A STUDY OF THE TRACE GAS COLUMNS OF O3, NO2 AND HCHO OVER THE MEDITERRANEAN REGION MAY 1999

Environmental Chemical Processes Laboratory
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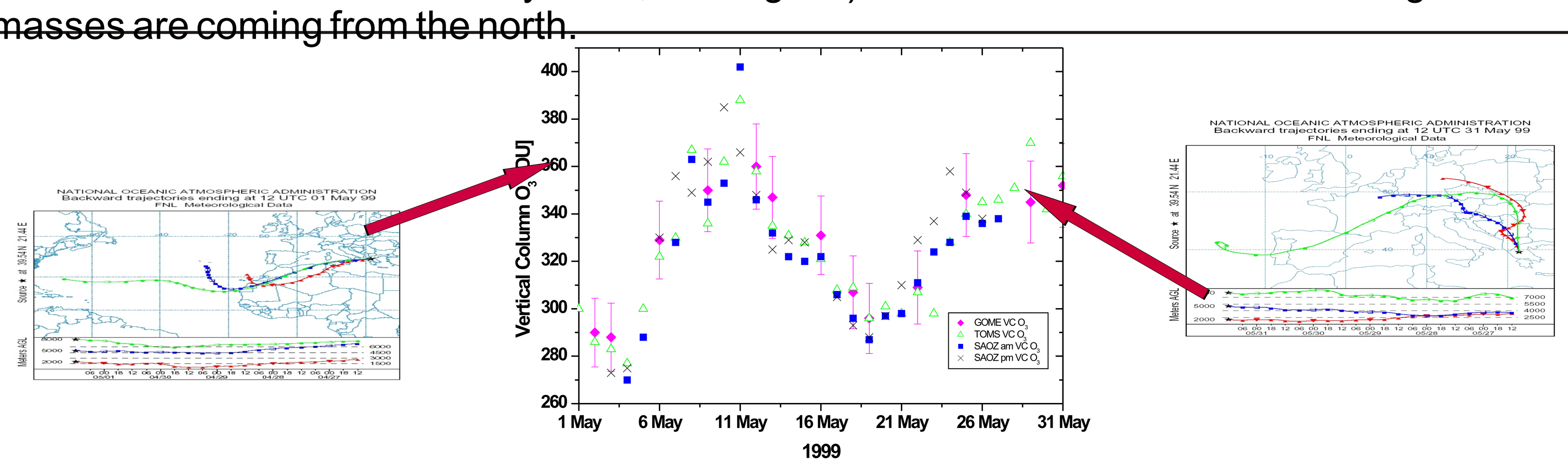
Introduction

As GOME (Global Ozone Monitoring Experiment) [Burrows et al. 1999 and 2000] is a nadir viewing instrument, both tropospheric and stratospheric absorptions contribute to the measured signal. This study focuses on the behavior of the trace gases O_3, NO_2 and HCHO over the Mediterranean region in May 1999. The results of GOME data were compared with those from ground based measurements (SAOZ (Systeme d'Analyse par Observation Zenithale) [Goutail et al. 1999]) carried out at Finokalia (35°24' N; 25°60') by the University of Crete [Kouvarakis et al., 2001], ozonesonde and LIDAR (LIght Detection And Ranging)-data collected during the PAUR (Photochemical Activity and Ultraviolet Radiation) experiment [Thompson et al. 2003; Simeonov.et al. 1998, Calpini et al. 1997]. By performing a global 3-dimensional chemical transport model like the TM3 [Houweling et al., 1998], the transport of air masses from different emission regions (e.g. from biomass burning and urban pollution over Africa and over N-NW-Europe depending of the wind fields) and the chemical composition were analysed. During May 1999 the total column amount of O_3 variies between 200 and 400 DU over Crete. This difference can be explained by the variation in tropospheric columns of O_3 which are influenced by both: in situ photochemical production and stratospheric-tropospheric-exchange (STE). In addition to this from time to time polluted air masses from the Balkans were transported towards the mainly clean air region over the Mediterranean leading to enhancements of the precursors of tropospheric O_3 like troposheric NO_2 and HCHO as observed from GOME.

Results

The comparison of the vertical columns of O_3 from GOME [Burrows et al. 1998 and 1999] with SAOZ (Systeme d'Analyse par Observation Zenithale) and TOMS (Total Ozone Mapping Spectrometer) (a.m. and p.m. data [Goutail et al. 1999] data show a variation of 120 DU (Dobson Units) during May 1999 over Crete (see Fig 1a) situated in the sub-tropical region. From the calculation of 5-day back trajectories it can be seen that in the case that Crete is affected by south winds (influence by the transport of air masses from the tropics) the total columns of O_3 are in the range of 270 DU (1st to the 4th of May 1999, see Fig. 1b) whereas high O_3 columns up to 402 DU (5th to the 10th and 28th to 31st of May 1999, see Fig. 1c) are reached for the same trace gas when air masses are coming from the north.



Figs. 1a/b/c. Total columns of O_3 measured by SAOZ and TOMS system and compared with GOME data for May 1999. 5-day back trajectories of air masses on May 1, 1999 (left) and on May 31, 1999 (right) showing strong influence from NW Europe and Balkans over Crete. The calculations were performed using the HYSPLIT 4 model (http://www.arl.noaa.gov/ready/ hysplit4.html).

The comparison of the tropospheric column amounts of O_3 based on ozonesonde [Thompson et al. 2003], LIDAR [Simeonov.et al. 1998, Calpini et al. 1997] and GOME data show (see Fig. 2) an increase of 23 DU (27DU up to 50DU) e. g. between the 5th and the 10th of May 1999 (north-wind) followed by a reduction down to background conditions of 20 DU (a value that is close to the 24 ±5 DU estimates by Hudson and Thompson [1998] for the back ground tropospheric O_3 column in the tropical regions) on the 22nd of May 1999 (south wind). During the pollution events when air masses were transported from N-NW (North-North-West) Europe and the Balkans (more polluted compared to the background conditions over the Mediterranean, see tab. 1) towards the Mediterranean region the precursors of tropospheric O_3, NO_2 and HCHO show an increase of a factor of 1.2 and of 1.2 respectively as can be seen from GOME when following air masses along the trajectory. Box model calculations show that such an increase of tropospheric amounts of NO_2 and HCHO column enhanced the tropospheric O_3 columns by only 1-2 DU per day. As no trend were observed for NO_2 and HCHO tropospheric columns for the time period of 1996 to 2002 (see figs. 3a/b) no significant increase of locally produced tropospheric O_3 is estimated.

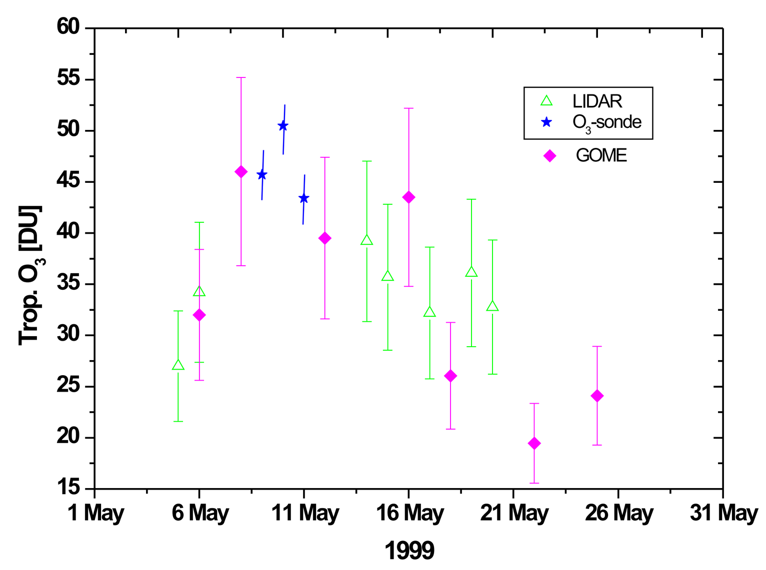
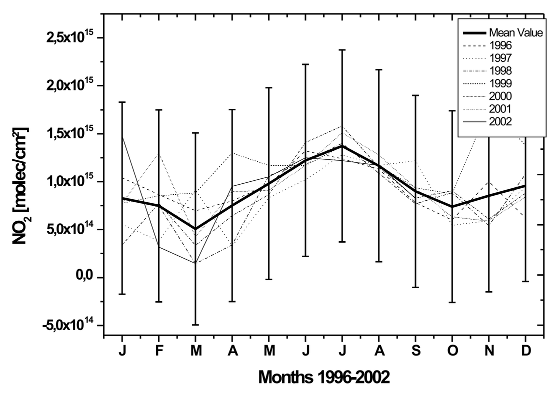
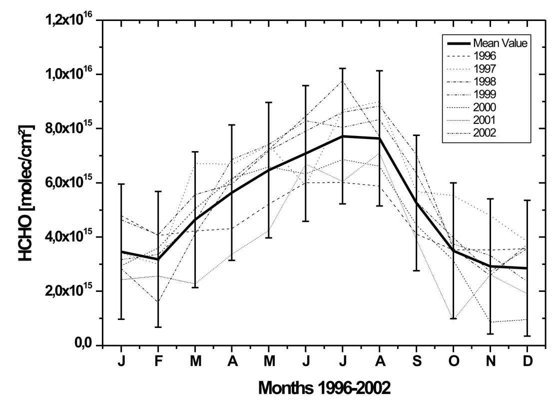


Fig. 2. Variation of tropospheric vertical columns of O_3 from satellite based observations by GOME, ozonesondes and ground based LIDAR observations as carried out at Nopigia, Crete for May 1999.

Trace Gas	Crete	Atlantic	Salonika	Po Valley	Istanbul
NO_2	$1.2x10^{15}$	$6.0 x10^{14}$	$2.7 x10^{15}$	$4.4 x10^{15}$	$2.7x10^{15}$
HCHO	$4.6 x10^{15}$	$3.1 x10^{15}$	$6.1 x10^{15}$	$6.6 x10^{15}$	$5.9x10^{15}$

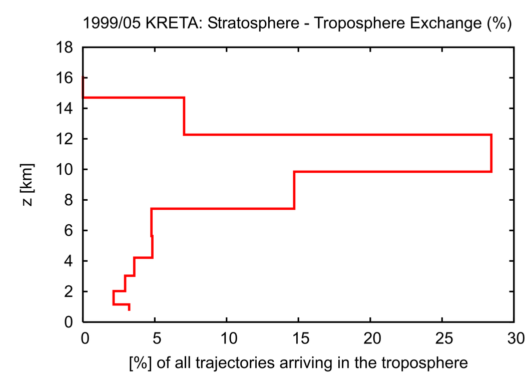
Tab. 1. Mean values of tropospheric NO_2 and HCHO (given in molecules cm^{-2}) for the month May based on GOME data for different regions.

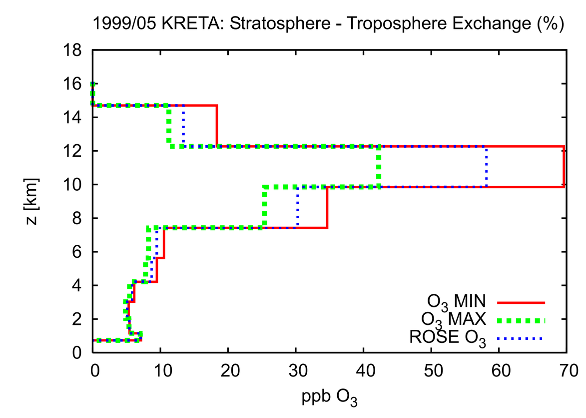




Figs. 3a/b. The monthly values over Crete of total column of tropospheric (a) NO_2 and (b) HCHO for the years 1996-2002 [all in molecules cm^{-2}] as retrieved from GOME observations.

In addition to photochemical activity during this time period stratospheric tropospheric exchange (STE) is probably responsible for a significant fraction of the troposphere O_3 [Waugh et al. 2000, Randriambelo et al. 1999]. As can be seen from figure 4a in a height of 10-12 km 30% of all trajectories arriving the troposphere are coming from the stratosphere. In the same altitude layer 70ppb O_3 can be expected based on the intrusion of air masses from the stratosphere into the troposphere. The calculation of the tropospheric column caused by STE including the chemical conversion of O_3 to OH shows values in a range of ~11.2 DU using the minimum, maximum data and the output of the 3D Chemistry-Transport Model ROSE [data are available from the World Data Center for Remote Sensing of the Atmosphere, WDC- RSAT (http://wdc.dlr.de)]. A similar increase can be received by the analysis of LIDAR O_3 profile observations (an increase of ~11 DU per day).





Figs. 4a/b. Altitude dependent influence of stratospheric and tropospheric air masses arriving over Finokalia (a) in May 1999. The percentage scale shows the differences of the stratospheric influence in the mid and lower troposphere for this location on a base of 10-day back trajectory calculation. The amount of

Conclusions

The Mediterraenen region is mainly influenced by clean air conditions but from time to time an increase of the total columns as well as of the tropospheric column amounts of O_3, associated with the transport of air masses from the north direction towards the Mediterranean region, can be seen from GOME data compared with SAOZ, TOMS and sonde measurements. Model calculations (TM3 and ROSE) showed that only ~1.33 DU are photochemical produced whereas ~11.2 are caused by transport processes mainly from the stratosphere irreversible to the troposphere (STE, ~11.2 DU).

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Acknowledgements

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