

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

### **Anonymous Referee #1**

Received and published: 21 August 2020

General Comments: The aim of this manuscript is to retrieve aerosol optical depth above clouds using a novel airborne measurement approach of simultaneously measuring scattered radiation above and below the aircraft, and thereby demonstrate an effective observational tool to validate satellite-based aerosol retrievals above clouds. The authors used NASA's Cloud Absorption Radiometer on board UW CV-580 during SAFARI-2000 field campaign off Namibia coast focusing on a case study on 13 September 2000. The major advantage of the instrument is its complete azimuth measurements of sky and reflected radiances. This capability allows above-cloud AOD retrieval for 1) above the aircraft and 2) below the aircraft, both of which were above maritime stratocumulus clouds. This work expands the capability of retrieving aerosols

C1

below aircraft that cannot be performed on an airborne sunphotometer. The authors also qualitatively addressed the 3D effect of clouds on the above-cloud AOD retrieval and the COD retrieval. The scientific novelty are suitable for publication in AMT but needs a better structuring, textual clarification, and major improvements on the figure quality. Please see below for the specific comments and technical corrections.

Specific Comments:

Line 72: Need to cite Redemann et al. (2020)

Redemann, J., Wood, R., Zuidema, P., Doherty, S. J., Luna, B., LeBlanc, S. E., et al. (2020). An overview of the ORACLES (ObseRvations of Aerosols above CLouds and their intEractionS) project: aerosol-cloud-radiation interactions in the Southeast Atlantic basin (preprint). Atmospheric Chemistry and Physics Discussions. <https://doi.org/10.5194/acp-2020-449>

Line 141 – 152. “Reflectances” is mentioned frequently in this paragraph, but Figure 4 only refers to sky radiance and reflected radiance. Also, please state the radiance and BRF unit.

Line 143 – 145. “reflectances. ...larger by factor of >3” Does this sentence refer to Figure 4e?

Line 145. “This asymmetry. ...directions” Which figure panel does it refer to ?

Line 185-284. Do the retrievals assume the same aerosol intensive properties in Table 3? It appears that Table 3 only applies to 3D effect analysis.

Line 205-207. The angle information should move to the methods section.

Line 209. “correlation” is a wrong word choice unless you provide a correlation coefficient for these comparisons. Otherwise, I would mention “A careful qualitative inspection”

Line 245- 247. Since ACAOD and COD retrieval uncertainties vary at various viewing

C2

zenith and azimuth (i.e., scattering angle), it is not enough to rely on the uncertainty analysis of a previous study. I expect some discussions on how ACAOD uncertainties vary at different sensor angles for different assumed aerosol model, particularly on the SSA.

Line 248-250. It's unclear how the AOD value for each case are obtained when the AOD values differ at various angles as shown in Figures 8 and 9. This question ties to whether bad retrievals in heterogeneous conditions are included to compute the AOD.

Line 271-274. It's true that BRF in Fig. 6 is relatively more homogeneous for cases h-m, but retrieved CODs of these cases (Fig. 10) do not convince the homogeneity of clouds.

Line 280. "...40% higher. ..." If the total AOD is 0.7 and AOD-cloudtop is 0.2, then total AOD is 3.5 times higher. Please clarify my confusion.

Line 294. "retrieved COD drops by roughly 50% while the retrieved ACAOD increases by roughly 50%." This sentence needs a reference to the figure numbers.

Lines 299 – 302. This paragraph should be in the methods section. Please include citations of this simulator

Line 319. The equation does not have 1D CR values for COD=4.7, so it's unclear how this equation is solved.

Lines 320-321. Percentage bias in color-ratios do not result in the same percentage bias in ACAOD.

Line 327. "similar" is unclear to the reader. Do you mean similar differences between 0.47 and 0.87 micron?

Line 351-352. The notion about anticorrelation between AOD\_cloudtop and COD for COD >10 and COD <10 is not mentioned before the conclusion. This finding needs to be addressed before the conclusion. Also, correlation coefficients need to be provided

C3

when describing anticorrelations.

Line 353. "3D effects increase retrieved ACAOD by about 3-10%" The comment for line 320-321 applies here and applies to the abstract too.

Table 3. should be moved to the methods sections.

Figure 4. The dashed lines should only be the borders, but there are several extra dashed lines within the figure that need to be removed.

Figures 5, 6, 8, 9, 10, 11. The font sizes are too small for publication quality. I suggest the authors increase font to appropriate sizes and print out a figure to make sure they can see it properly on a hard copy paper. Each figure (except for figure 10) should only have one colorbar to avoid redundancy. Panel (i) in each figure has a red underline that should be removed.

The borders of the panel letter are not in consistent places and have inconsistent sizes. The authors need to either code the letter location or remove the border around the panel letter and make sure that the letters are in a similar relative location in each polar plots.

Figure 8, 9. At which wavelengths are ACAOD reported? How were the wavelength ACAOD conversions done, if any?

Technical Corrections:

Line 42. Remove "The"

Line 46-47. Provide acronyms for aerosol optical depth and cloud optical depth.

Line 57. "wavelength" -> wavelengths

Line 76. Remove comma

Line 78. Remove extra parenthesis

Line 89. Is it 2.303 micron as mentioned in Figure 2d?

C4

Line 121-122. What do AATS and 4STAR stand for?

Line 127. Is it 9 or 8 channels?

Line 161. Case "P" has solar zenith angle of 35.76 degrees, so 34 degrees seems incorrect.

Line 171. Remove "the"

Line 182-183. Attach this paragraph to the previous paragraph

Line 288. Remove the website link

Figure 2c. In the figure title, change "Cumulus Nimbus" to "Cumulonimbus"

Figure 2d. bandwidth => bandwidth

Figure 4. Please include units for radiance

Line 494. Spell out "BDRF"

Line 604. "Fig." -> "Figure"

Line 624. "Figure 12 " is missing

Table 1: longitude of case F is partially missing

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