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Estimation of Snow Depth in Kushiro Area Using L-Band SAR Imagery

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Abstract

In this paper, snow depth in Kushiro area, the largest wetland in Japan, was estimated using L-Band SAR imagery. The SAR imagery can be used to observe land condition regardless of the weather condition. The accuracy of SAR however, is affected by topography or surface roughness. To remove the effects of topography or surface roughness, we applied the principal component analysis (PCA) to the SAR imagery. As a result, it was found that the proposed method could effectively estimate snow depth using SAR imagery because one principal component image of SAR calculated by PCA include the snow depth information without the effects of topography or surface roughness.

Key words: Principal component analysis, Remote sensing, Surface roughness

1. Introduction

Snow has both positive and negative impacts on ecosystem. On the one hand, it affects positively to water resources by adding itself when melted. On the other hand, it has negative effects to agriculture and forestry, and causes disasters such as avalanche. Nevertheless, it is an important factor of the ecosystem and climate most especially, when it comes to the natural vegetation in Japan. It is therefore, necessary to monitor the snow condition accurately.

Remote sensing technique is potentially an effective tool to estimate the snow cover and depth at synoptic scale. However, optical remotely sensed imagery in the visible and near infrared cannot observe the land condition under unfavorable weather conditions, particularly during cloudy days. Hence, a new methodology employing the use of SAR imagery is being proposed.

In this paper, the snow depth in Kushiro area, the largest wetland in Japan, was estimated using L-Band SAR imagery. The SAR imagery can observe the land condition regardless of the weather (Ulaby and Stiles, 1980). However, since SAR's accuracy is affected by topography or surface roughness, principal component analysis (PCA) was applied to the SAR imagery to improve the snow depth estimation.

2. Materials and Methods

The study area was the Kushiro area located in the eastern part of the Hokkaido region in Japan. The land is mainly composed of urban, agriculture, forest and wetland area. The mountain with forest is located at northern western part of the study area. The Kushiro wetland, which is located at southern part of the study area, is the largest wetland area in Japan with an area of 18,000 ha. Most of the wetland is covered with reeds and sedge grasses, while some parts are bog areas covered with sphagnum moss. The northern part of the wetland is covered with alder (Iwakuma, 1996).

In this study, two JERS-1 SAR (L-HH, 1.275GHz) images, were acquired on July 18, 1995 and January 10, 1996 (refer to Fig.1), and used to estimate the snow depth in Kushiro area. The spatial resolution of SAR images have been re-sampled to 12.5 m × 12.5 m. The study area images observed on January 10 was covered by dry snow. On the other hand, the image observed on July 18 wasn't covered by snow.

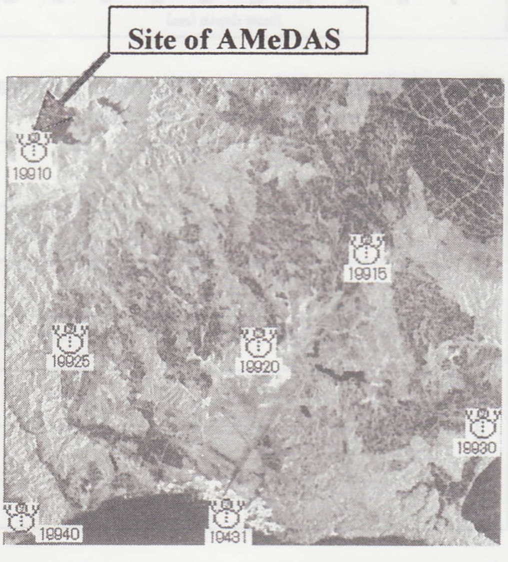

Fig. 1. JERS-1 SAR image acquired in Kushiro area on January 10, 1996. Seven sites of AMeDAS are shown in the image.

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To verify the snow depth estimated from JERS-1 SAR images, automated meteorological data acquisition system (AMeDAS) data set was used in this study. AMeDAS observes the precipitation automatically at about 1300 sites, which is located at every 17km × 17km in Japan. In these measurement points, there are about 200 sites that measure snow depth in the winter. In study area, seven sites in shown Fig.1. In this study, we used snow depth data of AMeDAS observed at 9 a.m. every day.

3. Results and Discussion

Figure 2 shows the relationship between the mean backscattering coefficients, which were calculated using 151 × 151pixels from image on January 10, and snow depth observed by AMeDAS data. Figure 3 shows the relationship between the mean backscattering coefficients of 151 × 151pixels calculated from the difference between the images, which were acquired under dry snow condition on January 10 and snow-free condition on July 18, and snow depth observed by AMeDAS data.

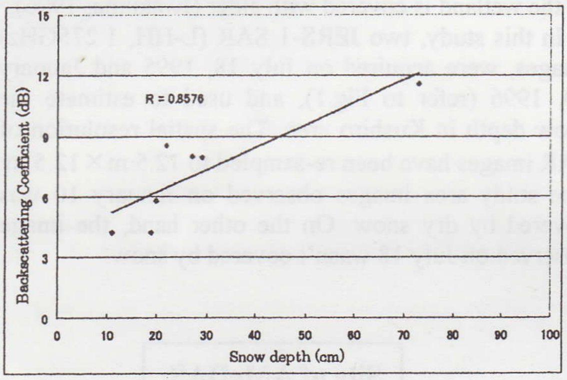

Fig. 2. Relationship between the mean backscattering coefficients and snow depth.

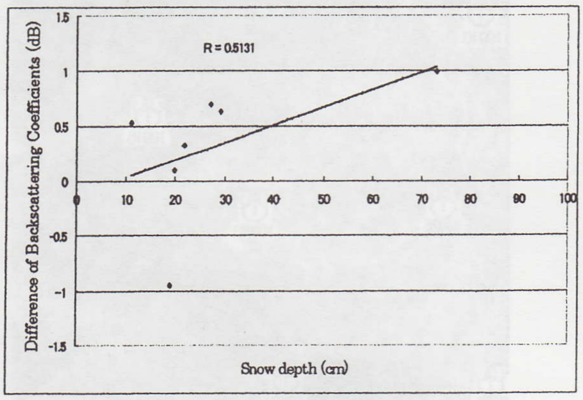

Fig. 3. Relationship between the difference of mean backscattering coefficients and snow depth.

In Fig.2, apparently, it can be observed that snow depth can be estimated by using mean backscattering coefficients observed in Kushiro area. Since, the backscattering signal is strongly affected by topography, it must be evaluated in order to estimate directly the snow depth from SAR images. In Fig.3, the difference between the images acquired under dry snow condition and snow-free condition was used to remove the effect of topography in Kushiro wetland. It was found out however, that snow depth cannot be estimated by the difference between the images. From these results, it can be said that the mean backscattering coefficients shown in Fig.1 have not expressed directly the snow depth. At any rate however, it was possible to estimate snow depth using the regression in Fig.1 which shows the indirect relation between snow depth and inclination of the landform. It is important to extract the direct signal of snow depth from the backscattering coefficients of SAR image, which contains the effect of surface roughness.

(a) First principal component image

(b) Second principal component image

Fig. 4. Images of first and second principal component value calculated by PCA.

To extract the direct signal of snow depth from the backscattering coefficients of SAR image, which contains the effect of surface roughness, we applied the principal component analysis (PCA) to the SAR imagery. PCA was applied to separate the information of snow depth and surface roughness using two SAR images which were acquired under dry snow condition on January 10,1996 and snow-free condition on July 18, 1996, respectively. Figure 4 shows the image of first principal component value and second principal component value calculated from images acquired under dry snow condition on January 10,1996 and snow-free condition on July 18, 1996.

From Fig.1 and Fig.4, it can be seen that the first principal component image is strongly dependent on the characteristics such as topography because the image is similar to original SAR image shown in Fig.1. The correlation coefficient was 0.963. Also, Fig.5 shows relationship between second principal component value and snow depth. Furthermore, Fig. 6 shows snow depth map in Kushiro area on January 10, 1996 estimated using a regression line shown in Fig.5.

From Fig 5 and Fig.6, it was found that snow depth can be estimated using second principal component image because the effect of surface roughness was removed in second principal component image, and the relationship between snow depth and the value of second principal component image. Therefore, a new method using second principal component image of PCA will be an effective technique to estimate snow depth in rugged mountain area.

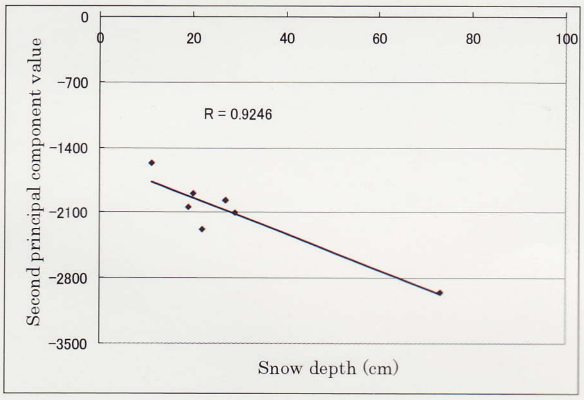

Fig. 5. Relationship between second principal component value and snow depth.

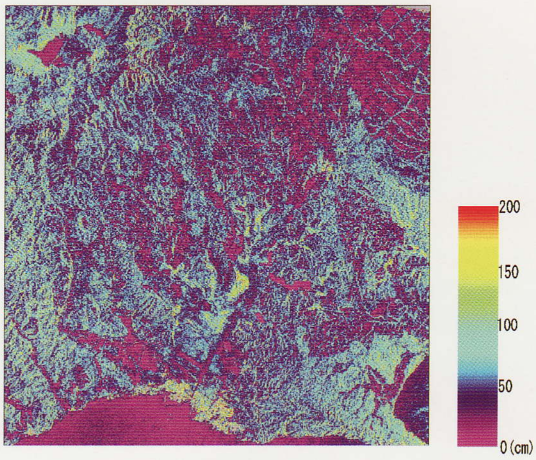

Fig. 6. Estimated snow depth map in Kushiro area on January 10, 1996.

References

Iwakuma, T., 1996: Mires of Japan: Environment of Kushiro Mire. *Nat Insti Environ Stud, Jpn.* 99-104.

Ulaby,F.T. and Stiles W. H., 1980: The Active and Passive Microwave Response to Snow Parameters. 2. Water Equivalent of Dry Snow. *J Geophys Res.*, **85**(C2), 1045-1049.