

Interactive comment on “A new measurement approach for validating satellite-based above cloud aerosol optical depth” by Charles K. Gatebe et al.

Anonymous Referee #2

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Summary:

This paper presents a method to quantify the aerosol optical depth above and below clouds from measurements of side scattered light by CAR instrument during SAFARI-2000, onboard the UW CV-580 research aircraft. This novel use of sky radiance and cloud reflectances in combination with the color ratio technique for retrieving aerosol optical properties above cloud seems very interesting. The manuscript presents extensively multiple measurement cases, and their related retrieval. The great agreement with an airborne sunphotometer gives much confidence to the methods and results presented.

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The manuscript is well written and reads well. It is suggested that this manuscript is to be published with major revision. The following shows major comment, and following with minor general and specific comments.

Major Comment:

There is little mention of the scattering phase function, asymmetry parameter or otherwise which are used in the retrieval methodology of this study. The retrieved above cloud aerosol optical depth presented seem to show distinct dependence on scattering angle, which is likely a large retrieval artifact, which is not at all discussed in this manuscript. There seems to be significant non-uniform aerosol optical depth within the hemisphere that seems to be related to scattering angle (at various view zenith angles) and not to the actual aerosol plume shape (Fig. 8). Is this a remnant of an inconsistent assumption in aerosol scattering phase function, or maybe incongruent asymmetry parameter? This calls into question much of the retrieval methodology. Similar considerations are raised with the seemingly always centered high in AOD_cloudtop. Albeit the very good match with AATS, one would suspect that the asymmetry parameter, or the underlying scattering phase function may be erroneous, but on average a good approximation, with its high biases compensating for its low bias.

This variation, that could be caused by a bad scattering phase function, may also be a causal link to one of the major findings of the paper, where the cloud optical depth is anti-correlated to the above cloud aerosol optical depth.

General Comments:

1. In the introduction there should be mention, and comparison of a color ratio method for above cloud AOD by Meyer et al., 2015, that is applied to MODIS, and/or similarly from Peers et al., 2015. Additionally, there is little mention of the recent work based on the ORACLES measurements that follows from SAFARI. Potential to reference Redemann et al., 2020, and potentially LeBlanc et al., 2020.

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2. Discussion of the impacts of the absorption properties of aerosol seems missing, particularly when referencing the color ratio technique in Section 2.2. Maybe a reference to the absorption properties from other radiative measurements during SAFARI; Bergstrom et al., 2003, or alternatively on the variations of the absorption as showcased by Pistone et al., 2019.

3. Presentation of the figure 12, combining the AOD_cloudtop and AOD_sky might be better suited if there is inclusion of the measurement altitude, which might help indicate the partitioning. P.9 line 261: AOD from AATS would be representative either if directly above clouds, or below all significant layer of aerosol in the event of a clear-air-slot between cloud top and the bottom of the aerosol layer. It is suggested to add this caveat. The conclusion mentions this note again, but some care can be taken by careful data selection of sunphotometer data as presented by LeBlanc et al., 2020.

Specific Comments:

4. P.4 lines 121-122, AATS and 4STAR acronyms are not defined, please define and add pertinent citations.

5. P.8 line 236: typo: 'between' should be 'between'

6. Table 1 shows an error value of 0.00 for much of the AATS AOD, this seems improbable and likely missing a significant digit. Additionally, there is no mention of what wavelength these AODs are reported (as compared to the retrieved ACAOD).

7. Figure 4, There are no units on the colorbars, or the title is misleading – shouldn't it be radiance values in $W/m^2/nm/sr$, or is it normalized radiances? If normalized radiance, it is normalized to what? The solar disc is apparently saturated, therefore if you normalize to that value, wouldn't that be misleading?

8. Figure 4 a) & c), the solar disc seems to be not centered on the scattered light plot. The 0° line does not seem to be in line with the principal plane.

9. Figure 8, the AOD above clouds retrieval at the solar disc seems drastically different

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than the surrounding region outside of the non-valid region.

10. Figure 12 – the figure caption lacks the identifier 'Figure 12:'

References:

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