Adriatic shelf response to Scirocco wind - A modelling inquiry -

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When Adriatic Sea upper shelf is forced by laterally and longitudinally uniform SE (scirocco) wind its topography responds with double-gyre structured field of vertically averaged currents. Spatial extent of the structure is asymmetrical: narrow anticyclonic gyre is formed along the Italian coast while broader cyclonic gyre covers rest of the upper shelf. It is important to elaborate further dynamic conditions that induce and maintain such a response, and particularly to identify empirical evidence that suggests the same or similar dynamics. In this paper we present a series of modelling experiments that address the first part of the problem exploring the role that (lateral) heterogeneity in the scirocco wind field can play in sustaining or destroying the double-gyre response.

The experiments were performed using a three-dimensional, linear, barotropic model. Details of the model formulation can be found in our previous papers (e.g. Kuzmic et al.,1985); an early application of the model to the whole Adriatic is reported in Kuzmic et al.(1986). Several groups of numerical experiments have been performed assessing various aspects of the forcing field variability. Major results of these studies are summarized in Fig. 1.

When the SE wind is laterally homogeneous a downwind flow is induced along the shallow Italian coastal strip contributing to the anticyclonic gyre (Fig. 1a). This particular flow pattern, also observable at other cross-sections, survives to various degrees when the stress is allowed to decrese linearly from the maximum on the Yugoslav side to 50%, 75%, and 100% lower values on the Italian side. It is totally destroyed, however, when the stress is allowed to drop to zero along the Italian coast (from a constant value over Yugoslav part of the basin, following a cosine function). In that case a single cyclonic gyre is formed over the upper shelf; a representative cross-section is given in Fig. 1b. Described schematized cases, as many others not presented, are useful for developing an insight, but eventually one has to address the problem of true wind field over the sea. In doing that we have relied on the work of Palmieri et al.(1976). They have used one-level primitive equations model to obtain wind field over the Adriatic, starting from known surface pressure field and taking into account orographical and frictional effects. We have used their particular prediction for February 21, 1966, 09 GMT , after appropriate preparation, to force our model. As Fig. 1c demonstrates a downwind flow along the Italian coast reappears at the selected cross-section, as does the anticyclonic gyre, although over reduced coastal stretch.

These simulations suggest that double-gyre structured field of transports is a rather robust feature of the Adriatic shelf; it has survived most forcing field variations in our model experiments. Further numerical experiments are in progress assessing the relation of the wind stress and eddy viscosity. But, of particular importance is empirical verification of presented modelling results.

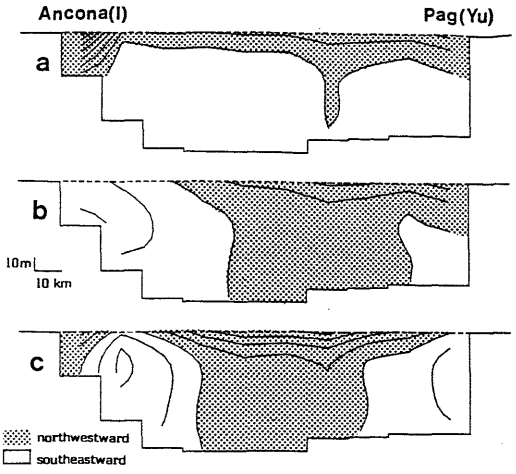

Fig. 1. Distribution of normal velocities in a section across the Adriatic for SE wind: a) laterally homogeneous, b) laterally decaying, c) quasi-empirical. Contouring interval is 10 cms^{-1}.

The coastal strip extending from the Po river delta down to the city of Ancona seems the most promissing area to offer such an evidence.

References

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Observations and modelling of upwellings in the Aegean Sea

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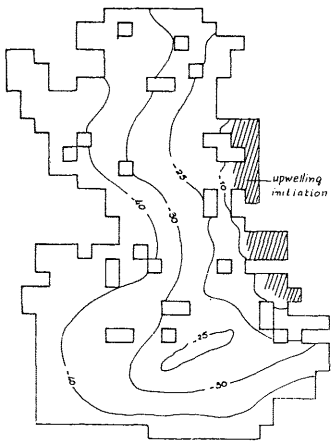
The combination of field measurements, satellite imagery and mathematical models for the investigation of the upwellings occurence in the Aegean Sea is the scope of the present study, of preliminary nature.

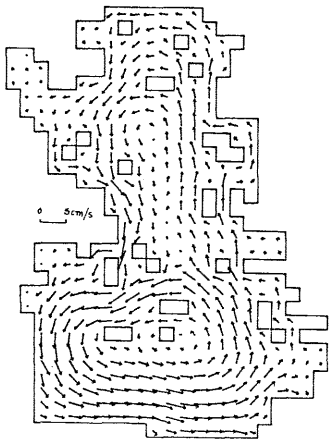
The field data were collected by the research vessel AEGEON of the National Centre of Marine Research during oceanographic expeditions within the context of the POEM and the Open Seas Research programs during the summers of 1986, 1987.

The temperature and salinity profiles recorder by CTD's and the deriving density profiles revealed that during summer distinct pycnoclines at depths ranging from 30 to 50 meters and $\Delta\rho/\rho$ values ranging from 2o/oo to 5o/oo appear along the basin. The whole area can be segmented in terms of the above two parameters in 5 distinct areas. The two layers system is a realistic hydrodynamic approximation for the basin.

Analysis of the characteristics of the water masses and satellite images indicate the occurence of strong upwellings during the warm season. Such a series of thermophotographs taken during summer 1986 by the AVHRR probe of NOAA satelite reveal intensive thermal features along the East part of the Aegean Sea. It was attempted here to explain the origin of that cold superfical water on the basis of in situ measurements of the thermal conditions of the upper layers, the prevailing meteorologic conditions and the use of a mathematical model.



Surface layer thickness after 80 hours of Etesian wind



Circulation in the surface layer under moderate wind conditions

From the meteorological information concerning the surface wind patterns it is concluded that during summer the pattern of the strong Etesian winds (of N-NE direction in the N. Aegean turning to NW-WNW in the south Aegean Sea) is typical. The mean frequency of that wind is 45% This cyclonic wind pattern influences the surface layer through the imposed friction.

The mathematical model used here was a reduced gravity model for wind generated circulation and evolution of the layer thickness. It was solved by a F.D. explicit scheme on a staggered orthogonal grid of mesh size equal to 20 km. The typical strong Etesian wind pattern was the forcing factor applied on the basin.

The model indicated that within 80 hours of wind application upwelling occured and extended along the East part of the basin with a cyclonic circulation pattern established along the basin. The fact that the cold, less saline Black Sea waters effluying from the Dardanelles straits enter a circulation pattern forming a westward coastal current along the coast of N and W Aegean Sea and the appearance of upwelling for the assumed realistic density stratification and wind patterns, lead to the preliminary conclusion that the thermal features revealed by the satellite imagery are indications of persisting summer upwellings along the East part of Ehe Aegean. Further investigation by models and tracers is proposed.