Multidecadal Oscillation of the Atlantic Meridional Overturning Circulation in CMIP5 Models

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In this study, we use the method of multichannel singular spectrum analysis (MSSA) to objectively identify the leading oscillations of the Atlantic meridional overturning circulation (AMOC) in seven multi-century preindustrial control simulations in Phases 5 of the Coupled Model Intercomparison Project (CMIP5). Then, a phase composite technique is applied to analyze the cyclic features of the spatial-temporal patterns of the major ocean-atmosphere circulation associated with the identified AMOC oscillations.

The results show a quasi 30-year oscillation as a common feature in several models. Such oscillation is dominant in the simulation by the Geophysical Fluid Dynamics Laboratory Climate Model, version 3 (GFDL-CM3.0). In this model, the anomalous positive overturning first appears in high latitudes, following a strong North Atlantic Oscillation (NAO). Its center then enhances and migrates southward to near 40°N. The strengthened AMOC is associated with warm anomalies of the upper ocean heat content and sea surface temperature (SST) in the north and eastern flank of the subpolar gyre. The warm SST anomalies force the NAO to its negative phase and lead to the weakening of the AMOC. During the process, the wind forcing to the subpolar gyre seems to play a major role. The surface evaporation generally damps SST anomaly but enhances surface salinity anomaly. As a result, the latter becomes dominant in the high-latitude mixed layer.

We have also examined the effects of the North Atlantic mean climate on the AMOC oscillation in different models. It is found that the much longer period (around 70 years) of the AMOC oscillation in the Community Climate System Model, version 4.0 (CCSM4.0), in comparison with the prominent quasi 30-year oscillations in its previous version (CCSM3.0) and GFDL-CM3.0, may partly be due to the weaker mean meridional temperature gradient across the Gulf Stream extension in the former.