FROZEN GROUND MONITORING USING PALSAR/ALOS DATA

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1. INTRODUCTION

Microwave remote sensing has shown proof of its effectiveness for frozen ground mapping due to the high difference of permittivity between frozen and unfrozen soil. However, the characterization of seasonal frozen ground still remains a problematic application. The Japan Aerospace Exploration Agency (JAXA) launched the Advanced Land Observing Satellite (ALOS) on the 24th of January 2006. This satellite has the Phased Array type L-Band Synthetic Aperture Radar (PALSAR) allowing fully polarimetric data acquisition. Furthermore, ALOS initial calibration phase has been achieved, showing good results for polarimetric calibration. Consequently, frozen ground characterization using PALSAR sensor is investigated in this paper.

2. AGREEMENT BETWEEN THE BARE SOIL BACKSCATTERING MODEL AND PALSAR DATA

Dealing with ground assessments, the necessity for a validated Electromagnetic model is of importance. That is why, a field experiment over unfrozen ground has been carried out in Alaska from July 25 to August 14, 2008. In parallel to a full-polarimetric PALSAR acquisition, soil moisture and soil roughness have been extensively measured by means of needle profiler and TDR (Time Domain Reflectometry) devices. As a preliminary but necessary step, a polarimetric EM model simulating the interaction between EM waves and ground surface is built based on the polarimetric Integral Equation Model [1]. First of all, its adequation with PALSAR data is assessed as follows.

Soil parameters such as the RMS surface height σ_s can be estimated by the polarimetric Oh's retrieval method [2]. Oh's method is based on a semi-empirical polarimetric backscattering model developed both with theoretical models (Integral Equation Model IEM and Geometrical Optics) and extensive database. From radar observations of VV, HH and VH, the direct model is inverted through an inversion diagram of 5 different equations resulting in the estimation of two parameters (σ_s and the soil moisture content Mv). The soil correlation length is then retrieved by the optimization of the IEM simulation regarding PALSAR measurements. Whatever the channel used in this optimization process, it seems that PALSAR data and IEM/Oh models are in very good agreement.

3. POLARIMETRIC STUDY OVER FROZEN GROUND

In order to estimate the polarimetric changes due to the cryosphere state, another test site was selected in the north of Hokkaido island, Japan. To avoid azimuth slope effect, and more generally, topographic effect on POLSAR, this test site matches a flat area covered by fields. Over this test site, eight fully polarimetric PALSAR data were acquired from May 2006 to February 2008. During the ALOS overpass on the 15th of February 2008, snow ground measurements were conducted within this test site indicating completely dry low-density snow pack over frozen soil. Following [3], frost depth is estimated to be equal to 14 cm. By using different polarimetric incoherent decomposition theorems, data acquired on the 15th of November 2007 show

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the lowest volume scattering contribution. At this date, no snowfall was measured by the Japan Meteorological Agency and the fields can be considered as "bare soil". This is in agreement with the sowing and harvest periods of this test site.

As expected, dry snowpack over frozen ground slightly affects polarimetric signature at L-band. It appears that backscattering coefficients of "snow with frozen ground" and "snow free" PALSAR data are relatively the same $\pm 1dB$. Consequently, a study on the polarimetric change due to dry snow cover is carried out. Different decomposition theorems (Freeman, Cloude-Pottier) are used in order to separate the effects of soil permittivity drop-off and snowpack density. Using the extracted eigenvalues [4], the entropy H and the anisotropy A12 indicate the statistical disorder of the scattering phenomenon, and the relative importance of the first two scattering mechanisms, respectively. It appears that the soil contribution is enhanced for "dry snow" cases. Furthermore, the mean parameters of the dominant scattering mechanisms such as $\overline{\alpha}$, $\overline{\beta}$, $\overline{\delta}$ or $\overline{\gamma}$ can be extracted from the coherency matrix. $\overline{\alpha}$ seems to be slightly dependent on snow presence. Over frozen fields covered by dry snow, other parameters such as pedestal height or scattered double-bounce power calculated by Freeman decomposition show particular behaviors too.

4. FROZEN GROUND CHARACTERIZATION

Finally, this study attempts to explain these polarimetric behaviors using the EM model previously validated in the first section. In this section, the snowpack is taken into account by considering an homogeneous layer which has refractive effects on the EM waves. As a result, the assumption that the aforementioned polarimetric modifications are only due to the modification of the soil permittivity between "snow free" (Nov. 2007) and "dry snow" (Feb. 2008) images seems to be dismissed. Snowpack slightly influences the EM signature at L-band.

In order to minimize the snowpack influence for a future soil inversion process, a combination of polarimetric parameters is found. By using these parameters and an adequate method, the residual liquid water content of frozen ground is finally retrieved. This method is based on the local optimization (Khi-2 statistics) between EM simulations and PALSAR measurements. The results are discussed and the method is applied over wider areas (Siberian plain).

5. CONCLUSION

This study tries to explore the capabilities of full-polarimetric PALSAR/ALOS data for frozen ground characterization. It appears that the EM backscattering over frozen ground at L-Band presents some interesting features, opening the way for the characterization of its residual liquid water content.

6. REFERENCES

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