

SCIAMACHY solar occultation

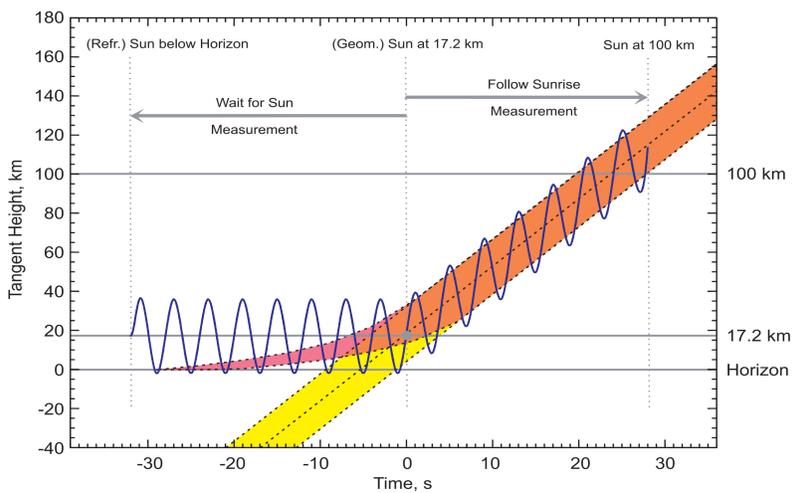


Fig. 1: Schematic view of an solar occultation measurement sequence. **Blue line:** movement of SCIAMACHY's FOV. **Shaded areas:** refracted and the imaginary true Sun, respectively. In the first part (*Wait for Sun*), SCIAMACHY scans the estimated sunrise region above the horizon. When the geometric centre of the sun reaches a tangent height of 17.2 km, the FOV starts to move up with a pre-calculated elevation rate up to an altitude of about 290 km. During the whole sequence, the sun is scanned up and down over the full solar disk. Although from SCIAMACHY's point of view a sunrise is observed, the local time at the tangent point is at sunset!

Ozone profile Validation

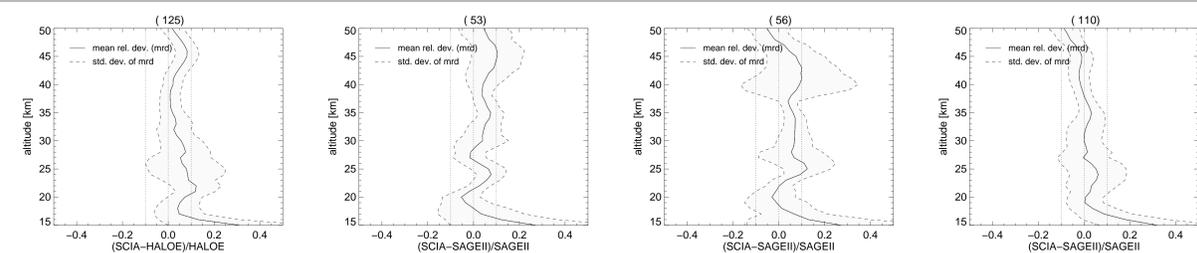


Fig. 2: Mean relative deviation (mrd) and standard deviation of mrd for ozone profiles compared to co-located profiles from HALOE and SAGE II. **Left plot:** HALOE Jul – Sep. **Second to fourth plot:** SAGE II for Jan – Mar, Apr – Jun, and Jul – Sep.

NO₂ profile Validation

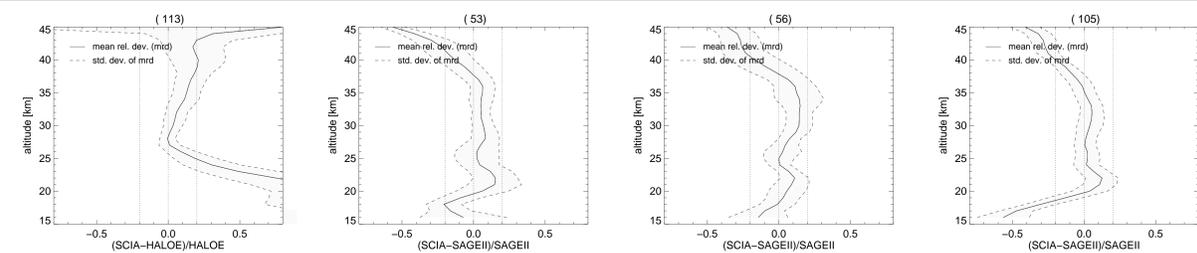


Fig. 3: Mean relative deviation (mrd) and standard deviation of mrd for NO₂ profiles compared to co-located profiles from HALOE and SAGE II. **Left plot:** HALOE Jul – Sep. **Second to fourth plot:** SAGE II for Jan – Mar, Apr – Jun, and Jul – Sep.

Time series

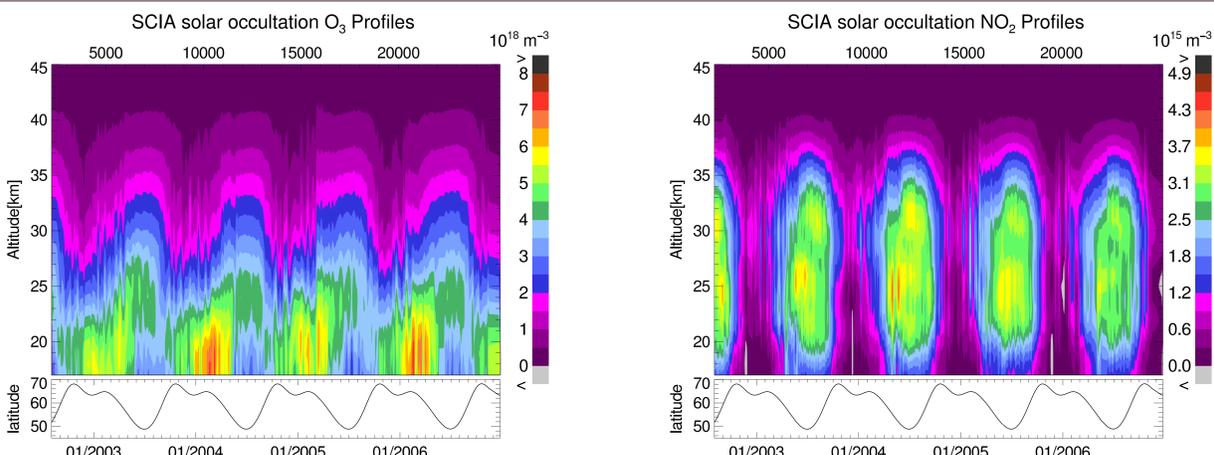


Fig. 4: Time series of NO₂ (top) and ozone (bottom) profiles derived from the solar occultation measurements over Siberia between 69° E and 90° E with one measurement per day (see Fig. 6). The small charts below indicate the latitudes of the tangent points of the measurements.

Case study

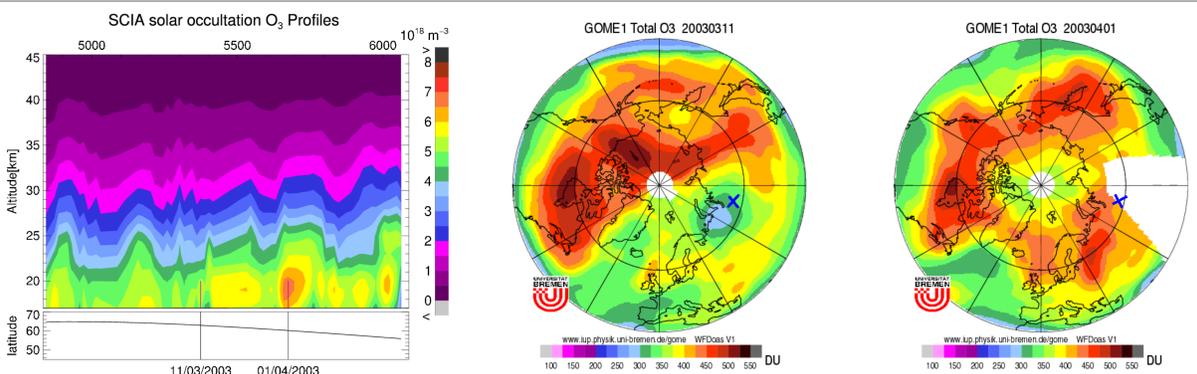


Fig. 5: **Left:** Time series of ozone profiles as in Fig. 4, restricted to February to April 2003. **Mid and right:** GOME WFM-DOAS total column for March 11, 2003 and April 1, 2003, respectively. The blue crosses mark the location of the occultation measurement of that day (where these dates are also marked).

Introduction

SCIAMACHY (SCanning Imaging Absorption spectroMeter for Atmospheric CHartography) is a passive remote sensing moderate-resolution imaging UV-Vis-NIR spectrometer on board the European Space Agency's (ESA) Environmental Satellite (EnviSat), launched in March 2002 from Kourou, French Guiana. The instrument observes the Earth atmosphere in nadir, limb and solar/lunar occultation geometries and provide column and profile information of atmospheric trace gases of relevance to ozone chemistry, air pollution, and climate monitoring issues. Here we present an almost complete dataset of ozone and NO₂ profiles derived from solar occultation for the period 2002 to 2006.

Geographical distribution of SCIAMACHY occultation measurements

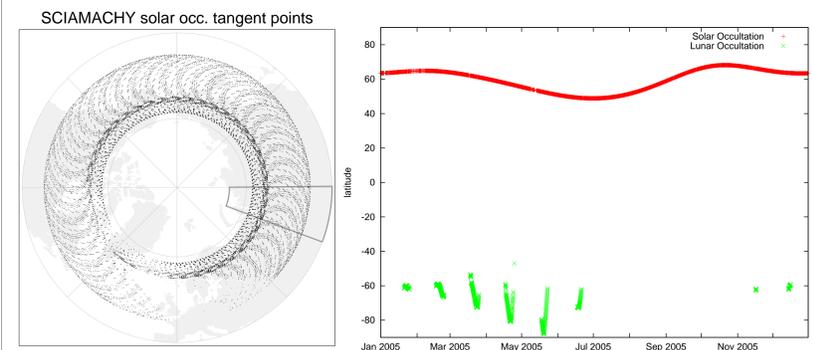


Fig. 6: **Left:** Distribution of used tangent points for solar occultation. In the region from Europe to Greenland without tangent points, a variant of the occultation measurement scheme is performed, which is not yet used for profile retrieval. As the SCIAMACHY orbit has a repeat cycle of 31 days, the area is not completely filled up. The occultation measurements inside the marked area over Siberia are used for the time series in Fig. 4. **Right:** Tangent points of SCIAMACHY solar and lunar occultation measurements for 2005. Whereas the solar occultation shows each year the same pattern with tangent points between 48° N and 68° N, the lunar occultation events depend on the visibility of the moon.

Profile retrieval

The retrieval setup

- forward model and retrieval code: SCIATRAN 2.1
- spectral windows: 425 – 453 nm (NO₂) and 525 – 590 nm (O₃)
- climatology a-priori profiles:
 - O₃ : Fortuin & Kelder, KNMI
 - NO₂ : Compiled from HALOE sunset measurements 1992-2005
- Retrieval scheme: Optimal estimation with Twomey-Tikhonov regularisation
- spectra from SCIAMACHY Level 1b, equivalent version 6 products
- Ozone and NO₂ profiles are simultaneously retrieved

Validation

O₃ and NO₂ profiles are compared with co-located profiles from HALOE and SAGE II. Both satellite instruments also observed the atmosphere in solar occultation geometry. Measurements are used with a maximum distance of 500 km and a time difference with less than 12 hours. For HALOE, co-locations are only found for July to September, whereas SAGE II covers January to September.

Fig. 2: Ozone validation shows very good agreement with HALOE and SAGE II with deviations below 10% from 17 to 50 km. SCIAMACHY values are slightly higher for most altitudes.

Fig. 3: NO₂ is highly variable trace gas in the atmosphere with a strong diurnal cycle. Therefore, only the sunset measurements can be used for direct comparison, if a photochemical correction should be avoided. For HALOE, a good agreement is observed with deviations below 20% from 25 to 42 km. The deviation to SAGE II is well below 20% from 19 to 40 km for all seasons with measurements. For lower altitudes, the results are contradictory.

Time series

In Fig. 6 a region over Siberia from 69° E to 90° E is marked. Exactly one occultation measurement is performed per day in this region. Fig. 4 shows a time series of the ozone and NO₂ profiles for that region. The overall seasonal variation in both time series reflects the yearly cycle of the latitude of the occultation events. Nevertheless, also variations from year to year can be observed.

Case study

In March 2003, the arctic ozone hole was moved towards Siberia and Europe. Around April, 1 the weakened ozone hole is centred over the pole with higher ozone columns also over Siberia. Fig. 5 gives insight to the dynamics from the solar occultation ozone profiles. During March, ozone profiles with reduced ozone maximum can be observed. The ozone total column plot from March, 11 is typical for that period. Around April, 1, more usual ozone profiles with higher maximum values are observed, as Siberia is now outside the polar vortex.

Conclusion

An almost complete dataset, containing about 31500 ozone and NO₂ profiles from SCIAMACHY solar occultation has been evaluated. Validation with the satellite instrument HALOE and SAGE II shows very good agreement between these three sensors. First geophysical application have been presented here. With the possible extension of the the mission until 2014, solar occultation measurement of SCIAMACHY will give improved insight to the constituents and dynamics of the atmosphere in Northern latitudes.

Selected References

- Bovensmann et al, SCIAMACHY: Mission objectives and measurement modes. *J. Atmosph. Sc.*, 1999
- Bramstedt et al, SCIAMACHY solar occultation: ozone and NO₂ profiles 2002-2006, *Proc. Envisat Symp.*, SP-636, 2007
- Meyer et al., Solar occultation with SCIAMACHY: algorithm description and first validation, *Atmos. Chem. Phys.*, 5, pp. 1589-1604, 2005.
- Rozanov et al. SCIATRAN 2.0 - A new radiative transfer model for geophysical applications in the 175 - 2400 nm spectral region, *Adv. Space Res.* 36, 1015-1019, 2005

Acknowledgement: SCIAMACHY is a national contribution to the ESA ENVISAT project, funded by Germany, The Netherlands, and Belgium. SCIAMACHY Level 1 data have been provided by ESA. We thank HALOE and SAGE II teams at Hampton University and NASA LaRC for providing data. This work has been funded by BMBF, by DLR-Bonn, and by the University of Bremen.