Seasonal and Diurnal Variability of Aerosol Number Size Distribution, Concentration and Gaseous Pollutants in Prague City Center

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SEASONAL AND DIURNAL VARIABILITY OF AEROSOL NUMBER SIZE DISTRIBUTION, CONCENTRATION AND GASEOUS POLLUTANTS IN PRAGUE CITY CENTER

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INTRODUCTION

Atmospheric aerosol is one of the key urban pollutants while much attention has focused to the size fractions of smaller particle diameter - D_p. The most significant sources of primary ultrafine particles (D_p<100 nm) in urban ambient air are outdoor combustion sources: vehicles, industry and power plants. The aim of this study was to investigate the relationship between ultrafine aerosol particles and gaseous pollutants (O_3, NO_x) and their temporal variation, to analyse the size distribution differences and to assess the major sources of ultrafine particles in Prague city center.

EXPERIMENTAL SETUP

Five minute integrates of particle number concentrations (PNC), size distributions, trace gases (NO_x and O_3) and meteorological parameters were measured in Prague city centre at the rooftop station (GPS: 50°40' 16.61"N, 14°25'15.28", height 15 m) of the Institute for Environmental Studies, Faculty of Science, in summer 2014 and winter 2015. The PNC and the number size distributions (14-723 nm) were measured by a Scanning Mobility Particle Sizer (TSI 3936L25, up/down scan 210/60 sec., waiting 30 sec., sheath/aerosol flow 3/0.3 LPM). Gases - O_3 and NO_x - were measured by automatic monitors (Horiba-360 Series).

RESULTS AND CONCLUSION

The Ultrafine particle (UFP) number and the NO_x concentration are higher in winter (+11%, +30%) while O_3 is higher in summer (+25%). In both seasons, higher PNC is related to NO_x peaks during morning rush hours (7 to 11 AM, weekdays). The PNC-NO_x association was observed also in the evening (7-10 PM, weekend included), with a delay beside the afternoon rush hours (4 to 6 PM) (Fig. 1). No peaks were registered during weekend mornings. The inverse relationship between PNC and NO_2/NO_x ratio suggests fresh emitted aerosol particles (Minoaura et al., 2005). Dilution of pollutants is

observed: the concentration of particles and gases decreases with the increase of the wind speed but clear relationship was not found between the UFP concentration and wind direction.

Particle bursts were registered in summer, under conditions of higher solar radiation intensity, temperature, wind speed, O_3 concentration, and lower NO_x (<20 ppb) and relative humidity (Fig. 2). Nevertheless, these events cannot be considered as new particle formation events, because clear growth was not observed. Only one event of new particle formation followed by condensational growth at the rate of 5 nmh^{-1} was observed in the summer (Fig. 3).

Regarding the urban atmospheric chemistry, the increase of solar radiation led to NO_2 photolysis and O_3 formation, which resulted in the O_3 typical diurnal profile. Maximum O_3 concentration was observed in the afternoon, simultaneously with a decrease in NO_2 (Fig. 2). Ozone concentration dropped at late afternoon, due to the decrease of photochemical oxidation and O_3 titration by NO.

During the morning rush hour, the aerosol number size distribution is generally bimodal, with nucleation/accumulation modes at 30/60-90 nm. This aerosol number size distribution was apportioned to the vehicles exhaust. The nucleation of low volatile vapors after the cooling generated the first mode, followed by coagulation and/or condensation of low-volatile vapors on primary particles, which generates the second mode (Morawska *et al.*, 2008, Wehner *et al.*, 2002). Nevertheless, differences are observed between winter and summer. In winter the nanoparticles in the rush hours are smaller than in summer: the vehicle-induced nucleation is temperature dependent, with higher nucleation rate in winter due to lower ambient temperature (Dall'Osto et al., 2011).

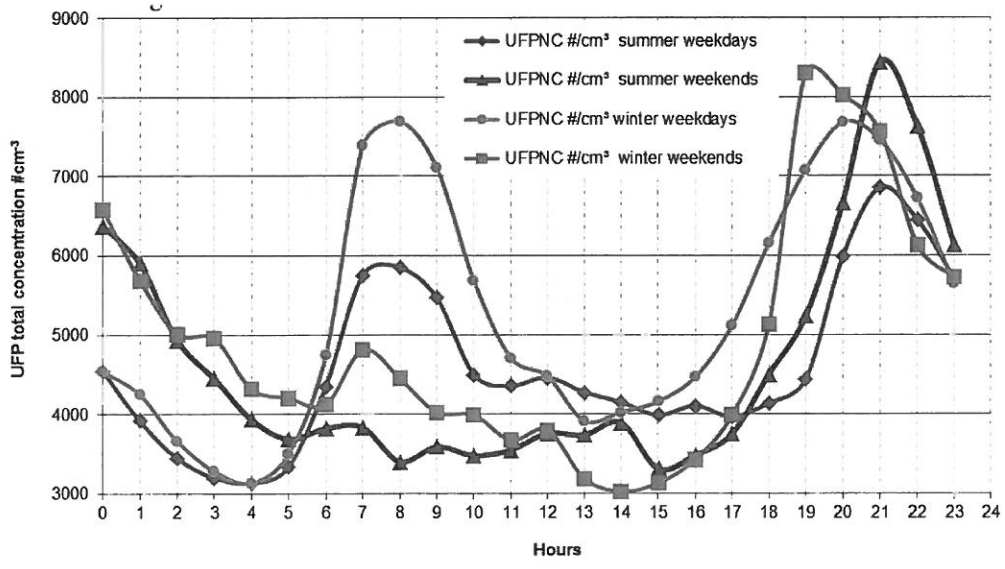

Figure 1 – Diurnal pattern of hourly averages of ultrafine particle number concentrations – UFPNC.

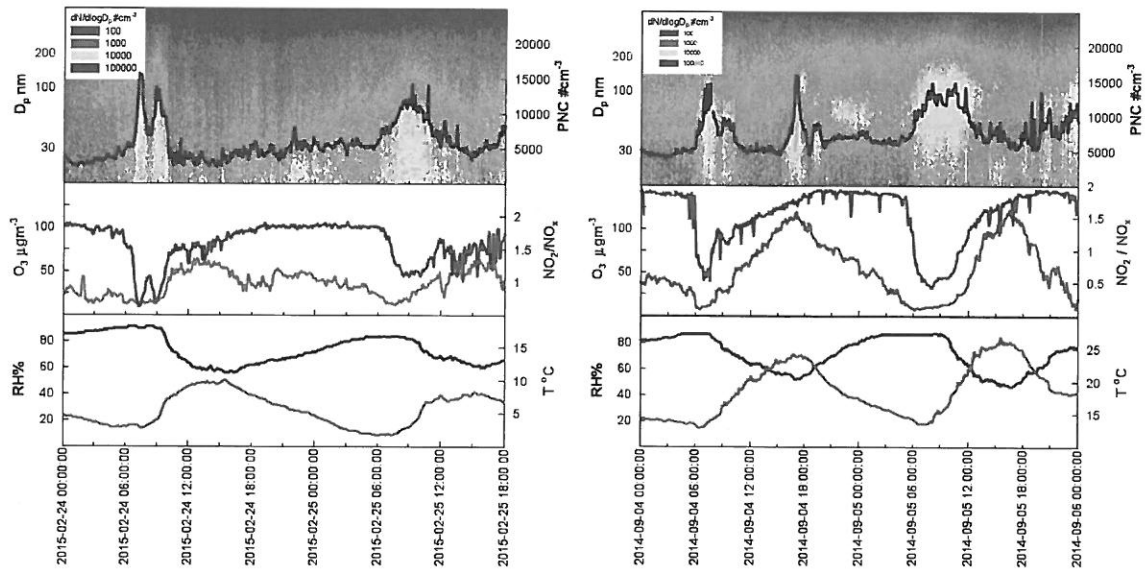

Figure 2. Top: Temporal variation of particle number size distributions and total PNC (black line); Middle: NO_x and O_3 spectra. Bottom: temperature and humidity; in winter (left) and in summer (right).

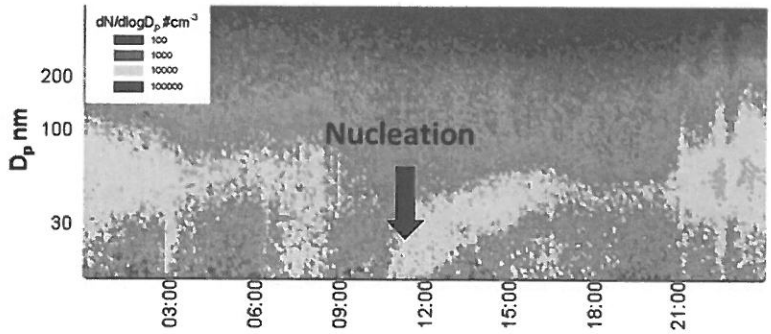

Figure 3. NPF event on the 08.08.2014.

To conclude, the diurnal pattern of gases and particles indicates a morning and evening polluted atmosphere. Major source of ultrafine particles is the traffic, while in summer photochemical reactions forming secondary nanoparticles contributed significantly to nanoparticle burden. Nanoparticle concentrations are not related to the wind direction, therefore their transport from more polluted parts of the city (i.e. Legerova traffic hot-spot) is not observed. Nanoparticles rather originated from nearby streets. In winter the particles concentration is higher due to additional emissions from home heating and lowering of atmospheric boundary layer mixing height.

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