PROCESS STUDY SIMULATIONS OF THE DENSE SHELF WATER CASCADING INTO THE CAP DE CREUS CANYON

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Abstract

Intense dense shelf water cascading events occurred in the North-Western Mediterranean Sea in early 2005. These events have contributed to the basin-wide spreading of a deep thermohaline and turbid anomaly, which has been extensively observed by many authors. The major volume of dense shelf water formed on the Gulf of Lions shelf is exported through the Cap de Creus Canyon, at the western edge of the gulf. The intensity of the 2005 events gives the chance to perform numerical process study simulations of the down-canyon dense water flow. The Regional Ocean Modeling System (ROMS) is used to study the dense plume cascading dynamics, first using an idealized but realistic canyon topography and then the multibeam derived bathymetry.

Keywords: Gulf Of Lions, Western Mediterranean, Models

The Gulf of Lions is one of the regions in the Mediterranean where dense water formation occurs by open-sea convection process as well as by dense shelf water cascading when coastal surface waters over the wide shelf become denser than the underlying water masses and cascade downslope until reaching their equilibrium depth [1]. Dense shelf water cascading is one of the main processes of shelf-ocean basin exchanges, enhanced by the presence of submarine canyons that deeply cut the continental shelf-edge and slope.

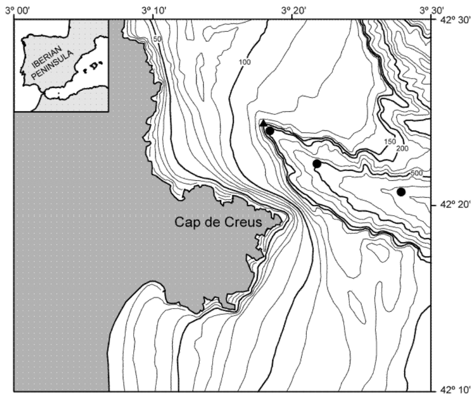

Fig. 1. Bathymetric map of the southwestern end of the Gulf of Lions showing the location of the Cap de Creus Canyon. Symbols represent the location of near-bottom instruments deployed along the canyon axis, at 145 m depth (tripod) and at 200, 500 and 750 m depth (moorings).

The occurrence and characteristics of dense shelf water cascades from the Gulf of Lions have been continuously monitored at the Cap de Creus submarine canyon head (between 145 m and 750 m depth), in terms of near-bottom current velocities, temperature, salinity and turbidity (Fig. 1).

The Regional Ocean Modeling System (ROMS), a free-surface, hydrostatic, primitive equations, general circulation ocean model, that uses stretched, terrain-following coordinates in the vertical and orthogonal curvilinear coordinates in the horizontal was setup with an idealized and a realistic bottom topography. The horizontal resolution was variable increasing from 500 m up to 100 m across the canyon axis (y direction of the model) to better describe the steep topography. Along the canyon (x direction of the model) the resolution was 500 m, while in vertical 40 levels were used, with higher resolution in the bottom boundary layer.

Different sets of numerical experiments have been done to explore how the downslope flow develops into a gravity current cascading event, and the time scales characteristics of such events.

Since the objective of the work was a process study, the background thermohaline field has been defined using the MEDAR winter climatology and the characteristics of the simulated plume from the mooring data available along the canyon. According to [2] and [3] the Cap de Creus Canyon is the main pathway for dense shelf water cascading, due to its strategic position at the point where the cyclonic circulation of the dense water formed in the Gulf converges. Dense waters preferentially enter the Cap de Creus Canyon across the southern canyon wall due to the coastal constrain, showing a pulsating nature with a periodicity of 3–6 days, presumably associated with the cross-slope fluctuation of a topographic wave [4]. For this reason, the model was setup with the plume entering the domain at its southwestern edge.

In order to compare model results with available data, the tripod and mooring mooring measurements (Fig. 1) were analyzed, focusing only on the beginning of the 2005 cascading event. In particular we chose the first plume, detected at the deepest mooring, from February 3rd to 8th 2005 (Fig. 2). Despite this event being constituted by a succession of 8-9 smaller impulses, each of them lasting less than 1 day (Fig. 2), its time scale resulted to be particularly suitable for being modelled with a process study approach, focusing on the dynamics of a “single” plume, instead of the dense water cascading during the whole winter.

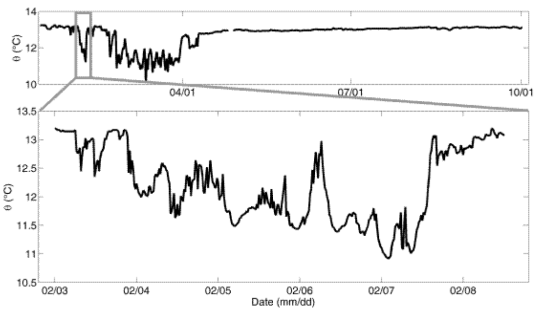

Fig. 2. Temporal evolution of potential temperature, recorded by the 750 m depth mooring, during the selected plume event extracted from the whole record.

This study could be the framework of a model-based experimental design, since the numerical results can provide helpful information about the most suitable locations of continuously measuring instruments along the canyon, increasing the probability to detect the main flow of the descending plume.

References

1 - CIESM, 2009. Dynamics of Mediterranean deep waters. N° 38 in CIESM Workshop Monographs [F. Briand, Ed.], 132 pages, Monaco.
2 - Ulses C., Estournel C., Puig P., Durrieu de Madron X. and Marsaleix P., 2008. Dense shelf water cascading in the northwestern Mediterranean during the cold winter 2005: Quantification of the export through the Gulf of Lion and the Catalan margin, *Geophys. Res. Lett.*, 35, L07610.
3 - Dufau-Julliand C., Marsaleix P., Petrenko A. and Dekeyser I., 2004. Three-dimensional modeling of the Gulf of Lion’s hydrodynamics (northwest Mediterranean) during January 1999 (MOOGLI3 Experiment) and late winter 1999: Western Mediterranean Intermediate Water’s (WIW’s) formation and its cascading over the shelf break, *J. Geophys. Res.*, 109, C11002.
4 - Puig P., Palanques A., Orange D.L., Lastras G. and Canals M., 2008. Dense shelf water cascades and sedimentary furrow formation in the Cap de Creus Canyon, northwestern Mediterranean Sea. *Cont. Shelf Res.*, 28: 2017-2030.