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Modelling the initial structure dynamics of soil and sediment exemplified for a constructed hydrological catchment

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Knowledge about spatial heterogeneity is of essential for the analysis of the hydrological catchment behavior. Heterogeneity is directly related to the distribution of the solid phase, and in initial hydrological systems, the solid phase is mainly composed of mineral particles. In artificial catchments, such sediment structures relate to the applied construction technology. It is supposed that the development of catchment ecosystems is strongly influenced by such specific initial spatial distributions of the solid phase. Moreover, during the initial development period, the primary structures in a catchment are altered rapidly by translocation processes, thereby subdividing the initial system in different compartments. Questions are: How does initial sediment distribution affect further structural development? How is catchment hydrology influenced by the initial structural development? What structures have a relevant impact on catchment-scale hydrological behavior?

We present results from a structural modelling approach using a process-based structure generator program. The constructed hydrological catchment 'Hühnerwasser' (Lower Lusatia, Brandenburg, Germany) served exemplarily for the model development. A set of scenarios was created describing possible initial heterogeneities of the catchment. Both the outcrop site from where the parent material was excavated and the specific excavation procedures were considered in the modelling approach. Generated distributions are incorporated in a gridded 3D volume model constructed with the GOCAD software. Results were evaluated by semivariogram analysis and by quantifying point-to-point deviations.
We also introduce a modelling conception for simulating the highly dynamic initial structural change, based on the generated initial distributions. We present a strategy on how to develop the initial structure generator into an integrative tool in order to (i) simulate and analyse the spatio-temporal development dynamics depending on initial structures, and (ii) relate the simulated structural development to the (observed) hydrological behaviour. For the description of the initial development, already established "structure-generating" models were chosen for the simulation of erosion and deposition structures, crusts and vegetation. The OpenMI software interface was chosen to provide parameter exchange between the models. The impact of the structural development on the hydrological behaviour of the catchment will be evaluated by modelling water flow with HYDRUS 2D/3D. For that purpose, an approach to estimate 3D distributions of soil hydraulic parameter from generated sediment properties using adapted pedotransfer functions was already developed. Model results can be validated by comparing them to measured discharges from the catchment. By comparing different scenarios, the impact of spatial structures on flow behaviour can be analysed. Results may be transferred to similar environments by identifying generalizable eco-hydrological compartments ('Process Domains') from model data.