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A numerical model of continental-scale topographic evolution integrating thin sheet tectonics, river transport, and orographic precipitation

Daniel Garcia-Castellanos and Ivone Jimenez-Munt
CSIC, ICTJA - Inst. Ciencias de la Tierra Jaume Almera, Barcelona, Spain (danielgc@ictja.csic.es)

How much does the erosion and sedimentation at the crust's surface influence on the patterns and distribution of tectonic deformation? This question has been mostly addressed from a numerical modelling perspective, at scales ranging from local to orogenic. Here we present a model that aims at constraining this phenomenon at the continental scale. With this purpose, we couple a thin-sheet viscous model of continental deformation with a stream-power surface transport model. The model also incorporates flexural isostatic compensation that permits the formation of large sedimentary foreland basins and a precipitation model that reproduces basic climatic effects such as continentality and orographic rainfall and rain shadow. We quantify the feedbacks between these 4 processes in a synthetic scenario inspired by the India-Asia collision. The model reproduces first-order characteristics of the growth of the Tibetan Plateau as a result of the Indian indentation. A large intramountain basin (comparable to the Tarim Basin) develops when predefining a hard inherited area in the undeformed foreland (Asia). The amount of sediment trapped in it is very sensitive to climatic parameters, particularly to evaporation, because it crucially determines its endorheic/exorheic drainage. We identify some degree of feedback between the deep and the surface processes occurs, leading locally to a <20% increase in deformation rates if orographic precipitation is account for (relative to a reference model with evenly-distributed precipitation). These enhanced thickening of the crust takes place particularly in areas of concentrated precipitation and steep slope, i.e. at the upwind flank of the growing plateau. This effect is particularly enhanced at the corners of the indenter (syntaxes). We hypothesize that this may provide clues for better understanding the mechanisms underlying the intriguing tectonic aneurisms documented in the syntaxes of the Himalayas.