Evolution of the Directional Properties of Surface Waves Propagating across the Shelf

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LONG-TERM GOAL

The long-term goals of this project is a better understanding of the evolution and interactions of the directional wave spectrum in the presence of surface currents and over shoaling bathymetry and how these interactions govern the spatial and temporal evolution of surface waves in finite depth water.

SCIENTIFIC OBJECTIVES

The specific scientific objectives of this study are:

a) To examine the space/time variability of the directional properties of surface waves in the coastal ocean. Especially time-frequency behavior to gain further insight into the forcing processes of ocean waves on the shelf.

b) To study the evolution of the directional wave spectrum as the waves shoal and refract and interact with currents.

c) To determine the response of the directional spectrum to surface current shears and variable bottom bathymetry.

d) To directly compare HF radar wave observations with multiple in-situ wave measurements, thereby establishing the statistical differences between the techniques over a range of wind, current and wave conditions.

e) To explore techniques similar in scatterometry to extract the marine surface wind vectors.

APPROACH

An extensive field program, SHOWEX (Shoaling Waves Experiment) was carried out to study the spectral balance of shoaling ocean waves in September – December 1999. Three air-sea interaction spar (ASIS) buoys were deployed at the inner and outer shelf off Duck, NC and acquired continuous timeseries of directional wave spectra using a nested wave wire gauge array, observations of meteorological variables and near-surface oceanographic variables. An HF Doppler radar system measured surface vector currents maps over most of the domain including the ASIS buoys and directional waveriders from other investigators. Raw data was also collected to estimate directly: 1) the directional wave properties and 2) marine surface wind vectors over the domain at high spatial and temporal resolution. Combining the surface current measurements with the spectral wave data from the HF radar and the buoys will be used to study the intensity and variability of wave-current interactions. Combining the spectral wave data from the HF radar and the buoys and the high-resolution bathymetric data will allow to study the variability of wave transformation due to small-scale variations in the bottom topography over the inner shelf. The estimates of the marine surface wind vectors from the radar data will provide high-resolution winds fields for local applications of numerical wave models and comparisons with airborne wind measurements.

Data processing of the HF radar data is completed. Vector surface current maps including data quality checks were processed at the University of Miami and Doppler spectral data was produced at Sheffield University in collaboration with Dr. Lucy Wyatt to generate directional wave spectra.

WORK COMPLETED

1. Successful collection and archiving of more than 25 days of colocated raw (I and Q) data that can be post-processed for extraction of directional wave spectra.

2. All surface current vector fields have been processed and quality controlled.

3. Preliminary results for near-surface wind vectors obtained.

4. Estimates of waveheight using simple methods are calculated.

RESULTS

Figure 1 shows the significant waveheight distribution derived from HF radar Doppler spectra over the nearshore SHOWEX domain on 7 November 1999 at 0545 UTC. Arrows represent the mean wave directions. Examples of the directional wave spectra are also displayed for a nearshore, mid and offshore location of the radar domain. The spectra show a swell system traveling towards the coast, while a windsea is developing offshore. The waveheights are generally small about 0.7 m. At the time the winds were blowing at 8.5 m/s from the northwest, but rapidly turning to the north and increasing to 12 m/s. This shift in wind direction and strengthening in speed is quite evident in Figure 2 which shows most of the waves offshore propagating south , while nearshore the waves refract and bend towards the coast. Now the waveheights increased to about 1.5 m and only one dominant wave system is propagating towards the coast.

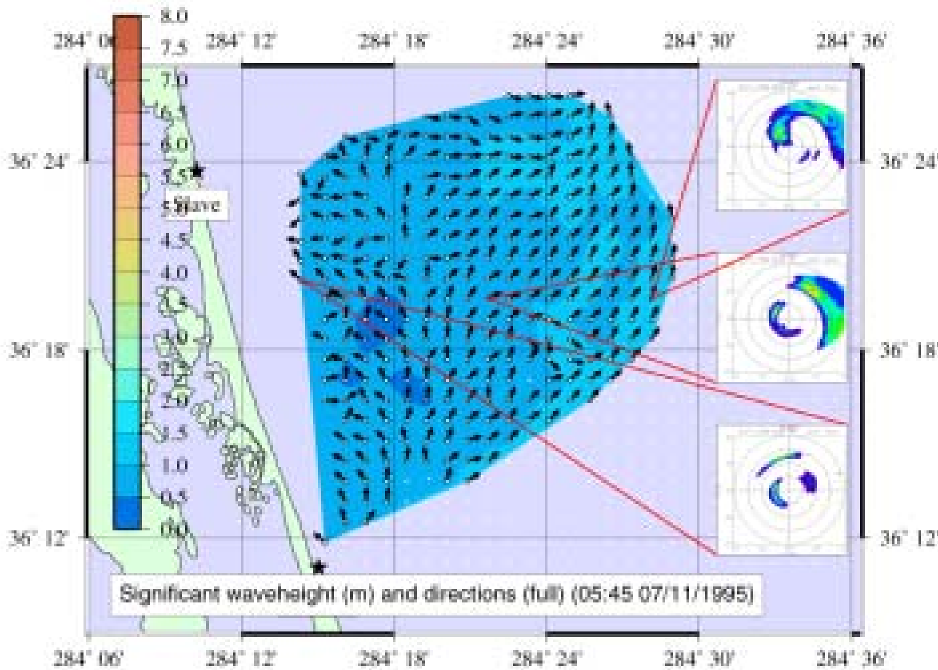

Figure 1: Waveheight map and mean wave directions derived from the HF radar measurements for 7 November 1999 at 0545 UTC during SHOWEX. Note the year for radar system was changed because of Y2K incompatibilities.

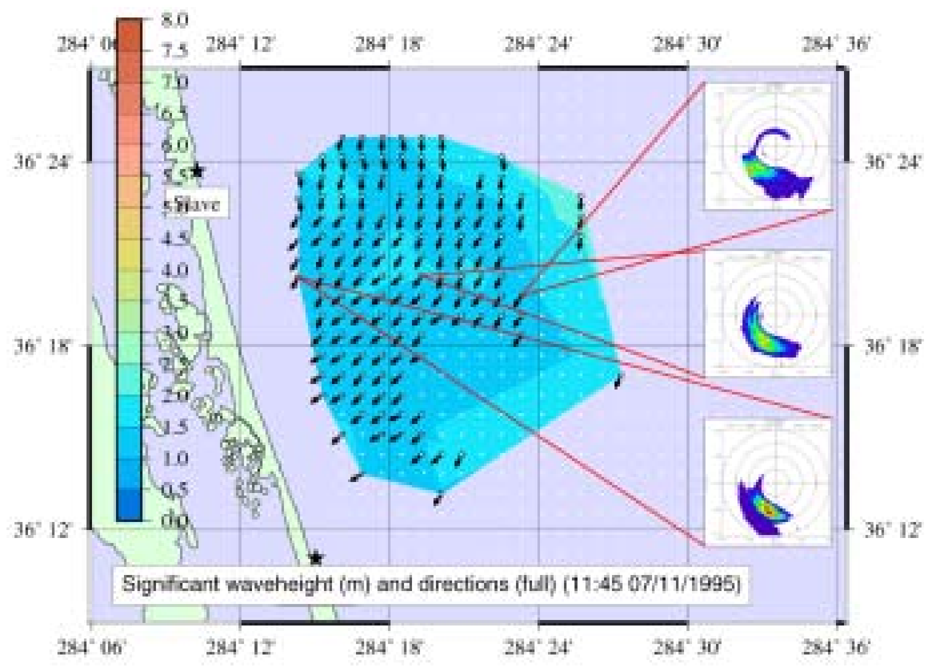

Figure 2: Waveheight map and mean wave directions derived from the HF radar measurements for 7 November 1999 at 1145 UTC during SHOWEX. Note the year for radar system was changed because of Y2K incompatibilities.

IMPACT/APPLICATION

We expect that the results of this study would considerably enhance the goals of SHOWEX, particularly in better understanding of the spatial/temporal evolution of the directional wave spectrum. Also we anticipate that the data set would provide a unique testbed for numerical modelers to test a range of different physics (shoaling, refraction, wave-current interaction) in their models and to validate wind-wave and swell models in the coastal ocean.

TRANSITIONS

None yet.

RELATED PROJECTS

Two projects are planned utilizing these results for: 1) better suppression of sea clutter during moderate sea states and 2) for providing integrated wind, sea state and current information for battle space environments.