Geophysical Research Abstracts
Vol. 21, EGU2019-5378, 2019
EGU General Assembly 2019

A 3D-spatial approach for modeling soil hydraulic property distributions on the artificial Huehnerwasser catchment

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Knowledge of catchment 3D spatial heterogeneity is crucial for the assessment and modeling of eco-hydrological processes. Especially during the initial development phase of a hydro-geo-system, the primary structural properties have the potential to determine further development pathways. Small-scale heterogeneity (cm to m scale) may have significant effects on processes on larger spatial scales, but is difficult to measure and quantify. The Hühnerwasser (Chicken Creek) catchment offers the unique opportunity to study early ecosystem development within an initial structural setup that is well-known, from the plot up to the catchment scale.

Based on information on the open-cast mining technology, catchment boundaries and sediment properties, we developed a structure generator program for the process-based modeling of specific dumping structures and sediment property distributions on the catchment. The structure generator reproduces the trajectories of spoil ridges and can be conditioned to reproduce actual sediment distributions according to remote sensing and soil sampling data. Alternatively, sediment distribution scenarios can be generated based on geological data from the excavation site, or can be distributed stochastically. Using pedotransfer functions, the effective hydraulic van-Genuchten parameters are then calculated from sediment texture and bulk density.

The main application of the 3D catchment model is to provide detailed 3D-distributed flow domain information for hydrological flow modeling. Observation data are available from catchment monitoring are available for determining the boundary conditions (e.g., precipitation), and the calibration / validation of the model (catchment discharge, ground water). The analysis of multiple sediment distribution scenarios allows to evaluate the effect of initial conditions on hydrological behavior development. Generally, the modeling approach can be used to pinpoint the influx of specific soil structural features on ecohydrological processes across spatial scales.