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Towards spatio-temporal comparison of transient simulations and temperature reconstructions for the last deglaciation

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An increasing number of Earth System Models has been used to simulate the climatic transition from the Last Glacial Maximum to the Holocene. This creates a demand for benchmarking against environmental proxy records, which have been synthesized for the same time period. Comparing these two data sources in space and time over a period with changing background conditions requires new methods. We employ proxy system modeling for probabilistic quantification of the deviation between temperature reconstructions and transient simulations. Regional and global scores quantify the mismatch in the pattern and magnitude of orbital- as well as millennial-scale temperature variations.

In pseudo-proxy experiments, we test the ability of our algorithm to accurately rank an ensemble of simulations according to their deviation from a prescribed temperature history, dependent upon the amount of added non-climatic noise. To this purpose, noisy pseudo-proxies are constructed by perturbing a reference simulation. We show that the algorithm detects the main features separating the ensemble members. When scores are aggregated spatially, the algorithm ranks simulations robustly and accurately in the presence of uncertainties. In contrast, erroneous rankings occur more often if only a single location is assessed.

Having established the effectiveness of the algorithm in idealized experiments, we apply our method to quantify the deviation between data from the PalMod project: an ensemble of transient deglacial simulations and a global compilation of sea surface temperature reconstructions. No simulation performs consistently well across different regions and components of the temperature evolution which we attribute to the larger spatial heterogeneity in reconstructions. Our work provides a basis for a standardized model-data comparison workflow, which can be extended subsequently with additional proxy data, new simulations, and improved

representations of uncertainties.