PL14A-2603 - Pacific/Circumpolar and North Atlantic Deep Waters in the Argentine Basin: Lateral Stirring within the AMOC

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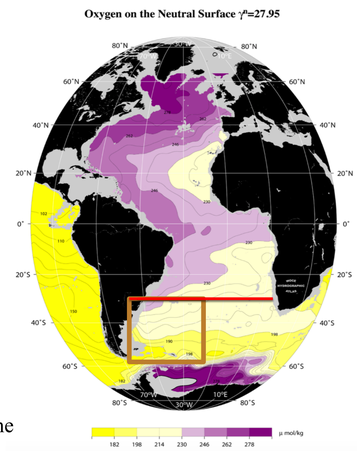
Abstract

The meridional overturning circulation (MOC) in the South Atlantic is usually characterized in terms of southward transport of North Atlantic Deep Water (NADW) and northward transport of Antarctic Bottom Water and Antarctic Intermediate Water/thermocline water. However, throughout the Deep Water depth/density range there is horizontal circulation of multiple water masses that interleave and mix. In the Argentine Basin, high oxygen, warm, saline NADW is modified by lateral mixing with low oxygen, cool, fresh Upper Circumpolar Deep Water (UCDW) that is dominated by Pacific Deep Water (PDW) entering from Drake Passage, which can be observed with Southern Ocean Carbon and Climate Observation and Modeling (SOCCOM) biogeochemical Argo floats. Two floats in the northern Argentine Basin have recorded anomalously low oxygen in the UCDW's oxygen minimum. One anomaly (33°S) averaged 15 micromol/kg lower than all other profiles from the same float (potential density range 27.5-27.7 kg/m3), while the other (39°S) averaged 25 micromol/kg lower than nearby profiles. Associated temperature/salinity anomalies were ~ 0.3°C and 0.05 psu lower on isopycnals than surrounding waters. Argo trajectory analysis suggests the source of Argentine Basin waters in this potential density range is mostly southeast Pacific waters, flowing through the Drake Passage. Therefore the anomalies are likely isolated eddies of nearly unadulterated PDW injected into the subtropical gyre at the Malvinas/Brazil Current confluence. T/S anomalies in this density range in the Argo data base in the Argentine Basin and T/S/O2 anomalies in the GLODAPv2 hydrographic data are investigated to show the historic distribution of anomalies and evidence of direct stirring. Mean circulation analyses (e.g. Reid, Progress in Oceanography 1994; Stramma and England, JGRO 1999) suggest a circuitous anticyclonic route for UCDW to the northern Argentine Basin, but these anomalies indicate a partial shortcut via eddies.

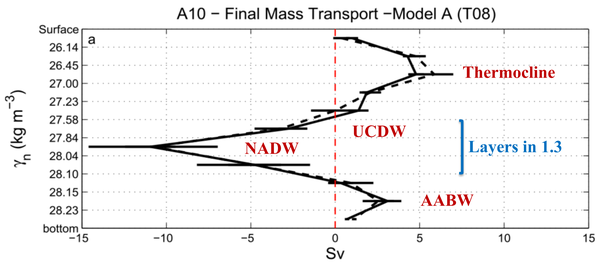
SAMOC and the Argentine Basin



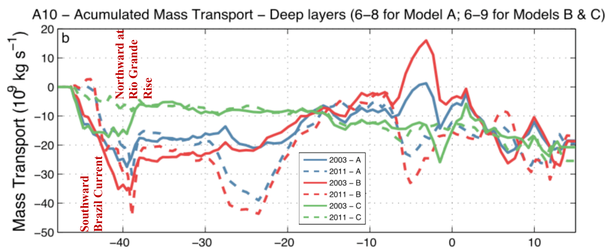
[Fig 1.1]: Oxygen at neutral density of 27.95

- NADW isopycnal
- Depth approximately 1700-2000m
- NADW: high oxygen (purple)
- CDW: low oxygen (yellow)

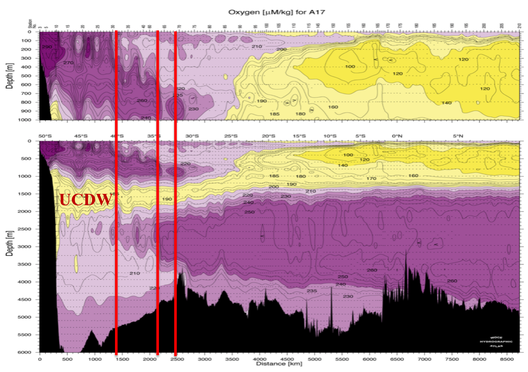
- South Atlantic Meridional Overturning Circulation (SAMOC)
- Net mass transport in Deep Water is Southward, due to NADW.
- Southward Brazil current
- Northward at Rio Grande Rise in Argentine Basin



[Fig 1.2] Mass transport across 30S, integrated zonally and in isopycnal layers. Hernandez-Guerra et al. (2019)



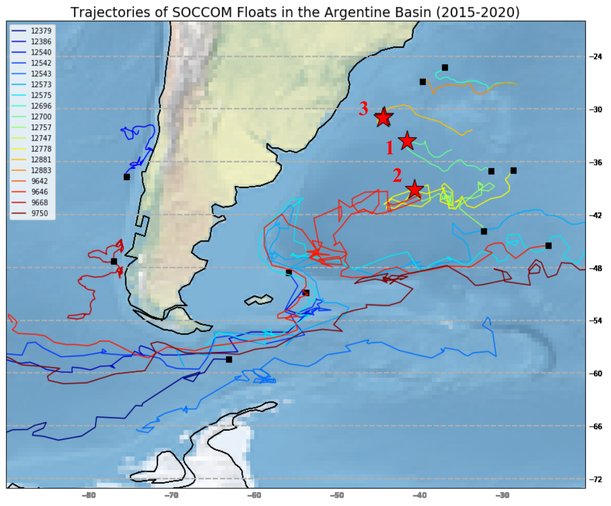
[Fig 1.3] Horizontal structure of Deep Water integrated transport at 30S from 3 inverse models, in 2003 and 2011.



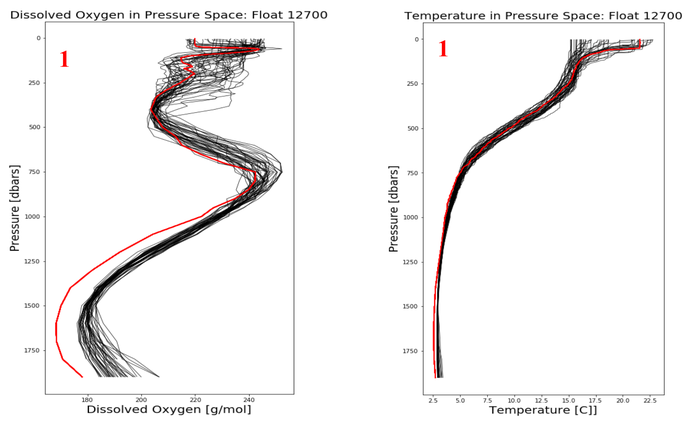
[Fig 1.4]: Section of dissolved oxygen taken along the west coast of South America (Koltermann et al., 2011). It shows a layer of Circumpolar Deep Water (light yellow signaling low oxygen) where our anomalies were found. Locations of anomalous profiles marked in red

Oxygen Anomalies Below 1000m

[Fig 2.1] SOCCOM BGC Argo float trajectories.
★: anomalously low oxygen profiles
■: last profile for each float



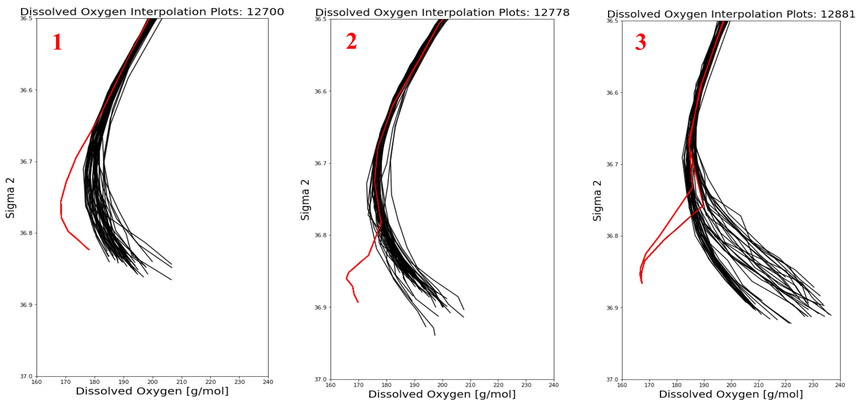
- 5 SOCCOM floats deployed in Argentine Basin in October 2018 from RV Discovery (UK) (AMT28)
- Three floats recorded anomalously low dissolved oxygen below 1000 m in the UCDW layer (oxygen minimum)
- Anomalous profiles found in 12700 (5905983), 12881 (5905982), and 12778 (5905985)



[Fig 2.2 a, b] Dissolved oxygen and temperature profiles of float 12700 with anomalous profile marked in red

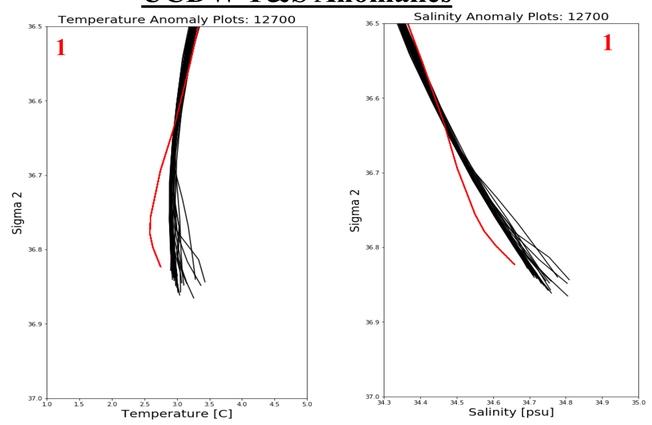
- Oxygen anomalies of 10 micromole/kg
- Deeper than 1400m
- Sigma 2 36.65 - 36.88 kg/m^3

- Temperature anomalies of 0.1C
- Salinity anomalies of 0.05 psu



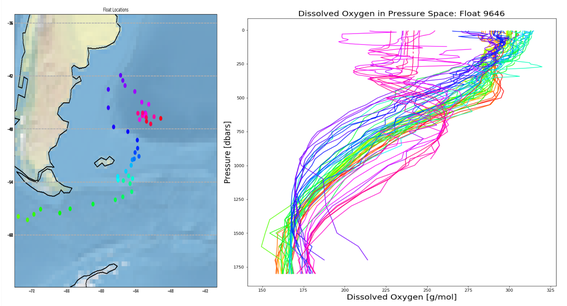
[Fig 2.3a, b, c] Dissolved oxygen profiles of SOCCOM floats vs sigma2

UCDW T&S Anomalies



[Fig 3.1a, b] Salinity and temperature profiles of float 12700 with anomalous profile marked in red

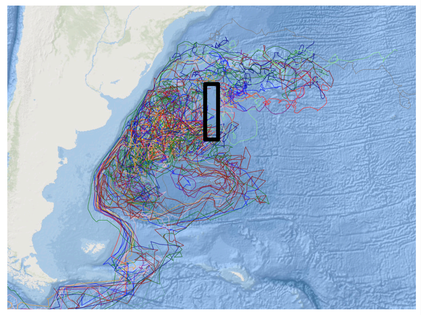
UCDW Source of Anomalies



[Fig 4.1a,b] Oxygen profiles on SOCCOM float originating from Drake Passage. Float 9646 [5904661]

- Source of low oxygen UCDW is Drake Passage
- This UCDW originates as Pacific Deep Water (PDW)

[Fig 4.2] Reverse trajectories of all Argo floats that arrive in the area of the anomalies. Argo floats park at 1000m: representing the 1000m flow field.



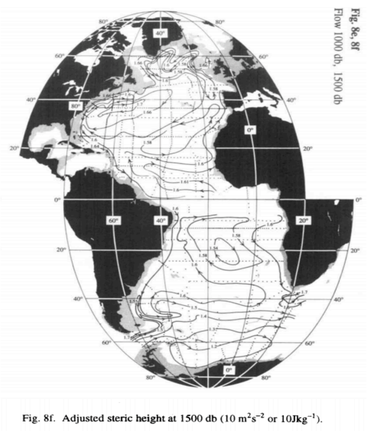
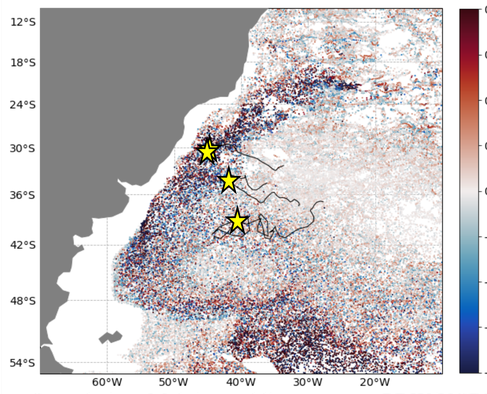


Fig. 8f. Adjusted steric height at 1500 db ($10 m^2 s^{-2}$ or $10 J kg^{-1}$).

[Fig 4.3] Circulation of Pacific Ocean at 1500 db. (Reid, 1994)

- Reverse trajectory analysis along with isopycnal analysis showed that the only viable source water would be from the South Pacific through Drake Passage
- The float oxygen anomalies suggest that relatively unmodified PDW can be transported to the Argentine Basin via subsurface eddies, a partial shortcut to the circuitous path suggested from mean circulation analysis (Reid, 1994).

Argentine Basin Temperature Anomalies: Eddy Field



[Fig 5.1] Temperature anomalies from a 1° bin average on sigma2 = 36.8 using all Argo floats

- ☆ = anomalous profiles
- Use T and S to increase information about UCDW influence
- Purer UCDW is low oxygen, cold ($\Delta T < -0.1$ ° C) , and fresh ($\Delta S < -0.05$ psu) on isopycnals
- Blue anomalies = purer UCDW

- Speculation: Malvinas eddies transport PDW/UCDW into Argentine Basin, through a northward DWBC

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