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Atmospheric Measurement Techniques Discussions



# *Interactive comment on* "CALIPSO Lidar Calibration at 532 nm: Version 4 Nighttime Algorithm" *by* Jayanta Kar et al.

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This very interesting paper by Kar et al describes the V4 CALIOP nighttime calibration at 532 nm, released from April 2014 as an update to the previous V3 scheme.

The main changes in the calibration procedure are: (1) The change of the calibration altitude from 30-34 to 36-39 km; (2) The introduction of a new averaging scheme that allows using data from consecutive orbits; (3) A new variable NSR threshold for the filtering of high energy events; (4) The use of meteorological data from MERRA-2 instead of GMAO; (5) The assumption of a R=1.01 backscatter ratio at the calibration altitude.

The sanity of the approach is checked by verifying how the instrument responded to hardware events, and the paper demontrates that the calibration can correct for instrument variations.

The main outcomes of the new data version are: - the advantage that calibration for noisy regions can benefit from better data from adjacent orbits; - a more smoothly varying calibration coefficient (Figure 9); - a 2-3% global decrease of the calibration coefficient; - reduction of biases in the representation of stratospheric aerosols; - reduction in biases in the representation of clear air in the upper troposphere (Figure 11); - reduction of biases with respect to the NASA LaRC HSRL.

The paper is clearly written and gives the necessary information needed to understand the calibration of an important instrument, such as CALIOP. The authors explain now how the calibration is applied to CALIOP datasets, and is generally convincing. I have however a few comments which hopefully can help present this work more effectively; each of them is minor, but their number is large. I also suggest more work on the abstract and on the conclusions. Therefore, my recommendation is intermediate between a minor and a major revision.

COMMENTS:

1) Abstract: The abstract could be more informative, by listing the 5 main changes in the calibration that I have listed above, together with the main outcomes that I have also listed above. On the other hand, the text at lines 24-28 could probably be moved to the introduction.

2) P2 L18-19: can be computed –> used to be computed in V3

3) P2 L19 (atmospheric model): replace these words with a term that specifies the type of model (forecast, analysis, reanalysis, climatology, standard atmosphere?)

4) P2 L19 (GMAO): with reference to the GMAO web site, where several products are listed (FP, FP-IT, Seasonal forecasts, MERRA-2, 7km-G5NR, SMAP L4), indicate which product is specifically being used in V3 (I can guess easily that some are not

relevant, but I feel that it should be specified).

5) P3 L5: are nearly absent –> are thought to be nearly absent

6) P5 L10: loading of ∼6-8% –> backscatter ratio of 1.06-1.08 (aerosol loading is an ambiguous term: it may suggest a percent expressed in terms of mass concentration)

7) P5 L11 (loading decreases to ∼1-1.5%): same comment as above

8) Equation 2 suggests that the laser pulse energy and the amplifier gain are monitored continuosly and accounted for on a pulse by pulse basis; however this is not explained in the text (nor in P09). I would suggest to clarify this. Note that if they are not accounted for on a pulse by pulse basis, then probably their indication in equation 2 is unnecessary.

9) P6 L5-6: the fact that the units of C are expressed in km3 sr suggests that S(z)/(E_0*G_A) is dimensionless. This should be clarified. I am inclined to think that the lidar signal S(z) will have some form of units (volts? photon counts? readings on an ATD converter?) which would reflect onto the units of C [note also that E_0 is an energy and should have units of J].

10) P6 L10 (measured): these values are not "measured" because they are from a model

11) Equation 4: I would suggest to give a plot of the two-way transmittance with z above 30 km, highlighting the contribution of ozone and of molecular scattering separately for a "average" conditions.

12) P6 L21: provides –> is thought to provide

13) P6 L21-22: has any comparison been made of the beta_m from GMAO and MERRA-2? Could the difference between the datasets be described in one-two sentences?

14) P6 L26-27: a few words could be spent to explain how you arrived at the value of

R=1.01. Does it derive from any measurements? Is it simply the value that yields best CALIOP data?

15) Figure 4: x-axes for figures use all different scales: latitude, along-track distance, granule elapsed time, etc. This may be confusing! It would be better to use a scale such as latitude, which does not need any particular explanation. If however you think that this is not the best way to represent the data, I suggest to indicate in each figure caption where the zero is for each granule (e.g. at the day-night terminator) and which way the satellite motion goes (e.g. North to South). See also Figure 6.

16) Figure 4: specify in the figure caption that these are V3 data calibrated at 30-34 km.

17) P9 L17-18 (PDACs for which all data points are rejected by this process are labeled as invalid): this should be better clarified. Do you mean that you would reject a PDAC that for instance has 0 data points, but would accept one with one data point or more? Would it not be safer to express the threshold as a percent? (e.g. invalid the PDACs that have less than 50% of the expected data points).

18) P9 L20: is 0.15% a global figure or does it refer to the % rejection in the SAA region?

19) P9 L28 (radiation-induced noise): specify if you refer to the SAA and the impact of high energy particles on the measurements, or to a photodetector non-linearity effect.

20) P10 L16-17: give size and date range for the test data, and indicate it also in percent of the whole dataset

21) P12 L7 (significantly lower success rates): it looks like if it approaches ZERO success rate in the SAA. Can you state the actual value reached at the minimum? This fact may deserve a comment in the text. In particular, re-state that in V4 the low calibration success can be overcome thanks to averaging over adjacient orbits. I do not quite understand, however, how in V3 you were able to calibrate in this area.

22) Figure 8: show the V3 calibration too.

23) P14 L10-12: comment and possibly explain about the large reduction in the first year and the subsequent recovery.

24) P14 L22: comment and possibly explain why C is so much smaller over the South pole.

25) Figure 10 (bottom): plot also for V3.

26) Equation 6: at high altitude, the attenuated scattering ratio R' should be identical to the backscatter ratio R unless there are clouds/aerosols above a layer. Is it worth mentioning?

27) P20 L16-17: a couple of peaks on the blue curve in Figure 15b could deserve a comment from the authors.

28) Figure 16: a negative R seems to be present above the calibration range in V4 (right hand panels). How is the trend above 40 km? Is what I see in the figure just statistical noise, or is there a decreasing trend above this altitude? I suggest that this deserves to be commented.

29) P23 L7-9: there is still a flight to flight variability (+/- 5%), and I suggest that this fact could be commented.

30) Conclusions L7 (two major changes): I believe that there are more than 2 changes. I did list 5 at the beginning of this review, based on what is described in the manuscript.

31) Conclusions: At the moment, this section is only an abstract/summary of the article. It could be expanded, by discussing with more detail and emphasis: (a) the repercussion of the V4 calibration on CALIPSO products; (b) the repercussion on major downstream users and on major scientific results that have made use of the CALIPSO mission (e.g. climate science applications); (c) a discussion of potential future work to improve the calibration even better. Any issues encountered and lessons learned could

also be described here. The conclusions should put the paper into the wider science perspective.

I hope that the authors may find these comments useful.

Best regards,

Franco Marenco

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