Review of “Development of a small unmanned aircraft system to derive CO_2 emissions of anthropogenic point sources”, *Atmospheric Measurement and Techniques*, by Maximillian Reuter et al., doi.org/10.5194/amt-2020-234

Anonymous Reviewer

This study outlines the development of a small unmanned aircraft system (sUAS) to measure CO_2 emission point sources, consisting of a drone platform hosting a non-dispersive infrared (NDIR) CO_2 sensor, a 2D ultrasonic anemometer, and pressure, temperature, and humidity sensors. Combined, this allows the system to take in-situ measurements of the mole fraction of CO_2 at various heights, with associated micrometeorological measurements. The development of drone based atmospheric sensors fills an important niche between ground based and airplane-based measurements, particularly for measuring point sources in areas without established ground based sensors. As such, this study is pertinent for these developments.

Overall, the manuscript is very well prepared. The outline of the development of the drone based platform is well presented, and the authors have shown the extensive steps they have taken to ensure that the micrometeorological sensors on the platform are correctly synced to the measurements of the CO_2 sensor. The authors have developed a robust correction for the CO_2 sensor for the flight conditions which they expect the sensor to operate, and have also developed a means to account for rotor downwash on their 2D ultrasonic anemometer measurements. The authors have taken the necessary steps to test these corrections via an intercomparison study with CO_2 and meteorological sensors at an ICOS station. The details provided through these stages are excellent, and consequently, I am convinced of the suitability of this sUAS for in-situ measurements, at height, of the mole fraction of CO_2. However, in order to be convinced of the suitability of the sUAS to derive emissions of CO_2 from anthropogenic point sources, there are some areas which could be elaborated upon or further clarified with regards to the field campaign as outlined in Section 6 of the manuscript. I would encourage the manuscript to be published, once these issues are addressed:

1. As outlined in the paragraph beginning **Line 341**, the authors note that the inferred total flux is significantly lower than the facility’s own estimate, and suggest that the discrepancy is due to the fact that only part of the plume was sampled. **Line 291** clarifies that the legal operational parameters for the drone flights allowed for a maximum height of 200 m. The authors assessment is therefore highly likely to be correct. This raises the question of how suitable the sUAS is, as a self-contained platform, for inferring anthropogenic point emissions. The authors do note this in **Line 388** (“Of course, quantitative comparisons require that complete cross-sections of the plume be examined”). The authors go on to suggest in **Line 421-423** that future studies with the sUAS could seek to investigate “how much averaging has to be applied on the cross sectional flux in order to converge on the actual emissions”. Would this not, however, require knowledge of the morphology of the plume? If so, then plume simulations would be required. I think it would be good to see in this study at least some modelling of the plume stack, such as using SHRMC-4S DAYSMOKE. I think inclusion of this would highlight the limitation of this sUAS for sampling plumes from industrial stacks, while concurrently explaining the difference between the study’s inferred CO_2 flux and the value taken from the facility. By doing this, it can be argued the sUAS is indeed suitable for point emissions measurements, but that in this example, legal limitations on drone operation prevented a full analysis. If it is not possible for the authors to do this, then the authors should include further technical argument in Section 6 and in the Summary regarding how emission sources could be inferred from sampling cross sections of the plume (perhaps outlining the steps that the authors would have taken if plume morphology was known).

2. Following from this point, an outline of the operating parameters of the sUAS, such as maximum allowed height of operation, maximum distance from observer, battery temperature etc., would be welcome somewhere in Section 2. The reader would benefit in understanding the limits to drone operation, particularly with regards to sampling heights. It is also important to clarify why this platform can operate at a 200 m flying height. Current EU legislation limits drones for both recreational and commercial flights to 120 m above surface level, so I’m a little confused as to why this sUAS was able to operate at 200 m! By adding this information, the reader would also be able to gauge whether this sUAS meets the requirements for their field site. Furthermore, it would also clarify some issues with turbulence. If the drone can only operate below a certain wind speed, then turbulence effects become less significant.

3. The x-axis on **Figure 9** is labelled “Distance [m]”. It is important to clarify what this distance is from. Presumably, it is the distance from the attitude of the drone when measurements were first taken?

4. CO_2 emissions from point sources are often associated with emissions of particulate matter. Have the authors considered the suitability of their sUAS to take downwind measurements of CO_2 in plumes that may contain PM? How would drone and sensor performance be affected?

Beside these points concerning the content of the work, the following stylistic points are suggested:

- The axis labels of all figures are quite small and difficult to read without zooming in. Could the authors enlarge the x-axis and y-axis labels for all figures?
- For **Figure 2**, a secondary y-axis plot could be used to plot pressure on the same sub-plot as RH.