Profiles of O_3, HCl, and HF as retrieved from ground-based FTIR spectra recorded at Kiruna (Sweden) during winter 1997/98

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Abstract
Atmospheric absorption spectra using the sun as the source of radiation were recorded by ground-based FTIR (Fourier Transform Infra Red) technique at Kiruna (Sweden, 68°N, 20°E). The spectrometer (Bruker 120HR) is in permanent operation at the IRF since March 1996, and is approved as complementary **NDSC** (**N**etwork for the **D**etection of **S**tratospheric **C**hange) site instrument since 1998. Mixing ratio profiles of O_3, HCl, HNO_3, HF, NO, N_2O, and CH_4 have been retrieved from these spectra and results for several days during winter 1997/98 are presented here.

Experimental Setup
Period: Oct. 22 - Nov. 4, 1997 and Jan. 30 - Apr. 24, 1998
Site: IRF, Kiruna, Sweden, 67.8°N, 20.4°E, 420 m a.s.l.
Instrument: Commercial instrument (Bruker 120 HR)
Detector: MCT + InSb detectors and several optical filters covering the spectral range of 700 - 5000 cm^{-1}
Observation mode: Solar absorption spectra
Spectral resolution: Up to 360 cm optical path difference

The analysis of the atmospheric spectra is sensitive to the instrumental line shape (ILS). To minimise systematic errors in the retrieved profiles of trace gases, the ILS of the instrument is checked regularly by means of cell measurements and LINEFIT software [1].

Data Analysis
KOPRA (**K**arlsruhe **o**ptimised and **p**recise **r**adiative transfer **a**lgorithm, [2]) is used as forward model along with NMC p, T-data and HITRAN 96 spectroscopic database.

PROFFIT non-linear least-squares-fit algorithm is used for the inversion of mixing ratio profiles. Since this problem is ill-posed, appropriate constraints on the solution have to be introduced. PROFFIT is capable to handle the Tikhonov-Phillips method as well as the optimal estimation ansatz given by Rodgers. Joint retrieval of several species is possible. In case of the species examined here, a smoothness constraint has been applied on a logarithmic scale. This method excludes negative excursions and thereby associated pertubations in the resulting mixing ratio profile emerging from height regimes, where the information content in the measurement is poor. The error bars given assign the noise level found in the measured spectra to the regularised solution vector.
In Fig. 6 the typical averaging kernels of O_3 are shown. Each kernel depicts the response in the regularised solution to an infinitesimal disturbance in a single layer and thereby allows to estimate the information content in the measurement. Since the inversion is performed on a

logarithmic scale, the kernels show relative variations in the retrieved volume mixing ratio values. The deduced vertical resolution corresponds to roughly 4 independent layers.

Results and Discussion

A few days of observation when Kiruna was below the polar vortex are selected. Besides the profiles itself the correlations with HF as dynamical tracer are shown to reveal chemical effects on HCl and O_3.

- Profiles of HF indicate a considerable downwelling of the air mass as compared to a pre-winter profile (Fig. 1).
- Profiles of HCl as well as their correlation with HF show a decrease of HCl within an altitude range of 15 to 25 km as compared to the pre-winter profile (Fig. 2, 4). The profiles from February show the strongest decrease of HCl, while on April 1 HCl is already partly recovered.
- Profiles of O_3 also indicate the subsidence of the air masses inside the vortex (Fig. 3). Around 40 km the steady increase of O_3 mixing ratio due to increasing solar irradiation is seen.
- The correlation of O_3 in respect to HF shows a decrease of O_3 in an altitude regime around 20 km. This is already distinct on Feb. 1 and persists at least until April 1 (Fig. 5).

Conclusions

The meteorological situation in winter 1997/98 was marked by a cold stratosphere until January. The variability of HF, HCL and O_3 volume mixing ratio profiles deduced from FTIR measurements performed in Kiruna are consistent with these conditions. Chlorine activation and O3 depletion are already distinct on Feb. 1, persisting up to mid of March / end of April, respectively. Ground based high resolution FTIR measurements are well suited to perform long term monitoring of relevant species with moderate vertical resolution.

References

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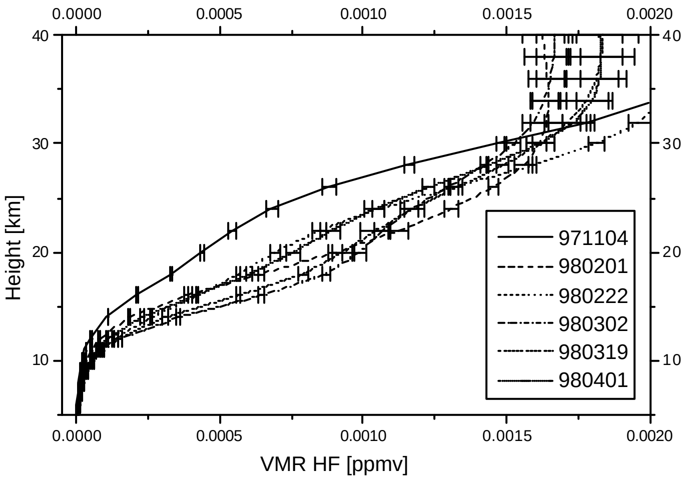
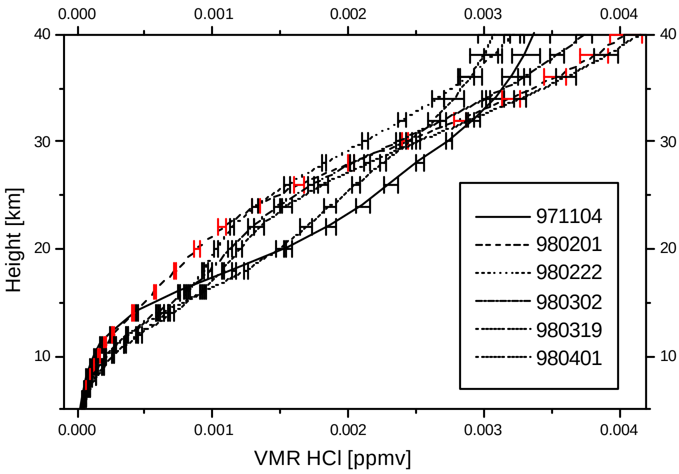
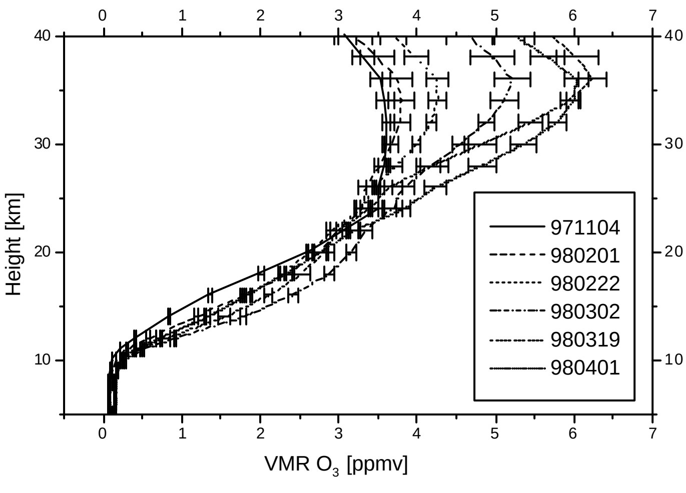
Figures







Figs. 1-3: Retrieved Profiles of HF, HCl, and O_3

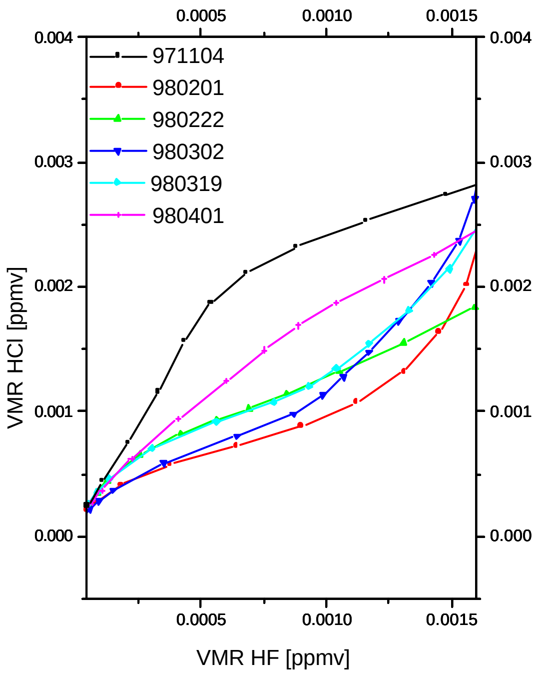


Fig. 4: Correlation between HCl and HF

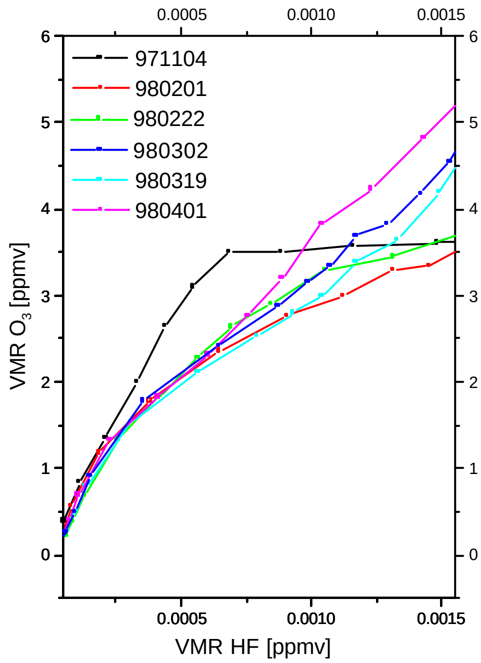


Fig.5: Correlation between O_3 and HF

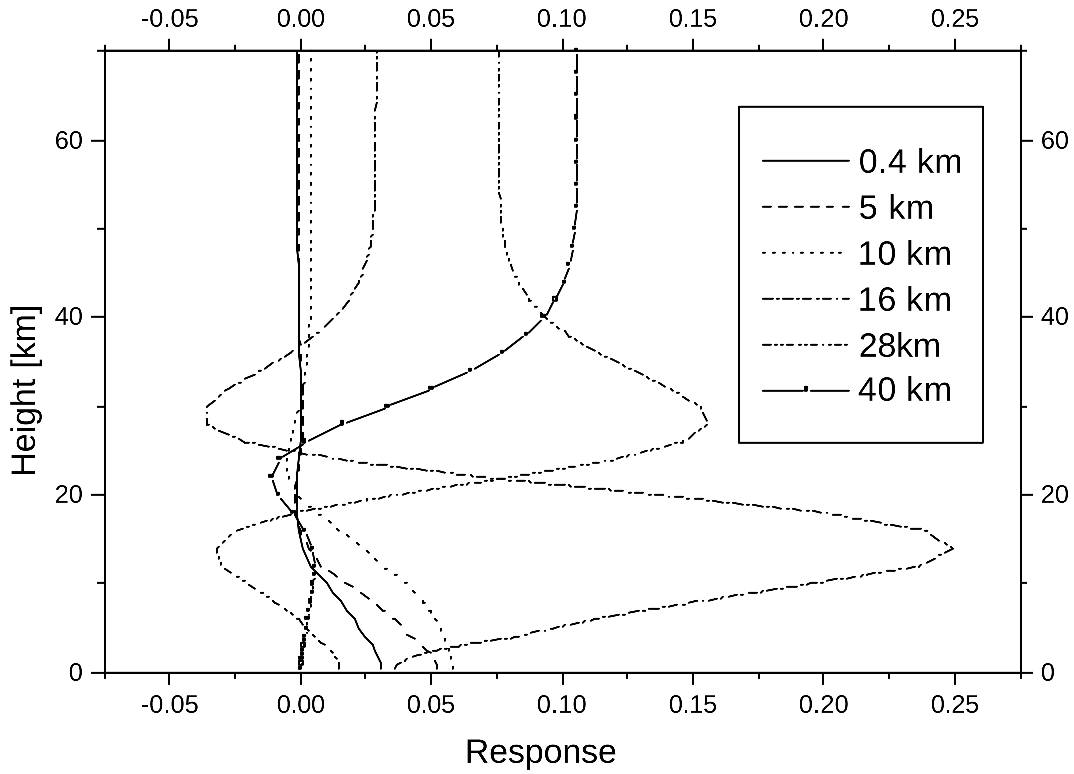


Fig.6: Typical averaging kernels for O_3 retrieval