IV.1 Suspended particulate matter

Air pollution by suspended particulate matter of PM_{10} and $PM_{2.5}$ fractions remains one of the main problems to be resolved in ensuring air quality in the Czech Republic. Exceeding of the pollution limit levels for PM_{10} and $PM_{2.5}$ continues to make a significant contribution to the extent of areas with above-limit air pollution.

IV.1.1 Air pollution by suspended particulates in 2019

Suspended particulate matter PM_{10}

The 24-hour pollution limit level for PM_{10} (50 µg.m^{-3}, 35 permitted cases exceeding the limit value) was exceeded in 2019 at 5% of stations (7 stations of a total number of 147 with a sufficient amount of data for the evaluation; Tab. XII.1, Fig. IV.1.1, and Fig. IV.1.2). The cases exceeding the limit value occurred mainly in January, February and October (more than 70% of cases of the total for all stations). It is a significant decrease compared to the year 2018 when exceeding of the daily PM_{10} limit value was recorded at 31% of stations (45 stations out of 144). The 24-hour limit value was exceeded only at stations in the O/K/F-M agglomeration and at the Kladno-Švermov urban station, where higher concentrations of suspended particles are measured due to emissions from local heating in the surrounding dense residential built-up area.

The pollution limit level for the average 24-hour concentration of PM_{10} was exceeded in 2019 on only 0.3% of the territory of the Czech Republic with approx. 0.9% of the population (Fig. IV.1.3). Compared to previous years (3.2% in 2018, 8.3% in 2017, 1.4% in 2016, and 2.5% in 2015), there was a decrease of the area of the Czech Republic exposed to the above-limit PM_{10} concentration (the 36th highest 24-hour concentration) corresponding also to low number of cases exceeding the limit value at the monitoring stations.

Inter-annual decrease of the territory where the 24-hour limit value was exceeded was apparent in all zones and regions of the Czech Republic. The most exposed continuous area, as in previous years (Fig. IV.1.4 and IV.1.5), was the O/K/F-M agglomeration where the 24-hour pollution limit level for PM_{10} was exceeded at one third of stations.

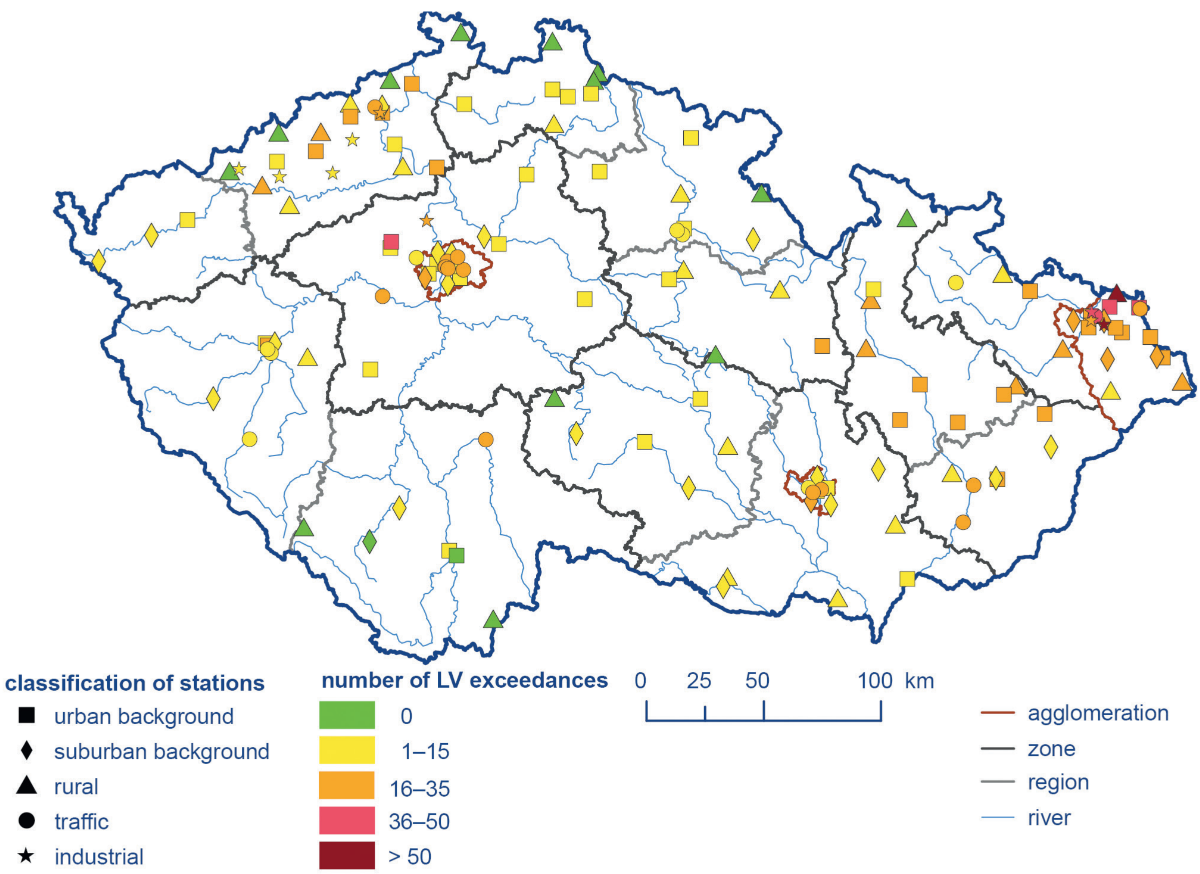

Fig. IV.1.1 Number of cases exceeding the pollution limit value of 24-hour average PM_{10} concentration at air quality monitoring stations, 2019

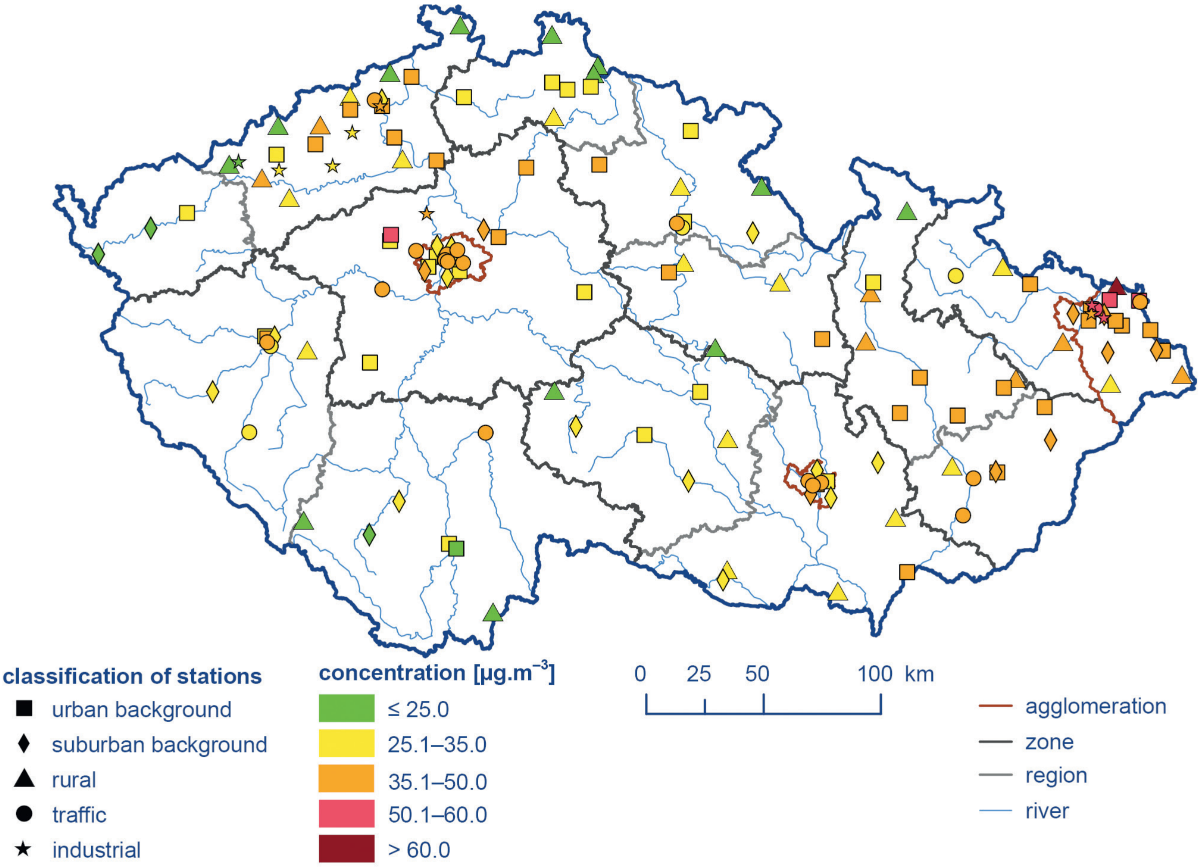

Fig. IV.1.2 36th highest 24-hour PM_{10} concentrations at air quality monitoring stations, 2019

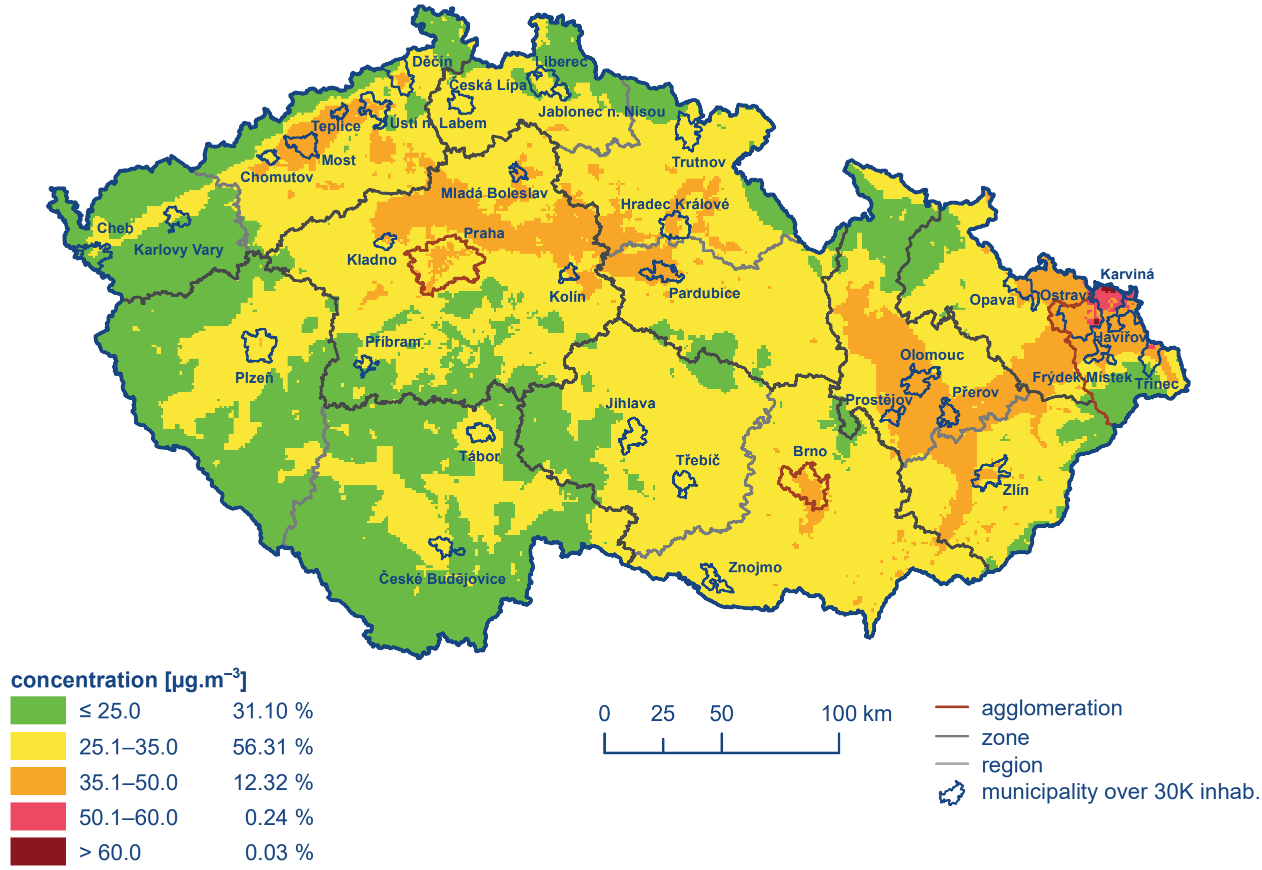

Fig. IV.1.3 Field of 36th highest 24-hour PM_{10} concentration, 2019

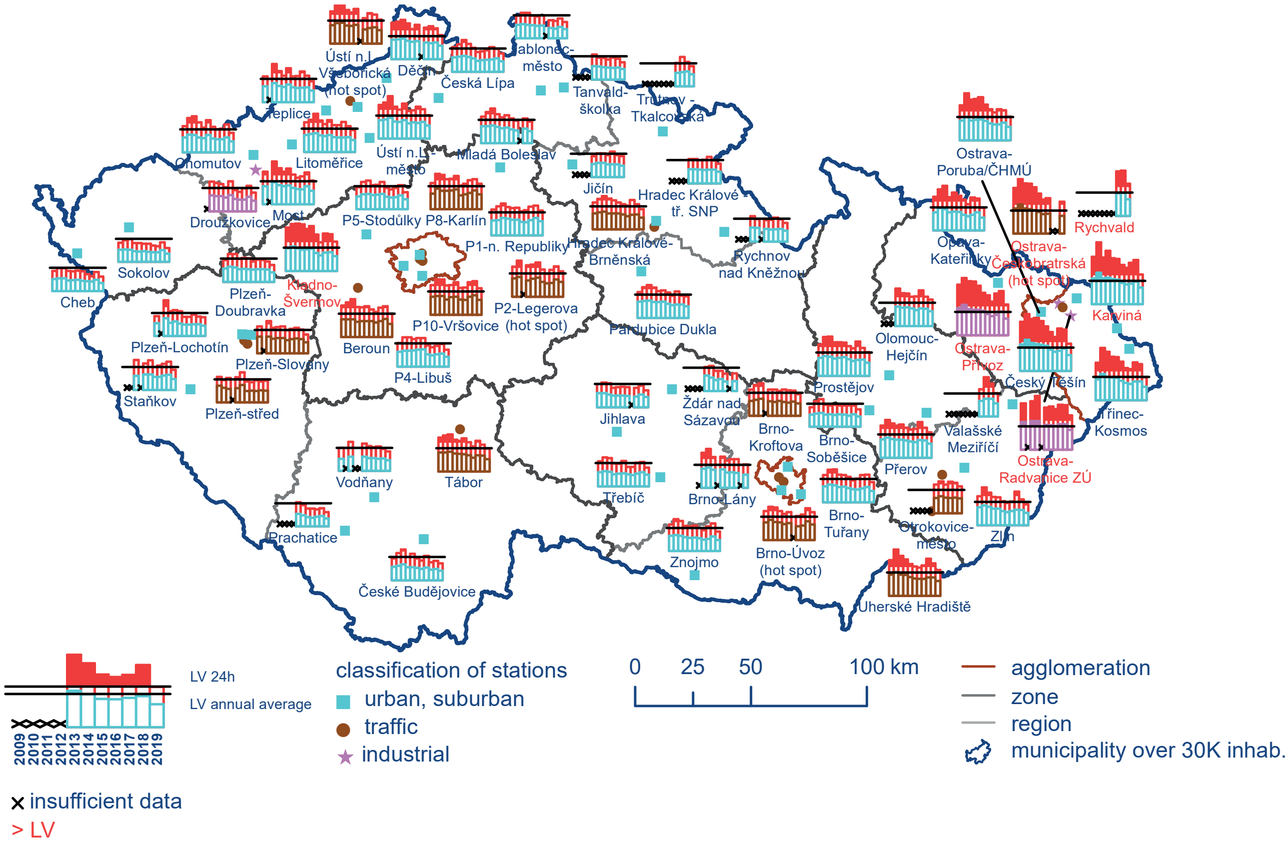

Fig. IV.1.4 36th highest 24-hour and annual average PM_{10} concentrations at selected stations of UB, SUB, I, and T classification, 2009–2019

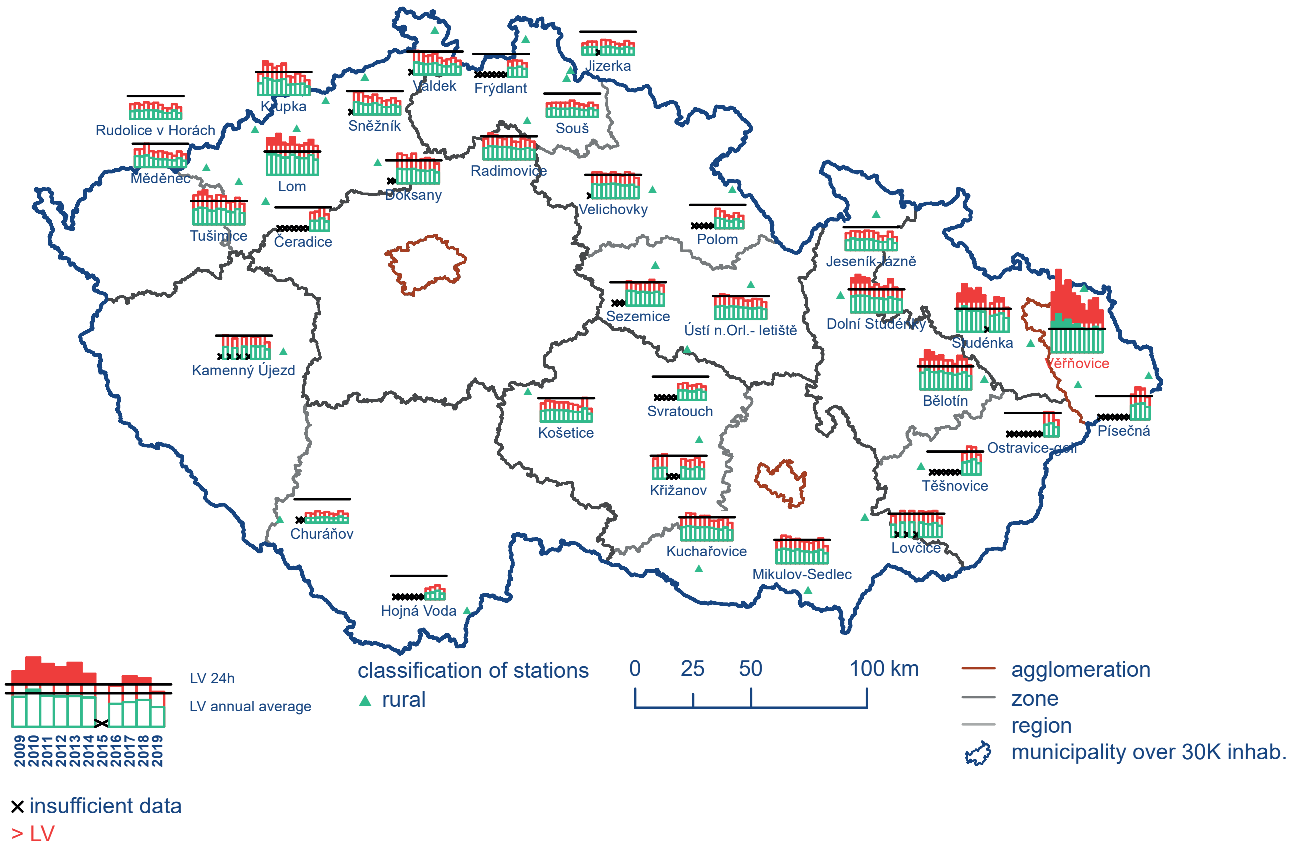

Fig. IV.1.5 36th highest 24-hour and annual average PM_{10} concentrations at selected rural (R) stations, 2009–2019

The pollution limit level for the average annual concentration of PM_{10} (40 μg.m^{-3}) was not exceeded at any station in the Czech Republic in 2019, for the first time in the evaluated period 2009–2019 (Fig. IV.1.6, Fig. IV.1.7, Table XII.2). Subsequently, no territory of the Czech Republic with an above-limit annual average concentration of PM_{10} was defined (in a spatial resolution of 1x1 km) (Fig. IV.1.8). However, even in previous years, the annual average concentration of PM_{10} was exceeded only on 0.1% of the territory of the Czech Republic in 2018, on 0.02% of the territory in 2017, only local cases occurred in 2016 that were not reflected in the scale resolution of the map of annual average concentration, and 0.02% of the territory was affected in 2015. In terms of the five-year average of annual average concentrations, the most polluted area is the O/K/F-M agglomeration (Fig. IV.1.9).

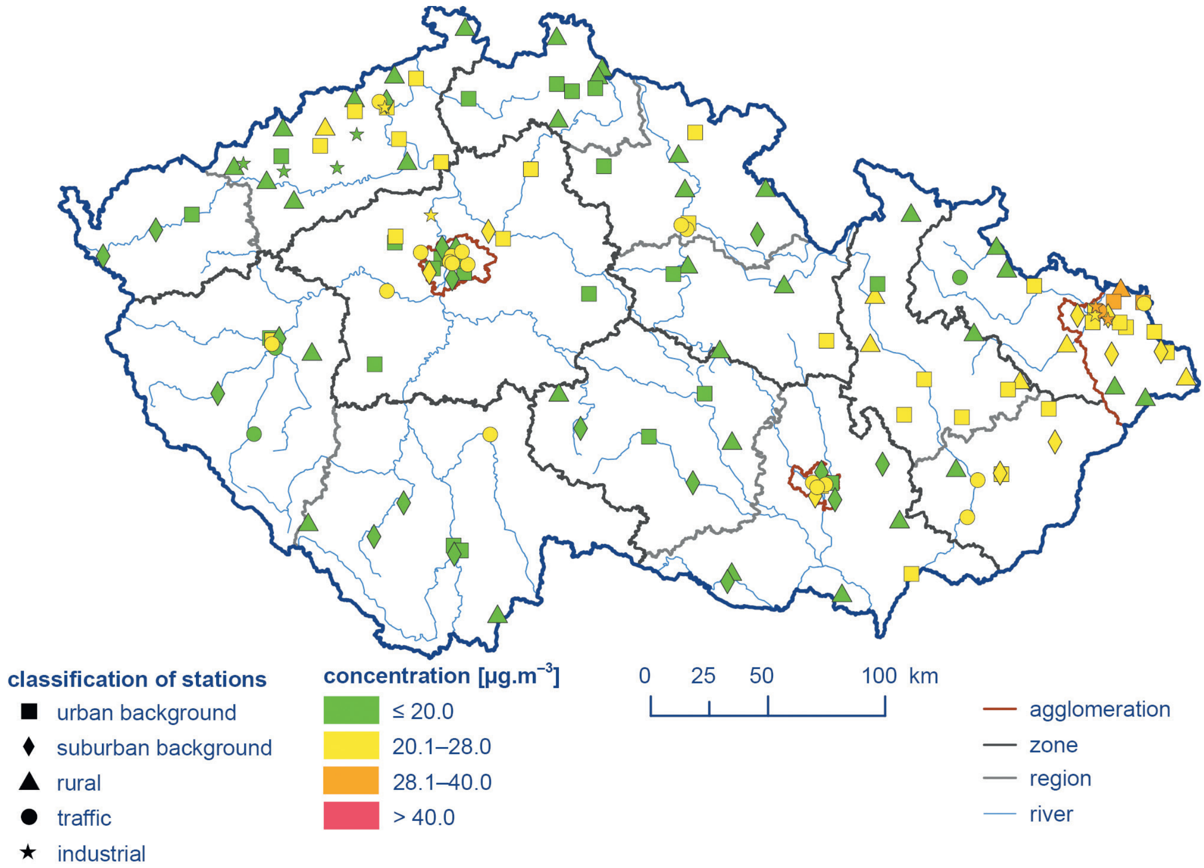

Fig. IV.1.6 Annual average PM_{10} concentrations at air quality monitoring stations, 2019

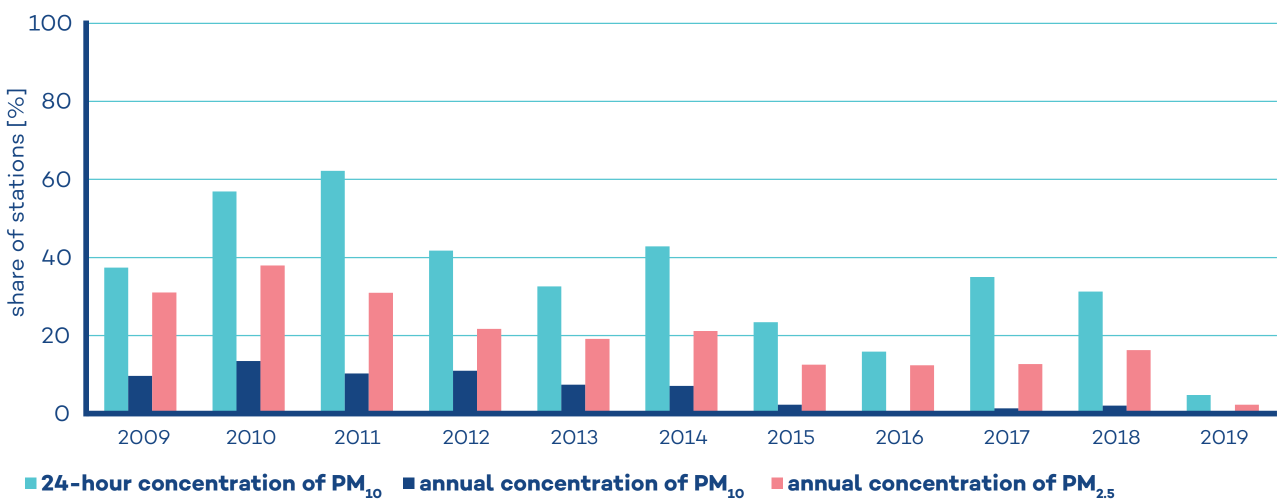

Fig. IV.1.7 Ratio of stations where the pollution limit level of 24-hour average PM_{10} concentration and of annual average PM_{10} and $PM_{2.5}$ concentration was exceeded, 2009–2019

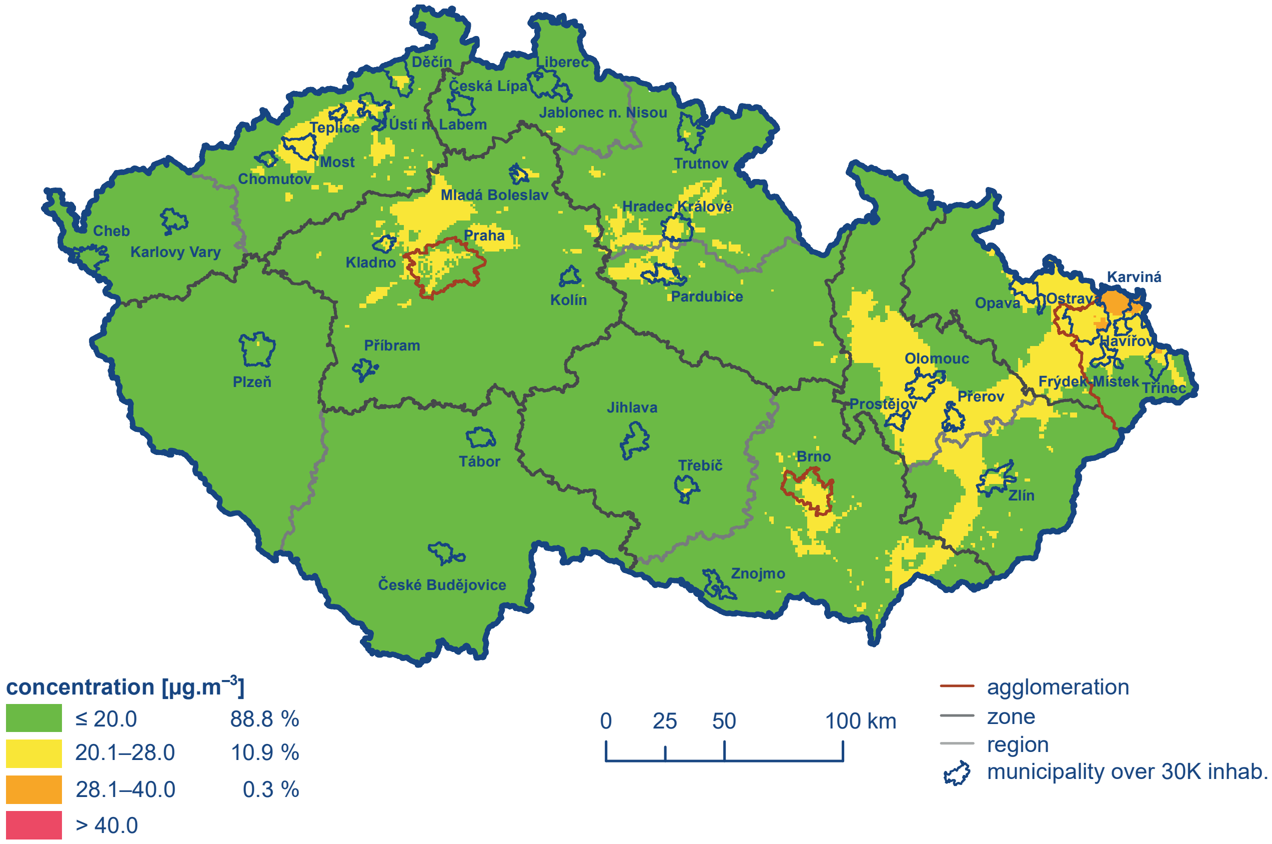

Fig. IV.1.8 Field of annual average $PM_{2.5}$ concentration, 2019

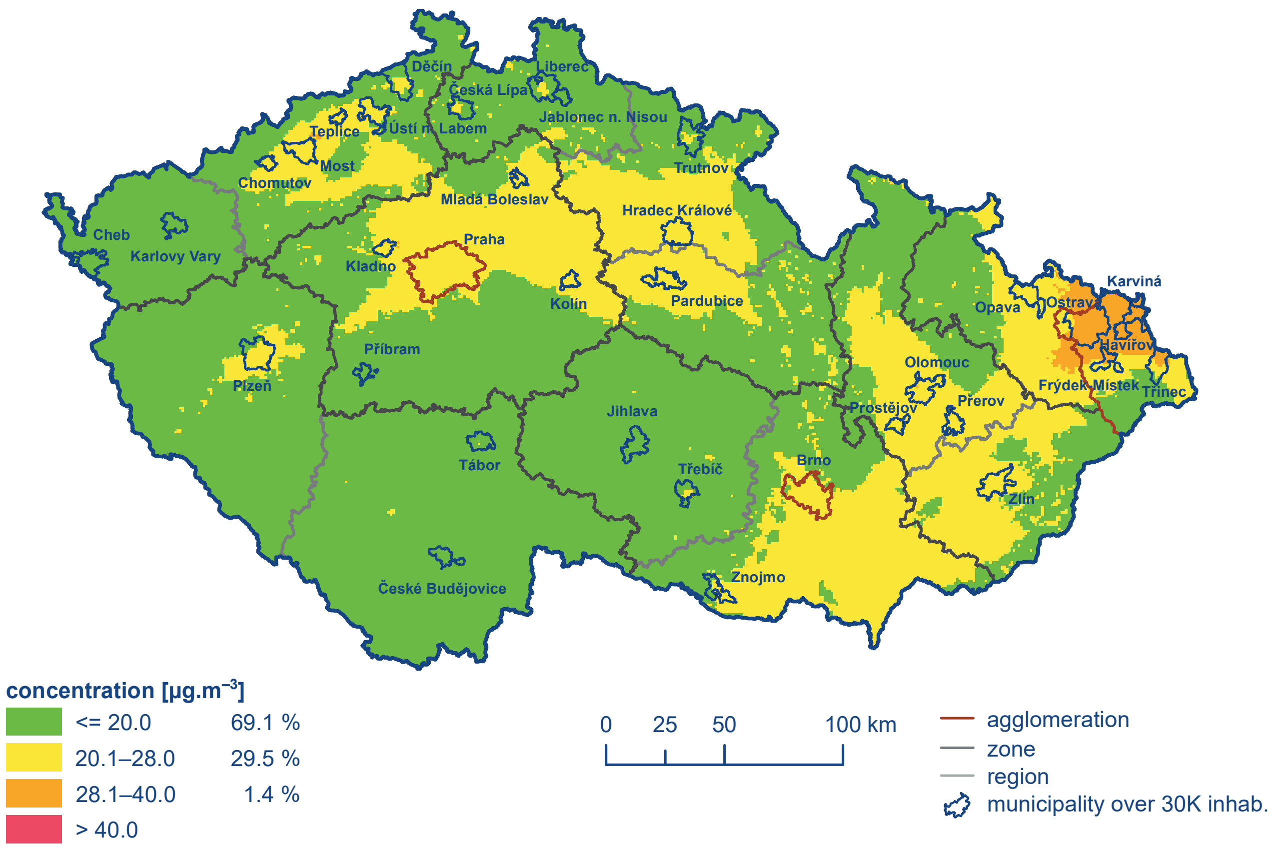

Fig. IV.1.9 Five-year average of annual average PM_{10} concentrations, 2015–2019

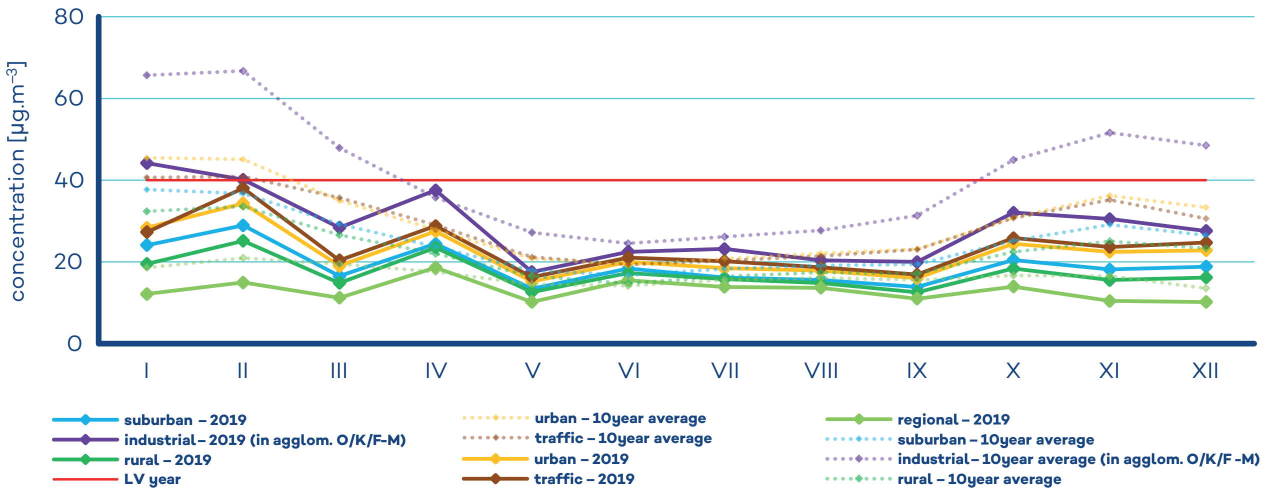

Fig. IV.1.10 Annual course of average monthly PM_{10} concentrations (averages for a given type of station), 2019

The PM_{10} concentrations exhibit a clear annual variation with the highest values in the colder months of the year (Fig. IV.1.10). Higher PM_{10} concentrations in the air during the colder season are related both to greater emissions of particulates from the seasonally operated heating sources and also to deteriorated dispersion conditions. For example, local heating sources contribute nearly 59% to PM_{10} emissions and 74% to $PM_{2.5}$ emissions in the Czech Republic (Fig. IV.1.20 and IV.1.22).

The annual variation of PM_{10} concentrations in 2019 demonstrated less distinct shape compared to ten-year average having a clear dominance of autumn and winter months characterised by the least frequent occurrence of good dispersion conditions. In 2019, the highest concentrations of PM_{10} were measured mostly in January and February which corresponds to the occurrence of moderately poor to poor conditions and, in addition, to below-normal precipitation amount in February. Higher concentrations were also measured in April, when the second lowest monthly precipitation total (after February) was recorded (in 2019).

Based on a comparison of monthly averages of PM_{10} concentrations with ten-year average (2009–2019), it can be stated that average monthly concentrations at monitoring stations were lower (by about 20–40%) in all months of the year except April, June and July, when they remained at similar levels. The decrease in PM_{10} concentrations at stations was significant especially in the winter months, the largest in January, March and November. In the period June – August, the change in monthly concentrations in 2019, compared to the ten-year average, was the smallest, which again points to the importance of seasonal sources and the importance of meteorological and dispersion conditions during winter months. The minimal change in concentrations until their increase in April 2019, compared to the ten-year average, corresponds to the already mentioned below-normal amount of precipitation in April 2019. The below-normal amount of precipitation probably caused a minimal change in concentration compared to the ten-year average at traffic stations in February 2019, experiencing stronger resuspension of particulates due to passing vehicles.

Due to the high concentrations of suspended PM_{10} particles, 5 smog situations were announced. All smog situations and regulations occurred in January. Smog situations were announced in the territory of the O/K/F-M agglomeration without Třinec, further in the Třinec district, in the Moravian-Silesia zone and in the Zlín and Olomouc regions (for more details see Chapter VI.).

Suspended particulate matter $PM_{2.5}$

In 2019, exceeding of the pollution limit level for the average annual concentration of $PM_{2.5}$ (25 µg.m^{-3}) was recorded at 2 stations (2.2%) of a total of 89 stations (Tab. XI.3; Fig. IV.1.11). In 2018, the values were 13 stations (16.2%) out of a total of 80 stations and in 2017 at 10 stations (12.7%) out of 79. Both stations (the Veřňovice rural background station and the Ostrava-Radvanice ZÚ industrial station), where the average annual concentration of $PM_{2.5}$ was exceeded in 2019, are located in the territory of the Moravian-Silesia region in the O/K/F-M agglomeration (Fig. IV.1.6 and Fig. IV.1.11).

The pollution limit level for the average annual concentration of $PM_{2.5}$ was exceeded, in 2019, over 0.04% of the territory of the Czech Republic with approx. 0.1% of the population (Fig. IV.1.12). In 2018, it concerned 1.2% of the area with 6.1% of the population, in 2017, it concerned 0.9% of the area with 4.9% of the population, in 2016, it concerned 0.5% of the area with 3% of the population, and in 2015, the indicators were 0,9% of the area with approx. 5.1% of the population.

In the evaluated period 2009–2019, the above-limit annual average concentrations of $PM_{2.5}$ were observed mainly on the territory of the O/K/F-M agglomeration (Fig. IV.1.13). In terms of the five-year average of annual average concentrations of $PM_{2.5}$, the most polluted area is the O/K/F-M agglomeration (Fig. IV.1.14).

Higher concentrations of $PM_{2.5}$ occur mainly in the colder part of the year (Fig. IV.1.15) and, similar to PM_{10}, are a consequence of

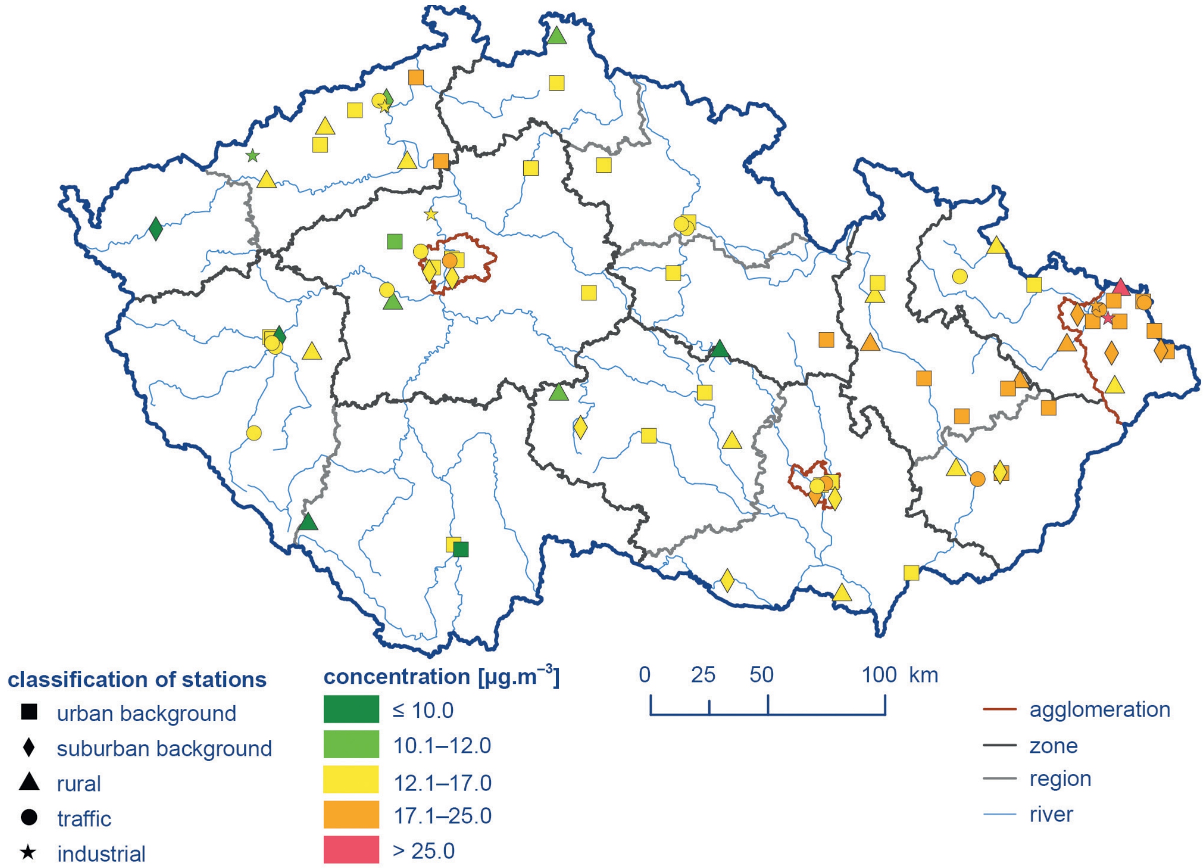

Fig. IV.1.11 Annual average $PM_{2.5}$ concentrations at air quality monitoring stations, 2019

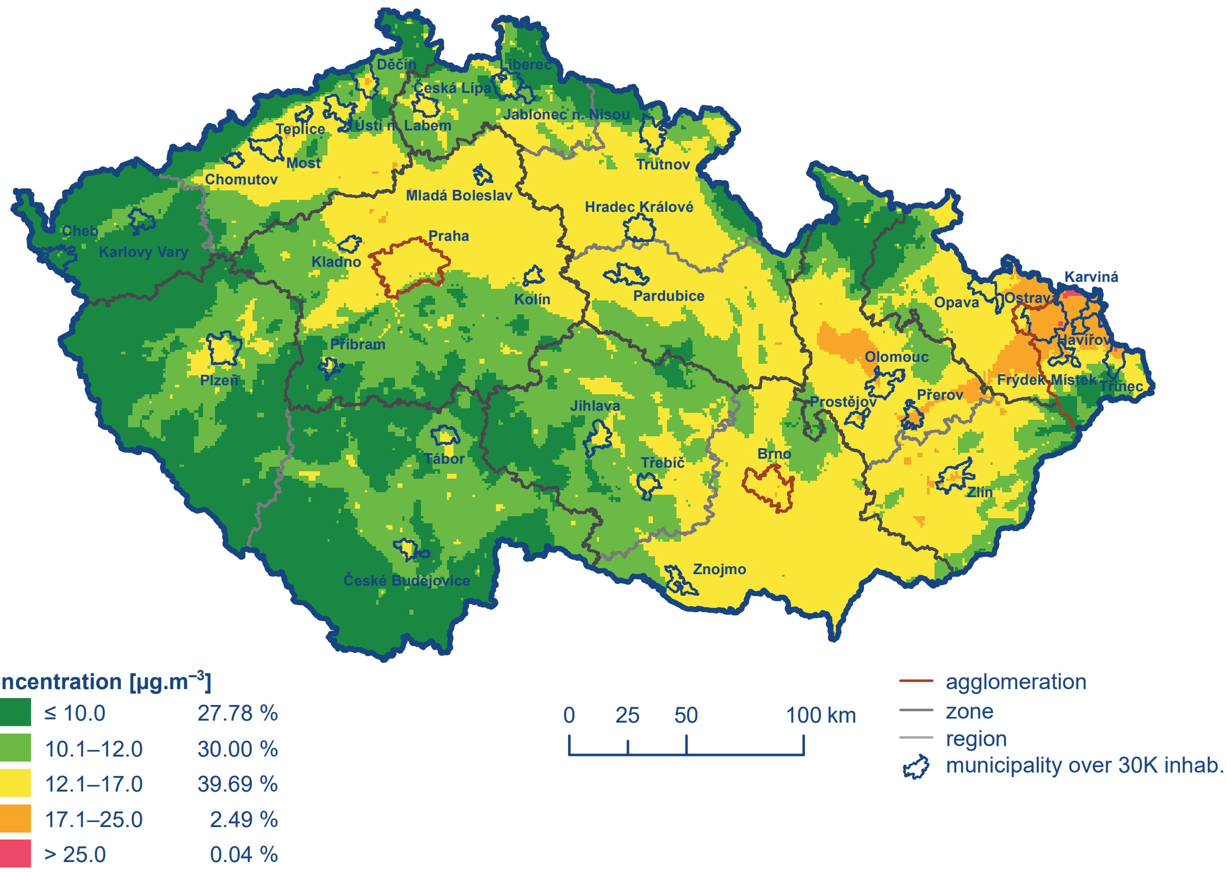

Fig. IV.1.12 Field of annual average $PM_{2.5}$ concentration, 2019

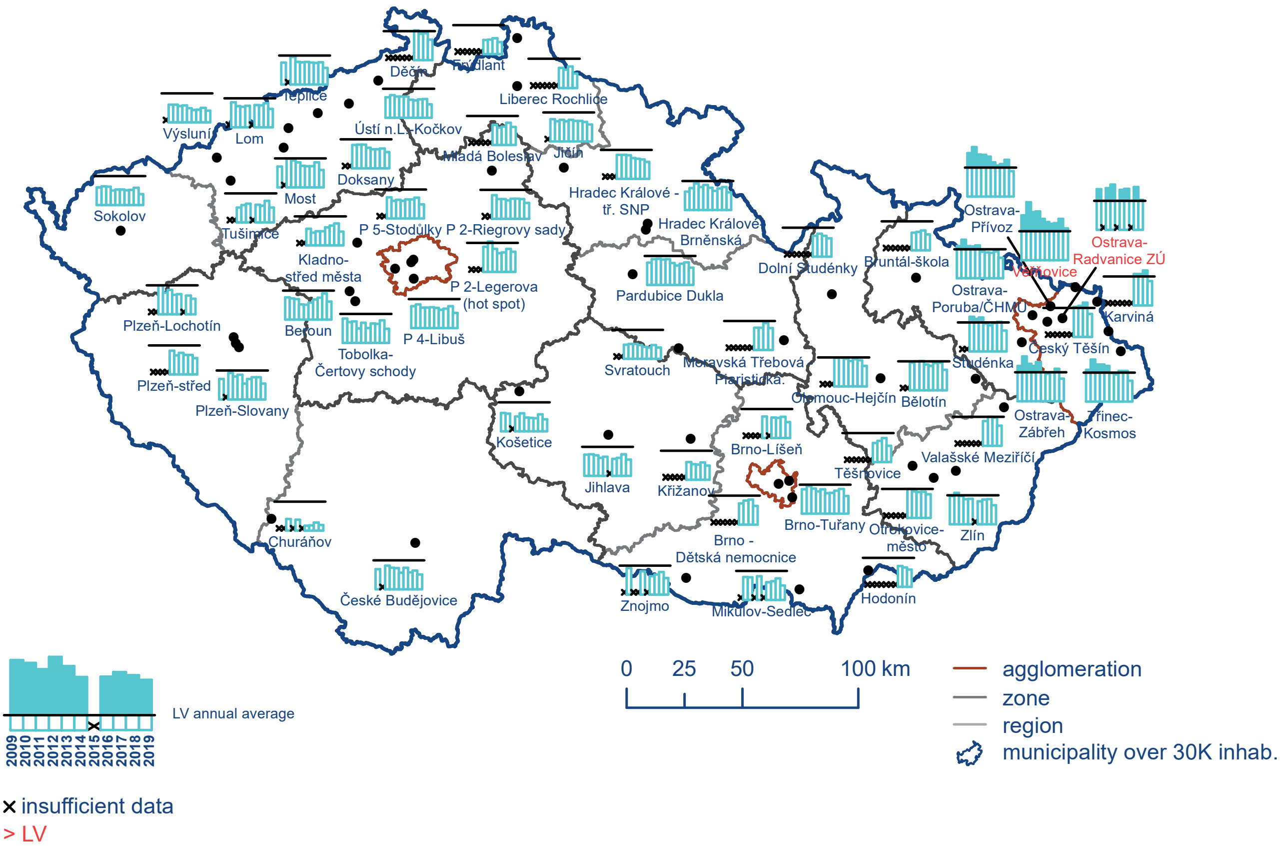

Fig. IV.1.13 Annual average $PM_{2.5}$ concentrations at selected stations, 2009-2019

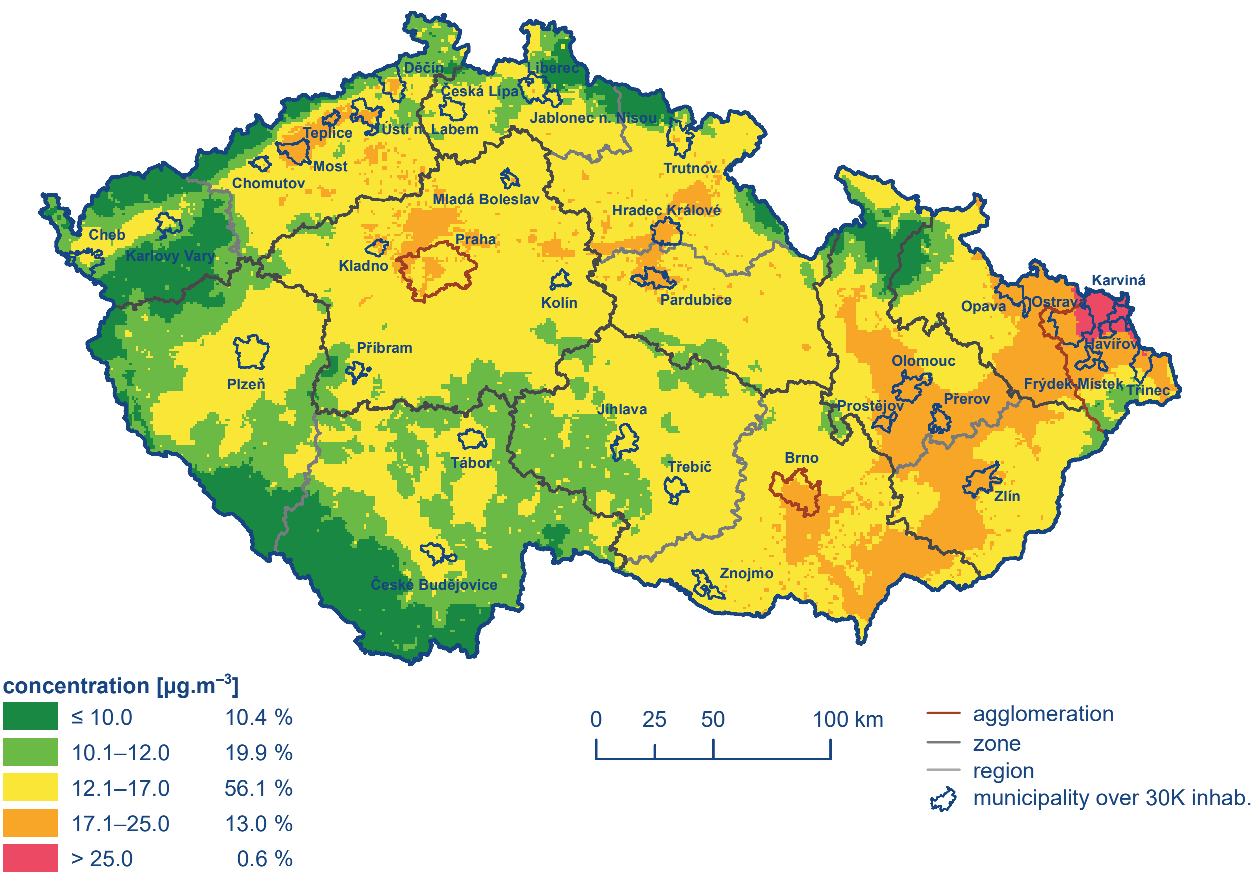

Fig. IV.1.14 Five-year average of annual average $PM_{2.5}$ concentrations, 2015–2019

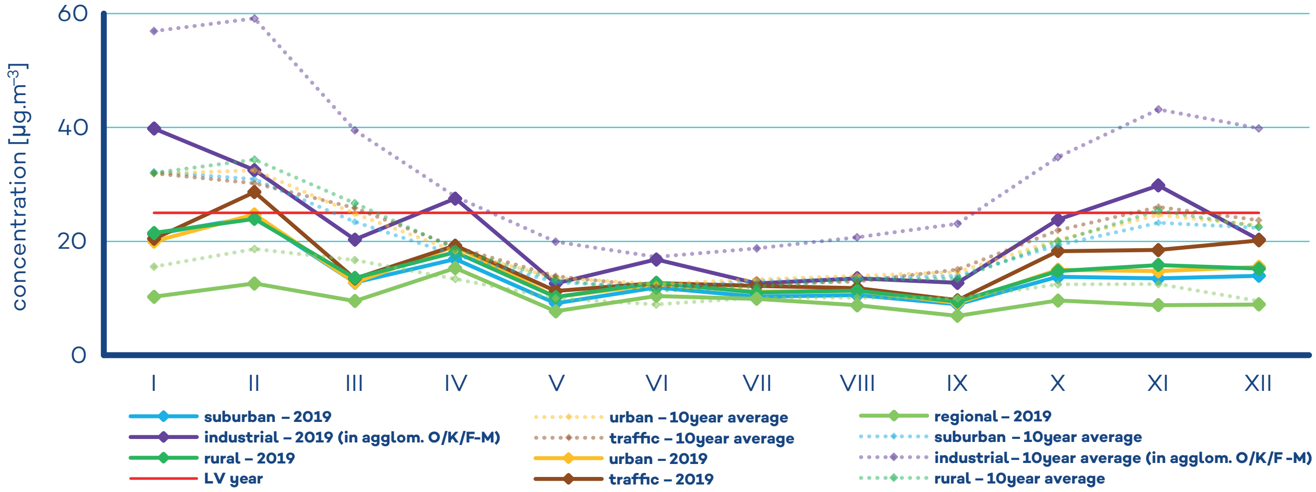

Fig. IV.1.15 Annual course of average monthly $PM_{2.5}$ concentrations (averages for a given type of station), 2019

emissions from heating sources and of worsened dispersion conditions. Monthly $PM_{2.5}$ concentrations show a variation very similar to the annual variation of PM_{10}, including a significant decrease in average monthly concentrations compared to their ten-year average.

A new pollution limit value for the annual average $PM_{2.5}$ concentration will come into force in 2020. An evaluation of the situation with respect to the future limit value (20 µg.m^{-3}) based on the concentrations measured in 2019 can be found in Annex II.

Ratio of the $PM_{2.5}$ and PM_{10} suspended particle fractions

The ratio of the $PM_{2.5}$ and PM_{10} fractions is not constant but exhibits seasonal variations and is also dependent on the character of the location (Fig. IV.1.16). In 2019, this ratio varied on an average from measurements at 58 stations in the Czech Republic, where $PM_{2.5}$ and PM_{10} are measured simultaneously and the locations have a sufficient number of measurements for the evaluation, in the range from 0.61 (July and September) to 0.84 (January). In Prague, where the annual variations are affected by the high fraction of traffic locations, this ratio was in the range from 0.57 (September) to 0.85 (January), in Brno from 0.62 (September) to 0.85 (January), in the Moravian-Silesia region from 0.65 (June, August, and September) to 0.87 (January) and in the Ústí nad Labem region from 0.58 (September) to 0.84 (January).

When the ratio of $PM_{2.5}$ and PM_{10} fractions is compared by a type of location, the ratio at rural locations ranges from 0.58 (July) to 0.86 (January), at urban background from 0.62 (September) to 0.85 (January), at suburban background from 0.60 (September) to 0.85 (January), at traffic locations from 0.58 (July) to 0.81 (Ja-

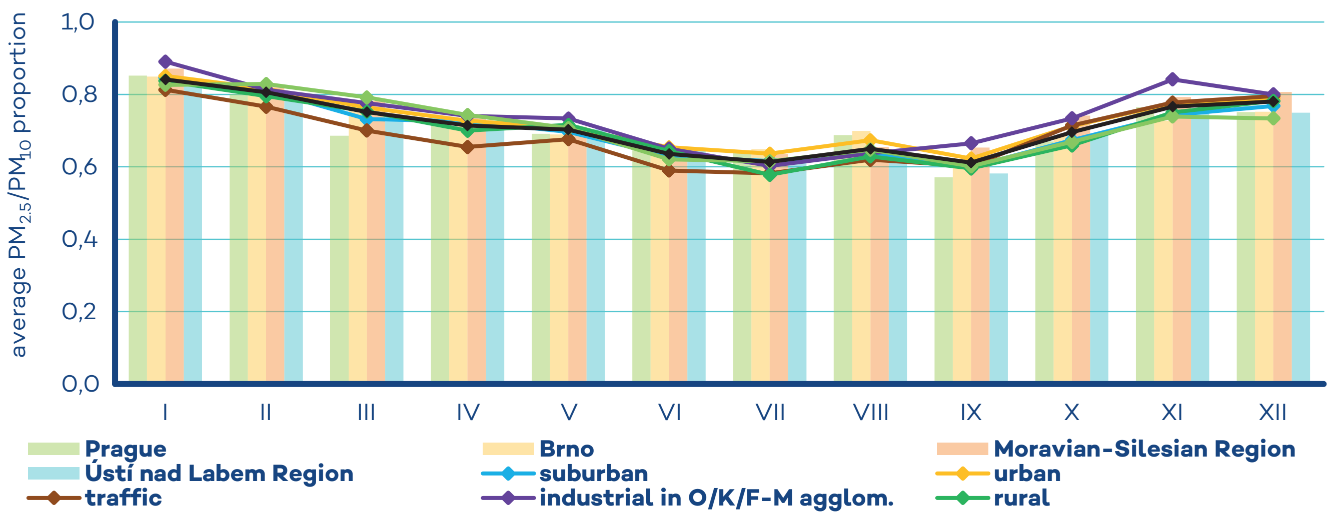

Fig. IV.1.16 Monthly average ratios of $PM_{2.5}/PM_{10}$, 2019

nuary), and at industrial locations from 0.60 (July) to 0.89 (January).

The annual variation in the ratio of the $PM_{2.5}$ and PM_{10} fractions is related to a seasonal character of certain emission sources. Emissions from combustion sources exhibit a greater content of the $PM_{2.5}$ fraction than, e.g., emissions from agricultural activities and resuspension during dry and windy weather. Heating in winter can thus lead to a greater content of the $PM_{2.5}$ fraction in the PM_{10} fraction. The decrease during the spring and beginning of the summer is explained by some studies also as being a result in the amount of larger biogenic particulates, e.g. pollen (Gehrig, Buchmann 2003).

The $PM_{2.5}$ to PM_{10} ratio is the smallest at traffic locations (Fig. IV.1.16). In combustion of fuel in traffic, the particulates belong mainly to the $PM_{2.5}$ fraction and the ratio should therefore be high at traffic locations. The fact that this is not the case emphasises the importance of emissions of the largest particulates from abrasion of tyres, brake linings and roads. The content of the larger fraction at traffic stations also increases as a consequence of resuspension of particulates from winter grit scattering. An increase in the PM_{10} concentration can also occur as a result of greater abrasion of the road surface by grit and subsequent resuspension of the abraded material (EC 2011). On the contrary, the higher ratio of $PM_{2.5}$ and PM_{10} fractions resulting from emissions from combustion processes is observed at industrial stations.

Suspended particulate matter PM_1

The fine particulate PM_1 fraction was measured at 24 stations in 2019, of which 19 stations had a sufficient amount of data for evaluation. These included four stations in Pilsen, three stations in the Brno agglomeration and in the Prague agglomeration, two stations in the O/K/F-M agglomeration and in the Ústí nad Labem district and one station each in the districts of České Budějovice, Klatovy, Litoměřice, Mělník and Zlín (Table XI.4). The highest annual concentrations (19.9 $\mu g.m^{-3}$) and the maximum daily concentrations (235.3 $\mu g.m^{-3}$) were measured at the Ostrava-Českobratrská traffic station (hot spot).

IV.1.2 Trends in the concentrations of suspended particulates PM_{10} and $PM_{2.5}$

The time variation of concentrations of suspended PM_{10} particles at particular types of stations is evaluated for the last 11 years, i.e. 2009–2019 (except for industrial stations where valid data are not available for 2009 and 2010). The highest concentrations of suspended particulates observed in 2010 were caused especially by the occurrence of poor meteorological conditions in winter and the coldest heating season since 1996 (Fig. III.6). In the period 2011–2016, the 36th highest 24-hour concentrations and the annual average concentrations show a decrease. The decrease in the PM_{10} concentrations was manifested at stations in all the categories (Fig. IV.1.17–18). A slight increase of concentrations occurred in 2017 mainly due to poor dispersion conditions at the beginning and at the end of the year. In 2018, the concentrations at individual types of stations remained at similar levels or slightly increased and, compared to 2017, increased on an average. In 2019, a significant decrease in the 36th highest 24-hour concentration and the annual average concentration of PM_{10} was observed. In 2019, the concentrations at most stations reached their minima in the evaluated period as well as since the beginning of measurements in the 1990s. Compared to the eight-year average of concentrations from all stations (which is almost the same as the ten-year average from all stations except industrial stations due to lack of valid data), the 36th highest 24-hour concentration and annual average concentration of PM_{10} decreased by about 23% and 22%, respectively.

The annual average concentrations of $PM_{2.5}$ show a similar time variation as the concentrations of PM_{10}, i.e. they reached their maxima in 2010, and then, by 2016, a decrease is apparent. In 2017 and 2018 there is an increase and in 2019 a significant decrease. Compared to the seven-year average (decades cannot be evaluated due to lack of valid data), annual average concentrations of $PM_{2.5}$ ranged around the average value of 19.4 $\mu g.m^{-3}$, in 2019 they decreased compared to the seven-year average by about 24% (Fig. IV.1.19).

The decrease in the concentrations of suspended particulates PM_{10} and $PM_{2.5}$ can be attributed to a combination of factors — the year 2019 was extremely above-normal in terms of temperature and normal in terms of precipitation. In addition, in 2019, compared with the ten-year average, there were improved dispersion conditions. These factors lead to lower emissions from heating and better dispersion of emissions from various sources. At the end of the year — in November and December — poor dispersion conditions did not occur as usual in comparison with other years (for more see Chapter III). The decrease in concentrations can also be attributed to the measures already implemented to improve air quality (replacement of boilers), the progressive renewal of the vehicle fleet and measures at large sources (see subchapters II and IV.1.3).

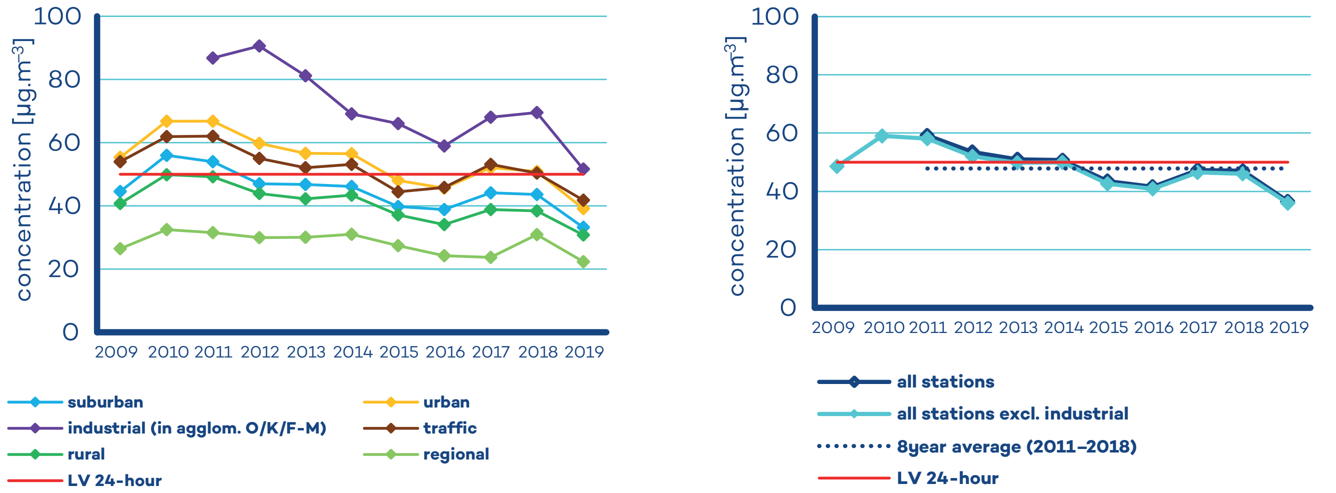

Fig. IV.1.17 36th highest 24-hour PM_{10} concentrations at particular types of stations in the Czech Republic, 2009–2019

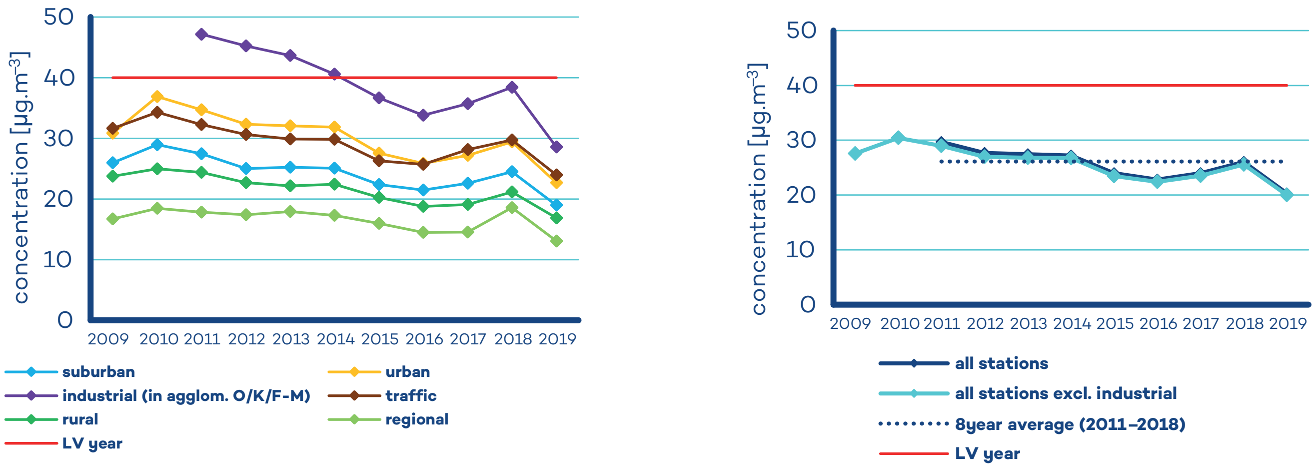

Fig. IV.1.18 Annual average $PM_{2.5}$ concentrations at particular types of stations in the Czech Republic, 2009–2019

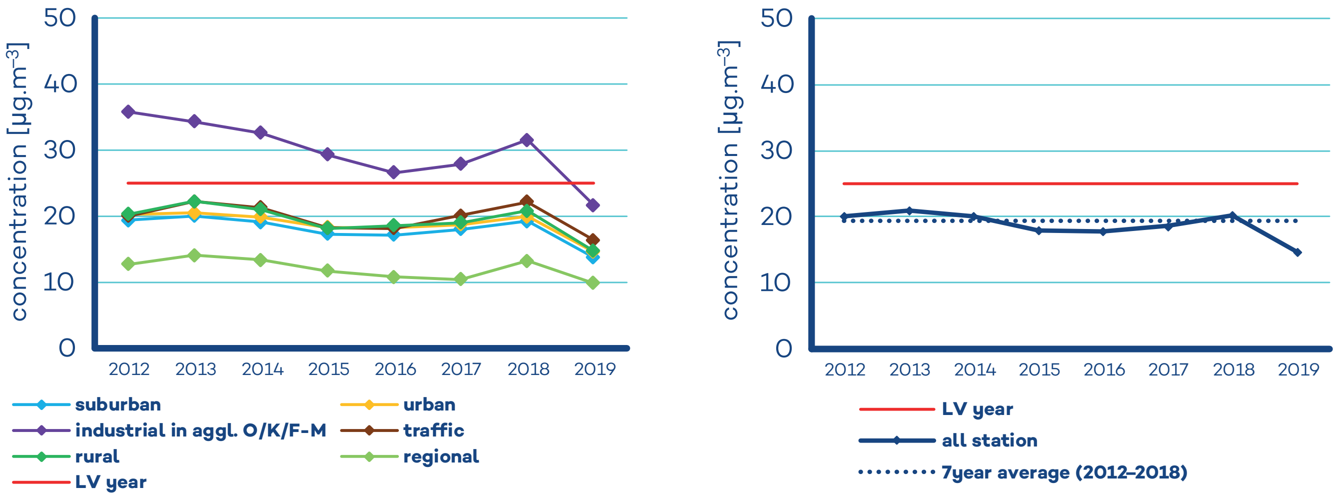

Fig. IV.1.19 Annual average PM_{10} concentrations at particular types of stations in the Czech Republic, 2009–2019

IV.1.3 Emissions of PM_{10} and $PM_{2.5}$

Aerosols originating from fuel combustion and other industrial activities can exist in a form of solid, liquid or mixed suspended matter. In their complexity, these aerosols are denoted as solid pollutants (SP) in the Czech legislation and as Total Suspended Particulates (TSP) in foreign literature. SP emissions have varying size and chemical composition resulting from the characteristics of the source and the mode of formation. They can contain heavy metals and act as a carrier medium for VOC and PAH. PM_{10} and $PM_{2.5}$ size fractions are most frequently distinguished in emission inventories in relation to pollution limit levels.

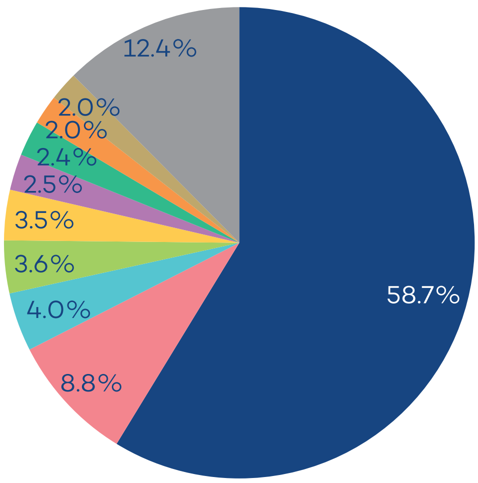

Fig. IV.1.20 Share of NFR sectors in total $PM_{2.5}$ emissions, 2018

Emission inventories of PM_{10} and $PM_{2.5}$ prepared according to current regulations include only the primary emissions of these substances. Simultaneously, a considerable contribution to concentrations of PM_{10} and $PM_{2.5}$ measured in the air comes from secondary suspended particulates formed directly in the air from gaseous precursors by physical-chemical reactions. The fraction of secondary suspended inorganic particulates in total $PM_{2.5}$ concentrations in urban environments can vary between 20 and 40% (Vlček, Corbet 2011). The contribution of secondary suspended organic particulates of biogenic origin under European conditions can equal 2–4 $\mu g.m^{-3}$ (Fuzzi et al. 2015).

Compared to emissions of other pollutants, particulate matter emissions in the air originate from a great many significant groups of sources. In addition to sources from which these substances are emitted through controlled chimneys or stacks (industrial sources, local heating units, transport), significant amounts of PM emissions originate from fugitive sources (quarries, dusty material dumps, operations involving dusty materials, etc.). Emissions from abrasion of tyres, brake linings and abrasion of roads calculated from traffic levels are also included. The quality of the air is also affected by resuspension of particles (stirring-up), which is not included in the standard emission inventories.

The main sources of particulate matter emissions in 2018 included 1A4bi sector — Residential: Stationary, which contributed to air pollution on a country-wide scale with 58.7% PM_{10} substances and 73.9% $PM_{2.5}$ substances. Further important sources of PM_{10} emissions included the 3Dc sector – Farm-level agricultural operations including storage, handling and transport of agricultural products where these emissions are formed during tillage of the soil, harvesting and cleaning agricultural crops. This sector represented 8.8% of PM_{10} emissions. A substantial risk to human

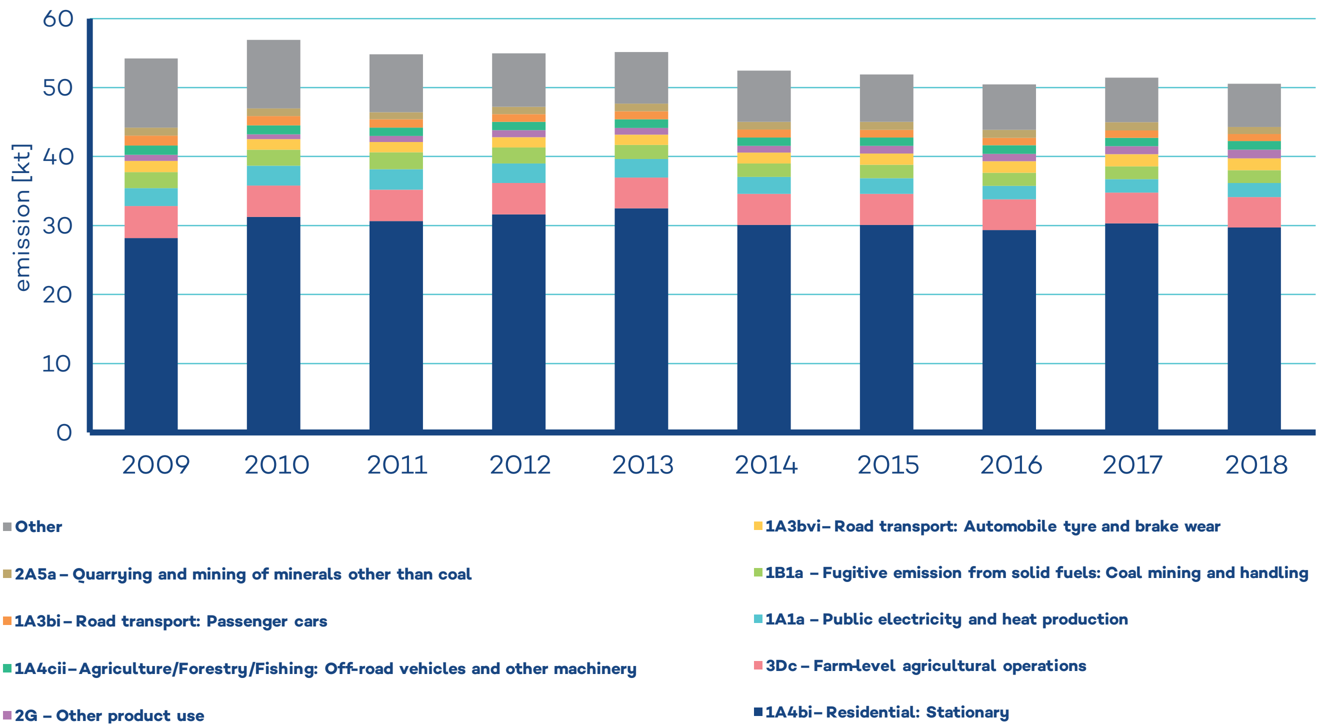

Fig. IV.1.21 Total PM_{10} emissions, 2009–2018

health is caused by particulates coming from transport, especially from fuel combustion in diesel engines which produce particles with a size of units to hundreds of nanometres (Vojtíšek 2010). Transport contributed 11.2% to PM_{10} emissions and 11.1% to $PM_{2.5}$ emissions (Fig. IV.1.20 and Fig. IV.1.22).

Fuel consumption in households in the period 2009–2018 can be characterised by a gradual growing trend in the use of biomass in contrast to other solid fuels related to a wide availability, affordability and subsidy support for the replacement of boilers. Natural gas consumption shows a slightly declining trend. The reduction in the consumption of not only natural gas but also coal fuels between 2017–2018 (Fig. II.7) can be attributed to the increased supply of firewood due to the bark beetle calamity. There is a slight reduction in PM emissions due to the natural renewal of the vehicle fleet, a decrease in agricultural production and steadily declining emissions of the listed sources, e.g. due to the application of the best available techniques for reducing SP emissions (fabric filters) in energy and industry. Total PM_{10} and $PM_{2.5}$ emissions in the period 2009–2018 declined (Fig. IV.1.21 and Fig. IV.1.23).

In individual regions of the Czech Republic, the contribution by sectors varies depending on the composition of sources in a given area. As the main source of PM_{10} and $PM_{2.5}$ emissions is represented by local heating, the production of these substances is also distributed throughout the territory of the Czech Republic with residential buildings (Fig. IV.1.24 and Fig. IV.1.25). When the territory of the Czech Republic is divided into 5x5 km grid, areas with higher emissions correspond to sites where important energy sources burning solid fossil fuels (the Ústí nad Labe region) and large industrial complexes (the Moravian-Silesia region) are located. The fraction of emissions from transport is greater primarily in large cities.

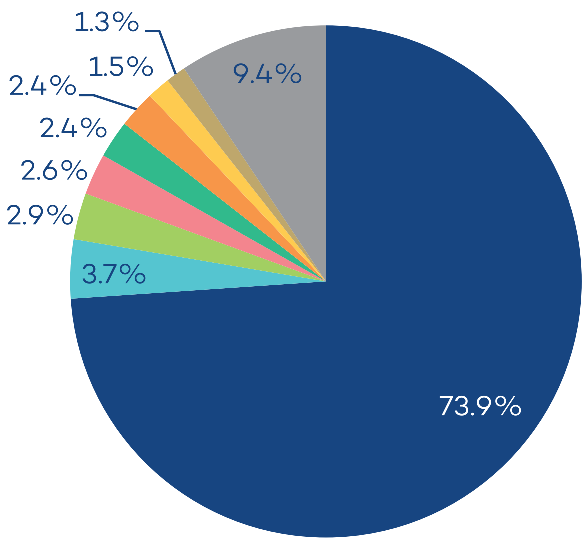

Fig. IV.1.22 Share of NFR sectors in total PM_{10} emissions, 2018

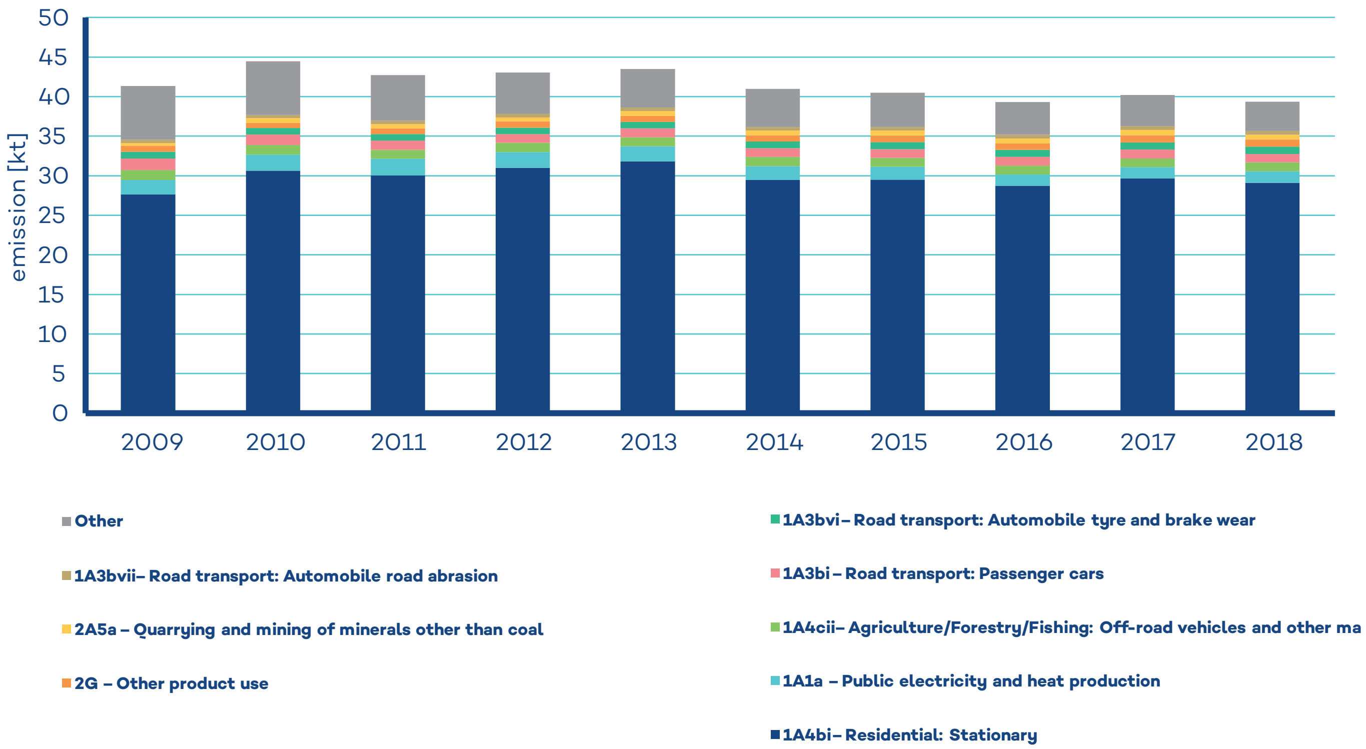

Fig. IV.1.23 Total $PM_{2.5}$ emissions, 2009–2018

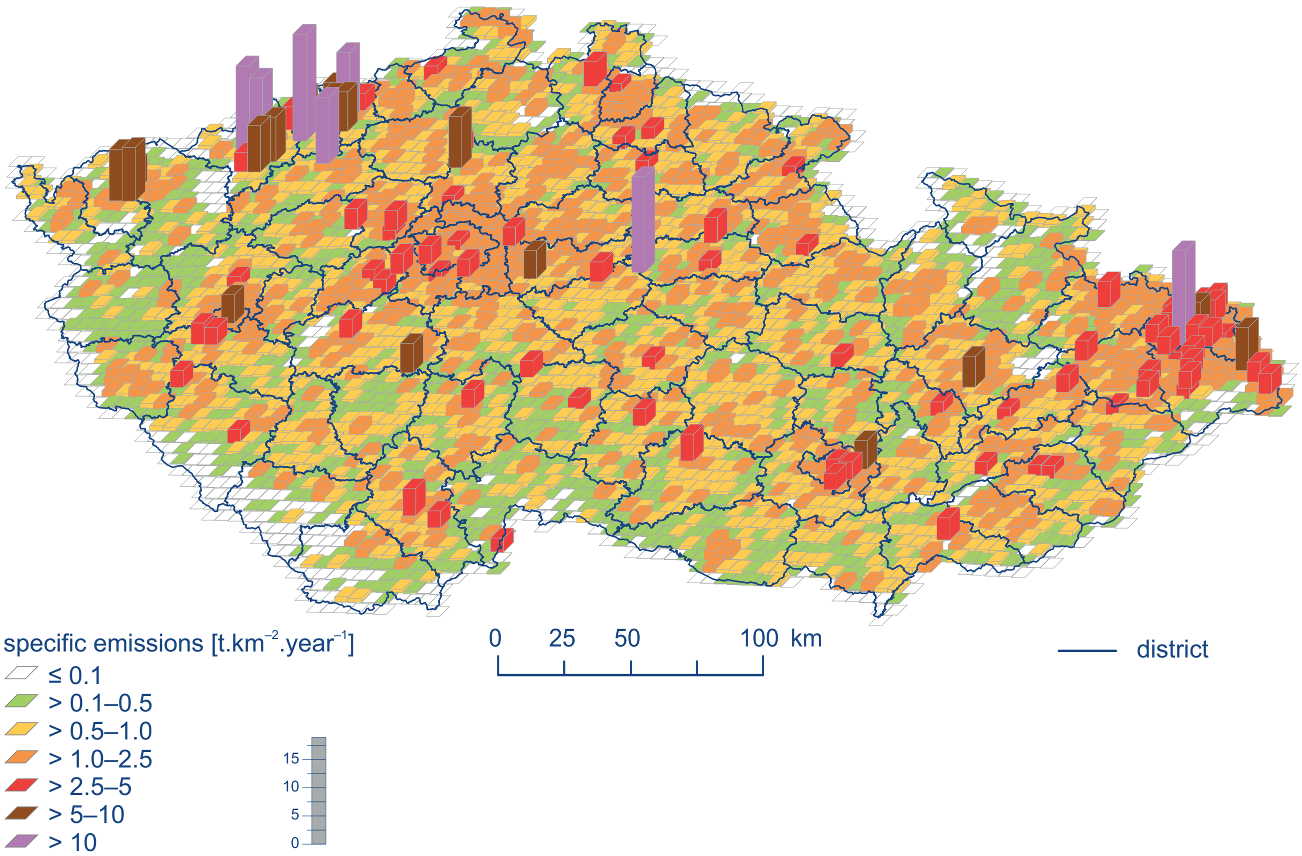

Fig. IV.1.24 PM_{10} emission densities in 5x5 km spatial resolution squares, 2018

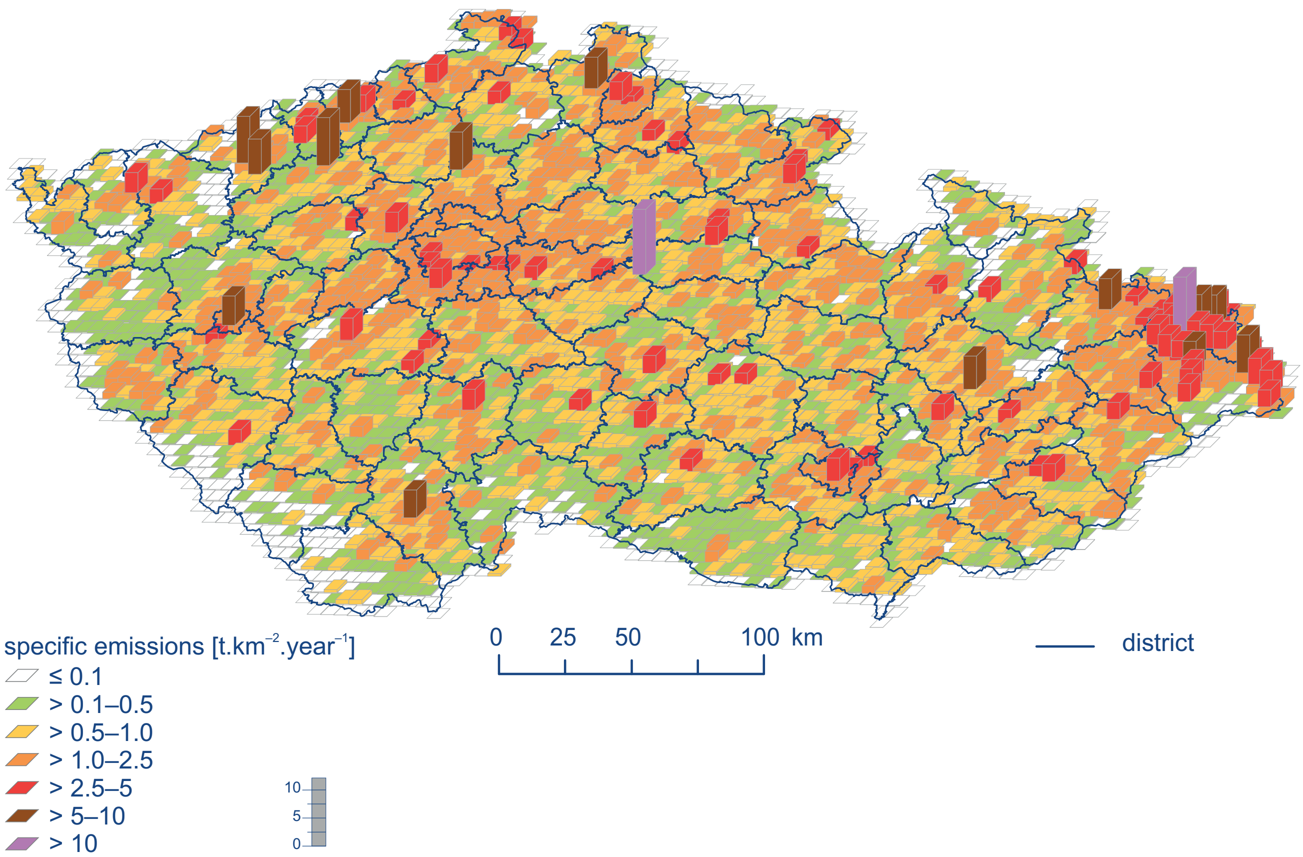

Fig. IV.1.25 $PM_{2.5}$ emission densities in 5x5 km spatial resolution squares, 2018