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Atmospheric Measurement Techniques Discussions

Interactive comment on "Validating MODIS Above-cloud Aerosol Optical Depth Retrieved from "Color Ratio" Algorithm using Direct Measurements made by NASA's Airborne AATS and 4STAR Sensors" *by* Hiren Jethva et al.

A. M. Sayer (Referee)

andrew.sayer@nasa.gov

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I am posting this review under my own name (Andrew Sayer) as I have collaborated with most of the co-authors of this manuscript on this or related topics. I agree with the other reviewers that the manuscript is good and is suitable for publication in AMT after some (mostly minor) revisions, and agree with the specific comments and suggestions that they have made. I'd be happy to review a revised version of the paper if the editor would like.

The one respect in which I disagree with the author (page 3 lines 20-21) and reviewers

is that this isn't the first time an above-cloud AOD product validation has been published. We did so (using the same SAFARI-2000 and ACE-Asia campaigns) for our own MODIS above-cloud aerosol algorithm in Sayer et al (2016). However as that is quite a new paper, perhaps the reviewers/lead author missed it (it is not cited). So this text should be amended (the abstract makes a similar statement although there it does say it is talking about the colour ratio method). Still, this does not diminish the fact that data set validation is very important and the availability of data to validate this type of algorithm is at present very limited. I strongly support the ongoing collection and analysis of more field data of this type, and congratulate the authors on achieving good performance for the colour ratio algorithm in these case studies.

What is also interesting is that in Sayer et al (2016) we found the same campaign-dependent differences between cloud optical depths from our product vs. the MODIS operational cloud data set (i.e. large positive offset for SAFARI, smaller offset for ACE-ASIA). We also attributed this to differences in aerosol optical properties between the campaigns. Given that our algorithms are distinct (although share similarities), this is perhaps worth mentioning in the revised paper.

I have a general comment about the co-location criteria discussed in section 2.2. The temporal aspect of the matchups was not discussed here. However, in most cases the airborne and satellite data were not collected simultaneously. For example, in the SAFARI-2000 case, the Terra overpass was at 09:25 UTC and the relevant flight segment was from 10:00-13:00 UTC (i.e. between 0.5 and 3.5 hours later). For this specific case we examined the spatiotemporal variability of the AATS and MODIS data, as well as AERONET data affected by the same large-scale smoke event, and concluded that spatiotemporal variability of the aerosol field was sufficiently small that it was probably ok to use this case for validation (it was a very large and fairly homogeneous smoke cloud). Still the idea of doing a pixel-to-pixel spatial match with this time difference is in my view stretching things a little because there will have been some scene changes. For this reason in Sayer et al (2016) we took a box-average for the comparison (i.e. one

point per case study scene) rather than a spatial match along the flight track (i.e. interpreting the spatial variability on the scales of several pixels and having multiple points in the scatter plot for this scene is probably overanalysing the data in terms of spatial structure, in my view). We reported satellite and AATS mean, median, and standard deviation.

For the 4 May ACE-Asia case, which we also looked at in Sayer et al (2016), the Terra overpass (02:25 UTC) was right in the middle of the flight segment (02:00-03:00 UTC for the cloud we identified) so there was much less temporal mismatch. I am not sure why this case is omitted from the maps in Figure 1? Could it be added, so we can see which cloud(s) were observed and how the retrieval looks?

We investigated but did not use the April 20-30 ACE-Asia cases because the time difference between the flight segments and Terra overpass was too large, so judged that the spatiotemporal variability of the aerosol was too high to use this as a validation case. Looking through my notes, the Terra overpass on April 20 was at 02:10 UTC and the flight was from around 00:00 to 09:00 UTC. Around 02:10 UTC, the plane was around 34.5 N, 140 E, and travelling NE. From Figure 1, there are not many clouds here. The aerosol-laden clouds in the lower panel are in two parts. The area with the clouds on the earlier leg of the flight (around 39 N, 146 E) was overflown around 03:30-04:00 UTC by the aircraft, so about 1.5-2 hours after Terra. The area with the clouds on the later leg of the flight (going from the northern part of the scene down to the SW, going along the northern side of Honshu), was overflown by the aircraft from around 06:00-09:00 UTC, about 4-7 hours after Terra.

For the April 30 flight, the Terra overpass was around 02:50 UTC. The flight was from about 03:10 to 8:20 UTC. The main region with above-cloud aerosols shown in Figure 1 is from about 26 N, 123 E to 32 N, 127 E and was overflown from around 05:45 to 07:30 UTC, around 3 to 4.5 hours after the Terra overpass.

These time mismatches make the idea of using the data points from these two ACE-

Asia flights for validation questionable, in my view, unless there is evidence (as in the SAFARI-2000 case) that the aerosol field was fairly spatiotemporally uniform on these scales. Figure 1 suggests that for these ACE-Asia scenes the AOD field was variable in space and time, based on AATS data, although the sampling is limited. These time mismatches might also explain the increased discrepancies compared to the expected retrieval error seen for some of the ACE-Asia cases in Figure 2 (or it might be coincidental).

We did not analyse the SEAC4RS case from August 6 2013 in Sayer et al (2016) so I'm unsure what the time difference was there, but it should be stated. Did Terra observe the same area? This is the only case study which happened during both Terra and Aqua's lifetimes, so if the timing is right then it would be an interesting opportunity to also compare MODIS Terra vs. Aqua in the presence of the 4STAR validation data.

It is probably fine to keep all these comparisons in the paper, but the time differences for each case and their potential effects should be stated since the measurements are not simultaneous. For 'standard' clear-sky AERONET validation we are fortunate that we are normally able to get near-simultaneous observations (typically within 30 minutes or less), so it is important to point out that we can't always be so lucky here as the reader may not think of this aspect.

Also in section 2.2, the scaling of AOD to the cloud top altitude is an important step. The authors describe their method on pages 5-6 lines 30-1. It would be good to add a figure to illustrate this process for one of the case studies as well, to show the vertical aerosol profile. Is there any estimate of the uncertainty added by this AOD scaling (due to e.g. measurement uncertainty and uncertainty in the satellite-retrieved cloud pressure)?

References:

Sayer A. M., N. C. Hsu, C. Bettenhausen, J. Lee, J. Redemann, B. Schmid, and Y. Shinozuka (2016), Extending "Deep Blue" aerosol retrieval coverage to cases of ab-

sorbing aerosols above clouds: Sensitivity analysis and first case studies, J. Geophys. Res. Atmos., 121, 4830–4854, doi:10.1002/2015JD024729.

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