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Sediment yield from a large alpine glacier over one season

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Hydropower operators in the Swiss Alps have noted increased reservoir sedimentation rates in the last decade. This material either originates from erodible periglacial areas, no longer stabilized by ice, or from subglacial environments, where it is transported by pressurized melt-water. In order to forecast sediment production on subyearly timescales as glaciers retreat and hydrological conditions evolve, the processes that transport subglacial sediment must be further described and integrated into numerical models. To determine and model these processes we have examined Gornergletscher in the Valais Alps.

By measuring suspended sediment expelled from the glacier, along with data from sediment traps used by the hydropower company to estimate bedload transport, we have quantified the glacier's sediment output during the 2016 melt season. The highest concentrations of suspended sediment occurred in late May and early June 2016 during drainage of an ice marginal lake. However, sediment evacuated during this two week period is not as high as during other parts of the season, at just above 5% the season total. This indicates that although an undeveloped drainage system can indeed erode considerable amounts sediment, the flux is heavily dependent on discharge and thus much sediment is available for transport below the glacier. In an effort to apply the observations at Gornergletscher to a broader context, a simple model has been devised and calibrated with the above mentioned data. Using the Darcy-Weisbach equation for pressurized flow through a pipe, we constrain the propensity for subglacial sediment transport. With inputs of hydraulic gradient, discharge and conduit shape, we determine shear stress of water flowing through the glacier's hydraulic system on subglacial sediments. This enables us to reconcile the competing process of decreased (increased) hydraulic gradient (discharge) which decrease (increase) the ability of water to erode sediment as conditions in glacierized catchments evolve. This model requires inputs of discharge and glacier topography and thickness, thus making it applicable to other glaciers with these datasets available.