COMPARISONS OF MIPAS O_3 PROFILES WITH GROUND-BASED MEASUREMENTS

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ABSTRACT

For the ENVISAT validation different ground-based techniques have been used. MIPAS O_3 profiles have been compared with data from different ground-based techniques such as FTIR, LIDAR, O_3 sondes, and MWR. All instruments used are operated within the NDSC (Network for the Detection of Stratospheric Change).

These comparisons covering different techniques as well as different latitudes show a consistent picture. Within 20 to 40 km MIPAS O_3 profiles are in good agreement with ground-based data. Here, the differences are within the combined error bars. Below 20 km and above 50 km the differences are increasing. At these altitudes MIPAS VMR values tends to be a bit too large.

1. INTRODUCTION

These validation instruments cover different techniques as well as different latitudes as shown in Tab. 1.

All MIPAS data used in this paper are processed with software version 4.61. These data are available for the period from July 2002 to the beginning of 2003. Since there is still an error in the technical height MIPAS profiles have been taken versus pressure. In most cases the coincidence criteria are 1000 km in space and 12 hours in time, otherwise they are stated in the text.

Tab. 1. Instruments used at different sites. AOID project number is given in the Table.

	Lat.	Sondes	LIDAR	MWR	FTIR
Kiruna	68 N				191
Uccle	51 N	300			
Hohen-peiss.	48 N		158		
Payerne	46 N	158		158	
Mauna Loa	20 N	179	179	179	
Lauder	45 S	179	9003	179	126
Arrival Heights	78 S				126

2. FTIR

Ground-based FTIR data from Lauder, New Zealand (45°S, 170°E), Arrival Heights, Antarctica (78°S, 167°E) and Kiruna, Sweden (68°N, 20°E) have been used within this paper. These measurements have been made in the framework of the NDSC (Network of the Detection of Stratospheric Change). Bruker high resolution spectrometers are used; their spectral resolution is up to 0.003 cm^{-1}. Solar absorption spectra are recorded. They have been analyzed applying a profile retrieval technique [1]. For O_3, the vertical resolution is about 8 to 10 km in a height range from ground to about 30 km. For further details please see individual report [2].

2.1 Lauder

Fig. 1 shows a comparison of partial column amounts above 220 hPa. Besides FTIR and MIPAS, Dobson data are shown. The annual cycle is captured well by MIPAS measurements.

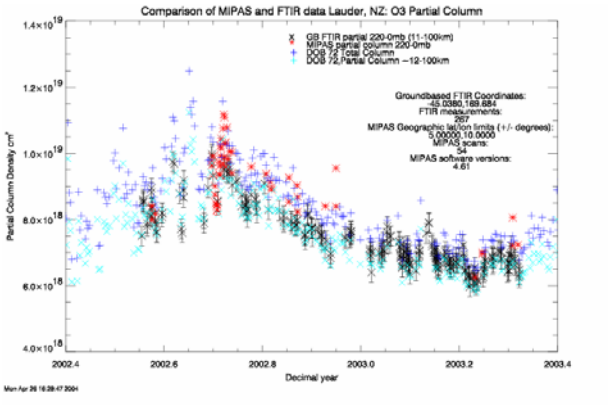

Fig. 1. Comparison of MIPAS O_3 column data above 220 hPa with Dobson and FTIR data at Lauder, NZ.

Fig. 2 shows mean O_3 profiles for Lauder as obtained by MIPAS and ground-based FTIR covering the period from July 27, 2002 to April 23, 2003. The difference is less than 1 ppmv and is within the 1σ standard deviation.

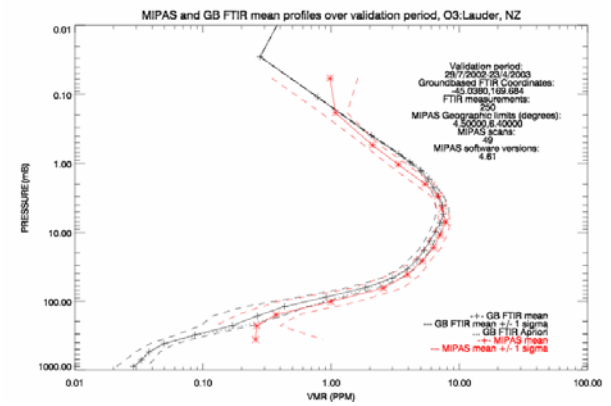

Fig. 2. Mean O_3 profiles from MIPAS and ground-based FTIR for Lauder, New Zealand.

2.2 Arrival Heights

Similar to Fig. 2 mean O_3 profiles are shown for Arrival Heights, Antarctica. Profiles from July 18, 2002 to April 28, 2003 are included. Within this period O_3 profiles differ strongly and therefore due to different sampling the mean profiles of MIPAS and FTIR also show larger differences as compared to the Lauder data.

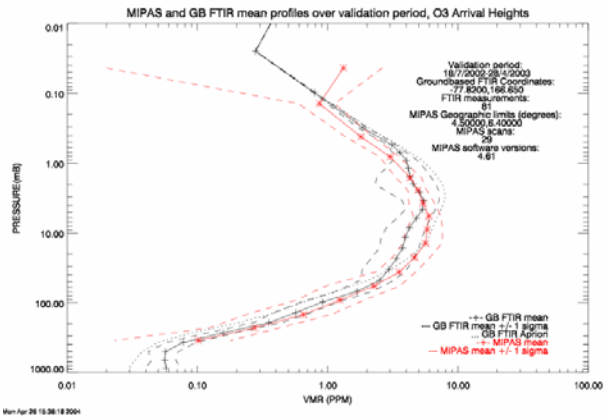

Fig. 3. Mean O_3 profiles from MIPAS and ground-based FTIR for Arrival Heights, Antarctica.

2.3 Kiruna

For comparisons with Kiruna FTIR individual profiles have been taken, see Fig. 4 for an example. Profiles were taken on a pressure scale. The resolution of the original MIPAS profile has been degraded to that of the FTIR. The difference versus height is shown on the right hand side. The dotted line shows the error of the FTIR profile only. The difference is bit larger than this error, but still within the combined error of MIPAS and FTIR.

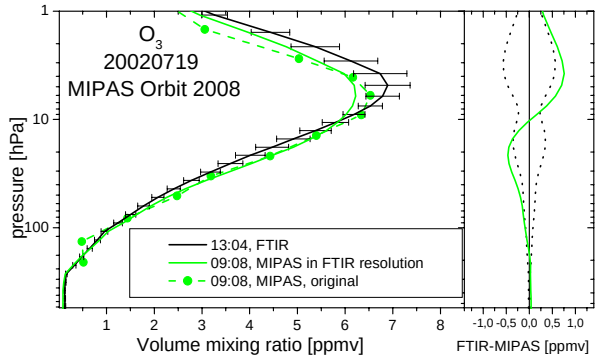

Fig. 4. An example of a comparison of MIPAS O_3 profiles with a ground-based FTIR profiles measured at Kiruna, Sweden. A MIPAS profile with degraded vertical resolution is shown, too.

Fig. 5 shows a statistics of 20 coincidences. Although the plot is made versus height all MIPAS profiles have been taken on a pressure scale. The differences are up to 12% at an altitude of about 22 km. Furthermore, coincidences clearly outside the polar vortex are shown separately. However, the coincidences made in the polar vortex do not significantly affect the inter-comparison.

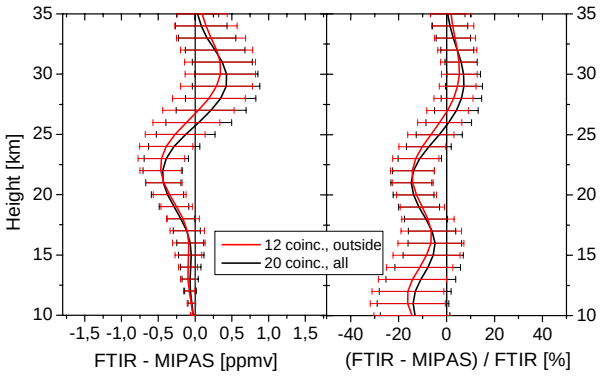

Fig. 5. Comparison of MIPAS O_3 profiles with data from ground-based FTIR at Kiruna.

2.4 Summary of comparisons with FTIR data

Using MIPAS 4.61 O_3 profiles on a pressure scale and degrading their vertical resolution to that of the FTIR profiles a good agreement is demonstrated. The precision of FTIR O_3 profiles is about 10%. The differences of MIPAS and FTIR are within the combined error bar. Since column amounts can be derived from FTIR measurements with better precision (3%) than profiles a statistical analysis of partial columns is envisaged.

3. MICROWAVE RADIOMETER

O_3 profiles from microwave radiometers (MWR) from Lauder (NZ), Mauna Loa (U.S.), and Payerne (CH) have been used to compare with. The NDSC ground-based microwave instruments at Lauder and Mauna Loa consist of heterodyne receivers coupled to 120 channel filter spectrometers, described in [3]. They measure the spectrum of an emission line produced by a thermally excited, purely rotational ozone transition at 110.836 GHz. The ozone altitude distribution is retrieved from the details of the pressure broadened line shape. Vertical resolution is achieved between about 20 and 75 km. We retrieve the ozone altitude distribution from the spectra using the optimal estimation method of C. D. Rodgers [4] as adapted by B. Connor for these instruments [5]. The coincidence criteria are 24 hours, 2.5° in latitude and 12° in longitude.

The MeteoSwiss MWR at Payerne consists of a heterodyne receiver coupled to two acousto-optical spectrometers. It measures the thermal emission line of ozone at 142.175 GHz. Vertical ozone profiles between about 20 and 65 km are retrieved from the recorded pressure-broadened spectra using C.D. Rodgers' optimal estimation algorithm [4]. For further details and about the MWR Payerne please see individual reports [6].

3.1 Lauder

Comparison with microwave radiometer at Mauna Loa are made and shown in Fig. 6. 21 coincident data sets for Lauder observations were available (Fig. 6). The MIPAS O_3 profiles agree well to the microwave data: The differences are within 5% for most altitudes up to about 30 km. Above the difference is increasing.

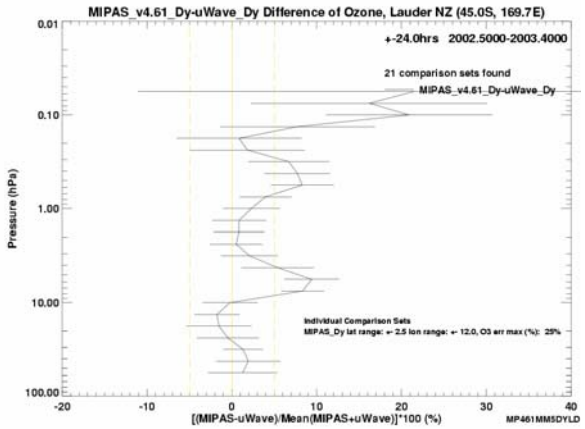

Fig. 6. Comparison of MIPAS O_3 profiles with data from microwave radiometer at Lauder, New Zealand. Dashed lines show +/- 5% difference as a guideline.

3.2 Mauna Loa

Comparison with microwave radiometer at Mauna Loa are made and shown in Fig. 7. 27 coincidences are available. The MIPAS O_3 profiles agree well to the microwave data: In the height range of 20 to 40 km the differences are within 5%, below and above they're about 10%. Above 50 km the differences are increasing.

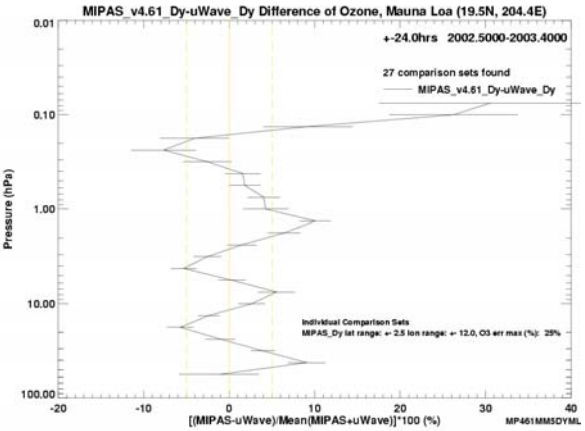

Fig. 7. Comparison of MIPAS O_3 profiles with data from microwave radiometer at Mauna Loa, Hawaii, U.S.

3.3 Payerne

At Payerne 138 coincidences of the microwave radiometer with MIPAS O_3 profiles have been found and analyzed (Fig. 8). The coincidence criteria are 500 km in space and 36 minutes in time. The direct comparison show a difference of up to 10% above 20 km.

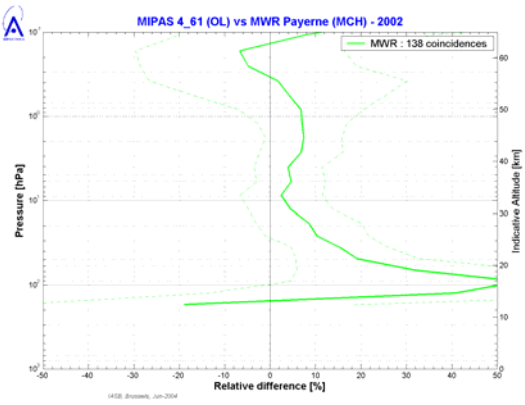

Fig. 8. Comparison of MIPAS O_3 profiles with data from microwave radiometer at Payerne, Switzerland.

3.4 Summary of comparisons with MWR data

Comparisons with microwave data show a good agreement. Within 20 to 40 km the differences are less than 10% which is the precision of the MWR profiles. Above 50 km the differences increase. For the height range of 20 to 50 km the differences are well within the combined error.

4. LIDAR

LIDAR data from Hohenpeissenberg (D), Lauder (NZ), and Mauna Loa (US) have been used to compare with MIPAS O_3 profiles. The high vertical resolution and precise height assessment of LIDARS allows one to particularly check for these parameters. For further details please see individual reports [7].

4.1 Hohenpeissenberg

Fig. 9 shows the result of the comparison of LIDAR data from Hohenpeissenberg with MIPAS O_3 profiles. The coincidence criteria are 500 km in space and 12 hours in time. They show good agreement; the differences are within +/- 10% for altitudes between 20 and 40 km.

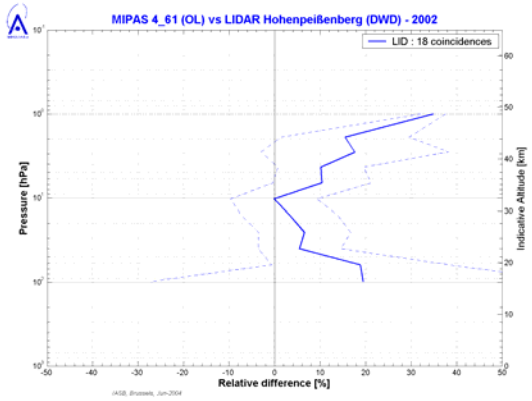

Fig. 9. Comparison of MIPAS O_3 profiles with data from ground-based LIDAR at Hohenpeissenberg, Germany.

4.2 Mauna Loa, Hawaii

Fig. 10 shows the comparison of LIDAR data from Mauna Loa with MIPAS O_3 profiles. While the agreement above about 25 km is very good, below 25 km there are differences of up to 15%.

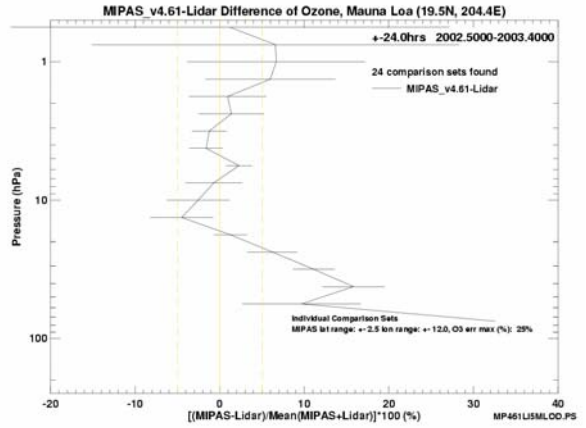

Fig. 10. Comparison of MIPAS O_3 profiles with data from ground-based LIDAR at Mauna Loa, Hawaii, US.

Fig. 11 shows an inter-comparison of MWR, LIDAR and MIPAS O_3 data. The difference of the mean of the three instruments is plotted. The MIPAS graph (in green) is well within the +/- 5% margin.

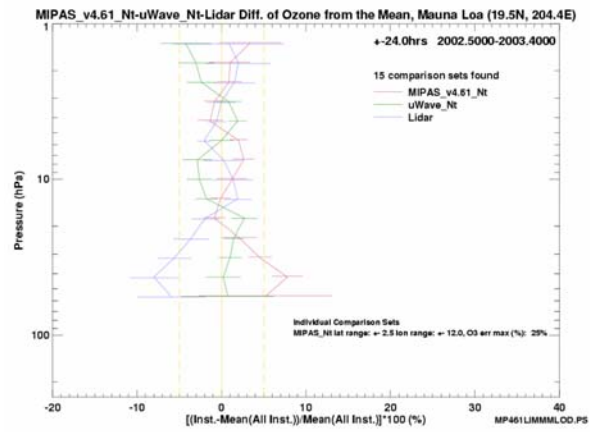

Fig. 11. Inter-comparison of MIPAS O_3 profiles with data from ground-based MWR and LIDAR at Mauna Loa.

4.3 Lauder

The comparison with LIDAR data from Lauder is shown in Fig. 12. The differences are smaller than 10% for altitudes above 20 km. On average the MIPAS VMR values are about 5% smaller than those of the LIDAR instrument.

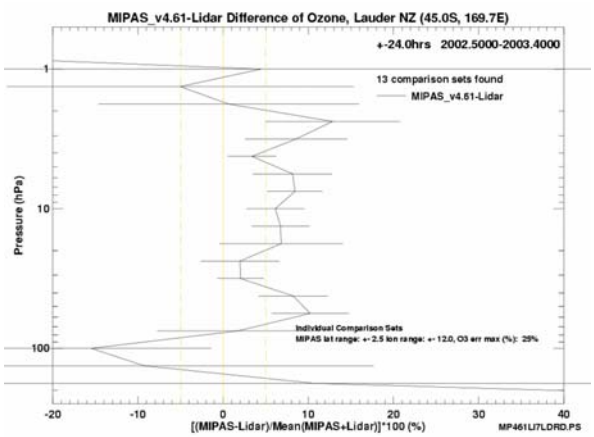

Fig. 12. Comparison of MIPAS O_3 profiles with data from ground-based LIDAR at Lauder, New Zealand.

Similar to Fig. 11 an inter-comparison of profiles of 3 different techniques is presented in Fig. 13 using Lauder data. Again, MIPAS O_3 data do not show significant differences to the mean of all three measurements. Only for high altitudes (above 35 km) the differences are increasing.

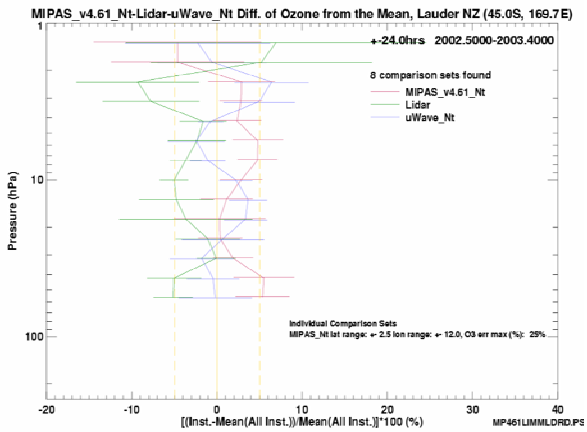

Fig. 13. Inter-comparison of MIPAS O_3 profiles with ground-based MWR and LIDAR at Lauder.

4.4 Summary of comparisons with LIDAR data

The precision of the LIDAR profiles is about 5% within 20 to 40 km. Assuming a precision of the MIPAS profiles of about 5%, too, the differences are within the combined error bars. At least for an altitude range of 20 to 40 km the agreement is excellent. Above, the differences increase. An inter-comparison of 3 different techniques also demonstrates the agreement.

5. OZONE SONDES

Ozone sonde data from Payerne (CH), Mauna Loa (US), Lauder (NZ) and Uccle (B) have been used to compare with MIPAS O_3 profiles. As in the case of LIDAR observations, ozone sondes provide a high vertical resolution. For further details please see individual reports [6+8].

5.1 Payerne

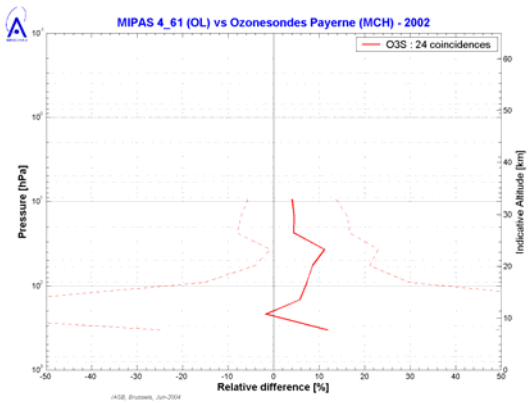

Fig. 14. Comparison of MIPAS O_3 profiles with data from sonde data at Payerne, Switzerland.

Fig. 14 shows the result of the comparison with sonde data from Payerne with MIPAS O_3 profiles. The coincidence criteria are 500 km in space and 12 hours in time. They show good agreement; the differences are within +/- 10% for altitudes above 20 km.

5.2 Mauna Loa, Hawaii

Fig. 15 shows the comparison of sonde data from Mauna Loa with MIPAS O_3 profiles. While the agreement above about 25 km is very good, below 25 km there are differences of up to 20%.

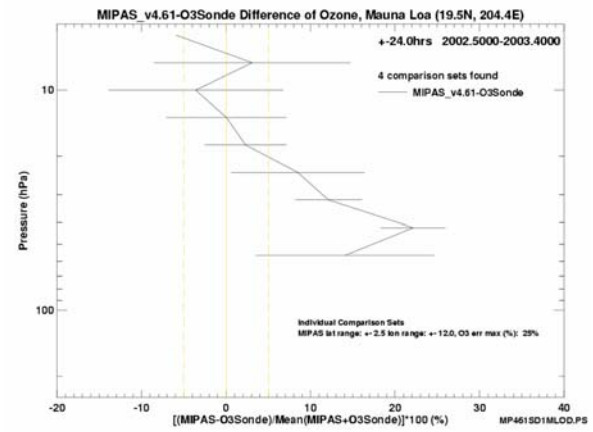

Fig. 15. Comparison of MIPAS O_3 profiles with data from sonde data at Mauna Loa, Hawaii, US.

5.3 Lauder

O_3 sonde data from Lauder are in good agreement with MIPAS data (Fig. 16). The differences are smaller than 5% for altitudes above 18 km.

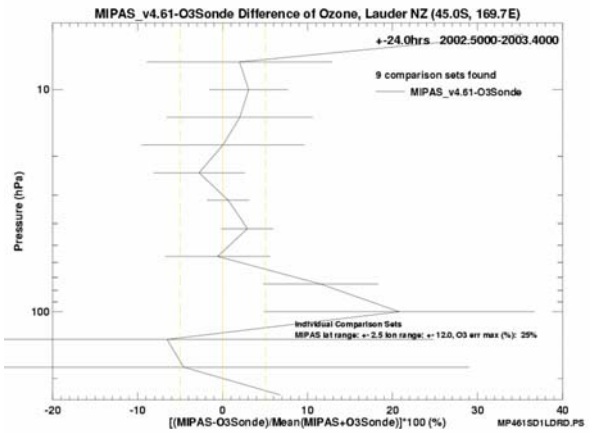

Fig. 16. Comparison of MIPAS O_3 profiles with sonde data from Lauder, New Zealand.

5.4 Uccle

A typical example of a comparison with O_3 sonde data from Uccle is shown in Fig. 17. The original sonde profile (black dots) has been smoothed to MIPAS vertical resolution of about 5 km (black line). The smoothed sonde profile is in excellent agreement with the MIPAS profile (in blue).

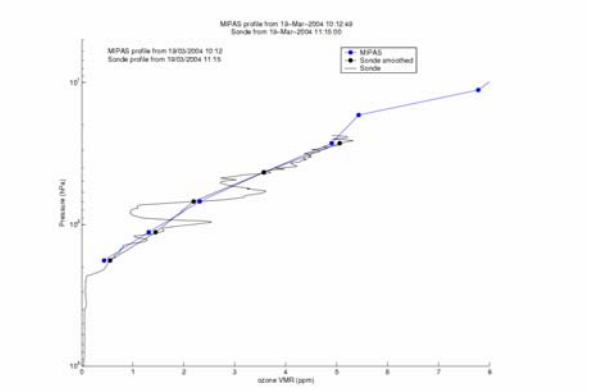

Fig. 17. Comparison of a MIPAS O_3 profile with sonde data from Uccle, Belgium. The original sonde profile (black dots) has been smoothed to MIPAS vertical resolution of about 5 km (black line)

Fig. 18 shows the statistics of all 64 comparisons made with Uccle O_3 sondes. The mean difference is about 0 ppmv, that means there is no real bias. The FWHM of the histogram is 0.2 ppmv.

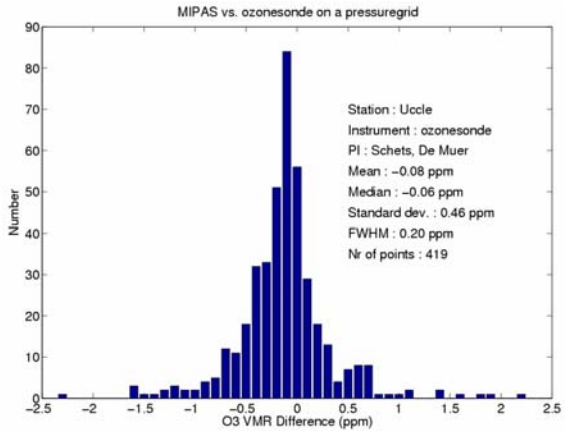

Fig. 18. Histogram of differences in VMR between MIPAS and O_3 sonde data from Uccle, Belgium.

5.5 Summary of comparisons with ozone sonde data

The precision of the sonde data is about 5% within 10 to 25 km. Assuming a precision of the MIPAS profiles of about 5%, too, the differences are within the combined error bars. At least for altitudes above 20 km the agreement is very good.

6. CONCLUSIONS

Different and fully independent ground-based techniques have been used to validate MIPAS O_3 profiles. As shown in Tab. 2 these different techniques give a consistent picture. Within 20 to 40 km MIPAS O_3 profiles are in good agreement with ground-based data. Here, the differences are within the combined error bars. Below 20 km and above50 km the differences are increasing. At these altitudes MIPAS VMR values tends to be a bit too large.

Tab. 2. Summary of differences of O3 profiles with data from different techniques in percentage.

Height [km]	Sondes [%]	LIDAR [%]	MWR [%]	FTIR [%]
< 20	> 20	> 20		15
20 – 30	10	10	5	12
30 – 40		10	10	
40 – 50		> 20	10-20	

7. REFERENCES

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