ESTIMATION OF SNOW WATER EQUIVELANT USING A PARAMETERIZED SNOW SCATTERING MODEL

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1. INTRODUCTION

Active microwave sensors, especially high-frequency radar systems, are highly sensitive to snow pack parameters, including Snow Water Equivalent (SWE), which is a crucial parameter in the studies of hydrology and climatology. For example, studies using Ku-band observations from scatterometer QuickSCAT and POLSCAT have shown significant radar backscattering responses on SWE variations. It has become an important objective to develop SWE inversion techniques for high-frequency radar systems, such as TerraSAR-X, QuickSCAT and a dual band, high-frequency (X- and Ku-Band) SAR system for the proposed mission Cold Regions Hydrology High-resolution Observatory (CoReH2O).

2. PARAMETERIZED SNOW SCATTERING MODEL

Theoretical snow scattering model has proved to be an effective tool to simulate snow backscattering on a variety of snow and soil conditions. For inversion problems, we developed a parameterized snow scattering model for X- and Ku-band radar observations [1], which can account for the multiple scattering effects inside snow layer at high-frequency radar observations and has a simple form similar to first-order radiative transfer model. The parameterization was carried out through regression techniques for snow volume scattering, ground scattering attenuated by snow and snow-ground interactions, respectively. The volume scattering component can be simply written as (1).

$$\begin{aligned} \sigma_{v\_pp} &= C_v \cdot 0.75 \cdot T_{pp}^2 \cdot \omega \cdot \mu \left[1-\exp(-2\tau/\mu)\right] \\ C_{v\_pp} &= m_1 + \exp(-\tau)\cdot m_2 \\ \log(\sigma_{v\_pq}) &= m_3 \cdot \exp(\log(\sigma_{v\_pp})/m_4) - m_5 \end{aligned} \quad (1)$$

3. SWE INVERSION TECHNIQUE

The SWE inversion technique is developed for dual band, high-frequency (X- and Ku-Band) SAR observations based on three steps. The first step in the SWE retrieval is to estimate snow volume scattering component from the total radar backscatter. This can be done from the analysis on depolarization factor – the ratio between cross-polarized backscatter and VV-polarized backscatter, which has been shown proportional to direct snow volume scattering [2]. Through the simulated database that was used in the snow model parameterization, we carried out the regression analyses and found that the volume scattering contributions can be expressed as a function of depolarization factor. The second step is to estimate snow optical thickness and single scattering albedo. It is noticed that direct snow volume scattering is a function of snow optical thickness and single scattering albedo only, as described in (1). Moreover, analysis has shown that snow scattering and extinction properties are highly correlated. Thus, the optical thickness and single scattering albeo of both X- and Ku-band can be estimated through (1) and the relationships between the two frequencies. In the third step, SWE is calculated through snow absorption optical thickness, which is linearly related to SWE.

4. VALIDATION

To validate the technique, simulated database and Ground-Based Synthetic Aperture Radar (GBSAR) measurements obtained from SARALPS-2007 field experiment were used. The estimated SWE is found to be well correlated with simulated/measured SWE with an acceptable accuracy.

5. REFERENCES

[1] Jinyang Du, J. Shi , "Development of A Parameterized Snow Scattering Model," Proc. 2007 IEEE International Geoscience and Remote Sensing Symposium (IGARSS'08), 2008.

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