Mechanisms of Atlantic Multidecadal Variability

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Atlantic Multidecadal Variability (AMV) has many important regional and global-scale climate impacts. Different mechanisms of AMV would have very different implications for future predictions of AMV-related climate impacts. Observational analyses reveal high coherence among subpolar North Atlantic sea surface temperature (SST), sea surface salinity (SSS), upper ocean heat and salt content, and the Atlantic Meridional Overturning Circulation (AMOC) fingerprint at low frequency. This key AMV feature cannot be explained as responses forced by atmospheric white noise, but are consistent with the ocean dynamics mechanism (e.g. low frequency AMOC variability). The correlation/regression between net surface heat flux and SST anomalies at low frequency have been identified as key indicators for the relative roles of oceanic vs. atmospheric forcing in SST anomalies, and they suggest that the oceanic forcing has a dominant role in the low frequency subpolar North Atlantic SST anomalies associated with AMV. The simulated linkages among AMOC, AMV, and associated climate impacts in CMIP5 models could be substantially hampered due to the underestimation of multidecadal AMOC variability. Some recent studies suggest that AMV is dominated by anthropogenic aerosols based on the similarity of the linearly detrended AMV index between observations and the externally forced response in some historical climate simulations. However, this similarity could be an artifact of linear detrending. Using the nonlinear detrending method with the signal associated with the global mean SST removed, the similarity disappears. This is because the simulated externally forced multidecadal SST signal is not unique to the Atlantic, but also appears in many other ocean basins and represents a global scale response to external forcings. On the other hand, the observed AMV is unique to the Atlantic and remains pronounced when the signal associated with the global mean SST is removed. Multivariate Empirical Orthogonal Function analysis has been applied to obtain a Multivariate AMV Index and reflect the observed multivariate nature of AMV. The simulated externally forced multivariate AMV in CMIP5 models disagrees strongly with that observed.

