Coastal Wave Studies

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LONG-TERM GOALS

Our long-term goal is to make significant advances to coastal and nearshore wave modeling through improved understanding of coastal and nearshore wave transformation processes.

OBJECTIVES

The objectives of this study are to

1. Make high-fidelity measurments of wave transformation processes in the nearshore and coastal zones. Provide high-quality test cases for model development and evaluation

2. Contribute to the improvement of WaveWatch III and SWAN through the integration of a state-of-the-art wave partitioning and swell system tracking technology

3. Develop and apply robust wave model assessment technology for community use (USACE in-kind support)

APPROACH

Wave observations.

USACE has developed, implemented and maintained a cross-shelf array of meteorological, directional wave and vertical current sensors suitable for capturing all phases of wave transformation across the continental shelf and through the nearshore zone. The nearshore array configuration is depicted in

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Figure 1. As data are collected, we are extracting a variety of events (pure wind sea, pure swell, mixed seas, etc) to use as model development test cases.

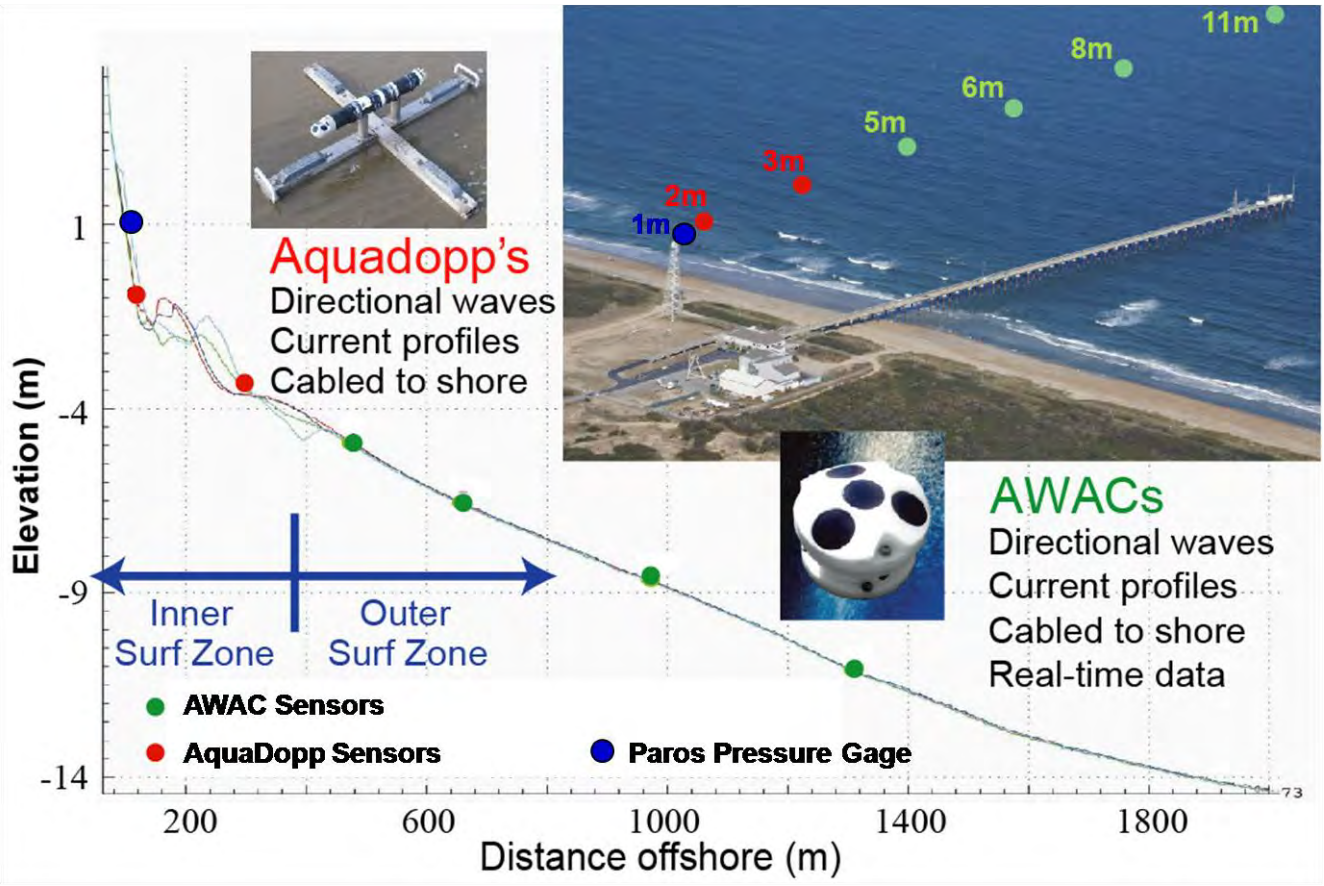

Figure 1. USACE FRF Nearshore wave and current array in Duck, NC. Scanning beach laser and offshore wave buoys not shown.

Model Improvements

USACE-FRF is working with WaveWatch III and SWAN developers at NOAA NCEP to implement (1) a wave partitioning capability in SWAN similar to what we previously provided for WaveWatch III, and (2) a spatial tracking capability that can be used in both models to track the space-time evolution of coherent wave systems in the model output. Once tested the resulting improvements are to be released as operational code.

Model validation.

USACE has developed the Interactive Model Evaluation and Diagnostics System (IMEDS) as a prototype GUI-driven toolbox to assess coastal process model performance using a variety of temporal and spatial metrics Hanson et al. (2009). As a diagnostic tool, IMEDS can ber used to explore model errors and performance as a function of many variables (station, time, components, etc). Our approach is to transition the prototype IMEDS system into a robust model evaluation tool kit for community use.

IMEDS will be split into 2 main components:

1. IMEDS desktop tool

2. IMEDS function library (MATLAB toolbox)

This phase of work focuses on improving existing capabilities (winds, waves, water levels and high water marks) and implementation of the IMEDS function library and the IMEDS Desktop tool. The system will be designed in such a way that follow-on work, including a virtual on-line tool (VMEDS) and addition of new parameters (currents, tides, beach profiles) can eventually be integrated into the architecture. To facilitate this development, USACE is providing in-kind support in the amount of $100,000 during FY11-12.

WORK COMPLETED

The major technical accomplishments for 2011 include:

Wave observations

- Maintaining the Duck cross-shore wave and current array in operational status
- Adding a new pressure gage (1-m depth) and scanning beach laser to the array
- Processing and posting data from 11 distinctive cross-shore wave events to the NOPP validation data archive
- Collecting a complete data set from Hurricane Irene

Model Improvements

- Delivered wave partitioning and spatial/temporal wave system tracking source code to NOAA NCEP for integration into WAVEWATCH III / SWAN
- Developed spatial/temporal wave system simulator for testing code performance
- Generated and delivered (to NOAA/NCEP) a variety of spatial/temporal wave system test cases for code evaluation

Model validation

- Completed and tested a prototype user interface for IMEDS
- Developed a scope of work for transitioning IMEDS to a robust tool for the scientific community
- Secured funds for executing the scope of work during FY12 (USACE in-kind support).

RESULTS

Wave observations

As indicated above, a set of unique cross-shore wave events have been processed and provided to the Waves NOPP validation data archive at NCEP. Care was taken to select events with a clear, distinctive wave signature ranging from pure wind sea events to pure swell events and including both offshore and onshore wind events. Table 1 provides a simmary of these events. Note that peak significant wave heights range from 0.7-5.2 m with peak wave periods ranging frm 3-17.3 s. Event data includes meteorological forcing, waves (spectra and time series), current profiles, tides, and sea surface temperature. Furthermore, supporting bathymetry survey data and Argus imagery are available for download from the FRF web site (http://frf.usace.army.mil/).

Table 1. NOPP Wave Events from the USACE-FRF Cross-Shore Wave and Current Array

				Winds		Waves		
Event	Type	Start	Stop	U10 (m/s)	Deg N	Hs (m)	Tp (s)	Description
E1	Hurricane Earl	2010090205	2010090323	24.0	4.0	4.5	8.5/15	Mixed sea and swell
E2	Hurricane Bill	2009082100	2009082323	4.0	326.0	3.6	17.3	Swell with harmonics; highly nonlinear
E3	Noreaster Ida	2009111112	2009111623	14.9	48.0	5.2	12.9	Wind sea event
E4	Noreaster	2008101800	2008102123	16.5	24.0	3.7	9-12 s	Wind sea event
E5	Noreaster	2008092300	2008092712	18.2	69.9	4.9	12.5	Wind sea event
E7	Swell	2009032600	2009032723	6.6	189.0	3.1	15.2	Swell, steady
E8	Swell	2009082715	2009083023	5.0	variable	1.6	8-14	Swell, light winds
E8	Swell	2010082912	2010083023	1.2	167.0	1.9	13.7	Swell
E9	Windsea	2009121900	2009122017	12.0	ENE	4.3	10-11	Wind sea event, shore parallel
E10	Tropical Storm Hanna	2008090420	2008090623	13.5	SE	2.8	7-12.5	Developing windsea over swell
E11	Fetch Limited windsea	2010022600	2010022623	12.0	W	0.7	3.0	Offshore winds, small opposing swell

In addition to the events in Table 1, a data set from Hurricane Irene (August 2011) is currently in preparation. Preliminary cross-shore wave data from this major hurricane appear in Figure 2. The lower panel provides the significant wave height time series at 8 array stations including the offshore NDBC Virginia Beach Buoy 44014 (which is in line with the array). The upper left panel provides an overplot of the storm-peak energy-frequency spectra from each of these stations, and the upper right panel shows the transformation of total wave energy across the array at the storm peak. As the eye of Irene nearly passed over the FRF, the winds shifted from onshore to offshore around the time of the peak wave conditions. The wave field leading up to the peak of the event was primarily wind-sea dominated. For the second half of this event, the offshore winds resulted in a strongly forced fetch-limited wind sea with an opposing swell.

IMPACT/APPLICATIONS

Due to the long-term operation of the Duck cross-shelf array (since late 2008), a variety of unique events, such as Hurricane Irene, have been collected. The resulting set of events is providing nearshore wave modelers with a rich set of information to improve numerical wave model source term performance in the challenging coastal environment.

RELATED PROJECTS

USACE Wave Information Studies (providing in-kind support for IMEDS)

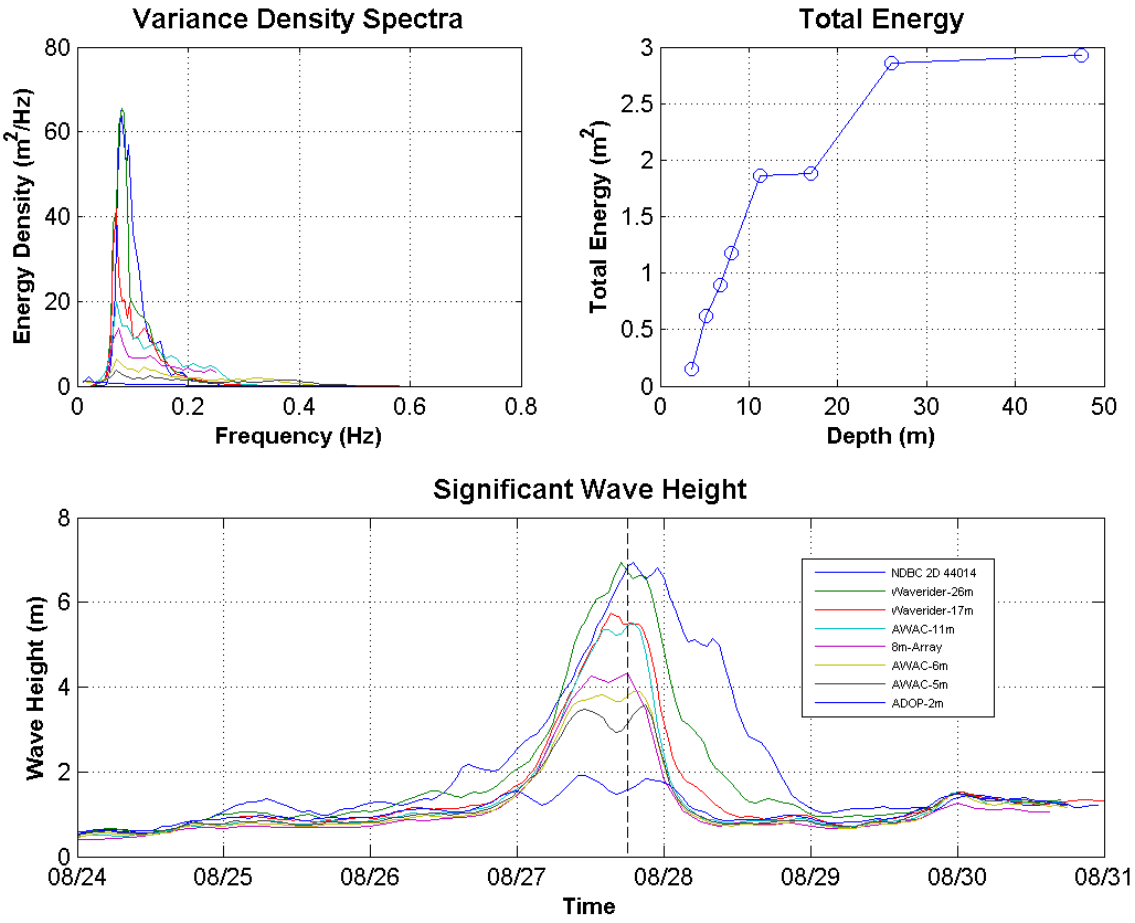

Figure 2. FRF cross-shore array preliminary wave data from Hurricane Irene (August 2011). See text for explaination

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