A MICROWAVE SCATTERING MODEL OF VEGETATED SURFACES BASED ON BOR/DDA AND NMM3D FOR SMAP MISSION

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1. ABSTRACT

In this paper, we present forward model of the microwave backscattering from a vegetated terrain at L band for application in the upcoming SMAP (Snow Moisture Active and Passive) mission. The objective of the SMAP mission is to provide global measurements of soil moisture and its freeze/thaw state [1]. These measurements will be used to enhance understanding of processes that link the water, energy and carbon cycles, and to extend the capabilities of weather and climate prediction models. One of the baseline retrieval algorithms of SMAP is snapshot algorithm which uses each radar acquisition independently to invert for soil moisture. The scattering properties of vegetation layer above the soil surface have a significant effect on the backscattering cross section in microwave remote sensing at L band [2]. The vegetated surface model includes a layer of cylinders and disks to represent the vegetation layer on top of the rough surface. The radar acquisition is sensitive to the vegetation water content (VWC) and physical structure of the vegetation. The physical-based forward scattering model is essential to understand the relationship between the vegetated surface and radar responses. The microwave scattering model in this paper is based on numerical solution of Maxwell equations using BOR and DDA for volume scattering and NMM3D (Numerical solution of Maxwell equations of 3D simulations) for rough surface scattering [3] [4].

We compared two types of the vegetation, grassland and corn field. Two shapes of scatterers, cylinders and disks are used to describe the physical structure. We followed the discrete scatterer model approach, which required the calculation of individual scatterer [5]. In this model, each scatterer is assumed to scatter independently. The total scattering cross section can be calculated through the addition of the single scattering of each component. In the past, the use of analytic method of infinite cylinder approximation was used for modeling scattering by cylinders. In this paper, the numerical solutions of Maxwell equations are solved for individual scatterers through discrete dipole approximation (DDA) and Body of Revolution (BOR) [6]. The advantage of using numerical method is the scattering dependence on radius and length of cylinder is seamless. The comparisons between the numerical simulation and analytical solution are illustrated.

For the layer of vegetation, distorted Born approximation is applied for the mean field calculation. The scattering cross section of the vegetation layer and its interaction with the underground soil surface were illustrated by half space Green's Function, which expressed explicitly as three scattering mechanisms. A) The direct volume scattering B) The double bounce effect as exhibited by rough surface effect on the interface of the vegetation layer and soil and C) The rough surface scattering of the soil. For double bounce effects and bare soil scattering, we used Numerical solution of Maxwell equations of 3 Dimensional simulations (NMM3D). The model predictions are compared with corn field experiment data collected from the SMAP mission.

We study the absolute values of backscattering of like-polarization and cross polarization. We also study 1) the ratio of the HH/VV 2) the cross polarization (HV). In the bare soil model, the HH/VV ratio is close to 1. However, due to the different distribution of the scatterers in the vegetation layer, the HH/VV ratio usually larger than the bare soil. On the other hand, the asymmetric structures of the vegetation scatterers contribute significant cross-polarization backscattering. The comparisons grassland and corn field are illustrated.

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