Reply to comments of reviewer #1

Gabriele Stiller et al.

Reviewer comments are in black, while our replies are in blue.

General Comments

The manuscript provides an overview of the new Version 8 MIPAS retrievals of CFC-11, CFC-12, and HCFC-22. The paper is very detailed, but I found it easy to read and that it provides excellent information both for readers interested in the retrieval process and potential users of the data. A comprehensive error analysis is also provided. In my opinion the manuscript is very useful to the community and can be published almost as is. I have provided some of my thoughts while reading through it that the authors can choose to consider if they wish.

We thank the reviewer for their positive and encouraging assessment. In the following we reply to each comment.

Specific Comments

p. 5: Figure 1: I find this figure a little difficult to follow. Clearly the retrieval involves a complicated flow of data. I don't know a better way of presenting it, but maybe the authors can think of something.

We agree that this figure is complicated. We have, however, not found a simpler way to communicate this information.

Sec. 3.1: Is the 2D temperature field used here? I see it mentioned in the CFC-11 section but not here.

Yes, the 2D temperature fields were used in the retrieval of all three species described here. We will add this information to the description of CFC-12 and HCFC-22.

p.6 l.140: "CFC-12 is retrieved on a vertical grid as follow:...": I see altitude here, presumably the altitude-pressure relationship is taken from a preceeding retrieval step? I don't see it mentioned unless I missed it.

Correct. We retrieve temperature and line-of-sight pointing information in a preceding retrieval step (see Kiefer et al., 2021) and construct the pressure at the tangent altitudes and the retrieval grid points with one (z,p,T) receference point taken from ERA-I and by making use of the hydrostatic equilibrium. We will add this information to the revised paper.

p.6 l.142: "This implies that the involved inverse problem is ill-posed...": I understand what the authors mean, and it is certainly true if a single spectral point was used, but the use of multiple spectral points can result in a problem that is well-posed with a spacing finer than the measurement spacing.

We agree that, due to spectral line-shape information, the system of equations to be solved is not underdetermined. However, in the case of MIPAS, the atmospheric line shape is, due to the instrument line shape function and Norton-Beer strong apodization, not fully resolved. The set of equations to be solved in the inversion is not fully linearly dependent, but it includes equations that are almost linearly dependent. This leads to a situation where the inversion is very unstable, and a tiny distortion of the measurement will lead to an enormous change in the result. This is what we call ”ill-posed”. For (H)CFCs the situation is even worse, because in the radiative transfer calculation the lineshapes are not evaluated explicitly as a function of pressure and temperature, but lab-measured absorption cross-section spectra, available at a limited number of pressure-temperature combinations, are simply interpolated to the actual pressure and temperature. Since we are not sure if our use of the term ”ill-posed” is exactly compliant with the definition by J. Hadamard (”Sur les problèmes aux dérivées partielles et leur signification physique”, Princeton University Bulletin Vol. 13, No 4, pp. 49–52, 1902), we consider to use a somewhat weaker wording: ” ... tends to be ill-posed ...”.

Sec. 3.4: Presumably here "nominal geolocation of the limb scan" is calculated based off of the 30 km tangent point? If you were to calculate horizontal displacement relative to the geolocation of each individual’s spectra tangent point is it essentially 0? I’m mostly wondering if it would be better to compare the MIPAS measurements to models by sampling the model at each spectra’s tangent location rather than the nominal location.

Yes, your understanding is correct and the displacement is meant with respect to the nominal geolocation of the limb scan at about 30 km altitude. However, the displacement calculated here is **not** identical to the displacement of the tangent point of each individual spectrum in the scan. Instead, the displacements are often larger and are the combined effect of the tangent point displacement, the non-linearity of radiative transfer, and the crosstalk with regularisation in the vertical domain. Since the displacements of individual tangent points do not help to overcome the problem regarding comparisons to models, we prefer to stay with our presentation relative to the nominal geolocation of the limb scan.

Sec. 3.6: My understanding is that essentially another iteration of the retrieval is performed with an adjusted grid to get the ML profile, I assume this is only done for CFC-12 and not for any of the input data? Can the change in averaging kernel of temperature for example have an influence on this coarse grid product?

In order not to propagate an unnecessary smoothing error of temperature onto the target gas coarse grid retrieval, we use the fully resolved temperature from the regular retrieval for the coarse grid gas retrievals. A changing temperature profile might

indeed affect the coarse grid profile, but this is a higher order effect.

Sec. 4.5: Can you speculate on which changes in the retrieval had the largest impact on the differences?

We have tested the retrieval by just exchanging the spectroscopic data, but leaving everything else, including the version of the measured spectra, as in the previous V5 retrieval. The change of spectroscopic data alone accounts for a reduction of about 4% over the altitude range of the profile up to ∼25 km. Additional changes of parameters (new level-1b data, the 2D temperature field, better information on pre-fitted constituents or a priori information on interferents) contribute another 2 to 5% of difference between V5 and V8 CFC-11. We will add this information to the revised version of the manuscript.

References

Kiefer, M., von Clarmann, T., Funke, B., García-Comas, M., Glatthor, N., Grabowski, U., Kellmann, S., Kleinert, A., Laeng, A., Linden, A., López-Puertas, M., Marsh, D. R., and Stiller, G. P.: IMK/IAA MIPAS temperature retrieval version 8: nominal measurements, Atmospheric Measurement Techniques, 14, 4111–4138, https://doi.org/10.5194/amt-14-4111-2021, 2021.