Atmospheric Measurement Techniques Discussions

Atmos. Meas. Tech. Discuss., referee comment RC1
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Comment on amt-2022-192

Anonymous Referee #2

Referee comment on "Investigating the dependence of mineral dust depolarization on complex refractive index and size with a laboratory polarimeter at 180.0° lidar backscattering angle" by Alain Miffre et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2022-192-RC1, 2022

This paper investigates the relationship between the particle depolarization ratio of mineral dust and the particles' complex refractive index and size, using a ð□□□-polarimeter that operated at a 180-degree backscattering angle, at two typical lidar wavelengths, 355 and 532 nm. Through laboratory experiments, the authors derive 16 dust-related particle depolarization ratio values that correspond to four different refractive indices (mineral dust samples with different mineralogy), for two size distributions (fine, coarse) and at two wavelengths (355, 532 nm).

The work falls well within the scope of AMT. Overall, the methodology is well explained and the results are clearly presented. However, the manuscript could be improved prior to publication, by addressing the comments provided below.

Major comments:

- The description of the dust samples (Sect. 2) should be more detailed. What exactly is Asian dust? Where do you get it from? Does it originate from a specific dessert? As I understand it, you use commercially available dust samples and silica and hematite as well. How are your four samples treated and prepared by the manufacturer? Furthermore, the paper would become richer, if the discussion about the mineralogical composition of desert dust samples could be added. There are various studies investigating the mineralogical composition including silica and hematite contributions. Apart from the finer/coarser SD differentiation (L144-L147), to which extent are the chosen dust samples representative/characteristic of what is being observed in the atmosphere?
- The size distributions (Fig. 1) are a finer and a coarser one as you often state, but it is not a fine mode and a coarse mode (as sometimes ambiguously stated, e.g., L12, L426). It is a fine mode size distribution and a fine + coarse mode size distribution or in

other words a size distribution with and one without coarse mode. Please clearly make this statement in Sect. 2.2.

- How do you estimate the uncertainty of your results (Tab. 1 + 2)? Is it the uncertainty of the fit? To which amount does the systematic error is considered?
- The discussion and comparison to previous literature is rather short and should be extended before publication. Even if previous laboratory setups did not operate at exactly 180° backscatter, the results should be discussed. Especially, I am missing a reference and discussion to the work by Sakai et al., 2010, who investigated fine and coarse mode dust from Asia and the Sahara at 532 nm. How do their results compare to your new findings? The comparison to lidar field experiments is rather short as well. It is hard to compare for Arizona Test Dust, but for Asian dust, there are plenty of field experiments reporting PDR at 355 and/or 532 nm, e.g., Sugimoto & Lee, 2006; Hofer et al., 2020 or Hu et al., 2020.

Minor comments:

- Please always state Arizona Test Dust and not just Arizona dust. Arizona Test Dust is a well-known term in the community.
- L43-47: need rephrasing. Also, the literature selected is rather limited, important studies are missing.
- L49: The particle linear depolarization ratio's importance for aerosol typing has been demonstrated in numerous studies (e.g., Burton et al., 2012). The authors should extend the literature provided here accordingly.
- L70- 82: It would have been better if the authors merged the list with the main body text.
- L102: new paragraph "The paper is structured…"
- L122-124: The imaginary part of the CRI varies by a factor of 10 between the literature values: 0.0925 (Longtin et al., 1988) and 0.9 or 0.6 (Go et al., 2022). Is there a reason for the difference?
- Just out of curiosity: Why do your size distributions (Fig. 1) all show a peak at 1 µm?
- In line 267 you're referring to the polarization lidar reference paper of Freudenthaler et al., 2009. There is an even more complete assessment of the polarization lidar calibration given by the same author (Freudenthaler, 2016). There, additional sources of uncertainties are discussed. In your case, the rotational misalignment around the optical axis might be worth discussing (even if it is probably very small).
- L282-284: Please provide an approximate particle concentration.
- Lidar particles depolarization ratio – lidar PDR: Does the term "lidar PDR" refers to the 180° backscatter direction? Or what is the difference to PDR?
- At one instance, you should mention that you are measuring the linear depolarization ratio.
- L351-353: Please rephrase. In field experiments, we do observe pure aerosol conditions with lidars- not only aerosol mixtures.
- Fig. 1: Larger fonts (for labels, markers, axis) are needed. Consider changing the grey colour, it is very hard to read.
- Fig. 4: Larger fonts are needed. Very hard to read. There is enough space in the plot to include the names of the dust samples (Arizona Test, Asian). The same holds for Fig. 5.
- Fig. 6: It would be recommended to insert the results for Asian dust and Arizona Test Dust into the figure. Even if they are not lying perfectly on the line, it illustrates better the consistency of your results. By the way, the information about the depolarization ratio of silicate and hematite is doubled (once next to the figure and once on the dashed line).

- Eq. 8: Indices should not be in italic.
- The figures should be provided in higher resolution, with larger fonts. In their current state, they are very difficult to read.
- Sections 4.3 and 5 are rather repetitive. I suggest merging those sections into one to avoid text repetitions.

References:

Burton, S. P.: Aerosol classification using airborne High Spectral Resolution Lidar measurements–methodology and examples, *Atmospheric Measurement Techniques*, 2012, 5(1), 73-98

Freudenthaler, V.: About the effects of polarising optics on lidar signals and the Δ 90 calibration, *Atmospheric Measurement Techniques*, 2016, 9, 4181-4255

Hofer, J.; Ansmann, A.; Althausen, D.; Engelmann, R.; Baars, H.; Fomba, K. W.; Wandinger, U.; Abdullaev, S. F.; Makhmudov, A. N.: Optical properties of Central Asian aerosol relevant for spaceborne lidar applications and aerosol typing at 355 and 532 nm, *Atmospheric Chemistry and Physics*, 2020, 20, 9265-9280

Hu, Q.; Wang, H.; Goloub, P.; Li, Z.; Veselovskii, I.; Podvin, T.; Li, K.; Korenskiy, M.: The characterization of Taklamakan dust properties using a multiwavelength Raman polarization lidar in Kashi, China*, Atmospheric Chemistry and Physics*, 2020, 20, 13817-13834

Sakai, T.; Nagai, T.; Zaizen, Y. & Mano, Y.: Backscattering linear depolarization ratio measurements of mineral, sea-salt, and ammonium sulfate particles simulated in a laboratory chamber, *Appl. Opt.*, OSA, 2010, 49, 4441-4449

Sugimoto, N. & Lee, C. H.: Characteristics of dust aerosols inferred from lidar depolarization measurements at two wavelengths, *Appl. Opt.*, OSA, 2006, 45, 7468-7474