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Investigation of erosion rill parameters extracted from digital terrain models

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Rill erosion is a significant factor contributing to soil loss and subsequent land degradation. Erosion rills exhibit a complex genesis influenced by rill hydraulics and soil detachment processes. Precise measurement of rills with high spatial and temporal resolution is necessary to investigate rill development. However, established field methods are time consuming, labor intense or restricted to few rills only. Furthermore, rill capturing is accompanied by surface impact, which inherits multi-temporal observation. These limitations can be resolved due to recent advances in digital surface mapping technologies – e.g. structure-from-motion (SfM) algorithms and unmanned aerial vehicle (UAV) platforms – allowing for fast and flexible measurement of detailed digital elevation models (DEM). However, automatic procedures are needed to extract relevant data and hence exploit the high information potential arising from the DEM.
In this study a workflow is presented to obtain rill characteristics with minimal manual input from high-resolution DEM calculated from UAV images. Rill extraction is performed using methods that evolve from image processing. Edge detection is conducted with the Canny operator utilizing intensity changes of the DEM raster height values. Rills are extracted at the position where the rill wall is steepest. Further data processing is necessary to estimate the upper edge of the erosion rill considering height changes in the immediate neighborhood of the detected Canny edge. Thereby, significant slope changes indicate the end of the rill wall. The developed rill extraction method enables rill measurement with at least cm-resolution. The detected rill walls and the DEM are used for the calculation of rill depth, width and cross section area. Surface roughness of the area enclosing the rill is estimated to account for possible runoff impacts. Erosion volumes per rill are also measured. Investigation of the rill evolution at field scale on loess soil reveals that rill deepening is the main process contributing to the eroded soil volume. Rill widening occurs due to side wall erosion in dependence of the rill orientation, resulting in a lateral shift of the erosion rill. Furthermore, an influence of surface roughness on rill development is detected. Automatic rill extraction enables new insights into rill observation because large number of rills and extensive areas are observable with high detail.