

Optical Imaging of the Nearshore

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LONG-TERM GOAL

The long-term goal of nearshore 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 [*Holman et al.*, 1990]. The format of those predictions is usually numerical predictions, merging model dynamics with inputs provided by either in-situ or remotely-sensed methods. Recent work has increasingly focused on the development of nearshore prediction systems that merge models with input data derived from remote sensing sources to yield dynamically-faithful environmental characterizations as well as short term predictions.

OBJECTIVES

Our immediate objectives are to develop and test innovative methods to estimate nearshore bathymetry, wave forcing and hydrodynamic response using optical methods, to marry these capabilities with operational models and to understand the dynamics of the nearshore system that we measure.

APPROACH

We exploit a number of approaches in our work. Our observational work continues to be primarily based on the Argus observing system, now approaching its 25th anniversary. This system allows collection of high resolution, time domain data of optical radiance at a number of focus research sites. Recently, we have collaborated with Dr. Merrick Haller of OSU to study the joint performance of synchronous optical and radar data from surf zone environments, mainly using data collected at Duck, NC. Finally, we are working closely with Dr. Tuba Özkan-Haller of OSU on testing and improving the performance of nearshore numerical models and on incorporating remote sensing inputs into those models.

In September, 2010, we participated in the Surf Zone Optics experiment, at Duck, NC. This experiment had several themes. One goal was to better understand the link between surf zone hydrodynamic processes and their associated optical signatures with the goals of both understanding surf zone visibility, and developing methods to exploit EO signatures as proxies for important geophysical processes. The second goal was to examine the potential advantages of multi-sensor

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fusion for nearshore applications, determining what added value opportunities are available when sensors with different modalities and scattering physics (EO, radar, IR) observe the same process.

WORK COMPLETED

We have completed participation in the September, 2010, Surf Zone Optics experiment, collecting an extensive data set of optical radiance for our research studies, but also in support of collaborative work with other investigators.

We have published a joint paper on the unique capabilities of fused EO/Radar data for distinguishing dissipating waves in the surf zone [*Catalan et al.*, in review]. Both EO and radar often see bright signatures that are not directly related to wave dissipation (residual foam for EO and specular glints for radar). However, the joint signatures can be exploited to eliminate each of these issues and data extracted that can be more directly related to incident wave dissipation.

We have completed the development and testing of a stereo method for measuring the profiles of nearshore sand dunes. We found the method to be accurate when compared to traditional survey methods but much simpler to implement, especially in storm situations of scientific interest when in-situ sampling is usually impossible. Dune erosion rates computed from profile differencing were found to be fairly consistent with a published simple empirical model. However the physics of that model were neither satisfying nor illuminating and a completely new model has been developed that is based on infiltration physics derived from the standard soil mechanics literature. Both predictions and understanding have been substantially improved [*Palmsten and Holman*, in review].

We have continued work with Brazilian colleagues on the dynamics of a surf zone infiltrated by fluid muds. The nature of a mud event has been well documented and the effect of the fluid mud on wave propagation has been described using Argus data [*Pereira et al.*, in press].

We have wrapped up work on a morphodynamical model of nearshore sand bar variability [*Splinter et al.*, in press]. Links between the alongshore variability and mean cross-shore migration rates have been formulated and tested using a four-year Argus data set from Palm Beach, Australia.

Finally, we have continued work with Tuba Özkan-Haller and Greg Wilson on various aspects of surf zone numerical models. The sensitivity of model predictions to bathymetric error or change has been investigated and exploited through the development of a data assimilation scheme that corrects prior estimates of bathymetry to be dynamically consistent with a small number of wave height and alongshore current measurements from the surf zone [*Wilson et al.*, in press]. We have also developed a simplified (but dynamically correct) filter model for longshore currents that explains the common observation that alongshore variability of currents reduces as current strength increases. Sensitivity is expressed in terms of a nearshore Reynold's number.

RESULTS

The presence of alongshore variability of nearshore sand bar systems, once thought to make no net contribution to system dynamics, has been shown to have important consequences to overall bar response to a varying wave climate. Nearshore circulation induced by these variations has been found

to be sensitive to the bathymetric variability in ways that can be exploited to yield improved bathymetric estimates by assimilation of wave and circulation data collected in the nearshore, essentially inverting the discovered flow sensitivity. These methods will be extended in the nearshore MURI that is just beginning. The combination of remote sensing and models, coupled appropriately using assimilation techniques, is beginning to provide robust methods of nearshore characterization.

IMPACT/APPLICATION

Nearshore remote sensing is of obvious importance to Naval Battlespace Characterization as well as to civilian applications in coastal zone management requiring extended observation (beyond the scope and available funding for focused experiments). The continual improvement in signal processing methods to reduce the high frequency noise that often dominates optics makes these methods robust, with well-understood statistics.

TRANSITIONS

The optical remote sensing approaches of Argus have been transitioned or are being further pursued in many ways. Argus has been made commercially available through transition agreements between OSU and Northwest Research Associates (for North America) and Delft Hydraulics (for the rest of the world) and is an accepted tool by the nearshore community throughout the world. Argus technology or spin-offs have been and are being actively used by the U.S Navy through products of the LRS program and, for NSW teams, through products of the research work of Dr. Todd Holland's group at NRL (we remain tightly connected to this group and are part of ongoing research on BWLite and UAV applications). The U.S. Army Corps of Engineers (through the FRF) continues to use Argus for both testing and applied projects. The USGS, particularly through Nathaniel Plant, also embraces Argus as an important tool in coastal monitoring and experimentation.

RELATED PROJECTS

- 1 - Joint work with Dr. Todd Holland, NRL-SSC on Argus methods and SUAV applications
- 2 – Numerous collaborations with the USACE Field Research Facility including Morphos and XBeach testing and operations.
- 3 – Work with USGS on Argus bathymetry methods (Plant) and shoreline vulnerability through foreshore-swash and dune erosion studies.

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