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Physically-based modelling of the competition between surface uplift and erosion caused by earthquakes and earthquake sequences.

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Large earthquakes deform Earth's surface and drive topographic growth in the frontal zones of mountain belts. They also induce widespread mass wasting, reducing relief.

Preliminary studies have proposed that above a critical magnitude earthquake would induce more erosion than uplift. Other parameters such as fault geometry or earthquake depth were not considered yet. A new seismologically consistent model of earthquake induced landsliding allow us to explore the importance of parameters such as earthquake depth and landscape steepness. We have compared these eroded volume prediction with co-seismic surface uplift computed with Okada's deformation theory. We found that the earthquake depth and landscape steepness to be the most important parameters compared to the fault geometry (dip and rake). In contrast with previous studies we found that largest earthquakes will always be constructive and that only intermediate size earthquake (Mw ∼7) may be destructive. Moreover, with landscapes insufficiently steep or earthquake sources sufficiently deep earthquakes are predicted to be always constructive, whatever their magnitude.

We have explored the long term topographic contribution of earthquake sequences, with a Gutenberg Richter distribution or with a repeating, characteristic earthquake magnitude. In these models, the seismogenic layer thickness, that sets the depth range over which the series of earthquakes will distribute, replaces the individual earthquake source depth.We found that in the case of Gutenberg-Richter behavior, relevant for the Himalayan collision for example, the mass balance could remain negative up to Mw∼8 for earthquakes with a sub-optimal uplift contribution (e.g., transpressive or gently-dipping earthquakes). Our results indicate that earthquakes have probably a more ambivalent role in topographic building than previously anticipated, and suggest that some fault systems may not induce average topographic growth over their locked zone during a significant extent of their lifetime. A subsequent challenge is to understand how the mass balance of earthquakes affects the growth and dynamics of faults, that was neglected in our models.