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Erosion dynamics in a coupled catchment- fan system under constant external forcing

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Changes in external forcing like climate or tectonic uplift are known to control the geomorphological evolution of mountain catchments and associated alluvial fans. For this reason, geomorphologic studies often use landscape morphologies like entrenchment as a marker of past climate or tectonic changes. However, recent studies have shown that the evolution of a catchment–fan system could also depend strongly on autogenic mechanisms and feedbacks between mountains and fans. These feedbacks can be strong because on one hand, the elevation of alluvial fans determines the base level of mountain catchments, and on the other hand, fluxes exiting on mountain catchments feed the piedmont fans. Thus, any change in one of the sub-system affects the other one. Recent theoretical studies showed that deep fan entrenchment could occur without any changes of influxes. We evaluate the conditions for such a behavior in a coupled catchment-fan system using a landscape evolution model (CIDRE). The mountain corresponds to an uplifting block and fans form over an initial horizontal surface. We confirm that deep entrenchment at fan apex can occur, pending to two necessary conditions: 1- transport threshold (critical shear stress) is significant and 2- the downstream boundary condition corresponds to a transversal river able to carry all incoming sediments. The entrenchment occurs always when sediments reach this boundary condition and then, it remains stable. It occurs whatever the evolution state of the mountain (transient or equilibrium). This could be explained by a depositional slope close to the critical transport slope during fan progradation, and then by a fan slope increase which allows the transport threshold to be overpassed. Fan entrenchment drives a strong erosion in the mountain, with an intensity and a response time similar to those observed for the initial mountain uplift. These results indicate that determining the part of natural erosion by autogenic mechanisms is primordial in order to link landscapes entrenchment with past external changes. Current investigations focus on the relative importance and stability of such natural entrenchments and those created by climate and tectonics.