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Tracking the Atlantic Multidecadal Oscillation during the Holocene: internal ocean variability instead of solar forcing?

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Oceanographic observations and climate proxy data from tree rings show that sea-surface temperatures (SST) in the North Atlantic region fluctuated with a 60- to 80-year cyclicity over the past few centuries. These SST fluctuations appear not only to have played an important role for changes in Atlantic hurricane activity and drying of the Sahel region, but also for global-scale climate trends. The underlying mechanism that drives the Atlantic Multidecadal Oscillation (AMO) is, however, poorly understood, and so far it has been a matter of debate whether the AMO is a permanent feature of the climate system.

To address this problem, we compare spectral-density patterns found in some carefully selected Holocene climate-proxy records from the region bounding the North Atlantic Ocean. The climate records were selected based on their documented sensitivity to fluctuations in Atlantic SST and their high temporal resolution throughout most of the Holocene period. The analyses show that highly pronounced cyclicities with periods around 60 years were present during large parts of the Holocene in all the climate records. The new spectral density approach used in this study allows a clear distinction between e.g. ∼60, ∼70, and ∼80-yr cyclicities and the results clearly show that the ∼60-yr cyclicity completely dominated the 80-90-yr cyclicities in all the studied records. Significance levels of this distinction exceed 99% based on red-noise analyses. We interpret these results to indicate that a quasi-periodic AMO was active during large parts of the Holocene, and that a ∼60-yr cyclicity was the most dominant feature of this Holocene AMO signal. The dominant cyclicity in this frequency range of the solar-activity spectrum is the ∼88-yr Gleissberg cyclicity. Consequently, solar forcing does not seem to be directly responsible for the dominant ∼60-yr Holocene AMO pattern, which implies that the Holocene AMO pattern reflects internal, quasi-periodic variations in Atlantic Ocean circulation, as suggested by e.g. the Hadley Centre's HadCM3 model.