

Do rapidly retreating valley glaciers increase catchment sediment export rates?

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In the face of rapid climate warming, rapid glacier recession should lead to a marked increase in the spatial extent of paraglacial processes operating in glaciated drainage basins. The paraglacial phase has been well established to be transient but there are very few studies of this transient response and what it means for sediment export. There is good reason to expect that glacier recession could increase basin-scale sediment connectivity as: sediment becomes less dependent on glacier surface transport; proglacial streams are more able to migrate laterally than subglacial streams and so access sediment for transport; and glacier debuitting may aid the development of gullies that can dissect moraines and so aid hillslope to proglacial zone connectivity. By using records of the flushing of hydroelectric power installations we were able to develop a record of coarse sediment (sand and gravel) export from a basin with a rapidly retreating valley glacier, the Haut Glacier d'Arolla, from 1977 to 2014. Modelling suggested that these data could only be partially controlled by transport capacity implying an important role for sediment supply and potentially for the influence of changing sediment connectivity. Indeed, there was evidence of the effects of glacial debuitting upon gully processes and hence a possible increase in the ease of connection of upstream basins to the proglacial area. More recently, it was possible to show possible temperature control on sediment export, which may only have become apparent because of the progressive development of better sediment connectivity. However, whilst rapid glacier recession should result in theory in a progressive increase in connectivity of sediment sources to the basin outlet, the supply to capacity ratio does not increase continually with glacier recession until maximum capacity is reached. We identify two examples of why. First, gully processes were also accompanied by the sediment accumulation at the base of moraines that was too coarse to be transported by the proglacial stream, maintaining disconnection of the upper basins. Second, the sediment capacity ratio appeared to be elevated during periods of more rapid retreat and we attribute this to the importance of a continued supply of unworked glacial till before fluvially-driven sediment sorting reduces sediment transport rates. Fluvial reworking of freshly exposed sediment may slow sediment transfer and hence export rates. Thus, the transient geomorphic response of glaciated basin to glacier recession may involve negative feedbacks that can reduce the extent to which increases in connectivity elsewhere in the basin lead to increased sediment export.