Polarization Dependent Backscatter Cross Sections of Composite Random Rough Surfaces for Normal to Near Grazing Incidence

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The small height/slope perturbation solutions, for the vertically and horizontally polarized backscatter cross sections of random rough surfaces have significantly different dependence upon the incident angle. Thus, for highly conducting surfaces, the ratio of vertically to horizontally polarized backscatter cross sections based on these solutions becomes very large for grazing angles of incidence and the ratio is independent of the roughness characteristics. The corresponding backscatter cross sections based on the physical optics solutions are polarization independent and the ratio is also independent of the roughness characteristics.

Ample experimental data, however, indicate that at near grazing angles of incidence the vertically and horizontally polarized backscatter cross sections of the earth surface, can be of the same order of magnitude and they are also significantly large than the values predicted by both physical optics and small perturbation theory. A unified full wave approach is used to express the backscatter cross sections as weighted sums of two cross sections. The first, associated with the larger scale rough surface height is given by the physical optics cross section, multiplied by the magnitude squared of the smaller scale rough surface height characteristic function. The second is the cross section associated with the smaller scale surface height, modulated by the slopes of the larger scale surface. When the composite rough surface is characterized by a continuous surface height spectral density function, it becomes necessary to judiciously separate the smaller scale surface from the lager scale surface. It is shown that this can be done using the unified full wave approach by seeking stationary solutions to the cross sections over a wide range of the variational parameters $r = \langle h_s^2 \rangle / \langle h^2 \rangle$ where $\langle h_s^2 \rangle$ and $\langle h^2 \rangle$ are the mean square heights of the smaller scale surface and the total surface respectively. These stationary values for the polarization dependent backscatter cross sections at grazing incidence can be practically equal and they are also significantly larger than the corresponding physical optics and perturbation results. These investigations also impact on the feasibility of relating the backscatter cross section to the remote sensing of moisture content of soil surfaces over gently undulating fields.