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Introduction

Among the upwelling systems along the Brazilian coast, probably the most well known and studied is the one near Cabo Frio. Occurring mainly at summer and spring seasons the presence of strong northeast winds in the region promotes the rise of the South Atlantic Central Water (SACW) near Cabo Frio. Additionally, the Cabo Frio region presents some physical features that contribute to upwelling events such as:

- Wider continental shelf;
- Abrupt change in coastline direction;
- Interaction with mesoscale system via Brazil Current meanders.

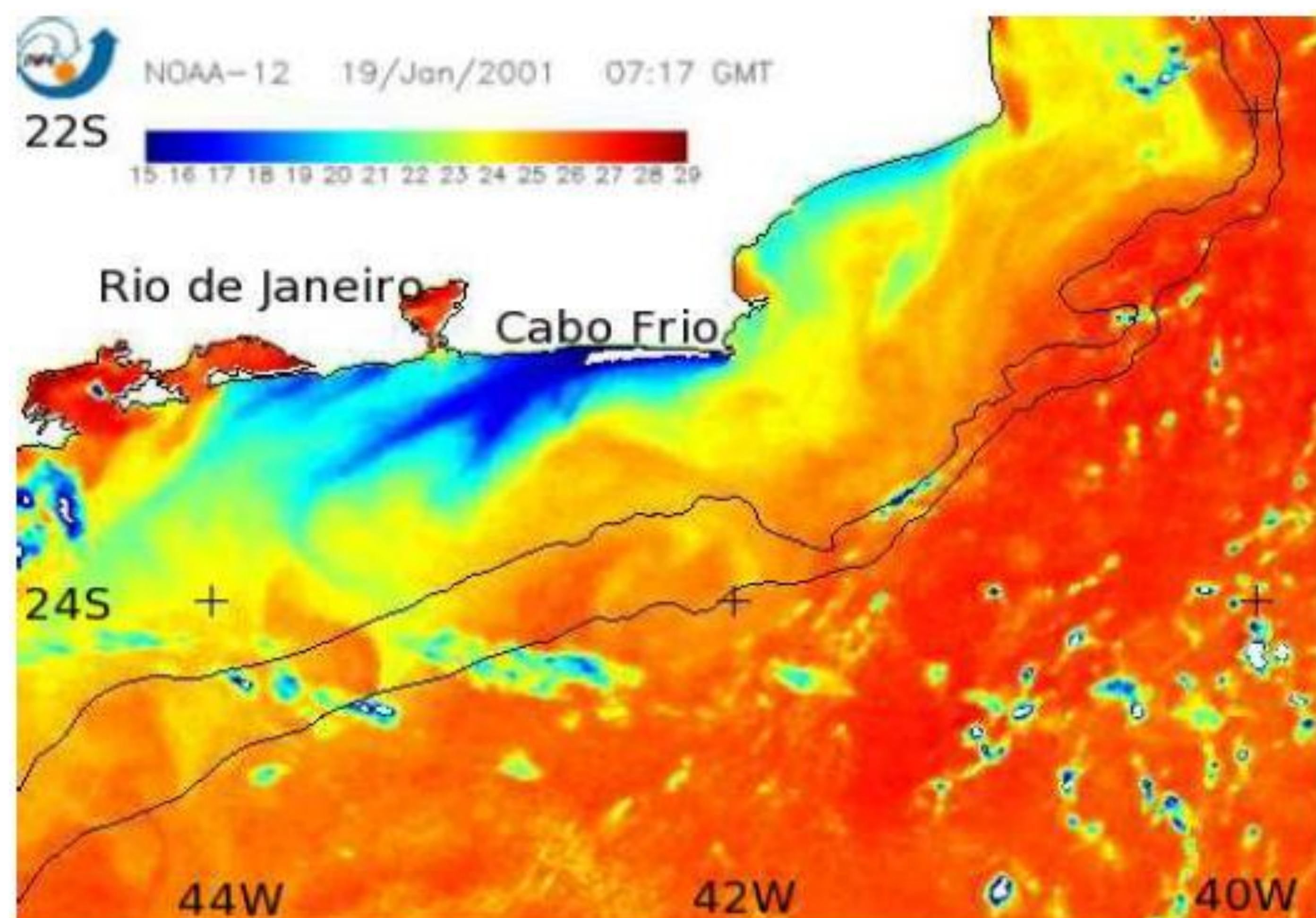


Figure 1: Sea surface temperature from AVHRR sensor. (Carriere et al. (2010))

Motivation

Although the upwelling on the coast of Rio de Janeiro is well studied, the upwelling plume around the Cabo Frio Island (CFI) and around the city of Arraial do Cabo (AdC) is not well understood. This work investigates the upwelling formation mechanisms and the plume pathways in this region.

Model configuration

ROMS is used to simulate the dynamics of the upwelling plume around Cabo Frio Island and around the city of Arraial do Cabo. A one-way (coarse to fine) nesting approach was used. Model configuration:

- ✓ 1km of resolution in the donor grid and 300m resolution to the receiver grid
- ✓ Initial conditions from Levitus
- ✓ Wind stress from NCEP NCAR Reanalysis (6-hourly data/ 4 times a day)
- ✓ 25 sigma layers at both grids
- ✓ Experiment for January/2001
- ✓ Tides from TPXO

Three experiments were conducted:

1. one with only the tide as a forcing;
2. one with only the wind;
3. one with both forcings (control experiment);

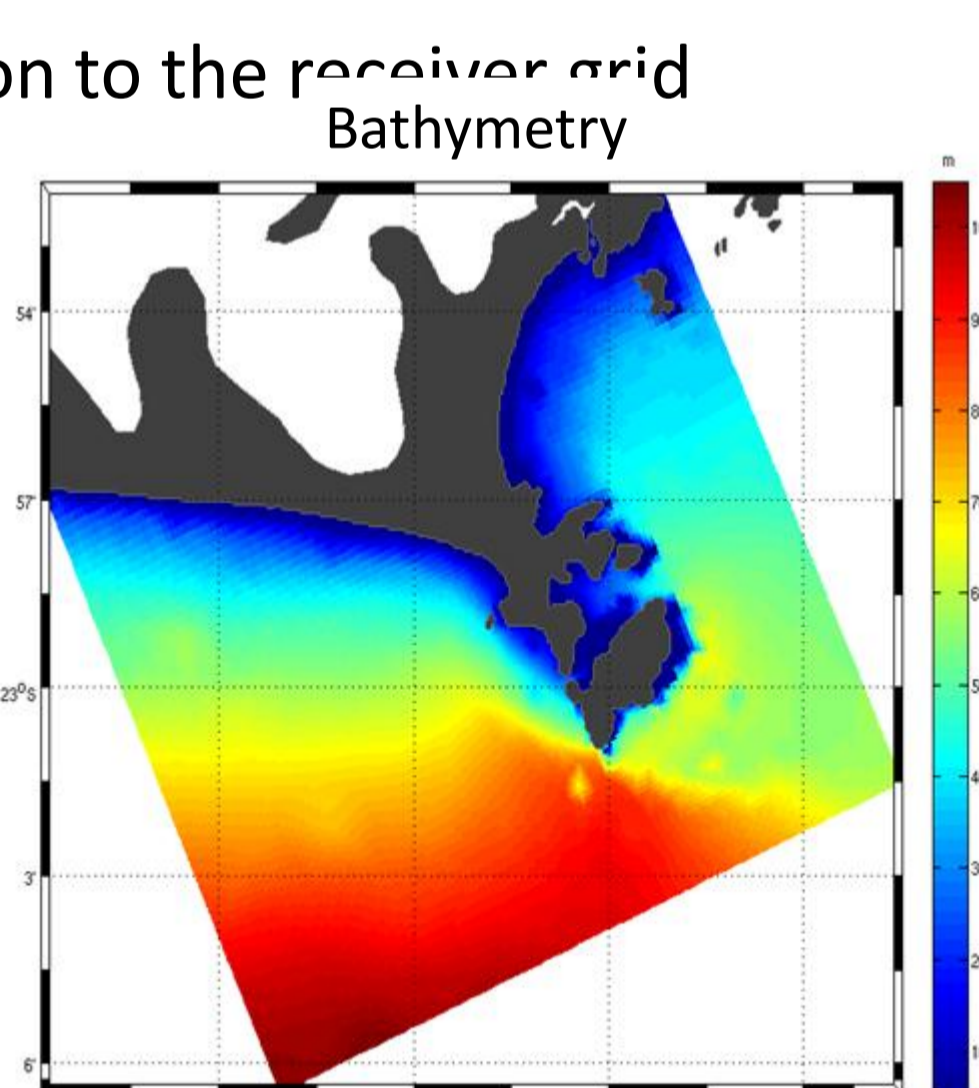


Figure 2: grid bathymetry.

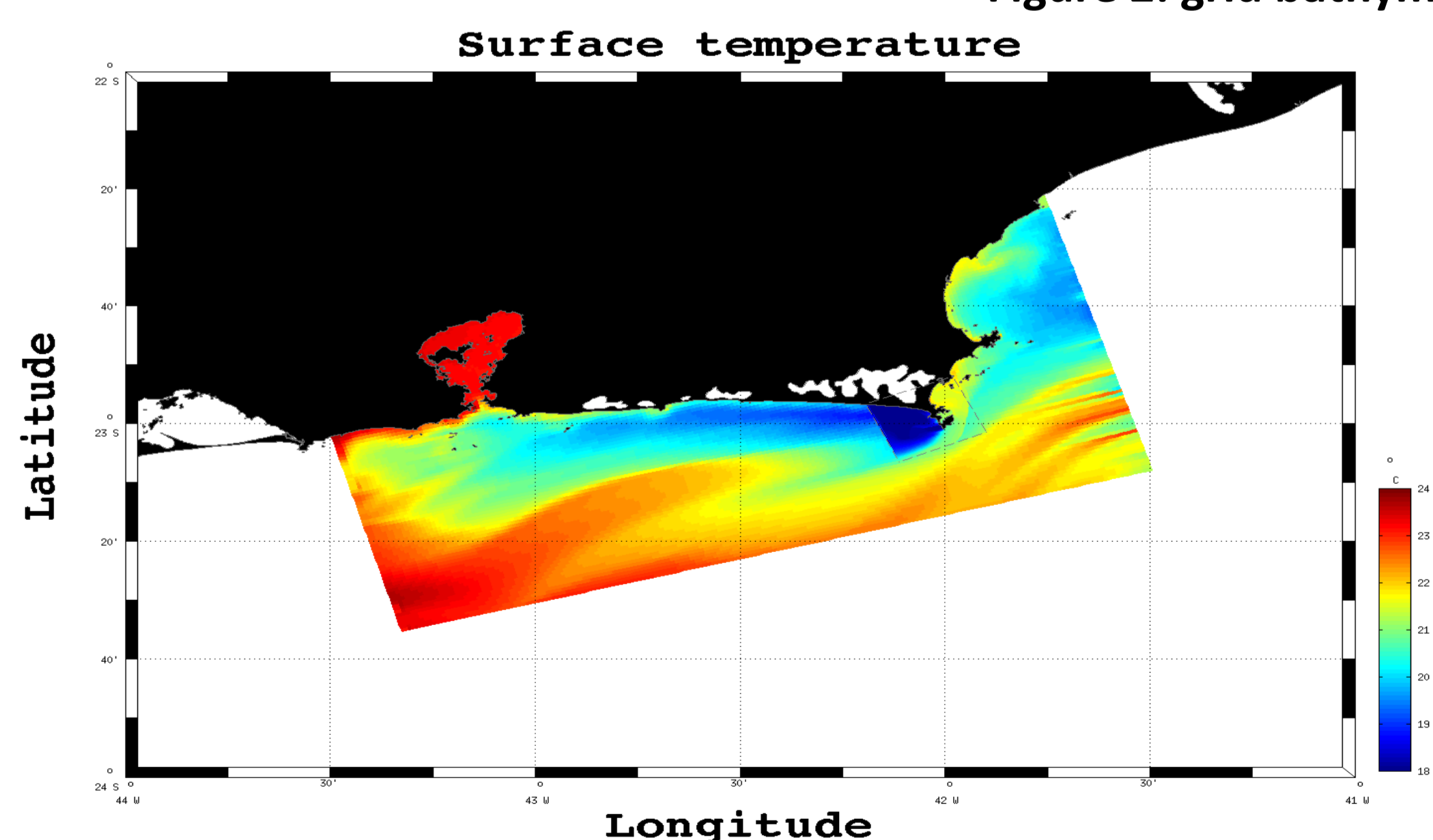


Figure 3: two nested grids with surface temperature.

Time series analysis

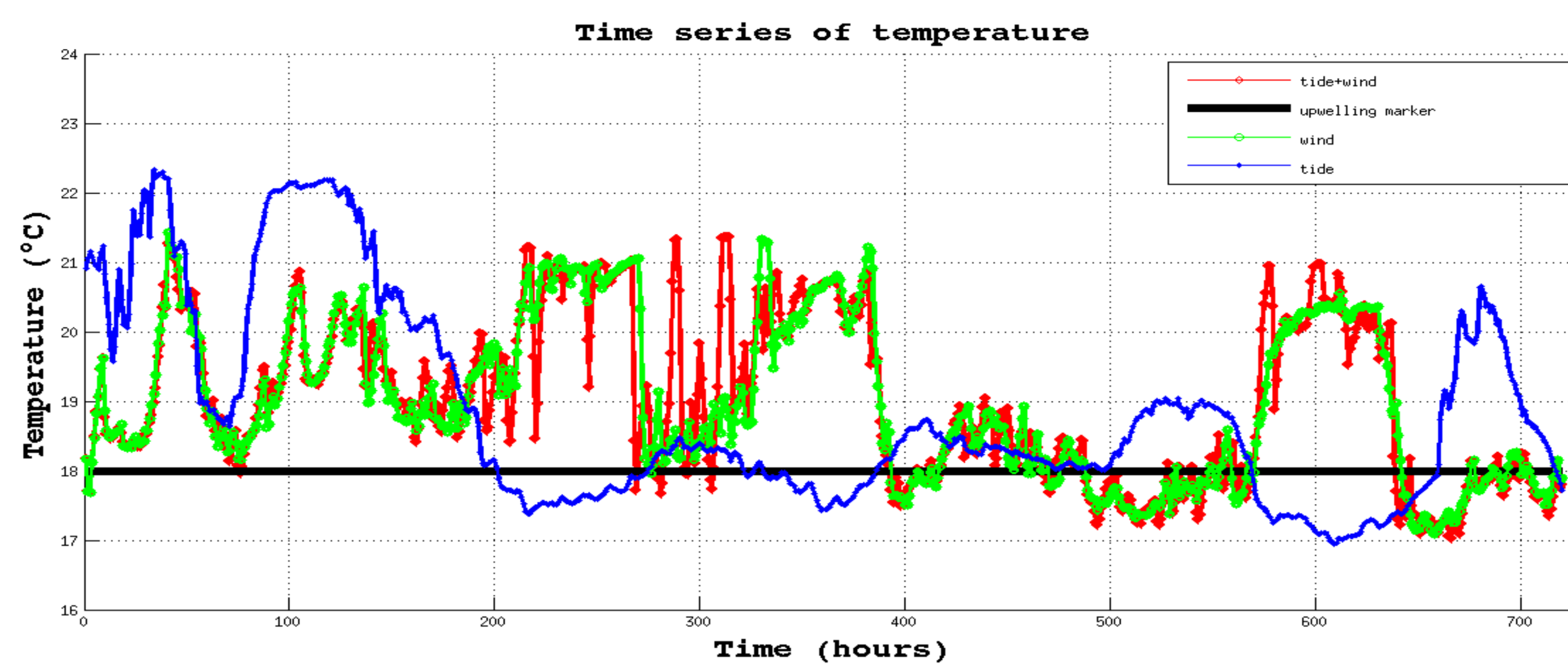


Figure 4: time series of temperature comparing each experiment.

- ✓ Time series analysis shows a greater correlation between wind and wind + tide data, when compared to the tide data only. This analysis indicates that the experiment with the only wind as a forcing is closer to the control experiment.

Surface

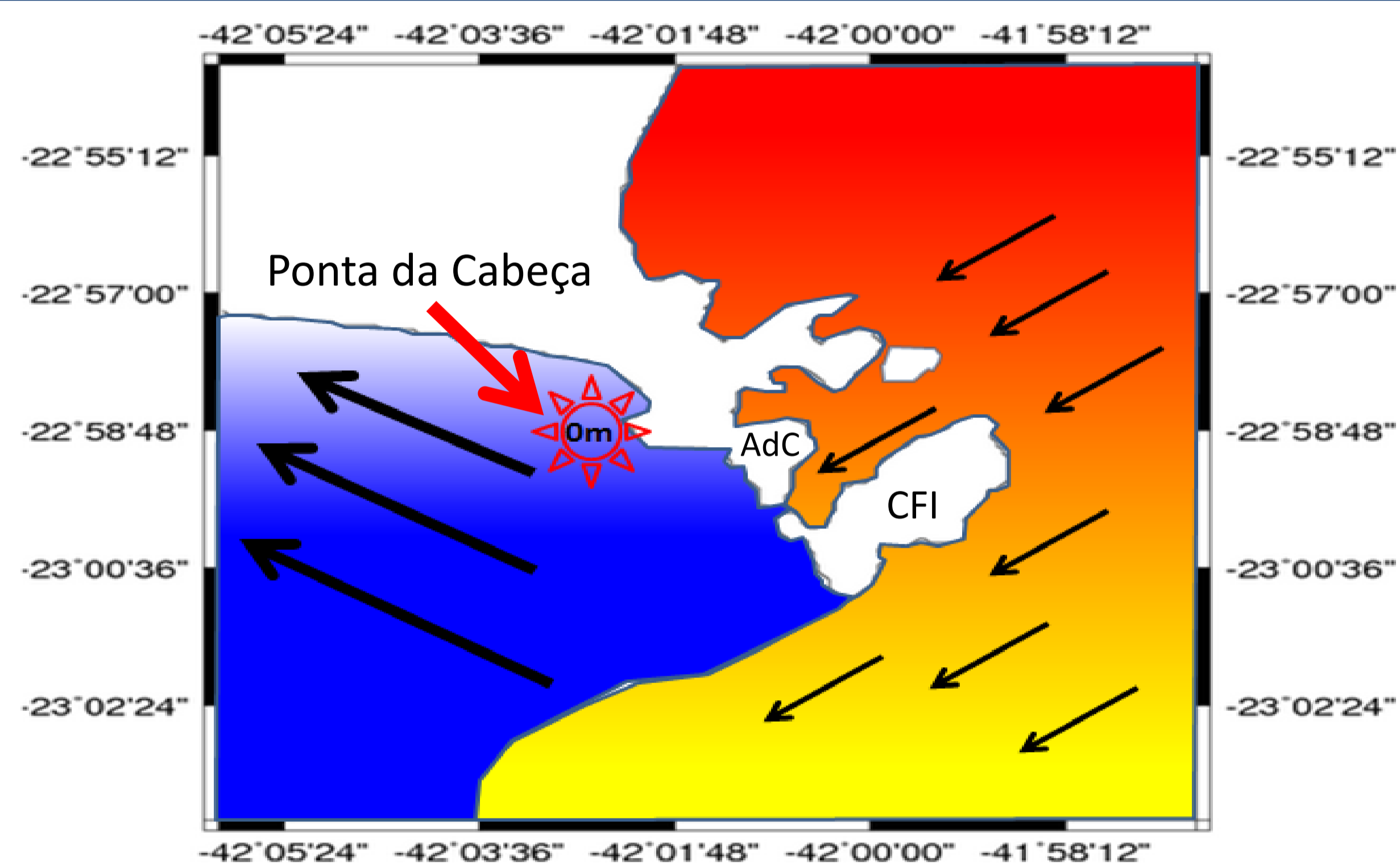


Figure 5: Representation of the surface circulation. Blue color is for the upwelled and non-blue for non-upwelled water. The black arrows indicate the current direction and the star is the focal point.

- ✓ Inside the bay there's only non-upwelled water (above 18°C);
- ✓ The northeast wind prevents the entrance of the upwelled SACW in the island bay and the plume follows its path to the south.
- ✓ The focal point of the upwelling is in a point called Ponta da Cabeça.

Bottom

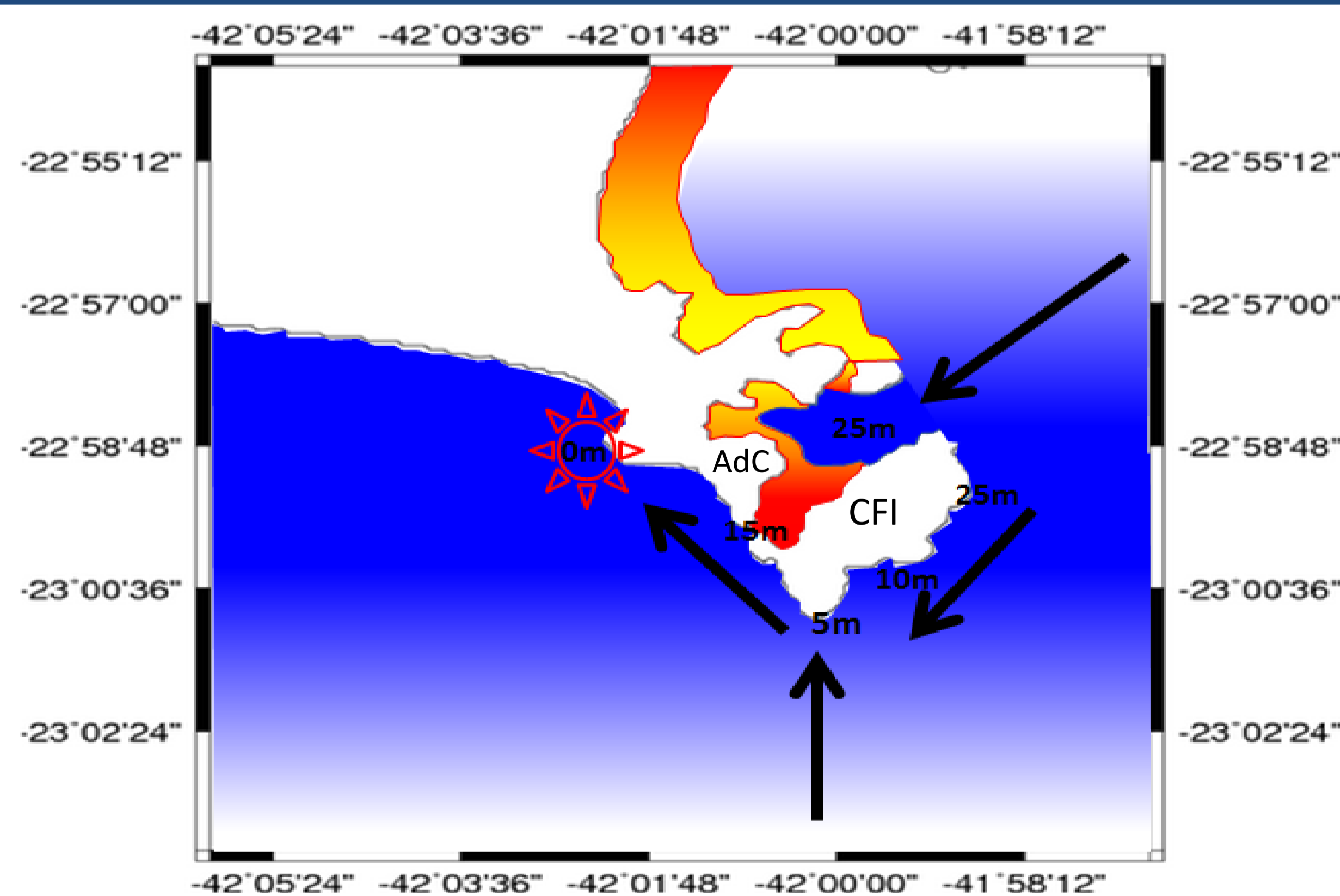


Figure 6: representation of the bottom circulation.

- ✓ The upwelled SACW enters the bay from the north channel and stays trapped by the bathymetry;
- ✓ The upwelled SACW could also be found around the Cabo Frio Island, outside the bay;
- ✓ The plume is barred by the bathymetry at the south channel

Conclusions

- ✓ The one-way nesting approach showed satisfactory results in understanding the region;
- ✓ The location of the focal point shows that the plume travels south the island at the bottom without rising until reaches lower depths. From that point the plume, because of the wind action, goes to the south along the coast of Rio de Janeiro.
- ✓ After the rising of the plume at the continental shelf the SACW is found around the island at the bottom with temperatures that can vary from 16°C to 17°C. The lower depths inside the Island's bay confine the plume at the north channel reach preventing the cold water to reach some points around Arraial do Cabo city.
- ✓ On the other hand, after reaching the surface, the wind direction keeps the plume outside the bay and away from the east and north sides of the Cabo Frio Island. As shown in figure 5, there's a well defined gradient of temperature at the south of the island between the upwelled and non-upwelled water. The wind acts preventing water to enter through the south channel and so moving towards south.