A SYSTEM OF THREE INTERACTING EDDIES IN THE ALGERIAN BASIN, SPRING 1993, AS SEEN BY AVHRR AND TOPEX/POSEIDON ALTIMETER DATA

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A very clear AVHRR image of April 19 1993, GMT 03:13, shows a very complex structure in the Algerian Basin, West Mediterranean Sea in an area between 6.5°E-8.5°E of longitude and 37.2°N-38.5°N of latitude. This area is delimited at South by the African coast and at East by the rising of bottom topography in the Sardinian channel.

This structure (see figure), strictly connected with the eastern flowing of the Algerian Current, constituted by MAW (Mediterranean Atlantic Water) incoming from the Strait of Gibraltar, has the shape of three highly convoluted spiral eddies, two of them zonally aligned (A and B, respectively centered in 38.0°E 7.0°N and 38.1°E 7.9°N) and the third one (C, centered in 37.5°E 8.1°N) South-East of the first two. The eddies have an almost uniform SST of 14.7°C with some cold patches of probably entrained water.

Their spiraling shapes suggest a cyclonic circulation for the North-Western (A) and the southern (C) ones and an anti-cyclonic for N-E one (B), as two coupled mushrooms sharing the middle eddy (B). They have a mean radius of about 30 km but A and, above all, C are elliptical.

In addiction to the preceeding analysis, one year of high quality TOPEX/Poseidon altimeter data of the West Mediterranean Sea have been processed with up-to-date algorithms using the repeated-tracks method (the repetition cycle for the tracks is about ten days) in order to extract the variable sea level topography. Many problems have been met as always happens when working with altimetric data in the Med. Sea (short tracks, tide corrections not well established, near coastal sampling not accurate, oceanic signal to noise amplitude ratio too low). Moreover this very recent satellite has orbits too spaced (about 100 km) with respect to the oceanographic typical length scales (in Med. Sea Rossby radius is of order of ten km).

In spite of these difficulties it was possible to observe a strong oceanic anomaly in the same area and in the same period of the AVHRR image. In particular one track (track number 146, passage number 22 and 23 of the same period ov AVHRR image) shows a good correlation with SST data, allowing to confirm the suggested circulation for eddies B and C.

Successive cycles of the TOPEX/Poseidon altimeter clearly show that the structure B moves towards North-West with a speed of about 3 km for day.

An attempt to explain this complex feature (see for instance FEDOROV and GINSBURG, 1986; HOPFINGER and VAN HEIJST, 1993 and VAN HEIJST, KLOOSTERZIEL and WILLIAMS, 1991) is possible in term of vorticity balance taking into account the Algerian current instabilities, the well established presence in the area of large barotropic anti-cyclonic eddies and interaction with bottom topography (see for instance MILLOT, 1991).

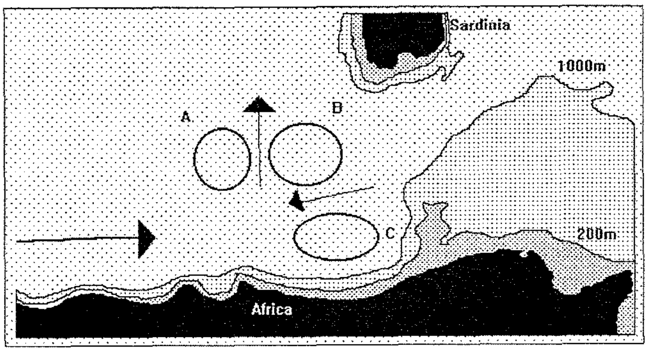

Figure : A schematic diagram of the phenomena

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FINITE ELEMENT MODELLING OF THE TIDE-CURRENT INTERACTIONS IN THE STRAIT OF GIBRALTAR

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The tidal wave propagation patterns and tide-current interactions in the Gibraltar Strait are examined by means of a quasi-3D finite element model of the shallow water equations (GONZALEZ, 1994). The spectral decomposition of the time-dependent variables allows the transformation of the transient problem into a number of simpler steady-state problems - one per each of the considered harmonic frequencies (see e.g. WALTERS, 1986). As per the residual flow, a 3D numerical approximation has been worked out making use of the ECADIS code developed by ESPINO (1994).

The numerical solutions are in quite good agreement with local observations reported by RICO and RUIZ (1988) and others. The M2 tide is seen to have eastward-decaying amplitude and to propagate southwards at the Mediterranean side of the Strait, just as expected. The solutions for the S2 and N2 tidal waves exhibit a similar character. On the contrary, the K1 co-range lines are parallel to the axis of the Strait, whereas the co-phase diagram indicates that the propagation of this wave is to the east (figure 1).

Figure 2 shows the vertical profiles of the M2 current velocity and phase obtained at a mooring site occupied during the Gibraltar Experiment 1986/87. It can be observed that the inclusion of realistic, vertically-varying density and residual flow distributions is crucial to reproduce the structure of the measured tidal circulation, whose major axis and phase decrease with depth.

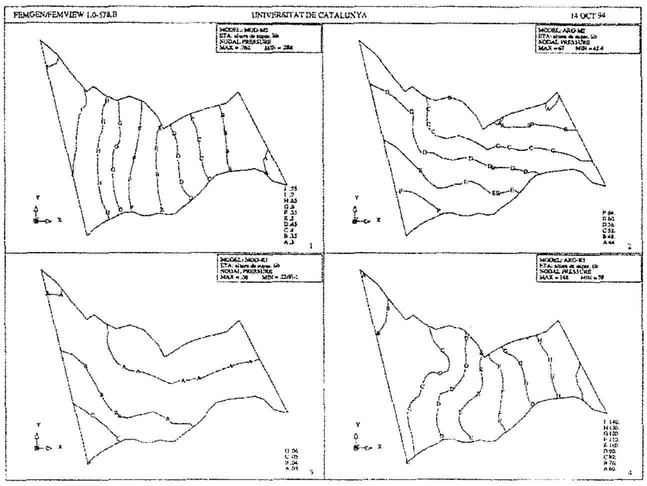

Figure 1. Numerical solutions for the M2 and K1 tides. Upper left: M2 amplitude. Upper right: M2 phase. Lower left: K1 amplitude. Lower right: K1 phase.

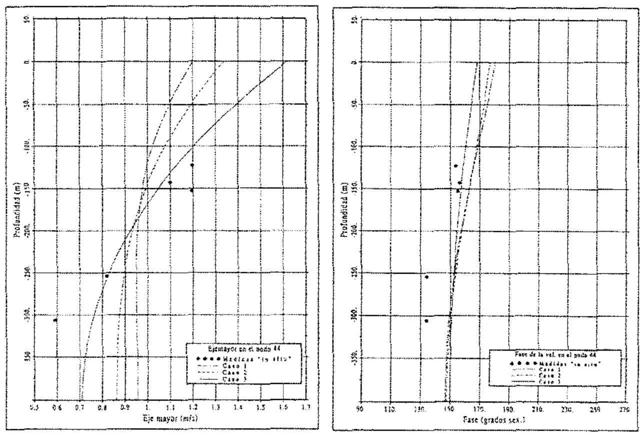

Figure 2. M2 current. Numerical solutions for the major axis (left) and phase (right) with 2 d.o.f. versus measured values on Camarinal Sill.
Case 1: only with bottom friction. Case 2: with friction and vertically-varying density.
Case 3: with friction and vertically-varying density and residual flow.

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