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Atmospheric Measurement Techniques Discussions

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2, S144–S149, 2009

Interactive Comment

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.

S. Chauhan et al.

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We would like to thank the referee for the useful comments and suggestions.

1. *Most importantly, there needs to be much more quantitative discussion of the effect of clouds on measurements in the upper troposphere. At the moment, these are mentioned only in the introduction and the conclusion, where the rather vague statement is: MIPAS trace gas observations at lower altitudes are in general more obstructed by clouds than those of MLS. Doesn't this lead to a significant bias in the comparisons in the upper troposphere, especially in water vapor compar-*

isons?

We entirely agree with the referee that the effect of clouds might affect the comparison between microwave and infrared limb sounders.

In case we would have measurements exactly at the same time and location there should be only minor effects since we determine from the MIPAS observations the lowest cloud-free tangent altitude on basis of a very conservative criterion. Since we compare only profiles of the two instruments above this altitude (and MIPAS is much more sensitive to clouds than MLS) the MW instrument might have data below this level (e.g. in presence of a thin cirrus), but these are not used for the comparison. In reality beside different locations, there is a difference in time: MIPAS measures at around 10 and MLS at 1:40 local time. Thus, though for the comparison of the two H2O altitude profiles, the conservative upper cloud free altitude of MIPAS is used, there might be a cloud in the MLS field-of-view at that height. At that altitude this could either lead to higher water vapour in case of MLS compared to MIPAS because inside the cloud the humidity might be higher. On the other hand, cases can exist where MIPAS observes a cloud-free but supersaturated environment which is no more the case when there is a cloud present. We've tried to investigate the presence of such effects by subdividing the H2O-comparisons into two sets. The first set contains only matches of daytime observations when there might be more clouds present in the early afternoon (MLS) compared to earlier observations (MIPAS). The second set consists of only nighhttime observations when the effect of clouds might be different.

The results (Fig. 1) show a slightly larger dry bias of MIPAS wrt MLS in the region of the southern sub-tropical upper troposphere during day than during night. This is, however, not the case at the northern sub-tropics. In summary, we could not identify a consistent picture pointing towards

AMTD

2, S144–S149, 2009

strong effects of clouds within the presented comparison. In the revised version of the manuscript the problem of clouds is described in more detail.

2. *A plot showing what fraction of measurements is obstructed by clouds at which altitude would be useful.*

   We would agree with the reviewer in case we could have such a plot detecting clouds with the same sensitivity at both, the MIPAS and the MLS measurement time and location. However, since MIPAS is much more sensitive to clouds than MLS this, unfortunately, is not possible.

3. *The authors should certainly state that the statistical uncertainty in the mean bias is very small, but it would still be nice to see actual standard deviations as well in and to compare them with the otherwise unvalidated measurement noise plots in Figures 1-5.*

   This suggestion has been taken into account: standard deviations of the bias distributions and combined estimated random noise error values of MIPAS and MLS have been included in the altitude-dependent bias plots for temperature and trace gases. The results are discussed in the revised manuscript.

4. *What is a zero-a-priori profile? Does this mean setting the species a priori to zero? If so, this does not seem like a good idea. If the a priori sensitivity is small then perhaps it doesn't matter, but, having brought up the matter, the authors need to state this.*

   We use a Tikhonov-type regularization (Tikhonov, 1963) where the first order profile difference of type (X_i - X_{i+1})-(X_{ai} - X_{ai+1}) rule the a proiri term of the penalty function rather that (X_i - X_{ai}) which is the driving term in the optimal estimation. Thus, in our case, in the absence of substantial measurement information, the solution is torn towards a constant profile, not a

AMTD

2, S144–S149, 2009

Interactive Comment

zero profile. This is because X$_{ai}$ - X$_{ai+1}$ is zero for X$_{ai}$ = X$_{ai+1}$ regardless of the values of X$_{ai}$. The only exception are the log retrievals where we have a numerical work-around to avoid log(x) =0.

5. *Table 1 - So, if I understand things correctly, in the FR mode the retrievals are done using data from the entire bands shown in the middle column (e.g. 685-970 cm^{-1})? Should the title (MIPAS bands used should also have a cm^{-1} next to it.*

   Sorry for this misunderstanding: the middle column of Tab. 1 does not show the spectral windows used for MIPAS full resolution mode measurements but the MIPAS spectral bands wherein spectral windows (microwindows) have been selected for reduced resolution UTLS-1 analysis. In the revised paper we report in more detail the chosen microwindows. The unit cm-1 has been added to the table as suggested

6. *Probably the striping in the vertical resolution plots is okay, but there should be some discussion of this obvious feature. This is not something that I recall ever having seen in plots of vertical resolution.*

   The vertical oscillation (striping) in the vertical resolution along latitude and altitude in the case of UTLS-1 mode and in the case of FR nominal mode is caused by oversampling in the altitude domain. The oversampling at these heights arises because, the atmospheric state is retrieved on a finer retrieval grid than the sampling grid spacing between tangent altitude. Typically at retrieval altitudes close to tangent altitudes the resolution is better than in between, such a behavior is not visible when the atmosphere is sampled on a grid whose width approximately matches the tangent altitude grid.

7. *the height constant regularization used. What does this mean?*

   This means the regularization is a scalar times the squared first order difference matrix and not a vector. In the revised version our MIPAS retrieval

AMTD

2, S144–S149, 2009

scheme is explained in more detail to cover these questions.

8. *Why is signal to noise better in the summer hemisphere?*

   For IR-emission observations the atmospheric signal is strongly connected with temperature, while the spectral noise remains constant in case of MIPAS. Thus, the signal to noise is better in the southern hemisphere during Nov-Dec due to higher temperatures there.

9. *The horizontal resolution at different altitudes seems to have a huge variation. What causes this? Is it because different bands are important at different altitudes? Some discussion would be appropriate here. As far as I know, such large variations are not shown in the MLS validation papers.*

   In a regularized retrieval, the horizontal smearing is coupled with the vertical resolution and thus is subject to similar variations with altitude and latitude.

10. *Figure 7 - Wouldn't it be better to lump these panels together with Figure 6?*

    The figures have been combined

11. *Some discussion of the structure in the MLS-MIPAS HNO_3 comparisons near 20 hPa would be appropriate. This structure is not apparent in the Santee paper.*

    First a small correction for which we apologise: the structure, which appears as low values of MLS mainly over the tropics is located at the 31.6 hPa level and not, as stated in the text, at 21.5 hPa. As reported, Kinnison et al. (2008) have observed such a feature in their comparison between HIRDLS and MLS. Further, since the structure appears like a second minimum over the tropics (which is difficult to explain) only in the MLS and not in the MIPAS distributions, we tend to attribute it to an unexplained problem with the MLS HNO_3 dataset. The manuscript has been extended accordingly.

Reference :

Tikhonov, A.: On the solution of incorrectly stated problems and method of regularization, Dokl. Akad. Nauk. SSSR, 151, 501–504, 1963

AMTD

2, S144–S149, 2009

Interactive Comment