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Comment on amt-2022-271

Anonymous Referee #3

Referee comment on "Methane retrievals from airborne HySpex observations in the shortwave infrared" by Philipp Hochstaffl et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2022-271-RC3, 2023

Review
Title: Methane retrieval from airborne HySpex observations in the short-wave infrared
Author(s): Philipp Hochstaffl et al.
MS No.: amt-2022-271
MS type: Research article
Special Issue: CoMet: a mission to improve our understanding and to better quantify the carbon dioxide and methane cycles (AMT/ACP/GMD inter-journal SI)

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.
- 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.
- 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.
- 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.
- 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.

Minor revisions
Line 33: Fossil fuel exploitation is responsible for 30-42% of all anthropogenic CH4 emissions (Saunoise, 2020).
Line 40: the absorption spectral ranges are not correct.
Line 54-57: example of too long sentence.
Line 75: moderate spectral resolution is defined as '>1nm'. And what about the coarse spectral resolution?
Line 77: I think you can make a more thorough distinction between data-driven methods and physically based methods (see Guanter, 2021).
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.
Line 112: I think '0955 UTC' is not a valid timestamp format.
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.
Line 166: DLR initials are already explained.
Line 319: interpolated band ratio (CIBR) from Green et al.(1989)…
Line 344: retrieval.
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'.
Line 445: What is (a,d,g), (b,e,h), and (c,f,i)? It is not clear.
Line 469: However.
Line 474: So far, only narrow…