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Response of Drainage Systems on Himalayan Tectonics

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We present early results from a numerical model we designed to explore the interaction of fluvial erosion (causing crustal thinning) with rock uplift (driven by crustal thickening) in plan view. Our model couples a mechanical finite element code (thin sheet) for large strains with fluvial erosion based on Hack's law. It allows to invoke specified uplift in discrete zones. We apply the model here to a series of conspicuous observations related to drainage geometries from the India-Asia collision zone. This zone represents the best example for the interaction of orogen scale tectonics, erosion and climate and its drainages bear a series of geometric features that can be used to constrain aspects of the tectonic evolution. For example: (i) The atypical orogen parallel flow of almost all south draining rivers north of the still active Main Frontal Thrust. Clearly, this is caused by deformation bypassing the rivers. (ii) The drainage of the orogens largest rivers through the zones of highest deformation. There, fluvial erosion leads to large scale exhumation of hot material, perturbation of the thermal structure of the crust and results in reduced crustal strength as suggested for the Namche Barwa region where the Tsangpo River crosses the eastern Syntaxes.

As the drainage systems play a significant role in the feedback cycle between tectonics, erosion and climate, the river networks bear important information about the evolution of the orogen.

1. A comparison between modelled and measured river profiles and drainage network pattern allow roughly determining the erodibility of the rocks.

2. Knowing the erodibility of the rocks it is possible to determine the timing of thrusts (e.g. Main Boundary Thrust) by interpreting the migration of knickpoints in rivers crossing such large scale tectonic structures.

3. The code can also be used to model minimum uplift rates to match river network

pattern as observed at the very southern margin of the orogen, where several rivers are bypassed by the strong uplift at the Main Frontal Thrust and are forced to drain orogen parallel until they confluence and break thru to the Gangetic plain.

4. We can also test the assumption for capturing east-west draining rivers by headward cutting of south draining rivers that are indicated by significantly higher erosion rates caused by the great topographic gradient between the Tibetan Plateau and the Gangetic plain. It can be shown that this process is very likely for the ancestral Tsangpo, that was captured by the Brahmaputra river system but might also be a plausible explanation for several other rivers (e.g. Arun, Sutlej)