

Interactive comment on “Intercomparison of aerosol measurements performed with multi-wavelength Raman lidars, automatic lidars and ceilometers in the frame of INTERACT-II campaign” by Fabio Madonna et al.

Anonymous Referee #1

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AMTD: Intercomparison of aerosol measurements performed with multi-wavelength Raman lidars, automatic lidars and ceilometers in the frame of INTERACT-II campaign

General Comments

The paper "Intercomparison of aerosol measurements performed with multi-wavelength Raman lidars, automatic lidars and ceilometers in the frame of INTERACT-II campaign" reports the results of a campaign using a variety of instruments to measure aerosol in cloud-free or clear-sky conditions. While the authors report interesting

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results, I think that they could make the analysis more rigorous and motivate the work more clearly. I have made recommendations below.

Specific Comments

1. I recommend that the authors provide general motivation in the introduction for this study. Why does anyone need to measure atmospheric aerosols using these types of instruments? Why is this intercomparison needed? Is it to help design better networks for measuring pollution, for example? I would like to understand this and to make sure the audience understands how the intercomparison gives us important and useful information. Can the authors say anything specific about the aerosols that were measured (type or other properties) during the campaign?

2. Please can the authors explain, again in a general way, which of the instruments is expected to measure aerosols (of a given type) most accurately and why. For example, can you give a general sense of where (in the atmospheric column) the instruments are expected to give the best results? And why? Perhaps it would be helpful to touch on differences in wavelength here as well as other differences in hardware or firmware? I realise that none of the instruments gives us "truth", but can the authors give the reader a sense of the accuracy expected? Thus, when the differences are reported, the readers immediately understand which of the instruments is believed to be closer to the true observed quantity.

I suggest these two points in order to give the reader a better sense of why these particular instruments are important to study (as I think that they are) and to make a stronger case for why the intercomparison analysis in this paper matters to the community.

3. In section 5 MUSA is referred to as the reference signal in the full overlap region. Why is MUSA the reference? Is it expected to be the highest standard of measurement to which we want to compute the ceilometer observations?

4. Please define the "fractional difference". For example in section 4 Paragraph 5,

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"average fractional difference" is not defined and later in the paragraph (line 327) an "average difference" is increasing. Are these the same metric? The authors need to define clearly the measure or measures of difference applied to the results.

5. There are a few places where the authors discuss "random uncertainty" (section 4 for example in line 322). Please could the authors define how they determine the random uncertainty? Also, if there are some statistical tests being performed to assess differences then please state which tests are being used. For example, is there a null hypothesis of random white noise?

6. At the end of the technical corrections, I have placed a number of comments on the figures which need to be addressed.

Technical Corrections

Title: Please change "frame" to "framework".

Text:

1. Many acronyms are undefined in the main body of the paper. To aid the reader, please explicitly define the following: CNR-IMAA, EARLINET, FOV, FWHM, GRUAN, RAOB, HYSPLIT and APD in line 149 (is it Avalanche Photo Diode?) used before line 161 Avalanche Photo Detector are these the same "APD"?,

2. Please put units on the RCS. I believe that the authors are using "arbitrary units" (a.u.) throughout. Is this correct? Can a.u. be placed next to all the measurements please?

Line 22 Is average difference a root mean squared difference? Absolute difference? Or something else?

Line 29 Rewrite to something more like: "Some tests performed during this campaign using the CHM15k ceilometer made it clear that the CHM15k historical dataset (2010-2016) available at CIAO should be reviewed in order to evaluate the potential effect of

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..."

L 39 systems not system

L 123 change to "...unit consists of a Cassegrain..."

L 135 change "system was operative" to "system operated"

L 137 change "when MUSA moves" to "when MUSA was moved"

L 167 remove "is". change to "The Vaisala ceilometer CL51, the second generation..."

L 169 add: "to diagnose vertical visibility"

L172 at "the" surface

L 175 remove is. "The instrument used in INTERACT-II..."

L184 add punctuation: " troposphere; thus, limiting"

L188 "in principle, but are eye-safe..."

L192-193 "limits which permit these ceilometers to operated unattended."

L 194 Change to "and, therefore, enhanced performance" not plural performances

L213 CHange to "In contrast to the ceilometers,"

L215 Split up sentence: "...performance. Using RCS allows a comparison to be made between the ..."

218 I am confused about what covers a shorter vertical range? Perhaps split into 2 shorter sentences here and be more explicit.

L220 assumption should be plural.

L221 What are you comparing here? I would say: "To perform the comparison between the MiniMPL and the MUSA/Pearl,"

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L223 say "...identified as negligible qualitatively using quicklooks..."
L226 change to "...applied to the data, but systems..."
L227 "...interpolated to the MUSA/PEARL..."
L237 Can you please clarify what is more frequent in the FT?
L239 Please could you briefly (in a sentence) say why the assumption of < 1% is a good one? I can see there is a reference, but a quick explanation would be helpful, if a brief one is possible.
L243 "... consider the attenuation of the backscatter signal by water vapour. In this study, a method for correcting for the attenuation by water vapour is..."
L260 "Drop "a". "to avoid unpredictable"
L271 Drop "for". "calculated through"
L275 remove the convoluted phrase at the beginning. Just write: "A comparison of..."
L276 What does "their own time" mean? Is it at the time resolution of the measurement taken by each instrument?
L280 "for MiniMPL the time resolution is 5 minutes and the vertical resolution is ..."
L282-283 "operator routinely checked each instrument during INTERACT-II to ensure that each one was performing according to the manufacturer specifications."
L285 "of each instrument"
L286 "weekly check on each instruments' acquisition..."
L290 "flooding method. Additionally, specific treatments to remove the stronger dust spots were performed..."
L293 "measurements were made twice..."

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L295 "profiles before normalization using the lidar..."
L295 "...dark current measurements were routinely..."
L299 "Simultaneous observations of aerosol made using the multi-wavelength..."
L305-306 are very confusing. Model levels are used under some kind of observed threshold, but the "top layer" is very confusing. What is being done?
L305 Need a reference for the NOAA HYSPLIT model. A paper or a technical report should be cited when the model is first discussed.
L309 and L318 Just say "good agreement" remove "a very good"
L310 What is the RCS random uncertainty?
Section 4 paragraph 4 does not state in the text which data are being compared.
Section 4 Paragraph 5 is confusing because fractional difference and difference are both being used without being defined.
L 344. Number is not in scientific notation.
L 348. Please define the variable alpha_par in the text explicitly. It sounds like alpha is the aerosol extinction coefficient, but "par" is undefined.
L 352 Is the output profile from Raman PEARL lidar? If so, is it interpolated to the same resolution as the RCS from which instrument?
L 353-356 Numbers are not type set correctly, missing the multiplication sign.
L364 What are these different altitude levels?
L367 "...CS135 in the region between 2.5 and ..."
L370 ranges should not be plural
L377-378 "...because MUSA is considered the reference signal only in the full over-

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lap...." Has this been stated before? Has MUSA been the reference all along?

L394 I would suggest the wording should be changed to "Dark current measurements or profiles", not just "dark currents"

L403-404. I wouldn't talk about the chosen data being "not random" as it suggests some kind of statistical test, but instead say something like: "The date 5 December 2016 was chosen because it was the closest clear-sky case to the date when the dark current measurement was taken (22 Dec 2016)." or something more concise and descriptive.

L421 increases should be increase

L423 constant is misspelled.

L423 change to " The CS135 measurements are similar to the CL51 in the region..."

L424 Start a new sentence with the comparison stated explicitly. Is it like this? "While in the region... the differences between the CS135 and the MUSA/PEARL vary between -40% and +40%."

L436. What is the effect that is similar between the two ceilometers in the region given by range of attenuated backscatter and extinction?

L439 which ceilometer "its" referring to? Which ceilometer shows improvement in the RCS?

L448 I don't think that indifferently is the correct word to use here. Do you mean interchangeably?

L453 Change "to the ancillary" to "of the ancillary"

L454 change to "revealed non-negligible sensitivity"

L460 "values up to 40-50%" The percentages in this paragraph are given without a reference value. Which variable are we discussing? 40-50% of what reference value?

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L462 Punctuation needed: "Presumably,"

L462 affect should be plural: affects

L463 remove "a" from "a decreasing"

L464 Change to "The number of laser pulses is included as..." The word assimilated might confuse readers as it is generally used in the context of data assimilation.

L466 change to "...signal. The effect is to decrease SNR in cooler temperatures... increase the uncertainty....from the ceilometer data

L469 It is not clear what "This" means. Please state explicitly.

L469 "aerosol free range" may be clearer to change to "aerosol-free atmosphere" or "aerosol-free atmospheric column"

L470 What exactly is the "calculated embedded constant"?

L475 Just say "Similar behaviour..."

L479 allows should be singular

L480. Split the sentence. "...photometer). For these methods..."

L484 "Say "During the INTERACT-II campaign"

L502-503 Change to "it is worth pointing out" and "partly due to the instrumental processing that is mainly.."

L512 "made available to the users"

L512-513. Split this sentence into 2.

Figures:

1. All sub-panels within all figures should be labelled with letters a,b,c, etc. 2. In the text and captions all of the sub-panels in the figures should be referred to using the

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figure number and letter together. Please do not use left/right, top/bottom. The letters make the text concise and precise. For example caption for figure 8 should read more like: "Panel a shows attenuated backscatter retrieved from ... Similarly, panel b shows the same comparison but for 01 December ..."

Figure 3, 4,6, 8, 9, 12 have a red line (or red bar) labelled "Lidar" but MUSA is in the caption. Lidar is not specific enough. Please make the legend consistent and more precise. Is it MUSA Lidar? In contrast, for example, Figure 10 has a red line called PEARL which is also a Raman lidar like MUSA.

Figure 4. Caption is confusing. Can authors please explain what they mean by "using NOAA HYSPLIT model started at the three levels from the ground the top layer observed by MUSA and MiniMPL lidars"? Are we talking about model levels? What is "the top layer observed"?

Figure 5. Should read "Blue line is the same as the black line but..." Also, captions usually put the line colour or line style in parentheses like this: "Profiles of the average fractional difference (black line)..."

Fig 9 End of caption: " Panel b shows the attenuated backscatter vertical profiles taken using the MUSA/PERAL lidar which operates at wavelength 1064 nm during the same time period as was used to create the average profiles in panel a."

Fig 10 Change to "Comparison between" not among. Also the line colour is "green" not "dark". This is the line with the dark current measurement subtracted away but the line is green.

Fig 11 Change "calculated on" to "calculated for"

Figure 14: What time does each square represent? Can't be 30 s resolution?! There are 7 years on the x-axis. How were the laser pulses averaged?

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