IUCliD

Workshop

Interdisciplinary workshop on “Uncertainties in data analysis”

September 30th to October 2nd, 2020

PIK

Potsdam Institute for
Climate Impact Research

The Right Behaviour During Your Stay at PIK

- Your stay at PIK has to be registered to enable necessary back tracing of potential Corona infections – staying at PIK is only allowed after registration.
- The maximum number of allowed participants in the meeting room is 40.
- Touching, such as shaking hands, hugging and touching your own face should be avoided.
- Sneezing and coughing should be carried out in the crook of your arm or in a tissue (which is then immediately disposed of).
- It is important to wash your hands regularly and thoroughly with soap (at least 20 seconds), especially after cleaning your nose, sneezing or coughing
- Regular ventilation of the meeting room is required.
- The minimum distance of 1.5m to other persons must be maintained.
- A mouth and nose mask must be used in the PIK buildings; this can be taken off in the meeting room, when all participants have taken their place, observing the minimum distances.
- WCs and lifts can only be used by one person at a time.
- Entry into printer rooms and staff kitchens is only possible on an individual basis; used surfaces must be disinfected by yourself (disinfectants are available).
- The instructions or information notices (e.g. route guidance system) of the service personnel or other local staff must be followed.

Workshop

Time series analysis plays a crucial role for observation-based understanding of real-world complex systems. However, most existing methods for analysing measured data are not equipped to deal with uncertainties arising from spatiotemporal variations or imprecision in the measurements themselves.

Notwithstanding the increasing attention given to the representation, estimation, visualization, and communication of uncertainties in the field of climate analyses and modelling over the past decade, there is a lack of a thorough framework for uncertainty estimation and propagation in the case of empirical analyses carried out on measurement datasets. This is an important point, particularly in the field of climate, where it is extremely critical to include uncertainties as doing so not only amounts to including additional information at the start of our analyses but it also has the potential thereafter to improve existing ideas about climatic characteristics, and even reveal new features of the climate system in the process.

The interdisciplinary workshop on “Uncertainties in data analysis” aims to increase the awareness and the discussion of the impacts of uncertainties in data analyses, in particular so in the field of climate science. Another important aspect is to highlight potential directions of further research and to stimulate new work in this field.

Invited Speakers

1. Maarten Blaauw (Queen's University Belfast, UK)
2. Nadine Berner (Safety Analysis Division, GRS gGmbH, Research Center, Garching near Munich, DE)
3. Sune Rasmussen (Niels Bohr Institute, University of Copenhagen, DK)
4. Rebecca Morrison (Department of Computer Science, University of Colorado Boulder, Boulder, Colorado, US)

Organizing Committee

- Norbert Marwan
- Bedartha Goswami
- Gabriele Pilz
- Anja Kliese de Souza
- Andyara Callegare

Hands-on workshop

The hands-on workshop will take place Friday afternoon, in parallel virtually and in the conference hall. Participants need their own computer and should install R (a recent version, e.g., 4.0.2) and the package rbacon. This can be done by the following commands:

```
install.packages('rbacon')
```

For users who have installed rbacon already, please run the above again (or type `update.packages()`), just to be sure that the latest version (rbacon 2.4.3) is installed. You can check the versions with `sessionInfo()` after you loaded rbacon with `library(rbacon)`.

Virtual participation

https://pik-potsdam.zoom.us/j/95932680663
Passcode: 961021

Location

The workshop takes place at the "Albert Einstein Science Campus", building A56, conference hall (basement).

The Telegraphenberg (telegraph hill) in the southern part of Potsdam is small hill of 94 m height and houses one of the most historic scientific sites of Germany. It is the place of the world's first Astrophysical Observatory (1874), the discovery of the cosmic dust, the famous "Einstein tower", the Michelson experiment, and many more scientific highlights. The today's "Albert Einstein Science Park" comprises the Helmholtz Centre German Research Centre for Geosciences (GFZ), the Leibniz Institute Potsdam Institute for Climate Impact Research (PIK), the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI), the Leibniz Institute Astrophysical Institute Potsdam (AIP), and the German Weather Service (DWD).

Breaks and Lunch

Beverages and coffee break snacks will be provided in front if the meeting room. Please follow the rules of conduct in regards the hygiene and safety during the breaks, as well.

Lunch is included in the workshop, too and is available in the canteen (and only there) of the science campus. Vouchers (as the payment method in the canteen) will be distributed during check-in.

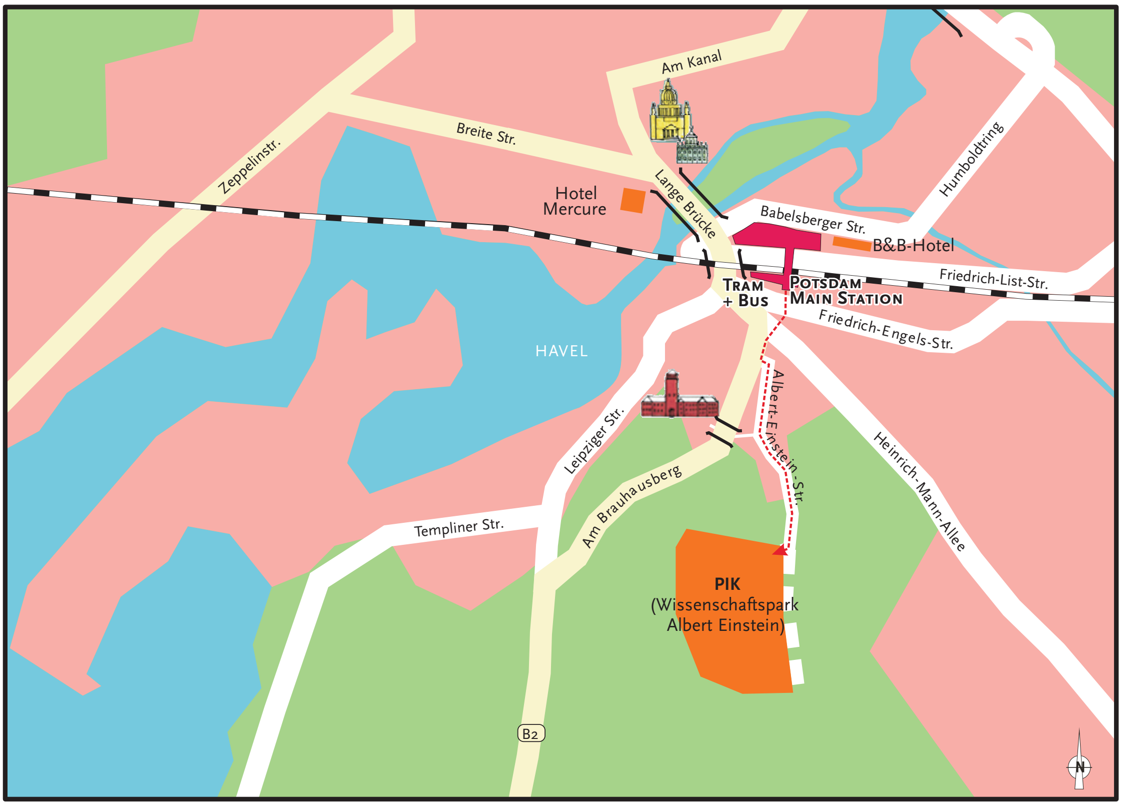
Financial support

The workshop is financially supported by the DFG, project MA4759/8-1 „Impacts of uncertainties in climate data analyses (IUCliD): Approaches to working with measurements as a series of probability distributions“.

DFG Deutsche Forschungsgemeinschaft

Note

The workshop will adhere to the rules of good scientific and ethical practice. This means that it is not allowed to copy presentations from the presentation computer or to record presentations during video conference sessions. It is also forbidden to take photographs of oral presentations without explicitly given permission of the presenter.



Time	Duration	Wednesday	Thursday	Friday
10:00 – 10:25	(00:25)		**Maarten Blaauw:** Modelling uncertainties in age-depth modeling and palaeoecological time series	**Nadine Berner:** Localization of transitions in observations and simulations via Bayesian Inference
10:25 – 10:50	(00:25)			
10:50 – 11:15	(00:25)	Check-in	**Janica C. Bühler:** Comparison of the oxygen isotope signatures in speleothem records and iHadCM3 model simulations for the last millennium	**Torben Kunz:** A spectral approach to estimating the timescale-dependent uncertainty of paleoclimate records
11:15 – 11:40	(00:25)		**Tiffany J. Napier:** Influences of the seasonal Indian monsoons, 1900-1993 CE: Sub-annual sea surface temperature and precipitation reconstructed from laminated	**Tobias Braun:** Extraction of seasonal variability from highly resolved age-uncertain speleothem record to quantify rainfall predictability in agricultural societies
11:40 – 13:20	(01:40)	Lunch	Lunch	Lunch
13:20 – 13:45	(00:25)	**Sune Olander Rasmussen:** When statistics and proxy uncertainties clash: Combining uncertainties from ice cores and other climate records without harming the math (too much)	**Thomas Laepple:** Quantifying uncertainty in paleoclimate archives to better constrain climate variability	**Ravi Kumar Guntu:** Wavelet entropy-based evaluation of intrinsic predictability of time series
13:45 – 14:10	(00:25)		**Thomas Münch:** Challenges and uncertainties in interpreting temperature data from ice cores	**Aurel Perşoiu:** Uncertainties in reconstructing past climate variability from cave ice deposits
14:10 – 14:35	(00:25)	**Maximilian Schanner:** Implementing strong correlation patterns to deal with uneven data distribution	**Saurav Raj:** Accounting magnitude, spatial extent and duration for ranking of extreme precipitation events in Indian Western Himalayan	**Annabel Wolf:** Reconstructing central Vietnam's hydroclimate and its forcing mechanisms during the Common Era
14:35 – 15:00	(00:25)	Break	Break	Break
15:00 – 15:25	(00:25)	**Sanja Panovska:** Age issues in long-term paleomagnetic field models and implications for paleomagnetic dating	**Rebecca Morrison:** Learning sparse representations of model error in coupled differential equations	**Maarten Blaauw:** Practicals on 14C dating and age-depth modelling
15:25 – 15:50	(00:25)	**Keno Riechers:** Investigating the exact chronological sequence of events at the onset of abrupt transitions under full consideration of uncertainties		
15:50 – 16:15	(00:25)	Group discussion	Group discussion	
16:15 – 16:40	(00:25)			

keynote talks

virtual talks

13:20

When statistics and proxy uncertainties clash: Combining uncertainties from ice cores and other climate records without harming the math (too much)

Sune Olander Rasmussen

Niels Bohr Institute, University of Copenhagen

Dating methods of climate proxy records vary widely, and so does the nature of the associated uncertainties. This makes combining uncertainties difficult and calls for smart solutions and/or pragmatic approaches. I will start with the example of ice-core annual-layer counting and describe some of the challenges we have faced in estimating and reporting uncertainties. I will present good and not-so-good examples of how to compare ice-core records with other climate records, advocating that the the way ahead is close collaboration between scientists who have deep insights into the dating methods and the scientists who model the uncertainties statistically as there are only few who master both areas. The talk will thus be more about what you shouldn't do and what the key challenges are, rather than suggesting mathematical solutions to these problems.

14:10

Implementing strong correlation patterns to deal with uneven data distribution

Maximilian Schanner[1], Stefan Mauerberger[2], Monika Korte[1] and Matthias Holschneider[2]

[1]Deutsches GeoForschungsZentrum GFZ, Sektion 2.3, Potsdam, Germany

[2]Applied Mathematics, University of Potsdam, Germany

Reconstructing the global geomagnetic field evolution over the past millenia is hampered by the fact that archeomagnetic records are unevenly distributed in space and time. Dates are often assigned to the closest 50-year interval and less records are available for earlier years. Additionally, records often come with large dating uncertainties. Spatially, there is a strong data bias towards the northern hemisphere with clusters in Europe and east Asia. Statistically sound models of the geomagnetic field should reflect these sources of uncertainty, together with measurement and modeling related errors.

To tackle this, we propose a Gaussian Process regression scheme based on a physically motivated kernel. The kernel is constructed from the assumption of uncorrelated spherical harmonics coefficients at a radius within the source region. It is available in closed form and allows for local variations while still assuming strong global correlations. We can therefore recover global features from the sparse data, even in regions with few or no direct observations. By implementing a linearized noisy input model we can account for dating uncertainties. Marginalization of prior parameters further translates modeling related uncertainties to the posterior distribution.

14:35 **Break**

15:00

Age issues in long-term paleomagnetic field models and implications for paleomagnetic dating

Sanja Panovska and Monika Korte

Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences

Lake and marine sediments are typical recorders of the geomagnetic field on time-scales from centuries to millennia and longer. The presently compiled paleomagnetic data allow global reconstructions of the geomagnetic field covering the past 100 kyr. An essential factor for studying these long-term variations is the accurate and high-resolution chronology of the records, for which a variety of dating methods has been used. In the 100 kyr data compilation, the most commonly used geochronological method is radiocarbon dating (37%), followed by oxygen isotope stratigraphy (23%). Other methods include varve counting and correlations based on physical or magnetic properties. Various methods are associated with a range of age uncertainties, which have to be considered when building paleomagnetic models. Chronological misalignment of the records limits the models' reliability and temporal resolution.

Paleomagnetic field models can also be used for dating by matching the paleomagnetic record with local model predictions. However, one has to consider the spatial correlation length of geomagnetic variations and temporal resolution in this case. One characteristic of long-term geomagnetic field variations are excursions – events when field directions deviate strongly from an axial-dipole dominated field, associated with globally low field intensities. Recent models provide global insight into these events over the past 100 kyr, including the Laschamp excursion, the best globally documented event that happened 41 ka ago. Geomagnetic excursions can also be used as stratigraphic markers for dating purposes, but again the correlation length has to be considered as the change cannot be considered globally uniform.

15:25

Investigating the exact chronological sequence of events at the onset of abrupt transitions under full consideration of uncertainties

Keno Riechers

Potsdam Institute for Climate Impact Research

The sequence of events at the onset of Dansgaard-Oeschger (DO) transitions is widely debated. Indications have been found in proxy data and modeling studies, that an atmospheric reorganization might lead abrupt Greenland warming and corresponding sea ice retreat. We reviewed high resolution calcium and sodium concentrations from time windows around 16 DO-events from the last glacial. The proxies, representing atmospheric conditions and sea ice cover respectively, were measured simultaneously in the NGRIP ice core and both entail abrupt transitions characteristic for DO-events. With noise blurring the transitions, we use a Bayesian MCMC-based algorithm designed by Erhardt et al. (2019) to derive probability densities for the lag between the two transition onsets. Regarding the 20 probabilistic lags as a an uncertain sample generated from an hypothezised population, we follow three approaches. First, we derive a distribution for the population mean. Finding a 77% chance for the population to exhibit a sodium lag on average we cannot preclude a generating population with an average sodium lead. Second, we apply hypothesis tests to the probabilistic sample. If uncertainties are averaged out in the representation of lags, the sample suggests that sodium lags calcium significantly. However, rigorous uncertainty propagation yields non-significant results. Last, we calculate the probability for n events being lead by a calcium transition. We find probabilities higher than 5% percent only for configurations with $8<n<13$, evidencing that our data comprises both, transitions being lead by calcium and transitions being lead by sodium. This contradicts the hypothesis that one transition exclusively triggers the other.

References:

Erhardt, T. et al. Decadal-scale progression of the onset of Dansgaard-Oeschger warming events. Clim. Past 15, 811–825 (2019).

15:50

Group discussion

10:00

Modelling uncertainties in age-depth modeling and palaeoecological time series

Maarten Blaauw

Queen's University Belfast

(TBA)

10:50

Comparison of the oxygen isotope signatures in speleothem records and iHadCM3 model simulations for the last millennium

Janica C. Bühler, Carla Roesch, Moritz Kirschner, Louise Sime, Max D. Holloway, and Kira Rehfeld

Institute of Environmental Physics, Heidelberg University

Global changes in the climate, especially the current anthropogenic heating, receive increasing public and scientific attention. Improving the future climate projections relies on a better understanding of changes in variability and in the mean as well as their relation, gained from e.g. $\delta^{18}O$ in speleothems. Model-data comparisons between isotope-enabled general circulation models and speleothem paleoclimate archives can test and validate the capability of models to simulate changes in variability. However, the $\delta^{18}O$ in speleothem mineral used for comparison, does not directly represent temperature or precipitation but results from multivariate non-linear processes in the lower and mid-latitudes.

Using three transient isotope-enabled past millennium simulations of the iHadCM3 model and the large global dataset of speleothem $\delta^{18}O$ SISALv2, we evaluate simulation biases across different parameters and distinguish main climate drivers for records and regions.

We find a small mean $\delta^{18}O$-offset between the simulation and the proxies. The strongly damped variability on decadal timescales, but higher centennial variability in the proxies compared to the simulations can mostly be attributed to the records' lower temporal resolution and signal averaging. The low signal-to-noise ratios found in the proxy data of records of one cave or one region, hint at a high influence of cave-internal processes and regional climate particularities, indicating a low regional representativity.

The methods used for this $\delta^{18}O$ model-data comparison are not restricted to speleothem $\delta^{18}O$ or to the iHadCM3 last millennium simulations investigated, but hold the potential to be applied to proxy data of a variety of archives and models.

11:15

Influences of the seasonal Indian monsoons, 1900-1993 CE: Sub-annual sea surface temperature and precipitation reconstructed from laminated Pakistan Margin sediments

Tiffany J. Napier[1], Lars Wörmer[1], Jenny Wendt[1], Andreas Lückge[2], Kai-Uwe Hinrichs[1]

[1]Organic Geochemistry Group, MARUM – Center for Marine Environmental Sciences and Department of Geosciences, University of Bremen, 28359 Bremen, Germany

[2]Bundesanstalt für Geowissenschaften und Rohstoffe (BGR), 30655 Hannover, Germany

We reconstruct 20th century sub-annual sea surface temperature (SST) and precipitation using varved Pakistan Margin sediment core SO90-58KG to examine variability in the seasonal Indian monsoons. The annual SST cycle is driven by upward mixing of cooler waters during the Northeast monsoon, and precipitation may be linked with the Southwest monsoon. We apply mass spectrometry imaging to measure and map the downcore distribution of GDGTs and alkenones in in-tact sediment surfaces with 100 µm resolution. These same samples are analyzed with micro-XRF in 50 µm resolution to generate complementary elemental maps. Reconstructed SSTs were calculated from CCaT and $U^{K'}_{37}$ ratios, with a temporal resolution of 6-8 points per year. Reconstructed SSTs for both biomarker proxies contain congruent trends, and align with the annual range of instrumental measurements. The annual cycles in SST are prominent in the reconstructed series. The first principal component (PC1) of the elemental measurements is associated with siliciclastic elements (Al, Si, K, Ti, Fe). The PC1 series is compared with historical precipitation records to develop a proxy for sub-annual precipitation-driven river runoff.

These paired measurements allow us to examine the seasonality of precipitation-driven river runoff. PC1 is typically highest when SST is low, suggesting precipitation-driven runoff/deposition from winter westerly storms. However, some years contain PC1 peaks that occur in-phase with warm SSTs, suggesting rainfall from the Southwest monsoon. This work demonstrates the cutting edge of high-resolution paleoclimate science, and provides new insights into Indian monsoon system variability from its arid western edge.

11:40 Lunch

13:20

Quantifying uncertainty in paleoclimate archives to better constrain climate variability

Thomas Laepple[1,2], Andrew Dolman[1], Thomas Münch[1], Torben Kunz[1], Raphael Hebert[1]

[1]Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung

[2]Universität Bremen

In order to adapt to the changing climate, not only changes in the mean state but also the magnitude and change of climate variability have to be known. Whereas synoptic to interannual variations in the climate system are well documented and current climate models are generally able to simulate them realistically, much less is known about the amplitude and the mechanisms of climate variability on longer time-scales. Paleoclimate archives such as ice-core and marine sediment records can provide the needed information about climate variability but are sparse, inherently noisy and and at times provide contradictory evidence. This hampered quantitative reconstructions of climate variability and systematic testing of the variability simulated from climate models.

In the last years, several advances have been made to better extract climate variability estimates from climate archives. These include a better characterisation of the non-climate effects and the proxy response based on replicate, multi-proxy and core-top compilations, proxy system models bridging the gap between climate and proxy variations as well as novel statistical techniques tailored to separate climate from noise components. Based on these advances we were able to considerably improve our understanding of the present climate variability as well as to estimate how climate variability responds to a changing climate.I will discuss recent advances in the toolbox of teasing out climate variability from marine and ice-core based proxy records and also point out future directions how to enhance the use of the paleoclimate record for quantitatively constraining present and future climate variability.

13:45

Challenges and uncertainties in interpreting temperature data from ice cores

Thomas Münch, Mathieu Casado, Alexandra Zuhr, Thomas Laepple

Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung

The isotopic composition measured in polar firn and ice cores is a major proxy archive of past climate variations. Although temperature is known to be the main driver of isotopic composition changes, the isotopic record that is derived from an ice core is in detail the result of a chain of several processes: (1) atmospheric temperature changes along with (2) isotopic fractionation during the pathway from atmospheric moisture to precipitation, (3) the effect of variable and intermittent precipitation and finally (4) local depositional and post-depositional effects. Considering temperature changes as the main process which we are interested in to reconstruct from ice cores, the additional processes constitute a significant amount of noise in the proxy record.

In this contribution, we summarise the state of the art concerning our understanding of these different processes, including their characterisation and quantification, based on field expeditions, analyses of climate model data, and proxy system modelling.

14:10

Accounting magnitude, spatial extent and duration for ranking of extreme precipitation events in Indian Western Himalayan

Saurav Raj and Ankit Agarwal

Indian Institute of Technology Roorkee

Extreme weather and climate events rarely occur at a single location (station) rather over a wider impacted area. In fact, the magnitude, spatial extent and duration, in general, have potential to indicate whether the particular event is local, regional or global. In this study, we rank the extreme precipitations events in the Indian Western Himalayan by accounting the precipitation magnitude, spatial extent and duration. The results reveal that multi day ranking scheme helps in better understanding the different air circulation patterns/precipitation bands causing precipitation over an area at different times. The single day event happening for four days was insignificant, if studied independently, but turns out be hazardous if studied through multi day ranking scheme. We observe that the ranking method apart from identifying such long temporal scales extremes also gives an idea that at what time scale it will be of high impact. Our result reveal that even in many cases, socioeconomic impacts are not just a result of short and intense events but also accumulated moderate events for a longer period which then become significant.

14:35 **Break**

15:00

Learning sparse representations of model error in coupled differential equations

Rebecca Morrison

University of Colorado, Boulder, Computer Science

In many applications of coupled differential equations, we are only interested in the dynamic behavior of a subset of all possible active variables. Models are thus often highly reduced, so that only the interactions among the variables of interest are retained, but this reduction introduces a model error, or discrepancy. In this talk, I'll explore the use of an embedded, sparse, and calibrated operator to represent model error. Under some conditions, the model error caused by severe reductions–e.g., elimination of hundreds of terms–can be captured with sparse operators, built with only a small fraction of that number. The operator is embedded within the differential equations of the model, which allows its action to be interpretable. Moreover, it is constrained by available physical information, and calibrated over many scenarios. These qualities of the discrepancy model–interpretability, physical-consistency, and robustness to different scenarios–are intended to support reliable predictions under extrapolative conditions. The talk will show these sparse operators in action, including examples from mathematical ecology, epidemiology, and combustion.

15:50 **Group discussion**

10:00

Localization of transitions in observations and simulations via Bayesian Inference

Nadine Berner

Safety Analysis Division, GRS gGmbH, Research Center, Garching near Munich

The localization of transitions influencing and occurring in complex dynamic systems is of great importance for our understanding of a system's behavior, particularly in the presence of uncertainty. For the quantification of uncertainty Bayesian statistics can be applied to infer on the location of transitions in observations, e.g. to detect change points in climate time series via kernel-based Bayesian inference, or simulations, i.e. by inferring on parameter regions leading into critical system states of an engineered system via Gauss Process-based adaptive sampling.

10:50

A spectral approach to estimating the timescale-dependent uncertainty of paleoclimate records

Torben Kunz[1], Andrew M. Dolman[1], and Thomas Laepple[1,2]

[1]Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung, Research Unit Potsdam, Telegrafenberg A45, 14473 Potsdam, Germany

[2]University of Bremen, MARUM – Center for Marine Environmental Sciences and Faculty of Geosciences, 28334 Bremen, Germany

Proxy records represent an invaluable source of information for reconstructing past climatic variations, but they are associated with considerable uncertainties. For a systematic quantification of these reconstruction errors, however, knowledge is required not only of their individual sources but also of their auto-correlation structure, as this determines the timescale dependence of their magnitude, an issue that is often ignored until now. Here a spectral approach to uncertainty analysis is provided for paleoclimate reconstructions obtained from single sediment proxy records. The formulation in the spectral domain, rather than the time domain, allows for an explicit demonstration as well as quantification of the timescale dependence that is inherent in any proxy-based reconstruction uncertainty.

The theoretical concept is presented and analytic expressions are derived for the power spectral density of the reconstruction error of sediment proxy records. The underlying model takes into account the spectral structure of the climate signal,

seasonal and orbital variations, bioturbation, sampling of a finite number of signal carriers, uncorrelated measurement noise, and it includes the effects of spectral aliasing and leakage. The uncertainty estimation method, based upon this model, is illustrated by simple examples and its applicability to real sediment proxy records is demonstrated.

11:15

Extraction of seasonal variability from highly resolved age-uncertain speleothem record to quantify rainfall predictability in agricultural societies

Tobias Braun[1], Erin Ray[2], Sebastian Breitenbach[3], James Baldini[4], Lisa Baldini[4], Franziska Lechleitner[5,6], Norbert Marwan[1], Keith Prufer[6]

[1]Potsdam Institute for Climate Impact Research

[2]Department of Anthropology, University of New Mexico, Albuquerque, USA

[3]Department of Geography and Environmental Sciences, Northumbria University, Newcastle upon Tyne, UK

[4]Department of Earth Sciences, Durham University, Science Laboratories, Durham, UK

[5]Department of Earth Sciences, University of Oxford, Oxford, UK

[6]Department of Chemistry and Biochemistry, University of Bern, Switzerland

[7]Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, USA

Measurement of proxy records is intrinsically linked to dating errors of the respective archives, yielding significant dating uncertainties. For any quantitative analysis of proxy time series, this raises the paramount question of how this uncertainty can be represented and propagated. COPRA is a popular depth-age model of speleothem chronologies and transforms time uncertainty into uncertainty of the magnitude by computing a high number of Monte-Carlo realizations. These are compatible with the respective dating errors and allow for representing uncertainties.

We study a highly-resolved 1600 year speleothem record of paleoseasonality from the Neotropics and demonstrate how high-frequency variability can be extracted in presence of irregular sampling and dating uncertainties. Instead of analyzing the median time series derived from all Monte-Carlo realizations, we pursue a scheme in which first the statistics of interest are computed on all realizations. This enables us to also quantify the high-frequency variability present in the record instead of averaging it out. Thereafter, counting of significant values for the statistics of interest among all realizations results in a frequency-time series that characterizes the full age model ensemble.

We therefore address the challenge of assessing subannual features of proxy time series while accounting for age uncertainty. Nonstationarity in the seasonal cyclicity, the regional severity of hydroclimatic extremes and subannual volatility are identified with potential repercussions for rainfall predictability in agricultural societies.

11:40 **Lunch**

13:20

Wavelet entropy-based evaluation of intrinsic predictability of time series

Ravi Kumar Guntu[1], Maheswaran Rathinasamy[2], Matjaž Perc[3,4,5], Norbert Marwan[6], Jürgen Kurths[6,7], Ankit Agarwal[1]

[1]Department of Hydrology, Indian Institute of Technology Roorkee, Roorkee 247667, India

[2]Department of Civil Engineering, MVGR College of Engineering, Vizianagaram 535005, India

[3]Faculty of Natural Sciences and Mathematics, University of Maribor, 2000 Maribor, Slovenia

[4]Center for Applied Mathematics and Theoretical Physics, University of Maribor, 2000 Maribor, Slovenia

[5]Department of Medical Research, China Medical University Hospital, China Medical University, Taichung 40402, Taiwan

[6]Potsdam Institute for Climate Impact Research, Telegrafenberg, 14412 Potsdam, Germany

[7]Institute of Physics, Humboldt University, 12489 Berlin, Germany

Intrinsic predictability is imperative to quantify inherent information contained in a time series and assists in evaluating the performance of different forecasting methods to get the best possible prediction. Model forecasting performance is the measure of the probability of success. Nevertheless, model performance or the model does not provide understanding for improvement in prediction. Intuitively, intrinsic predictability delivers the highest level of predictability for a time series and informative in unfolding whether the system is unpredictable or the chosen model is a poor choice. We introduce a novel measure, the Wavelet Entropy Energy Measure (WEEM), based on wavelet transformation and information entropy for quantification of intrinsic predictability of time series. To investigate the efficiency and reliability of the proposed measure, model forecast performance was evaluated via a wavelet networks approach. The proposed measure uses the wavelet energy distribution of a time series at different scales and compares it with the wavelet energy distribution of white noise to quantify a time series as deterministic or random. We test the WEEM using a wide variety of time series ranging from deterministic, non-stationary, and ones contaminated with white noise with different noise-signal ratios. Furthermore, a relationship is developed between the WEEM and Nash–Sutcliffe Efficiency, one of the widely known measures of forecast performance. The reliability of WEEM is demonstrated by exploring the relationship to logistic map and real-world data.

13:45

Uncertainties in reconstructing past climate variability from cave ice deposits

Aurel Perșoiu[1,2,3]

[1]Emil Racoviță Institute of Speleology, Romanian Academy, Cluj Napoca, Romania

[2]Stefan cel Mare University, Suceava, Romania

[3]Romanian Institute of Scence and Technology, Cluj Napoca, Romania

Over the past decade ice deposits in caves have been increasingly the subjects of studies aiming to reconstruct past climate variability. The most promising proxy in cave ice is the stable isotope composition of water that records both past local air temperature variability (through $\delta^{18}O$ and $\delta^{2}H$ of ice) and also changes of moisture sources or conditions at the moisture sources (through the derived d-excess parameter).

These underground glaciers form as continuous accumulation of snow or freezing of water (or the combination of the two), thus acting as an archive of winter-biased climatic conditions. However, contrary to most surface glaciers, cave glaciers may experience prolonged periods of ablation leading to the loss of continuity in the proxy records. Therefore, the combination of potentially problematic chronology and complex genetic mechanisms (involving, inter alia, kinetic fractionation processes during freezing) led to difficulties in interpreting the putative paleoclimatic signals. With careful monitoring and detailed knowledge of the investigated sites, novel and unique information on past environmental variability were obtained over the past decade, yet unsolved issues are still emerging.

In this presentation, I will 1) highlight the main results of paleoclimate studies targeting ice caves obtained in the past few years, 2) discuss the pitfalls, problems and some of the solution we have identified and 3) present unsolved (or party solved) issues related to dating uncertainties, proxy interpretation and seasonal bias(ses) to stimulate fruitful discussions.

14:10

Reconstructing central Vietnam's hydroclimate and its forcing mechanisms during the Common Era

A. Wolf, V. Ersek, A. French, S. Bernasconi, M. Jaggi, D. McGee, J. Longman, W. H. G., Roberts, D. A. Trinh, S. F. M. Breitenbach

Northumbria University Newcastle

The Asian monsoon impacts two thirds of the world's population and changes in the length and timing of the rainy season can have major economic and social impacts on Asian societies. Southeast Asia is influenced by the two largest monsoon systems, the Indian and East Asian monsoons, but has received less attention compared to India, or China. The region has very few well-dated, high-resolution climate reconstructions, which leaves much of the long-term regional climate variability unknown. For example, there is no consensus on whether internal ocean-atmospheric interactions (e.g. sea surface temperature) or external solar forcing are driving multidecadal to centennial climate variability.

We present the first high-resolution stable isotope ($\delta^{18}O$ and $\delta^{13}C$) and trace element (Mg, Sr, Ba, P, U) speleothem record from central Vietnam which spans from 490 to 2300 years BP. The cave has a rapid response to rainfall events, therefore our site is likely sensitive to short rainfall events. This is of interest since local climate in central Vietnam is dominated by non-monsoonal rainfall consisting mainly of tropical cyclones and heavy autumnal rainfall events. Our record shows that local droughts in central Vietnam are correlated to large-scale dry periods in the broader region. These results suggest a link between reduced Southeast Asian monsoon strength and tropical cyclone activity over the last two millennia. Decadal to centennial variability is likely driven by dynamical changes in the sea surface temperature in the Indian and Pacific Oceans.

14:35

Break

15:00

Practicals on ^{14}C dating and age-depth modelling

Maarten Blaauw

Queen's University Belfast

Science Campus Albert Einstein
Telegrafenberg Potsdam

- Helmholtz-Zentrum Potsdam - Deutsches GeoForschungsZentrum (GFZ)
- Alfred-Wegener-Institut für Polar- und Meeresforschung (AWI)
- Potsdam-Institut für Klimafolgenforschung (PIK)
- Leibniz-Institut für Astrophysik Potsdam (AIP)
- Deutscher Wetterdienst (DWD)