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Numerical modelling of transient bedrock channel dynamics and terrace formation

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Fluvial strath terraces result from the transient dynamics of bedrock channels. Despite their abundance and their importance in many fields of geosciences, few studies have tried to quantitatively predict their precise timing and mode of formation. This requires a good comprehension of the transient dynamics of bedrock channel width, which is scarcely known. Channel width results from the competition between tectonic deformation, sediment supply from hillslopes and incision processes on the channel banks and bed. Recent numerical models have started to model the dynamics of bedrock channel cross-section showing how a steady-state geometry can be attained. The resulting geometry is very similar to natural rivers in terms of scaling relationships with discharge. Yet, a critical aspect to study terrace generation is the correct modelling of sediment transport and cover, as well as the modelling of flood deposition on the terrace, something not yet taken into account in these models.

To address these questions we developed a numerical model of bedrock channel profile evolution in which we solve for (i) vertical incision on the bed, (ii) lateral incision on the banks, and (iii) sediment deposition. Vertical (resp. lateral) incision is supposed to occur mainly by abrasion of saltating (resp. suspended) particles. Protection of the bed by immobile sediment is accounted for. We specifically avoid the use of a constant effective discharge approach that is known to be an improper treatment of the problem when a non-negligible threshold for transport and incision exists. We rather compute water and sediment supply on a daily basis according to a probability distribution. This allows to study the contribution of very large events on the overall dynamics of the river. It also permits to study the response to climatically-driven changes in the mean and/or the variability of discharge.

We present the general dynamics of the model, including response to various tectono-climatic perturbations, and scaling of response time with the intensity of the perturbation.