

## Response to Reviewer 2

We thank the reviewer for the careful reading of our manuscript and for the constructive feedback. We appreciate the reviewer's recognition that the overall motivation of the study aligns with the journal's scope. The comments regarding references, figures, and presentation quality were helpful and contributed to improvements in the revised manuscript.

### Summary of revisions

In response to the reviewer's comments, the manuscript has been revised to improve referencing accuracy, figure clarity, and overall presentation quality. The main revisions include:

- adoption of the WFMD TROPOMI methane product in place of the earlier GEE-based dataset, together with updated methodological description and filtering criteria;
- verification and correction of all in-text citations and references;
- replacement of secondary references with primary sources where appropriate (e.g., IPCC reports and core methane literature);
- addition of key TROPOMI mission and product references;
- revision of all figure captions to provide standalone explanations;
- correction and verification of Figure 1b;
- correction of inconsistencies in supplementary tables and internal cross-references;
- improved separation between analytical results and interpretative discussion.

Detailed responses are provided below:

### Comment 1:

#### References

- The first citation appearing in the manuscript (Saleem et al., 2025) could not be located in the reference list. This should be checked and corrected across the full manuscript.
- Several citations in the Introduction appear to be tertiary or secondary sources for general statements. For foundational introductory points (e.g., general statements about methane and global warming potential), the reference choices feel unusual and weaken the scholarly basis of the paper.
- Data-source referencing follows a similar pattern by non-primary/less relevant references. Overall, the paper gives the impression of limited engagement with core mission/product literature (for example, key TROPOMI mission or instrument overview references are expected but appear to be missing).

### Response 1:

We thank the reviewer for identifying several issues related to referencing and citation consistency.

#### Changes in manuscript

- The missing citation Saleem et al. (2025) has been corrected and a complete cross-check of the reference list and all in-text citations has been performed.
  - Foundational statements in the Introduction now rely primarily on primary sources, including IPCC reports and core methane literature.
  - Secondary or tertiary references used for general statements have been removed where not necessary.
  - Key mission and product references have been added, including the TROPOMI mission overview paper (Veefkind et al., 2012) and the WFMD methane retrieval papers (Schneising et al., 2020, 2023).
- These revisions ensure appropriate referencing and engagement with the core mission and product literature.

## Comment 2:

### Figure captions are insufficient

- Many figure captions function only as titles. Captions should contain a short, direct description of what is shown, what dataset is used, what time period is covered, and what the reader should notice. The current captions are often not informative enough for a standalone reading.

## Response 2:

We agree that figure captions should provide sufficient information to allow figures to be understood independently of the main text.

### Changes in manuscript

All figure captions have been revised to include:

- dataset source (e.g., TROPOMI/WFMD or EDGAR v8.1).
- time period covered.
- spatial resolution.
- statistical methods used (e.g., Moran's I,  $G_i^*$ ).
- a concise explanation of the key patterns illustrated.

As a result, captions now provide clear standalone descriptions rather than functioning only as titles.

## Comment 3:

### Figure 1b histogram: unclear and possibly incorrect presentation

- The histogram in Figure 1b visually appears odd: the central part of the histogram looks incomplete (missing bars) and the plotted summary statistics are confusing.
- The text claims panel (b) contains annual mean, median, and variability, but the plot shows a 'mode,' while the median is not shown. In addition, what is labelled as 'mode' does not visually correspond to a typical mode?
- This figure should be revisited: explain exactly what is plotted.

## Response 3:

We thank the reviewer for carefully examining Figure 1b and identifying the inconsistency in the histogram presentation.

### Changes in manuscript

- The histogram panel has been corrected and re-generated to ensure proper bar representation.
- Summary statistics displayed on the figure have been revised for clarity.
- The figure caption and associated text have been updated to clearly describe the plotted statistics.
- The figure has been cross-checked against the underlying dataset to ensure full consistency between the visual representation and the reported statistics.

## **Comment 4:**

### **Table S5**

- The line 300 states: “A notable gap between the mode and other statistical measures suggests the potential presence of a skewed distribution (Table S5).” However, Table S5 does not contain the ‘mode.’

## **Response 4:**

We thank the reviewer for identifying this discrepancy between the text and the supplementary table.

### **Changes in manuscript**

- The supplementary table and the corresponding text have been corrected to ensure consistent reporting of statistical metrics. All internal cross-references between tables, figures, and text have been carefully verified throughout the manuscript.

## **Comment 5:**

### **Clarity and precision**

- Some of the explanatory statements read as broad qualitative interpretations without clear supporting evidence or linkage to specific analyses (for example, attributing hotspot regions to particular activity types without an explicit supporting comparison shown in the results).
- The manuscript would benefit from more precise wording and better separation between what is directly supported by the analysis versus what is proposed as interpretation.

## **Response 5:**

We appreciate the reviewer’s comment regarding the distinction between analytical results and interpretative statements. In the revised manuscript, we clarified the scope of the analysis and ensured a clearer separation between results derived directly from the spatial statistical analysis and broader contextual interpretation. In particular, the manuscript now emphasizes that the study investigates spatial clustering in the observed XCH<sub>4</sub> field rather than attributing methane emissions to specific sources.

### **Changes in manuscript**

- The Results section now focuses strictly on patterns identified by the spatial statistical analysis (e.g., clustering of XCH<sub>4</sub> values).
- Interpretative statements relating hotspot regions to potential activity types (e.g., oil and gas infrastructure, agricultural regions, or urban areas) are now explicitly presented as contextual explanations rather than source attribution.
- Several parts of the Discussion have been revised to improve precision and clearly distinguish observational findings from interpretation.
- Wording throughout the manuscript has been adjusted to avoid implying that the analysis directly identifies methane emission sources.

Sincerely,  
The Authors