# Impact of Reduced Resolution on MIPAS

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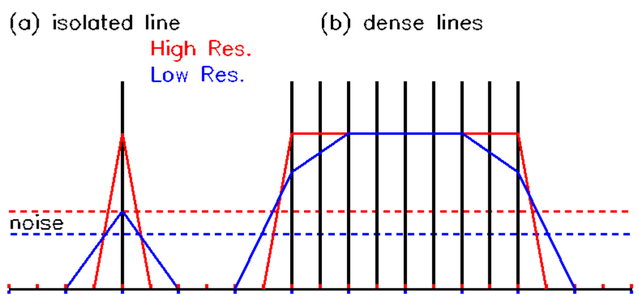
## ABSTRACT

MIPAS was operated from July 2002 – March 2004 at 20cm maximum OPD, giving a nominal 0.025cm-1 resolution. However, following problems with the interferometer slide mechanism, subsequent operations have been restricted to 40% resolution (8cm maximum OPD, or 0.0625cm-1).

The reduced resolution does not appear to cause any significant problem in retrieving the main emitting species and since more spectra can be measured in a given time this may actually represent an improvement in scientific return, either through improved horizontal or vertical resolution.

## THEORY

The figure shows the effect of reducing the spectral resolution by factor R when observing (a) isolated lines and (b) dense line spectra, assuming that the underlying atmospheric features (shown in black) are narrower than even the higher resolution ILS.




For isolated lines the 'signal' is reduced by a factor R while for dense features it remains constant.

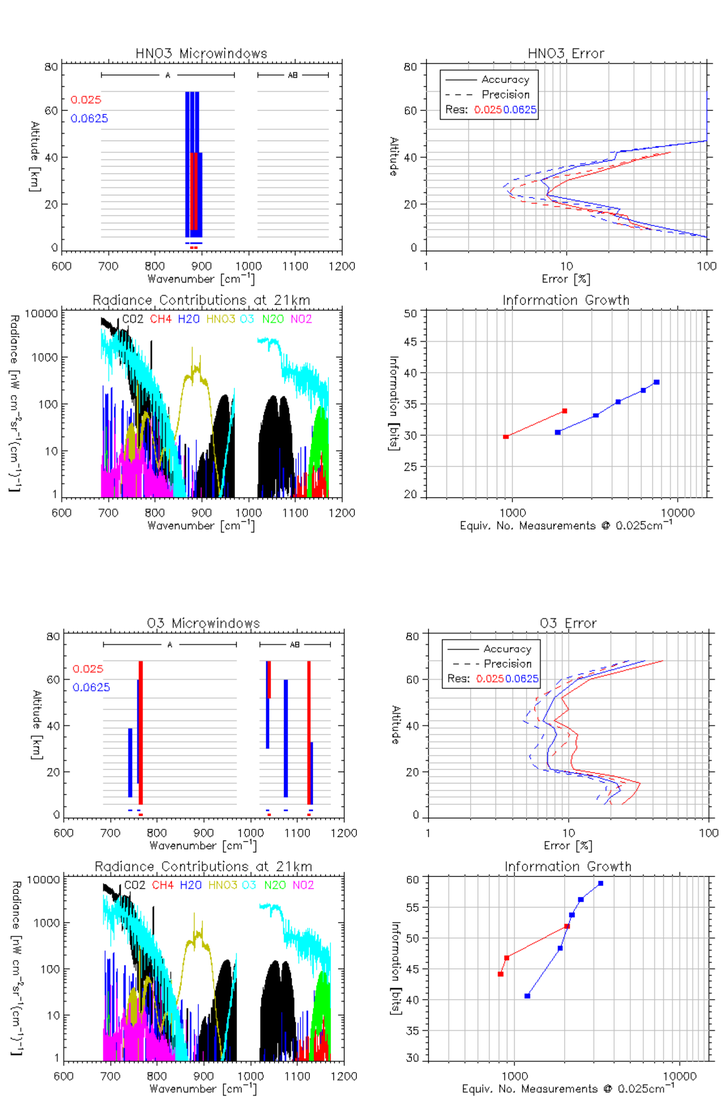
For a fixed interferometer slide speed the spectral noise (e.g. nW/(cm$^2$ sr cm$^{-1}$)) is reduced by a factor $\sqrt{R}$.

For isolated lines the S/N is reduced by a factor $\sqrt{R}$ while for dense features it is increased by a factor $\sqrt{R}$. However, the number of spectral points is reduced by a factor R so the integrated S/N across the dense feature remains constant.

So, for MIPAS the retrieval precision for a given total microwindow bandwidth would be expected to remain the same or worsen by a factor up to $\sqrt{R} = 1.6$, depending on the type of spectral features used.

## RESULTS

The plots below show a comparison of the microwindows selected for HNO3 (top) and O3 (bottom). See panel below for details.




## MICROWINDOW SELECTION

Microwindows are selected so as to minimise the total error covariance ('accuracy')

$$\mathbf{S}^{tot} = \mathbf{S}^{rnd} + \sum \mathbf{S}^{sys}$$

which is the combination of the random error ('precision', due to instrument noise) and various systematic errors arising from uncertainties in contaminant species profiles, instrument calibration, forward model approximations etc.

This minimisation is expressed as `Information Content' , H, measured in `bits'

$$H = -\tfrac{1}{2} \log_2 | \mathbf{S}^{tot} \mathbf{S}_a^{-1} |$$

where $\mathbf{S}_a$ is some *a priori* covariance, assumed here to be equivalent to a 100% uncertainty in concentration. One `bit' of information is equivalent to reducing the SD at one profile level by a factor 2

## DISCUSSION

The 0.025cm$^{-1}$ resolution microwindows are those which were used in the operational retrievals, restricted by CPU considerations. The first 5 selected 0.0625cm$^{-1}$ resolution microwindows are plotted for comparison, illustrating that for the major emitting species, accuracy can always be improved by adding more microwindows (at the expense of more computing time).

HNO3 is a molecule for which individual lines are resolved within each microwindow and random errors dominate, hence the information content curves for the two resolutions show a clear advantage for the higher resolution (i.e. require fewer measurements for a given information). .

O3 has a dense spectrum and significant systematic error contributions. The two information content curves overlap implying no clear advantage in using the higher spectral resolution.

## VERTICAL SAMPLING

The above discussion has assumed that the atmosphere is sampled at the same tangent heights at the two resolutions. Since the low resolution spectra are acquired in only 40% of the time of high resolution spectra this allows profiles to be obtained every 200km rather than every 500km. MIPAS was operated in such a mode during August 2004.

However, since the beginning of 2005 the scan pattern has been changed to increase the number of tangent heights per profile from 17 to 27, while reverting to the original horizontal resolution.

The new scan pattern includes oversampling the UTLS region: 1.5km steps with a FOV 3km high. Work is now under way to try and establish which, if any, species can be retrieved at 1.5km resolution. This will certainly require more microwindows than previously used, hence more CPU time.