Tracking of mesoscale eddies across the southern Mozambique Channel using Argo float technology

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The Mozambique Channel

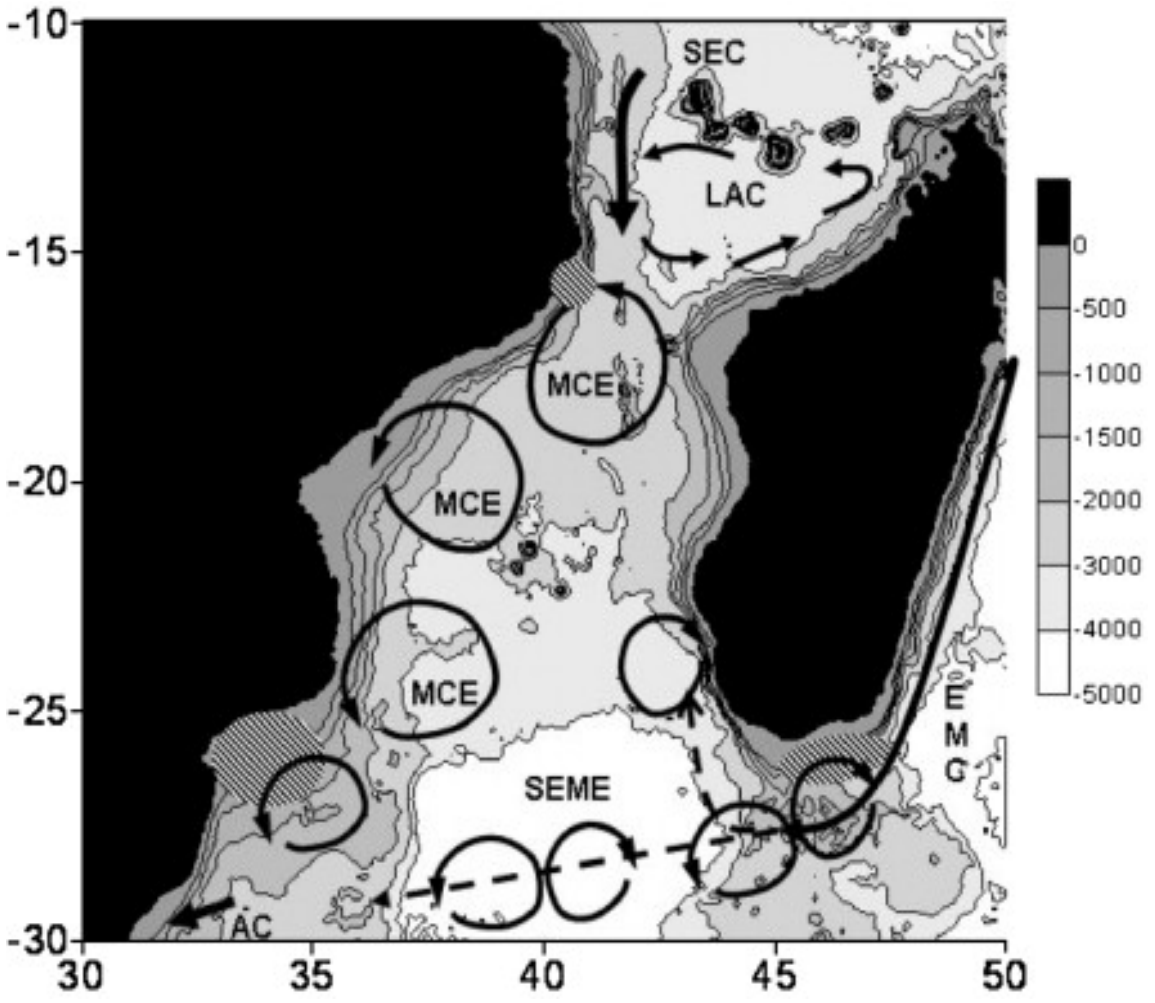
Series of eddies propagate down the Mozambique Channel, formed in narrows by bifurcating SEC and associated instabilities

SE of Madagascar, eddies shed from the EMC. Work done by Quartly *et al* (2006) and Ridderinkhof *et al* (2013) include:

1.Whether a retroflection of EMC causes ring shedding or not

2.Dipole eddies being shed and interacting with already formed eddies in the Channel

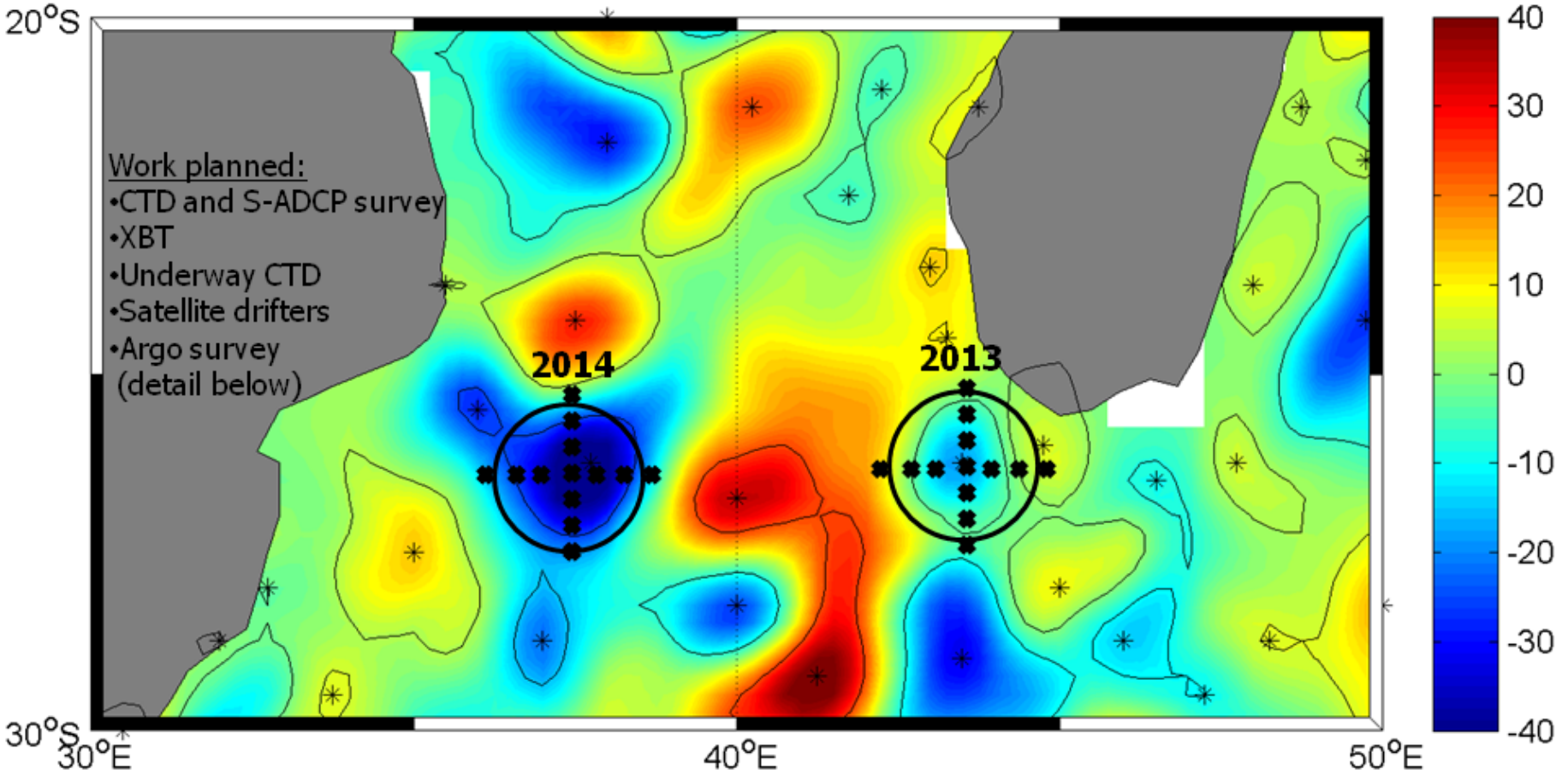
3.Whether eddies (a-c and c) are symmetrical and equal in terms of their relative vorticity



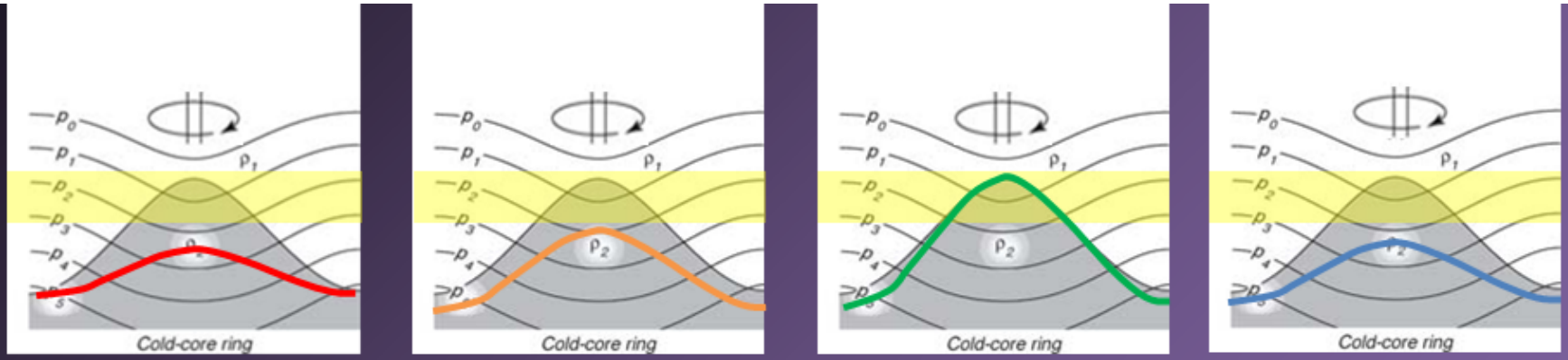
SEC – South Equatorial Current
EMC – East Madagascar Current
AC – Agulhas Current
MCE – Mozambique Channel Eddies
SEME – South East Madagascar Eddies

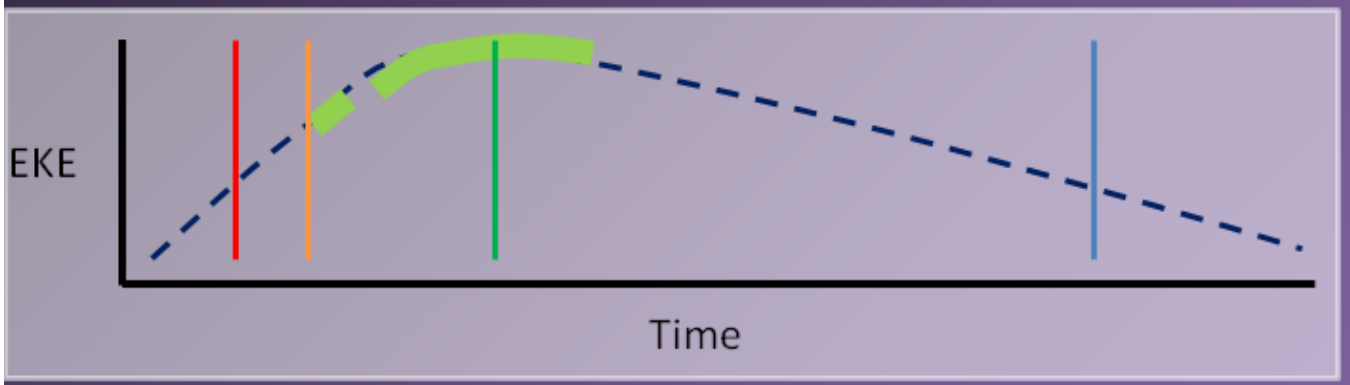
Tew-Kai and Marsac, 2009

The proposed experiment



The proposed experiment

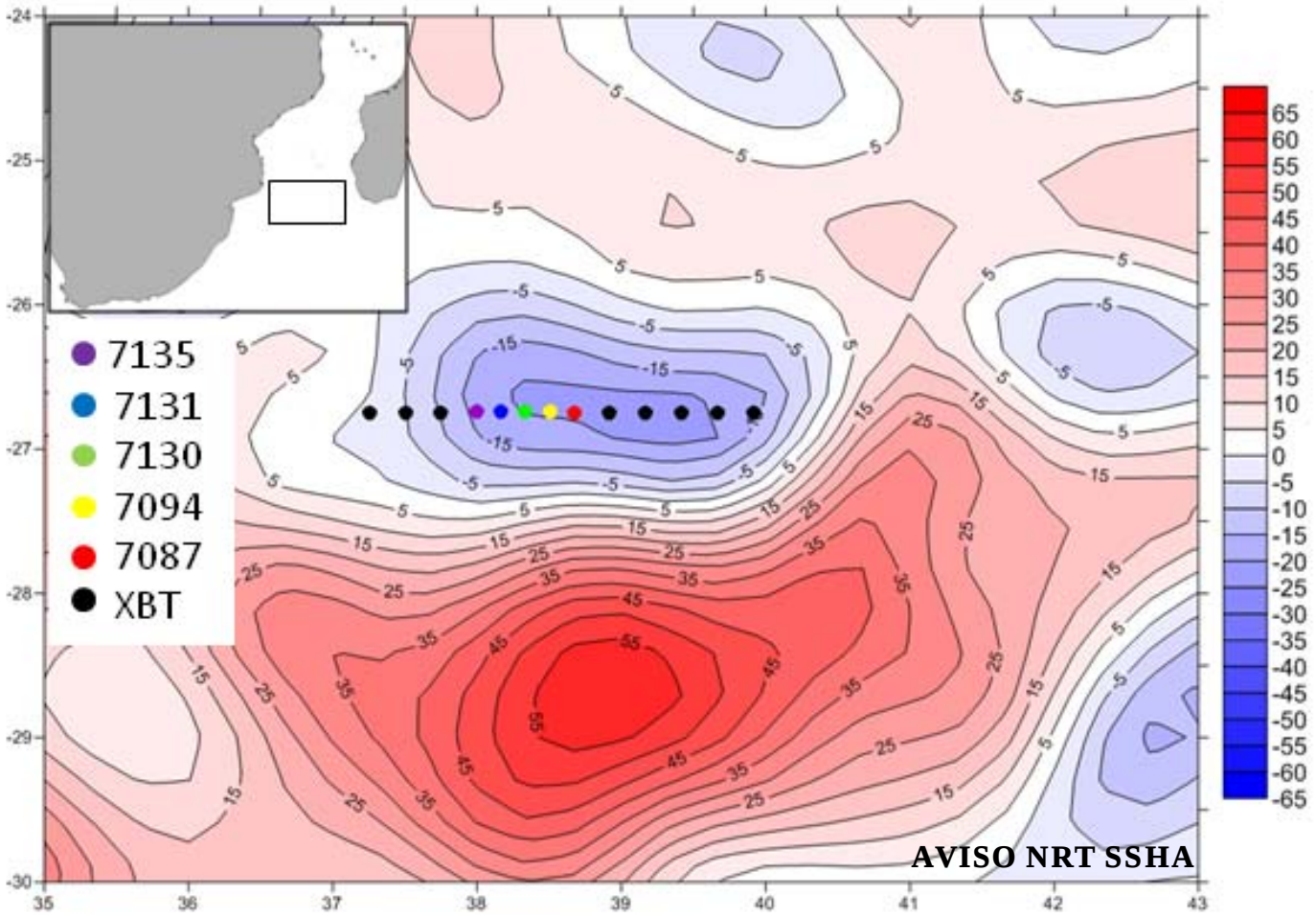




"Argo Dance"

- 6-8 (Bio)Argo floats
- 1 day profiles
- ~300 m depth
- Deployed in a transect across eddy
- Aim: to capture the euphotic zone pumping of a cyclonic eddy and thus its sustainablility

First experiment – April 2013



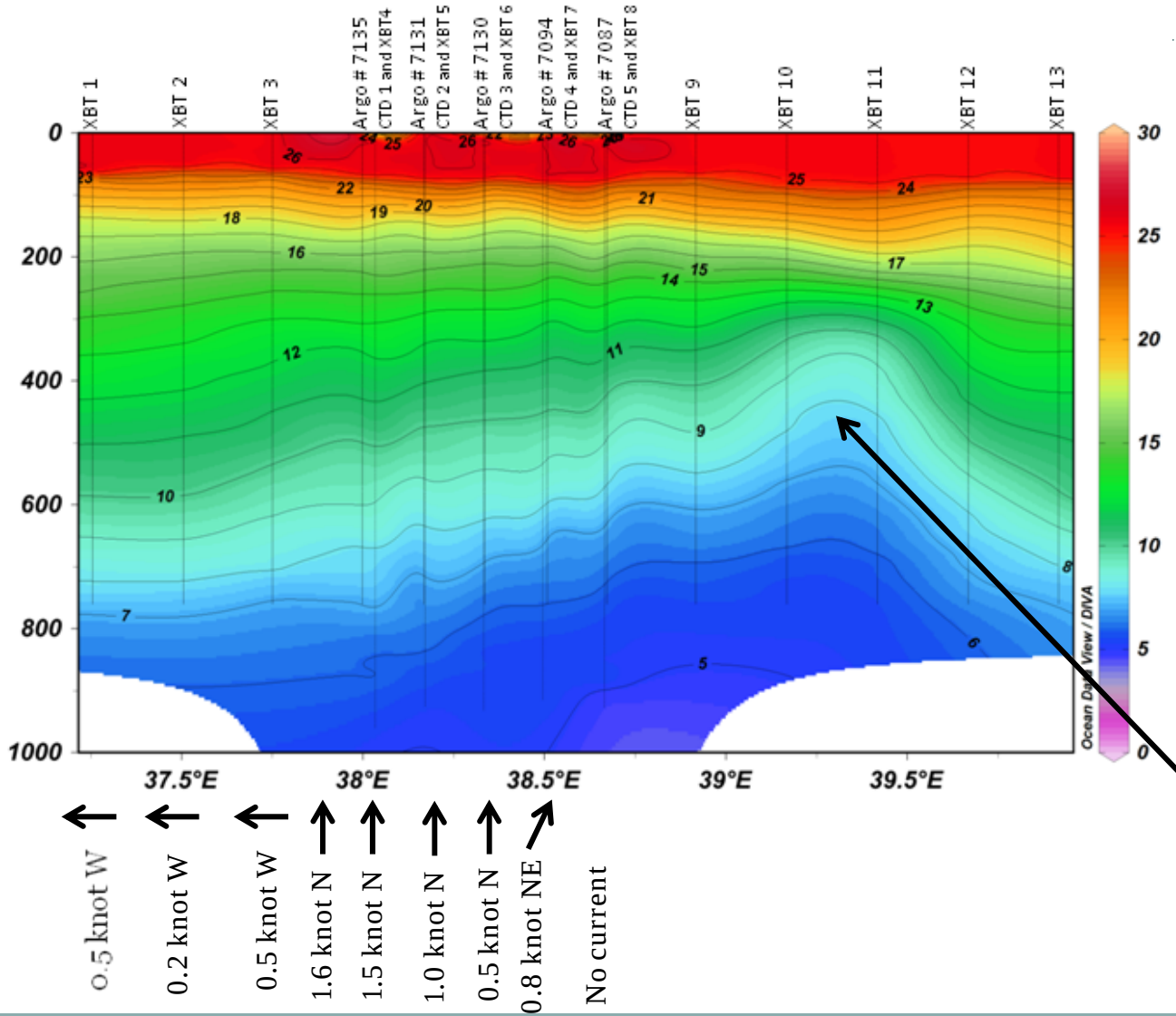
Five SOLO II floats, donated from WHOI with iridium communications

Daily profiles, 300 m park depth and 1000 m profiling. Ballasted with an extra battery for additional data collection

Tracked the cyclonic eddy from SE Madagascar from the beginning of March 2013 (CCAR imagery).

Deployment of floats took place on the 12th of April 2013.

First experiment – April 2013



Ship drift measurements

XBT casts done prior to and after the float deployments: 15 nm apart

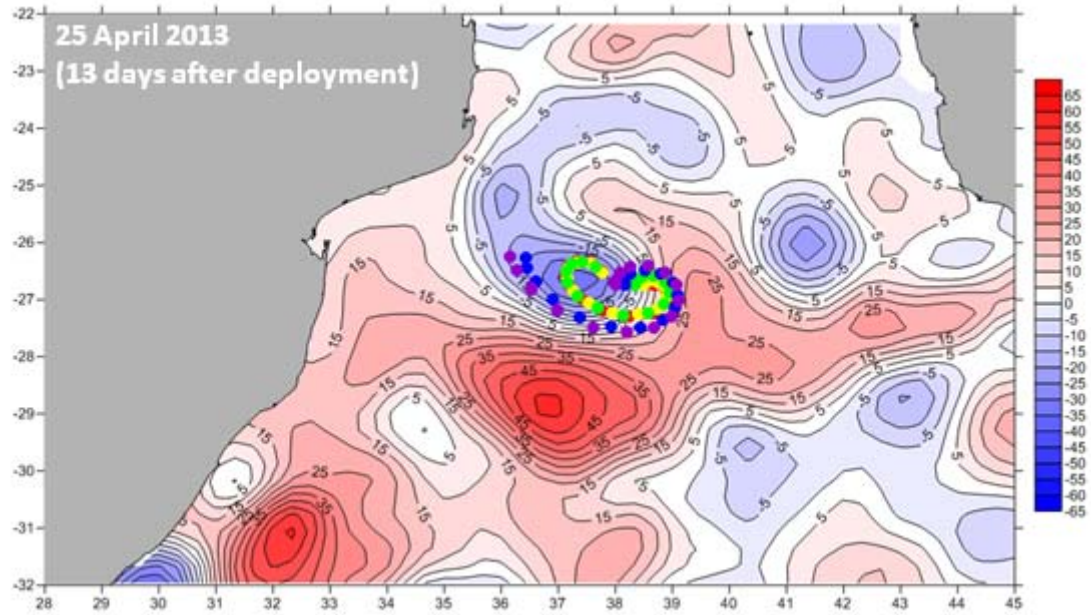
CTD and XBT (for inter-comparison) casts done on station prior to deploying each float: 10 nm apart

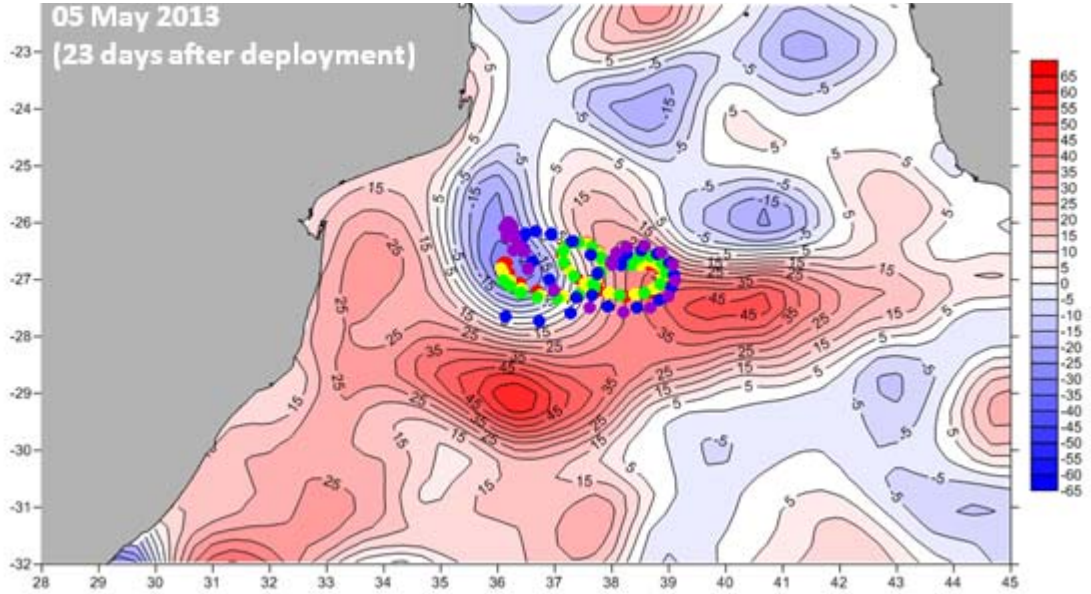
No working S-ADCP. Ship drift measurements taken to determine cyclonic eddy edge and core. Thus not completely reliant on the SSHA

Core situation further east than expected when tracking cyclonic eddy on CCAR imagery

Aim to get floats as close to the cyclonic eddy core as possible

First experiment – April 2013





<u>13 days after deployment:</u>

3 inner floats (7087, 7094 + 7130) closely follow each other and circulate core

2 outside floats (7131, 7135) move with eddy edge and caught in "tail" - cyclonic eddy merging with one from north (tracked to SE Madagascar as well)

At ~ 17th profile – floats were reprogrammed as follows:

7087 – no change

7094 – park to 500 m

7130 – park to 650 m

7131 – no change

7135 – park to 1000 m, ½ day profiling

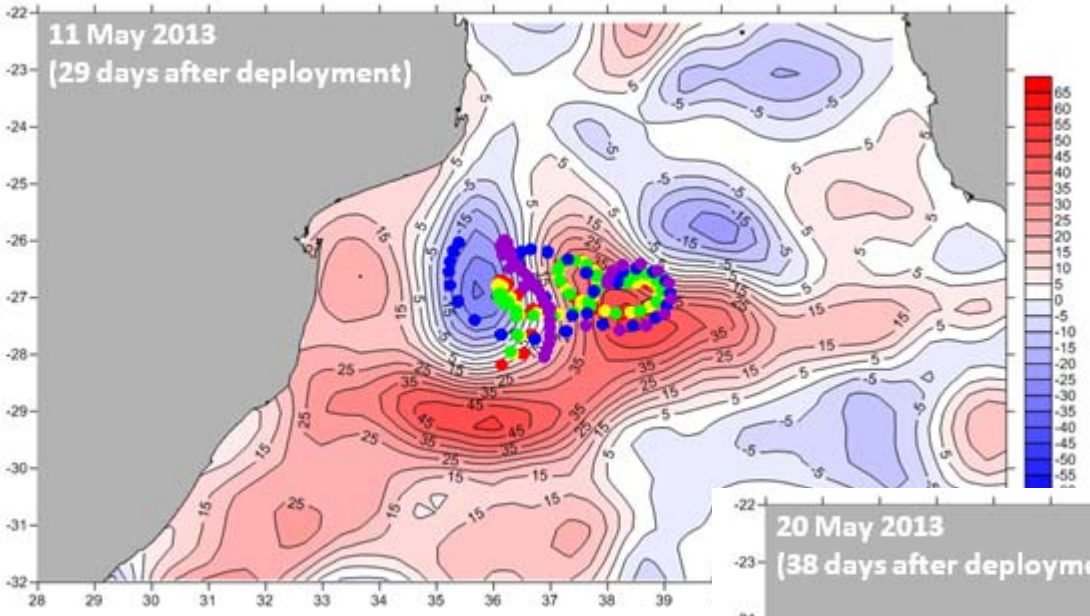
<u>23 days after deployment:</u>

3 inner floats still close together and have completed a 2nd rotation with cyclonic eddy core

7131 – completed 2nd rotation with eddy edge

7135 – on 2nd rotation, float moves slowly southwards with cyclonic eddy

First experiment – April 2013



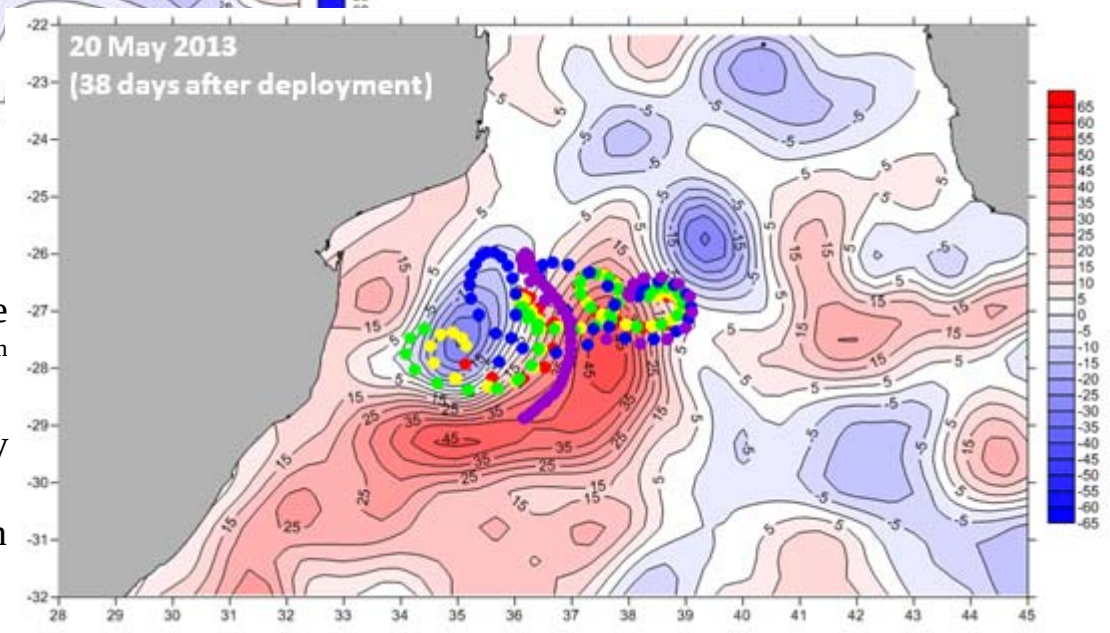
<u>29 days after deployment:</u>

3 inner floats begin moving apart

7087 - dies after 33rd profile

7131 - still with cyclonic eddy edge

7135 - still moving southwards, but becomes entrained with frontal area between cyclonic and anti-cyclonic eddy further south



<u>38 days after deployment:</u>

7087 – dead, but still shown on this image

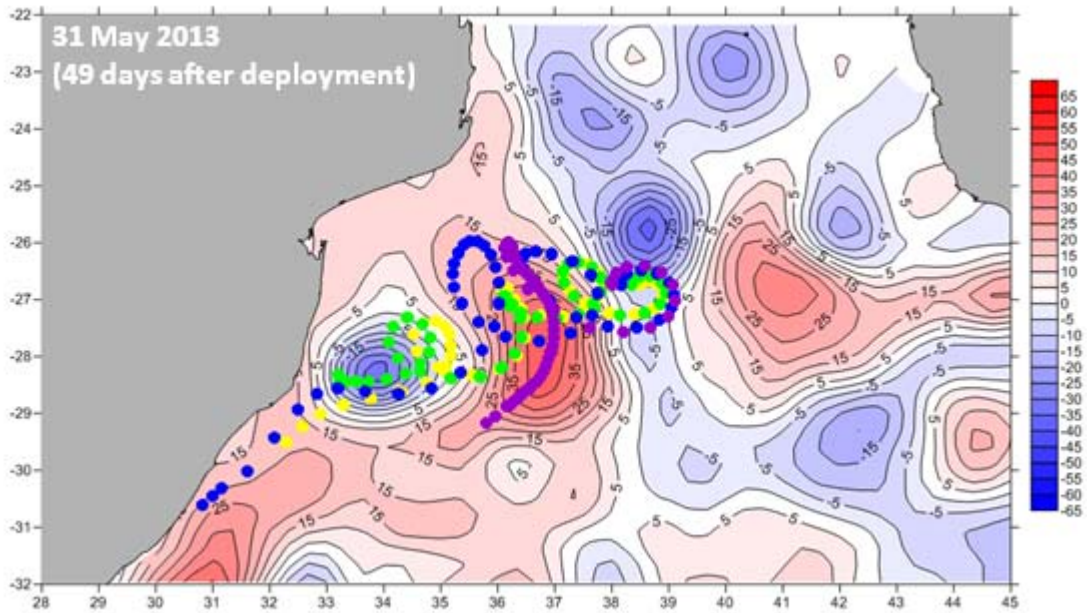
7094 + 7130 – still with cyclonic eddy

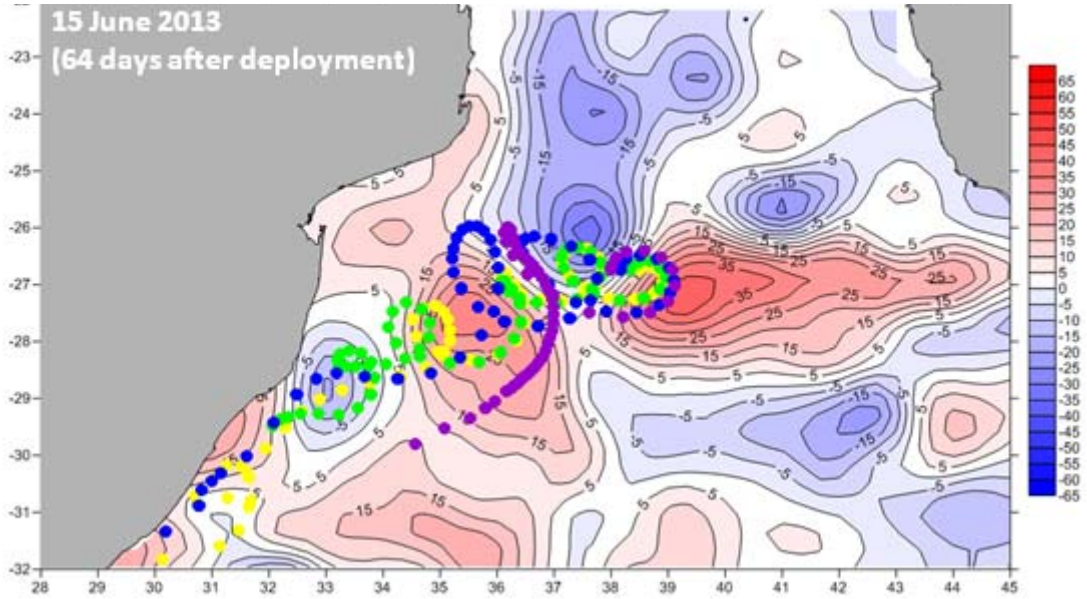
7094 is with the eddy core and 7130 the cyclonic eddy edge and onto their 4th rotations

7131 – completes 3rd rotation with eddy edge

7135 – moves into positive SSHA between the two high pressures

First experiment – April 2013





<u>49 days after deployment:</u>

7094 – completed 4 rotations but then moves southwards with an assumedly stronger Agulhas Current

7130 – completes 4 rotations and stays with eddy even though it was on the edge previously

7131 – only completed 3 rotations before moving southwards fairly briskly with Agulhas Current

7135 – programming change at ~ 50th profile to 5-day intervals and 2000 m profiling. Moves southwards with anti-cyclone

<u>64 days after deployment:</u>

All floats have now moved out of the cyclonic eddy, with 7130 having completed one final rotation

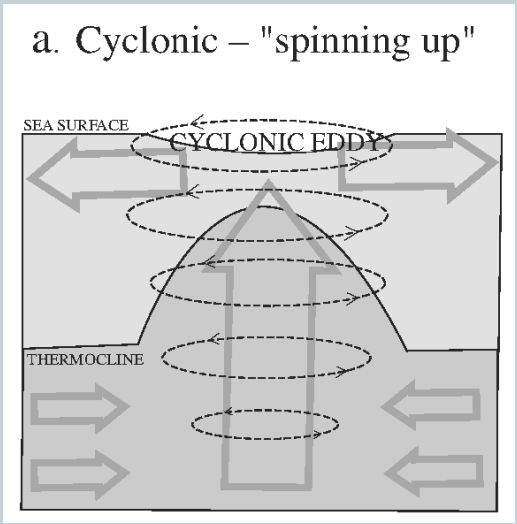
7094 becomes involved with a smaller cyclonic rotation off Durban assumed to be the Durban Cyclonic Eddy (trapped lee eddy)...no signature on SSHA of this anomaly

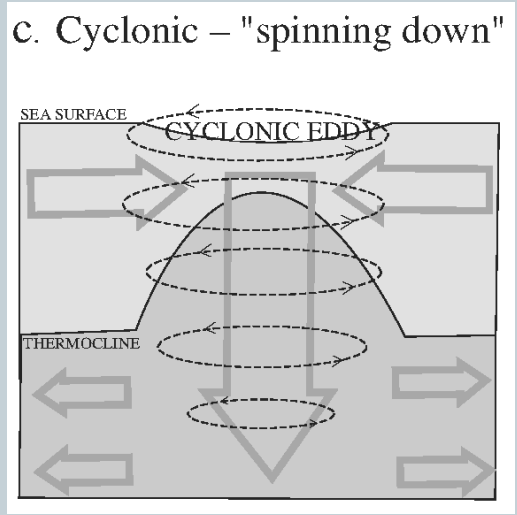
All moving with Agulhas Current (7135?)

Results and discussion so far...

- Borrowing from Bakun (2006) eddy theory – did the floats programmed to park deeper (7087 @ 300 m, 7094 @ 500 m and 7130 @ 650 m) stay longer in the cyclonic eddy before being pushed out as the eddy was spinning up?
- This would suggest internal flow
- Related to this, does the eddy spin down as it comes into contact with the South African coast or not?

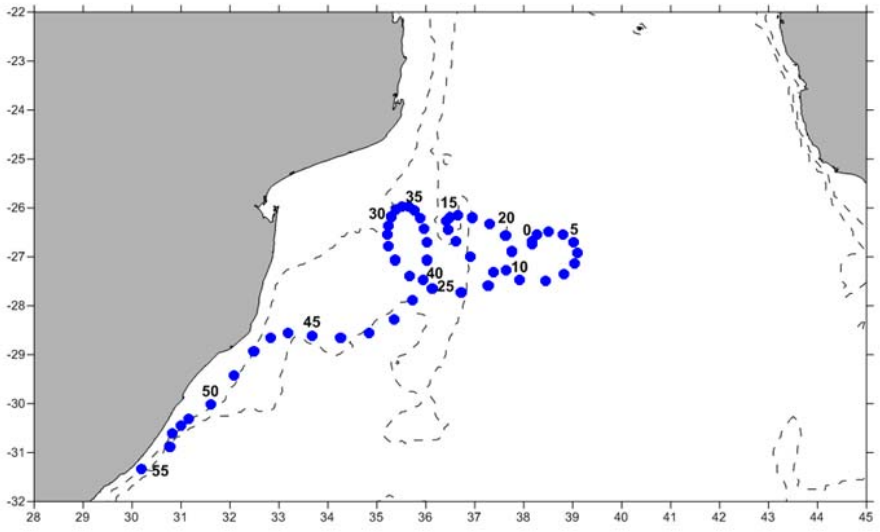
- Velocities in the northern section of the eddy rotations seem slower (weaker) than those to the south of the rotation
- Is this due to the general southward background flow and eventually the influence of the Agulhas Current, or are the eddies not symmetrical as suggested by Ridderinkhof *et al* (2013)? This requires further analysis on mass volume transport.

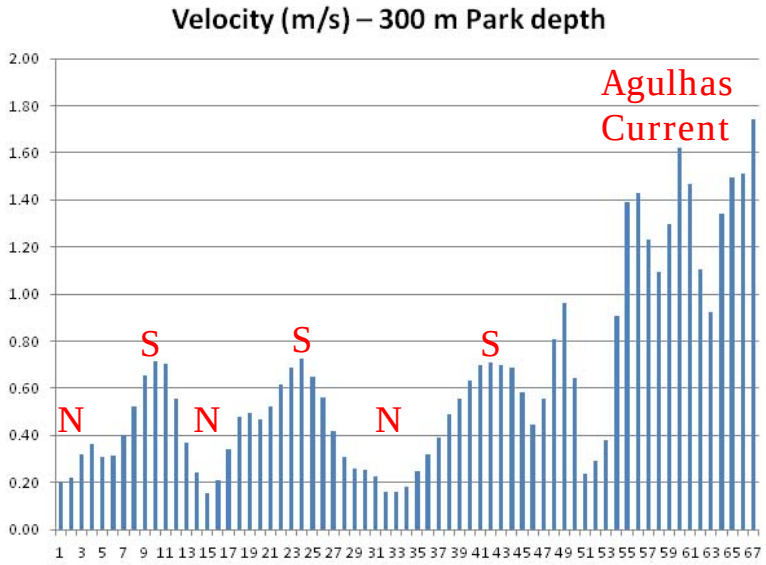




Results and discussion so far…

Example:
Float 7131 – no change to park depth (thus 300 m)



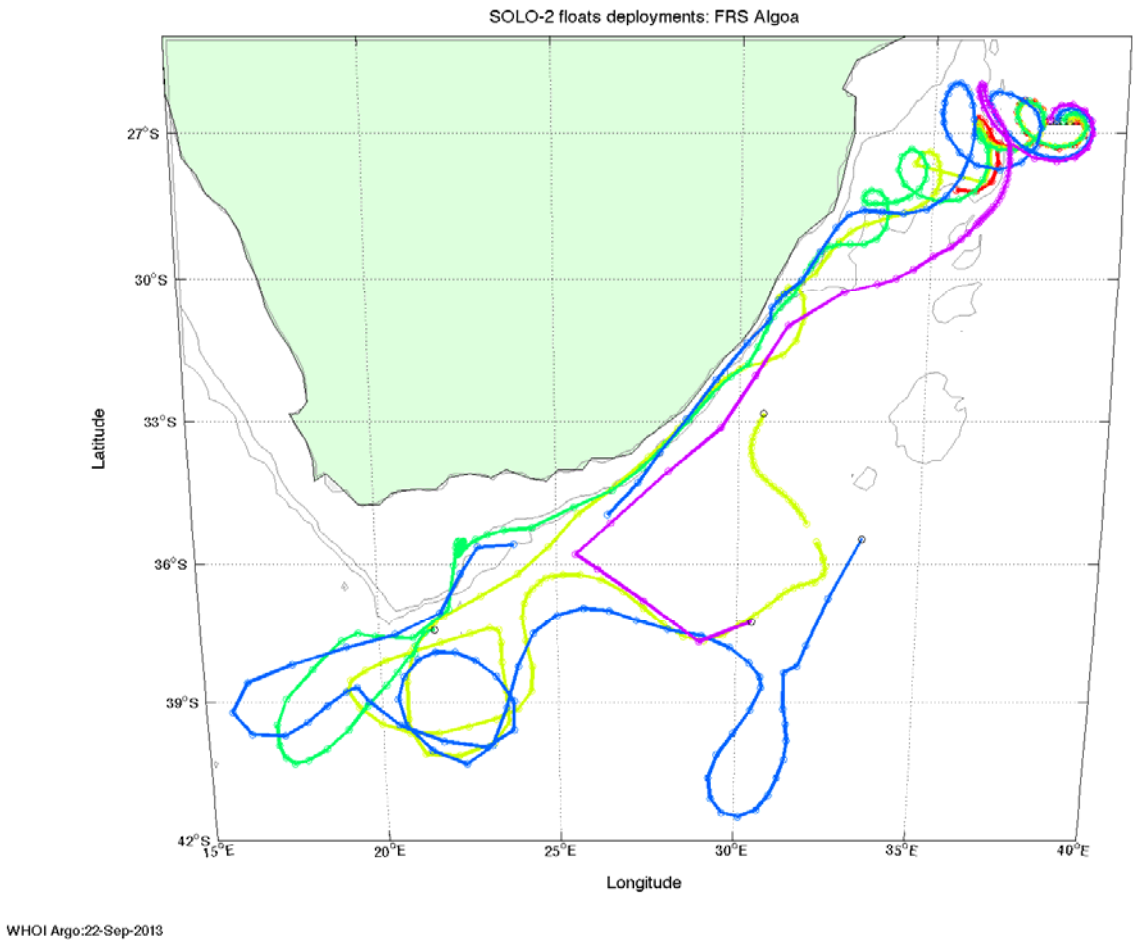


Additional analysis:

How does the eddy kinetic energy (EKE) change over time and how does this impact the float retention?

Are the water masses inside the cyclonic eddy conserved – thus a detailed analysis of the profiles themselves and water mass analysis still to do

And where are the floats now…



The second and third experiments:

Second:

4 x APEX floats donated by UK Met Office

Set to 500 m park depth, 5-day sampling and 1000 m profiling

Deployed in July 2013 into a cyclonic eddy – results still be analyzed

Third:

2 x APEX floats donated by CSIRO.

Still to be set up for deployment in December 2013. Potentially deploy within an anti-cyclonic eddy

References

- Bakun, A. – 2006. Fronts and eddies as key structures in the habitat of marine fish larvae: opportunity, adaptive response and competitive advantage. *Recent advances in the stufy of fish eggs and larvae.* M.P. Olivar and J.J. Govoni (eds). ISSN: 0214-8358. 105-122
- Quartly, G. D., Buck, J.J.H., Srokosz, M.A. and Coward, A.C. – 2006. Eddies around Madagascar – The retroflection reconsidered. *Journal of Marine Systems.* Vol. 63. 115-129
- Ridderinkhof, W., Le Bars, D., von der Heydt, A.S. and de Ruijter, W. P. M. – 2013. Dipoles of the South East Madagascar Current. *Geophysical Research Letters.* Vol. 40. 558-562.
- Tew-Kai, E. and Marsac, F – 2009. Patterns of variability of sea surface chlorophyll in the Mozambique Channel: A quantitative approach. *Journal of Marine Systems.* Vol. 77. 77-88.

THANK YOU

Merci!