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Reply on RC1

Liviu Ivănescu et al.

Author comment on "Accuracy in starphotometry" by Liviu Ivănescu et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2021-88-AC1, 2021

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 "Accuracy in starphotometry", the authors conducted a comprehensive and thorough study of error sources that affect optical depth (OD) retrievals using starphotometers, and further recommended favorable observing conditions including identifying 20 channels for mediating some of the error sources and improving accuracy in OD retrievals using starphotometers. I am not an expert in starphotometry; thus, I focus my comments on OD retrievals in general and hope other reviewers can comments on starphotometry related discussions. But in general, this is a well written paper that highlights various sources of error in starphotometry. The content of the paper is a significant contribution for further improving accuracies in starphotometery. I recommend publication of the paper after some minor corrections.

We thank the referee for the careful reading and the generally positive review!

Comments:

- *Thin cirrus cloud contamination can be a problem for sun-photometer data (Chew, B. N., Campbell, J. Reid, D. M. Giles, J. Welton, S. V. Salinas, and S. C. Liew (2011), Tropical cirrus cloud contamination in sun photometer data, Atmos. Environ., 45, 6724-6731, doi:10.1016/j.atmosenv.2011.08.017). Is this thin cirrus cloud contamination also a problem for starphotometry? Based on the paper, it seems both cloud and aerosol OD can be derived. How, then, do the authors perform the scene identification? Are there error sources related to misidentification of thin clouds and aerosols?*

Thin cirrus may, from the perspective of our paper induce two notable effects:

- An increase in coarse mode (CM) AOD with no change in the fine mode (FM) AOD. Putting aside, for the moment, the forward scattering error, there is no FM feature misidentification if one employs the (AERONET) SDA technique to back out the FM AOD. In cloudy scenes, one expects that cloud particles dominate the CM OD component. There is always some ice crystal presence in the air during the polar winter: this will likely dominate any CM aerosol presence (c.f., for example, O'Neill et al., 2016). We never explicitly observed large CM polar winter AODs: CM AODs are typically small (sub 0.01) and dominated by local dust and/or sea-salt during the spring and fall (Aboel-

Fetouh et al., 2020). Put simply, we do not try to measure CM AOD during the polar winter without complementary CM data retrieved from, for example, lidar profiles (c.f. Baibakov et al., 2015), surface PSD (particle size distribution) measurements or (in the case of sunphotometry) almucantar scans.
- A "forward scattering error" (see the "Forward scattering" section of our submitted manuscript). The very small starphotometer FOV largely ensures that this kind of error is generally negligible.

In the "Forward scattering" section of the revised manuscript we added some text to clarify the concept of the associated error (notably that it was only a problem in the presence of large-size cloud crystals and that accounting for multiple scattering contributions to that type of error were not a problem in starphotometry). A new paragraph was also inserted at the end of that section to clarify that the SDA algorithm could be employed to separate FM AOD from CM OD and that very-small FOV starphotometry was uniquely positioned to extract FM AOD (but not CM AOD) even in the face of the forward scattering error.

- *In section 8, the authors discussed optimal channel selections and provided recommendations for achieving OD accuracy of 0.01. Are the recommendations the same for the TSM and OSM methods?*

TSM provides an intermediate OD measurement for two observation directions. While the recommendations generally concern both methods, TSM is typically less accurate. **To emphasize the OSM vs TSM accuracy difference (and to address concerns from other referees), the "Measuring methods" section 3.4 was significantly updated.**

- *Eventually, either aerosol or cloud OD will be derived. This requires an understanding of Rayleigh OD, which is also a function of observing conditions. How much is the error in Rayleigh OD calculations based on the available observations associated with starphotometers?*

For our spectral range, the largest Rayleigh OD of 0.37 occurs at 400 nm. A surface pressure measurement error of 30 mb is required in order to limit the Rayleigh OD error to 0.01 (Bucholtz, 1995). Since such measurements are performed with 1 mb accuracy at Eureka, the associated starphotometer retrieval errors are expected to be negligible. Even if there are one-hour gaps between pressure measurements, the interpolation errors are generally within the same error margins. In the rare case of a low-pressure front crossing the site, Rayleigh errors could become significant (but the sky will likely be too cloudy to perform starphotometer measurements). **Since this error can be neglected, we did not make any modifications in the revised article.**

References

Please see the Reference section of our paper for citations that are not in the list below!

AboEl Fetouh, Y., N. T. O'Neill, K. Ranjbar, S. Hesaraki, I. Abboud, V. Fioletov, P. S. Sobolewski, Climatological-scale analysis of intensive and semi-intensive aerosol parameters derived from AERONET Arctic retrievals, JGR, 125(10), p.e2019JD031569, 2020.

O'Neill, N. T., K. Baibakov, S. Hesaraki, L. Ivanescu, R. V. Martin, C. Perro, J. P. Chaubey, A. Herber, and T. J. Duck. "Temporal and spectral cloud screening of polar winter aerosol optical depth (AOD): impact of homogeneous and inhomogeneous clouds and crystal layers on climatological-scale AODs." ACP, 16, no. 19, 12753-12765, 2016.