MODELING OF EMISSION FROM SNOW-COVERED GROUND FOR PASSIVE MICROWAVE REMOTE SENSING

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1. INTRODUCTION

Snow is an important variable in water resources, acting as the frozen storage term in the water balance. Characterizing regional snow cover patterns and atmospheric triggers to their accumulation and ablation is therefore significant given the important role that snow cover plays in global energy and water cycles. Passive microwave sensor has been used as a tool remotely acquire snow cover information because it has all weather imaging capabilities, rapid scene revisit time, and potentially the ability to derive quantitative estimates of snow water equivalent (SWE). Using accurate parametric model that relate snow layer emission to its physical properties, passive microwave remote sensing can provide useful information at large scale on snow cover characteristics for hydrological, climatic, and meteorological applications. The objective of this study is to investigate the effects of snow cover on soil emission through parametric modeling and filed measurements.

The paper is organized as follows: in the second section the snow emission model is described. The third section reported the sensitivity of different snow depth over soil surface using the DMRT_AIEM_MD model. The fourth part contained the snow pit measurements and the ground-based microwave radiometer at LSOS. And the final part showed the comparison of experimental result with the model, and then followed by the conclusion.

2. MODEL DESCRIPTION

The snow layer is modeled as a closely packed irregular inhomogeneous layer above a homogeneous half space. Specifically, the Dense Medium Radiative Transfer Model (DMRT) [1] is used to model emission from the snow layer; the rough soil and snow surfaces are modeled using the Advanced Integral Equation Model (AIEM)[2]; and the Matrix Doubling (MD) method[3,4], based on energy balance, is used to compute the combined emission and scattering effects of surfaces and volume.

3. MODEL SIMULATION AND SENSITIVITY ANALYSIS

Firstly, parametric sensitivity analyses of emission from ground with and without snow cover were conducted using DMRT_AIEM_MD model. Three snow conditions, including new accumulated snow with low depth, medium snow depth, and deep snow depth, were considered in the analyses. The brightness temperature simulated was carried out at the incidence angle of 55 deg and at three frequencies, 18.7 GHz, 36.5 GHz and 89.0 GHz.

4. THE SNOW PIT MEASUREMENTS AND THE MICROWAVE RADIOMETRIC DATA AT LSOS

Field measurements of emission from different snow accumulation stages were utilized to validate the model predictions. Microwave brightness temperatures at 18.7, 36.5, and 89 GHz were collected at the Local-Scale Observation Site (LSOS) of the NASA Cold-Land Processes Field Experiment in February, 2003 (third Intensive Observation Period) by the University of Tokyo's Ground Based Microwave Radiometer system (GBMR-7)[5]. The brightness temperature over the bare soil and new snow accumulation were observed by GBMR-7 at LSOS during Feb.19 –Feb.25, 2003. The incidence angle was set 55 deg, and the azimuth angle ranged from 270 to 290 deg. GBMR measurements were taken over ground with different snow cover thicknesses; first over ground with thick snow cover then over the layer as the snow was partially removed (in 4 steps). Emission from the bare soil surface was measured after the snow was completely removed. Also the snow pits close to GBMR were taken on Feb. 21, 25[6].

5. COMPARISON BETWEEN EXPERIMENTAL AND MODEL RESULTS

Next, based on the measured brightness temperature from ground with and without snow cover, we could see that the ground surface appears to be an electrically smooth surface and isotropic at 18.7 GHz (thus increasing the V and H separation, and almost azimuthally independent), but it behaves as a rough and non-isotropic surface at 36.5 GHz and 89 GHz. From the ground brightness temperature at 36.5 GHz, the surface seems to be rougher (or, more likely, with more scattering at the top soil layer) for azimuth at 275, 272, and 270 degrees. With snow cover, however, the layer seems to be electrically smoother as observed from 275, 272, and 270 degrees (larger separation of V and H). We used DMRT_AIEM_MD model to simulate and evaluate the above characteristics. Inputs to the model were averaged from LSOS GBMR snow pit measurements, although different averages were used for the lower frequencies vs. the highest one, due to the different penetration depths and to the stratigraphy of the snowpack. Mean snow particle radius was computed as a best-fit parameter. Results show that the model was able to reproduce satisfactorily brightness temperatures measured by GBMR-7. The values of the best-fit snow particle radii were found to fall within the range of values obtained by averaging the field-measured mean particle sizes for the three classes of small, medium and large grain sizes measured at the LSOS site.

6. CONCLUSION

In summary, we could characterize the snow emission behavior over soil surface through model simulation analysis and observation. For the LSOS measurements where the dry snow layer has small grain size and low density, the effects of snow cover on soil emission are negligible at 18.7 GHz but significant at 36.5 and 89 GHz.

7. REFERENCES

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