Announcing a Call For Proposals for a Departmental Research Initiative (DRI) to be supported by the Office of Naval Research (ONR), entitled

Assessing the Effects of Submesoscale Ocean Parameterizations (AESOP)

Beginning in Fiscal Year 2005

This announcement contains (1) the goal of this DRI, (2) a general overview of the motivation behind this initiative, (3) more specific guidance concerning desired proposal content and scope, (4) the proposed project timeline and funding, (5) requirements for proposal submissions, and (6) links to additional information.

(1) Goal

The overall goal of this DRI is to create an intellectual framework for assessing the impact of submesoscale ocean parameterizations on synoptic predictions of the ocean state using numerical models. The primary focus of this effort will be on developing metrics and methods of assessing existing parameterizations and consequent improvements, rather than the development of new parameterizations.

(2) Overview

Introduction

As computational power has continued to increase exponentially, it is now possible to run numerical ocean simulations at resolutions that allow mesoscale features (40km-400km) to be fully represented in basin and global simulations. Regional models are run at even higher resolutions in coastal regions, where ocean processes and dynamics are much more complex. These simulations exhibit interesting behavior - producing fronts, currents, and eddies on the smallest resolvable scales - but it is essentially unknown whether the models are simulating the dynamics in any realistic manner.

Even in high-resolution models, many of the key small-scale processes that drive the ocean dynamics are not resolved on the model grid and must be parameterized. Various parameterizations exist to incorporate these processes into models, but methods to unambiguously assess the correctness of their implementation (or even their impact) on the consequent model solution are difficult to identify. This DRI will explore methods by which submesoscale parameterizations used in ocean models might be tested to determine their suitability, and investigate whether they actually improve synoptic predictions of the ocean state.

Background

The overarching goal of modeling the ocean for naval use is to create a prediction system that provides useful nowcasts and forecasts of the ocean environment at the highest necessary resolution for operations. Information about the physical environment (T, S, ρ, u, v, etc) is useful in itself, as well as being an important component in atmospheric, acoustic, chemical, biological, and optical models. The requirements leading to a good prediction include (1) the correct initial condition, (2) appropriate forcing at the boundaries, and (3) an accurate numerical model that incorporates all of the relevant dynamics of the ocean. While all three are important, it is the third item on the list that must be addressed first, and one particular aspect of the models – the sub-grid-scale (SGS) parameterizations - will be addressed in this effort. Because future operational models will already resolve the mesoscale motions, we are interested in assessing the sub-mesoscale parameterizations that will be required. For the purposes of this DRI, “sub-mesoscale” processes are defined as those with spatial scales below 10km.

Representation and parameterization are fundamental concepts in numerical modeling. Representation involves how accurately a model simulates physical processes that are resolved on the model’s grid (e.g. getting the Gulf Stream to separate from the coast in the correct location, or having the right amount of entrainment in a convective plume). Parameterization involves the incorporation of unresolved small-scale processes into the model solution that would not otherwise be represented (e.g. the effects of breaking of waves, or, at the smallest scales, molecular diffusion). If all of the SGS physics are parameterized correctly, the model’s representation of the resolved processes may be quite good. Often times however, unphysical parameterizations are employed, either because they appear to improve the model solution (but for the wrong reasons), or because they are useful for other purposes, such as maintaining numerical stability. For some processes, inadequate parameterizations are used in models simply because nothing better exists.

As a model’s resolution changes, so does the dividing line between what is represented and what must be parameterized. For example, in many global climate models, the effects of mesoscale eddies must be parameterized along with all other SGS physics. In simulations run at higher resolutions, there is no longer any need to parameterize the mesoscale eddies, as those features are represented in the model, leaving only the remaining unresolved physics to parameterize. However, as model resolution continues to increase, the need for parameterization does not simply go away. In practice, the submesoscale processes that must be parameterized are even more troublesome, as not only is their formulation fundamental to the model solution, but the processes involved are often not well-understood or even well-defined. Among these processes are turbulence, boundary layer effects, unresolved eddies, breaking waves, interactions with small scale topography, and mixing in general. This list is not exhaustive, and there are many processes operating at these scales that we have yet to adequately observe and characterize, let alone attempt to parameterize. Additional complications in trying to account for these small-scale processes are that they are often intermittent in both space and time, are not distributed homogeneously across all grid points, and may result from non-local forcing, yet their aggregate effect must be incorporated into the resolved model solution in order to allow good predictions.

A typical problem in the assessment of parameterization schemes is the lack of adequate observations. Synoptic, high resolution data suitable for validating either a model's representations or parameterizations are difficult to obtain. Many field experiments in the past have investigated oceanic processes on small scales, but the data collected, while useful for process studies, typically cannot be used to verify the parameterization or representation of that process in the context of a larger numerical model. In a similar manner, coarse observations or stochastic measures may be used to assess a model's representation of ocean dynamics on the large scale, but their behavior on the finest resolved scales goes unchecked because observations are only available on larger temporal and spatial scales.

Expected Scope

The goal of this DRI is to create an intellectual framework for assessing model parameterizations and their affect on high resolution ocean predictions. Process studies in the ocean are occasionally motivated by the desire to create a better parameterization for use in numerical models, and model studies have been carried out to test model sensitivity to different parameterizations. However, little work has taken place examining the actual role of the parameterizations in improving model performance, primarily due to a lack of adequate data. This DRI will address issues related to parameterization through a combination of field experiments, theory, and modeling work.

The following questions indicate areas of knowledge in which the AESOP effort as a whole will attempt to make progress over the next five years. Individual proposal submissions are not expected to specifically address any particular question, rather these questions represent some limitations in our current knowledge of parameterizations, and in particular, how to choose the best ones for predictive purposes:

- Which processes are the most difficult to parameterize, and limit our ability to generate realistic, high-resolution simulations of the ocean state?
- How well (if at all) are the key processes physically or empirically represented in current parameterization schemes?
- How should one choose between different parameterizations?
- How can it be determined that a parameterization has been improved?
- Can generalized parameterizations be constructed that include many processes, or is it better to use multiple parameterizations, each describing a different process?
- Which processes dominate the model physics at higher resolutions?

- Is there a useful separation of scales for different processes?
- How sensitive are model predictions to various parameterizations?
- Are there observable quantities that tie different parameterizations together?

To make progress in these areas, at least one field study region must be examined, with observations that over-sample the domain to understand how the dynamics at scales unresolved by numerical models contribute to the ocean state. This requirement for high density observations may require the combined use of AUV's, moorings, gliders, towed systems, and other novel data collection systems that provide high-density observational capabilities.

Simulations of the field study areas are anticipated using different models operating at various spatial resolutions. The models may implement different parameterizations while directly computing any quantities of interest that might be comparable with direct observations. Predictions of the ocean environment can be made in hindcast mode, such that the effects of different parameterizations are apparent and the over-sampled data from the field observations are available to assess differences in the performance of the parameterizations and the quality of the predictions.

Summary

Small-scale processes in the ocean play an important role in determining the physical state of the ocean, and are vital in determining the acoustic, biological, chemical, and optical characteristics. It is expected that this DRI will generate:

- New methods for assessing the fidelity of present SGS parameterizations
- New knowledge about sub-mesoscale processes in the ocean
- Methods to determine which processes are most important at high resolutions
- Information concerning the effects of parameterizations on ocean predictions
- New methods to evaluate high resolution models and predictions
- First-order improvements in existing parameterizations, and necessary directions for future parameterization development

In an optimistic scenario, the parameterizations being implemented in numerical models at present may be excellent, but have yet to be rigorously tested at high resolutions with adequate observational data available for verification. In a pessimistic scenario, our current models and parameterizations can generate simulations that contain complex, interesting behavior, but that do not adequately represent actual ocean dynamics and cannot be reliably used for synoptic predictions. By focusing only on the submesoscale parameterizations in models, combined with a field program to make the necessary observations, it is hoped that a useful assessment of our current modeling and predictive capabilities can be determined, as well as providing direction for improvements in nowcasting and forecasting.

(3) Proposal Scope

The AESOP DRI will be primarily managed by the Physical Oceanography (322PO) program at ONR, with assistance from Marine Meteorology (322MM), Ocean Acoustics (321OA), and Optics and Biology (322OB).

The nature of this effort requires cooperation and collaborations between numerical modelers, process modelers, observational oceanographers, and theoreticians. Pairing, teaming, and discussions between these various groups before proposal submission would be valuable, and will be essential once proposals have been funded. Many useful issues were brought up during a preliminary workshop in early May, and the relevant documents can be found on the workshop website here [link].

For progress to be made in this scientific area, many different observations must be obtained over scales ranging from centimeters to tens of kilometers. By placing this submesoscale observational study within the context of a larger mesoscale field experiment, the available funding can be put to optimal use. For this reason, it is highly anticipated that the location of the primary AESOP field site will be in Monterey Bay, California, to allow leveraging against a MURI-funded program that will be making a number observations in that region. Monterey Bay is a well-studied environment in which many different processes occur. (For an overview of recent observations and modeling in the area, please see the links to the AOSN-II study in Section 6 below. The AOSN-II site will have details on the future MURI experiment soon.)

The MURI program will employ shipboard CTD measurements, deep and shallow glider observations, propeller-driven AUVs with various sensors, aircraft measurements of surface winds and fluxes, and mooring and HF radar, which will be used as inputs to a numerical model to define and describe the mesoscale flow. The primary objective of the MURI is the identification and maintenance of an optimal distribution of observational sensors for use in predictions; however, there are ocean science objectives within the MURI as well, some of which overlap the primary submesoscale AESOP objectives. The value of the MURI to the DRI is the description of the mesoscale environment, along with the actual observations, which can be used for validation, initial conditions, and boundary conditions for the AESOP modeling components.

The desire to leverage the AESOP DRI against the MURI experiment in Monterey Bay does not necessarily preclude the submission and funding of additional experiments in other site locations. However, the argument must be successfully made in such proposals that a sufficient number of observations will be available, via the submitted proposals or partnered with an outside study, to allow progress to be made on issues of relevance to AESOP. There is potential for a second field experiment at either the Monterey Bay site or a complementary site.

It is anticipated that awards will be made to 12 to15 individual PI efforts, rather than one or two large, multiple-investigator proposals. However, proposals that include potential links and synthesis with complementary proposals from other investigators are encouraged. Proposals that anticipate leveraging against additional resources, whether they be from future concurrent experiments or already existing datasets, are also encouraged. However, the submitted proposal should be as specific as possible concerning the nature of the outside observations or field work that would be utilized, including references to the leveraged efforts if necessary.

(4) Project Timeline

A general proposed timeline, subject to change by the consensus of project participants once funding decisions have been made, is as follows:

FY05	FY06	FY07	FY08	FY09 (tentative)
Planning meeting; model development; instrument acquisition and testing	First field experiment; theoretical work; model diagnostic work	Second field experiment; data analysis; model forecasts and hindcasts	Data analysis; field area modeling; assessment of parameterizations	Continued data analysis; synthesis and publication of results

Up to approximately $7 million may be available over the four-to-five year span of this project. Available funds will not be divided evenly among years, with higher levels of funding expected during instrument acquisition and the second field year. Participants must recognize the need for flexibility when developing research plans and operating budgets, and are requested to consider the overall budget limitations considering that researchers from many different fields are necessary to achieve the objectives of this DRI.

(5) Specific Requirements

There will not be a call for planning letters for this initiative. Some planning letters submitted to the core Physical Oceanography program will be encouraged to submit proposals to the AESOP DRI rather than the 322PO core program, but were not given any additional guidance outside of that presented in this document.

Full proposals are due no later that July 15, 2004. Proposals must be submitted electronically through ONR's Hopper system via the following link. [http://onroutside.onr.navy.mil/aspprocessor/prop322/]

Format
Proposals must adhere to ONR standards (link http://www.onr.navy.mil/02/how_to.asp)

Questions may be addressed to
322_PO@onr.navy.mil
703-696-4721

(6) Links to additional information

AESOP Workshop (with ONR presentations; working group questions and reports)
AOSN II Experiment (with links to other sites) http://www.princeton.edu/~dcsl/aosn/