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Rill hydrodynamics and its impact on rill vegetation encroachment: a modelling study of the constructed Hühnerwasser catchment

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The Hühnerwasser catchment is a monitored, early-development constructed catchment within the Lower Lausatia post-mining landscape in Germany. Observations have shown that a sequence of landscape-forming processes occurred, including the initial vegetation establishment stages, which are the main interest of this study. In the initial stages of geomorphic development a surface drainage network of rills was formed as vegetation started to appear on the hillslopes and subsequently inside the rill network. Observations and analysis of the rill vegetation establishment suggest that different vegetation types encroach into the rill network at different times, rates and form different directions. We hypothesize that these encroachment processes may respond to the runoff properties of the catchment at such time: velocity distribution in the rills might play a significant role in flushing seeds in high-velocity reaches of the rill network, thus favouring the appearance of vegetation in low-velocity regions. Consequently, the goal of this study is to assess the magnitudes and spatiotemporal behaviour of velocity in the rill network, to assess its possible impact on seed flushing and rill vegetation encroachment.

One rill subcatchment of Hühnerwasser was selected to perform an explorative study of rill hydrodynamics and their impact on vegetation establishment. Two vegetation states were simulated: bare hillslopes and vegetated hillslopes. The vegetated cover polygons were obtained from digitized aerial photography, and stochastically dissagregated 10-minute resolution precipitation data were used, selecting events with early, middle and late peak storm intensities. A 2D explicit finite volume scheme solving the Zero-Inertia approximation to the shallow water equations was used to simulate surface flow in the subcatchment.

The preliminary modelling results suggest that that there is no clear overall velocity gradient in the down-stream direction along the rills. In fact, velocity in the rills may increase or decrease along the rill following local topography and rill geometry. Consequently, no global trend for the probability of seeds being transported can be established. The results also shows that varying rainfall intensity and rainfall intrastorm distribution –in the absence of hillslope vegetation– does not affect the rill locations of maximum velocities, but mostly affect the magnitude of velocity. In the presence of hillslope vegetation –and thus heterogeneous infiltration conditions in the hillslopes– the spatial distribution of velocity is strongly affected, and can be in fact governed not by topography or rill geometry, but by the spatial heterogeneity of infiltration capacity. Furthermore, the time at which maximum discharge and velocities occur may not match that of maximum intensity. That is, emerging temporal dynamics arise due to the introduction of spatial heterogeneity, which also manifests in the fact that outflow from the subcatchment exhibits a intensity-thresholded behaviour.