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Tracking coarse sediment in an Alpine subglacial channel using radio-tagged particles

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Temperate Alpine glaciers produce substantial quantities of sediment that are exported via active subglacial meltwater channels to their proglacial environments. Measurements of suspended sediment and bedload in proglacial rivers have been used to estimate glacial erosion rates and downstream sediment yields, assuming that eroded sediment is rapidly evacuated by flowing meltwater; that subglacial sediment storage remains constant and that the measurements are unaffected by proglacial filtering effects. Studies generally focus on the suspended sediment fraction of export, due to the challenges involved in monitoring coarse sediment transport. It is not surprising that subglacial sediment transport dynamics are poorly understood, and a limited amount of field and model-based research indicates that subglacial sediment transport may be attenuated in the rapidly thinning and retreating snout marginal zones of many Alpine glaciers. This is likely due to the existence of non-pressurised subglacial channels with highly variable transport competence related to diurnal discharge variability, leading to cycles of alluviation and deposition. The potential attenuation of sediment and the unknown relationship between suspended load and bedload has important consequences for estimates of glacial erosion based on proglacial export measurements.

Here, we present results from a proof-of-concept for a method to track radio-tagged bedload particles through meltwater channels under shallow temperate glacier ice (<50 m). Active radio transmitters were inserted into natural pebbles and then deployed directly via boreholes into a 10 m wide snout-marginal subglacial channel at the Glacier d'Otemma, Switzerland. A roving antenna at the surface was used daily to estimate the planimetric point location and downstream transport distance of each tagged particle using Kernel Density Estimation (KDE) as it moved downstream through the subglacial channel. In addition, stationary antennas on the glacier surface monitored the passage of the particles through successive reaches of the subglacial and proglacial channel, constraining the timing of particle transport events. The roving and stationary antenna data were combined to create a transport distance model for each particle, which, when applied at scale, may be used in conjunction with river gauging data to examine the drivers and timescales of coarse subglacial sediment transport. We present results that confirm this method as a highly original means of quantifying subglacial sediment transport using particle tracking.