

Long term DOAS measurements at Kiruna

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1. Introduction

Since 1989 DOAS measurements in the UV and visible spectral range were performed at Kiruna (ESRANGE) during winter/spring to monitor the evolution of trace gases related to stratospheric ozone chemistry like O₃, NO₂, OClO, BrO [Fiedler et al., 1993; Otten et al., 1998, Wagner et al., 1998]. Since December 1996 the instruments were installed at the Institute for Space Physics at Kiruna and since then both spectrometers are operating continuously.

This poster deals with the following objectives:

- the time series of the detected stratospheric trace gases
- the ability to detect PSCs with the DOAS instruments (even under cloudy skies)
- the comparison of ground based and Satellite (GOME) observations

Special attention is given to a period of a halogen activated stratosphere in Jan 1997.

2. Method

DOAS evaluation of stratospheric trace gases

The UV and vis spectrometer cover the wavelength ranges of 300 - 400 nm and 374 - 682 nm, respectively where several stratospheric trace gases show characteristic absorption features in different wavelength regions (see Table 1).

Results of the spectral fitting of the different absorbers are presented in Fig. 1.

trace gas	wavelength region	fitted spectra
O ₃	430 - 585 nm	Ring, O ₃ , NO ₂ , H ₂ O, O ₄
NO ₂ and OClO	363 - 390 nm	Ring, OClO, NO ₂ , O ₄
BrO	344 - 359 nm	Ring, BrO, O ₃ (221 and 241 K), OClO, NO ₂ , O ₄

Table 1: Wavelength regions used for the evaluation of the different trace gas absorptions.

DOAS PSC detection by means of the Colour index

The broad band spectral intensity distribution of zenith scattered light depends on the relative contributions of Rayleigh- and Mie-scattering to the total signal. Thus clouds and aerosols can be detected by means of a so called colour index, CI, which is defined as the ratio of intensities at different wavelengths (here: 385 and 680 nm) [Sarkissian et al., 1991]. Since for solar zenith angles (SZA) > $\approx 90^\circ$ most of the detected light is scattered from above the troposphere the CI is a sensitive indicator for the detection of polar stratospheric clouds (PSCs). For that purpose the CI is normalised with respect to the values at 90° SZA to correct the influence of tropospheric clouds.

In Fig. 2 the dependence of this normalised CI from the SZA is shown for two different months in 1997. While in January the stratospheric temperatures often were

low enough for the formation of PSCs and consequently for several days enhanced values of the CI were found in March no enhanced CI were detected.

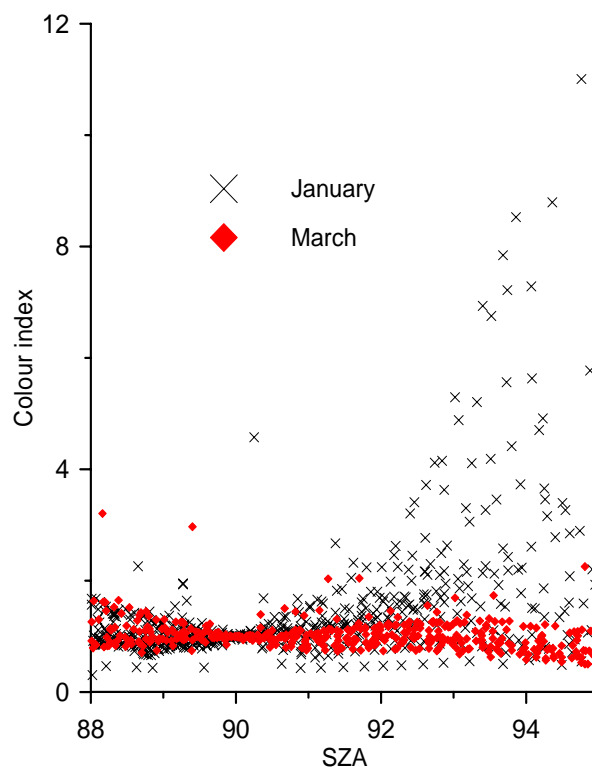
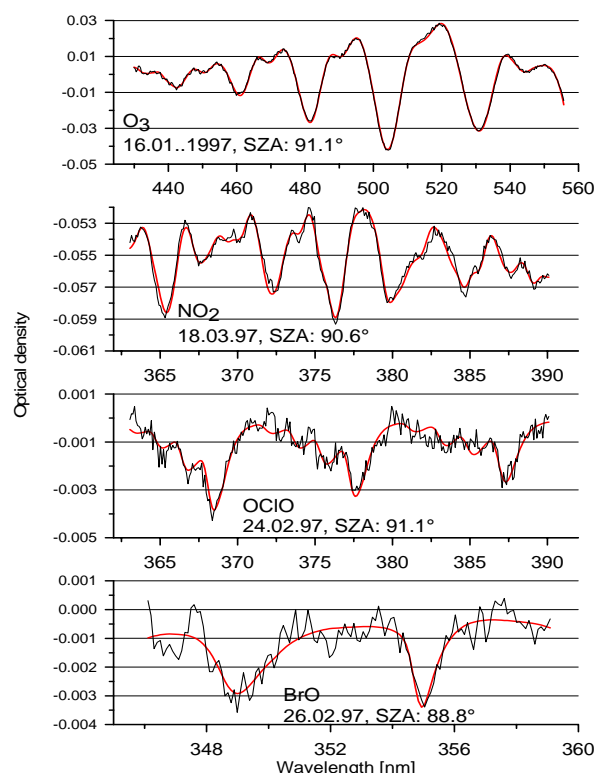


Fig. 1: Examples of the spectral fitting procedure of the different trace gases. Displayed are the absorption cross sections (red curves) scaled to the respective trace gas absorption in the measured spectrum (black curves).

Fig. 2: Values of the colour index normalised to the values at 90° SZA. The appearance of PSCs (only in January) shifts the broad band spectral intensity distribution towards the red.

3. Results

Time series of stratospheric trace gases

In Fig. 3 the time series of O₃, NO₂, OCIO and BrO as well as the development of the stratospheric temperature and potential vorticity above Kiruna are presented. It can be seen that during periods of temperatures low enough for the formation of PSCs enhanced values of OCIO indicate a halogen activation of the stratosphere. For these periods also decreased values of O₃ were detected. The seasonal variation of NO₂ and BrO can be attributed mostly to the evolution of the stratospheric temperature.

A more detailed description of the chemical composition of the stratosphere during a period of low temperatures in January and February 1997 is presented below (Fig. 4).

DOAS measurements, Kiruna 1996 - 98

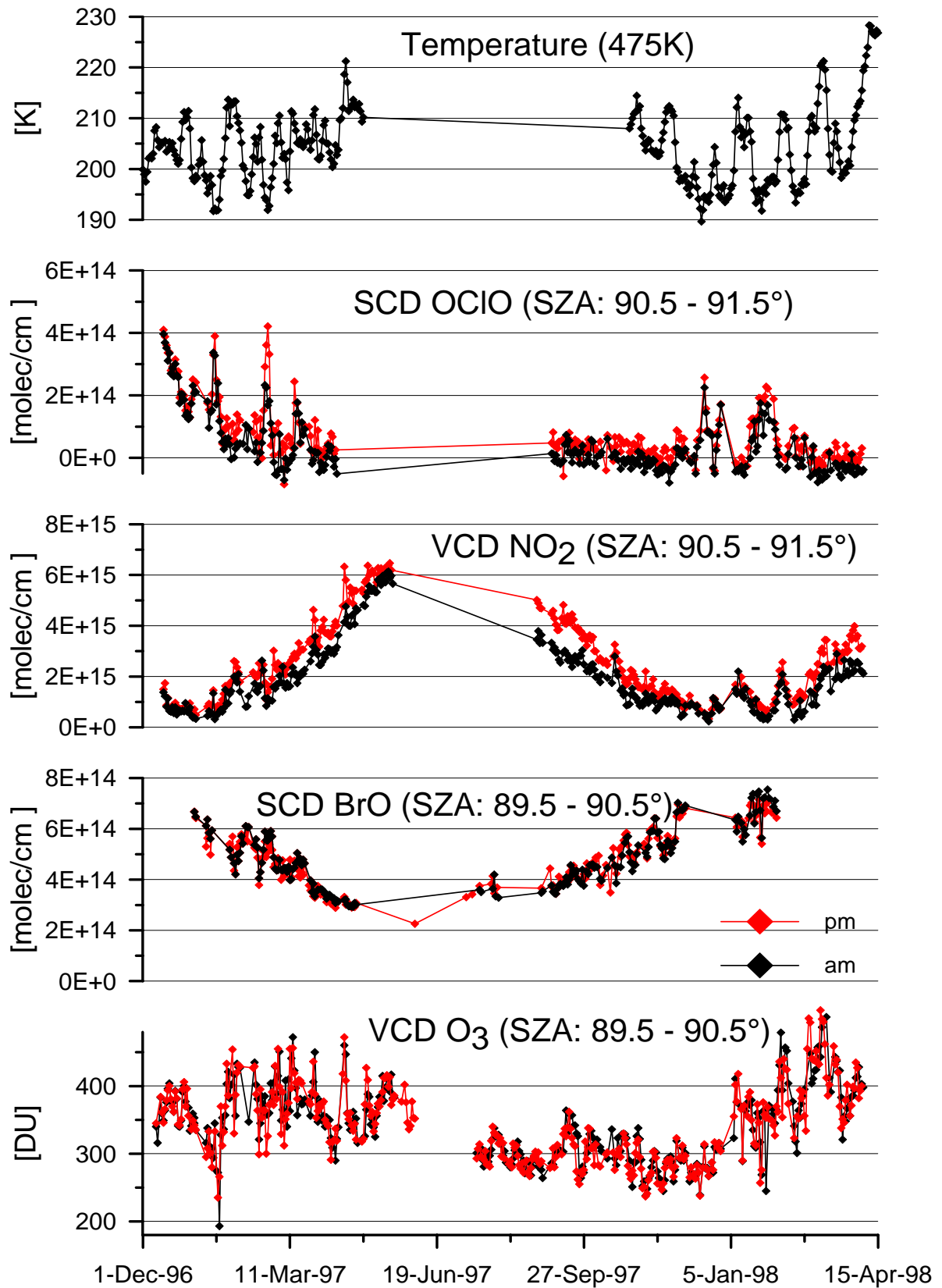


Fig. 3: Time series of the different stratospheric trace gases and the stratospheric temperature above Kiruna. The gaps in the summer months are due to small SZA

and/or too hot detector temperatures.

Case study winter 1997

In Fig. 4. the evolution of stratospheric trace gases, temperature, potential vorticity and the colour index is presented for January and February 1997. It was possible to detect PSCs for several days by enhanced values of the colour index. For most of these days accordingly the stratospheric temperatures above Kiruna were below the formation temperature of PSCs.

Due to heterogeneous reactions on the particle surface of these PSCs stratospheric NO_x is converted into HNO_3 (denoxification, indicated by low NO_2 values) and Chlorine species are converted to reactive compounds (indicated by enhanced OCIO values). Such low NO_2 values and high OCIO values were observed during the periods when PSCs were above Kiruna. However, during these periods enhanced OCIO values appear also on days when the CI shows normal values indicating transport of activated airmasses over the measuring site.

On Jan 19 when the highest OCIO amounts were detected enhanced OCIO values above Kiruna were also found in the satellite data (see Fig. 6).

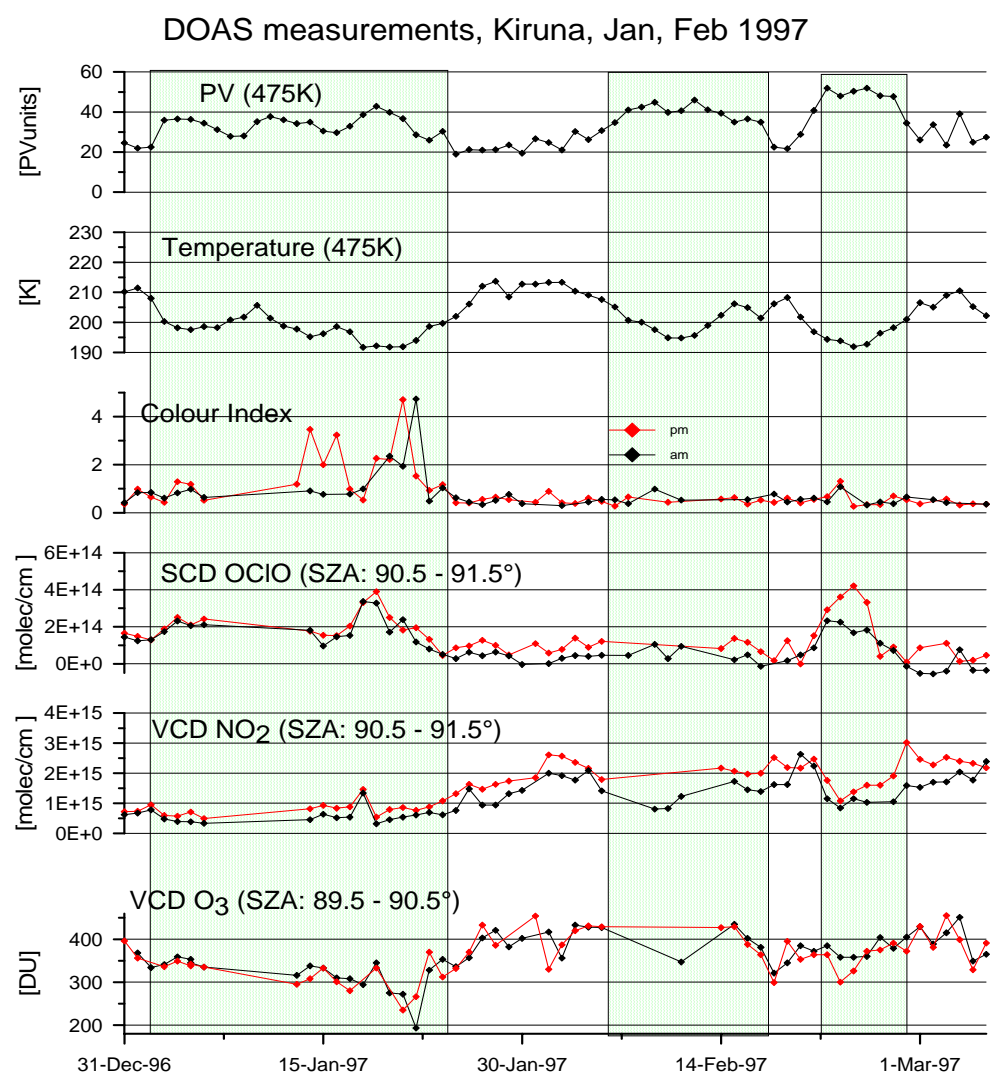


Fig. 4: Case study of the stratospheric chemical composition in winter 1997. During this period the stratospheric temperatures were low enough for PSC formation on several days. Accordingly PSCs were detected by enhanced values of the Colour

index. Around these days high OCIO values were measured indicating a halogen activation of the stratosphere; also low ozone columns were found probably due to chemical ozone destruction. The green shaded areas indicate periods when the polar vortex or its edge was above Kiruna.

Validation of GOME satellite measurements

Since mid of 1995 the GOME instrument (Global Ozone Monitoring Experiment) is operating aboard the European research satellite ERS-2. It measures the sunlight reflected from earth [ESA 1995] in the wavelength region between 240 and 790 nm with moderate spectral resolution (0.2 nm/0.4 nm) thus allowing to detect the absorptions of different atmospheric trace gases [ESA 1995]. These satellite measurements offer the unique possibility to monitor atmospheric trace gases on a global scale. However, to assess the accuracy of the satellite data it is of great importance to compare them to simultaneous ground based observations. Here we present examples of the satellite validation concerning the data of BrO and OCIO.

In Fig. 5 the time series of the BrO slant column densities (satellite as well as ground based measurements) above Kiruna are presented. Fig. 6 shows GOME measurements of enhanced OCIO columns above Kiruna when simultaneously high OCIO values were also detected from the ground (Fig. 3,4).

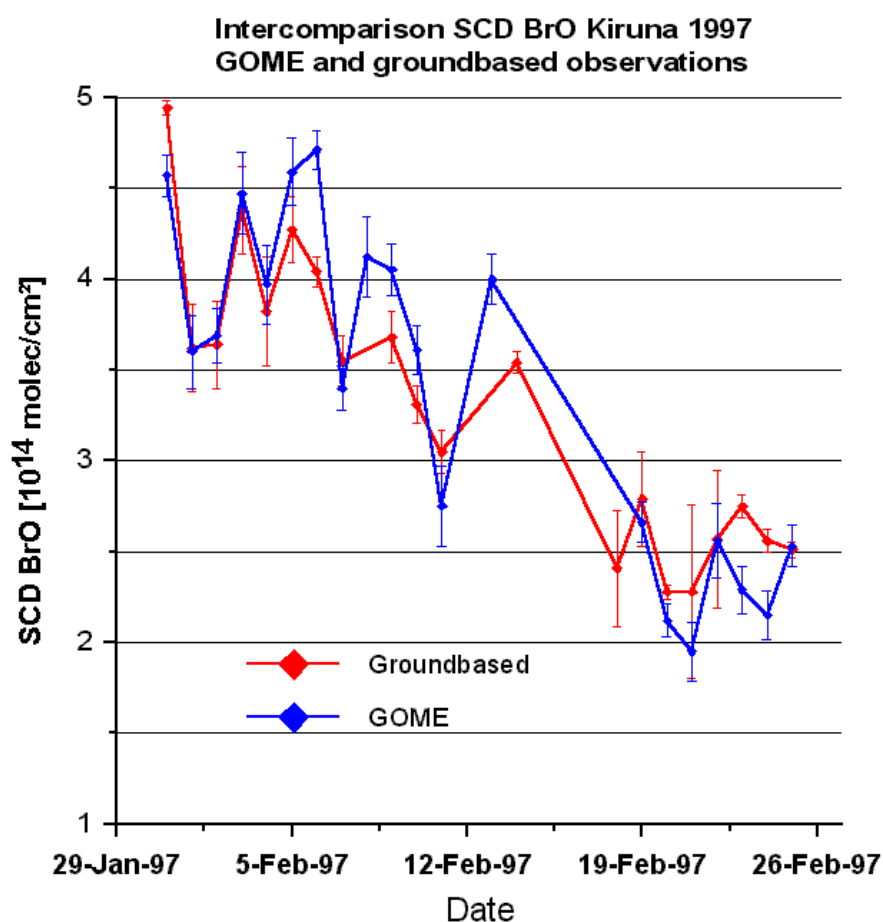


Fig. 5: Validation of the BrO satellite measurements above Kiruna with the BrO data from our ground based instrument. While the general decrease of the BrO SCD is due to the decreasing SZA at the times of the satellite overpass the short time variations indicate changes of the atmospheric BrO content.

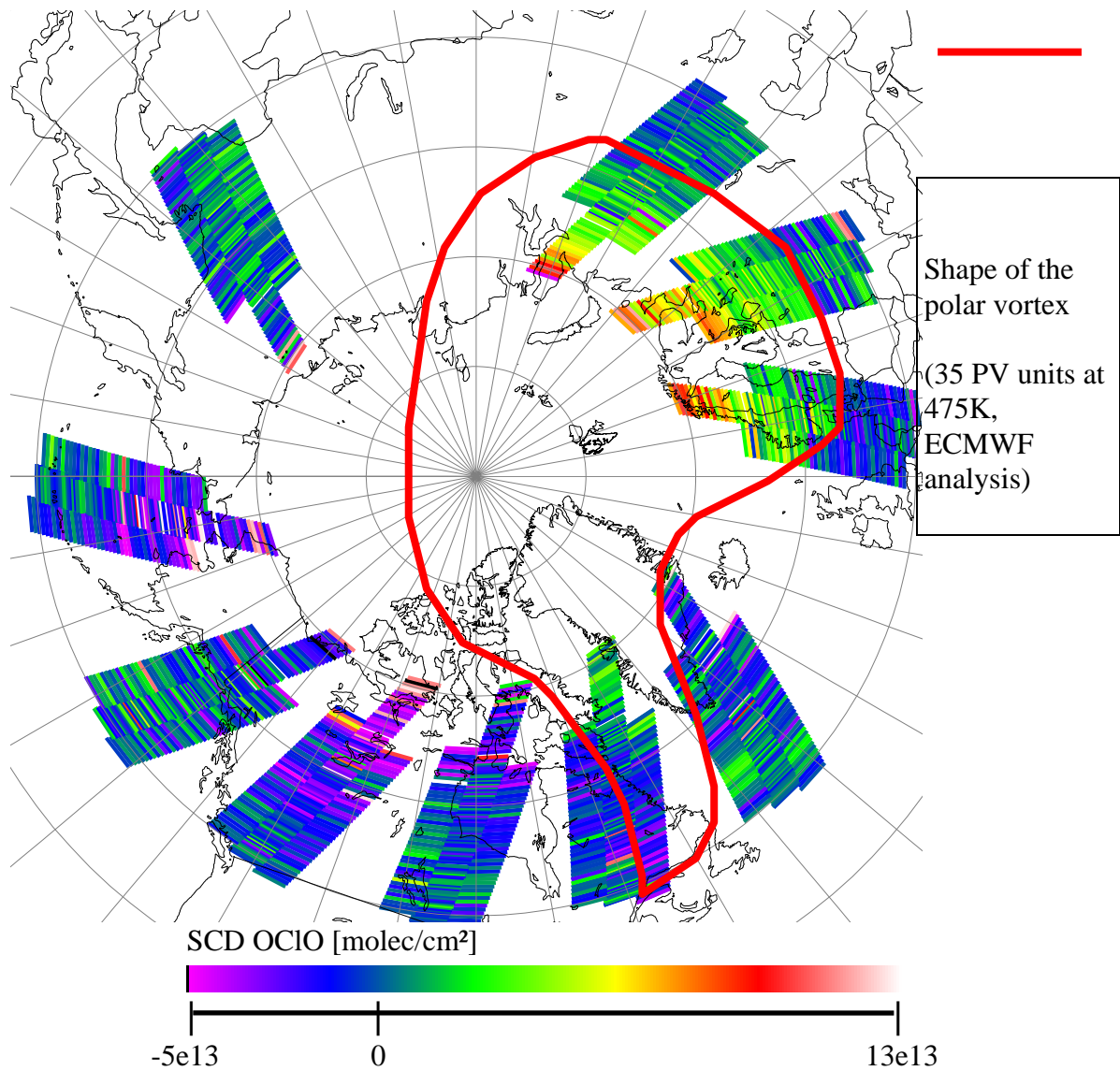


Fig. 6: Observation of OCIO from the GOME satellite instrument. On this day the polar vortex was deformed and located above northern Europe. Accordingly high OCIO values were found in the ground based data for this day (see Fig.3,4).

4. Conclusion and Outlook

From December 1996 two DOAS instruments (UV and vis) are operating continuously at the Institute for Space Physics at Kiruna. Time series for the stratospheric trace gases O₃, NO₂, OCIO and BrO have been evaluated from then up to April 1998. Thus it is possible to characterise the chemical disturbance during the Arctic winter/spring. In particular from our measurements it is possible to detect PSCs even for cloudy sky conditions.

The data of these ground based DOAS measurements are well suited for the validation of the GOME satellite measurements. For the BrO column above a good quantitative agreement between satellite and ground based measurements was found. Also OCIO above Kiruna was simultaneously detected from ground and satellite. Future work will address the continuation of the time series of the atmospheric columns of O₃, NO₂, OCIO and BrO. These data will then be subject of a comparison to model results as well as to the measurements of previous years. The validation of GOME data will be continued and also GOME NO₂ and O₃ measurements will be included. This further quantitative comparison between ground based and satellite data will in particular require the detailed study of the radiative transport through the atmosphere.

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