TIME–SERIES COMPARISONS OF MIPAS LEVEL 2 NEAR–REAL–TIME PRODUCTS WITH CLIMATOLOGY

Vivienne Payne, Anu Dudhia, and Chiara Piccolo

Atmospheric, Oceanic and Planetary Physics, Department of Physics, University of Oxford, Oxford, UK, e–mail: payne@atm.ox.ac.uk

ABSTRACT

Monthly mean profiles have been calculated for the MIPAS Near–Real–Time Level 2 products (temperature, H$_2$O, O$_3$, HNO$_3$, CH$_4$, N$_2$O and NO$_2$) from July 2002 until March 2004. The Level 2 profiles have been split into six latitude bands (90S–65S, 65S–20S, 20S–0, 0–20N, 20N–65N, 65N–90N) for the calculation of the means. Here we compare these monthly means with reference climatologies for each of the Level 2 products to provide an overview of the quality of these products over the timescale that MIPAS has been operating. The reference climatologies used in these comparisons are the COSPAR International Reference Atmosphere (CIRA) (2) for temperature and the IG2 dataset (1) (used in the construction of the initial guess for MIPAS retrievals) for the gases. Further details of the monitoring that has been taking place at Oxford can be found on the Oxford MIPAS Group web pages (3).

Key words: MIPAS; Level 2.

1. INTRODUCTION

Monitoring of the Level 2 products has been performed routinely at the University of Oxford. Monthly mean profiles have been calculated for the MIPAS Near–Real–Time Level 2 products (temperature, H$_2$O, O$_3$, HNO$_3$, CH$_4$, N$_2$O and NO$_2$) from July 2002 until March 2004. The Level 2 profiles have been split into six latitude bands (90S–65S, 65S–20S, 20S–0, 0–20N, 20N–65N, 65N–90N) for the calculation of the means, and the monthly mean profiles for each of the products plotted as time–series. Some spike detection has been used in the averaging process, mostly excluding values of N$_2$O greater than 1000ppmv, CH$_4$ greater than 10ppmv and H$_2$O greater than 2ppmv. This examination of the time–series of the monthly means of the MIPAS Level 2 products is intended to give an overview of the quality of the data and of any persistent features in the profiles. The intention was also to try to identify any step changes in the data with time that might have resulted from changes in the data processing chain. Changes in processing for which we thought we might see changes in the monthly mean profiles were a Level 1 fringe count error correction in March 2003, the implementation of cloud detection and the updating of HNO$_3$ look–up–tables in July 2003, and a number of improvements to the Level 1B processing that were implemented in November 2003.

In order to check whether the monthly mean profiles agree with what might be expected, we also compare them with reference climatologies. The reference climatologies used in these comparisons are the COSPAR International Reference Atmosphere (CIRA) (2) for temperature and the IG2 dataset (1) (used in the construction of the initial guess for MIPAS retrievals) for the gases. Further details of the monitoring that has been taking place at Oxford can be found on the Oxford MIPAS Group web pages (3).

2. TEMPERATURE

Fig. 1 shows a contour plot of the MIPAS monthly mean temperature profiles from July 2002 until March 2004, for the six different latitude bands. Evidence of annual cycles can clearly be seen in the polar latitude bands of both hemispheres, with particularly cold temperatures in the southern hemisphere polar winter of 2003 (June/July/August).

Fig. 2 shows the absolute difference of the MIPAS monthly mean temperature profiles from July 2002 until March 2004, for the six different latitude bands. Differences of as much as 30K are seen at the polar latitudes in the MIPAS-CIRA differences shown in Fig. 2. However, these large differences are due to the lack of a strong seasonal cycle in the CIRA profiles, and are not a cause for concern. In mid–latitudes and equatorial regions, it appears that the MIPAS temperatures are generally colder than the reference climatology throughout most of the stratosphere.

3. H$_2$O

Fig. 3 shows a contour plot of the MIPAS monthly mean H$_2$O profiles from July 2002 until March 2004. It shows the profile for all of the six latitude bands. The profiles tend to show a reasonably sharp decrease at the highest retrieval altitude, which is
not a feature expected in the real atmosphere. Also, values at the second–highest retrieval altitude seem rather larger than would be expected. There are also some unrealistically high values of H$_2$O VMR in the southern polar monthly means for the 2003 southern hemisphere winter. It is thought that this may have been due to polar stratospheric clouds, which would be consistent with the low temperatures observed for this time period, which could have caused difficulties in the MIPAS retrievals.

Fig. 4 shows the percentage difference between the MIPAS monthly mean H$_2$O and the IG2 climatology profiles. The sharp decrease in MIPAS H$_2$O at the highest retrieval altitude, the otherwise large MIPAS H$_2$O values at the second–highest altitude and the problems in the southern polar regions in winter can be clearly seen in these difference plots. In addition, it appears that the MIPAS H$_2$O at the lowest retrieval altitude is generally much higher than would be expected from the climatology. It is thought that this may be due to a problem with the implementation of the cloud detection algorithm in the MIPAS retrieval. Cloud detection was supposed to have been implemented in July 2003, and we might have expected to see a step change in the monthly means around this time. However, it seems that there have been some problems in the implementation of the cloud detection in the Near–Real–Time processing. This is currently under investigation. It should, however, be noted that the cloud detection is working in the Off–Line processing (the results of which are not dealt with in this paper), but that there are difficulties there in distinguishing cloudy sweeps from those with very high water vapour amounts.

MIPAS H$_2$O is, in general, much higher than the IG2 climatology at the lowest retrieval altitude (12 km, or around 100 mbar), around 20% lower than the IG2 climatology in the lower stratosphere (below 10 mbar), higher than the IG2 by up to 40% between about 4 mbar and 1 mbar, and around 30–50% lower than the IG2 at the highest retrieval altitude.

4. O$_3$

Fig. 5 shows a plot of the time-series of the MIPAS monthly mean O$_3$ profiles from July 2002 to March 2004. The plots show a maximum in the ozone VMR at around 10 mbar, with the highest O$_3$ values in the tropics and evidence of ozone depletion in the autumn seasons of both hemispheres, with the strongest depletion in southern polar latitudes, as would be expected.

Fig. 6 shows the percentage difference between the MIPAS monthly mean O$_3$ and the IG2 climatology profiles. Large differences from climatology can be seen in the polar profiles, but the reason for this is that the climatology does not contain such strong seasonal cycles as the real atmosphere, so this is not a cause for concern. In the mid–latitude and equatorial regions, MIPAS O$_3$ is much higher at the lowest retrieval altitude than would be expected from the climatology. As in the case of H$_2$O (see section 3.), it is suspected that this might be due to problems with cloud in the MIPAS retrieval. It can also be seen from the plots in Fig. 6 that the MIPAS O$_3$ is generally lower than climatology in the lower stratosphere and higher than climatology in the upper stratosphere. This is because the ozone peak in the MIPAS profiles occurs at a higher altitude than in the climatology.

5. HNO$_3$

Fig. 7 shows a plot of the time-series of the MIPAS monthly mean HNO$_3$ profiles from July 2002 to March 2004. Strong seasonal cycles can be seen in the polar regions and mid–latitudes, with the highest values of HNO$_3$ occurring in polar winter.

Fig. 8 shows the percentage difference between the MIPAS monthly mean HNO$_3$ and the IG2 climatology profiles. Large differences from climatology are seen in the polar regions, where the climatology does not have such a strong seasonal cycle as the real atmosphere. The problem with high MIPAS values at the lowest retrieval altitudes can be seen here as well as in the other gases. A marked change can be seen in the northern hemisphere equatorial difference plot around 10 mbar between June and July 2003. Before July 2003, MIPAS HNO$_3$ is less than climatology, and after, MIPAS HNO$_3$ is greater than climatology. The look–up–tables (effectively the spectroscopy data) were updated for HNO$_3$ in July 2003, and it is thought that perhaps this is the cause for the sudden change in MIPAS HNO$_3$ concentrations. However, this change is not seen in the southern hemisphere equatorial monthly means. The reason for this is not clear.

6. CH$_4$

Fig. 9 shows a plot of the time-series of the MIPAS monthly mean CH$_4$ profiles from July 2002 to March 2004. A strong seasonal cycle can be seen in polar regions, due to the general descending motion of the air at certain times of year. CH$_4$ is produced at the surface, is well-mixed in the troposphere, and broken down in the stratosphere by oxidation and photolysis. It is therefore expected that the CH$_4$ profiles should decrease monotonically with height. This is not the case for some of the equatorial monthly mean profiles. The MIPAS CH$_4$ in the equatorial latitude bands for some of the months shows a local minimum at around 15–18 km. The reason for this is not known, but it is thought that it may be due to the 3 km vertical resolution of MIPAS being unable to resolve temperature features around the tropopause region.

Fig. 10 shows the percentage difference between the MIPAS monthly mean CH$_4$ and the IG2 climatology profiles. As with the other gases, the MIPAS CH$_4$ at the lowest retrieval altitude seems unrealistically high when compared with climatological profiles. The problem with the local minimum in the equatorial tropopause region can be seen as blue regions in the equatorial plots. In general, MIPAS CH$_4$ is around 20% higher than would
be expected over most of the stratosphere, for all latitude bands.

7. N₂O

Fig. 11 shows a plot of the time-series of the MIPAS monthly mean N₂O profiles from July 2002 to March 2004. Like CH₄, N₂O is produced at the surface, is well–mixed in the troposphere, and falls off with height in the stratosphere. The shape of the N₂O plots would therefore be expected to be qualitatively similar to the CH₄ plots, and indeed this is the case. The problem of the local minimum in the tropical tropopause region can also be seen in the MIPAS N₂O profiles.

Fig. 12 shows the percentage difference between the MIPAS monthly mean N₂O and the IG2 climatology profiles. There are particularly large differences from climatology in polar regions, but again, as with the other gases, this is likely to be attributable to the lack of strong seasonal variations in the climatology. The difference plots for N₂O show some sort of banded structure: in general, MIPAS is higher than climatology at the lowest altitudes, lower than climatology in the region between 80 and 20 mbar, higher than climatology in the region between around 10 and 2 mbar and lower than climatology at the highest retrieval altitudes. Since we are looking at monthly means, this banded difference structure is unlikely to be due to the sort of retrieval–induced oscillations that are seen in individual N₂O profiles, as these tend to average out. It would appear that there is some kind of structure in the MIPAS profiles that is not seen in the climatology.

8. NO₂

Since NO₂ has a diurnally–varying concentration, the profiles have been further split into day and night profiles, separated based on the value of the solar zenith angle. Fig. 13 and Fig. 14 show plots of the time-series of the MIPAS day and night monthly mean NO₂ profiles from July 2002 to March 2004. The difference between day and night profiles can be clearly seen. For months where there is complete polar day or night, there are may be no NO₂ profiles in the polar latitude bands.

The IG2 climatology for NO₂ does not take diurnal variation into account. Therefore, comparisons with the IG2 dataset show very large differences. In an attempt to obtain a more useful comparison, the MIPAS monthly means for day and night were compared with mid–latitude day– and night–time climatologies. (These mid–latitude day and night profiles were also produced by Remedios (1) with MIPAS in mind, but, unlike the IG2 profiles, are not used in the construction of the initial guess for the MIPAS retrieval. Also, they show no seasonal variations at all). It can be seen from these plots that the MIPAS mid–latitude day–time NO₂ is very much lower (by 50–100%) than we might expect from this climatology. The night time profiles are also generally around 20–50% lower than we would expect from the climatology. It is difficult to say anything more about these plots, since the climatology here does not change with time. In addition, the real atmospheric NO₂ will show variation with time of day that cannot be adequately accounted for simply by splitting the profiles by solar zenith angle.

9. SUMMARY

This analysis of monthly means of the MIPAS Level 2 products shows that in general, MIPAS is producing good, useful data. There are, however, some persistent problems with the profiles visible in the monthly means, which have been outlined in the sections above.

ACKNOWLEDGMENTS

We would like to acknowledge all of the MIPAS team, particularly those responsible for the development of the operational retrieval, and the MIPAS QWG for their input.

REFERENCES


http://badc.nerc.ac.uk/data/cira
http://www.atm.ox.ac.uk/group/mipas

Figure 1. Time series of MIPAS near–real–time temperature retrievals, from July 2002 to March 2004.

Figure 2. Time series of absolute difference of MIPAS near–real–time temperature retrievals from CIRA climatology (MIPAS - CIRA), from July 2002 to March 2004. Red shows where MIPAS is hotter than CIRA and blue shows where MIPAS is colder.
Figure 3. Time series of MIPAS near–real–time $H_2O$ retrievals, from July 2002 to March 2004.

Figure 4. Time series of percentage difference of MIPAS near–real–time $H_2O$ retrievals from the IG2 climatology, from July 2002 to March 2004. Plots show $\frac{\text{MIPAS} - \text{IG2}}{\text{IG2}} \times 100$. Red shows where MIPAS $H_2O$ values are higher than the climatology and blue shows where MIPAS values are lower than the climatology.
Figure 5. Time series of MIPAS near–real–time $O_3$ retrievals, from July 2002 to March 2004.

Figure 6. Time series of percentage difference of MIPAS near–real–time $O_3$ retrievals from the IG2 climatology, from July 2002 to March 2004. Plots show $\frac{\text{MIPAS} - \text{IG2}}{\text{IG2}} \times 100$. Red shows where MIPAS $H_2O$ values are higher than the climatology and blue shows where MIPAS values are lower than the climatology.
Figure 7. Time series of MIPAS near–real–time HNO$_3$ retrievals, from July 2002 to March 2004.

Figure 8. Time series of percentage difference of MIPAS Near–real–time HNO$_3$ retrievals from the IG2 climatology, from July 2002 to March 2004. Plots show $\frac{\text{MIPAS} - \text{IG2}}{\text{IG2}} \times 100$. Red shows where MIPAS $H_2O$ values are higher than the climatology and blue shows where MIPAS values are lower than the climatology.
Figure 9. Time series of MIPAS near–real–time CH$_4$ retrievals, from July 2002 to March 2004.

Figure 10. Time series of percentage difference of MIPAS near–real–time CH$_4$ retrievals from the IG2 climatology, from July 2002 to March 2004. Plots show $\frac{\text{MIPAS} - \text{IG2}}{\text{IG2}} \times 100$. Red shows where MIPAS H$_2$O values are higher than the climatology and blue shows where MIPAS values are lower than the climatology.
Figure 11. Time series of MIPAS near–real–time \( N_2O \) retrievals, from July 2002 to March 2004.

Figure 12. Time series of percentage difference of MIPAS near–real–time \( N_2O \) retrievals from the IG2 climatology, from July 2002 to March 2004. Plots show \( \frac{\text{MIPAS}-\text{IG2}}{\text{IG2}} \times 100 \). Red shows where MIPAS \( H_2O \) values are higher than the climatology and blue shows where MIPAS values are lower than the climatology.
Figure 13. Time series of MIPAS near–real–time NO₂ retrievals, from July 2002 to March 2004 (day–time profiles only).

Figure 14. Time series of MIPAS near–real–time NO₂ retrievals, from July 2002 to March 2004 (night–time profiles only).

Figure 15. Time series of percentage difference of MIPAS near–real–time day–time NO₂ retrievals from a mid–latitude day–time climatology (1).

Figure 16. Time series of percentage difference of MIPAS near–real–time night–time NO₂ retrievals from a mid–latitude night–time climatology (1).