



Weak constrained localized ensemble transform Kalman filter for radar data assimilation

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The applications on convective scales require data assimilation with a numerical model with single digit horizontal resolution in km and time evolving error covariances. The ensemble Kalman filter (EnKF) algorithm incorporates these two requirements. However, some challenges for the convective scale applications remain unresolved when using the EnKF approach. These include a need on convective scale to estimate fields that are nonnegative (as rain, graupel, snow) and use of data sets as radar reflectivity or cloud products that have the same property. What underlines these examples are errors that are non-Gaussian in nature causing a problem with EnKF, which uses Gaussian error assumptions to produce the estimates from the previous forecast and the incoming data. Since the proper estimates of hydrometeors are crucial for prediction on convective scales, question arises whether EnKF method can be modified to improve these estimates and whether there is a way of optimizing use of radar observations to initialize NWP models due to importance of this data set for prediction of connective storms.

In order to deal with non-Gaussian errors different approaches can be taken in the EnKF framework. For example, variables can be transformed by assuming the relevant state variables follow an appropriate pre-specified non-Gaussian distribution, such as the lognormal and truncated Gaussian distribution or, more generally, by carrying out a parameterized change of state variables known as Gaussian anamorphosis. In a recent work by Janjic et al. 2014, it was shown on a simple example how conservation of mass could be beneficial for assimilation of positive variables. The method developed in the paper outperformed the EnKF as well as the EnKF with the lognormal change of variables. As argued in the paper the reason for this, is that each of these methods preserves mass (EnKF) or positivity (lognormal EnKF) but not both. Only once both positivity and mass were preserved in a new algorithm, the good estimates of the fields were obtained. The alternative to strong constraint formulation in Janjic et al. 2014 is to modify LETKF algorithm to take into the account physical properties only approximately.

In this work we will include the weak constraints in the LETKF algorithm for estimation of hydrometers. The benefit on prediction is illustrated in an idealized setup (Lange and Craig, 2013). This setup uses the non hydrostatic COSMO model with a 2 km horizontal resolution, and the LETKF as implemented in KENDA (Km-scale Ensemble Data Assimilation) system of German Weather Service (Reich et al. 2011). Due to the Gaussian assumptions that underline the LETKF algorithm, the analyses of water species will become negative in some grid points of the COSMO model. These values are set to zero currently in KENDA after the LETKF analysis step. The tests done within this setup show that such a procedure introduces a bias in the analysis ensemble with respect to the true, that increases in time due to the cycled data assimilation. The benefits of including the constraints in LETKF are illustrated on the bias values during assimilation and the prediction.