Review of “A tracer release experiment to investigate uncertainties in drone-based emission quantification for methane point sources”

Summary

The manuscript presents results from controlled release experiments, with methane concentrations and subsequently emissions calculated with a drone-based methodology. A DJI Matrice 600 drone is equipped with a low-cost RTK system, in-situ methane analyzer, and an AirCore for post-flight concentration analysis with a Picarro analyzer. Corrections for the AirCore sampling timing are presented, along with analysis of the drone altitude accuracy. To calculate emission rates, different variations of the mass balance technique are presented with comparison in some cases to OTM33A. In addition to these comparisons, a new technique based on cluster kriging is described.

Overall evaluation

The Introduction/references, scope of work, and scientific approach of the work are good.

Some issues I found already mentioned by Reviewer 2 include finding L13 of the abstract confusing about the stretching by 0.06 seconds, wondering whether the methane data in all the plots are already background-subtracted, and suggesting improvements to the general readability of figures (other than Fig 1).

Regarding the novel cluster kriging approach adapted here, the paper cited by van Stein et al. 2020 concluded the method is designed to ‘reduce the time and space complexity of the Kriging method’. While dividing into elevated and background clusters makes sense, I do wonder how the above statement fits in. Specifically, if the difference between cluster kriging and ordinary kriging shown here has less to do with the theoretical basis of the method, and more a difference in the parameters used given that Fig 5(d) on left has a significantly different appearance (length scale or search radius?) than that of Fig 5(c). Please explain. In general, while the math is presented if Section 4.5.2, I think some of the more practical details could be mentioned. Does the cluster kriging python package mentioned in the code availability statement also perform ordinary kriging, or that comes from elsewhere? Maybe add an example of the semivariogram or kriging parameters in the supplement to better illustrate the method?

Some minor details were unclear, especially regarding the altitude analysis and AirCore correction, as detailed below.

Specific comments

L27 Gurney et al. 2021 in *Nature Communications* is likely the wrong reference here. That paper is focused on FFCO2 from cities, not CH4 from oil and gas.

L48-50 Shaw et al. 2021 (“Methods for quantifying methane emissions using unmanned aerial vehicles: a review”) and/or Hollenbeck et al. 2021 (“Advanced Leak Detection and Quantification of Methane Emissions Using sUAS”) could be also considered adding here, as they are recent reviews on the subject of UAV methane quantification.

L114 ‘capturing raw streams’ – This is perhaps too vague. I think it is not so much a raw stream as a different stream (the carrier phase), see https://novatel.com/an-introduction-to-gnss/chapter-5-resolving-errors/real-time-kinematic-rtk

Figure 2: The 14 on the x-axis tick labels is unneeded (see presumably matplotlib.dates.DateFormatter)

Figure 2: Isn't 0 AGL [m] defined as the takeoff altitude for UAV-GPS by the Matrice? Also, are takeoff and landing locations here different or the same?

Figure 2: The pressure altitude is impressively consistent comparing against RTK altitude. The spikes seen in the bottom panel of Figure (2) could be a little misleading since they appear to be caused simply by small differences in timing relative to the RTK during ascent and descent where altitude is changing quickly.

Figure 2 caption – the meaning of subscript m in bottom panel legend could be mentioned (slope from linear regression). They must also have some impact on the pressure altitude drift estimate unless robust regression was used

L144 Later, the make/model of 3D sonic anemometer is mentioned (uSonic-3 Scientific). What was the type of 2.5D anemometer?

Table 1 stability here is presumably based on equation from L215, not the Pasquill stability classes, which are also mentioned (L180)

L250 It's a little unclear if the 3S algorithm is new to this manuscript, or if it is presented in the two manuscripts cited on L247 that are in preparation / review. With being able to read those, the writing here is a is a little hard to follow. A simple 1D Gaussian smoothing function need only have one parameter – a standard deviation. How does F(x,b) accommodate three parameters?

Figure 4 legend – 'Stretch' is written twice. Is one of them supposed to be shift? Also, the 0.06 s/s stretching is mentioned in abstract, but the other two numbers (12.81 and 17.90) are different?

Figure 4 – Frankly, the algorithm mainly just seems to correct for the shift, also called time lag by some other authors. Are the other two parameters really helpful?

L361 16.04 kg should be g for the molar mass of methane

Table 2 - In footnote about optimal conditions, suggest mentioning they are defined in Section 5.2.2

Table 5 – Suggest putting 'This study' (or similar) in the column next to Airborne CKPW mass-balance. Or somehow clarify, since the studies mentioned here - Golston et al. (2018); Yang et al. (2018); Shah et al. (2020) - do not use CKPW

L529 'Under these conditions, measuring at a downwind distance of 75 m ensures the true emission can be fully mapped both horizontally and vertically'. This is a little confusing, since it sounds like you need to be >= 75 m downwind to fully capture the plume, while L523 indicates underestimation at those distances.

Figure 6, 8, and 9 show 'residuals' in %, which here must mean the percentage error of the estimate versus the known controlled release amount (but without calculating absolute values). Where does the 'range of residuals' come from?

L742 Suggest replacing the dead link to U.S. EPA with the citation given at
https://cfpub.epa.gov/si/si_public_record_Report.cfm?Lab=NRMRL&dirEntryId=309632]