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Uncertainty assessment and data-worth evaluation for estimating soil hydraulic parameters and recharge fluxes from lysimeter data

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Transient measurements from lysimeters are frequently coupled with Richards-based solvers to inversely estimate soil hydraulic parameters (SHPs) and numerically describe vadose zone water fluxes, such as recharge. To reduce model predictive uncertainty, the lysimeter experiment should be designed to maximize the information content of observations. However, in practice, this is generally done by relying on the *a priori* expertise of the scientist/user, without exploiting the advantages of model-based experimental design. Thus, the main aim of this study is to demonstrate how model-based experimental design can be used to maximize the information content of observations in multiple scenarios encompassing different soil textural compositions and climatic conditions. The hydrological model HYDRUS is coupled with a Nested Sampling estimator to calculate the parameters' posterior distributions and the Kullback-Leibler divergences. Results indicate that the combination of seepage flow, soil water content, and soil matric potential measurements generally leads to highly informative designs, especially for fine textured soils, while results from coarse soils are generally affected by higher uncertainty. Furthermore, soil matric potential proves to be more informative than soil water content measurements. Additionally, the propagation of parameter uncertainties in a contrasting (dry) climate scenario strongly increased prediction uncertainties for sandy soil, not only in terms of the cumulative amount and magnitude of the peak, but also in the temporal variability of the seepage flow.