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Parameter and state estimation with ensemble Kalman filter based algorithms for convective scale applications

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Representation of clouds in convection permitting models is sensitive to NWP model parameters that are often very crudely known (for example roughness length). Our goal is to allow for uncertainty in these parameters and estimate them from data using the ensemble Kalman filter (EnKF) approach. However, to deal with difficulties associated with convective scale applications, such as non-Gaussianity and constraints on state and parameter values, modifications to the classical EnKF are necessary. In this paper, we evaluate and extend several recently developed EnKF based algorithms that either explicitly incorporate constraints such as mass conservation and positivity of precipitation, or introduce higher order moments on the joint state and parameter estimation problem. We compare their results to the localized EnKF on a common idealized test case. The test case uses perfect model experiments with the one dimensional modified shallow water model that was designed to mimic important properties of convection. We use a stochatic dynamical model for parameters in order to prevent underdispersion in parameter space. To deal with localization for estimation of parameters, we introduce a method called global updating, which is a computationally cheap modification of spatial updating and was proven succesful in this context. The sensitivity of the results on the number of ensemble members, localization, as well as observation coverage and frequency is shown. Although all algorithms are capable of reducing the initial state and parameter biases, it is concluded that mass conservation is important when the localization radius is small and/or the observations are sparse. In addition, accounting for higher order moments in the joint space and parameter estimation problem is beneficial when the ensemble size is large enough, or when applied to parameter estimation only.