Abstract

Determination of the instrumental line shape of the Fourier spectrometer MIPAS-B2 from stratospheric spectra

Since 1995 the second version of a cryogenic, balloon-borne Fourier-transform spectrometer has been used for remote sensing of the stratosphere and upper troposphere at the Institute for Meteorology and Climate research. The Michelson Interferometer for Passive Atmospheric Sounding (MIPAS-B2) measures limb emission spectra in the mid-infrared spectral range. In this region many signatures of trace gases are located which are relevant for the earth's climate. Vertical profiles have been retrieved from the measured spectra by means of an inversion method. A feature of these spectra is the change of the original line shape due to the spectrometer. This instrumental property is described with the instrumental line shape (ILS). Its influence can also be seen in the interferograms where the modulation is changed.

The aim of this work was to quantify the influence of the ILS on the retrieved volume mixing ratios (VMRs) of the trace gas profiles and to keep this influence below 1 %. Furthermore a method to calculate the ILS of MIPAS-B2 with the required accuracy was developed.

Calculations with artificial spectra show that for the required accuracy of the VMRs the ILS has to be determined with an accuracy of approximately 1.7 – 3 % (wavenumber dependent) in the full width half maximum (FWHM). Above that threshold the regularization during the retrieval has to be increased. This can lead to a degradation of height resolution of more than 20 % for temperature and trace gas profiles.

For determination of the ILS a deconvolution method has been developed which calculates the instrumental line shape from all lines within a microwindow simultaneously. Such a method is necessary because lines are densely accumulated in almost every spectral region. The average signal-to-noise ratio in the deconvolution window serves as an indicator for the presence of enough line intensity to apply the

deconvolution method. Under certain conditions, a single wavenumber-independent characteristic modulation function can be calculated from the spectral microwindows. This function is valid for the whole spectral channel. Thus, a method was created which allows to reduce the error of the ILS if calculated from that function. The characteristic modulation function also allows a description for the ILS with only few parameters. Thus, the ILS can be given for any wavenumber in the whole spectral channel.

A series of test calculations shows the ILS dependencies on spectral noise and uncertainties of temperature and VMR profiles which are required for the deconvolution method. The impact of noise becomes significant, if the average signal-to-noise ratio is 2 or less. In recent flights this threshold was exceeded for a sufficient number of spectral ranges in every channel. The FWHM error induced by inaccuracies of the profiles stays below 2 % for realistic assumptions. Using the characteristic modulation function this error can be reduced to less than 1 %.

The instrumental line shape in the considered MIPAS-B2 flights differs rarely more than 1 % from the theoretical FWHM of an interferometer with an evenly illuminated field stop. This shows the very good adjustment of the instrument. In case of increasing deviations during future flights, the calculated ILS must be taken into account in the retrieval of the VMR profiles. Also in this case the application of the described methods keeps the influence of the instrumental line shape on the retrieved volume mixing ratios below 1 %.