



Evolution, current state of the art, and interpretation of aircraft-based methane emission quantification at the natural gas basin-level

Dr. Stefan Schwietzke, Research Scientist

NOAA Earth System Research Lab / University of Colorado, Boulder

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Importance of methane (CH₄) emissions and the oil and gas (O&G) sector

CH₄

~25% radiative forcing impact of CO₂

3x atmospheric growth relative to CO₂ *

O&G

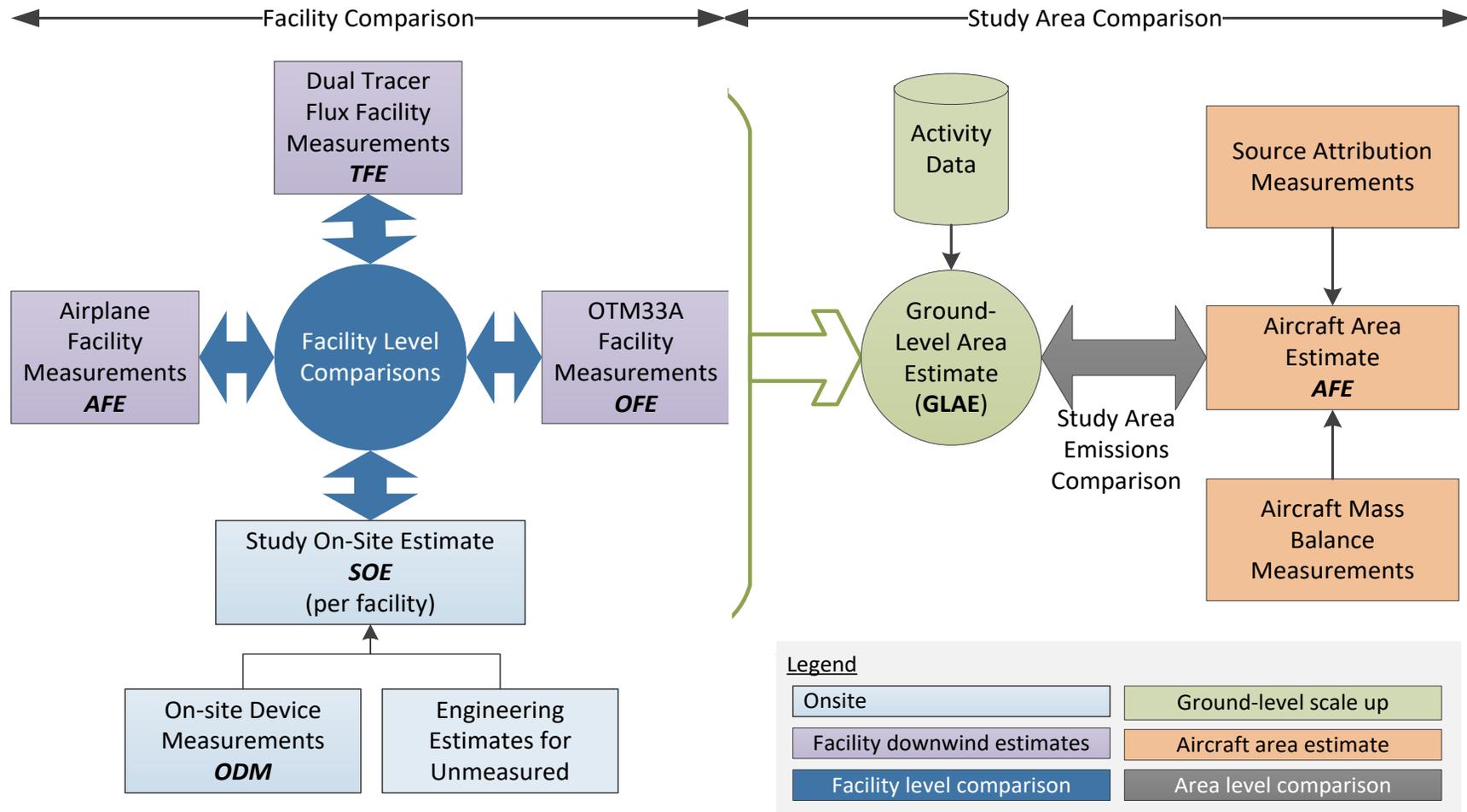
~25% of global anthropogenic CH₄ emissions

Air quality & health **, energy, mitigation technologies

The challenge of understanding and mitigating O&G CH₄ emissions

- **Source complexity:** CH₄ (fugitives, venting) vs. CO₂ (combustion)
- **Size:** 10⁶ wells, 10³ “large” facilities, 10⁶ pipeline miles in U.S. alone
- **Spatio-temporal variability:** Emissions vary by basin/facility & over time
- **Few measurements:** Small sample size, not continuous
- **Top-down vs. bottom-up difference:** Explanations?

Field measurement study design to address these challenges



Fayetteville Shale study team (public-private partnership)

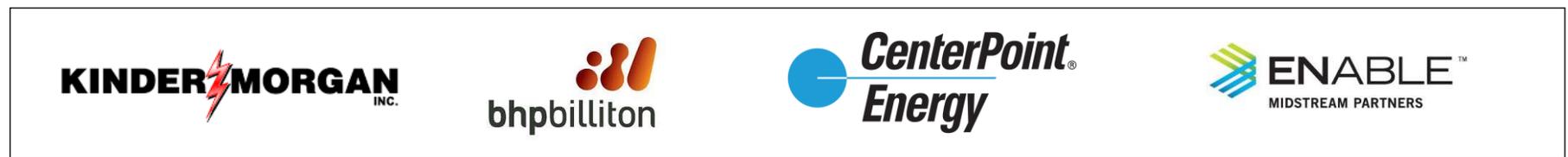
Research and administrative team



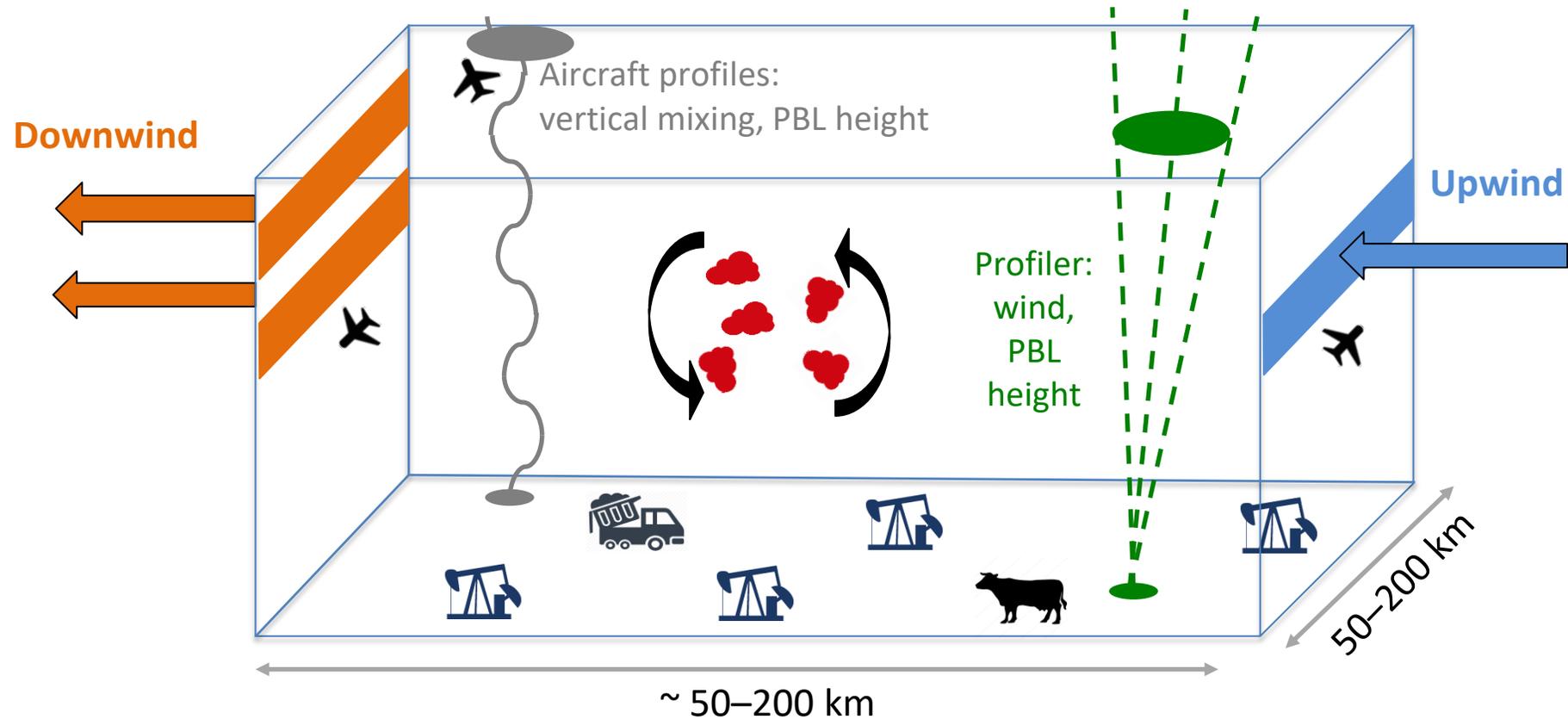
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Site access / data providers

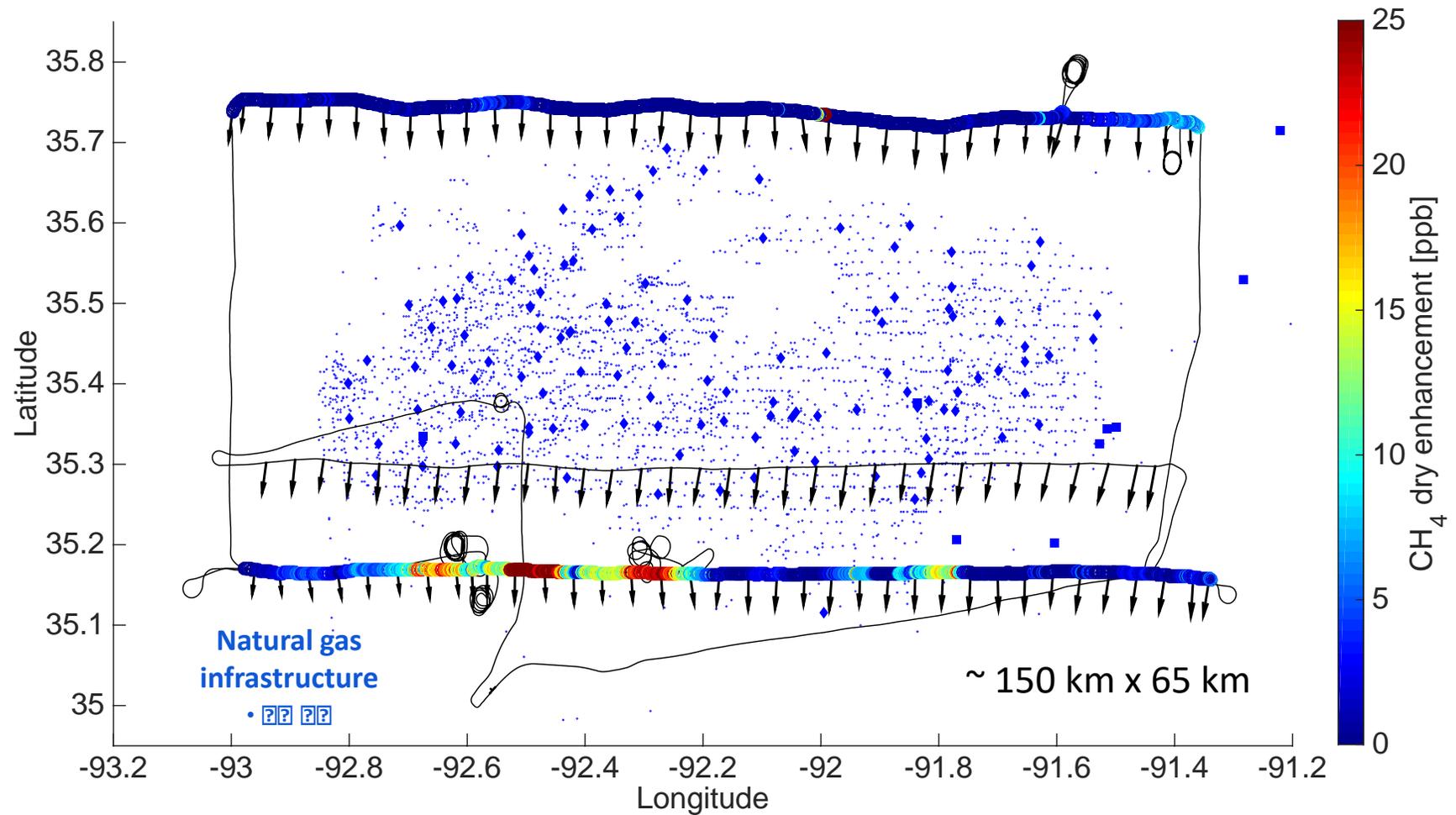


Aircraft-based CH₄ measurements at the O&G basin-level

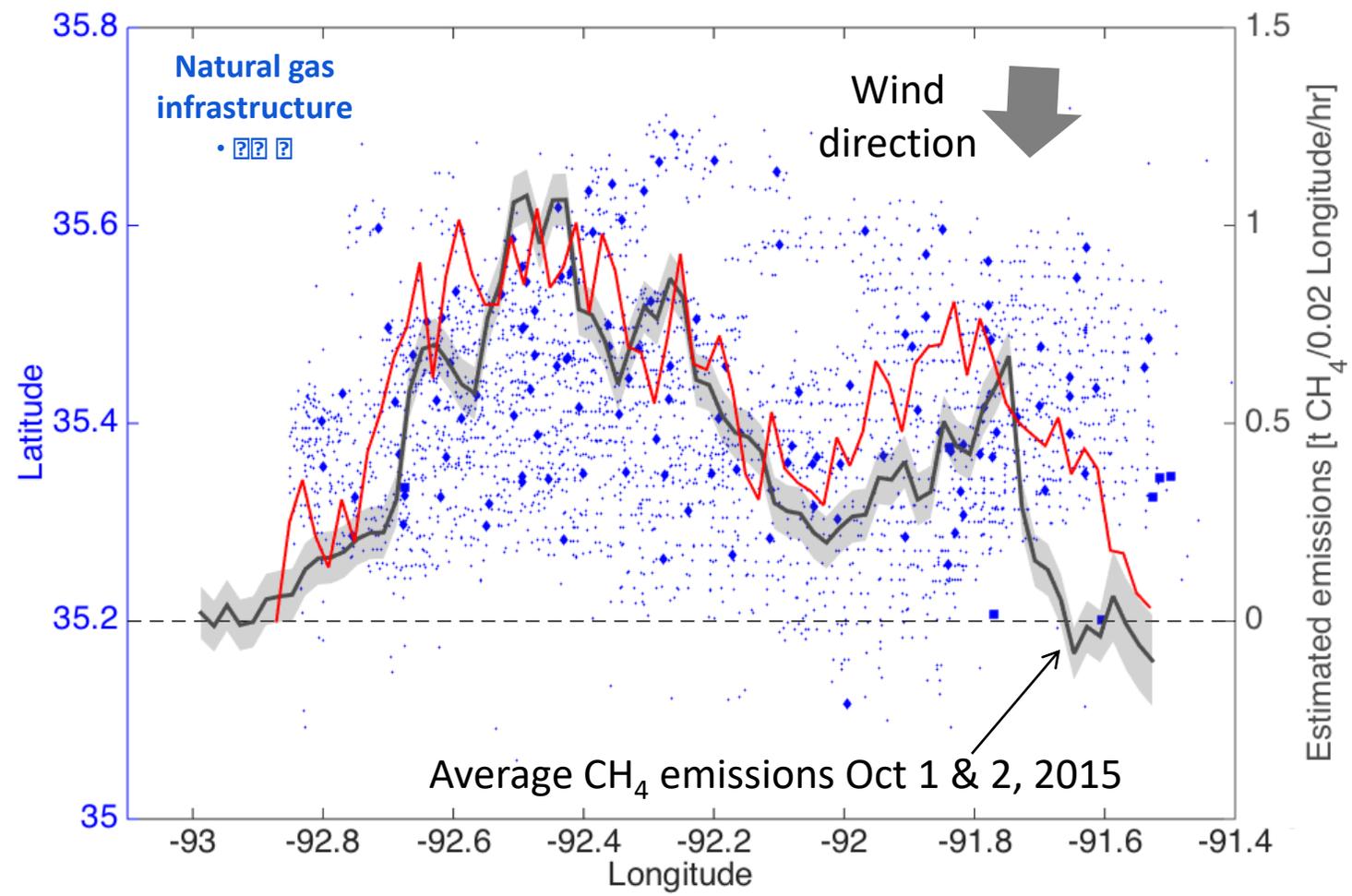


One day of aircraft data in the Fayetteville Shale study area

Oct 1, 2015

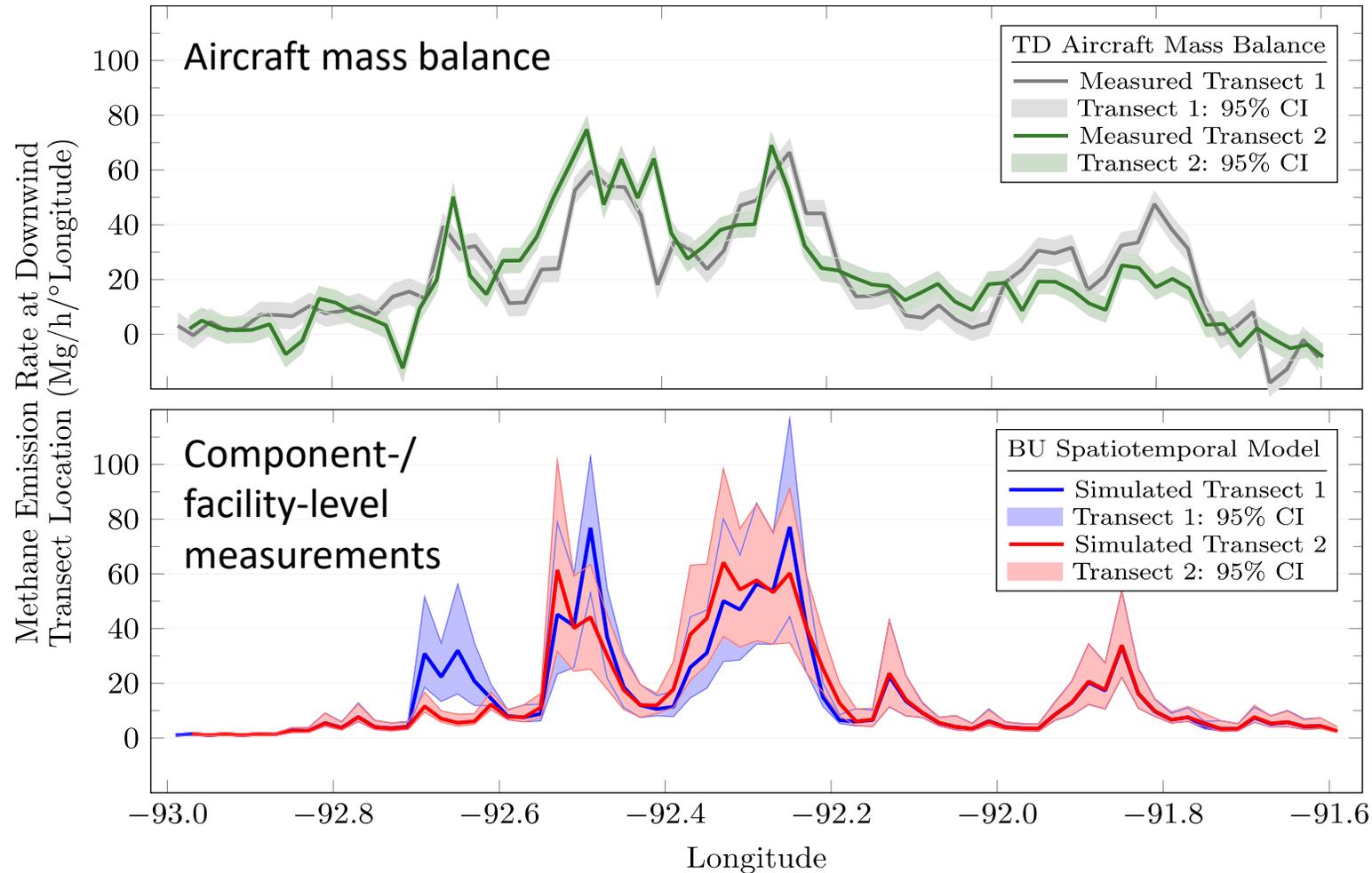


First spatially-resolved aircraft-based CH₄ emission estimates for a basin



Spatial top-down and bottom-up agreement in hourly emissions

Oct 1, 2015



Substantial episodic emissions midday during aircraft sampling

- “Leak rate” in Western half of study area double compared to Eastern half



- ✓ Operator hourly activity data
- ✓ Hourly bottom-up emission inventory



Manual liquid unloadings explain:

- 1/3 of total midday CH₄ emissions
- 2/3 of West-East difference in leak rate

- CH₄ emissions peaked midday when atmospheric conditions are ideal for aircraft sampling
- In contrast, emission inventories generally report long-term (e.g. annual) averages
- Investigate if inventory is representative of snapshot aircraft measurements!

Summary

- Detailed O&G activity data help understand concurrently measured CH₄ emissions (via aircraft) more mechanistically
- Mechanistic understanding is the basis for effective emission mitigation
- Additional scientific advances in this study reduced biases and uncertainties in estimated CH₄ emissions (*see conference paper*)
- Achieved through public-private partnership in this study
- Three decades of scientific method development precede O&G aircraft-based CH₄ measurements (*see conference paper*)