
Referee #2

Reply to referee #2 for the review of the manuscript:

Version 8 IMK/IAA MIPAS temperatures from 12–15 μm spectra: Middle and Upper Atmosphere modes (amt-2023-119)

We thank the reviewer for his/her valuable comments and suggestions. We have addressed all of them all. In this response, we go through the raised issues point by point and outline the changes we intend to make (see attached file). Additionally, we have corrected several typos.

Reviewer's summary:

The paper reports the new retrieval of temperature in the mesosphere using MIPAS latest released level 1b spectra. I am not a native English speaker, therefore I just made few language corrections. It deserves to be published after the following comments have been addressed.

Reviewer's suggestion:

Line 29 : Add some reference to the ESA site or to the official document

Author's response:

We will add a reference to the corresponding ESA file:

ESA: Product Quality Readme File for MIPAS Level 1b IPF 8.03 products – issue 1.1, ESA-EOPG-EBA-TN-1, available at:

https://earth.esa.int/eogateway/documents/20142/37627/Read_Me_File_MIP_NL__1PY_ESA-EOPG-EBA-TN-1-issue1.1.pdf (last access: September 2023), 2019.

Reviewer's suggestion:

Line 34: This part is officially known as Optimised Resolution, please add this name when you first mention the part of the measurements

Author's response:

We will add to the text: 'also called optimised resolution by ESA'.

Reviewer's suggestion:

Line 39: substitute 'a few days in a row' with 'few (or write the number if it always the same) consecutive days'

Author's response:

We will replace it by 'few consecutive days'.

Reviewer's suggestion:

Line 70: I assume each dataset refers to a single observation mode, I suggest making it clearer in the text here.

Author's response:

That is correct. We will add 'respectively' after 'dataset'.

Reviewer's suggestion:

Line 114-117: please add some reference to documents or papers that describe this.

Author's response:

We will add the corresponding references.

Reviewer's suggestion:

Line 124-125: there is a new release of HITRAN (2020) why did you not use it?

Author's response:

Our processing of the MIPAS v8 data began in 2019, prior to the release of HITRAN2020. In that processing, not only temperature but other numerous atmospheric species were retrieved, for which this version 8 of temperatures were used. For consistency, the HITRAN2016 version has been maintained in all retrievals.

Reviewer's suggestion:

Line 137: But you do not retrieve continuum above 58 km, so why you find problems?

Author's response:

The reviewer is right to ask this question. In fact, the altitude was not correct: the heights where the offset correction cannot be distinguished are also below 60 km (in particular, in the regions where radiative transfer is linear). This sentence will be changed in the revised version, replacing the value of 60 km by ~30 km.

Reviewer's suggestion:

Line 144: substitute 'km in just' with 'km just'

Author's response:

We will do it in the revised version .

Reviewer's suggestion:

Line 154-155: The sentence should be changed in 'In V5R_t_m21, the temperatureetc.'

Author's response:

We agree.

Reviewer's suggestion:

Line 192: Substitute 'in each iteration' with 'at each iteration'

Author's response:

We will change it.

Reviewer's suggestion:

Line 193: Substitute 'change slightly' with 'have been slightly changed'

Author's response:

We will do it in the revised version.

Reviewer's suggestion:

Line 200: Substitute 'is' with 'are'

Author's response:

We will change it. Thank you.

Reviewer's suggestion:

Line 208-210: Hard to see what you say in the figure due to the adopted color scale. Also checking the AK it looks that very small information is contained in the measurements above 100 km, so this comment doesn't hold very well

Author's response:

We agree that the color scale does not help. However, we think that the overplotted contour lines do. This is particularly true for the plots for solstice, where the isolines are inclined down towards the polar summer.

We also think there is considerable information up to 110 km in MA and NLC (averaging kernel diagonal ~ 0.18) and up to 115 km in UA (averaging kernel diagonal ~ 0.26), as the averaging kernels in Fig. 2 show.

Reviewer's suggestion:

Lines 213-215: Again very hard to see in the figure

Author's response:

This refers to the yellowish blob around 85 km at low latitudes during equinox. We will mention this explicitly in the text to make it easier to find.

Reviewer's suggestion:

Lines 219-222: Could you please explain better this point, I could not follow it! What 'elevated stratopause events' are?

Author's response:

Elevated stratopauses were mentioned in Labitzke (1972), described in detail in Manney et al. (2005). The term 'Elevated stratopause' refer to extreme events in which the stratopause reforms at uncommonly high altitudes (in the middle-upper mesosphere), occasionally occurring after sudden stratospheric warmings (see e.g., Manney et al. (2005), Siskind et al., 2007; Chandran et al., 2011, 2013; McLandress et al., 2013; Limpasuvan et al., 2016). We will add the reference to Manney et al. (2005) in the revised version:

Manney, G. L., Krüger, K., Sabutis, J. L., Sena, S. A., and Pawson, S.: The remarkable 2003–2004 winter and other recent warm winters in the Arctic stratosphere since the late 1990s, *J. Geophys. Res.*, 110, D04107, <https://doi.org/10.1029/2004JD005367>, 2005,

Reviewer's suggestion:

Line 224: 'wrinkled' is not very scientific, use oscillating or something more appropriate.

Author's response:

We chose "wrinkled" because we wanted to emphasize that it is an irregular structure. We would use "oscillating" to denote a regular structure. With this in mind and if the reviewer agrees, we prefer to stick to "wrinkled" in this context.

Reviewer's suggestion:

Line 230: what is the threshold you use of the AK peak to decide if there is information?

Author's response:

We should have written the threshold in the text, as the reviewer suggests. We will add the following sentence:

“Our recommendation for the data users is to discard data points at altitudes where the corresponding averaging kernel diagonal element is less than 0.03, because they lack significant measurement information.”

Reviewer’s suggestion:

Lines 235-239: Could you explain why the vertical resolution oscillates so much?

Author’s response:

This is a natural phenomenon characteristic of the retrieval when using more retrieved points (state vector) and measurements. and there is nothing wrong with it: at a tangent altitude (where the instrument provides measurements), the vertical resolution is better but the error by measurement noise is larger. Between two tangent altitudes, where the results depend on information of two measurements (above and below), noise is smaller but the resolution is worse. If averaging kernels were evaluated only on the grid given by the tangent altitudes, this effect would not be visible. We will include a sentence in the revised manuscript clarifying this behavior: “The oscillating behavior depicted arises because the vertical resolution is better at retrieval altitudes closer to the tangent altitudes (see Fig. 4), despite the larger error introduced by measurement noise.”

Reviewer’s suggestion:

Line 245: you say 34 scenarios: shouldn't them be 40? 5 latitude bands X 4 seasons X 2 (day/night)

Author’s response:

Please, note that we do not distinguish between seasons for tropical latitudes.

Reviewer’s suggestion:

Line 249: You say ‘in the following’, is it in the table or in the text?

Author’s response:

The expression was certainly not clear. In the revised version, we will replace: “In the following, we provide 1-sigma uncertainties.” with “All reported uncertainties are one sigma throughout.”

Reviewer’s suggestion:

Line 253: ‘propagation of measurement’ -> ‘propagation of the measurement’

Author’s response:

We agree. We will change the text accordingly.

Reviewer’s suggestion:

Line 255: The noise values change very much from the region around 700 cm-1 to the region at 900 cm-1, I would rather use the range than the average value here

Author’s response:

We will provide the noise range in the revised version. We would like to note that we do not use the entire band up to 900 cm-1.

Reviewer’s suggestion:

Lines 256-259: The calibration is performed as part of your analysis or as part of the level1 process?

Author's response:

In the revised version, we will specify that: "(...) there is still a remaining random uncertainty due to the wavelength dependence of the deep space measurements used for the level-1b radiance offset calibration."

Reviewer's suggestion:

Lines 260-261: do you analyse unapodised spectra? Otherwise the ILS shape should be dominated by the apodization used

Author's response:

We use apodized spectra, and this apodization is considered in the error estimation. It still does make an effect, particularly at higher altitudes.

Reviewer's suggestion:

Table 3: even if you explain it in the caption the word chief does not suggest what you have introduced in the column, could you use a different and more appropriate word?

Author's response:

We will substitute 'chief' by 'Char.' (from characteristic) in the column title.

Reviewer's suggestion:

Lines 275-278: HITRAN usually reports spectroscopic uncertainties, why haven't you used them?

Author's response:

Unfortunately, HITRAN spectroscopic uncertainties are not completely helpful because it is not reported whether they are 1-sigma, 2-sigma or 3-sigma. Contacting the HITRAN lead author did not help either. Thus, we decided to contact an expert in the field to provide these uncertainties (Manfred Birk, February 2020), as it is stated in the text.

Reviewer's suggestion:

Lines 279-283: the whole paragraph is rather confusing, could you explain it better? An educated guess is not a quantity, could you explicit the guess you made?

Author's response:

We will try to be clearer in the revised version. We shall specify the uncertainty used for the calculations. We will also re-write the paragraph:
"For gases derived in preceding MIPAS V5 retrievals, we have used the noise covariance information obtained from those retrievals. For interfering gases not previously retrieved from MIPAS measurements, we relied on our initial guess database (Kiefer et al., 2002, and updates thereof). In the latter case, accurate uncertainty information for these abundances is often unavailable and we have assumed a 100% uncertainty."

Reviewer's suggestion:

Lines 296-297: Some of the random errors are systematic, but of a random nature....

Author's response:

We are not certain if we have interpreted this comment correctly. In the context of data analysis and, consequently, for the benefit of data users, we believe it is advantageous to provide systematic and random errors separately. For instance, systematic errors will result in biases that need not be considered when analyzing variations relative to mean values. This is

discussed in Clarmann et al. (2020), as referenced in the text, and is beyond the scope of this manuscript.

Reviewer's suggestion:

Lines 305-306: Do you mean that you did not know the covariance matrix associated to those errors?

Author's response:

It depends on the error source. For instance, there was no covariance information available for CO₂. However, for most of the other error sources that we treated using the perturbation method, the covariance treatment is unnecessary since the uncertainties pertain to single, independent parameters. In other words, there would be little gained by using the covariance formalism because we are only dealing with the variances of the single, independent parameters.

In order to be more precise, we will add "due to unavailability of covariance information" after "not possible".

Reviewer's suggestion:

Lines 307-309: The whole sentence is not very clear, could you describe this better?

Author's response:

We propose to re-write the sentence as follows:

"There were error sources for which no specific values of their random uncertainty could be prescribed (for instance, CO₂ abundance and spectroscopy, non-LTE, ILS). Since temperature errors triggered by a systematic parameter uncertainty also exhibit a random component due to atmospheric variability, we also conducted statistical analyses on the responses to perturbations across the ensemble of temperature profiles, each ensemble representing a distinct atmospheric scenario. We took the dispersion within these responses as our estimate of the associated temperature error random component for those cases."

Reviewer's suggestion:

Line 313: what do you mean with 'chiefly'?

Author's response:

We mean 'not completely, but as a most important part', a synonym of 'mainly' or 'primarily'. Although we think both "Chiefly random errors" and "chiefly systematic errors" are grammatically and semantically correct, we will change word order in this sentence to write "Errors chiefly random" and "errors chiefly systematic", in the hope that the expression can be better understood.

Reviewer's suggestion:

Line 315 'for 34' -> 'for the 34'

Author's response:

We agree.

Reviewer's suggestion:

Line 430: Which NLTE model does Saber use? If it is the same as in this paper it should be mentioned, as in this altitude range it is the main contributor to the retrieved temperatures.

Author's response:

The references where the SABER non-LTE model is described are provided in the manuscript (Remsberg et al., 2008; Garcia-Comas et al. 2008). The SABER non-LTE algorithm is not the same as the MIPAS non-LTE model. However, some non-LTE parameters are set equal. That is the case for the quenching rates of CO₂(v₂) by O, N₂ and O₂, but, for instance, not the case for atomic oxygen abundance or the rate of CO₂-CO₂ v₂-quanta exchange. Consequently, for our SABER and MIPAS comparisons, we removed the contribution from the CO₂-O, CO₂-N₂ and CO₂-O₂ quenching rate uncertainties from the combined errors and the discussion in the text takes this fact into account. This is specifically stated in lines 447-450.

Reviewer's suggestion:

Line 481 onward: I did understand that the comparison were done on the smoothed profiles only, so please clarify this better in the text!

Author's response:

We propose to change the wording:

"Beyond this, we have also compared collocated MIPAS and SABER time series. For this purpose, MIPAS averaging kernels and a priori information were applied to the SABER profiles."

Reviewer's suggestion:

In the references at Line 699 'Fera, S.D.' -> 'Della Fera, S.'

Author's response:

Thank you. We will change this name in the reference.