Atmospheric Measurement Techniques Discussions

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Reply on RC2

Alexandra Tsekeri et al.

Author comment on "Polarization lidar for detecting dust orientation: system design and calibration" by Alexandra Tsekeri et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2021-30-AC2, 2021

We thank the reviewer for his/her constructive comments and suggestions.

We provide below the answers to these comments, along with the corresponding changes in the manuscript.

RC:

The main issue for me is that the largest part occupied by the development of the mathematical formulas. Whereas these equations are very important, in my opinion the article that explains them should mainly speak the language of the atmospheric sciences. I would suggest rewriting the text in such a way that the main principles governing the instrument are explained in words to the reader, with the equations relegated to one of the sections not taking up more than 20-30% of the paper. A scientist wishing to skip this section for brevity, should still be able to understand the article. I would also suggest: on one hand, to simplify the math where possible, and on the other hand to expand on the non-mathematical parts.

Reply:

We reduced the number of equations in the main text, moving most of them in the Appendices and in the Supplement.

RC:

Papers by Daskalopoulou (2020) and Tsekeri (2021) is mentioned, however they have not been submitted yet. I suggest that the main learnings from these papers should be summarised here in the mean time, and/or that a preview should be provided for the reviewers and the colleagues taking part in the interactive discussion.

Reply:

The paper by Daskalopoulou et al. (2021) is replaced with the conference paper:

Daskalopoulou V., Raptis I. P., Tsekeri A., Amiridis V., Kazadzis S., Ulanowski Z., Metallinos S., Tassis K., and Martin W.: Monitoring dust particle orientation with measurements of sunlight dichroic extinction, 15th COMECAP, conference proceedings, 2021.

The paper by Tsekeri et al. (2021) has been deleted and the main learnings from this work have been added in lines 146-151: " The methodology for defining the optimum measurements includes extensive simulations for different atmospheric scenarios and machine learning tools. Briefly, the backscattered light is simulated for different mixtures of dust particles with realistic sizes and irregular shapes, including cases with random and preferential particle orientation. We investigate a large number of possible polarizations for laser B, and we evaluate their information content based on the performance of the corresponding neural network retrievals that use the simulated lidar measurements to retrieve the oriented dust microphysical properties. This is an ongoing work, with the first results identifying that the emission from laser B should be elliptically-polarized with the angle of the polarization ellipse at 5.6^{o} and degree of linear polarization of 0.866."

RC:

The introduction should place the research into context more. At present, the general presentation of the atmospheric science problem on dust orientation is discussed in the first 10 lines, and I believe that the topic deserves more, together with previous observations and to hypotheses on why it is believed to happen (e.g. dust electrification). See e.g. Nicoll et al (Env. Res. Lett 2010), Merrison et al (Plan. Sp. Sci. 2012), van der Does (Sci. Adv. 2018), Toth III (Atmos. Chem. Phys. 2020), Mallios et al (J. Aer. Sci. 2020, 2021). The topic of mineral dust in general could also be introduced before discussing the specific topic, citing a number of articles (easy to locate as there is plenty of literature), and mentioning the main points that need investigation (composition, particle size and shape, transport mechanisms, gaps in the observations, radiative effects, etc.) and the main methods used (in situ, remote sensing, modelling, etc.). The main applications of this research could also be mentioned.

Reply:

A brief description of the a) importance of dust for climate and ecosystems, b) the retainment of the large dust particles for longer distances than explained from their gravitational settling, c) the possible explanation due to dust electrification and d) the orientation of dust along the electric field, have been added in line 12.

RC:

There are some points which are unclear as well, and I suggest could be more explicitly be clarified, e.g. is the lidar a scanning one? It sounds like yes at the beginning, but later on there is a sentence about not using any moving parts. What is the preferred viewing geometry and why? Is the orientation controlled through a stepped motor, or is it manual?

Reply:

The lidar has scanning capabilities. The text in line 128 refers to the moving parts used for the emission or detection of light. In order to clarify we added in line 128: "... without using any moving parts for the emission or the detection of light"

Moreover, in the "First measurements" Section, we show measurements acquired using a viewing angle of 80° off-zenith, in order to emphasize the scanning capabilities of the system.

There is no "preferred" viewing angle, since this depends on the orientation angle of the particles.

The viewing geometry (i.e., zenith and azimuth angles) are controlled manually. We added in line 95: "The positioning of the head at various viewing angles is controlled manually."

RC:

Angles are expressed with respect to the horizon, but to the reader it is not fully clear what this means: it seems to make sense perhaps for a horizontal observation but not e.g. for a zenith geometry. I admit that I got lost with the different angles expressed in the article and that it should be made clearer every time what are the two planes between which an angle is measured.

Reply:

The horizon is used to describe the x-axis of the "frame coordinate system", based on which we describe all the different geometries of the system. The change to the zenith geometry would require a major rewrite of the parts describing all different geometries of the system.

We agree with the reviewer that it is difficult to follow the discussion about all the different angles. This is the reason we provide a very detailed description of all the angles in Fig. 8.

RC:

The hardware set-up of the receiver could probably be better illustrated with a drawing than with Figure 3.

Reply:

We moved the drawing of the system (Fig. 7) in the beginning of Section 2.

RC:

The function of some units of the hardware (LPC, precipitation sensor, UPS) is leaved implicit. I believe it should be explicit (e.g. "detection of precipitation causes shutdown of the lidar", "UPS can keep the system running for X hours in case of power failure", "the purpose of LPC is XXX", etc.). You also mention shutting down the lasers in case of emergency: what type of emergency and how is it detected?

Reply:

We provide more information about the function of the LPC, the precipitation sensor, the UPS and the hardware interlocks:

For the LPC, the precipitation sensor and the hardware interlocks (i.e., external push buttons that shut down the system in case of emergency) we changed lines 113-118 as following: “The lidar system is controlled from the LPC unit. This is an "enhanced" embedded computer with specific I/Os that fits the lidar requirements, providing several ethernet interfaces that make the controlling (local or remote) of the lidar easy and safe. The LPC controls all lidar sub-components (e.g. the lasers, data acquisition systems), along with any auxiliary equipment used by the lidar system (e.g., the precipitation sensor, temperature and humidity sensors, cameras for the alignment). Additionally, it controls the mechanical rotators of the optical elements used for calibration purposes (Section 4), and it stores the acquired raw measurements. The precipitation sensor (Fig. 6) provides information about precipitation conditions and causes shutdown of the lidar when precipitation is detected. Moreover, several external easy accessible push buttons are connected to the LPC and can be used by the operators to shut down the lasers in case of emergency.”

We added the info for the UPS in line 102: “The UPS can provide power to the system for about one hour, in case of power failure. This is enough time for a proper cool down of the lasers and shutting down of the system.”

RC:

In general the reasons behind the design choices could be given: why two telescopes and not e.g. a single telescope with a more complex optical system behind, allowing the same states of polarisation to be measured? Why does the second laser emit elliptically polarised light and not circular polarised, and how is the optimal polarisation ellipse chosen?

Reply:

The two lasers/two telescopes configuration helps in achieving good signal-to-noise-ratio in short measurement times. This was mentioned in the abstract, but it is now included in Section 2 as well, in lines 59-60: "The system uses this "two-laser/two-telescope/four-detector" setup to record eight separate signals with good SNR in short measurement times."

The definition of the polarization of laser B is a work in progress. We clarify this in the manuscript by changing lines 146-151: "The methodology for defining the optimum measurements includes extensive simulations for different atmospheric scenarios and machine learning tools. Briefly, the backscattered light is simulated for different mixtures of dust particles with realistic sizes and irregular shapes, including cases with random and preferential particle orientation. We investigate a large number of possible polarizations for laser B, and we evaluate their information content based on the performance of the corresponding neural network retrievals that use the simulated lidar measurements to retrieve the oriented dust microphysical properties. This is an ongoing work, with the first results identifying that the emission from laser B should be elliptically-polarized with the angle of the polarization ellipse at 5.6^{o} and degree of linear polarization of 0.866."

RC:

First measurements are shown very briefly and they show that the system works, but the case study chosen does not allow to highlight particle orientation (the main goal of this new instrument). I would support Anonymous Referee #1’s suggestion that it would be useful to show an example where particle orientation is observed (not necessarily dust if an example has not yet been identified).

Reply:

Although we agree with the reviewer that it would be better to show measurements of e.g. rain orientation, we haven't managed to acquire them by now, due to the technical challenges these measurements entail, mainly due to the analog detection of our signals, which are saturated from overlaying clouds and/or the rain. Although this is not impossible to cope, it requires extensive experimentation, which we think it is out of the scope of this paper.

Another issue is that we had to go through repairs for the lasers (once due to laser malfunction and once due to improper operation), which delayed our field measurements.

We decided that in order to avoid confusion, we include a dust-free case to the "First measurements" section, which shows no orientation (as expected). We use these measurements to show that the instrument works as expected and provides "no orientation" flags, for dust-free atmospheres. The measurements used were acquired at viewing angle of 80o off-zenith, to highlight the scanning capabilities of the system. Moreover, we provide the Rayleigh fit of the lidar signals, as a quality standard of our measurements.

RC:

Finally, the 1-page long overview and future perspectives section is merely a summary of the article followed by a brief description of future plans. I believe that it would be useful to tie the research more widely to the wider field of research, going back to the main questions raised in the introduction and explaining how you are contributing to answer some of them. This section could be completely rewritten.

Reply:

We revised the Section "Overview and future perspectives" accordingly, trying to tie the work presented in the manuscript to the wider field of research.