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Sensitivity Analysis of a process based erosion model using FAST

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Erosion, sediment redistribution and related particulate transport are severe problems in agro-ecosystems with highly erodible loess soils. They are controlled by various factors, for example rainfall intensity, topography, initial wetness conditions, spatial patterns of soil hydraulic parameters, land use and tillage practice. The interplay between those factors is not well understood. A number of models were developed to indicate those complex interactions and to estimate the amount of sediment which will be removed, transported and accumulated. In order to make use of physical-based models to provide insight on the physical system under study it is necessary to understand the interactions of parameters and processes in the model domain. Sensitivity analyses give insight in the relative importance of model parameters, which in addition is useful for judging where the greatest efforts have to be spent in acquiring or calibrating input parameters.

The objective of this study was to determine the sensitivity of the erosion-related parameters in the CATFLOW model. We analysed simulations from the Weiherbach catchment, where good matches of observed hydrological response and erosion dynamics had been obtained in earlier studies. The Weiherbach catchment is located in an intensively cultivated loess region in southwest Germany and due to the hilly landscape and the highly erodible loess soils, erosion is a severe environmental problem.

CATFLOW is a process-based hydrology and erosion model that can operate on catchment and hillslope scales. Soil water dynamics are described by the Richards equation including effective approaches for preferential flow. Evapotranspiration is simulated using an approach based on the Penman-Monteith equation. The model simulates overland flow using the diffusion wave equation. Soil detachment is related to the attacking forces of rainfall and overland flow, and the erosion resistance of the soil. Sediment transport capacity and sediment deposition are related to overland flow velocity using the equation of Engelund and Hansen and the sinking velocity of grain sizes, respectively.

The sensitivity analysis was performed based on virtual hillslopes similar to those in the Weiherbach catchment. We applied the FAST-method (Fourier Amplitude Sensitivity Test), which provides a global sensitivity analysis with comparably few model runs. We varied model parameters in predefined and, for the Weiherbach catchment, physically meaningful parameter ranges. Those parameters included rainfall intensity, surface roughness, hillslope geometry, land use, erosion resistance, and soil hydraulic parameters.

The results of this study allow guiding further modelling efforts in the Weiherbach catchment with respect to data collection and model modification.