Adaptive Sampling in a Research Observatory During the Shallow Water 2006 Acoustics Experiment

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LONG-TERM GOALS

Develop and demonstrate in a collaborative Mid-Atlantic Bight test-bed a coupled observation and data assimilative modeling capability that contributes to our understanding of continental shelf processes, provides societal benefits, and is relocatable worldwide in both collaborative and non-collaborative environments. Our approach will leverage the complementary capabilities of academic, industry and government groups through NOPP-style partnerships to develop new satellite remote sensing algorithms, new HF radar hardware and processing software, and new autonomous underwater vehicles and sensors for subsurface adaptive sampling. We will use the new technologies to sustain a continuous long-term presence on the New Jersey Shelf with enhanced coverage during an ongoing series of scientific process studies that includes advanced data assimilation in coupled atmosphere/ocean physical, biological, biogeochemical, and sediment transport models.

OBJECTIVES

A) Prepare and deploy a fleet of gliders to occupy a series of closely spaced repeat transects across the shelf-slope front within and around the SW06 mooring array, maintaining a continuous presence for the full duration of the joint experiment.

B) Distribute the glider CTD datasets in near real-time to the ocean modeling community for assimilation by forecast models.

C) Use the full resources of the New Jersey Shelf Coastal Observatory to support real-time shipboard operations in the SW06 region, emphasizing the detection and characterization of internal waves during the first half of the experiment and resolution of the sub-mesoscale variability of the shelf-slope front for acoustics applications during the second half.

Report Documentation Page

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D) Actively participate with other SW06 scientists in the collaborative post-analysis of the SW06 dataset.

E) Use the SW06 dataset as the starting point for a Rutgers student's Ph.D. thesis.

APPROACH

During the field component of this program, efforts focused on using the observatory to optimize ship and aircraft assets. Ship to shore computer communications were enabled by the WHOI HiSeasNet using the Knorr as the offshore hub with broadband wireless connections to other vessels within range. WHOI ExView provided a logistics interface for discussions and data product exchange supporting a distributed network with intermittent connectivity. The Coastal Ocean Observation Lab was restructured for enhanced observatory operations by forming operational teams consisting of a 5 person glider operations team, one operations person each for satellites, CODAR, and weather forecasting, and a 4 person data analysis team.

WORK COMPLETED

The COOL group provided real-time data and high resolution weather forecasts throughout the experiment. This data was collated, synthesized into a daily report, and delivered to the greater SW06 community through daily emails for 3 months. During extreme events (tropical storms and hurricanes), extra ocean reports were constructed and delivered to the wider community. The daily environmental report and storm alerts were made available to shipboard crews via ExView at WHOI. Spatial maps of surface currents and SST were provided by the shore based CODAR and satellite imagery collected from the international constellation of satellites. These maps were complemented with high resolution weather forecasts run throughout the experiment. The group maintained a sustained Glider fleet within the experimental area offshore New Jersey using Gliders being constructed and delivered as part of the Rutgers Glider Technical Center. The glider team successfully dealt with the compact delivery schedule that resulted in the majority of the gliders running their first check out mission during the experiment. Glider operations total 17 deployments sampling over 6,400 km and acquiring over 50,000 CTD casts (Figure 1). The data analysis team produced a real-time quality controlled Glider CTD dataset that was made available to modelers for assimilation.

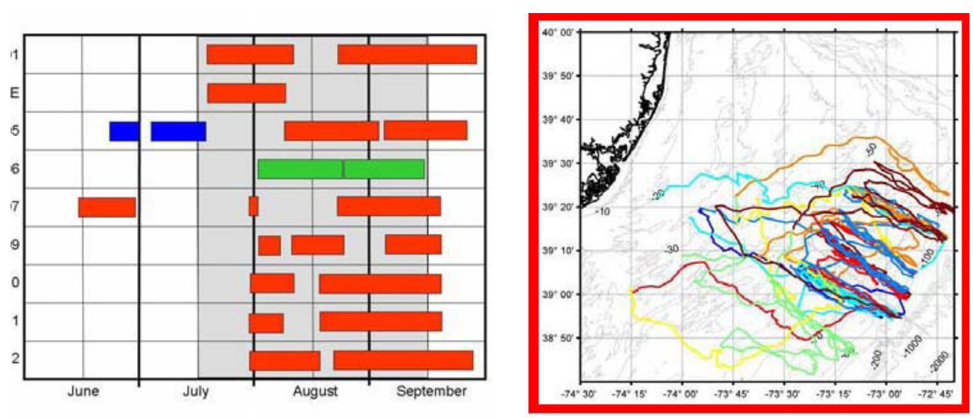

Figure 1. Composite of Glider deployment intervals and tracks for the Shallow Water 2006 Joint Experiment.

RESULTS

Persistent southerly winds through June, July and August resulted in persistent upwelling along the inner NJ shelf and along the southern coast of Long Island. Albany's wettest June in over 200 years of record keeping produced the fifth largest Hudson River discharge in nearly 90 years of record keeping. The result was a persistent offshore surface flow from the NY Bight Apex along the Hudson Shelf Valley that then turned southward, flowing through the SW06 area. This produced a pool of fresher than normal water on the outer shelf during the initial months of SW06. The pooling of water on the outer shelf was aided by the eastward flows from the Delaware interrupting the southward flows from the Hudson Shelf Valley. September brought hurricanes and northeasters, resulting in a significant change in the surface currents to a more uniform shelf-wide flow to the southwest. Offshore in the Slope Sea, a large warm core ring formed in the spring, sweeping the region clear of the typical size warm core rings before being reabsorbed itself by the Gulf Stream, resulting in an offshore influence dominated by the smaller shelf break eddies.

Within the mooring array, glider CTDs combined with CSTARS SAR imagery indicated the nearly constant presence of internal waves on an extremely strong summer pycnocline caused by surface freshening and intense heating. Internal wave patterns often appeared circular to the north of the array in the vicinity of the Hudson Canyon and often appeared linear and parallel to the shelfbreak along the main cross-shelf mooring transect (Figure 2). The foot of the shelf-slope front appeared as a salinity intrusion along the bottom with a 3-D structure that was influenced by interactions with numerous alongshore ridges in the bottom topography. Strong high temperature and salinity intrusions were observed within the thermocline, especially during the later months. The intrusions spread rapidly shoreward with significant variability in the alongshore direction (Figure 3). Storm mixing later in the season eroded but did not eliminate the summer pycnocline on the middle to outer shelf, resulting in well mixed waters above and below a slightly weakened pycnocline.

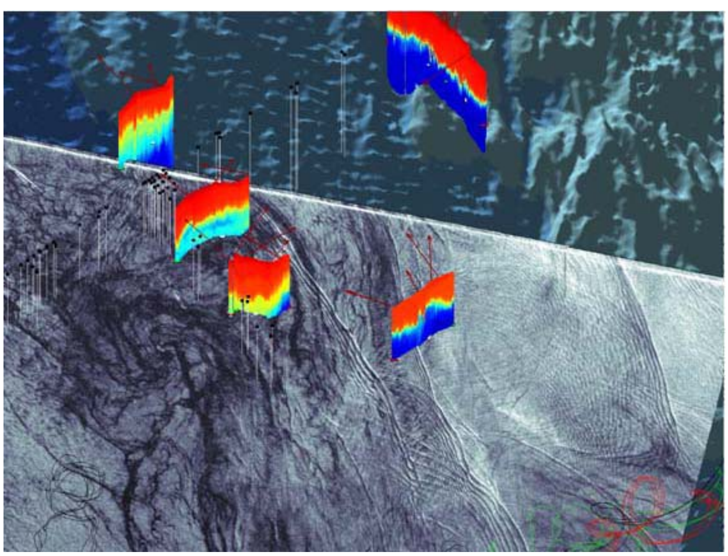

Figure 2: SAR imagery provided by U. Miami CSTARS inserted just below the thermocline in the 3D plot of the glider transects through the SW06 mooring array. The SAR data illustrates the ubiqutous nature of the internal waves, their predominantly circular shape over the Hudson Canyon, and their predominininantly linear shape through the array.Glider temperature data over 1 tidal cycled centered on the time of the SAR image illustrate the internal waves identified by the large and rapid vertical excursions of the thermocline.

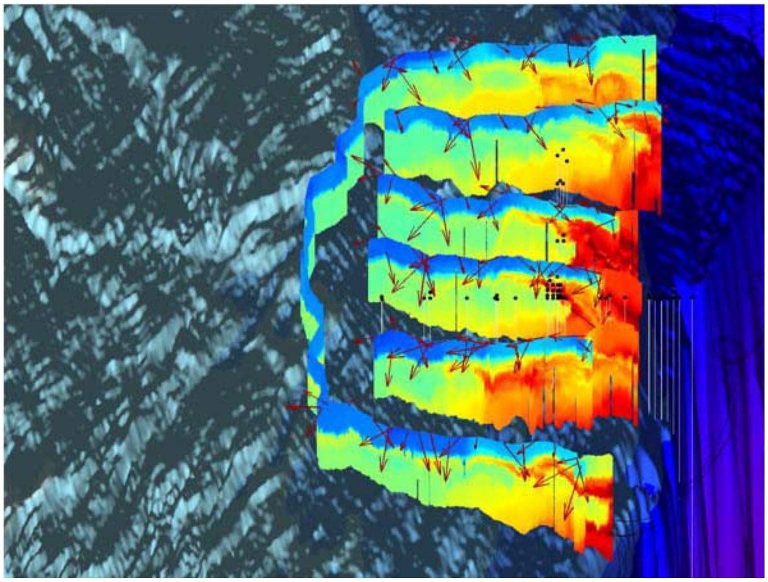

Figure 3: Glider CTD transects showing salinity data on the outward bound sweep through the SW06 array. The mid-depth high salinity intrusions are clearly visible.

IMPACT/APPLICATIONS

The New Jersey Shelf Coastal Observatory has already demonstrated its ability to provide a critical spatial and temporal context for multi-ship and mooring array based scientific process studies of the Hudson River plume on the inner shelf. Use of the same Coastal Observatory in the SW06 process studies on the outer shelf provides a similar context to help optimize the extensive ONR and academic investments while simultaneously presenting new challenges to the observatory. New challenges include spinning up and then sustaining a large coordinated fleet of gliders for unprecedented coverage of the outer NJ shelf for a duration over twice the typical battery life of an individual shallow glider mission, and providing environmental guidance to a distributed fleet of research vessels outside of shore-based computer communication networks. Meeting both of these challenges demonstrated that sustained glider and shipboard operations can be coordinated via satellite.

TRANSITIONS

The success of the gliders in a variety of the field exercises has stimulated plans for a large glider purchase for Naval operations by NAVOCEANO. A large purchase such as this will require significant training of support personnel. Plans to continue to help train NAVOCEANO glider pilots and technicians continue to evolve. The Littoral Battle Space Fusion and Integration program has funded Rutgers to help transition the Slocum CTD glider processing software to NAVOCEANO. The software includes the processing and formatting of the data to facilitate the data assimilation into operational Naval models. CTD data collected during SW06 were automatically transferred in KKYY format to NAVOCEANO via email in real-time for processing through the standard Navy procedures.

RELATED PROJECTS

One of the major advantages of the Webb Glider is that it provides a modular platform for ocean sensors. The development of an optical science bay that can support mine counter measures will thus be of great utility to evolving fleet of Naval gliders. Student projects during SW06 included installing a digital camera in a payload bay and towing an acoustic Bioprobe. A Rutgers Post-Doc project included the design of a 15 minute test mission that is run at the beginning of each deployment that then returns the engineering performance parameters necessary to automatically tune the response coefficients for flight control, and automatically send the tuned coefficients to the glider during its next surface interval.

The experience and the engineering efforts with the gliders will also directly benefit the ONR glider consortium. The effort will provide data, models, and improved glider operations that will directly benefit a recently funded Major University Research Initiative (MURI) which will develop a data assimilative physical-optical modeling-observation system consisting of an ensemble of optical models of varying complexity in order 1) to improve our predictive skill for forecasting ocean color and 2) improve physical models by using ocean color to discriminate hydrographic features not detected using traditional data streams. This MURI will study the regulation of ocean color for a broad western boundary continental shelf with a specific focus on regions of high optical variability (fronts), which coincide with regions of high acoustic uncertainty.