

This manuscript developed a lightweight UAS sampling system for the measurements of pollution emission factors from biomass burning. Gas emissions were collected by Tedlar bag for offline analysis, while PM and BC were measured by sensors onboard UAS. Sensor performance was assessed by comparing the sensor results to those from high-fidelity equipment in the laboratory smoke experiments. And the performance of the UAS system was evaluated by comparing to co-located mast measurements for prescribed burning experiments in the Kruger national park in South Africa. Combining laboratory characterization and field measurements, the authors demonstrated that with proper correction factors applied, the UAS system can serve as a promising tool for obtaining representative biomass burning emission factors. Overall, the manuscript is well written. The techniques proposed are valuable to the literature. I recommend the manuscript be considered for publication only after my following comments are fully addressed.

General comments:

1. Title: For the UAS system, there are quite a lot of differences between fixed-wing and copter-type UASs with regard to factors such as payload, battery limitation, propeller influence, and sensor integration. Until reading the Method section, I realized that this study used a copter-type UAS (DJI Matrice 100). I suggest that the authors mention this information directly in the title. The title can be modified as, for example, “A copter-type unmanned aerial system based methodology for measuring biomass burning emission factors”
2. Page 3 line 34: “Most atmospheric models account for photochemical processing, but not the chemical changes associated with the initial cooling of the smoke to ambient temperature.”

What types of chemical changes are associated with the initial cooling of the smoke?
Please clarify. How can UAS-enable technique help to address this issue?

3. Section 2.1.2: A picture of the Mast and UAS setup would be helpful for the readers to gain a better idea of the measurement design (e.g., mast height, gas inlet of the mast, locations of equipment and sensors on mast, and locations of Tedlar bag and sensors on UAS).
4. Page 5 lines 26-31: This paragraph is apparently too short, as this manuscript focuses on UAS-based measurement. The description regarding UAS sampling needs to be significantly improved. Although the authors mentioned that detailed methodology can be found in Vernooij et al. (2021), there are only two short paragraphs presented in that paper.

Questions to clarify:

- a. Why DJI M100 was selected? What was the payload limit of DJI M100?

- b. How was the Tadar bag mounted to the UAS? How was gas sampling performed? Was a pump used during the sampling? Was it a Teflon pump? What was the flow rate of the sampling? How much air was collected in each bag? Was the flow rate recorded during the sampling? Was temperature recorded during the sampling for concentration correction? Was sampling quality control well performed (e.g., no leaking)? Samples were analyzed within 12 hours of sampling. How were the samples stored? Did it affect the concentration of the species inside the bag?
 - c. What were the weights of the AE51 and AM520? Given the payload, how long was each flight? Was the sampling inlet position on the top of UAS or below UAS? Were the data of AE51 and AM520 transmitted to the UAS controller at real time? Or they were stored in SD cards and retrieved after each flight?
 - d. Were UAS gas sampling and PM measurement influenced by the propellers? What were the influence lengths of the UAS-induced wind field above and below the UAS? Did it affect the mixing of biomass burning emissions and thus impact the estimation of emission factors?
5. Page 5 line 27: UAS sampling was conducted at an altitude of 15 m, similar as the sampling altitude at the mast. Why was 15 m selected for emission factor calculation? Please clarify.
 6. Page 6 line 12: “For the bag and mast measurements, we used the PM to CO ratio based on AM520 and CRDS measurements, with carbon accounting for 68% of the PM-mass (Reid et al., **2005a**).”

This sentence is confusing. I understand that PM to CO ratio was calculated based on AM520 and CRDS. How was the PM carbon fraction calculated? Did you calculate the carbon fraction? Or it was obtained from Reid et al. (**2005**). If the fraction was obtained from the literature, why this value was selected? How representative is this value?

7. Page 7 lines 20-23 and Page 13 lines 3-5: as the authors mentioned, one of the reasons that AE51 is not as accurate as AE33, especially at low concentrations, is that AE51 operates at a much lower flow rate. One suggestion for future improvement can be increasing the sampling flow rate of AE51 using an external pump, as demonstrated by Wu et al. (*Science of the Total Environment*, **2021**).

Reference: Wu et al., Vertical profiling of black carbon and ozone using a multicopter unmanned aerial vehicle (UAV) in urban Shenzhen of South China, *Science of the Total Environment*, **2021**, 801, 149689.

8. Page 11 lines 5-6: “After the flaming phase ceased, mixing ratios and thus temporal varying EFs (green lines) for CO, CH₄ and PM_{2.5} sharply rose.”

What do you mean by “After the flaming phase ceased”? Do you mean after around 3 min in Figure 1? The emission factors of CO, CH₄, and PM_{2.5} increased sharply after 3 min in Figure 1. However, why no increases in emissions were observed? Instead, the emissions decreased significantly after 3 min.

9. Page 16 line 32: “concentration. Cross-correlation of the UAV-mounted AM520 to five co-located AM520 modules revealed measurement errors of up to 20%.”

Can the authors provide the figures showing the good correlation between the datasets collected from AM520 onboard UAV and those from AM520 on the mast? This can be good supporting information demonstrating the validity of UAS data.

10. The authors did a very good job discussing the assumptions and the uncertainties of this study. It would also be valuable to the readers if the authors can provide some recommendations (or improvements) for future studies using the UAS system for emission factor measurement.

Technical comments:

1. Page 2 line 25: change “different fuel types” to “different fuel type”
2. Page 3 line 9: typo “usuall”
3. Page 4 line 5: typo “measuremetns”
4. Table 2 is shown and discussed before Table 1 in the manuscript. Please adjust the order.
5. Page 9 equation 8: “MAAP” not “MAAB”
6. Page 10 line 18: delete “with a”
7. Page 13 line 7: typo “wether”
8. Page 13 line 20: Fig. 8? There is no Fig. 8. Do you mean Fig. 6?
9. Page 20 line 30: “Such FRP measurements were not available where, and although we measured the atmospheric concentrations continuously as the different stages...”

Missing information after “where”