Some Recent Applications of the Observed Extra-Tropical AMOC Fingerprint

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To reconstruct the past AMOC variations when no direct observations are available, as well as to evaluate the climate impacts of AMOC variability, it is very useful to develop fingerprints for AMOC variability that can be derived from both climate models and observations. This presentation will be focused on the observed extra-tropical AMOC fingerprint, which is defined as the leading mode of the subsurface ocean temperature variations in the extra-tropical North Atlantic. The observed extra-tropical AMOC fingerprint exhibits a dipole spatial pattern with opposite changes in the subpolar gyre and the Gulf Stream region, similar to that simulated in climate models. This presentation will include discussions of some recent applications of this observed AMOC fingerprint. At low frequency, both the observed and simulated normalized power spectra of subpolar North Atlantic SST/SSS closely resemble those of the AMOC fingerprint, and there is high coherence between the AMOC fingerprint and the subpolar North Atlantic SST/SSS and upper ocean heat/salt content, indicating the important role of the AMOC in the Atlantic multidecadal variability (AMV). Using both the observed and modeled AMOC fingerprints, it is found that the AMOC has an important impact on the observed multidecadal variability of Atlantic major hurricane frequency. The results also highlight the influence of the recent weakening of the AMOC (which is directly observed by the RAPID program and also inferred from the observed AMOC fingerprint) on the decline of Atlantic major hurricane frequency during 2005-2015. The observed North Atlantic sulfate aerosol optical depth has not increased (but shows a modest decline) over this period, suggesting that the decline of the Atlantic major hurricane frequency during 2005–2015 is not likely due to recent changes in anthropogenic sulfate aerosols. The reconstructed past AMOC variations, using both the observed AMOC fingerprint and the direct AMOC observations from the RAPID program, suggest that most CMIP5 models underestimate the amplitude of low-frequency AMOC variability. Models with relatively stronger (weaker) low-frequency AMOC variability have stronger (weaker) linkages between the AMOC and key variables associated with the AMV, and between the AMV and northern hemisphere surface air temperature. The Atlantic decadal predictability is much higher in models with relatively stronger low-frequency AMOC variability, and much lower in models without AMOC variability. The results suggest that simulating realistic low-frequency AMOC variability is crucial for simulating realistic linkages between AMOC and AMV and associated climate impacts, and for achieving substantially higher Atlantic decadal predictability.