Observations on the Atlantic water present in the Ionian Sea during POEM-V-87 cruise (August 31 - September 19, 1987)

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From August 31 to September 19 1987, as taking part of the international oceanographic cruise, we made 81 hydrological stations covering the Ionian sea area and the strait of Otranto, from 35.5 to 40.5 of latitude North and from 16 to 19.5 of longitude East. (Fig. 1). The T-S diagrams and the temperature and salinity fields show that the area is interested by three distinct mass of waters (excluded the surface layer of approximately 20 meters depth):

a) The Atlantic Water (AW) that interest the first 100 m, its thermohaline characteristics vary strongly from one side to the other of the area investigated. The salinity minumum ranges from 37.3 PSU at the South of the Ionian Sea, to 38.4 PSU in the northern part.

b) The Levantine Intermediate Water (LIW) with temperature of approximately 14°C and a salinity greater than 38.80 PSU (the maximum that we found was 39.08 PSU in station 79), the depth of the core varies from 200 to 500 m.

c) The Deep Water (DW) with a temperature less than 13.8 °C(we found the minimum of 12.84 °C at the bottom of the station 12) and a salinity less than 38.75 PSU.

The AW enter in the Mediterranean Sea from the Strait of Gibraltar and spread eastward with a certain number of branches that leave the main flow (Lacombe 1970).

One of these branches interst the Ionian Sea. The distribution of salinity minima (fig. 2) show that the core of the AW is in the centre of the area and is surrounded by nuclei of saltier and warmer water. The AW it keeps at the left of the 19^{th} meridian.

In fact approximately along this meridian is present a very definit thermic front, from the surface to about 50 meters, at the depth of 30 m the front is sharper than at the surface.

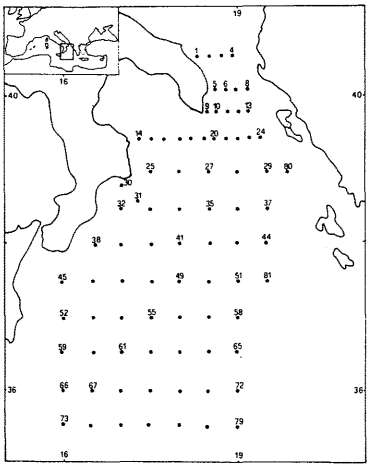

Fig. 1 - Map of the stations.

At the station 73, in the South-West part of the area, the AW dominate from the surface to further 100 m. with the minimum of 37.29 PSU at 34 m.

In the northern part of the area, near the Strait of Otranto, the minimum of salinity is deeper (in station 20 is of 37.89 PSU at 38 m depth and in station 27 is of 38.29 PSU at 45 m depth). The layer of the AW is compressed between a mass of surface water, saltier than 38.60 PSU, and the LIW that in this part of the area we found from 500 m until 100 meters.

The planimetries and sections of temperature and salinity show filaments, termohaline fronts and many detached parcels of AW.

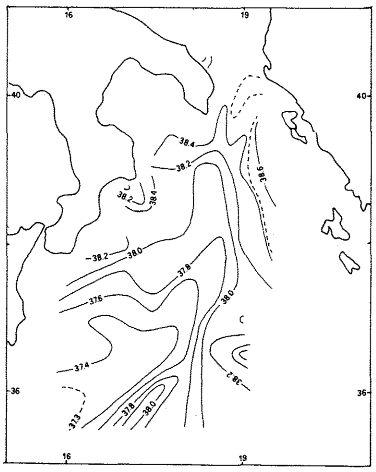

Fig. 2 - Distribution of the salinity minima.

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Horizontal oceanic circulation generated by deep water formation

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In this paper, we study the horizontal circulation generated by vertical convection and subsequent deep water formation. This work was initiated in order to explain the cyclonic circulation which is observed in the northern part of the Western Mediterranean basin (i.e. the Ligurian-Provencal sea). Attention is focused on mesoscale motion generated by buoyancy forcing and the role played by non linearities and instability phenomena on their long term evolution. In order to investigate the importance of the above processes, we use a 3 D primitive equation numerical model, where temperature and salinity are included.

First, we deal with an "academic scheme". The Ligurian sea is schematized by a rectangular domain of 500 * 250 km whose center is located at 42ºN. We start from rest. The density is homogeneous horizontally and the vertical gradients of temperature and of salinity are those encountered in winter. The grid mesh in the horizontal is 5 km which is smaller than the radius of deformation of the first baroclinic mode (≃ 8 km). Variation in the vertical is modelled by 12 levels whose separation is variable (from 10 m near the surface to 1700 near the bottom). In the vertical, we choose the parametrization of diffusion as a function of the Richardson number (PHILANDER and PACANOVSKI 1981).

The forcing occurs over an oval area of 200*100 km. It corresponds to a total heat flux (sensible plus latent) of 220 Wm^{-2}. The evaporation is 6.3 mm per day and triggers the latent and the salt fluxes. This forcing is constant during the first three months of the year and equal to zero thereafter. As long as the thermohaline forcing is active, the temperature decreases and the salinity increases. Hence, a homogeneous column of water is formed in the forcing area. The horizontal density gradient which is generated drives a horizontal baroclinic current in geostrophic balance. A gyre is formed and its pattern is linked to that of the forcing. The current flows in the cyclonic sense in the surface layer, and it is anticyclonic in the deep layer. Its maximum speed occurs near the surface where it is about 0.1 ms^{-1}. The flux of the cyclonic current is about one Sverdrup, a value which is close to valus computed from observations (GASCARD - 1978, CREPON et al 1981).

After two months, oscillations begin to develop along the front that defines the homogeneous column. Horizontal sections taken at different levels show waves whose wave length λ is about 40 km. They propagate in the cyclonic direction with a speed of about 1.8 cms^{-1} which corresponds to 1/5 of the mean velocity of the current. A phase lag in the vertical of $\lambda/4$ is found between the surface and the bottom. This phase lag is typical for baroclinic instabilities which has been found in analytical models (TANG - 1975, GASCARD -1978, CREPON et al -1981) and which has been observed in situ measurements by J. C. GASCARD (1978).

When the forcing stops, the oscillations decrease; they vanish after two months. At the end of the year a small dome is still observed. The isopycnal elevation is about 100 m and preconditions the stratification for the following year.

In order to enhance the similarity between the model results and the observations, we have done a numerical experiment with a realistic coast. One observes good agreement between the patterns observed in NOAA infra-red satellite images and the surface thermal field produced by the model.

In those experiments we nave neglected the surface circulation that flows through the Corsica channel towards the Gulf of Lion. This circulation will be taken into account in the model of the general circulation of the Western Mediterranean Basin that we are in the process of developing.

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