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What can we learn from the hydrological modeling of small-scale catchments for the discharge and water balance modeling of mesoscale catchments?

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The application of 3D hydrological models remains a challenge both in research and application studies because the parameterization not only depends on the amount and quality of data available for calibration and validation but also on the spatial and temporal model resolution. In recent years, the model parameterization has improved with the availability of high resolution data (e.g. eddy-covariance, wireless soil sensor networks). Unfortunately, these high resolution data are typically only available for small scale research test sites.

This study aims to upscale the parameterization from a highly equipped, small-scale catchment to a mesoscale catchment in order to reduce the parameterization uncertainty at that scale. The two nested catchments chosen for the study are the 0.38 km^2 large spruce covered Wüstebach catchment and the 42 km^2 large Erkensruhr catchment characterized by a mixture of spruce and beech forest and grassland vegetation. The 3D hydrogeological model HydroGeoSphere (HGS) has already been setup for the Wüstebach catchment in a previous study with a focus on the simulation performance of soil water dynamics and patterns. Thus, the parameterization process did not only optimize the water balance components but the catchment's wireless soil sensor network data were utilized to calibrate porosities in order to improve the simulation of soil moisture dynamics.

In this study we compared different HGS model realizations for the Erkensruhr catchment with different input data. For the first model realization, the catchment is treated heterogeneous in terms of soil properties and topography but homogeneous with respect to land use, precipitation and potential evapotranspiration. For this case, the spruce forest parameterization and the climate input data were taken directly from the small-scale Wüstebach model realization. Next, the calibrated soil porosity for the Wüstebach catchment is applied to the Erkensruhr. Further model realizations stepwise introduce more spatial heterogeneity in the Erkensruhr model (land use properties, potential evapotranspiration and precipitation).

In addition, we investigated how the water balance, discharge components and soil moisture dynamics of the Wüstebach HGS simulation change with the usage of the land use parameterizations 'beech forest' and 'grassland' of the Erkensruhr applied to the soil texture and saturated conductivity information from the Erkensruhr (1:50.000) and the Wüstebach (1:2.000).

Preliminary results for the Erkensruhr model realizations show that the discharge simulation is insensitive to a distributed land use input as the discharge sum and dynamics are not altered. Those model realizations which use the climate input from the Wüstebach suffer from an overestimation of the total discharge sum (Nash-Sutcliffe Coefficient of 0.48) though dynamics are well simulated with an R^2 of 0.8.

The usage of soil information of the Erkensruhr in the Wüstebach simulation reduces the fraction of subsurface flow and increases the fraction of return and surface slow whereas the usage of mesoscale land use information alters the evapotranspiration components. The discharge quality measures R^2 and Nash-Sutcliffe Coefficient only slightly reduce from 0.7 to 0.65 when using mesoscale soil and land use information.