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MEASUREMENTS OF TROPOSPHERIC NO_2 IN A ROMANIAN REGION USING A MOBILE DOAS SYSTEM

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ABSTRACT: This paper presents tropospheric NO_2 measurements made in the South-Eastern part of Romania, during several days in the summer season, using a portable DOAS (Differential Optical Absorption Spectroscopy) system placed on a motor vehicle. A GPS (Global Positioning System) device was used for location tracking. The measurements were made in zenith view and the NO_2 DSCD (Differential Slant Column Density) was determined with QDOAS software package developed by the Belgian Institute for Space Aeronomy. The aim of this study is to investigate short-term and local variations of NO_2 loading dependence on location and proximity to traffic or industrial areas.

INTRODUCTION

Nitrogen dioxide (NO_2) is a trace gas with important implications in atmospheric chemistry. Measurements of NO_2 are important for the understanding of tropospheric and stratospheric chemistry, its role being known in ozone cycle.
The DOAS passive method consists in two steps. Firstly molecular absorption cross-sections are fitted to the logarithm of the ratio of the measured radiance and direct solar irradiance without atmospheric absorption. The resulting fit coefficients are the integrated number of molecules per unit area along the atmospheric light path for each trace gas, also called the Slant Column Density (SCD). SCD is converted to a Vertical Column Density (VCD) by ratio of SCD to an Air Mass Factor (AMF) which is influenced by geometry (Solar Zenith Angle (SZA) and Line Of Sight (LOS)), albedo, visibility, and wavelength.

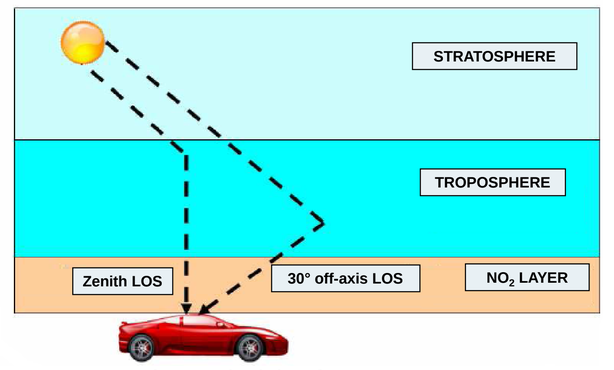


Fig.1. Principle of measurements

EXPERIMENTAL SET-UP

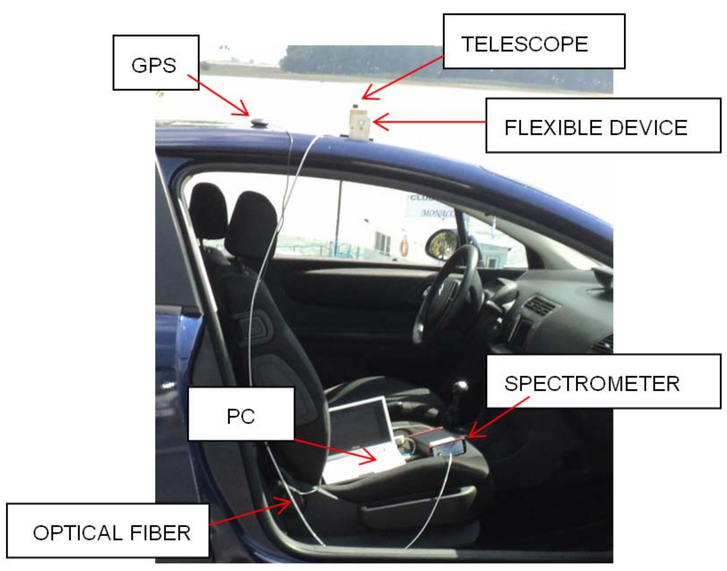


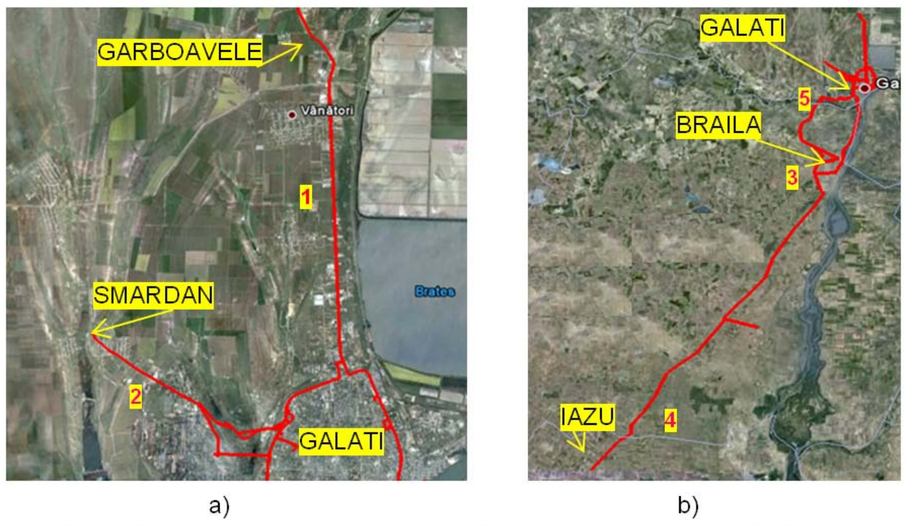
Fig.2. The mobile DOAS system

The mobile DOAS system consist in: 1x UV-VIS spectrometer USB Avantes 2000 1.5nm resolution (FWHM) (with dimensions 175x110x44mm, 716 g and 75mm focal length), Optical fiber, Telescope with FOV 2.5°, GPS, Laptop, Inverter. The entire set-up is shown in Fig. 2.

Table 1.The track and time of experiments

DAY	UTC (FT*)	TRACK
28.07.2011 MEASUREMENTS IN ZENITH VIEW (90°)	09.55-09.85	GARBOAVELE-STEEL FACTORY
	09.97-10.53	GALATI-BRAILA
	10.57-12.05	BRAILA-IAZU
	12.09-13.47	IAZU-GALATI
08.08.2011 MEASUREMENTS IN ZENITH AND OFF AXIS (30°)	05.60-06.20	RING ROAD OF GALATI CITY

*Fractional Time



a) b)
Fig. 3. Track measurements on Google Earth with: (a) Galati city. (b) The entire experiment

DOAS RETRIEVAL OF NO2 DSCD

For the analysis of zenith-sky spectra we used QDOAS, a program dedicated to the DOAS retrieval from ground-based and satellite measurements. The NO_2 column density was retrieved in the spectral region 425-530 nm where NO_2 has strong absorption signatures at 439.5, 445 and 448 nm. The cross sections of NO_2, O_3, O_4, H_2O and a Ring spectrum calculated with QDOAS were included into the fit. A low order polynomial representing the contribution of broad-band absorption in the atmosphere (Rayleigh and Mie scattering) was used in QDOASanalysis.

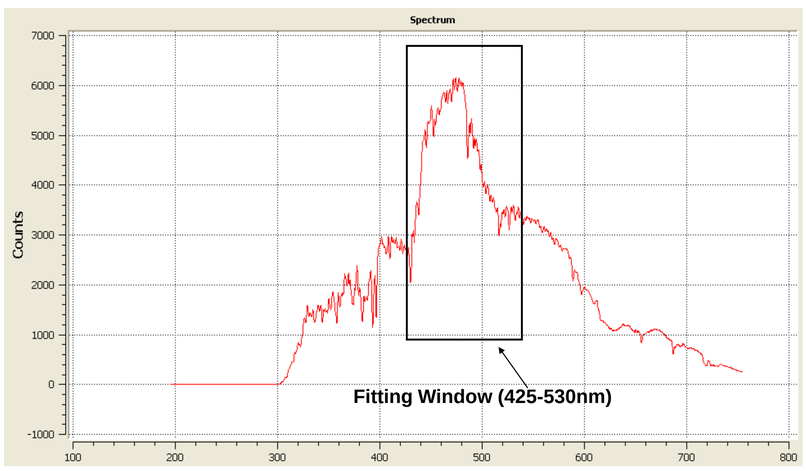


Fig.4. Example of a spectrum collected and some results of its analysis with QDOAS software.

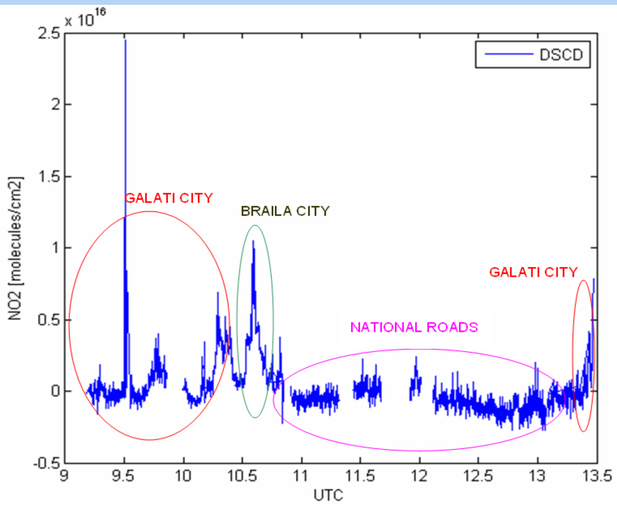


Fig. 5. NO_2 DSCD during the round trip (measurements performed on July 28th)

RESULTS & DISCUSSIONS

DEDUCTION OF THE TROPOSPHERIC NO2 VCD

Method A (Wagner, 2010)

$$\begin{cases} Meas_{Zen} = SC_{Strato} + SC_{TropoZen} - SC_{Res} \\ Meas_{Off} = SC_{Strato} + SC_{TropoOff} - SC_{Res} \end{cases}$$

$$Meas_{Off} - Meas_{Zen} = SC_{TropoOff} - SC_{TropoZen}$$

$$Meas_{Off} - Meas_{Zen} = VC_{Tropo}(AMF_{TropoOff} - AMF_{TropoZen})$$

$$VC_{Tropo} = Meas_{Off} - Meas_{Zen}$$

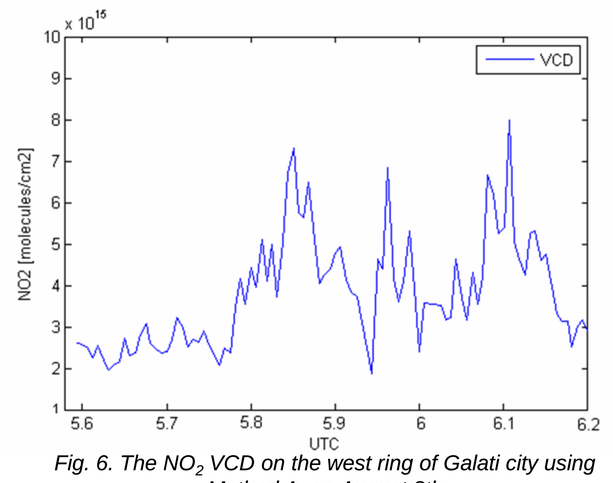


Fig. 6. The NO_2 VCD on the west ring of Galati city using Method A, on August 8th

Method B (Wagner, 2010)

$$\begin{cases} VC_{Tropo} = Meas_{Off} - Meas_{Zen} \\ VC_{Tropo} = \dfrac{Meas_{Off} - SC_{Strato} + SC_{Res}}{2} \end{cases}$$

$$SC_{Res} - SC_{Strato} = Meas_{Off} - 2 * Meas_{Zen}$$

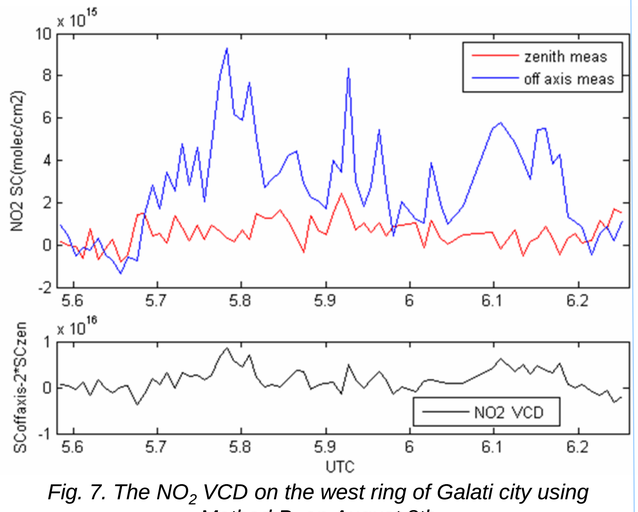


Fig. 7. The NO_2 VCD on the west ring of Galati city using Method B, on August 8th

Fig. 6 and Fig.7 are the result of two different measurements, one at 90° and another one at 30°, on the same track in a short time (15 kms in approx. 20 minutes each measurement), with the next supposition: the weather conditions and NO_2 concentrations did not change in 20 minutes, same stratospheric contribution for the two LOS measurements, scattering above the NO_2 layer (Fig.1) and SCres-SCstrato is assumed to be stable.

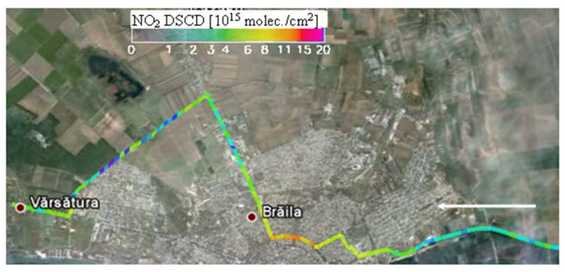


Fig. 8. The NO_2 DSCD in Braila city plotted on Google Earth

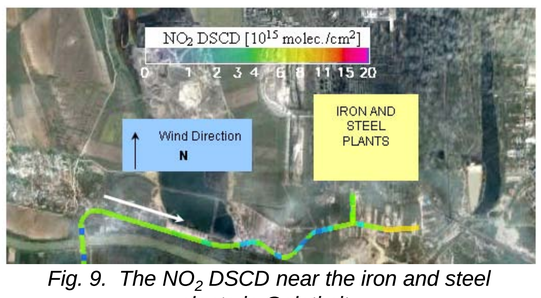


Fig. 9. The NO_2 DSCD near the iron and steel plants in Galati city

CONCLUSIONS & FUTURE WORK

DOAS technique is a very useful method to show the atmospheric pollution differences between urban areas, rural areas or traffic roads. We found that most polluted places are located very close to the industrial zone (e.g. Galati) or downtown (e.g. Braila). As future works we will determine the NO_2 VCD from zenith measurements using a 3D CTM for removing of stratospheric contribution. Another direction is comparison with data from satellite instruments (SCIAMACHY, OMI, GOME-2).

Acknowledgements

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Selected references

Wagner T., Ibrahim O., Shaiganfar R., and Platt U., *Mobile MAX-DOAS observations of tropospheric trace gases*, Atmos. Meas. Tech., 3, 129-140, 2010.