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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 2

Ideally, sensitivity studies should be part of a paper that also shows applications, to make it more palatable to the reader. However, the lack of any sensitivity experiment in the literature, made us decide to dedicate a full paper to it.

We differ with the reviewer's view that 'the results are [not] generic enough to guide the set-up of data assimilation system different from this version of this specific system'. What ultimately determines the values of the (generic) EnKF parameters and the success or failure of some experiments, is the general structure of the model covariant matrix P. In an EnKF, this matrix is calculated, at assimilation time, from an ensemble

of model runs. Typical correlation distances in this matrix and the accuracy with which a limited ensemble can estimate it, have to change dramatically for our results to be very different. The robustness of the results in the current paper and recent results for MODIS observations both seems to support this view.

1) The relative patch is still 8 gridsizes wide (ie, it has a npatch of 4 gridpoints). At the equator this amounts to 2500 km. Correlations in the aerosol field usually extend over no more than 500-1000 km (based on observations, see e.g. Anderson, JAS 2003, Kovacs, JGR 2006). Whether EnKF performs better than 'a simple application [. . .] with clever prior errors', we can not check at the moment. However, we have made plots of the model covariant P at various sites, and it shows a correlative structure which is far from the Gaussian that 'simple applications' usually assume. Their size also warrants npatch = 4, although the covariants were plotted at only 3 sites at only one time. See also Hoelzeman JGR 114, 2009 who shows spatial AOT correlations for selected sites in South America (derived from MODIS observations), which supports our assumptions.

2) True, we have adopted this suggestion.

3) With so many experiments, we are forced to choose a practical but not very poetic identification. The system is (see also table 1), R<region size>E<ensemble size/10>P<patch size>_extra_info, which seems rather explicit to us.

4) It is true that often authors make little of the tuning of an EnKF, that is nevertheless required. However, this is not work that has to be repeated over and over again. Currently we are also assimilating MODIS observations, and we require no adjustment of our parameters. This is not surprising, as we show in this paper that results are quite robust for reasonable parameter values. Finally, we have already argued that results in our paper can likely be used as good initial parameter values in other systems (patch size may need some scaling for grid resolution).

5) Actually, we do perturb initial mixing ratios as well. This is now explicitly mentioned in

the paper in Sect. 2 (before, it was only mentioned in Sect. 3 and 8). However, nothing in our experience suggests that this perturbation is very important (due to the short lifetime of aerosols). This is borne out by the R128EP4_IC experiment, which uses different initial conditions than the baseline experiment (but is otherwise identical).

6) This is an interesting issue. Zhang & Reid (JGR 2008) discuss an extra error contribution to the observations due to incorrect H. However, it seems they consequently assume this contribution to be negligible (probably because it is difficult to assess). We agree with the reviewer and Zhang & Reid that our observation operator H likely has errors due to assumption on the scattering properties. However, due to the nature of these errors (over/underestimating hygroscopicity; over/underestimating effective size; over/underestimating refractive indices) and due to spatial and temporal correlations, such errors are likely biases and not random. Only random errors would warrant inclusion in the overall observation error. By using H as it is and not include extra error sources, we introduce biases in the analysed mixing ratios, but this seems preferable to watering down the impact of observations when we know the model has problems with aerosol emission. In contrast to weather prediction, aerosol modeling does not suffer from chaotic behaviour (as far as we know) and biases do not lead to widely divergent evolutions. The biases, moreover, can be reduced by introducing improved scattering properties. We added a discussion to Section 2, paragraph 4.

7) We have since found out that the instability disappears when a larger ensemble size is used. We discuss this in the paper.

8) ‘More than enough’ is probably too strong a statement and has been replaced with ‘seems to be sufficient’. Obviously, conclusions in our paper will be resolution dependent, although for reasons already discussed we do not expect large differences in tuned parameter values if the resolution were to double (one has to scale npatch however). Also, our recent experiments with MODIS data suggest that data source and observation errors do not change our conclusions.

9) True, but among most common assimilation schemes (Optimal Interpolation, 3D-VAR, 4D-VAR, EnKF), it is exactly that ‘trick’ that allows EnKF (and only EnKF) to interpret the spread that way. We have adapted the text.

10) We do not think this is necessarily so (see the introductory text above), but thank the reviewer for pointing out something that needed to be discussed. The text has been adapted.

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