POSEIDON II: Upgrading the monitoring and forecasting services in the Eastern Mediterranean Sea

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Abstract

The POSEIDON monitoring and forecasting system of the Eastern Mediterranean is being upgraded over the past 3 years (2005-2008) in order to a) extend the buoy network to the Ionian and the Levantine seas with 5 new buoys b) upgrade the observing capacity in selected locations of key importance including physical and biochemical parameters c) enhance the forecasting skill and extend it to the whole Mediterranean including ecosystem modelling. Apart of the standard network, the monitoring system now includes the totally re-built multi-parametric E1-M3A observatory of the Cretan Sea and a second deep sea mooring with an autonomous sea-floor platform in the Ionian Sea. The forecasting component includes high resolution weather, wave hydrodynamics and ecosystem modelling for the whole Mediterranean and the Aegean Seas. The POM-based hydrodynamic forecasting component has two configurations: the first downscales the MERSEA-MFS basin scale forecast products (1/16°) into the Aegean Sea (1/30°) and the second covers the whole Mediterranean (1/10°) with downscaling to the Aegean Sea. The latter configuration uses data assimilation of satellite and in situ observations. The same nesting approach is followed for the wave model which is based on the WAM-Cycle4 code, while the ERSEM-based ecosystem model runs on a single Mediterranean-scale configuration (1/10°). Atmospheric forcing is provided by the 1/20° non-hydrostatic ETA model and covers the whole Mediterranean and Black Sea areas. Finally, the oil spill forecasting service is made available for both the Mediterranean and Aegean Seas and is extended with an object drift module (Leeway model).

Keywords: Monitoring and forecasting systems, buoy network, Mediterranean Sea, time-series stations

1. Introduction

During the last decade, operational oceanography is developing fast in the Mediterranean Sea under the coordination of MedGOOS (www.medgoos.net) and

MOON (www.moon-oceanforecasting.eu). Important steps have been made through international collaborative projects funded by EC Research Framework Programmes, such as MFSPP (1998-2001, FP4), MFSTEP (2001-2005, FP5), MAMA (2000-2004, FP5), MERSEA (2004-2008, FP6) and ECOOP (2007-2009, FP6). These projects improved the networking of the main research and operational agencies in the Mediterranean Sea and developed important elements of the basin scale monitoring and forecasting system. During the same period large national projects such as POSEIDON in Greece, ESEOO in Spain and Adricosm in Italy, developed the capacity in the shelf and coastal areas but also contributed to the basin scale system.

In 1997-2000 the POSEIDON-I project developed the basis of an operational monitoring and forecasting system for the Greek Seas (Nittis et al., 2001). The main components of the POSEIDON system are: its buoy network that provides real time in-situ observations, the forecasting system based on a suite of meteorological, wave and hydrodynamic models and the operational center where data are analysed, forecasts are issued and products are generated and disseminated to users. The system is operational since January 2000 with marginal upgrades through research projects such as MFSPP & MFSTEP (introduction of multi-parametric Eulerian observations, use of XBT data), FerryBox (introduction of surface observations along ferry lines, use of assimilation techniques), MARSAIS and ROSES (improvement of the oil-spill service, use of SAR data, Nittis et al. 2006). The present paper describes a major upgrade of the system that is being carried out through the POSEIDON-II project (2005-2008) and includes: a) upgrade and expansion the buoy network b) introduction of biochemical and deep sea observations c) an improved forecasting capacity based on advanced downscaling and assimilation techniques d) a new ecosystem forecasting model e) new computing facilities and product dissemination methods.

2. The in-situ observing system

The eleven (11) POSEIDON-I SeaWatch buoys were upgraded and the fleet has been enriched with five (5) more open-sea Wavescan buoys to operate a network of 10 permanent sites (see figure 1). The upgrade of SeaWatch buoys included: a) a new central processing unit with a more modular software and additional / new type communication ports, b) new communication systems; an Iridium modem was added to the standard Inmarsat-C and GSM/GPRS systems c) new floaters, internal cabling, solar panels and navigation lights, re-arrangement of batteries for increased safety, a wind power generator for additional energy, d) new sensors for wind speed / direction, upper layer CTDs and current speed/direction e) inductive modem technology for underwater sensors attached to mooring line and acoustic modem for communication with the deep platform.

The five new Wavescan buoys will be used for the 3 deep sea sites: the E1-M3A site of the Cretan sea, the Pylos site in the SE Ionian and a possible M3A-type site in the north Aegean Sea. The E1-M3A system operates in the Cretan Sea since 2000 under various configurations. It is part of OceanSITES, the global network of long-term deep water reference stations (www.oceansites.org), and has been developed through the MFSPP and MFSTEP projects (Nittis et al., 2007). The new E1-M3A system operates at the same site (1440m depth) and has a single mooring line configuration that hosts sensors for temperature and salinity at 9 depths (1, 20, 50, 75, 100, 250, 400, 600, 1000m) as well as chl-a, dissolved oxygen, PAR and light attenuation at 20, 50, 75 and 100m. The surface buoy hosts a complete set of sensors for air-sea interaction studies (wind speed and direction, air pressure, air temperature, wave height and direction, relative humidity, precipitation, radiance, irradiance, radiometer and pyranometer) as well as an ADCP for current speed measurements in the upper 100m. A second system with the same characteristics ("complex buoy") has been built and tested in the north Aegean Sea (figure 1) however the long term operation of two multi-sensor reference stations with only two available systems is not feasible. Therefore, only the Cretan Sea reference site is expected to be maintained in the future. This rebuilt E1-M3A station is operational since January 2007 and preliminary results indicate that the copper shutters used by the new optical sensors have eliminated the problems of biofouling that has been reported for previous configurations of the M3A (Petihakis et al., 2007).

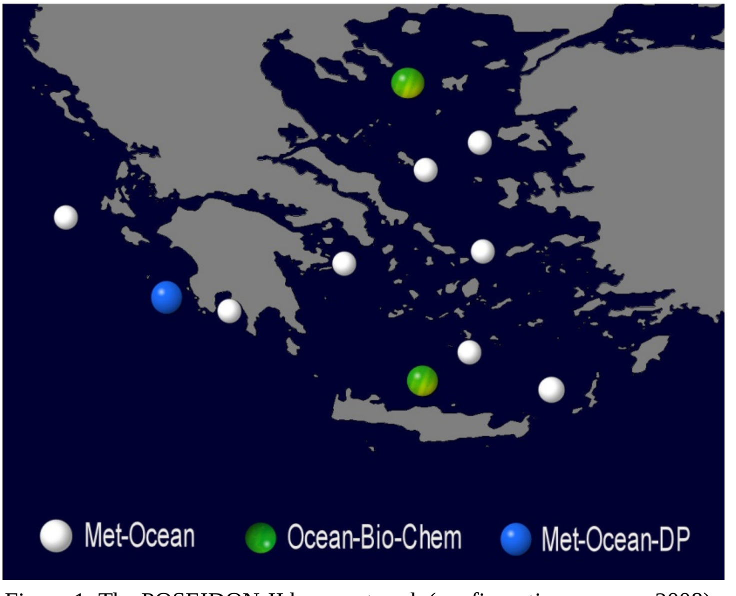

Figure 1: The POSEIDON-II buoy network (configuration summer 2008).

The second deep site of the SE Ionian ("Pylos" site) is moored at a depth of 1660mm, in the vicinity of the area where a sea-floor cabled observatory is being developed (Nestor neutrino telescope). Temperature and salinity sensors at the same 9 depths of E1-M3A provide real time hydrological observations of this key-area where the Cretan Intermediate and Deep Waters (CIW, CDW) spread northwards towards the Adriatic and meet the Eastern Mediterranean Deep Waters (EMDW, Theocharis et al, 2002). At the same site an autonomous sea-floor platform will be deployed in November 2008. The platform is equipped with a high accuracy pressure sensor for tsunami detection as part of an early warning system. It will be also equipped with a CTD probe that will initially carry out temperature and salinity observations but will be expanded in the future with dissolved oxygen and turbidity sensors, offering for the same time near-floor deep observations in the Eastern Mediterranean sea. Data from the deep platform are transmitted through acoustic modems to the Pylos surface buoy for real time telemetry at the standard 3hours interval of the POSEIDON network. However, the sampling rate for the pressure sensor is 15sec and in case a tsunami event is detected the deep platform operates in alarm mode and sends data at a high rate of 15-60sec to the surface buoy and then to the operational center. The Pylos mooring line will also host a set of Passive Aquatic Listeners (PALs) for rainfall estimates and marine mammals detection. These systems have been recently evaluated against X-band radar measurements in this area and were found to provide realistic estimates of precipitation (Anagnostou et al., 2008).

3. The new modelling – forecasting system

All three operational forecasting models, atmospheric-waves-hydrodynamics, have been upgraded, with ultimate goal to improve the accuracy of predictions and relevant end-user products. The new meteorological model that provides atmospheric forcing for the ocean forecasts is based on the non-hydrostatic ETA model and covers the whole Mediterranean and Black Sea areas with a very high resolution of 1/20°. A preliminary assessment of the model's skill is described by Papadopoulos et al (2008).

The hydrodynamic forecasting component has two configurations. The first one downscales the MERSEA-MFS basin scale forecast products (1/16°) into a high resolution 1/30° implementation of the Princeton Ocean Model (POM) for the Aegean Sea using VIFOP variational initialization techniques. The second one is based on a 1/10° configuration of POM for the Mediterranean Sea and the same 1/30° downscaling for the Aegean. The latter configuration uses data assimilation based on the Singular Evolutive Extended Kalman (SEEK) filter which is an error subspace extended Kalman filter that operates with low-rank error covariance matrices as a way to reduce the computational burden (Korres et al., 2008). The assimilated data set is multivariate including AVISO sea level height, AVHRR sea surface temperature, MEDARGO floats T and S profiles and XBT observations.

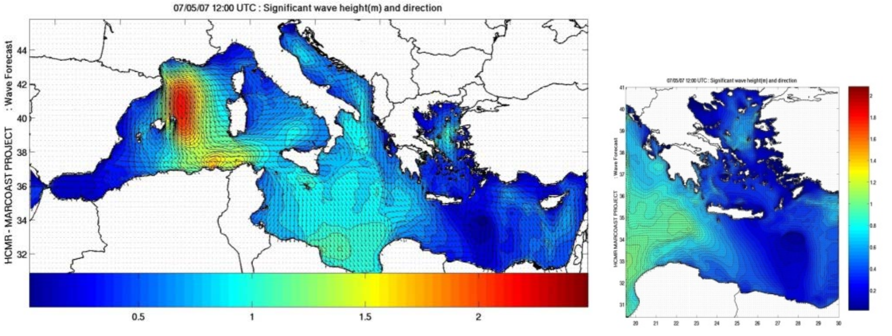

Figure 2: Basin scale and regional forecasting products for the wave model. The same domains and downscaling approach are followed by the H/D model.

The wave model is based on the WAM-Cycle4 code and follows the same resolutions and nesting approach (from 1/10° for the Mediterranean to 1/30° for the Aegean). A higher resolution (1/20°) product based on WaveWatch-III that covers both Mediterranean and Black seas is currently under pre-operational evaluation.

Finally, pre-operational ecosystem forecasting is carried out for the whole Mediterranean Sea using an ERSEM-based ecosystem model at a resolution of 1/10° coupled to the basin scale hydrodynamic POM model of the same resolution (figure 3). The system has been evaluated in hindcasting mode against remote sensing ocean colour data (MODIS, 2003) and in-situ observations and appears to reproduce well the main biochemical characteristics of the Mediterranean (Tsiaras et al., 2008). The next phase will be assimilation of ocean colour data using the same SEEK method applied for hydrodynamical forecasting.

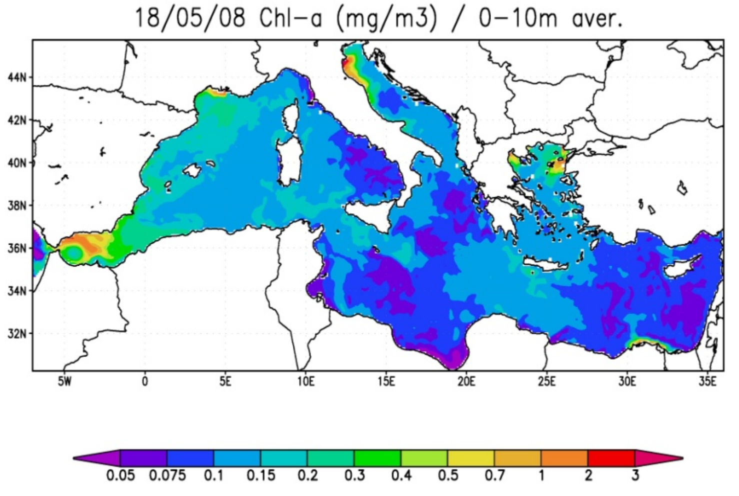

Figure 3: Example of forecasting products from the POSEIDON ecosystem model.

To facilitate access to the forecasting products by the scientific community, all model results are made available through the POSEIDON LAS server in addition to the usual dissemination of information products to the wider public through the standard system web page (www.poseidon.ncmr.gr). Furthermore, an OpenDAP server is being setup for easier dissemination of in-situ data compared to the standard ftp services currently used.

4. Future perspectives

The above described upgrades of the POSEIDON system have improved its functionality and, more important, the quality and range of operational products available for the Mediterranean and Aegean Seas. The system is considered the Greek contribution to the marine component of Kopernicus (GMES) and GEOSS and supports the efforts of MOON and MedGOOS for the development of an operational capacity in the Mediterranean Sea. Through the MyOcean project, POSEIDON will be linked to the Marine Core Service production as a national system that contributes to the in-situ observations and regional forecasting while it provides a wide range of downstream services (high resolution subregional forecasting, oil-spill and water quality / ecosystem health services).

The improvement of the observing capacity is an ongoing process and the introduction of CO2 and pH sensors is already underway through the EuroSITES (FP7) project. The third phase of POSEIDON will focus on sea-floor observatories, based on the experience of the autonomous platform that will be soon be deployed, and contributing to the developments of ESONET and EMSO.

Apart of the ongoing development of new models and assimilation methods, the forecasting skill is expected to be improved in the future by the increase of available real time observations. To that direction, the success of EuroARGO (ESFRI program for the European contribution to the global ARGO program) as a major European infrastructure that should be supported by Member States is crucial, especially for the Mediterranean Sea where open sea observations are limited.

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