

Tracking NH₃ Emissions from Large Agricultural Sources in Larimer and Weld Counties

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1. NE Colorado is home to large NH₃ sources.

NH₃ is an important trace gas that contributes to particle formation. Deposition of NH₃ causes eutrophication and nutrient imbalances. Concentrated animal feeding operations (CAFOs) are a major source of NH₃ emissions in northeastern Colorado, and those NH₃ sources are understudied. Northeastern Colorado ranks No.4 in the U.S. for confined-fed livestock production. The Transport and Transformation of Ammonia (TRANS²Am) project is characterizing the emissions of NH₃ from CAFOs and the near-field evolution of plumes using two platforms: the University of Wyoming King Air research aircraft and the CSU Tahoe for mobile sampling.

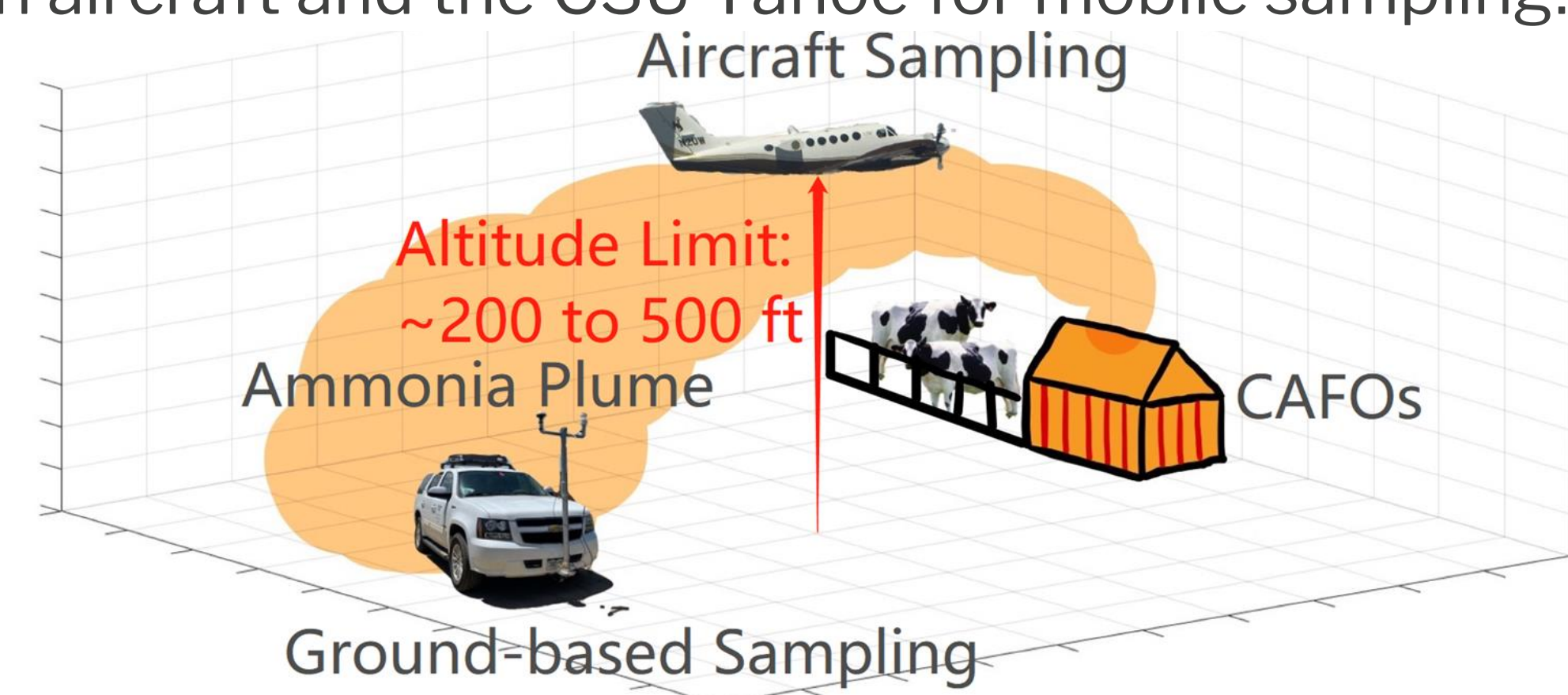


Figure 1. 3-D plot shows University of Wyoming King Air Aircraft and CSU Tahoe Sampling

2. A Mobile Lab (Chevy Tahoe) outfitted with instrumentation is used to circle facilities.

Instrumentation:

- Picarro G2508: mixing ratios of NH₃, CH₄, N₂O, CO₂, and H₂O
- GPS: latitude, longitude, and altitude
- Sonic Anemometer: wind speed and wind direction
- Ambient temperature and relative humidity



Figure 2. Photo of Tahoe and Sampling Instruments

Sampling Strategy:

- Drive at 10-15 mph to achieve good spatial resolution.
- Background conditions are measured upwind of the facility.
- Elevated plumes of NH₃ and CH₄ are detected downwind.

3. Methodology accounts for background, as well as CH₄ and NH₃ time response differences.

Mixing ratios of NH₃ and CH₄ are measured using the Picarro analyzer.

- An upwind “background” is subtracted from within-plume measurements to isolate emission enhancements (Δ NH₃ and Δ CH₄) from a single facility.
- CH₄ rapidly indicates the presence of a plume.
- NH₃ response time lags due to interaction with the inlet surfaces.
- We align NH₃ and CH₄ peaks by peak maxima.

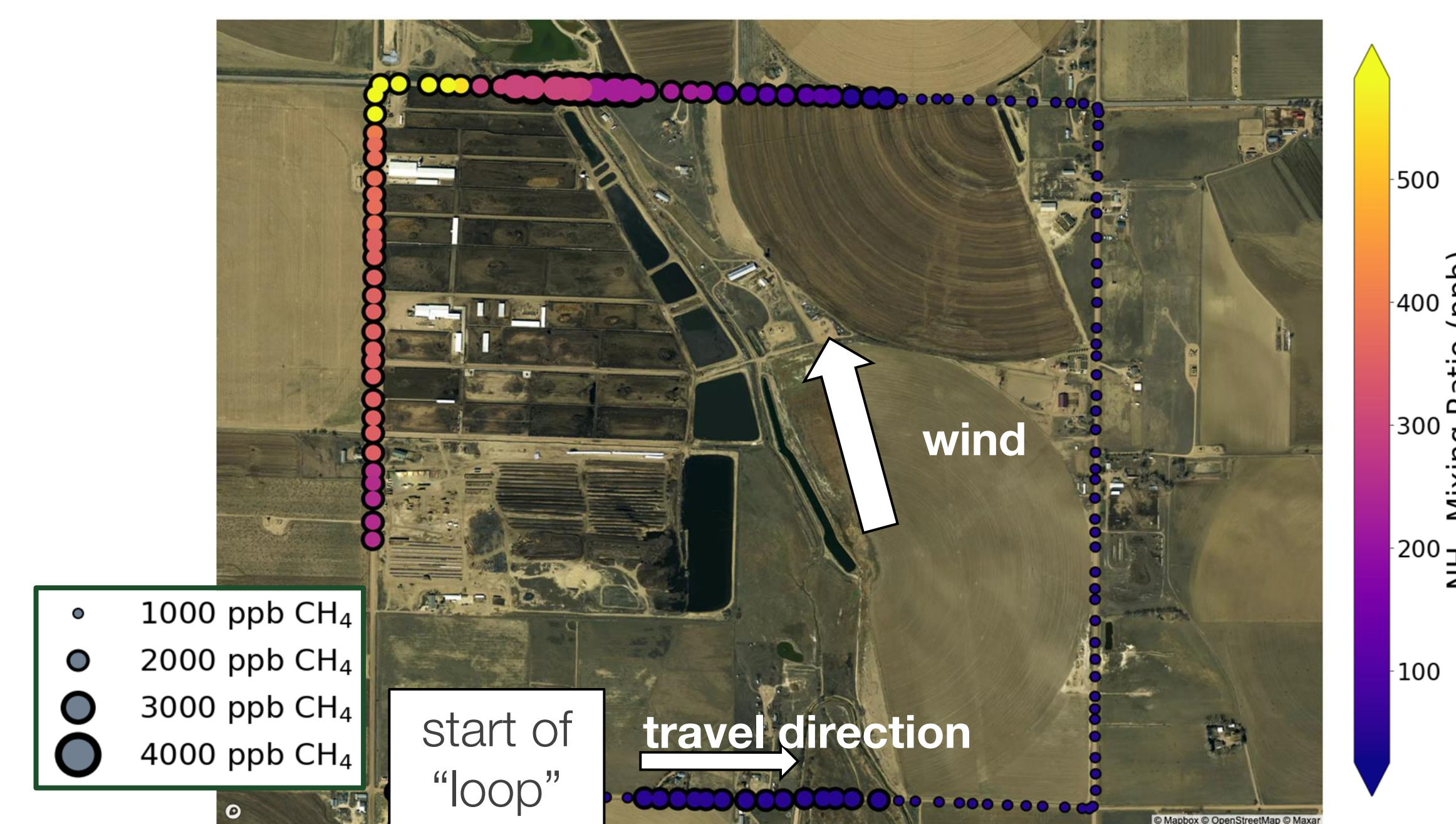
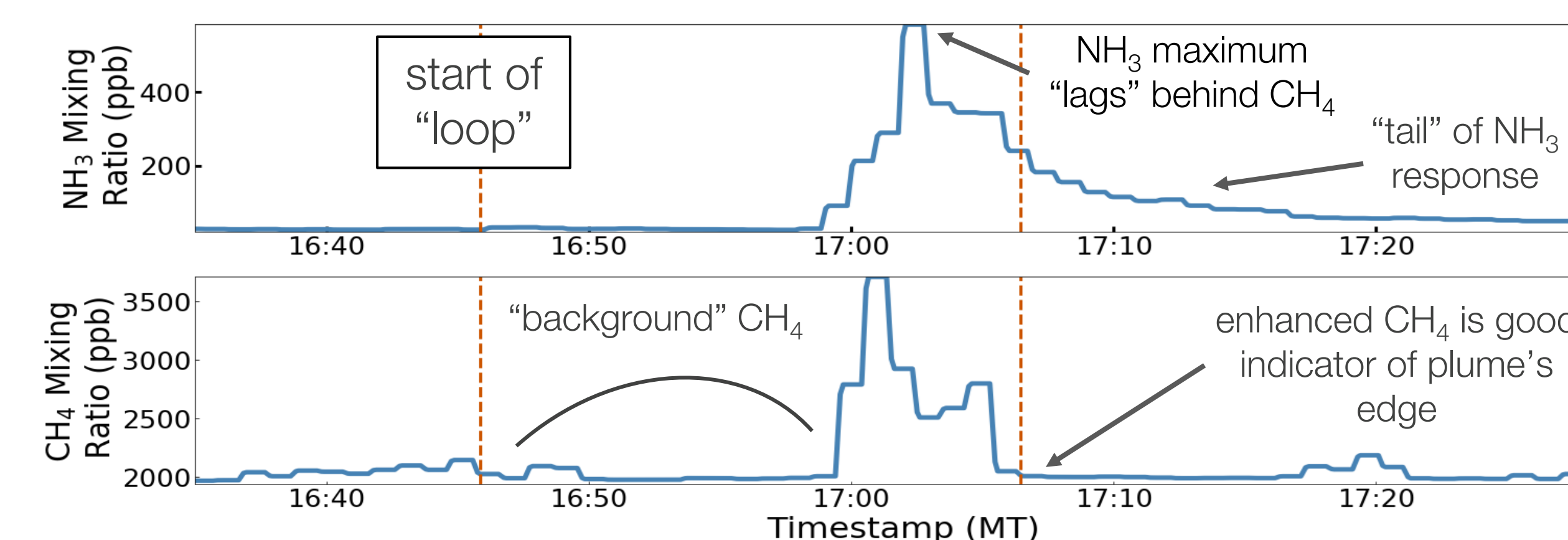


Figure 3. Map from Sampling NH₃ and CH₄ Near a Dairy CAFO.



Reduced major axis (RMA) regression is used to obtain an average NH₃ to CH₄ enhancement ratio (Δ NH₃: Δ CH₄) for a specific facility.

- RMA minimizes error in both variables.
- More appropriate than Ordinary Least Squares(OLS), since both measurements have error.
- Δ NH₃: Δ CH₄ serves as a metric of emission makeup, which can change as the plume is transported downwind and NH₃ is deposited.

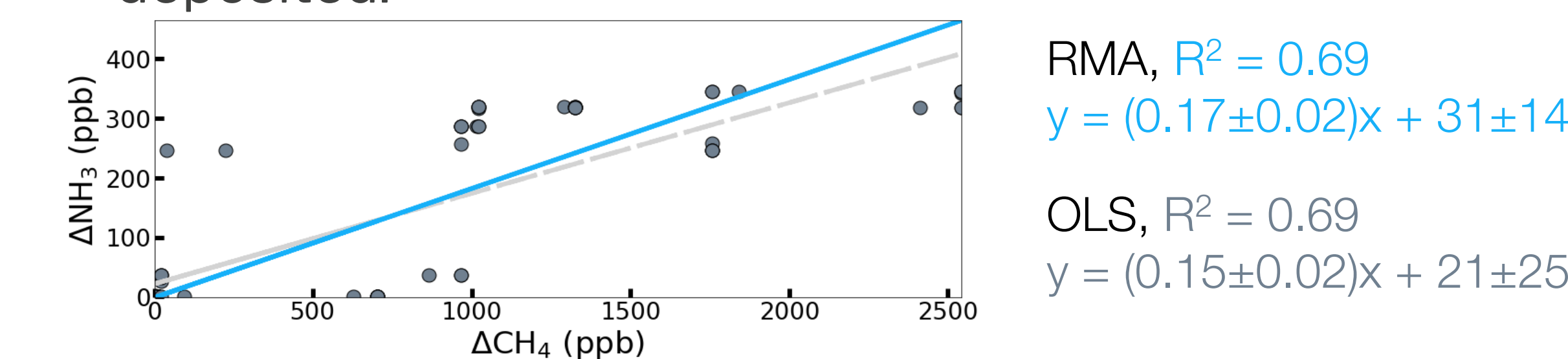


Figure 5. Example Δ NH₃: Δ CH₄ Regression with RMA (blue) & OLS

4. Δ NH₃: Δ CH₄ varied from 0.17 - 1.7 across 3 facilities (1 feedlot and 2 dairies).

- Feedlot Δ NH₃: Δ CH₄ > dairy Δ NH₃: Δ CH₄
- Dairy Δ NH₃: Δ CH₄ values are consistent with prior work.
- Feedlot Δ NH₃: Δ CH₄ higher than expected from prior work
- Variation likely caused by temperature and facility practices

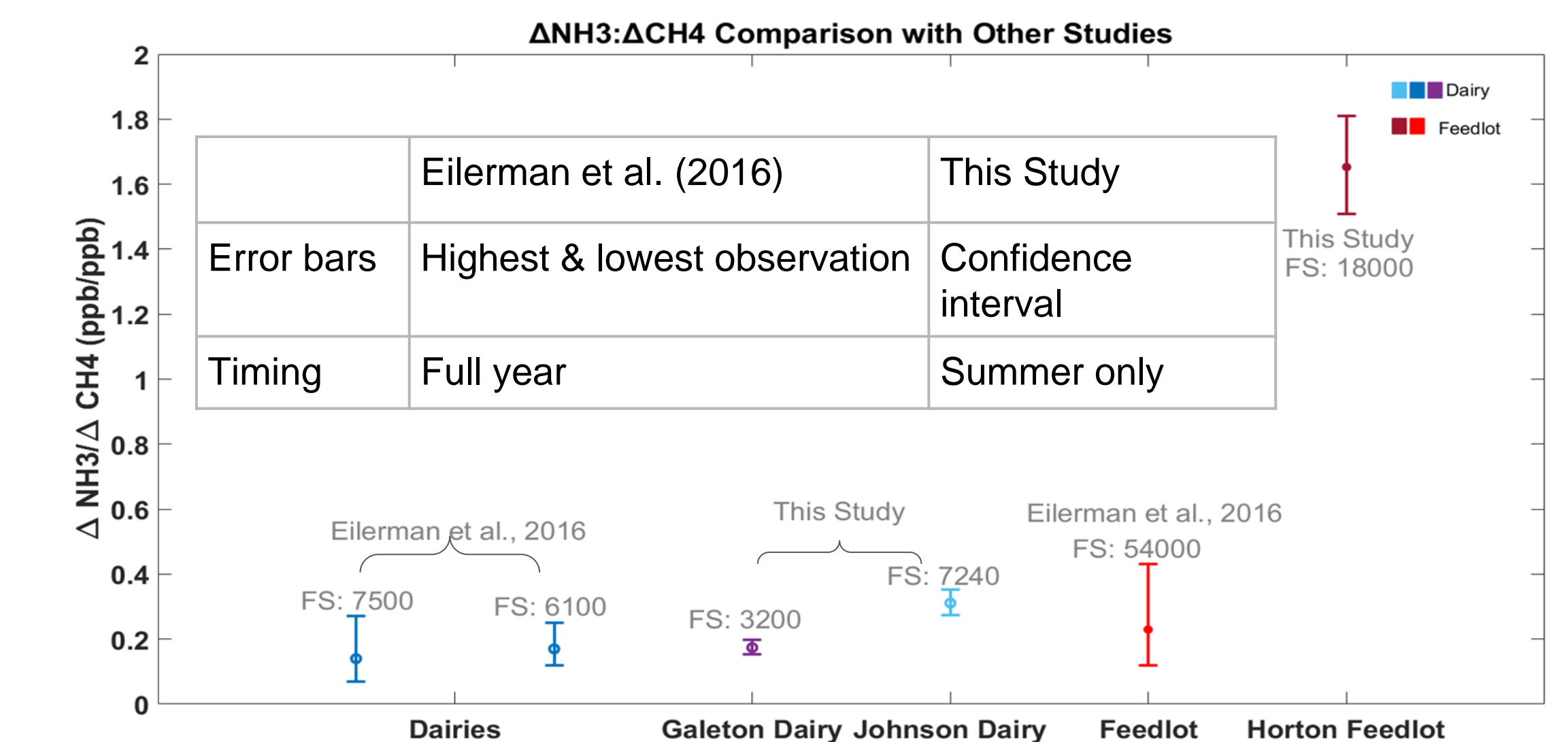


Figure 6. Δ NH₃: Δ CH₄ Comparison with Eilerman et al. (2016)

5. The mobile lab is capable of ER measurements but has limitations.

- Slow NH₃ response needs careful strategy to mitigate.
- Δ NH₃: Δ CH₄ were successfully calculated for three CAFOs, with a range of 0.17 - 1.7.
- Dairy Δ NH₃: Δ CH₄ consistent with prior work(Eilerman, et al., 2016).
- Feedlot Δ NH₃: Δ CH₄ was higher than prior work (Eilerman, et al., 2016).

6. This project provided opportunities to learn fieldwork and data analysis skills.

- Conduct NH₃ and CH₄ measurements using a mobile lab.
- Display and map mobile measurements.
- Calculate and statistically analyze Δ NH₃: Δ CH₄ using Matlab.
- Learn more about atmospheric chemistry and applications
- Conduct field campaign under the variable weather conditions.
- Academically communicate with others through symposium and poster session.

7. Reference

Eilerman, et al., (2016),DOI: 10.1021/acs.est.6b02851.