Black: Referee's comments
Blue: Author's reply

We sincerely appreciate the Referee's time and effort in reviewing our manuscript. Below, we provide a point-by-point response to the comments.

This manuscript by Ortega et al. presents an extensive evaluation of retrieval strategies for two major greenhouses gases, namely, methane and nitrous oxide, applied to high resolution solar absorption spectra obtained with Fourier transform infrared (FTIR) spectrometers.

For both targets, the authors carefully investigate the effect of the line parameters selection and of the adopted regularization on the retrieved geophysical products, using the SFIT4 algorithm. The parametrization is tuned such as to reach comparable information content (degree of freedom for signal or DOF of 2-2.5). Observations obtained at Boulder, CO, in the framework of the NDACC network are the focus here. Indeed, the authors capitalize on concurrent airborne (air core or aircraft) in situ measurements available in the vicinity of this site over several years.

This way, the numerous strategies investigated can be ranked not only on the basis of the smallest spectral residuals achieved, but also, and importantly, by minimizing the bias between the remote-sensing and in situ data.

The inter-technique bias for CH4 and N2O are determined considering large samples and found small or even not significant. Uncertainty budgets are also evaluated and presented considering the prescribed strategies.

Overall, the results are appropriately presented and discussed, and the manuscript reads well despite the large number of figures and tables.

Major comments

This work will undoubtedly be very useful for the NDACC FTIR community, likely leading to better harmonization and consistency across the stations while potentially minimizing biases with other techniques, consolidating the resulting data sets, making of them more reliable and relevant ensembles for satellite and atmospheric model validation.

Still, this manuscript remains very technical by nature and possibly of limited relevance for the broader scientific community. In my view, it could be more appropriate to consider this work as a "Technical note" and to include in a supplement the detailed descriptions of the selected and recommended retrieval strategies, including the regularization (especially for the optimal estimation approach). This way, this paper would be optimized for its most likely end users.

We appreciate the reviewer's recognition of the value of this work for the NDACC FTIR community and its potential impact on data harmonization, bias minimization, and broader applications in satellite and model validation. Given the extensive analysis of retrieval strategies, uncertainty assessment, and validation against independent in situ measurements, we believe that AMT is an appropriate venue for this study. We do not believe adding the phrase 'Technical note' is required as it is implicit within the journal scope and focus. While the results are highly relevant for NDACC, they also extend beyond this network by providing insights applicable to other FTIR retrieval efforts, satellite validation studies, and atmospheric modeling. The methodology and findings contribute to the broader atmospheric science community by improving the accuracy and consistency of ground-based remote sensing techniques for CH_4 and N_2O, which are critical for understanding greenhouse gas trends.

Finally, I found the section on the trend analysis quite irrelevant in the present context, considering that this study aims at the determination of optimum FTIR products as part of a network effort. Moreover, this section suffers from flaws and does not bring very useful information to the reader. More specifically:

- there is no information about the tool or method that is used to derive the trends, what is the approach used to estimate the trends and their associated uncertainties?
- the statistical uncertainties are extremely small: are they really representative and robust?
- there are some dissimilarities among the NH and SH trends in the stratosphere (see Table 13): this might be at least partly related to well-known stratospheric asymmetries that were the subject of earlier studies for other long-lived tracers (e.g., by Strahan et al., 10.1029/GL088567, 2020), but the authors do not discuss neither comment this feature
- furthermore, the tropospheric trends are also statistically different; can we really expect this for such a well-mixed greenhouse gas?
- the CH4 trend is evaluated, but not the N2O one; this is not explained nor justified

My suggestion would therefore be to just remove the trend section (section 4.4) and to investigate the CH4 and N2O trends in a follow-up paper, involving a larger number of FTIR stations after network-wide implementation of the recommended strategies.

We appreciate comments/feedback on the trend analysis section. Given these valid points (and also note by Reviewer #2), we agree that trend analysis is beyond the scope of the current manuscript. Thus, we have removed Section 4.4 and will consider investigating CH_4 and N_2O trends in a dedicated follow-up study, incorporating a larger number of FTIR stations after the recommended retrieval strategies are implemented network-wide.

Specific comments and suggestions

An originality of this manuscript is the use of concurrent in situ data to assess FTIR retrieval strategies. I would suggest mentioning that strength in the title, perhaps by adding "FTIR observations with the support of airborne in situ measurements".

We have incorporated the suggestion and the title now is: "Advancing CH_4 and N_2O retrieval strategies for NDACC/IRWG FTIR observations with the support of airborne in situ measurements"

Line 36: its relatively short atmospheric…

Done

Lines 88-89: it might be relevant to provide information about the filters 3 and 4? What are their characteristics and respective advantages or limitations? Or provide a reference?

We have provided additional details on the filters. The revised paragraph is as follows:

"Optical bandpass filters are employed to optimize the signal-to-noise ratio (SNR) within the near and mid-infrared spectral range. Hannigan et al. (2009) provide a list of typical band limits for each NDACC filter, along with the gases exhibiting absorption features and typically retrieved, covering a spectral range of 750–5000 cm^{-1}. For CH_4, NDACC filter 3 is used, while for N_2O, both filters 3 and 4 can be used, though filter 3 is predominantly used."

Line 90: maximum optical path difference

Done

Line 124: to a common altitude scheme…

Done

Figure 2.a. why is the methane scale in ppm here, and in ppb previously? Perhaps harmonize?

Done

Table 5 and similar: would bolding the best results helps the reader to identify the most relevant strategy?

Thank you for the recommendation; we have implemented this suggestion.

Line 308: remove double opening parenthesis

Done

Figure 11 (and 12): is it relevant to show the altitude range above 30-35 km, where there is no information available?

Thank you for the suggestion. While we acknowledge that there is limited information above 35 km, we have chosen to keep the axis limit at 50 km as there is not much difference in the results between 35 km and 50 km, and the legend remains more legible in the current layout.

Line 331: can we consider that 13 years of data provide a “long-term” view for a geophysical parameter?

As suggested above, we have removed this section.

Figure 12: are the uncertainties similar for “filter 3” and filter 4”?

Yes, uncertainties are very similar. In the updated manuscript we have mentioned that the uncertainty reported in table/figure are for both filter 3 and filter 4.

Figure 13 (and 14): I found counterintuitive to place the panel for the stratosphere below the one for the troposphere; also and of kept, they could be enlarged for readability

As suggested above, we have removed this section.

Line 395: remove the question mark after “Sweeney et al., 2015”?

Updated: The latest manuscript includes an additional reference that was previously omitted in the earlier version.