Methane Source Attribution in the DJ Basin using Mobile Surveys and Computational Analytics

E. Atherton[1], C. Fougère[1], O. Sherwood[2], D. Risk[1], B. Vaughn[2], G. Pétron[3,4]

[1]St. Francis Xavier University, Antigonish, Nova Scotia Canada

[2]Institute of Arctic and Alpine Research (INSTAAR), University of Colorado, Boulder, CO

[3]Cooperative Institute for Research in Environmental Sciences (CIRES) University of Colorado, Boulder, CO

[4]NOAA Earth System Research Laboratory, Global Monitoring Division (GMD), Boulder, CO

Methane Emissions

CH_4 is a potent GHG with a warming potential 28-36 times than that of CO_2 over 100 years, making anthropogenic CH_4 emissions an effective target for GHG reductions (Nisbet et al. 2014). In order to reduce CH_4 emissions, it is important to quantify contributions from various sources, such as agriculture and oil and gas (O&G) development. Well-known offsets between emissions inventories and top-down measurement approaches (Brandt et al. 2014) highlight the need for improved CH_4 detection and attribution technologies. Here we demonstrate the coupling of mobile survey data with computational analytics to identify CH_4 emissions sources in the Denver-Julesburg Basin of Northeastern Colorado, a multi-use landscape of intense O&G and agricultural activity.

Data Collection

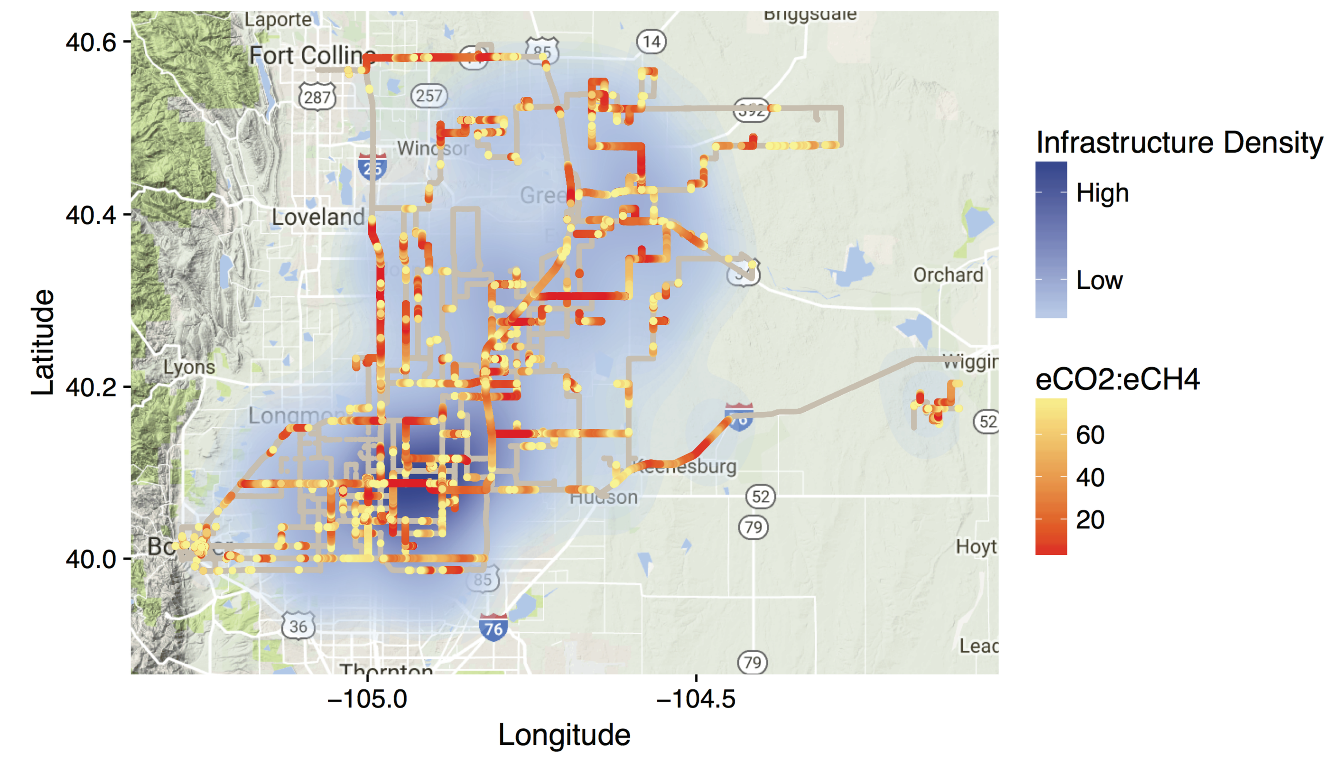
In summer 2014, mobile surveys totaling 3744 km in distance were carried out in the DJ Basin. A Picarro Surveyor Cavity Ring Down Spectrometer (CRDS) was used to measure CH_4, CO_2 and other gases at 1 Hz recording frequency. Measurements were geo-located using GPS, and potential emissions sources were identified using a sonic anemometer to measure wind speed and direction while underway. In total, **> 350 000 geo-located gas and wind measurements** were recorded.

Plume Detection

We distinguished plumes from background CH_4 and CO_2 variability with an adaptive technique (ExACT), in which background concentrations could vary throughout a survey, to reveal excess concentrations. Depressed excess (super-ambient) CO_2:CH_4 values revealed anomalously CH_4-enriched plumes. A threshold ratio of 80 was applied because it represented a significant departure from natural atmospheric background ratio (~215). **Plumes were identified by 3+ consecutive datapoints with excess CO_2:CH_4 < 80.**

Source Attribution

O&G infrastructure (wells and gas processing facilities) and Concentrated Animal Feeding Operations (CAFOs) **upwind and within 300 m of plumes** were considered potential emission sources. We classified sources as emitting when the same source was considered a potential emitter **at least 50% of the times it was surveyed.**



Survey routes are shown in tan.

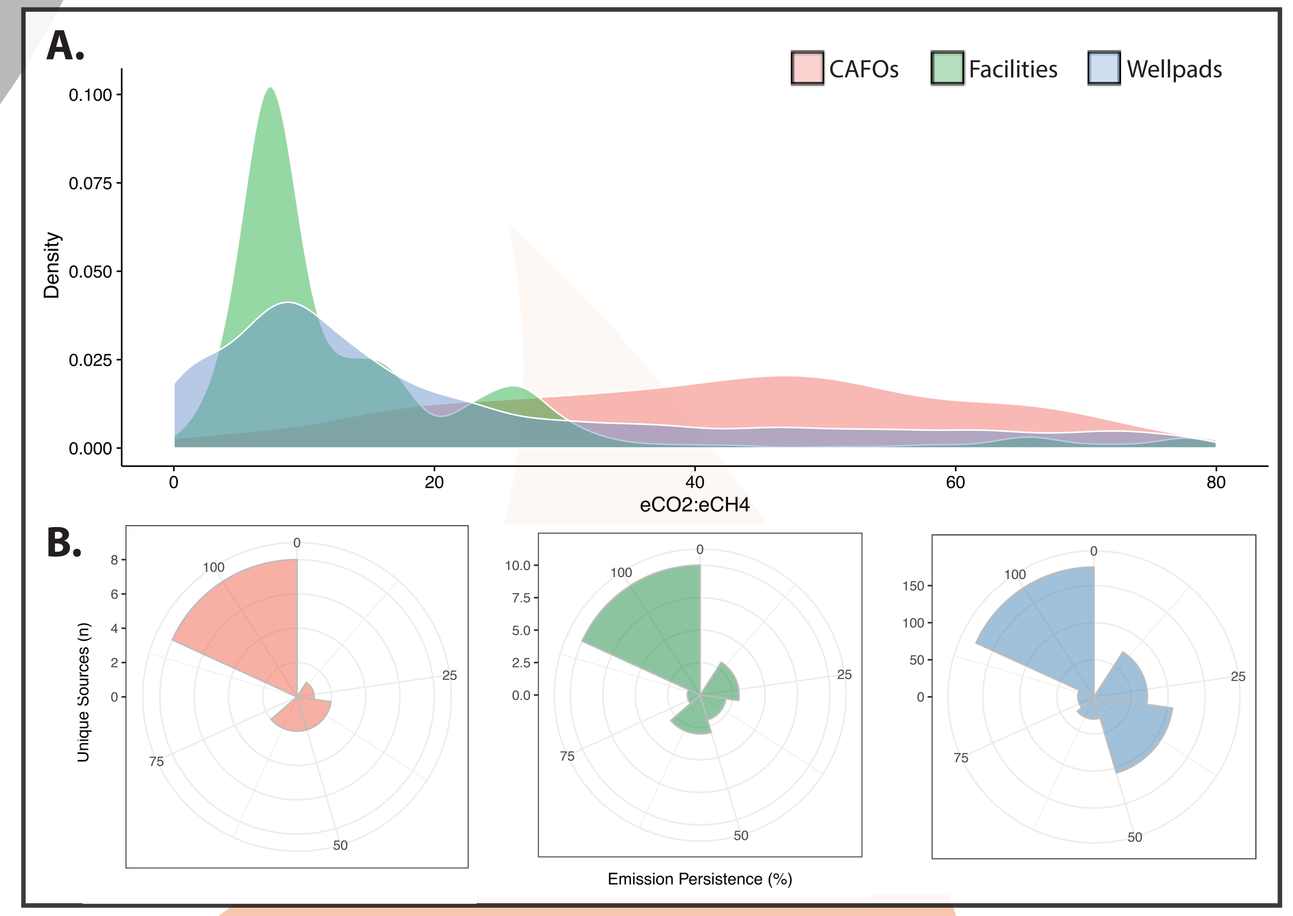
CH_4-enriched plumes (excess CO_2:CH_4 < 80) are shown in yellow to red colour-scale (red indicating more CH_4-enriched).

The density of infrastructure, including CAFOs and O&G wellpads and facilities, is shown in blue.

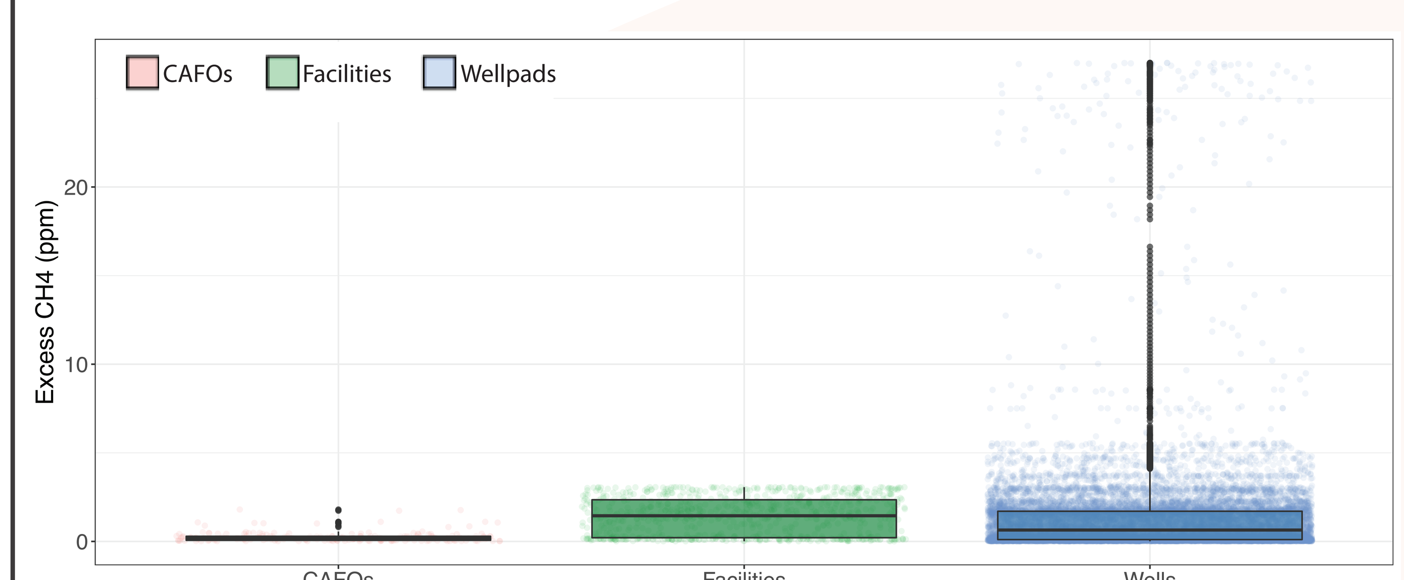
CH_4-enriched plumes were located throughout the entire survey region, but were most abundant in areas of high infrastructure density.

A. Density plots showing distributions of CH_4-enriched plumes for each source type. Although O&G wells were sampled most often, O&G facilities were associated with the most CH_4-enriched plume measurements.

B. Emission persistence refers to the repetition of CH_4 plume detections from the same source each time it was sampled. Emission persistence for each source type are shown. Many wellpads had emission persistence values from 20-50%, suggesting that wellpads were associated with the most episodic emissions. Episodic emissions may be caused by routine maintenance at the wellhead, such as venting or flowback. Facilities and CAFOs were mainly associated with persistent emissions.



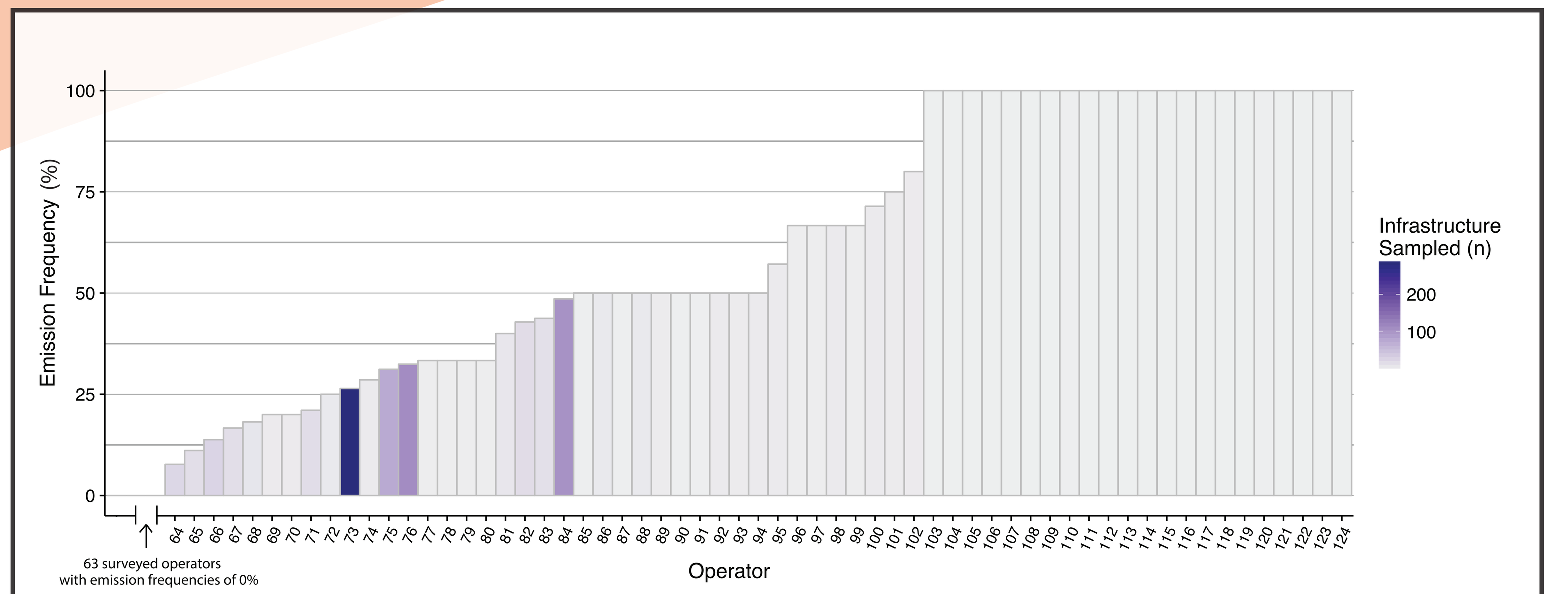
Source Type	Sampled (n)	Emission Frequency (%)	Unique Emitting Sources (n)	Cumulative eCH4 from Unique Sources on Each Survey: Total (ppm)	Cumulative eCH4 from Unique Sources on Each Survey: per Unit Emitting (ppm)
O&G Wellpad	943	31	410	295	0.72
O&G Facility	34	44	19	13	0.68
CAFO	23	48	13	6	0.46



Excess CH_4 (concentrations of CH_4 above background levels) were used to compare relative magnitudes of CH_4 emissions from the three different source types. This comparison assumes that plume dispersion and mixing with background air was similar for all measurements.

The table shows the number of sampled infrastructure, their respective emission frequencies (%), the number of emitting sources, the cumulative excess CH_4 in total, and per unit emitting. The cumulative excess CH_4 calculations include the maximum excess CH_4 measurement from each unique source on each survey. All excess CH_4 measurements for each source type are shown by the boxplots.

Emission frequencies for O&G infrastructure by operator, coloured by number of potential emission sources sampled. The four operators that we sampled most had 25-50% emission frequencies, which were close to the overall emission frequencies for wells and facilities (31% and 44% respectively). The general trend suggests that operators we sampled less were associated with higher emission frequencies.



Sensitivity in Mobile Surveys

Atmospheric gas concentration collection using a mobile survey technique, paired with ExACT's background subtraction and plume detection algorithms, proved useful for identifying CH_4-enriched plumes within the DJ Basin. Using wind direction and a pre-defined radius of 300 m, we were able to attribute these plumes to their probable O&G or agricultural sources. The spatial comprehension of mobile surveys, coupled with the sensitivity of ExACT, lend to the applicability of this approach to regional CH_4 source attribution.

Characterizing Emissions

CH_4 emission characteristics varied between source-type. Plumes associated with O&G facilities were the most CH_4-enriched, suggesting that CH_4 plumes from facilities may be more severe, however, CH_4 plumes from wellpads were much more common. Our geospatial technique of plume attribution associated very few plumes with CAFOs, and in general these plumes were less CH_4-enriched.

Emissions frequencies from O&G infrastructure varied significantly between operators, suggesting that operator -specific best practices have a significant impact on emissions.

Targeting Sources

We found that O&G wells and facilities emitted about 1.5 times more CH_4 per emitting unit than CAFOs. This result conforms to a previous study based on aircraft measurements (Petron et al. 2014) pointing to O&G infrastructure as a major contributor to CH_4 emissions in the DJ Basin. Our data reveal large variability in emissions frequency (from 0 to 100%) by operator, suggesting improvements in operator best practices could help mitigate CH_4 emissions.

Future work

Future work on this project will involve estimating CH_4 emission rates for sources by taking into account both our distance from source while measuring, as well as the atmospheric wind conditions leading to plume dispersion. With this information we would be able to roughly estimate CH_4 emission volumes from each source type.

We will also attempt to use concentration data from other gases recorded on these field campaigns (such as $\delta^{13}CH_4$) to test their usefulness in source discrimination during mobile surveys.

References

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