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Analysis of meteorological data and the surface energy balance of Keqicar Glacier, Tien Shan, China

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Northwestern China currently experiences a climate change with fundamental consequences for the hydrological cycle. In the strongly arid region where water resources are essential for agriculture and food production, glaciers represent important water resources, contributing significantly to streamflow. The debris is an important glaciological feature of the region and has major impact on melt rates. It is essential to understand and quantify the interaction of climate and sub-debris melt in order to assess the current situation and to predict future water yield. Note that the surface energy balance determines glacier melt. However, little is known about the variability characteristics of the surface energy fluxes in this region.

For this reason, we set up two automatic weather stuation (AWSs) in the ablation area of Keqicar Glacier. Keqicar Glacier is located in the Tarim River basin (largest inland river basin in China), southwestern Tien Shan, China. It is a representative debris-covered glacier with a length of 26.0 km and a total surface area of 83.6 km2. The thickness of the debris layer varies from 0.0 to 2.50 m in general. In some places large rocks are piled up to several meters.

In this study, we report on analysis of meteorological data for the period 1 July-13 September 2003, from two automatic weather stations, aimed at studying the relationship between climate and ablation. One station is located on the lower part of the ablation area where the glacier is covered by debris layer, and the other near the equilibrium line altitude (ELA). All sensors were sampled every 10 seconds, and data were stored as hourly averages. The stations were visited regularly for maintenance at two weeks intervals depending on the weather conditions and location of the AWS. A total of 17 ablation stakes were drilled into the glacier at different elevations to monitor glacier melt during the study period. Readings were taken regularly in connection with AWS maintenance.

The weather station on the glacier measured an average temperature of 2.6 °C (at 2m height above surface). The lapse rate of air temperature is close to the standard free atmospheric lapse rate (0.6 °C per 100m), which shows the cold effect of glacier is not significant. The local mountain-valley winds is significant, the speed of which is 2.3 m s-1 (at 2m height). Glacier is dominated by the convectional precipitation, 75% of which occurs in day time. The ablation stakes indicate a specific mass balance of -2.5 m w.e. between 1 July and 13 September. The specific mass balance calculated from the surface energy balance, -2.6 m w.e., is in close correspondence to this. The thermal processes on the debris layer are quite different from those on bare ice or snow. The main physical characteristics of the debris layer are the thermal conductivity and albedo that control heat conduction to the ice-debris interface. Net radiation is the main melt energy whether the debris layer is taken into consideration or not, which is lager between July and the middle of August, and then decreases. This is coincides with the glacier ablation. On the debris-covered area, the sensible- and latent-heat fluxes contribute 19.6% of the melt energy, higher than that on the debris-free ice (4.1%). Hence, due to the existing debris layer, the ablation shows a significant spatial distribution.