INVESTIGATING THE LONG-TERM DYNAMICS OF DEBRIS-COVERED GLACIERS IN THE HINDU KUSH-KARAKORAM-HIMALAYA

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In combination, the Hindu Kush – Karakoram – Himalaya (HKH) ranges contain the largest concentration of ice outside of the Polar Regions. However, a quantitative understanding of ongoing and future mass changes of HKH glaciers remains elusive, in particular because the mass change, meltwater production and dynamic response of glaciers in the HKH are influenced by the widespread presence of supraglacial debris throughout the mountain range.

Supraglacial debris cover forms by a cascade of inter-related processes that are connected by a series of feedback loops. Both the processes and the feedback mechanisms vary in space and time. Consequently, the influence of debris must be considered as a dynamic component of the mountain glacier system in order to accurately predict both the manner in which debris-covered glaciers will respond to climate forcing, and the timescales involved in their response.

Models that include simplified representations of ice flow and surface debris cover have been presented in the literature, but none explicitly include the flux of debris through the glacier system in a space- and time- dependent manner. The proposed research will address this gap by developing a coupled glacier mass balance and ice flow model in which debris redistribution within, and at the surface of, the glacier is explicitly related to the three-dimensional velocity fields of a full-Stokes ice flow model, and to the rates at which debris is delivered to the glacier surface by melt-out and fluxes from the surrounding terrain. The model will be driven by parameterized supra- and sub- debris supply terms, and a surface mass balance condition that depends on the time-evolving thickness of supraglacial debris cover at the glacier surface.

This model will provide the first realistic representations of the time-dependent spatial distribution of debris within, and at the surface of, the glacier. The model will be used to perform a number of sensitivity experiments to understand the general behavior of idealized debris-covered glacier systems whose characteristics are sampled from the parameter space of HKH glacier hypsometry and climatic conditions. Subsequently, the model will be applied to a well-studied glacier in the HKH.

The proposed model and associated research will represent a significant step forward in our understanding of all mountain glacier systems, but in particular, it increase process-based understanding of the debris-covered glaciers that dominate the cryosphere of the HKH. The model results can also be used to develop accurate representations of debris-covered glaciers in simpler model systems used to determine longer term cryospheric contributions to water resources and sea-level rise, both from the HKH and other mountain regions where debris-covered glaciers are prevalent.