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Discussions

Interactive comment on "Impact of the choice of the satellite aerosol optical depth product in a sub-regional dust emission inversion" *by* Jerónimo Escribano et al.

Anonymous Referee #2

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The manuscript presents estimates of dust emission from Northern Africa and Arabian Peninsula for the year 2006. Aerosol optical depth (AOD) retrievals from five different satellite instruments are individually assimilated into a global model that includes a simplified aerosol model. The individual assimilation allows to evaluate the spread of the estimated dust emission due to the different AOD datasets. These are very interesting and new results in the study, which should be published. Besides providing new estimates for dust emission from Northern Africa and the Arabian Peninsula, which are based on the assimilation, these results demonstrate that using only selected AOD retrievals for estimating dust emission or model evaluation will likely lead to an underestimation of the uncertainty in the results.

The structure of the manuscript needs improvement in some parts. The authors should also carefully revise with respect to the English language, especially the phrasing of some sentences.

Following points should particularly be taken into consideration before publication. Quotes from the manuscript are in italic:

1. **Abstract, lines 11–12:** *"We also show how the assimilation of a variety of AOD products can help to identify systematic errors in models".*

   It is not clear to me how the manuscript has shown such a thing as a guideline that can be generalized to other models. The authors make some short general statements in the conclusions of the manuscript about possible biases in the specific model that was applied by them, but that is not sufficient for such a general statement in the abstract.

   I recommend to remove the last sentence in the abstract.

   Alternatively, the authors could add a more systematic discussion of how the assimilation of the AOD retrievals can help identify model biases in general. This would further improve the paper.

2. **Page 2, lines 1–7**

   The relevant scientific references should be added to each of the points about the importance of dust aerosols.

3. **Page 2, line 27 to page 3, line 3**

   The scientific references for each of the listed instruments should be added.

4. **Page 4, lines 27–28:** *"...the use of efficient algorithms to ensure semi positiveness of some matrices involved in the inversion ..."*

For the purpose of reproducibility, it should be specified what algorithms were used in the current study to ensure this, instead of making a general statement only.

5. **Page 5, lines 11–12:** *Using this coefficient we derive the 550-nm AOD from these retrievals, for total and fine mode over ocean and fine mode over land.*

   Even though it may appear trivial to the experts, the formula for deriving the 550-nm AOD should be presented here.

6. **Page 5, lines 28–29:** *"(i) we calculated the contribution of each aerosol model to the total AOD, using the reported fitting parameters and considering the 8 basic aerosol models of MISR algorithm;"*

   This statement is not clear. Were only eight basic aerosol models out of the 74 aerosol mixture models considered and their contributions calculated? In any case, the sentence should be rephrased to clarify what was done.

7. **Page 5, lines 31–33:** *"In practice, our approximation of the AOD reprojected on the three modes of the SPLA model is accurate with a relative error of (maximum) 5% of the total AOD for the 5% less accurate recomputed retrievals"*

   How was this relative error estimate derived? The information about the methodology how this relative error was obtained should be added to the manuscript.

8. **Page 7, lines 3–4:** *"The standard deviation of the observational errors have to be prescribed to the data assimilation system."*

   This sounds more like an introductory statement to the discussed aspect and seems to be out of place in the structure here. It rather should be moved to the beginning of the paragraph.

9. **Page 8, lines 17–18:** *"..., so we decided not to inflate the covariance matrices."*

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This has already been stated at the beginning of the paragraph. The repetition here is redundant, and it can be removed from the text.

10. **Page 8, lines 18–19:** *"Additionally, a common configuration for all the inversions is fairer to draw consistent conclusions across the five observational datasets."*

    This statement is a little bit difficult to understand. What does "fair" mean in this context here? Are the conclusions the ones that are consistent? Or does choosing a common configuration ensure a consistent approach for all the inversions to draw conclusions across the five observational datasets?

11. **Page 9, lines 3–14**

    This whole part is an introduction in the five satellite instruments that have been used for the assimilation. This part is presented after details of the treatment of the data from the instruments have already been discussed. It should be moved to the beginning of the section on the observations, before the details are discussed.

12. **Section "3. Results", Figures 1 and 2**

    Figures 1 and 2 present very interesting information about the differences between the AOD retrievals from the various satellites. One part of this information are the differences between the retrievals with respect to the relative fraction of the AOD that is coming from the fine mode relative to the total. However, this is difficult to evaluate from Figure 1 or 2, especially due to the different scales that are used for the fine mode AOD and the total AOD. I suggest to add a figure that displays the geographical distribution of the relative fractions of the fine mode AOD compared to the total AOD for the instruments for which it is available.

13. **Subsection "3.4 Mineral dust flux"**

    One result that is puzzling to me is the decrease in the mineral dust flux simulated with the model after assimilation, in the case of almost all satellite products

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(except for PARASOL), even though the prior AOD in the model is on average lower than the AOD from the observations. This appears to be counterintuitive. If the model AOD increased after assimilation of the observations I would expect that this increase comes with a higher dust load and higher dust emission.

How do the authors explain this? This should be discussed in the manuscript.

Language and typos:

1. **Page 4, line 26:** Replace *"The later is mainly..."* with "The latter is mainly ...".

2. **Page 5, line 30:** Replace *"independent from"* with "independent of".

3. **Page 6, line 32:** Replace *"... difference with EBCH16 ..."* with "... difference to EBCH16 ...".

4. **Page 6, line 33:** Replace *"... the standard deviation of the observational errors were set to ..."* with "... the standard deviation of the observational errors was set to ..."

5. **Page 9, line 21:** Replace *"for year 2006"* with "for the year 2006".

6. **Page 9, lines 21–22:** *"Several characteristics can be identified in these yearly averages of AOD and they will impact the assimilation analysis."*

   I propose a rephrasing of the statement as follows: "Several characteristics that will impact the assimilation analysis can be identified in the yearly averages of the AOD."