Ann. Rep., Inst. Geosci., Univ. Tsukuba, no. 13, pp. 58-64, Dec. 25, 1987

The snow cover environment in Sugadaira, central Japan

Tetsuzo Yasunari and Ken-ichi Ueno

Reprinted from;
Annual Report of the Institute of Geoscience,
the University of Tsukuba, No. 13, pp. 58 ~ 64.
Dec. 25, 1987

Ann. Rep., Inst. Geosci., Univ. Tsukuba, no. 13, pp. 58-64, Dec. 25, 1987

The snow cover environment in Sugadaira, central Japan

Tetsuzo Yasunari and Ken-ichi Ueno

Introduction

Sugadaira is a highland located about 1200 m above sea level at the eastern border of Mikuni Mountain range, which is one of the major mountain ranges in central Japan. This highland is surronuded by other mountains such as Higashi-Kubiki hills, Hida Mountains and Tadeshina Highlands. It is supposed that the snowfall in this area is brought about not only by the convective clouds of winter monsoon developed over Japan Sea, but also by the extra-tropical cyclones passing along the south coast of Japan.

Snow surveys have been made every winter season since 1983 to understand the basic characteristics of snowfall and snow cover in and around Sugadaira.

Some results obtained through these surveys are reported in this paper.

Method of observation and Data analysis

Snow cover depth was measured by using the sounding bar. Stratigraphic observation of snow cover,

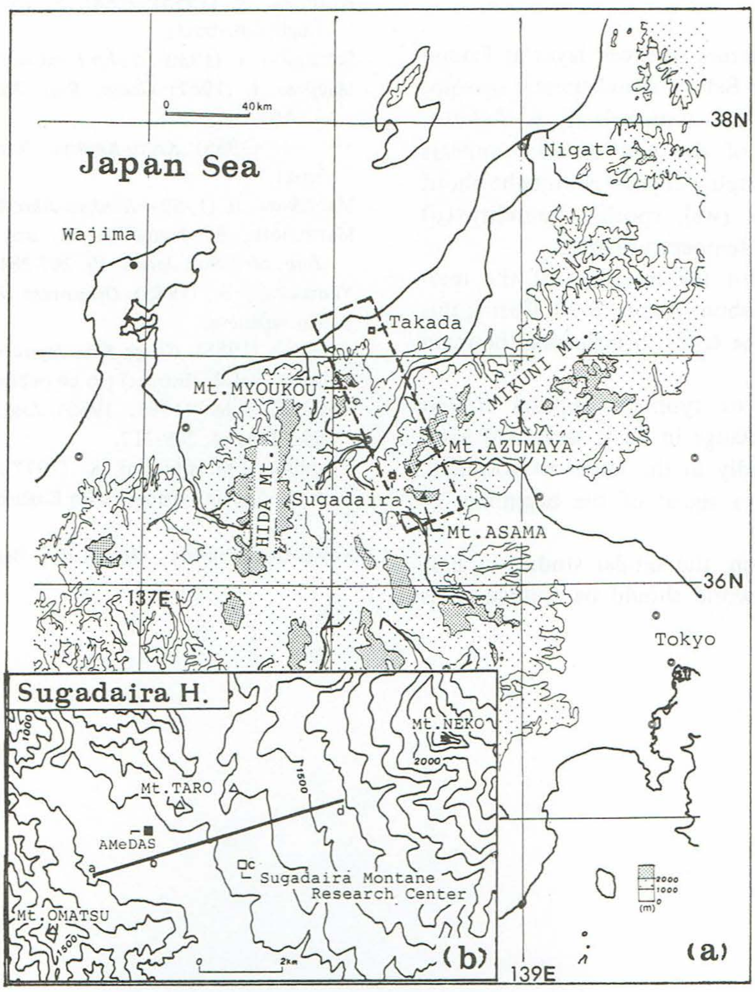

Fig. 1. Map of the study area
Cross sections in Fig. 4 are made with the highest and lowest points from NNW to SSE trough the region surrounded by dashed lines in Fig. 1(a).
Cross section in Fig. 6 is made trough the solid line in Fig. 1(b).

classification of snow type, measurement of snow density and snow temperature were also made.

The snow density was calculated from the weight of volume collected with 100cc snow sampler. The snow temperature was measured by the pocket thermometer.

Meteorological data of AMeDAS at Sugadaira and Takada, and aerological data at Wajima (see Fig. 1) were additionally used to examine the meteorological conditions of snowfall and snow accumulation.

Snow cover characteristics of Sugadaira

Fig. 2 shows the seasonal change of snow depth and daily precipitation at Sugadaira and 500mb temperature at Wajima for each year. Winters of 1984 and 1985 were cold, but that of 1986 was warm with few cold waves from the continent and with frequent passes of extra-tropical cyclones in high latitudes. Winter precipitation at Sugadaira is attributed both to cold air surge of the winter monsoon and to extra-tropical cyclones. Particularly, the cold air outbreak of winter monsoon after the pass of cyclones contributes mostly to the accumulation of snow. On the other hand, snowmelt occurrs by the advection of warm air associated with the cyclone passing to the north of Japan islands. Otherwise snowmelt was hard to occur because of cold climate of this highland.

Fig. 3 shows the snow depth and the stratigraphic diagrams around Sugadaira obtained through the wider-area mobil observation in February, 1986. The depth of snow cover increases from Japan Sea coast toward the windward side of the Mikuni mountain ranges and decreases rapidly in the lee side of mountain ranges. At Sugadaira, the snow depth was about 60 cm in February which was nearly a normal value for that month of year.

Fig. 4 shows the changes of the new snow depth during one cold surge period along the line from Naoetsu city at Japan Sea side to the mountain ranges of central Japan. The depth reaches the maximum at the north-facing slope of the mountain range just to the south of Takada Plain, but there is a secondary maximum in the inner highland region. There is no clear difference in the density of accumulated new snow, which may imply that dry snow fall occurred in Takada region during this period.

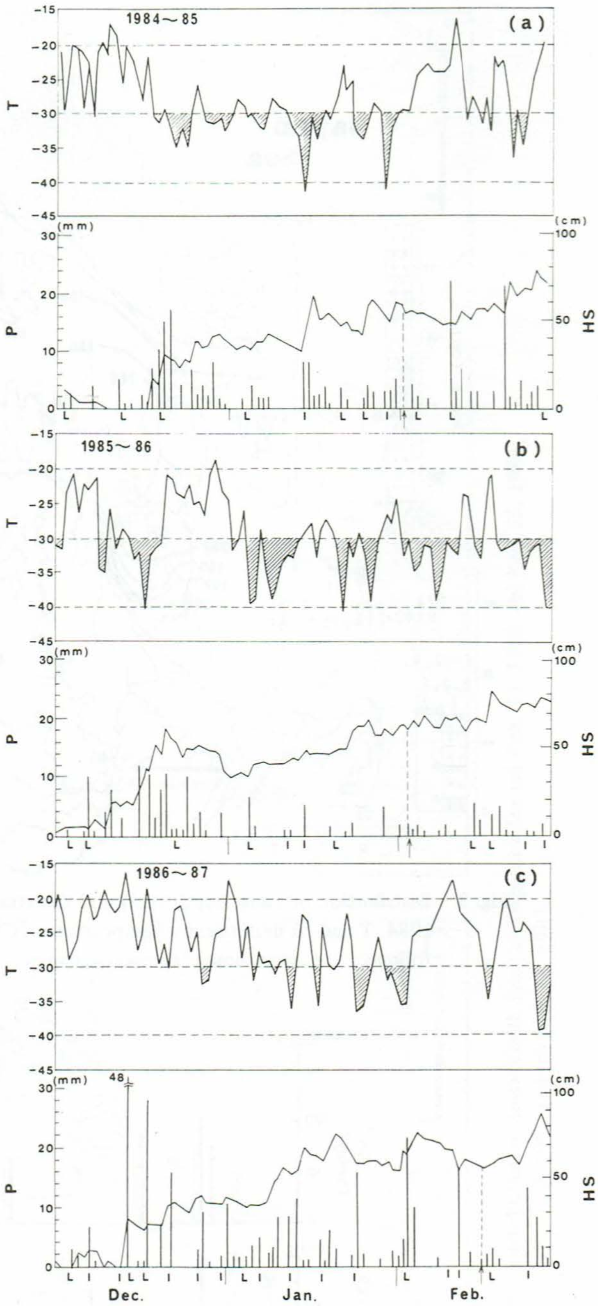

Fig. 2. Daily changes of 500 mb temperature change at Wajima (T), snow depth change (SH) and daily precipitation (P) at Sugadaira during the winter of (a) 1984-85, (b) 1985-86 and (c) 1986-87.

Interannual change of snow cover depth at Sugadaira

Fig. 5 shows the interannual change of snow cover in February at Sugadaira, when the depth usually reaches the seasonal maximum at Sugadaira. The contoured area is slightly different from year to year depending on the observation points. The characteristics of spatial distributions are noted as follows:

Isoline of depth are generally parallel to the contour lines. The snow depth is larger at the mountain slopes such as Mt. Omatsu and Mt. Neko. It is smaller at Sugadaira basin. There is a thick snow cover halfway up Mt. Neko at the altitude of 1800-2000 m probably because of the entrappment of snow by white birch (*Betula platyphtlla* var. *japonica*) and birch (*Betula ermani*) forest. The regions of relatively lower depth area are seen in the south east side of Sugadaira basin and at the top of Mt. Neko, where drifting of snow is dominant because of the strong north west winter monsoon.

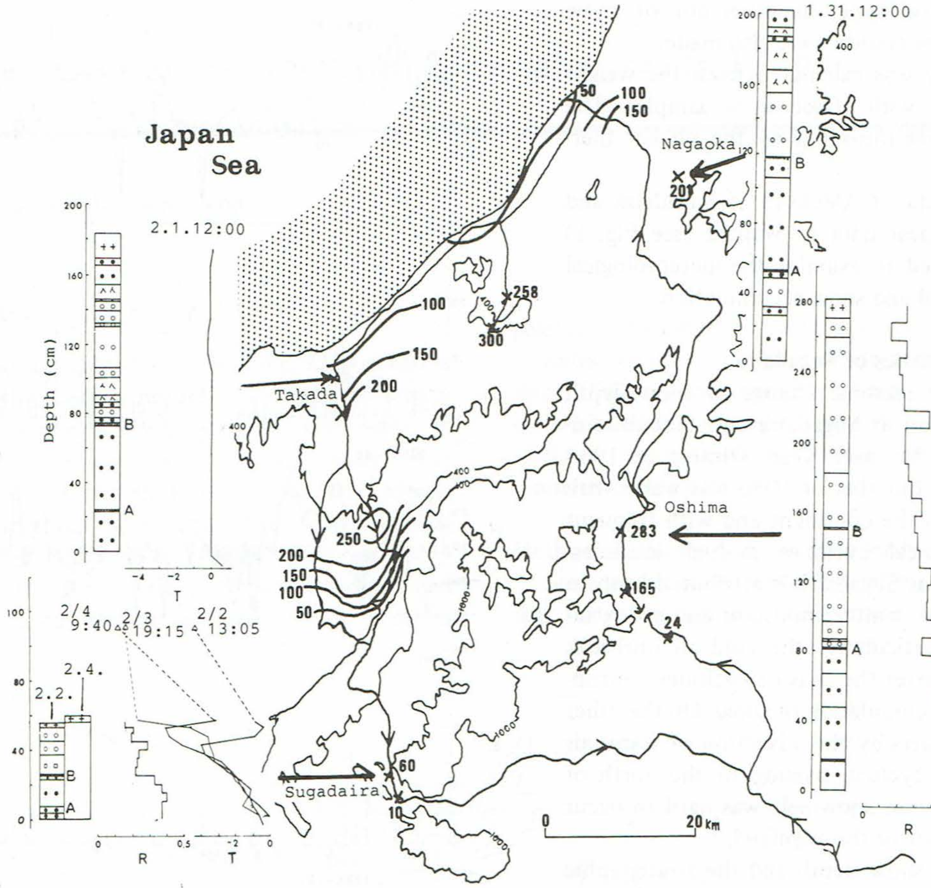

Fig. 3. Distribution of snow depth (cm) and the stratigraphic diagrams around Sugadaira during Jan. 30-Feb. 2, 1984. T and R denote snow temperature (°C) and snow density (g/cm³). Simbols of snow type are as follows: + new snow, ○ compact snow, ● granular snow, □ depth-hoar, ▨ ice layers.

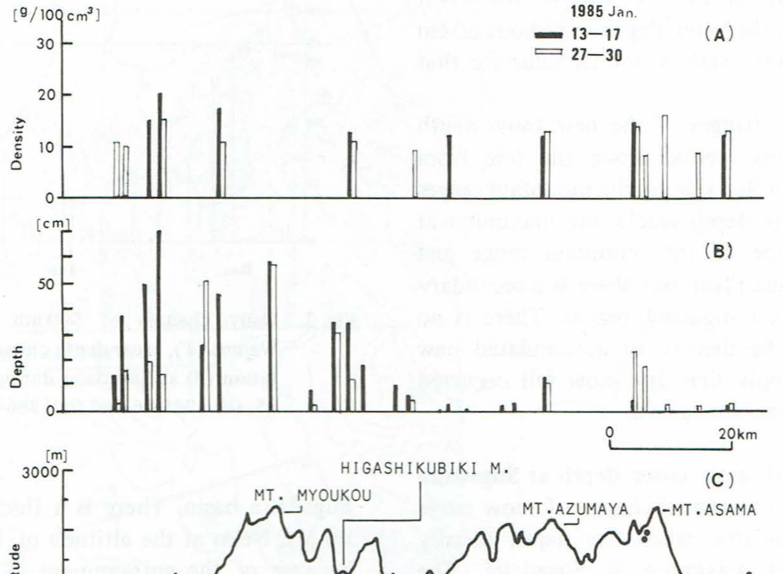

Fig. 4. Change of accumulated new snow density (A) and new snow depth (B) during 13-17 and 27-30, 1985 Jan. through cross section (C) shown in Fig. 1(a).

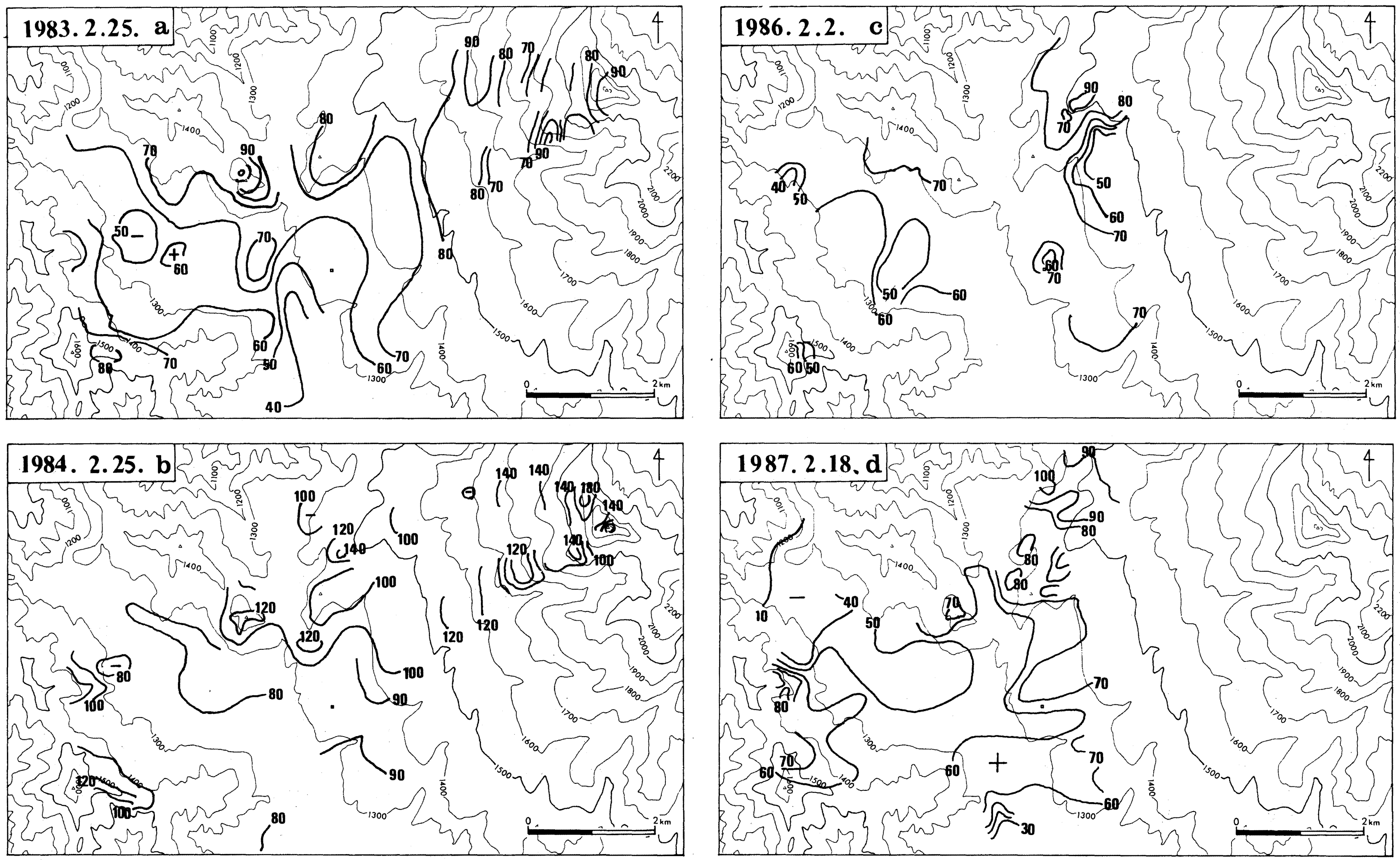

Fig. 5. Distribution of snow depth (cm) at Sugadaira for (a) Feb. 25, 1983, (b) Feb. 25, 1984, (c) Feb. 2, 1986 and (d) Feb. 18, 1987.

The snow cover depth measured at Sugadaira Montane Research Center is generally consistent with the distribution as shown in Fig. 5.

Stratification of snow cover at Sugadaira

Snow cover at Sugadaira consists of dry snow and the cold area snow metamorphism is dominated there.

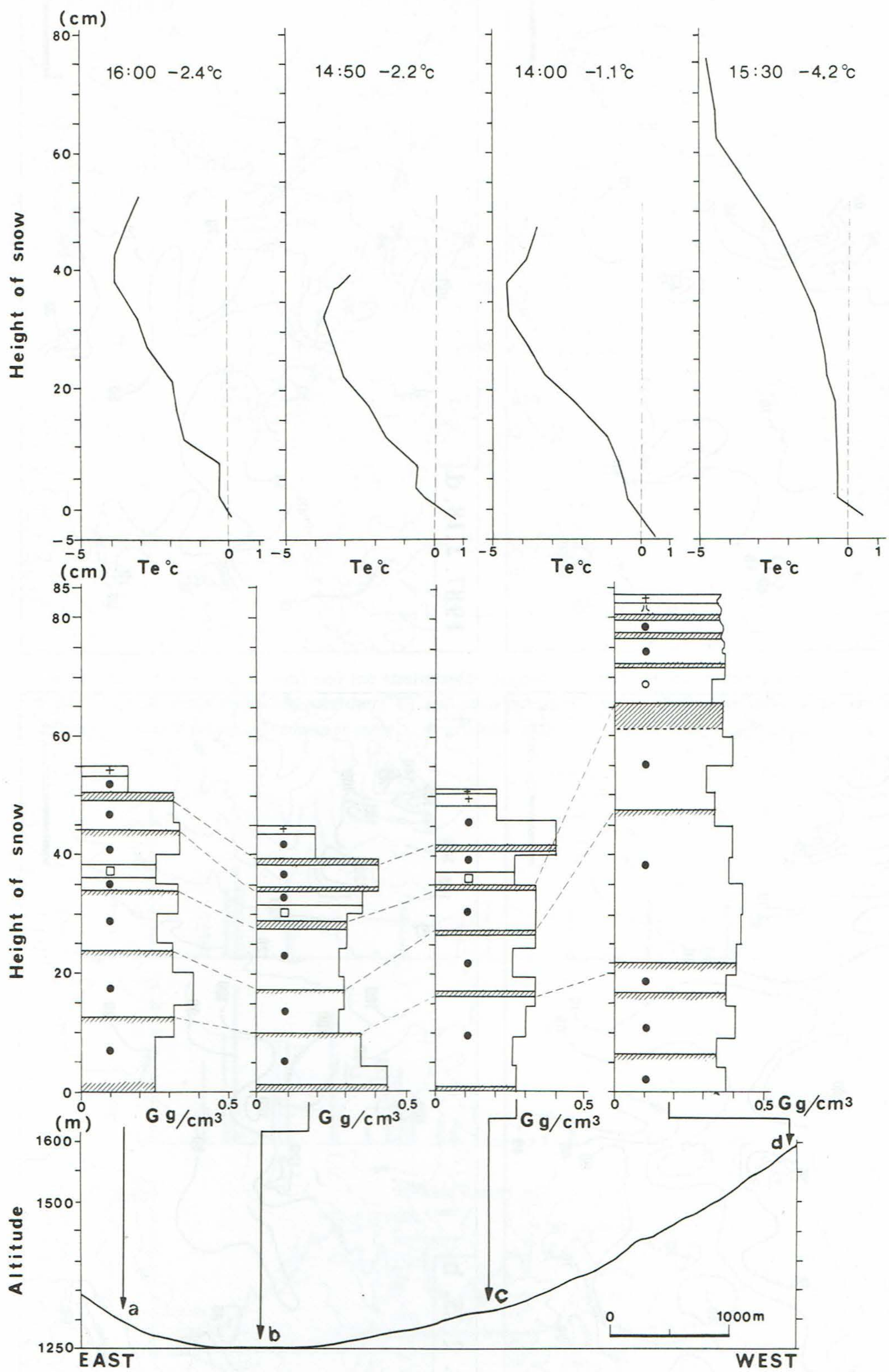

Fig. 6. Vertical profile of snow temperature (upper), stratigraphic diagrams of four snow layers (middle) along the cross section (lower) shown in Fig. 1(b). Units are °C for snow temperature (Te), g/cm^3 for snow density (G).

From the climatological view point, the stratification before snow melting is mostly associated with the precipitation rate and the mean temperature. Local topographical and cimatological conditions also affect the fine structure of snow cover.

Fig. 6 shows the four stratigraphic sections along the east-west cross section of Sugadaira observed in February 17,1987. Most part of the snow cover consists of granular snow at each observation point. Though each section is different in the depth of layer, a very similar layer structure were observed for each section, which means that snowfall and snow melting of the same period occurred nearly uniformly over the whole area of Sugadaira.

Thickness of the layers in the snowcover halfway up Mt. Neko was large compared to those of the other observation points. This suggests that the snowfall is enhanced on the slope of Mt. Neko.

Snow cover data at Sugadaira Montane Research Center represent well the snow cover of Sugadaira, which can be compared with the synoptic climate condition in winter season for each year. Fig. 7 shows the stratigraphic diagrams at the center in February of 1985, 86 and 87. The depth of snow cover is about 50-60 cm for each year. The main snow type is compact snow in the upper layers and granular snow in the lower layers in the winter of 1985, 1986, but granular snow is dominant through all the layers in 1987. This feature in 1987 is associated with the warm winter condition as shown in Fig. 2. The rates of water equivalent depth of snow cover with the precipitation calculated from AMeDAS data were 0.64 at Sugadaira and 0.47 at Takada. This result suggests that the stratigraphic structure of the snow cover at Sugadiara well preserves the synoptic weather condition of winter even in warm winters such as 1987.

Condition of depth-hoar formation at Sugadaira

Another feature in the stratigraphic structure of snow cover is the appearence of an underdeveloped depth-hoar in February below 30-40 cm the snow surface. This snow type is the transitional stage from compact snow to depth-hoar. The depth-hoar developes by the water vapor transfer under the condition of strong vertical gradient of snow temperature. Izumi, Akitaya (1986) described the geographical potential distribution of depth-hoar in Honsyu by the estimation of the relationship between surface meteorological data and Ram hardness of snow cover, but the condition of depth-hoar formation at Sugadaira has not been examined yet. Then the average Ram hardness at the end of January for the past three years was estimated following the formula of Akitaya, Endo (1980, 1982) in Hokkaido;

$$\overline{R} = 0.339\,(\overline{H}/|\overline{T}|)^{1.21} D^{0.21} \qquad (1)$$

where $\overline{R}$ (kg), D (cm) respectively indicates Ram hardness and snow depth of the final day in February, and $\overline{T}$ (°C), $\overline{H}$ (cm) respectively indicates mean minus surface temperature and mean snow depth through

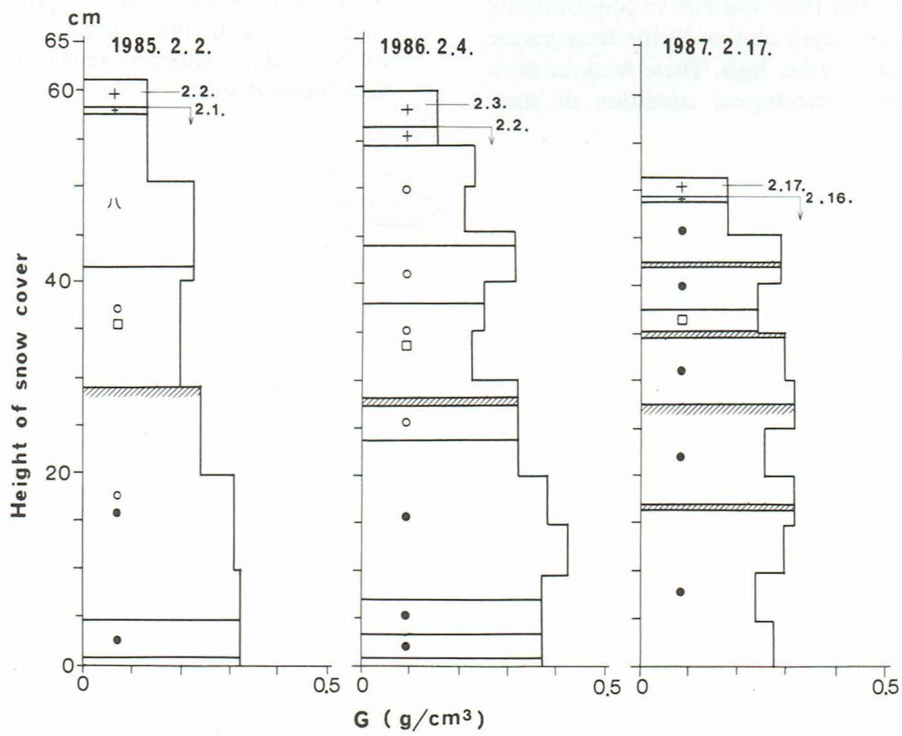

Fig. 7. Stratigraphic diagrams at Sugadaira Montane Research Center in February for the past three years.

↓ Caution! D and H differ from those in the formula.

p	$\overline{T}$	$\overline{D}$	H	$\overline{R}$
1984,12.17. – 1985.2.2.	-6.9	41.3	61	7.1
1985.12.8. – 1986.2.4.	-10.3	43.1	60	4.5
1986.12.15. – 1987.2.17.	-6.6	50.8	51	9.1

Table 1. Meteorelogical data used for the formula-(1).
P, $\overline{T}$, $\overline{D}$ and H denote the period for the calculation, mean surface temperature, mean snow depth during the period and height of the depth of snow in the final day of period (P), respectively.
$\overline{R}$ denotes the calculated Ram hardness.

January and February. But the stratigraphic observations were carried out at the beginning of February. So mean values through the snow covered period were adapted for $\overline{H}$ and $\overline{T}$. Depth of snow at the final day of the period was used for D. Izumi and Akitaya (1986) suggest the possibility of the development of depth-hoar under the condition when Ram hardness ($\overline{R}$) is less than eight kirograms. At Sugadaira region, R became less than eight kirograms except in 1987 (see Table 1). Though we have not made the observation of micro snow grain shape construction, the result calculated here suggest the potential possibility of the development of depth-hoar snow in this region.

On the other hand, the large value of estimated Ram hardness in 1986-1987 was due to comparatively large value of snow depth alothough the temperature during this period is rather high. These features show the difference in climatological condition of snow cover metamorphism between the highland in Honsyu and the plain in Hokkaido.

Conclusion

Some characteristics of the environment of snowfall and snow cover at Sugadaira were clarified. Interannual change of the distribution of snow cover depth and stratification were observed. Particulary, due to its geographical location and altitude, the structure of snow cover well preserved the synoptic climate conditions even in warm winter. Ram hardness of snow cover deduced from the empirical formula by Akitaya, Endo (1986) suggests that there is a climatic condition for the formation of depth-hoar at Sugadaira.

Acknowledgements

The snow surveys were carried out partly as a study for B.Sc thesis of the second author. Most part of this study was made by the snow survey group of our institute. The author express hearty thanks to Dr. Y. Kashiwagi, Miss. Y. Morinaga and Prof. M. Aniya. for their continuous supports. They are also grateful to Prof. I. Hayashi at Sugadaira Montane Research Center for providing us the field work facility and the meteorological data. This study was also made as part of field seminor of climatology and meteorology in College of Physical Sciences. Thanks are extended to the students who participated in this seminor.

Reference

Akitaya, E., Endo, Y. (1980): *Low Temperature Science*, Ser. A, 39, 55-61, (in Japanese with English summary).

Izumi, K., Akitaya, E. (1986): *Journal of the Japanese Society of Snow and Ice* (SEPPYO), 48 (4), 119-206, (*in Japanese with English abstract*).