Variability of the South Atlantic Meridional Overturning Circulation

PIs: F. W. Landerer, K. Bentel, C. Boening, and V. Zlotnicki
Jet Propulsion Laboratory / California Institute of Technology, Pasadena, CA

Project goal

The goal of this project is to determine the feasibility of measuring Atlantic Meridional Overturning Circulation (AMOC) variations from satellite gravimetry (GRACE) via monthly ocean bottom pressure (OBP) variations. The first phase of the project uses only synthetic data to study the sensitivity of the OBP-based AMOC reconstructions, and we've limited the analysis to the North Atlantic.

Challenge

The time variable gravity signals, associated with AMOC related bottom pressure variations, are relatively small and very close to (if not smaller than) the spatial resolution that GRACE can provide (about 300 km). The zonal bathymetry gradients are steep OBP variations and are difficult to resolve with GRACE.

Recent results

We used synthetic ocean bottom pressure data from ECCO2 and establish a baseline of bottom pressure inferred AMOC transports. We then combined the ocean model data with terrestrial hydrology (total land water storage), and evaluated the errors that are introduced to the AMOC reconstruction by using a GRACE-like resolution of the bottom pressure variations, as well as the contaminating effects of land hydrology on the OBP signals.

Not surprisingly, the AMOC 'reconstruction' from GRACE-like OBP variations is degraded relative to the baseline model resolution. A major challenge is the contamination of near coastal ocean bottom pressure signal with land hydrology variations (often much stronger than ocean signals). However, our synthetic results (at two GRACE-like OBP resolutions) indicate that, despite the challenges, transport estimates from GRACE derived OBP variations provide skillful estimates over some depth intervals at specific latitudes in the North Atlantic.

Specifically we found that:

- The reconstruction from ECCO2 data (0.25° grid) works well, yielding correlations between 0.53 and 0.95, with RMS errors of approximately 0.7 Sverdrup or less (compared to 'model-truth' transports);
- The AMOC anomaly detectability is slightly reduced when we use the coarser resolution of GRACE-like ocean bottom pressure observations, but the most significant error source is the OBP signal contamination from nearby land hydrology; and
- Nonetheless, monthly AMOC variations at some latitudes can be inferred from monthly OBP via satellite gravimetry observations.
- The AMOC estimate can be further improved if we apply 'leakage corrections' on the OBP fields near the coastlines. These corrections attempt to filter and differentiate between land and ocean signals to increase the OBP signal/noise ratio.

Next steps

We will use real GRACE observations to apply our method to infer AMOC variability from 2003 – 2014, and extend the analysis of both synthetic and real OBP data to the South Atlantic.