NUMERICAL MODEL FOR THE WIND INDUCED CURRENTS IN THE KASTELA BAY

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The Kastela Bay is small semi–enclosed sea placed on the East Adriatic coast with total area of 61 km^2 and mean depth of 23 m. It has two openings; the wider one connects the bay with adjacent sea of the Brac Channel. The basin depths increase from the coast to the wider opening, reaching about 50 m.

The great influence of wind forcing on the Kastela Bay current field has been observed from the result of the several empirical analyses (ZORE–ARMANDA, 1980; GACIC, 1982).

Beside data analysis wind induced currents in the Kastela Bay were examined also by numerical hydrodynamical models. Heaps spectral three–dimensional model (ORLIC *et al.*, 1989) and non–linear three–dimensional multilevel model (BONE, 1993) were used to simulate currents induced by two most frequent wind systems bora (NE) and scirocco (SE). Results of the numerical experiments were compared with current meter measurements obtained in seven field experiment in period from 1980 to 1990. The best agreement between measurement results and model results of both models was obtained for the northernmost station in the bay centre. The comparison between empirical wind induced currents and model predicted results shows their poor agreement in the bay inlet during bora and scirocco wind. The magnitudes of measured currents were order of magnitude higher than modeled currents. Furthermore, the measurements and numerical model results for the current driven by bora are opposite direction in the bottom layer, while during scirocco wind current directions in these two cases were similar. There are several possible reasons for discrepancy between measured currents and currents obtained by numerical simulations in the bay inlet. First, the open boundary condition might be wrongly chosen. In the Heaps model radiation conditions in the opened boundary were chosen, while in the non–linear model zero elevation was assumed. Better results would be obtained involving realistic elevation at the open boundary. In addition, discrepancy between measurements and numerical results could be consequence of some nonlocal effect constrained on the bay inlet area. There are two possible process : northwest incoming Adriatic current could create density gradients in the inlet and therefore generation of gradient currents or discrepancy could be result of atmospheric pressure effect. Atmospheric pressure effect would be taken into consideration by involving realistic elevation at the open boundary. Both models assume spatial homogeneity in the wind field. The validity of this assumption should be checked.

In order to avoid discrepancy between empirical and model predicted currents caused by model limitations, in this paper the Princeton numerical ocean model was used (BLUMBERG AND MELLOR, 1987). This model contains an imbedded second momentum turbulence closure sub–model to provide vertical mixing coefficients, so theerrors coming from parametrisation of turbulence are avoided. The model uses sigma coordinate system, convenient in dealing with significant topographical variability such as that encountered in the Kastela Bay. Using the turbulence sub–model and sigma coordinate system, the model produces realistic bottom boundary model layers which are important in coastal waters and are often source of non-realistic modeled currents. Beside these two characteristics especially important in coastal areas such as Kastela Bay, model also includes complete thermodynamics with fully three–dimensional non-linear primitive equations and Boussinesq and hydrostatic approximation. The horizontal grid uses curvilinear orthogonal coordinates and staggered difference scheme called an Arakawa C–grid. The horizontal time differencing is explicit whereas the vertical differencing is implicit. The model has a free surface and split time step. The external mode portion of the model is two–dimensional and uses a short time step based on the CFL condition and the external wave speed. The internal mode is three–dimensional and uses a long time step based on the CFL condition and the internal wave speed.

In numerical simulations of the wind induced currents in the Kastela Bay by the Princeton numerical ocean model three elements are examined :

1) effect of the various open boundary conditions (radiation condition, zero elevation, realistic elevation obtained from tide–gauge registration);
2) effect of the density gradient in the bay inlet;
3) effect of the heterogeneity in the wind field.

The result of the numerical simulations are compared with averaged current vectors on three levels (surface, intermediate and bottom) obtained from seven current meter experiment from 1980 and 1990. Averaged current vectors were computed from low–pass filtered time series in the periods with filtered wind speed over 5 m/s. The numerical simulations and comparison with empirical data were performed for both bora and scirocco wind.

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TIME DEPEDENT OPTIMAL MAPS OF THE POEM HYDROGRAPHIC SURVEYS OBTAINED THROUGH THE ADJOINT METHOD

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The GFDL primitive equation model in its fully time-dependent non linear version has been used in the Eastern Mediterranean together with its adjoint to find the model state optimaly consistent with the model dynamics, the prescribed climatology, and which is steady in time. We now have used the adjoint method in its fully time dependent form, i.e. assimilating the data at the time and at the spatial location they were collected. We have produced time-dependent optimal maps for the POEM general surveys of ON85, MA86, AS87 and ON91.

This means that, starting from a first guess initial condition given by the climatology for the corresponding month (season) the hydrographic data (temperature/salinity casts at standard depth levels) are assimilated at the time in which the hydrographic station was actually taken and at the location (latitude, longitude) of the station itself. Thus, the cost function is constructed in a time dependent manner following the time space trajectory of the research vessel(s) during the surveys in the forward integration of the model. The adjoint is then integrated backward in time in the usual manner to modify the first guess initial condition. The procedure is iterated until the cost function has decreased to an "acceptable" level, where the measure of success is assessed through the examination of the final data misfits residuals (BERGAMASCO *et al.*, 1993). Thus, a time-dependent optimal map is reconstructed consistent with primitive equation dynamics and the specific hydrographic survey. We have optimally mapped the POEM surveys (ON85 through ON91) with the exception of MA87 in which data are too sparse. These time-dependent optimal maps will quantify in a definitive manner the space scales of the sub-basin and mesoscale structures of the eastern Mediterranean, their persistence versus variabilities.

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