—研究ノート—
Scientific Note

Some Observations of Sea Ice in the Vicinity of Lützow-Holm Bay, Antarctica

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南極リュツォ・ホルム湾地域における海氷観測について

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要旨: 1981年，南極リュツォ・ホルム湾内での海底地形調査を実施するに際して，海氷調査が行われた．調査は，地上および航空機による目視観測，NOAA衛星画像受信による海氷分布の推定，昭和基地付近での経時的な海氷氷厚測定，および 9 月末から 11 月初めの一冬氷の厚さがほぼ最大になる時期の，500 km の調査ルートに沿う氷厚測定などからなる．これらの調査は現時点で系統的な研究に結びつけることはできないが，海氷研究のための基礎的な資料の蓄積に有用と考え，結果を簡単に報告する．

Abstract: We conducted the sea ice investigation in the Lützow-Holm Bay region in 1981 in conjunction with the field work of submarine geomorphology. The investigation comprised observations on ground and from the air, simplified analysis of NOAA satellite images, and measurements of ice thickness in time sequence near Syowa Station and along 500-km long traverse routes during the period of the nearly maximum thickness of the first-year ice. The brief report presented here may be useful for future studies of sea ice conditions near Syowa Station.

1. Introduction

Sea ice observations in and around Lützow-Holm Bay have been conducted since the beginning of the Japanese Antarctic Research Expedition (JARE) in several ways. Visual observations of a pack ice zone aboard the expedition ship have been carried out not only for the scientific purpose but also for ship navigation (*e.g.* KUSUNOKI, 1958; SAIHYOKAN SHIRASE, 1987). KUSUNOKI (1981) discussed long term variations of sea ice conditions based partly on these data. The drifting of the ice-locked ship provided the occasion to observe pack ice movement (MURAUCHI and YOSHIDA, 1959). NARUSE *et al.* (1971) and WAKATSUCHI (1977) investigated the relationship between the sea ice growth and the freezing index. Freezing process of the sea was observed around Syowa Station (KOBAYASHI *et al.*, 1982). However, the broad fast ice zone of Lützow-Holm Bay has been rarely documented (KUSUNOKI *et al.*, 1970).

On the other hand, sea ice observation with satellite images has become increasingly important since early 1970s. Discrimination of an edge of sea ice area in the vicinity of Lützow-Holm Bay was attempted using the NOAA Microwave Sounding Unit data (YAMANOUCHI and SEO, 1984). Annual march of ice conditions from Lützow-Holm Bay to the offing of Enderby Land was traced with NOAA-AVHRR

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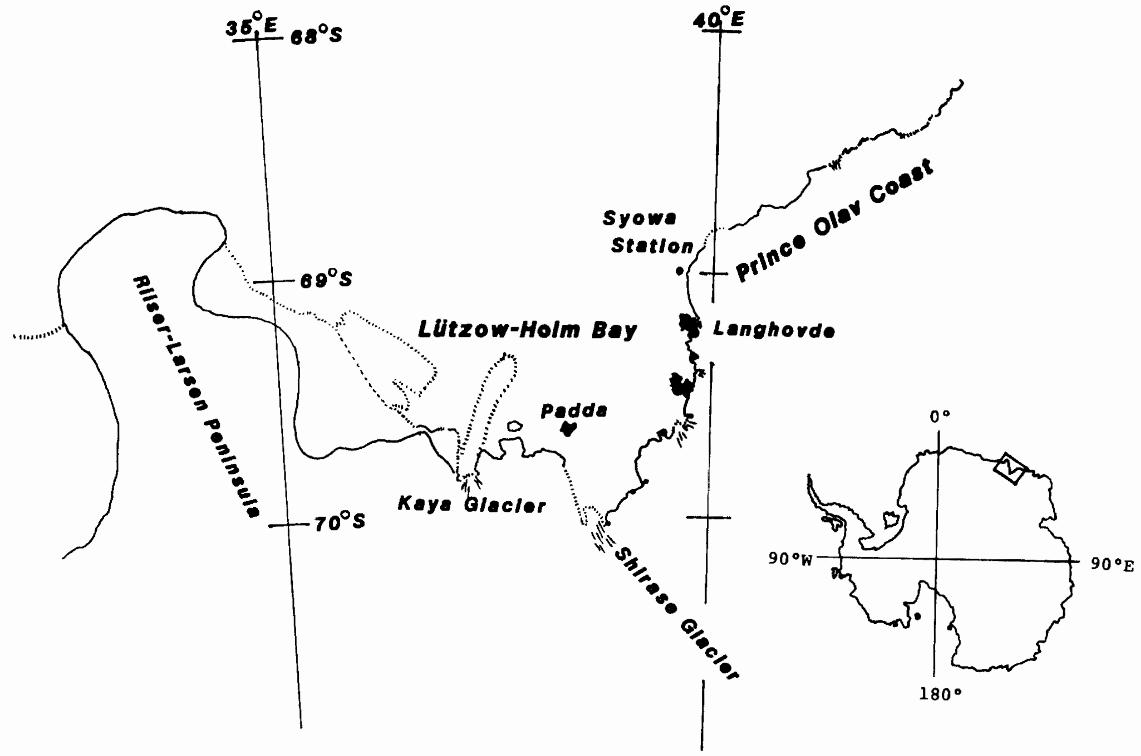

Fig. 1. Location map of Lützow-Holm Bay.

images for investigations of air-sea-ice interaction in the Antarctic Climate Research Program (ISHIKAWA *et al.*, 1989). Accumulation of ground truth data would be indispensable for the remote-sensing research of sea ice to accumulate ground truth data.

We conducted sea ice observations in the Lützow-Holm Bay region (Fig. 1) in 1981 mainly for the operation of submarine geomorphological survey by snow-vehicle and sledge traverse parties from the surface of sea ice (YOSHIDA and MORIWAKI, 1983). Data were obtained by ice thickness measurement, visual observation on ground and from the air and monitoring NOAA-6 and -7 satellite images of sea ice conditions. Results of these observations together with other sporadic observations are reported, because such kind of data ought to be amassed for sea ice researches in this region.

2. Distribution of Sea Ice

The following are thought to be usual characteristic features of sea ice, based on ground and aerial visual observations and satellite images. The fast ice covers Lützow-Holm Bay almost completely in winter, and a shore recurring polynya is formed along the northeast coast of the bay in late summer. The shore polynya extends its area by melting of ice in late summer from late January to February and by breaking off of ice caused by heavy wind from late summer to May or June. Degree of development of the polynya differs greatly from year to year. The ever-recorded latest breaking off of fast ice near Syowa Station took place in August of 1968 (FUJIWARA, 1969). On the other hand, melting of sea ice in the western part of the bay seems very rare to occur.

A flaw lead, or polynya, is often formed at the boundary between pack ice and fast ice zones. The lead expands, narrows and disappears, affected by the prevailing wind. The position of the lead seems to coincide roughly with the outer edge of the continental shelf in summer and perhaps throughout the year, if the pack ice remains north of the fast ice.

The observations in 1981 showed that the shore polynya began to form near the Langhovde ice-free area in early January, then enlarged extensively to occupy more than a fourth of the bay area in March, and survived until the beginning of June (Figs. 2–5). Melting of fast ice which generates the shore polynya at the start appears to be influenced by the presence of blue (bare) ice area on fast ice near the coastline and the sandy dust on it blown from the ice-free area. Therefore, the occurrence of the polynya seems to be affected considerably by the accumulation of new snow in November and December when the melting of snow and ice is remarkable. The number of days of snowfall in November and December was 39, the largest in the last 26 years record, almost double of the mean 20.6. As a result, very few puddles on sea ice were produced in January 1982, and the polynya by melting of fast ice did not occur. In 1985, the number of days of snowfall in November and December was 30, the second largest in the last 26 years record. This would also have caused a smaller amount of sea ice melting.

Fig. 2. A processed NOAA-6 image of Lützow-Holm Bay and its surroundings, January 3, 1981.

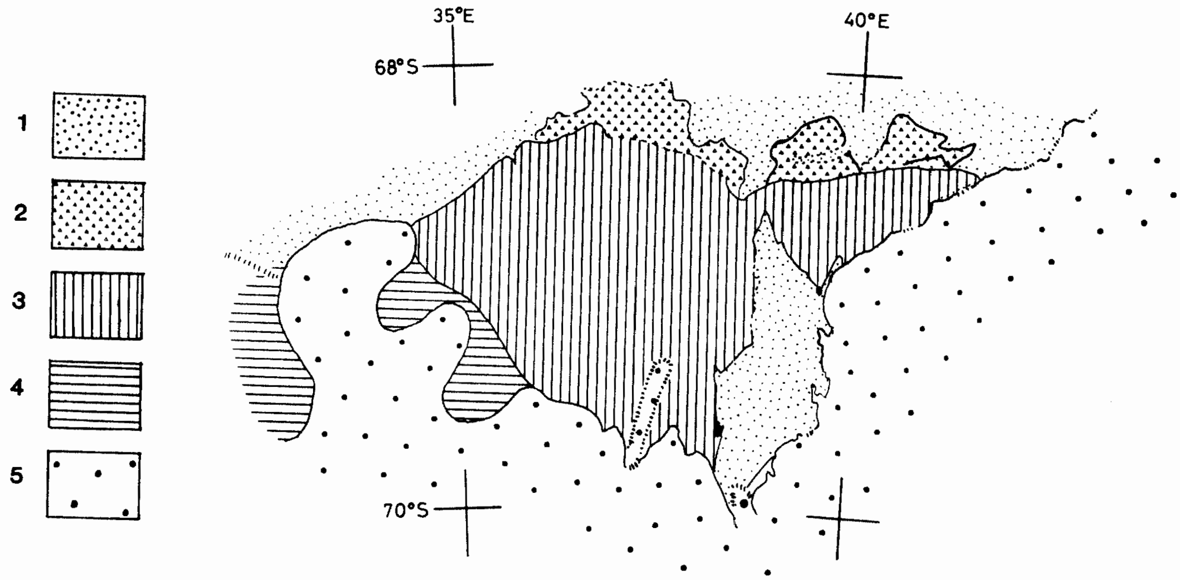

Fig. 3. A sketch map of distribution of sea ice in Lützow-Holm Bay, March 30, 1981.
1: Open water, 2: Pack ice, 3: Mostly fast ice, 4: Shelf-like ice, 5: The ice sheet and a glacier tongue.

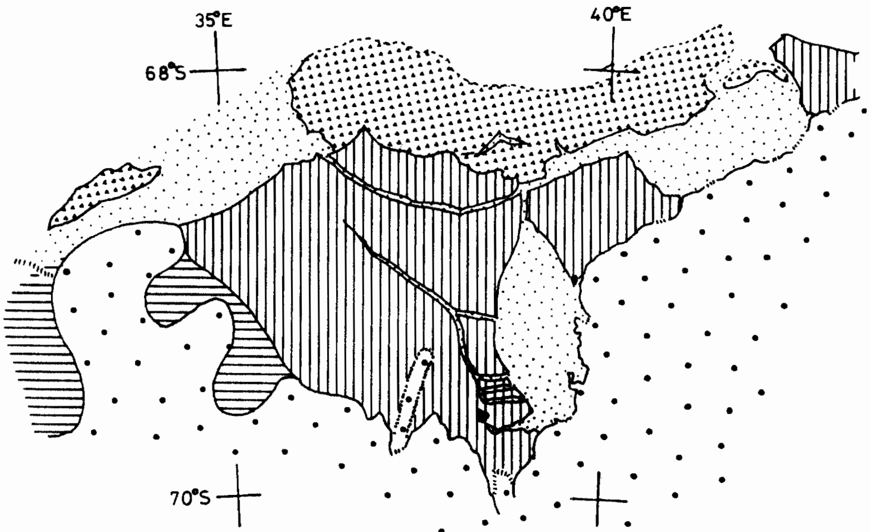

Fig. 4. A sketch map of distribution of sea ice in Lützow-Holm Bay, May 26, 1981.

3. Ice Thickness Measurements

The ice thickness measurements were carried out at 1 to 2 km intervals along the traverse routes 500 km long in Lützow-Holm Bay. Figure 6 shows the ice thickness distribution, based on the measurements from the end of September to the beginning of November when the fast ice thickness seems to become nearly maximum.

The thickness of first-year ice in the eastern part of the bay ranges from 100 to 140 cm and thins generally toward the eastern coast. The thickness of second-year

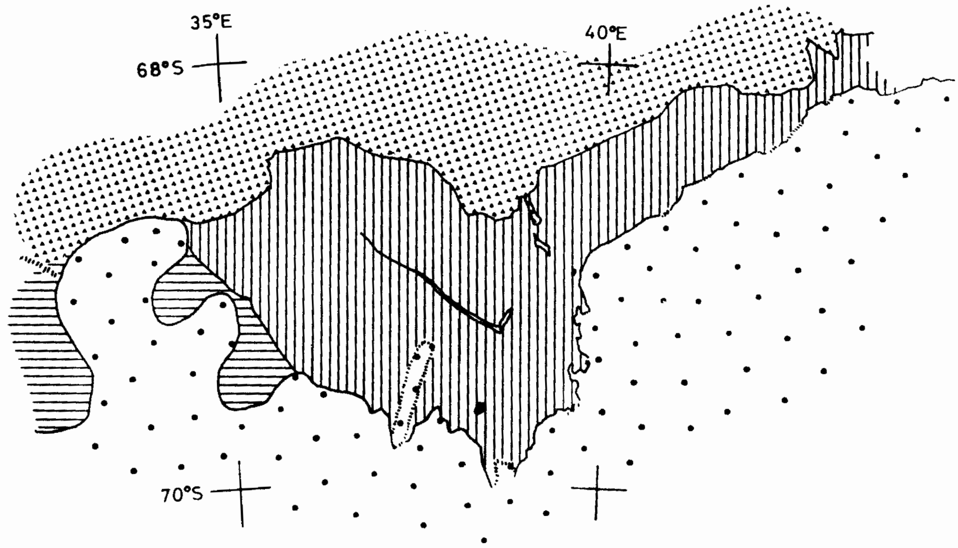

Fig. 5. A sketch map of distribution of sea ice in Lützow-Holm Bay, August 15, 1981.

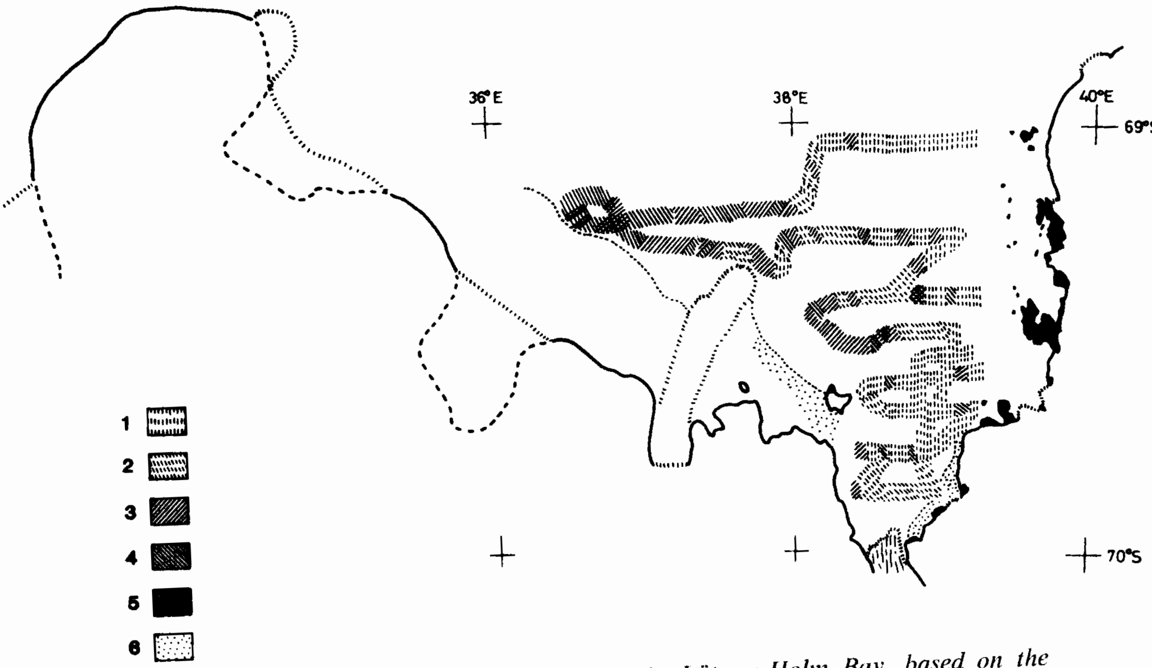

Fig. 6. Distribution of fast ice thickness in Lützow-Holm Bay, based on the measurements between the end of September and the beginning of November 1981.
1: 100–120 cm, 2: 130–140 cm, 3: 160–180 cm, 4: 200–300 cm, 5: >300 cm, 6: Probably more than 1000 cm.

or multi-year ice in the west increases toward west from 160 cm to more than 300 cm. In some places, the thickness of old ice appears to exceed 1000 cm, inferred from the surface elevation above sea level. Such thick ice, which rarely breaks out, locks iceberg tongues, glacier tongues and many icebergs in the western Lützow-Holm Bay.

On the other hand, the relationship the between growth of ice thickness and the freezing index ($\sum \theta$: degree-days, $-$°C) is shown in Fig. 7, based on the measurements near Syowa Station in 1981. The empirical equations thus obtained were almost same as those obtained by NARUSE *et al.* (1971).

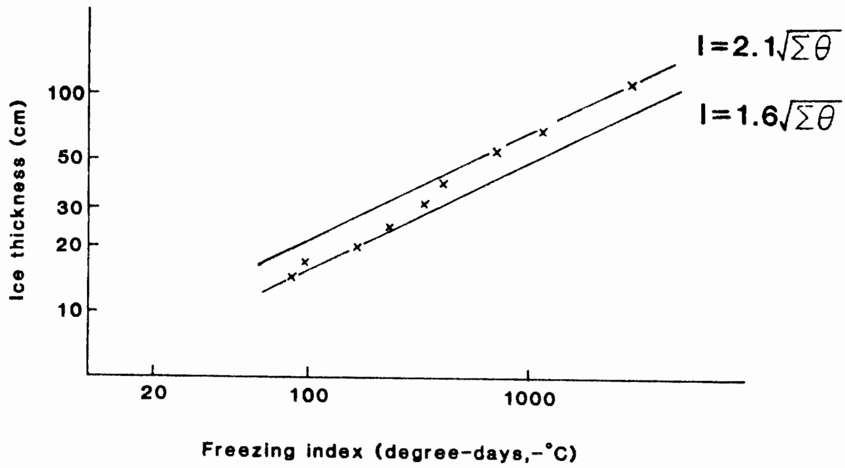

Fig. 7. Relationship between the fast ice growth and the freezing index (degree-days, $-$°C).

4. Concluding Remarks

Sea ice observations in 1981 yielded the information on the fast ice thickness of a considerable part of Lützow-Holm Bay for the first time. The data are limited to the 1981 season, but they would be useful as ground truth for future investigation by satellite image interpretation. The observations would also be one of the bases for qualitative description of characteristics of sea ice in the Lützow-Holm Bay region for field and ship navigation operations.

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