Atmospheric Measurement Techniques Discussions

Atmos. Meas. Tech. Discuss., author comment AC4
https://doi.org/10.5194/amt-2021-209-AC4, 2021
© Author(s) 2021. This work is distributed under
the Creative Commons Attribution 4.0 License.

# Reply on RC 1

Ruoyang Yuan et al.

Author comment on "Measurement of black carbon emissions from multiple engine and source types using laser-induced incandescence: sensitivity to laser fluence" by Ruoyang Yuan et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2021-209-AC4, 2021

We thank Reviewer #2 for the review of the manuscript and supportive comments. The response to each comment (shown below in italics) is provided below.

**General comments:**

- *The LII community also uses the term nrBC (non-refractory black carbon), for example in atmospheric studies using the SP2 instrument. To allow for a better understanding between different communities, it would be valuable to discuss the terminology relations (nvPM vs. nrBC, for example) in addition to "soot" and "black carbon" already in the introduction. It could be also valuable to mention/discuss the SP2 approach, expected similarities, and differences in mass measurements, for example, etc.*

This paper we focused on the particular application for aircraft engine. The authors feel it may introduce confusion if using other terms (such as refractory Black Carbon (rBC) or single-particle soot photometer (SP2) instrument used in atmospheric studies).

2. *Maybe I missed it, but how is the fluence measured? The graphs are in a.u., and the authors talk about nominal fluence. I guess this is the fluence measured by some photodiode in the instrument itself. Is that correct? Is there any information provided on the calibration (linearity and slope) of these fluence values?*

The fluence was measured from an energy meter in the LII instrument and laser beam cross-section area in the probe volume, obtained from a beam profile camera. The information is added in the revised manuscript, in L257 and L359. The arbitrary unit of the laser fluence was changed to the measured value in $mJ/mm^2$ in the text and figures (Fig. 2c, Figs. 4-7, and Figs. 9-11).

Figure 7 shows that the relationship between fluence and q-switch delay is consistent from instrument to instrument and lends confidence to the determination of laser fluence in this work.

3. *I think a summary table with the optimal fluence ranges for the different sources would help in the future to provide a quick view of best operational conditions.*

Optimal fluence ranges were clarified in the text for the different sources. Although with laser fluences shifting, these optimal range can collapse, the actual values (fluence shifting or the original optimal fluence range) may differ from source to source and be affected by the soot particle properties. Therefore, a summary table would not add additional value to the manuscript.

**Specific comments**

- *Lines 23-25: I find the following sentence a bit confusing, if an optimized and therefore constant (?) fluence is used, why would different fluence levels be used? Maybe the authors mean that in a range of fluence around the optimized vale, the mass concentration is unchanged? "It was found that an optimised laser fluence can be valid for real-time measurements from a variety of sources, where the mass concentration was independent of laser fluence levels covering the typical operating ranges for the various sources."*

Sorry for the confusion. A constant (optimal) fluence is used in the real-time engine test.

To obtain this optimal fluence value, a series laser fluence sweep tests need to be performed covering the range of operation conditions of the source, such as demonstrated in Fig. 4 that the fluence sweep was performed at the idle and the high-power output conditions. The optimum value is determined from the optimum ranges from the sweep tests, as described in L303-307.

2. *Lines 190 – 194: Filter-based measurements can also be negatively affected by humidity.*

While it is true that filter-based measurements can be affected by humidity, the exhaust source for the measurements was heavily diluted prior to sampling (see figure 1). We did not observe any negative effects of humidity for the filter samples.

3. *Line 198: I guess the PAX operates at 870 nm, but what about the MSS? Also 870 nm? Please clarify.*

The MSS operates at a wavelength of 808 nm. The manuscript has been updated with this information (P7, L200).

4. *Line 199: Even with RI constant, the AAE might deviate from 1 somewhat, so the equivalence might not be perfect.*

Since the measurements reported in this manuscript are for non-volatile particulate matter, the assumption of an AEE = 1 is reasonable.

5. *Line 200: What source was it? Also, how was the PAX calibrated?*

The calibration source for the MSS was a CAST. The PAX was calibrated separately with ammonium sulphate and Aquadag solutions. The information is added to the revised manuscript in L200 - 202.

6. *Lines 258-260: Consider rewording the sentence to something like "A time-weighted normalisation (TN) method was used to account for scatter caused by any modest variations in the concentration of the source emissions". Also, why could one use the SMPS concentrations or the photoacoustic signals to account for source concentration fluctuations?*

The sentence has been reworded as suggested. One could use data from another measurement such as SMPS, PAX to account the source concentration fluctuations. In Fig. 12a, it shows the good response and agreement of PAX, MSS and LII to the fluctuation in the real-time measurement. But for the current study, the focus is on fluence characteristics from the LII instruments, especially in the fluence sweep characteristics, we weren't look at other instruments behaviours to account for the fluctuations.

**Additional change made:**

Added Figure 11c (attached in the supplement) and the text, showing the fluence data from six rigs and a total of 11 conditions after shifting the fluence axis of Rig C and E, load 1.

Please also note the supplement to this comment:
https://amt.copernicus.org/preprints/amt-2021-209/amt-2021-209-AC4-supplement.pdf