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Rill soil erosion mapping on arable land by UAV-borne remote sensing

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Erosion rills are an important feature of water erosion on agricultural land often accounting for much of the sediment loss on a hillslope. Surveying rill erosion systems is hence important for monitoring the extent of the problem and providing data for erosion modelling. High spatial and temporal resolution remote sensing offers new perspectives in generating necessary data that previously have been prohibitively expensive. Our aim was to investigate the feasibility of estimating the spatial extent and volume of erosion rills on managed farmland from ultra-high resolution optical data derived from unmanned aerial vehicles (UAV). We claim that UAV-borne remote sensing data provide means for highly detailed analysis of rill and channel properties despite their varying shapes and size ranging from a few centimeters up to decimeters in depth and width.
Our mapping procedure is based on the application of single-date UAV-derived images with sub-centimeter spatial resolution. These data were collected over two study sites located in central Jutland, Denmark, and representing different type, growing stage and density of vegetation cover.
Due to different conditions met on the fields including vegetation cover, different soil type, soil moisture and sun illumination, only 3D information derived from UAV data was used in the form of digital surface models (DSMs). Geomorphological terrain attributes including surface curvatures, gain in height, openness, rank and roughness were calculated from DSMs. These attributes were combined in an object-based image analysis environment to provide information on rill extent. The classification procedure assumes a hierarchical analysis based on a sequence of segmentation and classification steps, in which the surface attributes are thresholded at various levels in a predefined order. Information about the spatial extent of rill incision was further used to estimate the volume of eroded soil. This was done by first simulating a model of the pre-erosion relief, and second, subtracting from it the UAV-derived DSM representing the eroded surface. The pre-erosion surface was simulated by interpolating elevation values for the eroded areas from the elevation of the detected incision edges.
Our method yielded a very high overall accuracy (>90%) and high level of correctness and completeness of rill recognition enabling rather precise estimation of rill volume. The results showed that rill system mapping is more dependent on the type and structure of growing vegetation rather than vegetation coverage alone. The extraction of rill extent is also sensitive to the presence of features common on fields like furrows or wheel tracks leading in some cases to misclassification. Nevertheless, our study provides a new perspective for monitoring rill erosion on managed farmland.