Effective process descriptions for the unsaturated soil zone

To explain the behaviour of hydrological systems process based models are developed. Due to their complexity, the predictions of these models are associated with uncertainties. The uncertainties can be more easily handled, when simple (effective) process descriptions are used to replace more complex process description.

The objective of this study is to analyse under which boundary and system conditions of a climate-soil-plant system simple bucket-filling models predicting either the actual evapotranspiration or the leakage can approximate a complex hydrological model based on the Richards equation. To address these issue, for each quantity of interest three simple bucket-filling models are developed. Hydrus1D, presenting the complex model is chosen to construct a virtual environment varying in soil and plant type and is used to generate synthetic data. The combination of the virtual environment with climatic data from four sites leads to 36 synthetic locations with different boundary and system conditions. For each of these locations two-hourly fluxes and daily cumulative fluxes of both, the actual evapotranspiration and the leakage are generated for one year. From this data base, ten data sets of evaporation fluxes and the respective cumulative fluxes and six data sets of leakage fluxes and the corresponding cumulative fluxes are chosen. For the comparison between the complex and bucket-filling models the fluxes as well as the cumulative fluxes are used to optimise the simple models.

For all ten locations the bucket models predicting the actual evapotranspiration can reproduce the fluxes as well as the cumulative fluxes for the whole year. Two of the evaporation models even predict identical results for a wheat location with loam and mediterranean climate during the rainy phase. For the same location during the dry phase the agreement of all models is poor and the evaporation models have to be expanded by a process description for capillary rise. Two bucket models predicting cumulative leakage flux achieve a good agreement for all six locations, whereas no leakage model can reproduce the dynamic of leakage fluxes for any of the six locations and a model term describing upward soil water fluxes within the root zone have to be introduced into these bucket models. It depends on the underlying hydrological process as well as on the system conditions whether simplified models can approximate the results of more complex models.

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