Measurement of Mesospheric CO during Winter/Spring 2007/08 over Kiruna, Sweden

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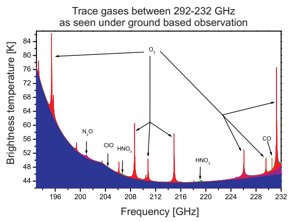

Figure 1: Synthetic spectrum of the atmospheric trace gases within the KIMRA frequency range. A winter standard profile for polar latitudes was used for this forward calculation.

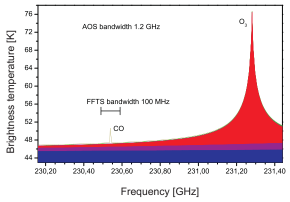

Figure 2: Same as above but narrowed to the KIMRA frequency range of 1.2 GHz according to the acousto-optical spectrometer. The bandwidth of the Fourier-Transform Spectrometer for the CO measurements is depicted as the small bar above the CO signature.

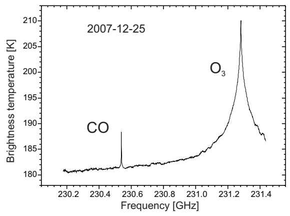

Figure 3: Measurement of strato-mesospheric CO and O_3. This graph shows the full width of the acousto-optical spectro-meter of 1.2 GHz. The small CO signature to the left is presented in Fig. 4 as measured by the high resolution FFT spectrometer.

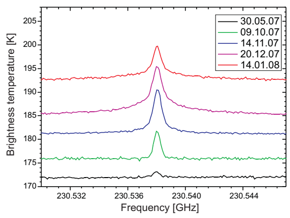

Figure 4: CO spectra for different days of the year. An arbitrary offset is chosen for clarity reasons. The variation in the shape of the CO line corresponds to different vertical distributions of CO in the course of the year.

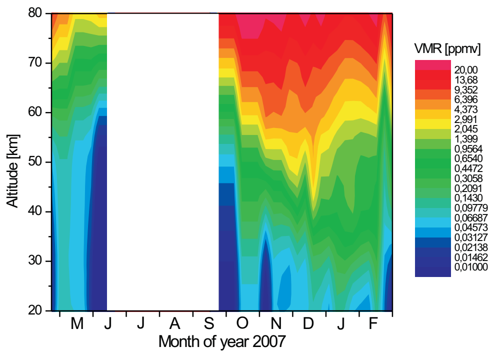

Figure 8: Time series of CO from May 2007 to February 2008. The contour plot shows the volume mixing ratio in ppmv between 20 and 80 km altitude. Every month is represented by at least 4 data points.

Introduction

The location of IRF Kiruna above the polar circle (67.8º N/20.4º E) allows the investigation of the atmosphere within the polar vortex during Arctic winter. The ground-based observations of atmospheric trace-gases by the IRF millimetre wave radiometer KIMRA cover the altitude range from 15 up to 80 km, depending on the constituent.

In 2007 KIMRA has been upgraded with a high resolution Fast-Fourier-Transform spectrometer which enabled the first strato-mesospheric CO measurements of this instrument. A medium resolution acousto-optical spectrometer was operated simultaneously to the FFT spectrometer covering a broader spectral range than the latter. Carbon monoxide has been observed continuously during the winter/spring period 2007/2008 and from the measurements one strato-mesospheric CO profile per week has been retrieved.

Measurements

Continuous observation of strato-mesospheric CO and ozone at 230 and 231 GHz has been performed with the heterodyne radiometer KIMRA. Measurements provided a time series of almost uninterrupted CO data for the period October 2007 to March 2008 (c.f. Figure 8). The integration time was 2 h under dry winter conditions but much longer during summer.

Data Analysis

For the data retrieval Tikhonov-Phillips-Regularization on a logarithmic scale was used (Schneider et al., 2006). NCEP data as provided by the Goddard automailer system was used as meteorological input up to an altitude of 45 km. Above climatological data as provided by the NRLMSISE-00 model was used. This model is fed with daily measurements of the sun activity and geomagnetic parameters. Using the inverse diagonal elements of the averaging kernel matrix as a criterion a vertical resolution of the CO profiles of at best 15 km can be acheived.

Results

Measurements of CO have been successfully performed at IRF Kiruna. The high spectral resolution of the new digital FFT spectrometer provides information of the vertical distribution of CO up to the mesopause. Due to an advanced retrieval scheme CO profiles covering the altitude range between 20 and 80 km could be derived. In the contour plot (Fig. 8) the subsidence of air masses inside and above the polar vortex with subsequent transport of thermospheric CO into the mesosphere in the course of the winter can be seen.

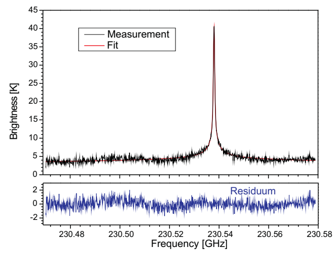

Figure 5: Measured CO spectrum overlayed by a fit (upper panel) and the resulting residuum (lower panel). In the residuum some instrumentally induced baseline artifacts can be seen.

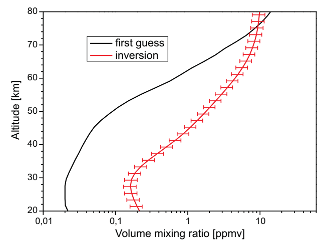

Figure 7: First guess for the retrieval and retrieved vertical CO profile with error bars. Note the logarithmic scale!

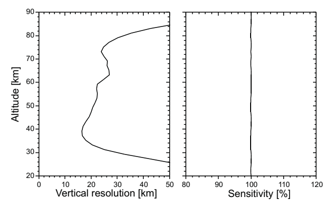

Figure 6: Vertical resolution of the retrieved CO profile and its sensitivity to the measurement. The highest vertical resolution can be achieved in the altitude region between 30 and 80 km.

Reference

M. Schneider, F. Hase, and T. Blumenstock, Water vapour profiles by ground-based FTIR spec-troscopy: study for an optimised retrieval and its validation, Atmos. Chem. Phys., 6, 811-830, 2006.

Acknowledgements

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