ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

Section Paleoclimate Dynamics **Proposed Master Thesis Project**

Evaluating the performance of a climate model based on the agreement between simulated Pliocene climate states and the terrestrial geologic record

Abstract

The Mid-Piacenzian Warm Period (MPWP, about 3.3 to 3.0 Million years ago) is a relatively recent pre-Quaternary time-slice, located within the Piacenzian Stage of the Pliocene Epoch. It receives particular attention from the climate modelling community due to the assumption that it could be a potential past analogue for future climate. This idea is based on the inference that the MPWP land surface shows strong similarity to modern geography; furthermore, reconstructions of MPWP atmospheric carbon dioxide reveal similarity to recent or modern conditions (Jansen et al., 2007, and references therein).

A climate model's ability to reproduce past climate states can be tested by comparing the simulated climate to independent information that can be inferred from various data sources in the geologic archive. The motivation of testing a climate models' ability to reproduce the climate of the past is to assess its utility in producing meaningful results in a framework that differs from the modern state of earth surface, atmosphere and oceans. Such a modelling exercise helps to assess the reliability of simulated potential future climate states for which, of course, no similar model-independent quantitative benchmark exists.

In the framework of the proposed master thesis project such a model-data comparison shall be conducted for the MPWP. An ensemble of simulated surface air temperatures (SAT) provides the model data sets. These have been created by employing varying boundary conditions and climate forcings in simulations with the Community Earth System Models (COSMOS) in the framework of the Pliocene Model Intercomparison Project Phase 2 (PlioMIP2, Haywood et al., 2016). The modelling-independent data set is based on reconstructions of SAT that have been derived from terrestrial sediments. This data has been collected by Salzmann et al. (2013) in their supplementary Tables S3a and S3b. Goal of the model-data comparison is to identify simulations that (regionally) provide a best match, with the geologic record being the benchmark, and to rank the COSMOS PlioMIP2 simulation ensemble according to agreement with the terrestrial record. To this end, global and regional quantification of the model-data discord is computed based on a suitable statistical measure like the root mean square deviation. The model-data comparison can be conducted in a similar manner as in the study by Salzmann et al. (2013), where a multi-model ensemble of simulations, each based on similar boundary conditions and forcings, has been examined. In contrast to Salzmann et al. (2013), the here proposed project employs a simulation ensemble that is based on one specific climate model but considers varying boundary conditions and forcings.

Likely, not one simulation outperforms other ensemble members globally. A simulations' relative performance will rather depend on the analysis region. Reasons for regional dependency of model

performance shall be studied and discussed. In this respect, it is purposeful to consider and reflect on degrees of freedom and sources of uncertainty in both modelled and reconstructed data sets – such as individual simulations' boundary conditions and climate forcings, as well as individual reconstructions' confidence assessments (Tables S3a/S3b by Salzmann et al., 2013).

References

Haywood, A. M., Dowsett, H. J., Dolan, A. M., Rowley, D., Abe-Ouchi, A., Otto-Bliesner, B., Chandler, M. A., Hunter, S. J., Lunt, D. J., Pound, M., and Salzmann, U.: The Pliocene Model Intercomparison Project (PlioMIP) Phase 2: scientific objectives and experimental design, Clim. Past, 12, 663-675, https://doi.org/10.5194/cp-12-663-2016, 2016.

Salzmann U., Dolan A. M., Haywood A. M., Chan W.-L., Voss J., Hill D. J., Abe-Ouchi A., Otto-Bliesner B., Bragg F. J., Chandler M. A., Contoux C., Dowsett H. J., Jost A., Kamae Y., Lohmann G., Lunt D. J., Pickering S. J., Pound M. J., Ramstein G., Rosenbloom N. A., Sohl L., Stepanek C., Ueda H., and Zhang Z.: Challenges in quantifying Pliocene terrestrial warming revealed by data–model discord, Nat. Clim. Change, 3, 969-974, 2013.

Jansen, E., J. Overpeck, K.R. Briffa, J.-C. Duplessy, F. Joos, V. Masson-Delmotte, D. Olago, B. Otto-Bliesner, W.R. Peltier, S. Rahmstorf, R. Ramesh, D. Raynaud, D. Rind, O. Solomina, R. Villalba, Zhang, D: Palaeoclimate, in: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

---

formal details

proposed project duration: ca. 6 months

proposed supervisors:
- Dr. Christian Stepanek (direct supervisor)
- Prof. Dr. Gerrit Lohmann (formal supervisor)

requirements:
- background in climate dynamics
- solid basic knowledge on statistics and statistical analysis and the willingness to deepen the knowledge wherever necessary
- basic knowledge/experience in employing common data-analysis software (e.g. python, R, octave, Matlab, CDO) or the motivation and ability to gain this 'on the fly'
- experience with UNIX/SHELL is an advantage

skills to be gained in this project:
- writing scripts for data analysis in your preferred language
- (more) experience with UNIX/SHELL and processing NetCDF
- analyzing climate model output
- insights into the comparison of climate model output to proxy data

contact: Christian.Stepanek@awi.de