Effect of mesoscale eddies on mode water formation, transport and heat uptake in the world ocean

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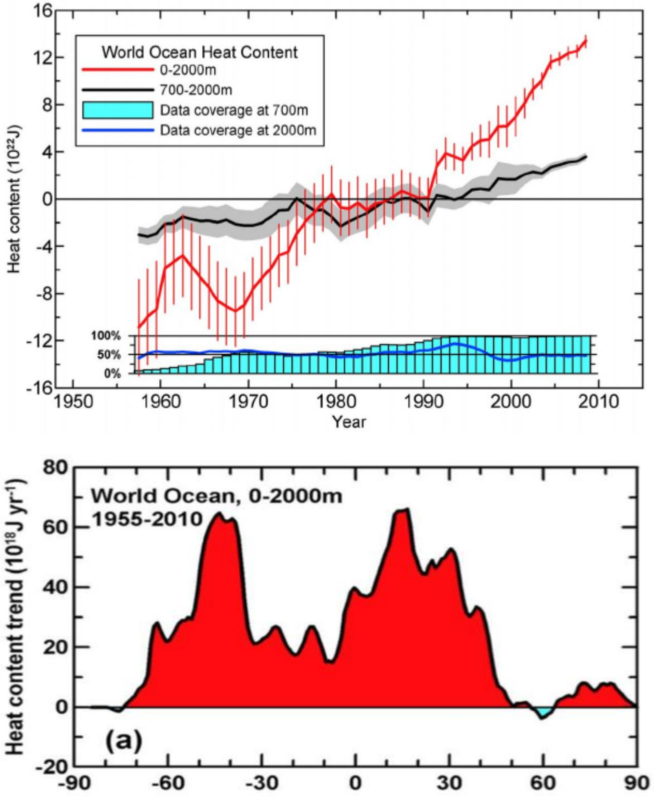
Outline

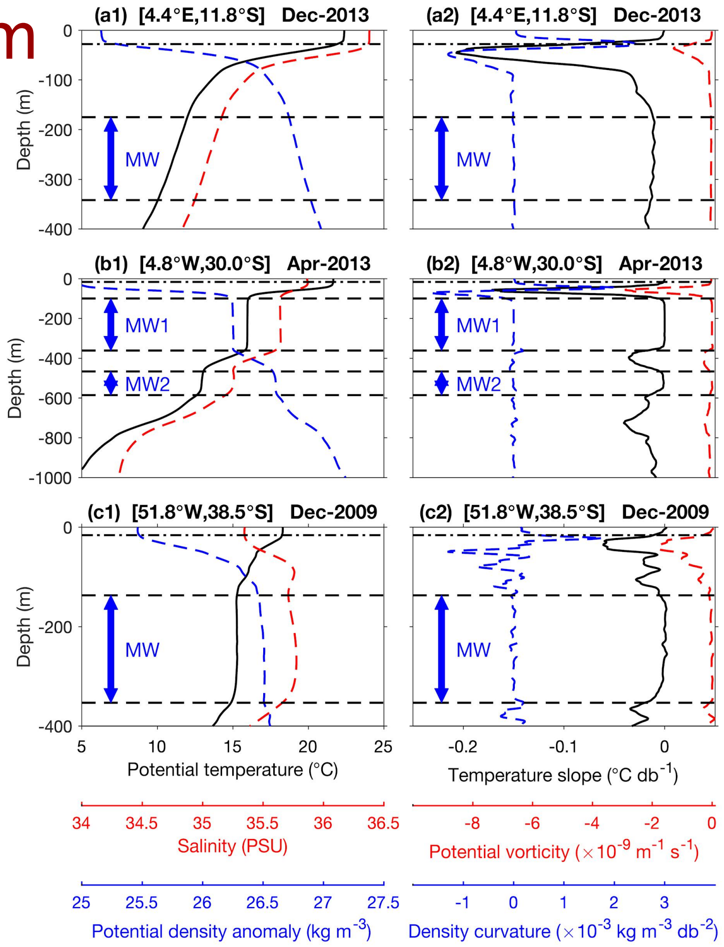
- ➢ Ocean serves as a heat reservoir of the Earth system, uptaking more than 90% of the warming.
- ➢ Mode water plays a major role in modulating the surface temperature signals (Alexander et al., 1999).
- ➢ Here, we develop a new algorithm to determine the mixed layer depth (MLD) and mode water (MW) thickness applied to the Argo global array.
- ➢ Then specifically, we revisit the spatial and temporal evolution of the South Atlantic subtropical mode water (SASTMW) following Sato and Polito (2014).
- ➢ By colocating mesoscale eddies from satellite altimetry using the newly developed TOEddies algorithm (Laxenaire et al., 2018) and Argo profiles, we also assess the role of eddies in mode water subduction and transport.



Ocean heat content. (Levitus et al., 2012)

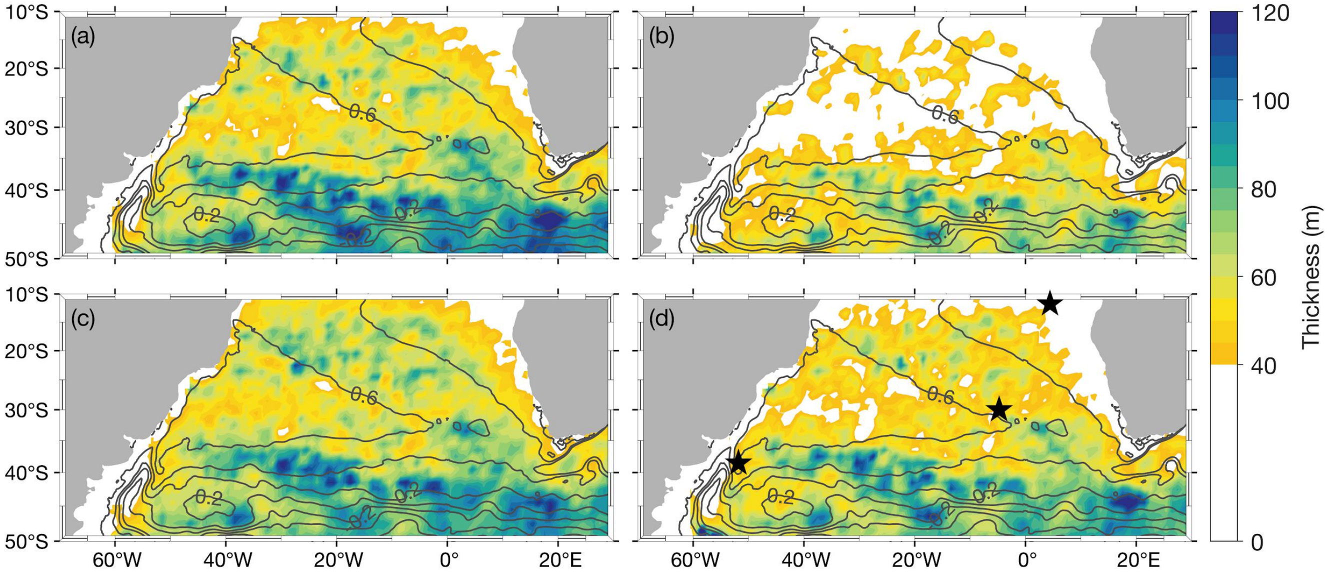
The MLD and MW detection algorithm

- Start
- Calculate the gradient and second derivative of each density profile (or temperature profile)
- Determine the MLD → Validate with a prescribed density threshold → Surface mode water? If thick enough
- Determine the pycnocline (or thermocline)
- Determine the potential presence of a subducted mode water layer by a limitation of the density 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



Three profile examples.

Comparison of MLD calculation



MLD calculations in the South Atlantic, identified by:

(a) A density threshold

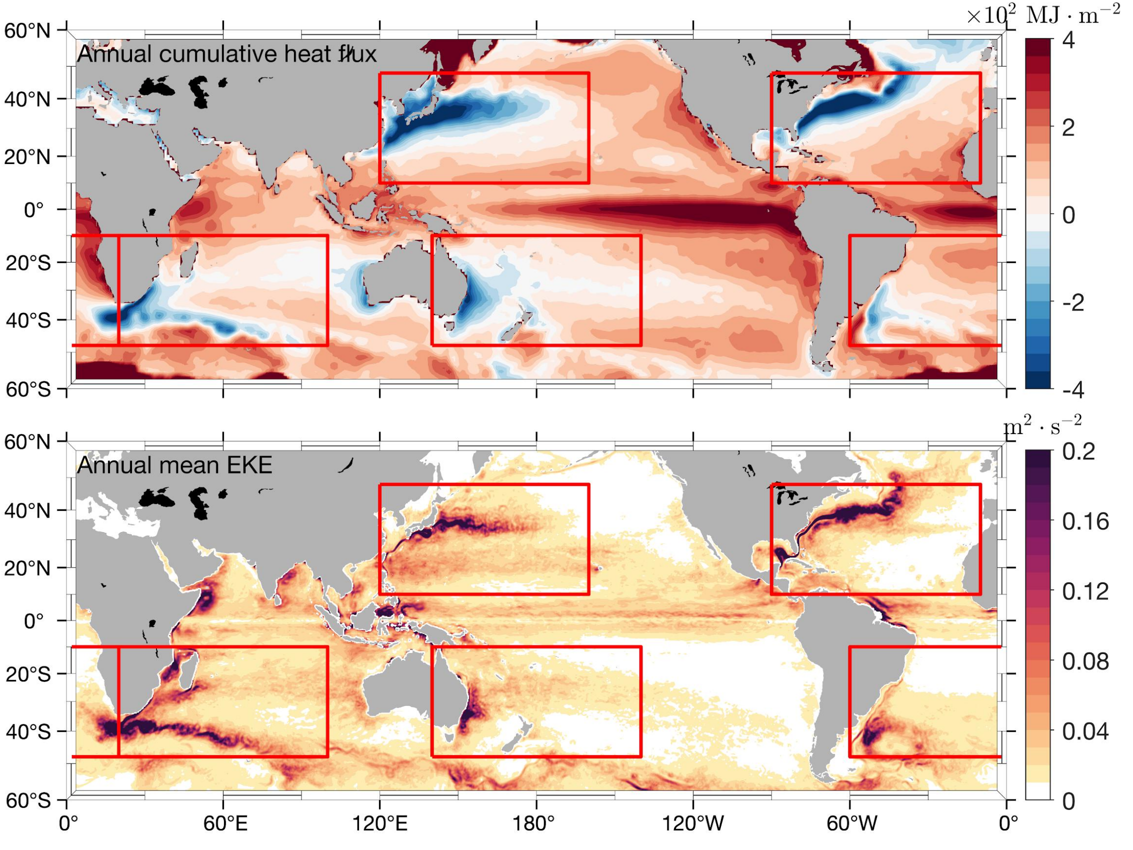
(b) A density gradient threshold

(c) A hybrid method (Holte and Talley, 2009)

(d) The new algorithm

- A uniform density threshold overestimates the MLD, while the application of density gradient threshold results in the shallowest estimate.
- In the subtropical regions where the seasonal cycle is weaker than its diurnal cycle, our detection by looking for the local extreme curvature can precisely trace the depth at which the gradient greatly changes.

Heat fluxes and the eddy kinetic energy



Global heat fluxes (positive downward) and EKE.

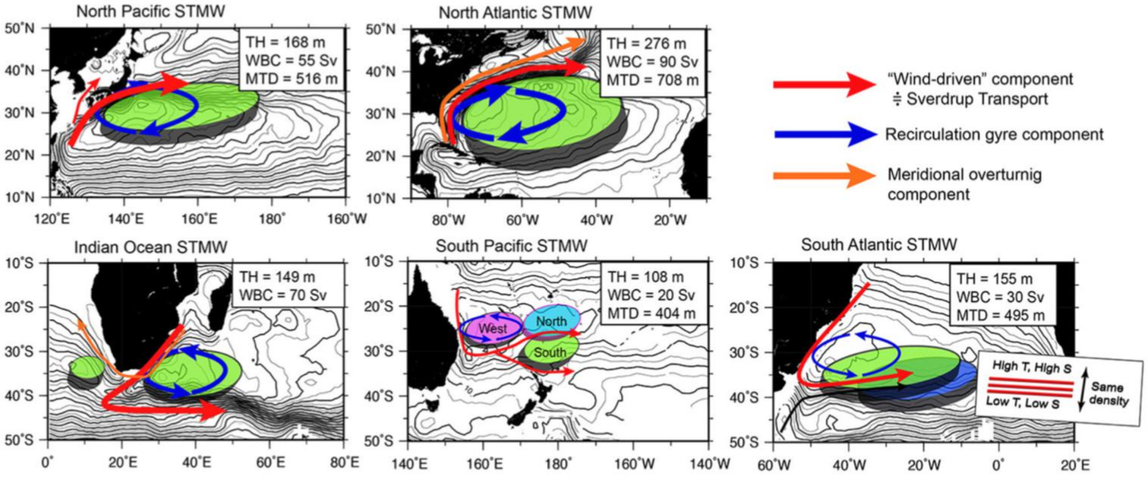
- The net heat loss coincides with western boundaries that are abundant of fronts and eddies.

- The South Atlantic subtropics: two regions strike as hotspots of heat loss.

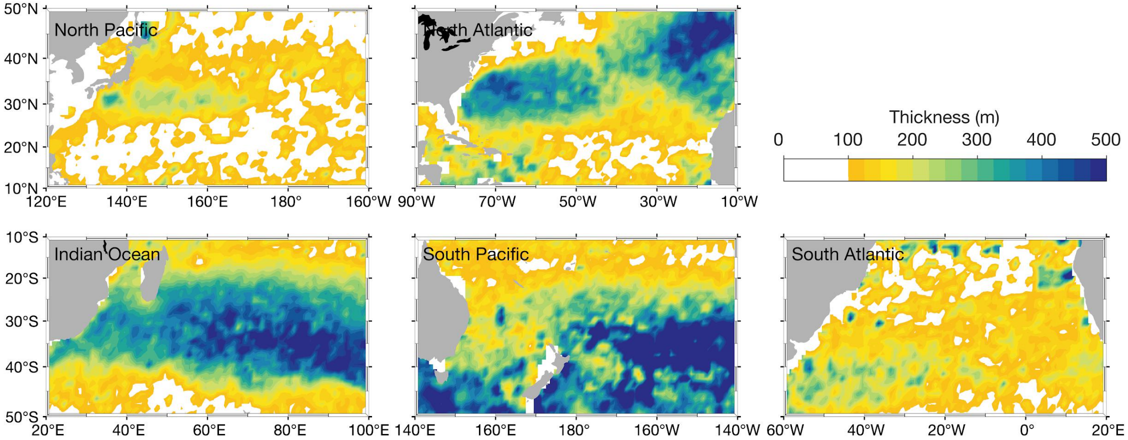
  - One is located on the western side where the Brazil Current encounters the northward flowing Malvina Current.

  - The second area with intense heat loss is on the eastern side where the Indian Ocean waters enter through the Agulhas Current leakage.

Subtropical mode water in the global ocean



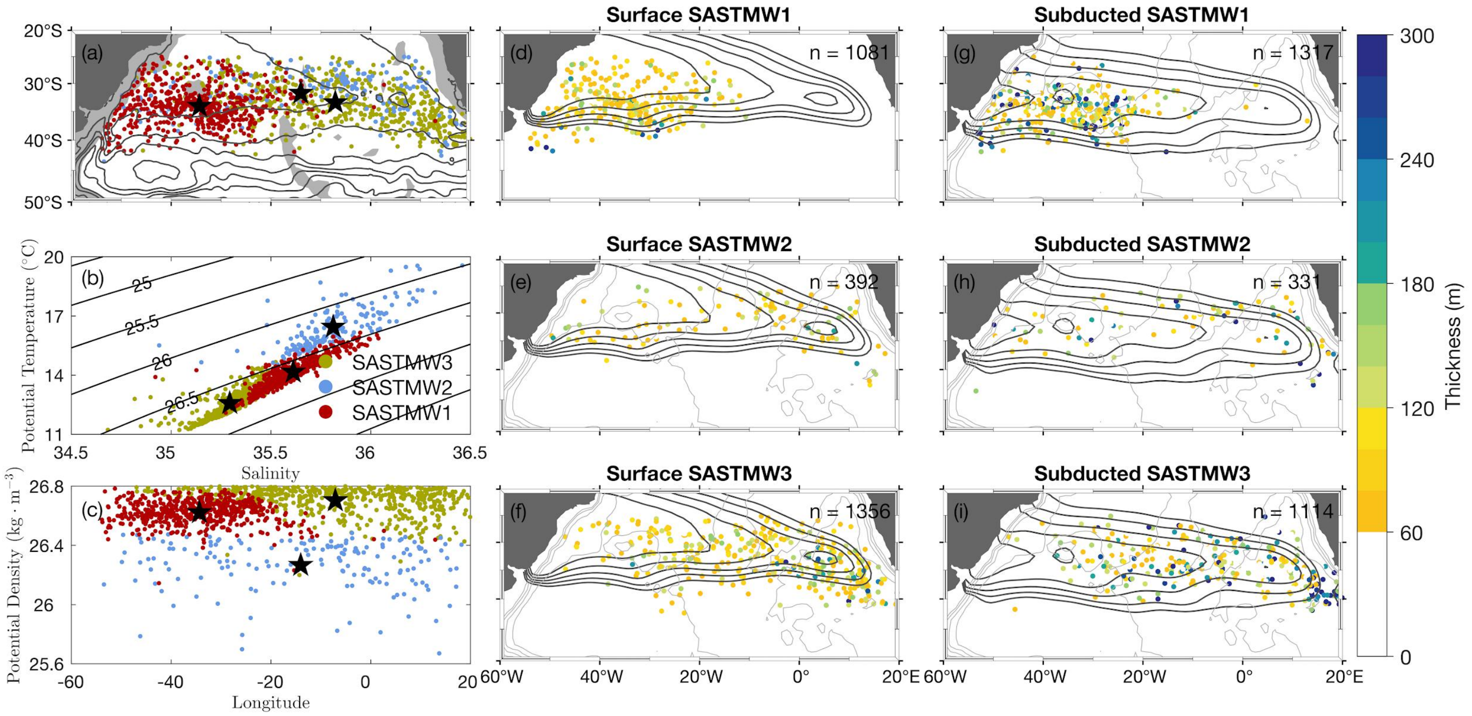
- ➢ Schematic figure of subtropical mode waters and the associated western boundary currents (Tsubouchi et al., 2016).



- ➢ Mode water thickness

Thickest: NA subtropical MW
Thinnest: SP subtropical MW
Special: SA subtropical MW

South Atlantic subtropical mode water clustering

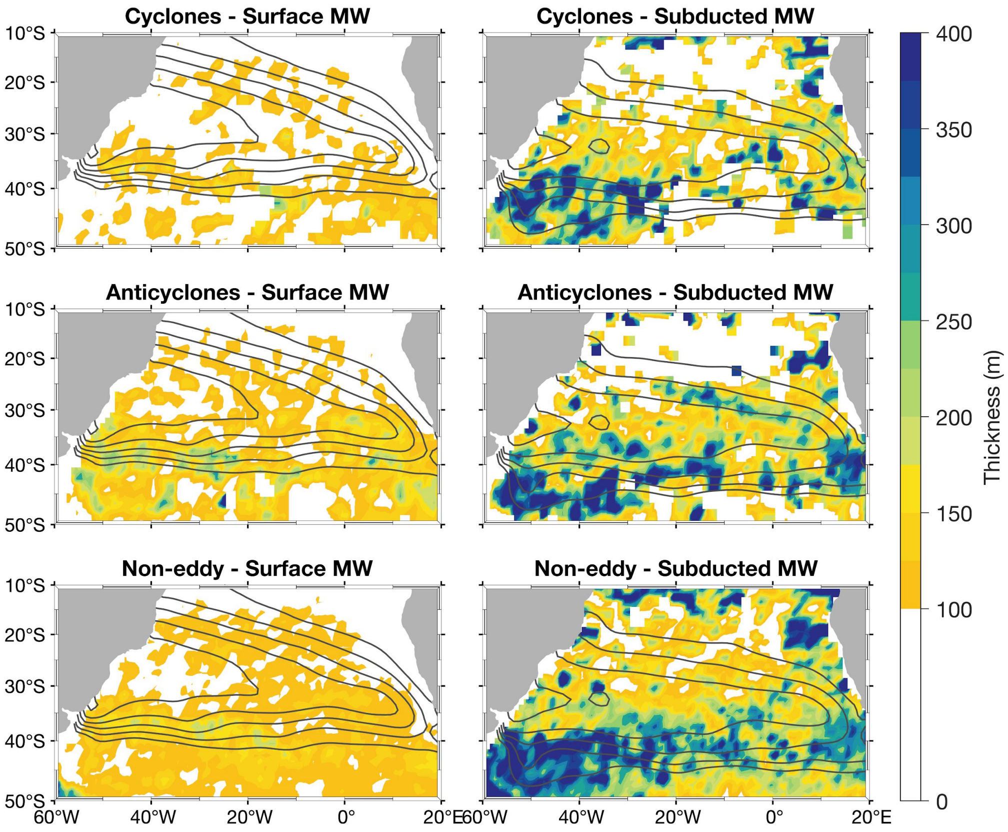


Three types of South Atlantic subtropical mode waters:

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

Colocation of MW with eddies

- ➢ Colocate mesoscale eddies from the satellite altimetry (TOEddies algorithm from Laxenaire et al., 2018) and the Argo profiles.
- ➢ Mode water colocalized with anticyclonic eddies are thicker than that inside cyclones.
- ➢ A route of water subduction following the Benguela Current associated with anticyclones.
- ➢ Out-of-eddy domain may still contain non-tractable eddies.



Take home messages and future work

A new algorithm is developed to identify mixed layer depth and mode water layers based gradients and curvature of individual Argo profile.

This new algorithm is stricter than previous method to define mode water (a threshold of potential vorticity) but more reliable.

The colocalization between mesoscale eddies from satellite detection and Argo profiles makes it possible to evaluate the role of eddies in water subduction and transport.

In the South Atlantic subtropics, two regions noticeably stand out: one is associated with the confluence region on the western side of the basin; the other is in the Cape Basin, promoted by the intrusion of Indian Ocean waters through the Agulhas Current leakage.

Anticyclonic eddies carry more mode waters than their cyclonic counterparts. Some mesoscale eddies are not tractable from satellites after subduction. Later it will need more attention on this topic.