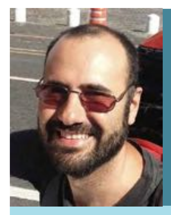

Water mass structure and flow pathways in the southwest South Atlantic

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1. INTRODUCTION

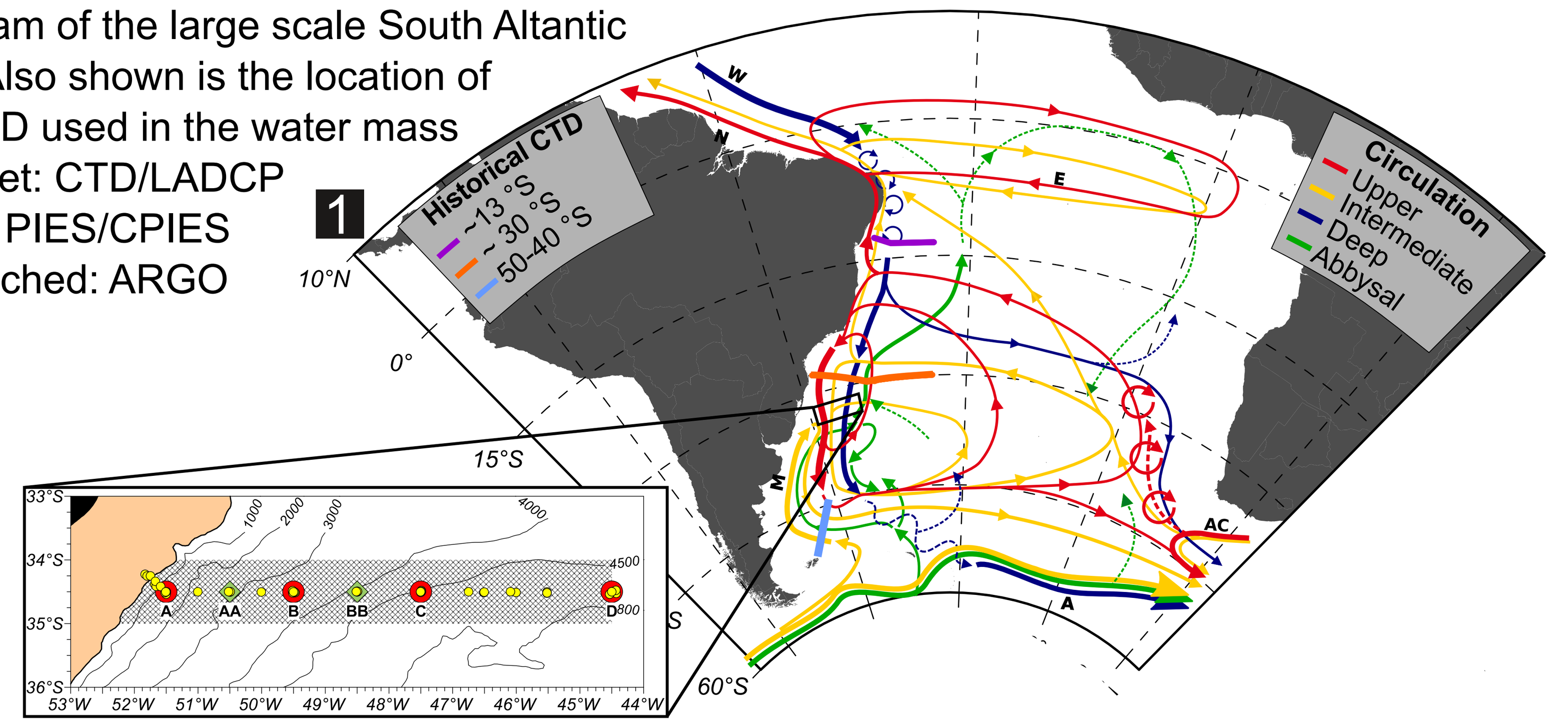
The South Atlantic actively participates in the mixing, transformation and redistribution of water masses formed around the globe, significantly influencing the structure of the Atlantic Meridional Overturning Circulation (AMOC). We report CTD/LADCP sections extending 650 km from the South Atlantic western boundary as part of the South Atlantic MOC Basin-Wide Array (SAMBA) monitoring system at 34.5°S. The "SAMBA-W line", as we call it, has been regularly occupied since 2009. We analyze this unprecedented high-quality data set to establish the hydrographic conditions of the northwestern Argentine Basin and the likely pathways of the major water masses flowing through the region.

Data

- ✓ 10 hydrographic CTD sections occupied along 34.5°S between 2009 and 2018 (**Inset Fig. 1**)
- ✓ 7 Lowered-ADCP (LADCP) sections occupied along 34.5°S between 2011 and 2018 (**Inset Fig. 1**)
- ✓ Historical CTD data at different latitudes along the eastern margin of South America (**Fig. 1**)
- ✓ Delayed mode Argo profiles collected during 2003 and 2016 within the region bounded by 34°S, 35°S, 44.5°W and the shelf break (**Inset Fig. 1**)

2. REGIONAL CIRCULATION & HYDROGRAPHY

Fig.1. Diagram of the large scale South Atlantic circulation. Also shown is the location of historical CTD used in the water mass analysis. Inset: CTD/LADCP stations and PIES/CPIES location. Hatched: ARGO profiles.



The potential temperature (θ, **Fig. 2a**), salinity (S, **Fig. 2b**) and dissolved oxygen (O_2, **Fig. 2c**) are used to determine the water mass structure at SAMBA-W. The repeated hydrographic sections capture an extremely rich vertical structure, characterized by seven distinct water mass layers of northern and southern origin, each with unique property signatures. For example, AAIW and NADW are characterized by S and O2 extrema (2b); UCDW and LCDW are primarily determined by their O2 minima, near 1500 and 3500 m (2c). Almost all of these layers exhibit a sharp zonally banded structure, which is indicative of ubiquitous recirculation cells offshore from the western boundary.

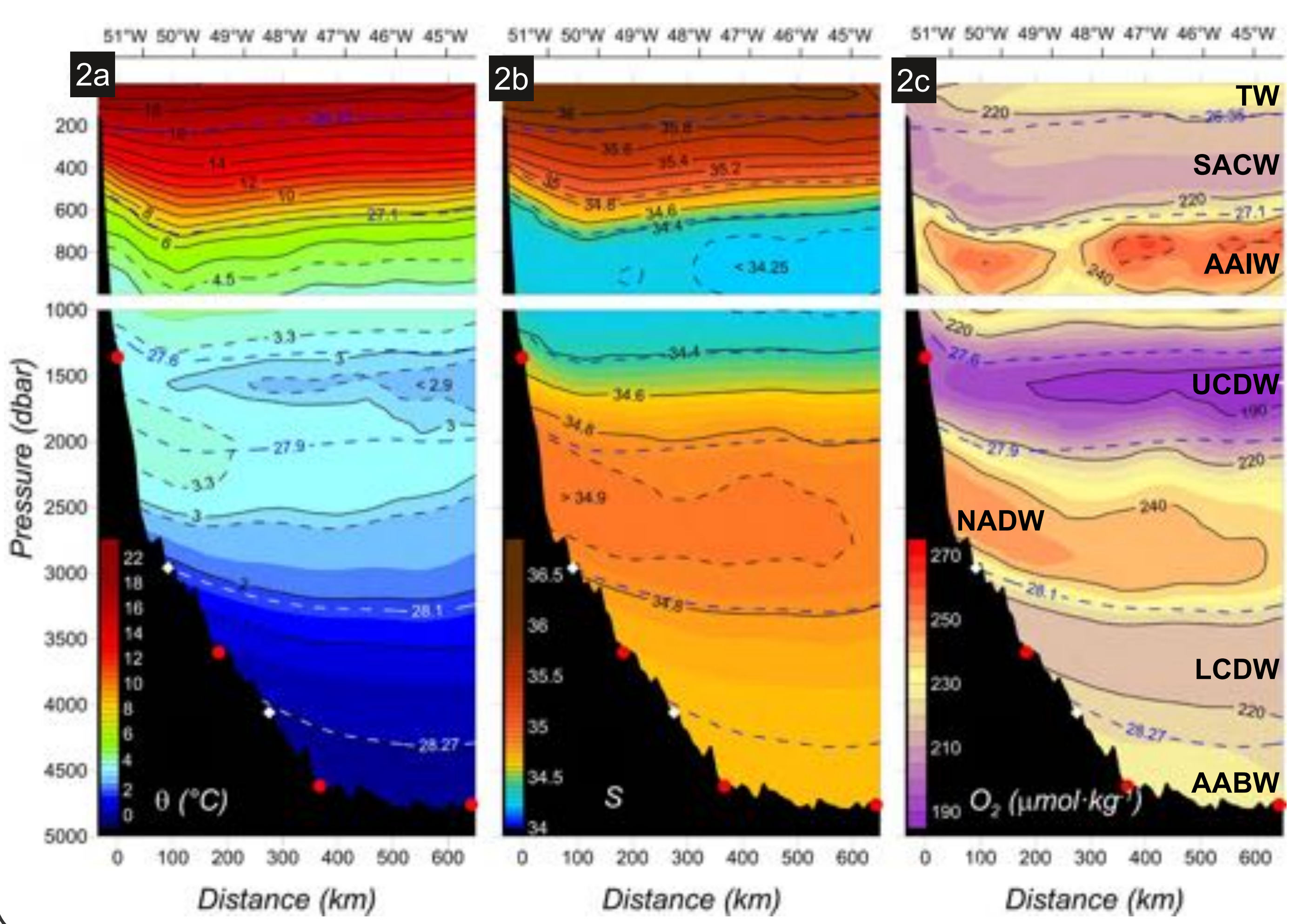
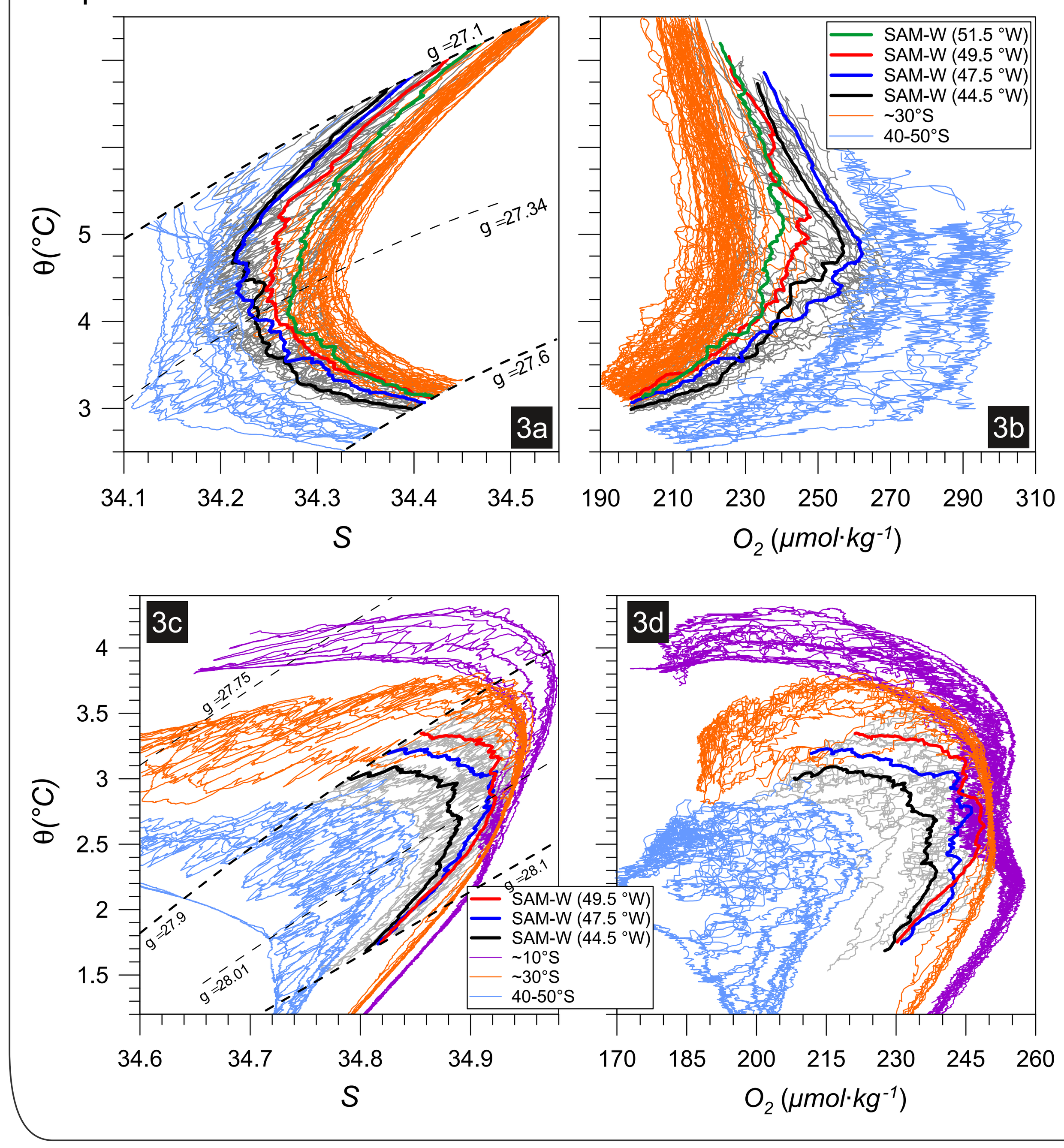


Fig. 2: Average sections of potential temperature (θ), salinity (S), and dissolved oxygen concentration (O_2) at the SAMBA-W line using CTD profiles collected between 2009 and 2012 and all available Argo profiles in the region. The dashed lines indicate the averaged γ surfaces used to delimit the water masses, which are indicated in (**3c**). TW: Tropical Water; SACW: South Atlantic Central Water; AAIW: Antarctic Intermediate Water; UCDW: Upper Circumpolar Deep Water; NADW: North Atlantic Deep Water; LCDW: Lower Circumpolar Deep Water; AABW: Antarctic Bottom Water.

3. WATER MASS PROPERTIES

The vertical and zonal structure of θ, S and O_2 are analyzed in a regional context to infer the flow and recirculation patterns in the vicinity of the SAMBA-W line. The averaged properties at four longitude along the SAMBA-W line are compared with historical data collected south an north of this latitude. The main results for the AAIW and the NADW are shown as an example. The most pristine varieties of AAIW (S<34.25, O_2>250 μmol·l^{-1}) at SAMBA-W resemble those observed over the slope near 45° S within the core of the Malvinas Current (cyan profiles in **Fig 3a** and **3b**). Elements of recirculated AAIW (S>34.3, O_2<240 μmol·l-1) are also observed at 34.5°S. These waters have admixtures with saltier, less oxygenated waters from the subtropical gyre, similar to the AAIW observed at ~30°S (orange profiles in 3a and 3b) and therefore must be advected from north of SAMBA-W. A similar analysis can be conducted at the deep levels. As it spreads southwards from its source, the NADW becomes colder, fresher, and less oxygen-ated. At SAMBA-W, recently ventilated NADW is found near the slope whereas significantly older, eroded varieties are found farther offshore (Fig. **3c** and **3d**)

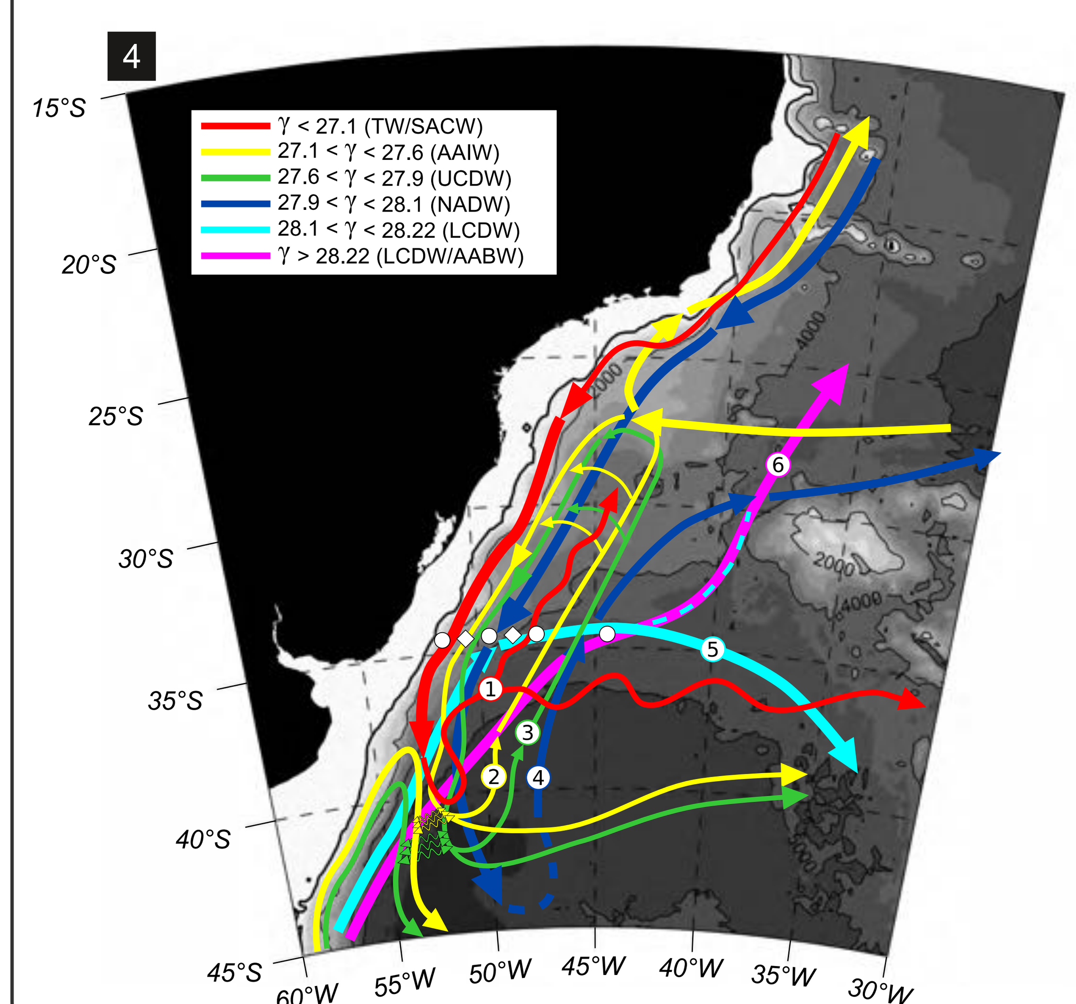


4. WATER MASS PATHWAYS

Upper level (1) Southward flow with the Brazil Current close to the continental slope, mixing with waters of subantarctic origin at the Brazil-Malvinas front, and a northward recirculation across the SAMBA-W line east of ~49.5°W.

Intermediate (2) (3) The properties of the intermediate level waters at SAMBA-W suggest a previously undetected recirculation cell in which a portion of the recently formed AAIW/UCDW flows northward along the western boundary and located about 400-600 km east of the slope.

Deep (4) The difference between the more recently formed NADW observed close to the continental slope and the eroded varieties located farther offshore indicates the presence of a DWBC flowing parallel to the continental slope across the SAMBA-W line and a offshore northward recirculation located offshore.



Abyssal (5) The upper portion of the LCDW flows northward across SAMBA-W and is almost absent north of this latitude. As a result, a well-defined deep front separates the NADW to the north from the LCDW to the south, therefore suggesting that the major part of LCDW veers eastward aftercolliding with the southward flowing NADW.

Abyssal (6) Denser LCDW and AABW are observed at 27°S and 13°S with overall similarity to that observed at 34.5°S, thus indicating that the waters within this density range that cross the SAMBA-W are not blocked by the NADW.

5. VELOCITY OBSERVATIONS

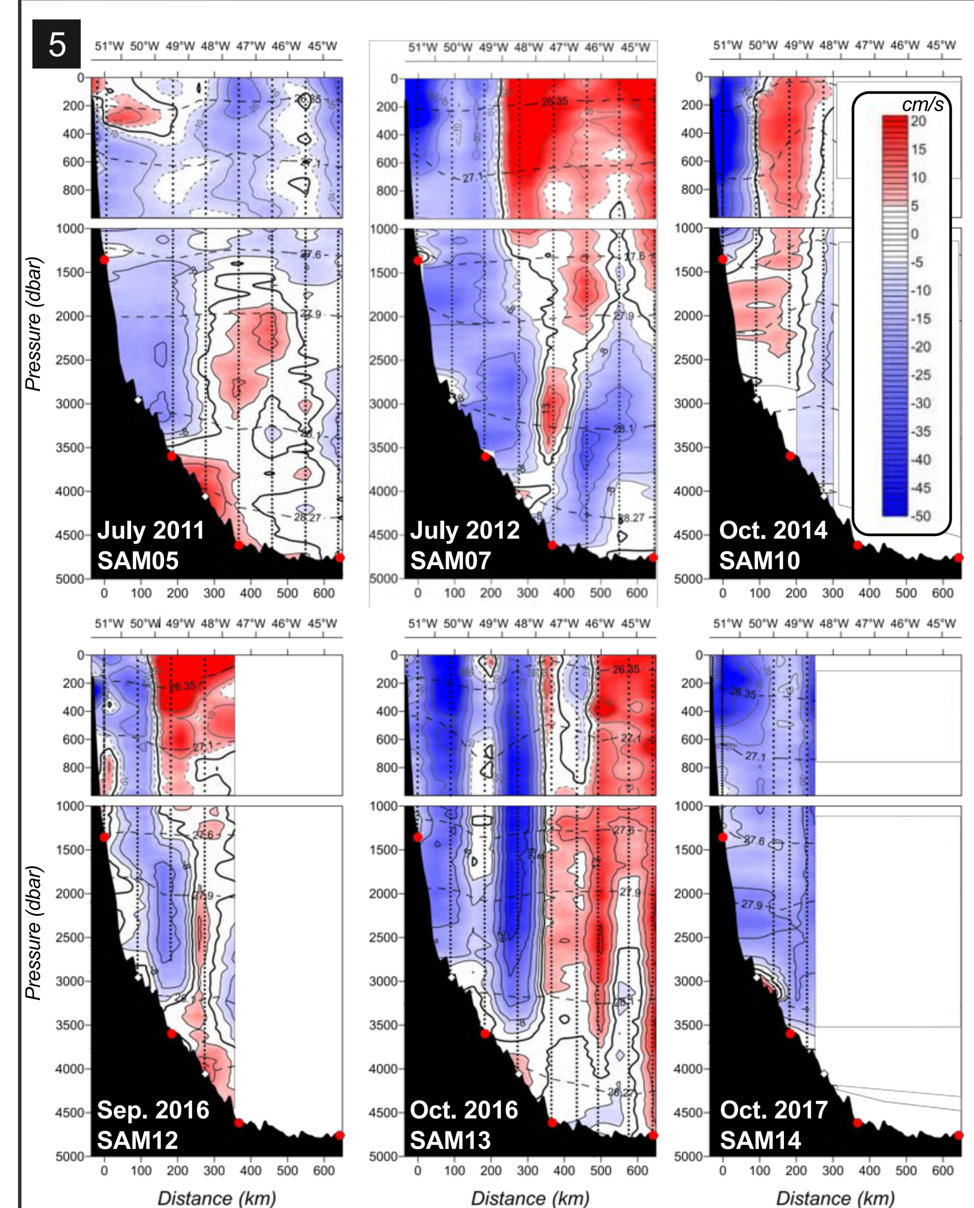


Fig. 5: Direct velocity measurements collected using a Lowered Acoustic Doppler Current Profiler (LADCP) during our last seven cruises at SAMBA-W. Only the alongshore component of the velocity (43.5°T) is shown for each section.

Direct velocity measurements from seven full-depth LADCP sections corroborate the proposed pathways. A mean southeastward flow is observed throughout the water column west of ~ 48 °W with stronger velocities (> 30 cm/s) associated with the Brazil Current confined to the upper 500 m, while a somewhat weaker mean flow (typically 5-10 cm/s) in the northeastward direction is observed farther offshore. This observations are in good agreement with multi-year time series velocity observations inferred from pressure-equipped inverted echo sounders deployed at the same latitude shown in previous studies (e.g., Meinen et. al (2017), JGR: Oceans, DOI : 10.5194/os-13-175-2017)

Summary / Take Home Message

- ✓ *The water masses at SAMBA-W at the upper, intermediate and deep levels present a well defined zonal structure characterized by primary types close to the slope and subvarieties farther offshore*
- ✓ *Previously undetected recirculation cells are observed at the intermediate and deep levels*
- ✓ *This recirculations may have an important role in the meridional volume transport associated with the South Atlantic MOC, for example, by modifying the western boundary density field in the upper and intermediate levels.*
- ✓ *Their role on the western boundary net volume, fresh water and heat transport is being investigated by combining historical CTD/ LADCP/VMADCP data with observations from moored instruments.*

For additional details, please see the following paper:

Valla, D., Piola, A. R., Meinen, C. S., & Campos, E. (2018). Strong mixing and recirculation in the northwestern Argentine Basin. Journal of Geophysical Research: Oceans, 123. https://doi.org/10.1029/2018JC013907

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