CORRELATIVE MEASUREMENTS OF SELECTED MOLECULES OVER THE MEDITERRANEAN REGION

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ABSTRACT

The vertical distribution of three minor atmospheric constituents (O_3, N_2O, HNO_3) has been obtained from far infrared limb thermal emission in the 22-24 cm^{-1} spectral region. Measurement were made with a high resolution interferometer on a balloon payload launched on July 29, 2002 from Trapani (Sicily). Several limb scan sequences have been analysed and the resulting profiles have been compared to those measured by the MIPAS instrument flown on the ENVISAT satellite. An extra result, not required by the validation, has been the measurement of ClO vertical profile.

1 INTRODUCTION

Atmospheric emission has been measured in two narrow spectral intervals centred at 23 and 120 cm^{-1} with a polarising interferometer (Martin-Puplett type [1]) which provided an unapodized resolution of 2.5E-03 cm-1; the two detectors, one for each band, were housed in a ^{3}He cooled dewar. Apart for a few upgrades (on board data recording, new detectors, better control of the limb scan direction), the system is still the one described in [2] and which has been used in the past, among other campaigns, for the Balloon Intercomparison Campaigns (1981, 1982) [3] and for UARS validation (1991,1992,1994) A schematic of the original instrument is shown in Fig. 1.

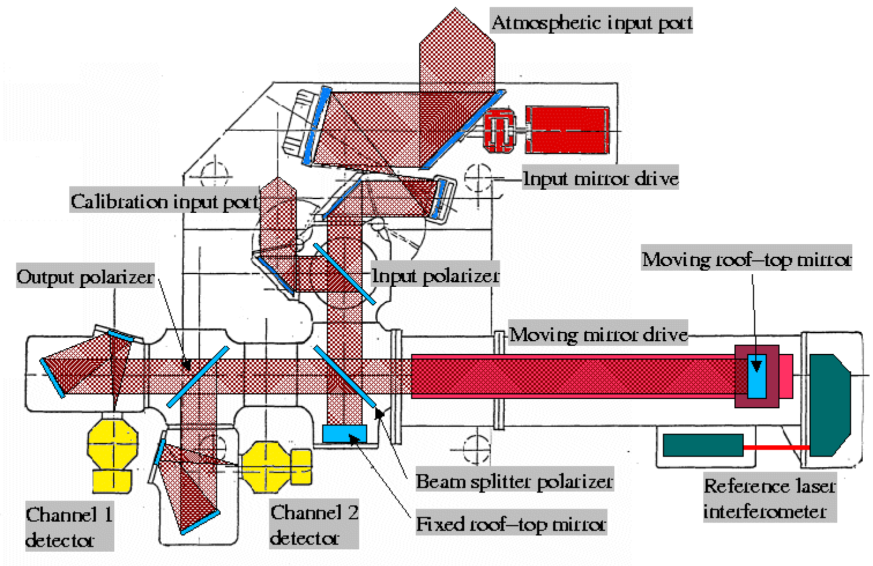

Fig. 1 - Schematic layout of the IBEX interferometer

The instrument was launched on July 29 2002, about 21.00 UT, in the frame of the ENVISAT validation programme from the Italian Space Agency base in Trapani (30°N, 12°E) reaching a float altitude of about 38 km after three hours. The flight ended over Sierra Nevada (Spain) after 20 hours. All measurements were made looking to North with an accuracy and stability with a few arcmins.

Originally the flight had been scheduled for July 22, in coincidence with overpasses of ENVISAT and with the flight of the M55 Geophysika aircraft, but for technical problems at first, and then for weather conditions, the launch was made when no ENVISAT overpasses were expected, so we could not have of superposition of measurements; the nearest orbits of ENVISAT on the same day were about 10° away; passage of ENVISAT on the region we measured occurred about 24 hr before (please note that this is a crude guess as we have learned that the tool we use for planning, ESOV, has still some systematic error). For this preliminary analysis, because of lack of better choice, we have used the nearest available data (orbit 2081) extracting results for the latitude range 35°N-45°N.

2 OBSERVED SPECTRA

During the first part of the flight (about 8 hours) it was possible to record several high quality sequences. Step in tangent heights between successive measurements was set at 1.5 km; this value (which is an improvement over previous flights, has been made possible by the narrow field of view of the detectors and by the accuracy and stability of the Single Axis Platform used to control the limb scan mirror. After sunrise a failure in the batteries used to power the detectors prevented recording more data so all the information from this flight comes from night measurements but for the last sequence.
Fig. 2 shows a complete limb sequence of the observed spectra in the 22- 23.5 cm^{-1} spectral interval.
On top of the figure we have also shown the microwindows used for the retrieval of the different components. Each spectrum is measured in 3 minutes and is the difference between the atmospheric signal and the emission of a calibration source which in our case was an Eccosorb mask acting as a near black body. Calibration in flight was done both by looking at high angle over horizontal and by inserting a another black body in the atmospheric port. Each sequence is composed of 19 measurements (with calibrations) so about 1 hour is required for a complete limb scan corresponding to about 1° for the movement of the balloon over the globe.

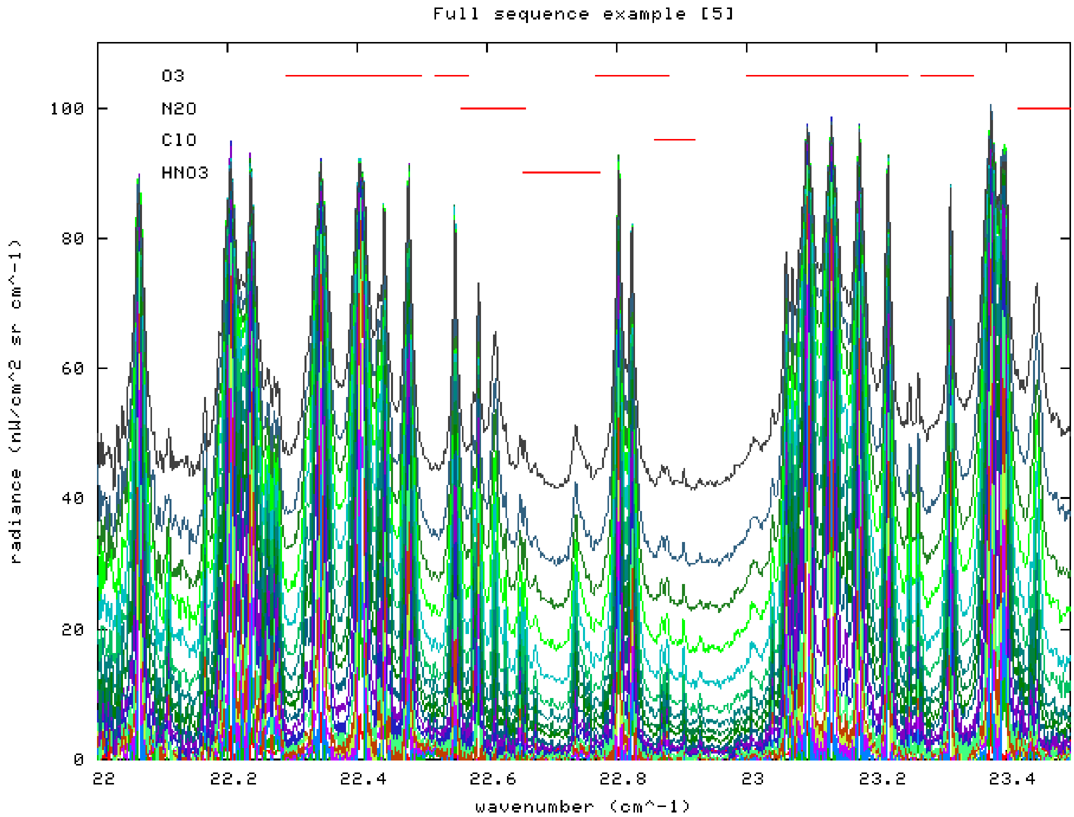

Fig. 2 - A complete limb scan sequence

3 ANALYSIS

The analysis for the retrieval of profiles employs line by line and layer by layer radiative transfer calculations and includes curvature and refraction effects. Molecular spectral data are from HITRAN96 [4] but for HNO_3 for which we adopted values from JPL [5] . The water vapour continuum CKD-2.1 suggested by Clough [6] has been incorporated in the calculations.
The inversion program is built on top of the know how developed since the first global fit model [7] and is mainly the same program used for the analysis of the SAFIRE-A instrument mounted on board of the Geophysika aircraft. As we do not have O_2 lines falling in our spectral range the observation angle could not be checked by inversion of O_2 lines, so a great deal of attention went to calibration of the Single Axis Platform before the launch. Accuracy and stability of the observation angle is estimated to be with 2 arcmin, that is within the errors in evaluating tangent height due to the balloon altitude oscillations.
As already mentioned before, the unavailability of overpasses with MIPAS prevented a full validation (that is a measurement made both at the same time and at the same location). As a preliminary comparison we have therefore chosen to use for MIPAS data recorded in the same day, for the same latitude range observed by us (35° - 45° N) even if at different longitudes. The inversion of MIPAS data has been made in Florence by Dr. P. Raspollini using the program written for the the near real time inversion. In the next future it could be interesting to explore the possibility of other measurement made by other instruments (Odin ?) with better superposition in order to achieve some kind of 'third party' validation.

4 RESULTS

4.1 Ozone

Ozone has 5 microwindows (see Fig.2 for location); and with 8 sequences for each microwindow a grand total of 40 profiles is expected, that is a good statistics. Because of the balloon altitude fluctuation however the mean float altitude changes from one sequence to the other and the retrieval grid is not the same for all sequences. In this preliminary phase of analysis we have chosen not to interpolate the results over a fixed grid so each sequence will be examined singularly (same consideration apply also to other molecules). In the Fig. 3 we show the results for the different sequences for two microwindows.

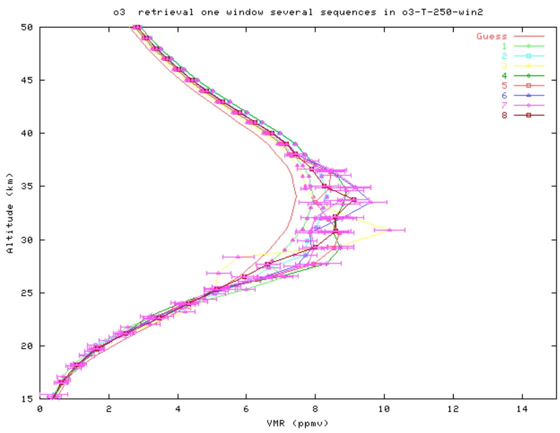

Fig. 3 - Ozone profile (all sequences)

The null error at high altitudes is due to the fact that these values are simply the initial guess model shifted by a constant multiplier to ensure continuity with the profile measured at and below the float altitude. The small errors below the float altitude are in turn due to the fact that the program does not at the moment take into account all the contribution to the error budget. A different view of the same data is shown in Fig. 4 and Fig. 5 where the profiles are given averaging all microwindows for a given sequence.

In Fig. 4 and Fig. 5 we show two sequences after averaging the results obtained by the different micro windows. Each curve is therefore the mean of 5 profiles (one per microwindow) and the error bars are the rms deviation of the single profiles which in principle represent the contribution of uncertainty in spectroscopic parameters to the total error budget.

As explained above a direct comparison of our results with ENVISAT measurements is made impossible because of the missing overpass. For these perliminary results we present here two comparisons. First, see Fig. 6, the O_3 profiles for three sequences are compared with a profile measured in situ over Rome. Because of the difference in latitude between the balloon and Rome the air mass observed by the in situ instrument is the one corresponding to the lower part of our profile. A second test (see Fig. 7) had been done comparing the average profile for ozone (obtained by interpolating and averaging all our 40 profiles) to the profile obtained from MIPAS measurements (orbit 2081, latitude range 35° – 45° N, see above)

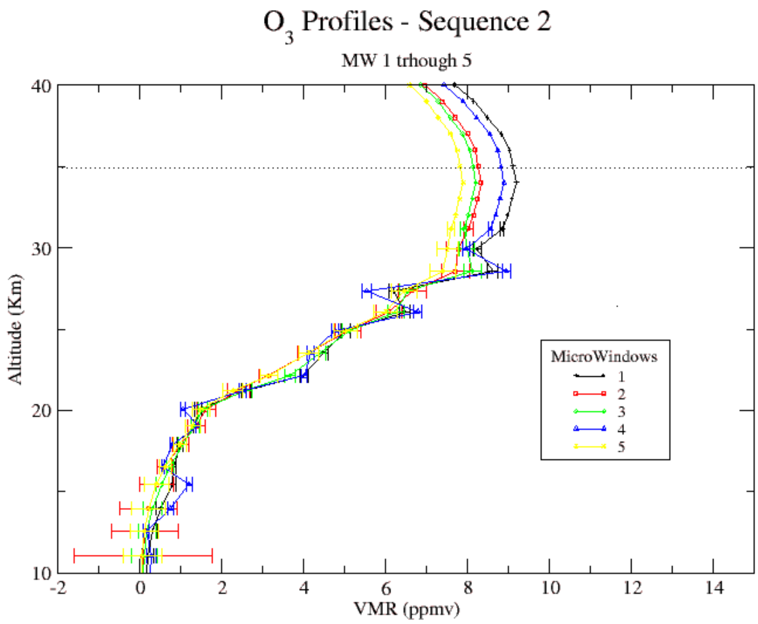

Fig. 4 O_3 profile for sequence 2

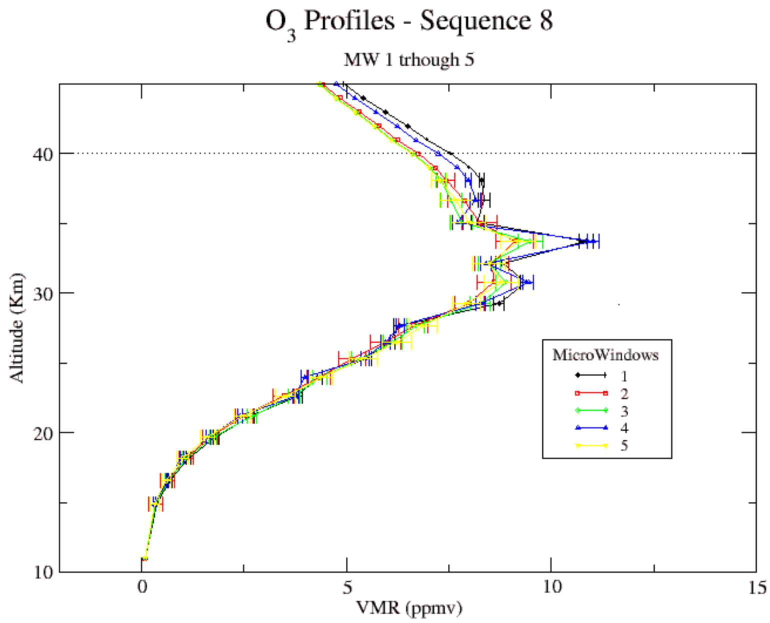

Fig. 5 O_3 profile for sequence 8

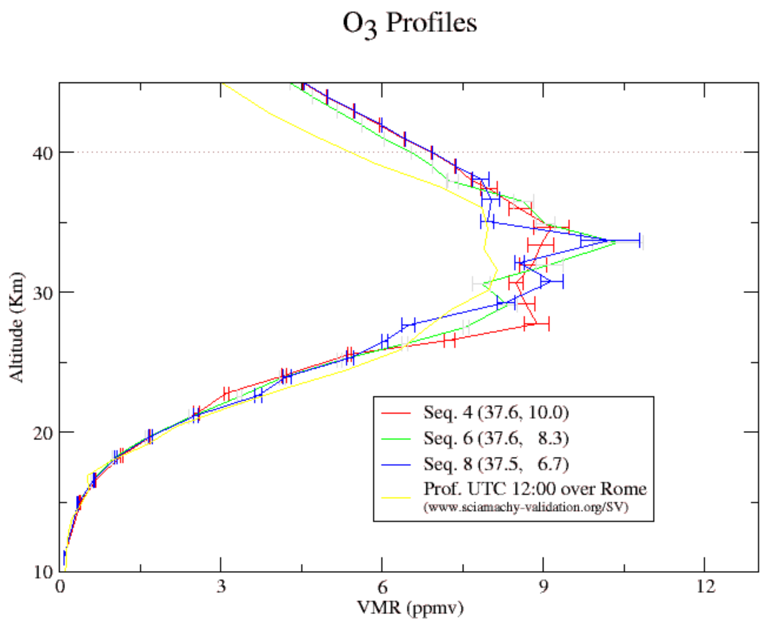

Fig. 6 O_3 profile for different sequences compared to on situ measurements

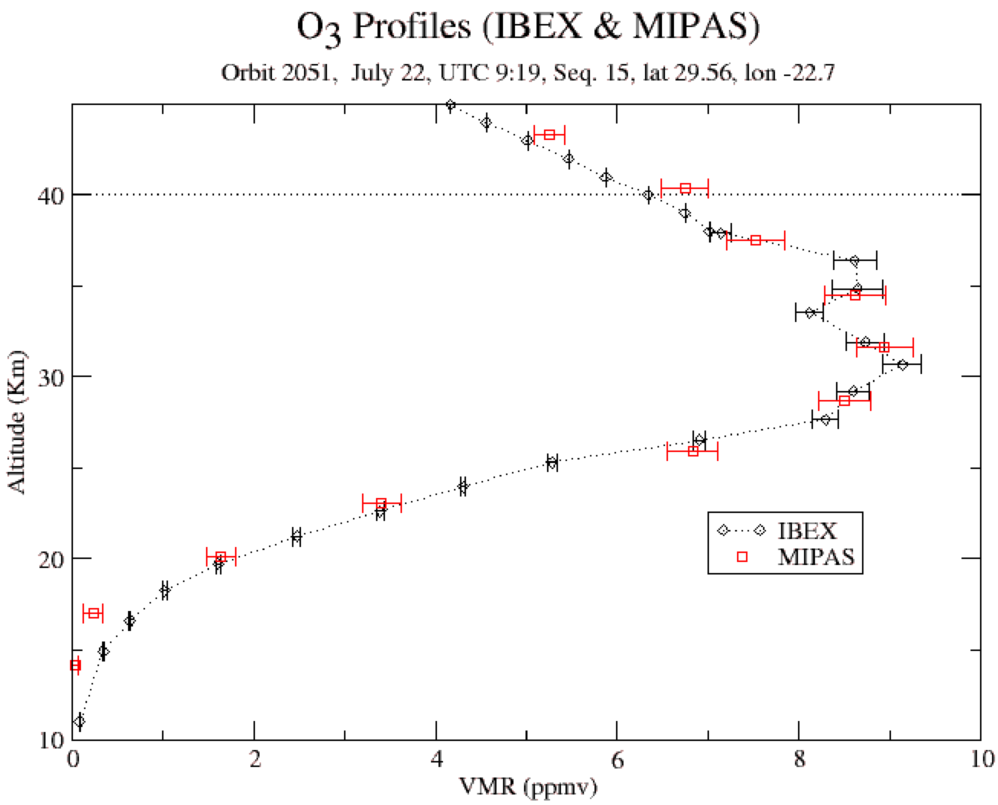

Fig. 7 Comparison of the average ozone profiles measured from balloon from Mipas

4.2 N_2O

N_2O has two micro windows over the spectral region of interest; for this preliminary report we have used only one of them because the second (higher frequency) has a nearby interfering ozone line. In Fig. 8 we show the profiles obtained for the different microwindows and the results obtained by inverting MIPAS measurements again corrected for the systematic shift..

4.3 HNO_3

For HNO_3, one microwindow only, we have plotted results of two sequences (Fig. 9). Note that in the low altitude range the results show some differences but there is an overall agreement with MIPAS. This is particularly important since the two insrument use different spectral range and the result suggests the general correctness of the spectral catalogues adopted in the analysis.

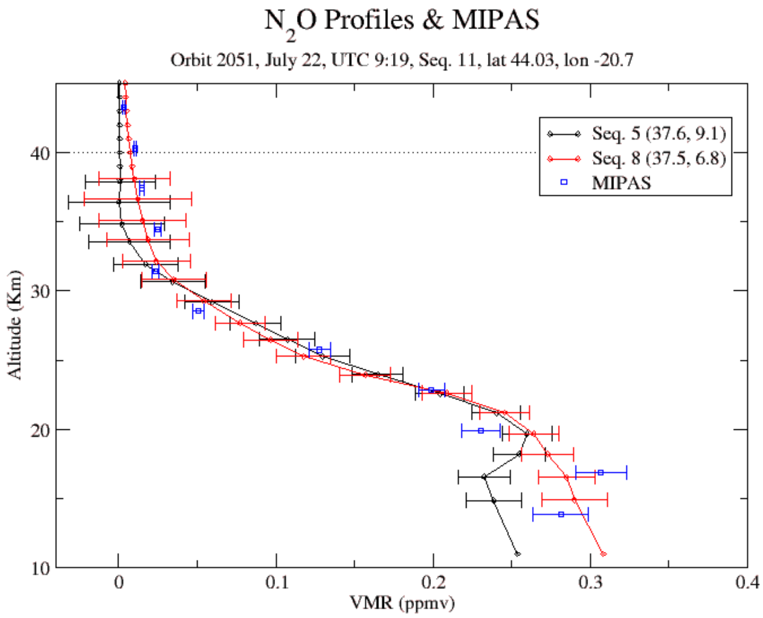

Fig. 8 – Profiles of N_2O measured from balloon and from Mipas

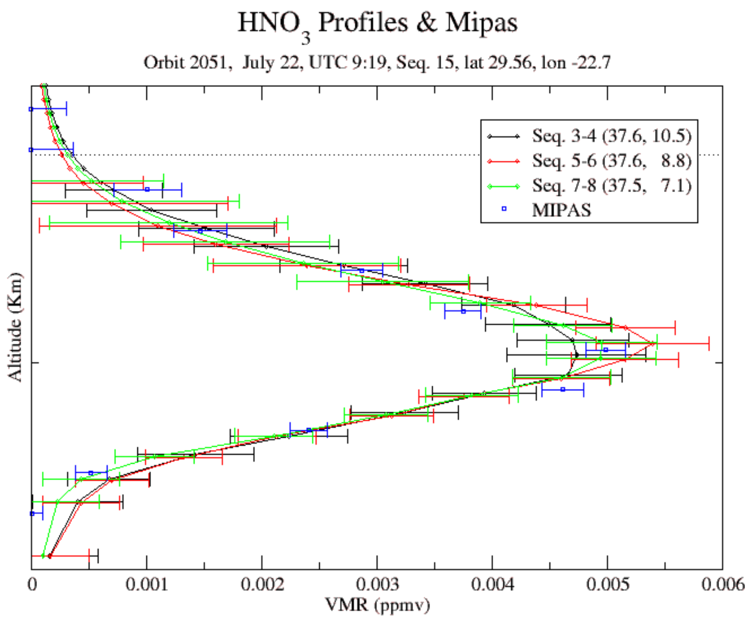

Fig. 9 – Profiles of HNO_3 measured from balloon and from Mipas

4.4 ClO

A final consideration will be devoted to ClO; this molecule was not within the scope ot the validation but the occurrence of a ClO microwindow in the spectral region observed suggested to make a run for retrieving its profile. Results for the profiles in the different sequences are shown in Fig 10. Note that while most of the profiles show a low vmr, one of them (corresponding to last sequence) is clearly higher even if lower than the initial guess (theoretical profile). This is explained if we consider that the measurements of sequence 8 were taken between 4:30 and 5:15 UT, that immediately after the sunrise (slightly later taking into account balloon altitude): what we are seeing is the build up of ClO as explained by photochemical effects. The comparison of these results with the one previously obtained [8] shows how better detectors and improvements in the instruments have improved the measurement capability of IBEX

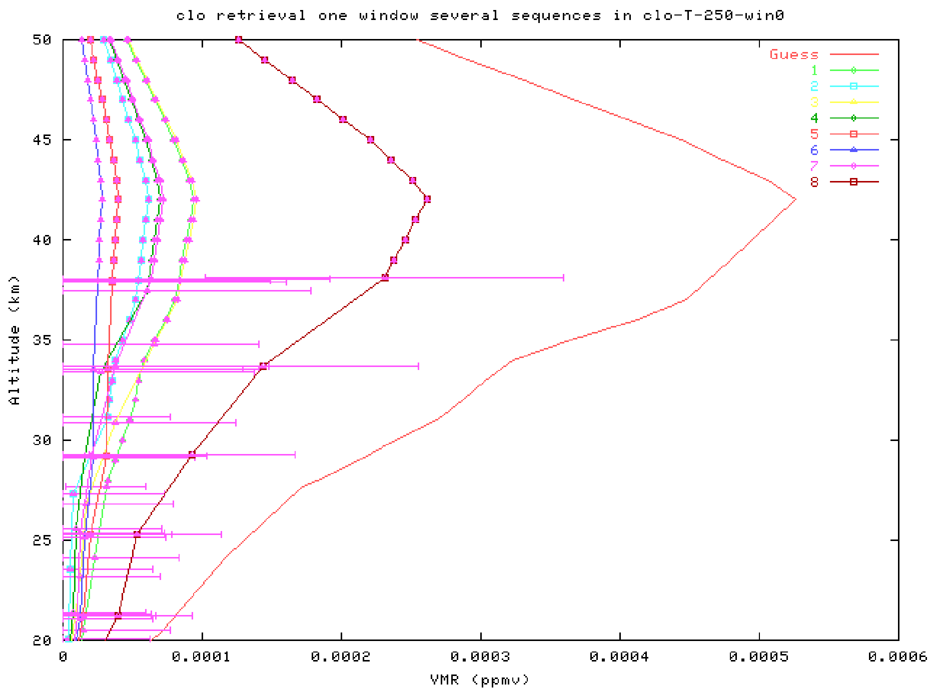

Fig. 10 – Profile of ClO measured from balloon

5 CONCLUSION

Preliminary analysis of the measurements taken during the transmediterranean flight show that, within the limits of a comparison made using data taken several degrees apart (or several hours apart), the results obtained by MIPAS and those obtained by IBEX are in close agreement. Self consistency of results obtained by IBEX for Ozone and external consistency for ClO confirm that the instrument was working properly.
It has not been possible up to now to start analysis of the results for the 120 cm^{-1} band (molecules: H_2O and HCl) .

6 ACKNOWLEDGEMENTS

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