Development of a Universal Correction Algorithm for Use with any Filter-Based Absorption Photometers (amt-2019-336)

Reply to Anonymous Referee #1:

We appreciate the reviewer's time in reviewing our submission and are grateful for the comments and questions the reviewer provided. These appear to be related to some confusion that the reviewer had in reading our manuscript, which highlights to us that we were not as clear as we should have been with some of the text. We apologize for this lack of clarity and provide clarification in our response to the specific comments below.

- The algorithm is shown in Eq. (9) Looks interesting although quite complicated. How did you get AAE into it? Please show intermediate steps from Eqs. (8) to (9). I read the supplement but did not find steps leading to Eq. (9).

There are no intermediate steps between Equations 8 and 9, and in re-reading our text, we understand why the reviewer has this expectation.

Equation 8 represents a generalized form of both the Bond and Virkkula correction equations, i.e., for either formulation of f(Tr(λ)) present in the literature. Equation 9 is our new proposed correction equation for the "g term" in Equation 8, which was developed as a multiple linear regression using ln(Tr), SSA, and AAE with interaction terms. To clarify, we have modified the text in Line 345 to read "We define a *new* function "g" that can be used in Eq. (8). Specifically, we construct a multivariate linear model for "g", introducing AAE as a dependent variable and including interaction terms between SSA, AAE, and ln(Tr)… "

- The remainder of the reviewer's comments are related to Bond et al. (1999), which was updated in Ogren (2010), and Virkkula et al. (2005), updated by Virkkula (2010).

First, we would like to clarify that we refer to as "updated B1999" and "updated V2005" are not simply the updated corrections in Ogren (2010) and Virkkula (2010). Those updated corrections are what we refer to as "B1999" and "V2005" in e.g., Figure 2. For our "updated B1999" and "updated V2005" results, we have re-fit the coefficients using the respective "g functions" from those papers, yielding a new set of coefficients that we provided as Table S7. We have added a new section (Section 2.4.3) to indicate that our updates are based on new coefficients rather than the adjustments from Ogren (2010) and Virkkula (2010).

Line 316: "2.4.3 Refitting the coefficients in B1999 and V2005

With the reference measurements of B_{abs} from the photoacoustic instruments, we are able to refit the coefficients in the B1999 and V2005 corrections (C_2 to C_7 in Eq. (5) and Eq. (6)) using our data. Specifically, we use the Levenberg-Marquardt algorithm (1944) to iteratively fit the coefficients until the chi-square of the coefficients are minimized. The fitting is implemented using the "Curvefit" function in Igor Pro. It is worth noting that the derived coefficients may only be valid for the SGP and FIREX data. For aerosol properties different from our study, the optimal coefficients are likely to be different from the ones reported here. Hereafter, the B1999 and V2005 results with refitted coefficients are referred to as “updated B1999” and “updated V2005”, respectively.”

This appears to be the root of the reviewer’s concern, but we provide additional information below.

Response to the reviewer’s first and second observations on Figure 2 and Table 3:

- If I compare the scatter plots in Fig. 2a of V2005 where the B1999 correction was used as such, with Fig. 3 in Virkkula (2010) where the B1999 correction with the coefficients updated by Ogren 2010 the regression lines don't change nearly as much as as in your Fig. 2. The difference between the original B1999 and that adjusted by Ogren (2010) is not big, definitely not as much as in your Fig. 2. and in Table 3. For instance, now you claim that the slope for the green changes from 2.5 to 1.01 when using the original B1999 formula and the one adjusted by Ogren (2010). That cannot be true. The additional correction factor Ogren (2010) derived was 0.97 ± 0.01. Otherwise it is B1999. Also in your Table 3 the change of the slope from 2.83 to 1.03 when using either the original V2005 or the corrected constants in Virkkula (2010) is far from realistic. Both of these can easily be tested by using the constants from those papers. I have added some examples below.

The second observation is that in the above-mentioned scatter plots in V2005 and Virkkula (2010) the absorption coefficients calculated with the B1999 correction without and with the updates are either lower than or close to the absorption standard. The V2005 correction and its adjustment in Virkkula (2010) resulted in increasing the absorption close to the 1:1 line of the respective scatter plots, not decreasing like in your Fig. (2). This is obvious especially for dark aerosol with SSA < 0.3 in those two papers.

Since Ogren (2010) and Virkkula et al. (2010) have respectively adjusted the original corrections (Bond et al. (1999) and Virkkula et al. ((2005))) to universal PSAP spot area and “true” flow rate, we expect the coefficients reported in their publications to be more precise. Thus, we simply use these coefficients when correcting our B_{ATN} data (the coefficients are presented in Table 2), instead of the ones in the original publications. The coefficients provided by the reviewer at the end of the comment are same as the ones reported in Table 2.

Using the coefficients in Table 2 (B1999 and V2005) and Table S7 (B1999 and V2005 updated coefficients), we generated Figure 2 and Table 3. As B_{abs} from the photoacoustic instruments was used as reference when updating the coefficients, the red and blue curves (B1999 and V2005 updated coefficients) are closer to 1:1 in Figure 2 and yield slopes closer to 1 in Table 3.

Reply to the reviewer’s third observation on Figure 2 and Table 3:

- The third observation is that you get essentially the same absorption coefficients with B1999 and V2005 and their respective updates. In Fig 2 the data points are almost on top of each other. And their regression lines are almost identical. This would be correct for high SSA (>0.7) but now your SSA went down to < 0.6 for the FIREX data (your Fig 6) and < 0.5 in the SGP data (your Fig 9). For such low SSA the two methods do not yield so similar absorption coefficients unless you used only data where transmittance > 0.8. What Tr range was used for the regressions?

We definitely agree with the reviewer that the performance of B1999 and V2005 may vary with Tr and SSA. The simulated B_{abs} / B_{atn} (“g” term in Eq. 8 and Eq. 9) using different values of Tr and SSA are presented below. The results of B1999 and V2005 are generated using the updated coefficients from Table S7 (FIREX-CLAP). As the reviewer mentioned, the B1999 and V2005 corrections are more agreed for greater values of Tr (as seen in panel d) and the combination of lower values of Tr and greater values of SSA (as seen in panels e and f).

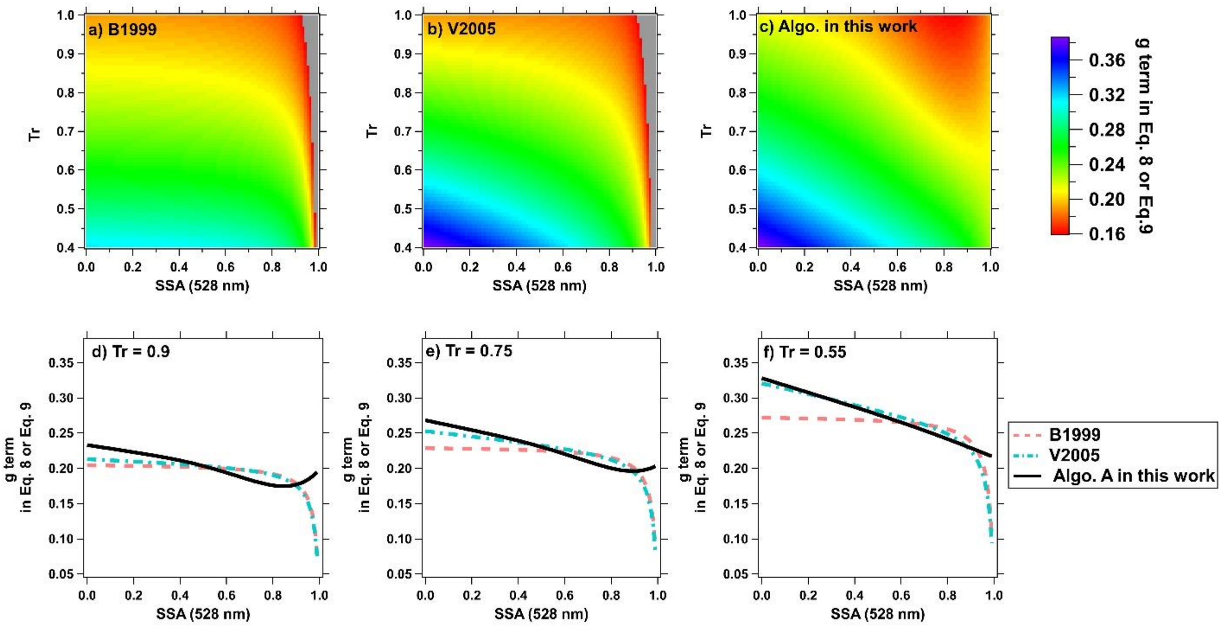

Figure 1. Simulated “g” term (528 nm) in Eq. (8) or Eq. (9). In panel a) and b), the grey regions correspond to “g” values less than 0.16. The results of the B1999 and V2005 are generated using updated coefficients from Table S7 (FIREX-CLAP).

Regarding the reviewer’s comment about the overlap in B1999 and V2005 in Figure 2, we provide the following figures to demonstrate our results. In these figures, B_{abs} derived by the two corrections (467 nm as an example) are plotted against each other, and colored by either SSA (0.3-1) or Tr (0.4-1). Here, we zoom in the original axes (0 - 7000 Mm^{-1}) in Figure 2 to better display our results (0 - 2000 Mm^{-1}). As seen in the figures, the biases between the two corrections are apparently associated with SSA (yet less obvious for Tr), consistent with the trends observed in the previous figure.

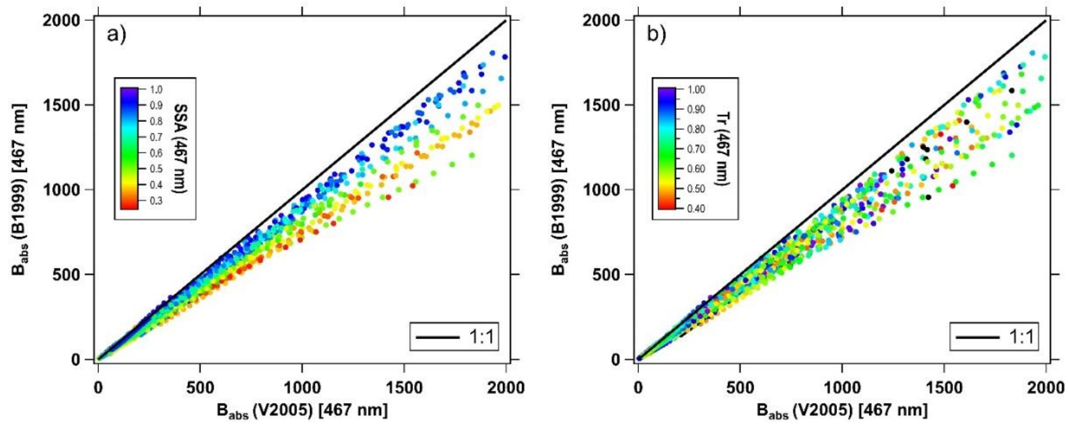

Figure 2. B_{abs} (B1999) against B_{abs} (V2005) for the FIREX data (467 nm). The points are colored by a) SSA and b) Tr. In panel b), there are a few black points, which are associated with $0.25 < Tr < 0.4$.

We apologize again for some of the ambiguity in our original manuscript regarding B1999, V2005, and our updated versions of both with new coefficients. The revisions prompted by the reviewer's comments have resulted in more clarity within the manuscript, and we thank the reviewer again for his/her comments.