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Atmospheric Measurement Techniques Discussions

Interactive comment on "Impact of temperature field inhomogeneities on the retrieval of atmospheric species from MIPAS IR limb emission spectra" *by* M. Kiefer et al.

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We thank anonymous referee #1 for the wealth of comments and suggestions, and we feel that the points put forward help us to improve the paper. Below we address all of the referee's remarks, except the Technical Corrections.

General Comments

1) In the paper 1-D retrievals for H2O, CH4, N2O, CFC-11, and CFC-12 are analyzed. However, the presentation of the results is a bit unsystematic, I think. Fig. 1-7 show the impact of neglected temperature gradients for individual latitude bands, individual altitudes, or individual retrieval schemes. This is fine to illustrate that the effect is

important in many situations. However, a scientific user of IMK, ESA, or Oxford MIPAS L2 data will likely also need to know the individual retrieval errors for other latitude bands and altitudes? If the authors have carried out a more comprehensive survey than presented in the paper, I suggest they consider publishing the results, e.g. as an electronic supplement to this paper?

Reply: A more comprehensive representation of the ascending/descending differences for ESA L2 data will be given as an electronic supplement to the revised paper.

2) Given its general importance in atmospheric chemistry and physics, and being a major data product of Envisat MIPAS, the impact on ozone retrievals should be analyzed and presented.

Reply: Differences from ozone retrievals will be shown and discussed in the revised paper.

3) The explanation of the impacts of neglected temperature gradients on the trace gas retrievals is appellative (although I find it convincing). A more detailed physical explanation on how temperature gradients affect the radiative transfer and how the retrieval feedbacks due to the assumption of a homogeneously stratified atmosphere work would be interesting.

Reply: see answer to point 4) below

4) To explain or illustrate the retrieval feedbacks a retrieval experiment based on synthetic measurements and idealized atmospheric conditions (constant background profile plus constant T-gradients) would be helpful. The results of the retrieval experiment based on real MIPAS measurements presented in section 4 (Fig. 10-12) might be obscured to some extent by measurement errors and atmospheric variability?

Reply: We missed to cite Stiller et al., JQSRT 72, no.3, 249-280, 2002. This work, which deals with the influence of simplifying approxiamtions in radiative transfer calculations will be cited in the revised paper. Together with the analysis by Steck et al.

2005 (already cited in the paper) and a technical note by Dinelli and Castelli, which will be attached to the paper as electronic supplement, this gives exactly the analyses the referee would like to see. We will add some more text to put these citations into the right context within our paper.

5) The authors suggest to include prescribed temperature gradients in the radiative transfer to improve 1-D retrieval quality. However, as presented here this recommendation is based on the analysis of four MIPAS orbits. I think a more comprehensive survey is necessary to identify potential pitfalls with this approach. Running the retrieval tests for more orbits may improve the statistical comparison of old and new retrievals presented in Fig. 13.

Reply: Larger data sets will be included. The examples with only four orbits was included to prove that approach under discussion does not only improve the results in a statistical sense (e.g. monthly means), but also for individual observations.

Specific Comments

title: Suggest to replace 'temperature field inhomogeneities' by 'horizontal temperature gradients' to be more specific.

Reply: We do not quite agree: the term gradients suggests a linear spatial variation of a state variable, while the paper includes the general case of irregular horizontal distributions. Inclusion of horizontal temperature gradients in 1D retrievals as a remedy is only one aspect of our work.

p1708, l2: Suggest to write '... (MIPAS) on board Envisat' or similar, to name specific MIPAS instrument in the abstract.

Reply: OK

p1708, l8: Fig. 5 shows differences for H2O up to 50% rather than 20% mentioned here?

Reply: Yes, but the statement in the Abstract refers to the lower stratosphere (see line 7). There 20% is the appropriate number.

p1715, l10-15: How large is the statistical basis for this analysis, i.e. what fraction of MIPAS measurements was processed with the different retrieval schemes and what fraction of L2 data is used for the analysis presented here?

Reply: This strongly depends on the year/month and a little bit on the altitude. For a given latitude band there are extreme values of 10 and approximately 500 single profiles entering the monthly means and differences calculations. After December of 2002 for each month there are more than 150 profiles per month available to calculate means and differences. Half of those months got more than 250 geolocations. However, at altitude levels below 200 hPa the numbers are considerably reduced since cloud contaminated altitudes were rejected. The data of ESA, Oxford and IMK were all reduced to dates common to all data sets, to get the differences comparable. We will include some text on this topic at the beginning of section 3 of the revised version.

p1715, l20-22: Are there any difference in the mean latitudes of the analyzed MIPAS profiles for the ascending and descending orbit parts within the bins? Such differences would cause systematic asc/desc temperature differences if an atmospheric temperature gradient is present.

Reply: Species will be influenced by this effect if there is a horizontal gradient in their mixing ratio, therefore this is an important question! The mean latitudes usually differ by less than 1 degree for the regions dicussed in the paper. However, there are regions/times with much larger differences, notably the latitude band 75N-90N and the first 5 months of the time series. Currently we try to further minimize the differences in the means of contributing latitudes per latitude bin. Unfortunately, this will in turn decrease the number of available profiles. If there will be significant changes, which we do not expect from initial tests, the plots and the text will be changed accordingly in the revised paper

p1716, l6-8: This is most likely due to the presence of the polar vortex boundary?

Reply: Partly; the argument only holds for southern winter season. However, for e.g. DJF months there is also a horizontal gradient in temperature (see Fig. 8).

p1716, l25-26: There are situation in which CFC-11 gradients may be positive with latitude (horizontal transport) or even altitude (in the vicinity of deep convection events). Just write 'which are _generally_ negative'.

Reply: OK

p1717, l9-11: I am surprised that the regularization can cause such severe differences between IMK and Oxford retrievals. Is the smoothness constraint rather different in this two schemes?

Reply: Yes, Oxford retrievals are performed as optimal estimation with climatological CFC-11 as a-priori information, while the IMK/IAA retrievals for the CFC-11 data used in this work employed a Tikhonov type regularization with constant zero a-priori profile.

p1721, l1-19: I would have preferred to see Fig. 8 and 9 already at the begin of section 3, i.e. before the presentation of the results for the trace gas retrievals.

Reply: Our paper is organized such that first the problem is presented and then explanations are discussed. To move figures in the proposed way would, in our opinion, perturb the logical flow.

p1722, l10: Is 400km extent kind of an optimum value? The individual temperature kernel functions along the line of sight are broader than this.

Reply: From IMK experience for many atmospheric situations this is a reasonable value to take. The optimal value depends on the actual state of the atmosphere. E.g., near the polar vortex boundary, this value might be even too large, because the region where the region is applicable is confined to a narrow area.

p1725, l9-12: Might be worth to point out that standard deviations estimated from

both ascending and descending orbit parts will be severely affected by the retrieval errors described in this paper. It seems variance computed from either ascending or descending data alone might be more representative?

Reply: Agreed; we will add a caveat on this in the revised version to guide the data users.

Fig. 1: The mean CFC-11 data from IMK and Oxford shows significant differences. Are these due to the different retrieval schemes? Are the analysis based on the same subset of retrieved profiles? In the caption write '(asc-desc) differences' or '(desc-asc) differences', to assist the reader.

Reply: Yes, see answers to p1715, l10-15 and p1717, l9-11 above.

Fig. 5: There seem to be outliers in ESA data around 20 hPa in summer 2003 and 2004? If these outliers can be easily identified they should not be included in the analysis presented here.

Reply: In the revised paper the faulty data will be removed (no change to the plots in other regions is induced).

Fig. 8: Suggest to include arrows/symbols in the plot to indicate the north/south orientation of the line of sights to assist the reader.

Reply: Arrows will be attached to the LOS in the revised version's corresponding figure.

Fig. 10: Suggest to include arrows in the plots to indicate satellite track and/or orientation of line of sight to assist the reader.

Reply: Arrows will be attached to the tracks in the revised version's corresponding figure.

Technical Corrections

Note: The suggested technical corrections will be included in the revised version.

Interactive comment on Atmos. Meas. Tech. Discuss., 3, 1707, 2010.