The strait of Gibraltar and Alboran sea circulation : a process study

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The water exchanges through the strait of Gibraltar are one of the major forcing of the Mediterranean circulation. Satellite observations over the Mediterranean basin reveal extremely complex circulation patterns which seem to be highly time-dependent. The knowledge of the physical processes connecting the forcing through the strait of Gibraltar with the dynamics of the water motion in the Western Mediterranean Sea still represents a challenge. The LODYC 3D primitive equations model has been undertaken in order to elucidate these driving interactions. In all the experiments the strait circulation has been initiated by connecting two reservoirs filled with homogeneous waters of different density.

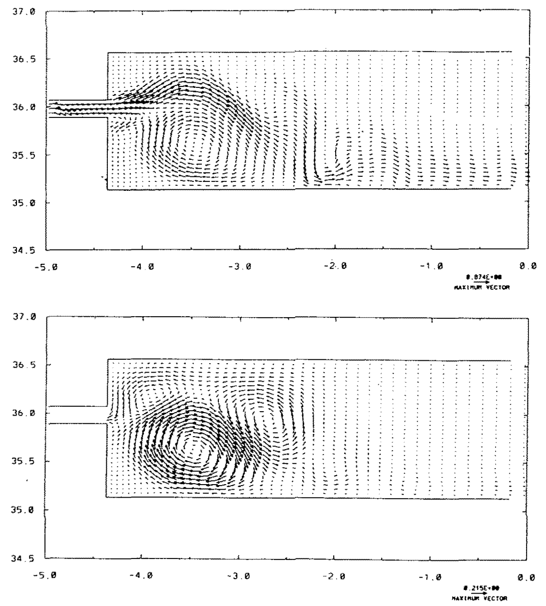
The results are in agreement with observations. In the strait a baroclinic circulation sets up: the light Atlantic water flows into the Mediterranean Sea in the form of a surface layer while the dense Mediterranean water flows out to the Atlantic Ocean near the bottom. The surface water enters the Alboran Sea in the shape of a shallow and narrow buoyant jet with currents over 1 ms-1. After a 3 day spin-up period, the flow transport in the strait reaches a steady value of 1 Sv. The surface inflow presents an internal hydraulic control at the exit within the Alboran Sea. After several days this flow extends in the Alboran basin forming a large anticyclonic gyre that slightly moves northward, while the head of the plume propagates along the southern cost of the Alboran Sea as a coastal Kelvin front.

By this simple academical study we are able to reproduce the high variability of the Alboran Sea circulation during the spin up phase, in particular some mesoscale cyclones that develop North of Gibraltar and displace around the bigger anticyclone (as shown in the figure where the velocity vector field at the sea surface and at 350 m of depth is displayed), as it has been observed both experimentally and through satellite imagery (TINTORE 1991; LA VIOLETTE 1984).

Systematic series of sensitivity experiments have then been performed in order to specify the conditions that control the gyre formation, its space scale and the major characteristics of the inflow and outflow in the strait. The results reveal that the gyre dimensions are very closely related to the density gradient between the two basins and, by a secondary effect, to the presence of the southern coastline in the Alboran Sea. The boundary conditions at the coast as well as a slight inclination towards the north of the Strait, although sometimes argued, do not exhibit any relevant role in the gyre formation and in the overshooting of the inflowing jet.

In addition to these main conclusions it has been possible to identify the physical parameters responsable for the gyre genesis as well as to follow its development till the Alboran Basin general circulation steady state is reached, by studying the potential vorticity conservation and analysing the balance of the dynamical equation terms, as well as referring to mesoscale vortex and modon theories.

In recent numerical experiences we have introduced the real geometry and topography of the investigated region to weigh their impact on the circulation dynamics and structure. A final investigation has been performed by initialazing the density values on the Levitus climatology in order to approach reality.



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Eddies, Meanders and Mushroom vortices in the coastal current system of the Black Sea

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The Nimbus 7 CZCS visible images for June 1980 have been processed to display the variability of chlorophyll within the Black Sea Coastal Current. In addition to displaying the productivity variations along the coast, plankton related ocean colour in a time-series of high resolution images are used as a tracer identifying the unique dynamical features of the Coastal Current System. A meandering current system with an embedded train of mesoscale eddies is observed along the Turkish coast in the pattern of a wave motion progressing to the east between the Bosphorus region and Inceburun (Sinop). There is close correlation of the flow features with the continental slope topography. The abrupt termination of the wide western continental shelf at Sakarya Canyon appears to excite the oscillatory motion progressing rapidly to the east. In the east of the region of interest, the flow takes the form of a wide jet separating further from the coast, when, once again, the continental shelf becomes wider. The wide jet terminates with a dipole-like cap extending to the mid-basin region from the Arhangelsky Ridge east of Sinop. Ocean productivity that can be traced back to the low salinity waters of the Danube plume is transported along the western continental shelf and later becomes incorporated into the dynamically unstable current system in the southwestern Black Sea. In early summer, the continuous plume of chlorophyll observed during the spring appears to be rapidly depleted at the centers of eddies. The structure of the offshore filaments and dipole eddies associated with the Danube plume are also observed in the same series of images.

A unique visualisation of a mushroom eddy occurs offshore of the mouth of the Kizilirmak river in the October 1981 images. The mushroom is connected to the river mouth and the coastal maximum of pigment by a plume. The pigment distribution shows assymmetric spirals withint the dipole eddy. Momentum pulses acting across a coastal jet flow such as the Black Sea Coastal Current are suspected to create a vortex doublet confined in the surface layers with the observed deformation of the chlorophyll field. Such a pulse could be imparted by a local extremum of wind stress or the river plume itself. The filament connecting the dipole eddy to the coast follows the topographic contours of the local canyon topography adjacent to the Arhangelsky Ridge.

It is evident that the bio-optical features of coastal eddies is directly associated with the physical dynamics and the entrainment of surrounding water masses. It is of great utility to find that, unlike thermal images which yield data from a thin layer of surface water influenced by short-term surface heat fluxes, and provided that the pigments are available, the CZCS data produce a depth integrated (to about 20m) signature of colour, faithfully reproducing features of the underlying flow dynamics.

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