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Atlantic Multidecadal Variability and the Atlantic Multidecadal Oscillation over the last millennium

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Atlantic Multidecadal Variability (AMV) impacts the climate around the North Atlantic and in many other parts of the world. There is an ongoing debate about the extent to which AMV is driven by external (e.g., solar, volcanic, and/or aerosol) forcing versus internal variability. We provide new evidence for persistent multidecadal temperature variability during a millennium-long (AD 800–2010) summer AMV reconstruction using a network of 46 annually-resolved terrestrial proxy records from the circum-North Atlantic region. The reconstruction was produced using nested principal component regression (assessed using a pseudo-proxy ensemble) and is relatively insensitive to methodological choices including pre-screening proxies, exclusion of hydroclimate-sensitive proxies, and different options for calibration and verification.

We find that both large volcanic eruptions and solar irradiation minima can induce cool phases of AMV and both forcings together explain approximately 30% of the variance of AMV (on timescales > 30 years). We define the Atlantic Multidecadal Oscillation (AMO) as the internally-generated component of AMV, and calculate it by empirically estimating and removing the variations that are linearly correlated with natural external forcings. The AMO reconstruction shows persistent multidecadal variability throughout the last millennium and suggests that internal variability makes the largest contribution to AMV.

The reconstructed AMV is significantly correlated with Northern Hemisphere (NH) temperature reconstructions, perhaps partly because both are responding to common external forcings. However, the reconstructed AMO (i.e. with an empirical estimate of the forced component removed) also shows coherence with an estimate of NH temperature internal variability (i.e. also with an empirical estimate of the forced signal removed) and this is the case even when NH temperature is reconstructed using only proxies that are independent of the 46 used for our AMV/AMO reconstruction. This supports a dynamical link between the AMO and NH temperature variability during the last millennium and suggests that the apparent influence of AMV on regional or hemispheric climate, in a long-term context, does not arise solely from common responses to external drivers.