ALTIMETRIC OBSERVATIONS OF PROPAGATING OPEN-SEA EDDIES IN THE ALGERIAN BASIN

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Abstract

A key question to adequately understand the circulation of the Western Mediterranean sea is the dynamics of the eddies within the Algerian basin. Such eddies in most cases are generated by instabilities of the Algerian current and last for several months within the basin. To adequatley study their dynamics and evolution we need observational data able to track them over their lifetime. This may be done efficiently by means of remote sensing data and commonly the infrared thermal images are used as a source to identify such mesoscale structures. In this work we present some results obtainned by analyzing the Sea Level Anomalies (SLA) maps, with a technique based on the second Galilean-Invariant of the velocity gradient tensor. This technique allows us to clearly detect the core regions of the mesoscale eddies within the Algerian basin. The analysis applied on SLA maps between 1992 and 1999 show that this methodology is coherent with previous studies and is able to distinguish two interacting eddies which can not be distinguished from visual inspection. It reveals that eddies follow a circuit in the eastern part of the Algerian basin composed by three main branches. In particular, The observations and the analysis show a region in the Algerian coast, near 3 ° E, where eddies detach and drift westwards following the continental slope south of Ibiza Island.

Keywords : Algerian basin, mesoscale phenomena, remote sensing

The Algerian basin occupies most of the southern part of the western Mediterranean Sea. The Algerian basin dynamics is dominated by the interaction between light waters incoming from the Atlantic Ocean through the strait of Gibraltar and resident denser waters. The major feature of this thermohaline circulation is the coastal flow of Atlantic waters along the African slope which is called the Algerian current (AC). Instabilities of the Algerian current are manifested as coastal meanders and eddies, that in some cases develop into bigger open sea anticyclonic eddies. As seen in satellite infrared images, these mesoscale structures can last for many months or even years while strongly interacting between them and with the Algerian current. They lay a major role in the configuration of the general circulation and the distribution of water masses and biogeochemical parameters in the western Mediterranean [1]. The difficulties to survey the dynamics of the generation and propagationof such eddies are beyond the traditional experimental designs (ship cruises and moored instruments). Most part of studies have focused in the systematic analysis of thermal images which can cover the whole domain synoptically with enough resolution. However, the studies only can cover small time periods (free cloud periods) and limits to the sea surface temperature. Here we present results of a methodology able to extract information on such eddies by means of the analysis of altimetric data. To study the eddy dynamics and survey their evolution from data, one needs to unambiguously identify them. The eddies cores can be defined as the connected region with a positive value of the second Galilean-invariant of the velocity gradient tensor [2.3]:

$$Q = \left(\frac{\partial u}{\partial x}\right)^2 - \left(\frac{\partial u}{\partial v}\right)\left(\frac{\partial u}{\partial y}\right)$$

then the vorticity sign of the detected regions allows to distinguish between cyclonic and anticyclonic eddies (figs.1, 2). Once detected, the eddies can be tracked and their evolution can be studied. We have applied this criterion to geostrophic velocities derived from Sea Level Anomalies (SLA) maps. First we test our methodology with previous results and then we study eddies evolution for the period from October 1992 to September 1999.

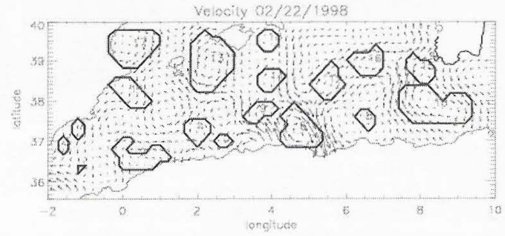

Fig. 1. Anticyclonic structures detected by Q>0

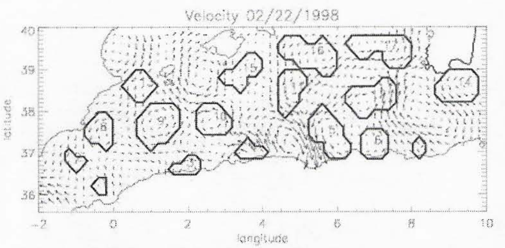

Fig. 2. Cyclonic structures detected by Q>0

SLA maps are regularly produced by the CLS laboratory (Toulouse, France) combining TOPEX/POSEIDON and ERS data interpolated onto a regular grid of 0.2° \ 0.2° [4,5,6,7]. One of the major problems in using altimetric data in the Mediterranen is the spatial and temporal resolution of the sensor relative to the characteristic scales of the structures of interest. As it has already shown [8,9,1] Algerian eddies are structures with length scales of 100-200 km and surface elevations of the order of 10-20 cm, thus within the range of detection by altimeters. Furthermore, series of AVHRR images have also revealed [1] that such eddies drift slow enough (2-5 km/day) that a sample rate of 10 days between consecutive SLA maps is rather adequate to survey their evolution.

First, the methodology is tested for three of such eddies that were imultaneously sampled by *in situ* measurements (CTD, drifters) and infrared imagery during ALGERS98 and ELISA cruises. Results, using our methodology, show a rather good agreement between our procedure and field observations but it is able to distinguish two interacting eddies which can not be distinguished from visual inspection.

Second, by applying this technique to the whole data set we can analyze the indivudal trajectories followed by such structures (fig. 3). Results show the presence of a clear circuit followed by eddies in the Algerian basin. They tend to do counterclockwise loops between 5-8° E . We can also appreciate that the circuit is composed of two loops with different size. In the larger one eddies may reach 38.5° N and a second loop where eddies remain trapped between 37-38° and are located between 6-7° E. Finally it can also be appreciated a third circuit, where eddies detach approximately at 3° E and drift westwards following the isobaths along the continental slope south of Ibiza Island.

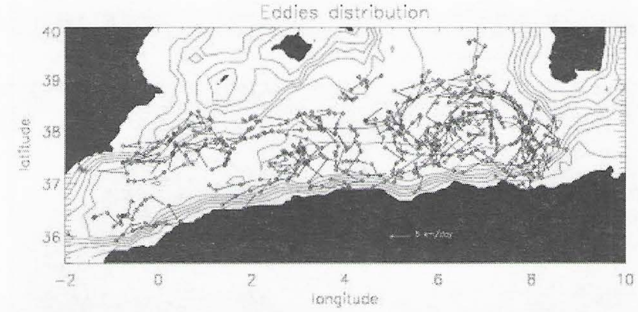

Fig. 3. Eddies distribution and velocities observed Sea Level Anomalies maps from October 12,1992 to September 30, 1999

Sumarizing, the simple technique presented here is able to detect and track, on a regular basis, the evolution of eddies within the Algerian basin by only using altimetric maps. This constitutes a first step to understand the dynamics and behaviour of such eddies. When applied to a rather long series of data we could obtain the main circuits followed by such structures. Results evidence that bottom topography and beta effect probably are the two key elements that determine the dynamics of such eddies but further analysis and comparison with numerical simulations need to done to conclude.

Acknowledgments. This is a contribution to GPS Radar Altimeter (GRAC) project funded by the Spanish R+D Plan and the European Union (2FD97-0588). Altimetric maps for the period October 1992 to October 1997 were elaborated and provided by CLS (Toulouse, France) under contract (MAS3-CT96-0051) of the MATER (Mass Transfer and Ecosystem Response) project funded by the European Comission. Altimetric maps for the period October 1997 September 1999, also produced by CLS, where kindly provided by Giles Larnicol. ALGERS98 and ELISA surveys were also funded by the MATER project.

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