Estimates of surface melt-rate on mountain glaciers

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1. Introduction

A glacier is often regarded as a barometer of global warming. Climate change effects melt of snow and ice especially on mountain glaciers. Global warming causes their volume changes drastically. Mass balance of a glacier consists of accumulation and ablation, and most of the ablation is due to surface melt. Since the pattern of melt rate on the glacier surface is complex, it is not easy to obtain accurate estimate of melt-rate for the whole glacier, nor melt water run off. The objective of this study is to estimate the distribution of melt-rate over a glacier, under the different climatic and topographic conditions.

2. Study site

Storglaciären (Fig.1) is a mountain glacier, which is located in northern Sweden (67°55'N, 18°35'E) and has an area of 3km^2 ranging from an elevation of 1120m to 1730 m a.s.l. Some extensive studies have been made at the glacier during the last some decades.


Fig.1. Storglaciären


Fig.2. Radiation station


Fig.3. Profile station

3. Methods

Mass balance study is performed every year on the glacier by Stockholm University. During the summer 2003, the author made meteorological observations; net radiation (Fig.2), air temperature, relative humidity and wind speed. In July, net radiation ware measured at the center of the glacier and the other factors were observed at 0.5 m, 1 m, 2 m and 4 m above the surface (profile measurement) at the center of the glacier, as well (Fig.3). In August, spatial distribution of meteorological factors ware observed at three stations on the glacier.

Based on the observations, the author analyzed heat balance on the glacier. Sensible and latent heat fluxes were calculated by the gradient and bulk methods with the profile data assuming that the air condition is neutral.

4. Results

During the summer 2003, air temperature in observation area was also high as well as others in Europe, and melt rate on the glacier was larger than those in the last some years.

Radiation measurement (Fig.4) shows that there were more days with high global radiation during the summer than usual, and albedo (Fig.5) was low until the snowfall events.

The profile measurements show that the gradient of air temperature tend to change at 1 m above the surface and wind speed at 1 m was weaker than at 0.5 m and 2 m.

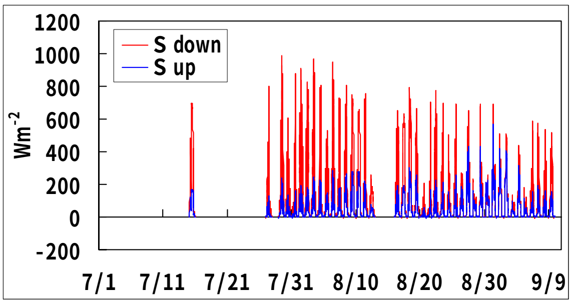


Fig.4. Downward and upward shortwave radiations at Storglacoären

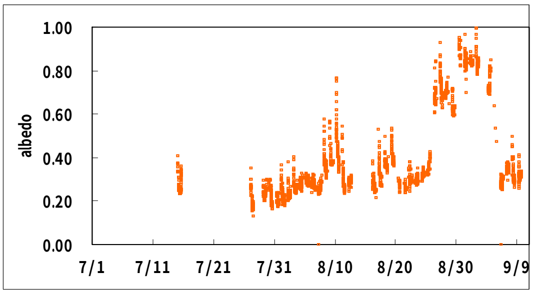
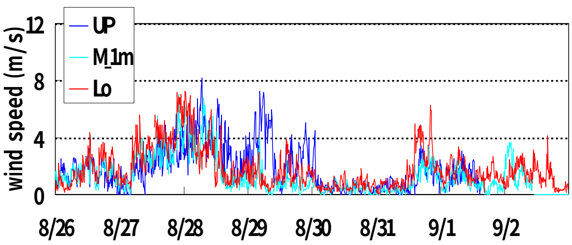


Fig.5. Time series of albedo change

Humidity and wind speed at three sites indicate slight variations with three sites. (Fig.6), and air temperature changes by altitude with the lapse rate 5.5 Kkm^{-1} during the period from the middle of August to the beginning of September (Fig.7).



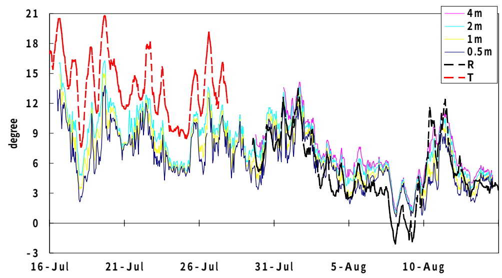


Fig.6. Wind speed observed on Storglaciären (UP: upper site, M_1m: center, Lo; lower site)

Fig.7. Air temperature observed on the glacier, at R: ridge and T: Tarfala

Based on these measurements, we estimated the surface energy balance for the period between the end of July and the end of August 2003. The results calculated by the two methods were different depending on the measurement levels due to the characteristics of gradients of temperature and wind speed over the glacier (Fig.8). Net radiation contributes 53% of the energy available for melt. This rate is close to that in the summer 1999.

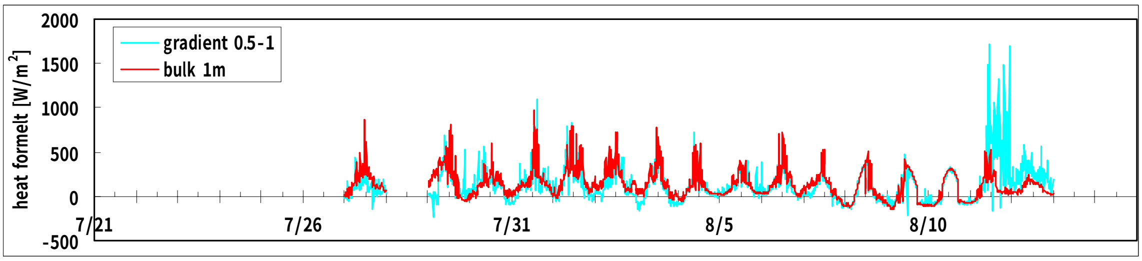


Fig.8. The result of heat balance calculation (gradient 0.5-1 m: gradient method with the data taken at 0.5 m and 1 m, bulk 1m: bulk method with data taken at 1 m)

5. Discussion

The profile measurements with four levels indicate that the top of the stable boundary layer is located at about 1 m above the glacier surface.

Each of the gradient and bulk methods will be applied to a melt model, which calculates distributed melt-rates over the glaciers taking account of the shading effect of radiation and the lapse rate of air temperature.

6. Conclusions

Field observations of meteorology and heat balance were carried out on Storglaciären during the summer 2003 both radiation and air temperature was high on the glacier. Profile measurements of air temperature and wind speed showed characteristics of air condition over the glacier. From the observation at three stations on the glacier show that there are slight differences in the variety of humidity and wind speed over the glacier. The results of heat balance calculation reflect the structure of air near the glacier surface.

7. Publication

Keiko Konya, Regine Hock and Renji Naruse: Distributed melt-rate calculations based

on the energy balance over Storglaciären, Sweden. IGS symposium "Arctic Glaciology", Aug 2004, Geilo, submitted.

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