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Modelling the emergence of surface erosion rills in an artificial catchment

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Surface erosion rills are dominant structures in young developing ecosystems, and as such they fundamentally affect water flows by channeling surface runoff, by locally changing the infiltration capacity of the soil, or by preventing the establishing of a vegetation cover.
Therefore, water balance and drainage pathways of such ecosystems cannot be understood based on soil hydraulic properties and subsurface flow models alone without considering emerging networks of erosion rills.

To successfully model the hydrology of a slope system, it is indispensable to simulate the generation of the erosion rills adequately. We chose the artificial catchment 'Chicken Creek' near Cottbus (Germany) as experimental area for this modelling study. The construction of the catchment with a surface area of 6 ha and an average slope of 3.5% was finished in 2005 and since has been left to an undirected primary succession. An erosion rill network formed on the surface of the catchment during recurring rainfall events in the last few years. Based on aerial photographs and laser scanning data the evolving network was quantified with respect to length and connectivity.

We applied three model approaches on the artificial catchment to simulate the emergence of the erosion rills. First, we used a surface runoff model based on Manning's equation to compute surface water flow paths depending on topography. Second, a growth model algorithm (modified Eden model) was applied to generate networks with minimised energy dissipation. Finally a self-organised channel network approach was used, where soil erosion was simulated based on the exceedance of local critical shear stress thresholds. We discuss the pros and cons of the three approaches and compare the predictions with observations to deduce the mechanisms determining the erosion rills.