Report of the Study:

Development of Algorithms for the Exploitation of MIPAS Special Modes Measurements
ESA-ESRIN Contract No: 16700/02/I-LG

Geophysical Validation Tests

IFAC-GA-2004-18-SC

Issue: Draft

17 November 2004

Prepared by:

Name	**Institute**
Simone Ceccherini	IFAC-CNR Florence
Francesco Mencaraglia	IFAC-CNR Florence

CONTENTS

1. Background

1.1 Introduction

MIPAS (Michelson Interferometer for Passive Atmospheric Sounding) is an ESA developed instrument operating on board ENVISAT. It performs limb-sounding observations of the atmospheric emission spectrum in the middle infrared region and concentration profiles of several species can be derived from MIPAS observed spectra.
For about 80% of its measuring time, MIPAS operates in the “nominal” observation mode, that is rear viewing along the track of the orbit with limb-scanning sequences spanning from 6 km to 68 km in tangent altitude. For the remaining 20% of measuring time MIPAS operates in the so called “special modes”.
The special mode measurements are defined as:

S1 Polar Chemistry and Dynamics:
rear view; tangent heights = 7-55 km, height resolution = 2-10 km,
horizontal spacing = 420 km.

S2 Stratosphere/troposphere exchange, troposphere chemistry:
rear view, tangent heights = 5-40 km, height resolution = 1.5-10 km,
horizontal spacing = 420 km.

S3 Impact of Aircraft emission:
side view; tangent heights = 6-40 km, height resolution = 1.5-10 km,
horizontal spacing = 330 km.

S4 Stratospheric Dynamics:
rear view; tangent heights = 8-53 km, height resolution = 3 km,
horizontal spacing = 390 km.

S5 Diurnal changes:
side views; tangent heights =15-60 km, height resolution = 3 km,
horizontal spacing = 480 km.

S6 Upper troposphere / Lower stratosphere:
rear view, altitude range 6-35 km, height resolution 7-2 km, horizontal spacing = 120 km.

S7 Upper atmosphere:
rear view; tangent heights = 20-160 km, height resolution = 3-8 km,
horizontal spacing = 800 km.

ESA will provide level-2 data only for the nominal observation mode, while for the special modes only level-1 data (calibrated spectra) will be provided to the end users.
The main objective of the project “Development of Algorithms for the Exploitation of MIPAS special Modes Measurements” is the development of an open source software tool (called GMTR: Geofit Multi-Target Retrieval) for the analysis of MIPAS special mode measurements.

1.2 Scope of the document

In order to validate the code developed under the project “Development of Algorithms for the Exploitation of MIPAS special Modes Measurements” a study was performed to check the

availability of correlative measurement data corresponding to special mode measurements. The special mode orbits including scans in coincidence with some independent measurements were processed with GMTR and the retrieved profiles were compared with those of the correlative data.
Besides other coincidences were found between MIPAS nominal mode measurements and the measurements acquired by the SAFIRE-A (Spectroscopy of the Atmosphere by using Far InfraRed Emission Airborne) airborne spectrometer. Also the profiles obtained by the SAFIRE measurements were compared with those retrieved by the MIPAS measurements using the GMTR code.
This document describes the validation work and discusses the results of the comparisons.

2. Databases explored in order to find coincidences with MIPAS special mode measurements

A preliminary work was performed to check the availability of correlative data for the validation of GMTR in the processing of MIPAS special mode measurements. Three databases were explored in order to find independent measurements in spatial and temporal coincidence with the MIPAS special mode measurements:

a) NADIR database
b) SHADOZ database
c) NDSC database

The NADIR (NILU's Atmospheric Database for Interactive Retrieval) database at NILU contains the correlative data for the geophysical validation of the ENVISAT instruments.
The data are available in the web site:
http://nadir.nilu.no/calval/index.php
and the files in the database are stored in HDF format.

The SHADOZ (Southern Hemisphere Additional OZondesondes) organization coordinates the launches of ozone sondes from several stations operating in the southern hemisphere and provides a central archive for the results of the measurements.
The data are available in the web site:
http://croc.gsfc.nasa.gov/shadoz/
and the files in the database are stored in ASCII format.
In fig. 1 the sites participating to SHADOZ are shown.

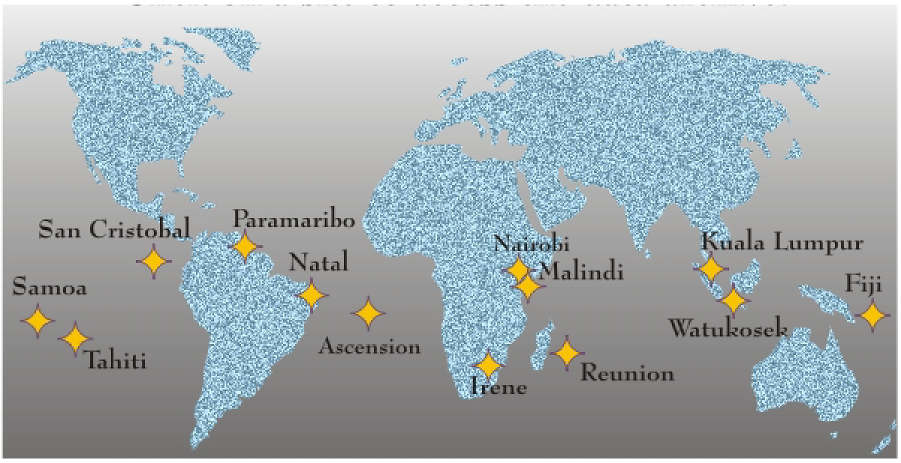

Fig.1 Sites participating to SHADOZ

The NDSC (Network for the Detection of Stratospheric Change) network consists of a set of remote sounding research stations observing ozone and key ozone-related chemical compounds and parameters.
The data are available in the web site:
ftp://ndsc.ncep.noaa.gov/pub/
and the files in the database are stored in AME ASCII format.
Only the data that are more than 2 years old are given available in the NDSC database, so no coincidence with MIPAS special mode measurements could be found in this database.

3. Coincidence criteria

Since it is impossible to find in the databases profiles whose geolocation exactly coincides spatially and temporally with some MIPAS special mode measurement, some tolerance criteria have to be established in order to define when two measurements are in coincidence.
The correlative data in the databases have been selected if their geolocation is inside the following ranges with respect to a MIPAS special mode measurement.

- Plus or minus 3 degrees in latitude
- Plus or minus 12 degrees in longitude
- Plus or minus 3 hours in time

4. Considered special mode orbits

In table 1 the MIPAS orbits corresponding to special mode measurements that have been considered in order to find coincidences with independent measurements are reported.
In the first column there is the special mode, in the second column the number of the considered orbits and in the third column the dates of the measurements.
Totally 27 orbits have been considered

Special Mode	Orbits	Date
S1	6675. 6676. 6679	10 June 2003
	10267,10268,10269,10270,10271	16 February 2004
S2	6681, 6687, 6688, 6689	10-11 June 2003
S3	9322. 9323. 9324	12 December 2003
S4	9325	12 December 2003
S5	9300	10 December 2003
S6	7020, 7021, 7022, 7023, 7024, 7025, 7030, 7033, 7034, 7035	4-5 July 2003

Table 1. MIPAS orbits considered in order to find coincidences with independent measurements.

Only the measurements acquired for special modes S1 and S2 are of good quality, because the data corresponding to the other special modes show a large number of corrupted sweeps. As a consequence of this only the measurements acquired for special modes S1 and S2 have been processed by GMTR.

5. Found coincidences

In table 2 the number of coincidences according to the tolerance criteria defined in section 3 for every special mode are reported.

Special Mode	Number of coincidences
S1	19
S2	11
S3	3
S4	2
S5	0
S6	25

Table 2. Number of coincidences for every special mode found in the databases.

In total 55 coincidences have been found in the NADIR database and 5 coincidences in the SHADOZ database, for a total number of 60 coincidences.
Since only the measurements acquired for special modes S1 and S2 were processed by GMTR only the 30 coincidences corresponding to these special modes have been used for the comparison.
The correlative data found in coincidence with the MIPAS special mode measurements correspond to four different types of measurements:

1) Assimilation of GOME measurements.
The comparison with MIPAS retrieved profiles has been done for temperature and ozone as a function of pressure. The temperature reported in the assimilation of GOME data is that estimated by ECMWF.

2) Balloon sonde measurements.
The comparison with MIPAS retrieved profiles has been done for pressure, temperature, water and ozone as function of altitude. The ballon sondes do not measure water volume mixing ratio (VMR) but the relative humidity. So in order to perform the comparison with the water VMR measured by MIPAS the relative humidity was converted into VMR by the following formula:

$$VMR = \frac{hum}{100} \frac{P_W(T)}{P}$$

where VMR is the volume mixing ratio, hum is the relative humidity, P is the pressure and $P_W(T)$ is the vapor pressure of water given by the Goff Gratch equation [Gibbins, C. J., A survey and comparison of relationships for the determination of the saturation vapour pressure over plane surfaces of pure water and of pure ice, Annales Geophys., 8, 859-886, 1990]

3) Ground-based microwave radiometer measurements.
The comparison with MIPAS retrieved profiles has been done for ozone as function of altitude. In the files with the microwave radiometer measurements also profiles of pressure and temperature were reported, but since they are a-priori estimations they were not used for the comparison.

4) Satellite POAM III measurements.
The comparison with MIPAS retrieved profiles has been done for water, ozone and NO2 as function of altitude. In the files with the satellite POAM III measurements also profiles of pressure and temperature were reported, but since they are a-priori estimations they were not used for the comparison.

6. Results of the comparisons

In this section the plots of the comparison between the profiles retrieved by MIPAS special mode measurements with GMTR and the correlative data are reported. For each coincidence a table shows the geolocations of the two compared profiles and then the comparison plots for the different species are shown.
Above every plot there is the list of the measurements reported in the graphic and the order in which the measurements appear in the list defines the colors of the lines representing the measurements according to fig. 2.

Fig. 2. Legend for the plots of comparison. The way to read the legend is the following:the first profile in the list above the comparison plots is in red, the second is in green, the third (if present) is in blue, the fourth (if present) is in magenta, the fifth (if present) is in cyan.

6.1 Orbit 6675 – 10 June 2003 – Special mode S1

NILU	MIPAS scan 15	Balloon sonde
Species		P, T, Humidity,O3
Time	10:07	12:06
Latitude	50.93	52.10
Longitude	2.08	5.18
Altitude range	7 – 55 km	0.004 –33.996 km (GPH)

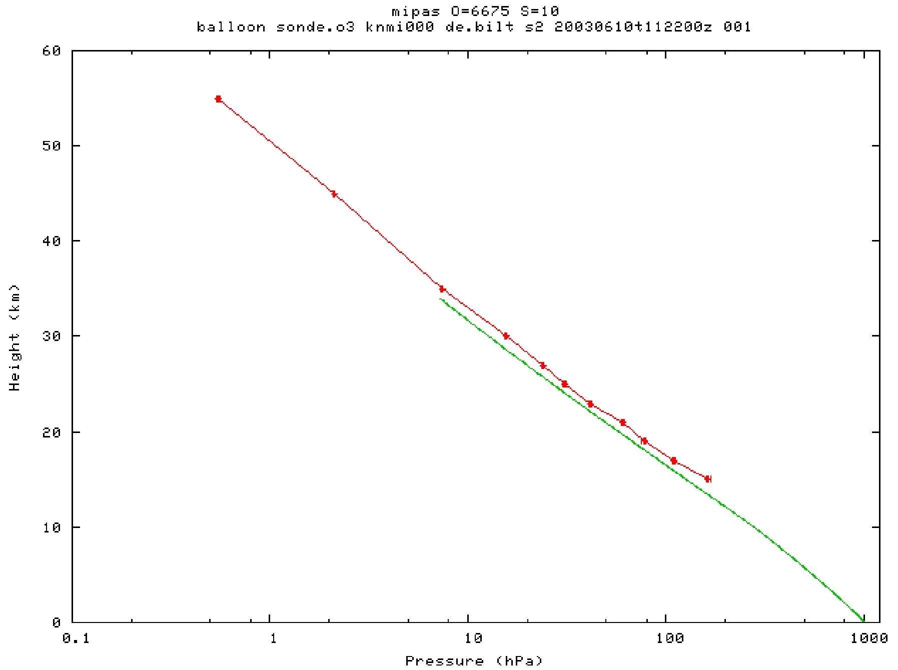

Fig. 3. Comparison of pressure as function of altitude.

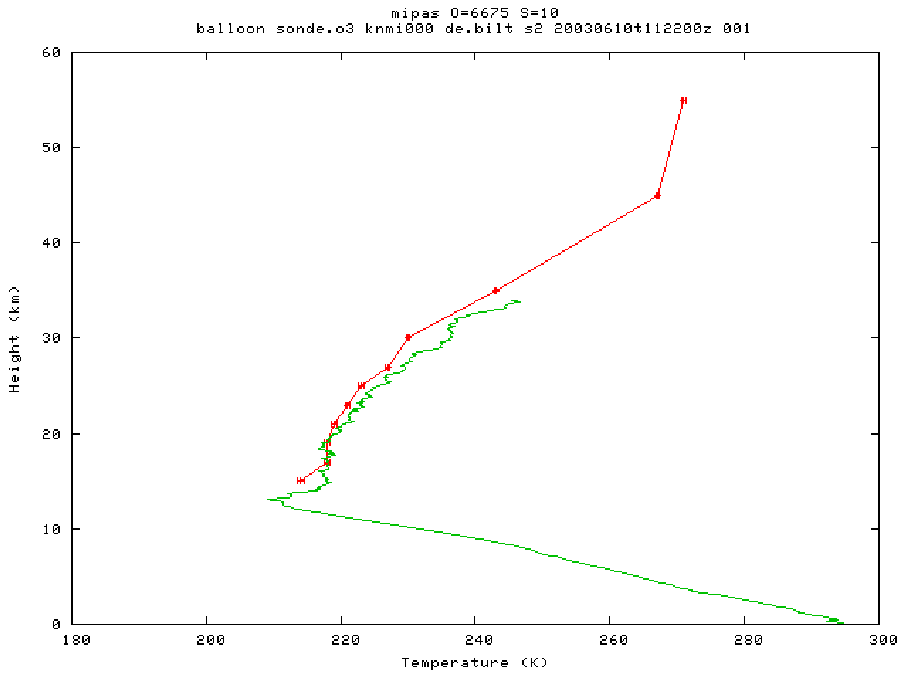

Fig. 4. Comparison of temperature as function of altitude.

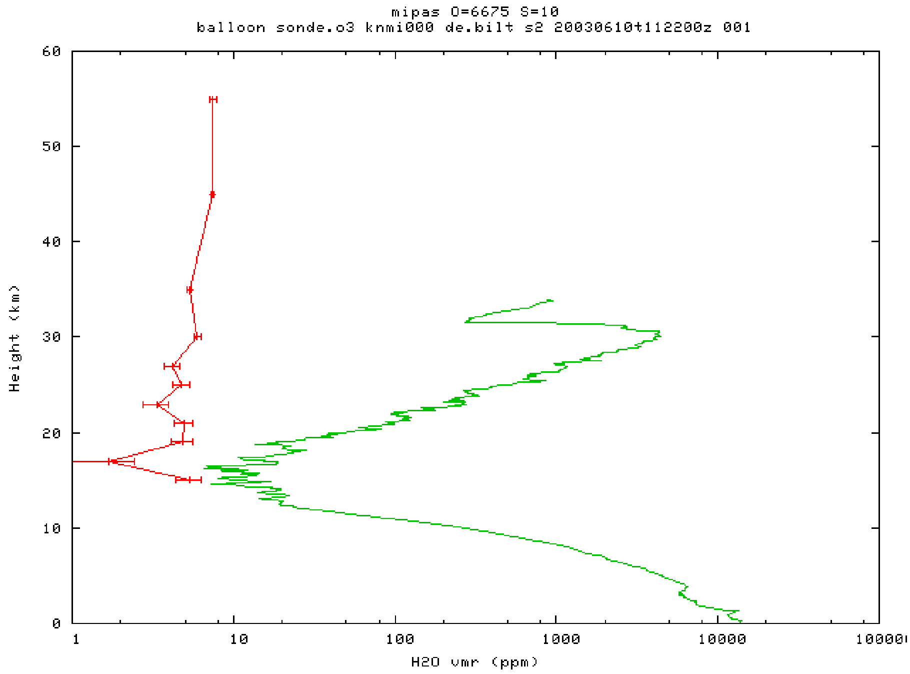

Fig. 5. Comparison of H2O VMR as function of altitude.

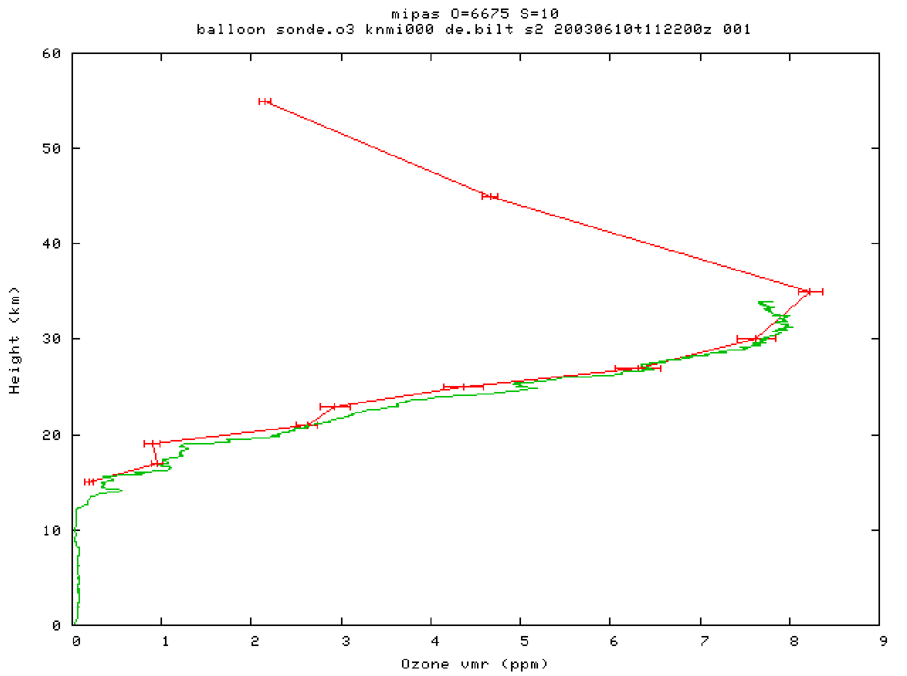

Fig. 6. Comparison of O3 VMR as function of altitude.

NILU	MIPAS scan 16	assimilation of GOME data #1	assimilation of GOME data #2	ground-based microwave radiometer
Species		P, T, O3	P, T, O3	O3
Time	10:08	12:00	12:00	10:19
Latitude	46.31	47.50	46.60	46.49
Longitude	0.84	11.10	8.00	6.57
Altitude range	7 – 55 km	0.1 – 925.33 hPa	0.1 – 892.91 hPa	13 – 76.5 km

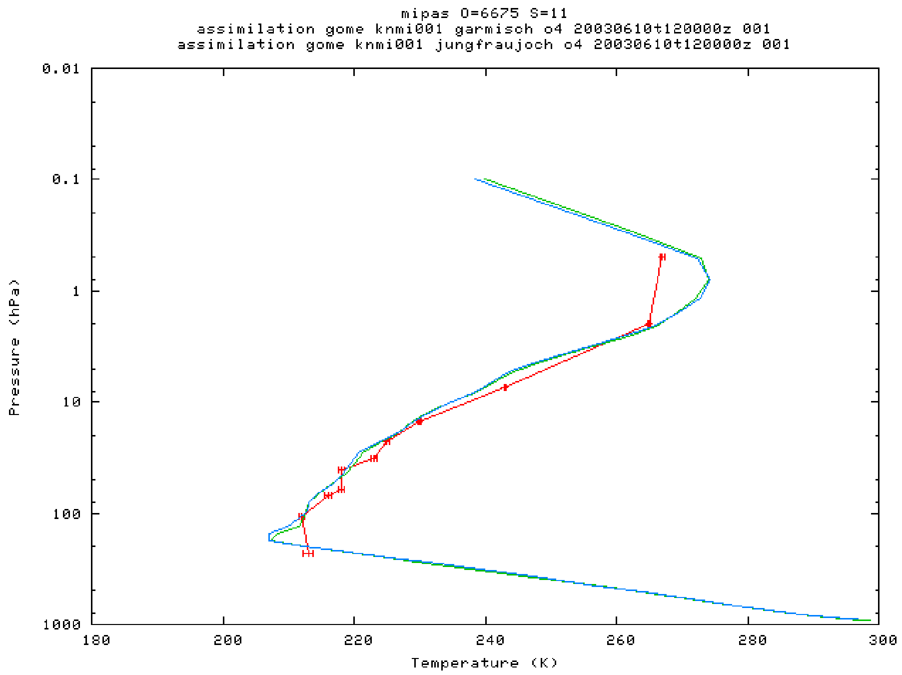

Fig. 7. Comparison of temperature as function of pressure.

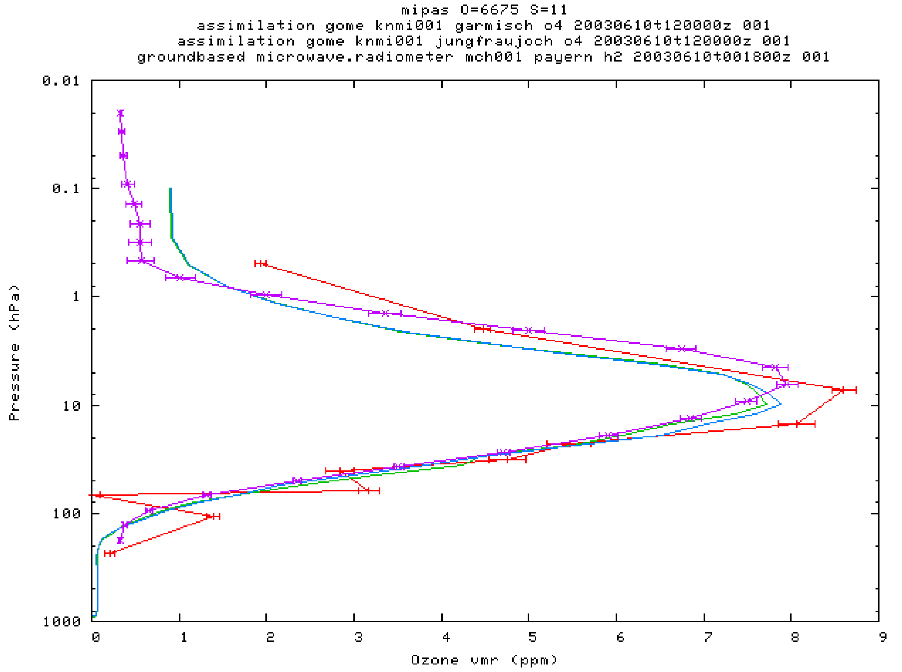

Fig. 8. Comparison of O3 VMR as function of pressure.

NILU	MIPAS scan 17	Assimilation of GOME data
Species		P, T, O3
Time	10:09	12:00
Latitude	42.20	43.9
Longitude	2.77	5.7
Altitude range	7 – 55 km	0.1 – 966.33 hPa

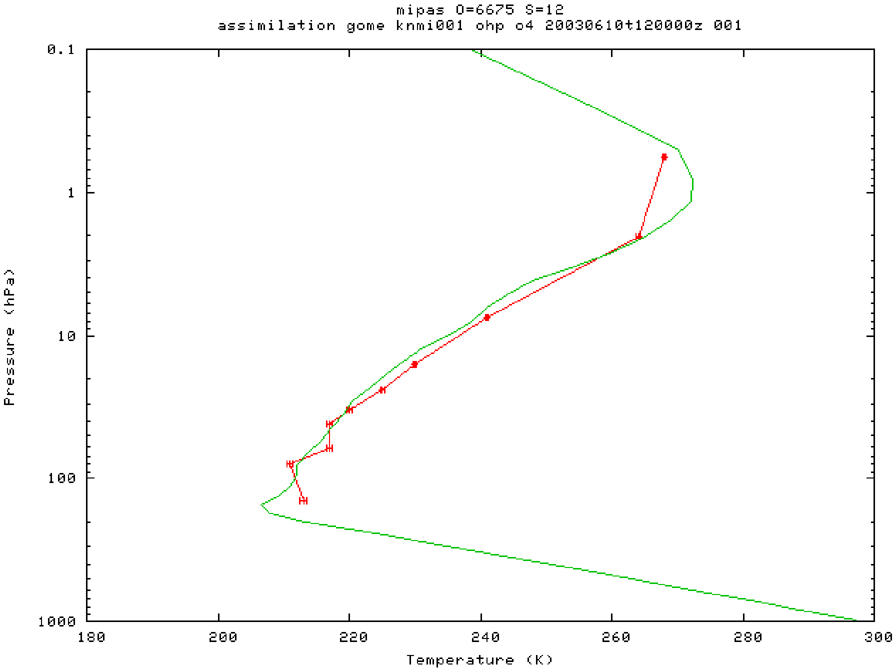

Fig. 9. Comparison of temperature as function of pressure.

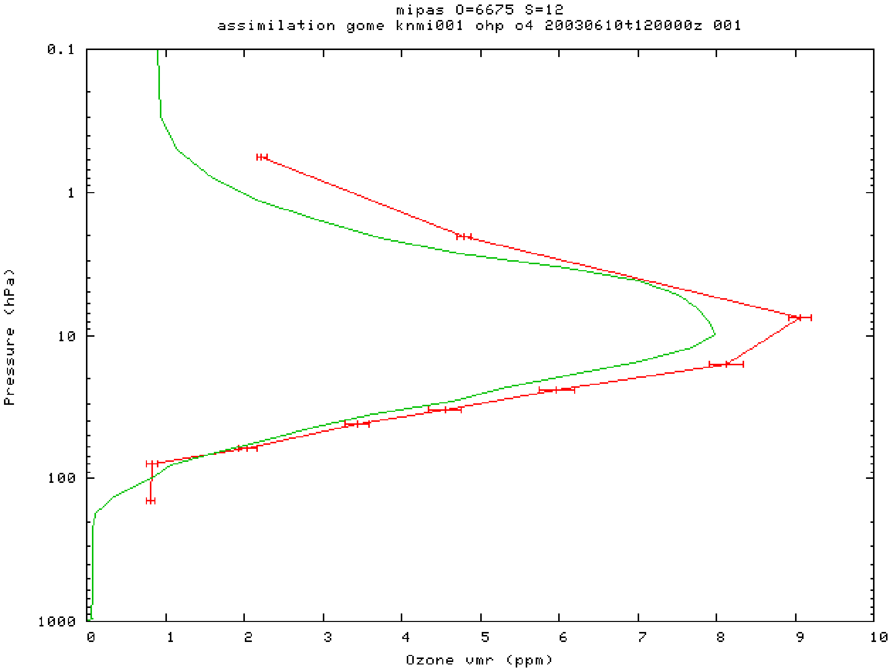

Fig. 10. Comparison of O3 VMR as function of pressure.

6.2 Orbit 6676 – 10 June 2003 – Special mode S1

SHADOZ	MIPAS scan 28	Balloon sonde
Species		P, T, Humidity, O3
Time	12:03	14:07
Latitude	-4.40	-5.42
Longitude	-28.65	-35.38
Altitude range	7 – 55 km	0.014 - 33.208km

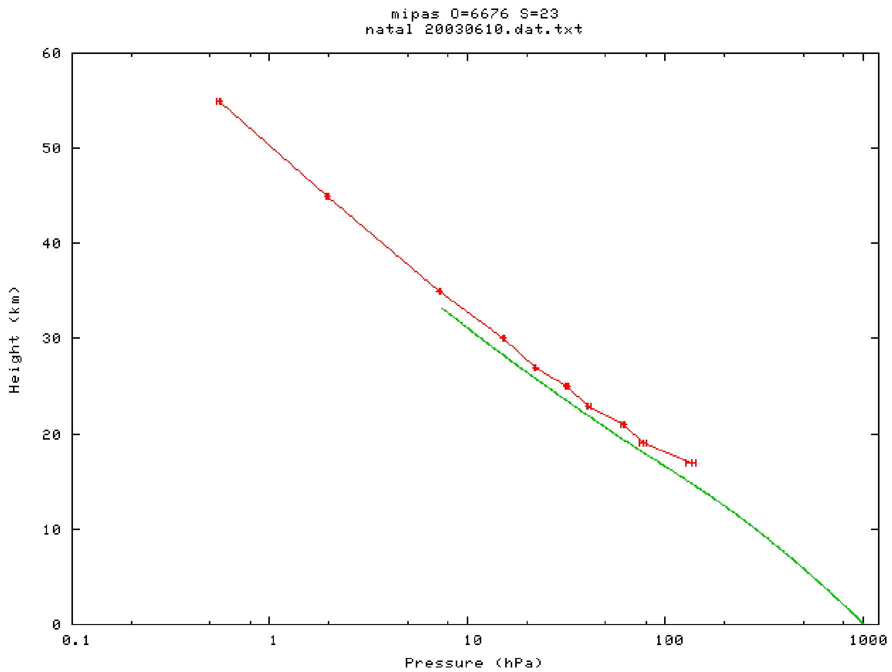

Fig. 11. Comparison of pressure as function of altitude.

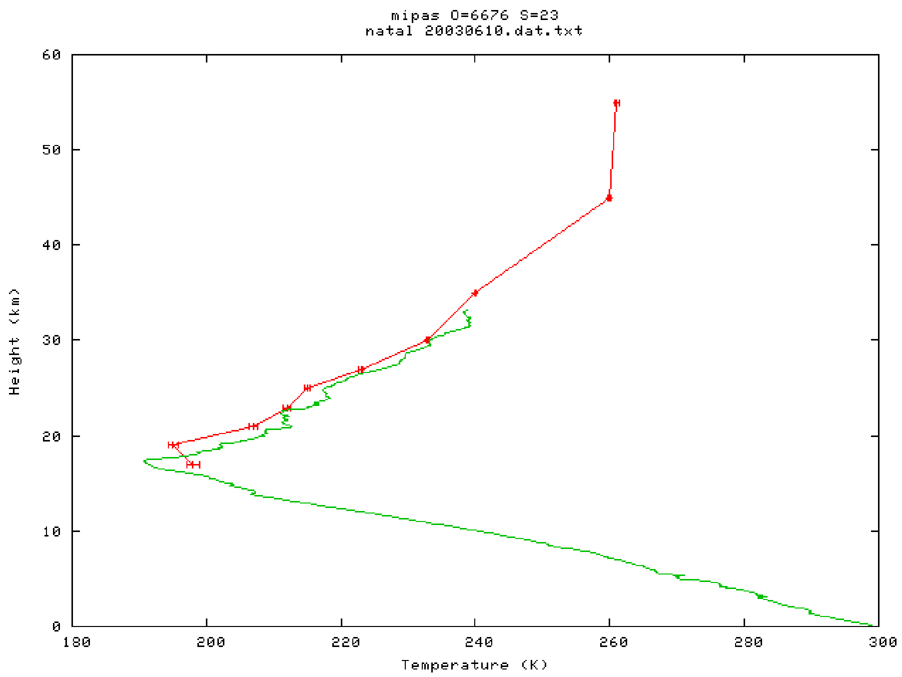

Fig. 12. Comparison of temperature as function of altitude.

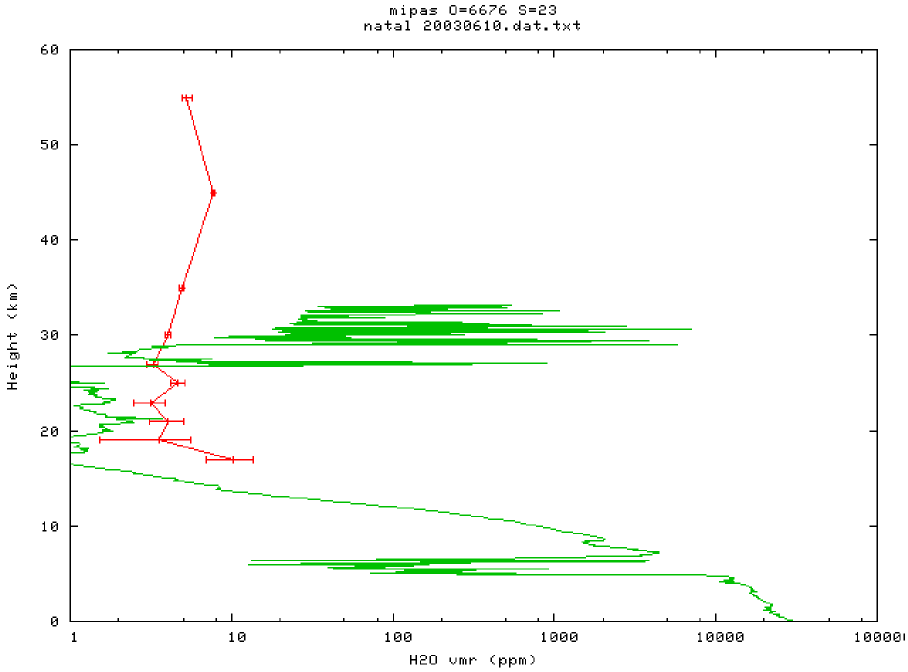

Fig. 13. Comparison of H2O VMR as function of altitude.

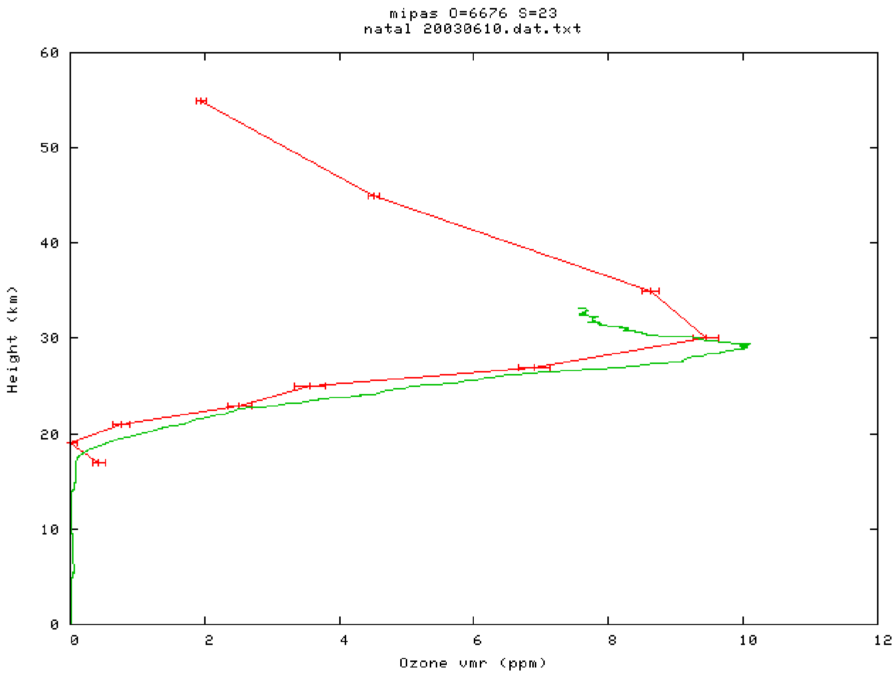

Fig. 14. Comparison of O3 VMR as function of altitude.

NILU	MIPAS scan 43	Satellite POAM 3
Species		H2O, O3, NO2
Time	12:20	12:14
Latitude	-66.08	-65.60
Longitude	-37.67	-25.64
Altitude range	7 – 55 km	0 – 60 km

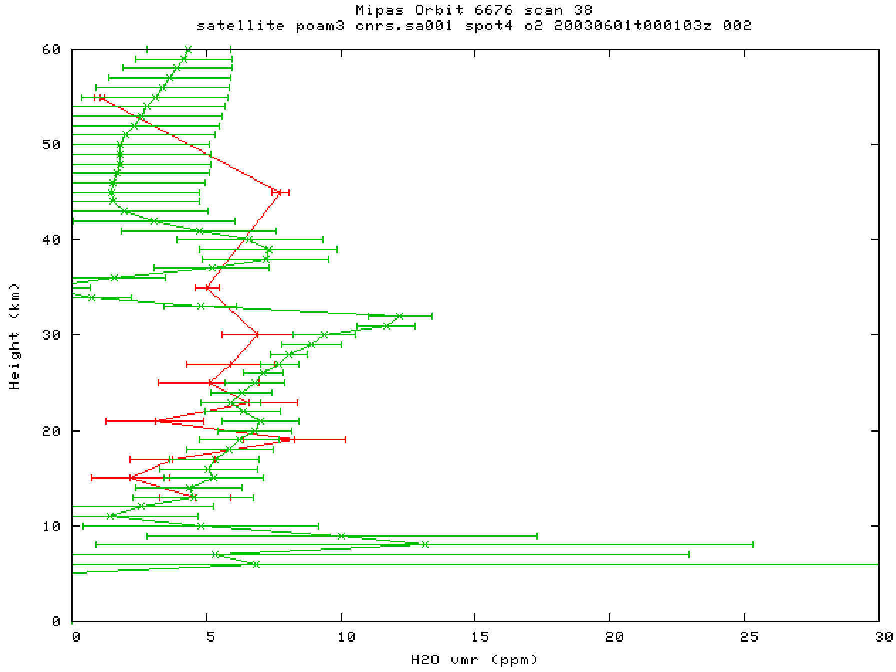

Fig. 15. Comparison of H2O VMR as function of altitude.

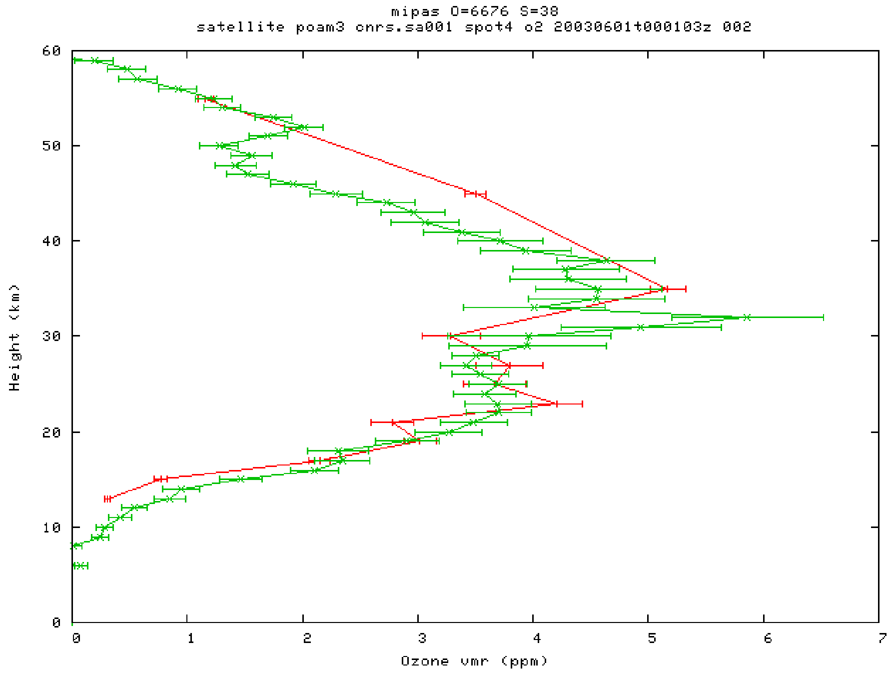

Fig. 16. Comparison of O3 VMR as function of altitude.

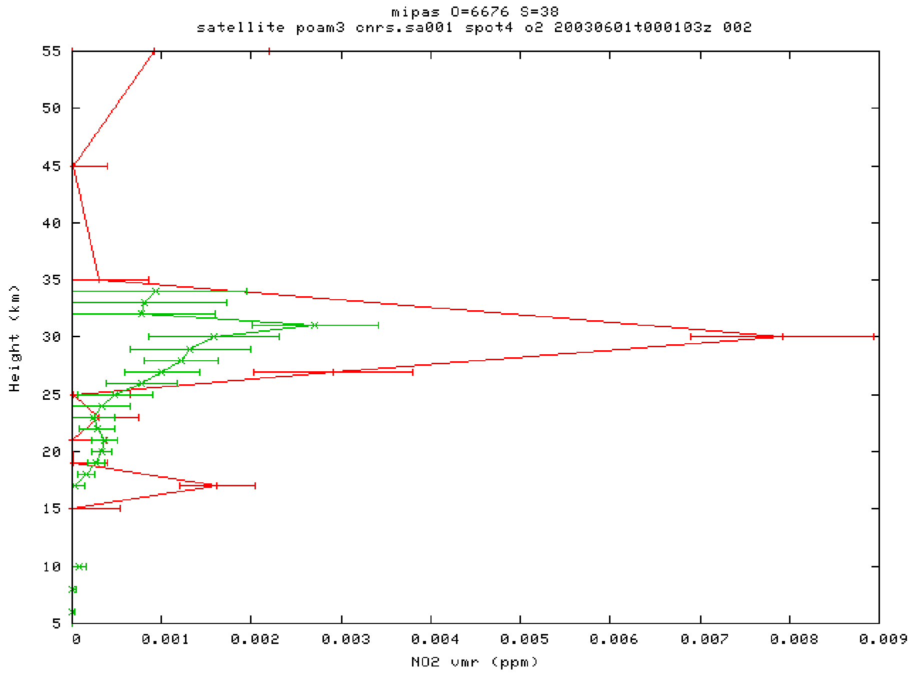

Fig. 17. Comparison of NO2 VMR as function of altitude.

NILU	MIPAS scan 51	Assimilation of GOME data
Species		P, T; O3
Time	12:31	12:00
Latitude	-76.54	-77.80
Longitude	159.83	166.70
Altitude range	7 – 55 km	0.1 – 985.86 hPa

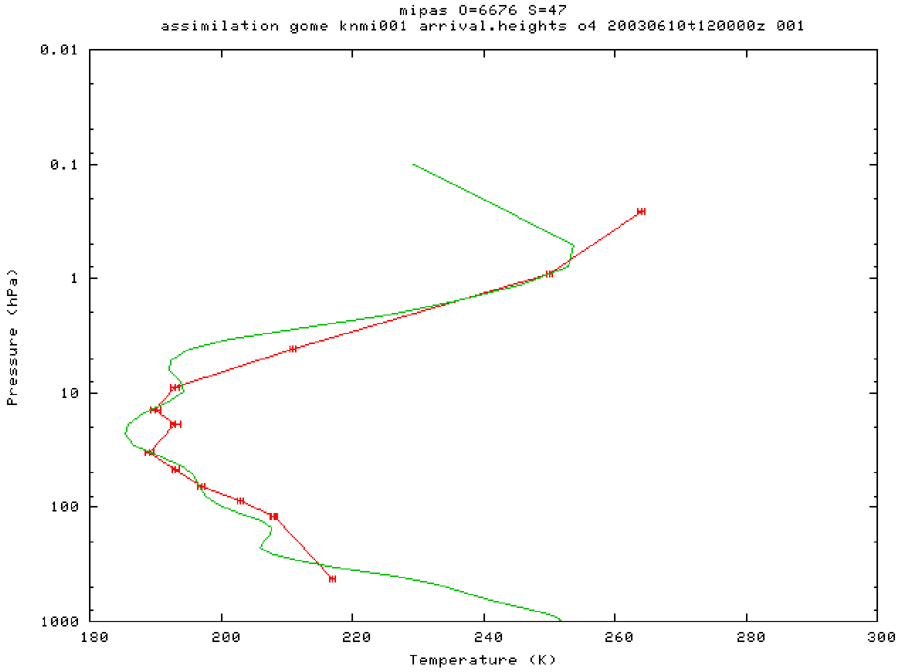

Fig. 18. Comparison of temperature as function of pressure.

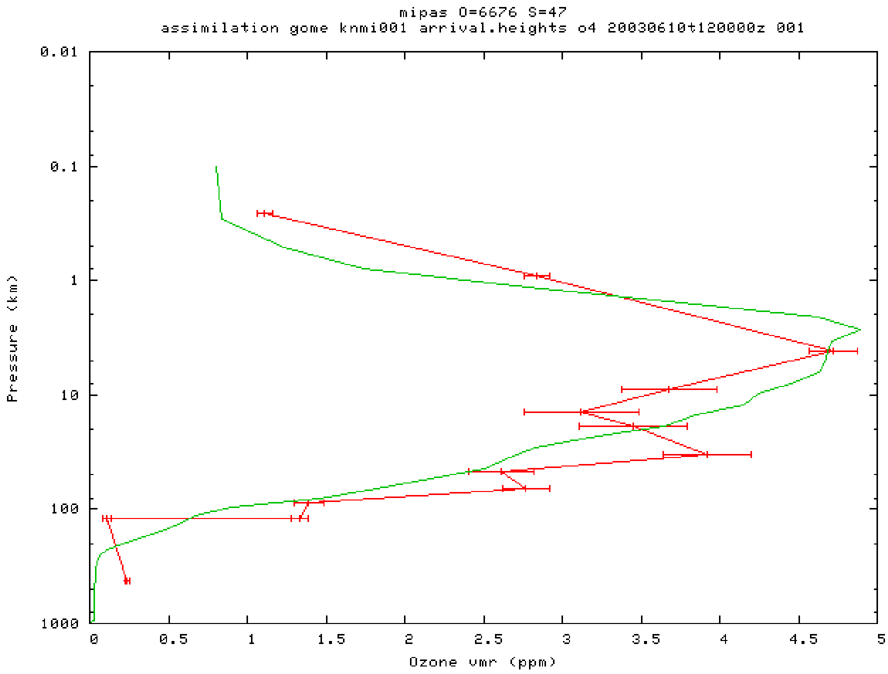

Fig. 19. Comparison of O3 VMR as function of pressure.

NILU	MIPAS scan 55	Assimilation of GOME data
Species		P, T; O3
Time	12:34	12:00
Latitude	-64.78	-66.70
Longitude	150.21	140.00
Altitude range	7 – 55 km	0.1 – 915.63 hPa

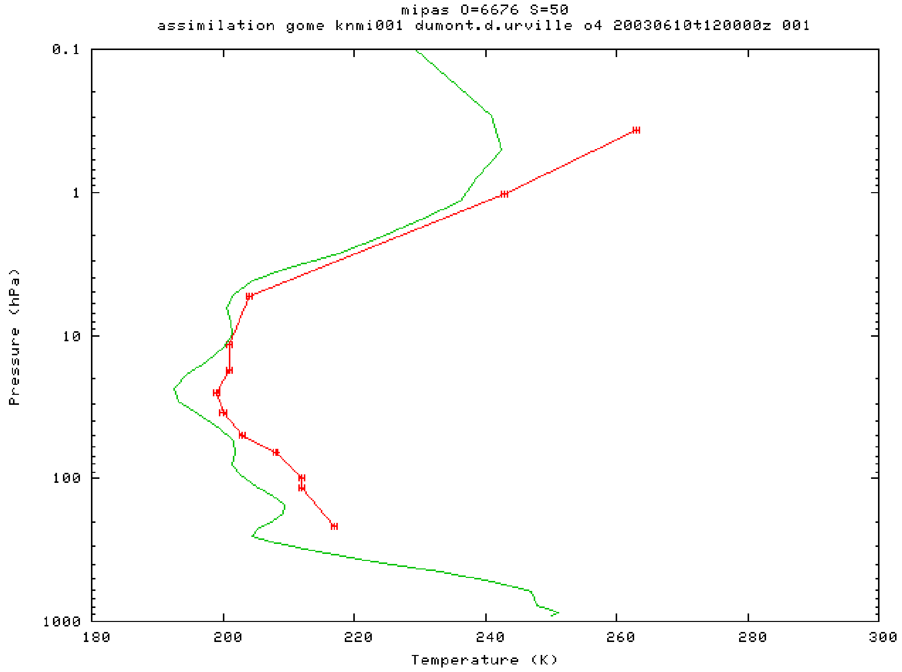

Fig. 20. Comparison of temperature as function of pressure.

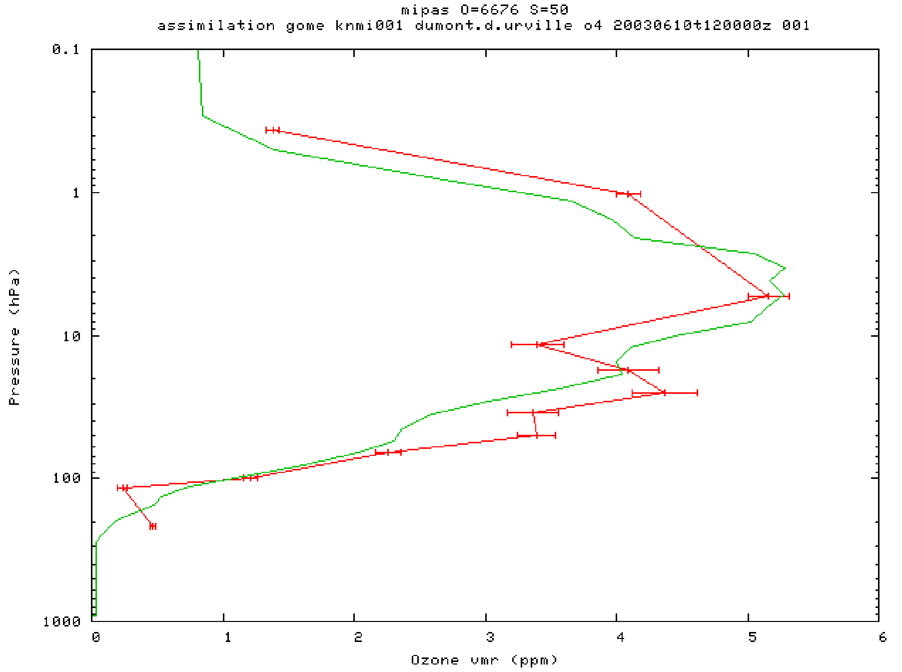

Fig. 21. Comparison of O3 VMR as function of pressure.

6.3 Orbit 6679 – 10 June 2003 – Special mode S1

NILU	MIPAS scan 49	Satellite POAM 3
Species		H2O, O3, NO2
Time	17:22	17:16
Latitude	-66.62	-65.59
Longitude	-113.34	-101.72
Altitude range	7 – 55 km	0 – 60 km

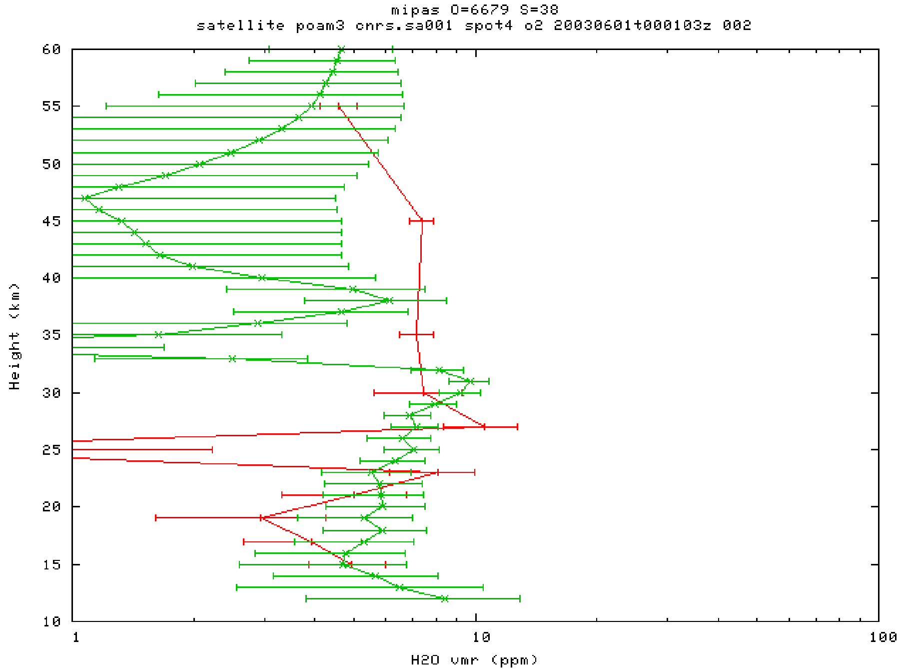

Fig. 22. Comparison of H2O VMR as function of altitude.

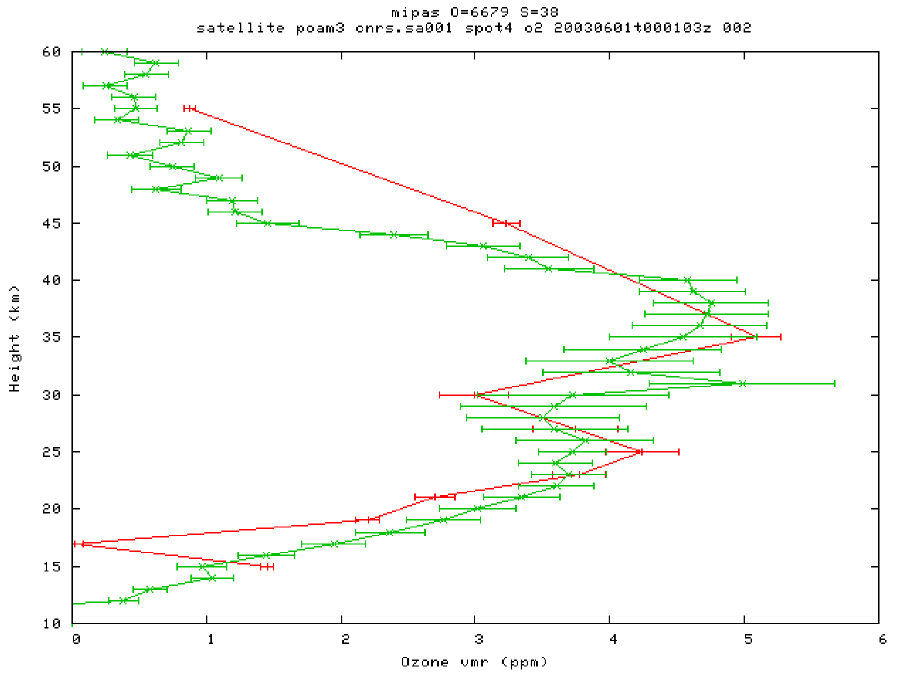

Fig. 23. Comparison of O3 VMR as function of altitude.

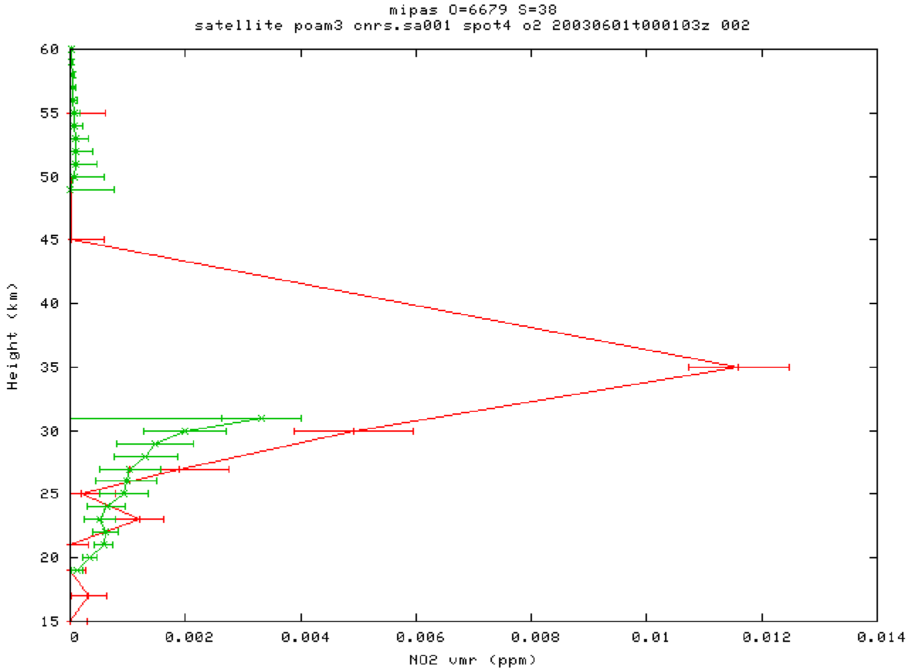

Fig. 24. Comparison of NO2 VMR as function of altitude.

6.4 Orbit 10267 – 16 February 2004 – Special mode S1

NILU	MIPAS scan 50	Satellite POAM 3
Species		H2O,O3,NO2
Time	9:22	6:58
Latitude	-73.13	-72:63
Longitude	-156.71	-146.11
Altitude range	7 – 55 km	0 – 60 km

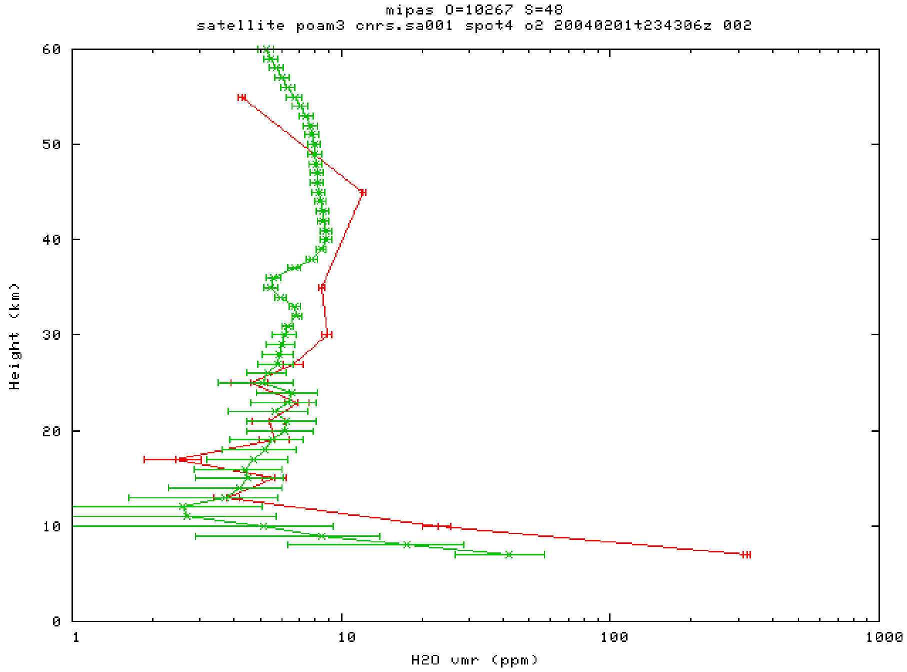

Fig. 25. Comparison of H2O VMR as function of altitude.

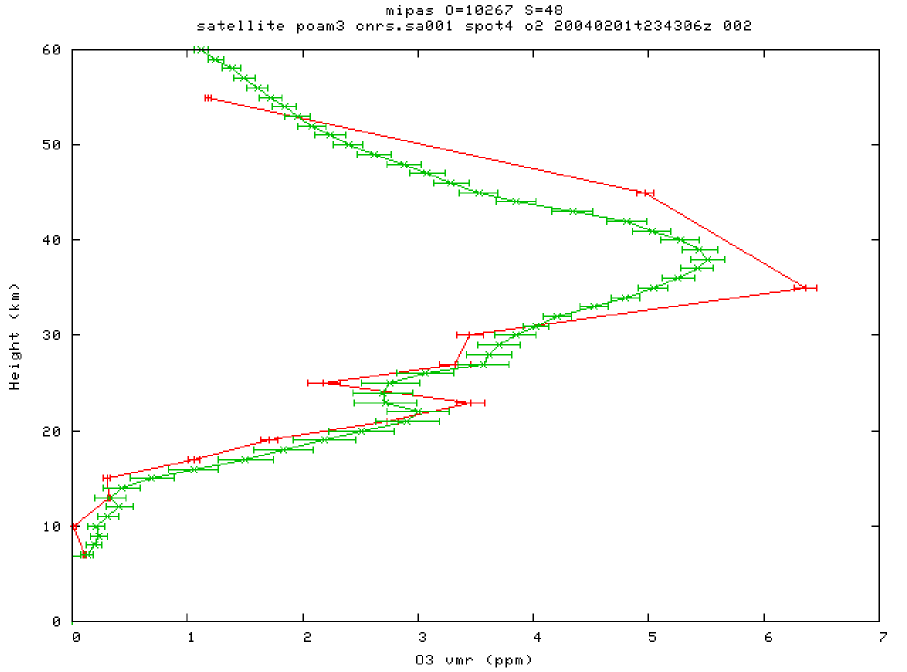

Fig. 26. Comparison of O3 VMR as function of altitude.

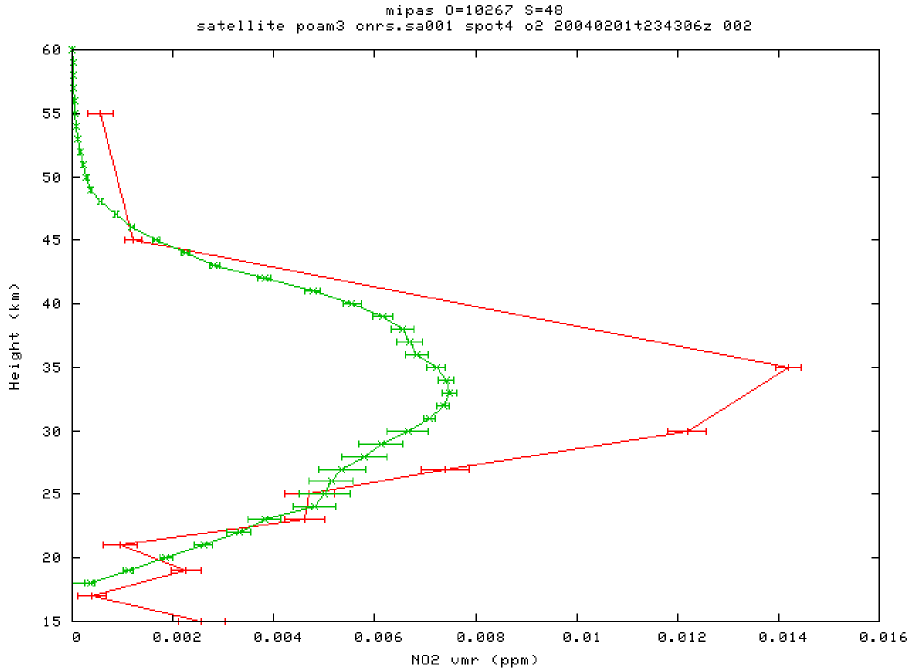

Fig. 27. Comparison of NO2 VMR as function of altitude.

6.5 Orbit 10268 – 16 February 2004 – S1

NILU	**MIPAS scan 13**	**Balloon sonde**	**Balloon sonde**
Species		P,T,Humidity,O3	P,T,Humidity
Time	10:19	12:07	12:00
Latitude	49.98	50.80	52.02
Longitude	-1.06	4.35	5.22
Altitude range	7 – 55 km	0.10 – 33.00 km (GPH)	0.004 – 24.699 km (GPH)

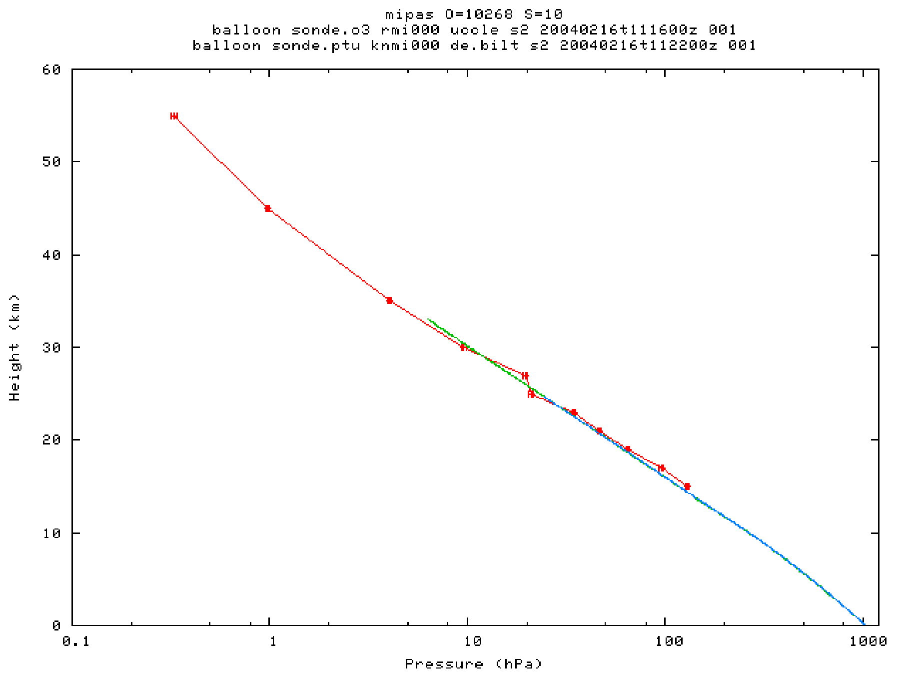

Fig. 28. Comparison of pressure as function of altitude.

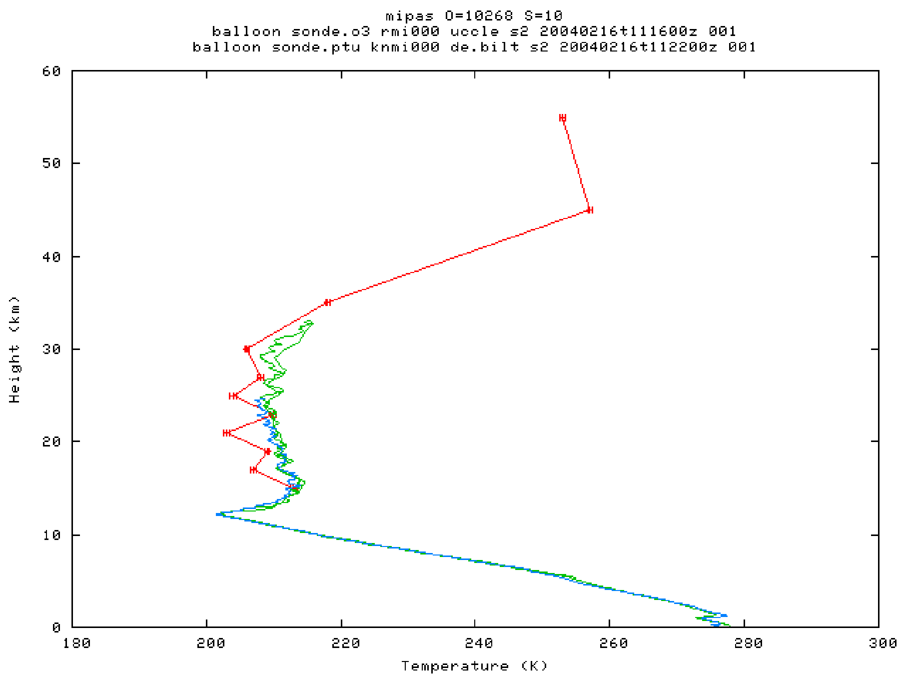

Fig. 29. Comparison of temperature as function of altitude.

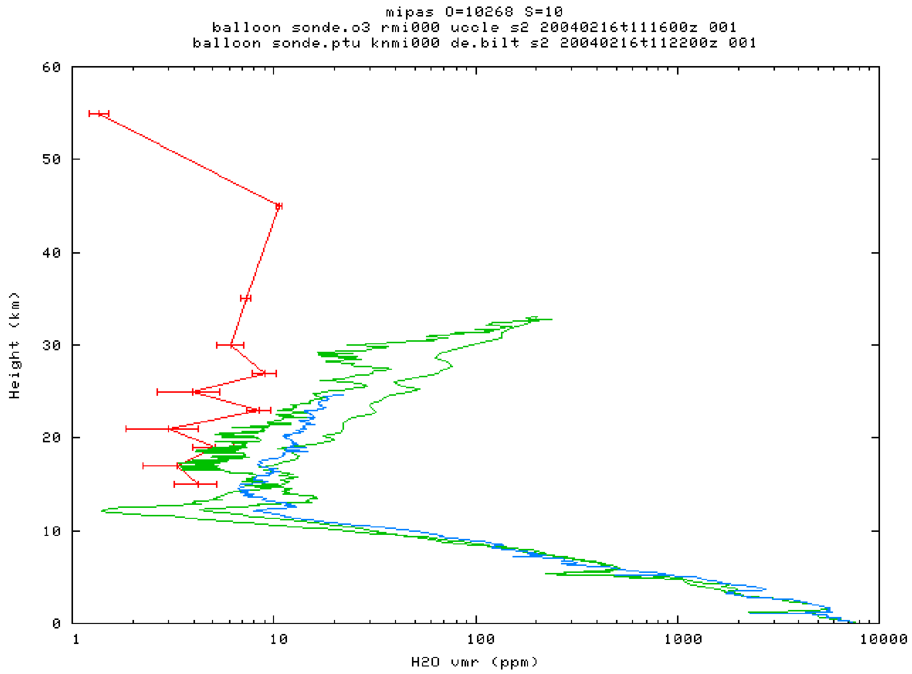

Fig. 30. Comparison of H2O VMR as function of altitude.

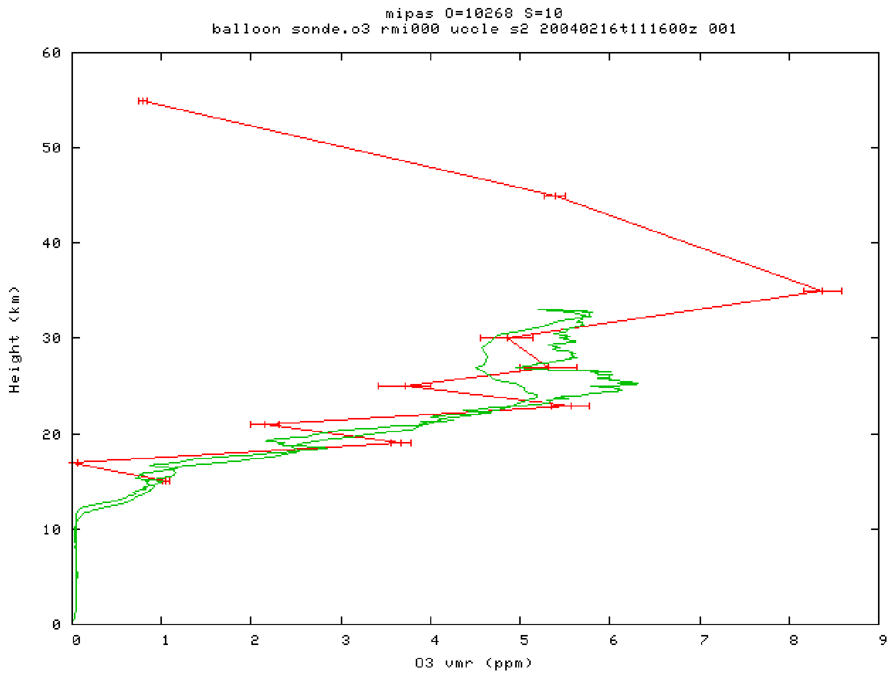

Fig. 31. Comparison of O3 VMR as function of altitude.

NILU	MIPAS scan 14	Balloon sonde
Species		P,T,Humidity,O3
Time	10:20	12:00
Latitude	45.97	46.80
Longitude	-2.13	7.00
Altitude range	7 – 55 km	0.491 – 31.336 km (GPH)

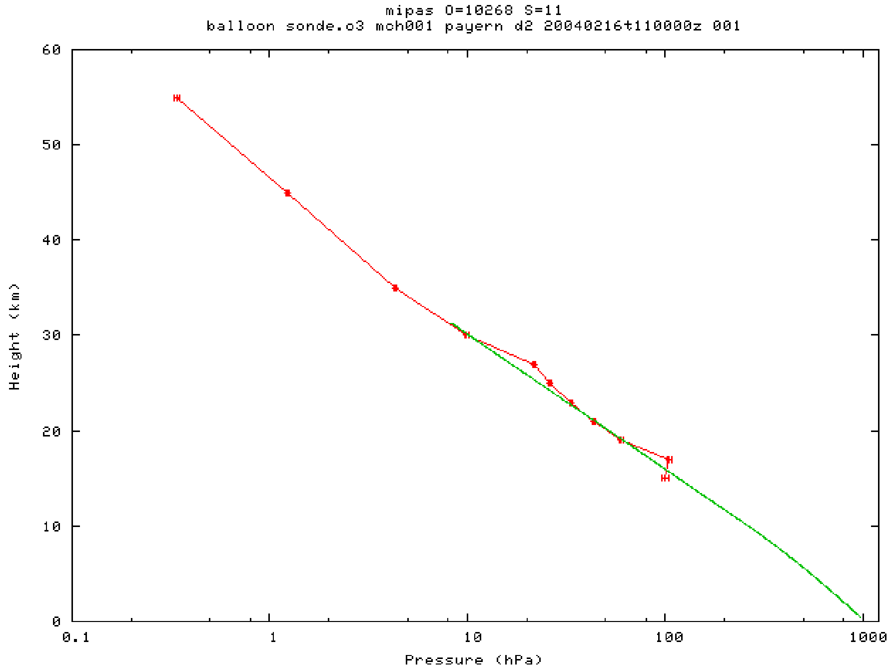

Fig. 32. Comparison of pressure as function of altitude.

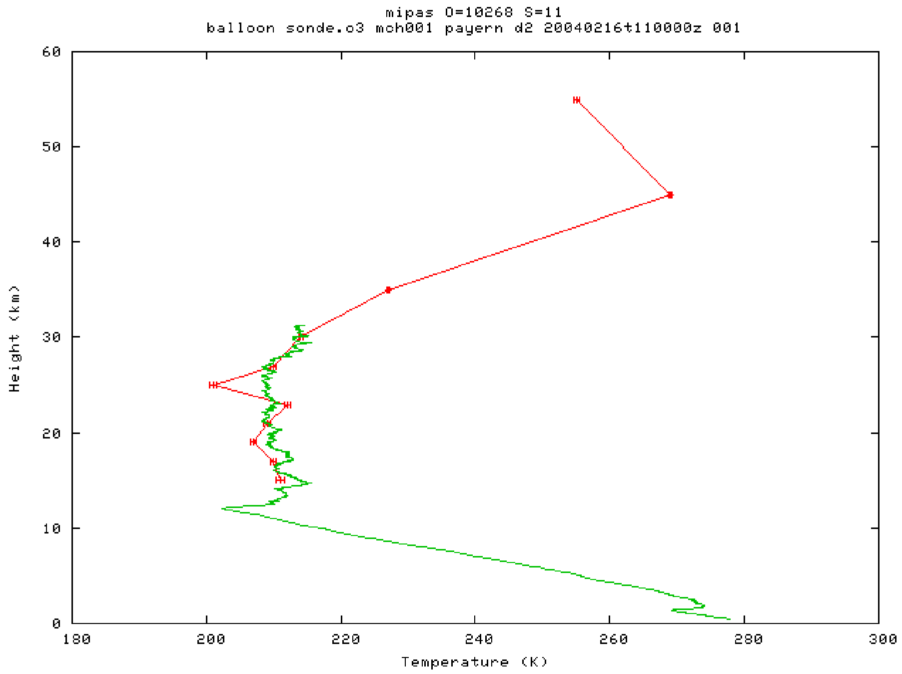

Fig. 33. Comparison of temperature as function of altitude.

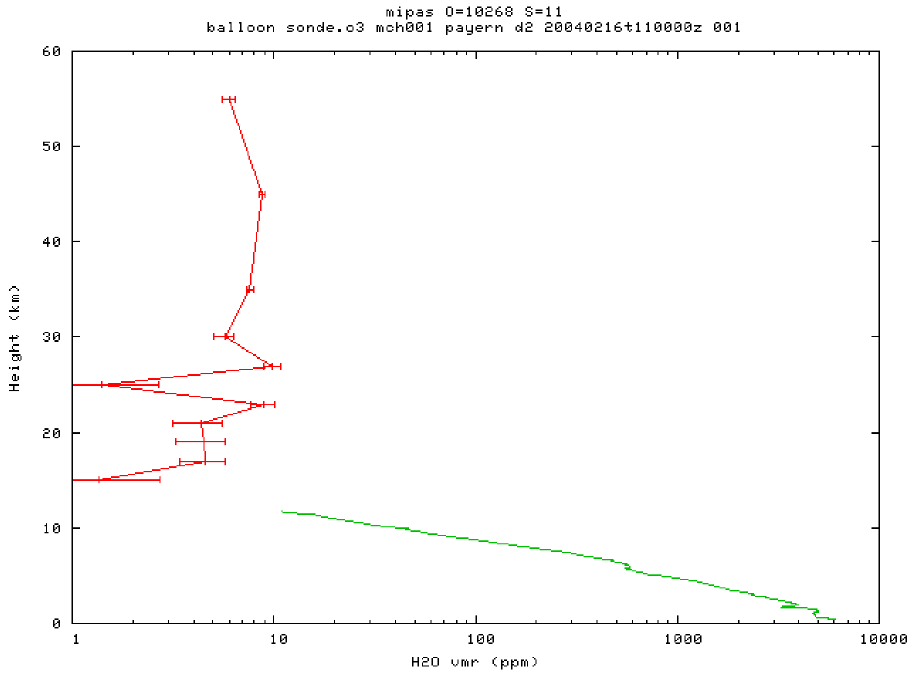

Fig. 34. Comparison of H2O VMR as function of altitude.

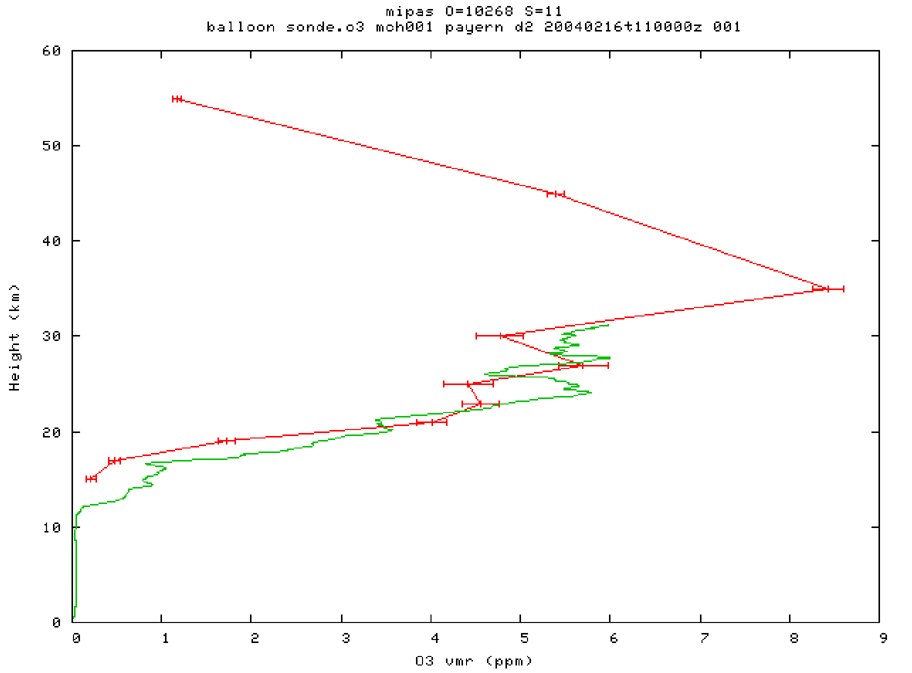

Fig. 35. Comparison of O3 VMR as function of altitude.

NILU	MIPAS scan 51	Satellite POAM 3
Species		H2O,O3,NO2
Time	11:03	8:38
Latitude	-73.00	-72.66
Longitude	178.02	-171.49
Altitude range	7 – 55 km	0 – 60 km

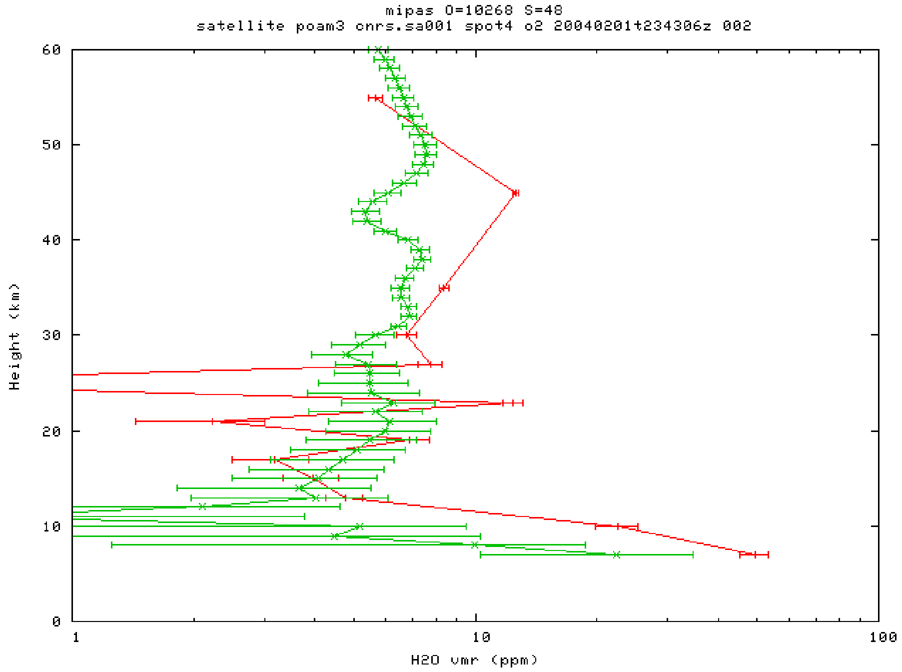

Fig. 36. Comparison of H2O VMR as function of altitude.

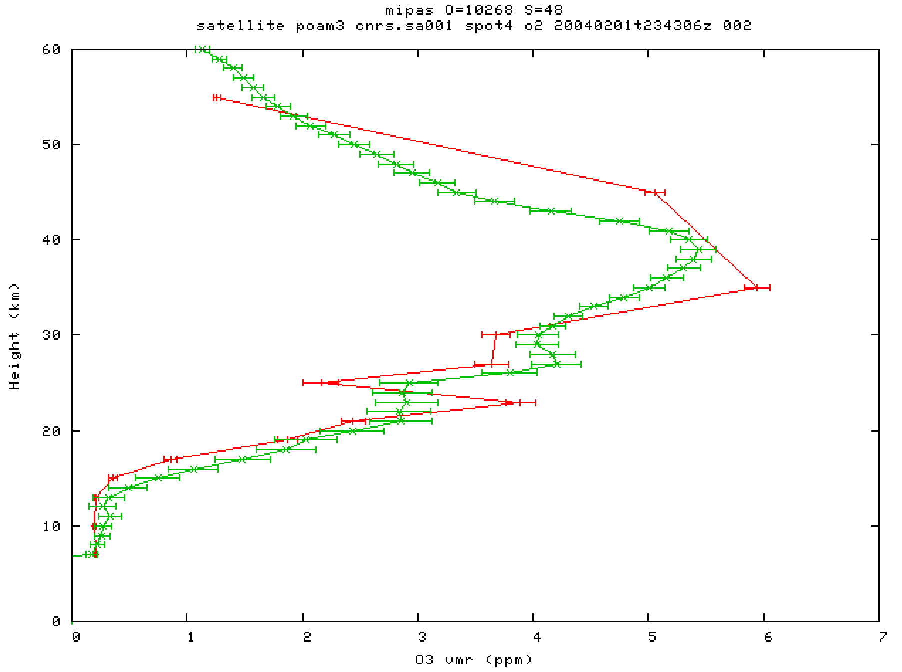

Fig. 37. Comparison of O3 VMR as function of altitude.

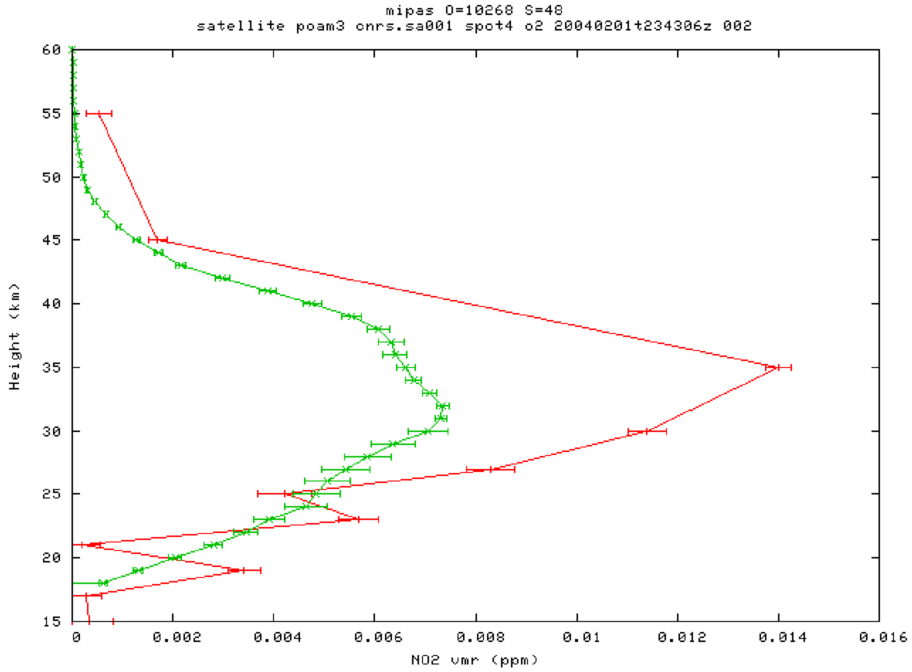

Fig. 38. Comparison of NO2 VMR as function of altitude.

6.6 Orbit 10269 – 16 February 2004 – S1

NILU	MIPAS scan 52	Satellite POAM 3
Species		H2O,O3,NO2
Time	12:43	10:19
Latitude	-73.46	-72.69
Longitude	153.30	163.12
Altitude range	7 – 55 km	0 – 60 km

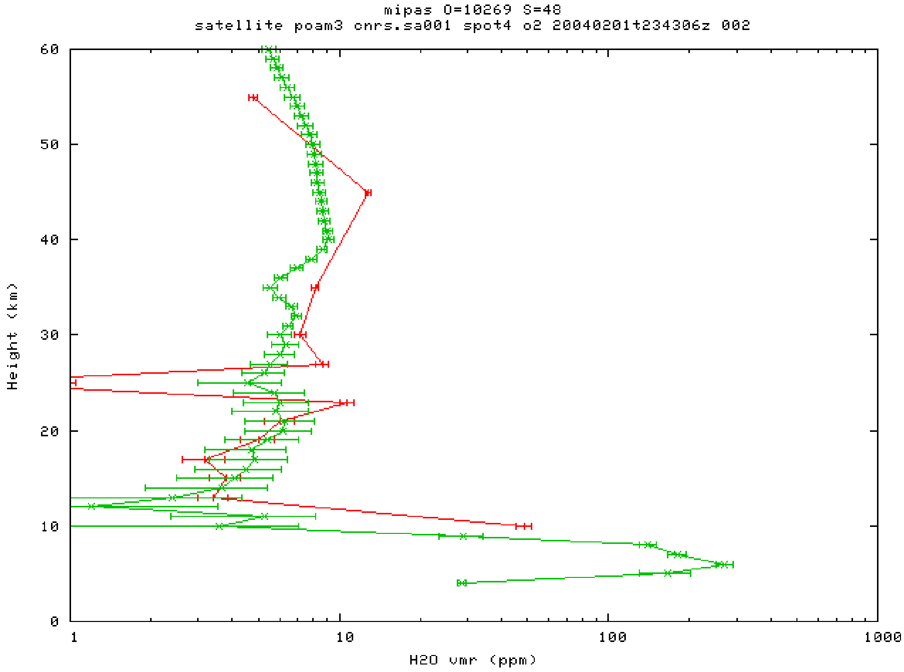

Fig. 39. Comparison of H2O VMR as function of altitude.

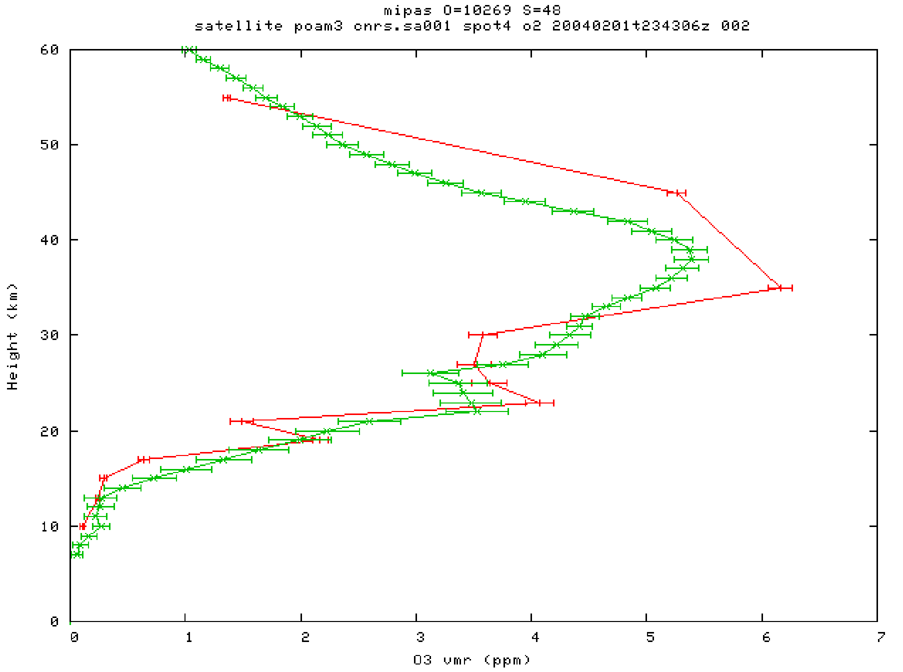

Fig. 40. Comparison of O3 VMR as function of altitude.

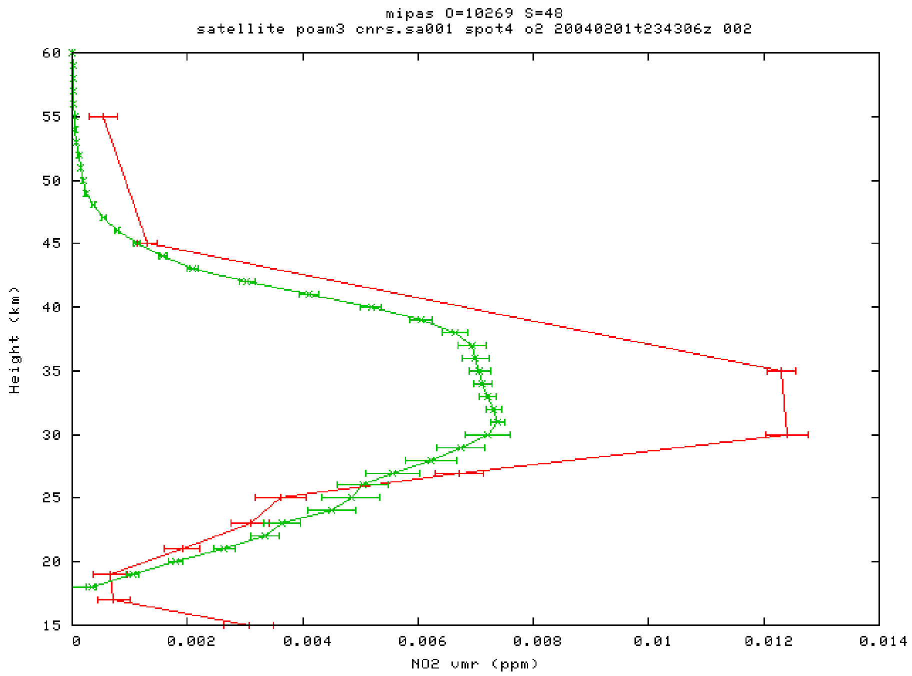

Fig. 41. Comparison of NO2 VMR as function of altitude.

6.7 Orbit 10270 – 16 February 2004 – Special mode S1

NILU	MIPAS scan 26	Balloon sonde
Species		P,T,Humidity
Time	13:53	12:14
Latitude	4.80	5.81
Longitude	-54.52	-55.24
Altitude range	7 – 55 km	0.007 – 28.613 km (GPH)

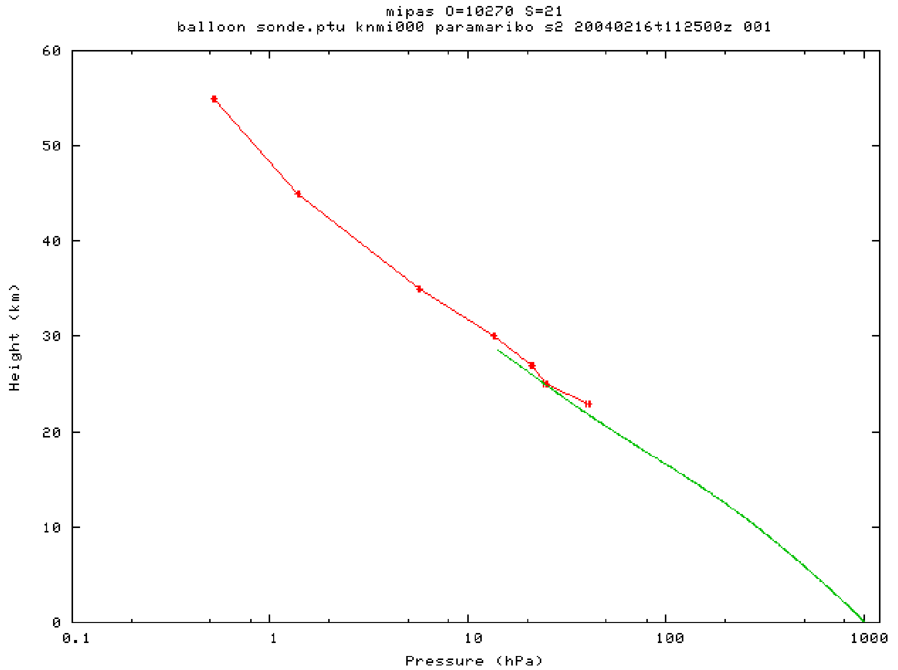

Fig. 42. Comparison of pressure as function of altitude.

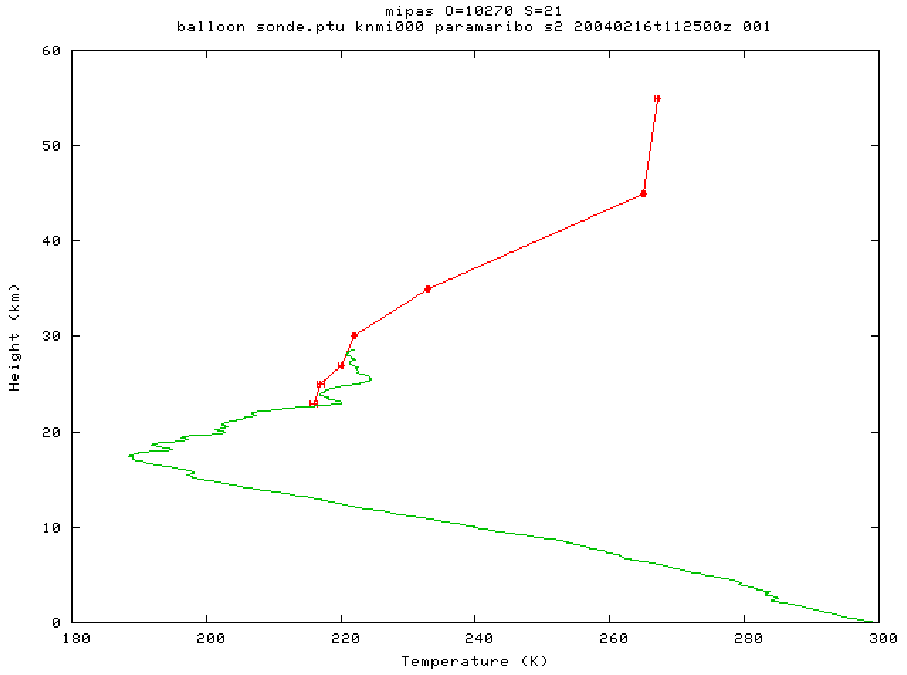

Fig. 43. Comparison of temperature as function of altitude.

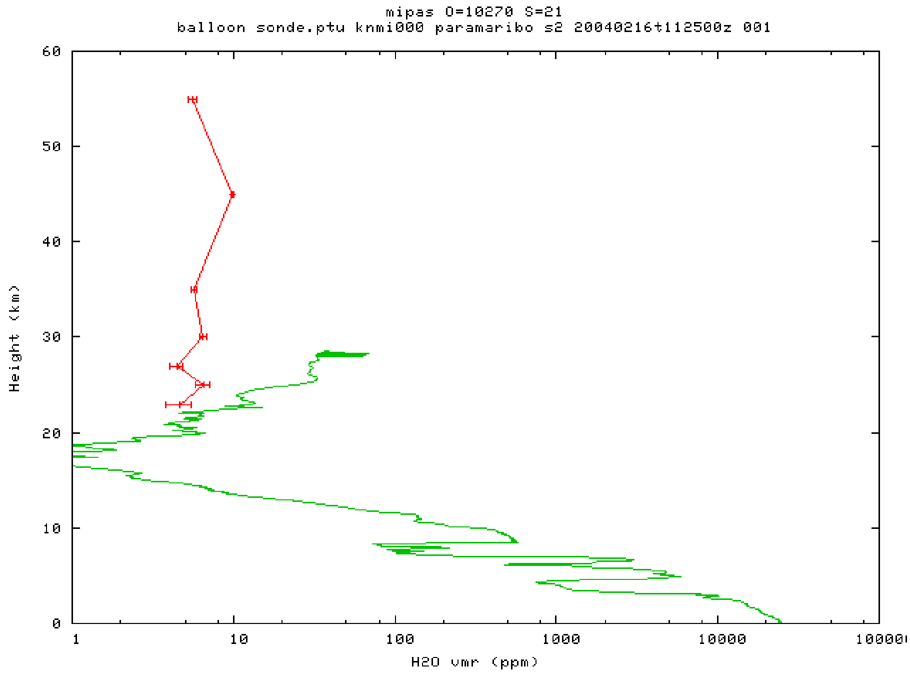

Fig. 44. Comparison of H2O VMR as function of altitude.

NILU	MIPAS scan 54	Satellite POAM 3
Species		H2O,O3,NO2
Time	14:24	12:00
Latitude	-72.80	-72.72
Longitude	127.52	137.74
Altitude range	7 – 55 km	0 – 60 km

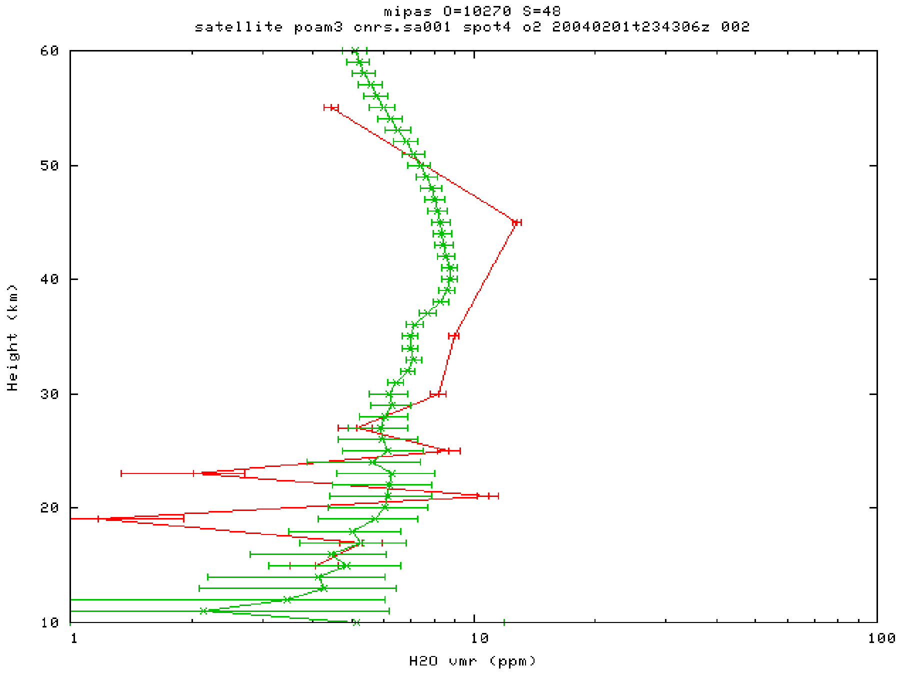

Fig. 45. Comparison of H2O VMR as function of altitude.

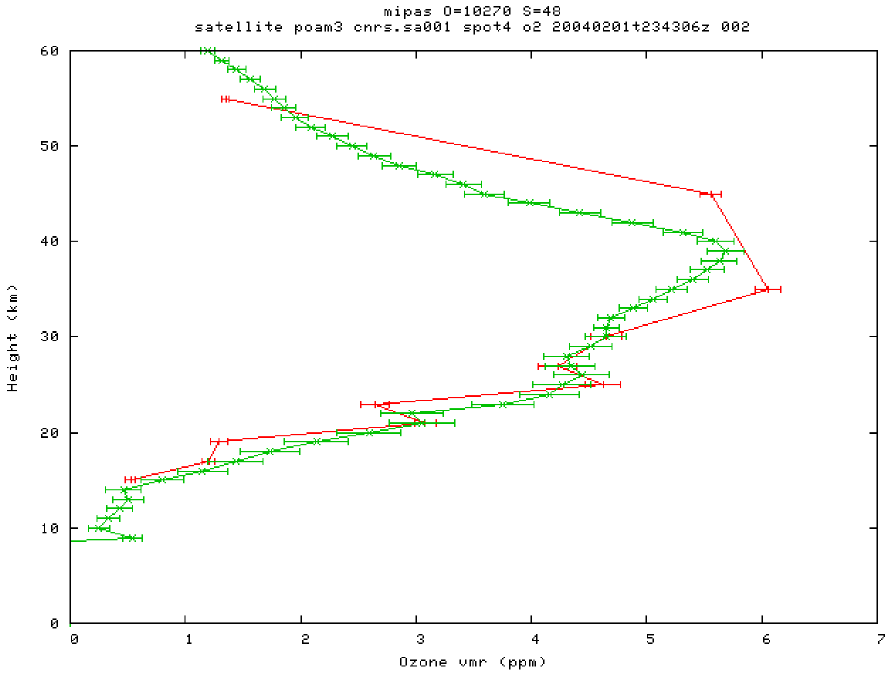

Fig. 46. Comparison of O3 VMR as function of altitude.

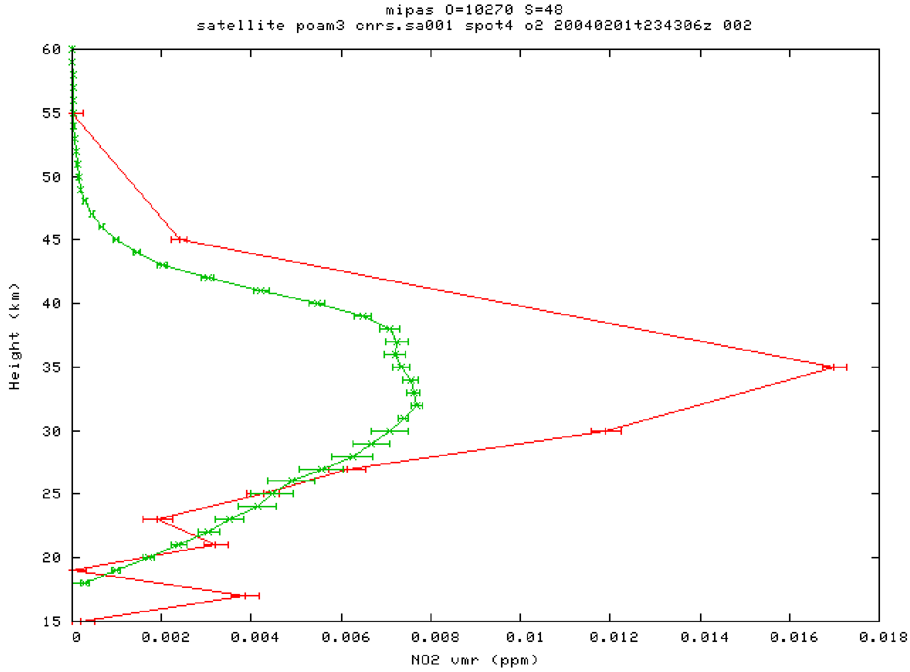

Fig. 47. Comparison of NO2 VMR as function of altitude.

6.8 Orbit 10271 – 16 February 2004 – Special mode S1

NILU	**MIPAS scan 55**	**Satellite POAM 3**
Species		H2O,O3,NO2
Time	16:05	13:40
Latitude	-72.67	-72.74
Longitude	102.25	112.35
Altitude range	7 – 55 km	0 – 60 km

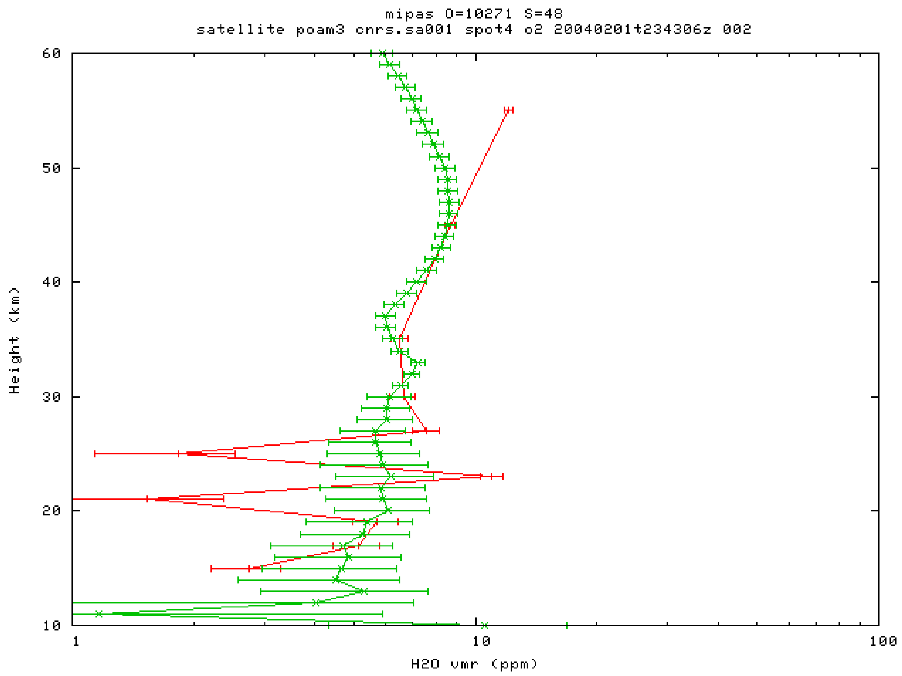

Fig. 48. Comparison of H2O VMR as function of altitude.

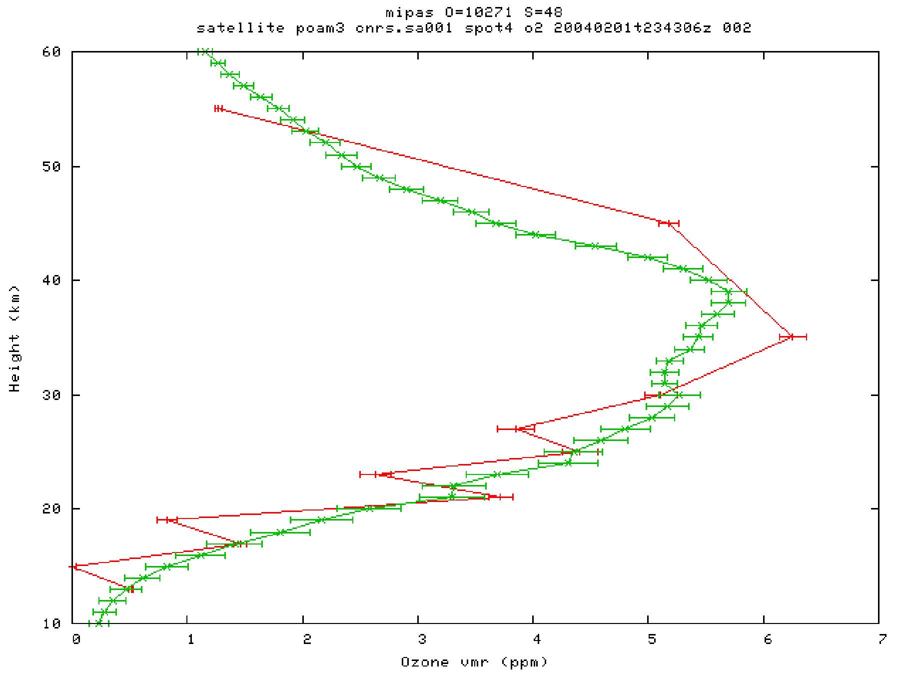

Fig. 49. Comparison of O3 VMR as function of altitude.

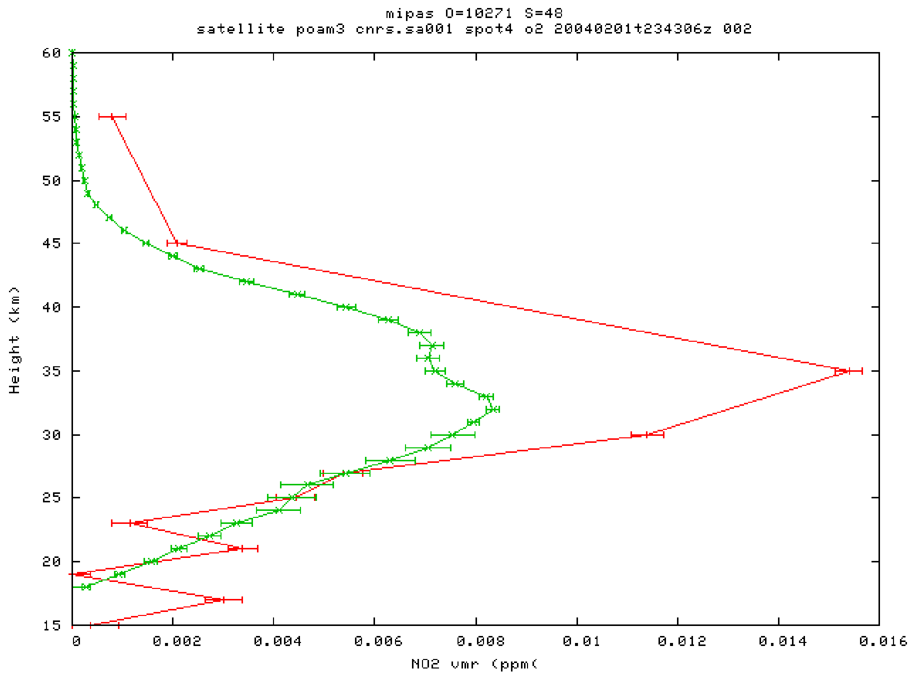

Fig. 50. Comparison of NO2 VMR as function of altitude.

6.9 Orbit 6681 – 10 June 2003 – Special mode S2

NILU	MIPAS scan 53	Satellite POAM 3
Species		H2O, O3, NO2
Time	20:43	20:52
Latitude	-65.18	-65.57
Longitude	-164.12	-152.45
Altitude range	5 – 40 km	0 – 60 km

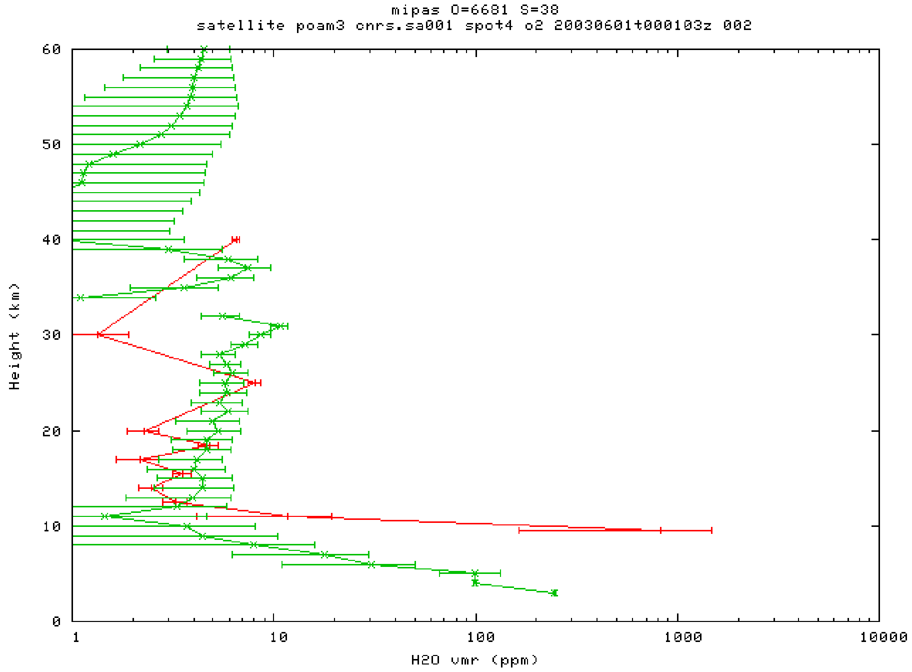

Fig. 51. Comparison of H2O VMR as function of altitude.

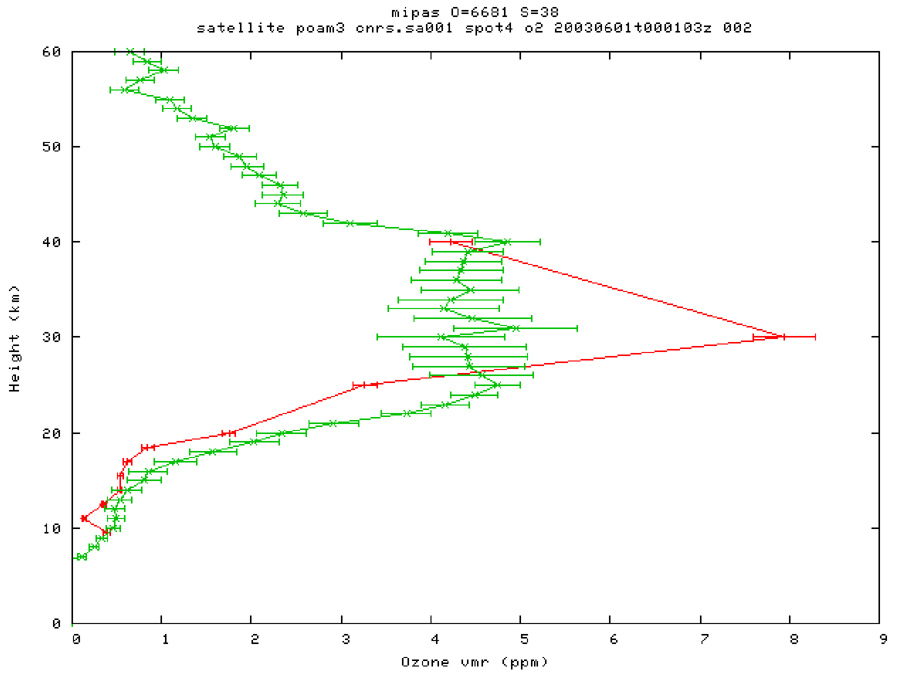

Fig. 52. Comparison of O3 VMR as function of altitude.

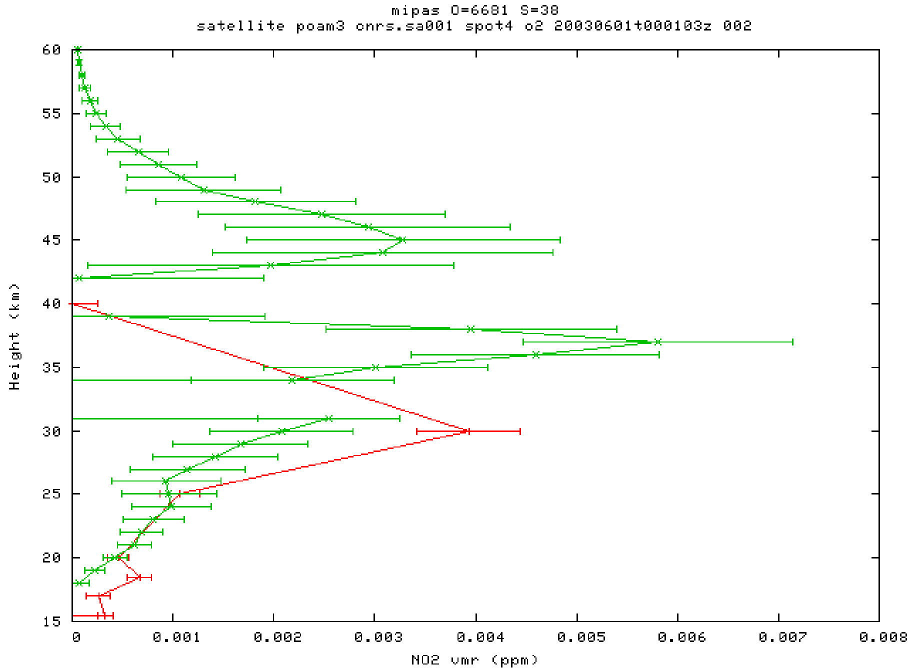

Fig. 53. Comparison of NO2 VMR as function of altitude.

6.10 Orbit 6687 – 11 June 2003 – Special mode S2

NILU	MIPAS scan 42	Satellite POAM 3
Species		H2O, O3, NO2
Time	6:47	6:57
Latitude	-66.09	-65.54
Longitude	45.73	55.37
Altitude range	5 – 40 km	0 – 60 km

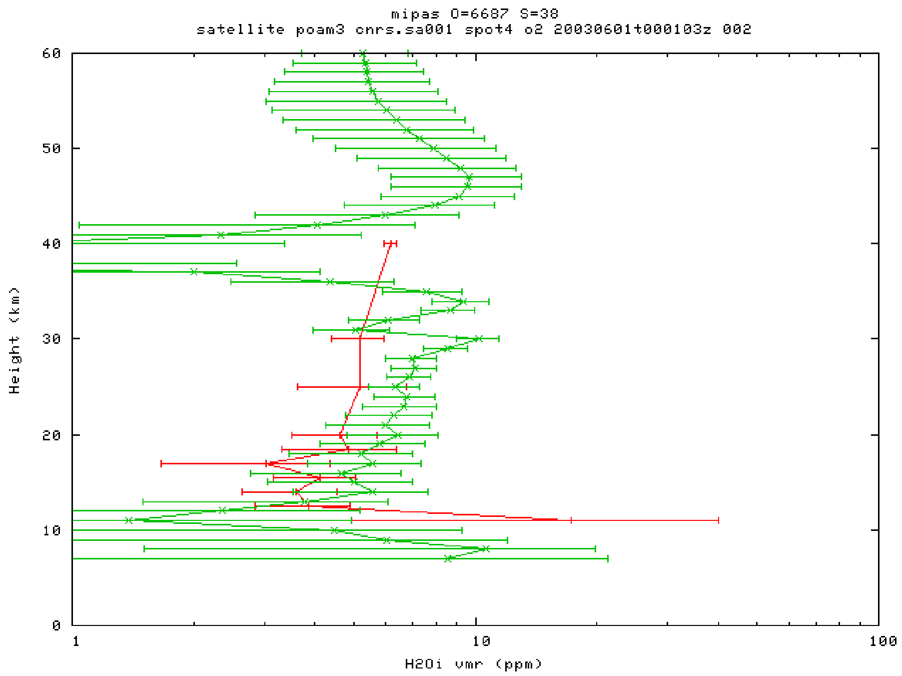

Fig. 54. Comparison of H2O VMR as function of altitude.

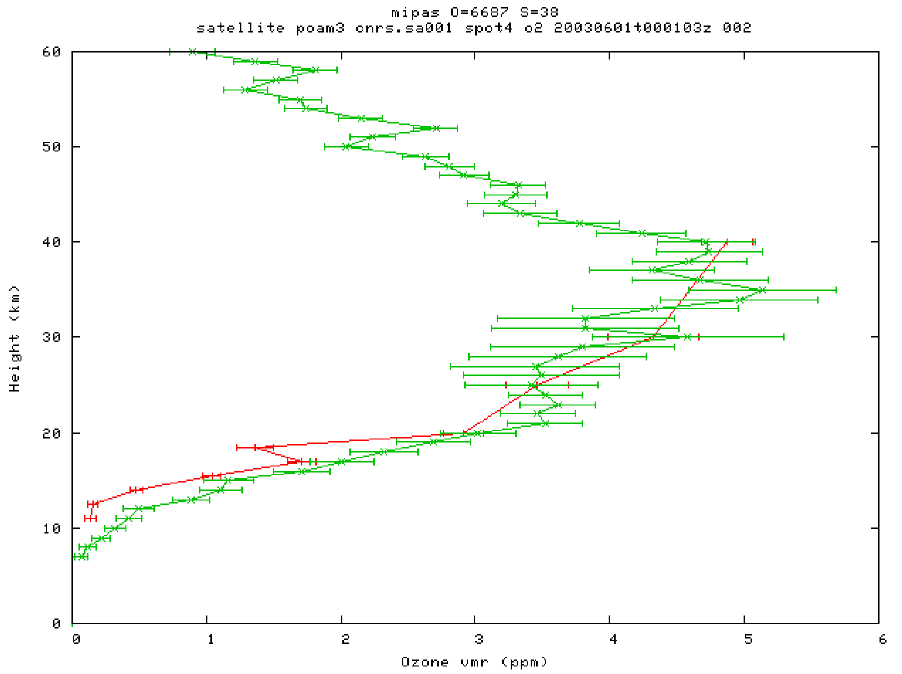

Fig. 55. Comparison of O3 VMR as function of altitude.

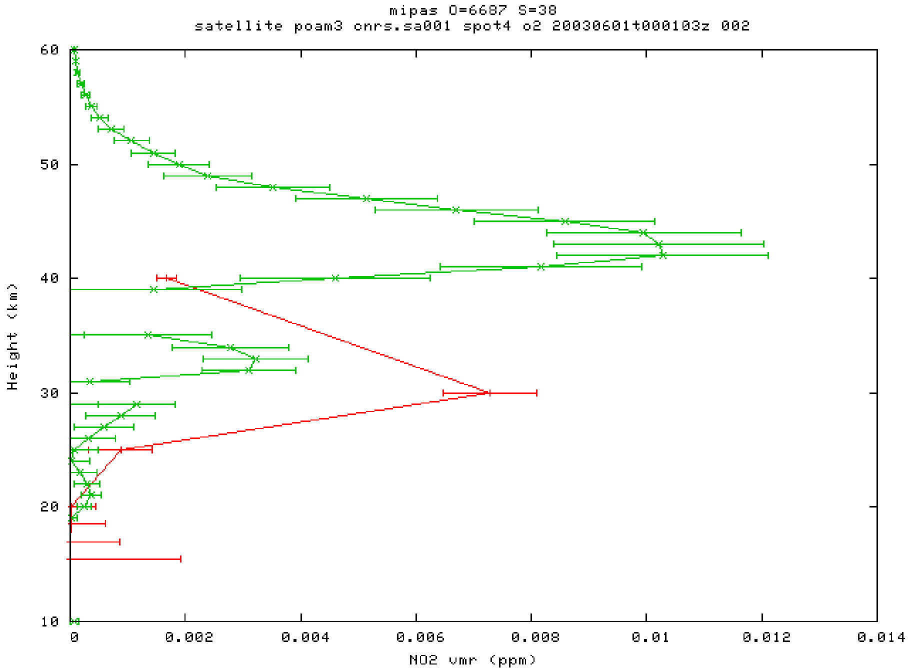

Fig. 56. Comparison of NO2 VMR as function of altitude.

6.11 Orbit 6688 – 11 June 2003 – Special mode S2

SHADOZ	MIPAS scan 24	Balloon sonde
Species		P, T, Humidity, O3
Time	8:08	7:32
Latitude	0.09	-1.27
Longitude	30.60	36.80
Altitude range	5 – 40 km	1.795 - 37.541 km

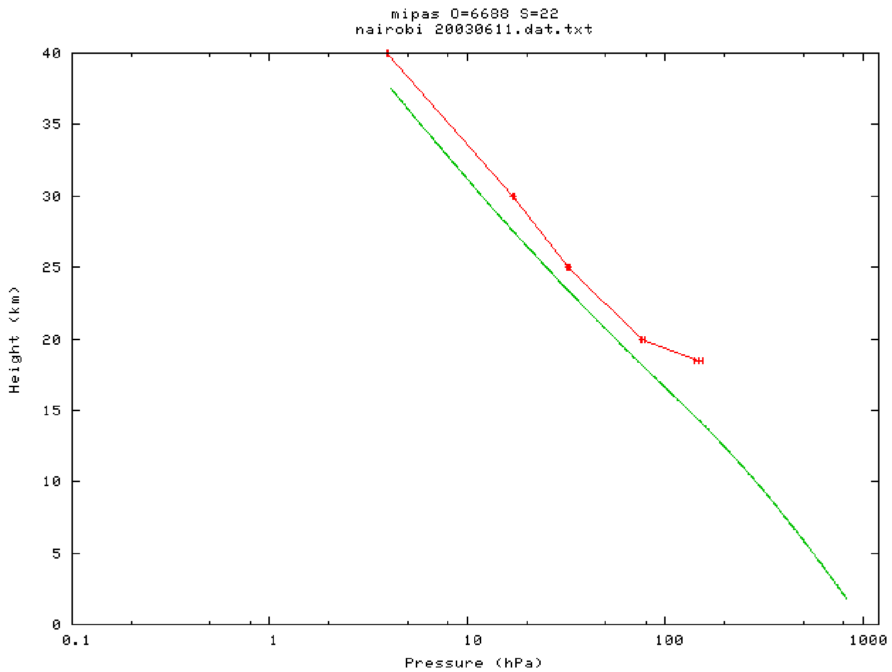

Fig. 57. Comparison of pressure as function of altitude.

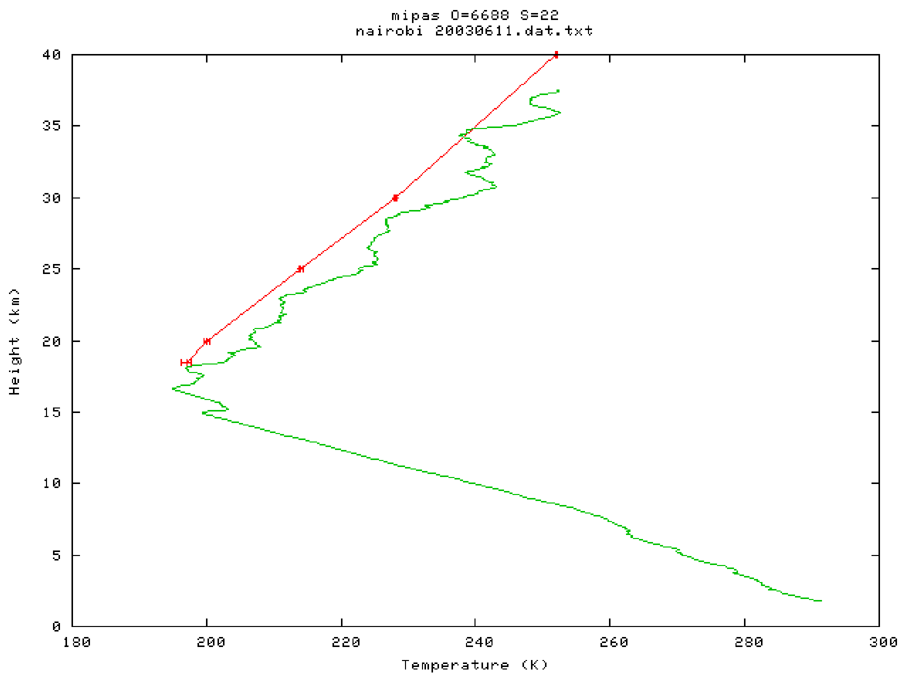

Fig. 58. Comparison of temperature as function of altitude.

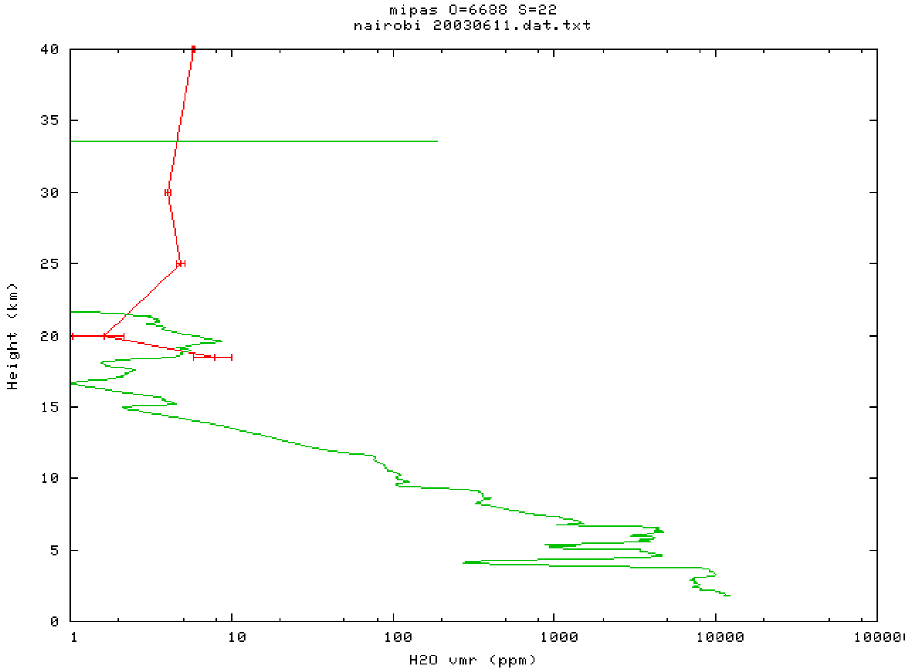

Fig. 59. Comparison of H2O VMR as function of altitude.

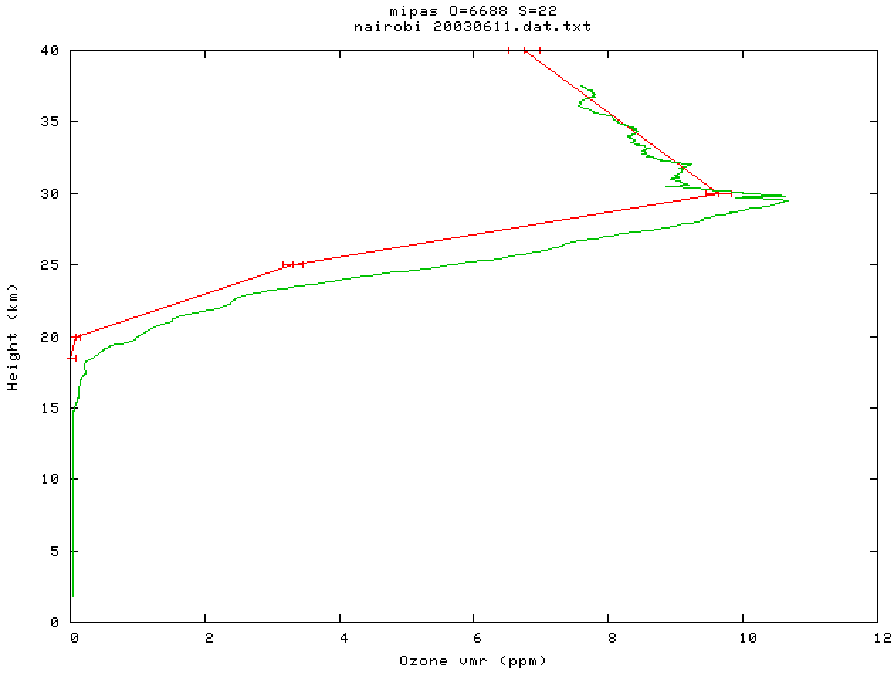

Fig. 60. Comparison of O3 VMR as function of altitude.

SHADOZ	MIPAS scan 30	Balloon sonde
Species		P, T, Humidity, O3
Time	8:16	8:47
Latitude	-24.78	-25.90
Longitude	27.12	28.22
Altitude range	5 – 40 km	1.556 - 32.239 km

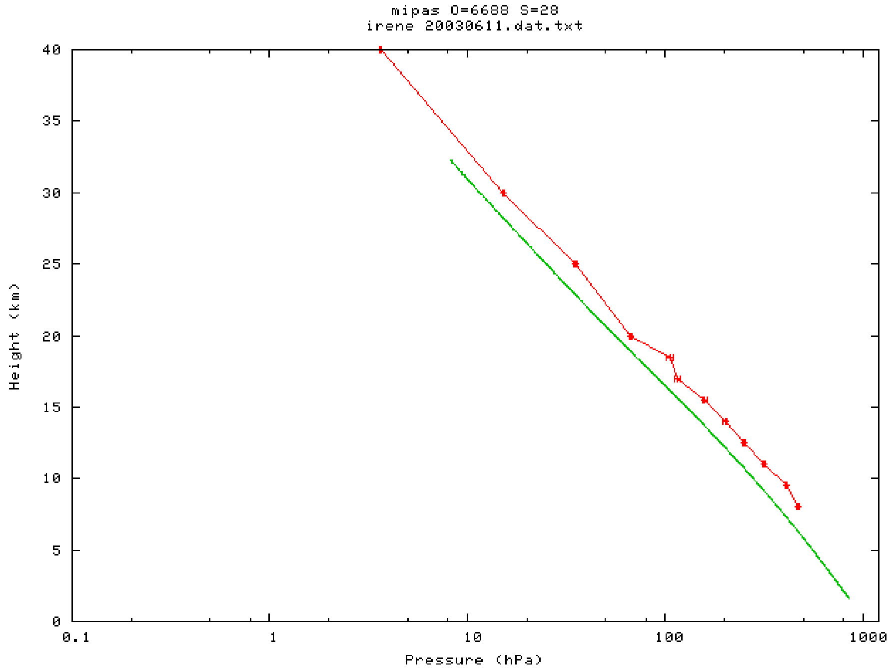

Fig. 61. Comparison of pressure as function of altitude.

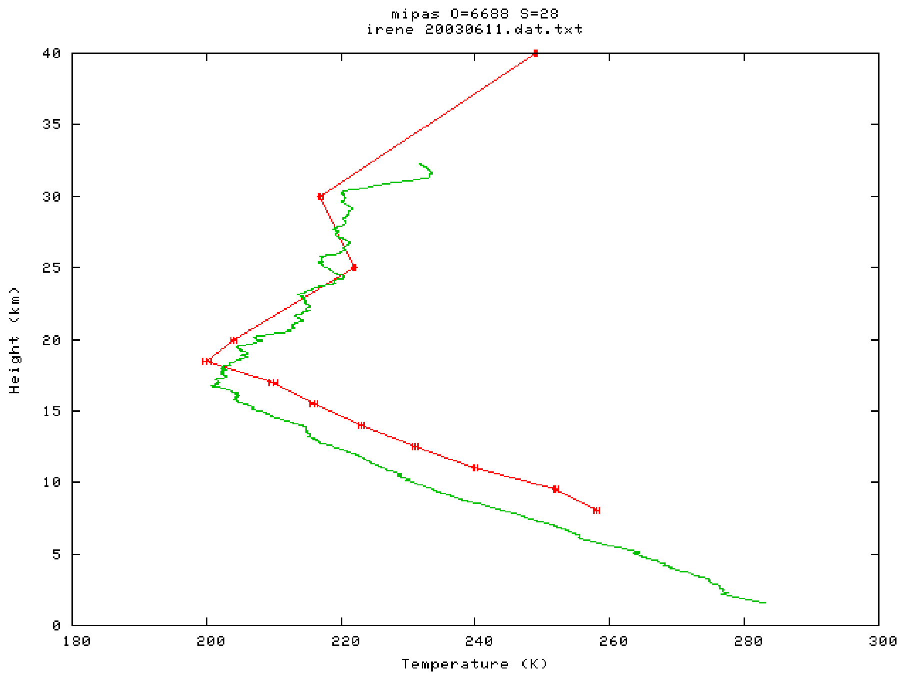

Fig. 62. Comparison of temperature as function of altitude.

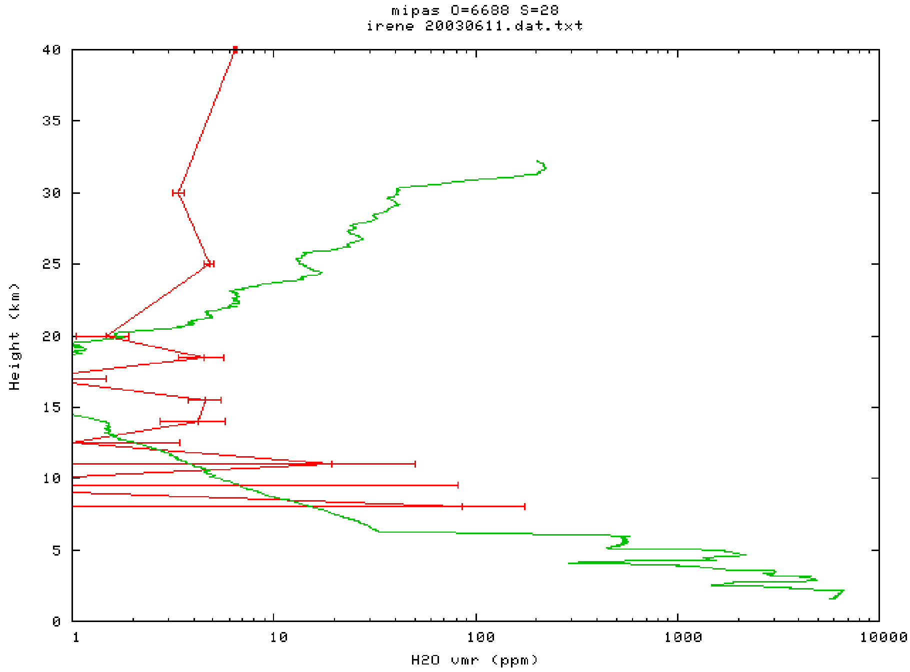

Fig. 63. Comparison of H2O VMR as function of altitude.

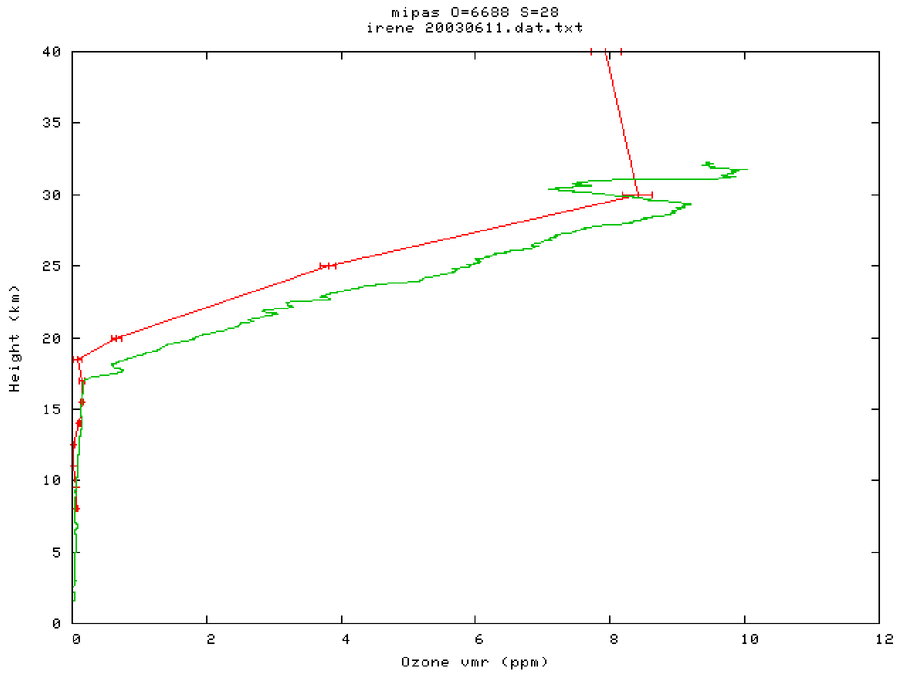

Fig. 64. Comparison of O3 VMR as function of altitude.

NILU	MIPAS scan 40	Satellite POAM 3
Species		H2O, O3, NO2
Time	8:27	8:38
Latitude	-65.46	-65.54
Longitude	19.72	30.01
Altitude range	5 – 40 km	0 – 60 km

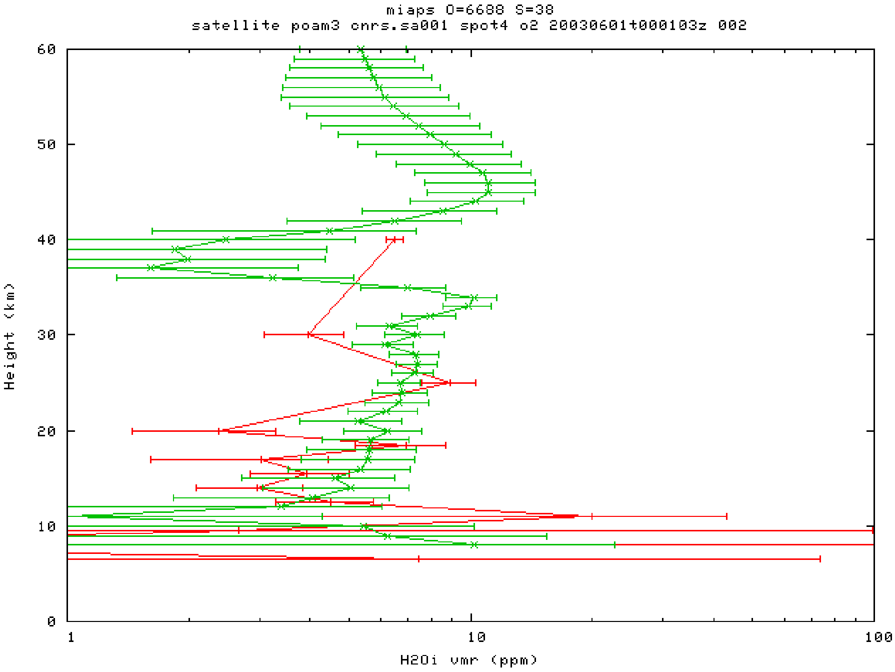

Fig. 65. Comparison of H2O VMR as function of altitude.

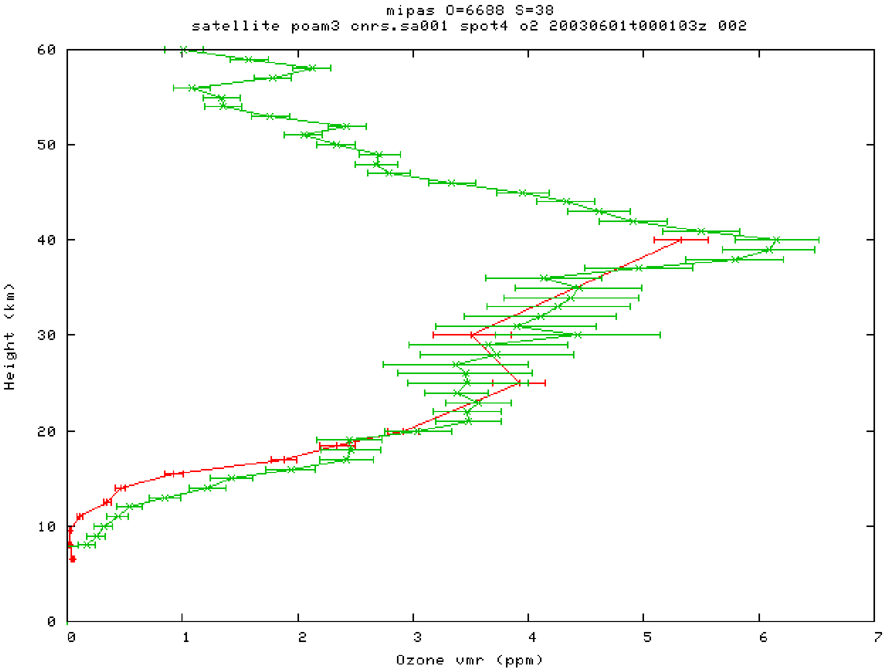

Fig. 66. Comparison of O3 VMR as function of altitude.

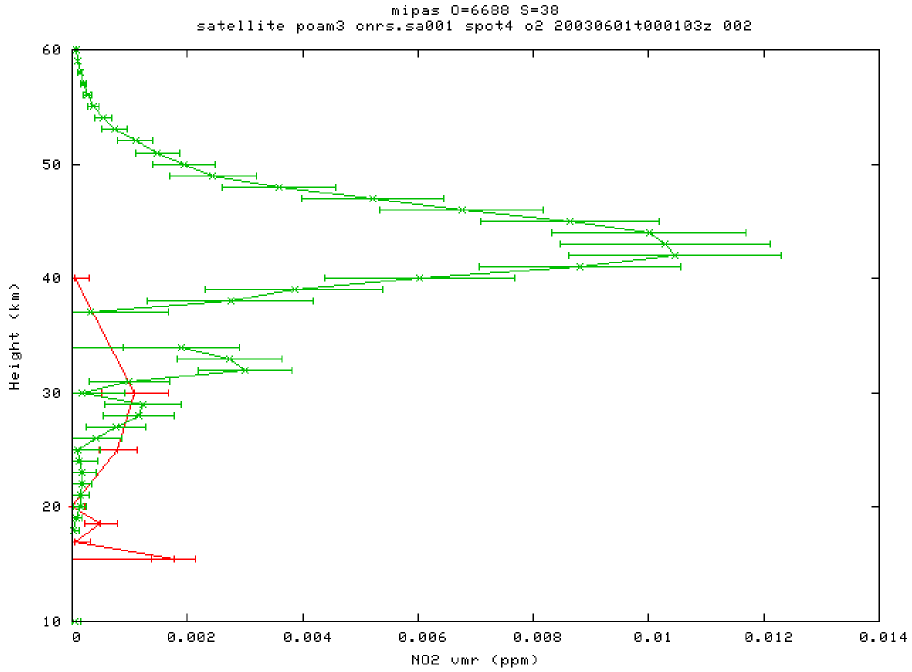

Fig. 67. Comparison of NO2 VMR as function of altitude.

6.12 Orbit 6689 – 11 June 2003 – Special mode S2

NILU	MIPAS scan 4	Assimilation of GOME data
Species		P, T, O3
Time	9:28	12:00
Latitude	78.31	78.90
Longitude	11.89	11.90
Altitude range	5 – 40 km	0.1 – 990.1 hPa

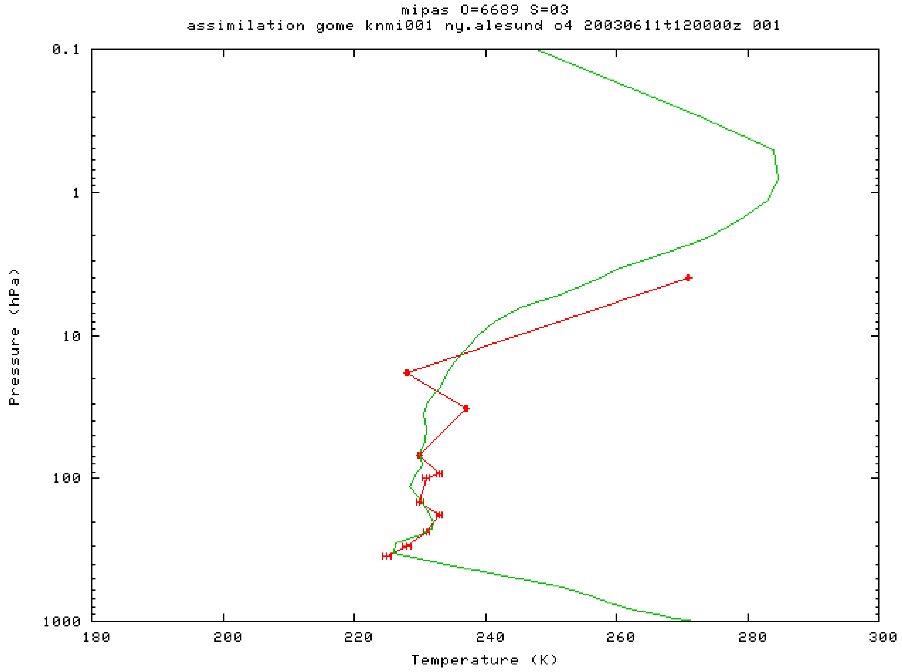

Fig. 68. Comparison of temperature as function of pressure.

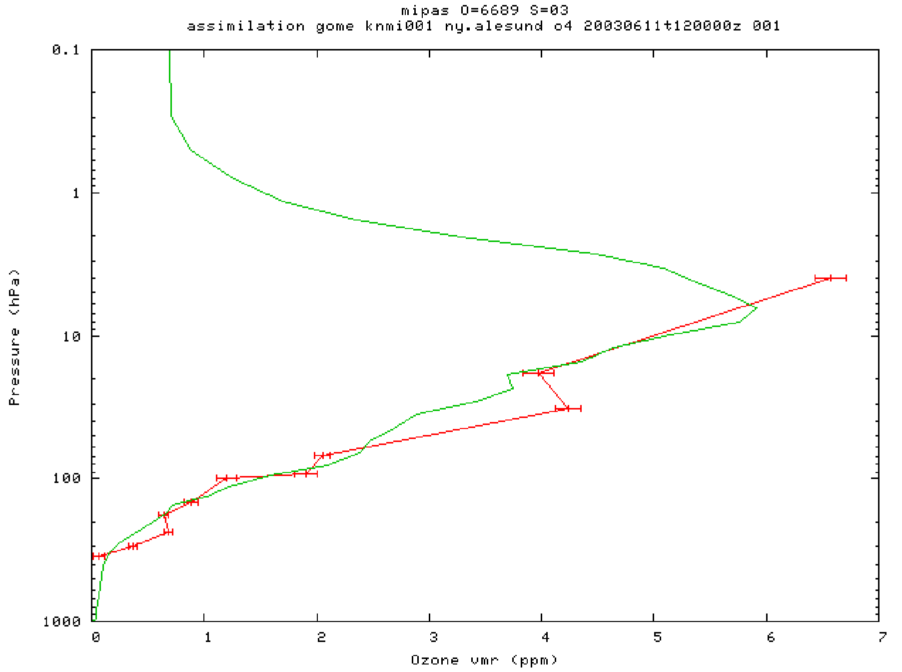

Fig. 69. Comparison of O3 VMR as function of pressure.

NILU	MIPAS scan 12	balloon sonde
Species		P, T, Humidity, O3
Time	9:35	11:59
Latitude	49.99	50.80
Longitude	9.64	4.35
Altitude range	5 – 40 km	0.100 – 31.265 km (GPH)

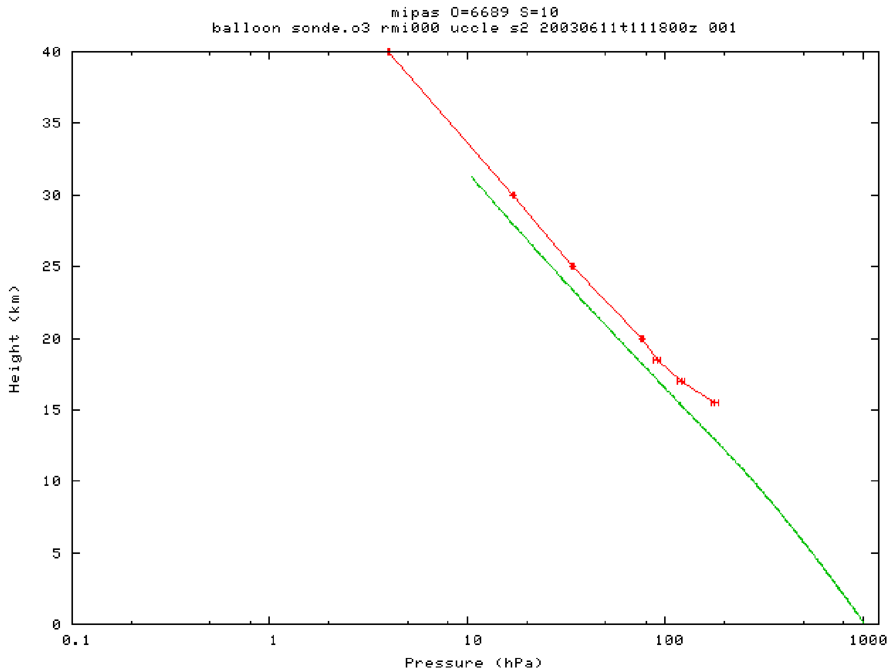

Fig. 70. Comparison of pressure as function of altitude.

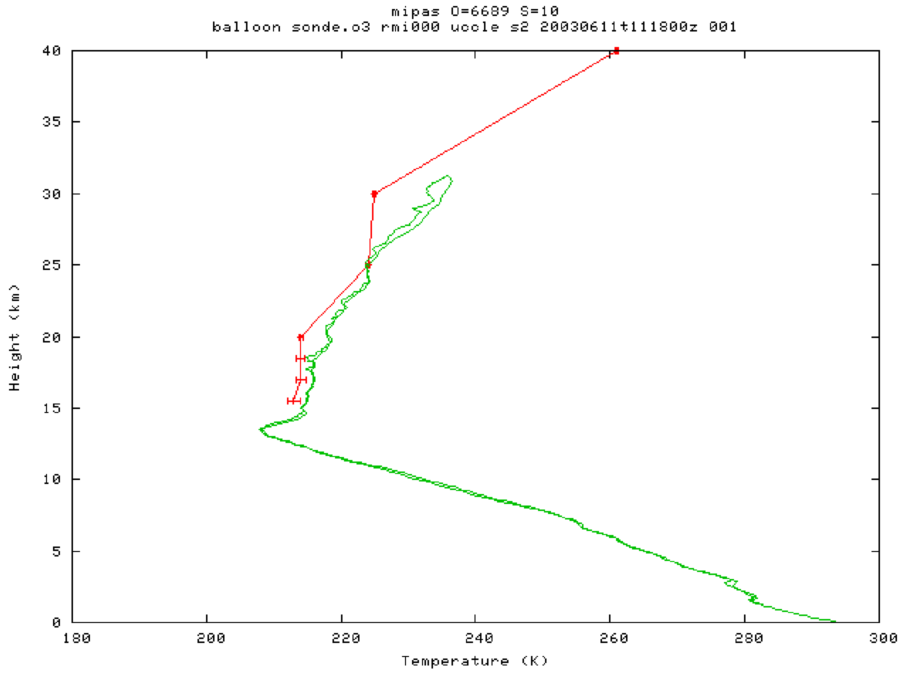

Fig. 71. Comparison of temperature as function of altitude.

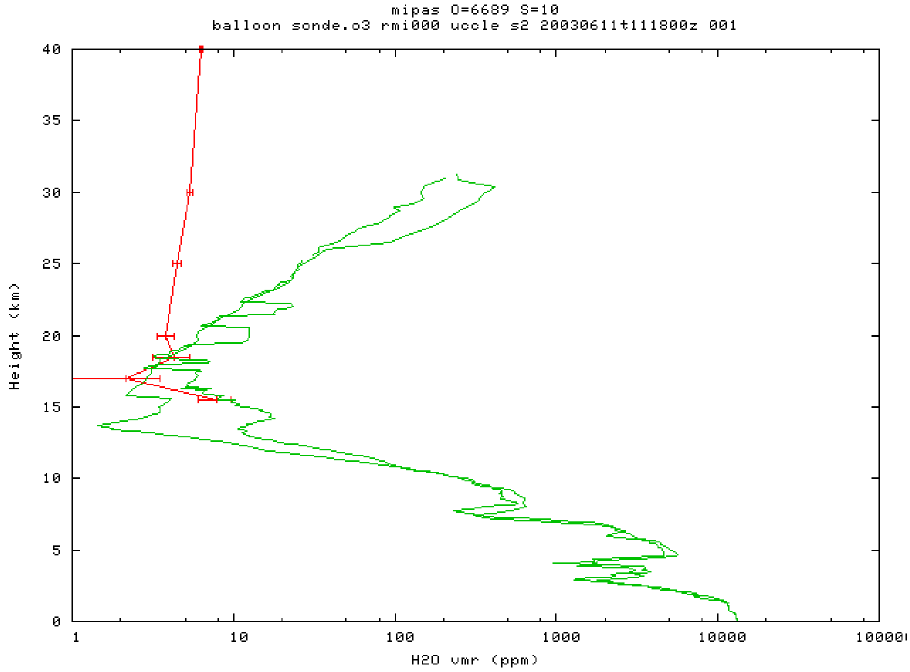

Fig. 72. Comparison of H2O VMR as function of altitude.

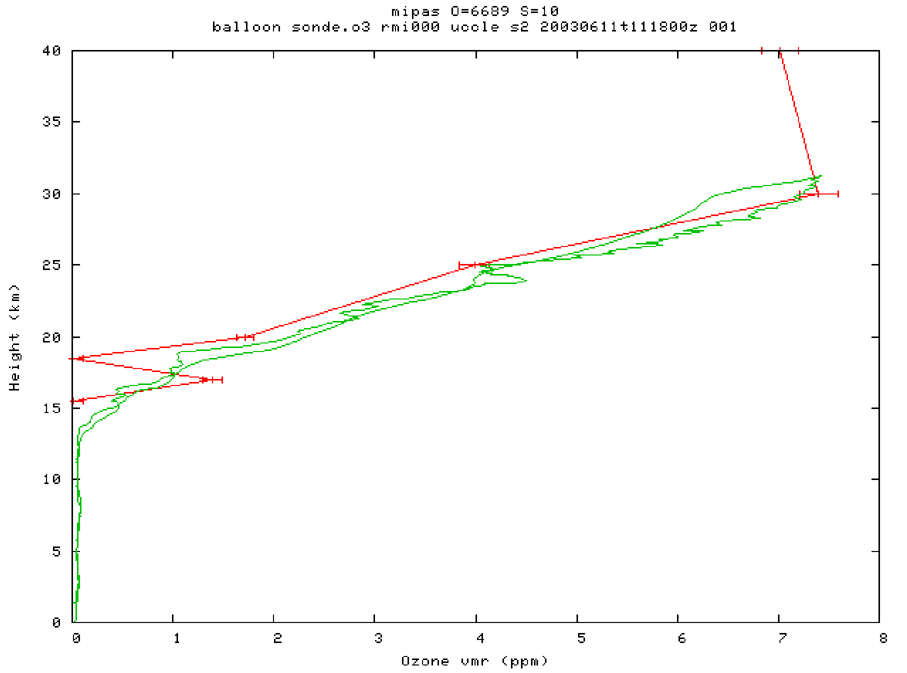

Fig. 73. Comparison of O3 VMR as function of altitude.

NILU	MIPAS scan 13	Balloon sonde	ground-based microwave radiometer
Species		P, T, Humidity, O3	O3
Time	9:36	11:45	9:50
Latitude	45.99	46.80	46.49
Longitude	8.58	7.00	6.57
Altitude range	5 – 40 km	0.491 – 28.346 km (GPH)	13 – 76.5 km

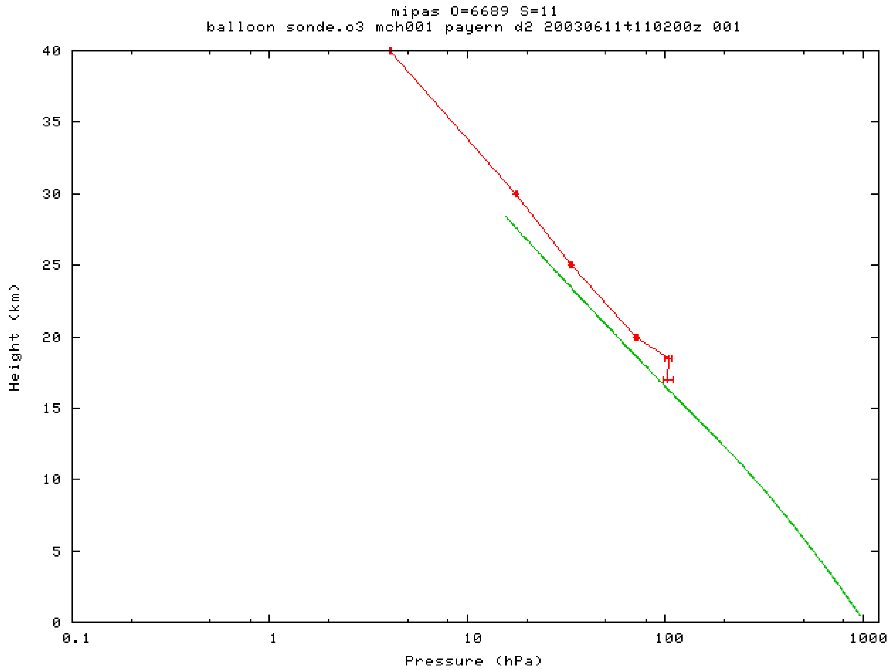

Fig. 74. Comparison of pressure as function of altitude.

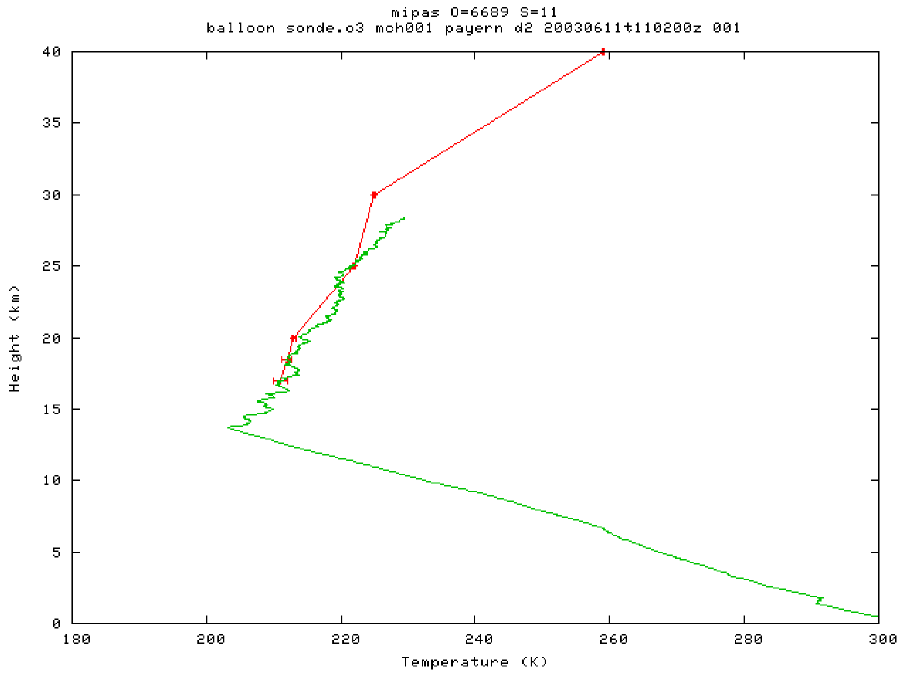

Fig. 75. Comparison of temperature as function of altitude.

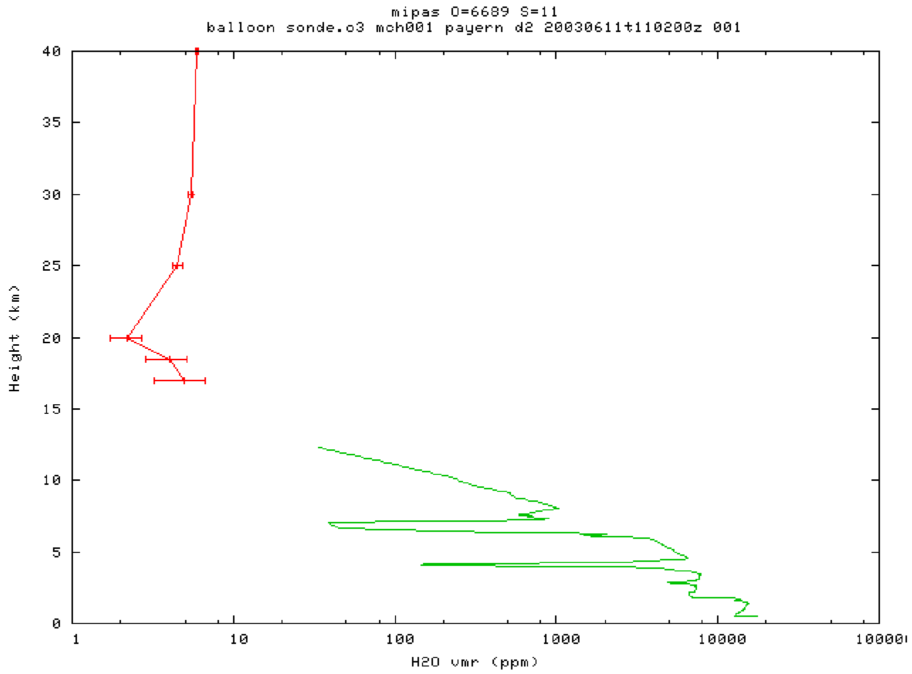

Fig. 76. Comparison of H2O VMR as function of altitude.

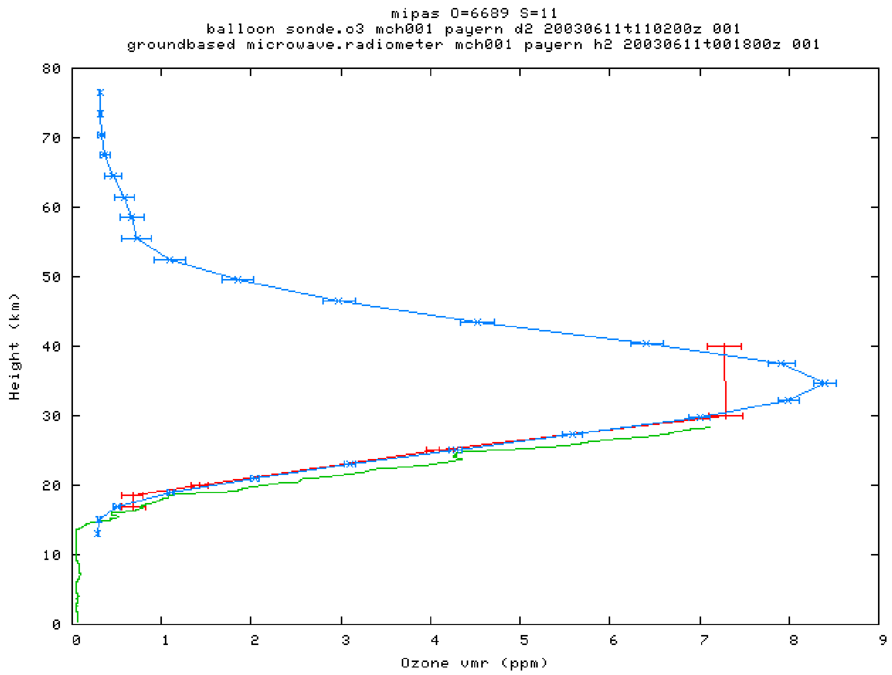

Fig. 77. Comparison of O3 VMR as function of altitude.

NILU	MIPAS scan 40	Satellite POAM 3
Species		H2O, O3, NO2
Time	10:08	10:19
Latitude	-66.22	-65.53
Longitude	-5.72	4.64
Altitude range	5 – 40 km	0 – 60 km

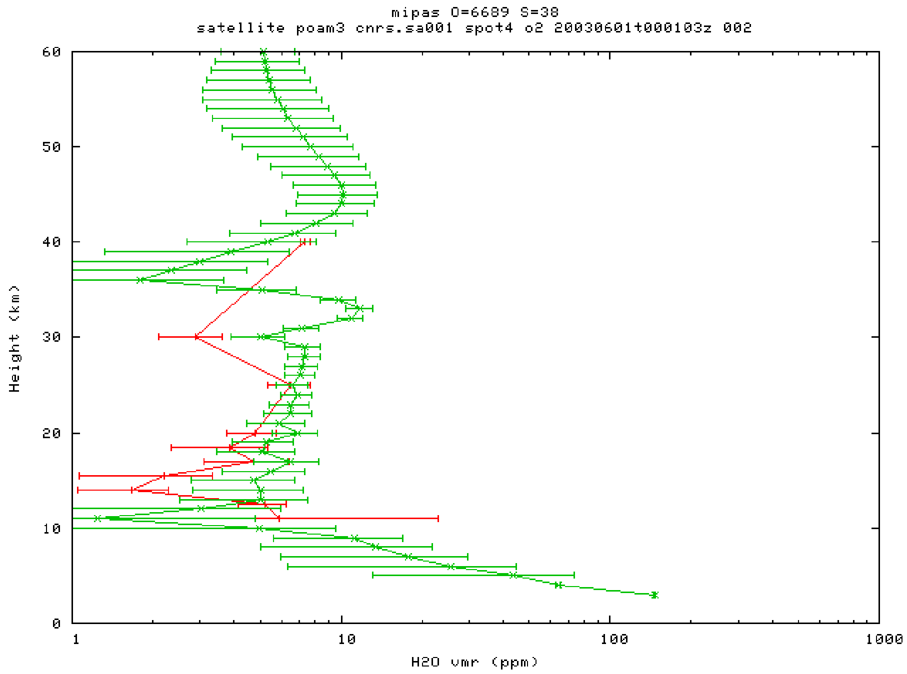

Fig. 78. Comparison of H2O VMR as function of altitude.

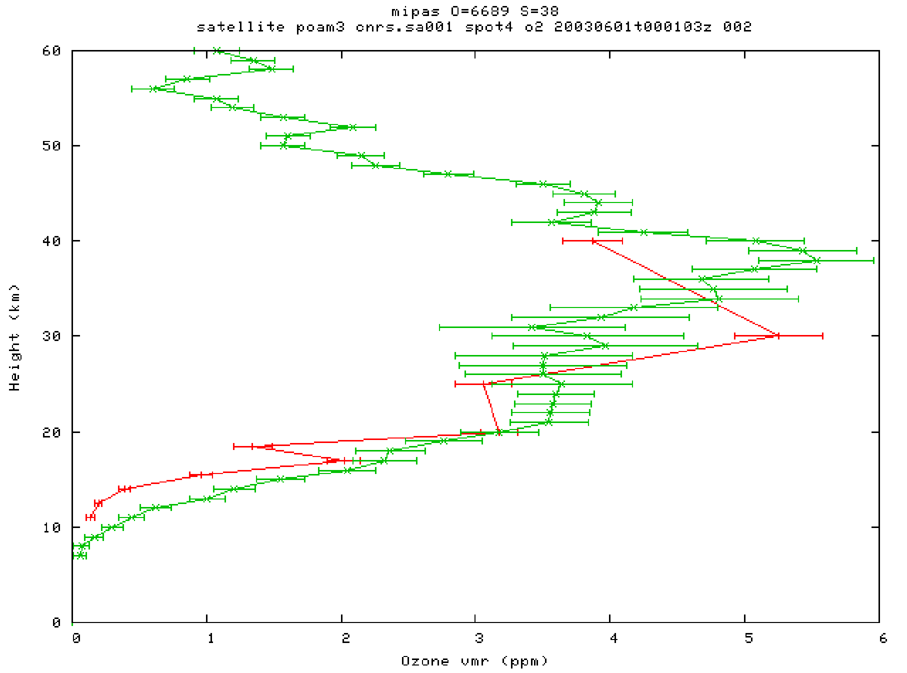

Fig. 79. Comparison of O3 VMR as function of altitude.

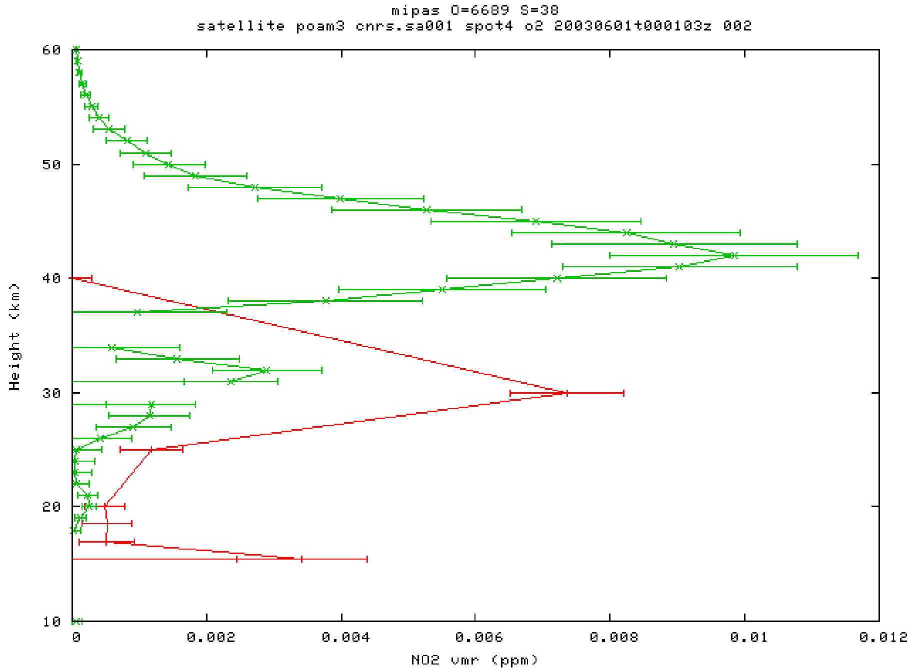

Fig. 80. Comparison of NO2 VMR as function of altitude.

NILU	MIPAS scan 57	Assimilation of GOME data
Species		P, T, O3
Time	10:28	12:00
Latitude	-43.81	-45.00
Longitude	178.41	169.70
Altitude range	5 – 40 km	0.1 – 978.61 hPa

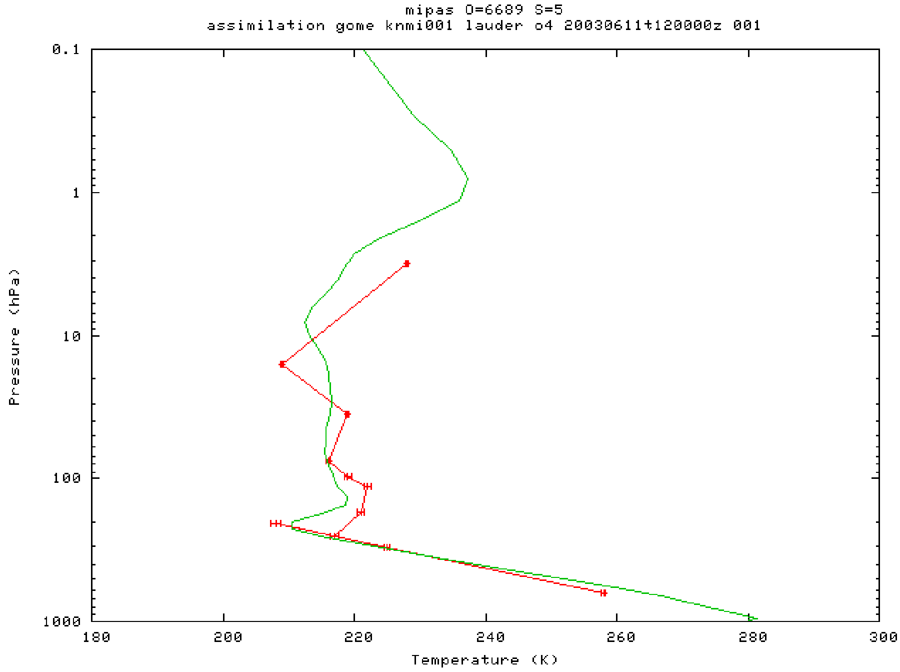

Fig. 81. Comparison of temperature as function of pressure.

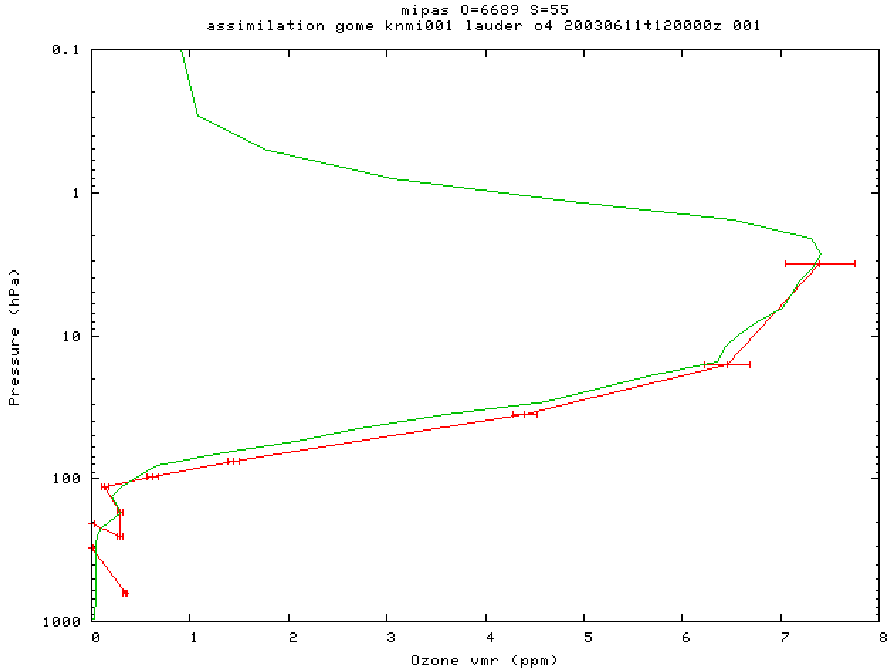

Fig. 82. Comparison of O3 VMR as function of pressure.

7. Comparison with SAFIRE for MIPAS nominal mode measurements

The SAFIRE-A high resolution FT-FIR spectrometer is a passive remote sensor operating aboard the M-55 Geophysica high altitude aircraft and capable to perform limb sounding observations of the atmospheric emission in the far infrared region, in narrow spectral bands (bandwidth = 2 cm^{-1}) between 20 and 200 cm^{-1}, with a spectral resolution of 0.004 cm-1 unapodized.
A full description of the spectrometer and details of its upgraded configuration are provided in:

- Carli B. , et al., SAFIRE-A: Spectroscopy of the Atmosphere using Far InfraRed emission /Airborne, *Journal of Atmospheric and Oceanic Technology*, Vol. 16, p.1313, October 1999

- Bianchini G., et al., SAFIRE-A: optimized instrument configuration and new assessment of spectroscopic performances, *Applied Optics*, Vol. 43, N. 14, pp. 2962-2977, May 2004

An inversion algorithm developed at ISAC-CNR was used to retrieve the vertical profiles for the selected species from the limb sounding sequences recorded by SAFIRE-A. This algorithm uses a radiative transfer calculation based on a line-by-line and layer-by-layer model including curvature and refraction effects. The retrieval process relies on the global fit technique.
Three coincidences have been found between MIPAS nominal mode measurements and the measurements acquired by SAFIRE-A on the flights performed from Kiruna on 2nd and 12th March 2003 (MIPAS orbits #5250, #5386 and #5387).
The profiles retrieved by the SAFIRE measurements were provided by Ugo Cortesi (IFAC-CNR).
In the following sections the comparison between the profiles retrieved by MIPAS and SAFIRE-A measurements are shown.

7.1 Orbit 5250 – 2 March 2003 – Nominal mode

	MIPAS scan 8	SAFIRE scan 12
Species		O3, HNO3. N2O
Time	20:34	20:32
Latitude	61.00	61.90
Longitude	23.78	24.66
Altitude range	6 –68 km	10.7085 – 17.8220 km

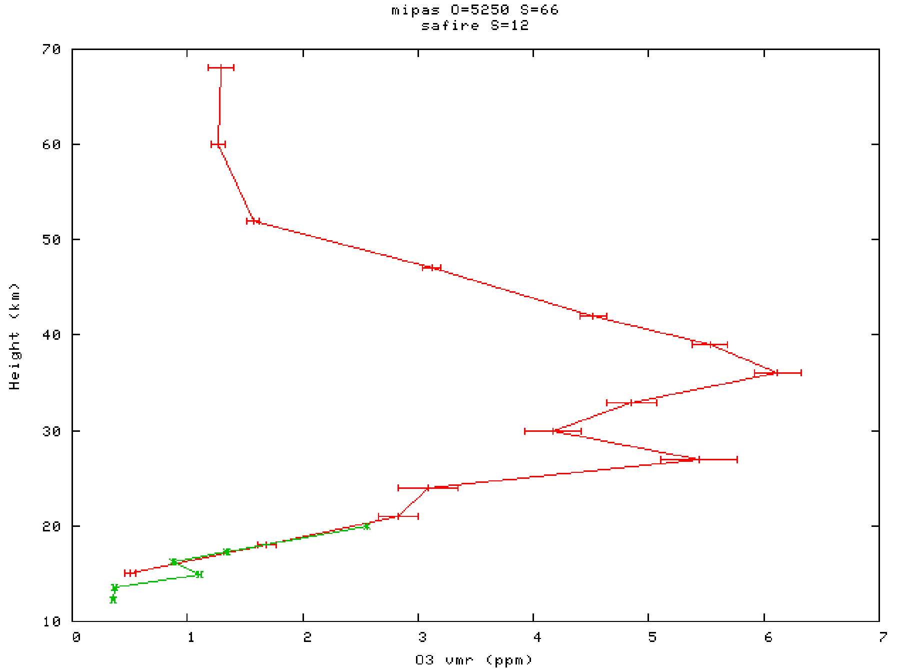

Fig. 83. Comparison of O3 VMR as function of altitude.

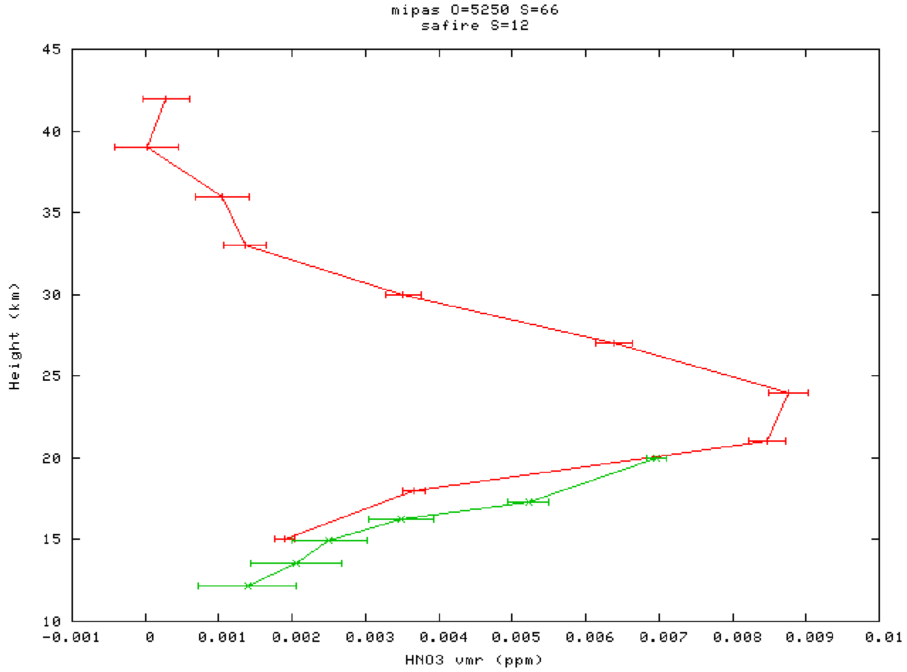

Fig. 84. Comparison of HNO3 VMR as function of altitude.

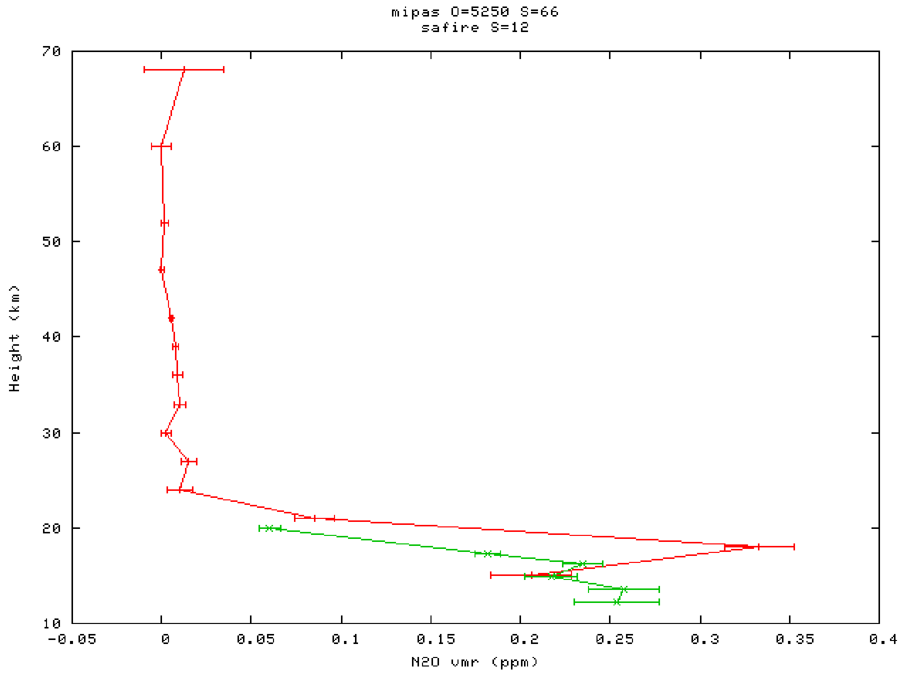

Fig. 85. Comparison of N2O VMR as function of altitude.

7.2 Orbit 5386 – 12 March 2003 - Nominal mode

	MIPAS scan 5	SAFIRE scan 11	SAFIRE scan 12
Species		O3	O3
Time	8:48	8:51	8:59
Latitude	75.85	74.84	75.57
Longitude	25.97	22.17	22.28
Altitude range	6 – 68 km	10.0596 – 17.1990 km	10.0605 – 17.1480 km

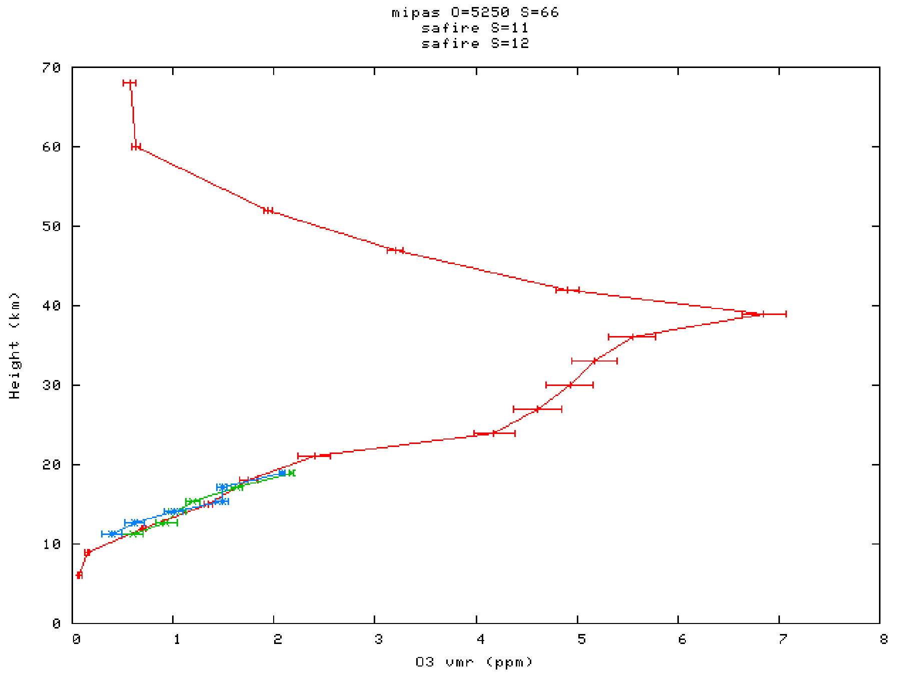

Fig. 86. Comparison of O3 VMR as function of altitude.

7.3 Orbit 5387 – 12 March 2003 – Nominal mode

	MIPAS scan 7	SAFIRE scan 23	SAFIRE scan 24
Species		O3	O3
Time	10:30	10:30	10:38
Latitude	70.49	71.01	70.35
Longitude	-2.03	9.58	11.13
Altitude range	6 – 68 km	11.4917 – 18.5470 km	11.4966 – 18.5740 km

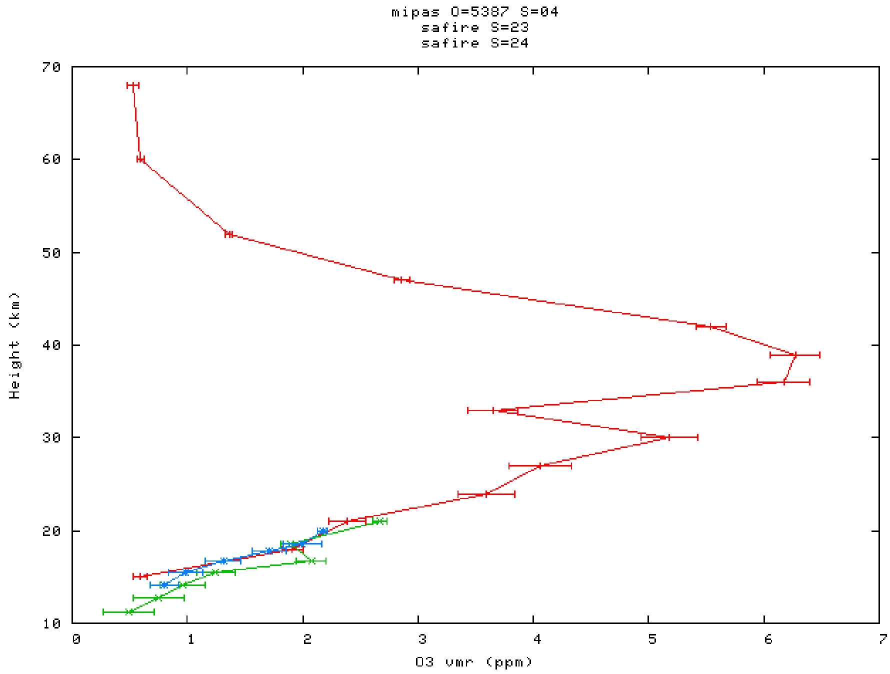

Fig. 87. Comparison of O3 VMR as function of altitude.

8. Conclusions

In this document we have shown the comparison between the profiles retrieved by MIPAS measurements using GMTR with correlative independent data.
Because of the small quantity of found coincidences and of the fact that the result of every comparison is determined by the different geolocations of the two measurements (the performed comparisons consist of a statically non-homogeneous set of events) we have not performed a statistic analysis of the results. As a consequence of this we can only give a conclusion on the general consistence between the profiles retrieved by MIPAS measurements using GMTR and the correlative independent data.
From the analysis of the comparison plots we can observe the following disagreements between the MIPAS retrieved profiles and the correlative data:

i. When the profiles are represented as a function of altitude some times there is a vertical shift between the compared profiles. This is a consequence of an already identified error in the engineering altitude of the tangent points.

ii. Disagreement is observed in the comparison with water measured by balloon sondes, especially at high altitudes. It is known that the balloon sondes measure wrong relative humidity at high altitude (above the tropopause) when the temperature of the sonde is smaller than that of the surrounding air. Besides the conversion from relative humidity to VMR (that is very sensitive to temperature) can introduce a further error.

iii. Disagreement is observed in the comparison with NO_2 measured by the satellite POAM III. POAM III makes measurements using the solar occultation technique, so the observations are made at sunrise and at sunset. Because NO_2 is very sensitive to the sunlight, the not perfect coincidence between the compared measurements can explain the observed differences.
In the comparison plots with NO_2 measured by the satellite POAM III we observe that the NO_2 VMR measured by MIPAS is always larger than that measured by POAM III. From the analysis of the solar zenith angles (SZA) related to the MIPAS and POAM III measurements we obtain that the SZA of the MIPAS measurements is systematically larger (of 2-4 degrees) than that of the POAM III measurements. This means that in the geolocation of the MIPAS measurements there is always less sunlight than that there is in the geolocation of the POAM III measurements, and this explains why MIPAS measures more NO_2 with respect to POAM III.

iv. Generally the MIPAS retrieved profiles show an oscillation between the values of two consecutive altitudes that are not present in the correlative measurements. This is probably due to the lack of regularisation in the retrieval algorithm GMTR.

Taking into account the differences between the geolocations of the compared profiles and the problems listed above, from the comparison plots shown in this document we can conclude that there is a general consistence between the MIPAS profiles retrieved by the code developed under this project and the independent measurements used for the validation study.
These results, when compared with validation results of operational retrieval performed with nominal measurement scenario, show a good consistency between ORM (Optimised Retrieval Model that is the scientific code used as basis for the operational code) and GMTR.