SNOW COVER EFFECTS ON SAR INTERFEROGRAMS

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1. INTRODUCTION

SAR interferometric technique is used to measure earth surface's topography and movement. The theory is based on that SAR interferograms show differences of radar wave path length between a master and slave images. When the ground is covered with snow, equivalent path length in snow increases. If an image with snow cover is interfered with an image without it, interferometric phases due to snow cover are expected to appear. In this paper, a theoretical relationship between snow cover depth and interferometric phase is derived, and ALOS PALSAR interferograms are analyzed as a case study.

2. THEORY

Snow is a dielectric medium and a relative dielectric constant of dry snow is 1.4 to 2.0 [1]. When radar wave passes through snow, it is refracted following Snell's low.

$$\frac{\sin\theta_0}{\sin\theta_1} = \sqrt{\varepsilon_r} \qquad (1)$$

where θ_0 is incidence angle, θ_1 is refraction angle and ε_r is the relative dielectric constant of snow. In addition, radar wavelength in snow is

$$\lambda_s = \frac{\lambda_0}{\sqrt{\varepsilon_r}} \qquad (2)$$

where λ_0 is radar wavelength in air.

Fig. 1 shows geometry of radar wave ray. The interfeometric phase brought by snow cover becomes

$$\phi_d = 4\pi\left(\frac{l_1}{\lambda_s} - \frac{l_0}{\lambda_0}\right) = 4\pi\frac{\sqrt{\varepsilon_r} - \cos(\theta_0 - \theta_1)}{\lambda_0 \cos\theta_1} d \qquad (3)$$

where d is snow cover depth. From (3), dry snow cover of 1 meter depth brings 10 to 25 radian interferometric phase at 24 cm wavelength and 40 degree incidence. Here scattered wave at the ground under snow cover is expected to be received by the SAR. Dry snow is a low-loss medium, so that is the case.

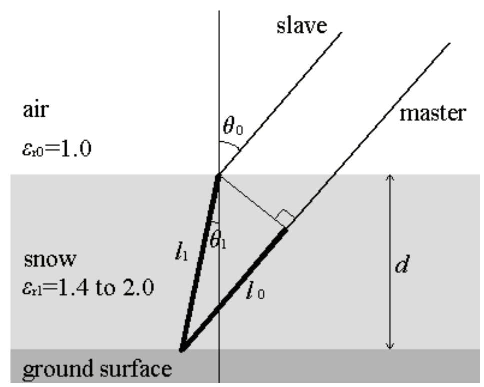

Fig. 1 Geometry of wave ray

3. CASE STUDY

ALOS PALSAR L-band interferograms over Hokkaido, Japan were analyzed. Three consecutive scenes acquired on 1 Feb 2008 and 3 May 2008 were interfered. Hokkaido is said to have dry snow in winter. During this period significant seismic and volcanic activities did not happen. All interferograms were flattened and topographic phases were removed. Interferometric phase was compared with measured snow depth at 13 ground stations of the Meteorological Agency of Japan. It is observed that snow cover degrades interferometric coherency particularly in mountainous areas, but in other areas the coherence is so moderate that phase values can be measured. Phase discontinuity or jump was sometimes detected in urban areas. One of possible reason is snow-removal in relevant areas. Fig. 2 is a derived relationship between measured snow depth and PALSAR interferometric phase. This result shows a good correlation between them (R=0.95) and the relative dielectric constant of snow cover is 1.7 on average. A perpendicular baseline component of these interferograms is about 800 m. Other analyses of different interferograms of the same region show a poor correlation in case of small snow cover or a longer baseline.

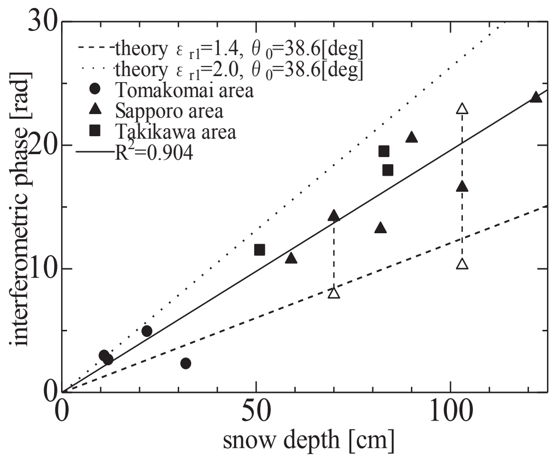

Fig. 2 Relation between measured snow depth and ALOS PALSAR interferometric phase.

REFERENCES

[1] F.T.Ulaby, R.K.Moore and A. K. Fung: MICROWAVE REMOTE SENSING ACTIVE AND PASSIVE VOLUME II, p.828, ARTECH HOUSE INC., 1982.