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Modeling the initial 3D distribution of sediment structures of an artificial hydrological catchment

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Knowledge of the initial spatial heterogeneity of catchments is a prerequisite for the understanding of flow and transport processes. It also represents the starting point of catchment and ecosystem development. Current geostatistical methods are unable the capture spatially complex conditions, e.g. abrupt changes in structures.

More deterministic structure generator approaches are currently discussed in hydrogeology. Our objective was to describe the heterogeneous soil properties of the artificially constructed “Hühnerwasser” (“Chicken Creek”) catchment. The site 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 calibration of the structure generator and the verification of results, we used data from remote sensing (3D spatial geometry of catchment borders and spoil ridges), geological information (sediment composition and profiles), and soil sample data.

The basic structural elements in the spatial model are 2D cross sections of spoil ridges / spoil cones. The structure generator calculates the appropriate cross section geometries, particle size distributions and bulk densities. By sequencing along the known stacker trajectories, a high-resolution 3D distribution of 2D-structural elements is generated. Different scenarios are generated to account for the remaining uncertainty in sediment composition. Mass balances were calculated. The spatial data are subsequently interpolated in a 3D volume grid, representing the sediment body of the catchment. Results can be analyzed and edited further using the GOCAD software.

The results are used to derive information on structural dynamics and the associated process dynamics. In a comprehensive synopsis with data from monitoring (e.g. ground water table, vegetation cover, soil crust development), process domains and ‘hot spots’ of structural change can be identified. For instance, data from (i) geophysical exploration could be used for a direct verification of internal structures and discharge; and (ii) tracer data for indirect verification of proper parameterization by including the assumed hydraulic structure in the flow and transport models for the catchment. The resulting 3D spatial distribution patterns are especially useful for describing hydrological processes at different scales.