The Algerian Current Instability: Analytical and Numerical Investigation

Jean-Marie BECKERS(1), Jacques C.J. NIHOUL and Jacques HAUS(2)

GHER, University of LIEGE **(Belgium)**
(1)Research Assistant, National Fund of Scientific Research.
(2)IBM UK Scientific Centre, Winchester UK.

It is well known that the Atlantic water, after a trip around the Alboran Sea gyre(s), flows (guided by the Corilis force) along the Algerian coast as a light water intrusion. This current is unstable, and mesoscale activities generate cyclones and anticyclones, but only the latter ones grow enough to separate from the mean flow.

In order to demonstrate that the GHER 3D mathematical and numerical model is able to reproduce the eddies and instabilities of the Algerian current, an academic test case has been studied. Initially we have a dense water ocean with a southern coast. Along this coast flows a lighter water intrusion in geostrophic equilibrium (Fig.1).

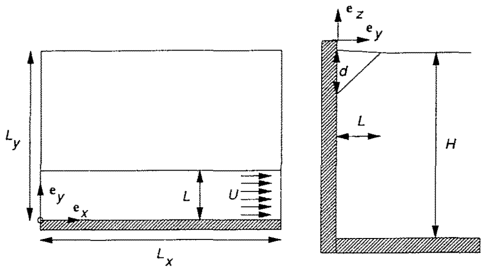

Fig. 1.- Base current

The geometrical and physical values are choosen in such a way that the transport in the lighter water is about 1.4Sv, corresponding to a typical value of the Algerian current (MILLOT, 1991). The boundary conditions in along-shore direction are periodic, which of course triggers the instabilities of a particular wavelenght.

The analytical solution shows that this current is stable in the framework of a reduced gravity model. The question of the type of the instability arises, because nature and direct simulation show strong instabilities.

The numerical grid uses a 2.5kmx2.5km horizontal Arakawa C-grid, with a vertical discretization of 17 levels, with a higher resolution in the light water mass. The time step was 2s for the barotropic part and 240s for the baroclinic one. The day to day variation of the shore current is shown, which gives a nice illustration of the instability growth and the development of an anticyclone accompanied with filaments spreading into the basin. After 50 days, the anticyclone ends up with a diameter 3 times larger then the initial current width, and its centre stays more or less at rest. Figure 2 shows the salinity field as computed after 55 days of simulation.

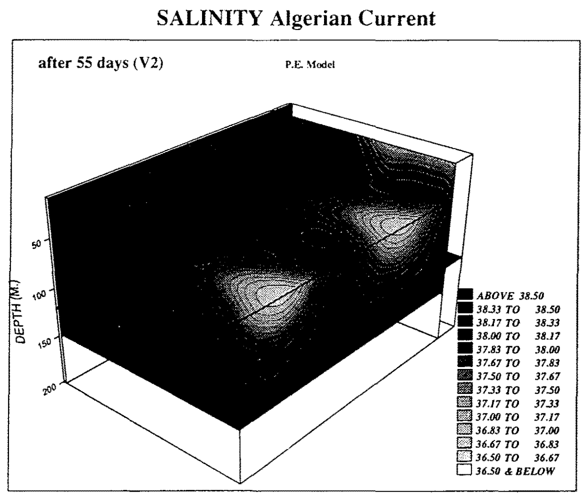

Fig. 2.- 3D view of the Salinity field in the periodic channel. The 3D view is from south-west to north-east. One can clearly see the big anticyclone.

One may question if other boundary conditions than the periodic ones would move the anticyclone northward, or if real topography should be included for this purpose.

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Waves and wave groups in shallow water : numerical and field results

Guido BENASSAI and Emilio SANSONE*

Istituto di Idraulica di GENOVA **(Italia)**
*Instituto di Meteorologia e Oceanografia, Istituto Universitario Navale, NAPOLI **(Italia)**

Random waves and wave groups on deep water can be closely reproduced through the superposition of linear component waves with amplitudes determined from the target energy spectrum and with uniformly distributed random phases [1]. A spectral form usually adopted to represent random waves on deep water is the JONSWAP one. This stochastic random wave simulation technique can be applied also to shallow water when the local spectral forms are known and the non linearities are taken into account.

In this study the behaviour of the random waves and wave groups on shallow water deduced by non linear numerical simulations is compared with the one deduced by field shallow water data excluding the surf zone.

The local spectral form on shallow water was obtained by the transfer of the JONSWAP spectrum on deep water [2]. The shallow water frequency spectrum so obtained (fig. 1) presents a single peak even for very shallow water, while both theory and experiments support the occurrence of a secondary peak in the shallow water spectrum due to the increased importance of the nonlinearities. So a model was performed to give the 2nd order component of the vertical displacements η_2 starting from the 1st order ones η_1 with a perturbation method [3]. Fig. 2 shows η_1 and $\eta_1+\eta_2$ obtained with the nonlinear numerical simulations starting from the spectrum on the lowest depth in fig. 1.

The field data were recorded for ten minutes every four hours by a pressure gauge placed on six meters depth offshore Massa, on the Tuscan coast. The data, consisting of vertical displacements and current velocities and directions on the bottom, were collected for Ministry of Public Works during the whole year 1989, in order to monitor the erosion of the shoreline. A preliminary selection of the sea states was made to avoid disturbances and breaking waves through a check of the autocorrelation function of the vertical displacements. The field sea states were analyzed with the spectral density method in order to compute their peak frequency f_p, and then selected through the value of the dimensionless parameter

$$\sigma_{hp} = 2\pi f_p \; h/g$$

h being the depth and g the gravity. The recorded sea states for which the value of σ_{hp} differed more than ±10% from the value 0.63 of the simulated ones were rejected.

For both the simulated and field sea states the wave groups were identified with a discrete approach based on the individual waves obtained by the zero upcrossing method. The length of the wave groups, that is the number of individual waves exceeding a given threshold, and the energy density of the groups were computed for both the simulated and recorded waves on shallow water, and the relevant results were compared.

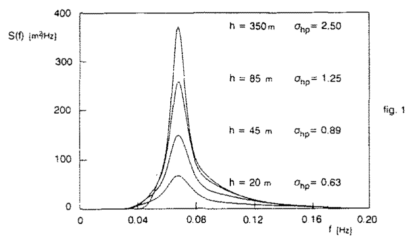

fig. 1

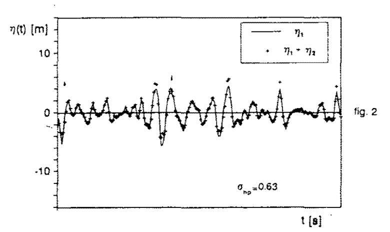

fig. 2

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