# Methane emission detection, localization, and quantification using continuous point-sensors on oil and gas facilities

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## Project overview

Methane is a potent greenhouse gas. Oil and gas facilities are a promising avenue for emission reduction, as leaks can be mitigated if addressed quickly. We propose a generic, modular framework for emission event detection, localization, and quantification on oil and gas facilities. The algorithm uses methane concentration and wind speed and direction data collected by continuous point sensors.

## Contributions

- Provide a more accurate data-driven algorithm for detection, localization, and quantification to replace traditional bottom-up inventories.
- Utilize the Gaussian puff model as the atmospheric dispersion model for modeling methane transport, which accounts for varying wind conditions more comprehensively than the commonly used Gaussian plume model.

## Data and experiment setup

- We test our algorithm using controlled release data from Colorado State University's METEC facility.
- Continuous point-sensors are placed around the facility and provide methane concentration and wind speed and direction data every minute.

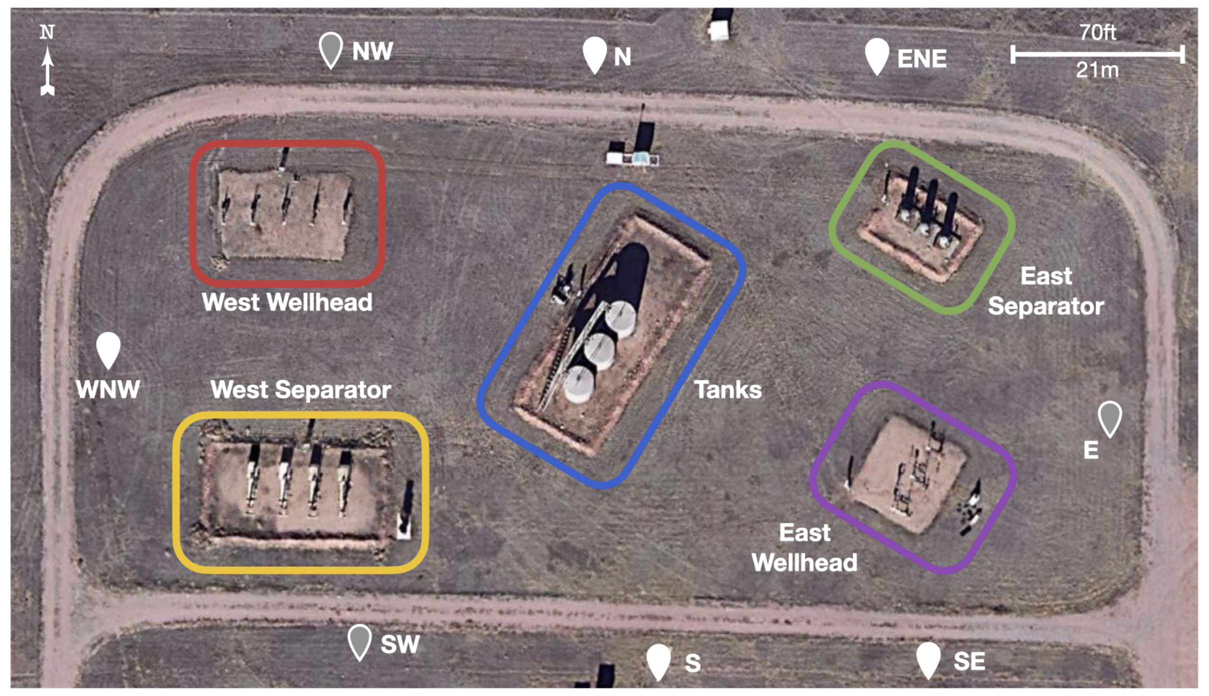


Figure 1: Satellite imagery of the METEC facility. Source locations are marked with colored boxes and sensor locations are marked with pins. Pins with gray interiors indicate that the corresponding sensor measures wind speed and direction in addition to methane concentrations.

## Detection, localization, and quantification algorithm

**Step 1: Background removal and event detection**
Removes background from the raw concentration data and identifies time periods during which we think emissions are occurring using a gradient-based spike detection technique.

**Step 2: Simulation**
Uses the Gaussian puff model to simulate concentrations at each sensor given different potential emission sources and the observed wind data.

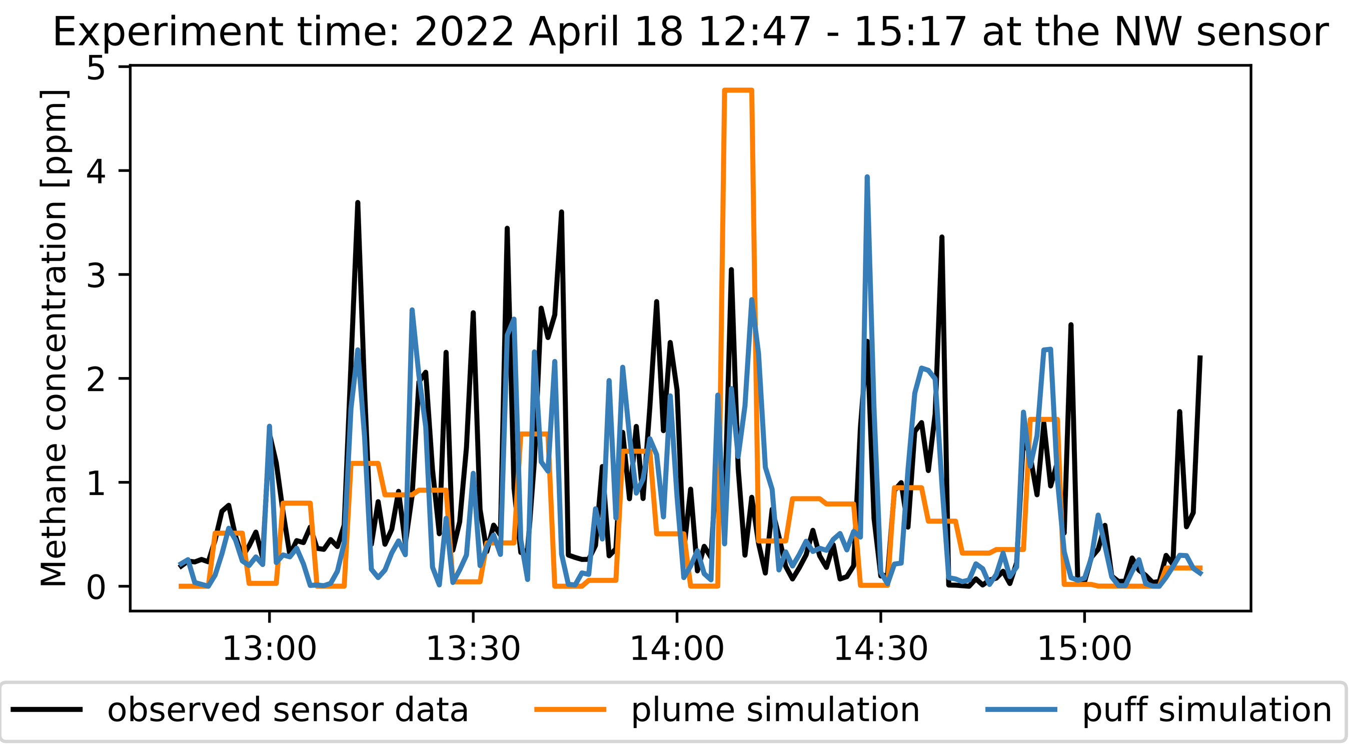


Figure 2: A comparison of simulation predictions from the Gaussian plume and puff models.

**Step 3: Localization**
Compares the simulated concentrations to the actual concentration observations to identify the most likely source.

**Step 4: Quantification**
Scales the simulated concentrations from the most likely source identified in the previous step to optimally match the actual observations, which provides an emission rate estimate.

## Future work

- Expand the emission localization and quantification algorithm to accommodate scenarios with multiple emission sources.
- Implement the algorithm to improve methane emission site inventories.
- Use the Gaussian puff model to optimize methane sensor deployment on complex oil and gas sites.
- Investigate more complex atmospheric dispersion models to improve the localization and quantification accuracy.

## Results

### Detection, localization, and quantification results

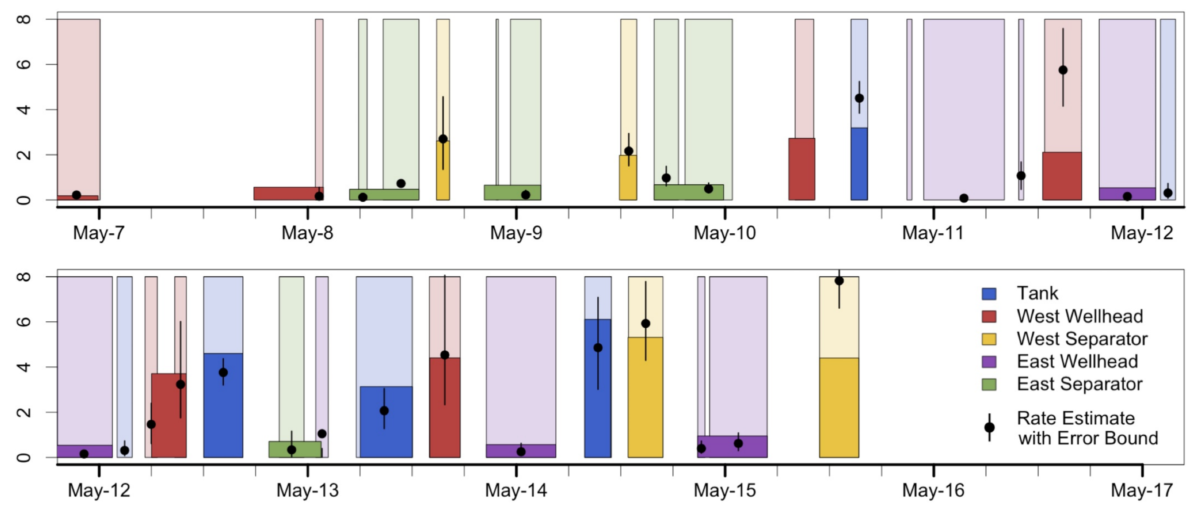


Figure 3: Detection, localization, and quantification results over a selected period from May 7 to May 16, 2022.

### Detection and localization Accuracy

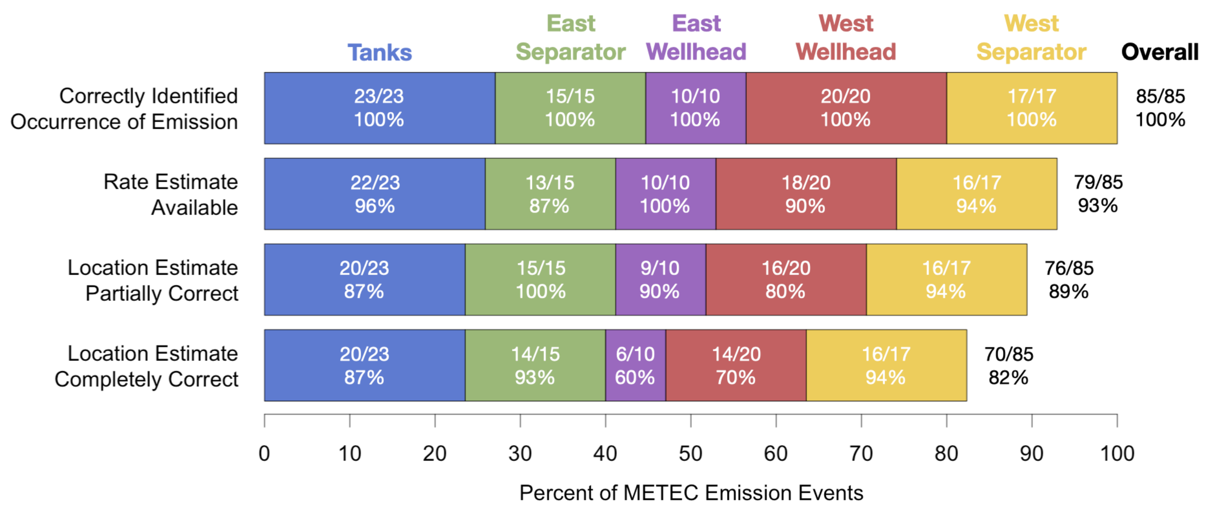


Figure 4: Summary of event-level emission detection and localization performance.

### Quantification Accuracy

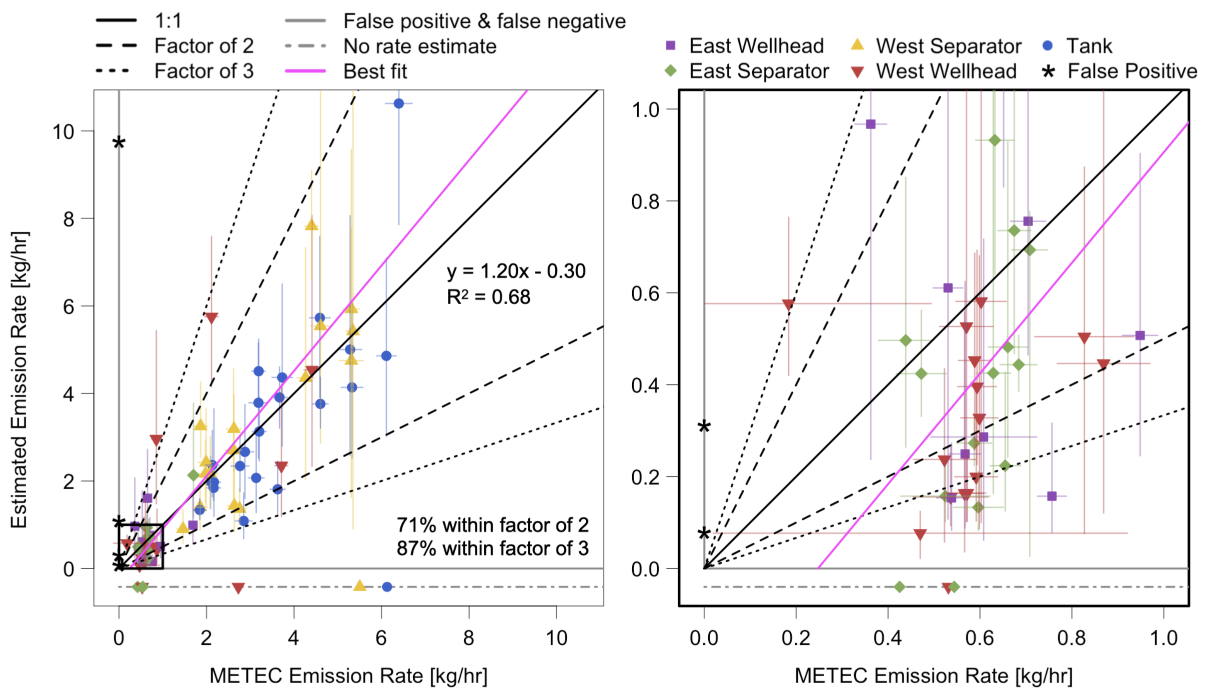


Figure 5: Parity plots of true and estimated emission rates.

## References

[1] W. Daniels, M. Jia, and D. Hammerling, "Methane emission detection, localization, and quantification using continuous point-sensors on oil and gas facilities," 2022.

[2] M. Jia, W. Daniels, and D. Hammerling, "Comparison of the gaussian plume and puff atmospheric dispersion models on oil and gas facilities," 2023.