Bulletin of Glacier Research 5 (1987) *49 – 53*

Seasonal variation of snowline in Langtang Valley, Nepal Himalayas, 1985–1986

Yuki Morinaga[1], Katsumoto Seko[2] and Shuhei Takahashi[3]
1 Institute of Geoscience, University of Tsukuba, Ibaraki 305 Japan
2 Water Research Institute, Nagoya University, Nagoya 464 Japan
3 Kitami Institute of Technology, Kitami 090 Japan

(Received December 21, 1986 ; Revised manuscript received January 29, 1987)

Abstract

The seasonal variation of snowline altitude in Langtang Valley in the Nepal Himalayas was studied for a whole year, from July 1985 to June 1986, based upon the photograph observations.

The snowline is compared with the altitude of 0 ℃ air temperature, derived from the observational data at the valley station. The results show that the snowline does not always coincide with the 0 ℃ altitude through the year. And the relation between them greatly change from season to season. The snowline well agreed with the 0 ℃ altitude with a little difference in monsoon season and spring season, while it varied intermittently owing to occasional precipitation in dry season.

1. Introduction

The snowline is one of the important climatic parameters, relating to the development of glaciers and the river runoff. It is such an intriguing problem to know how the snowline is determined. There have been various studies on the snowline (Nogami, 1970; Hoshiai and Kobayashi, 1957; Ota and Nogami, 1979). Many of them treat the snowline as an index of climatic fluctuations. There exist a number of definitions of the snowline such as orographic snowline, climatic snowline, glaciation limit and so on (Nogami, 1970). The term "snowline" in this study is defined as a boundary of snow covered area.

It was revealed by the NOAA satellite observations that the snowcover over the Tibetan Plateau including Himalayan Mountains are known to have considerable effect on the atmospheric circulation of monsoon season (Hahn and Shukla, 1976; Dickson, 1984 *etc.*). Their results suggest that the broad snowcover area of this region in winter and spring suppress the diabatic heating of atmosphere, which makes the monsoon circulation weak in succeeding summer season. It means that in this area, the snowline is not only an index of climatic fluctuations but also a controlling factor of the climate. It has been also pointed out that on the other hand, the satellite derived snowcover area on the Himalayan region need to be carefully checked by the ground truth observation (Dickson, 1984). However, the precise observational studies on the snowline have not been made in this region.

In Langtang Valley, Napal Himalayas, the seasonal snowline variations are observed from July 1985 to June 1986 by taking photographs of the snowline. The meteorological, hydrological and glaciological observations have been simultaneously carried out during this period. We discuss the seasonal variation of snowline in Langtang Valley in relation to the meteorological conditions.

2. Methods of observation

The snowline variations were observed continuously from July 9, 1985 to July 3, 1986 by taking pictures of surrounding landscape at the Base House (hereafter referred to as B. H.), 3920 m in Langtang Valley, Nepal Himalayas (Fig. 1). The snowline in this area was almost horizontal.

Two reference slopes were chosen to obtain the altitude of snowline; one is north-facing slope with the

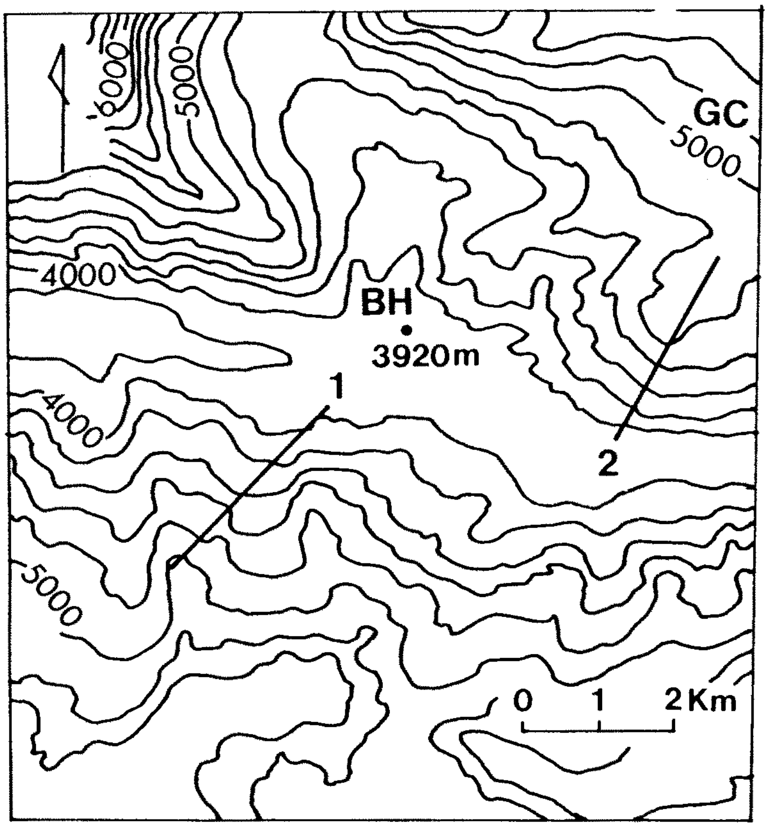

Fig. 1. Location of observational site. 1: The north-facing slope. 2: The south-facing slope.

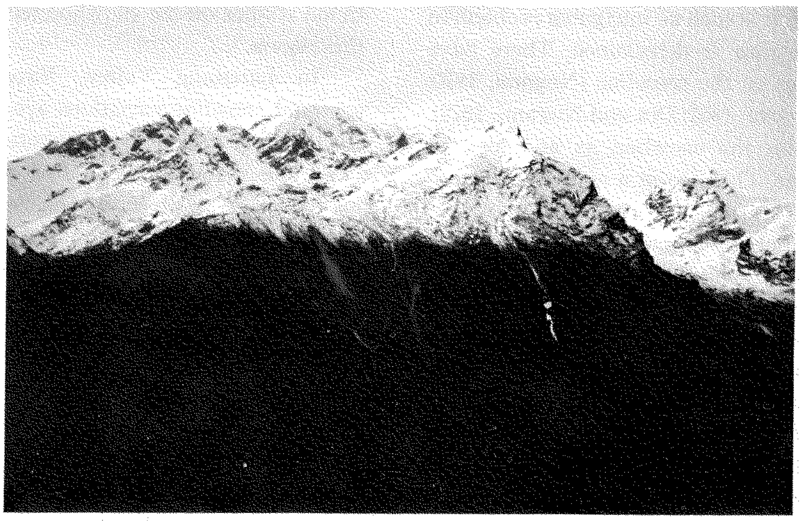

Fig. 2. The snowline on the north-facing slope. (November 5, 1985).

peak of 4957 m and another is south-facing slope with the peak of 4986 m. The typical snowline (November 5, 1985) on the north-facing slope to the south of B. H. is shown in Fig. 2. The altitudes of several points on the slopes were examined by a pressure altimeter. The snowline below B. H. (3920 m) was obtained from visual observations. The number of days of taking pictures were 140 days for north-facing slope and 113 days for south-facing slope.

At the meteorological observatory of B. H., temperature, relative humidity, wind speed, solar radiation, cloud amount and others were observed (Takahashi *et al.,* 1987) and the daily data were available. From the data of temperature at B. H. and Glacier Camp (G. C.), 5090 m, the lapse rates of temperature were obtained.

3. Results

a. Seasonal variation of snowline

The observed seasonal variation of snowline between July 1985 and June 1986 on the north-facing and the south-facing slopes are shown in Fig. 3 with the precipitation and the temperature at B. H. Black and white circles indicate south-facing and north-facing slopes, respectively. When the snowlines were lower than B. H. (3920 m) circles were plotted on the lower line of the figure. When they were higher than the peaks, circles were plotted on the higher line of the figure.

During the monsoon season, July to mid-September, the snowline were higher than the peaks of reference slopes, that is higher than at least about 5000 m. At the beginning of August, the snowline, as a boundary of old ice surface and new snow cover was about 5300 m from the visual observation on Yala Glacier above G. C. In this season, the precipitation occurred almost everyday although its daily amount was not large.

From mid-September, the snowline remarkably descended three times by a great amount of snowfall. The precipitation in rain at B. H. was 102 mm on September 16−17, 79 mm on October 9−10 and 172 mm on October 17−18. Soon after descending by the snowfalls, the snowline ascended rapidly at first, but the ascending rate slowed down gradually along the seasonal decrease of air temperature. Around October 18, the monsoon was over and there was no precipitation for two months and the snowline remained stable at 4300 m on north-facing slope and 4550 m on south-facing slope.

In winter season, the snowline descended lower than B. H., 3920 m, after the snowfall of 82 mm at B. H. on December 26−28. After that B. H. was covered with snow and the largest snow depth was 77 cm on February 10, 1986. There were two large snowfalls on December 26−28 and February 10, and the precipitation were 81.6 mm and 40.5 mm respectively.

From the beginning of April, the snowline exceeded the altitude of B. H. and kept ascending. Although it was descended temporarily by occasional snowfalls, the snowline quickly returned to the former altitude.

b. The snowline and 0 °C altitude

The snowline may be determined by the two factors; one is the rate of ablation and the other is the rate of precipitation of snow. As the temperature depends on altitude, the ablation varies with altitude;

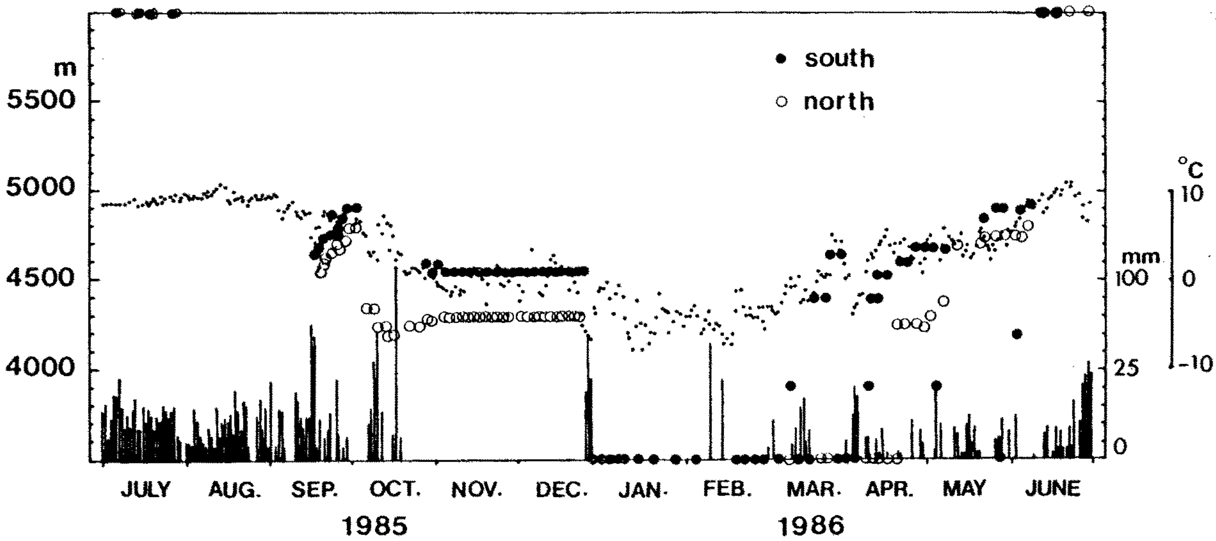

Fig. 3. The altitude of snowlines on north and south-facing slopes and the daily precipitation and temperature.

larger in lower altitude and zero at a certain altitude of a nearly 0 ℃ temperature. On the contrary, the precipitation of snow would be zero at a level which is lower than another certain altitude, where precipitation is rain and temperature would be also near 0 ℃. Thus, we compare the snowline with the altitude of 0℃.

Among the heat budget components for the ablation, the shortwave radiation is considered constant with altitude. On the other hand, the sensible heat, the latent heat and longwave radiation vary with the altitude because of their temperature dependence. Sum of those, as heat of ablation, is a function of several meteorological factors, and becomes zero near 0 ℃.

Here, we estimate the 0 ℃ altitude above which the snowmelt would be zero and compare its 10-day running mean data with the observed daily snowline (Fig. 4). 0 ℃ altitude was estimated from the daily mean temperature at B. H. and the lapse rate 0.6 ℃/100 m, obtained by the temperature difference between B. H. and G. C. Circles are same as Fig. 3.

The observed seasonal snowline shows some agreement with 0 ℃ altitude since they are strongly controlled by temperature. If only the sensible heat is effective to the snowmelt, the snowline should coincide with the 0 ℃ altitude. However, the relation between the snowline and 0 ℃ altitude shows the seasonal differences both on north-facing and south-facing slopes. This implies that the latent heat, the shortwave radiation and the longwave radiation also have some or considerable influences on the snowline variations. This problem will be discussed in the forthcoming paper.

The snowline on the north-facing slope is compared with 0 ℃ altitude as follows. At the end of monsoon season, the snowline was a little lower than the 0 ℃ altitude and the variation of the two was similar. After October 18, the 0 ℃ altitude descended as it became colder, and became lower than the snowline. Then the snowline variation depended on precipitation.

After April, with the increase of temperature and a constant precipitation, snowline again followed the 0 ℃ altitude and showed a similar variation with it.

c. The snowline variations on the north-facing and the south-facing slopes.

As shown in Fig. 3, the difference of the snowline variations between the north-facing and the south-facing slopes are prominent in dry season and small in monsoon season. This is probably because the smaller cloud amount in dry season increases the difference of incoming solar raidation upon the slopes.

4. Concluding remarks

The observed seasonal variation of snowline was as follows: During the monsoon season, the snowline was likely to depend on temperature because of a constant precipitation. The snowline was a little lower

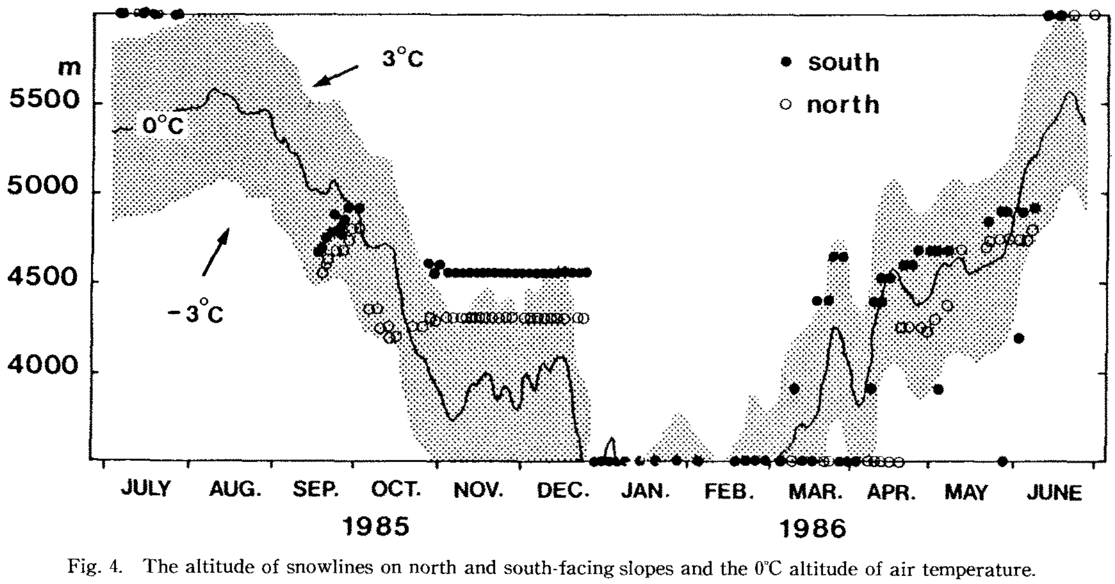

Fig. 4. The altitude of snowlines on north and south-facing slopes and the 0℃ altitude of air temperature.

than the 0 ℃ altitude and their variations were similar. When the seasonal trend of temperature is decreasing, from mid-September for 1985, the interannual variability of precipitation is large (Seko, 1987). The snowline of this season as a result seems to fluctuate very largely from year to year. In winter, the snowline descended intermittently owing to the occasional precipitation. It is speculated that in this region where the snowline is higher than 0 ℃ altitude the temperature determines the lower limit of snowline and the precipitation determines the upper limit of it. As the interannual variability of precipitation is also large, the snowline would depend rather on the precipitation than on temperature. As the total amount of precipitation gets larger in the western part of the Himalayan Mountains, (Yasunari and Fujii, 1983) this tendency would be more pronounced in the western part.

In spring, the snowline kept ascending and varied with the 0 ℃ altitude, as a result of temperature increase and a constant precipitation. The effect of spring snowcover in this region upon the succeeding summer monsoon is discussed by Hahn and Scukla (1976) and others. The amount of winter precipitation and the starting time of the spring temperature increase which may differ greatly year to year, may be some controlling factors of the snowcover area in spring. To discuss the interactions between the snowcover and the atmosphere in this area, it will be important to find out what determines the starting period of the temperature increase in spring.

Acknowledgments

We would like to express our appreciation to Dr. Tetsuzo Yasunari of University of Tsukuba for his kind and useful suggestions. Also we wish to thank the members of Glaciological Expedition of Nepal-Langtang Project, supervised by Prof. K. Higuchi of Nagoya University, who supported our observations.

References

Dickson, R. R., 1984 : Eurasian snow cover versus Indian monsoon rainfall ……an extension of the Hahn-Shukla results. J. Appl. Meteor., **23,** 171-173.

Hahn, D. G. and J. Shukla, 1976 : An apparent relationship between Eurasian snow cover and Indian monsoon rainfall. J. Atmos. Sci., **33,** 2461-2462.

Hoshiai, M. and K. Kobayashi, 1957 : A theoretical discussion on the so-called "snow-line", with reference to the temperature reduction during the Last Glacial Age in Japan. Japan J. Geol. Geog. **28,** 61-75.

Nogami, M., 1970 : The snowline : its definition and determination. Quart Res., **9,** 1, 7-16.

Ota, Y. and M. Nogami, 1979 : Altitude of the modern snowline and Pleistocene snowline in the Andes. Professional Geog., **31,** 4, 71-84.

Seko, K. (1987) : Seasonal variation of altitudinal dependence of precipitation in Lantang Valley, Nepal Himalayas. Bulletin of Glacier Research, **5,** 41-47.

Takahashi, S., Motoyama, H., Kawashima, K., Morinaga, Y., Seko, K., Iida, H., Kubota, H. and Turadahr, N. R. (1987) : Meteorological features in Langtang Valley, Nepal Himalayas. Bulletin of Glacier Research, **5,** 35-40.

Yasunari, T. and Y. Fujii, 1983 : Climate and glaciers of the Himalayas. (in Japanese). Tokyo-do Syuppan, 254p.