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ON TOPOGRAPHIC AND WIND VORTICITY EFFECTS IN BURA DRIVEN CIRCULATION IN THE NORTH ADRIATIC

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Model

In the base of numerical modelling of flow pattern is the model of verticaly integrated velocity (e.g. Nihoul et al.,1979,discussion of 2D+1D type of three dimensional model). Here model of verticaly integrated velocity was usedin order to illustrate the importance of bottom topography and vorticity in the wind field in evolution of characteristic flow pattern of drift current in the North Adriatic for the bura (NE wind).

The hydrodynamic equations are

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(1)    Dt(U)-F*V=-G*Dx(S)+Tx/H-C*Q*U/H ,Q=Sqrt(U**2+V**2)
(2)    Dt(V)+F*U=-G*Dy(S)+Ty/H-C*Q*U/H
(3)    Dt(S)+Dx(H*U)+Dy(H*V)=0
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where Dt,Dx,Dy denote partial derivatives per time T and spatial coordinates (X,Y) respectively, (U,V) are velocity components, F Coriolis parameter, G acceleration of gravity, S sea level denivelation, (Tx,Ty) components of wind drift force and H bottom depth.

On the rigid boundary the kinematic condition is assumed and on the open boundary the conservation of mass in the considered basin is assumed, i.e. the zero total mass transport trough the open boundary. In the here considered case (see Fig.1) it is

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(4)    Int(H*V*Dx)=0 , X=0,L
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where Int denotes integration and X=0,L denotes domain of integration.

By inserting condition (4) in the integrated equations (1)-(3) for X=0,L where linear bottom friction is assumed and assuming in good approximation in the boundary region (Y=Yb): U(0,Yb)=U(L,Yb)=0 (from kinematic boundary condition), H=H(Y) and Dx(S)=(S1-S0)/L where S0=S(0,Yb) and S1=S(L,Yb) , follows

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(5)    S(X,Yb)=(Tx-(Cm/H*F)*Ty)/G*H
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where Cm is linear bottom friction coefficient.

The equations are numericaly solved in C grid (notation after Arakawa and Winningoff) and leap-frog time scheme.

Results

In the case of flat bottom H=const=30 m and homogeneous wind field from NE the hydrostatic equilibrium occurs, i.e. the gradient force is in hydrostatic equilibrium with drift force.

The flow pattern for the homogeneous wind from NE (bura), Tx=5dyn/cm**2 , Ty=0 with real bottom topography is given in Fig.2. In this case the current field is well developed.

Fig.3 presents current field for assumed flat bottom H=30 m and NE wind (bura) having the vorticity: Tx=C*(1+((2*Y-Yb)/Yb)**2) , C=5 dyn/cm**2 , Ty=0. There is well developed current field.

Fig.4 presents current field for real bottom topography and wind from NE (bura) having the vorticity.

The hydrostatic equilibrium is obtained only in the case of flat bottom and homogeneous wind. The bottom topography and vorticity in the wind field are the effects of the same order in formation of flow field as it is demonstrated in Fig.2 and Fig.3.

Conclusion

The input of the atmospheric vorticity to the sea was observed by Stravisi (1977) in the numerical solution for the bura drift current in the North Adriatic. The importance of the vorticity input was observed by Zore-Armanda and Gacic (in press) from the experiment results and the importance of bottom topography was observed by Kuzmic et al. (1985) from numerical solution.
The results of this article demonstrate that in the case of bura wind in the North Adriatic the effect of bottom topography and the atmospheric vorticity on drift current are of the same order of magnitude.

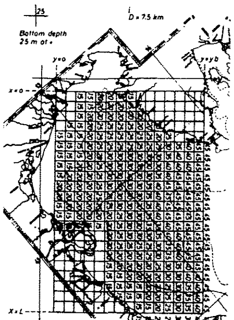

Fig.1. Domain of numerical integration.

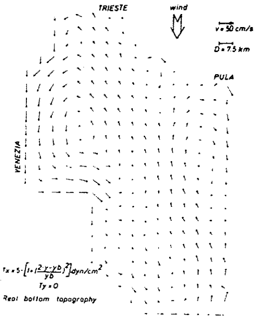

Fig.4.Real bottom topography and non-homogeneous NE wind

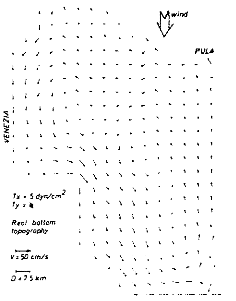

Fig.2.Real bottom topography and homogeneous NE wind.

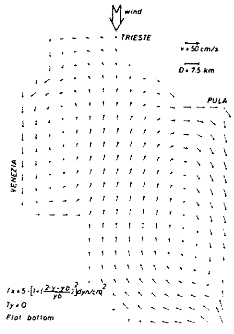

Fig.3. Flat bottom and non-homogeneous NE wind.

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O-V9

ON THE STERIC SEA LEVEL OF THE EASTERN MEDITERRANEAN SEA

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The steric fluctuation is defined in terms of the seasonal fluctuation in specific volume. Intensive study of the seasonal and annual variations of the steric sea level of the Eastern Med. Sea was made on the basis of comparison of the variation of water density in the anomalous warm and cold years, which makes it's possible to estimate the maximum magnitude of the annual variation in the sea level due to the steric effect.

The hydrographic material in the anomalous warm and cold years was taken from the work of Maiyza(1984).

Formulation:

Pattullo et al(1955) equation was used to estimate the steric departures from the mean sea level(MSL):

$$Z_{\alpha} = g^{-1} \int_{P_a}^{P_o} \Delta\alpha_2 \, dP \qquad (1)$$

Where:

$\Delta\alpha_z$: is the departure in specific volume due to small ΔT & ΔS given by:

$$\Delta\alpha = \alpha(\bar{T}, \bar{S}, \bar{P}) - \left(\frac{\partial\alpha}{\partial T}\right)\Delta T + \left(\frac{\partial\alpha}{\partial T}\right)\Delta S \cdots$$

ΔS & ΔT: are the difference between the annual mean salinity and temperature and their respective monthly means,

P_a : is the atmospheric pressure,

P_o : is the pressure to which the integration has been carried, presumably the pressure at which all seasonal effects vanish.

g : acceleration of gravity.

For practical estimation of the steric level equation(1) was transformed by Galerkin(1961) as:

$$h = 0.1\, \Delta h\, \Delta\alpha_z \qquad (2)$$

h steric level in cm.; Δh: the depth of the studied layer.

For the computation of the differences in steric departures between the anomalous warm and cold years, equation(2) can be written in the form:

$$\Delta h_s = \sum_{i=1}^{n} 0.1\, \Delta h_i \alpha\, h_i$$

Where:

$$\Delta\alpha_i = \alpha_i(w) - \alpha_i(c)$$

α_i : the difference in specific volume in the layer i between anomalous warm(w) and cold(c) years.

Results:

The steric departures in the Eastern Med. Sea were higher in the warm years than those in the cold ones except in the center of the Ionean Sea and the north of the Levantine Sea in winter and the strait of Sicily and the southern part of Levantine Sea in summer. The thickness of the layer in which the steric variations take place was 200-1000m. The magnitude of the differences of the steric departures in summer is larger (16cm.) than that in winter(12cm.).

The effect of temperature on the steric departures in the upper 50m layer was more than that of salinity, but deeper the reverse is true.

From the seasonal point of view, the steric level in summer is higher than that in winter(12cm.) in the warm years, In the cold ones the vibration of the steric departures is smaller(about 4cm.).

Conclusion:

The steric departures of sea level between anomalous warm and cold years in the Eastern Med. Sea were calculated. This study proved that the effect of water density on sea level may reach 50% of the seasonal observed values of sea level. The layer thickness of the steric variation reach 1000m, and this may be related to the processes of the formation of the Med. deep waters.

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