O-VII2

TEMPO Experiment : Characteristics of the circulation in the Northern Tyrrhenian Sea

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The Tyrrhenian circulation is largely cyclonic, with very weak currents organized in two main structures bordering at about 40° North of latitude. The early observations (e. g. Krivosheya and Ovchinnichov (1973) and Moen (1984)) indicate that, whereas the wind can be considered responsible for the basin-wide circulation, the wind blowing from the Bonifacio Strait is the principal source of energy for the cyclonic structure in the north.

In order to evaluate the characteristics of the circulation in this part of the basin, an experimental program involving annual current measurements at different places together with periodic hydrographic campaigns and drifting buoys, has been carried out from September 1989 as a part of the international project TEMPO (Tyrrhenian Eddy Multi-Platform Observation Experiment). The purpose of this project is the investigation of the Tyrrhenian circulation by an integrated use of different data collected from different platforms (satellite, aircraft and ship). In the following a preliminary description will be given of the conditions existing in the fall season with a particular focus on the vertical structure of the water column and the circulation pattern at various depths.

The extension of the mixed layer varies from 20m in the central area to 45m in the southern part of it, just underlined by a well developed thermocline. The surface layer of Modified Atlantic Water (MAW) has its core (pointed out by a minimum in salinity) at about 50m of depth, nearly uniform all over the area, while the core of the Levantine Intermediate Water (LIW) is at 350-400m of depth and has the highest values in the southernmost part of the basin.

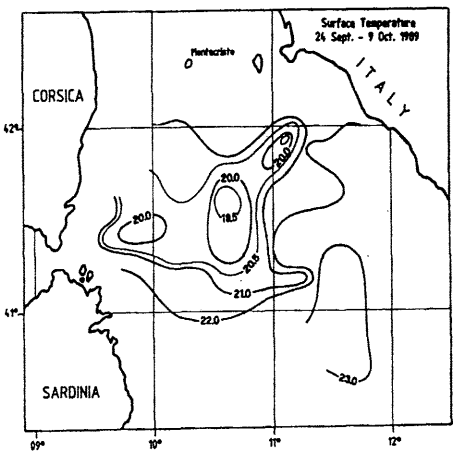
The horizontal distribution of the surface temperature shows that the lower temperatures are found in the central basin. Close to the 41° parallel a marked frontal structure develops in the surface layer (MAW), dividing the colder water in the north from that warmer in the south. In the intermediate and deep layers the temperature and salinity values decrease progressively along a southeast-northwest direction, having the highest gradients near the 41th parallel. The density distribution at all depths is consistent with a cyclonic circulation of the water mass involving most of the water column.

The current measurements at all the observed depths (50, 150 and 350m) show a cyclonic pattern with very low mean values (3cm/s or less), the highest values being recorded near the boundary frontal system.

The computation of the surface dynamic depths starting from a reference level of 350m, indicates the presence of a cyclonic gyre having the same velocity values as those directly observed.

Finally the trajectory of the surface drifting buoy released near the frontal signature shown in the horizontal temperature distribution, fully supports the indication that the area is affected by a cyclonic circulation, that is stationary for the considered period.

In conclusion all the measurements indicate that a cyclonic circulation having a very low dynamics prevails in the northern Tyrrhenian basin. From the surface signature of this structure, easily detectable in the thermal maps of the area, important indications can be obtained for the comprehension of the structure below.



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O-VII3

AVHRR/2 observations of the Tyrrhenian eddy during TEMPO

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The large scale circulation in the Tyrrhenian Sea is mainly cyclonic. Superimposed on this large scale circulation is a pair of eddies rotating in opposite direction and separated by a zonal front (henceforth called front) running at approximately 40° N. The northern eddy (henceforth called Tyrrhenian Eddy) is cold core and cyclonic while the southern is anticyclonic and relatively warmer.

The Tyrrhenian Eddy Multi-Platform Observations (TEMPO) experiment, whose intensive phase was carried in September 26th - October 9th, 1989, was devoted to both improving the understanding of the air-sea interaction dynamics of the North Tyrrhenian Sea and testing a methodology based on simultaneous observations collected from different platforms in view of the ERS-1 launch.

The utilization of AVHRR/2 data for TEMPO reflected the two phases into which TEMPO was divided: 1) an extended phase involving analysis of a long time series of images to select the most appropriate period for the execution of the oceanographic campaign and 2) an intensive phase, during the two-week campaign to support ship and aircraft operations by indicating frontal position and strength and to provide a source of synoptic data for the subsequent analysis.

One year worth of satellite imagery was examined in order to construct the statistics of persistence, intensity and evolution of the front and the Tyrrhenian Eddy. The edges of the SST front and the Tyrrhenian Eddy were digitized for each AVHRR/2 image. Analysis of the digitized frontal time series indicates the presence during fall and winter of a zonal SST front between Sardinia and the Italian Peninsula which is only visible in some of the spring and summer images. During the transition period between summer and fall the front evolves into a well organized cyclonic eddy which persists for the entire winter. An occasional cyclonic eddy, visible in some of the summer images, appears to be related to periods of intense wind in the Strait of Bonifacio. These observations support Moen's (1984) hypothesis which relates the presence of the North Tyrrhenian Eddy to baroclinic adjustment to the forcing by the wind stress curl. The radius of the Tyrrhenian Eddy varies from 50 to 75 km while the temperature difference between the eddy core and the surrounding waters ranges from 1 °C (in winter) to 2.5 °C (in fall).

On the basis of the AVHRR/2 observations from the extended phase the period September-October appeared to offer the best compromise between the need for cloud-free imagery and the likelihood of sampling the formation stages of the Tyrrhenian Eddy.

During the intensive phase, NOAA-11 passes received by the Italian Meteorological Service were processed by Telespazio in Rome. From each acquired pass a SST image of the Northern Tyrrhenian Sea was atmospherically corrected, remapped to Mercator projection, compressed (down to 20% of the original size) to save on transmission time and cost and relayed via Inmarsat to the ship approximately two hours after the satellite pass. On the ship the image was decompressed and presented on a PC screen. On the basis of the looks at this imagery the scientists on board the ship directed the ship to the area of strong SST fronts to perform multi-platform observations. The analysis of the images collected during the intensive phase indicates that a transition between a summer and a winter condition occurred. Namely, the imagery of 19-20 September displays a meridionally banded SST structure that progressively disappears, as well as a zonal SST front. From 21 September onwards the zonal front appears to evolve into a cyclonic cold core eddy which can be observed starting 30 September. This transition process may have indeed been accelerated by the passage of an atmospheric perturbation which lasted the 28 and 29 September.

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