Performance comparison of different EnKF variants is far from trivial

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The estimation of permeability values alongside their uncertainty is vital in the assessment of groundwater flow and heat transport. The Ensemble Kalman Filter (EnKF), an efficient tool for sequential data assimilation, has proved to be useful in estimation of parameters that display complex spatial patterns. Several variants of the EnKF have been proposed to improve the assimilation for small ensemble sizes, highly nonlinear systems or with non-Gaussian probability distributions. In this study, we evaluate the performance of different EnKF-methods in runs with $50, 100, 250, 500, 1000$ and 2000 ensemble members. These experiments are carried out for eight different variants of EnKF and repeated 1000 times.

The computation of a tracer test in a 2D heterogeneous permeability model provided the measurement values for the EnKF. The considered EnKF methods include the standard EnKF, a damped EnKF, EnKF including localization, a Normal Score EnKF, a Hybrid EnKF scheme, a Dual EnKF, iterative EnKF and square root EnKF. For each simulation the Root Mean Square Error was recorded yielding a RMSE distribution for the 1000 synthetic experiments.

The main outcome from the simulation experiments was that the comparison of different EnKF-variants needs many repetitions in the form of different synthetic tests, even if the ensemble size is large, in order to reach a sound conclusion. In addition, it was found that for a small ensemble size of 50 members most EnKF-variants outperformed classical EnKF. On the other hand, for large ensembles sizes differences between methods were smaller and classical EnKF was hardly outperformed. EnKF with dampening and iterative EnKF gave the best results.