Investigating Variations in Deep SAMOC Properties: First Steps

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I. Introduction

The South Atlantic Ocean is a crossroads. Influenced by Southern Ocean inflow from both the east and the west, it is a place where deep and bottom water masses formed in northern and southern hemispheres meet. Here, Antarctic Bottom Waters (AABW), North Atlantic Deep Waters (NADW) and Antarctic Intermediate Waters (AAIW) are transformed through mixing, upwelling and subduction in this region where geography subdivides basins, both supporting and inhibiting abyssal inflow and maintaining regional asymmetries in diapycnal mixing. Also intriguing is the recognition that these water masses appear to be evolving in time in their formation regions.

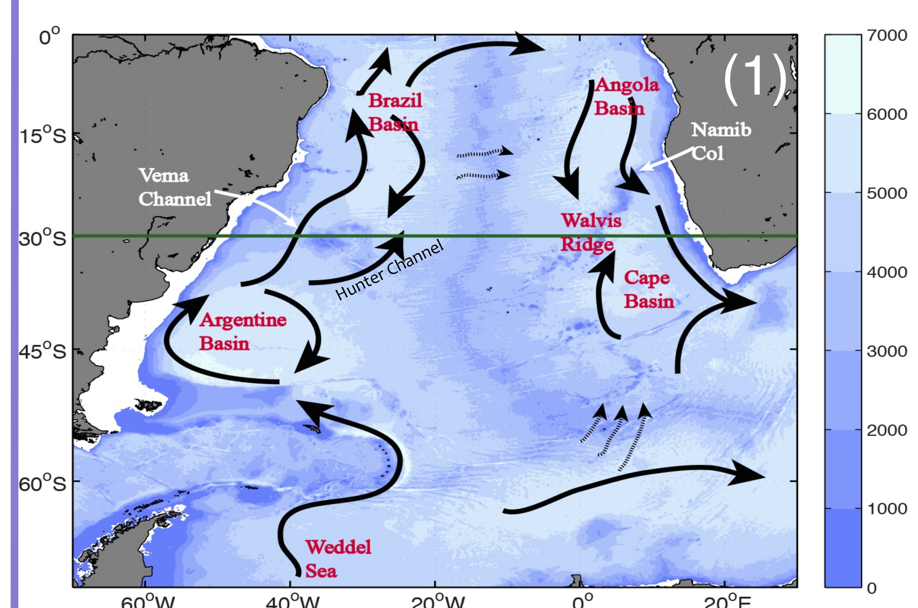

Figure 1: Schematic illustration of bottom water pathways through the numerous bathymetric features that define the South Atlantic. All arrows are schematic only. Dashed arrows represent possible passage through gaps and fractures, not specific pathways. Reference line shown at ~30°S.

II. Goals

Our NOAA/CVP AMOC study encompasses 3 interrelated aspects of the subsurface South Atlantic to shed light on:

a) regional (sub-basin) **properties distributions** and their associated carbon, oxygen, nutrient, freshwater & heat budgets;

b) **pathways and spatial transformation** of deep waters through overturn and mixing; and

c) the **temporal evolution** in overturning pathways and properties from the 1990s to present-day.

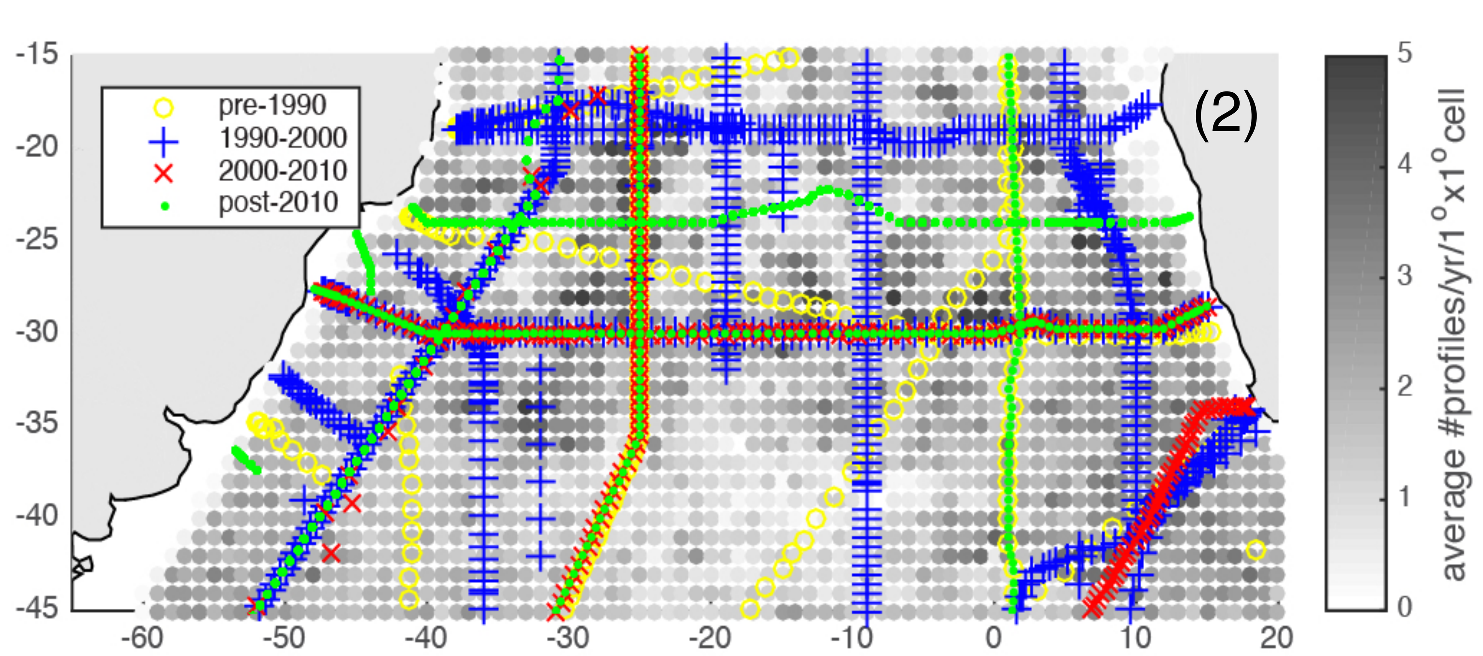

Figure 2 Gray shading - average number of Argo profiles per 1°x1° cell between 1997-2015. Overlaid with repeat long transect data (pre-1990 through 2005) from qc'd GLODAP/CARINA databases (courtesy of B. Carter) and select later GO-SHIP transects from CCHDO (http://cchdo.ucsd.edu/). Colors indicate 10-year bins.

III. Data

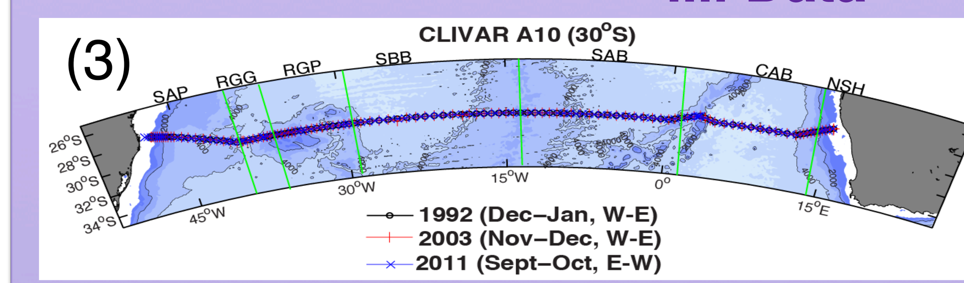

Figure 3: The A10 cruise tracks for 1992, 2003, & 2011 along 30°S overlaid on Smith and Sandwell (1997) bathymetry. Green vertical lines divide the regional boundaries used in this study. See region acronym definitions in Figure (4).

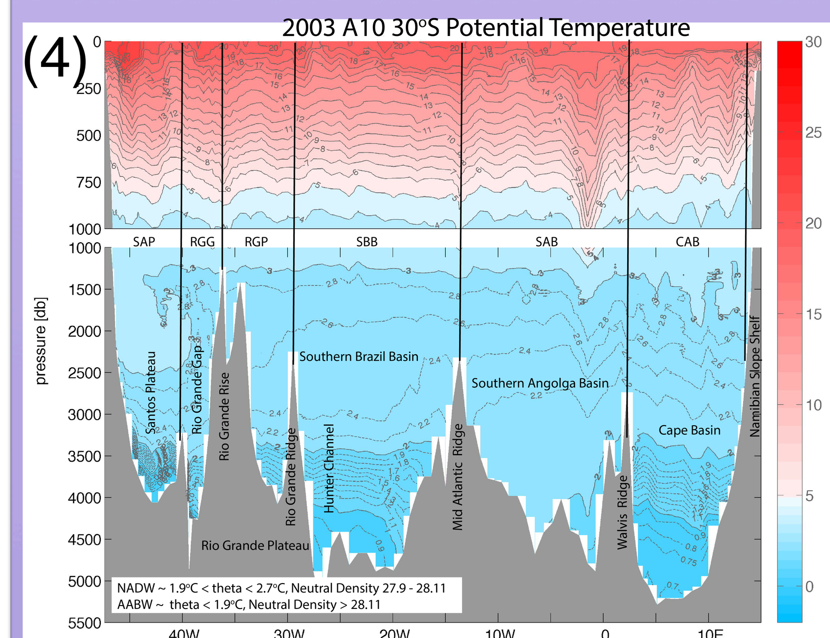

Figure 4: 2003 A10 30°S potential temperature. Vertical lines divide regions to be used in the study and acronyms are defined. The 30°S Rio Grande Gap and Hunter Channel are the main paths for AABW northward, as other routes are cut of by bathymetry.

IV. Methods (A)

We focus on these subsurface waters where they pass through the subtropics between 30°S and 24°S, but include in our study many of the multiple repeat transects occupied by the WOCE, CLIVAR and GO-SHIP programs, and will enhance temporal resolution in the upper water with Argo float profiles (Figure 2) using the Desbruyères et al. (2016) technique. Beginning with the 3 occupations of A10 at 30°S (Figures 3-4) we will grid, smooth and difference fields in both pressure and density space to obtain a broad view of potential changes (Figure 5).

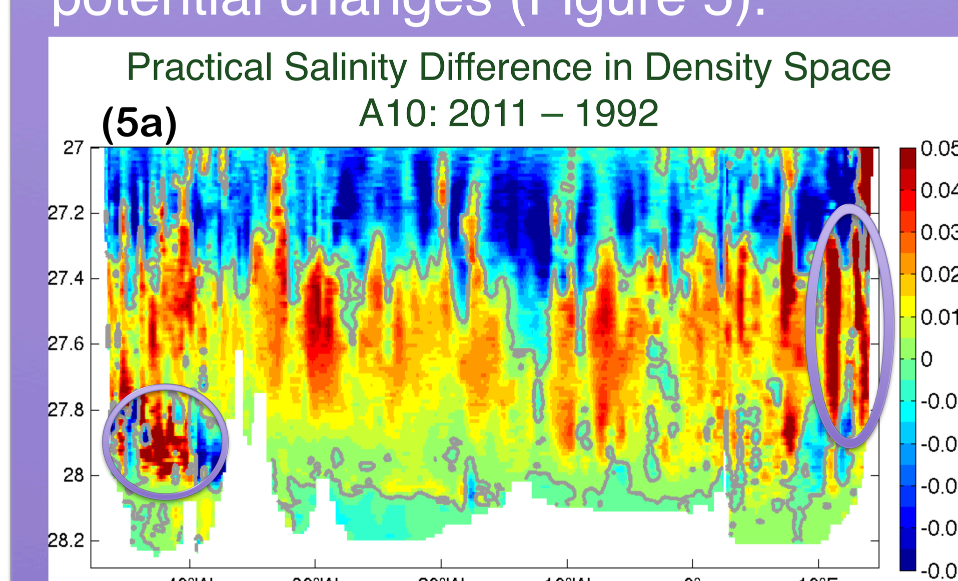

Figure 5a: A10 practical salinity differences in density space suggesting freshening of waters with $\gamma^n < \sim 27.4$ (AAIW) and increasing salinity in waters with $\gamma^n < \sim 28.0$, (NADW). Note the strong increase seen both in the west and near the Namibian Shelf. (circled).

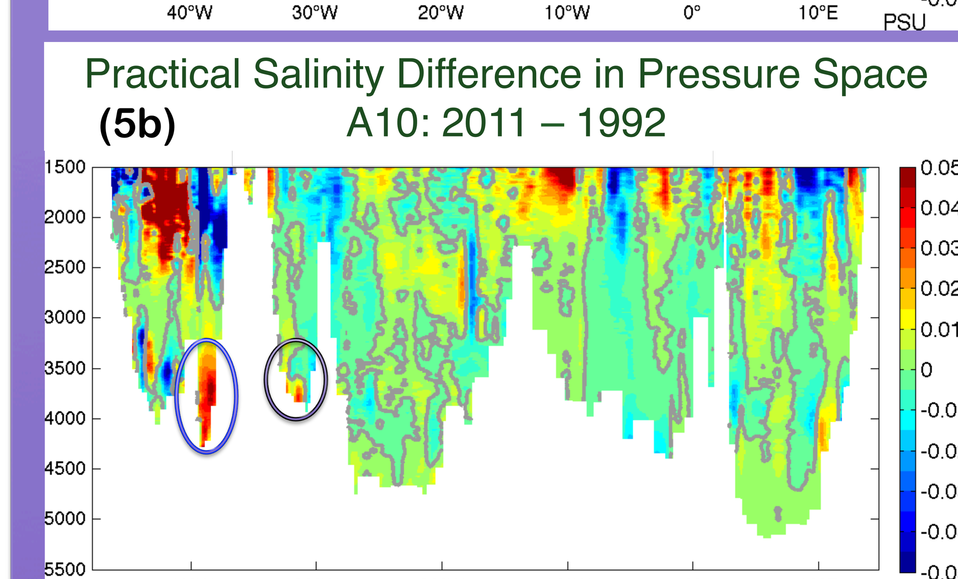

Figure 5b: A10 practical salinity differences in pressure space highlight the salinification (and warming – not shown) over the last two decades of RGG AABW (blue oval). Interestingly the same is true of non-through flow bottom waters in the RGP region (black oval).

IV. Methods (B)

b) We will apply the differencing techniques of Purkey and Johnson (2013) not only to temperature and salinity, but also carbon, oxygen and, if feasible, nutrients. This analysis will be compared to an analysis of variance (ANOVA) intended to separate the spatial variability in the water mass characteristics associated with each regions from remaining variability, which is assumed to be temporal (e.g. Figure 6).

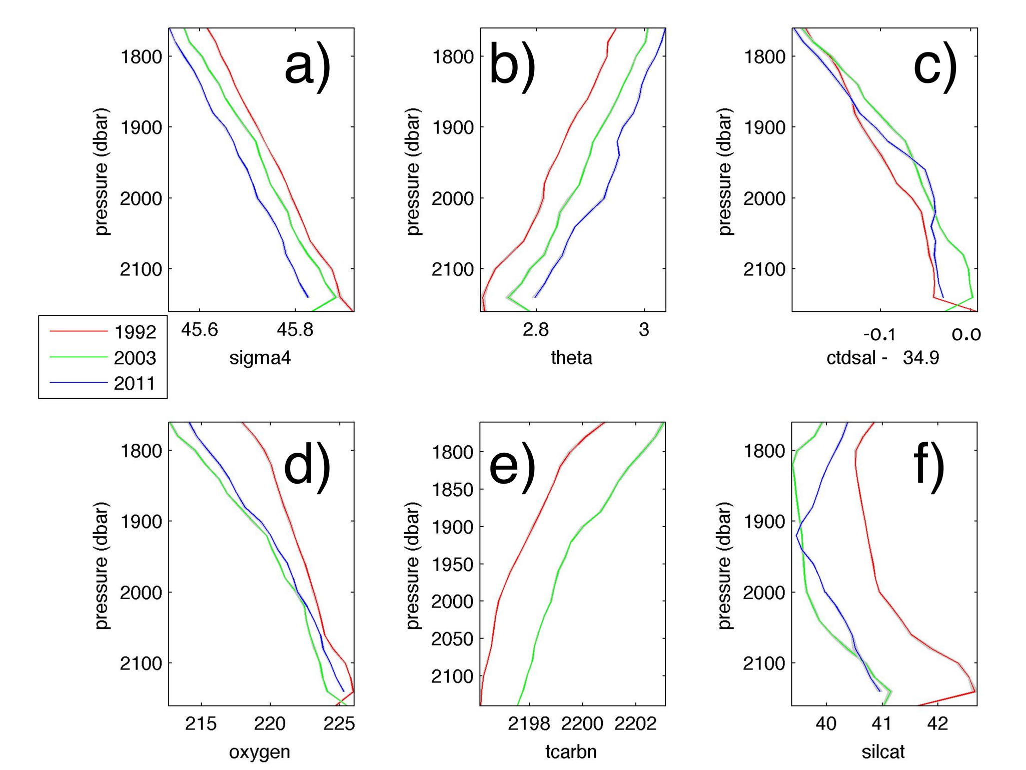

Figure 6: Example of preliminary ANOVA results for NADW in NSH indicating that in pressure space there has been an overall decrease in density (a) resulting from the increase in temperature (b) that has only partially been offset by the increasing salinity (C), as well as a significant decrease in oxygen (d) and nutrients (f) between 1992 and 2003 and little significant change between 2003 and 2011, and an increase in TIC in the first decade (e). The TIC numbers for the second decade have yet to be analyzed.

We will compare to similar analyses that have been performed at 24°S (e.g. McCarthy et al., 2011). The effect E/W geography at 24°S compared to the multiple basins at 30°S is of interest.

V. Next

Combining this analysis with estimates of associated velocity fields we seek to answer the question: How do circulation (collaboration with A. Hernandez-Guerra), mixing (collaboration with T. Capuano) and gyre changes affect the temporal property changes and spatial differences observed in the subtropical S. Atlantic (30°-24°S)?

With quantitative estimates of observed changes in this region, we will then apply the same techniques to three numerical models with similar physics and differing resolution to answer the question: Is resolution the driving factor in discrepancies between the observed and modeled spatial and temporal differences?

References

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