Atmospheric Measurement Techniques Discussions

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Reply on RC 2

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-AC5, 2021

We thank the Reviewer #1 for the review of the manuscript and supportive comments. The response to each comment (shown below in italics) is provided below.

Points should be improved:

- *The MSS is known to be influenced from ambient effects, like changes in humidity. I suspect a similar behavior of the LII, and I am convinced the manuscript would benefit from an additional discussion of ambient effects on LII measurements. E.g., what were ambient conditions during the measurements?*

In many investigations, we have never observed effects of humidity on the mass concentration reported by the LII 300 instrument. The instrument does measure the pressure and temperature in the sample cell and corrects the mass concentration to that at STP conditions of 0 °C and 1 atm. In other words, the ambient conditions do not have an impact on the measurement.

LII is not an absorption-based instrument, and at the temperatures the particles are heated to (~4000 K) the ambient conditions do not have an effect on the measurement of mass concentration. MSS is an absorption-based instrument, which only perturbs the temperature slightly from ambient conditions, and may be more susceptible to temperature and humidity.

- *The authors performed the measurements on the different rigs over different periods of time: Other than in Fig. 3, the reader gets very little information how the authors made sure to assume "stable combustion conditions" for all rigs. Was there any CO2 measurement attached to the rig? Is there any EGT measurement available, which could be used as a potential tracer for combustion stability? As well, little is known about the warm-up sequence of the engines, neither do the author describe if any exhaust gas treatment (especially for rigs E & F) was present.*

In terms of the warm-up and stabilising, the engines/rigs were running at the set point for a short period while the real-time data of temperature and other operating conditions were monitored. Once these operational parameters were determined to be stable, the data collection for that particular set point was initiated. In terms of the EGT, a

thermocouple was fitted on the exhaust of each engine/rig. The temperature along with other data were monitored and available as a tracer for combustion stability. There were no exhaust after-treatment on any of the engines/rigs.

- *What is the essence of the project? What are, after all the measurements performed by the authors, the recommendations? Can a low-cost engine like in rig F be used as a calibration device for an LII, if aircraft emission measurements following ICAO Annex 16 Vol. 2 be performed operationally? If yes, how large are the remaining uncertainties in terms ov nvPM mass, and how does this uncertainty compare to e.g. MSS measurements?*

In section 3.5, P23, L527, we discussed that 'In terms of identifying a substitute for the aircraft gas turbine helicopter engine (Rig A) for calibrating the LII 300, Rig C (APU) appears to be the closest in terms of LII 300 response, with 1% higher than EC from TOA on the same source, well within the uncertainty of the methods'. The uncertainties were shown in Fig. 13 for each rig and addressed in P23, the second paragraph.

From the rigs investigated in this study, the APU seems to be the closet low-cost alternative engine calibration source for an LII. The next candidate would be the diesel generator but operating at a high power output (i.e., in the cases studied, Rig D, at 5 kW). The mass concentration results are within 1% between LII and MSS, and are about 10% higher than the TOA EC results. The error bar of each instrument (LII, MSS, PAX) overlaps within the uncertainty (16.7%) of the TOA EC determination. However, to assess suitability of replacing an aircraft gas turbine engine as a calibration source, 'further work is required to establish the repeatability and reproducibility of particles sources, as well as investigating additional laboratory sources including the miniCAST, MISG (mini-inverted soot generator), and nebulized carbon black particles', addressed in the summary section.

Specific Comments

- *L165: Add information what total volume was sampled onto the quarz filter*

Information on the total volume sampled on to the quartz filter, along with other measurement details, has now been included in the manuscript (L165-169).

- *Methods: How did you define "stabilized conditions" for representative measurements? How long did you wait after any load change on the engines? Were the engines warmed up? Was any of the reciprocal engines fitted with any exhaust treatment mechanism?*

In terms of the warm-up and stabilising, the engines/rigs were running at the set point for a short period while the real-time data of temperature and other operating conditions were monitored. Once these operational parameters were determined to be stable, the data collection for that particular set point was initiated. In terms of the EGT, a thermocouple was fitted on the exhaust of each engine/rig. The temperature along with other data were monitored and available as a tracer for combustion stability. There were no exhaust after-treatment on any of the engines/rigs.

- *Fig. 2/4 & others: It is only explained in line 358/359 why you are using arbitrary units instead of mJ/mm^2. I suggest adding this information earlier in your manuscript.*

The arbitrary units were replaced with mJ/mm^2 in the graphs and texts in the revised manuscript. We added a note on how the fluence was determined in the text, in P11, L267.

- *Fig. 10/11: I recommend adding a Loess curve as in Fig. 9 for consistency*

The Loess curve are added in Fig. 10 and Fig. 11 as suggested.

- *Fig. 13: I am missing an explanation why the range for Rig E & F can't be more specifically indicated ("uncertainty" or "variability"?)*

The range for Rig E and F has now been added in the caption of Fig. 13.

Technical Corrections

- Added 'The' in L44.
- L49: Removed CAEP, SARPs abbreviation as suggested.
- L80: Moved all cited papers at the end of the sentence as recommended.
- L123: Added the two wavelengths information in the sentence.
- L141: Added comma after "or EC".
- L151: Revised the sentence adding 'therefore'.
- Changed relative to relatively in L429.
- Rewrote the sentence in L451-L455.
- *L514: reformulate sentence after ", although was still..."* This sentence has been reworded (now in L533).