

Interactive comment on “Looking through the haze: evaluating the CALIPSO level 2 aerosol optical depth using airborne high spectral resolution lidar data” by R. R. Rogers et al.

Anonymous Referee #1

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The authors perform an extensive evaluation of the CALIOP/ CALIPSO cloud-free total column and layer AOD, using co-located airborne HSRL measurements over North America and the Caribbean region. Two major advantage in this study are that 1) the authors use very accurate HSRL measurements that are closely collocated within a few kilometers of the CALIOP track and 2) in addition to the CALIOP column AOD, the authors evaluate the CALIOP layer AOD and subsequent extinction-to-backscatter lidar ratio.

A thorough evaluation of the CALIOP extinction product is of great interest to the community and worthy of publication. This paper is of good quality. It is well written and

C1811

well structured.

P 6142, L5: I suggest “In this paper we investigate the CALIOP 532 nm aerosol layer optical depth (AOD) product (i.e. the AOD of individual layers), and the column AOD product (i.e. the sum AOD of the complete column), using an extensive database of coincident measurements.

P 6142, L27: I suggest “Multiple sources of error contribute to both positive and negative errors in the CALIOP column AOD, including multiple layers in the column of different misclassified aerosol types, ...”.

P6146, L6: “... the next step will be to apply this validation strategy to the aerosol profile product and the vertical distribution of extinction...”. It looks like the authors refer to the fact that they have looked at the CALIOP L2 layer product only and the next step is the evaluation of the CALIOP profile product. This statement comes before the description of L2 CALIOP layer vs profile product of section 2.1 which might make it difficult for the reader to understand the distinction.

P6149, L6: “(although it must be noted that that the flights have thus far been confined largely to North America and the Caribbean, and thus do not represent a global validation)

P6151, L6: “... (denoted by “Other” in Table 1)”

P6152, L3: “in the stratosphere is typically small in the (i.e. approximately in the 0.003 to 0.01 range) ...”

P6153, L25: “Secondly, any CALIOP 5 km profile containing a nonzero cloud optical depth or an HSRL detected cloud was excluded from the comparison.” We found very recently that although some cloud COD were equal to -9999 (i.e. potentially cloud-free profiles), those same profiles were showing high QA cloud features on the vertical (i.e. detected in the V3 Atmospheric_Volume_Description, one example is line #485 in CAL_LID_L2_05kmAPro-Prov-V3-01.2006-08-01T00-40-33ZN.hdf). This was found in

C1812

the CALIOP profile product. We do not know if it figures in the layer product as well. The authors might be aware of such a bug. In any case, their HSRL-CALIOP dataset should be safe from any CALIOP cloud contamination due to the AOD > 0.5 criterion.

P6154, L29: I suggest “Table 2 also highlights the statistics of the SIBYL layer detection at night relative to the daytime (i.e. more aerosol layers and detected with less horizontal averaging)”

P6155, L1: “HSRL spent ~ 45 h on track during the nighttime and ~100 h on track during the daytime although counting layers is perhaps not the best measure of the SIBYL’s efficacy.” The link between the HSRL flight hours and the SIBYL detected layers is not clear.

P6155, L22: I suggest “Although the data are sparser at larger AOD values (i.e. AOD > 0.3)?, the relative error of HSRL AOD comparing out and back legs for any loading is within 16% for these observations.” Also, it would help to draw an envelope around the 1:1 line on Figure 2.

P6155, L26: “The flight duration of the King Air aircraft is about 4 to 5 h, so no time difference larger than ~ 1.5 h can be examined.” I don’t understand the link here. Why can’t times >1.5h be examined?

P6156, L2: “...Shinozuka and Redemann (2011), who found that in the absence of plumes aerosols remained well correlated ($r > 0.9$) for spatial extents of approximately 35km (a typical boundary layer advection velocity of 20 kmhr⁻¹ translates to 1.5 h).” I understand the high correlation in each bin show low aerosol spatial variation but it’s not clear how the authors made sure that there weren’t any aerosol plumes in their study. The conditions might be very different from the conditions in the Alaskan experiment of Shinozuka and Redemann [2011]. Actually, Figure 2 shows a few HSRL AOD above 0.3 and up to 1. The Alaskan phase of Shinozuka and Redemann [2011] show 95% of the AOD below 0.17 at 499nm. Also, 20km.hr⁻¹ translates to 1.5h for 30 km but the authors refer to 35 km as in Shinozuka and Redemann [2011].

C1813

P6156, L13: “...and the excellent calibration of the CALIOP 532nm total attenuated backscatter product”. This needs further explanation. In general, the CALIOP 532 nm calibration remains a (small) source of error in the extinction retrieval.

P6158, L28: “The CALIOP column AOD uncertainty range (i.e. the AOD±the quoted one standard deviation uncertainty in the Level 2 files) given in the CALIOP data products encompassed the AOD measured by the HSRL for 50% of the nighttime columns and 40% of the daytime columns, indicating that the CALIOP uncertainty estimates are too low” This statement is not clear.

P6159, L2: I suggest “... and $\pm 0.08 \pm 0.1 \times \text{AOD}$ for the daytime (see Table 3).”

P6159, L5: “Note that although there can be multiple layers represented in a column AOD, each layer usually spans multiple columns, and the result is more column AOD points than layer AOD points”. This statement is not clear.

P6162, L10: I suggest “This is the case of the daytime ARCTAS mission flights. Although they represent about 20% of the flight data in this study, ...”

P6162, L19: I suggest “in those columns where the layer sum is less than the column value (i.e. where CALIOP either did not identify the complete layer, or missed another layer)”

P6163, L15: Clarify “due to the complexity and attenuation from the aerosol loading”.

P6164, L1: not clear what “aerosol layer grid” means

P6165, L27: I suggest “This study does, however, provide statistics on the variation of the lidar ratio that may help make CALIOP AOD uncertainty estimates give a better indication of the likely error in the AOD product.”

P6166, L10: I suggest “a mixture of aerosol types, or the lidar ratio distribution inadequately representing a given aerosol model (this is what many studies are now finding)”. Also, provide reference.

C1814

P6166, L21: “Since a given CALIOP layer must be of a single type, the next section implicitly implies only the layer AOD is plotted and discussed.” This is not clear. Rephrase.

P6168, L26: I suggest “The HSRL dataset contains a significant trans-Atlantic transported Saharan dust component from the Caribbean 2010 campaign, which is relevant to the CALIOP lidar ratio global selection process . . .”

P6169, L8: “It is also important to note that in this dataset we saw no indication of the multiple scattering impact on depolarization described by Liu et al., (2010). Indeed, these were primarily non-opaque dust layers with aerosol extinction less than 1 km⁻¹ so the multiple scattering impact is expected to be small (Liu et al., 2010).” Specify what would indicate multiple scattering impact in the case of large aerosol extinction?

P6170, L9: I suggest “There are insufficient coincident HSRL data on dust and smoke mixtures to evaluate CALIOP’s lidar ratio in terms of a mixture of these types. The lidar ratio used by CALIOP for this polluted dust type is considerably larger than the value that HSRL measures for layers it identifies as such by night (Fig 11).”

P6171, L11: IAB instead of “Integrated Attenuated Backscatter”

Table 4: slightly lowering line “51 ±15 425” in between line “Poll. Continental/” and “Biomass Burning” would help the reader understand that both types are grouped together in this study.

Table 5: “. . . as a function of CALIOP AOD. . .”

Figure 8 (and Figure 4): it would help to change magenta into a color further away from red (green for example)

Figure 10: Add a description of the red line (CALIOP standard Sa)”

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