Measurement of Local Scale Wave Transformation Effects at NCEX Using AROSS Imagery

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LONG-TERM GOALS

This work seeks an improved understanding of shoaling-wave phenomenology, particularly in areas of complex bathymetry, through the use of novel, large-area, high-resolution, remote-sensing approaches.

OBJECTIVES

This effort will study the transformation of deep-water waves to the surf-zone as they shoal over a large spatial domain with complex bathymetry. The investigation will compare wave model output parameters, such as significant wave height and period as well as directional spectra, with the values obtained from an airborne, electro-optical, remote sensor. Data will also be used for the investigation of propagation and surf-zone physics with emphasis on the evaluation of the importance of reflection and diffraction effects.

APPROACH

This effort will use the Airborne Remote Optical Spotlight System – MultiChannel (AROSS-MC) at the Nearshore Canyon Experiment (NCEX) to provide remotely-sensed, electro-optical data of shoaling waves from deep water through the surf zone. NCEX is a multi-institutional experiment that will be conducted in Fall 2003 near La Jolla, CA. AROSS-MC is a compact, turret-based optical system that has been designed and constructed for imaging ocean waves from commercial, aerial-photography aircraft. It consists of a bank of four digital cameras with filters for red, green, blue and near-infrared passbands; an IMU; a GPS receiver; and computer control. The system was designed to spotlight or stare at a specific geographic location for up to several minutes and collect time series of images along with precise navigational and pointing data. By mapping the imagery to a geodetic grid at the level of the mean ocean surface, the space-time characteristics of the waves can be extracted.

Data cubes of information (two spatial dimensions plus time for four spectral channels) will be available from AROSS –MC overflights with durations of up to 4 hour over multiple coverage areas of up 3 x 3 km. These measurements are necessary to properly characterize the transformation of deep-water waves to the surf-zone over the complicated bathymetry present at the experiment site. Imagery from AROSS will cover the entire shoaling region, as well as the surf, providing data suitable for deriving directional spectra at multiple locations over the NCEX area. These spectra can be compared to calculations from shoaling-wave models to aid the identification and investigation of the relative importance of physics not represented in the models. Algorithms developed for extracting surf-zone parameters from tower-based video will also be applied to AROSS imagery in near-real time and the nowcasts from this analysis will be made available to NCEX investigators.

WORK COMPLETED

Work this past year has focused on preparation for the deployment of AROSS-MC and participation in NCEX. The AROSS-MC sensor, which is funded through an ONR SBIR contract, has been completed and is undergoing final testing. Figure 1 shows an example of imagery from the red and blue channels from the initial test flight of AROSS-MC. Note that ground features are more resolved in the red channel (600 nm – 700 nm) than in the blue channel (500 nm – 600 nm). This is due to greater scattering of the light by the intervening atmosphere in the blue band.

Figure 1. AROSS-MC Imagery from the test flight on Sep 11, 2003 over the Martisnburg, WV airport, the left frame is the red channel and the right frame is the blue channel. [images of runway and hangars, left image has greater resolution than right image]

Experimental planning and logistics have also been completed. AROSS-MC will be fly at NCEX from October 23 through November 17. A total of 13 flight days, up to 6-hour duration, are scheduled. Figure 2 shows the flights plans and the areas that will be covered by the sensor. The two circle sizes represent the collections at 5000 ft altitude with 1 m resolution (blue circles) and 1000 ft altitude with

2 m resolution (green circles). Twin Otter International, a private aerial photography company, has been contracted to provide the platform for AROSS-MC. Twin Otter International, a DOE and NASA approved operator, provides aerial survey, surveillance and airborne research aircraft as well as engineering and technical support to the Science Community. A photograph of the Twin Otter aircraft, a DHC-6-300 Vistaliner, that will be used at NCEX is shown in Figure 3. Funding for the aircraft flight cost is being provided by the Naval Research Laboratory – Stennis Space Center (NRL-SSC) platform support.

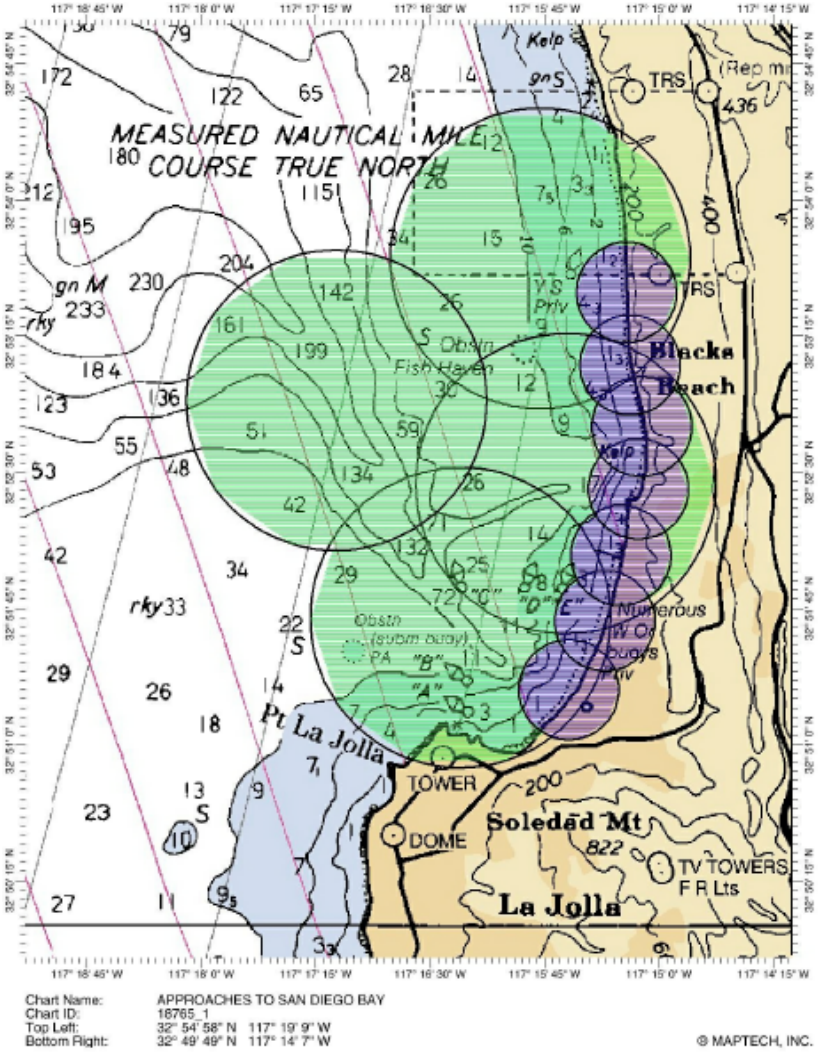

Figure 2. Planned coverage of the NCEX area by AROSS-MC
[map showing depth contours and land elevations with overlay of area coverage]

In addition to the overflights by AROSS-MC, a series of tower-based cameras will provide continuous coverage of the area north of the Scripps pier. These cameras will be calibrated for the production of geo-rectified imagery for comparison with AROSS-MC.

Software to perform quicklook, qualitative analyses on the imagery has been also completed. An Internet web server has been acquired and will be used to provide access to the results of quicklook

analyses. This will allow collaborators and other principal investigators at NCEX to review results of the AROSS-MC flights and provide feedback to the data collection efforts. Other preparation efforts include finalizing the image mapping techniques as well as modifications of algorithms and code from the AROSS program for AROSS-MC.

Concurrent with the experimental preparations, modeling efforts have also continued. These efforts use the Shoaling Waves Nearshore (SWAN) model, driven by the Navy Swell Model, to perform wave forecasts for the NCEX region.

RESULTS

Figure 4 is a model prediction for the nowcast and the 72 hour forecasts for the NCEX site. The forecast uses the SWAN model with forcing conditions provided from the Navy Swell Model. The swell model takes NAVO WAM analysis fields from the globe, removes the active wind sea (T<11.8s) and then determines great circle propagation paths to the grid boundaries. Currently, a SWAN nest, in which data from a larger SWAN grid will be applied to the boundaries of the NCEX domain, is being developed. The nested grid will give better boundaries conditions for the model, particularly along the southern boundary.

Figure 3. Twin Otter International's DHC-6-300 Vistaliner, which will be the platform for AROSS-MC

IMPLICATIONS/APPLICATIONS

With the emphasis of the ONR Coastal Dynamics Programs on model-driven experiments, AROSS-MC has the potential for a unique contribution to this effort. *In situ* measurements provide detailed information of local nearshore phenomena at discrete points in space. These measurements are often used to validate shoaling models, which are initialized with deep-water measurements or large-scale propagation model output. The validation offers no further information concerning the performance of the model elsewhere in space. Data collected by AROSS-MC will provide medium scale measurements and effectively fill the information gap between the two extremes. A self-consistent set

of bathymetry, currents, and directional spectra over the entire shoaling region can be retrieved from AROSS-MC data for the evaluation and development of shoaling-wave models.

TRANSITIONS

None

RELATED PROJECTS

Areté Associates is developing a new EO imaging system, based on the Airborne Optical Spotlighting System (AROSS) design, which will collect time-series imagery of the ocean surface suitable for scientific research. The new system, AROSS-MC, is a multi-channel AROSS designed for low-cost production, through the use of commercial-off-the-shelf (COTS) components, and low-cost operation, through the use of commercial aerial photography airplanes. This work is funded under the SBIR Phase II contract N00014-02-C-0183 for Solicitation Topic N01-035, "Four Dimensional (4-D) Atmospheric and Oceanographic Instrumentation". Areté was awarded this contract based on a proposal entitled, "A Low-Cost Airborne EO Oceanographic Measurement System".

Findings and algorithms improvements resulting from this effort will be incorporated into the NRL Littoral Environmental Nowcasting System (LENS) program that seeks to use remotely derived information to drive state-of-the-art models of littoral dynamics.

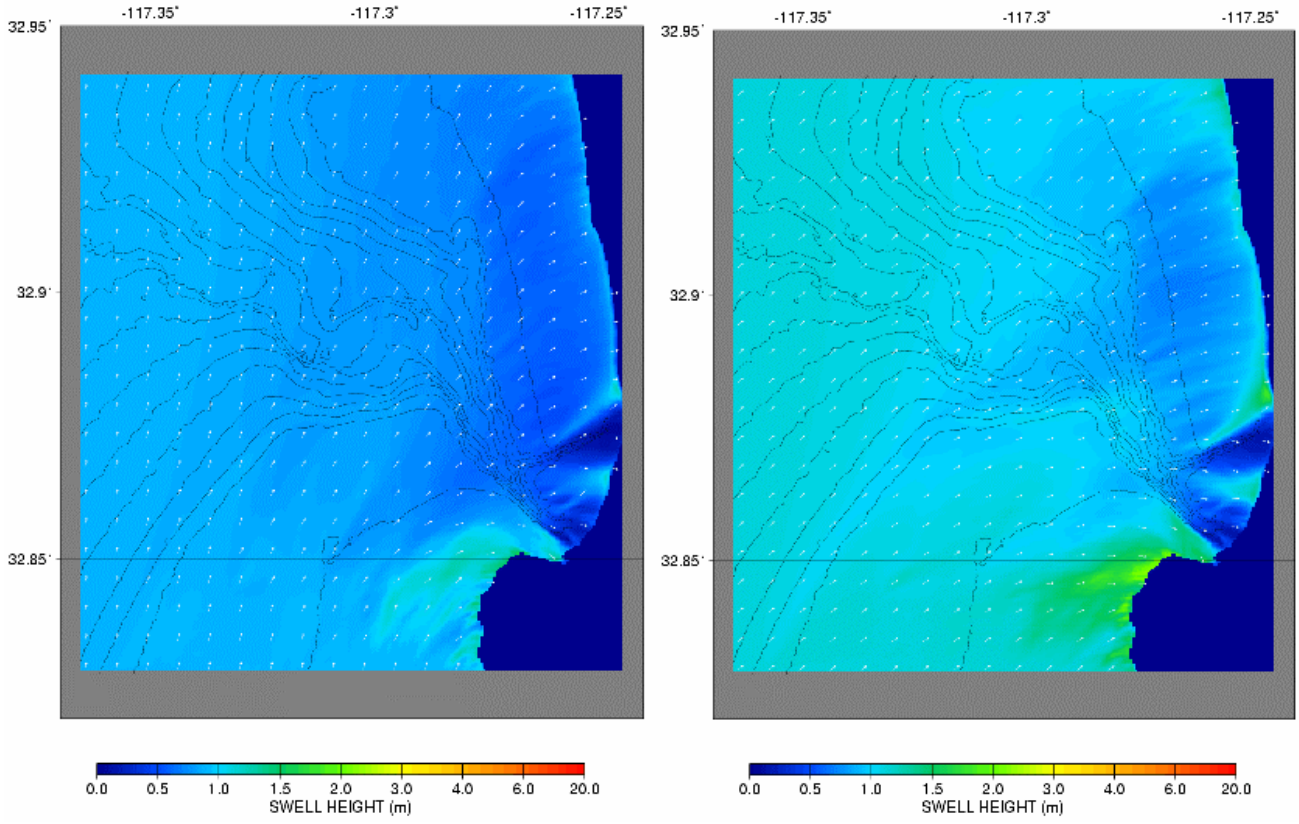

Figure 4: SWAN analysis of swell in the NCEX area for Sep 26, 2003 (nowcast) (left image) and Sep 29, 2003 (72 hours) (right image)

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