Bridger Photonics

Gas Mapping LiDAR™

Next-Gen Methane Detection and Quantification

Contents

Slides 1 & 2. These slides reinforce that there is a sweet spot for detection sensitivity thresholds that provides both effective emission reduction potential and sensible economic burden.

Slide 3. This slide highlights research demonstrating that Gas Mapping LiDAR detects emissions more comprehensively than ground-based Optical Gas Imaging surveys.

Emissions Reduction Potential and Response Cost Evaluated by Detection Threshold

Table 1. Mitigation costs and emissions reduction potential evaluated by detection sensitivity threshold. Both the fraction of cumulative emission that would be detected at a threshold and the relative response costs are evaluated compared to a 1 kg/h detection threshold baseline. As example insight from this data, in the Permian Basin, 95% of cumulative emissions above 1 kg/h are detected at rates ≥4 kg/h. Correspondingly, 70% as many facilities would be discovered to have emissions compared to those that would be discovered with a 1 kg/h detection threshold. The dark green shaded cells correspond to practical detection thresholds where emissions reduction potentials and response cost are both favorable. At more stringent detection thresholds, the response cost is greater. At less stringent detection thresholds, the emissions reduction potential is no longer sufficient. The values in this table are derived from Figure1 and Figure 2, which are shown on the following slide.

Detection Sensitivity	Permian Basin		Eagle Ford Basin	
90% PoD (kg/h)	Fraction detected	Relative response cost	Fraction detected	Relative response cost
1	1.00	1.00	1.00	1.00
2	0.99	0.90	0.97	0.93
3	0.97	0.80	0.91	0.84
4	**0.95**	**0.70**	**0.84**	**0.73**
5	0.93	0.62	0.78	0.62
7.5	0.88	0.47	0.64	0.42
10	0.82	0.38	0.55	0.30
15	0.74	0.28	0.43	0.18
30	0.58	0.15	0.26	0.07

Fraction Cumulative Emissions by Rate, Fraction Facilities with Emissions by Rate

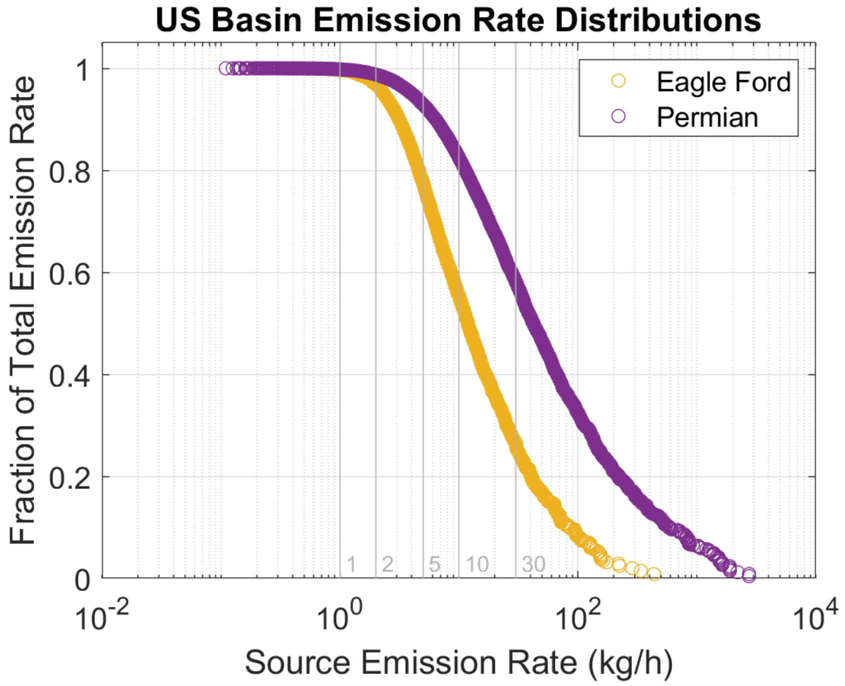

Figure 1. Normalized cumulative emission rate distributions for Gas Mapping LiDAR detections of methane emission sources at Permian Basin and Eagle Ford Basin production facilities. This plot illustrates what percent cumulative detected emissions corresponds to a given emission rate. For example, in the Eagle Ford Basin, 84% of cumulative measured emissions sources come from sources with rates above 4 kg/h whereas 43% of total measured emissions come from sources with rates greater than 15 kg/h.

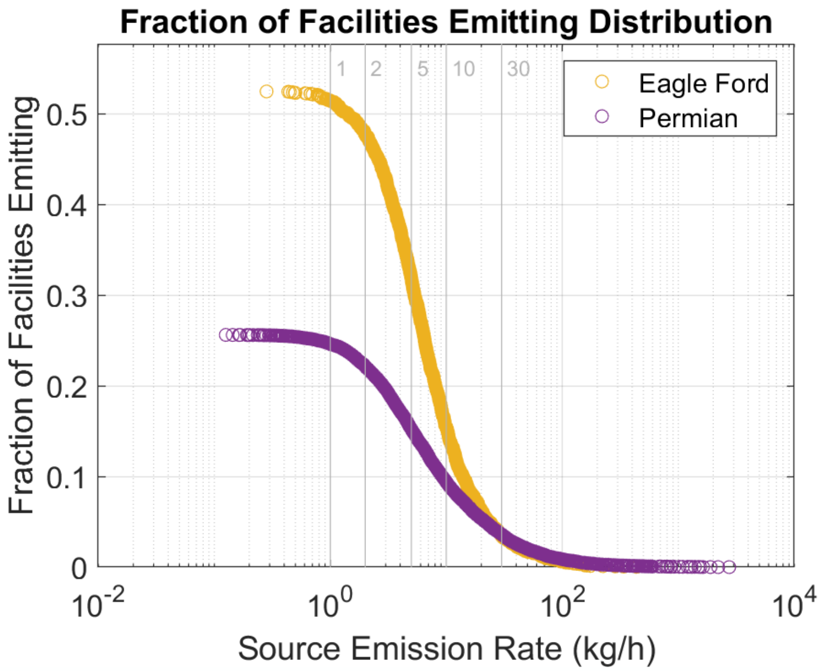

Figure 2. Fraction of facilities found to be emitting as a function of emission rate for Gas Mapping LiDAR detections of methane emission sources at Permian Basin and Eagle Ford Basin production facilities. This plot can be used to determine what fraction of facilities are found to have emissions as a function of emission rate detection threshold. For example, in the Permian Basin, if a technology finds emissions down to 1 kg/h, 24% of facilities would be found to have emissions. Meanwhile, if a technology finds emissions down to 4 kg/h, 17% of facilities would be found to have emissions.

Gas Mapping LiDAR is More Comprehensive Than OGI

Reference point 1. Comparing the volume of emissions measured by Gas Mapping LiDAR to emissions estimated from comprehensive OGI surveys at the same sites, it was found that Gas Mapping LiDAR detections constituted a much greater volume of emissions.

"The total emissions measured by the aerial survey were 18 times greater than those found during the OGI survey."

Tyner, D. R.; Johnson, M. R. Where the Methane Is—Insights from Novel Airborne LiDAR Measurements Combined with Ground Survey Data. *Environ. Sci. Technol.* **2021**, *55* (14), 9773–9783. https://doi.org/10.1021/acs.est.1c01572.

Reference point 2. Gas Mapping LiDAR uses automated methane gas plume detection and measures emissions wherever there is line of site from the air. Comparatively, the detection of methane emissions using OGI is heavily influenced by the instrument user.

"[OGI] surveyor experience was the strongest predictor of detection rates, differences in protocols between LDAR surveyors (who generally move close to equipment) and compliance surveyors (who generally survey from farther away) also contribute to detection differences."

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"These data provide a more robust baseline to compare OGI to next generation leak detection solutions, which are typically automated to a greater degree than OGI surveys"

Zimmerle, D.; Vaughn, T.; Bell, C.; Bennett, K.; Deshmukh, P.; Thoma, E. Detection Limits of Optical Gas Imaging for Natural Gas Leak Detection in Realistic Controlled Conditions. *Environ. Sci. Technol.* **2020**, *54* (18), 11506–11514. https://doi.org/10.1021/acs.est.0c01285.

Reference point 3. Despite sites being subject to triannual ground-based LDAR surveys, significant tank emissions were detected by Gas Mapping LiDAR, including for tanks with emissions routed to control devices.

"Examples of strongly emitting controlled tanks and uncontrolled tanks are both found…this is especially surprising given…regulations in place requiring three times per year LDAR inspections that should theoretically be capturing and fixing/reducing emission events from controlled tanks"

A potential contributing factor is the variable efficacy of ground-based monitoring.

"A closer analysis of available LDAR reporting data in BC shows significantly lower magnitudes of methane sources found in internal versus third-party LDAR surveys"

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"[For OGI] in particular, visual access to tank tops and flare stacks can be challenging within the effective range of an OGI camera and would be compounded by factors such as reduced detection sensitivity at low temperatures and/or low temperature difference between plume and background."

Also of note is the inability of OGI to determine emissions from incomplete combustion of methane, which is not the case for Gas Mapping LiDAR.

"While OGI cameras are useful in detecting non combustion sources of methane, they are unable to detect methane within combustion plumes such as engine exhaust."

Johnson, M. R.; Tyner, D. R.; Conrad, B. M. Origins of Oil and Gas Sector Methane Emissions: On-Site Investigations of Aerial Measured Sources. *Environ. Sci. Technol.* **2023**, *57* (6), 2484–2494. https://doi.org/10.1021/acs.est.2c07318.