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Atmospheric Measurement Techniques
Discussions

Interactive comment on "MIPAS temperature from the stratosphere to the lower thermosphere: comparison of version vM21 with ACE-FTS, MLS, OSIRIS, SABER, SOFIE and lidar measurements" *by* M. García-Comas et al.

M. García-Comas et al.

maya@iaa.es

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Response to Reviewer 1:

We thank Anonymous Referee 1 for reviewing our manuscript and for his/her comments and suggestions. We think we addressed all issues he/she raised. The authors' answers (AA) to this referee's general and technical comments (RC) are given below.

Comments:

RC: p. 6656, l. 16: I do not understand "and temperature decreases above" in this context. Similarly in l. 21. Maybe the authors mix the temperature changes between the two versions (temperatures increase or decrease from vM11 to vM21) with the resulting difference and its altitude dependence. I suggest rephrasing this section.

AA: We meant '(...) decreases above that altitude'. Added 'that altitude' in both cases.

RC: p. 6657: Is there any possibility to estimate the accuracy of the WACCM-SD O concentrations? Maybe by comparison with the (indirect) observations or by comparison with temperature data sets being less dependent on [O]?

AA: We now include a short discussion based on comparisons with SABER atomic oxygen:

'As mentioned above, the atomic oxygen from the WACCM-SD model significantly differs from that from the NRLMSISE-00 model. The response of the retrieved temperature to that change shows that special care should be taken when selecting the atomic oxygen for MIPAS temperature retrievals. In order to detect potential differences with the real atmospheric atomic oxygen, we have compared its WACCM-SD abundance with that measured by SABER. Mlynczak et al. (2013) describe the derivation of atomic oxygen concentration below about 95 km from SABER measurements with a 20-30% uncertainty. Except for the polar summer, comparisons of SABER and WACCM-SD atomic oxygen show differences smaller than 20% around and above 90 km. Differences around 85 km reach 50%. In the polar summer, however, WACCM-SD atomic oxygen is 2 times larger than SABER's above 90 km. Around the polar summer mesopause (88 km), that difference reaches a factor of 5. In other words, the comparison with SABER suggests that an overestimated WACCM-SD atomic oxygen may lead to overestimated polar summer mesopause temperatures. It is worth noting that, additionally, Kaufman et al. (2014) show that SABER's atomic oxygen abundance in the mesopause region is around 30% larger than that measured by WINDII, OSIRIS and SCIAMACHY, although their comparisons are limited to latitudes lower than 60°, i.e., they do not comprise polar latitudes.'

RC: p. 6664, section 3.1: Uncertainties and systematic errors of Rayleigh lidars are large around 80 km. I suggest (for upcoming studies) using additionally resonance lidars that provide temperatures between 80 and 100 km, i.e. in the region with largest differences between satellite data sets. The differences between MIPAS and lidars partially increase drastically at and above 80 km. Is this an effect of seeding temperatures or seeding altitude for the Rayleigh retrieval? Below 60 km partly large differences occur, mostly if the number of profiles is small. Are these systematic differences or an effect of large spatio-temporal distances between lidar and MIPAS data?

AA: We take into account the referee's suggestion and will include comparisons with resonance lidars in upcoming studies. MIPAS and lidar temperature differences above 80 km are mainly explained by the large errors of the lidar measurements at those altitudes. The main sources for those errors are detection noise, seed uncertainty, smoothing error and background noise extraction error. Those are widely discussed in: Leblanc et al., Evaluation of optimization of lidar temperature analysis algorithms using simulated data, Journal of Geophysical Research, 103, D6, 6177-6187, 1998. We now also include that new reference in Sect. 3.1 of the manuscript, where we write:

'A detailed description of the lidar error sources is also provided in Leblanc et al. (1998)'.

The MLO and TMF profiles used here are cut-off 10 km below seed altitude, where the propagated seed uncertainty decreases to about 4K (note that, as stated in the text, the overall systematic error at 80 km is around 10K). Another source of potential difference between lidar and MIPAS is atmospheric variability. At 80 km all of the above (i.e., uncertainty from lidar measurement, and atmospheric variability) can easily reach 20 K. At 60 km though it should not exceed 5K. Nevertheless, when larger than 1K (in absolute value), MIPAS temperature differences with the lidars below 60 km occur in each season every year and are mainly independent of the spatio-temporal distance of

the co-located pairs. We now mention explicitly that these differences are systematic in the text in Sect. 4.1 and also in the summary.

RC: p. 6667, l. 23: Spatial differences of 1000 km can induce large systematic differences, e.g. due to the meridional temperature gradient or longitudinal temperature differences ("standing" planetary and tidal waves). What are the reasons for choosing these criteria?

AA: We include now the following paragraph at the beginning of Sect. 4:

'These criteria minimize differences coming from atmospheric variability without compromising the statistical significance of the comparisons. In order to optimize this balance, we have performed tests by increasing and decreasing both the spatial and temporal differences between the measurements. Decreasing the distance and the time difference between co-located pairs to 500 km and 1 hour, respectively, barely changes the results.'

RC: p. 6671, ll. 17-21: Please comment on these oscillations. Are they presumably realistic? What can be the cause for these oscillations and what are the implications for the MIPAS data?

AA: Firstly, note that there is a mistake in the text: the cause of the oscillation in the differences is actually not a corresponding oscillation in MIPAS temperature, as written, but in the temperature vertical gradient, with an amplitude of 2K/km and which is not present in the other datasets. The text has been changed accordingly. The reason for that gradient oscillation is not yet known. There are no obvious discontinuities around this altitude (75 km) in the retrieval setup. The effect can neither be due to a degraded vertical resolution around this altitude since that would have been taken into account when applying the averaging kernels. Therefore, this remains an open issue. This is now stated in the text.

RC: p. 6674, l. 12: The differences are not "slightly" larger, but by 10 K, i.e., quite significantly. Please provide some explanation why differences increase so strong with the NLC dataset.

AA: We deleted 'slightly'. The reason for the larger differences are not due to the NLC dataset itself but to the set of co-locations found for these instruments with the NLC measurements. We included the following paragraph:

'All MIPAS-NLC and ACE-FTS co-locations during the polar winter occurred only over the South Pole during JJA-2005. ACE-FTS temperatures around the stratopause are then lower than the other instruments' measurements. ACE-FTS comparisons with MIPAS-UA for the same period and latitudes also present the same behavior (there are then no MIPAS-MA co-locations). Those larger differences do not show up in comparisons for other years. OSIRIS temperatures around 80 km are larger than the other instruments' measurements when close to the solstices (when NLC measurements take place), where the temperature vertical gradients are largest.'

RC: p. 6674, Section 4.2.1: Please comment on the very large differences between SABER and MIPAS near 35 km in Fig. 11, 50°-70° and 30°-50°.

AA: We thank the referee for this comment. The lowermost altitude used in the plotting program was out of the MIPAS NLC mode altitude range (and also the UA mode range) and the results shown around that altitude were an extrapolation. Since the altitude range of these two modes rarely extends below 40 km, the y-axis in Figs. 10-11 and S1-S4 is now [40km,100km].

RC: p. 6677, Section 5: Please provide a conclusion for the observation of hemispheric differences from MIPAS data (or satellite data in general). Which differences can be found, where are no differences between hemispheres and where is the data set inconclusive (because data sets disagree)?

AA: Using the terminology used in our manuscript, we guess that the referee refers to the hemispheric anomalies measured by the instrument and not to their differences with

the other instruments. We would like to note that, as explained in the manuscript, we used for the comparisons temperatures from the co-location set with each instrument instead of seasonal means from each instrument mainly to avoid sampling effects. That means that, precisely due to those time and spatial sampling effects, the inter-hemispheric asymmetries deduced for each set of co-located measurements are not necessarily the same as the average seasonal values (for example, the co-locations with certain instrument might have happened around the beginning of the season but at the end of the season for another instrument). We would also like to mention that a thoughtful study on MIPAS climatology of inter-hemispheric anomalies (using the full MIPAS dataset) is in fact ongoing and, since it deserves detailed explanation of the results and is beyond the scope of this manuscript, it will be the focus of a separate one. In the revised version of the present manuscript, we now provide a summary of the MIPAS inter-hemispheric asymmetries averaged for the sets of co-locations found with each instrument and its standard deviation:

a) at the end of the third paragraph in Sect. 5:

'Nevertheless, it is important noting that this approach implies that the absolute inter-hemispheric asymmetries derived using only the co-location sets (written below for the case of MIPAS) instead of each instrument complete dataset do not coincide necessarily with the mean seasonal inter-hemispheric asymmetries measured by each of those instruments. This is precisely due to the limitation imposed by the different temporal and spatial distributions of the co-locations along a season and a latitude box for each instrument pair.'

b) and in the corresponding following paragraphs:

'MIPAS stratopause temperature and altitude NH-SH asymmetries averaged for all co-location sets are -3K±2K and 0 km±0.3km, respectively, for 70°-90° and -4K±1K and 0km±0.5km, respectively, for 50°-70°.' 'MIPAS winter stratopause temperature and altitude NH-SH asymmetries averaged for all co-location sets are -16K±5K and

1km±2km, respectively, for 70°-90° and -6K±3K and -2km±2km, respectively, for 50°-70°.' ' MIPAS summer mesopause temperature and altitude NH-SH asymmetries averaged for all co-location sets are -9K±4K and 0.5km±1km, respectively, for 70°-90° and -6K±7K and -0.5km±1km, respectively, for 50°-70°. We note that a large standard deviation does not denote a large error of the anomaly measured by MIPAS but a wide spread due to the different periods in a season and/or locations in a latitude box of each set of MIPAS co-locations with each instrument.' 'MIPAS winter mesopause temperature and altitude NH-SH asymmetries averaged for all co-location sets are 5K±5K and 1km±0.4km, respectively, for 70°-90° and 8K±4K and 1km±1km, respectively, for 50°-70°.'

c) at the end of the summary:

'Despite larger differences between the temperatures measured by each instrument that sometimes exist, the comparisons of the inter-hemispheric temperature anomalies determined from the co-located observations indicate that MIPAS provides summer and winter stratopause and summer mesopause anomalies generally within 2K of the other instrument measurements. The winter mesopause anomaly is generally within 4-5K. This is not the case for the mesopause temperature anomaly comparison with MLS during summer and polar winter, SOFIE during the winter, and ACE-FTS in the polar winter, which even observe then anomalies of opposite sign.'

Technical comments:

RC: p. 6653, l. 20: replace "with" by "between MIPAS and"

AA: Done.

RC: p. 6657, l. 12 and elsewhere: "larger temperatures" should read "higher temperatures", "smaller temperatures" should read "lower temperatures"; similarly with "latitudes". Also "warmer" and "colder temperatures" should be avoided.

AA: We think we changed everything accordingly.

RC: p. 6661, l. 7: "in (Funke et al., 2012)" should read "in Funke et al. (2012)."

AA: Done.

RC: p. 6670, l. 17: "partial" should read "partially"

AA: Done.

RC: p. 6670, l. 26: "differences present ..." should read "differences are slightly more negative (3-5 K)"

AA: We write now: 'where the negative differences -(3-5K) are slightly larger, in absolute value'

RC: p. 6673, l. 15: "value" should read "values"

AA: Done.

RC: p. 6676, ll. 14-15: "axies" should read "axes", "difference" should read "differences"

AA: Done.

RC: Fig. 1-3: The labels are extremely small. A larger font should be used. In Fig. 2: Typo "tproduced".

AA: Done.

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