Tropospheric Ozone analysed with FURM (Full Retrieval Method) and compared with SHADOZ-O_3-sondes measurements

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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) [Ladstätter-Weißenmayer 1999], nitrogen oxides (NO_x=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. In order to investigate the effects of these emissions on tropospheric ozone production, the FUll Retrieval Method (FURM) Algorithm [Rozanov, 1997] was used to derive the tropospheric ozone vertical column for Watukosek, Indonesia not only for the year 1997, but also for 1998 (see fig. 1). These results were compared with results of O_3-SHADOZ(Southern Hemisphere Additional OZonesondes)-sondes [Thompson et al. 1999] and TTO-(Tropospheric tropical Ozone [Thompson et al. 2001])-data in view to the influence of the amount of tropospheric O_3 in the tropics.

An other discovery was a dynamical interaction of total column of ozone with the strong El Niño event in 1997 that led to a jump in the ozone over Indonesia well correlated to the intense biomass burning period.

Figure1: The location of Watukosek (Lat 7.57S, Long 112.65E), Java is shown.

El Niño-Event and Tropospheric O_3

During El Niño episodes like in summer 1997 the rainfall is reduced over Indonesia, Malaysia and northern Australia and finally these warm episodes results in abnormally dry conditions and leads to more intensive and longer lived fires over these regions. So an increasing of vertical columns of O_3 compared to the vertical columns of O_3 in 1998, a so called La Niña year, is observed (s. fig. 2). The sighted increase is caused by the intensive tropospheric ozone production during burning events, provided that there is no significant changing in the stratospheric amounts of the sighted increase is caused by the intensive tropospheric ozone production during burning events.

FURM (Full Retrieval Method)

The FUll Retrieval Method [Rozanov et al., 1997; Hoogen et al. 1999] was developed at the Institute of Remote sensing, University of Bremen to enable the retrieval of height resolved ozone information from GOME [Burrows et al., 1997, Burrows et al, 1999] sun normalized spectra. It uses temperature dependence absorption in the Hartley-Huggins bands of ozone. It is made up of two major parts:-

A forward Model, based on the radiative transfer model (RTM) GOMETRAN *[Rozanov,1997]* which calculates the top of the atmosphere (TOA) radiance and the weighting functions for a given state of the atmosphere as defined by, the Ozone vertical distribution; trace gas distribution; surface albedo, and aerosol scenario.

An Inversion Scheme which matches in iterative steps the calculated TOA radiance and the measured GOME radiance by modifying model atmospheric parameters such as the vertical distribution of ozone using an appropriate weighting function as defined by GOMETRAN.

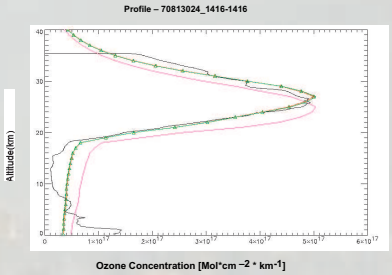

Figure 2: Ozone vertical profiles for a GOME ground pixel extracted for the 13th of August 1997. The black, green and pink curves indicate the sonde, FURM and apriori profiles respectively.

The FURM algorithm uses spectral information from Channel 1a (240-308 nm, 12s integration time) and Channel 2 (316-400 nm, 1.5s integration time). The ground coverage of Channel 1a corresponds to a surface area of 960 x 80 km^2, and that of Channel 2 to a smaller surface area of 320 x 40 km^2. In order to obtain an approximately identical surface coverage in each spectral GOME channel, the channel 2 spectrum is co-added from the three spectra available in the across-track scan direction, i.e. east, nadir, and west ground pixels. Both Channel 1A and 2 spectra are fitted simultaneously in FURM.

The fitting parameters in FURM are the ozone column densities at 61 equidistant levels between 0 and 60 km, the height integrated Rayleigh scattering and aerosol coefficient, total column of NO_2 and the scaling factor of the Ring spectrum.

GOME nadir ground pixels were extracted for those days sonde measurement were available. The implementation for the selected pixels was carried out separately in the FURM algorithm. Here properties such as the cloud top height, exact geolocation, cloud fraction, scan solar zenith angle and effective albedo for each pixel were defined.

Shown in figure 2 is an ozone vertical profile for a GOME ground-pixel extracted for the 13th of August 1997. The black curve indicates the sonde profile, while the green and the pink curves are for the FURM and apriori profiles respectively.

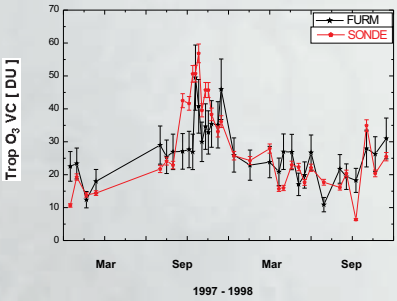

Figure 3: Tropospheric ozone vertical column from sonde (red curve) and FURM (black curve) plotted as a function of time (months) including the error bars.

Results and Conclusion

Generally the differences in the sonde and FURM measurements fall within the 10% error allowed for the FURM. This implies a good agreement in measurements. Despite the good agreement, however larger deviations of about 20% were observed between August and September, 1997. This could be due to differences in geolocation in some instances.

Another source of error could have been cloud cover and the effect of these (cloud fraction and cloud top height) on the result was investigated. Cloud fraction and cloud top height was derived using the O_4 absorption band.

Evidence of biomass burning could be seen from figure 3, where the ozone concentration peaks at around October to November 1997 and 1998. This period corresponds to the burning season at this region, where photochemical reactions involving NO_x and VOCs lead to photochemical production of tropospheric ozone.

El-Niño events are also seen to have influenced the photochemical production of tropospheric ozone in 1997 with a maximum ozone value of about 55 DU recorded. In 1998, the La-Niña conditions is a major factor in the much lower maximum of about 35 DU recorded during the biomass burning period.

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