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Handling the unknown soil hydraulic parameters in data assimilation for unsaturated flow problems

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Model predictions of flow in the unsaturated zone require the soil hydraulic parameters. However, these parameters cannot be determined easily in applications, in particular if observations are indirect and cover only a small range of possible states. Correlation of parameters or their correlation in the range of states that are observed is a problem, as different parameter combinations may reproduce approximately the same measured water content. In field campaigns this problem can be helped by adding more measurement devices. Often, observation networks are designed to feed models for long term prediction purposes (i.e. for weather forecasting). A popular way of making predictions with such kind of observations are data assimilation methods, like the ensemble Kalman filter (Evensen, 1994). These methods can be used for parameter estimation if the unknown parameters are included in the state vector and updated along with the model states. Given the difficulties related to estimation of the soil hydraulic parameters in general, it is questionable, though, whether these methods can really be used for parameter estimation under natural conditions.
Therefore, we investigate the ability of the ensemble Kalman filter to estimate the soil hydraulic parameters. We use synthetic identical twin-experiments to guarantee full knowledge of the model and the true parameters. We use the van Genuchten model to describe the soil water retention and relative permeability functions. This model is unfortunately prone to the above mentioned pseudo-correlations of parameters. Therefore, we also test the simpler Russo Gardner model, which is less affected by that problem, in our experiments. The total number of unknown parameters is varied by considering different layers of soil. Besides, we study the influence of the parameter updates on the water content predictions. We test different iterative filter approaches and compare different observation strategies for parameter identification. Considering heterogeneous soils, we discuss the representativeness of different observation types to be used for the assimilation.

G. Evensen. Sequential data assimilation with a nonlinear quasi-geostrophic model using Monte Carlo methods to forecast error statistics. Journal of Geophysical Research: Oceans, 99(C5):10143-10162, 1994