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Modeling interactions between tectonics and surface processes in the Zagros Mountains, Iran

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In many fold-and-thrust belts the growth of tectonic structures has interacted with surface processes to produce a variety of landscape forms (e.g. wind gaps, diverted rivers) and sedimentary features (e.g. alluvial fans, growth strata). In addition, the interplay between tectonic and surface processes has a key role in the distribution and behavior of river systems and thus affects the transport and delivery of sediments from mountains to basins.

Numerous landscape evolution models have been developed over the past decades to study interactions between erosion and deformation. However, only few of these have used a mechanical representation of the deformation, and usually they have remained in 2D. The use of advanced 3D deformation models is essential to better understand the interaction between tectonic and surface processes in typical 3D settings, for which planview changes of the drainage patterns and sedimentation are the crucial observables.

We tackle this challenge in the frame of the FP7 funded TOPOMOD project and present here the first results of our work. We use the finite-element method (FEM) to calculate erosion based on a non-linear diffusion formulation. From a methodological point of view we have compared quadrilateral elements versus triangular elements, and different water-redistribution-schemes for calculating the drainage area. We observe that these different approaches yield different drainage patterns. For example when using the steepest-descent flow algorithm, triangular elements tend to produce more realistic rivers, while rivers modeled with quadrilateral elements remain straight. We argue that the water-redistribution-schemes are not really physical, but rather descriptive and depend on the numerical mesh (i.e. size and shape of used elements). In addition, we present our first tests and results of the coupling between the parallel 3D deformation code LaMEM and the surface process model. We use the Zagros Mountains of Iran as a case study.