Optical Imaging of the Nearshore

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LONG-TERM GOAL

The long term goal of neashore processes research has been 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. Practically speaking, this occurs at two time scales. Shorter term predictions strive to model the details of a particular realization of the nearshore fluid domain and/or topography. At time scales longer than a few weeks, the nonlinearities in the system render this impossible and predictions can only be made of statistical or broader aspects of the nearshore system. Behavior at time scales of a year or longer is called Large Scale Coastal Behavior (LSCB) and the associated science is still exploratory.

OBJECTIVES

We continue to address the nearshore problem at both short and long time scales. At nowcast and near-term prediction time scales, we strive to develop optical remote sensing techniques to simplify acquisition of the data needed for comprehensive models of nearshore waves and currents. These data are useful in both an operational nearshore observing system capacity, but also to improve our understanding of dynamics, particularly the forcing of mean flows and intermittent rip currents. At long time scales, we wish to continue the discovery of new phenomenology that has been associated with the long time series data collections of the Argus program as well as develop a top-down modeling capability for LSCB.

APPROACH

The primary approach to the Coastal Imaging Lab (CIL) near term goals was participation in the Nearshore Canyon Experiment (NCEX) at Black's Beach in Southern California during the fall of 2003. The objective of this multi-institution program was to test models for the propagation of wave fields over the complex and abrupt topography of the La Jolla canyon, and for the resulting complex nearshore circulation.

CIL participation involved multiple aspects. Since wave direction was considered a diagnostic observable for the wave propagation models, a first-order goal has been to test optical remote sensing methodologies, based on MLE spectral analysis of time series from appropriate arrays of pixels, against available ground truth data. Figure 1 shows initial comparisons of optically-derived directional wave spectra and in situ results from co-located PUV sensors. In each case, optical spectra: a)

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provided an excellent representation of the dominant incident wave frequency and direction, b) provided a considerable improvement in resolution from PUV sensors, and c) were less responsive to higher frequency waves. Spectra such as these were found over a large experiment region and will yield high resolution maps of the refracting wave patterns. CIL data collections also included estimation of longshore currents over the southern region of the experiment [*Chickadel et al.*, 2003]. Figure 2 shows an example result in which longshore current convergence is obvious and is co-located with a visually-apparent rip current. CIL sampling also included runup data throughout the experiment and participation in the RTK-GPS surveys of the foreshore.

A key to future progress is the integration of Argus optical data with models of nearshore dynamics. This work is joint with Dr. Tuba Ozkan-Haller of OSU and is described more fully in her annual report.

At LSCB time scales, the lab continues to exploit the Argus long-term data collections of nearshore morphology from the twelve worldwide Argus sites.

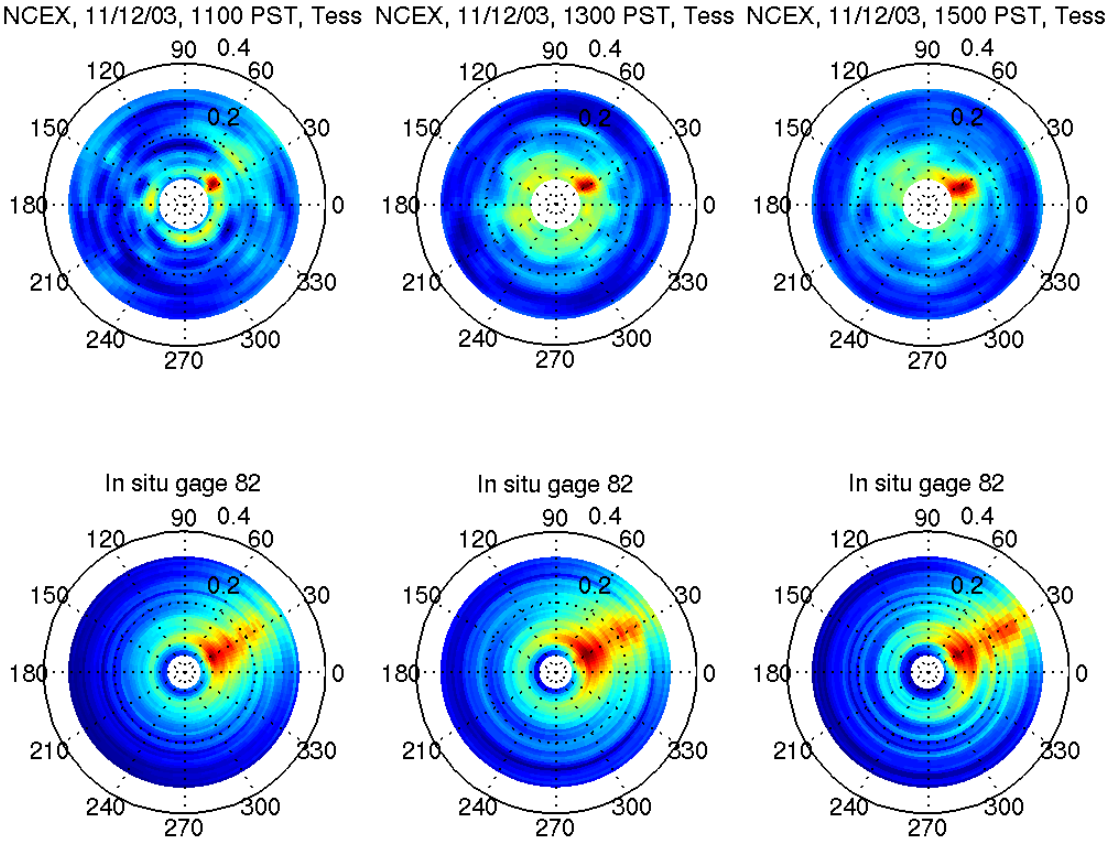

Figure 1. Example comparisons of directional wave spectra calculated from optical data (upper panels) and in situ PUV gages (lower panels). Azimuth corresponds to wave direction, while radius corresponds to frequency. Optical spectra do an excellent job identifying the frequency (0.11 Hz) and direction (30°) of the dominant swell in all cases and show considerably better resolution than PUV gages. Higher frequency waves are not as well identified in optical data.

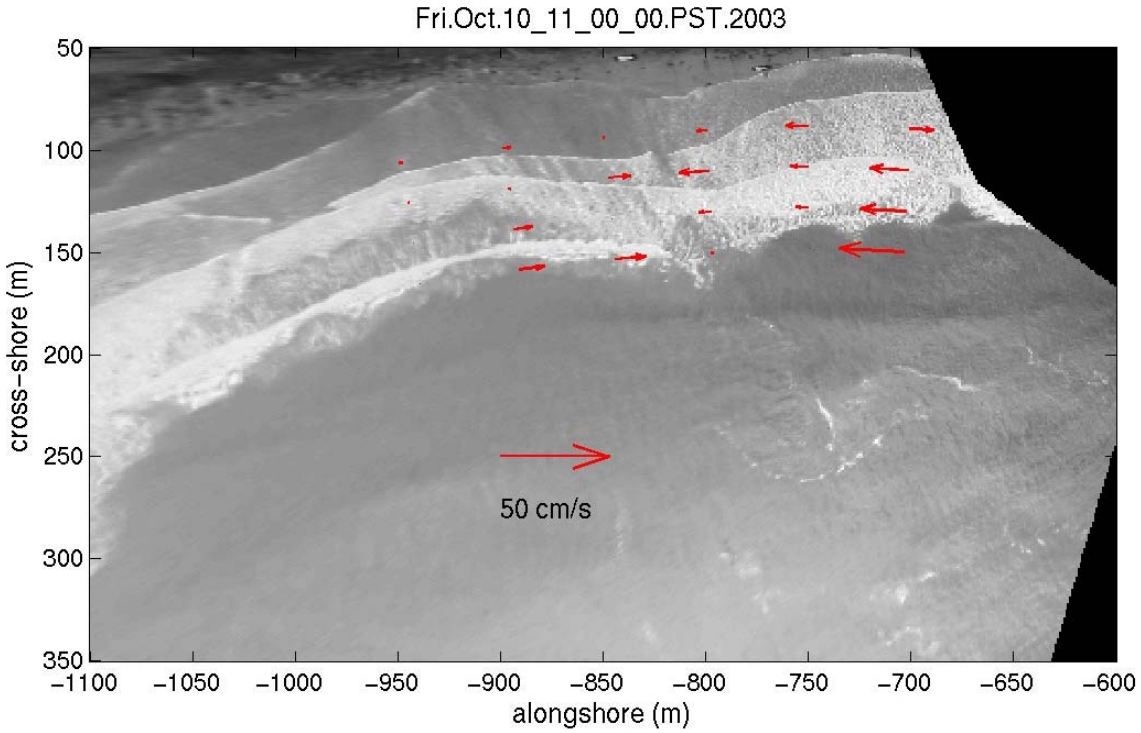

Figure 2. Example map of longshore currents from NCEX, October 11, 2003. Convergence of the currents is obvious at y = -790 m. The figure background is a rectified snap image showing the offshore drift of foam from a rip current at the location of current convergence.

WORK COMPLETED

The field component of NCEX is now complete and analysis is in progress. Initial comparisons of optical methods for directional wave spectral estimation are very promising. Argus III, the next generation of digital Argus station has performed well, has allowed a range of new capabilities [*Holman et al.*, 2003], and will be the basis of a system upgrade in the near future. Initial comparisons of optical data with numerical models have been very promising, particularly regarding the presence and location of intermittent rip currents.

Several studies have extended our understanding and statistical description of natural runup into a wide range of natural beach types [*Ruggiero et al.*, 2004; *Stockdon et al.*, in review].

Our work on LSCB has included progress in techniques to quantify and describe beach morphology [*Alexander and Holman*, 2004], as well as a number of results on characterization of LSCB across a range of sites [*Alexander and Holman*, 2004; *Haxel and Holman*, 2004; *Ruessink et al.*, 2003; *van Enckevort et al.*, 2004].

IMPACT/APPLICATION

The development of a robust set of optical remote sensing techniques opens many doors. From the point of view of the U.S. nearshore processes research effort, Argus data continues to provide surprising and wide-ranging data that are available quickly on the web. Long time series, such as can really only be collected by a program like Argus, have proved themselves invaluable to understanding previously unsuspected inter-annual variability in the nearshore. We expect that Argus data will have a large impact on our understanding of the NCEX field program due to the range of fluid variable estimates such as peak wave direction that can be made with a fine granularity. These will complement and supplement the in-situ arrays during the actual experiment.

The impact of Argus on society is becoming increasingly apparent. In addition to the 12 sites run by the Coastal Imaging Lab, there are now more than 13 sites being operated by others worldwide. Argus is the focus of a three year EU program (CoastView), designed to integrate Argus into everyday Coastal Zone Management practices.

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, a second station at Waveland, MS, and a third station recently installed at Eglin Air Force Base. In fact, the Argus data base, now spanning over 70 site-years of data, is actively mirrored at NRL-SSC for both back-up and collaboration purposes. Many aspects of Argus technology have fed into Navy METOC activities, principally through the LRS program and continuing interactions with government and contractor scientists in that program. Transition of LRS to the WSC has required considerable collaboration and has provided many opportunities for Argus-associated research to find application at NAVOCEANO. 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. Argus is now becoming “mainstream” in Europe with the progress of the CoastView EU program for the integration of Argus into standard Coastal Zone Management practice. Argus has been transitioned to commerical availability through transition agreements between OSU and Northwest Research Associates (for North America) and Delft Hydraulics (for the rest of the world).

RELATED PROJECTS

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

2 – Collaboration with Melody Bledsoe and Houston Costolo of the WSC at Navoceano on nearshore remote sensing

3 – LRS program collaboration

4 – EU CoastView Program (2002 – 2005)

5 – Numerous collaborations with the Field Research Facility

6 – Three month sabbatical at the NATO research center in La Spezia (09-12/04)

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PATENTS

None

HONORS/AWARDS/PRIZES

SECNAV/CNO Chair in Oceanography, 2003-2007