IV.3 Nitrogen oxides

IV.3.1 Air pollution by nitrogen oxides in 2021

In monitoring and evaluating the quality of ambient air, the term nitrogen oxides (NO_X) is understood to refer to a mixture of nitrogen oxide (NO) and nitrogen dioxide (NO_2). A pollution limit level for the protection of human health has been set for NO_2, while a limit level for the protection of ecosystems and vegetation has been set for NO_X.

Air pollution by nitrogen dioxide in 2021 in relation to pollution limit levels for the protection of human health

The limit value for the annual average nitrogen dioxide (NO_2) concentration (40 $\mu g \cdot m^{-3}$) was not exceeded at any station in the CR in 2021, which happened, along with 2020, for only the second time in the entire history of the measurement (i.e., since the 1990s) (Fig. IV.3.1). Due to a measurement failure following a technical defect at the Prague 2-Legerova station (hot spot) during the year, it was not possible to include this most pollution loaded station in the evaluation. At this station, the highest values of NO_2 concentrations have been measured for a long time in connection with the high traffic intensity in the immediate vicinity of the station and its location in the street canyon, where the possibility of ventilation is significantly reduced. In the case of year-round measurement without a technical defect, the possibility of exceeding the annual NO_2 pollution limit cannot be ruled out. The highest annual average NO_2 concentration values were traditionally recorded at transport stations in big cities, especially in Prague and Brno. Higher concentrations of NO_2 can also be expected in the vicinity of busy roads in municipalities and cities with intense traffic, where traffic flow is often reduced. The lowest NO_2 concentrations are measured at regional stations (Churáňov, Košetice, Polom), i.e., in areas far from the influence of emission sources.

The limit value for an hourly NO_2 concentration (200 $\mu g \cdot m^{-3}$ with a maximum permitted number of 18 cases exceeding the limit per year) was not exceeded at any station in 2021. The hourly NO_2 limit value was once exceeded at one station (Ostrava-Poruba DD).

The modelled annual average concentration of NO_2 did not exceed 26 $\mu g \cdot m^{-3}$, i.e., the value of the lower assessment threshold, in almost the entire territory of the CR, except for the centres of large cities (Fig. IV.3.2). However, it is important to note that NO_2 concentration maps are prepared in a resolution of 1×1 km, and therefore the effect of higher concentrations measured at transport stations with a low radius of representativeness (up to 100 m) are not

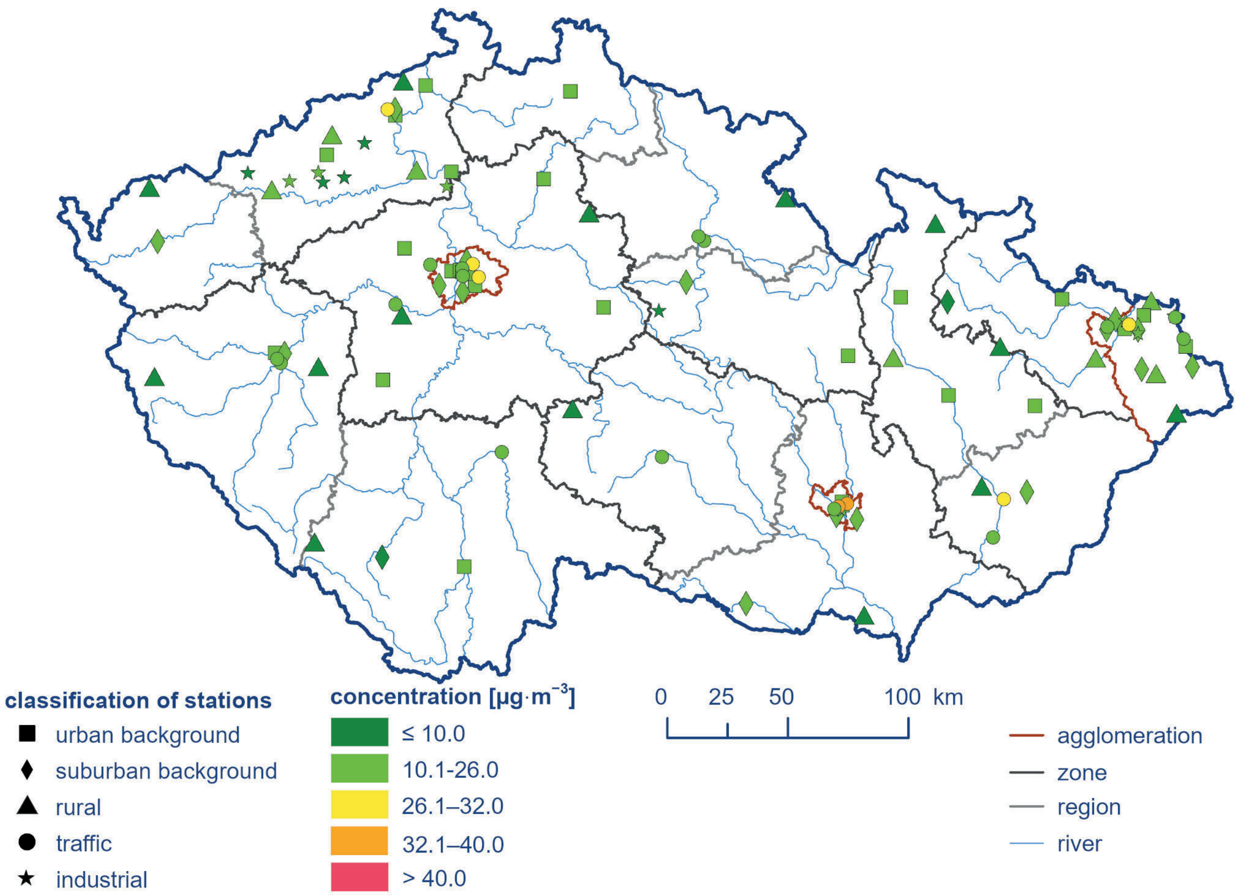

Fig. IV.3.1 Annual average NO_2 concentrations at air quality monitoring stations, 2021

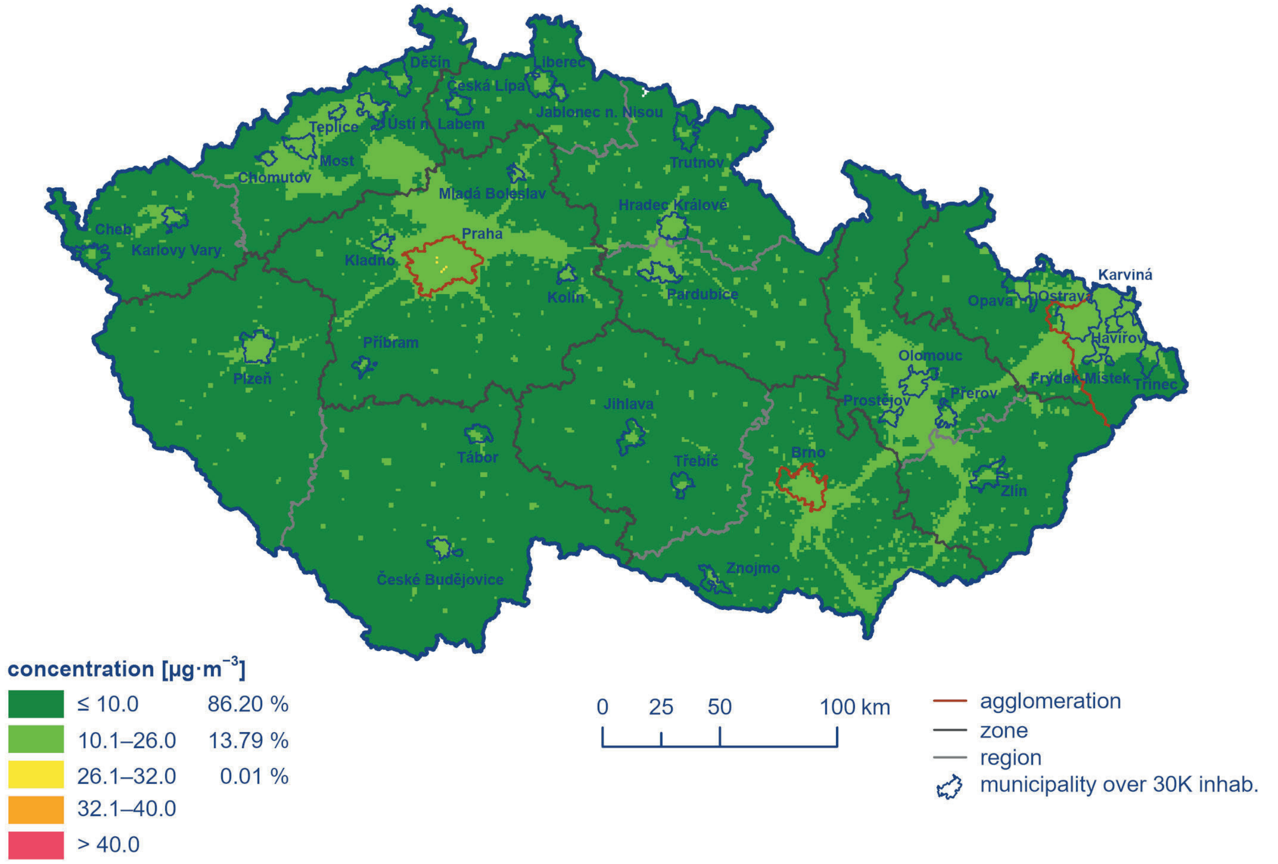

Fig. IV.3.2 Field of annual average NO_2 concentrations, 2021

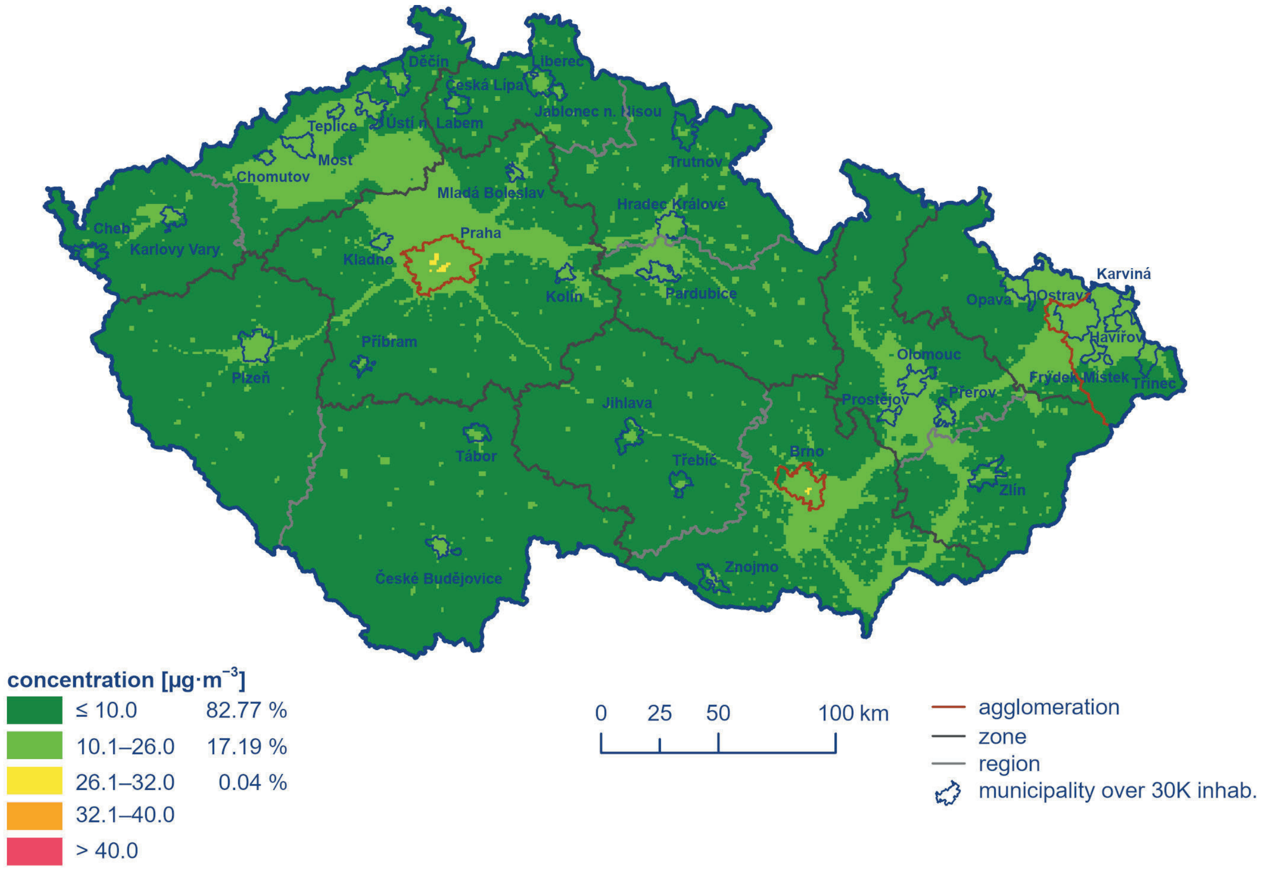

Fig. IV.3.3 Five-year average of annual average NO_2 concentrations, 2017–2021

reflected in the final image. The low radius of representativeness of transport stations is related to a sharp decrease in NO_2 concentrations with increasing distance from roads. From a long-term perspective (Fig. IV.3.3), higher concentrations are expected in centres of large cities with high traffic intensities (Prague and Brno).

The annual variation of monthly average concentrations is similar for all types of stations. The highest values of NO_2 concentrations are observed at transport stations in connection with strong influence from a nearby emission source – transport (Fig. IV.3.4.). As transport is the main source of NO_2, which operates throughout the year, the variation of concentrations during the year is affected by meteorological and dispersion conditions. In addition, peaks in the colder period of the year occur due to increased emissions from domestic heating and car cold ignition. On the contrary, in the period April-September, there is generally a decrease in NO_2 concentrations. The reason for this decrease is higher intensity of solar radiation in this season, which results in decomposition of NO_2 and its participation in photochemical reactions forming ground-level ozone. During the summer holiday months, there is also a reduction in traffic intensity in large cities, which improves the flow of traffic and thus reduces NO_2 emissions. The average monthly NO_2 concentrations are the lowest and well below the lower assessment threshold at regional rural localities remote from direct exposure to emission sources, showing thus less distinct annual variation. The highest monthly average NO_2 concentrations in 2021 were measured in February and were close to or even exceeded the 10-year average concentrations. The higher consumption of natural gas for heating houses and flats, including water heating, contributed to the increased NO_2 concentrations in February, whether at a centralized or local level in connection with the occurrence of low temperatures in combination with moderately poor to poor dispersion conditions. Conversely, the lowest monthly NO_2 concentrations were recorded in July. In 2021, all monthly average NO_2 concentrations, except February, were lower compared to the ten-year average 2011–2020. Significantly lower monthly average concentrations of NO_2 compared to the ten-year average 2011–2020 were in August, by about 30 %.

Air pollution by nitrogen oxides in 2021 in relation to pollution limit levels for the protection of ecosystems and vegetation

The pollution limit level for the protection of ecosystems and vegetation for the average annual NO_x concentration (30 μg·m^{-3}) was not exceeded in 2021 at any of 21 rural stations with a sufficient amount of data for evaluation. The concentration map of annual average NO_x concentrations was prepared using combined data from all stations measuring NO_x and a dispersion model. Higher NO_x concentrations are measured in the vicinity of busy roads in municipalities. On the map, point symbols designate only rural stations because average annual NO_x concentrations are evaluated only at these locations, following the Czech legislation in force in relation to the pollution limit level for the protection of ecosystems and vegetation (Fig. IV.3.5).

IV.3.2 Trends in nitrogen oxide concentrations

The trends in NO_2 and NO_x concentrations at stations are evaluated over the last 11 years, i.e., 2011–2021 (Fig. IV.3.6, Fig. IV.3.7, Fig IV.3.8, and Fig. IV.3.9). The long-term decrease in NO_x emissions related to the gradual modernization of emission sources (large sources, renewal of the vehicle fleet) is manifested by a decrease in both NO_2 and NO_x concentrations in the air. However, the level of inter-annual concentrations of NO_2 and NO_x, as well as other pollutants, is significantly influenced by meteorological and dispersion conditions in individual years. During the evaluated period, the highest NO_2 and NO_x annual concentrations were recorded in 2011, in association with the recurrence of poor meteorological and dispersion conditions in the cold period of the year. Since 2011 until 2016, it is possible to observe a gradual decrease or stagnation in all monitored nitrogen oxide characteristics.

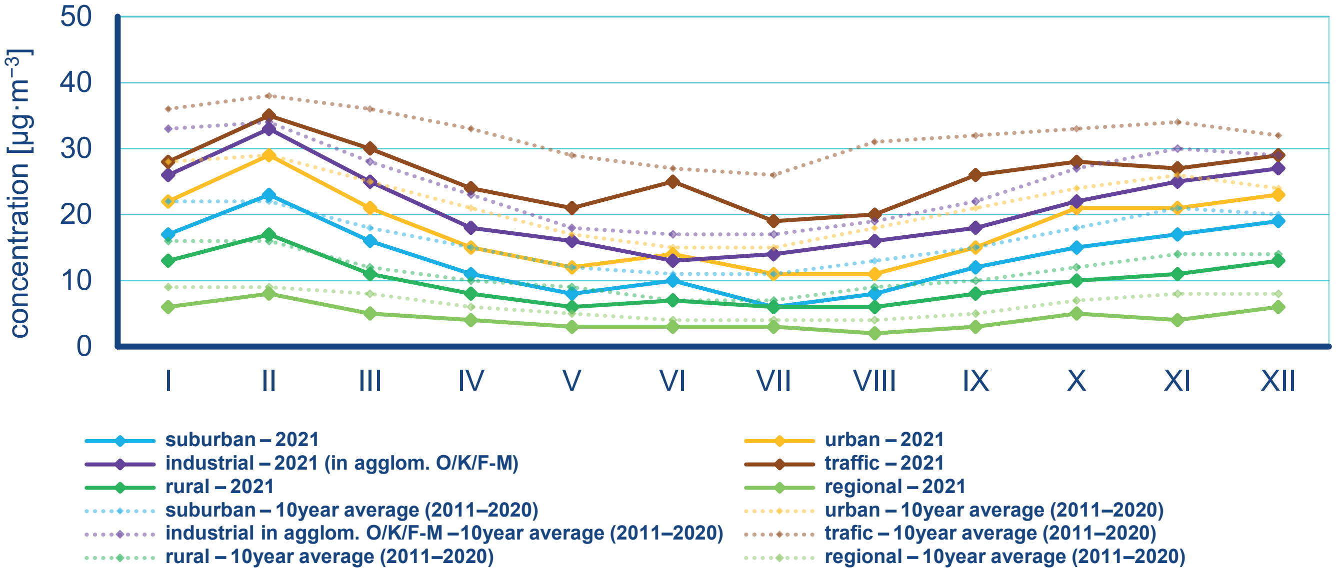

Fig. IV.3.4 Annual course of average monthly concentrations of NO_2 (averages for a given type of station), 2021

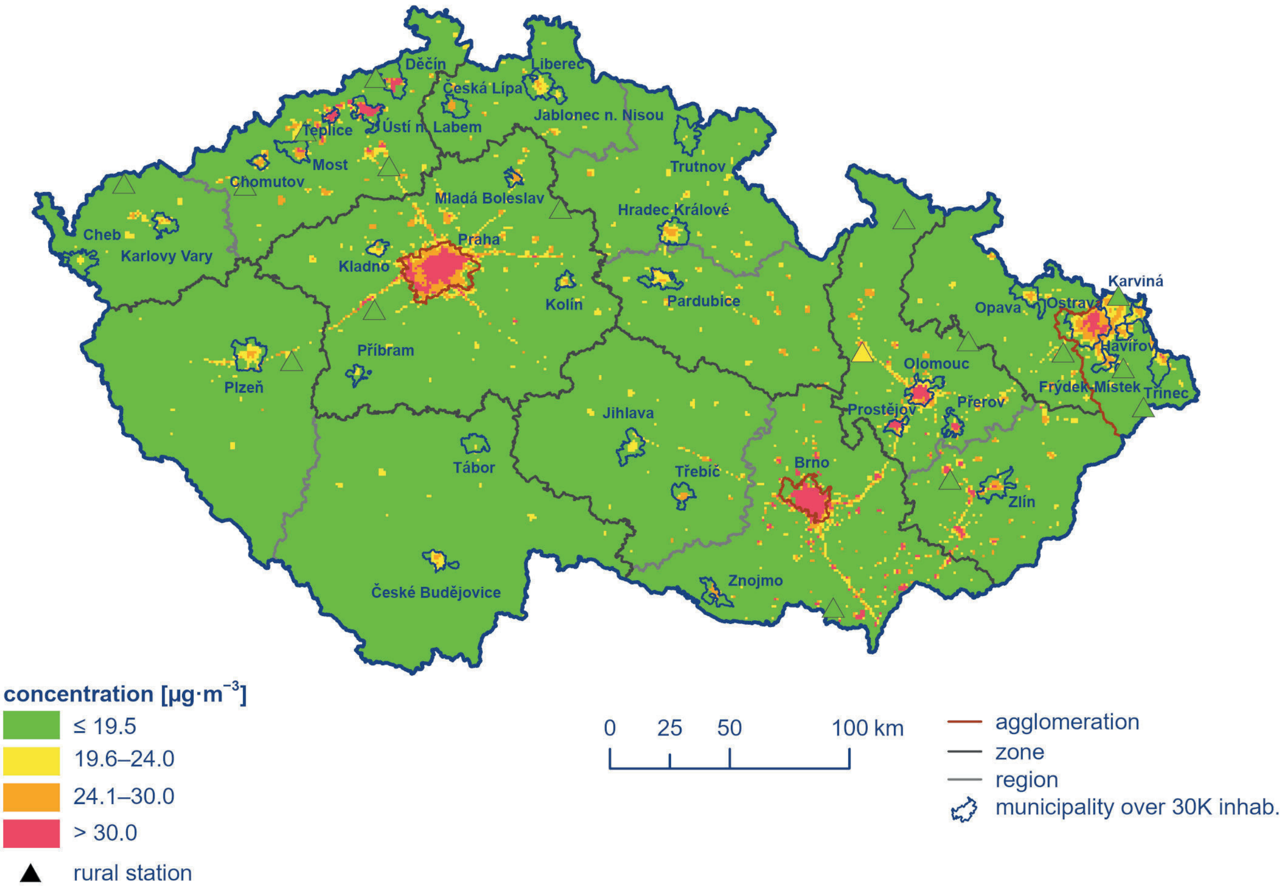

Fig. IV.3.5 Field of annual average NO_x concentration, 2021

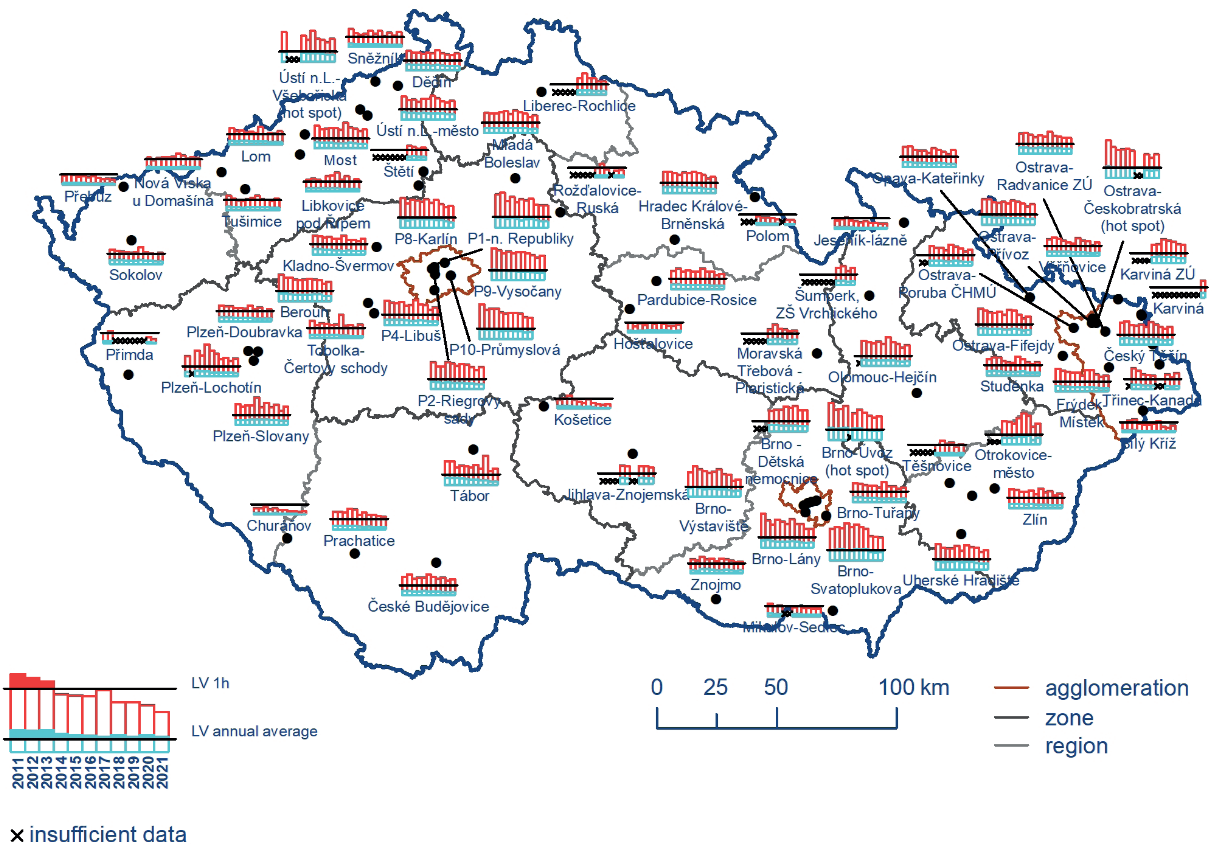

Fig. IV.3.6 The 19th highest hourly and annual average NO_2 concentrations at selected stations, 2011–2021

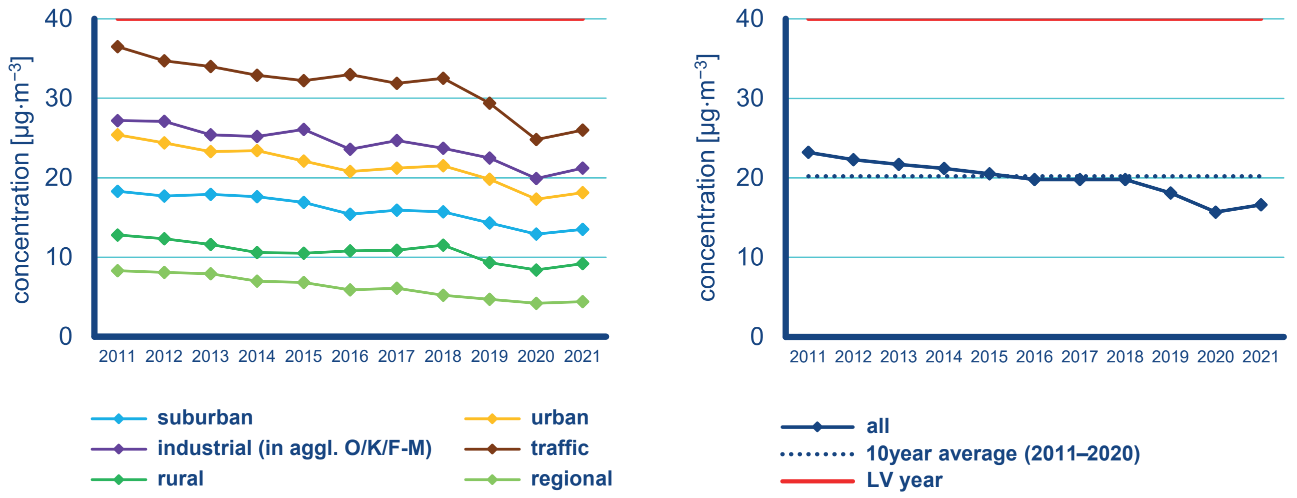

Fig. IV.3.7 Annual average NO_2 concentrations at particular types of stations, 2011–2021

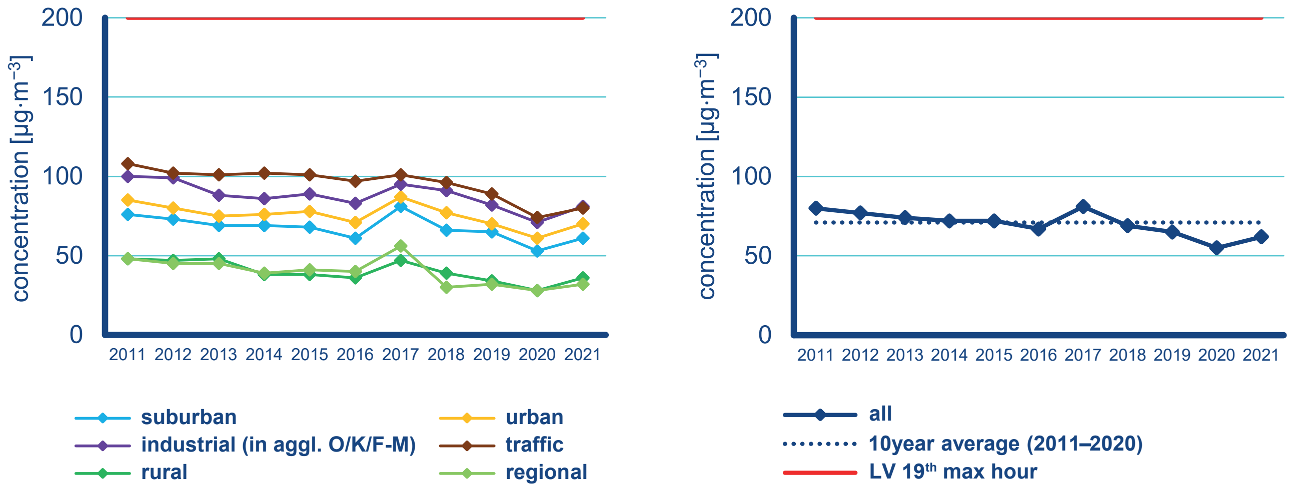

Fig. IV.3.8 The 19th highest hourly NO_2 concentrations at particular types of stations, 2011–2021

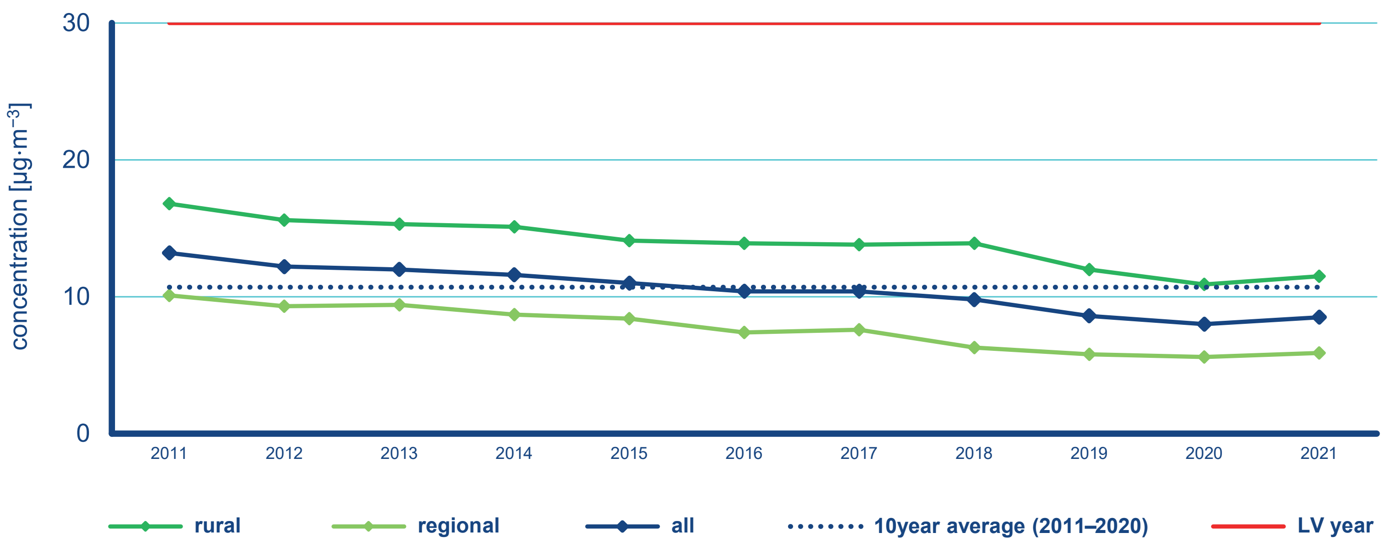

Fig. IV.3.9 Annual average NO_x concentrations at particular types of stations, 2011–2021

The slight increase in NO_2 and NO_x concentrations in 2017 was associated with poor dispersion conditions in the cold part of the year. During 2019 and 2020, NO_2 and NO_x concentrations decreased significantly. After the excellent year 2020, there was a slight increase in the average annual concentration of NO_2 and NO_x, in year-on-year comparison 2020/21, and the concentration values returned to the level of 2019. Compared to the ten-year average of concentrations (2011–2020) from all stations (20.2 $\mu g \cdot m^{-3}$), the annual average NO_2 concentration (16.6 $\mu g \cdot m^{-3}$) in 2021 was almost 18 % lower. The most significant differences in measured NO_2 concentrations compared to the ten-year average (2011–2020) were recorded at transport stations (by 6 $\mu g \cdot m^{-3}$, approx. 19 % lower), which was also positively reflected by lower regional background concentrations in clean areas of the CR, being about more than a third lower. In the case of the 19th maximum average hourly NO_2 concentration in 2021 compared to the ten-year average (2011–2020) from all stations, the values were lower by 13 %. A decrease also occurred in NO_x concentrations, and compared to the ten-year average (2011–2020), annual average NO_x concentrations from all rural background stations were 21 % lower.

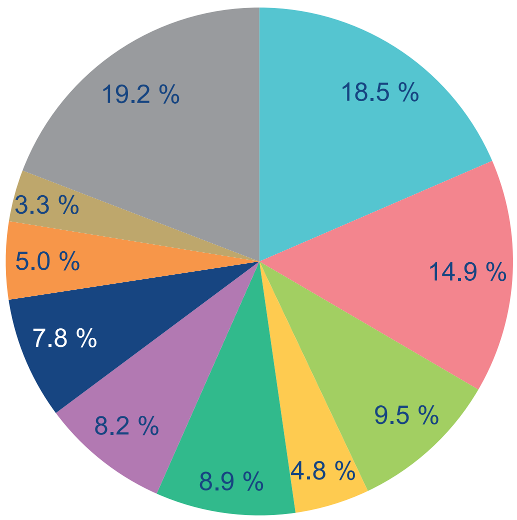

Fig. IV.3.10 Share of NFR sectors in total NO_x emissions, 2020

The concentrations of NO_2 and NO_x in 2021 can be evaluated as very good, despite the slight year-on-year increase, because, just like in the previous year 2020, the pollution limits established for the protection of human health and for the protection of vegetation were not exceeded. Meteorological and dispersion conditions have a great influence on the inter-annual variability of NO_2 and NO_x concentrations, as well as other pollutants. In 2021, both NO_2 and NO_x concentrations were quite well affected by meteorological conditions in May and August, which were above normal in terms of precipitation with better dispersion conditions compared to the ten-year average during autumn. In addition, in 2021, similar to 2020, a state of emergency was declared on the territory of the CR in connection with the ongoing SARS-CoV-2 coronavirus pandemic. From the point of view of the influence on the level of NO_2 and NO_x concentrations in the ambient air, the protective measures taken in the first quarter of 2021 were essential, when schools were closed, and especially in March, when movement between districts was prohibited and thus the mobility of residents was fundamentally reduced. The restriction of the movement of the population manifested itself in a decrease in the

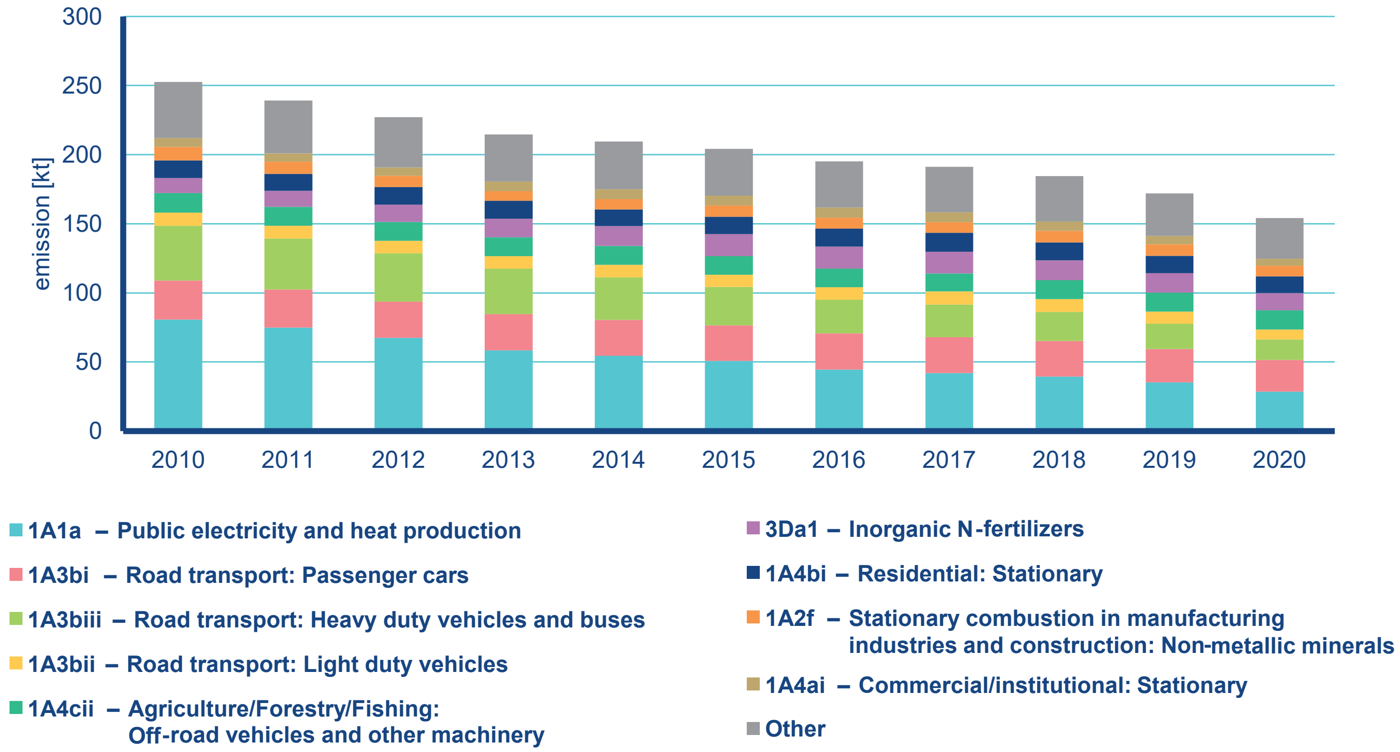

Fig. IV.3.11 Total NO_x emissions, 2010–2020

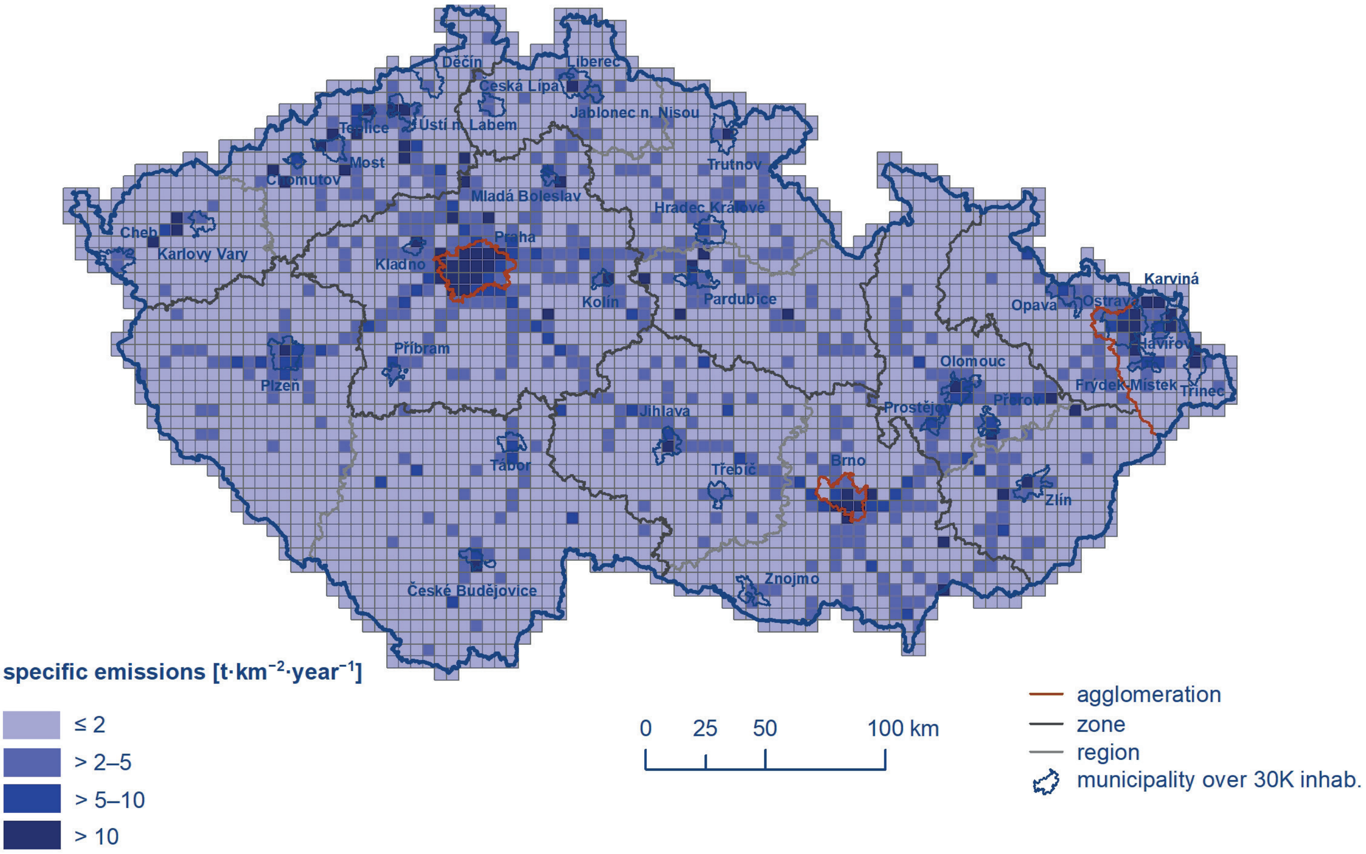

Fig. IV.3.12 Total NO_x in 5×5 km spatial resolution squares, 2020

intensity of traffic, which resulted in a decrease in emissions from traffic and subsequently in a decrease in the concentration of pollutants in the air. It can be assumed that under normal conditions, without protective measures to limit the pandemic, the measured concentrations of NO_2 and NO_x in 2021 would be higher.

IV.3.3 Nitrogen oxide emissions

Nitrogen oxides (NO_x) are formed during the combustion of fuels, depending on the temperature of combustion, nitrogen content of the fuel and excess of combustion air, and are also formed in some chemical-technological processes (the production of nitric acid, ammonia, fertilisers, etc.). While during the combustion of fuels in boilers the fraction of NO_2 in NO_x emissions is usually up to 5 %, the fraction of NO_2 in some chemical-technological processes can reach up to 100 % of total NO_x emissions (Neužil 2012). NO_x emissions with a higher fraction of NO_2 (10–55 %) are also produced by diesel engines (Carslaw at al. 2011).

The largest amount of NO_x emissions comes from mobile sources (CHMI 2021d). In 2020, 29.2 % of nationwide NO_x emissions came from sectors 1A3bi – Road transport: Passenger cars, 1A3biii – Road transport: Heavy duty vehicles over 3.5 tons, 1A3bii – Road transport: Light duty vehicles, and 8.9 % of emissions from sector 1A4cii – Agriculture/Forestry/Fishing: Off-road vehicles and other machinery. 18.6 % of NO_x emissions were introduced into the air from sector 1A1a – Public electricity and heat production, 8.2 % of emissions from sector 3Da1 – Use of inorganic N-fertilizers, and 7.8 % emissions from sector 1A4bi – Households: Heating, water heating, cooking (Fig. IV.3.10). The decreasing trend in NO_x emissions in the 2010–2020 period is related primarily to natural renewal of the vehicle fleet and the introduction of emission ceilings including stricter emission limits for NO_x emissions from sources in sector 1A1a – Public electricity and heat production (Fig. IV.3.11). The evaluation of the impact of the SARS-CoV-2 coronavirus pandemic on the year-on-year reduction of emissions in this sector by almost 5 kt cannot be carried out precisely with regard to the above-mentioned contexts. However, the presented data indicate an apparent year-on-year decrease in emissions related to traffic restrictions in 2020 due to the SARS-CoV-2 coronavirus pandemic. This applies mainly to sector 1A3biii – Road transport: Heavy duty vehicles over 3.5 tons (from 18.3 kt to 14.7 kt) and partly also to sector 1A3bi – Road transport: Passenger cars, for which emissions decreased from 24.6 kt to 23 kt.

The contributions of particular emission sources differ depending on the composition of sources in a given area. The production of NO_x emissions is concentrated primarily along motorways, roadways with heavy traffic, in large cities, and in the regions where more significant energy production facilities are located (Ústí nad Labem, Central Bohemia and Moravian-Silesia regions) (Fig. IV.3.12).