Seasonal behavior and the plume evolution of the Cabo Frio coastal upwelling, Brazil

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Introduction

The coastal upwelling process is characterized by the deep water ascension through the shelf. In the brazilian coast, the most intense upwelling occurs around Cabo Frio, RJ. The Cabo Frio coastal upwelling presents the South Atlantic Central Water (SACW), transported by the Brazil Current (BC), rising at the continental shelf. The isotherms and isopycnals blooms near the shelf break, with temperatures under 18 ºC [1]. The main forcing in this case is the northeast wind. The interaction between the BC-coastal upwelling systems causes a thermal gradient up to 10 ºC [2].

Objective

This work consists of a four-year (2007 - 2011) simulation of the sea surface temperature to characterize the seasonal behavior of the coastal upwelling in Cabo Frio region and its plume propagation.

The numerical simulation was performed using ROMS forced by the 6-hours Reanalysis II wind fields (NCEP/NOAA). A high resolution (1 km grid) is used to resolve the area between Cabo Frio and Guanabara Bay.

A classic coastal upwelling is shown at figure 4. We can observe the upwelling evolution in depth. The cold water is also present in front on Guanabara Bay, even the plume appears far from some kilometers.

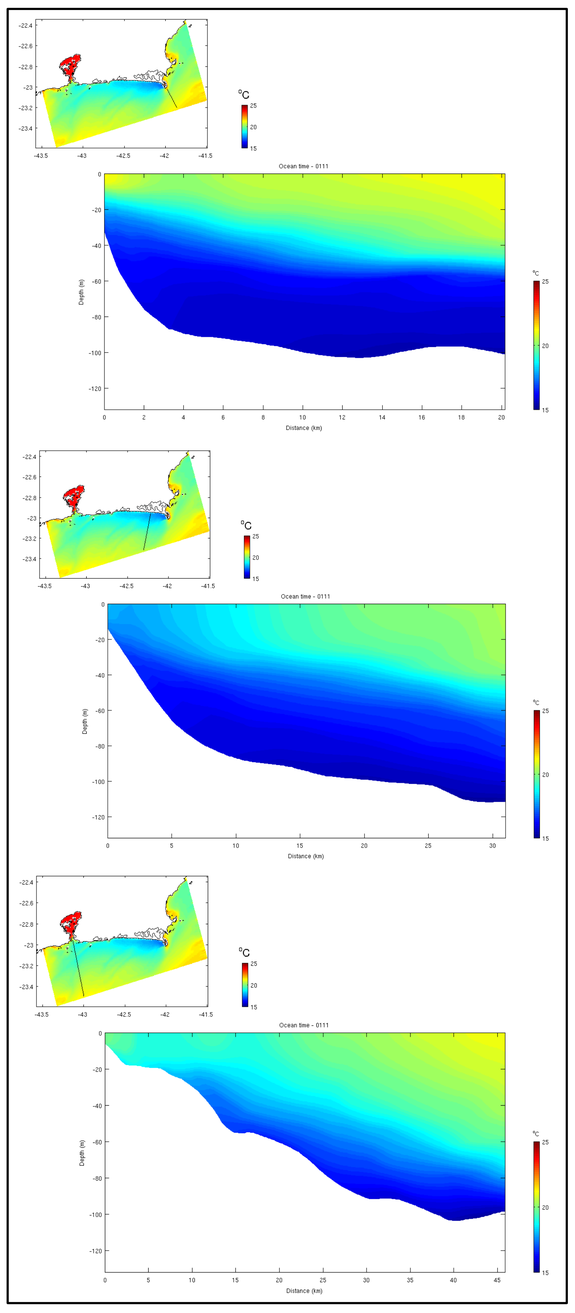

Figure 4. The coastal upwelling plume evolution.

Results

The sea surface temperature (SST) values are from the locus Ponta da Cabeça (shonw on figure 3), where the upwelling emerges. These values were compared with the MUR-SST (Multiscale Ultra-high Resolution - Sea Surface Temperatura) data, showing a good similarity (Figure 1).

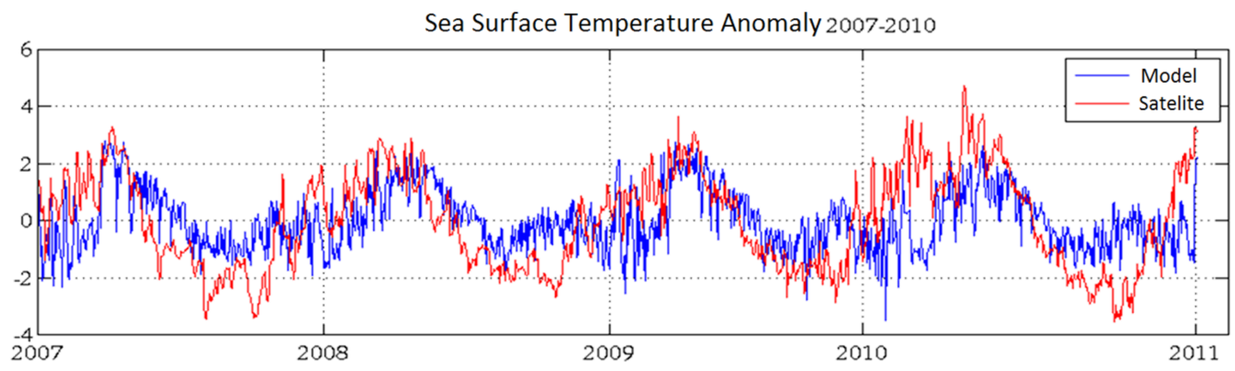

Figure 1. SST anomalies from the model results and MUR-SST satellite data.

Figure 2 presents the 18 and 16 ºC isothermals varying with depth, sampling the SACW presence. The graphics are limited by 40 m of depth, because up this layer the turbulence hinders the precision of this particular thermal signature.

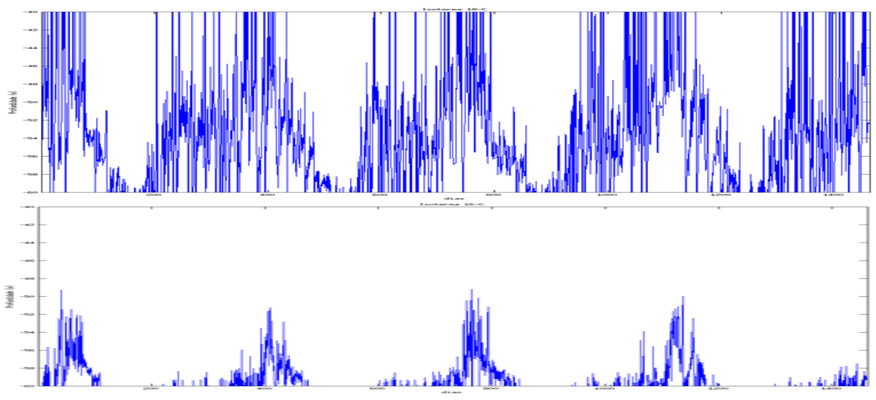

Figure 2. 18 and 16 °C isothermals varying with the depth.

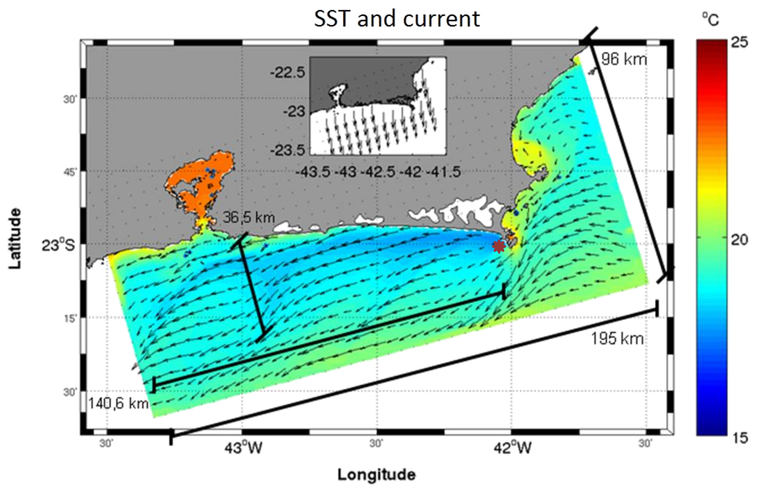

Figure 3. Estimated size of the coastal upwelling plume. Highlighted in red, the region of Ponta da Cabeça.

The coastal upwelling plume reached distances of about 140.6 km alongshore, towards the Guanabara Bay, and 36.5 km offshore, from its rising region (Figure 3).

Conclusions

- The model results compared with the MUR-SST satellite data showed the same trend of SST fields during the whole simulation.
- SST anomalies range on the model results were about 5 °C and for the satellite data, 6.5 °C, presenting a difference about 1.5 °C.
- The coastal upwelling plume maximum were estimated about 140.6 km alongshore and 36.5 km offshore; this size were observed mainly during the summer seasons. In the summer of 2007 was observed 708 hour of this process, in 2008 was 438 hours, 2009 was 540 hours and in 2010 was 618 hours.
- The coast upwelling also occurs during the spring and winter season, but less intense and frequent. For example, the year of 2007: 708 hours during the summer, 282 hours in the winter and 372 in the spring.
- In the whole period simulated, even during the autumn seasons, when the SACW does not reach the surface, the SACW was present on the bottom on the continental shelf. Due to the SACW availability, in Cabo Frio region even in periods of non favorable wind, can occurs rise of this water mass.

References

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[2] Carriere, O., Hermand, J., Calado, L., De Paula, A., & Silveira, I., 2010. Feature-oriented acoustic tomography: Upwelling at Cabo Frio (Brazil). 1–8