



MERSEA Report Summary

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A European system for monitoring and forecasting of the ocean physics, biogeochemistry and ecosystems

The development of ocean monitoring and forecasting systems on global and European regional scales calls for a broad range of research and development activities to ensure that they operate on firm scientific and technical grounds; that optimal use is made of all data available; that the systems are fully validated and robust from an operational standpoint; that they are well integrated into an efficient system of systems, with easy access and smooth exchange of data; and that the systems are fit for purpose with engagement of the stakeholders.

Those are some of the objectives and challenges that we set in the Mersea work plan. The conception of the project was based on the view that a prerequisite to the development of ocean and marine applications is the provision of reliable, generic data and information products serving the needs of several classes of intermediate users, to enable them to fulfill their mission and to provide the services required by their final users.

Broadly speaking, the project activities can be grouped in several inter-related categories: those dealing with data (from earth observing satellites, in situ data, and forcing fields); system development, implementation and operation; research and development; and user products and applications. Moreover, we had several actions of outreach, training, communication, and publications.

Data

Ocean data come from three broad classes of sources: in situ platforms (buoys, ships, floats); satellites; and numerical weather prediction (NWP) from meteorological services. Those observations are valuable as unique global data sets, and are used as input for assimilation or forcing fields of predictive numerical ocean models.

For remote sensed data, the focus of the project has been on improving the retrieval algorithms required to determine with high accuracy the geophysical parameters (e.g. ice concentration and extent, ice drift, chlorophyll, suspended matter, sea surface temperature, sea surface height, mean dynamic topography). Whenever possible, data from different satellites and sensors are used to obtain uniform merged data products, mapped onto geographic grids. Specific algorithms have been derived to obtain data sets adapted to the regional seas.

The data are available in real time and in delayed mode, for which long time-series are reprocessed. The data centres are linked into an integrated network of thematic portals, enabling data access and exchange. Detailed documentation on the processing, format, and all other relevant meta-data is also available on the portals.

The forcing fields necessary for ocean forecasts are provided by numerical weather prediction (NWP) from the ECMWF or national meteorological services. However the predictions made for the atmosphere, do not necessarily give the best estimates of the fluxes (moisture, heat, wind stress) over the ocean. We have derived improved formulae for the fluxes, with validation from buoy data, which can be incorporated into the NWP predictions. A new technique has been developed to improve wind estimates over the ocean by combining satellite data (from scatterometers) with NWP fields. Although this technique cannot provide predictions, it delivers high resolution wind fields in near-real time (24 hrs delays) and retrospective analysis.

The project could not support a large contribution to in situ observing networks, but a few operations were conducted, if only as a reminder that no ocean monitoring is conceivable without in situ data. A set of Argo floats were deployed, most significantly in high latitudes, where a specific ice-detection algorithm was developed to allow for the first time data collection under the ice. Updated climatology of the Atlantic and the Global oceans have been obtained by retrospective synthesis of the global Argo array data, revealing large scale patterns of variability.

As a European contribution to the Ocean Sites programme, three moored stations were maintained in representative locations in the North Atlantic, and two in the Mediterranean. The stations allow real time transmission of multi-parameters, including bio-geochemical ones. The point time series are unique for validation of numerical models. Several tests and operations at sea of gliders have been conducted, including several runs over 1.000 km long in the

Atlantic and the Mediterranean, where multi instruments operations were conducted. Those glider experiments confirmed the high quality and value of the data collected, but pointed out also the high demand on personnel to conduct them, at least at the early development stage of this promising new technology. Research vessels should play a key role in the routine collection of surface data and as support for XBT launch; although some data was collected in this mode as part of the project, there is still considerable difficulty in convincing ship operators to carry out those simple operations. Considering the cost of data collection at sea it is necessary to ensure that all global data are available easily to users in the shortest delays. In performing that task, the Coriolis in situ data centre has very significantly increased (by a factor of three) the amount of quality controlled data available in real time, a large part of that increase being related to the ramping up of the Argo array.

Somewhat paradoxically, in situ data are scarce in the regional seas. While in situ monitoring is conducted in the framework of the Conventions (OSPAR, Helcom, Barcelona) and of Eurogoos cooperation, the data are usually not available in real time, and sometimes not freely available. Thus there are few data available for assimilation into the models, which are mostly constrained by the meteorological forcing fields, and by the satellite data sets.

System design, development, implementation and operation

One of the main challenges of the project was to integrate into a coherent system of systems the various centres that were operating in different contexts and stages of development. The design has led to the final structure of a distributed system comprising Monitoring and Forecasting Centres (MFC) and Thematic Assembly Centres (TAC). The MFCs cover the global ocean and the main European seas (Arctic, North East Atlantic, Baltic, and Mediterranean); the TACs process the data from satellite remote sensing (seaice, ocean colour, altimetry, and sea surface temperature), and from global in situ networks. All the Centres fulfil common functions (Production and delivery, system management, monitoring, service provision, user desk, quality assessment). Common data formats have been agreed upon, and consistent documentation is available on the systems specification, their catalogues and inventories. The services provided include search and discovery, viewing, and download, consistently with the Inspire Directive. The protocols for data exchange have been defined as the Mersea information management system. Thus different classes of users can be served according to their needs. As the concept of marine core serviced evolved with the GMES implementation panel, it was recognised that the primary function of the system would be to deliver common baseline products and data to intermediate users, who would in turn develop bespoke services to final users. All those design concepts form the basis for the further developments to be carried out in the Myocean project.

The monitoring and forecasting centres have been upgraded in several respects: model resolution, assimilation of satellite and in situ data, more frequent analysis and forecasts, adoption of new modelling framework (Nemo). The improved performance has been achieved by the introduction of new parameterisation and algorithms resulting in higher efficiency and realism of the models (e.g. bottom and interior mixing, ice modelling, topographic effects, mixed layer dynamics, advection schemes, assimilation techniques).

Implementation into the operational suites at the centres has entailed major computer engineering, transfer to new machines or to associated agencies; for instance: the Arctic system (based on the TOPAZ code at the Nansen Remote Sensing Centre) has been transferred to the met.no operational centre; or the high resolution global system has been run on the Météo France super computer.

All systems include bio-geochemical modelling, some in a demonstration mode, since those models still require extensive validation. Nonetheless, the primary ecosystem forecasts have been introduced in the operational suite at the Met Office (Northwest shelves) and in a pre-operational mode at INGV (Mediterranean).

The systems evolution and performance has been regularly evaluated for quality and consistency, with the aid of metrics, a methodology which has been adopted by the Global Ocean Data Assimilation Experiment. The continuous improvement of the systems has been quantified, and in particular the positive impact of assimilation of in situ profiles from the Argo array (where they are available).

At the end of the project, some of the upgrades still need further validation and development before being fully integrated into the operational suites. Examples include the global high resolution model (1/12°, i.e. about 10 km) which requires large computing power; the ecosystem modelling already mentioned; or the nesting of models. The latter has been attempted (Mediterranean, North East Atlantic and Arctic into the global, and Baltic into the North Sea), but all scientific questions (proper implementation of boundary conditions) or technical problems (timeliness of the provision of boundary data) have not been fully resolved.

Nonetheless, all system components are presently operating continuously, delivering high quality data, analysis and forecasts over the global ocean and regional seas.

Research on ocean modelling and data assimilation

While research has been conducted regularly in all work packages, most notably to develop high quality data sets from remote sensing observations, specific activities have been carried out in the domains of ocean modelling, including bio-geochemical, data assimilation, and seasonal forecasting. Some of the results have been directly transferred to the operational suites, as indicated above, leading to more accurate representation of processes, and more efficient computing. However it is recognized that research operates on longer time scales than implementation and production;

some of the developments will bear fruits in future versions of the systems. Promising results have been obtained in ecosystem modelling (class size approach), in advanced data assimilation schemes, in nesting and grid refinement, data assimilation in coastal models. The long list of publications is a record of the advances made by the scientists engaged in the project in many diverse topics.

The special focus experiments were devoted to the development of the coupling between the model system and the basic and generic model products of MERSEA with marine biogeochemical models for ecosystem forecasting, at the level of primary producers biomass and for the short time scales; and global atmospheric models for seasonal forecasting.

Serving user needs

Two broad classes of users have been considered in the project: those in the public sector, responsible for environmental monitoring and reporting; and maritime operations.

Several applications in the maritime sector have been explored: ship routing, offshore industry support, and oil spill drift prediction. In all cases the positive impact of high resolution ocean products has been demonstrated, but very stringent requirements are placed by users on accuracy, which cannot always met by state of the art products. They also expect specific products tailored to their applications, and appropriate delivery mechanisms. Further investment and reliance by the industry on the MCS hinges on the establishment of a reliable perennial service.

Related information

Result In Brief	Robust ocean monitoring and forecasting
Documents and Publications	Final Report - MERSEA (Marine Environment and security for the European Area)

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Collaboration sought: Further research or development support

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