# SPATIAL VARIATION OF WAVES, STRESS AND WIND FIELD IN THE SHOALING ZONE

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## LONG TERM GOALS

Existing atmospheric models for predicting surface stress and turbulent structure in the shoaling zone fail because of their inability to properly account for wave age, shoaling and internal boundary layer development. Accurate model simulation of the surface stress and turbulence above the air-sea interface is important for many applications including understanding wave growth and decay. Under this ONR Advanced Research Initiative our goals are:

(1) to measure the spatial variation of the wind, surface stress and ocean wave fields in the shoaling zone and to provide quality-controlled data to the shoaling community; and

(2) to study the relationship between the spatially varying mean wind, stress, turbulent structures, and surface wave fields to model effects of wave age, shoaling, and internal boundary layer development on the drag coefficient and momentum transfer.

## OBJECTIVES

A key to achieving our goals is the development of a data archive containing simultaneous observations on the wave, wind and stress fields in the shoaling zone. Since an instrument system to make these observations has not yet been developed, no such spatially dependent measurements currently exist. Therefore, our first objective is to development an efficient measurement system to collect the necessary observations.

## APPROACH

Within NOAA, we have developed a high fidelity airborne wind system on a Long-EZ aircraft. This airborne wind system has demonstrated the ability to observe both mean meteorological parameters and mass, momentum and energy flux in marine boundary layers. This year’s focus was on design, fabrication and test of the airborne wave measurement system. To measure the ocean height and directional spectra from the Long-EZ aircraft, three lasers distance sensors (accuracy 10 mm) were mounted in a “down-looking” triangular array with a one meter

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separation distance. This measurement approach is similar in design to wave wires. However, being airborne, we can freely explore waves from shore to deep ocean. All laser beams are parallel and aligned to the aircraft's ±0.05° resolution attitude system. The laser array is strobed at 50 Hz to provide simultaneous distance measurements.

The laser array approach is limited to wavelengths greater than about 3 m. To extend our measurement to smaller waves, a Ka-band radar was developed to measure total wave slope for wavelengths from 1-50 cm at our 15m-flight altitude. These small waves are important since they strongly influence aerodynamic roughness and therefore influence surface shear stress.

## WORK COMPLETED

Preparations for the November 1997 Duck, NC field experiment included the paper "Experimental Plan for the Shoaling Experiment" and the design, construction and test of the airborne wave measurement system.

The airborne wave measurement system is based on three Riegl model LD90-3100VHS-NOAA lasers and a specially designed 36 GHz Ka-band radar. On 7 March 1997, a standard model LD90-3100VHS was mounted on the Long-EZ and tested over the ocean. Tests showed the standard laser had high dropouts over ocean waves. Over the next several months, we worked with Riegl Laser Measurements Systems to modify both laser hardware, firm-ware and optics for our specific application. At the same time, the Long-EZ aircraft was modified to receive the laser array and Ka-band radar. The Ka-band radar is mounted in an aerodynamic housing below the fuselage and centered in the laser array. This gives the best footprint location relative to other measurements and provides excellent range to interpret the radar data. In May the new wave measurement system was successfully tested. Test results of the laser and radar are available in the Experimental Plan for the Shoaling Experiment (July 1997) and on the referenced World Wide Web pages.

## RESULTS

A new low-cost measurement system has been developed and demonstrated. This airborne system simultaneously measures total wave slope, wave spectra and phase speed, and basic meteorological parameters including mass, momentum, and energy exchange with the ocean surface. This new airborne system, allows for the first time, efficient exploration of coupled but spatially varying atmospheric and ocean surface conditions.

## IMPACT

The high-utility and low-cost of the developed system will accelerate our ability to measure and understand ocean-atmosphere coupling in complex and spatially varying settings. Mass, momentum and energy exchange at the ocean surface impact not only wave development but also physical phenomenon such as down wind meteorology and "ducting" control of electromagnetic wave propagation. By combining the measurement of meteorological and ocean surface parameters on an airborne system, efficient research into a broad range of phenomenon is now possible.

## REFERENCES

Experimental Plan for the Shoaling Experiment. Jielun Sun, Larry Mahrt, Timothy Crawford, Chris Vogel, Ed Dumas, Pierre Mourad and Douglas Vandemark. July 1997

The Web addresses describing this effort is www.atdd.noaa.gov/wave_fram.htm. Additional web references of interest include:

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| Ka-Band Rader test: | http://osbl.wff.nasa.gov/rows/rockwood.html |
| Laser Drop Test: | ftp://ftp.atdd.noaa.gov/pub/wave/LASER.HTML |
| Long-EZ Aircraft: | www.atdd.noaa.gov/long_ez.htm |

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