A Generalized Stability Analysis of the AMOC in Earth System Models: Implication for Decadal Variability and Abrupt Climate Change

PI: A. Fedorov[1],
International Collaborators: F. Sevellec[2]
[1]Yale University, New Haven, CT
[2]National Oceanography Centre, Southampton, U.K.

The central goal of this project is to study the mechanisms that control the stability of the Atlantic Meridional Overturning Circulation (AMOC), including the mechanisms of abrupt climate change and its predictability, by means of a generalized stability analysis. An additional inherent component of the project is to evaluate AMOC variability and its climate impacts in the Coupled Model Intercomparison Project Phase 5 (CMIP5) dataset.

Recent results

Over the past year we have investigated how variations of the AMOC affect sea surface temperature (SST) within the simulations of CMIP5 (Muir and Fedorov 2014). In particular, we explore whether the SST response is interhemispheric in nature, specifically as reflected in the Atlantic SST dipole index, or whether the response is localized more in the North Atlantic Ocean. In the absence of direct observational data, this dipole index has been proposed to approximate AMOC variations over the duration of the instrumental temperature record.

We find that typically, on timescales between decadal and centennial, the SST dipole index correlates with the AMOC with coefficients ranging from 0.2 to 0.7, typically with a 0 to 6 year lag, and thus explains less than half of the AMOC variance. In just two models this value slightly exceeds 50%. Even for the models with the highest correspondence between the AMOC and the dipole index, the correlation between the two variables is controlled mainly by SST variations in the North Atlantic, not the South Atlantic, both for the model control and historical simulations. While the relationship between the AMOC and the North Atlantic SST is largely consistent across the models, the relationship of the AMOC and the South Hemisphere Atlantic SSTs temperatures shows little to no consistency, as seen for example from SST regression maps (Figure 1). Consequently, in nearly all models, the North Atlantic SST provides a better indicator of AMOC variations than the Atlantic dipole. Thus, on decadal to centennial timescales, AMOC variability affects mainly the North Atlantic Ocean, with the sensitivity of the North Atlantic SST between 40-60°N, given by the multi-model average, of about 0.3°C per 1 Sv of AMOC change, explaining roughly one third of the SST variance.

We discuss our results in the context of the connection between the AMOC and the Atlantic multidecadal variability (AMV). On one hand, our results support the notion that a significant albeit not too large a fraction of the AMV should be related to AMOC variations. In fact, we find that the region of the maximum SST response to AMOC simulated by the models, south of Iceland and Greenland and east of Canada, generally coincides with the region of the strongest AMV signal in the observations. However, finding a robust SST response of the Southern Atlantic to AMOC variation in the north on decadal to centennial timescales was not successful.

The main manuscripts are available online: http://earth.geology.yale.edu/~avf5/index.cgi?page-selection=4

Bibliography

Muir L., and A. V. Fedorov, 2014: How the AMOC affects ocean temperatures on decadal to centennial timescales: the North Atlantic versus an interhemispheric seesaw. *Climate Dynamics,* doi:10.1007/s00382-014-2443-7.