Geophysical Research Abstracts
Vol. 14, EGU2012-9785, 2012
EGU General Assembly 2012

A sediment structure model for describing the 3D spatial distribution of soil hydraulic properties of an artificial catchment using pedotransfer functions

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Modelling the spatial heterogeneity of catchments is a prerequisite for the understanding of flow processes and the application of hydrological models. The initial structure represents also the starting point for catchment and ecosystem development.
The quality of hydrologic modeling is often limited due to a lack of data or an oversimplification of aquifer properties. Predictions can be significantly improved by using spatial models that reproduce specific structural characteristics. Current geostatistical methods are unable the capture spatially complex conditions, e.g. abrupt changes in structures. More deterministic structure generator approaches are currently been discussed in hydrogeology for exploration. Process-based structure generators deduce structural characteristics e.g. from the known formation processes of the aquifer.

The objective was to describe the spatial distribution of soil hydraulic properties in a catchment based on generated 3D sediments distributions. The approach was tested for the artificially constructed "Hühnerwasser" ("Chicken Creek") catchment. The catchment is located in the post-lignite mining area of Welzow-Süd in Lower Lusatia, Brandenburg, Germany. Here, the initial sediment distribution was governed primarily by dumping processes of the large-scale mining technology and the geological conditions at the excavation site.

For the initially organic matter-free sandy sediments, the structure model generated the distributions of soil texture and soil bulk density within dumping spoil cones. These were represented by 2D cross sections with compacted central parts and particle-segregated flanks. The 3D geometry of the catchment was generated by sequencing of these basic structural elements along identified stacker trajectories, finally yielding a discretized 3D volume model using the GOCAD software. Based on these data, spatial distributions of hydraulic properties were calculated using well-established pedotransfer functions (Vereecken et al. 1989 and Arya and Paris 1981). Qualitative comparisons of estimated hydrostatic soil moisture conditions with wetness distributions derived from aerial images suggested relatively similar patterns reflecting highly-saturated stagnant areas near compacted impact zones that originated from sediment dumping. In order to account for the remaining uncertainty in sediment composition and mass balances, different scenarios of sediment distribution were analyzed. The generated 3D-spatial distribution patterns were analyzed on different scales to determine the effects of spatial upscaling and to understand local effects on hydrological processes at larger scales. The hydraulic property distributions will be coupled with hydrological modeling, and results will be validated using hydrological monitoring data.