Retrieval of stratospheric and tropospheric ozone from SCIAMACHY limb and nadir observations

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Introduction

Tropospheric ozone is of great importance to society due to its potential hazards to human health, agriculture, and as a greenhouse gas. The ability to determine tropospheric ozone globally and continuously from space is therefore of major interest. Fishman [Fishman and Larsen, 1987] pioneered the concept of determining tropospheric ozone from the difference between total and stratospheric ozone, using TOMS (Total Ozone Mapping Spectrometer) total ozone and SAGE (Stratospheric Aerosol and Gas Experiment) stratospheric profile measurements. The main challenge of this approach is the fact that most of the atmospheric ozone is located in the stratosphere. In this poster, we present the application of limb nadir matching to SCIAMACHY data.

SCIAMACHY Instrument

The SCIAMACHY instrument [Bovensmann et al., 1999] is a spectrometer designed to measure sunlight, transmitted, reflected and scattered by the earth atmosphere or surface in the ultraviolet, visible and near infrared wave region at moderate spectral resolution. In nadir mode, the atmospheric volume directly under the instrument is observed. Each scan covers an area on the ground of up to 960 km across track with a maximum resolution of 26 km x 15 km. In limb mode, the instrument looks at the edge of the atmosphere. Scans at different tangent altitudes over a range of up to 960 km in horizontal direction are performed with a geometrical vertical resolution of approximately 2.6 km. One of the most important features of SCIAMACHY is the possibility to observe the same atmospheric volume first in limb and then after about seven minutes in nadir geometry. Global coverage at the equator is achieved within six days.

Data Analysis

The limb retrieval method for ozone profiles was described by von Savigny et al. [2003]. Profiles are obtained by iterative optimal estimation driving a spherical radiative transfer model. Integrating the concentration profiles from the tropopause upwards yields stratospheric vertical column densities. The tropopause height is calculated from ECMWF (European Centre for Medium Range Weather Forecast) data.

Stratospheric slant column densities (SCD) are derived from the vertical column densities (VCD) by applying appropriate air mass factors (AMFs) according to SCD = VCD x AMF. These AMFs are calculated using a radiative transfer model, taking into account the actual difference between the total and the stratospheric slant columns, tropospheric slant columns except for special cases.

These AMFs are calculated using a radiative transfer model, taking into account the actual difference between the total and stratospheric slant columns, tropospheric slant columns except for special cases. So far, full consideration of all these factors and the calculation of AMFs for each ground pixel has not been feasible except for special cases.

Global Trop. O₃ - Preliminary Results

This figure shows preliminary results for tropospheric ozone (in Dobson Units, DU) averaged over the period August 1-25, 2003, based on a purely geometrical AMF (1 sec (SZA), SZA being the solar zenith angle) for the troposphere. This most likely leads to an under-estimation of tropospheric ozone values especially for mid- and high latitudes. Data for cloudy ground pixels were filtered out.

The main sources of error in the DOAS slant column determination are uncertainties in the ozone differential absorption cross sections, estimated to be on the order of 2-3% or 5-10 DU. The errors in the stratospheric profile retrieval are estimated to be about 4-5% under optimum conditions [von Savigny et al., 2003], or 10-16 DU. Errors in the calculation of tropospheric AMFs could be as high as 50%. Other error sources include uncertainties in the determination of the stratospheric AMFs, uncertainties in the tropopause height determination, and stratospheric variability within a limb state. Future attempts to improve the retrievals will address all these factors.

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Conclusions

- The retrieval of tropospheric ozone from SCIAMACHY limb and nadir measurements yields generally reasonable results, given estimated errors of the procedure.
- The comparison with ozone sondes shows that with full consideration of viewing geometry and ozone profiles shapes, good agreement can be achieved.

Selected References

König-Langlo, G., personal communication

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