Standards for methane point source detection and attribution

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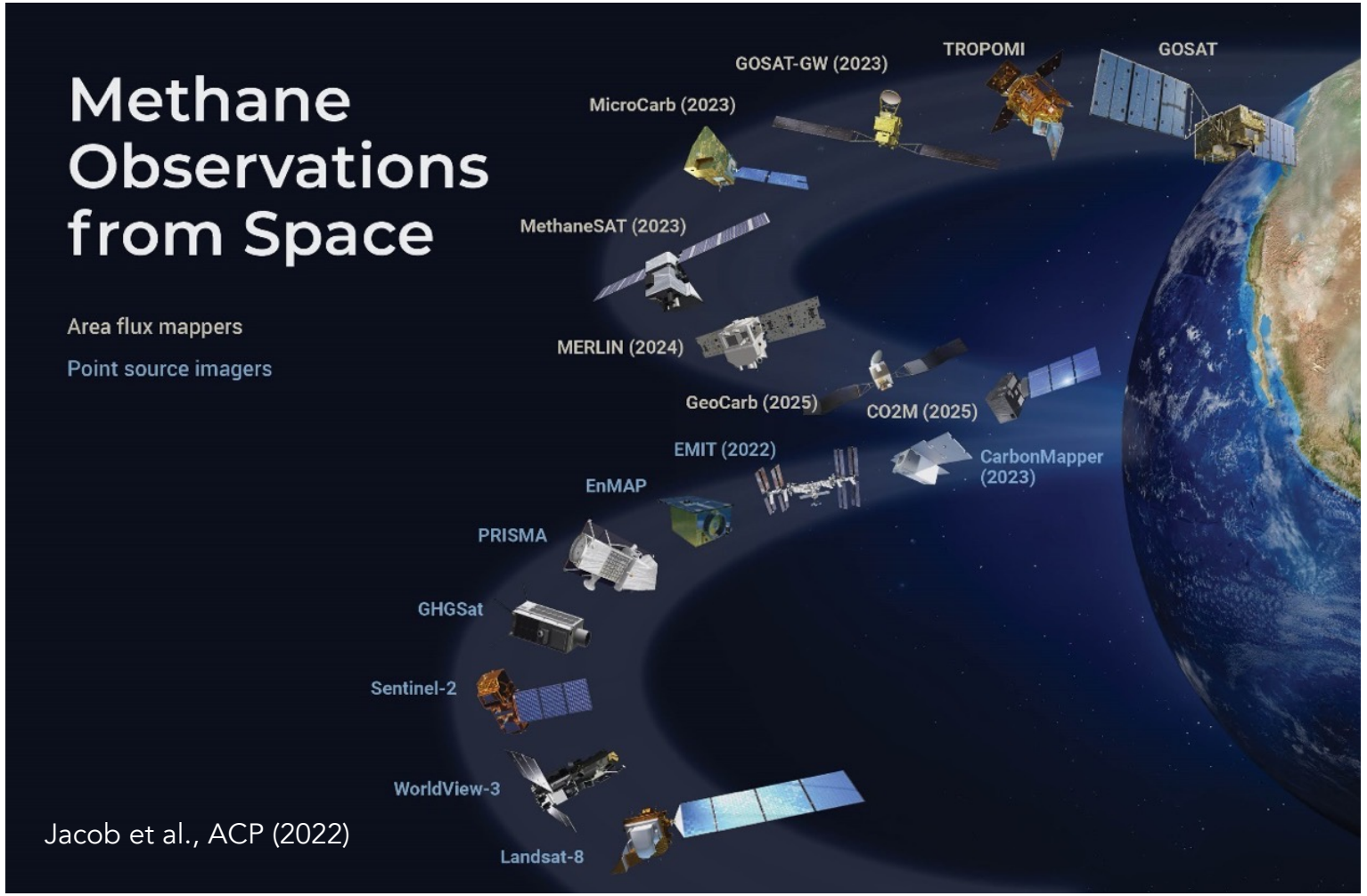
Carbon Mapper

Point source vs. area flux mappers provide data on some similar, but many different use cases.



Jacob et al., ACP (2022)

Use Cases (non-exhaustive)

Area flux mappers
- Global to regional flux
- Inventory falsification
- Verify national budgets

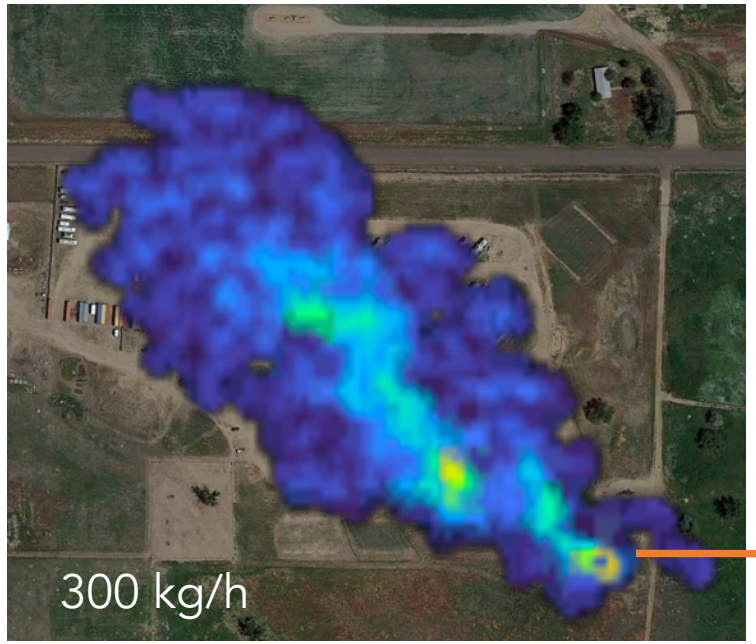
Point source imagers
- Leak detection and repair
- Super-emitter quantification
- (some) inventory development
- Facility-level intensity
- Sub-sector quantification (e.g., upstream vs. midstream)

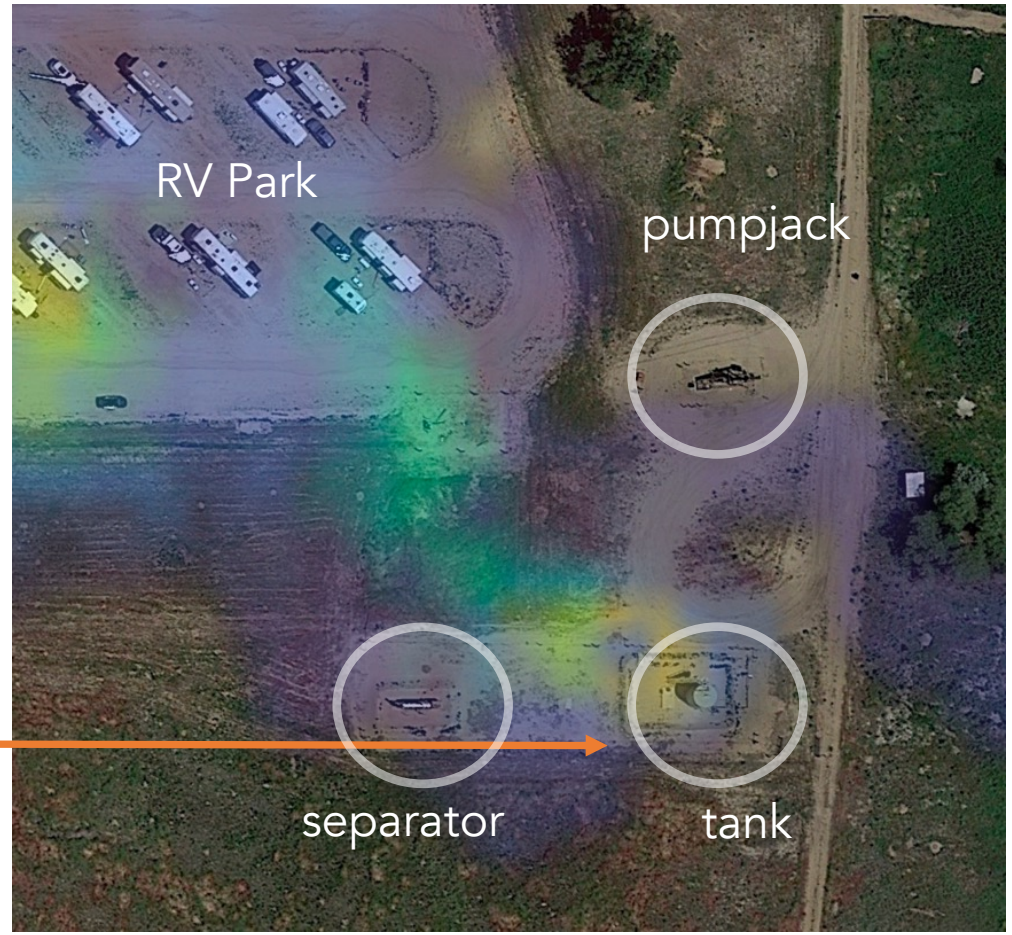
Need standards and definitions that meet use-case descriptions (validation vs. verification)

To be useful for facility-level applications, need to be clear on definitions and standards for point sources.

Point Source: High concentration region of methane that is **connected** and can be **attributed geographically** to an origin and **emission sector**

Point source observed outside Denver by Carbon Mapper airborne **on Sep 12, 2023**





Beginning of formulation of standards. Need to drill into each of these to understand sources of error, how to report uncertainty, and how to validate.

Detection

- Is this a true plume or false positive - confounding surface features?
- Are there any nearby flares and spectral artifacts in the scene?
- Do the plume flags adequately represent scene characteristics?
- Is the shape of the plume consistent with wind direction?
- Does the plume appear to be “physical”?

Quantification

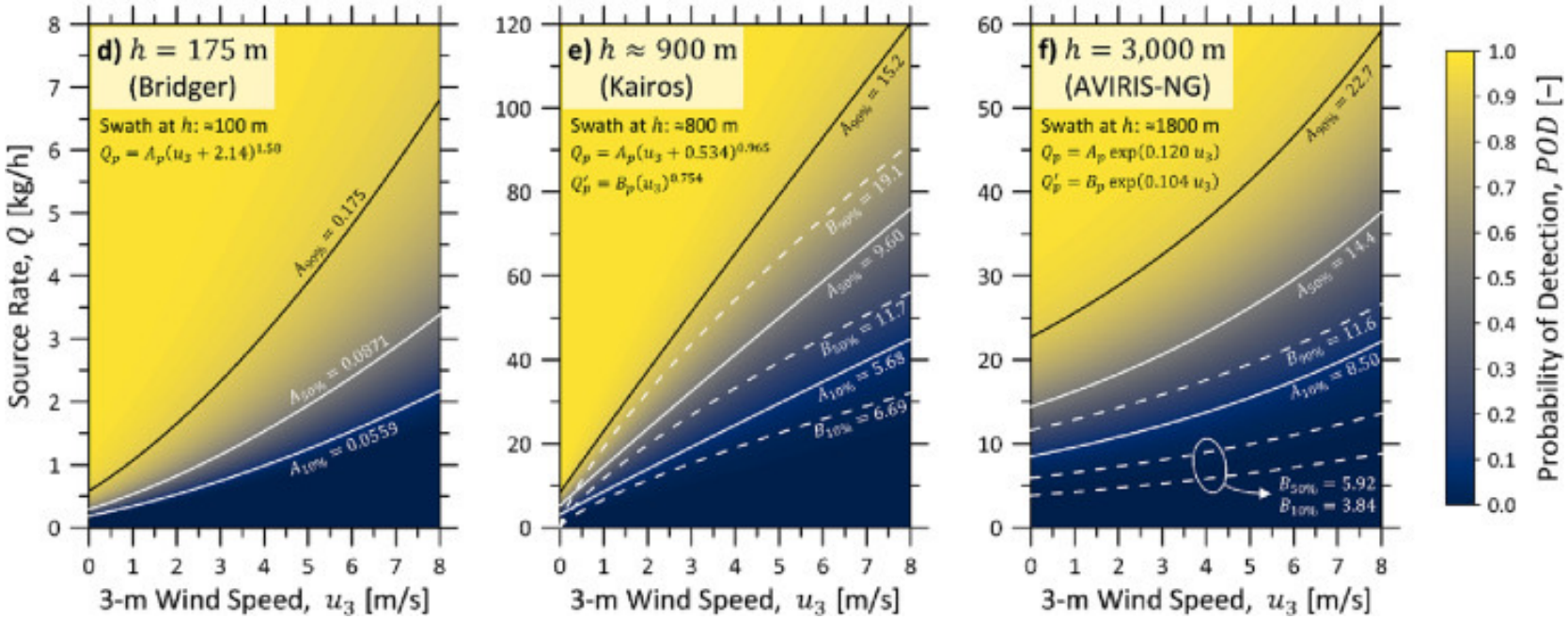
- Is the size of the plume consistent with the emission rate and wind speeds?
- Are plume artifacts present that could impact enhancement estimate?
- Does wind speed or plume shape suggest pooling that could impact emission estimate?

Attribution

- Is credible emissions infrastructure visible in high-res imagery?
- Was the right equipment type/sector selected by the analyst?

Blinded controlled releases in ideal and non-ideal situations verify detection performance and derive probability of detection functions per instrument.

Probability of Detection curves derived from controlled release experiments (Conrad et al., 2023)



Observed detection → $D \sim Bernoulli(\mathrm{POD}(\boldsymbol{x}))$

$$\mathrm{POD}(\boldsymbol{x}) \equiv F(g(\boldsymbol{x};\boldsymbol{\phi}),\boldsymbol{\theta})$$

$$\ell(\boldsymbol{\phi},\boldsymbol{\theta}) = \sum_i -(D_i \ln F_i + (1-D_i)\ln(1-F_i))$$

$$g(\boldsymbol{x};\boldsymbol{\phi}) = \phi_7 \frac{\left(Q_{[\mathrm{kg/h}]} - \phi_1\right)^{\phi_3}}{\tilde{n}^{\phi_4}_{[\mathrm{ppm\cdot m}]} \left(\frac{h_{[\mathrm{m}]}}{1000}\right)^{\phi_5} \left(u_{3\left[\frac{\mathrm{m}}{\mathrm{s}}\right]} - \phi_2\right)^{\phi_6}}$$

Carbon Mapper

- **Carbon Mapper (NGO)**: public good mission to drive methane and CO_2 mitigation with actionable data
- **Carbon Mapper (Coalition)**: Public-private partnership to expand satellite completeness, powered by philanthropy

- Phase 1: Launching 2 satellites in early-mid 2024
- Phase 2: Expanded constellation

- All methane and CO_2 data is <u>public</u>
- Rapid leak detection service for subscribing agencies and operators
- Single multi-sensor data platform: Carbon Mapper satellites, NASA EMIT instrument, aircraft observations