Ultrawideband Radar Backscatter from Breaking Water Waves with Simultaneous Optical and Infrared Imagery

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This paper will summarize the results of two sets of radar scattering experiments that were carried out at the University of Maryland-College Park wavetank facility. The first set was conducted in September, 2000, and the second is scheduled for February, 2003.

In the September 2000 experiments, spilling and plunging breakers with a water wavelength of approximately 80 cm were generated through dispersive focusing of a chirped wave packet, and were then imaged with a high-speed camera in conjunction with a laser sheet. Simultaneously, the radar backscatter generated by the breakers at a nominal grazing angle of 12 degrees was measured by an ultrawideband, dual-polarized, X-band radar with a range resolution of approximately 4 cm. In addition to providing both quantitative profiles of the evolving water surface and the corresponding ultra-high resolution radar backscatter, this experimental setup also included a moving instrument carriage that allowed the sensors to follow the breakers throughout their entire evolution. Numerical scattering simulations that use the measured surface profiles as inputs complement these experimental investigations by providing a means to investigate the scattering mechanism.

An analysis of the results shows that when the radar views the spilling breaker in the "upwave" direction, over 90% of the horizontally (HH) polarized radar backscatter is generated during the initial stage of breaking by the small bulge near the wave crest. For vertical (VV) polarization, the crest bulge produces about 60% of the total backscattered energy. For VV, the remainder of the backscattered energy is generated by the turbulent, post-breaking surface, and in fact a close correlation is observed between increases in the VV backscatter amplitude and the shedding of vortex ripples after the wave breaks. Agreement between the experimental and numerical results is good, particularly in the Doppler domain. For the plunging breaker, the initial feature on the crest (an overturning jet) generates a lower percentage of the total backscattered energy. In this case, initial Doppler velocities are somewhat higher than the dominant wave phase speed, particularly for HH polarization.

In the experiments scheduled for February 2003, an improved radar system with a wider bandwidth will be used, and waves will be generated by wind forcing as well as by dispersive focusing. An additional camera will also be used to image the surface signatures of these breaking waves in the infrared (wavelength 3-5 micron).