ABSTRACT

Wave scattering from randomly rough surfaces is of interest in many electromagnetic applications. The recent development of efficient analytical and numerical models allows new insights into electromagnetic scattering from rough surfaces. However, the detailed scattering behaviors have not well understood even from the analytical models. Radar imaging techniques as more descriptive approaches offer a unique tool for better understanding of rough surface scattering phenomena. In this dissertation existing rough surface scattering theories are investigated through analysis of radar images. The approximate theories include the physical optics (PO) approximation, the small perturbation method (SPM) and the local/non-local small slope approximations (SSA/NLSSA). Numerical results are obtained from an accelerated method of moments based on a forward-backward iterative algorithm (MoM-FB/NSA). Back-projection tomography is applied to form synthetic aperture radar (SAR) images. Backscatter results at X-band are considered for deterministic one-dimensional random rough surfaces. Surfaces with Gaussian and Pierson-Moskowitz spectra are examined first. Radar images from numerical models are compared with those obtained from approximate scattering theories to discern differences in the resulting scattering mechanisms. A simple ray tracing algorithm is applied to analyze possible multiple scattering effects observed in the image domain. For ocean-like surfaces described

by P-M spectrum, images at high incident angles show strong backscatter contributions from the "Bragg" components of the surface and the long-wave "tilting" effects. Several simulated time-evolving breaking waves are investigated to study the "super-event" or "sea spike" phenomena. A radar image study reveals the significant multipath scattering effects. A "four-path" model is incorporated into the analysis of these effects. Scattering from a layered medium bounded by a rough interface is also investigated. The scattering formulation is derived based on the small slope theory which accounts for interactions between a rough interface and target layers. Radar images are examined to show the effects of the presence of sublayers. Finally, two-dimensional rough surface scattering problems and the associated three-dimensional radar imaging algorithm are addressed. A modified expression of SAR image formation is provided. The PO backscatter results are considered for image construction. A possible application of higher order scattering theories to three-dimensional radar image studies is discussed.