# Effect of mesoscale eddies on subtropical mode water formation and ocean heat storage


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## Introduction

Mode water, a thick homogeneous layer caused by wintertime convective cooling, represents regions of water mass formation in the world ocean (Hanawa and Talley, 2001).

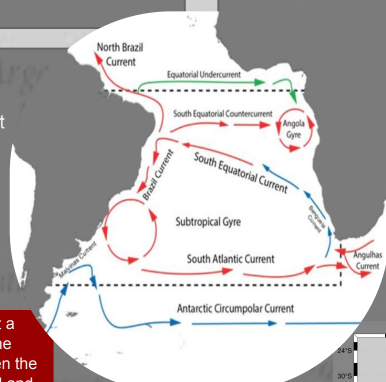
Mode water serves as a heat reservoir that modulates surface temperature signals (Alexander et al., 1999) and ventilate the ocean thermoclines (Dewar et al., 2005). They are suspected to play a major role in the ocean uptake of the surplus heat generated by human induced increase in greenhouse gas emissions. With the aim to quantify such uptake and the main variability of such reservoir, we have developed a new algorithm to determine mixed layer depth (MLD) and mode water thickness applied to the Argo global array. As a test bed, we revisit here the spatial and temporal evolution of the South Atlantic subtropical mode water (SASTMW) following Sato and Polito (2014) by using our newly developed algorithm.

Moreover, recent results from observations (Laxenaire et al., 2019) and eddy-resolving models (Nishikawa et al., 2010; Xu et al., 2014; Xu et al., 2016) suggest that mesoscale eddies contribute to the mode-water transport and subduction, on the same order of magnitude as that by the mean flow. By colocating ocean eddies from satellite altimetry using the newly developed TOEddies algorithm (Laxenaire et al., 2018) and Argo profiles, we try to assess if mesoscale eddies play an effective role in SASTMW subduction and transport.

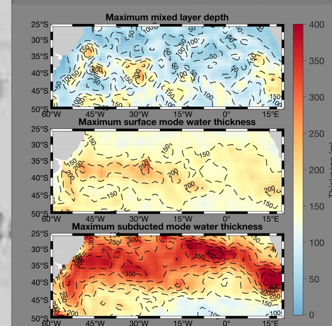
## Methods and framework

We revisit the calculation of MLD by looking for vertical gradient changes of three properties (T, S and density anomaly). As a test for robustness, we compared our method estimates with Holte and Talley's algorithm.

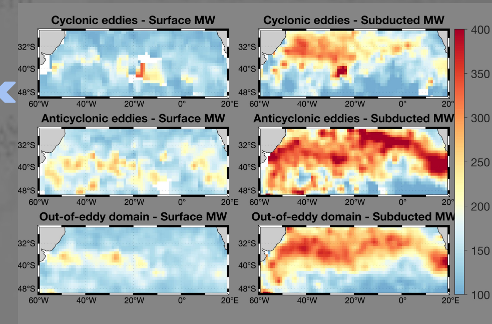
- Start
- Calculate the gradient and second derivative of each temperature, salinity or density profile
- Determine the MLD → Tested against a threshold of the difference between the value at this level and that of the surface
- Determine the pycnocline (thermocline, halocline) → Surface mode water? If thick enough
- Determine the potential presence of a subducted mode water layer by a limitation of the density anomaly gradient (same as the potential vorticity)
- Determine the bottom boundary of this mode water in the same way as for the MLD → Determine deeper mode water layers with the same method
- End




## Results

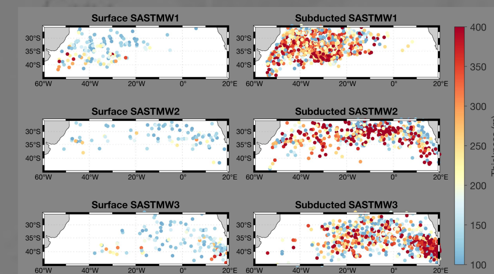


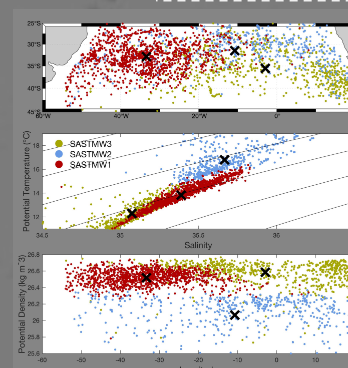

Mode water colocalized with anticyclonic eddies seems thicker than that inside cyclones.




Observe different hot spot regions of maximum MLD compared with other definition methods.

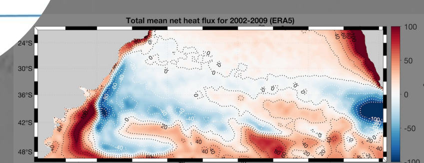
This figure also illustrates the potential routes of water subduction and advection into the South Atlantic thermocline. The Benguela and South Atlantic currents stands out as a major route for SASTMW.




Three types of SASTMW (following Sato and Polito, 2014):

- SASTMW 1 is mostly concentrated in the western-half of the basin, contained between the South Brazil and South Atlantic current;
- SASTMW 2 occupies a broad area from the eastern side of the basin and reaches the western boundary;
- The densier subtropical mode water, SASTMW 3, is formed along the Subtropical Front.




The total mean net heat flux from ERA5 data was calculated by averaging the daily maps between 2002 and 2009. In the subtropical South Atlantic, two regions strike as sites of net heat loss to the atmosphere. One of these regions is located on the western side, where the Brazil Current encounters the northward flowing Malvinas Current. The second area is on the eastern side, in the Cape Basin, promoted by the intrusion Indian Ocean waters through the Agulhas Current leakage.

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