**Atmospheric
Chemistry
and Physics
Discussions**

Interactive comment on "Assessment of the CALIPSO Lidar 532 nm attenuated backscatter calibration using the NASA LaRC Airborne High Spectral Resolution Lidar" by R. R. Rogers et al.

Anonymous Referee #1

Received and published: 21 December 2010

GENERAL COMMENTS

The authors present a detailed and thorough analysis in which they assess the accuracy of the CALIPSO lidar 532-nm attenuated backscatter signals by using the airborne High Spectral Resolution Lidar. The method uses the primary advantage of the HSRL, that of being internally calibrated and not needing to calibrate by normalizing against a molecular atmosphere in a region that is assumed to be free of particulates.

Because the HSRL flies in the upper troposphere and CALIPSO at 705 km, and there is a substantial region between the HSRL and the height where its transmitter and receiver beams overlap, there is the possibility that there is unaccounted attenuation

in the region between the top of the atmosphere and the overlap altitude, which could bias their results. The authors rigorously examine all the potential contributions to a bias and correct for them.

Because temporal and spatial variability of the atmosphere, especially of the aerosol loading, can invalidate any comparison of measurements made by different instruments at different times and locations, the authors take particular care either to minimize the effects of aerosol loading by restricting their measurements to the free troposphere, or when they examine the PBL, by ensuring that the atmosphere does not change significantly during the period of comparison. (Note that although the same location is sampled by both instruments around the same time, the HSRL takes longer to measure over the same distance so it is important to ensure that the atmosphere has not changed significantly during this period.)

As CALIPSO data are becoming widely used, and as the higher level data products such as the location and extent of cloud and aerosol layers, and their optical properties, are critically dependent on the correct calibration of the attenuated backscatter data, the work described in this paper makes an important contribution to the science. It the most extensive effort at calibration reported to date and, by using measurements from an internally calibrated instrument that were collocated in space and time with CALIPSO's measurements, they are arguably the highest quality calibrations to date.

The paper is well structured, clearly written and the work thoroughly and rigorously carried out. Once some points, raised below, are attended to, I would have no hesitation in recommending that this work be accepted for publication.

SPECIFIC COMMENTS

Use of term "transmission" e.g. p 28364 line 7 and elsewhere:

Isn't the standard radiometric term "transmittance"?

p 28370 lines 11 & 12. Reference to Russell et al. (1979)

You cite Russell et al. (1979) for your use of 1% as the uncertainty in the molecular transmittance arising from uncertainties in the GMAO temperature profile. However, these authors state that this value is only appropriate above the boundary layer and "within about 100 km and 6 h of the radiosonde measurement", "provided there are no frontal air mass movements". They then state "When density models or interpolations are used (i.e. above about 30 km and at great distances from a radiosonde) much larger errors can result unless great care is taken to use the most appropriate model or interpolation procedures. If these precautions are taken, the density errors can be limited to 3%". (Note too that this latter estimate is based on "personal communication".)

I suggest that you need to include more justification for your use of 1% instead of the higher uncertainty.

p. 28378 bottom and 28379 top, Reference to Ansmann (2006):

You probably need to qualify the figure of 20% as it is likely to be unduly pessimistic in the present context. The 20% difference was found when Ansmann used a column-effective lidar ratio to solve a complete atmospheric profile, instead of using values appropriate to each individual layer. When he used the latter approach he found much closer agreement between the downward- and upward looking lidars.

I suggest that in the current context, where neither the HSRL nor CALIPSO uses the same lidar ratio for the whole column, the situation is closer to the latter example given by Ansmann. Your text needs qualification.

p 28379 - discussion of results of Mona et al. (2009) in the PBL – also in Table 3.

I am surprised that you include reference to the differences that these authors found between their lidar's measurements and CALIPSO's in the PBL given the very different nature of the locations and their separation. To quote the authors directly "CALIPSO is typically smaller than the corresponding one obtained by PEARL profiles, because the 2 sampled volumes are more distant than 40 km and very different in nature: mountain

region with industrial and rural area for PEARL and low altitude and coastal region for CALIPSO."

Given that you are so careful in your present work to ensure that you only compare signals that are spatially and temporally correlated, the inclusion of the other work seems rather anomalous, unless it is used to reinforce the need for the care you have taken to ensure that correlation.

Use of "unattenuated" and "attenuated".

Admittedly, this is a minor quibble, but I find the persistent use of the term "unattenuated" to be both unnecessary and unattractive. The quantities "backscatter" and "scattering ratio" are well defined in the literature and refer to atmospheric quantities. It could be argued that the quantity "attenuated backscatter" is really just another way of describing a scaled, raw (elastic backscatter) lidar signal.

The beauty of the HSRL technique is that it produces a calibrated profile of scattering ratio as a direct measurement (after dividing your scaled parallel and perpendicular channels by your molecular signal.)

You could make this point at the start and remind readers that the HSRL measures the atmospheric quantities of backscatter and scattering ratio, whereas CALIPSO and other such lidars measure the attenuated quantity, which is indicated in this paper and elsewhere in the literature by the primed symbols. (This is just a suggestion.)

TECHNICAL COMMENTS

Page 28356 line 23: "compared to" should be "compared with" when comparing similar things.

p. 28359 line 21: Hunt et al. 2009 reference is not listed in References.

p. 28361 lines 22 and 23: The subscripts for the perpendicular components are used instead of those for the parallel components.

p. 28363 line 1: Is the word "channel" missing after "parallel"?

p. 28363 line 5: Shouldn't this be "... perpendicular channels, K_PGR, to be determined." ?

p. 28365 line 15: "... channels to produce the of 532 nm total ..." needs correction.

p. 28367 line 26: "the altitude range ... was restricted to ..."

p. 28369 line 15: " ... is due to aerosol ... " ?

p. 28370 line 25: "... but to estimate an upper bound of a COT of 0.0125 is estimated ..." ? Check wording.

p. 28370 line 27: 0.075 should be 0.0075.

p. 28371 line 1: McGill et al. (2006) is not listed in References. Do you mean to cite the 2006 paper, which is listed?

p. 28371 line 15: Accent missing above "a" in "Jager" – See your References.

p. 28371 line 15: Rogers et al. 2009 is not listed in References.

p. 28374 line 1: "Table 2" should be "Fig. 6".

p. 28374 line 7: "The means of these data points are ...". You have "mean".

p. 28375 line 19, Hunt et al. 2009 reference is not listed in References.

p. 28376 lines 24, 25: "A total ... were found" should be "A total ... was found".

p. 28376 lines 19, 25, 26: "criteria" should be "criterion" in each case if you are talking about just one condition (time offset within 30 mins). Otherwise you need "these criteria".

p. 28377 line 3 – 10. It would be clearer if you used instead, or included as well, an expression of the form "diff = (A +/- dA) + (B + / - dB) * Z".

p 28377 lines 11 – 18 – discussion of Fig. 11. Again, as in the comment above, an expression would help clarify the link between the text and the bias and rms data on the figure.

p. 28378 line 19: Again, do you mean McGill et al. (2007)?

p. 28378 line 21: Do you mean Kim et al. (2008)?

p. 28378 line 29: Ansmann (2006) is missing from references.

References:

Ansmann (2006) and Hunt et al. (2009) are missing

p 28381 lines 16, 17: Charlson et al. (1992) reference is not cited in text.

p 28381 lines 26, 27: Haywood and Boucher (2000) reference is not cited in text.

Figure Captions:

p. 28391 Caption to Fig. 4, line 1: "Relative differences were binned ...".

p. 28393 Caption to Fig. 7, line 1: " ... same as Fig. 2 ...". (not Fig. 1)

p. 28395 Caption to Fig. 8, line 1: Should this be " Flight track map ..."?

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Interactive comment on Atmos. Chem. Phys. Discuss., 10, 28355, 2010.