# Reconnaissance on the No.31 Glacier in the Suntar-Khayata Range, Sakha Republic, Russian Federation

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## Abstract

We carried out a preliminary glaciological research on the No.31 Glacier in the Suntar Khayata Range, Sakha Republic, Russian Federation, in the summer of 2001. This glacier was intensively studied, including mass balance, ice temperature measurements and surveying, by Russian researchers in 1957-58 (the 3rd International Geophysical Year) (Koreisha, 1963). We aimed to obtain the change of the glacier volume since 1958 to study climate change during the last 40 years, and to know the possibility of ice core drilling and analyses for paleoclimatic study in the eastern Siberia. The glacier is a valley-type cold glacier of approximately 3.85 km long and covers the altitude from 2728 m to 2050 m a.s.l. The accumulation area of the glacier is mostly underlain by superimposed ice, which is slightly capped with water-saturated firn. The ablation area is characterized by well-developed longitudinal foliations, and basal ice layers at the very end of the terminus. The air temperature was as high as 12.7 °C in average at the Base Camp (ca. 2000 m a.s.l.) during the observation period (July 21-27, 2001), and we observed intensive melting at the whole area of the glacier. From this observation, we conclude that the glacier is not suitable for the ice core study because it is probably difficult to reconstruct a continuous ice core climate record.

Beside glaciological studies, we conducted a topographical survey of the glacier, which showed that the glacier terminus had retreated approximately 200 m in distance and lowered by approximately 20 m from 1957-59 to 2001.

## 1. Introduction

It is well known that the global warming at Siberia is most clearly detected for the last 30 years: air temperature increased by more than 2 °C from 1966 to 1995 (Chapman and Walsh, 1993). Air pollution in the Arctic region is believed to be attributed to the human activities parts of which center on Siberian industrial cities. However the degrees of global warming and the pollution in the far eastern part of Siberia are still not well known and extensive studies are necessary for understanding recent climate and environmental changes in the far eastern Siberia.

In reconstructing histories of climate and environmental changes in Siberia, ice core record is one of the most promising archives since glaciers contain successive records of climate and environmental signals in the past. The recent climate in the eastern part of the Sea of Okhotsk has been investigated by ice cores obtained at Ushkovsky Ice Cap of the Kamchatka Peninsula (Shiraiwa *et al*., 1999; in press). This was conducted as a part of the integrated research project of "Atmosphere-Ocean-Cryosphere Interaction in the Sea of Okhotsk and the Surrounding Environment" which was initiated in 1995 as a COE (Center of Excellence) Project designed by the Institute of Low Temperature Science, Hokkaido University, Japan (Kobayashi *et al*., 1997). On the other hand, groups led by the National Institute of Polar Research, Tokyo, Japan, have studied seasonal snow and glaciers in

Siberia under the umbrella of ICAPP (Ice Core Circum-Arctic Paleoclimate Program) since 1998 (Watanabe, 1995; 1997; Fujii *et al.*, 2000). Both the Institutes jointly planned to conduct a new ice coring in Siberia aiming at the reconstruction of paleoclimate of the far eastern Siberia dating back to the past 300 years.

We have chosen No. 31 Glacier in the Suntar-Khayata Mountains, Sakha Republic, Russian Federation as a preliminary target for the ice core-drilling. It is the only glacier that was previously studied in the far eastern Siberia. Various glaciological studies, such as mass balance, ice temperature measurements, mapping, meteorological observations, were intensively carried out at the glacier during several years in the occasion of 3rd International Geophysical Year (IGY) in 1957-58 (Koreisha, 1963).

This paper reports our preliminary studies on the glacier No. 31 by Russian - Japanese Collaborative Research in 2001. We summarize the results on logistics of the field campaign, temporal meteorological observations, ablation measurements and survey of the glacier to assess the possibility of ice core drilling at the No. 31 Glacier.

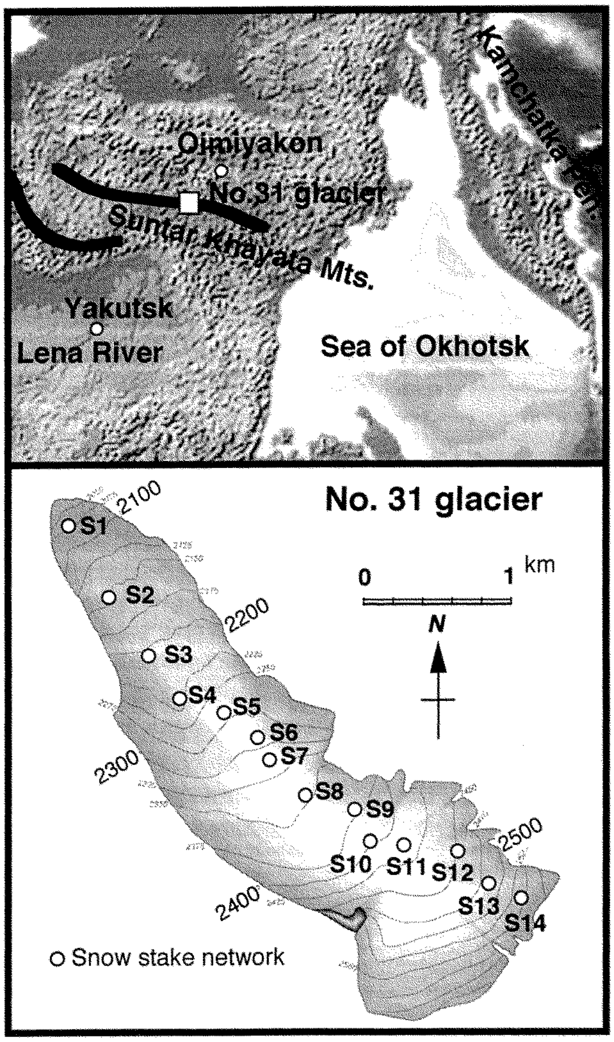


Fig. 1. Location and the outline of the No. 31 Glacier.

## 2. Geographical setting

No. 31 Glacier is situated in the northern ranges of Suntar-Khayata Mountains which divides the Indigirka river drainage to the arctic ocean and the south-oriented drainage to the Sea of Okhotsk (Fig. 1). The No. 31 Glacier is located at 62°35′N, 140°52′E and approximately 510 km west from Yakutsk, the capital city of Sakha Republic. One of the Northern-Hemisphere coldest places, Oimiyakon, is situated at 110 km northeast of the glacier. The glacier is accessible only by a helicopter after 3.5-hours flight from Yakutsk.

According to Koreisha (1963), the glacier faces to northwest with the area of 3.2 km$^2$, length of 3.85 km and the width of 0.85 km (Fig. 2). The highest and the lowest parts of the glacier are 2778 and 2023 m a.s.l., respectively. The accumulation area of the glacier is connected with that of the No. 29 glacier from which a small amount of ice discharges to the ablation area of the No. 31 Glacier (Fig. 3). The ablation area is

Fig. 2. The No. 31 Glacier photgraphed from north. Bulky moraine complex surrounding the present terminus is considered to be the Little Ice Age moraine. The Base Camp is located just below the left-lower corner of the photograph.

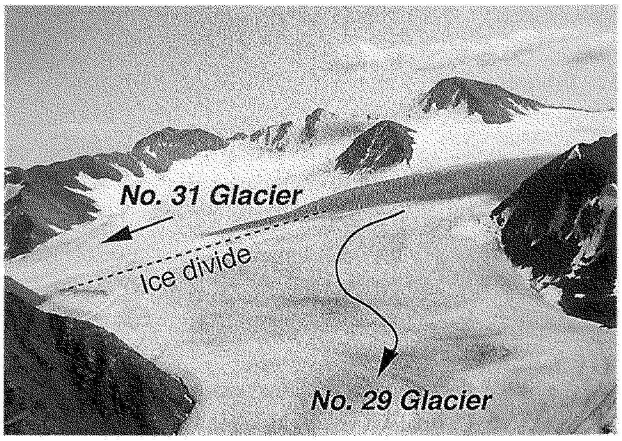


Fig. 3. Aerial view of the upper parts of the No.29 and No. 31 Glaciers. The two glaciers are connected each other with an ice divide. It is clearly seen that the surface of the glaciers are mostly covered with ice.

characterized by well-developed longitudinal foliations, and basal ice layers at the very end of the terminus.

## 3. Members of the field campaign

The members of the field campaign to No. 31 Glacier consisted of the following three Japanese and five Russian scientists:

*Leader:*
Tomomi Yamada: Dr. (Glaciologist), Associate Professor, Institute of Low Temperature Science, Hokkaido University, Sapporo, Japan

*Members:*
Takahashi Shuhei: Dr. (Glaciologist), Professor, Kitami Institute of Technology, Kitami, Japan
Takayuki Shiraiwa: Dr. (Glaciologist), Assistant Professor, Institute of Low Temperature Science, Hokkaido University, Sapporo, Japan
Yuriy Kononov: Dr. (Geomorphologist), Researcher, Institute of Geography, Russian Academy of Sciences, Moscow, Russia
Maria D. Ananicheva, Dr. (Hydrologist), Researcher, Institute of Geography, Russian Academy of Sciences, Moscow, Russia
Michael M. Koreisha, Dr. (Glaciologist), Professor, Glaciology Group of Productive Scientific Research Institute for Engineering Investigation for Construction (PNIIIS), Russian Academy of Sciences, Moscow, Russia
Yaroslav D. Muravyev, Dr. (Glaciologist), Senior scientist, Institute of Volcanology, Russian Academy of Sciences, Petropavlovsk-Kamchatsky, Russia
Taras Samborsky, Dr. (Hydrologist), Researcher, Department of Geography, Moscow State University, Moscow, Russia

## 4. Itinerary

Three Japanese members left Japan from Niigata International Airport for Vladivostok on 15 July 2001. Y. Kononov, who left Moscow for Vladivostok on 14 July, met the Japanese members at the custom of Vladivostok International Airport. Y. Kononov prepared official documents at Moscow to clear the custom issues at Vladivostok and this worked well. After a delay of one and half days, the four members arrived at Yakutsk on 18 July 2001 and joined other Russian members who already arrived there on 16 July from Moscow. After a few days in Yakutsk for preparation of the field campaign and the negotiation of a helicopter flight, we left Yakutsk for No. 31 Glacier on 21 July and came back to Yakutsk on 28 July. The duration of the field activities were seven days from 21 to 28 July. The three Japanese left Yakutsk for Japan on 1 August and arrived at Niigata on 2 August. Y. Kononov came to Vladiostok on his way back to Moscow to help the Japanese members in clearing the custom. Four other Russian members left Yakutsk on 2 August for Moscow.

## 5. Results

### *5.1. Meteorological observations*

Air temperature and global solar radiation were measured at the Base Camp (B.C.; 62°36′46.3″N; 140°50′38.2″E; 2005 m a.s.l.) with a measurement interval of 1 hour. Air temperature was also measured every 1 hour on the glacier at S1 (62°36′22.6″N; 140°51′14.5″E; 2073 m a.s.l.), S5 (62°35′55.7″N; 140°51′50.1″E; 2234 m a.s.l.), S9 (62°35′28.3″N; 140°52′27.5″E; 2327 m a.s.l.), S11 (62°35′20.6″N; 140°52′51.2″E; 2395 m a.s.l.), S14 (62°35′04.8″N; 140°53′29.0″E; 2484 m a.s.l.) and the river-side station near the Base Camp (B.C.(river); 2000 m a.s.l.) by compact thermistors (Ondotori) (Table 1).

Figure 4 shows the hourly air temperature and global solar radiation at the Base Camp. The weather condition during the field campaign was generally good and the air temperature at the Base Camp varied from 7 to 20 °C with an average air temperature of 12.7 °C. Global solar radiation was also generally high: it reached nearly 1kW $m^{-2}$ occasionally in daytime. These temperature and radiation conditions were responsible for the intensive surface melting mentioned below.

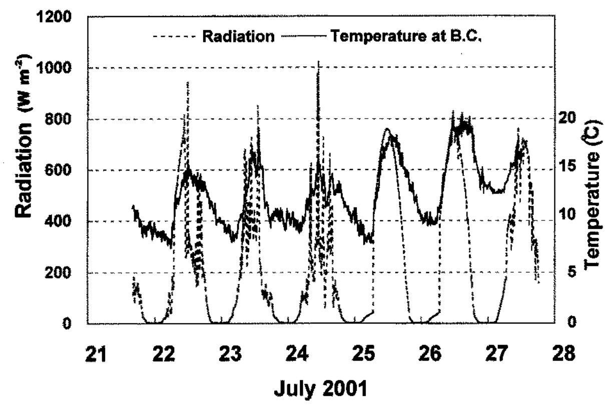


Fig. 4. Hourly air temperature and global solar radiation observed at the Base Camp from July 21 to July 27, 2001.

### *5.2. Ablation measurements at the glacier surface*

Ablation of the glacier surface was measured by means of conventional snow stake method. Fourteen stakes were installed along the central flow line of the glacier and the heights of the stakes were measured twice a day. The height difference was converted to water-equivalent values by measuring densities of the surface snow and ice at several times near the stakes.

Figure 5 shows the time-series of surface mass balance (cm in water eq.) at each stake during the

Table 1. Air temperature measured at various sites at the Base Camp and the No. 31 Glacier.

| | Temperature data (1 hour interval) [°C] | | | | | | | | Temperature data (1 hour interval) [°C] | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date/Time | B.C. | S1 | S5 | S9 | S14 | S11 | B.C.(river) | Date/Time | B.C. | S1 | S5 | S9 | S14 | S11 | B.C.(river) |
| (JST, GMT+09h) | R-1 | R-2 | R-3 | R-4 | R-5 | R-7 | R-8 | (JST, GMT+09H) | R-1 | R-2 | R-3 | R-4 | R-5 | R-7 | R-8 |
| 2001.7.21 18:00 | | | | | | | | 2001.7.24 16:00 | 15.1 | 12.3 | 10.9 | 9.2 | 9.8 | 9.7 | 15.4 |
| 2001.7.21 19:00 | 10.2 | | | | | | | 2001.7.24 17:00 | 12.7 | 10.0 | 6.9 | 6.5 | 7.0 | 7.4 | 12.6 |
| 2001.7.21 20:00 | 9.1 | | | | | | | 2001.7.24 18:00 | 12.7 | 10.3 | 8.3 | 8.1 | 9.6 | 8.9 | 12.4 |
| 2001.7.21 21:00 | 8.4 | | | | | | | 2001.7.24 19:00 | 13.2 | 12.6 | 7.6 | 6.8 | 5.6 | 8.2 | 12.8 |
| 2001.7.21 22:00 | 8.9 | | | | | | | 2001.7.24 20:00 | 11.6 | 9.4 | 7.8 | 5.7 | 7.2 | 6.2 | 11.3 |
| 2001.7.21 23:00 | 8.6 | | | | | | | 2001.7.24 21:00 | 10.8 | 7.6 | 6.7 | 6.0 | 7.3 | 6.6 | 10.6 |
| 2001.7.22 0:00 | 9.2 | | | | | | | 2001.7.24 22:00 | 10.1 | 7.9 | 7.1 | 4.9 | 7.5 | 6.9 | 9.6 |
| 2001.7.22 1:00 | 8.2 | | | | | | | 2001.7.24 23:00 | 9.3 | 8.3 | 6.2 | 6.9 | 6.3 | 7.6 | 8.4 |
| 2001.7.22 2:00 | 8.3 | | | | | | | 2001.7.25 0:00 | 10.7 | 9.0 | 6.1 | 5.3 | 4.3 | 6.1 | 9.7 |
| 2001.7.22 3:00 | 8.5 | | | | | | | 2001.7.25 1:00 | 9.1 | 7.8 | 4.9 | 6.3 | 5.5 | 6.6 | 8.0 |
| 2001.7.22 4:00 | 8.5 | | | | | | | 2001.7.25 2:00 | 8.4 | 7.9 | 4.5 | 5.9 | 5.9 | 5.7 | 7.4 |
| 2001.7.22 5:00 | 8.2 | | | | | | | 2001.7.25 3:00 | 8.6 | 7.0 | 4.3 | 4.3 | 4.8 | 5.0 | 7.3 |
| 2001.7.22 6:00 | 6.9 | | | | | | | 2001.7.25 4:00 | 7.7 | 6.0 | 3.9 | 4.9 | 4.6 | 4.6 | 7.5 |
| 2001.7.22 7:00 | 9.8 | | | | | | | 2001.7.25 5:00 | 7.9 | 6.6 | 5.4 | 4.2 | 3.6 | 5.2 | 7.6 |
| 2001.7.22 8:00 | 13.0 | | | | | | | 2001.7.25 6:00 | 7.6 | 6.6 | 4.5 | 6.8 | 4.6 | 6.7 | 6.9 |
| 2001.7.22 9:00 | 13.6 | | | | | | | 2001.7.25 7:00 | 10.9 | 11.0 | 8.8 | 10.6 | 10.3 | 9.7 | 12.2 |
| 2001.7.22 10:00 | 16.5 | | | | | | | 2001.7.25 8:00 | 12.9 | 11.8 | 9.8 | 8.5 | 11.5 | 10.4 | 12.7 |
| 2001.7.22 11:00 | 16.2 | | | | | | | 2001.7.25 9:00 | 15.1 | 13.8 | 8.6 | 11.7 | 11.9 | 11.3 | 14.9 |
| 2001.7.22 12:00 | 18.7 | | | | | | | 2001.7.25 10:00 | 17.3 | 15.5 | 7.9 | 12.5 | 12.6 | 12.2 | 17.3 |
| 2001.7.22 13:00 | 15.7 | | | | | | | 2001.7.25 11:00 | 17.7 | 14.1 | 11.2 | 14.6 | 14.6 | 14.8 | 17.2 |
| 2001.7.22 14:00 | 14.5 | | | | | | | 2001.7.25 12:00 | 18.0 | 15.0 | 9.0 | 10.6 | 14.3 | 16.6 | 17.7 |
| 2001.7.22 15:00 | 15.3 | | | | | | | 2001.7.25 13:00 | 18.4 | 14.6 | 11.5 | 11.9 | 13.1 | 17.2 | 17.3 |
| 2001.7.22 16:00 | 14.8 | | | | 8.7 | | | 2001.7.25 14:00 | 18.6 | 14.6 | 11.4 | 12.6 | 17.1 | 12.5 | 17.5 |
| 2001.7.22 17:00 | 14.9 | | | 8.9 | 8.8 | | | 2001.7.25 15:00 | 18.0 | 13.5 | 11.0 | 11.8 | 15.0 | 12.0 | 16.7 |
| 2001.7.22 18:00 | 14.2 | | 6.9 | 8.1 | 7.6 | | | 2001.7.25 16:00 | 17.6 | 12.5 | 10.8 | 13.1 | 13.2 | 15.1 | 15.5 |
| 2001.7.22 19:00 | 12.4 | 10.6 | 5.9 | 6.9 | 5.7 | | | 2001.7.25 17:00 | 16.5 | 11.5 | 10.1 | 13.8 | 12.8 | 15.0 | 14.9 |
| 2001.7.22 20:00 | 11.6 | 9.6 | 5.4 | 5.8 | 5.4 | | | 2001.7.25 18:00 | 15.3 | 13.0 | 8.6 | 12.4 | 13.6 | 14.6 | 14.6 |
| 2001.7.22 21:00 | 10.9 | 7.8 | 5.6 | 6.0 | 4.4 | | | 2001.7.25 19:00 | 14.7 | 13.3 | 8.4 | 11.4 | 11.4 | 12.6 | 13.9 |
| 2001.7.22 22:00 | 10.5 | 9.0 | 6.3 | 5.5 | 4.1 | | | 2001.7.25 20:00 | 12.6 | 11.2 | 8.0 | 9.8 | 9.8 | 10.7 | 11.5 |
| 2001.7.22 23:00 | 10.0 | 6.9 | 5.1 | 4.8 | 4.8 | | | 2001.7.25 21:00 | 13.1 | 10.2 | 7.0 | 8.0 | 8.2 | 9.3 | 11.8 |
| 2001.7.23 0:00 | 9.9 | 7.2 | 4.9 | 4.0 | 3.6 | | | 2001.7.25 22:00 | 11.7 | 9.0 | 6.9 | 6.5 | 7.1 | 8.1 | 10.5 |
| 2001.7.23 1:00 | 9.8 | 8.4 | 5.4 | 4.6 | 3.7 | | | 2001.7.25 23:00 | 10.2 | 7.6 | 6.3 | 6.6 | 7.6 | 7.8 | 10.4 |
| 2001.7.23 2:00 | 8.6 | 7.4 | 4.6 | 4.3 | 4.6 | | | 2001.7.26 0:00 | 10.1 | 8.3 | 6.1 | 6.3 | 6.9 | 7.2 | 9.4 |
| 2001.7.23 3:00 | 8.6 | 7.5 | 5.9 | 5.5 | 6.1 | | | 2001.7.26 1:00 | 10.1 | 7.3 | 4.9 | 7.0 | 6.0 | 7.3 | 9.1 |
| 2001.7.23 4:00 | 7.6 | 7.2 | 6.0 | 5.5 | 6.0 | | | 2001.7.26 2:00 | 10.2 | 6.8 | 6.3 | 7.8 | 5.2 | 7.8 | 10.0 |
| 2001.7.23 5:00 | 8.2 | 8.1 | 6.1 | 5.3 | 6.1 | | | 2001.7.26 3:00 | 9.3 | 8.1 | 5.4 | 6.5 | 4.7 | 5.9 | 8.2 |
| 2001.7.23 6:00 | 9.2 | 8.4 | 5.9 | 7.5 | 6.7 | | | 2001.7.26 4:00 | 9.6 | 7.6 | 6.5 | 5.4 | 4.6 | 5.4 | 9.0 |
| 2001.7.23 7:00 | 11.5 | 11.6 | 9.6 | 6.0 | 5.9 | | | 2001.7.26 5:00 | 9.3 | 6.6 | 6.0 | 6.0 | 4.8 | 6.5 | 9.2 |
| 2001.7.23 8:00 | 12.7 | 9.4 | 10.2 | 7.3 | 5.1 | | | 2001.7.26 6:00 | 10.4 | 8.9 | 7.2 | 9.1 | 6.0 | 8.1 | 8.6 |
| 2001.7.23 9:00 | 14.6 | 9.4 | 9.1 | 8.5 | 5.2 | | | 2001.7.26 7:00 | 12.2 | 10.5 | 8.2 | 7.9 | 12.4 | 8.9 | 12.5 |
| 2001.7.23 10:00 | 16.1 | 14.8 | 11.0 | 9.1 | 5.7 | | | 2001.7.26 8:00 | 15.2 | 14.8 | 10.1 | 7.8 | 14.3 | 8.7 | 14.2 |
| 2001.7.23 11:00 | 16.4 | 14.3 | 11.4 | 11.9 | 5.7 | | | 2001.7.26 9:00 | 15.9 | 11.7 | 12.6 | 12.7 | 14.9 | 12.6 | 16.5 |
| 2001.7.23 12:00 | 15.4 | 12.3 | 9.3 | 11.0 | 6.0 | 11.5 | | 2001.7.26 10:00 | 17.7 | 14.9 | 11.3 | 11.7 | 14.8 | 12.0 | 19.2 |
| 2001.7.23 13:00 | 15.3 | 11.9 | 9.2 | 9.4 | 13.7 | 10.0 | 15.1 | 2001.7.26 11:00 | 17.6 | 17.2 | 11.0 | 11.6 | 16.3 | 16.3 | 16.9 |
| 2001.7.23 14:00 | 15.2 | 12.1 | 7.8 | 12.8 | 10.7 | 12.1 | 14.6 | 2001.7.26 12:00 | 19.0 | 12.9 | 12.5 | 12.1 | 17.7 | 13.8 | 18.2 |
| 2001.7.23 15:00 | 14.6 | 11.3 | 6.9 | 7.0 | 6.8 | 7.5 | 13.5 | 2001.7.26 13:00 | 18.4 | 12.6 | 11.4 | 15.9 | 17.5 | 17.9 | 18.7 |
| 2001.7.23 16:00 | 10.6 | 7.6 | 5.4 | 5.0 | 4.9 | 5.8 | 10.3 | 2001.7.26 14:00 | 18.7 | 13.3 | 11.9 | 14.9 | 17.7 | 16.5 | 18.9 |
| 2001.7.23 17:00 | 9.7 | 8.9 | 7.6 | 6.1 | 7.2 | 5.7 | 8.8 | 2001.7.26 15:00 | 19.5 | 13.9 | 11.6 | 16.0 | 16.4 | 16.4 | 19.8 |
| 2001.7.23 18:00 | 9.8 | 9.0 | 7.2 | 6.6 | 6.9 | 5.6 | 8.7 | 2001.7.26 16:00 | 19.2 | 13.3 | 10.6 | 15.3 | 15.7 | 16.6 | 19.1 |
| 2001.7.23 19:00 | 10.0 | 7.9 | 7.9 | 7.1 | 7.5 | 7.4 | 8.2 | 2001.7.26 17:00 | 19.1 | 15.1 | 10.0 | 11.3 | 15.1 | 16.2 | 19.3 |
| 2001.7.23 20:00 | 10.2 | 7.0 | 7.8 | 6.3 | 6.7 | 6.7 | 9.4 | 2001.7.26 18:00 | 19.1 | 17.5 | 9.8 | 11.4 | 14.0 | 14.3 | 17.1 |
| 2001.7.23 21:00 | 10.0 | 8.2 | 8.6 | 7.3 | 7.2 | 7.6 | 9.0 | 2001.7.26 19:00 | 17.0 | 13.1 | 7.6 | 8.7 | 11.3 | 11.8 | 14.1 |
| 2001.7.23 22:00 | 10.3 | 9.0 | 7.7 | 6.5 | 6.8 | 6.9 | 9.0 | 2001.7.26 20:00 | 15.0 | 11.4 | 10.3 | 7.6 | 9.7 | 9.5 | 14.0 |
| 2001.7.23 23:00 | 8.9 | 8.1 | 6.8 | 7.4 | 7.1 | 8.0 | 7.7 | 2001.7.26 21:00 | 14.2 | 10.2 | 5.7 | 8.0 | 9.3 | 11.1 | 12.2 |
| 2001.7.24 0:00 | 9.7 | 6.3 | 6.8 | 6.4 | 5.9 | 6.1 | 9.0 | 2001.7.26 22:00 | 14.6 | 11.7 | 5.8 | 8.5 | 8.6 | 10.0 | 11.3 |
| 2001.7.24 1:00 | 9.2 | 7.1 | 6.8 | 6.4 | 5.9 | 6.6 | 8.4 | 2001.7.26 23:00 | 13.1 | 10.4 | 9.3 | 8.3 | 8.3 | 8.2 | 12.1 |
| 2001.7.24 2:00 | 10.2 | 7.1 | 6.3 | 7.1 | 6.3 | 7.5 | 9.3 | 2001.7.27 0:00 | 12.9 | 9.5 | 8.8 | 7.0 | 8.1 | 9.2 | 12.4 |
| 2001.7.24 3:00 | 9.1 | 8.8 | 8.0 | 7.4 | 6.3 | 8.0 | 8.3 | 2001.7.27 1:00 | 12.9 | 10.1 | 9.5 | 7.6 | 7.8 | 8.4 | 12.1 |
| 2001.7.24 4:00 | 9.3 | 9.0 | 7.7 | 6.4 | 6.5 | 7.5 | 8.6 | 2001.7.27 2:00 | 12.6 | 10.2 | 8.4 | 8.7 | 7.6 | 8.0 | 10.9 |
| 2001.7.24 5:00 | 9.3 | 9.3 | 7.4 | 7.6 | 7.0 | 6.5 | 8.3 | 2001.7.27 3:00 | 12.3 | 9.8 | 9.0 | 7.9 | 7.5 | 7.6 | 11.6 |
| 2001.7.24 6:00 | 10.0 | 7.3 | 7.6 | 10.5 | 7.6 | 9.3 | 9.6 | 2001.7.27 4:00 | 12.6 | 10.0 | 8.5 | 5.8 | 7.5 | 8.5 | 12.3 |
| 2001.7.24 7:00 | 11.3 | 8.6 | 9.1 | 8.7 | 8.2 | 8.8 | 11.3 | 2001.7.27 5:00 | 12.3 | 10.4 | 7.9 | 5.7 | 5.7 | 8.6 | 12.0 |
| 2001.7.24 8:00 | 14.3 | 11.6 | 12.6 | 12.0 | 10.9 | 11.7 | 14.3 | 2001.7.27 6:00 | 12.9 | 10.4 | 8.2 | 6.5 | 7.7 | 9.3 | 12.5 |
| 2001.7.24 9:00 | 13.0 | 11.9 | 11.9 | 10.7 | 10.2 | 10.2 | 12.3 | 2001.7.27 7:00 | 14.0 | 12.2 | 9.0 | 7.7 | 11.5 | 10.0 | 13.5 |
| 2001.7.24 10:00 | 14.8 | 11.1 | 11.9 | 10.8 | 9.4 | 10.6 | 14.5 | 2001.7.27 8:00 | 14.9 | 12.7 | 9.6 | 7.8 | 15.3 | 10.9 | |
| 2001.7.24 11:00 | 15.6 | 12.6 | 16.1 | 12.3 | 10.7 | 11.0 | 14.7 | 2001.7.27 9:00 | 15.3 | 13.9 | 10.9 | 7.5 | 11.6 | 11.9 | |
| 2001.7.24 12:00 | 14.1 | 11.0 | 9.3 | 7.6 | 7.9 | 9.2 | 13.9 | 2001.7.27 10:00 | 16.6 | 15.9 | 11.9 | 7.6 | 16.9 | 11.2 | |
| 2001.7.24 13:00 | 14.1 | 10.1 | 8.7 | 9.2 | 8.7 | 9.3 | 14.1 | 2001.7.27 11:00 | 18.7 | 18.5 | 13.6 | 11.8 | 19.7 | 13.4 | |
| 2001.7.24 14:00 | 10.6 | 6.9 | 7.5 | 6.6 | 9.3 | 8.2 | 10.5 | 2001.7.27 12:00 | | 13.5 | 11.1 | 12.2 | 15.7 | | |
| 2001.7.24 15:00 | 13.4 | 11.2 | 10.0 | 8.6 | 11.2 | 10.1 | 15.3 | 2001.7.27 13:00 | | 14.4 | 15.6 | 16.6 | | | |

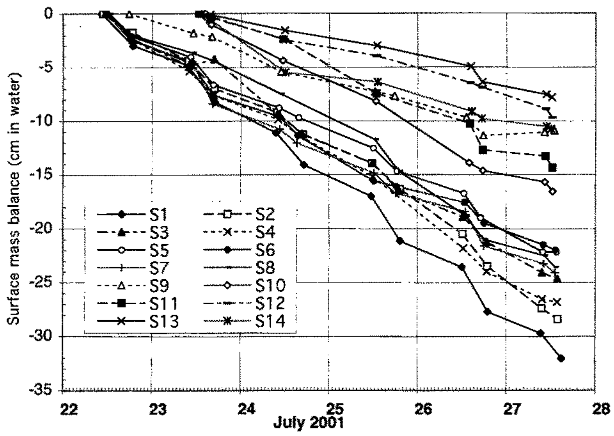


Fig. 5. Surface mass balances (cm in water eq.) at each snow stake on the No. 31 Glacier.

observational period. The results at all sites showed negative balances. Transient snow line was located between S8 and S9. Approximately 20-30 cm in w. eq. was lost at the ablation area, while 7-15 cm in w. eq. at the accumulation area of the glacier.

Accumulated amounts of snowmelt (cm in water eq.) at the sites where air temperature was measured were compared with accumulated hourly positive air temperatures (°C h) (Fig. 6). The results were then converted to daily relations to obtain positive-degree-day factors (cm $°C^{-1}day^{-1}$) for each site. They were calculated as 0.62 (S1), 0.55 (S5), 0.26 (S9), 0.36 (S11) and 0.26 (S14), respectively.

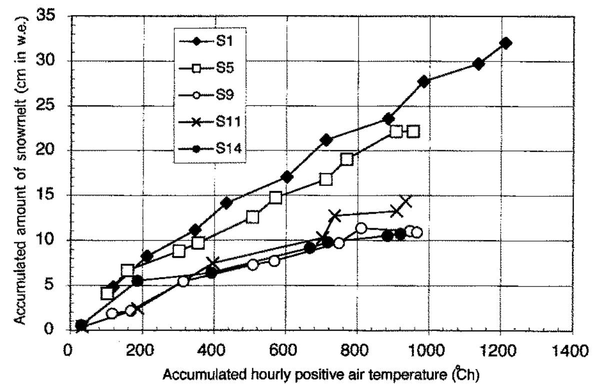


Fig. 6. Relationship between accumulated amount of snowmelt (cm in water eq.) and accumulated hourly positive air temperature (°Ch) at four sites.

## 5.3. *Snow pits and shallow core drillings*

Since the principal objective of the present campaign was the assessment of the possibilities to obtain a "good quality" ice core, excavations of snow pits and shallow ice coring were the most important tasks of the campaign. They were, however, not possible because 1) the accumulation area of the glacier was composed entirely of ice where it was difficult to dig snow pits; 2) the surface was covered with water-saturated firn which was underlain by cold ice at the accumulation area of the glacier, and this condition was not suitable for ice coring: the drill was every time frozen in the borehole due to cold ice beneath the surface.

From the reasons above, we were compelled to give up the pit and ice core studies in 2001. If the intensive melting observed in the summer in 2001 was the normal condition at this glacier, we conclude that the glacier is not suitable for ice core study, because chemical and isotopic signals might have been disturbed by percolation and discharge of the melt water in the glacier.

## 5.4. *Survey of the glacier configuration*

As we mentioned before, the No. 31 Glacier was intensively studied in the years of 1957-1959 by one of the present authors (M. M. Koreisha). Previous investigation depicted the configuration of the glacier, so it is possible for us to compare the change of the morphology of the glacier between 1959-2001. We therefore surveyed the terminal part of the glacier by a theodolite, an electric distance meter and a handy GPS.

Figure 7 shows the change of the terminal features between the two periods. Massive ice-cored moraines were observed both in 1957-1959 and 2001. The glacier termini at the two periods were located at the boundaries between the ice-cored moraine in 1957-1959 (dark hatched) and that in 2001, and between the moraine in 2001 (light hatched) and the glacier terminus in 2001 (white part). The glacier retreated approximately 200 m and lowered by approximately 20 m from 1957 to 2001.

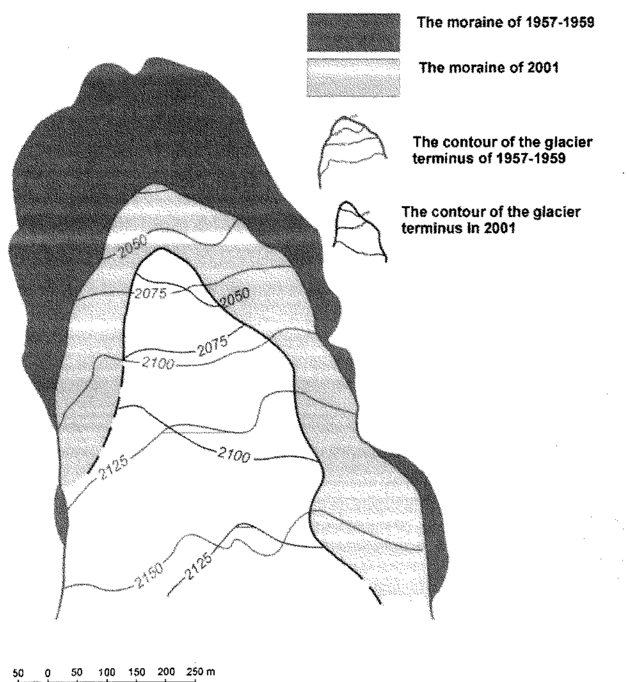


Fig. 7. Change of the terminus of the No.31 Glacier from 1957-1959 to 2001.

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## References

Chapman, W. L. and Walsh, J. E. (1993): Recent variations of sea ice and air temperature in high latitudes. Bulletin of the American Meteorological Society, **74**, 2-16.

Fujii, Y., Nishio, F. and Kameda, T. (2000): Glaciological investigation at Sofiyskiy glacier, Russian Altai Mountains. Seppyo, **62** (6), 549-556. (In Japanese with English abstract.)

Kobayashi, D., Muravyev, Ya. D., Kodama, Y. and Shiraiwa, T. (1997): An outline of Russo-Japanese joint glacier research in Kamchatka, 1996. Bull. Glacier Res., **15**, 19-26.

Koreisha, M. M. (1963): Modern glaciation of the Suntar -Khayata Ridge. Glaciology IX Section of IGY Program, No.**11**, Publication House of the Academy of Sciences of the USSR, Moscow, 170pp.

Shiraiwa, T., Muravyev, Ya. D., Kameda, T., Nishio, F., Toyama, Y., Takahashi, A., Ovsyannikov, A. A., Salamatin, A. N. and Yamagata, K. (in press): Characteristics of a crater glacier at Ushkovsky volcano as revealed by the physical properties of its ice cores and borehole thermometry. J. Glaciol., in press.

Shiraiwa, T., Nishio, F., Kameda, T., Takahashi, A., Toyama, Y., Muravyev, Ya. D., and Ovsyannikov, A. A. (1999): Ice core drilling at Ushkovsky ice cap, Kamchatka, Russia. Seppyo, **61** (1), 25-40. (In Japanese with English abstract.)

Watanabe, O. (1995): Japanese glaciological environmental studies in the Arctic cryosphere. Seppyo, **57** (4), 331-338. (In Japanese.)

Watanabe, O. (1997): Recent activities in Arctic glaciology. Seppyo, **59** (2), 111-114. (In Japanese.)