Radar Doppler spectra from a nonlinear sea surface with breaking waves: numerical simulations

Valery U. Zavorotny and Alexander G. Voronovich
NOAA/Earth System Research Laboratory, Boulder, CO, 80305,
http://www.esrl.noaa.gov/psd/psd3/

Recently significant progress was made in numerical modeling of ocean wave breaking and subsequent modeling of full-wave electromagnetic (EM) scattering. However, to employ Monte-Carlo–type simulations one would need to greatly reduce computational time. In our previous studies, we developed a numerical approach that deals with breaking of individual 2D nonlinear waves by solving the Laplace equation. Using this approach we managed to simulate an evolution of non-single-valued surface waves, including the last stage of wave breaking. Also, we successfully reproduced the main features of temporal and polarization behavior for a scattering cross section from an individual breaking wave and corresponding Doppler spectra using a full-wave numerical code which deals with electromagnetic scattering from those waves.

The next step was to consider a statistical ensemble of breaking waves driven by an initial elevation spectrum of surface gravity waves, and to calculate the corresponding ensemble of electromagnetic fields scattered off such surfaces. To significantly accelerate the simulation of a lengthy nonlinear wave evolution, we have developed a fast code which is based on a so-called Hamiltonian approach. However, it can deal only with single-valued surfaces, so when the wave under consideration is reaching a near-breaking stage we change back to the Laplacian code.

Using this combined approach and initial wave conditions derived from a power-law–type surface spectrum, we generated a large number of wave realizations pertaining to a time interval before and during wave breaking. Each of those realizations included thousands of consecutive wave profiles separated by a short enough time step in order to calculate well-defined radar Doppler spectra. In our presentation we discuss the behavior of radar Doppler spectra at two polarizations obtained by such an approach for various types of breakers in various stages of the breaking process.