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# Subgrid-scale modeling in numerical simulations of landscape evolution

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Landscapes share many similarities with turbulence: both systems are chaotic, multi-fractal, and their dynamics can be described using very similar prognostic equations. In particular, modified versions of the Kardar-Parisi-Zhang (KPZ) equation (a low-dimensional analog to the Navier-Stokes equations) are able to describe and simulate landscape evolution. This suggests that modeling techniques developed for turbulence may also be useful in landscape simulations.

Using a landscape evolution model based on a modified 2-D KPZ equation, we find that the simulated landscape evolution has a clear dependence on grid resolution. In particular, mean longitudinal profiles of elevation at steady state and bulk erosion rates show an undesirable dependence on grid resolution, because the erosion rate increases with resolution as increasingly small channels are resolved.

A new subgrid-scale model is proposed to account for the scale dependence of the sediment fluxes. The approach is patterned after the Large-Eddy Simulation (LES) method from turbulence. The erosion coefficient, assumed exactly known at the finest resolution, is multiplied by a scale-dependence coefficient, which is computed dynamically at different time steps and positions in the landscape based on the dynamics of the resolved scales. This is achieved by taking advantage of the scale similarity that characterizes landscapes over a wide range of scales. The simulated landscapes obtained with the new model show a realistic evolution and a relatively small dependence on resolution.