Review of the manuscript

“Methane retrieval from MethaneAIR using the CO2 Proxy Approach: A demonstration for the upcoming MethaneSAT mission” by Chan Miller et al.

Comprehension

The manuscript presents shortwave infrared methane measurements using MethaneAIR, an airborne demonstrator for the MethaneSAT satellite. The study focuses on retrieval performance and validation of the CO2 proxy method for CH4 retrieval, addressing instrumental challenges like ISRF drifts, and implementing bias correction techniques. It also validates MethaneAIR's measurements against ground-based data. The preprint aims to extrapolate its findings to anticipate the performance of the forthcoming MethaneSAT mission, particularly in terms of precision and detection limits for methane emissions.

The study presents valuable and relevant research but necessitates revisions, particularly in the description of methodologies and structural organization, to ensure clarity and completeness before it is suitable for publication.

General comments

The manuscript's extrapolation of findings from MethaneAIR to MethaneSAT requires improvement, as it frequently lacks comprehensible detail on how this projection is methodologically executed (including the assumptions and limitations).

What types of errors can lower spatial resolution introduce, such as the omission of low-contrast pixels, among others?

The discussion about e.g. the 0.15% target precision for MethaneSAT and its relation to MethaneAIR's performance is limited and I can’t clearly see how this extrapolation is methodologically done.

A numerical analysis of the uncertainties associated with emission estimates would be desirable.

Section 8 of the manuscript is relatively brief considering its title, suggesting a need for more extensive coverage and depth in its content.

Certain sections of the paper could benefit from a more concise description, and the overall structure could be improved for clarity and better organization. Consider introducing additional subsections to achieve this.

Consider to display the mathematical expression used to compute the squeeze factor in the forward model. Overall, provide some more details on the forward model (e.g. input quantities, etc.).

Emphasize that the ISRF squeeze is a nominal fit parameter and clarify that the remaining bias is a result of defocusing, which cannot be resolved solely through the ISRF squeeze adjustment but necessitates an additional preprocessing step, such as PLS regression.

The bias analysis would benefit from additional details regarding the underlying assumptions and background information.

Specific comments

63: Consider to add some recent literature sources on airborne methane retrieval (e.g. methane by HySpex)

99: Could you provide some brief insights into the command chain involved in operations like near real-time satellite commanding, which relies on forecasts and other factors? I

132: The accuracy of the proxy method could potentially be compromised if there is gas flaring occurring in close proximity?

137: The MethaneAIR ground pixel size significantly differs from the nominal resolution of MethaneSAT. Any conclusions for MethaneSAT need to address assumptions and limitations in such a projection.

185: Consider to be more explicit. But if I understand correctly, there are a total of 19 layers from the Bottom of the Atmosphere (BOA) to the Top of the Atmosphere (TOA), with 13 of these layers situated within the troposphere.

18 + Table 1: Why scale all 19 layers when the enhancement primarily originates at or near the surface and likely remains concentrated in the lower layers for several kilometers, especially under steady wind and stable atmospheric conditions?

199: An Instrument Spectral Response Function (ISRF) squeeze factor of less than 1 typically indicates squeezing, while a factor greater than 1 signifies stretching. So, ISRF squeeze < 1 means squeezing, and ISRF squeeze > 1 means stretching? Be more explicit.

203: Where is this shown?

Eq.(3): Consider to include the complete formula for the squeeze factor.

220: "… high optical depth,…"?

Fig. 4: Is it plausible or reasonable to assume that XCH4 (XCH4 typically refers to column-averaged dry-air mole fraction of methane) is enhanced at the position of the cloud?

264: Is "mechanistically" the right term?

268: "… 10 s of observations"?

Fig. 5: In (a1) and (a2), where is the representation of the XCH4 bias located or depicted?

276: Repeating "valuable"

Fig. 7: Check first sentence in caption. Add XCH4 label to colorbar. Show Beta from Eq. (5) or at least add some information in the caption that helps to better relate the figure with Eq. (5).

318: Clarify.

341: Was the TROPOMI L2 product destriped as part of the processing, or was it delivered already destriped? My assumption is that they provide a destriped product.

369-372: The XCH4 albedo dependence analysis in Fig. 12 is conducted only for a single scene. Is this sentence required?

377: Where to find Fig. S3?

401: Review the sentence (IME is not directly a plume detection method).

Fig. 8: Add more details to the caption. The stripes are in the along-track direction due to the cross-track bias? Do I see multiple parallel flight tracks here?

Fig 9 & Fig. 10: Was the averaging kernel actually considered in the comparison? It may be beneficial to show the formula to accommodate the varying vertical.

Fig 12: Consider providing a brief description of the y-axis label in the caption. Additionally, could you explain why the lines do not exhibit a consistent trend towards either higher or lower values? If scattering is the underlying process responsible for this bias, it's puzzling why it does not consistently manifest as either a positive bias (indicative of multiple scattering) or a negative bias (indicative of single scattering).

390: Please provide details on how the value of 35 ppb was determined. Is it based on the standard deviation or another statistical measure?

Fig 14: Check axis labels on right panel.

545: The resolution is similar to TROPOMI's resolution (at least it is in the same order of magnitude.)

545: Provide more context or specify where the analysis yielding the result of 0.15% is located? Additionally, it would be helpful to understand the assumptions made to arrive at this conclusion.