Middle Atmosphere retrievals using ENVISAT MIPAS data

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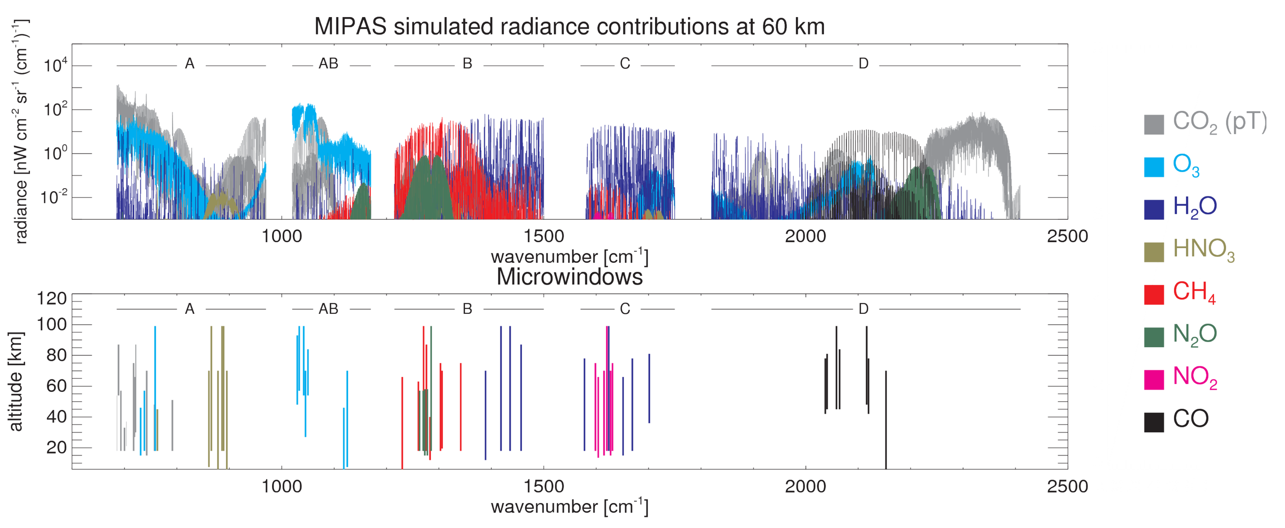
INTRODUCTION

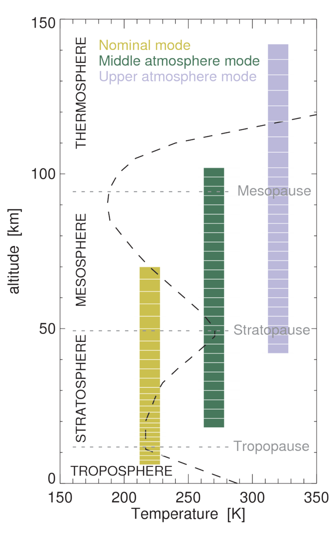
MIPAS is a high resolution Fourier Transform Spectrometer on board the ENVISAT satellite (launched in March 2002). It makes global measurements in the infrared spectrum in the range 685-2410 cm^{-1}. MIPAS nominally scans between 6 to 70 km, but under special viewing modes its altitude coverage can be extended well into the thermosphere [1].

We present a brief comparison of retrievals of middle atmospheric (MA) data, obtained using MIPAS Orbital Retrieval using Sequential Estimation (MORSE), with the satellite observations from the Microwave Limb Sounder (MLS), the Sounding of the Atmosphere using Broadband Emission Radiometry (SABER) instrument and the closest MORSE nominal (NOM) mode observations.

The MORSE retrieval algorithm develped at Oxford University [2] uses an optimal estimation constraint [3]. It exploits redundancy in the MIPAS measurements which allows the selection of subsets of spectra (Microwindows) that maximize the information content. Although MORSE makes no allowance for nonLTE emissions the microwindows selection attempts to minimise such effects.

Below is a simulated spectrum for a tangent height of 60 km with the microwindow positions for all the retrieved parameters in the middle atmosphere observations, and figure illustrating the different MIPAS observational modes.





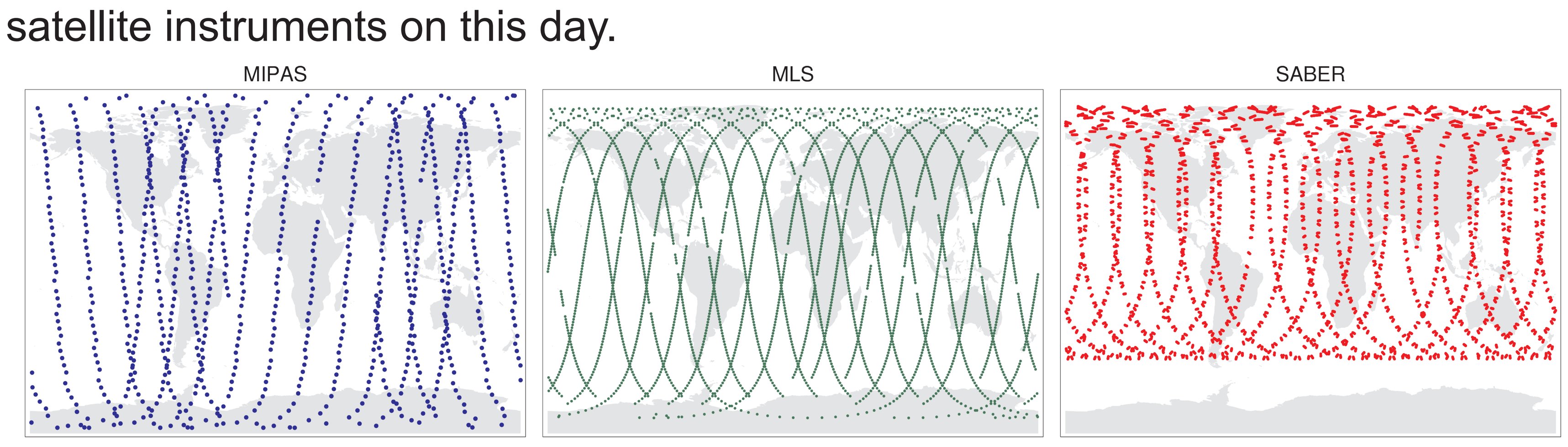
The Microwave Limb Sounder (MLS) on board the AURA spacecraft (launched in July 2004) is an instrument that measures thermal microwave limb emission in five spectral regions from 115GHz to 2.5THz. MLS scans the limb vertically to ~95 km every day, with coverage between 82S to 80N, providing near global coverage [4].

The Sounding of the Atmosphere using Broadband Emission Radiometry (SABER) instrument is an infrared radiometer on board the TIMED satellite (launched in December 2001). TIMED has a circular orbit which precesses relative to the local solar time, and is therefore rotated 180º in the yaw direction every 60 days. SABER observes thermal infrared limb emission in 10 channels between 650-5880 cm^{-1} up to 400 km [5]. It obtains profiles from 52S to 83N for about 60 days and then from 83S to 52N for another 60 days before returning to the first latitudinal coverage.

METHODOLOGY

As a first method of comparison, the zonal mean and their relative difference for the 7th June 2007 for MIPAS MA, MLS and SABER datasets are shown in the following column for temperature, ozone and water vapour. In addition the zonal mean for the 8th of June 2007 for MIPAS NOM is shown. This approach allows the differences between the datasets to be spotted easily.

The Figure below illustrates the different degrees of spatial coverage for the satellite instruments on this day.

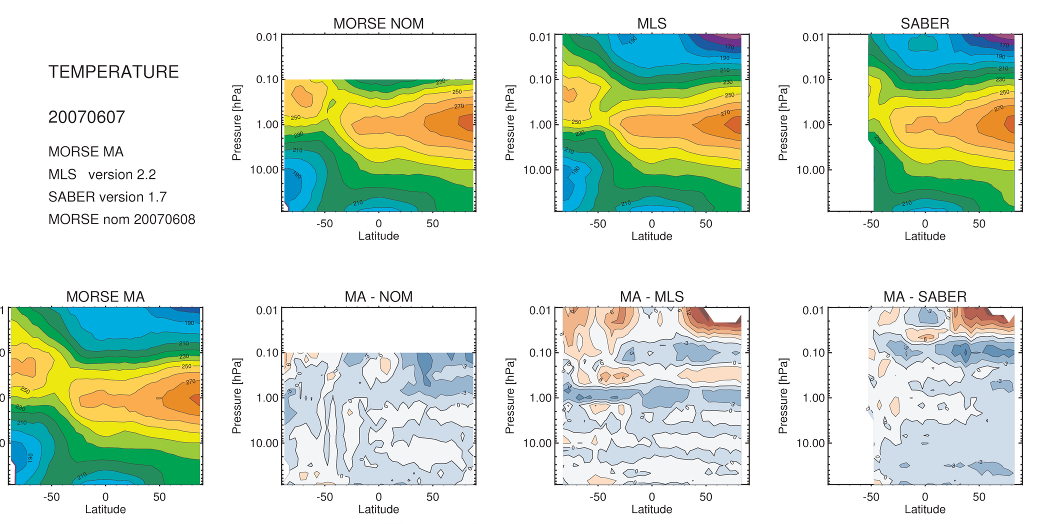


To confirm the conclusions drawn from the zonal mean plots, the data for MA observations between April 2007 and May 2008 (84 days) were averaged into seasonal bins to produce a summary of the biases (MIPAS MA - others) between the datasets. These data were divided into latitude bins (80S-50S, 20S-20N and 50N-80N) and then sorted into polar winter, equator and polar summer according to the day analysed.

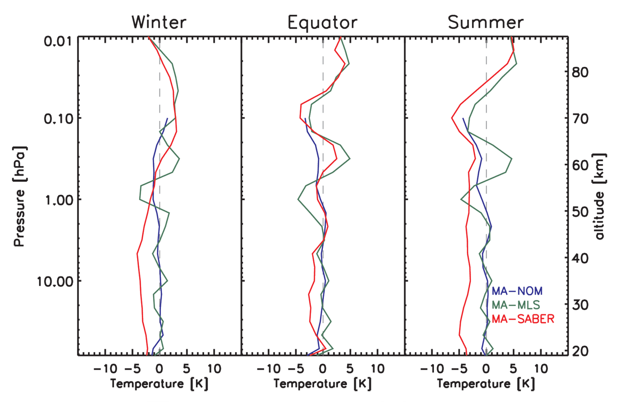
The final test is a comparison of the day and night differences (except for the SABER dataset because its local solar time varies). Each dataset is divided into day and night observations and the difference between the two is taken. Considering that all the instruments should observe the same diurnal variation, any major difference between them should reveal systematic errors. This test should also reveal problems at high altitudes related either to nonLTE emission (MIPAS MORSE) or Zeeman splitting (MLS).

Although these comparisons are shown only for temperature, ozone and water vapour, they could equally applied to any of the retrievable parameters for the MA.

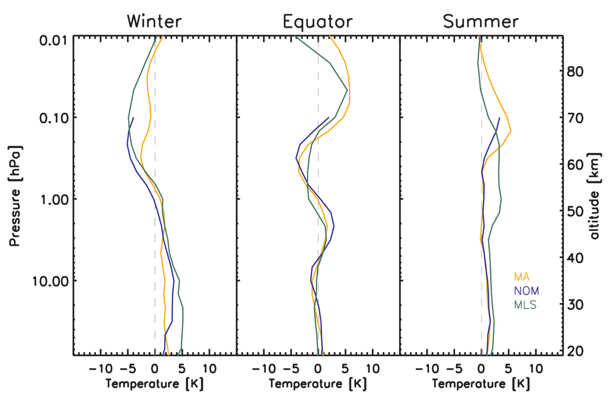
TEMPERATURE



Zonal mean



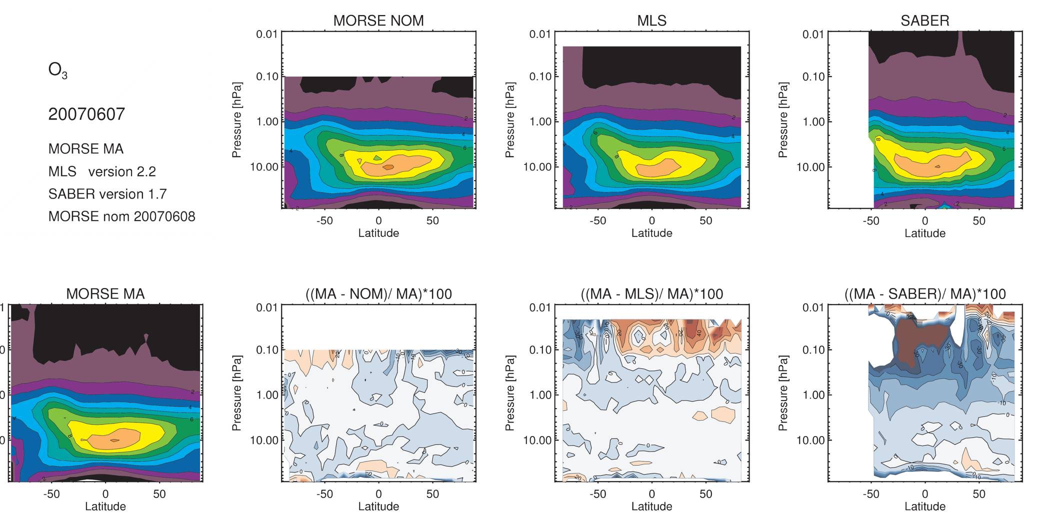
Temperature biases



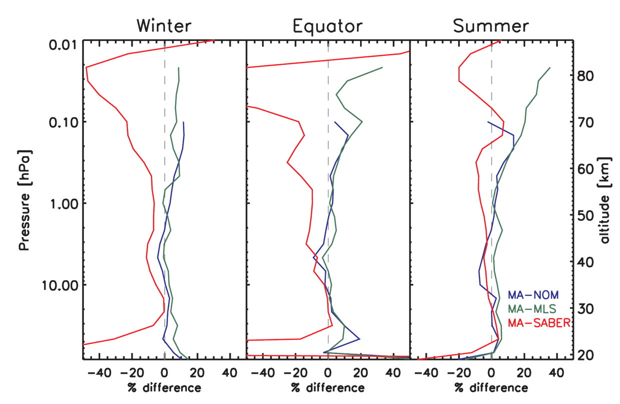
Day - Night differences

- As can be seen, below 0.5hPa, the biases are less than 3K for all datasets except for the SABER bias which always presents a negative bias up to ~5K.
- Between, 0.5hPa and 0.1hPa there is a series of maxima and minima when comparing to MLS and SABER which may be due to the different local solar times.
- Above 0.1hPa, there is a clear positive bias, specially at the polar summer region probably due to nonLTE emission.
- MIPAS MA, MIPAS NOM and MLS show the same diurnal variation up to 0.2hPa.
- In the day-night differences, a clear signature of the diurnal tide can be found in the equatorial bin.

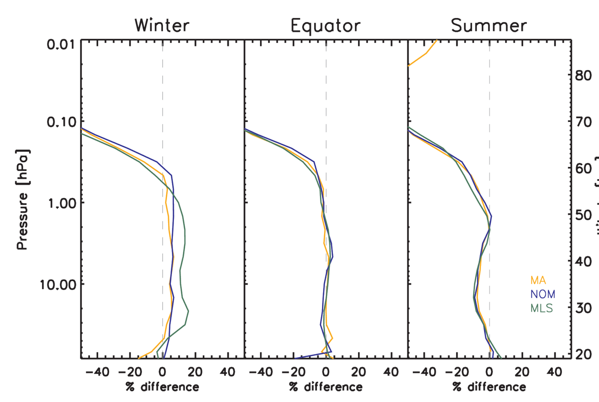
OZONE



Zonal mean



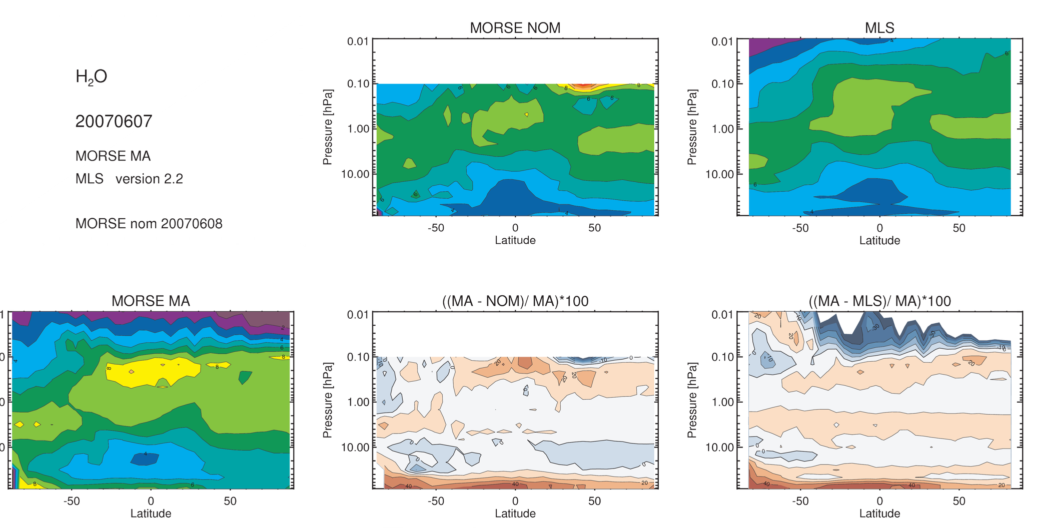
Ozone biases



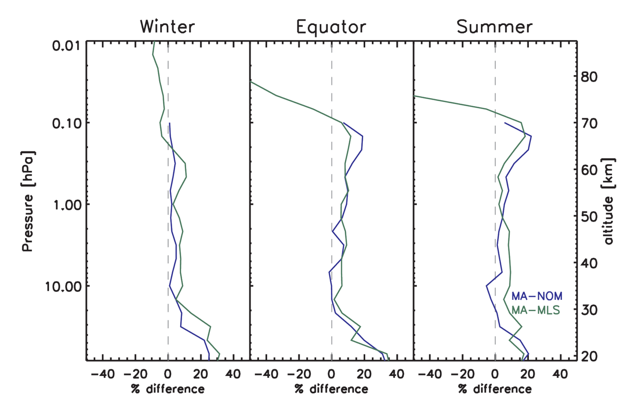
Day - Night differences

- Except for the lowest pressure level, the ozone biases between MA, NOM and MLS below ~0.1hPa is less than 10%.
- Above ~0.1hPa there is a positive bias presumably due to the temperature bias at those heights
- The Ozone polar winter descent can be seen in the Zonal mean plots for MA and MLS.
- SABER ozone biases shows clear discrepancies in the SABER dataset.
- MIPAS MA, MIPAS NOM and MLS shows the same diurnal variation.

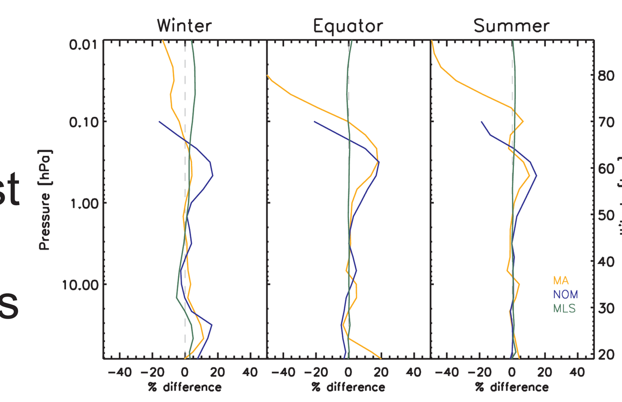
WATER VAPOUR



Zonal mean



Water Vapour biases



Day - Night differences

- MIPAS MA again shows a problem at the lowest pressure level.
- There is clear positive bias in all seasonal bins ~0.3hPa (also found in the zonal mean graph)
- Above ~0.3hPa there is a negative bias.
- MIPAS MA and MIPAS NOM shows a diurnal variation not present in the MLS dataset.
- Unfortunately, SABER water vapour data is not yet publicly available

CONCLUSIONS

Problems around the lowest altitude levels of the MA were found and therefore a revision of these tangent heights retrievals is needed. Also, nonLTE effects are probably biasing the MIPAS retrievals at high altitudes.

Despite these problems, some atmospheric features were distinguished such as the polar winter ozone descent and the solar tide signature.

REFERENCES

[1] Endemann,M, 1999: MIPAS instrument Concept and Performance
[2] Dudhia: http://www.atm.ox.ac.uk/MORSE
[3] Rodgers, C, 2000: Inverse methods for atmospheric sounding Theory and Practice. World Scientific
[4] Waters et al. 1999: The UARS and EOS Microwave Limb Sounder Experiments. Journal of Atmospheric Sciences, 56, 194-218
[5] Mlynczak, M, 1997: Energetics of the mesosphere and lower thermosphere and the SABER experiment. Advance Space Research, 20, 1177-1183

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