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On the Characteristic Distribution of Snow Crystals during a Snowfall on the Ishikari Plain, Hokkaido

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Abstract

In the morning of February 1st, 1966 during the snow crystal and the snow cloud observations on the Ishikari Plain in Hokkaido, a considerable snowfall occurred extending over almost all of entire plain. It was noted that, at several of the observational points distributed on the plain, a number of the snow crystal of bullet type were observed, while at the remaining points, plane and rimed crystals were predominant.

As a result of analysis, the pattern of the snowfall was divided into three groups from the distribution of the type of snow crystal. The type of snow crystal in the first group, observational points; Yamaguchi, Sapporo and Mt. Teine, consisted of almost all of bullet type without riming. On the other hand, in the second group; Tarukawa and Bannaguro, the majority of the type of snow crystal were rimed and plane type. And the third group; Ishikari, San-sen and Syukutsu, showed intermediate of the first and the second groups. Especially, it was noted that the area of the second group coincided with the region of strong radar echo.

Thus, it may be possible to assume the location of a main active band of clouds from the horizontal distribution of the type of snow crystals even when the whole sky is overcast.

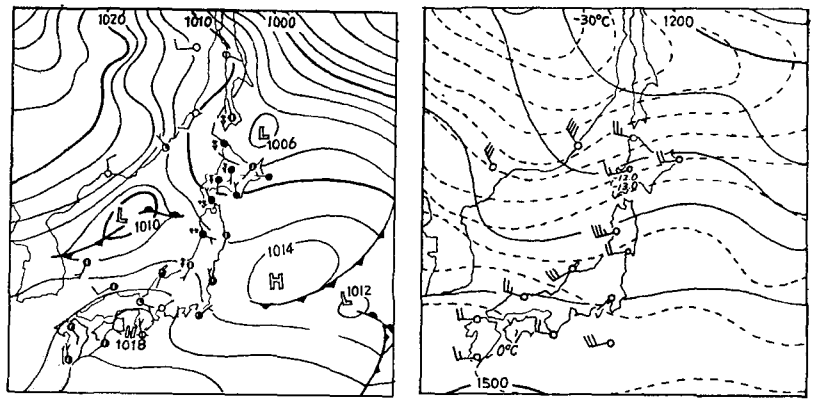
1. Introduction

The horizontal distribution of the depth of snow on the Ishikari Plain in Hokkaido has several patterns. A typical pattern is the band type distribution[1]. And it was observed by Higuchi[2),3)] and Magono et al.[4)] that the horizontal cloud distribution over the Ishikari Plain showed a typical band structure. Since 1963, the snowfall phenomena on the plain have been observed and analyzed in detail by the members of the Cloud Physics Group from January through to February[5)]. In the 1966, the main objective was the measurement of the widths of the bands and of the spaces between the band clouds. For this objective, a mesoscale network was projected. In the morning February 1st during snow crystal and the snow cloud observations, a considerable snowfall occurred extending over almost all of the entire plain. At several of the observational points, the snow crystal of bullet type were

observed[6], while at the remaining points, plane and rimed crystals were predominant. In this paper, the result of observations of such a characteristic distribution pattern of the snow crystals will be described.

2. General descriptions

The surface weather chart in the morning in Fig. 1 (a) shows that Hokkaido was covered by a low pressure area, the center of which was located over the sea to the northeast of Hokkaido. By the effect of the low pressure area, a considerable snowfall was brought to the west coast of Hokkaido. On this day, especially, it was calm with southerly surface winds prevailing and the wind speed was lower than 2 knots. At the 850 mb level as shown in Fig. 1(b), the wind direction was west-southwest, and the wind speed was around 15 knots which is considerably low compared with the strong winds



(a) Surface weather chart (b) 850 mb weather chart

Fig. 1 Surface and 850 mb weather charts at 0900 JST on 1 February 1966.

during a typical northwest monsoon period. Therefore, it was considered that this snowfall was a special case in this area.

3. Observational network

As described above, the main objective of the observation in the present work was the measurement of the width of the bands and the spaces between the band type clouds. Therefore, eight observational points were set up over the plain. Five observational points; Ishikari, San-sen, Bannaguro,

Tarukawa and Yamaguchi as shown in Fig. 2 were distributed along the coast, perpendicular to the prevailing wind direction. At all eight points, the observation of the type of snow crystals was carried out by means of a replica solution method at ten minute intervals. At four points; Ishikari, Bannaguro, Tarukawa and Sapporo, cloud observations were carried out by means of cameras of "fish-eye lens" and "cloud mirror". In addition, snow crystal sondes[7] and UD sondes[8] were released from Syukutsu. And from the summit of Mt. Teine, the diurnal variation of clouds was observed by means of a 16 mm time lapse movie camera every five seconds. And routine radar observation was carried out by the Sapporo District Meteorological Observatory.

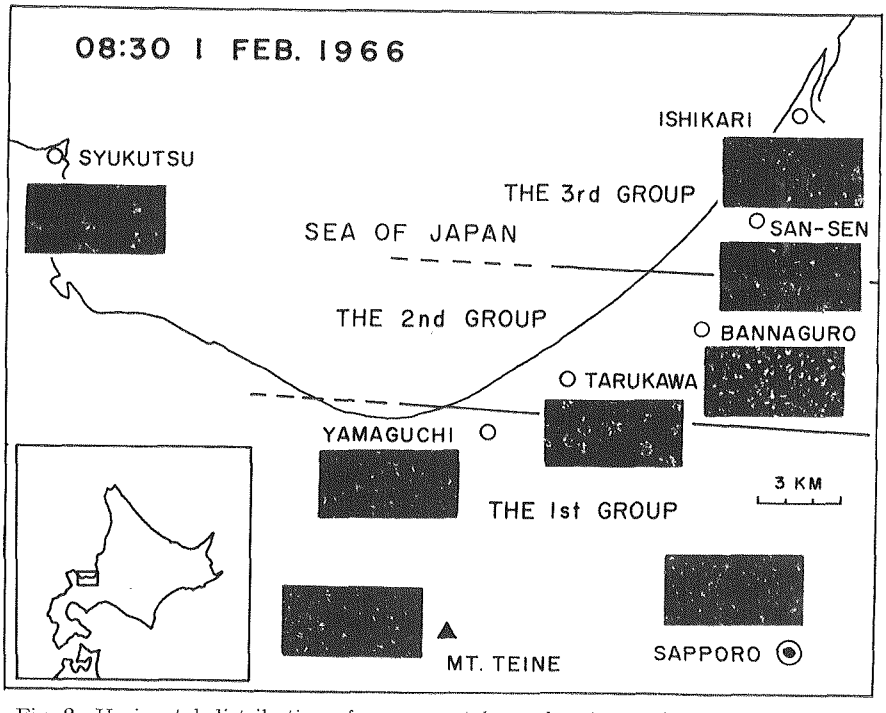


Fig. 2 Horizontal distribution of snow crystals at the observational points at 0830 JST on 1 February 1966.

4. Results

Fig. 2 shows the result of the observation of the distribution of snow crystals which were observed by the replica solution method at eight observa-

tional points at 0830 JST on February 1st, 1966. The photographs in this figure are the center parts (2.5 cm×4 cm) which were cut from photographs which were printed directly from the original replicas on slide glasses (6 cm× 9 cm). It was impossible to compare the snowfall intensity with each other from these photographs directly, because the exposure time of the slide glass during snowfall differed from each other. However, it may be seen that there are three groups in the type of snow crystal as shown in Fig. 2. In the first group: Yamaguchi, Sapporo and Mt. Teine, the type of snow crystal was the columnar type, that is, single bullets, combination of bullets and long prisms without riming. Tarukawa and Bannaguro belong to the second group. Almost all of the snow crystals in the group were the rimed and the plane type, while some of them formed snowflakes. And the third group was observed at Ishikari, San-sen and Syukutsu. They were the intermediate of the first and the second groups. In other words, they were snow crystal of columnar and plane types, while some of them were rimed. Fig. 3 shows a better example

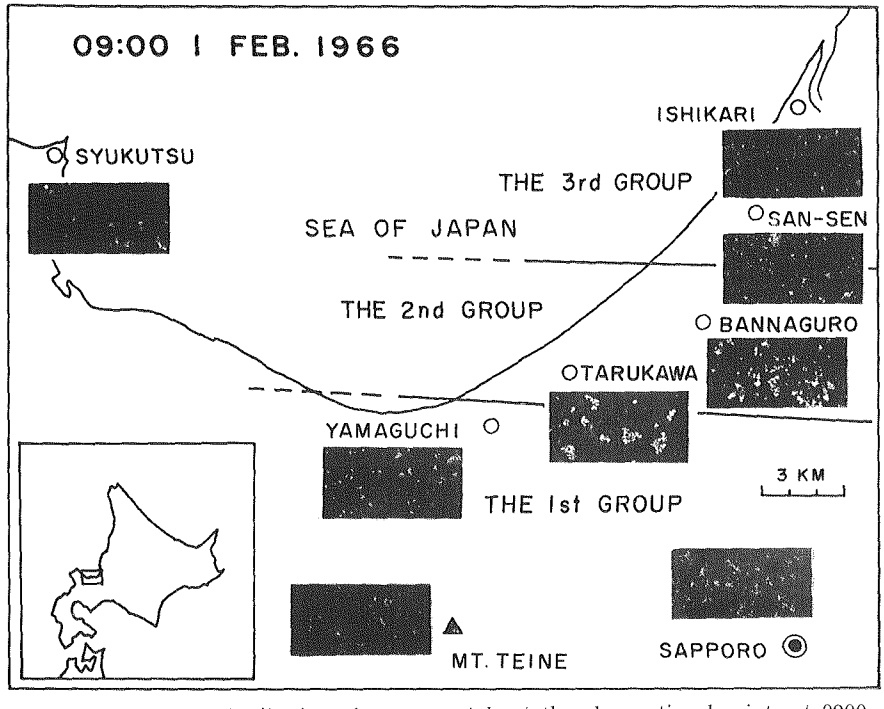


Fig. 3 Horizontal distribution of snow crystals at the observational points at 0900 JST on 1 February 1966.

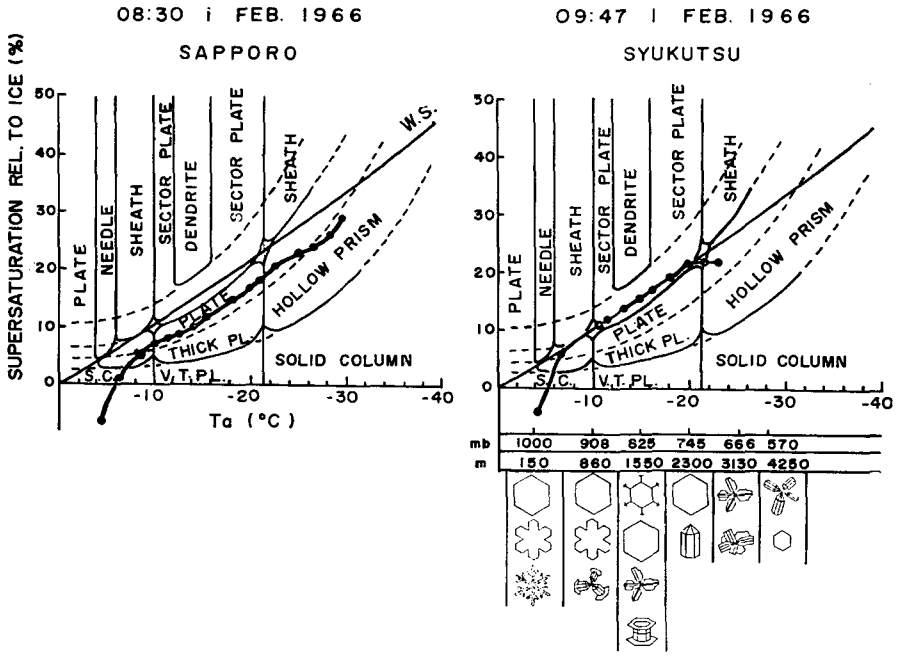


Fig. 4 Ta-s diagrams plotted from data obtained by routine radiosonde release from Sapporo (left side) and by the UD sonde and snow crystal sonde release from Syukutsu (right side).

of 30 minute after Fig. 2. Especially, in the second group (Tarukawa and Bannaguro), almost all of the snow crystals formed snowflakes, and were rimed. The size of the snowflakes were much larger than those at 0830. On the other hand, no changes in the type of snow crystal were observed in the first group. In the third group, some of the collected snow crystals were very beautiful dendritic crystals and other crystals were rimed. They formed snowflakes but they were not so large, and some bullet type crystals were observed among the snow crystals. A distinct difference in the type of snow crystals, especially at Yamaguchi in the first group and Tarukawa in the second group was expected from the sounding curves on the Ta-s diagrams[9] (Fig. 4) plotted from the aerological data which was obtained by routine radiosonde release from Sapporo and by the UD sonde release from Syukutsu. The sounding curve of Syukutsu at 0947 is shown instead of at 0830, because data of snow crystal sonde sounding at 0947 only were available. It was confirmed that the aerological condition at Syukutsu did not change during

the two observations. The analysis of records of snow crystal sonde was carried out by Tazawa[10]. In both Ta-s diagrams in Fig. 4, thick solid lines connecting dots show the sounding curves at each observational point. The great difference between the two sounding curves was found in the rate of supersaturation relative to ice, that is, the sounding curve of Sapporo showed values a little lower than the curve of water saturation in the whole temperature region. While at Syukutsu, the sounding curve agreed with the water saturation at a temperature region –6° to –20°C. From the sounding curve at Sapporo, it was expected qualitatively that snow crystals of prism and thick plate type would be formed at the cloud level. On the other hand, from the sounding curve at Syukutsu, the type of snow crystals were expected to be plate, sector and dendrite rather than prism and thick plate.

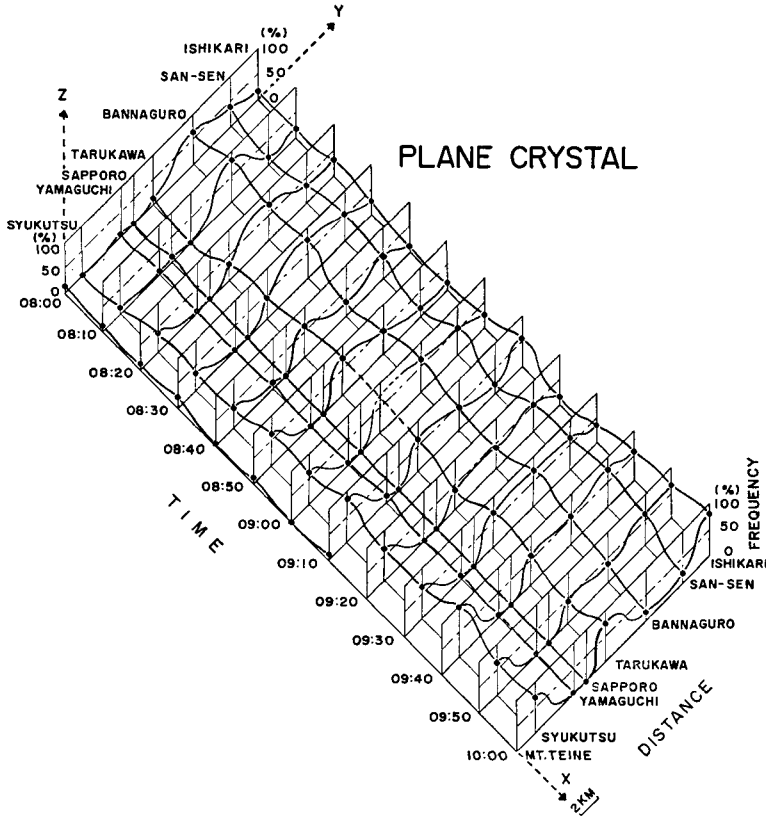


Fig. 5 The time variation of frequency distribution of the snow crystals of plane type at eight observational points on the Ishikari Plain, Hokkaido.

These expected types of snow crystal were actually observed by the snow crystal sonde as shown in the lower part of right hand side in Fig. 4.

As described hitherto, the type of snow crystal which were observed at the observational points were mainly composed from distinctly different types: the plane type and columnar type. Then the time variation of the number of each snow crystal type at each observational point was studied. Fig. 5 shows the time variation in the frequency of the snow crystal of plane type at each point. The axes of the directions of x, y and z show the time, the distance and the frequency, respectively. The axis, x shows the time from 0800 of the beginning time to 1000 of the closing time of the observation. The distance axis, y shows the distance which is directed from northeast to southwest, on a straight line parallel with the coast of the Ishikari Bay, although Sapporo, Syukutsu and Mt. Teine were not on a straight line. The frequency axis, z shows the ratio of the numbers of snow crystal of plane type to the total number of snow crystals which were observed at each observational point. Therefore, in this figure, eight curves in planes parallel to the x-z plane show the time variations at each point, and thirteen curves in planes parallel to the y-z plane show the local variations in the frequency of the snow crystals of plane type at each observational time. For example, at 0830, the ratio of the snow crystals of plane type was high at Tarukawa, Bannaguro and San-sen, while it was low at Yamaguchi and Sapporo. It is noted generally in the figure that, in the second group (Tarukawa and Bannaguro), the ratio of the plane type was high, and in the first group (Yamaguchi, Sapporo and Mt. Teine), the ratio was low, and in the third group (Ishikari, San-sen and Syukutsu), the ratio was high some times and low some times, namely, the condition was intermediate. Fig. 6 shows the time variation in the frequency of the snow crystal of columnar type. It shows the opposite ratio to the former figure. But some of the ratios of the total of two types of snow crystals did not show one hundred percent of crystals because some of them were not classified as plane type or columnar type since they were dense rimed crystals. Nevertheless a distinct difference between the three groups described above was recognized, i.e., in the first group, the ratio of the columnar type was high, and in the second group, it was low. And the third group showed an intermediate nature. Further the difference of the three groups was clear in the frequency of the snow crystal of rimed type as shown in Fig. 7. Especially, no rimed snow crystals were observed in the first group throughout the observational period. On the other hand, in the second group, almost all of

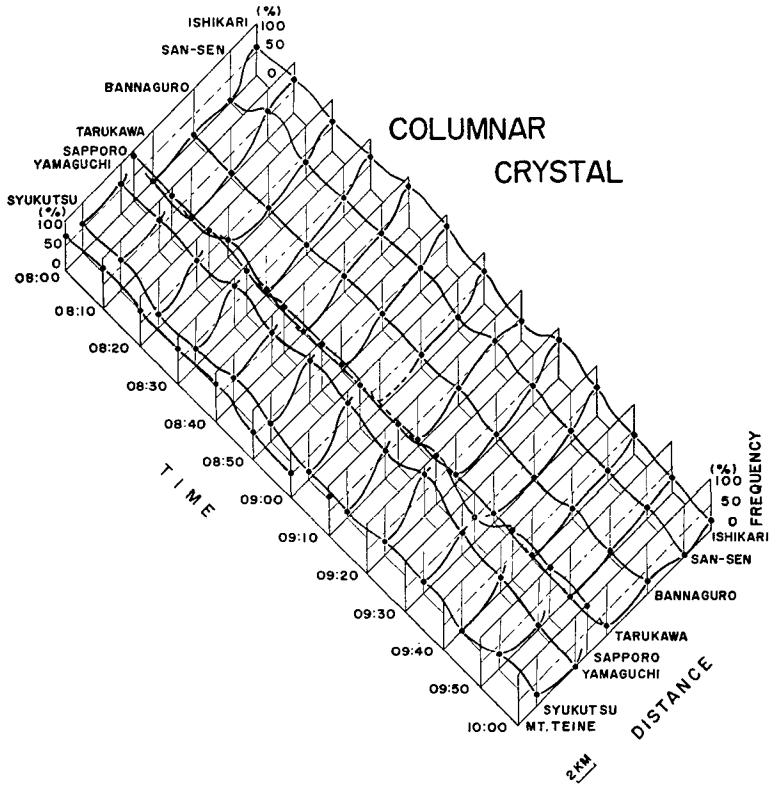


Fig. 6 The time variation of frequency distribution of snow crystals of columnar type at eight observational points on the Ishikari Plain, Hokkaido.

the snow crystals were rimed. These results showed that the former phenomenon was a trough and that the latter was a ridge in Fig. 7. It was very interesting that San-sen and Ishikari showed a remarkable variation at each observational time independently. This will be discussed in the next section.

5. Considerations

Fortunately data of radar echoes of the snowfall were obtained by the Sapporo District Meteorological Observatory. The sketches of the radar echoes are given in Fig. 8. In this figure, the broad areas of wave marks shows regions of a weak snowfall intensity in the radar echo and the areas with black dots show regions of a strong intensity. In the figure, it may be

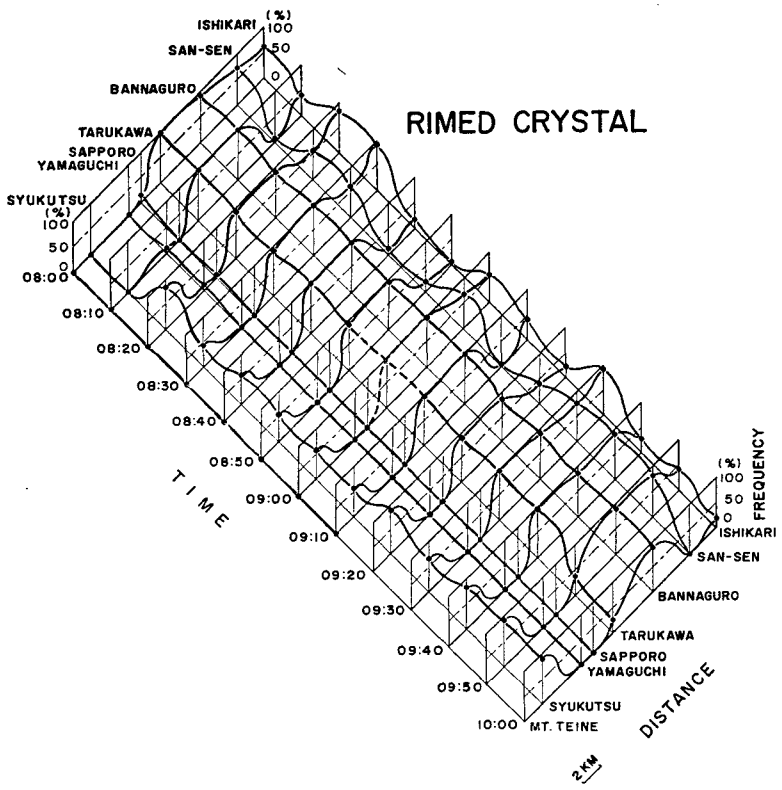
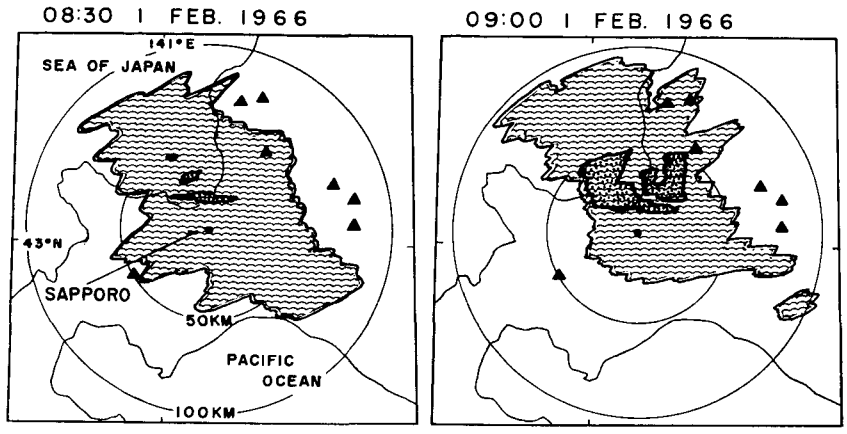


Fig. 7 The time variation of frequency distribution of rimed snow crystals at eight observational points on the Ishikari Plain, Hokkaido.

seen that there were three strong echoes at 0830. We noted that the echo of a typical band type extended eastward from Syukutsu. At this time, the location of the second group; Tarukawa and Bannaguro were covered by the strong echo, and the boundary of the south side of this echo is located just between Yamaguchi and Tarukawa. That is to say, the region of this strong echo coincided with the area of the second group, namely the snow crystals of plane type. It was considered that the snow crystals of plane type grew in a relatively higher supersaturation region with respect to ice, and became rimed snow crystals. On the other hand, the boundary of the north side of this echo was located around the third group; at San-sen and Ishikari. At 0900 after 30 minute from this time, the region of this strong echo became wide, but the boundary of the south side did not move, and the north side



(a) 0830 JST (b) 0900 JST

Fig. 8 Sketches of radar echoes on 1 February 1966. (From the Sapporo District Meteorological Observatory)

developed widely. This result corresponds well with the time variation in the snow crystal type in which the first group which was located at the south side of the boundary of this strong echo, no time change of the type of snow crystals was seen, nor any rimed snow crystals were observed. While in the third group which was located at the north side of the boundary of this strong echo at 0830 was covered by the echo. Both time changes in the type and in the frequency were observed frequently. In this snowfall, it was expected that a main active band of clouds, in which a strong radar echo occurred, was located over the area of the second group.

6. Concluding remarks

From the results described above, in a snowfall under quiet weather conditions with a calm or weak wind, such as in the present snowfall, it will be possible to assume the location of a main active band of clouds from the horizontal distribution of the type and of the frequency of snow crystals even when the whole sky is overcast.

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References

1) The Sapporo District Meteorological Observatory: Preliminary reports of the local heavy snowfall on the Ishikari Plain. (in Japanese) (1963).
2) Higuchi, K.: On the characteristics of snow clouds. Jour. Met. Soc. Japan, Ser. II, 40 (1962) 193–201.
3) Higuchi, K.: The band structure of snowfalls. Ibid. 41 (1963) 53–70.
4) MAGONO, C., K. KIKUCHI, T. KIMURA, S. TAZAWA and T. KASAI: A study on the snowfall in the winter monsoon season in Hokkaido with special reference to low land snowfall. Jour. Fac. Sci., Hokkaido Univ., Ser. VII, 2 (1966) 287–308.
5) MAGONO, C., K. KIKUCHI, S. Lee, T. ENDO and T. KASAI: An observation of snowfalls and their mother cloud (Investigation of natural snow crystals V). Ibid. (1965) 123–148.
6) KIKUCHI, K.: On the snow crystal of bullet type. to be published.
7) MAGONO, C. and S. TAZAWA: Design of "Snow Crystal Sondes". Jour. Atmos. Sci., 23 (1966) 618–625.
8) KIMURA, T.: Design of "UD Sondes". to be published.
9) KOBAYASHI, T.: The growth of snow crystals at low supersaturations. Phil. Mag., VI (1961) 1363–1370.
10) TAZAWA, S. and C. MAGONO: Snow cloud observations by means of S.C. Sonde (III). Paper presented at the meeting of the Met. Soc. Japan held in October 1966.