Referee D. Baumgardner on “An Evaluation of three methods for measuring black carbon at Alert, Canada” by Sangeeta Sharma et al. First of all, the authors like to thank Dr. D. Baumgardner for accepting to review this paper with such constructive remarks. The suggestion of including the aerosol Absorption Angstrom Exponent (AAE) is great as we initially included AAE in the earlier version of the paper but it didn’t show any distinction between various combustion source influences at Alert location and was thus removed. The hourly average AAE between March 2011 and December 2013 are shown in Figure below. Values of AAE between 0.5 and 1.5 represent absorption primarily due to fossil fuel BC. A value near 1.0 is considered to be an example of graphitic carbon particles (Petzold et al., 2009), while AAE values close to 0.5 may reflect different absorption characteristics of elemental carbon (Bahadur et al., 2012). There are brief episodic increases in AAE where values over two are reached, indicating the presence of non-BC absorbing aerosol, but most of the fine mode absorption measurements fall within 0.5-1.5, suggesting that BC is the primary absorbing component with episodic influences of non-BC absorbing components. Mineral dust gives AAE values of three and larger at visible wavelengths (Petzold et al., 2009), which are not evident in the Figure.


Since the AAE is clearly and dominantly influenced by fossil fuel combustion, we are adding this Figure_Supplemental_2a showing 550 nm absorption and Figure_Supplemental_2b showing AAE time-series. The method, uncertainty calculation and discussion of AAE has been added to the Supplement and few sentences to support fossil fuel influence on the aerosol in the paper.

P 16, lines 10-13... The aerosol Absorption Ångstrom Exponent (AAE) values, as discussed in the supplemental section (see Figure_supplemental_1b), also suggests predominately fossil fuel sources of rBC and little biomass burning influence (AAEavg (April and Oct)=0.75±0.12). P 17, lines 18-20... The influence of brown carbon may be minimal at Alert as values of the aerosol Absorption Ångstrom Exponent (AAE) are between 0.5 and 1.5 suggesting predominantly fossil fuel influence (see Figure_Supplemental_1b). P 20, lines 6-8... "As discussed earlier, the influence of brown carbon due to biomass burning is minimal at Alert during the Arctic haze time for the data collected during the 2011-2013 (AAEavg for April =
0.75±0.12). Thus, that effect of brown carbon will be minimal on the MAC. Also added this to supplemental section: Calculation of Aerosol Ångström Absorption Exponent: The aerosol Ångström absorption exponent (AAE) was calculated from the PSAP absorption measurements. The AAE is defined as AAE=(ln\(\alpha_{\lambda_1}\)\(\alpha_{\lambda_2}\))/((\(\sigma_{\lambda_1}\)−\(\sigma_{\lambda_2}\))/((\(\sigma_{\lambda_1}\)−\(\sigma_{\lambda_2}\)))/(\(\ln\alpha_{\lambda_1}\)\(\alpha_{\lambda_2}\)\(\lambda_1\))/((\(\lambda_2\))/\(\lambda_2\))\(\lambda_1\))) where \(\lambda_1=467\) nm and \(\lambda_2=660\) nm and \(\sigma_{\lambda_1}\) is absorption at 467 nm and \(\sigma_{\lambda_2}\) is absorption at 660 nm.

Uncertainty in AAE Standard techniques were applied to determine combined uncertainties in the Aerosol Absorption Exponent calculated at two wavelengths; \(\lambda_1=467\) nm and \(\lambda_2=660\) nm. The uncertainty in AAE is determined by Eq. 2 has also been used in Sherman et al. (2015).

\[
\Delta\text{AAE}(467\text{nm}/660\text{nm})=(\frac{(\partial\text{AAE}/\partial\lambda\sigma_{\lambda}\sigma_{\lambda})(ap,467)}{\lambda_1})^2 + (\frac{(\partial\text{AAE}/\partial\lambda\sigma_{\lambda}\sigma_{\lambda})(ap,660)}{\lambda_2})^2 + 2\frac{\partial\sigma(\text{ap,467})}{\partial\sigma(\text{ap,660})} (\frac{\partial\sigma(\text{ap,660})}{\partial\lambda\sigma_{\lambda}\sigma_{\lambda}})(ap,467,\text{ap,660}) \cdot \frac{\lambda_1}{\lambda_2} \lambda_2^2 \lambda_1^2 (2)
\]

The time series of hourly light absorption measurements from the PSAP at Alert at 550 nm wavelength is shown in Fig._Supplemental_1a. The light absorption has been corrected according to Bond et al. (1999) and also Ogren (2010) for loading and scattering interferences. Episodic increases in absorption during winter/spring reach as high as 4 Mm−1 and overall lower values are measured during the summer and fall. Dust and brown carbon each have strong wavelength dependences, but BC does not. The impact of non-BC light absorbing species will appear as deviations from near unity absorption characteristics of pure elemental carbon and increase with varying amounts of OC (Bhadur et al., 2012). There are brief episodic increases in AAE where values over two are reached, indicating the presence of non-BC absorbing aerosol, but most of the fine mode absorption measurements fall within 0.5-1.5, suggesting that EBC is the primary absorbing component with episodic influences of non-BC absorbing components. Mineral dust gives AAE values of three and larger at visible wavelengths (Petzold et al., 2009), which are not evident in Fig._Supplemental_1b. Addition of Supplemental_Fig1:...
in this paper. The enhancement in the absorption due to total scattering has been compensated by using a higher $\alpha_{\text{ap}}$ value used by the Aethalometer firmware. Also added to Section 4.1.1, pg 17 lines 21-25: “In addition, the Aethalometer response depends on filter loading and multiple scattering by the filter medium and sampled aerosol particles. Scattering correction thus becomes important in cases when the aerosol has higher scattering with respect to total extinction (absorption+scattering), i.e. absorption is low. This is not the case at Alert especially during the Arctic haze time. Summertime measurements could fall into this scenario.”

Also Pg 18, lines 1-2: EBC (unmodified) needs to be evaluated due to these reasons in comparison to absolute measurements mass techniques. PSAP absorption coefficients have been corrected by using scattering data measured by a 3-w TSI Nephelometer. The main purpose for applying scattering corrections for PSAP absorption was to derive a MAC values at this location by using best estimate of averaged mass of EC and rBC measurements. The scattering correction was absolutely necessary for this purpose.

Added on P6, lines 30, P7 lines1 &2 Aerosol light scattering, $\tilde{\alpha}_\text{sp}$ was measured at Alert by using a TSI nephelometer at three different wavelengths: 450, 550 and 700 nm. The truncation error of the nephelometer, which is due to an angular integration restriction to 7 and 170° (Anderson and Ogren, 1998) was estimated and applied to scattering measurements. Scattering correction was applied to absorption measurements as shown in equation 4.

P7, Line 6: How was PSAP measurements converted from 530 to 550 nm? Added on P7, line6, “by using $(\tilde{\alpha}_\text{sp})^{-1}$ relationship to the wavelength…."

Section 2.4: The uncertainty estimates should be added in Table 1. Uncertainties were added to column #1.

Section 4.1.4: Should explain why EBC is not used in the best estimate of BC

We haven't included EBC in the best estimate of BC as it is light attenuated inferred mass measurement. Our comparison at the end of the paper tells us that these measurements are very close to best estimated absolute mass measurements. Added to P19, lines 17-18, “Considering all arguments, including EC and rBC being more specific direct mass measurements than EBC, which is light attenuation inferred mass indirect measurement,…..”

Added to P19 lines 23-25, “EBC mass is not used in the determination of best estimate mass of “BC” as it is an inferred mass derived from optical measurements and need to be evaluated with more direct mass measurements techniques at Alert, presented in the later section.”

Page 21 Supplement figure. Fixed the caption as shown below.

"...(green and red triangles are for data during spring and winter)"

Please also note the supplement to this comment: https://www.atmos-chem-phys-discuss.net/acp-2017-339/acp-2017-339-AC2-supplement.pdf

Supplemental Fig-2: Improved agreements were obtained between the best estimated black carbon mass and masses obtained by optical techniques such as Aethalometer (green and red triangles are for data during spring and winter). EBC Aethalometer and rBC data were averaged to EC sampling times.

\[ \frac{(EBC+\text{rBC})}{2}, \text{ng m}^{-3} \]

- **Aethalometer_winter**
  - slope = 1, \( b(0) = 18.3 \), \( r^2 = 0.9 \)
- **Aethalometer_spring**
  - slope = 0.9, \( b(0) = 24 \), \( r^2 = 0.6 \)

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**Fig. 1.**

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