Tropospheric Ozone based on satellite measurements of SCIAMACHY and GOME

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Introduction

Every summer important areas of forests and grasslands are burning in the tropics and emit into the atmosphere large amounts of precursors of tropospheric ozone (O_3), hydrocarbons, carbon monoxide (CO), oxygenated organics, including formaldehyde (HCHO), nitrogen oxides ($NOx=NO+NO_2$), sulfur dioxide (SO_2)) and aerosols. Tropospheric O_3 is subsequently photochemically produced in the presence of NO_x during the oxidation of CO and organic gases (volatile organic compounds (VOC)) including methane. Therefore SCIAMACHY (Scanning Imaging Absorption Spectrometer for Atmospheric Chartography) aboard ENVISAT [Noël et al. , 2002] and GOME (Global Ozone Monitoring Experiment) aboard ESA ERS-2 measurements [Burrows et al. 1993 and Burrows et al. 1999] were analysed and compared with results of O_3-SHADOZ-sondes for the time period of July to December 2002 [Thompson et al. 1999] for the locations Nairobi (Kenya: 1.27 S, 36.8 E), Natal (Brazil: 5.42 S, 35.38 W), Ascension (7.98 S, 14.42 W) and American Samoa (14.23 S, 170.56 W) in view to the influence of the amount of tropospheric O_3 in the tropics.

SCIAMACHY

The SCIAMACHY (Scanning Imaging Absorption Spectrometer for Atmospheric CHartographY) project is a German, Dutch and Belgian contribution to the ESA ENVISAT, which was launched on the 28th of February 2003. The instrument is a spectrometer designed to measure simultaneously sunlight, transmitted, reflected and scattered by the earth, atmosphere or surface in the ultraviolet, visible and near infrared spectral regions (e.g. 240 nm - 2380 nm) at moderate spectral resolution (0,2 nm - 1,5 nm dependent on channel).
Mathematical inversion of the measurements yields the amounts and distributions of the following trace constituents and parameters: O_3, BrO, OClO, ClO, SO_2, H_2CO, NO_2, CO, CO_2, CH_4, H_2O, N_2O, p, T, aerosol parameters (optical thickness, absorbing aerosol), cloud parameters (cloud cover, cloud top height and cloud optical thickness). A special feature of SCIAMACHY is the combined limb-nadir measurement mode, which enables the tropospheric column amounts of several trace gases to be determined.

Figure 1: ENVISAT in the Orbit [ESA]

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GOME

Since 1995 GOME on board of the European satellite ERS-2 is measuring in the wavelength range of 240-780 nm with a spectral resolution of 0.2 to 0.4 nm. The main objective of GOME is the global measurement of O_3 columns, but other trace gases such as NO_2, SO_2, HCHO, BrO and OClO can be retrieved from the spectra as well and vertical profiles of ozone can be obtained. Using the Differential Optical Absorption Spectrocopy (DOAS) technique, a number of atmospheric trace gases like, O_3, NO_2, BrO, OClO, SO_2 and HCHO can be retrieved from the spectra. Under cloud free conditions GOME is able to measure tropospheric amount of some constituents.

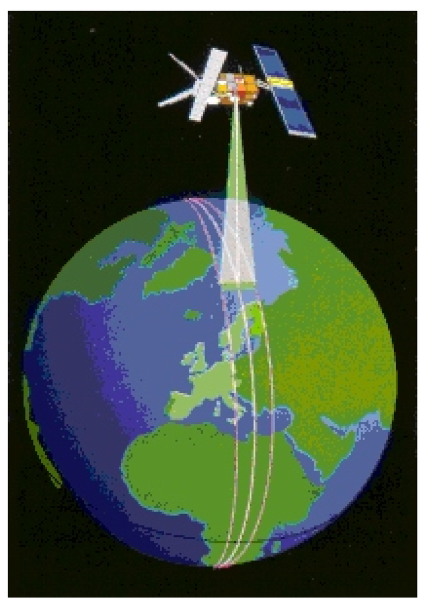

Figure 2: GOME aboard ERS-2

Analysis

SCIAMACHY is measuring scattered sunlight in nadir and limb mode. Therefore global maps of the total ozone columns and in addition ozone profiles can be obtained. Whereas GOME is a nadir viewing spectrometer.
In this study the tropospheric O_3 columns were derived from limb-profiles based on SCIAMACHY data. That means the stratospheric amount based on SCIAMACHY limb-data were subtracted from the total amount based on GOME data.
For the determintion of tropospheric O_3 based exclusively on GOME data the GOME spectra were analysed using the Tropospheric Excess Method (TEM). The background amounts of the reference orbit was obtained by using the SHADOZ-O_3-sondes measurements.
The validation of the tropospheric O_3 amounts using satellite based SCIAMACHY and GOME data was carried out with SHADOZ-O_3-sondes results.

First Results

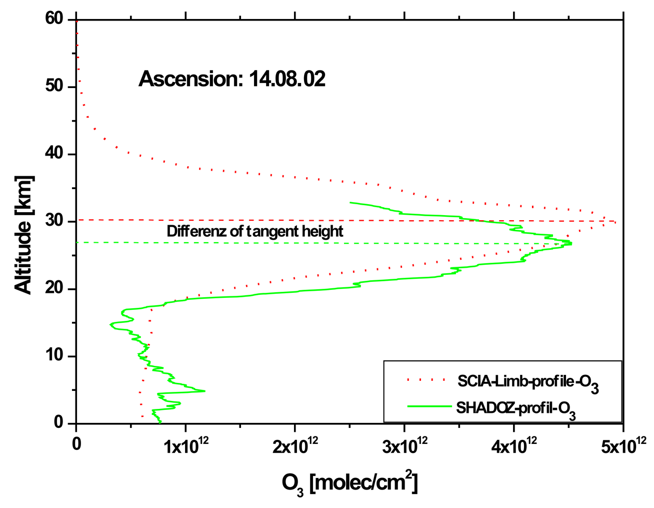

Figure 4: O_3 -profiles calculated from SCIAMACHY-limb-measurements and compared to the profil based on SHADOZ-O_3- measurements.

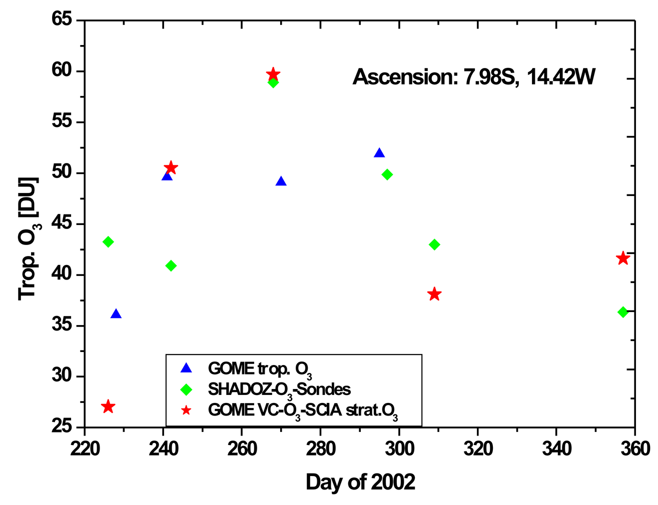

Figure 4: Comparison of tropospheric O_3 columns based on the combination of SCIAMACHY-GOME-data, GOME-results and SHADOZ-O_3-measurements.

Conclusions

For the analysis of tropospheric O_3 the height of the tropopause was determined from the temperature-profile of the radiosondes measurements as well as from the O_3-profile measurements based on SHADOZ-data. Then the limb-O_3-profiles based on SCIAMACHY-data were corrected in view to the tangent height. That means the profiles based on SCIAMACHY-limb-measurements were fitted on the SHADOZ-profiles. Therefore the maximum value of both measurements were used and fixed on the same height-level. So differences between -4.1-0.5 km have to be shifted.
The comparison for tropospheric O_3 (see fig. 4) based on (a) the difference of stratospheric O_3 (SCIAMACHY) from total $O_3$3 (GOME), (b) on the tropospheric O_3 (GOME) and (c) on the tropospheric O_3 of the SHADOZ-O3-sondes measurements leads to deviations in a range of 10-40% compared to the results of the SHADOZ-sondes. One reason can be that the collection of the satellite data are around 10:00 a.m. and the launches of the sondes are often in the afternoon. Therefore different air masses were observed with different photochemical activities (see fig. 3).

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