Response to the reviewers' comments on amt-2022-260.

We thank the reviewers for their valuable comments, questions and suggestions. Please find below our detailed point-by-point replies (in blue color) to the comments, which we hope have addressed all satisfactorily, as well as the actions taken on the manuscript.

In addition to the suggested changes by the reviewers, we have added a supplement document with detailed error budget information for all data products (V8H_NO_61 (NOM) for the FR period, and V8R_NO_261 (NOM), V8R_NO_561 (MA), V8R_NOwT_662 (UA) and V8R_TwNO_662 (UA) for the RR period) discussed in the manuscript. Further, we have updated Figure 5 which showed the error budgets only for V8H_NO_61 and V8R_NO_261 for four different atmospheric conditions, by two new figures (Figure 5 and 6) showing the error budgets for all products for a reduced set of atmospheric conditions. The complete set of figures for all atmospheric conditions can be found in the supplement.

Point-by-point responses to the comments of Referee #1

We thank Chris Boone for his thoughtful comments and suggestions, which certainly helped to improve the clarity of the manuscript.

Comment: This paper describes a new combined data product of NO and thermospheric temperature retrieved from MIPAS measurements. The analysis procedure and error assessment are described. Comparisons are made to previous processing versions.

Overall, nice work. I have no real changes to suggest.

Reply: Thank you very much!

Comment: I will point out that this article makes heavy use of acronyms that are not defined. To name some: GRANADA, SAMONA, SMR, NOEM, SNOE, NRLMSIS, ECMWF, ERA, JPL, HITRAN, EUV. While most people reading the article will likely be familiar with these acronyms, it makes it somewhat jargon heavy. Perhaps the greatest concern might be the fact that seasonal acronyms (MAM, JJA, SON) are not defined.

Reply: All undefined acronyms are now defined in the revised version.

Comment: In a retrieval paper, it would have made me happy to see a figure showing observed and calculated spectra, to see how well things fit. However, this is just personal preference, the spectroscopist in me.

Reply: We agree that it could be useful to show measured and modeled spectra in a retrieval paper, in particular, if the paper deals with retrievals from spectral signatures that are difficult to detect. However, since the NO 5.3 um emission is a well-known spectral feature, and further taking into account the already quite exhaustive number of figures in the manuscript, we would prefer not adding additional figures in this particular case.

Comment: Minor items:

Lines 233 and 450: peroxyacyl nitrate. I believe peroxyacyl nitrate is a class of molecules. Why do you not call it peroxyacetyl nitrate?

Reply: This has been changed accordingly.

Comment: Caption to Figure 2: …2006–2012 period. I can't tell if the averages excluded 2005 for some unspecified reason or this was a typo.

Reply: The reason for excluding 2005 from the composite is that, due to operation interruptions, there is only a poor and uneven temporal coverage in this particular year. We thus decided to remove 2005 from the composite in order to guarantee a homogeneous seasonal coverage.

Comment: Figure 5: NO error budget for FR (a, c, e) and RR (b, d, f). No 'a, b, c, d, e, and f' labels in the figure.

Reply: This figure has been replaced by the new Figure 5 and 6.

Comment: Line 571: Northern hemispheric. Northern Hemispheric

Reply: This has been changed accordingly.

Comment: Line 701: In the mesosphere, biases of the version 5 NO data in comparison with correlative measurements, found at 65–100 km, seem to have been considerably reduced or even removed in the new version. The new NO data is likely also in better agreement with NO observations from other satellite instruments in the upper mesosphere, where the MIPAS NO from version 5 was low-biased,

What is the difference between "correlative measurements in the mesosphere" and "observations from other satellite measurements in the upper mesosphere?"

Reply: There is no difference. Both expressions are used as synonyms in order to avoid repetition. We have rephrased to "In the mesosphere, biases of the version 5 NO data in comparison with correlative measurements, found at 65–100 km, seem to have been considerably reduced or even removed in the new version. The new NO data is likely also in better agreement with correlative measurements in the upper mesosphere, where the MIPAS NO from version 5 was low-biased."

Point-by-point responses to the comments of Referee #2

We thank Referee #2 for the thoughtful comments and suggestions, which certainly helped to improve the clarity of the manuscript.

Comment: This is a very well written and comprehensive paper that is of relevance to AMT. I suggest it be published after a few minor issues are addressed:

Reply: Thank you very much!

Comment: Lines 18-21: If you're going for completeness, I'd recommend adding the OSIRIS NO measurements (doi:10.1029/2009JD013205, doi:10.1029/2011GL048054). Or, if you're just giving examples, please put "e.g." at the beginning of the list.

Reply: We have added the OSIRIS reference (Sheese et al., 2011) in the revised manuscript.

Comment: Line 78: I think "constraints" should be "constrains"

Reply: You are right. This typo has been corrected.

Comment: Line 334: In what sense are you using the word significant? According to Table 3, the improvement to the convergence rate is ~0.4-0.7%. Are you saying that the improvement significantly affects mean NO results or simply that the increase of converged retrievals is non-trivial?

Reply: In the latter sense. We now state that the improvement is noticeable (instead of significant) in order to make this clearer.

Comment: Section 3: Is there a reason why you use just the diagonal elements for data filtering instead of the retrieval response (i.e., sum of Ak) as is more typical with other instruments? It could be interesting to have the retrieval response plotted in Fig 1 as well.

Reply: The use of the sum of AK would be adequate to discriminate data points with high a priori information content in case of an optimal estimation approach. Since we use a Tikhonov regularization (smoothing constraint), our retrievals contain in principle no a priori information (except for the a priori profile shape), such that the AK sum is close to one over most of the profile range. In contrast, the AK diagonal indicates the content of ***local*** *information. A small diagonal element means that most of the information comes from other (typically lower) altitudes.*

Comment: Line 363: I'm not sure I understand where the statistical biases come from. Wouldn't leaving those retrievals data points with Akd < 0.03 in the averaging lead to a bias towards the a priori?

Reply: Statistical biases arise because the averaging kernels (and hence their diagonal elements) depend on the vmr of the retrieved profile. This is because the Jacobian in a logarithmic retrieval scales with the vmr. In consequence, akd-filtering favors high vmr values (low vmr values with smaller akd will be discarded), such that the result is prone to be high-biased. A sentence has been added to clarify this.

Comment: Figure 2: What is the reason for the worsening vertical resolution in the Northern mid latitudes (MA and UA, especially)?

Reply: We speculate that the worse vertical resolution around 30N-50N in December is caused by the relatively low vmrs found in that region. Due to the "self-adapting" effect of regularization in a logarithmic retrieval (stronger for low vmrs), resolution is degraded, there.

Comment: Figure 6: plot titles all have the term “esd,” which I don’t believe has been defined.

Reply: esd (estimated standard deviation) is now defined in the revised version.

Comment: Line 575: I found this sentence a bit confusing. Are you saying that differences between v8 and v5 for MA are consistent with those for UA? Please consider rephrasing.

Reply: This has been rephrased to “Differences of both MA and UA datasets with respect to their respective predecessor versions are very similar”.

Comment: Figure 15: please add a legend.

Reply: All symbols and colors used in the panels of this figure are explained in the caption. Thus, we think that an additional legend would be redundant.

Comment: Line 634: “allow to assess” doesn’t sound right. I’d suggest something like “allows for an assessment of”

Reply: This has been changed accordingly.

Comment: Lines 634-642: The description of the migrating diurnal tide could use a reference. Perhaps Brasseur and Solomon (and refs therein)?

Reply: This reference has been be added.