Morphodynamic modelling of landslide evacuation in bedrock rivers

T. Croissant, Géosciences Rennes, UMR 6118, Université de Rennes 1 and CNRS, Rennes, France
D. Lague, Géosciences Rennes, UMR 6118, Université de Rennes 1 and CNRS, Rennes, France
P. Steer, Géosciences Rennes, UMR 6118, Université de Rennes 1 and CNRS, Rennes, France
P. Davy, Géosciences Rennes, UMR 6118, Université de Rennes 1 and CNRS, Rennes, France

Key words: river morphodynamics, extreme events, sediment transport

Mass wasting triggered by large-magnitude earthquakes deliver large amount of sediment to mountain rivers (Fig. 1a) [1, 2]. The timescale and mechanisms by which rivers evacuate small to gigantic landslide deposits are poorly known, but are critical for predicting post-seismic geomorphic hazards, interpreting the signature of earthquakes in sedimentary archives and deciphering the coupling between erosion and tectonics. The remote and hard-to-access properties of mountain rivers tend to make direct measurements difficult and lead to the use of a numerical approach to understand the processes controlling the coarse sediment evacuation. In this context, a morphodynamic approach is mandatory to account for the feedback between the river geometric accommodations caused by the introduction of large volumes of sediment and its transport capacity. Here, we investigate the different factors controlling landslides evacuation with the 2D morphodynamic model Eros [3] in a bedrock valley experiencing the introduction of small to large volume of sediment in a variety of boundary conditions (slope, width, discharge and grain size). Our simulations demonstrate that river self-organization into a narrower alluvial channel within the bedrock valley (Fig. 1b) lead to a significant increase of sediment transport capacity and accelerate large landslides evacuation [4]. Moreover, the predicted export times obey a universal non-linear relationship of landslide volume and pre-landslide valley transport capacity. Upscaling these results to realistic populations of landslides shows that removing half of the total coarse sediment volume introduced by large earthquakes in the fluvial network would typically take 5 to 25 years in various tectonically active mountain belts, with little impact of earthquake magnitude and climate.

Figure 1: a. Satellite image showing the introduction of a landslide inside a bedrock river and the subsequent incision of the deposit by the river. This is the example of the Sun Koshi landslide that occurred in Nepal in 2014. Source: Landsat 8 - USGS. b. Numerical simulation of a landslide evacuation by a river. Both natural data and model show the landslide being vertically incised by a narrow river.
References