

Interactive comment on “Simplified aerosol modeling for variational data assimilation” by N. Huneeus et al.

N. Huneeus et al.

nicolas.huneeus@lsce.ipsl.fr

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We thank the reviewer for the useful comments. The main changes made to the manuscript include i) restructuring the paper according to the reviewer's comments; including in section 3 the description and the validation of SPLA and leaving for section 4 the description of the tangent linear and adjoint models; ii) extending the scope of the paper by not limiting it to MODIS AOD but to any equivalent satellite AOD product within a given range of wavelength; and iii) the analysis of SPLA's performance to reproduce the observed daily variability was included. We believe that we have responded satisfactorily to the reviewer's comments, which has contributed to an improved manuscript. Detailed answers to the reviewer's comments follow:

Section 3 and 4: I believe the section with the validation of SPLA should come before
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the section on the nonlinearity and the sensitivity studies. I suggest switching section 4 with 3.

Section 3.1 and section 4 have been merged together and now are section 3, while section 3.2 and 3.3 are now section 4.

Section 3.2, last paragraph: What made the authors choose to restrict the linearity and adjoint sensitivity analyses to areas where MODIS data are available?

Necessary changes were made in the text and figures in order not to restrict the article to a single satellite product.

Section 3.2.1: how long of an integration did the authors perform with the tangent linear? Please elaborate on how the average for the month of July was obtained. Non-linearities are of course more severe the longer the integration. Usually, the tangent linear is deemed suitable for assimilation if it can reproduce the nonlinear model results over a span of 48 hours, given that the assimilation window in 4D-VAR system is usually 12 hours. Of course, this also depends on the specific application. Perhaps for the evaluation of the emissions one can get away with longer assimilation window. Can the author comment on this?

The linearity tests were conducted with one-month simulation and the results are for the month of July. The average for the month of July corresponds to the average of daily values over the entire month. Indeed the assimilation window for the estimation of concentration (NWP) is in the order of hours whereas for the estimation of emission the assimilation window is a function of the lifetime of the species involved: for CO₂ in the order of month to years and for aerosols in the order of weeks.

Section 4.1.2: Can the authors comment on the implications of the large variability of SPLA on the assimilation? Specifically, what are the implications on the choice of the assimilation window? Of course, for the assimilation, the variability with respect to the observations that are to be assimilated is more crucial than that with respect to the

full-blown model

As stated above, the performance of the simplified model to reproduce the observed variability is more crucial than reproducing the one from the original model. A failure to reproduce the variability of the observations will negatively influence the performance of the assimilation. Following the reviewer's suggestion, we included in the text the analysis of the daily variability of SPLA with respect to the observations (AERONET). This has been added to section 3.2.2 (old section 4.2).

Section 5, last paragraph: only at the very end do the authors state clearly that they are going to assimilate daily averages of AOD. I would recommend making this statement before so that the reader can make sense of the results keeping the final goal in mind.

Changes were made in the last paragraph of the introduction to clearly state that aim of the model is to be applied in the assimilation of daily averages of AOD.

Page 642, line 10: Replace "into numerical weather prediction (NWP)" with "into the Naval Research Laboratory (NRL) numerical weather prediction (NWP) system".

Changed accordingly

Page 644, line 9: Replace "account" with "account".

Changed accordingly

Page 645, line 14: Parenthesis missing after "Å" symbol.

Changed accordingly

Page 646, line 1: Replace "than" with "as".

Changed accordingly

Page 646, line 11: Remove line (statement has already been made at the beginning of the page).

Line removed

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Page 648, line 5: Replace "one" with "coefficient".

Changed accordingly

Page 648, line 6: Replace "followed" with "follows"

Changed accordingly

Page 651, line 17: Put a period after "AOD" and start a new sentence with "Results correspondin...".

Changed accordingly

Page 651, line 21: Have symbols "BB" and "FF" been defined before? Please check throughout the document that all acronyms are defined before using.

Definition of symbols "BB" and "FF" was included in the specified line and text was checked for definition of other acronyms.

Page 652, line 17: See previous comment on showing global fields instead of restricting the analysis to regions where the MODIS AOD data are available.

See response to corresponding comment.

Page 653, line 18: I could not see the region of sensitivity over western Central Africa in figure 2g and 2h.

Reference to western Central Africa was eliminated from text.

Page 654, line 3: References have already been provided, no need to repeat them.

Reference deleted

Page 654, line 5: For the benefit of the reader, please explain better what the adjoint test is and why it is so important to attain such an high accuracy.

The line "The accuracy of the test reveals the efficiency of the adjoint in the assimilation; the higher the accuracy the more efficient the variational minimization will be." was

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added. Further detail would require the introduction of several concepts we consider unnecessary at this point and we leave them to the forthcoming article presenting the assimilation system.

Page 654, line 15: Replace “the single observation is most” with “the fine mode AOD in that particular location is more”

Changed accordingly.

Page 654, line 16: A strong sensitivity to the east of the observation is also visible in figure 3a.

This strong sensitivity is indicated in the text as the biomass burning emission in Central Africa.

Page 654, line 25: Please comment on the implications for the assimilation. If the assimilation is performed over a 12-24 hour window, it will be mainly the local sources that will be corrected. If the assimilation window is longer then more distance sources will also be adjusted.

Short assimilation windows (~days) optimize the initial state as well as the emissions whereas for long assimilation windows (~weeks) only the emissions are optimized.

Page 659, line 20: Sentence starting with “Variational data . . .” is a bit heavy. Please rephrase.

The sentence was changed to “Previous works have used variational data assimilation techniques to estimate the emission field for single aerosol species. This field represents the best compromise between a given set of observations and the a priori information.”

Figures 4-7: a third panel showing differences between the SPLA and the LMDz runs would be helpful.

We have tried to achieve a balance in terms of the text and accompanying figures in

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order not to saturate the reader. When writing the section 4 (now section 3.2 in new version) we considered that we had to decide between either using one panel illustrating the difference or two panels showing the simulated fields from each model version. We chose to use two panels since we could better illustrate not only the individual performance but also the good performance of SPLA to simulate LMDz. We consider that including an additional panel would not contribute significantly to the section but increase considerably the load of figures.

Figure 8: labels do not show well. Please re-do the figure.

Changed accordingly

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