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Atmospheric Chemistry and Physics
Discussions

Interactive comment on "Measurement report: Balloon-borne in-situ profiling of Saharan dust over Cyprus with the UCASS optical particle counter" *by* Maria Kezoudi et al.

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Interactive comment on "Measurement report: Balloon-borne in-situ profiling of Saharan dust over Cyprus with the UCASS optical particle counter" by Maria Kezoudi et al.

AC: We would like to thank the Referees for their comments which helped to improve the quality of our manuscript. Please find our point-by point replies in blue font below.

Please note that we have added Johannes Bühl to the list of co-authors. He operated and maintained the PollyXT instrument during its deployment at Limassol and, thus,

assured consistently high data quality. We have also revised the Acknowledgment to include further people that deserve to be mentioned there.

Anonymous Referee #1

RC: This paper aims to validate a state-of-the-art sonde for dust profiling based on an in-situ optical particle counter approach. The experimental design is really interesting because it can help, for instance, to explore the lowermost troposphere where lidars are typically blind, leading to complement their measurements for modelling applications. The manuscript is very well structured, allowing for a clear comprehension of the research involved. However, I found some issues to be addressed, mainly minor comments.

AC: We thank the Referee for the overall positive assessment of our work.

RC: lines 107-108: It is supposed that the use of Mie scattering has a small effect on the calculated size distributions even in the presence of non-spherical particles. Can you provide a quantification of this?

AC: The following text is added in line 110: "More specifically, Johnson et al. (2011) estimate a maximum error of 21% related to the assumption of spherical dust particles which they assess as moderate compared to the other errors inherent in the derivation of the total optical parameters."

RC: lines 188-189: In the instrumentation section (2.2.) is mentioned that the PollyXT allows for measuring polarized components at 355 and 532 nm. It seems (from the sentence in lines 188-189) that only total signals at these wavelengths are used. Does not GARRLIC use polarized components?

AC: The polarization information is a -relatively- new feature of the GARRLiC retrieval. To be more specific, when we performed the retrievals, it was still in an experimental phase, whereas it has been some time now available for use.

RC: lines 193-199: it would be nice to provide an estimation of the uncertainties of the

GARRLIC derived products.

AC: The following text is added in line 206: “Estimation of the different uncertainties of the GARRLiC derived products is provided in previous works (e.g. Torres et al., 2017), and it has been lately tested for integration in the algorithm (Herrera et al., 2019).” Lines 226-233: How are you sure what is dust and what is not? Taking into account the different origin of air masses shown in figure 3, I recommend to include in fig 1 an additional panel ploting information from depolarization (at least volume linear depol ratio, but particle depol ratio is preferred). This also brings me an additional point. What is the uncertainty for depolarization products? How were those channels calibrated? A detailed description is not needed, some relevant references should be enough.

We thank the Referee for this comment. Based on the suggestion above, we have added a new Figure 2 that shows the profiles of the volume and particle linear depolarization ratio around the times of the five UCASS launches shown in Figure 1. These clearly show the presence of mineral dust over the lidar site. The uncertainty of these products is outlined in Engelmann et al. (2016). Calibrations are performed following EARLINET protocol, i.e. Freudenthaler (2016). The following text has been added to Section 2.2 when listing the measurement capability with respect to the particle linear depolarisation ratio: “The latter parameter is highly sensitive to particle shape and the corresponding measurements are calibrated following the methodology outlined in Freudenthaler (2016)”

In addition, a description of new Figure 2 was added to Section 3.1: “The profiles of the particle linear depolarisation ratio at 532 nm in Figure 2 provide evidence that mineral dust was present over the measurement site and occurred in well-mixed layers. Values larger than 0.20 and as high as 0.33 are generally observed for this particle type (Freudenthaler et al., 2009) and are detected throughout the better part of the aerosol layer while the influence of local aerosols leads to the lower values close to the surface.”

Engelmann, R., Kanitz, T., Baars, H., Heese, B., Althausen, D., Skupin, A., Wandinger, U., Komppula, M., Stachlewska, I. S., Amiridis, V., Marinou, E., Mattis, I., Linné, H., and Ansmann, A.: The automated multiwavelength Raman polarization and water-vapor lidar PollyXT: the neXT generation, Atmos. Meas. Tech., 9, 1767–1784, https://doi.org/10.5194/amt-9-1767-2016, 2016.

Freudenthaler, V., Esselborn, M., Wiegner, M., Heese, B., Tesche, M., Ansmann, A., Müller, D., Althausen, D., Wirth, M., Fix, A., Ehret, G., Knippertz, P., Toledano, C., Gasteiger, J., Garhammer, M., and Seefeldner, M.: Depolarization ratio profiling at several wavelengths in pure Saharan dust during SAMUM 2006, Tellus B, 61, 165-179, doi:10.1111/j.1600-0889.2008.00396.x, 2009.

Freudenthaler, V.: About the effects of polarising optics on lidar signals and the $\Delta 90$ calibration, Atmos. Meas. Tech., 9, 4181-4255, https://doi.org/10.5194/amt-9-4181-2016, 2016.

RC: Lines 413-414: How did you deal with the incomplete overlap region to estimate AOTs?

AC: We identified the lowermost trustworthy value and extended the profiles to the surface using that value. A corresponding statement was added to Section 2.2: “Lidar-derived values of aerosol optical depth are inferred by extending the profiles down to the surface using the lowermost trustworthy value above the overlap range.”

RC: Lines 426-428: Because you used GRASP in this study combining Sunphotometer and PollyXT data, profiles of refractive index and single scattering albedo can be retrieved. This information might support your argument here.

AC: In this paper we focus on UCASS results that can be validated with the help of independent in-situ measurements, i.e. the height-resolved information on particle number concentration and particle size distributions. Nevertheless, we have looked at the findings of the GARRLiC retrieval for measurements during launches 1 and 2 and found the following results at 532 nm: For launch 1: a real part of 1.48 $\pm$ 0.05 and an imaginary part of 0.003 $\pm$ 0.02 leading to a single-scattering albedo of 0.89 $\pm$ 0.07 For launch 2, a real part of 1.47 $\pm$ 0.03 and an imaginary part of 0.006 $\pm$ 0.03 leading to a single-scattering albedo of 0.92 $\pm$ 0.03

RC: Figure 1: For the sake of clearness, I recommend to use symbols or colors with more contrast for Limassol and Paphos data.

AC: We appreciate the Referee's concern. However, we don't think that it is necessary to provide a large contrast between the data from the two sites. In fact, the purpose of showing data from both sides is to demonstrate that there has been little difference in the aerosol conditions. This allows us to discuss the combined measurements with UCASS launched from Paphos and the Polly lidar based at Limassol. No changes have been made to the figure.

RC: Figure 4: Is there no information about the horizontal distance above roughly 5 km for the case launch 1?

AC: This is now corrected: the black line in what is now Figure 5a was extended to the maximum altitude.

RC: Figure 8: Why do the Klett profiles shown here? It is well-known that this method cannot provide consistent extinction information. Even more, why is the full overlap height different from the extinction and the backscatter profiles shown here?

AC: The figure shows extinction profiles derived by using the Raman method (blue line) and the Klett method (solid and dotted lines). For the comparison to the UCASS measurements and to resolve the same vertical features as identified in the UCASS data (with a height resolution of 5 m), we intended to keep the true vertical resolution of the lidar measurements as fine as possible. As a consequence, the Raman extinction profiles are rather noisy. We therefore also derived Klett extinction profiles using lidar ratios of 40 sr and 60 sr to cover the likely range of values. Indeed, the blue line of the

Raman extinction coefficient mostly stays between the two Klett extinction profiles with a tendency towards the one derived with the lower lidar ratio of 40 sr. The Klett profiles are obtained from the combination of far-field and near-field channels (Engelmann et al., 2016) and, thus, extend further down to the surface. Overall, we believe that the reader gets a better impression of the dust conditions from this comprehensive display of extinction profiles. âĂČ

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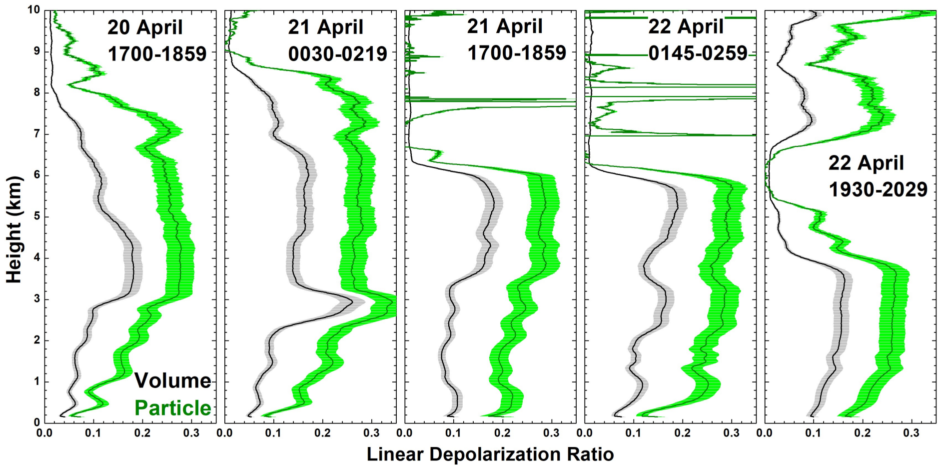

Fig. 1. Figure 2: Profiles of the linear volume depolarization ratio (black line with grey error range) and the particle linear depolarization ratio (dark green line with light green error range) measured by

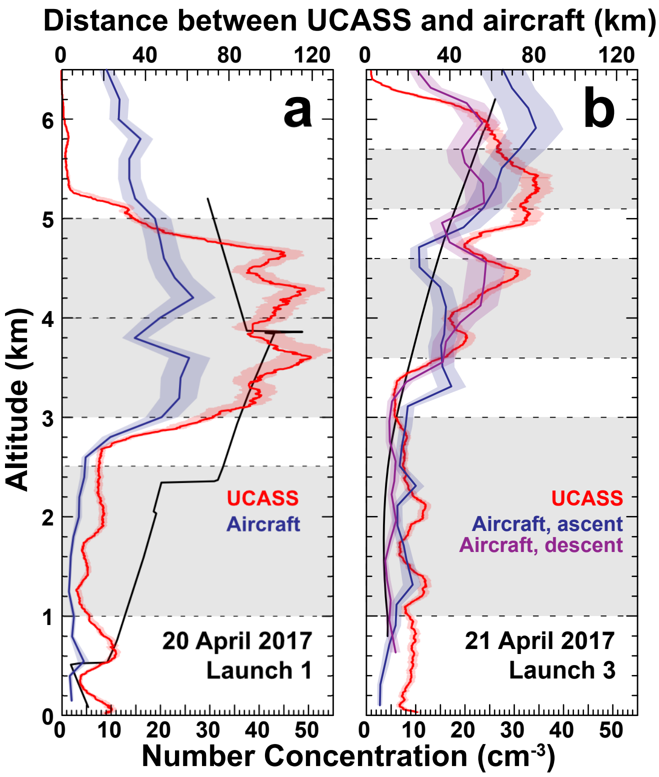

Fig. 2. Figure 4

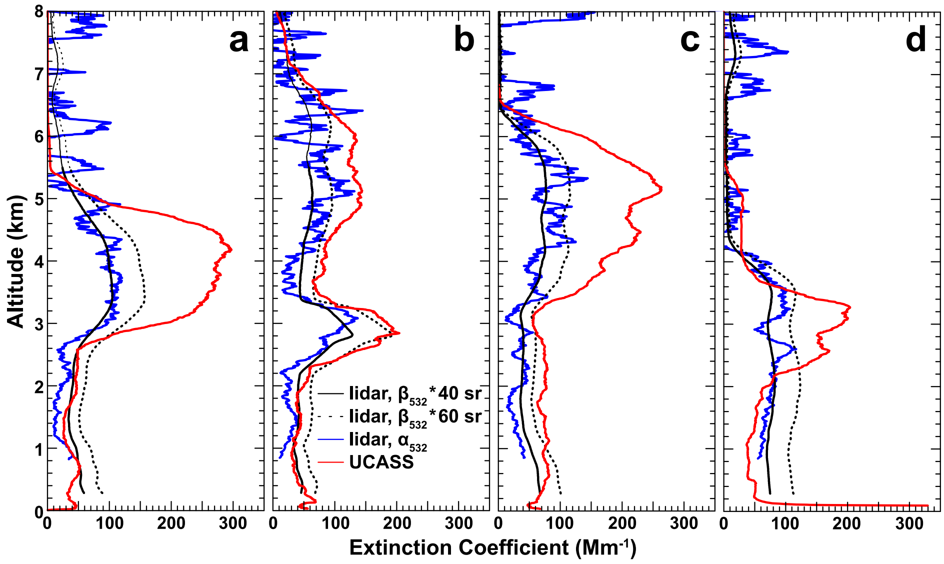

Fig. 3. Figure 8