EGU25-6713, updated on 08 Apr 2026
https://doi.org/10.5194/egusphere-egu25-6713
EGU General Assembly 2025

Spectral divergence in hydroclimate and temperature between models and reconstructions

Thomas Pliemon[1], Nathan Steiger[1], Thomas Laepple[2,3], Kira Rehfeld[4,5], and Raphaël Hébert[2]
[1]Fredy and Nadine Herrmann Institute of Earth Sciences, Hebrew University, Jerusalem, Israel
[2]Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Potsdam, Germany
[3]MARUM—Center for Marine Environmental Sciences, University of Bremen, Bremen, Germany
[4]Department of Geosciences, University of Tübingen, Tübingen, Germany
[5]Department of Physics, University of Tübingen, Tübingen, Germany

The relatively short observational record limits our ability to understand the long-term variability of key climate factors like temperature and hydroclimate. Climate models and paleoclimate proxies appear to have long-term temperature variabilities that diverge from each other at local and long time scales. But it is unclear whether these divergences also apply to hydroclimate and whether long-term hydroclimate variability is fundamentally different than temperature variability.

Here we evaluate the long-term variability over the Common Era of temperature and hydroclimate using a climate model (the Community Earth System Model-Last Millennium Ensemble, CESM-LME) and a paleoclimate reconstruction based on this model (the Paleo Hydrodynamics Data Assimilation product, PHYDA); this framework allows us to see how a model's long-term climate variability is affected by informing it with proxy data. We specifically focus our analyses on the continuum of temperature (tas) and the Palmer Drought Severity Index (PDSI) in four regions of low reconstruction uncertainty: the Western USA, the Eastern USA, Central Europe, and Scandinavia.

Using the power-scaling exponents β from the relationship $S(\tau) \propto \tau^{\beta}$, where S denotes the power spectral density (PSD) and τ the period, we find universally higher values of β in PHYDA (except for tas globally); in these four regions PHYDA's β values are 0.30 to 0.63 higher than CESM-LME. Thus, long range dependence behavior is more pronounced in PHYDA than in the CESM-LME model. We find that PHYDA has different spatial distributions of β than CESM-LME. We also find that hydroclimate is spectrally flatter than temperature in CESM-LME, whereas temperature and hydroclimate β-values are comparable in PHYDA. These results show that CESM-LME's hydroclimate and temperature is less dominated by long timescales compared to PHYDA's. The robustness of the low-frequency variability signal in PHYDA was verified by performing pseudoproxy experiments. Furthermore, preliminary results of other temperature DA reconstructions over the Holocene and since the Last Glacial Maximum also reveal spectral divergencies with model data. In particular, for the PSD of the global mean temperatures, higher beta values were obtained for the reconstructions compared to the model data, indicating a deficit

in simulated low-frequency.