Modelling the general circulation of the Aegean Sea
Part 1: Wind Forcing Experiments

K. NITTIS and A. LASCARATOS

University of Athens, Department of Applied Physics, Lab. of Meteorology and Oceanography, ATHENS (**Greece**)

The Princeton Ocean Model (POM) is used to study the wind induced general circulation of the Aegean Sea. POM is a free-surface sigma-coordinates 3-D primitive equation model (BLUMBERG & MELLOR, 1987) designed to simulate both coastal and open sea dynamics. Depth integrated and 3-D equations are solved with different time step using a time splitting technique. The model includes the MELLOR-YAMADA 2.5 turbulence closure scheme (MELLOR & YAMADA, 1982) to calculated vertical heat and momentum diffusivities while the Smagorinsky formula is used for horizontal diffusivities. The model grid covers the area 21°-30° E and 33°-41°10' N with a spacing of 1/6th of a degree in cartesian coordinates and the topography used has been smoothed by an 8th order Shapiro filter. The vertical resolution is 16 levels with logarithmic distribution near the surface. The Levitus hydrological data interpolated in the model grid and mapped into sigma coordinates have been used as initial conditions. The model is forced by monthly climatological wind stress data (HELLERMAN & ROSENSTEIN, 1983). On the open boundary points an upstream advection equation is used for temperature and salinity with boundary values of T and S held fixed to the climatological profiles. At the surface, temperature and salinity are also held fixed to climatology.

In figure 1 the annual mean barotropic transport streamfunction after 5 years of integration is presented. Although a perfectly repeated seasonal cycle is observed in the kinetic energy of the model, almost all the general circulation features maintain their structure throughout the year with seasonal variations only in velocity magnitudes. This absence of strong seasonal variability is concurrent with the almost steady wind field pattern provided by the climatological data. Barotropic and baroclinic velocities are of the same order with typical values 5-10 cm/sec. A number of well known circulation features can be recognized in figure 1. In the SE part (Rhodes area) a cyclonic circulation with flow parallel to the eastern straits is established. This flow enters the Aegean mainly through the central of the eastern straits and bifurcates towards the central Aegean and the Cretan sea, being similar to the typical winter circulation pattern in the area. South-east of Crete a well formed anticyclone can be observed similar to the so called "Ierapetra Gyre" observed from both hydrological data (ROBINSON *et al.*, 1991) and infrared satellite images. This gyre seems the most energetic feature of the area with maximum velocities of -30 cm/sec. South-west of Crete a large cyclonic feature also known from the POEM data as Cretan Cyclone is observed. Another strong mesoscale feature is the double anticyclonic gyre SW of the Peloponnesian peninsula. This gyre has been found to be the most intense feature of the summer 1986 general circulation of the Ionian sea (NITTIS *et al.*, 1992) and is known to be a permanent feature of the area. In the Cretan sea, two anticyclonic and two cyclonic gyres are present. In the central Aegean, the flow is northward in the centre and southward along both eastern and western coasts forming a complex system of one cyclone and one anticyclone. In the northern Aegean sea, the prevailing feature is the anticyclonic gyre south of the Athos peninsula.

Wind Forcing Experiment (Year 5)

Barotropic Transport (in Sv)

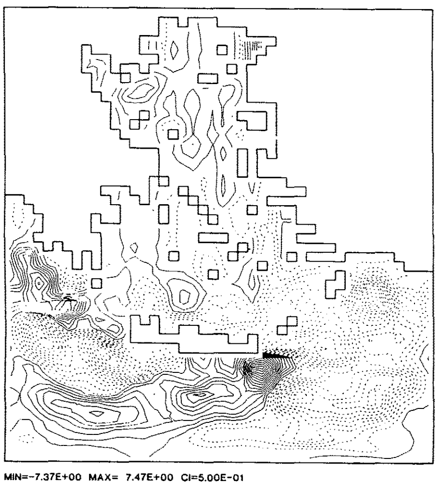

Figure 1

MIN=-7.37E+00 MAX= 7.47E+00 CI=5.00E-01

REFERENCES

BLUMBERG A.F. & MELLOR G.L., 1987.- "A description of a three-dimensional coastal ocean circulation model", Three dimensional coastal ocean models, Vol. 4, edited by N. Heaps, pp.208, AGU, Washington D.C.

HELLERMAN S. & ROSENSTEIN M., 1983.- "Normal wind stress over the world ocean with error estimates", *J.P.O*, 13, 1093-1104.

MELLOR G.L & YAMADA T., 1982.- "Development of a turbulence closure model for geophysical fluid problems", *Rev. Geophys. Space Phys.*, 20, 851-875.

NITTIS K., PINARDI N. & LASCARATOS A., 1992.- The summer 1987 general circulation of the northern Ionian sea, submitted to JGR

ROBINSON A.R., GOLNARAGHI M., LESLIE W.G., ARTEGIANI A., HECHT A., LASSONI E., MICHELATO A., SANSONE E., THEOCHARIS A. & UNLUATA U., 1991.- The eastern Mediterranean general circulation: features, structure and variability. *Dynamics of Atmosphere and Oceans*, 15, 3-5, 215-240.

A numerical investigation for the mesoscale structure of the Rim Current along the Southern Black Sea Coast

Temel OGUZ

Institute of Marine Sciences, Middle East Technical University, Erdemli-ICEL (**Turkey**)

Contrary to the traditional view of circulation in the Black Sea, the recent high resolution data provided by satellites and hydrographic surveys suggest the presence of complex eddy-dominated mesoscale circulation, often masking the general circulation field. The cyclonic boundary current encircling the basin exhibits strong meandering with wavelengths of 100-150 km, accompanied with eddies and coherent structures.

Despite the growing number of observational work on the mesoscale variability of the Black Sea circulation, little is yet known quantitatively about the mechanisms ultimately responsible for their generation, evolution and decay. A series of numerical model experiments has been performed to explore the dominant mechanisms which may lead to variability observed in the structure of the Rim Current. Particular attention is given to the flow structure along the southern coast of basin. The flow was represented by the inflow-outflow model in a channel of approximately 1000 km long and 200 km wide extending in the west-east direction along the Turkish coast.

The barotropic response of the flow, investigated by the nonlinear barotropic PE model, shows that the interaction of the Rim Current with the bottom topography may contribute to the flow meandering and lead to a number of topographically-induced quasipermanent coastal eddies. The curvature of the coastline in the western part of the analysis region is found to be responsible for generating cyclonic vorticity which ultimately tends to split the Rim Current into two branches at approximately 34 E longitude; one branch proceeds eastward along the coast, the other one bifurcates cyclonically towards the interior. This result indicates that the well-known dual-dome cyclonic circulation of the Black Sea is controlled by the geometry of the basin.

The multi-layered (three layer in the present application) model further reveals that the mean flow becomes subject to mixed instability; the baroclinic instability being the dominant one. The finite amplitude topographic and coastline irregularities as well as the local wind stress variability trigger the instability mechanisms leading to generation of time dependent intense meandering flow pattern and formation of filaments and pinched-off eddies, being simultaneously advected downstream. The filaments are strong offshore jets elongated cyclonically across the shelf-slope boundary into the interior of the basin and are found to be generated in the regions of strong coastline curvature. Their considerable transport capacity of mass, momentum and biochemical materials between the coastal and nterior waters are evident from the observations.

O