

Reply to referee 4

We thank the referee for the review and the comments. They will be considered in the revised version of the paper. In the following, the original reviewer comments are given in *italics*, our answer in normal font.

This paper describes the new v3.0 FOCAL retrievals for GOSAT and GOSAT-2, used to retrieve XCO₂, XCH₄, XCO, XNO₂, XH₂O, and the relative ratio of semi-heavy water to water vapour. The paper describes the methods used in the retrievals and validates the new dataset against the TCCON network. Overall, the paper clearly describes the retrieval methods and demonstrates the value of the new data products. Therefore, I recommend publication, with several minor revisions based on the comments below.

Specific comments

1. *Title: Should the title list the species being retrieved?*

We think listing all species in the title would make it too long. We will actually shorten the title as suggested by Referee #1.

2. *Abstract: Are the new FOCAL v3.0 datasets publicly available?*

The FOCAL data are available by request from the authors as stated later in the paper.

3. *Line 10: I found this paragraph a bit difficult to follow. For lines 10-11, do you mean something like this? "For XCO₂, the new FOCAL retrieval (v3.0) significantly increases the number of valid XCO₂ data compared with the previous FOCAL retrieval version (v1) by 50% for GOSAT and about a factor of two for GOSAT-2." Are "All FOCAL data products" in line 11 referring to all v3.0 data products?*

We will update the text accordingly and clarify that we refer to v3 products.

4. *Line 165: For the filtering procedure - how do you ensure that real variability isn't accidentally filtered out from the dataset?*

Real variability (e.g. local sources) are not filtered out as long as there are no correlations between the filter variable and e.g. a local XCO₂ enhancement. This is why we use a very restricted set of possible variables and a large test data set (one full year). This will be explained in the revised version.

5. *Line 216: Could you add a brief definition of the full physics vs proxy datasets for CH₄ and explain why there are more data for the proxy products? Are the full physics and proxy comparable or do they have different applications/uncertainties?*

The proxy data are less sensitive to light path / scattering effects which allows for a relaxed filtering in post-processing and therefore more data. The error of the XCH₄ proxy product is in fact larger than for the full physics product, because it includes also the error of the retrieved XCO₂. We will mention this in the revised version.

6. *Line 252: Add a brief description of the CO₂ timeseries to the text since this is also shown in the figure? Is the timeseries qualitatively in line with other versions of the CO₂ retrieval? Other monitoring?*

We will add this.

7. *Line 263: Is there also no temporal trend in delta_D? Is it expected that year-to-year variations for delta_D be larger?*

From visual inspection of the time series it seems that GOSAT delta_D is slightly decreasing. We cannot tell if this is significant or not without a detailed trend analysis, which would be a subject of its own and beyond the scope of this paper. Note that trends may also be effected by the varying

sampling of the data over time (see Fig. 1). Therefore we do not discuss a possible Δ_D trend here.

Year-to-year variations are also affected by sampling. The prominent peaks in July 2012 in the southern hemisphere and in December 2018 in the northern hemisphere are due to very few data in these regions in these months. We will explain this in the paper.

8. *Line 287: Please add a bit more detail about the comparison quantities being calculated. Perhaps including formulae would be helpful. For example, how is the seasonal variation of the difference at each station being calculated?*

We use a well established validation method which we also used in the v1 paper. The seasonal bias is derived from a trend fit as mentioned later in the text. A detailed description of the method (incl. formulas) is given in:

Reuter, M. and Hilker, M.: End-to-End ECV Uncertainty Budget Version 3 (E3UBv3) for the FOCAL XCO₂ OCO-2 Data Product CO₂_OC2_FOCA (v10), Tech. Rep. version 3, 6 Feb 2022, ESA Climate Change Initiative “Plus”(CCI+), https://www.iup.uni-bremen.de/carbon_ghg/docs/GHG-CCIplus/CRDP7/E3UBv3_GHG-CCI_CO2_OC2_FOCA_v10.pdf.

We will replace the reference to Reuter et al. (2019b) by this reference in the text.

9. *Figure 1: This figure takes a bit of effort to read. Is there a reason that the full timeseries is shown instead of, e.g., a summary of the count during the measurement period with all available datasets? If so, describe the timeseries more in the text. Perhaps it would be easier to read if colours were used consistently across figure panels and if the FOCAL data product was somehow distinguished from the other products (e.g., with a distinct colour choice, cross-hatching or something else?). In panel (d), could the FOCAL v1.0 and focal v3.0 XCO₂ be put next to each other so that they can be more easily compared?*

As can be seen in this figure, the number of data products varies with time and therefore also the sampling of data. We already discussed this in the previous (v1) paper, but will add some info on this in the revised version.

As suggested by referee #1 we will split the figure into two parts:

- Subfigures (a) and (b) for GOSAT XCO₂ and XCH₄ from all algorithms.
- Subfigures (c) and (d) for all other (FOCAL) products.

We will adjust colours to make them more consistent within each of these plots and also mark data from different retrieval teams with different hatches. FOCAL v1 and v3 XCO₂ will be put next to each other in the last sub-figure.

10. *Figures 6-10 are barely described in the text. Can these be moved into an appendix or the supplementary material? Also, please make font sizes bigger. Tables: There are a lot of tables included in the paper. Some of these are not referenced from anywhere in the text (Table 2, 4, 5). Are all tables needed in the main body of the text - if so add descriptive text. (Otherwise, could move to appendix or supplement)*

Figures 6-10 include information on individual TCCON stations, therefore we prefer to keep them in the main part.

We will modify / split / combine these figures also following the comments of the other referees. Increasing font sizes is however somewhat limited as figure width is limited by AMT and the text has to fit into the layout of the plots (which is difficult especially if many products are shown as for XCH₄). We will try our best on this.

Technical comments

1. *Line 266: Rephrase so that it is clear what XCO is similar to. E.g., "Across different latitudes, GOSAT-2 XCO shows similar values and seasonal variations, except in the southern hemisphere..."*

Will be changed.