The Global Monsoon Response to Volcanic Eruptions in the CMIP5 Past1000 Simulations

Session: Last Millennium & Past2K
Author: Wenmin Man / manwenmin@mail.iap.ac.cn / LASG, Institute of Atmospheric Physics, Chinese Academy of Sciences
Co-author: Tianjun Zhou, LASG, Institute of Atmospheric Physics, Chinese Academy of Sciences;
Abstract:
We examine the global monsoon (GM) precipitation response to volcanic eruptions in the CMIP5 past1000 simulations. The spatial patterns of precipitation exhibit drying in the monsoon regions in their respective warm season for years 1 and 2 combined following volcanic eruptions. The cooling in the western Paci?c is much stronger than that in the eastern Pacific. This zonal SST gradient across the Paci?c induces lowering SLP in the EP where the two subtropical Highs straddle the equator. This will weaken the trades which transports and converges moisture into the eastern hemisphere monsoon regions, thereby leading to the reduced GM precipitation. The ‘‘cold land-warm ocean’’ and ‘‘cold NH-warm SH’’ mechanisms can also explain why the NH monsoon has a strong reduction, while only the ‘‘cold land-warm ocean’’ lead to a weak SH monsoon. The summer monsoon rainfall shows a general decreasing anomaly across the majority of the regional monsoon regions. In contrast to a weakened global summer monsoon precipitation, most arid and semiarid desert regions, located to the west and poleward of each monsoon region, show wetting anomalies. The water budget analysis indicate that the change of the dynamic and thermodynamic terms equivalently dominate the change of precipitation.

I have focused on last millennial climate modeling since I was a PhD student. My research interests are model-data comparisons of the East Asian climate variability during the last millennium. I have finished the last millennium simulation using the FGOALS-s2 climate model and released it to PMIP3. Our group also participates in the PMIP4 past1000 simulation and the VolMIP. I would be grateful if I can receive financial support as an Early Career Scientist from the conference organization. Information of reference: name: Tianjun Zhou institution: LASG, Institute of Atmospheric Physics, Chinese Academy of Sciences email address: zhoutj@lasg.iap.ac.cn

Different global precipitation responses to solar, volcanic and greenhouse gas forcing

Session: Last Millennium & Past2K
Author: Fei Liu / liuf@nuist.edu.cn / Nanjing University of Information Science and Technology, China
Co-author: Bin Wang, University of Hawaii at Manoa;
Jian Liu, Nanjing Normal University;
Abstract:
Understanding climate change caused by different external forcing is urgent for crisis management and sustainable economic development. Although previous works have demonstrated that more rainfall is generated by the natural forcing-induced global warming than by the anthropogenic greenhouse gas (GHG) forcing, it is not clear how differently the global precipitation changes in response to the global warming induced by the change of single forcing of solar radiation, volcanic activity or GHG. We address this issue using paleoclimate experiments forced by single forcing for the period of 501 to 2000 AD. The results show that the strong low-frequency variability longer than one decade can be excited by such external forcing, and that global warming can be induced by strong solar radiation, high GHG concentration or global cooling due to strong volcanic eruption. For a given temperature change, the global precipitation change is the largest under volcanic forcing, while it is the smallest under GHG forcing. The reason is that GHG forcing tends to excite stronger high-latitude warming, especially stronger Arctic amplification of global warming than the other two individual forcing does, and there is no Arctic amplification of temperature decrease under the volcanic forcing-induced global cooling. Volcanic forcing, however, causes a strong precipitation decrease in the Intertropical Convergence Zone (ITCZ) and Asian monsoon. In other words, volcanic forcing excites ITCZ and Asian monsoon amplification of precipitation decrease. It seems that a strong volcanic eruption can reduce precipitation rather than stopping the Arctic amplification of temperature increase under the GHG-induced global warming in future. The underlying mechanisms for these different climate responses are also discussed.

Multi-proxy reconstructions of May–September precipitation field in China over the past 500 years

Session: Last Millennium & Past2K
Author: Feng Shi / feng.shi@uclouvain.be / Georges Lemaître Centre for Earth and Climate Research, Earth and Life Institute, Université catholique de Louvain, Louvain?la?Neuve, Belgium
Co-author: Sen Zhao, School of Ocean and Earth Sciences and Technology, University of Hawaii at M?noa, Honolulu, HI, USA;
Zhengtang Guo, Key Laboratory of Cenozoic Geology and Environment, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, China;
Hugues Goosse, Georges Lemaître Centre for Earth and Climate Research, Earth and Life Institute, Université catholique de Louvain, Louvain?la?Neuve, Belgium;
Qiuzhen Yin, Georges Lemaître Centre for Earth and Climate Research, Earth and Life Institute, Université catholique de Louvain, Louvain?la?Neuve, Belgium;

Abstract:
The dominant modes of variability of precipitation for the whole of China over the past millennium and the mechanism governing their spatial structure remain unclear. The first reason is probably that it is difficult to reconstruct the precipitation field in western China because the published high-resolution proxy records for this region are scarce. Numerous tree-ring chronologies have recently been archived in publicly available databases through PAGES2k activities, and these provide an opportunity to refine precipitation field reconstructions for China. Based on 600 proxy records, including 491 tree-ring chronologies, 108 drought/flood indices, and a long-term instrumental precipitation record from South Korea, we revised the precipitation field reconstruction for China for the past half millennium using the optimal information extraction method. A total of 3971 of 4189 grid points in the reconstruction field passed the cross-validation process, accounting for 94.8% of the total number of grid points. The first leading mode of variability of the reconstruction shows coherent variations over most of China. The second mode, a north–south dipole in eastern China with variations of the same sign in western China and southeastern China, may be controlled by the El Niño-Southern Oscillation (ENSO) variability. The third mode, a “sandwich” triple mode in eastern China with variations of the same sign in western China and central China. Five of the six coupled ocean-atmosphere climate models (BCC-CSM1.1, CCSM4, FGOALS-s2, GISS-E2-R and MPI-ESM-P) of the Paleoclimate Modeling Intercomparison Project Phase III (PMIP3), can reproduce the south-north dipole mode of precipitation in eastern China, and its likely link with ENSO. However, there is mismatch in terms of their time development. This is consistent with an important role of the internal variability in the precipitation field changes over the past 500 years.

Solar Irradiance in the Holocene: A Consistent Multi-proxy Reconstruction

Session: Last Millennium & Past2K
Author: Chi-Ju Wu / wu@mps.mpg.de / Max-Planck-Institut für Sonnensystemforschung, Göttingen, Germany
Co-author: Ilya Usoskin, Space Climate Research Unit, University of Oulu, Finland;
Natalie Krivova, Max-Planck-Institut für Sonnensystemforschung, Göttingen, Germany;
Gennady Kovaltsov, Ioffe Physical-Technical Institute, 194021 St. Petersburg, Russia;

Abstract:
The Sun is the main external energy source to the Earth's system. The overall energy input and its spectral distribution are described by the total and spectral solar irradiance, respectively. The irradiance has only been measured directly for the last four decades, and thus models need to be used to reconstruct the past changes. Such models require an input proxy of solar magnetic activity. The directly observed sunspot number goes back to 1610 and covers the Maunder Minimum. To go further back in time one has to rely on indirect proxies, such as concentrations of cosmogenic isotopes 10Be or 14C in terrestrial archives. These isotopes are produced in the atmosphere by cosmic rays, whose flux is modulated by the solar magnetic field. Although the cosmogenic isotope series retrieved from the natural archives around the globe show a high degree of similarity due to their common origin, significant deviations over some periods of time can be observed due to, e.g., their differing geochemical paths in the atmosphere or local conditions. We will present the most recent total and spectral irradiance reconstruction based on a new method of consistent analysis of multi-isotope proxy series covering the last 9000 years. The record reveals the global and robust nature of solar variability in the past.

Name: Dr. Natalie Krivova Institution: Max-Planck-Institut für Sonnensystemforschung, Göttingen, Germany Email: natalie@mps.mpg.de

Changes in the South Atlantic Subtropical Gyre during the Last Millennium

Session: Last Millennium & Past2K
Author: Fernanda Marcello de Oliveira / fernandamaol@gmail.com / University of São Paulo
Co-author: Ilana Wainer, University of São Paulo;
Abstract:
This study investigates changes in the circulation of the South Atlantic Subtropical Gyre (SASG) during the Last Millennium, especially in its northern boundary, represented by the bifurcation of the southern branch of the South Equatorial Current (sSEC) into the North Brazil Undercurrent/Current (NBUC/NBC) to the north and the Brazil Current (BC) to the south. The sSEC Bifurcation Latitude (SBL) marks the transition between waters flowing equatorward within the upper branch of the Atlantic Meridional Overturning Circulation (AMOC) and those flowing poleward and recirculating in the subtropical gyre. Analysis of the large-scale ocean gyre dynamics are performed using simulation results from the Last Millennium Ensemble experiment of the Community Earth System Model version 5 (CESM-CAM5 LME), for the period ranging 850-2005. Results point to an increase in the total anticyclonic circulation and a southward displacement of the subtropical gyre system. More specifically, it is found increased values of Wind Stress Curl, Sea Surface Height and Barotropic Stream Function within the dynamical rims of the subtropical gyre, together with a synchronous poleward migration of the system, which is demonstrated by displaced climatological isopleths of these fields. It is also observed a consistent southward migration of the SBL, associated with a significant increase in the equatorward advection of waters within the sSEC-SBL-NBUC system, which contributes to the AMOC upper branch. Accordingly, time series of the basin-integrated meridional transport which estimates the overturning strength displays a considerable increase in the AMOC cell, suggesting that although the governing dynamics of the subtropical gyre favors a spinned-up circulation, the bulk of the increased sSEC transport is directed to the Northern Hemisphere with the NBUC feeding the AMOC instead of heading southward with the BC and recirculating in the SASG. It is revealed that for the end of the 20th century the observed changes in the SBL and the SASG dynamics have reached levels that had rarely, if ever, been exceeded in the preceding past 1000 years.

My PhD supervisor is prof. dr. Ilana Wainer (wainer@usp.br), from University of São Paulo.

Impact of Last Millennium Volcanism for the South Atlantic Ocean

Session: Last Millennium & Past2K
Author: Laura Sobral Verona / verona.laura@usp.br / Ocenographic Institute of University of São Paulo (IO/USP)
Co-author: Ilana Wainer, Ocenographic Institute of University of São Paulo (IO/USP);
Abstract:
Quantifying how much the climate system is impacted by natural forcing is a key aspect for understanding how the Earth´s climate system is changing. Volcanism is the cause of great non-anthropogenic perturbations on the Earth climate through energy imbalance changes. Which occurs due to injection of sulfuric gases (e.g. SO2 and H2S) in the stratosphere that interacts with the incoming radiation. Thereby causing surface and low troposphere cooling. The climate effects of great volcanic eruptions have been studied mostly for the Northern Hemisphere. There is still much to be uncovered relative to the impacts on the Southern Hemisphere, even more with respect to the Southern Ocean. The South Atlantic and its Southern Ocean sector response to volcanism are examined using simulation results from the Last Millennium Ensemble Experiment of the Community Earth System Model version 5 (CESM-CAM5-LME), for the period ranging 850-2005. With a composite analysis and Wilcoxon Rank-Sum test, we evaluate significant changes in the air-sea properties due to great tropical and southern eruptions. The sea surface temperature and salinity anomaly pattern change in the first austral summer (DJF) following the eruption. North of 60S, SST gets ~0.6C colder, as expected because of the higher albedo. Contrarily, near the Antarctic Peninsula we observe a local warming of approximately 0.4C, significant at the 90% level. All surface anomalies seem to disappear after the 5th subsequent year eruptions compared to the composite average of the years before the event. The same happens with the surface salinity. There are not significant changes in the explosion year. However, from the first to the 4th subsequent DJF, a positive salinity anomaly (~0.1) is observed in the northern region off Antarctic Peninsula. On the other hand, volcanism impacts on the associated zonal wind stress are faster. The greatest anomaly is observed during the DJF of the volcano explosion year, which generates an increased zonal gradient.

Prof. PhD. Ilana Wainer Ocenographic Institute University of São Paulo ilanawainer@gmail.com

Understanding ENSO ISM teleconnectins during LM with Emphasis on MWP and LIA, a PMIP3 Approach

Session: Last Millennium & Past2K
Author: Charan Teja Tejavath / charan0239@gmail.com / University of Hyderabad, Hyderabad, India
Co-author: Karumuri Ashok, University of Hyderabad, Hyderabad, India;
Supriyo Chakraborty, Indian Institute of Tropical Meteorology, Pune, India;
Ramesh Rengaswamy, National Institute of Science Education and Research, Bhubaneswar, India;

Abstract:
Here, using the available model simulations from the PMIP3, we study the mean summer (June-September; JJAS) climate and its variability in India during the Last Millennium (CE 850-1849; LM) for which instrumental observations are unavailable, with emphasis on the Medieval Warm Period (MWP; CE 1000-1199 as against the CE 950-AD1350 from the proxy-observations) and Little Ice Age (LIA; CE 1550-1749 as against the CE 1500-1850 from proxy observations). Out of the eight available models, by validating the corresponding simulated global and Indian mean summer temperatures and mean Indian summer monsoon rainfall (ISMR), and their respective trends, from historical simulations (CMIP5) against the various observed/reanalyzed data sets for the 1901-2005 period. From this exercise, we identify seven 'realistic' models. The models simulate higher (lower) mean summer temperatures in India as well as globally during the MWP (LIA) as compared to the corresponding LM statistics, in confirmation of several proxy data sets. Our Analysis shows a strong negative correlation between the NINO3.4 index and the ISMR and a positive correlation between NINO3.4 and summer temperature over India during the LM, as is observed in the last one-and-half centuries. The magnitude of the simulated ISMR-NINO3.4 index correlations, as seen from the multi-model mean, is found to be higher for the MWP (-0.19; significant at 0.05 level) as compared to that for the LIA (-0.09; insignificant). Our analysis also shows that the above (below) LM-mean summer temperatures during the MWP (LIA) are associated with relatively higher (lower) number of concurrent El Niños as compared to the La Niñas. Distribution of boreal summer velocity potential at 850 hPa in the central tropical pacific and a zone of anomalous convergence in the central tropical pacific, flanked by two zones of divergence in the equatorial pacific, suggesting a westward shift in Walker circulation as compared to the current day signal. The anomalous divergence center in the west also extends into the equatorial eastern Indian Ocean, which results in an anomalous convergence zone over India and therefore excess rainfall during the MWP as compared to the LM. The results are qualitative, given the inter-model spread.

Tejavath Charan Teja PhD Student University center for Earth and Space Sciences University of Hyderabad email:- charan0239@gmail.com Reference:- Dr Karumuri Ashok Associate Professor University center for Earth and Space Sciences University of Hyderabad email :- ashokkarumuri@uohyd.ac.in

Winter amplification of the European Little Ice Age cooling by the subpolar gyre

Session: Last Millennium & Past2K
Author: Eduardo Moreno-Chamarro / chamarro@mit.edu / Massachusetts Institute of Technology. Cambridge. USA
Co-author: Davide Zanchettin, Venice University. Venice. Italy;
Katja Lohmann, Max Planck Institute for Meteorology. Hamburg. Germany;
Jürg Luterbacher, Justus Liebig University of Giessen. Giessen, Germany;
Johann H. Jungclaus, Max Planck Institute for Meteorology. Hamburg. Germany;

Abstract:
Climate reconstructions reveal a strong winter amplification of the cooling over central and northern continental Europe during the Little Ice Age (LIA; here defined as c. 16th–18th centuries), via persistent, blocked atmospheric conditions. Although several potential drivers have been suggested to explain the European LIA cooling, including solar minima and/or volcanic eruptions, together with a persistent negative phase of the North Atlantic Oscillation (NAO) and/or a weakening of the Atlantic meridional overturning circulation (AMOC), no coherent mechanism has yet been proposed for the seasonal contrast in the European LIA cooling. Here we demonstrate that such exceptional wintertime conditions arose from sea ice expansion and reduced ocean heat losses in the Nordic and Barents seas, driven by a multicentennial reduction in the northward heat transport by the subpolar gyre (SPG). However, these anomalous oceanic conditions were largely decoupled from the European atmospheric variability in summer. We reject previous hypotheses that linked the European LIA cooling with a weakened AMOC or with a persistent negative NAO. Our novel dynamical explanation is derived from analysis of an ensemble of last millennium climate simulations, performed with Max Planck Institute Earth System Model, and is further supported by reconstructions of European temperature and atmospheric circulation variability and North Atlantic/Arctic paleoceanographic conditions. We conclude that SPG-related internal climate feedbacks related were responsible of the European LIA winer cooling amplification. Thus, characterization of SPG dynamics is essential for understanding multicentennial seasonal variability in the European/North Atlantic sector.

Quantifying the effects of Neotropical land use change on global carbon cycle and climate after 1492 in an Earth System Model

Session: Last Millennium & Past2K
Author: Alexander Koch / alexander.koch.14@ucl.ac.uk / University College London
Co-author: Chris Brierley, University College London;
Simon Lewis, University College London;

Abstract:
Agricultural activity was widespread over the American continent before Europeans arrived. Following European contact, Old World diseases, warfare and slavery led to an indigenous population loss of up to 90% and a near-cessation of agriculture. Several studies argue that the additional carbon uptake from the following reforestation event had an substantial impact on the global carbon cycle and is partially responsible for the CO2 minimum observed around 1610 CE in Antarctic ice cores. This hypothesis is supported by a d13C-CO2 signal pointing towards an increased terrestrial sink for this period. Modelling studies suggest that depopulation-induced land use changes could have a magnitude ranging from near-zero to accounting for the full magnitude of expected carbon sink. These results are partially down to the choice of land use datasets with different magnitudes of forcing, but may easily be model-dependent. Here we outline and present initial results from a new approach to estimate the effect of the land use change following European conquest of the Americas. We are performing an ensemble of simulations spanning the period from initial European contact until 1750 with an Earth System Model (CESM 1.2; T31 resolution, interactive carbon cycle). We compare the effects of the three available land use forcing datasets (PO10, HYDE 3.2 & KK10) and a best guess land use estimate based on available archaeological data. This approach should allow us to reliably detect variations in the carbon cycle response to different land use forcing at 1500 CE, one focus point of the Landcover6k initiative. Furthermore we should be able to constrain the contribution of land use change on the decline in atmospheric CO2 seen at 1610 CE and address the question whether humans had an impact on the carbon cycle and climate immediately prior to the Industrial Revolution.

Chris Brierley, University College London, c.brierley@ucl.ac.uk

Atmospheric dynamics leading to decadal droughts in the Mediterranean region

Session: Last Millennium & Past2K
Author: Eduardo Zorita / eduardo.zorita@hzg.de / Helmholtz-Zentrum Geesthacht, Germany
Co-author: Sebastian Wagner, Helmholtz-Zentrum Geesthacht, Germany;
Abstract:
The land areas surrounding the Mediterranean are prone to naturally occurring multi-year and decadal droughts. Precipitation in this region is concentrated during the winter half years and its variability at inter-annual time scales is strongly controlled by the North Atlantic Oscillation, although this influence is weaker in the Eastern Mediterranean. The mechanisms is the dependence of the North Atlantic storm tracks on the intensity of the North Atlantic Oscillation pattern The analysis of past-millennium simulations of the PMIP3 model suit, however, indicates that decadal drought events are linked by pattern sea-level pressure patterns that are different, and that seem to be more associated with the anomalies of moisture advection by the seasonal mean winds. In the Mediterranean region, these patterns imprint a distinct east-west dipole of precipitation anomalies, which is not clearly present at interannual time scales. This zonal contrast of decadal precipitation variability is consistent with previous analysis of moisture sensitive dendrochronologies. The decadal drought episodes doe not show an imprint of the external climate forcing, either due to volcanic eruptions nor to the more slowly varying solar irradiance. At longer time scales than 1000 years, the sea-level-pressure trends caused by the orbital forcing may also have an influence on Mediterranean precipitation, more strongly so in the Eastern Mediterranean, and thus are appear related to trends in the South Asian Monsoon.

Simulations over the Common Era and integrated analyses of reconstructions and multi-model simulations

Session: Last Millennium & Past2K
Author: Johann Jungclaus / johann.jungclaus@mpimet.mpg.de / Max Planck Institute for Meteorology, Hamburg, Germany
Co-author: Past2k Working Group, ;
Abstract:
The working group “Past2k” aims at: • Promoting community simulations of the Late Holocene with state-of-the-art Earth System Models (ESM), such as the PMIP4/CMIP6 “past1000” experiments; coordinating the experimental design and analysis framework • Coordinating collaborative effort to asses model performance and process-based analysis • Promoting model-data comparison activities cooperating with climate reconstruction groups, statisticians, and dynamicists The WG has coordinated and initiated efforts to update the experimental protocol and reconstructions of external forcing, such as solar irradiance and volcanic aerosols as well as a data protocol. The manuscript, published in GMD as part 3 of a series of PMIP papers, discusses in detail the forcing agents: orbital, solar, volcanic, land-use/land-cover changes, and variations in greenhouse gas concentrations. The past1000 simulations covering the pre-industrial millennium from 850 Common Era (CE) to 1849 CE have to be complemented by historical simulations (1850 to 2014 CE) following the CMIP6 protocol. The external forcings for the past1000 experiments have been adapted to provide a seamless transition across these time periods. Protocols for the past1000 simulations have been divided into three tiers. A default forcing data set has been defined for the “tier-1” (the CMIP6 past1000) experiment. However, the PMIP community has maintained the flexibility to conduct coordinated sensitivity experiments to explore uncertainty in forcing reconstructions as well as parameter uncertainty in dedicated “tier-2” simulations. Additional experiments (“tier-3”) are defined to foster collaborative model experiments focusing on the early instrumental period and to extend the temporal range and the scope of the simulations. On-going efforts regarding model-data comparison have focused on regional temperature reconstructions and have extended the scope of target variables to assess hydroclimatic reconstructions. A workshop was held in Lamont in June 2016 as a joint effort of PAGES 2K and the PMIP PastK working group. The aim oft he meeting was to review CE proxy archives appropriate for hydroclimate assessment and the current ensemble of coupled model simulations. The participants discussed outstanding challenges and made recommendations for best practices for how to perform reconstruction-model intercomparisons for hydroclimate.

Planetary waves modulate summer climate variability over Europe during the Common Era

Session: Last Millennium & Past2K

Author: Johann Jungclaus / johann.jungclaus@mpimet.mpg.de / Max Planck Institute for Meteorology, Hamburg, Germany

Co-author: Rohit Ghosh, Max Planck Institute for Meteorology, Hamburg, Germany;
Wolfgang Mueller, Max Planck Institute for Meteorology, Hamburg, Germany;
Sebastian Wagner, Helmholtz Centre Geesthacht, Germany;

Abstract:
We investigate European summer climate variability and its tele-connections in reconstructions and model simulations covering the Common Era (CE). Simulations of summer temperature reproduce important features of recent reconstructions obtained by the EuroMed2k group of the PAGES2k framework. The model experiments have been carried out with the Max Planck Institute for Meteorology Earth System Model (MPI-ESM-P) and cover the pre-industrial millennium and (partly) the entire CE. Both in simulations and gridded field reconstructions, the first and second empirical orthogonal functions (EOF) of spatial variations are well separated. The principal component of the first EOF is an expression of a planetary-wave-like pattern that is prominent in the upper troposphere and that resembles the previously defined circumglobal wave train (CGT) pattern. The CGT mode of surface air temperature variability is accompanied by a zonally-oriented pattern in precipitation. Composites of related sea surface temperature (SST) and ocean-atmosphere heat flux fields reveal prominent anomalies in the Gulf Stream region, which might modulate the Rossby waves. The SST patterns are related to changes in the large-scale ocean gyre and overturning circulation. We also investigate the influence of external drivers (volcanic eruptions, solar modulations).

Simulated changes in gross primary productivity during the Last Millennium: a new approach to evaluating PMIP simulations

Session: Last Millennium & Past2K

Author: Kamolphat Atsawawaranunt / K.Atsawawaranunt@reading.ac.uk / University of Reading
Co-author: Sandy P. Harrison, University of Reading;
I. Colin Prentice, Imperial College London;

Abstract:
Climate changes during the Last Millennium were insufficient to cause major changes in vegetation distribution, but did cause changes in vegetation productivity that are documented e.g. in peatland accumulation rates. We use a light-use efficiency model, the P model, to simulate changes in gross primary productivity driven by outputs from an ensemble of CMIP5/PMIP3 Last Millennium simulations. Temporal changes in GPP reflect changes in light (PAR) modulated by changes in cloud cover, atmospheric drought as reflected by vapour pressure deficit (VPD), growing season temperature and CO2. The relative importance of these factors varies spatially. For example, while the effect of increasing CO2 is always positive, the impact of such changes is larger in more arid regions because it enhances water-use efficiency. Although the differences in simulated climate between the Medieval Warm Anomaly (MWA: 1000-1200 CE) and the Little Ice Age (LIA: 1600-1800 CE) only resulted in moderate changes in GPP globally, regional differences can be large and thus should be discernable in palaeorecords. Despite broadscale similarities in GPP changes between members of the ensemble, there are differences between the individual simulations. Thus, comparison of the simulated temporal and spatial patterns in GPP with palaeoenvironmental records should allow discrimination between different models and different forcings. Furthermore, the impact of large volcanic events is seen in the simulated GPP, again offering the potential to evaluate the realism of alternative forcings and individual model responses.

Professor Sandy P. Harrison, University of Reading, s.p.harrison@reading.ac.uk

Spatial patterns of drought/flood over eastern China in the periods of anomalous solar activity during the past millennium

Session: Last Millennium & Past2K
Author: Jingyun Zheng / zhengjy@igsnrr.ac.cn / Key Laboratory of Land Surface Pattern and Simulation, Institute of Geographical Sciences and Natural Resources Research, CAS
Co-author: Zhixin Hao, Key Laboratory of Land Surface Pattern and Simulation, Institute of Geographical Sciences and Natural Resources Research, CAS;
Xuezhen Zhang, Key Laboratory of Land Surface Pattern and Simulation, Institute of Geographical Sciences and Natural Resources Research, CAS;

Abstract:
Based on five new reconstructions of solar irradiance, the anomalous solar activity periods during the past millennium, including 5 Solar Minimum periods, 2 Solar Maximum, were identified. Furthermore, the spatial patterns of drought/flood over eastern China for these periods were reconstructed using an index of difference between drought and flood frequency derived from a 63-site yearly drought/flood grade dataset. The simulations from CESM forced by the variation of irradiance under Solar Minimum/Maximum started with initial conditions for different phases of PDO were also performed. The reconstructions show that there are different drought/flood patterns over eastern China among 5 Solar Minimum (1010-1050, 1280-1350, 1460-1550, 1645-1715, 1795-1823), with a higher probability of drought (flood) dominating the middle and lower reaches of the Yangtze River (North China Plain). The ensemble mean patterns of drought/flood for all the 5 Solar Minimum presented a zonal distribution with flood in South China, drought in the middle and lower Yangtze River and flood in most parts of North China. Whereas in the periods of solar maximum, drought prevailed over most of eastern China during Medieval Maximum (1100-1250) and in North China Plain and southwestern China during Modern Maximum (1920-2000) respectively. While the ensemble mean for simulations started with various initial conditions show that drought (flood) prevailed over north (south) of eastern China during Solar Minimum, and flood prevailed over most of eastern China during Solar Maximum. However, the patterns varied with different initial conditions started different phases of PDO, which suggest that the anomalous hydroclimate spatial pattern may be dominated by the internal variability(e.g., phase of PDO) of climate system, rather than abnormal solar irradiance.

The Model Intercomparison Project on the climatic response to volcanic forcing (VolMIP)

Session: Last Millennium & Past2K
Author: Myriam Khodri / myriam.khodri@locean-ipsl.upmc.fr / LOCEAN/IPSL, France
Co-author: Davide Zanchettin, University of Venice, Italy;
Claudia Timmreck, Max-Planck-Institute for Meteorology, Hamburg, Germany;

Abstract:
Our understanding of the climatic response to volcanic forcing is hampered by the large uncertainties affecting the instrumental records, due to the limited number of observed events, and the available climate reconstructions, and by the non-robust dynamical responses simulated by different climate models. The lack of agreement between model results is crucially determined by differences in the model's characteristics such as resolution, complexity and implementation strategy of the forcing, and uncertainty in the eruption details including magnitude, latitude and season, input data and background climate. The multiple and varied nature of these factors prevents their contribution to uncertainty from being distinguished within existing transient simulations or non-coordinated multi-model experiments. The Model Intercomparison Project on the climatic response to Volcanic forcing (VolMIP) presented here focuses on the response of the coupled ocean-atmosphere system to strong volcanic forcing. VolMIP is a CMIP6 endorsed project, which defines a common protocol to subject Earth system models and coupled general circulation models to the same volcanic forcing and under a similar range of background climate conditions. By doing so, VolMIP aims at assessing to what extent simulated responses are robust across models and at identifying the causes that limit robust behavior, especially as far as different treatment of physical processes is concerned. VolMIP provides context to the PMIP4-past1000 simulations, where volcanic forcing is among the dominant sources of climate variability. In particular, VolMIP and PMIP4 have defined a hierarchy of experiments focused on the early 19th century that will allow us to investigate the interactions between different natural forcing factors and the role of background climate conditions during one of coldest periods of the last millennium. In this contribution, we will present an overview of VolMIP and discuss how ongoing and planned coordinated activities contribute to strengthen the synergies between VolMIP and PMIP4.

The PAGES 2k Network, Phase 3: Introduction, Goals and Call for Participation

Session: Last Millennium & Past2K
Author: Hans Linderholm / hansl@gvc.gu.se / University of Gothenburg, Sweden
Co-author: Nerilie Abram, The Australian National University, Australia;
Oliver Bothe, Helmholtz-Zentrum Geesthacht, Germany;
Belen Martrat, Spanish Council for Scientific Research, Spain, & University of Cambridge, UK;
Helen McGregor, University of Wollongong, Australia;
Raphael Neukom, University of Bern, Switzerland;
Steven Phipps, University of Tasmania, Australia;
Scott St. George, University of Minnesota, USA;
Lucien von Gunten, PAGES International Project Office, Switzerland;

Abstract:
The past 2000 years (the “2k” interval) provides critical context for recent anthropogenic forcing of the climate, baseline information about Earth’s natural climate variability, opportunities to improve the interpretation of proxy observations, and evaluation of climate models. The PAGES 2k Network (2008-2013 Phase 1; 2014-2016 Phase 2) used peer-reviewed data from various archives at a wide range of resolutions, which met strict quality control requirements, to build regional and global surface temperature reconstructions for terrestrial regions and the oceans. Comparison with realistically-forced climate model simulations, including the PMIP3 Last Millennium ensemble, was used to identify mechanisms of climate variation on interannual to bicentennial time scales. In May 2017 Phase 3 (2017-2019) was launched, focusing on the following goals: 1) Further understand the mechanisms driving regional climate variability and change on interannual to centennial time scales (Theme: “Climate Variability, Modes and Mechanisms”) 2) Reduce uncertainties in the interpretation of observations imprinted in paleoclimatic archives by environmental sensors (Theme: “Methods and Uncertainties”) 3) Identify and analyse the extent of agreement between reconstructions and climate model simulations (Theme: “Proxy and Model Understanding”) In Phase 3, research is organized as a linked network of well-defined projects and targeted manuscripts, identified and led by 2k members in a culture of collegiality, transparency, and reciprocity. The 2k projects focus on specific scientific questions aligned with Phase 3 goals, rather than being defined along regional boundaries. Phase 3 seeks to stimulate community based projects and facilitate collaboration of researchers from different regions and career stages, drawing on breadth and depth of the global PAGES 2k community; support end-to-end workflow transparency and open data and knowledge access; and develop collaborations with other research communities and engage with stakeholders. Links with the climate modelling community, and particularly PMIP, will be critical to our success. In this contribution we illustrate some relevant applications using results from Phase 2 as a basis for working together with the PMIP4 Working Group on similar questions. If you would like to participate in PAGES 2k Phase 3 or receive updates, please join our mailing list, or speak to a coordinating committee member.

Improved volcanic forcing in PMIP4 and beyond

Session: Last Millennium & Past2K
Author: Matthew Toohey / mtoohey@geomar.de / GEOMAR Helmholtz Centre for Ocean Research Kiel
Co-author: Michael Sigl, Paul Scherrer Institute;
Johann Jungclaus, Max Planck Institute for Meteorology;
Claudia Timmreck, Max Planck Institute for Meteorology;
Davide Zanchettin, University of Venice;
Kevin J. Anchukaitis, University of Arizona;
Julien Emile-Geay, University of Southern California;
Andrew Schurer, University of Edinburgh;
Rob Wilson, University of St Andrews;

Abstract:
Radiative forcing resulting from major explosive eruptions is the dominant natural driver of climate variability over the Late Holocene. Reproducing the forced component of climate variability in numerical simulations relies on accurate information regarding the timing, magnitude and location of major volcanic eruptions, the radiative properties of the resulting volcanic stratospheric aerosols, and implementation of the reconstructed volcanic forcing time series into climate models. Here, we report on recent progress on these fronts, including the construction of more accurate volcanic histories from ice cores covering the past 2500 years and new methods used in the construction and implementation of volcanic radiative forcing in climate models. Model results based on these new reconstructions, including available first results from the PMIP4 Last Millennium and Past2k experiments will be explored, including comparisons to proxy-based climate reconstructions like the Northern hemisphere TREe-Ring Network Development (N-TREND) and the Last Millennium Reanalysis. Furthermore, results will be shown from preliminary experiments utilizing “forcing ensemble” techniques, incorporating improved understanding of the uncertainties connected to the volcanic forcing reconstruction. Implications for other experiments within PMIP—e.g. the Mid-Holocene and Last Glacial Maximum experiments—will be discussed.

Last millennium regional temperatures and associated uncertainty over East Asia: a model-data analysis

Session: Last Millennium & Past2K
Author: Elena Garcia-Bustamante / elgarcia@ucm.es / CIEMAT (Madrid, Spain)
Co-author: J. Fidel Gonzalez-Rouco, UCM (Madrid, Spain);
Laura Fernandez-Donado, UCM (Madrid, Spain);
Juerg Luterbacher, JLU-Giessen (Germany);
Johann Jungclaus, MPI-Hamburg (Germany);

Abstract:
A pool of existing published temperature reconstructions covering the last millennium over East Asia/China provides a suitable framework to investigate the variability of paleotemperatures at the regional scale. A sensitivity analysis based on the impact of a few methodological variants, as for instance the nature and number of proxies, the instrumental data or the method used to calibrate the reconstructions, is conducted to help constrain the uncertainty associated to the regional estimates. An ensemble of state-of-the-art simulations from various climate models following the PMIP3/CMIP5 protocol is used to evaluate the similarity between reconstructed and simulated regional temperature trajectories. Special emphasis is given to last decades warming trends in the region from the reality of models, reconstructions and simulations. New estimates of seasonal temperatures for the last thousand years over East Asia are proposed.

Tree growth and climate: an analysis of current assumptions and the advantages of forward modelling as an alternative approach for data-model comparison

Session: Last Millennium & Past2K
Author: Guangqi Li / g.li2@reading.ac.uk / Centre for Past Climate Change and School of Archaeology, Geography and Environmental Sciences (SAGES), Reading University, Reading, UK
Co-author: Sandy P. Harrison, Centre for Past Climate Change and School of Archaeology, Geography and Environmental Sciences (SAGES), Reading University, Reading, UK;
I. Colin Prentice, AXA Chair of Biosphere and Climate Impacts, Department of Life Sciences, Imperial College London, Silwood Park Campus, Ascot, UK;

Abstract:
The derivation of Last Millennium climate reconstructions from tree-ring series is based on several assumptions including that (a) ontogenetic effects on radial growth can be removed statistically, (b) tree growth at a given site is controlled by a single climate variable or at most a simple combination of two variable, (c) the statistical relationship between radial growth and climate variables is invariant through time, (d) changing CO2 concentrations [CO2] have negligible impacts on growth, and (e) carbon allocation to stem growth is a constant proportion of total productivity. Here we show that inherent temporal sampling biases mean that standard techniques to account for ontogeny still preserve the impacts of changes in long-term mean climate on growth. We also show that tree growth is always controlled by multiple climate variables, including light, atmospheric drought, soil moisture and growing season temperature. The relationship between growing season temperature and tree growth is non-monotonic, such that increasing temperature has positive effects on radial growth in cool climates but negative effects on growth in more temperate regions. The strength of the relationship between any one climate factor and growth varies spatially, but more importantly is not invariant through time. Finally, we show that while changes in [CO2] increase photosynthesis and gross primary production, this is not always reflected in increased stem growth. Tree responses to changing [CO2] involve changes in carbon allocation to leaves and rooting systems. Given that changes in [CO2] affect water-use efficiency, changes in allocation are also expected as a response to persistent drought and will therefore modulate the apparent relationship between stem growth and climate. While these analyses raise serious issues about the reliability of climate reconstructions based on tree-ring series, we propose a way forward through process-based modelling. By building on ecophysiological theory, process-based modelling avoids unrealistic assumptions about tree growth, and should allow more soundly based interpretations of tree-ring data and comparisons with palaeoclimate simulations.

Sandy P. Harrison, University of Reading, s.p.harrison@reading.ac.uk

South American Monsoon System over the Last Millennium: Climate Simulations of PMIP3.

Session: Last Millennium & Past2K
Author: Igor Stivanelli Custódio / igor.custodio@iag.usp.br / Institute of Astronomy, Geophysics and Atmospheric Sciences, University of São Paulo
Co-author: Tatiana Jorgetti, Institute of Astronomy, Geophysics and Atmospheric Sciences, University of São Paulo;
Pedro L. da Silva Dias, Institute of Astronomy, Geophysics and Atmospheric Sciences, University of São Paulo;
Ilana Wainer, Oceanographic Institute, University of São Paulo, SP/Brazil;
Leila M. V. Carvalho, Earth Research Institute, University of California, Santa Barbara;
Tatiana Jorgetti, Oceanographic Institute, University of São Paulo, SP/Brazil;

Abstract:
The natural climate variability is an important factor to be understood for exploring the predictive potential of the climate and to evaluate the role of the anthropogenic forcing. Paleoclimate records provide indications of the past variability and cover a much longer period than the instrumental era. The main purpose of this study is to evaluate the changes of the South American Monsoon System (SAMS) during the Last Millennium (LM) in the numerical simulations of PMIP3 and to verify, in general, the influence of some climatic indexes on the monsoon. Large-scale aspects associated with the SAMS are explored, as well as its relations with the indicator of the low-frequency climate variability. The analyses have been based on the Large-scale Index for South American Monsoon (LISAM) applied in the weighted average set of the climate models simulations CCSM4-M, GISS-E2-R, IPSL-CM5A-LR, MIROC-ESM, MPI-ESM-P and MRI-ESM. The LISAM is based on the analysis of combined Empirical Orthogonal Functions (EOFc) between the variables at 850 hPa: precipitation, temperature, humidity and wind. The first (second) mode of the EOFc represents the spatial patterns of the SAMS (South Atlantic Convergence Zone – SACZ). Regarding with the LISAM the patterns related of the first two modes (SAMS and SACZ, respectively) during LM were similar to those found in the historical period. The temporal variability of the expansion coefficient series of the LISAM modes showed periods of variation associated with the variability of solar cycles and sunspots, as well as the systems internal oscillations. The internal variability of the SAMS and SACZ showed strong influences of the North and South Tropical Atlantic Ocean and the Pacific Ocean. Moreover, the time series of the first mode of EOFc proved to be a good indicator of climatic transition since it was possible to determine through the application of a regime change detection test the beginning and the end years of the Climate Medieval Anomaly and the Little Ice Age. Also, it was possible to verify the influence of some of the major volcanic eruptions of the LM period.

Name: Pedro Leite da Silva Dias Institution: Institute of Astronomy, Geophysics and Atmospheric Sciences, University of São Paulo (IAG/USP) email: pedro.dias@iag.usp.br

Long-Term Surface Temperature (LoST) Database as a Complement for GCM Control Simulations

Session: Last Millennium & Past2K
Author: Francisco José Cuesta Valero / fcuestavaler@mun.ca / Environmental Sciences Program, Memorial University of Newfoundland, St. John's, NL, Canada and Climate & Atmospheric Sciences Institute, St. Francis Xavier University, Antigonish, NS, Canada
Co-author: Almudena García García, Environmental Sciences Program, Memorial University of Newfoundland, St. John's, NL, Canada Climate & Atmospheric Sciences Institute, St. Francis Xavier University, Antigonish, NS, Canada;
Hugo Beltrami, Climate & Atmospheric Sciences Institute, St. Francis Xavier University, Antigonish, NS, Canada and Centre ESCER pour l'étude et la simulation du climate à l'échelle régionale, Université du Québec à Montréal, Montréal, QC, Canada;
Eduardo Zorita, Institute of Coastal Research, Hemlholtz-Zentrum Geesthacht, Germany;

Abstract:
Control climate simulations aim to provide a stationary state to General Circulation Models (GCMs) under constant preindustrial conditions (piControl simulations). This stationary state is then used as initial conditions in GCM simulations to provide a stable and realistic climatology, reducing the potential bias in such simulations. However, it is difficult to provide a reference to assess the climatology of piControl simulations due to the lack of long-term preindustrial observations. We explore the use of long-term ground surface temperature estimates from borehole temperature profiles as an additional reference that may be useful for the initialization procedure of GCM simulations. We compare five last millennium simulations and five preindustrial control simulations from the third phase of the Palaeoclimate Modelling Intercomparison Project (PMIP3) and the fifth phase of the Coupled Model Intercomparison Project (CMIP5) archives against estimates of long-term preindustrial ground surface temperatures from 514 borehole temperature profiles over North America. These long-term surface temperatures are retrieved from the quasi-equilibrium state of the subsurface thermal regime in each temperature profile, which is estimated from the deepest section of the profile. That is, the equilibrium state is recovered from the least affected part of the temperature profile by the recent changes in the surface energy balance. The subsurface temperatures at the bottom part of each profile depend linearly on depth, and the extrapolation of this linear behavior to the surface is interpreted as the long-term surface temperature (T0 temperature) at each borehole site. Our results suggest that the ground surface temperature estimates from borehole data could be employed as a reference within piControl simulations to enhance the quality of the initial conditions in GCM climate simulations.

1.- Hugo Beltrami. 2.- Climate & Atmospheric Sciences Institute, St. Francis Xavier University, Antigonish, NS, Canada and Centre ESCER pour l'étude et la simulation du climate à l'échelle régionale, Université du Québec à Montréal, Montréal, QC, Canada. 3.- hugo@stfx.ca

Summer temperature and drought co-variability across Europe since 850 CE

Session: Last Millennium & Past2K
Author: Fredrik Charpentier Ljungqvist / fredrik.c.l@historia.su.se / Stockholm University

Abstract:
An increasing risk of droughts in some regions, with potentially severe consequences for agriculture and economy, entails a major challenge associated with ongoing and future global warming. However, climate model simulations do not show consistent projections as to hydroclimate changes with global warming on regional scales. We also have increasing evidence from around the world that the relationship between temperature and drought is highly timescale-dependent – thus the relationship seen in instrumental measurements over shorter time-scales might not hold true for longer time-scales. Therefore, a new PAGES2k project will study how the variations in the spatio-temporal distribution of droughts during past warm and cold periods in Europe can provide tentative information for future changes in European droughts associated with global warming. In light of recent progress in developing high-resolution European climate reconstructions it is now possible for the first time to assess the co-variability between summer temperature and drought frequency and severity over the past millennium. To realize this goal, we assess the co-variability between an updated version the Old World Drought Atlas, providing a spatially revolved tree-ring based gridded summer drought index for the European-Mediterranean area extending back two millennia, and a spatially resolved summer temperature reconstruction from tree-ring and historical documentary from 850 to 2003 CE. Additionally, we compare the high-resolution summer temperature and soil moisture simulations from the CCSM4 and MPI-ESM-P models over the same time period with the proxy-derived results. We also compare the co-variability between summer temperature and drought in the CRU TS 3.21 instrumental data for 1901–2012. We perform the comparison of the co-variability by: 1) cross-correlation calculations between gridded instrumental, proxy, and model fields, 2) sign tests of agreement between gridded instrumental, proxy, and model fields, 3) analysing the distribution of correlations in the various data series, 4) performing cross-spectral analyses of the various data series, and 5) conducting cluster analyses of the various data series. Preliminary results suggest that the co-variability between temperature and drought indeed depends on the time-scales chosen and spatial patterns of co-variability are more complex in the proxy-derived reconstructions than in the model simulations.

Impact of land model depth on long term climate variability and change.

Session: Last Millennium & Past2K

Author: J. F. González-Rouco / fidelgr@ucm.es / Universidad Complutense de Madrid, IGEO (CSIC-UCM), Astrofísica y Ciencias de la Atmósfera, Madrid, Spain

Co-author: E. García-Bustamante, CIEMAT (Energy, Environment and Technology Research Centre), Madrid, Spain;
S. Hagemann, Max Planck Institute for Meteorology, Hamburg, Germany;
S. Lorentz, Max Planck Institute for Meteorology, Hamburg, Germany;
J. Jungclaus, Max Planck Institute for Meteorology, Hamburg, Germany;
P. de Vrese, Max Planck Institute for Meteorology, Hamburg, Germany;
C. Melo, Universidad Complutense de Madrid, Astrofísica y Ciencias de la Atmósfera, Madrid, Spain;
J. Navarro, CIEMAT (Energy, Environment and Technology Research Centre), Madrid, Spain;
N. Steinert, Universidad Complutense de Madrid, Astrofisica y Ciencias de la Atmosfera, Madrid, Spain;

Abstract:
The available evidence indicates that the simulation of subsurface thermodynamics in current General Circulation Models (GCMs) is not accurate enough due to the land-surface model imposing a zero heat flux boundary condition that is too close to the surface. Shallow land model components distort the amplitude and phase of the heat propagation in the subsurface with implications for energy storage and land-air interactions. Off line land surface model experiments forced with GCM climate change simulations and comparison with borehole temperature profiles indicate there is a large reduction of the energy storage of the soil using the typical shallow land models included in most GCMs. However, the impact of increasing the depth of the soil model in ‘on-line’ GCM simulations of climate variability or climate change has not yet been systematically explored. The JSBACH land surface model has been used in stand alone mode, driven by outputs of the MPIESM to assess the impacts of progressively increasing the depth of the soil model. In a first stage, preindustrial control simulations are developed increasing the lower depth of the zero flux bottom boundary condition placed for temperature at the base of the fifth model layer (9.83 m) down to 294.6 m (layer 9), thus allowing for the bottom layers to reach equilibrium. Starting from piControl conditions, historical and scenario simulations have been performed since 1850 yr. The impact of increasing depths on the subsurface layer temperatures is analysed as well as the amounts of energy involved. This is done also considering permafrost processes (freezing and thawing).

Last millennium atmosphere and soil temperature coupling in surrogate climates: Implication for borehole temperature reconstruction technique.

Session: Last Millennium & Past2K
Author: camilo melo aguilar / camelo@ucm.es / universidad complutense de madrid
Co-author: jesús fidel gonzález rouco, universidad complutense de madrid;
elena garcía bustamante, Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas;
jorge navarro montesinos, Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas;

Abstract:
Past climate variations are known both from reconstruction methods that use proxy data as predictors and from simulations with climate models. Among them, borehole reconstruction is a well established method to reconstruct past surface air temperature (SAT) based on the assumption that SAT changes are coupled to ground surface temperature (GST) changes and transferred to the subsurface by thermal conduction. However, some physical processes can impact this hypothesis since they decouple SAT and GST. Climate model simulations from the Community Earth System Model Last Millennium Ensemble (CESM-LME) were considered for assessing the main processes that corrupt the SAT-GST coupling at local, regional and large to global scales. In addition, its implications for borehole temperature reconstruction are evaluated. The analysis of SAT-GST coupling focuses here on the covariance structure during the last millennium (850-1850 CE) and specifically on the trend changes during industrial times (1850-2005 CE). During this period the influence of different anthropogenic external forcings such as greeenhouse gases (GHG), land use land cover (LULC) and ozone/aerosols is considered . The results indicate that global long-term coupling is not significantly affected by local and regional decoupling processes although they are significant at smaller spatial scales. LULC changes play an important role in decoupling SAT-GST at local and regional scales with some implications for borehole temperature reconstructions therefore this must be considered in such type of reconstructions.

Jesús Fidel González Rouco Universidad Complutense de Madrid, facultad de ciencias físicas, departamento de física de la atmósfera. fidelgr@fis.ucm.es

Last Millennium Simulations using UK Met Office models: PMIP3 simulations and plans for PMIP4

Session: Last Millennium & Past2K
Author: Andrew Schurer / A.Schurer@ed.ac.uk / The University of Edinburgh
Co-author: Gabi Hegerl, The University of Edinburgh;
Massimo Bollisina, The University of Edinburgh;
Simon Tett, The University of Edinburgh;

Abstract:
We will run the PMIP4 past1000 simulation using the UK Met Office model HadGEM3. The model set-up and any initial results will be shown. In addition, timeseries and spatial patterns of temperature and precipitation variability from the last millennium PMIP3 simulation run using the UK Met Office model HadGEM2-ES will be presented and compared to those from a lower resolution HadCM3 model, both run with identical boundary conditions.

The role of solar and volcanic forcing in North Atlantic climate over the past 800 years

Session: Last Millennium & Past2K
Author: Jesper Sjolte / jesper.sjolte@geol.lu.se / Department of Geology -- Quaternary Science, Lund University
Co-author: Christophe Sturm, Department of Geological Sciences, Stockholm University;
Florian Adolphi, Oeschger Centre for Climate Change Research, University of Bern;
Bo M. Vinther, Centre for Ice and Climate, Niels Bohr Institute, University of Copenhagen;
Martin Werner, Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Sciences;
Gerrit Lohmann5, Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Sciences;
Raimund Muscheler, Department of Geology -- Quaternary Science, Lund University;

Abstract:
External climate forcings are known to affect climate and atmospheric circulation. However, the analysis of the role of external forcings based on observational data is hampered due to the short observational period, and the sensitivity and persistence of effects of external forcings are debated. On average, a positive phase of the North Atlantic Oscillation (NAO) is observed after major tropical volcanic eruptions the first following winter. Solar activity has also been suggested to influence atmospheric circulation. However, the solar link to the NAO found by modelling studies is not unequivocally supported by reconstructions, and is not consistently present in observations for the 20th century. Here we present a reconstruction of atmospheric winter circulation (DJF) for the North Atlantic region covering the period AD 1241-1970. Based on seasonally resolved Greenland ice core records and a 1200-year long climate model run, we reconstruct atmospheric pressure fields by matching the spatio-temporal variability of the modelled isotopic composition to that of the ice cores. This method allows us to capture the primary and secondary modes of atmospheric circulation in the North Atlantic region, while, contrary to previous reconstructions, preserving the amplitude of observed year-to-year atmospheric variability. We find the average response to major tropical volcanic eruptions to be a positive NAO for the five consecutive winters after eruptions, which is more persistent than previously suggested. Contrary to expectations we do not find a connection between solar activity and the NAO. Instead we find a Scandinavian blocking-type pattern in response to the 11-year solar cycle, resembling the sea level pressure response found in observations. Furthermore, the response to the longer-term deep solar minima of the last millennium is a high-pressure anomaly south of Greenland. This pattern is associated with cooling across Greenland, Iceland and western Scandinavia.

A 1,300-year moisture-balance reconstruction from the dry eastern rift valley of East Africa: the sediment record of hypersaline Lake Bogoria

Session: Last Millennium & Past2K
Author: De Cort, Gijs / gijs.de.cort@africamuseum.be / Department of Earth Sciences, Royal Museum for Central Africa, Tervuren, Belgium
Co-author: Verschuren, Dirk, Limnology Unit, Ghent University, Ghent, Belgium;
Ryken, Els, Limnology Unit, Ghent University, Ghent, Belgium;
Wolff, Christian, Climate Geochemistry, Max Planck Institute for Chemistry, Mainz, Germany;
Renaut, Robin W, Department of Geological Sciences, University of Saskatchewan, Saskatoon, Canada;
Creutz, Mike, Limnology Unit, Ghent University, Ghent, Belgium;
Van der Meeren, Thijs, Limnology Unit, Ghent University, Ghent, Belgium;
Haug, Gerald, Climate Geochemistry, Max Planck Institute for Chemistry, Mainz, Germany;
Olago, Daniel O, Department of Geology, University of Nairobi, Nairobi, Kenya;
Sinnnesael, Matthias, Analytical, Environmental and Geo-Chemistry, Vrije Universiteit Brussel, Brussels, Belgium;
Goderis, Steven, Analytical, Environmental and Geo-Chemistry, Vrije Universiteit Brussel, Brussels, Belgium;
Keppens, Edward, Analytical, Environmental and Geo-Chemistry, Vrije Universiteit Brussel, Brussels, Belgium;
Mees, Florias, Department of Earth Sciences, Royal Museum for Central Africa, Tervuren, Belgium;

Abstract:
High-quality paleoclimate records are rare in the dry eastern branch of the East African Rift System, due to frequent desiccation of lakes which form the major source of paleoenvironmental information in the region. In this study, we present a 1,300-year history of hydrological change at hypersaline, alkaline Lake Bogoria (Central Rift Valley, Kenya), which has survived more recent destructive episodes of drought. Multi-proxy analyses on sediment cores from five key positions, supplemented with seasonal sediment-trap data, resulted in a detailed characterization of lacustrine deposits in Lake Bogoria's three basins and on the two sills separating them. Variability in sedimentation dynamics at the different core sites allowed a semi-quantitative reconstruction of historical lake-level fluctuations over the past 1,300 years, constrained in time by a robust chronological framework. Moisture-balance variability throughout this period greatly exceeded the 20th-century range known from historical records. Between ca. AD 690 and 1100, drought isolated Lake Bogoria's central and southern basins as separate, shallow brine pools with intense evaporation leading to the deposition of sodium carbonates and other evaporative minerals. A pronounced highstand between ca. AD 1100 and 1350 was followed by another lake-level decline, and the northern basin was disconnected from the joint central and southern basins for most of the time until ca. AD 1800. During the last two centuries, lake level has uninterruptedly been relatively high. With the sedimentological framework in place, new stable-isotope and XRF analyses currently underway will translate the sediment archive from Lake Bogoria into a unique, high-resolution hydroclimate record of the past millennium in equatorial East Africa.