

Interactive comment on “A comparison of three optical absorption photometers at a boreal forest site – effects of different correction algorithms” by Krista Luoma et al.

Anonymous Referee #3

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The manuscript covers an important topic that has puzzled researchers for decades: the need to accurately measure light absorption by aerosol particles. Light absorption by aerosol particles are fundamental when assessing the direct radiative impacts of aerosols in the air but also on snow and ice. The work investigates how these measurements differ based on which post processing method is used in the quest to determine the absolute amount of light absorption by aerosol particles. The work covers three different filter based absorption photometers and how they compare against each other. The work further extends the analysis to cover how these post processing methods affects the spectral dependence of the light absorption coefficients and how this can lead to misleading conclusions when comparing one measurement to another

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if not considering that the post processing method is of great significance.

General comments:

The Introduction would need a section where the goals of the study are clearly stated and then these goals should be addressed one by one in the conclusion section. This would help readers to grasp the extent of the research covered by the article.

The manuscript has dedicated a substantial proportion to the multiple scattering enhancement factor used in the Aethalometer post processing algorithms in the quest to make them perform better against the reference instrument MAAP. It is justified to scrutinize the multiple scattering enhancement factor of the Aethalometer but no attempt is made to scrutinize the multiple scattering enhancement in PSAP filters. PSAP filters are not as optically thick as the more rigid MAAP and Aethalometer filters but multiple scattering is bound to occur in those filters too which would warrant a similar kind of investigation that is now presented for the AE31.

I wonder if the title of the manuscript couldn't be changed to something more inviting. The focus is on which effects different correction algorithms have on the post processed data which is an important topic indeed. Could the authors consider being more specific other than saying the manuscript deals with 'effects on different correction algorithms'. E.g. Effects of different correction algorithms on absorption photometers can lead to wrong interpretations if not ... or something along those lines.

The English is generally good and it is easy to understand what the authors mean. There are however grammar errors that would need to be corrected and would improve the readability of the manuscript; e.g. definite articles and prepositions can be wrong or missing. In my specific comments I have made comments on those but the list is not exhaustive.

After addressing these comments and the specific comments below the manuscript is within the scope and of high enough scientific quality to be published in AMT. Please

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do also consider the specific comments below for the revision.

Specific comments:

P1L16 resulted to → resulted in

P1L20 filter measurements → filter-based measurements

P2L8 climate in global → climate on a global

P2L10: of the particles → of aerosol particles; scatter the light → scatter light

P2L11: “in color” is tautology so remove it

P2L12: suggest changing “light colored” to “bright”

P2L12: The sign of the radiative forcing is mentioned but could you be a bit more specific in what those signs actually mean i.e. write out cooling and warming instead of referring to the signs.

P2L16-19: sigma is a measure of light absorption and scattering, so it does more than “describe” it.

P2L24: I think that they are actually more unknown or not understood than actually defined.

P2L32: depends also → also depends

P2L34-P3L5: The discussion on Cref is focused on the different types of environments but does not address the fact that those studies cited weren’t conducted in the same way. Some reference instruments were different than others which is likely to be a factor when comparing Cref values between studies E.g. a study using a MAAP as a reference instrument would yield different results compared to a study using a photoacoustic instrument as a reference measuring the same aerosols.

P3L8: correct “cast a so-called shadowing effect”. Something casts a shadow but not a shadowing effect.

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P3L10: remove “and determined coefficients”

P3L13-14: Here you could cite Collaud-Coen & al 2010 and Backman & al 2014 as those are relevant for what is claimed in the sentence.

P3L30: “remarkable” does not seem to be the correct word here

P4L6-9: Why mention CAPS if it is not used?

P4L10: Wouldn’t the period be from Jun 2013 – March 2016 when all instruments are running? Why is then the period Jan 2012 – Dec 2017 chosen with the arguments of concurrent measurements?

P4L17: Remove the in ‘measured the b_sca ...’

P4L27: above accepted → above the accepted

P5L2-3: What is the Nephelometer actually measuring? The switch between PM1 and PM10 is done every 10 minutes and the flow through the comparatively large sensing chamber is 4.3 lpm. How fast is the Nephelometer flushed after a change in the inlet cut-size? It is not in seconds, but rather minutes as it does not flush evenly

P5L15 Bouguer is needlessly underscored.

P5L17-20 deltaT needs to be defined as the measurement interval.

P6L1 In the filter → In a filter

P6L7-8 It sounds like Weingartner is the cause of the “shadowing effect” when it is the filter and the particles that are the cause. Please rephrase.

P6L17-19: There isn’t a correction algorithm for MAAPs but that does not mean that they don’t need one. See e.g. Müller et al 2011 for e.g. the cross sensitivity to purely scattering aerosols as a function of filter loading.

P6L26: A radiative transfer scheme is no motivation for using the instrument as a reference instrument. The uncertainty and unit to unit variability (in that order) are argu-

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ments why it could be used as a “reference” although it does not provide the absolute truth either, as it is also filter based.

P6L28 ‘absorption instrument’ sounds rather sloppy. Please use absorption photometer or something similar. . .

P7L1 remove ‘again’

P7L2 ‘functional and popular’ says who? Why not say widely used?

P7L6-7 Please be more specific than ‘wavelength range is not as good’

P7L8 Problem for who? It can also be an advantage since it does not leak through the side of the filter tape.

P7L19-20 R can depend on other things too, not just ATN. R can be a function of single-scattering albedo, particle size, back scatter fraction etc. etc. This is the crux of the problem. Could be worth mentioning those things too.

P7L27-28 What were the criteria which lead you to choose these algorithms and not the others listed earlier? E.g. Schmid & al or Arnott & al are listed earlier but omitted here. Maybe they perform better and therefore warrants more investigation as more promising. You might want to state that if those were your criteria.

P8L11-16: Correct the grammar: e.g. remove articles before f, a and omega where not needed.

P8L16 resulted → resulting

P9L27-28: 14 days and filter changed on average once a day gives me 14 data points, not 9. The authors might want to rephrase a bit or write out the average filter change in days with a few decimals, like on average 1.55 days.

P10L8 Arnott & al 2005, not 2003.

P10L26 sigma_PSAP is not defined in the text.

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P10L28 Shouldn’t this equation be the Ogren 2010 adjusted equation as written out by Virkkula 2010 so that it reads $\sigma_{ATN}/(1.5557 \cdot \tau + 1.0227)$. Or which equation did you use? The old Bond 1999 or the Ogren adjusted?

P11L5: Rephrase “we agreed the results”

P11L17: Which data did you use? PM1 or PM10? The uncertainty is greater for PM10 than for PM1 since the more signal is truncated when bigger particles are present.

P11L19 averaged for → averaged to

P11L25-26 concentration of the particles → concentration of particles, amount of the → amount of

P12L12 It is not a model but rather an equation that is used to make the source apportionment.

P12L13 Used for what? Just say that it is important measure of the aerosols ability to interact with light.

P12L25 less sensitive? The range for b is smaller than a_sca but how would it be less sensitive? I think you mean that the range is smaller. I suggest you remove this sentence as it is not relevant for the analysis in the manuscript.

P12L29 amount → amounts

P13L9 corrected by → corrected using

P13L18 within 1% limit → within a 1% limit

P13L12 why focus on WEI and COL when the biggest difference was to VIR?

P13L13 Similar effects? What effects I wonder? Do you mean average or mean concentrations? Being more precise would be more informative here.

P15L1-3 Would it be possible that the different Cref values in the mentioned studies is due to the reference instrument being something else than a MAAP?

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P15L7 'describes' is not the correct word here

P15L15 real b_{abs} → true b_{abs}

P15L16 Which algorithms would be good if the reader is encouraged to use different algorithms based on their performance? At least you could state that e.g. the property derived from the AE31 should not depend on ATN after post processing. E.g. Fig. 8 shows clearly that some correction algorithms perform better than others when it comes to a_{abs} .

P15L20-31 Can the authors say something about which studies to trust and which ones not to trust?

P15L33 A linear fit does not average. Please rephrase.

P16L26 The sentence could need rephrasing. The fact that the C_{ref} value changes is a strong indication that it is not a constant.

P17L3 'relatively more weight' could use rephrasing. How about saying that the optical size changes? This implies that smaller particles (Rayleigh regime) aren't necessarily adding to the behaviour.

P17L13 correct: '... the relatively more the ...'

P17L19-27 I understand that it can be hard to quantify the effect of RH on b_{abs} in this dataset but that is a very interesting topic. Based on your findings it appears that RH is more important than the aerosols single scattering albedo. Where was the RH measured? In the nephelometer? It is now shown in the schematics figure. How do you know that the observed RH dependence isn't from RH fluctuations in the MAAP sampling line which is not actively dried which then affects the CNC values as if that was something to do with the Aethalometer performance.

P19L21-27 The numbers mentioned in the text does not seem to match the figure. Please check if this is true or not. E.g. the lowest median a_{abs} value in the figure

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does not seem to be 0.85 but rather close to 1 and the highest seems to be above 1.5 when in the text it is 1.48.

P19L32 measurements on → measurements at

P20L20 Figure 8 is only discussed here and is an excellent figure which I feel could be discussed a bit more. For example, the authors could for example use the figure as an illustration to state that whether it is b_{abs} or a_{abs} , the values should not depend on ATN and is an excellent test to check if the algorithm works. An important point to raise here would be that a_{VIR} seems to be the algorithms that performs the best.

P20L23 grew → grew or better still increased

P20L23 As a → In

P21L24 I suggest changing correlation to behaviour

P21L32-33 Please, rephrase the sentence

P22L7 remove 'about the'

P22L24 is the an model → is an old model

P22L28 You might want to mention that there are three different makers of tape for the AE33 and all of those have different C_{ref} values.

P22L30 we observed also → we also observed

P23L24 Effect of increasing filter attenuation is sometimes called shadowing effect and sometimes filter loading effect. The authors should be consequent in what they call the effects.

Figures and tables

Table 1

Remove 'Also, ' and 'are presented in the table' To me it does not seem to be enough

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to have the coefficients in the table with only two digits. Three decimals would seem appropriate if possible.

Table 1 (which should read Table 2) These values are reported at the Aethalometer...
→ These values are reported at the MAAP..

Table 4 (should be Table 3) Remove 'the' from before k (a_k)

Figure 2 I am curious what the setup was like during the other years as this figure only illustrates the setup for 33% of the data.

Figure 3 The last sentence in the caption could say that the dashed line is the median for all the data as there are already other medians shown in the figure.

Figure 4 Adding Root Mean Square Errors could be a more quantitative way of expressing how well the instruments agree in addition to the correlation coefficient

Figure 6 Colored be → colored by

Figure 7 Please explain what the whiskers are in this figure as well. In the text it says that the statistics are as in Fig 5 but there is no boxplot there and in e.g. Fig 3 the mean is shown as an o whereas in this figure using an x.

Figure 8 and 9 Same thing here, explain the statistics of the boxplot.

The box plots could use some text about what the whiskers and boxes represent. For some figures it is a matter of a simple copy/paste.

Fig. 5 A better matrix for the performance of the various algorithms would be to include the Root Mean Square Error of the fits which would actually yield a quantitative value of the goodness of the fit in Mm^{-1} . R^2 in all respect, but RMSE could be a good addition to the analysis.

Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2020-325, 2020.