the dynamics and processes involved in the adjustment of the production systems to the cooler and moister European climates are largely unknown. Recent finds of impressive Neolithic upland and lakeshore settlements in Northern Greece and adjacent areas have the potential to improve our understanding of the timing of the Neolithic transition in this region and the driving factors for change involved in it. It has been hypothesized that the 8.2 ka cooling event fostered this major technological and social change in Northern Greece, although agriculture had likely been introduced some centuries before. During this event, the climate became colder and much drier in Anatolia. As a result, agrarian societies in this region could not be sustained in their entirety anymore. Contrastingly, in Northern Greece and the Southern Balkans this event may have enhanced seasonality and potentially released wetter summers, with unclear consequences for agriculture. The rarity of late Mesolithic finds in this region, the dating uncertainties of Neolithic archeological sites, and the absence of high-resolution paleoclimatic reconstructions make it difficult to reconstruct the chain of events and processes involved. We will reconstruct past climate in that area to investigate whether the 8.2 ka event influenced the Neolithic social and technological revolution in Northern Greece. We will use organic biogeochemical proxies, such as Glycerol Dialkyl Glycerol Tetraethers (GDGT) and n-alkane δD, for paleoclimatic reconstructions from lake sediments in Northern Greece. These proxies have only recently started to be used in climate reconstructions, with few available studies and none from southeastern Europe. Using these proxies, we will be able to precisely reconstruct temperature and humidity changes in the northeastern Mediterranean region. In order to achieve an optimal precision, we will calibrate the proxies to the area of interest. We selected ~40 lakes spread over Greece and Italy. They

embrace a temperature gradient ranging from arctic-alpine ~0°C to subtropical 20°C mean annual air temperature, and a precipitation gradient from dry ~400 mm to wet 1500 mm per year. These gradients should be representative of the climatic oscillations that occurred at mid-altitude in Northern Greece during the Deglaciation and Holocene. We collected surface sediments from each selected lake, and are measuring the GDGT composition and the δD of n-alkanes in the lake surface sediments. We will compare the resulting data with historical temperature and precipitation observations to get regionally calibrated climate reconstruction proxies. We are going to present preliminary results of this calibration dataset, which will provide insights into the performance of these methods in this geographical setting. This calibration will greatly improve the accuracy and precision of regional paleoclimate reconstructions in southeastern Europe.

Keywords : Neolithic, paleoclimate, biomarker, sediment, Greece

Continuous Sublimation Extraction/Laser Spectroscopy - a novel method for greenhouse gas measurements in the oldest ice.

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Abstract :

Ice cores are natural archives that preserve valuable information of past atmospheric greenhouse gas concentrations (CO2, CH4 and N2O) and changing climate systems.

To understand how these complex changes of biochemical cycles will respond in the future, we need to decipher the role of changing greenhouse gas concentration and the rearrangement within the major carbon reservoirs (sediment, terrestrial biosphere, ocean and atmosphere) in the past.

For this purpose, δ13C measurements (ratio of the stable isotopes 13C:12C) are a useful tool to identify variations of CO2 (the most important greenhouse gas after water vapour) driven by biogeochemical processes and to disentangle short- and long-term carbon cycle changes.

The main goal of this PhD project will be to enable high-resolution and high-precision isotopic studies of δ13C in ice core samples via a noble continuous laser-sublimation extraction technique. A quantitative statement of the most common greenhouse gases (CO2, CH4 and N2O) is to be made to reconstruct quantitative environmental processes controlling past greenhouse gas concentration changes.

Keywords : ice core, d13C(CO2), greenhouse gases, sublimation, laser spectroscopy

Reconstruction of bottom water conditions at the SW Iberian margin during the Early Pleistocene using benthic foraminifers.

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Abstract :

The Pliocene-Pleistocene transition marked a profound change in the Earth´s climate system, with the expansion of the ice sheets in the Northern Hemisphere and the establishment of the glacial-interglacial cycles typical of the Pleistocene. Despite the importance of this event, its causes are still not fully understood and little knowledge exists on the behaviour of the Mediterranean Outflow Water (MOW) during this period. The MOW is an important component of the Earth´s climate system because it carries warm and saline water into the Atlantic's intermediate depths and modifies the strength of the Atlantic Meridional Overturning Circulation.

In order to better understand the behaviour of the MOW during the Pleistocene first glacial-interglacial cycles, benthic foraminifer assemblages have been studied from IODP Site

U1391 (37°21.5′N; 9°24.6′W, 1085 m water depth), recovered during the IODP Expedition 339 at the Southwest Iberian margin. We reconstructed changes in bottom water oxygenation and carbon export and their relation to MOW oscillations across Marine Isotope Stages (MIS) 103 to 82. We calculated the Shannon diversity index, the abundance of epifaunal and infaunal taxa and performed Principal Component Analysis (PCA) on the benthic foraminifer abundances.

PCA yields three components that explain up to 58% of the total variance. The first component (PC1 – 26%) is exclusively defined by Uvigerina auberiana and reflects changes in the export of sea surface productivity resultant from the upwelling. During MIS 103-98 and MIS 86-82, an alternation between eutrophic and mesotrophic conditions occurred, while during MIS 97-87 bottom waters remained mesotrophic for longer periods. The second component (PC2 – 18%) is constituted by Globocassidulina subglobosa and Bulimina mexicana with positive and negative correlation, respectively, and seems to be associated with bottom water ventilation and may indicate vertical migrations of MOW, particularly during MIS 103-100 and MIS 91-82. Finally, the third component (PC3-14%) is composed by Uvigerina peregrina, Bulimina mexicana and Gyroidina orbicularis with positive correlation and Melonis barleeanum with negative correlation, and seems to reflect the expansion of the nitrate reduction zone, particularly during MIS 97 to 92.

Keywords : Benthic foraminifers, MOW, IODP Site U1391

Westerly drives long-distance transport of radionuclides from nuclear events to the Third Pole.

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Abstract :

Major nuclear bomb tests and nuclear power plant incidents release large amounts of radionuclides that spread dispersion worldwide. Radionuclides deposited in glaciers are transported through atmospheric circulations. The beta (β) activity of radionuclides in ice cores is traditionally used as a chronological tool. This study investigates β activities of radionuclides from four ice cores in the TP to understand the transport routes and related atmospheric processes affecting the radionuclides deposition in glaciers in the Third Pole (TP) region. All the ice cores show three major β activity peaks in the ice layers corresponding to 1963, 1986, and 2011. The β activity peak in the 1963 ice layer is well-known due to the wide deposition in all the ice cores from polar and mountain regions and referred to the 1962 massive atmospheric Nuclear Bomb Test (NBT). Beta activity peaks in 1986 and 2011 ice layers are from the Chernobyl and Fukushima Nuclear Incidents (CNI, FNI), respectively. Hysplit forward and backward trajectory analyses from the origins of the three events to the four TP ice core sites suggest that the radionuclides were transported by the prevailing westerly into the stratosphere and then to the high elevation glaciers in the TP. In the case of the FNI, the radionuclides traveled over Japan, Europe, and central Asia before being deposited in the TP glaciers. We Investigate the atmospheric circulation after the CNI and FNI confirm that the stronger northern westerly is responsible for the high β activity of radionuclides during the FNI recorded in the TP ice cores. Less precipitation and the divergence of water vapor flux component with descending motion process after the FNI also contributed to the enriched radionuclides in ice core records. The low β activity of radionuclides during the CNI results from the weaker northern westerly, more precipitation, and the convergence of water vapor flux component with ascending motion process after the FNI.

Keywords : Nuclear Events, Radionuclides, Ice Core Records, Westerly, Third Pole .

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The 6th Open Science Meeting
PROGRAMME CALENDAR

Title	Room	Date	Start Time	End Time
Opening Ceremony	Plenary session	16-05-2022	07:30	08:00
Block 1-Oral Sessions :		16-05-2022	08:00	10:00
OSM05: From the LGM to the Anthropocene: Environmental changes driven by climatic variability, sea-level fluctuations and human activities in East Asia	Virtual room 4	16-05-2022	08:00	10:00
OSM19: Understanding Past Hydrological Changes in Africa since the Last Glacial Maximum	Virtual room 3	16-05-2022	08:00	10:00
OSM36: Quaternary climate change and human evolution in Africa	Virtual room 2	16-05-2022	08:00	10:00
OSM02: The last interglacial	Virtual room 1	16-05-2022	08:00	10:00
Plenary session 1 :				
R. Cheddadi-Glacial refugia and future microrefugia: an effective plan to save plant species?	Plenary session	16-05-2022	10:00	10:30
Break		16-05-2022	10:30	11:00
Lightning talk session 1	Virtual room 1	16-05-2022	11:00	12:00
E-posters session 1 : OSM02, OSM19, OSM05	Virtual room 2	16-05-2022	12:00	14:00
Side event:		16-05-2022		
Inclusivity round table	Virtual room 3	16-05-2022	14:00	15:00
Break		16-05-2022	15:00	16:00

Title	Room	Date	Start Time	End Time
Block 2-Oral Sessions :		16-05-2022	16:00	18:00
OSM36: Quaternary climate change and human evolution in Africa	Virtual room 2	16-05-2022	16:00	16:45
OSM02: The last interglacial	Virtual room 1	16-05-2022	16:00	18:00
OSM06: Sedimentary varves: High-resolution archives of past climate and environmental change	Virtual room 4	16-05-2022	16:00	18:00
OSM14: Past extremes and risks assessment: Linking the instrumental and the paleo record	Virtual room 3	16-05-2022	16:00	18:00
OSM11: Tropical and subtropical interhemispheric teleconnections during the last 2000 years: A transatlantic approach	Virtual room 2	16-05-2022	16:45	18:00

Plenary session 2 :				
J-J. Hublin-The origin of Homo sapiens: a North African perspective	Plenary session	16-05-2022	18:00	18:30
Lightning talk session 2	Virtual room 1	16-05-2022	19:00	20:00
Break		16-05-2022	20:00	20:30
E-posters session 2 : OSM02, OSM11, OSM14, OSM06	Virtual room 2	16-05-2022	20:30	22:30

Block 3-Oral Sessions :		17-05-2022	08:00	10:00
OSM05: From the LGM to the Anthropocene: Environmental changes driven by climatic variability, sea-level fluctuations and human activities in East Asia	Virtual room 1	17-05-2022	08:00	08:45
OSM13: Climate variability across scales and climate states	Virtual room 2	17-05-2022	08:00	10:00
OSM37: Peatland ecosystem functioning and ecosystem services: How paleoscience and management can feed back to each other	Virtual room 4	17-05-2022	08:00	10:00
OSM26: Past climates in our changing mountains: Contributions from the paleoscience community	Virtual room 3	17-05-2022	08:00	10:00
OSM15: Art and science in a changing planet: A past global perspective	Virtual room 1	17-05-2022	08:45	10:00
Plenary session 3 :				
H. Cheng-High and low latitude climate interactions at multiple timescales	Plenary session	17-05-2022	10:00	10:30
Break		17-05-2022	10:30	11:00
Lightning talk session 3	Virtual room 1	17-05-2022	11:00	12:00
E-posters session 3 : OSM15, OSM13, OSM26, OSM37	Virtual room 2	17-05-2022	12:00	14:00
Side event:	Virtual room 3	17-05-2022	14:00	15:00
PAGES-Ocean KAN	Virtual room 3	17-05-2022	14:00	15:00
Break		17-05-2022	15:00	16:00

Block 4-Oral Sessions :	Virtual room 1	17-05-2022	16:00	18:00
OSM33: Quantifying and predicting terrestrial ecosystem responses to changing climates and land use	Virtual room 1	17-05-2022	16:00	18:00
OSM13: Climate variability across scales and climate states	Virtual room 2	17-05-2022	16:00	18:00
OSM26: Past climates in our changing mountains: Contributions from the paleoscience community	Virtual room 3	17-05-2022	16:00	18:00
OSM03: New developments in speleothem paleoclimate and paleoenvironmental science	Virtual room 4	17-05-2022	16:00	18:00
Plenary session 4 :				

T. Lenton-Learning from past climate tipping points to avoid future ones	Plenary session	17-05-2022	18:00	18:30
Lightning talk session 4	Virtual room 1	17-05-2022	19:00	20:00
Break		17-05-2022	20:00	20:30
E-posters session 4: OSM33, OSM13, OSM26,OSM03	Virtual room 2	17-05-2022	20:30	22:30

Block 5-Oral Sessions :		18-05-2022	08:00	10:00
OSM25: Tipping points in the Earth system: Can the past inform us about the future?	Virtual room 4	18-05-2022	08:00	10:00
OSM30: Hydrology of arid regions	Virtual room 3	18-05-2022	08:00	10:00
OSM27: Variation and responses in fire regime behavior over time and space	Virtual room 1	18-05-2022	08:00	10:00
OSM18: Using high-resolution marine archives to investigate marine climate, marine environment, and maritime societies through the Holocene	Virtual room 2	18-05-2022	08:00	10:00
Plenary session 5 : P. Braconnot-Thoughts on the role of paleoclimate model-data comparisons in assessing climate projection levels of confidence	Plenary session	18-05-2022	10:00	10:30
Break		18-05-2022	10:30	11:00
Lightning talk session 5		18-05-2022	11:00	12:00
E-posters session 4 : OSM27, OSM18, OSM30, OSM25	Virtual room 2	18-05-2022	12:00	14:00
Side event: Expand the reach of your science: Archiving your data in community repositories	Virtual room 3	18-05-2022	14:00	15:00
Break		18-05-2022	15:00	16:00

Block 6-Oral Sessions :		18-05-2022	16:00	18:00
OSM30: Hydrology of arid regions	Virtual room 3	18-05-2022	16:00	17:00
OSM25: Tipping points in the Earth system: Can the past inform us about the future?	Virtual room 4	18-05-2022	16:00	17:00
OSM18: Using high-resolution marine archives to investigate marine climate, marine environment, and maritime societies through the Holocene	Virtual room 2	18-05-2022	16:00	18:00
OSM13: Climate variability across scales and climate states	Virtual room 4	18-05-2022	17:00	18:00
OSM39: Obliquity vs precession: How long exactly is a 100-ka cycle and does it even exist?	Virtual room 3	18-05-2022	17:00	18:00
Plenary session 6 : Y. Maezumi-Legacies from the past as lessons for the future	Plenary session	18-05-2022	18:30	19:00
Break		18-05-2022	18:00	18:30

Conference dinner-cooking session with our local master chef	Plenary session	18-05-2022	19:00	20:00

Block 7-Oral Sessions :		19-05-2022	08:00	10:00
OSM42: Open session on past global changes	Virtual room 2	19-05-2022	08:00	10:00
OSM34: Cryosphere change impacts on arctic coastal environments and ecosystems during the Holocene	Virtual room 1	19-05-2022	08:00	10:00
OSM17: Dendrochronology: A flashlight into an elusive past and a tool for an uncertain future	Virtual room 4	19-05-2022	08:00	10:00
OSM28: Regional and transregional climate variability over the last 2000 years	Virtual room 3	19-05-2022	08:00	10:00
Plenary session 7 :				
P. Srivastava-Flood history of the Himalaya: A geologist's perspective	Plenary session	19-05-2022	10:00	10:30
Break		19-05-2022	10:30	11:30
PAGE e-socer Cup		19-05-2022	11:00	12:00
E-poster session 6: OSM34, OSM42, OSM28, OSM17		19-05-2022	12:00	14:00
Break		19-05-2022	12:00	14:00

Block 8-Oral Sessions :		19-05-2022	16:00	18:00
OSM12: Volcanic impacts on climate and society	Virtual room 1	19-05-2022	16:00	18:00
OSM42: Open session on past global changes	Virtual room 2	19-05-2022	16:00	18:00
OSM28: Regional and transregional climate variability over the last 2000 years	Virtual room 3	19-05-2022	16:00	18:00
OSM07: Charting future pathways to sustainability using concepts of resilience and adaptation	Virtual room 4	19-05-2022	16:00	18:00
Plenary session 8 :				
M.E. Ferrero-Dendrochronology and climate in the tropical Andes and lower lands: What we know and what to expect	Plenary session	19-05-2022	18:00	18:30
Lightning talk session 6	Virtual room 1	19-05-2022	19:00	20:00
Break		19-05-2022	20:00	20:30
E-posters session 7: OSM18, OSM30, OSM39, OSM28, OSM42, OSM20, OSM22	Virtual room 2	19-05-2022	20:30	22:30

Block 9-Oral Sessions:		20-05-2022	08:00	10:00
OSM41: Towards a global past human land-use and land-cover synthesis over the Holocene	Virtual room 4	20-05-2022	08:00	10:00
OSM24: Regional synthesis of environment-climate-human interactions during the past 2000 years	Virtual room 3	20-05-2022	08:00	10:00

OSM01: Quaternary paleoenvironments of southern Africa	Virtual room 1	20-05-2022	08:00	10:00
OSM16: Towards an improved understanding of past flood variability and examples on how such data can have a bearing on present and future flood risk management	Virtual room 2	20-05-2022	08:00	10:00
Plenary session 9 : L. Gillson-A past-present-future perspective on using paleoecology to conserve African ecosystems	Plenary session	20-05-2022	10:00	10:30
Break		20-05-2022	10:30	11:00
Lightning talk session 7	Virtual room 1	20-05-2022	11:00	12:00
E-posters session 8 : OSM01, OSM24, OSM41	Virtual room 2	20-05-2022	12:00	14:00
Side event: 2k Network townhall	Virtual room 3	20-05-2022	14:00	15:00
Break		20-05-2022	15:00	16:00

Block 10-Oral Sessions :		20-05-2022	16:00	16:45
OSM24: Regional synthesis of environment-climate-human interactions during the past 2000 years	Virtual room 3	20-05-2022	16:00	16:45
OSM42: Open session on past global changes	Virtual room 4	20-05-2022	16:00	17:00
OSM38: Ice-sheet variability and behavior through the lens of geologic data and numerical modeling	Virtual room 1	20-05-2022	16:00	17:00
OSM16: Towards an improved understanding of past flood variability and examples on how such data can have a bearing on present and future flood risk management	Virtual room 2	20-05-2022	16:00	18:00
OSM22: Historical climate reconstruction and impacts utilizing written records	Virtual room 3	20-05-2022	16:45	18:00
OSM20: Societal risk arising from global change: Past, present, future	Virtual room 1	20-05-2022	17:00	18:00
Closing Ceremony	Plenary session	20-05-2022	18:00	19:00