The northward flow of Mediterranean water in the Adriatic Sea in the light of oxygen isotope measurements

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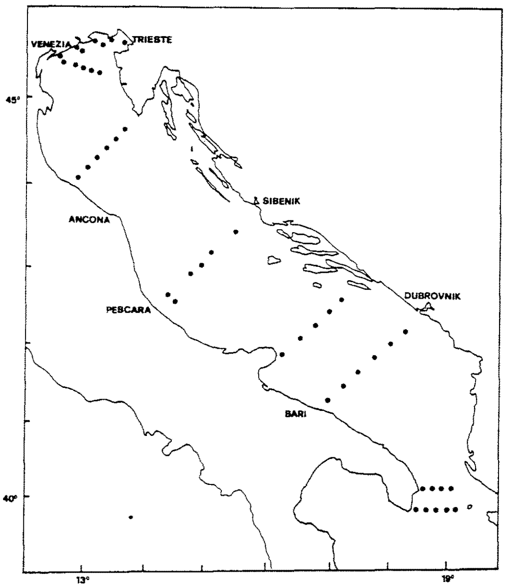
Despite the research work carried out by several authors the Adriatic sea is not yet known in detail from the point of view of circulation and distribution of the characterizing variables like salinity, temperature and density of the water. Our knowledge regarding the distribution of the oxygen and hydrogen isotopic composition of Adriatic seawater and the latitudinal and vertical changes of these variables is pratically inexistent. To start the collection of reliable data in this field we analyzed up to now a few hundred samples of Adriatic seawater from vertical profiles from southern, central and northern Adriatic (Figure 1). For many of these samples other variables (e.g. salinity, temperature and density) are available and were or will be published by other authors. Our isotopic measurements, though largely incomplete, already yielded data which are of importance for a better knowledge of the circulation in this sea. In fact, sets of bottom water samples between Venice and Trieste showed repeatedly $\delta^{18}O(H_2O)$ values ranging from +1,1 to +1,4 per mil (V-SMOW). These are very positive values which drastically differ from those of surface water samples which generally range, in this area, between +0,8 and -0,5 per mil. In this case the depletion in ^{18}O is clearly and obviously due to the inflow of river water whose $\delta^{18}O$ is considerably negative. The range of values goes from about -12,5 per mil in the case of the Adige river to about -10,0 per mil in the case of the Po river to values of about -8 to -9 per mil for other minor rivers in the area. This means that only when a marked cooling of surface water takes place in this area or strong winds increase the dynamic of water masses, a real homogeneization of the different water layers takes place in northern Adriatic, as shown, e.g., by sets of samples collected in the winter period. When, on the other hand, surface warming and/or the absence of strong wind increase the vertical stability of different water layers, no vertical mixing takes place and even diffusion processes seem to be drastically reduced. Under these conditions, bodies of Mediterranean water from the eastern and central basins -characterized by very positive $\delta^{18}O$ values- may apparently flow all the way to the northernmost section of the Adriatic sea as a thin bottom layer. Despite a course of hundreds of kilometers this bottom water layer, under favourable conditions, may largely preserve its original isotopic composition through time and space. In fact, eastern and central Mediterranean are the only sources of isotopically positive water wihch may explain the most positive values obtained. The northward evolution of the $\delta^{18}O(H_2O)$ values from the Otranto channel and the dynamic of the Adriatic water masses are discussed in some detail on the basis of the isotopic values obtained and their comparison with other classical variables measured in seawater.



An estimation of surface heat flux over the Northern Adriatic

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Heat exchange between the atmosphere and sea plays an important role in the Northern Adriatic dynamics. In this note preliminary results of the surface heat flux evaluation at three stations in the region are presented.

Monthly means of conventional climatological data (air pressure, air temperature, wind speed, cloud cover, specific humidity, precipitation) and sea surface temperature were used to compute monthly averages for the period 1966 - 1971 at stations Trieste, Rovinj and Mali Losinj. Total downward heat flux was determined from:

$$Q = Q_s - Q_l - Q_e - Q_c$$

where Q_s is the absorbed global solar radiation, Q_l is the net longwave radiation, Q_e is the latent (or evaporative) heat flux, and Q_c is the sensible heat flux. Terms Q_l, Q_e and Q_c were computed according to GILL (1982). Q_s was computed using theempirical relation (PENZAR and PENZAR, 1991):

$$Q_s = Q_{s0}\,(1 - (1 - a)\,N)\,(1 - \alpha)$$

where Q_{s0} monthly average of the clear sky radiation, is corrected for the cloud cover N and reduced with an albedo $\alpha = 0.08$. Term a represents an empirical coefficient.

Figure 1 shows annual cycle of total heat flux into the sea, at three stations in the Northern Adriatic. The sea gains heat in the warm period, from March/April to August/September. This compares well with the results obtained by COLACINO and DELL'OSSO (1975), but not with those published by STRAVISI and CRISCIANI (1986). There is a maximal heat gain in May or June, whereas the maximal heat loss occurs in December at all the stations.

At Trieste and Mali Losinj the sea loses heat with an annual mean surface flux of 17.7 and 30.1 W/m^2, respectively. Conversely, annual mean heat gain is observed at the Rovinj station (25.9 W/m^2). At all the stations Q_s has an annual mean value of about 120 W/m^2, annual mean Q_l is everywhere close to 70 W/m^2, whereas annual mean Q_c range between 5 (Rovinj and Trieste) and 11 W/m^2 (Mali Losinj). The difference between the total annual mean flux at three stations arises mainly from different amount of heat lost by evaporation. At Rovinj Q_e averaged over the year is only 26 W/m^2, at Trieste 55 W/m^2, while at Mali Losinj it amounts to 72 W/m^2.

Difference between total annual precipitation (about 1 m at all the stations) and evaporation has also been evaluated. The precipitation prevails over evaporation everywhere: the annual mean difference is 146 mm at Mali Losinj, 292 mm at Trieste and 584 mm at Rovinj.

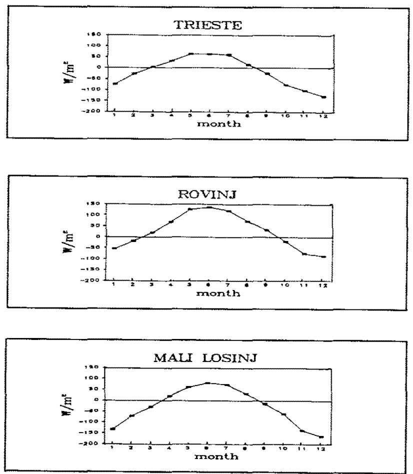

Figure 1: Annual cycle of the total surface heat flux at three stations in the Northern Adriatic.

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