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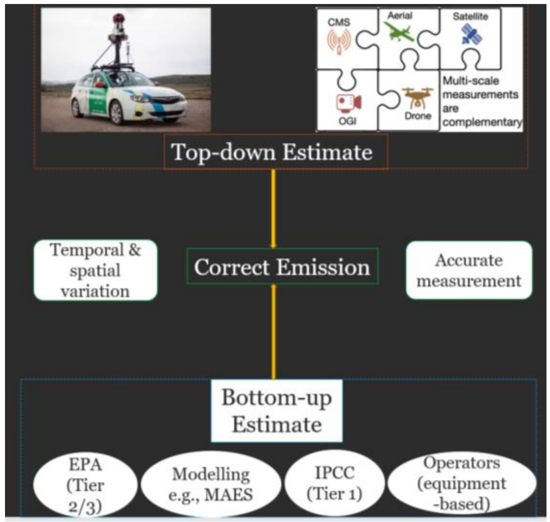


Current Project Overview

The Site-Aerial-Basin Emissions Reconciliation (SABER) project aims to reconcile top-down (TD) and bottom-up (BU) methane (CH_4) emission estimates in the Denver-Julesburg (DJ) basin and apply the same approach in the Upper Green River basin. Different studies have reported that BU methods underestimate emissions by a factor of about 3 to 6, while TD methods have been reported to overestimate emissions. As BU methods use emission factors (EFs) and activity factors (AFs) to calculate emissions, some of the EFs are considered out-of-date and largely depend on the sample used to generate the EFs which may be unrepresentative nationally or regionally. The most common BU inventories include the Intergovernmental Panel on Climate Change (IPCC) Tier 1 and the Environmental Protection Agency (EPA) Tier 2/3 approaches. In some cases, operator-informed inventories are used. On the other hand, TD estimates have been reported to overestimate emissions by capturing maintenance activities and incorrectly extrapolating these rare events as frequent annual emissions. Currently, the frequency and duration of rare large events commonly called 'super-emitters' is unknown. The relatively short timescale of most TD measurements and incorrect attribution makes it hard to understand the mechanistic causes of super-emitters. Most studies conduct individual measurement campaigns at the site level or basin level, scale to national scale, and then compare the reported emissions to the EPA greenhouse gas inventory. The EPA has worked on updating the inventory using field studies' results. Also, operators are currently required to report their emission factors through the EPA Subpart W.

Through detailed and comprehensive fieldwork and modeling studies, the SABER project aims to:

1. Demonstrate that high-frequency sampling can be used to create inventory emissions estimates that accurately represent emissions in a basin.
2. Develop a method for estimating emissions that can be replicated in other basins.

The project is a collaboration between Colorado State University, Pennsylvania State University, the University of Wyoming, and Bridger Photonics.

Research Progress

In the 1st phase, I developed a bottom-up (BU) inventory of the DJ basin for the oil and gas, and non-oil and gas sources. This provided a baseline BU estimate of emissions in the basin.

Methane emissions were estimated for oil and gas systems, agriculture (concentrated animal feeding operations, CAFOs), waste (landfills, solid waste, wastewater, and composites), and natural waterbodies (reservoirs and lakes). The DJ is defined by longitude >= -105.3 and <=-104.2 and latitude >= 39.9 and <= 40.7 (Figure 1).

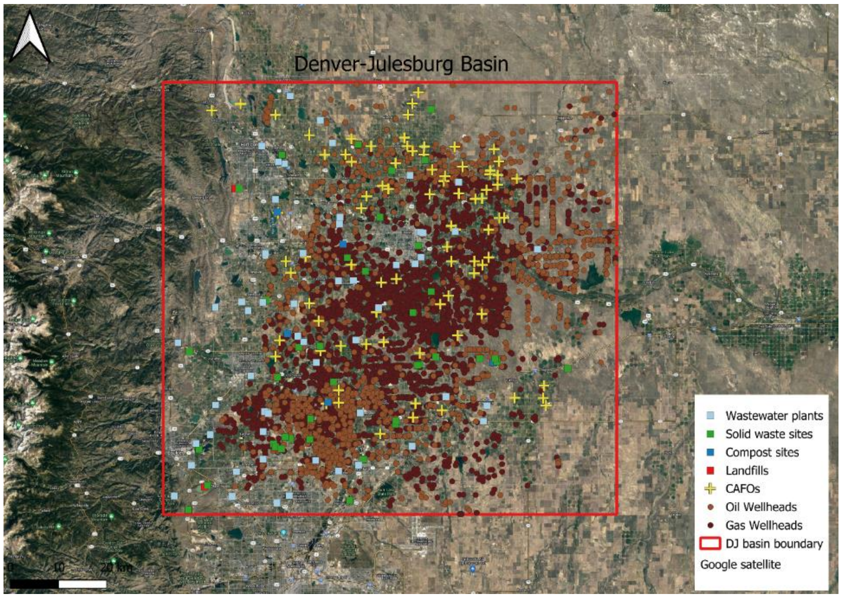
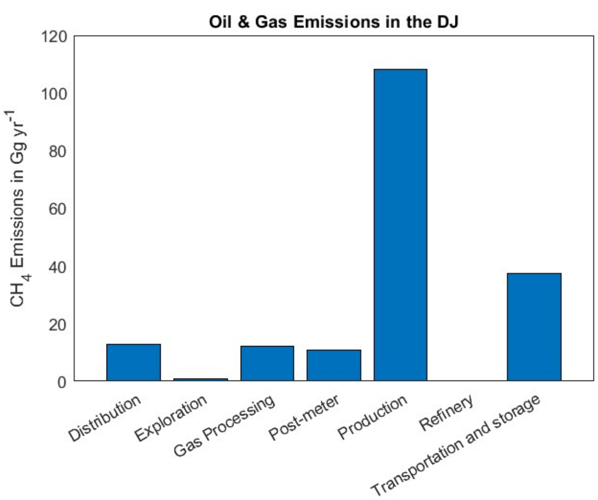


Figure 1. DJ basin inventory and location of possible CH_4 sources

Oil and Gas Sources

The total CH_4 emission from the oil and gas sector in the DJ basin was 182.6 Gg CH_4 yr^{-1}, with 96.3% from NG systems and only 3.7% from petroleum systems. The analysis showed that most CH_4 emissions came from the production sector, 59.2% (Figure 2). The production sector emissions by the contributing source showed that the highest emissions were from pneumatics followed by gathering and boosting equipment (Figure 3). As gathering and boosting equipment consists of multiple sources, pneumatics controllers in the production seem to significantly supersede any other single CH_4 source.



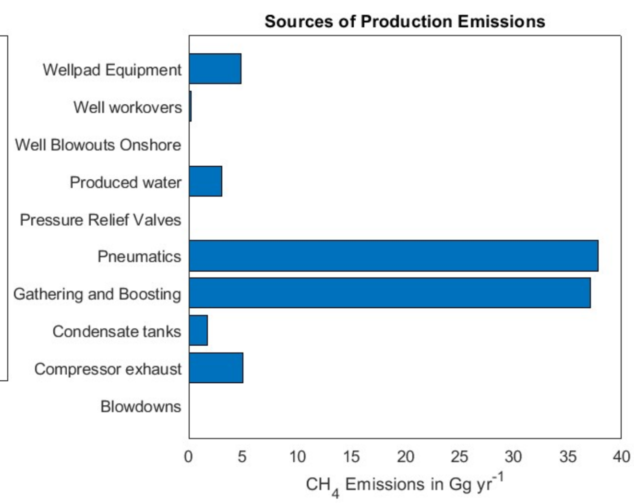


Figure 2. Whole sector emissions

Figure 3. Production emissions by source type

Oil and gas emissions showed a negatively skewed distribution where most emissions come from the few super-emitters. For sources that were classified as petroleum systems, 90% of emissions emit less than 0.26 Gg of CH_4 annually, compared to natural gas systems where 90% of emissions emit less than 4.64 Gg of CH_4 every year (Figure 4).

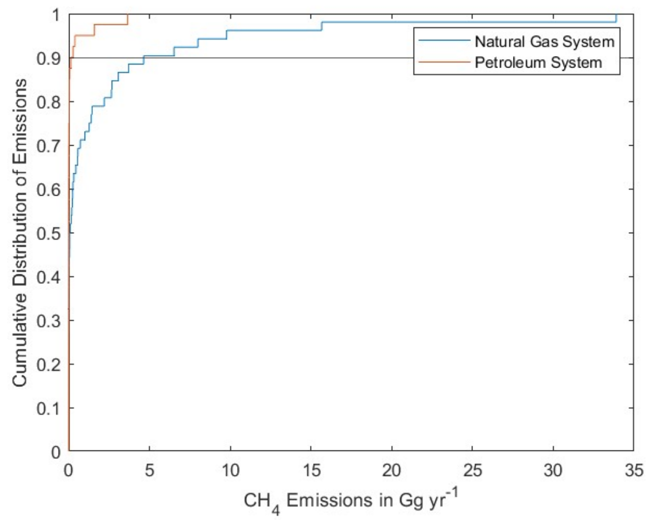


Figure 4. Cumulative distribution of emissions from natural gas and petroleum systems

Non-oil and Gas Sources

The estimated total CH_4 emissions from non-oil and gas sources were 118.1 Gg yr^{-1} from CAFOs, 15.77 Gg yr^{-1} from landfills, 0.107 Gg CH_4 yr^{-1} from wastewater plants, 0.354 Gg yr^{-1} from composites, 0.024 Gg yr^{-1} from solid waste sites, and 0.07 Gg yr^{-1} from waterbodies. The total CH_4 emissions from non-oil and gas sources classified as CAFOs, waste sector, and waterbodies are shown in Figure 5. The total CH_4 emission in the DJ is estimated to be 317.04 Gg yr^{-1}, with the largest emission coming from oil and gas.

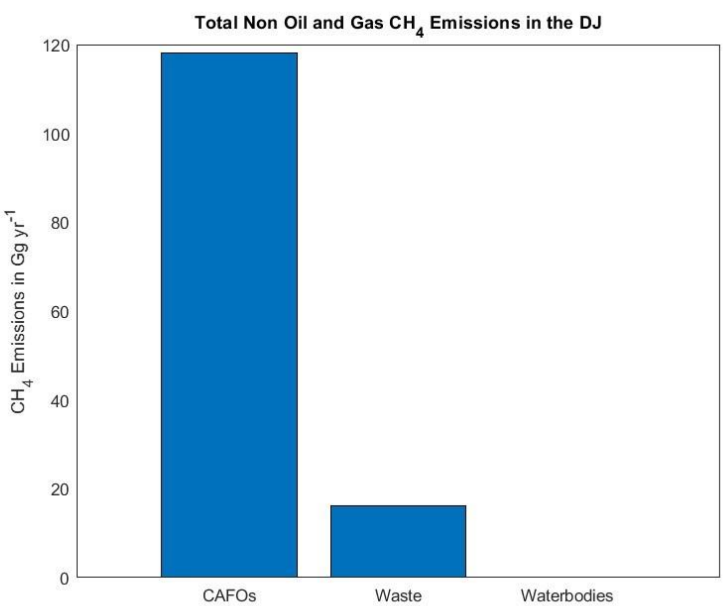


Figure 5. Emissions from Non-Oil and Gas Sources in the DJ

Conclusion

- This study reported CH_4 emissions in the DJ to be 317.04 Gg yr^{-1}, 57.6% from oil and gas systems, 37.3% from CAFOs, 5.1% from the waste sector, and 0.02% from water bodies.
- The reported emission is higher than a TD estimate by Pétron et al. (2014) that reported total CH_4 emissions in the DJ at 227.76 Gg yr^{-1},169.07 Gg yr^{-1} from oil and gas, and 58.69 Gg yr^{-1} from non-oil and gas.
- As most BU studies tend to be lower than the TD estimate, this study could not point out the reason for the reversed result in this study.
- This could have been due to the increased number of CH_4 sources in the DJ since 2014 which increased emissions.
- Also, the source of non-oil and gas inventories used in this study is the latest (2021-2022) compared to the inventories used in the Pétron et al. 2014 study.
- The EPA inventory has focused in recent years on updating their EFs by incorporating the latest fieldwork studies, as well as requiring operators to report their emissions yearly through Subpart W.

Current measurement data is needed to accurately estimate and report CH_4 emissions.

Research Plans

Currently working on a bottom-up paper for the DJ basin.

Next steps:

Working on a study that will investigate the uncertainties of OTM 33A methods in quantifying and scaling up emissions by comparing emissions quantification methods in a controlled environment (METEC):

1. Gaussian Plume Inversion method
2. Mass balance open system
3. Eddy covariance
4. Aerodynamic flux gradient

The objective of this study is to evaluate whether quantification methods currently applied accurately represent emissions, uncertainties, and their accuracy in different meteorological and leak conditions. The methods will be evaluated and applied during the upcoming 2024 SABER measurement campaign in the DJ basin.

Publications

Mbua, M., Riddick, S.N., Tian, S., Cheptonui, F., Houlihan, C., Smits, K.M., Zimmerle, D.J., 2023. Using controlled subsurface releases to investigate the effect of leak variation on above-ground natural gas detection. Gas Sci. Eng. 120, 205153. https://doi.org/10.1016/j.jgsce.2023.205153

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