Comparison 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. All MIPAS data used in this paper are processed with software version 4.53. In most cases the coincidence criteria are 1000 km in space and 12 hours in time, otherwise they are stated in the text.

MIPAS O_3 profiles measured before November 13, 2002 show an error in altitude assignment of about 1 to 1.5 km. MIPAS O_3 profiles versus pressure are not affected by this. The update of the pointing characterization in the data processor as implemented on November 13 has clearly solved this problem.

The MIPAS profiles agree quite well with ground-based data. The mean differences are within 10% in an altitude range of about 20 to 40 km. Below 20 km MIPAS tends to slightly overestimate the vmr while above 25 km MIPAS tends to slightly underestimate the vmr. However, more coincidences are needed for a more quantitative analysis.

1. FTIR

Ground-based FTIR measurements have been made at Izaña Observatory on Tenerife Island (28°N, 16°W) and at IRF Kiruna (68°N, 20°E). At Kiruna a Bruker IFS 120HR and at Izaña a Bruker IFS 120M is used; their spectral resolution is about 0.003 cm^{-1}. Solar absorption spectra were recorded, while coadding up to 10 min. Profiles are derived by using the retrieval code PROFFIT [1]. The profile retrieval technique uses the pressure broadening of absorption lines, and therefore allows us to derive profiles of species with pressure dependent absorption signatures like O_3, HCl, HF, HNO_3, N_2O, and CH_4. 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].

1.1 TENERIFE ISLAND

Fig. 1 shows two examples of a comparison of MIPAS O_3 profiles with a profile from ground-based FTIR at Izaña Observatory. Since the height resolution of the ground-based instrument is lower than those of MIPAS the original MIPAS profiles have been 'smoothed' by convolving them with averaging kernels of ground-based FTIR. Both comparisons show a shift in altitude of about 1 to 1.5 km. Besides that, the comparison from Oct. 31 shows quite good

agreement. In contrast, the MIPAS profile from November 14 shows some differences compared to the FTIR profile. Furthermore, there are some oscillations on the MIPAS profile, which are still partly present in the smoothed profile, but could not observed in the FTIR profile.

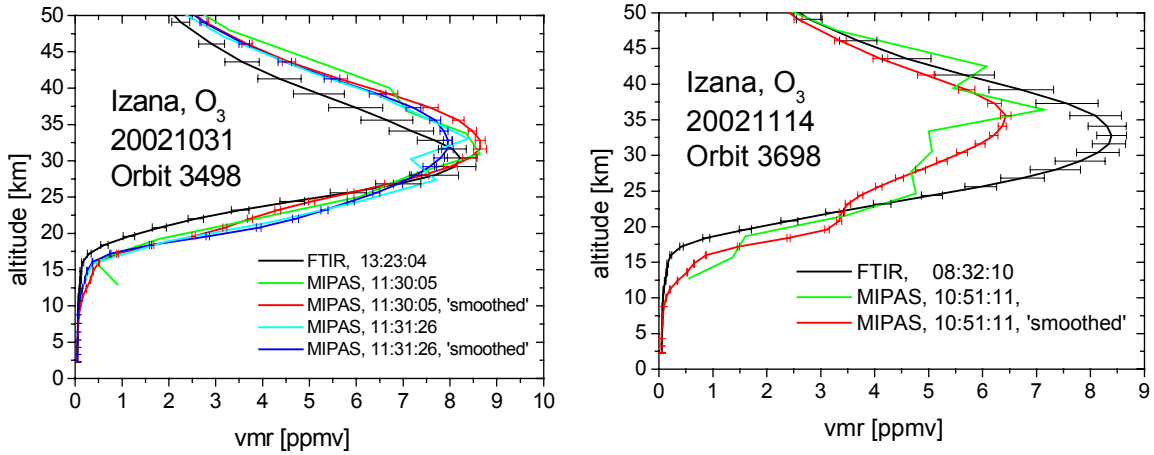

Fig. 1. Comparison of MIPAS O_3 profiles with data from ground-based FTIR at Izaña on Tenerife Island. 'Smoothed' means convolved with averaging kernels of ground-based FTIR. The difference in geolocation was less than 3° in latitude and less than 6° in longitude.

1.2 KIRUNA

Two examples of MIPAS O_3 profiles compared with ground-based FTIR at Kiruna are shown in Fig. 2. Again, the altitude assignment of MIPAS is wrong by about 1.5 km. Many validation instruments (see below) have detected this and the MIPAS height assignment has been updated on November 13, 2002 [3]. The altitude assignment has been discussed elsewhere in detail [4].

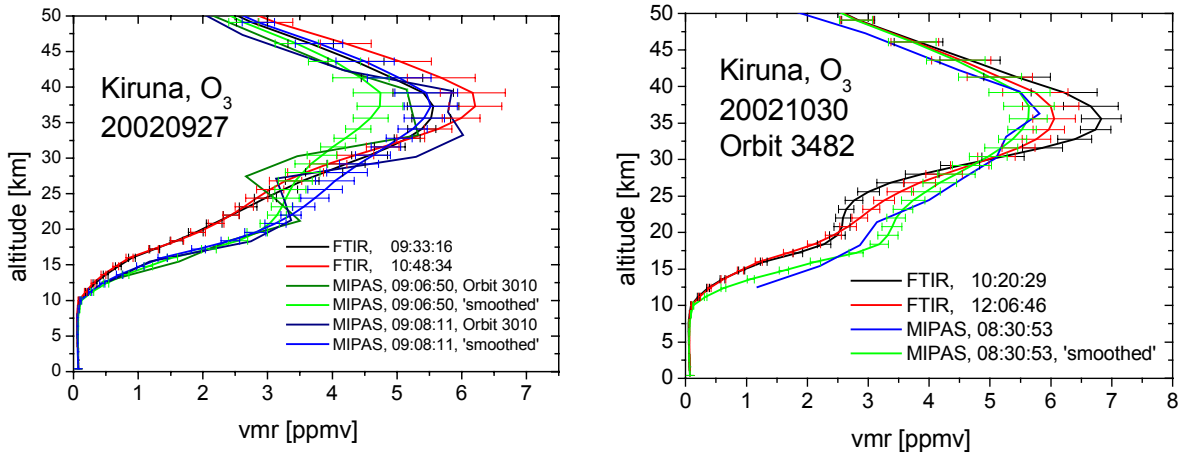

Fig. 2. Comparison of MIPAS O_3 profiles with data from ground-based FTIR at Kiruna. 'Smoothed' means convolved with averaging kernels of ground-based FTIR. The difference in geolocation was less than 3° in latitude and less than 6° in longitude.

Comparing MIPAS O_3 profiles versus pressure show a much better agreement (Fig. 3), for the example from October 30 as well as for the mean difference of all 7 coincidences. While MIPAS profiles versus height are up to about 0.8 ppmv too large at altitudes around 20 km, MIPAS profiles are about to 0.8 ppmv too low at altitudes around 30 km. In contrast, MIPAS profiles versus pressure differ less than 0.4 ppmv. That means that most of the differences are due to

the incorrect altitude assignment applied before November 13, 2002. Furthermore, the MIPAS profiles on a pressure scale agree quite well with the profiles from ground-based FTIR.

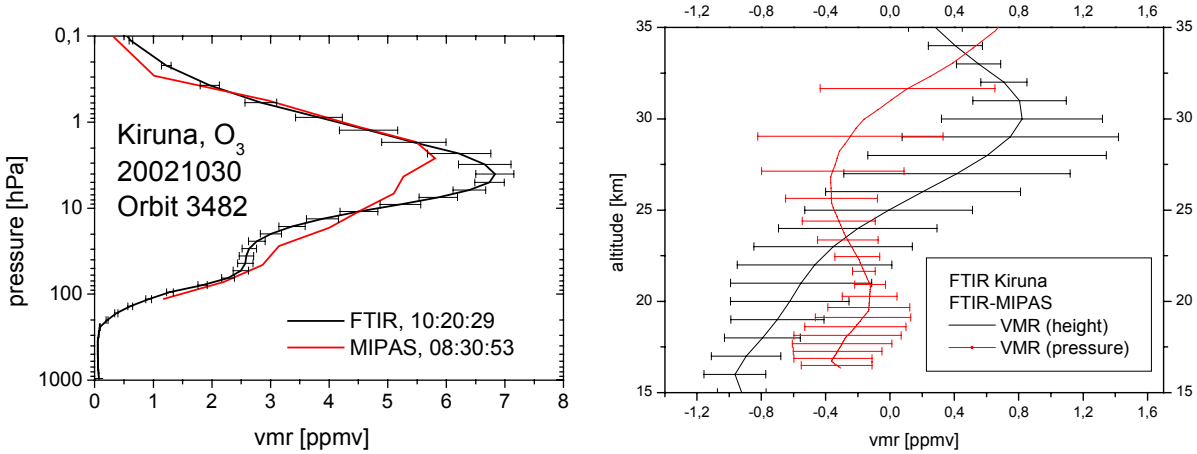

Fig. 3. MIPAS O_3 profile versus pressure compared with a profile from ground-based FTIR at Kiruna (left hand side). The right hand side shows the mean difference and standard deviation of 7 comparisons with ground-based FTIR.

The comparisons shown above are made using data from September 23 to November 5, 2002. During this period of the year there are very little gradients in O_3 as can be seen by assimilated GOME total ozone plots (Fig. 4). So it can be expected that with the given coincidence criteria the comparisons are not distorted by large-scale atmospheric variability.

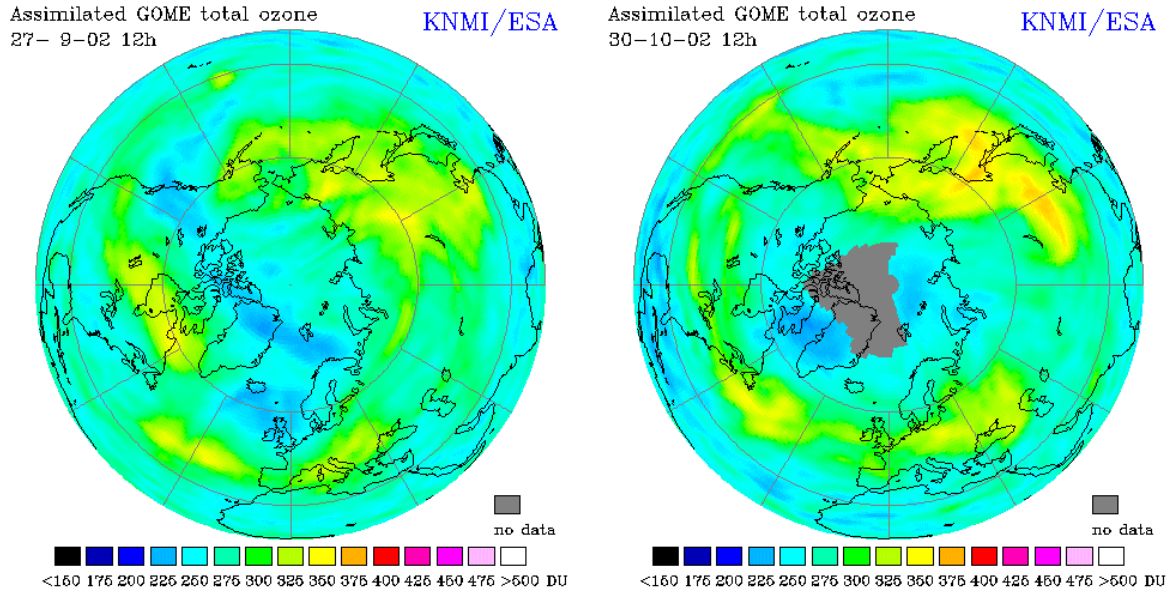

Fig. 4. Assimilated GOME total O_3 fields for 2 days within the period of coincidences with ground-based FTIR observations [5].

2. LIDAR

LIDAR data from Lauder (NZ), O.H.P. (F) and Alomar (N) 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 [6-8].

2.1 LAUDER

Fig. 5 shows two examples of the comparison of LIDAR data from Lauder with MIPAS O_3 profiles. They show good agreement. In some cases the volume mixing ratio (vmr) on the lowermost tangent height differ significantly.

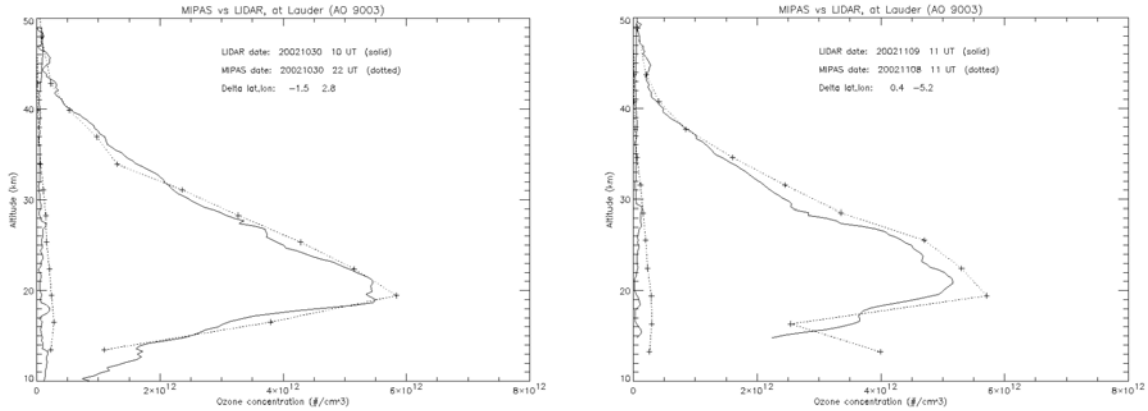

Fig. 5 Comparison of MIPAS O_3 profiles with data from ground-based LIDAR at Lauder, New Zealand.

2.2 O.H.P.

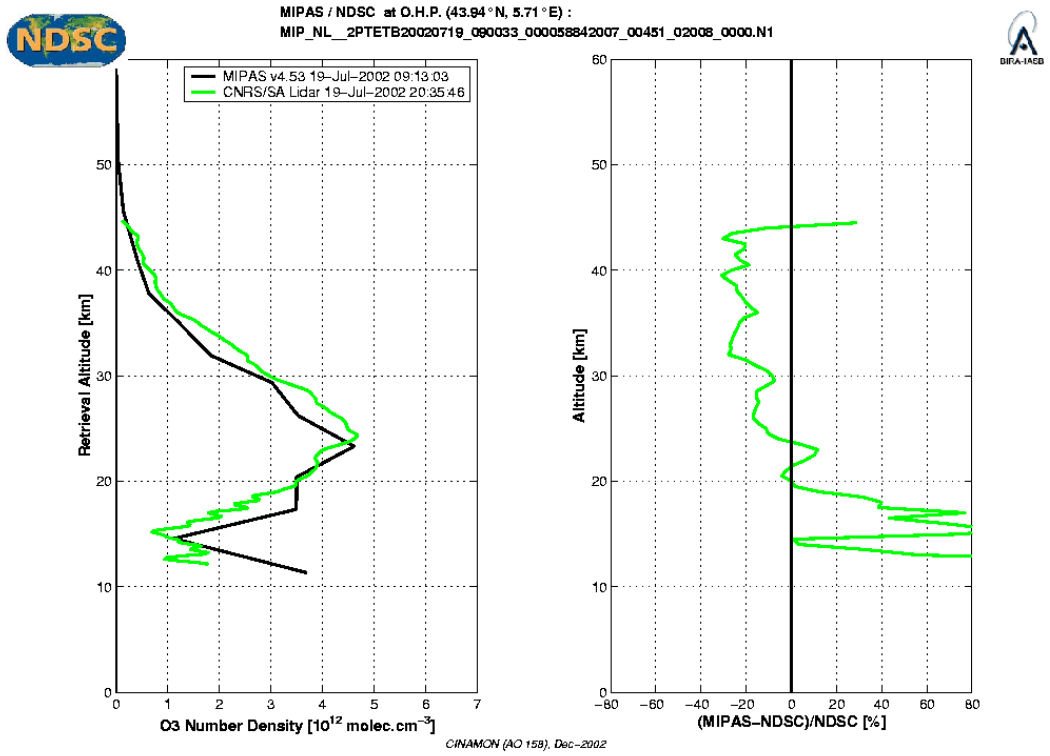

Fig. 6 Comparison of MIPAS O_3 profile with data from ground-based LIDAR at O.H.P., France. The difference in geolocation was less than 1000 km.

Fig. 6 shows a typical example of a comparison with an O_3 profile obtained by ground-based LIDAR at O.H.P. Since data processed before November 13 is used a shift in altitude of about 1 to 1.5 km is observed. Partly related to that the MIPAS O_3 number density is too large at lower altitudes and about 20% too small for altitudes above 20 km.

2.3 ALOMAR

The comparison with LIDAR data from Alomar shows the same result (Fig. 7). Imaging a shift in altitude of about 1 km even small-scale structures as obtained by MIPAS can be found in the LIDAR O_3 profile.

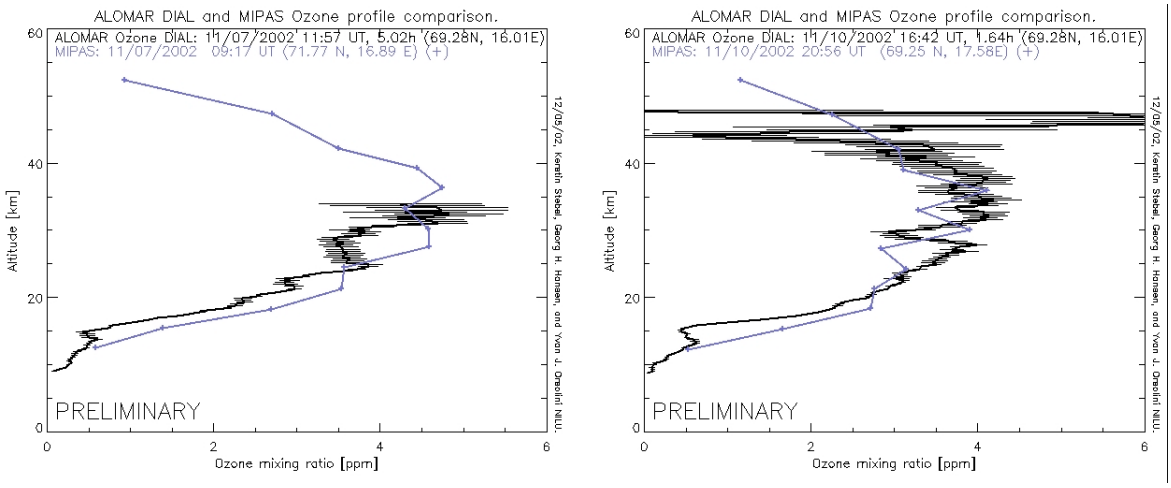

Fig. 7 Comparison of MIPAS O_3 profiles with ground-based LIDAR at Alomar, Norway.

In order to have a closer look on the MIPAS O_3 profile which has been retrieved on a pressure scale a comparison of profiles versus pressure is made, too (Fig. 8). The agreement is quite good, in particular in the range of 20 to 100 hPa. Within the range of 1 to 10 hPa the mean difference is about 15%.

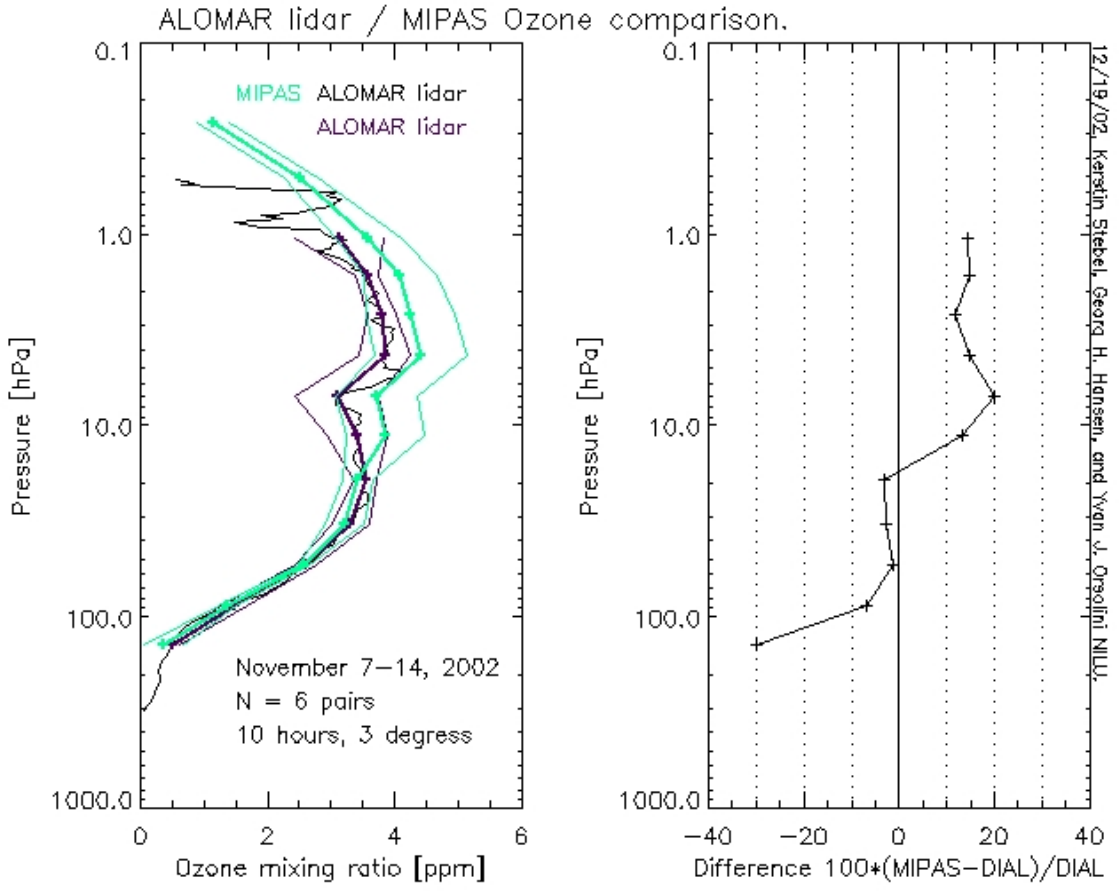

Fig. 8 Comparison of MIPAS O_3 profiles versus pressure with data from ground-based LIDAR at Alomar, N.

3. OZONE SONDES

Ozone sonde data from Hohenpeissenberg (D) and Uccle (B) have been used to compare with MIPAS O_3 profiles. Furthermore, O_3 sonde data from Lauder (NZ) and Payerne (CH) have been used when comparing with microwave data (Chapt. 4). As in the case of LIDAR observations, ozone sondes provide a high vertical resolution. For further details please see individual reports [9+10].

3.1 Hohenpeissenberg

A typical example of a comparison with O_3 sonde data from DWD station Hohenpeissenberg is shown in Fig. 9. Observations made before November, 13 have been used. Again, the O_3 number density obtained by MIPAS is too large at altitudes below 20 km and about 10% too small above 20 km.

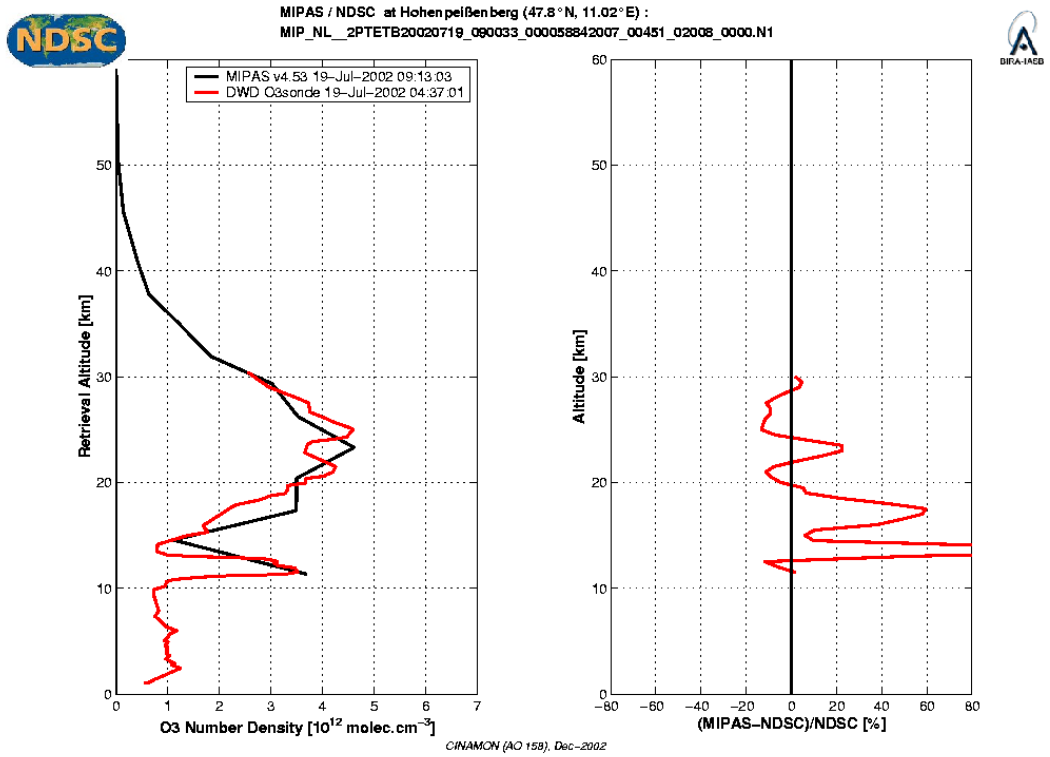

Fig. 9 Comparison of MIPAS O_3 profiles with O_3 sonde data from Hohenpeissenberg, Germany. The coincidence criteria are 3° in latitude and 10° in longitude, and 12 hours in time. The difference in geolocation was less than 1000 km.

3.2 UCCLE

At Uccle 34 coincidences with MIPAS data have been found, some of them with data processed after November 13, 2002 [10]. Fig. 10 shows a typical example for each case. While the earlier MIPAS O_3 profile show a shift in altitude the profile obtained after November 13 show a good agreement.

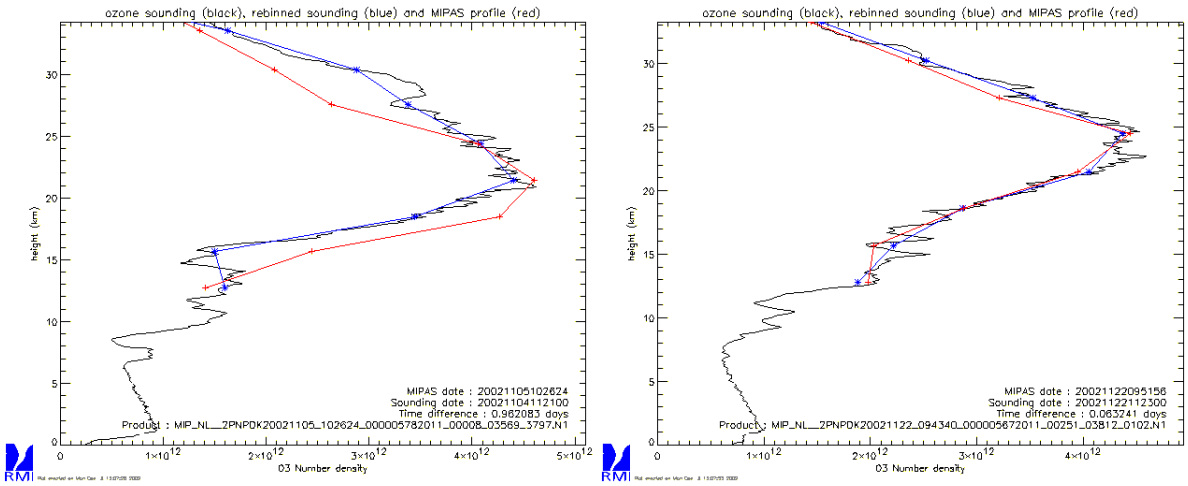

Fig. 10 Comparison of MIPAS O_3 profiles with data from O_3 sondes from Uccle, Belgium (left hand side: data obtained before Nov. 13, 2002, right hand side: data processed after Nov. 13.). The coincidence criteria are 1000 km in space and 12 hours in time.

4. 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 [11]. 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 [12] as adapted by B. Connor for these instruments [13]. For further details and about the MWR Payerne please see individual reports [9]. 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 [12].

4.1 LAUDER

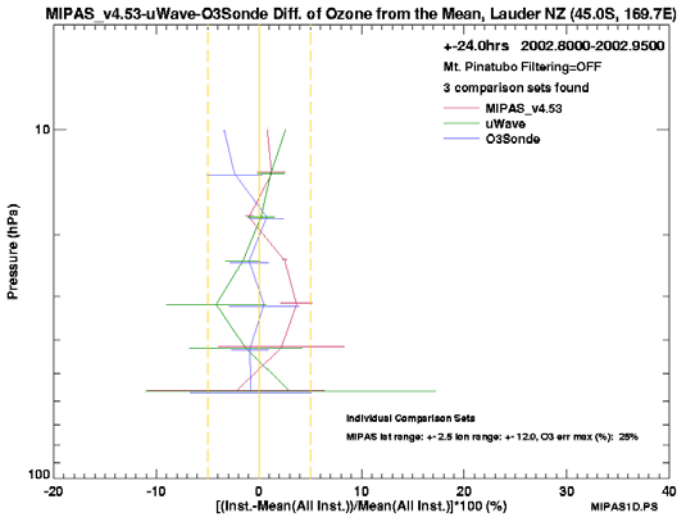

Fig. 11 Comparison of MIPAS O_3 profiles with data from O_3 sondes at Lauder, New Zealand.

Three coincident data sets for Lauder observations were available. The MIPAS O_3 profiles agree well to the O_3 sonde as well as to the microwave data from Lauder (Fig. 11). The mean of the differences is smaller than 6% in a pressure range of about 10 to 60 hPa.

4.2 MAUNA LOA

Nighttime as well as daytime MIPAS O_3 profiles agree within 10% with microwave data from Mauna Loa (Fig. 12).

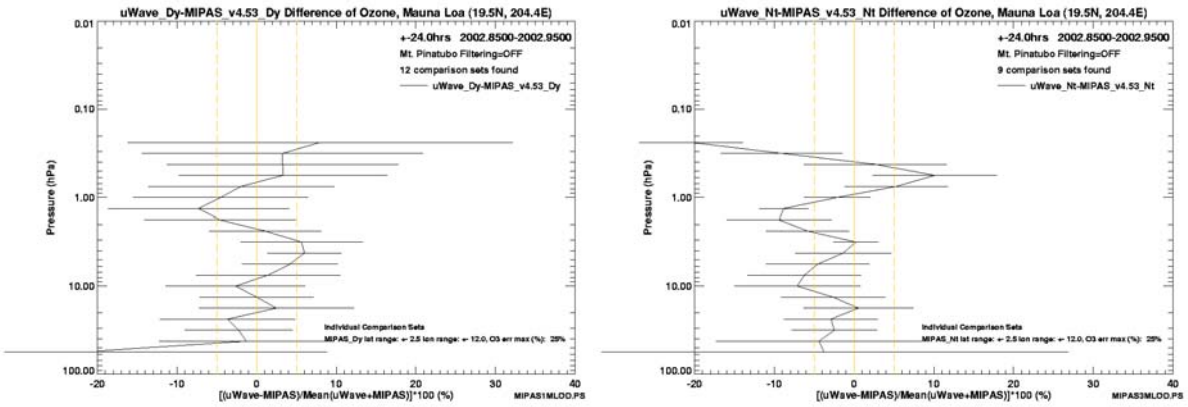

Fig. 12 Comparison of MIPAS O_3 profiles with microwave radiometer at Mauna Loa, Hawaii, U.S.

4.3 PAYERNE

At Payerne 106 coincidences of the microwave radiometer with MIPAS O_3 profiles have been found and analyzed. 75 of them are with data processed before November 13, 31 coincidences include data recorded after November 13, 2002. Figs. 13 and 14 show a typical example for each case while Fig. 15 shows the statistics of all coincidences. The coincidence criteria are 1000 km in space and 12 hours in time.

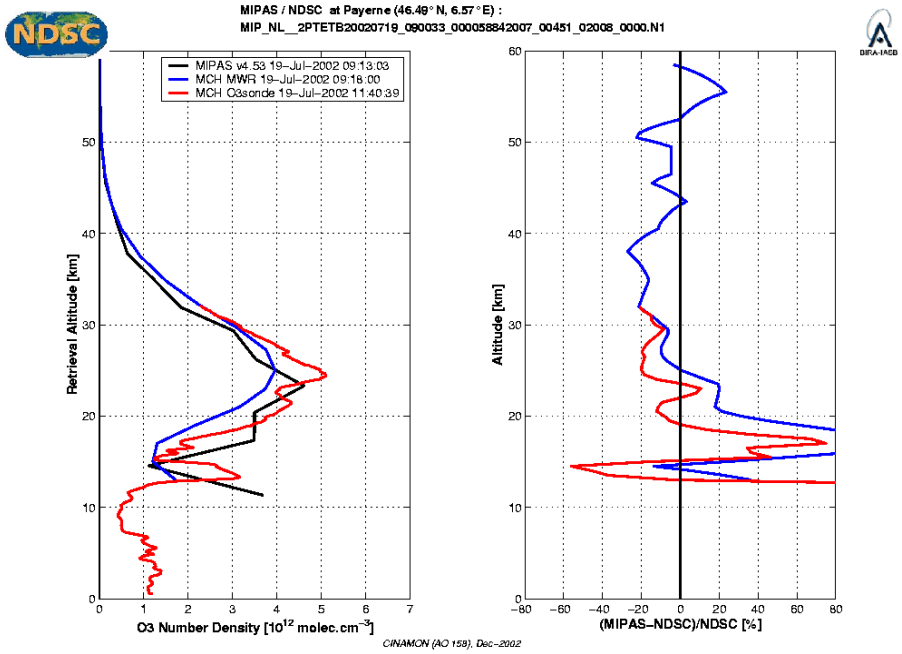

Fig. 13 Comparison of MIPAS O_3 profiles with microwave radiometer at Payerne using observations made before November 13, 2002.

Again, data processed before November 13 show an error in altitude assignment of about 1 km (Fig. 13). The update of the pointing characterization in the data processor as implemented on November 13 has clearly solved this problem.

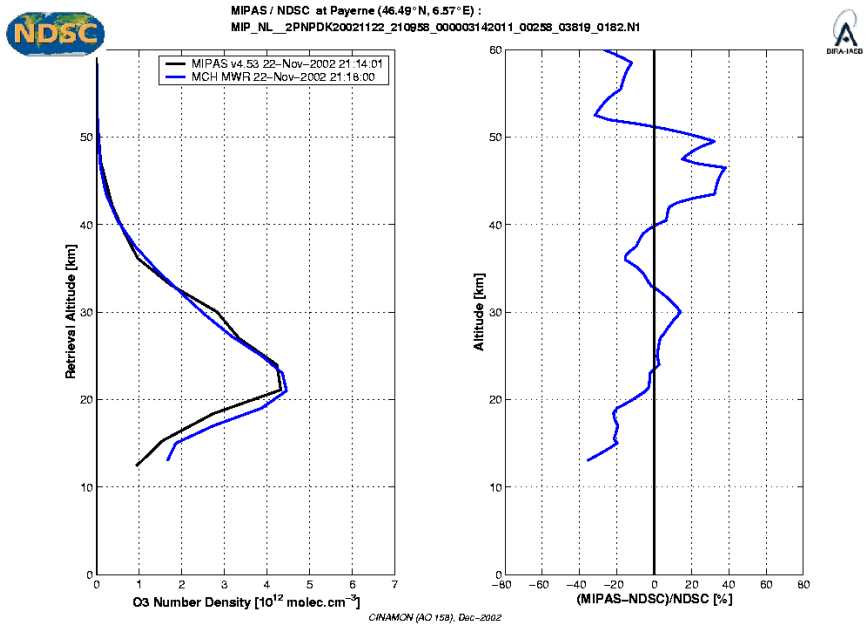

Fig. 14 Comparison of MIPAS O_3 profiles with microwave radiometer at Payerne using observations made after November 13, 2002.

The mean difference of MIPAS O_3 profiles to microwave data from Payerne is improving significantly for data obtained after November 13, 2002. The latter data set shows a good agreement with mean differences of less than 10% over nearly the entire height range. To correct for different height resolution the MIPAS profiles have been folded with the averaging kernels of the microwave instrument, which gives slightly smaller differences (Fig. 15).

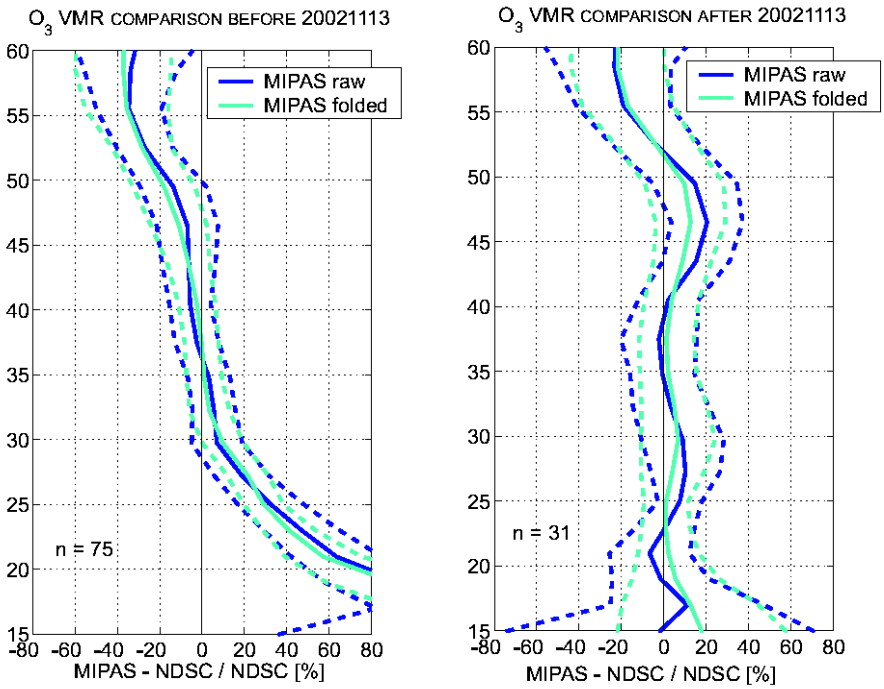

Fig. 15 Comparison of MIPAS O_3 profiles with microwave radiometer at Payerne, Switzerland. The coincidence criteria are 1000 km in space and 12 hours in time.

5. CONCLUSIONS

MIPAS O_3 profiles have been compared with data from different ground-based techniques such as FTIR, LIDAR, O_3 sondes, and MWR. These comparisons covering different techniques as well as different latitudes show a consistent picture.

MIPAS O_3 profiles measured before November 13, 2002 show a systematic offset in altitude assignment of about 1 to 1.5 km. MIPAS O_3 profiles versus pressure are not affected by this. The update of the pointing characterization in the data processor as implemented on November 13 has clearly solved this problem.

The MIPAS profiles agree quite well with ground-based data. The mean differences are within 10% in an altitude range of about 20 to 40 km. Below 20 km MIPAS tends to slightly overestimate the vmr while above 25 km MIPAS tends to slightly underestimate the concentration. However, more coincidences are needed for a more quantitative analysis.

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