Remote Sensing of Soil Moisture Content of Composite Rough Terrain with Large Slope Fluctuations Based on a Variational Approach

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ABSTRACT

Remote sensing of soil moisture content is often based on the measurements of the ratio of the vertically and horizontally polarized cross sections for large angles of incidence, where the cross sections could be significantly different. Using the high frequency, physical optics model of the earth's surface, this ratio depends primarily on the Fresnel reflection coefficients for the two polarizations, while the impact of surface roughness factors out of the cross section ratio. Using the low frequency, small height-small slope perturbation model of the earth's surface, the vertically and horizontally polarized cross sections are critically dependent on polarization for large angles of incidence, even for highly conducting rough surfaces. Using the standard perturbation model, the ratios of the cross sections are also independent of the surface roughness. For highly conducting rough surfaces, the ratio of the horizontally to vertically polarized cross sections approaches zero for grazing angles of incidence, for which the two cross sections differ significantly. There is ample experimental evidence that neither the physical optics nor the small perturbation models are adequate.

The standard hybrid, two scale physical optics-perturbation approach depends critically upon the decomposition of the composite surface into smaller and larger scale surfaces. The smaller scale surface is restricted to small Rayleigh roughness parameters, proportional to the mean square height, and the larger scale surface is restricted by the large radii of curvature criteria.

Using a two scale full wave approach, the cross section are expressed as a weighted sum of a physical optics cross section for the larger scale surface, reduced by a factor equal to the square of the small scale surface characteristic function, and a cross section for the smaller scale surface that is modulated by the slopes of the larger scale surface. A variation technique is used to decompose the surface height spectral density function in a continuous, smooth manner into spectral density functions for the larger and smaller scale surfaces. It is shown that the corresponding polarization dependent rough surface cross sections are stationary over a wide range of the variation parameters.

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