The AMAXDOAS Experiment - Data Retrieval and Sensitivity Studies

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Introduction

We present a novel spectroscopic instrument for the operation on aircrafts which will yield profile information for several atmospheric trace gases. The AMAXDOAS (Airborne Multi-AXis Differential Optical Absorption Spectroscopy) instrument consists of two spectrometers (covering the UV and visible spectral range) connected to 10 telescopes. From these telescopes 5 are pointed upwards into the stratosphere under different angles and the other 5 telescopes are pointed downwards into the troposphere (Fig. 1).From this instrumental set-up it will be possible to separate the tropospheric and stratospheric trace gas columns for a significant number of the species (e.g. O_3, NO_2, OClO, BrO, H_2O, SO_2, and HCHO). For some of the atmospheric trace gases (most probably for O_3 and NO_2) it will even be possible to Resolve the atmospheric profiles at moderate vertical resolution.

Motivation

- Separation of tropospheric and stratospheric columns
- Retrieval of profile information for atmospheric trace gases (most probably for Ozone and NO_2)
- Large range of data coverage from the Arctic to the Tropics within one campaign

This extends the successful work carried out with airborne DOAS as used aboard the German Airforce Transall during EASOE (European Arctic Stratospheric Ozone Experiment 1992) [4].

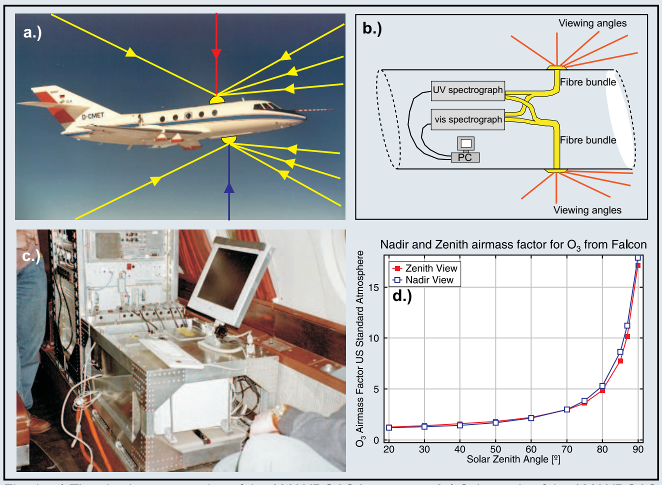

Fig. 1: **a.)** The viewing geometries of the AMAXDOAS Instrument. **b.)** Schematic of the AMAXDOAS instrument. **c.)** The instrument during preparations for the first test flight in May 2001. **d.)** Comparison of airmass factors (AMF) for Ozone at 475 nm and zenith and nadir viewing modes assuming the aircraft is flying at an altitude of 10 km and the US standard atmosphere is used.

The AMAXDOAS Instrument

- Platform: research aircraft FALCON (German Aerospace Organisation)
- Consists of two imaging spectrometers (UV: 320 to 450nm, vis: 400 to 700nm)
- CCD detectors are used for data acquisition
- Two domes are mounted on top and below the FALCON, each housing several small telescopes directed into the atmosphere at different angles to collect scattered sun light.
- 1st successful test flight was performed in May 2001 and another test flight will follow in December 2001
- Two campaigns are planned for February and September 2002

Data Analysis

- The DOAS method is used for data analysis
- The concept of airmass factors (AMF) is applied. The AMF is the enhancement factor of the vertical column due to the light path through the atmosphere in case the solar zenith angle (SZA) is non-zero (SZA = 0°: overhead sun).
- AMF = (slant column) / (vertical column)
- The reason for using different line of sights (LOS) is to derive information not only on the total column of absorbers, but also on their vertical distribution.
- The most straightforward information comes from the difference between nadir and zenith measurements.
- This technique enables tropospheric and stratospheric columns to be separated.

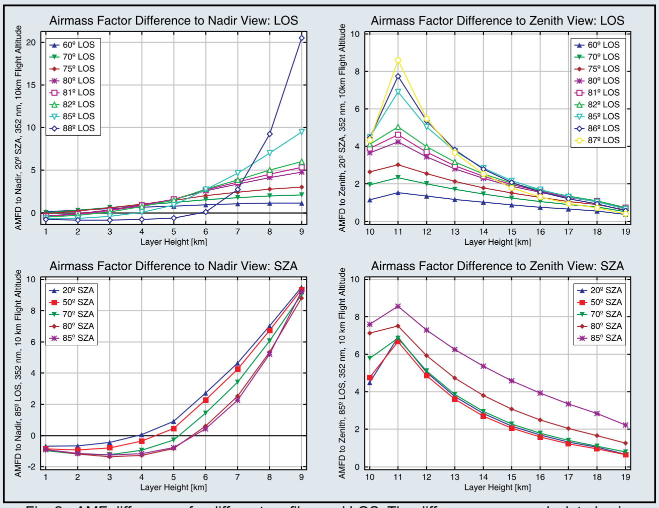

Fig. 2: AMF differences for different profiles and LOS. The differences were calculated using the AMF for each viewing angle divided by the AMF of the zenith geometry in case the absorber was above the aircraft or by the AMF of the nadir geometry in case the absorber was below the aircraft. It is assumed that the aircraft is flying at 10 km altitude.

Sensitivity Studies

- The radiative transfer model SCIATRAN [3] was used
- AMF were calculated for various LOS and SZA
- The used profiles consists of layers 1km thick (6-7km, 7-8km, ..., 19-20km)
- It is assumed that the aircraft is flying at 10 km altitude

Results of the Sensitivity Studies

- In Fig.1d it is shown that the stratospheric Ozone AMF for zenith and nadir mode are almost identical.
- The results shown in Fig.2 are presented as AMF differences. The differences were calculated using the AMF for each LOS subtracted by the AMF of the zenith geometry in case the absorber was above the aircraft and by the AMF of the nadir geometry in case the absorber was below the aircraft.
- This form of presentation was chosen to demonstrate the enhancement in light path of each LOS compared to the light path of the zenith/nadir geometry.
- In Fig.2 it is shown that the largest changes in AMF differences are obtained when the trace gas layer is closest to the flight altitude of the aircraft. The sensitivity due to changing SZA is small.
- A study for the visible region (475nm) showed that the sensitivity near flight altitude is larger than in the UV region. In other respects this study showed the same general behaviour as the study covering the UV wavelength region.

Conclusions

The AMAXDOAS instrument measures solar radiation in different LOS (see Fig.1a and 1b). The advantage of various LOS is the possibility to retrieve total columns of trace gases and vertical profile information. It is concluded:

- 1st successful test flight was performed in May 2001
- The AMAXDOAS instrument will be part of the SCIAMACHY validation campaign
- The AMAXDOAS instrument is able to resolve about three layers above the aircraft and about two layers below the aircraft:

layers above aircraft	layers below aircraft
10-14 km	below 6 km
14-19 km	6-10 km
above 19 km	

- The main LOS should be above 80° zenith angle.

References:

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