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Atmospheric Chemistry and Physics Discussions

Interactive comment on "AMALi – the Airborne Mobile Aerosol Lidar for Arctic research" *by* I. S. Stachlewska et al.

Anonymous Referee #2

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General comments:

This paper provides a very detailed presentation of the airborne lidar and the data retrieval schemes. The level of detail is appropriate in case of the instrument description but should be extended in case of the iterative airborne inversion section. Several details discussed in the frame of the data analysis are well known and should be excluded to make the paper concise and more readable. The presented instrument comparison with the KARL lidar shows only one case study and should be extended to give more credibility to the presented results. A detailed error assessment and a validation using independent instruments are missing. The structure of the article needs to be revised.

The paper is recommended for publication subject to mandatory revisions which in my opinion include the shortening of the article and the revision of the error assessment /

sensitivity analysis as stated below.

Introduction: p. 18747, 20: How was the system validated before the Artic campaigns?

A brief overview of recent airborne lidar developments should be given.

Instrument description: Figure 2 can be left out because it does not provide relevant information.

Figure 3 (left) should be larger and Figure 3 (right) can be left out. The differences in the setups can be explained in the caption. Figure 3 caption: '22. PMT for perpendicular 355nm detection'. The word 'perpendicular' is misplaced. This detector measures both perpendicular and parallel polarization components at 355 nm.

p. 18751, 17: 'The waveplate is specially designed for 532nm and 355nm and shifts the polarization of the 532nm wavelength by lambda/2 to match the polarization of the 355nm wavelength, shifted by lambda.' The wording should be changed: The dual waveplate rotates the polarization of the 532nm wavelength to match the polarization of the 355nm wavelength.

How is the assembly of waveplate and polarizer adjusted? Can you comment on the degree of linear polarization of the transmitted 532 nm beam?

p. 18752, 10: What is the required SNR? Does it vary from case to case?

Detection range limitation: This chapter better fits after the description of the receiver system.

Eye-safety constraints: This section should be shortened significantly because it provides no scientific content. From a technical point of view it will suffice to mention that the instrument parameters and the values of the MPE go along with the respective law and regulations.

Receiver subsystem: p. 18755, 27: For clarity: Is there a benefit of a non circular aperture?

p. 18757, 12: Can you comment on the overall depolarization extinction ratio, i.e. the minimal depolarization cross talk?

p. 18757, 26: What is a 'double plain mirror' ? p. 18757, 27: Change 'mounded' to 'mounted'

Data acquisition subsystem: p.18758, 12: The wording should be concretized: The lidar system provides highly resolved measurements of the spatial distribution of aerosol and clouds . . .

p.18758, 15: Do the laptop computer specifications have to be mentioned?

p.18758, 22: 'For the detection of the 1064nm channel a Peltier cooled Si Avalanche Photo-Diode (APD) was used, and Hamamatsu R7400 photomultipliers (PMT) for the detection of the 355nm channel and the two 532 nm channels for the parallel and perpendicular component.' This sentence fits rather in section 2.2.

p.18759, 20-28: This paragraph can be moved to section 2.1.1. Again, please specify the acceptable SNR. A table listing typical integration times to achieve a specific SNR in the different modes of operation would be beneficial.

It is confusing to read about different combinations of measurement range, SNR, and integration time at different places in the manuscript.

Quick-look data processing and display: This section should be left out because it does not provide any scientific content. Figures 5 and 6 can be left out. It is worth to note that the onboard visualization enables pathfinder missions during coordinated or sequenced research flights. This can be said in the introduction there is no need for an own chapter.

Sections 3.1, 3.1.1, and 3.2 contain basics that are all well known and should be shortened to the essential equations. The heading of section 3 is not applicable: There are no data evaluation algorithms described in this section. I suggest to combine sections 3 and 4.

Qualitative and quantitative data analyses: p.18764, 15: There is no need to paraphrase 'range corrected signal' and 'particle backscatter/extinction coefficient'. These terms are more common and self-explanatory than 'first/second type end-product'.

Sections 4.1, 4.1.1, 4.1.2, 4.2, 4.2.1 predominantly contain basics that are well known and should be left out. A table can be made listing the different modes of operation (ground-based zenith, ground-based horizontal, airborne nadir, airborne zenith) together with the respective retrieval algorithms and an appropriate reference.

4.2.2 Nadir-aiming iterative airborne inversion: p.18768, 26: 'Using this approach the backscatter coefficient profiles are calculated from these profiles using an assumption of the lidar ratio B(h)'. The wording should be changed: . . . are calculated from the profiles of attenuated backscatter using . . .

How is the lidar constant C determined? Later on it is mentioned that C is determined using collocated Raman lidar measurements. How is the relative accuracy of 7% achieved, how many flight legs over KARL were analyzed?

Please comment on the variability of C. How do pulse-to-pulse and long term power fluctuations of the flash-lamp pumped laser affect the constant C? How do sensitivity variations of the detectors affect C? How does it change from flight to flight due to alignment?

How is the depolarization of the 532nm channel accounted for? Please comment on how the relative efficiency factor of both channels (cross-parallel / co-parallel) is determined.

p.18769, 13: What is h_egc ?

p.18769, 26: How is the transmittance of the layer [h_f, h_gc] estimated? You mentioned that the transmittance is assumed to be 1.

p.18770, 2: '. . . alpha-profiles calculated as precise as the choice of the lidar ratio B(h)'. The wording '. . . alpha-profiles with the uncertainty of the assumed lidar ratio' seems

more appropriate.

Lidar signal calibration and instrumental constant estimation: This section should be part of chapter 4.

1) Background light correction This section can be shortened.

2) Rayleigh calibration Is the instrumental constant for nadir observations determined by Rayleigh calibration during zenith observations?

3) Depolarization ratio calibration It should be noted that the molecular depolarization ratio depends on the amount of rotational Raman scattering detected. The stated value is the minimum ratio. Moreover, even a small amount of background aerosol in the free troposphere can change the depolarization ratio significantly.

p. 18772, 24: 'In our case both channels were checked for the cross talk in an experimental way, and it was found that cross talk is not an issue.' It is interesting to know how the cross talk was checked. If cross talk is no issue what is its value?

4) Lidar ratio assumption: Again, please shorten. p.18773, 17: 'An accurate inversion can be made only if the lidar ratio is adequately estimated' should be changed to 'An accurate inversion can be made only if the lidar ratio is known'.

p. 18773, 26: 'In such cases the accuracy of the independently obtained information strongly depends on the quality of the inelastic measurement.' I suggest to skip this sentence.

AMALi intercomparison with KARL: Why haven't both instruments been normalized between 4.8 and 5.0 km using the same backscatter ratio?

There is no error analysis. Please add error bars to the measurements.

p. 18775, 15: More comparisons and statistics on the data correlation would be beneficial. Agreement of both instruments during only one case study provides only zeroth order credibility to the measurements.

It is stated that the system was validated before the Arctic campaigns. The validation results could be added here.

p. 18775, 16: Why is noise of no concern?

Sensitivity study of the iterative airborne approach: p. 18776, 5: 'permits the accurate estimation of'. Skip the word 'accurate'. This estimation is not accurate, because both the transmittance and the instrumental constant C are error-prone.

p. 18776, 11: 'Hence, the clearer the atmosphere and the better the knowledge of the molecular contribution to the extinction alphaˆmol (for example from nearby meteorological sounding) the better the transmittance estimate, i.e. the lower uncertainty of the beta_h_gc calculation.' This has been said before and can be skipped.

p. 18776, 26: How was C_A = (1.4 +- 0.1)*10ˆ13 mVmˆ3 sr with the relative accuracy of 7% determined?

p. 18777, 5: Why did not you use the lidar ratio profile obtained by KARL for your retrieval? The values listed in table 3 seem a little low especially in the case of pollution aerosol.

Figure 8. A flight path could illustrate the place and range of the measurement.

What I miss in this sensitivity study is a graph which shows the influence of several error sources (e.g. transmittance estimate, lidar ratio estimate, instrumental constant errors, depolarization errors) on the profiles of aerosol backscatter and extinction.

Conclusion: p.18778, 5-9: This has been already said in the introduction.

p.18778, 13: I doubt that an iterative retrieval based on assumptions can be 'precise'. p.18778, 17: Here, as well, 'knowledge' should be changed to 'estimate'. p.18778, 21: Please specify the error of the backscatter ratio instead of saying 'These assumptions were found to be not too critical to retrieve an accurate backscatter'

p. 18778, 27: What are the relative deviations of the backscatter coefficients?

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