Chapter 18

OPERATIONAL OCEANOGRAPHY: A EUROPEAN PERSPECTIVE

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1. Introduction

Operational oceanography aims at providing services and products to users of the ocean, and to help in sustainable exploitation of its resources. Indeed, one observes worldwide an increasing perception of ocean issues, such as its environment and climate, resource exploitation, or usage of the ocean space.

There are a lot of international legislations, treaties and declarations on environmental protection, marine resources, transport, fisheries, policies to take into account. These include for example KYOTO, UNFCCC, UNCLOS, AMAP, OSPARCOM, MARPOL, BARCELONE, and HELCOM. This variety induces public policies which are among the main drivers for operational oceanography.

The huge range of users interested in operational prediction systems, include among others:

- European Environmental Agency (EEA)
- Meteorological services
- Coastal protection agencies
- National and international environment administrators
- Water basin authorities
- Climate and environmental research organisations and communities

Knowledge and technologies developed during the last decades allows us to propose new services for all intermediate and end users, including monitoring activities, systems allowing impact studies, and prediction systems, all three aspects being complementary. In general, operational oceanography is used to describe prediction systems for ocean currents and its ecosystem: indeed, it is the new development which can potentially encompass observation and impact study systems. Many operational and preoperational prediction systems are being implemented. This note discusses some general issues of this development.

2. Open ocean operational oceanography in France

The CNES, NASA Jason-1, and its Jason-2 extension: Jason-1 was launched on December 7, 2001, on the same orbit as Topex/Poseidon. It carries an altimetry payload derived from Topex/Poseidon. The Jason-1 commissioning phase was successfully completed on 4 March 2002. Jason Operational Sensor Data Records are delivered within three hours.

An international effort is being made in the operational high precision satellite altimetry programme, with the recent decision of the National Oceanic and Atmospheric Administration (NOAA) and the European Organisation for the Exploitation of Meteorological Satellites (Eumetsat) to contribute to Jason-2. Furthermore, new technological developments, such as Altika, are on their way.

Coriolis: Coriolis is the French contribution to ARGO (an international programme that calls for the deployment of 3,000 free drifting profiling floats distributed over the global oceans by 2006). It includes instrument development, deployment and a near real-time global scale data centre. In the year 2001 there were data sets from XBT, CTD, and moorings providing global coverage with 165 190 profiles (T, S).

Prediction systems: MERCATOR is the preoperational open ocean current-prediction system which has been implemented in France. The partners in this project are CNRS (the French national scientific research centre), METEO-FRANCE (the French national weather service), CNES (the French space agency), SHOM (the French Navy's hydrography & oceanography department), Ifremer, and IRD (the French development research institute), and their goal is to progressively develop an operational capacity to analyse and predict the global ocean, through assimilation of near real-time satellite and *in situ* data into an ocean model. Customers of the system will be public services, civil security, defence, and commercial applications of oceanography. MERCATOR already provides weekly bulletins predicting the state of the ocean for the next two weeks, including outputs on the temperature and salinity of ocean currents at various depths, and sea surface height at a 5 km resolution in the North Atlantic and the Mediterranean Sea and at a lower resolution globally. It is a contribution to the Global Ocean Data Assimilation Experiment (GODAE).

The next steps: Existing preoperational systems need to be transformed into operational systems. This requires:

- Satellite recurrent systems, which is potentially feasible because of the lower cost of new technologies and the involvment of operational agencies;
- *In situ* observation operational teams and tools which requires long term coordinated commitment by national agencies;
- Permanent modelling and prediction systems;
- Services to intermediate and end users though public or private service companies.

3. GMES and GEOSS

It is clear that such an implementation requires an European or global perspective. GMES (Global Monitoring for Environment and Security) is a joint initiative of the European Commission and the European Space Agency (ESA) to provide a sound basis to European policies related to environment and security. GMES will provide Europe with an independent access to global information useful, for example, for international conventions such as the Kyoto Protocol. GMES will also develop applications for global change, environmental security, and natural hazards.

GMES will include an extended partnership between the European commission space agencies, industry and science. Development of GMES is based on the ESA GMES services element (funded €83 million, 2002-06), the 5^{th} FP call for proposals, and the 6^{th} FP Integrated Projects and Networks of Excellence. GMES should become the European contribution to a GEOSS (Global Earth Observation System of Systems) to be developed on the world scale.

4. The MERSEA concept

General objectives: MERSEA intends to produce, assess, and deliver real-time and continuous observations of the ocean’s three-dimensional structure and associated biochemical components. MERSEA will also produce, assess, and deliver in real-time hindcasts and forecasts of the three-dimensional ocean variability at the highest resolution possible for the short time scales (a few weeks). MERSEA intends to deliver a global scale operational system. This will include support for shelf sea systems and interconnection with coastal zone systems.

A "European Centre for Ocean Monitoring and Forecasting" (ECOMF): The ECOMF concept aims to operate a global system, with a short to medium-term (e.g., one month) prediction capacity at high resolution. The ECOMF should have strong research connections and build partnerships with national centres.

Some European countries are already running national global ocean systems for practical or political reasons (e.g., defence needs). These national systems should enter into partnerships with the ECOMF, so as to share services and products for their mutual benefits. It is expected that several services currently operated under national systems will be transferred to the ECOMF.

Most practical issues and applications are regional and require very high resolution monitoring and modelling. Such systems can be best managed in a distributed manner. Regional "outcentres" can be run as integrated systems, carrying out observations, modelling and assimilation, real-time and off-line operation, validation, analysis, distribution of products, and regional services. For example, they could use ECOMF outputs as boundary conditions and will contribute to data acquisition and model development useful for ECOMF. Outcentres will generally develop in an open and competitive manner, but some can be part of an institutional network (e.g. the Mediterranean, Baltic, and Artic Seas).

MERSEA data processing modules: MERSEA does not contribute to infrastructures (e.g., ships, satellites, computers), but includes modules necessary to ensure that ocean observations are adequately processed.

MERSEA *in situ* observations: A global *in situ* observation system is required, such as continuing ARGO and time series observations. MERSEA includes part of the European contribution to this world scale system. MERSEA will aim at creating real-time access to environmental ocean monitoring data, and at implementing their assimilation into numerical models to improve the value of this environmental monitoring.

The Biogeochemistry component: There are a number of contrasting requirements for ecosystem prediction. Global requirements include CO_2 fluxes (for climate change) and primary production. These are of interest to end-users and decision makers.

Regional requirements include trophic interactions to zooplankton and predators, and harmful algal blooms. These are interesting to intermediate and end-users such as fisheries, aquaculture, and tourism.

Local (coastal) requirements include complex ecosystems with benthic, pollutants and suspended matter. These are important to intermediate and end-users, such as tourism managers and local policymakers.

This is a complex problem: preoperational systems are less developed and there is a lack of data. We need global primary production with ocean colour data assimilation. Models should have regional and local very high resolution with operational dispersion modelling, requiring preoperational complex systems.

We are talking about an evolutionary system, which will have to include both continuous improvments and occasional decisions implement new generations.

MERSEA interfaces: MERSEA will have to establish interfaces with many other organisations, including:

- Marine science activities of relevance, including European networks of excellence and integrated projects;
- Other operational systems, more particularly those dealing with meteorology, climate prediction, fisheries, and marine environment monitoring;
- National agencies and private companies involved in the development of operational oceanography, whether at global or regional scales (likely to become members or associates of ECOMF).

The MERSEA general principles: MERSEA will build on incremental developments of ongoing science and technology. It will aim at establishing a European operational system. MERSEA will identify and help organise a set of European agencies to implement and fund a long-term operational system as a component of a worldwide organisation by 2008. It should have the capacity to adjust to new requirements, research results and technologies.

5. Operational oceanography and research

Operational Oceanography must maintain connections with research, as:

- Evolution of the systems will benefit from open research and technological developments;
- Evolution of requirements will lead to define research and development questions to be addressed;
- Research activities devoted to outputs is an essential component of their validation, beyond the operational, in-house validation;
- Research will be a customer of services and products

It is necessary to organise this link. It is simpler to think of it at various levels, including:

- The general research and technology development in laboratory, with the need to identify the progress of internet for operational oceanography through science advisory committees ;
- The targeted research and technology developments, dealing with subjects identified by operational oceanography services; such developments can be supported by programs oriented by the operational services; this should also include validation exercises. Beside ecosystem issues, developments are very much needed in three directions : higher vertical resolutions, including near bathymetric features; higher horizontal resolutions, for example in frontal regions or near continental slopes and margins; higher frequencies, in particular in the mixed layer;
- Developments of the operational service, such as for example adaptation of new codes; it is more easily done inside the operational service, or through contracts to research terms.

In addition to these, outputs from operational services are necessary for research teams. They should be made available at the minimum cost, as their use by research is clearly at the benefit of all.

6. Services using operational oceanography

The success of operational oceanography will be measured by the number of public or private services which will be derived from the outputs. At the present stage, it is necessary to facilitate their implementation, through specific developments, demonstrations and access to appropriate outputs.

In particular, one should not underestimate the additional developments required by such services. It is first necessary to adjust the core production of the operational center to take into account their requirements: for example, high frequency outputs applications in fishery science or for Defence needs. Secondly, transformations of the outputs should be made possible for the service: for example, the precise position of high energy currents for oil platform operation.

7. Conclusion

Operational oceanography should be considered as one of the most important strategic axes of oceanographic research. It will not only contribute to sustainable exploitation of the ocean, as it is already concentrating and orienting a very significant fraction of the research and technology effort in the discipline. It is very strongly focused by the need to implement systems; yet, it is a fascinating adventure with many opportunities.