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MEASUREMENTS AND CORRELATIONS BETWEEN SEVERAL ATMOSPHERIC PARAMETERS

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Abstract. *Diurnal atmospheric air-ion concentrations have been investigated at a site where synchronous aerosol, ozone, temperature and relative humidity measurements were also made. Air-ions, temperature and relative humidity were measured with Gerdien type Cylindrical Detector of Air-Ions (CDI-06) made in the Institute of Physics, Belgrade. Ozone and aerosols were measured with commercial instruments owned by the Institute of Public Health, Belgrade. Typical daily variations of the measured parameters were analyzed and showed that air-ions of both signs and ozone are positively correlated, while aerosols show strong inverse correlation with air-ions. Also, concentrations of air-ions and ozone are decreasing with temperature while aerosol concentration and humidity are increasing. These processes could be explained concerning properties of the specified parameters, measuring place properties and weather conditions.*

Key words: *air-ions, ozone, radon, aerosols, troposphere, temperature, humidity, Gerdien*

INTRODUCTION

Aim of this work is to establish dependences between air-ions concentration with relevant atmospheric parameters: aerosols (particulate matter smaller than 10 μm, PM_{10}), radon, tropospheric ozone, temperature (T) and relative humidity (RH). Aerosols and tropospheric ozone in big cities are mostly consequences of anthropogenic activities such as transport, industrial activities, biomass burning and others. Also, charged particles are continually generated in atmospheric air. Interaction between natural air-ion pair production and atmospheric particles is complicated with possibility that air-ions are implicated in particle formation. One of ways to examine mentioned dependences and interactions is measuring simultaneously all off these parameters at one place.

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Air-ions

The electrical conductivity of the air is predominantly determined by concentration of the small air-ions with mobility's ≥ 10^{-4} $m^2V^{-1}s^{-1}$ [1]. Small air-ions are cluster ions of 4–12 molecules and typically exist in concentrations of a *few hundred per cm*^{3} in fine weather conditions and clean air [2]. Their life time is up to 100 *s* depending on air pollution. There are three natural sources that are responsible for air-ion production in the lower troposphere: cosmic rays, radon and terrestrial gamma radiation. Cosmic radiation is composed of extremely energetic particles, primarily protons, originating from the Sun, other stars or outer space. Ionization from cosmic rays comprises approximately 20 % of the total surface ionization rate. Rest of 80 % arises from natural α and β emitters in the air and soil, although air-ion pair generation near the ground varies mostly with concentration of ^{222}Rn and its progenies. Half-life of ^{222}Rn is 3.82 *days* and decay product is alpha particle with energy 5.49 MeV. Decay of ^{222}Rn generates 10^5 nitrogen and oxygen molecular ions per each α-particle. ^{222}Rn moves through ground into air by exhalation. Rate of this process is determined with local meteorological and microphysical factors of the local soil. The major removal mechanism of air-ions near the ground level is their attachment onto aerosol particles:

$$\frac{dn_{\pm}}{dt} = q\text{-}\alpha n_{\pm}^2 - \beta Z n_{\pm} - \gamma n \qquad (1)$$

where: q ion production rate, n concentration of small ions, α self-recombination coefficient (ion-ion), β ion-aerosol attachment coefficient, Z large aerosol number concentration, γ ion-induced nucleation coefficient.

Tropospheric ozone

Tropospheric ozone (O_3) is presently the third most important greenhouse gas with continuous increasing trend. Tropospheric ozone is component of photochemical smog formed mostly from fossil fuel combustion. Ozone and PM_{10} are potentially most harmfully pollutants in the atmosphere. Tropospheric ozone formation occurs when nitrogen oxides (NOx), carbon monoxide (CO) and volatile organic compounds (VOCs), react in the atmosphere in the presence of UV component of the sunlight.

Photodissociation of O_3 by solar UV radiation will produce electronically excited $O(^1D)$ atoms:

$$O_3 + h\nu \rightarrow O(^1D) + O_2 \quad (\lambda \leq 325\ nm) \qquad (2)$$

this metastable reacts with water

$$O(^1D) + H_2O \rightarrow 2OH \qquad (3)$$

which determines oxidation efficiency of the atmosphere [3].

Aerosols

Aerosols are a suspension of fine solid or liquid droplets in gas. Generally, urban pollution is composed of soil-derived particles (PM_{10} and $PM_{2.5}$), particles from combustion processes, SO_2, NOx, NH_3, VOC and carbon. VOCs participating in reactions, resulting in sulfuric acid, nitric acid, particle phase organics and ozone, can have carcinogenic effects on human health. The notation PM_{10} is used to describe particles of 10 micrometers or less. Anthropogenic aerosols, particularly sulfate aerosols from fossil fuel combustion, exert a cooling influence on the climate. Aerosols are influencing Global radiation budget on two ways, direct which is represented through scattering and absorption and indirect which is by changing optical properties, life time and quantity of clouds [4].

MEASURING METHOD

Air-ions measurements in this work were performed using Cylindrical Detector of Air-ions (CDI-06) made in the Institute of Physics, Belgrade [5]. CDI-06 measures air-ions mobility ≥ 10^{-4} $m^2V^{-1}s^{-1}$, temperature, relative humidity, pressure, real time and date. A current signal of 10^{-14} – 10^{-12} A which is collected at the measuring electrode is measured by an electrometer. CMOS dual operation amplifier LPC662 is used as current amplifier. Second half of the chip is used for level shifting, providing unipolar input voltage for the ADS1224 A/D converter. Clock for the A/D converter is optimized for 50 *Hz* rejection. Possibility of the system zeroing enables long term measurements with high stability and confidence.

Temperature and relative humidity were measured by ″Sensirion: SHT 15″ sensor and acquisited in internal memory of the CDI-06, together with air-ions cocnentration, date and time.

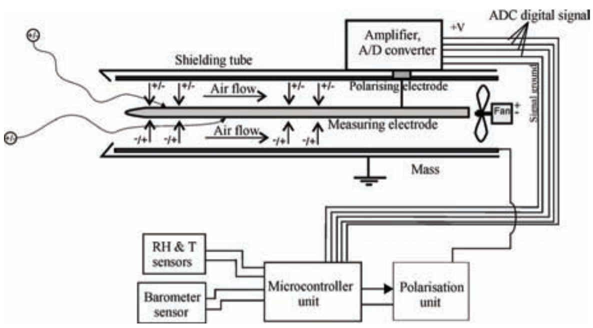

Fig. 1. Cylindrical Detector of Air-Ions ″CDI-06″, measuring action concept. Measuring electrodes and supply/control units are connected via 1*m* long cable.

Other parameters were measured with commercially available instruments. Ozone was measured by "AMBIENT O3 MONITOR APOA-360“, PM_{10} by "Thermo Scientific FH 62 I-R“.

RESULTS

Measurements were performed in Omladinskih brigada street, New Belgrade, Serbia. All parameters were measured 3 *m* above the grassy ground during fine weather conditions concerning atmospheric electricity observations. Measurement lasted for 20 days. Representative measurements are given in Figure 2.

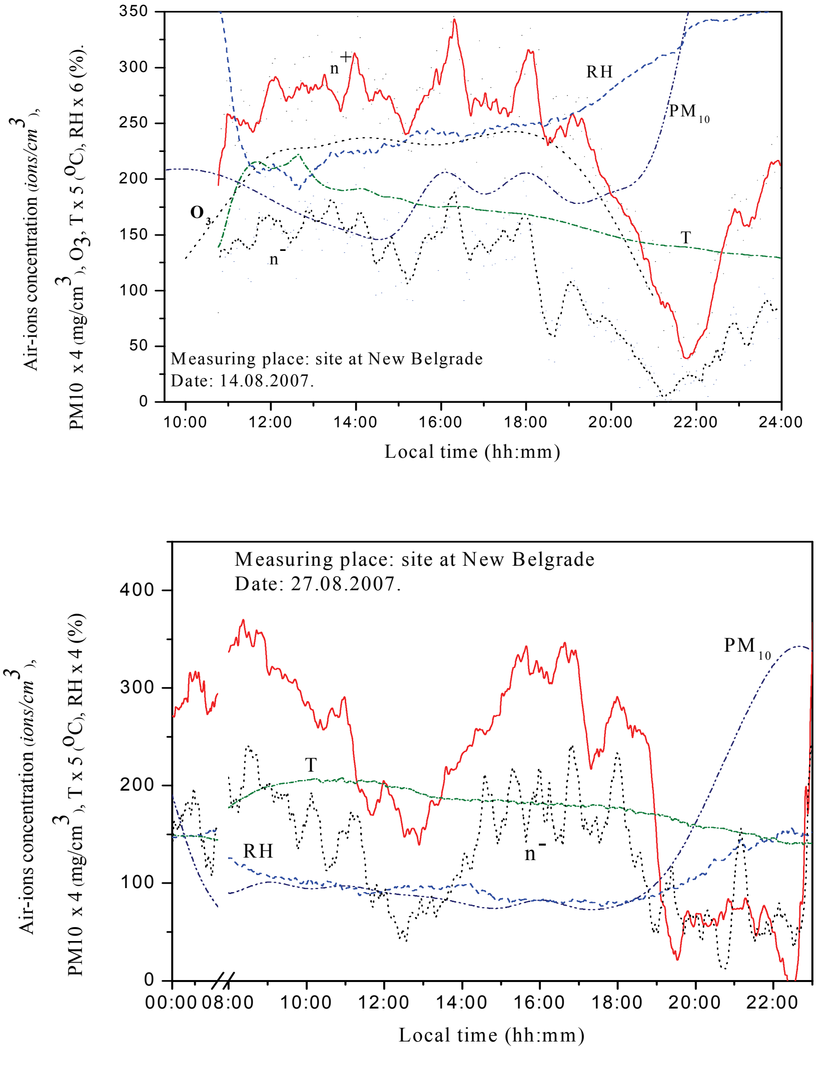

Fig. 2. Daily variations of the air-ion concentration ″$n^{+/-}$″ (*ions/cm*^{3}), particulate is matter smaller than 10 µm (PM_{10}) x 4 (*mg/cm*^{3}), Ozone ″O_3″ (only upper), Temperature ″T″ (^oC),), Relative Humidity ″RH″ (*%*),measured at Omladinskih brigada street,New Belgrade,Serbia, at 14.08.2007. and 27.08.2007.

DISCUSSION AND CONCLUSION

One can see from Figure 2, that daily variations of the measuring parameters are similar for both measuring days. PM_{10} show strong inverse correlation with the air-ions, according to relation (1), which is implying participation of the air-ions in particle formation processes. Positive and negative air-ions have very symmetrical change of concentration with factor of unipolarity (n^+/n^-) between 1.5 and 2. Most interesting result is that air-ions of both signs and ozone are positively correlated with correlation coefficient (r) of the positive air-ions and ozone r=0.85. Direct dependence between PM_{10} and ozone is very difficult to establish, but some measurements also show correlation with the aerosol concentration [6].

As expected, T and RH are inversely correlated. The air-ions concentration of both signs is increasing while RH is decreasing. This could be understood considering that the air-ions concentration is directly related to radon exhalation from the soil. Factors that most affect the dynamics of radon exhalation are humidity and soil thermal gradient [7]. These values are directly related to micrometeorological and geophysical parameters of the measuring place.

This kind of measurements could provide us new information about atmospheric processes of the ion induced particle conversion and ion induced reactions during ozone production.

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MERENJA I KORELACIJE IZMEĐU NEKOLIKO ATMOSFERSKIH PARAMETARA

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Dnevne atmosferske koncentracija jona u vazduhu su merene na mestu gde je takođe vršeno i sinhronizovano merenje aerosola, ozona, temperature i relativne vlažnosti vazduha. Joni u vazduhu, temperatura i relativna vlažnost su mereni pomoću cilindričnog detektora jona u vazduhu (CDI-06) Gerdien tipa, proizvedenog u Institutu za fiziku u Beogradu. Ozon i aerosoli su mereni pomoću komercijalnog instrumenta koji pripada Institutu za zdravlje u Beogradu. Tipične dnevne varijacije izmerenih parametara su analizirane i pokazuju da je koncentracija i pozitivnih i negativnih jona u vazduhu direktno korelisana sa koncentracijom ozona, dok koncentracija aerosola pokazuje jaku inverznu korelaciju sa koncetracijom jona. Takođe, koncetracije jona i ozona opadaju sa porastom temperature, dok koncetracija aerosola i vlažnost vazduha rastu. Ovi procesi mogu biti objašnjeni uzimajući u obzir osobine specifičnih parametara, karakteristike mesta na kome je vršeno merenje i vremenske uslove.