Paleoclimate networks: a concept meeting central challenges in the reconstruction of paleoclimate dynamics

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Statistical analysis of dependencies amongst paleoclimate data helps to infer on the climatic processes they reflect. Three key challenges have to be addressed, however: the datasets are heterogeneous in time (i) and space (ii), and furthermore time itself is a variable that needs to be reconstructed, which (iii) introduces additional uncertainties. To address these issues in a flexible way we developed the paleoclimate network framework, inspired by the increasing application of complex networks in climate research. Nodes in the paleoclimate network represent a paleoclimate archive, and an associated time series. Links between these nodes are assigned, if these time series are significantly similar. Therefore, the base of the paleoclimate network is formed by linear and nonlinear estimators for Pearson correlation, mutual information and event synchronization, which quantify similarity from irregularly sampled time series. Age uncertainties are propagated into the final network analysis using time series ensembles which reflect the uncertainty. We discuss how spatial heterogeneity influences the results obtained from network measures, and demonstrate the power of the approach by inferring teleconnection variability of the Asian summer monsoon for the past 1000 years.