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The influence of flood frequency, riparian vegetation and threshold on long-term river transport capacity

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Climate fluctuations at geological timescales control the capacity of rivers to transport sediment with consequences on geochemical cycles, sedimentary basins dynamics and sedimentation/tectonics interactions. While the impact of differential friction generated by riparian vegetation has been studied for individual flood events, its impact on the long-term sediment transport capacity of rivers, modulated by the frequency of floods remains unknown. Here, we investigate this effect on a simplified river-floodplain configuration obeying observed hydraulic scaling laws. We numerically integrate the full-frequency magnitude distribution of discharge events and its impact on the transport capacity of bedload and suspended material for various level of vegetation-linked differential friction.

We demonstrate that riparian vegetation by acting as a virtual confinement of the flow i) increases significantly the instantaneous transport capacity of the river independently of the transport mode and ii) increases the long term bedload transport rates as a function of discharge variability. Our results expose the dominance of flood frequency rather than riparian vegetation on the long term sediment transport capacity. Therefore, flood frequency has to be considered when evaluating long-term bedload transport capacity while floodplain vegetation is important only in high discharge variability regimes.

By comparing the transport capacity of unconfined alluvial rivers and confined bedrock gorges, we demonstrate that the latter always presents the highest long term transport capacity at equivalent width and slope. The loss of confinement at the transition between bedrock and alluvial river must be compensated by a widening or a steepening of the alluvial channel to avoid infinite storage. Because steepening is never observed in natural system, we compute the alluvial widening factor value that varies between 3 to 11 times the width of the bedrock channel depending on riparian vegetation and discharge variability. This result is well supported by measurements made in natural river systems in different worldwide locations (Taiwan, Himalayas and New Zealand). Although bank cohesion is often invoked to as a property that sets alluvial river width, we propose unconfinement as another important control factor.