Continuous Monitoring of Landfill Methane – Complexities & Applications

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Applications

Working Face Emissions Measurement and Quantification

- Cannot be covered using Method 21 (safety issues) or downward-looking lasers (dispersed sources)
- High **temporal variability** of emissions from working face
- Can help **differentiate allowable emissions** from leaks
- **Nighttime emissions** monitoring (temporal coverage)

Fenceline Emissions Measurement

- Determine **beyond-fenceline impact** of the landfill operation with high temporal resolution

Complementing Other Measurement Techs

- Can inform other technologies on emissions event **duration and frequency**
- Provides **site-specific atmospheric measurements**
- Can improve source flux rate estimation by **localizing active sources**
- Informs **frequency of additional surveys** using other methods

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Complexities

Complexities – compared to upstream oil and gas

- Large areas
- Complex terrain
- A combination of point and diffuse sources
- Higher background emissions
- Weather dependency of emissions

Technical Needs

- Understanding different sources of **uncertainties** related to each measurement and quantification solution
- Investigation of **optimum CMS configuration** (sensor density and placement)
- Developing tools to understand **local dispersion patters** resulted from microclimate and turbulence motions
- Developing enhanced **quantification** methods accounting for topographical complexities

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Uncertainties in Emissions Estimates

1. Measurement uncertainty

- Comparison of measured concentrations to ground-truth data (gold-standard measurement)

2. Emission rate estimation uncertainty

- Determining uncertainties resulted from estimating flux rate at the source locations based on the observed concentrations at the sensor location

3. Extrapolation uncertainty

- Extrapolating limited observations to longer times (mainly applicable to snapshot measurements)

Measurement Uncertainty – Collocation Studies

(Source: EPA)


(Source: EPA)

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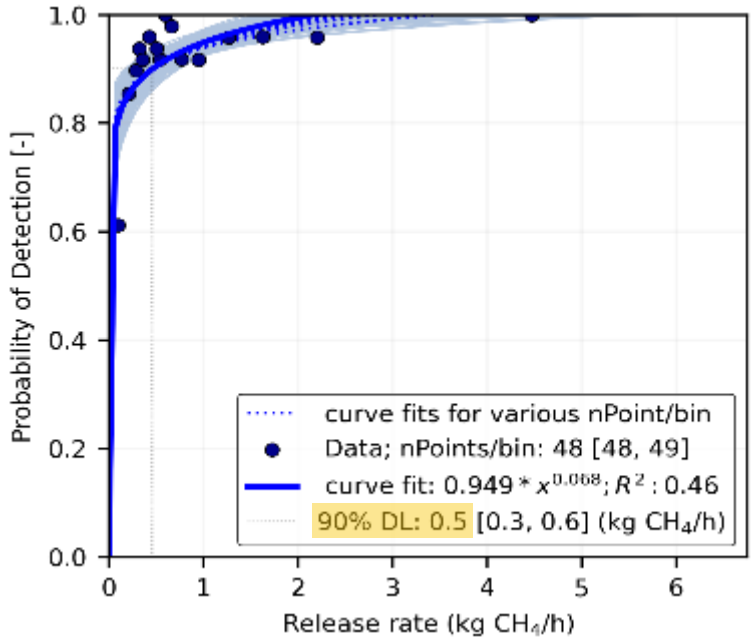
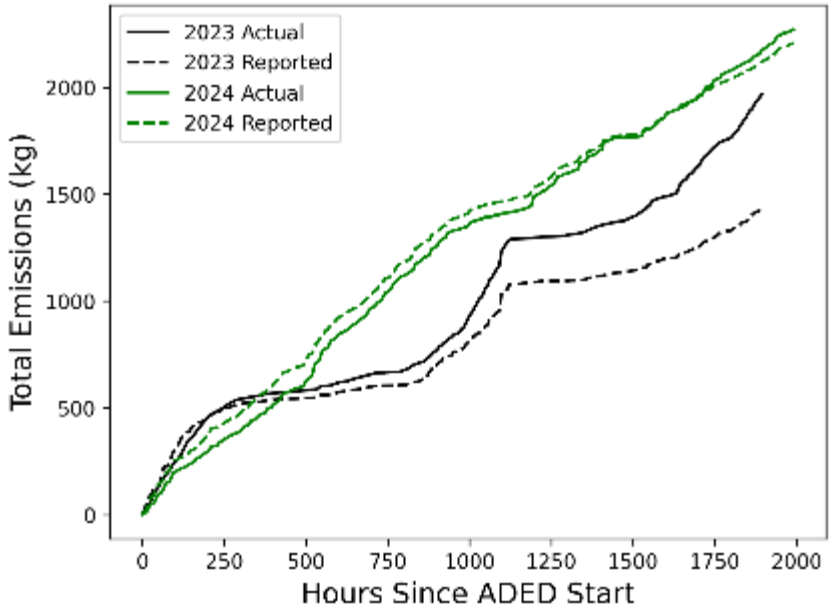
Controlled Release Studies – ADED2024

DETECTION & LOCALIZATION NUMBERS ARE DIRECTLY FROM OUR 2024 METEC ADED REPORT

0.5	PROBABILITY OF DETECTION (KG/H)
98.7	% OF RELEASES ACCURATELY LOCATED
2.8	% CUMULATIVE QUANTIFICATION ERROR





- Rates are held constant in time for each experiment
- Every source turns on/off simultaneously
- No “background emissions”

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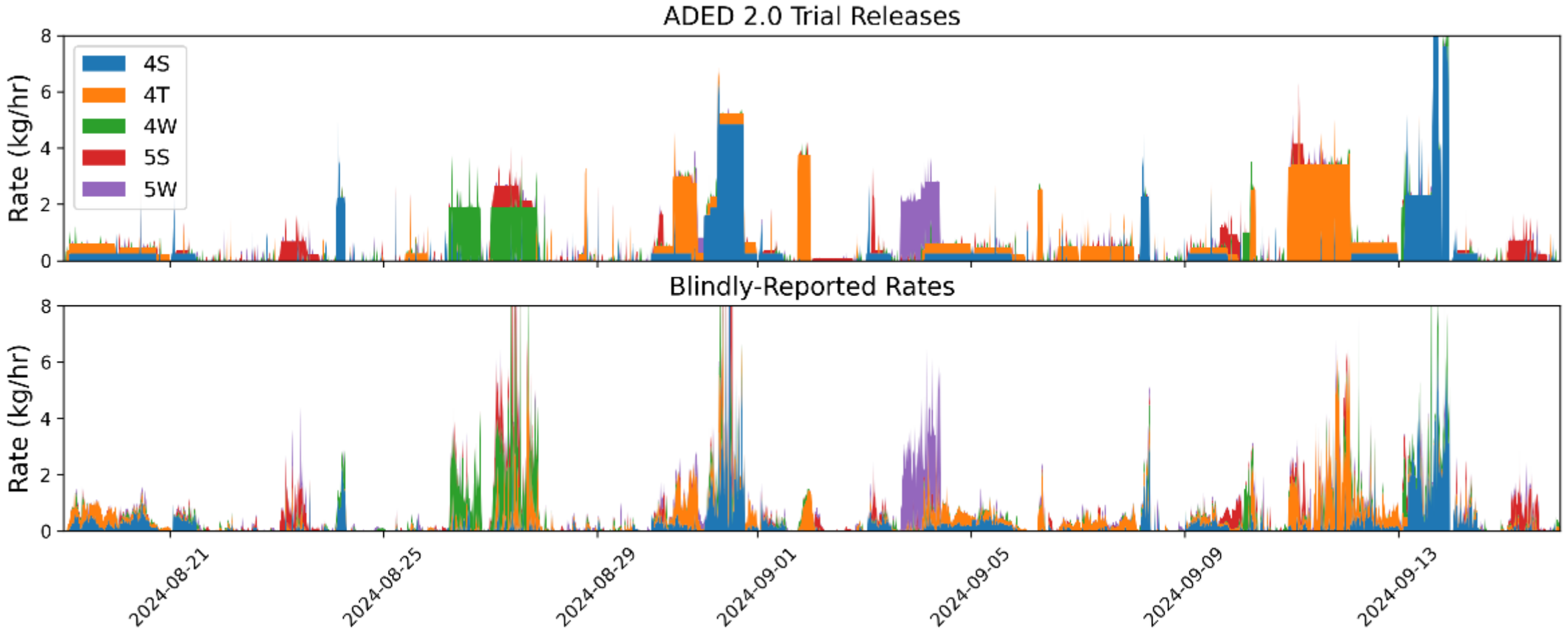
ADED2.0 Trial Study Results

- A **blind** study, we did not know rates, locations, or any general features of the testing ahead of time.



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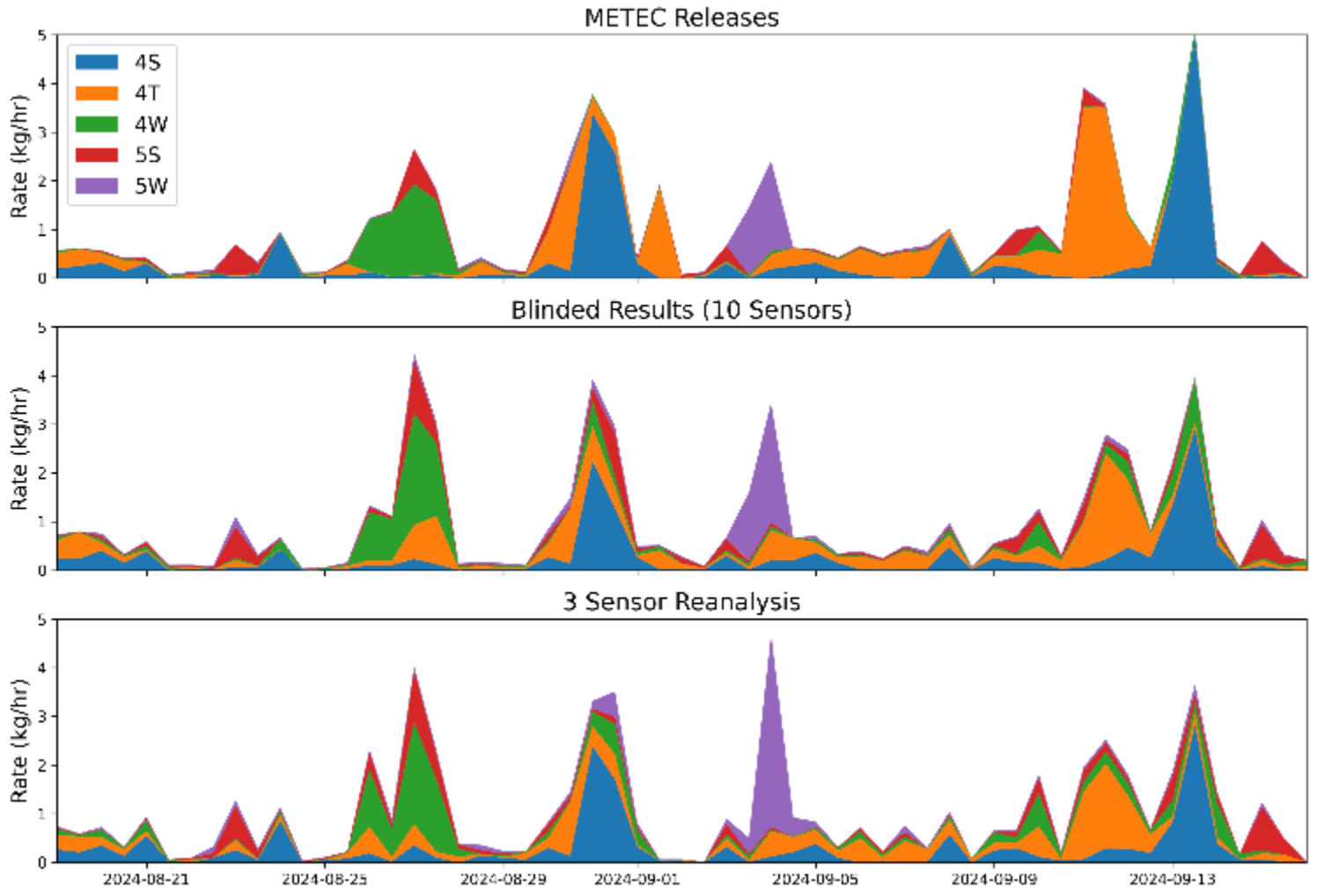
ADED2.0 – Impact of Reduced Sensor Count

12-hour aggregated rates (via a mean) compared to the blindly reported actual 12-hour averages from METEC

Impact of Reduced Sensor Count

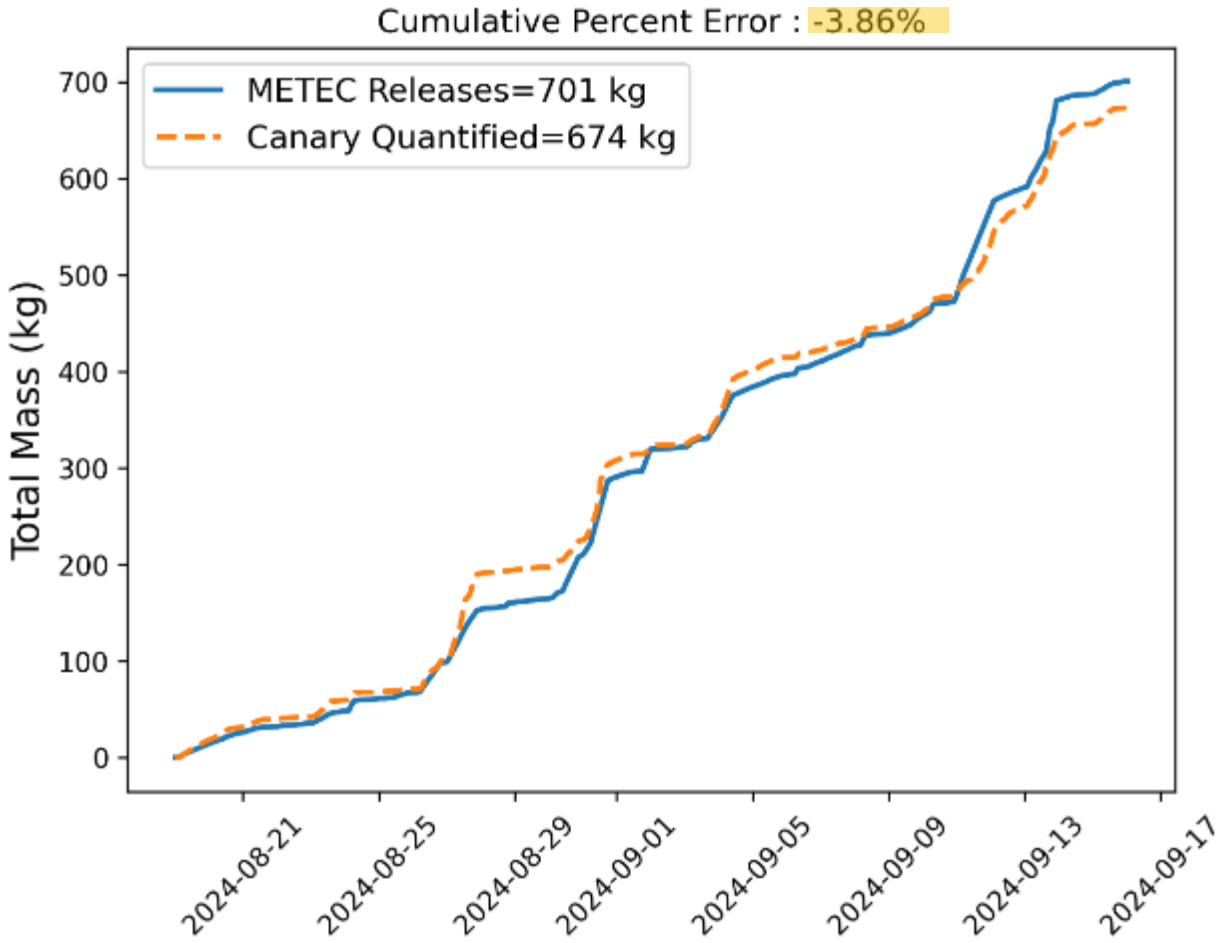
We recompute quantified rates with subset of sensors to ensure that results are robust against varying sensor density

Takeaway: reducing the sensor count mainly affects localization and time-to-detection, the total site-level emissions estimates remain accurate



ADED2.0 Trial Study Results

We underestimated the total mass by 27 kg over a span of 28 days corresponding to a mean error of: -0.04 kg/hr



SENSOR NETWORK DENSITY & PLACEMENT

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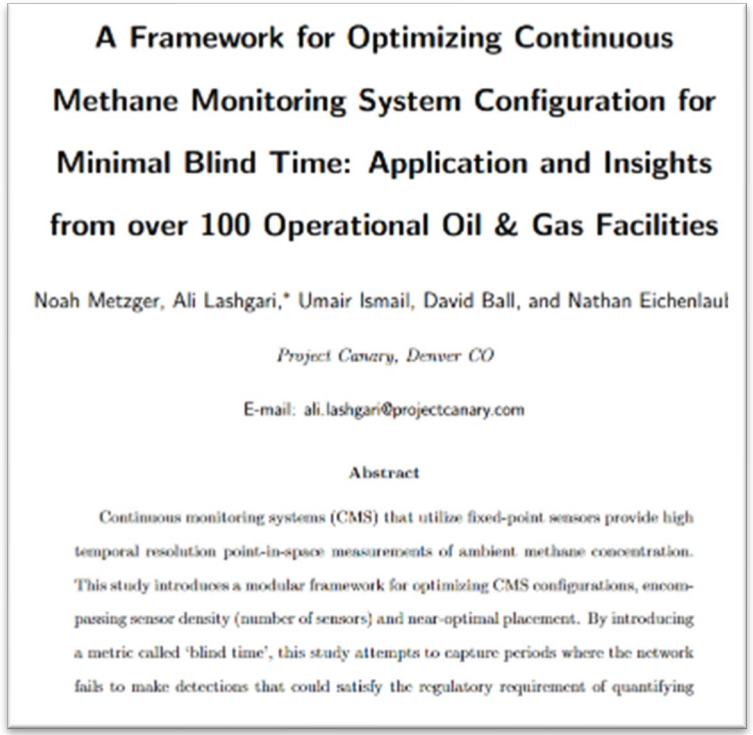
CMS Configuration – Sensor Density & Placement

➢ O&G applications

With proper continuous monitoring system (CMS) configuration and sufficient sensitivity, on average, a CMS with 3 sensors can reliably **detect emissions on 12-hr time blocks in 92.9%** of cases in regular upstream O&S facilities, and also provide **alerts of anomalous emissions within less than 1.5 hrs** of the event starting time.



A Framework for Optimizing Continuous Methane Monitoring System Configuration for Minimal Blind Time: Application and Insights from over 100 Operational Oil & Gas Facilities

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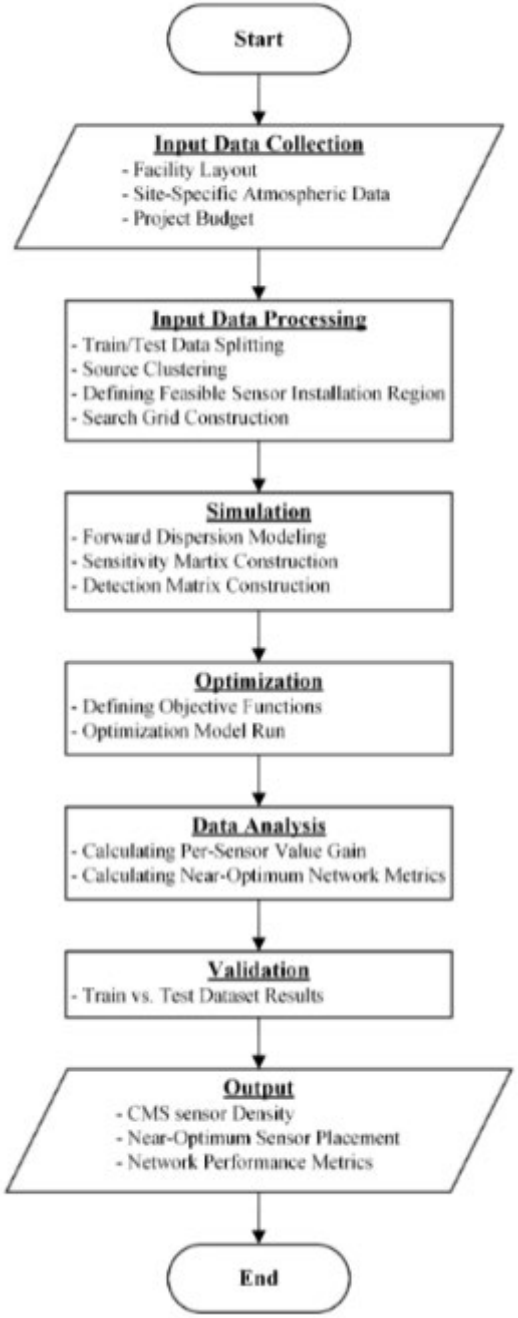
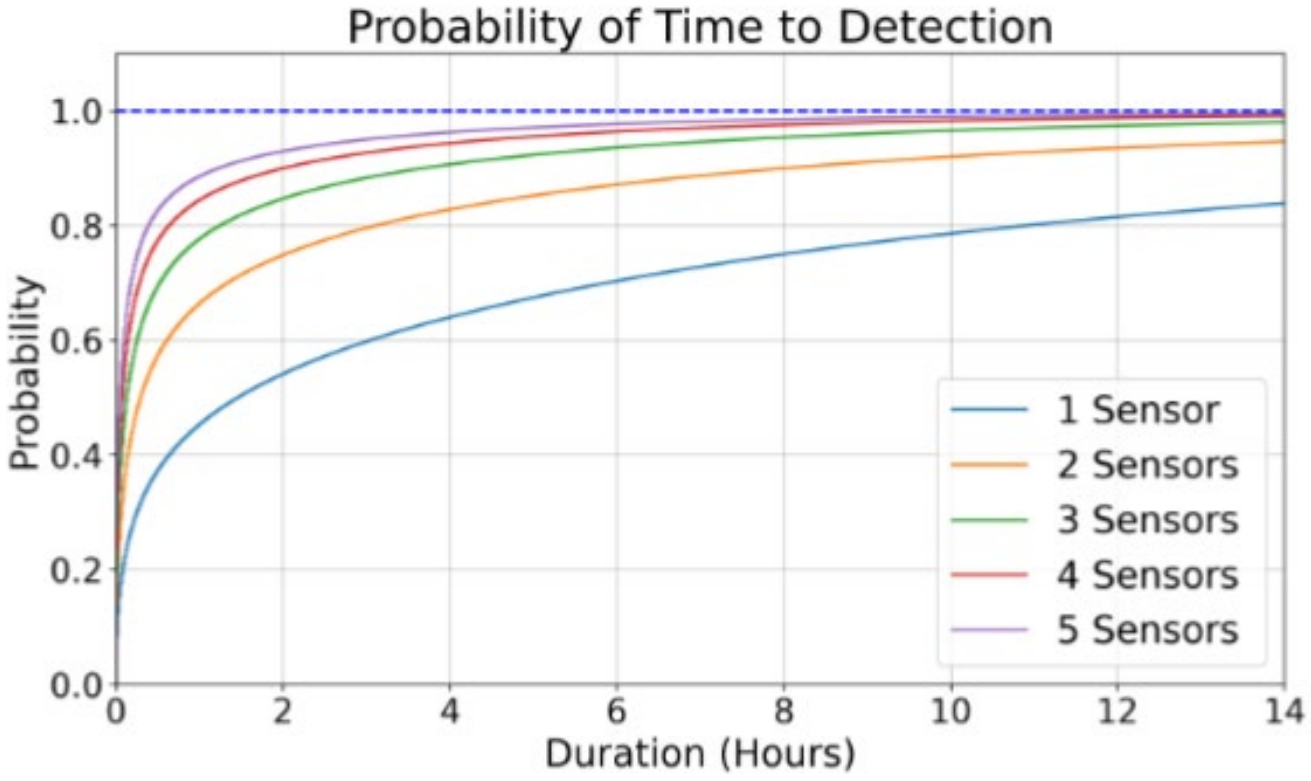
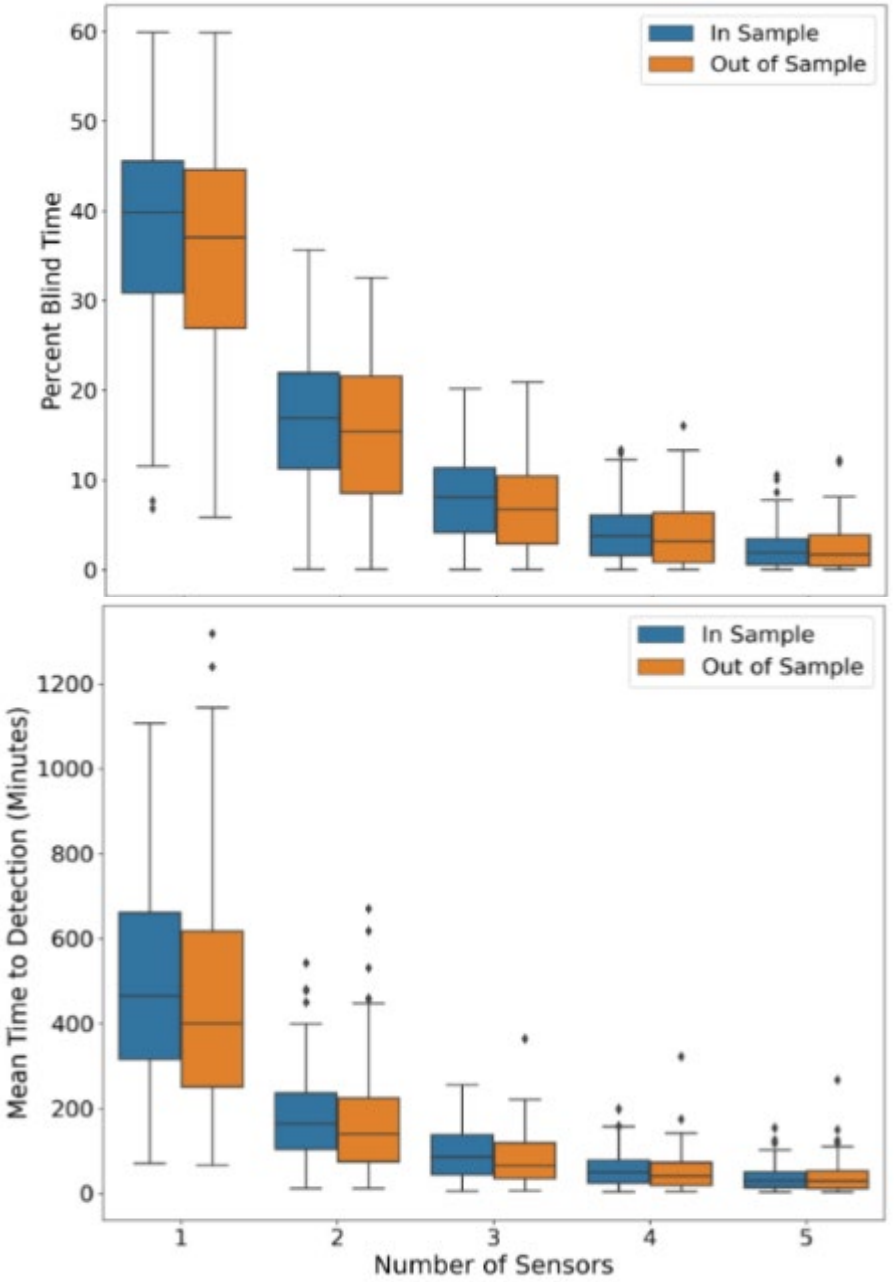
Abstract

Continuous monitoring systems (CMS) that utilize fixed-point sensors provide high temporal resolution point-in-space measurements of ambient methane concentration. This study introduces a modular framework for optimizing CMS configurations, encompassing sensor density (number of sensors) and near-optimal placement. By introducing a metric called 'blind time', this study attempts to capture periods where the network fails to make detections that could satisfy the regulatory requirement of quantifying

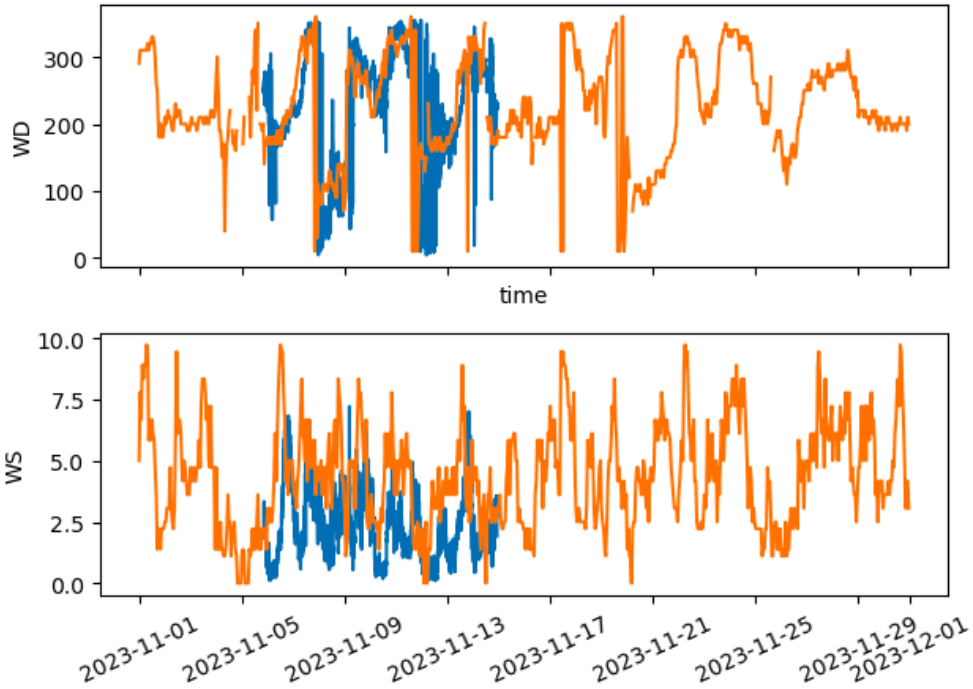


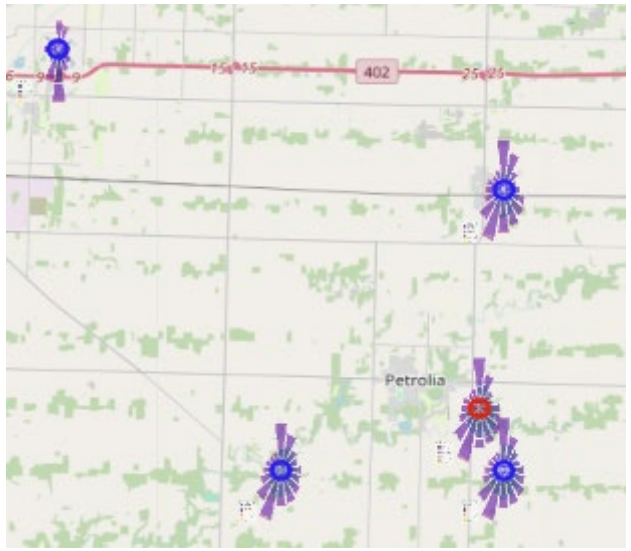
CMS Configuration – O&G applications



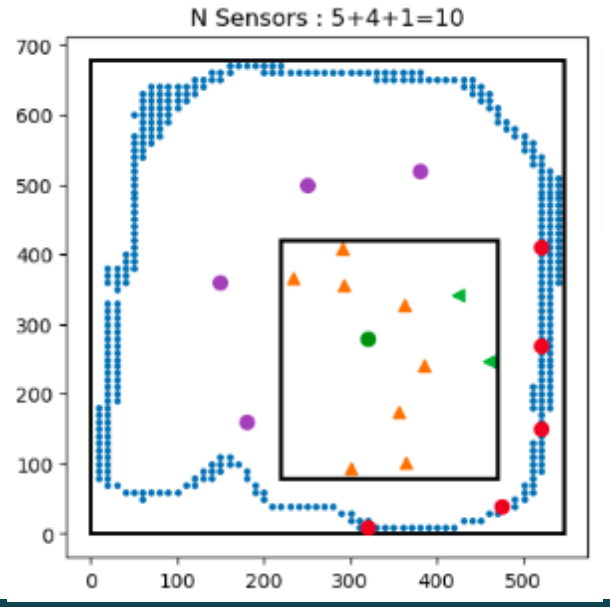


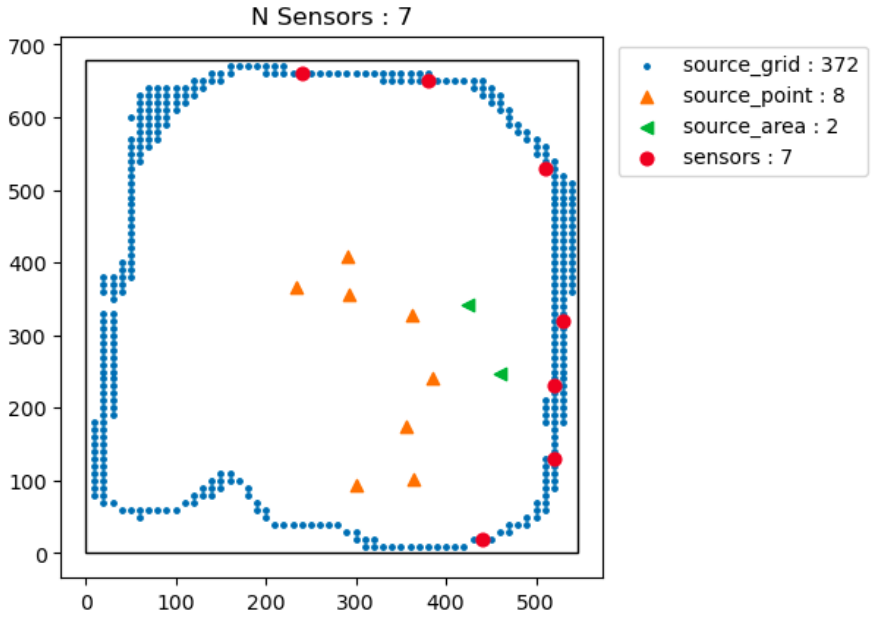
CMS Network Configuration

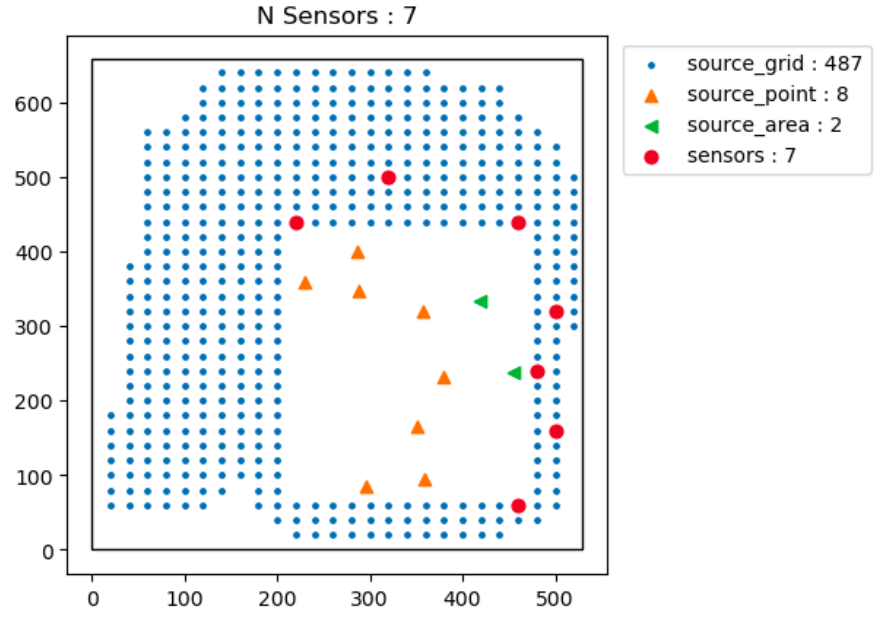




CMS Network Configuration







IMPACT OF COMPLEX TERRAIN

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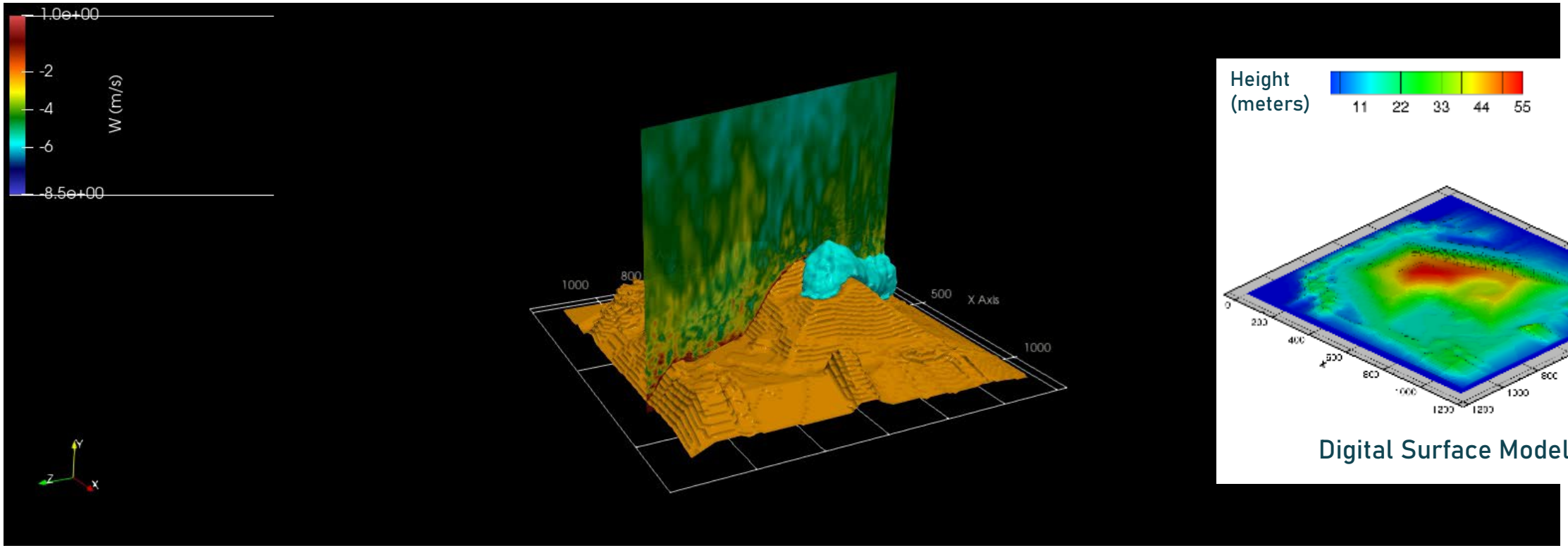
Large Eddy Simulation of Pollutant Dispersion in a Landfill



- Visualization of the ABL above the undulating terrain (gold color)
- Two distinct releases of methane (30 minutes) identified via iso-surfaces (cyan color)
- The vertical plane plots the wind velocity in the Z direction in m/s

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MULTISCALE MEASUREMENT

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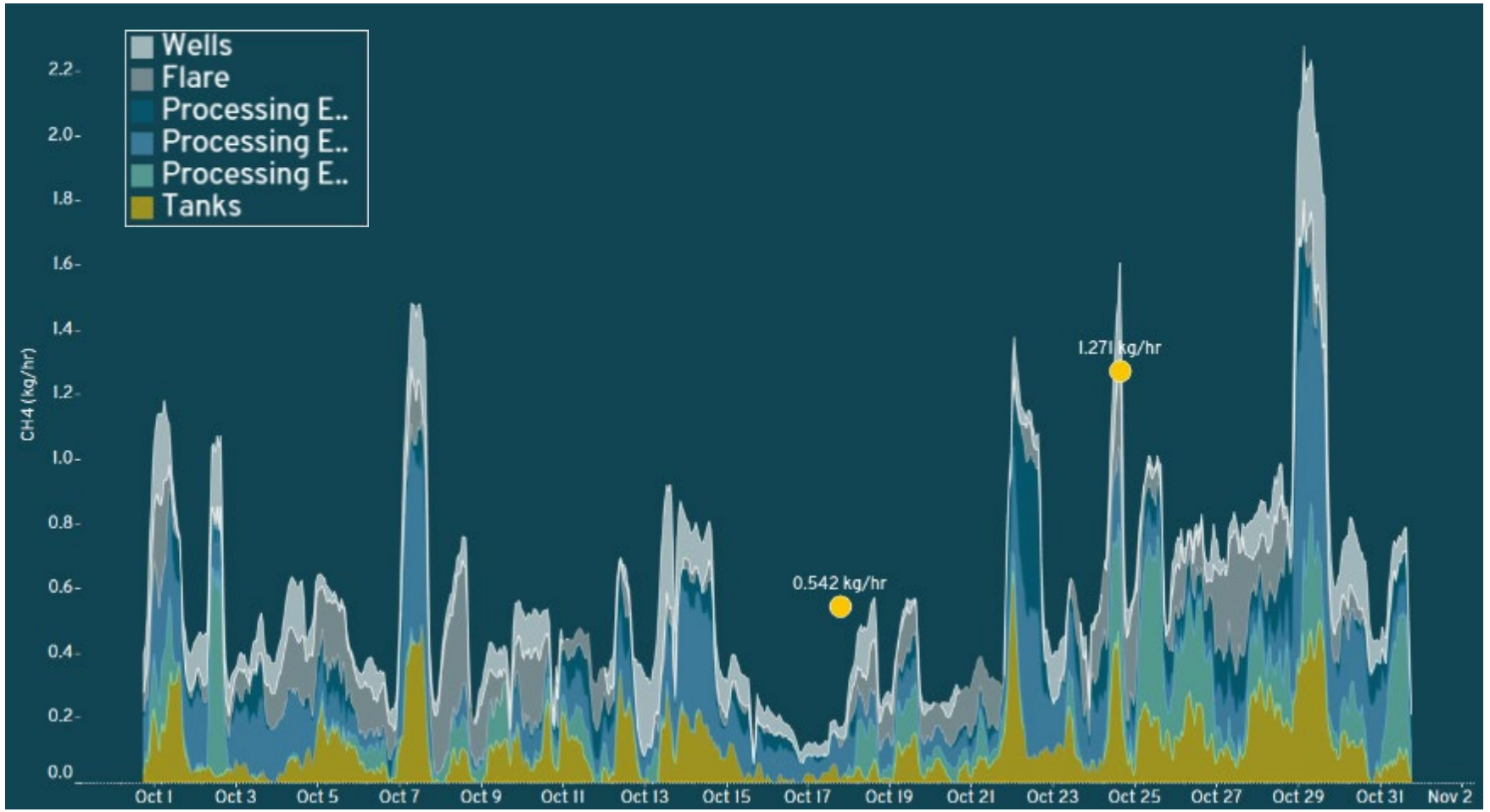
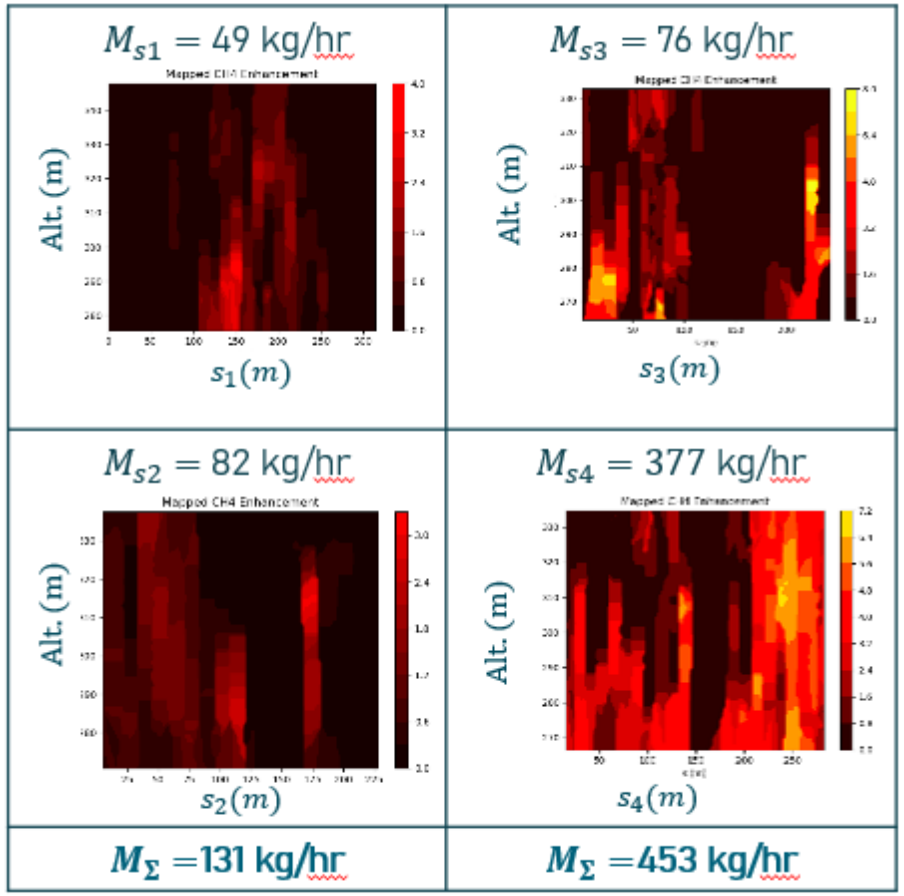
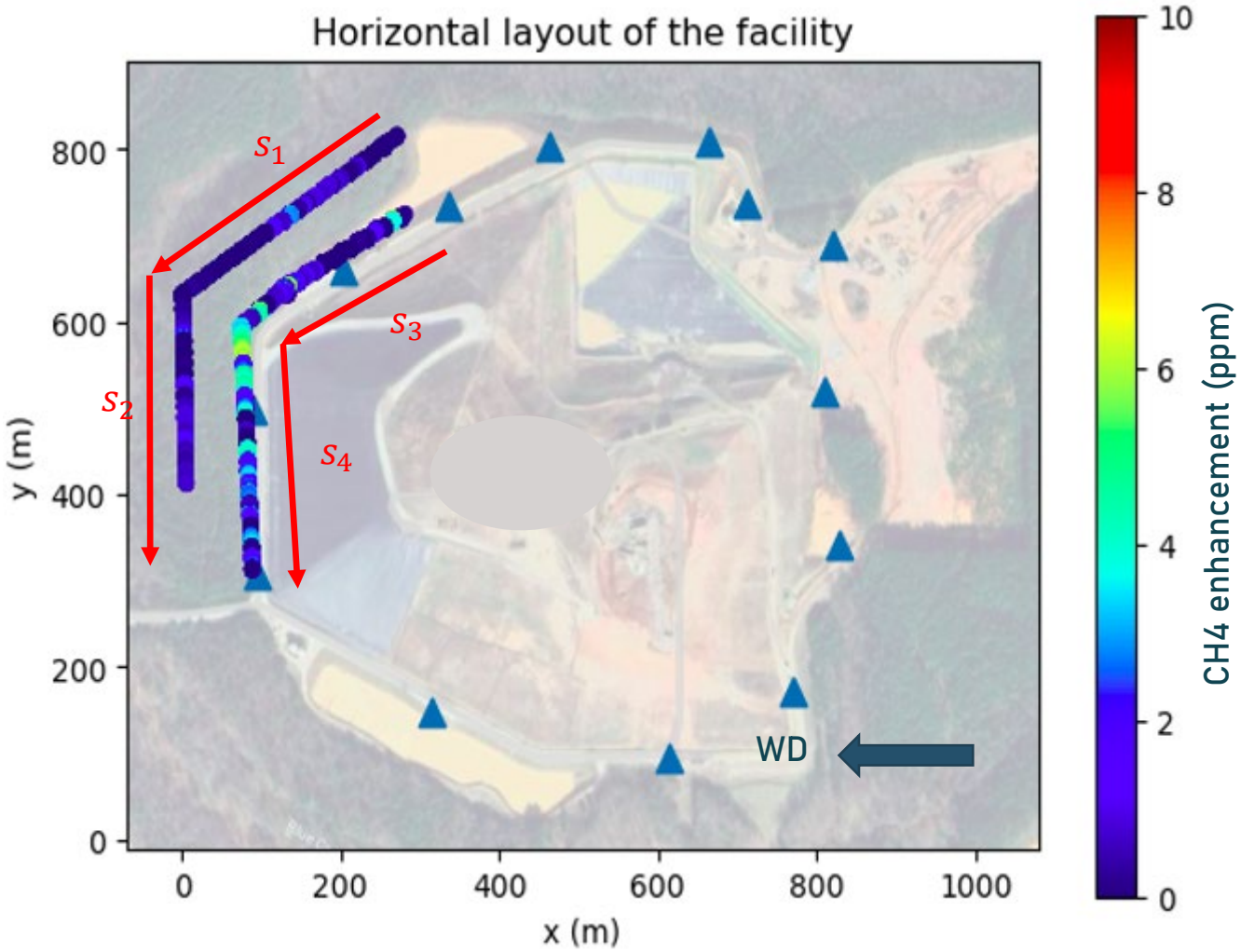
CMS + Flyover

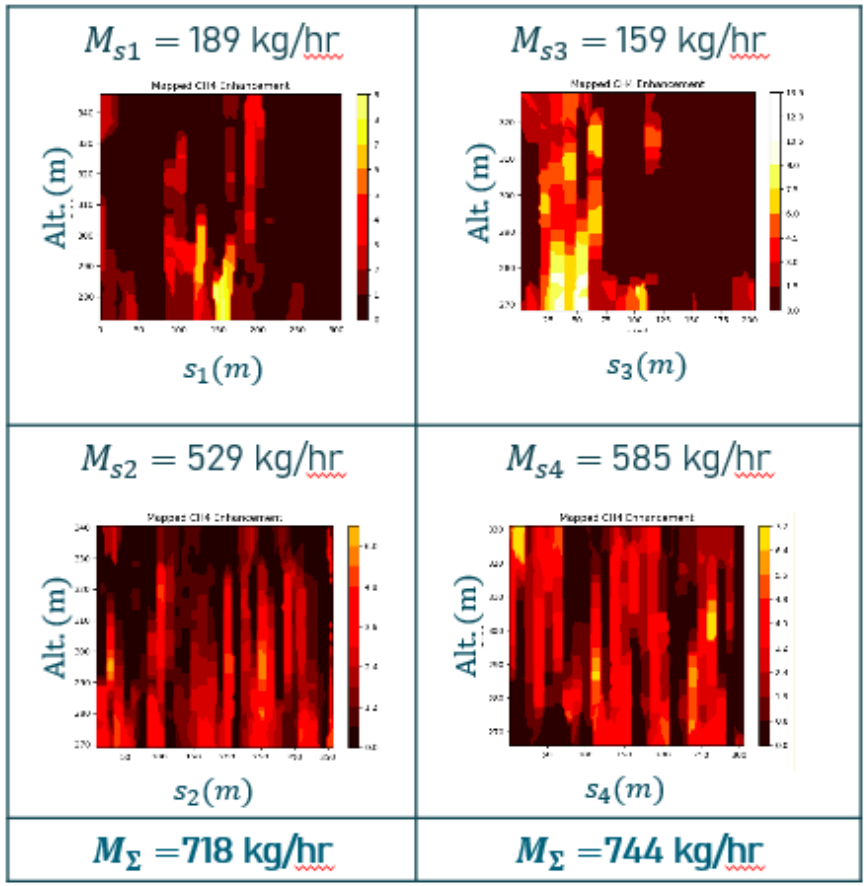

Wells
Flare
Processing E..
Processing E..
Processing E..
Tanks
CH4 (kg/hr)
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.542 kg/hr
1.271 kg/hr
Oct 1
Oct 3
Oct 5
Oct 7
Oct 9
Oct 11
Oct 13
Oct 15
Oct 17
Oct 19
Oct 21
Oct 23
Oct 25
Oct 27
Oct 29
Oct 31
Nov 2

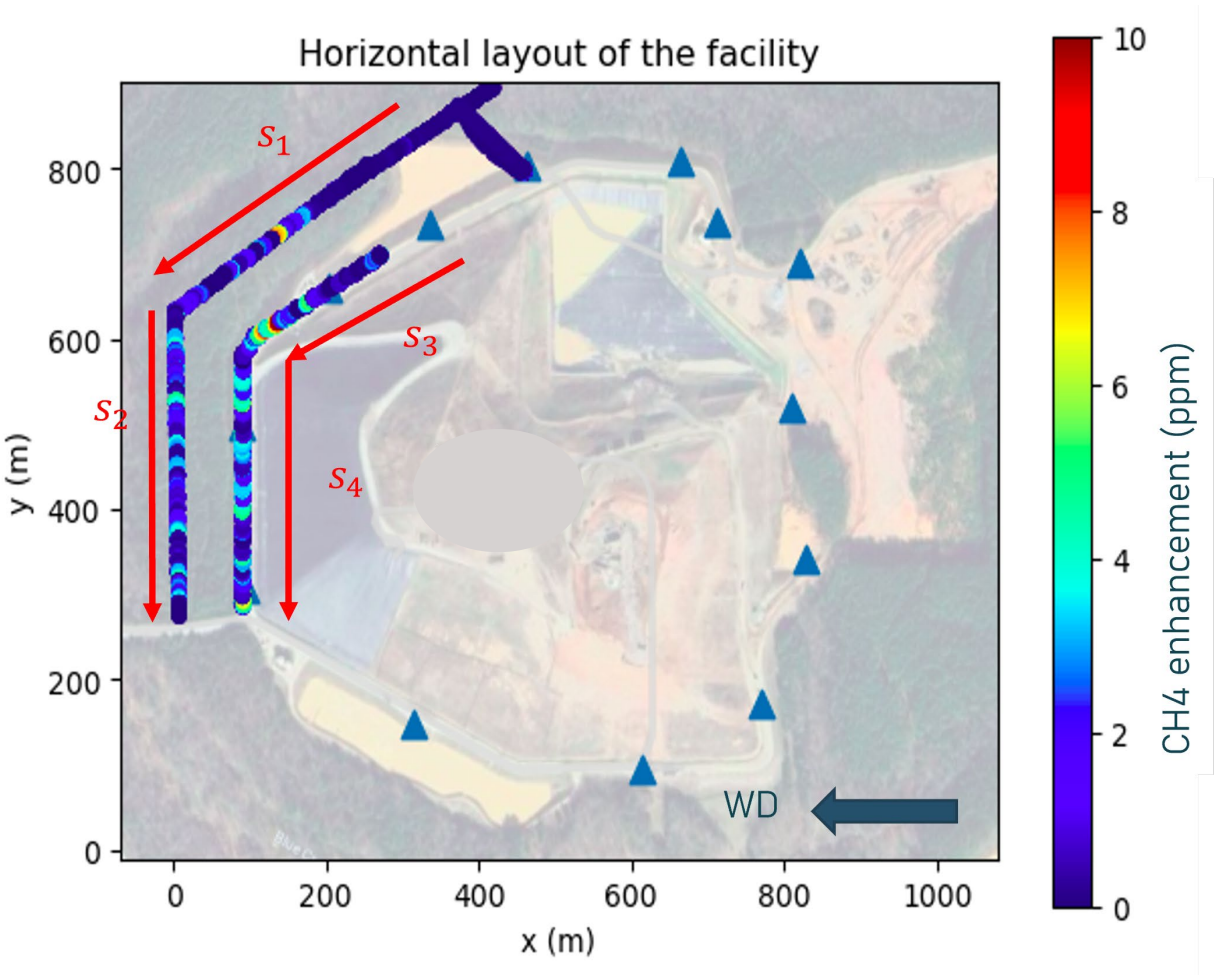
CMS + Flux Plane Measurement – Day 1



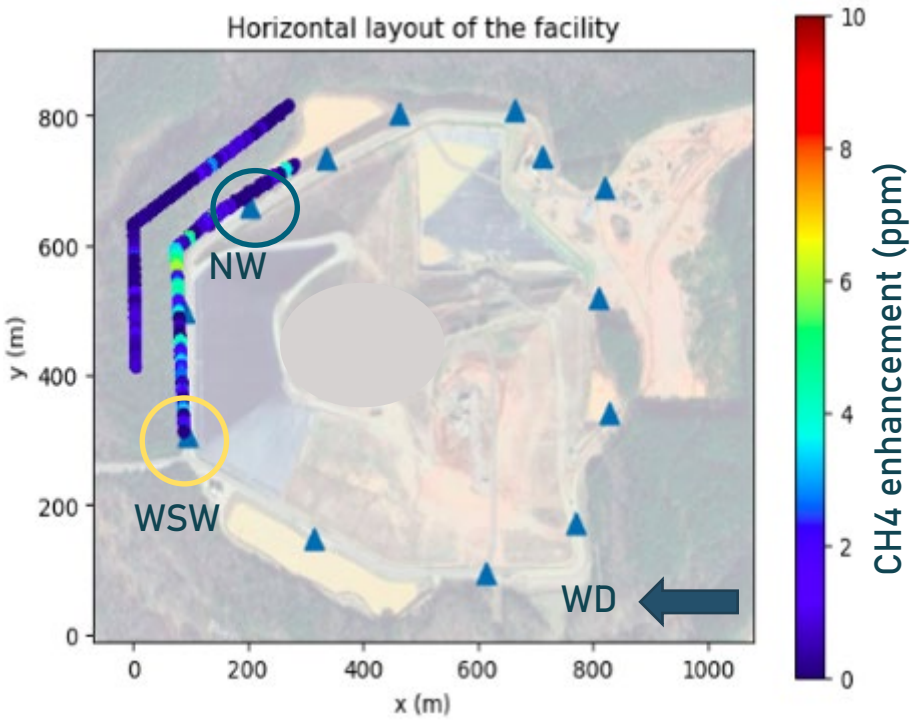


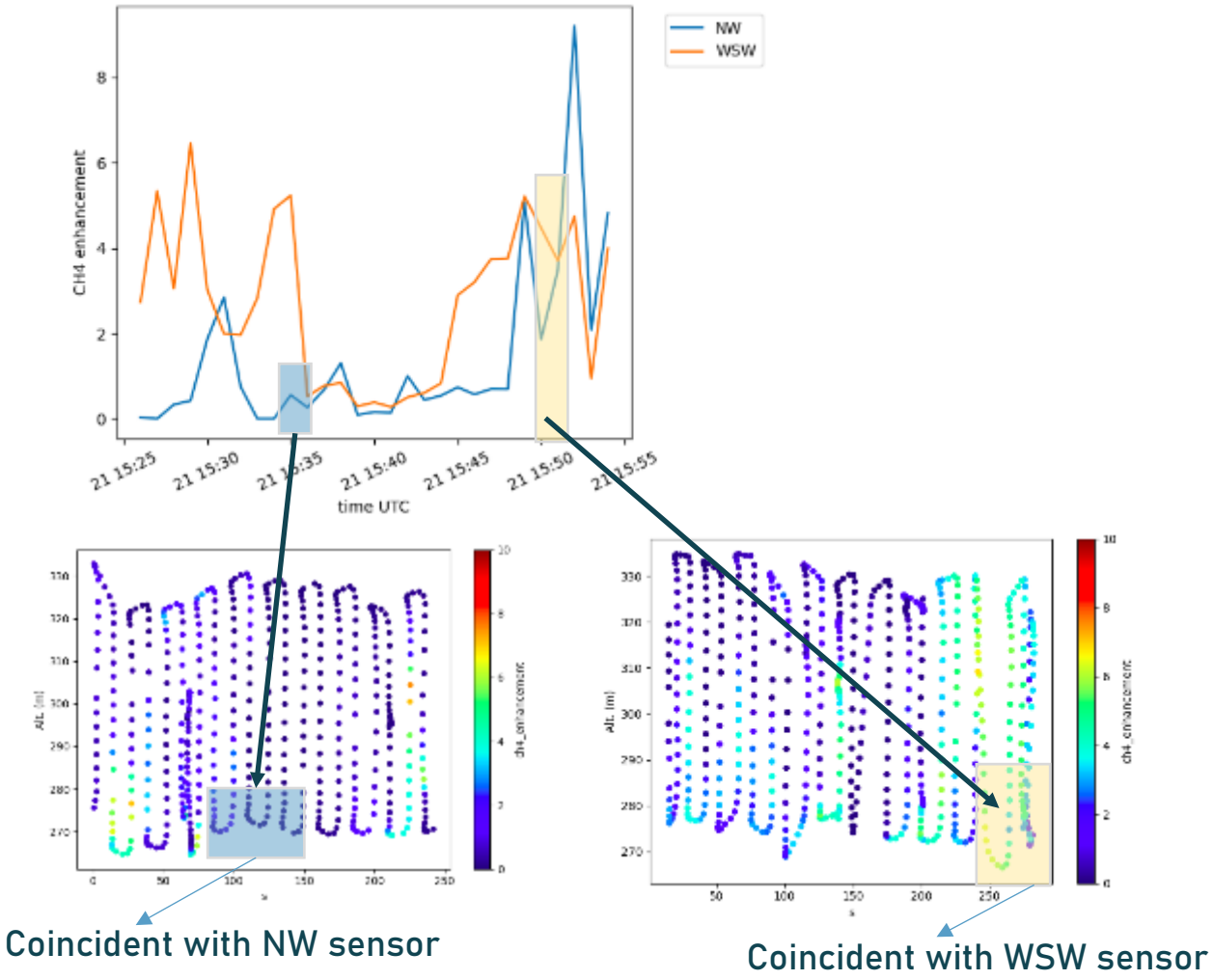
CMS + Flux Plane Measurement – Day 2





CMS + Flux Plane – Evidence of temporal correlation






Questions
Count it. Cut it. Prove it.
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