Geophysical Research Abstracts
Vol. 19, EGU2017-12878, 2017
EGU General Assembly 2017

Preferential flow across scales: how important are plot scale processes for a catchment scale model?

Barbara Glaser (1,2), Conrad Jackisch (3), Luisa Hopp (2), and Julian Klaus (1)

(1) Luxembourg Institute of Science and Technology, Catchment- and Ecohydrology Research Group, (2) University of Bayreuth, Department of Hydrology, (3) Karlsruhe Institute of Technology, Institute of Water Resources and River Basin Management, Chair of Hydrology

Numerous experimental studies showed the importance of preferential flow for solute transport and runoff generation. As a consequence, various approaches exist to incorporate preferential flow in hydrological models. However, few studies have applied models that incorporate preferential flow at hillslope scale and even fewer at catchment scale. Certainly, one main difficulty for progress is the determination of an adequate parameterization for preferential flow at these spatial scales.

This study applies a 3D physically based model (HydroGeoSphere) of a headwater region (6 ha) of the Weierbach catchment (Luxembourg). The base model was implemented without preferential flow and was limited in simulating fast catchment responses. Thus we hypothesized that the discharge performance can be improved by utilizing a dual permeability approach for a representation of preferential flow. We used the information of bromide irrigation experiments performed on three 1m2 plots to parameterize preferential flow. In a first step we ran 20.000 Monte Carlo simulations of these irrigation experiments in a 1m2 column of the headwater catchment model, varying the dual permeability parameters (15 variable parameters). These simulations identified many equifinal, yet very different parameter sets that reproduced the bromide depth profiles well. Therefore, in the next step we chose 52 parameter sets (the 40 best and 12 low performing sets) for testing the effect of incorporating preferential flow in the headwater catchment scale model.

The variability of the flow pattern responses at the headwater catchment scale was small between the different parameterizations and did not coincide with the variability at plot scale. The simulated discharge time series of the different parameterizations clustered in six groups of similar response, ranging from nearly unaffected to completely changed responses compared to the base case model without dual permeability. Yet, in none of the groups the simulated discharge response clearly improved compared to the base case. Same held true for some observed soil moisture time series, although at plot scale the incorporation of preferential flow was necessary to simulate the irrigation experiments correctly.

These results rejected our hypothesis and open a discussion on how important plot scale processes and heterogeneities are at catchment scale. Our preliminary conclusion is that vertical preferential flow is important for the irrigation experiments at the plot scale, while discharge generation at the catchment scale is largely controlled by lateral preferential flow. The lateral component, however, was already considered in the base case model with different hydraulic conductivities in different soil layers. This can explain why the internal behavior of the model at single spots seems not to be relevant for the overall hydrometric catchment response. Nonetheless, the inclusion of vertical preferential flow improved the realism of internal processes of the model (fitting profiles at plot scale, unchanged response at catchment scale) and should be considered depending on the intended use of the model. Furthermore, we cannot exclude with certainty yet that the quantitative discharge performance at catchment scale cannot be improved by utilizing a dual permeability approach, which will be tested in parameter optimization process.