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EnKF with closed-eye period - bridging intermittent model structural errors in soil hydrology

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The representation of soil water movement exposes uncertainties in all model components, namely dynamics, forcing, subscale physics and the state itself. Especially model structural errors in the description of the dynamics are difficult to represent and can lead to an inconsistent estimation of the other components.
We address the challenge of a consistent aggregation of information for a manageable specific hydraulic situation: a 1D soil profile with TDR-measured water contents during a time period of less than 2 months. We assess the uncertainties for this situation and detect initial condition, soil hydraulic parameters, small-scale heterogeneity, upper boundary condition, and (during rain events) the local equilibrium assumption by the Richards equation as the most important ones.
We employ an iterative Ensemble Kalman Filter (EnKF) with an augmented state. Based on a single rain event, we are able to reduce all uncertainties directly, except for the intermittent violation of the local equilibrium assumption. We detect these times by analyzing the temporal evolution of estimated parameters. By introducing a closed-eye period - during which we do not estimate parameters, but only guide the state based on measurements - we can bridge these times.
The introduced closed-eye period ensured constant parameters, suggesting that they resemble the believed true material properties. The closed-eye period improves predictions during periods when the local equilibrium assumption is met, but consequently worsens predictions when the assumption is violated. Such a prediction requires a description of the dynamics during local non-equilibrium phases, which remains an open challenge.