Comment on Section 4.5 „Further comments about Dust Lidar Ratio“

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Section 4.5 of the manuscript refers to recommendations on the dust lidar ratio provided by Amiridis et al. (2013) and Tesche et al. (2013). The authors have obviously misinterpreted these recommendations. The work of Amiridis et al. (2013) and Tesche et al. (2013) is based on the study of Wandinger et al. (2010). In this study, it has been shown that the discrepancy between ground-based measurements of the Saharan dust lidar ratio giving values of the order of 55−60 sr and dust lidar ratios of about 40 sr derived from constrained CALIPSO retrievals, and applied in the CALIPSO data evaluation schemes, can be explained by the multiple-scattering influence in the CALIOP measurements. Therefore, neither in the work of Wandinger et al. (2010) nor in the papers of Amiridis et al. (2013) and Tesche et al. (2013) it has been suggested to apply lidar ratios of 56−58 sr in the non-linear scheme of attenuation correction as implied by the authors in the discussion of Section 4.5. As the authors correctly show in their Eq. (2), this retrieval requires the use of the effective lidar ratio, ηS_a, and not of the true (single-scattering) lidar ratio S_a. In Wandinger et al. (2010) it has been shown that η is of the order of 0.7−0.8 for the CALIOP geometry (and not 0.9−0.95 as stated by the authors), if one considers effective dust particle radii of 3−6 µm as actually measured in situ in Saharan dust plumes (Weinzierl et al., 2009). It is therefore correct to apply ηS_a = 40−45 sr for the attenuation correction of CALIOP data, when the single-scattering lidar ratio is 56−58 sr. The same effective lidar ratio of 40−45 sr would be derived with the OWC constrained retrieval in this case, according to Eq. (3) and (4). Please note that η primarily depends on the effective particle size (size matters!) and less on optical depth (which the authors claim to be the driver).

CALIPSO Level 2 retrievals apply the attenuation correction using a lidar ratio of 40 sr for dust to the attenuated backscatter in order to obtain the backscatter coefficient (Omar et al., 2009; Young and Vaughan, 2009). Wandinger et al. (2010) and Tesche et al. (2013) demonstrated that CALIPSO backscatter coefficients obtained in this way show very good agreement with ground-based observations (which are not influenced by multiple scattering), i.e. the use of the effective lidar ratio of 40 sr is justified. In the second step, CALIPSO retrievals calculate the extinction coefficient and optical depth by multiplying the retrieved backscatter coefficient with the same (effective) lidar ratio of 40 sr. This simple, linear procedure does not provide the true single-scattering particle extinction, since in this step the true single-scattering lidar ratio has to be applied. As shown by Wandinger et al. (2010) and Tesche et al. (2013) respective CALIPSO extinction coefficient values are about 30% smaller than those obtained from ground (while the backscatter coefficients agree). Therefore, the recommendation in all of the mentioned papers was to apply the true values of S_a as measured from ground in the (duly linear) calculation of extinction from backscatter coefficients.

Finally, we would like to note that the multiple-scattering influence on the lidar ratio is of course only one aspect of the discussion and that true dust lidar ratios depend on a number of physical and chemical parameters such as mineralogical composition (Schuster et al., 2012), size and shape of the particles. Nevertheless, the intensive study of Saharan dust with in-situ and remote-sensing techniques in recent years has provided us with a consistent picture of lidar-relevant parameters for this specific region which is the largest source of particles in the Earth's atmosphere. Therefore, Amiridis et al. (2013) decided to apply a Saharan-dust lidar ratio of 58 sr as measured from ground to convert CALIPSO-derived backscatter into extinction coefficients for the North African and European region which is mainly influenced by dust from the Sahara. This procedure led to a considerably improved agreement of CALIPSO data with AERONET and MODIS observations (and not the other way around as wrongly described by the authors on page 23610, lines 1 to 4). Further studies will be necessary to account for the different composition of dust in other regions of the globe, in particular in Arabia and Asia.

We would strongly recommend that the authors revise their misleading interpretation of the aforementioned work and revisit the text parts related to multiple-scattering issues to correct for contradicting statements (as also pointed out by Anonymous Referee #1).

References (not provided in the paper)

Wandinger, U., M. Tesche, P. Seifert, A. Ansmann, D. Müller, and D. Althausen (2010), Size matters: Influence of multiple scattering on CALIPSO light-extinction profiling in desert dust, Geophys. Res. Lett., 37, L10801, doi:10.1029/2010GL042815.

Weinzierl, B., A. Petzold, M. Esselborn, M. Wirth, K. Rasp, K. Kandler, L. Schütz, P. Koepke, and M. Fiebig (2009), Airborne measurements of dust layer properties, particle size distribution and mixing state of Saharan dust during SAMUM, Tellus, Ser. B, 61, 96–117, doi:10.1111/j.1600-0889.2008.00410.x.