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Inner shelf circulation on the north-western continental margin of the Gulf of Cadiz

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It has been recurrently attested that the inner shelf, generally defined as the region where the surface and bottom boundary layers overlap, shows a circulation pattern somewhat independent of the outer shelf. The forcing set that governs the outer shelf dynamics is considerable modified at the inner shelf. Over the outer shelf alongshore flows are geostrophic, as a result of the balance between cross-shore pressure gradients, induced by the wind driven upwelling mechanism, and the Coriolis forces. Contrarily, over the inner shelf alongshore flows may be directly driven by the existence of any alongshore pressure gradient, because Coriolis force cannot balance the pressure gradient force due to the presence of the coastline. This is one reason why warm counter-currents flowing over the inner shelf attached to the coast, inshore of the cold water previously upwelled, are recurrently observed in the Eastern Boundary Upwelling Systems, as revealed by sea surface temperature (SST) satellite imagery. The feature is particularly evident along the western part of the northern continental margin of the Gulf of Cadiz, mainly during the decay of coastal upwelling events. Along this coast the wind driven upwelling prevails roughly from April till October, but it is weak and intermittent. We can define two regimes, upwelling and non-upwelling, that temporally alternate in dominating the alongshore circulation. During non-upwelling conditions, the warm near shore counter-current propagates eastwards, sometimes turning northward at the Cape São Vicente, the western limit of the northern margin of the Gulf of Cadiz.
In the present research the flow patterns are studied for two periods, May-Dec 2008 and Aug-Dec 2010. Contemporaneous data of the flow velocity and temperature from a bottom-mounted ADCP deployed on the 25 meters isobaths, along with wind data from the ASCAT scatterometer and from a buoy in the Gulf of Cadiz, remotely sensed SST data and sea level data are analysed. Current reversals associated with relaxation/reversal of upwelling favourable winds and raised water temperatures were identified and the vertical structure of the flow inversion was analysed. Results indicate time lagged temporal agreement between patterns of local wind forcing and current velocities, with propagation of the counter-current during relaxations or reversals of upwelling favourable winds. However, results from a momentum analysis indicate large influence from other factors on this propagation. The magnitude of the external influence calculated by the momentum analysis corresponds to forcing by an alongshore pressure gradient involving sea level differences of around 5 cm over a distance of 100 km in barotropic conditions. This agrees well with earlier sea level measurements, supporting that alongshore pressure gradients are the main factor governing the alongshore circulation along the eastern part of the northern margin of the Gulf of Cadiz.