Comparison of EnsKF and 4D Var chemical data assimilation with the BASCEO system

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The ensemble Kalman filter (EnsKF) using an observation perturbation approach has been applied to the stratospheric chemical transport model of BASCOE (Belgian Assimilation System for Chemical ObsErvations). BASCOE was developed originally with a 4D-Var and is providing near-real time analyses for the European project MACC-II. In this study we compare the results of 4D-Var with the EnsKF over a period of four months using MLS EOS-Aura ozone data. Each assimilation system uses the same observation error statistics and share the same spectral formulation of the prescribed error covariances (i.e. the model error covariance in EnsKF and the background error covariance in the 4D-Var). The model error variance and the observation error were also adjusted to yield a stable χ^2 over the whole integration time period. In their own respective setup, 4D Var and EnsKF are optimally tuned assimilation systems providing their best analysis [1]. The results shows the analyses of the EnsKF are more realistic and smoother than those of the 4D Var. Also the O-F of the EnsKF has systematically (all regions, all altitudes) smaller variances than the O-F of the 4D Var. Two aspects that can explain this discrepancy is discussed and explored through experimentation. One is the accumulation of information (or their lack of it) from one Var window to the next. Two is the effect of model error that is not accounted in 4D Var. The analysis shows that the continuous accumulation of information improves the performance of EnsKF but is limited in time by the presence of model error. Overall the absence of a strong constraint in the EnsKF, accounted by model error is responsible for the EnsKF performance over that of 4D Var.

References
[1] Errera, Q., and R. Ménard. "Technical Note: Spectral representation of spatial correlations in variational assimilation with grid point models and application to the Belgian Assimilation System for Chemical Observations (BASCOE)" *Atmosphere Chemistry and Physics*, vol. 12, 10015-10031, Nov. 2012.