SNOW OBSERVATION BY MICROWAVE SCANNING RADIOMETER

Masahiro SUZUKI, Masami SASAKI, Tadashi MATSUMOTO
Hokkaido Institute of Technology
419-2, Teine-Maeda, Nishi-ku, Sapporo 006

Kazuo FUJINO
I.L.T.S., Hokkaido University
Kita-19, Nishi-8, Kita-ku, Sapporo 060

Takeo ABE
Niigata University
8050, Igarashi-Ninomachi, Niigata 950-21

1. Introduction

The Marine Observation Satellite (MOS) - 1 is the first Japanese earth observation satellite launched in February 1987. This satellite has the Microwave Scanning Radiometer (MSR) as a passive microwave sensor with other two optical sensors [1].

Microwave remote sensing from space has a great potential for monitoring large scale snowcovered areas in a short time and also for obtaining depth/ water equivalent and other physical properties of snowpack. However, there are many ambiguities for making the interpretation of the data obtained by the MSR.

MOS-1 airborne verification program for snowpack was planed by National Space Development Agency (NASDA) of Japan and conducted on February 9 and 10 in 1988, at the central part of Hokkaido, synchronised passing orbital sensors of MOS-1 over Hokkaido area. Several field experiments were carried out at the same time, as a part of this program, for obtaining ground truth data of snowpack in the area.

In this report, some of the results obtained for the correlation between the brightness temperature measured by MSR and the physical parameters of snowpack including snow depth measured in situ are discussed.

2. Field experiments

Several flights were carried out by an aircraft mounting MSR in the area. Among them, one route from Iwamizawa to Sapporo, the distance between them is about 40 km, was selected for this analyses. Seven test sites were set along the flight route at appropriate intervals. Snowpack parameters such as density, temperature profiles, snow depth, stratigraphy and so forth were measured at each site using pit digged in the snowpack. Snowpack parameters obtained in each site were shown in Fig.1.

Remarkable difference in snowpack parameters, especially in stratigraphic feature, was observed in each site along the route. That was caused by the followings, a small cyclone invaded from Ishikari Bay, brought about a heavy snow fall around the Bay few hours before the flight of 10th of February. New snow layer formed by that snow storm and the snowpack around the bay, west side of the site 3, covered by that new snow layer.

Near the site 1, continuous observations of the microwave property and stratigraphic features of the snowpack were carried out using an FM-CW radar with frequency 6-12 GHz [2].

3. Analyses of the data obtained by MSR mounted on aircraft and MOS-1

Cruising altitude of the aircraft mounting MSR along the route was 5000 m. So that, the received microwave radiation at the frequency of 31 GHz by the MSR covers circular area with the diameter of about 260 m and scans with the swath width of about 1.7 km on the ground. An aerial view along the flight route composed of the data of MSR is shown in Fig.2.

The measured values are containing contributions not only from the snowpack but also from various objects such as highway, rail roads, forests and farm houses existing in the area. So that, it is almost impossible to separate the contribution of the snowpack from those of other objects.

As the first approximation, the radiation from snowpack is assumed the lowest among the objects existing in the area and the minimum values of the brightness temperature on the transverse line to the flight route are selected for those of snowpack, as shown in Fig.3.

The snow depth measured in each site along the flight route are plotted against the brightness temperature of each point. The results obtained are shown in Fig.4A and those of the water equivalent versus brightness temperature are also shown in Fig.4B. As is clear from figures, correlation between them are fairly well except the points covered by new snow layer. The slopes of the regression lines for the snowpack without new snow layer are negative. However, those for the snowpack with new snow layer seem to be inverted. This might be caused from body scattering of new snow layer which has a fairly low density [3].

The data of brightness temperature measured by MSR mounting on MOS-1 which are provided from NASDA are also shown a fairly good correlation with snow depth, as shown in Fig.5. Seasonal variations of brightness temperature are shown in Fig.6. These variations are also caused by snow depth and snow extent in the area.

4. Conclusion

Analyses have been conducted to related snowpack parameters to the microwave radiometric observations made by aircraft and orbiting sensors (MOS-1).

A comparison between ground truth data and data obtained by MSR for snowpack was made and the following is concluded:

1) The brightness temperature obtained by MSR exhibits a remarkable sensitivity to snow depth and water equivalent of snowpack.

2) Snow depth/water equivalent and the brightness temperature obtained by MSR are correlated with regression line of a negative slope. However, when the snowpack covered with new snow layer, the slope of regression line is inverted.

3) The seasonal variations in the brightness temperature obtained by MSR on MOS-1 are correlated with those of snowpack in the area.

Acknowledgment

This study has been done under the MOS-1 Verification Program conducted by NASDA.

References

[1] H. Sato and K. Maeda (ed.), "The second symposium on MOS-1 verification program (MVP)", Earth observation center, NASDA of Japan (1988).

[2] M. Sasaki, et al., "An experimental system to measure the microwave property of snowpack over a long time", Papers of Tech. Group IEICE, Japan (in Japanese), AP 88-14, pp.29-36 (1988).

[3] F. T. Ulaby, "Snow observations by microwave sensors", First Japan/US Snow and Evaportranspiration Workshop (1982).

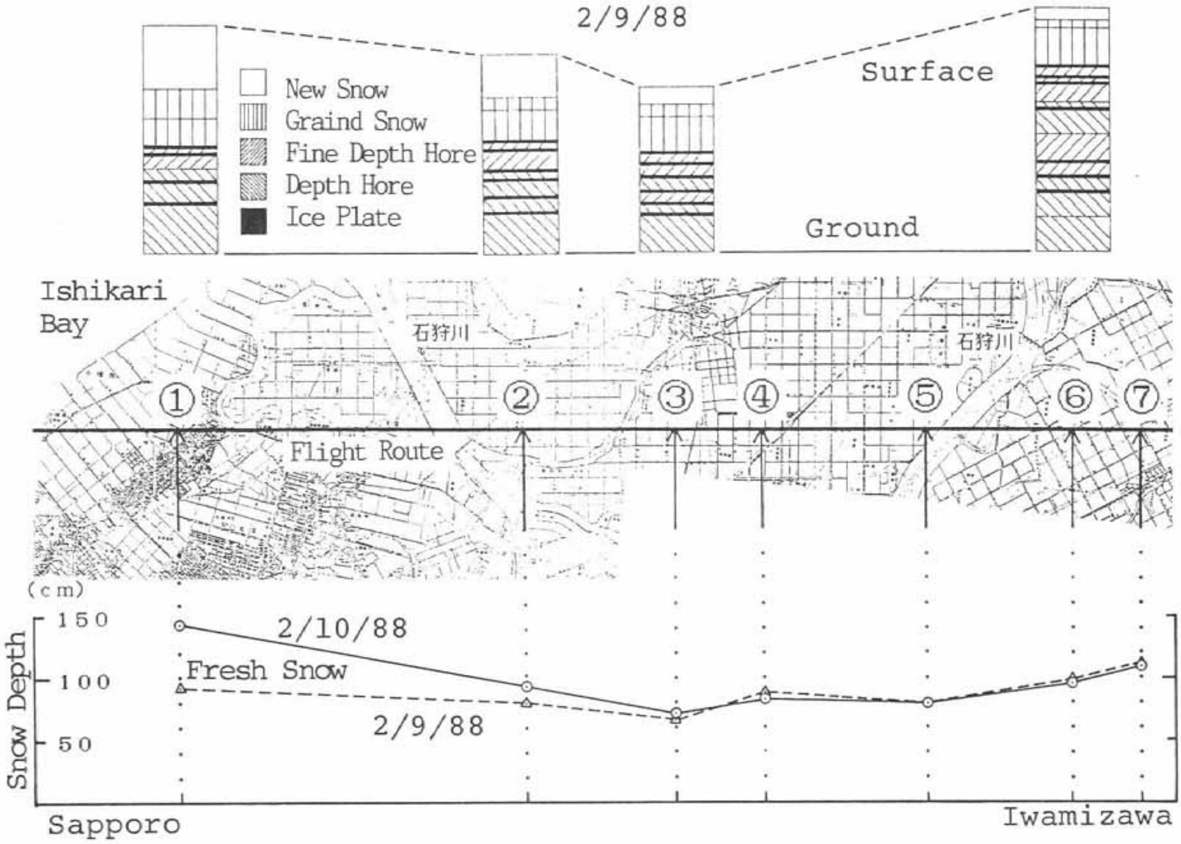


Fig. 1. Physical parameters in snowpack at the test sites along the flight route from Iwamizawa to Sapporo.

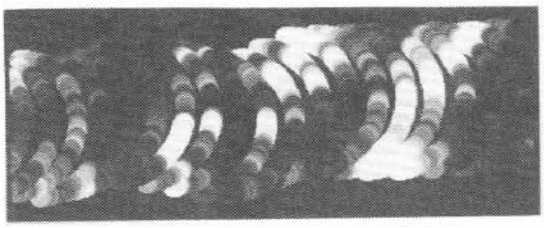


Fig. 2. An aerial view along the flight route composed of the data of MSR.

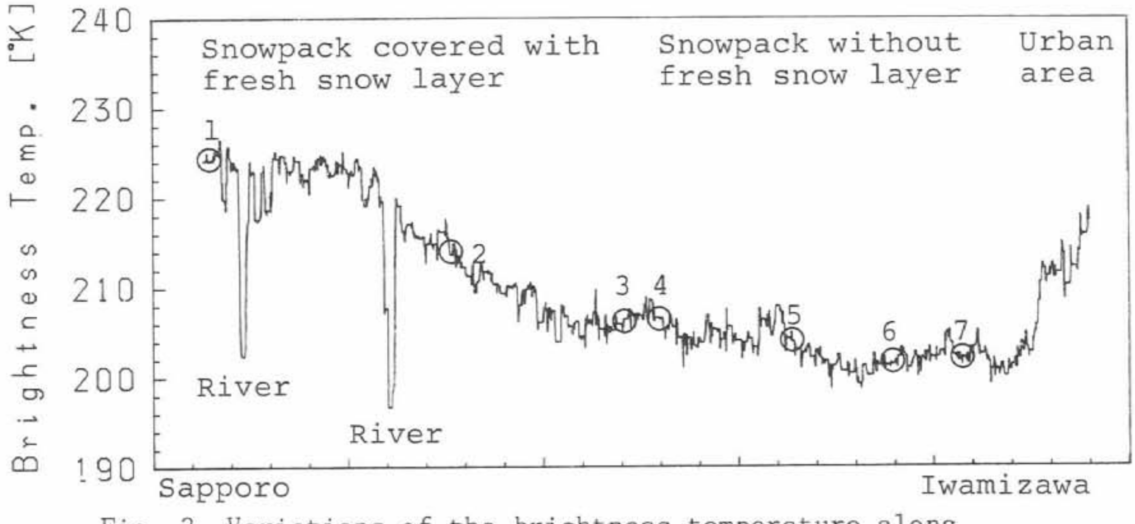
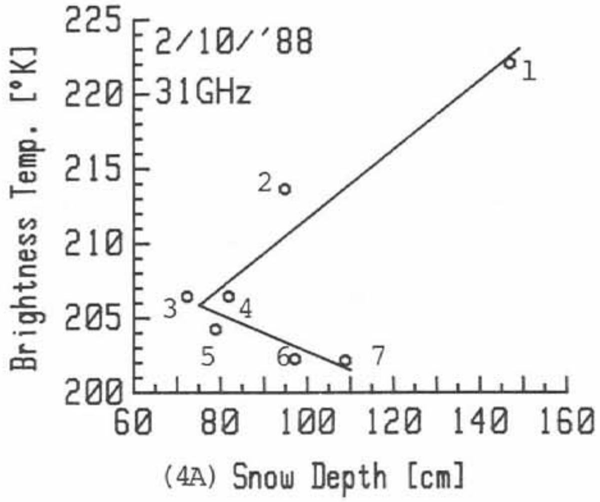


Fig. 3. Variations of the brightness temperature along the flight route.



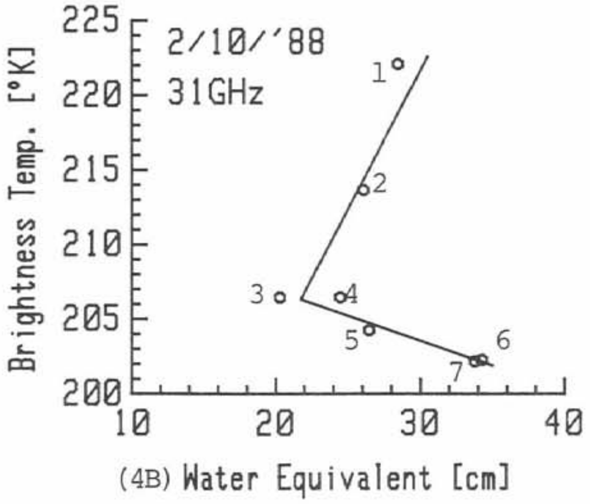


Fig. 4A. Snow depth versus brightness temperatue.
Fig. 4B. Water equivalent versus brightness temperature.

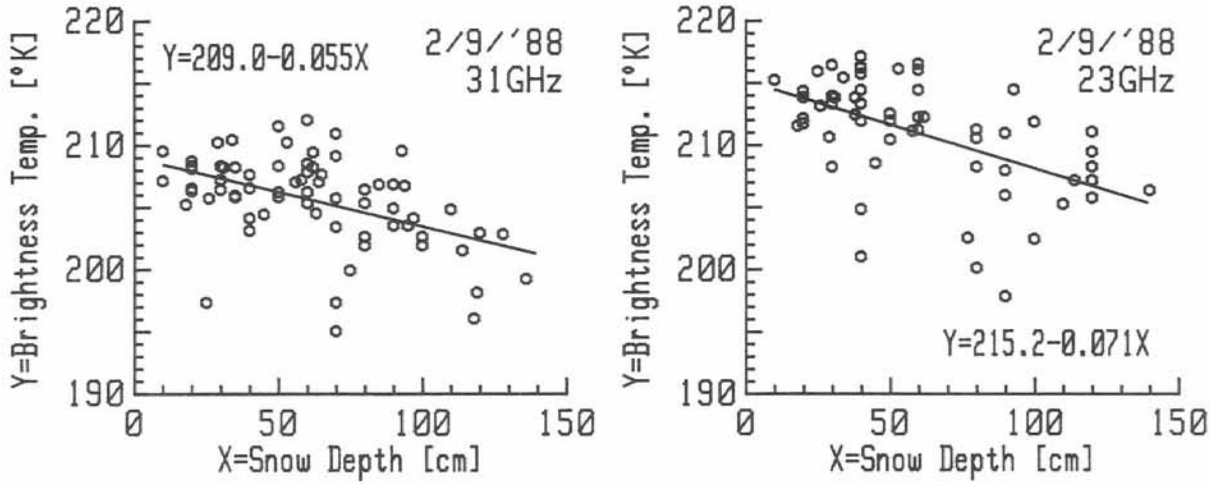


Fig. 5. Correlation between snow depth and brightness temperature over Hokkaido area.

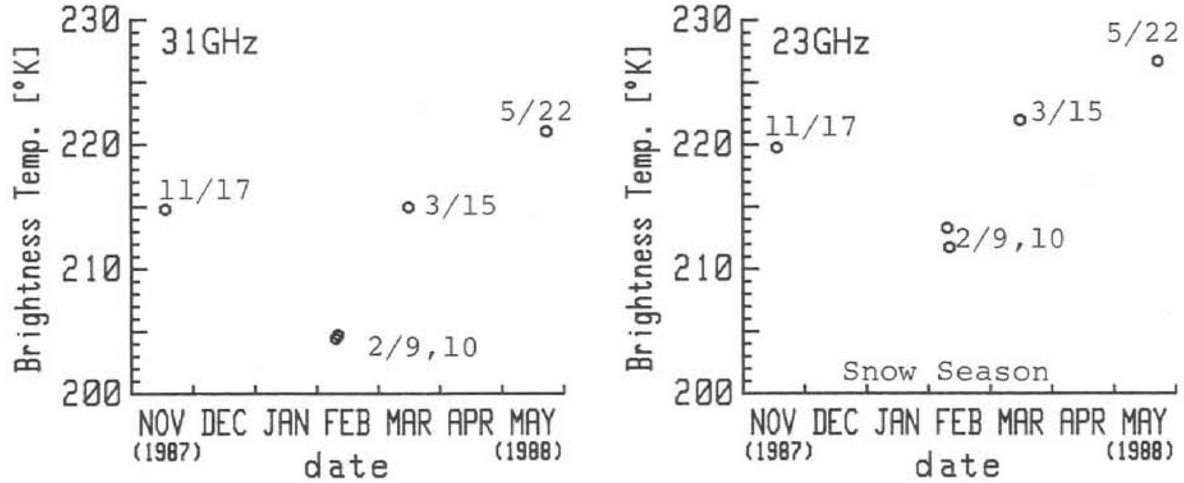


Fig. 6. Seasonal variations of average brightness temperature in Hokkaido.