IV.9.2 Measurement of the numerical size distribution of aerosol particles

The numerical size distribution of aerosol particles is measured within the Czech Hydrometeorological Institute (CHMI) in the ultrafine particle network consisting of five basic stations: Hradec Králové-Brněnská, Lom, Mladá Boleslav, Plzeň-Slovany and Ústí nad Labem-město. Thanks to the long-term cooperation of the CHMI with the Institute of Chemical Process Fundamentals of the Czech Academy of Sciences (ICPF CAS), data from experimental measurements of the particle number size distribution from the Košetice observatory are also available. These measurements are part of the ACTRIS European Research Infrastructure monitoring network (Aerosols, Clouds, and Trace gases Research Infrastructure Network). Since 2016, this type of measurements has also been supported by ACTRIS-CZ, the Czech part of the large research infrastructure project, which also focuses on the Košetice locality. For operations involving research activities of

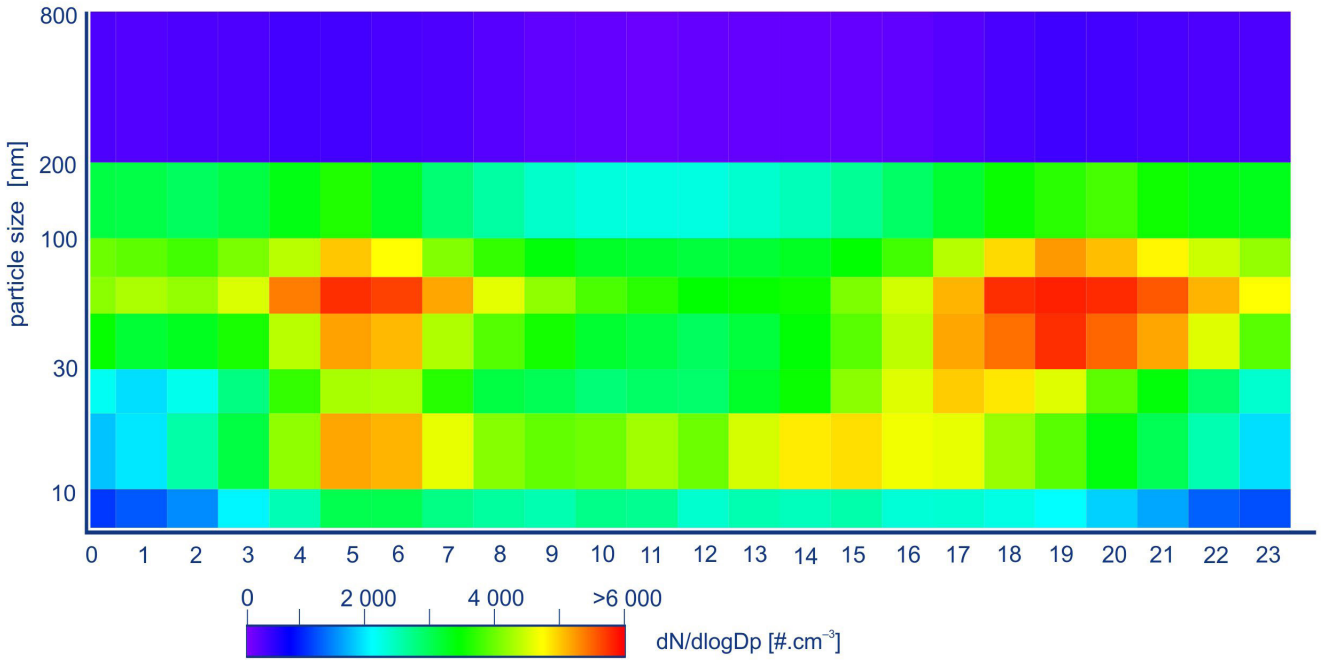

Fig. IV.9.2.1 Median spectrum of the daily progression of the number of particles, Hradec Králové-Brněnská, 2020

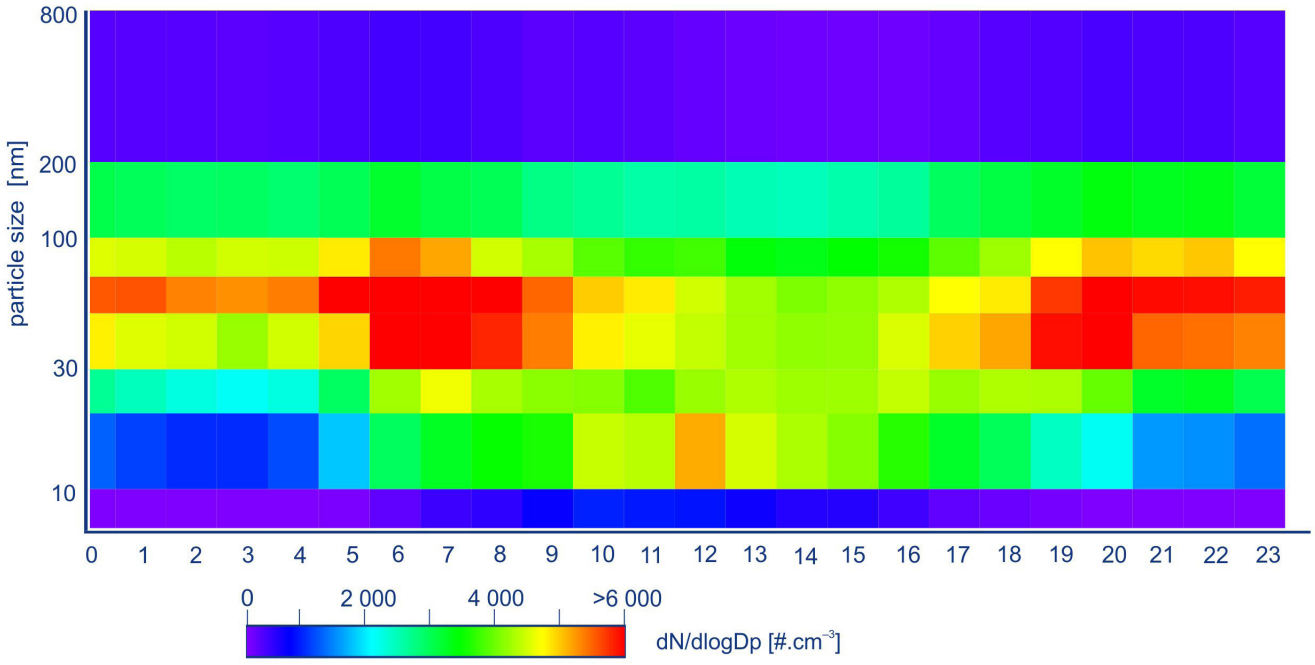

Fig. IV.9.2.2 Median spectrum of the daily progression of the number of particles, Lom, 2020

the CHMI, two institutes of the Academy of Sciences of the Czech Republic, and Masaryk University, a collective designation of the locality is used, namely the National Atmospheric Observatory Košetice (NAOK).

In the daily spectra measured at six localities (Hradec Králové-Brněnská, Lom, Mladá Boleslav, NAOK, Plzeň-Slovany and Ústí nad Labem-město) the differences in the number of particles in different size categories are detectable, which reflect the character of the localities. While the median spectrum of the NAOK station in the Vysočina region (Fig. IV.9.2.4) is rather affected by long-distance transport, at other stations, the influence of local sources (e.g. transport, industry) of anthropogenic origin can be identified. Despite some differences, the spectra can be described using common features. The highest concentrations of the number of particles are usually measured in the late evening, night and early morning hours. This phenomenon is probably associated with the development of an atmospheric boundary layer altitude and its stability during the night hours. This can lead to an accumulation of pollutants,

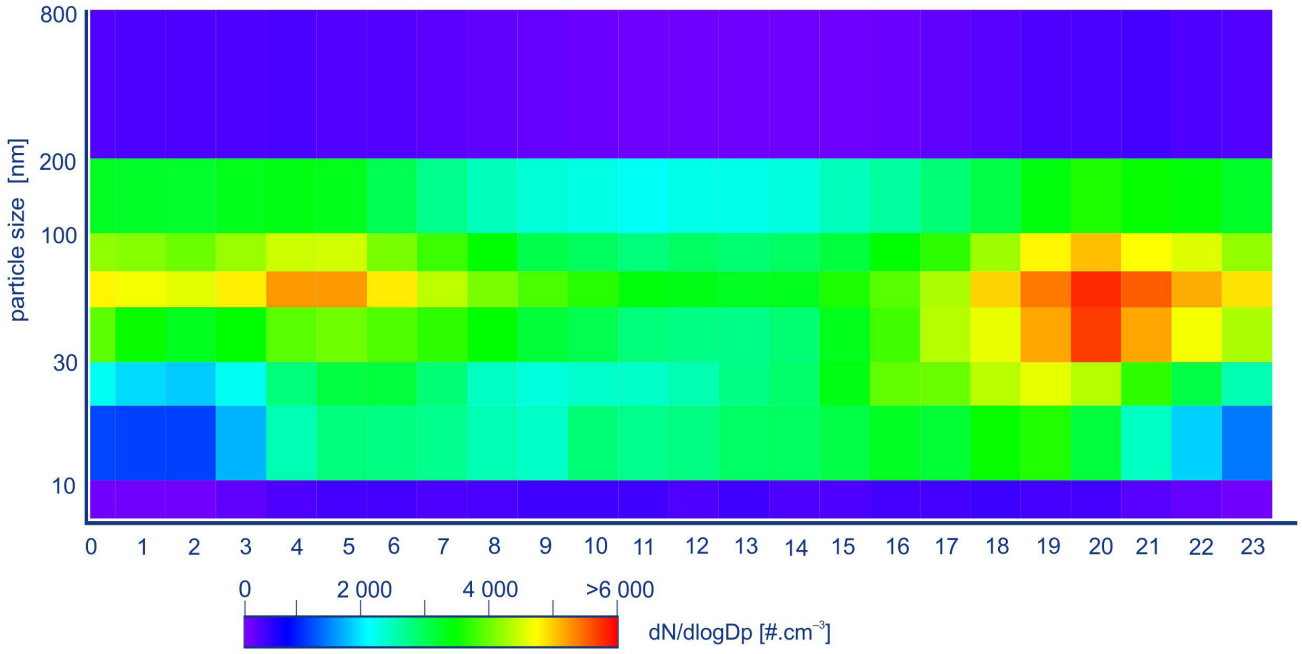

Fig. IV.9.2.3 Median spectrum of the daily progression of the number of particles, Mladá Boleslav, 2020

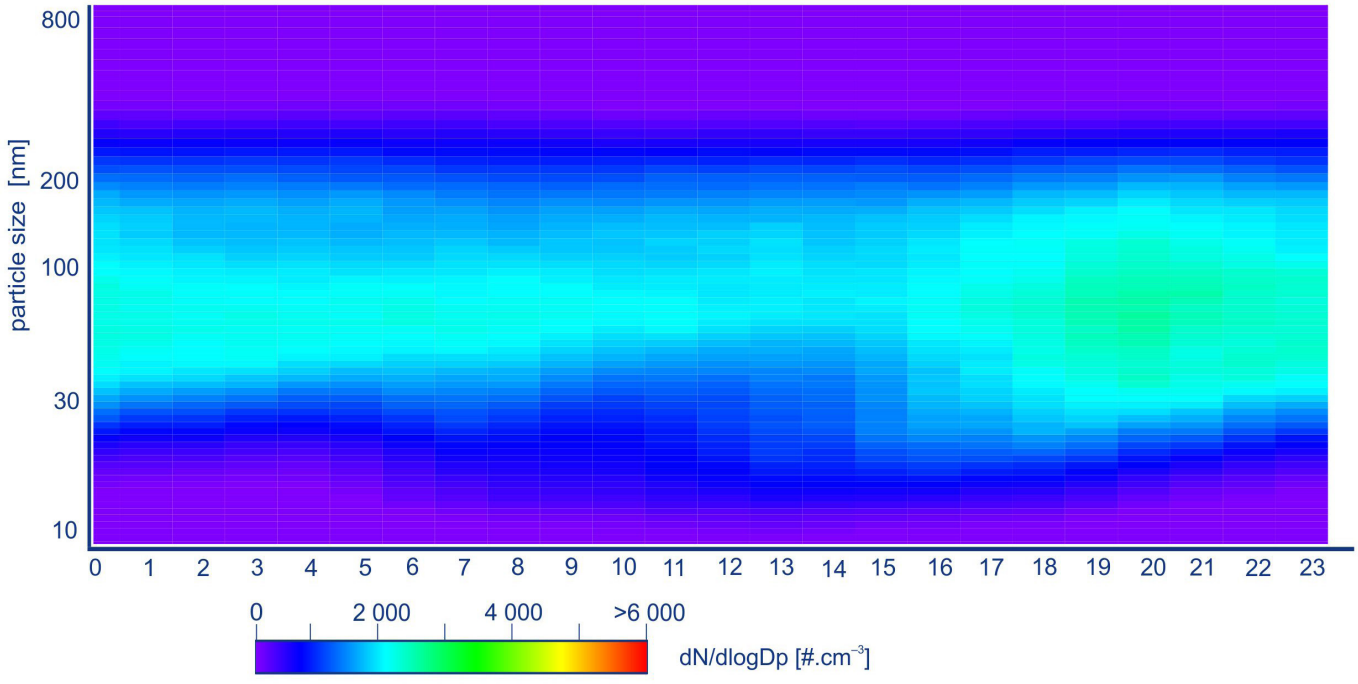

Fig. IV.9.2.4 Median spectrum of the daily progression of the number of particles, NAOK, 2020

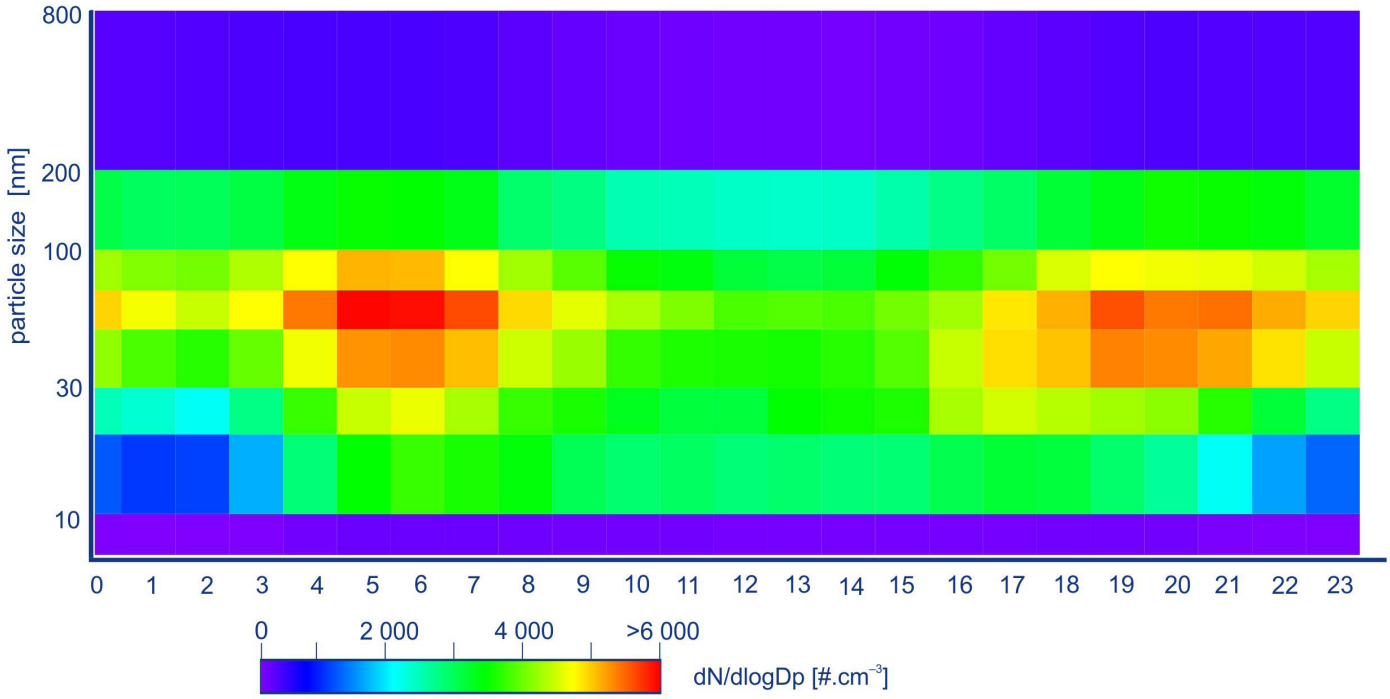

Fig. IV.9.2.5 Median spectrum of the daily progression of the number of particles, Plzeň-Slovany, 2020

and therefore aerosol particles, during the night. After sunrise, an increase in photochemical reactions between accumulated substances can be observed, which can lead to the formation of secondary aerosols.

The impact of human activities in the form of increased traffic is evident at all stations except NAOK. The increasing number of particles in the morning and afternoon hours in all parts of the spectrum reflects not only the traffic peak but also the increasing occurrence of combustion products from industrial and local heating sources. These sources are associated with increased production of both particles and their gaseous precursors, from which secondary particles can be formed by photochemical processes. The most pronounced increase in particles is between 20 and 100 nm, which reaches a maximum between 4 and 8 h in the morning (Figs. IV.9.2.1, IV.9.2.2, IV.9.2.3, IV.9.2.5 and IV.9.2.6)[1]. At the Mladá Boleslav station a gradual increase in the number of nucleation mode particles (particle size up to 20 nm) was observed from morning to evening hours, which may indicate a constant source of these particles, whether of primary or secondary origin (Fig. IV.9.2.3). A secondary increase of nucleation mode particles was observed at both stations in the Ústí nad Labem region (Lom and Ústí nad Labem-město) with a peak at 12 h UTC (Figs. IV.9.2.2 and IV.9.2.6). This pattern of particle number evolution may be affected by industrial sources from the chemical industry and the topography of the local terrain. In addition to emission sources and other processes in the atmosphere, changes in numerical concentration are also influenced by the stability of the atmosphere. While the atmosphere is well mixed during the day due to turbulent flow, the atmosphere becomes more stable in the evening when turbulence subsides (Stull 2003).

The median daily particle size spectrum in 2020 was, as in previous years, less distinct at NAOK compared to other measurements. Relatively constant concentrations of accumulation mode particles can be observed, which decrease slightly during the day (between 6:00 and 14:00 UTC) due to atmospheric dilution. On the contrary, the numbers of nucleation mode particles increase from the morning and reach a maximum after 16:00. The increase in the number of nucleation mode particles is probably associated with the process of particle formation and their subsequent growth to larger sizes. At NAOK, the effect of long-distance transport of particles in the form of relatively stable accumulation mode concentrations, and the effect of dilution and stability of the atmosphere on the concentrations of particles, can be well observed (Fig. IV.9.2.4).

The annual variability of the total number of particles is very similar for the Hradec Králové-Brněnská, Mladá Boleslav, Lom and Plzeň-Slovany stations. Higher values (in the range of 4 499–9 076 particles per cm^3) were recorded at the Hradec

1 The dN/dlogDp unit denotes the normalized number of particles in a given size category. The distribution of the number of aerosol particles does not correspond to a symmetrical normal distribution, therefore a logarithmic transformation is used to display the aerosol spectrum to obtain a log-normal distribution (Hinds 1999). The Y-axis indicates the nano-meter particle size categories of aerosol particles, the colour scale shows the number of particles in a given size category (the number of particles increases from cold to warm colours).

Králové-Brněnská station, while the lowest variability among the stations was measured at the Mladá Boleslav station (4 105–6 441 particles per cm³). The annual course of the total number of particles at these stations was also identical with the NAOK station (range of values 1 523–3 570 particles per cm³). The Ústí nad Labem-město station had several measurement failures during the year, so it is not possible to say whether the annual course of concentrations is the same or different from the other stations. While all stations had the highest total concentrations measured in April, the Ústí nad Labem-město station recorded a maximum in September, at 13 486 particles per cm³ (Fig. IV. 9.2.7).

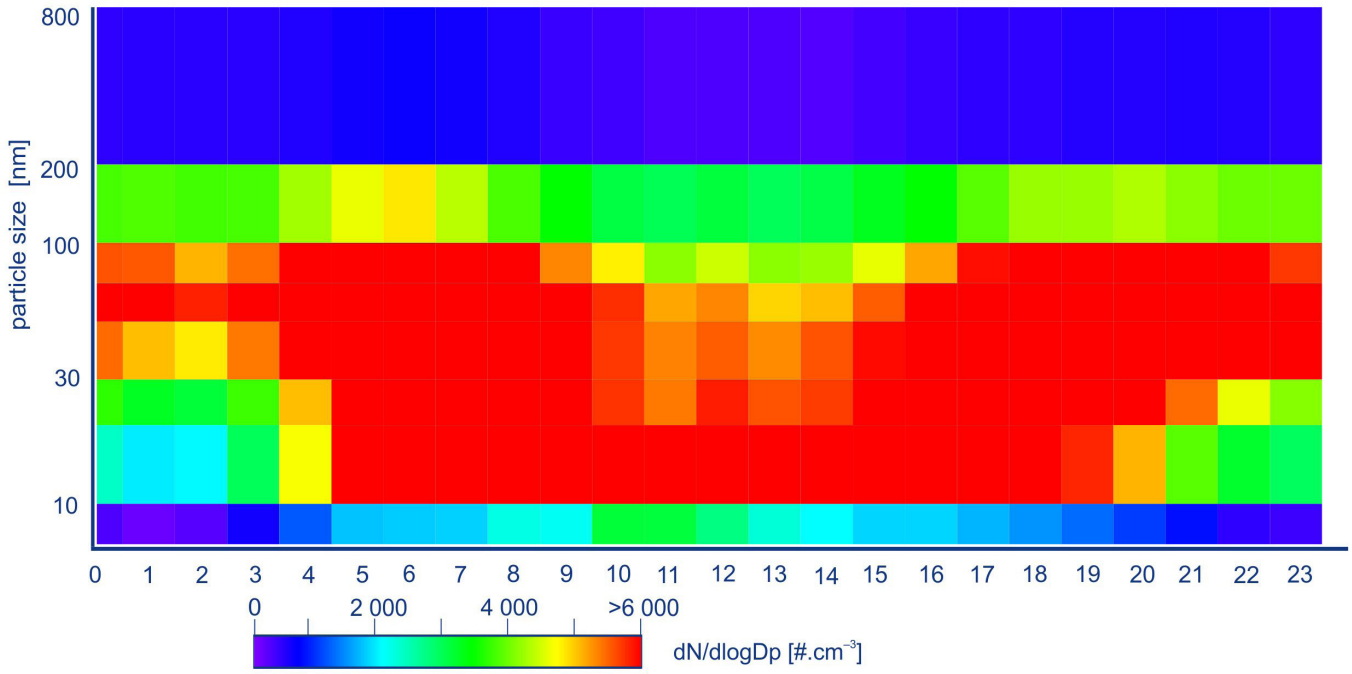

Fig. IV.9.2.6 Median spectrum of the daily progression of the number of particles, Ústí nad Labem-město, 2020

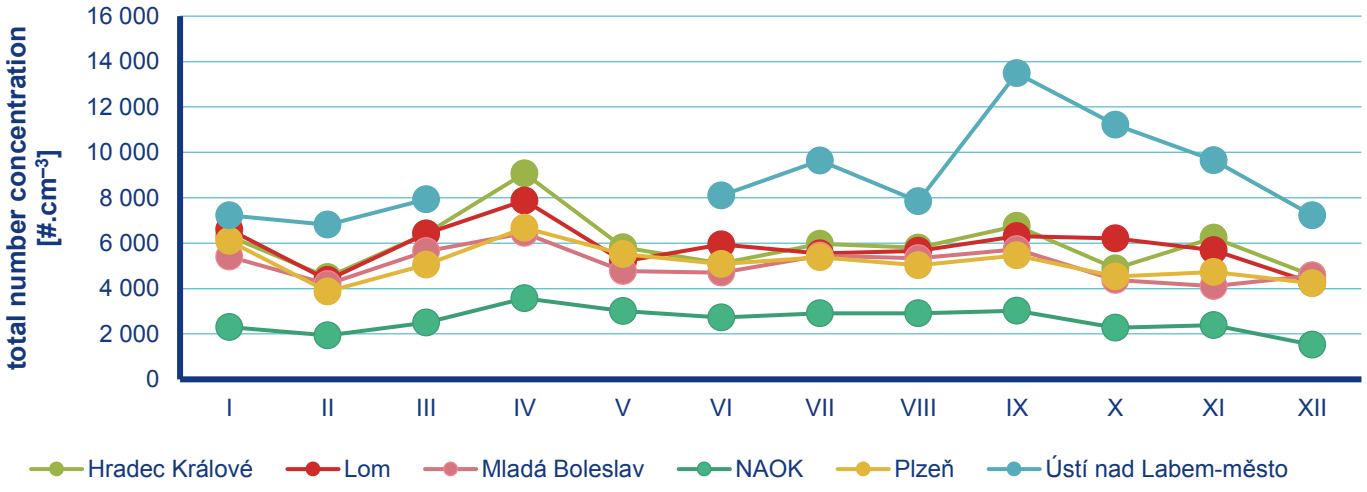

Fig. IV.9.2.7 Average monthly variability of the total particle number concentration Hradec Králové-Brněnská, Lom, Ústí nad Labem-město, Lom, Mladá Boleslav, NAOK, Plzeň-Slovany a Ústí nad Labem-město, 2020