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Interactive comment on "How much of the global aerosol optical depth is found in the boundary layer and free troposphere?" *by* Quentin Bourgeois et al.

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This is a well-written and scientifically important paper.

The authors compare the CALIOP extinction retrievals with 40 profiles derived from a balloon-borne optical particle counter, only one of which was co-located in space and time with the CALIOP profile. There is a much larger data set available for comparison with aircraft flights over Illinois in the USA, where a total of 63 co-located profiles were obtained (Sheridan et al., www.atmos-chem-phys.net/12/11695/2012/, doi:10.5194/acp-12-11695-2012). CALIOP profiles were available for 28 of the 63 co-located aircraft profiles. The conclusion of the comparison reported in Sheridan et

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Discussion paper

al. (2012) is: “For in situ extinction levels larger than 50 Mmˆ−1 , CALIPSO makes a retrieval 95% of the time (77 out of 81 cases). For the 40–50 Mmˆ−1 extinction bin, CALIPSO’s retrieval frequency drops to < 80 %. Below about 20 Mmˆ−1 , CALIPSO detected aerosol extinction only in about 11% (12 out of 109) of the cases, and below 10 Mmˆ−1 , CALIPSO rarely (1 case in 76) retrieved any extinction. For all 244 cases, a 50% probability of detection falls at an in situ extinction level of 20–25 Mmˆ−1.”

The inability of CALIOP to detect low levels of aerosol extinction likely leads to a low bias in the retrieved AOD and in the fraction of AOD in the free troposphere. As Andrews et al (Atmos. Chem. Phys., 17, 6041–6072, 2017; www.atmos-chem-phys.net/17/6041/2017/, doi:10.5194/acp-17-6041-2017) reported, roughly 95% of Earth’s surface has AOD below 0.4 (at 440 nm wavelength), and 50% has AOD below about 0.1. If the Sheridan et al. (2012) results, which were based on the CALIOP version 3.01 processing, apply to the Bourgeois et al. results (based on CALIOP version 4.10 processing), then it would seem likely that the global statistics reported by Bourgeois et al. are biased low.

It would be helpful if the authors would include an uncertainty analysis that reflects CALIOP’s decreasing probability of detection of aerosol layers as the extinction coefficient drops below 40 Mmˆ-1.

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