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Topographic evolution of orogens: The long term perspective

Jörg Robl (1), Stefan Hergarten (2), and Günther Prasicek (1)

(1) University of Salzburg, Geography and Geology, Geography and Geology, Salzburg, Austria (joerg.robl@sbg.ac.at), (2) Institute of Earth and Environmental Sciences - Geology, University of Freiburg, Germany (stefan.hergarten@geologie.uni-freiburg.de)

The landscape of mountain ranges reflects the competition of tectonics and climate, that build up and destroy topography, respectively. While there is a broad consensus on the acting processes, there is a vital debate whether the topography of individual orogens reflects stages of growth, steady-state or decay. This debate is fuelled by the million-year time scales hampering direct observations on landscape evolution in mountain ranges, the superposition of various process patterns and the complex interactions among different processes. In this presentation we focus on orogen-scale landscape evolution based on time-dependent numerical models and explore model time series to constrain the development of mountain range topography during an orogenic cycle.

The erosional long term response of rivers and hillslopes to uplift can be mathematically formalised by the stream power and mass diffusion equations, respectively, which enables us to describe the time-dependent evolution of topography in orogens. Based on a simple one-dimensional model consisting of two rivers separated by a watershed we explain the influence of uplift rate and rock erodibility on steady-state channel profiles and show the time-dependent development of the channel - drainage divide system. The effect of dynamic drainage network reorganization adds additional complexity and its effect on topography is explored on the basis of two-dimensional models. Further complexity is introduced by coupling a mechanical model (thin viscous sheet approach) describing continental collision, crustal thickening and topography formation with a stream power-based landscape evolution model. Model time series show the impact of crustal deformation on drainage networks and consequently on the evolution of mountain range topography (Robl et al., in review).

All model outcomes, from simple one-dimensional to coupled two dimensional models are presented as movies featuring a high spatial and temporal resolution.

Robl, J., S. Hergarten, and G. Prasicek (in review), The topographic state of mountain ranges, Earth Science Reviews.