Analysis of Low Grazing Angle Scattering from Composite Random Rough Surfaces Using the Steepest Descent Fast Multipole Method

M. El-Shenawee
Northeastern University
Center for Electromagnetics Research
360 Huntington Ave, Boston, MA 02115, USA

V. Jandhyala
Ansoft Corporation
Four Station Square
Pittsburgh, PA 15219, USA

E. Michielssen and W. C. Chew
University of Illinois at Urbana-Champaign
Center for Computational Electromagnetics
1406 W. Green St., Urbana IL 61801, USA

The Steepest Descent Fast Multipole Method (SDFMM), a fast multipole inspired integral equation solver for quasi-planar structures, has been used successfully to analyze low grazing angles (LGA) scattering from perfectly conducting rough surfaces. As demonstrated in our previous work, at LGA the length of the finite simulated surface should be at least ten times larger than the width of the surface to adequately project the incident beam onto the surface. As a result, the number of the moment method surface current unknowns becomes excessively large. The SDFMM has been successfully and efficiently used to solve for more than a million surface current unknowns. In our previous work, the random rough surface was assumed to have a single scale roughness with Gaussian statistics. In reality, many rough surfaces exhibit multi-scale roughness, e.g., ocean like surfaces. In this work, we assume that the rough surface is characterized by two-scale roughness, i.e., two root mean square heights and correlation lengths characterize the surface. The rough surface is still assumed to adhere to Gaussian statistics for both the random heights and the auto-correlation functions. The small- and large-scale random surfaces are independently generated using the random Gaussian generator. The composite two-scale surface is obtained by imposing the small-scale surface on the large-scale one. The incident wave is assumed to be a Gaussian beam with incident angle equal to 80 degrees from the normal to the surface and the rough surface is assumed to be perfectly conducting. The goal here is to investigate the effect of the small-scale roughness versus the large-scale roughness on the RCS at low grazing angles. Monte Carlo simulations are used to calculate both the coherent as well as the incoherent RCS as function of the scatter angle. As shown before, for single-scale rough surfaces, the RCS has a peak in the specular direction at LGA. There are still several studies related to the LGA scattering phenomena that need an efficient, fast and accurate algorithm such as the SDFMM to be solved.