Dear associate editor and reviewer, please find our responses inline below. The original text has been kept in black, our responses are in blue, and explicit changes are in underlined blue.

The revised manuscript is significantly shortened and much easier to read. All major issues are fixed. Some minor issues are still to be dealt with. The manuscript can be published after minor corrections listed below.

Detailed comments

• LIne 98: I am wondering why OMPS-LP instrument is not mentioned here.

OMPS-LP has now been added to the sentence.

• Line 60 -26: "In the UV, Sentinels 4 and 5 (Ingmann et al., 2012), Tropospheric emissions: Monitoring of pollution (TEMPO) (Zoogman et al., 2017) and the Geostationary Environmental Monitoring Spectrometer (GEMS) (Nicks et al., 2018) will augment this record." - the sentence seems to be grammatically incorrect and should be reworded.

We have modified this paragraph to flow with the previous sentence about the TIR, and removed the augment this record.

• Line 144 -147: "Chemical reanalysis datasets, which provide global and consistent ozone, can be constrained by multiple satellite observations including precursor data, (e.g., NOx emissions). These cross-comparisons provide insight into how the retrievals are capturing chemical processes. Their data fields use a more stringent co-location criteria owing to their higher data abundance." - this text seem to refer to the removed comparisons and has to be removed as well.

Thank you for spotting, we have removed this.

• Fig. 2: It is fine to cite previous studies for a detailed description but all basic terms has to be defined within the paper. Please provide a definition for "Noise Equivalent Spectral Radiance (NESR)" in the text.

We have now included equation 4, which is the top level definition of NESR based on the CrIS noise defined by Zavyalov et al 2013.

• Line 303: "... while TROPOMI has a more constant bias." - Is it really the case? Standard deviation of the bias (absolute residual radiance mean) is largest for TROPOMI.

We based this statement of the RMSE, which we think gives less weight to large outliers, and therefore a more robust indication of the variability of the fit. However, we have also added the following sentence.

“the absolute standard deviation suggests more large outliers as opposed to CrIS”.

• Lines 303 -304: ”These quality of fit parameters form a part of the MUSES quality assurance procedure (described in 3.6).” - the statement is unclear.

This sentence has been changed to the following.

“These quality of fit parameters are included in the overall quality control of the retrievals”

• Line 305: The paragraph starting at this line does not seem to have any connection with the previous text and with the ”quality of fit” subsection in general.

The Jacobian section must have accidently been moved during other changes, it has now been moved to join the information content section where it fits better.

• Line 305: ”show greater sensitivity in the UV to stratospheric ozone.” - with respect to what?

The has been changed to, “the most sensitivity”

• Line 307: ”in the 9.6 and 10.43 micron bands” - the text discusses wavelengths in microns while x-axis is given in wavenumbers. Please use the same units in the figure and in the text.

Good catch, this was supposed to be in wavenumbers, have changed the text to say wavenumbers.

• Lines 358-359: ” For example, focusing on the Atlantic Ocean, there are regions with clearly improved DFS values from CrIS-TROPOMI, as opposed to CrIS.” - I cannot identify the discussed feature. Are you referring to Fig. 5 of Fig B1?

This is Figure 5, there are several regions we can identify, in the North Atlantic ocean, and over Egypt, these are admittedly subtle and we will identify this in the text.

• Lines 367-368: ”... with the most reduction above the tropopause ( 100 hPa).” - I would rather say the most reduction occurs just below 100 hPa.

Corrected.

• Lines 373-375: ”The key difference is that the variability of the total uncertainty is smaller than that of CrIS, and the total/smoothing error is slightly smaller. Suggesting that the inclusion of the TROPOMI radiances reduces the uncertainty of the CrIS

retrievals slightly." - looking at the plot it is impossible to say if this statement is true. To my opinion the variability is the same for CrIS-TROPOMI and CrIS-only.

These differences are subtle, but if you concentrate on the region above 10 hPa, it is apparent. We have made this clearer in the text by modifying the relevant paragraph as follows:

The key difference is that the variability of the total uncertainty (as indicated by the shaded area) is smaller than that of CrIS, most notably above 10 hPa and the total/smoothing error is slightly smaller above 10 hPa. Suggesting that the inclusion of the TROPOMI radiances reduces the uncertainty of the CrIS retrievals slightly in the stratosphere.

• Line 389: The text "chemical reanalysis datasets and" should be removed as it refers to the removed comparison

Removed, thank you.

• Line 393 and line 394: "the chemical reanalysis or" - same as above

Removed, thank you.

• Fig. 7: the plot has an extremely bad resolution

We have replaced this figure to account for your comments below, but this figure is already quite large (1.6Mb), we hope that the publication process will produce the figure at a better resolution, as can be seen outside of latex compilation.

• Lines 406-407: "The Asian monsoon has been found to enhance tropospheric ozone concentrations (Worden et al., 2009), as can be seen in the spatial maps, as well as the profile plots (Fig. C1)" - for a clear illustration plots outside the monsoon season should be provided

Unfortunately the additional processing performed to update this paper has not been done at sufficient spatial resolution to capture these events. We hope future papers that explore this data in more detail will provide this analysis.

• Lines 411-412: "Both the 316 and 68 hPa pressure levels identify an interesting significant ozone enhancement (roughly double the surrounding regions) in the southern Indian ocean (60◦S)." - It is unclear what is meant here, I do not see anything special at 60◦S in the Indian ocean.

This particular enhancement was mostly visible in the 316 hPa plots, which were removed in a previous iteration. This has now been brought back in this version of the paper where it is much clearer.

• Line 422: ”in the middle row” - which figure you are talking about?

This was an accidental reference to an old figure which no longer exists in this paper, have removed.

• Line 445: Here you should provide the reason why comparisons for longer periods are not feasible (as you did in the replies).

We have added the following text.

Limited comparisons are shown due to computational cost in longer term comparisons.

• Line 447: You should make a statement whether the profile comparisons for MLS and AIRS-OMI shown below are done with or without AK convolution.

We have added the following text.

Note the observation operator described in Sec 3.7 is only applied to ozonesondes.

• Lines 450 - 452: ”This co-location criterion (along with AIRS-OMI) is the least stringent of all the comparisons shown in this study, due to the reduced coincidences from different satellite orbits and the relative low variability in stratospheric ozone.” - I think this statement refers to the deleted comparisons and should be removed as well.

Good catch, we removed this reference.

• Line 482: ”Differences of between 10-40% are seen” - I think the difference are rather below 20% below 1 hPa.

We have qualified this, with the following text.

for CrIS-TROPOMI, and are less than 20% for CrIS-only

• Fig. 10: CrIS-TROPOMI retrieval shows a significant jump after June 2020, this needs to be discussed.

We have added the following text.

Note however the mean difference for CrIS-TROPOMI reduces in July 2020 in comparison to earlier retrievals, a trend that is not apparent in CrIS-only. However, the TROPOMI retrievals for these dates do show more negative mean differences, indicating that TROPOMI is the cause of these differences.

• Fig. 10: Suboptimal placement of the legend covering the data points

Updated legend placements

• Line 523: ”For the tropospheric trends ...” - I guess you mean ”columns” not ”trends”.

We have replaced with tropospheric columns.

• Line 536 - 540: ”The low information content of TROPOMI in the troposphere means the application of Eq. 8 yields the TROPOMI precision.” and the following 3 sentences. - I do not think this is true. With zero precision Eq. 8 gives H = xa, which has nothing to do with the precision and the retrieval in general.

We possibly jumped a few steps ahead on the details in this paragraph, we have modified to be clearer as indicated below

The low information content of TROPOMI in the troposphere means the application of Eq. 9 to the ozonesonde profile yields the TROPOMI apriori. When calculating the difference between the TROPOMI profile (which in the troposphere is a noisy replication of the a priori) and the modified ozonesonde profile (which is just the apriori after the application of Eq. 9) the remainder is the TROPOMI precision.

• Lines 544 - 545: ”Suggesting CrIS-TROPOMI/CrIS-only have comparable or improved performance in the troposphere.” - This might be also the case if the sensitivity is significantly lower.

This is possible, but according to Fu et al (2016) both CrIS-TROPOMI and CrIS-only have larger DFS values in the troposphere than AIRS-only and OMI-only, and fairly similar DFS values to AIRS-OMI. Therefore this does not seem convincing to us.

• Line 558: ”...in this paper and the supplementary material...” - is there still a supplementary material?

No, we have removed this reference.

• Lines 616 - 617: ”The MUSES CrIS-TROPOMI ozone data set is a valuable new product for characterising the variation of ozone in the atmosphere.” - This was already said in the first sentence of the Conclusions.

We removed this sentence.

• Lines 617: ”Future developments and refinements to the MUSES algorithm, will improve the product,...” - I suggest to replace ”will” by ”are expected” as you cannot know it for sure now.

Agreed, we have changed to:

Are expected to

Technical corrections

• Line 124: remove line break in the link

Removed.

• Caption of Fig. 9: ”The three subplots ...” –→ ”The four subplots ...”

Corrected

• Line 502: Remove ”while” at the end of the sentence.

Removed

• Line 561: ”Comparisons with satellite data and reanalysis in the troposphere” –→ ”Comparisons with satellite data in the troposphere”

Corrected

• Line 607: ”Resulting in substantially larger data volumes in the final retrieval products.” - Incomplete sentence.

We’re not sure why this is considered incomplete?

• Line 612: ”MUSES quickly be able” –→ ”MUSES will quickly be able”.

Corrected