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Evidence for external forcing of the Atlantic Multidecadal Oscillation since the termination of the Little Ice Age

Mads Faurschou Knudsen (1), Bo Holm Jacobsen (1), Marit-Solveig Seidenkrantz (1), and Jesper Olsen (2)

(1) Centre for Past Climate Studies, Department of Geoscience, Aarhus University, Denmark, (2) Department of Physics and Astronomy, Aarhus University, Denmark

Variations in North Atlantic sea-surface temperatures (SSTs) are particularly prominent on multidecadal timescales. These changes, which exert a strong influence on climate in the North Atlantic region, are dominated by the alternation between warm and cold SST anomalies on a timescale of 60-80 years, a phenomenon known as the Atlantic Multidecadal Oscillation (AMO).

The forcing mechanism pacing the AMO remains subject to considerable debate. One school of thought holds that the AMO is driven by internal ocean variability and related to multidecadal fluctuations in the Atlantic meridional overturning circulation (AMOC). In contrast, a recent model study concluded that the combined external forcing due to solar variability and volcanic eruptions has dictated the pace and phasing of the AMO over the past 600 years, as the combined solar and volcanic forcing is highly correlated to the AMO in the model with the forcing leading this AMO by $\sim$5 years. Identifying the relative roles of internal ocean variability and external forcing agents in driving multi-decadal SST variability in the North Atlantic is important, in particular because the AMO purportedly influence climate variables of key importance to society, such as precipitation and hurricane activity.

In the present study, we examine the relationship between the AMO and potential external forcing agents over the past 450 years based on statistical analyses of available high-resolution proxy data. The evidence suggests that external forcing played a dominant role in pacing the AMO after termination of the Little Ice Age (LIA; ca. 1400-1800), with an instantaneous impact on mid-latitude sea-surface temperatures that spread across the North Atlantic over the ensuing $\sim$5 years. In contrast, the role of external forcing was more ambiguous during the LIA. Our study further suggests that the Atlantic Meridional Overturning Circulation (AMOC) is important for linking external forcing with North Atlantic sea-surface temperatures, a conjecture that reconciles the two opposing theories concerning the origin of the AMO.