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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Bias correction in assimilation of AOD observations with WRF-Chem" *by* Anton Kliewer et al.

Anonymous Referee #1

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This manuscript deals with BIAS correction of after the assimilation of observations of Aerosol Optical Depth into an ensemble system with WRF-Chem. This problem is not new, however I think that this work can become an important contribution since (a) the proper 3D representation of aerosols in the littoral area (or any area) is not an easy task and is one that is finally being tacked, (b) it helps in using existing satellite observations in more precise. Of course one would like to avoid these pesky biases from the beginning, but since then correcting them is what can be done.

I believe this article can be accepted after the following considerations (and of course those from other reviewers).

Major comments 1. I am not aware if there has been work on bias correction in the case of aerosols and satellite data. However, the bias correction problem has been

studied in the past. I am quite sure some operational centres (e.g. UK Met Office and ECMWF) which have included the presence of biases in their cost functions, and solve this problem in a direct or approximate manner. This should be mentioned and reviewed in the introduction. Probably some off-line methods are also used. 2. As with any study that involves a type of verification/validation, it is always better to have an independent set of observations to validate against, instead of validating with respect to the same observations used in the assimilation. Is this possible in your case? Can you at least cross-validate by partitioning the observations that you have and just using some for the assimilation and bias correction? If not, do you think this would change the results? 3. Some more details of the MA and Boostrap experiments are required. In the MA experiments, it is noted that the procedure can be done regionally. In this study cases I guess that this was done for the whole region of interest, is this correct? How would a 'regional' method look like? I guess one can partition by vertical levels, etc. I am not asking to do this (if it is too much trouble), but at least discuss it. For the bootstrap method, can you say anything about the changes in sample statistics (mean and covariance for instance) of the innovations (after the sampling with replacement). How does this change as the number of resampled elements increased. I am just thinking of the fact that you have only used two sizes differing by an order of magnitude. Is it because at those values convergence had been achieved?

Clarifications 1. Page 2, Line 12. The definition of bias is incomplete. From the text one could have the wrong impression that a bias is an instantaneous difference between the estimator and the true value. I think an expected value is missing. 2. Page 3, Line 25. The description of Pf in terms of the 'square' of a matrix of perturbations is not quite clear. Please re-formulate. 3. Page 5, Line 8. It was not clear to me if the h operator is an existing one (from previous works) or if it was developed and/or adapted for this work. 4. Section 3, line 15. Can you indicate why is necessary to show diagnostics both in the model and observation space? Are there differences on what can be measured in each space? 5. Sensitivity to ensemble size? If not, at least some description of the inflation and/or localisation that is used in the DA of your experiments. Does the

localisation differ from the original (meteorological) state variables of the model to the extended variables (which include the variables related to the aerosols).

Format 1. No indent is necessary when text continues after an equation (and of course it is not a new paragraph). Use \noindent. 2. Be consistent in the way you denote operations in the equations. Some times the scalar product (simple multiplication) is expressed with a cross (x), whereas in other occasions it is represented with a dot (.). 3. Some expressions would benefit from superindices (or subindices), such as in the case of departures from observations: y-h(xˆb), or y-h(xˆa) to indicate if they refer to background or analysis. 4. Equation 8. I do not think it is necessary to write the RMSE equation twice. 5. Section 3.1. I think the manuscript would have a more logical flow if this section were introduced after 2.6 when the diagnostics are mentioned. Then the result section would not need to be interrupted to discuss information theory. 6. Tables 2 and 3 are a great way to summarise the results. I wonder if it is worth to represent some of these results in a graphical manner.

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