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3D sediment mass balances of an artificially-created catchment using multi-temporal digital elevation data and GOCAD

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The development of a soil or geo-ecosystem depends on the mostly unknown initial sediment distribution as the starting point and on early redistribution processes during the initial, unvegetated periods. An artificially-created and intensively monitored hydrological catchment may be used to quantify and reconstruct 3D sediment distributions.
The objective of this study was to develop and evaluate methods for the quantification of initial sediment distribution and following mass changes in the three spatial dimensions and in time.
The initial sediment volume of an artificially constructed catchment was reconstructed in a 3D numerical grid model using GOCAD. Physical and chemical properties from borehole samples were assigned to the grid model. Volume and mass changes were analyzed based on 3D volume change models, which were constructed from a temporal sequence of Digital Elevation Models (DEMs). Elevation data recorded by different methods (photogrammetry, ground-based laser scanning, airborne laser scanning) was used to construct the models. Initial and further developed surface structures were characterized by topographic indices.
The distributed models of volume change show runoff-induced erosive mass relocations. Uncertainty assessment shows that the use of different sources of elevation data leads to models of change that depict processes in different quality, dependent on surface and vegetation structures. The calculated catchment sediment budgets show different amounts of imbalance, mainly due to data quality. However, some consistent conclusions can be drawn: Erosion seems to be more intense and spatially more variable in the eastern than in the western part of the catchment. Mass changes are correlated to initial surface structures, while surface structures, in turn, are reinforced by mass translocations. Constructing the models of change from multi-date elevation data of various time slices and from different methods of recording allows a critical evaluation of the method for modeling sediment budgets.