MESOSCALE ANTICYCLONIC EDDIES IN THE CATALAN SEA: ORIGIN AND DYNAMICS

Anna Rubio [1], Manuel Espino [2], Bernard Barnier [3] and Gabriel Jordà [4] *

[1] LIM-UPC, C./Jordi Girona 1-3,08034 Barcelona, Spain * Now at IFREMER Centre de Mediterranée, BP330, 83500 La Seyne sur Mer, France

[2] LIM-UPC, C./Jordi Girona 1-3,08034 Barcelona, Spain

[3] LEGI, BP 53, 38041 Grenoble, France

[4] IMEDEA (CSIC-UIB), Palma de Mallorca, Spain. - gabriel.jorda@uib.es

Abstract

The origin and dynamics of mesoscale anticyclonic eddies in the Catalan Sea is investigated using a numerical model of the NW Mediterranean circulation at 3 km resolution. Model eddies are compared with an anticyclonic eddy observed at the Catalan shelf break in September 2001. Model eddies generated at the southeast of the Roussillon coast are found to compare well with the observed eddy. The model suggests that the generation of these eddies is related to a flow separation mechanism that takes place over the shelf together with intense downwelling during NW wind events.

Keywords : Mesoscale Phenomena, Circulation Models, Continental Shelf.

As shown by previous works the presence of anticyclonic mesoscale eddies in the Catalan Sea is recurrent throughout the year and they have significant effects on the local dynamics. These eddies are responsible for local flow inversions over the shelf and are an effective mechanism for water and particulate matter shelf/slope exchanges [1].

In September 2001, a cruise in the Catalan Sea was carried out to investigate their main characteristics [2]. The joint analysis of the *in situ* hydrographic data and SST satellite imagery permitted, for the first time in this region, to make a 3D description of one of these eddies. The anticyclonic eddy was characterized by a vertical extent of 100 m, a diameter of 40-45 km, surface velocities of 30-40 cm/s and a low density (high temperature, low salinity) core. During the survey the eddy drifted southwestwards at 6-8 km/day with an associated transport across the shelf break of 0.15-0.3 Sv. Concerning the generation of this eddy, the lack of continuity in the SST images (gaps of 3-4 days between consecutive images) did not permit to investigate its origin and path.

In order to deepen into the investigation of the origin of these eddies, the SYMPHONIE [3] 3D primitive equations numerical model was used in the NW Mediterranean. Initial conditions and forcing at the open boundaries are provided by the MFS-Mediterranean model [4] and high resolution atmospheric forcing is obtained from ALADIN (Météo-France). One year of realistic simulations is performed with a horizontal resolution of 3 km and 41 vertical sigma-z levels. Simulations are validated with climatological, satellite and *in situ* data. They reproduce realistically the main characteristics of the circulation (i.e. the Northern Current path and variability, the wind induced circulation over the shelf and the generation of mesoscale eddies with similar properties to that of the observed one).

Numerical results point out two main areas of eddy generation in the NW Mediterranean: the coast in front of Marseille and the southeast coast of Roussillon. Model results for Marseille show that eddy generation in this area is linked to barotropic processes associated to perturbation of the Northern Current by the bathymetry. A major variation in the slope direction induces flow separation during the Northern Current intensifications. As a consequence of flow separation eddies generate over the slope (i.e. 600-1000 m isobaths). Due to their barotropic origin, these eddies have a deep structure (300-400 m) which does not correspond with that of the eddy surveyed in the Catalan sea. In the coast of Roussillon, a flow separation mechanism is also responsible for eddy generation. In this case flow separation occurs over the shelf and as a consequence eddies generated in this area have a limited vertical extent, around 100 m. Properties of these eddies are found to compare well with the eddy observed during the 2001 cruise. Thus, the study of the evolution of Roussillon model eddies allows us to hypothesize about the origin and path of the observed eddy.

In this area flow separation occurs downstream of Creus Cape during the coastal current intensifications (for current intensities over 30 cm/s) induced by strong NW winds in the Gulf of Lions. Moreover, as a consequence of NW winds intense downwelling processes take place over the shelf and eddies incorporate the low density downwelled waters (fig. 1).

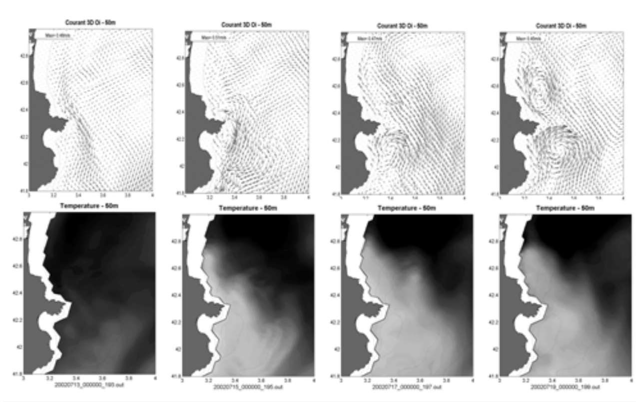

Fig. 1. Evolution of model velocity (top) and temperature (bottom) fields at 50 m. Warmer waters are in light grey. From left to right, one sees the growth of the downwelling and its associated flow, the current separation and shedding of one anticyclonic eddy at the south-east of Roussillon. The eddy is trapping warm water in its core.

To better understand the generation mechanism of these eddies we have examined the energy (APE and EKE) transfers between mean and eddy fields during a typical eddy generation event. Energy conversions suggest that during the NW wind event the generation of these eddies is mainly barotropic (i.e. eddy shedding by a flow separation mechanism). However, baroclinic processes may also account for their growth when the wind forcing weakens. This baroclinic contribution is associated to the release of available potential energy during the relaxation of the downwelling and is significant in conditions of high stratification. After they are generated, these eddies are advected first by the coastal current towards the shelf break and then by the slope current towards the Catalan Sea.

References

1 - Tintoré J., Wang D.P. and La Violette P.E., 1990. Eddies and thermohaline intrusions of the shelf/slope front off the northeast Spanish coast. *J. Geophys. Res.*, 95(C2): 1627-1633.

2 - Rubio A., Arnau P.A., Espino M., Flexas M., Jordï£¡ G., Salat J., Puigdefï£¡ bregas J. and Sánchez-Arcilla A., 2005. A field study of the behaviour of an anticyclonic eddy on the Catalan continental shelf (NW Mediterranean). *Prog. Oceanog.*, 66: 142-156.

3 - Marsaleix P., Estournel C., Kondrachoff V. and Vehil R., 1998. A numerical study of the formation of the Rhône river plume. *J. Marine Syst.*, 14: 99-115.

4 - Pinardi N., Allen I., Demirov E., De Mey P., Korres G., Lascaratos A., Le Traon P.-Y., Maillard C., Manzella G., and Tziavos C., 2003. The Mediterranean ocean forecasting system: first phase of implementation (1998-2001). *Ann. Geophys.*, 21: 3-20.