Lagrangian tracking of meso and submesoscale features in the Southwestern Atlantic

M. Saraceno (1,2,3)*, N. Bodnariuk (1,2,3), L.A. Ruiz-Etcheverry (1,2,3), M. Berta (4), C.G. Simionato (1,2,3), F.J. Beron-Vera (5), J. Olascoaga (6)

(1) Departamento de Ciencias de la Atmósfera y los Océanos, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires (DCAO, FCEN-UBA), Intendente Guiraldes 2160, Ciudad Universitaria, Pabellon II 2do. Piso; C1428EGA Ciudad Autónoma de Buenos Aires, Argentina; (2) Centro de Investigaciones del Mar y la Atmosfera (CIMA/CONICET-UBA); (3) Instituto Franco-Argentino para el Estudio del Clima y sus Impactos (IRL-IFAECI/CNRS-CONICET-UBA); (4) CNR-ISMAR, La Spezia, Italy ; (5) Rosenstiel School of Marine, Atmospheric, and Earth Science (RSMAS), Atmospheric Department, University of Miami, FL 33149 USA; (6) Rosenstiel School of Marine, Atmospheric, and Earth Science (RSMAS), Oceanographic Department, University of Miami, FL 33149 USA

Abstract

The Southwestern Atlantic (SWA) is characterized by its large Eddy Kinetic Energy as the result of the confluence of two major western boundary currents, the northward flowing Malvinas Current (MC) and the southward flowing Brazil Current.

The present study constitutes the first effort to sample a portion of the SWA, with a dense drifter array (N = 62), anchored at 15 m depths. Drifters were set to deliver their position every 10 and 60 minutes, providing accurate Lagrangian trajectories that give information on a large range of space and time scales of the surface currents.

Three regions are clearly identified based on the analysis of the de-tided speed of the drifters and of their trajectories: the continental shelf, the slope and the open ocean.

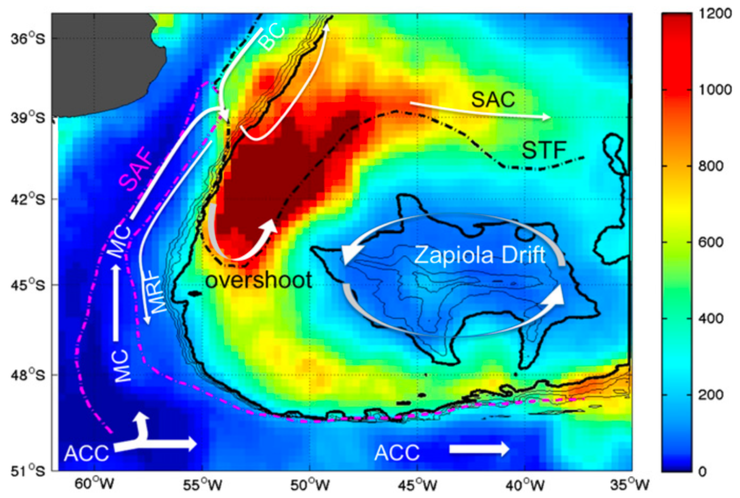


Fig. 1. Colors indicate the EKE values (units $cm^2\ s^{-2}$) of sea-level anomalies for the period 1992–2010 estimated from satellite altimetry data (see text for details of the dataset). Black lines indicate potential vorticity isolines (units $-1x10^{-8}\ m^{-1}\ s^{-1}$) and range from $-2.1x10^{-8}\ m^{-1}\ s^{-1}$ to $-1.92x10^{-8}\ m^{-1}\ s^{-1}$. The boldface closed potential vorticity contour centred at 43°W, 45°S corresponds to the $-1.92x10^{-8}\ m^{-1}\ s^{-1}$ value and is used to represent the Zapiola Drift area (Saraceno et al., 2009). The mean positions of the Subtropical Front (STF) and the Subantarctic Front (SAF) are from Saraceno et al. (2004) and are indicated by black and magenta dash-dotted lines, respectively. Representative positions of the Brazil Current (BC), Malvinas Current (MC), Malvinas Return Flow (MRF), Antarctic Circumpolar Current (ACC), South Atlantic Current (SAC) and overshoot region are indicated. Adapted from Saraceno and Provost, DSR-I 2012.

Drifter trajectories & satellite altimetry

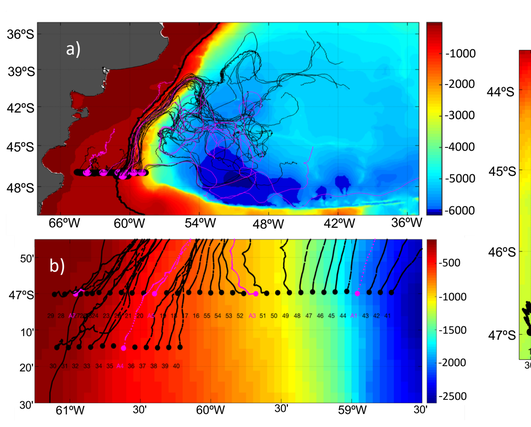


Figure 1: Trajectory of the 62 drifters deployed. Large dots correspond to the initial position. 55 custom drifters correspond to black lines; 7 magenta lines correspond to drifters provided by NOAA. In the background the topography is represented (m, IOC,2003). The 200m isobath is indicated with a black width line. (a) shows the complete trajectories; (b) shows a zoom for the drifters located over the continental slope and (c) shows a zoom over the continental shelf.

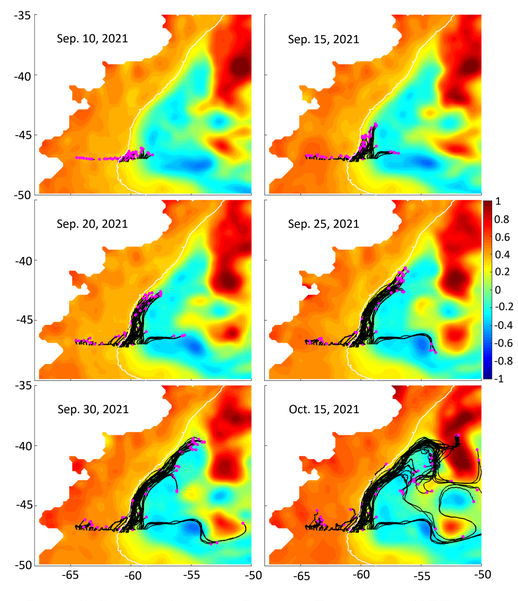


Figure 2: Satellite Absolute Dynamic Topography (ADT, in m) and drifter trajectories for different days after deployment.

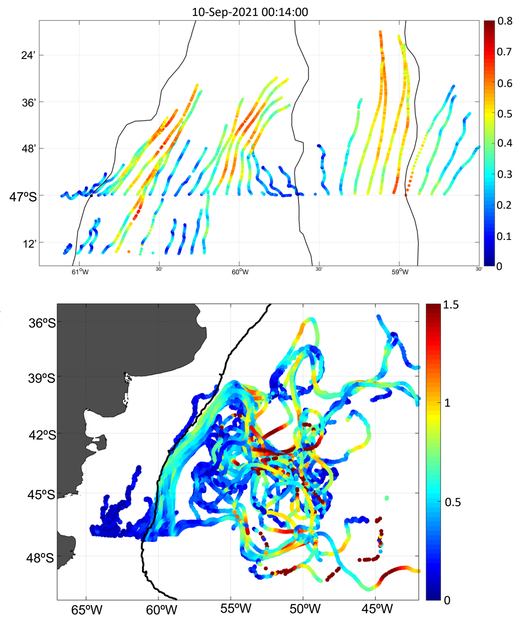


Figure 3: De-tided speed velocity of the drifters

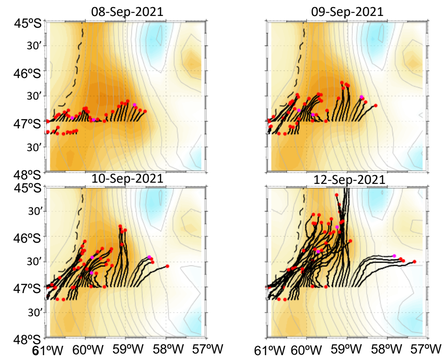
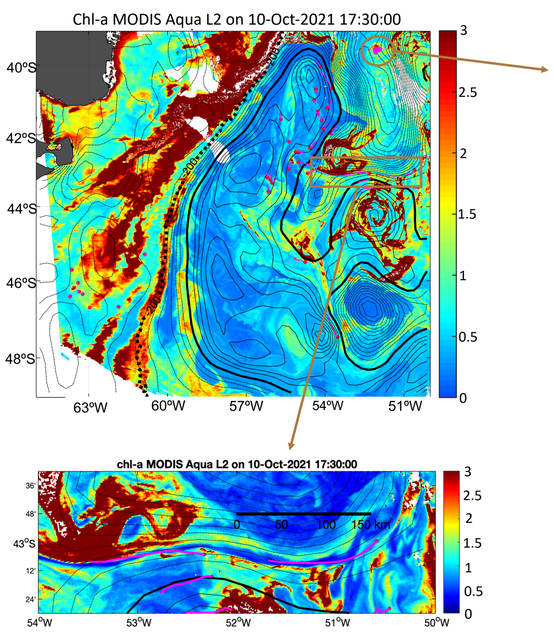


Figure 4:SLA (colors, m) and ADT (gray contours) and drifter trajectories (black lines) during the first four days after deployment. ADT contours are each 0.05 m

Drifter trajectories & color images



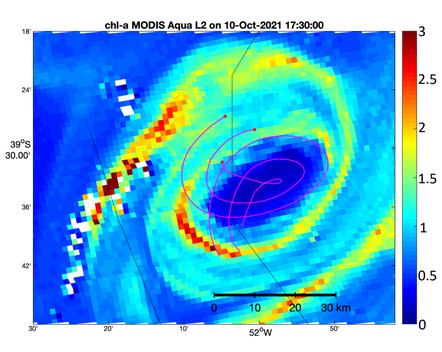


Figure 5: Background colors is chlorophyll-a concentration (mg/m^3) from MODIS Aqua L2 on 10 October 2021, 17:30 GMT. Black lines: positive contours of ADT; dash-dot black lines: negative contours of ADT; bold black line: zero contour of ADT. All ADT contours are each 0.05 m. Trajectories of all the drifters during the 24hs centered on satellite image are displayed in magenta; the red dot indicates the latest position within the trajectory parkoured during the day of the image. The 200 m isobath is indicated with a black bold dot line.

Discussion & Conclusions

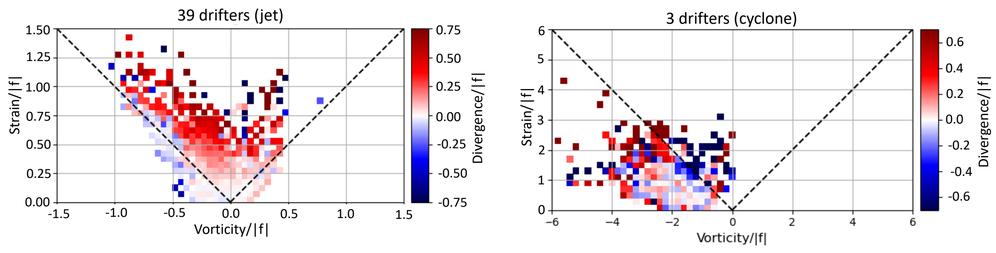


Figure 6: scatterplots of normalized strain versus normalized vorticity for the 39-drifter experiment (left panel) and for the 3-drifter configuration (right panel). Colors are normalized divergence in both panels.

- The comparison of the trajectories of the drifters with satellite altimetry images shows that, in general, drifters follow mesoscale features that are detectable in satellite altimetry maps.
- In particular regions, as within the MC, the deployment design of the drifters allowed to show the presence of three jets, while satellite altimetry data suggests only the presence of two.
- The analysis of drifter trajectories allowed also the study of submesoscale features of the flow (1 to 10 km) that are not observable in satellite altimetry data.
- Comparison with cloud-free, high-resolution color images, shows that drifter trajectories organized by the mesoscale flow might also locally follow sub-mesoscale features.
- In frontal regions it was found that drifter velocities double satellite altimetry geostrophic velocities, which suggests that the dynamics at those regions is largely dominated by ageostrophic components.
- Finally, the spatial density distribution of the drifters during the first hours after deployment and within a submesoscale eddy allowed also to characterize the flow in terms of its divergence, vorticity and strain, indicating that the MC is geostrophic and has a jet-like behavior while the eddy is largely ageostrophic and has a dominant vorticity component over strain.
- We conclude that the analysis of a dense array of drifters provides valuable information of the flow that cannot be attained solely on the basis of satellite data.

Acknowledgements

The following projects support this research: **EUMETSAT/CNES** (France), Studying physical processes in the Southwestern Atlantic to understand BIOlogical productivity & regional ecosystems (SABIO) & ONR On the permeability of the Malvinas Current, Proposal #6000002212, grant 12275382