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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Hybrid ensemble 4DVar assimilation of stratospheric ozone using a global shallow water model" *by* Douglas R. Allen et al.

T. Milewski (Referee)

thomas.milewski@mail.mcgill.ca

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General notes

This manuscript addresses the outstanding issue of wind extraction from the assimilation of ozone (O3) in an advanced data assimilation system: a hybrid ensemble 4DVar. This paper is a logical follow-up on its parent studies that looked at wind extraction from O3 assimilation in a 4DVar system (A14) and an EnKF system (A15). The authors studied the issue in a simplified yet properly-constructed framework and appropriately described the limits of the experimental setup. The results are interesting and instructive on the ability of this advanced data assimilation system of reconstructing wind analyses in the absence of wind observations, versus the more standard 4DVar and EnKF data assimilation systems. Based on these considerations, we recommend

that this paper be published in ACP following minor revisions.

Specific notes

1) The choice of using streamfunction and velocity potential as control variables seems to be based on the experiments ran in A15 with the EnKF. What about the impact of choosing this set of control variables versus zonal and meridional winds in the 4Dvar system?

2) How did the authors come up with the value of 1518 as the number of dynamical state variables in the T21 system? If I understand correctly, this is roughly the number of degrees of freedom in the dynamical system, but does it include the influence of O3? If not, this might explain why the optimal blending factor was not 1.0 for the large-ensemble Z/O3 assimilation (before NNMI).

3) Optimal localization lengths for Z-only and Z/O3 assimilation are very different, suggesting that O3 error covariance structures and Z error covariance structures are probably different. Ideally, this should require separate localization lengths. Did you try tuning Z and O3 localization lengths separately?

4) In figures 7, 8 and 9, the hybrid system is only compared to 4DVar, not EnKF. Since EnKF seems to outperform 4DVar for moderate to large ensemble sizes (at least in terms of WEP), it would be instructive to see the improvement that the hybrid system brings with respect to second-best performing system.

5) Considering that this paper seems to complete a trilogy on the topic of wind extraction in a hierarchy of data assimilation systems, it would be interesting to have a final paragraph in the "Conclusions" section that is a more extensive review of the behavior of the different DA systems, possibly including the pros and cons of each.

Technical notes

1) P.6 L.16: Please correct "The WEP value for of Z/O3"