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Comment on amt-2021-312

Anonymous Referee #3

Referee comment on "Empirical model of multiple-scattering effect on single-wavelength lidar data of aerosols and clouds" by Valery Shcherbakov et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2021-312-RC1, 2021

The paper presented by Shcherbakov et al. aims to establish an empirical relationship to account for the effects of multiple scattering on lidar measurements from the ground, aircraft and satellite. As stated by the authors, there have already been many studies to take this effect into account. Some have directly used Monte Carlo modelling; others have used radiative transfer codes allowing the development of phase functions over several orders. From these previous studies, parameterizations have already been developed, in particular to take into account the forward scattering which is preponderant in the multiple scattering for large particles.

The proposed parameterization is based on cases where the optical thickness (OT) remains below 7, which is indeed an upper limit for the vast majority of lidars. It explores mainly FOVs of 0.25 and 1 mrad which may appear somewhat limiting for existing ground-based and airborne lidar systems. The contribution of this study is not sufficiently demonstrated. It is clear that the definition of a lidar system is generally carried out taking into account the constraints linked to the observation geometry and that Monte Carlo simulations are performed by the designers, as was done for CALIOP and is done for airborne and ground-based lidars. This aspect of Monte Carlo simulation is therefore not original in itself and many models exist in laboratories around the world. It is a basic design tool.

There are several points that need to be better explained in this article, such as

1) The justification of the optical properties considered as initial conditions for the modelling. Are they common, extreme?

2) The sensitivity of the parameterization to the adjusted parameters (a1, a2 and a3),

3) Better justify the choice of an altitude interval of 8 to 11 km which is not optimal for aerosol layers. It would have been preferable to choose realistic layers such as a Saharan boundary layer that can extend from the surface to 3-5 km above.

4) Clarify the results on ð□□□ð□□□ð□□□(â□□), the parameter initially defined by Platt. At the entrance to the scattering layer, the multiple scattering is small and ð□□□ð□□□ð□□□ = 1 (Eq. 7), but this is not the case when looking at the figures. Is it really the in-cloud distance that is on the x-axis? Or maybe I have misunderstood, and better explanations are needed.

5) The results should be presented in a more synthetic way in order to lighten the reading of the article. It could be interesting to make 2D figures ð□□□ð□□□ð□□□ = f(FOV,OT).

6) It is difficult to properly assess the robustness of the parameterization. In the case of CALIOP corrections are applied and it would be interesting to compare them to those proposed via the parametrization.

Other aspects:

P4. How are the number of realizations (photons) chosen? How are the results degraded?

P5. Degassing feathers = ash feathers?

Table 1. Define the parameters in the caption table.

P8. The number of significant scattering orders is closely related to the number of photons. It would be nice to see this relationship.

P10L160. For figs 3,5 and 8 it is R that is used while the adjustment is made on G. In order to make it more understandable for the reader, it would be better to present G or to adjust on R. At this stage of the paper, there is nothing to justify such a model. Why this choice?

Eq.18. Development to 2nd order of arctan whereas before it was 1st order

P11L292. This is an important result for the paper and should be in the body of the paper or at least in an appendix. Furthermore, it would have been nice to show graphically the fits on an example and a sensitivity study to these fits against the coefficients a1,a2 and a3.

Figure 3: What explains the difference in the spread of points between the layer types?

P14L330. Why 5%?

P14L336. 8 km of higher = 8 km or higher?

Table 2. The values in the table are in %?

Appendix A. It is not clear what the authors are trying to demonstrate here. The functions are indeed different, but they remain related. It depends on the initial hypothesis that is considered. Is this appendix useful?