Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2019-326-RC2, 2019

Atmospheric Measurement Techniques Discussions

Interactive comment on "Scanning Polarization Lidar LOSA-M3: Opportunity for Research of Crystalline Particle Orientation in the Clouds of Upper Layers" *by* Grigorii P. Kokhanenko et al.

Anonymous Referee #2

Received and published: 8 October 2019

The authors describe a scanning dual-wavelength lidar capable of measuring the linear (at 1064 and 532 nm) and circular (at 1064 nm) depolarization ratio. They carefully characterize the polarization properties of their well-designed lidar system. The near-zenith scan is applied to several cirrus measurements to demonstrate the advantages of their system. For the intensity of the horizontal plane of polarization an exponential dependence with the tilting angle was found with maximum values at 0° (zenith). The new lidar system (LOSA-M3) will enable advanced studies of ice clouds and (in future) aerosol layers. Therefore, I recommend it for publication in AMT. However, Section 4 and the corresponding figures need major revisions.

Printer-friendly version

Discussion paper

General (major) comments:

1. “Clouds of Upper Layers” in the title sounds strange. It would be better to replace it with “ice clouds” or “clouds in the upper troposphere”. Why you mention “upper layers”, you can as well observe clouds and ice clouds in lower parts of the troposphere. In general, I would omit the term “upper layers” throughout the whole manuscript. It can be replaced by “upper troposphere”.

2. I miss a bit the discussion about the atmospheric relevance of your findings. What does the additional information we get by scanning through the cirrus help us in characterizing cirrus clouds? It is interesting to know, if a cirrus cloud consists of orientated or randomly orientated ice crystals. In the introduction you mention the sun glare. You could add discussion about the atmospheric implications of your findings. This will further underline the importance of your newly developed lidar system.

3. You give an exponential parameterization (equation 1). But the reader finds nowhere in the manuscript any parameters for this fit. You should definitely provide some fitting parameters for your curves (A, alpha_0, w).

4. To discuss the differences in the cirrus observations, it would be extremely helpful to provide some more information about the cirrus cloud.

Firstly, the temperature profile within the cirrus. You show some radiosonde data in Fig. 7+8, but you don’t use this information in the text. At which temperature do you observe the two cirrus clouds on 6 April 2018? At colder temperatures, the ice crystals may have different properties. To improve the Figures, I would show a temperature profile exactly for the same height range (6 – 10 and 7.5 – 12 km) as in Fig. 7a+b and 8a+b instead of the shown diagram. And please add the time of radiosonde launch.

Secondly, the different exponential behaviors in Fig. 11 are related to different cirrus clouds. What additional information do you have about these cirrus clouds? Cloud height? Cloud thickness? Cloud top temperature? Temperature profile within the

cloud? Age of the cirrus cloud? Formation process? May this information help to explain the different behavior?

5. Where did you perform the measurements? In Tomsk. Can you add some coordinates? How far was the radiosonde station?

6. How did you select the measurements in Fig. 11 (ln 280)? Which criteria did you use?

7. The symbols âĹě and âŁě correspond to parallel and orthogonal normally linked to linear polarization. Circular polarization is right handed or left handed or more general it can be described as co-polar and cross-polar. Or at least mark the intensity as a circular polarized component whenever it is used to not confuse the reader with the linear polarization.

In general, you should be more careful in distinguishing the linear and circular depolarization ratio throughout the text (often it is just stated “depolarization ratio”).

8. The paragraph line 286-292 describing the relation of circular and linear polarization should be placed earlier. The same holds for the information in line 300-303. Till these lines, it remained unclear how you deal with two wavelengths and a quarter wave plate. This has to be mentioned when describing Fig. 4.

9. Overall the figure captions are very short. The explanation is given in the text, but it would be very useful to include this information in the figure caption. The reader must be able to understand a figure without reading the whole text. You never know, how the final type setting of your paper will look like. Sometimes the text is quite far from the corresponding figures.

10. The figures need some improvements to be publishable:

Bring Fig. 5 + 6 in a better shape, e.g., with a white background.

Add units and/or title to the y-axis in Fig. 3, 5b, 9, 10, 11, 12

Add units and/or title to x-axis in Fig. 5b, 7c, 8c, 9

Add color bar to Fig. 9

Indicate the used wavelength in Fig. 3, 5a, 7, 8, 9, 10, 11

Indicate the date and time (and height) of the observations in Fig. 10, 11, 12

Use a better plot to illustrate the height profile of the temperature (and other necessary meteorological parameters) – Fig. 7d + 8d

Specific (minor) Comments:

11. Some formulations are not well-suited throughout the whole manuscript:

“upper layers” – use “upper troposphere” or “high altitude (clouds)”

“near zone”, “far zone” – use “near range”, “far range”

“chaotically oriented” – use “randomly oriented”

“sounding” – better use “measurement” or “lidar measurement” (only for the radiosonde “sounding” would be the appropriate term)

12. The date should be always in the same format: 2 June 2018 – change ln 264 and Fig. 9

13. line (ln) 34 “However” seems not necessary at this point.

14. ln 45 “mid latitudes”

15. ln 67 “the polarization characteristics are measured at . . .”

16. ln 89 “to evaluate some elements of BSPM” Which elements? Be more precise.

17. ln 89 “The lidar appearance is shown in Fig. 1” – “A photograph of the lidar system is shown in Fig. 1” – In the photograph it is pointing horizontally.

18. ln 94 “PP1 with the phase shift of 20 wavelengths is used for λ = 532 nm, and 9.5

wavelengths for λ = 1064 nm." What do you mean by this?

19. In 101 "Usually, it takes from ten seconds to ??? minute." – one minute?

20. In 144 "(α is a small setting angle error)."

21. In 146 Where do you get this value from?

22. In 148-150: 45° * 0.68 ms /0.3° = 102 ms Using the information you provided, the quarter wave plate would need 102 ms to turn by 45°. That would be too slow for a laser repetition rate of 10 Hz. Maybe you just have to report one more significant digit for time?

23. In 157-158 Here it would be helpful to already mention Fig. 5. Otherwise, the number of steps seems somehow arbitrary.

24. Fig. 5a Why do you show this plot? To my opinion Fig. 5b would be enough to understand the procedure. In 160 "the lidar signal from two photodetectors" – From which photodetectors?

25. In 159-164: The same procedure is done for plate B without plate A, isn't it?

26. In 172: Haarig et al., 2017 and Althausen et al., 2000 do not describe HSR lidars such as Burton et al., 2015 and Eloranta, 2005, but Raman lidars with several wavelengths.

27. In 180 "and 355+532+1064 nm" I would consider to add a reference to Hu et al., ACP 2019 and change the Haarig et al., 2016 reference to Haarig et al., 2017.

28. In 211 "before the polarization prism in the receiver"

29. In 220 The calibration was made 7 May 2017, the measurements are performed one year later. Did you perform calibration measurements in 2018 as well? What can you say about the stability of such calibration measurements?

30. In 227 "with an error of $\pm$ 5 minutes" These are arc minutes. At this point the reader

may easily be confused with minutes in time.

31. In 232 “initial circular polarization”

32. Why do you study the range -1 to 4° only? Many lidar systems are operated at an off-zenith angle at 5°. It would be interesting to extend your tilt angle up to 5°, even if the change from 4° to 5° will not be significant.

33. In 250 “Values outside the vertical are close throughout the entire cloud thickness.” – Close to what?

34. In 255 “However, the signal intensity and the depolarization ratio do not remain constant”

35. In 265-266 “ The following . . .” already said before

36. In 273 How to determine I_0 (for alpha » 4°) if the scanning cycles are only done up to 4°?

37. In 278-279 Can you provide a mean and a standard deviation? Or maybe add it as a dashed line in Fig. 10.

38. In 287+289 “depolarization ratio”

39. In 305 “thus, the amplitudes of signals are reduced to one value” – How?

40. Fig. 1 Change order: First describe the left and then the right picture. It makes more senses.

41. Fig. 2 Add information on photocounting and analog detection in the picture. Otherwise, it is not clear why do you have two 532 nm detectors (PM2 and PM4) in the co-polarized branch.

42. Fig. 4a What does the green line stands for? Why green? The circular polarization is only measured in the NIR.

Fig. 4b needs more explanation.

43. Fig. 5 What signals do I see? The same question for Fig. 6.

44. Fig. 7a + 8a in the title of the color bar “Backscattering Intensity, mV”

45. Fig. 9 Do you use all data marked by a box? Where do you use it?

46. Fig. 10 Give somewhere the fit values for the exponential and Gaussian fit.

47. Fig. 11 You just show some fitting results without showing the original data points. Can you underlay your fitting curves (in bold) with the data points in the corresponding color (in a light hue). Then, the reader will see the data used for these fits.

Additionally you should definitely state in the caption or legend which data are used (date, time and probably height). Otherwise, no one will know which curve corresponds to which event even if you don’t show all events (not necessary).

In general, this is a very interesting figure, showing the different behavior of cirrus clouds. The exponential decay with tilt angle is an important finding. Maybe the different width of the distribution can be used to extract more information about the state of the cirrus cloud (and its forming process or aging). And it is good to see that it holds for the circular and linear depolarization ratio (Fig. 12). As mentioned before, it would be nice to have some fit parameters for the exponential dependence. I am already curious to see some results in highly depolarizing aerosol layers. But in general the aerosol particles should be randomly orientated. It is a long list of comments made to improve the manuscript.

Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2019-326, 2019.

Printer-friendly version

Discussion paper