

Dear Reviewer,

We thank you for the detailed revision of our manuscript. We have considered all your suggestions and we have modified the manuscript accordingly. We believe that the manuscript has been significantly improved in clarity of the text, readability and visualisation of the data in the graphics. Below we provide the answers to the general and detailed comments of the Reviewer.

General comments

It appears that the structure of the manuscript has not been thought through well (e.g. a few singular subsections exist that are not followed by matching subsections) and the manuscript often reads like an extensive lab report. The resulting lengthiness of the manuscript makes it difficult for the reader to grasp the main messages. In addition, the manuscript needs a thorough editorial read (if possible by a native speaker).

A thorough editorial revision of the manuscript has been done. The whole text has been improved for the level of English, the readability and clearness of the independent sections. Many sections have been merged and the stand-alone sub-sections have disappeared. Parts that were too technical and did not need to stay in the manuscript have been moved to the supplement.

The comparison to the in-situ measurements is not very convincing and needs a thorough revision. After studying the manuscript, it is not really clear to the reviewer what new findings have actually been brought up to the table.

The comparison of the retrieved layers by PathfinderTURB with the in-situ measurements at Jungfraujoch is now easier to understand and the correlation between the two datasets is straightforward. Figures 6-9 have been completely re-done.

Point-by-point answer to the Reviewer

The current manuscript is full of acronyms. I suggest to add a table with a summary of all acronyms at the end of the manuscript.

Done.

Page 3: Before describing the retrieval algorithm I would suggest to add a paragraph/ subsection on the instruments being used.

We agree with the Reviewer that a description of the used ceilometer should go before the section describing the PathfinderTURB, we have then moved section 4 after section 2 and right before section 3. Section 4 (now Section 3) has been re-written to improve the readability and avoid all repetitions that occurred in the previous version. The overall section has also been shortened.

Page 5, line 31: Why are different bin heights used for the two different sites? Do the numbers given here relate to the vertical or to the slant path?

We added a phrase to the text to explain the different resolutions used. The different range and time resolutions, with longer integration at KSE, are necessary to compensate the slant path effect and the fact that at KSE the SNR is normally smaller than at PAY due to the smaller concentration of aerosols at these high altitude.

Page 6, line 10: This statement (“... the overlap of the ceilometer is normally sufficiently large ...”) implies that there are exceptions. Please clarify.

Yes, each and every ceilometer can have a different receiver-transmitter overlap function, the bi-static ceilometer like the CHM15k can have as large overlap as 0.5 at 350 m, which means that physical measurements of range corrected signal can be performed already at that level.

Page 7, line 7-8: Why are the gradients different for the early morning periods?

The text has been modified and improved for clarity. A full explanation about why we use different thresholds has also been added.

Page 7, Eq. 1 and 2: Please use a more mathematically sound way to describe your formulas (i.e. avoid entire words like ‘weights’ and use Greek letters instead, also add the specific time and height dependencies).

Done

Page 9: Second sentence is a repetition from page 6.

We have modified the text.

Figure 1: The first and last panel show more or less the same thing and could be combined.

We have preferred to keep the two panels separated in order not to start directly with a panel with many parameters displayed and the weights.

Avoid the sub-panel titles since the date is already given in the caption.

Done

Please define the acronyms in the legend once more in the figure caption. The colour scheme in panel c is not very suitable to detect the overlaying retrieval results.

They all are defined in the current and previous sections.

Page 12, line 9: Here, the full overlap is stated to be at 800 m while on page 6 it is stated to be 350 m. Please clarify.

Here we speak about the full overlap, which for the KSE and PAY ceilometers corresponds to 800 m. Before in the text, the 350 m is just a level situated well above the first overlap point (80 m) and at which physical measurements of range corrected signal can be performed.

Equation 3: It should be $S(r; t)$ to be consistent.

Done

Page 13: Section 4.2.1 is not followed by a section 4.2.2 as one would expect. There are also some repetitions in that section which should be removed (e.g. the information on the tilted angle). Parts of this paragraph are of motivative nature and should be moved to the introduction.

We have moved section 4 after section 2 and right before section 3. Section 4 (now Section 3) has been re-written to improve the readability and avoid all repetitions that occurred in the previous version.

Figure 3: Are both plots really needed here? The lower plot could be moved to the supplement and the key-numbers could be mentioned in the text. The size of the figures is quite large and could be decreased. Please improve the figure caption by avoiding individual acronyms (like 'manualPBL') and by writing full meaningful sentences so that the reader understands the figure without going to the text and finding the acronyms.

We believe that the two plots bring different point of views that allow the reader to understand the different density regions of the comparison between manual and automatic retrieval of the CBLH (top panel), and to have a more detailed and quantitative information about the Gaussian-like shape of the distribution, all statistics and the distribution of the outliers (bottom panel). We have then decided to keep both panels. The caption has been improved for readability.

Page 17, line 18: bR is not defined yet.

The *bR* method is now defined in Section 6.1.

Figure 4: Again, these two panel figures can be reduced to one main figure. The lower panel could be moved to the supplement.

Same as above

Please add uncertainty bars in the scatter plots. The caption is also not consistent with the axis labelling (in the figure MLHbR is shown which is called RS(bR 12H) in the caption).

Done

Page 20: Again, no section 6.1.2 is followed after 6.1.1. Have the authors really carefully thought about the structure of their manuscript?

We removed the sub-section title.

Sect 6.3.3, Table 1 and Figure 7: I have my doubts that these results are really robust and trustworthy. On page 22, line 2-5, the authors state that the results of the LCBLH retrieval for the winter months were not taken into account due to the lack of statistical significance. However, they are now (in terms of the LCBL and CAL reaching JFJ) discussed in detailed and presented in Table 1 and Figure 7.

Figure 7 has been removed (as requested also by the other Reviewer). Figure 6 shows now also the winter daily cycle of TCAL and LCBLH.

If the algorithm can't retrieve the height of the LCBL, how can you be sure that the JFJ is inside the specific layers? This part needs to be thoroughly revised by adding statistical values (like data coverage) to the table. The reader needs to know how trustworthy these values are.

The algorithm PathfinderTURB have no problem retrieving the LCBL when the layer exists and the ceilometer shows it. The winter statistic consist of less data just because the LCBL can rise above the

KSE only rarely during winter. Nevertheless, we have decided to show the winter average daily cycle in Figure 6d and to discuss quantitatively the related statistics. The entire Section 6. has been rewritten accordingly to the new figures and to improve the text clarity.

Figure 7 can be omitted since it is a repetition of Table 1 and nothing new is learned from it.

Figure 7 has been removed.

Section 6.4: The comparison to the in-situ measurements is not very convincing. Why did the authors choose the absorption measurements (MAAP) instead of the scattering measurements (nephelometer)? Most of the signal of the ceilometer comes from particle scattering (backscattering) so I would assume it is more related to the nephelometer measurements.

The author's intention is to study the impact of an aerosols layer on an in-situ measurement that provide a proxy for the presence of the layer itself. In this sense, any extensive aerosol property is an excellent proxy for the presence of an aerosol layer. Moreover, the absorption coefficient is indirectly a measurement of the black carbon concentration, which is a good proxy for CBL air. Incidentally, for most of the studied period, the nephelometer measurements were not available.

Figure 8 is also not convincing at all. All individual seasons show almost no correlation, while the improved annual correlation is therefore only a result of the overall seasonal variations. Besides the fact that the axis ranges in Fig. 8 are poorly chosen, I still don't understand why one would expect a linear relationship. The linear relationships are not at all clearly seen in the figures. Please clarify and revise.

We agree with the Reviewer that the previous Figure 8 was difficult to read and did not bring a straightforward message about the relation between the TCAL/LCBLH and the in-situ measurements. We have decided to change completely the visualization of the sought relation and we have found a clear and robust way to show this relation. The majority of the text has been changed accordingly to the changed figures. The current figures 7, 8 and 9 have now the same layout and are very consistent with each other.

Figure 9: This figure is very difficult to interpret. The differences in the specific seasons are impossible to distinguish. Why would one expect a linear relationship? Maybe plot the seasons separately. The y-axis range should be improved.

As explained above

The conclusion part has to be revised and shortened to the main findings. Currently it is just a repetition of the result section. What have we actually learned?

The Conclusions have been entirely re-written.

In all figures with linear regressions: Please specify which regression type (orthogonal?) has been applied.

No linear regression has been performed anymore in the new plots. So no confusion will arise from it.

For many of the figures it is not clear which averaging time or temporal resolution was used. Also an uncertainty analysis (error bars) are missing which should be added.

All necessary information about data clustering, temporal resolution and uncertainty is now provided for Figures 7, 8 and 9.

Minor comments

Abstract and beginning of section 4: CHM15k is not properly defined.

It is now specified that is a specific type of ceilometer.

Page 9: Add the specific figure number before the panel label (i.e. Fig. 1a).

Done

Page 2, line 31: Define 'TURB' at its first occurrence.

Done

Page 1, line 25: Operating the ceilometer/lidar in a tilted mode is actually not so novel and has been performed at Kleine Scheidegg in previous work (see Zieger et al.(2012), Spatial variation of aerosol optical properties around the highalpine site Jungfrauoch (3580 m a.s.l.), Atmos. Chem. Phys., 1, 7231-7249, doi:10.5194/acp-12-7231-2012).

Thanks to the Reviewer for highlighting the missing reference. Zieger et al have already used a tilted LIDAR at JFJ but only for 9 days back in 2010. What was missing then was the creation of a dataset large enough to create a statistics. The study is now cited and discussed in the introduction.

Page 11, line 24: Remove KSE from the parenthesis.

Done

Page 17, line 33: Mention the specific panel labels.

Done

Page 24, line 3: Two dots

All figures have now a full stop punctuation in the caption (Figure XX.)

Page 24, line 15: I would call them pie charts and not circle charts.

Figure 7 has been removed

Page 25. line 7: I would not use the word 'polluted' here.

"polluted" has been replaced by "aerosol-laden"

Page 27, line 2: Add the missing figure number.

Done

Sect. 6.4 and throughout the text: Define the height of TCAL as TCALH to be consistent with LCBLH.

TCAL is already a height, it is the Top (height) of the CAL.

Figure 9: The superscript in the y-axis label is not properly set.

Figure 9 has been replaced with a new one.

All figures: Please be consistent with the format of your axis labels (i.e. obeying the case sensitivity). If you use acronyms, please define them once more in the figure caption.

Done.