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Influence of discharge variability on denudation rates and relief : example from the south-eastern margin of the Massif Central, France

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The evolution of continental relief results from the combined action of tectonic and climatic forcings. These processes do not act continuously but often through punctual events (earthquakes, major floods, landslides) whose integrated action over time (100 Kyr to Myr) leads to the formation of landscapes. The distribution of these extreme events is often described by statistical functions involving power-law relationships between frequency and magnitude, which, coupled with the non-linearity of the geomorphological response and threshold effects for the activation of erosion agents, leads to a complex and often poorly understood relief dynamics.

Studying the influence of discharge variability helps to better constrain river incision and long-term relief evolution. The south-eastern margin of the Massif Central (France) is a very interesting target for such investigations because it presents episodes of very intense precipitation focused on the relief resulting in marked differences in the statistical discharges distributions across the landscape. Some theoretical river incision models incorporate such variability (Lague et al., 2005) but they have been confronted with real data only in a limited number of cases (DiBiase et al., 2011; Scherler et al., 2017; Campfort et al., 2020). Here we test these models in the Massif Central area and in particular on Cévennes, Ardèche and Margeride mountains by quantifying denudation rates using cosmogenic nuclides (¹⁰Be), characterizing discharges variability and performing morphological analysis on longitudinal rivers profiles.

The analysis of 326 river gauging stations allow us to observe a strong gradient in discharge variability from the external SE border to the interior of the Massif Central. The ¹⁰Be concentrations measured from river sediments in 36 catchments imply a large variation of denudation rates between 29 mm/kyr and 126 mm/kyr. We compare these denudation rates with the spatial distribution of mean annual precipitations, local relief, slope and concavity index, and also integrate all the observations in the frame of a stochastic threshold incision model. Our results confirm the complex model predictions of non-linear relationships between mean denudation rates and the channel steepness index and their dependence on hydrological variability and run-off.

key-words : extreme events, stochastic threshold incision model, denudation rates, discharge variability, morphometric parameters, Massif Central