

Patterns of forced changes in spatiotemporal climate reconstructions of the Common Era

Session: Invited talks

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Abstract:

Spatiotemporal climate reconstructions offer opportunities to examine patterns of climate anomalies in both time and space and use these to diagnose causal mechanisms linked to radiative forcing or internal modes of ocean-atmosphere variability. Here, we use two recent Common Era temperature reconstructions to investigate the response of the climate system to volcanic eruptions as well as to radiative changes due to solar variability and greenhouse gas emissions. Our new NTREND field reconstruction of Northern Hemisphere summer temperatures shows coherent, broad-scale cooling associated with large tropical volcanic eruptions. Cooling persists in some cases for 2 or more years following eruptions and different eruptions reveal different magnitudes and spatial patterns that are not clearly associated with the estimated radiative forcing. We also detect temperature anomalies linked to centennial-scale changes in insolation and we quantify in time and space the temperature patterns linked to the Medieval Climate Anomaly, Little Ice Age, and modern warming. The PAGES2k Oceans2k High Resolution (HR) reconstruction of tropical sea surface temperatures shows cooling of the western Pacific and Indian Ocean in response to well-dated tropical eruptions but no statistically significant response in the eastern tropical Pacific, suggesting a reduction in the tropical Pacific temperature gradient but not a canonical El Niño pattern. Climate models simulate an overall larger cooling in the western Pacific and Indian Ocean than the reconstructions and produce a variety of anomalies in the eastern Pacific. New spatiotemporal climate reconstructions can provide useful benchmarks for comparing proxy reconstructions with model simulations and may help identify possible sources of disagreement.

Is the “Green Sahara” problem solved?

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Abstract:

Palaeoclimatic theory and modelling seem to converge in the interpretation of archaeological and geological evidence of the Sahara and Arabian deserts being much greener than today during the early and mid-Holocene. Currently it is understood that the change in the Sahara and Arabian deserts was triggered by changes in insolation due to steady variations in the Earth orbit. The climate and ecosystem response to insolation changes was amplified by feedbacks between atmosphere, ocean and land. The atmosphere - land feedbacks include changes in vegetation cover, vegetation composition, lake coverage, soils and emission of mineral dust. Depending on the specific biases and the different complexity of models, some models match data better than others. Hence, it is not yet possible to quantify the efficiency of the various feedbacks involved. Likewise, the interpretation of local data is limited given the coarse spatial resolution of current climate models. The situation becomes even more challenging when addressing the question of the termination of the African Humid Period. And even if model and data converge, then it might be attributed just to a successful tuning of model parameters. Some important processes like the dynamics in plant diversity or the large uptake of mineral dust by small-scale intense convective systems are not adequately represented by current climate system models. In conclusion, we might have available most, if not all, ingredients for making the Holocene Sahara greener than today, but the precise recipe is still missing.

East Antarctic ice sheet variability during the last 3 Ma in the central & eastern Droning Maud Land

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Abstract:

Reconstructing past variability of the Antarctic ice sheets is essential to understand their stability and to anticipate their contribution to future sea level rise. Recent studies have reported a significant decrease in thickness of the East Antarctic Ice Sheet (EAIS) during the last several million years. However, the geographical extent of this decrease and subsequent isostatic rebound remain uncertain. Recently, we reconstructed magnitude and timing of ice sheet retreat at the eastern Dronning Maud Land (DML), East Antarctica, based on geomorphological evidence and glacial isostatic adjustment modeling (GIA) (Suganuma et al., 2014). The data indicate that ice sheet thinning was estimated to be at least 500 m during the last 3 Ma. Although this study was the first attempt to estimate the absolute thickness of the EAIS thinning, local effects, such as regional ice flow and damming, to the ice sheet thickness reconstruction remain unclear. To provide a better constraint for the EAIS thickness reconstruction, we have carried out new field expeditions in wider area of the central DML. In this presentation, I will talk about preliminary results from the expeditions, which show that the significant ice sheet retreat since the Pliocene-Pleistocene boundary also occurred in the central DML.

Climate syntheses to benchmark CMIP6/PMIP4 Last Interglacial equilibrium simulations

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Abstract:

The Last Interglacial (LIG, ~129-116 thousand years ago, ka) represents an excellent case study to investigate the response of sensitive components of the Earth System and the associated mechanisms to a climate globally warmer than preindustrial. However, a spatio-temporal representation of the LIG climatic changes remains difficult to obtain, mainly because aligning paleoclimatic records from various archives from around the globe is challenging. First, we summarize our recent studies that highlight how the coupling of HadCM3 equilibrium experiments with a synthesis of surface air and sea temperature records associated with harmonized chronologies from the appropriate time interval improved our spatio-temporal representation and understanding of the LIG high-latitude climate evolution. In particular, our integrated model-data approach shows that a freshwater input into the North Atlantic (due to the Northern Hemisphere ice sheet early melting) needs to be accounted for, in addition to the orbital and greenhouse gas concentration forcing, in 130 ka HadCM3 simulations, to explain the evolution of the early LIG climate. Second, we present a new 127 ka surface temperature time slice associated with quantitative uncertainty estimates to serve as benchmark for the upcoming CMIP6/PMIP4 127 ka equilibrium simulations. At 127 ka, summer sea surface temperatures were on average 1.1°C and 1.8°C warmer relative to preindustrial in the North Atlantic and in the Southern Ocean respectively. In Antarctica, average 127 ka annual surface air temperature was 2.2°C warmer compared to preindustrial. Finally, we provide a critical evaluation of the latest four LIG surface climate compilations and guidance on the use of these syntheses for upcoming model-data comparison exercises in the framework of the CMIP6/PMIP4 127 ka experiments. Overall, we do not recommend the use of LIG peak warmth-centered syntheses. Instead we promote the use of the most recent syntheses that are based on coherent chronologies between paleoclimatic records and provide spatio-temporal reconstruction of the LIG climate.

The Ice Sheet Model Intercomparison Project for CMIP6 (ISMIP6) and collaboration with PMIP

Session: Invited talks

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Abstract:

The aim of the Ice Sheet Model Intercomparison Project for CMIP6 (ISMIP6) is to produce process-based projections of the contribution of the ice sheets to future sea level based on the climate projections of the on-going CMIP6 activity. The project consists of three types of efforts, the analysis of simulated climate over and surrounding the ice sheets, standalone ice sheet simulations forced by AOGCM climate data and coupled ice-sheet climate experiments. ISMIP6 and PMIP have joined forces to propose a climate and ice sheet simulation of the last interglacial period as a first collaborative effort. This presentation gives an overview of ongoing and planned ISMIP6 activities and highlights current and possible future collaborations with PMIP.

AMOC response to climate forcing: Past, Present and Future.

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Abstract:

The responses of AMOC to the deglacial change of atmospheric greenhouse gases (GHG), ice sheet and meltwater forcing (MWF) is discussed using the TRACE21 simulations and the implication to the present and future AMOC is discussed. During the deglaciation, AMOC intensity is strengthened in response to the slow rise of atmospheric GHG, opposite to the weakening forced by the rapid increase of GHG in the future. In the meantime, AMOC intensity is weakened in response to the ice sheet retreat, which opposes the AMOC response to GHG such that the strength of AMOC is not changed significantly between LGM and the present. In both the AMOC responses to GHG and ice sheet, sea ice feedback plays a critical role. Furthermore, our model fails to produce the abrupt change of AMOC in response to deglacial MWF unless the MWF is prescribed to change abruptly. This may be an artifact of a model bias related to the present day freshwater budget that is common across all present coupled general circulation models (CGCMs). This overstabilization of AMOC may have underestimated the possibility of abrupt AMOC response and climate change to global warming in the future.

Palaeoclimate sensitivity, state dependence, and how well do we understand albedo changes through deglaciations

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Abstract:

I will go through a method of palaeoclimate sensitivity reconstruction, and will highlight key assumptions. These are currently key targets for several teams aiming to capture potential state dependence of palaeoclimate sensitivity. Such work focuses on deglaciations, to see if and how climate sensitivity changed between glacial and interglacial states. But how do we assess changes in the second major slow feedback after carbon-cycle feedbacks, namely the ice-volume albedo feedback? We need well-dated, and precise sea-level reconstructions for that. For Termination I, the last deglaciation, corals and other coastal landforms have been used to make very detailed sea-level record that are well dated. But do these sufficiently represent the uncertainties? For older terminations, continuous sea-level records (e.g., Red Sea, Mediterranean Sea) offer better control, but not the absolute age control – so detailed frameworks are needed to establish both relative and absolute chronological comparisons with other key climate parameters. These introduce their own level of uncertainty. I will go through an array of issues and solutions that are being investigated. Termination II now emerges as the most promising interval of time for palaeoclimate sensitivity assessment: its sea-level history is simpler (essentially monotonic) and better understood than that for Termination I – in part this is because there is less short-term “noise” that complicates temporal comparisons than in Termination I. For other Terminations, we’re still a ways off, further than we might like, but the problem can be resolved.

Coral constraints on late Holocene tropical Pacific climate

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Abstract:

Ocean-atmosphere interactions in the tropical Pacific drive a large spectrum of natural climate variability, and modulate the response of the global climate system to external climate forcing. Newly available datasets of past tropical Pacific climate resolve interannual to millennial-scale variability spanning from the last glacial period to the last century, and their relationship to both internal and external climate forcing. In particular, this study presents new coral-based reconstructions of central equatorial Pacific temperature and hydrology spanning the last seven millennia, with a particular focus on the last millennium. We uncover evidence for a sustained, significant reduction in El Niño-Southern Oscillation (ENSO) variability from 3-5kybp, outlining a new target for simulations of the ENSO's response to precessional forcing. We also uncover a significant response of tropical Pacific climate to volcanic forcing during the last millennium, focusing in particular on the Samalas eruption of 1258-1259AD. Our new dataset of pre-industrial ENSO activity has significantly lower variance than the ENSO activity of last decades, raising the specter that anthropogenic climate change has already altered the character of ENSO extremes. Lastly, we outline a new strategy for producing continuous, replicated reconstructions of tropical Pacific over the last 1-2 centuries for more robust comparisons with model hindcasts of historical trends in temperature and hydrology in this key region.