Submitted Abstract

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Abstract

Debris cover is poorly represented in most glacier models although it plays a key role in the regulation of melt processes. Debris cover that is more than a few centimeters thick reduces melt by insulating glacier ice. Mass loss and retreat of debris-covered glaciers are slower than those of clear ice. Debris-covered glaciers are widespread in the North Caucasus. It is important to reliably quantify their evolution because the contribution of glacial runoff to total discharge is significant in the region.

This paper assesses the influence of debris cover on the evolution of glaciers in the basins of the Terek and Kuban rivers in the Northern Caucasus in the 21st century and quantifies its effects on glacier mass balance, ice velocity, changes in glacier area, volume, and position of the glacier fronts as well as runoff. The GloGEMflow glacier model is used to which a new debris cover dynamic module has been introduced. The mass balance is calibrated separately for the explicitly modelled debris cover and for clean-ice glaciers (debris cover is implicit in the degree-day factor calibration). The model is calibrated using newly mapped debris cover outlines and ice thickness data from Rounce et al. (2021). The debris evolution is simulated with a steady deposit model adapted from Verhaegen et al. (2020) and Anderson & Anderson (2016), where debris input onto glacier surface is generated from a fixed point on the flow line. The outputs from the glacier model, as well as future climate projections, are used to force the hydrological model ECOlogical Model for Applied Geophysics (ECOMAG) in order to assess changes in runoff throughout the 21st century.

The debris cover evolution patterns differ significantly between the Terek and the Kuban basins. In the Kuban basin, glaciers positioned generally at lower elevations retreat rapidly and lose ice at the debris-covered glacier tongues. In the Terek basin, expansion of the supraglacial debris cover is observed. It causes a six times larger effect on glacier volume evolution than for the Kuban basin glaciers. We compare glacier evolution including evolution of debris cover and changes in runoff for the explicit and implicit debris cover formulation for five SSP scenarios from CMIP6.

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