MIPAS AS A MESOSPHERIC INSTRUMENT

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ABSTRACT

The mesosphere has not attracted much attention from the science community mainly due to a lack of instruments capable of sounding this region. MIPAS includes the lower mesosphere in its nominal scan mode and its altitude coverage can be extended well into the thermosphere by using special viewing modes. In this paper mesospheric spectra are analyzed from a calibration point of view although similar techniques can be applied to detect real atmospheric features. After applying spectral masks to remove atmospheric emission lines, large number of the remaining spectra are averaged to check the calibration of the forward and reverse offset and to validate the noise equivalent spectral radiance (NESR).

Key words: Mesosphere; offset; NESR.

1. INTRODUCTION

The Michelson Interferometer for Passive Atmospheric Sounding (MIPAS) is a Fourier transform spectrometer conceived to detect limb emission spectra on a global scale. MIPAS covers the infrared spectral region between 4.1 μm (2410 cm^{-1}) and 14.6 μm (685 cm^{-1}) where emissions features from many atmospheric species are present. Although the main goal of MIPAS is the study of stratospheric chemistry, the lower mesosphere is part of its nominal observation sequence and by using special viewing modes its altitude coverage can be extended well into the thermosphere. Fig. 1 summarizes three of the current MIPAS observation modes that measure a part or the whole mesosphere: (1) the nominal mode cover heights between 7-70 km with a floating altitude grid consisting in 27 steps per scan, (2) the middle atmosphere mode covering the altitude from 18 to 102 km in 29 steps per scan, and (3) the upper atmosphere mode which covers the altitude region from 42 to 172 km in 35 steps per scan.

At mesospheric heights, the emission lines from most gases are sparse and weak in amplitude and so the signal to noise ratio (S/N) is low. In this region non local thermodynamic equilibrium (non-LTE) effects become more

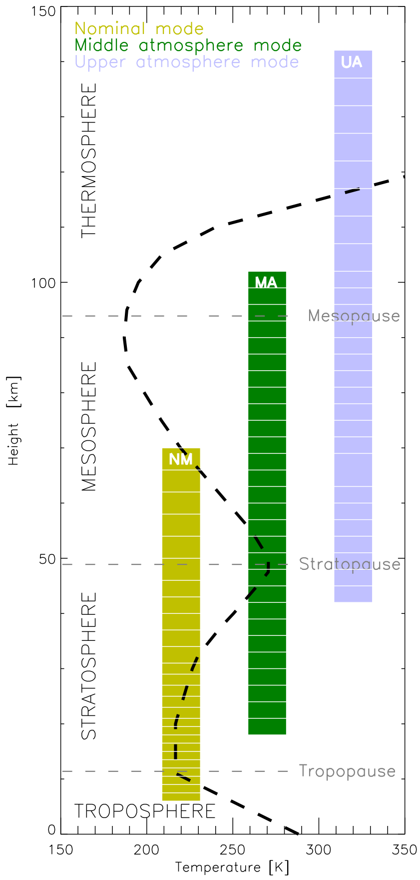

Figure 1. MIPAS observation modes that covers a part or the whole mesosphere.

significant[1]. In this scenario the use of the standard microwindow approach (as used for the retrievals of the L2 products) is impractical. However mesospheric spectra can be used for checking the calibration.

Mesospheric emission lines have been identified and masked with the help of a line-by-line radiative transfer model. Considering that all atmospheric emissions have been masked, the remaining spectra are assumed to be the space offset (mainly the self thermal emission of the in-

[1] non-LTE effects imply that the local kinetic temperature and the Planck temperature of the radiation fields are different.

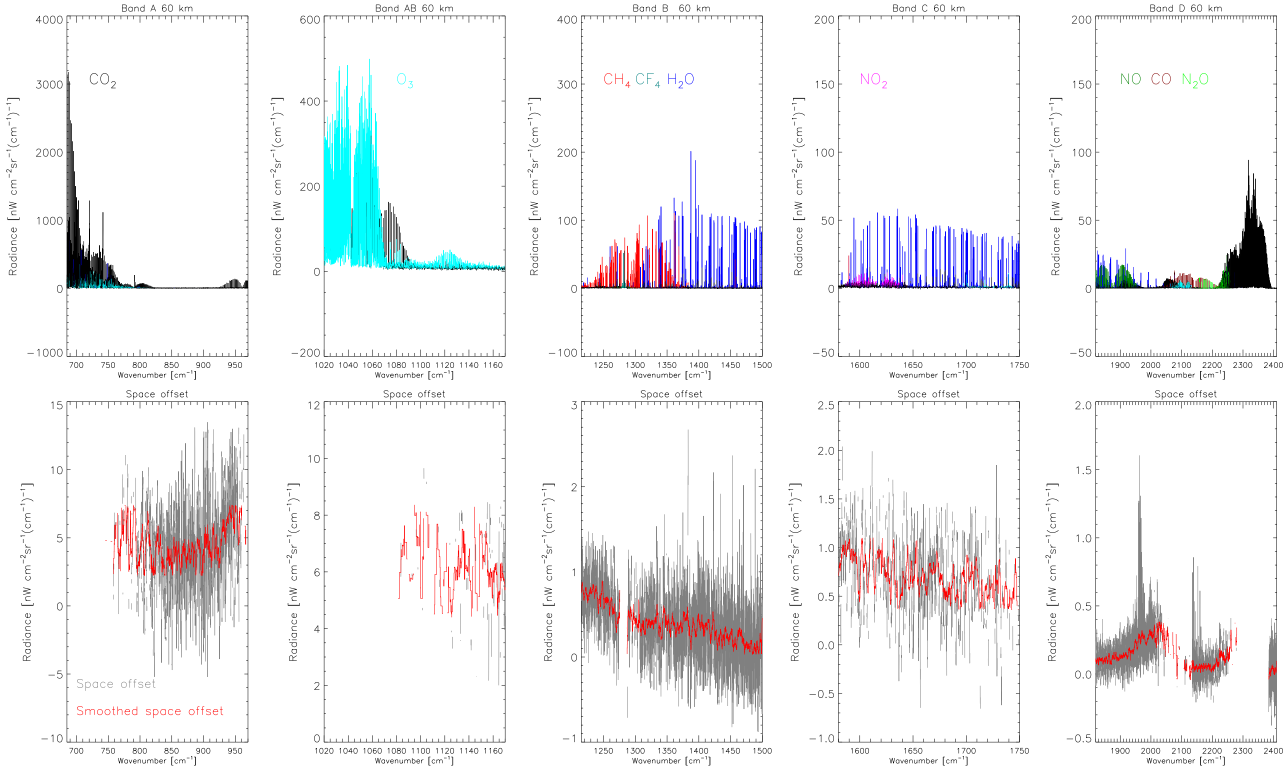

Figure 2. Averaged spectra measured for 07 June 2003, each detected molecule is represented by one colour (top panels), and the space offset remaining after applying spectral masks (bottom panels).

strument) and can be used to detect instrument artefacts or to verify the radiometric noise estimates. A large number of spectra can be averaged to improved the S/N ratio. Fig. 2 displays (the top panels) the averaged spectra measured for 07 June 2003, as well as (the bottom panels) the space offset remaining after the application of the spectral masks, for the 5 MIPAS bands at 60 km. An unexpected emission feature remains in band D at 1920 cm^{-1}. Further research should be done to identify this molecule and apply the appropriate spectral mask. The space offset remains below 10% of the noise specifications. The specified NESR values varies from 50 (at Band A) to 4.2 nW cm^{-2}sr^{-1}(cm^{-1})$^{-1}$ (at band D). Fig. 3 shows the distribution of the mean of the space offset for band A at the tangent height of 60 km for the observations made on 07 June 2003. The highest offsets of the order of 10 nW cm^{-2}sr^{-1}(cm^{-1})$^{-1}$ (approximately 20% of the noise expected for this band) are at the south east of South America revealing a systematic error that needs to be understood. This behaviour may be related to the South Atlantic anomaly.

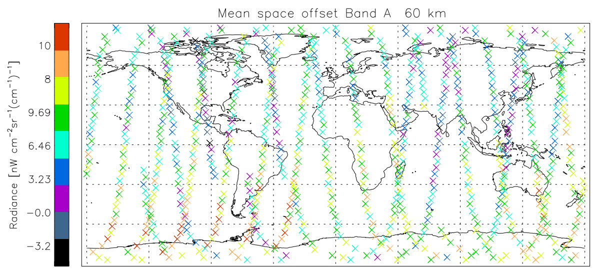

Figure 3. Latitude and longitude distribution of the mean smoothed space offset for band A at 60 km.

2. FORWARD AND REVERSE OFFSET

The MIPAS instrument design is based on the classical Michelson interferometer. Each spectrum is obtained either by a forward or a reverse sweep of the mirrors, and forward and reverse spectra are calibrated independently. Ideally the space offset should be zero for both directions. Fig. 4 compares the radiometric forward (in blue) and reverse (in red) space offset averaged over one day, for full and reduced resolution data for the 5 MIPAS bands at 60 km. For the full resolution data, small systematic differences remain in the calibrated spectra. These differences agrees with the results obtained by [1]. In the case of the reduced resolution data no evident difference between the two directions was found although the offset is still nonzero. Two different days are shown (first two rows) for the full resolution mode to show that the systematic difference was persistent in time.

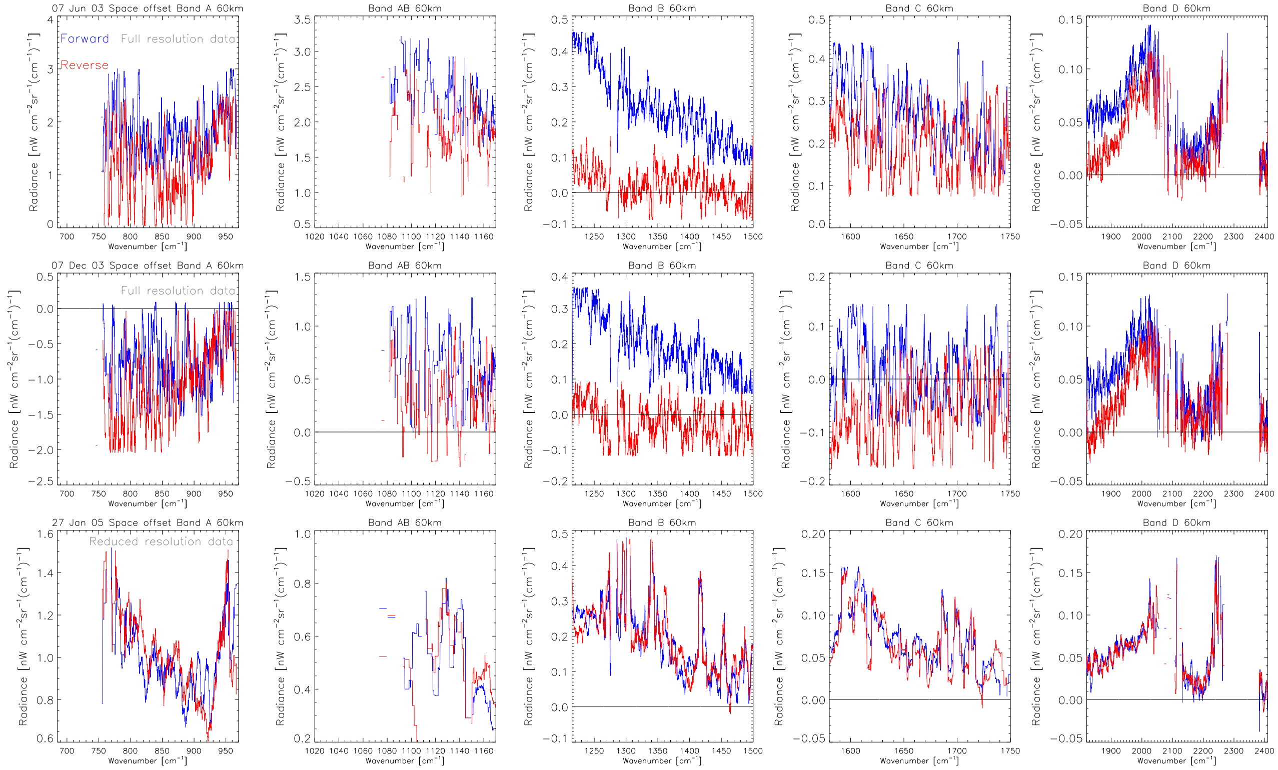

Figure 4. Forward and reverse offsets derived from the mesospheric space offset for full resolution data (first two rows) and for the reduced resolution data (bottom).

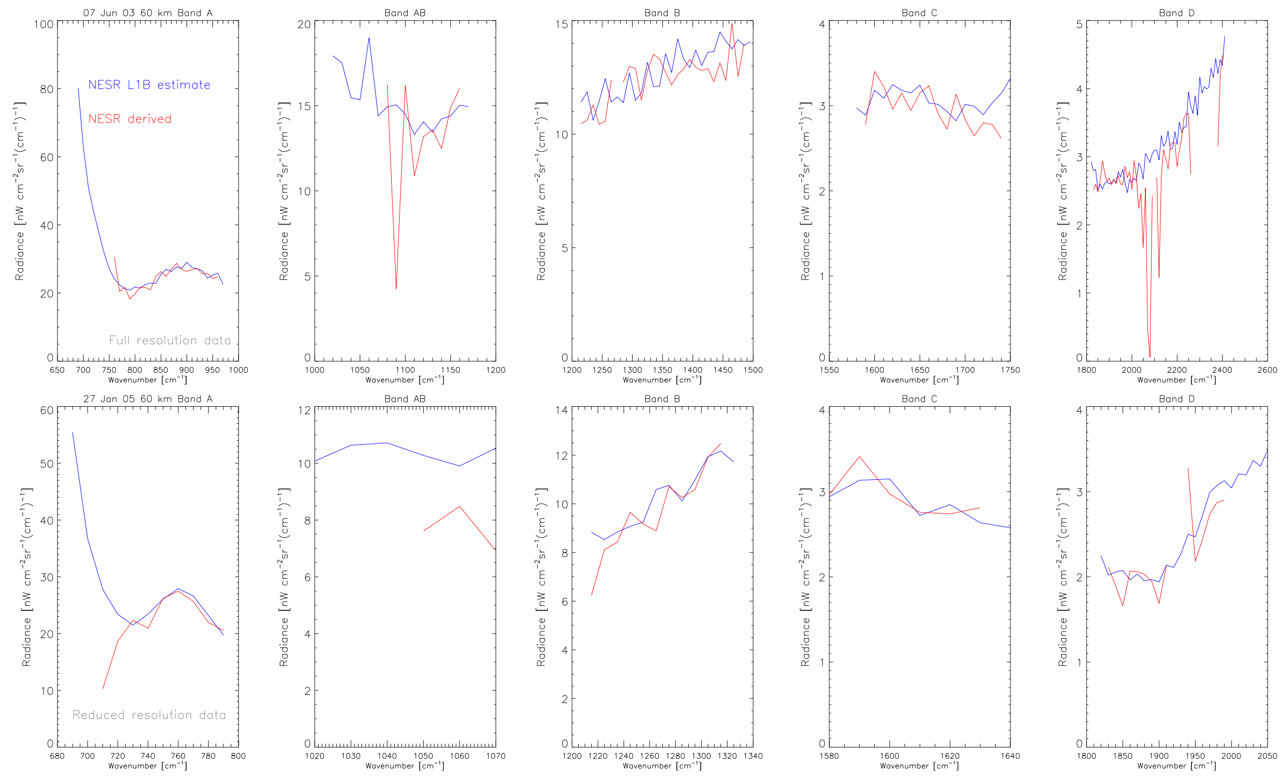

Figure 5. Comparison between the reported L1B NESR and the derived NESR from the mesospheric space offset for full resolution data (top panels) and reduced resolution data (bottom panels).

3. NOISE EQUIVALENT SPECTRAL RADIANCE

MIPAS estimates NESR from the imaginary part of the spectra based on the assumption that this part should be composed only of noise. The NESR is reported for the whole MIPAS spectral range and can be found in the L1B data. Using a simple standard deviation approach the space offset at mesospheric altitudes can be used to derived the noise estimate. Fig. 5 shows the difference between the noise estimates coming from the L1B data and the derived noise using the mesospheric space offset standard deviation for full resolution data (top panels) and for reduced resolution data (bottom panels) for the 5 MIPAS bands at 60 km. Generally these are in good agreement, the large variability in the derived values is due to the averaging over spectral regions containing zero values. In that regions atmospheric emission lines were present and therefore masked out. The NESR values remains into the design specifications.

4. ATMOSPHERIC FEATURES

Mesospheric spectra can also be used to investigate atmospheric phenomena. Assuming that the tangent paths are optically thin, it may be possible to use the mesospheric spectra to retrieve mesospheric temperature and composition using a simple linear retrieval. This should allow the full spectral signature of the target molecules to be used, rather than just microwindows, and provide retrievals of improved precision, if not accuracy, compared to the operational products at altitudes above 50 km. Also, signatures of polar mesospheric clouds (PMC) should appear in the space offset either as an offset increment or as an emission feature. Unexpected molecular emissions should also be observable.

5. CONCLUSION

Mesospheric spectra have been used to check the calibration of the forward and reverse offset. An small systematic difference has been found for the full resolution data. For the reduced resolution data good agreement has been found between the two directions offsets. In the two data sets, the offsets remain below 10% of the NESR specifications and are still non-zero. Also, the NESR estimated with the imaginary part of the spectra has been verified against the derived NESR from the space offset spectra. No systematic difference has been found between the two. A brief description of how mesospheric spectra can be used to derived real atmospheric features has been given. The mesosphere investigation is an ongoing research and MIPAS observations are an important database for work in this branch.

REFERENCES

[1] Kleinert A., Status of the Level-1b processing of MIPAS data in the full resolution mode, (this workshop)