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Nonlinear processes in mountain building

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The growth of a mountain belt is classically believed to be a quasi-stationary process ending in a steady state. Starting from a simple 2D analytic model of mass conservation during mountain growth we explore the domains of stability of a mountain for both nonlinear erosion laws and deformation laws that lead to quasistatic yielding of the mountain over different time scales. This model is composed of a pure shear mountain attached to a critical wedge. We show that if erosive processes are focused on the front ranges of growing mountains then uplift is enhanced in mountain belt interiors. This model of rain shadow development has important implications for plateau uplift and makes predictions about changes in erosive flux to sedimentary basins. However, mass conservation integrated over the models does not make predictions about the movement of material within a mountain belt without the adoption of specific mass flux boundary conditions and a rheological model. We therefore extend our models by using a simple force balance between the Mohr-Coulomb wedge and the mountain interior, which deforms by pure shear. We also choose to model the mountain interior as a viscoelastic material. This allows us to test the effects of stress change in the mountain belt due to the formation of localized semibrittle shear zone at the depth of the brittle ductile transition. Once the mountain belt grows to sufficient size, nonlinear deformation within its interior becomes important and leads to nonlinear macroscopic behavior of mountains, such as long-period aseismic oscillations that interact with shorter-time-scale seismic processes. These dynamical models make direct predictions about the movement of material within a mountain belt and can therefore be constrained by surface observations.