

Title: Comparison of the ensemble Kalman filter and 4D-Var assimilation methods using a stratospheric tracer transport model

Authors: Skachko et al., 2014

This paper presents the implementation of the EnKF method in a stratospheric tracer transport model BASCOE, and compares the performance of EnKF to the BASCOE's existing 4D-Var assimilation system. The authors carefully designed the EnKF and 4D-Var systems, so that they use the same numerical model, an identical set of observations, the same observation error covariance matrix and the same observation operator. The background error covariances have also been carefully calibrated. They showed that the analyses from EnKF and 4D-Var statistically have the same accuracy when using the difference between observation and 24-hr forecast as validation metric. They also found that the performance of EnKF degraded when the ozone hole forms. They attribute this degradation to the lack of chemistry process in the tracer transport model. Overall, the experiments were thoughtfully designed and the paper was well written. I recommend publishing the paper in Geosci. Model Dev after my following comments are being addressed.

Major comments:

1. In section 2.4, the paper describes the method to generate initial ensemble members and model errors in EnKF. It is not clear from the paper whether the initial ensemble members were created at the beginning of every 24-hour assimilation cycle or only at the beginning of the 6-month run. If it is at the beginning of every 24-hour assimilation cycle, the EnKF implemented in this paper did not take the advantage of the flow-dependent error covariance from one-assimilation cycle to the next. If it is at the beginning of the 6-month run, then it is not clear whether the constant magnitude model error is sufficient to overcome the filter divergence. I suggest the authors to clarify this point in this text.
2. EnKF can easily calculate the uncertainty of the analysis field along with the mean state, while 4D-Var would need approximation to obtain analysis uncertainty. I suggest authors adding some discussion about the uncertainty estimation from the EnKF, and adding the range of OMF statistics from EnKF when compared to 4D-Var estimates, such as in Figures 3, 4, 5, and 6.
3. The authors manually tuned the magnitude of model error term and the observation error in the paper. In the conclusion, the authors argued that EnKF requires more tuning than 4D-Var to get comparable performance even with relatively easier implementation. It is known that EnKF needs inflation in the background error covariance to avoid filter divergence, equivalent to the model error term in this paper, Anderson, J. L (2007b, 2009) and Miyoshi (2011) have discussed adaptive inflation. Li et al. (2009) discussed estimating the adaptive inflation factor and observation error covariance simultaneously in EnKF. I recommend the authors implementing the adaptive inflation method and observation error estimation strategy to their EnKF. The implementation of these methods would significantly reduce the tuning time for EnKF. If these methods could not apply in their EnKF, the authors should add some comments on why.

Anderson, J. L., 2007b: An adaptive covariance inflation error correction algorithm for ensemble filters. *Tellus*, **59A**, 210–224.

Anderson, J. L., 2009: Spatially and temporally varying adaptive covariance inflation for ensemble filters. *Tellus*, **61A**, 72–83.

Li, H., Kalnay, E. and Miyoshi, T. (2009), Simultaneous estimation of covariance inflation and observation errors within an ensemble Kalman filter. *Q.J.R. Meteorol. Soc.*, **135**: 523–533. doi: 10.1002/qj.371

Miyoshi, Takemasa, 2011: The Gaussian Approach to Adaptive Covariance Inflation and Its Implementation with the Local Ensemble Transform Kalman Filter. *Mon. Wea. Rev.*, **139**, 1519–1535.

Minor comments:

There are several places with spelling and grammar mistakes.

1. Line 25 on Page 357: "...the differences (bias) between observations and forecasts, as well as the and their standard deviation", should be: "...the differences (bias) between observations and forecasts, as well as their standard deviation".
2. Line 13 on page 359: "the 4D-Var providing values slightly lower that those from the EnKF". It should be: "the 4D-Var providing values slightly lower than those from the EnKF".
3. Line 23 on page 360: "the standard deviation is smoother that displayed by the χ^2 ", should be: "the standard deviation is smoother than displayed by the χ^2 ".