

Interactive
Comment

Interactive comment on “Statistical analysis of water vapour and ozone in the UT/LS observed during SPURT and MOZAIC” by A. Kunz et al.

A. Kunz et al.

Received and published: 12 September 2008

We thank referee 1 for the careful reading, the detailed questions and the useful comments on our paper. The revised version contains nearly all of them. The referees comments are repeated first (in italic type) and we reply to the respective statements.

>> *The focus of the authors is on the description of the method and the climatological comparison of both data sets, which is very well done. However, they eventually could extend their very interesting results by discussing a bit more the link to the underlying atmospheric processes (partly leading to the observed differences between both data sets, see also last point).* <<

The main motivation of our paper is to investigate the comparability of two different data sets (SPURT and MOZAIC) concerning climatological questions. We give an

S6991

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper



answer if the single flights during SPURT are sufficient to represent the atmospheric variability of trace gases as observed by the MOZAIC measurements and on which timescales they play a role. So we are not intended on a discussion of the underlying atmospheric processes, particularly this would be out of the scope of this paper and the amount of this work would get still larger. There are other interesting studies, which deal with the discussion of the underlying processes (e. g. Krebsbach et al. 2006, Thouret et al. 2006).

>> *Looking at Fig. 3 and the selection of MOZAIC-H₂O (but also SPURT H₂O) I am a bit surprised to see that the entire extratropical stratosphere seems to be as moist as indicated by the measurements. In particular the increasing MOZAIC H₂O with increasing distance to the tropopause is difficult to understand. How representative is the selection of data in a given DTP-bin comparing the amount of data in the original data and in after the selection process (a plot showing the fraction of selected data relative to the total number in each DTP bin would be useful here)? Could it be the case, that after the selection process only the extreme cases remain or the sensitivity of the MOZAIC H₂O sensor is still overestimated (compare Fig. 3A, white lines)? How does the data reduction influence the variability analysis, since the “unperturbed” background H₂O values and therefore variabilities are removed from the data. <<*

Figure 3 c shows the representativeness of the single H₂O DTP bins for the unselected MOZAIC H₂O data set (filled blue contours). Additionally the zero contour line of the selected H₂O data set is shown in pink. We modified the figure in two ways. On the one hand there are three further pink contour lines (100, 500, 5000 counts per H₂O-DTP bin) to show a more detailed picture of the bin size in the selected H₂O data set. According to the referees idea the fraction of selected data relative to the total number in each DTP bin in percent is now shown as yellow triangles in the same picture. The same x-axis dimension is used, therefore only bin sizes greater than 1 % are marked. The lowest data loss is just above the tropopause and gets larger in the entire stratosphere. Due to the data selection the 60 K DTP bin contains only 20

S6992

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper



% of original data in this bin and the bins above less than 1 % of original data in the bin. The data density above 60 K is low (see blue contours in Fig. 3. C). This shows that the representativeness of the DTP-bins above the 30 K DTP bin, where the mean MOZAIC H₂O profile of selected data (cyan) increases, decreases more and more. In the entire stratosphere extreme cases of high H₂O remain. This small amount of data in the stratosphere relative to the whole data set does not have a great influence on the statistical analysis. We are aware of the artificial shape of the mean vertical profiles after the selection process both for SPURT and MOZAIC H₂O. This is one more reason why we do not want to discuss underlying atmospheric processes as the referee already mentioned. The data selection is necessary to receive a special part of both data sets which fulfills the instrumental limitations and campaign specific conditions and allows for a statistical comparison. The resulting data sets do not reflect the real background of the atmosphere. The interpretation of underlying processes is possible but should be carefully done in awareness of these limitations.

The referee further asks for the influence of the data selection on the variance analysis. The variance of H₂O reduces both in SPURT and MOZAIC in the stratosphere and troposphere. Both variance curves (red and black) in Fig. 8 accommodate due to the selection process. The reason for the lower variances after the selection is that low mixing ratios in the stratosphere and high mixing ratios in the troposphere are removed. The mean value is now greater in the troposphere and lower in the stratosphere and the respective variance of data around this mean lowers. You can see this fact even in the PDFs (Fig. 3 B and 3 C). The broadness of the PDF in the single DTP bins is much smaller for the selected data.

>> *abstract: p.12562,1.7 seems to be in contradiction with the conclusions: "While the SPURT data...": Does this hold for both species? I guess the conclusion on p.12579,1.2/3 is, that O3 from SPURT can be used for climatological studies. Please change the abstract accordingly (also 1.9, "The SPURT H2O data set does not..."). p.12567, end of par3.: Why is the region of 5 K around the 2PVU iso surface not*

[Full Screen / Esc](#)[Printer-friendly Version](#)[Interactive Discussion](#)[Discussion Paper](#)

analyzed? <<

The abstract is changed as the referee noted. The region of 5 K around the tropopause is not contained in our analysis because of the large trace gas gradient in the vicinity of the tropopause. This is already mentioned in the text at the beginning of chapter 3. The tropopause is not always defined as 2PVU isoline. Some scientists even separate the stratosphere and troposphere by the 1.5 PVU or the 3 PVU isoline. The 5 K limit should account for this.

>> p.12567., l26.f: What is meant here? The 5 % RH-uncertainty lead to a decreasing precision of H₂O volume mixing ratio deeper in the stratosphere? <<

The text is misleading. The passage, the reviewer refers to, is: (p.12567., l26.f: Hereby, the 5 % uncertainty of the MOZAIC sensor in the UT/LS must be accounted for. An uncertainty of ± 5 % relative humidity with respect to liquid water leads inter alia to a decreasing MOZAIC H₂O vertical profile in the stratosphere (see white dashed lines).). This text is rewritten and the revised version of the paper contains the following text: "Hereby, the 5 % uncertainty of the MOZAIC sensor in the UT/LS must be accounted for. The uncertainty range of ± 5 % relative humidity with respect to liquid water is shown as white dashed lines. The uncertainty range in volume mixing ratio scale is expanded in the entire stratosphere, attaining even negative values 40 K above the tropopause. The 5 % RH uncertainty leads to a decreasing precision of H₂O volume mixing ratio deeper in the stratosphere. "

*>> p.12568,l.2 do instead of does
p.12569,l.9: tropospheric instead of troposphere?
p.12569,l.18: According to?
p.12571,l.22: each other <<*
Modifications are performed.

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper



>> *Fig. 5: Please rescale stratospheric ozone* <<

The y-axis dimension of the stratospheric O₃ frequency distribution is not rescaled in the revised paper. We want to keep the y-axis dimension constant between the stratospheric and tropospheric O₃ frequency distribution for comparability reasons. Instead of that we added a small subplot with rescaled y-axis to highlight the exact shape of stratospheric O₃ frequency distributions.

>> *Fig. 6 and p.12572,l.21: What do you mean with “.. all cases, despite the troposphere?” “Is not it in contradiction to the next sentence where you state, that tropospheric ozone is larger in that case? Maybe you should introduce arrows in Fig. 5 for the means and medians instead of the symbols.* <<

The referee is right. This text phrase is misleading and has wrong implications! The sentence “For O₃, the medians are larger for the SPURT data than for the MOZAIC data in all cases despite the troposphere.” has to be changed in “The O₃ medians are larger for the SPURT data than for the MOZAIC data in the stratosphere.” The following sentence “But for the troposphere the calculated SPURT O₃ mean and median are even in this case larger than MOZAIC.” has to be removed, because this sentence remained from an earlier version of the paper and is not linked to the text anymore. We finally decided to remove the sentences (p.12572,l.15-l.22) with the discussion about means and medians, because it is a repetition in text and is already discussed at the end of section 3.1 in combination to the frequency distributions in Fig. 5. This goes further along with the comment of referee 2 to tighten the text in section 3.2.2. The suggested arrows for the means and medians are now introduced in Fig. 5. When comparing Fig. 5 with Fig. 6 we were conspicuous, that there was a bug in the plotting procedure that only had consequences to the plotted means and medians in Fig. 5. They are corrected and now consistent to Fig. 6.

>> *p.12572,l.25: Which critical value is meant?* <<

[Full Screen / Esc](#)[Printer-friendly Version](#)[Interactive Discussion](#)[Discussion Paper](#)

Sorry, we mean the cutoff value D_α . The word "critical value" is changed into "cutoff value" in the text.

>> *p.12572, 1.28/29: The cumulative distribution functions for O₃ and H₂O for the stratosphere are consistently different between SPURT and MOZAIC (higher ozone corresponds to lower water). Why is are the distributions for the troposphere inconsistently different? Is this what you mean with the term sampling difference? <<*
The distributions in the troposphere are inconsistently different with respect to the expectation higher ozone corresponds to lower water and vice versa. We think the reasons might be the different sources for the ozone concentration in the upper troposphere. On the one hand the O₃ concentration is affected by the photochemical O₃ formation in the boundary layer and on the other hand in the entire stratosphere. Both from above the tropopause and from the boundary layer O₃ is transported in the upper troposphere, while the H₂O concentration is affected by upward transport from the boundary layer due to convective systems. Therefore the expectation (higher ozone corresponds to lower water) might not be satisfied everywhere. Sampling difference means that the two platforms might have systematic differences in flight profiles, for example a tendency for larger altitudes.

>> *p.12573,1.2: Each campaign consisted of typically four flights, therefore 8 flights per season. <<*
Is changed in the revised version of the paper.

>> *p.12574,1.9 and Fig. 7(bottom): Do the authors have an idea about the discrepancy around 10-15 minutes? <<*
We think the deviation of the variance around 15 minutes is not due to discrepancies in the two data sets. It is rather caused by symmetry features of the data sets. The time scale analysis consecutively divides the dataset into smaller and smaller intervalls.

S6996

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper



Sometimes there are sort of resonances which create small scale variations similar to the derivative of a peak. A closer look at the time scale 10-15 minutes in figure 7 shows the similar behaviour (a minimum around 0.01 days) in both datasets with a slightly different "overtone". The variance analysis of the SPURT data in general has a larger amplitude of these overtones, for example at 0.003 days.

>> *p.12574,l.19-22: The separation into four slopes is rather arbitrary, one could also deduce an almost continuous increase of tropospheric MOZAIC H₂O-variability from hours to 100 days.* <<

The separation of the variances is in fact somehow arbitrary and is performed according typical timescales of atmospheric processes in the atmosphere. The word 'slope' is in this context misleading and removed from the text. The revised version now contains "There are four consecutive timescale regions, [...] " (p.12574,l.18).

>> *p.12575: Stratospheric H₂O from MOZAIC: How does a larger uncertainty of the measurements in the stratosphere at low H₂O affect the stratospheric variability of MOZAIC H₂O? Could this lead to a higher "artificial" variability on the short time scales? In the presented analysis most MOZAIC low H₂O-data have been excluded, but can one expect still some enhanced variability at low water vapour due to limited measurement sensitivity?* <<

A larger uncertainty of measurements in the stratosphere at low H₂O would certainly increase the variance on each timescale. A larger uncertainty has an impact on the variance on short timescales, which is increased. Consequently the variance is increased on each timescale. The variance curves in Fig. 8 would therefore be shifted upwards to larger variances.

Due to the selection criteria low H₂O values are excluded. Our in-flight comparison of both measurement systems during one CIRRUS III flight should demonstrate that there is no enhanced variability at low H₂O left due to limited measurement sensitivity.

[Full Screen / Esc](#)[Printer-friendly Version](#)[Interactive Discussion](#)[Discussion Paper](#)

The variances on short timescales of both the FISH instrument and the MOZAIC sensor agree well and there is no shift between the variance curves.

>> p.12576,l.18:,but on a... <<
... is changed.

>> p.12577,l.16-20: *You find the same variabilities of MOZAIC and SPURT H₂O high above the 2PVU surface. However, if you state that the MOZAIC H₂O data are ("difficult to use"(p.12577, l.21) above DTP > 20 K), why are they included in the analysis (Fig. 3)? Either data quality is sufficient, then it would be very valuable to show that plot for DTP > 20K. If however, the variability is dominated by instrumental noise, then the data should be excluded from the whole analysis. Given, that the same variabilities in both observations are the result of real atmospheric dynamics, this would be an important result, since it could help to constrain the processes which are responsible for water vapour in the extratropical UTLS or to investigate the role of convection versus quasi horizontal transport. Could one conclude, that mainly convection strongly affects H₂O in the region above DTP=20K (maybe also using other tracers?). Since interseasonal time scales are not covered by SPURT the fact, that MOZAIC and SPURT-H₂O show the same variability seems to indicate that processes, which require timescales of days to several weeks (e.g. slow decay of tropospheric filaments in the stratosphere over several days, stirring over a broader spatial and temporal scale) do not significantly affect water vapor variabilities on these time scales.* <<

Thanks to the referee for responding to the subordinate clause which refers to the H₂O variances in the entire stratosphere. The respective plot is not shown. This result is left from a very early version of the manuscript. At that time there had been a bug in the routine concerning the data selection criteria. The second criterion (see section 3.1) did not concern H₂O values with a relative humidity with respect to ice, i. e. $RH_{ice} \leq 100\%$. The values were selected according a relative humidity with respect to

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper



liquid water due to a flag failure. Consequences are that the H₂O variances 20 K above the tropopause nearly coincide when selecting relative humidities with respect to liquid water. The correct picture with the correct flag and selecting according relative humidities with respect to ice lower equal 100 % exhibits variances of MOZAIC and SPURT H₂O, which are also different in the entire stratosphere 20 K above the tropopause. We apologize for this misleading statement and take the sentences (p.12577,l.16-23) out. Despite the decision to remove the misleading sentences we still point on the MOZAIC H₂O data quality in the entire stratosphere 20 K above the tropopause. Our selection criteria in section 3.1. are necessary to fulfill the instruments and campaign specific characteristics during MOZAIC and SPURT to allow for a statistical comparison. The in-flight comparison of selected H₂O data of both instruments shows that there is no discrepancy left due to unequal measurement techniques. But we still point again on the quality of MOZAIC H₂O data in the stratosphere. Because of the measurement specific problems (uncertainty, response time etc.) of H₂O data in this atmospheric branch one should be careful when interpreting them concerning the underlying atmospheric processes.

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 12561, 2008.

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper