Multi-axis DOAS observations of atmospheric trace gases at the Greenland ice cap

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Introduction

Figure 1: Location of the new MAX-DOAS instrument in Greenland.

In July 2003 a new MAX- DOAS [1] instrument has been installed at Summit (Greenland see figure 1). MAX-DOAS is based on the well-known UV/VIS instruments, which use the sunlight scattered in the zenith sky as the light source and the method of **D**ifferential **O**ptical **A**bsorption **S**pectroscopy (**DOAS**) to derive column amounts of absorbers like ozone and nitrogen dioxide. Substantial enhancements have been applied to this standard setup to use different line of sights near to the horizon as additional light sources (**MAX** - multi axis).
In addition, this measurement technique can be used for both ground based observations (e.g. Network for Detection of Stratospheric Change - NDSC) and validation of satellite instruments (e.g. Global Ozone Monitoring Experiment - GOME, Scanning Imaging Absorption Spectrometer for Atmospheric Chartography - SCIAMACHY) which allows to combine highly time and spatial resolved data of selected locations with data of global coverage.
First results from measurements at the Summit part of the BREDOM (**Bre**mian **DO**AS Network for Atmospheric **M**easurements) are presented and interpreted with the full-spherical radiation transport model SCIATRAN [2].

Figure 2: View of the Big House at Summit camp (72,34'N, 38,29'W).

Measurement Site

The Summit camp sponsored by the National Science Foundation (NSF) is a scientific research station located at the peak of the Greenland ice cap at 3200 m altitude. This high altitude Arctic site is characterized by:

- low temperatures,
- very low water vapour column and
- a clean troposphere.

In figure 3 the temperature stabilized measurement container of the Bremen RAMAS group (Radiometer for Atmospheric Measurements At Summit) is shown where the DOAS instrument is installed.

Figure 3: The DOAS instrument is located inside the RAMAS measurement container.

Experimental Setup

Figure 4: View of the DOAS telescope on top of the RAMAS container.

Sunlight scattered from the sky is collected by a telescope (figure 4) and transmitted to a Czerny-Turner spectrograph L.O.T. MS260i via a depolarizing quartz-fibre bundle. A charge coupled device (CCD) Andor DV-420BU (1024x256 pixel) is used as a detector. The pointing of the telescope is alternating between zenith and horizon, which yields profile information of the absorbers. The observation in different lines of sight (4 off-axis between 0 and 30° above horizon, 1 zenith) is realized by a mirror fixed on a rotation stage moved by a computer controlled servomotor.

First Results

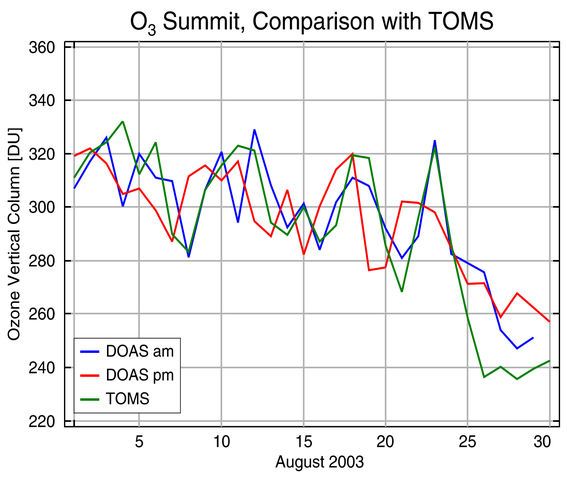

Figure 5: *Vertical Columns of O_3 compared with TOMS [4].*

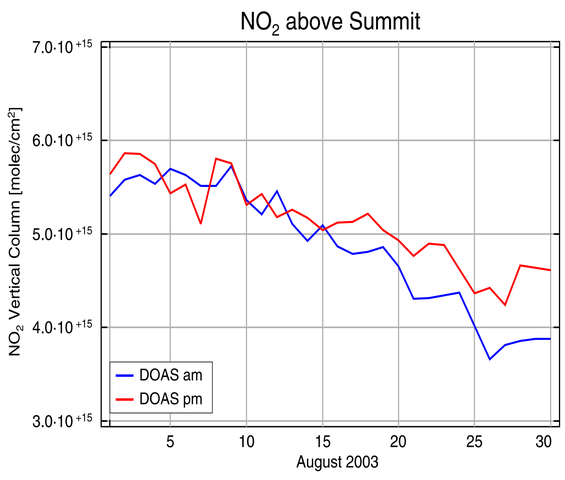

Figure 6: *Vertical Columns of NO_2 .*

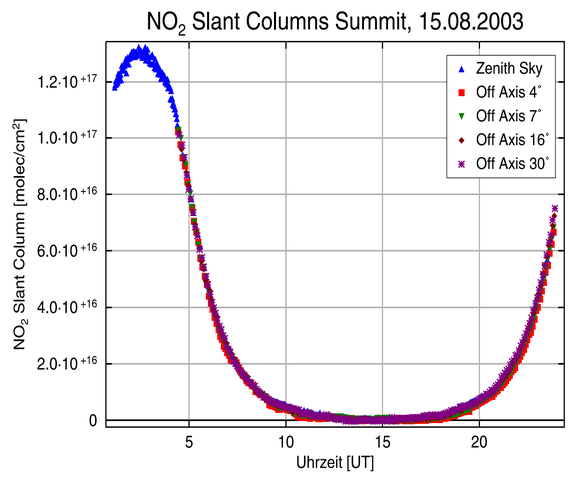

Figure 7: *Slant Columns of NO_2 for different viewing directions.*

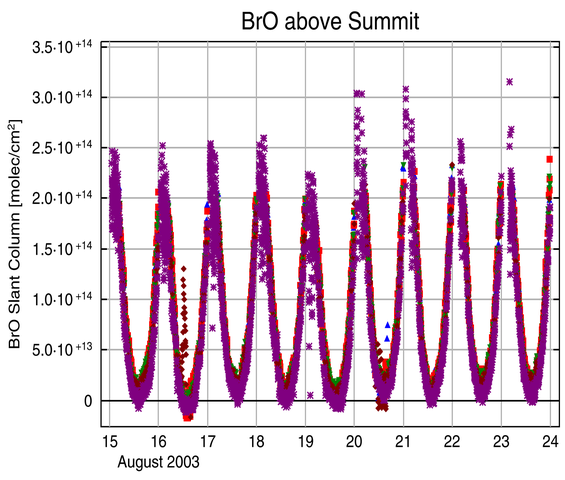

Figure 8: *BrO Slant Columns for different viewing directions.*

In this section first preliminary results of the Summit DOAS instrument are presented. Figure 5 shows the comparison of the ozone measurements with TOMS. There is a good agreement of the TOMS data with the Summit measurements, the absolute values as well as the variation with time. For the ground based measurements morning and afternoon values are given. There appears to be no strong diurnal variation of ozone. The vertical columns of NO_2 are shown in figure 6. A decreasing of NO_2 can be seen during the observed period related to the increasing darkness.

In figure 7 the slant columns of NO_2 for different lines of sight for the 15th of August 2003 are shown. It can be seen that the values for all lines of sight are very similar, which is the case if the tropospheric NO_2 present in the atmosphere is low.
A time series of BrO slant columns for Aug. 15-24 for different lines of sight is shown in figure 8. During these period the BrO slant columns are very similar which indicates nearly constant atmospheric conditions.

References

[1] Wittrock, F., H. Oetjen, A. Richter, A. Rozanov, and J.P. Burrows, MAX-DOAS measurements of atmospheric trace gases, to be submitted to Applied Optics, 2003
[2] Rozanov, A., V. Rozanov, and J.P. Burrows, A numerical radiative transfer model for a spherical plantary atmosphere: combined differential-integral approach involving the Picard iterative approximation, Journal of Quantitative Spectroscopy & Radiative Transfer, 69, 491, 2001.
[3] Wittrock, F., M. Eisinger, A. Ladstätter-Weißenmayer, A. Richter and J.P. Burrows, Groundbased UV/VIS measurements of O3, NO2, BrO and OClO over Ny Alesund (78°N), Polar stratospheric ozone, Air pollution research report 56, Proceedings of the 3rd European Polar Ozone Symposium, Schliersee, Germany, CEC, 329-334, 1996.
[4] TOMS data provided by NASA, http://toms.gsfc.nasa.gov/

Conclusions

At end of July 2003 the Summit DOAS station started its measurements. Preliminary results of the first measurement of O_3 , NO_2 and BrO are presented.
The O_3 vertical columns of TOMS and DOAS are in good agreement. A decreasing of NO_2 related to the increasing darkness and the low amount of tropospheric NO_2 can be seen in figure 6 and 7. For BrO a ten day time series is shown where the slant columns are very similar.

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