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Non-climatic factors affecting glacier mass balance (on the example of avalanche nourishment)

Alla Turchaninova, Sergey Sokratov, Yury Seliverstov, Dmitry Petrakov, Anton Lazarev, and Ekaterina Bashkova

Lomonosov Moscow State University, Faculty of Geography, Moscow, Russian Federation (alla_wave87@mail.ru)

Glacier mass balance is affected by non-climatic factors such as topography, debris cover and geometric parameters of glaciers themselves, avalanche activity, volcanism, etc. The contribution of snow avalanches to the snow accumulation on a glacier is still among the least studied components of the glacier's mass balance. We propose a possible approach for the numerical assessment of snow avalanche contribution to accumulation at mountain glaciers. The approach consists on the following steps: terrain analysis; weather data analysis; snow avalanche volume assessment during an analyzed balance year; numerical simulation of snow avalanches using RAMMS; evaluation of snow avalanche contribution to glacier accumulation. The proposed methodology was tested on three glaciers (Batysh Sook, № 354, Karabatkak) with an area up to 6,5 km² in the Inner Tien Shan and Kolka glacier with an area 1,2 km² in the Central Caucasus. To evaluate snow avalanche contribution to the winter accumulation, we reconstructed avalanche release zones that were most probably active during the analyzed balance year and corresponding snow fracture height in each zone. The numerical simulations of most probable released snow avalanches during the analyzed year using avalanche dynamics RAMMS software were performed and compared with the field observations and UAV orthophoto images. The outlines of avalanches deposits were realistically reproduced by RAMMS according to the results of field observations. The estimated contribution of snow avalanches to the accumulation on the studied glaciers during the analyzed balance year was as follows: Batysh Sook – 7,4±2,5%; № 354 – 2,2±0,7%; Karabatkak – 10,8±3,6% of the winter mass balance. In strong contradiction to the benchmark glaciers in the Tien Shan, the Kolka glacier demonstrates rapid mass gain in the Caucasus. It might be explained by significant, up to 80% share of avalanche nourishment to glacier mass gain. We note that avalanche-fed glaciers seem to be more stable at current stage of regional warming observed both in the Caucasus and the Tian Shan. The obtained results show the importance of the non-climatic factors for glacier surface mass balance control.