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Organized ridge and valley patterns in detachment-limited conditions

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Landscapes display a variety of self-organized features, with topographic patterns of ridges and valleys being among the most recognizable examples. However, a complete understanding of the physical processes leading to the formation of regular ridge and valley patterns and a rigorous examination of the underlying equations are still elusive. Here we focus on the analysis of organized ridge and valley patterns in the detachment-limited regime and re-cast the runoff erosion component of the landscape evolution equation in terms of specific catchment area, thus providing a minimalist framework for landscape evolution. Numerical simulations show that a sequence of increasingly complex channel networks emerges from the interplay between soil creep, runoff erosion, and tectonic uplift. This branching cascade is described by a dimensionless number accounting for the bulk properties of the system and is shown to have striking similarities with other nonlinear complex systems found in nature. The spatial organization of the resulting patterns, their hypsometric curves, and the channelization cascade are shown to be strongly dependent on the boundary conditions and runoff-erosion laws assumed.