

Incorrect manuscript title, see title below

A fully autonomous ozone, aerosol and night time water vapor LIDAR: a synergistic approach to profiling the atmosphere in the Canadian oil sands region

by K. Strawbridge et al.

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The authors would like to thank the reviewer for their comments and suggestions.

The paper describes a very promising lidar trailer featuring autonomous measurements of the three most important species that can be measured with lidar. The capability of the system is well documented and demonstrates the high value of simultaneous and continuous lidar measurements of several species. I recommend publication after modifications based on the following comments:

P. 2, line 4: Add a statement on the level of dryness found in intrusions.

Statement added giving measured values.

P. 3, line 8: I am not sure if these two references are suitable for documenting ozone production in biomass-burning plumes. This process has been verified at lower latitudes, but there is doubt in ozone formation at high latitudes. See also my remarks below.

The reference of Aggarwal et al. was chosen because it is another recent documented case of ozone production in a biomass-burning plume in the region.

Also added another reference

P. 3, line 10: The selection of literature in some way seems to reflect a historic sequence. Thus, I suggest to cite Stohl and Trickl, J. Geophys. Res. 104 (1999), 30445-30462, instead of (Trickl et al., 2015). Another nice paper is J. Geophys. Res. 117 (2012), D18305, doi:10.1029/2012JD017695.

Perhaps the review means Trickl et al., 2014. Trickl et al., 2015 is the forest fire reference and Trickl et al., 2014 is the STT reference.

Trickl reference removed and replaced with Stohl and Trickl reference.

P. 3, line 14: Please, add “and water vapor”.

Added “and water vapor”

P. 3, lines 27-28: “aerosol processes” are (e.g.) particle growth, particle evaporation, chemical transformation, heterogeneous chemistry. I doubt that lidar measurements can yield insight into these processes. Lidar measurements can yield hints on transport or optical properties. Please, rephrase!

Sentenced rephrased, removed “aerosol processes”.

P. 4, line 4: Water vapour is the primary greenhouse gas, responsible for 2/3 of the greenhouse effect. Please, change phrase to “Also, as the primary greenhouse gas”.

Phrase changed.

P. 4, line 7: You could add a sentence concerning the extreme spatial and temporal variability of

water vapour (Vogelmann et al., Atmos. Chem. Phys. 14 (2015), 3135-3148). This is a great problem for trend studies, but a strong motivation for lidar measurements because of the good spatial and temporal resolution.

Sentence added and Vogelmann et al., reference also added.

P. 4, line 15: “Garmisch-Partenkirchen/Zugspitze”? In principle, “Garmisch-Partenkirchen“ would be enough since the Zugspitze mountain belongs to that town.

Zugspitze removed.

P. 4, line 17: Replace “However, all of” by “Several of”: OHP is not a high-mountain site at all, and in Garmisch-Partenkirchen most lidar systems are not located at high altitude. I think all three species are also measured at Table Mountain.

Replaced “However, all” with “Several”.

P. 5, lines 1-4: There are several lidar networks such as the lidar team of NDACC, EARLINET, the East Asian lidar network and others. References: For NDACC: web site; for EARLINET Papayannis et al., J. Geophys. Res. 113 (2008), D10204; doi: 10.1029/2007JD009028, Pappalardo et al., Atmos. Chem. Phys. 13 (2013), 4429-4450.

Added references

P. 5, line 10: AB presumably means “Alberta”. There may be readers who do not know this.

Changed “AB” to “Alberta”

P. 5, lines 16-17: What does CAMI and the text in brackets mean?

Fixed text

P. 7: In an autonomous system automatic data evaluation is an important issue. I did not find much on this topic, in particular on the quality of automatic aerosol corrections. This is a rather demanding procedure that usually introduces additional uncertainty. Several methods exist and are discussed in (Eisele and Trickl, Appl. Opt. **44** (2005), 2638-2651).

text added to the conclusions and future work to address this

P. 7, line 10: Add reference (e.g., Leblanc et al., Atmos. Meas. Tech. 9 (2016), 4029-4049).

Reference added.

P. 7, line 15: “the addition of just a few optics”; one could mention the small addition space requirement. A DIAL would require much more space and is more complex, but would allow daytime measurements.

Added text and reference to Figure

P. 7, line 24. “absorption” is perhaps not fully adequate. Raman scattering is a two-photon scattering process. An “intermediate electronic state” may exist or not. In general non-resonant scattering is considered. Please, rephrase!

Sentence was rewritten.

P. 9, line 12: Unfortunately, somebody in the remote past who obviously had no idea about the benefits of the ideal gas law introduced g/kg for H₂O instead of the volume mixing ratio.

Generations of H₂O researchers then followed this example. In atmospheric sciences usually the volume mixing ratio is used and I recommend the authors to join the community in the future.

P. 10, line 19: Please, add statement about the section where the figure is described.

Statement added

P. 11, line 6: What kind of optic?

Added more to the description and provided manufacturer

P. 22: Computer cards pick up noise from the computer. How clean is the signal?

Assuming this comment is for P. 11, line 22: I added a sentence

P. 11, line 29-30: Only one of the two 45° optics is explained!

Added sentence.

P. 12, line 31: 45 mJ: 266 nm?

Added 266 nm to sentence.

P. 13, line 2: 20 %????

Changed to 20%

P. 13, line 17: The events are not mixed! Change to “in long term events” (“in long-term events”).

Added dash

P. 13, line 23: The two color-coded plots?

Added “color-coded”

P. 13, line 25: “mixes down”: There is not much mixing in the free troposphere. “descends” is more adequate. See also Fig. 10.

Changed “mixes down” to “descends” here and in Fig. 10

P. 14, line 9: Explain “boxcar smoothing” (at least add a reference)

Added text

P. 14, line 24-25: Confusing sentence! If you mean “all corrections but” (comma removed): the cross sections are no correction!

Changed “corrections” to “terms”

P. 15, line 31: “observing the impact of many atmospheric processes” (see above).

changed

P. 16, lines 5-6: This is a highly remarkable statement and deserved a few more words! At lower latitudes (Granados-Munoz, Leblanc, Atmos. Chem. Phys. 16 (2016), 9299-9319) also high fractions were reported for winter, but not for summer. It seems that STT is more important (at least in mid-latitudes) than previously thought, as indicated by Trickl et al. (Atmos. Chem. Phys. 10 (2010), 499-524).

Statement removed - given this paper is on only one year of data, the authors are uncomfortable making statements about seasonal characteristics of STT events

P. 16, line 15: How dry? 50-100 ppm would be indicative for UTLS air, 4-5 ppm for free stratospheric air (e.g., Hurst et al., J. Geophys. Res. 116 (2011), D02306, doi: 10.1029/2010JD015065). For consistency you should convert 50-100 ppb and 4-5 ppb to g/kg.
Included actual value of “dry air”

P. 16, line 23: Please specify where 120 ppb is reached (not in the intrusion peaks!).
Time is now specified

P. 17, line 19: “well documented”: See above (P. 3)! How do you know?
Removed statement

P. 17, line 25: The air seems to be dry: Can you exclude an intrusion? See (Trickl et al., 2015) for examples. Did you calculate trajectories?
Added some text to link enhanced ozone with high aerosol and depolarization ratio. Also added a reference.

P. 17, lines 29-30: On what basis do you hypothesize?
See above.

P. 18, line 14: Please, define S!
S ratio is the extinction-to-backscatter ratio – added dashes

P. 18, line 30: The determination of lidar ratios is highly uncertain since the calculation of small extinction coefficients is based on derivate formation. A few error bars in the lidar-ratio plots would be helpful.
Error bars added

P. 19, line 1: “in this case”?
Added “in”

P. 19, line 10 “: “is due to the forest fire activity”: Please, provide evidence. The air seems to be rather dry which could, again, suggest STT. Did you calculate trajectories?
See P17 line 25 above

P. 19, line 20.21: levels are, level is?
Changed “is” to “are”

P. 20, line 11-13: Error bars are missing (see above); add a few.
Error bars added

P. 21, line 32: The “valuable dataset” was already emphasized. Maybe you could write “provide further value”.

Changed text

Figures:

The symbols are frequently rather small. The colour coding is no clear. Black looks like absence of data. I suggest to use a brighter grey to achieve more contrast. At least statements about the concentrations in the “black” altitude range would be helpful. Finally: Add numbers to the colour scales!

Plots have been redone

Figs. 2, 3, others: Add something like “The abbreviations are explained in a separate box in the plot”.

Text added to figure caption

Fig. 11, 12, 15, 20: The colours are hard to distinguish in the legend (the text is also small)

Changed plots

Fig. 5: Please, specify the shift of the local time with respect to UTC.

Text added

Style:

P. 1, line 29: “we added” instead of “we have added”?

Removed “have”

P. 3, line 20: “travel over”?

Added “over”

P. 3, line 27: “therefore” / ”,therefore,”: There is an obvious trend in the literature for less punctuation. Within the papers I have reviewed this one is record setting in omitting commas and hyphens.

Added comma

P. 4, line 24: “to simultaneously measure” (and other examples in the paper, e.g., P. 5 line 6, P. 14, line 3): split infinitive!

corrected

P. 12, line 9: Stanford

Corrected spelling

P. 12, line 13: Add a comma between “week” and “except” for clarity.

Added comma

P. 13, line 18: signal to noise ratio (signal-to-noise ratio)

Added dashes

P. 21, line 16: “The three-LIDAR system” would be clearer

Added dash