Comparing continuous methane monitoring technologies on operating oil and gas sites

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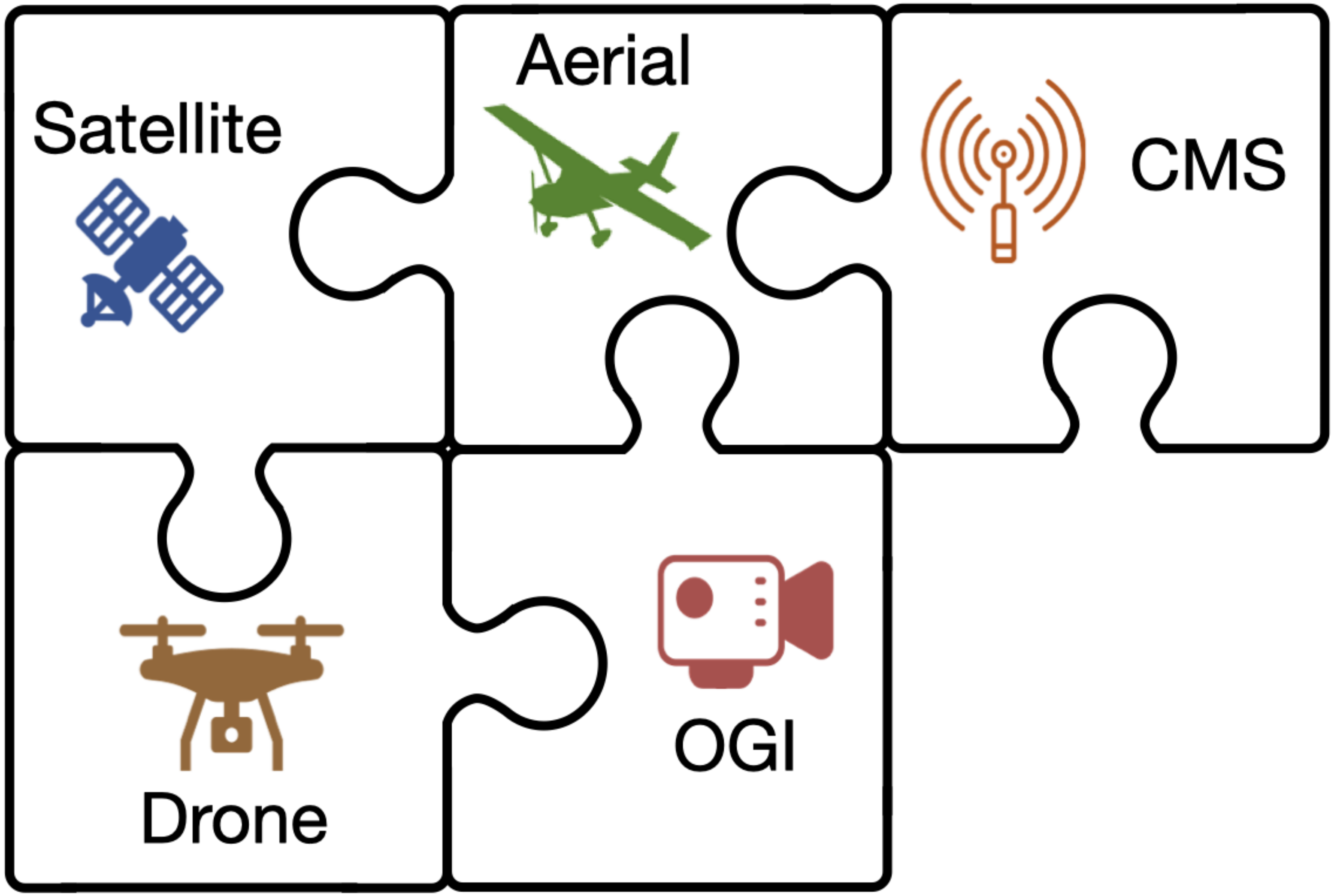
COLORADO SCHOOL OF MINES

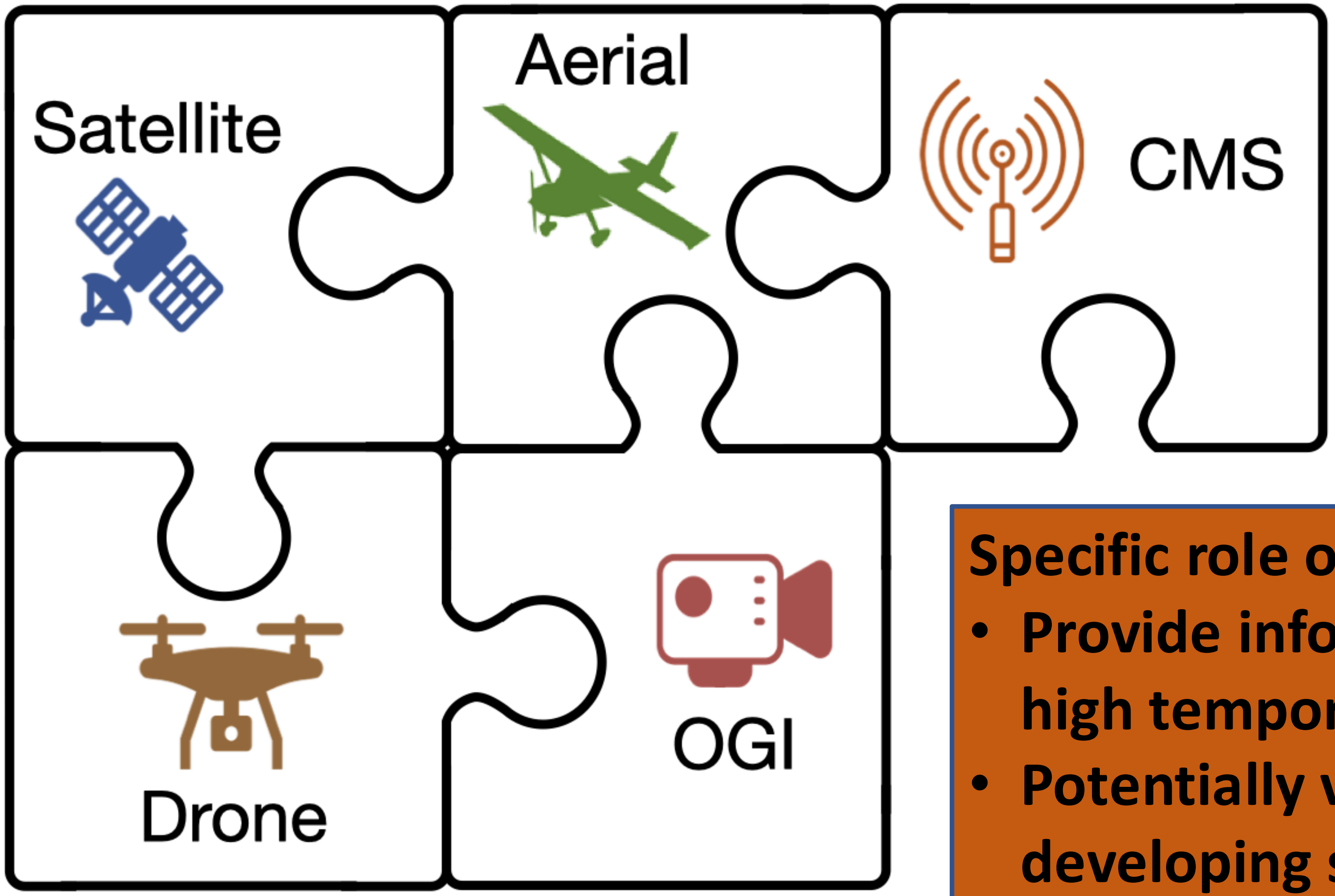
EEMDL
Energy Emissions Modeling and Data Lab

Lots of complementary ways to measure methane



Continuous
Monitoring
System

Lots of complementary ways to measure methane

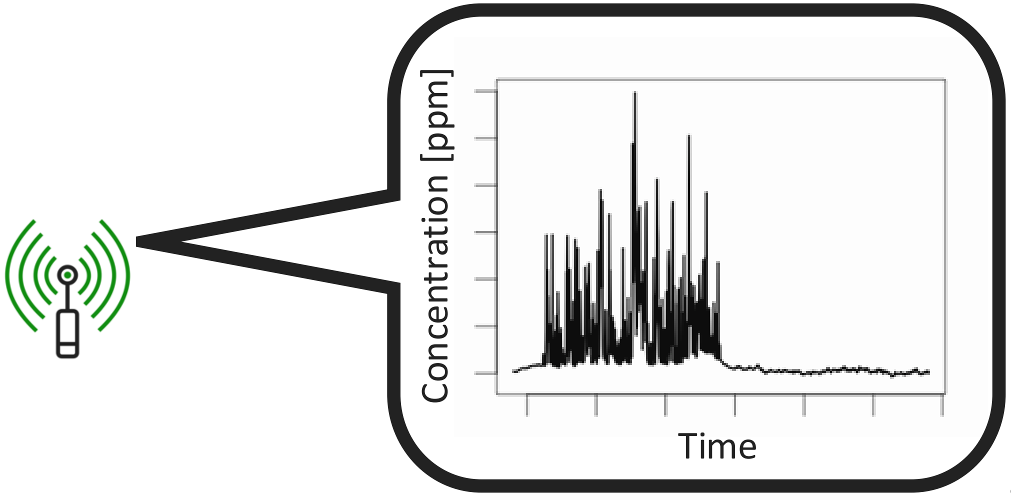


Continuous
Monitoring
System

Specific role of CMS:

- **Provide information at high temporal frequency**
- **Potentially very useful for developing site-level inventories**

Continuous monitoring point-in-space sensors: we have only indirect measurements of what we care about



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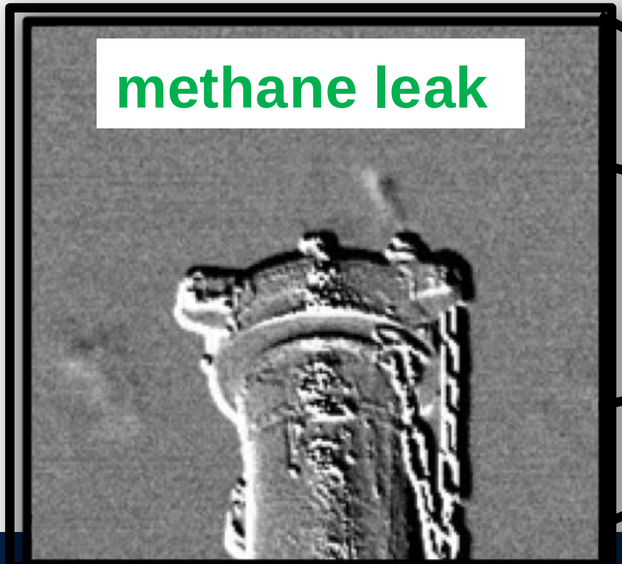
We have only indirect measurements of what we care about

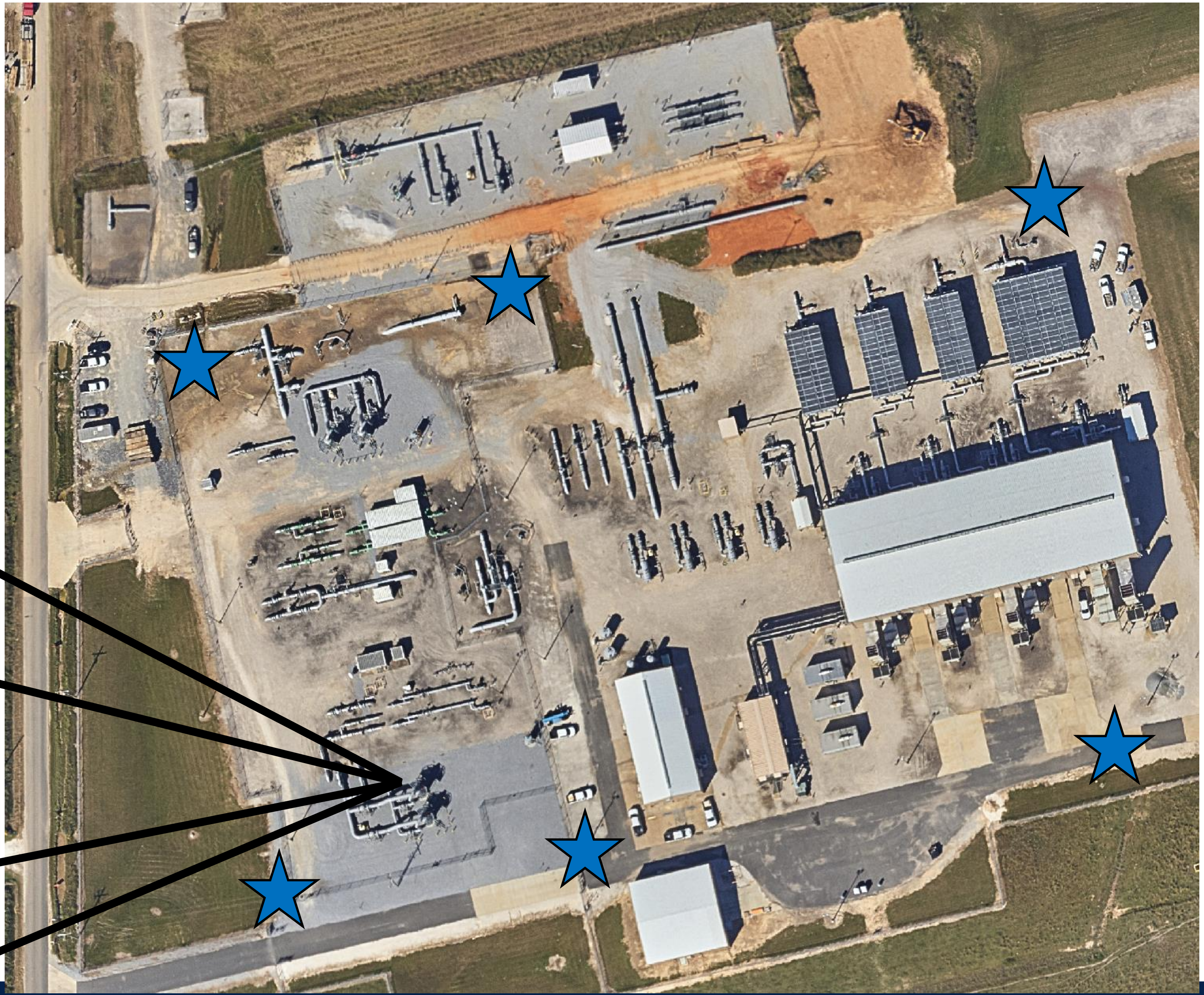
This is an inverse problem: **m** = ***F***$^{-1}$**(d)**

m: methane emission leak rate and location

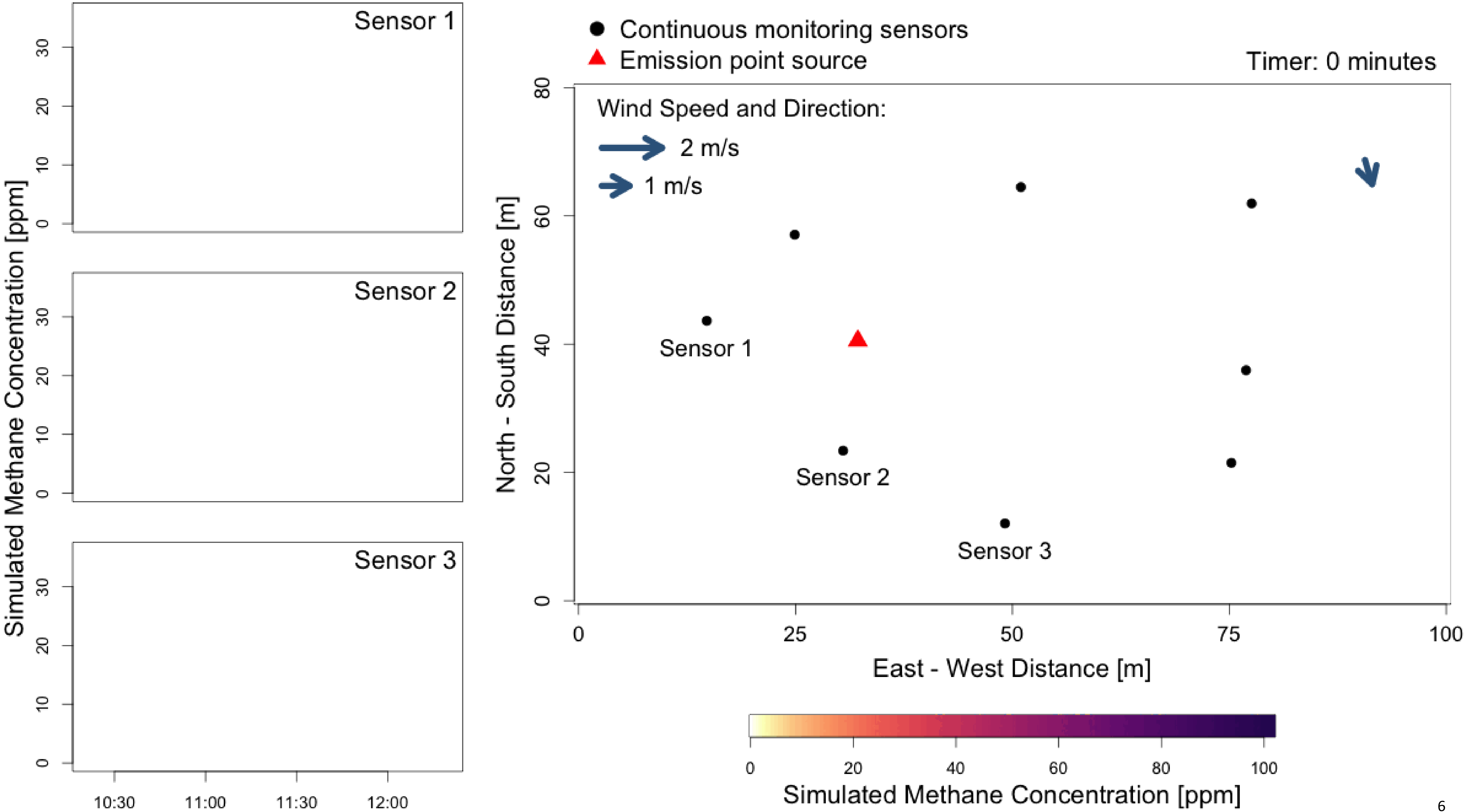
d: methane concentrations from continuous monitors

***F*( )**: atmospheric transport model





★ = continuous monitoring sensors



Sensor 1
Sensor 2
Sensor 3
Simulated Methane Concentration [ppm]
0
10
20
30
10:30
11:00
11:30
12:00
Continuous monitoring sensors
Emission point source
Timer: 0 minutes
Wind Speed and Direction:
2 m/s
1 m/s
Sensor 1
Sensor 2
Sensor 3
North - South Distance [m]
East - West Distance [m]
0
20
40
60
80
0
25
50
75
100
0
20
40
60
80
100
Simulated Methane Concentration [ppm]

Event detection, localization, and quantification framework

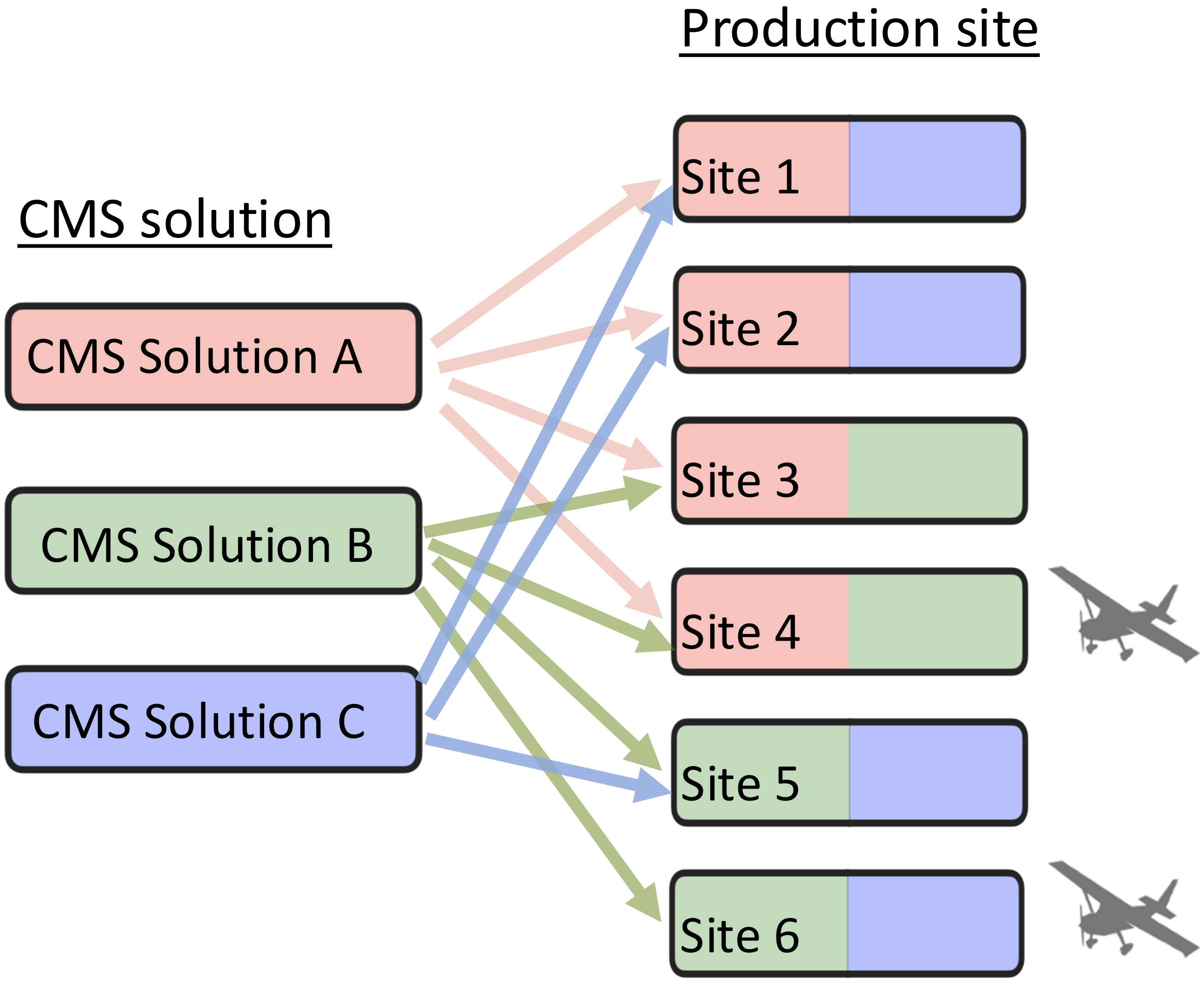
STEP 1: Background removal and event detection → STEP 2: Simulation → STEP 3: Localization → STEP 4: Quantification

Key features:

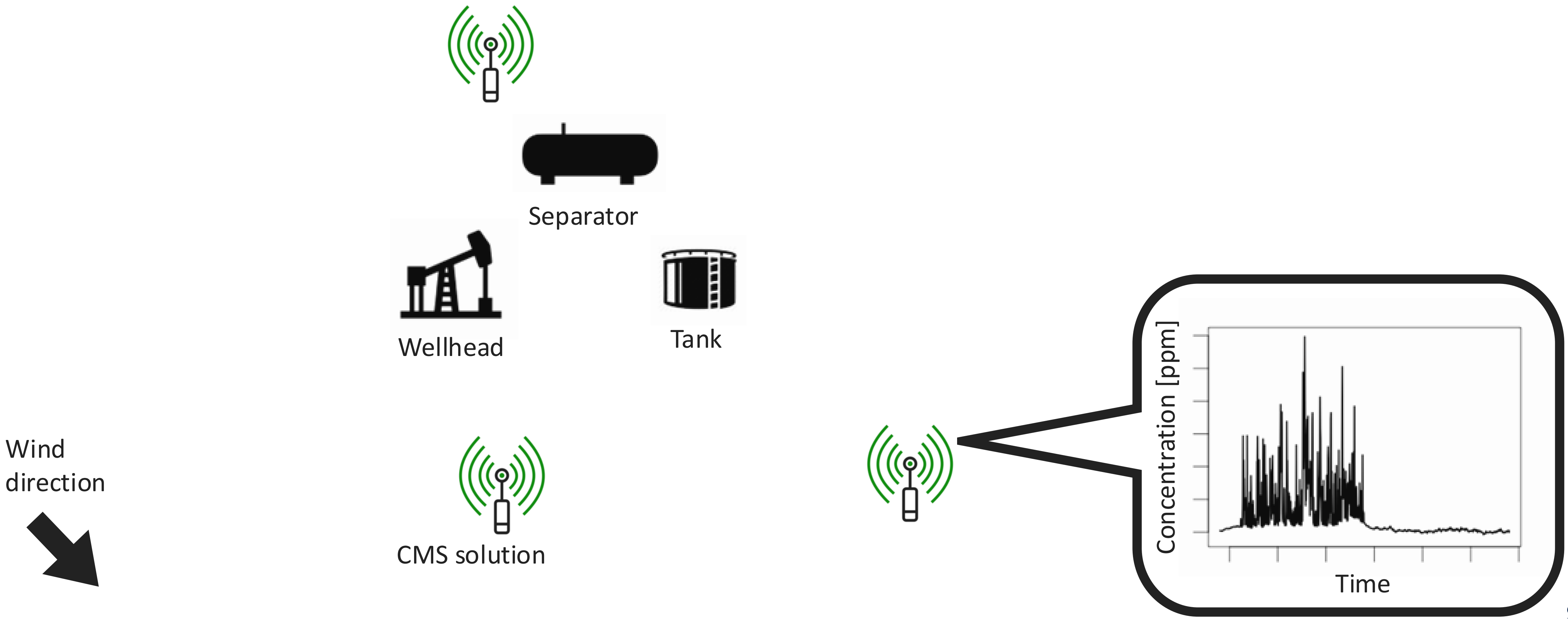
- Modular
- Sensor-agnostic
- Published
- Open-source

"Open-source DLQ algorithm"

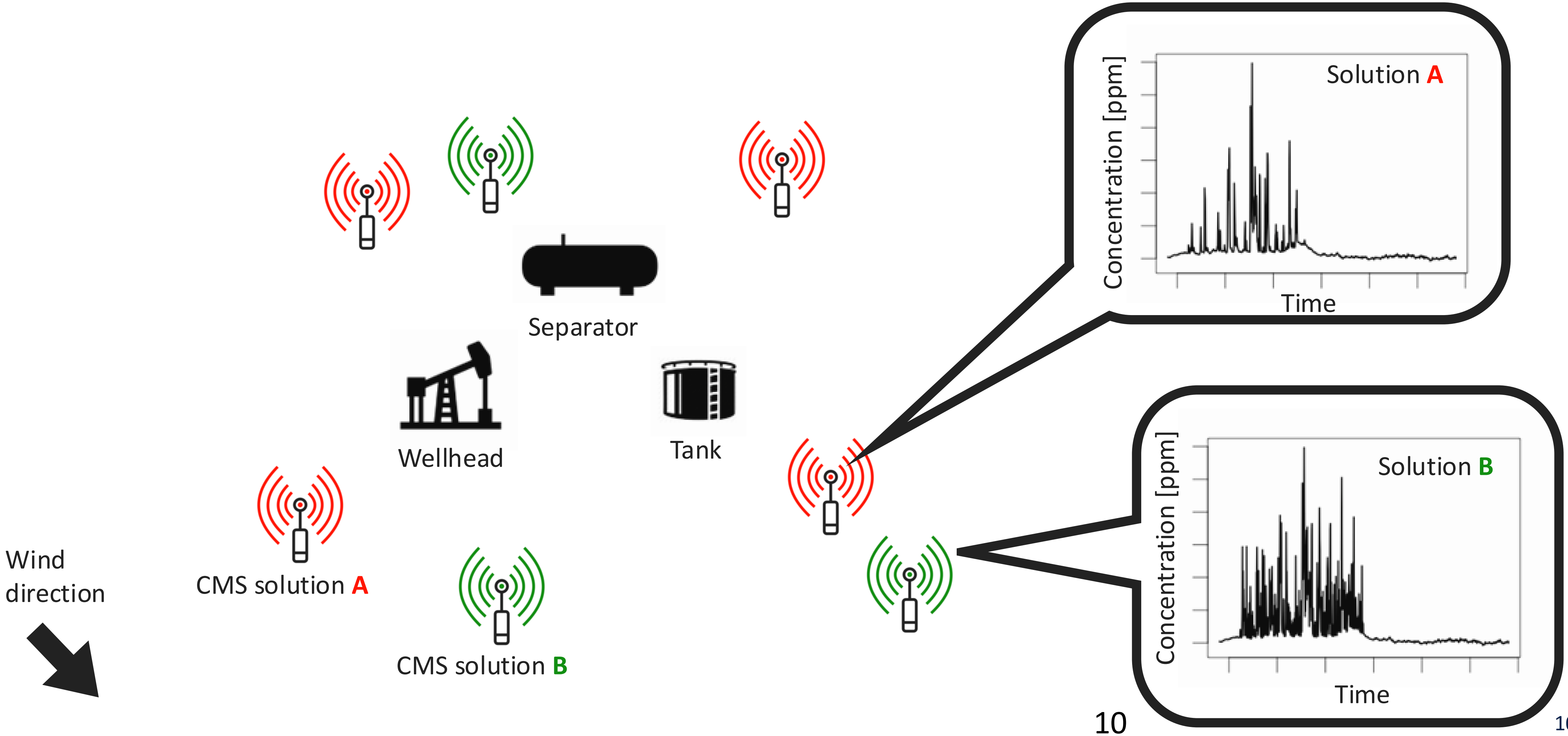
Experimental setup across six Oil & Gas sites



Typical CMS setup on a production site in the study



Each site in the study was equipped with TWO CMS solutions



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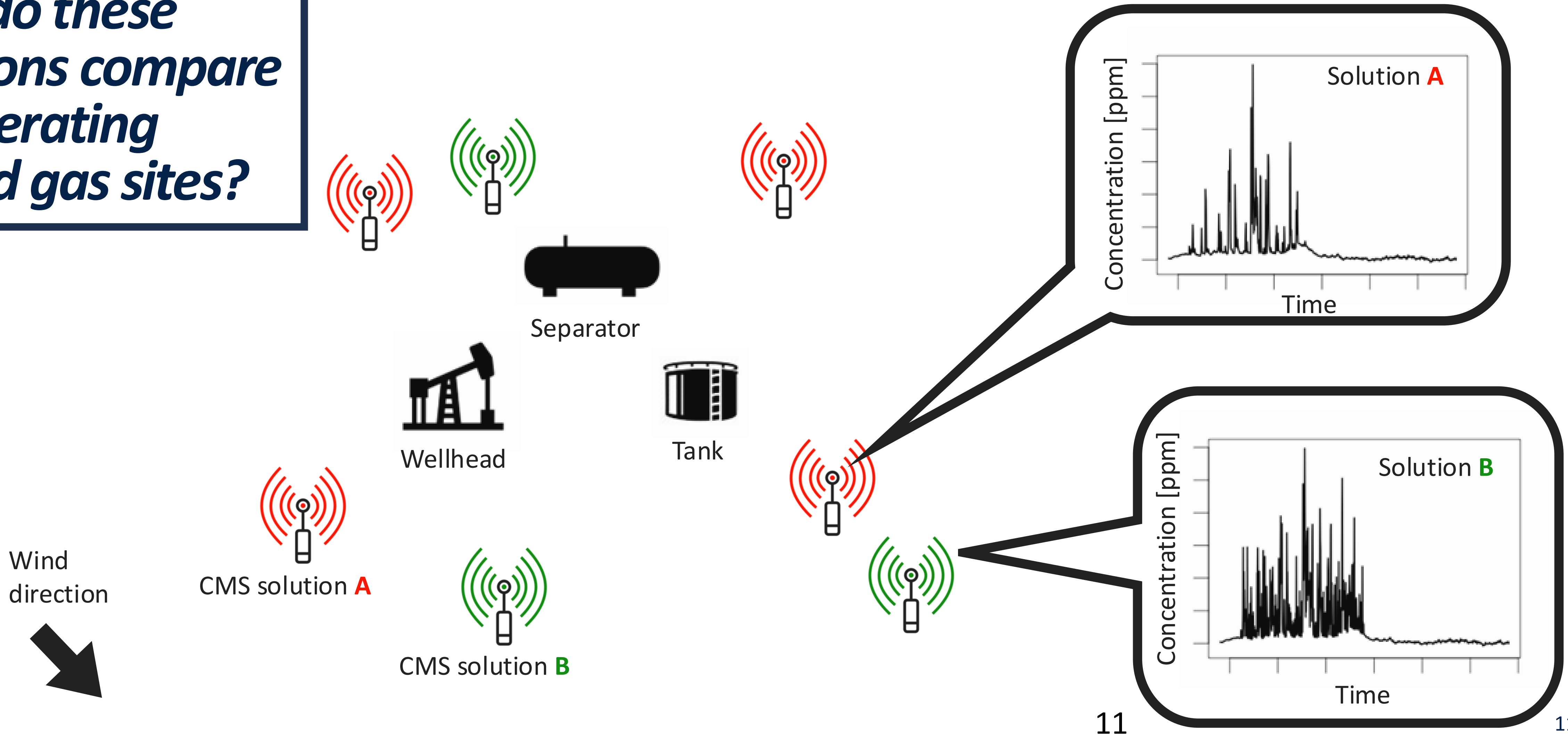
Each site in the study was equipped with TWO CMS solutions

Our question:
How do these solutions compare on operating oil and gas sites?



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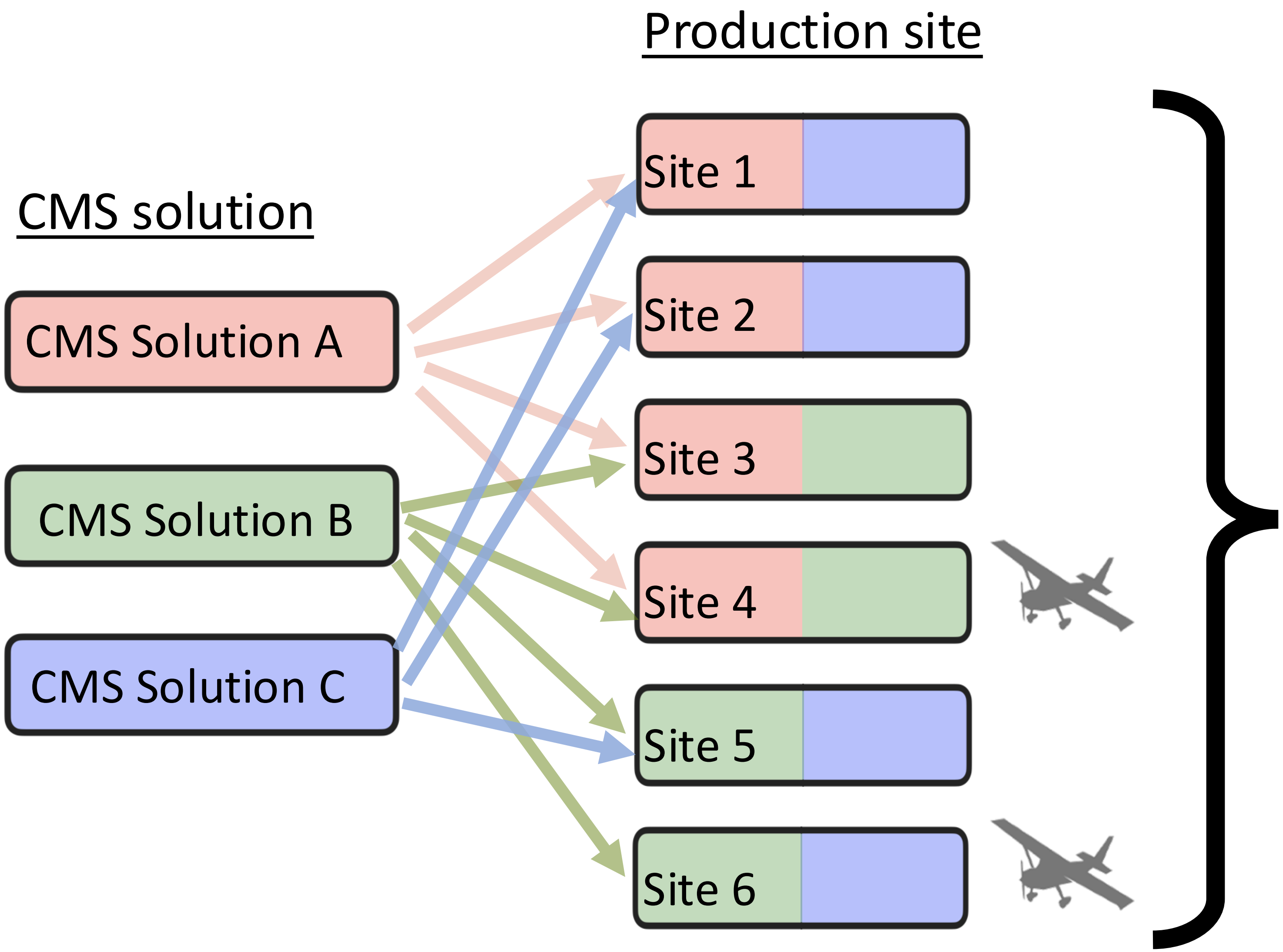
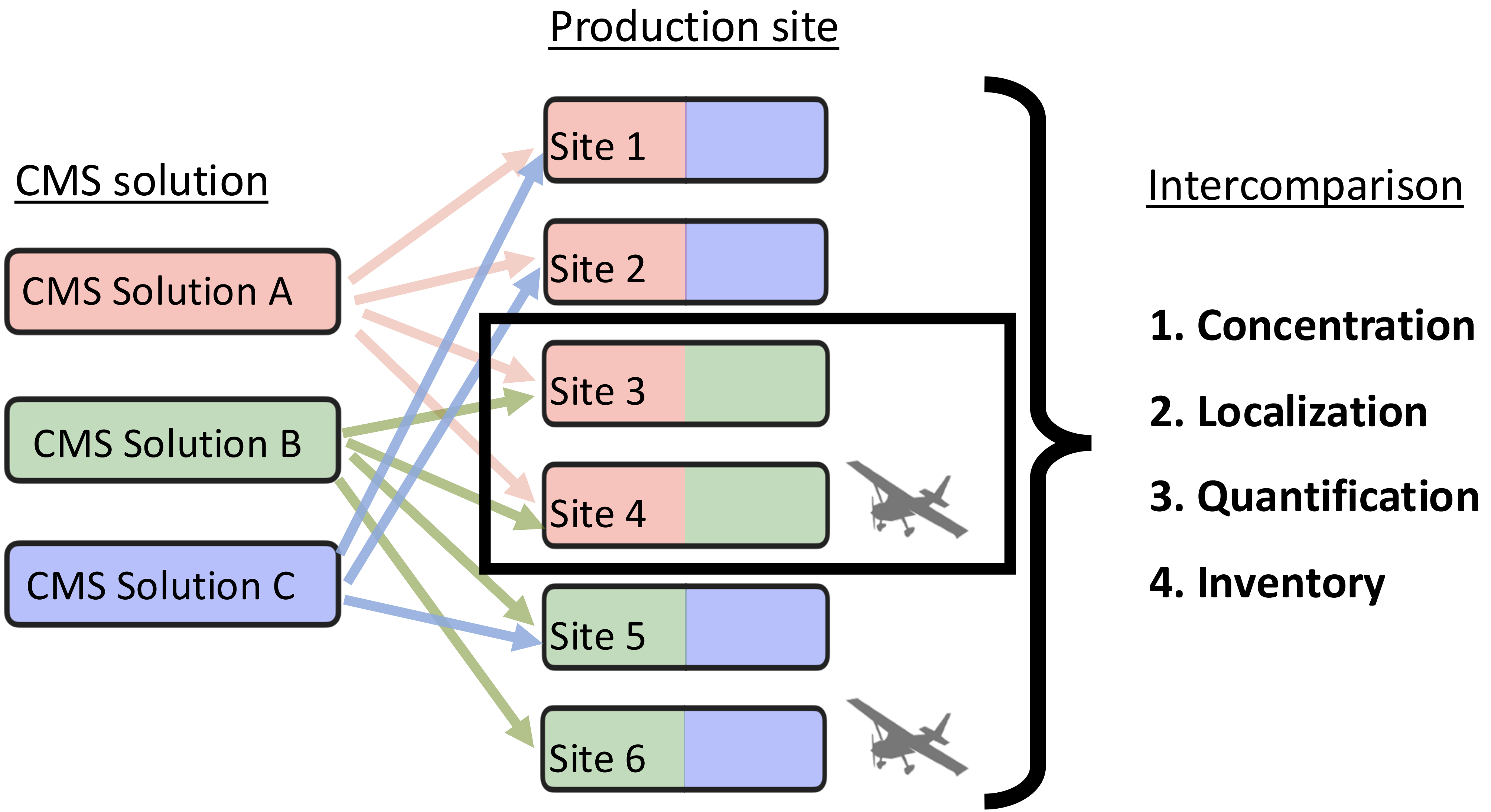
Experimental setup across six Oil & Gas sites



Intercomparison

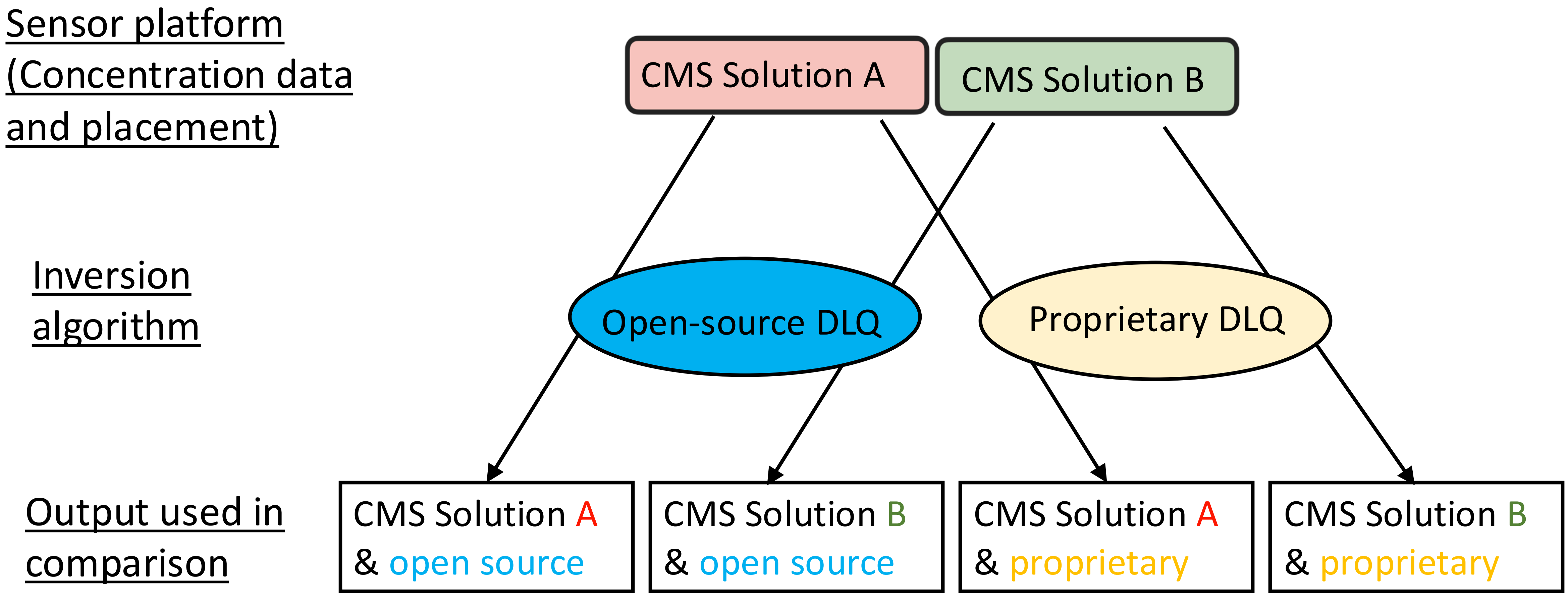
1. **Concentration**
2. **Localization**
3. **Quantification**
4. **Inventory**

Experimental setup across six Oil & Gas sites

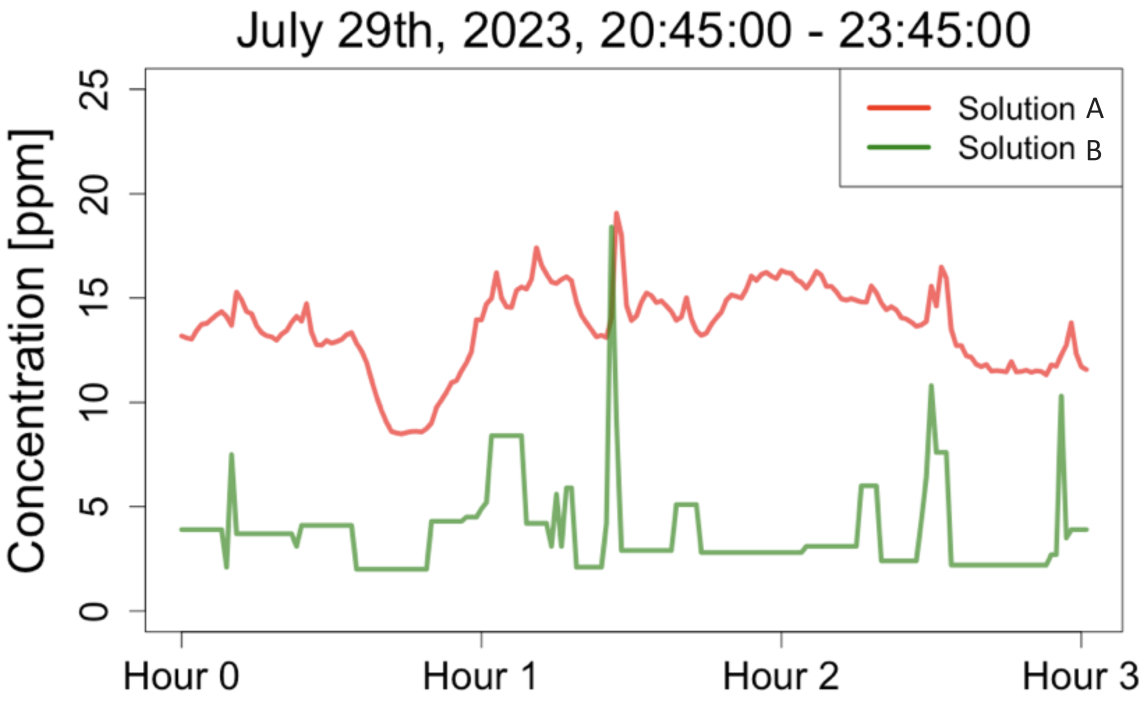


We focus on the Solution A to Solution B comparison here for brevity.

Separation of effect of platform from inversion algorithm



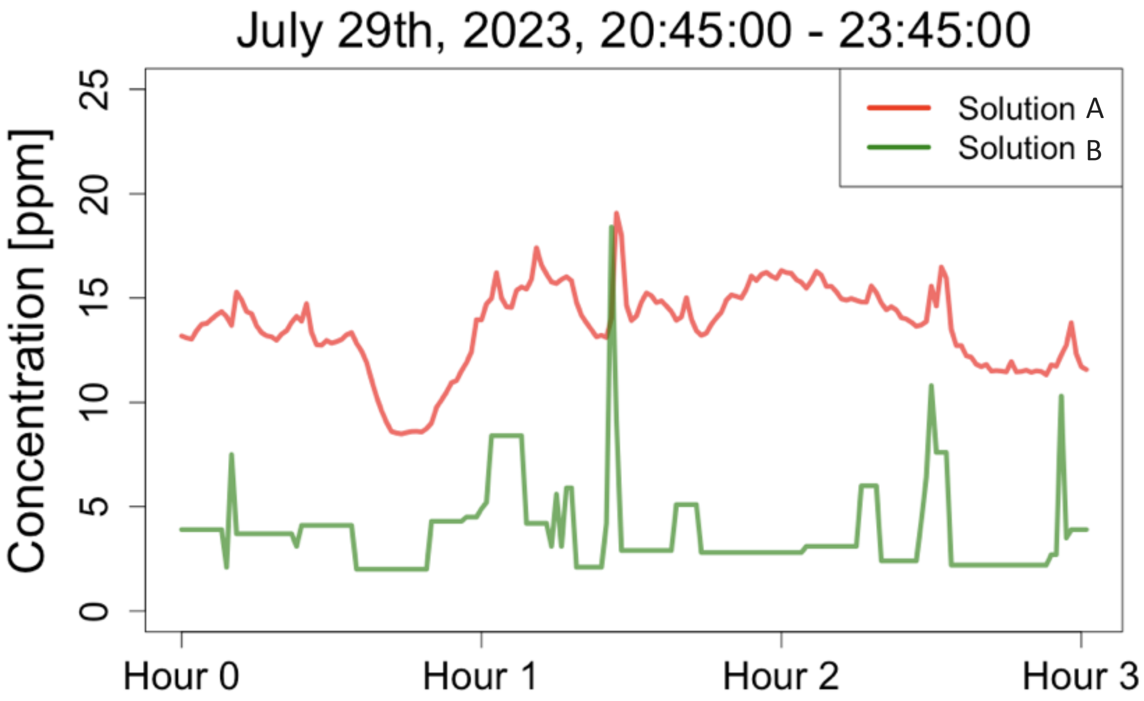
Comparison of concentration data for near co-located sensors



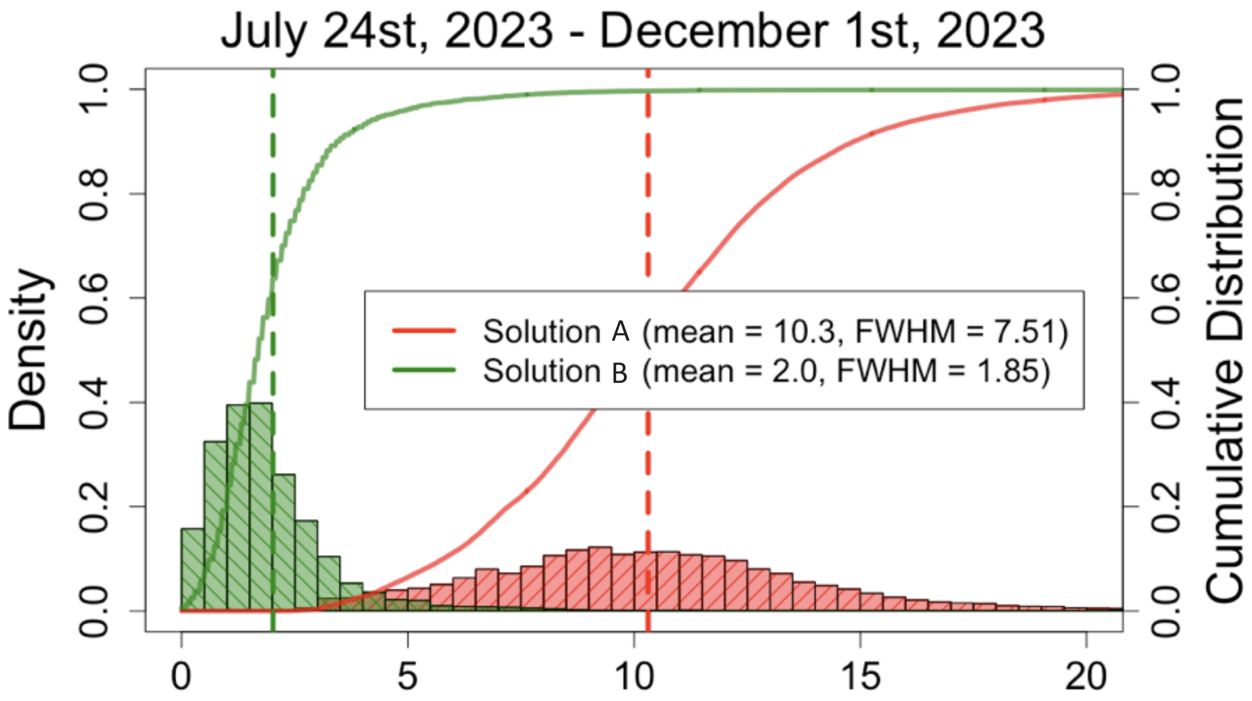
Concentration value from nearly co-located **CMS solutions** in time

Finding #1: Spikes in concentration data aligned in time,

Comparison of concentration data for near co-located sensors



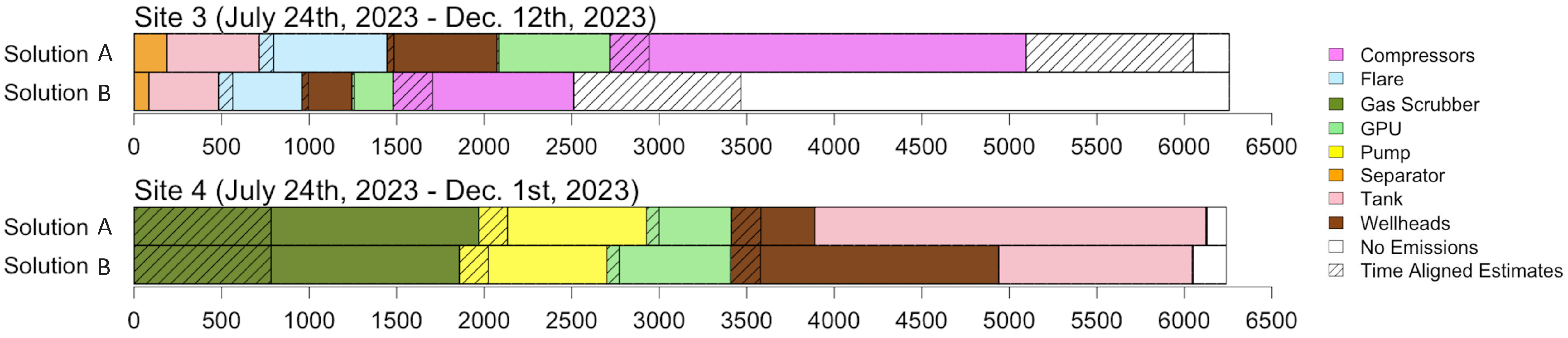
Concentration value from nearly co-located **CMS solutions** in time



Concentration value from nearly co-located **CMS solutions** in distribution

Finding #1: Spikes in concentration data aligned in time, but distributions have different characteristics.

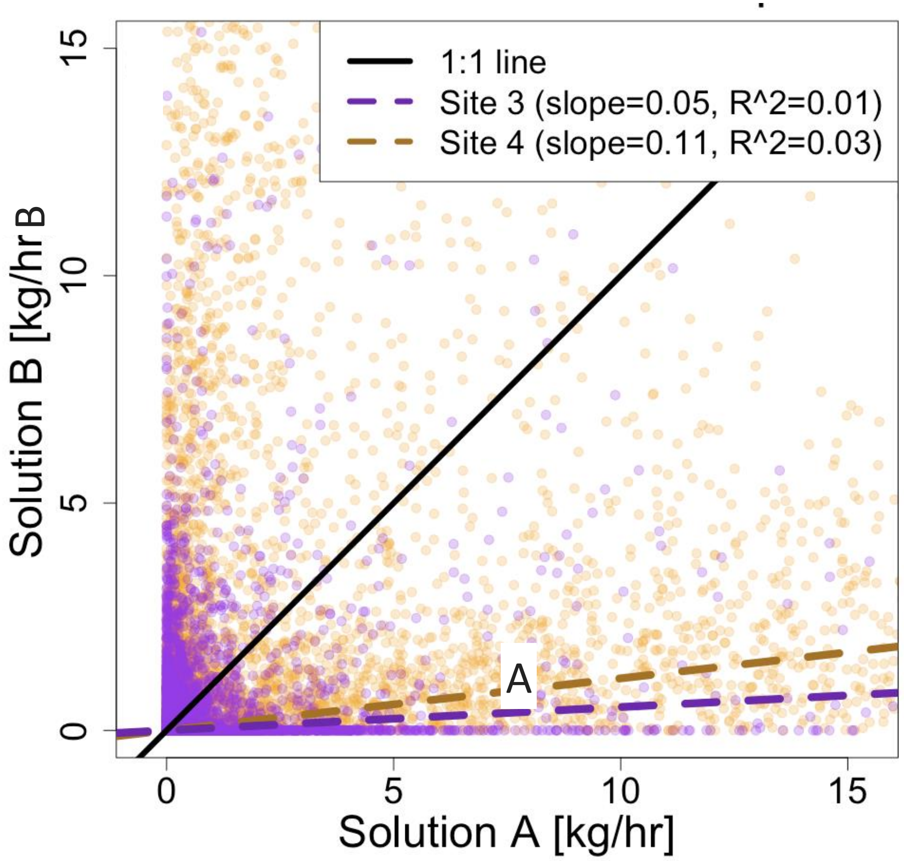
Localization estimates using the open-source DLQ algorithm



Finding #2: Localization estimates vary highly at 30-minute scale but begin to align over longer time periods.

Comparison of quantification estimates at 30-minute scale

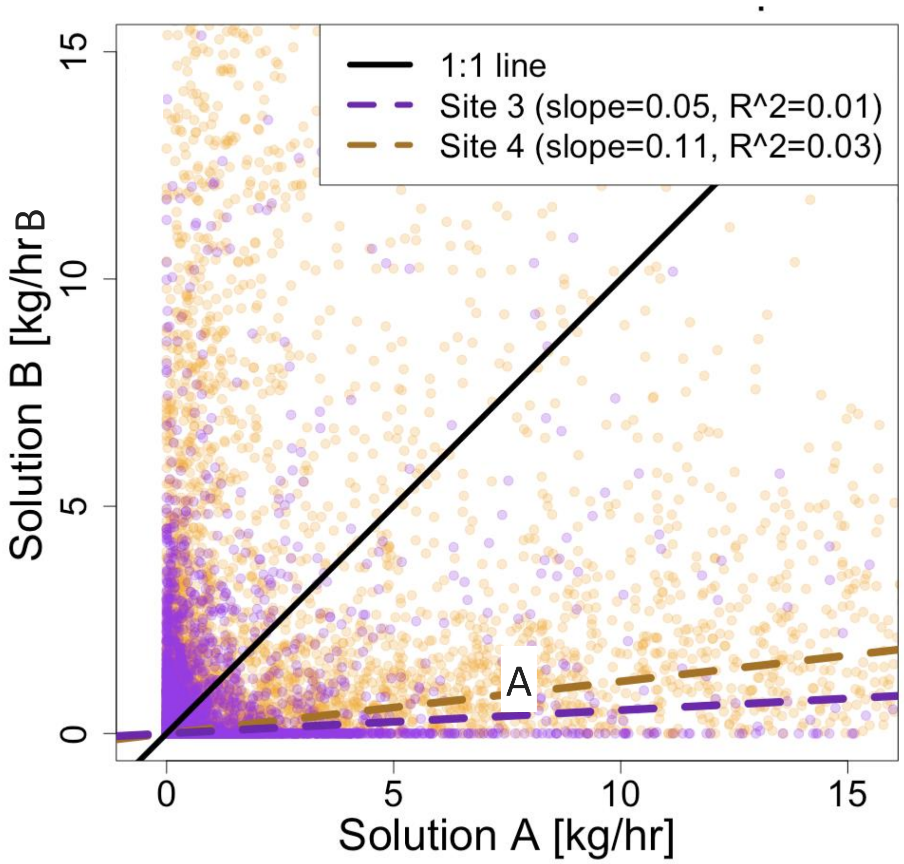
Emission rate estimates from
proprietary algorithm



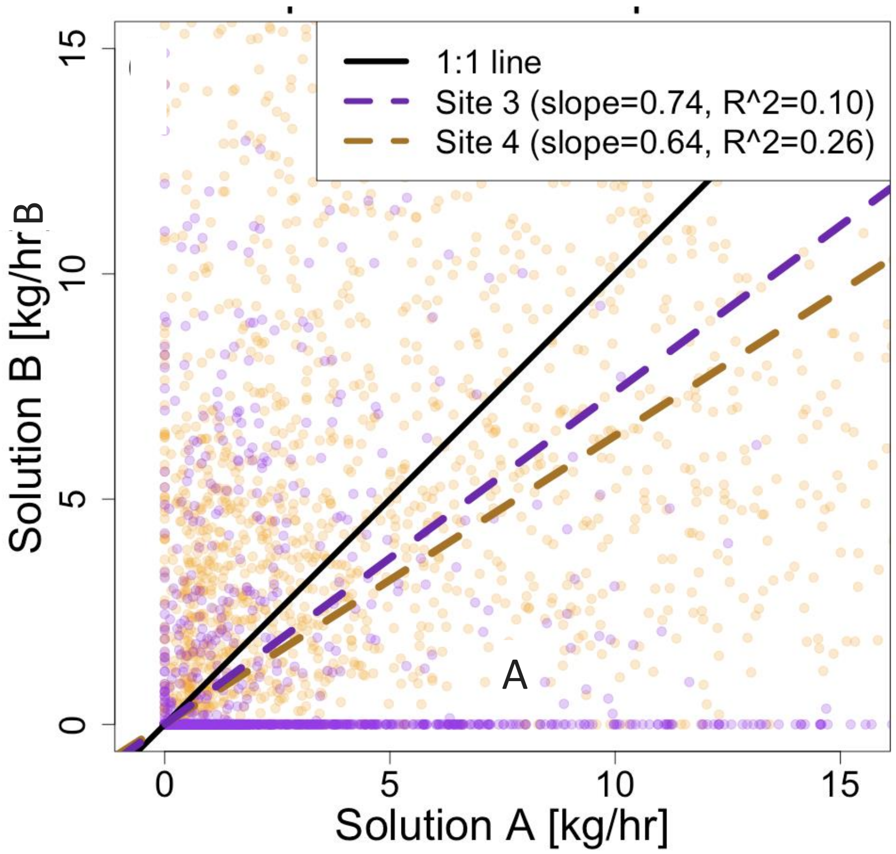
Finding #3: Quantification estimates vary highly at the 30-minute scale.

Comparison of quantification estimates

Emission rate estimates from
proprietary algorithm



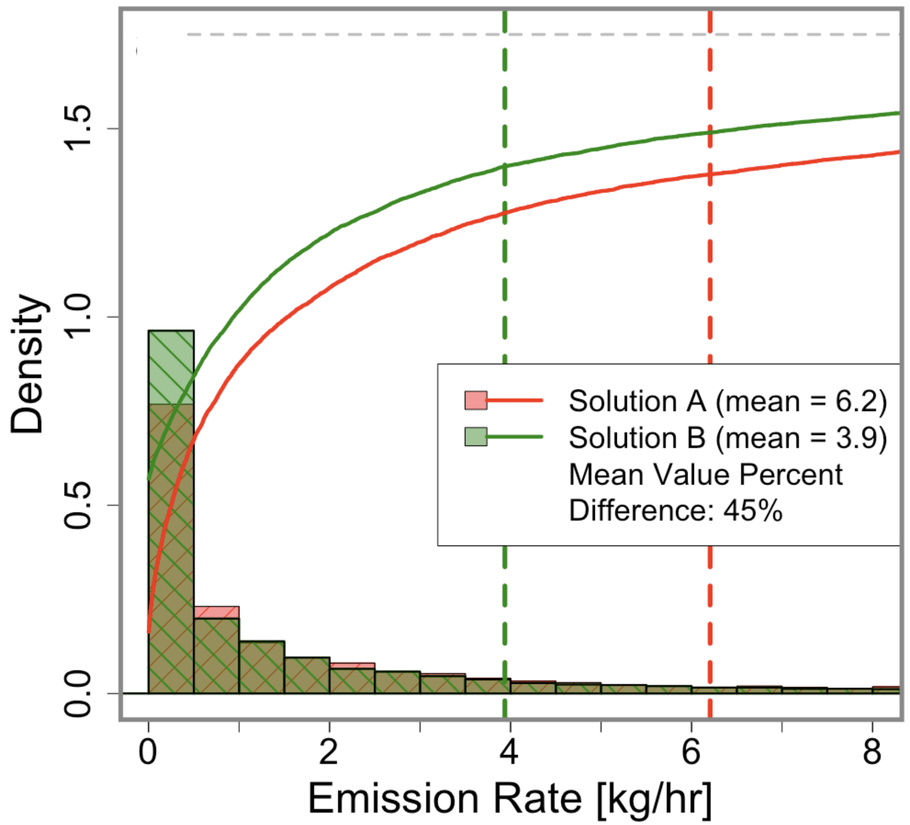
Emission rate estimates from
open-source DLQ algorithm



Finding #3: Quantification estimates vary highly at the 30-minute scale.

Comparison of quantification estimates at monthly scale

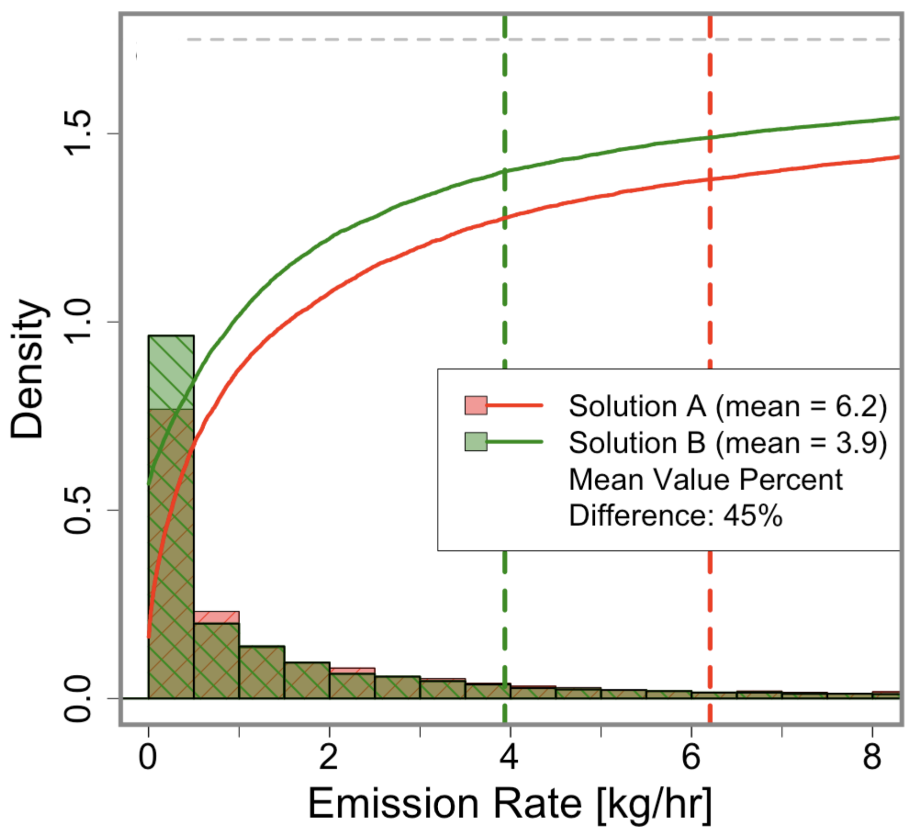
Emission rate estimates from
proprietary algorithm



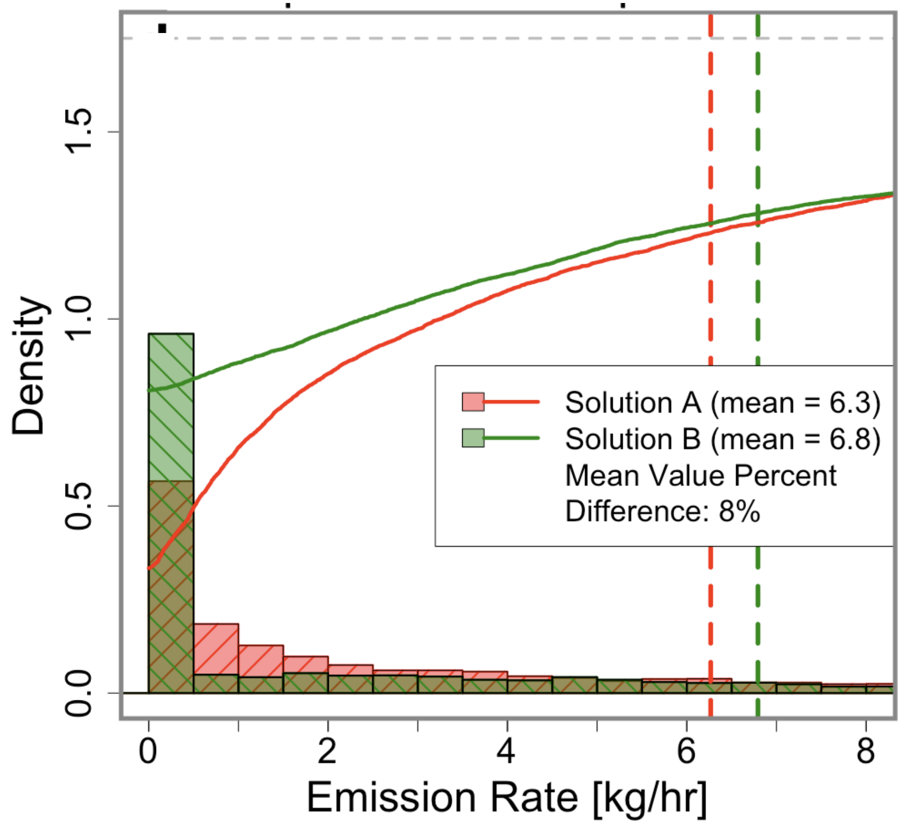
Finding #4: Quantification estimates are more aligned at the month-scale,

Comparison of quantification estimates at monthly scale

Emission rate estimates from
proprietary algorithm

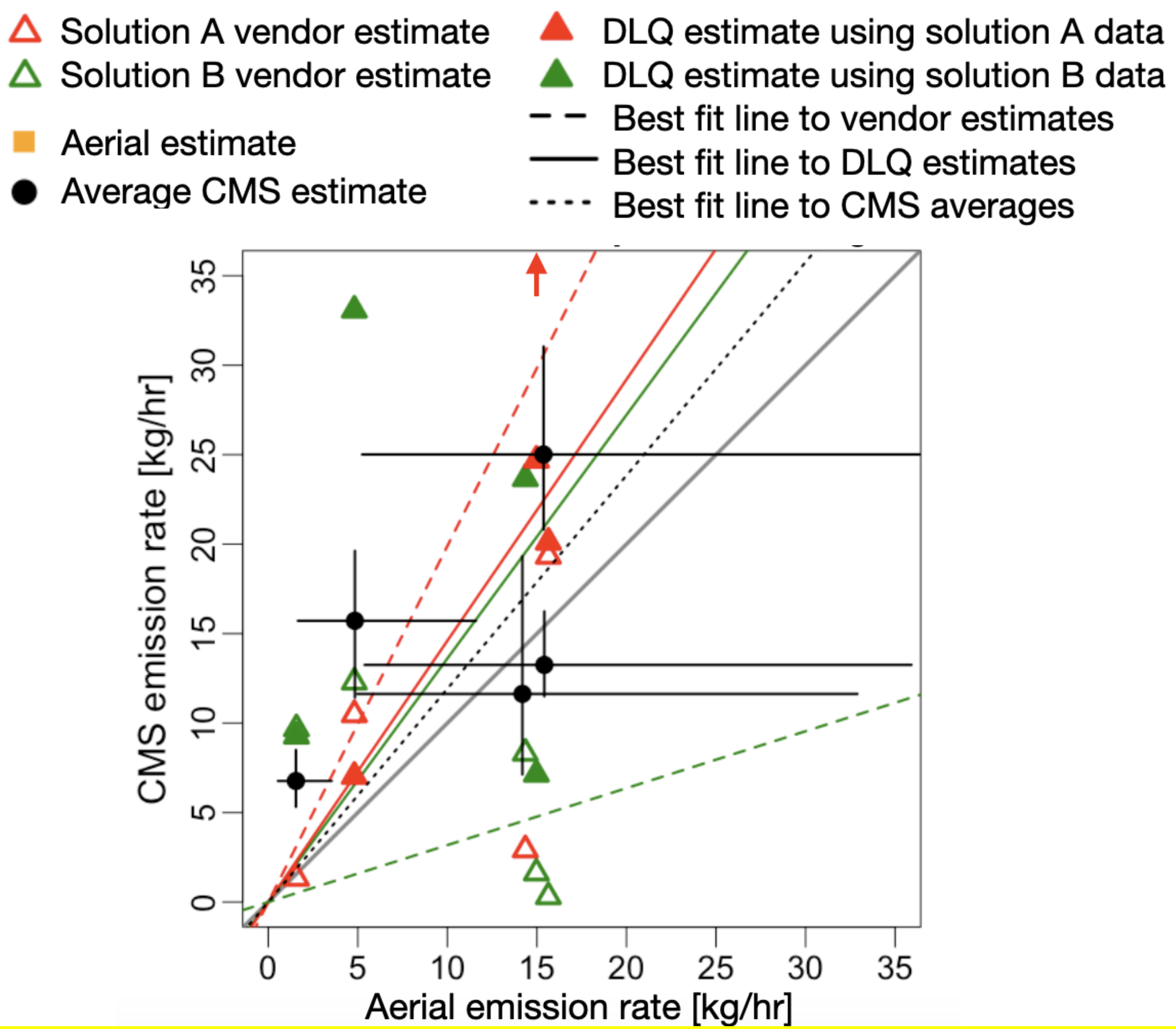


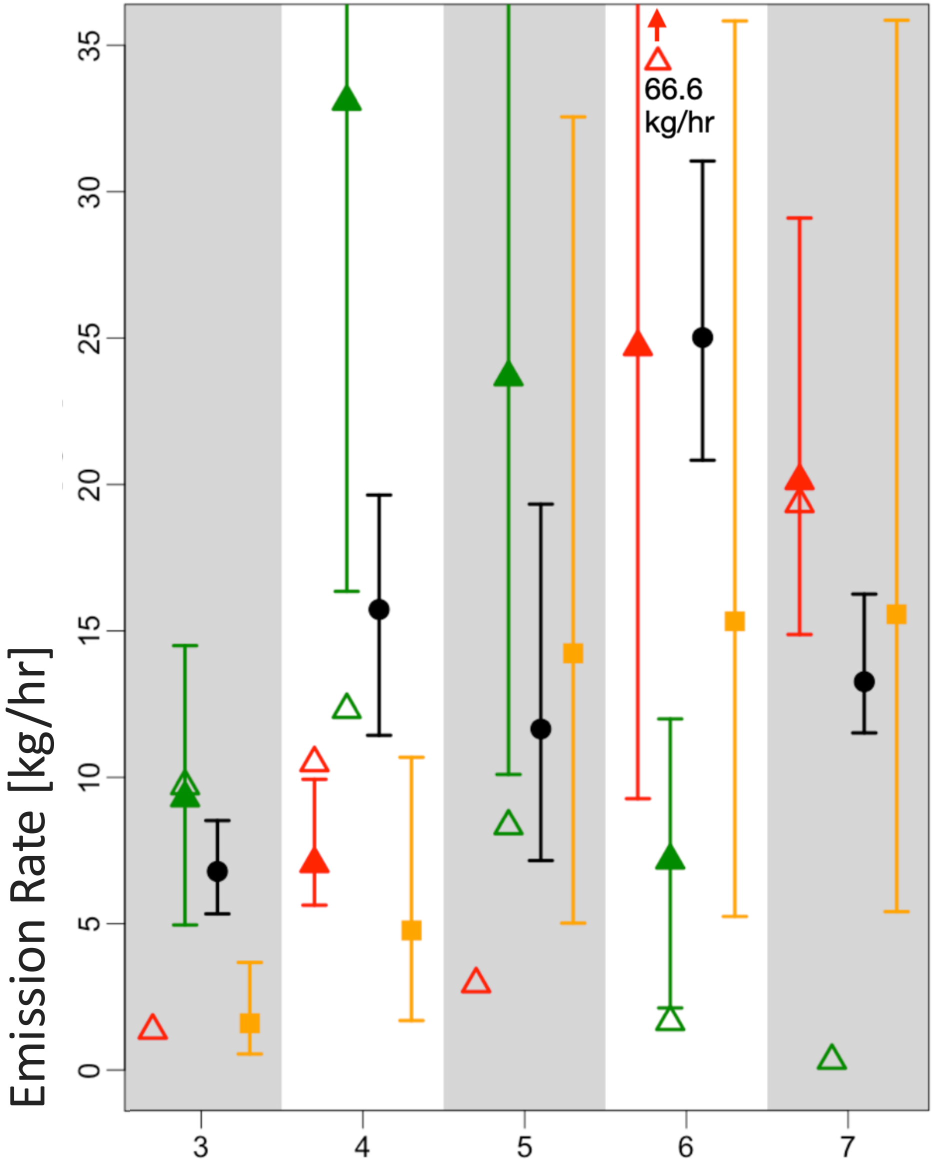
Emission rate estimates from
open-source DLQ algorithm



Finding #4: Quantification estimates are more aligned at the month-scale, especially when controlling for the inversion algorithm

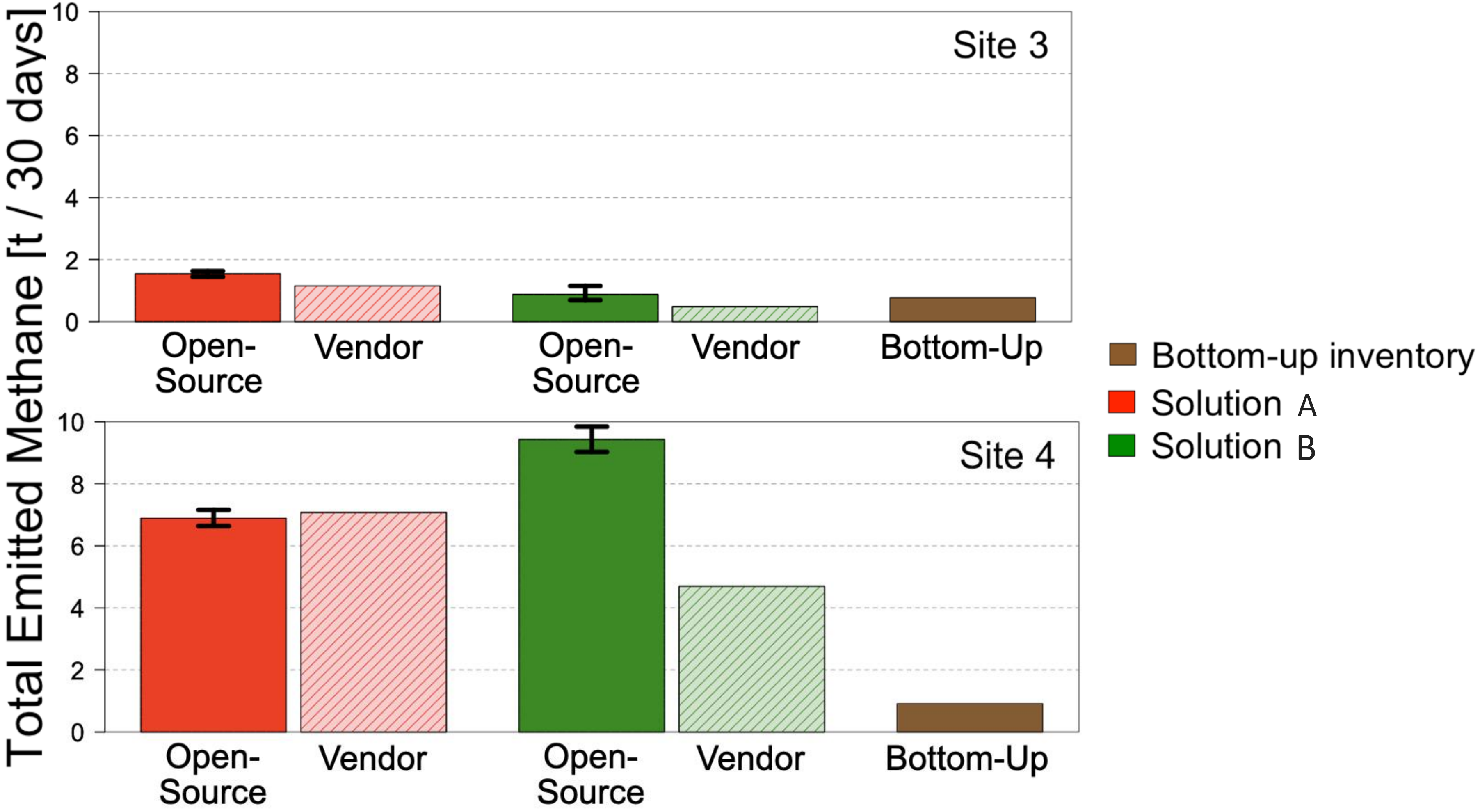
Comparison to aerial data





Finding #5: CMS estimates relatively close to aerial estimates when averaged

Comparison across similar sites



Finding #6: Similar sites do not necessarily have similar emission characteristics

Main Conclusions

- Raw CMS concentration data have different characteristics depending on sensor type and CMS solution.
- There is high variability in both localization and rate estimates at the 30-minute scale, however longer-term aggregates (e.g., multi-hour) provide more meaningful information.
- Emission location and quantification estimates from CMS broadly agree in distribution when aggregated over months, meaning that on longer time scales (e.g., for annual-inventories) the estimates are less sensitive to the type of CMS deployed.
- Differences between CMS derived rate estimates are mainly driven by the inversion algorithm, rather than the sensor platform (sensor type and arrangement)
- Comparing CMS-based measurement informed inventories to bottom-up inventories reveals that similar oil and gas sites do not necessarily have the same emission characteristics.

Thanks! Any questions: hammerling@mines.edu

Intercomparison of three continuous monitoring systems on operating oil and gas sites.

William Daniels*, Spencer Kidd*, Lydia (Shuting) Yang, Shannon Stokes, Arvind Ravikumar, Dorit Hammerling, under review, (2024). Preprint