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Atmospheric Measurement Techniques Discussions

Interactive comment on "MIPAS reduced spectral resolution UTLS-1 mode measurements of temperature, O_3, HNO_3, N_2O, H_2O and relative humidity over ice: retrievals and comparison to MLS" *by* S. Chauhan et al.

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We would like to thank the referee for the valuable comments and corrections.

Specific Comments

1. *Page 443, last paragraph - A brief explanation of why the tangent altitude grid is latitude dependent in the UTLS-1 mode, but not in the FR mode would be instructive, given the significant impact of this latitude dependence in causing the wavelike behavior in vertical resolution and measurement noise seen in Figures 1 to 5.*

A latitude-dependent floating altitude-sampling grid is used in the MIPAS UTLS-1 (and nominal) observation modes since 2005 in order to follow roughly the tropopause height along the orbit with the requirement to collect at least one spectrum within the troposphere but to avoid too many cloud-affected spectra. For the operational period of 2002-2004 this approach had not been implemented for reasons of simplicity.

2. *Page 444, first paragraph - Although the reader can look up details of the retrievals in the papers cited, it would be helpful to have a short description of the MIPAS IMK/IAA retrieval approach, providing some introduction for the discussion of the Tikhonov-type formalism mentioned on page 447, paragraph 2.*

   A new section which describes the IMK/MLS retrieval approach, including the Tikhonov-type formalism, has been introduced in the text.

3. *Page 444, second paragraph - Clarify what is different between the UTLS-1 mode and the FR mode for each of these five points, and give the reason for each difference (as is done for point 5).*

   In the manuscript we have added a more detailed description of these items:

   (1) Microwindows: Tab. 1 now contains information on the channels and the detailed ranges of microwindows used for temperature/line-of-sight and trace gases in the UTLS-1 mode retrievals setup. Microwindow boundaries had to be adjusted to suite the spectral resolution and sampling of the RR resolution UTLS-1 mode. Further, due to problems of non-LTE, affected microwindows have been discarded.

   (2) Zero-a-priori (or in case of log-retrieval altitude-constant) profiles for all trace gases have been applied to avoid any possible artefacts in retrieved profiles due to the chosen a-priori information. E.g. in previous

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retrieval set-ups discontinuities occurred occasionally at the edges of latitude bands where the a-priori changed from one latitude-dependent climatology to a different one.

(3) Horizontal temperature inhomogeneities are taken into account as gradient profiles for the retrieval of all trace gases. This helped significantly to overcome problems of non-convergence.

(4) As far as possible, altitude and latitude independent regularization is used to ensure that all the structures visible in the retrieval originate from the measurement and are not artifacts due to any constraint.

(5) in the case of H_2O, log(vmr) instead of vmr values are used as primary retrieval parameters. This helps in constraining the vmr profiles in spite of the large dynamic variation of H_2O in the upper troposphere.

4. *Page 445, line 2 - Explain briefly how the vertical resolution and measurement noise were calculated.*

   The vertical resolution is calculated on basis of the averaging kernel (AK) matrix (Rodgers, 2001) of the retrieval. The rows of the AK contain the contribution of the true values to the retrieved values while columns are the response to delta-peak-like perturbations at each altitude. In our case the full-width at half-maximum of the columns is used as a measure for the vertical resolution. The estimated measurement noise is obtained from the error covariance matrix (Rodgers, 2001). In the revised version, both quantities will now be explained in more detail.

5. *Page 445, line 26 - Add some discussion of the results reported in Table 2, e.g., comment on the differences in the horizontal resolution with respect to species and altitude, and the reasons for them.*

   In a regularized retrieval like the actual one, the horizontal smearing is coupled with the vertical resolution and thus is subject to similar variations

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with altitude and latitude.

6. *Page 445, line 27 - Are the horizontal resolution results for this reference geolocation over the south polar region typical or are there any significant differences for other orbits and locations?*

   The values of horizontal resolution given here are intended as an exemplary case. There will be differences depending on the actual state of the atmosphere. Thus, for purposes of detailed quantitative analysis like data assimilation it is suggested to use actual full 2-d averaging kernels.

7. *Page 446, line 3 - Same as the previous question - are the error analysis results for this reference limb scan over mid-latitudes typical or are there any significant differences for other orbits and locations?*

   As in the case of horizontal averaging kernels, the given error estimates are strictly speaking only valid for the actual geolocation for which they have been determined because they depend on the atmospheric state. Optimally these should be determined for each single retrieval, which, however, is not possible due to restrictions on processing time. However, from experience with error analyses of different MIPAS observations, a mid-latitude case of systematic error estimation is often suited to obtain a valid guess also for other latitude bands. This is confirmed by the newly included bias validation, where the MIPAS-MLS global bias values can be well explained by the assessed systematic errors.

8. *Page 446, section 3 - This section describing MLS is very brief. It would be helpful to add a short discussion of the retrieval approach, typical errors and vertical resolution for temperature and the four species of interest, and to cite the relevant validation papers. Some of this information is given later in the paper, but would be appropriate here.*

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As suggested by the referee, in the revised manuscript we have summarized the information regarding MLS in a common paragraph.

9. *Page 447, second paragraph - The discussion of the impact of the a priori here seems strange if the a priori profiles were set to zero as implied on page 444, line 17 - clarify.*

   As we explain in the new retrieval section, in the framework of first order Tikhonov-regularization a zero-profile does not lead to a systematic bias, but to a smoothing of the retrieved profile which is more pronounced the less information stems from the measurement. The strength of regularization can be estimated from the vertical resolution-this has been analysed in the quoted section. We agree with the referee that the wording 145; a priori influence 146; may be a bit narrow since it is the general influence of regularization which is presented here.

10. *It would also be helpful to know what retrieval approach is used by MLS (see previous point) when considering the impact of the a priori on MLS retrievals.*

    The MLS data processing algorithm uses a two-dimensional retrieval approach based on optimal estimation to retrieve temperature, geo-potential height and trace gas concentration (Livesey et al., 2006). This is explained in the new section on MLS retrievals in the revised manuscript.

11. *Page 448, line 6 - This states that the mean differences were calculated for 5 degree latitude bins. However, the plots on altitude-latitude grids in Figures 6 to 19 do not appear to be binned. If the binned results have been smoothed for the contour plots, state this. Perhaps it would be better to show the results in the bins?*

    The binned values have been interpolated to obtain contour plots. This is clarified in the new version.

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12. *Page 449, line 21 - For Figures 8, 11, 16, 18, and 20, add a panel showing the SEM on a different scale. It would also be informative to include the MIPAS and MLS measurement errors on such plots, particularly given that some attention has been given to calculating the UTLS-1 mode measurement noise shown in Figures 1 to 5.*

    Figures 8, 11, 16, 18 and 20 have been updated accordingly. We now additionally show the combined estimated random error profiles of MIPAS and MLS, the combined estimated systematic errors, and the standard deviation of the bias distribution. As proposed by the referee, the SEM is plotted on a different scale.

13. *Page 461, Table 1 - This table should be more clearly explained in the caption and/or in the text. What is the significance of A, B, and C? Are bands (column 2) the same as microwindows (column 3)? Why were different microwindows used for the UTLS-1 and FR modes? Delete brackets on wavenumber ranges. Add units for column 2.*

    The comment has been taken into account. A detailed explanation of the table will be given in the text. Reasons for different microwindows are given above.

    Technical Corrections

    All technical corrections have been performed as suggested by the referee.

References

Rodgers, Inverse Methods for Atmospheric Sounding: Theory and Practice,World Scientific,Series on Atmospheric, Oceanic and Planetary Physics, F. W. Taylor, ed.,vol.2,2001

Livesey,N.J., et al.: Retrieval algorithms for the EOS Microwave Limb Sounder (MLS) instrument, IEEE Trans. Geosci. Remote Sensing,vol. 44,pages: 1144-1155, 2006.

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