Technical Note on

MIPAS-B2 Flight 7 data analysis with the Oxford MWs selected for balloon measurements

Draft
28 june 2001

Delivery of the second part of WP 7240 of the CCN#5 of the study:
"Development of an Optimised Algorithm for Routine p, T and VMR Retrieval from MIPAS Limb Emission Spectra"
Contract no. 11717/95/NL/CN

Prepared by:

Name	Institute
B.M. Dinelli	ISM-CNR

Approved by:

Name	Institute
M. Carlotti	University of Bologna

Reference documents

1. F. Friedl-Vallon et al. '*MIPAS-B-Flight report: Flight #7 of 26/27.1.1999 Esrange/Sweden*'
2. B.M. Dinelli, E. Battistini and M. De Marco *'Implementation of balloon geometry option and MIPAS-B data analysis'* - TN-ISM-0001
3. B.M. Dinelli, E. Battistini *'MIPAS-B2 data analysis'* - TN-ISM-0002
4. B.M. Dinelli, E. Battistini *'MIPAS-B2 Flight 6 data analysis with Oxford MWs data base developed for balloon measurements'* - TN-ISM-0003

1- Introduction

This technical note reports the results of the data analysis operated on MIPAS-B2 data collected during the flight (identified as flight 7) from Kiruna in January 1999, using the Microwindows (MWs) database developed by the University of Oxford for balloon measurements. The process leading to the calibrated spectra used in the retrievals described in this document is reported in reference document 1. The retrievals were carried out with the version of ORM specifically developed at ISM for the balloon-borne MIPAS instrument and described in reference document 2. This version includes the possibility of handling altitude dependent logical masks.
The present document uses as a starting point the reference document 4 that refers to flight 6 using the same set of MWs. In reference document 4 the problems found when using this set of MWs are discussed.

2 – Flight 7 details

Since flight 7 was performed around the arctic circle during winter time, the instrument settings were different from those of flight 6. First of all the average floating altitude of the balloon was 32.1 km that is lower than that of flight 6. Moreover the lowest measurement geometry was performed at a tangent altitude of about 10 km, a couple of kilometres higher than that in flight 6. This implies that the altitude coverage of flight 7 is reduced with respect to flight 6 and the total number of geometries to be analysed is 8 instead of 11. Table 1 shows the list of the pointing angles and the corresponding nominal tangent altitudes used in the retrievals.

Table 1 - nominal pointing

LS Angle	90.76	91.96	92.64	93.16	93.61	94.01	94.4	94.71
Tangent Altitude (km)	31.4	28.3	25.2	22.1	19.3	16.3	12.6	9.9

Also the spectral coverage of flight 7 was different with respect to flight 6. Table 2 shows the comparison between the spectral coverage of the four channels in the two flights. The major differences can be found in channel I and II, where frequency regions where calibration problems were found in flight 6 have been excluded in flight 7 .

Table 2 - Spectral coverage of flight 6 and 7

Channel	*Flight 6*	*Flight 7*
I	698 – 963 cm^{-1}	760 – 970 cm^{-1}
II	1010 – 1380 cm^{-1}	1135 - 1350 cm^{-1}
III	1580 – 1750 cm^{-1}	1570 - 1690 cm^{-1}
IV	1820 – 2410 cm^{-1}	1820 – 2410 cm^{-1}

3 - Occupation Matrices

The Occupation Matrices used in this analysis are the same as in the analysis reported in reference document 4 and were selected by Oxford on the basis of a mid-latitude spring atmosphere for a night flight.
For some molecules it was not possible to use all the selected MWs because some of them are outside the frequency ranges measured in flight 7. Tables from 3 to 8 show, for all target quantities, the full list of the MWs in the original OMs, and the MWs that have been actually used in the analysis of flight 7.

Table 3 - MWs used in the p,T retrieval

MW	*Label*	*spectral range (cm^{-1})*	
1	PT__0012	953.925 - 954.525	yes
2	PT__0003	1895.750 - 1898.025	yes
3	PT__0002	1909.425 - 1912.425	yes
4	PT__0011	1931.750 - 1934.725	yes
5	PT__0008	1936.375 - 1937.875	yes
6	PT__0005	2062.850 - 2065.850	yes
7	PT__0013	2073.850 - 2076.850	yes
8	PT__0015	2076.875 - 2077.600	yes
9	PT__0014	2092.975 - 2094.675	yes
10	PT__0010	2262.875 - 2263.075	yes

Table 4 - MWs used in the H_2O retrieval

MW	*Label*	*spectral range (cm^{-1})*	
1	H2O_0011	921.450 – 923.525	yes
2	H2O_0006	1373.425 – 1376.425	-
3	H2O_0012	1390.100 – 1394.100	-
4	H2O_0003	1399.250 – 1402.250	-
5	H2O_0009	1572.125 – 1576.125	yes
6	H2O_0010	1615.975 – 1616.600	yes
7	H2O_0005	1616.775 – 1617.825	yes
8	H2O_0001	1649.350 – 1652.350	yes
9	H2O_0008	1669.450 – 1671.400	yes
10	H2O_0004	1684.900 – 1687.775	yes

Table 5 - MWs used in the O_3 retrieval

MW	*Label*	*spectral range (cm^{-1})*	
1	O3__0019	1077.350 – 1078.575	-
2	O3__0014	1084.975 – 1087.625	-
3	O3__0016	1111.300 – 1113.475	-
4	O3__0017	1113.625 – 1116.150	-
5	O3__0011	1123.250 – 1126.025	-
6	O3__0015	1129.900 – 1132.400	-
7	O3__0013	1142.275 – 1144.500	yes
8	O3__0020	1145.850 – 1146.225	yes
9	O3__0012	1149.325 – 1150.875	yes
10	O3__0018	1155.800 – 1156.550	yes

Table 6 - MWs used in the HNO_3 retrieval

MW	*Label*	*Spectral range (cm^{-1})*	
1	HNO30004	868.525 – 871.500	yes
2	HNO30009	871.525 – 874.525	yes
3	HNO30001	877.325 – 880.325	yes
4	HNO30005	881.700 – 884.700	yes
5	HNO30002	885.425 – 888.425	yes
6	HNO30008	888.450 – 891.450	yes
7	HNO30010	891.475 – 894.475	yes
8	HNO30003	895.025 – 898.000	yes
9	HNO30006	899.575 – 902.575	yes
10	HNO30007	1324.025 –1327.025	yes

Table 7 - MWs used in the CH_4 retrieval

MW	*Label*	*Spectral range (cm^{1})*	
1	CH4_0002	1215.200 – 1218.200	yes
2	CH4_0001	1227.275 – 1230.275	yes
3	CH4_0008	1230.325 – 1233.325	yes
4	CH4_0004	1235.025 – 1237.775	yes
5	CH4_0009	1263.425 – 1264.975	yes
6	CH4_0006	1271.125 – 1271.925	yes
7	CH4_0010	1297.800 – 1298.575	yes
8	CH4_0005	1336.100 – 1339.100	yes
9	CH4_0003	1346.650 – 1349.650	yes
10	CH4_0007	1351.250 – 1354.025	-

Table 8 - MWs used in the N_2O retrieval

MW	*Label*	*spectral range (cm^{-1})*	
1	N2O_0002	1234.275 – 1235.275	yes
2	N2O_0001	1255.050 – 1258.025	yes
3	N2O_0010	1261.125 – 1261.575	yes
4	N2O_0009	1261.700 – 1262.475	yes
5	N2O_0004	1264.275 – 1265.325	yes
6	N2O_0005	1265.875 – 1267.425	yes
7	N2O_0006	1269.675 – 1270.725	yes
8	N2O_0003	1272.925 – 1274.600	yes
9	N2O_0008	1277.500 – 1279.625	yes
10	N2O_0007	1307.675 – 1310.675	yes

3 - Retrievals

For the MWs reported in tables from 2 to 8, tabulated LookUp Tables (LUT) and Irregular Grids (IG) are not available, therefore a line by line calculation had to be performed in the forward model built in the retrieval system. The spectroscopic data used for the simulations were specifically selected by IMK while University of Oxford provided LUTs for the molecules for which only temperature- and pressure- dependent cross sections are available (see reference document 4).
The retrievals were performed a first time with the following initial guess profiles:

- pressure and temperature profiles were provided by IMK (coming from climatology and radiosondes measurements).
- VMR profiles were the preliminary polar winter average profiles generated by J. Remedios.

The first run highlighted that in the simulated spectra the HOCl features were stronger than in the measured spectra, therefore the VMR profile quoted as “lower limit-atmosphere for polar winter” was adopted for this molecule. After completion of this analysis J.M. Flaud found that the line strengths of HOCl in the IMK database (that are the same of the HITRAN database) were wrong. So the observed intensity of the HOCl lines should be attributed to spectroscopic errors and not to a wrongly assumed VMR profile.

3.1. Trade-off between p,T and water retrievals

In Figure 1 the water profile retrieved in the first run is compared with the initial guess profile. It is evident in the figure the big difference at low altitudes. Since the p,T retrieval is very sensitive to the assumed profile of water and, in turn, all the other retrievals are very sensitive to the results of the p,T retrieval, a second run was performed adopting as initial guess for water the profile retrieved in the first run. Table 9 reports the χ-test values obtained when using the different initial guess VMR profile for water.

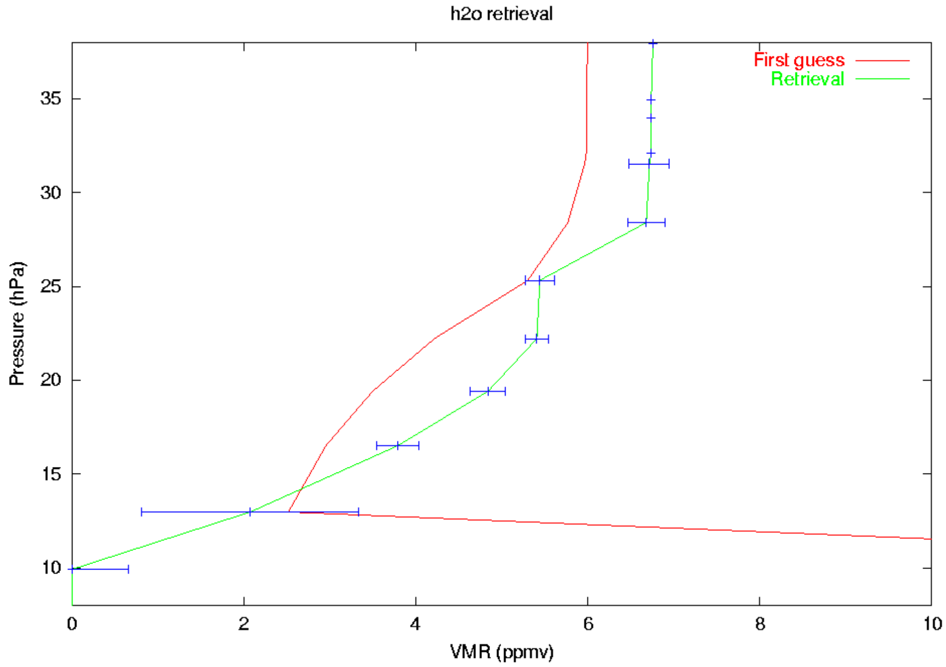

Figure 1 Initial guess (red) and preliminarly retrieved (green) water profiles. The blue lines mark the esd of the retrieval

Table 9 – final χ-test values

retrieval	***Remedios' H₂O***	***retrieved H₂O***
p,T	1.02	1.00
H_2O	18.7	16.3
O_3	3.5	3.6
HNO_3	33.0	33.0
CH_4	2.4	2.2
N_2O	1.8	1.6

3.2. Other retrievals

The comparison with the χ-test values predicted by the OM-generating algorithm (as performed in reference 4) is in this case not feasible, because these values are predicted for the full OM but, in our case, we are using a reduced OM due to the reduced altitude and spectral coverage of flight 7 measurements.

As it can be seen in table 9, even in the second run the final χ-test values for the retrievals of water and HNO_3 remain quite high. In the case of water, the high χ-test values can be attributed to the badly reproduced CFC emissions in MW H2O_0011 that are unmasked at some altitudes. An empirical attempt to correct the CFC VMR profile in the second run resulted in a slightly reduced χ-test value. In the case of HNO_3 the high χ-test value can be attributed to errors in the line

strengths of some of its vibrational bands. This has been confirmed by the analysis on ATMOS spectra and new spectroscopic data are going to be available in the near future.
Figure 2 reports a comparison among the altitude corrections obtained in the two analyses. Also in this case the retrieved altitude corrections depend on the initial guess profile of water. However, the use of the previously retrieved water vapour profile reduces the magnitude of the altitude corrections.
Fig. 3 reports the retrieved temperature profile. In this figure it can be noticed that the oscillations of the profile are small. This suggests that the instability found in the temperature profile retrieved from flight 6 (that made use of the same OM) is due to the different systematic errors present in those measurements.
Figures from 4 to 9 report the results of the VMR retrievals. The retrieved water profile shows a quite high random error, possibly caused by the use of a reduced OM. This is more evident in the ozone retrieval (whose profile is shown in fig.5) that is now performed on an extremely reduced set of MWs (because of the reduced spectral coverage only 4 out of 10 MWs could be used in this analysis). For the other molecules there are no evident anomalies in the results, indicating that the retrieval system performed quite well also in this extreme atmosphere.

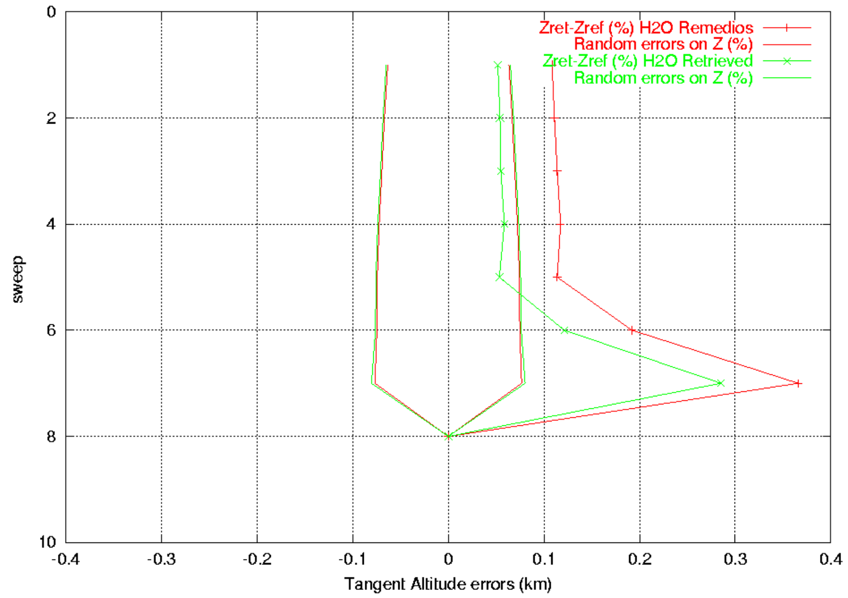

Figure 2 tangent altitude corrections for the first analysis (red) where the Remedios' water profile was used and the final analysis (green) where the preliminarily retrieved water profile was used.

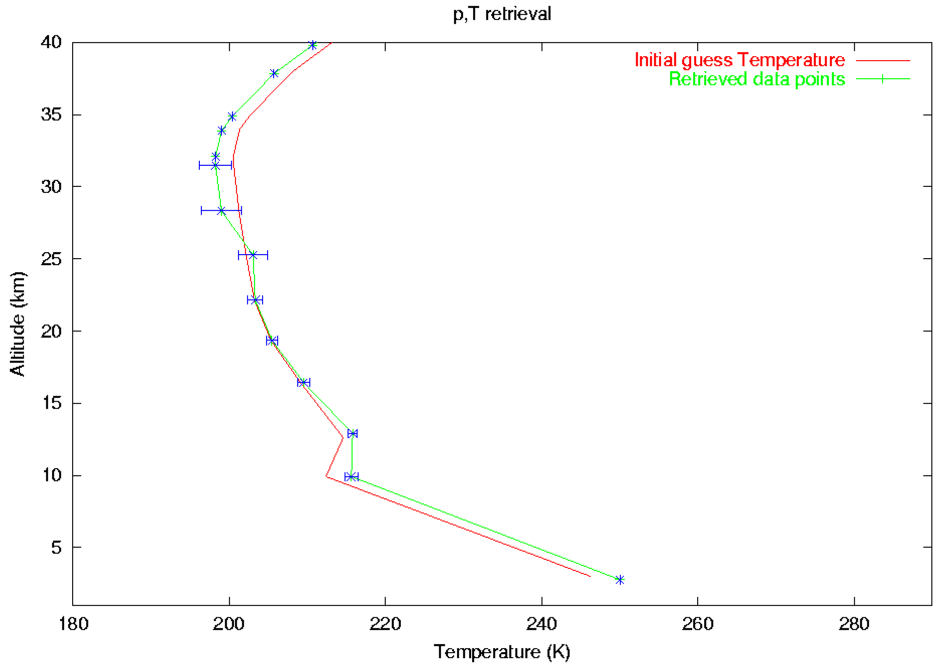

Figure 3 Initial guess (red) and retrieved (green) temperature profiles. The blue lines mark the esd of the retrieval

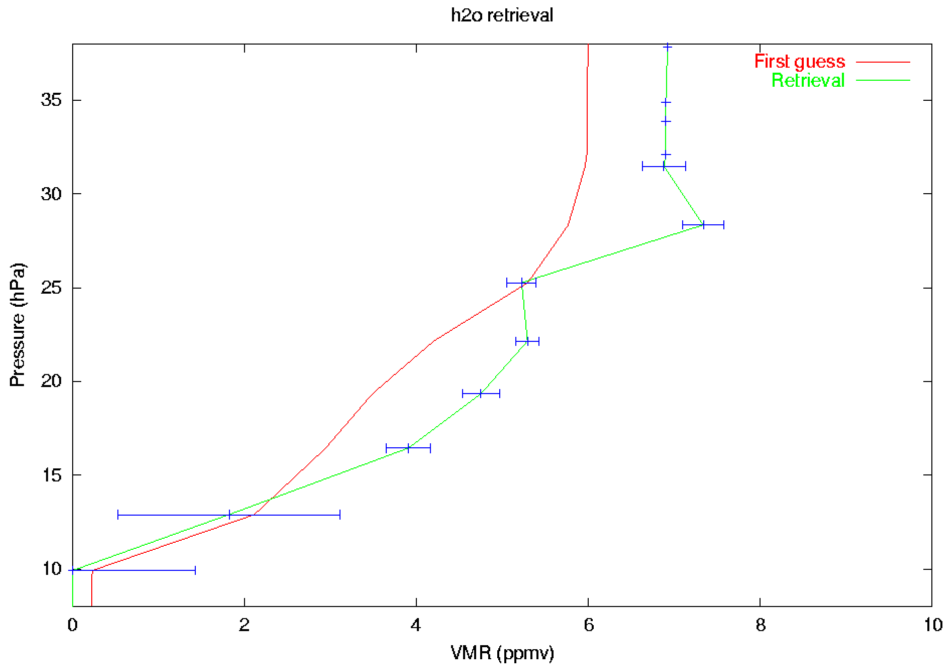

Figure 4 Initial guess (red) and retrieved (green) water profiles. The blue lines mark the esd of the retrieval

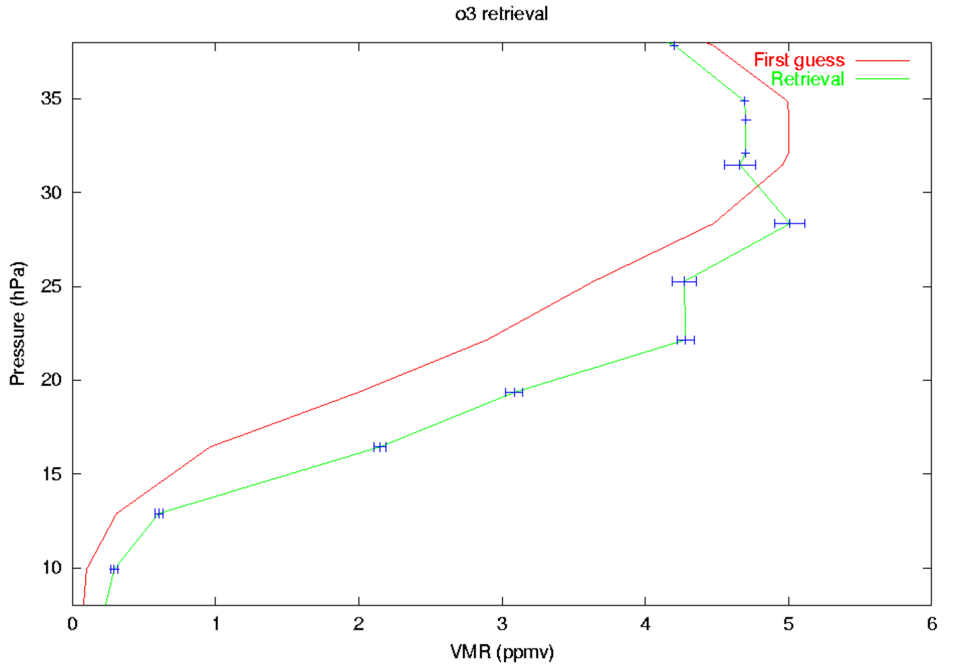

Figure 5 Initial guess (red) and retrieved (green) ozone profiles. The blue lines mark the esd of the retrieval

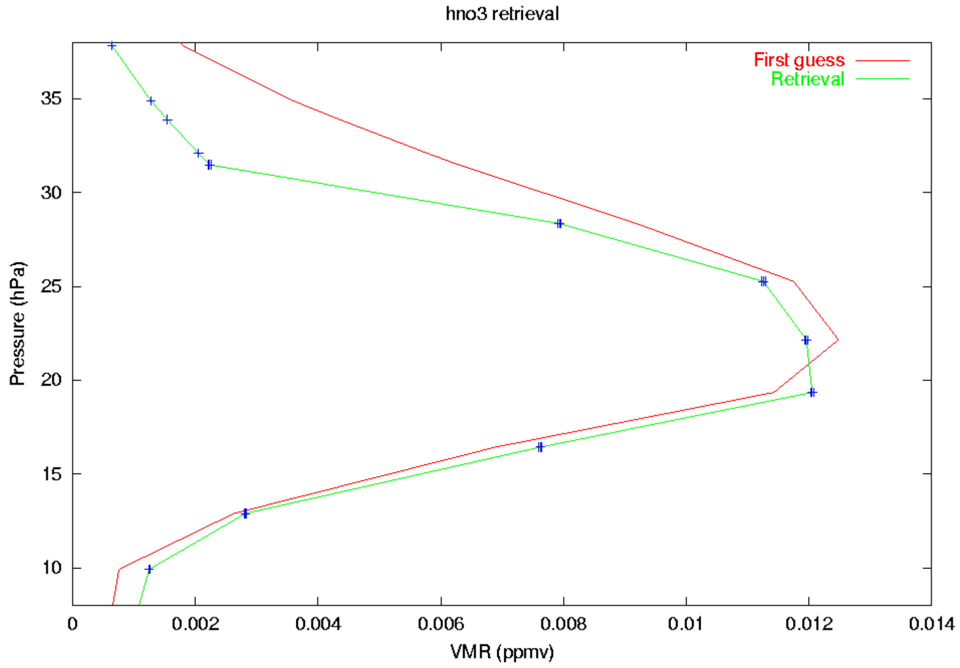

Figure 6 Initial guess (red) and retrieved (green) HNO_3 profiles. The blue lines mark the esd of the retrieval

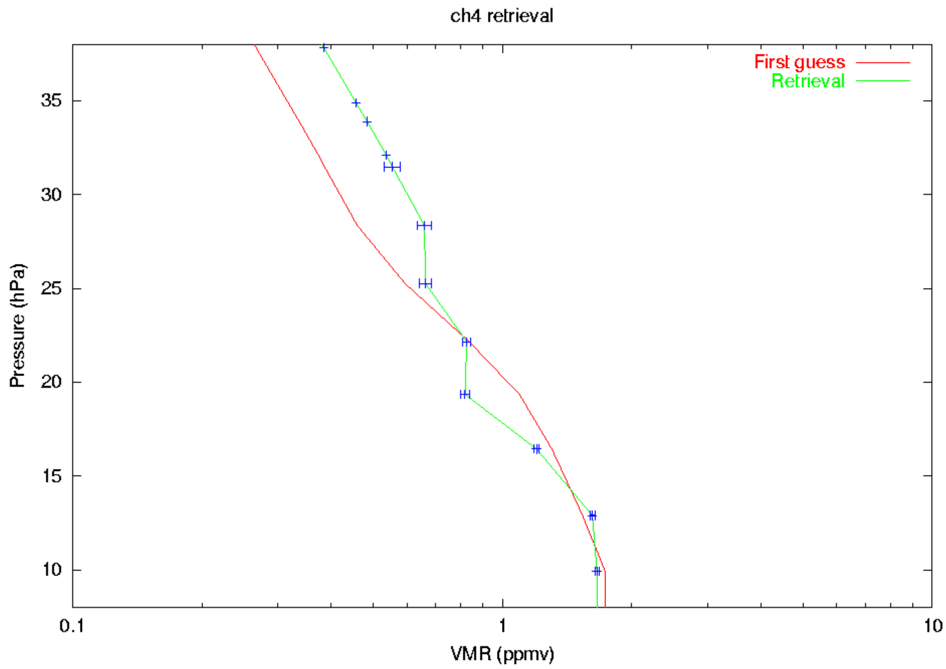

Figure 7 Initial guess (red) and retrieved (green) methane profiles. The blue lines mark the esd of the retrieval

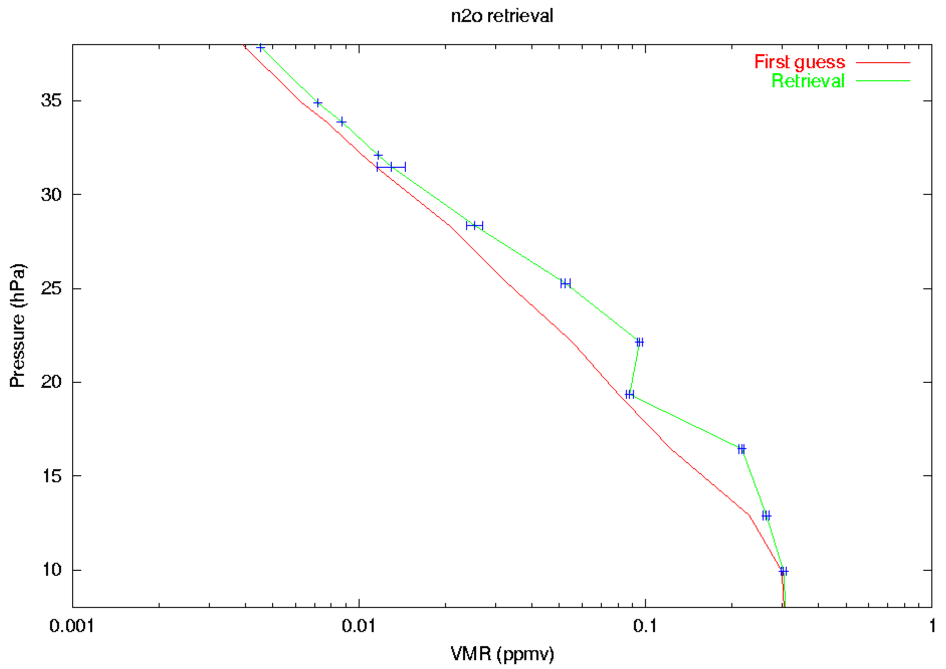

Figure 8 Initial guess (red) and retrieved (green) N_2O profiles. The blue lines mark the esd of the retrieval

Conclusions

As a general conclusion we can state that:

- The OMs selected by University of Oxford for a mid-latitude spring atmosphere, provide a satisfactory performance even in the case of an extreme atmosphere as the one measured in flight 7 (polar winter atmosphere). This suggests that the OMs to be used in the satellite operations do not need to be latitude or season dependent. In other words, the operational choice of using unique OMs for the whole orbit is supported by the analysis of flight 7.
- The importance of performing the p,T retrieval using a water VMR profile as close as possible to reality is confirmed by the analysis of flight 7.
- The retrieval system performance was satisfactory even when operating on measurements from an extreme atmosphere. This fact provides an estimate of the robustness of the code.
- MIPAS-B2 measurements have proven to be a very useful tool to check the performances of the retrieval system and the spectroscopy of the analysed MWs.
- This exercise has contributed to highlight possible problems that may arise in the analysis of MIPAS-SATELLITE measurements.