Geophysical Research Abstracts
Vol. 18, EGU2016-7732, 2016
EGU General Assembly 2016

Climate-sensitive feedbacks between hillslope processes and fluvial erosion in sediment-driven incision models

Daniel S. Skov and David L. Egholm
Aarhus University, Department of Geoscience, Aarhus C, Denmark (daniel.skov@geo.au.dk)

Surface erosion and sediment production seem to have accelerated globally as climate cooled in the Late Cenozoic, [Molnar, P. 2004, Herman et al 2013]. Glaciers emerged in many high mountain ranges during the Quaternary, and glaciation therefore represents a likely explanation for faster erosion in such places. Still, observations and measurements point to increases in erosion rates also in landscapes where erosion is driven mainly by fluvial processes [Lease and Ehlers (2013), Reusser (2004)].

Flume experiments and fieldwork have shown that rates of incision are to a large degree controlled by the sediment load of streams [e.g. Sklar and Dietrich (2001), Beer and Turowski (2015)]. This realization led to the formulation of sediment-flux dependent incision models [Sklar and Dietrich (2004)]. The sediment-flux dependence links incision in the channels to hillslope processes that supply sediment to the channels. The rates of weathering and soil transport on the hillslopes are processes that are likely to respond to changing temperatures, e.g. because of vegetation changes or the occurrence of frost.

In this study, we perform computational landscape evolution experiments, where the coupling between fluvial incision and hillslope processes is accounted for by coupling a sediment-flux-dependent model for fluvial incision to a climate-dependent model for weathering and hillslope sediment transport.
The computational experiments first of all demonstrate a strong positive feedback between channel and hillslope processes. In general, faster weathering leads to higher rates of channel incision, which further increases the weathering rates, mainly because of hillslope steepening. Slower weathering leads to the opposite result.
The experiments also demonstrate, however, that the feedbacks vary significantly between different parts of a drainage network. For example, increasing hillslope sediment production may accelerate incision in the upper parts of the catchment, while at the same time the channel bed in the lower parts become shielded from incision by a perpetual sediment cover and incision stalls. These differences cause transients of erosion to migrate through the drainage network.

Beer, Alexander R., and J. M. Turowski. "Bedload transport controls bedrock erosion under sediment-starved conditions." Earth Surface Dynamics 3.3 (2015): 291-309.

Herman, Frédéric, et al. "Worldwide acceleration of mountain erosion under a cooling climate." Nature 504.7480 (2013): 423-426.

Lease, Richard O., and Todd A. Ehlers. "Incision into the Eastern Andean plateau during Pliocene cooling." Science 341.6147 (2013): 774-776.

Molnar, Peter. "Late Cenozoic increase in accumulation rates of terrestrial sediment: how might climate change have affected erosion rates?." Annu. Rev. Earth Planet. Sci. 32 (2004): 67-89.

Reusser, Luke J., et al. "Rapid Late Pleistocene incision of Atlantic passive-margin river gorges." Science 305.5683 (2004): 499-502.

Sklar, Leonard S., and William E. Dietrich. "Sediment and rock strength controls on river incision into bedrock." Geology 29.12 (2001): 1087-1090.

Sklar, Leonard S., and William E. Dietrich. "A mechanistic model for river incision into bedrock by saltating bed load." Water Resources Research 40.6 (2004).