

NUMERICAL SIMULATION OF SCATTERING FROM BREAKING
SURFACE GRAVITY WAVES IN PRESENCE OF SMALL-SCALE
ROUGHNESS

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Description of the ocean gravity waves as a weakly-nonlinear, nearly-Gaussian statistical ensemble albeit convenient often contradicts observations. Calculation of microwave backscatter from the ocean surface in the low-grazing-angle (LGA) regime based on this representation does not produce such features as sea spikes with high horizontal-to-vertical polarization ratio, or anomalous behavior of Doppler spectra registered in field observations. There are many experimental facts speaking in favor of breaking waves as a primary source of those LGA backscatter effects.

In this paper, bistatic scattering from the 1-D impedance rough surface is numerically studied. A model of the rough surface consists of two types of waves: large-scale periodic non-linear gravity waves, and random short-scale capillary-gravity waves riding atop longer waves. Evolution of the longer surface waves is modeled by a hydrodynamic code allowing temporal description of the profiles of the steep and breaking waves. The short waves are described statistically by a stationary and spatially-uniform power-law spectrum with a lower cutoff spatial frequency three times smaller than the spatial frequency of the EM wave.

The simulations proceed in three steps. First, the hydrodynamic equations for potential surface waves including surface tension but without viscosity are solved producing a temporal sequence of large-scale wave profiles. The approach used allows appearance of non-single-valued profiles. As a result, it becomes possible to follow through various stages of wave breaking: steepening, cresting, involution, and jetting. Then scattering of EM wave is calculated from those profiles. Finally, using surface fields obtained at this step as sources for the small-perturbation theory the Bragg-type scattering on the small-scale roughness is calculated and added to the cross sections caused by steep breaking waves.

Calculations have been performed for 1.0-m wavelength surface waves and 4.65-cm EM wavelength and two orthogonal polarizations for various incident and scattering angles. For backscattering regime and for the upwind, front-face incidence at grazing angles about or less than 20° the results evidently support observable behavior of backscatter with an expected spike-like increase of HH-pol. that exceeds VV-pol. when the surface wave is passing the cresting stage and goes into involution. Onset of jetting leads to a relative subsiding of backscatter with HH-pol. getting smaller than VV-pol. Also, for the strongly non-linear waves alone, the corresponding Doppler spectrum at HH-pol. is broader than at VV-pol.

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