Nearshore Wave-Topography Interactions

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LONG-TERM GOAL

My long term goal is to develop a predictive understanding of the fluid dynamics of a random wave field shoaling over the complicated bathymetry of a natural beach, and the response of the beach to those overlying wave and current motions. Success requires improvements in understanding and modeling as well the development of innovative methods for collecting measurements needed to seed those models.

OBJECTIVES

Over the last decade, our scientific focus has been on the development and implementation of an extensive, robust sampling capability for nearshore processes (the Argus Program) and documentation of the plethora of new phenomenology that were observed. Our current work sees a re-focussing on understanding the physics of electro-optical imaging. We wish to develop a physics-based model for the Modulation Transfer Function (MTF) relating optical radiance to underlying geophysical variables. Thus, observations will shift from a basis in contrast (for waves) and morphology (patterns of sand) to actual time series of sea surface elevation and bathymetry. This work includes both optical processes outside the surf zone where radiance is based on Fresnel reflection from a sloping and wavey sea surface as well as radiance for breaking-induced foam. Results are then applied to a range of nearshore phenomena.

APPROACH

Our approach has been to develop a sampling strategy based around optical remote sensing through the Argus Program. This involves two phases. First is the development and ground-truth testing of techniques for the estimation of a variety of important geophysical variables. Ground truth data is primarily from the SandyDuck data set, collected in 1997. The second phase is application of these collection techniques to the 10 Argus stations around the world and examination of the sampled dynamics.

In addition, the Coastal Imaging Lab carries out a regular GPS survey program at our home site at Agate Beach, Oregon. This involves monthly surveys of a 3 km stretch of beach at spring low tide. This provides not only an excellent data set in its own right, but also provides ground truth data for the local Argus station.

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14. ABSTRACT
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WORK COMPLETED

Argus sampling has traditionally focussed on image-based data collection aimed at the extraction of bathymetry or morphology metrics, particularly shoreline and sand bar locations. Some research had been done on methods for the estimation of fluid variables but these were not production techniques.

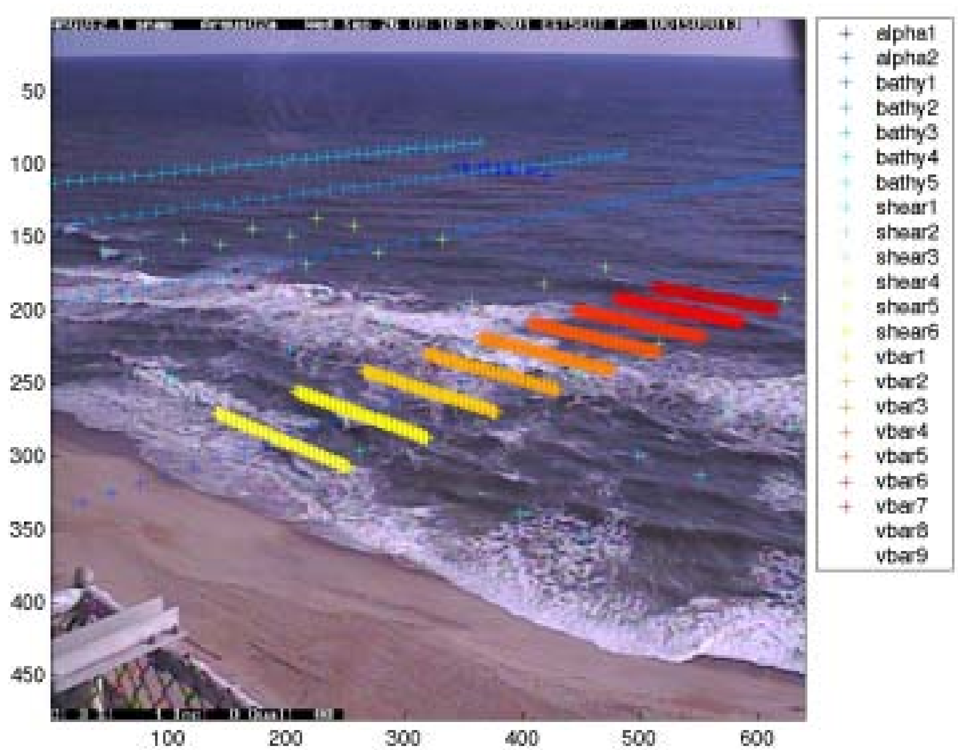

Figure 1. Duck, NC
[Snapshot of the Duck surf zone overlain with pixel locations for which time series are routinely collected. The four type of instruments (alpha for wave angle, bathy for depth, vbar for longshore current and shear for shear wave cross-shore flows) are indicated in the legend]

Over the last year, we have institutionalized the concepts of fluid variable sampling through the introduction of pixel instruments. These are arrays of pixels, in configurations that vary with application, at which time series of optical radiance are recorded. Figure 1 shows an example collection strategy, with four types of instruments being simultaneously collected. Most obvious are eight longshore lines of pixels, labeled vbar1 to vbar8, designed to allow estimation of the cross-shore profile of time-varying longshore current. Seventeen-minute time series (2 Hz.) are collected hourly from each pixel in each of these instruments.

Figure 2 shows an example result, with time on the vertical axis and y-scale of the stack across the page. Each instrument is 30 m long (see y-scale axis) with the eight stacks spanning from 25 to 200 m from the shoreline (25 m cross-shore spacing; Figure 1). An image of pixel intensity versus distance and time is called a time stack. The eight stacks have been placed contiguously to allow visual comparison of the foam streak pattern.

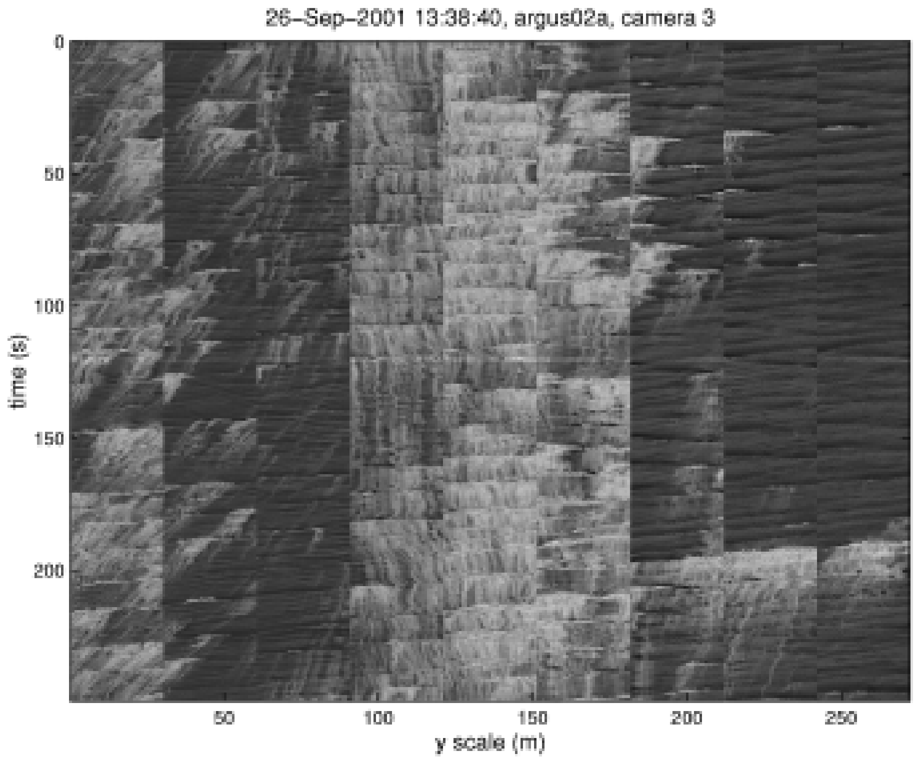

Figure 2. Time stack of longshore currents
[Nine sub-stacks are shown across the page. The angle of foam streaks is used to estimate the strength of the longshore current. The current is weak to northerly over the three center sub-stacks over the sand bar, but southerly adjacent to the bar.]

Streaks in the stack result from the longshore advection of foam and bubbles left in the water after passage of a breaking wave. The slope of the streaks is a measure of the rate of change of longshore location with time, so can be used to estimate the strength of the longshore current. Vertical streaks change longshore position only slowly (slow currents), while oblique streaks are changing longshore location rapidly and correspond to faster currents.   It is apparent from Figure 2 that the currents close to the shore are moving rapidly to the south while the water velocity over the sand bar (increased breaking signatures) is moving very slowly, if at all, to the north. Offshore of the bar, the few breaking waves present indicate southward flow.

From the time stacks for each vbar instrument, time series of currents are computed based on a 16 second window with 50% overlap. Figure 3 shows the mean current as a function of cross-shore location based on the 17 minute means from each stack. Curiously, there appears to be only a slight northward current over the bar, while the current in the trough and offshore of the bar is southward.

The statistics of such sheared flows and of the low-frequency shear wave energy in these regimes is currently under investigation.

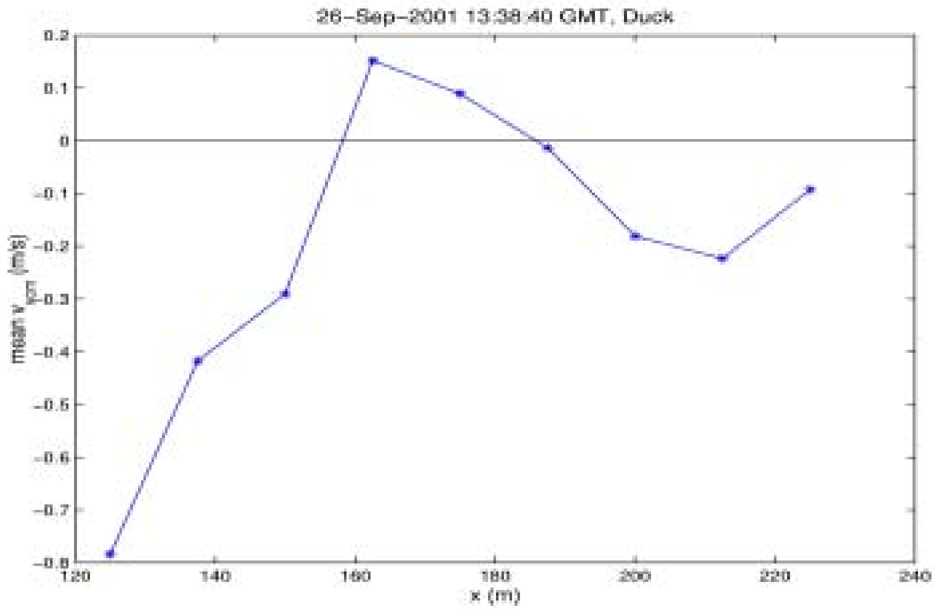

Figure 3. Cross-shore profile of mean longshore current
[Consistent with the time stacks in Figure 2, the mean current is weakly to the north over the bar crest, but southerly away from the bar. This current reaches 80 cm/s to the south near the swash zone at x = 125 m]

An intercomparitive study of the statistical morphodynamics of four of the Argus beaches has now been completed and formed the basis for the MSc thesis of Soupy Alexander (Alexander 2001). A set of relevant statistical measures of nearshore variability were tested and the techniques applied to four beaches ranging from very dissipative to moderately reflective regimes. Bar scaling was found to depend on both wave height and beach steepness. Longshore variability appeared statistically to average 15-18% of the cross-shore bar distance over all sites and the wide range of associated wave conditions. Some variation of the ratio of interannual to sub-annual variance was found among the sites, although no systematic dependence on Iribarren Number was found.

A study was also complete of the inter-annual variability of the sub-aerial beach at Agate Beach, Oregon, a dissipative end-member among the Argus sites. Wave heights were found to have steadily increased over the five-year study period and to have swung steadily to the south. The combination has driven increased volumes of sand to the northern terminus of the beach, against Yaquina Head. In addition, two natural modes of variability were found; a lower level beach response to stormy waves and swash and a higher level (in the vertical) aeolian dune response. The division between the two modes occurs at approximately mean high water.

IMPACT/APPLICATION

The development of robust pixel instruments has opened doors to a rich set of data. We are beginning to seem the complexity of natural current systems, with strong shears across sand bars, including flow revearsals. The consequences to shear waves is being investigated.

The study of morphometric variability among four diverse Argus sites is beginning to shed light on universal scalings. Bar distance is a function of both wave height and beach slope. Longshore variability appears to be rather robust among sites, averaging 15-18% of the cross-shore bar distance. The relative importance of interannual variability varies from site to site, but not in a way that we can yet explain.

Work on Agate Beach has helped shed light on the issue of forced versus free energy sources for Large Scale Coastal Behavior (LSCB, the multi-year, large scale response of natural coastlines). For this case, the response over a five-seven year period is clearly forced.

TRANSITIONS

Argus technology has been embraced by NRL-SSC in a program run by Dr. Todd Holland. We continue to have strong collaboration with his group, including cooperative work associated with the VISSER station at Camp Pendleton. We continue collaboration with the U.S. Army Corps of Engineers both through Bill Curtis at Vicksburg and through the FRF on a variety of Argus issues. Skills and ideas in handling EO data developed due to Argus interest have lead to the PI spending substantial lengths of time either at Navoceano, or at OSU, working directly on problems of implementation of nearshore remote sensing to Naval needs. The PI is also involved in the LRS program and continuing interactions with government and contractor scientists.

RELATED PROJECTS

1 - Joint work with Dr. Todd Holland, NRL-SSC

2 - Collaboration and data sharing of pixel time stack data with Dr. Jim Kaihatu or NRL-SSC

3 – Collaboration with Craig Cobb of the WSC at Navoceano on nearshore remote sensing

4 – LRS program collaboration

5 – NICOP joint program with several European groups

6 – NICOP joint program with Dr. Graham Symonds of Australia

7 – Joint work with Bill Curtis of US Army Corps

8 – Numerous collaborations with the Field Research Facility

REFERENCES

PUBLICATIONS

Alexander, S. (2001). Quantitative analysis of nearshore morphological variability based on video imaging. COAS. Corvallis, Oregon State University**:** 112.

Holman, R. A. (2001). Waves on Beaches. Encyclopedia of Ocean Sciences. J. Steele, S. Thorpe and K. Turekian. London, Academic Press.

Konicki, K. and R. A. Holman (2000). "The statistics and kinematics of transverse sand bars on an open coast." Marine Geology **169**: 69-101.

Plant, N. G., B. G. Ruessink, et al. (2001). "Morphologic properties derived from a simple cross-shore sediment transport model." Journal of Geophysical Research **106**(C1): 945.

PATENTS

None