PAYNE INSTITUTE COMMENTARY SERIES: **COMMENTARY**

New Method for Tracking Down Methane Emissions on Oil and Gas Sites

By William Daniels, Dorit Hammerling, and Morgan Bazilian

Reducing methane emissions is a key component of short-term climate action. Methane is a potent greenhouse gas with 84 times more heat trapping potential than carbon dioxide over a 20-year period.

Methane has a relatively short lifetime in the atmosphere, meaning that emission reduction efforts can be felt in our lifetime. The oil and gas sector accounts for 32% of anthropogenic methane emissions in the United States, making it a promising avenue for emission reduction.

Empirical data and transparent models are key pillars of emission reduction efforts. Actual measurements of methane are necessary to fully understand where emissions are coming from and how much is being emitted, as conventional bottom-up inventories from the oil and gas sector have been found to underestimate emissions on average.

Open-source models and independent verification are critical aspect of building public trust in methane data and moving toward measurement-informed emissions reporting.

Payne Institute researchers William Daniels, Meng Jia, and Dorit Hammerling have developed a completely open-source analytical framework for detecting single-source methane emissions, determining the source location, and estimating an emission rate using data from continuous monitoring systems (CMS).

CMS measure methane concentrations in near real time, making them well suited for capturing rare, potentially short-lived, super-emitter events that might be missed by quarterly or yearly flyovers. Reporting these events is critical for accurate site-level emissions estimates and is required by proposed updates to the EPA's Greenhouse Gas Reporting Program (GHGRP) coming online in 2025.

The detection, localization, and quantification (DLQ) framework developed by Payne Institute researchers was evaluated on non-blinded, single-source controlled releases at the Methane Emissions Technology Evaluation Center (METEC) shown in Figure 1. All 85 controlled releases were detected, 82% were localized correctly, and 76% had quantification estimates within a factor of 2 from the truth.

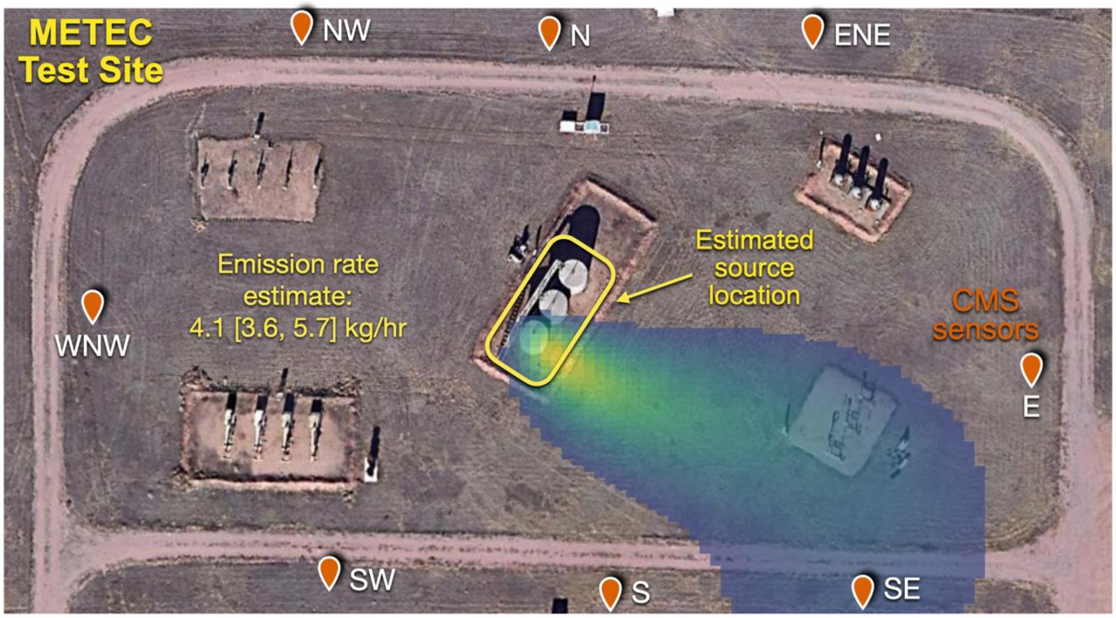

Figure 1: Methane Emissions Technology Evaluation Center (METEC). CMS sensor locations are marked with orange pins. The estimated source location for an example emission event is boxed in yellow.

What does this mean moving forward?

First, the current DLQ framework is intended for relatively simple sites where it is reasonable to assume that only one source is emitting at a time. Quantifying multi-source emissions is a considerably harder problem, but a statistical model for doing so is currently under development.

Second, CMS are in a unique position to complement snapshot measurement technologies (e.g., airplanes and satellites) that can measure many sites in a day but typically only offer a few repeat measurements of any one site.

For example, consider a snapshot measurement of 100 kg/hr at an oil and gas site. More data are needed to answer two important questions: 1) how long did this emission last, and 2) was this emission larger or smaller than the typical emission on this site. Near continuous data from CMS can help answer these questions.

Third, as quantification capabilities improve, CMS can be used directly for site-level quantification and reporting. An example of this is shown in Figure 2, where quantification estimates from the DLQ framework were averaged and compared to a bottom-up inventory at a monthly cadence. The CMS-based inventory captured persistent, elevated emissions from an operational event in February that were not included in the bottom-up inventory.

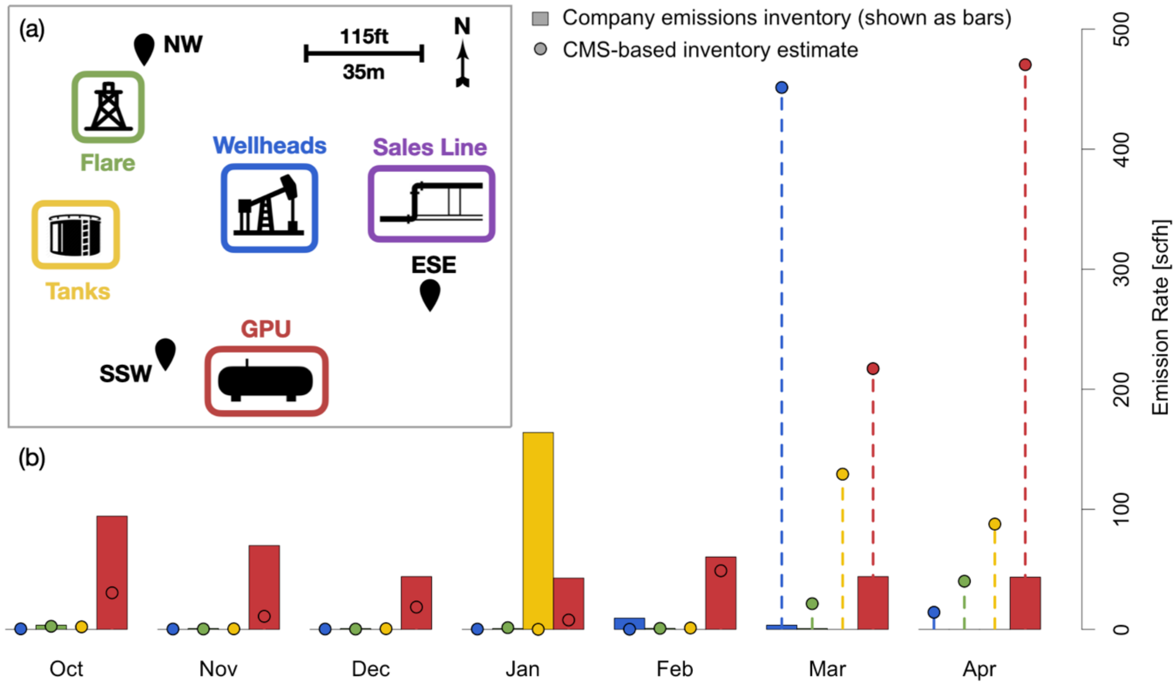

Figure 2: Comparison of a CMS-based emissions inventory and a conventional bottom-up inventory. The CMS-based inventory captured persistent, elevated emissions from an operational event in February that were not included in the bottom-up inventory. Reproduced from [Daniels et al. (2023), Environmental Science & Technology](#).

Finally, because this DLQ framework is completely open source, it can serve as a transparent testbed and benchmarking tool for stakeholders in this field. While academic studies can drive scientific and analytical solutions forward, private companies are often the ones to further develop and implement solutions at scale. Partnerships between academia, industry, and regulators are incredibly important to ensure that cutting-edge ideas are shared, technology is transparent, and progress is made toward rapid mitigation of methane emissions.

ABOUT THE AUTHORS

William Daniels

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William Daniels is a PhD candidate in the Department of Applied Mathematics and Statistics at the Colorado School of Mines. His current research focuses on reducing methane emissions from the oil and gas sector, including methods for emission detection, localization, and quantification using continuous monitoring systems and for developing measurement-informed inventories using multiscale measurements. He is a student researcher at the Payne Institute for Public Policy and the Energy Emissions Modeling and Data Lab (EEMDL) and serves as a Core Team Member of the Methane Emissions Technology Alliance (META).

Dorit Hammerling

Associate Professor, Applied Mathematics and Statistics

After 8 years working in the cement industry on process and quality control, Prof. Hammerling obtained a M.A. and PhD (2012) from the University of Michigan in Statistics and Engineering developing statistical methods for large satellite data. This was followed by a post-doctoral fellowship at the Statistical Applied Mathematical Sciences Institute in the program for Statistical Inference for massive data. Prof. Hammerling subsequently joined the National Center for Atmospheric Research, where she led the statistics group within the Institute for Mathematics Applied to the Geosciences and worked in the Machine Learning division before becoming an Associate Professor in the Department of Applied Mathematics and Statistics at the Colorado School of Mines in January 2019. Prof. Hammerling received the Early Investigator Award from the American Statistical Association, Section on Statistics and the Environment, in 2018.

Morgan Bazilian

Director, Payne Institute and Professor of Public Policy

Morgan Bazilian is the Director of the Payne Institute and a Professor of public policy at the Colorado School of Mines. Previously, he was lead energy specialist at the World Bank. He has over two decades of experience in the energy sector and is regarded as a leading expert in international affairs, policy and investment. He is a Member of the Council on Foreign Relations.

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The mission of the Payne Institute at Colorado School of Mines is to provide world-class scientific insights, helping to inform and shape public policy on earth resources, energy, and environment. The Institute was established with an endowment from Jim and Arlene Payne and seeks to link the strong scientific and engineering research and expertise at Mines with issues related to public policy and national security.

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