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Transient sediment supply in a high-altitude Alpine environment evidenced through a 10Be budget of the Etages catchment (French Western Alps)

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Although 10Be concentrations in stream sediments provide useful synoptic views of catchment-wide erosion rates, they cannot be used to identify the intrinsic spatial variability of erosion and sediment discharge within a catchment. Therefore we measured 10Be concentrations (n = 19) of different morphologic features and detrital material resulting from high-altitude erosion processes that ultimately feed the sediment routing system. We focussed on the Etages catchment (∼14 km2, Ecrins-Pelvoux massif, French Western Alps), located within the altitudinal range where periglacial and especially frost-controlled processes are the most efficient. This catchment also hosts a small cirque-glacier, which is a relict from the Little Ice Age (LIA) glacial advance. Thus, this basin allows identifying the glacial influence on 10Be concentrations in stream sediments.

10Be concentrations vary from $\sim 0.1 \times 10^5$ to 4.5×10^5 atoms g-1 in the Etages catchment, while displaying consistent 10Be signature within each representative source. 10Be contents of glacial materials vary from 0 (i.e. undistinguishable from procedural blanks) close to the present-day glacier position to $\sim 0.3 \times 10^5$ atoms g-1 towards the LIA moraines. Debris-flow material collected at different catchment levels has slightly higher 10Be concentrations ($\sim$0.4-0.7$\times 10^5$ atoms g-1). Regolith material collected close to the highest crests (morphologic features currently affected by frost-cracking processes) carries much higher concentrations ($\sim$1.3-1.8$\times 10^5$ atoms g-1), while bare rock surfaces are also characterized by relatively high and heterogeneous 10Be concentrations ranging from $\sim$1.4 to 4.5×10^5 atoms g-1. Finally, stream sediments collected along the main stream and at the catchment outlet carry 10Be concentrations of only $\sim 0.2 \times 10^5$ atoms g-1, without any downstream trends.

We interpret these 10Be concentration measurements combining a geomorphological map and surface 10Be production-rate estimates within a mass-balance model. We show that the 10Be signature of sediments exported from the Etages catchment does not fulfil the steady-state equilibrium required for inferring catchment-wide denudation rates. Most important, the 10Be concentrations measured in the alluvial sediments along the stream reflect the glacial material signature, showing that the Holocene variability in denudation has not imprinted on the 10Be concentration of the trunk stream yet and implying a strong transient state in this high-elevation catchment of the Alps.