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Investigation of height-resolved information in ground-based high-resolution Fourier infrared solar spectra above the Jungfraujoch

B. Barret, M. De Mazière
Belgian Institute for Space Aeronomy, Brussels, Belgium

P. Demoulin, E. Mahieu, F. Mélen
Institut d'Astrophysique et de Géophysique, Université de Liège, Liège, Belgium

B.J. Connor and N. Jones
National Institute for Water and Air Research, Lauder, New Zealand

Abstract.

Vertical profiles of HF, O_3 and HNO_3 have been retrieved from high-resolution solar spectra recorded at the Jungfraujoch Observatory (Swiss Alps, 46.5°N latitude, 8.0°E longitude, 3.58 km altitude). Two algorithms for the retrieval of vertical concentration profiles based on the Optimal Estimation Method have been used. The results of the vertical profile retrievals are compared to the Halogen Occultation Experiment (HALOE) profiles for HF, to the Cryogenic Infrared Spectrometers and Telescope (CRISTA2) second mission (August 1997) profiles for HNO_3 and O_3 and also to nearby ozonesondes and lidar profiles for O_3.

Introduction

For more than a decade, high-resolution Fourier-Transform infrared (FTIR) solar absorption spectra have been recorded at the Jungfraujoch Observatory, which is one of the primary Alpine stations of the Network for Detection of Stratospheric Changes (NDSC).
Two codes have been employed to derive vertical concentration profiles for HF, HNO_3, and O_3. Both algorithms are based on the Optimal Estimation Method. The first one, SFIT2, has been developed in collaboration between NASA Langley Research Center and the New Zealand National Institute for Water and Air Research (NIWA). The second one, SFSP2, has been developed at the Belgian Institute for Space Aeronomy. The performances of the codes are studied using comparisons with other measurements. The retrieved HF profiles are compared with profiles from HALOE for 4 days during the winter 1996. HNO_3 and O_3 profiles are compared to profiles from CRISTA2 (August 1997). Ozone profiles are also compared to profiles from nearby ozone soundings (Payerne) and from the ground-based Lidar at the Observatoire de Haute Provence (OHP). Some examples of these comparisons are given in this extended abstract. More detailed results and discussions will be shown at the conference.

Method

The retrieval method consists in fitting a calculated spectrum to the measured one by adjusting the vertical profile of the target species.
In both codes SFIT2 and SFSP2, the inverse models are based on the Optimal Estimation Method [Rodgers, 1976]. This method is using a statistical approach. The retrieved profile is calculated from a combination of the direct measurement and of an a priori constraint representing a climatological mean profile. Each contribution is weighted by the inverse of its covariance matrix. The method is iterated until the residuals of the fit are below a certain noise level.

HF

HF profiles were retrieved from high resolution solar spectra recorded at the Jungfraujoch Observatory during 4 days during the winter 1996 using both SFIT2 and SFSP. These spectra were recorded with an unapodised resolution of 0.004 cm^{-1} and a signal to noise ratio above 1000. The fits were performed in the microwindow from 4038.70 to 4039.10 cm^{-1}. Figure 1 shows the average retrieved HF profiles using both codes together with the HALOE profiles for latitudes between 44°N and 49°N and for longitude between 98°E and 82°W on January 20th 1996. The average profile retrieved with SFSP falls within the HALOE profiles error bars (1σ standard deviation) at all altitudes while the average profile retrieved with SFIT2 shows a large peak between 15 and 20 km which is above the HALOE errorbars at 19 km. The reasons for this discrepancy between the results from both codes will be discussed.

O_3

For the analysis of O_3, two different microwindows have been used, namely one centered at 1146 cm^{-1} and another one centered at 3039 cm^{-1}. Seven days of correlative measurements with CRISTA2 have been investigated, between August 10 and 16, 1997. Figure 2 shows the result of a retrieval from SFIT2 in the

1146.15 – 1146.9 cm^{-1} window for August 15, compared with the mean of correlative CRISTA profiles, the sonde profile from Payerne and the lidar profile from OHP, all for the same day except for the lidar profile which has been measured one day earlier (August 14). The FTIR spectra have spectral resolutions of 4.0 or 6.1 x 10^{-3} cm^{-1}, and signal-to-noise ratios of order 1000. Correlative CRISTA profiles are located within a square of ±2.5° in latitude and in longitude around the location of the Jungfraujoch. The agreement is very satisfactory. To obtain this result, a climatological O_3 profile was used for the a priori, depending on the season and the local tropopause height [De Mazière et al., 1999].. The choices of the a priori profile, of the microwindow, and of the instrument function turn out to be very important in the FTIR retrieval: they will be discussed in more detail.

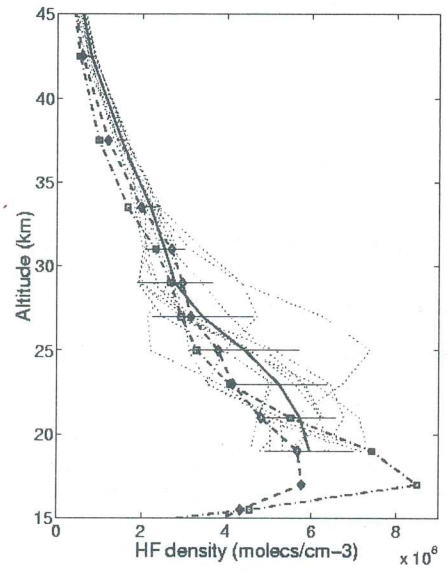

Figure 1. HF density profiles for January 1996 the 20th. -Dotted lines- individual HALOE profiles (44°N to 49°N, 98°E to 82°W), -full line- average HALOE profile (error bars 1σ standard deviation), -diamonds and dashed line- SFSP retrieved profile, -squares and dash-dotted line- SFIT2 retrieved profile.

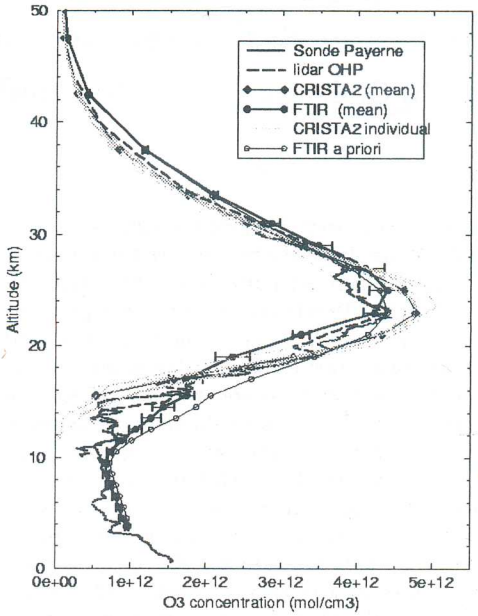

Figure 2. Correlative O_3 density profiles for August 15, 1997. The error bars on the FTIR retrieved profile represent 1 standard deviation between the individual retrievals. The solid CRISTA2 profile is the mean of all individual profiles (grey lines).

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