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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Multi-Satellite Retrieval of SSA using OMI-MODIS algorithm" *by* Kruthika Eswaran et al.

Anonymous Referee #1

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First of all I need to apologize to the authors and to the editor for not understanding that I was supposed to review this manuscript and for the late return of the review.

I will summarize my overall impression of the manuscript.

The authors apply a method developed by Satheesh et al. (2009) that uses MODIS retrievals to constrain the AOD in an OMI retrieval of aerosol layer height (ALH) and single scattering albedo (SSA). Currently the operational OMI retrieval uses climatology to constrain ALH and thus retrieves AOD and SSA. The point is that OMI has three variables and only two pieces of information. Something has to be constrained or assumed. The authors apply the OMI-MODIS retrieval over the global oceans and compare with the operational OMI product. The global study points them to two regions of particular interest: the tropical Atlantic and the seas surrounding the Indian

subcontinent. They want to know more about the aerosol in these regions so they pick a point in each region and do a lot of trajectory analysis to find out from where the air mass originates at three different altitudes. I am still unclear on how the trajectory analysis ties into the comparison of the two different retrieval methods. After the trajectory analysis they go back to comparing the results of the two methods. Here they find that when OMI-alone underestimates SSA, it also underestimates ALH. Because they believe the OMI-MODIS retrieval is more "truth" than OMI alone, they conclude that OMI-alone underestimates SSA when the aerosol is at low altitude. Note, we haven't seen any validation yet. Then they run some radiative transfer and rediscover the interplay between aerosol absorption, AOD and ALH, all because of Rayleigh scattering. Then we compare SSA retrievals with in situ measurements made during a cruise in the Bay of Bengal, where we find that both retrieval methods match the cruise data equally well within their respective uncertainties, but that the OMI-MODIS retrieval exhibits less over all mean bias.

For the most part the writing is good enough for me to understand the authors' intent. The exceptions are noted in the line by line analysis below. However, the typical grammar errors expected of new-to-English writers do permeate the manuscript. I will attach an annotated pdf that corrects some, but not all of the English problems.

In some ways this manuscript represents a lot of very good work in search of a paper. What is this paper? 1. A proposal to use the MODIS-OMI retrieval instead of the operational OMI retrieval? 2. A picture of the global (or regional) SSA, as retrieved by this new method, assuming that it is already established as a better method? 3. An attempt to better understand the regional aerosol system in the north tropical Atlantic, Arabian Sea and Bay of Bengal? Right now it takes steps in each of these 3 directions without really succeeding at any of them because the reader is pulled in multiple directions. The paper needs a rethinking and a rewrite, but the work itself is worthy of publication (with the possible exception of the re-discovery of the importance of Rayleigh scattering). I would recommend either Major Revision or Reject with the Encouragement to

Resubmit.

Initially I worried that this work may duplicate the Gassó and Torres (2016) paper, but it does not. It is very different, and the authors do an excellent job of putting their work into context with this previous work. Be sure to put the accent over the 'o' in Gassó when citing.

Here are my line-by-line comments. The most important are indicated by ******.

Line 30. "Forcing" or "effect". Some people use forcing only when the aerosols are anthropogenic. Clarification in definition here. IPCC reference to 'forcing' is only anthropogenic and that is where that statement is leading later on in the paragraph.

Line 40-41. 'the fraction of the total extinction of radiation attributed to scattering'

Line 44-45. "However, SSA values lack high certainty (Bond and Bergstrom, 2006; Bond et al., 2013)" What has high uncertainty? Measurements of SSA? Attributing SSA to different aerosol types? Understanding the overall SSA of aerosols globally or regionally? "SSA values" is too ambiguous.

Line 44-51. Lots of ambiguities here between measurements, retrievals and physical properties.

Lines 52-72. *****While Table 1 is very good and a major contribution of the paper by itself. This paragraph needs clarification between "direct" and "indirect" measures of SSA. Again, what is a measurement? What is a retrieval? What are the pluses and minuses of each? I see that in the next paragraph some of this explanation is attempted, but the organization of the whole delivery is confusing.*****

Figure 1 caption. State the wavelength.

Line 214-215. Some places on the globe will not have a lot of retrievals because AOD is usually low and there is an AI criteria as to when to retrieve. There might only be one retrieval in that grid box in 5 years. Do the plots in Fig. 1 show points like these?

Is that a fair representation of the climatology?

Lines 217-219. Are these statements based on Figure 1 or some previous work or understanding? Because they don't match what I see in Figure 1. Even if you ignore the tropical Atlantic because of dust, I see a lot of SSA in the 0.9 to 0.95 range in the open oceans and near land, I don't see anything that gets lower than 0.85. Where is the 0.75?

Line 220-221. From my own studies based on AOD_550, not AI, the threshold is AOD_550 = 0.30. Greater than that and I don't see the ocean anymore.

Lines 238-240. What happens when one method has a value and the other method does not? This should be stated in the text, and possibly the caption to Figure 2. This in itself is of a lot of interest to people. *****Why is OMI retrieving so much more than OMI-MODIS?**** You mention OMI is cloud contaminated and MODIS is not. Is this difference in number of retrievals due to cloud masking? Can you prove that? *****Because the cloud masking issue is never addressed anywhere in the paper.*****

Figure 2 caption. We need the wavelength of the SSA, and in the caption, it should tell us that it is OMI-MODIS minus OMI. It should also tell us what happens when one product has values and the other does not.

Line 245-247. What are natural aerosols here and what are anthropogenic? Dust and smoke? Please clarify. Also, at least at this point it's not easy for me to see how differences in the method results are linked to actual aerosol properties. The speculation here seems premature. Most importantly, rather than dwelling on the differences in aerosol types/properties the text should mention problems with the height assumption. That would be my first guess as to what I'm seeing here, not aerosol types. Also the differences are relatively small, within what I would expect to be the uncertainty in any satellite retrieval of SSA.

Figure 4. That isn't southern Africa. Maybe call it Central Africa? Same for Figure 5.

Table 2 and 3. Don't use numbers for regions. Use their names. Also, this is not for the "Atlantic Ocean", but for one specific point in the Atlantic Ocean. Likewise for the Arabian Sea.

Lines 286-291. "Harriss et al. (1984), found that there is advection of anthropogenic pollutants from North America to the North Atlantic Ocean." I don't have time to look up that reference, but does it include that one point at 15N 45 W? Also 1984 is a long, long time ago. Aerosols in North America have changed significantly since then and your study period is 2009-2010. Also there is no reference on the NOAA-11 study. 1988-2004. That's a bit better in terms of matching this paper's study period, but not much.

Lines 299-300. I can visualize, maybe, a large scale circulation that is creating westerlies aloft during winter and spring at that point. It would have to be the winter time baroclinic systems dipping far south. The question though is that at least in winter there would be no aerosol associated with that flow. Spring time you may be getting biomass burning from Mexico. ****It would be useful to better describe the meteorology affecting the situation.*****

Lines 302-331. The meteorological description here is much better than that over the Atlantic. Here, a single point in the middle of the Arabian Sea is better representative of the entire region than a single point in the north tropical Atlantic trying to represent the entire "Atlantic Ocean". But also the authors just convey a much clearer understanding of the meteorological and aerosol forces influencing that point in the Arabian sea than they do in the north tropical Atlantic.

Lines 332 -336. These sentences are so convoluted I don't understand the point the authors are trying to make.

Lines 355-357. Here the terms natural and anthropogenic are being used without really defining them.

****Trajectory analysis overall. I don't see how all this work connects to the rest of the paper.****

Lines 362-365. From the histograms I don't see much differences between the Atlantic and the Arabian Sea in terms of how well the results from the two methods match. What is considered "reasonably good agreement"?

Line 363. Can you remind the reader which season is the dust season? From the histograms, it looks like MAM is the least biased season, and that is not the dust season, right?

Line 365, but I do agree that height should be the important factor, not aerosol type.

Lines 367-369. I'm not sure what is meant here. In this work the ALH is calculated for OMI using the best estimate of SSA retrieved from OMI. This is the operational OMI-only retrieval we are talking about, not the OMI-MODIS retrieval, right? How is the best estimate SSA determined? This retrieval returns 5 ordered pairs of (SSA, ALH) and the retrieval fixes ALH and returns SSA. Fine. Now, in this work, the authors are going to fix SSA and return ALH. Ok. But. . . how do they decide on an SSA? The caption for Figure 7 explains it, but the text should match.

Figure 7. Very good and informative caption. They should all be this good.

Lines 372-373. This assumes that the OMI-MODIS retrieval is correction, which has not been proven. The wording is also awkward for me. What I would say is this: The most important observation from this analysis is that the operational OMI-only retrieval of SSA overestimates SSA when it also overestimates ALH, and vice-versa.

Lines 374-379. Does it matter whether or not the operational OMI uses CALIPSO climatology or the prior assumptions? Did you study this? I don't think so. The algorithm isn't using real-time collocated CALIPSO. It is using CALIPSO climatology. There could still be issues. Anyway, because you didn't actually study the difference between CALIPSO climatology and prior climatology, these details here are just distracting.

Lines 379-381. This sentence is very good and valuable.

Lines 382-390. I don't know understand the point the authors are trying to make here. The paragraph wanders.

Line 396 is unfinished

Lines 391-404, and Figures 8 and 9. These are not earth-shattering results. We all know this. I don't have time to look back into the old Deep Blue papers, but this is the basis for that algorithm. *****I'm not opposed to including this analysis in the paper, but it has to be put into context with previous work. **** Also, I might combine Figures 8 and 9 into a single 2-panel figure.

Figure 10 caption needs a lot more detail. What does each point represent in terms of spatial/temporal averaging? What is the correlation? Is there any correlation?

Line 428. I think it is an accident that the MODIS-OMI mean matches the cruise exactly. The statistics tell the same story that I see with my eye. . . The two retrievals match the cruise about the same, to within their expected uncertainties.

Section 5.4 as a whole. It's dangerous to expect the total column ambient retrievals to match whatever was making in situ measurements at the ocean surface. Different everything. Some of these caveats need to be expressed in this section. ****Also and this is critical. . . we need to know what instrument was used on the cruise and exactly what it measured. What wavelength? What method? Did it dry aerosols or not? The name of the ship. Other things. Details here are essential.****

Lines 457-458, or chances in ALH as the SAL cools and descends, right? I saw that gradient and I thought ALH right away, not changing aerosol properties.

Line 459. "OMI overestimates SSA at lower ALH and underestimates at higher values of ALH." Sure, if the OMI-MODIS is true.

Lines 459-463. ****Again, I don't think you can say anything about the differences

between CALIPSO climatology versus prior climatology. This should not be here in the major conclusions. What I might say here is, "Despite the operational algorithm moving to CALIPSO climatology, we continue to find systematic differences in the algorithm's SSA-ALH retrieval, when compared with the more robust OMI-MODIS retrieval. This may be due to situations when CALIPSO climatology is missing and the algorithm reverts to prior assumptions, or more likely, it may be due to lingering uncertainties in ALH even when using the improved climatology."****

Line 464-466. ****Again, we all already know this. It is strange to find it in the major conclusions.****

Lines 467-470. ****I think you are writing the way you wished it turned out. What you actually found that there was no significant difference between the OMI and OMI-MODIS retrieval in matching the cruise data, although the overall mean OMI-MODIS SSA for the area and period showed virtually no bias against the cruise data, while the OMI-only retrieval mean was biased 0.013 too high.*****

Lines 471-472. I'm not sure about this point at all.

Line 474-475. ****What makes you say that the OMI-MODIS is able to detect absorbing aerosols much better than OMI? Detect is not the same as retrieving SSA. Keep that in mind. Note also in the global maps OMI has much better coverage than OMI-MODIS. Why? You never discussed that and it's important. Is OMI reporting cloud contaminated results? Or is OMI much better at detection? *****

Please also note the supplement to this comment:
https://www.atmos-chem-phys-discuss.net/acp-2018-564/acp-2018-564-RC2-supplement.pdf

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