Review of Baibakov et al. 2015 "Synchronous starphotometry and lidar measurements at Eureka in High Canadian Arctic"

This paper reviews starphotometer and lidar measurements acquired in the High Arctic region during a few days in the spring of 2011 and 2012. The paper briefly describes starphotometer and lidar instruments and then provides a description of the analysis techniques used to calibrate the starphotometer. The paper describes briefly how the starphotometer was used to infer fine and coarse mode aerosol optical depth. They also discuss cloud screening procedures used in the analysis of the starphotometer data.

The authors present some examples showing how they used the starphotometer and lidar measurements to infer fine and coarse mode measurements for a few days in the spring of 2011 and 2012. They discuss the use of these measurements to study aerosol and cloud distributions.

The paper is suitable for AMT. The novel part of the paper is the use and description of the starphotometer data and the combined use of the data with the lidar measurements. These instruments provide important measurements for studying the amount and distributions of aerosols and clouds in the Arctic regions during the winter when solar based instruments are unable to provide such data. Moreover, the paper presents ways of using these measurements to infer to fine and coarse mode components of optical depth. I recommend publication after the authors revise the paper as per the comments discussed below.

General comments:

1. There are several instances of where the phrase "good agreement" is used. The level of agreement should be expressed in a quantitative fashion.
2. The authors describe this lidar as a Raman lidar which raises the expectations of reader regarding quantitative aerosol measurements. However, there is very little description of this lidar and its capabilities and limitations. Based on what is presented in the paper, one would have expected more useful output from this lidar in these analyses. The authors should provide a more complete description of the lidar and at least indicate the wavelengths of the various channels, and its measurement capabilities and limitations. For example, in the section describing the analysis techniques, it is apparent that, for some reason, this Raman lidar has limited capability to measure the nitrogen Raman return signals (apparently both in visible and UV) so that aerosol and thin cloud extinction profiles (or layer optical depths) cannot be directly derived. Why not? Could there not at least been some long time averages (one or more hour averages) to derive at least some layer optical thicknesses as well as some estimates of the aerosol and cloud extinction/backscatter ratio (lidar ratio)? This is especially true since these measurements were acquired at night with little or no solar background present.
3. As discussed above, the Raman lidar was not used for some reason to directly derive extinction or layer optical thicknesses. Consequently, the authors had to rely on Klett solution of lidar equation to estimate aerosol and cloud optical thicknesses. This methods requires estimates of the aerosol (and cloud) extinction/backscatter ratios (i.e. lidar ratios). The authors had to assume constant values for both aerosols and clouds which introduces significant uncertainties in these analyses. It would have been nice if the authors had tried, at least in some cases, to derive appropriate lidar ratios using the starphotometer measurements of aerosol and cloud

optical thicknesses as constraints to the lidar equation. This would have provided at least some information as to the appropriateness of the assumed lidar ratio values.

4. Following item 2 above, there us but a single footnote that indicates that depolarization ratio data for 2011 were apparently too noisy for practical use. However, such data were at least somewhat useful for interpretation for the case in 2011 as shown in Figure 8 and presumably more useful for 2012. If so, why were the depolarization not used more extensively? These data would have not only been useful for assessing the cloud screening procedure for the starphotometer but also for separating the aerosol (spherical) from ice cloud (nonspherical) fractions of optical thickness and backscatter signals. Why were the depolarization signals not used for this purpose?

5. The lidar wavelengths were not listed. Were signals measured at both 355 and 532 nm? If so, why not use the ratio of backscatter signals at these two wavelengths to also provide information regarding the distribution of fine and coarse mode aerosols?

6. There was considerable description of the process of determining the backscatter threshold used to discriminate aerosol and clouds. However, there was no clear statements that indicated the size of the uncertainties in the inferred fine and coarse mode optical depths due to the uncertainty in this backscatter threshold.

7. The text in the figures is generally too small to read.

8. For a description of ice and aerosol lidar ratios, see Burton, S. P., Ferrare, R. A., Hostetler, C. A., Hair, J. W., Rogers, R. R., Obland, M. D., Butler, C. F., Cook, A. L., Harper, D. B., and Froyd, K. D.: Aerosol classification using airborne High Spectral Resolution Lidar measurements – methodology and examples, Atmos. Meas. Tech., 5, 73-98, doi:10.5194/amt-5-73-2012, 2012. Much of the uncertainty and and bias in the lidar retrievals of aerosol and cloud optical thicknesses can be attributed to uncertainties in the lidar ratios.

9. The paper describes that reliable backscatter ratios could not be determine for altitudes below 200m due to overlap uncertainty. If so, the figures should be modified to blank out this region. Also, what is the estimated impact on the derived fine and coarse mode optical thicknesses if this region is neglected?

Additional comments:

10. Abstract (line 11) Suggest "…and a very low altitude ice crystal event…

11. Abstract (line 21) "is" should be "are"

12. Abstract (line 15) What constitutes "good" agreement?

13. Abstract (line 22) Suggest adding "using starphotometry" after "trends"

14. Abstract (line 24) What constitutes "moderately well"

15. Abstract (line 24) The sentence is confusing as it says that temporal cloud screening was found to agree well with temporal cloud screening.

16. Abstract (line 26) Does this mean to say that the better cloud screening conditions developed in this paper can be implemented, or that better cloud screening conditions than those developed in this paper can be implemented?

17. (page 2016, line 10) Suggest also adding Arctic Climate (ARCPAC) (see Brock et al.: Characteristics, sources, and transport of aerosols measured in spring 2008 during the

aerosol, radiation, and cloud processes affecting Arctic Climate (ARCPAC) Project, Atmos. Chem. Phys., 11, 2423-2453, doi:10.5194/acp-11-2423-2011, 2011.) and Polar Study using Aircraft, Remote Sensing, Surface Measurements and Models, of Climate, Chemistry, Aerosols, and Transport (POLARCAT) (see Schmale, J., Schneider, J., Ancellet, G., Quennehen, B., Stohl, A., Sodemann, H., Burkhart, J. F., Hamburger, T., Arnold, S. R., Schwarzenboeck, A., Borrmann, S., and Law, K. S.: Source identification and airborne chemical characterisation of aerosol pollution from long-range transport over Greenland during POLARCAT summer campaign 2008, Atmos. Chem. Phys., 11, 10097-10123, doi:10.5194/acp-11-10097-2011, 2011.)

18. (page 2017, line 28) "was" should be "were"

19. (page 2020, line 2) What are the eight Raman lidar wavelengths?

20. (page 2023, line 11) "needs" should be "need"

21. (page 2023, line 23) At what wavelength is the 0.35 limit applied?

22. (page 2027, line 16) Is 0.025 the estimated AOD error due to calibration for all wavelengths in the 420-862 nm range?

23. (page 2030, line 11) particles and molecules diminish the laser beam intensity.

24. (page 2031, line 4) This sentence is confusing. What does the star photometer have to do with the estimate of the lidar ratio? Is this attempting to say that the star photometer measurement of AOD is used to help estimate the lidar ratio?

25. (page 2032, line 25) This should indicate that the lidar profiles of extinction were integrated.

26. (Figure 2) This annotations, labels, etc. in Figure 2 are too small to read. It would also be helpful to add additional labels to this figure. In Figure 2a, third panel, there should be some legend to indicate what the color represent.

27. (page 2033) The text refers to Figure 2b before 2a. It may help to rearrange the graphs to match the text.

28. (page 2037,line 2) There is a consistent bias between τ_f and τ_f'; RMS difference does not represent that.