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Sequential data assimilation for parameter estimation of subsurface hydrological models: an overview and new developments

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Sequential data assimilation (SDA), and in particular the Ensemble Kalman Filter (EnKF), has become a popular approach for parameter estimation of groundwater flow models. The reasons are that SDA (i) allows for the characterization of the full posterior probability density function of states and parameters; (ii) can easily be implemented in combination with a forward model and does not require the formulation and solution of adjoint state equations; (iii) performs well for the estimation of strongly heterogeneous hydraulic conductivity fields and (iv) is flexible for incorporating multiple sources of uncertainty and assimilating multiple data types. However, a drawback of SDA is a large ensemble size needed to estimate a reliable posterior variance. For a small ensemble, the underestimation of variance and filter divergence occur both for EnKF and the particle filter. A number of possible strategies has been proposed in literature to alleviate the problem of filter inbreeding with EnKF, like localization, covariance inflation, iterative approaches and data transformations, amongst others. An overview will be given and some recent work will be presented which illustrates the degree of improvement that can be achieved with these measures.