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On the nature of the Madagascar dipoles: An analysis from Argo profiling floats and altimetry measurements

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The South East Madagascar Current (SEMC) flows poleward along the eastern coast of Madagascar as a western boundary current which further south provides some of the source waters of the Agulhas Current, either directly or in the form of eddies. We investigate the region of dipole formation south of Madagascar combining vertical T/S profiles from Argo floats, altimetry measurements and an existing eddy detection algorithm.

Results from our analysis show that the dipole consists of an anticyclonic intrathermocline eddy (ITE) formed on its southern flank and a cyclonic ITE formed on its northern flank. Both lobes of the dipole exhibit similar T/S properties throughout the water column, although vertically shifted within the thermocline depending on its nature: upward in a cyclonic ITE and downward in an anticyclonic ITE. A subsurface salinity maximum of about 35.5 psu characterizes the upper layers with Subtropical Surface Water (STSW). At intermediate levels, a well defined path of South Indian Central Water (SICW) extends throughout the water column up to reach a minimum in salinity of 34.5 psu, corresponding to Antarctic Intermediate Water (AAIW). Below, at deep layers, the North Atlantic Deep Water (NADW) is found.

The intrathermocline nature of the Madagascar dipoles has not been previously reported and represents an important feature to be considered when assessing the heat and salt fluxes driven by eddy movement and contributing to the Agulhas Current. Unlike surface eddies, intrathermocline eddies strongly influence the intermediate/deeper layers in the oceans and, hence, may have a larger contribution in the spreading rates and pathways of water masses. Because the intrathermocline nature of eddies is invisible to altimetry measurements, these results stress the importance of combining altimetry with historical records of Argo profiles which uncover eddy dynamics below the sea surface.

Lastly, we further investigate from altimetry the area of dipole formation. The main axis of the SEMC appears flanked on its northern and southern borders by a semi-isolated semicircular region where kinetic energy of the mean flow is being transfered to the eddy kinetic energy field, in this case to the dipole formation, through barotropic instabilities without the need of an evident SEMC retroflection. In this regard, future work will be addressed to account for the mechanism by which Madagascar dipoles thus generated present an intrathermocline structure.