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Flow processes on the catchment scale – modeling of initial structural states and hydrological behavior in an artificial exemplary catchment

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Landscapes that are heavily disturbed or newly formed by either natural processes or human activity are in a state of disequilibrium. Their initial development is thus characterized by highly dynamic processes under all climatic conditions. The primary distribution and structure of the solid phase (i.e. mineral particles forming the pore space) is one of the decisive factors for the development of hydrological behavior of the eco-hydrological system and therefore (co-) determining for its – more or less – stable final state.

The artificially constructed ‚Hühnerwasser' catchment (a 6 ha area located in the open-cast lignite mine Welzow-Süd, southern Brandenburg, Germany) is a landscape laboratory where the initial eco-hydrological development is observed since 2005. The specific formation (or construction) processes generated characteristic sediment structures and distributions, resulting in a spatially heterogeneous initial state of the catchment.

We developed a structure generator that simulates the characteristic distribution of the solid phase for such constructed landscapes. The program is able to generate quasi-realistic structures and sediment compositions on multiple spatial levels (1 cm up to ∼100 m scale). The generated structures can be i) conditioned to actual measurement values (e.g., soil texture and bulk distribution); ii) stochastically generated, and iii) calculated deterministically according to the geology and technical processes at the excavation site.

Results are visualized using the GOCAD software package and the free software Paraview. Based on the 3D-spatial sediment distributions, effective hydraulic van-Genuchten parameters are calculated using pedotransfer functions. The hydraulic behavior of different sediment distribution (i.e. versions or variations of the catchment's porous body) is calculated using a numerical model developed by one of us (Caviedes-Voullième). Observation data are available from catchment monitoring are available for i) determining the boundary conditions (e.g., precipitation), and ii) the calibration / validation of the model (catchment discharge, ground water). The analysis of multiple sediment distribution scenarios should allow to approximately determine the influx of starting conditions on initial development of hydrological behavior. We present first flow modeling results for a reference (conditioned) catchment model and variations thereof. We will also give an outlook on further methodical development of our approach.