We would like to thank all reviewers for their valuable insights and comments made to improve this work. We believe we have addressed all comments made by the reviewers as shown below, and the suggested changes have greatly improved this manuscript.

Our response to all comments is structured so that the reviewers comments are shown in "**bold"**, our responses are shown in *"italics"*, prior text in the manuscript is shown in "blue", added text is shown in "red", and any deleted text in the manuscript is shown in ~~"blue strikethrough"~~.

We would once again like to thank the reviewers for their valuable insights and comments regarding this manuscript.

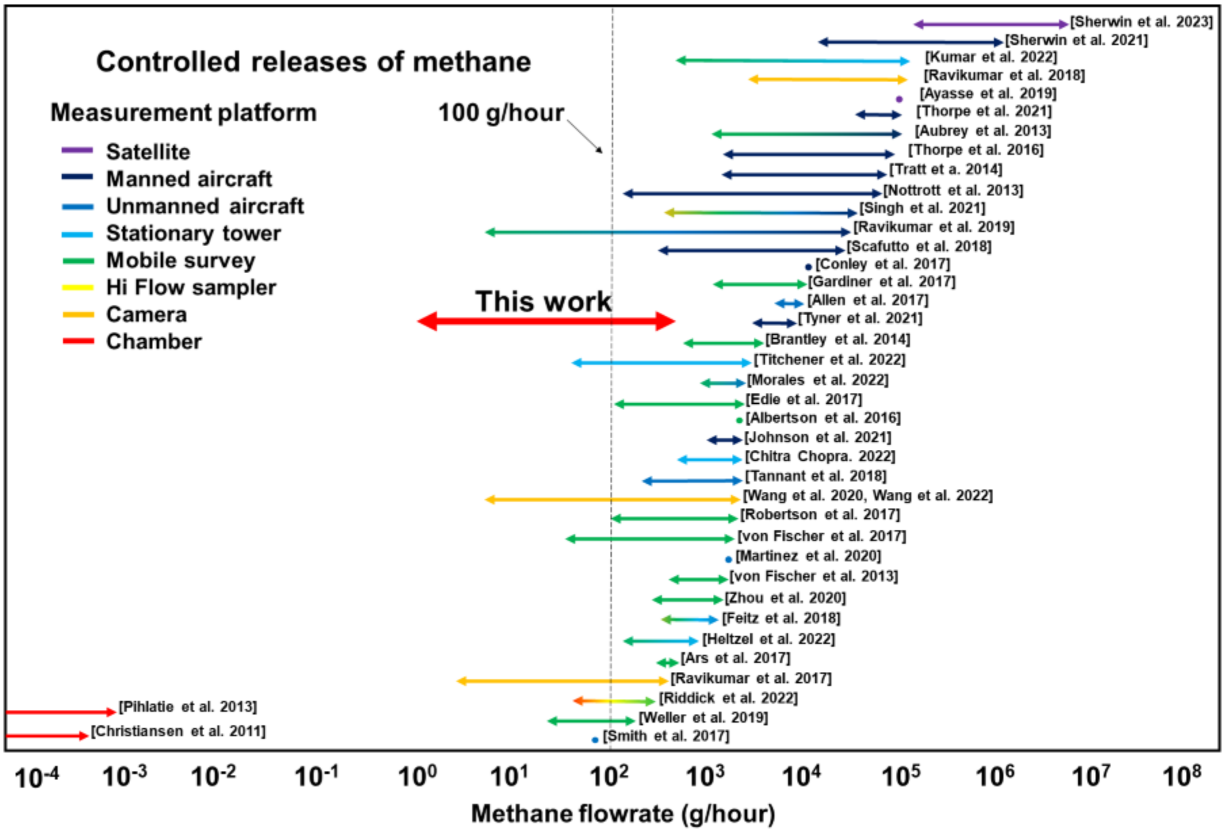
In addition to the changes outlined below for this reviewer, we also performed additional edits that we believe improve on the current version of the manuscript without significantly altering any results. First, we address some previously unmentioned methods we used for the linear regressions for controlled releases where methane concentrations were expected to rapidly reach steady-state. We also modified our presentation of the accuracy of measurements to encapsulate the median of the over- and underestimates to better represent the bias in our measurements. Finally, we incorporated two new studies on prior controlled releases into Figure 2 and the subsequent analysis section. The changes are outlined as follows:

Line 140: "For some experiments, methane concentrations within the chamber were expected to rapidly reach steady-state. Steady-state is reached when methane concentrations no longer increase over time in the chamber and the concentration of methane within the chamber is equal to the concentration of the released gas. The residence time, or time to reach steady-state, is defined by (2): where τ is the residence time, V is the volume of the chamber, and Q is the volumetric flowrate of gas (i.e., methane and balance gas combined) into the chamber. For any controlled releases where the expected residence time was two minutes or lower, we only used the initial ten data points for the linear regression to avoid the period of exponential decay as methane concentrations approach steady-state (Pihlatie et al., 2013).

(3) $\tau = V/Q$

For each factor being investigated, we grouped the results depending on whether the measurement was an under- or overestimate of the true methane flowrate. We calculated the accuracy of measurements as a range spanning from the median of the over- and underestimated methane flowrates, respectively. We determined the bias of measurements as the average of the raw percentage errors to determine whether tests were biased more towards the under- or overestimation of methane flowrates. "

New Figure 2:



Reviewer #3

This was a very interesting read and the author shows the value of improving methane emission quantification at the component level. The paper compares previously used emission factors and evaluates previous controlled direct and indirect controlled release tests. The study also examines direct measurements techniques from static chambers for estimating methane emission rates. These types of techniques have solely been tested and examined in detail which provides useful information for scientists studying methane emissions looking for the right techniques.

In general, the paper is a nice contribution to this research area. The writing and structure is clear and well organized, but “we found” can be used less. The paper could use more visuals and photographs of the tested experiments and measurements. Overall, I approve of this paper with the minor revisions:

We thank the reviewer for the valuable insights and comments regarding this work. With regards to the excessive use of “we found”, we have modified the text for better flow for the *reader which we hope improves this work. The outlined changes in that regard are outlined below:*

Line 178-185: "Our analysis of chamber volume with respect to quantification accuracy showed that the accuracy of measurements increased with smaller chamber volumes (Figure 4). The <20 L chambers had the highest accuracy at +12/-12% with an error standard deviation of 12%. The 322 L chamber had a lower accuracy of +15/-17% with a standard deviation of 23%. Our highest errors were measured from the largest 2,265 L chamber with an accuracy of +50/-16% and a standard deviation of 26%. We analyzed all three chamber sizes for bias and found that the <20 L chambers showed a slight tendency for underestimation of flowrates with an average bias of >0%, the 322 L chamber showed a stronger tendency towards the underestimation of flowrates at -18%, and the 2,265 L chamber showed a slight bias towards overestimating flowrates at +7% (Figure 4)."

Line 187-193: "Our comparisons of different chamber shapes showed that the cylindrical chambers were more accurate than the rectangular chambers, showing an accuracy of +5/-14% and a standard deviation of 18% (Figure 5). We found that the rectangular chambers showed a lower accuracy of +17/-14% with a standard deviation of 22%. Similar to the chamber volume, the median percentage error was smaller than the average error for both chamber shapes, which indicates an extreme distribution in percentage errors. We analyzed both chamber shapes for bias and found that the cylindrical chambers were biased towards the underestimation of methane flowrates with an average bias of -13% whereas the rectangular chambers showed a small bias towards the overestimation of methane flowrates with an average bias of +6% (Figure 5)."

Line 195-199: "The most impactful physical factor we observed on chamber measurement accuracy was the presence of fans, where chambers with fans present had a median percentage error of +6/-5% and a standard deviation of 17% (Figure 6), which was higher than chambers without fans which had an accuracy of +17/-17% and a standard deviation of 22%. For both data-sets we observed median values lower than the mean indicating a skewed data-set. We analyzed both data-sets for bias and found that both chambers with and without fans showed slight biases towards the underestimation of methane flowrates at -2% and -4% respectively (Figure 6)."

Line 202-208: "We tested four different mass flowrates for our controlled release tests: 1.02 g/hour, 10.2 g/hour, 102 g/hour, and 511 g/hour (Figure 7). The lowest errors were measured from the 10.2 and 102 g/hour mass flowrates each with accuracies of +8/-11% and +7/-13% respectively. The lowest accuracy of +56/-15% was attributed to the highest mass flowrate of 512 g/hour. We found that the 1.02, 10.2, and 102 g/hour mass flowrates all had negative biases of -11%, -1%, and -6% respectively. The mass flowrate of 512 g/hour had a slight bias of +4% towards the overestimation of mass flowrates, and also the highest upper accuracy estimate of +46% we observe among the different factors we analyzed.”

Line 210-215: “We analyzed six different volumetric flowrates for the range of methane flowrates we tested: 0.238 L/min, 0.476 L/min, 2.38 L/min, 4.76 L/min, 11.9 L/min, and 23.8 L/min (Figure 7). We found that the lowest accuracies were attributed to both the highest and lowest volumetric flowrates with accuracies of +50/-15% and +21/-14% respectively, whereas higher accuracy was observed with the mid-level volumetric flowrates of 11.8, 4.76, 2.38, and 0.476 SLPM with accuracies ranging from +26/-3% to +9/-11%. Similar to the mass flowrates, we also found the highest accuracies were associated with the mid-level volumetric flowrates while the lowest accuracies were observed at the upper and lower volumetric flowrates.”

Line 217-222: “We analyzed four different percentages of methane in the leaking gas for the controlled releases (Figure 7). The lowest accuracies were associated with the 5% methane gas with an accuracy of +31/-16%, whereas the highest accuracies were observed with the 10% methane at +15/-8%. The three highest percentages of methane in the leaking gas all had small negative biases ranging from -5% to -3%, whereas the 5% methane leak had a slight positive bias at +1%.”

Line 225-226: “We ~~found~~ analyzed how ~~that~~ chamber configurations (i.e., chamber volume, usage of fans, chamber shapes) can be optimized…”

Line 229: “ We also ~~found~~ saw that smaller chambers performed similarly if fans…”

Line 231: “~~We also found that s~~Smaller chambers performed slightly better…”

Line 233: “For larger sized chambers (i.e., ≥20L), ~~we found that~~ the usage of fans was critical…”

Line 238-250: “At low mass flowrates of methane (i.e., ≤ 100 g/hour), we found that smaller sized chambers were more accurate than larger chambers, with ~~median percentage errors of ±10% and ±16%~~ with accuracies of +12/-8% and +15/-19% respectively. ~~We found that t~~The usage of fans had little impact on the accuracy of smaller sized chambers at these low flowrates, with smaller chambers with fans producing ~~a median percentage error of ±9%~~ an accuracy of +16/-8% and smaller chambers without fans having an accuracy of +7/-13% ~~producing median percentage errors of ±13%~~. In contrast, ~~we found that~~ the usage of fans was important for the accuracy of larger chambers at ~~these~~ lower mass flowrates.~~, with~~ Larger chambers with fans ~~producing a median percentage error of ±10% and larger chambers without fans~~

~~producing a median percentage error of ±27%~~ had an accuracy of +4/-30% and larger chambers without fans had an accuracy of +48/-19%. In terms of chamber shape, ~~we found that~~ at low flowrates smaller cylindrical chambers had an accuracy of +1/-11% compared to small rectangular chambers which produced an accuracy of +15/-3% ~~produced a median percentage error of ±8% compared to small rectangular chambers which produced a median percentage error of ±14%~~. For larger chambers at low mass flowrates, we ~~found~~ observed a contrasting result with large rectangular chambers producing an accuracy of +6/-16% and large cylindrical chambers producing a median percentage error of +24/-48%. ~~a median percentage error of ±14% and large cylindrical chambers producing a median percentage error of ±33%.~~ ~~Overall, we found that at these smaller mass flowrates of methane, small cylindrical chambers with fans produced the lowest median percentage error of ±10% compared to ±16% from large chambers."~~

Line 251-258: "We observed similar results for optimizing chamber configurations for high methane mass flowrates (i.e., ≥100 g/hour). We found ~~observed~~ that the usage of fans was critical for measurement accuracy for larger sized chambers at these higher mass flowrates of methane. Larger chambers with fans had an accuracy of +4/-4% ~~a median percentage error of ±4%~~ compared to larger chambers without fans which had had an accuracy of +66/-35% ~~a median percentage accuracy of ±50%~~. For chamber shapes, ~~we found that~~ cylindrical chambers were more accurate than rectangular chambers with an accuracy of +6/-14% compared to +26/-15% from rectangular chambers ~~with median percentage errors of ±13% compared to ±17% from rectangular chambers~~. At ~~these~~ higher mass flowrates of methane, we found that large cylindrical chambers were highly accurate at +2/-3% of the true methane flowrate ~~with fans produced the lowest average percentage errors of ±3%~~. "

Line 26: add a more detailed description of what component level means or provide distinct examples.

We have added new text in the introduction that better defines the various spatial scales and provided examples.

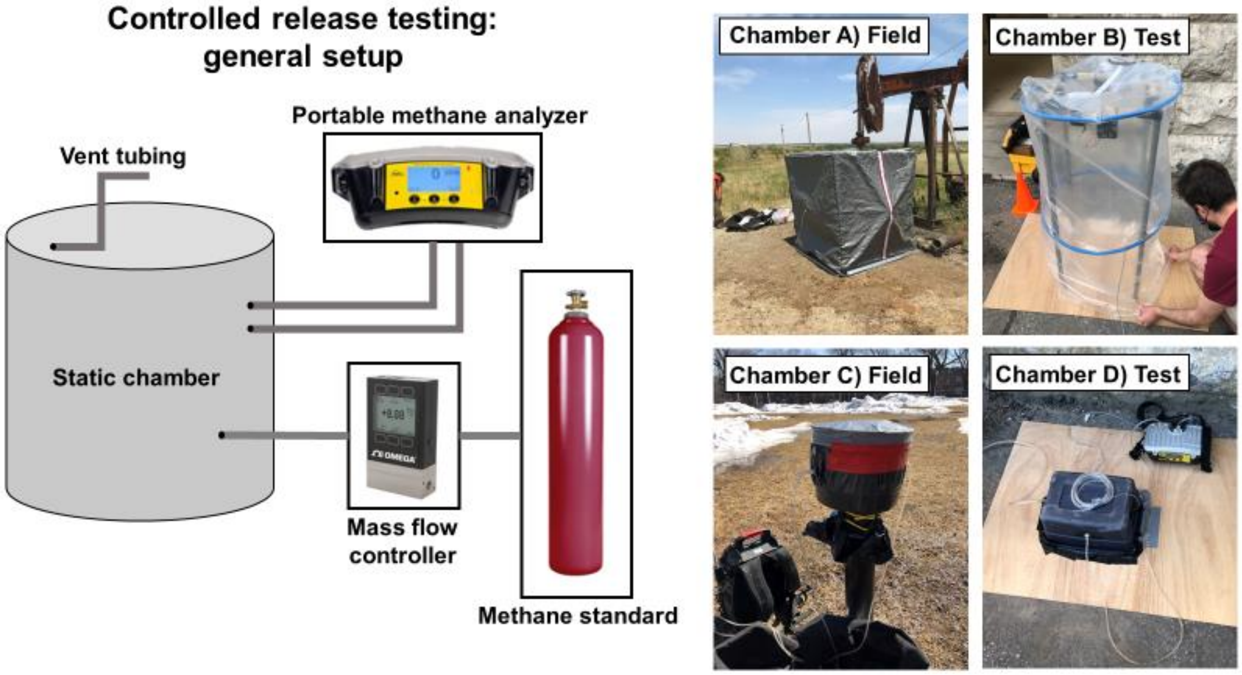
Lines 45-48: "Methane sources can be classified as component, site, facility, regional, and global level sources in order of increasing spatial scales (NACEM, 2018). As an example, a valve on an abandoned oil and gas well would constitute a component level source whereas all abandoned oil and gas wells in the Appalachian basin would comprise a regional methane source. The advantages of methane inventories created from component level measurements are high resolution and easy comparisons to regional inventories ,which are predominantly made using component level data (U.S. GHGI, ECCC GHGI), where specific discrepancies can be identified (Rutherford et al., 2021). Indirect measurements can be used to measure ~~a large number of sources quickly and efficiently~~ methane emissions at site/facility/regional levels, but have higher limits of detection when compared to direct methods and additional challenges related to source attribution at the component level. On the other hand, direct measurement methods are labour intensive and ~~typically limited to measuring emissions at a smaller scale~~ can omit methane sources when scaling up measurements to facility/regional/global levels , but can quantify and attribute methane emissions at the component level."

Line 41: list the recent paper on satellite estimations by de Foy et al., 2023 (DOI 10.1088/1748-9326/acc118).

Excellent reference, thank you for the suggestion. We have added added to introduction.

Lines 100-135: A visual would be useful for the reader here. I would suggest a general diagram or image of the static chambers with the main components and also a schematic or field photo of how the controlled release was set-up. The author could also include a material list and description of the construction in the SI with what each component/material was used for and why.

Agreed, we have since added a new figure 1 that shows the general set-up as well as photos of all chambers in field and test settings.



Discussion: It would be beneficial to include more comparison to the other static

chamber studies mentioned in the introduction and describe how the results from this study could explain outcomes in the other studies.

Unfortunately the studies aren't exactly comparable since the only two static chamber studies with documented uncertainties (Pilahtie et al. and Christiansen et al.) focused on relativelysmall emission rates compared to the ranges we tested, and they also focused specifically on soil gas emissions whereas our focus is on component sources. Another recent study (Riddick et al. 2022) withdrew their static chamber results from their submission, so we could not compare to that study either. However, we can compare with Lebel et al. who mention in their SI that the static chamber method underestimated methane flowrates by 10-20% on average based on their tests (flowrates not reported unfortunately). We have added some text in the Discussion to reflect this.

Line 290: "Our results show that the static chamber methodology can quantify methane emissions ranging from 1.02 g/hour to 512 g/hour with a median percentage error of ±14%. In comparison to indirect methods, Johnson et al., 2023 state that their aircraft-based method has a multi-pass uncertainty range of -46/+54%, which roughly corresponds to an absolute error of ±50%. In von Fischer et al., 2017, they state an uncertainty range of -24/+32% after five mobile survey passes, which roughly corresponds to an absolute error of ±28%. With regards to other controlled release tests on static chambers, we do find that our median uncertainty of ±14% falls within the 10-20% range reported by Lebel et al. 2020 and below the 33% estimated from Pihlahtie et al. 2013 for the linear calculator method."