UP 2: Climate, Climate modelling & Energy

Time: Tuesday 9:45–13:10 Location: HSZ 105

Introduction

Invited Talk UP 2.1 Tue 9:50 HSZ 105
Towards process-based narratives for seasonal climate predictions — •Johanna Baehr — Institute of Oceanography, Center for Earth System Research and Sustainability, Universität Hamburg

Skillful seasonal climate predictions for European climate remain a formidable challenge. I will present recent progress in predicting European climate variability using prediction systems based on the Max-Planck-Institute Earth System Model (MPI-ESM). In the presentation, I will challenge the current practice in seasonal climate predictions to focus on the analysis of the ensemble-mean forecast. In addition, I will suggest process-based narratives, which I will illustrate by analyzing seasonal re-forecasts for European summer and winter climate.

UP 2.2 Tue 10:20 HSZ 105
Variability of surface climate in model simulations of past and future climate — •Kira Rehfeld[1], Raphaël Hébert[2], Juan Lora[3], Marcus Lofverström[4], and Chris Brierley[5] — [1]Institut für Umweltphysik, Heidelberg University, Germany — [2]Alfred-Wegener Institute for Polar- and Marine Research, Potsdam, Germany — [3]Department of Geology and Geophysics, Yale University, US — [4]Department of Geosciences, University of Arizona, US — [5]Department of Geography, University College London, UK

Mean surface temperature of the Earth is projected to rise under all considered emission scenarios, yet little is known about future changes in climate variability. We assess changes in the variability of surface temperature, precipitation, and modes of variability over the entire model ensembles of the Paleoclimate Modeling Intercomparison Project, including the time slices of the Last Interglacial, Last Glacial Maximum, the Mid Holocene, idealized warming experiments and future projections. We examine changes at the local scale and relate them to global mean temperature and precipitation changes. We investigate systematic changes in modes of variability, such as the North Atlantic Oscillation, with global mean temperature change. Mean precipitation across the ensemble is correlated with mean temperature, but the correlation with precipitation variability is weak. We find decreases (increases) of precipitation variability for warm (cold) simulations in western continent regions. Compositing extreme precipitation events we show that, in these regions, they are dominated by the same climatic modes in palaeoclimate and future simulations.

UP 2.3 Tue 10:40 HSZ 105
Understanding and modeling the scaling spectrum of climate — •Beatrice Ellerhoff and Kira Rehfeld — Institute of Environmental Physics, INF 229, 69120 Heidelberg, Germany

Modeling climate dynamics in a comprehensive way and improving its predictability in a warming world requires a better understanding of climate variability across scales. However, fundamental mechanisms governing variability on long timescales are still poorly understood. The temporal evolution of climate can be inferred from paleoclimate records, such as ice cores or marine sediments. The reconstructed continuous spectrum of surface temperature shows a scaling break, following different power-laws on monthly to decadal versus millennial to longer periods. It is yet mostly unexplained, how these power-laws arise and whether a coupling between different timescales can be deduced from it. We study these questions by comparing and applying spectral analyses to paleoclimate records and climate model simulations for the Quaternary. The temperature spectrum is computed from both, climate forcings and responses on diurnal to astronomical timescales. Higher order spectra test for correlations between forcings and responses. In particular, the bispectrum and bicoherence is computed for statistical processes and evaluated for temperature records in order to study whether the scaling properties are related to energy transfers between different states in time. We elaborate the potential of these methods to reveal dynamical processes governing the continuous spectrum of surface temperature.

30 minute break

Invited Talk UP 2.4 Tue 11:30 HSZ 105
Earth-system model simulations of the effect of the asteroid impact 66 million years ago — •Georg Feulner[1], Julia Brugger[1,2], Matthias Hofmann[1], and Stefan Petri[1] — [1]Potsdam-Institut für Klimafolgenforschung (PIK), Potsdam, Germany — [2]Institut für Physik und Astronomie, Universität Potsdam, Potsdam, Germany

Numerical models of Earth's climate system have become essential tools in modern climate science. They provide a glimpse into our future in a warming world, but they also allow us to explore the past and thus to investigate Earth-system dynamics and stability under a range of different boundary conditions. After an overview of palaeoclimate work in my group, I will present recent results on one of the most dramatic events, the asteroid impact 66 million years ago which has been linked to the end-Cretaceous mass extinction event, and particularly to the demise of the (non-avian) dinosaurs. Specifically, we study the climate effects of sulfate aerosols and carbon dioxide formed during the impact using a coupled ocean-atmosphere model and the biogeochemical effect of sulfur, carbon, iron and phosphate from the impact using a marine biogeochemistry model. We find a strong decrease of annual global surface air temperatures by at least 26°C, returning to pre-impact temperatures after about 100 years. The cooling induces vigorous ocean mixing that leads to changes in oxygen distributions and nutrient availability. Importantly, we find a significant increase in primary productivity once the light returns after the impact.

Invited Talk UP 2.5 Tue 12:00 HSZ 105
Sonne oder Treibhaus? Globale Erwärmung einfach und physikalisch nachgerechnet — •Axel Kleidon — Max-Planck-Institut für Biogeochemie, Jena

Die globale Klimaerwärmung zeigt sich zunehmend stärker. Aber woher wissen wir, dass die beobachtete Erwärmung durch den Treibhauseffekt und nicht durch die Sonne verursacht wird? Was ich hier zeige ist, dass man die Erwärmungsmuster durch den Treibhauseffekt klar von denen durch Solarstrahlung unterscheiden kann, weil sie unterschiedliche Terme in der Energiebilanz beeinflussen. Ein stärkerer Treibhauseffekt führt zu den beobachteten, stärkeren Erwärmungen während der Nacht, des Winters, und in den Polargebieten, also zu Zeiten, in dem die Erwärmung durch Solarstrahlung gering ist oder fehlt. Diese Muster können somit nicht durch eine erhöhte Absorption von Solarstrahlung erklärt werden. Ich nutze eine einfache Formulierung der Energiebilanz, um diese unterschiedlichen Wirkungsweisen von Treibhauseffekt und Solarstrahlung zu quantifizieren. Die grundlegenden Muster des Klimawandels lassen sich somit auch einfach und physikalisch verstehen und berechnen, und man ist dafür nicht auf komplexe Klimamodelle angewiesen.

UP 2.6 Tue 12:30 HSZ 105
Energy Storage in Concentration Gradients — •Ulrich Platt and Florian Dinger — Institut für Umweltphysik, Universität Heidelberg

Reliable systems for energy storage are a central component of energy supply systems with a high fraction of renewable energy. Here we propose energy storage using two reservoirs of water with different salt concentrations. Storage of excess energy takes place by reverse osmosis increasing the salt concentration in one reservoir. The produced fresh water will be stored in a second reservoir or discarded, e.g. in a river. Release of the stored energy by an osmosis power station (OPS), exploiting the osmotic pressure of the high concentration reservoir. Energy storage density can reach 8 kWh/m3, up to one order of magnitude higher than in typical pumped-storage hydroelectricity (PSH) at comparable efficiency. Besides the described onshore application using fresh water, an OPS can also be installed at the coast or offshore utilizing the still large concentration gradient between ocean water and saturated salt solution. The technology of such a system is readily available: Reverse osmosis for production of fresh water from ocean water is in widespread use and the technical components (large area membranes, pressure exchangers) are commercially available. Also, the principle of OPS was realized in a demonstration plant in 2009. Compared to PSH our new approach requires no altitude difference of reservoirs, therefore large storage capacities can be realized very economically. A series of different realization schemes and sample calculations of power and energy densities are provided.

UP 2.7 Tue 12:50 HSZ 105

Energy harvesting Technologies for IIoT Applications in Electricity Grid Management — •Joana R. C. Faria and Francisco J. A. Cardoso — LIBPhys - University of Coimbra, Portugal

Being based on the significant advances in different technological areas - sensors, Microsystems, wireless networks, and web service programming -, the Internet of Things (IoT) represents a concept that enables data produced at a number of different locations to be aggregated in a central database. A single IoT device can be useful on its own, but it is the combination of information from numerous devices that tends to increase their intrinsic value, thus underlying the concepts of smart buildings, factories and cities.

The Industrial Internet of Things (IIoT), which is a major tool for the upcoming Industry 4.0, has grown at a faster pace because it can help businesses operate more efficiently, make better informed decisions and unlock new revenue sources. Numerous connected devices demand innovative ways to supply their power demands in a permanent and sustainable way. Energy harvesting technologies reuse ambient energy which is otherwise wasted, creating a practical and self-sufficient solution for IoT power supply.

Here, it is shown that opportunities for energy harvesting technologies exist even in electricity grids. Energy harvesting from two energy sources in the surrounding environment (solar and thermoelectric) are presented in different application contexts of electricity grid management, including the respective experimental results.