Real-time observation and forecasting applications

Forecasting systems are comprised of observation networks and dynamical models linked by data assimilation schemes. Observation networks can acquire numerous diverse datasets in real-time, but sensors alone cannot continuously sample the full 3-D volume for all variables at the multitude of oceanic time and space scales that exist. Data assimilation schemes can constrain a dynamical model with the real-time observations, enabling the ocean model to produce a hindcast or nowcast in which the observations are interpolated to finer space and time scales. This requires the observations to first be transformed into the same state variables used by the model, a potentially heavy constraint on the observation networks (one example of this is a dynamical model designed to forecast the subinertial frequency flow fields cannot directly assimilate ocean current observations that may also include contributions from surface and internal waves, tides, and inertial waves). The dynamical models also forecast forward in time, and ensemble forecasts can provide estimates of the error fields associated with the predictions. Ensemble forecasts potentially include not only sensitivities to initial conditions, but also sensitivities to predicted boundary forcing or internal model dynamics (Robinson and Glenn, 1999). In contrast to the deep ocean, coastal forecasts rely heavily on forecast meteorological fields from weather models, several of which may be available.

Real-time observation and forecasting systems have the potential to support numerous activities in the coastal environment, including the following:

Safe and efficient navigation and marine operations

The increasing drafts of oil tankers, cargo and container ships, some of which are restricted from entering and leaving depth-limited ports to times of high water, illustrate the need for real-time water level data as a more accurate substitute for astronomical tide predictions in areas where wind and river discharge effects are significant. Real-time current observations in ports, instead of tidal current predictions, are required for critical ship maneuvering situations such as docking, turning, and determining the right of way between two ships approaching each other. Real-time density information for ports with varying river discharge is important for accurate predictions of a ship's static draft. The maritime community and its customers also need short-term water level forecasts to know how much cargo they can load, or when to leave port, instead of astronomical tide predictions from national tables, which do not include important wind, pressure, and river effects.

Efficient oil and hazardous material spill trajectory prediction and clean up

When a maritime accident leads to a hazardous spill, real-time and forecast current information can provide more accurate predictions of where the spill will be transported so that the most efficient clean up strategy can be initiated. In this case, 2-D observed or modeled surface current fields become especially important, since they can also be used to define convergence zones where floating materials tend to accumulate.

Monitoring, predicting and mitigating coastal hazards

Real-time water level gauges have been used for many years to monitor the growth of storm surge as part of coastal warning systems. Gauges modified to recognize rapid changes in water level have also been part of tsunami warning systems. Real-time water level data are further used to initialize storm surge forecast models, which may involve assimilation over a period of time prior to the forecast period.

Military operations

The strategic objectives of the naval oceanographic community are to provide the environmental information necessary for the safety of day-to-day operations and, if required, to support the warfighter. Safe naval operations anywhere, even along our own coast, depend on local value-added observations to supplement larger scale predictive models. Warfighter support depends on the development of new methodologies for using real-time remote sensing and *in situ* data for rapid environmental assessment in denied areas. The existing observational and predictive infrastructure available along the U.S. coasts enables the Navy to test new sensors, platforms, models, and ampling techniques in logistically simple situations before deployment in less favorable situations.

Safe naval operations anywhere, even along our own coast, depend on local value-added observations to supplement larger scale predictive models.

Search and Rescue

Search and Rescue (SAR) is one of the Coast Guard's oldest missions. Approximately 95% of their SAR responses occur within 20 nautical miles of the coast, with 20% lasting longer than 24 hours. Because of the urgency of SAR, ongoing real-time observations and short-term forecasts for the coastal ocean would help reduce the search time, resulting in more lives saved, reduced costs, and fewer Coast Guard personnel placed at risk.

Prediction of harmful algal blooms, hypoxic conditions, and other ecosystem or water quality phenomena.

Physical models, and physical models coupled to water quality or ecosystem models, are beginning to be