Weather, water and air

2022

Czech Hydrometeorological Institute

CHMI operates

29
professional meteorological stations

208
automated meteorological stations

180
rain gauge stations

296
manual rain gauge stations

2
meteorological radars

1
aerological station

2
sodars

4
windprofilers

547
surface water limnographic stations

1 536
hydrogeological wells

317
springs

655
ground water quality monitoring objects

48
automated snow gauge stations

17
automated snow pillows

48
surface water quality monitoring locations (sediments, biota, suspended sediments)

102
automated ambient air quality monitoring stations

31
manual ambient air quality monitoring stations

14
rain water quality monitoring stations

28
phenological monitoring locations

Meteorological stations

Hydrology station network

Air quality monitoring

Products and services

Institute structure reflects regional and disciplinary classification. Four specialized departments, meteorology and climatology, hydrology, air quality and forecasting service, are complemented by an economic and administrative department and a separate IT department for technical support of computational and communication activities. Regional activities are carried out by CHMI branch offices in Prague, České Budějovice, Pilsen, Ústí nad Labem, Hradec Králové, Brno and Ostrava.

Numerical weather forecasting model – ALADIN

Weather forecasts ranging from nowcasting, short-term, medium-term, long-term to special meteorological forecasts.

- Meteorological support in the field of air transport (Air Navigation Services, aerial observers, airport management)
- Meteorological support in the field of road network management and maintenance
- Meteorological support in the field of agriculture
- Meteorological support for the operation of nuclear energy facilities

Prediction and warning systems

- Early warning system (EWS)
- Integration warning system service

Flood reporting and forecasting service

Smog warning and regulation system

Information systems – web pages

- National greenhouse gas emission inventory system
- Climatological database CLIDATA
- Public administration information system VODA
- ISVS system in the field of hydrology (ARROW, HYDROFOND)
- Air quality information system (ISKO)

Calibration laboratory

Expert studies

Communication and promotion

- Info web https://info.chmi.cz
- Social networks – Facebook, Twitter, YouTube, Instagram, LinkedIn
- Yearbooks – **meteorology and climatology**, **hydrology**, **air quality** – https://info.chmi.cz/rocenka
- Press releases, materials for media
- Popularization events – open day, science festival

ČHMÚ, ČHMÚ Plus mobile apps

Expert assessments and activities in the fields of competence

Being a semi-autonomous organisation the CHMI serves as the Czech Republic's central government institution for the fields of air quality, hydrology, water quality, climatology and meteorology as specialist services provided to state administration as a priority.

Content

21

November 11 – December 23. **End of vegetation period.**

26–27

In November, another air quality monitoring campaign focused on the air quality in small settlements took place. How did the energy crisis affect air pollution?

6

October was very warm with a monthly temperature deviation from the normal of 1991–2020 was +2.5 °C. October 2022 was therefore a significantly **above-average month in terms of air temperature**.

7

September was **rich in rainfall** – the average precipitation amount for the Czech Republic was 35% higher than the normal of 1991–2020.

13

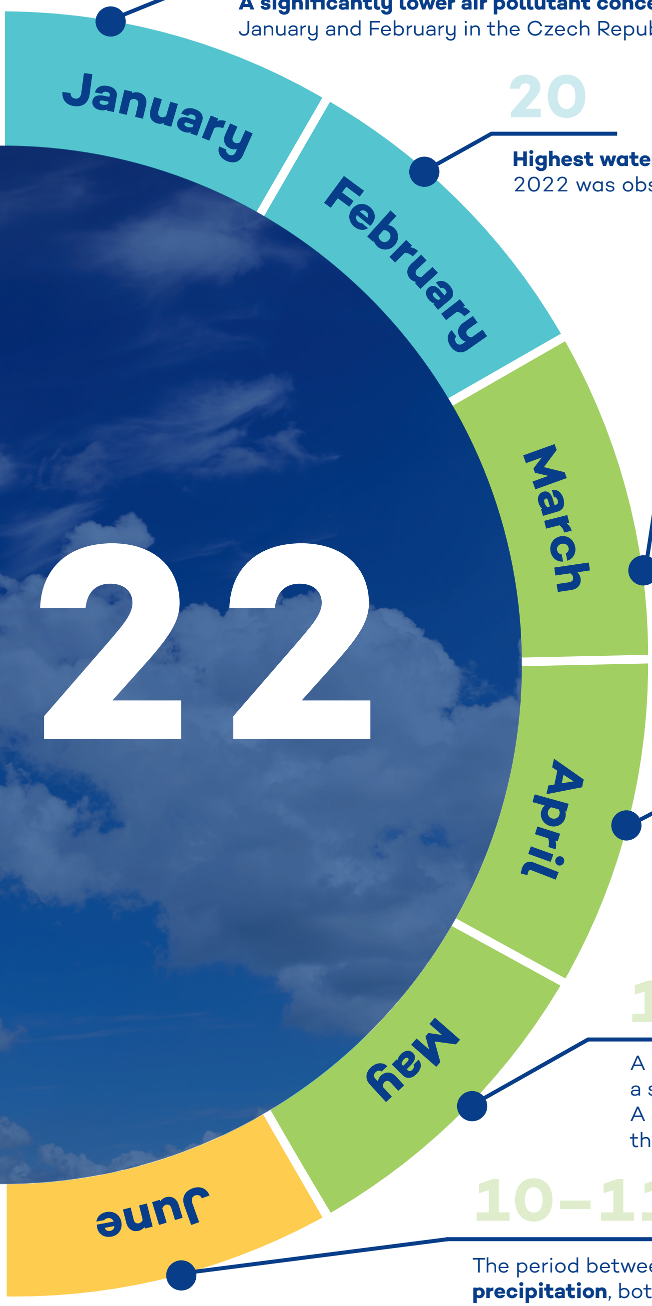
Up to **extreme soil drought** occurred in August in Northwest and West Bohemia.

25

5 smog situations were declared at the end of July and beginning of August due to high concentrations **of ground-level ozone**.

16–17

A large wildfire in the Czech Switzerland national park was reported on July 27. What were the effects of the weather on the wildfire spread? How did the fire affect air quality?



22

A significantly lower air pollutant concentrations than usual were observed in January and February in the Czech Republic.

20

Highest water content in snow in the Czech Republic in 2022 was observed on February 2 (1.294 bil. m^3).

8

Insufficient amount of precipitation in March caused a significant decrease in surface water levels and March was **the driest month of the year** in terms of precipitation amount and runoff conditions.

21

March 6 – April 5
Start of vegetation period.

6

April was very cold. Air temperature deviation from the normal of 1991–2020 was −2.1 °C.

10–11

A significant convective wind storm, a so-called **derecho**, hit the Czech Republic on May 20. A wind speed of 35 $m{\cdot}s^{-1}$ (126 $km{\cdot}h^{-1}$) was recorded at the station Pilsen-Mikulka.

10–11

The period between June 24 and 29 was **a period of significant precipitation**, both in terms of its duration and in terms of its spatial extent. Daily precipitation amount of **109.7 mm (4.32 in)** was recorded on June 24 at the station **Prague, Komořany**.

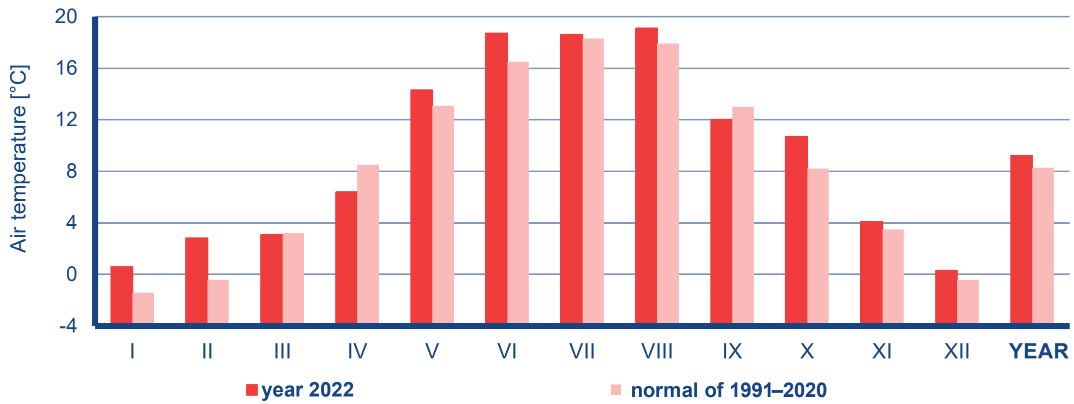
Content

Air temperature

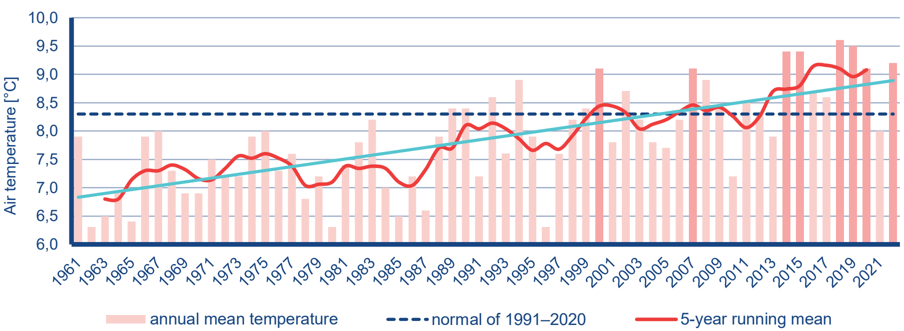
The year 2022 was warmer than normal. The annual mean air temperature over the area of the Czech Republic (9.2 °C) was 0.9 °C above the normal of 1991–2020.

Temperature in the year 2022

Very warm months were June and October which were the fourth warmest June or October on record (since 1961). Monthly mean air temperature in June (18.7 °C) was 2.2 °C above normal and in October (10.7 °C) was 2.5 °C above normal. Warmer-than-normal months were also winter months of January and February and then months of May and August with temperature anomalies +2.0 and +3.2 °C, +1.2 and +1.2 °C, respectively. In contrast, April was very cold. Monthly mean air temperature in April (6.4 °C) was 2.1°C below normal.



Annual and monthly mean air temperature over the area of the Czech Republic [°C] in the year 2022 in comparison to the normal of 1991–2020.



Annual mean air temperature over the area of the Czech Republic [°C] in comparison to the normal of 1991–2020 and fitted linear line (blue) from 1961–2022.

Long-term course of air temperature

The year 2022 was the fifth warmest according to the annual mean air temperature since 1961. All of the warmer years occurred in the last 10 years, namely the years 2014 and 2015 (9.4 °C), 2019 (9.5 °C) and 2018 (9.6 °C).

In the series of annual mean air temperature over the area of the Czech Republic from 1961–2022, we observe a trend of increasing by 0.34 °C in 10 years. The strongest increase is observed in summer months (June, July and August) and in winter months (December and January), approximately 0.4 °C in 10 years. In contrast, the weakest and statistically non-significant increase occurs in autumn months of September and October (less than 0.2 °C in 10 years).

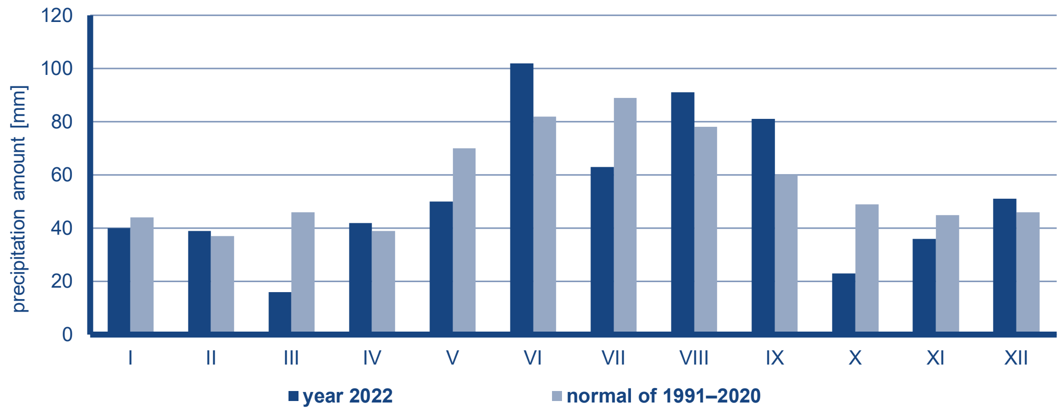
Precipitation

In the year 2022, the Czech Republic received near-normal precipitation amount. The mean annual precipitation amount over the area of the Czech Republic was 634 mm (93% of the normal of 1991–2020).

It was the 23–24. driest (39–40. wettest) year in the series of the annual precipitation amounts since 1961.

Precipitation in the year 2022

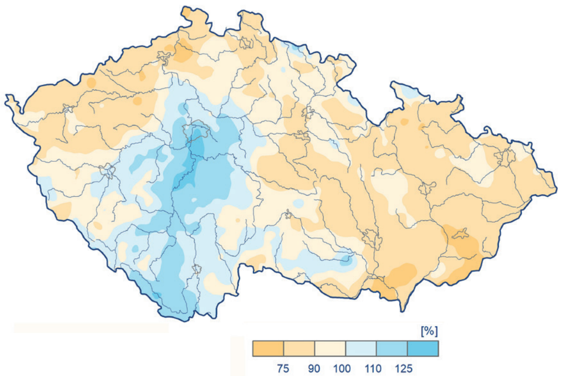
Near-normal precipitation amounts were recorded in most of the months of the year 2022. However, wetter-than-normal months were June and September with the mean monthly precipitation amounts of 102 mm (124% of normal) and 81 mm (135% of normal), respectively. In contrast, March was very dry. It was the third driest March for the Czech Republic on record (since 1961). The mean precipitation amount was only 16 mm (35% of normal). Drier-than-normal month was also October with precipitation amount of 23 mm (47% of normal).



Mean monthly precipitation amount over the area of the Czech Republic [mm] in the year 2022 in comparison to the normal of 1991–2022.

Spatial distribution of precipitation

In the year 2022, Bohemia received 656 mm of precipitation (96% of normal), Moravia and Silesia received 591 mm (85% of normal). The wettest regions in comparison to the normal were Prague, Central and South Bohemian regions, where the mean annual precipitation amounts were slightly above normal (106 a 107% of normal). All other regions received slightly below-normal or below-normal precipitation. The driest region in comparison to the normal was Zlín region (79% of normal).



Annual precipitation amount in the year 2022 in % of the normal of 1991–2020.

Runoff conditions

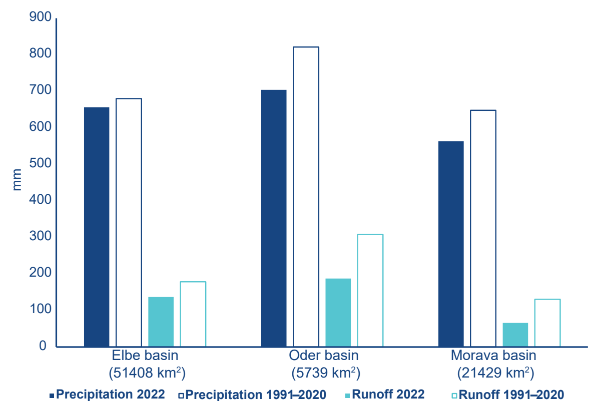
The year 2022 can be assessed as below-average in the whole territory of the Czech Republic.

Annual runoff

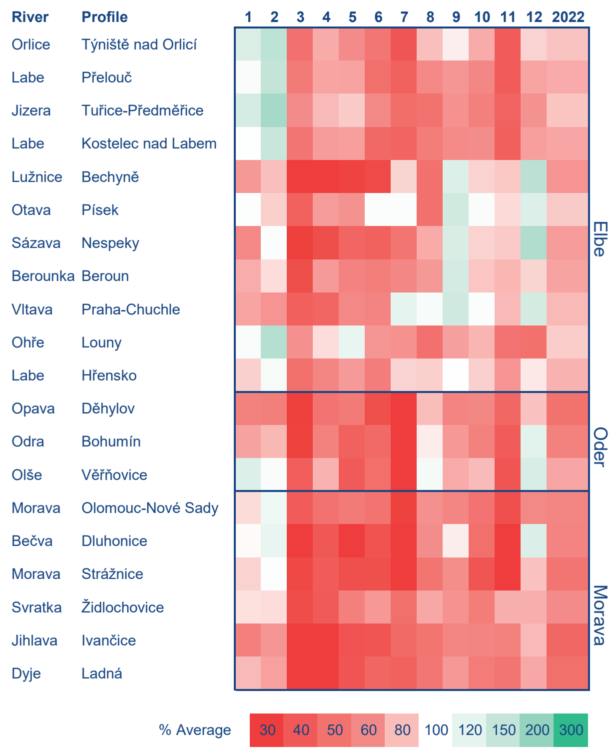
The annual runoff can be assessed as below-average to strongly below-average in relation to the long-term mean for the period 1991–2020, with the fact that the situation in the Elbe basin was slightly better than in the Oder basin and in the Morava basin, due to a smaller precipitation deficit. Specifically, the Elbe basin drained about 76%, the Odra basin 57% and the Morava basin 50% of the long-term mean.

Runoff distribution during the year

The mean monthly discharges were significantly regionally different in January and February due to their long-term monthly values, in the Elbe basin above the confluence with the Vltava due to periods of melting of snow cover with a positive deviation from the average, in the rest of the territory they were around the average with a predominance of negative deviations. The lack of precipitation in March led to a significant decrease of discharges, and March was the driest month of the year overall, during which there were strongly below-average discharges throughout the Czech Republic, which, with some exceptions, did not even reach 50% of the long-term average. Subsequently, the below-average discharges persisted from April until the end of August and only rarely reached higher than their long-term values. In September, due to several precipitation episodes, the discharges in the tributaries of the Vltava significantly exceeded their long-term values, in the rest of the territory they were rather below-average to average. October and especially November were less watery than September, when the discharges in the Elbe basin above the confluence with the Vltava, in the Oder basin and part of the Morava basin were up to strongly below-average. In December, the discharges increased to their average to above-average values in the whole territory, due to rainfall and snow melting in the second half of the month.



Comparison of precipitation and runoff for 2022 with long-term averages for the period 1991–2020 for the main river catchments.



Mean monthly discharges in 2022 in % of long-term monthly mean discharges over the period 1991–2020.

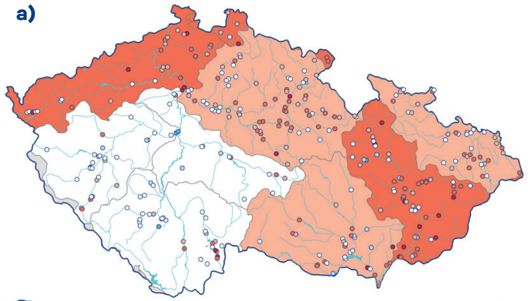
Groundwater

Groundwater levels were generally moderately below-normal in the shallow circulation and much below-normal in the deeper circulation (water-important areas) in 2022.

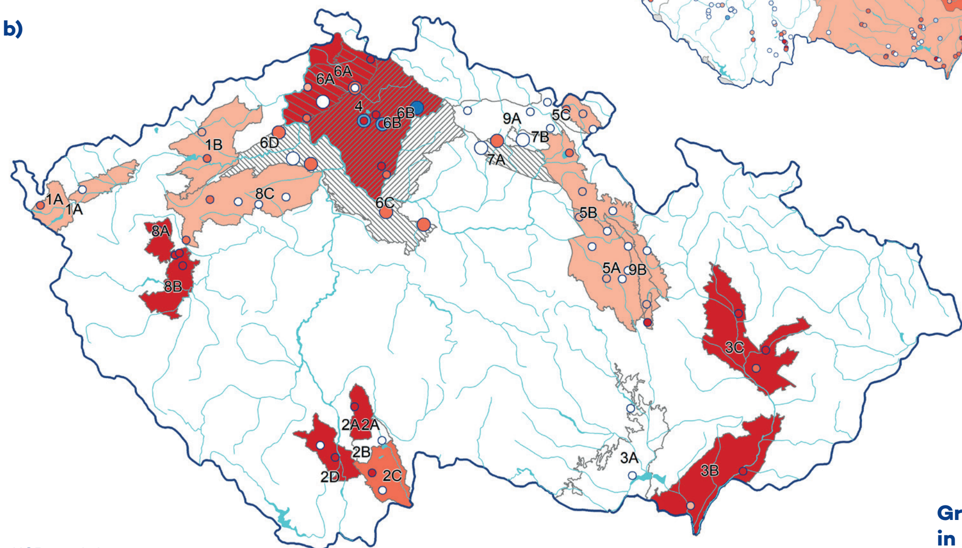
Shallow boreholes

Groundwater levels reached a normal annual maximum in February, then declined until August, when the annual moderately below-normal minimum occurred. The water level was much below-normal from March to June. From July onwards, the water level started to improve to normal in some catchments (Upper and Lower Vltava) and the improvement to overall normal occurred in September. However, the situation was regionally different. In the Ohře, Lower Elbe and other tributaries of the Elbe and Lužická Nisa basins, moderate or severe drought then persisted until the end of the year. In contrast, in the Upper and Lower Vltava and Berounka basins, the level rose and was moderately or much above-normal in December.

a)



b)



Groundwater levels in 2022 compared with the reference period 1991–2020: a) in shallow wells in river basin districts, b) in deep boreholes in groups of hydrogeological regions (HGR).

Deep boreholes

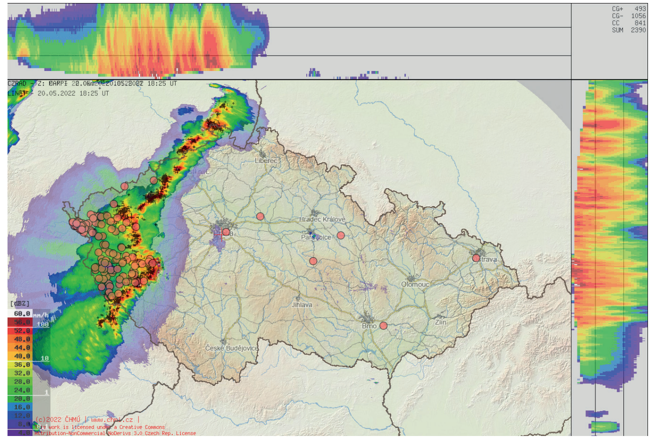
The most severe drought was in the North Bohemian Cretaceous and South Bohemian basins, where extremely below-normal conditions prevailed during the year. In contrast, in the deepest aquifer Cenomanian of the North Bohemian Cretaceous basin, which has a distinctly perennial regime, levels were normal throughout the year.

Convective season

Last year was very rich in convective phenomena and we recorded more or less all the types of dangerous phenomena associated with convection. Extensive wind damage, large hail, heavy rainfall, and even tornadoes.

May 20, 2022 Derecho

On May 20, a large part of the Czech Republic was hit by a significant convective wind storm, a so-called derecho (pronounced deh-rey-cho). The storm system advanced from Germany and close to the Czech border with Bavaria it formed into a typical radar signature, the so-called bow echo and began to intensify. Bow echo is a term describing a more or less linear convective system, which however bends over time (a bit like a bow – hence the name bow echo) and accelerates in the direction of the wind flow. It is at the front of such a system that significant wind gusts and downbursts (descending cold air causing significant damage) occur. The highest wind gust was recorded at the station Pilsen-Mikulka, almost 35 m·s^{-1} (126 km·h^{-1}). Gusts above 30 m·s^{-1} (108 km·h^{-1}) were later measured in central and eastern Bohemia and even later in Silesia.



Derecho May 20, 2022: radar image from a period when the derecho was in western Bohemia and quickly progressed eastwards. Red circles represent fire brigade reports. It can be seen that the impact of the strong winds was significant.

Largest hail

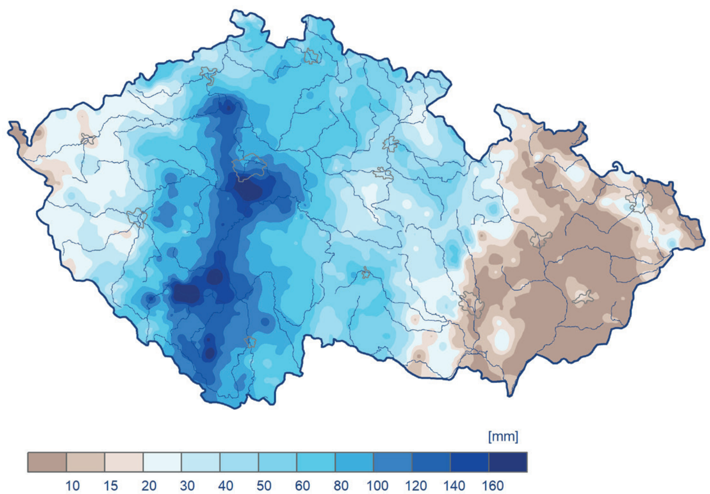
Around noon on July 1, relatively intense storms formed in eastern and central Bohemia, which quickly transformed into a quasi-linear belt that progressed north and northeast.

A little later, a solitary strong thunderstorm cell first formed in the Mladá Boleslav region, which then began to show signs of a supercell. This cell then merged with the storm line in the region of Semily. This merging of individual convective cells and formations can have a significant effect on storm intensification and creation of suitable conditions for a number of dangerous phenomena, such as hail or even tornadoes. In this particular case, hailstones with a size between 6 and 11 cm were recorded. In general, hail with a size around 10 cm is very rare in the Czech Republic and does not occur every year.

One of the 10 cm large hailstones observed in Rovensko pod Troskami on July 1, 2022. Source: Ivanna Ryabová – Facebook.

June 24–29, 2022 Period of heavy rainfall

The most significant situation with regard to heavy rainfall occurred at the end of June. It was unusual in terms of its duration and the extent of the area affected. It was initially due to an almost stationary frontal boundary of an undulating cold front, at the end of the period another front passed from the west, ending the whole series of significant rainfall. The orientation of the boundary caused convective precipitation to progress almost exactly from south to north, and over virtually the same area. Thus, the southwest of Bohemia (Pošumaví) and also western (Brdy) and southern Bohemia were affected several times. In addition to the areas mentioned above, central Bohemia and the area around Prague were also affected. On June 24, 27 and 29, daily totals of precipitation higher than 50 mm were recorded at several stations. The highest values of daily precipitation amount were measured on June 24 at the station Prague, Komořany (109.7 mm) and Jíloviště in the Prague-West district (104.5 mm) and on June 27 at the station Katovice in the Strakonice district (187.5 mm). Series of these almost identical situations increased the soil saturation and gradually third level of flood activity has been reached in the following days, especially on watercourses draining Šumava.



Precipitation amount in the period from 24th to 29th June, 2022.

Tornadoes in 2022

Overall 5 tornadoes has been reported in the Czech Republic in 2022. The first one was observed on May 17 in the Pardubice region. The situation was well documented on a video, however the contact of the condensation vortex with the ground was only estimated from the video footage. No direct damage has been recorded.

One of the strongest tornadoes of the last year occurred on June 13 in a supercell which passed through Břeclav and Lanžhot. Based on subsequent damage analysis the intensity of the tornado has been estimated as IF-1, however local damage on vegetation and roofs of some buildings were relatively significant and the tornado as such has been recorded on a video.

Just 16 days later another tornado was observed in southern Bohemia near Sviny. Based on the damage caused (assessed by a drone) the intensity was estimated as category IF-1. In this case the tornado moved through uninhabited region so damages were limited to vegetation.

The remaining two tornadoes occurred in September, at the very end of the convective season, in particular on September 10th and 15th. They were, however, relatively weak tornadoes. The more interesting one was the one observed on September 15th in Malenovice (Zlín region).

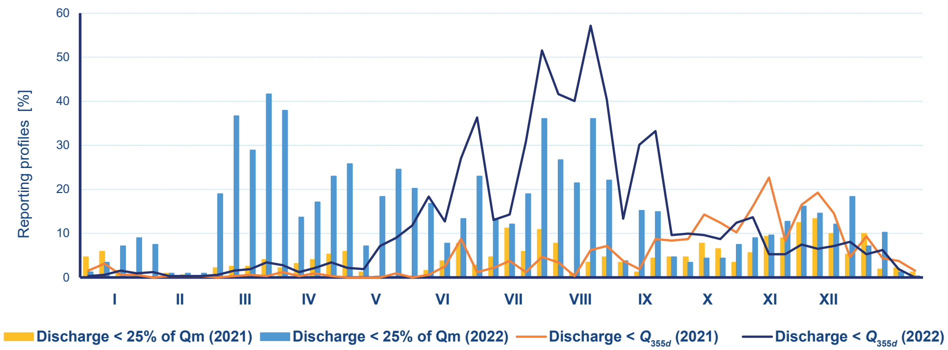
Damage caused by an IF-1 tornado, June 13, 2022 in Lanžhot.

Drought

In terms of surface and groundwater drought, 2022 was drier than 2021, but did not reach the drought levels of 2018.

Surface water

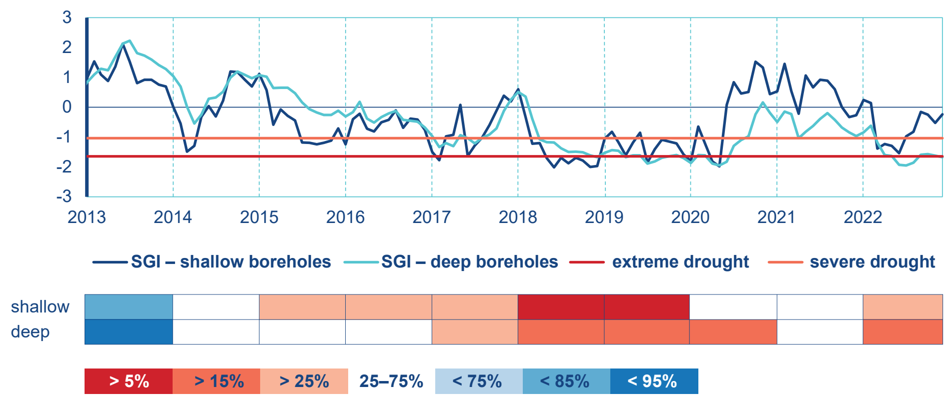
In spring, the drought was particularly pronounced in March, when below-average precipitation resulted in flows falling below one-quarter of normal for up to about 40% of profiles in some weeks. From mid-May onwards, the number of profiles with significant drought (Q_{355d}*) gradually increased, even though local intense showers and thunderstorms were quite frequent. River levels rose rapidly in response to these precipitation events, but often only briefly, before falling back again relatively quickly, often to or below drought (Q_{355d}). Most such low water levels, sporadically up to ca 55% of the reporting profiles, were reached during July and August (up to 10 times more than the previous year). From September to the end of the year, significant drought (Q_{355d}) occurred only sporadically, usually at less than 10% of the profiles.



Weekly drought trend (Q_{355d}*) in 322 reporting profiles in the Czech Republic in 2021 and 2022. *Qm* – mean monthly discharge.

Groundwater

The year 2022 was the third driest year (after 2018 and 2019) in the last 10 years in both the shallow and deep circulation. The drought was more pronounced in the deeper circulation, which represents water-important areas where overall conditions were much or extremely below-normal for most of the year. In the shallow circulation, which recharges more quickly from precipitation, conditions improved in September and remained normal through the end of the year.

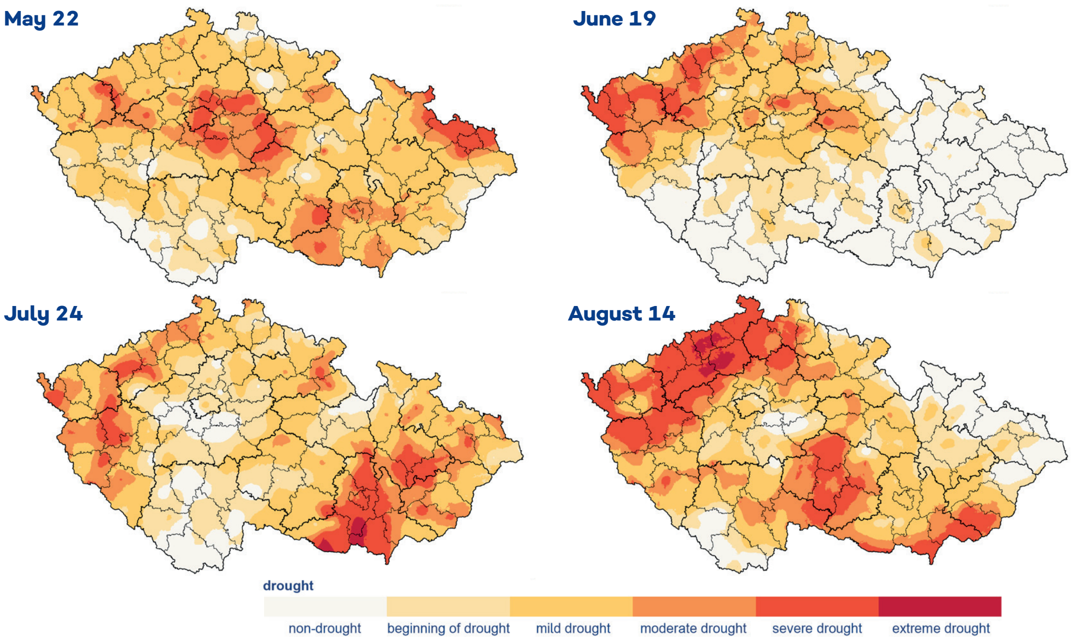


Monthly values of the SGI index. The coloured bands represent the annual SGI values. Colours correspond to (from left) the categories of extremely, much and moderately below-normal, normal, moderately, much and extremely above- normal.**

* Q_{355d} – represents the flow that was reached or exceeded in the profile on average 355 days per year (relative to the reference period 1991–2020)

** SGI – Standardised Groundwater Index, which represents the groundwater level in shallow and deep boreholes

The state of soil drought in the surface layer of 0–40 cm varied significantly in the individual months and regions of the Czech Republic. In southern and central Moravia and western Bohemia the drought peaked in July. In August, exceptional drought was observed in northwest and west Bohemia.

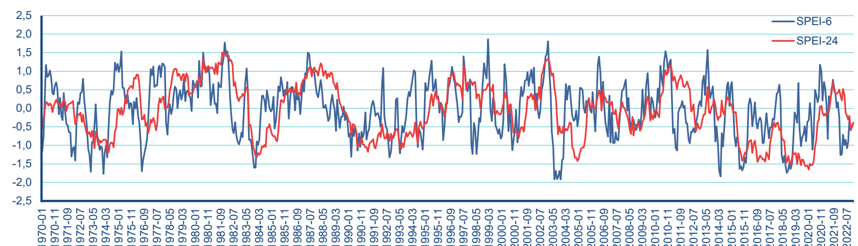


Soil drought in the surface layer of 0-40 cm on May 22, June 19, July 24 and August 24, 2022.

In April, drought began to manifest at prevailing part of the Czech Republic, while in southern Moravia there was already a mild drought. In May, moderate and severe drought was already observed in some parts of the country. In June, there was moderate to severe drought mainly in western Bohemia, while in the eastern part of the country drought was mostly absent. In July, however, drought peaked in southern and central Moravia and western Bohemia, where severe and sometimes exceptional drought was observed. In August, drought was severe to exceptional, especially in north-western and western Bohemia.

Course of the SPEI index*

Throughout the entire 2022 the SPEI-6 values were lower than 0, which means prevailing drought conditions. Values of SPEI-24 were positive between June 2021 and June 2022. This interrupted the longest continuous drought period (based on SPEI-24) in the last 50 years. However, in the second half of 2022 the SPEI-24 values dropped below 0 again.



Course of SPEI indices for 6 and 24 months between 1971 and 2022 for the region of the Czech Republic. The lower the values, the more intense the drought.

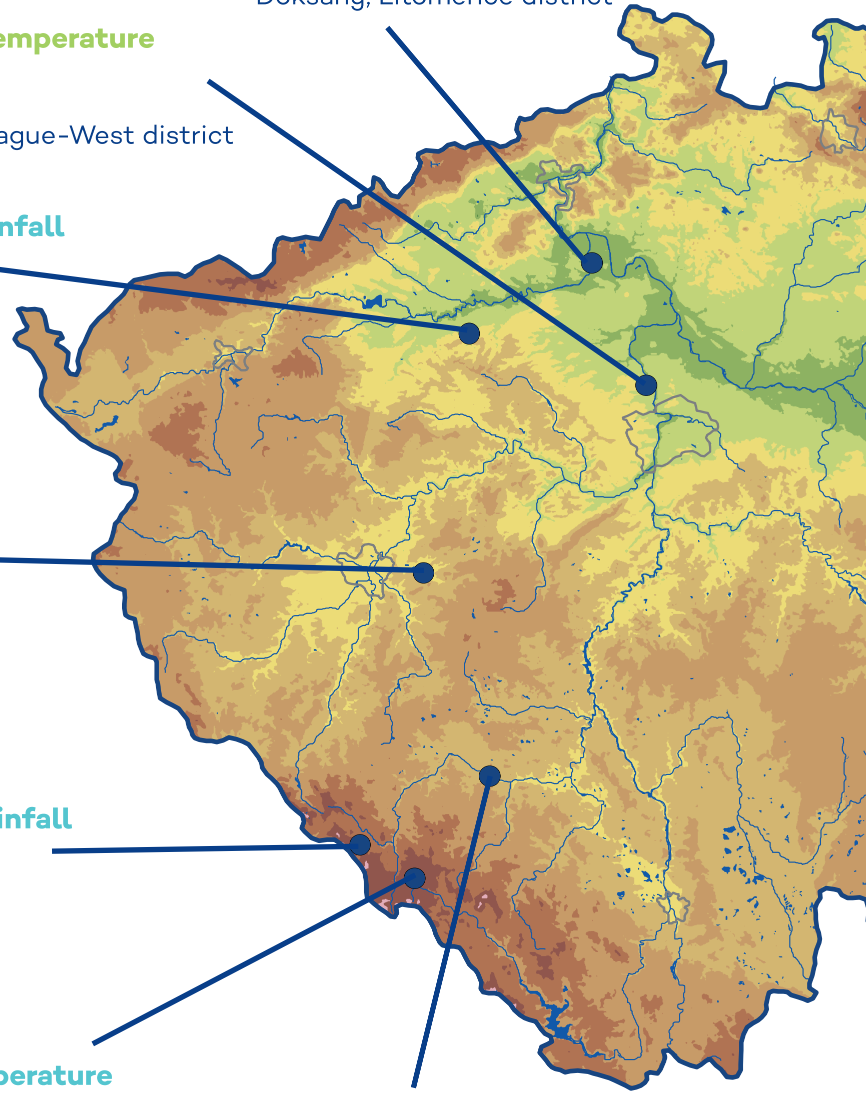
Soil drought

* SPEI index (Standardized Precipitation-Evapotranspiration Index) is based on the difference between precipitation amount and potential evapotranspiration. It is a standardized quantity, which means its values can be compared across various regions and periods.

SPEI can be calculated for periods of various length. In this case values of SPEI-6 (6 months) and SPEI-24 (24 months) are given. SPEI-6 can be used for evaluation of agricultural drought, while SPEI-24 is used to assess the course of long-term drought.

Map of extreme events

- **Tropical (hot) day – day with a maximum air temperature of at least 30.0 °C**
- **Ice day – day with a maximum temperature below 0.0 °C (all-day freezing temperatures)**
- **Sunny day – ratio between actual and astronomically possible sunshine duration larger than 0.8**



Highest number of tropical days
35 days
Doksany, Litoměřice district

Maximum air temperature
39.0 °C
June 19, 2022
Husinec, Řež*, Prague-West district

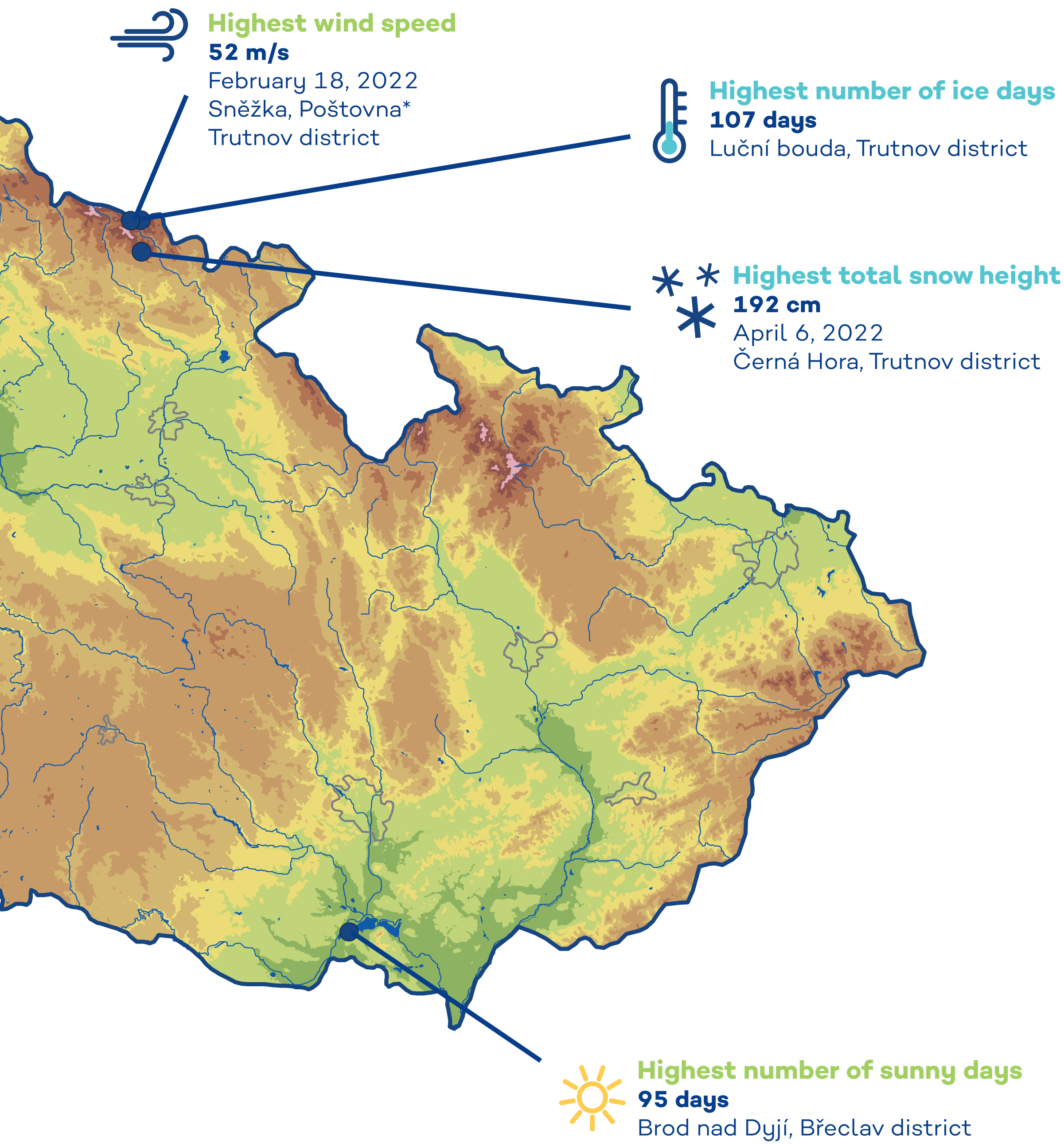
Lowest annual rainfall
356 mm
Hřivice
Louny district

Highest hourly rainfall
70.1 mm
June 27, 2022
Rokycany
Rokycany district

Highest annual rainfall
1 548.2 mm
Prášily
Klatovy district

Minimium air temperature
−28.1 °C
December 18, 2022
Kvilda-Perla*
Prachatice district

Highest daily rainfall
187.5 mm
June 27, 2022
Katovice, Strakonice district



Highest values of average monthly discharges in main basins were observed in September in the Vltava basin (149% Q_{IX}).

Highest ratio of discharge gauging sites (approx. 50%) indicating hydrological drought (Q_{355d}) was observed in August, in particular August 13 and 19. The highest ratio of sites below the threshold of hydrological drought was in the basin of lower Elbe and Ohře (up to 65% of stations).

Highest peak discharge from the perspective of return period (20–50 years) was reached at night on June 29 at Zlatý potok in Hracholusky.

Highest snow height (40 to 140 cm) was measured on February 7, 2022 in Šumava and Krkonoše, in Krkonoše almost 160 cm. In Jeseníky, Beskydy and Orlické mountains 35 to 130 cm, in Krušné mountains 30 to 90 cm. In Bohemian-Moravian highlands 5 to 30 cm of snow.

Overall lowest value of average monthly discharge (22% Q_{IV}) was recorded in April on the Thaya river.

*** Stations not operated by the CHMI**

Wildfire in Czech Switzerland National Park, July 24 – August 12, 2022

On July 24 a wildfire was reported in Malinový důl in the Czech Switzerland National park. At the time of the report, a warm weather was observed, with very good dispersion conditions and a mild to extreme drought was observed in the region of the national park.

Wildfire initiation

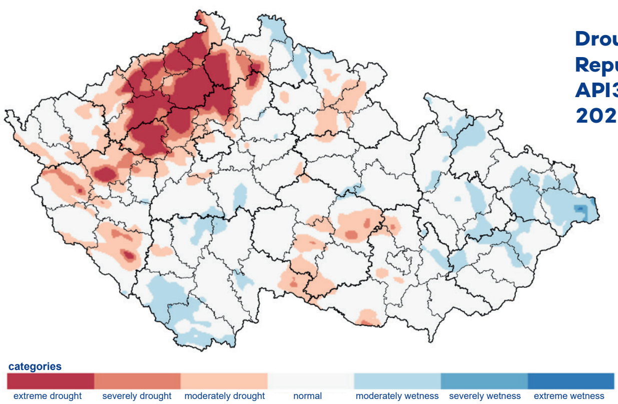
The massive spread of the fire was partly caused by the change in wind direction, most significantly when a cold front passed in the evening of July 25, which brought rain only in the eastern part of the country. Also in the following days only minimal rainfall was observed in the northern Bohemia.

Localization and prevention of further spread of the fire was only possible after a week, thanks to the deployment of hundreds of firefighters as well as an improvement in the meteorological situation with the passage of a frontal wave associated with a slight decrease in temperature and light precipitation.

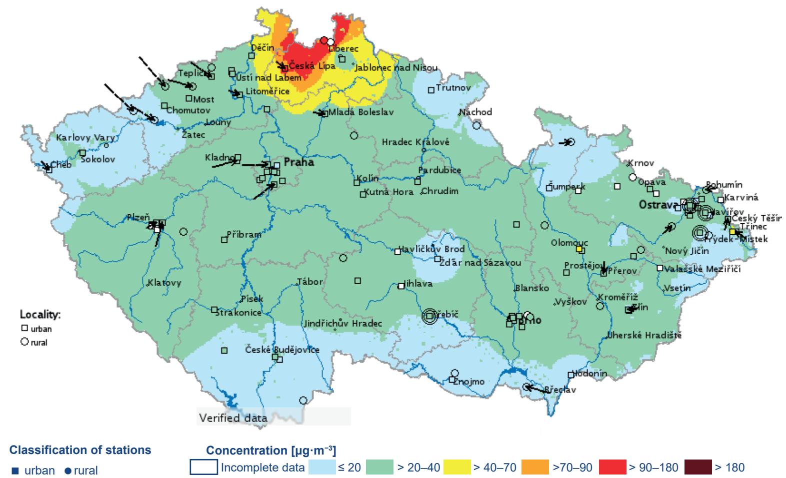
Air pollution during the wildfire

Based on satellite estimates[1], approximately 240–480 tons of solid air pollutants was released into the air during the fire. 80–90% of this amount was emitted between July 25, 2 AM and July 26, 2 AM CEST. After July 29, no further emissions were released into the air based on satellite imagery.

Higher concentrations of suspended PM_{10} particles were recorded even hundreds of kilometers away from the wildfire, especially in the first days of the fire. Highest PM_{10} concentrations were observed at night on 25/26[th] July and during the day on 26[th] of July. Higher PM_{10} concentrations at the ambient air pollution stations were only temporary and depended on the station location and meteorological and dispersion.



Drought in the Czech Republic based on API30 on July 24, 2022.



Distribution of average hourly PM_{10} concentrations, July 26, 2022, 1-2 AM CEST.

conditions. Increase in concentrations thus did not manifest in a very significant way.

Highest average hourly PM_{10} concentrations were observed at an urban background station in Česká Lípa (258 µg·m^{-3}, July 26, 2022 2 AM CEST) and at an urban background station in Kolín SAZ (264 µg·m^{-3}, July 26, 2022 7 AM CEST). Average hourly PM_{10} concentration above 200 µg·m^{-3} was also observed at an industrial station of Kralupy nad Vltavou-sportoviště (207 µg·m^{-3}, July 26, 2022 6 AM CEST). By the end of July, as the wildfire was gradually being extinguished, the emissions were lower and concentrations gradually decreased to normal August values.

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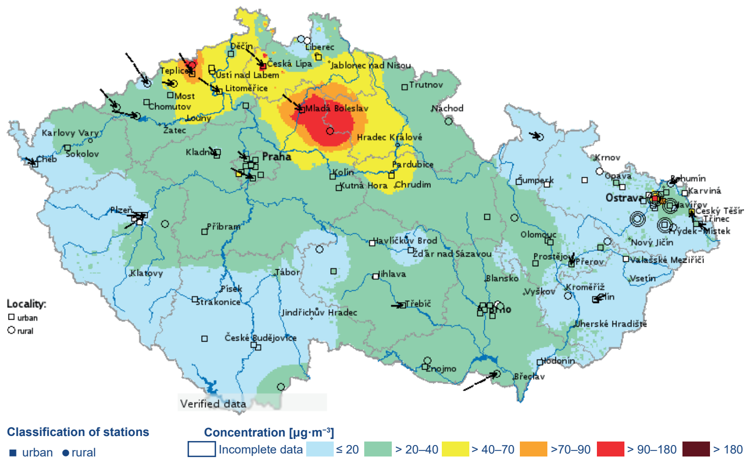
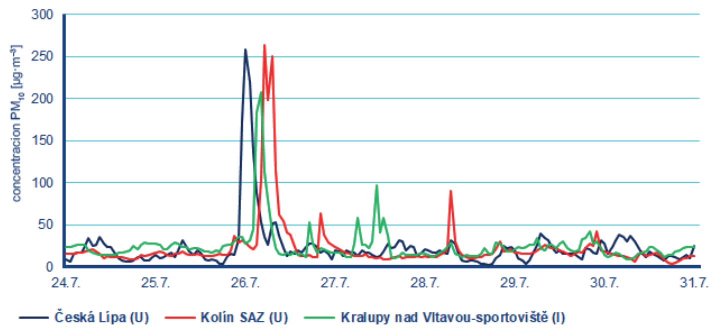
[1] CAMS global biomass burning emissions based on fire radiative power (GFAS): data documentation. [online]. [cited 26. 8. 2022]. Available at WWW: https://confluence.ecmwf.int/display/CKB/CAMS+global+biomass+burning+emissions+based+on+fire+radiative+power+%28GFAS%29%3A+data+documentation Global Fire Emissions Database. [online]. [cited 26. 8. 2022]. Available at WWW: https://www.globalfiredata.org/



Distribution of average hourly PM_{10} concentrations, July 26, 2022, 4–5 AM CEST.



Course of hourly suspended PM_{10} particles concentrations at Česká Lípa, Kralupy nad Vltavou-sportoviště and Kolín SAZ stations between July 24–30, 2022.

Surface water quality

In 2022, the most common exceedances in surface waters were for nutrients (especially total phosphorus) and pesticides. The highest ratio of profiles with worse water quality was recorded in the Lower Vltava and Dyje river basin districts.

Nutrients and organic pollution indicators

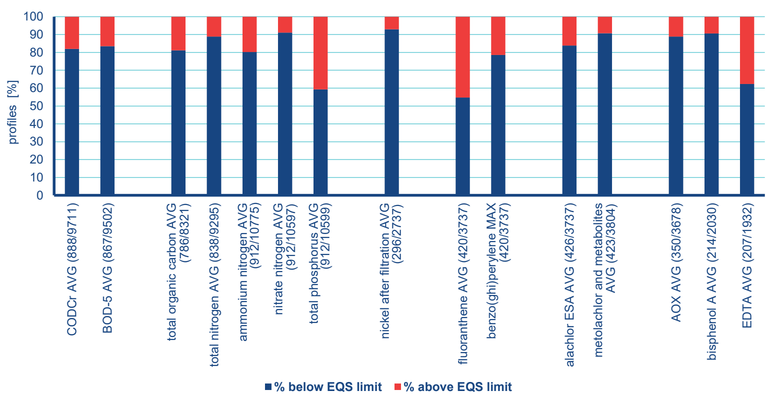
Of the nutrients, total phosphorus was the most frequent to exceed the limit value (about 40% of the profiles). Ammonium nitrogen, total organic carbon were at concentrations above the limit in less than 20% of the profiles and about 10% of the profiles were above the limit for total and nitrate nitrogen. The sources are mainly wastewater and agriculture. The limit for biochemical oxygen demand (BOD_5), which is an indicator of organic pollution, was exceeded in about 20% of the profiles.

Pesticides

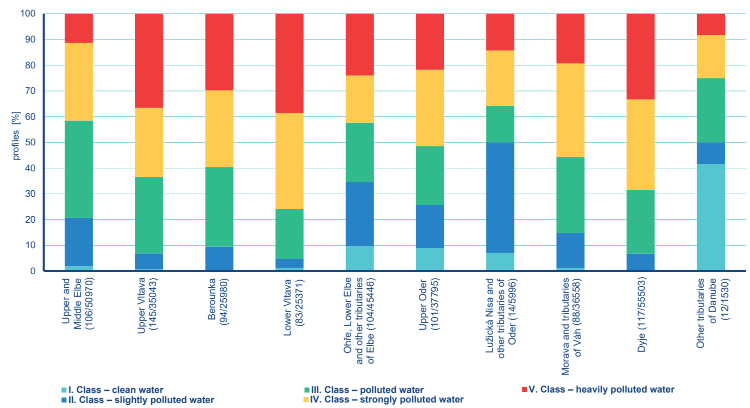
Pesticides were found in 95% of the profiles assessed. The most frequent pesticide substances found at above limit levels were metabolites of alachlor (15% of profiles, used in the Czech Republic in rape cultivation until 2007) and metolachlor and its metabolites (20% of profiles, used in maize cultivation).

Heavy metals, polycyclic aromatic hydrocarbons (PAHs), other pollutants

Heavy metals belonging to the priority pollutants are dissolved forms of nickel, cadmium, lead and mercury. Of these, nickel exceeded the limits most frequently (7% of profiles), the other metals mentioned above did not meet the limits in 1–3% of profiles. Among the PAHs, fluoranthene (> 45% of profiles) and benzo(ghi) perylene (> 20%) of profiles occurred at concentrations above the limit. Of the other pollutants, ethylenediaminetetraacetic acid (EDTA, a component of detergents and washing agents) was the most abundant.



Percentage of profiles with EQS (Environmental quality standard) limit exceedance for selected determinants according to Government Order No. 401/2015 Coll. (on the X axis in parentheses: number of evaluated profiles / number of samples used for evaluation).



Classification of surface water quality determinands in river basin district pursuant to the standard ČSN 75 7221 in 2022 (on the X axis in parentheses: number of evaluated profiles / number of samples used for evaluation).

Groundwater quality

In 2022, the most frequently detected pollutants in groundwater were those related to agricultural production – pesticides and nitrogenous substances.

Pesticides, nitrogenous substances

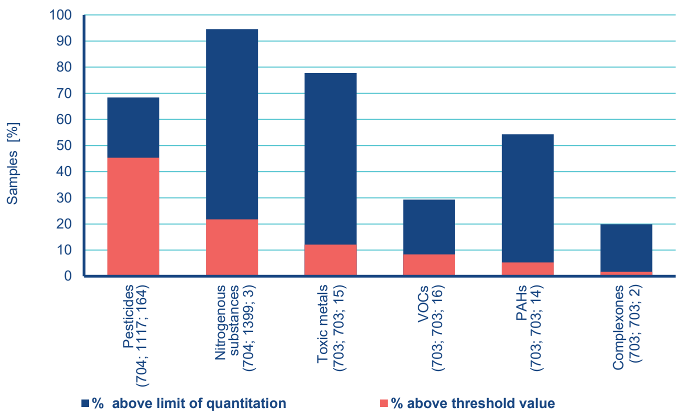
Over 40% of groundwater samples in 2022 contained at least one pesticide substance in concentration exceeding the limit concentration. More often than pesticides themselves, pesticide metabolites, which are formed by the decomposition of active substances contained in crop protection products mainly for beet, rape, corn and cereals treatment, were detected in groundwater. Another important source of groundwater pollution, nitrogenous substances, is also related to agricultural production. Nitrate was present at concentrations above the limit in > 10% of the samples.

Heavy metals

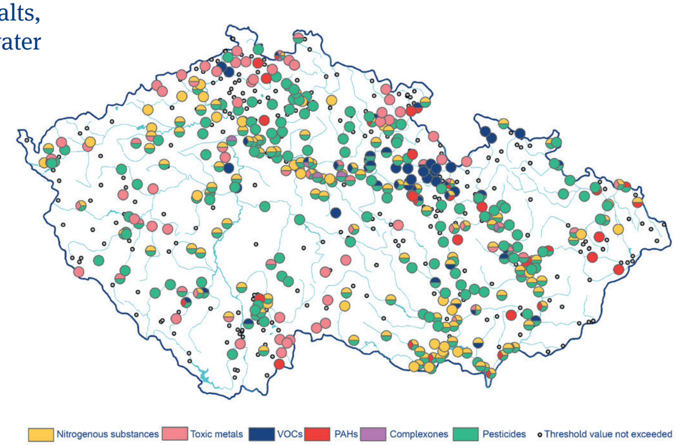
Cobalt, arsenic and cadmium were the most frequently detected heavy metals in concentrations above the limits (> 3% of samples). Sources can be both natural weathering of rocks and anthropogenic pollution, in particular metal-containing agrochemicals, industrial emissions, fossil fuel combustion, transport emissions or the use of sewage sludge.

Volatile organic compounds, polycyclic aromatic hydrocarbons, complexones

Volatile organic compounds (VOCs) that exceeded concentrations most often included toluene and 1,2-cis-dichloroethene, which is a by-product of the production of vinyl chloride, from which PVC plastic is made, and is also a degradation product of other chlorinated hydrocarbons. Of the polycyclic aromatic hydrocarbons (PAHs), phenanthrene, pyrene and fluoranthene have been most frequently detected. Of the complexones, the best known and most widely used is ethylenediaminetetraacetic acid (EDTA) and its salts, which are used in detergents and in the paper industry and as preservatives in cosmetics. The groundwater limit was exceeded in almost 2% of samples.



Frequency of values of determinants from the main groups in groundwater samples in 2022. In parentheses is given: number of monitored sites; number of samples determined; number of determinants in the group, VOCs – volatile organic compounds. PAHs - polycyclic aromatic hydrocarbons.



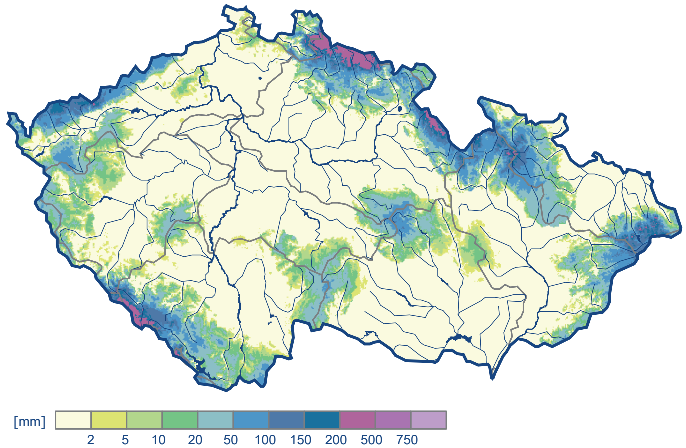
Exceedance of treshold values for pollutants (nitrogenous substances, toxic metals, pesticides, VOCs, PAHs, complexones) in groundwater.

Snow

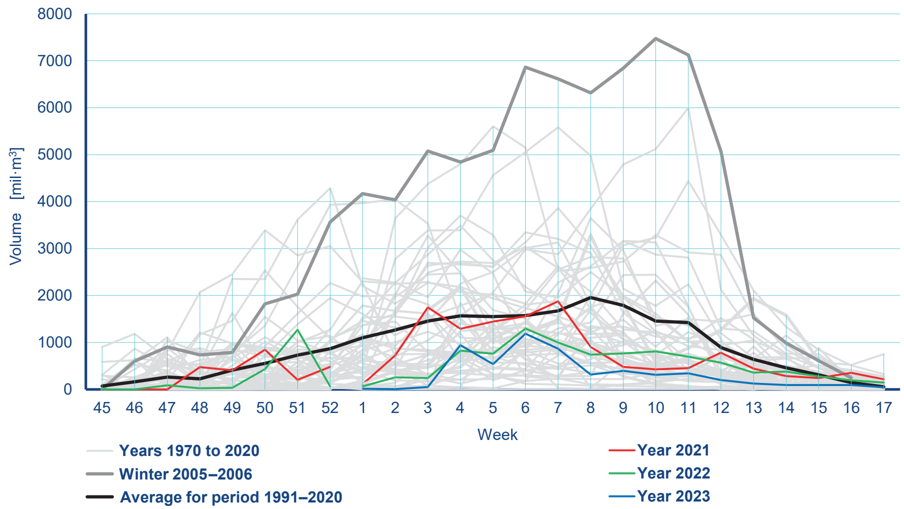
Snow storage was generally below average in the winter of 2021/2022 and even significantly below average in the latter part of the year (2022) compared to the reference period 1991–2020. The beginning of the winter period 2022/2023 (November and December) was also significantly below average.

Snow storage changes

In the winter of 2021/2022, snow cover did not start to form until late November. The maximum snow storage water equivalent was reached on 7 February 2022 (approx. 1.294 billion m^3). Overall, however, the first week of February was slightly below or close to average and much of the area was completely snow-free. The last assessment of snow storage took place at the beginning of May (2 May 2022), when, except for the ridges of the Krkonoše, Šumava and Jeseníky mountains, snow was no longer continuously present. Snow storage in the winter of 2022/2023 also started to form only at the end of November.



The maximum snow storage water equivalent on the territory of the Czech Republic in 2022 (7. 2. 2022, 1.294 billion m^3, runoff 16.4 mm).



Snow storage changes on the territory of the Czech Republic in individual winter periods since 1970.

Phenological progression of wild plants

The beginning of the major growing season in 2022 was between 6th March and 5th April (almost a month earlier than in 2021); end of the major growing season was between 11th November and 23rd December (approximately 14 days later than in 2021). The major growing season lasted between 220 and 250 days.

In January and February the plants were dormant, only the common foxglove (an important pollen allergen) started flowering in some areas at the beginning of February, thus starting the pollen season. Snowdrop started to bloom already before 17th February and its flowers could be enjoyed until the beginning of April. The vegetation began to slowly wake up during March, its onset was initially (in the second half of March) faster than average (e. g. the marsh-marigold bloomed 17 days earlier than usual in Benešov u Prahy), but in April the vegetation development slowed down due to cooler weather and freezing night air temperatures. Thanks to this one could enjoy flowers of spring herbs longer and Forsythia bloomed for almost 2 months.

Marsh-marigold

Common snowdrop

After a significant warming at the beginning of May, the vegetation started to develop in full swing. Almost all the tree species were in leaf, e. g. buttercups, strawberries, chestnuts and lilacs blossomed. The apple, pear and plum trees also came into full bloom. Fortunately there were no further frosts at this time so the vegetation was not affected by spring frosts (fruit trees and vines in bloom). During May, other trees and herbs (e.g. acacia, cranberries, conifers, lilies of the valley and blueberries) gradually started to bloom. Conifers flowered to an extreme extent this year and their pollen was a significant burden on the population, with the pollen indicator being at the highest degree at the time of their flowering.

Phenological phases were normal during the summer (vegetation caught up with the spring lag already during May). September was relatively cool and rainy, while October was above-average in terms of temperature, especially at its end, with minimal rainfall. This meant it was possible to enjoy the colors of autumn for longer than usual. Larch trees leaf fall did not occur in most of the country until the first half of December.

Air quality in the CR

Due to the process of data analysis the assessment of air quality only includes data from stations with automated measurements (with the exception of benzo[*a*]pyrene).

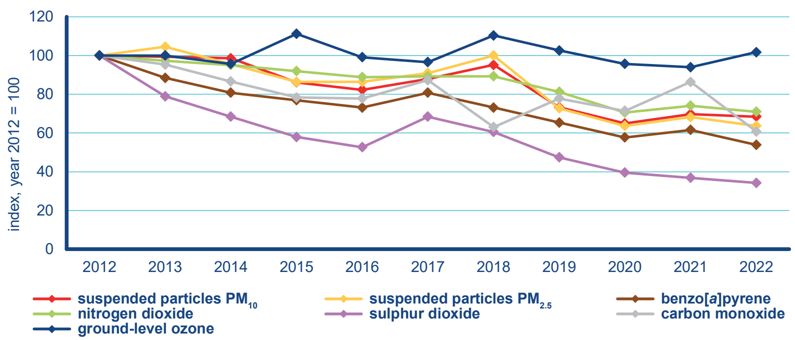
In terms of air quality, the year 2022 was favorable, similar to the previous years 2020 and 2021. Concentrations of air pollutants, with the exception of ground-level ozone, reached the lowest or second lowest values in 2022 over the 10-year period 2012–2022. Concentrations of air pollutants excluding ground-level ozone show a decreasing trend over the assessment period.

Ground-level ozone concentrations are strongly dependent on the meteorological conditions in the warm part of the year and have not shown a significant trend since 2012 like other pollutants.

The relatively good air quality in terms of concentrations of pollutants other than ozone in 2022 is mainly due to significantly low air pollutant concentrations in January and February, the months when concentrations tend to be the highest throughout the year. Such low concentrations in these two months were due to above-normal temperatures associated with lower emissions from local domestic heating, average amount of precipitation (self-cleaning of the atmosphere) and good dispersion conditions in February with occasional strong winds. Also, the ongoing measures aimed to improve air quality have contributed to the long-term decrease of air pollutant concentrations.

Air quality index

The air quality index provides an overall information about the air quality at a specific measuring station. The index was devised by the Air Quality Department of the Czech Hydrometeorological Institute in cooperation with the National Institute of Public Health. The assessment based on the Air Quality Index (AQI) shows that the air quality in 2022 was mostly very good to good (AQI 1). At urban and suburban stations, very good to good air quality was most frequently observed in the South Moravian region excluding the Brno agglomeration.



Trends in concentrations of selected air pollutants, 2012–2022.

Distribution of air quality index at urban and suburban background measuring stations, 2022.
Note: O/K/F-M – Ostrava/Karviná/Frýdek-Místek agglomeration

Particles PM_{10} and $PM_{2.5}$

Suspended particles PM_{10} and $PM_{2.5}$

Suspended particles (i.e. atmospheric aerosol) are composed of a mixture of solid and liquid particles with an aerodynamic diameter smaller than 10 µm (PM_{10}) or 2.5 µm ($PM_{2.5}$). The abbreviation PM stands for Particulate matter. These particles float in the atmosphere, slowly deposit on the ground and are able to stay in the air for longer periods and can be transported over very long distances. Particles have a wide spectrum of effects on the cardiovascular and respiratory systems and are carcinogenic for humans.

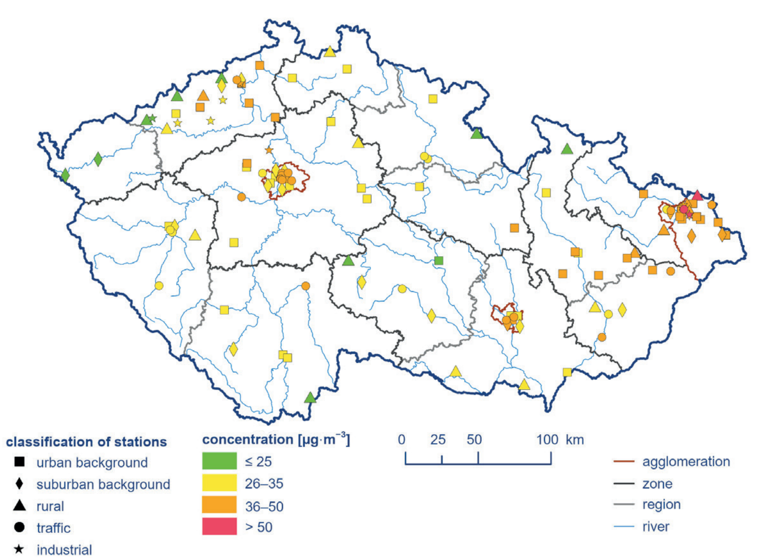
The 24h ambient air quality limit for PM_{10} concentrations (50 µg·m^{-3}) was exceeded at 2% of stations in 2022.

All the stations where the limit value was exceeded are located in the Ostrava region. A similar extent of exceedance was also observed in the years 2020 and 2021, however, for example in the years 2017 and 2018 the limit was exceeded at more than 30% of stations. The ambient air quality limit for annual PM_{10} concentration (40 µg·m^{-3}) was not exceeded at any of the 123 stations in 2022 – for the fourth time in a row since 2019 in a time series since 1993.

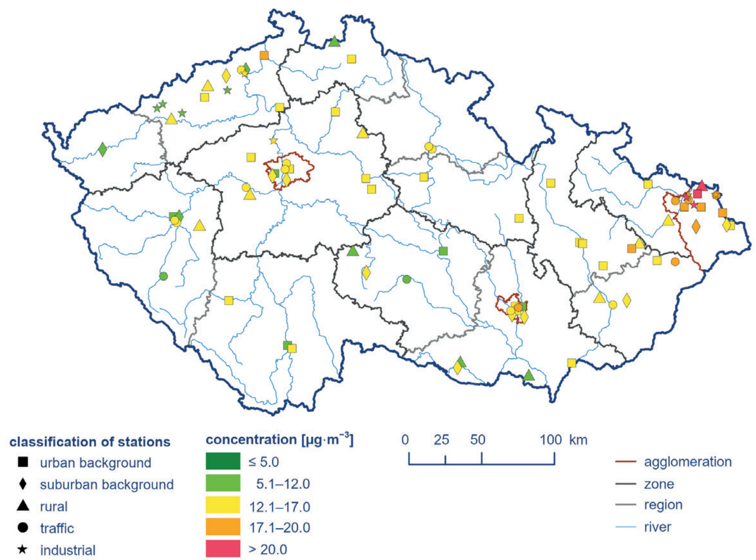
From the human health perspective, the smaller $PM_{2.5}$ particles pose a higher risk. The ambient air quality limit for average annual $PM_{2.5}$ concentration (20 µg·m^{-3}) was exceeded at 4% of stations.

All stations with above-limit concentrations are similarly to PM_{10} found in the Ostrava region.

Particle concentrations are highest in the cold part of the year. This is due to the higher emissions from local domestic heating and traffic as well as a more frequent occurrence of poor dispersion conditions.



36th highest 24h average concentration of PM_{10} for the individual ambient air quality monitoring stations.



Average annual $PM_{2.5}$ concentrations for the individual ambient air quality monitoring stations.

Nitrogen dioxide and ground-level ozone

Ambient air quality limit for ground-level O_3 (120 µg·m^{-3}, daily maximum 8h moving average, maximum allowed number of exceedances 25/year in 3-year averaging period) was exceeded at 4% of stations in the 3-year period 2020–2022.

Ground-level ozone (O_3)

The stations with exceeded limit are regional stations (i.e. far from emission sources) situated at higher elevations in the Ústí nad Labem region. Higher ozone concentrations in this region within the Czech Republic are typical.

The annual course of monthly average O_3 concentrations is generally characterized by an increase in concentrations in the spring and summer months due to the occurrence of favorable meteorological conditions for the formation of O_3.

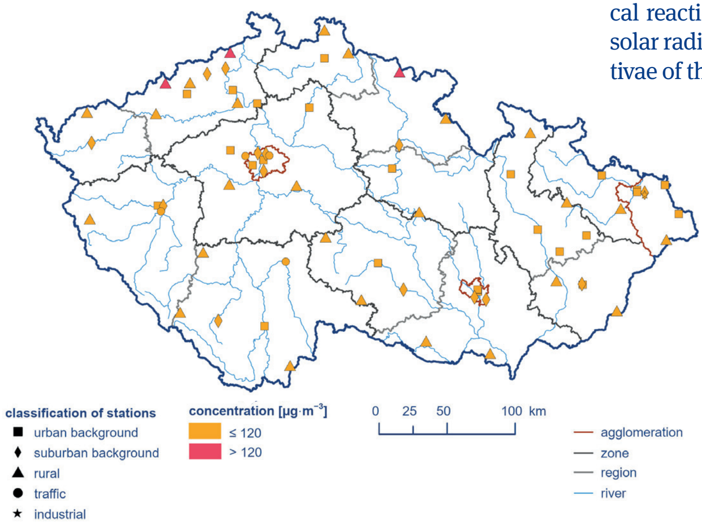
Ground-level O_3 is referred to as a secondary air pollutant. It is formed in the air by a number of chemical reactions of other substances in the presence of solar radiation. Ground-level O_3 irritates the conjunctivae of the eyes and can cause respiratory problems.

Average annual ambient air quality limit for NO_2 (40 µg·m^{-3}) was for the third time in a row not exceeded at any station. Highest annual average concentrations were as usual observed at the traffic station Prague 2-Legerova.

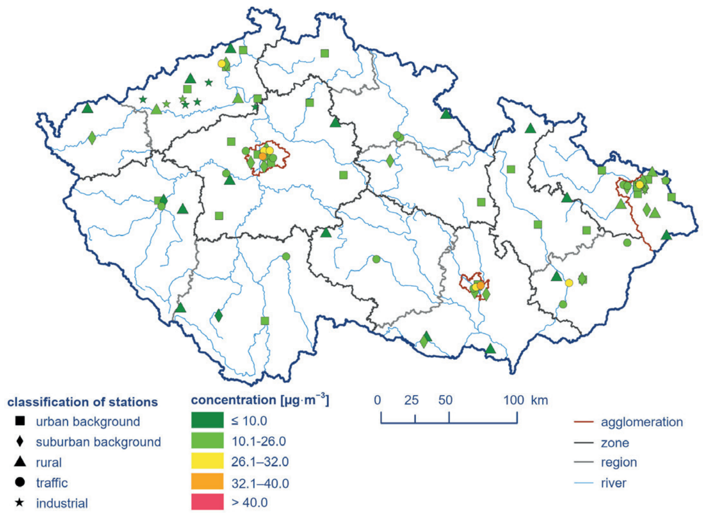
Nitrogen dioxide (NO_2)

Higher NO_2 concentrations are typically observed in larger cities with heavy traffic, higher buildings and dense road network with common traffic congestions. Highest NO_2 concentrations are usually observed in the colder months, when poor dispersion conditions are more frequent and as a result of higher emissions from heating and traffic.

NO_2 primarily affects the human respiratory system, increasing the reactivity of airways and consequently increasing asthma symptoms. It can also cause respiratory diseases in children due to reduced immunity to infection. Exposure to NO_2 is associated with an increase in mortality, but it is difficult to distinguish between the effects of other co-occurring air pollutants.



Concentrations of ground-level ozone at the individual ambient air quality stations (26th highest values of maximum daily 8h moving average over 3-year period), 2020–2022.



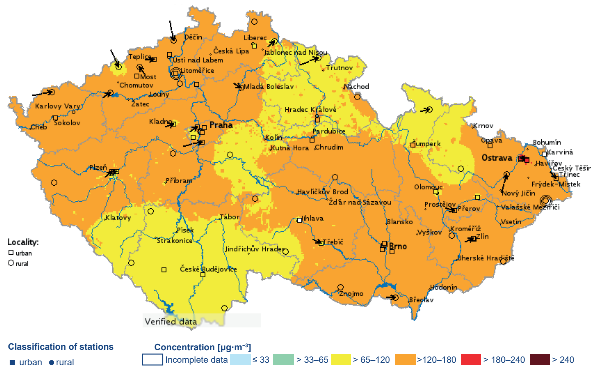
Annual average concentrations of NO_2 at the individual ambient air quality stations in 2022.

A total of five smog situations were declared in 2022 due to exceedance of the threshold value for O_3 concentrations in the O/K/F-M agglomeration on July 22–23 and in the Prague agglomeration, Central Bohemian region, Liberec region and the Ústí nad Labem region on August 5. Its total duration was 53 h. Conditions for announcement of a smog situation for PM_{10}, NO_2, SO_2, or a alert for O_3, NO_2 and SO_2 were not met.

SVRS
(Smog warning and regulation system)

Situation on July 19–23, 2022

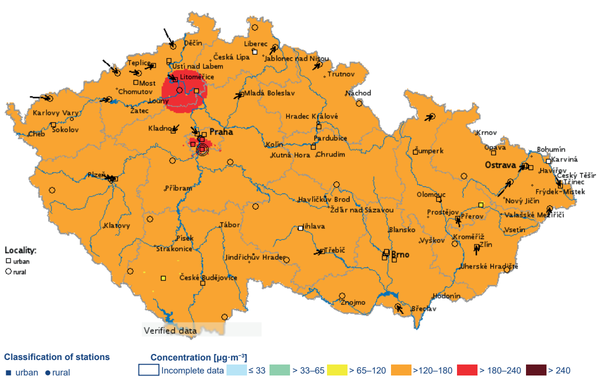
An area of higher air pressure persisted over the central European region with sunny weather and air temperatures exceeding 30 °C. With predominantly lower wind speeds and sunny weather the ground-level ozone concentrations increased. Then gradually an undulating cold front advanced from western Europe and the resulting decrease in temperature and a higher cloud cover brought a decrease in the O_3 concentrations.



Distribution of average hourly O_3 concentrations, July 22, 2022, 2–3 PM CEST.

Situation on August 3–6, 2022

An area of higher air pressure spread into central Europe from the southwest on August 2. In the following days, its center slowly moved towards the northeast and warm air from the south moved in along its back side. The resulting hot sunny weather initiated increase in the ground-level O_3 concentrations. During August 5, a cold front advanced from the west, leading to a decrease in ground-level O_3 concentrations.



Distribution of average hourly O_3 concentrations, August 5, 2022, 3-4 PM CEST.

Overview of declared smog situations due to high concentrations of ground-level ozone in 2022.

Region	Smog situation				
	Number	Duration		Declared	Lifted
		h	day	day and hour (CEST)	day and hour (CEST)
Agglomeration of O/K/F-M	**1**	25	1	22.07.2022 15:20	23.07.2022 16:17
Agglomeration of Prague	**1**	7	0.29	05.08.2022 15:10	05.08.2022 21:44
Central Bohemia region	**1**	7	0.29	05.08.2022 15:10	05.08.2022 21:44
Liberec region	**1**	7	0.29	05.08.2022 15:10	05.08.2022 21:44
Ústí nad Labem region	**1**	7	0.29	05.08.2022 15:10	05.08.2022 21:44
Czech Republic	**5**	**53**	**2.2**		

O/K/F-M – Ostrava/Karviná/Frýdek-Místek

Energy crisis – did it affect air quality in the Czech Republic?

Due to the energy crisis, energy prices have skyrocketed and the inflation rate was high. As a result, some households have looked for a less costly way of heating than, for example, using gas or electricity. Some of them have returned to solid fuel boilers and used wood or coal for heating.

Domestic heating as the major source of air pollution

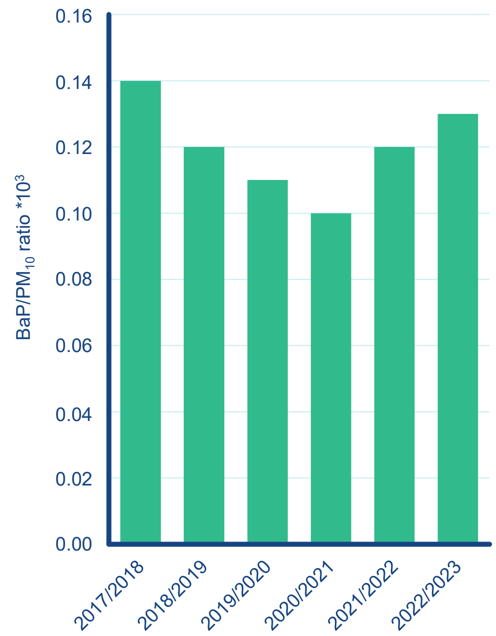
Local domestic heating using old solid fuel boilers is a major source of emissions of several significant air pollutants. In addition to suspended (dust) particles PM_{10} and $PM_{2.5}$, local heating is also an almost exclusive source (> 95%) of the cancer-causing benzo[*a*]pyrene (BaP). And It is these very air pollutants that exceed the ambient air quality limits in the Czech Republic.

The highest level of air pollution in the Czech Republic occurs in the cold part of the year, especially in small towns, where the proportion of households heated by solid fuels is higher than in larger cities. Thus, the assessment of the potential impact of the energy crisis on air quality focused on these small towns and particulate matter (PM) and BaP concentrations.

Focus on small towns

A long-term CHMI measurement campaign focused on small towns and monitored concentrations of BaP, PM particles and heavy metals in a total of eight small towns across the Czech Republic. Aim of this campaign was to determine whether there is a change – a desired decrease – in pollution levels as a result of the implementation of measures aimed to improve air quality in these small settlements (i.e. mainly replacement of old solid fuel boilers).

It should be noted that air quality is strongly influenced by meteorological and dispersion conditions. For example, rain or windy weather have a positive effect on air pollution levels. Conversely, low wind speeds, the occurrence of ground temperature inversion combined with low temperatures (and thus higher heating intensity) are a combination of factors that significantly increase air pollutant concentrations. Therefore, inter-annual variations in absolute air pollutant concentration values are also strongly influenced by the inter-annual changes in weather patterns. When assessing trends, these factors need to be taken into account and evaluated on a long-term basis.



Average BaP/PM_{10} concentration ratio in the individual winters during the campaign focused on small settlements.

Air quality trends in small settlements

In the case of absolute values of benzo[*a*]pyrene concentrations measured during the campaign in small towns a decreasing trend is observed. A more significant improvement in air quality was observed especially in the period from 2019 to 2021, when, among other things, the renewal of boilers or switch of households to alternative desirable heating methods (solar panels, heat pumps etc.) has already had a clear positive effect. The lowest values were recorded in the winters of 2019/20 and 2021/22, which were to a certain extent influenced by very favorable meteorological and dispersion conditions. The last winter assessed, that of 2022/23, was similar to the 2020/21 winter in terms of meteorological conditions and it was also similar in the absolute BaP concentration values. One can therefore say that a significant increase in BaP concentrations as a result of the energy crisis is not observed in the data regarding absolute concentrations.

Energy crisis effects are apparent in the data

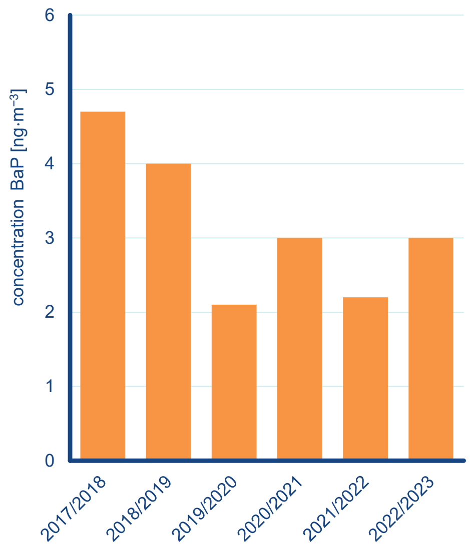
In addition to the absolute concentration values, it is interesting to look at the BaP ratio in the PM particles. Such ratio provides an approximate measure of the quality of heating in the given area. It mostly separates the effects of the weather and thus allows for a much more representative comparison between years in terms of air pollution that is not affected by meteorological conditions variation between them. In this case one can see a positive trend since the beginning of the monitoring in the winter of 2017/18. However, this changed in 2020/21 and from then on one sees a gradual increase in the ratio in the next two years.

The energy crisis could have been observed in the data already in the winter of 2021/22 when the energy prices were already significantly higher for many. The increase in BaP/PM_{10} ratio in the winter of 2022/23 suggests a deterioration in the heating quality compared to the previous four years, i.e. a return of many households to cheaper means of heating.

The results of the latest campaign therefore show that although BaP/PM_{10} ratio has increased, showing a deterioration in the quality of domestic heating, the deterioration was not so significant that it would lead to a significant increase in the observed absolute values of concentrations. The on-going renewal of domestic boilers and switch to alternative heating by many households has likely mitigated the impact of the energy crisis on air quality. However, the results do indicate a return to cheaper heating and less suitable fuels by some households.

How can one decrease emissions from heating?

BaP and PM_{10} concentrations and their ratios measured in the eight small towns over a period of six years show considerable differences in air pollutant levels between these sites. There are also large differences between sites in the case of year-to-year changes in air pollutant concentration levels and ratios. It is therefore possible that some towns have experienced a much more significant deterioration or improvement of air quality due to the energy crisis than what show the overall results of these selected eight locations. One must also remember that the amount of air pollution from solid fuel heating can be influenced. It depends, for example, on the type and quality of the fuel, the type of boiler, the way the boiler is maintained, but also on the temperature to which the rooms are heated and last but not least, the way the boiler is operated, i.e. the regulation of the combustion process. In the case of heating using wood as a fuel, it is important that the wood is properly dried (1–2 years).



Average concentration BaP in the individual winters during the campaign focused on small settlements.

CZECH HYDROMETEOROLOGICAL INSTITUTE

Na Šabatce 2050/17, 143 06 Prague 4-Komořany

tel.: +420 222 222 215

e-mail: chmi@chmi.cz

Branch Praha
Na Šabatce 2050/17
143 06 Prague 4-Komořany

Branch České Budějovice
Antala Staška 1177/32
370 07 České Budějovice 7

Branch Plzeň
Mozartova 1237/41
323 00 Plzeň

Branch Ústí nad Labem
Kočkovská 2699/18, poštovní schránka 2
400 11 Ústí nad Labem-Kočkov

Branch Hradec Králové
Dvorská 410/102
503 11 Hradec Králové-Svobodné Dvory

Branch Brno
Kroftova 2578/43
616 67 Brno

Branch Ostrava
K Myslivně 2182/3
708 00 Ostrava-Poruba

www.chmi.cz