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Atmospheric Chemistry and Physics Discussions

Interactive comment on "An annual cycle of long lived stratospheric gases from MIPAS" *by* M. N. Juckes

Anonymous Referee #1

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A. GENERAL COMMENTS:

This paper presents assimilated MIPAS observations of ozone, water vapour and methane from 2003. The assimilation method was already presented in a previous paper (Juckes, 2006) while the paper considered here presents comparisons of the MIPAS assimilated products with measurements from a comprehensive sweet of other satellite instruments. In addition the MIPAS data is displayed in various ways to illuminate well known phenomena regarding stratospheric dynamics, transport, and chemistry. The observations of these phenomena are in general not new, but serve well as a validation of the MIPAS data, which in my opinion is important, and illustrate the usefulness of the assimilation technique.

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I find the data presentation techniques (plotting) innovative and informative, although sometimes hard to read due to the limited figure sizes. There are some scientific issues that in my opinion require substantial revision, in particular the simplified nature of the comparisons between different satellite observations, without regard for differences in spatial and temporal coverage. Such plots (figures 1-6) should either be redesigned or additional discussion must elaborate on the limitations of the methodology of the comparisons. Also, although the paper is generally very clear and well written I provide some specific comments and technical corrections that I believe would improve the overall clarity and quality of the paper. For example, I think the paper would benefit from further comparisons with previous studies. If these issues can be addressed I recommend this nice work for publication in ACP.

In the following I use capital letters for suggested additions to the text.

B. SPECIFIC COMMENTS:

1) page 9390, line 23-35: "Water vapour is also increasing, ... (e.g. Rosenlof et al., 2001; Rind and Lonergan, 1995; Shindell, 2001)". This information is to some extent outdated. Recent studies (e.g Randel et al., 2006) show that low water vapour values have been observed in the lower stratosphere after 2001, with significant influence on the long term positive trend discussed in the referred papers. I suggest to either add a comment on the recent decline and refer to Randel et al. or to modify the sentence to something like: "Water vapour HAS BEEN INCREASING IN RECENT DECADES, ...".

2) page 9393, line 21: "Figure 1 shows...". It should be clearly stated, in the text and in the figure caption, that the results shown are global averages ("mean for each day" as written in the figure caption is not descriptive enough), as this is a severe limitation in these comparisons (figure 1-3). A lot of information is buried in these plots. Drifts, or lack thereof, between the different observational records may well be explained by differences in spatial and temporal coverage of the various instruments, rather that by real instrument biases. Plots of this sort (figure 1-3) would be much more useful if

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shown as a function of latitude, including information on the number of observations. I suggest that figures 1-3 be redesigned in this manner, or at least that the author elaborates in detail on the effects of differences in spatial and temporal coverage for the results. See also comment B.5.

3) page 9393, line 22: "...on the 850 K isentropic surface". It would be helpful if an approximate height in kilometres could be given within brackets. In this case, the author may choose to move the sentence on page 9394, lines 27-28, to this point in the text. Also, although this sentence refers the reader to figure 7 for translation of potential temperature surfaces to height coordinates, it would make the reading experience much smoother if approximate height references were given in general in brackets after potential temperatures are stated.

4) page 9394, line 15: "In Figs. 1-3 the orange curve shows the mean and standard error of the MIPAS observations minus analysis". It is not clear whether the term the author uses here, "standard error", is actually the "standard error" in the statistical sense, or the "standard deviation". The author uses both terms in various parts of the text". For example, the caption of figure 1 speaks about "standard deviation" while the reference to figure 1 (page 9394, line 15) mentions "standard error". The same ambiguity occurs with figure 4 (and figures 5 and 6) and elsewhere in the text. Please clarify. In statistics, the standard error of a measurement, value or quantity is the standard deviation of the process by which it was generated, after adjusting for sample size (http://en.wikipedia.org/wiki/Standard_error_(statistics)). The caption of figure 4 mentions RMS differences, suggesting that is actually standard deviation that is meant, not standard error.

5) page 9394, line 24: "Figure 4 shows vertical profiles of the isentropic mean of the observations...". See comment B.2. It should be clearly stated, in caption and text, that these plots (figure 4-6) show global and annual averages ("isentropic mean" is technically correct, but not very descriptive). Limitations of comparing such fields, regarding differences in spatial and temporal coverage of the various measurement platforms for

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the results should be discussed, or the plots (figure 4-6) should be redesigned to illustrate the biases as a function of space and perhaps time. Of course, if the author can present another way to display the instrument biases, such that coverage information is taken into account, he should be free to do so.

6) page 9395, line 8-9: "This suggests that the assimilation of the data is reducing the random error present in the input data". I don't understand this statement and why such a conclusion can be drawn from the preceding text. Can this be elaborated on?

7) page 9395, line 17-18: "For both water vapour and methane, Figs. 5 and 6 also show results of a nearest neighbour comparison...". Why is this not shown for ozone too (figure 4)?

8) page 9395, line 19-21: "The mean differences are very similar to those found with the assimilated data, but the standard errors are larger in the nearest neighbour comparisons". What are the implications of this?

9) page 9396, line 10: "20 m/day". How does this number compare to other estimates in the literature?

10) page 9396, line 10-11: "The tape-recorder signal is not visible in the methane fields (Fig. 7g)". Neither would one expect it to, since the the tape recorder reflects the seasonal variation of input water vapor from the troposphere from different freeze-out properties of the tropical tropopause for different seasons. I don't understand the point of this sentence.

11) page 9396, line 11-13: "In the mid and upper stratosphere, in contrast, the methane and water vapour isolines follow each other closely, being displaced upwards in September to January, and downwards in March to July". I assume that this sentence refers to the tropical plots (7f and 7i), but as it is not clearly stated the text is confusing. I suggest to write "In the TROPICAL mid and upper stratosphere, ..." instead. However, in the tropics at 30-50 km, the water vapor and methane isolines are not being clearly

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displaced upwards through September to January and neither are they clearly being displace downwards in this whole region through March to July, as the author suggests. Can the author please clarify this. I suggest that the author should be more exact in specifying the height region he refers to.

12) page 9396, line 16-17: "In the lower stratosphere the chemical relaxation is slower and the anomalies reflect the air mass history". What does this mean exactly? Can an example be given from the figures?

13) page 9396, line 20-21: "..., the coldest temperatures are reached towards the end of July". It is hard to tell with such detail the timing of the coldest temperatures from figure 8. It would be more appropriate to say "the coldest temperatures are reached IN EARLY JULY TO MID AUGUST".

14) page 9396, line 24-25: "...there is, somewhat counter-intuitive, a drop in potential temperature...". Why is this counter-intuitive?

15) page 9397, line 5-6: "In Fig. 7a we see the onset of chemical ozone loss in late September". This is not a very outstanding feature in the figure. I would suggest to give a height range to help the reader finding it.

16) page 9397, line 9-10: "The ozone loss is preceded by drying out of the lower stratosphere in late June (Fig. 7d)". Why does this happen? Could you comment briefly, or include a reference?

17) page 9397, line 25: "100 m/day": Please compare this estimate with previous studies, if available.

18) page 9398, line 12: "..., suggesting that this phenomenon is a recurring one". The author suggests that this is a recurring phenomena, but can one really say that just from identifying it in the SH and NH of a single year?

19) page 9398, line 25-27: Footnote 4: "Such dynamically forced descent occurring below the level of evidence of "downward control" (Haynes et al., 1991), but the papers

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presenting this idea fail to distinguish between diagnostic determination and causal determination". The English may need to be improved here. Also, I don't see what the comment "but the papers presenting this idea fail to distinguish between diagnostic determination and causal determination" has to do with anything in the current paper. In my opinion this criticism should be removed or further developed, in the main text.

20) page 9399, line 10-11: "The dynamical anomaly is a response to rapid meridional transport...". OK, but I don't understand how an event of enhanced meridional transport would lead to an ozone minimum inside the vortex, since transport of air from lower latitudes into vortex would inject ozone-rich air from middle latitudes?

21) page 9399, line 11-12: "...and does not show any obvious influence of diabatic processes". How is this obvious? Please explain.

22) page 9400, line 17-18: "The main reaction affecting water vapour and methane in the stratosphere is the gradual photolysis of methane to water vapour". This is not strictly correct. Methane is dissociated in the stratosphere by reactions with chlorine (Cl), hydroxyl (OH) and excited atomic oxygen (O(1D)). Methane photolysis (CH4+hv) is important mainly in the mesosphere and has little to do with the methane to water vapor conversion in the stratosphere being discussed here.

23) page 9400, line 18-19: Should be "This reaction leaves the quantity total observed hydrogen (H_TO) APPROXIMATELY constant" since molecular hydrogen (and other minor hydrogen containing species) are not considered.

24) page 9401, line 2-3: "This may be due to photo-dissociation of water vapour in the upper mesosphere into hydrogen and oxygen." This is almost certainly the correct interpretation, so you can use a stronger wording here. So, I suggest to change "This may be due to" to "This IS due to".

25) page 9401, line 5: "This is consistent with the findings of Harries et al. (1996) who attribute it to...". What does "it" refer to here? Please spell out what is meant.

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26) page 9401, line 12-14: "At the poles, however, the fields to not show the clear patterns of downwards advection seen in the water vapour and methane fields". What are the implications of this? Is it important? If so, please explain why this difference with respect to methane and water vapour exist. If not, remove it. In my opinion, simple description, without interpretation or explanation is not very valuable.

27) page 9402, line 9-10: "The persistence of the high HTO into the core of the winter vortex, where it would be advected by the meridional circulation, ...". "Meridional circulation" within the vortex is an unknown concept to me. What is meant? Downward advection as part of the Brewer-Dobson circulation?

28) page 9402, line 12-14: "There is again a contrast between the tropics and high latitudes, but here the change takes place mainly across the sub-tropical barrier, not across the vortex boundary". Why is there such a fundamental difference between the southern and northern hemispheres?

29) page 9403, line 19-21: "At high latitudes, both water vapour and methane show a deep region of descent within the polar vortex, with a rate of around 100 m/day. In the course of the winter air from the mesosphere descends to below 20 km". To *below* 20 km seems a little excessive, judging from the figure. I would remove the word "below". Also the descent estimate of 100 m/day is not really consistent with air descending by more than 30 km (from above 50 km to below 20 km) within the course of a winter.

30) page 9408, Fig 1. and page 9411, Fig 4.: OSIRIS observations are included in these two plots, but are never mentioned in the text. Could they be removed?

31) page 9411, Fig 4.: This way of presenting the differences in terms of both absolute and relative values is very informative. Nice!

32) page 9419-9421, Fig 10.: The crosses are very hard to see in these plots, and their colors are impossible to discern from the background. I don't think these crosses are mentioned in the text, so perhaps they could be removed? Also, the caption should say

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that the plots show the northern hemisphere.

33) page 9423, Fig 12. caption: Missing text after "...from data on isentropic".

C. TECHNICAL CORRECTIONS:

1) page 9392, line 15: Add a zero for consistency (and a space) -> "=0.0068 sm-1".

2) page 9392, line 23: "...where A is THE differential operator...".

3) page 9392, line 24: Spell out "with respect to".

4) page 9394, line 4-5: Move the word "the". -> "...that THE bias in MIPAS..."

5) page 9394, line 15: "...the orange curve...". This curve looks more like a dirty yellow or light green in my PDF and print.

6) page 9394, line 24: "Figure 4 shows...". The results in figure 4b should be presented in the text, as is done for figures 5b and 6b.

7) page 9395, line 3: "...in the upper stratosphere". Please provide a potential temperature interval (and optionally, heights) for this region.

8) page 9395, line 3: Unnecessary paragraph break.

9) page 9395, line 4: "As with the 850 K time series shown in Fig. 2, ...". There is no discussion of this type in association with figure 2 as far as I can see.

10) page 9395, line 11-12: "Between 500 K and 850 K the bias relative to POAM III is very small (around 2%), but there are larger biases relative to SAGE II and POAM III". I suggest to reorder the text regarding figure 5 (lines 2-12) so that figure 5a is discussed first and figure 5b last, instead of flipping back and forth, which makes it hard to follow the reasoning. Thus, I suggest to move this sentence (line 11-12, page 9395) to after "in the upper stratosphere." on line 3 on the same page.

11) page 9396, line 3: Move the footnote (3) to the first occurrence of the phrase "equivalent latitude bands" on this line.

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12) page 9396, line 11: The tropical methane field is shown in figure 7i. -> "...in the methane FIELD (7I)".

13) page 9396, line 22-23: "The onset of gradual warming after that date coincides with an increase in variability (Fig. 9)". I suggest to present figure 9 more explicitly as it is easy to miss it otherwise (it is not mentioned elsewhere in the text?). So, perhaps "..., as shown in Fig. 9." would do it?

14) page 9397, line 25-26: "In March to May the descent rate at 30 km is around 100 m/day (the slope of the red arrows in Fig. 7)". To avoid confusion please specify in the text that this statement regards the 80S region. Also specify which sub-panels this refers to -> "...(the slope of the red arrows in Fig. 7D AND 7G)". Figure 7 is very rich in information, so any help that can be given the reader in navigating it is valuable.

15) page 9397, line 27-28: "At this level, the descent is weak in June and July but becomes strong again in August to October". In the latter period, the descent occurs at 20-25 km, so saying "At this level" is not strictly a correct description.

16) page 9398, line 6-7: "Engel et al. (2006) observe a layer of mesospheric air descending from 30 km in late January to 25 km in early March 2003, ...". Please specify which hemisphere -> "Engel et al. (2006) observe a layer of mesospheric air descending IN THE ARCTIC from 30 km..."

17) page 9398, line 9: "Figs. 7e, h". I'm not sure what the ACP standards are, but "Figs. 7e and 7h" sounds better to me.

18) page 9398, line 10: "persists and DESCENDS".

19) page 9398, line 11: "A similar pattern is seen in Fig. 7g...". To be a bit more descriptive helps the reader -> "A similar pattern is seen in in THE SOUTHERN HEMISPHERE METHANE (Fig. 7g)..."

20) page 9398, line 12-13: Add a figure reference. -> "The pattern is not so clear in the southern hemisphere water vapour (FIG. 7D)".

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21) page 9398, line 20: "...water vapour AT the start of August...".

22) page 9399, line 6: "form" should be "from".

23) page 9400, line 23-24: "The last column in Figs. 12 AND 13 displays the EQUIVALENT zonal mean HTO. We see THAT THE tape-recorder signal is resolved, and ...".

24) page 9401, line 2 and 13: "DOWNWARD advection".

25) page 9401, line 12-13: "At the poles, however, the fields DO not show...".

26) page 9402, line 1: Remove one "are not".

27) page 9402, line 8: "Figure 15 ILLUSTRATES".

28) page 9403, line 7, 9 and 13: In the Conclusions, the term "random error" is used three times. The use of this term is not consistent with the wording used in Section 3, where the author tended to use the term "standard error" or "standard deviation". It would be better to use a consistent terminology throughout the paper.

29) page 9408, Fig 1.: The label "SAGE III(L" should be "SAGE III [L]".

30) page 9417, Fig 8. caption: Change to "South OF 80S" and "North OF 80N".

REFERENCES:

Juckes, M.: Evaluation of MIPAS ozone fields assimilated using a new algorithm constrained by isentropic tracer advection, Atmos. Chem. Dyn., 6, 1549-1565, 2006.

Randel, W. J., F. Wu, H. Vomel, G. E. Nedoluha, and P. Forster (2006), Decreases in stratospheric water vapor after 2001: Links to changes in the tropical tropopause and the Brewer-Dobson circulation, J. Geophys. Res., 111, D12312, doi:10.1029/2005JD006744.

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