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Reconstructing the leading mode of multi-decadal North Atlantic variability over the last two millenia using functional paleoclimate networks

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The increasing availability of high-resolution North Atlantic paleoclimate proxies allows to not only study local climate variations in time, but also temporal changes in spatial variability patterns across the entire region possibly controlled by large-scale coherent variability modes such as the North Atlantic Oscillation (NAO) and Atlantic Multidecadal Oscillation.

In this study, we use functional paleoclimate network analysis [1,2] to investigate changes in the statistical similarity patterns among an ensemble of high-resolution terrestrial paleoclimate records from Northern Europe included in the Arctic 2k data base. Specifically, we construct complex networks capturing the mutual statistical similarity of inter-annual temperature variability recorded in tree ring records, ice cores and lake sediments for multidecadal time windows covering the last two millenia. The observed patterns of co-variability are ultimately connected to the North Atlantic atmospheric circulation and most prominently to multidecadal variations of the NAO.

Based on the inferred networks, we study the dynamical similarity between regional clusters of archives defined according to present-day inter-annual temperature variations across the study region. This analysis identifies those time-dependent inter-regional linkages that are most informative about the leading-order North Atlantic climate variability according to a recent NAO reconstruction for the last millenium [3]. Based on these linkages, we extend the existing reconstruction to obtain qualitative information on multidecadal to centennial scale North Atlantic climate variability over the last two millenia. In general, we find a tendency towards a dominating positive NAO phase interrupted by pronounced and extended intervals of negative NAO. Relatively rapid transitions between both types of behaviour are present during distinct periods including the Little Ice Age, the Medieval Climate Anomaly and for the Dark Ages Little Ice Age.

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