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Quasi-Decadal and Multidecadal North Atlantic Climate Variability and Predictability

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North Atlantic sea surface temperature (SST) varies on a number of time scales. While multidecadal SST variability is in the North Atlantic region most commonly found to originate from variability in the Atlantic Meridional Overturning Circulation (AMOC), the driver of North Atlantic SST variability on decadal and shorter timescales is still unknown. Moreover, the driving role of the AMOC in multidecadal North Atlantic SST variability was contested recently. Here, we disentangle oceanic and atmospheric drivers of SST variability on quasi-decadal and multidecadal time scales, and show implications for interannual-to-decadal climate predictability of North Atlantic SST.

Analysis of observations, reanalysis products, and a decadal prediction system based on the MPI-ESM-LR shows that on quasi-decadal time scales, an oscillatory signal from the North Atlantic Oscillation (NAO) controls SST variability directly via air-sea fluxes. This NAO-related signal also influences ocean circulation variability on decadal time scales. On multidecadal time scales, the relation between the NAO and SST variability changes: an approximately 20-year lag positive relationship between NAO and SST emerges that cannot be explained by direct action of air-sea fluxes. Instead, an AMOC-related mode of variability is likely to take over on this time scale, implying a more active role for the ocean in shaping North Atlantic SST variability on the multidecadal than on the quasi-decadal time scale.

Decadal hindcasts with the MPI-ESM-LR show different patterns of prediction skill for the quasi-decadal and multidecadal modes of North Atlantic SST variability. The NAO-driven quasi-decadal mode of SST variability exhibits significant hindcast skill for 1-3 years, much of which is connected to an integration of the heat flux forcing from the NAO in the upper ocean. However, the multidecadal mode of SST variability is significantly predictable for 10 years into the future and possibly further. This high prediction skill is related to low-frequency AMOC variability, highlighting the important role of AMOC variability for decadal SST predictability in the North Atlantic region.