Wind and Western Boundary Currents driven the Eastern Brazilian Shelf Circulation (10°S – 16°S): a numerical study

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Introduction

The region of study (Fig. 1) encompasses an important dynamic part of the Eastern Brazilian Shelf (EBS), which hosts the bifurcation of the South Equatorial Current (SEC) into the two major Brazilian Western Boundary Currents (WBC): the southward Brazil Current (BC) and the northward North Brazil Current/Undercurrent (NBC/NBUC). The SEC bifurcation, in the top 400 m, undergoes a strong meridional seasonal cycle due to the north-south displacement of the marine Inter-Tropical Convergence Zone (ITCZ), reaching a southernmost (northernmost) position at 17°S (13°S) latitude in July (November) (*Rodrigues et al., 2007*). The bifurcation also undergoes a latitudinal excursion with depth, reaching ~22°S at ~400 m depth.

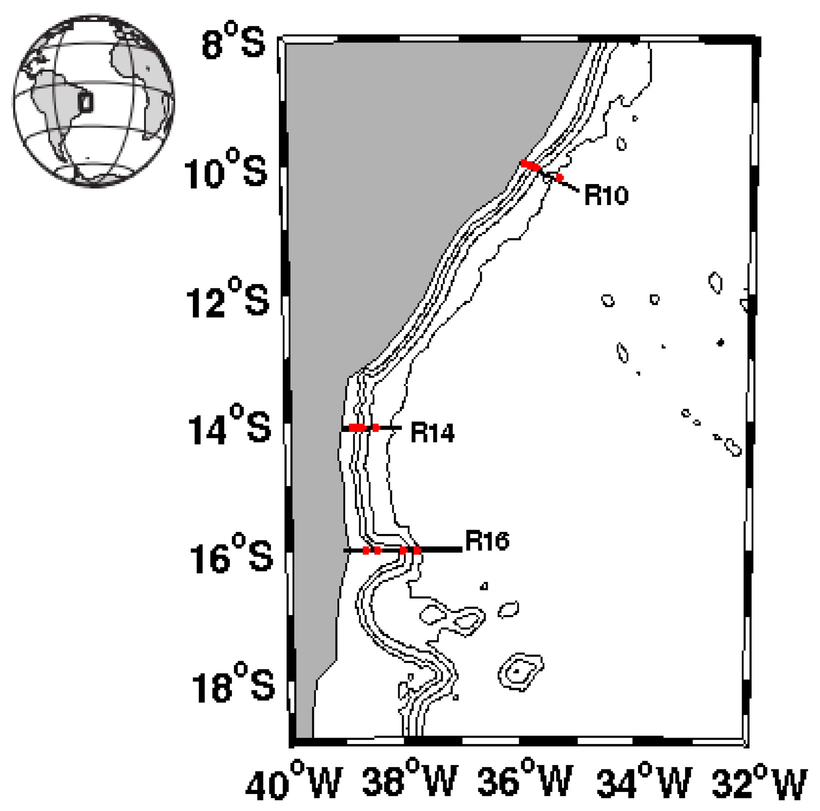

Figure 1 – Modeling domain presenting the radials selected to evaluate the seasonal hydrodynamics. The red dots represent the locations at inner-shelf, mid-shelf, shelf-break and slope regions, where the current time-series are evaluated. The bold black line represents the 70 m isobath (shelf-break) and the light black lines represent the 200 m, 1000 m and 3000 m isobaths.

Following the large scale seasonality of the trade winds, the shelf currents along the EBS are mainly wind driven, experiencing a complete reversal of the mean flow between seasons due to a similar change in the wind field (*Amorim et al., 2011, 2012*). The arrival of cold-frontal systems during the spring season is able to cause periodical reversals of the depth-integrated flow (*Amorim et al., 2012*). These authors have also shown that the shelf currents are influenced by the local topography and the meso-scale WBC dynamics, which can cause a total reversal of the mean flow or enhance the upwelling system characteristic of the spring/summer seasons.

Based on a long term regional model simulation, this work aims to investigate the influence of the wind and WBC driven the EBS shelf and slope circulation.

Methodology

A long-term integration (January 1st/2004 to December 31st/2009) was performed with the Regional Ocean Modeling System (ROMS), with embedded nesting capabilities based on AGRIF, configured with a refined grid (1/36°) and realistic forcings: i) topography from ETOPO1; ii) daily initial and boundary conditions from the 1/12° HYCOM Global Circulation Model (GCM) coupled on the NCODA system analysis. The model temperature, salinity and velocity (2D and 3D) were nudged towards the GCM daily values with a variable relaxation time scale; iii) surface boundary fluxes based on the 6-hourly NCEP Reanalysis 2; iv) 6-hourly surface wind stress and intensity from the QuickSCAT scatterometer and SMM/I radiometer provided by CERSAT/IFREMER and v) sea surface elevation and barotropic currents from TPXO tidal model.

The influence of the sub-inertial alongshore wind in the currents at shelf/shelf-break was investigated based on lagged cross-correlation functions, which are also used to investigate the correlation between the depth-integrated currents at the slope with those at the shelf/shelf-break.

Results

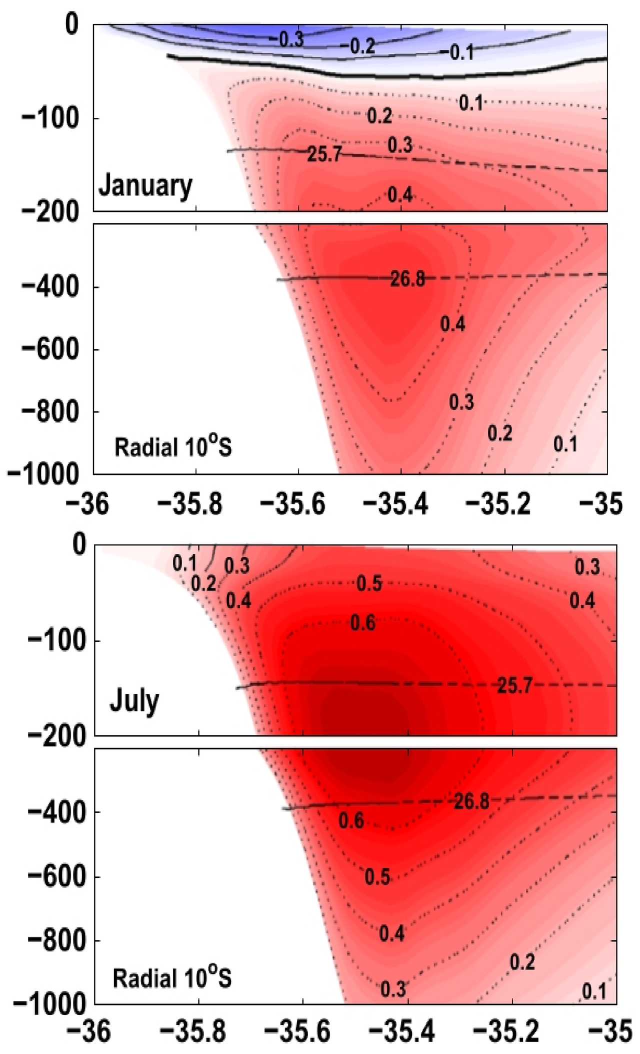

Figure 2 – Mean vertical sections of the alongshore velocity (m s⁻¹), positive (red) northwards, at radial R10. The dashed lines indicate the isopicnal limits of the Tropical Water and South Atlantic Central Water.

The model results show that for the 10°S region (Fig. 1, radial R10), the northward flow is the dominant pattern along the year, occupying the whole water column during the austral winter (see Fig. 2 for July). The southward flow appears as a shallow flow confined to the top 50 m of the water column during the austral spring/summer seasons (see Fig. 2 for January).

The surface circulation at the inner and mid shelf is mostly influenced by the wind forcing, while the bottom currents show a strong influence of the slope currents, presenting an uncoupled system (Fig. 3, IS and MS).

At the shelf break, the currents along depth are mostly driven by the slope currents during all seasons. As a result, during the autumn/winter scenario, when the surface circulation is northward, the surface and bottom currents are similar in intensity and direction (Fig. 3, SB).

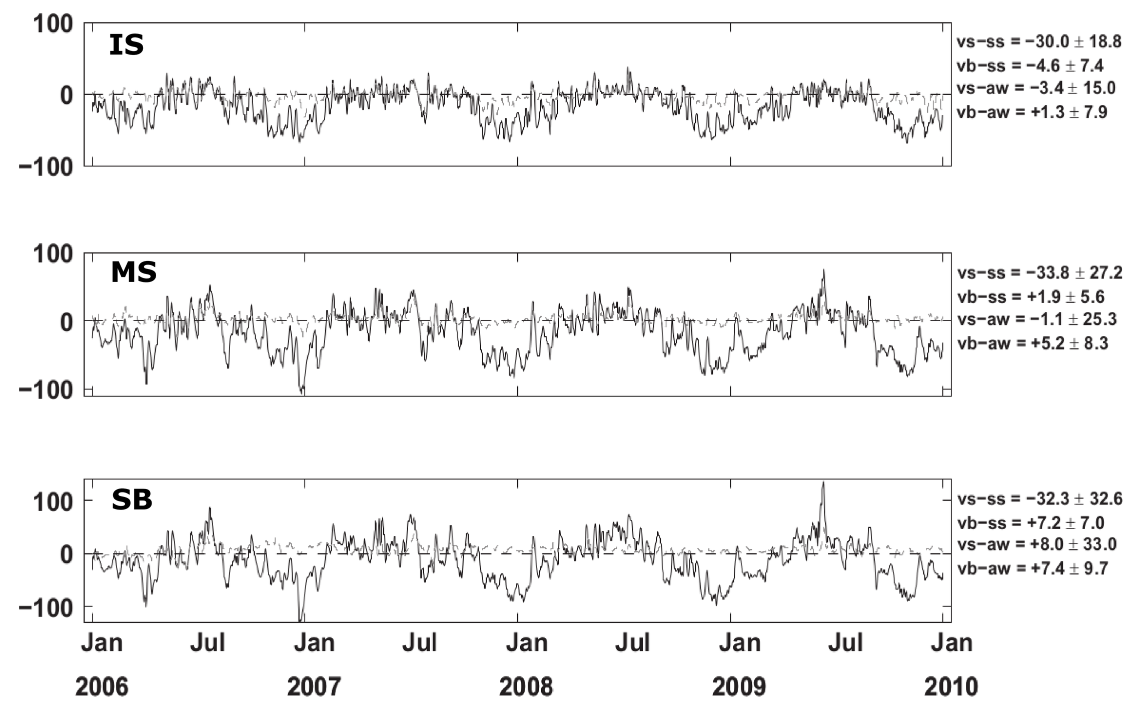

Figure 3 – Sub-inertial time-series (cm s⁻¹) of the alongshore surface (black lines) and bottom currents at the Inner-Shelf (IS), Mid-Shelf (MS) and Shelf-Break of radial R10.

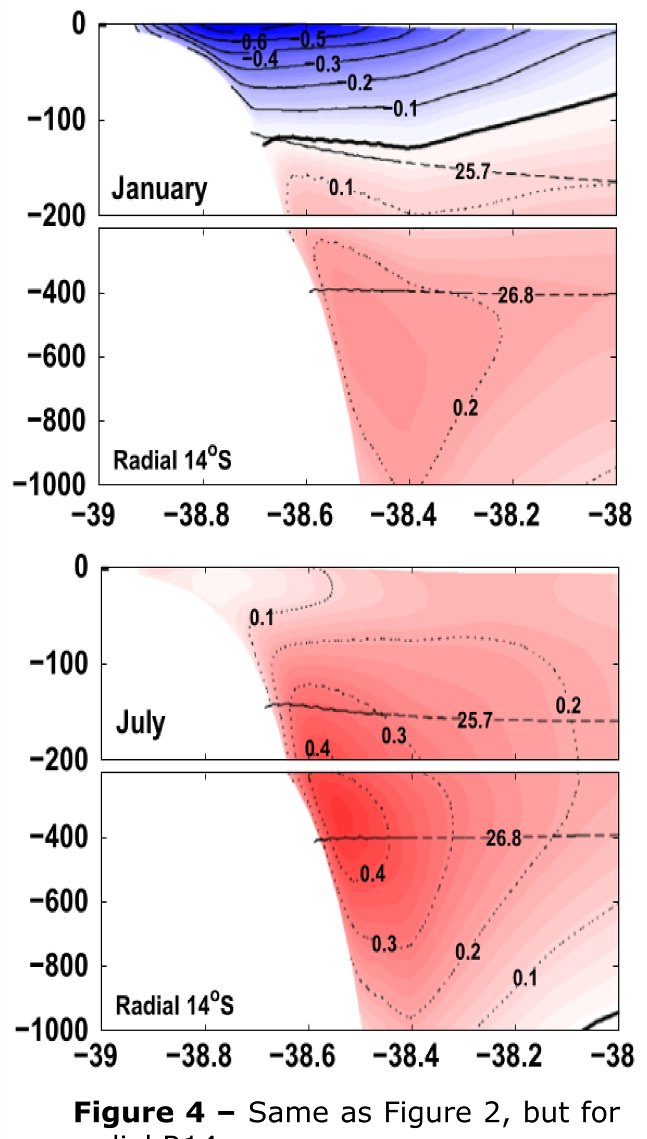

Figure 4 – Same as Figure 2, but for radial R14 .

At 14°S (Fig. 1, radial R14), there is an alternate dominance of the southward/northward flow for the first 150 m of the water column (*Amorim et al., 2013*), with the dominance of the southward (northward) flow between October-February (March-September).

On the other hand, in the sub-surface depths (~150 m–400 m) the dominance of the northward flow is clear (Fig. 4).

The inner shelf circulation at R14 is mainly driven by the wind forcing, presenting almost no shear along water column (Fig. 5, IS). At the mid shelf, the circulation is forced by both the wind and the flow over the slope, presenting a marked seasonal signal of baroclinicity, which is stronger during the austral autumn/spring seasons (Fig. 5, MS).

The currents at the shelf-break are more influenced by the currents at the slope (Fig. 5, SB).

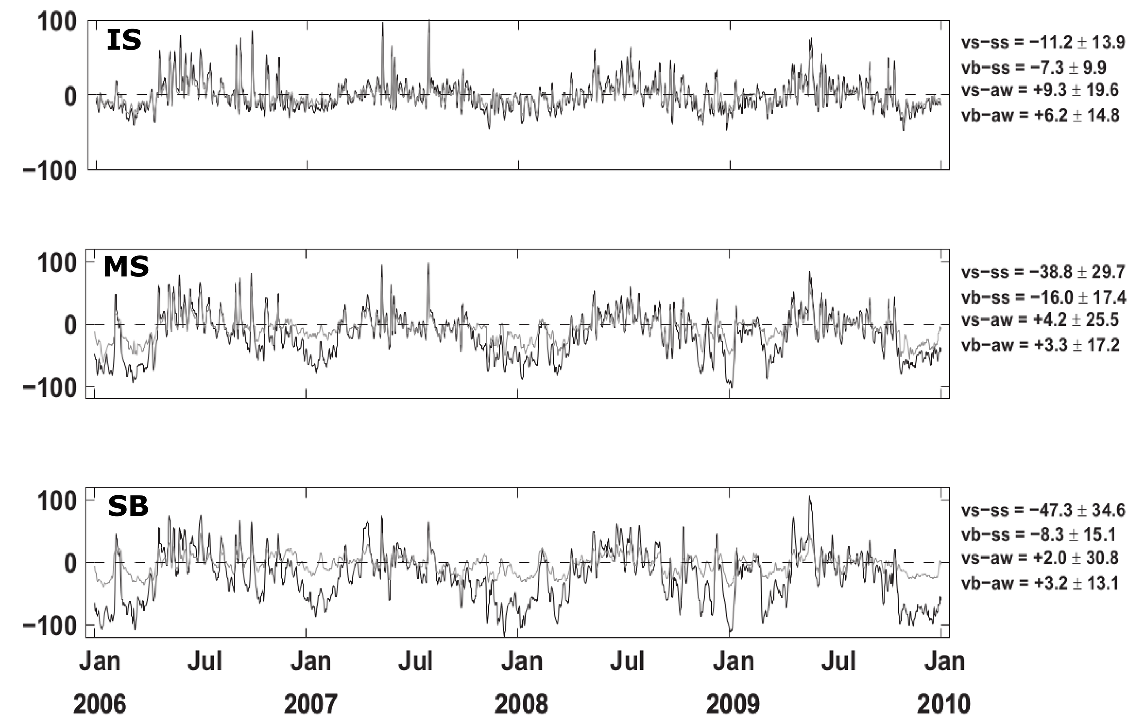

Figure 5 – Same as Figure 3, but for radial R14.

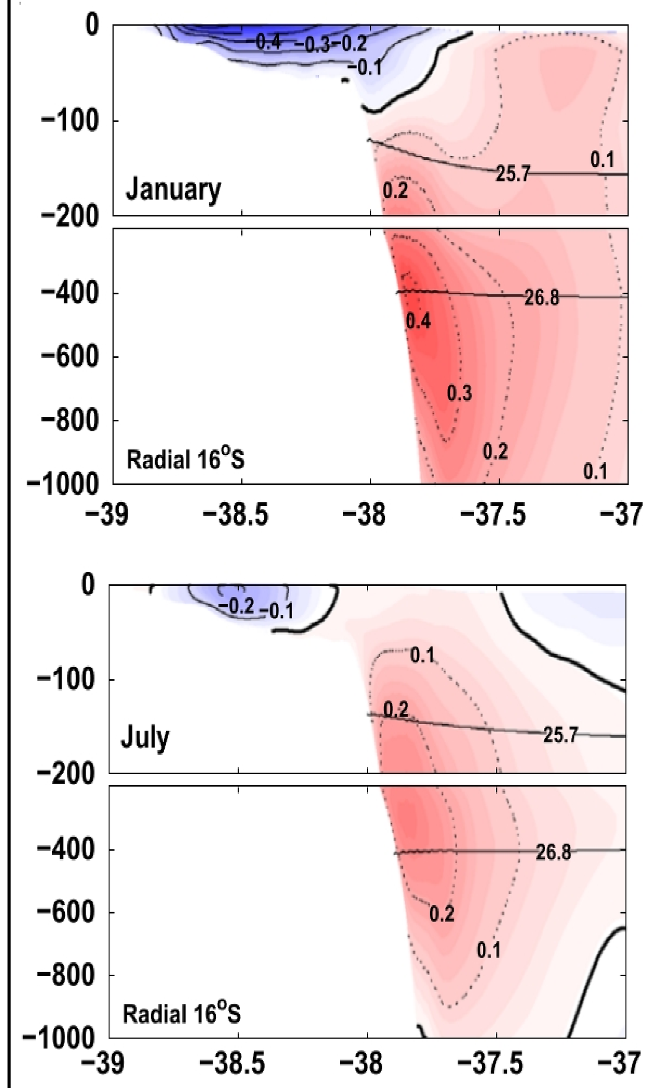

Figure 6 – Same as Figure 2, but for radial R16.

The circulation at 16°S (Fig. 1, R16) presents a continuous flow over the shelf/shelf-break along the year (Fig. 6), but an alternate dominance between the southward/northward flow is observed between seasons, with the dominance of the northward flow during the austral autumn/winter (*Amorim et al., 2013*).

The inner and mid shelf currents at this region are mainly driven by the wind forcing (Fig. 7, IS and MS).

The shelf-break currents present a poor correlation with the wind and a strong influence of the WBC dynamics (Fig. 7, SB).

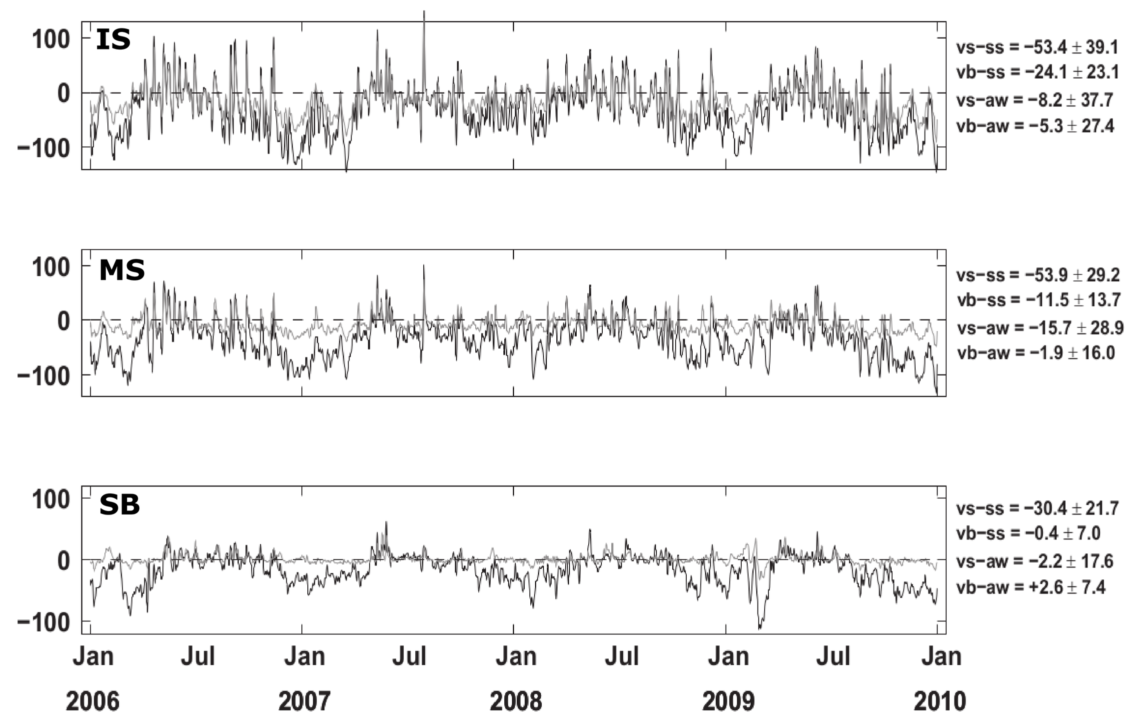

Figure 7 – Same as Figure 3, but for radial R16.

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