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Space and time variations of erosion rates in steady and non-steady mountain ranges

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Active orogenic belts with high tectonic convergence rates and high erosion rates tend towards a flux steady state in which a tectonic flux of crustal material into the orogen is balanced by the erosional flux out of the mountain belt. Even with such a steady state, the spatial distribution of surface erosion or exhumation rate may be highly variable in space. Furthermore, variations in tectonic or climatic forcing will produce a transient response in erosional flux and local exhumation rate as measured by sediment yield, cosmogenic or thermochronometric methods. Two suites of numerical models are presented to demonstrate the variability in space and time of exhumation rates within a near-steady orogen. First, we present a model for the distribution of kilometer-scale relief and exhumation rate in a steady-state orogen that attains a critical shape. A critical slope at the regional scale is defined by an average topography. Transverse rivers typically define the low topographic points in a mountain landscape and with finite concavity, these must be balanced by convex-upward interfluvial ridges. Local relief must therefore increase from the foreland to a maximum value near the range divide. Under constant precipitation, the rock uplift rate must correlate with interfluvial relief, implying non-uniform uplift rate. Furthermore, if precipitation is non-uniform, tectonic uplift will respond on the scale of the interfluvial relief, thus providing a direct correlation between precipitation and tectonic rock uplift at the 1 to 10 km scale, an observation that has been observed in a number of mountain belts. In the second set of models, we use a coupled tectonic, landscape evolution model to show the transient response of a steady-state orogen to perturbation in either climate or tectonic forcing. We find a characteristic sediment yield function and exhumation rate response to changes in forcing and demonstrate how sediment volume or thermochronometric

ages can be used to distinguish between climatic or tectonic forcing.