Interstate Natural Gas Association of America

April 3, 2024

U.S. Environmental protection Agency
Climate Change Division (6207A)
1200 Pennsylvania Ave, NW
Washington, DC 20460

RE: Lack of certainty in quantification of methane emissions from remote sensing technologies, submitted for consideration in Docket ID No. EPA–HQ–OAR–2023–0234

INGAA submits the following studies which highlight the lack of certainty in quantification of methane emissions from remote sensing technologies.

1) **Evaluating Development of Empirical Estimates Using Top-Down Methods at Midstream Natural Gas Facilities.** Published April 3, 2024 and available here.

While inventories are evolving to incorporate empirical data, it is important that the data being used are defensible. The results from this study confirm our previous finding that the top-down ("TD") estimates disagree. With an increase of sample size by repeated measurements, compared to the baseline, the disagreement between the methods expanded. Across all 15 facilities in the baseline deployment, the methods exhibited a relative difference of 28% [5.7% to 52%] in the mean, which increased to 49% [32% to 69%] over 14 facilities during the EOP, despite a dramatic increase in estimates by both methods (from 28 total estimates in the baseline to 773 estimates). This becomes particularly significant when considering methane or other GHG fees, as the choice of TD measurement method can lead to substantial variations in the fees assessed.

Increasing the number of TD measurements at a facility presented both methods with more opportunities to capture facility emissions accurately. It also allowed for better control of the analysis to account for changes in operations at the facility and/or transient events, compared to what could be done during the baseline analysis. At 6 out of the 14 facilities, the mean of the TD method estimates differed by at least 2:1; i.e., one or both methods did not provide accurate estimates for nearly half of these midstream facilities. This result has a direct impact on any voluntary or regulatory reporting program focused on per-facility reporting. For example, the EPA's recently proposed 'super-emitter' reporting program and the 'other large release event' reporting would rely on approved anonymous surveillance by third parties to detect and report a "large release event of at least 250 mt CO_2e per event or have a methane emission rate of 100 kg/h or greater at any point in time" at oil and gas facilities, including midstream facilities such as a compressor station or natural gas processing plant. Reported emission rates for these large emitters would be used to estimate total emissions, with emissions duration assumed to be a default of 182 days unless the operator can prove otherwise. Over- or under-estimation of emissions by 10 s to 100 s of kg/h—a difference seen multiple times in this analysis—would result in substantial errors in quantification and, given methane fees of USD 1500 per tonne of methane, significant financial impacts for individual facilities and their operators. Similarly, the European Union (EU) is considering methane emission rules covering operators within the EU, and also additional reporting requirements on emissions data for importers of natural gas and liquified natural gas (LNG) from the exporting suppliers. Voluntary programs do not address the inter-measurement technology considerations presented in this work.

Given longstanding issues with inventory estimates, there is a strong case for utilizing measurements to inform, supplement, or potentially replace inventory estimates. However, in order to rely on measurements, the results of this study indicate methods must improve quantification accuracy, produce more representative uncertainty estimates, and provide robust quality control indicators to identify when estimates are suspect or potentially in error.

2) **Informing Methane Emissions Inventories Using Facility Aerial Measurements at Midstream Natural Gas Facilities.** Published September 20, 2023 and available here.

Significant disagreement was observed at most facilities, both between the two TD methods (e.g., drone-based, LiDAR) and between the TD estimates and operator inventory. These findings have two implications. First, improving inventory estimates will require additional on-site or ground-based diagnostic screening and measurement of all sources. Second, the TD full-facility measurement methods need to undergo further testing, characterization, and potential improvement specifically tailored for midstream facilities.

The TD estimates are statistically higher than the contemporaneous inventory, and that daily facility inventory was developed to include all sources, not just those that require reporting (i.e., under the GHGRP) or would be regulated under the Subpart OOOOa/b/c series of regulations. For midstream facilities, there is no ready explanation of why this disagreement exists. While per-source measurements at facilities may under-report emissions due to challenges mentioned earlier, it is unlikely that these issues would explain the TD/BU disagreements seen in the study; at 35 of 43 comparisons, there is a disagreement by more than a factor of 2. In several instances, there are gross discrepancies –e.g., the TD survey estimating emissions more than eight times higher than the operator inventory for a higher emitting facility with multiple engines operating and over forty-eight times higher than the operating inventory for a facility with relatively low emissions and a single turbine operating. All known large sources are included in the enhanced inventory process used here, and additional large sources were not identified by the source-locating TD method (Solution 1) in sufficient quantities and sizes to account for the differences. Therefore, the results of this study indicate the need for better characterization of the TD method accuracy and uncertainty for midstream facilities; this could be coupled with more extensive on-site identification and measurement of midstream sources and/or more complete and representative emission factor data, when emissions factors are used.

3) **Evaluating development of empirical estimates using two top-down methods at midstream natural gas facilities.** Published October 12, 2023 and available here.

This study suggests that the TD methods mis-estimate emissions an unknown fraction of the time, for unknown reasons. While two methods were selected for this study, it is unlikely that the issues identified here are confined to these two methods; similar issues may exist for other similar whole-facility methods, on midstream and/or other facility types. These findings have important implications for the construction of voluntary and regulatory reporting programs that rely on emission estimates for reporting, fees or penalties, or for studies using whole-facility estimates to aggregate TD emissions to basin or regional estimates.

4) **Evaluating development of empirical estimates using two top-down methods at midstream natural gas facilities.** Published March 7, 2023 and available here.

This study outlines a first step toward ongoing, operational blind testing of satellites quantifying methane point sources. Significantly more blind testing—like we performed above—is needed to ensure rapid uptake and trust. Such tests should include offshore releases, undisclosed location testing, onshore releases with varying weather and ground cover, diffuse-source releases, and possibly multi-source releases. As technology evolves, the validation task remains similar scientifically, but becomes increasingly important. Our test was conducted under near-ideal land surface and wind speed conditions, and teams were aware in advance of the approximate emission location. Rigorous characterization of the detection and quantification capabilities of airplane-based methane remote sensing systems requires of order 100 measurements, as in18, more than 10 times the number for any satellite in this study. Achieving similar evaluation of existing and emerging satellites will thus require further data collection. Satellites are already providing invaluable insights into methane emissions from multiple industries7,12. Additional independent empirical validation under a range of field conditions will enable satellites to play an even greater role in reducing global methane emissions from oil and natural gas and industries including waste management, agriculture, and mining. Notably, the emissions rates (metric tons per hour) tested are large when compared to source-specific emission rates likely at transmission compressor stations for sources other than short duration process blowdown events. For example, for the 2022 reporting year only 21 of 677 compressor stations and storage facilities reported had methane emissions exceeding 25,000 metric tons (mt) CO_2e. On average across the entire year, this threshold is equivalent to about 0.1 mt/hr for the entire facility. In contrast, the rates discussed in this paper are about double that rate on the low end of measurement and seventy times higher at the upper end of the measurement rates evaluated.

5) **Robust probabilities of detection and quantification uncertainty for aerial methane detection: Examples for three airborne technologies.** Published April 1, 2023 and available here.

Successful application of these technologies and interpretation of collected data requires a thorough understanding of the probability of detecting unknown sources under different conditions and uncertainty in quantifying emissions from detected sources.

Using a subset of controlled release data for Bridger's GML and Kairos' LeakSurveyor that included source rate estimates for comparison with ground truth, controlled source rates, quantification uncertainties were separately characterized, including analysis of effects of using four optional database sources of wind speed for Kairos' LeakSurveyor. The developed statistical model intends to analyze measurement bias, variability in measurement bias (where data permit), and measurement precision, where the latter two are treated as probabilistic variables. Using the Meteoblue wind speed data product, the source rate relative error ratio (RER – i.e., actual over estimated source rate) for Bridger's GML averaged to 0.92 with a 95% confidence interval of 0.31–2.13. The analysis of Kairos' LeakSurveyor identify that source rate RER was highly sensitive to the wind speed data source and statistic (i.e., gust vs. average wind speed) and gust wind speed provided significantly less-biased results. One-minute gust wind speed from the Dark Sky database and one-hour gust wind speed from the HRRR database yielded mean source rate RERs of 1.07 and 1.34 with 95% confidence intervals of 0.45–2.17 and 0.57–3.74, respectively. Data from the present controlled release study of Bridger's GML demonstrated that day-to-day variability in measurement bias was strongly correlated with wind speed error and appreciably increased the dispersion of the source rate RER. These results identify the need to target an assortment of different measurement locations and maximize measurement days during future controlled release studies. Importantly, the study conclusions highlighted "the importance of using controlled release data from a range of sites and times to avoid underestimating measurement uncertainties." As it pertains to applying such methods to site emission estimates, this highlights the need for methods and processes to be defined to better understand uncertainties and limitations of aerial methane quantification technologies.

6) **Single-blind determination of methane detection limits and quantification accuracy using aircraft-based LiDAR.** Published November 14, 2022 and available here.

For 95% of controlled releases above Bridger's stated production-sector detection sensitivity (3 kg/h with 90% probability of detection), the accuracy of individual emission rate estimates produced using HRRR wind ranged from −64.1% to +87.0%. Across all controlled releases, 38.1% of estimates had error within ±20%, and 87.3% of measurements were within a factor of two (−50% to +100% error). At low wind speed (less than 2 m/s) and low emission rates (less than 3 kg/h), emission estimates are biased high. When removed these data do not impact the regression significantly but indicate challenges in different wind speed regimes. Aggregating all data indicates quantification error including all detected emission events was +8.2% using the HRRR wind source, but this performance is not indicative of the likelihood of accurately measuring individual events/sources. The resulting detection curves and quantification accuracy illustrate important implications that must be considered when using measurements from GML or other remote emission measurement techniques to inform or validate inventory models or to audit reported emission levels from oil and gas systems.

7) **Methods for quantifying methane emissions using unmanned aerial vehicles: a review.** Published September 27, 2021 and available here.

Methane emissions can be detected qualitatively using thermal imaging. This is particularly useful for leak detection, but not for flux quantification, without additional supporting measurements. Tratt et al. used airborne thermal-infrared hyperspectral imaging spectrometry to visualize methane emissions from various fossil fuel sources while Lehmann et al. used high-resolution colour infrared images to map methane hot spots and upscale independent chamber-derived methane emission fluxes in a natural peat bog ecosystem. Tanda et al. used airborne infrared thermography to detect methane emissions from landfill and were able to provide a crude estimate of methane flux rate using a simple relationship between observed heat exchange and the heat associated with methane production. Similarly, a UAV-mounted thermal-infrared camera was used to visualize methane emissions from a Danish landfill, but methane flux was quantified more rigorously using independent surface chamber measurements. This paper provides a literature review overview of evolving and promising technology circa 2020, but does not provide data or direction regarding migration of these technologies for regulatory applications.

8) **Single-blind test of nine methane-sensing satellite systems from three continents.** Published July 18, 2023 and available here.

Satellite-based remote sensing enables detection and mitigation of large point sources of climate-warming methane. These satellites will have the greatest impact if stakeholders have a clear-eyed assessment of their capabilities. We performed a single-blind test of nine methane-sensing satellites from three continents and five countries, including both commercial and government satellites. Over two months, we conducted 82 controlled methane releases during satellite overpasses. Six teams analyzed the resulting data, producing 134 estimates of methane emissions. Of these, 80 (58 %) were correctly identified, with 46 true positive detections (34 %) and 34 true negative non-detections (25 %). There were 41 false negatives and 0 false positives, in which teams incorrectly claimed methane was present. All eight satellites that were given a nonzero emission detected methane at least once, including the first single-blind evaluation of the EnMAP, Gaofen 5, and Ziyuan 1 systems. In percent terms, quantification error across all satellites and teams is similar to aircraft-based methane remote sensing systems, with 55 % of mean estimates falling within ±50 % of the metered value. Although teams correctly detected emissions as low as 0.03 metric tons of methane per hour, it is unclear whether detection performance in this test is representative of real-world field performance. Full retrieval fields submitted by all teams suggest that in some cases it may be difficult to distinguish true emissions from background artifacts without a known source location. Cloud interference is significant and appears to vary across teams and satellites. This work confirms the basic efficacy of the tested satellite systems in detecting and quantifying methane, providing additional insight into detection limits and informing experimental design for future satellite-focused controlled methane release testing campaigns. Similar to the study above that presented satellite date, the low end of the emission rates discussed are multiple times higher than station-level annual average emission rates for compressor stations and storage facilities.

9) **Single-blind inter-comparison of methane detection technologies – results from the Stanford/EDF Mobile Monitoring Challenge.** Published September 10, 2019 and available here.

This paper from five years ago assesses technology status and discusses the path forward for improvements to facilitate real world application. In general, emissions quantification needs improvement as most technologies were only able to generally provide order of magnitude emissions estimates. Improvements to quantification algorithms, reducing false positive detection rates, and identifying early applications will be critical for deployment at scale. Even as this study provides the first independent verification of the performance of mobile technologies, it only represents the first step in the road to demonstrating that these technologies will provide emissions reductions that are equivalent to existing regulatory approaches.

Regards,

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