South Atlantic Meridional Overturning Circulation: Pathways and Modes of Variability

PIs: R. Perez[1,2], S. Garzoli[1,2], and R. Matano[3]
Collaborators: R. Msadek[4]
[1]University of Miami, Miami FL
[2]NOAA Atlantic Oceanographic and Meteorological Laboratory, Miami, FL
[3]Oregon State University, Corvallis, OR
[4]NOAA Geophysical Fluid Dynamics Laboratory, Princeton, NJ

The objective of this project, which began in September 2013, is to improve our understanding of the pathways of the upper and lower limbs of the Meridional Overturning Circulation (MOC) in the South Atlantic (SA). Our research is focused on the analysis of state-of-the-art eddy-permitting and eddy-resolving NOAA/GFDL climate model simulations, non-eddying CMIP and IPCC AR5 models including the NOAA/GFDL coarse resolution models, process-oriented numerical experiments using regional ocean models, and observations.

Recent results

During the first year of the project, we examined the fate of the Deep Western Boundary Current (DWBC) in the SA (Garzoli et al., 2014). In this study, historical and new observations including hydrographic sections, Argo data (Figure 1,) and chlorofluorocarbon measurements, are examined together with two different analyses of a global ocean-only numerical model to trace the pathway of the DWBC through the SA. When the very energetic, eddying DWBC reaches the Vitória-Trindade ridge (~20°S), the flow branches due to conservation of potential vorticity. Both observations and model experiments indicate that the main portion of the flow continues along the continental shelf of South America in the form of a strong reformed DWBC, while a smaller portion, about 20%, is advected towards the interior of the basin. It is hypothesized that this eastward motion results from eddy thickness flux divergence due to overlying Agulhas Ring decay and enhanced mixing caused by the energetic eddy field at the Vitória-Trindade ridge.

We have also developed a nested model of the SA circulation using the Agrif version of the Regional Ocean Modeling System (Combes and Matano,\ 2014). In this model setup, a high-resolution “child” model (1/12°) is embedded into a coarser resolution “parent” model (1/4°). In addition to the model development during the first year of the project, we completed two numerical simulations. The first simulation, which is the benchmark, was spun-up for 20-years and run in a diagnostic mode for another 20-years. This experiment will be used to investigate the sensitivity of the SA circulation (surface, intermediate, and deep) to changes in the model configuration (e.g., bottom topography, wind stress forcing, mixing parameterization). Preliminary assessment of slightly modified version of this model shows good agreement with observations (Combes and Matano 2014; Guerrero et al., 2014; Matano et al., 2014). To determine the pathways of the main water masses in the SA, we released passive tracers at different density levels of the model. For example, we released tracers at the Agulhas Retroflection region to show the pathways of the Indian Ocean waters in the SA. Many of the Agulhas eddies persist throughout the basin and can be tracked until they impinge on the eastern boundary of South America and, on occasion, to the Brazil/Malvinas Confluence.

Lastly, using observations and simulations by the NOAA/GFDL CM2.5 high-resolution, eddy-permitting, coupled climate model and an ocean-only (CORE forced) version of the same model, we analyzed the sensitivity of the seasonal cycle of the maximum northward volume transport by the MOC to wind forcing at the latitudes of the RAPID/MOCHA array (nominally 26.5°N) and the developing SAMBA array (nominally