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The effects of (supra-, en-, and sub-glacial) sediment on mountain glaciers

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In mountainous environments, steep hillslopes tend to erode rapidly. These hillslopes, where present above glaciers, trundle rocks onto glacier surfaces below them. The loose rocks (debris) are subsequently transported along with glacial ice as it moves down valley. Debris can be so abundant that it produces continuous blankets across glaciers. Where debris cover is extensive it reduces ice melt and lowers the surface slope of glaciers. This feeds back to reduce basal sliding, thus impacting bedrock erosion. The erosion of bedrock produces loose sediment that is transported down valley along with the ice and by subglacial water flow.

Here, using a coupled numerical model, we tie three realms of sediment transport (supraglacial, englacial, and subglacial) with feedbacks between ice dynamics and surface melt. The model runs in 2D (x, z) using the shallow-ice approximation and a simple formulation for melt under debris. Our simulations use glaciological parameters meant to loosely represent glaciers in the Khumbu region of Nepal. We present numerical experiments to reveal the first order effects of debris cover on erosion and landscape evolution.