LOCALIZATION AND VERTICAL STRUCTURE ESTIMATION OF AN AGULHAS RING BASED ON ALTIMETRY AND ARGO FLOATS DATA

João Marcos A. C. de Souza[1], C. de Boyer Montégut[2], C. Cabanes[3], P. Y. Le Traon[2], P. Klein[4].

[1]LOS / IFREMER, Brest, France, jmazeved@ifremer.fr
[2]LOS / IFREMER, Brest, France
[3]LOS / CNRS, Brest, France
[4]LPO / CNRS, Brest, France

OBJECTIVES:

To present a comparison between the 3 implementations of methods to locate and track mesoscale eddies and to reconstruct the vertical structure of an Agulhas Ring from SSH anomaly (AVISO reference product) and ARGO profile floats data.
The study was conducted in the South Atlantic, in the years 2005 to 2008.

METHODS:

Eddies Identification and Tracking:

Three methods for automatic detection of mesoscale coherent structures are applied to Sea Surface Height Anomaly (SSHA) fields in the South Atlantic. The first method is based on the **wavelet** packet decomposition of the SSH anomaly data, the second on the estimation of the **Okubo-Weiss** parameter and the third on a **geometric** criterion using the winding-angle approach.
The same tracking algorithm was used for the results from the 3 methods. To minimize problems due to attenuation of the SSH anomaly in the gridded altimetry product, eddies continuations were searched for 2 consecutive time steps. A dissimilarity parameter was calculated to provide an objective way to differ eddies continuations from newly formed structures.

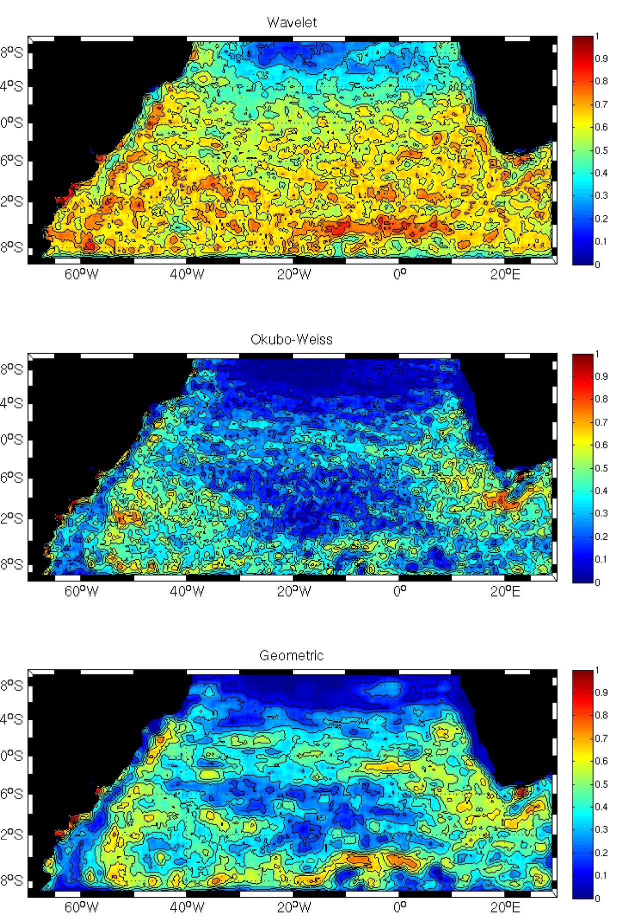
Eddies sections reconstruction:

ARGO profiles within a distance of 2° of an eddy center, in each time step, were select to be used in the vertical structure reconstruction. The temperature and salinity anomalies were obtained by subtracting the ARIVO monthly climatology from the profile data.
The profiles positions were projected in reference to the eddy center.
To include the effect of the eddies attenuation with distance from their birth place, the distance from the eddy center and the T/S anomalies values were normalized by the eddy diameter and SSH anomaly, respectively:

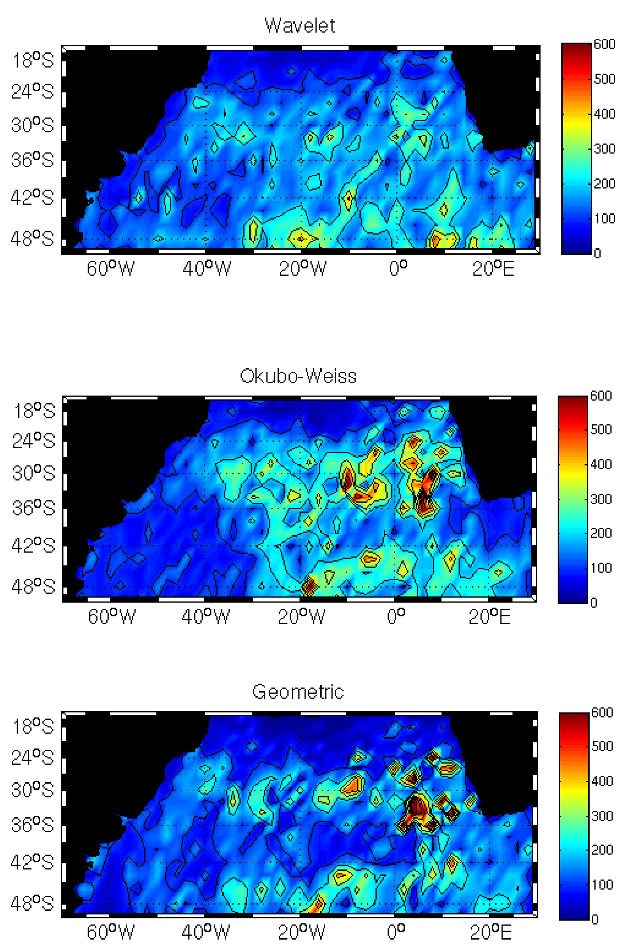
$$\text{Dist. from Centre} = \frac{Profile\ dist.}{Inst.\ Diameter}\, x\,(Mean\ Diameter)$$

$$\text{T/S Anomaly} = \frac{Profile\ T\,/\,S\ Anomaly}{Inst.\ Amplitude}\, x\,(Mean\ Amplitude)$$

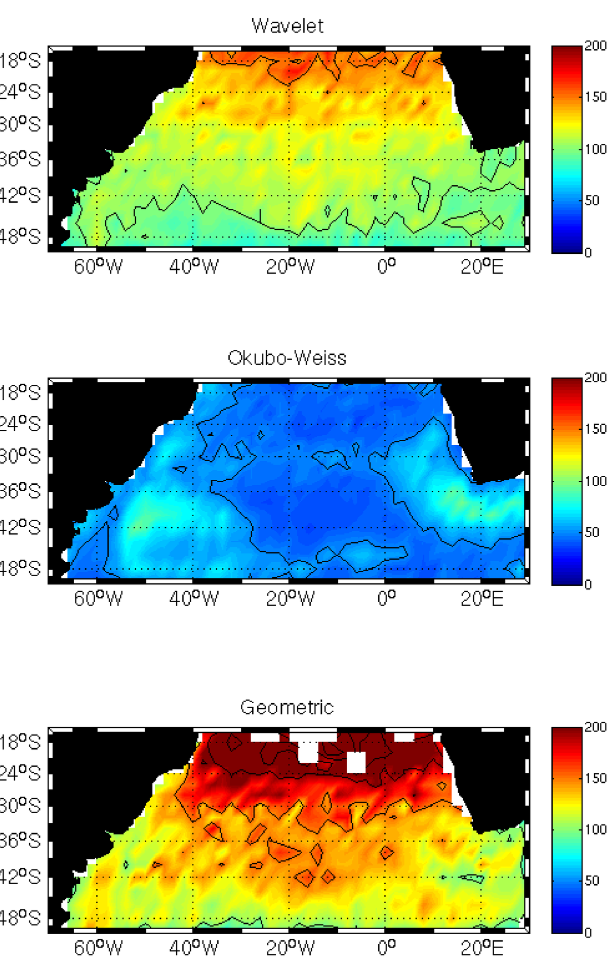
RESULTS:



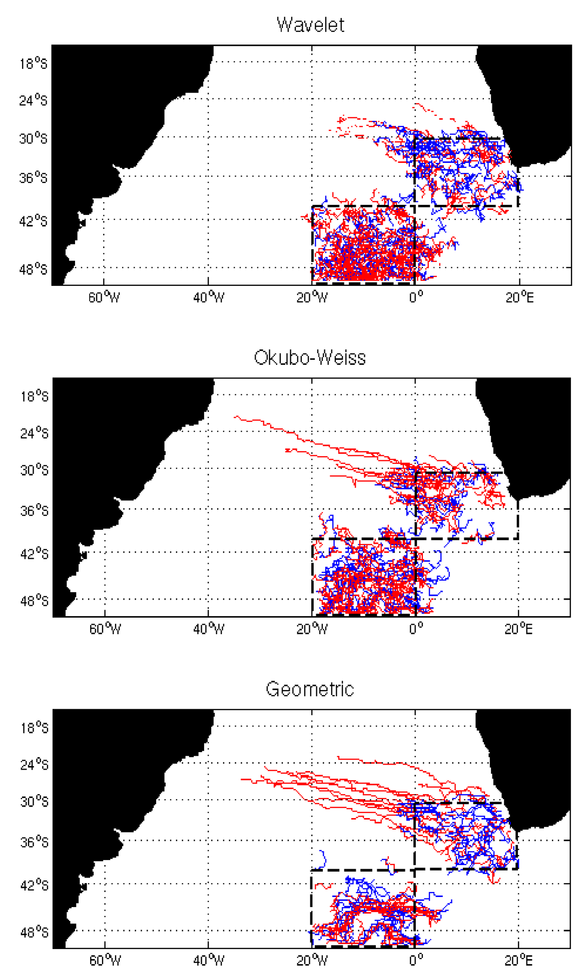
Total number of identified eddies per grid point for the three automatic identification algorithms, normalized by the maximum number of identifications.



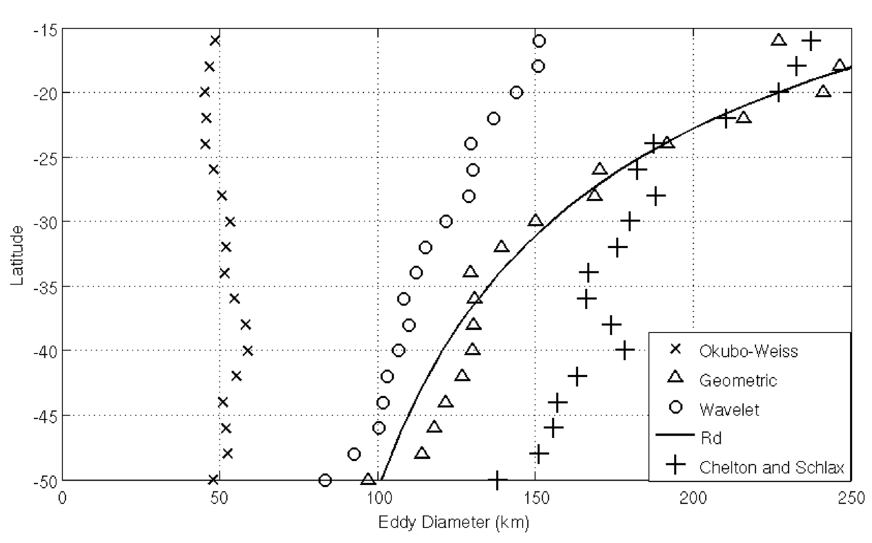
Eddies lifetimes (days) at their birth points. The color contours indicate the duration of the identified eddies plotted in their first observation locations. The black contours represent intervals of 100 days.
Two regions of higher duration eddies origin are observed: The Agulhas Retroflection and the ACC.



Mean eddy equivalent diameters (km) in the formation moment, as derived from the three identifications algorithms. The black contours indicate intervals of 50km.

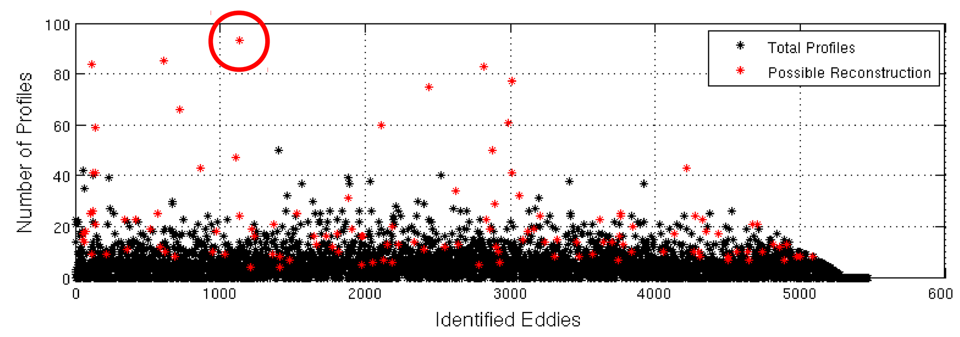


Track of the long living eddies (duration > 12 weeks) originated in the Agulhas retroflection (northeastern black rectangle) and Antarctic Circumpolar Current (southwestern black retangle). The blue lines indicate **cyclonic** and the red lines **anti-cyclonic** eddies.
For the Agulhas eddies, only the anti-cyclones present a long track crossing the South Atlantic.



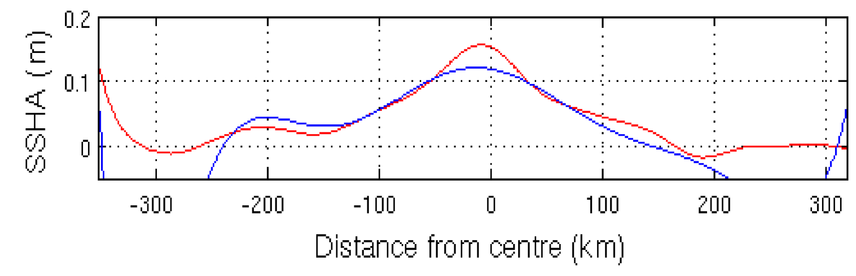
Zonal mean eddy equivalent diameters obtained from the three identification algorithms. The solid line is a estimation of the first baroclinic mode Rossby deformation diameter (Rd). The mean diameters for the South Atlantic obtained by Chelton and Schlax (http://cioss.coas.oregonstate.edu/eddy/) are present for comparison.

The geometric method is observed to present a better agreement with the Rd.

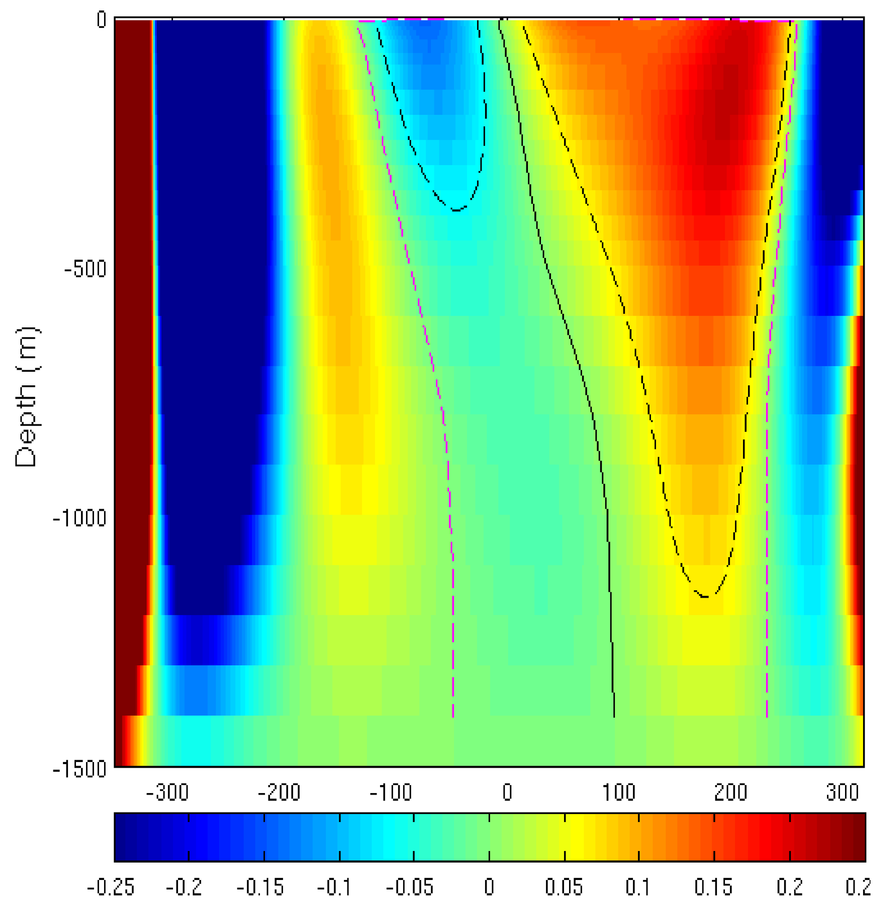


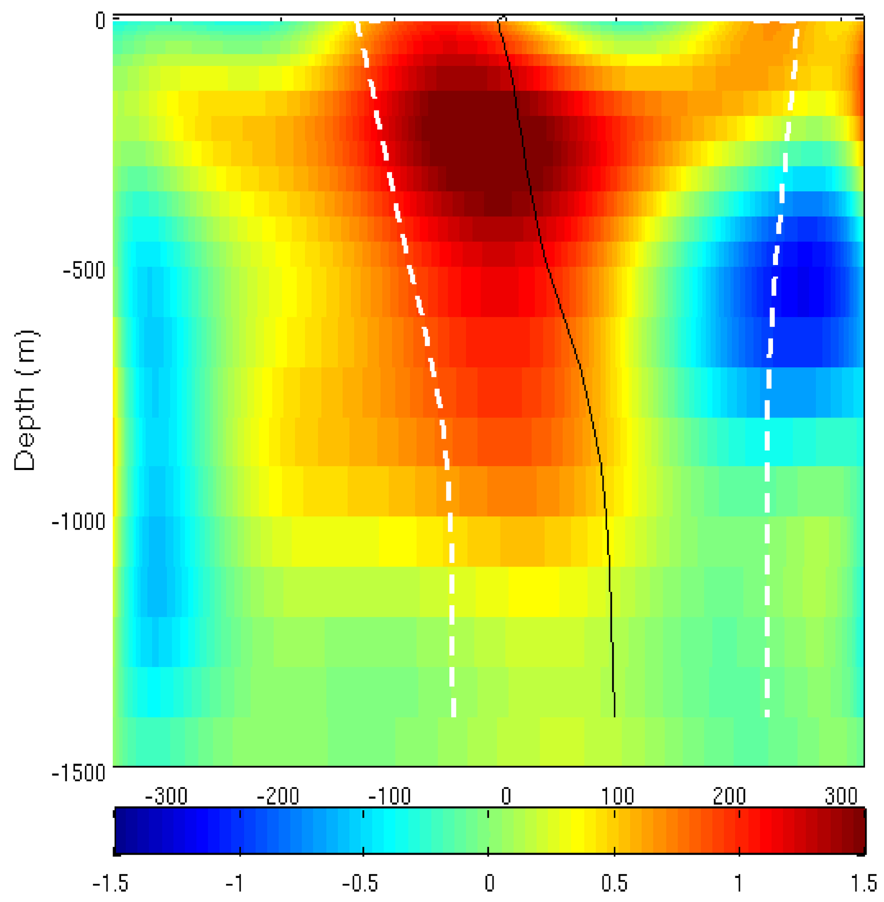
Number of ARGO profiles per eddy in the South Atlantic region (70W – 30E and 50S – 15S). It were considered all the profiles less than 2° from a eddy center in each time step. The red circle indicates the eddy selected for the present study, that presented 93 ARGO profiles.

Only 2% of the eddies (red points) presented at least 4 profiles inside the eddy diameter, minimum criterion to a possible reconstruction.



A good concordance is observed between the **SSH anomaly** and **dynamic height**, calculated in relation to a 1500m reference depth.

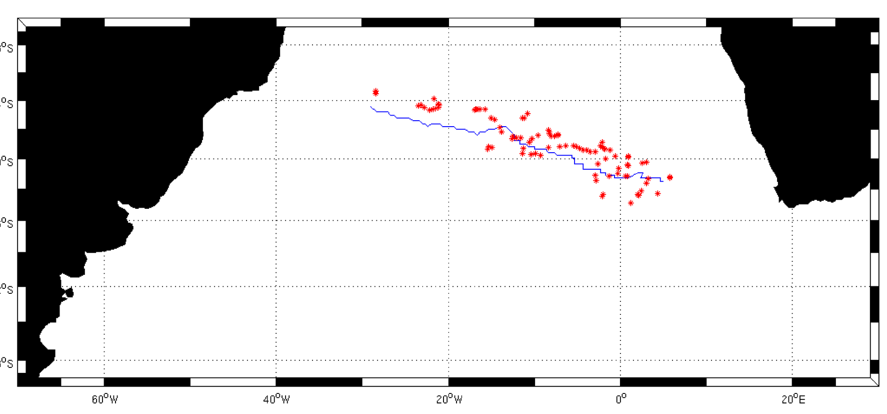




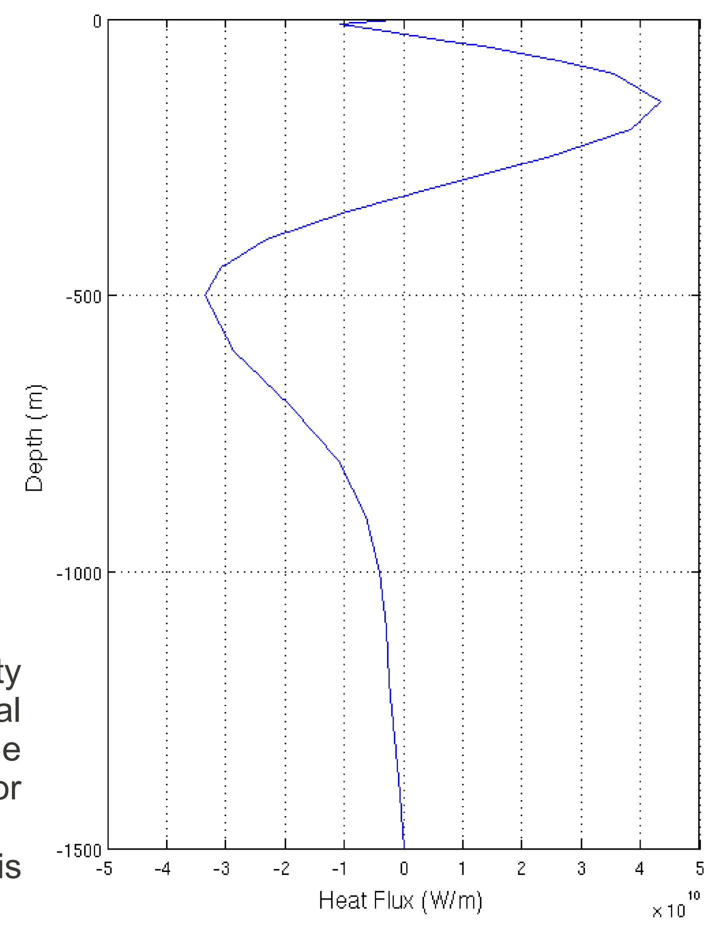
Anti-cyclonic Agulhas eddy (Agulhas Ring) structure:

(left) Eddy velocity vertical section, reconstructed using the ARGO profiling floats data. The magenta dashed lines are the **eddy boundaries**, determined by the velocity Laplacian, and the black dashed lines are the **area of trapped water**, following the Flierl (1981) criterium.

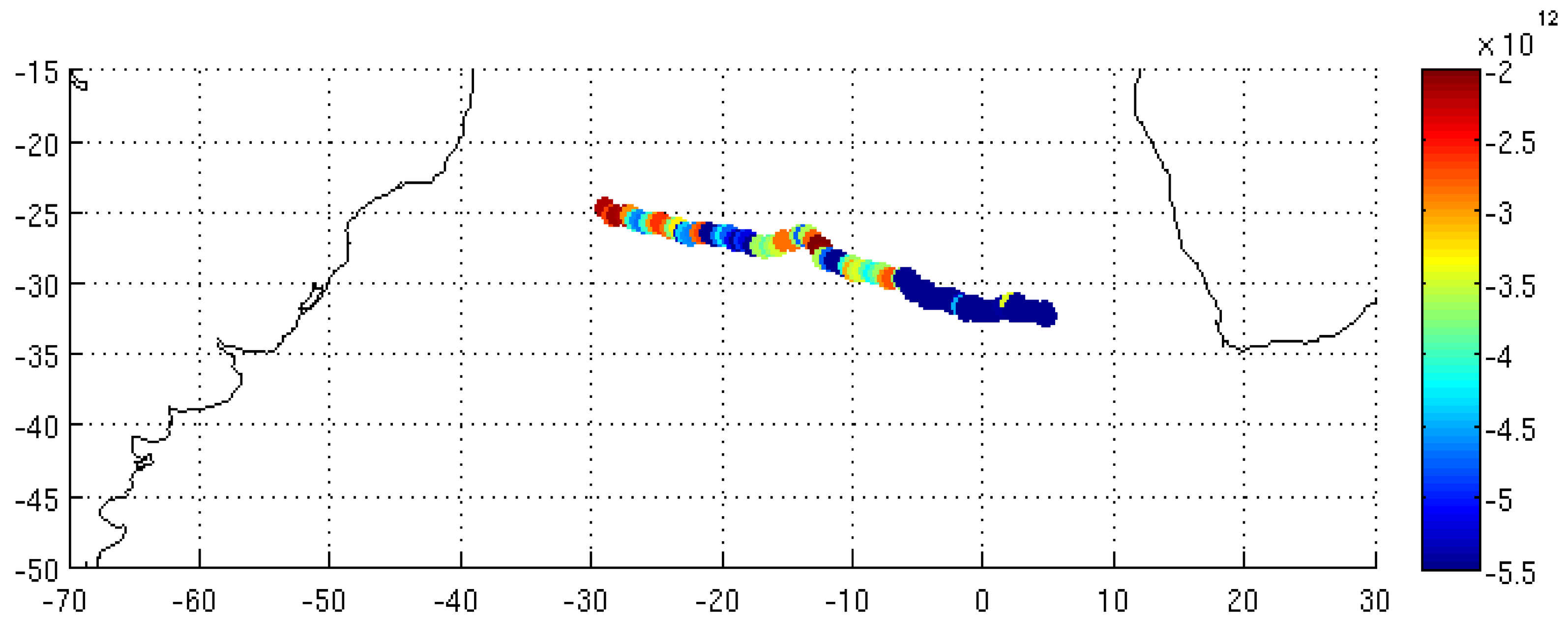
(right) Rebuild temperature anomaly section. A 2D 9th degree lagrange polynomial was used to interpolate the ARGO data from the profiles positions. A phase shift between the velocity and the temperature is observed, with important consequences on the eddy heat flux.



Map showing the track of the selected Agulhas anti-cyclone. The red stars indicate the positions of the ARGO profiles used in the vertical profiles reconstruction.



From the temperature anomaly and eddy velocity reconstructed sections, it is possible to calculate the vertical structure of the eddy heat flux. The limits obtained through the Laplacian of the velocities were used to determine the area for the heat flux integration.
A resultant heat flux of **-5.6 x 10¹² W** is observed for this Agulhas Ring.



Inverting the equations used to normalize the eddy anomalies amplitudes it is possible to estimate the variability of the eddy heat flux, based on the mean eddy reconstructed structure. Estimations of the total eddy heat flux provided by coherent structures can be obtained by expanding this approach to the other identified eddies.

Although results for the South Atlantic shows that only 2% of the eddies can have their mean structures reconstructed through this method, the Agulhas Rings seams to be well represented.
Feature models can be used to extrapolate the structures that can be estimated through the present method to the rest of the observed eddies, giving rise to a method to follow the variability of the eddy heat flux in the basin.