Satellite observations of snow cover, melting and property changes over Alaska

Shizuka KIMURA[1], Hiroyuki ENOMOTO[1], Tomonori TANIKAWA[1], Ryo TOSHIRO[1], Yongwon KIM[2], and Yoshihiko SAITO[3]

1: Kitami Institute of Technology, Japan

2: International Arctic Research Center/University of Alaska Fairbanks, USA

3: Yukiken Snow Eaters Company, Japan

1. Introduction

Satellite-based snow-hydrologic information can be used to solve the problems; water resources, environmental problems, and climate changes. Since polar region is sensitive to climate changes, we monitored the snow cover and the melting of snow in Alaska using satellite passive microwave data and snow algorithms, and compared these results with ground-truth data.

2. Data

2-1 Satellite data

The snow cover and the melting of snow were estimated using Aqua/AMSR-E brightness temperatures observed twice a day (daytime and nighttime). The satellite data were used in the two seasons from July 2004 to May 2006.

2-2 Ground-truth data

(1) Temperature data at Tundra and Boreal forest sites

To know the timing of the snow accumulation, the temperature sensors from ground to the height of 5 cm, 20 cm, 40 cm and 100 cm were set at Tundra and Boreal forest sites (Fig.1). When the sensor was covered with the snow, we used the temperature change to extract the timing of the snow accumulation.

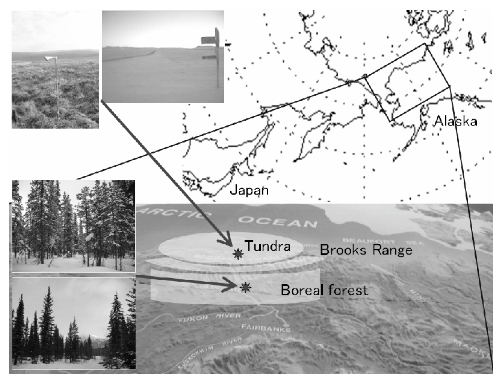

Figure 1 Map showing the location of validation sites in northern Alaska.

(2) Snow depth data at Wiseman, Tundra and Boreal forest sites

Wiseman site is located in the Boreal forest. In this site, snow depth data observed at 20:00 LT have been stored since 1999.

For Tundra and Boreal forest sites, we measured the snow parameters (snow depth, density, grain size, snow characteristics) along the Dalton Highway every 20 miles in January 2005 and February 2006.

3. Algorithms

To estimate the snow cover, we used snow depth retrieval algorithm (Chang *et al.*, 1987) as follows:

$$SD = a\,\Delta TB,$$

where SD is snow depth [cm], a=1.59 [cm/K] and it corresponds to the snow of grain radius of 0.3 [mm] and snow density of 300 [kg/m^3]. The ΔTB is the difference in brightness temperature between 19 GHz and 37 GHz channels (horizontal polarization). This model works well under the non-complex snow conditions (flat land, no significant forest cover, single layer dry snow).

For the estimation of melting of snow, we used diurnal amplitude validations (DAV) (Ramage and Isacks, 2002) as follows:

$$DAV = \Delta TB,$$

where ΔTB is the difference in brightness temperature [K] between daily and night of 37 GHz channels (vertical polarization). DAV>10 K is considered to be a melting of snow.

4. Result of discussion

4-1 Snow cover

Figure 2 showed seasonal change of snow distribution in Alaska using the snow depth retrieval algorithm. The snow covered area increased gradually from the north, and it became the maximum in February. After that, the snow covered area decreases gradually from the south in April.

Figure 3 show the comparison of estimated snow depth and in-situ measured one at Wiseman-site in the Boreal forest. The estimated snow depth was lower than the in-situ measured one, and its difference increased with increasing snow depth. This is because Wiseman-site is in the forest which has the effect of increasing the brightness temperature. Therefore, the forest affects the snow depth retrieval in the algorithm.

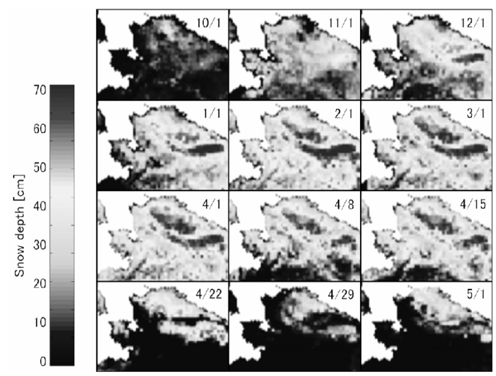

Figure 2 Season change of snow-cover distribution in 2005.

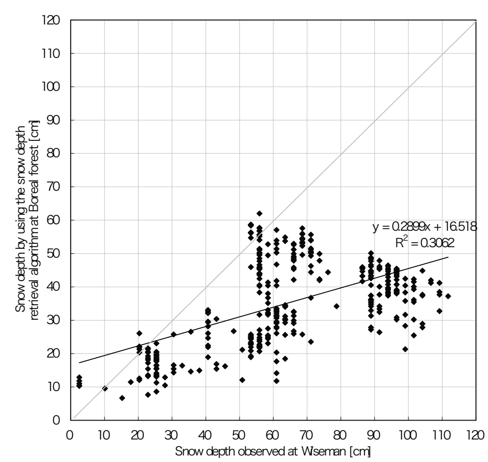

Figure 3 Comparison of snow depth for two winter season in 2005 and 2006.

4-2 Snow-melting

The seasonal change of snow-melting distribution in Alaska using DAV was able to be caught as well as snow distribution (not shown in this paper).

Figure 4 shows the comparison of DAV and in-situ measured temperature at Tundra and Boreal forest sites. DAV estimated the start of snow-melting at 22 April in Tundra-site. This result agreed with the temperature very well. However, it could be difficult to estimate the melting of snow clearly at Boreal forest because the change of DAV is not remarkable.

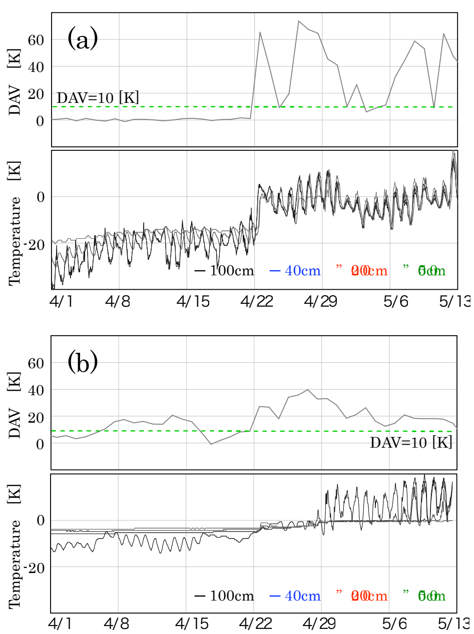

Figure 4 Comparison of DAV and ground-truth temperature data in 2005, (a) Tundra and (b) Boreal forest sites.

5. Summary

We monitored the distribution of the snow cover and the melting of snow in Alaska using the Aqua/AMSR-E data, and showed the seasonal change of the snow cover and the melting of snow from July 2004 to May 2005. The snow increases gradually from the north, and it becomes the maximum in February. The snow decreases gradually from the south in April. In the comparison with ground-truth data, the estimated snow depth was underestimated at Boreal forest site. This is because the forest cover affects snow depth retrieval algorithm. The detection of the melt using DAV was consistent with ground-truth data at Tundra site. But it could be difficult to estimate the melting of snow at Boreal forest. The consideration of the effect of the forest on the snow retrieval algorithm is necessary for detecting the snow cover and the melting of snow.

References

Chang, A.T.C. and R. Kelly, 1998: Description of snow depth retrieval algorithm for ADEOSII AMSR. Annals of Glaciology 9, 39-44

Ramage, J.M. and B.L. Isacks, 2002: Determination of melt-onset and refreeze timing on southeast Alaskan icefields using SSM/I diurnal amplitude variations. Annals of Glaciology 34, 391-398