Manuscript 2017-391: Aggarwal et al., Airborne Lidar Measurements …

Response to Comments from Reviewer 1

Note: changes in the revised manuscript have been highlighted in yellow

General Comment from the Authors

The authors appreciate the meticulous work by both reviewers. Substantial improvements have been made in response.

The first author recently completed her Ph.D. examination and through that process there have been a few improvements to the analysis that were not requested by the reviewers.

a) Equation 5 of the submitted manuscript included an approximation in terms of the effective radius. This was not necessary. This equation now has the integral over the size spectrum as for the other calculations in equations (3), (4), (6) and (7). The explanation is now easier to follow and the calculations are more accurate. The calculated aerosol corrections are slightly different, but the results have not changed.
b) The temporal averaging was previously 1.3 minutes for some figures and 3 minutes for others. The temporal averaging is now consistent at 1.5 minutes for all of the O_3 analysis in the figures. This corresponds to a distance of about 7.5 km along the flight track. This had an impact on the histograms of Fig. 16 since previously the averaging was 3 minutes. Now the averaging is 1.5 minutes for both the lidar and in situ measurements represented in Fig. 16. The description of the histograms has been changed slightly on page 18, lines 7 to 25.

Reviewer 1, Comment 1

UV signals were vertically smoothed over 45 m. The retrieved ozone profiles (Fig. 3b) appear to be reported at a much higher resolution. Error bars are given roughly every 100 m. Is that the effective resolution of the ozone profile observations (i.e. the separation of truly independent data points)? How did the authors compute the derivative of the logarithmic signal ratio? Least-square linear fit over multiple adjacent data points or Savitzky-Golay method? How were the two partial ozone profiles (AN 276/299 and PC 266/299) shown in Fig. 3b combined into one profile? Weighted averaging in the altitude region where both profiles overlap?

Response to R1, Comment 1

An improved description is now provided. See page 5, line 27 to page 6 line 15.

R1, Comment 2

What is the source of the air number density profile to convert ozone number density to mixing ratio? Ancillary pressure/temperature profile observations (e.g. nearby radiosondes)? Reanalysis data? Standard air number density profile?

Response to R1, Comment 2

Radiosondes launched from Edmonton. Now mentioned on page 6, line 9.

R1, Comment 3

The authors need to describe briefly how their aerosol correction technique differs from other, previously published approaches. Also, include several references.

Response to R1, Comment 3

Description of the difference has been added on page 6, lines 20 to 28.

R1, Comment 4

What reference height for aerosol extinction calibration do the authors typically use? Is it an altitude close to the aircraft (it appears that way from the aerosol extinction time/height plots, e.g. Fig 7a)?

Response to R1, Comment 4

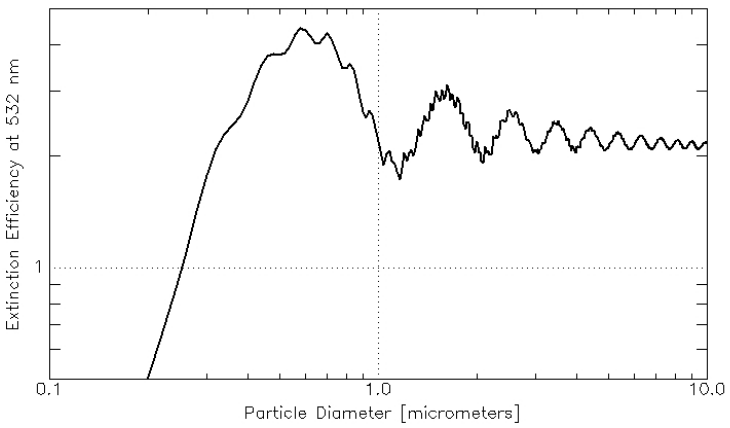
The reference height was a minimum of 200 m above the top of the boundary layer. This has been added to the manuscript on page 7, line 17.

R1, Comment 5

Only the aerosol particle refractive index is needed to compute Qext and Qback from Mie theory. I don't understand why aerosol size distribution measurements are needed to calculate the efficiencies. (?)

Response to R1, Comment 5

Q_{ext} and Q_{back} depend on particle size. The following figure shows a calculation of Q_{ext} based on an aerosol size distribution used in this study.



R1, Comment 6

*I double-checked the SO2 interference estimates using the Brion et al. (1992-1998) O3 and Vandaele Hermans, and Fally (2009) SO2 absorption cross section data. I got interference terms of approximately 1, 5, and 35%*SO2 concentration for the 266/299, 276/299, and 287/299 wavelength pairs, respectively. The 1% interference that I computed for the 266/299 pair would result in an ozone bias of up to 1.5 ppbv (larger than the 0.3 ppbv bias stated by the authors, but still quite small). Obviously, the magnitude of the interference terms depends on the choice of absorption cross section data. The SO2 data in particular seem to vary quite a bit between the different published data sets. The authors need to state their sources of O3 and SO2 absorption cross section data and provide an error estimate of the interference terms due to absorption cross section data uncertainty.*

Response to R1, Comment 6

The text has been changed in the paragraph starting on page 11, line 17 in response to the referee's comment. We now provide a range of values for bias due to SO_2 absorption based on three separate sources of absorption cross sections.

R1, Comment 7

The authors stated on page 5 that the 276/299 pair was used for O3 profile retrieval to 1.8 km below the aircraft or about 1.1 km ASL (Fig. 3). On some flights, the boundary layer (with potential SO2 concentrations of up to 30 – 150 ppbv) reached about 2 km ASL (Figs. 7a and 9a). Therefore, the 276/299 pair with its higher SO2 sensitivity may have been used to retrieve the O3 profile in the upper part

Response to R1, Comment 7

The transition was at a height of at least 300 m above the boundary layer. A better description is now provided on page 6 lines 9 to 15.

R1, Comment 8

Perhaps the absence of enhanced ozone downwind was at least in part due to low concentrations of suitable VOCs? Did the Convair aircraft measure VOCs?

Response to R1, Comment 8

The measurements of VOCs on the Convair aircraft are beyond the scope of this study. Those measurements will be taken into account in a different study by a separate group of researchers (not published in this issue) in which the Canadian Air Quality forecast model will be used to assess the production/destruction of ozone.

R1, Comment 9

Fig. 4

Change figure labeling: (b) Uncorrected, (c)-(e) Molecular (in black), Aerosol + Molecular (in red). Was the PC 266/299 pair not used in this case?

Response to R1, Comment 9

See the new caption for Fig. 4.

R1, Comment 10

Fig. 5: Indicate location of main emission sources.

Response to R1, Comment 10

A box has been drawn around the region of oil sands industrial emissions.

R1, Comment 11

Fig. 12a: Near 15 km and between 60 and 90 km distance, the extinction coefficient is near 0 within the boundary layer. What caused this? Aerosol fluctuations in the reference region

Response to R1, Comment 11

Yes, there was an issue with aerosol fluctuations in the reference region and this has been fixed.