On the Evolution of AMOC Fingerprint in the North Atlantic

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The objective of this research is to investigate the evolution of the AMOC fingerprint, its connection with the meridional coherence of AMOC variability, and the implications for decadal predictability.

Recent results

It has been revealed previously that the AMOC anomaly associated with changes in the North Atlantic Deep Water (NADW) formation has meridional coherence in density space and propagates southward with an advection speed north of 34°N due to the existence of interior pathways of NADW in this region, resulting in a several-year time lead between subpolar and subtropical AMOC variations. In this study, we found that the several-year time lead between subpolar and subtropical AMOC variations is crucial for the evolution and the enhanced decadal predictability of the AMOC fingerprint – the leading mode of upper ocean heat content in extra-tropical North Atlantic. To investigate the evolution of the AMOC fingerprint, we conducted two sets of experiments using GFDL CM2.1. The first set of experiments includes an ensemble of 10-member control experiments and an ensemble of 10-member perturbed experiments. The ensemble of perturbed experiments is initialized with the same positive salinity anomaly in upper northern North Atlantic and Nordic Sea. The initial positive salinity perturbation induces a positive AMOC anomaly at northern high latitudes, which propagates with slow advection speed north of 34°N, and with fast coastal wave speed south of 34°N. The associated Atlantic meridional heat transport (MHT) anomaly propagates in the same way as the AMOC anomaly, resulting in a convergence/divergence of the Atlantic MHT in the subpolar/Gulf Stream region respectively, thus warming (higher upper ocean heat content) in the subpolar gyre (SPG) and cooling (lower upper ocean heat content) in the Gulf Stream region after several years. Hence this distinctive dipole pattern of upper ocean heat content, i.e. the AMOC fingerprint is predictable on decadal time scale. The analysis of the GFDL CM2.1 1000-year control simulation exhibits the same mechanism for the evolution of the AMOC fingerprint.

The second set of experiments is the same as the first set except that the deep branch of AMOC in the subpolar region are fixed with time in both control and perturbed experiments, so that the AMOC anomaly cannot propagates southward through this region. There is no AMOC fingerprint developed, thus no predictable signal in the SPG and Gulf Stream region in the second set of experiments. This is because without the southward propagation of the AMOC anomaly, there is no convergence/divergence of the Atlantic MHT anomaly. The results show that the initialized subpolar salinity anomaly is important for triggering the AMOC anomaly at northern high latitudes, but itself cannot directly lead to a predictable temperature signal in the SPG and Gulf Stream region without the southward propagation of the AMOC anomaly with the slow advection speed. Recently several decadal prediction studies successfully predict the observed warm shift in the SPG in mid 1990's, and it is found that initializing a positive AMOC anomaly at northern high latitudes is the key for successful predictions. Our results here provide the physical mechanism for the enhanced decadal prediction skills in subpolar North Atlantic ocean temperature.