THE MEDITERRANEAN OCEAN FORECASTING SYSTEM: THE FIRST PHASE OF IMPLEMENTATION

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***ABSTRACT** - The first phase of implementation of the Mediterranean Forecasting System Pilot Project is being completed. It consists of: 1) elements of a large scale automatic observing system with near real time data release through internet and GTS; 2) a modeling and data assimilation component which initialize basin wide weekly forecasts; 3) a coastal modeling downscaling component which uses the basin wide forecasts to initialize regional and shelf models; 4) an ecosystem modeling component for selected test site shelf areas; 5) an experimental user community which can access and use both the observations and nowcasting/forecasting information.*

1 – INTRODUCTION

In the past five years, EuroGOOS [EGOO 96] has promoted the formation of a Mediterranean Test Case Task Team (MTCTT). This is composed of representatives of all European and non-European countries bordering the Mediterranean Sea, together with several other European and non-EU countries. The MTCTT involves directly a large number of scientists from countries bordering the Mediterranean Sea with an exchange of expertise in order to : 1) build a cost-effective basin wide multi-platform, multi-use monitoring system ; 2) build capacity in local centers to model the shelf areas with state of the art hydrodynamic and ecosystem modeling ; 3) create a network between all the nations bordering the Mediterranean Sea and other European countries which will freely share observational data and model results in order to build a ocean forecasting local user community.
The MTCTT has elaborated a Mediterranean Forecasting System Science and Strategic Plan [MFSP 98] which describes the rationale and the strategy of implementation of marine environmental predictions in the Mediterranean Sea.

The overall Mediterranean ocean Forecasting System goal can be synthesized as follows :

Scientific

To explore, model and quantify the potential predictability of the ecosystem fluctuations at the level of primary producers from the overall basin scale to the coastal/shelf areas and for the time scales of weeks to months through the development and implementation of an automatic monitoring and a nowcasting/forecasting modeling system, the latter called the Mediterranean Forecasting System as a whole.

Pre-operational

To demonstrate the feasibility of a Mediterranean basin operational system for predictions of currents and biochemical parameters in the overall basin and coastal/shelf areas and to develop interfaces to user communities for dissemination of forecast results

The European Union fourth framework research program decided to fund a Pilot Project, hereafter called the Mediterranean Forecasting System Pilot Project (MFSPP), which has started the activities to implement the research directions and the monitoring system needed for practical basin-wide forecasts. |n the following we will outline the major initiatives and results of the MFSPP.

2 - THE MULTI PLATFORM MONITORING SYSTEM

The elements of the monitoring system developed and implemented in MFSPP are a Voluntary Observing Ship (VOS) network, a multi-purpose moored buoy and satellite data in near real time.

The VOS network is composed of eight tracks (see Fig. 1) repeated approximately every fifteen days with XBT data collection at 12 n.m. resolution. These sampling parameters were decided based upon a compromise between resources available and the knowledge of the internal Rossby radius of deformation and the large scale size and structure of the basin gyres. These sampling requirements are typical of limited extension or semi-enclosed seas, like the Mediterranean, the Baltic, The North Sea, the Sea of Japan, etc. and they are not really met by the conventional VOS system since the frequency of XBT launch is about 30 minutes or shorter. Future developments of VOS systems in semi-enclosed seas should consider the technological improvements needed for such surveys to meet the sampling requirements automatically. The actual eight tracks implemented in the Mediterranean are working with a GTS (Global Telecommunication System using the ARGOS satellite communication channels) data telemetry system which transmit decimated profiles in the first 400 meters of the water column. Due to the steep gradients in the shallow thermocline, 15 points instead of the traditional 12 were selected as decimation interval. A land based data collection center re-collects the data from the GTS and makes them available in near real time through the internet to the forecasting center and to the users. Decimated profiles will be available every two days while the full 1 meter resolution profiles will be updated every two weeks.

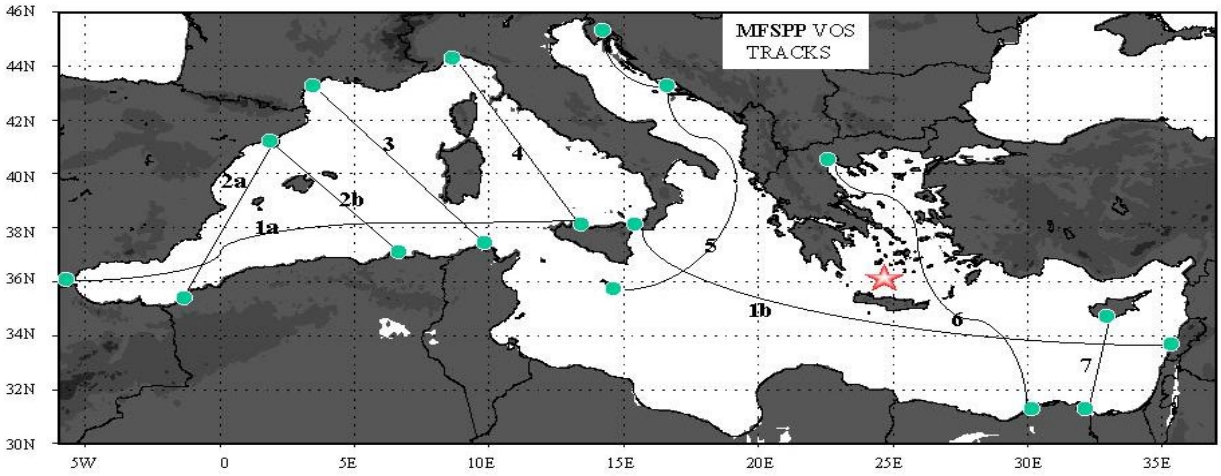

Fig. 1: The eight tracks of the VOS XBT measurements in the Mediterranean Sea. The star indicates the location of the M3A buoy test site.

A test buoy system is being deployed in the Cretan Sea (see Fig.1), called the Mediterranean Multisensor Moored Array (M3A) first test site. This mooring system has a large surface buoy which allows the measurement of air-sea interaction parameters and surface waves. The subsurface is sampled by a set of three moorings, one connected to the surface buoy and the other two near by. The surface buoy mooring has irregularly spaced CTD sensors in the first 500 meters of the water column. The other mooring is equipped with CTD, turbidity, oxygen, chlorophyll and PAR sensors at high resolution in the upper 100 meters of the water column. The air-sea interaction parameters (air temperature, wind, air pressure, relative humidity) and the subsurface measurements are subsampled every 3 hours and sent through GTS. A land based data collection center re-collects the data from GTS and makes them available through internet in near real time with an update every two days. These data will be initially used for validation of the Ocean General Circulation Model (OGCM) and calibration of the one dimensional ecosystem model for this near shelf area.

The near real time analysis of satellite sea surface height (SSH) anomalies and sea surface temperatures (SST) will be made ensuring weekly maps of SSH anomalies, as well as SST, for the entire Mediterranean Sea. Surface Chlorophyll retrieved observations will be also put on the internet but only in a delayed mode with a time frequency of two weeks. The near real time analysis of satellite SSH is complicated since the retrieved data could be less accurate than the delayed mode data due to the inaccurate knowledge of the orbit and the mean SSH in near real time mode. A near real time altimeter SSH data processing scheme has been envisaged to work on a weekly time scale, e.g., giving an updated map of SSH every week.

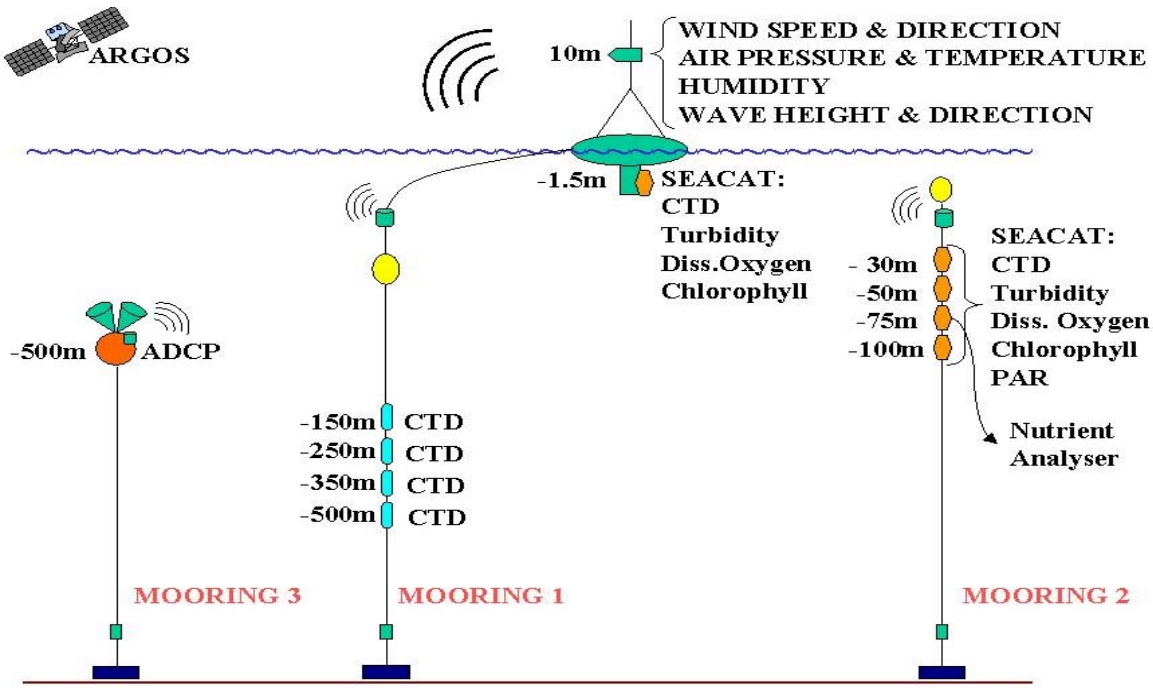

Fig. 2 : The schematic of the M3A buoy design. Note the three mooring lines, one with the surface buoy which supports the ARGOS transmission system.

The data management system organizes multiple levels of quality control procedures and provides the near real time dissemination to the research community via Web and ftp communication systems. The initial quality control is only for extreme outliers with respect to the climatology of the region : on the basis of this either the profile is rejected and nothing is sent or there is enough time to make another station. At the land center, more accurate quality control procedures are done on the data transmitted to the modeling centers and the user community. The final quality control is made by the assimilation system working at the modeling center which will feedback to the observing data collection center the reasons for which the profiles has been discarded. For climate studies, the full resolution profile is archived, when possible, in place of the decimated profile. The Web system, designed to access data from the GTS, is necessarily a near real time system since there is delay between the actual measurement, its transmission to the GTS and the storage at the Web sites. However, this is a system which allows the research community to fast communicate with the data acquisition systems and it can easily generate multiple users of the data itself as recommended by [Moli 99].

2 - OCEAN MODELLING FOR FORECASTING AT THE BASIN SCALE AND IN THE SHELF AREAS

The past ten years the research community has developed a suite of OGCM and regional models capable of simulating the seasonal and interannual variability of the basin currents with good accuracy [Korre 99]. These models have skill in SST predictions [Pina 97] and water mass formation rates interannual variability [Lasc 98]. One of the previously implemented OGCM in the Mediterranean Sea will be used as a forecast model for the basin currents and for the time scales of a week. The forecasting system will work assimilating the VOS XBT and satellite data in near real time.

The OGCM has been spun up in simulation mode from January 1997 with 6 hr atmospheric operational analyses entering an air-sea interaction submodel which determines momentum, water and heat fluxes for the OGCM. At the same time, sea surface height anomalies will be assimilated

starting from January 1998 to try to reach the best estimate of the ocean initial condition for march 1, 2000. An example of the OGCM simulation for august 1999 is shown in Fig. 3.

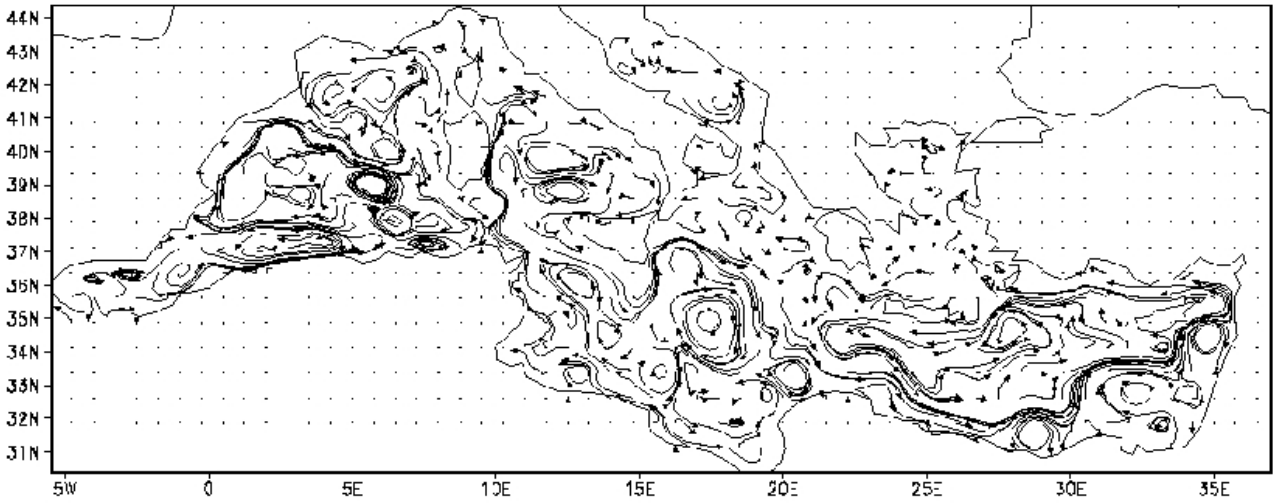

Fig. 3 : OGCM simulation for last five days of august 1999. The picture shows surface trajectories for the 5 days mean flow field at 30 meters. The model is 1/8 X 1/8 degree and it has 31 unevenly spaced vertical levels. It is forced with atmospheric operational analyses from January 1997 and run without data assimilation in this case.

Starting from march 1, 2000 the model will be run in free mode for one week with atmospheric forecast parameters instead of analyses. Concomitantly VOS XBT, satellite SST and SSH anomalies will be assimilated for one week preparing the next week forecast initial condition. We call this the Asynchronous Ocean Forecasting System (AOFS) shown schematically in Fig.4. The AOFS nowcast, forecasts and simulations will be put on the Web for the users community. The M3A data will be used to assess the skill of the model both in nowcast and forecast mode.
The OGCM in simulation mode will be used to initialize regional and shelf models, which will receive also boundary fields at the requested time frequency. The downscaling will bring the OGCM 12.5-km resolution fields down to 1-2 km resolution for the shelf areas. This is at the base of the coastal forecasting system of the future, e.g., the initialization of the regional and shelf models will crucially depend upon the OGCM dynamical fields. This is contrary to most coastal forecasting systems that started with the observations tuned to the coastal areas leaving as a secondary aspect the remote effects of the general circulation on the shelf. The Mediterranean Sea shelf area is narrow and the general circulation can determine a large portion of the coastal hydrodynamics variability.

3 - CONCLUSIVE REMARKS

In September 1999 the MFSPP has started its VOS-XBT data collection and the M3A test site should be completed by December 1999. The satellite sea surface height anomalies from January 1998 and the OGCM simulations are already available and the regional/shelf models have been implemented. It is hoped that in the future the observing system will be completed with more in situ measuring platforms, such as more M3A and a system of drifting buoys, surface and subsurface.
As a final remark we would like to note that ecosystem models are also being implemented during MFSPP and the basic forecasting work at the hydrodynamics level will serve as the initial platform to start predictions at the level of primary producers variability in the coastal areas.

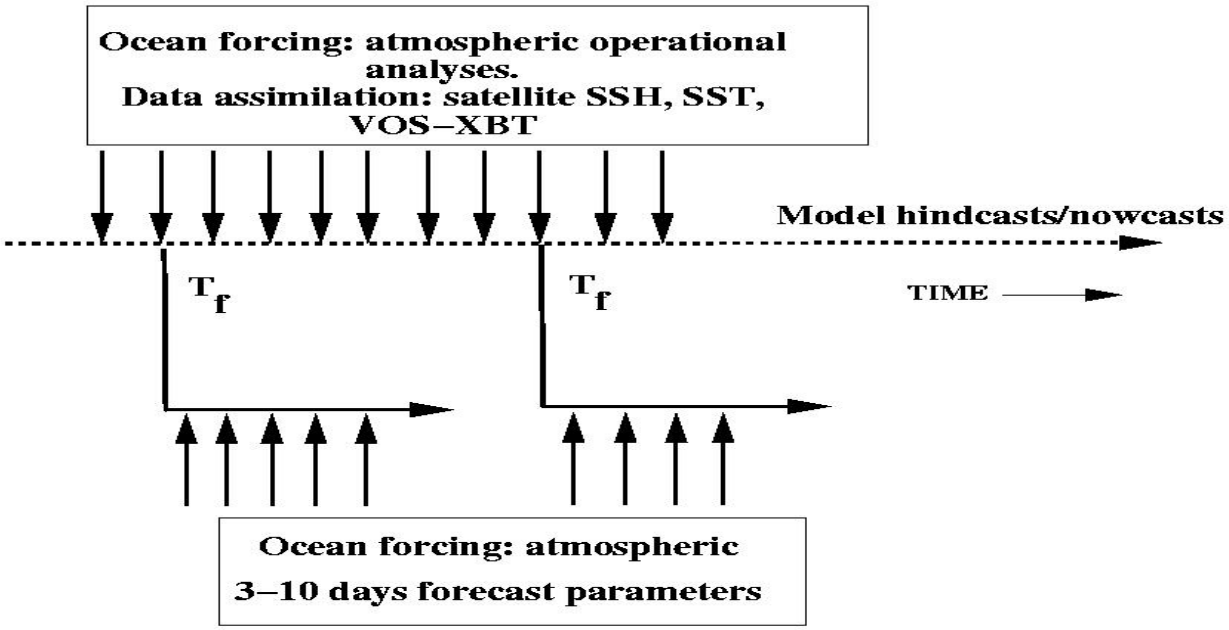

Fig. 4 : Schematic of the Asynchronous Ocean Forecasting System for the MFSPP.

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