HICO Data User's Proposal

Resolving Complex Flow's in the Reef/Island Environment of the Republic of Palau

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Abstract/Project Summary
While reef/island areas have traditionally been difficult to sample, new platform and sensor technology afford the opportunity to systematically study the complex flows in and around these systems, and the influence of wind, waves, tides, bottom topography, bottom roughness, and internal waves on these processes. In an ongoing ONR project, the PI is applying new underwater observations from UUV's, current profilers, LIDAR and other tools to provide data for a new hydrodynamic model for the environment. The fine-scale flows will be resolved in conjunction with bottom mapping and characterization and time series measurements. Measurements in turn will serve to inform model parameters. Initial results have led to examining remote sensing products to assist in providing larger context and continuity in the modeling effort. Specifically, HICO data requested will be used to evaluate bottom type for roughness calculations, identifying fine-scale flow features by evaluating in water optical constituents, and comparing against in water optical measurements being made as part of the project.

1. Statement of Work/Project Description
Over the past two years in March, the PI has made a series of observational campaigns off the islands of Palau to define the flow and characterize bottom type in and around the reef/island environment. The project supported by ONR uses an existing set of REMUS UUV platforms and time series to measure at scales of O(1 hr) and O(10-100m). The fine-scale flows are being resolved in conjunction with bottom mapping and characterization and time series measurements. Optimal methods for executing surveys in regions of high currents and in regions of rapid changes in bottom relief (i.e. coral heads) are being developed. Surveys include both physical oceanographic measurements (velocity, temperature, salinity), optical measurements (i.e. particle tracking), and bottom surveys using imaging and sidescan sonar. The spatial mapping is being conducted with a set of REMUS UUVs. One of these systems is outfitted with radiometers for measurement of bottom reflectance, remote sensing reflectance, and water leaving radiance to evaluate small scale differences in bottom types in conjunction with sidescan sonar.
For time series measurements, ADCPs and self-contained water level (waves/tides) and temperature sensors have been deployed at regions around the island group to characterize the flows within the reef environment. Time series measurements have been nominally deployed on a 1 year turnaround cycle every March.
These spatial and temporal measurements are being used to develop and refine a DELFT-3D hydrodynamic model of the area to test the predictability of the flows, and use the model as a diagnosis tool for examining the influence of forcing terms (i.e. roughness) on the flow field. There are two research challenges related to the proposed model approach: 1) the evaluation of the existing applied circulation model with appropriated accounting for the range of flow phenomena associated with reef and reef lagoon and coastal systems, and 2) the adaptation of recent formulations in DELFT3D-FLOW for characterizing reef as roughness elements in an applied model.

The recent modifications to DEFLT3D-FLOW include a more advance treatment for bed roughness which can account for grain size distribution of bed sediment, bedforms and vegetation. A combination of these can be accounted for each computational cell. For an applied circulation model where lagoon and coastal water exchanges are to be examined, the computational cells will have lengths scales from 10-100 meters. Whereas the scale of a coral colony volume can be from 10^{-3} to 30 m^3 and reef boundary layers have length scales of 1 to 10 meters (Monismith, 2007). An important research question will be how to effectively incorporate coral reef features as roughness elements using the recent enhancement to DELFT3D-FLOW with the recognition that the coral reef features will likely be sub-grid scale. The DELFT-3D FLOW model grid has been rendered with bathymetry from the local hosts (Coral Reef Conservation Foundation) and augmented with LIDAR in particular areas with tides and wind as the input. Results from the ADCPs and temperature/pressure sensors will follow and as data become available, refinement of the model and improved define the grid spacing needed to approximate the measured flows in the field will be conducted.

To assist in this overall effort, HICO data is requested for the region around the Republic of Palau. The size of the main island group is comparable to the nominal target size of a HICO acquisition scene of 200km x 50km (see figure). The request is for HICO imagery of this area of Palau at a spatial resolution of 90 m and 87 channels (400-900nm). The area of specific interest are bounded by the following coordinates, with primary interest in the southern half of this box:

Northern Boundary – 8º 31N
Southern Boundary – 6 º 44N
Western Boundary – 134 º 3E
Eastern Boundary – 134 º 47E

HICO data will assist the ongoing project in a number of ways. First, the data will be used to identify bottom types. These will include sea grass, macro algae, coral, rubble, and the few muddy areas. Palau has one of the highest diversity in corals and sea grasses, with high complexity in coral distribution, islands, channels etc. The bottom types are particularly important for applying roughness calculations over the model domain. Bottom types identified by in situ observations made by the optical UUV will be used to identify similar HICO signatures in the domain. The second application will be to identify flow features near shore from river discharge and or from erosional processes. Observations have seen these flows through channels and over the outer reef atolls and the flow regimes will help inform the model of source types (river – high CDOM or erosion – high backscatter). The third anticipated use of the data is to use the in water measured AOPs and IOPs to compare with the reflectance data from the HICO imagery. We are presently in the process of evaluating an especially diverse area with 300 validated ground stations, WorldView-2, and the REMUS UUV reflectance, and hope to use HICO as a comparison database (lower spatial resolution but high spectral resolution).

It is hoped that this data can be collected concurrently with the ongoing field effort scheduled from 4-25 March, 2012 for the flow comparisons, but will welcome any data collected from the area.

2. Biographical sketch and available facilities

Initial training in optical oceanography and remote sensing began during graduate school when deployed bio-optical tools were used to model primary productivity in the Southern Ocean. In situ observations continued during a postdoc at Rutgers University which lead to the ONR HYCODE DRI. During this project, HIS remote sensing was used to characterize the coastal environment, specifically in water IOPs and phytoplankton community structure. During this period, AUV with optical payloads were developed to evaluate optical variability (in situ and remotely sensed) on small horizontal and vertical scales. This work has continued and is now being applied in the current ONR project on which this request is based.

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Education

1991-1996 Ph.D. Biology, University of California, Santa Barbara
1982-1987 B.A. Biology, St. Olaf College

Professional Appointments

2012-Pres. Director, School of Marine Science and Policy, University of Delaware
2007-2012 Professor, California Polytechnic State University
2004-2012 Director, Center for Coastal Marine Science
2003-2007 Associate Professor, California Polytechnic State University
2000-2004 Adjunct Professor, UC Santa Barbara
1998-2003 Assistant Professor, California Polytechnic State University
1996-1997 Postdoctoral Associate, Rutgers University

Awards and Honors

Fulbright Distinguished Arctic Chair, (2011); Senior Fellow, California Council on Science and Technology (2008); Distinguished Scholarship Award, Cal Poly State University (2007); Editors' Citation for Excellence in Refereeing, AGU (2005); Frontiers Scientist, NAS (2002); Earth Systems Scholar, NASA (2004); National Research Distinction Award, Cal Poly State University (2002); Presidential Early Career Award for Scientists and Engineers (2002); Young Investigator Award, ONR (2000); New Investigator Program Award, NASA (1999); DIALOG II Scientist, ONR/NSF/NOAA (1997); Graduate Dissertation Fellowship, UCSB (1995); Departmental Distinction, Biology, St. Olaf College (1987); Antarctic Service Medal, U.S. Navy (1986); National Sea Grant Fellow, University of Maryland (1985).

Remote Sensing and Radiative Transfer Related Publications

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In Situ Sampling

In situ sampling will include measurements for AOP's (spectral Rrs, Lw, Ed, Ru) and IOPs (spectral a, b, c). These will be made from stationary and mobile platforms.

Data Processing

Data processing of HICO imagery will be done using ENVI for classification of bottom types and in water constituents. Dr. Moline will conduct work in his laboratory at Cal Poly State U and U Delaware (after 7/1/12). Bottom maps will then be used in the DELFT-3D hydrodynamic model.

3. Output and deliverables

HICO data will help the performance of the primary goal of the ongoing ONR program, to improve flow characterization in reef/atoll environments. The product will be an improved functioning DELFT-3D model of the area with the ability to project results to similar habitats. Validation of HICO products will be attempted with in water observations. Attendance of the annual HICO team meeting will be done to present results and discuss HICO data and their uses and applications. It is estimated that 2-3 peer-reviewed papers will include or focus on HICO data sets.

4. References

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