



5 – 8 June 2024, University of Bern, Switzerland

# Climate of the past and societal responses to environmental changes

The conference is organized by researchers from history, archaeology, environmental and climate sciences of the Universities of Bern and Yale. It aims to provide a comprehensive framework, exploring the broader theme of societal responses to historical climate changes and the evolution of societies, institutions, and economies in both prehistoric and historical contexts. Key topics are:

- Climate and environmental changes in the societal context
- Social vulnerability, and resilience to climatic change
- Spatial and temporal scales
- Novel methods and approaches, including computational methods, to better understand human-environmental systems

## Organizing Committee

Prof. Dr. Joseph Manning, Yale University, New Haven, USA  
Prof. Dr. Albert Hafner, University of Bern, Switzerland  
Prof. Dr. Martin Grosjean, University of Bern, Switzerland  
Dr. Caroline Heitz, University of Bern, Switzerland

Dr. Martin Hinz, University of Bern, Switzerland  
Prof. Dr. Heli Huhtamaa, University of Bern, Switzerland  
Prof. Dr. Christian Rohr, University of Bern, Switzerland  
Prof. Dr. Willy Tinner, University of Bern, Switzerland

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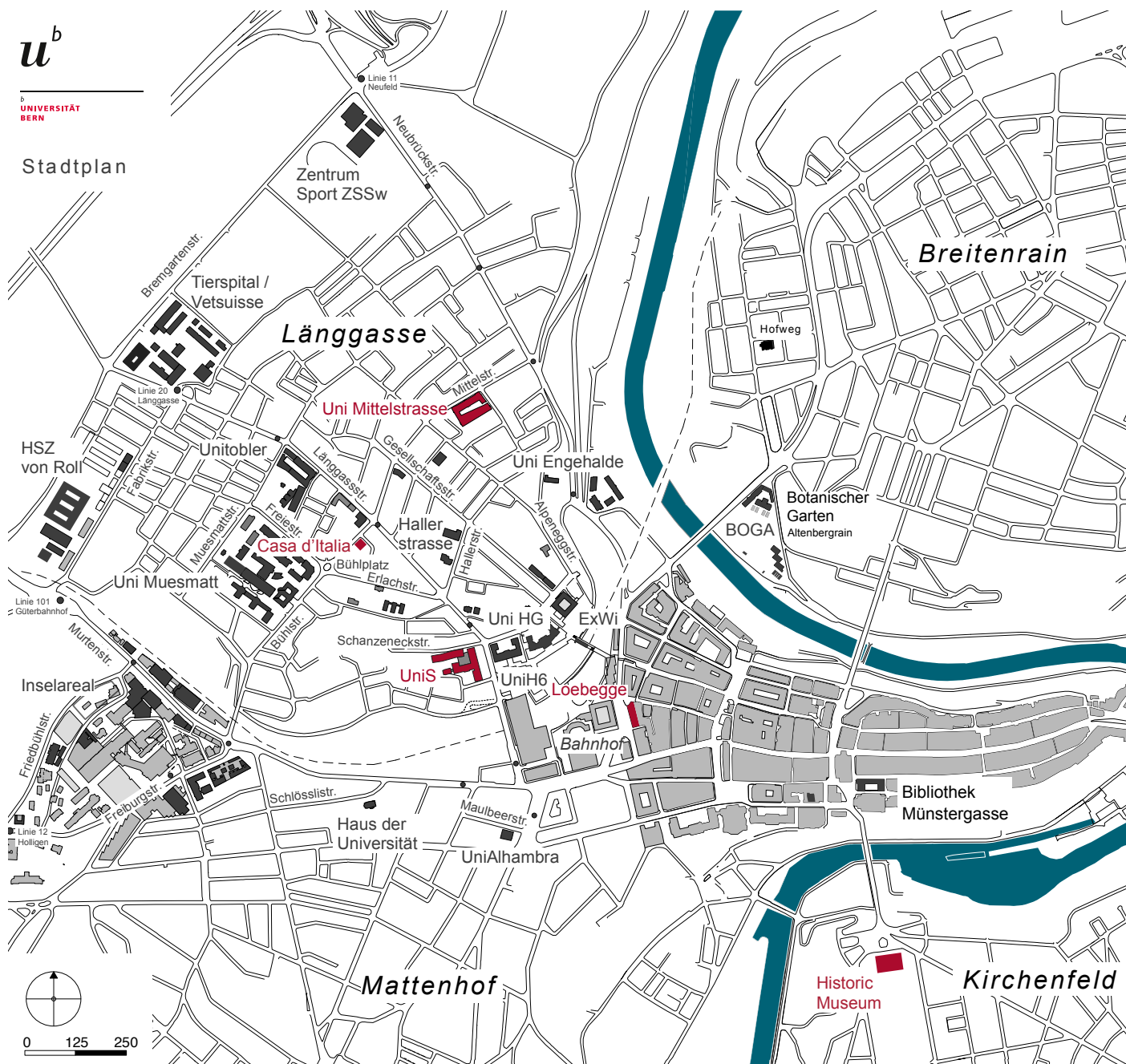
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Time	Programm	Where
13.00 – 14.00	Conference Registration	UniS, Foyer
14.00 – 16.00	<p><b>Pre-conference workshop I</b>  <b>Caroline Heitz: Climate change Archaeology Handbook</b>  Workshop co-organizers: Amy Bogaard, Felix Riede, Albert Hafner</p> <p>Climate change is a rapidly growing interdisciplinary field of archaeological research with increasing urgency and societal relevance in times of global warming – but also a high interdisciplinary complexity. The organizers of the workshop aim at editing a handbook on «The Archaeologies of Climate Change» that will compile the most relevant research results in this field for a deeper understanding of current issues and debates in order to target future directions. To discuss the relevance, thematic focus and the need of such a publication and expand the preliminary table of contents, the participants of the workshop will brainstorm and map the diverse and dynamically evolving research field of climate change archaeology: from different climate events to interdisciplinary methodological connections between paleoclimate sciences, archaeology, history, as well as heritage studies.</p> <p>The workshop is open to all conference participants, please register until 4.6.2024 here: <a href="https://nuudel.digitalcourage.de/HtntH3t6ELrISZ6Q">https://nuudel.digitalcourage.de/HtntH3t6ELrISZ6Q</a>.</p>	UniS, Room A-122
16.00 – 17.00	<p><b>Pre-conference workshop II</b>  <b>ClimeApp: Bringing the very latest climate reanalysis data into your research</b></p> <p>What happened to the climate in Europe after the eruption of Mount Tambora in 1815? Is there a correlation between cold winters in the 17th century and increased crime rates? Are crop yields and mortality more closely related to temperature or rainfall in the 20th century? To answer such questions, researchers need to be able to acquire, process and interpret the very latest climate data. ClimeApp is a newly developed web application designed for precisely this. It gives access to the state-of-the-art ModE-RA paleo-climate reanalysis, a new dataset providing monthly temperature, precipitation and pressure reconstructions for the entire globe, from 1421 to 2008 C.E.</p> <p>The workshop will give an introduction to using ModE-RA and ClimeApp to bring climate data into your own work. Attendees are encouraged to experiment with ClimeApp before the workshop and then bring their own data and/or research questions. These will then be addressed in the interactive part of the session where the ClimeApp team will work with attendees to discuss how to use ClimeApp for their own research. ClimeApp is available at <a href="https://mode-ra.unibe.ch/climeapp/">https://mode-ra.unibe.ch/climeapp/</a>.</p> <p>ClimeApp analyses annual datasets, allowing them to be compared to the ModE-RA climate data through composite, correlation and regression functions. Your historical data could be anything from grain prices and harvest yields to mortality statistics or phenological observations. Data should be structured as follows: column A: year; column B and further: your own data. You will require your own laptop for this workshop.</p>	UniS, Room A-122
17.00 – 18.00	<p><b>Pre-conference workshop III</b>  <b>Michael White: How to publish in Nature</b>  Michael White has been Nature's editor for climate science since 2008. He is primarily responsible for submissions on atmospheric science, the cryosphere, hydrology, and oceanography – but collaborates widely with editors working on human history, biogeochemistry, ecology, and sociology.</p> <p>Do you have a fascinating and novel finding that seems like a potentially good match for a high impact journal – but are unsure how to craft the paper and navigate the review process? Michael White, Nature's editor for climate science, will demystify the process, from abstract to appeals. The journey will span minutiae like cover letters to the higher-level philosophy guiding decisions. Bring your criticisms and questions!</p>	UniS, Room A-122
17.00 – 18.00	Conference Registration	UniS, Foyer
18.00 – 19.30	<p><b>Opening lecture</b>  Martin Grosjean, OCCR director, and Peter Schneemann, Dean, Faculty of Humanities: Welcome address</p> <p>Albert Hafner: 1924–2024 – Celebrating One Hundred Years of Prehistoric Archaeology at the University of Bern: From the Beginnings to Interdisciplinary Projects on Humans, Landscapes and Environments.</p>	UniS, Room 003
20.00	Social event / icebreaker	Uni Mittelstrasse 43

**Time**      **Session 1. Volcanic Eruptions. Chair: Joseph Manning**

08.00 – 08.45

Conference Registration

08.45 – 09.00

**Welcome and information**

Welcome Address, Virginia Richter, Rector des. University of Bern

09.00 – 09.20

**Volcanic eruptions, climate extremes and the collapse of ancient civilizations****Michael Sigl<sup>1,2</sup>, Peter Abbott<sup>1</sup>, Imogen Gabriel<sup>1</sup>, Evelien Van Dijk<sup>1,2,3</sup>, Jörg Franke<sup>1</sup>, Mike Baillie<sup>4</sup>, Andrea Burke<sup>5</sup>, Kirstin Krüger<sup>2</sup>, Francis Ludlow<sup>6</sup>, Joseph Manning<sup>7</sup>, Joseph McConnell<sup>8</sup>, Charlotte Pearson<sup>9</sup>, Gill Plunkett<sup>4</sup>**<sup>1</sup>Oeschger Centre for Climate Change Research, University of Bern, Switzerland; <sup>2</sup>Department of Geosciences, University of Oslo, Oslo, Norway; <sup>3</sup>Department of Archeology and Heritage Studies, Aarhus University, Aarhus, Denmark; <sup>4</sup>School of Natural and Built Environment, Queen's University Belfast, UK; <sup>5</sup>School of Earth and Environmental Sciences, University of St Andrews, St Andrews, UK; <sup>6</sup>Trinity Centre for Environmental Humanities, and Department of History, School of Histories and Humanities, Trinity College Dublin, Dublin, Ireland; <sup>7</sup>Departments of History and Classics, Yale University, New Haven, USA; <sup>8</sup>Desert Research Institute, Reno, USA; <sup>9</sup>Laboratory of Tree-Ring Research, University of Arizona, Tucson, USA; michael.sigl@unibe.ch

09.20 – 09.40

**Winds of change: Volcanically induced wind pattern changes and their impacts on past societies****Laurits Støvring Andreassen<sup>1</sup>, Claudia Timmreck<sup>2</sup>, Felix Riede<sup>1</sup>**<sup>1</sup>Aarhus University, Denmark; <sup>2</sup>Max Planck Institute for Meteorology, Germany; laurits.andreassen@cas.au.dk

09.40 – 10.00

**Explosive volcanism and the timing of Athenian food crises in the fourth century BCE****Andrew Martin Hill**

Trinity College Dublin, Ireland; hillan@tcd.ie

10.00 – 10.20

**The Potential Climatic and Societal Impacts of Volcanic Eruptions in the Former Han Dynasty (206 BCE–8 CE): A Comparative Study****Zhen Yang**

Trinity College Dublin, Ireland; zhyang@tcd.ie

10.20 – 11.00

**COFFEE BREAK****Time**      **Session 2. Conquest, Conflicts and Indigenous water management. Chair: Caroline Heitz**

11.00 – 11.20

**Medieval Climate Wars? The Eastern Mediterranean between precipitation anomalies and geopolitical turbulences in the late 12th and early 13th century CE****Johannes Preiser-Kapeller\***

Austrian Academy of Sciences, Austria; Johannes.Preiser-Kapeller@oeaw.ac.at

11.20 – 11.40

**Climate of Conquest – Climate of Raids: Could dry and wet shifts support the Hungarian conquest (895–900) and the tenth-century raids?****Andrea Kiss**

TUWien, Austria; kiss@hydro.tuwien.ac.at

11.40 – 12.00

**Nomads' southeasterly and farmers' northwesterly migrations: Climate change and nomad-farmer crash in central imperial China****Qing Pei**

Hong Kong Polytechnic University, Hong Kong S.A.R. (China); qing.pei@polyu.edu.hk

12.00 – 12.20

**Diving into the Desert: Mapping sophisticated Indigenous water management infrastructure and adaptation practices to environmental and climatic changes on Mithaka Channel Country, QLD/SA****Anna Maria Kotarba-Morley<sup>1</sup>, Tracey Hough<sup>2</sup>, Trudy Gorringe<sup>2</sup>, Shawnee Gorringe<sup>2</sup>, Joshua Gorringe<sup>2</sup>, Duncan Keenan-Jones<sup>3</sup>, Jennifer Silcock<sup>4</sup>, Patrick Moss<sup>5</sup>, Kelsey Lowe<sup>4</sup>, Ray Kerkhove<sup>4</sup>, Mike W. Morley<sup>6</sup>, Michael Westaway<sup>4</sup>**<sup>1</sup>University of Adelaide, Adelaide, Australia; <sup>2</sup>Mithaka Aboriginal Corporation, Australia; <sup>3</sup>University of Manchester, Manchester, UK;<sup>4</sup>University of Queensland, Brisbane, Australia; <sup>5</sup>Queensland University of Technology, Brisbane, Australia; <sup>6</sup>Flinders University, Adelaide, Australia; ania.kotarba@adelaide.edu.au

12.20 – 14.00

**LUNCH BREAK**

### Time Session 3. Climate Variability, 500 AD – today. Chair: Christian Rohr

14.00 – 14.20	<p><b>Abdominal Illness of Riverine Fish: Fishing on the Seventeenth-century Southern Coastline Amidst Climatic Variability</b></p> <p><b>Baihui Duan*</b> University of Oxford; Lancaster University; UK; baihui.duan@ames.ox.ac.uk</p>
14.20 – 14.40	<p><b>Climate and the end of population growth in Europe around 1300</b></p> <p><b>Christian Pfister</b> University of Bern, Switzerland; christian.pfister@unibe.ch</p>
14.40 – 15.00	<p><b>The Little Ice Age energy transition, or: Did climate cooling lead to fossil fuels?</b></p> <p><b>John Brolin</b> Department of Economic History, Lund University, Sweden; john.brolin@ekh.lu.se</p>
15.00 – 15.20	<p><b>Impacts of heat waves and cold waves in Ireland</b></p> <p><b>Carla Mateus</b> Maynooth University, Ireland; Carla.Mateus@mu.ie</p>
15.20 – 15.40	<b>Poster Session: 90 seconds pitch for poster presenters</b>
15.40 – 16.40	<b>COFFEE BREAK and Poster Session</b>

### Time Session 4. Historical archives to weather, climate and societies. Chair: Heli Huhtamaa

16.40 – 17.00	<p><b>The first 20 years at the Cape of Good Hope (1652–1671): Weather, Climate and Society</b></p> <p><b>Stefan Walter Grab, Ravanya Naidoo</b> University of the Witwatersrand Johannesburg; stefan.grab@wits.ac.za</p>
17.00 – 17.20	<p><b>Breaking Free from the Shackles of the Baltic Sea Ice: A climatic perspective on the development of Finnish winter seafaring 1890–1940s</b></p> <p><b>Stefan Norrgård</b> Åbo Akademi University, Finland; stnorrگا@abo.fi</p>
17.20 – 17.40	<p><b>Impact of Droughts on Rural Communities in Early Modern Provence and Southern French Alps: A Comparative Analysis</b></p> <p><b>Nicolas Maughan</b> Aix-Marseille University, France; nicolas.maughan@gmail.com</p>
17.40 – 18.00	<p><b>Historical archives to document the climate of the past in northeastern Canada</b></p> <p><b>Marie-Michèle Ouellet-Bernier<sup>1,2</sup>, Najat Bhiry<sup>1,2</sup>, Laura Brassard<sup>1,2</sup></b> <sup>1</sup>Department of Geography, University Laval, Canada; <sup>2</sup>Centre for Northern Studies, University Laval, Canada; marie-michele.ouellet-bernier.1@ulaval.ca</p>
18.30	<p><b>City Tour for Young Researchers (Loebegge)</b></p> <p>Why do the street signs in Bern have different colours? Why do we have a Dutch Tower in Bern? What is a Ligu Lehm? And why do parts of the town brook flow uphill? These and many more questions about the History of Bern will be answered on our young researchers' city tour during a walk from the famous Loebegge to the cosy Tram Depot.</p> <p>Guide: Niklaus Bartlome</p>

## Time Session 1. Pleistocene to Holocene Environmental Transformations. Chair: Joseph Manning

08.30 – 08.40	Welcome and information
08.40 – 09.00	<p><b>From glacial to Green Sahara to the post-industrial world: fire interactions with climate, vegetation, and human land use change in African ecosystems</b></p> <p><b>Nicholas A. O'Mara*<sup>1,2</sup>, Esther N. Githumbi<sup>3</sup>, Ali Aldous<sup>1</sup>, Juliette Garcia<sup>1</sup>, Marie Norwood<sup>4</sup>, A. Carla Staver<sup>2,4</sup>, Jennifer R. Marlon<sup>1,2</sup></b></p> <p><sup>1</sup>Yale School of the Environment, Yale University, USA; <sup>2</sup>Yale Institute for Biospheric Studies, Yale University, USA; <sup>3</sup>Institute of Soil Science and Site Ecology, TUD Dresden University of Technology, Germany; <sup>4</sup>Department of Ecology and Evolutionary Biology, Yale University, USA; nicholas.omara@yale.edu</p>
09.00 – 09.20	<p><b>A «Multiple Evidence Base Approach» to the compound impact of climate change and the ~13ka BP Laacher See volcanic eruption on Final Palaeolithic foragers in Europe</b></p> <p><b>Felix Riede*</b></p> <p>Aarhus University, Denmark; f.riede@cas.au.dk</p>
09.20 – 09.40	<p><b>Cultural discontinuity and cultural response to rapid climate changes at the end of the Pleistocene in the Middle Dnieper basin</b></p> <p><b>Pavlo Shydlovskiy<sup>1</sup>, Marharyta Chymyrys<sup>1</sup>, Ostap Tsvirkun<sup>2</sup></b></p> <p><sup>1</sup>Taras Shevchenko National University of Kyiv, Ukraine; <sup>2</sup>National Museum of the History of Ukraine; pav.shy@gmail.com</p>
09.40 – 10.00	<p><b>Assessing the climate resilience of human populations during prehistory</b></p> <p><b>Ariane Burke<sup>1,2</sup>, Simon Paquin<sup>1</sup>, Benjamin Albouy<sup>1</sup>, Timothee Poisot<sup>1</sup>, Masa Kageyama<sup>3</sup></b></p> <p><sup>1</sup>Universite de Montreal, Canada; <sup>2</sup>University of Bern, Oeschger Centre for Climate Change Research (OCCR); <sup>3</sup>Laboratoire des Sciences du Climat et de l'Environnement, LSCE (UMR 8212); a.burke@umontreal.ca</p>
10.00 – 10.20	<p><b>Late Quaternary Climate Change and the Peopling of the Arid and Semiarid Regions of Chile</b></p> <p><b>Claudio Latorre Hidalgo*<sup>1,2</sup>, Mauricio Lima<sup>1,3</sup>, Eugenia M. Gayo<sup>3,4</sup>, Carolina Godoy-Aguirre<sup>1</sup>, Calogero M. Santoro<sup>5</sup></b></p> <p><sup>1</sup>Facultad de Ciencias Biológicas, Pontificia Universidad Católica de Chile; <sup>2</sup>Institute of Ecology and Biodiversity (IEB), Chile; <sup>3</sup>Center for Applied Ecology (CAPES), Chile; <sup>4</sup>Facultad de Arquitectura y Urbanismo, Universidad de Chile; <sup>5</sup>Instituto de Alta Investigación, Universidad de Tarapacá, Chile; clatorreh@uc.cl</p>
10.20 – 11.00	<b>COFFEE BREAK</b>

## Time Session 2. Bronze Age to Ancient Nile Valley. Chair: Martin Hinz

11.00 – 11.20	<p><b>Same but different? A comparative analysis of societal and climate changes in Bronze Age Greece</b></p> <p><b>Erika Weiberg*<sup>1</sup>, Martin Finné<sup>1,2</sup></b></p> <p><sup>1</sup>Department of Archaeology and Ancient History, Uppsala University, Sweden; <sup>2</sup>Department of Human Geography, Uppsala University, Sweden; erika.weiberg@antiken.uu.se</p>
11.20 – 11.40	<p><b>Volcanic Forcing of the East African Monsoon and Egyptian History</b></p> <p><b>Joe Manning<sup>1</sup>, Francis Ludlow<sup>2</sup></b></p> <p><sup>1</sup>Yale University, United States of America; <sup>2</sup>Trinity College Dublin; joseph.manning@yale.edu</p>
11.40 – 12.00	<p><b>Simulating Inundated Area for Ptolemaic Nile River Flooding</b></p> <p><b>James H. Stagge<sup>1</sup>, Irene F. Munyejuru<sup>1</sup>, Joseph Morgan<sup>2</sup>, Francis M. Ludlow<sup>3</sup>, Joseph G. Manning<sup>4</sup></b></p> <p><sup>1</sup>The Ohio State University, Department of Civil, Environmental and Geodetic Engineering; <sup>2</sup>Florida State University, Department of Classics; <sup>3</sup>Trinity College Dublin, Department of History; <sup>4</sup>Yale University, Department of History; stagge.11@osu.edu</p>
12.00 – 12.20	<p><b>A Bioarchaeological Perspective on Human Responses to Climate Change in the Ancient Nile Valley</b></p> <p><b>Michele R. Buzon*<sup>1</sup>, Iwona Koziaradzka-Ogunmakin<sup>2</sup></b></p> <p><sup>1</sup>Purdue University, USA; <sup>2</sup>PCMA University of Warsaw and University of Exeter; mbuzon@purdue.edu</p>
12.20 – 14.00	<b>LUNCH BREAK</b>

**Time**      **Session 3. Pleistocene to Holocene Sea Level Change. Chair: Amy Bogaard**

14.00 – 14.20      **Rise and fall of the Liangzhu culture (5.3–4.3 ka B.P.) in the Yangtze delta in response to sea level change**  
**Chaochao Gao<sup>\*1</sup>, Fei Liu<sup>2</sup>, Xinjun Gang<sup>1</sup>**  
<sup>1</sup>Zhejiang University, People's Republic of China; <sup>2</sup>Sun Yat-Sen University, People's Republic of China; gaocc@zju.edu.cn

14.20 – 14.40      **Sea level rise and human response in the southern Argolid, Greece, from the Palaeolithic to the Late Roman/ Early Byzantine period**  
**Julien Beck<sup>1</sup>, Dimitris Sakellariou<sup>2</sup>, Patrizia Birchler Emery<sup>1</sup>, Flavio Anselmetti<sup>3</sup>, Andreas Sotiriou<sup>4</sup>**  
<sup>1</sup>University of Geneva, Switzerland; <sup>2</sup>Hellenic Centre for Marine Research; <sup>3</sup>University of Bern, Switzerland; <sup>4</sup>Ephorate of Underwater Antiquities; julien.beck@unige.ch

14.40 – 15.00      **The Holocene marine transgression and its effects on the Prehistoric coastal population in the Adriatic Basin: A case study in Zambratija Bay, Croatia**  
**Katarina Jerbić**  
 University of Bern, Switzerland; katarina.jerbic@unibe.ch

15.00 – 15.20      **Investigating drivers of marine resource exploitation in NW Ireland from the fifth to the third millennium BC**  
**Rory Connolly**  
 Trinity College Dublin, Ireland; rory.connolly@tcd.ie

15.20 – 16.00      **COFFEE BREAK**

**Session 4. Rapid Environmental Change and Resilience. Chair: Ariane Burke**

16.00 – 16.20      **Some thoughts on climate resilience of prehistoric societies**  
**Niels Bleicher<sup>1</sup>, Renata Huber<sup>2</sup>**  
<sup>1</sup>Underwater Archaeology and Dendroarchaeology Zurich, Switzerland; <sup>2</sup>Office for Monument Preservation and Archaeology, Canton of Zug, Switzerland; niels.bleicher@zuerich.ch

16.20 – 16.40      **Domesticated Resources, Diet, and Population: Human Responses to Late Holocene Climate Change in Central-Western Argentina**  
**Adolfo Fabian Gil<sup>\*1,2</sup>, Jacob Freeman<sup>3</sup>, Eva Peralta<sup>1</sup>, Manuel Lopez<sup>4,2</sup>, Ricardo Villalba<sup>5</sup>, Teresa Michieli<sup>6</sup>, Fernando Franchetti<sup>1,2</sup>, Gustavo Neme<sup>1,2</sup>, Mariano Morales<sup>5</sup>**  
<sup>1</sup>Instituto de Evolución, Ecología Histórica y Ambiente (CONICET / Universidad Tecnológica Nacional); <sup>2</sup>Universidad Nacional de Cuyo  
<sup>3</sup>Utah State University; <sup>4</sup>CONICET-IADIZA; <sup>5</sup>CONICET-IANIGLA; <sup>6</sup>Centro de investigaciones Precolombinas (CIP); agil@mendoza-conicet.gob.ar

16.40 – 17.00      **The 8.2k cal BP Climate Event: Rapid Environmental Change versus Long-Term Social Change during the Neolithic and Chalcolithic in the Near East**  
**Peter F. Biehl<sup>1</sup>, Arkadiusz Marciniak<sup>2</sup>**  
<sup>1</sup>University of California Santa Cruz, United States of America; <sup>2</sup>University of Poznan, Poland; pbiehl@ucsc.edu

17.00 – 17.20      **Boom-bust Dynamics in European Neolithic Societies: A Multiscale Approach**  
**Detlef Gronenborn<sup>1</sup>, Kai Wirtz<sup>2</sup>**  
<sup>1</sup>Leibniz-Zentrum für Archäologie, Germany; <sup>2</sup>Helmholtz-Zentrum Hereon, Germany; detlef.gronenborn@leiza.de

**Saturday, June 08, 2024****Time**      **Session 1. Resilience, and Socio-Ecological Systems. Chair: Willy Tinner**

09.00 – 09.20      **Linking Resilience, Global Climate Change, and Local Socio-Ecological Systems in the Past along the Georgia Coast, USA**  
**Isabelle Holland-Lulewicz<sup>\*</sup>**  
 Pennsylvania State University, United States of America; ihlul@psu.edu

09.20 – 09.40      **What makes a community resilient to aridification? Perspectives from archaeology**  
**Matthew James Jacobson<sup>\*</sup>**  
 Swedish University of Agricultural Sciences (SLU), Sweden; matthew.jacobson@slu.se

09.40 – 10.00      **Coping with the Cold – Climate Change Resilience and Vulnerabilities of Bronze Age Communities during the 3.7 ka 'Lössen' Glacier Advance (ca. 1900–1450 BCE)**  
**Caroline Heitz<sup>1</sup>, Kristin Ismail-Meyer<sup>2</sup>, Cyrielle Aellen<sup>1</sup>, Joe Roe<sup>1</sup>**  
<sup>1</sup>University of Bern, Switzerland; <sup>2</sup>University of Basel, Switzerland; Caroline.Heitz@unibe.ch

10.00 – 10.20      **Chalcolithic to Early Bronze Age (6400–4000 calBP). Climate, Environment and Human Response in the Forest Steppe Region of ECE Europe**  
**Enikő Katalin Magyari<sup>1,2</sup>, Heikki Tapani Seppä<sup>3</sup>, Janos Korponai<sup>4</sup>, Abigail Amponsaah Ofosu- Brakoh<sup>1</sup>, Akos Bede-Fazekas<sup>5,1</sup>, Aneta Formackova<sup>1</sup>, Volker M. Heyd<sup>6</sup>**  
<sup>1</sup>Department of Environmental and Landscape Geography, Eötvös Loránd University, Budapest, Hungary; <sup>2</sup>HUN-REN-MTM-ELTE Research Group for Palaeontology, Budapest, Hungary; <sup>3</sup>Department of Geography and Geosciences, University of Helsinki, Helsinki, Finland; <sup>4</sup>Department of Water Supply and Sewerage, Faculty of Water Science, National University of Public Service, Baja, Hungary; <sup>5</sup>HUN-REN Centre for Ecological Research, Institute of Ecology and Botany, Vácrtót, Hungary; <sup>6</sup>Department of Cultures / Archaeology, University of Helsinki, Finland; volker.heyd@helsinki.fi

**Time**      **Session 2. Neolithic Environmental Transformations and Demography I. Chair: Martin Grosjean****10.20 – 11.00**      **COFFEE BREAK****11.00 – 11.20**      **Synchronous land-use phases and forest succession patterns during the Neolithic in Central Europe**  
**Fabian Rey<sup>1</sup>, Willy Tinner<sup>2,3</sup>, Lucia Wick<sup>1</sup>, Erika Gobet<sup>2,3</sup>, Sönke Szidat<sup>3,4</sup>, Albert Hafner<sup>3,5</sup>, Urs Leuzinger<sup>6</sup>, Oliver Heiri<sup>1</sup>**<sup>1</sup>Geocology, Department of Environmental Sciences, University of Basel, Switzerland; <sup>2</sup>Institute of Plant Sciences, University of Bern, Switzerland; <sup>3</sup>Oeschger Centre for Climate Change Research, University of Bern, Switzerland; <sup>4</sup>Department of Chemistry, Biochemistry and Pharmaceutical Sciences, University of Bern, Switzerland; <sup>5</sup>Institute of Archaeological Sciences, University of Bern, Switzerland; <sup>6</sup>Department of Archaeology Canton Thurgau, Switzerland; fabian.rey@unibas.ch**11.20 – 11.40**      **Dynamics of Change: Investigating Social and Environmental Transformations in Lakeside Settlements of the Alpine foreland between 3400 and 2700 BCE****Mirco Brunner<sup>1,2</sup>, Corina Gottardi<sup>1</sup>, Matthias Bolliger<sup>1,3</sup>, Delphine Schiess<sup>1</sup>, Martin Hinz<sup>1,2</sup>, Caroline Heitz<sup>1,2</sup>, Regine Stapfer<sup>1,2,3</sup>, Albert Hafner<sup>1,2</sup>**<sup>1</sup>Institute of Archaeological Sciences, University of Bern, Switzerland; <sup>2</sup>Oeschger Centre for Climate Change Research (OCCR), University of Bern, Switzerland; <sup>3</sup>Archaeological Service Canton of Bern, Switzerland; mirco.brunner@unibe.ch**11.40 – 12.00**      **Climatic variations, Land management and Demography in the Neolithic: the Example of the Grandson-Corcelettes Bay (Vaud, Switzerland)****Elena Burri-Wyser, Marie Canetti, Chrystel Jeanbourquin**

Etat de Vaud, DGIP, Switzerland; elena.wyser@vd.ch

**12.00 – 12.20**      **The Effects of Novel Environments on Domesticated Taxa****Xinyi Liu**

Washington University in St. Louis, United States of America; iuxinyi@wustl.edu

**12.20 – 13.30**      **LUNCH BREAK****Time**      **Session 3. Neolithic Environmental Transformations and Demography II. Chair: Albert Hafner****13.30 – 13.50**      **Reconstructing prehistoric land use and biodiversity changes across the Alps****Christoph Schwörer, Erika Gobet, Laura Dziomber, Sina Aregger, Ursula Huonder, Lara Schiltknecht, Willy Tinner**

University of Bern, Switzerland; christoph.schwoerer@unibe.ch

**13.50 – 14.10**      **Environmental and Societal Developments in Western Europe in the 4th-2nd Millennium BCE****Julien Schirrmacher, Mara Weinelt**

Christian-Albrechts-Universität zu Kiel, Germany; jschirrmacher@sfb1266.uni-kiel.de

**14.10 – 14.30**      **Neolithic land use in uncertain climates: new insights from the EXPLO project****Amy Bogaard<sup>1</sup>, Rachel Ballantyne<sup>1</sup>, Michael Charles<sup>1</sup>, Müge Ergun<sup>1</sup>, Kathrin Ganz<sup>2</sup>, Eugenia Gkatzogia<sup>3</sup>, Erika Gobet<sup>2</sup>, Amy Holguin<sup>1</sup>, Valasia Isaakidou<sup>1</sup>, César Morales del Molino<sup>4</sup>, Patrick Schläfli<sup>2</sup>, Elizabeth Stroud<sup>1</sup>, Lieveke van Vugt<sup>2</sup>, Doris Vidas<sup>1</sup>, Albert Hafner<sup>5</sup>, Kostas Kotsakis<sup>3</sup>, Willy Tinner<sup>2</sup>**<sup>1</sup>University of Oxford, United Kingdom; <sup>2</sup>Institute of Plant Sciences & Oeschger Centre for Climate Change Research, University of Bern; <sup>3</sup>Department of Archaeology, Aristotle University of Thessaloniki; <sup>4</sup>Departamento de Ciencias de la Vida, La Universidad de Alcalá; <sup>5</sup>Institute of Archaeological Sciences & Oeschger Centre for Climate Change Research, University of Bern; amy.bogaard@arch.ox.ac.uk**14.30**      **Farewell, end of conference****15.30**      **Historic Museum Bern (Helvetiaplatz 5, 3005 Bern), Visit of Bronze Age Exhibition: And then came Bronze!****18.30**      **Dinner, Casa d'Italia (Bühlstrasse 57, 3012 Bern)**



**Session 1. Volcanic Eruptions. Chair: Joseph Manning**

09.00 – 09.20 | Thursday, June 06, 2024

**Volcanic eruptions, climate extremes and the collapse of ancient civilizations****Michael Sigl<sup>1,2</sup>, Peter Abbott<sup>1</sup>, Imogen Gabriel<sup>1</sup>, Evelien Van Dijk<sup>1,2,3</sup>, Jörg Franke<sup>1</sup>, Mike Baillie<sup>4</sup>, Andrea Burke<sup>5</sup>, Kirstin Krüger<sup>2</sup>, Francis Ludlow<sup>6</sup>, Joseph Manning<sup>7</sup>, Joseph McConnell<sup>8</sup>, Charlotte Pearson<sup>9</sup>, Gill Plunkett<sup>4</sup>**

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There is a long tradition of ascribing decline or collapse of ancient civilizations to environmental factors (e.g. climate conditions) going back to the early 20th century, e.g., *Civilization and Climate* (Huntington, 1915). Starting in the 1970s, in times of emerging environmental awareness, this tradition had a revival (e.g. Diamond 2005) often criticized as promoting «environmental determinism», i.e. explaining complex societal processes with simplistic mono-causal interpretations dominated by environmental factors. With continued global warming and the advent of modern paleoclimatology there was a surge in «neo-deterministic» approaches in the beginning of the 21st century with prominent examples tying the collapses of Akkadian Empire from c. 2200–1900 BCE, the Classic Maya collapse from c. 750–1050 CE, or the fall of the (Western) Roman Empire primarily to external factors such as climate deterioration and diseases.

Establishing causal relationships between external (i.e. climatic factors) and societal consequences remains challenging even in present days for which there is a wealth of precise indicators of natural changes and human actions. For historical and pre-historical collapse scenarios, this is even more difficult because detailed information on both the relevant climatic conditions and the possible socio-economic consequences is in most cases incomplete and imprecise or completely missing. Coarse resolution and dating uncertainties in the archives of nature (proxy records) and in the archives of humans (used in history and archaeology) are often the limiting factor to even allow reliable temporal correlations, which is the basic prerequisite for further investigations of possible causal relationships.

In this paper, we will highlight recent advances in the natural sciences to improve our understanding of past climate variability over the past 4,000 years and how such information can be used to tackle long-standing questions on the influence of climate change on ancient civilizations. Volcanic eruptions can impose major global climate perturbations and were responsible for numerous cold spells, droughts and famines in history. Some historians even proposed a volcanic eruption was responsible for the «worst year to be alive» in 536 CE. Using state-of-the-art forensic techniques within the ice-core sciences, we decipher the exact timing and climate forcing of major eruptions providing new insights on eruptions like Kuwae 1458 CE, the eruption(s) producing the infamous «mystery cloud» in 536 CE, Okmok in 43 BCE and the eruptions of Santorini/Thera and Aniakchak some 3,600 years ago. Using transient Earth System model simulations and global monthly paleo-reanalysis, next to high-resolution proxy records, we investigate in several case studies how the global climate system responded following these eruptions, and how these additional environmental stressors may have impacted agriculture and human societies.

We acknowledge funding from the European Research Council (THERA, # 820047). This work benefitted from participation by the authors in the Past Global Changes Volcanic Impacts on Climate and Society (VICS) working group.

09.20 – 09.40 | Thursday, June 06, 2024

**Winds of change: Volcanically induced wind pattern changes and their impacts on past societies****Laurits Størring Andreasen<sup>1</sup>, Claudia Timmreck<sup>2</sup>, Felix Riede<sup>1</sup>**

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Extra-tropical cyclones their number, and the precipitation they bring are critical environmental agents in the lives of mid- and high-latitudes societies both past and present. Today, the rapid changes in cyclone statistics – their number, position, wind force, and attendant precipitation – driven by global warming are a major concern for the contemporary insurance industry and for local indigenous communities alike. Yet, despite the evident contemporary societal importance of extra-tropical cyclones, the impact they had on past societies is not well studied. Here, we present pioneering work connecting changes in this weather-related parameter to societal changes in two specific cases: (i) Cultural change among north European hunter-gatherer societies in the wake of the Late Glacial Laacher See volcanic eruption (13,009±6 BP), and (ii) the decline and eventual disappearance of the Medieval Greenlandic Norse following the volcanic eruptions that led to the onset of the Little Ice Age period from ~1350 CE onwards. Building on recent work suggesting that larger volcanic eruptions can impact the number and position of extra-tropical cyclones, we use an Earth System Model and existing ice core and terrestrial proxy data to explore how changes in cyclone statistics link to societal conditions in the two contrasting target cases. By articulating our model and proxy results with archaeological, ethnographic, and literary studies, we assert that changing storm patterns may be one causal factor linking climatic change with societal impacts: Our simulated increase in cyclone frequency after the LSE seems to agree with changed mobility patterns and an archaeologically detectable societal reorganisation. Further, a simulated increase in cyclone frequency in the waters between Greenland and Iceland after volcanic eruptions fits well with existing research suggesting that maritime travel between Iceland and Greenland declined, leading to the increasing isolation and, eventually, the disappearance of Norse settlers from Greenland. We suggest that the societal impact of cyclone operates through modifying the accessibility of the land- and seascapes, by extending the time and energy expended on travel and, vitally, by increasing the risk of injury or death during travel. Both societies were characterised by low population densities, small population sizes, and limited population connectivity making them vulnerable to the stochastic loss of cultural knowledge and to demographic collapse.

## Session 1. Volcanic Eruptions. Chair: Joseph Manning

09.40 – 10.00 | Thursday, June 06, 2024

### **Explosive volcanism and the timing of Athenian food crises in the fourth century BCE**

**Andrew Martin Hill**

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Athens and its peninsular hinterland province, Attica, were home to around 300,000 people in the middle of the fourth century BCE, an unsustainable number in decline. Depending on productivity estimates of the countryside, up to two thirds of this population were dependent on imported grain, much of which originated from the Black Sea region. The Athenian economy was, therefore, particularly vulnerable to the shifting political and military landscapes characteristic of the early Hellenistic period which often affected trade lanes and the passage of grain. Yet while the historical dynamics effecting the timing of grain shortages are well recognised in modern scholarship on early Hellenistic Athens, the role of climatic change and variability at local and regional scales in influencing land productivity, and thus economic and societal security, is less explored.

Based on archaeological evidence, Camp (1982) argued that drought was an intermittent and serious problem in the Athens of the mid-late fourth century tackled by the publicly funded construction of <no fewer than four major hydraulic installations>, and a general switch in private water supply from wells to rain-collecting cisterns. That much of Greece faced acute grain shortages during this period is reflected in the writings of the contemporary statesman and orator Demosthenes (384–322) who refers to two severe food shortages in 361 and 357 (Demosth. 50.5–6; 20.33). From dendroclimatological records, we now know that a particularly cold decade in Europe began in 361 – the sixth coldest of the past 2,500 years. Over the last decade in particular, research has increasingly demonstrated the prominent influence of volcanically induced forcing on the climate across timescales of several years to decades. That the cold <long decade> of the 350s corresponds with significant eruptions in 362, 356 and 352 (+/- 2 years) (Sigl et al. (2015)) may, therefore, suggest that it was partially volcanically induced.

In this paper, I discuss the possibility that a series of climatically effective volcanic eruptions in the fourth century (indicated by elevated sulphate levels in ice cores) caused cooling which negatively affected crop productivity across a wide area spanning the Mediterranean and Black Sea regions and which had cascading consequences for the grain trade. Such an explanation offers context for the introduction of new Athenian state mechanisms to buffer against shortages in the middle of the century, including the creation of new offices for the procurement of overseas grain from a variety of Mediterranean state actors, and an increased number of civic honours awarded for private contributions to the public grain fund during times of scarcity – evidence of which can be found on dateable inscriptions. Till the end of the century, six subsequent food shortages are discernible from epigraphic evidence (Garnsey (1988); Oliver (2007)), four of which also took place within a year of an eruption (338/337; 330/329; 328/327; 302). Statistical testing of the temporal association here may indicate a causal link between explosive eruptions and fourth century Athenian food crises.

10.00 – 10.20 | Thursday, June 06, 2024

### **The Potential Climatic and Societal Impacts of Volcanic Eruptions in the Former Han Dynasty (206 BCE–8 CE): A Comparative Study**

**Zhen Yang**

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The well-documented climate history in China provides sufficient written records for multidisciplinary scholars to explore and reconstruct the climate and environmental changes in different historical times. The Former Han dynasty (206 BCE – 8 CE) experienced several periods of climatic anomalies, and the evolving «ominous politics» continuously and profoundly influenced how society perceived and responded to calamities. This research selects two historical periods, from 180 BCE to 150 BCE, and from 60 BCE to 40 BCE, to comparatively analyze the climatic and societal stresses, atmospheric optical anomalies, as well as how society reacted to consecutive natural disasters in these times. The two periods are chosen because of evidence of massive volcanic eruptions from natural archives and cryptic phenomena reported in historical sources. For instance, in 43 BCE, when the Okmok volcano in Alaska erupted, the pale-blue sun and extreme cold summer were documented by historians, and the Empire suffered continuous floods, famines and plagues since the 40 BCEs. On the other hand, in the 160 BCEs, records of similar climatic phenomena can be found, and they may be related to the volcano eruptions in 168 BCE, 164 BCE, 161 BCE and 158 BCE.

To examine the possible association between these climatic anomalies and volcano eruptions, both qualitative and quantitative research methods are employed. This study categorizes and quantifies the relevant climatic stresses (e.g., the frequency and severity of different types of natural disaster records) and selected societal events (e.g., warfare, food price hike) of the former Han Dynasty. It uses methods like superposed epoch analysis, to examine the patterns between natural proxies (e.g., ice cores, tree rings) and the recorded climatic and societal changes. Furthermore, policies of the decades before, during and after climatic anomalies are carefully studied to understand how the Han society tried to restore its political, economic and societal stability. Building on these, a comparative analysis of the two historical periods is conducted, as the latter period inherited the political legacy from the earlier period, but significant changes took place in multiple aspects, such as state-governing and the perceptions of natural anomalies. By comparing the societal responses to calamities of these two periods, we can examine whether such changes were effective in terms of disaster prevention and mitigation, thereby identifying factors that may contribute to better resilience to drastic environmental changes. In addition, this mixed-method approach also allows further exploration of the possible short, middle and long terms effects brought by disasters.

**Session 2. Conquest, Conflicts and Indigenous water management. Chair: Caroline Heitz**

11.00 – 11.20 | Thursday, June 06, 2024

**Medieval Climate Wars? The Eastern Mediterranean between precipitation anomalies and geopolitical turbulences in the late 12th and early 13th century CE****Johannes Preiser-Kapeller\***

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Judging from historical sources as well as paleoenvironmental proxy data (such as tree rings from Southwestern Anatolia or speleothems from Northern Iraq), several regions of the Eastern Mediterranean and Middle East between 1175 and 1250 CE experienced some of the most severe dry periods of the second Millennium CE. Equally, Egypt suffered from dramatic low floods of the Nile around 1200 and 1231 CE. At the same time, the entire area from Byzantium to the Persian Gulf was unsettled by internecine conflicts as well as invasions by crusaders from Western Europe throughout the period and by the Mongols towards its end.

The paper explores the possible interplay between environmental and socio-political developments, but without suggesting any deterministic scenario or linear correlation between climate extremes and political crisis. In particular, it highlights the spatial and temporal diversity of precipitation dynamics, of regional ecologies and economic systems and of strategies of governments and communities in the face of such challenges. After all, while some polities and regions suffered from instability and hardship, others prospered or even profited from their neighbour's calamities. The paper also asks what role information on climate extremes in the region played in the strategies of external aggressors. Finally, it compares its results with recent deliberations on the impact of climate extremes on unrest and conflict in the Middle East in the 21st century.

11.20 – 11.40 | Thursday, June 06, 2024

**Climate of Conquest – Climate of Raids: Could dry and wet shifts support the Hungarian conquest (895–900) and the tenth-century raids?****Andrea Kiss**

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In the presentation the climatic and environmental background of the late ninth-century Hungarian conquest, the period of the tenth-century European raids until the foundation of the medieval Hungarian state in the Carpathian Basin are analysed with the help of an extensive Eurasian multiproxy (documentary, archaeological, tree-ring, stalagmite and sedimentary) database. Based on a complex socio-economic and environmental analysis and with applying historical parallels, we seek to answer the question to what extent weather conditions could influence the course (and outcome) of events during this stirring century.

With the steppe expansion of the toned-up Samanid Empire in Central Asia after gaining its independence in 892, the Hungarian conquest was the indirect consequence of a late ninth-century steppe «migration domino» and a temporary power vacuum in the Carpathian Basin. Overpowering the northern neighbours in 893–894, the Samanid Empire, located east and south to the Lake Aral, also gained extensive territories from the north-western nomad Oguz tribes backed by the Khazar Empire. The Oguz tribes compensated themselves from the territories of the north-western neighbours, the Pechenegs, who attacked the Hungarian tribal confederation in exchange – resulting in the Hungarian conquest of the Carpathian Basin from 895.

Based on low- and medium-resolution multiproxy (sedimentary, stalagmite, archaeological) evidence, the decades around 900 are marked by a shift in hydroclimate, amongst others, in Central Asia, considered by some as the beginning of the Medieval Climate Anomaly. Annual-resolution streamflow, hydroclimate (and temperature) reconstructions (Pages2k consortium database) suggest drier (and/or cooler) conditions in 893 and 894 in Central Asia that might have negatively affected the nomadic pastoral steppe tribes and provided a supportive weather background to the campaigns of the Samanids whose main economic foundation was irrigation-based agriculture and trade.

Align with the annual-resolution (spring-)summer hydroclimate reconstruction of the Old World Atlas, a characteristic shift from drier to wetter conditions occurred in the Carpathian Basin around 894. Wetter conditions after this date are also detectable in the Mediterranean, but not in Western Europe or – based on the scarce information available – the steppe region east to the Carpathian Basin either. The wet or average hydroclimatic conditions lasted in the Carpathian Basin (and, particularly, in the Great Hungarian Plain) until the late 970s, and might have provided a favourable (home) background to the Hungarian military campaigns to Western and Southern Europe. This relatively peaceful period in the Carpathian Basin (not so peaceful for the rest of Europe), the so-called «period of raids», immediately preceded the last two decades of the tenth century, notably richer in hydroclimate anomalies and other environmental hazards. In a rather different European political environment (changed already by the 870s), the 880s and 890s passed with laying the foundations of the Christian medieval state, a task successfully accomplished in 1001.

## Session 2. Conquest, Conflicts and Indigenous water management. Chair: Caroline Heitz

11.40 – 12.00 | Thursday, June 06, 2024

### **Nomads' southeasterly and farmers' northwesterly migrations: Climate change and nomad-farmer crash in central imperial China**

**Qing Pei**

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There are quite rich studies to examine migration as a response to climate change in the past, which deeply shaped Chinese history during the imperial era. However, insufficient studies have been conducted to understand climate-migration in some certain regions. Therefore, the study will focus on Central China during the imperial period (from 221BC to 1911AD). Among different migration events, nomads' southeasterly and farmers' northwesterly migrations will be particularly selected for examination under the perspective of climate change. According to our quantitative results, decreased precipitation and drought provoked nomads' southeasterly migrations in a north-to-south direction. Northern nomads, with an apparent preference for central China as a major destination, triggered the most conflicts with resident agriculturalists. Statistical evidence also implies that the northwesterly movements of farmers increased when the climate was drier. However, northwest China was the least attractive place to farmers because of its much harsher climatic conditions. The historical records were then consulted to further explain this seemingly atypical pattern. The farmers' northwesterly migration increased during dry periods mainly as a response to the nomads' southeasterly migration, which was also a result of increased aridity. These conclusions add to the growing literature that indicates climate change as a central driver in intergroup conflict, having geopolitical implications. Furthermore, it raised the importance of scale to bridge the research methods of history and geography. The study results empirically identify the limitation of quantitative analysis in history with a detailed answer of scale thinking. Last but not least, forward-looking strategies relating to trade and immigration in the region, including the One Belt and One Road Initiative, should consider the shrinkage of rainfall under the potential threats of global warming. Increased aridity could have sizable effects on political, social, or economic structures far from north-central China.

12.00 – 12.20 | Thursday, June 06, 2024

### **Diving into the Desert: Mapping sophisticated Indigenous water management infrastructure and adaptation practices to environmental and climatic changes on Mithaka Channel Country, QLD/SA**

**Anna Maria Kotarba-Morley<sup>1</sup>, Tracey Hough<sup>2</sup>, Trudy Gorringe<sup>2</sup>, Shawnee Gorringe<sup>2</sup>, Joshua Gorringe<sup>2</sup>, Duncan Keenan-Jones<sup>3</sup>, Jennifer Silcock<sup>4</sup>, Patrick Moss<sup>5</sup>, Kelsey Lowe<sup>4</sup>, Ray Kerkhove<sup>4</sup>, Mike W. Morley<sup>6</sup>, Michael Westaway<sup>4</sup>**

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Freshwater environments are regarded as some of the most threatened ecosystems on the planet. The largely detrimental environmental impacts of floodplain management since European settlement, such as drastic reduction in fish and plant populations and biodiversity, are well-known in places like the Murray-Darling Basin (e.g. Jackson & Head, 2020) but are not well documented elsewhere. Situated at the nexus of four states (QLD, NSW, NT, and SA), Australian Channel Country is one of the world's last unregulated desert drainage systems offering unique opportunities to better understand how Aboriginal communities sustainably managed and exploited wetland ecosystems.

Our interdisciplinary team including Mithaka Aboriginal Corporation aims to reconstruct and publicise the long and sophisticated cultural histories of how Indigenous people adapted to and managed inland floodplains to inform current and future decisions and policies. Through a detailed underwater geophysical mapping of submerged Aboriginal water and flood management infrastructure and ground-truthing by means of underwater scuba diving survey our pilot project aims to restore this valuable lost heritage and technical knowledge of the Mithaka Traditional Owners of the region, simultaneously informing and improving on sustainable floodplain management practices of Australia, and by inference farther afield.

The 6th Intergovernmental Panel on Climate Change (IPCC) Report signals unparalleled climate emergency with all corners of the world affected by human influence on the climate system. Heatwaves (leading to bushfires and drought) and floods are projected to become incessant parts of our future. Whilst we are slowly making headway in learning from 65,000 years of sustainable fire management from Aboriginal communities there is currently minimal empirical evidence that might inform modern best practices of Indigenous water management (Fisher & Altman, 2020). It is clear that, as a nation, Australia has a unique opportunity and, arguably, a responsibility to reconstruct and draw upon Indigenous land management knowledge.

Mithaka Country comprises 33 752 km<sup>2</sup> of the Channel Country, mostly drained by Eyre Creek and the Diamantina River. Multiple sources document more recent, pastoral experiences of the Channel Country floodplains, but much remains to be learnt about past Indigenous management of the area. The unpredictable nature of the Channel Country's intermittent flooding and drought (‘Boom and Bust’) environment required the Mithaka people to adapt, with incredible sophistication, to an environmental system more complex than that of most hunter-gatherer groups across the planet.

Ethnographic sources show that the study area supported large ‘village’ settlements, generally near permanent waterholes made possible by complex infrastructure. This was achieved through a combination of intensive seed and water harvesting and storage systems, hunting, and fishing. Large numbers of fish were caught using stone fish pens, coolabah and reed fish traps, near-shore fishing platforms (oodleys), and very large and complex nets and traps – including alleys to trap game coming to waterholes (yelka yelkas). Weirs (mokhani) were used to store water and live fish and perhaps to increase flooded areas and hence food supplies and seed plant growth. Early European settlers noticed a marked degradation of waterholes once Indigenous management was replaced with early European settlers.

**Session 3. Climate Variability, 500 AD – today. Chair: Christian Rohr**

14.00 – 14.20 | Thursday, June 06, 2024

**Abdominal Illness of Riverine Fish:****Fishing on the Seventeenth-century Southern Coastline Amidst Climatic Variability****Baihui Duan**

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Climatic variations have direct impacts on fishing activities, as temperature fluctuations affect the geographical distribution of certain marine fish, and precipitation deficits, particularly in the form of drought, result in adverse effects on river fish populations, leading to their distress and mortality. The seventeenth century, known as a global crisis era, witnessed climatic anomalies in the Northern Hemisphere, including discernible impacts on the Korean peninsula. Drawing upon local diaries, this research examines the climatic impacts on both marine and riverine fish behaviours, alongside the ensuing socioeconomic ramifications on the indigenous population. Coastal communities, traditionally reliant on fishing activities, exhibited a discernible seasonal agenda aligned with climatic fluctuations. For example, premodern Koreans inhabiting the southern coastline strategically anticipated the seasonal presence of specific fish varieties, such as sweet fish (*Plecoglossus altivelis*) in summer, and herring and bass in winter. However, sometimes the irregular occurrences of these species, whether in abundance or scarcity, prompted an exploration in this paper to correlate such phenomena with climatic changes. This investigation delineates the consequential movements of oceanic and riverine fish, respectively induced by direct temperature variations and irregular precipitation patterns. Given that fish constituted a primary dietary staple, particularly during periods of famine, their sudden mortality due to environmental contamination posed a dual threat to public nutrition and health. Furthermore, fish held significance as essential tribute goods for the central government, with local communities assuming responsibility for their preparation. Consequently, abrupt alterations in fish populations wielded direct implications on public health, as well as on societal obligations, including tax duties and broader social responsibilities. This paper examines the societal responses to shifts in fish populations and human health attributable to climatic changes.

14.20 – 14.40 | Thursday, June 06, 2024

**Climate and the end of population growth in Europe around 1300****Christian Pfister**

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Reasons for the end of population growth around 1300 are still debated. This paper challenges the widespread view that the climate deteriorated at the end of the so-called Medieval Climate Anomaly. It draws on a documentary based seasonal temperature reconstruction for central Europe. Indications of long-term population growth between 1170 and 1300 are provided by regional data on urbanization, about the deforestation process in Germany and France and by grain prices. Population growth ran parallel to high warm-season temperatures before 1300. Disregarding climate, it was also due to deforestation and improved cultivation methods. The growth process faltered out around 1300, though summers were still mainly warm prior to the Dantean Anomaly in the second decade of the 14th century. Obviously, non-climatic reasons played a role in this development. Possibly, the increasing scarcity of fertile arable forced to cultivate poorer soils. This was only possible at the cost of decreasing fertility and a higher fluctuation of yields. The economic law of diminishing returns states that in all productive processes, adding more of one factor of production (in this case labour), while holding all others constant («ceteris paribus»), will at some point yield lower incremental per unit returns.

14.40 – 15.00 | Thursday, June 06, 2024

**The Little Ice Age energy transition, or: Did climate cooling lead to fossil fuels?****John Brolin**

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The transition to fossil fuels began in England in the late 16th century, driven by rising residential heating. Leading explanations argue that the shift was caused by population pressure leading to a supply-side crisis for organic-energy sources, or that commercial developments and the invention of the chimneyed fireplace caused a soaring demand for coal. However, population was larger in 1300 (before the Black Death) than in 1600, and the chimney-flue-fireplace combination became widespread in London already in the 14th century. So why was there no transition until the late 16th century? I argue that climate cooling between 1300 and 1600 (repeated in shorter-term fluctuation between 1500 and 1600) contributed to both limiting supply and increasing demand, providing a possible solution to this conundrum. Using a temperature reconstruction for eastern England, I calculate the growing and heating degree days (GDD and HDD) of London's supply area back to 1200. The change in 31-year average from 1300 (and in shorter-term fluctuation also 1500) to 1600 corresponds to exchanging one summer month (average temperature 15 °C) with no heating and maximal wood growth for one winter month (average temperature 5 °C) with maximal heating and no wood growth.

On the supply side, fewer GDD will materialize in a reduced supply of wood/charcoal via coppice rotation cycles becoming longer for the same amount of wood. Between 1300 and 1600 average rotation cycles in eastern England increased from 4–8 to 10–20 years, and the shortest recorded cycles from 2–4 to 6–8 years. While there are other contributing factors, fewer growing-degree days would be an obvious candidate for (partially) explaining these shifts. Assuming that the minimum thickness was constant, an increase from 4 to 6 years would imply a 50% increase. Using a range of yields from previous estimates, this would correspond to a fall from 2 to 1½ tonnes of dry wood per acre, and given the similarly forested supply area, a corresponding decrease in fuel availability. However, assuming a linear relation between wood growth and GDD suggests that cooling climate occasioned a smaller but still marked 17% decrease in supply.

On the demand side, lower temperatures and a ~15% increase in HDD would have to be met by more, or more efficient, heating and/or insulation (clothing, etc) to maintain thermal comfort. While fashion changed towards warmer clothing, the preference for open hearths in maritime western Europe precluded adopting more efficient stoves (as in central and northern Europe). Rather than improving efficiency, the chimneyed fireplace allowed burning more fuel in cooler weather without smoke becoming unbearable. This initiated the high-energy path continued in Britain and North America, while simultaneously facilitating the move from charcoal to coal. Unlike organic energy sources, the production of coal was not affected by colder climates except via increased demand. The chimneyed fireplace was not new to the late 16th century but meant that thermal comfort could be regulated by the amount of fuel. Colder and longer winters therefore brought increased demand for fuel, but only coal could satisfy it.

### Session 3. Climate Variability, 500 AD – today. Chair: Christian Rohr

15.00 – 15.20 | Thursday, June 06, 2024

#### Impacts of heat waves and cold waves in Ireland

**Carla Mateus**

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Ireland has a great heritage of historical instrumental meteorological observations and documentary sources (Mateus, 2021a). The analysis of long-term instrumental series and documentary sources is paramount to examining modern climate warming within a historical context. The assessment of frequency, duration, intensity and geographical distribution of heat waves and cold waves (Mateus, 2021b) was made on long-term rescued, quality-controlled and homogenised maximum and minimum air temperature series, respectively, and based on diverse definitions from 1885 to 2023 (Mateus et al., 2020, 2021; Mateus and Potito, 2021, 2022).

In addition, documentary sources comprising meteorological registers and diaries, newspapers, monographs and other publications were assessed to examine the frequency, duration, intensity, geographical distribution, and environmental and socio-economic impacts of heat waves back to AD. 583 and cold waves back to AD. 582 up to the 21st century in Ireland.

This comprehensive catalogue of heat waves and cold waves events based on the analysis of documentary sources is important for understanding the vulnerability and adaptation of societies to extreme air temperature events.

### Session 4. Historical archives to weather, climate and societies. Chair: Heli Huhtamaa

16.40 – 17.00 | Thursday, June 06, 2024

#### The first 20 years at the Cape of Good Hope (1652–1671): Weather, Climate and Society

**Stefan Walter Grab, Ravanya Naidoo**

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Current understanding of southern hemisphere (SH) climates remains limited for times prior to the 19th century and depends largely on tree ring records sensitive to temperature and precipitation. However, such a natural proxy cannot provide a daily account of weather, or on associated societal impacts and responses. For this, «Archives of Society» are necessary. To this end, original copies of the Dutch East India Company «day registers» were sourced from the Cape Town (South Africa) and The Hague (Netherlands) Archives for photography and transcription. The registers, which cover the years 1652–1791, contain daily accounts of weather, state of the ocean, and weather-related consequences and human responses at the Cape in southernmost Africa.

Our aim is to use these registers to establish the weather and climate for the first 20-years (i.e. 1652–1671) of European (primarily Dutch) colonization at Cape Town and compare findings with those of the late 18th century (1773–1791) and early 21st century (2000–2018). This represents the earliest continuous daily weather chronicle for the SH and Africa. Extraction of daily weather information for basic statistical analysis includes recording the number of days with rain; very strong to gale force winds; mist/haze; lightning/thunder; hail and snow. Although somewhat more qualitative, we also account for the number of mentions of summer heat days and winter cold days to establish cooler/warmer periods. In addition, we provide an annual chronology of weather-related consequences and human responses. These broadly include implications for early town development (buildings, roads), agriculture (crops and livestock), human health, and shipping (trade).

Findings suggest that relative precipitation was considerably less (64 rain days/pa) than that during the late 18th century (1773–1791 = 83 rain days/pa), but similar to that of the early 21st century (2000–2018 = 67 rain days/pa). Society had to contend with, and adapt to, seasonal climatic extremes of dry/hot summers and cold/wet winters, periods of devastating drought with livestock deaths and fires (e.g., early 1658, 1663 and 1664), and other times (most winters) of intense rains and floods causing major destruction to crops and infrastructure. Particularly anomalous climatic conditions occurred during the apparent coldest winters of 1652 (high hail & mist/haze incidence; snow) and 1663–1665 (snow; ground ice). Coincidentally, the years 1663 and 1664 also recorded highest occurrences of rough/stormy ocean conditions. Highest incidences of weather-related shipping disruptions (measured on a per ship basis) occurred in 1652 and 1665–1667; this included delayed departures, delays in getting ill sailors onto land for medical treatment, shipwrecks and associated material losses. Climate-related coping mechanisms used during extreme weather events included staying indoors; work stoppages; livestock management initiatives; repair works and strengthening infrastructure. The necessity to adapt to the climate was acknowledged and became evident through initiatives such as the building of canals for peak water discharge, improved building materials, the temporal shift in peak shipping arrivals/departures, and agricultural experimentations and changes over the years.

**Session 4. Historical archives to weather, climate and societies. Chair: Heli Huhtamaa**

17.00 – 17.20 | Thursday, June 06, 2024

**Breaking Free from the Shackles of the Baltic Sea Ice: A climatic perspective on the development of Finnish winter seafaring 1890–1940s****Stefan Norrgård**

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During winters, before the use of reinforced steel-hulled ships and icebreakers, Finland used to be isolated from the rest of the world. The reason was the impenetrable Baltic Sea Ice.

In the winter of 1871, the Finnish and Swedish Postal offices started an experiment wherein the aim was to uphold postal traffic between Stockholm and Hanko. This was enabled by a ship that was especially built for the task. Albeit a slow and troublesome start, the experiment continued successfully until Finland acquired its first icebreaker in the spring 1890.

During the following winters, the icebreaker was stationed in Hanko, which due to its geographical location, was chosen as the official winter port of Finland. Turku was considered because a climatic report suggested that Turku was better suited than Hanko. However, Turku was dismissed because of its geographical location. Navigating the archipelago, to reach Turku, was considered too risky. The dismissal of Turku was the start of a rivalry between Hanko and Turku. Thus, to increase its competitiveness, Turku acquired the first privately owned icebreaker in 1899. Hereafter it was Hanko and Finland versus Turku. Which city was better suited for winter navigation and why? Bear in mind, the idea of opening up all Finnish harbours for winter seafaring did not hatch until the late 1960s. Thus, it took about 100 years (1871–1971) until technological advances enabled Finland to adapt to, and conquer, its largest economic and climatic adversary, the Baltic Sea ice.

The narrative explaining how Finland conquered the Baltic Sea ice is known; however, it lacks a climatic narrative. I will discuss how interannual climate variability (warm versus cold winters) in the early decades of the 1900s influenced winter navigation and subsequently the economic development of Hanko and Turku. By comparing the climatic conditions (such as the extent of the Baltic Sea ice) to the registered tonnage for each harbour, I will provide a novel perspective on the strange relationship between Finland and the Baltic Sea. I employ winter seafaring as an example to show how and why climatic reports should not be dismissed when planning the future.

17.20 – 17.40 | Thursday, June 06, 2024

**Impact of Droughts on Rural Communities in Early Modern Provence and Southern French Alps: A Comparative Analysis****Nicolas Maughan**

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Mediterranean societies have always coped with specific climatic constraints (summer heat waves, persistent droughts, violent and flashy floods) causing agricultural and economical disasters but also sometimes subsistence crises (crop failure); these events are key factors of coupled human-environment systems throughout history in this region. In the case of the Provence area and the Southern French Alps, if various aspects of the environmental and climate history during the Little Ice Age have already been explored, especially from the early 18th to mid-19th century, consequences due to repeated extreme drought events on the long run since the early 13th century have been neglected, notwithstanding available specific regional documentary archives. Therefore, a long-term analysis of the impact of these climate fluctuations, on both rural and urban societies in a comparative perspective between two contiguous areas, with distinct topographies, soils and natural resources, thus appears original and interesting. After describing the hydro-climatic context in Southeastern France during the late LIA, major social, economic and sanitary outcomes (food shortages, famines or infectious disease outbreaks) as well as ecological crises (changes in agricultural landscapes) due to extreme drought events which impacted this area will be presented, but also their effects on the evolution of regional urban-rural systems. Significant differences between lowland/coastal areas and mountainous regions of the Southern Alps about the socio-environmental consequences of these events and mechanisms underlying resilience will also be described in detail.

17.40 – 18.00 | Thursday, June 06, 2024

**Historical archives to document the climate of the past in northeastern Canada****Marie-Michèle Ouellet-Bernier<sup>1,2</sup>, Najat Bhiry<sup>1,2</sup>, Laura Brassard<sup>1,2</sup>**<sup>1</sup>Department of Geography, University Laval, Canada; <sup>2</sup>Centre for Northern Studies, University Laval, Canada; marie-michele.ouellet-bernier.1@ulaval.ca

Nunavik and Nunatsiavut (northeastern Canada) are facing a fast anthropogenic warming, and a considerable reduction of sea-ice cover. To better understand the current situation, it is necessary to have access to reliable climatic data to document the past variability and highlight the recent increase of temperature. However, in these regions, the national weather network compiled only data since 1921 in Quaqtaq (Nunavik) and since 1927 in Nain (Nunatsiavut) and are mostly discontinuous throughout the 20th century. Human observation of weather, ice, nature, or animal migration compiled in written historical archives provides key elements to better understand the climate of the past. Traveler and missionary journals, expedition reports, life-stories and institutional archives reported on temperature perception and the human-environment relationship (i.e. presence of sea-ice in relation with mobility). A 5-point climatic index of summer and winter temperature from northeastern Nunavik was built from climate and environmental observation. A confidence scale was developed based on the quality, density, and temporality of the sources. A 5-point garden productivity index from Nunatsiavut was constructed from Moravian missionaries' observation. Both records showed a regional variability in phase with the North Atlantic Oscillation (NAO). Colder climatic conditions were documented during the positive phase of the NAO (i.e. 1830–1840, 1880–1885, 1905–1915). Our analysis suggested that temperature perception reported in historical archives was also influenced by the wind cooling effect enhanced by the strong prevailing north-west wind. Conditions leading to freeze-up and break-up of land-fast ice along the Hudson Strait suggest that freeze-ups were sensitive to the decreasing temperature during autumn, and that break-ups were more influenced by preconditioning temperature and prevailing wind. While comparing the historical records (1880 to 1950) with present-day records (2016 to 2020), our data showed that the length of sea-ice cover has decreased by approximately 3 weeks. Instrumental archives also show similar mean summer and winter temperature from 1911 to 1980. Impacts of global warming are recorded since the 21st century with an increase of about 1.5 to 2°C (2004–2016 and 2018–2022).

**Session 1. Pleistocene to Holocene Environmental Transformations. Chair: Joseph Manning**

08.40 – 09.00 | Friday, June 07, 2024

**From glacial to Green Sahara to the post-industrial world: fire interactions with climate, vegetation, and human land use change in African ecosystems****Nicholas A. O'Mara<sup>\*1,2</sup>, Esther N. Githumbi<sup>3</sup>, Ali Aldous<sup>1</sup>, Juliette Garcia<sup>1</sup>, Marie Norwood<sup>4</sup>, A. Carla Staver<sup>2,4</sup>, Jennifer R. Marlon<sup>1,2</sup>**<sup>1</sup>Yale School of the Environment, Yale University, USA; <sup>2</sup>Yale Institute for Biospheric Studies, Yale University, USA; <sup>3</sup>Institute of Soil Science and Site Ecology, TUD Dresden University of Technology, Germany; <sup>4</sup>Department of Ecology and Evolutionary Biology, Yale University, USA; nicholas.omara@yale.edu

Humans and our hominid ancestors have exploited naturally occurring fires as tools for cooking and hunting for at least the last one million years. By circa 200–300 thousand years ago, they developed the skills required to actively set and control fires. Today, fire regimes are heavily influenced by human activities, including direct effects such as fire suppression, controlled burning, and increased accidental ignitions, as well as indirect effects from global temperature and rainfall pattern shifts due to anthropogenic climate change. Remote sensing from satellites reveals a global decline in burned areas, primarily driven by reduced burning in African grassy ecosystems as fire-dependent savanna environments are converted to agricultural land. Conversely, forest ecosystem fires are on the rise, fueled by warmer, drier conditions and deforestation practices. Disentangling human from climatic influences on fire is crucial for making accurate predictions about fire's future role as an ecological process, a component of the carbon cycle and global climate, and a natural hazard. This task is challenging with only ~20 years of satellite data over a limited range of climatic conditions. We address this challenge by examining the paleorecord. Our work combines new and existing proxy records of past fires from marine and lacustrine sediment cores to explore the history of burning on the African continent, which currently hosts over half of the world's fires. Our study spans from the Last Glacial Maximum through to the present, a period marked by significant changes in temperature, atmospheric greenhouse gas concentrations, rainfall, biogeography, and human land use, including a deglaciation, a Green Sahara period, multiple millennial-scale climate events, and the advent of agropastoralism and large-scale agriculture.

By integrating this new compilation of paleo-fire records with other paleoclimate/paleoecological data and archaeological evidence, we investigate the complex interplay between climate, vegetation, and human land use changes with fires in Africa. This approach aims to enhance our predictive capabilities regarding future fire activity changes in these ecosystems.

09.00 – 09.20 | Friday, June 07, 2024

**A «Multiple Evidence Base Approach» to the compound impact of climate change and the ~13ka BP Laacher See volcanic eruption on Final Palaeolithic foragers in Europe****Felix Riede\***

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It was 13,006 ± 9 years ago – right around early June perhaps – that the Laacher See volcano located in present-day western Germany erupted cataclysmically. This extreme event occurred right after a centennial-scale cooling event that punctuated the otherwise mild Allerød interstadial named the «Gerzensee Oscillation» after a lake near Bern – and devastated the proximal regions. Catastrophic as it was for all life nearby, the ejecta from this eruption covered and so preserved a late ice age landscape replete with the remains of plants and animals as well as traces of human presence. Via its widespread ash fallout, the eruption also affected far-flung areas – from Switzerland to Denmark, from France to Poland – where its ecological and societal impacts may have been more subtle but no less significant. With inspiration from contemporary sustainability science, I here develop a «Multiple Evidence Base Approach» adapted to maximise the evidential input from a wide range of different disciplines: Earth System Science, volcanology, palaeoecology, materials science, anthropology, as well as archaeology. In so doing, I draw on an extended battery climatic, environmental, and behavioural proxies that together allow me to sketch a vivid picture of social vulnerability and resilience of past hunter-gatherer societies to such a compound event. In closing, I reflect on how a case study of human-environmental interactions that is chronologically so remote and where the affected societies' lifeways are so foreign to our own can be made relevant to contemporary quandaries of climate change adaptation.

09.20 – 09.40 | Friday, June 07, 2024

**Cultural discontinuity and cultural response to rapid climate changes at the end of the Pleistocene in the Middle Dnieper basin****Pavlo Shydlovskiy<sup>1</sup>, Marharyta Chymyrys<sup>1</sup>, Ostap Tsvirkun<sup>2</sup>**<sup>1</sup>Taras Shevchenko National University of Kyiv, Ukraine; <sup>2</sup>National Museum of the History of Ukraine; pav.shy@gmail.com

The traditional view of cultural development in the Stone Age often based on the idea of gradual replacement, where one cultural phenomenon is superseded by another, supposedly more developed one. This perspective fosters the notion of cultural stability, portraying a continuous growth in human achievements, expansion of the resource base, and successful use of natural resources by prehistoric groups. However, presenting such linear schemes can create misconceptions regarding the accuracy and internal logic of historical development, fostering a false sense of stability and infinite growth potential. Recent research in the field of prehistoric archaeology in Eastern Europe, coupled with the rapid advancements in natural sciences and radiocarbon dating, is fundamentally reshaping our understanding of the development of prehistoric cultures. Contrary to the previously held belief in a slow, steady, and gradual progression, modern studies of the Upper Palaeolithic of the Middle Dnieper region allow us to reconstruct a nuanced picture of the interaction between nature and society spanning from the appearance of anatomically modern humans to the end of the Pleistocene.

A pivotal period in human existence in northern Ukraine was the Last Glacial Maximum (LGM), which marks a chronological gap of several millennia in the distribution of archaeological sites (23–19 ka calBP). This temporal discontinuity raises questions about the evolutionary relationship between the late Gravettian industries and the Middle Dnieper Epigravettian.

Within the eastern Epigravettian in the end of the Pleistocene, several synchronous types of industries can be distinguished: the Mezhyrichian, Mizynian, and Yudinovian. These cultures shared common features, such as the tradition of constructing settlements with mammoth-bone dwellings, the extensive use of mammoth remains in daily life for fuel, building materials, and tool manufacturing, as well as the widespread use of stylized figurines crafted from tusk. The time of the spread of these industries coincides with the relative mitigation of the climate following the LGM and preceding the onset of the last Würm interstadial (19–14 ka calBP). During this period, several levels of landscape mastery can be observed, characterized by complex site structures, a certain settlement system, and the development of patterns of seasonal mobility. Architectural elements and household objects found in these sites, as well as the settlements themselves, exhibit rhythmicity and symmetry, indicative of the organization of living space by prehistoric hunters.

Following the peak of the Epigravettian mammoth hunters' culture, during the transition to the final Pleistocene, it is possible to observe the absence of technological successors to the Epigravettian industry in these regions in the subsequent millennia (13–11 ka calBP). Archaeological data suggest that vast areas were uninhabited, and new traditions associated with North European industries of making arrowheads on blades appeared during the Younger Dryas. Current data allow us to assert that global changes have led to depopulation in large areas, the disappearance of large groups of people during times of crisis, and complex migration processes. This knowledge enables us to draw conclusions about the vulnerability of human networks to abrupt climate change and underscores the necessity of objectively analyzing the current situation.



## Session 1. Pleistocene to Holocene Environmental Transformations. Chair: Joseph Manning

09.40 – 10.00 | Friday, June 07, 2024

### Assessing the climate resilience of human populations during prehistory

**Ariane Burke<sup>1,2</sup>, Simon Paquin<sup>1</sup>, Benjamin Albouy<sup>1</sup>, Timothee Poisot<sup>1</sup>, Masa Kageyama<sup>3</sup>**

<sup>1</sup>Université de Montréal, Canada; <sup>2</sup>University of Bern, Oeschger Centre for Climate Change Research (OCCR); <sup>3</sup>Laboratoire des Sciences du Climat et de l'Environnement, LSCE (UMR 8212); a.burke@umontreal.ca

The permanent settlement of Eurasia by modern humans (*Homo sapiens*) coincides with the demographic decline and eventual disappearance of endemic human populations such as the Denisovans and the Neanderthals. The loss of human diversity during MIS 3 remains largely unexplained although cultural, demographic and climate processes have been invoked. The archaeological and paleontological records indicate that Neanderthals and modern humans coexisted for several thousand years in Europe, during which time climate conditions were marked by a succession of relatively short stadial/interstadial cycles. This research uses archaeological data, climate simulations and species distribution models to assess the climate resilience of these two human groups, investigating the role of climate change as a potential driver of human evolution.

10.00 – 10.20 | Friday, June 07, 2024

### Late Quaternary Climate Change and the Peopling of the Arid and Semiarid Regions of Chile

**Claudio Latorre Hidalgo<sup>\*1,2</sup>, Mauricio Lima<sup>1,3</sup>, Eugenia M. Gayo<sup>3,4</sup>, Carolina Godoy-Aguirre<sup>1</sup>, Calogero M. Santoro<sup>5</sup>**

<sup>1</sup>Facultad de Ciencias Biológicas, Pontificia Universidad Católica de Chile; <sup>2</sup>Institute of Ecology and Biodiversity (IEB), Chile; <sup>3</sup>Center for Applied Ecology (CAPES), Chile; <sup>4</sup>Facultad de Arquitectura y Urbanismo, Universidad de Chile; <sup>5</sup>Instituto de Alta Investigación, Universidad de Tarapacá, Chile; clatorreh@uc.cl

Past droughts and pluvial events have likely played a pivotal role in understanding the population expansion of agricultural societies across the arid regions of the Americas. El Niño-Southern Oscillation (ENSO) is one of the major climate drivers of such events in the arid and semiarid regions in northern and central Chile. Positive (negative) ENSO events are related to increased (decreased) precipitation (drought) to central semiarid Chile but decreased (increased) precipitation in northern hyperarid Chile. Such drivers are particularly relevant during the Late Holocene as major agricultural societies began to flourish in both regions. Here, I will review the evidence for these climate changes along with reconstructions of major regional population trends. Expansion of agricultural societies began earlier in the inland basins of the Atacama Desert and central Andes beginning at around 4 ka. Major population booms and expansion into the hyperarid basins peaked between 2 and 0.7 ka in sync with major pluvial events in the southern central Andes, followed by drought and population collapse after 0.7 ka. In contrast, early ceramic populations in central Chile expanded much later at 2.0 ka and were still growing at the time of European arrival. This correlates with major ENSO changes as a major regime shift from a positive to negatively dominated phase occurred between 700 to 500 yrs ago at the onset of the Little Ice Age. This brought drought to northern Chile and the abandonment of most Late Intermediate Period villages but also brought wetter conditions to central Chile and consequent population expansion. Later population dynamics during the Late Period and the southward expansion of the Inka Empire are also very likely related to these major environmental and population changes.

## Session 2. Bronze Age to Ancient Nile Valley. Chair: Martin Hinz

11.00 – 11.20 | Friday, June 07, 2024

### Same but different? A comparative analysis of societal and climate changes in Bronze Age Greece

**Erika Weiberg<sup>1</sup>, Martin Finné<sup>1,2</sup>**

<sup>1</sup>Department of Archaeology and Ancient History, Uppsala University, Sweden; <sup>2</sup>Department of Human Geography, Uppsala University, Sweden; erika.weiberg@antiken.uu.se

The Bronze Age on the Greek mainland (ca. 3200–1050 BCE) comprises two cycles of societal expansion and contraction: one during the Early Bronze Age and the other during the Late Bronze Age. The two cycles share many general trajectories, but the pace of change differed across time, as did the number and size of settlements, the level of specialization and socio-political complexity, as well as the overall scale of human endeavours. Across two thousand years, the societal changes also developed in parallel with comparable fluctuations in climate, alternating between periods of on average wetter or drier climate conditions. There is a long-standing debate on the value of the resemblances between the two time-series, and thus whether climate variability may have had an either positive or negative effect on the societal trajectories of change. Comparisons between different cycles of societal change are nevertheless seldom attempted. As will be shown, the similarities and differences between the two cycles of societal change provide a significant long-term perspective on human-environment dynamics and therefore an excellent background for a discussion on the significance of different factors of societal and environmental change, the uncertainties involved and the variable effects – if any – of climate change on the living conditions of these Bronze Age societies.

11.20 – 11.40 | Friday, June 07, 2024

### Volcanic Forcing of the East African Monsoon and Egyptian History

**Joe Manning<sup>1</sup>, Francis Ludlow<sup>2</sup>**

<sup>1</sup>Yale University, United States of America; <sup>2</sup>Trinity College Dublin; joseph.manning@yale.edu

I present, along with Francis Ludlow, key results from the US National Foundation – funded project on the relationship between the volcanic forcing of the Nile river flood via the EAM and societal responses during the Ptolemaic period (305–30 BCE) in Egypt. We will briefly treat the various parts of the project, from building an historical database to climate and hydrological modeling. We will conclude with some broader implications of the work for climate history and human societies.

## Session 2. Bronze Age to Ancient Nile Valley. Chair: Martin Hinz

11.40 – 12.00 | Friday, June 07, 2024

### Simulating Inundated Area for Ptolemaic Nile River Flooding

James H. Stagge<sup>1</sup>, Irene F. Munyejuru<sup>1</sup>, Joseph Morgan<sup>2</sup>, Francis M. Ludlow<sup>3</sup>, Joseph G. Manning<sup>4</sup>

<sup>1</sup>The Ohio State University, Department of Civil, Environmental and Geodetic Engineering; <sup>2</sup>Florida State University, Department of Classics; <sup>3</sup>Trinity College Dublin, Department of History; <sup>4</sup>Yale University, Department of History; stagge.11@osu.edu

Basin irrigation in response to the annual flood of the Nile was the primary method of agricultural production in Ptolemaic Egypt (305–30 BCE) as it was in earlier periods of Egyptian history. Understanding the relationship between Nile flow and flood inundated area is therefore critical for understanding the impact of extreme low or high flood years on Egyptian economies and society. This study addresses this need by developing a hydraulic model of the Nile River from Aswan to Cairo, designed to approximate pre-19th century conditions, with a specific focus on behavior during the Ptolemaic period. Hydraulic modeling was performed using the US Army Corps of Engineers' Hec-Ras model, which is widely used for flood inundation modeling of major waterways worldwide. In keeping with our focus on Ptolemaic Egypt, we chose to summarize inundated area for four relevant regions: the Upper Thebaid (Aswan to Esna), Qena Bend (Esna to Nag Hammadi), Middle Thebaid (Nag Hammadi to Assiut/Abydos), and Middle Egypt (Assiut to modern Cairo). Our Nile flood model uses a 1-dimensional flow and energy balance at each cross-section within the main channel, but employs a 2-dimensional model for the floodplain of the Middle Egypt region. This accounts for the wider floodplain and more complex flow paths, particularly around the Bahr Yussef, or Dioryx Megale (Great Canal), and its connection to the Fayyum. The Fayyum, a special focus of the Ptolemies and their major land reclamation project in the third century BCE, is not currently part of the model. Floodplain topography was based on the Multi-Error-Removed Improved-Terrain (MERIT) Digital Elevation Model, which merges and bias corrects remotely sensed elevation estimates from multiple products with an approximate 90 meter spatial resolution. River channel bathymetry is not accessible from satellite estimates, so river geometry was based on the surveyed channel bottom from modern hydraulic models and validated against historical cross-sections taken in 1901 to confirm relatively stable channel conditions. River bathymetry and interpolated floodplain elevations were then merged to create a 25 m resolution terrain map used in the model. River channel roughness was based on published estimates, while floodplain roughness was based on MDA's remotely sensed land cover dataset, with adjustments to convert modern urban areas to agricultural land cover. Our model assumes that Egyptians created levee cuts to facilitate flood irrigation, so we directly connected the floodplain to the river. We then simulated flood inundation area for a series of typical flow rates during the flood season, from 3,000 to 13,000 m<sup>3</sup>/s, without the influence of modern dams. The resulting flood inundation area estimates indicate a non-linear increase in area with flow and slightly different responses by region. Notably, when compared with a database of historical Ptolemaic locations, nearly all were above the flood zone, protecting them from high flows, while enabling irrigated agriculture in the surrounding areas. This serves to validate the findings. Understanding of flood inundation links with flow can be used, for example, to estimate potential losses of agricultural production during historical disruptions of Nile floods.

12.00 – 12.20 | Friday, June 07, 2024

### A Bioarchaeological Perspective on Human Responses to Climate Change in the Ancient Nile Valley

Michele R. Buzon<sup>\*1</sup>, Iwona Kozieradzka-Ogunmakin<sup>2</sup>

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This presentation uses an anthropological and bioarchaeological approach to understanding the impact of possible climate changes on human populations in the ancient Nile River Valley. Through the analysis of ancient human remains contextualized with other types of data such as archaeological, medical, historical, and environmental information, this study provides an important perspective on the challenges facing communities and individuals. Climate change is associated with a number of biological responses, such as emerging infections and resource deficiencies. Social responses, such as increasing violence are also linked to environmental fluctuations, although groups may also cope through migration and sociopolitical change. Evidence for changes in health status (infection, nutrition), physical activity and injury, and residential mobility is examined for individuals buried at sites in the Nile River Valley during times associated with key climate events during the end of the Old Kingdom in Egypt/Ancient Kerma in Nubia, the end of the New Kingdom/early Napatan in Nubia, decline of the Meroitic Kingdom in Nubia, and the Late/Greco-Roman Period in Egypt. This review of human responses demonstrates difficulties experienced as well as resilience. In concert with the examination of mortuary practices, it is clear that strategies and outcomes are highly dependent on variety of factors including microenvironmental variation, urban/rural distinctions, and sociopolitical nuances and that it is problematic to produce a generalized picture of response in a larger region.

## Session 3. Pleistocene to Holocene Sea Level Change. Chair: Amy Bogaard

14.00 – 14.20 | Friday, June 07, 2024

### Rise and fall of the Liangzhu culture (5.3–4.3 ka B.P.) in the Yangtze delta in response to sea level change

Chaochao Gao<sup>\*1</sup>, Fei Liu<sup>2</sup>, Xinjun Gang<sup>1</sup>

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The Liangzhu culture in the Yangtze River Delta was among the world's most advanced Neolithic cultures, as evidenced by a large «capital city» with palaces and inner and outer city walls four times the size of the Forbidden City, an elaborate water management system, and a sophisticated jade industry. In this talk, comparative analyses of temporal-spatial distribution features of the Holocene archaeological sites, and sedimentary stratigraphy and micropaleontology investigation of representative sites will be presented.

Results suggest that the emergence, flourish, and demise of the rice-based Liangzhu culture were synchronized with environmental changes, especially sea-level fluctuations on the banks of Hangzhou Bay. The culture benefited from mid-Holocene climate optimum and gradually stabilizing sea level, when rice cultivation reached a relatively high level. Large-scale hydraulic complexes were constructed between 5.3 and 4.7 ka B.P. suggesting effective flood mitigation and irrigation management. An unprecedented flooding and inundation around 4365 ± 80 yr B.P. however, may have destroyed the hydraulic complex and rice cultivation, forcing the Liangzhu people to abandon their land.

**Session 3. Pleistocene to Holocene Sea Level Change. Chair: Amy Bogaard**

14.20 – 14.40 | Friday, June 07, 2024

**Sea level rise and human response in the southern Argolid, Greece, from the Palaeolithic to the Late Roman/Early Byzantine period****Julien Beck<sup>1</sup>, Dimitris Sakellariou<sup>2</sup>, Patrizia Birchler Emery<sup>1</sup>, Flavio Anselmetti<sup>3</sup>, Andreas Sotiriou<sup>4</sup>**<sup>1</sup>University of Geneva, Switzerland; <sup>2</sup>Hellenic Centre for Marine Research; <sup>3</sup>University of Bern, Switzerland; <sup>4</sup>Ephorate of Underwater Antiquities; julien.beck@unige.ch

The southern Argolid, Greece, has a long tradition of multidisciplinary research focusing on sea level rise and its impact on local populations. It began with the excavations at Franchthi Cave in the 1960s and 1970s, which showed that the cave was occupied almost continuously from the Upper Palaeolithic to the Neolithic period. This led to pioneering marine research in the 1970s and 1980s, including geophysical survey and shallow-water coring, to study the submerged prehistoric landscape in the vicinity of the cave, and reconstruct sea level rise during its occupation.

In 2012, the University of Geneva and the Greek Ephorate of Underwater Antiquities resumed marine research in the area, using updated technologies and techniques. A submerged Early Bronze Age settlement was discovered at Lambayanna, close to Franchthi Cave. A wider portion of the Argolic Gulf was surveyed by means of multi beam echosounders, side scan sonars, subbottom profilers and coring during multiple cruises on board the research vessels of the Hellenic Centre for Marine Research. Investigations also comprised more shallow-water coring, with a coring rig from the University of Bern's Institute of Geological Sciences, reconstruction of palaeo-shorelines and palaeo-environment, detailed mapping of the landscape, and underwater excavations.

The latest results indicate significant subsidence in the area, which suggests that local coastal populations were also affected by sea level rise in more recent times. This could explain why there are many submerged Late Roman/Early Byzantine sites along the coasts of the southern Argolid. Glacio-isostatic Adjustment models for the broader area indicate sea level rise in the order of 2.5 meters in the last 5000 years, and less than 1 meter in the last 2000 years. However, the pattern of subsidence observed at submerged sites on the coasts of the southern Argolid deviates significantly from the modelled rate and amount of glacio-isostatic sea level rise. Early Bronze Age sites such as Lambayanna are found at more than 4 meters waterdepth. Classical sites, such as Halieis, and Late Roman/Early Byzantine sites are submerged by more than 2.5–3 meters. As there is still no direct evidence on the palaeo-shorelines at each one of these sites when they were inhabited, the aforementioned depths reflect minimum subsidence. These observations imply that other factors, like active tectonics, may also have contributed locally to the total relative sea level and land subsidence. Future research will help further define the processes involved, and their implications.

14.40 – 15.00 | Friday, June 07, 2024

**The Holocene marine transgression and its effects on the Prehistoric coastal population in the Adriatic Basin: A case study in Zambrotija Bay, Croatia****Katarina Jerbić**

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This paper will provide an archaeological perspective on the climatic changes and sea-level rise which occurred after the last glacial maximum (LGM) in the Adriatic Basin, focusing on a case study in Zambrotija Bay, Croatia. The submerged prehistoric pile-dwelling site in Zambrotija Bay was discovered in 2008 on the ridges of a submerged sinkhole at 3 metres below mean sea level (MLS). Prehistoric pottery, stone artefacts, zoological and botanical remains were found scattered around the area, making it evident that the site represents a unique opportunity for investigating the part of Mediterranean Prehistory «lost» due to the Holocene marine transgression and landscape evolution. Between 2008 and 2014, a few investigations were performed on site, including a bathymetric survey as well as underwater archaeological excavations. The presence of wooden piles and peat as well as the radiocarbon dates and the typological assessment of Prehistoric finds attributed to the Late Neolithic and Early Copper Age periods, indicated a connection to the well-known Prehistoric pile-dwellings of the Alpine lakes. In 2017, a series of collaborative investigations were conducted on site, for the purposes of the author's PhD research project at Flinders University in Adelaide, South Australia. The methods used in this campaign (geological coring and underwater archaeological research) were chosen to contribute to the understanding of the chronology, palaeoenvironment, and cultural connections in the post-Neolithic Mediterranean, through the theoretical lens of Climate Change Archaeology. Most recently in June 2023, as a part of a postdoctoral project «Between the Alps and the Balkans: Prehistoric pile-dwellings across Croatia» at the University of Bern, funded by the Swiss National Science Foundation (SNSF), a larger scale underwater archaeological excavation was conducted on the site, giving a more detailed insight into the settlement's everyday life and adaptations to a dynamic coastal climate. This paper demonstrates a comparative analysis of all currently known archaeological, geophysical, stratigraphic and paleo-environmental data from 2008 until 2023 with the aim to understand the adaptive pathways of the Zambrotija Prehistoric population towards preserving sustainability in the time of rapid environmental changes, therefore endorsing archaeology into being an equal contributor in modern climate change debates.

15.00 – 15.20 | Friday, June 07, 2024

**Investigating drivers of marine resource exploitation in NW Ireland from the fifth to the third millennium BC****Rory Connolly**

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Coastal shell middens are a valuable archaeological resource with the potential to shed light on many aspects of human interaction with coastal environments across time. Over 500 such sites containing anthropogenic marine shell deposits can be found along the c. 7500km of Ireland's coastline, with dates spanning from the Mesolithic to relatively recent times. Unfortunately, a significant number of these sites are under threat from a combination of natural processes — such as sea-level rise, coastal erosion, bioturbation, and an increase in the number and intensity of storm surges — as well as human activities, including visitor footfall, certain agricultural practices, and encroaching development.

Here we describe a recent radiocarbon dating programme which targeted six eroding coastal shell midden sites in County Sligo. The results of this study point to persistent exploitation of the marine environment between the Later Mesolithic and Late Neolithic in this region. An apparent uptick in marine resource use from the Middle to Late Neolithic appears to correspond with a period of climatic variability, as evidenced by a number of regional proxies. At the same time, indicators of arable farming become more rare in the palaeoecological record and changing landscape use is apparent through several lines of archaeological evidence. Taken together, this may point to a regional response to changing environmental and climatic conditions. These newly acquired dates not only contextualise the shell middens within the broader archaeological landscape but are also instrumental in combating the loss of valuable archaeological information to coastal erosion and accelerating climate change impacts.

**Session 4. Rapid Environmental Change and Resilience. Chair: Ariane Burke**

16.00 – 16.20 | Friday, June 07, 2024

**Some thoughts on climate resilience of prehistoric societies****Niels Bleicher<sup>1</sup>, Renata Huber<sup>2</sup>**<sup>1</sup>Underwater Archaeology and Dendroarchaeology Zurich, Switzerland; <sup>2</sup>Office for Monument Preservation and Archaeology, Canton of Zug, Switzerland; niels.bleicher@zuerich.ch

A number of studies have postulated dramatic climatic impact on prehistoric societies of the circumalpine realm. In some cases, these were conceptually imagined as especially vulnerable to weather or climate changes. Moreover, some studies focus on the climate affecting the economy, while others suggest an effect on the settlements themselves as mediated through changing lake levels and their effect on the inhabited spaces.

In this talk, I want to outline the latest results and interpretations of the economy and the settlement systems of the late Neolithic in Switzerland and Southern Germany. These may have far-reaching consequences for our understanding of these societies and allow for new hypotheses concerning their climate vulnerability and resilience. We argue that we need to redefine the term «settlement» and even question the idea that the Neolithic Package was delivered in one piece in order to reach a more consolidated idea of the climate resilience and vulnerability.

16.20 – 16.40 | Friday, June 07, 2024

**Domesticated Resources, Diet, and Population: Human Responses to Late Holocene Climate Change in Central-Western Argentina****Adolfo Fabian GIL<sup>1,2</sup>, Jacob Freeman<sup>3</sup>, Eva Peralta<sup>1</sup>, Manuel Lopez<sup>4,2</sup>, Ricardo Villalba<sup>5</sup>, Teresa Michieli<sup>6</sup>, Fernando Franchetti<sup>1,2</sup>, Gustavo Neme<sup>1,2</sup>, Mariano Morales<sup>5</sup>**<sup>1</sup>Instituto de Evolución, Ecología Histórica y Ambiente (CONICET / Universidad Tecnológica Nacional); <sup>2</sup>Universidad Nacional de Cuyo<sup>3</sup>Utah State University; <sup>4</sup>CONICET-IADIZA; <sup>5</sup>CONICET-IANIGLA; <sup>6</sup>Centro de investigaciones Precolombinas (CIP); agil@mendoza-conicet.gov.ar

The impact of climate on farming production and its consequences for the resilience and transformation of socio-natural systems is a central topic of research across disciplines. The long-term perspective offered by archaeological and paleoclimate data can reveal patterns of change in socio-natural systems that are not visible in short-term records. The Late Holocene archaeological and paleoclimate records of central-western Argentina provide an important opportunity to investigate the effects of climate on farming and the transformation of socio-natural systems. Central-western Argentina, an arid region with limited primary productivity, lies on the historical border between hunter-gatherers and farmers. In this presentation, we evaluate the impacts of climate changes on subsistence and population dynamics, contrasting the human response between areas with different levels of maize consumption. We test the hypothesis that regions more committed to maize production were less sensitive to climate changes than areas occupied by hunter-gatherers.

16.40 – 17.00 | Friday, June 07, 2024

**The 8.2k cal BP Climate Event: Rapid Environmental Change versus Long-Term Social Change during the Neolithic and Chalcolithic in the Near East****Peter F Biehl<sup>1</sup>, Arkadiusz Marciniak<sup>2</sup>**<sup>1</sup>University of California Santa Cruz, United States of America; <sup>2</sup>University of Poznan, Poland; pbiehl@ucsc.edu

The paper aims to outline major aspects of the cultural, social, economic, and symbolic transition between the Neolithic and Chalcolithic in Central Anatolia, as revealed at the Çatalhöyük East and West Mounds (ca. 7,000 cal BC–5,500 cal BC). It further intends to examine available paleo-environmental evidence and its relation to the 8.2k cal BP climate event. Exploring this wide range of datasets, out of potential different scenarios, we plan to assess the impact of the 8.2k cal BP climate event on long-term socio-economic changes at the settlement from ca. 6,200 cal BC to 5,900 cal BC. It gradually shifted from the East to the West Mound around this time, which offers an exceptional chance to analyze human responses to this event on a micro-scale and gives us the possibility to answer the question of why and how the shift from the East to the West Mound took place at this time. Çatalhöyük offers a microcosm that may help us unlock some of the key questions surrounding this period in the Konya plain. Once we understand the regional process, we can widen our lens and try to determine the broader effects the shift had across the Near East.

17.00 – 17.20 | Friday, June 07, 2024

**Boom-bust Dynamics in European Neolithic Societies: A Multiscale Approach****Detlef Gronenborn<sup>1</sup>, Kai Wirtz<sup>2</sup>**<sup>1</sup>Leibniz-Zentrum für Archäologie, Germany; <sup>2</sup>Helmholtz-Zentrum Hereon, Germany; detlef.gronenborn@leiza.de

Population boom-bust dynamics are increasingly reconstructed for Mid-Holocene societies. While quasi-periodic fluctuations in human activity and population size are described for many regions worldwide, their potential triggering or forcing factors are not well understood. Here, we evaluate possible factors that may have contributed to booms as well as bust events, based on local case studies from the western Central European Neolithic. Our analysis distinguishes between endogenous – social – and exogenous – climatic/environmental – factors. We particularly concentrate on one endogenous factor, namely changing properties of social cohesion, as coded in ceramic motifs but also interpreted from other archaeological data.

On a local and regional scale, the analysis excludes dominance of single-factor explanations but suggests an interaction of endogenous and exogenous factors. For example, beneficial climate/environment circumstances may have led to societies with a shared social identity and strong cohesion, and subsequent population rises. At high population densities, and eventually triggered by a deterioration of environmental conditions, societies underwent intensifications of mortality processes such as intra- and inter-group social violence. One prominent example is the decline and ultimate transformation of the Early Neolithic Linear Pottery Culture around 5000 BCE, particularly in its western regions. Such boom-bust-cycles also appear on continental scales, which reveals a certain degree of synchronicity in local and regional dynamics. This synchronicity may reflect both common external forcings of subsistence success as well as the migration of people, diseases, and conflict intensity. We argue that such explanatory models for the European Neolithic are also relevant for understanding socio-demographic dynamics in modern times.

**Session 1. Resilience, and Socio-Ecological Systems. Chair: Willy Tinner**

09.00 – 09.20 | Saturday, June 08, 2024

**Linking Resilience, Global Climate Change, and Local Socio-Ecological Systems in the Past along the Georgia Coast, USA****Isabelle Holland-Lulewicz\***

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Global climatic change can act as an operative force in past social, economic, and political organization and change. Some of these climatic and environmental changes occur at a pace relevant to the human experience. However, utilizing the expected environmental conditions related past global climatic trends presents an issue of scale when linking the dynamics past societies to climatic change. Primarily, the manifestation of global climate change in local environments may diverge from the expected. Thus, understanding the exact context under which past people made decisions is imperative to situate the trajectory of past human societies and socio-ecological systems. This paper addresses the importance of localized paleoenvironmental reconstructions, how these deviate from global trends, and how the understanding of local climatic signatures is imperative to investigating past socio-ecological systems, particularly how people make economic decisions regarding resource management strategies in the face of shifting ecological regimes associated with changing coastal dynamics. To this end, this paper discusses this within the context of the Georgia Coast, USA to discuss trends in the vulnerability and resilience of fisheries and fisheries management strategies, the primary resource base for US coastal people, over millennia.

09.20 – 09.40 | Saturday, June 08, 2024

**What makes a community resilient to aridification? Perspectives from archaeology****Matthew James Jacobson\***

Swedish University of Agricultural Sciences (SLU), Sweden; matthew.jacobson@slu.se

Narratives of «mega-droughts» causing «societal collapse» are often thrown around in both academic and popular archaeological literature. There is no doubt that aridification and droughts are a significant threat to humans, with around 4 billion people expected to experience water scarcity every year going forwards, according the IPCC. This threat would also have existed at times in the past and palaeoclimate evidence has indicated long- and short-term shifts to drier conditions that have been linked to negative human impacts, such as population declines or economic downturns. However, there are also countless examples where dry shifts did not result in catastrophic consequences, and the magnitude of drying alone has been shown to be a poor predictor of the severity of these impacts. So then, the question is: what does? Humans can persist in dry conditions, as exhibited by the fact that many drylands and hyper-arid areas have been occupied for thousands of years. There are clearly environmental, economic and socio-political conditions – and importantly, combinations of these conditions – that can enable resilience to aridity. Archaeology and palaeoclimatology together are uniquely situated to evidence these circumstances on a longer timescale and reveal what kind of community is resilient to such swings in aridity. Yet, this information has not yet been utilized to inform modern policy or decision-making. In this talk, I will discuss research into this topic, including my own work into the Sasanian Empire, and present a plan for how we can learn about resilience to aridification from the as-yet largely untapped archaeological datasets and case studies that are already out there.

09.40 – 10.00 | Saturday, June 08, 2024

**Coping with the Cold – Climate Change Resilience and Vulnerabilities of Bronze Age Communities during the 3.7 ka «Löbben» Glacier Advance (ca. 1900–1450 BCE)****Caroline Heitz<sup>1</sup>, Kristin Ismail-Meyer<sup>2</sup>, Cyrielle Aellen<sup>1</sup>, Joe Roe<sup>1</sup>**<sup>1</sup>University of Bern, Switzerland; <sup>2</sup>University of Basel, Switzerland; Caroline.Heitz@unibe.ch

Exploring how waterfront communities coped with floods and long-term lake level changes in the prehistoric past is crucial for a deeper understanding of vulnerabilities and resilience capabilities to climate-driven hydrological hazards in the present and future. In this paper, we explore responses to climate change effects of lakeshore settlement communities (UNESCO World Heritage pile dwellings) in the Alpine region. The archaeological settlement data is unique in terms of its high temporal resolution (annual to decadal scale) thanks to dendrochronological dating. While lake shores were populated in the northern Alpine Foreland during the Early Bronze Age, there is a lack of settlements in the Middle Bronze Age between the 15th and the 13/12th c. BC – or ca. 1480 and 1190 BCE as the dendrochronologically dated sites show. The reason for this absence of pile dwellings is an ongoing debate in research. While a research gap can be excluded, unfavorable preservation conditions or hiatuses in the stratigraphies at the lake shores should be further checked as possible reasons. Furthermore, this ca. 250 yearlong «settlement gap» correlates with the dendro-dated high stands of Alpine glaciers during the Löbben Advance Period (LAP), a cold period that might have led to changed hydrologies of the lakes. A long-standing hypothesis states that cold climate led to rising lake levels that rendered former lake shore settlement areas uninhabitable. However, the relations between climatic changes, lake levels and lake shore settlements are still poorly understood. To omit pitfalls of environmental determinism and to critically assess the narrative of the causal influence of climatic variability, we apply a socio-archaeological mixed methods approach that combines qualitative and quantitative methods from archaeology and micromorphology with time series statistics on temporally highly resolved archaeological and paleoclimatic proxy data. With this methodology, we aim at gaining a deeper understanding of communal responses towards hydrological hazards related to climatic changes in the scope of the SNSF research project «RISE: Climate Change Resilience and Vulnerabilities of Bronze Age Waterfront Communities (2200–800 BCE)».

## Session 1. Resilience, and Socio-Ecological Systems. Chair: Willy Tinner

10.00 – 10.20 | Saturday, June 08, 2024

### **Chalcolithic to Early Bronze Age (6400–4000 calBP). Climate, Environment and Human Response in the Forest Steppe Region of ECE Europe**

**Enikő Katalin Magyari<sup>1,2</sup>, Heikki Tapani Seppä<sup>3</sup>, Janos Korponai<sup>4</sup>, Abigail Amponsaah Ofofu- Brakoh<sup>1</sup>, Akos Bede-Fazekas<sup>5,1</sup>, Aneta Formackova<sup>1</sup>, Volker M. Heyd<sup>6</sup>**

<sup>1</sup>Department of Environmental and Landscape Geology, Eötvös Loránd University, Budapest, Hungary; <sup>2</sup>HUN-REN-MTM-ELTE Research Group for Palaeontology, Budapest, Hungary; <sup>3</sup>Department of Geography and Geosciences, University of Helsinki, Helsinki, Finland; <sup>4</sup>Department of Water Supply and Sewerage, Faculty of Water Science, National University of Public Service, Baja, Hungary; <sup>5</sup>HUN-REN Centre for Ecological Research, Institute of Ecology and Botany, Vácrátót, Hungary; <sup>6</sup>Department of Cultures / Archaeology, University of Helsinki, Finland; volker.heyd@helsinki.fi

During the fourth millennium BCE socioeconomic change from a Neo-Eneolithic sedentary village based agriculture to more itinerant pastoralism dramatically changed European society. There are opposing views on the transitional vs. abrupt nature of this change, with climate change often invoked as an important driver in addition to technological advance. In this talk we summarize existing climatic and environmental data from East-Central and Eastern Europe to address this question. We use pollen- based climate reconstructions reconstructions in addition to chironomid and stable isotope based temperature reconstructions and gridded paleoclimate hindcasts for the 4000–8000 cal BP period. Our results show that the western part of this belt was characterised by rapid decrease in summer temperatures between 4400–4200 BCE accompanied by an increase in available moisture. This was associated with a rather rapid collapse of the Late Neolithic (LN) tell settlement structure and dispersal to smaller colonies. A few centuries later, by 4100 BCE, the Lower Danube LN communities transitioned to the Eneolithic Tripolye cultural complex associated with the ongoing exploitation of the Ukrainian chernozem belt. A prominent decrease in annual mean temperatures is detected in E Romania by lipid biomarkers between 3.4 and 3.2 BCE. Lowland and alpine lakes indicate increasing summer evaporation, low winter precipitation and drought events with a maximum at ~3kyr BCE, followed by rapid available moisture increase at ~2800 BCE. In the Pontic territory the forest steppe zone enlarged, steppe narrowed down suggesting an increase in available moisture at the onset of westward Yamnaya migration (~3300 BCE). Overall, we can conclude that climatic instability during the fourth millennium BCE was regionally variable and resultant demographic responses were highly targeted and heterogeneous in nature.

## Session 2. Neolithic Environmental Transformations and Demography I. Chair: Martin Grosjean

11.00 – 11.20 | Saturday, June 08, 2024

### **Synchronous land-use phases and forest succession patterns during the Neolithic in Central Europe**

**Fabian Rey<sup>1</sup>, Willy Tinner<sup>2,3</sup>, Lucia Wick<sup>1</sup>, Erika Gobet<sup>2,3</sup>, Sönke Szidat<sup>3,4</sup>, Albert Hafner<sup>3,5</sup>, Urs Leuzinger<sup>6</sup>, Oliver Heiri<sup>1</sup>**

<sup>1</sup>Geoecology, Department of Environmental Sciences, University of Basel, Switzerland; <sup>2</sup>Institute of Plant Sciences, University of Bern, Switzerland; <sup>3</sup>Oeschger Centre for Climate Change Research, University of Bern, Switzerland; <sup>4</sup>Department of Chemistry, Biochemistry and Pharmaceutical Sciences, University of Bern, Switzerland; <sup>5</sup>Institute of Archaeological Sciences, University of Bern, Switzerland; <sup>6</sup>Department of Archaeology Canton Thurgau, Switzerland; fabian.rey@unibas.ch

The successional patterns and related vegetational processes during the Neolithization are not well understood, especially at high temporal resolution. Further well dated, decadal-scale palaeoecological investigations are therefore necessary to shed light into this vegetation tipping point in prehistory, when pristine landscapes were progressively humanized.

We recovered lake sediments from four small lowland lakes (Moossee 521 m a.s.l., Burgäschisee 465 m a.s.l., Lützelsee 500 m a.s.l., Hüttwilersee 435 m a.s.l.) situated in different parts on the Swiss Plateau. The sediments from two lakes (Moossee, Burgäschisee) are annually laminated (varved), aiding in refining the chronological framework. Our high-resolution palaeoecological analyses including pollen, non-pollen palynomorphs and microscopic charcoal are supported by comprehensive radiocarbon dating. This allowed us to examine large-scale synchronous land-use phases and plant successional patterns that may result from complex interactions between human activities and climate at exceptionally high time resolution.

For millennia, mixed *Fagus sylvatica* (beech) forests dominated the Central European lowland vegetation. However, our results show that between 6500 and 4200 cal BP, three significant forest disruptions occurred, coinciding with increased fire and agricultural activities around 6400–6000 cal BP, 5800–5500 cal BP, and 5100–4600 cal BP. These land-use phases typically led to the creation of new open areas, generally enhancing the plant biodiversity. Land-use phases often corresponding to local lake shore dwellings and lasted for several decades to centuries. Subsequently, arboreal vegetation rebounded, with early successional *Corylus avellana* (hazel) shrubs and *Betula* (birch) trees being gradually replaced within 150–200 years by late-successional mixed beech forests. *Abies alba* (silver fir) was co-dominant in the vicinity of the Jura and Napf Mountains (Burgäschisee) and close to the pre-Alps (Lützelsee) but very rare in the Lake Constance region (Hüttwilersee). Early agrarian societies were sensitive to climate fluctuations and we propose that climate-driven, simultaneous agricultural expansions and contractions contributed to large-scale, spatially synchronous successional trajectories.

## Session 2. Neolithic Environmental Transformations and Demography I. Chair: Martin Grosjean

11.20 – 11.40 | Saturday, June 08, 2024

### **Dynamics of Change: Investigating Social and Environmental Transformations in Lakeside Settlements of the Alpine foreland between 3400 and 2700 BCE**

**Mirco Brunner<sup>1,2</sup>, Corina Gottardi<sup>1</sup>, Matthias Bolliger<sup>1,3</sup>, Delphine Schiess<sup>1</sup>, Martin Hinz<sup>1,2</sup>, Caroline Heitz<sup>1,2</sup>, Regine Stapfer<sup>1,2,3</sup>, Albert Hafner<sup>1,2</sup>**

<sup>1</sup>Institute of Archaeological Sciences, University of Bern, Switzerland; <sup>2</sup>Oeschger Centre for Climate Change Research (OCCR), University of Bern, Switzerland; <sup>3</sup>Archaeological Service Canton of Bern, Switzerland; mirco.brunner@unibe.ch

Understanding the transformations of early societies is a central focus of European prehistoric archaeology. A significant cultural change occurred in the Late Neolithic around 2800 BCE, marked by the widespread occurrence of the «Corded Ware» phenomenon, encompassing Europe from Scandinavia to the Alps. These transformations are characterized by specific burial practices and pottery styles.

Current Europe-wide research has overlooked the various local social conditions that preceded the Corded Ware phenomenon and their importance for its spread. Specifically, in Switzerland, Germany, and France, well-preserved Neolithic lakeside settlements from the period 3400 to 2700 BC offer valuable insights in the period before and during expansion of the Corded Ware. The period around 2800 BCE is pivotal due to a climatic cold event impacting farming and the spread of new genetic variants in Central Europe, suggesting the arrival of people from the East, which could be related to the spread of the Corded Ware.

To comprehend the continuities and disruptions before and after 2800 BC, our focus lies on the interplay of climatic and social factors influencing settlement relocations and spatial mobility. The excellently preserved and dendrochronologically dated lake settlements in the French Jura, Swiss Plateau, and southwest Germany contribute significantly to the global discourse on the reasons for past social transformations.

By investigating vulnerability, resilience, and adaptation during a transformative period traditionally associated with mobility of different ranges due to climatic events or socio-political threats, we aim to generate new insights.

In our research we operate on the macro-, meso- and micro-level. The macro-level entails a network analysis based on ceramic vessels produced in the settlements of different regions from Switzerland, Southern Germany and the French Jura. For the meso-level we look at the development of village structures from lake settlements sites. At the micro-level the ceramic-ensembles of the individual settlements come into play.

At every level there are changes in the archeological remains through time. Do these changes happen at the same time? What are the triggers for these changes? Are these changes a social response to the climate at the time? Are the changes a result of social changes, possibly migration, or a change in network relations and mobility?

The intention of our paper is to contribute to the ongoing global dialog on the triggers of change in the past and their impact on societies in transition.

11.40 – 12.00 | Saturday, June 08, 2024

### **Climatic variations, Land management and Demography in the Neolithic: the Example of the Grandson-Corcelettes Bay (Vaud, Switzerland)**

**Elena Burri-Wyser, Marie Canetti, Chrystel Jeanbourquin**

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La richesse archéologique de la baie de Grandson-Corcelettes est connue depuis la fin du 19<sup>e</sup> siècle avec la découverte puis l'exploration du site de l'âge du bronze récent des Violes, inscrit au patrimoine mondial de l'UNESCO depuis 2011.

Des sondages et des fouilles effectués entre 1995 et 2022 ont permis de découvrir d'autres sites palafittiques à côté de celui connu précédemment. Parmi eux, le site des Corcelettes Les Pins remonte au Néolithique final. Sa fouille a été l'occasion de réaliser des études environnementales telles que l'analyse des sols, des sédiments lacustres, des macrorestes végétaux et de la faune, ainsi que l'étude géomorphologique de la baie, la caractérisation des bois architecturaux et l'identification de la source de certaines matières premières utilisées pour l'outillage.

Ces données suggèrent une nouvelle compréhension de la gestion des forêts, de l'utilisation des terres, des modes d'occupation et de la capacité des sociétés du Néolithique récent à s'adapter aux variations climatiques.

La découverte d'un autre site néolithique à Grandson – Borné Nau, à quelques centaines de mètres à l'intérieur des terres de Corcelettes Les Pins mais pas dans un contexte de zone humide, apporte également un éclairage nouveau sur la chronologie et la question de l'occupation alternative des sites d'habitation terrestres et littoraux ainsi que sur la gestion plus large des terres au cours du Néolithique.

Dans la région des Trois-Lacs, les données extraordinaires fournies par les habitations lacustres et les sites mégalithiques permettent d'aborder les questions relatives à la densité de population et à la complexité des sociétés. La mise en relation des données environnementales, démographiques et sociétales souligne le caractère non linéaire de l'évolution des sociétés, ainsi que les limites de leur adaptabilité aux changements environnementaux au cours de la période néolithique.

12.00 – 12.20 | Saturday, June 08, 2024

### **The Effects of Novel Environments on Domesticated Taxa**

**Xinyi Liu**

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There has been considerable recent momentum in understanding variations of modes of human subsistence in changing Holocene climates.

Clarity has been improved in understanding two principal episodes of social-ecological changes which transformed human history: first, associated with the awareness of plant/animal domestication as a gradual process spanning millennia, and second, with the documentation of dispersals of major domesticated taxa across continents ranging thousands of miles. What is missing from our repertoire of explanations is a conceptual bridge between the protracted process over millennia and the multiregional, globally dispersed nature of domestication. What is equally unclear is the role changing climates played in the temporal and spatial ranges of the domestication processes.

The evidence reviewed in this paper bears upon how we conceptualize domestication as an episode or a process. It highlights the challenges to forging meaningful communications between disciplinary communities and the necessity of creating such platforms, bringing together expertise traditionally separated by institutional boundaries. The paper explores the effects of new conditions (physical and cultural) on domesticated species, including farming and herding practices in marginal environments such as the Tibetan Plateau and the interplay between human selections, gene flow and morphological variations. By bringing together the topics concerning paleoenvironment, crop domestication and crop movement, those complex, protracted and continuous outcomes come more clearly into view.

**Session 3. Neolithic Environmental Transformations and Demography II. Chair: Albert Hafner**

13.30 – 13.50 | Saturday, June 08, 2024

**Reconstructing prehistoric land use and biodiversity changes across the Alps****Christoph Schwörer, Erika Gobet, Laura Dziomber, Sina Aregger, Ursula Huonder, Lara Schiltknecht, Willy Tinner**

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Mountain ecosystems in the European Alps have been shaped by millennia of human impact. Already during the Early Neolithic, humans have used alpine meadows for livestock grazing during the summer months, establishing cultural practices that continue until the present day. Technological innovations during the Bronze, Iron and Middle Ages led to an increase in population size and intensity of agricultural activities. The transformation of pristine ecosystems into agriculturally managed landscapes resulted in an overall increase in species diversity, due to the creation of a mosaic of different habitats. With increasing land abandonment due to economic pressure and centralization of industrialized agricultural production outside mountain areas, the high biodiversity of this cultural landscape is threatened.

Here, we provide for the first time a quantitative overview of land use intensity across the Alps since the onset of farming activities, by compiling the Land Use Probability Index (LUP) based on a large dataset of fossil pollen sequences. By comparing the LUP to climatic reconstructions, we explore the effect of climatic fluctuations on prehistoric societies. We are also able to correlate changes in land use intensity to trajectories in species diversity, which has important implications for future ecosystem conservation.

13.50 – 14.10 | Saturday, June 08, 2024

**Environmental and Societal Developments in Western Europe in the 4th–2nd Millennium BCE****Julien Schirrmacher, Mara Weinelt**

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Exploring patterns of socio-environmental change on deep historical time scales increasingly contributes to the current climate and socio-environmental impact debate. This new perspective can in particular help to narrow down the large uncertainties inherent to predicted global change scenarios; to identify and to assess adequate and more sustainable mitigation strategies. Such efforts require an intense debate among paleo-environmental experts and archaeologists, and a robust database to empirically test hypotheses of socio-environmental interaction.

Here we present an empirical approach based on a supra-regional comparison of past human and climate dynamics, covering the mid-Holocene period and spanning major late Neolithic and Bronze Age transformations. Our analyses build i) on an extensive dataset of radiocarbon data from archaeological contexts serving as a proxy for past human activities; ii) a palaeo-climatological dataset comprising bi-centennially-resolved temperature and precipitation changes; iii) selected regional compilations of pertinent socio-economic and settlement variables in context of different climate sensitivity. This synoptic approach enables us to reconstruct the magnitude and rate of climate changes and of the intensity of human activities and/or changes in population density, and to assess external environmental vs endogenous societal triggers determining regional boom and bust patterns.

Regional scale detailed trajectories of socio-environmental developments are discussed for the Iberian Peninsula and Germany, regions prone to aridification and to cooling events. Regional responses are discussed under the lens of how people build resilience to cope with enhanced socio-environmental stress.

Results on a supra-regional scale suggest under typical NAO climate variability a complex mosaic of human activities where boom and bust regions coexisted next to each other. Along with the escalating 4.2 climate crisis also the demographic patterns converged, suggesting a widespread population decline or slowed growth in central western Europe, followed by a new mosaic of recovery shaping asymmetries in capacities to build resilience. Archaeobotanical and archaeozoological evidences imply that prehistoric societies adapt to climate change by managing the risk of subsistence failure.

14.10 – 14.30 | Saturday, June 08, 2024

**Neolithic land use in uncertain climates: new insights from the EXPLO project****Amy Bogaard<sup>1</sup>, Rachel Ballantyne<sup>1</sup>, Michael Charles<sup>1</sup>, Müge Ergun<sup>1</sup>, Kathrin Ganz<sup>2</sup>, Eugenia Gkatzogia<sup>3</sup>, Erika Gobet<sup>2</sup>, Amy Holguin<sup>1</sup>, Valasia Isaakidou<sup>1</sup>, César Morales del Molino<sup>4</sup>, Patrick Schläfli<sup>2</sup>, Elizabeth Stroud<sup>1</sup>, Lieveke van Vugt<sup>2</sup>, Doris Vidas<sup>1</sup>, Albert Hafner<sup>5</sup>, Kostas Kotsakis<sup>3</sup>, Willy Tinner<sup>2</sup>**

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Here we present results of the ongoing ERC Synergy EXPLO project (Bern, Oxford, Thessaloniki), bringing insights from palaeoecological analysis of lake sediment sequences together with bioarchaeological (archaeobotanical and faunal) analysis of on-site occupation layers of lakeshore settlements in southeast Europe. Building on radiocarbon and dendrochronological sequences and analysis of material culture as part of EXPLO, we frame new palaeoecological data from multiple lakes and sites regarding land use responses before, during and after the 8.2K rapid climate event. We refine reconstruction of specific cultivation and herding practices using on-site bioarchaeological data, as upland lakeshore settlements (excavated as part of EXPLO) were established in the wake of the 8.2K event, from the early 6th millennium BC.



## Posters

**LEarning from the Past: the LEAP project. Investigating the impact of abrupt climate changes on society and environment in Belgium**

**Giacomo Capuzzo<sup>1,2</sup>, Hannah Leonard<sup>2</sup>, Possum Pincé<sup>3</sup>, Mathieu Boudin<sup>4</sup>, Christian Burlet<sup>5</sup>, Philippe Crombé<sup>6</sup>, Koen Deforce<sup>3</sup>, Sophie Verheyden<sup>5</sup>, Marine Wojcieszak<sup>4</sup>, Philippe Claeys<sup>2</sup>, Isabelle De Groote<sup>6</sup>, Guy De Mulder<sup>6</sup>, Christophe Snoeck<sup>2</sup>**

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Current climate change has an important impact on human populations and the environment worldwide. These effects are also visible in Belgium, such as the recurring heat waves in 2022 or the devastating floods in Wallonia during the summer of 2021. However, this is not the first time we faced abrupt climate changes. Our ancestors also experienced rapid climate changes with temperature fluctuations and climate worsening. However, due to the short duration of these events (lasting only 100 to 200 years) and the absence of written sources, it is challenging to assess their impact on society and the environment.

The LEAP (Learning from the past: The impact of abrupt climate changes on society and environment in Belgium) project studies the impact of the 9.3, 4.2, and 3.2 ka cal. BP rapid climate changes on past societies and ecosystems in Belgium, with a particular focus on the Meuse basin. This is done using a transdisciplinary approach which combines high precision <sup>14</sup>C and U/Th dating with different proxies, such as palaeoclimatic records from cave deposits (speleothems), palaeoenvironmental data based on the analysis of subfossil pollen, spores and charcoal from peat bogs, palaeomobility information resulting from oxygen and strontium isotope analyses of prehistoric human remains, and palaeodemographic reconstructions derived from statistical modelling of radiocarbon dates and raw counts of archaeological sites.

By improving our understanding of the climatic effects on the environment and populations in pre-complex and early-complex societies during the Early and Middle-Late Holocene in the Meuse basin of Belgium, we can better address the challenges we face today in this region. This includes extreme weather events like droughts, floods and forest fires, as well as population movements and adaptations.

**Climate of the Maunder Minimum in SOCOLv4 model simulations and reanalysis data**

**Tatiana Egorova, Jan Sedlacek, Eugene Rozanov, Timofei Sukhodolov**

PMOD/WRC, Davos, Switzerland

Centennial climate evolution correlates with the solar activity proxies. However, this correlation hasn't yet been proven or disproven as a causal relationship because of the large uncertainties in the amplitude of solar forcing reconstructions from these proxies and uncertainties in responses to other forcings like volcanic eruptions. Motivated by recent developments in modeling that allow direct simulations of volcanic aerosols in the Earth system model (ESM) framework, and the availability of homogenized climate reconstruction data, we focused our study on establishing the approximate amplitude of long-term solar forcing variation exploiting these two components. In other words, we aimed to answer the question of how large the solar forcing must be to reproduce the observations. We focused on the period around the Maunder Minimum (17th–18th centuries), characterized by a substantial decline and recovery in solar activity overlapping with a series of volcanic eruption clusters. We exploited the ESM SOCOLv4 that was explicitly designed for simulating the volcanic- and solar-related processes in the atmosphere, which has been forced by the latest estimates for the volcanic SO<sub>2</sub> emissions and a range of solar scenarios with varying amplitudes. As a reference, we used the Modern Era Reanalysis data and individual regional temperature reconstructions from the proxy data. To better understand regional sensitivities and non-linearities in climatic responses to volcanoes and variations in solar activity, we additionally performed 200-year-long time-sliced simulations with different solar forcing amplitudes ranging from -20 to +10 Wm<sup>-2</sup> and the ensemble Tambora-like simulations.

**Responses of socio-ecological systems to climate change: A comparative perspective for the Subtropical Andes during the Holocene**

**Adolfo Fabian Gil<sup>\*1,2</sup>, Manuel Lopez<sup>3,2</sup>, José Rogán<sup>2</sup>, Eva Peralta<sup>1</sup>, Mariano Morales<sup>4</sup>, Fernando Franchetti<sup>1,2</sup>, Jacob Freeman<sup>5</sup>, Ricardo Villalba<sup>4</sup>, Gustavo Neme<sup>1,2</sup>**

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<sup>3</sup>CONICET-IADIZA- (Argentina); <sup>4</sup>CONICET-IANIGLA; <sup>5</sup>Utah State University

Central Chile and Central Western Argentina are located at about 30 to 35° SL, but on different sides of the Andes. They are close in space but have significant differences in ecosystems, resource structure, and climate. Both areas incorporated domesticated resources, mainly maize, in the late Holocene. In this poster we assess how these differences in ecosystems and climate have affected socio-ecological systems in both regions, and whether these regions show similar responses to Late Holocene climate change.

## Posters

**An Archaeological Exploration of Prehistoric Land Use and Adaptations to Climate in the Southern Balkans****Marco Hostettler**

University of Bern, Switzerland

The Southern Balkans designate a region comprising the territories of North Macedonia, Albania and Greece. The landscape of this area was mainly created by tectonic activity and limestone weathering and is one of the geographically most diverse regions of Europe. It spreads from high altitude plains and lake systems to the Aegean Sea with its Mediterranean climate. Around 7000–6500 BC farming practises reached the Aegean Coast and subsequently spread into the European mainland in the millennia to follow. Here, farming and the involved societies underwent the adaptations which allowed them the further spread into the continent along different routes.

Radiocarbon data taken from archaeological contexts in the area show that after an initial phase, a wide range of diverse environmental zones on different elevations was settled. This means, people had adapted to different climatic conditions, possibly taking advantage from coinciding climate changes at the time. Archaeological evidence suggests unbroken presence of human activities in the Balkans until ca. 4000 BC, when the evidence for human activities sharply decreases. The phase coincides with maxima in forestation at least in parts of the region as suggested by independent sources. Only after 3500 BC a growing human presence connected to the Onset of the Early Bronze Age can be detected using radiocarbon dates.

During these early millenia of farming societies in the Balkans, several backlashes in human activities can be observed. These have been discussed to be connected to climate events, such as the 8.2 ka BP event at the onset of the Neolithic on the European mainland or the 4.2 ka event at the end of the Early Bronze Age. The aim of this talk is to discuss how the diachronically changing food systems might have been affected by these climatic impacts and what that might have meant for the involved societies. By exploring the respective subsistence economies and land use systems of the Neolithic and Bronze Age societies, probable resilience strategies or vulnerabilities facing climatic variability will be discussed.

**Abnormal climate and the market economy: the relationship between reconstructed solar radiation and rice price during the famine of the 1830s in Japan****Mika Ichino<sup>1</sup>, Kooiti Masuda<sup>2</sup>, Takehiko Mikami<sup>3</sup>, Yasuo Takatsuki<sup>4</sup>**<sup>1</sup>Joint Support-Center for Data Science Research, Research Organization of Information and Systems, Japan; <sup>2</sup>Rissho University; <sup>3</sup>Tokyo Metropolitan University;<sup>4</sup>Kobe University

Examining historical climate fluctuations and associated societal responses is crucial to enabling sustainability. To understand the impacts of climate change on the Japanese society prior to the establishment of official meteorological observations, reconstruction of climate variations with a greater temporal resolution is imperative.

Here, we aimed to reconstruct solar radiation, a phenomenon that plays a crucial role in maintaining the global energy balance, influencing agricultural productivity, and driving the hydrological cycle, in Japan from 1821 to 1850, a duration that encompassed the ‘Tempo Famine’ of the 1830s, which threw Japan’s society into crisis. Rice was an important crop in Japan during this period, with strict trade controls causing domestic production to be the primary determinant of rice prices, while weather exerted a significant impact on production. Thus, this period is an important case study for examining the relationship between climate and economic outcomes. Furthermore, we examined the impact of solar radiation–influenced climate variation on market prices during this period.

This study used daily weather descriptions from 18 historical documents (1821 to 1850) curated in the Historical Weather Database and economic data from the ‘Sho Soba no Hikae’ records, which documented the monthly rice price in Osaka from 1833 to 1839. A method that pivots on the relationship between solar radiation and weather descriptions was adapted for historical weather descriptions. This method is effective year-round and yields results with greater temporal resolution than techniques based on other proxies. The advantage of this method is that it allows discussion using high-resolution social data.

Monthly mean solar radiation from 1821 to 1850 was reconstructed using historical diaries. Our results, visualized as distribution maps of 18 locations in Japan from May to September during the severe famine years of 1833, 1836, and 1838, revealed notable patterns. These included weaker estimated solar radiation in Tohoku, the northern part of the Japanese mainland, than in other areas during 1833, whereas similar low solar radiation in most locations except Tohoku and southern parts of Japan in July and August of 1838 and 1836.

Monthly rice price data were linked to the reconstructed solar radiation to understand the relationship between famines and climatic conditions. For instance, we found that rice prices increased substantially after July 1836 owing to unfavorable weather conditions before the harvest season in October and November. Prices rose to four times the usual before stabilizing and falling in September 1837. Although rice prices rose during the summers of 1833 and 1838, they were only two to three times higher than usual and quickly returned to normal.

These results indicate that the anomalously low solar radiation in July and August may have been responsible for the societal effects during the famine years. Abnormal rice price hikes during the summer of 1836 were attributed to the irregular distribution of solar radiation, which exacerbated famine severity. Linking reconstructed solar radiation data with rice price records revealed significant comparative differences, even among years labeled as ‘famine years’ in historical documents.

## Posters

**Weather to climate, past to present: Human response and adaptation to climate change in the Maya lowlands over the past two millennia****Eva Jobbova**

Trinity Centre for Environmental Humanities, Trinity College Dublin, Ireland

Both the perceived «successes and failures» of the Maya are often linked to their relationship with the local environment, and their response to episodes of climate change over a period of nearly two thousand years. However, we still know very little about the human-environment relationship dynamics, especially with respect to choices humans make in response to environmental change. Does society become increasingly complex? Is collapse inevitable? Does the local environment affect the choices people make in the face of environmental stress and if so, how? An increased interest in climate change within the last few decades has meant that a large amount of paleoclimatic data have been collected from the Maya area, often indicating considerable changes in rainfall patterns during the mid-to late Holocene. These data, beside other things, challenged the general assumption of unproblematic water supply in the tropics. The ethnographic research conducted among contemporary Maya communities (Downey and Jobbová 2011) supports this new outlook; it showed that «drought» and especially high variability in rainfall patterns are real phenomena with often severe consequences for people's livelihoods. Combined with archaeological and epigraphic evidence, the results also confirmed that both ancient and modern Maya developed a wide variety of strategies to cope with extreme climate events; as well as to adapt to changes in the long run.

This paper responds to recent debates and new analytical opportunities in Maya studies provided by increased amounts of paleoclimatic data, the growing field of settlement archaeology and advances in Maya epigraphy. By combining a range of evidence, it explores the relationships between Maya society and the local environment, especially the choices humans make in response to extreme variability in rainfall in different environmental conditions and on multiple spatial and temporal scales, while also considering socio-cultural agencies. The paper specifically focuses on how different perspectives, derived from written sources and ethnographical studies, combined with scientific data collated from sediments, speleothems and other proxies, as well as material culture, can elucidate the complex human decision-making process in the face of changing environmental/climatic conditions and the ramifications this has on cultural change.

**Medieval floods and long-term water-level changes, adaption strategies and flood resilience in the Middle-Danube area based (primarily) on archaeological evidence****Andrea Kiss**

TUWien, Austria

The ongoing investigations, based mainly on excavation reports in Hungary, partly in other countries of the Carpathian Basin, are concentrated on four major research areas:

- 1) Based on excavations of medieval island and riverine – royal, ecclesiastical, private – (stone) building complexes, identify great/extraordinary floods (damages, Danube flood sediments, evidence of enhanced prevention in response to increased flood danger), flood-rich periods and periods with higher (or lower) average water-levels along the Danube (partly of other rivers/lakes). Compare and combine results with the information derived from contemporary documentary evidence, in order to extend the reconstruction of flood-rich periods back in time, beyond the timeframe covered by documentary evidence.
- 2) With combining the information derived from archaeological and documentary (and palaeo-environmental, when available) evidence in island and riverine building complexes, detect and describe flood mitigation and adaption strategies and their development along the Danube (and in other areas of the Carpathian Basin) throughout the Middle Ages.
- 3) Complex investigations of Danube (and other) island monasteries: when and why medieval island monasteries were deserted and reinhabited until the early 16th century, what role (and when) hydrological conditions, variability and change could play in their desertion and reoccupation.
- 4) Identification of prolonged drier and wetter periods in different parts of the Carpathian Basin, with predominant low and high (ground) water-level conditions in the Middle Ages (ca. 500–1500; and partly before/after), based on settlement, cemetery, large stone building and well excavation reports.

In the presentation, major archaeological source types, methodologies, the chief results of analyses (i.e. Danube flood-rich periods, extended back to the early 13th century, low and high water-level phases in other main catchments in the Middle Ages, main groups of prevention/adaption strategies) are provided, with the help of three case studies (Visegrád and the Margaret Island along the Danube, Miskolctapolca in the Tisza catchment).

## Posters

**Archaeology of Ghost Patches****Einar Kristensen, Martin Callanan**

Norwegian University of Science and Technology (NTNU), Norway

As global warming alters climatic conditions and local weather patterns, cryospheric features in the mountains, such as glaciers and ice patches, are experiencing significant changes. For glacial archaeology, one of the most important tasks is to observe and describe a cryosphere in various stages of decay while salvaging as much knowledge as possible. Monitoring programs map the yearly mass balance of glaciers in many mountain areas worldwide, but less attention is paid to other features of the cryosphere. With respect to ice patches for example, we do not know what we are currently losing every year, what we have already lost, or what we stand to lose in a future of increasing global temperatures.

Ice patches are perennial bodies of ice and snow in various stages of transformation. Unlike glaciers, they are stationary – affecting little to no movement of, or within, the ice mass. Subjected to limited turnover of materials, some have remained in place throughout the Holocene. Ice patches in high altitude alpine areas function as archives in various ways. It is their combination of temporal stability and minimal movement of mass that make ice patches such valuable archives of past climatic conditions and environmental, biological, and cultural datasets. Any material integrated in the ice mass has a chance of being preserved more or less indefinitely – or until the ancient ice itself melts, leaving behind a «ghost patch».

This paper presents a recently started PhD-project on glacial archaeology. In this presentation we discuss some of the key themes of the project, with particular focus on ice patches in relation to past climatic conditions. The focus will be an elaboration of the conceptual and methodological frameworks for the project, particularly on discussing novel methods for examining ice patches as constituents of gradually changing cryospheric landscapes in various stages of decay.

Climatic shifts of the past have impacted the current spatial distribution of ice patches. We plan to examine them as a proxy for understanding past climatic developments – and the societal and cultural responses to the environmental changes brought on by the loss of ice. The integration of remote sensing data from satellites, aerial photography, and LIDAR as well as field observations and historical data into existing GIS-models will enable us to identify ice patches that no longer contain ancient ice. The potential of this novel approach to examine what is left behind once the ancient ice is gone and the accompanying targeted fieldwork to evaluate the knowledge potential of these «ghost patches» is of relevance to a wider discussion on glacial archaeology in general. It is also pertinent to how we, as a society in the midst of accelerating global warming, can best manage the knowledge potential of ice patches – in the uncertain future that they face.

**Setting the scenes? Pride and prejudice in climate-conflict studies****Kuan-Hui Elaine Lin<sup>1</sup>, Pi-Ling Pai<sup>2</sup>, Jing-Wen Chen<sup>3</sup>, Yu-Shiuan Lin<sup>3</sup>, Pao K. Wang<sup>3,4,5</sup>**

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In 1975, the economist Prof. William D. Nordhaus at Yale University has warned the steadily rising temperature on the earth surface. At the time he already suggested that we should keep warming below 2°C to prevent a tremendous loss from society. He was awarded the Nobel Prize in 2018 for the distinguished contribution to integrate climate change into macroeconomic analysis. Consequently, in 1990 the IPCC released its First Assessment Report (FAR), since then the suspicions about global warming have restlessly grabbed the societies. The latest IPCC Sixth Assessment Report finally gives strong evidence proving the indispensable role of human activities leading to ca. 1.1 °C of warming since 1850–1990. Warming is further anticipated to be faster and will make holistic impacts on every part of the earth systems especially resulting in alternation or destruction of the ecosystems. The threat of the allegorical Sixth Extinction (Kolbert 2014) has hence triggered a general nerve; we started to question the consequences of human future between climate and conflict particularly when stronger competition over scarce environmental resources is likely to happen for survival.

Humans have defined how the world developed in the last centuries. Aside from warming, in 1993 geographers in Massachusetts published an influential book on «The Earth as Transformed by Human Action» (edited by Turner, B. L., et al.) to document the unprecedented changes in the biosphere that have taken place over the last 300 years. In reality, it is us, humans, who set the scene for the environments and land use relationships to be changed and allow for greenhouse gas emissions to accumulate and in the end alter the atmospheric composition producing global warming. Nowadays, when facing the many problems, we keep using the same attitude and further consciously or subconsciously attempt to define the views of how climate might be related to societal consequences particularly warfare and conflict. We endeavor to produce and collect data, and develop new algorithms and methods to advance our knowledge on this important question from a positivist tradition. But again, have we really critically examined ourselves in the pursuit of answering the question or, progressively, have we questioned ourselves from what epistemology have we built our understanding to ask and approach the question?

The case study given in this study is the White Lotus Rebellion (WLR)(1794–1804 CE). The 18th century China was marked a warmer period during Little Ice Age and politically it was viewed as High Qing, the golden era of Qing dynasty, undergoing rapid population growth, commercial revolution, and territorial expansion. The outbreak of WLR began in the last years of High Qing in central-western inland, a mountainous region bordering Sichuan, Hubei and Shaanxi Provinces. Since earlier High Qing, this impoverished region had received a large quantity of immigrant populations who were disadvantaged, lost properties from land reform, and failed to feed families in the climate and social crises. Also, the migration policy was encouraged by government to ease land-population pressure in core provinces. From time series analysis, the timing of WLR outbreak perfectly matched higher drought and flood frequency in China. However, spatial analysis reveals a clear spatial mismatch of hazard hotspot areas and WLR location. By bringing together new datasets of REACHES and SIER, our preliminary analysis suggests a need of deeper investigation on the social-spatial processes of the event and the linkage to climate. It is also necessary to test whether the climate-conflict relationships exist independently or the relationships only appear under intervention of other factors. WLR marked a sharp decay of the dynasty gradually stepping into its downfall.

## Posters

**«AnthropoCENE»: Expanding the foodscape was key for Homo sapiens in the past. Considerations on present day drawback of an evolutionary success****Laura Longo<sup>1</sup>, Alessandra Carbone<sup>2</sup>, Clarissa Cagnato<sup>1</sup>, Elena Badetti<sup>1</sup>, Silvana Condemi<sup>3</sup>**<sup>1</sup>Ca' Foscari University of Venice, Italy; <sup>2</sup>Pierre et Marie Curie Universite- Sorbonne Universite; <sup>3</sup>UMR 7268 CNR-Aix-Marseille Université AMU

Our reasoning is based on the entanglement of the biological and behavioral traits that contributed to the successful colonization by Homo sapiens of the northern latitudes during the MIS 3 (65–25 ka), and then the rest of the globe. We start from a novel perspective to investigate the reasons of Homo sapiens success during its expansion towards the northern latitudes: what if expanding its foodscape was key for its successful colonization? Our investigative approach is multidimensional and combines bioinformatics, paleoanthropology, functional analysis of ground stone tools and the associated biogenic residues physical-chemical characterization. The aim is to integrate information to get to very basis of human dietary adaptation.

Bioinformatics analyzed the CNV trend of several genes i.e. AMY1A/B/C, SULT, MUC7 among others, selected within the publicly available genomes of the hominins roaming across Eurasia during MIS 3 (60–25 ka BP). The result is a strong indication that an adaptive force acted on the duplication of these genes in the archaic populations, modifying the capacity of the metabolic process with consequences on dietary habits and adaptation to different life conditions.

On the behavioral side, ground stones tools' functional analysis informs on the transformative potential of macro-lithic tools as directly involved in the transformation of plant starch-rich storage organs, The analysis combined the conventional microscopic imaging with use-related residues chemoprofiling, and, finally compared the results with the actualistic reference collection of starch-rich plants that enabled us to gain unexpected insights into the foodscape of the early waves of modern humans entering the boreal latitudes.

We are here presenting those biologic and cultural traits related to the efficient access to dietary carbohydrates like a pool of genes involved in starch metabolic pathways, the recognition of ground stone tools used for starchy plants mechanical processing in EUP sites across the Eurasian steppe and an overview of dental features and pathologies putatively related to sugar-rich foods. Considerations regarding the pathologies affecting humans before and after the massive introduction of dietary carbohydrates will be also addressed.

**Simulating Hydrologic Impacts of Historical Explosive Volcanic Eruptions on Nile River Discharges****Irenee Felix Munyejuru, James H. Stagge**

The Ohio State University, United States of America

The Nile River water resources played a crucial role in Egypt's civilization whereby agricultural activities were heavily dependent on the summer floods. In general terms, increased summer floods meant more irrigated and fertile land, thus generating higher revenue and contributing to the betterment of society. Conversely, decreased annual floods lowered the amount of arable land for a given year, and occasionally persistent droughts triggered economic, societal, and political instabilities. Previous studies showed a correlation between major political unrest following major volcanic eruptions. There are two direct ways that the aerosol deposition from volcanic eruptions impacts the global climate and natural flow of the Nile River in particular: (1) by decreasing the atmospheric potential to hold water which leads to decreased precipitation, and (2) by constraining northward migration of the Inter Tropical Convergence Zone. Both phenomena potentially decrease the availability of precipitation over the Blue Nile and Atbara, the two watersheds responsible for up to 85% of the summer floods. To date most studies have focused on disruptions in precipitation; however, changes in precipitation do not linearly translate into changes in the annual flood due to the spatial heterogeneity of the Nile system.

This study explores the hydrological impacts of the explosive volcanic eruptions on the Nile River discharges. To this end, we perform a reconstruction of historical Nile River discharges using a well-calibrated hydrologic model forced with bias-adjusted hydroclimate data from the Fourth Phase of the Paleoclimate Modeling Intercomparison Project (PMIP4). We anticipate that the reconstructed flow of the Nile River will exhibit similar patterns and trends as observed in the Nilometer records. Detection of impacts associated with volcanic eruptions will be explored by analyzing hydrological responses during the periods corresponding to elevated aerosol forcings as shown in the PMIP4 simulation protocol. In general, our findings will serve as a baseline to assess the multifaceted hydrological impacts of volcanic eruptions across the Nile River basin and provide insights into comprehending vulnerability to Egyptian society aligning with historical records.

## Posters

**Vegetation dynamics in relation to abrupt climate changes at 4.2 and 3.2 ka cal BP in Southeast Belgium – Continuity or a potential tipping point?**

**Possum Pincé<sup>1</sup>, Nathalie Fagel<sup>2</sup>, Giacomo Capuzzo<sup>3</sup>, Mathieu Boudin<sup>4</sup>, Christian Burlet<sup>5</sup>, Philippe Claeys<sup>6</sup>, Philippe Crombé<sup>7</sup>, Isabelle De Groote<sup>7</sup>, Guy De Mulder<sup>7</sup>, Hannah Leonard<sup>6</sup>, Christophe Snoeck<sup>6</sup>, Sophie Verheyden<sup>5</sup>, Marine Wojcieszak<sup>4</sup>, Koen Deforce<sup>1</sup>**

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The ongoing climate change is having significant impacts on people and the environment around the world. During the Mesolithic to Late Bronze Age (ca. 12000–2800 cal BP), several climate fluctuations lasting 100–200 years have been observed in marine and ice core records. However, we still know very little about the nature, extent and impact of these rapid climate changes (RCCs) on contemporaneous ecosystems and human populations, especially in the temperate biomes of northwest Europe.

The «Learning from the Past» project (LEAP) investigates past regional climate change, ecological dynamics, and changes in demography and mobility in the Meuse basin of Belgium during the 9.3 ka, 4.2 ka, and 3.2 ka cal BP RCCs. The archaeological record associated with these periods indicates cultural transitions such as changes in hunting equipment, site density and funerary practices, suggesting a potential connection with the rapid climate changes.

This study presents the palaeoenvironmental results of the LEAP project. These results derive from a high-resolution analysis (at 1 cm intervals) of pollen and spores from raised bogs in the Hautes Fagnes (Southeast Belgium), covering the 3.2 and 4.2 ka cal BP climate changes. To enhance the correlation with the RCCs, high-resolution radiocarbon dating (at ca. 10 cm intervals) has been applied. This approach enables a discussion on the impact of these RCCs on specific vegetation changes and cultural shifts, as well as on the resilience of the ecosystem in Southeast Belgium.

**The global impact of the 5624 BCE Mount Mazama eruption – the largest Northern Hemisphere extratropical eruption of the Holocene**

**Evelien van Dijk<sup>1,2</sup>, Felix Riede<sup>2</sup>, Claudia Timmreck<sup>3</sup>, Kirstin Krüger<sup>4</sup>, Michael Sigl<sup>1</sup>**

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In this study we analyse Earth System Model simulations to gain understanding of the potential impacts of the Mt. Mazama (Crater Lake, USA) eruption on global climate and contemporaneous societies. This eruption, dated using sulfate deposition in ice cores to 5624 ± 35 BCE, was one of the largest eruptions during the Holocene (the last 11,700 years). For comparison, the eruption is estimated to have injected 320 Tg of SO<sub>2</sub> into the atmosphere, whereas the last large volcanic eruption impacting the global climate, Pinatubo in 1991, injected an estimated 17 Tg of SO<sub>2</sub>. We use the Max Planck Institute Earth System Model Mazama ensemble, which consists of ten fully coupled simulations from 5629 BCE to 5601 BCE.

The ensemble mean simulates a decrease in Northern Hemisphere annual mean 2m air temperature of 2°C, with regional decreases of >7°C. In addition, drastic changes are simulated in the hydroclimate. The model suggests a post-eruption southward shift of the Inter Tropical Convergence Zone (ITCZ), causing the summer monsoon to shift southward. This results in major droughts in parts of Africa, India, and Southeast Asia. Consequently, this also leads to a shift of the adjacent atmospheric circulation cells, resulting in a major increase in precipitation and runoff in the Mediterranean and the Near East. We argue that the compound event of severe cooling together with the major increase in precipitation likely had a significant impact on agrarian societies in this region, with crop failures and high potential for flooding. Another effect of the Mt. Mazama eruption that stands out in the model simulations is the development of an El Niño in the two years after the volcanic event, which in present day impacts the livelihood of fishermen at the west coast of South America. Our study powerfully illustrates how an eruption of this magnitude can alter the surface climate in different ways depending on the region, with singular and especially compound climate extremes covering much of the land surface. Studying these extremely large past eruptions presents us with evidence-based scenarios that in turn assist in understanding what would happen when such an eruption occurs in the future, as the impact would likely have severe consequences for large areas around the world.

## Posters

**Did Early Holocene climate instability facilitate the start of Neolithic farming in Northern Greece?**

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The interactions between vegetation, climate and land use are highly complex and not well understood, especially for the Mesolithic-Neolithic transition in the Southern Balkans, where agriculture was introduced to Europe ca. 8500 years ago. The introduction of the Neolithic lifestyle, with the associated crops and livestock, changed the natural biomes and environments of Europe forever. New land use practices had a notable impact on the vegetation structure and composition and profoundly altered fire regimes. First farmers were highly dependent on their natural environment and had to adapt their practices to changes in climate and vegetation. Therefore, rapid climate change (RCC) events like the «8.2 ka event» are often proposed as an important factor driving cultural changes and migrations in the Eastern Mediterranean. Continuous, high-resolution multi-proxy time series of past vegetation dynamics, fire histories and climate reconstructions are needed to understand the long-term relationships between the first Neolithic European farmers, climate and their environment.

We analysed sediments from several lakes (Orestiás Kastorias, Vegoritís, Volvi and Zazari) in Northern Greece to study the interactions between climate, land use, fire and vegetation. Here we present multiple high-resolution records of vegetation, environment, climate and fire history spanning the Mesolithic and Neolithic (ca. 11,600–5,000 cal yr BP), reconstructed by using pollen, spores, microscopic charcoal, brGDGTs and geochemical data.

Our results show that during the Mesolithic, mixed deciduous oak woodlands interspersed with open grassland communities dominated the landscape. Around ~8,500 cal yr BP, significant changes in the deciduous oak forests occurred, and despite local differences vegetation openness peaked at ~8,000 years ago at all sites. The environmental and climate reconstructions suggest a ~500 year long period of drier and colder conditions as an important driver behind the vegetation changes. Moreover, synchronous increases in anthropogenic indicators suggest the start of agriculture in the area during this period. On the basis of our novel multiproxy evidence, we assume that climate instability at the transition between the Early and Mid Holocene facilitated the start of Neolithic farming in Northern Greece. After ~8,000 cal yr BP deciduous oak forests only partly recovered and the forest composition started to change, with increases in *Pinus*, *Ostrya* and *Carpinus*. Neolithic farmers had a limited impact on the forest cover, but markedly altered the vegetation composition.

Our study describes the interactions between vegetation, climate and the first European farming communities, with an emphasis on primeval forest response dynamics. A better understanding of the processes and mechanisms of past societal and ecosystem adaptation to climate change and disturbance may provide useful insights on future dynamics under global change conditions.

**Resilience strategies during the Late Antique Little Ice Age: a hilltop settlement in the Judicarian valleys (Trentino, Italy) and its surroundings**

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Since 2008, the hilltop fortress on Monte San Martino (AD 480/520–800), 12 kilometres north of Lake Garda, and its territory has been the focus of a binational multidisciplinary research project of the Archaeological Heritage Superintendence of Trentino and the Bavarian Academy of Science and Humanities. Archaeological excavations accompanied by detailed pollen analyses in the nearby Fiaavè bog and macro-remain analyses of charred food supplies from the hilltop settlement provided in-depth insights into the provisioning of the site and the economic practices in the region during late Antiquity.

The fortification served strategic purposes, so it was used to control the pass route and to secure valuable goods. The construction technique and details of the architecture, as well as the construction effort, suggest that the founders belonged most probably to late Antique government authorities. Various small finds (belt fittings, lamellar armour, silver coins, personal ornaments) emphasize an elite component, while evidence of a permanent settlement by a larger number of people is largely absent.

In the cultural layers of the hilltop settlement, several food crops were recovered from features dating to the Late Antique Little Ice Age of the 6th/7th century. In some cases, the dominant poor weather conditions were reflected by the conspicuously small dimensions of certain cereal grains. Amazingly, the entire crop spectrum shows that particularly climatically less demanding crops were cultivated in response to the adverse climatic conditions at that time. Moreover, the findings of the pollen analyses for this period in the associated valley are exciting. Contrary to the unfavourable climatic conditions, there was a noticeable intensification of agricultural activities, especially for cereals.

Among other things, the fortress was a fortified storehouse. The charred provisions from the period around 600, which were recovered from inside the hilltop settlement, far exceeded what the few people who stayed on Monte San Martino would have needed for their own supply. Valuables were stored here at a central location and behind fortress walls, including food as well as collected scrap metal. Plant macro-remain and pollen analyses, together with the archaeological findings on the mountain, indicate that stockpiling was probably managed from a central location. The sources of the time, especially the official letters handed down by Cassiodorus, speak several times of bad harvests and famines, which were to be dealt with through state-managed food storage and the organization of supplies. The multidisciplinary results from the Monte San Martino and the Judicarian valleys substantiate such efforts by higher authorities.