The Medieval Climate Anomaly and the Little Ice Age: testing the NAO hypothesis

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Medieval Climate Anomaly (MCA) terrestrial proxy records (speleothem, NW Scotland; tree rings, Morocco) from close to the centres of action of the winter North Atlantic Oscillation (NAO) indicate that the MCA was characterized by a pervasive positive phase of the NAO(1). Spatial gradients across Europe in this MCA synoptic climatological interpretation were analyzed using the Proxy Surrogate Reconstruction approach based on general circulation model simulations. Changes in pervasive NAO phase result in synoptic shifts in surface pressure, wind fields and precipitation. It is hypothesized that these NAO changes are associated with oceanic responses/feedbacks including upwelling intensity and heat transport via the Atlantic Meridional Overturning Circulation (AMOC). Positive (negative) phases of the NAO are associated with enhanced (reduced) AMOC.

We review high quality palaeoceanographic data from the North Atlantic covering the last 1000 years to test this hypothesis. These data include proxies for sea surface temperature, bottom water temperature, sea ice cover, upwelling intensity and reconstructions of ocean hydrographic variability, including Gulf Stream outflow, North Atlantic Deep Water return flow and the position of the oceanic Polar Front. Palaeoceanographic data are consistent with the hypothesis that the MCA (Little Ice Age, LIA) was characterized by more (less) intense AMOC. However, there are multiple datasets, including the Na ion ice core proxy from the Greenland Ice Sheet(2), that indicate enhanced storminess across the North Atlantic during the LIA. These data conflict with the hypothesis in that enhanced winter storminess (cyclone frequency) should correspond to the NAO positive rather than negative phase. A possible explanation of this problem has been provided by ensemble simulations of the cyclone-resolving Climate Community System Model (CCSM) coupled ocean-atmosphere general circulation model for the Maunder Minimum (LIA)(3). These indicate major mid-latitude blocking anticyclones and reduced cyclone frequency constructions for the LIA consistent with NAO negative phase. But the intensity of cyclones during the LIA is found to be increased when anticyclones break down. The enhanced storminess during the LIA indicated by the ice core and coastal proxies and archival data may therefore be a product of more intense, rather than more frequent, storms during the LIA.

