Biophysical Regions and Surface Fronts in the Western South Atlantic

Martin Saraceno (1), Christine Provost (1) and Alberto Piola (2)

1: Laboratoire d'Océanographie Dynamique et de Climatologie (LODYC), Université Pierre et Marie Curie - Tour 45, Etage 5, Boite 100, 4 Place Jussieu, 75252 Paris cedex 05. France
2: Departamento de Oceanografía, Servicio de Hidrografía Naval, Av. Montes de Oca 2124, (1271) Buenos Aires, and Departamento de Ciencias de la Atmósfera y los Océanos, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Buenos Aires, Argentina.

Contact: Martin.Saraceno@lodyc.jussieu.fr

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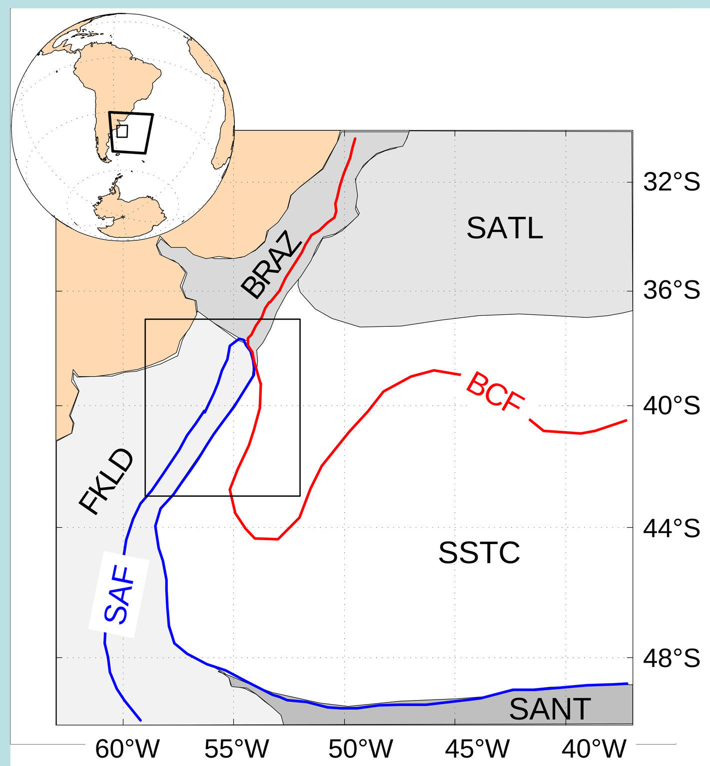
a. The South Western Atlantic Ocean

The South Western Atlantic (SWA) ocean circulation is characterized by the Brazil/Malvinas Confluence region, which makes this region one of the most energetic of the world ocean.



Mean BCF and SAF positions are from Saraceno et al (in press).

Fig. 1: The Confluence is formed by the collision between the Malvinas Current (MC) and Brazil Current (BC) near 38°S (Fig. 1).

The Brazil Current Front (BCF) is the southern limit of the warm and salty South Atlantic Central Water transported by the BC.

The Subantarctic Front (SAF) is the northern limit of the Subantarctic water in the SWA.

After its confluence with the MC, the BC flows southward and returns to the northeast at about 44°S (overshoot of the Brazil Current).

After the collision with the BC the main flow of the MC describes a sharp loop forming the Malvinas Return Flow (MRF).

Longhurst (1998) defines the following Biophysical Provinces in the SWA: South Atlantic Gyral Province (SATL), Brazil Current Costal Province (BRAZ), Southwest Atlantic Shelves Province (FKLD), South Subtropical Convergence Province (SSTC) and Subantarctic Water Ring Province (SANT).

Objectives: better describe and understand the surface dynamics of the region …

- Position of the Brazil-Malvinas Collision front
- The Zapiola Rise
- Overshoot of the BCF
- Limits of the Biophysical Regions

b. Data and Methods

…using chlorophyll-a as a tracer of the fronts.

Chlorophyll-a is a good tracer of the frontal dynamics: Fig. 2 shows high (up to 15 mg/m³) chlorophyll-a concentration values along the BCF.

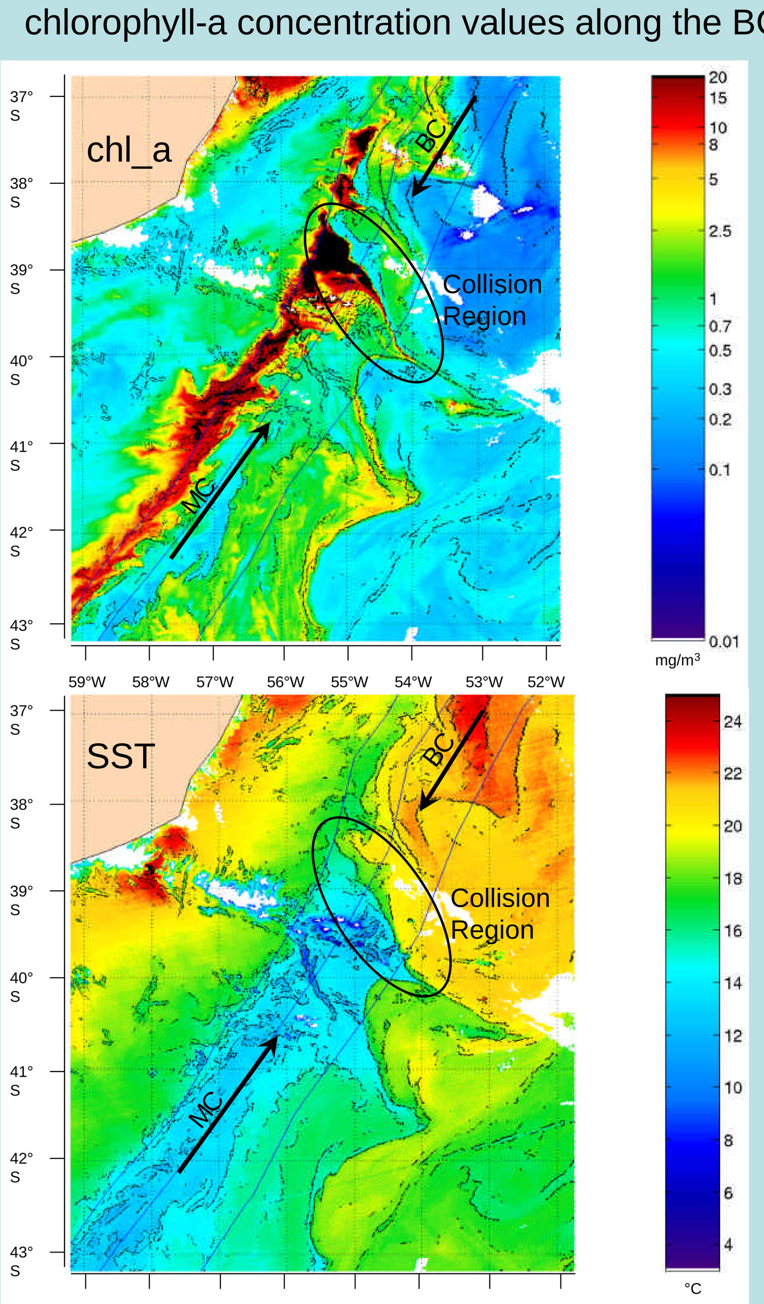


Fig. 2: 1Km spatial resolution of chlorophyll-a (top) and Sea Surface Temperature (SST - bottom) in the Brazil/ Malvinas Confluence Region on January 13, 2003. The region corresponds to the rectangle marked in Fig. 1. Data were obtained from the MODIS satellite. Thin blue lines correspond (from west to east) respectively to the 300, 1000 and 3000 m isobath depth. Thin black lines are maximum SST gradients.
The highest values (up to 20 mg/m³) along the 300m isobath correspond to the Shelf-Break Front.

MODIS collects chlorophyll-a and SST images at the same time, and both kind of fronts can be compared. Unfortunately MODIS data are available only since December 1999. In this work we compare longer time series with an appropriate cloud mask applied to the region:

-9 years (1985-1996) of AVHRR data (4 Km spatial resolution, 5 days interpolated).

- 5 years (1998-2002) SeaWiFS level 3 data for the chlorophyll-a (9Km spatial resolution, 8 days interpolated).

c. Observations

Monthly climatologies representative of the space-time variability of the Chlorophyll-a and SST gradient.

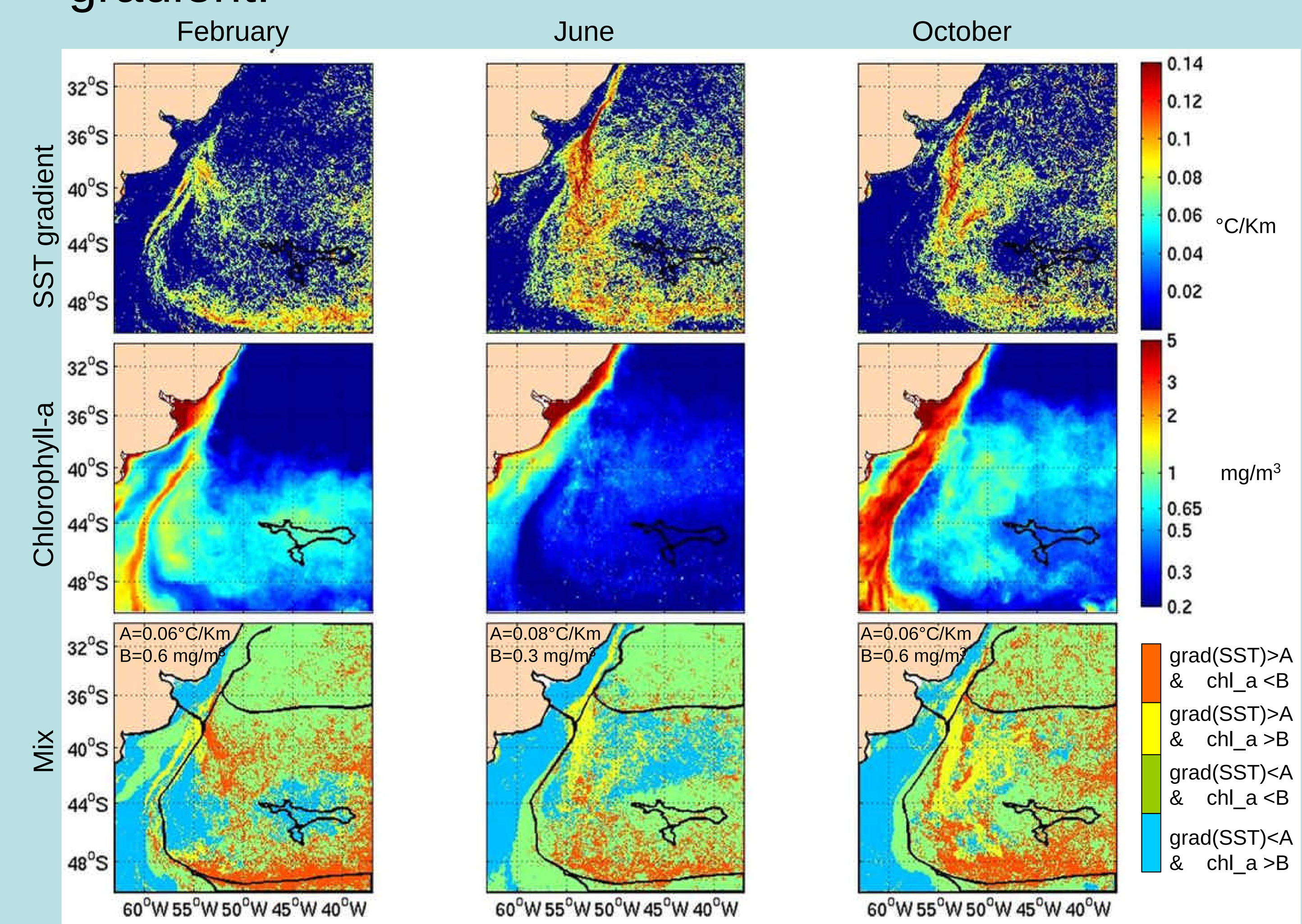


Fig. 3: February, June and October monthly climatologies of SST gradient magnitudes and Chlorophyll-a (upper and middle row respectively). The thin black line centered at 45°S 43°W is the closed planetary vorticity contour indicating the presence of the Zapiola Rise. The bottom row shows the spatial correspondence between SST gradient and chlorophyll-a values; A and B are the threshold used to select values. Other black lines are the limits of the Biophysical Provinces marked in Fig. 1. Climatologies are constructed using 9 years (1985-1996) of AVHRR data (4 Km spatial resolution) for the gradient of SST and 5 years (1998-2002) SeaWiFS level 3 data for the Chlorophyll-a (chl_a).

- Relatively high SST gradient magnitude and chl_a values are present throughout the year in the BM Collision region (yellow pixels in the bottom row).

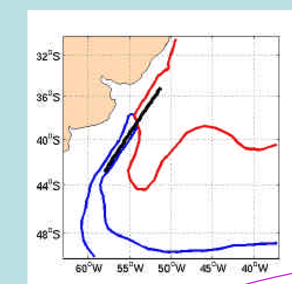
- The Overshoot Region shows a good correspondence (yellow pixels in the bottom row) between relatively high SST gradient and high chl_a values in June and October but not in February where top SST gradient values (orange pixels) are north of top chl_a values (cyan pixels). Southern high SST gradient values may be masked by the very strong shallow seasonal thermocline that develops in austral summer in the region.

- The Shelf-Break Front is remarkably well detected in chl_a values and has a good correspondence with SST gradient values in February.

- The Zapiola Rise shows up as a free SST gradient region throughout the year, and exhibits a locally maximum concentration in chl_a in February and a minimum in October.

Chlorophyll-a space-time sections

Brazil-Malvinas Collision



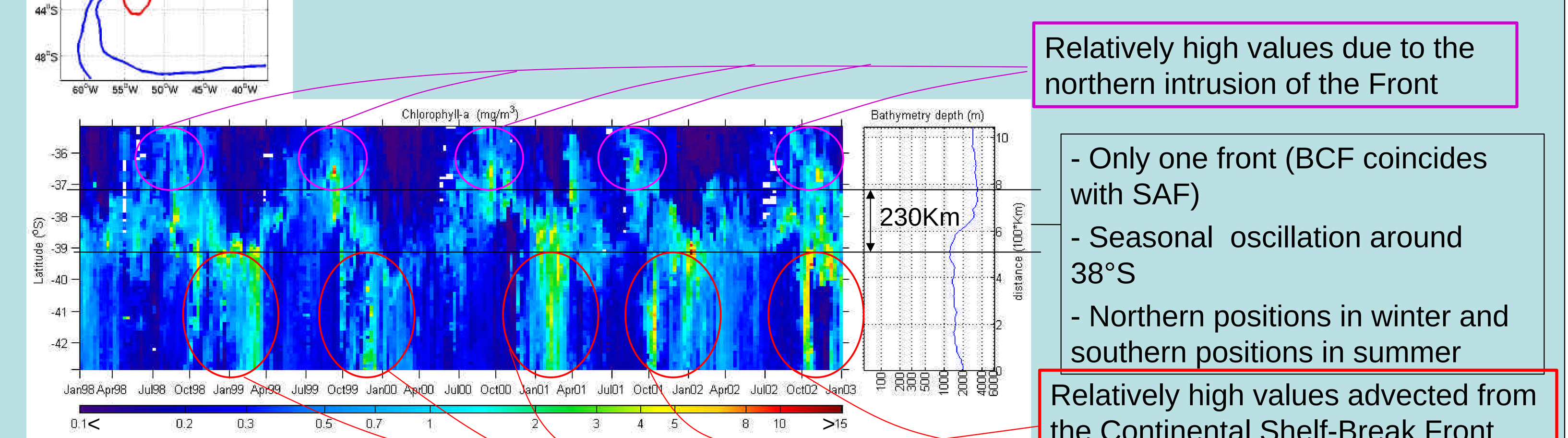
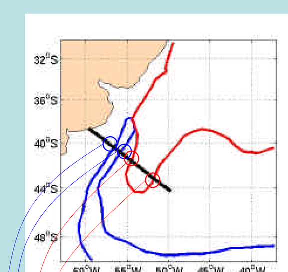


Fig. 4: Chlorophyll-a (SeaWiFS level 3, 8-day average) versus time along the section indicated with the black line on the map.

Malvinas Current + Brazil Current Overshoot



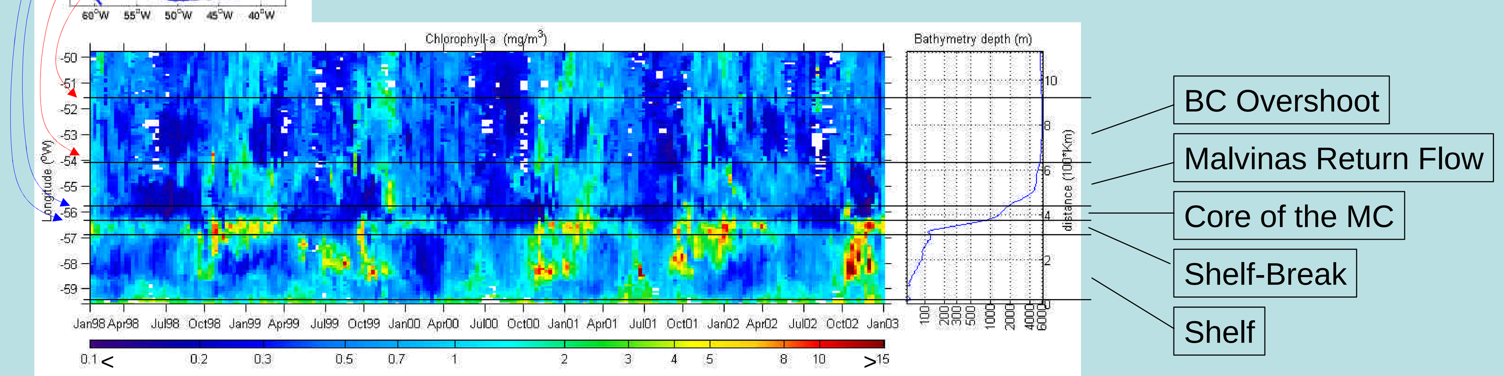


Fig. 5: Chlorophyll-a (SeaWiFS level 3, 8-day average) versus time along the section indicated with the black line on the map.

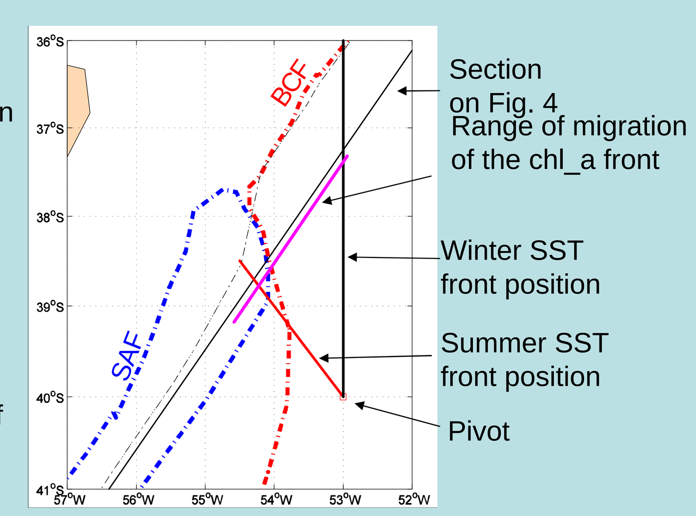
- The highest chl_a values on the section are present over the shelf and the shelf-break.
- The shelf-break presents high chl_a values during austral spring and summer.
- A relative minimum around 56°W in the section indicates the presence of the MC.
- The shelf-break determines the position of the MC.
- At ~54°W and ~51.5°W a relative maximum marks the position where the BCF crosses the section.

d. Results

SST and surface chl_a fronts show similar frontal migration in the BM Collision Region

In the collision region chl_a shows only one front (Fig. 4).
Frontal probability maps obtained from SST gradient fields also show only one front that pivots around a fixed point having a NS direction in winter and a NW-SE direction in summer (Saraceno et al, in press).
The range of migration of the chl_a front along the section used on Fig. 4 is slightly larger (50Km) than the separation between the winter and summer positions of the SST front (Fig. 6).

Fig. 6: Schematic positions of the surface fronts in the BM collision region. Summer, winter and pivot positions as mean BCF and SAF position are from Saraceno et al (in press). Dash-dot line is the 1000m isobath depth. The magenta segment is the range of migration of the chl_a front along the section used on Fig. 4.



The Zapiola Rise stands out as an independent region

The Zapiola Rise stands out as an independent region inside the SSTC province: dynamically isolated (see below) chl_a values present a different behavior from surrounding areas.

The Zapiola Rise stands out as a region devoid of SST gradients. Fu et al (2001) suggested that the closed planetary potential vorticity contours provide a mechanism for the confinement of the waves associated with the topographic feature of the Zapiola Rise. The region is therefore dynamically isolated and consequently corresponds to local minimum SST gradient values (Saraceno et al., in press).

Influence of the bathymetry

- Bathymetric features such as the continental shelf, shelf-break and the Zapiola Rise strongly affect the chl_a distribution.
- The Shelf-Break front (FKLD Province) presents high chl_a values that persist in the region longer than inside the shelf.
- In contrast, the Collision and Overshoot regions show high chl_a values without any correlation with the bathymetry.
- A relative maximum in chl_a (Fig. 3) shows a seasonal movement (to the north in winter and to the south in summer) of the limits of the SSTC Province. High SST gradient values have coincident positions throughout the year but in summer, probably because of the seasonal thermocline that homogenizes SST values in austral summer.

Future work / Open questions:

- What are the main forcing mechanisms responsible for the pivoting of the front in the Collision Region?
- Why does chl_a show a minimum over the Zapiola Rise in austral spring?
- How much do eddies affect the chl_a distribution in the SSTC Province?

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