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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Applying an ensemble Kalman filter to the assimilation of AERONET observations in a global aerosol transport model" *by* N. A. J. Schutgens et al.

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Reply to comments by referee 1:

General comments.

C: Referee suggests that the figures for the comparison with MODIS data are redone in colour and maybe also included in Figure 6 (AERONET sites)

A: Figures 6, 7 (AERONET) and 10,11 and 12 (MODIS) are redone in colour which enhances readability. Inclusion of MODIS data in Fig. 6 and 7 may not be very useful. First of all, these figures are intended to validate temporal evolution and for that inde-

pendent AERONET data is far superior to MODIS (MODIS has a revisit time of 3 days, in case of no clouds). Also, we have found several instances where MODIS AOT over land was unreliable (discussed in second paper). Furthermore, MODIS AE data over land is unreliable.

C: The referee suggests to present error statistics, like remaining bias and RMS error after assimilation

A: Clearly, such error statistics are important but we feel that they are rather meaningless when presented for only a small set of (8) AERONET sites. We are currently making exactly such error statistics for studies where: 1) MODIS Aqua is assimilated and error statistics derived from all AERONET sites; 2) MODIS Aqua and AERONET are assimilated and error statistics derived from MODIS Terra.

C: The referee suggests that the subsection of AOT and AE observational error requires more explanation.

A: Our basic idea is that AERONET variability within 1 or 2 hours is essentially random noise around a constant value. SPRINTARS should be able to predict this constant value, but not the noise, which is caused by small scale aerosol physics.

Fig 3 argues this by comparing variation in both SPRINTARS and AERONET, but one problem is that we do not have data available at the same time scales. Our SPRINTARS experiments had a time sampling of three hours, but we really want to average AERONET observations over 1 or 2 hours (and so need an estimate of representation error for these time windows).

Anyway, the most important issue is the observed variability of AERONET around the SPRINTARS sampling times. It stands to reason that this variability increases with time, so we consider AERONET variability in both a central hour and in two "wings" of 30 minutes. All together that makes for a time window of 2 hours, over which we want to average AERONET.

So we collect all two hour intervals of continuous observations within one year of AERONET observations, and calculate the relative difference between observations in the central hour and the central hour average. The standard deviation over all found intervals is the representation error within one hour. Next, we calculate the relative difference between observations in the "wings" and the central hour average. The standard deviation over all found intervals is the representation error within 2 hours (but not within 1 hour). These values are shown in Fig. 3 for all AERONET sites.

Now, within 1 hour this representation noise is about 5% (see Fig 3), and within 2 hours it grows up to 10% (these values are averages for all available AERONET sites). An individual AERONET observation within a two hour window is thus assigned a 5% representation error if it is within 30 min of the central time, and a 10% error if it is outside 30 min and inside 60 min of the central time. Eq 7 is a convenient FORTRAN code representation of the previous statement.

C: The referee is interested in seeing an analysis of the characteristic of the ensemble runs, e.g. the ensemble spread.

A: Actually, this will be discussed in the second paper (mentioned in the current paper and currently submitted to ACPD). In that paper, we show that as a result of assimilation, the ensemble spread reduces, as one would expect. For the reviewer's sake we include a figure from that paper which shows relative ensemble spread (see Fig 1). It shows a monthly average of the ratio of the ensemble spread for two experiments, one with assimilation and one without assimilation (free ensemble run). The white dots are the AERONET sites. Clearly around these sites assimilation strongly reduces ensemble spread (i.e. knowledge is gained by adding observations). Note that not all sites provide observations which explains results for e.g. Canada and South America.

C: The referee is interested in seeing examples of the covariant structure.

A:We include several examples(Fig 3) taken from earlier experiments which we did not discuss in this paper. They clearly show that: 1) this structure is location-dependent;

2) it is not Gaussian, and not even rotation invariant (assumptions often made in IO,3D and 4D-var). In addition (not shown) the structure is time dependent (see attached powerpoint).

Specific comments

C: The referee suggest more explanation of certain parameter choices

A: As the referee indicated, this will be discussed in more detail in the second paper. Results from that paper were actually used to choose the parameter values used in the current paper. These parameters are not in any way related to the scenarios in Table 1 (except that both are used in our experiments). A better explanation of Table one will be included in Section 5. A brief explanation of the parameter choices has been added to Sect 2.2:

"For LETK, these are (roughly from most to least important): ensemble size ne , local patch size lp , horizontal localization factor lh (together lp and lh define the maximum range, in grid-points, at which observations still influence the assimilation) and inflation parameter g (a multiplier to increase the ensemble spread to mitigate the negative influence of a limited ensemble size)."

C: The referee wonders about correlations between fine and coarse mode aerosol.

A: Actually, we have not considered this yet. It is worthwhile to do this for future experiments, if only because such correlations may help explain the added value of ensemble Kalman filters. However, correlations are routinely not saved during calculations, to reduce memory footprints. At the moment, we therefore can not show them.

C: The referee ask for more explanation on the error assignment

A: See the answer to the referee's general comments.

C: The referee ask for comments on why AE does not appear to have a big impact on the assimilation.

A: There are several aspects to this. First, AE does have a clear impact for desert sites like Cinzana or BAHRAIN. Second, AE observational errors are large when AOT is small (AE error $\sim$ 1/AOT). In such cases, unless the ensemble AE spread is also large, the Kalman filter will see no need to adjust the model. Thirdly, in the second paper we revisit this issue and show that AE assimilation does have an impact in a wider region than just Cinzana and BAHRAIN. One of its figures is here included for the referee's sake (see Fig. 2). It shows the monthly average AE difference of two assimilation experiments. In one only AOT was used, in the other both AOT and AE were assimilated.

Technical reviewer comments that we did not specifically address, were used to improve the paper.

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 23835, 2009.

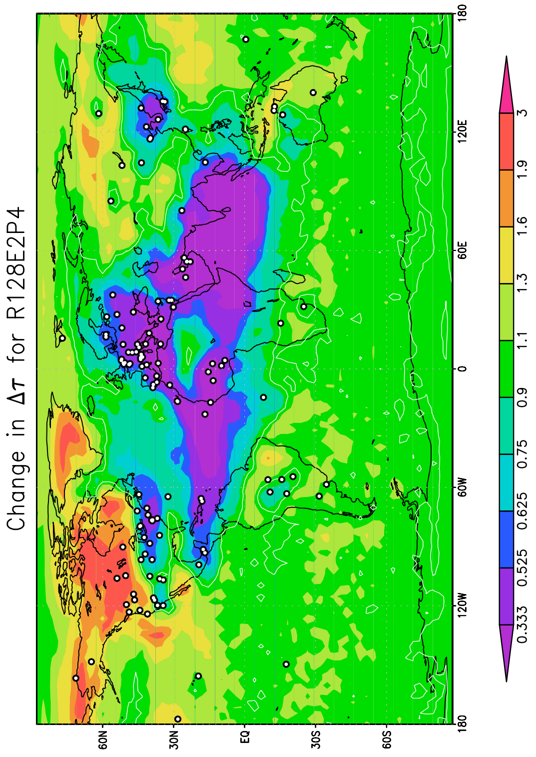

Fig. 1. impact of assimilation

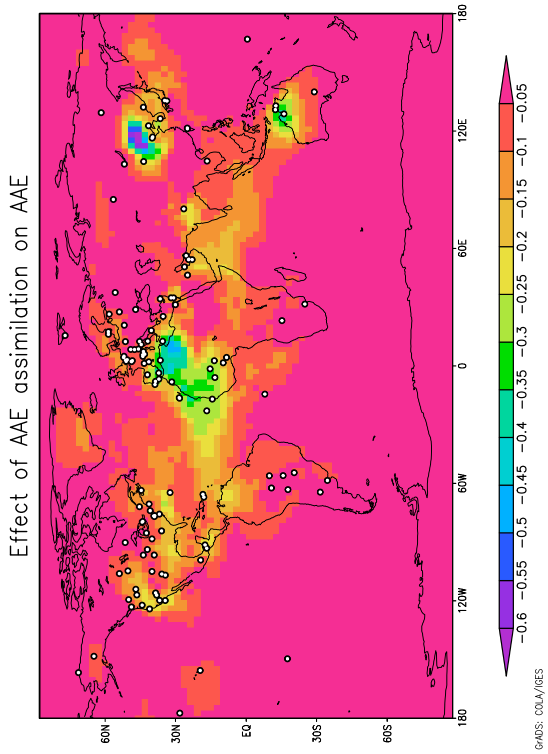

Fig. 2. impact of AE

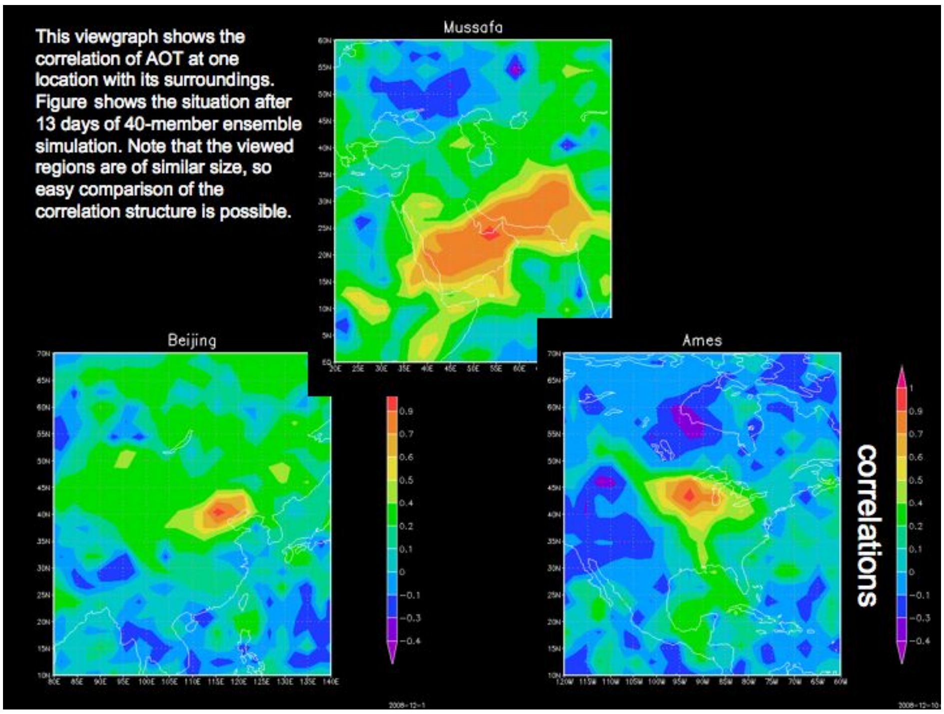

Fig. 3. correlation structure