ANALYSIS OF NIMBUS-7 SMMR DATA*

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ABSTRACT

The brightness temperature obtained with SMMR of NIMBUS-7 over snow field of Hokkaido, one of the four major islands of Japan located in the north indicates the following features. (1) The relationship between snow depth and brightness temperature changes when snow depth becomes deeper than 50 cm. (2) Average brightness temperature of the daytime indicates negative correlations with snow depth except 6.6 GHz channel data which indicates weak positive correlation.

INTRODUCTION

It has been reported that NIMBUS-7 SMMR data are applicable to the study of snow [1,2]. As a part of Japan/US cooperative study on snow properties, SMMR data have been analyzed with an objective to find out the applicability to a comparatively small area, such as Hokkaido, one of the 4 major islands of Japan located in the north. The result of the analysis is described in the following sections.

SMMR DATA USED IN THE STUDY

Three types of SMMR data are analyzed, one is the average brightness temperature of day and nighttime passes. The others are the average daytime brightness temperature and the average night-time brightness temperature. The time of the data are February 1979, March 1979, February 1980, March 1980 and March 1981.

Since the IFOV of SMMR is fairly large, Hokkaido is divided into the subareas consisting of 0.5 degrees of latitude and 0.5 degrees of longitude as is indicated in Fig. 1 (a). As ground truth data, snow and meteorological data are collected from 178 observing stations among them 95 are in the subareas. Based on the snow depth data the average snow depth for each subarea is computed and used in the analyses. For the sake of simplicity the term ''average'' will be dropped hereafter and referred to simple as ''the snow depth''. There is at leat 1 station in such subarea except subarea 20 for which average snow depth was extrapolated. An example of the snow depth distribution map on March 4, 1981 is indicated in Fig. 1 (b) in the unit of cm.

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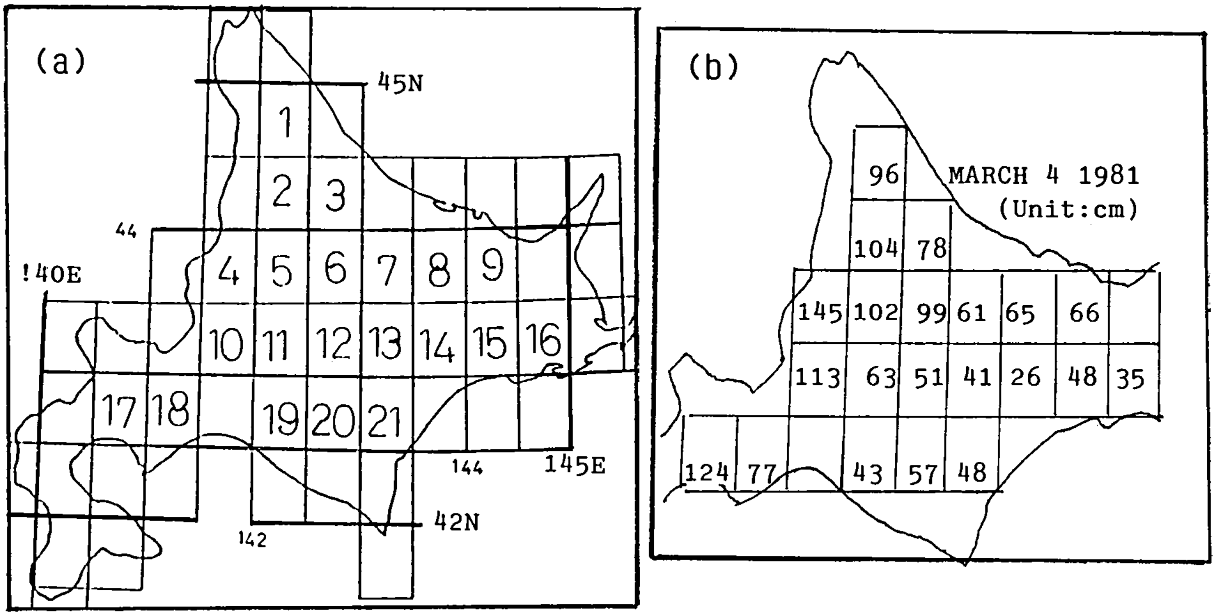


Figure 1. (a) Subareas and Their Number for the Study Area, Hokkaido and (b) Average Snow Depth (cm) on March 4, 1981.

THE RESULT OF THE ANALYSES

Relationship between the snow depth and average brightness temperature of day and nighttime on March 4, 1981 is shown in Fig. 2 for 6.6, 18 and 37 GHz respectively in which due to the limitation of the field of view of SMMR only eastern half of Hokkaido is included.

In the figure it can be seen that there are two clusters, i.e. one is the group with more than 50 cm snow depth while the other is characterized with that less than 50 cm snow depth. The latter indicates a negative correlation between the two. It is found that the latter case is for the subareas located in the plain snow field while the former is for the mountainous subareas.

To differentiate the day and nighttime brightness temperature vs snow depth relationship, Fig. 3 is made. Fig. 3 is the relationship between the brightness temperature and snow depth for the subareas of 14, 15, 16 and 21 which are plain areas. It can be seen that 37 GHz horizontally polarized brightness temperature versus snow depth has a negative correlation, however this feature is not so clear in the rest of the channels. It should be added the average maximum temperature for all the subareas was below freezing point, which indicates the snow was dry condition.

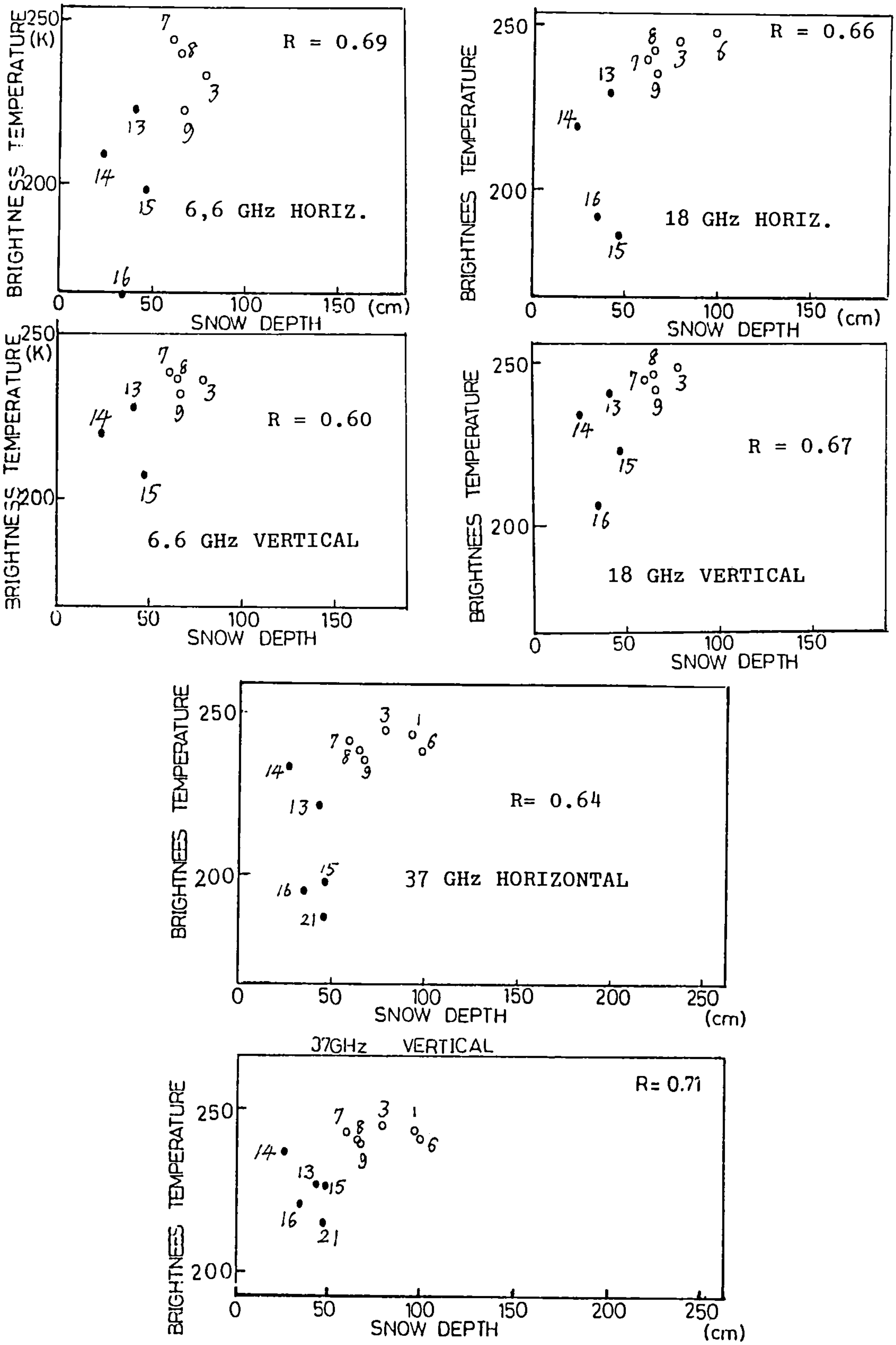


Figure 2. Relationship Between the Snow Depth and Average Brightness Temperature of the Day and Night Passes. March 4, 1981. Numerals are Subarea Number. R is Correlation Coefficient.

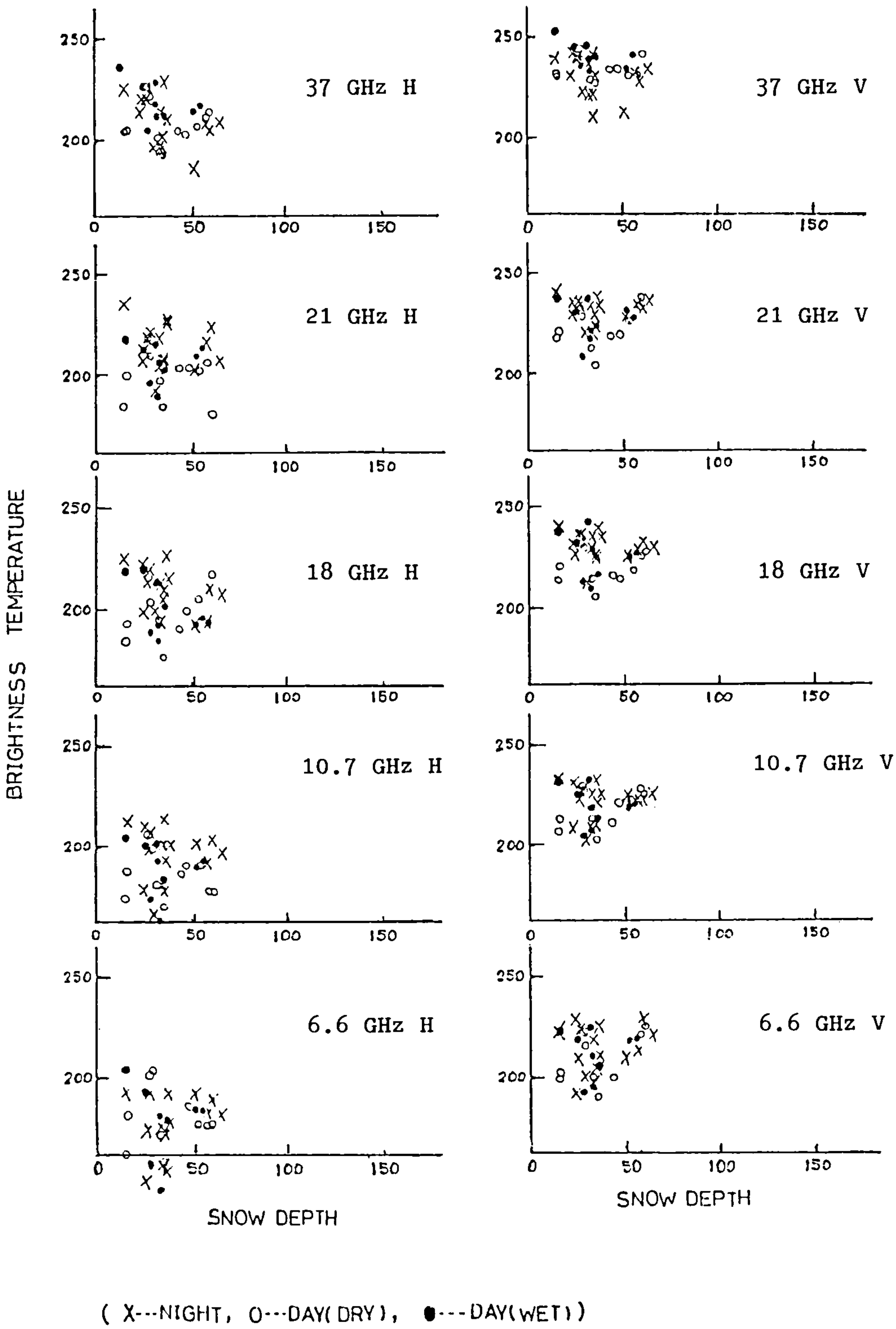


Figure 3. Relationship Between Brightness Temperature and the Snow Depth for the Subareas 14, 15 16 and 21.

The relationship between the snow depth and the daytime average brightness temperature is shown in Fig. 4 for the study period of Feb. 1979. In the figure existence of weak positive correlation is recognized in the lower frequency below 50 cm snow depth which is against a common understanding on the relationship between the two.

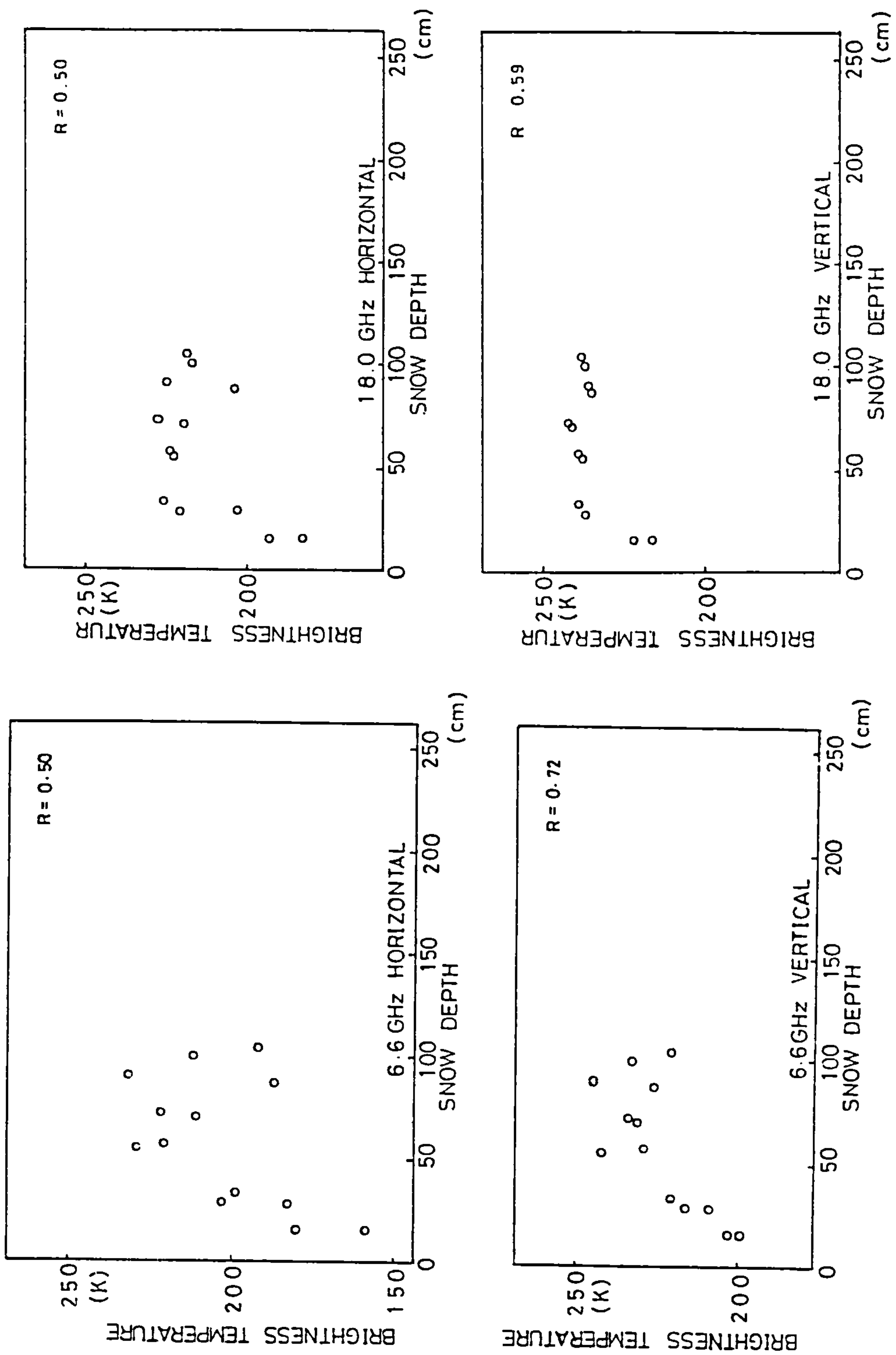
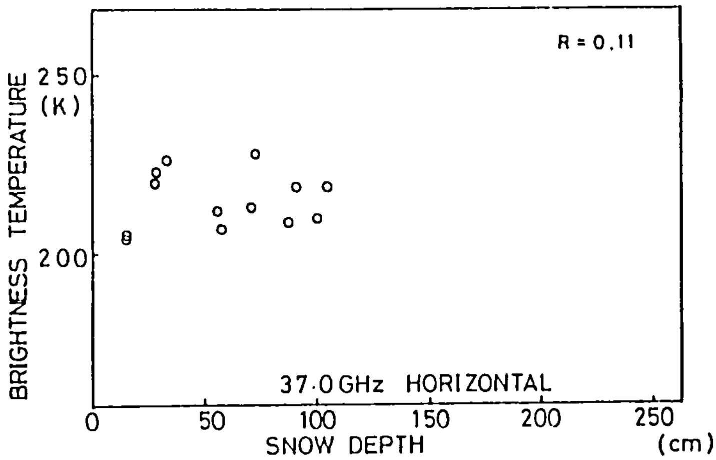
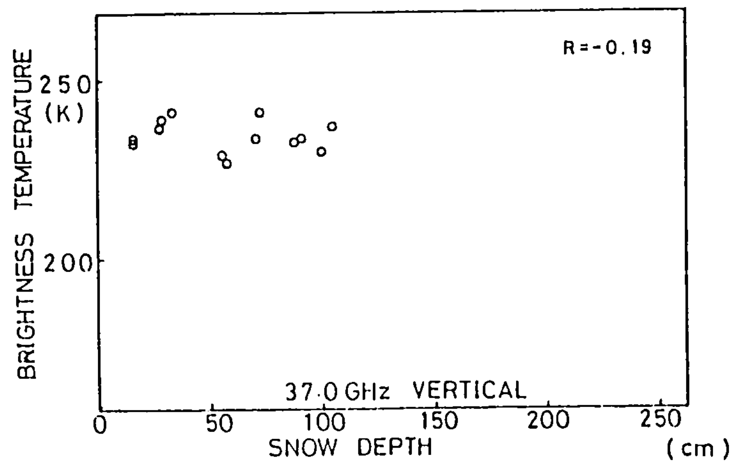


Figure 4. Relationship Between the Snow Depth and the Brightness Temperature of the Daytime in February 1979.





The effect of forest coverage to the brightness temperature was well studied by Hall et al [3]. Here in order to see an influence of vegetation, vegetation index map showing a relative occupation of conifer (evergreen) trees is made and indicated in Fig. 5 which differentiates hardwood area from that of softwood. Here hardwood is defined as the trees which are defoliated in winter.

The relationship between vegetation cover index and the brightness temperature is shown in Fig. 6 which indicates the existence of weak positive correlation between the two parameters in 6.6 GHz.

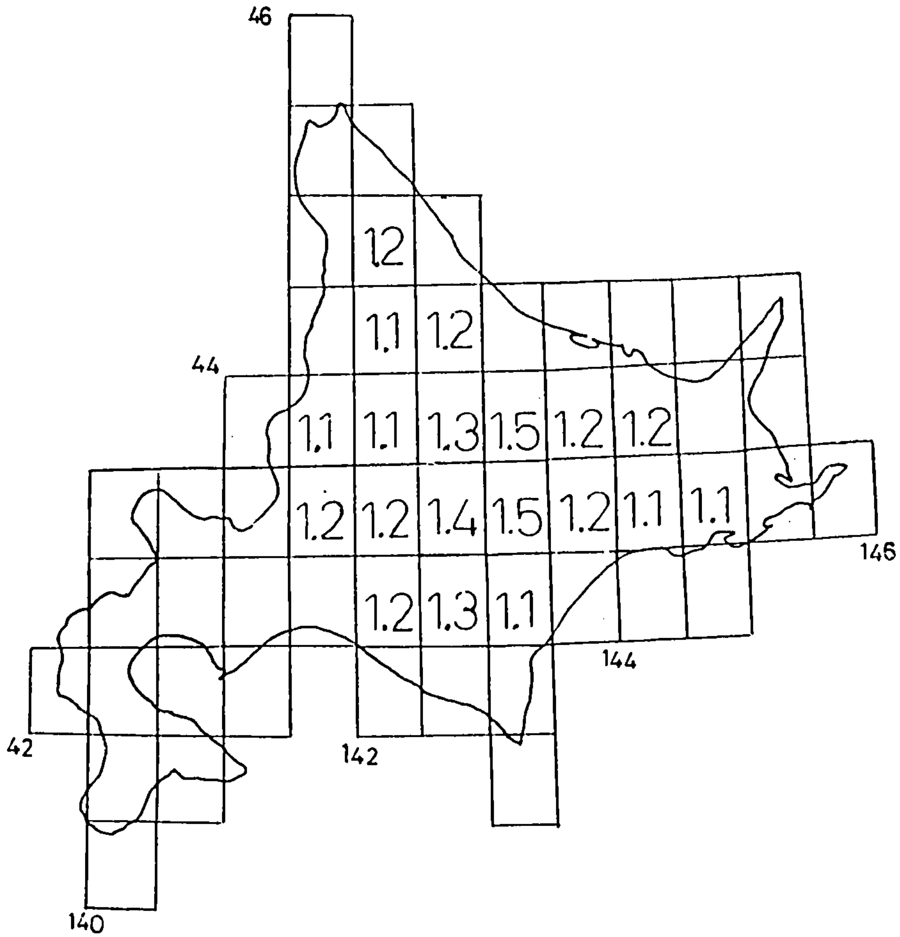


Figure 5. Vegetation Cover Index. 1.0: Sparse (Hardwood), 2.0: Dense (Softwood).

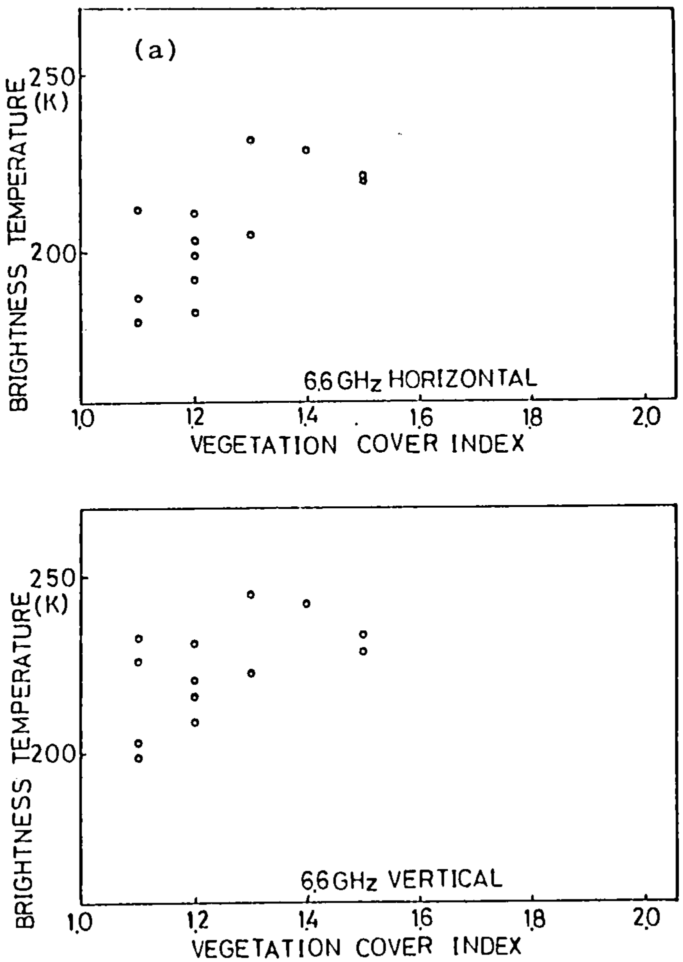


Figure 6. Relationship Between Vegetation Cover Index and Brightness Temperature for the Daytime of February 1979. (a): 6.6 GHZ, (b): 18 GHz, (c): 37 GHz.

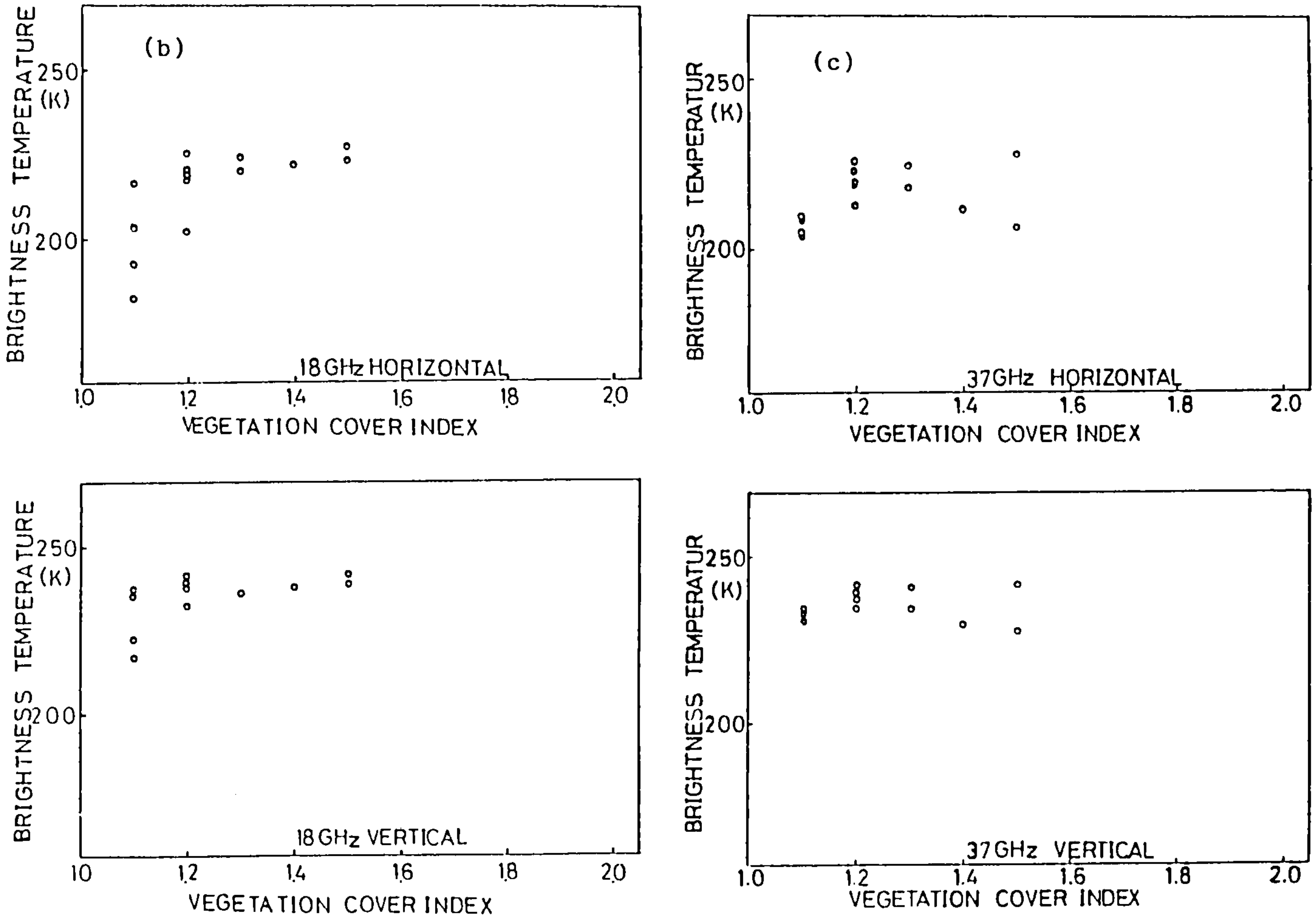


Figure 6. Continued.

Through the analysis of correlation between the snowdepth and the brightness temperature together with the brightness temperature distribution, it is found that there are subareas characterized with lower and higher brightness temperatures which is considered due to surface condition such as lakes and forest type. These subareas are classified as follows (as to the location see Fig. 1).

(i) Subareas characterized with low brightness temperature
(a) extremely low: 15, 16 and 21, (b) comparatively low: 17 and 18.

(ii) Subareas characterized with high brightness temperature
(a) extremely high: 3, 6, 7 and 8, (b) comparatively high; 1, 2, 3, 9, 11, 12 and 13.

If corrections for these effects are made to the brightness temperature, it is found that good negative correlation between the brightness temperature and the snow depth as well as snow equivalent water is obtained.

CONCLUDING REMARK

The foregoing analyses indicate that the interpretation of microwave radiometer data is not so simple since the brightness temperature is affected by various parameters.

ACKNOWLEDGEMENT

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