Advanced Leak Detection Technologies for Landfill Methane

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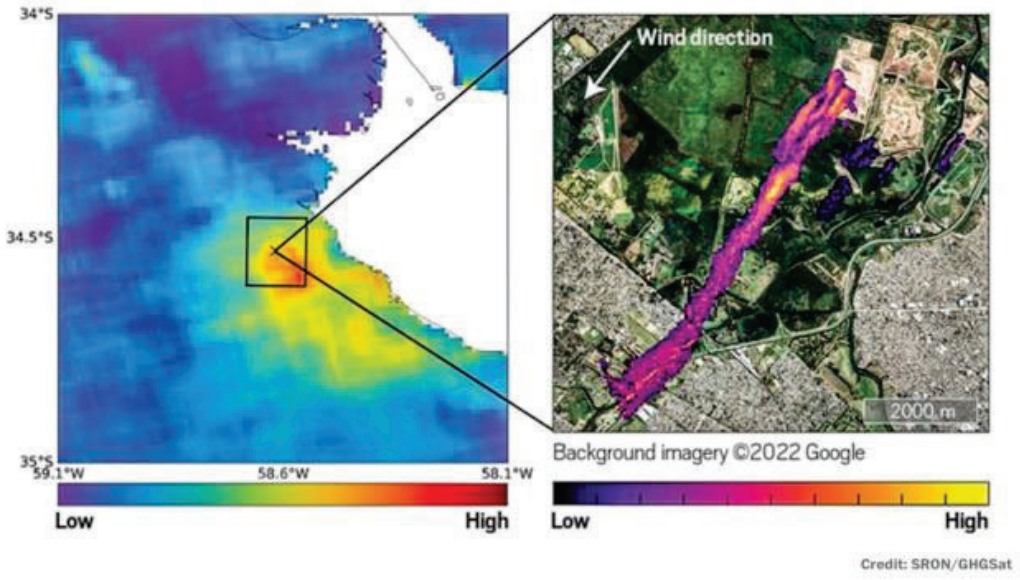
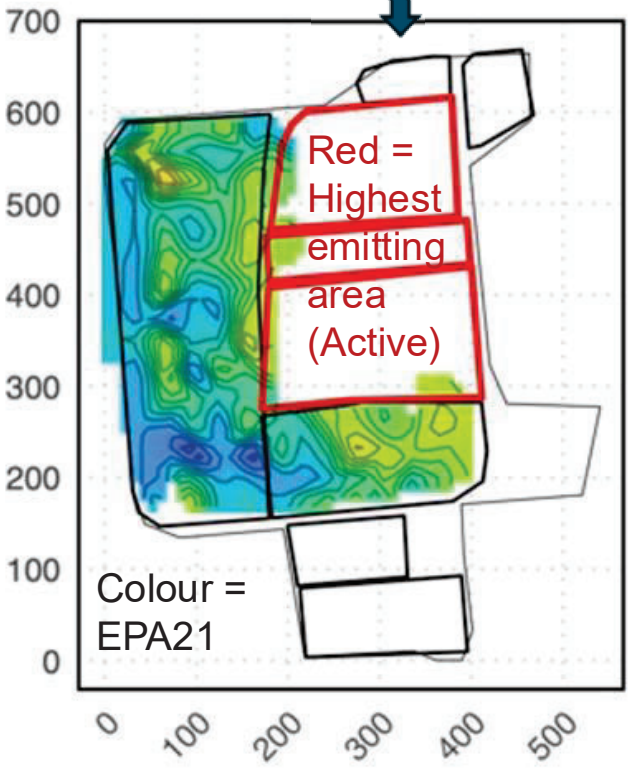
Catching up on landfill methane

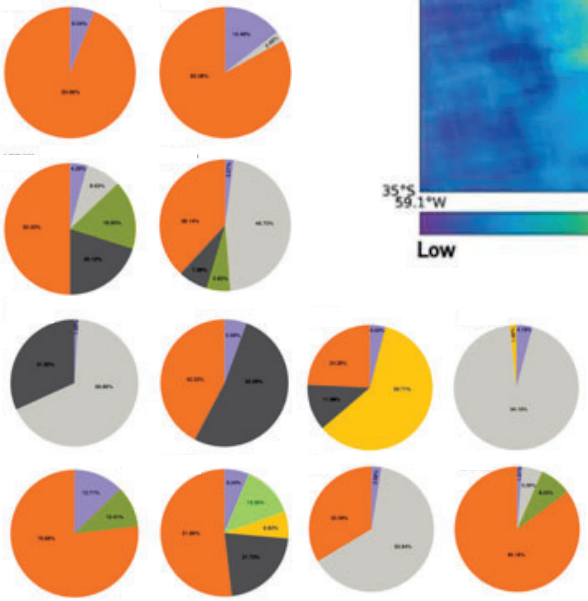
Global Methane Pledge not achievable without waste sector action!

Global patrol



Insufficient regulatory methods





Old perspectives – Active working face "surprise"

- 60% of total, 12 sites, Canada – orange=active (FluxLab *in prep*)
- 79% of total, 217 sites, US (*Scarpelli et al. EST 2024*)

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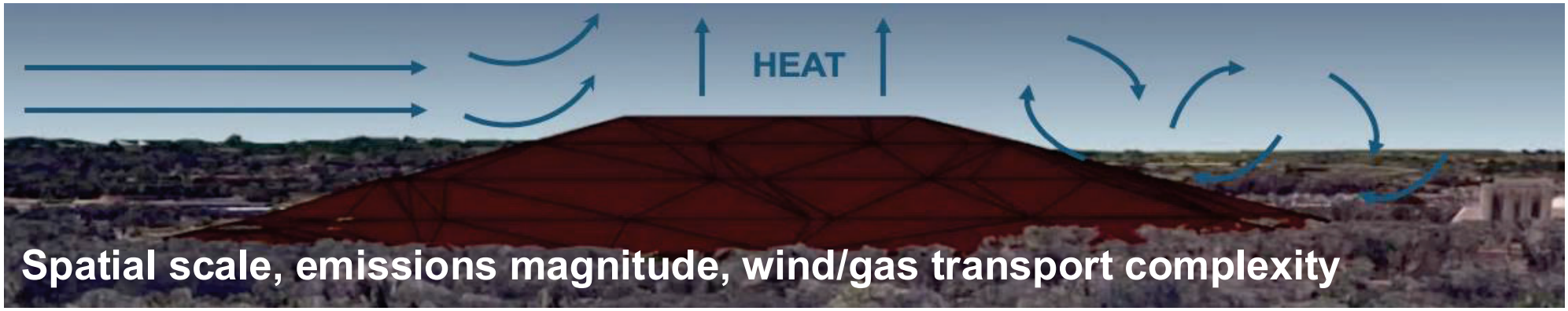
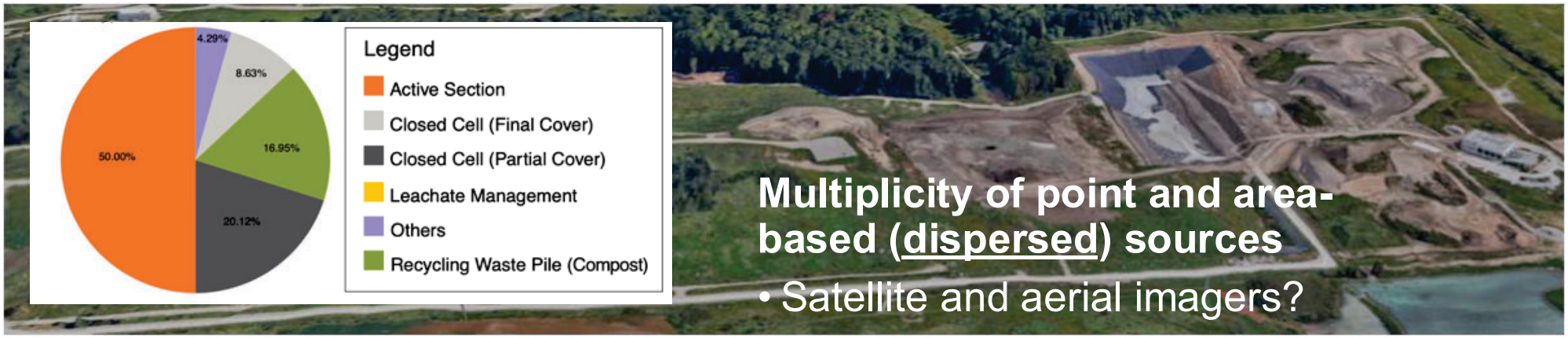
Landfill measurement challenges





Need to rapidly accelerate measurement validation and development for:

• Inventories • Policies • Regulation • Triage • Capacity building • Air/Space • Ground

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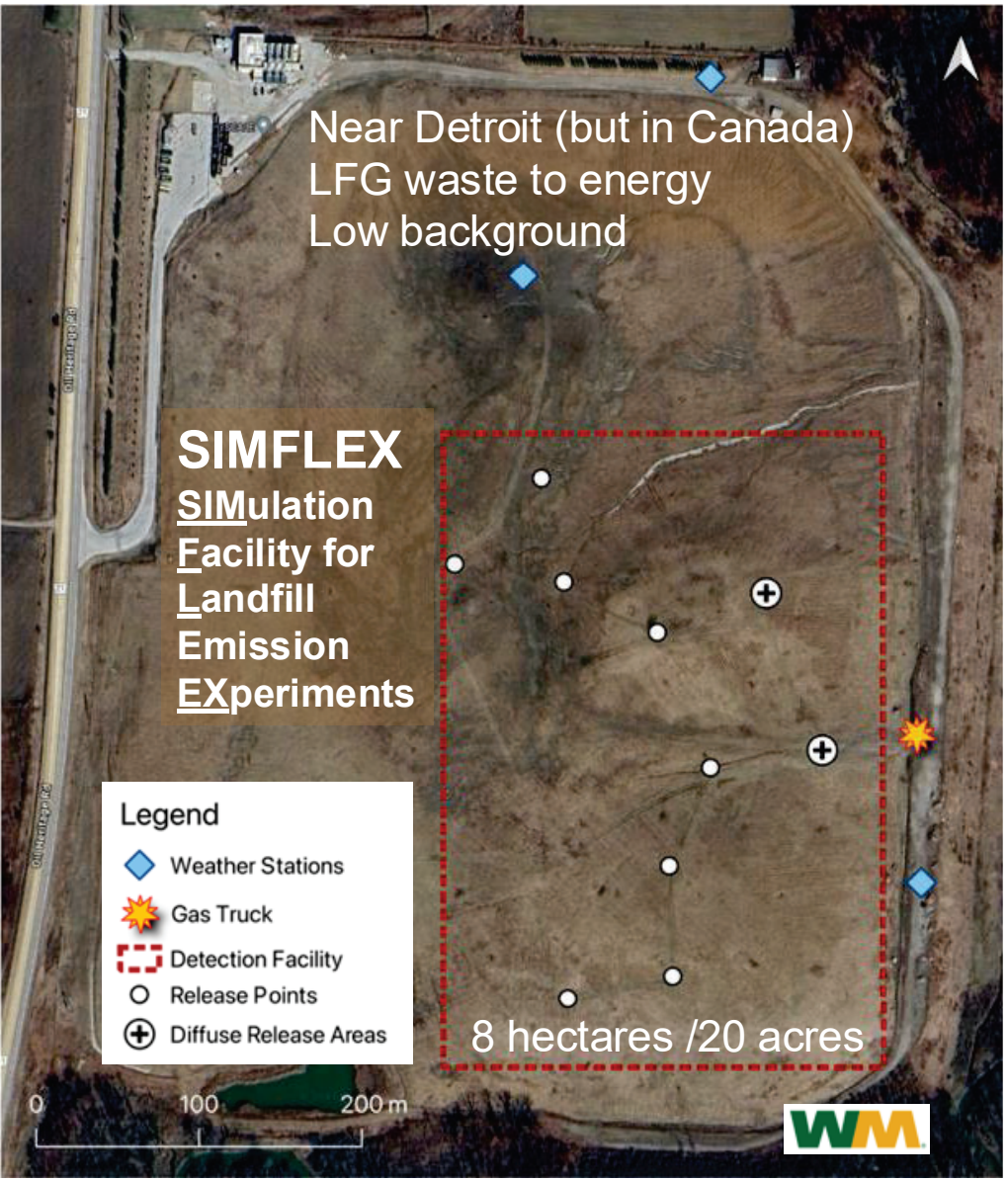

ALD Tech Release Tests

Original (Nov 2023, at left)

- 10 release points over ~20 acres
  - 8 x point, 2 x large area
- To 300 kg/hr total
- One set of experiments Nov 2023

Renewed Install (Nov 2024)

- 11 new release points over ~20 acres
  - 8 x point, 3 x large area
- Buried system
- To 840 kg/hr total
- One set of experiments Nov 2024

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[1]FluxLab / Earth and Environmental Sciences, St. Francis Xavier University
[2]Engineering, Florida State University

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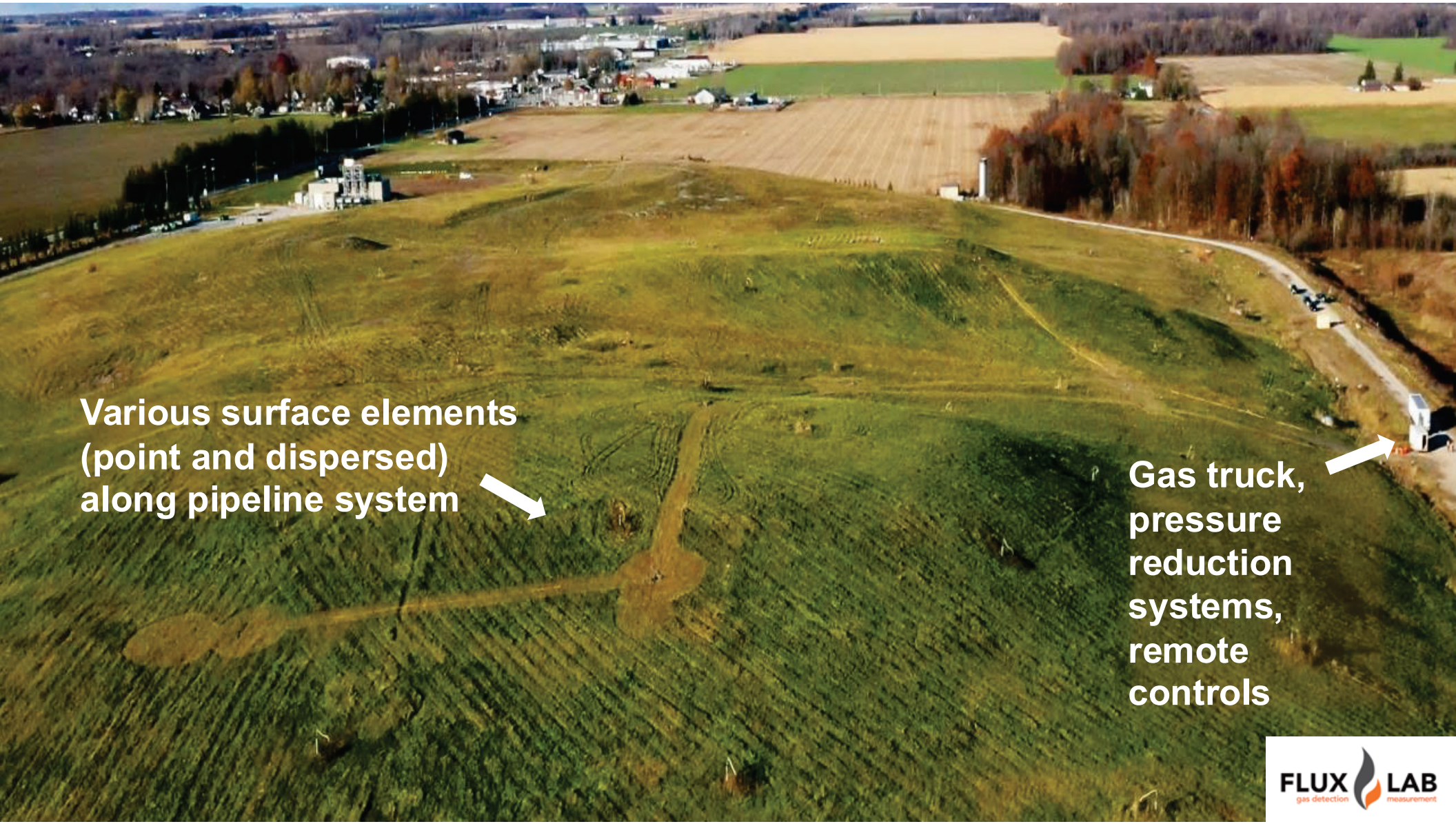
2 km of trenches
(gas, electrical)


some dispersed
release zones
before regrowth


Various surface elements
(point and dispersed)
along pipeline system
Gas truck,
pressure
reduction
systems,
remote
controls
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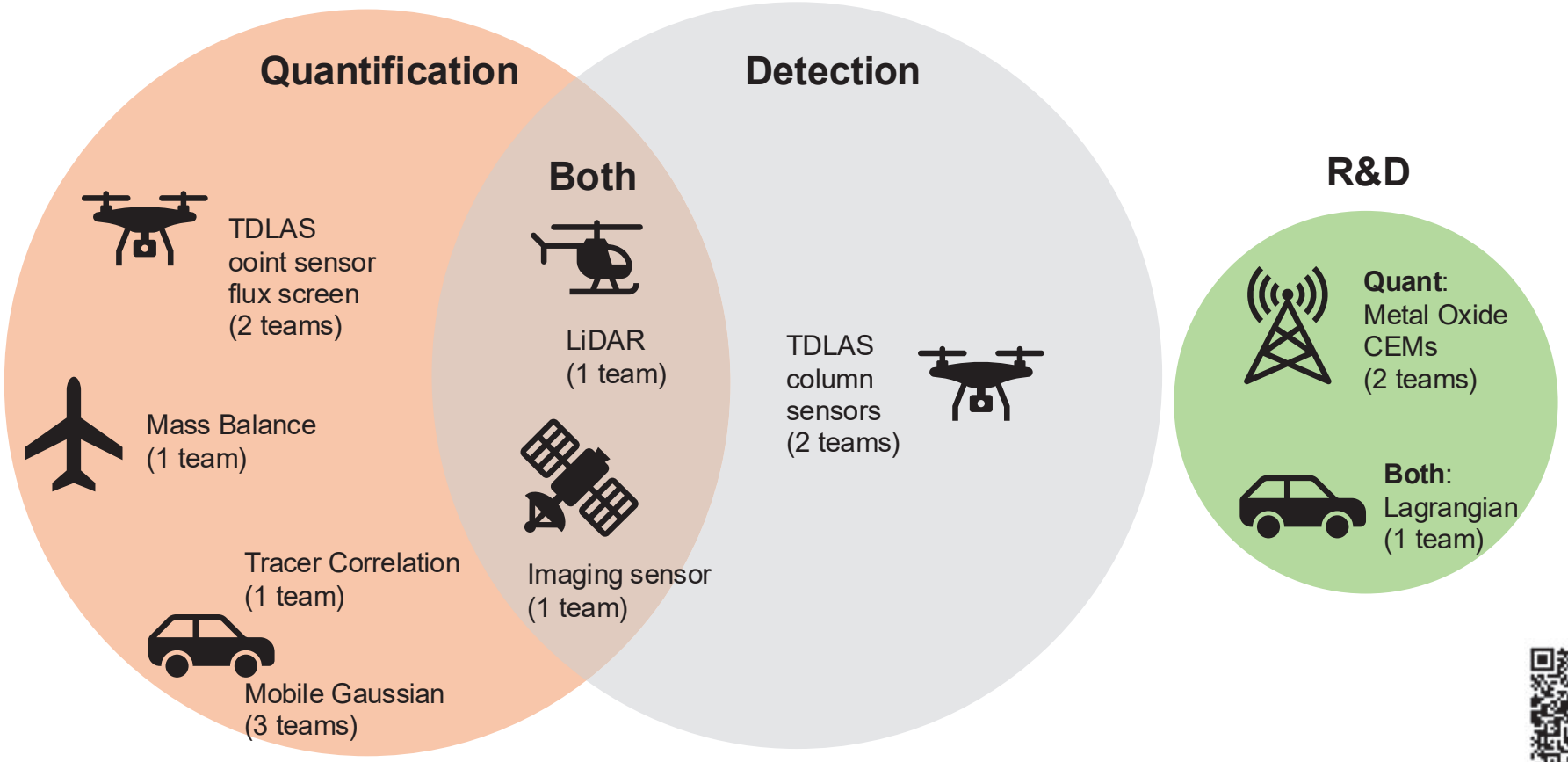
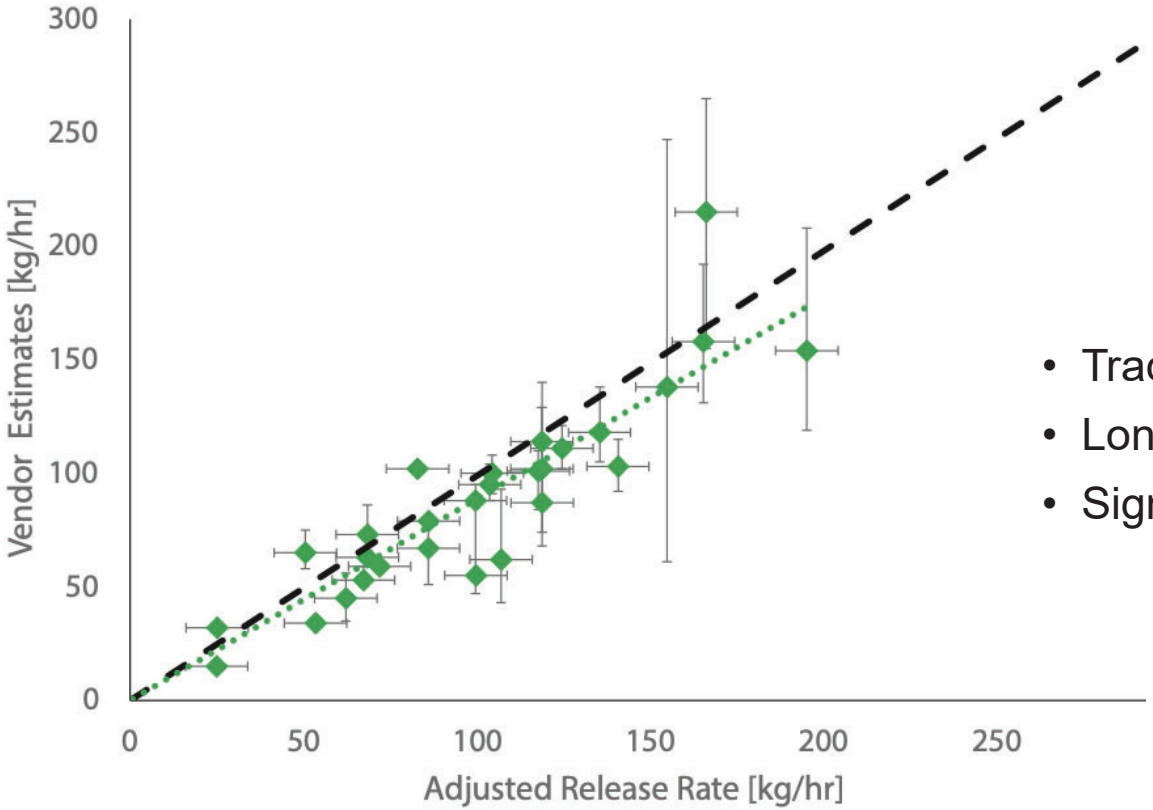
November 2023 Experiments - Participants



Report:

- Protocol adapted from the Methane Emissions Technology Evaluation Centre (METEC)
- 71 blind experiments – Quantification and Detection

Truck-based Tracer Correlation



- Tracer Correlation
- Long the gold standard for landfill research
- Significant setup time and complexity

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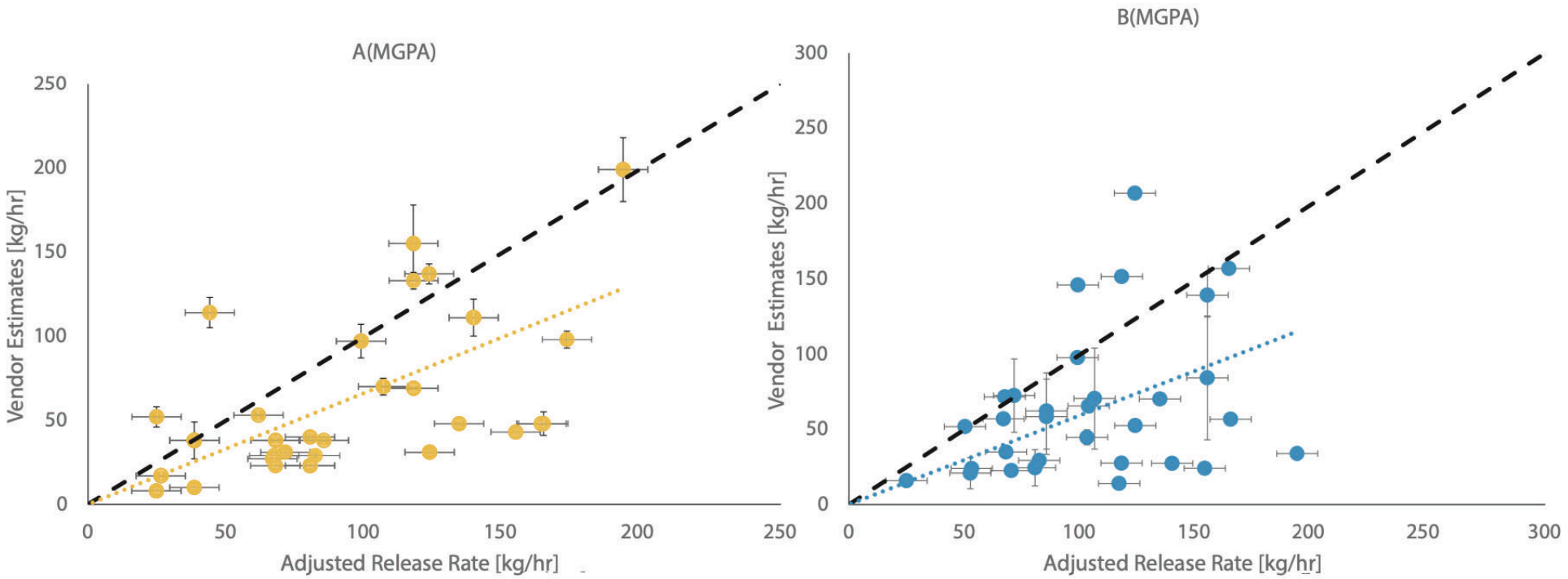
Quantification performance - trucks



- Releases were very short and adapted workpractice (often just 1 rep) increased variance
- Systematic underestimation bias for both teams

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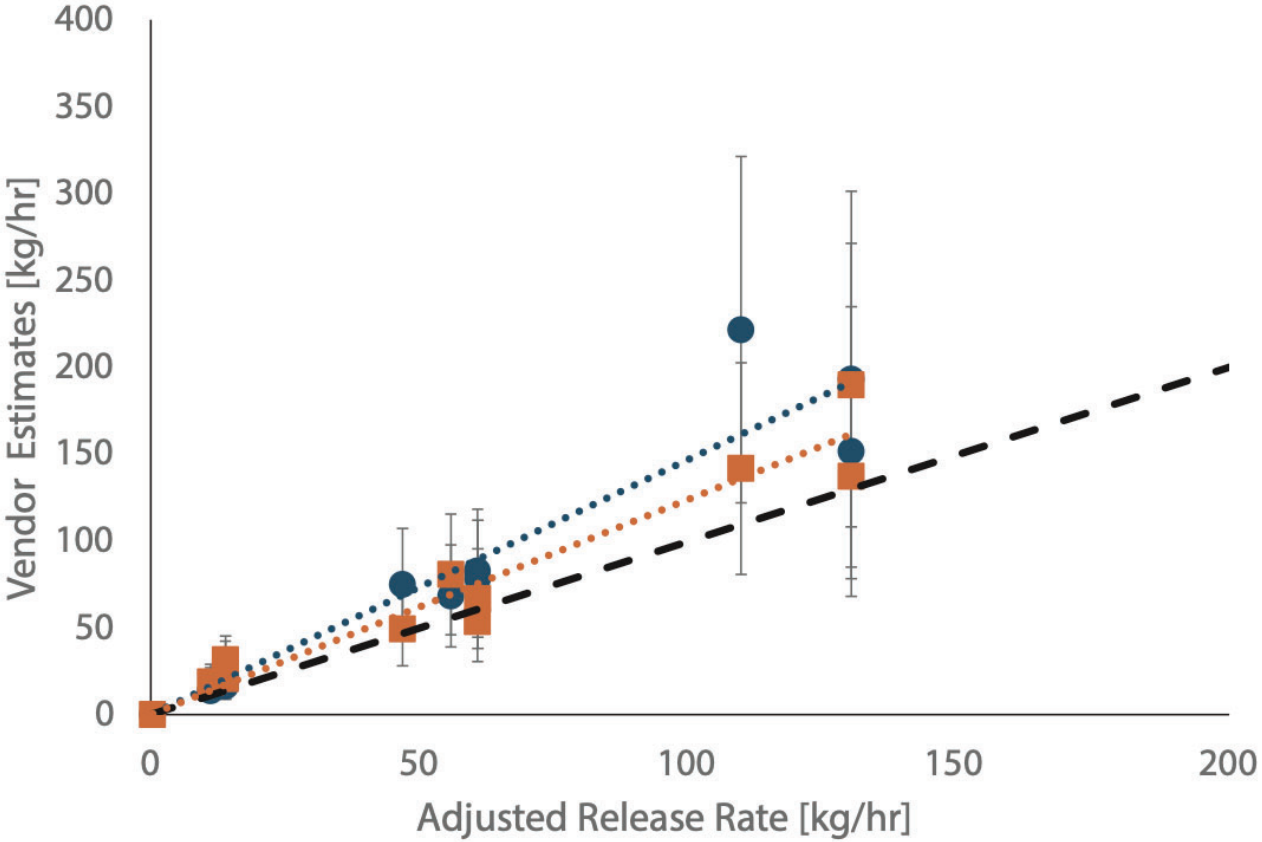
Quantification performance – LiDAR



Before and after ground wind data

Overestimate bias was reduced with onsite wind data

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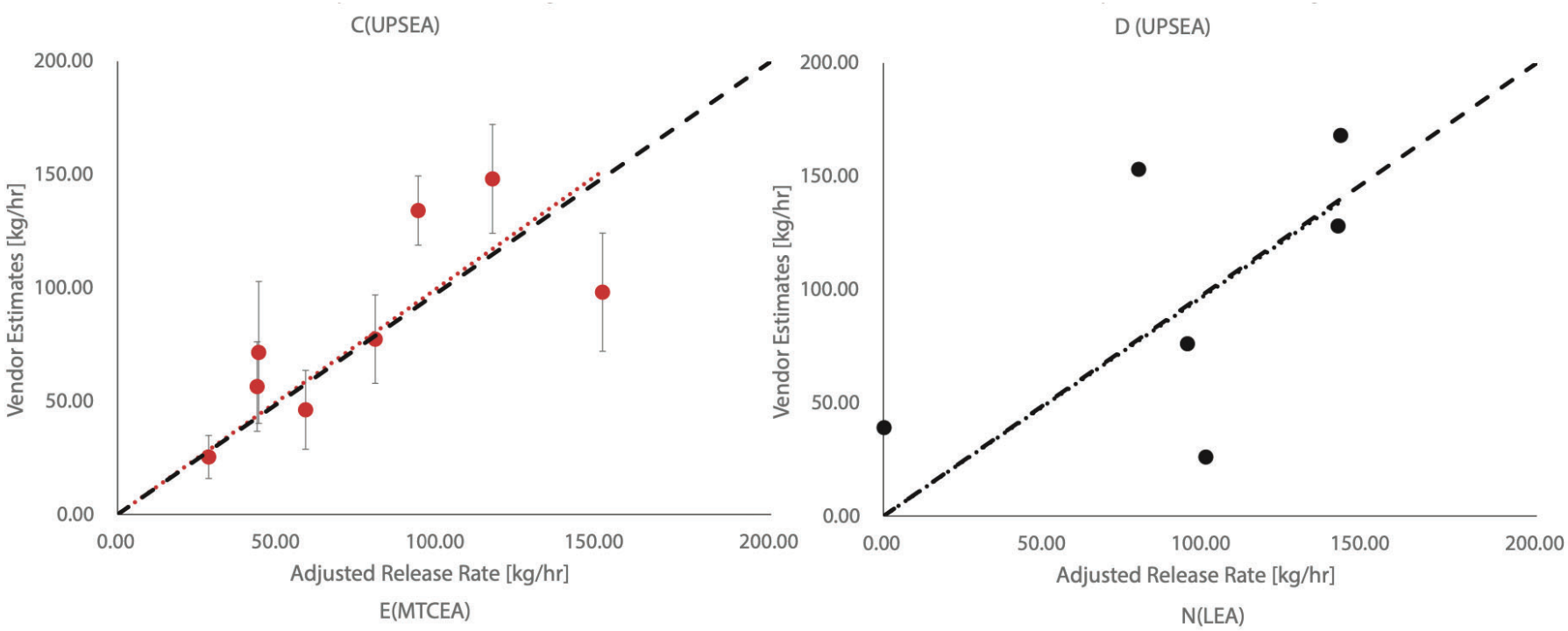
Quantification performance – UAV flux plane



- Relatively little bias, but a difference in variance between teams

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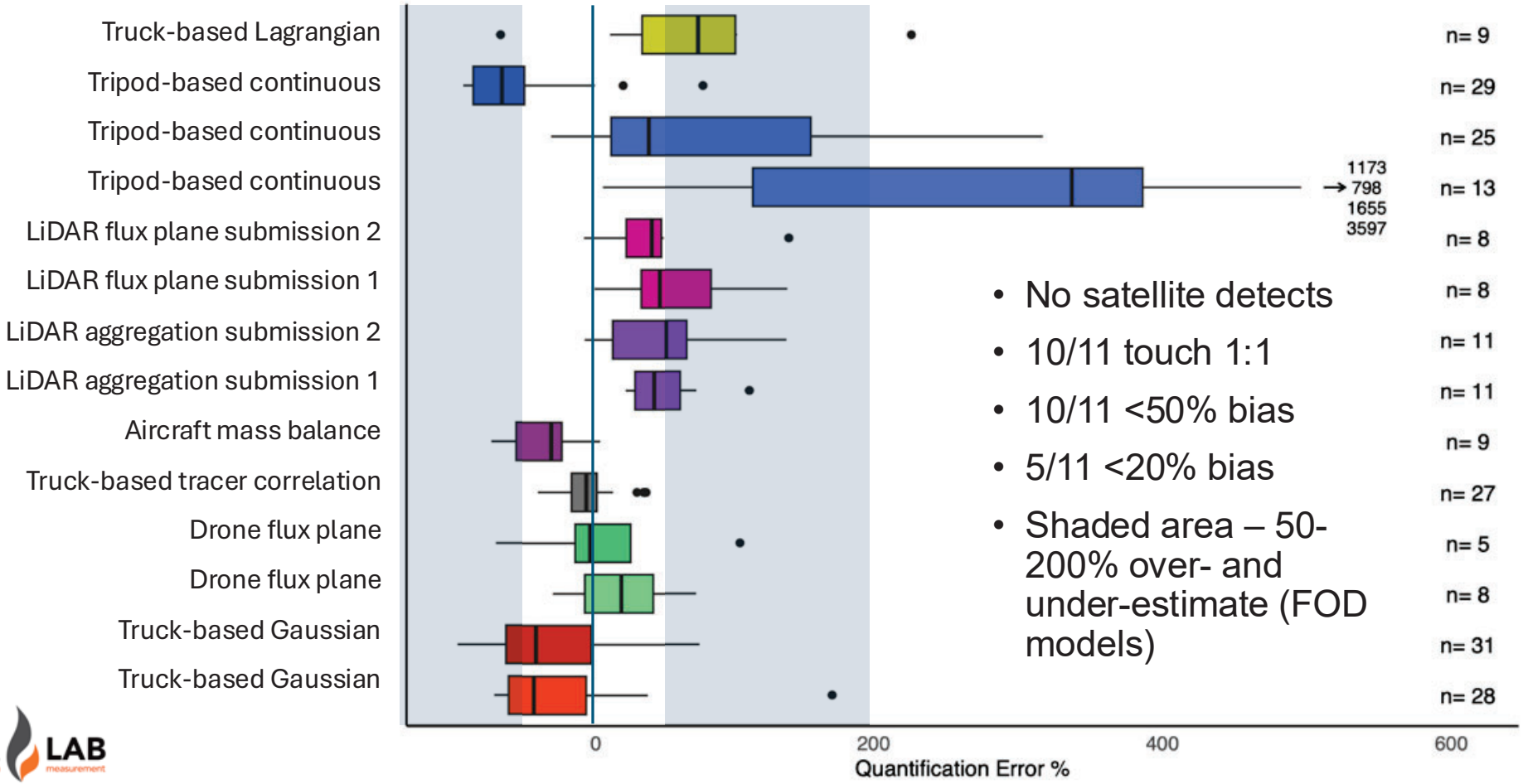
Quantification performance overall good



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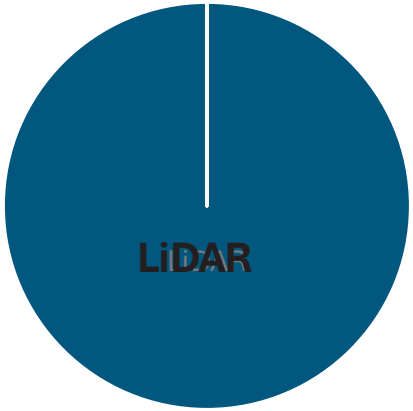
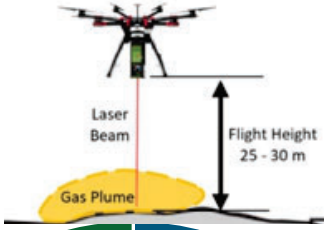
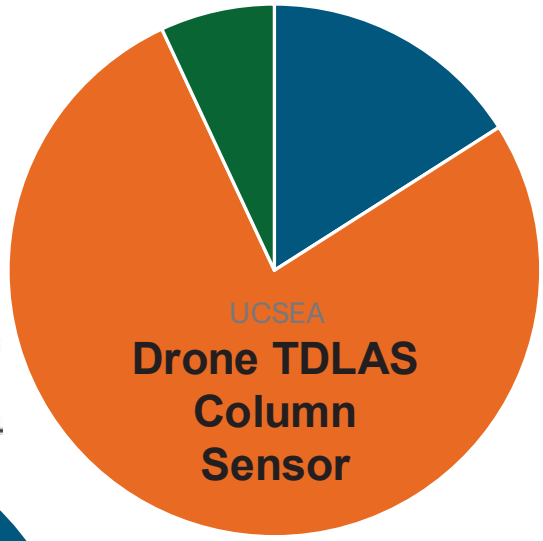
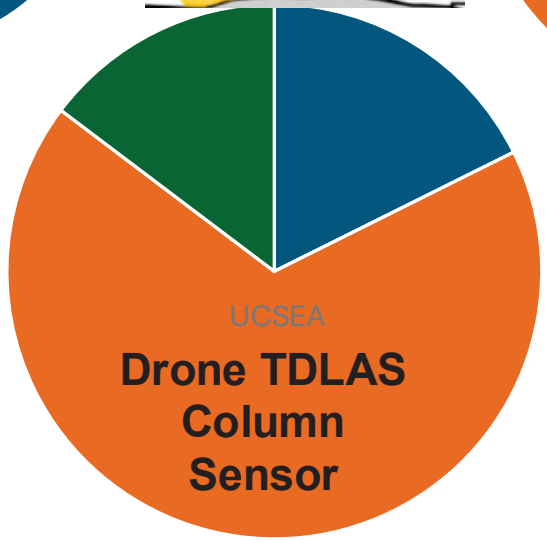
Detection performance was more varied









- LiDAR very sensitive to leaks down to 1 kg/hr without any false positives
- Drone TDLAS column sensor recorded many false readings. A sensor or work practice issue?
- Looks much different this year.
- How would EPA21 perform??

True positive – Emission successfully detected at the right location

False positive – No emission at the location but an emission detected

False negative – Emission present at the location but wasn't detected

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Next steps

Maintain focus on dispersed releases

Spring 2025 experimental priorities

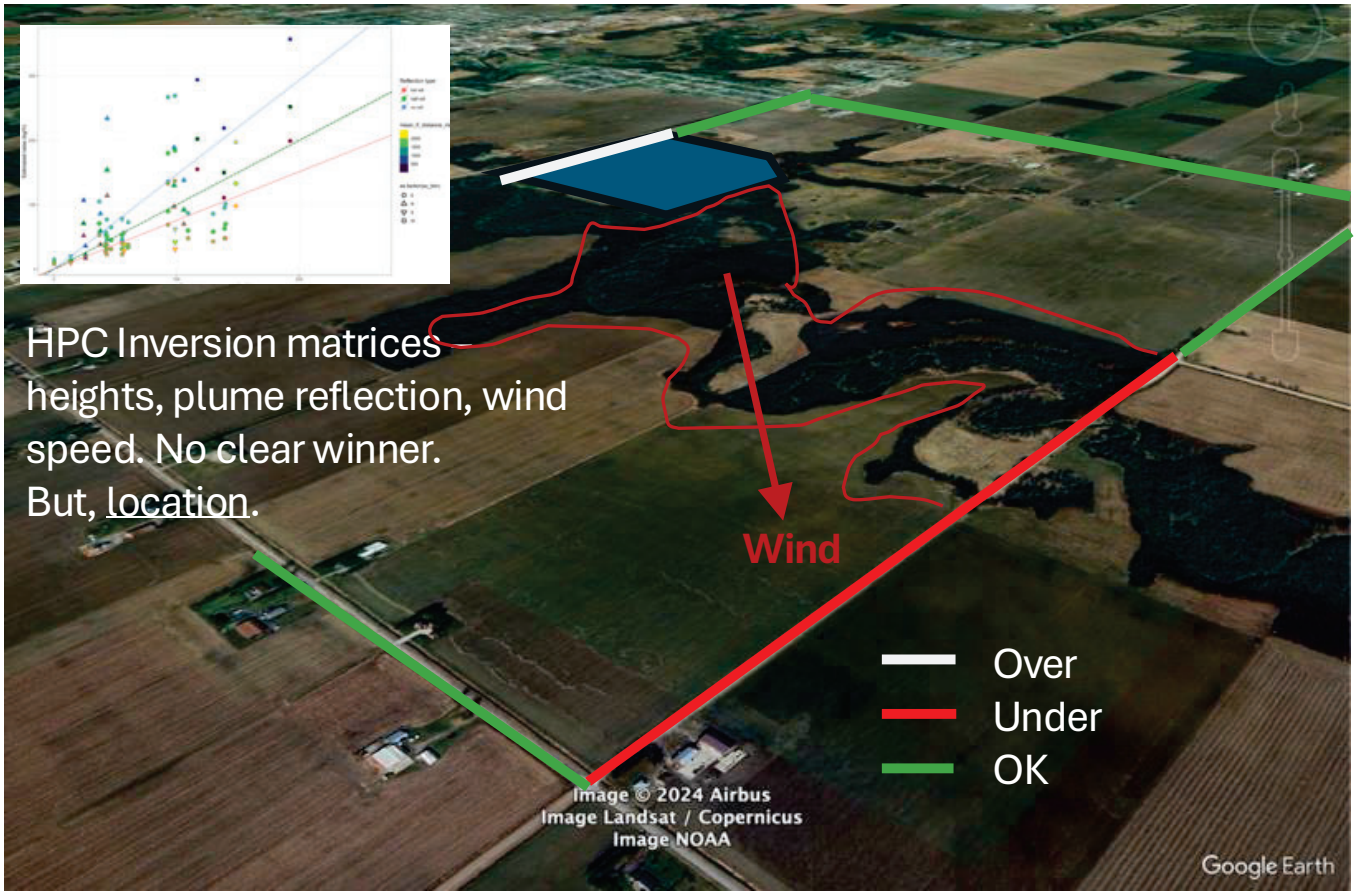
1. SEM vs Drone column sensors vs OTM51
2. **Satellite**
3. **Aircraft imagers and mass balance**
4. Drone flux plane
5. CEMs (maturing)
6. Mobile truck
7. Wind studies

Late April and early May 2024.

Adjunct site under development

- More convenient for exploring aerial and satellite MDLs on dispersed sources

WHY? Explaining mobile/truck under-estimation



- Transects downwind with CRDS or equivalent, inversion
- Precision – Noise related to low replication in fast tests
- Bias – Terrain blocking and distance (losing Gaussian edges into background)

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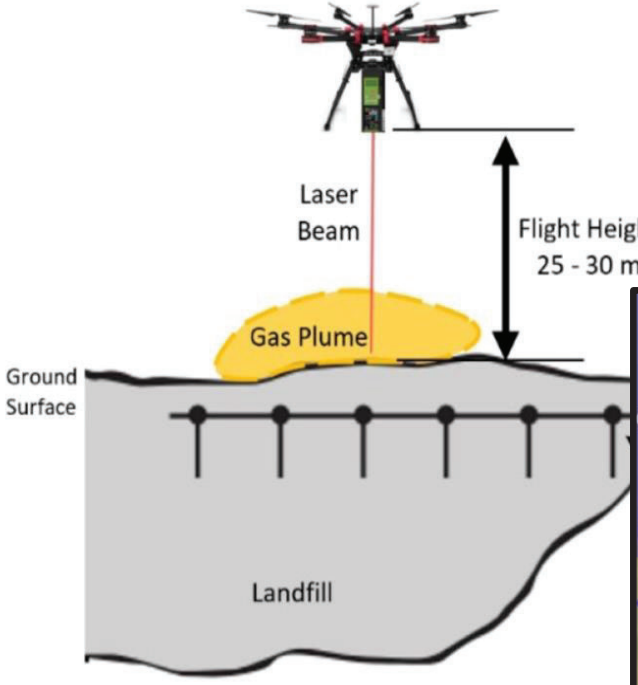
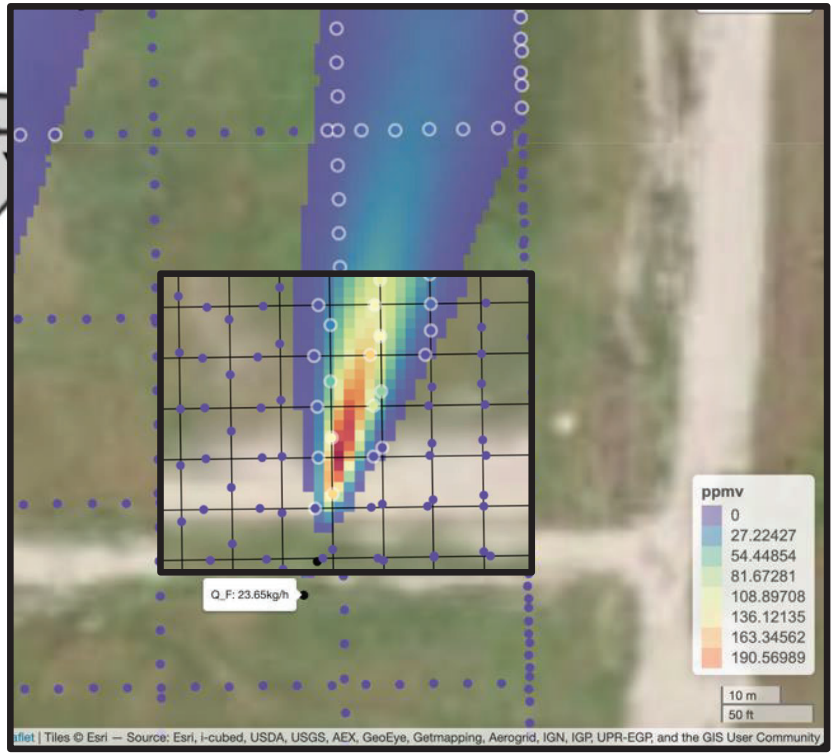
WHY? Explaining TDLAS column issues





- Workpractice involved 0.5 Hz, 30 m spacing
- Explaining false readings:
  - FN: 30 m -> must run right over the location
    FP: Detecting at points downwind
- Explaining FN on slopes
  - Gimbal
- Workpractice -> all new ‘24
  - 10 Hz
  - 7.5 m screen
  - microgrid 1 m survey

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New walking SEM learnings - coverage

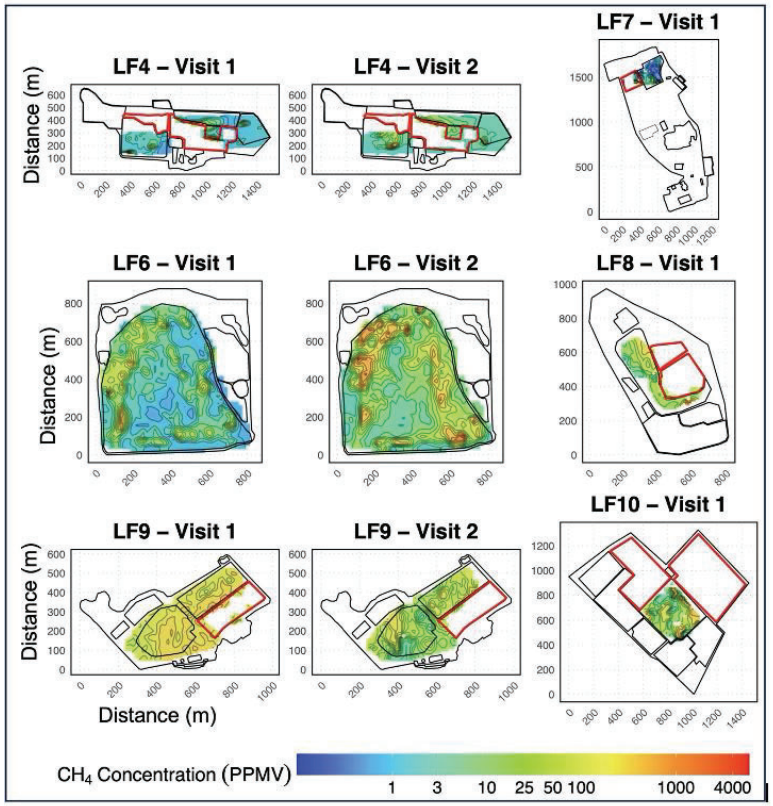
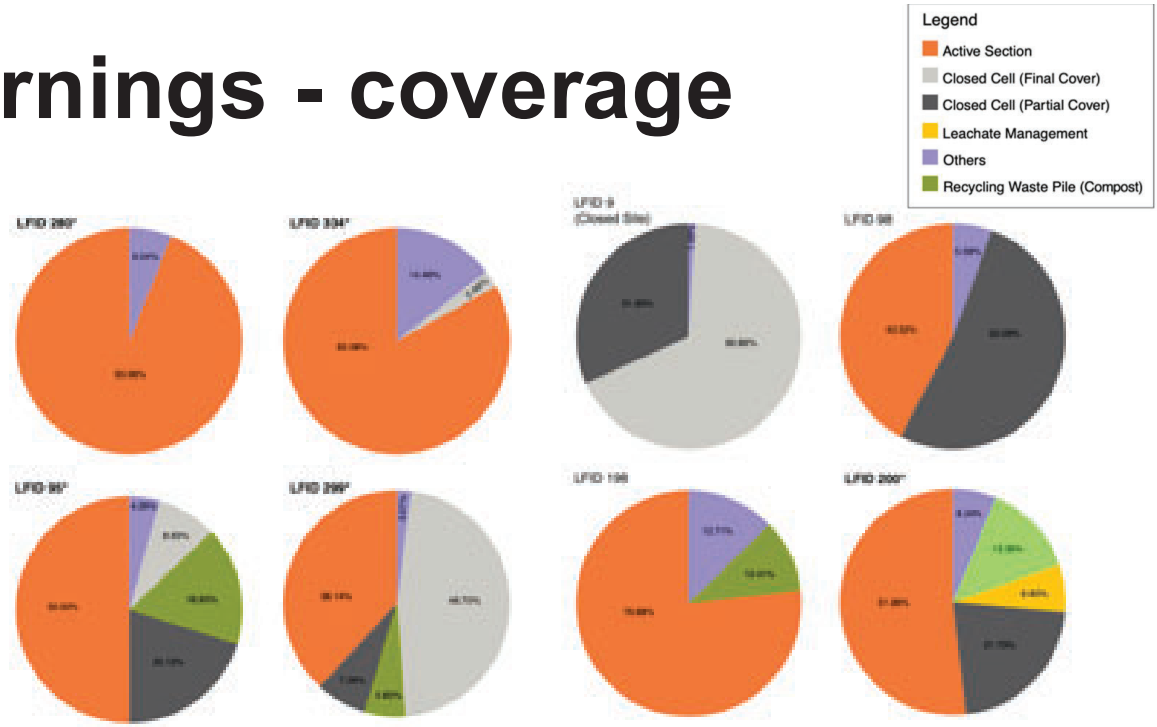


Figure 2. SEM maps of surveyed landfills LF4, LF6, and LF9 from both Visit 1, conducted between August and September 2023, and Visit 2, conducted between October and November 2023, as well as LF7, LF8, and LF10, which were surveyed once. The colors represent different CH_4 concentrations, with red indicating the highest levels and dark blue showing the lowest. The outlined borders mark the landfill perimeter and different component areas. Red borders highlight active face zones, identified through mobile surveys as major contributors to emissions at most sites. These active areas are typically not covered by SEM measurements.

Professional contractor. Interpolated SEM in color. Red shows highest emitting areas.



Active working face “surprise”

- 60% of total, 12 sites, Canada – orange=active
  - SEM effectiveness would **top out at 40% of emissions**
- 79% of total, 217 sites, US (*Scarpelli et al. EST 2024*)
  - SEM effectiveness would **top out at 21% of emissions**

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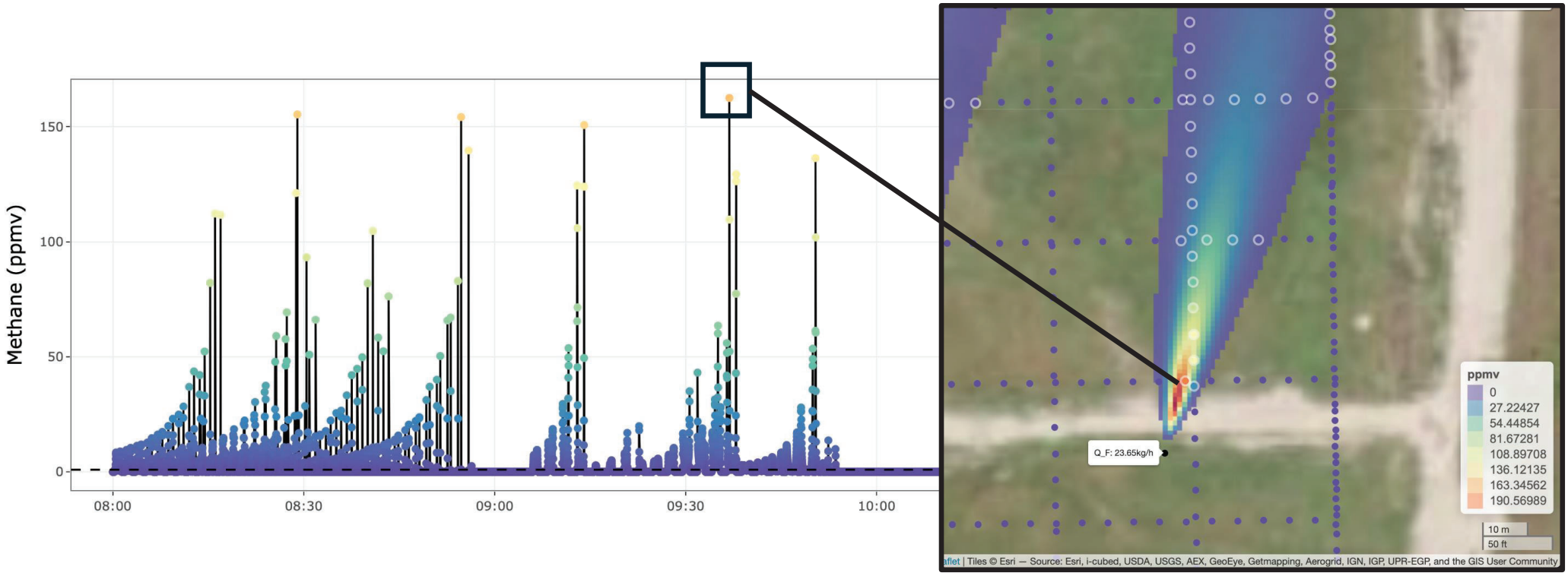
New walking SEM learnings - probability



- On a 30 m grid, direct detection probability is low (here just 190 ppm near a 23 kg/hr source)
- SEM success is based on behaviour, and desire to find emissions off-grid
- Behavioural bias + coverage issues = uncertain measurement-information for management

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Advanced Leak Detection Opportunities

Methodology	Readiness	Resolution	Cost	Coverage	Versatility	By Source	Quantification
Walking SEM	High	Low	Med	Low	Low	Yes	No/Maybe
UAV OTM51 SEM	High	Med	Med	Low	Med	Yes	No/Maybe
UAV Column SEM	Med	Low-High	Med	Complete	High	Yes	No/Maybe
UAV / Aerial Flux Plane	High	High	Med-High	Complete	Med	Maybe	Yes
Aerial LiDAR	High	High	High	Complete	High	Yes	Yes
Tracer Correlation	High	High	High	Complete	Med	Maybe	Yes
Truck Gaussian	High	Med	Low	Complete	Med	Maybe	Yes
Fixed Sensors	Low	Low	Med	Complete	High	Maybe	Yes
Aerial Imagers	Med	Med	High	Complete	Low	Yes	Yes
Satellite Imagers	Med	Low	High	Complete	Med	Yes	

- At least 98 different ALD tech vendors and methodologies exist in these classes, others

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ALD Tech Framework – Options

Adapted from OOOOb Table 1

Periodic Screening Matrix

For compressor stations, centralized production facilities with major production or processing equipment, and well sites with major production or processing equipment. See OOOOb Table 2 for other site types.

Minimum Screen Frequency	Minimum Detection Threshold of Screening Technology (Based on a 90% Probability of Detection)
Quarterly	≤ 3 kg/hr for two years *(≤1 kg /hr afterwards)*
Bimonthly	≤ 2 kg/hr
Bimonthly + Annual OGI	≤ 10 kg/hr
Monthly	≤ 5 kg/hr
Monthly + Annual OGI	≤ 15 kg/hr

Need a framework to integrate ALD techs

EPA O&G rules provide one approach – “matrix”

Based on rate (not concentration)

Frequency ~ Resolution

ALD tech approval process

Equivalency modeling was used to develop the matrix. Modeling helps us understand the effectiveness of different leak detection and repair (LDAR) programs, where ALD tech(s) with resolution x are applied at intervals to detect leaks at assets from which leaks occur probabilistically. Models include FEAST, AroFEMP, LDARSim.

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Taking applicants for late April / early May 2025 controlled release test program at the Simulation Facility for Landfill Emission Experiments (SIMFLEX)

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Micrometeorology / air modeling positions currently open to applicants from Canada/US/Mexico

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