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Effective discharge for sediment transport: the sorting role of river flow regimes

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The effective discharge is a key concept in geomorphology, river engineering and restoration. It is used to design the most stable channel configuration, to estimate sedimentation rate and lifespan of reservoirs and to characterize the hydrologic forcing in models studying long-term evolution of rivers. Previous empirical, theoretical and numerical studies found the effective discharge to be affected by climate, landscape and river morphology, type of transport (dissolved, suspended or bedload), and by streamflow variability. However, the heterogeneity of values observed for the effective discharge challenges a clear understanding of its pivotal drivers, and a consistent framework which explains observations carried out in different catchments and geographic areas is still lacking.
This work relates the observed diversity of effective discharge values to the underlying heterogeneity of river flow regimes. The effective ratio (i.e. the ratio between effective discharge and mean streamflow) is derived as a function of the empirical exponent of the sediment rating curve and the streamflow variability, resulting from climatic and landscape drivers. The proposed analytic expression helps to disentangle hydrologic and landscape controls on the effective discharge, and highlights distinct effective ratios of persistent and erratic hydrologic regimes (respectively characterized by low and high flow variability), attributable to intrinsically different streamflow dynamics. The framework captures observed values of effective discharge for suspended sediment transport in a set of catchments of the continental United States, and may allow for first-order estimates of effective discharge in rivers belonging to different climatic regions.