Data-Driven Detection of Methane Leaks from Oil and Gas

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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. Current alerting practices use static thresholds that result in many false positives. To better alert oil and gas operators to emissions on their sites, we developed a framework to identify when an emission is occurring and where it is coming from.

Data and Experiment Setup

- We develop our algorithm using controlled release data from Colorado State University's METEC facility, which has three potential sources: tanks, wellheads, and separators.
- Continuous monitors from Project Canary are placed around the facility and provide methane concentration data every minute.

Figure 1: Configuration of METEC experiment

Methods

Step 1: Remove background from methane observations

Estimate background via non-parametric regression fit to local "non-spike" observations.

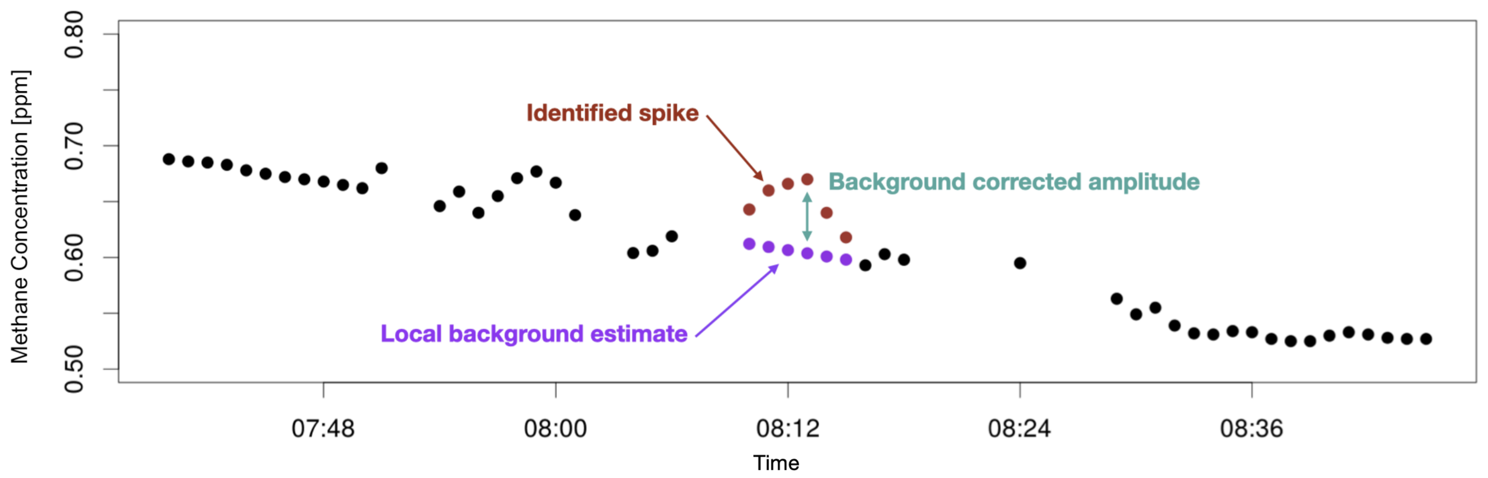

Figure 2: Sketch of our background removal algorithm.

Methods (Continued)

Step 2: Simulate methane concentrations from each source

We use a Gaussian puff model to simulate methane concentrations at the sensor locations. This model accommodates non-constant wind and source characteristics. The x-axis is aligned with the wind direction. Concentrations are given by:

$$C(x,y,z,t) = \frac{Q_t}{(2\pi)^{3/2}\sigma_y^2\sigma_z} \exp\left(-\frac{(x-ut)^2+y^2}{2\sigma_y^2}\right) \left[\exp\left(-\frac{(z-H)^2}{2\sigma_z^2}\right) + \exp\left(-\frac{(z+H)^2}{2\sigma_z^2}\right)\right]$$

where:

- $C(x,y,z,t)$ is the predicted concentration at location (x,y,z) and time t
- Q_t is the amount of methane released at time t
- u is the wind speed at time t
- H is the height of the source
- σ_y and σ_z are the standard deviation of the concentration distribution in the cross-wind (y) and vertical directions (z), respectively

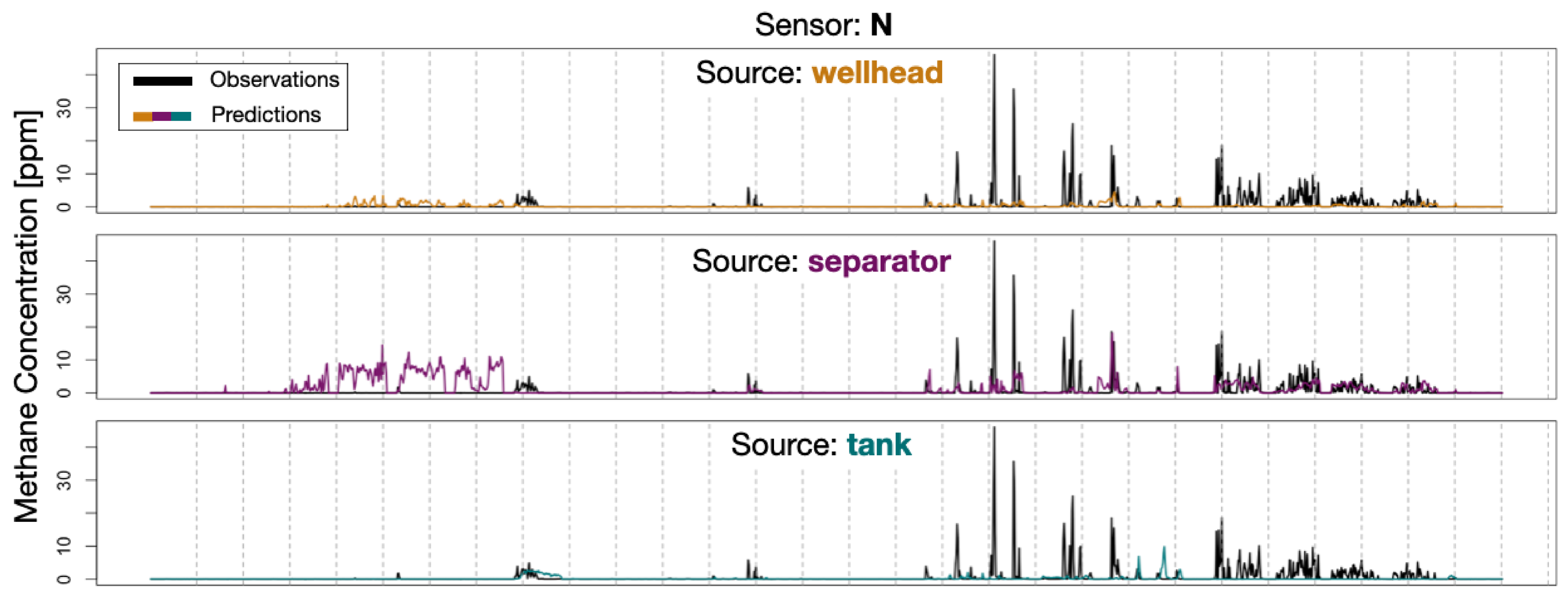

Figure 3: Observed (black) and simulated (yellow, purple, green) methane concentrations at the North sensor.

Step 3: Compare simulations with observations at each sensor

Pattern match simulated concentrations from each potential source with the observations using a custom metric to identify most likely source for each sensor.

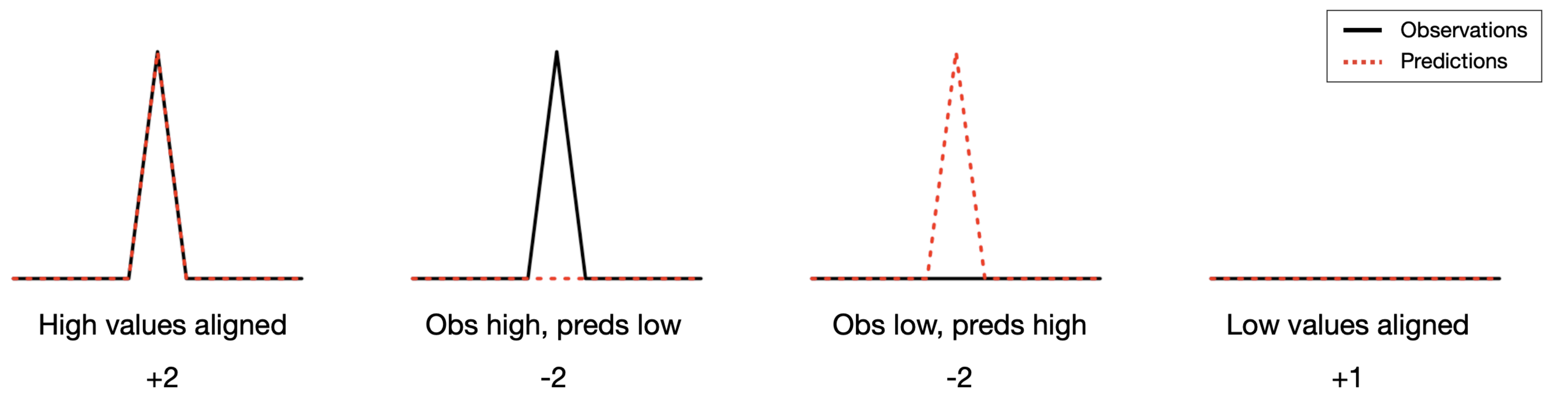

Figure 4: Sketch of our spike alignment metric to assess fit between simulations and observations.

Methods (Continued)

Step 4: Synthesize localization results across sensors

Use wind data and site geometry to combine localization results across sensors. Only use data from downwind sensors.

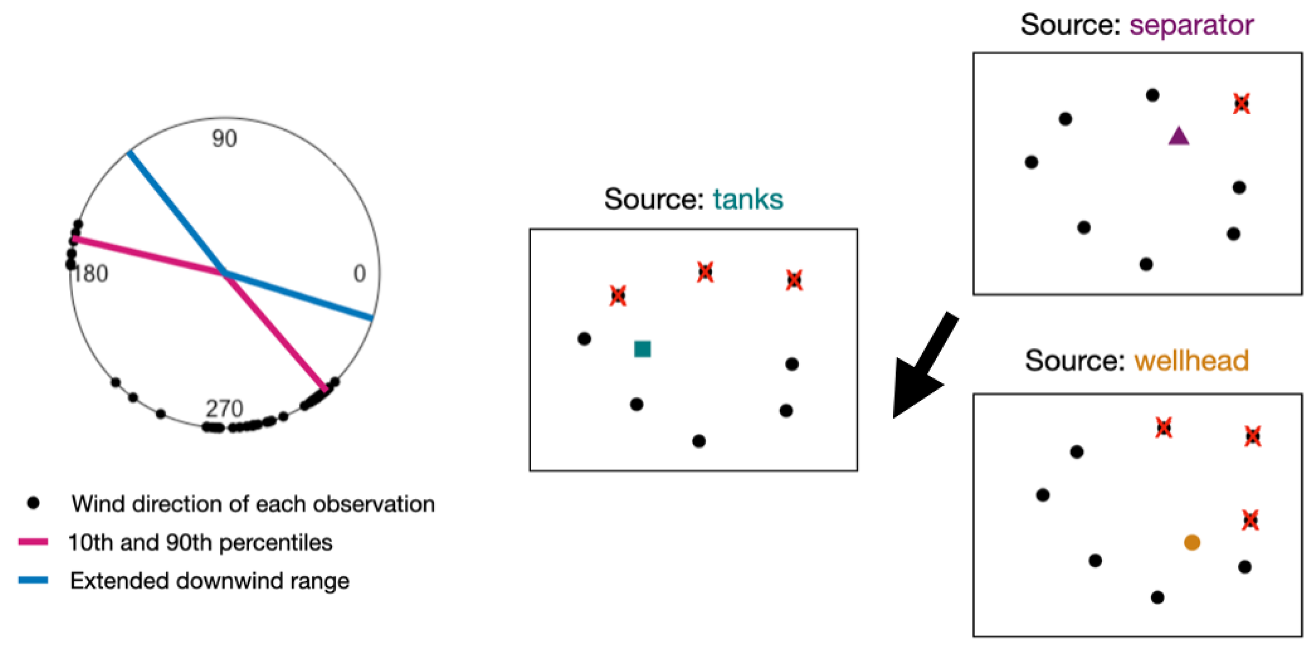

Figure 5: Sketch of our scheme for combining localization results across sensors.

Results

- We run our emission detection and localization algorithm on the METEC data using 60-minute prediction intervals.
- The source with the highest metric value is selected.
- The confidence value is defined as the difference between the best and second best metric value.

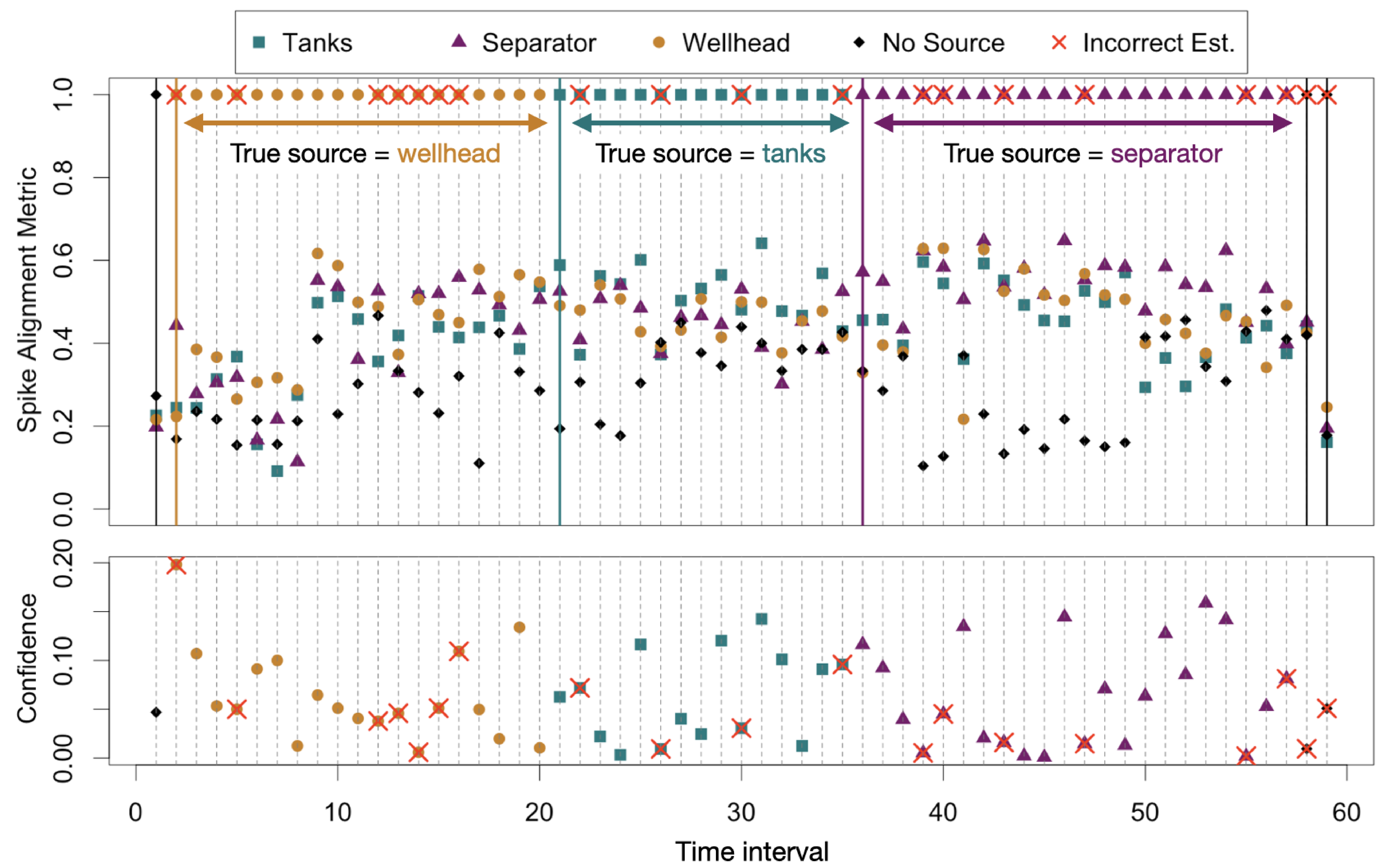

Figure 6: Localization results for each 60-minute interval of the METEC experiment.

Conclusion

Our framework provides source localization with confidence measures, and hence more informative alerts that can lead to more directed site investigations and less emissions.