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Source Attribution of Methane Enhancements at the Southern Great Plains Atmospheric Radiation Measurement Site Field Campaign Report

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November 2025

ARM

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Acronyms and Abbreviations

AFO	animal feeding operation
ARM	Atmospheric Radiation Measurement
PBL	planetary boundary layer
ppb	parts per billion
SGP	Southern Great Plains

Contents

1.0 Summary

Tower data from 2017 to 2020 revealed that the U.S. Department of Energy's Southern Great Plains (SGP) Atmospheric Radiation Measurements (ARM) observatory in Oklahoma exhibited significant CH_4 enhancements compared to other U.S. tower sites. On average, near-surface CH_4 at the ARM site was higher, had larger diurnal and seasonal variations, and had sharper near-surface increases at night compared to other tower sites in the U.S. A field campaign was conducted in June 2024 to identify and quantify the surrounding CH_4 emission sources by two researchers from the University of Oklahoma.

During the campaign, a mobile measurement was conducted using a LI-COR 7810 tracer gas analyzer mounted on a vehicle during June 23-26, 2024 near the SGP site (within 7 km distance). We sampled CH_4 along predefined routes surrounding a suspected source, i.e., a large animal feeding operation (AFO) farm 5.8 km northwest of the SGP ARM site. Measurements were collected between 04:30 and 09:00 local time when the planetary boundary layer (PBL) was shallow, increasing sensitivity to surface emissions. Driving speed was kept below 5 mph to minimize pressure-related artifacts. CH_4 concentrations downwind of the AFO exceeded 6000 ppb on the early morning of June 26, corresponding to an emission rate of ~95 $kg \cdot hr^{-1}$ estimated using the mass balance method. Additional sources identified during the campaign include nearby open-range cattle and leaks from a nearby natural gas pipeline.

2.0 Results

We used long-term (2012-2022) tower data to pinpoint wind directions associated with high surface CH_4 anomalies at the SGP site. The data pointed to two primary sectors: 140°-240° and a narrow sector around 300°. Guided by this analysis, we conducted a targeted mobile field campaign during June 23-26, 2024, to investigate these areas.

Investigation of the 300° wind sector led us to a large AFO with around 15,000 cattle, located 5.8 km from the SGP C1 tower. Mobile transects downwind of this AFO on June 26 recorded extreme CH_4 enhancements far exceeding background levels. We measured concentrations exceeding 6000 ppb downwind of the wastewater pond, over 4000 ppb near the open lots, and greater than 3000 ppb adjacent to the composting area. Using a mass balance method, we calculated a minimum emission rate from the AFO of 92 $kg \cdot hr^{-1}$. This is the critical finding of our investigation: the emission rate from this single, uninventoried facility is larger than the 84 $kg \cdot hr^{-1}$ reported in the U.S. Environmental Protection Agency Greenhouse Gas Inventory for the entire 625 km^2 grid cell. A comparable study by Hu et al. (2025) estimated a emission rate of 65 $kg \cdot hr^{-1}$ from the same facility on June 23, based on plume observations and simulations during the morning boundary-layer transition. Taken together, these independent estimates consistently demonstrate that this AFO is a dominant, previously missing source capable of explaining a significant portion of the SGP CH_4 anomaly.

The campaign further revealed that this hotspot sector contains multiple sources. We also detected a significant natural gas pipeline leak with concentrations spiking to 40,000 ppb. Our survey further accounted for the secondary anomaly from the 140°-240° sector, which we attribute to open-range cattle (~100 head). Although not exceptionally strong sources in absolute terms, their close proximity to the SGP C1 tower allows their emissions to cause high CH_4 enhancements during stable nights. Nevertheless, the AFO is clearly the dominant driver. In conclusion, the SGP CH_4 anomaly is driven by potent, local

agricultural and fossil fuel emissions that are unaccounted for in current inventories and amplified by the region's characteristic nocturnal stability.

3.0 Publications and References

Hu, X-M, W Honeycutt, C Wang, B Weng, B Zhou, and M Xue. 2025. "Observation and simulation of methane plumes during the morning boundary layer transition." *Journal of Geophysical Research – Atmospheres* 130(7): e2024JD042317, https://doi.org/10.1029/2024JD042317

Wang Q-Y, and X-M Hu. 2024. "Examination of Meteorological Factors and Emissions Sources Leading to the Large Methane (CH4) Enhancements at the ARM Site in Oklahoma." Presented at the 2024 American Geophysical Union annual meeting.

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