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Which state variables matter to estimate water flow and transport parameters of layered soils?

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Understanding the movement of water in terrestrial ecosystem is of crucial importance to protect groundwater resources and to remediate contaminated sites. Thus, the knowledge on soil properties is mandatory for predictive modeling of hydrological behavior at large scales. In the last two decades the estimation of soil hydraulic and transport parameters by the use of in situ observations of state variables and inverse modeling strategies has become more and more common and showed promising results to reliable identify parameters, which regulate the transport of water and solute in the unsaturated zone. However, little attention has been given in the past to investigate systematically which types of in situ observations are necessary, to inversely calibrate water flow and transport models of the unsaturated zone.
In this contribution, we show and analyze different optimization strategies to investigate, which type of observation data are necessary in the objective function to describe the temporal evolution of soil moisture, matric potential, and water stable isotopes. We used for the model calibration data from in total 4 lysimeters over a period of 28 months. The comparison of different optimization strategies showed that simultaneously multiple observation types are needed in the objective function during the inverse model calibration to optimize the identification of soil hydraulic properties and parameters of the longitudinal dispersivity of a layered soil. The results revealed that both water content and matric potential need to be monitored in order to be able to determine the soil water retention characteristic. The use of δ18O ratios in the soil water contained not only information content to inversely estimate solute transport, but also soil hydraulic properties.