

Eddy variability east of Madagascar

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Abstract A strong but variable western boundary current flows south along the east coast of Madagascar, and at the island's southern end interacts with eddies propagating zonally from the east. These two routes of variability are compared using altimetric sea surface height (SSH) data and dynamic height from a high-resolution numerical model. The effects on biological productivity are also discussed.

Hydrographic analysis The westward-flowing South Equatorial Current branches on reaching Madagascar, with the East Madagascar Current (EMC) flowing southward along the coast. A mooring at 23°S recorded a mean near-surface current of 0.7 ms⁻¹, with variations throughout the year, but no clear seasonal signal (Schott et al., 1988). Analysis of ship drift data suggest a seasonal variation, with slightly greater speeds during the austral winter and spring (Lutjeharms et al., 2000). Here we build upon these observations using satellite data and output from a numerical model.

Satellite analysis The EMC carries warm, nutrient-poor water poleward; however, the flow aids coastal upwelling of cold nutrient-laden waters, which encourages phytoplankton growth. Usually this results in a sharp chlorophyll boundary parallel to the coast. An exception is shown in Fig. 1b, where there is a tongue of high productivity water extending more than 200 km from the coast. This is due to a cyclonic eddy embedded within the EMC (Fig. 1a). Altimeter data reveal a number of cyclones and anticyclones moving southward within the EMC each year, but not all seem to affect the near-surface chlorophyll.

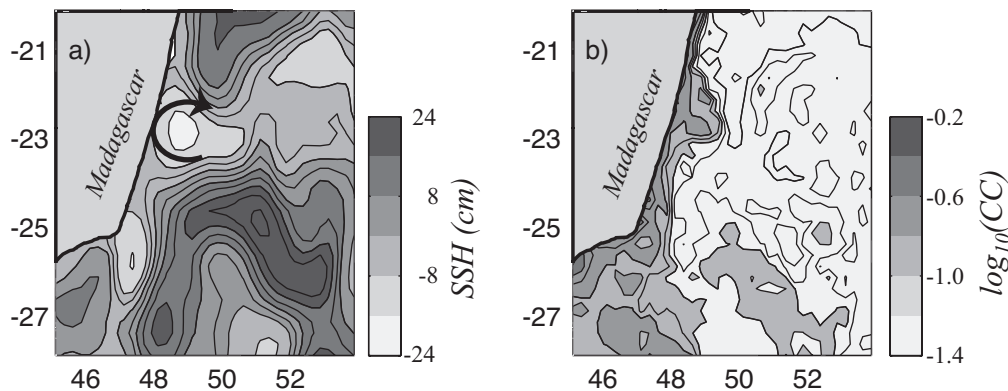


Figure 1 : 10-day composite of a) sea surface height, b) chlorophyll concentration (April 2001).

Eddy variability in altimetry, ocean colour and model output Analysis of 6 years of altimetry data shows a strand of slightly increased variability along the east coast of Madagascar, and a more pronounced band of variability along 24°-26°S. The interpretation of this band is not yet clear. Westward-propagating Rossby waves are prevalent throughout the south Indian Ocean, and at many latitudes have associated thermal and optical signals (Quartly et al., 2003). Some of the individual highs and lows in SSH are elongated meridionally, suggestive of wavefronts, whilst others are approximately circular as might be expected for eddies. Feature-tracking shows these features to move westward at 3.7 to 7.4 cm s⁻¹ (Buck et al., manuscript in preparation). Although chlorophyll variations are generally weak in the centre of the gyre, there is a marked secondary bloom along this latitudinal band during austral autumn (Longhurst, 2001). The chlorophyll is concentrated on the edge of eddies, and mixing induced by the latter may be responsible for the

appearance of an eastward-moving "plankton wave" (Srokosz et al., 2004). OCCAM, a high-resolution numerical model run at Southampton Oceanography Centre, shows similar patterns of small-scale variability (Fig. 2b). The overall variability in the model output is much weaker (partly due to the absence of measurement errors associated with altimetry). The other key difference is that the zonal band of variability (at 25°-27°S in the model) is weaker than that associated with the EMC.

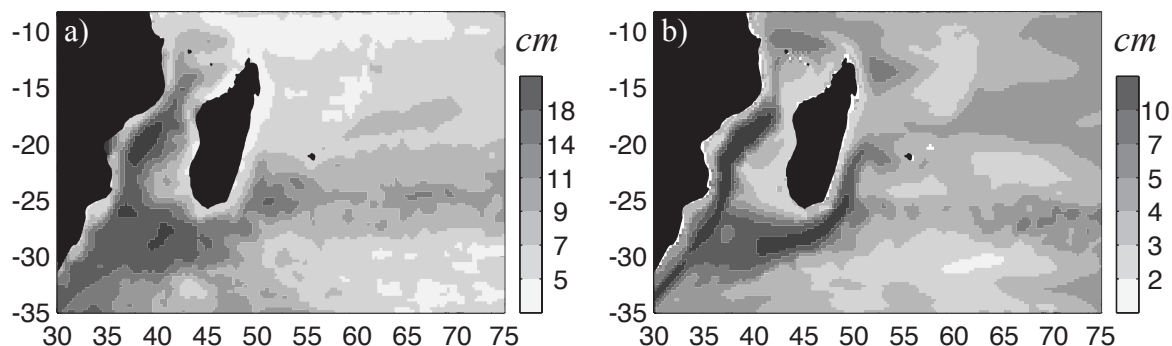


Figure 2 : Variability of a) MSLA altimetry data, b) OCCAM output. (Both datasets have first had large-scale coherent variability reduced by EOF removal technique of Quartly & Srokosz, 2002.)

Continuation The passage of eddies through this region is complex, and understanding is best advanced using multiple satellite datasets, plus model output. Tracking by Buck et al. (manuscript in preparation) reveals westward-bound eddies in the latitude range 25°-34°S, with the Madagascar Ridge often a temporary barrier to their movement. Quartly & Srokosz (2002) used thermal signatures for eddy-tracking west of this ridge, and ocean colour can be used to follow eddies that have acquired a chlorophyll signature close to the Madagascar coast (Quartly & Srokosz, 2004). These observations need to be combined with altimetric tracking to give a fuller picture of how eddies affect the biology present in this region.

Acknowledgements The altimetry data used were the Mean Sea Level Anomaly product produced by CLS, and the ocean colour figure was based on SeaWiFS data distributed by NASA/GSFC. The OCCAM output were provided by Andrew Coward and Beverley de Cuevas, and details of the model and animation for the Agulhas region may be found at <http://www.soc.soton.ac.uk/JRD/OCCAM>.

References

- Longhurst, A., 2001, A major seasonal phytoplankton bloom in the Madagascar Basin. *Deep-Sea Research I* **48**, 2413-2422.
- Lutjeharms, J.R.E., P.M. Wedepohl, and J.M. Meeuwis, 2000, On the surface drift of the East Madagascar and Mozambique Currents. *South African Journal of Science*, **96**, 141-147.
- Quartly, G.D., P. Cipollini, D. Cromwell and P.G. Challenor, 2003, Rossby waves: Synergy in action. *Phil. Trans. Roy. Soc. Lond. A*, **361**, 57-63.
- Quartly, G.D. and M.A. Srokosz, 2002, TMI observations of the Agulhas and Madagascar retroreflections. *Journal of Physical Oceanography*, **32**, 1585-1592.
- Quartly, G. D. and M. A. Srokosz, 2004, Eddies in the southern Mozambique Channel, *Deep Sea Res. II*, in press.
- Schott, F., M. Fieux, J. Kindle, J. Swallow, and R. Zantopp., 1988, Boundary currents east and north of Madagascar. 2. Direct measurements and model comparisons, *J. Geophys. Res.*, **93**, 4963-4974,
- Srokosz, M.A., G.D. Quartly, and J.J.H. Buck, 2004, A possible plankton wave in the Indian Ocean, submitted to *Geophysical Research Letters*.