RADIOMETRIC OBSERVATION OF SNOWPACK BY MOS-1

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1. Introduction

Snowpack observation over a extensive region by passive microwave sensors mounting on orbital satellite was started in the 1970's. Many investigations to verify the availabilities has been conducted in U.S.A. and Canada. However, it had been in question to consider that the same discussion was certainly possible in such islands as having complex configuration of the ground.

MOS-1 and MOS-1b are the Japanese earth observation satellites launched in 1987 and 1990 respectively. Two Microwave Scanning Radiometer (MSR) at the frequency of 23.8 GHz and 31.4 GHz are mounted on them. Using the data obtained by MSR, the authors have made analyses of relation between the brightness temperature and snowpack parameters in Hokkaido, Japan[1][2][3].

In this paper, some of the results obtained from the verification for snowpack parameters to the brightness temperature observed by MSR mounted on the orbital satellites and an airplane, are presented, and several discussions for the results are also reported.

2. Analyses of the satellite data

The data set of MSR onboading MOS-1 or MOS-1b were collected from the snow seasons of 1987-88, 1988-89, 1989-90 and 1990-91 over Hokkaido island, where thick snowpack covers in winter time. One of examples of brightness temperature obtained is shown in Fig. 1. Whole area of Hokkaido island is covered with about 90 and 200 pixels, having 32 x 32 km^2 for 23.8 GHz and 23 x 23 km^2 for 31.4 GHz respectively.

The ground truth data of snowpack were collected by AMeDAS stations which were scattered all over the area, as shown in Fig. 2. Relation between the brightness temperature at the frequency of 23.8 GHz and 31.4 GHz, and the corresponding snow depth, obtained by AMeDAS stations are shown in Fig. 3.

As is clear from Fig. 3, the brightness temperature of coastal region, marked by (▲), are lower than those of inland areas, marked by (●). The reason of that might be the contamination by lower brightness temperature of the sea, depending on the areal ratio of sea and land in the pixel and also coarse spatial resolution. So that, for analyses of the correlation between MSR brightness temperature and AMeDAS snow depth, the data of coastal region were excluded.

The data set of the brightness temperature of inland area had a good inverse relation. Results obtained are shown in Table 1. As is clear from the table, the slopes of the regression lines changed with time of the season. These changes were reflecting the snow characteristics such as grain size, metamorphoses and layering within the snowpack.

3. Analyses of the airborne data

The NASDA airborne verification experiment carried out in Hokkaido area, on Feb. 9-10, in 1988. The MSR data obtained had a good spatial resolution of 360 m for 23.8 GHz and 260 m for 31.4 GHz respectively. Two flight routes, which covered different terrains, were analysed. The snowpack characteristics along the flight route such as depth, grain size, layering and so on were observed at the same time with those flight.

The flight route from Iwamisawa to Sapporo crossed flat plane of rice-fields and pasture lands, where thick snowpack covered them. The western part of the flight route was covered by the fresh snow layer(case 1), whereas the eastern part of the route was not covered by that layer and kept with old snowpack surface(case 2). The correlation between the snow depth and the brightness temperature is different in each case, as shown in Table 2.

The slope of regression lines depended on the stratification of the snowpack having various grain sizes and also observed frequencies. In case 2 of the Table 2, the slopes of regression line became negative and changed with observed frequencies. On the other hand, as seen in case 1 of the Table 2, when the snowpack covered with fresh snow layer, having a fairly small gain size and low density, the slopes of regression line were positive and did not change with observed frequencies.

The flight route from Asahigawa to Nayoro crossed mountain regions, mainly covered with forest.

Though a significant correlation was not found between the brightness temperature and the depth of the snowpack, the MSR brightness temperature showed a remarkable change with the elevation of the terrain as shown in Fig. 4.

These results showed that the MSR brightness temperature obtained had a strong sensitivity not only for snow characteristics such as depth, grain size and layering of the snowpack but also for the topography of the terrain.

4. Discussion

Our results might be indicated that the received microwaves by MSR mounted on the satellites are mainly radiated from unfrozen ground, and attenuated exponentially within the snowpack, so that, the received microwave has inverse proportional to the thickness of the snowpack.

The snowpack parameters such as stratification, density, grain size and so on, have an important roll on the radiative characteristics and also affect the brightness temperature of the snowpack. The results obtained so far show a strong sensitivity for the thickness of snowpack, however, do not indicate remarkable differences due to the characteristics, that is, such differences are included within the deviation of regression lines, so far as the spatial resolution remains at the present stage.

These results indicate that, at the present stage, the remote sensing of the snowpack by MSR mounting on satellite has an availability for the macroscopic estimation of seasonal and annual snowcover such a vast extent as Hokkaido, though the precise analyses on the effects such as snowpack, terrain, forest, and so forth should be needed together with improvement in the spatial resolution.

References

[1] M. Suzuki, et al.,"Snow observation by microwave scanning radiometer", ISAP '89, vol. 4, pp. 1049-1052 (1989).

[2] K. Fujino, et al., "Microwave remote sensing of snowpack by MOS-1", IGARSS '90, pp. 1145-1148 (1990).

[3] K. Fujino, et al., "Microwave signatures from snowpack", IGARSS '91, pp. 1959-1960 (1991).

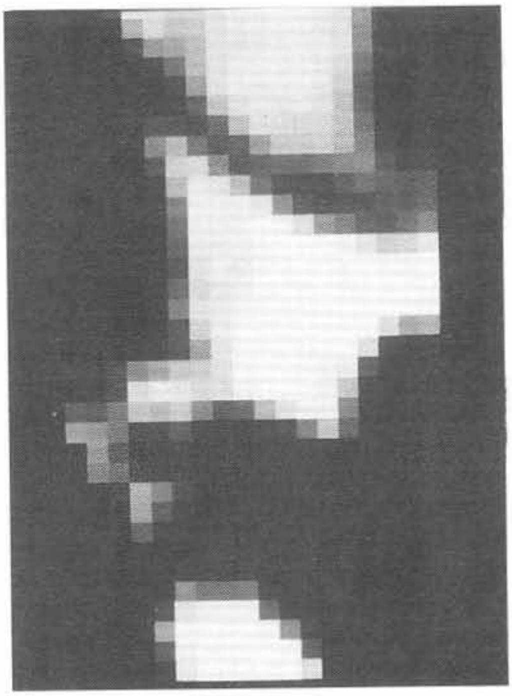
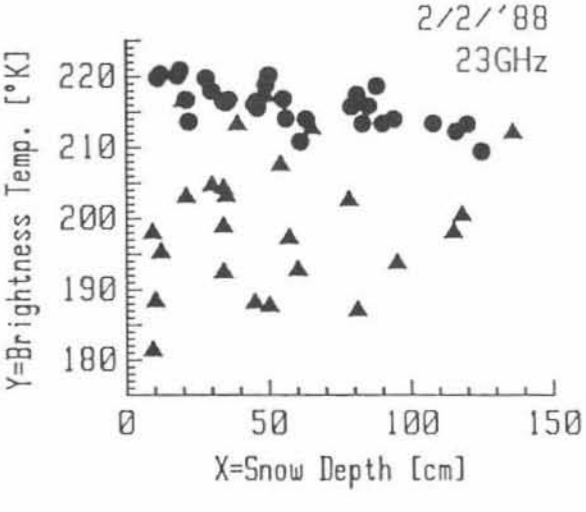
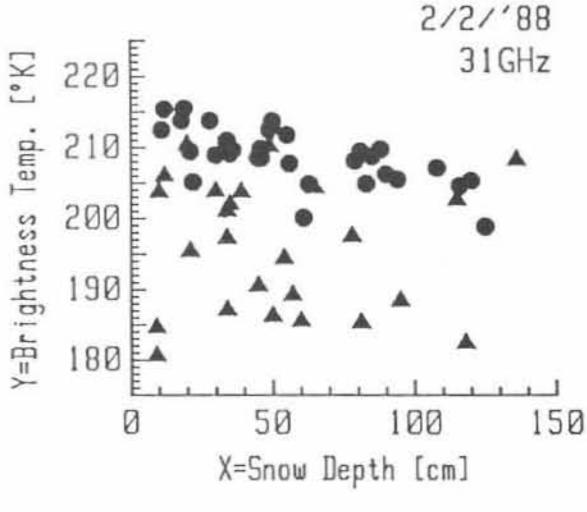


Fig. 1. Image of MSR.
(23.8 GHz)

Fig. 2. Locations of AMeDAS stations
in Hokkaido.



(a) 23.8 GHz



(b) 31.4 GHz

Fig. 3. Relation between AMeDAS snow depth
and MSR brightness temperature.

Table 1. Regression lines between AMeDAS snow depth (X) and MSR brightness temperature (Y) obtained by the satellites.

Date	23.8 GHz	31.4 GHz
2/ 2/88	Y=219.6−0.061X	Y=213.2−0.078X
2/ 9/88	Y=215.7−0.089X	Y=209.0−0.059X
2/19/88	Y=214.9−0.024X	Y=207.2−0.015X
3/15/88	Y=224.0−0.026X	Y=219.3−0.019X
12/28/88	Y=212.6−0.035X	Y=209.5−0.023X
1/14/89	Y=212.5−0.061X	Y=207.8−0.057X
2/26/90	Y=218.8−0.093X	Y=214.8−0.177X
3/15/90	Y=220.4−0.028X	Y=216.0−0.025X
1/ 8/91	Y=213.1−0.048X	Y=216.6−0.052X
2/27/91	Y=210.3−0.086X	Y=213.4−0.052X

Table 2. Regression lines between observed snow depth (X) and MSR brightness temperature (Y) obtained in the airborne verification.

frequency	case 1	case 2
23.8 GHz	Y=201.5+0.246X	Y=225.3−0.069X
31.4 GHz	Y=187.6+0.245X	Y=215.8−0.122X

(Case 1: Covered with fresh snow layer. Case 2: Old snow surface.)

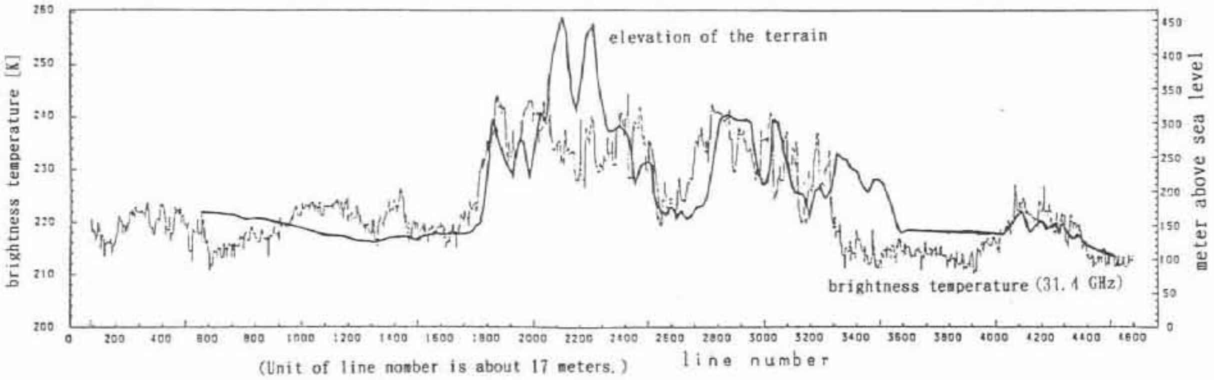


Fig. 4. Relation between elevation of the terrain and MSR brightness temperature obtained in the airborne verification.