MIPAS Ozone Retrievals in the UTLS

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INTRODUCTION

The UTLS is a region of the atmosphere with steep vertical gradients in the concentrations of trace constituents important to climate studies. Changes in the levels of ozone in the UTLS lead to increases in UV flux at the Earth's surface, and changes to the temperature structure and radiative properties of the atmosphere. The new generation of satellite instruments for remote sounding of the atmosphere will provide large amounts of data relevant to our understanding of ozone in the UTLS. The Michelson Interferometer for Passive Atmospheric Sounding (MIPAS), on the ESA ENVISAT-1 platform, observes the atmospheric limb in thermal emission between 6 to 68 km at 3 km intervals. Infrared spectra, in 5 spectral bands between 685 to 2410 cm^{-1}, are measured at each tangent height with an integration time of 4.5 s.

MIPAS Ozone Retrievals

The operational processor for MIPAS data utilizes 3 cm^{-1} wide spectral intervals, or 'microwindows', based on the concept of information content. These microwindows are selected for the whole altitude range (12 to 60 km) and are based on a full error analysis. However, the "total" information content, calculated over the whole profile, is not necessarily the same as the information content calculated over a narrower range of altitudes. In this investigation microwindows are selected for information content calculated over an altitude range covering the UTLS. Figure 1 shows the distribution of the random errors for ozone over MIPAS band AB (1020 to 1170 cm^{-1}). Ozone has strong emission lines at the centre of a band, which saturate around 40 km. Away from the band centre, the emission lines are weaker and it is possible to sound lower in the atmosphere. The random errors $\mathbf{S_x}$ are calculated:

$$\mathbf{S_x} = \left(\mathbf{S_a}^{-1} + \mathbf{K}^T\mathbf{S_y}^{-1}\mathbf{K}\right)^{-1}$$

$\mathbf{S_a}$ is the *a priori* error covariance (taken to be 100% at all levels), $\mathbf{K}$ is the weighting function matrix and $\mathbf{S_y}$ is the measurement error covariance (scaled to a nominal noise equivalent spectral radiance equal to 40 $nWcm^{-2}sr^{-1}(cm^{-1})^{-1}$).

Weighting functions are calculated for a mid-latitude daytime atmosphere containing O_3, CO_2, H_2O, N_2O and CH_4, on the MIPAS scan pattern.

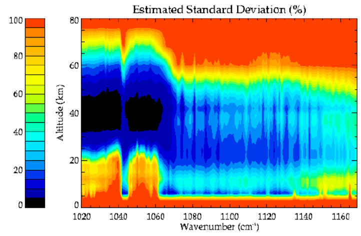

Figure 1

The Information Spectrum

The information content, **H**, of a measurement represents the improvement in the uncertainty of the retrieval when the measurement is used.

$$\mathbf{H} = -\frac{1}{2}\log_2\left|\mathbf{S_x}\mathbf{S_a}^{-1}\right|$$

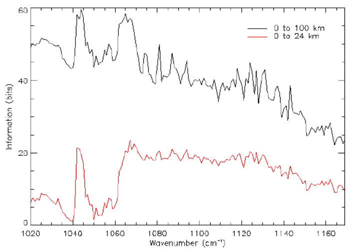

Figure 2

Figure 2 shows the information spectra for MIPAS band AB for altitude ranges between 0 to 100 km and 0 to 24 km.

The MIPAS band is divided into 1cm^{-1} wide 'microwindows' and the information content is calculated for each one. The microwindow with the highest value is selected first. The information content for the remaining microwindows is recalculated, with the highest value selected and the process repeated until all microwindows are selected.

Figure 3a shows how the random error in the lower atmosphere improve as microwindows selected using the whole altitude range are added. The microwindow selection for information content calculated over an altitude range between 0 to 24 km provides a set of microwindows optimised for the lower atmosphere. The index in figures 3a and 3b corresponds to the order in which the microwindows are selected.

UTLS Results

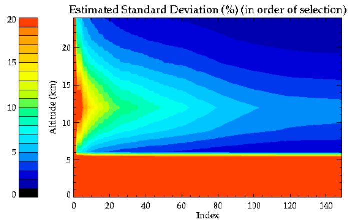

Figure 3a

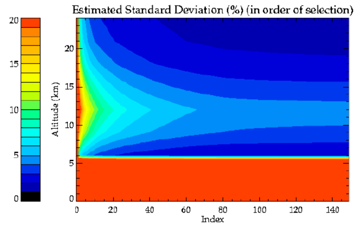

Figure 3b

Figure 3b shows the reduction in random error as microwindows covering 0 to 24 km are selected.

Errors

Errors due to spectral contaminants are linearly mapped into state space by

$$\mathbf{S_{x_b}} = \mathbf{M}\mathbf{S_b}\mathbf{M}^T$$

$$\mathbf{M} = \mathbf{S_x}\mathbf{K}^T\mathbf{S_y}^{-1}\mathbf{K_b}$$

$\mathbf{K_b}$ are the weighting functions of the parameter to be mapped and $\mathbf{S_{x_b}}$ is the total error covariance of the parameter.

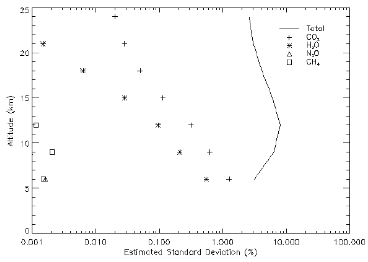

Figure 4

Figure 4 shows the contribution of errors due to the uncertainty in CO_2, H_2O, N_2O and CH_4 to the total uncertainty in the retrieval using the first 20 selected microwindows for the lower atmosphere.

Summary

•Simulations show that microwindows optimised for ozone in the UTLS reduce the total error covariance of the retrieval more rapidly in the UTLS than microwindows selected over the whole profile.

•Inclusion of other spectral contaminants (e.g. CFCs) and ozone lines in other MIPAS bands will further improve the selection.