Pollution events over the East Mediterranean : Synergistic use of GOME, ground based and sonde observations and models

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ACCENT ATMOSPHERIC COMPOSITION CHANGE THE EUROPEAN NETWORK OF EXCELLENCE

AT2 activity

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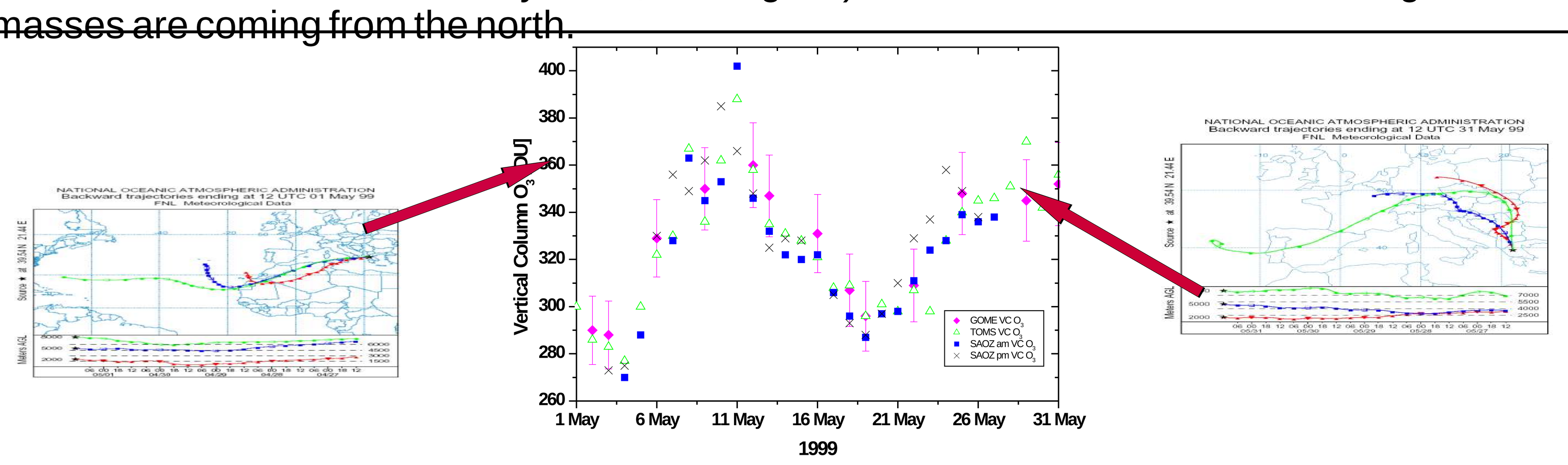
Introduction

Retrievals of trace gas columns of O_3, NO_2 and HCHO from the measurements of backscattered radiation by GOME (Global Ozone Monitoring Experiment) [Burrows et al. 1999 and 2000], interannual comparisons and comparisons with Systeme d'Analyse par Observation Zenithale (SAOZ) [Goutail et al. 1999], balloon [Thompson et al. 2003; Simeonov.et al. 1998, Calpini et al. 1997] and LIDAR measurements show that the East Mediterranean in spring, and particularly in May 1999 during the international PAUR II campaign in Crete carried out at Finokalia (35°24' N; 25°60') by the University of Crete [Kouvarakis et al., 2001], is influenced normally by back ground conditions but also by biogenic emissions and urban pollution related to distinct changes in wind direction between north and south. When following air masses along the trajectory we derived that air masses transported from N-NW (North-North-West) Europe towards the Mediterranean region are associated with an increase of tropospheric amounts of NO_2 by a factor of 1.4 to 1.5 and of HCHO by a factor of 1.6 to 1.8 as can be seen from GOME. 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 locally. In addition to that backward trajectories emerging Crete were calculated to analyse the amount of 11-19 DU from the intrusion of stratospheric air masses into the troposphere during May 1999. As follows the long-range transport of O_3 rich air masses and its precursors from industrial areas towards the Mediterranean region as well as stratospheric-tropospheric-exchange (STE) contribute mainly to enhanced tropospheric O_3 levels both at the ground and in the free troposphere.

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 from tropospheric O_3, NO_2 and HCHO show an increase of a factor of 1.4-1.5 and of 1.6-1.8 respectively as can be seen from GOME when following air masses along the trajectory. Box model calculations show that such 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 NO2 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.

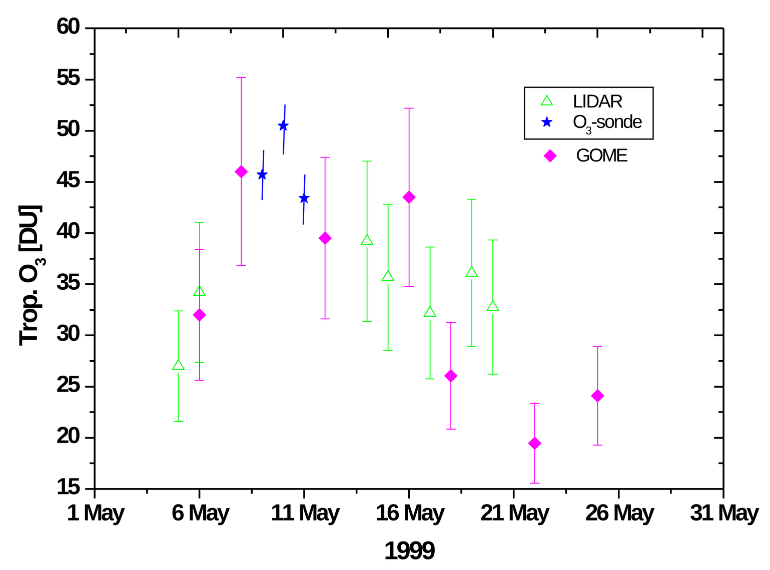
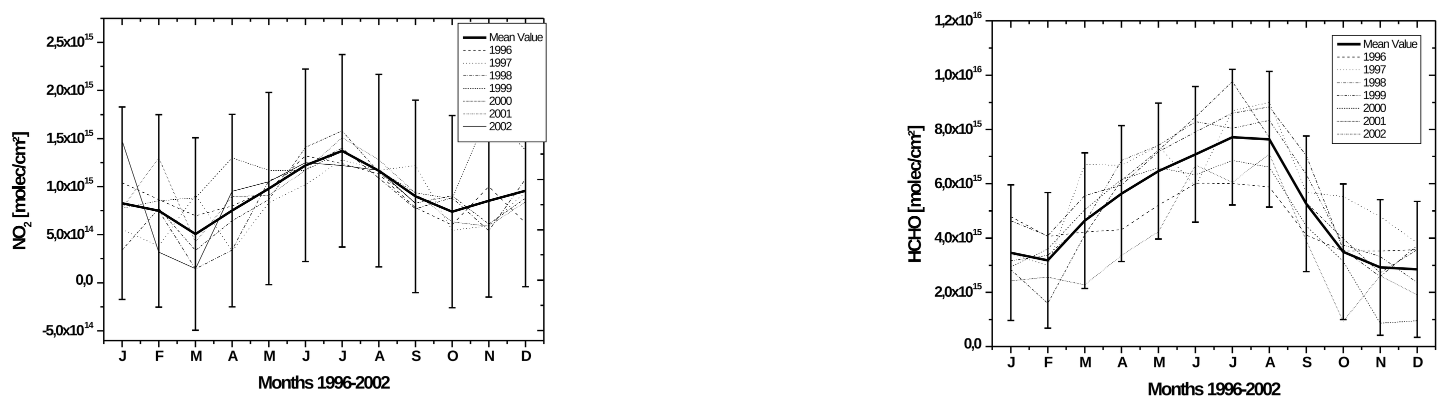


Fig. 2. Variation of tropospheric vertical columns of O_3 from satellite based observations by GOME, ozonesondes and ground based LIDAR observations as carried out at Nopigia, Crete for May 1999.

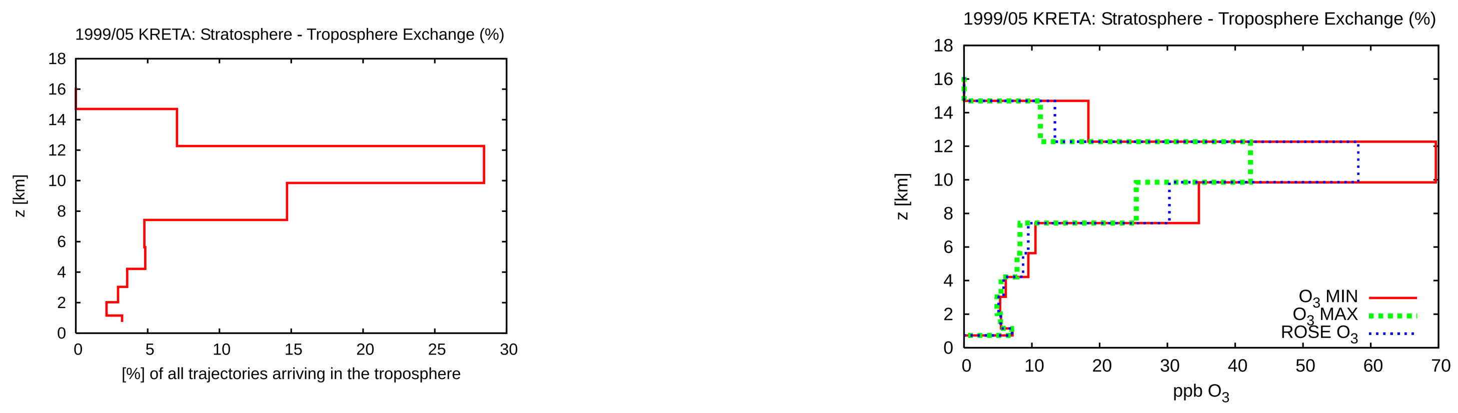
Trace Gas	Crete	Atlantic	Salonika	Po Valley	Istanbul
NO_2	$1.2x10^{15}$	$6.0\ x10^{14}$	$2.7\ x10^{15}$	$4.4\ x10^{15}$	$2.7x10^{15}$
HCHO	$4.6\ x10^{15}$	$3.1\ x10^{15}$	$6.1\ x10^{15}$	$6.6\ x10^{15}$	$5.9x10^{15}$

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 tropospheric 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).

References

Burrows, J. P. et al., The Global Ozone Monitoring Experiment (GOME): Mission Concept and First Scientific Results, *J. Atm. Sciences*, 56, 151-175, 1999.

Burrows, J. P. et al., Satellite observations of tropospheric and stratospheric gases, in: Chemistry and Radiation Changes in the Ozone Layer, eds. C. Zerefos et al., 301-329, *Kluwer Academic Publisher*, 2000.

Kouvarakis G.,Vrekoussis M., Mihalopoulos N., Kourtidis K., Rappengluck B., Gelasopoulos E. annd Zerefos C., Spatial and temporal variability of tropospheric ozone (O3) in the boundary layer above the Aegean Sea (Eastern Mediterranean), *J. Geophys.Res.*, 107, 8137, 10.1029/ 2000JD000081, 2002 JGR, 2001.

Simeonov, V. et al., The EPFL UV Ozone DIAL: results and upgradings, Proc., 19th ILRC, NASA editor, 399-402, 1998.

Solomon, S. et al., On the interpretation of zenith sky absorption measurements, *J. Geophys. Res.*, 92, 8311-8319, 1987.

Thompson, A. M. et al., Southern hemisphere additional ozonesondes (SHADOZ) 1998-2000 tropical ozone climatology - 1. Comparison with Total Ozone Mapping Spectrometer (TOMS) and ground-based measurements, *J. Geophys. Res.*, Vol. 108 No. D2, 8238, doi: 10.1029 /2001JD000967, 30 January 2003.

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