Anonymous Referee Comments: amt-2022-77

Summary:

This manuscript presents a comparison of EFs calculated for CO, CO2, CH4, and N2O from measurements attained from a UAV (DJI Matrice 100) equipped with Tedlar bags for offline analysis with continuous measurements attained from a more heavily, traditionally-instrumented 15-m tall mast tower. In the second phase, “UAS-compatible” aerosol sensors were evaluated for accuracy and reliability of BB measurements using a series of chamber studies to estimate useful calibration factors.

General Comments:

The manuscript’s evaluation of UAS performance and EF estimates was somewhat lacking, and instead it presented a rigorous, significant evaluation of small aerosol sensors that can potentially be deployed aboard a UAV. However, the sensors themselves were not actually outfitted for and/or deployed on an UAV platform. As it is presented, it was challenging to glean this information from the text and the title seems misleading. This would be better presented as two separate papers, with much greater detail on the UAV sampling strategy and evaluation of measurement capabilities (*e.g.*, sampling lofted versus RSC emissions, impacts of UAV prop wash, etc.) as one paper and another evaluating small aerosol sensor measurements of BB emissions. The only connection drawn between the small aerosol sensors and UAVs is that the authors mention these are “UAS-compatible,” however, there is no description of power requirements, sampling time constraints, or evaluation of UAV specific turbulence/dilution impacts that could occur when deployed on a UAV. Additionally, it is not clear the UAV could carry the weight required to collect Tedlar bags as well as the aerosol sensors, therefore this is not a complete UAS BB sampling system as seemingly implied by the manuscript title. The authors rightly state that multiple carbonaceous species are necessary to calculate CMB EF, however, they don’t actually present a UAV system that is capable of carrying all this instrumentation required to estimate EFs. I believe the manuscript needs to be reorganized, retitled, and instead focus only on small aerosol sensor characterization for BB sampling as significant advances to EF estimates from BB are not fully supported or described here-in.

Specific Comments:

The authors describe sampling biases towards RSC for ground measurements and lofted flaming emissions for airborne sampling. The UAV sampling approach described measures at the height of the stationary mast to compare with. While these comparisons are useful to evaluate the onboard drone measurements, it would be interesting to show the utility of UAVs by sampling different areas of the plume and evaluating varying emissions for their dependences on burn/ environmental conditions. How do these differences compare to laboratory and ground/air measurements? What new information is available by sampling with the UAV? We obviously aren’t attaining more speciated emissions, but are these EFs useful and what can they additionally provide compared to more traditional fire-integrated biome specific EFs used in inventories?

P3 L16 You mention "Better understanding of this BB EF variability would improve our quantification of fire emissions, and would aid understanding of the effects of future climate- and human-induced changes in fire regimes." -- How does knowing the BB EF variability actually improve upon our current fire emissions estimates? There are currently no methods to implement time-varying, burn condition (MCE) varying EFs. Additionally, the biome-average EF is shown to be one of the smaller uncertainties when estimating total emissions from fires (*i.e.*, fuel consumption and burned area estimates have larger uncertainties). I would like to see stronger support describing the importance/motivation for UAV-based EF measurements, especially since the methods described don't provide any detailed speciation or spatial plume variability.

P5 L26 Did you use an onboard pump to fill the bag? The UAV experimental details are lacking in this manuscript. It is insufficient to refer readers to sampling details outlined in Vernooij et al., 2021 since the title of this manuscript is UAS-methodology. What are the flight times and flight restrictions (wind, instrument load, power draw)?

How does airflow/downwash from propellers impact dilution of smoke sample? How would this turbulence and dilution impact your aerosol optical properties or loading? Would gas-phase and particle-phase collection be impacted by dilution differently? What strategies are necessary when setting up sampling inlets for both on a UAV with different flow rates?

P6 The authors assume a total amount of carbon emitted using literature reported NMHC and carbon-containing particles, shouldn't this vary depending on whether you were sampling a high or low MCE fire? What uncertainties are associated with assuming this is constant across the entire sampled fire or for different fuels and on different days? Are you biased or limiting the measurement variability you observe by assuming a constant carbon contribution from these species?

P2 L7 I wouldn't say BB is a "main source" of GHGs, especially with the CO2 sequestration you mention in the following sentences. A slight rewording would be nice.

P3 L4 The authors only mention burned area based approaches, you could also mention FRP-based approaches since many still rely on EFs

P3 L20 Many more recent references could be added. As an example, Yokelson has used a land-based cart for ground measurements for many years. Also, the way this is phrased implies there have not been many studies investigating EFs, and even recently there are many BB-focused airborne campaigns in the U.S. (WE-CAN, FIREX-AQ, BBOP, SEAC4RS) and internationally that could be mentioned.

P3 L23-26, The authors question the applicability of aerosol EFs from laboratory measurements, due to the uncertain evolution of aerosols, however, an emission factor has nothing to do with evolution and is by definition the amount emitted by the actual fire, not the amount following transformation and ageing.

P3 L32 What do you mean by "fire products?" Do you mean the distribution of emissions is not equally distributed over all areas of a smoke plume. Please clarify this sentence

Figure 1, can you show the stationary mast average mixing ratio over the UAS sampling time? You show the EFs correlate across the entire fire sampling interval in Figure 2, so I assume they mostly agree though it'd be good to see the absolute difference. You can also shorten the x-axis since there is no detail or additional UAS sampling beyond 15 minutes since ignition.

P11 L10 what do you mean by cumulative emissions? Does this mean you sum the emissions across all sampled bags in a single fire to get one value per fire?

To derive CFs you use hay, wood, and wood chips, why not just burn savanna grasses. Hay seems most similar, but I'd expect some differences. Do you even use the chamber experiments that burned peat and straw anywhere else in this manuscript?

It isn't clear why you have three separate chamber experiments. Maybe detail what the usefulness and differences are between each chamber experiment and what the science foci of each set of experiments were.

P12 L25 should you reference Fig 3b here?

Fig 4 Is this for multiple fires?

Fig 6 What is your justification for using the average of all to estimate a CF rather than just using the field (KNP) average value?

Fig 7 What are the fits shown? For instance, in plot (b) the red dashed line doesn't seem to be the fit for the red crosses.

P14 L26-32 This paragraph seems out of place and doesn't tie to your measurements well.

I think some reorganization is necessary. For instance, sect 4.2 seems out of place and instrument performance should move to the methods section. I needed to jump around frequently to try and follow UAV measurements and chamber measurements. The mix of aerosol sensor/chamber analysis versus UAV sampling is mixed in an unorganized fashion.

P18L30 "for variability within individual fires was difficult as separate filters for smaller periods of the fire (e.g. the flaming and smouldering phase) resulted in insufficient filter loading." This is important to highlight in more areas of the text as this would have important implications when sampling with a UAV-based system.

Technical corrections

P3 L9 "usuall calculated as from" should be "usually calculated from"

P3 L11 "is dependent on weather conditions and fuel characteristics" should also list "burn conditions"
P3 L15 EF variability "show high intra-biome variability" This should be less than 30%, which is small relative to larger burned area uncertainties

Table 2 is mentioned in text before Table 1

P4 L3 “maybe” should be “may be”

P4 L4 (airplane),?

P4 L5 “maybe” should be “may be”; also misspelled “measurements”

P12 L13 “and the gravimetrically” -rephrase

P13 L7 “wether” should be “whether”

P20 L30 change “where” to “here”