Hydrol. Earth Syst. Sci. Discuss., 6, C24–C27, 2009
www.hydrol-earth-syst-sci-discuss.net/6/C24/2009/

Hydrology and Earth System Sciences Discussions

Interactive comment on "Field scale effective hydraulic parameterisation obtained from TDR time series and inverse modelling" *by* U. Wollschläger et al.

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Received and published: 7 March 2009

In essence, this paper uses a rather old approach to inverse analysis of soil moisture data, and does not offer new insights with respect to vadose zone flow modelling. This is unfortunate, because the collected data set is rich, and could result in interesting new findings when used with the appropriate tool and model setup.

Parameter estimation problems in vadose zone hydrology are known to exhibit complex response surfaces in at least some parts of the parameter space. Local search methods such as the Levenberg–Marquardt algorithm exhibit difficulty finding the global solution in such responses surfaces with multiple optima. The final solution of local

methods is therefore essentially dependent on the starting solution, which necessitates the use of multiple different starting points. Yet, such approach is computationally inefficient as each individual gradient search operates completely independent of each other without sharing of any information (Duan et al. 1992, Effective and efficient global optimization for conceptual rainfall-runoff models. Water Resources Research, 1992, 28, 1015-1031). It is not known how many starting points to use to guarantee finding the true global solution. The problems with local search methods inspired researchers to develop global search methods that utilize a population of individuals to better explore the parameter space, and avoid getting stuck in a single basin of attraction in pursuit of the global minimum. Population based approaches are admirably suited to deal with the complex and multimodal response surfaces frequently encountered in vadose zone modelling. Within the current context, we would certainly recommend using a global search algorithm such as SCE-UA, Particle Swarm Optimization, Differential Evolution, or all of them together in a self-adaptive multi-method approach such as AMALGAM. Such approach can handle many more parameters and should make it much easier to consistently locate the global minimum.

We were surprised that the authors have not properly addressed uncertainty within their work. Much focus in recent years has been given to appropriate treatment and inference of uncertainty to better understand which parts of the model (parameters => processes) are well resolved, and which one require significant more attention. Parameter uncertainty can be efficiently explored using Markov Chain Monte Carlo methods such as the Shuffled Complex Evolution Metropolis (SCEM-UA) or DiffeRential Evolution Adaptive Metropolis (DREAM) algorithm. We anticipate that such an approach with the current data set would make a very nice contribution. Boundary condition uncertainty would also be possible to be handled within such a framework. Finally, by recursive implementation (Sequential Monte Carlo), such approach could answer the important question in this paper, whether the soil hydraulic parameters are constant, or whether they are time varying? Posterior tracking of the model parameters and/or states contains all the necessary information to make an informed decision about this.

Note that, the parameters presented here constitute but a small portion of the feasible parameter space. Many other model parameterizations may exist, which calibrate the model similar well (or possibly better).

In the following, we like to offer some comments on the proposed numerical HYDRUS-1D model. It was set up for a depth of 4.0 m, but the observations are located in the upper 1.16 m. As indicated by the data, the water transport is most dynamic in the active root zone whereas it is much less dynamic already in the 0.63 m depth and almost stationary at the 1.16 m depth. Presumably a model depth of 1.2 – 1.5 m would be sufficient to simulate the water flow in this profile. The additional soil layers and the assumption of the water table in 4.0 m depth could in fact create artefacts when used in the model inversion. Please consider the relatively low values of effective saturated conductivity for the gravels portrayed by the model layer 5. Since the depth of the water table is reportedly deep; the lower boundary of the (shorter) model could be described by a free drainage boundary type. Also, different rooting depths are considered in the analysis, which begs the question why the rooting depth was not considered to be a calibration parameter? Please note, that initial conditions in HYDRUS-1D can be specified using (measured) volumetric water content directly and the transformation in pressure head via the water retention curve is not necessary for model state initialization. The authors indicate that preferential flow might be responsible for some of the deficiencies of the model results. The uniform flow Mualem-van Genuchten model is probably not the best choice to describe such processes. A "better" model could be found by testing different model structures such as dual-porosity (mobile-immobile) models. However, there are cases where the data calibrates several model structures comparably well and yet give different predictions. This can be explored using model averaging methods.

A final but not least important remark: The calibrated model should be tested against independent data which was not used in the calibration.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 6, 1489, 2009.