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Reply on RC1

Norman T. O'Neill et al.

Author comment on "Relationship between the sub-micron fraction (SMF) and fine-mode fraction (FMF) in the context of AERONET retrievals" by Norman T. O'Neill et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2022-284-AC1, 2022

The referee's comments are presented in italic and our answers are written in plain text.
Modifications of the manuscript, if any, are written in plain bold text.

In this paper "Relationship between the sub-micron fraction (SMF) and fine mode fraction (FMF) in the context of AERONET retrievals", the authors explored differences between two AERONET products: sub-micron fraction from the AERONET inversion method and fine mode fraction (FMF) from the Spectral Deconvolution Algorithm. This is a well written paper with both the methods and results nicely presented. Also, FMF/SMF are widely used for discriminating fine from coarse mode aerosols, and thus this paper shall be of interest to AERONET data users as well as other readers. I recommend publication of this paper after some minor changes as listed below.

We thank the referee for the insightful feedback.

Comments:

1. *AERONET data may be subject to thin cirrus cloud contamination. How would thin cirrus cloud contamination affect results as illustrated in this study?*

As mentioned in line 199 (page 9) of our initial submission, all the data used is Version 3 Level 2.0. This is a cloud screened product, as mentioned at:
https://aeronet.gsfc.nasa.gov/new_web/data_description_AOD_V2.html
The AERONET cloud screening criteria are explained at:
https://aeronet.gsfc.nasa.gov/new_web/Documents/Cloud_scr.pdf
If, despite the screening criteria, some data is contaminated with very thin cirrus cloud, the cirrus will simply contribute to the coarse mode optical interpretation (as a large coarse mode aerosol). The analysis that is carried out in this paper will not change in any essential way.

2. *This is more of a thought than a request for changes. Log-normal size distributions are assumed for fine mode and coarse mode aerosols in this study. However, aerosol particle size distributions may not be perfect log-normal. Could some of the observed differences between FMF and SMF be attributed to non-perfect log-normal distributions?*

The SDA-derived FMF retrieval is a purely spectral (optical) retrieval while the AERinv PSD is perfectly general (aside from the constraints of finite bin size): lognormal fits are not part of the overarching arguments of the paper. The log-normal distribution employed in Figures 1 and 2 are only illustrative. We see that the sentence we wrote (in the discussion of Figure 2) wasn't clear enough: so we tried to clarify it:

We emphasize that lognormal fits to AERinv PSDs are not part of the empirical analysis process presented in this paper (nor do they have any role in the purely spectral SDA retrieval): rather the purpose of Figure 2 is to confirm the expected strong correlation between optical and microphysical CM cutoff fractions and thereby facilitate an understanding of ε_c's role in the dynamics of equation (7a).

3. *Page 160, "Figure 2 is a plot of ð□□□ð□□□ vs Δð□□□ð□□□/ð□□□ð□□□ for a variety of retrievals from the sites listed in Table 1". Could the authors be more specific about "a variety of retrievals"? Any criteria for selecting retrievals from the sites listed in Table 1? It is also confusing as the Figure 2 caption seems to indicate data points shown in Figure 2 are "simulated optical depth retrievals".*

Figure 2 is based on log-normal distributions and exact Mie calculations (for which we controlled all microphysical and optical parameters) that matched, as closely as possible, the actual AERinv and SDA inputs and retrievals. This allowed for exact (Mie- and lognormal-based) calculations of the ε_c and $\Delta S_c/S_c$ values in Figure 2. The only selection criteria for all the cases of Figure 2 was to cover a large ε_c range (a large variety of coarse mode aerosol types).

4. Figure 3, "$1 - \varepsilon_f$" shall be "$1 - \varepsilon_c - \varepsilon_f$" ?

No, when $\eta = 1$, at the extreme right of the Figure 3 scattergram, then $\eta' = (1 - \varepsilon_c - \varepsilon_f)\,\eta + \varepsilon_c = 1 - \varepsilon_c - \varepsilon_f + \varepsilon_c = 1 - \varepsilon_f$

5. *Line 200, "within a time window of ± 16 minutes about the nominal". Any reason for picking +- 16 minutes as the temporal window? Do the authors considered temporal homogeneity in spectral AODs in their data selection steps?*

The selected time window is a trade-off between insuring temporal homogeneity and maximizing the number of SDA retrievals (to attain statistically meaningful average whose natural variation is minimal). It was a time window recommended by AERONET co-author Tom Eck.

6. *Line 207, need a citation for the SDA method.*

The SDA was referenced in lines 46-47 of the submitted manuscript.

7. *Line 300, "The values corresponding to the four red-colored". It looks like 5 red-colored circles above the ε_c=0 line to me.*

Corrected in the new draft.

8. *Figure A1 caption. "η′ − η vs ð□□□ð□□□" shall be τ_f vs τ_f' "?*

Yes, this was corrected in the new draft with the caption:

τ_f' vs τ_f FO distributions for GSFC and Mongu. The FO colour scale is tied to variations on a logarithmic scale (with an attendant tendency to enhance the contributions of large FO values). $N(r_0)$ is the total FO at a given r_0 value.