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. Success requires advances in our understanding of nearshore physics, improvement in our capabilities for numerical modeling, and development and testing of methods for the rapid collection of the data required for model initial and boundary conditions.

OBJECTIVES

Our program follows three themes; studies of nearshore fluid dynamics, studies of the morphodynamic variability of the nearshore fluid-sediment system at longer time scales, and development of new or better data collection methods. The first two components address deficiencies in our understanding of the basic physics of the nearshore and of the nonlinear dynamic system composed of nearshore fluid motions and nearshore bathymetry. The third addresses the critical need to provide sufficient input data such that the accuracy of nearshore predictions will be limited by physics or models issues, not simply by input data scarcity.

APPROACH

Since the early 1980s, Coastal Imaging Lab (CIL) research has been based on optical remote sensing methods for the collection of data appropriate to nearshore problems of interest. The history and contributions of Argus have been recently documented by Holman and Stanley [*in review*], but developments continue. Conley *et al* [*in review*] describes the application of Argus to Rapid Environmental Assessment (REA) in the NATO context.

Rip currents have a large effect on nearshore circulation but remain difficult to locate and measure. In the past year, we have explored novel optical methods to estimate the location and strength of nearshore rips based on differences in cumulative phase patterns between waves progressing against a current and those that are not. Wave phase is estimated using the first EOF from pixel time series from a tesselation array [*Holman and Stanley, in review*]. Figure 1 shows wave phases for an example data from NCEX. The shoreward bulge of wave phase at y = 1600 corresponds to a local rip current. We also continue to work on development of optical proxies for gradients in radiation stress, such that estimates of these variables can be directly assimilated into numerical models.

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14. ABSTRACT
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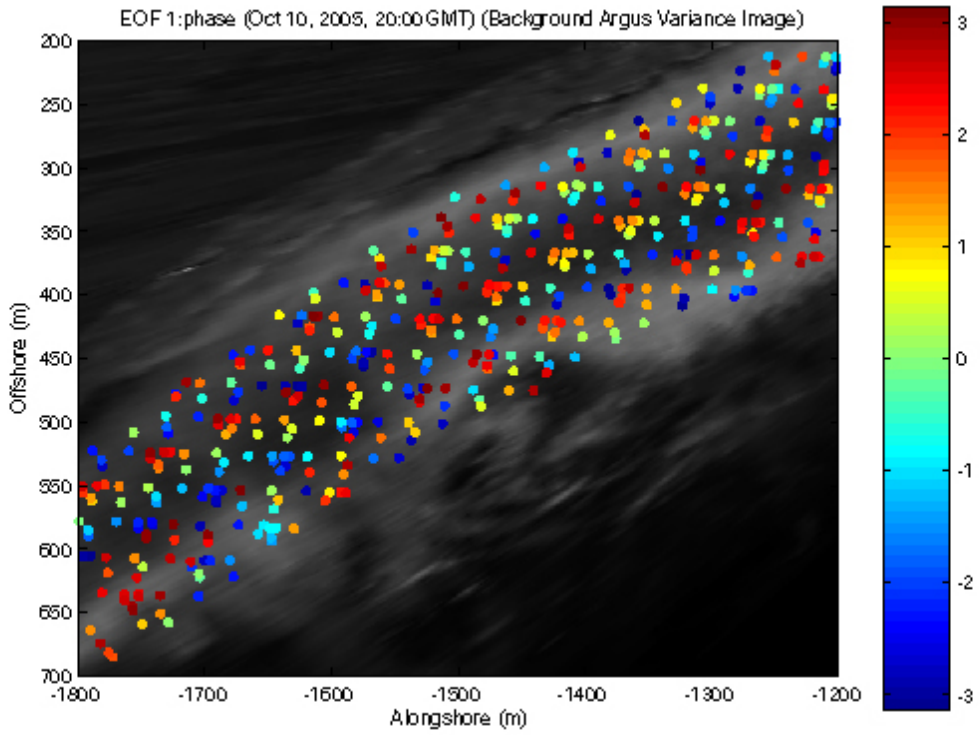

Figure 1. Phase map for incident wave frequencies for October 10, 2003, from the NCEX field experiment. The figure background is a rectified variance image showing regions of wave breaking. The slight seaward bulge of wave phase near y=1600 corresponds to a rip current.

We continue to improve the underlying foundation for Argus and optical image processing by incorporation of improvements from other fields, most commonly from medical imaging and computer vision. We are currently in the midst of upgrading all of our algorithms to take advantage of very powerful homogeneous coordinates algorithms that are now available. We are also investigating new approaches for automated sub-pixel image co-registration through the use of mutual information theory.

Our regular Argus sampling program at twelve sites around the world is ongoing and is in the process of upgrading through other ONR funds.

WORK COMPLETED

We have completed collection and analysis of 14 months of longshore current measurents, collected optically twice per day at 28 locations in a 2D array. In contrast to recent papers, we found that longshore gradient terms could not usually be neglected in the alongshore momentum balance and that rip currents were quite common (see examples in Figure 2). This work is in final editing (*Chickadel and Holman, final edits*).
Argus continues to be the basis for a great deal of research on large scale nearshore morphodynamics, for example, the statistical description of the characteristics of natural crescentic sand bar systems by Van Enckevoort et al [*2004*]. A study of rip channel dynamics, based on four-years of daily Argus

measurements from Palm Beach, Australia, has established that, while rip channels are present the vast majority of the time, rip channel generation from an initial longshore uniform beach is very uncommon, occuring only about four times per year. Instead, the evolution of rips is almost always tied to the coupled dynamics of nearshore fluid motions with a pre-existing complex topography [*Holman et al, in press*]. Thus, rip generation models that assume initial alongshore uniformity have little applicability to natural beaches.

Collaborative work with PIs at NRL-SSC on modeling the basic characteristics of sand bar systems and their interaction with waves and currents has shown the fundamental structure of these interactions [*Plant et al, submitted?*]. This is primarily the work of Nathaniel Plant.

IMPACT/APPLICATION

Argus forms the basis for a wide range of research efforts around the globe. In Europe, Argus is now a strong program in the United Kingdom, The Netherlands, Italy and Spain, while more that 10 stations now operate in Australia. Argus forms the basis for research in each of these countries and was the heart of the recent EU CoastView Program. Argus also samples a wide range of locations within the US. We have strong connections with NRL and work jointly on a range of remote sensing problems with littoral applications.

Argus remains the only practical method to collect the long time series needed to study the nearshore as a nonlinear dynamical system and to reveal the interannual variations that are now being discovered. Optical remote sensing through Argus or a clone will be the best source of data for any future nearshore observing system.

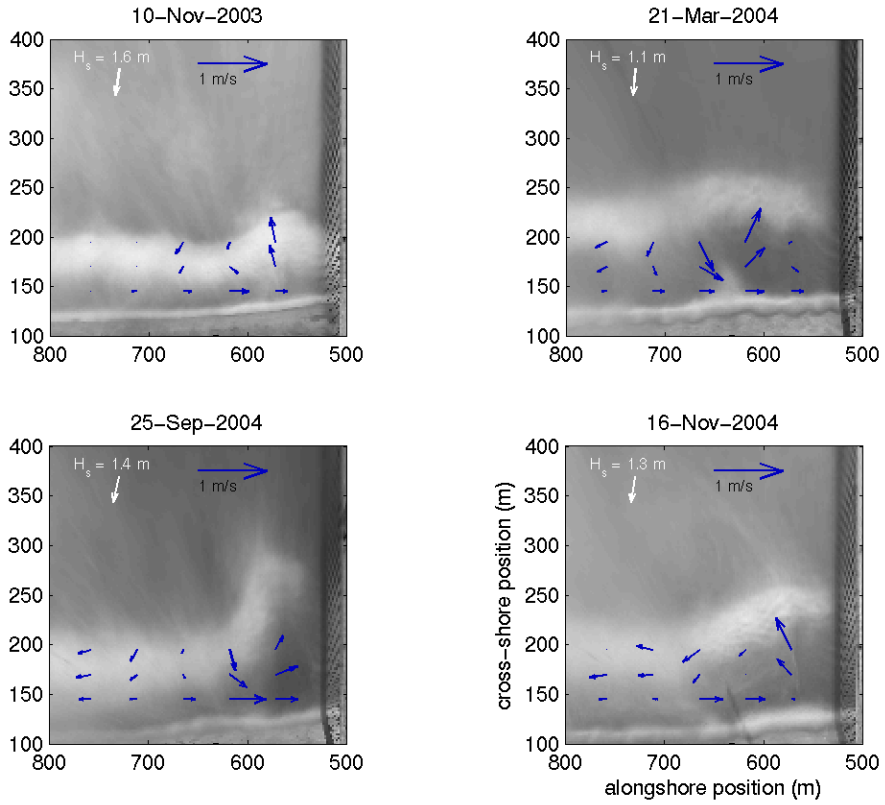

Figure 2. Four examples of complex circulation from the 14-month Duck collection. The figure background is a rectified time exposure image showing enhanced breaking at the shoreline and over the inner sand bar.

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 and a second station recently installed at Eglin Air Force Base. A third site at Waveland, MS, was destroyed by Hurricane Katrina, along with most of the town. 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 the WSC at Navoceano on nearshore remote sensing

3 – LRS follow-on efforts, particularly UAV development

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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