NEARSHORE WAVE-TOPOGRAPHY INTERACTIONS

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LONG-TERM GOAL

The long-term goal of nearshore processes research is to develop a predictive understanding of the fluid dynamics of a random wave field over the shoaling bathymetry of a beach and the response of the beach to those overlying wave and current motions.

SCIENTIFIC OBJECTIVES

The principal focus of this program has been on understanding the nearshore problem from a top down point of view. At time scales longer than storm periods and length scales larger than 100 meters, the behavior of the nearshore appears surprisingly complex, with subtantial interannual variability and variability on all scales. We believe that this results from feedback between the fluid and bathymetric components of the system and that the coupled problem represents a nonlinear dynamical system whose phenomenology arises more from robust aspects of the feedback than from details of the various processes.

APPROACH

Our principal approach has been to collect long, quantitative time series of system behavior using a variety of video-based measurements. Time exposure images, best for locating the shoreline and submerged sand bars, have been collected from Duck, NC, for 11 years, while six other sites have been measured for periods ranging from 5 years to 6 months (the most recent installation). Comparison of system behavior from sites with these widely varying wave climates and geology should help constrain nearshore models.

We have also developed a suite of techniques to allow extraction of wave period, direction and celerity. From celerity, depth may be estimated. Measurement of foam streaks can be used to estimate longshore currents.

Finally, we have been exploring the use of long time series of high precision survey data to quantify net sediment transport for two sites.

WORK COMPLETED

The Argus program of remote video measurements has expanded to 7 sites with the recent installation of stations on a very active intermediate beach (Palm Beach, Australia) and a macro-tidal dissipative beach (Perranporth, England). Comparisons among the sites has been begun, based on the several existing morphodynamic classification schemes. Alternate beach descriptors such as fractal dimension

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or a thermo-dynamic equivalent are being investigated. We have also begun the routine collection of variance images and pixel time series from Argus stations.

A very exciting advance has been the upgrade of Argus technology from the old PC based-machines to a new SGI Unix workstation platform.This brings a several order of magnitude improvement in power and capability. Figure 1, an example image from the SandyDuck experiment, shows the capability of the new stations to merge five different views into a panorama (bottom) or into a rectified map view (top). This seamless handling of multiple cameras allows tremendous flexibility in collection of a wide range of imagery. For example, time series of pixel intensity can be collected over cross-shore arrays and wave celerity estimated. From these, water depth can be estimated based on shallow water celerity (figure 2).

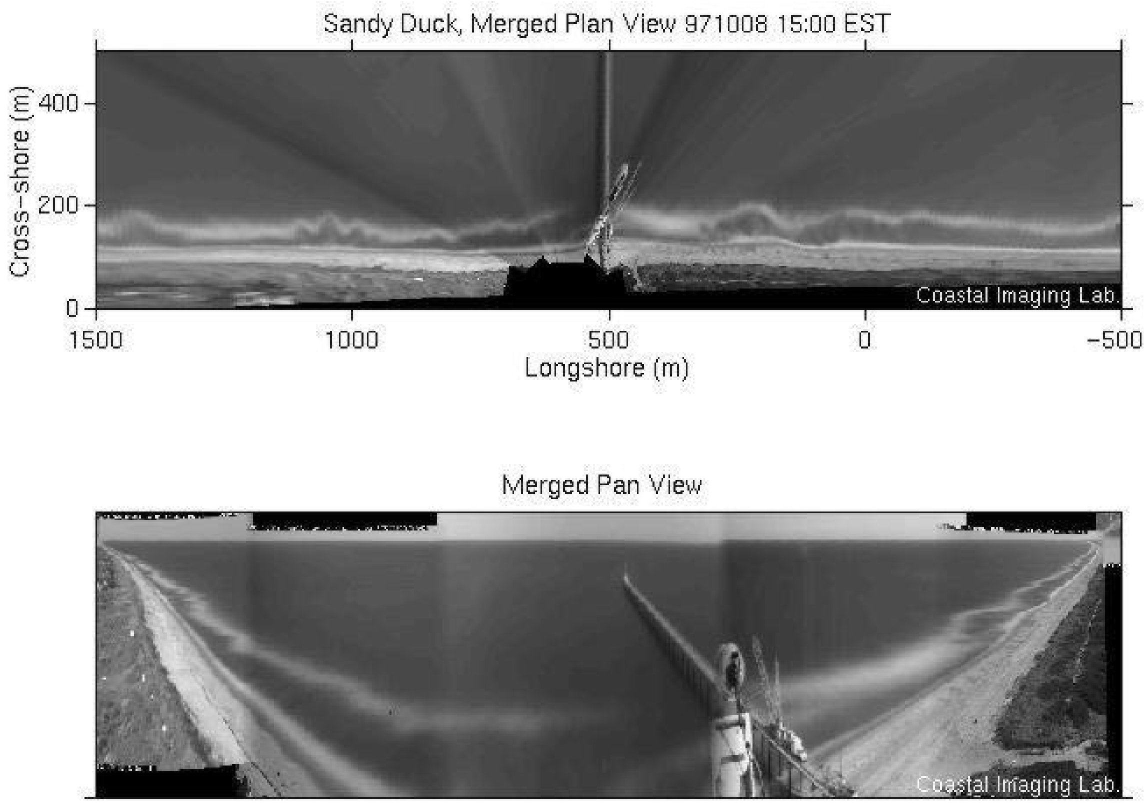

Figure 1. Example merged time expoure images from the Sandy Duck field experiment. The bottom panel shows a 180 degree panorama constructed from five cameras (distinguishable from the bands of darkness). The pier is obvious as well as a camera housing that slightly obsructs the view to the southeast. The narrow white band just offshore represents the region of preferential wave breaking over the submerged sand bar. The upper panel shows a rectified plan view computed from the lower pan using standard photogrammetric procedures. The bar shows variability on many scales. At y=1000, a set of three or more rip channels has incised the bar crest. At y=250, a set of oblique bathymetric features run between the bar and the shoreline. These latter features have been ground-truthed using a new jet-ski sounding system.

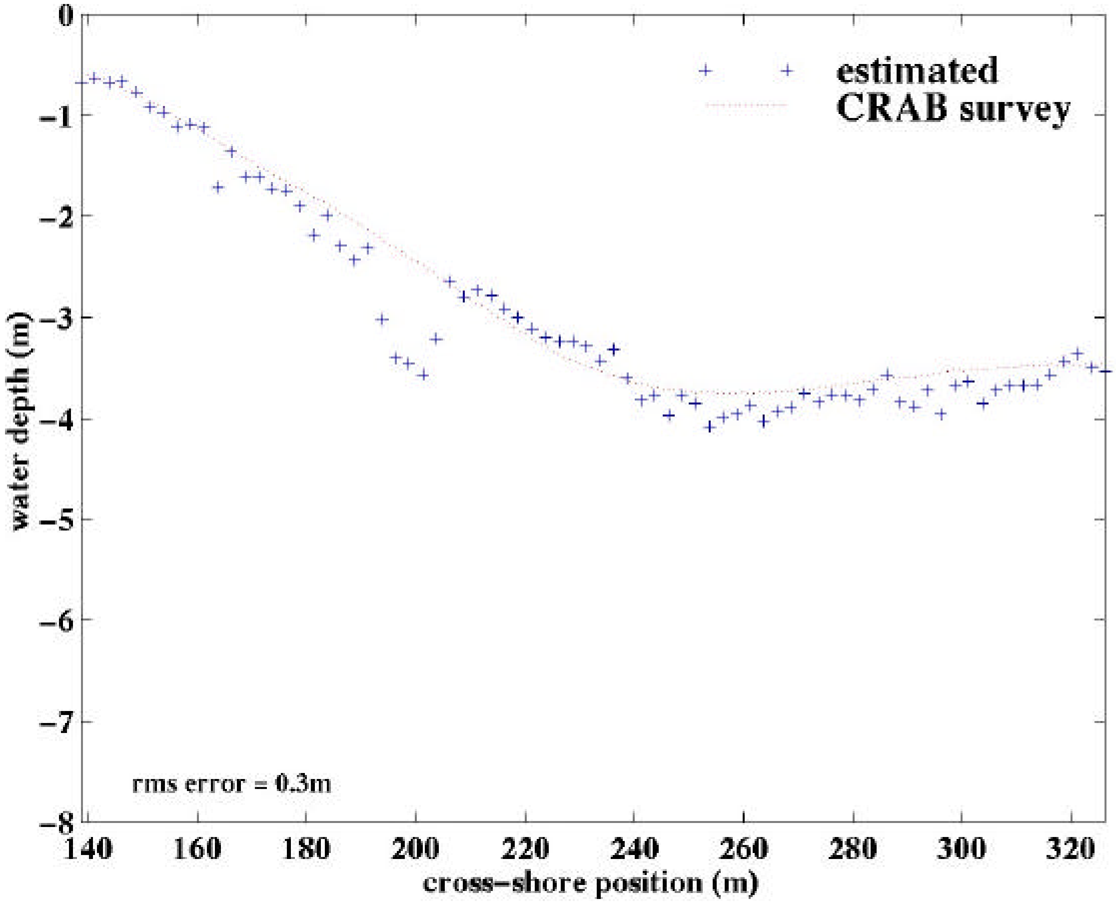

Figure 2. Comparison of remotely-estimated bathymetry with ground-truth depth measurements made by the CRAB on 10/24/97 during the SandyDuck field experiment (y=742m). The remote sensing approach, developed by Hilary Stockdon for her MS thesis, is based on video measurements of wave celerity. These are then inverted for bathymetry using linear wave theory. Wave height and period were 0.43 m and 10.2 sec, respectively. Video results are based on 17 minutes of data and are collected hourly for each CRAB line.

At the time of writing, we are just finishing the data collection phase of the SandyDuck field experiment. One component of this work has involved extensive ground truth testing of several remote sensing techniques including the depth estimation algorithm mentioned above, approaches for the estimation of wave period and angle, and of longshore current. Analysis of these results will continue in the future. Data have also been collected on the behavior of the nearshore system throughout the experiment. Valuable in its own right, these image data also provide useful support information for the overall SandyDuck field experiment as well as fitting in to the long time series of Argus imagery from Duck.

RESULTS

Examination of nearshore system behavior over time period greater than one year demonstrated the tremendous amount of variability that exists on interannual time scales. Data from both the long term CRAB surveys and from the Argus video results show that well more than half of the natural variability of the system is interannual and that phenomenology exists that is certainly not incorporated in models.

We believe that the ultimate explanation of this behavior will be tied to nonlinear dynamical aspects of fluid-topography feedback and that top-down modelling will be very useful and informative. At shorter time and space we have been overwhelmed by a range of unusual behavior.

Should the above be true, then there is a clear requirement for the collection of long time series of important variables from a range of sites. We have continued to develop remote sensing capabilities for these measurements that will provide increasingly useful information as record lengths increase.

IMPACT/APPLICATION

Video remote sensing has become an increasing valuable tool. In large focus experiments such as SandyDuck, video provides a larger-scale context for in-situ sampling as well as unique measurements of variability at a number of scales that are not sampled by the CRAB or other instruments. In times of no focus experiment, video continues to collect data on variability on large time and space scales and over a range of different sites (different regions in the relevant parameter space).

The weight of results from these data and from the careful analysis of Duck bathymetry records collected over 17 years show strong interannual variability of an, as yet, unexplained nature. This suggests that future focus efforts such as the SandyDuck field experiment should always be augmented with a suite of long-term measurements.

TRANSITIONS

The video techniques developed in this program have beened passed to NRL through Dr. Todd Holland and to the US Army through Kent Hathaway of the Army Corps. Within the navy, these approaches have been tested during excercises Foal Eagle and the 1997 ACTD. Data collected as part of this program are routinely integrated into navy metoc reports and appear on SIPRNET. Several of the techniques, particularly that for the remote estimation of bathymetry are of great interest to the navy and have lead to substantial interactions of the PI with NRL and NAVOCEANO.

RELATED PROJECTS

1. Joint work with Dr. Todd Holland, NRL-Stennis
2. Bathymetry IPT, with NAVOCEANO, NRL
3. LRS program collaboration
4. SandyDuck field experiment
5. NICOP joint program with several European groups.
6. NICOP joint program with Graham Symonds of Australia
7. Miscellaneous other involvements too unusual to mention

http://cil-www.oce.orst.edu:8080. Coastal Imaging Lab home page
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