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Dear Dr. Ansmann and Anonymous Reviewers,

we wish to thank the Reviewers for their feedback and careful consideration of this paper. We summarized below the changes we have made on the manuscript in response to their constructive criticisms. We hope the revised version of the manuscript clarify better all the points underlined by the Reviewers.

The title of the paper was slightly changed and in this way adopted to the title of the companion paper „EARLINET Single Calculus chain – technical – Part1: Pre-processing of raw lidar data“.

Thank you again for your consideration.

Yours Sincerely,

Ina Mattis, Giuseppe D’Amico, Holger Baars, Aldo Amodeo, Fabio Madonna, and Marco Iarlori

Reviewer #1

All the Reviewer's comments have been considered and addressed. We report below the changes applied to the paper with respect to each specific Reviewer's comment.

1. *General comments: The paper describes in detail the procedure of the automatic calculation procedure of optical products from pre-processed lidar data that can be used for all the different EARLINET lidars. A brief overview over the data evaluation methods commonly used in the lidar community and thus also in this algorithm is given without unnecessarily repeating their previously described details. More important, some specific algorithms derived for this automatic algorithm are outlined, as are automatic vertical smoothing, temporal averaging, and the merging of near and far range profiles. A validation of the algorithms is provided and the deviations of the different methods are discussed. The paper is the third in a series and completes the description of the EARLINET automatic data evaluation SSC algorithms. It is very valuable for the EARLINET members and the data user community. The paper is written in a clear and understandable way. I recommend the paper for publication with minor corrections.*

We want to thank reviewer #1 for the careful consideration of our manuscript and the helpful comments.

2. *Specific comments: The description of the algorithm parts is very detailed and runs over a long number of pages. The reader needs to follow these explanations carefully to not to get lost. A flow chart as suggested by quick reviewer 2 would probably help to follow these steps while reading. Some figures are very busy and need some clarifications. Those suggestions are given in the page and line comments below.*

According to the suggestions of reviewers #2 and #1, we included 3 work flow diagrams for the illustration of automated vertical smoothing, temporal averaging, and merging of near-range and far-range products.

3. *p2, line 33 - p3, line 9: the term "this paper" is used several times referring to at least two papers. It may be confusing for the reader which paper actually is meant. Please clarify.*

The term "this paper" always refers to our manuscript. We modified the sentences in order to provide a better separation between the other papers and "this paper".

4. *p3, line 13: "were" instead of "have" especially developed.*

We replaced "have developed" by "have been developed"

5. *p3, line 30-31: can you specify "high and lower resolution" by numbers?*

Unfortunately, we cannot provide more specific numbers here because the resolution depends on the raw resolution of individual instrument, on the signal-to-noise ratio of the actual measurement, and on the actual meteorological conditions. Here, we just provide a short summary of the EARLINET data format which is defined and described in more detail in the provided reference.

6. *p6, line 4: Compiler - compiler, not upper case*

Done

7. p5, lines 27-28: "The SCC daemon module automatically starts ELDA as soon as there are pre-processed signals of a new measurements available." is the same piece of information as: p6, lines 11-12: "When operated as module of the SCC, ELDA is started by the SCC daemon software automatically as soon as there are new intermediate NetCDF files available which have been produced by the pre-processing module."

This duplication was removed

8. p7, line 12: "... was found that ..." this part of the sentence may be redundant? Or do you mean: "...it was found that..." ?

We meant "...it was found that..." and reformulated the sentence.

9. p9, Fig 1: Unfortunately, the bold black line cannot be seen.

The agreement is so close that the black line below the colored lines can be seen only in the lowest parts of the profile. We additionally indicated in the text that the black lines is below the colored lines.

10. P10, line 9-11: please specify "agree very well" and "good agreement".

It is already indicated in the text that "agree very well" corresponds to mean relative deviations smaller than 15%.

11. p11, line 13: "once" instead of "ones"

According to reviewer #2, this sentence was reformulated and changed to "In case of Monte Carlo error estimation, all individual Monte Carlo solutions are obtained with the same vertical resolution profile derived from the original signal."

12. p11, line 27 and Fig. 2: olive and green lines are difficult to distinguish.

Indeed, the green and olive curves in Figures 1 and 2 are identical because both results differ only in the method of uncertainty estimation. We have included the following sentence: „Therefore, the green (error estimation with Monte Carlo method) and olive (error propagation) curves in the left panels of Figures 1 and 2 are identical.“

13. p14, line 13: blank between "section" and "3.4"

Corrected

14. p15, Fig. 4: ... on May 28..., as in Fig. 3.

Corrected.

15. p17, line 19: ... used-defined -> user-defined p17, line 24: ... user defined -> user-defined

Corrected. All occurrences of 'user defined' have been replaced by 'user-defined'.

16. p18, line 2 two times "the"

Corrected.

17. p18, line 18, please give a number for the SNR too small for data analysis.

The SNR is not calculated by ELDA. Instead, quality control is done by comparing the retrieved statistical errors with the user-defined thresholds. The position of the merge interval in the presented example is based on the users experience with this specific lidar

instrument (PollyXT). There have been no manually analyzed measurements where the retrieved uncertainties of the near-range product do not exceed the thresholds at altitudes above 5km.

18. p19, Fig. 5: *Since AMT is a European journal, I would suggest to use "grey" (BE) instead of "gray" (AE).*

All occurrences of “gray” have been replaced by “grey”.

19. p21, line 25: *... typical atmospheric situations ...*

Corrected.

20. p21, line 31: *just "both methods", not "the" both methods*

Corrected.

21. p24, Fig. 7: *A blank is missing before the second sentence.*

Corrected.

22. p26-28, Fig. 8-12: *These figures contain a lot of information. To keep it a bit clearer:*

1. *the names PBL, FT, and LL for the three layers used in Fig. 7 should also be used here. Or at least be explained again in the figures text.*

The names PBL, FT, and LL have been included into the legends. Further, the legends now are organized as tables in order to better provide the connection between layers and symbols. The caption was changed to „Layer mean absolute (top) and relative (bottom) deviations between particle extinction coefficient profiles at 355 and 532 nm calculated by ELDA and the simulation input profile for three different altitude regions PBL, FT, and LL (filled symbols). Open symbols show the root-mean-square deviation which was normalized with the mean value of the input profile (nRMSD) of the corresponding layer“.

2. *Having the error bars not equidistant around a value is confusing at first sight. Here further explanation than just the description of the error bars would help the reader to understand the figure more quickly.*

The description of the error bars in the figure caption was extended to: “The error bars indicate the uncertainties estimated by ELDA. They are layer mean values of the profiles of absolute (top) and relative (bottom) uncertainties. The error bars are centered around the zero line and allow for a direct comparison between estimated uncertainties and deviations.“

23. p24 – 29: *The conclusion are a summary! The title of the chapter should be changed accordingly.*

We have changed the title of this section.

24. *Several occurrences: Different use of upper and lower case of the word "Figure / figure" inside a sentence were found.*

All occurrences of figure x were replaced by Figure x

Reviewer #2:

All the Reviewer's comments have been considered and addressed. We report below the changes applied to the paper with respect to each specific Reviewer's comment.

1. *The paper is well written and suitable for publication in AMT. I would like to ask the authors to address the following points:*

We want to thank reviewer #2 for the careful consideration of our manuscript and the helpful comments.

2. *Major comments: As already stated during the quick review, I would like to see charts of the ELDA work-flow similar to Figures 2 and 3 in the SSC technical part 1 (D'Amico et al., 2016).*

Altogether we have included 3 work flow diagrams for the illustration of automated vertical smoothing, temporal averaging, and merging of near-range and far-range products.

3. *You mention that the merge region needs to fulfill all of the criteria given on page 17. But in Figure 5 you present an example where the merge window is put into a height region where one or more criteria are not fulfilled (as is shown by gray shading). Do the criteria only have to be fulfilled in the center of the merge window? Please clarify.*

The reviewer is right. The most criteria have to be fulfilled in the center of the window (merge point). Only the vertical gradients are tested in the window range. The description in section 4.3, point 3 was clarified.

4. *page 3, line 31: It's worthwhile to point out that the lower vertical resolution is the result of signal smoothing*

We included the explanation "...because extinction retrievals with the Raman method are associated with vertical smoothing."

5. *page 11, line 12/13: What is meant with this statement?*

We have simplified the statement to "In case of Monte Carlo error estimation, all individual Monte Carlo solutions are obtained with the same vertical resolution profile derived from the original signal."

6. *page 23, line 4: It might be better to rename the clear layer into aerosol-free layer. Please check if this applies elsewhere in the text.*

The term "clear layer" was replaced by "aerosol-free layer".

7. *page 29, line 21/22: Please add a comment about future plans regarding the automated analysis of depolarization ratio measurements with ELDA.*

We added the statement: "Currently, two new products *Raman backscatter and linear depolarization ratio* and *Elastic backscatter and linear depolarization ratio* are implemented. Those products will be stored in *b-files* which contain profiles of particle backscatter coefficients, volume linear depolarization ratio, and particle linear depolarization ratio."

8. *Figure 1 and discussion: For completeness, it would be nice to know where the calibration*

height range was identified and what the reference value was in that region.

We added the information “It was assumed that there are completely particle-free conditions within the calibration window. The individual calibration windows of the different backscatter products have been found between 7.5-8.5 and 9.0-10.0 km altitude.”

9. *Figure 3: caption mentions 8 iteration steps, legend gives 10 for the blue line ...*

The legend of the plot was corrected.

10. *Figure 7: clarify in the caption that OVL is the overlap region*

Done. We added the statement „The layer of incomplete overlap (OVL) has been excluded from validations.“ into the figure caption.

11. *Figures 8-12: I am confused about the error bars in those figures. Do they refer to the error of the ELDA retrieval? Are they ever discussed in the text? Clarification is needed.*

The description of the error bars in the figure caption was extended to: “The error bars indicate the uncertainties estimated by ELDA. They are layer mean values of the profiles of absolute (top) and relative (bottom) uncertainties. The error bars are centered around the zero line and allow for a direct comparison between estimated uncertainties and deviations.“

Reviewer #3

All the Reviewer's comments have been considered and addressed. We report below the changes applied to the paper with respect to each specific Reviewer's comment.

1. *The paper presents the methodology of the software tool ELDA as part of the EARLINET Single Calculus Chain. The description of this software is important as the software will be used by many different groups in the future. I recommend publication after consideration of a few mostly minor comments.*

We want to thank also reviewer #3 for the careful consideration of our manuscript and the helpful comments.

2. *General comments: The paper is overall a bit long and shortening in some parts of the paper seems possible and should be considered.*

We considered a shortening of the manuscript, but finally decided against it. Due to the helpful comments of all co-authors and reviewers most of the unclear points of the original manuscript could be solved. Any shortening may cause again such unclear points without a chance for future improvements. According to the suggestions of reviewers #1 and #2, we added three new figures (flow diagrams).

3. *It might be worth thinking of changing Section 3 and Section 4 as the standard algorithms are applied on the smoothed, glued and cloud flagged data as far as I understood.*

We prefer to keep the order of sections 3 and 4 unchanged. The standard algorithms and the ELDA specific algorithms are all applied to pre-processed data which already have been glued (combination of analog and photon-counting signals) and re-sampled in range and time by ELPP. In contrast, section 4 describes smoothing, averaging and merging (combination of data from different telescopes) procedures which are part of the optical retrievals.

4. *How is the correctness of temporal averaging tested? What happens in cases of high temporal variability – can they be analyzed with ELDA? Does ELDA mark these analysis as analysis with insufficient temporal stability?*

There is no test for temporal variability within ELDA. We have added the following statement „Temporal averaging may cause systematic errors in the retrieved backscatter and extinction profiles if atmospheric conditions or instrument behaviour change during the averaging period significantly (Ansmann et al. 1992b). Those effects are not yet taken into account in the ELDA averaging scheme. It is the responsibility of the user not to submit raw data with high temporal variability within one measurement file. If conditions changed significantly during a measurement, the submitted raw signals should be split in two or more measurement files.“

5. *Are systematic uncertainties considered and calculated? And if yes, how is this done? How do you separate the different uncertainties (retrieval, statistical, systematic)?*

Most of systematic uncertainties are not handled by ELDA and the different sources of uncertainties (retrieval, statistical, systematic) are not handled separately. We added table 1 to section 3.3 and the following statement „Table 1 provides a list of the different error

sources which are taken into account by the two methods of uncertainty retrievals. All those error sources are combined by ELDA and then reported in the EARLINET NetCDF *e-files* and *b-files* as statistical errors. Currently, the separated handling of statistical errors of the lidar signals, of systematic errors of the lidar signals, and of uncertainties of the retrieval algorithms is under research within the EARLINET community (Amodeo et al. 2016). It is foreseen to implement the results of this research in future versions of the SCC. “

6. *How do you determine calibration height and value?*

The determination of calibration height and value is described in section 3.1.3 „Handling of backscatter calibration“

7. *Minor comments: p.2, l. 6: ‘... instrument and hardware level ...’ – do you really mean hardware?*

The reviewer is right. We mean software level. → Corrected.

8. *p. 7, l. 10: Freudenthaler 2016*

Corrected

9. *Section 4.3: Is the merging applied on the averaged profile or on each single profile before averaging?*

The merging is done within each step of the automated averaging procedure. The temporal resolution of pre-processed signals is in the order of some minutes. We added the following sentence: „In case of automated temporal averaging, the merging is performed during each of the iteration steps (see section 4.1 and Figure 5) separately.“

10. *p.21, l. 20ff: ‘Here, the accuracy of SCC retrieved optical profiles will be tested ...’ It is not clear on what this sentence refers to.*

We refer to the analysis done in this paper. The term „Here“ was replaced by „In this study“