Atmospheric Measurement Techniques Discussions

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Comment on amt-2021-312

Anonymous Referee #1

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-RC3, 2021

This paper develops simple functions to characterize the impacts of multiple scattering on lidar observations, based on simulations from a physics-based Monte Carlo multiple scattering code. The simulations are performed for one type of coarse aerosol, one water cloud case, and two cirrus cases, for typical configurations of ground-based and airborne lidars and for the CALIOP and ATLID spaceborne lidars.

I think this paper is a useful introduction to and overview of lidar multiple scattering effects. I disagree with the comment from RC2, who says "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." Not every lidar group considers multiple scattering or applies corrections. Multiple scattering codes should be a basic design tool, but it is often not considered in lidar retrievals under an assumption that the lidar design ensures they are insignificant. The results presented in this paper are helpful to groups which haven't previously considered multiple scattering, and to users of lidar data who want to understand under what conditions the impacts should be considered and perhaps apply corrections to the data which is not already corrected.

The discussion of the method is sufficiently detailed but the discussion of the results is mostly a factual description of the simulations and fitting results. Some interpretation and synthesis of the results into general conclusions and guidance is needed. The major goal of the paper seems to be to identify conditions where multiple scattering are small enough they can be ignored. The paper identifies these conditions for the four particle types considered and two 'standard' FOVs. The authors should use their results to make more general statements. Only a few specific lidar viewing geometries and particle cases are considered. What are the limitations in using these fitting equations to estimate multiple scattering for other conditions (range, FOV, extinction, particle size). Are the aerosol, water cloud, and cirrus types defined in a way that they predict typical multiple scattering effects? Are the conclusions valid over expected variations in particle size? There is some variability in cirrus phase functions due to differences in particle habit. Would you expect variations in habit to change these conclusions?

Specific comments

Line 23: The authors should quantify here what is meant by "acceptable"

Line 126: Is "coarse aerosol" meant to represent dust? More details should be provided on the model for coarse aerosol: index of refraction, shape (spheres, spheroids, aspect ratio), and size. Why was this particular model chosen, is it generally representative of coarse aerosol? Is multiple scattering different for desert dust or hydrated sea salt aerosol of similar size? How sensitive are the results to changes in aerosol optical properties?

Line 321: Explain why 5% is selected as the threshold where the multiple scattering contribution must be considered. Because 5% is smaller than other sources of error typically found in lidar retrievals?

Technical corrections

Line 24 and 40: "of 1 km" does this mean 'equals 1 km', 'less than 1 km'?

Line 65: "techniques" should be "technique"?

Line 77: when "the" impact

Line 100: "The" other two …

Line 265, 383, 409, and 452: "again" rather than "another time"

Line 632: "drown" should be "shown"?

Line 637: “the shown in Fig. A1b function” should be “the function shown in Fig. A1b”, I think