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Soil erosion and organic carbon export by wet snow avalanches

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A growing number of studies have begun to use sediment budgets to indirectly estimate the cycling of biogeochemical constituents in mountainous terrain. In this context little is known about mobilization, transport, and export rates during the snow pack season, when large portions of alpine landscapes appear inactive compared to the more rigorous geomorphic activity between spring and autumn. Here we expand the scarce knowledge base on debris transport by snow avalanches and report first-order estimates of related sediment and organic carbon export, based on field samples of some 30 wet snow-avalanche deposits in the eastern Swiss Alps. These deposits formed snow bridges across second- to third-order mountain river channels, and contained detritus in their surficial layers. Repeated point samples of these detrital layers indicate a median thickness of 2-4 cm, which translates into 0.02 to 0.04 m^3 of sediment per m^2 avalanche deposit surface. Grab samples encompassing a total of $>$350 kg of debris indicate concentrations from 1 to 43 kg m^{-2} of deposit area. Sieving and loss-on-ignition analyses show that, on average, particulate organic carbon (POC) constitutes (37 +/- 34)% of particle sizes $<$2 mm, and slightly less for larger sizes, although a complete sample of large woody debris turned out to be infeasible. This translates into a deposit surface concentration of 0.02 to 6.6 kg POC m^{-2}. Assuming a yearly recurrence of these snow avalanches with comparable size range and LiDAR-DEM derived release-area conditions leads to estimated median sediment and organic carbon yields of 83 t km^{-2} yr^{-1} and 2 t km^{-2} yr^{-1}, respectively. The range of rates sprawls on an order of magnitude, but support reported debris transport rates by snow avalanches. Given that the bulk of fine POC is delivered to steep headwater channels upon meltout of the snow bridges during the spring seasons, we argue that carbon export by snow avalanches may be an important mechanism of episodically flushing POC from steep mountain drainage basins.