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Timescales of fluvial response to climate and tectonic perturbations

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Earth's landscapes are composed of connected elements such as hillslopes, bedrock and alluvial rivers, alluvial fans and floodplains for example. Because these entities are dominated by different processes, they might respond in different ways and at different rates to external forcings depending on the nature, magnitude and time scale of changes. Knowledge of those response times is fundamental if we want to extract past climate and tectonics from landscape forms and sedimentary archives. Moreover, the interactions between different landscape elements and their response times also control the response of the landscape as a whole, and the delivery of sediment flux to the basins. Here we review the timescales of fluvial response to perturbations in bedrock and alluvial rivers and discuss the implications for delivery of sediment to basins over multi-millenial timescales.
We first use existing relationships for bedrock rivers to study their response to climatic and tectonic perturbations. For alluvial rivers, we consider a simple 1D alluvial reach with a single grain size and an equilibrium slope determined by classical bedload relations. Upstream perturbations of grain size, sediment concentration and water discharge induce river aggradation or degradation according to their effect on river equilibrium slope. While minimum aggradation time can be computed analytically as a function of slope change and sediment supply, the time necessary to degrade to a lower equilibrium slope may be only a function of the timescale of the perturbation in a transport-limited system. We explore the field of natural rivers and their possible response to upstream perturbations.