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# Modeling soil erosion with evolving rills on hillslopes

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Whereas current erosion models are successful in quantitative estimates of soil erosion by water flow, modeling the coevolution of geomorphological features, particularly rill network properties and soil erosion on hillslopes, is still a major challenge. In this study, we propose a rill evolution modeling approach, and combine it with a rainfall-runoff and soil erosion model to simulate the feedback loop of hillslope geomorphic development and soil erosion processes. Rill evolution is mainly characterized by three rill network attributes, comprised of rill density, orientation angle, and rill width, all modeled with physical equations. The entire rainfall-runoff-erosion and rill evolution model is tested against a set of rill network evolution and soil erosion data from an experimental hillslope subjected to successive rainfall events. The simulated spatial and temporal variations of rill network characteristics and soil erosion agree well with the measured data. The results demonstrate that the three rill network characteristics continually alter the partitioning of interrill and rill flows and affect the interrill and rill flow erosivity and soil erosion, which in turn modify the rill geometry and rill network planform. Comparatively, existing approaches such as WEPP that ignore the rill evolution processes largely underestimate the hillslope soil erosion when using time independent model parameters. Moreover, a sensitivity analysis indicates that both the rill evolution and soil erosion processes are sensitive to the rill evolution parameters, rainfall intensity, and slope angle. These results can inform the development of general geomorphic evolution and soil erosion models on evolving rilled hillslopes.