Response to comments

Authors suggest an approach to inversion of multiwavelength lidar measurements to the particle microphysical parameters based on iteration scheme with prior assumption about particle properties. In this manuscript authors make an important step considering parameters both the fine and the coarse mode. Simulation performed with synthetic data provides estimation of retrieval uncertainties for different lidar configurations. The manuscript is well and clearly written and matches AMT scientific criteria.

I have just several short comments.

Authors consider 12 independent parameters of aerosol, when even for "super-lidar" only 9 observations are available. The problem is underdetermined and unique solution does not exist. I think this principal question should be discussed in the beginning of the manuscript.

This becomes especially critical when configuration corresponding CPL or ATLID lidar are considered.

Thanks, we do indeed need to further emphasise the ill-posed nature of the problem, and the underdeterminedness of the system, and the motivation of our experiments, which is to investigate where the information in the lidar measurements goes in an iterative retrieval. To that end, around line 110 in the introduction we have changed the description of the method as such: "Keeping in mind the results of uncertainty/information content analysis, we apply an iterative retrieval scheme, taking the lidar measurements and investigating where the information in the measurements goes in a retrieval of microphysical parameters. The problem is clearly ill-posed, and the system underdetermined, as the number of microphysical parameters we attempt to retrieve can be around twice the number of measurements, depending on the configuration"

Additionally, we have included the following in the summary and conclusion, in the first paragraph: "For the HSRL-2 configuration, the three measurements of depolarisation ratio yield information on the spherical fraction of the aerosol distribution. This leaves the two extinction measurements and the three backscatter measurements to provide information on the remaining microphysical properties. The problem is clearly ill-posed, and the system is underdetermined, with the number of unknowns exceeding the number of measurements by almost a factor of two. Thus, it is clear that a prior is needed to provide a constraint on the microphysical properties of the aerosol distribution."

Choose of model refractive indices for different types of aerosol is somehow convenient, but question is how sensitive are results to the choice of model. For example, in Table 1 the imaginary part of dust at 355 nm is 1.66*E-2. The same time, in recent study the Im for dust at 370 nm is below 0.005 (Di Biagio, Atmos. Chem. Phys., 19, 15503–15531, 2019) for dust of different origin. Will it influence the inversion?

The influence of different refractive indices is outside of the scope of this study, as the aim was to carry out aerosol retrievals in a manner aligned as closely as possible to those carried out previously in polarimeter retrievals (e.g. in Fu et al. 2020)). As such, we used the same refractive index values as in Fu et al., as this is also crucial for the next part of the study involving a combination of lidar and polarimeter in a retrieval. There is an option to separately fit the imaginary and real refractive index spectra, which leaves more room to adjust the imaginary part whilst keeping the real component fixed.

In Table 7 the parameters of the coarse mode obtained from the lidar measurements are not provided. Any reason?

The coarse mode contribution is negligible compared to the smoke-dominated fine mode (fine mode AOD 24 times higher than coarse mode AOD). The AOD of the coarse mode retrieved from the ACEPOL HSRL-2 measurements is 0.021. For such low mode AOD it is virtually impossible to retrieve meaningful information on the microphysical properties of that mode.

Fig.1. Axis title fonts should be increased.

Thanks, we have enlarged the fonts and improved the presentation of all figures.

References

Fu, G., Hasekamp, O., Rietjens, J., Smit, M., Di Noia, A., Cairns, B., Wasilewski, A., Diner, D., Seidel, F., Xu, F., Knobelspiesse, K., Gao, M., da Silva, A., Burton, S., Hostetler, C., Hair, J., and Ferrare, R.: Aerosol retrievals from different polarimeters during the ACEPOL campaign using a common retrieval algorithm, Atmospheric Measurement Techniques, 13, 553–573, https://doi.org/10.5194/amt-13- 553-2020, 2020.