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Quantification of initial sediment redistribution in an artificially-created catchment using a time series of digital elevation models

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Processes of sediment erosion and deposition rapidly alter the structures of developing soil- and ecosystems. Intensity and spatial distribution of sediment relocation can be reconstructed in sediment budgets, quantified from models of change based on a time series of digital elevation models (DEMs). In this study, initial changes in the 3D sediment mass balance of the artificially-created and intensively monitored catchment "Hühnerwasser" were quantified.

Remotely-sensed elevation data were evaluated regarding their useability for the quantification of sediment budgets, and DEMs from digital photogrammetry were modified based on logical combinations and basic morphological principles in defined regions. High-resolution aerial photographs were used to digitize the developing network of erosion rills. Topographic parameters and drainage pathways were derived from DEMs. Three-dimensional (3D) models of volume change were established and rates of volume change in time intervals were computed.

Evaluation of DEMs reveals outliers and artifacts as well as an underestimation of erosion rill depth in photogrammetry-based DEMs. By applying regionally-limited modifications, a comparable time series of eight DEMs, depicting surface development between November 2005 (the beginning of catchment evolution) and March 2010, could be obtained. Analysis of aerial photographs shows that a widespread network of erosion rills evolved during the first two years of development and that the spatial extent of actively eroding rills decreased in the subsequent years. Morphometric analysis of DEMs affirms the spatial concentration of surface runoff. Quantification of volume change in 3D-models suggests decreasing rates of rill erosion since the beginning of catchment evolution, and combined analysis of 3D-models and the digitized rill network indicates that lateral erosion becomes more important compared to vertical erosion in the main rills.

Due to general DEM inaccuracy, significant quantification of sediment budgets in 3D-models based on photogrammetric elevation data is only possibly where major changes in elevation occur. In other areas, the combined analysis of 3D-models, DEMs and aerial photographs allows an approximation of erosion-affected surface structural dynamics.