

Oceanographic monitoring of the Mediterranean Sea

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SUMMARY OF THE TALK

The anti-estuarine circulation forced by the climatology of the basin, the processes that ultimately transform the relatively fresh and warm Atlantic water into cooler and saltier Mediterranean water, the general pattern of the surface, intermediate and deep circulation, all them are well-understood issues that have been addressed for decades by oceanographers studying the Mediterranean Sea. The general pattern undergoes important fluctuations at different spatial-temporal scales, from mesoscale, to seasonal, interannual and decadal and, finally, to long-term trends, which have become an important target in the new scenario of global warming. An essential tool to deepen our knowledge on the variability of these processes and their possible impact is the availability of good-quality series of data and the ongoing initiatives to systematically monitor the Mediterranean Sea at key locations. A suitable monitoring strategy must face not only scientific aspects, but many others such as international cooperation, politics, economical issues, scientific coordination, data policy, dedicated staff, etc... The first ones are the focus of this talk.

Probably the simpler classification of variables to be monitored is surface (ocean-atmosphere boundary) and interior (thermohaline, velocity fields) variables. The second category provides more information about changes taking place in the Mediterranean but it is more expensive and requires greater degree of cooperation. Surface monitoring in turn can provide insights into the ocean interior. In addition to these categories and considering the response of the ocean to atmospheric forcing, a suitable meteorological monitoring of the Mediterranean comes up in order to facilitate data for assimilation in

numerical meteorological models which in turn provide suitable series of surface forcing for oceanic models.

SURFACE MONITORING.

In situ observing networks:

Sea level (tide-gauge): In addition to its relevance to follow the sea level rise due to the warming trend of the oceans and the melting of glaciers and ice sheets, sea level difference across straits has dynamical relevance as a proxy of flow variability. It is particularly interesting in narrow straits such as Gibraltar where across-strait sea level slope correlates quite well with the observed inflow.

Open-sea, in situ air-sea fluxes: Network of meteorological buoys strategically distributed in the basins where deep convection takes place in order to assess interannual variability. They can also be used to calibrate-validate atmospheric models.

Satellite derived variables:

Sea level (altimetry): Useful for determining global sea level trends (complements tide gauges). More interestingly, it provides dynamic topography at meso-macro scale spatial scales and, hence, the upper ocean circulation and its variability.

Sea Surface Temperature (SST): SST spatial distribution often indicates underlying mesoscale dynamics. It has been helpful to determine the largely eddy-dominated dynamics of the southern Mediterranean where *in situ* observations are rather scarce.

Ocean colour: Sensors that operate in the visible and near infrared, measuring the Earth's reflected energy. They complement SST and altimetry observations.

INTERIOR MONITORING.

Time series at fixed points:

Thermohaline observations: The changing climate forcing at the surface affects the properties / volume / localisation of the deep waters yearly formed. As they sink and flow from one basin to the other, they can be easily monitored by a autonomous CTD installed in deep basins and over sills few meters above the sea floor. Such is the thinking behind the HydroChanges network that was born in 2002 following a CIESM initiative (<http://www.ciesm.org/marine/programs/hydrochanges.htm>, see also figure 1)

Flow monitoring: It is a second ingredient of Hydrochanges after thermohaline monitoring. Key locations for monitoring are the main straits / passages isolating sub-basins of deep water formation from the large Mediterranean basins as some straits of the Cretan Arc, Otranto, Sicily and, obviously, Gibraltar. The monitoring should use arrays of uplooking ADCPs. The network is less developed than the hydrological counterpart.

Basin-wide CTD information:

Revisit historical information: It is the sensible first step in long term studies. MEDAR MEDATLAS database gathers the information.

CTD transects through relevant sections: Hydrological transects across straits and wide passages connecting basins accomplished periodically (at yearly time-scale at least).

ARGO floats: They would provide information of the sea interior in places / times of difficult or expensive access during key periods of the year (in case of deep convection, winter storms after which sinking and spreading of deep waters takes place). In 2004 and 2005, within MFSTEP EU program, 23 ARGO floats were deployed in the Mediterranean Sea (figure 2) with a configuration that suits the Mediterranean Sea characteristics (5 days cycling, around 2 years lifetime).

In this talk we will focus on the potential and complementariness of the different monitoring strategies and show examples illustrating their performance.



Figure 1.- HydroChanges network of CTD stations. Names of responsible institutions are indicated: SHOMAR: Service Hydrographique et Océanographique de la Marine Royale, Maroc. COM-LOB: Centre Océanographique de Marseille, Laboratoire d'Océanographie et de Biogéochimie, France. UMA University of Malaga, Spain; IEO: Instituto Español de Oceanografía, Spain; ICM-CSIC: Institut de Ciències del Mar, Consejo Superior de Investigaciones Científicas, Spain. INSTM: Institut National des Sciences et Technologies de la Mer, Tunisia. ISMAR-CNR: Istituto di Scienze Marine, Consiglio Nazionale delle Ricerche, Italia. OGS: Istituto Nazionale di Oceanografia e di Geofisica Sperimentale, Italy, HCMR: Hellenic Centre for Marine Research, Greece.

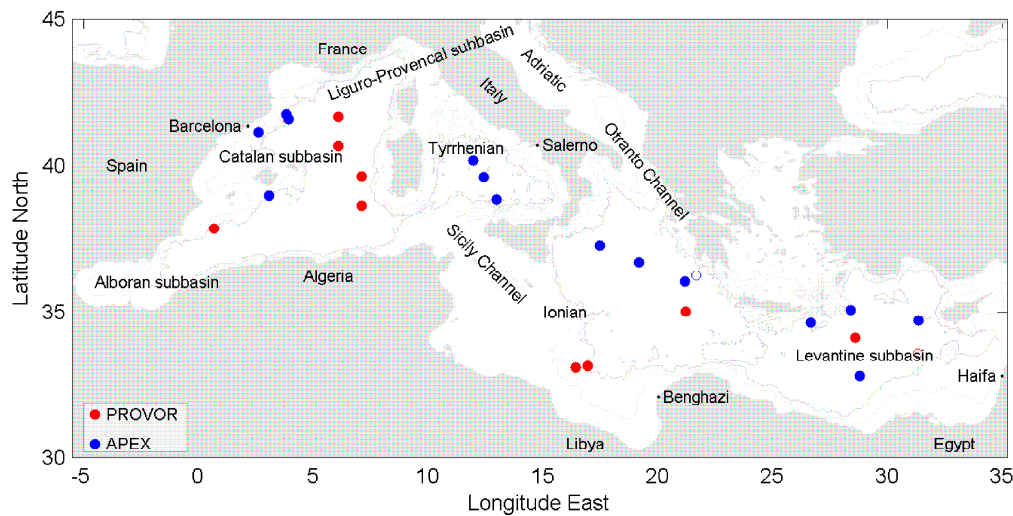


Figure 2.- MedArgo profilers: ARGO floats deployed within MFSTEP EU funded program during years 2004 and 2005. Colour indicate the ARGO model (see insert). Source: Poulin et al, 2007.

RELEVANT LITERATURE

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