The document lists the comments (written here in small font slanted) and our responses to **Reviewer #3** .

We kindly appreciate the review of our manuscript and the comments were great guidelines to improve the paper. Note that in the *Specific comments* some comments are only answered with DONE if the corrections were directly applied to the manuscript but all the aspects were addressed if not otherwise stated in an answer.

General comments:

This work study the performance of methane retrievals deduced by non-linear and linear methodologies from data obtained by airborne HySpex observations. Methods are applied in several spectral ranges in the SWIR, where methane absorption features are located.

Within non-linear methods we find the Nonlinear Least Squares, the Separable Least Squares and the Generalized Least Squares and within the linear methods we find the Linear Least Squares, the Matched Filter, the Single Value Decomposition, and the

Spectral Signature Detection. While non-linear methods are more time-consuming and get a best estimate, linear methods are faster and can be more suitable for real-time onboard measurements.

This study is helpful in order to understand the limitations of HySpex in detecting methane emissions with several methods. A good understanding of these limitations can establish a strategy to get optimal methane concentration maps on real time and after the flight.

The results introduced in this work are of remarkable interest and a great amount of work must have been involved. Methane retrieval and methane retrieval error figures are very self-explanatory and visual. Moreover, there are a great diversity of methodologies that have been explored, which is a decision that helps to determine more thoroughly the limitations of Hyspex for methane mapping.

I find high value in the objectives of this paper and the figures, but I see strong shortcomings that make me decide to accept this paper with 'major revisions'.

Major revisions:

The paper is hard to read: there are very long sentences that are difficult to understand, and I find a strong lack of coherence and consistency in writing. I would recommend a rewriting that makes the work easier to read.

In a great efforts the issues related to the readability of the paper were addressed. Many parts of the manuscript were rewritten to improve coherence and consistency, hopefully resulting in a more understandable text.

Figures are not exploited. Although the figure can be mentioned in the text, there is little feedback between text and figures. This happens with Fig. 3, Fig. 4, Fig. 6, Fig. 7. I doubt if these figures are necessary. Besides, I find information that does not contribute to the paper, such as a lot of details about the in the aircraft measurements, determining the nature of absorption features (vibrational transition), etc. Altogether, the paper could be shorter and preserve the important information at the same time.

In the revised version we adds more relevant information in the captions and try to reference the figures more clearly in the text. After review of the figures led to the decision that Fig. 3 and 5 can be removed without compromising comprehension while all other figures in the manuscript were revised according to the reviewers suggestions and to hopefully better align them with the text. The elimination of irrelevant information should also contribute to a more more focused and streamlined paper.

- Methods are not clearly introduced. Some parameters are not explained and some formulas appear without a previous justification or citation. As a consequence, the reader could doubt about the theoretical basis of the diverse methods. There is also a lack of consistency in nomenclature: some variables are written in different ways along the study, which makes it difficult to keep up with the paper.

To improve this aspect, we carefully reviewed the manuscript and made necessary adjustments to ensure that variables are written in the same way throughout the study. This was also a big concern of Reviewer #2. We hope that the revised version now uses a consistent nomenclature, and that sufficient references are provided to support the theoretical basis of the diverse methods.

Results are nor exposed nor discussed in a consistent manner. For example, methane retrievals are showed in both single spectral intervals and also the multi-interval in the NLS, but the multi-interval is not shown in GLS. Besides, I think a more thorough discussion would have been appropriate. A table gathering statistic information about the performance of every method could be an adequate manner to do it.

We made sure to show the methane retrievals in a consistent manner across all methods, including both single spectral intervals and the multi-interval approach in both NLS and GLS. We have also added a table summarizing the performance statistics of each method to provide a clearer comparison of their performance.

Additionally, we have revised the discussion section to provide a more thorough and consistent analysis of the results, including correlations between methods and a more detailed discussion of the strengths and weaknesses of each approach.

Conclusions about the different methods are not clear. Which are then the best methods? Which is the best strategy to map methane in real-time flight and after the flight? Maybe this could be clearer with the table that I commented previously.

A table for the nonlinear and the linear schemes that summarize the performance of each method is now provided. Moreover a statistical analysis is performed in Sec. 3.3. This should make it easier to compare the methods and determine the best methods for mapping methane in real-time flight (performance is key) and post-flight (accuracy and precision is key). The strengths and limitations of each method are now hopefully better highlighted.

Minor revisions:

Line 33: Fossil fuel exploitation is responsible for 30-42% of all anthropogenic CH4 emissions (Saunoise, 2020).

I am afraid but I was not able to find this reference. Could you please provide the DOI so we can include it.

Line 40: the absorption spectral ranges are not correct.

Reformulated to: ... around 1.6 μm and and 2.3 μm.

Line 54-57: example of too long sentence.

Splited sentence.

Line 75: moderate spectral resolution is defined as '¿1nm'. And what about the coarse spectral resolution?

Do you mean the coarse spatial resolution in addition to the coarse spectral resolution? The aspect is described in Line 51.

Line 77: I think you can make a more thorough distinction between data-driven methods and physically based methods (see Guanter, 2021).

The updated Methodology section now better describes the differences between the methods.

Line 96: 'a VNIR-1600 and a SWIR-320m-e'. I supposed the former can measure VNIR radiation and the latter SWIR radiation, but this is not explicitly explained.

This is described in the reference provided.

Line 112: I think '0955 UTC' is not a valid timestamp format.

Changed to '09:55 UTC' but without seconds.

Line 156: 'methane enhancement' instead of 'Gaussian plume'. The gaussian plume would be the result of the methane enhanced pixels close to an emitting source.

Line 166: 'BIRRA level 2 processor' could be in italics.

DONE

Line 166: DLR initials are already explained.

DONE

Line 319: interpolated band ratio (CIBR) from Green et al.(1989)...

DONE

Line 344: retrieval.

DONE

Line 399-400: 'The algorithm employs the inverse of a scene's covariance structure to account for backgorund statistics in the retrieval'. This was already stated in 'Methodology'.

Removed the reoccurrence.

Line 445: What is (a,d,g), (b,e,h), and (c,f,i)? It is not clear.

Not applicable anymore.

Line 469: However.

DONE

Line 474: So far, only narrow...

Not applicable anymore.

With best regards,

Philipp Hochstaffl and co-authors