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Atmospheric Measurement Techniques Discussions
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Interactive comment on "Consistency of aerosols above clouds characterisation from A-Train active and passive measurements" *by* Lucia T. Deaconu et al.

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Manuscript title: Consistency of aerosols above clouds characterisation from A-Train active and passive measurements

Authors: Lucia T. Deaconu and Co-authors

General comments to the Editor:

Dear Editor,

The author presents a comprehensive regional as well as a global comparison of

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Discussion paper

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the above-cloud aerosol optical thickness (ACAOT) and Angstrom Exponent (AE) retrieved from the satellite-based active (CALIOP onboard CALIPSO) and passive sensors (POLDER on board PARASOL), with an aim to check the consistency between the fundamentally different retrieval techniques. The comparative analysis for the hotspot regions of absorbing aerosols above clouds, i.e, Southeastern Atlantic Ocean (smoke above cloud), tropical/North Atlantic Ocean off the coast of Sahara which is also commonly referred to as 'dust belt', and biomass burning areas of Siberia, reveals an overall good agreement between POLDER and CALIOP-based De-polarization method (DRM) retrievals when either fine or coarse mode particles are dominant in the respective regions. The comparison was also found reasonable on a global scale when the aerosol layer was well-separated from clouds in the vertical column. The author finds a lower correlation between the active/passive retrievals when mixtures of aerosols are expected and/or when the aerosol layer is attached to the top of the cloud deck. The agreement between the ACAOT retrievals from POLDER retrievals and that from the standard operational CALIOP method is found consistently poor, where the later was hugely underestimated by a factor of two to four. Author also investigates different causes of potential biases in both POLDER as well as DRM based results through sensitivity analysis and finds that dynamics in the cloud microphysics, i.e., variations in cloud effective radius and aerosol-cloud mixture at the cloud top, which if unaccounted in the inversion algorithm, can potentially impact the retrievals from CALIOP-based DRM and POLDER method, respectively.

The first thing that struck me while reviewing the paper was that authors didn't include the CALIOP-based "color ratio" retrievals, which have been shown to perform best in the smoke-above-cloud environment (Chand et al., 2007, 2008, Jethva et al., 2014), in the present analysis. This product is currently not available in the public domain. However, I strongly recommend authors to take Duli Chand (PNNL), the developer of color ratio based ACAOT retrieval, on board and include the results at least for the Southeastern Atlantic region where smoke particles above the cloud decks are observed during biomass burning period (July-Aug-Sep).

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We, the OMI aerosol group at NASA Goddard, have also developed a near-UV based method to detect and retrieve ACAOT on a global scale [Torres et al., 2012; Jethva et al, 2016]. The method has been applied to the entire record of OMI on board Aura platform (Oct 2004 to present). The resultant OMACA (OMI above cloud aerosols) product was made available freely to public in July 2016 and can be accessed at the Aura validation web portal:

https://avdc.gsfc.nasa.gov/pub/data/satellite/Aura/OMI/V03/L2/OMACA/

The paper is already length and full of POLDER-CALIOP results. However, if space and time permit, I would suggest the author carry out a comparison between POLDER and OMI on a monthly scale for the Southeastern (smoke) and North Atlantic Ocean (dust) regions in order to check the consistency between the two passive retrieval techniques. Regional maps of ACAOT from POLDER/OMI for a season (say July-Aug-Sep) would be sufficient.

While the paper presents the results of the comparison in detail and also investigates the causes of differences between different techniques, a discussion on how to actually 'validate' the satellite-based ACAOT against the airborne 'truth' is completely missing. I am sure the authors are aware of the ongoing ORACLES (https://espo.nasa.gov/oracles) and CLARIFY-2016 field campaigns that are specifically aimed to provide us in situ and remote sensing measurements of the optical and microphysical properties of aerosols above cloud over the Southeastern Atlantic Ocean. These datasets will be extremely valuable in validating not just the satellite-based ACAOT retrievals but also for verifying and improving the aerosol and cloud models assumed in the inversion. A paragraph or two is needed that describes the validation plan for the CALIOP and POLDER above-cloud aerosol products.

The paper is well-organized with sufficient details both in the text as well as in Figure and Tables. The language and grammar are easy to follow. The methodology, data analysis, and conclusions look consistent. The content presented in the manuscript

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perfectly fits within the scope of the Atmos. Meas. Tech.

Please share my general addressed to you with the authors who are requested to provide satisfactory explanations on my specific comments and suggestions given below.

Thanks,

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Specific comments:

Abstract Page 1 Line 11: CALIOP/CALIPSO (in order to be consistent with POLDER/PARASOL)

Line 12: "We compare" would be the better word. Line 12: "...between the results derived from the active and passive measurements" Line 19: "Four and a half year of data..." Line 27: "...between the CALIOP operational method and POLDER is found to be low"

Introduction Page 2 Line 7: "...by modifying the cloud reflectivity and micro-physics" Line 11: "..but also on the reflective properties of underlying surface" Line 20: "..as a source of uncertainty for the estimation of all-sky DRE of aerosols" Line 21: Sundar Christopher's group at UAH has published a paper on measurements based estimation of DRE. Here is the citation. Please include it. Feng, N., and S. A. Christopher (2015), Measurement-based estimates of direct radiative effects of absorbing aerosols above clouds. J. Geophys. Res. Atmos., 120, 6908–6921. doi: 10.1002/2015JD023252. Line 24: "...remains a subject of large uncertainty" Line 30: "...when aerosol layers are in contact with the top layers of cloud deck"

Page 3 Line 4: "Passive imagers offer larger spatial coverage" Line 7-8: These claims are referred to the cloud-free aerosol retrievals. Torres et al. (2012) paper introduced

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the near-UV technique to quantify the AOD above cloud, not SSA. Line 23: "..situated underneath the aerosol layer as the background"?

Page 4: Line 24: "...with an aim of assessing the consistency (and lack thereof) between the two independently derived ACAOTs. Line 32: Chand et al. (2008, 2009) and Jethva et al. (2014) have shown that the CALIOP-based CRM works best for fine mode absorbing particles. Two of the regions selected in this study, i.e., Southeastern Atlantic Ocean and Siberian wildfire areas are known for the presence of strongly absorbing biomass burning aerosols. The CRM retrieval owing to its suitability in these environments would give a better estimate of aerosol loading above clouds. Note that CRM, similar to the DRM, does not require to assume specific aerosol and cloud microphysical model. I strongly recommend the author to take Duli Chand, the developer of CRM, on board and include the ACAOT retrievals for the inter-comparison.

Page 6, Line 1-2: "Lastly, AOT retrieved at 6 km spatial resolution are aggregated to 18 km x 18 km spatial grid." Page 6, Line 2-3: Restricting the standard deviation in AOT to 0.1 would likely mask the actual spatial inhomogeneity in the above-cloud aerosol field. Page 8, Line 6: "the developers of" Page 10, Line 8: "The A-train satellite pass through close orbits within several minutes"

Page 10, Last paragraph: CALIOP Aerosol Layer Product ALay uses the signal at 532 nm to locate the layers of aerosols. In the presence of heavy loading of absorbing aerosols, such as observed over the Southeastern Atlantic Ocean, the signal at 532 attenuates rapidly due to aerosol absorption effects within the top layers of aerosols. This results in diminished magnitudes of back-scatter as the lidar light penetrates further into the aerosol layer. After some depth of penetration, the signal falls within the noise levels and therefore rejected for any meaningful interpretation. This is precisely the reason why standard CALIOP above-cloud AOD product at least over the Southeastern Atlantic Ocean is underestimated compared to other A-train based above-cloud AOD retrievals [Jethva et al., 2014]. I believe in such cases, the CALIOP ALay product would show a greater number of separated ("detached") layers than mixed layers.

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Page 12, Line 3-4: It would be extremely useful to also show the CALIOP 1064-nm back-scatter curtain plot for these events. I expect the 1064-nm results would show deeper extent aerosols in the vertical column. Page 17, Line 9: Please refer to Meyer et al. [2015] paper which documents the uncertainty in the cloud effective radius retrievals due to the presence of absorbing aerosols over cloud. I guess it is <5%.

Here is the citation: Meyer, K., S. Platnick, and Z. Zhang (2015), Simultaneously inferring above-cloud absorbing aerosol optical thickness and underlying liquid phase cloud optical and microphysical properties using MODIS. J. Geophys. Res. Atmos., 120, 5524–5547. doi: 10.1002/2015JD023128.

Page 17, Line 10-14: The effect of cloud effective radius on DRM(SODA) could be larger for moderate to high aerosol loading ("detached" cases). Page 20, Line 7: "Aerosols as a solution within the cloud droplets..." Page 20, Line 13-14: What is the overall uncertainty in DRM-retrieved AOT when lidar ratio changed from say 19 sr to 25 sr or 29 sr. Page 20, Line 28: "...with respect to other methods." Page 20, Line 31: "impacts" Page 21, Line 23-23: Do author think that the imaginary part of the refractive index is also important and can affect the retrieval accuracy?

Figure 9. Aerosols above cloud is a regional phenomenon. The global plot of attenuated back-scatter shown in Figure 9 is not a representative of what is happening over the prominent region of AAC i.e., over the Southeastern Atlantic Ocean, the tropical Atlantic Ocean off the coast of Sahara, South-East Asia (springtime agricultural fires), and northern Arabian Sea (dust above cloud). The author should focus on these regions and create similar plots, particularly for the Southeastern Atlantic Ocean, tropical Atlantic Ocean.

Figure 10 should be recomputed in accordance with the CALIOP back-scatter results for above regions. Figure 10. This simulation is a bit confusing. The cloud layer is located between 0 and 1 km and two of four aerosol simulation cases (blue and red) locate aerosols within the clouds. The third case (orange) has an aerosol layer with

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half the depth merged into the clouds and the half on top of the cloud. The fourth one is truly a detached case.

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