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Mass balance of glaciers in the East Kunlun and Tanggula Mountains, Tibetan Plateau

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Abstract

Mass balance studies were carried out on Meikuang Glacier in the East Kunlun Mountains and on Da Dongkemadi and Xiao Dongkemadi Glaciers in the Tanggula Mountains, by the China-Japan Joint Glaciological Expedition on the Tibetan Plateau, 1993. The annual mass balance was positive in all cases ; the annual balance in the Tanggula was higher than that in the East Kunlun for 1992/1993 measurement year.

1. Introduction

Observations of glacier mass balance have been carried out since 1989 by the China-Japan Joint Glaciological Expedition on the Tibetan Plateau (Fig. 1 in Ageta *et al.*, 1994). First, stakes for measurement of accumulation and ablation were set up on the Meikuang Glacier (area : 1.1 km^2, length : 1.8 km, altitude range : 5520 m$-$4800 m) on the north slope of the East Kunlun Mountains in the north Plateau (Fig. 1), and also on Xiao Dongkemadi Glacier (1.77 km^2, 2.8 km, 5930 m$-$5400 m) in the Tanggula Mountains, the central Plateau (Figs. 1, 2 in Seko *et al.*, 1994). Then, in 1992, a longitudinal section for measuring mass balance along the east main flow line of Da Dongkemadi Glacier (14.63 km^2, 5.4 km, 6100 m$-$5270 m) was set up. The details of Xiao Dongkemadi Glacier are described by Seko *et al.* (1994). In this paper, the observed data in the East Kunlun and Tanggula Mts. in 1992/1993 are preliminarily analysed.

2. Observed quantities and methods

From May to September, 1993, the glaciers mentioned above were investigated again. For study of mass balance of those glaciers, the accumulation and ablation were measured in more detail in the investigation period by means of stakes and snow pit observations.

The quantities measured every time include, among them, height of stakes, density and structures of the snow layers. Based on the data measured, the balance (b) can be computed at each observation site from the following equations.

$$b = b_i + b_s + b_f$$
$$b_i = d_i[(m_o + h_{fo} + h_{so}) - (m + h_f + h_s)]$$
$$b_s = d_s(h_s - h_{so})$$
$$b_f = d_f h_f - d_{fo} h_{fo}$$

Here b_i, b_s, and b_f are balance values for glacier ice, superimposed ice and firn, and d_i, d_s and d_f are their densities, respectively ; m_o and m are stake height when ablation begins and ends, respectively ; h_{fo} and h_f are firn thicknesses at the two observation times, respectively ; h_{so} and h_s are thicknesses of superimposed ice at the two observation times, respectively.

After isograms of balance were drawn, the mass balnce (B) of the whole glacier can be calculated from the following formula :

$$B = C + A = \sum_1^n S_{cn}c_n + \sum_1^n S_{an}a_n$$

Here C and A are net accumulation and ablation amounts on the whole glacier, respectively ; S_{cn} and S_{an} are areas between two adjacent isopleths in the accumulaton and ablation areas, respectively ; c_n and a_n are mean values of balance in the accumulation and ablation areas, respectively. Through the studies of mass balance of these typical glaciers, the states of mass balance of other glaciers in the area would be

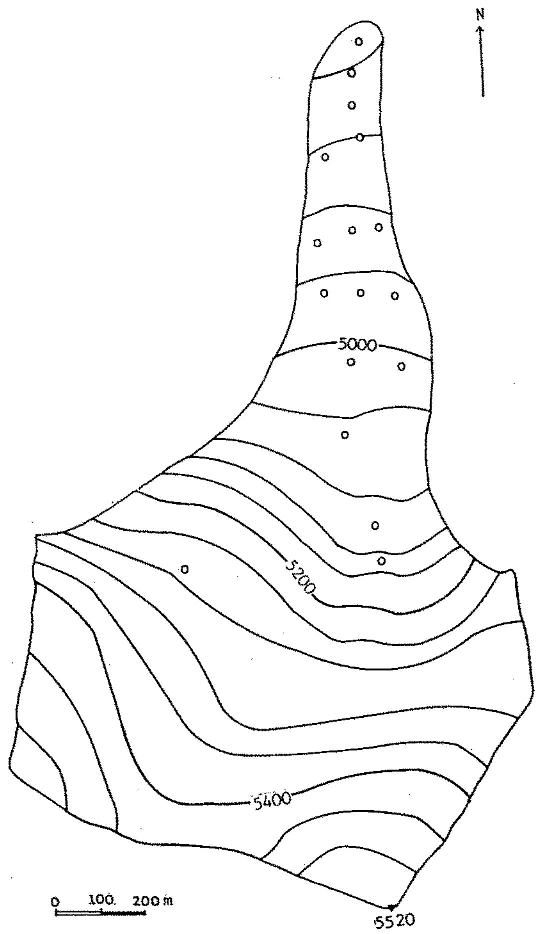

Fig. 1. Location Map of stakes on Meikuang Glacier in the East Kunlun Mountains.

understood.

On the Meikuang Glacier, the measurements of all 18 stakes were done on May 13, July 6 and September 25 in 1993. On the Xiao Donkemadi Glacier, 28 stakes arranged were measured once each 10−15 days from May 23 to September 21. On the Da Dongkemadi Glacier, 9 stakes were measured twice, on May 26 and September 19.

3. Calculated results and discussion

Based on the calculated results, it is found that the annual mass balance of the glaciers monitored in the Tibetan Plateau was positive for the measurement year of 1992/1993 (from the beginning of October to the end of September), which is more than the mean values of annual mass balance since 1989. With regard to the annual mass balance of 1992/1993 on Meikuang Glacier, it was 10.53×10^4 m^3, which equals 95.7 mm water depth on the whole glacier ; on the Xiao Dongkemadi Glacier, 37.35×10^4 m^3, 211 mm. In 1993, the equilibrium line altitude (ELA) was lower and the accumulation area ratio was larger in these glaciers than each average since 1989 (Table 1).

From the data, the variations of mass balance in the balance year of 1992/1993 can be divided into four stages ; from the beginning of October, 1992, to the end of May, 1993, was a period in which both accumulation and ablation amounts were small, due to low precipitation and low air temperature on the plateau, which made the glaciers "colder" (*e.g.* the ice temperature in the surface layer with a depth of 5 meters of the Xiao Dongkemadi Glacier was below −10 °C) that tends to preserve glaciers' existence. About one month, from the beginning to the end of June, abundant accumulation occured. From the beginning of July to the last ten-day period of August was an intensive ablation period, much glacier mass was lost and ablation intensity reached a maximum at the end of this period. From the end of August to the end of September, ablation weakened, and then the glaciers entered the next accumulation period.

The variations of mass balance with altitude show an undulating increase trend as shown in Fig. 2. Winter mass balance in the balance year of 1992/1993 increased generally with altitude. On the Meikuang Glacier, winter mass balance in its tongue area, in the range of −1.5∼60 mm, did not increase gradually with altitude, and in the firn basin increased gradually, but it is emphasized that large positive value of mass balance occured in the lowest tongue of the glacier where there was plenty of deposited snow. On the Xiao Dongkemadi Glacier, winter mass balance was negative on the tongue area and positive above 5600 m a.s.l., which shows that winter mass balance increased with altitude on the glacier. However, negative values of mass balance appeared at the observational points around 5700 m a.s.l.. On the Da Dongkemadi Glacier, owing to the locations of stakes in the higher altitude area, most of them in the accumulation area, the values of witner mass balance measured were all positive, but decreased with height.

Table 1. The equilibrium line altitude (ELA) and the accumulation area ratio (AAR) of the monitored glaciers on the Tibetan Plateau in 1992/1993.

Glacier name	ELA (m a.s.l.)	AAR(%)
Meikuang Glacier	5040	83
Xiao Dongkemadi Glacier	5510	81
Da Dongkemadi Glacier	5470	87

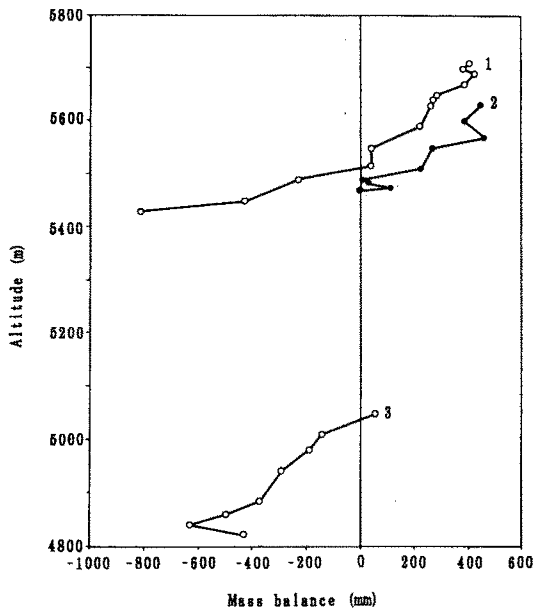

Fig. 2. Altitudinal distribution of mass balance of glaciers on the Tibetan Plateau.
1. Xiao Dongkemadi Glacier
2. Da Dongkemadi Glacier
3. Meikuang Glacier

These unexpected phenomena are probably related to the redistribution of deposited snow by wind.

References

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