Seasonal Surface Ozone Patterns at Sofia, Bulgaria

A contribution to subproject TOR-2

V. Grigorieva and M. Mihalev

Institute of Electronics, Bulgarian Academy of Sciences, 72 Tzarigradsko Chaussee, 1784 Sofia, Bulgaria

Abstract

The first systematic measurements of the surface ozone concentrations in Sofia, Bulgaria have been carried out in 1994. The study has shown that meteorological conditions determine the ozone content near the ground and the patterns of the diurnal ozone variations. The observed seasonal ozone distribution with a summer maximum of 60–100 $\mu g/m^3$ and a winter minimum of 20–35 $\mu g/m^3$ is similar to that detected at northern mid-latitudes. Four episodes with ozone concentrations of the order of 140–160 $\mu g/m^3$ occurred in 1994.

Introduction

Tropospheric ozone is a major atmospheric pollutant, which plays a key role in atmospheric chemistry and at heightened levels causes damage to human health, forest ecosystems, agricultural crops and building materials. A great deal of attention has been devoted to the ozone problem over the world. In Europe, long-term systematic surface ozone observations have been made at latitudes higher that 45°, but comparatively little is known about the ozone behaviour near the ground in southern and south-eastern Europe (Borrell *et al.*, 1997).

Initial investigations of the surface ozone in Bulgaria began in 1994. The following goals were pursued: to evaluate the surface ozone state in Sofia, to ascertain the diurnal and seasonal ozone variations and, to investigate ozone behaviour with respect to meteorological conditions. In this paper initial results from the ozone measurements in the ambient air near the ground are reported.

Proceedings of EUROTRAC Symposium '98
Editors: P.M. Borrell and P. Borrell

Experimental

Site description

The measurements were performed in Sofia, located in the western part of Bulgaria (42° 49' N, 23° 23' E, 530 m. a.s.l.). The observation site is about 7 km to south-east of the centre of Sofia and possesses ground cover of fairly good vegetation. A road with considerable car traffic runs at *ca.* 100 m from the site. The ozone recorder was installed at height of about 10 m above ground level.

Instrumentation

The ozone detector used in the investigations is chemiluminescent analyser, model 3-02P1, produced by OPTEC Inc. (Optical and Ecological Scientific Instruments), Russia. The measuring principle of the sensor is the chemiluminescence of an organic dye, adsorbed on a solid, in the presence of ozone. The ozone analyser has the following characteristics: response time is no more than 1 s and a sensitivity of 2 $\mu g/m^3$. Periodically, the analyser was calibrated using an external O_3 generator.

Results and discussion

The measurements were performed mostly during the day and, less regularly, over a twenty-four hour period. The analysis of the diurnal ozone variations is carried out by using the hourly values of the ozone concentrations determined as 15-min averages.

Diurnal variations

The pattern of diurnal variations of the surface ozone concentrations is strongly influenced by meteorological conditions. The pronounced O_3 maximum in the daytime which is explained in terms of vertical mixing process and photochemical ozone production occurred on clear windless afternoons (Fig. 1a). The ozone data show a maximum in summer months roughly three to four times higher than that in winter months. During fine windy weather dilution of the atmospheric pollutants takes place, so decreased ozone concentrations are detected and the ozone level is approximately constant throughout the day (Fig. 1b). However, in the case where vertical exchange is limited (autumn-winter period, nocturnal inversions) the wind enhances the vertical mixing and increases the ozone content near the ground. The cloudiness strongly decreases the ozone concentrations near the ground but when it is foggy the ozone content is very low, often zero. So the ozone

concentration sensitively reflect meteorological conditions at which measurements are performed. It is very likely that more realistic information about temporal and spatial ozone variations may be obtained when ozone data received at similar meteorological situations are analysed.

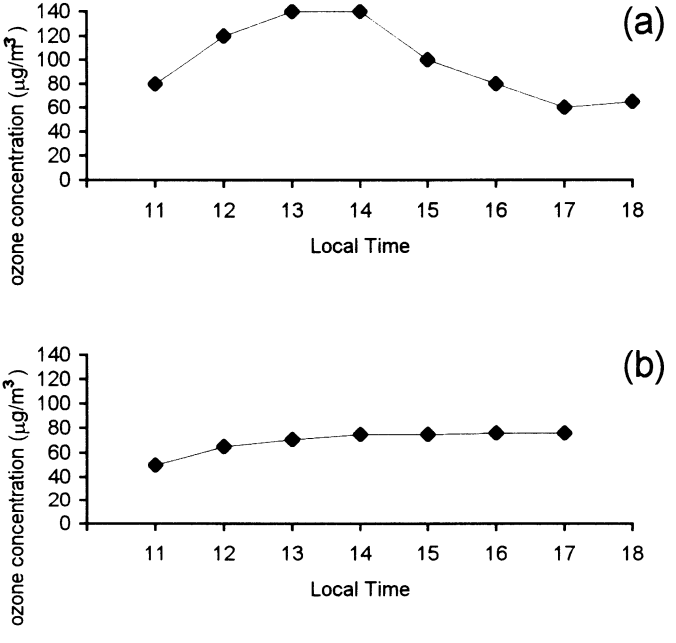

Fig.1: Daytime variations of the surface ozone concentrations. (a) – profile from 3rd June 1994, wind speed is zero; (b) – profile from 2 June 1994, wind speed does not exceed 3 m/s.

Seasonal variations

As seen in Fig. 2 the surface ozone behaviour clearly shows a seasonal variation with a summer maximum. The variations are indicated by monthly means, obtained by averaging the mean concentrations for clear and overcast days. The minimum, 20–35 $\mu g/m^3$, ozone concentrations were detected during the winter period, the maximum, 60–100 $\mu g/m^3$, ozone content near the ground was observed in the summer months. During the summer of 1994 the surface ozone concentrations of the order of 140–160 $\mu g/m^3$ occurred in four episodes. The recorded seasonal pattern of ozone concentrations is similar to that observed at northern mid-latitudes (Logan, 1985). The collected data show,

that the surface ozone concentrations in Sofia agree with the Bulgarian standard value of 100 μg/m^3, 8-hourly average, and with European Union standard of 180 μg/m^3, 1-hourly average.

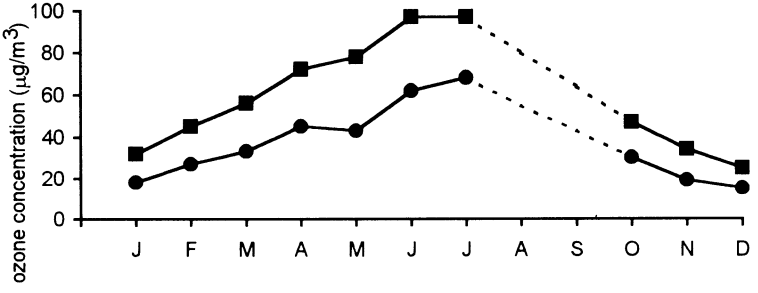

Fig.2: Seasonal distributions of the surface ozone concentrations at Sofia, Bulgaria during 1994, as indicated by monthly mean, obtained by averaging clear days ozone concentrations (▪) and overcast days concentrations (●).

Conclusions

The following conclusions may be drawn from the data on the surface ozone concentrations measured in Sofia.

* The patterns of diurnal variations significantly depend on meteorological conditions.
* The seasonal distribution of the surface ozone shows the summer maximum and is not different from that observed at northern mid-latitudes.
* It is possible that investigation of the ozone spatial and temporal behaviour will be more correct if one analyses the ozone concentrations, measured at similar meteorological conditions.
* The episodes during which the ozone concentrations exceeded EU standard of 180 μg/m^3 were not observed.

Acknowledgements

This work was supported by Bulgarian Ministry of Education and Science.

References

Borrell, P., P. Builtjes, P. Grennfelt, Ø. Hov (eds); *Photo-oxidants, Acidification and Tools: Policy Applications of EUROTRAC Results,* Springer, Heildeberg 1997, p. 19 and p. 52.

Logan, J.A.; *J. Geophys. Res.* **90 (D6)** (1985) 10 463–10 482.