Signature of the Atlantic Meridional Overturning Circulation in the North Atlantic Dynamic Sea Level

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The objective of this project is to study how the Atlantic Meridional Overturning Circulation (AMOC) modifies sea level rise along the East Coast of the US and Canada, and how sea level rise patterns along this coast and in the North Atlantic can be used as an important fingerprint to detect AMOC variability and change. Recently, *in situ* observations of the AMOC reveal a 30% downturn of the AMOC during 2009-10. This event provides a valuable opportunity to study the climate impact of the AMOC, quantify the AMOC-sea level rise relationship, and test model simulation results.

Recent results

We have been focusing on the sea level signals of the 30% AMOC downturn (Goddard et al., 2015). We analyze the long-term tide gauge data along the East Coast of North America. To minimize the effect of local factors and reveal regionally coherent behavior, we calculate the time series of the sea level composite for the three sea level rise regimes: Northeast, Mid-Atlantic and Southeast. Based on the sea level composite, we identify an extreme sea level rise event during 2009-10 along the Northeast coast of North America. Within a two-year period, the coastal sea level north of New York City jumped by up to 128 mm. Despite significant year-to-year fluctuation, this magnitude of sea level rise is unprecedented (1-in-850 year event) during the entire history of the tide gauge records. We use various observational and modeling data, including those from high resolution models with an eddying ocean. We show that this extreme sea level rise event is a combined effect of two factors: an observed 30% downturn of the AMOC during 2009-10, and an onshore/alongshore wind stress anomaly associated with the significant negative North Atlantic Oscillation (NAO) index.

Significant findings

- Regression analysis indicates that for every 1 Sv of AMOC weakening, the coastal sea level north of New York City rises by 13-17 mm (Figure 1).
- Most of the state-of-the-art climate models show good correlation between the AMOC strength and the sea level rise along the Northeast coast of North America on the interannual time scale.
- The observational estimate of the AMOC-sea level rise relationship is comparable with the modeling results.
- The extreme nature of the 2009-10 sea level rise event suggests that such a significant downturn of the AMOC is very unusual.
- The negative NAO in 2010 contributed to the extreme sea level rise along the Northeast coast of North America, but is not the dominant mechanism.
- During the 21st century, most of the state-of-the-art climate models project an increase in magnitude and frequency of extreme sea level rise events on the interannual time scale along the densely populated Northeast coast of North America.

In addition, we have also contributed to the comprehensive and systematic analysis of the newly developed high-resolution models at GFDL (CM2.6 and CM2.5) (Griffies et al., 2014). The analysis foci include ocean heat transport, simulations of the AMOC and its response to future greenhouse-gas scenarios, and the sea level variability and change in the control and future projection runs.