

Observed and modeled patterns of circulation in a semi-enclosed bay: Ria de Vigo (NW Iberia)

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Abstract

The Ria de Vigo, is a semi-enclosed bay belonging to the area so-called Rias Baixas, located at the northern tip of the Iberian coastal upwelling system. The Ria de Vigo behaves as a partially-mixed estuary with a two-layered residual circulation, caused by year-round density stratification. The estuary, connects to the ocean through two main mouths separated by the Cies Islands, whereby is influenced by water exchange with the surrounding ocean. The implementation of four nested domains to increase the spatial resolution (up to 150m resolution) allowed solving the interactions between Ria de Vigo and surrounding coastal ocean in a realistic way. Our research revealed that in the Ria de Vigo exist two new patterns of circulation which not reported in this region.

Background

The coastal circulation and hydrology in this region are influenced by the evolution of weather systems. During northerly (upwelling favorable) winds, water enters into the Ria through the northern mouth and leaves through the surface layer of the southern mouth, with a double layer circulation at this mouth. Nearly opposed situation occurs during downwelling favorable wind periods.

Methods

Two different upward looking moorings were deployed in the N and S mouths of Ria de Vigo (RDI 300 KHz ADCP and AANDERAA DCM12, respectively). Data from ADCP, were collected during two different periods (from 27th of November 2004 to 11th of December 2004, and from 2nd of February 2005 to 4th of March 2005). In our studies ROMS-AGRIF numerical model was implemented. We used the implementation of four nested subdomains (Fig. 1) to increase the spatial resolution (up to 150m resolution, with thirty sigma levels vertically).

Results

In particular conditions associated with northerly wind relaxation, there are two-layer circulation, occurring in both mouths of the Ria, consisting of outflow and inflow through the surface and bottom layers (Fig. 2 a,b and Fig. 3 a,c). Based on model output, we may conclude, that this situation happens in the absence of stratification during winter.

One-layer circulation in the southern mouth of the Ria, where typically there are two layers, can occur during long periods of persistent upwelling-favorable wind, with fluctuations of the wind strength (Fig. 2 c,d and Fig. 3 b,d). The northerly wind pulses control alongshore pressure gradients. Inshore poleward countercurrent have been observed whenever upwelling favorable winds relax. The alongshore pressure gradients seems to be a major forcing for the poleward flow on the inner shelf.

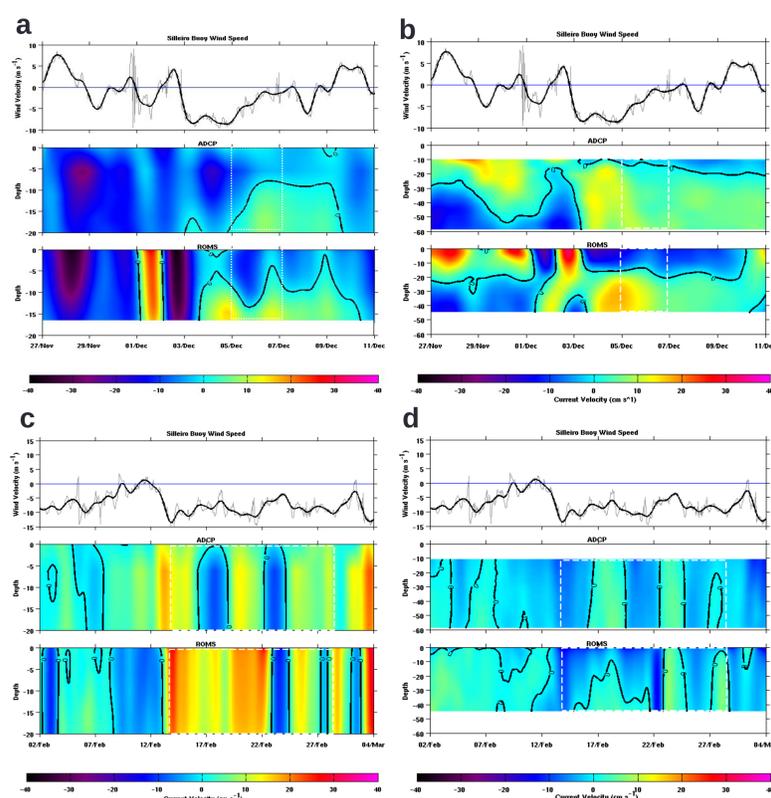


Fig. 2. Time series of the northward component of wind of Cabo Silleiro (grey lines are hourly averages, solid lines represent low-pass filtered data) and current velocity rotated in accordance with the main axis of the Ria de Vigo. Data from ADCP (upper panel) and model output (lower panel) are presented. Solid black line on the current plots represents the level of no motion. Studied periods are marked by white dashed lines.

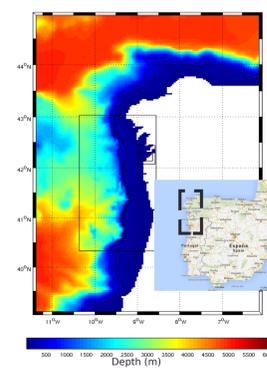


Fig. 1. Map of the region under study, the Ria de Vigo in the Iberian Peninsula, showing nested subdomains used in ROMS AGRIF model. The star in the upper left panel represents the location of Cabo Silleiro Buoy, yellow points are locations of ADCP in the northern and southern mouth of the Ria

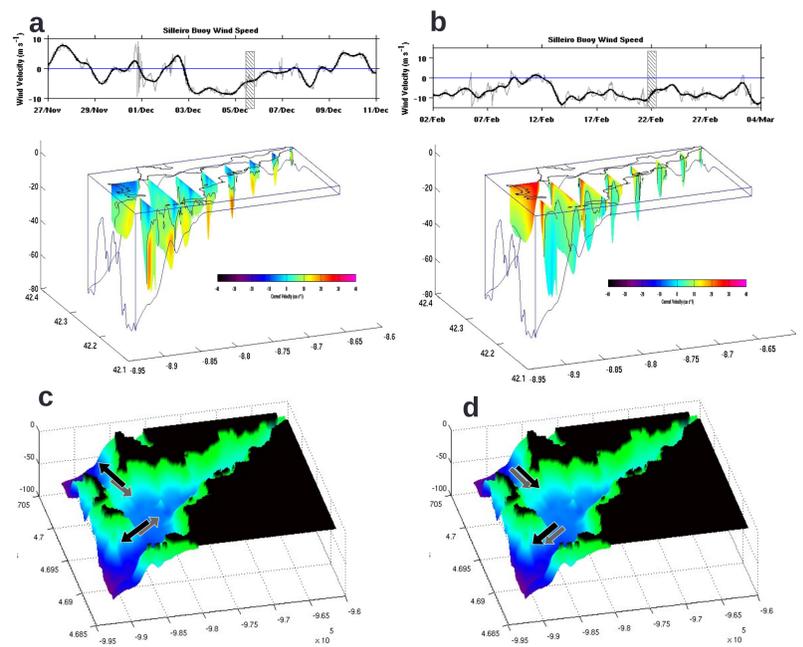


Fig. 3. (a, b) The 3D representation of the currents in Ria de Vigo, including mouths of the Ria and also its interior. Solid black line represents the level of no motion. (c, d) Scheme of the new patterns of the circulation found at the Ria de Vigo. Black arrows indicate surface flow, gray ones are related to the bottom layer. Particular days of the investigation are marked by gray hatched rectangles.

Conclusion

Our research has provided a detailed study of the two new patterns of circulation and hydrology of the Ria de Vigo, explaining specifically new mechanisms of water exchange with coastal waters.

References

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