ACCUMULATION AND ABLATION AT SYOWA STATION

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Abstract: The results of the observations of accumulation and ablation in the period 1968–1975 in the vicinity of Syowa Station are summarized. There were two typical areas on sea ice; one was the area characterized by the accumulation of several tens cm and situated near the obstacles to wind such as island or iceberg, and the other characterized by little accumulation, free from such obstacles.

The process of ablation can be separated into two stages by the critical temperature of $-3°C$ in daily mean air temperature. Ablation was related to meteorological factors and the relation between ablation and daily mean air temperature was formulated as

$$A=0.40T^2+4.8T+17.0.$$

Using this equation, the depth of snow to be melted in one summer period was estimated at 1184 mm as the average of five summer periods from 1968–1969 to 1972–1973. Ablation on East Ongul Island was about three times that on sea ice. This difference may be explained by the effect of bare ground as a heat source.

1. Introduction

Only a few studies had been carried out on accumulation and ablation near Syowa Station before 1966 (SEINO, 1967; MAEGOYA, 1969). Since then, the continuous observation of accumulation was made in the vicinity of Syowa Station, together with the observation of ablation in some periods. This paper deals with accumulation and ablation in this area on the basis of these observations. The term "accumulation" used in this paper stands for "net accumulation of snow", but when the term is used in contrast with "ablation", it means ordinary accumulation. The amount of accumulation and ablation is represented by the depth of snow here.

2. Observations

Table 1 shows site, period, item and reference of observations. Fig. 1 shows the location of the observation sites. All measurements were made by the stake

Table 1. Site, period, item and reference of observations.

Site	Period	Observation item	Reference
Line I	June 1973–Nov. 1973	net accumulation	
Line II	Apr. 1972–Jan. 1973	net accumulation	YAMADA *et al.*, 1975
Site 1	Feb. 1968–Dec. 1968	net accumulation	NARUSE *et al.*, 1971
	Mar. 1969–Jan. 1970	same	same
	Apr. 1970–Dec. 1970	same	ÔNO *et al.*, 1971
	Mar. 1971–Sept. 1971	same	YAMADA *et al.*, 1975
	Feb. 1972–Jan. 1973	same	same
Site 2	Dec. 1970–Jan. 1971	ablation	
	Nov. 1974–Dec. 1974	same	

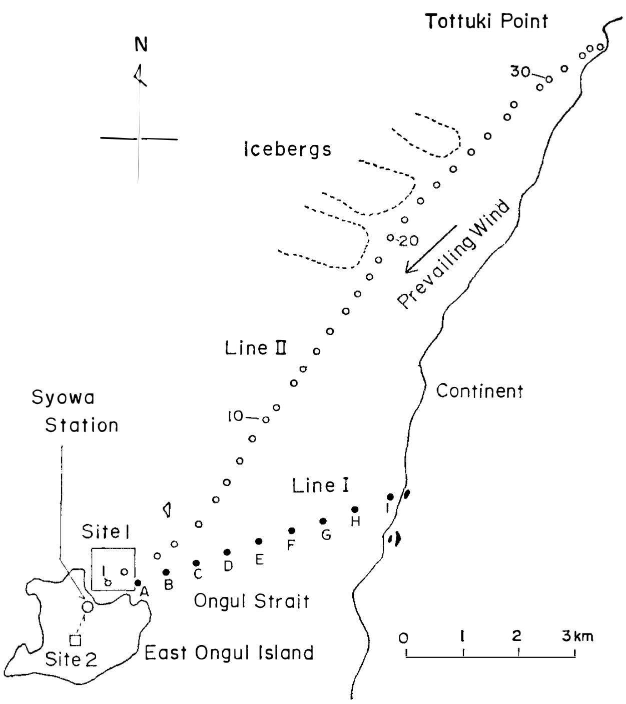

Fig. 1. Areal map of observation sites of accumulation and ablation in the vicinity of Syowa Station.

method. At Site 1, measurements were made at 15 stakes in 1968 and 13 stakes in 1969–1970 distributed in the area of about 1 km square, and 12-stakes farm of about 100 m square in 1970–1973, every week or every month throughout the years. Along Line I, measurements were made every 5–14 days at 9 stakes which were set across the Ongul Strait throughout the year, and along Line II at 34 stakes, four times from June to November. At Site 2, ablation was measured in two summer seasons of 1970–1971 and 1974–1975.

3. Accumulation of Snow on Sea Ice near Ongul Islands

3.1. Observation at Site 1

The cumulative curves of accumulation and the accumulation rate at Site 1 in the period of 1968–1972 are shown in Fig. 2. The plotted values in this figure are the average of all stakes measured in each period. The curves for 1968 and 1969–1970 are quoted from NARUSE *et al.* (1971). The start of observation is not the same each year, but the cumulative curves can be compared with each other since the amount of snow accumulation in February, March and April is fairly small. The general trend of accumulation and ablation can be stated as follows: Accumulation starts around June; the accumulation rate rises to a maximum in August and the first half of September; accumulation of significant amount does not occur after the latter half of September; ablation excels accumulation and ablation rate increases after November. The period of maximum accumulation rate coincides with that of the maximum frequency of blizzard (MURAKOSHI, 1958; MURAKOSHI and YATA, 1962; YAMAZAKI *et al.*, 1969).

The maximum values of accumulation in 1971 and 1972 were about twice of those in the other three years. Since this tendency of accumulation did not coincide with that in the coastal region of the continent shown by YAMADA *et al.* (1978), it cannot be explained by climatic condition, but by other factor unknown yet.

3.2. Observation along Line I

Fig. 3 shows the accumulation at 9 stakes along Line I. At stakes A and B, the similar trend of accumulation as Site 1 was observed, and the maximum values of accumulation were several tens cm. On the contrary, at stakes F, G and H, little accumulation was observed. According to such characteristics of accumulation, the feature of accumulation in this region can be stated as follows: There are two typical areas; one is the area characterized by maximum accumulation amount of several tens cm (A, B and Site 1), and the other by little accumulation (F, G and H); the area between these two areas is a transitional one (C, D, E and I).

3.3. Observation along Line II

Fig. 4 shows the accumulation at 34 stakes along Line II. Curve A in Fig. 4

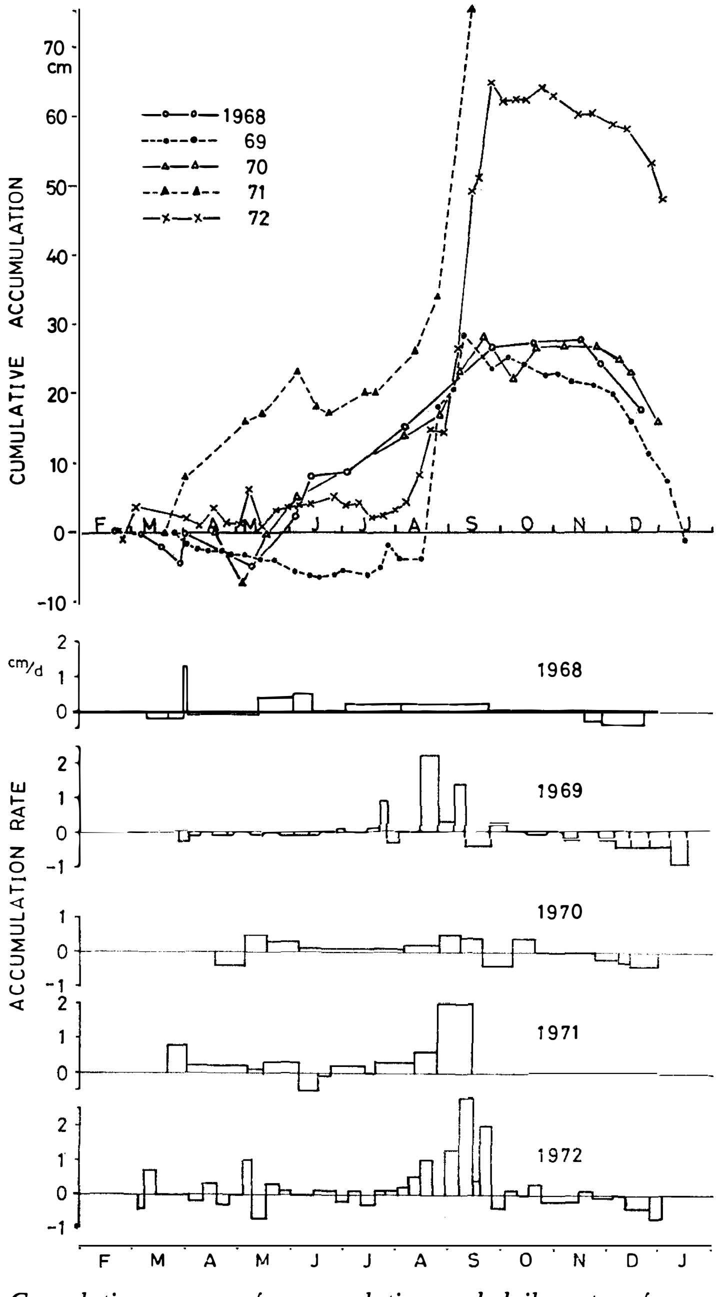

Fig. 2. Cumulative curves of accumulation and daily rate of accumulation at Site 1 from 1968 to 1972.

indicates the value for the whole period, 157 days from June to November, while curve B, C and D are for three subdivisional periods, 26 days from June to July, 39 days from July to August and 92 days from August to November. The amount of accumulation shown by curve A is considered as accumulation in the accumulation season at Site 1 shown in Fig. 2. The areal distribution of accumulation

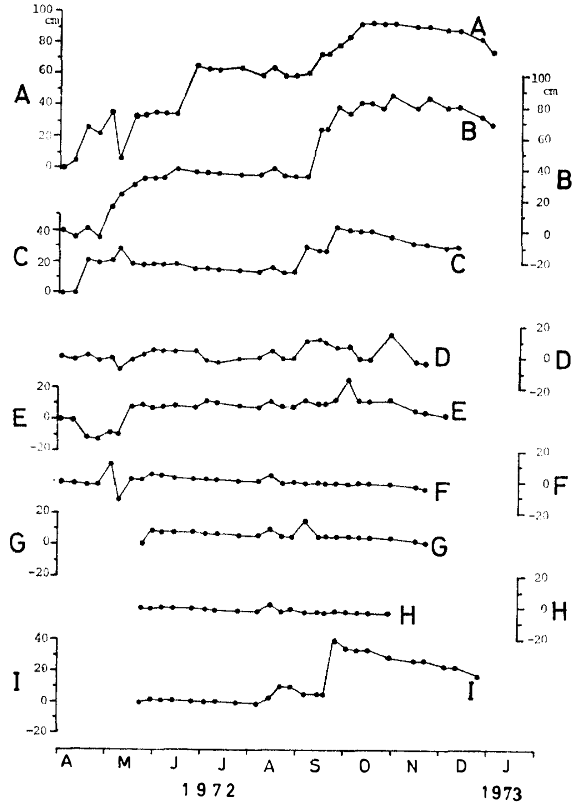

Fig. 3. Cumulative curves of accumulation at stakes along Line I from April 1972 to January 1973.

along Line II can be explained by the same way as Line I, though more complicated. On the other hand, another remarkable feature of accumulation is shown by curves C and D in Fig. 4. At the stakes where a large amount of accumulation was observed in the second period indicated by curve C, the amount of accumulation in the third period indicated by curve D was small, or negative as seen in the cases of stakes 3, 11, 18 and 22. It may be predicted that there is an upper limit of accumulation. On the contrary, at stakes 15–17, 25–28 and 34, a fairly small amount of accumulation was observed. At these stakes accumulation was always small in every period.

3.4. General feature of areal distribution of accumulation

NARUSE *et al.* (1971) pointed out that the amount of accumulation at the stakes near the East Ongul Island was larger than that at the stakes away from the island. Similar tendency can be seen at the stakes along Line I. The area of little amount of accumulation along Line I was free from any obstacle to wind in the direction of prevailing wind indicated by the arrow in Fig. 1. At stakes 18–25 of Line II situated very close to large icebergs, a large amount of accumulation was observed. From the facts mentioned above, it may be considered that

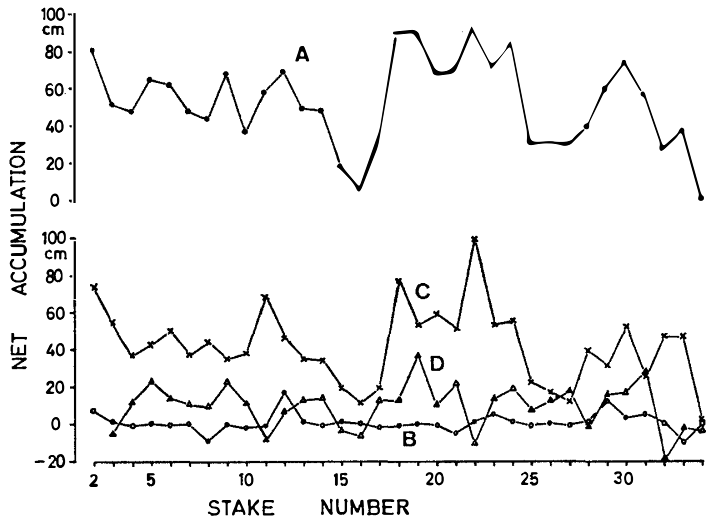

Fig. 4. Net accumulation of snow at stakes along Line II for 1973.
A: Whole period, 6 June–10 November (157 days)
B: 6 June–2 July (26 days).
C: 2 July–10 August (39 days).
D: 10 August–10 November (92 days).

areal distribution of the amount of accumulation is controlled by obstacles to wind such as island or iceberg in relation to the wind system, as formerly supposed by NARUSE *et al.* (1971).

4. Ablation at Syowa Station

4.1. Daily ablation and meteorological elements

Measurements of short-term ablation were made in the snow field behind Syowa Station called Site 2 here. Observation periods were from 11 December 1970 to 11 January 1971 and from 4 November 1974 to 3 January 1975.

The ablation rate is shown in Fig. 5, with related meteorological data at Syowa Station. It can be seen that ablation is quite little on the days with subzero air temperature in November. As air temperature rises and becomes around 0°C in December, ablation increases largely. In order to see this transition clearly, the relation between the daily rate of ablation and the daily mean air temperature is shown in Fig. 6. All data on the days without snowdrift or snowfall during both periods are plotted in this figure. From this figure, critical temperature for the transition between the stages of ablation can be estimated at −3°C. This critical temperature was also mentioned by ÔNO *et al.* (1971). When the daily mean air temperature is below the critical value, the daily maximum air temperature does not exceed 0°C. In this case evaporation will be the predominant factor in ablation. This case has been studied in detail by BUDD

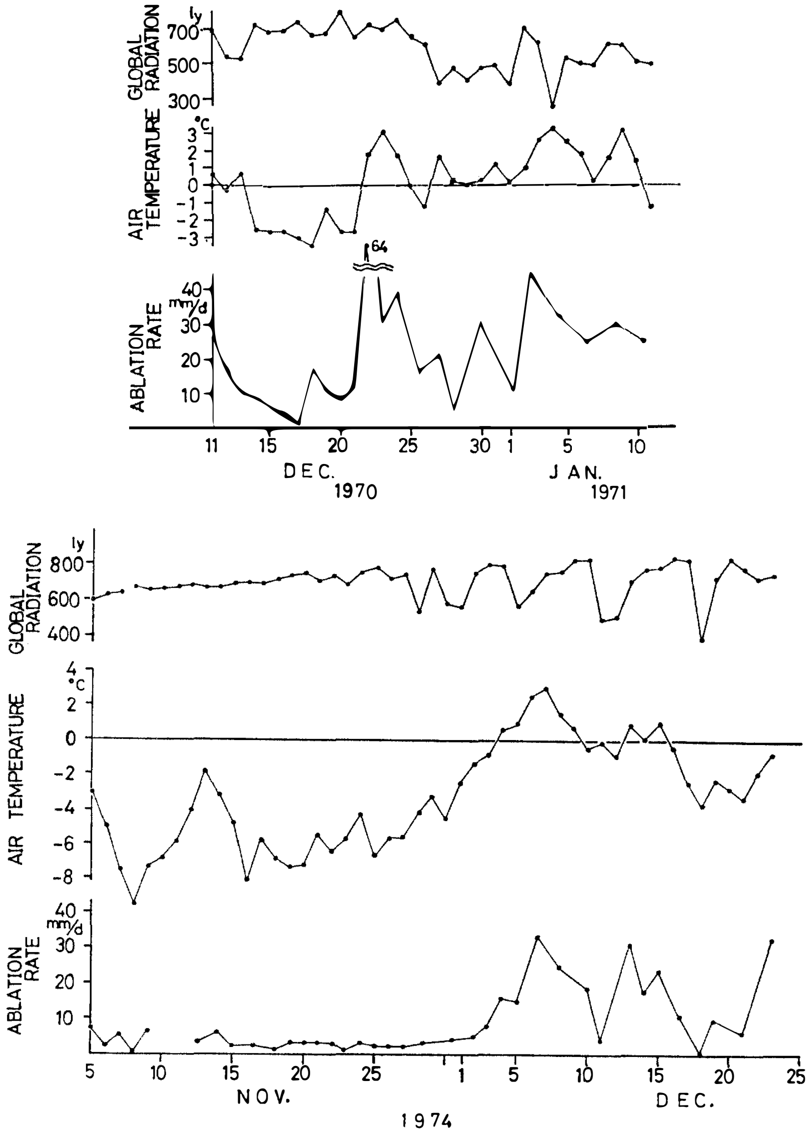

Fig. 5. Ablation rate, mean air temperature and global radiation for each day of two summer season, 11 December 1970–11 January 1971 (above) and 5 November–25 December 1974 (below).

(1967). When the daily mean air temperature exceeds the critical temperature, air temperature will become higher than 0°C in the daytime, and melting occurs due to short wave radiation and sensible heat from the air. This is the reason for the transition of the stage of ablation at around −3°C in Fig. 6. The ablation on the days with the daily mean air temperature above −3°C will be discussed here, since ablation on such days contributes more to the amount of seasonal ablation in this season.

In the polar region, the global radiation is quite high as shown in Fig. 5,

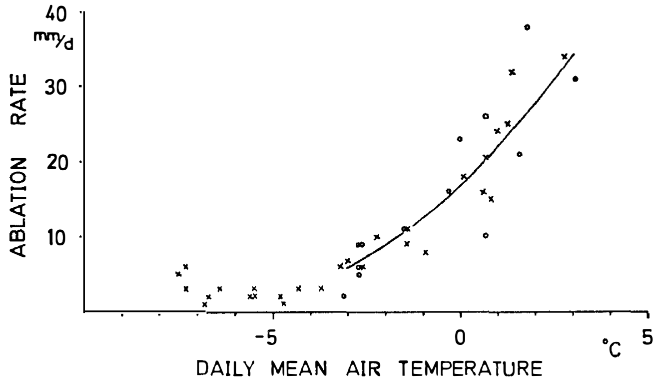

Fig. 6. Relation between ablation rate and daily mean air temperature.

namely, 600 lys/day or more, and the air temperature is relatively low. Therefore, it will be important to analyze the data from the viewpoint of radiation balance or heat balance. However, it is difficult to make such analysis at present, since the direct observations of long wave radiation and the temperature at the snow surface and inside the snow cover are not carried out yet, but it should be made in future.

Therefore, in order to correlate ablation with meteorological factors, the air temperature is used as one of the simple factors. This method is often employed when no observation is done on the radiation balance or heat balance. In this case, the daily mean air temperature had the best correlation to ablation as seen in Fig. 6. The regression line can be formulated as

$$A=0.40T^2+4.8T+17.0 \qquad (1),$$

where A is the ablation rate in mm/day, and T the daily mean air temperature in °C. The curve of eq. (1) is shown in Fig. 6.

On the basis of this equation, it is possible to estimate the depth of snow to be melted in one summer period at Syowa Station; the depth is denoted by "D" in this paper. According to the critical temperature for the transition of ablation stage, one summer period was assumed as that from 21 November when the daily mean air temperature rises above −3°C to 28 February when it becomes below −3°C. The daily ablation was estimated by eq. (1) for the days when the mean air temperature is above −3°C. For the days when it is below −3°C, the daily ablation is assumed as 2.7 mm/day, which is the average value of the daily ablation for the days with such temperature condition as shown in Fig. 6. The value of D can be obtained after summation of such daily ablation during one summer period. The values thus obtained for five summer seasons from 1968–1969 to 1972–1973 were 1320, 1117, 1264, 1263 and 936 mm respectively. The average value was 1184 mm.

4.2. Effect of bare ground on ablation

The ablation at Site 2 at Syowa Station is compared with that at Site 1, 12-stakes farm on sea ice for the period of 7–14 December 1970. This period was selected because no snowfall or drifting snow was observed within this period. The ablation amount for that period was more than 60 mm (8 mm/day) at Site 2 as seen in Fig. 5, and about 20 mm (3 mm/day) at Site 1 as seen in Fig. 2. Though these two places were within a distance of no more than a few hundred meters from each other, there was such a large difference in ablation amount between them. This difference can be ascribed to heat supply from the bare ground to the air and then to the snow surface. In the area near Syowa Station, the bare ground exists in summer season, and absorbs solar radiation enough to heat this area locally. Since Site 2 is surrounded by the bare ground, the ablation amount is greater than that at Site 1 where there is no heat source.

RUSIN (1965) reported on the effect of oasis, that is snow-free ground surrounded by snow or ice surface, on the air temperature. Air temperature over oasis and ice surface in the nearby Antarctic coastal area was observed. Air temperature at oasis was 1°C–3°C higher than that at ice surface, on the average for the summer season. Such difference of air temperature can be correlated to the size and landform of the oasis, and the meteorological elements such as wind. It can be considered that such "oasis effect" has an influence on the ablation at Syowa area.

At this moment, it is difficult to conclude whether this effect is the only reason for such difference in ablation amount or not. Another reason to be considered is difference of albedo. The surface condition of sea ice may be slightly different from that of snow surface at Site 2. If so, the albedo is different between the two places, and would produce some effect on the ablation. But, this effect is not considered in this case. Heat balance observation should be done simultaneously.

5. Conclusion

In the preceding sections, the observational results of accumulation and ablation of snow in the vicinity of Syowa Station have been described. In order to discuss mass budget in this region in detail, the amount and distribution of accumulation should be studied in relation to the topographical features of this region, and ablation should be studied with the method of heat balance taking into account the condition of landsurface.

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