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# Why the South Atlantic?

While the North Atlantic is the sole provider of North Atlantic Deep Water (NADW) to the global ocean.....



.... the South Atlantic is also the sole recipient for upper and bottom waters flowing into the North Atlantic to balance the NADW export. Export of NADW to other ocean basins is compensated for by net northward flow through the South Atlantic and across the equator of surface, intermediate and bottom water layers.

## The compensating meridional flows



From Garzoli and Baringer, 2007, adapted from Stramma & England 1999

#### **Results from OCCAM** (Donners and Drijfhout 2003)

Streamfunction (Sv) of particles traced backward from the Atlantic equator to 20°E or Drake Passage. Only particles lighter than  $s_1 = 32.16 \text{ kg/m}^3$  are included.





The leakage (in Sv) accumulated with temperature at 20°E that reaches the Atlantic equator (solid) or recirculates beyond 20°W and reenters the Indian Ocean (dashed). The thin line is the fraction of the leakage that is transported to the Atlantic equator. The relevance of the SA to the MOC depends on whether these circulation passages are affected by their passage through the basin.



The South Atlantic volume flux divergences



• there are significant water mass conversions within the SA

• these conversions are mostly concentrated in regions of intense mesoscale variability such as the southwestern Atlantic or the Cape Basin.





*Total, Ekman and Geostrophic components of the Heat transport across the AX18 lines.* (After Garzoli and Baringer, 2007)

## Comparison with other results

0.53 ±0.11 PW





<sup>(</sup>Garzoli and Baringer, 2007)



Largest correlation at depth, and both models show very similar structure. The main differences are at the surface in the South Atlantic.

Observations (*Dong presentation*) and models (Barreiro, 2006; *Munoz presentation*) show a correlation between the Northward Heat Transport in the South Atlantic and the AMOC.

#### Heat budget and the role of inter-ocean exchanges in northward heat transport and air sea heat flux.

Objective. To analyze the AMOC variability in the South Atlantic using both available observations and a non data-assimilative simulation of the AMOC with the aim of defining the importance of variations in inter-ocean and inter-basin exchange and the connectivity.



#### "The SA Box"

#### Models: Different versions of HYCOM



The main pathways of the subsurface (left) and the deep (right) flow from calculated from the Global High Resolution HYCOM model.(*Garraffo's poster*)



Data: XBT lines • AX 22 September 1996 • AX 18 since July 2002 • AX 25 February 2004



Air-sea heat fluxes: NCEP/NCAR, SOC, ECMWF

Altimeter data: 1992 to present (to extend the time series of XBT to study inter-annual variability)

Argo data: velocities and hydrographic profiles

### South Atlantic Meridional Overturning Circulation



Argentina, Brazil, France, Germany, Italy, Russia, South Africa, UK, US.

### Use the observations to validate the model Use the model to complement the observations







Seasonal variations in the heat transport across Drake Passage from XBT (black) and HYCOM model (red).

# Altimeter validation: relation between SSH and volume transport.



Vertical T structure from altimeter data: GEM and synthetic profiles





## Results from the mean fields

#### Total



#### Different components



0.08 PW

2 Sy

1.26 PW

24.15 Sv

0.84 PW

174.58 Sv\_

25°E

2.08 PW

0<sup>0</sup>

24 Sv



2.5PW enter the box from Drake and Leakage.2.2 PW leave the box south of Africa. The difference 0.3 PW crosses 35°S plus 0.2 PW from air sea heat flux





Anomalies after removing seasonal signal. Both oceanic heat convergence and air-sea heat flux are important for the heat content change. (HYCOM)



# AAIW contribution to the AMOC





	Transports at	Transports at the AAIW layer (600-1200)			Model
		XBT Argo		$\sigma$ = 27.0 to 27.4 600-1200m	
	Brazil Current	-10 SV	-11 Sv	-5 Sv	-5 Sv
	Benguela Current	5 Sv	5 Sv	4 Sv	4 Sv
Iner	Interior	9 Sv	11 Sv	4 Sv	5 Sv
4111 III A	Total across nominally 35°S				
ŏ		4 Sv	5 Sv	3 Sv	4 Sv



(from Schmid and Garzoli, 2009)

# Some preliminary Conclusions

>Both observations (0.5 PW) and models (0.3 PW) indicate in the mean a net northward heat flux across  $35^{\circ}$ S.

The SA box region gains heat from atmosphere (0.22 PW). It also gains large amount of heat from Agulhas leakage (1.08 PW). Those heat gains are partly transported to the north, and partly to the east through the return Malvinas flow and the ACC.

>2.5 PW enter the box from Drake Passage and the Agulhas Leakage.

2.2 PW leave the box south of Africa.

0.5 PW crosses 35°S (0.3 PW from oceanic heat convergence + 0.2 PW from air sea heat flux).

► As suggested from HYCOM output, although the air-sea heat flux controls the seasonal cycle in the heat content change, oceanic heat convergence plays an important role in the anomalous heat content variability.

▶Both model and observations suggest that a combination of XBT data and SSH difference across the Drake Passage and south of Africa can be used to estimate the variability of the total transport.

To observe the AMOC at mid latitudes in the South Atlantic, observations should be collected across the whole basin and water column.





Volume transport and SSH difference from HYCOM (2003-2006) across the Drake Passage (left) and south of Africa (right).

The changes in the regression slope suggest that we may want to approximate volume transport using various relationship with the SSH difference for the major three ACC frontal regions.



Sep Oct Nov Dec

Day of Year

Feb Mar Apr May Jun Jul Aug

Jan





Annual cycle of the Ekman component, geostrophic component, and total heat transport across the AX18 21 realizations. Results from the 4 lines occupied from Cape Town to Rio are shown in a different color (yellow).





