Ice avalanche activities at Soler Glacier, northern Patagonia, in the summer of 1998

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Abstract

At Soler Glacier in northern Patagonia, ice avalanches were observed in daytime during 13 days using video camera recorder. Analysis of frequency and relative size of 659 avalanches recorded indicates that the duration time of almost all the avalanches did not exceed 30 seconds and the number of avalanches decreased sharply with the avalanche size (a lot of small-size and a few of large-size avalanches). It was also indicated that small avalanches often occurred after receiving strong solar radiation, while large avalanches seemed to occur due to the plenty supply of melt water to the base of glacier ice with a time lag from the melting peak.

1. Introduction

Soler Glacier is a valley-type outlet glacier from the eastern part of the Northern Patagonia Icefield, Chile. The ablation area of the glacier is about 7 km long and 2 km wide (Fig. 1). The southern half of the ablation area consists of clean ice which is supplied from the icefield through an icefall, 700m high, while the northern half, which is fed mainly by ice avalanches from the southeastern slope of Mt. Hyades (3078 m a.s.l.), is covered by debris (Aniya and Naruse, 1987; Naruse *et al.*, 2000). Therefore the avalanching of ice is one of the predominant ways of ice supply from the accumulation area to the ablation area of Soler Glacier. However, about ice avalanche activities on Soler Glacier, there is only one observation made by Kobayashi and Naruse (1987) for four days in 1984 -1985. For further investigation into ice avalanches, successive observation from 26 November to 9 December in 1998 was carried out using a video camera recorder near the terminus of the glacier.

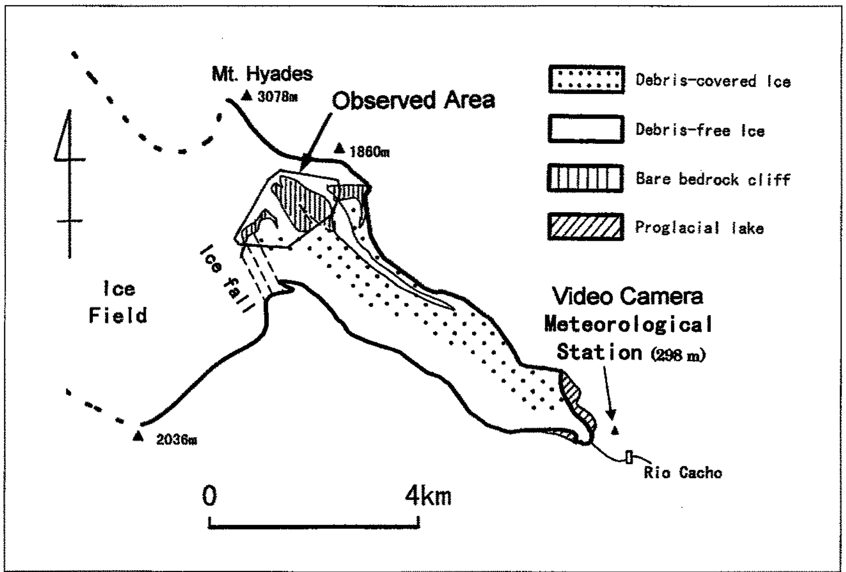

Fig. 1. Map of Soler Glacier with locations of the observed area and a video camera.

2. Method of observation

Ice avalanches starting from the hanging glacier above rock cliffs (Fig. 2) were recorded in the daytime during 13 days using an 8-mm video camera recorder from the meteorological station (298 m a.s.l.) near the terminus of the glacier (Fig. 1). The video camera was set up about 8 km downstream of the observed area for ice avalanches near the icefall (Fig. 2). Although the video camera could record on an 8-mm videotape for six hours by the long play mode, it could not record ice avalanches in the nighttime and under low visibility due to cloud or fog. Average recording time was about ten hours a day for 13 days.

The inclinations of rock cliffs and hanging glacier surfaces above them were about 50-60° and 30-40°, respectively (Kobayashi and Naruse, 1987). The occurrence and duration time of ice avalanches were detected at the lower edge of the hanging glacier.

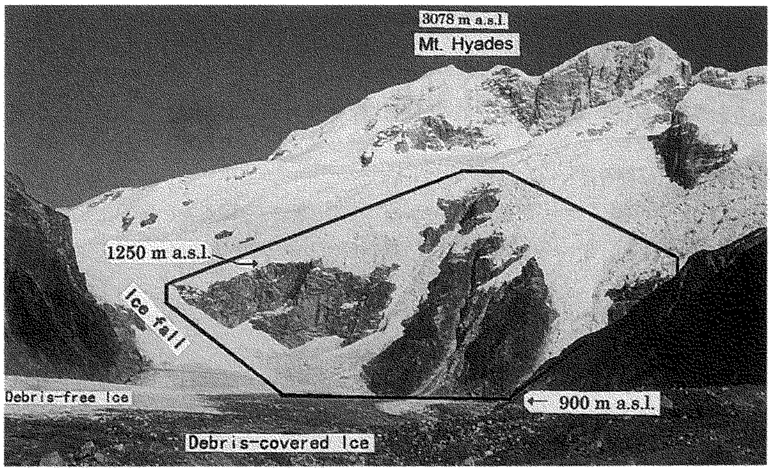

Fig. 2. View of the southeastern slope of Mt. Hyades from the meteorological station. Polygonal solid line indicates the observed area of ice avalanches, which corresponds to that in Fig. 1.

3. Frequency and relative size of ice avalanches

The total number of ice avalanches observed was 659 in 13 days. The frequency distribution of duration time of those avalanches is shown in Fig. 3. The maximum frequency was observed in 5-10 seconds of duration time and no ice avalanches with a duration time over one minute occurred. This distribution of duration time is similar to the result obtained by Kobayashi and Naruse (1987).

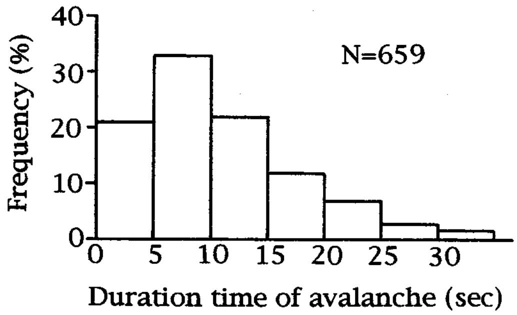

Fig. 3. Frequency distribution of duration time of ice avalanches.

The duration time does not necessarily correlate with the size of ice avalanche. Then the size of ice avalanche was classified into three relative grades (small, middle and large) taking account of its width at the edge of the hanging glacier, its spread at the bottom of rock cliff, and snow cloud associating with it. However, ice avalanches deviated from these three grades could be observed occasionally. One is the extra small avalanche, a slight falling of a snow or ice block, which falls to pieces and disappears on the way of its falling on the rock cliff. The other is the extra large avalanche which has a width over one hundred meter at the edge of the hanging glacier, covers ridges on the rock cliff and blows up snow cloud extremely after falling. Therefore, the size of ice avalanche was classified finally into five grades; size A (extra small), B (small), C (middle), D (large) and E (extra large). An example of size E avalanche due to falling of wide edge of glacier ice is shown in Fig.4.

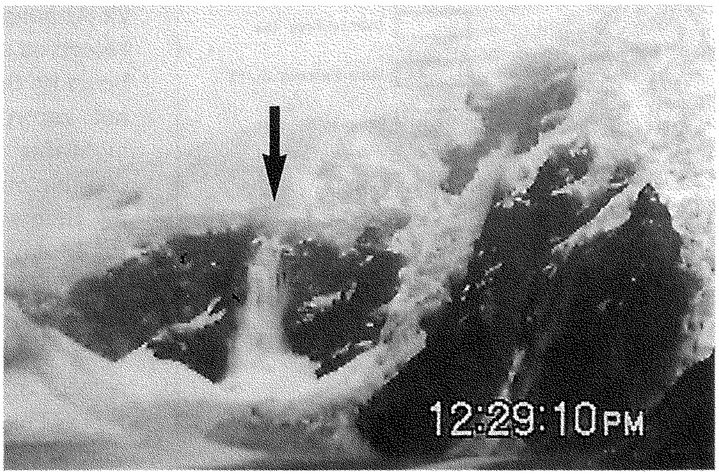

Fig. 4. An extra large avalanche (arrow) occurred at 12:29 on 28 December 1998.

The size distribution of observed 659 ice avalanches is shown in Fig. 5. Small ice avalanches (size B) occurred most frequently. Extra small avalanches (size A) must occur more frequently than small avalanches, but they can be detected on video recording only under good visibility. Therefore, it is considered that the real frequency of size A is higher than that of size B.

Figure 6 shows hourly occurrence of ice avalanches from 26 November to 9 December. In this figure open bars indicate the number of size A and B avalanches, while solid bars indicate the number of C, D and E avalanches. We could observe ice avalanches only in the hours between vertical segments on the time axis owing to weather conditions or darkness.

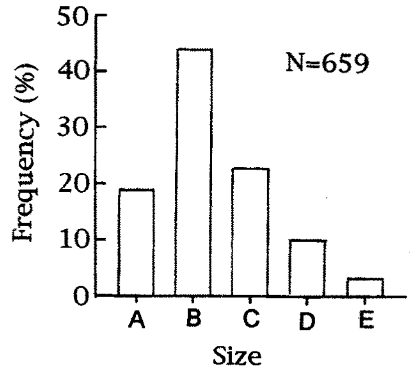

Fig. 5. Size distribution of ice avalanches. A: extra small, B: small, C: middle, D: large, E: extra large

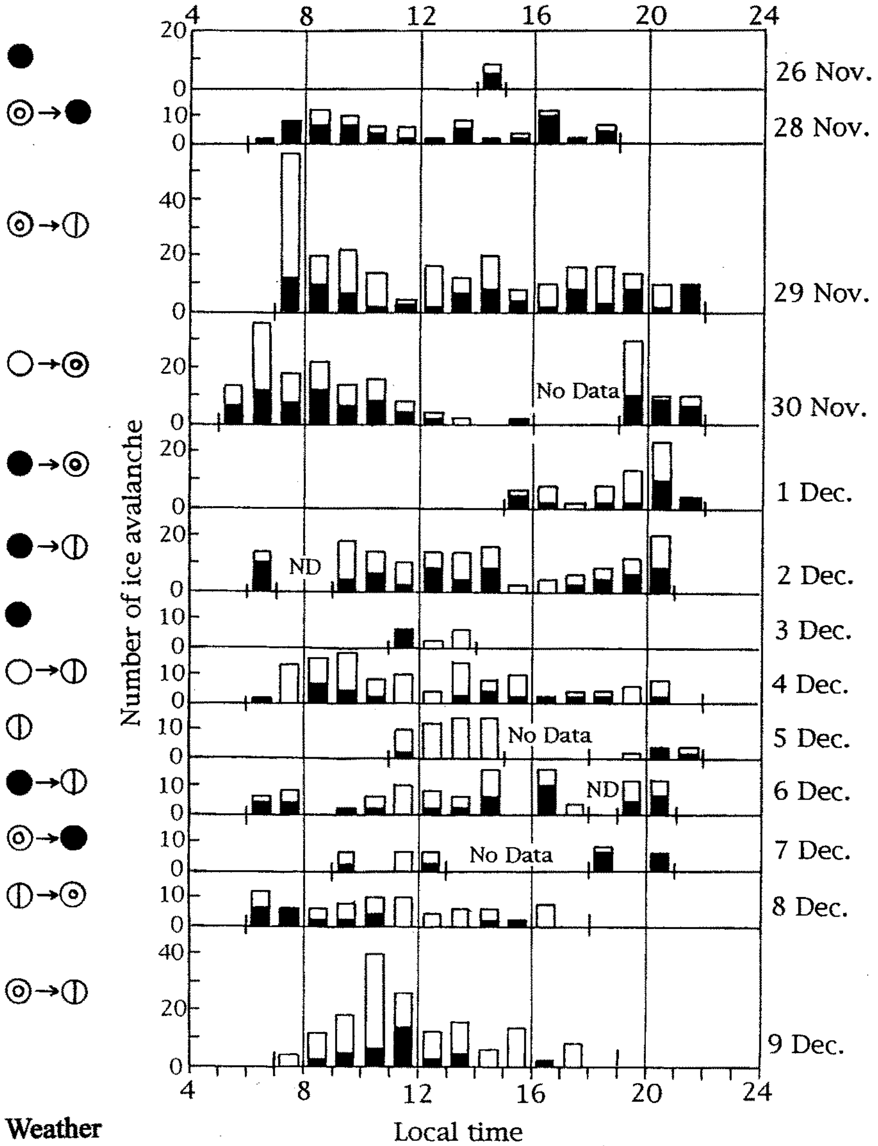

Fig. 6. Hourly occurrence of ice avalanches from 26 November to 9 December 1998. Open bars indicate size A and B, and solid bars indicate size C, D and E. Observations were possible between vertical short lines across time axis. (Weather; ○: clear, ◐: fair, ◎: overcast, ●: rain)

The occurrence of ice avalanches varies greatly with time. We examine this fluctuation on the basis of meteorological data (Fig. 7) that were observed at the meteorological station (Matsumoto *et al.*, 2001). In general, a number of small avalanches (size A or B) tended to occur just after receiving strong solar radiation. For example, small avalanches occurred intensively at six or seven o'clock in the fine morning on 29 and 30 November. Also, the number of small avalanches increased after solar radiation became strong due to the recovery of bad weather. Even at seven or eight o'clock in the evening, a certain number of small avalanches occurred because some part of the glacier facing westward received solar radiation from the setting sun. A possible significant cause of ice avalanches should be weakening of ice due mainly to infiltration of water into cracks or other voids in ice.

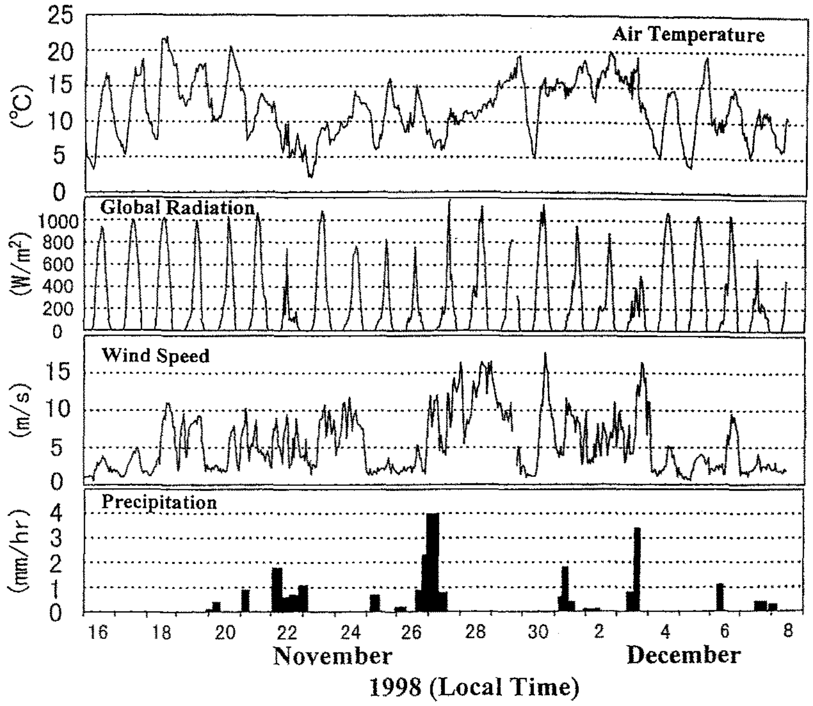

Fig. 7. Variations in meteorological elements observed at the meteorological station (Matsumoto *et al.*, 2001).

Large avalanches (size C, D and E) occurred frequently from 28 until the morning of 30, November. We had a lot of rain (4 mm/hr at most) near the meteorological station from 26 to 27 November. This rain precipitated as snow at high altitudes. After this precipitation air temperature increased up to 19°C on 29 November at the meteorological station. It is considered that snow melting proceeded on the hanging glacier surface and a lot of melt water was supplied to the base of the glacier. In fact, several water currents flowing out from the hanging glacier were found on rock cliffs. Abundant water from ice melting may accelerate the basal sliding of a glacier (Naruse, 1987). It is considered that this abundant melt water at the base of the hanging glacier caused large ice avalanches at the edge of the glacier ice.

However, the occurrence of large avalanches had a time lag from the peak of snow/ice melting. Some large ice avalanches occurred even in eight o'clock p.m. or thereabout of the day with much snow/ice melting during daytime. The time lag is supposed to be about 6 to 8 hours.

4. Other features of ice avalanches

We found the following features about the occurrence of ice avalanches. Before and after a large avalanche happened, small avalanches fell from the same point where the large avalanche occurred. This is the similar tendency with snow avalanches that small snowslides often precede a large avalanche. We may predict the occurrence of a large ice avalanche by monitoring the preceding small ice avalanches.

When the activity of ice avalanches was high, many ice avalanches occurred at the same place. And the highly active place of ice avalanches moved occasionally on the edge of the hanging glacier. It is suggested that the flow conditions of the glacier are different in places on the rock cliffs.

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