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Atmospheric Measurement Techniques Discussions
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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.

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RC: Referee comments

AR: Author's response

We thank anonymous referee # 3 for his comments and suggestions that have helped us in improving our manuscript.

RC: p. 2, line 19: particular instead of paricularl

AR: Typo corrected.

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RC: p. 2, line 22: About use of SWIR vs NIR terminology

AR: We agree with the reviewer. We used term SWIR loosely here; the 860 nm measurements used in the above-cloud AOD retrieval belongs to near-IR region. SWIR term has been replaced with near-infrared (NIR) throughout the manuscript.

RC: p. 5, line 2: "MODIS visible/NIR observations"

AR: Reviewer is correct; the 'color ratio' technique uses both visible (470 nm) and NIR measurements (860 nm).

Suggestion added in the revised text.

RC: p. 5, line 4: I assume the authors use the newest Collection 6 MODIS data? This should be clearly stated.

AR: Yes, we have used MODIS Collection 006 dataset for all case studies presented in the manuscript. The text in section 2.2 MODIS (under section 2.0 Dataset) is revised as "In the present analysis, we use MODIS Collection 006 products obtained from http://ladsweb.nascom.nasa.gov/data/".

RC: p. 5, line 34 – p. 6, line 1: Looking at the RGB images in Fig. 1, it appears that the aircraft samples a quite diverse region of the aerosol plumes (e.g., both the middle and edges), particularly evident in the Apr 20, 2001 ACE –ASIA case and the SEAC4RS case. Is the assumption that the AOD profile is constant throughout the flight therefore valid? It seems to me that the profile could be quite different at plume edge than at plume center. Can the authors comment on this, and perhaps provide the profile statistics for each flight?

AR: The scaling of AOD from aircraft-level to the cloud top pressure was done using the measured profile of AOD at a particular location during respective flights. While it is possible that vertical structure of aerosols over the cloudy regions away from the measured location may be different, the profile measured by AATS/4STAR is the best educated guess at our disposal to scale the AOD to cloud top pressure. A sensitivity study for the SAFARI-2000 case in which the cloud top pressure perturbed by ± 50 hPa and ±100 hPa from its retrieved values from MODIS resulted in the RMS difference (MODIS minus AATS) of ±0.02 and ±0.05, respectively. These magnitudes of error are comparable to the absolute error in the AATS measurements. The reason for low errors in AOD scaling for this case could be the fact that the AOD measured by AATS between 850 and 900 hPa is almost similar and the MODIS-retrieved cloud top pressure for the matchups points mostly fall in this range of pressure, making not much difference in the scaling even if cloud top pressure is perturbed by ±100 hPa. It is possible that the uncertainty associated with the scaling of AOD would be larger than 0.05 if the sign of error in measurements and cloud retrievals both are on one side, or even can cancel each other if the sign is in opposite direction.

The scaling procedure is now better demonstrated with equations accompanied by a figure for the SAFARI-2000 case in section 2.3 Co-location of Satellite-Airborne Sensors. Also the sensitivity results discussed above have been included in section 4.1 Sources of Uncertainties in ACAOD in the revised manuscript.

RC: p. 7, lines 5 & 7: The authors refer to SSA at 470nm when discussing the absorption effects on the MODIS cloud optical thickness retrievals. However, the MODIS retrievals use either 670nm (over land) or 860nm (over ocean) to retrieve COT. Consider referring to SSA at 860nm instead.

AR: The SSA is now referenced at 860 nm in the revised text as follows. Long-term ground-based aerosol inversions made by AERONET over respective regions shows that carbonaceous aerosols generated from biomass burning over southern Africa are strongly absorbing with SSA of âĹij 0.85 and âĹij 0.79 at 470 nm and 860 nm, respectively, whereas aerosols encountered over North-East Asia and western USA during months of the events studied here exhibit relatively weaker absorption capacity (SSA at 860 nm âĹij 0.92 and âĹij 0.86).

RC: p. 7, lines 9-11: Not only is the aerosol absorption smaller for the radiative models assumed in these cases, but the retrieved AOD is also smaller than what is retrieved in the SAFARI case, which implies a smaller impact on retrieved COT regardless of the aerosol model absorption.

AR: We agree with the reviewer that both smaller magnitudes of AOD and higher SSA (less absorption) imply smaller impact on retrieved COT. As stated in the manuscript "the negative bias in COD retrieval is directly proportional to the strength of absorption above cloud, which is expressed as the absorption aerosol optical depth (AAOD=AOD*(1-SSA))." Smaller amounts of aerosol loading with higher SSA yield smaller AAOD and thus result in lesser bias in COT retrieval.

The lower AOD aspect of the bias in cloud retrieval as suggested by the reviewer has been discussed in the revised paper.

RC: p. 8, line 31: Passive satellite imagers do not "measure" any quantities other than reflected/emitted radiation. All retrievals are therefore derived, or inferred, quantities.

AR: The statement has been revised as "Now satellite-based remote sensing techniques using passive sensors are beginning to quantitatively retrieve aerosol loading above cloud over a large spatial domain"

RC: p. 9, lines 19-20: Indeed, constraining the aerosol model is perhaps the most important contribution these campaigns will provide to the passive satellite retrieval science. In my opinion, for these passive above-cloud AOD retrievals, validation efforts such as the one shown here are fundamentally assessments of the aerosol models assumed in the retrievals.

AR: Since the above-cloud AOD retrievals are most sensitive to the assumption about radiative properties of aerosol model, specifically the imaginary index and thus SSA [Torres, et al., 2012; Jethva et al., 2013; Meyer et al., 2015], the accuracy (or lack thereof) of the satellite-based ACAOD can be interpreted as the assessment of the aerosol models assumed in the inversion. The ORACLES campaign has already been kicked off in Namibia during the last week of August 2016 (https://espo.nasa.gov/oracles). In situ and remote sensing measurements from ORACLS of both lofted aerosol layers and cloud beneath will be germane to assess the validity of the algorithmic assumptions and resultant accuracy of the satellite-based ACAOD retrievals.

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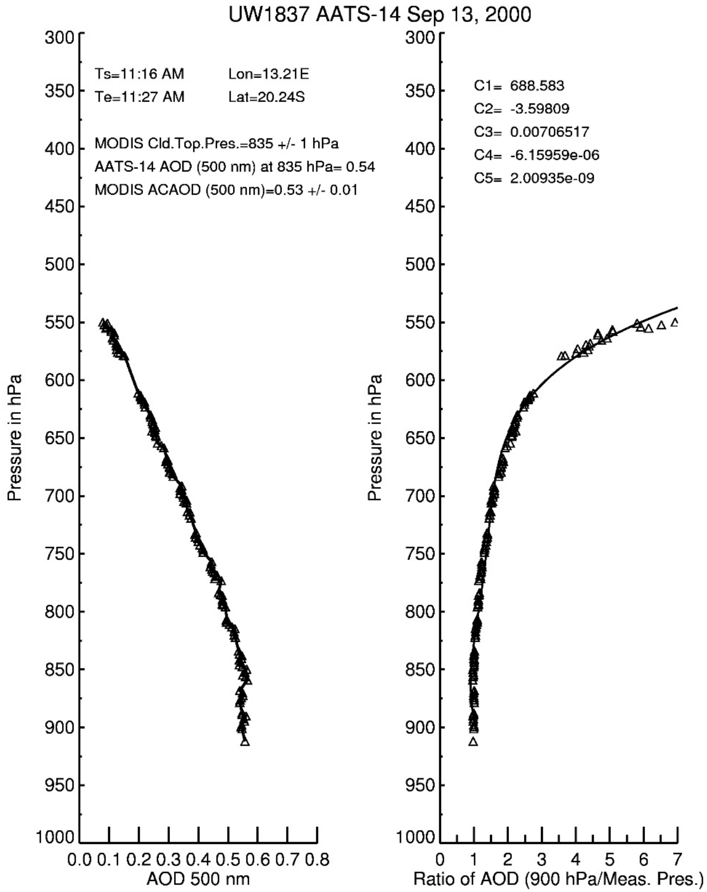

Fig. 1. Vertical profile of above-aircraft columnar AOD (left) and ratio of AOD (right) measured by AATS-14 during SAFARI-2000 flight UW1837 flew on September 13, 2000 over the Walvis Bay.

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