Assessing the Impact of GODAE Boundary Conditions on the Estimate and Prediction of the Monterey Bay and California Central Coast Circulation

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LONG-TERM GOALS

The practical demonstration of basin-scale ocean state estimation has been realized through the Global Ocean Data Assimilation Experiment (GODAE) whose projects provide complete descriptions of the temperature, salinity, and velocity structure of the global ocean. The ocean circulation, temperature and salinity distributions of coastal regions are characterized by smaller scale processes typically not resolved by basin-scale estimates of the ocean structure. The overarching goal of this project is to assess the impact of the large-scale ocean structure (as produced by GODAE), when used in conjunction with satellite observations, on the numerical prediction of the coastal ocean environment.

OBJECTIVES

Although the coastal circulation of the Monterey Bay and greater California central coast is in part driven by strong local forcing when present, the generally narrow continental shelf and open coastline of this region also leave it exposed to the energetic circulation of the California Current System offshore and more generally to the stratification and transports of the eastern Pacific ocean. The objective of this proposal is to use the Regional Ocean Modeling System (ROMS) and a recently developed suite of numerical tools (the ROMS 4 Dimensional variational data assimilation, ensemble prediction, and generalized stability analysis toolkits) to quantitatively explore the influence that open boundary conditions from Global Ocean Data Assimilation Experiment (GODAE) products and satellite-derived data have on the observability and predictability of the circulation in this coastal region.

APPROACH AND WORK PLAN

Using ROMS and its newly developed set of analysis tools, this project will (1) investigate the sensitivity of specified metrics to the imposed boundary conditions and surface forcing fields using the ROMS adjoint model and ROMS 4-dimensional variational assimilation capability; (2) measure the mean and variance of metrics obtained from perturbed ensemble calculations; (3) analyze representer functions to identify regions observable and unobservable to boundary (GODAE) or surface forcings and recommend observations of particularly high or valuable information content for future ocean observing systems. In addition, we will (4) explore feedbacks between the ocean temperature and atmosphere for weather prediction; and (5) develop oceanographic feature tracking capability useful for both model and data analysis. Our domain of interest is the central California coast, and the time-period of focus is 2002-2004 which represents a period of excellent overlap between the basin-scale state estimate and existing coastal observations.

Several partners are responsible for the key components of the program. Dr. C. Edwards (UCSC) and Dr. A. Moore (CU) carry out the development and execution of the high resolution modeling, data assimilation, sensitivity analysis, and ensemble prediction of the central California coast region. Dr. C. Wunsch (MIT) is responsible for the basin-scale ocean state and uncertainty estimates from the global ocean model as produced by the GODAE project, Estimating the Circulation and Climate of the Ocean (ECCO-GODAE). Dr. J. Doyle (NRL) provides best-estimate atmospheric fluxes from a high resolution, data-assimilative atmospheric model (COAMPS™- the Coupled Ocean/Atmosphere Mesoscale Prediction System), and will analyze feedbacks to meteorological prediction. Dr. F. Schwing (NOAA/PFEL) and D. Foley (NOAA/PFEL) provide support for satellite data products and will develop methods of analysis for tracking mesoscale ocean features.

In the coming year, we expect to make significant progress toward several components of the project. In particular, we will (1) develop the strong constraint data assimilation capability within the ROMS California central coast model, focusing on assimilation of satellite-derived products (sea surface height and temperature); (2) carry out sensitivity calculations using the ROMS adjoint model to understand the sensitivity of chosen metrics to open ocean and surface forcing; (3) complete COAMPS reanalysis simulations to provide ocean fluxes for the 2002-2004 period; (4) continue to provide support for ECCO-GODAE products; (5) begin investigation of oceanographic feature tracking; and (6) develop the project website.

WORK COMPLETED

This project began 9/1/05, with only 1 month in the fiscal year ending 9/30/05. As of that date, no tasks had been completed. However, in anticipation of the expected funding, we held our first PI meeting on July 29, 2005.

As of 12/23/05, Task 1 of the proposal is completed at this time: we have linked the global ocean estimates of ocean velocity, temperature and salinity as produced by the ECCO-GODAE project as a boundary condition for the regional circulation model of the U.S. west coast. Tasks 3, 6, 7, and 9 of the proposal (related to sensitivity calculations, atmospheric model reanalysis, ECCO-GODAE support, and the project website) have begun and continue at various stages of completion at this time.

RESULTS

The completion of Task 1 represents a meaningful accomplishment as it is a demonstration of interoperability between ocean models of highly different structure. The ECCO-GODAE product derives from an ocean model discretizing the equations of motion using horizontal levels. In contrast, the regional model of the central California coast has a coordinate system that follows ocean bathymetry. Although we expect to learn considerably more about the ways in which these heterogeneous models interact at the open boundary as this project proceeds, our initial implementation of their coupling is a very positive development.

IMPACT AND APPLICATIONS

National Security

The improved estimate and prediction of the coastal ocean circulation can contribute toward U.S. Naval operations in coastal waters and U.S. Coast Guard search and rescue.

Quality of Life

Although this project focuses on the sensitivity of the coastal circulation, temperature and salinity structure, with an ultimate goal of improved state estimation and prediction, such information in combination with data assimilative biological models has the potential to contribute positively to ecosystem health and ultimately fisheries management. An understanding of the sensitivity of the coastal circulation to open ocean and surface forcing may aid in the prediction of pollutant dispersion as well as the fate of harmful algal blooms.

Science Education and Communication

Results from this investigation will be incorporated into graduate student education at the partner institutions as well as to the greater public via the project web site.

RELATED PROJECTS

The NOPP-funded ECCO-GODAE (Estimating the Circulation and Climate of the Ocean – Global Ocean Data Assimilation Experiment) project (http://www.ecco-group.org/).

The NOAA-funded Center for Integrated Marine Technology (CIMT) (http://cimt.ucsc.edu/).

The NRL-supported Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS) (http://www.nrlmry.navy.mil/coamps-web/web/home).

The NOAA CoastWatch mission (http://coastwatch.noaa.gov/).