Submitted Abstract

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Abstract

Glaciers expel sediment, in addition to ice and water. The quantity of sediment depends on the subglacial hydrological conditions, as well as the bedrock erosion rate. As a result, changing glacier dynamics and melt will cause changes to glacier erosion and sediment discharge, which can impact the landscape surrounding retreating glaciers, as well as communities and ecosystems downstream. Thus, there lies an imperative to understand these systems. Due to the difficulties in observing subglacial erosional processes, numerical models provide a valuable means to understand sediment transport and erosion process below glaciers. In turn, insights into these processes can be used to better evaluate landscape changes in alpine regions as climate warms

Here, we present a numerical model to demonstrate the ways in which spatial heterogeneities in subglacial water velocity and sediment availability impacts sediment discharge and bedrock erosion below glaciers. This model operates by evolving a subglacial till layer in response to sediment transport conditions and sediment availability over hourly to decadal time scales.

Numerical experiments with synthetic test cases show the potential role of sediment availability and the heterogeneity of sediment transport across a glacier's bed. When compared to field data, the model captures measured sediment discharge volumes from the Griesgletscher in the Swiss Alps. A parameter search shows that sediment grain size is a key control on the discharge of sediment due to the role it plays in mobilizing sediment from distal areas of the glacier bed, outside of main channels. Additionally, the model is applied to understand differential erosion patterns on debris-covered glaciers.

We hope that processes identified in the modelling framework can be used to guide field studies and data collection. Future model development includes integrating hillslope and other periglacial processes into the framework. Additionally, the modelling framework is available for use by other researchers to evaluate subglacial erosion and sediment transport processes.