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Modeling bank erosion in gravel bed rivers: a stochastic approach

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Alluvial rivers are dynamic systems that typically migrate across a landscape over time. This movement may occur in the form of progressive erosion at the outside of meander bends, or as rapid widening during large flood events. Lateral migration contributes to channel complexity by incorporating roughness elements such as large wood into the channel, and by producing side channels. However, despite providing ecological benefits lateral migration also poses a significant hazard to communities, as well as linear infrastructure such as roadways. It is therefore necessary to quantify the likelihood of erosion – as well as its potential magnitude – to evaluate and mitigate existing hazards to infrastructure. Quantifying erosion can also assist in land use planning, thereby reducing future hazards to infrastructure.

In this work we present a simple, stochastic bank erosion model that can be used to predict the flow threshold for channel widening in gravel-bed streams, as well as the potential erosion magnitude associated with floods that exceed the erosion threshold. The physically based model relies on several key assumptions that have emerged from flume experiments and numerical modeling. We assume that channel stability depends on the stability of coarse grains on the bed surface, and that bank undercutting and retreat occur when the coarsest grains on the bed are mobilized. Beyond this threshold, the channel widens rapidly during a single flood event. As widening progresses, the flow depth and shear stress decrease allowing the coarse bed material to re-stabilize.

The model uses a Monte Carlo approach enabling the user to incorporate variability in input parameters, and provides a probabilistic distribution of bank erosion predictions for floods exceeding the erosion threshold. This approach allows the user to present the uncertainty associated with the channel response to a given flood event, and is preferable to deterministic models which provide a single prediction. In this presentation we use the model to model erosion in several gravel bed rivers. We demonstrate that the model provides a useful tool for predicting channel response to large floods in dynamic alluvial systems.