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Comparison of WRF 3D-Var with the DART EnKF for a COPS IOP

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Three dimensional variational data assimilation (3D-Var) and Ensemble Kalman Filter (EnKF) are two typical methods for data assimilation in the field of weather forecast. For global models, EnKF performed better than or at least comparable to 3D-Var as shown in recent publications. A few studies furthermore showed some advantages of the EnKF compared to 3D-Var for limited area models. The advantage of the EnKF is that the background error covariance matrix (B), which is not explicitly calculated for EnKF algorithm but implicitly represented by the ensemble, is sequentially updated during an assimilation cycle. For 3D-Var, however, a stationary (constant) B matrix is used instead.

The two methods use also different approximations in the representation of the B matrix. The ensemble representation is based on the assumption that a few ensemble members are enough to describe the uncertainties and correlations. The 3D-Var B matrix, however, needs to be inverted, which requires coordinate transformations and a-priori assumptions.

As a case study, the two methods were compared for an intensive observation period (IOP) during the COPS campaign. Beside using the same model (Weather Research Forecast Modeling System, WRF), the same modelling domain, and the same types of observations, the initial background error covariance matrix for the 3D-Var is created from the same ensemble as the EnKF is applying to perform a fair comparison.

An ensemble driven by a global ensemble taken from the ECMWF was simulated over a spin-up period of 24h to generate realistic correlations for the WRF model domain. Based on this ensemble, mean and B matrix was calculated for the WRF 3D-Var. The comparison between 3D-Var and EnKF, which was implemented in the data assimilation research test bed (DART), was performed for a 24h assimilation cycle with 3h analysis intervals. The choice of observations to be assimilated were determined by DART and therefore limited to surface and upper-air observations.