Bistatic Reflection and Transmission of Electromagnetic Scattering by Rough Surfaces with Large Heights and Slopes

By

Ding Liang[1], Peng Xu[2], Kun Shan Chen[3], Zhiqian Gui[1]

And Leung Tsang[1]

Affiliation: [1]Department of Electrical Engineering, University of Washington, Box 352500, Seattle, WA 98195-2500, USA

[2] School of Electronic Information, Wuhan University, Wuhan 430079, P.R.C.

[2] Center for Space and Remote Sensing Research, National Central University, Taiwan, R.O.C.

E-mail: Ding Liang: dliang@ee.washington.edu, 1-206-221-6513

Peng Xu: pxu@whu.edu.cn,

Kun Shan Chen: dkschen@csrsr.ncu.edu.tw

Zhiqian Gui: alfredg@u.washington.edu

Leung Tsang: tsang@ee.washington.edu, 1-206-616-0959

Abstract: In this paper we study electromagnetic scattering properties of rough surfaces with large heights and large slopes. This is a problem of interests because for active and passive remote sensing of land at 5GHz, 10GHz, 19 GHz and 37GHz, the rms height of rough surface of land can be moderate to much larger than the microwave wavelength. For instance, the sastrugi type rough surface in Greenland, the heights of 8 cm to 30 cm are larger than wavelengths. Further more, the rough surface profiles are similar to random rectangular grating so that there are large slopes on the surface between 45 degrees to 90 degrees. This becomes particularly important as the incident angle is between 40 degrees to 50 degrees. Although the permittivity of medium like snow is only between 1.3 to 1.8, but the large slope with large incident angles can have important bistatic scattering and transmission properties.

Bistatic scattering and emissivities of rough surface with exponential correlation functions has been studied [1]. We study the bistatic reflection and transmission of electromagnetic scattering by rough surfaces with large heights and large slopes. We study the angular, polarization and frequency dependences. We used numerical NMM2D simulations of Maxwell equations. Tapered wave formulation is used. The periodic boundary condition was used in solving the interaction of rough surface with layering reflections [2]. We solve the surface integral equations to get the surface field on the rough surface. The method of moment (MOM) is used to discretize the matrix equation and rooftop basis function and Galerkin's method are used. Due to the large slope of the rough surface, we discretized the rough surface along the surface instead of along the horizontal direction. Then bistatic reflection and

transmission coefficients are calculated from far field scattering from the surface field. The reflection and transmission coefficients are calculated by integrating the bistatic reflection and transmission coefficients over the reflection angles and transmission angles respectively.

We study the reflection and transmission coefficients for different height and slope. We study the reflection and transmission coefficients at frequencies of 10GHz, 18GHz, and 37GHz. The results show small frequency dependence. This is because the scale of the rough surface characters, like height, is several wavelengths from 10GHz to 37GHz. We also study the bistatic reflection and transmission coefficients at different incident angles. The transmission still exists at transmission angles much larger than incident angle for rough surface with large slope. This makes total internal reflection possible if there are 2 layers below the rough surface and the lower layer has smaller dielectric constant than the above one [2].

Key words： microwave remote sensing, rough surface, sastrugi, Greenland numerical solutions of Maxwell equations

REFERENCES

[1] P. Xu, and L. Tsang, "Bistatic Scattering and Emissivities of Lossy Dielectric Surfaces with Exponential Correlation Functions," *IEEE Trans. on Geoscience and Remote Sensing*, vol. 45, no 1, pp. 62-72, Jan. 2007.

[2] L. Tsang, P. Xu, and K. S. Chen, “Third and Fourth Stokes Parameters in Polarimetric Passive Microwave Remote Sensing of Rough Surfaces over Layered Media,” *Microwave and Optical Technology Letters,* vol. 50, no. 12, pp. 3063-3069, Dec. 2008.