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Modelling Spatial and Temporal Scale Effects in Soil Erosion

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We investigate spatial and temporal scale effects on erosion processes and sediment delivery using a one-dimensional finite volume implementation of the Hairsine-Rose soil erosion model coupled with the St. Venant equations.

The Hairsine-Rose model distinguishes between sediment size classes and recognizes the development of a deposited layer over time that differs from the underlying parent soil in its size distribution and cohesion. The dynamics of erosion and sediment transport arising from changes to the eroding soil can therefore be captured. By treating erosion and deposition processes separately—with net erosion or deposition being the result of a dynamic balance between the processes, the model can handle changes to erosion regimes seamlessly. We model the change from a net erosion (entrainment-limiting) to a net deposition (transport-limiting) regime on a steep-gentle compound hillslope. Soil erosion and deposition result in changes to the hillslope which in turn alter sediment delivery on long timescales. We capture this feedback by introducing a morphological equation into the model. Applying this to the compound hillslope, we show its evolution into a simple slope over a long time period, with a resultant reduction in sediment delivery. Finally, we model, based on recent experimental data, the interaction and thresholds of rainfall and runoff erosion processes.

A two-dimensional extension of the proposed model can potentially be used to predict sediment routing and redistribution over complex evolving topographies at scales ranging from plot to hillslope to sub-watershed.