Response to RC2

General Comments:

Possibility to estimate the particle concentration (and so CCN and INP) from extinction/backscattering lidar measurements by using corresponding conversion factors is quite attractive. As suggested in publications of Ansmann with co-authors, the conversion factors can be estimated from AERONET measurements and this study improves the knowledge of these factors for dust, applying POLIPHON technique for different дщсфешщты. Paper is well written, presents new results and is suitable for publishing in AMT after minor revision.

Response: We appreciate the reviewer's thoughtful review and constructive comments. All the comments have been addressed in the revised manuscript, and the responses to each comment are given below.

Specific comments

Comments: Ln.89. "*The new scheme is based on the particle linear polarization ratio in AERONET Version 3 aerosol inversion product, which is considered a better indicator for non-spherical 90 dust particles (Shin et al., 2018, 2019)*"

Depolarization ratio in AERONET is calculated with the model of randomly oriented spheroids. There are many challenges in application of this model to the dust particles and accuracy of depolarization calculation is the subject of discussions (e.g. Gasteiger, J., Wiegner, M., Groß, S., Freudenthaler, V., Toledano, C., Tesche, M., and Kandler, K.: Modeling lidar-relevant optical properties of complex mineral dust aerosols, Tellus B, 63, 725-741, 2011). I think corresponding comment should be added to the manuscript.

Response: Thank you for the reviewer's reminder. The spheroid shape model may indeed raise errors in particle linear depolarization ratio for mineral dust according to the results of a modeling study by Gasteiger et al. (2011). Even though, dust is the predominant particle to trigger significant depolarized signal, which can be well captured by AERONET spheroid model. We take a large threshold of particle depolarization ratio (0.30) to mitigate the error introduced by the spheroid model, in terms of the wrong characterization of dust. We have added some sentences to mention the spheroid model of AERONET retrieval and discuss the benefit of using irregular particle shape in the modeling study by Gasteiger et al. (2011) in the introduction of the revised manuscript as follows

'…It should be noted that the particle linear depolarization ratio values in AERONET retrieval are calculated from the combination of the particle size distribution and complex refractive index based on a spheroid light scattering model (Dubovik et al., 2006). Based on a modeling study, Gasteiger et al. (2011) found that the lidar-measured particle linear depolarization ratio values for pure

mineral dust can be better reproduced by using an irregular particle shape assumption compared with using the spheroid shape assumption. Nevertheless, we consider it adequate to adopt AERONET-derived particle linear depolarization ratio values to qualitatively identify the presence of dust in the atmospheric column (Noh et al., 2017).' (Please see Line 99-105)

Comments: Table 1. Uncertainties of estimation is really important point. In estimation of dust backscattering depolarization ratio of smoke is assumed 0.05. But actually it varies in 0.04-0.09 range (Burton et al., 2013), though provided uncertainty 10-30% looks reasonable. However, lidar ratio of dust may vary in 30 sr-60 sr range, so uncertainty of extinction calculation should be higher, but authors provide 15-25% range. Uncertainty of mass concentration should be even higher, but in Table 1 the range 20-30% is given. I think these uncertainties should be clarified.

Response: Thank you for pointing out this issue. Considering this reviewer's comments together with the comments from RC3, we have reevaluated the uncertainties for the parameters provided and updated them as seen in the revised Table 1. Now, the uncertainties in the dust backscatter coefficient and dust extinction coefficient should be approximately <49% and <59%. Thus, we consider the uncertainties in M_{d}, $n_{250,\mathrm{d}}$, s_{d}, and $s_{100,\mathrm{d}}$ are estimated to be approximately <60%. The final uncertainties in INPC and CCNC are still estimated to be <500% and <200% because the largest uncertainty is still contributed by CCN and INP parameterization schemes.

Reference:

Burton, S. P., Ferrare, R. A., Vaughan, M. A., Omar, A. H., Rogers, R. R., Hostetler, C. A., and Hair, J. W.: Aerosol classification from airborne HSRL and comparisons with the CALIPSO vertical feature mask, Atmos. Meas. Tech., 6, 1397–1412, https://doi.org/10.5194/amt-6-1397-2013, 2013.

Comments: Ln 125. "a good proxy for dust-related CCN concentration $n_{CCN,ss,d}$ " I think should be explained, why "ss" used in subscript.

Response: We have added the following sentence **'Here, the subscript 'ss' denotes the water supersaturation.'** (Please see Line 141)

Comments: Eq.3. Notations look a bit strange for me. For example, authors use $N_{250,j}$ and in the right part it becomes $n_{250,d,j}$. Why index "d" is absent in the left part?

Response: Thank you for pointing out this. We confirm that the subscript 'd' than denotes 'dust aerosol type' should be present in the left part of Eq. (3), (4), and (5). These Eqs. have been modified accordingly. (Please see Line 149-151)

Comments: Eq.6. What is c_d?

Response: $c_{100,\mathrm{d}}$ is a CCN-relevant conversion factor. Together with χ_{d}, $c_{100,\mathrm{d}}$ can be used to calculation $n_{100,\mathrm{d}}$ with the following equation $n_{\mathrm{CCN,ss,d}}(z) = f_{\mathrm{ss,d}} \times n_{100,\mathrm{d}}(z)$ in Table 1.

Comments: Ln 195. Ok, here authors start discussion of spheroids model. But may be better to do it in introduction.

Response: We have added some related discussions on the spheroids model of the AERONET depolarization ratio in the introduction. Please see the response to the first specific comment above.

Comments: Eq.8 actually repeats Eq.1.

Response: We agree with the reviewer's comment that Eq. (8) is similar to Eq. (1). Here we still give Eq. (8) because column-integrated PLDR data at 1020 nm from AERONET aerosol inversion are used to obtain the column-integrated dust ratio ($R_{\mathrm{d,1020}}$), which is somewhat different from the application in height-resolved lidar retrieval. Thus, we would like to retain Eq. (8) for clarity.