Surface and Internal Wave Processes in the Coastal Zone of an Atoll Island

Mark A. Merrifield
University of Hawaii
1000 Pope Road, MSB 317
Honolulu, HI 96822
phone: (808) 956-6161 fax: (808) 956-2352 email: markm@soest.hawaii.edu

Award Number: N00014-14-1-0146
http://www.soest.hawaii.edu/oceanography/faculty/merrifield.html

LONG-TERM GOALS

To understand processes impacting circulation in the vicinity of a Pacific atoll and to improve prediction capabilities based on model-data comparisons.

OBJECTIVES

In situ observations have been proposed to examine the following processes:

- Breaking surface waves are expected to be the main driver of coastal circulation around an atoll island out to some distance from the coast that remains to be specified. We seek detailed descriptions of radiation stress gradients and topographic controls on wave-driven flows;

- Cross-shore exchange between the island coastal zone and the deep ocean likely is amplified where wave-driven currents are redirected offshore at topographic features such as channels and points. Assessments of three-dimensional wave setup and associated pressure gradients are needed to assess and predict these pathways;

- Locally generated internal tides are expected to provide a continuous source of energy for the coastal boundary layer with the majority of energy radiating away from the atoll. Remotely generated internal tides likely provide an additional source of incoherent internal tide energy. Observations are required to understand enhanced tidal mixing and tidally driven exchange around the islands.

APPROACH

Our initial work plan called for a focus on surface and internal wave processes in the coastal zone of an atoll. We include here the approach based on that plan; however, we appreciate that the project scope may change considerably as described in the following paragraph and we emphasize that our field program will adapt as necessary. The initial plan called for current meter mooring and bottom-mounted sensor deployments at representative locations around the island. The primary component of the surface wave experiment will be 3 to 4 transects of wave and water level recorders and Aquadopp acoustic current profilers spaced along the shoreline, with sensors placed across surf zones and down fore reef slopes out to diver depths. Each instrumented transect will include a Nortek AWAC and SBE26plus pressure sensor, which will allow us to specify the directional wave spectrum of the incident sea and swell adjacent to the reef, the fraction of incident wave energy that is reflected at the steep reef face, and the offshore water level, which we will reference to in the calculation of setup. Additional instrumentation will be added for the purpose of mapping internal tide energy across the inner shelf. At the 100-m isobath, an upward-looking 300 kHz ADCP and a SBE56 thermistor string will used to capture high frequency internal waves that are present. All the Aquadopp sensors used for estimating low frequency wave-driven circulations will serve the dual purpose of providing coverage of internal tide related currents. The thermal structure of the internal tide will be sampled as well with 30 additional SBE56 sensors that will be distributed throughout the inner shelf array using gravity mounts at diver depths, and pods with acoustic releases at deeper depths. The thermistors will be deployed individually at the bottom, or in short thermistor strings to capture the vertical structure of the internal tide at different locations shoreward of the main ADCP/thermistor string site.

The final site selection is still under consideration and will be finalized after consultation with the program manager and other principal investigators involved in the larger program. Based on preliminary feedback, it appears that the scope of our project is likely to expand to include deeper flow-topography interactions, such as the impact of ridges on mesoscale and low frequency regional currents and perhaps lee effects around an island obstacle. It is likely that we will change our focus from shallow circulation to deeper flows, and hence deep moorings installed by our group will be used in combination with gliders, shipboard surveys, and regional models provided by other investigators to estimate flow interactions with ridge and/or island topography.

The deep ocean mooring components will include 75 kHz and 300 kHz ADCPs, McLane Moored Profilers (MMPs), and an assortment of SeaBird temperature and conductivity recorders. For a two-dimensional ridge feature, we plan on mooring deployments on either flank and over the crest of the ridge. At least two six-month long deployments are expected, with sampling set to span finescale to mesoscale variability.

WORK COMPLETED

The project is just underway and we are in the early stages of instrument preparation. The shallow sensors are available and can be deployed quickly with available resources on Palau or Guam. The deep moorings require more time for fabrication and the availability of a ship with adequate infrastructure. We are targeting the summer of 2015 as the earliest deployment date for these moorings. In addition to instrument preparation, we also are gathering existing numerical model simulations for the region to assist in site selection. We are especially interested in how shallow ridge topography impacts upper ocean mesoscale circulation and lower frequency currents in the model runs, and whether these sites are important for internal tide generation and/or scattering.

RESULTS

At this early stage of the project, we do not have significant results to report at this time.

IMPACT/APPLICATIONS

Likewise, we have not reached the stage where impacts and applications can be reported.