in der Helmholtz-Gemeinschaft

Universität Karlsruhe (TH)

M. Kiefer, T. von Clarmann, F. Hase, M. Höpfner, H. Fischer, N. Glatthor, U. Grabowski, S. Kellmann, A. Linden, G. Mengistu Tsidu, M. Milz, T. Steck, G. P. Stiller, and D.-Y. Wang

Universität Karlsruhe/Forschungszentrum Karlsruhe GmbH, Institut für Meteorologie und Klimaforschung, Karlsruhe, Germany

Bernd Funke and Manuel López-Puertas

Instituto de Astrofísica de Andalucía, CSIC, Granada, Spain

SOME RESULTS ON MIPAS/ENVISAT INFLIGHT INSTRUMENT CALIBRATION

Noise (NESR) and Noise Correlation

NESR is estimated by statistical analysis of calibrated spectra in gaps between spectral lines. Gaps are selected from synthetic spectra as spectral regions with at least 20 consecutive spectral points, where radiance values are less than 10% of the expected NESR, and variance of radiance is less than 5% of squared expected NESR.

In the gaps the standard deviation of the measured spectrum, which gives an estimate of the NESR, was calculated and assigned to the centre of the respective gap. Figure 1 (upper panel) shows an example. The criteria for gap selection allow for some residual variance in the gaps, even for noise free synthetic spectra. Hence the NESR determined by this method is an upper estimate of the real NESR.

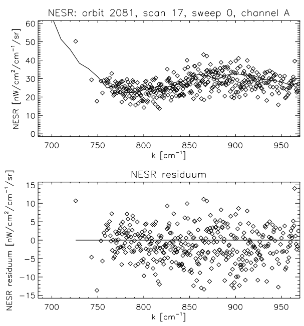

Figure 1: NESR estimate and NESR residuum in channel A for orbit 2081, altitude is 69 km.

From the estimates for NESR, the NESR value delivered with the level 1b data were subtracted. Since this latter data is only defined as a constant value for intervals of width 10cm^{-1}, the calculation of the differences was done accordingly. The result is one NESR residuum value per spectral gap, channel, scan, and height (Figure 1, lower panel). The squared NESR residuals then were summed up over spectral gaps and scans and the square root of the resulting quantity is taken. The resulting value ΔNESR depends on MIPAS channel and height.

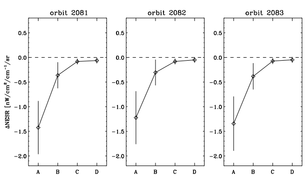

Figure 2: Dependence of ΔNESR on MIPAS channel for orbits 2081–2083 at altitude 69 km.

Figure 2 shows that NESR delivered with L1B data is somewhat overestimated. Since the estimated NESR is an upper estimate the differences might be larger as depicted here.

To calculate the noise correlation radiance values for wave numbers within the spectral gaps were collected from subsequent scans of one orbit into one data series for each tangent height separately. Covariance matrices were calculated between series of this kind for spectral grid points located within one spectral gap of at least 20 spectral points. The maximal lag in the spectral domain is given by the width of the gaps. Accordingly the covariance matrices are symmetric 20×20 matrices. The matrices were coadded for given height (sweep), channel and orbit to get the values $C_{i,j}$ with $i,j = 1\ldots20$. The matrix entries then were $C_{i,j}$ divided by the according diagonal entries, which gave the correlation coefficients $r_{i,j} = C_{i,j}/\sqrt{C_{i,i}C_{j,j}}$.

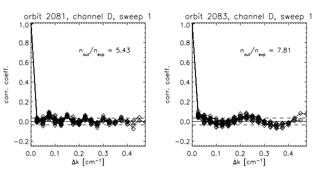

Figure 3: Rows of correlation coefficient matrix $r_{i,j}$ in MIPAS channel A for altitude 69 km.

In Figure 3 two examples of $r_{i,j}$ values are shown. There are residual oscillations with highly significant amplitude. This is a hint for residual spectral features which are not of atmospheric origin.

Instrument Line Shape (ILS)

Two parameters which describe the ILS, "modulation efficiency" and "phase error" (see [1] for more details), were retrieved from averaged L1B spectra of approx. 47 and 53 km nominal tangent height. The parameters describe the additional corrections to be applied to spectra convolved with the nominal ILS model and thus allow an assessment of the nominal ILS parameters. A modulation efficiency less than 1 means that the actual ILS is broader than the nominal ILS. A nonzero phase error parameter maps to a shift in the spectrum. If the ILS parameters gave the ILS of MIPAS perfectly, modulation efficiency would be one and phase error would be zero.

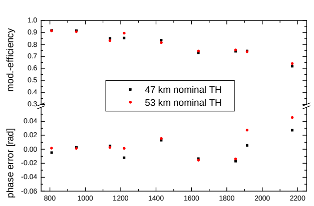

Figure 4: Modulation efficiency and phase error for coadded orbits 2081–2083.

Single spectra generally were much too noisy to allow for a reliable estimate of modulation efficiency and phase error. Due to this reason spectra for the two altitudes were coadded separately for all three orbits (2081–2083) and the SNR therefore increases by a factor of approx. 14.

Figure 4 shows the result of the retrievals of modulation efficiency and phase error for several wave numbers. The modulation efficiency steadily decreases with wave number, while the shift error develops from virtually zero at low wavenumbers towards positive values. This indicates that the ILS parametrization delivered with the L1B data can be improved. In particular the wave number dependence is not sufficiently described.

Spectral Shift

The spectral shift was retrieved with the IMK retrieval processor for all five spectral bands of MIPAS together. A set of 20 microwindows was used. The retrieved shift values were fitted to the linear model $k_{\text{corr}} = f_{\text{corr}}\ k + k_{\text{offset}}$. The wavenumber which does not need a shift correction is given by $k_0 = -k_{\text{offset}}/(f_{\text{corr}} - 1)$.

Table 1: Mean values and standard deviations for $f_{\text{corr}} - 1$, k_{offset}, and k_0.

orbit	2081	2082	2083
$f_{\text{corr}} - 1[-]$	$2.11\cdot10^{-6} \pm 3.8\cdot10^{-7}$	$1.92\cdot10^{-6} \pm 4.0\cdot10^{-7}$	$2.05\cdot10^{-6} \pm 2.9\cdot10^{-7}$
k_{offset} [cm^{-1}]	$-2.55\cdot10^{-3} \pm 2.8\cdot10^{-4}$	$-2.51\cdot10^{-3} \pm 2.5\cdot10^{-4}$	$-2.56\cdot10^{-3} \pm 2.1\cdot10^{-4}$
k_0 [cm^{-1}]	1233 ± 196	1341 ± 227	1264 ± 180

Table 1 shows that there exists a small systematic spectral shift. The reason is that the shift correction at ESA's processing facilities is done according to a linear model $k_{\text{corr}} = K_{\text{SC}}\ k$ which obviously is not perfectly suited for this purpose.

Line of Sight (LOS)

The LOS was retrieved directly from the MIPAS spectra along with the temperature profile, offset and continua, using the IMK data processor (see Ref. [2] for details). Figure 5 shows an example for the difference between retrieved tangent altitude and engineering height information. Pointing differences of up to 3 km have been detected (limb scans 0—10), as well as pointing discontinuities (between limb scans 10 and 11). ESA finally could attribute the pointing discontinuities (pitch jumps) to updates of the on-board orbit model coefficients sent to the satellite's attitude and orbit control system. Furthermore a bias as well as harmonic correction has been applied to the nominal pointing calibration, which is based on measurements of appearance/disappearance times of bright infrared stars in the MIPAS field of view. For measurements taken on December 2, 2002 (orbit 3959) MIPAS pointing as inferred with the upgraded ESA pointing scheme has been investigated (see Fig. 6). There is some indication of over-compensation, since now there is a bias of the ESA pointing data of -780 m with respect to the IMK-retrieved pointing data. However, the remaining differences between corrected nominal pointing and retrieved pointing are within the accuracy specification of the star-tracker based pointing system.

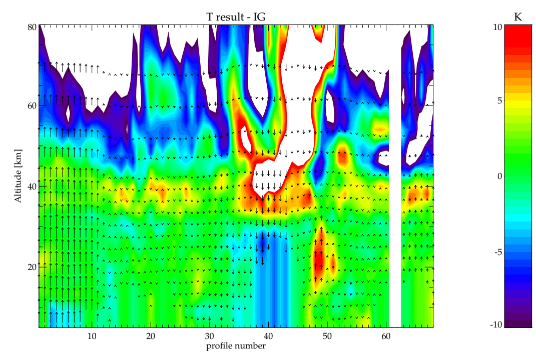

Figure 5: Difference between retrieved temperature and ECMWF field (coloured background) and difference between retrieved tangent altitude and engineering height (arrows) for orbit 2081.

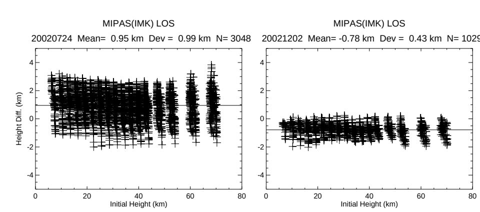

Figure 6: Scatter of differences between LOS retrieved at IMK and engineering pointing information. Left: summary for orbits 2081–2083, right: orbit 3959.

References

[1] F. Hase, T. Blumenstock and C. Paton-Walsh, Analysis of the instrumental line shape of high–resolution Fourier transform IR spectrometers with gas cell measurements and new retrieval software, Appl. Opt. 38, No. 15, pp. 3417–3422, 1999

[2] T. von Clarmann et al., Retrieval of temperature and tangent altitude pointing from limb emission spectra recorded from space by the Michelson Interferometer for Passive Atmospheric Sounding (MIPAS), J. Geophys. Res., accepted, 2003

Acknowledgment: This work was funded by ESA under contract no. 15530/01/NL/SF.