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# Sea Ice Thickness and Snow Depth Data Collected by Ship-based Video Observations during the 29th to 48th Japanese Antarctic Research Expeditions

Shotaro Uto[1*], Haruhito Shimoda[1], Shigeru Aoki[2], Shuki Ushio[3], Fumihiko Nishio[4]
Hiroyuki Wakabayashi [5], Gen Hashida[3], Kumiko Goto-Azuma[3]
Atsushi Furusaki[6] and Kazutaka Tateyama[7]

[1] National Maritime Research Institute
6-38-1, Shinkawa, Mitaka city, Tokyo181-0004.
[2] Institute of Low Temperature Science, Hokkaido University
Kita-19, Nishi-8, Kita-ku, Sapporo 060-0819.
[3] National Institute of Polar Research, Research Organization of Information and Systems
Kaga 1-chome, Itabashi-ku, Tokyo 173-8515.
[4] Center for Environmental Remote Sensing, Chiba University
1-33 Yayoi, Inage, Chiba 263-8522.
[5] College of Engineering, Nihon University
1 Naka-gawara, Tokusada, Tamura-machi, Koriyama, Fukushima 963-8642.
[6] Asahikawa National College of Technology
2-2-1-6, Shunkoudai, Asahikawa, Hokkaido 071-8142.
[7] Department of Civil and Environmental Engineering, Kitami Institute of Technology
165, Koen-cho, Kitami, Hokkaido 090-8507.
*Corresponding author. E-mail: uto@nmri.go.jp

## Introduction

The Japanese Antarctic Research Expedition (hereafter denoted as JARE) initiated the ship-based video observations of sea ice and snow thicknesses in December 1987 (JARE-29, Kamimura and Kitagawa 1989).

A downward-looking video camera was mounted at the side deck of the Japanese Antarctic Research vessel, icebreaker "*Shirase*" for measuring sea ice and snow thicknesses during its outbound and homebound voyages ( to and from Syowa Station (69° 00'E, 39° 35' S)).

These observations had been conducted consecutively from December 1988 to January 1991 (JARE-30 to 32) as part of the Japanese Antarctic Climate Research (ACR) program. The results were reported by Shimoda *et. al* (1997).

After two periods of observation in December 1997 (JARE-39) and December 1999

(JARE-41), video observations have been conducted consecutively since December 2000 (JARE-42).

This report summarizes the results of ship-based video observations of sea ice and snow thicknesses from JARE-29 to 48.

## Method and accuracy

Fig. 1 shows the sea ice monitoring system onboard "*Shirase*" since December 2000. Ice and snow thickness are measured using a downward-looking video camera situated at the side deck. Ice is broken into pieces at the bow and a few of them turn into side-up positions. Using these images, ice and snow thicknesses can be measured along the vessel's track (Fig. 2).

It is reported that this method has good accuracy for level and moderately deformed ice (Shimoda *et al.,* 1996, Lensu and Haas, 1998). Shimoda *et al.* (1996) conducted the uncertainty analysis of the measurement error for relatively thin ice in the Sea of Okhotsk. They concluded that the 95% confidence interval is within 11% for 1m-thick ice (Table 2).

Deformed ice such as ridged and hummocked ice often contains an unconsolidated part, which falls off by ice breaking process. Thus it is recognized that this method is not suitable for such highly deformed ice. This method is fundamentally suitable for the measurement of land fast ice in Lützow-Holm Bay, which Bay mostly consists of level and moderately deformed ice.

Uto *et al.* (2006) derived the following correlation equation of total thickness (=ice plus snow thickness) measured by the video and Electro-magnetic induction (EM) methods (see Fig. 1) using the concurrent measurement dataset in Lützow-Holm Bay.

$$Z_{I\_EM} = Z_{I\_Video} + 0.179 \times Z_{I\_Video}^2 \qquad (1)$$

Here, $Z_{I\_EM}$ and $Z_{I\_Video}$ denote the total thickness by the EM and video methods, respectively. This equation indicates that the video method gives thinner total thickness than the EM method, the difference increases as the thickness.

It is observed that the thick multi-year, summer ice often contains the loose undermost layer, which falls off during turning into the side-up position (Uto *et al.,* 2006). It might cause the under-estimation of thickness for thick multi-year ice like highly deformed ice. The equation (1) supports that the video method gives the thickness of the consolidated part of thick multi year ice. Thus this equation might be helpful for correcting thickness measured by the video method to the overall thickness, if it is thick multi-year land fast ice including loose undermost layer.

## Results

Table 1. Summary of the video observations of ice and snow thicknesses

| JARE | Voyage | Principal Observer | Date of Observation | | No. of Data | | Position Data |
|---|---|---|---|---|---|---|---|
| | | | from | to | Total Thickness | Snow Depth | |
| 29 | Outbound | Uto | 1987/12/16 | 1988/1/1 | 130 | 48 | Suzuki and Fukuchi(1997) |
| | Homebound | | 1988/2/3 | 1988/2/5 | 93 | 0 | |
| 30 | Outbound | Endoh | 1988/12/25 | 1988/12/29 | 729 | 0 | Log book of Shirase |
| 31 | Outbound | Takizawa | 1989/12/15 | 1990/1/10 | 5885 | 211 | Log book of Shirase |
| 32 | Outbound | Ohshima | 1990/12/15 | 1991/1/6 | 3089 | 0 | Ohtaka, Private communication |
| 39 | Outbound | Aoki | 1997/12/12 | 1998/1/25 | 264 | 54 | Aoki, Private communication |
| 41 | Outbound | Ushio | 1999/12/17 | 1999/12/24 | 181 | 50 | Ushio, Private communication |
| 42 | Outbound | Uto | 2000/12/23 | 2000/12/30 | 308 | 81 | Dedicated GPS measurement |
| | Homebound | | 2001/1/22 | 2001/2/17 | 184 | 13 | |
| 43 | Outbound | Nishio | 2001/12/15 | 2001/12/23 | 504 | 51 | Dedicated GPS measurement |
| | Homebound | | 2002/2/10 | 2002/2/12 | 85 | 8 | |
| 44 | Outbound | Hashida | 2002/12/15 | 2002/12/26 | 217 | 62 | Dedicated GPS measurement |
| | Homebound | Wakabayashi | 2003/2/10 | 2003/2/22 | 122 | 63 | |
| 45 | Outbound | Azuma | 2003/12/15 | 2003/12/21 | 463 | 189 | Dedicated GPS measurement |
| 46 | Outbound | Furusaki | 2004/12/15 | 2004/12/21 | 1496 | 949 | Dedicated GPS measurement |
| | Homebound | Azuma | 2005/2/9 | 2005/2/18 | 1553 | 603 | |
| 47 | Outbound | Shimoda | 2005/12/16 | 2005/12/24 | 598 | 134 | Dedicated GPS measurement |
| | Homebound | | 2006/02/12 | 2006/02/12 | 80 | 22 | |
| 48 | Outbound | Tateyama | 2006/12/17 | 2006/12/23 | 686 | 236 | Dedicated GPS measurement |
| | Homebound | | 2007/02/11 | 2007/02/19 | 544 | 185 | |

Table 2. Upper and lower values of the 95% confidence interval
(Shimoda *et al.* 1996)

| h (cm) | U+ (cm) | U- (cm) |
|---|---|---|
| 10 | 2.05 | 2.13 |
| 20 | 2.34 | 2.63 |
| 30 | 2.76 | 3.30 |
| 40 | 3.26 | 4.05 |
| 50 | 3.89 | 5.82 |
| 60 | 4.49 | 6.86 |
| 70 | 5.11 | 7.92 |
| 80 | 5.74 | 8.99 |
| 90 | 6.38 | 10.06 |
| 100 | 7.03 | 11.14 |

U+ and U- give the upper and lower values of the 95% confidence interval, respectively.

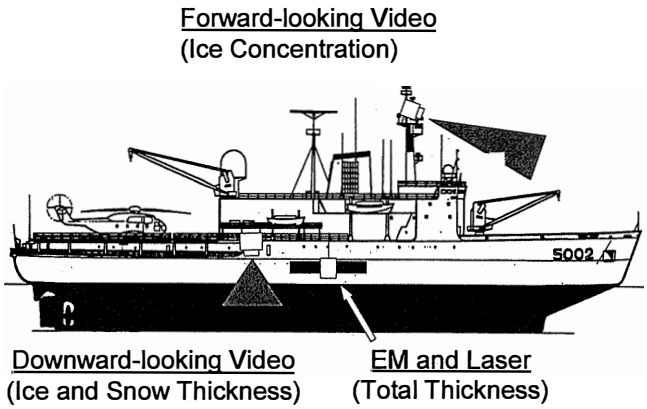


Fig. 1. Sea ice monitoring system onboard *"Shirase"* since December 2000.

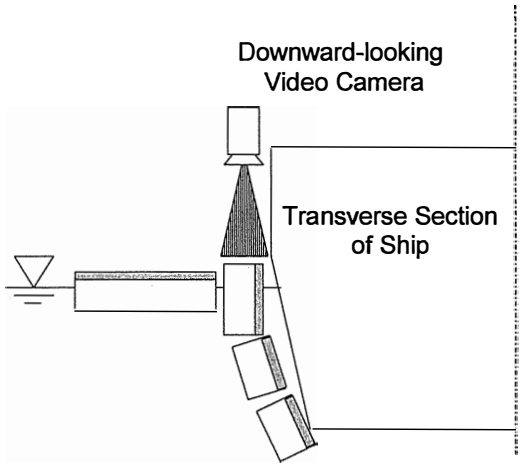


Fig. 2. Principle of ice and snow thickness measurement using a downward-looking video camera.

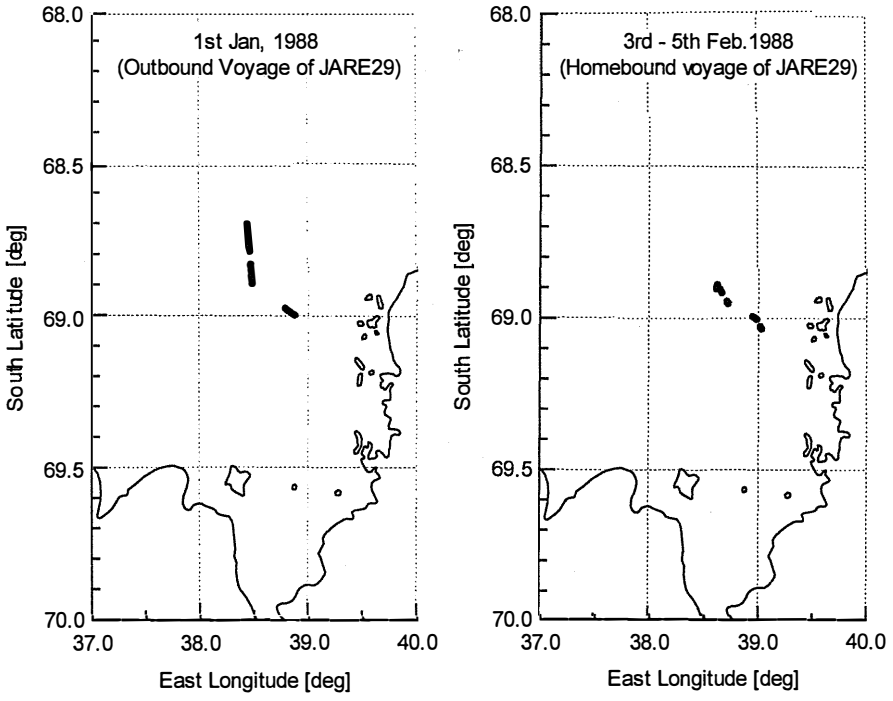


Fig. 3 (a) Locations of ice and snow thickness measurements of land-fast ice in Lützow-Holm Bay during the summer operations of JARE-29 (left : outbound voyage, right : homebound voyage).

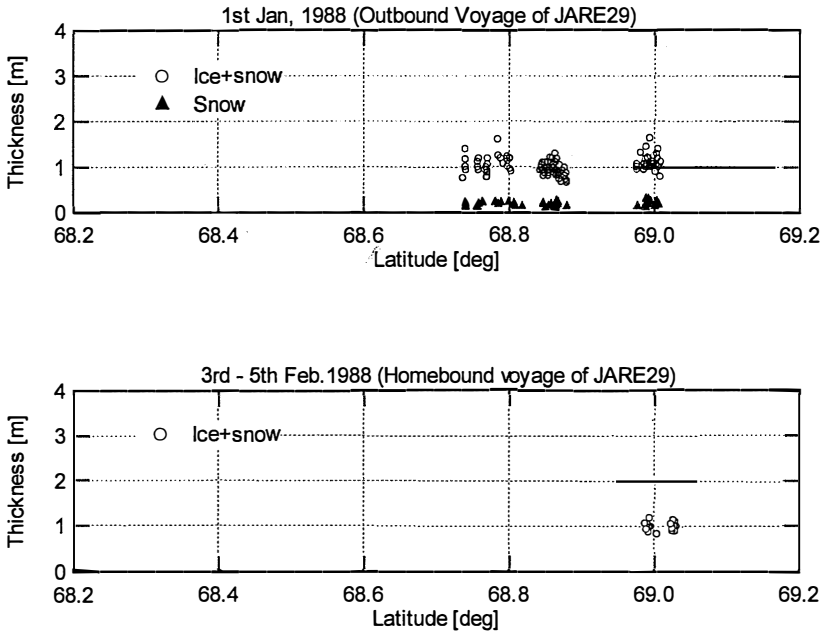


Fig. 3 (b) Ice and snow thickness distributions of land fast ice in Lützow-Holm Bay during the summer operation of JARE-29 (top : outbound voyage, bottom : homebound voyage).

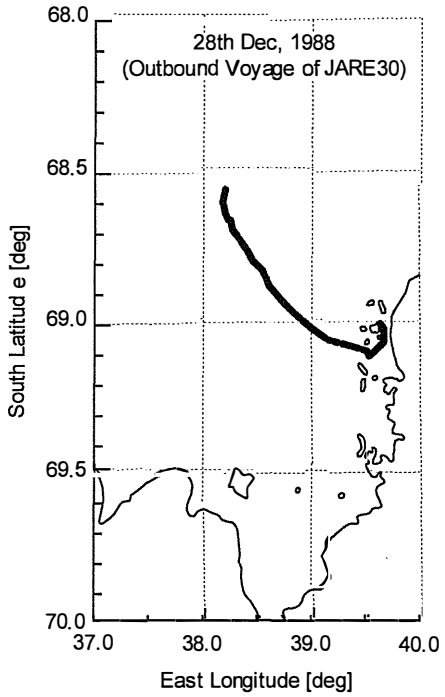


Fig. 4 (a) Locations of ice and snow thickness measurements of land-fast ice in Lützow-Holm Bay during the outbound voyage of the summer operations of JARE-30.

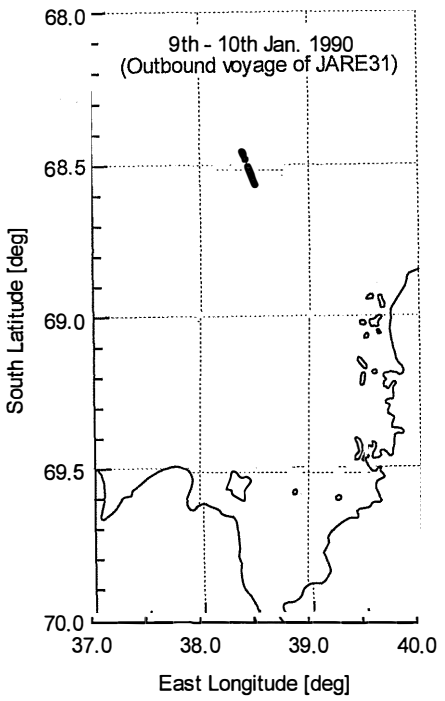


Fig. 5 (a) Locations of ice and snow thickness measurements of land-fast ice in Lützow-Holm Bay during the outbound voyage of the summer operations of JARE-31.

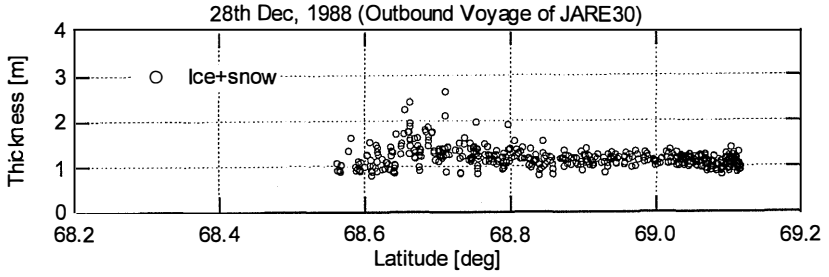


Fig. 4 (b) Ice and snow thickness distributions of land fast ice in Lützow-Holm Bay during the outbound voyage of the summer operations of JARE-30.

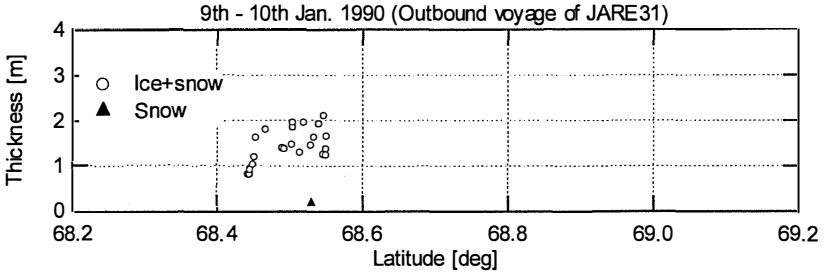


Fig. 5 (b) Ice and snow thickness distributions of land fast ice in Lützow-Holm Bay during the outbound voyage of the summer operations of JARE-31.

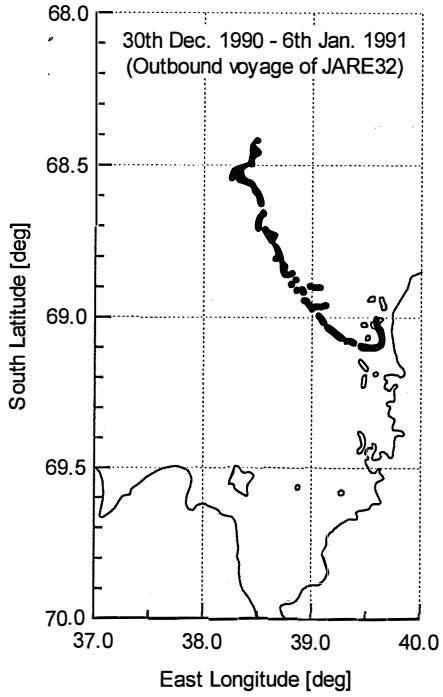


Fig. 6 (a) Locations of ice and snow thickness measurements of land-fast ice in Lützow-Holm Bay during the outbound voyage of the summer operations of JARE-32.

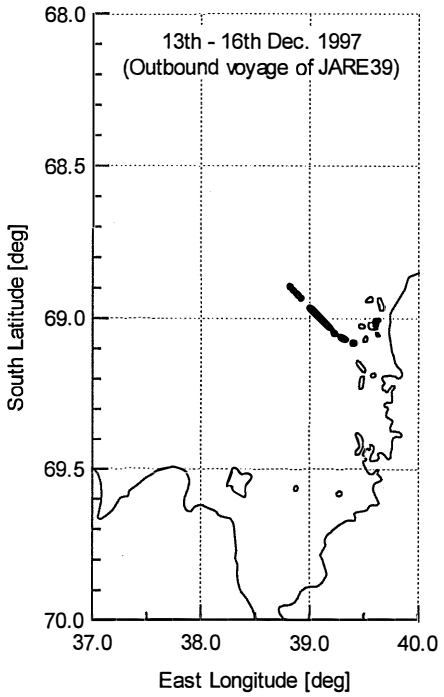


Fig. 7 (a) Locations of ice and snow thickness measurements of land-fast ice in Lützow-Holm Bay during the outbound voyage of the summer operations of JARE-39.

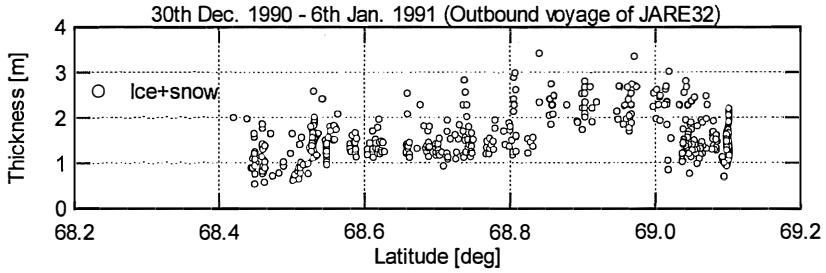


Fig. 6 (b) Ice and snow thickness distributions of land fast ice in Lützow-holm Bay during the outbound voyage of the summer operations of JARE-32.

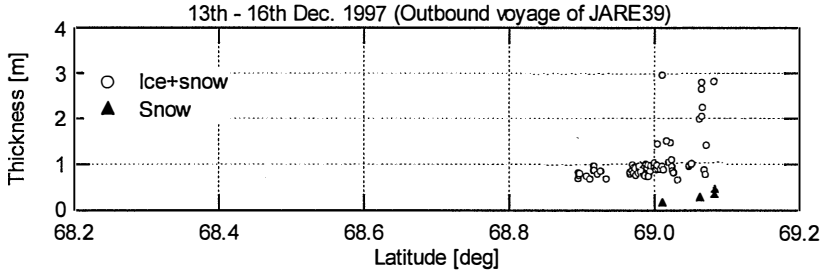


Fig. 7 (b) Ice and snow thickness distributions of land fast ice in Lützow-Holm Bay during the outbound voyage of the summer operations of JARE-39.

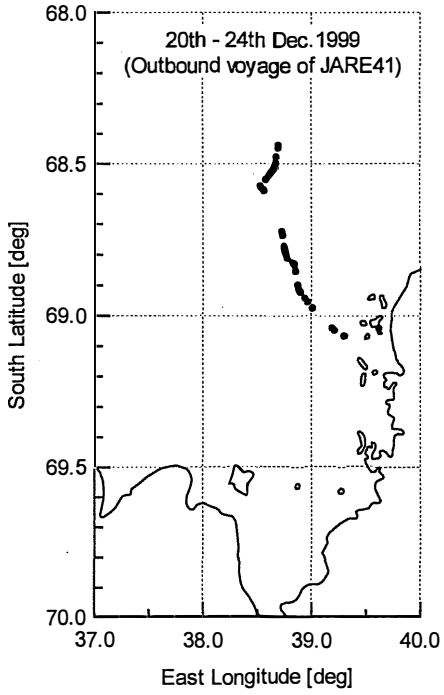


Fig. 8 (a) Locations of ice and snow thickness measurements of land-fast ice in Lützow-Holm Bay during the outbound voyage of the summer operations of JARE-41.

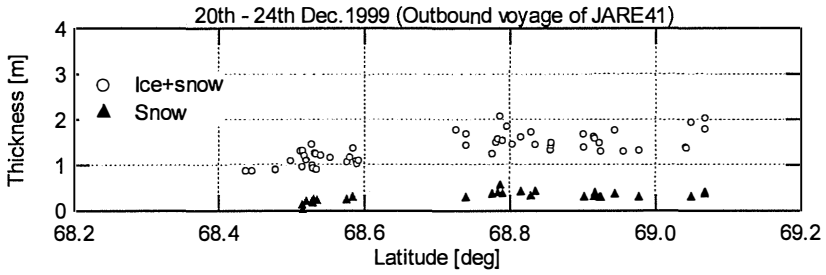


Fig. 8 (b) Ice and snow thickness distributions of land fast ice in Lützow-Holm Bay during the outbound voyage of the summer operations of JARE-41.

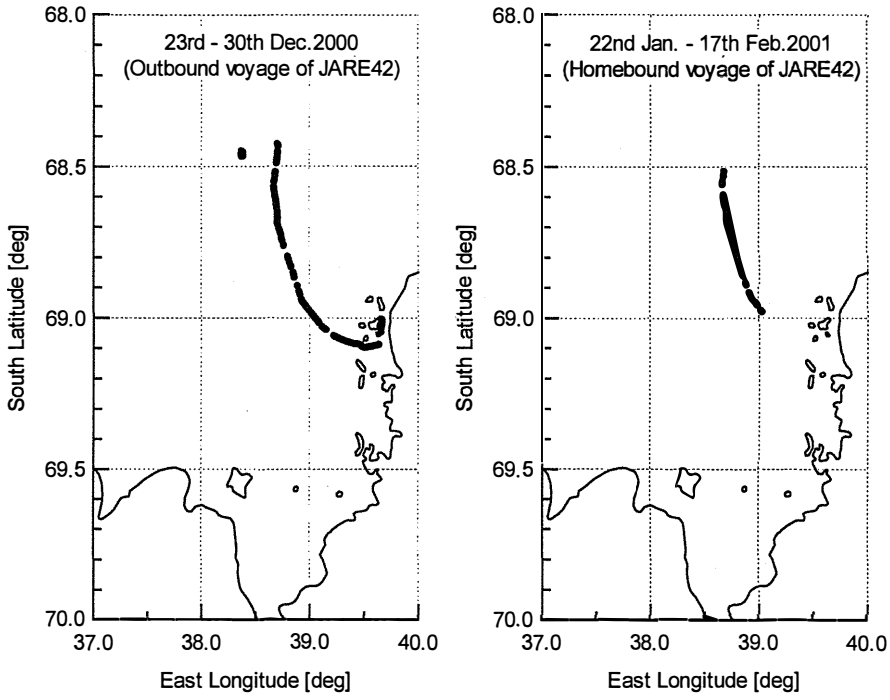


Fig. 9 (a) Locations of ice and snow thickness measurements of land-fast ice in Lützow-Holm Bay during the summer operations of JARE-42 (left : outbound voyage, right : homebound voyage).

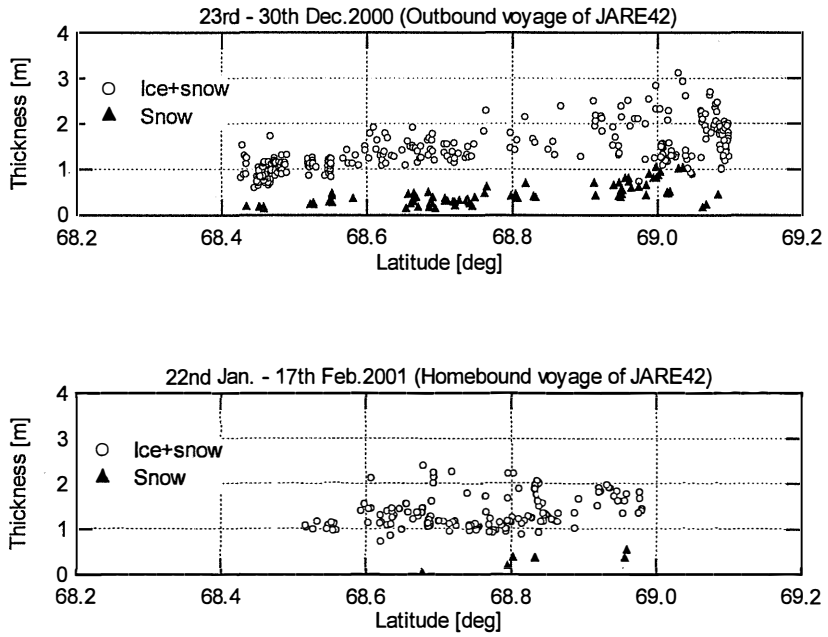


Fig. 9 (b) Ice and snow thickness distributions of land fast ice in Lützow-Holm Bay during the summer operations of JARE-42 (top : outbound voyage, bottom : homebound voyage).

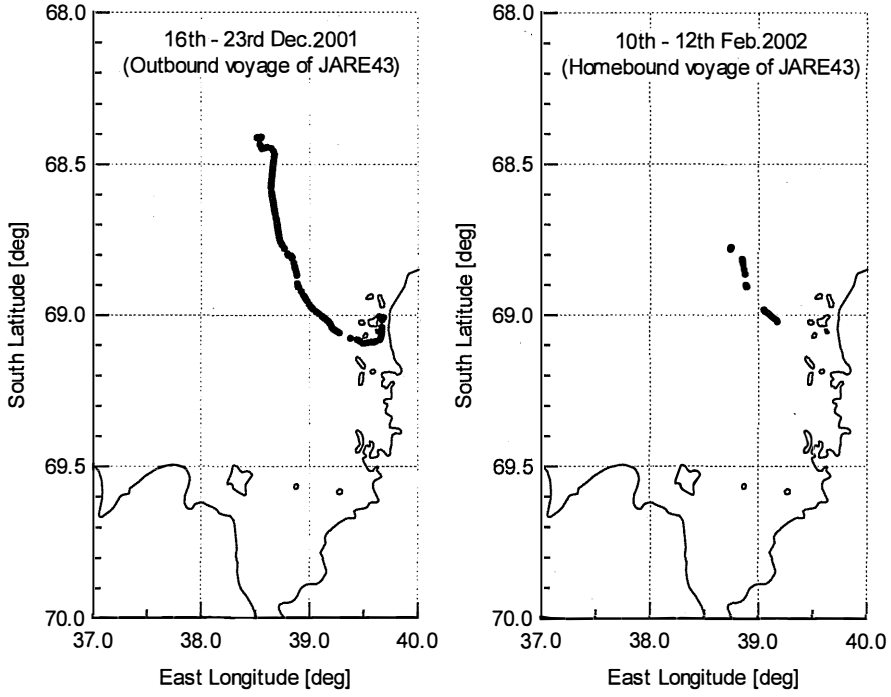


Fig. 10 (a) Locations of ice and snow thickness measurements of land-fast ice in Lützow-holm Bay during the summer operations of JARE-43 (left : outbound voyage, right : homebound voyage).

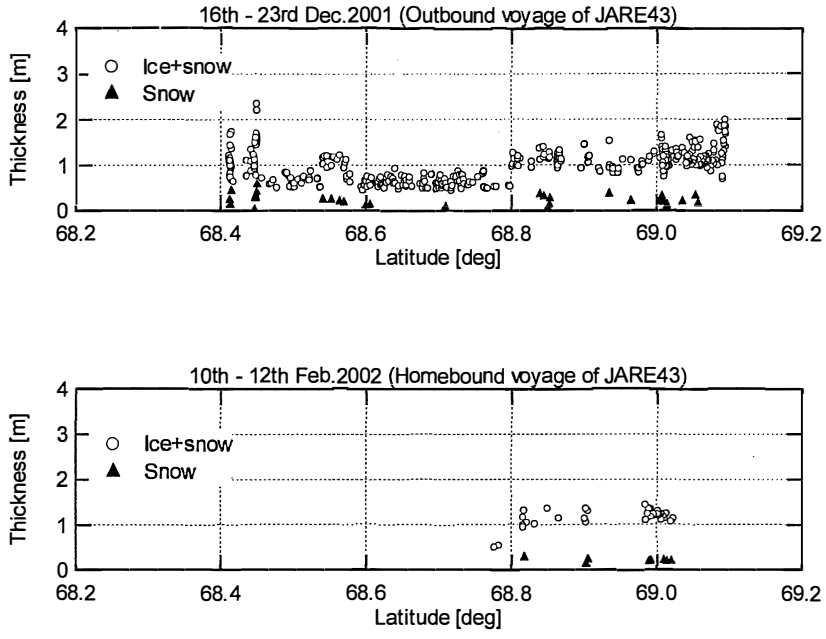


Fig. 10 (b) Ice and snow thickness distributions of land fast ice in Lützow-Holm Bay during the summer operations of JARE-43 (top : outbound voyage, bottom : homebound voyage).

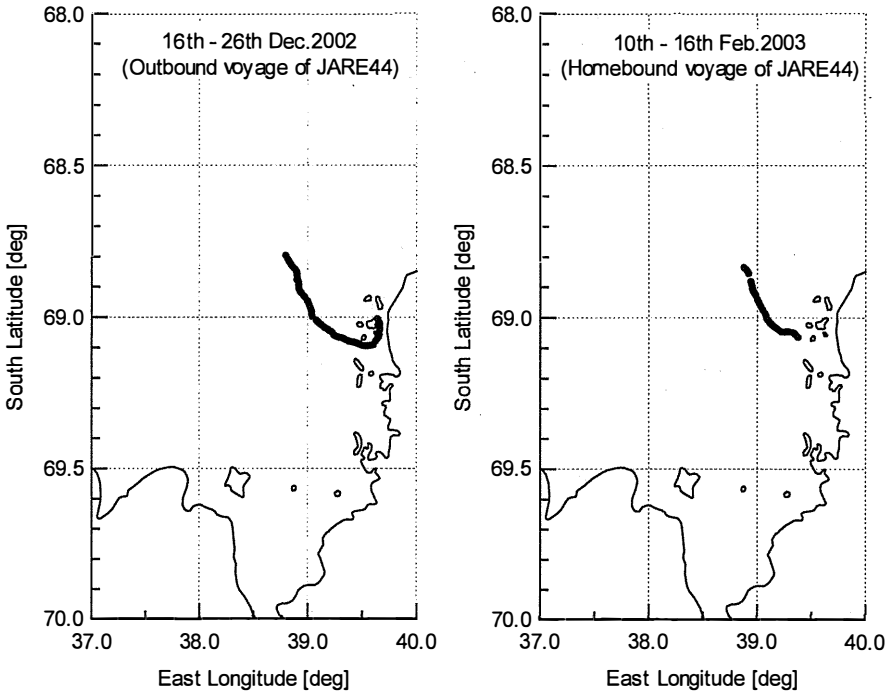


Fig. 11 (a) Locations of ice and snow thickness measurements of land-fast ice in Lützow-Holm Bay during the summer operations of JARE-44 (left : outbound voyage, right : homebound voyage).

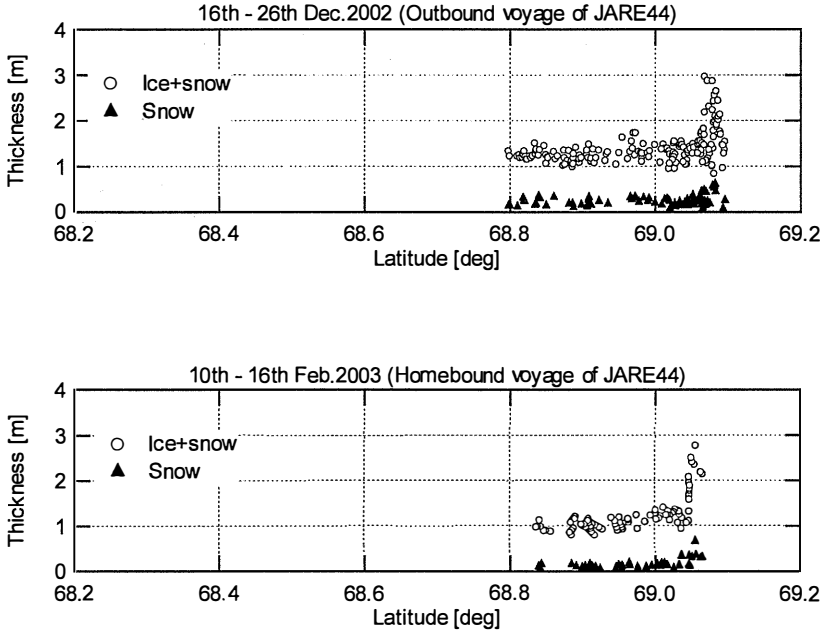


Fig. 11 (b) Ice and snow thickness distributions of land fast ice in Lützow-Holm Bay during the summer operations of JARE-44 (top : outbound voyage, bottom : homebound voyage).

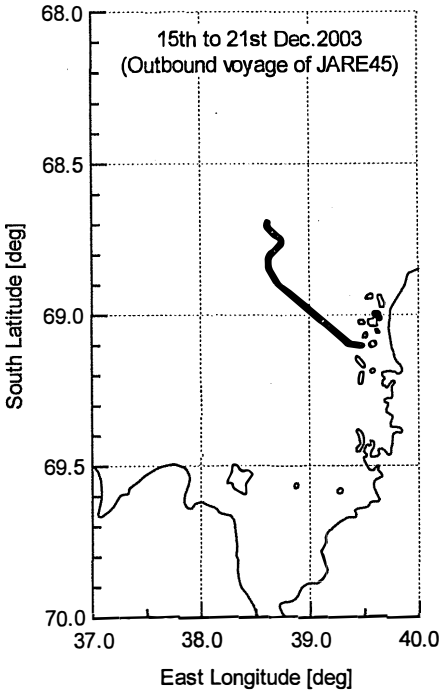


Fig. 12 (a) Locations of ice and snow thickness measurements of land-fast ice in Lützow-Holm Bay during the outbound voyage of the summer operations of JARE-45.

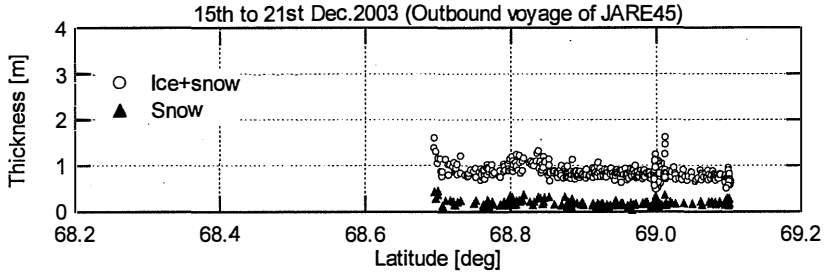


Fig. 12 (b) Ice and snow thickness distributions of land fast ice in Lützow-Holm Bay during the outbound voyage of the summer operations of JARE-45.

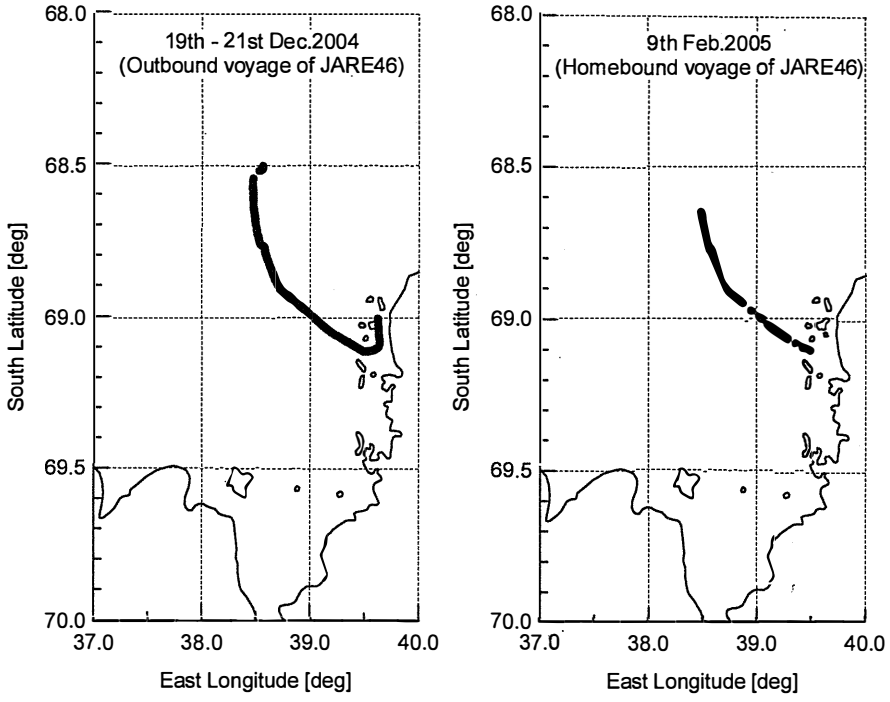


Fig. 13 (a) Locations of ice and snow thickness measurements of land-fast ice in Lützow-Holm Bay during the summer operations of JARE-46 (left : outbound voyage, right : homebound voyage).

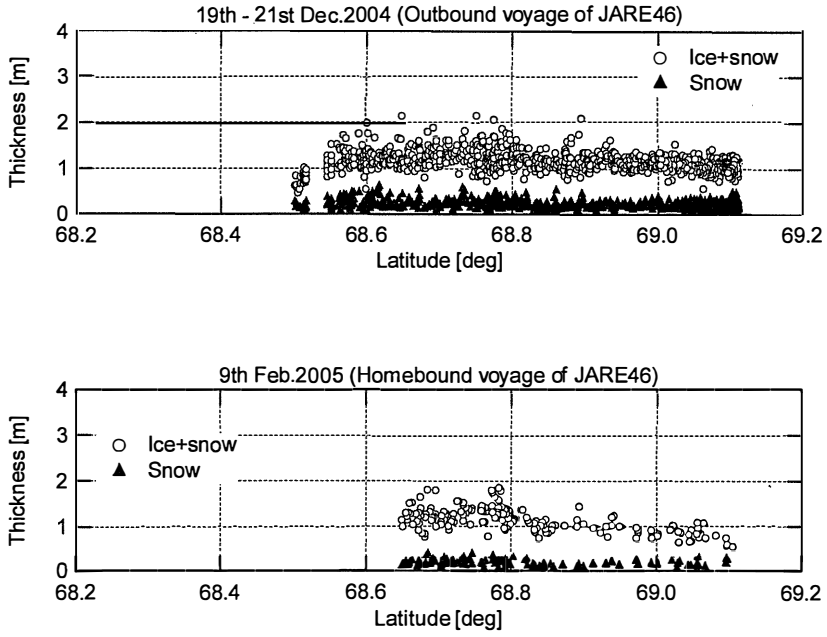


Fig. 13 (b) Ice and snow thickness distributions of land fast ice in Lützow-Holm Bay during the summer operations of JARE-46 (top : outbound voyage, bottom : homebound voyage).

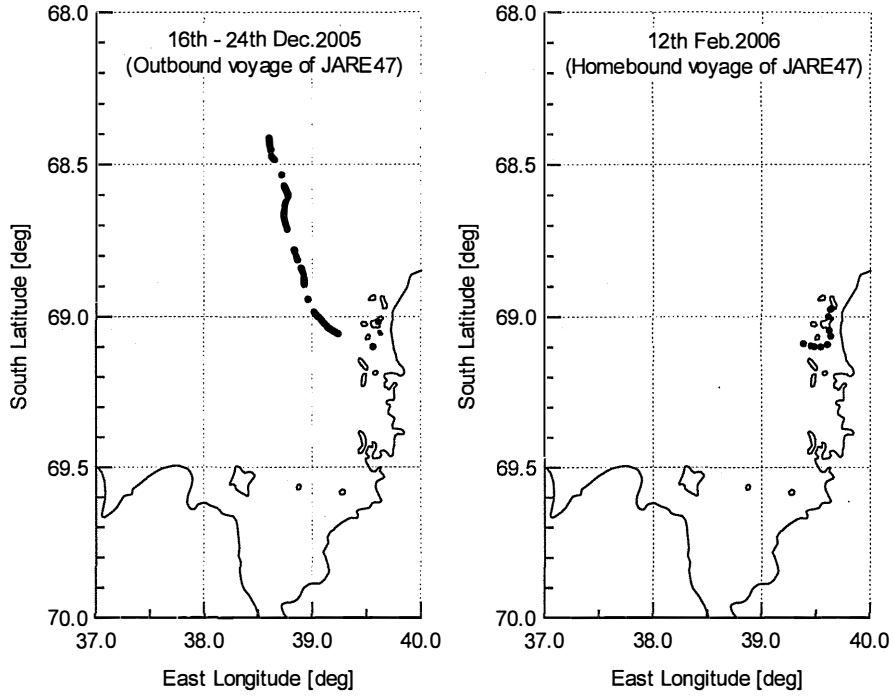


Fig. 14 (a) Locations of Ice and Snow Thickness Measurements of land-fast ice in Lützow-Holm Bay during the summer operations of JARE-47 (left : outbound voyage, right : homebound voyage).

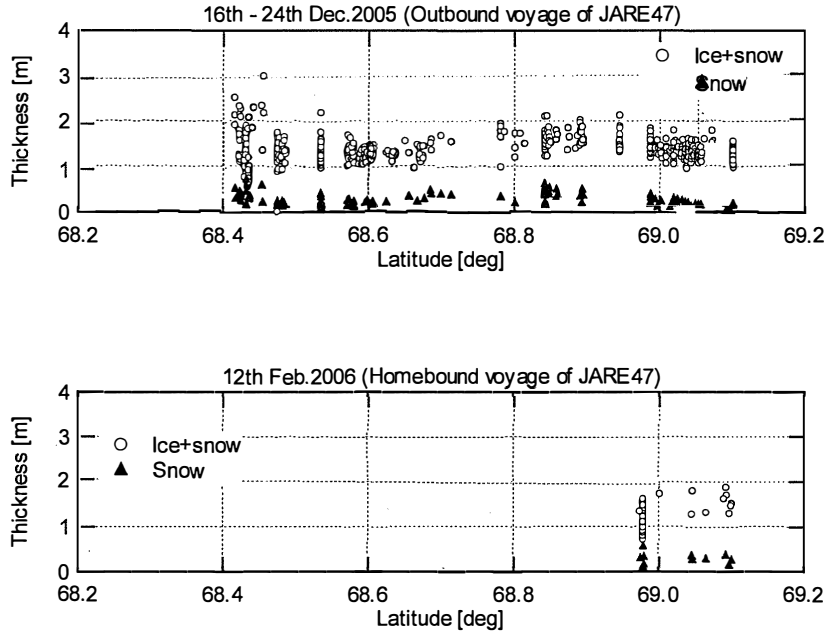


Fig. 14 (b) Ice and snow thickness distributions of land fast ice in Lützow-Holm Bay during the summer operations of JARE-47 (top : outbound voyage, bottom : homebound voyage).

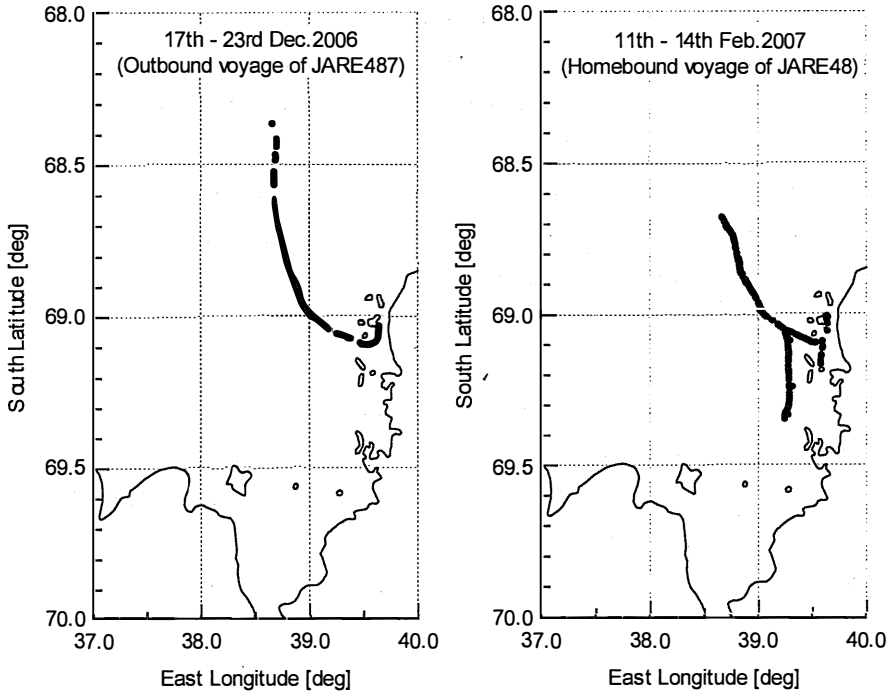


Fig. 15 (a) Locations of ice and snow thickness measurements of land-fast ice in Lützow-Holm Bay during the summer operations of JARE-48 (left : outbound voyage, right : homebound voyage).

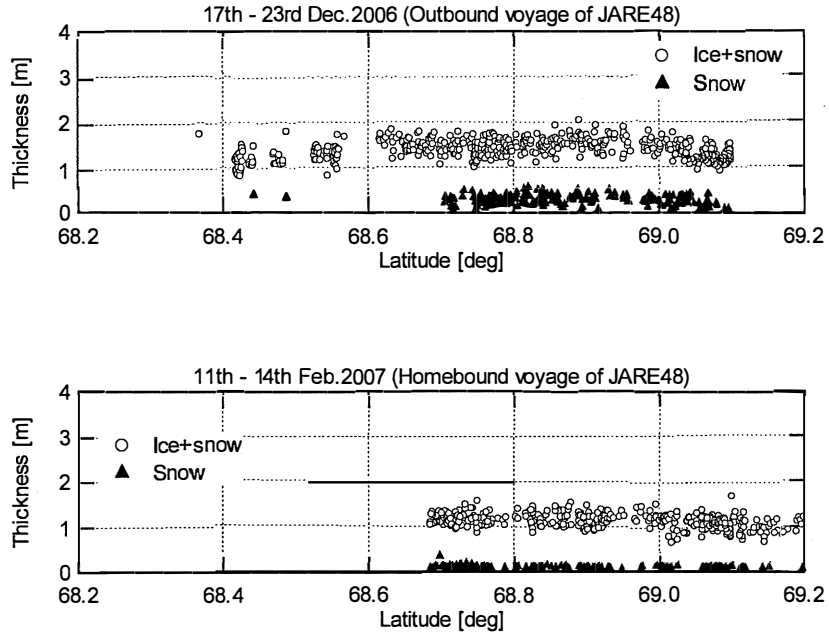


Fig. 15 (b) Ice and snow thickness distributions of land fast ice in Lützow-Holm Bay during the summer operations of JARE-48 (top : outbound voyage, bottom : homebound voyage).

## Publication

Archived data are accumulated and available *via* the Internet from the 'polar science data library system (POLARIS)' of the National Institute of Polar Research, Japan. Metadata in Japanese and English are available from :

http://polaris.nipr.ac.jp/~dbase/300/300_data(uto).htm in Japanese

http://polaris.nipr.ac.jp/~dbase/e/300/e/300_data(uto).htm in English

The digital data (MS EXCEL format) are available from :

http://polaris.nipr.ac.jp/~dbase/300/300_data(uto).htm


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