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Atmospheric Chemistry and Physics Discussions



# *Interactive comment on* "Sensitivity tests for an ensemble Kalman filter for aerosol assimilation" *by* N. A. J. Schutgens et al.

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Reply to comments by reviewer 1

1) No, we do not actively perturb meteorology. However, SPRINTARS contains direct and indirect aerosol feedbacks on the meteorology, so each ensemble member will evolve slightly differently (note they are all nudged to NCEP reanalysis data). This is apparent in the seasalt emission (dependent on windspeed), which is not actively perturbed. Yet, over remote oceans seasalt AOT is not identical for all members (see also Fig 22), as windspeeds differ slightly.

Recently we have been studying the impact of meteorology by nudging SPRINTARS with either NCEP or GPV (by the Japanese Meteorological Agency) reanalysis data.



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Interactive Discussion

Discussion Paper

Initial results indicate that the choice of meteorology does not have a profound effect on the assimilation.

2) Comparing simulated AOT (after assimilation of AOT observations) with observed AOT (even when independent) bypasses the thorny issue of scattering properties. However, ultimately we want to improve aerosol mixing ratios and not just optical properties. As our system adjusts mixing ratios based on AOT and AE observations, it certainly allows validation of concentrations, for instance by comparison to the IMPROVE or EMEP datasets. This work is planned for the future, and seems to warrant a separate publication due to the new issues it will raise (scattering properties, hygroscopicity, vertical profiles, etc).

Also, note that the AOT used for assimilation and validation comes from different sensors at different times and locations. So, mixing ratios are adjusted based on AOT, then transported and finally converted to AOT again for validation.

3) Obviously, assimilating more observations will improve spatial and temporal coverage. It also makes issues like bias correction, error correlations and random error estimation of the observations much more important (and difficult). We are currently doing this for MODIS and CALIPSO data. Also, we have developed a framework for Observing System Simulation experiments in which synthetic observations (generated from a SPRINTARS run) are assimilated. OSSEs are perfectly suited to study sampling impacts on assimilation. However, we believe that sensor choice/sampling only has a small impact on the sensitivity study we presented in the paper, for a practical reason: limited sensitivity studies for MODIS data support results in the current paper.

4) The instability ($\lambda$<0 in Table 1 in paper) occurs during the assimilation phase, and manifests itself by analysed (after assimilation) mixing ratios that are much larger than the forecast (before assimilation) mixing ratios. As a matter of fact, the analysed mixing ratios have unphysical values, due to an instability in the matrix solution of the Kalman equation. This instability is connected to the use of Angstrom exponent and ensemble



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Interactive Comment

size. That is, if we do not assimilate AE or increase the ensemble size, the instability disappears. The ensemble size, of course, directly controls the accuracy of the calculated model covariant. The unphysical mixing ratios are advected by SPRINTARS without further issues. We now discuss this in the paper.

5) The six sites were chosen randomly, with the following constraints: 1) they should have sufficient observations; 2) they should have sufficient sites nearby that have sufficient observations; 3) they should be distributed over the globe. For these reasons, no Asian sites were used (especially (2) failed). We now mention this in the paper.

6) Regrettably, we do not have any experiments that allow us to better understand what is causing this instability. If we increase the ensemble size from 20 to 40, experiments with 2 AOT do not show the instability. However, AE at the validation sites is poorer than when AOT &AE are assimilated. We surmise that: 1) convergence (and stability) of the Kalman filter depends on ensemble size (obviously); 2) convergence happens quicker when decorrelated observations are used (there is some evidence of this in our experiments). Note that even if we could calculate the covariant exactly (ie from an infinite ensemble), results between the two experiments would likely differ (slightly). The transformation between the two sets of observations (AOT & AE or 2 AOTs) is non-linear and hence the ensemble mean observations will correspond to (slightly) different atmospheric states. We now discuss this in the paper.

7) Such a map is now provided.

8) We have added a second reference to Takemura et al 2000, which introduces SPRINTARS and discusses these emission data.

9) AERONET direct sun algorithm lev2.0, this is now mentioned in the paper.

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Interactive comment on Atmos. Chem. Phys. Discuss., 10, 5947, 2010.