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Atmospheric Measurement Techniques Discussions

Interactive comment on "Synchronous starphotometry and lidar measurements at Eureka in High Canadian Arctic" *by* K. Baibakov et al.

Anonymous Referee #4

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Summary:

This paper discusses retrieval of nighttime aerosol optical depths using a raman scattering lidar and a starphotometer. The 2 instruments are located at Eureka, Canada, a remote research station in the high Arctic. Aerosol optical depth retrievals were performed over several nights in February and March of 2011, and March of 2012.

This paper describes a novel concept for performing ground-based nighttime aerosol retrievals in the Arctic by combining star photometer and raman lidar measurements. Overall the paper is well-written, and makes a good case in the introduction for why

these continuous ground-based measurements of aerosol properties in the Arctic are challenging but important. The sections on cloud-screening and estimating measurement uncertainties are in particular clearly explained. The last section, "Summary and conclusions" is clear and concise.

This paper is recommended for publication in AMT once the following comments are taken into account.

General remarks

1. In the abstract, the term "process-level" seems somewhat ambiguous and should be defined or dropped. This term is also used in the summary.
2. In the abstract, quantify "good agreement" and "moderately well". Many of the main quantitative findings are already listed in the summary, but should also be highlighted in the abstract.
3. In the abstract in general, it should be modified to be a bit more concise, using the last section "Summary and conclusions," as a model. For example, the last sentence could be revised to make a stronger case for the importance of continuous ground-based measurements of aerosol properties in the Arctic (for example to provide a climatological record and/or to validate aircraft and satellite-based retrievals.)
4. In the introduction, a reference to the FIRE-ACE/SHEBA mission could be mentioned along with the others.
5. In the introduction, line 18, what is the purpose of this reference to "lidars"? If you wish to provide a reference to lidars in general then this reference should be supplemented with additional references.

6. In the introduction, for example on line 12, a reference should be provided to AERONET aerosol retrieval algorithm.

7. In the introduction, it may also be worth referencing the GARRLiC algorithm, which uses a lidar and sunphotometer to retrieve aerosol properties (although not in the Arctic).

8. In the abstract, clarify what the variables are for R^2, the coefficient of determination, *i.e.* fine/coarse aerosol optical depth from SPSTAR vs CRL?

9. In Section 3.1, list the measurement uncertainties associated with the starphotometer channels.

10. In Section 3.2, list the wavelengths/channels associated with the CRL lidar.

11. In Section 3.2, list the measurement uncertainties associated with the CRL lidar channels.

12. In Section 4.1.1, Eq. (1), state that “CN" is proportional to the flux?

13. In Section 4.1.2, line 13, the equation should be a reference to Eq. (3) not Eq. (5)?

14. In Section 4.1.2, it may be simpler to rewrite the sentence on line 18 as “Thus $M - M_0 = -2.5\log_{10}(I/I_0)$, and the factor $\approx 1.086\tau$m in Eq. (5) ...”?

15. In Section 4.1.5, for completeness it would be useful to at minimum list the basic equations/methodology for the spectral deconvolution algorithm (SDA).

16. In Section 4.1.5, give a brief description of SDA retrieval errors, which are referred to in Section 5.3, pg 2039, line 4 and in Section 5.4.

17. In Section 4.1.6, line 27, the triplet measurements are taken over a total of 1 minute 30 seconds and not 1 minute?

18. In Section 4.1.6, line 22, there is a reference to a “Table 4" but it should be “Table 2"?

19. In Section 4.1.6, pg 2023, line 22, provide a reference to the AERONET outlier filter.

20. In Section 4.1.6, line 23, the sentence “Finally, the outliers filter of.." could be made less confusing.

21. In Section 4.2 and 4.3.1 there are a total of 3 references made to [A. Gröschke, unpublished data.] If the data are unpublished, but available for example on the web, then a citation should be provided to the website. If the data are not available, then perhaps these references should be dropped.

22. Section 4.2 and 4.3 could be merged into a single section since they are closely related?

23. In Section 4.2, line 12, the “normal field measurement accuracy" should be defined.

24. In Section 4.3, the starphotometer nominal calibration error is listed, but not explained?

25. In Section 4.4 (“CRL processing"), please add a brief quantitative discussion of aerosol optical depth uncertainties associated with the lidar measurements.

26. In Section 4.5.1, pg 2031, line 3, change “backscatter coefficient values" to “backscatter coefficient values at 532 nm" for clarification.

27. For the same reason it may be prudent to change “β_{thr}" to “$\beta_{532,\text{thr}}$".

28. In Section 4.5.2, pg 2032, lines 1-20, the discussion of Figure 2b is confusing and should be clarified as much as possible. The caption for Figure 2b is quite a bit

clearer. In the discussion, should it be that $< \tau_f >$ and $< \tau_a >$ are superimposed and not $< \tau_c >$? Finally, I would like to see clarification on why the coefficients of determination are meaningful when calculated against a fixed value (the unprimed average values from the starphotometer) – is this sensitivity study valid for different average values?

29. In Section 4.5.2, in the discussion of the sensitivity study, for example when discussing Figure 3, comment on how the assumption of the lidar ratio affects the choice of the backscatter threshold at 532 nm. If the lidar ratio is incorrect for either the fine or coarse modes, then how will this affect the CRL AOD and R^2 analysis? Or is this method generally insensitive to changes in the lidar ratio? It appears that there is already some discussion of this in Section 5.1, pg 2037, but it may be better to consolidate all the algorithm discussion into Section 4.5.2, and then discuss the application of the algorithm to the specific events in Section 5.

Figure comments

1. Figure 2: the font size should be increased for the x and y labels, and the legends and color bars.
2. Figure 2b, all 3 panes: it is very difficult to tell what lines are being plotted. Recommend using the same colors/line types as was used in Figure 2a, top pane, which should make it far more readable. (Or just plot dots/circles without the connecting lines.)
3. Figure 2b, bottom pane: The legend should have form R^2_x and not $R^2 - x$?
4. Figure 2, and Figures 4-9: increase the overall figure size.
5. Figure 2a (top pane) and Figures 4-9 (top pane): add error bars to the AOD retrievals, primed and unprimed. (If it's too crowded to add error bars to each

point, do a representative sampling or use a lightly filled in color to represent the error bar.)

6. Figures 4, 6 (top pane): if there is no retrieval for the starphotometer, omit those points rather than plot a straight line.

Miscellaneous/Technical comments

1. In the abstract, line 20, “coarse" typo.
2. In the abstract, line 25, “homogeneous clouds" typo.
3. It depends on the style guide, but generally the word “arctic” is not always capitalized, for example it should be “arctic aerosol"? Similarly for “polar winter”?
4. In the introduction, line 6, should it read “the availability of ground-based data” and not simply “of data"?
5. In the introduction, Ny-Ålesund should have a hyphen.
6. In the introduction, it is pointed out that there “are only a few permanent Arctic stations with a continuous track of aerosol measurements.” The term “a few" is ambiguous, so it may be better to simply list the approximate number of stations.
7. In Section 4.1.3, line 7, Section 4.1.4, line 20 and Section 4.2, line 18: “extraterrestrial” typo.
8. In Section 4.1.4, line 15, change “(see calibration section below)” to reference the actual Section number?
9. In Section 4.1.4, line 19, change “accuracy" to “measurement accuracy"?
10. In Section 4.1.6, line 11, “data” should be plural, so change “needs" to “need".

11. In Section 4.1.6, line 20, there is a superfluous “)”.

12. In Section 4.1.6, the sentence “For a cloud-free atmosphere.. AODs should not exceed 0.02.." could end with “over this short time interval."

13. In Section 4.2, there should be a period after Equation 10.

14. In Section 4.2, line 8, “straightforward" typo.

15. In Section 4.3.3, pg 2029, line 2, for clarification change “in the retrieval of τ_f ..." to “in the retrieval of the aerosol fine mode optical depth, τ_f, ..."?

16. In Section 4.3.3, pg 2029, line 3, change “This is an attempt" to “This case is an attempt"?

17. In Section 4.5.2, pg 2035, line 9, change “general" to “generally" or “in general".

18. In Section 5.3, pg 2039, line 4, change “classification etc" to “classification, etc.".

Interactive comment on Atmos. Meas. Tech. Discuss., 8, 2013, 2015.