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Linking the coastal zone to GOOS

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Abstract

The EC project GRAND aims at supporting the GOOS Regional Alliances (GRAs) to improve local operations in coastal waters by using products from the Global Ocean Observing System. The GRAs link over 100 institutions from 83 countries all around the world. They have begun to co-ordinate their efforts to maximise the benefits of GOOS for operational oceanography. EuroGOOS is leading the way. In GRAND the GRAs have identified two key technical problems that must be overcome to link the coastal zone to GOOS:

1. Bridging the gap in scales between global observations and local needs
2. adding ecosystem information.

GRAND is designing a regional strategy to address these problems by using advanced technologies and methods. It will start by adapting two state-of-the-art European modelling technologies using unstructured adaptive meshes and Lagrangian Ensemble ecology. These technologies will then be integrated into a prototype What-If? Prediction system. GRAND is also assessing the status of assets and needs of each regional system. These activities lie in the mainstream policy of the IOC/UNESCO Inter-governmental Committee for GOOS.

Keywords: GOOS, I-GOOS, GRAND, GRAs, GRC, operational oceanography, regional strategy, nowcast, forecast, what-if? prediction.

1. Introduction

1.1 Operational oceanography

Operational oceanography provides information and predictions about aspects of the sea to address a range of customer needs such as water quality, port and off-shore installation design, fisheries and aquaculture, tourism, transportation, exploitation of resources and coastal development. Operational oceanographers use tools developed to explore the sea and modelling methods that oceanographers have developed to understand what they discover. The classical techniques of observation and prediction by induction assume that the system is linear and stationary. They have been successful in solving many problems. But a new framework, no longer stationary and linear, is emerging because of the pressure of population growth on natural resources, the legacy of non-sustainable exploitation, and the response of the biosphere to changes in pollution and radiative forcing. Inadequate simulation of ecology and lack of data at the regional scale are limiting coastal operational oceanography.

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1.2 The role of GOOS in operational oceanography

WOCE successfully tested the use of global observations to describe coherent structures in the marine environment. This led John Woods to launch, at the Second World Climate Conference in 1990, a Global Ocean Observing System to enable permanent observation of seas and oceans and prediction of future change (Woods 1991, 1992, 1993). In 1992 the UNCED endorsed this global system of ocean observations and the IOC formally initiated the GOOS, later joined by WMO, UNEP and ICSU. It is steered by I-GOOS, the Inter-Governmental Committee for GOOS.

GOOS is a global system designed to produce global-scale products with the potential to improve operational oceanography at local level. It also provides the marine data needed for the Global Climate Observing System, proposed to WMO soon after GOOS was launched. Climate has since become the major driver for GOOS products. GODAE is the first global trial. It will assess the products obtainable from a prototype GOOS array, mainly of satellite altimeters and ARGO floats.

However, the great majority of customers for operational oceanography, and therefore for GOOS, are concerned with processes in the coastal zone that are important even when the climate is stationary. So the IOC has strongly supported the development of a coastal strategy for GOOS, and the coastal states have focused the I-GOOS goals in 2002−2005 on coastal customers. The I-GOOS goals are:

1. transfer prototypes from research into operations
2. learn from the regions
3. empower the regions
4. address operations in EEZs.

Specific initiatives were taken to support each goal. The EC project GRAND supports these I-GOOS goals.

1.3 The regional approach and GRAND

I-GOOS recognises that creating an effective GOOS will depend critically on the co-ordinated development of regional activities. Thus I-GOOS is supporting the GOOS Regional Alliances, each of which is grouping major institutions from countries with a shared interest in a specific area of the marine environment. The GOOS Regional Forum, initiated by I-GOOS, facilitates the sharing of best practice. The GOOS Regional Council (GRC), formed by the heads of the GRAs, provides a decision-making body for the regions acting collectively. The GRC provides a coherent voice expressing the needs of coastal customers in GOOS. In so doing it balances the Climate Convention which expresses the needs of climate customers in GOOS.

I-GOOS and MedGOOS proposed GRAND to the EC to empower the regions to link their coastal zones to GOOS. The partners of the project are eleven GRAs (Figure 1): MedGOOS, Africa GOOS, Black Sea GOOS, EuroGOOS, GOOS Regional Alliance of South Pacific, Indian Ocean GOOS, IOCaribe GOOS, North East Asia GOOS, OceAtlan, Pacific Islands GOOS, and South East Asia GOOS. The advanced technologies are being developed by Imperial College London.

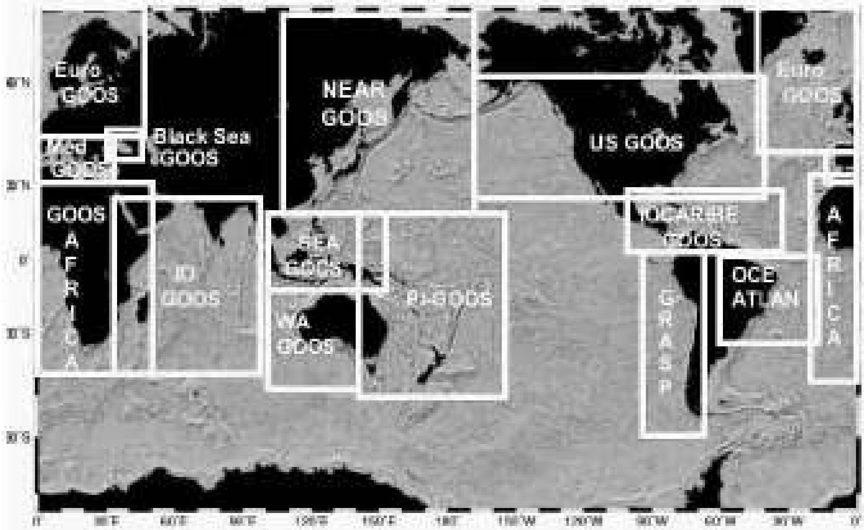

Figure 1 The GRAs in 2005. Their boundaries are indicative. From www.grandproject.org.

2. The challenge of GRAND

The main challenge for GRAND is to design a regional strategy to extract local benefits from the global scale products of GOOS. This is supported by identification of essential technologies, a survey of regional assets and needs, advanced training workshops and publications. GRAND strongly supports the participation of developing countries in GOOS and GEOSS, while promoting the European contribution to the global observing systems, GMES. To derive maximum benefit from GOOS for coastal communities the GRAs require action in two broad areas: technical — data, science and technology; organisational — co-ordination, skilled people and funds. GRAND is helping the GRAs to address this challenge of linking the coastal zone to GOOS.

2.1 Data

The work done in GRAND has shown that considerable capability already exists throughout the GRAs to collect data at the length and timescales necessary to solve local problems. The GOOS is designed to collect data at the global scale. There is a gap in the spectrum of data collection at a regional level between the local and global ocean scale. Field trials are needed to assess the impact of this gap on local services and to design an effective way forward. They will extend the work of GODAE.

2.2 Science and technology

The GRAs have identified two key technical barriers to linking coastal needs to GOOS products:

1. gap in scales
2. lack of ecosystem information.

Predictive techniques and modelling are a particular weakness. The traditional method of nesting models within models can lead to errors. An important goal is to introduce modelling techniques that permit an error-free transition between scales.

Many problems in coastal areas are related to chemical and ecological factors rather than just the physics of the marine environment. Yet the majority of marine models are physical. Simulating the ecosystem better in operational models is a high priority. Biofeedback in ecosystem models produces non-linearity that cannot be addressed effectively by the method of induction used in operational oceanography.

3. The GOOS gap

Coastal communities should benefit from the large investment in GOOS, but concentration of effort has so far been on physical properties of the ocean, and there is a lack of capability to address ecosystem response. The Climate Convention has developed a strong customer-pull for a clearly-defined problem. The GOOS observations are at the appropriate scale for that problem. The Coastal Scientific Community has not developed a similar customer-pull because the problems are diverse, the observation length and time scales are different, and there are technical and scientific problems with the transition between global and local scales, and of ecology. Before the founding of the GRC there was no clear organisational structure that could co-ordinate a coherent input to GOOS from the multitude of local end-users. This has resulted in a "GOOS Gap" illustrated schematically in Figure 2.

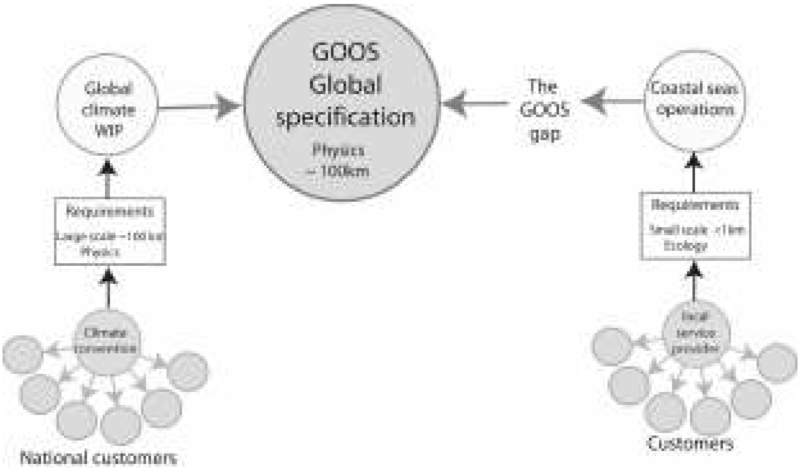

Figure 2 The GOOS Gap (Woods and Morrice, 2006).

4. New technology

A significant element of the "GOOS Gap" arises from deficiencies in three areas:

1. modelling error generation
2. What-if? predictive capability
3. addressing ecosystem response.

The capacity building in GRAND focuses on the transfer of new technologies to close that gap, plus the training and support necessary to exploit these technologies within the regions.

4.1 Ocean circulation modelling

Closing the GOOS gap has top priority for service providers seeking to use GOOS global-scale products to improve their products for coastal customers. The classical solution, nested models, is known to produce errors. Those errors can be avoided by adaptive mesh modelling, developed at Imperial College London (Ford *et al.*, 2004). This technology permits much more realistic representation of bathymetry (Figure 3) and ocean circulation by automatically providing enhanced resolution wherever it is needed, for example to describe flow interaction with bathymetry, or transient jets and fronts. Such very high resolution is computationally affordable because it is only provided where needed. Adaptive mesh technology is incorporated in the Imperial College Ocean Model (ICOM), which also features non-hydrostatic dynamics and advanced data assimilation. ICOM was presented at the GRAND Workshops. The effectiveness of ICOM is being demonstrated by simulating the interaction between circulation in a coastal lagoon and the open Mediterranean Sea.

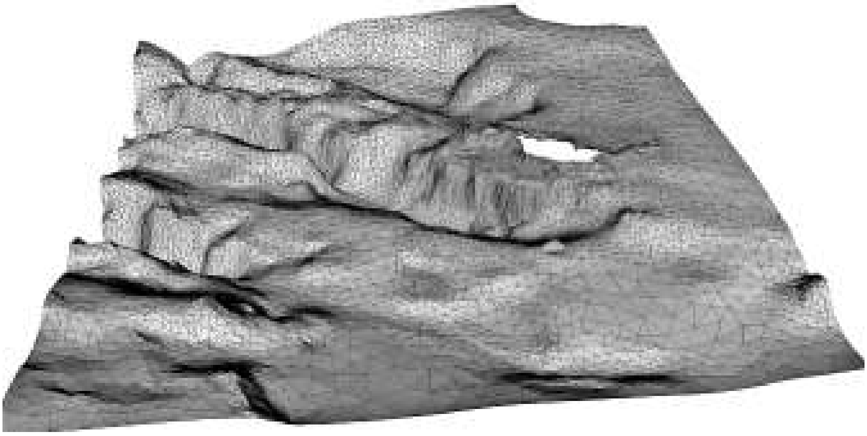

Figure 3 Unstructured mesh bathymetry around Malta produced for MAMA (Gorman, 2005).

4.2 Ecology

Many of the customer needs for operational oceanography, such as fisheries, pollution, toxic blooms and cholera epidemics require the model to incorporate ecosystem processes. It is necessary to adopt an ecosystem metamodel that guarantees global stability and therefore reliable predictions under a wide range of conditions. Popova *et al.* (1997) have shown that the Eulerian metamodel widely used in research on biological oceanography (e.g. in ERSEM) is not globally stable. However Woods *et al.* (2005) have demonstrated that the Lagrangian Ensemble metamodel (Woods, 2005) is globally stable. LE modelling underpins the new science of Virtual Ecology, which promises useful predictability for operational oceanography, especially for What-If? Prediction in support of planning (Woods, 2006). The Virtual Ecology Workbench (VEW), which automates the creation and analysis of Virtual Ecosystems was demonstrated in the GRAND Workshops. The VEW training manual is one of the GRAND publications.

5. The GRAND publications

5.1 The GOOS Regional Prospectus

The GOOS Regional Prospectus gathers all the ideas and data generated by GRAND into a self-contained publication that will be used by the GRAs to explain the strategy they are adopting to improve coastal operational oceanography by exploiting the global-scale products of GOOS. The chapters address: Operational oceanography; The challenge; Global Ocean Observing System; New technology; A regional approach; Regional funding opportunities, A regional strategy. The GOOS Regional Prospectus is being written by John Woods and Alex Morrice with input from all GRAND members. The follow-up project GRACE will (if funded) produce a detailed implementation plan.

5.2 The VEW Training Manual

The VEW (Virtual Ecology Workbench) is a powerful and flexible software tool for creating virtual ecosystems without the need for programming. Its graphical user interface helps the user to specify the model, the scenario for forcing by exogenous processes, and the environmental events that are the subject of What-If? Prediction. GRAND is funding the preparation of the VEW training manual.

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Acronyms and URLs

ARGO		www.argo.ucsd.edu/
EC	European Commission	www.europa.eu.int
ERSEM	European Regional Seas Ecosystem Model	www.pml.ac.uk/ecomodels/ersem.htm
FP6	Sixth Framework Programme	www.europa.eu.int
GEOSS	Global Earth Observation System of Systems	earthobservations.org
GOOS	Global Ocean Observing System	www.ioc.unesco.org/goos
GRA	GOOS Regional Alliances	www.grandproject.org
GRACE	GOOS Regional Alliances Collaboration for Empowerment	
GRC	GOOS Regional Council	
GMES	Global Monitoring for Environment and Security	www.gmes.info
GRAND	GOOS Regional Alliances Network Development	www.grandproject.org
GODA E	Global Ocean Data Assimilation Experiment	www.USGODAE.org
I-GOOS	Inter-Governmental Committee for GOOS	www.ioc.unesco.org/goos
ICOM	Imperial College Ocean Model	http://amcg.ese.ic.ac.uk/cgi-bin/index.pl?page=home.htm
ICSU	International Council for Science	www.icsu.org
IOC	Intergovernmental Oceanographic Commission	www.ioc.unesco.org
MAMA	Mediterranean network to Assess and upgrade Monitoring Forecasting Activity in the basin	www.mama-net.org
MedGOOS	Mediterranean GRA	www.medgoos.org
UNEP	United Nations Environment Programme	www.unep.org
VEW	Virtual Ecology Workbench	www.ic.ac.uk/ese/research/cosmic
WMO	World Meteorological Organization	www.wmo.org
WOCE	World Ocean Circulation Experiment	www.woce.org