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Exploring behavior of soil modules with spatially inhomogeneous parameters in water balance models

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Our current research examines and develops methods to transfer hydrological soil maps into parameters of soil representing modules of water balance models. The main goal of this transformation is the spatially distributed parameterization of the model LARSIM.

In this model, the catchment is subdivided into elements, each of which representing a certain section of a river and its contributory area. Each element is again subdivided into single compartments with homogeneous land use. During the simulation, the relevant hydrological processes are simulated individually for each compartment. The simulated runoff of all compartments leads into the river channel of the corresponding element. Finally, channel routing is simulated for all elements .

Today, one parameter set is used for the soil module within all compartments. The parameters mainly control the partitioning of water yield into three different components representing overland flow, interflow and deep percolation. This parameter set is calibrated manually by experts. As the same parameters are used in all compartments, the heterogeneous hydrological behavior, which can be observed in the catchment, is not represented.

Hydrological soil maps, which indicate the dominant runoff process of areas for the complete catchment, are available since a few years (Behrens et al. 2005 & 2006). These maps indicate how different compartments of the model should behave.

Assuming the usage of this map during parameterization, fundamental questions arise: Is there a reasonable difference between homogenously and spatially inhomogeneous parameterized models? Do parameter sets, which are contradictory concerning the partitioning of water, result in similar hydrograph behavior? If there is a way to find optimal parameters for each compartment: Does the partitioning of water yield correspond to the indicated processes of the areas?

To answer these questions, we generate two sets of model realizations by applying Monte Carlo methods: one set with in each realization homogeneously parameterized members, and another set with in each realization inhomogeneously parameterized members. Both sets are analyzed using self-organizing maps based on signature indices like proposed by Herbst et al. (2009). These maps allow for differentiating the model realizations concerning their hydrological behavior – similar realizations are close to each other on the map. Furthermore, we introduce a measure to quantify the degree of spatial inhomogenity of a parameter set.

By interpreting the map in combination with the measure, we can answer aspects of the previously formulated questions: Homogeneous models and inhomogeneuos models should be separated by the map. Parameter sets, which partition water yield generally differently, should not be projected on the same node of the map. By projecting the measured discharge time series to the map, we can identify parameter sets resulting in similar simulated hydrographs and evaluate whether or not the processes indicated by the soil map match the partitioning of these parameter sets.