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NUMERICAL CALCULATION OF THE VERTICAL VELOCITIES IN THE WESTERN PART OF THE MEDITERRANEAN SEA.

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ABSTRACT

Using a three dimensional model similar to that used by Dzukov ,the vertical components of the current velocities in the western part of the Mediterranean Sea were calculated for the summer season,assuming stationary conditions.

Starting with the wind speed and direction with a free sea surface,the velocity field was calculated for the surface (0-10m.) layer and at other depthes .The values of the vertical velocities with depth were of order of 10^{-4} cm/sec,and the maximum was generally at depth of 100 m.The distribution of the vertical velocities varies only in detail.

Area of upwelling and sinking came out,sinking appearing in ceteral part of the region, while upwelling appeared at the borders, obviously the north wester part of the region .Velocities in the upwelling region reached about 8^{-4} cm/s.The general cyclonic motion in the basin maintans the calculated upwelling.The area of sinking agree well with the observed area of sinking of maximum salinity water as observed by Wust.

INTRODUCTION

The western part of the Mediterranean Sea is poorly studied using the mathematical methods. In this part of the sea, different water masses spread with different directions at different depths. In the recent times there are many mathematical models for studying the formation of the water masses and the their circulation. In the present work the author has calculated the water circulation of the western part of the Mediterranean Sea, with a three dimensional model.

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MATERIAL AND METHODS

Taking in consideraton that the wind field over the area is stable, it is possible to study the current in the sea using a stationary condition. A three dimensioal mathematical model similar to that used by Dzukov (1966), is used to calculate the horizontal and the vertical components of the current velocity in the western part of the Mediterranean Sea. The stationary motion affected by the wind field is considered in a sea of non-homogenous field of density.

Taking the right hand-side co-ordinate system with X axis directed to the right, the Y axis directd to the noth and the Z axis upright. The equation may be written as follows

The equation of motion

$$fv - \frac{1}{\rho}\frac{\partial P}{\partial x} + \frac{\partial}{\partial z}\nu_z\frac{\partial u}{\partial z} + \nu_l \Delta u = 0$$

$$-fu - \frac{1}{\rho}\frac{\partial P}{\partial y} + \frac{\partial}{\partial z}\nu_z\frac{\partial v}{\partial z} + \nu_l \Delta v = 0$$

The hydrostatic equation

$$\frac{\partial P}{\partial z} = -\rho g$$

The equation of continuety

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial \bar{\omega}}{\partial P} = 0$$

Where, u, v = The horizontal velocity components in the X and Y directions,
ν_z, ν_l = The vertical and the horizontal viscosity coefficients,
f = 2ω sin is the Coriolis parameter,
ρ = Denisity,
g = Force of the earth's gravity and
ω = The angular vilocity of the earth's rotation.

The analog of the vertical velocity is determined by

$$\bar{w} = u\frac{\partial P}{\partial x} + v\frac{\partial P}{\partial y} + w\frac{\partial P}{\partial z} = \frac{dP}{dt}$$

Since we are looking for a stationary motion, represents the change of pressure with time in moving body, the pressure will change only with depth. Thus, the vertical velocity is represented by the following equation

$$W = -\frac{\bar{\omega}}{g\rho} + u\frac{\partial H^*}{\partial x} + v\frac{\partial H^*}{\partial y}$$

Where H^* = The dynamic height.

The first term of the right-hand side of the equation is too large compared with the second and the third terms, except for the surface where, =0 Thus, approximation gives rise to

$$W \simeq -\frac{\bar{\bar{\omega}}}{g\rho}$$

The vertical velocity of the lower boundary of the surface layer (0 - 10 m) can be represented by

$$W_{P=P'} = -\frac{P'}{g\rho} \Delta \bar{\varphi}$$

Where $\bar{\varphi}$ = The potential function.

While on other deeper levels the vertical velocity is determined by

$$W_K = W_{K-1} + \frac{\Delta \varphi_K + \Delta \varphi_{K-1}}{2} \frac{\delta \rho}{g\rho}$$

RESULTS

During the summer season the values of the vertical velocities in the western part of the Mediterranean Sea, were of order of 10^{-4}cm/s. The changes of the vertical velocities with depth varies in detal. Areas of upwelling and sinking came out. Sinking in the western basin is found in the center of the basin, while the upwelling appeared between the sinking area and the borders of the basin. The north western borders of the basin showed relatively higher vertical velocity (more than 15 x 10^{-4}cm/s). The general cyclonic movement in the basin maintains the calculated upwelling motion. The araes of sinking agree well with that observed by Wust (1961), for sinking of the water of the maximum salinity and their spreading. (Figs. 1 and 2).

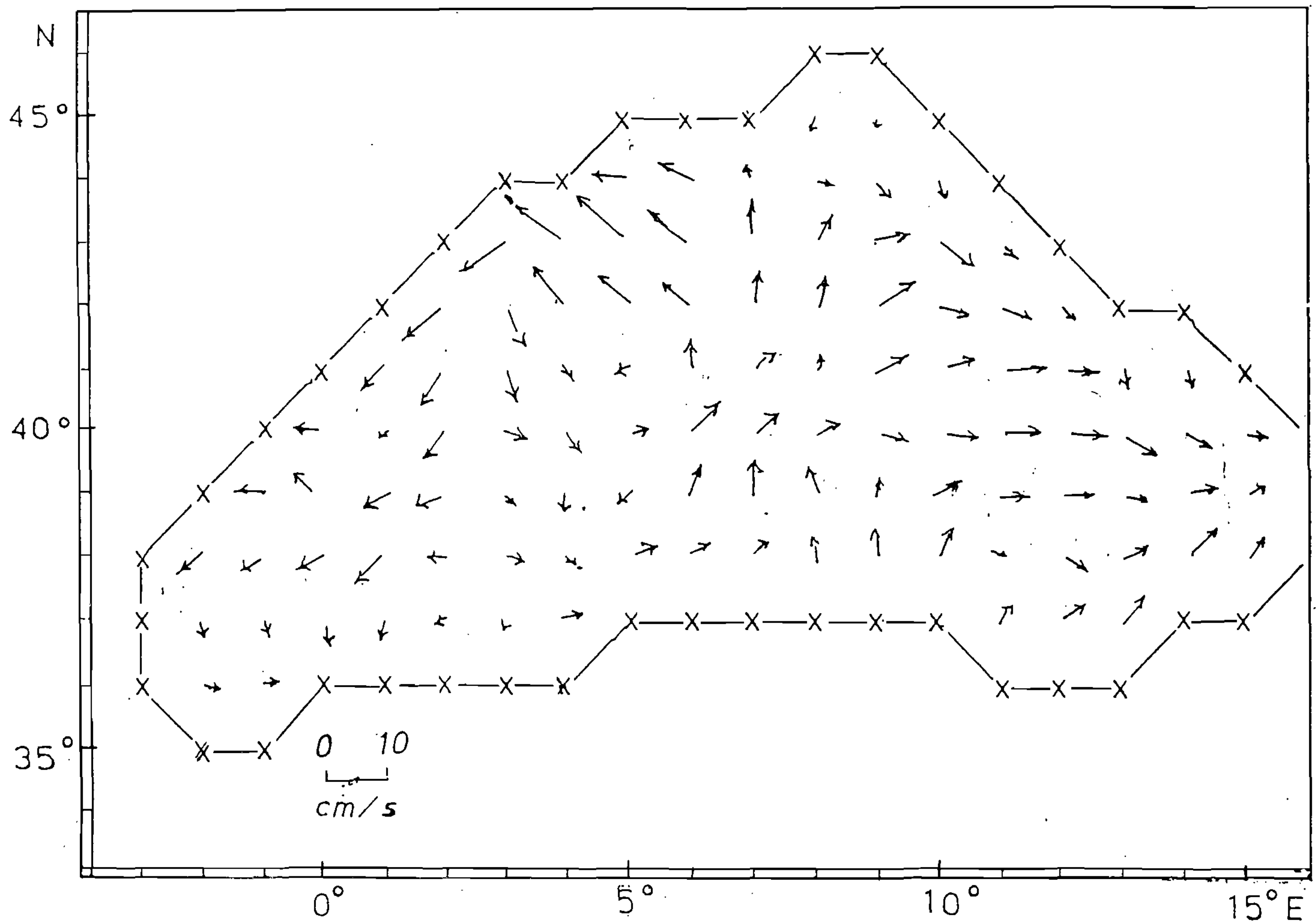

Fig. (1). The field of the horizontal current velocities at (0 - 10 m.) level, cm./s.

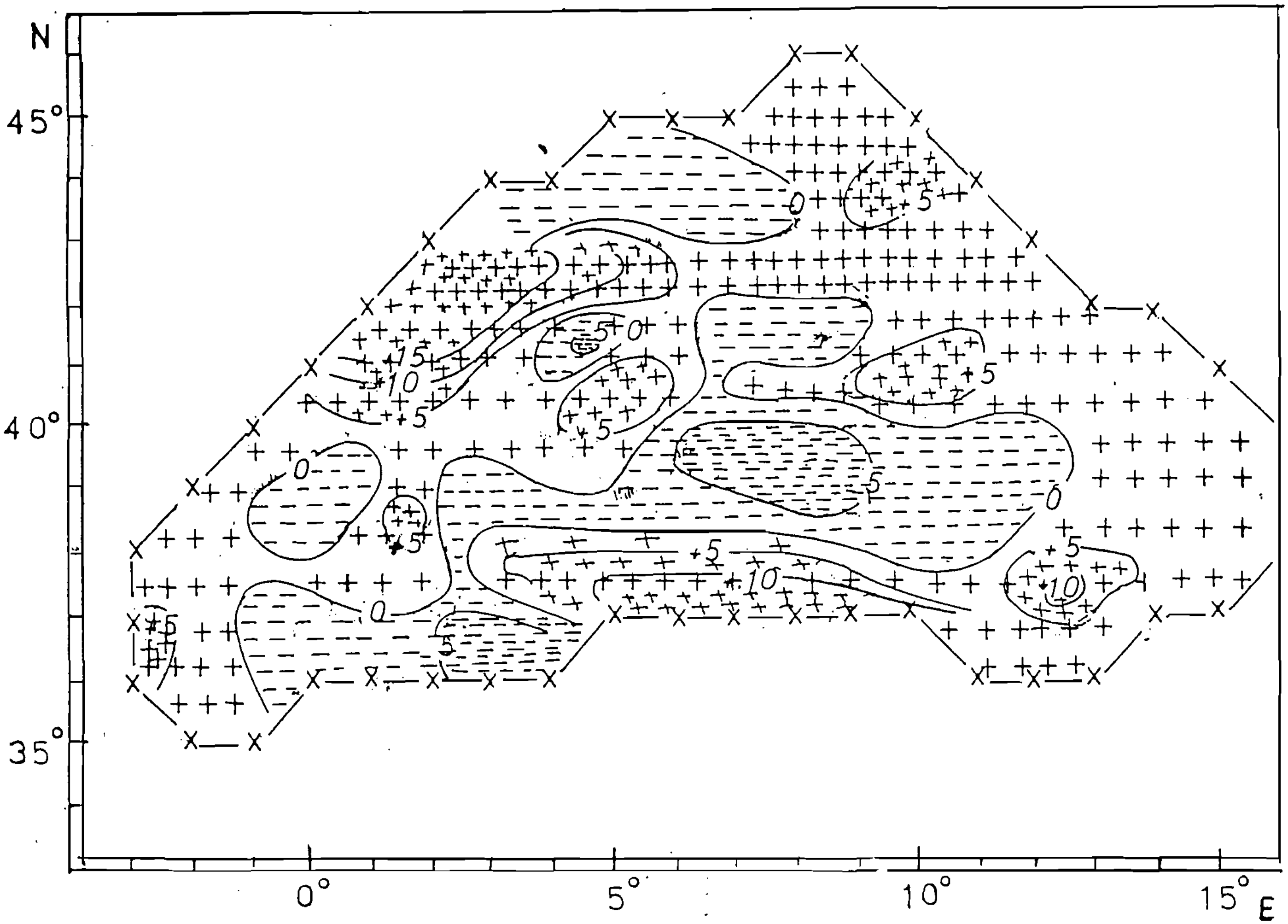

Fig. (2). The field of the vertical velocities at (0 - 10 m.) level X 10^{-4}, cm./s.

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