AMT-2013-175 Määttä, et al.: OMI aerosol model uncertainty

Anonymous Referee #3

Response to Referee #3

We would like to thank Referee for reading the manuscript and for useful and valuable comments and suggestions for improvements. They have been taken into account for improving the manuscript. Our point-by-point answers are found below.

> *The paper quantitatively explores and discusses the error in retrieved AOD caused by uncertainties in the modeled aerosol reflectance used for the retrieval. Identification and quantification of the individual errors within aerosol retrieval algorithms is of high interest for existing and emerging satellite instruments (specifically, TROPOMI), and the manuscript under review presents a new approach to this challenge. In this sense, I believe that the paper is worthy of publication in AMT, after some minor revisions. In particular, I would like to see the results put into more context by addressing the following questions: (1)roughly how large is the error caused by the aerosol model in comparison to other error sources, such as incorrect surface reflectance function or even cloud contamination?*

This is a difficult question. If we look at the uncertainty of AOT retrieval from one individual model based solely on the assumed observation noise, we see this "within model" uncertainty is smaller than the variability between those models that fit the same observations equally well. The "between model" uncertainty reflects the uncertainty coming from using discrete LUT based approximate aerosol microphysical model, but it can also include other sources of uncertainties as the model choice related uncertainties are probably correlated with other forward model approximation errors. The model discrepancy term tries to account for repeating non-modelled systematic features in residuals by using a statistical approach. Also, averaging over different models and allowing for statistical model discrepancy will hopefully account for most of the uncertainties in the AOT retrieval. Judging very roughly from the example cases, we could conclude that uncertainty from the discrete model choice can be from 2 up to 10 times larger that the uncertainty from the assumed measurement noise and this model choice uncertainty may contribute (or can be used to account for) at least one half, and typically even more, of the total uncertainty budget. We have added one paragraph regarding this in the Discussion and conclusions. Also, we have included one new multi-pixel example, where we can compare the variability in the operational OMAERO result in neighbouring pixels and the corresponding uncertainty estimates from discrepancy adjusted and model averaged results.

> *And (2), how do your results apply to other aerosol retrievals, like that from MODIS, the most popular aerosol sensor?*

We have now: For example, the MODIS AOT retrieval algorithm is based on finding the best combination from a set of pre-defined coarse and fine modes (over ocean) and coarse-dominated and fine-dominated aerosol microphysical models (over land) (Levy et al., 2009). The methodology introduced here could potentially also be applied to MODIS retrieval to take into account the uncertainty in the microphysical model selection.

> *The manuscript is well-structured and well written, although the authors may consider inserting articles at several positions.*

Thank you for this positive comment. In our new revision we have tried be more careful with the language.

> *Other minor comments are given below.*
> *P. 8511 - on lines 2-7 you list satellite instruments used for aerosol retrieval, but fail to mention instruments on geo-stationary platforms, e.g. SEVIRI.*

That is important point. We have added SEVIRI in the revised version of the manuscript. In addition, we have modified the second paragraph of Introduction as suggested by Anonymous Referee #1.

> *P.8512, line 1 - composes -> plays*

Done

> *P.8512, line 18 - build up -> built up (or, even better: composed)*

Corrected: "composed" chosen

> *P.8513, lines 17-18 - "The retrievals from (...) aerosol characteristics" -> "OMI- measured Earth radiance and solar irradiance spectra with moderate spatial resolution are used to retrieve (among others) aerosol characteristics, ..."*

We have reworded the sentence as suggested.

> *P.8514, lines 7-8 - "OMAERO product uses (...) five years." -> "OMAERO product uses a surface albedo climatology based on five years of OMI observations (cite Kleipool et al., JGR 113, D18, 2008) for pixels over land"*

Thank you for the correction. We have modified this sentence as suggested, and added the given reference.

> *P.8514, line 10 - "chlorophyll concentration climatology" -> "chlorophyll concentration from a climatology"*

Corrected

> *P.8514, line 25 - ending up -> adding up*

Corrected

> *P.8514, line 25 - "the content of the aerosol models" -> what do you mean? The calculated reflectance?*

You are right, this need to be clarified. We have modified this sentence in the revised manuscript to be as "The results of the radiative transfer model calculations are stored in multidimensional look-up tables.".

> *P.8515, line 6 - remove "at present pixel"*

Done

> *P.8515, line 10 - please specify the range of L*

The text now says: "where L is the number of wavelength bands (14 in our case), "

P.8517, line 5 - data sets -> data set

Corrected

P.8517, line 5 - "infinite" is an exaggeration; "many" or "a large number of" seems more appropriate

We used the word "infinite" since, in theory, there exists infinitely many models that fit the data equally well. We have added "Theoretically speaking," to the beginning of this sentence in the revised version of manuscript.

P.8520, line 11 - reflectance spectra -> reflectance spectrum
Done.

P.8520, lines 14-15 - "and the modeled reflectance … but opposite way" -> " and the two modeled curves show similar, though opposite deviations from the observed curve"
Reworded.

P.8520, line 19 - "acknowledging" -> account for
Done

P.8521, lines 4-10 - this paragraph is quite unclear. Can you explain in more detail what was done? What "different atmospheric situations" did you include? Figure 2 doesn't clarify anything at this point.

The residuals were collected from set of pixels from different orbits. Each colour in Fig. 2 represents residuals from one orbit. The single spectral residual has been calculated (Eq. 13) as the difference between the observed reflectance and reflectance generated from the aerosol model. The aerosol models involved were the retrievals from the operational OMAERO product. As there can be more than one likely model that fits to the observations, there can be more than one residual curve for the single pixel. We have modified the text in the manuscript to make this point more clear. We have also changed Fig. 2 to be clearer.

P.8525, lines 3-6 - why do you use a different surface albedo climatology?

When we started this study within the Finnish Technology and Innovation Agency (TEKES) funded project PP-TROPOMI, we took the surface albedo climatology based on TOMS and MODIS data, from year 2006. Later, we used the same look-up-tables although newer ones would have been available. As the main focus in our study was the uncertainty related to aerosol microphysical model selection, we have not studied, in detail, the important contribution to the total uncertainty from the surface albedo. In the revised text the importance of surface albedo is now mentioned more clearly, and this aspect will surely be a subject of further study.

P.8527, line 17 - storm -> storms
Corrected

P.8527, line 18 - helped the dust to transport a long way -> transported the dust a long way
Reworded.

P.8528, lines 8-9 - "limited" is a euphemism here; "too small" is probably more appropriate

We agree. We have replaced "limited" by "too small" in the revised text.