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How does the presence of debris-cover on a glacier influence hydro-sedimentary dynamics? A comparison study from two proglacial streams in the Sulden catchment (Eastern Italian Alps)

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Proglacial streams show complex hydro-sedimentary dynamics controlled by different meltwater contributions and sediment fluxes. This study investigates how these patterns may vary with respect to the degree of debris-cover on the glacier tongue and to the bedrock lithology. The study area is the upper Sulden catchment in the Eastern Italian Alps (14 km^2 drainage area, 38 % of glacier cover), which ranges in elevation between 2225 and 3905 m a.s.l..

In 2017 and 2018, proglacial streams from the Eastern Upper Sulden glacier (almost debris-free, located on metamorphic rocks) and the Western Lower Sulden glacier (large parts are debris-covered, average thickness about 30 cm, located on metamorphic and Dolomitic rocks) were monitored. From June to September, we performed bi-weekly to monthly sampling of bedload (by Bunte samplers) and suspended sediment content (SSC), and measured tracers such as stable water isotopes (δ^2H and δ^{18}O) and electrical conductivity (EC). During each sampling event, we measured water stages and carried out discharge measurements derived from salt dilution method. Moreover, we continuously logged stream turbidity at the outlet at 10 min measuring interval. Meteorological data were measured at the Madritsch weather station at 2825 m a.s.l. and a weather station installed on the Western Lower Sulden glacier at about 2625 m a.s.l. During the snowmelt period in June 2017 and 2018, we observed high flows in both proglacial streams with almost no bedload transport (capturing none to only few particles) and very low SSC (up to 60 mg l^{-1}). These hydro-sedimentary conditions recurred also during a cold spell at the end of July 2017. In contrast, during days of intense ablation in August 2017 and 2018, increasing discharge at the time (or slightly delayed by 2 hours) of maximum air temperature and global radiation led to a peak bedload transport of 3.1 kg min^{-1}at the debris-covered glacier. A slight isotopic depletion and increasing EC indicated a change of the dominant runoff component during the peak flows. Interestingly, SSC patterns were ambiguous: while SSC followed increasing discharge and bedload transport on 22 Aug 2018, SSC revealed a dilution effect during highest flows on 30 Aug 2017.

In general, bedload transport and SSC were clearly smaller at the non-debris covered glacier ($<$ 0.01 to 2.1 kg min^{-1} and 390 to 1210 mg l^{-1}, respectively) than at the debris covered glacier ($<$ 0.01 to 19 kg min^{-1} and 115 to 2786 mg l^{-1}, respectively). These observations clearly highlight the difference of sediment availability on both glaciers and on different bedrock lithology. The findings may help to estimate the sediment transfer from glacial areas to the river network.