General Comments

This manuscript presents a novel application of MethaneAIR airborne data to detect and quantify methane emissions from concentrated animal feeding operations (CAFOs) across the United States. The authors develop and apply a scene-based extraction method combined with 2D discrete wavelet denoising and a Gaussian-based Divergence Integral (DI) flux quantification approach. The work demonstrates that agricultural plumes, generally weaker than oil and gas signals, can be isolated and quantified by spatially subsetting flight mosaics around known CAFO locations, and that measured per-animal emission rates frequently exceed EPA inventory values, particularly for dairy operations.

The topic is timely and policy-relevant, given ongoing uncertainty in agricultural methane inventories and the increasing deployment of airborne and spaceborne methane sensors. The methodological contribution, combining scene-based subsetting with wavelet denoising to improve detection of low-magnitude agricultural plumes, is a useful extension of existing MethaneAIR workflows. The paper is generally well-written and the figures are informative.

However, I have several major and minor concerns that should be addressed before the manuscript is suitable for publication in ACP. The most significant issues relate to: (1) the quantitative treatment of uncertainty; (2) the use of maximum permitted animal capacity rather than actual animal numbers as the denominator for per-animal emission estimates; (3) insufficient characterization of the background removal procedure; and (4) a number of conclusions and comparisons that appear to be overreaching given the data available. Addressing these points will substantially strengthen the paper.

Specific Comments

Major Comments

1. Use of maximum permitted capacity as a proxy for actual animal numbers (critical)

The per-animal emission estimates throughout the manuscript (Figure 5, Table 1, Sections 3 and 4) are computed by dividing observed plume fluxes by the maximum registered animal capacity reported by the Colorado Department of Public Health and Environment (CDPHE, 2017). The authors acknowledge that CAFOs may not operate at full permitted capacity and that the CDPHE data are now seven years out of date. This is a fundamental problem that severely limits the interpretation of the per-animal results. A farm operating at 50% capacity would yield emission estimates twice the EPA factor even if actual per-animal emissions were entirely consistent with inventory values. The authors must either obtain more representative animal count data (e.g., from state livestock census records, permit renewal filings, or satellite-based footprint estimation as used in some recent studies) or, at minimum, perform a systematic sensitivity analysis showing how the per-animal conclusions change across a plausible range of actual-to-permitted capacity ratios. Without this, the statement that measurements "exceed EPA emission factor estimates" for dairy (Section 3, Table 1) cannot be taken at face value. It is equally possible that the exceedance is an artefact of the capacity denominator rather than a genuine emissions signal.

2. Background methane field removal and spatial correlation of residuals

The manuscript does not describe in sufficient detail how the background XCH4 field is removed prior to plume detection and DI flux calculation. For the wavelet denoising step (Section 2.4), it is unclear whether a scene-level background subtraction is applied before or after denoising, or whether the wavelet approach itself implicitly handles the background through low-frequency component removal. This distinction matters because any spatially correlated background signal (e.g., regional methane enhancement from oil and gas fields) will propagate into the DI flux estimate. The authors should provide a dedicated methodological description of their background treatment, including any spatial smoothing kernels or polynomial fitting that is applied, and demonstrate with at least one example scene that the residual background is spatially uncorrelated at the scene scale.

3. Uncertainty quantification and robustness criterion

The robustness criterion, a ratio of the standard deviation to the mean DI-derived flux less than 1 (i.e., relative uncertainty below 100%), is quite permissive for a study making quantitative comparisons with inventory estimates. A plume with a central estimate of 200 kg h^{-1} and a 1-sigma uncertainty of 190 kg h^{-1} passes this criterion, yet the confidence interval spans a factor of approximately four. The authors should discuss whether comparisons with EPA emission factors (which carry their own uncertainty) remain meaningful at this level of DI uncertainty, and consider showing the distribution of relative uncertainties across the 89 robust plumes. Additionally, the standard deviation across the growing-box series is used as the uncertainty, but this captures only variability in the box-integration approach; it does not include wind field uncertainty (HRRR vs. actual on-site winds) or retrieval precision uncertainty. A brief discussion of error budget contributions, even qualitative, is needed.

4. Comparisons with prior studies (Table 1)

Table 1 compares mean MethaneAIR-derived per-animal emission rates with values from the EPA inventory, IPCC Tier 2, Golston et al. (2020), and McCabe et al. (2023). Several aspects of this comparison are problematic and require clarification. First, the Golston et al. (2020) and McCabe et al. (2023) measurements were conducted under specific seasonal and meteorological conditions, whereas the MethaneAIR data span multiple seasons and years; aggregating across these without accounting for seasonal variability introduces a systematic confounding factor. Second, McCabe et al. (2023) is described in a footnote as focusing primarily on beef feedlots but including a small number of dairy operations, yet the blended mean (13 ± 2 g $animal^{-1}$ h^{-1}) is placed in the table in a row shared with both CAFO types. This is potentially misleading and should be restructured. Third, the IPCC Tier 2 values listed (~6.62 for beef and ~13.95 for dairy) differ substantially from the EPA Colorado values (6.67 and 22.25 respectively); the reasons for this discrepancy should be explained.

5. Source attribution methodology and its limitations

The plume source attribution (Section 2.5) is described as a manual, qualitative process based on proximity, wind-consistent alignment, morphology, and absence of nearby competing sources. While this approach is pragmatic, the manuscript provides no inter-analyst reliability estimate (e.g., from duplicate independent evaluation of a subset of scenes) nor any false-positive rate estimate from the qualitative assignment. This limits the reader's ability to judge the confidence of the 200 agricultural plume attributions. The authors should provide at least some quantification of this uncertainty or whether a subset of scenes was evaluated by two independent analysts.

Minor Comments

6. Lines 103–106: DI detection threshold (500 vs. 120 kg h^{-1})

The introduction states that the DI method was effective over 500 kg h^{-1} in Chulakadabba et al. (2023), while Guanter et al. (2025) achieved 120 kg h^{-1}. The present study claims to detect plumes below these thresholds using scene-based subsetting. The authors should more explicitly quantify the effective detection threshold achieved in the present agricultural application, and explain mechanistically why scene subsetting enables detection at lower flux rates.

7. Figure 6 and Section 3.1: Detection threshold curves

Figure 6 shows detection rates as a function of estimated CAFO emissions and wind speed. The "estimated CAFO emissions" on the x-axis of the left panel appear to be derived from the same CDPHE permitted capacity data that is used as the denominator in per-animal calculations. If correct, this means the detection curve is not independent of the capacity data uncertainty. The authors should clarify what exactly is shown on the x-axis and how it was calculated.

8. Lines 257–260: Averaging of "robust, disconnected, non-unique plumes"

The procedure for computing total scene emissions is described as averaging robust disconnected non-unique plumes and summing remaining unique plumes. This distinction between "disconnected non-unique" and "unique" plumes should be more carefully defined earlier in the methods section, with a schematic or example to clarify how these categories are assigned and averaged.

9. Section 4, Lines 371–378: Overstated causal interpretation

The conclusion that dairy CAFOs exceed EPA estimates "likely due to higher operational intensity or greater contributions from manure management systems" is speculative without supporting evidence from the data themselves. The alternative explanation, that permitted capacity substantially underestimates actual capacity at dairy facilities, should be given equal weight in the interpretation, especially given the concern raised in major comment 1 above.

Technical Corrections

- **Line 141:** "were were" should be "were"
- **Line 280:** "6.67" in the text does not match "6.57" cited earlier (line 264); one of these appears to be a typographical error and should be made consistent with the EPA source.
- **Line 360/362:** "89 (42%)" is reported in the conclusions but the abstract and Section 3 state 44%; please reconcile.
- **Line 377:** "are be needed" should be "are needed"
- **Line 185:** "a the scene" should be "the scene"
- **Figure 3 caption:** The caption states "~0.005 degrees surrounding CAFO" but the methods describe a ±0.02° subset (Section 2.3). These dimensions should be made consistent.
- **Line 115:** McCabe et al. reference: the units "13 +- g of CH4 animal^{-1} h^{-1}" appear incomplete; please supply the full value.
- **Zhang et al. (2026):** This reference (line 567–569) is to an EGUsphere preprint; if it is not yet published in a peer-reviewed journal, please clarify its status and ensure it is accessible to reviewers.