

General Comments:

This paper is the first assessment of MethaneSATs point source methane plume mapping and quantification. The subject of this paper is important to the methane mapping community due to the high-profile nature of the MethaneSAT mission. It is my recommendation that this paper be published with significant revisions. This paper aims to do two things, first it aims to quantify MethaneSATs detection limits using a combination of synthetic and real imagery. Second it aims to provide an assessment of plumes detected by MethaneSAT in key global methane hotspots.

This study provides a good assessment of MethaneSAT's plume detection capabilities. However, it could be strengthened by 1. Using the MethaneSAT data archive to do the analysis. 2. Including a probability of detection analysis. 3. Doing a quantitative plume comparison with a higher quality point source imager. Details on these points are provided below.

The assessment of the global hotspots provides nice examples of MethaneSAT plume data however the analysis of the hotspots lacks scientific rigor and unique insights. Details on suggested improvement are provided below.

Major/Specific Comments:

Abstract

In line 9 a probability of detection would be preferable to a minimum detection (I have more comments below on POD). Please define favorable condition (windspeed, albedo, etc.)

Line 14 to 16. This statement seems to overstate the results of the paper and the potential of the MethaneSAT archive. Here and throughout the paper, the authors should take caution not to overstate the significance of the plumes highlighted in this study.

Methods and Materials

In line 74 this paper would benefit from a summary of the methods in addition to a reference to a paper.

For the data used in this study, one goal of this paper is to evaluate plume detection with regards to surface albedo, retrieval noise, pixel size, and wind speed. The paper would be improved if the authors showed that the data used represents a diversity of albedo, XCH₄ noise, and windspeed (for example a histogram of each variable for all data used in the study). In addition, the authors could go further and use the XCH₄ and XCH₄ noise to show the precision for all data used in the analysis.

Assessment of plume detection limits

The analysis of the drivers of the MethaneSATs detection limit overall is good and I especially like figure 3 as a visual interpretation of the main drivers. However, the analysis relies too heavily on the Jacobs 2016 equation (equation 1 in this paper). Given that the MethaneSAT archive is complete, this section would be strengthened by an empirical assessment of the drivers of detection limits. For example, the albedo, XCH₄ noise, and wind speed can be calculated for every detected plume in the MethaneSAT archive and the authors could show or deduce a relationship between the afore mentioned factors and the emission rate. Results from the actual data would make the analysis much stronger. Relying too heavily on a model does not highlight the actual performance of the data which is a major aim of this paper.

Probability of detection (POD) has emerged as a more common and more accurate measure of detection limit. Point source images generally report a 90% or 50% POD at a 3 m/s wind speed. This paper would be greatly improved if the authors attempt to construct a POD curve for MethaneSAT. This would not only provide a state of the science analysis but also make it more easily comparable to other point source imagers. The authors could use the complete MethaneSAT archive and MethaneAir or other IMEO data to construct a figure similar to figure 2 in Kunkel et al 2023 or figure 2 in Ayasse et al 2024. This type of analysis would significantly strengthen this paper and provide a key finding to highlight.

Impact of spatial sampling on plume detection and attribution

I think the impact of spatial sampling is a good analysis and found those results interesting.

Comparison with plume data from high-resolution missions

The intention of this analysis is good, but the quality of the Landsat methane plume data detracts from the quality of this analysis. Comparing MethaneSAT to a higher quality or better validated point source imager (such as MethaneAIR or an imaging spectrometer) would make this analysis not only show consistency but also validate MethaneSATs quantitative emission estimates. Better yet, if controlled release data is available for MethaneSAT this would be an excellent place to display the results. These data may not be available, and if this is the case, an explanation of why this is the best available data for this analysis would strengthen the paper.

Potential of Δ XCH₄ maps from the matched-filter retrieval for improved plume detection

This section could get added to the methods section. The matched filter is the industry standard detection algorithm, but the issues listed here are enough to justify using the CO₂ proxy for qualification. The methods section could be expanded to include this analysis and the justification for the final quantification choice.

Assessment of super-emissions across major methane hotspot regions around the world

This section lacks scientific rigor and unique insights. This section should get reduced (although if reduced, I recommend expanding the plume detection limit analysis) or narrowed in scope with a more in-depth analysis. MethaneSAT is advertised as being able to do regional trends and point sources (in fact this paper highlights this capability in the introduction). This section would be very strong if the authors could do a regional flux + point source analysis exclusively with MethaneSAT data for a few key regions. This type of analysis would highlight MethaneSATs unique capabilities and it would be truly novel work. This maybe out of the scope of the paper therefore the comments below offer other suggestions that only utilize point source data.

Super-emissions from Turkmenistan's South Caspian basin

Turkmenistan is one of the easiest places on earth to observe methane plumes and there is a rich methane plume data archive from a multitude of instruments for Turkmenistan. The MethaneSAT images alone do not yield any new or interesting insights regarding this region. Both persistence and the evolution of O&G extraction in this region, while interesting topics, could be done better by incorporating more data. I would consider removing this section.

Super-emissions from the US' Permian Midland sub-basin

Again, this is one of the most highly studied methane emitting regions globally, therefore the bar for meaningful analysis is higher than just plume detection and quantification. To strength this paper and to highlight the capability of MethaneSAT think it would be better to attempt to do a quantitative analysis of the total basin super emitter emissions or intensity in the basin. This could then be compared to work from previous studies (for example, Zhang 2020, Cusworth 2022, Irakulis-Loitxate 2021, Chen 2022, Varon 2022, or many others). This is one idea but other in depth or unique analysis could be added here to strengthen this section.

In addition, the data presented in this section does not seem strong enough to state the observed plumes are due to the addition of pipeline capacity. This region is known for extreme day to day variability in emissions and I think more images/data are needed to link observed emissions to this specific activity.

Global view of O&G methane super-emitters based on Methane

Although not a rigorous scientific study, this section and these figures do highlight the diversity of plumes in the methaneSAT archive. However, this section would be strengthened if the authors could elaborate on how a year of MethaneSAT observations are a valuable contribution to the field and provide a discussion of what MethaneSAT data provides that the current constellation of point source imagers do not.

Conclusions

Line 385 states that the results confirm that MethaneSAT can fill the observational gap between TROPOMI and high resolution missions, however it is not clear to me know the analysis or the results show this. Line 390 also states capabilities that are not discussed in this paper. I would add the contents of the sentence in line 397-389 to the paragraph below and remove the remainder of this paragraph.

In Line 399 the paper does not provide “new insights to the global O&G methane hotspots.” The authors should be more cautious about overstating the results of this analysis.

Minor Comments:

Line 30 -> delete “on the one hand”

Lin3 33 -> define “very large point sources”

Line 36 -> delete “on the other hand”

Line 63 -> what does the .08 nm in parenthesis represent?

Figure 1 -> a scale bar on (b) would make it easier to compare to the methaneSAT image.

line 110 -> Delete on the other hand and replace with however

line 117 -> delete “on the other hand”

Line 155 -> curious about this plume, it doesn't look like the other plumes in the XCH₄ in figure 1 and given it is not in any other data from the day has more analysis been done to 1. Confirm it is a real plume by attributing it to infrastructure that could potentially have a <70 min 100 t/hr emission and 2. doing a due diligence evaluation to make sure it is not an artifact or false positive

Line 174 -> delete “on the other hand”

Figure 8 -> one point is orange while the others are blue, please explain this in the figure caption or correct if an error.

Line 271 -> delete “on the other hand”

Line 296 -> delete “on the other hand”

Figure 10 and 11 -> These figures could be combined, and the south Caspian and Permian basin images could be dropped as these areas are discussed elsewhere.

Line 392 -> delete “on the other hand”