Anonymous Referee #2

We would like to thank the anonymous referee for taking the time to carefully read the submitted paper and for commenting it. The comments were very useful for improving the readability and effectiveness of our paper. In the following, answers to comments are reported in italics, just below each related comment. When needed, the part of the manuscript we modified or added to the old version is reported in bold.

SPECIFIC COMMENTS:

1. (Page 31199, lines 1-2) "The… CL3 product, available since December 2011, is the most recent data set produced…" Actually, the most recent version of the CL3 product is Version 3, released in September 2015. The December 2011 product was Version 1 Beta. Technically, Version 3 was released after this paper was submitted to ACP, but it may be worthwhile to change the wording to reflect that the product has been available since 2011 and delete the "most recent version" language.

Correct. It will be corrected in the revised version of the manuscript.

"The CALIPSO Level 3 (CL3) Version 1 Beta is available since December 2011 by the Cloud-Aerosol Lidar and Pathfinder Satellite Observations (CALIPSO) space platform."

2. (Page 31203, lines 19-20) "The main outputs are the aerosol extinction coefficient at 532 nm and its vertical integral (AOD)." The column AOD mean output in version 1 of the CL3 product is not the vertical integral of the mean aerosol extinction coefficient profile. It is the average of the vertically integrated level 2 aerosol extinction profiles. In other words, the procedure is integrate then average, not average then integrate. This statement implies the latter. Maybe a better choice of words would be "…and mean column aerosol optical depth (AOD)."

The phrase has been corrected as suggested by the referee as:

"The main outputs are the aerosol extinction coefficient at 532 nm and mean column aerosol optical depth (AOD)."

3. (Page 31205, lines 21-22) Quality assurance step 2 is not unique to Campbell et al. 2012). The CALIOP level 3 algorithm also requires that the Atmospheric Volume Description bits 1-3 equal 3 to include the aerosol extinction coefficient in averaging.

Although the step corresponds to basic screening techniques, it wasn't explicitly mentioned in the CALIPSO data user's guide webpage for Level 3. Hence, in the revised manuscript our assertion has been corrected.

4. (Page 31206, lines 3-4) "…a value of 0.0/km is assigned: : :where the screening criteria are invoked or no retrieval was made above 2.5 km." When screening criteria are invoked, the corresponding level 2 aerosol extinction coefficients are ignored, not assigned a value of 0.0/km. The statement "…or no retrieval was made above 2.5 km" is confusing and does not accurately depict what happens with the CALIOP level 3 algorithms. This statement refers to the quality filtering strategy designed to avoid low biases in mean aerosol extinction when aerosol layers are not detected entirely to the surface in level 2. When the lowest aerosol layer base is below

2.5 km but is not in contact with the surface, the "clear-air" below these aerosol layers are ignored in the average. Please add more details to this statement to clarify what is happening. The CALIPSO data user's guide webpage for level 3 aerosol has the details under the "Undetected Surface Attached Aerosol Low Bias Filter" heading in the quality filters section. Note that the lower limit changed from 2.5 km to 250 meters between Version 1 and Version 3 of the level 3 aerosol product.

Indeed, our statement is confusing. We assign a value of 0.0 km^{-1} to clear air samples before we perform the averaging procedure. Yet, for the clear air samples that lie between the surface and the first aerosol layer in the profile – i.e., the lowest in height aerosol layer – when the layer base is below 2.5 km the samples are ignored. For the corrected phrase, see our reply to comment #6.

5. (Page 31206, lines 5-6) "…the portion of the extinction profile below the range bin that meets those conditions is excluded." This statement suggests that extinction is always excluded below 2.5 km. Please reword and clarify.

Again, our statement is confusing. Here, we refer to the removal of the portion of extinction below the sample that has extinction uncertainty ≤ 10 km^{-1}. For the corrected phrase, see our reply to comment #6.

6. To be clarify the three points above, here is a summary of how the CALIOP level 3 algorithms decide which level 2 range bins to exclude and which to assign 0.0/km. Please comment on any discrepancies between these conventions and the conventions used in CL3*. a. Aerosol samples not passing quality filters are excluded. Note that if the extinction uncertainty is deemed bad, then all samples in the level 2 profile below the first bad sample are excluded. b. "Clear-air" samples (as identified by the Atmospheric Volume Description) are assigned a value of 0.0/km except in the case that the base of the lowest aerosol layer in the column is below 2.5 km. In that case, "clear-air" below the layer is excluded" c. Cloudy samples (as identified by the Atmospheric Volume Description) are excluded. But this does not matter since the analysis here evaluates only cloud-free columns.

Here, we can jointly answer and correct our statement following the comments #4, #5, and #6. The misunderstanding stems to our not accurate explanation and we acknowledge both referees for pointing it out. Our analysis follows the steps (a) and (b) described by the Referee's #6 comment. We rephrased the text as:

"To produce the CL3* monthly profiles, we use the CL2 Version 3.01 Aerosol Profile product, which includes aerosol extinction and backscatter coefficient profiles at 532 nm. The spatial domain onto which the CL2 data are mapped is nearly 2°×2° and is closely related to the EARLINET sites. This means that the longitudinal resolution is smaller owing to the distance of CALIPSO overpasses (<100km) from the EARLINET measuring site. The 6-step methodology to quality assure the CL3 profiles (Winker et al., 2013; Appendix A) is modified adjusting an existing metric according to the rubric used by Campbell et al. (2012). In particular, the metric is adjusted as:

Extinction_Coefficient_Uncertainty_532≤10 km^{-1}.

The lower boundary, here, is set to a smaller value, whereas within CALIPSO procedure, retrievals deemed unstable are set to 99.9 km^{-1}. In this case, samples that meet this condition are removed as well as samples at lower altitudes. Prior to averaging, samples are excluded where the screening

criteria are invoked and moreover, for samples that represent clear air a 0.0 km^{-1} value is assigned. Although, clear air samples over the surface are ignored from the averaging process in the case that the base of the lowest aerosol layer in the profile is below 2.5 km."

7. The relative differences in mean extinction and backscatter profiles shown in Figure 11 and discussed on page 31215 need to be treated carefully at high altitudes. Closer to the surface where scattering is strong (let's say below 4 km based on Figure 3), errors in lidar ratio could be ascribed to the relative differences shown in Figure 11. However at higher altitudes, detection of weak layers should be the limiting factor for CALIOP mean level 3 extinction. At very high altitudes, the large relative difference shown in Figure 11 arise from taking the ratio of very small numbers. I get the feeling that the average relative differences based of Figure 11 which are quoted in lines 12-13 of page 31215 include these high altitude differences. Should they? Perhaps a better way to quantify the relative difference between the two mean profiles be to calculate the relative difference below the altitude with which contains say, 90 percent of the total AOD. That way the relative difference would be with respect to the altitude regime containing most of the aerosol. There are other ways to do this of course. Perhaps just showing the numerical difference between the mean extinction profiles along with the relative difference will be enough for readers to understand where scattering is strong and where it is weak. Or perhaps just calculating the relative difference below 5 km will suffice. In short, when summarizing those relative differences into a single number, it is important to add context to that number. Please consider revising how the averaged relative differences are computed for lines 12-13 on page 31215. Ultimately, this should bolster the argument made on that page (the better agreement of backscatter is due to higher influence in lidar ratio assumption).

Following the referee's suggestions, we use a different way to show the differences between the extinction and backscatter comparison. First, using the extinction profiles, we calculate the height below which the 90% of the columnar AOD is confined. The relative difference is presented in the next figure. Note that, here, we omit the vertical averaging as this was included in the submitted manuscript for improving the lines' visualization. Regarding the performance of the comparisons, we once more identify that the mean relative difference for the averaged backscatter profiles improves, 18%, in comparison to the averaged extinction profiles, 25 %. As underlined by the referee's comment, removing the comparison at upper altitudes reduces the overall improvement, however it is still significant. For this new approach, we included the phrase in Section 3.2:

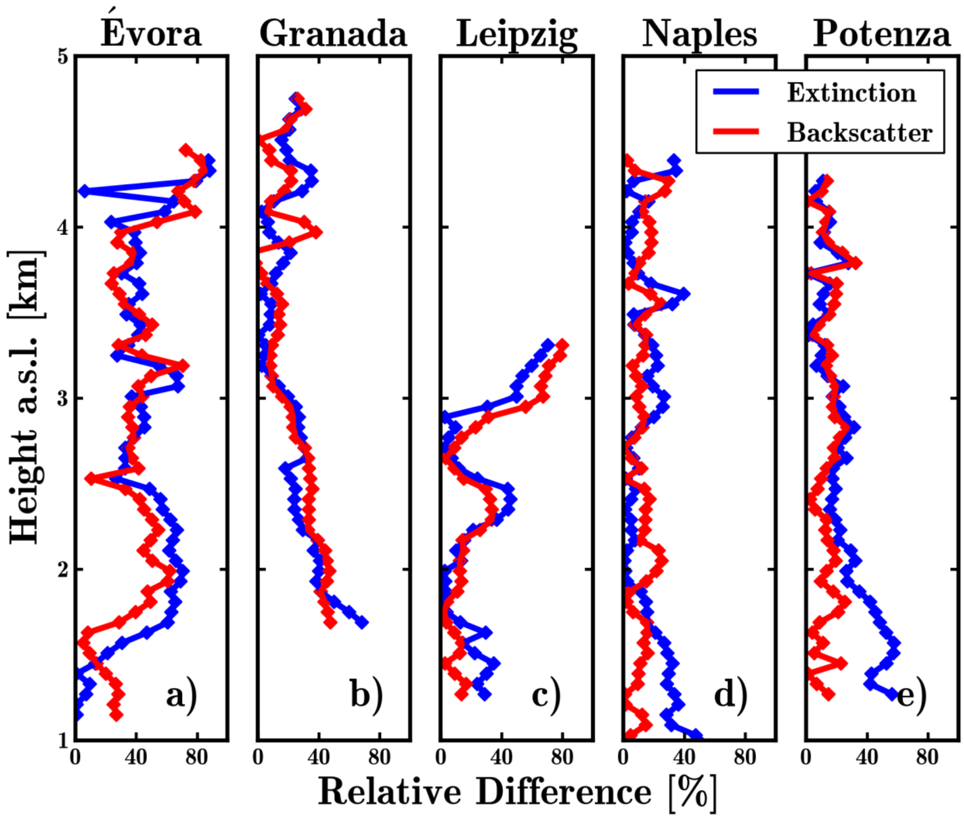
"First, we calculate the height below which the 90% of the columnar AOD is confined using the extinction profiles. Next, the relative biases are estimated as ($x_{CALIPSO}$-$x_{EARLINET}$)/$x_{EARLINET}$, where x is the extinction or backscatter profile."

This, now, leads to changes in the resulting values. Therefore, we changed the following phrases.

Abstract: ***"The mean relative difference in the comparison improved from 25% to 18% for backscatter, showing better performances of CALIPSO backscatter retrievals"***

Section 3.2: ***"In particular, the mean relative difference for the averaged backscatter profiles was found 18% whereas for the extinction profiles was 25%. Note that this outcome should be treated with care as the differences are mainly located in the lower troposphere where typing and subsequent lidar ratio inference is complicated due to complexity of the scenes."***

Conclusions: ***"A mean relative difference of 18% was found for the aerosol backscatter coefficient, while a larger difference – 25% – was obtained for the extinction coefficient.*** **It should be noted that the improvement in the backscatter comparison is mainly associated to the low troposphere where both the CALIPSO typing and the lidar ratio inference are more complex."**



Page 31245 - Figure 11: Relative difference of extinction and backscatter coefficient for each considered site.

TECHNICAL CORRECTIONS:

1. (Page 31207, line 7). Either delete "of the" or make "subtype" plural.

The phrase is corrected as:

"Table 2 shows the values set in the CALIPSO classification scheme for each of the aerosol subtypes."

REFERENCES

Campbell, J. R., Tackett, J. L., Reid, J. S., Zhang, J., Curtis, C. A., Hyer, E. J., Ses-sions, W. R., Westphal, D. L., Prospero, J. M., Welton, E. J., Omar, A. H., Vaughan, M. A., and Winker, D. M.: Evaluating nighttime CALIOP 0.532 μm aerosol optical depth and extinction coefficient retrievals, Atmos. Meas. Tech., 5, 2143–2160, doi:10.5194/amt-5-2143-2012, 2012.

Winker, D. M., Tackett, J. L., Getzewich, B. J., Liu, Z., Vaughan, M. A., and Rogers, R. R.: The global 3-D distribution of tropospheric aerosols as characterized by CALIOP, Atmos. Chem. Phys., 13, 3345–3361, doi:10.5194/acp-13-3345-2013, 2013.