In this work, the extinction profile and the effective radius are retrieved simultaneously from the CALIOP lidar based on look-up tables. In general, the topic is important and falls within the scope of AMT. However, some revisions should be made before it is considered for publication.

Response: We thank the reviewer for such positive comments on our work! Below we answer the omments point-by-point, and we have also revised the manuscript accordingly.

1. The look-up tables are based on Mie scattering, which assumes spherical aerosols. However, aerosols in the atmosphere have a complex morphology. I do not assume that the morphologies significantly affect the extinction calculations, but you need to point this out. However, when calculating the backscatter factor or backscatter cross section, morphology is expected to have a large influence. Since the lidar properties, AE and polarimetric properties of aerosols are significantly affected by particle shape (Luo et al. 2019, Kahnert et al. 2020, Gialitaki et al.2020, Luo et al. 2022), the authors may need to add some clarifications. We do not expect a large influence on the extinction retrieval, but the effective radius retrieval may be significantly influenced by aerosol shape.

Luo, J., zhang, Q., Luo, J., Liu, J., Huo, Y., & Zhang, Y. (2019). Optical modeling of black carbon with different coating materials: The effect of coating configurations. Journal of Geophysical Research: Atmospheres, 124, 13230–13253.

https://doi.org/10.1029/2019JD031701

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Gialitaki, A., Tsekeri, A., Amiridis, V., Ceolato, R., Paulien, L., Kampouri, A., Gkikas, A., Solomos, S., Marinou, E., Haarig, M., Baars, H., Ansmann, A., Lapyonok, T., Lopatin, A., Dubovik, O., Groß, S., Wirth, M., Tsichla, M., Tsikoudi, I., and Balis, D.: Is the near-spherical shape the "new black" for smoke?, Atmos. Chem. Phys., 20, 14005–14021, https://doi.org/10.5194/acp-20-14005-2020, 2020.

Luo, J., Li, Z., Fan, C., Xu, H., Zhang, Y., Hou, W., Qie, L., Gu, H., Zhu, M., Li, Y., and Li, K.: The polarimetric characteristics of dust with irregular shapes: evaluation of the spheroid model for single particles, Atmos. Meas. Tech., 15, 2767–2789, https://doi.org/10.5194/amt-15-2767-2022, 2022.

Response: Thanks for your advice! We have studied these papers carefully and improved the discussion sections of our manuscript with references in Lines 300-302 as following:

"possibly by taking advantage of the depolarization ratio (Gialitaki et al., 2020; Kahnert et al., 2020; Luo et al., 2022; Luo et al., 2019) measurement that is not used here."

2. Equation 12: The authors should clarify the definition of $Qb(\lambda, r)$ and how to calculate the optical properties (which code?). I think the $Qb(\lambda, r)$ is calculated based on the scattering efficiency and phase function at the backward angles. Please clarify it.

Response: We are sorry for the confusion. $Q_b(\lambda, r)$ is the scattering efficiency of the particle at 180° calculated with phase function. We use the Lorenz–Mie scattering FORTRAN program (Mishchenko and Yang, 2018) to obtain the optical properties ($\mathrm{Q_e(\lambda, r)}$ and $\mathrm{Q_b(\lambda, r)}$). We have revised the manuscript accordingly in Lines 128-131 as following:

"*$Q_e(\lambda, r)$ and $Q_b(\lambda, r)$ denote the extinction and backscatter efficiencies of the particle (the scatter factor of the particle at 180°) with size r at wavelength λ respectively. The size parameter is defined as $x \equiv 2\pi r / \lambda$, where $1 < x < 50$ for typical aerosols and thus the Mie scattering theory (Mishchenko and Yang, 2018) can be applied.*"

3. Please clarify how to retrieve the optical properties, which object function?

Response: Thanks for this comment! As shown in Figure 2, we retrieve the optical properties by solving the lidar equation using the Fernald method (Fernald, 1984) by establishing a look-up table. Firstly, we calculate the extinction coefficients ($\sigma_{532\,nm}$ & $\sigma_{1064\,nm}$) of two wavelengths ($532\,nm$ & $1064\,nm$) from an initial guess of the lidar ratios ($S^0_{532\,nm}$ & $S^0_{1064\,nm}$) by solving the lidar equation (Eq. 6), and then obtain the Ångström exponent (AE) through Eq. (10). Secondly, the look-up table is used to determine a set of new lidar ratios ($S'_{532\,nm}$ & $S'_{1064\,nm}$), which is used to calculate the new $\sigma_{532\,nm}$ & $\sigma_{1064\,nm}$ and Ångström exponent (AE'). This procedure is repeated until the difference between the updated AE' and previous AE reduces to a very small value (10^{-3}). The final values of $\sigma_{532\,nm}$, $\sigma_{1064\,nm}$, $S_{532\,nm}$ and $S_{1064\,nm}$ are the retrieved optical properties of this layer, and the backscatter coefficients $\beta_{532\,nm}$ and $\beta_{1064\,nm}$ can also be obtained by Eq. (5). We have revised the manuscript accordingly in Lines 77-78 and Lines 156-157 as following:

"*by solving the lidar equation using the Fernald method (Fernald, 1984) with a look-up table approach in the iteration procedure.*"

"*and the final values of $\sigma_{532\,nm}$, $\sigma_{1064\,nm}$, $S_{532\,nm}$, $S_{1064\,nm}$ and $\bar{r}$ are the retrieved results of this layer.*"

4. Equation 13: I think that this equation does not reflect the lognormal distribution, and this is the normal distribution. Please modify it. Is "the average particle radius" "the geometric mean radius"? is "standard deviation" "geometric standard deviation"?

Response: We are sorry for this mistakes. The "standard deviation" is "geometric standard deviation", and "the average particle radius" actually is "the median radius". We have revised the manuscript accordingly in Lines 132-139 as following:

"*As the limited information provided by two-wavelength lidar, we assume the volume-size distribution of aerosols conform to the lognormal distribution, and the size distribution is expressed as follows (Deshler et al., 2003; Hara et al., 2021):*

$$n(r) = \frac{N}{r\,ln\,s_d\sqrt{2\pi}} e^{-\frac{(ln\,r - ln\,r_0)^2}{2\,(ln\,s_d)^2}}, \qquad (13)$$

Where N *is the total particle concentrations;* r_0 *and* s_d *are the median radius and the geometric standard deviation of aerosol size distribution, respectively. When we assumed a constant* s_d *for the same aerosol, the* AE *can be calculated when given an* r_0*. The particle effective radius (*$\bar{r}$*)* is defined *by:*

$$\bar{r} = \frac{\sum n(r)r^3}{\sum n(r)r^2}, \qquad (14)$$ ”

5. Line 137 “When we assumed a constant sd for the same aerosol””the AE can be calculated when given an r” ?

Response: Thanks for your advice! We have revised the sentence accordingly in Lines 137-138 as following:

“*When we assumed a constant* s_d *for the same aerosol type, the* AE *can be calculated with a given* r_0 *value.”*

6. Line 138-139: Please provide references.

Response: Thanks for your advice! We have added the references following this sentence in Lines 140-141 as:

“*We choose the six types of aerosols with their parameters in Table 1, which is consistent with the aerosol classification used in the operational algorithm of CALIOP (Winker et al., 2009).*”

7. Lines 116-117. I do not understand why it says: “The two-wavelength lidar can give two independent profiles of the attenuated backscatter coefficients”, and why the

profiles of the aerosol extinction coefficients were calculated based on the attenuated backscatter coefficients. From equation 6, the aerosol extinction coefficient profiles can be determined. This theorem is confusing.

Response: We are sorry for the confusion. The attenuated backscatter coefficents profiles, provided by the measurements of CALIOP with calibrated and range-corrected, are the source data for our inversion algorithm. $\mathrm{E(R)}$ in Eq. (6) is calculated by Eq. (4) with the attenuated backscatter coefficents $\beta'(\mathrm{R})$ and the transmittance of air molecules $\mathrm{T_m^2(R)}$, which means that the profiles of the aerosol extinction coefficients must be calculated based on the attenuated backscatter coefficients. The two-wavelength lidar have two independent measurements of attenuated backscatter coefficients. We have have revised this sentence in Lines 114-115 as following:

"*The two-wavelength lidar can give two independent profiles of attenuated backscatter coefficients at different wavelengths*,"

8. How do you define the effective radius? Please give a definition. Have you used the geometric mean as a substitute for the effective radius? Please explain this.

Response: Thanks for your advice! We have revised the manuscript accordingly in Lines 138-139 as following:

"*The particle effective radius ($\bar{\mathrm{r}}$) is defined by:*

$$\bar{r} = \frac{\sum n(r)r^3}{\sum n(r)r^2}, \qquad (14)$$"

9. The authors say that the CALIOP products classify the aerosols into different

types and that this is not sufficient to represent the aerosols in the atmosphere, but the refractive indices and the geometric standard deviation of the size distributions from CALIOP are still used and only change the geometric mean radius. Please justify the use of these parameters, as you have said that this is not sufficient.

Response: Thanks for this comment! Indeed the CALIOP classification might be insufficient, especially in our application we find that some profiles could not yield an valid retrieval, which is very likely duet to limitations of the look-up table constructed with CALIOP aerosol type. However, the CALIOP types are contructed using AERONET observations, which is the most extensive ground based aerosol network up to date. It is therefore very difficult to overcome the limitations in the aerosol types for the moment. We also plan to refine our look-up table to improve the retrieval accuracy in the future once there are more surface observations. We have thus removed "*However, due to the limited coverage and spatial representativeness of surface stations, these lidar ratio assumptions may not be appropriate or representative at certain locations (Josset et al., 2011), which is an important source of retrieval uncertainty.*" from the manuscript.

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