Geophysical Research Abstracts
Vol. 13, EGU2011-3906, 2011
EGU General Assembly 2011

Ocean Surface Roughness and Remote Sensing

Paul Hwang
Remote Sensing Division, Naval Research Laboratory, Washington DC, United States (paul.hwang@nrl.navy.mil / 202-4047453)

The ocean surface roughness plays an important role in air-sea interaction. It is the major cause of wind drag, thus affecting the mass, momentum and energy transfers across the air-sea interface. It is also an important topic in remote sensing of the ocean environment because the electromagnetic (EM) emission or scattering is modified by the surface roughness condition. The primary contribution of the ocean surface roughness is from surface waves with length scale much shorter than the energetic wave components near the peak of surface elevation spectrum. The physical mechanisms governing the evolution of short scale waves are very different from those for the energetic long waves, on which the major research efforts of surface wave dynamics have been focused. For example, for long waves, the three major source functions of the wave energy or wave action conservation equation are wind input, wave breaking dissipation and four-wave nonlinear resonance interaction. For short waves, nonlinear resonance interaction occurs at the three-wave level and wave breaking is in fact a generation term more than a dissipation term. The process of breaking generation of surface roughness can be envisioned as a combination of impulses of breaking water jets, surface disturbances and bubble plumes propagating downward from the wave crest and the subsequent rising of the entrained bubble clouds to the water surface. The complex sequence of events creates surface roughness covering a broad range of length scales of short waves.

In this presentation, results from microwave remote sensing are used to help improve our understanding of the ocean surface roughness properties. In active remote sensing, the dominant backscattering mechanism is Bragg resonance. The secondary mechanism is the modification of local incidence angle caused by the longer waves tilting the Bragg resonance surface roughness components. In passive remote sensing, the situation is much more complicated because the bistatic nature and mutiple EM sources. The two modes of remote sensing are connected through the Kirchhoff's law, which relates the emissivity and reflectivity of the medium (emissivity = 1 – reflectivity), but for emissivity computation, the reflectivity is an integral over the upper hemisphere of the bistatic scattering coefficients in the reciprocal active scattering problem. The surface roughness contributing to passive remote sensing thus covers a much wider spectral band than it does in the active mode. Both modes of remote sensing can provide invaluable information about short scale surface waves in sub-centimeter to decimeter wavelengths that are the main contributors of ocean surface roughness, and forms the basis of obtaining global ocean surface wind velocity measurements using the active and passive microwave sensors. Presently, in the derivation of wind speed from altimeter, scatterometer, or radiometer output, operational algorithms rely on empirical relations established from correlating collocated and simultaneous datasets of in situ wind speeds and backscattering cross sections. The physics of wind generation of waves and emission or scattering of EM waves from the ocean surface are totally avoided. With the empirical approach described above, there is little room for improvement in the accuracy of the derived geophysical parameters even when major enhancements in sensor hardware and software have been implemented. Oceanographic community can contribute to improved global wind products, which drive the surface wave models, by advancing our understanding of the dynamics of short scale ocean surface waves, especially those in sub-centimeter to meter length scales.