Weather, water and air

2023

Czech Hydrometeorological Institute

CHMI operates

Photo: Archive CHMI

29
professional meteorological stations

208
automated meteorological stations

180
rain gauge stations

297
manual rain gauge stations

2
meteorological radars

1
aerological station

2
sodars

4
windprofilers

554
surface water limnographic stations

1 541
hydrogeological wells

319
springs

50
automated snow gauge stations

18
automated snow pillows

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

103
automated ambient air quality monitoring stations

83
manual ambient air quality monitoring stations

14
rain water quality monitoring stations

28
phenological monitoring locations

Meteorological stations

Hydrology station network

Air quality monitoring

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 and 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

Products and services

Photo: Archive CHMI

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

Photo: Adobe Stock

16–17

Record low daily average PM particle concentrations in the air were measured on December 21. This was due to a combination of very favorable dispersion and meteorological conditions.

22–23

The **most significant discharge situation occurred** between December 24 and 27. Flood activities were observed in all major basins. The Svatava gauging station water levels peaked at a value of 20-year discharge.

7

November was **very rich in precipitation**. On average twice as much precipitation fell in the Czech Republic compared to the long-term average 1991–2020.

12

Drought conditions persisted until the end of October, improving only later at the end of the year due to sufficient rainfall.

24

September was **exceptionally warm and very dry**. It was the warmest and driest September on record based on average air temperature and precipitation amount in the Czech Republic. This also led to **high ground-level ozone concentrations**. One smog situation was declared in Ústecký region, lasting for a total of 16 hours.

10–11

On August 26, thunderstorms swept through the Czech Republic, being the most significant convective system of the year. It traveled across southern Bohemia through Vysočina and Moravia and Silesia. Four days earlier, **hailstones of up to 8 cm** in diameter were observed.

14

Right in the middle of July, on July 15, the **highest air temperature** in 2023 was measured in Pilsen-Bolevec (38.6 °C).

6

A new **absolute maximum air temperature in January in the Czech Republic** was measured on January 1 at the station in Javorník (Jeseník district) at night (+19.6 °C).

14

The **lowest air temperature** in 2023 was observed on February 6 at the station Kvilda-Perla (Prachatice district) of −29.9 °C.

21

The **major vegetation period** in 2023 began in March, one week earlier than the previous year 2022.

7

April was very cold and with high amount of rainfall. With an average air temperature deviation of −2.1 °C and a precipitation total of 174 % of the 1991–2020 average it is classified as **strongly below average in terms of temperature and strongly above average in terms of precipitation**.

8

In terms of recurrence time, the **most significant flood situation in the summer half of the year** occurred in May, affecting eastern Moravia.

10–11

Strong thunderstorms were observed on June 21. They formed a typical radar signature referred to as **bow echo**. Significant damages were mostly in southern Bohemia and Vysočina.

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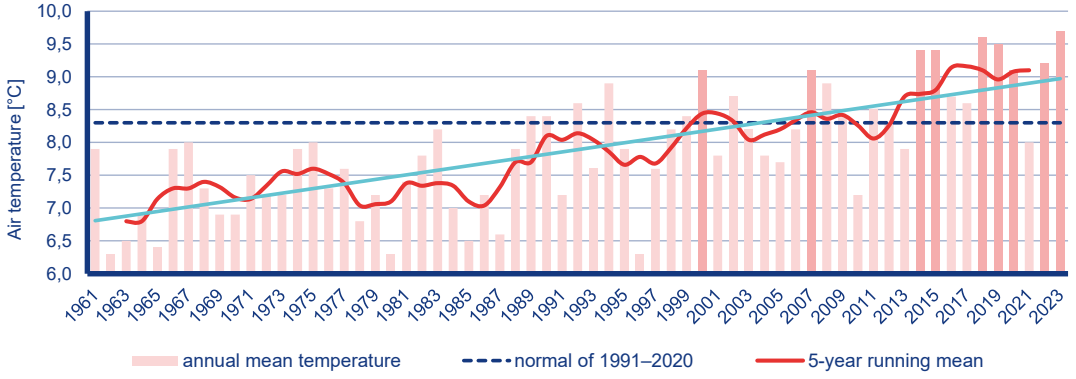
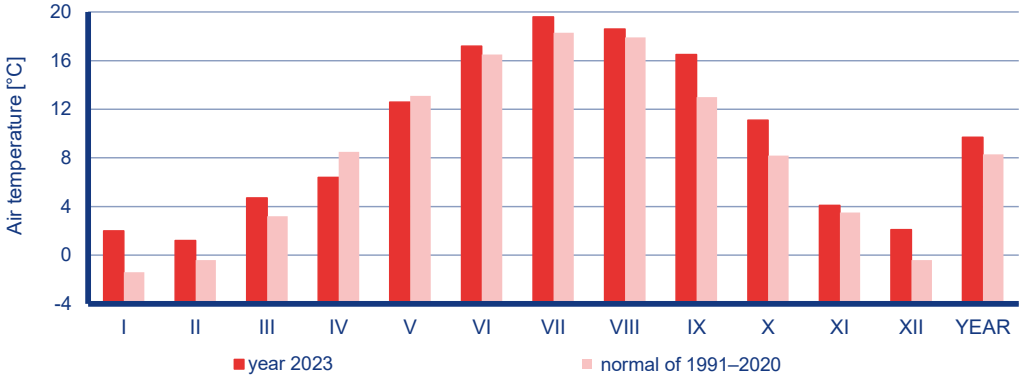
Air temperature

The year 2023 was much warmer than normal. The annual mean air temperature over the area of the Czech Republic (9.7 °C) was 1.4 °C above the normal of 1991–2020. Thus, it was the warmest year on record (since 1961).

The previous highest mean air temperature of the year 2018 (9.6 °C) was exceeded. In total, nine years with mean annual temperature of 9.0 °C or higher have already been recorded. All of these years occurred after 2000 inclusive.



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 1961–2023.



Annual and monthly mean air temperature over the area of the Czech Republic [°C] in the year 2023 in comparison to the normal of 1991–2020.

Temperature in the year 2023

Monthly mean air temperature over the area of the Czech Republic was above the normal in all months of the year 2023, apart from April and May. Very warm months were January, September, October and December with temperature anomalies +3.4, +3.5 °C, +2.9 and +2.5 °C, respectively. January 2023 was the 3–4th warmest January for the Czech Republic on record. On January 1, 2023, the highest maximum air temperature on record for January was recorded when +19.6 °C was measured at Javorník station (Jeseník district). The September was the warmest on record and the October the 3th warmest on record over the area of the Czech Republic.

In contrast, April was very cold. Monthly mean air temperature in April (6.4 °C) was 2.1°C below normal.

Precipitation

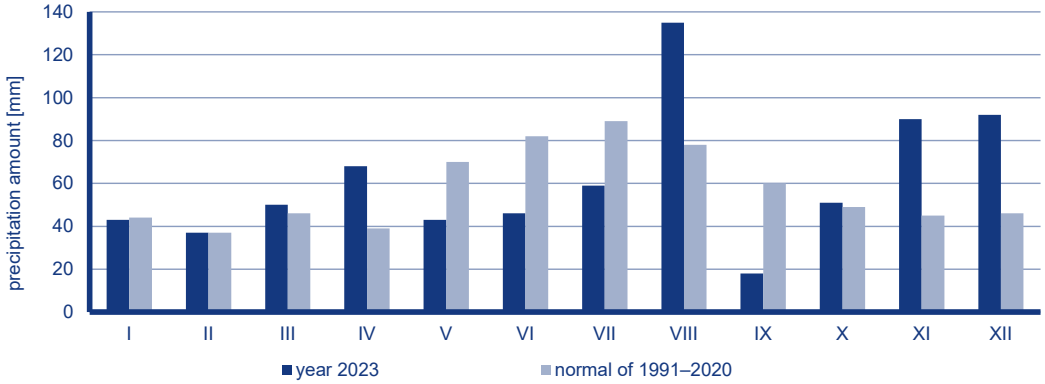
In the year 2023, the Czech Republic received near-normal precipitation amount. The mean annual precipitation amount over the area of the Czech Republic was 732 mm (107% of the normal of 1991–2020).

It was the 15th wettest year in a series of the annual precipitation amounts since 1961. The previous higher annual precipitation amount was recorded in 2020 (766 mm, 112 % of the normal).

Precipitation in the year 2023

During the year 2023, both precipitation-rich and precipitation-poor months were recorded. Much-wetter--than-normal months were April (precipitation amount of 68 mm, 174% of normal), August (precipitation amount of 135 mm, 173% of normal), November (precipitation amount of 90 mm, 200% of normal) and December (precipitation amount of 92 mm, 200% of normal). November 2023 was the wettest and December 2023 was the second wettest corresponding month for the Czech Republic on record (since 1961).

In contrast, September was very dry with a mean precipitation amount of 18 mm (30% of normal). It was the driest September (together with September 2006) for the Czech Republic on record (since 1961). May and June were also drier than normal, with precipitation amount of 61% and 56% of normal, respectively.

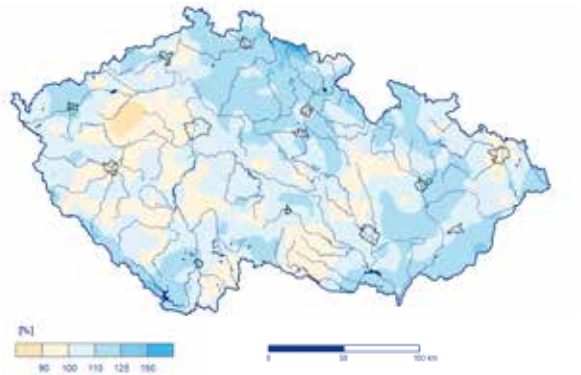


Mean monthly precipitation amount over the area of the Czech Republic [mm] in the year 2023 in comparison to the normal of 1991–2020.

Spatial distribution of precipitation

In the year 2023, Bohemia received 726 mm of precipitation (107% of normal), Moravia and Silesia received 743 mm of precipitation (107% of normal). The annual precipitation amounts were above normal in all regions of the Czech Republic. The wettest regions in comparison to normal were Liberec and Hradec Králové regions with precipitation of 116% and 117% of normal, respectively. The driest regions compared to normal were Vysočina and Plzeň regions (102% and 103% of normal).


Photo: Adobe Stock



Annual precipitation amount in the year 2023 in % of the normal of 1991–2020.

Runoff conditions

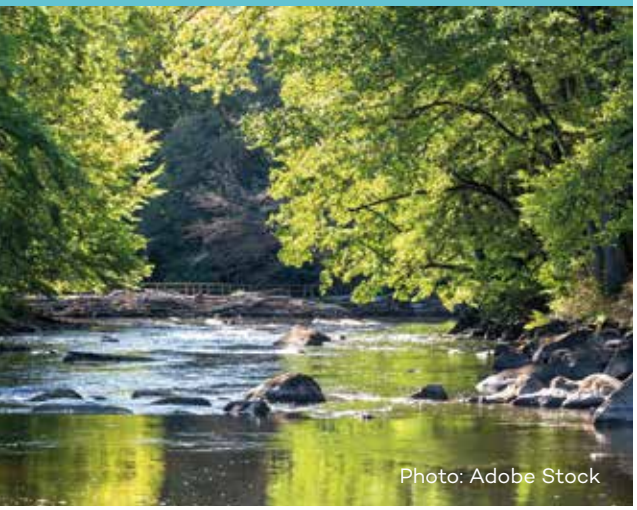
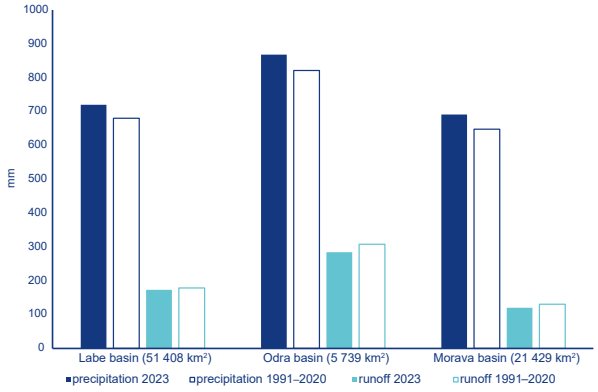


Photo: Adobe Stock



Comparison of precipitation and runoff for 2023 with long-term averages for the period 1991–2020 for the main river catchments.

The year 2023 can be assessed as average in the whole territory of the Czech Republic.

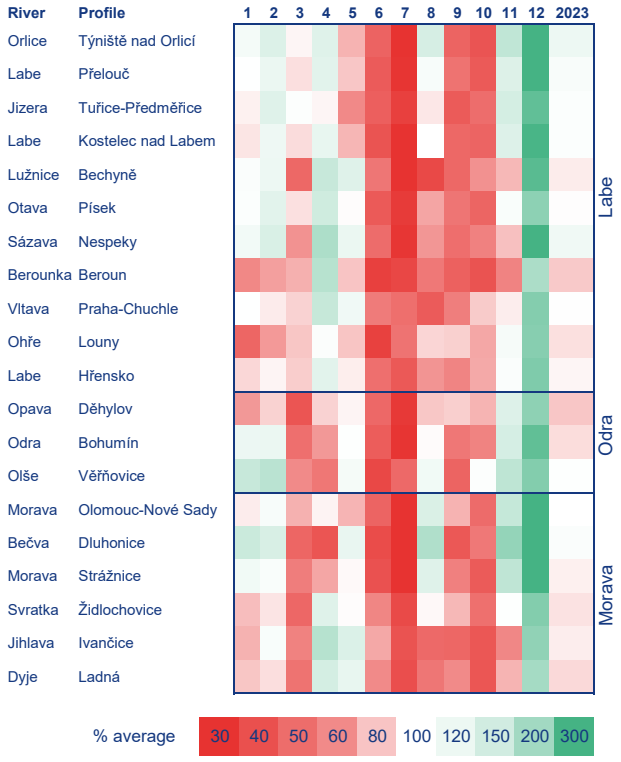
Annual runoff

The annual runoff can be assessed as average in relation to the long-term mean for the period 1991–2020. In particular, approximately 97% of the Labe basin and 92% of the long-term average have drained from the Odra basin and the Morava basin.

Runoff distribution during the year

The values of average monthly discharges during the year exhibited considerable variability in comparison to the long-term monthly averages. On the Morava River, in the Strážnice profile, only 21% of the average monthly flow was recorded in July, which represents an extremely below-average phenomenon. Conversely, in December, the discharge in this profile reached 305% of the long-term value, which is an extremely above-average phenomenon. Between January and April, the variability of flows was regional, with March exhibiting below-average conditions and April exhibiting above-average conditions. May was characterised by average flows.

In the summer months, especially in June and July, below-average precipitation and above-average temperatures led to a reduction of streamflow to below-average and extremely below-average values in some locations. In August, however, significant rainfall episodes ended the dry season, especially in parts of Moravia, Silesia and eastern Bohemia. September and October were once again characterised by below-average runoff. Runoff increased from average values in November to exceptionally above-average levels in December. This significant increase culminated in regional flooding during the Christmas period, caused by heavy rainfall and snowmelt.



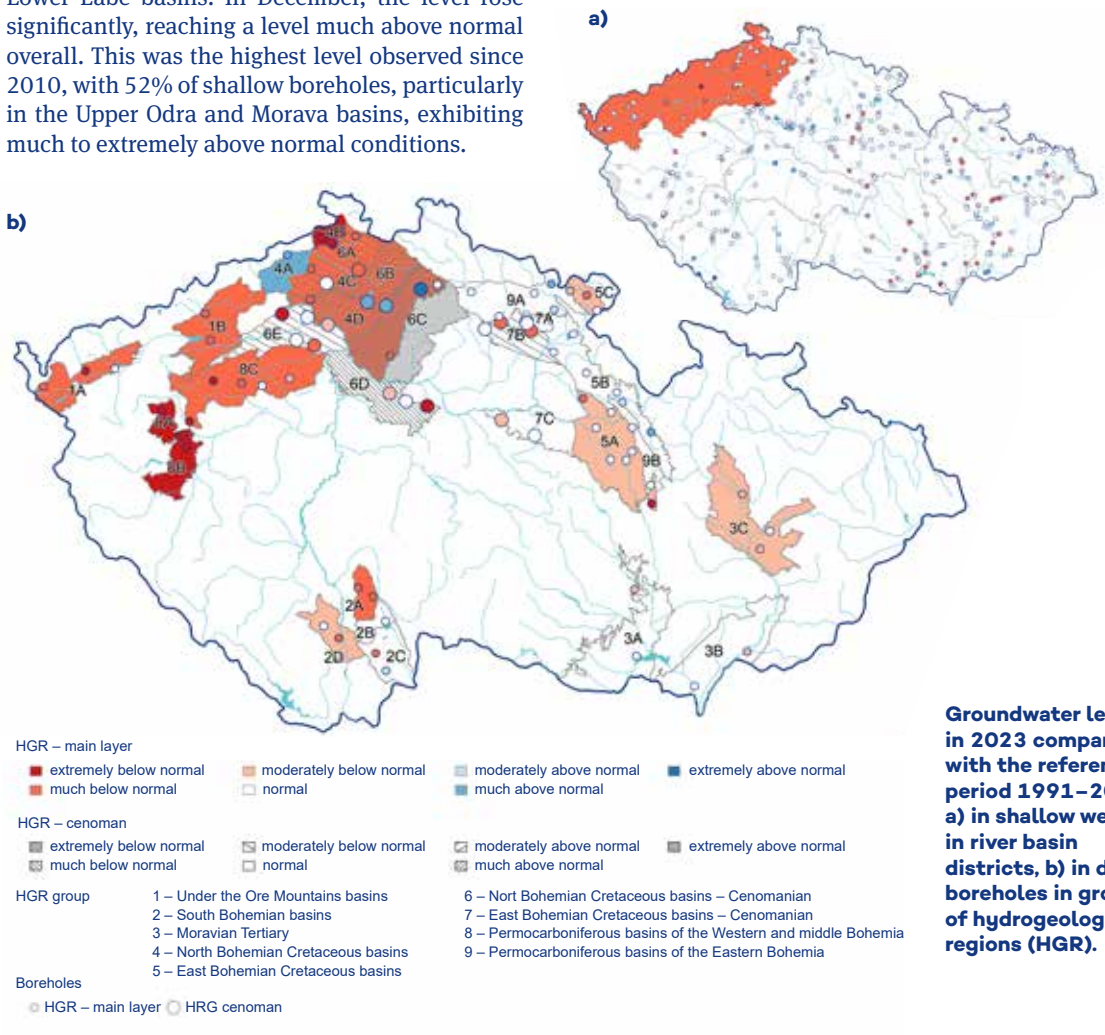
Mean monthly discharges in 2023 in % of long-term monthly mean discharges over the period 1991–2020.

Groundwater

Groundwater levels were generally normal in the shallow circulation and much below-normal in the deeper circulation (water-important areas) in 2023.

Shallow boreholes

In the initial quarter, the water level in shallow circulation was predominantly within the normal range. In April, the overall normal annual maximum was much above normal in the Upper Vltava, Lower Vltava and Berounka basins. The most severe overall much below normal condition occurred in July, but levels were already normal in August and September. The annual overall moderately below normal minimum occurred in October, with the most severe condition (extremely below normal) observed in the Ohře and Lower Labe basins. In December, the level rose significantly, reaching a level much above normal overall. This was the highest level observed since 2010, with 52% of shallow boreholes, particularly in the Upper Odra and Morava basins, exhibiting much to extremely above normal conditions.



Groundwater levels in 2023 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).


Photo: Archive CHMI

Deep boreholes

The drought from previous years persisted in deep boreholes. The most severe drought was observed in the North Bohemian Cretaceous basins and Permocarboniferous basins of the Western and middle Bohemia, where levels remained persistently extremely below normal throughout the year. Furthermore, the level was also extremely below normal from January to April in the Under the Ore Mountains basins. In contrast, the best condition was observed in the Permocarboniferous basins of the Eastern Bohemia, where the level was normal for most of the year and in December there was a significant increase to a much above-normal level.

Convective season

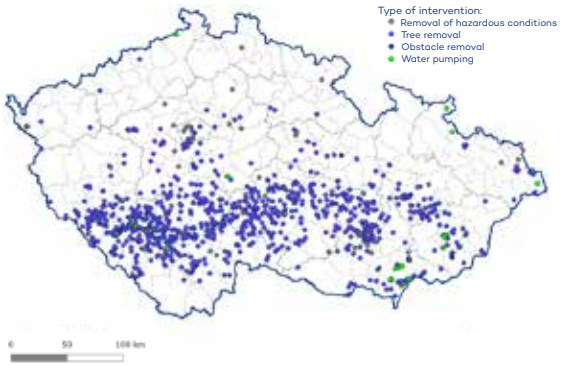
Photo: Adobe Stock

The year 2023 has again brought a number of interesting convective situations. For example, a number of tornadoes (fortunately weak) has been encountered as well as large hail over 5 cm in diameter and significant rainfall totals measured. The area of the Czech Republic was also hit by several large-scale convective systems that produced strong wind gusts. In terms of the number of weather warnings, last season was comparable to the previous one. However, there was a significant increase in the proportion of warnings for observed phenomena that were issued from regional forecast offices, which is a positive change.

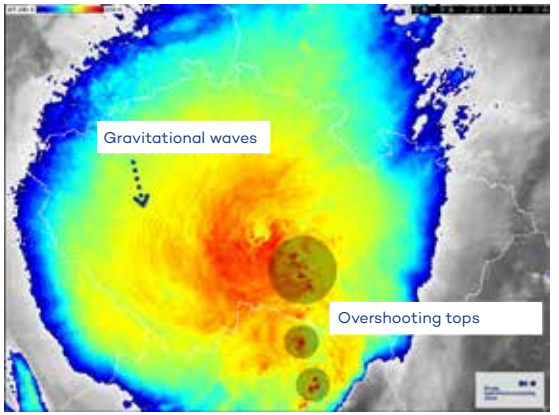
Convective systems

There were two situations with very significant large-scale convective systems. The first one occurred on June 21. It was typical in that the convective system followed its usual trajectory from the Bavarian region through Šumava (Bohemian Forest) to the east and northeast. However, the timing of the system was unusual. It crossed the borders and entered the Czech Republic in the Šumava region in the early afternoon after 2PM CEST, which is rather rare. The system, which gradually formed into a bow echo (a typical radar signature) caused a large amount of damage, especially in southern Bohemia and the Vysočina (Highlands) region. Significant wind gusts were recorded at the stations in Kocelovice (25.7 $m \cdot s^{-1}$) and Tábor (25.5 $m \cdot s^{-1}$), the most significant one later on in Tišnov (27 $m \cdot s^{-1}$). Considering the length of the system trajectory and the recorded wind gusts, it was classified as the first so-called derecho of the year.

A second, even more significant convective system, was observed in the evening and night hours of August 26. In terms of its extent, it was even larger than the one in June and it passed over the similar region, particularly southern Bohemia and Vysočina. The system had a lot of available convective energy and thus its intensity was very strong. Severe damages were also observed in Moravia and Silesia, where the system moved during night. Apart from strong



Map of fire department reports after June 21, 2023 derecho. Each blue circle represents one reported fire-department intervention. Processed by: David Ryva.

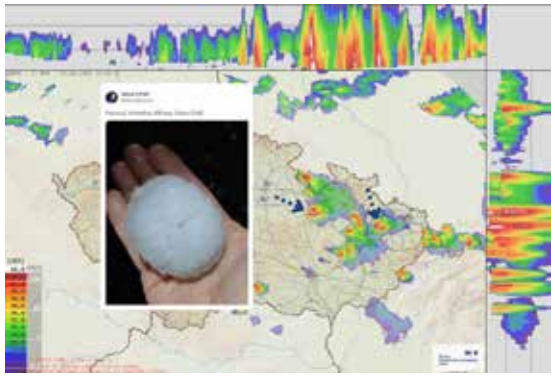


Detailed image of convective system from a polar satellite, IR-BT channel.

wind gusts also very intense rainfall was observed in the northern part of the system. Precipitation intensity at selected stations in south Bohemian region ranged around 50 $mm \cdot h^{-1}$. The system was also very interesting in terms of what could be observed on radar and satellite images. What could very well be observed on satellite images were so-called gravitational waves and many overshooting tops. A mesoscale convective vortex formed in the northern part of the system, which does not happen very often. It was in the region of the vortex where the most intense rain was observed.

Hail

Several situations of large hail were observed in 2023, the most significant one on August 22, when several solitary supercells (convective storms with rotating updraft) produced hail larger than 5 cm in diameter. Largest hail was recorded near the town of Klokočov in the northeast with a diameter of up to 8 cm. Such large hail caused significant damages on roofs and vehicles. Fortunately, such large hail was only limited to a relatively small region near Vítkov.



Radar image from August 22, 2023, when hail of up to 8 cm in diameter was observed.

Radar image shows the situation around 9:50 PM CEST. One can clearly see white regions with highest reflectivity, which in vertical direction reach up to 10 km high. This suggests a possibility of very large hail. In both cases these were right-moving supercells (right movers), characterized by diverging to the right from the predominant wind direction. Arrows show the two most significant ones, which produced hail larger than 6 cm in diameter. The image shows the moment when the eastern one produced the largest hail of up to 8 cm in Vítkovsko region. This large hail is also depicted on the image, having 8 cm in diameter. Such large hail does not occur every year in the Czech Republic.

Tornadoes

Several weaker tornadoes have been observed in the year 2023. The first one occurred already on March 31 in Letovice na Blanensku. On April 29, two tornadoes were recorded, one near Nejpín u Chotěboře and one near Lubná u Poličky. Another weak tornado was observed near the very same town of Lubná u Poličky two months later on June 10. This hard to believe fact is, however, merely a coincidence and probability of two tornadoes at the same location within just a few months is extremely low. All the nine tornadoes reported in 2023 were fortunately weak and short-lasting, in some cases their occurrence is disputable.

Photo: Adobe Stock

Drought


Photo: Adobe Stock

Groundwater

In the shallow circulation, 2023 was less dry than 2022, but drier than 2020 and 2021. In the deep circulation, the drought of previous years continued, and 2023 was the third driest (after 2019 and 2022) since 2013. In the shallow circulation, there was a deterioration from normal to severe drought from June to July. In August, conditions improved back to normal. In September and October, severe to exceptional drought occurred only in the Ohře and Lower Labe basins. Deep boreholes demonstrated generally severe, in July even exceptional, drought for most of the year, except for an improvement to normal in December.

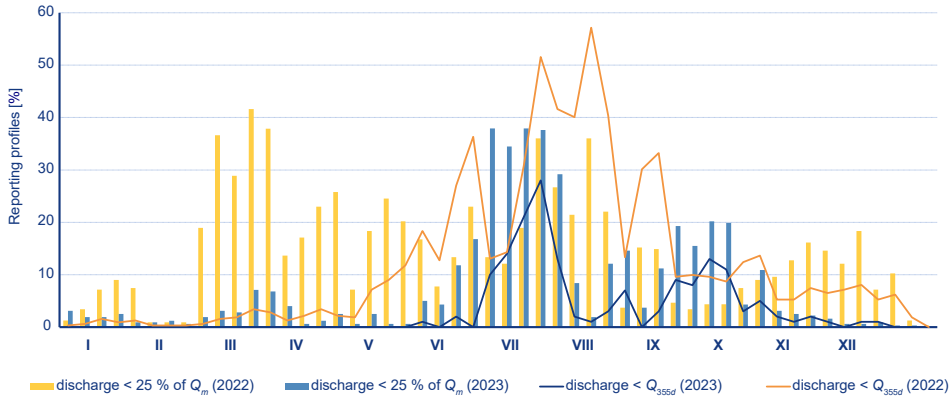
* Q_{355d} – represents the flow that was reached or exceeded in the profile on average 355 days per year (relative to the reference period 1991–2020)

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

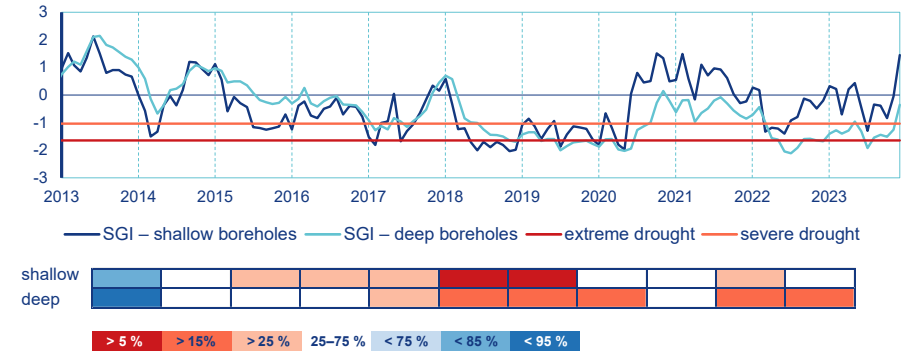
In terms of surface and groundwater drought, 2023 was significantly wetter than 2022.

Surface Water

2023 was the least dry year since 2020. The first five months of the year were characterized by frequent precipitation and snowmelt, resulting in minimal occurrence of "dry" profiles. From June onwards, there was a gradual development of drought. June and July were the least watery months of the year. Most streams in the main catchment areas were below 50% of the long-term monthly average. The worst drought on surface waters was recorded in July, when almost 40% of the profiles experienced flows of less than 25% of Q_{VII}, most notably in the Morava and Odra catchment areas. The proportion of profiles with flow rates below Q_{355d} in July ranged from 10 to 30% and occurred mostly in the Lower Labe and Ohře basins and in the Vltava basin. Profiles indicating hydrological drought were present until October in most of the main catchment areas. Their number decreased in November and by the end of the year their occurrence was sporadic.



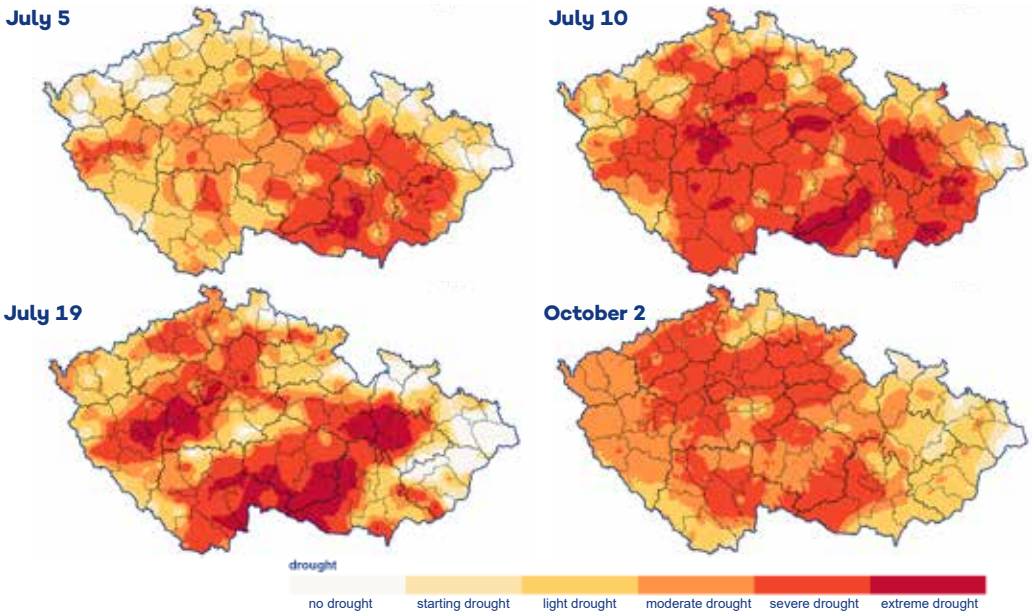
Weekly drought trend (Q_{355d}*) in 322 reporting profiles in the Czech Republic in 2022 and 2023. *Qm* – mean monthly discharge.



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

Soil drought

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. Mostly, the drought peaked in July, when a severe drought over most of the area and even an extreme drought in parts of the area was observed. Severe drought occurred also at the turn of September and October.



Soil drought in the surface layer of 0-40 cm on July 5, July 10, July 19 and October 2, 2023.

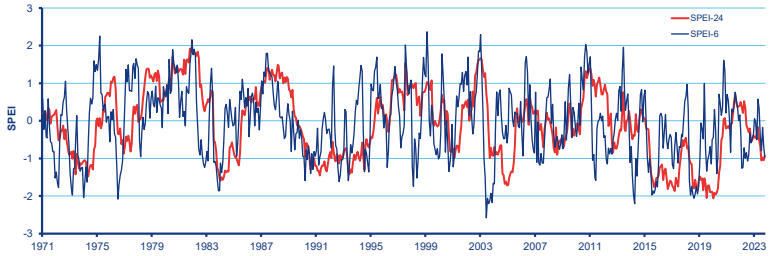
In April, starting to light drought affected some parts of the area. In May and early June, moderate to severe drought was already observed in northwest and west of the area. In late June and early July, moderate to severe drought was observed in southern and central Moravia and eastern Bohemia, while the rest of the area was affected by starting to light drought. In July, the drought peaked at the end of the first decade, when severe drought occurred in most of the area. In mid-July, even an extreme drought was observed, especially in southern part of the area. In August, drought did not occur in most of area. In September, light to moderate drought was prevailing. At the end of September and beginning of October, even a severe drought occurred.

* 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 lengths. 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.

Course of the SPEI index*

From January to the end of October 2023, SPEI-24 values were less than 0, which means prevailing drought conditions. The lowest SPEI-24 values below –0.9 were recorded from July to the end of October. Negative SPEI-24 values occurred continuously from June 2022 to the end of October 2023. At the very end of 2023, SPEI-24 reached values close to 0 again.



Course of SPEI indices calculated for 6 and 24 months from 1971–2023 for the region of the Czech Republic. The lower the values, the more intense the drought.

Map of extreme events

Photo: Adobe Stock

- **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 6-day rainfall
308.1 mm
December 20–25, 2023
Dvoračky**
Semily district

Highest number of tropical days
39 days
Doksany, Litoměřice district

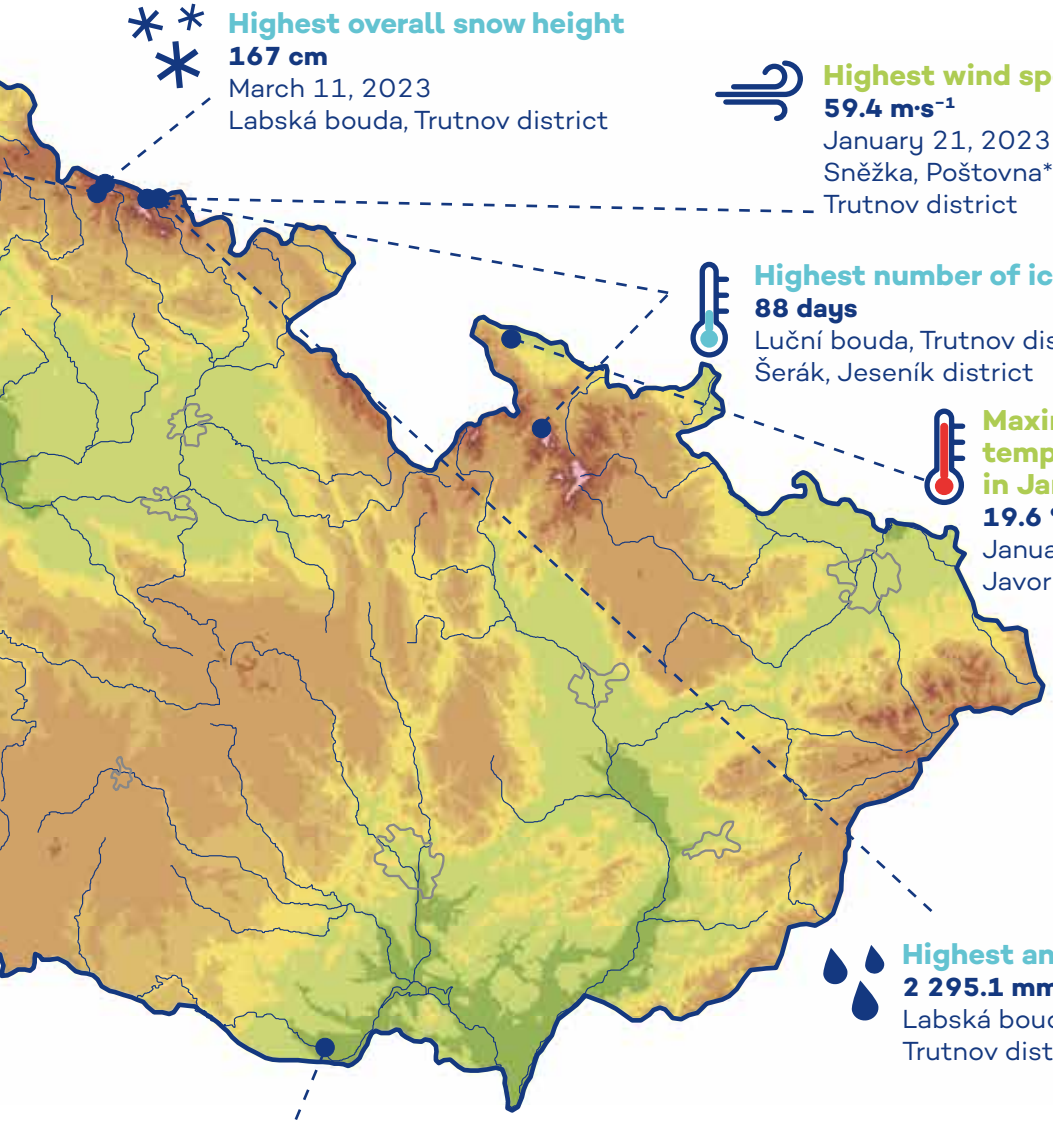
Lowest annual rainfall
421.6 mm
Kounov
Rakovník district

Maximum air temperature
38.6 °C
July 15, 2023
Pilsen, Bolevec
Pilsen-city district

Minimum air temperature
–29.9 °C
February 6, 2023
Kvilda-Perla*
Prachatice district

Highest daily rainfall
139.5 mm
August 26, 2023
Brloh, Český Krumlov district

Highest hourly rainfall
65.3 mm
August 26, 2023
Černovice, Dobešov
Pelhřimov district



Highest overall snow height
167 cm
March 11, 2023
Labská bouda, Trutnov district

Highest wind speed
59.4 m·s^{-1}
January 21, 2023
Sněžka, Poštovna*
Trutnov district

Highest number of ice days
88 days
Luční bouda, Trutnov district
Šerák, Jeseník district

Maximum air temperature in January
19.6 °C
January 1, 2023
Javorník, Jeseník district

Highest annual rainfall
2 295.1 mm
Labská bouda
Trutnov district

Highest number of sunny days
73 days
Dyjákovice, Znojmo district

Highest values of average monthly discharges in main basins were recorded in December in the Morava basin (305% Q_{XII}).

Drought in surface waters was most frequently observed in the second half of July. The ratio of gauging sites with discharges below Q_{355d} in July ranged from 10 to 30% (31 to 91 stations). Most often in the Labe and Ohře basins (up to 79%, total of 19 stations) and in the Vltava basin (32%, total of 33 stations).

Highest peak discharge from the perspective of return period (20 years) was reached on May 17 on Velička, stations Velká nad Veličkou and Strážnice.

Highest amount of water available in snow in the 2022/23 winter was recorded on December 19, 2022 (1.277 billion m^3). On that day snow height in Beskydy was 25–65 cm, Krkonoše, Jizerské mountains, Jeseníky and Šumava 15–55 cm, Orlické mountains 10–35 cm and Krušné mountains 5–30 cm.

Overall lowest value of average monthly discharge (21% Q_{VII}) was observed in July at the Morava River.

*** Stations not operated by the CHMI**
**** At some stations (Krkonoše, Jizerské hory) the 6-day rainfall amount was highest in at least 100 years**

December 2023 Flood

In December 2023 and early January 2024, the Czech Republic faced the most significant runoff situation in recent years. This flood was exceptional because of the extent of the affected area rather than the magnitude of the peak flows. Flood activity was recorded in all major river basins. The highest level of flood activity was recorded at dozens of hydrological profiles. On the Svatava River, the peak flow reached the 20-year return period flow value.

Sázava River in Zruč nad Sázavou December 26, 2023.

Causes of the Flood Episode

Two main factors were responsible for the occurrence of such a widespread flood event. The first was the melting of a significant amount of snowpack that formed in early December 2023. In terms of accumulated water in the snowpack, the snowpack in early December was the largest since 1980; snow occurred in large quantities at all elevations, including lower elevations. By the beginning of the third decade of December, snow had melted from all lower and middle elevations throughout the country, and the amount of snow had been reduced to one-eighth of that at the beginning of December. This significant reduction in snowpack resulted in substantial saturation in the vast majority of the catchment areas. The significant precipitation totals were the second factor. They were evaluated in terms of the return period for the period from December 19 to 26, 2023 (eight-day precipitation totals) at some stations in the Krkonoše and Jizera Mountains as up to a 100-year return period, in Šumava as up to a 20-year return period.

Labe River in Stanovice on December 22, 2023, recorded discharge 91 $m^3 \cdot s^{-1}$ (2. SPA). Photo by Zdeněk Brendl.

Runoff Episodes

The high saturation of the Czech Republic land combined with often extreme precipitation events accompanied by strong winds, which significantly accelerated the melting of the snow cover, caused a significant runoff response in most areas of the Czech Republic. Based on the precipitation pattern, three runoff episodes can be identified in the runoff response.

The first runoff wave, with peaks mainly on December 21 and 22, 2023, particularly affected the upper Labe River basin. The second runoff wave, with peaks mainly between December 24 and 27, then affected most of the Czech Republic and was the most significant in terms of the extent of the affected area and peak flows. The third flood wave

Flood warning levels recorded between December 21, 2023 and January 7, 2024.

at the beginning of January (January 3–7) was not so significant, as shown by the return periods of the peak flows, which in no case exceeded the value of a 2-year return period flow.

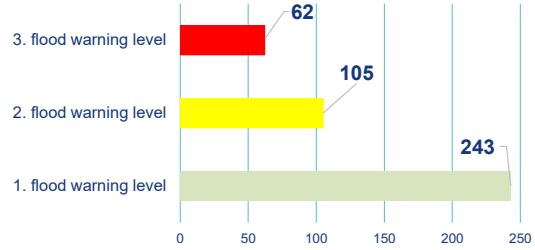
Flood Warning Levels

Flood warning levels were recorded in all major river basins during the period from December 21, 2023 to January 7, 2024. With the exception of the Moravian part of the Odra River basin, where only 1st flood warning level was recorded, 2nd and 3rd flood warning level were frequently reached in other basins. In total, 257 hydrological profiles recorded some of the flood warning levels.

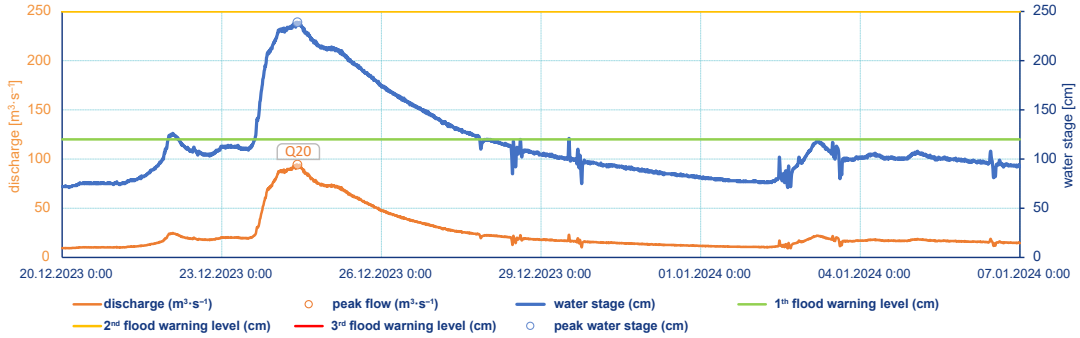
Peak Flows during Floods

In terms of the magnitude of the return period of the peak flows, the highest flow was achieved on the Novohradka River in the Úhřetice profile and on the Pramenský Brook in the Mnichov profile. The peak flow at the mentioned water gauging stations reached the level of a 20 to 50-year return period flow. Regarding the significant water resources, noteworthy is the Svatava River, where a flow with a return period of 20 years was achieved in the Svatava profile. Peak flows with a return period of 10 years occurred, for example, on the Nežárka River in Rodvínov, the Svatava River in Kraslice, the Teplá River in Teplička, the Novohradka River in Úhřetice, the Sázava in Chlístov, the Šlapanka River in the Mírovka profile and the Labe River in the Kostelec nad Labem profile.

Cidlina River in Nový Bydžov on January 3, 2024, recorded discharge 22 $m^3 \cdot s^{-1}$ (1th flood warning level). Photo by Zdeněk Brendl.



Number of profiles with exceeded flood warning levels in the period from December 21, 2023 to January 7, 2024.



Hydrograph of the Svatava profile (Svatava River) reaching the highest *N*-year return period discharge during the December flood.

Orlice River banks overflow in Týniště nad Orlicí on January 4, 2024, recorded discharge in Týniště profile 136 $m^3 \cdot s^{-1}$ (2nd flood warning level) by Zdeněk Brendl.

Surface water quality


Photo: Adobe Stock

In 2023, the most common exceedances in surface waters were for nutrients (especially total phosphorus, total nitrogen), pesticides and PAHs. The highest ratio of profiles with worse water quality was recorded in the Lower Vltava and Dyje river basin districts.

General indicators of basic physico-chemical analysis and nutrients

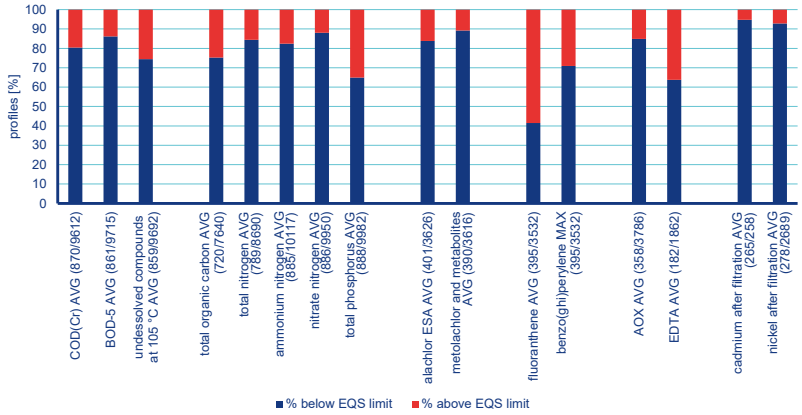
Total phosphorus was the most frequent nutrient to exceed the limit value (35% of the profiles). Total nitrogen, ammonium nitrogen and chemical oxygen demand (COD_{Cr}) were at concentrations above the limit in less than 20% of the profiles, while approx. 25% of the profiles exhibited concentrations above the limit for total organic carbon. The limits for nitrate nitrogen and biochemical oxygen demand (BOD_5) were exceeded in approx., 15% of the profiles. The pollution sources are mainly wastewater and agriculture.

Pesticides

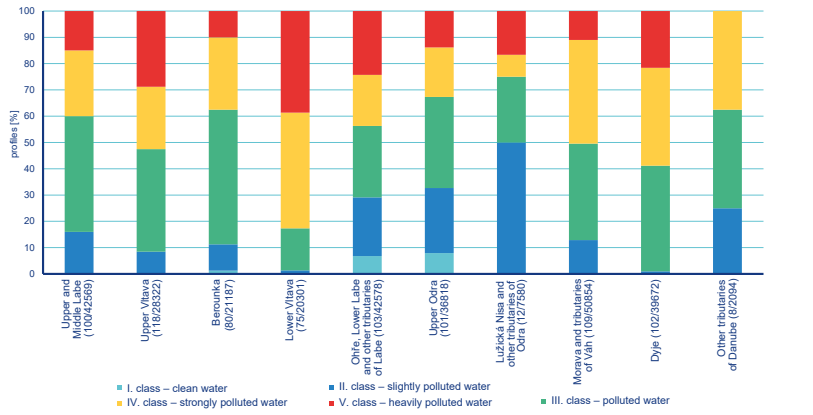
The most frequent pesticide found at above limit levels were metabolites of herbicides alachlor, especially alachlor ESA (16% of profiles, used in rape cultivation) and metolachlor and its metabolites (about 10% of profiles, used in maize cultivation).

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

Heavy metals (in dissolved form) nickel and cadmium exceeded the limit values in 7%, respective 5% profiles and lead and mercury in 1–2% of profiles. Among the PAHs, fluoranthene (< 60% of profiles) and benzo(ghi) perylene (about 30% of profiles) were detected at concentrations above the limit, with combustion identified as the source. Of the other pollutants, ethylenediaminetetraacetic acid (EDTA), adsorbable organically bound halogens (AOX) and bisphenol A were the most frequently detected at concentrations above the limit.



Percentage of profiles with EQS (Environmental quality standard) limit exceedance for selected determinants according to Government Order No. 401/2015 Coll. in 2023 (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 2023 (on the X axis in parentheses: number of evaluated profiles/number of samples used for evaluation).

Bioaccumulation

In 2023, the highest contamination levels of hazardous pollutants in adult fish were found at the Labe – Obříství profile, where the highest concentration of polychlorinated biphenyls was measured, and at the Otava – Topělec profile with the maximum concentrations of mercury detected.

Mercury, brominated flame retardants

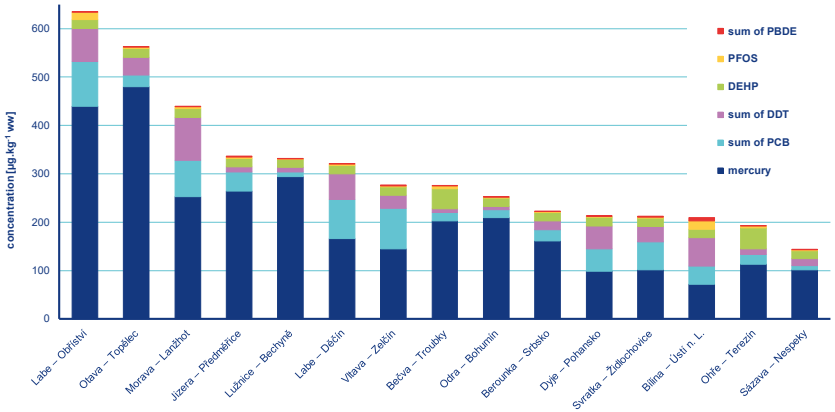
Mercury accumulates at the highest concentrations in adult fish, with concentrations regularly exceeding the limit (20 µg·kg^{-1}) at all monitored profiles. The maximum concentration measured in 2023 was 480 µg·kg^{-1} at the Otava – Topělec profile. Mercury concentrations in juvenile fish ranged from 5 µg·kg^{-1} (Vltava – Zelčín) to 40 µg·kg^{-1} (Bečva – Troubky), while those in benthos ranged from 10 µg·kg^{-1} (Labe – Lysá n. L.) to 24 µg·kg^{-1} (Bečva – Troubky). As in previous years, the limit value for polybrominated diphenyl ethers (PBDEs) was exceeded at all profiles.

Industrial Chemicals and Organochlorinated Pesticides

The highest concentrations of perfluorooctane sulfonic acid (PFOS) are repeatedly measured in juvenile fish, where the limit value was exceeded at 57% of monitored profiles in 2023. For benthic organisms, the PFOS limit concentration was exceeded at 24% of profiles, and in adult fish at the Bílina – Ústí nad Labem and the Labe – Obříství profiles. The highest concentration of di(2-ethylhexyl)phthalate (DEHP) was measured in benthos at the Bečva – Troubky profile (440 µg·kg^{-1}). The maximum concentration in adult fish was measured at the Ohře – Terezín (44 µg·kg^{-1}), while in juvenile fish it was at the Jizera – Předměřice (70 µg·kg^{-1}). The highest levels of DDT and polychlorinated biphenyls (PCBs) are found in adult fish, with comparable levels measured in both cases.

Toxic by-products of incomplete combustion

In adult fish, the sum of these chemicals (polychlorinated dibenzodioxins, dibenzofurans and dioxin-like PCBs) reached a maximum at the Labe – Obříství profile (15 ng·kg^{-1} TEQ – toxic equivalents). The limit value (6.5 ng·kg^{-1} TEQ) was exceeded at the following profiles: Labe – Obříství, Morava – Lanžhot, Labe – Děčín and Vltava – Zelčín.



Concentrations of hazardous substances found in adult fish in 2023. PBDE: polybrominated diphenyl ethers. PFOS: perfluorooctane sulfonic acid. DEHP: Di(2-ethylhexyl) phthalate. DDT: sum of DDT and metabolites. PCB: polychlorinated biphenyls. ww: wet weight.

Photo: Adobe Stock

For the monitoring of pollutants not usually present in water, samples of benthic organisms, juvenile fish and adult fish (chub) are collected. The majority of the analysed compounds are persistent and fat-soluble, with a high potential to accumulate in living organisms.

Limit value: Environmental quality standard according to Government Regulation No. 401/2015 Coll.
All reported concentrations are based on wet weight
Benthos: Organisms living on the bottom of water bodies (leeches, caddisflyes, gammarus)

Snow

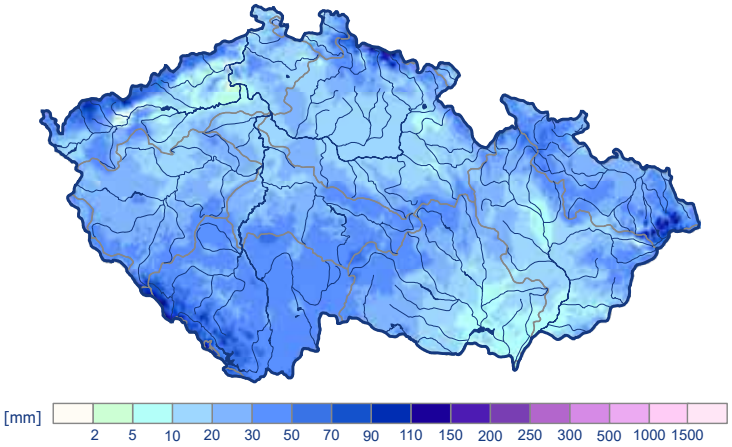
Photo: Adobe Stock

Snow storage was initially (2022) average in the winter of 2022/2023 relative to the 1991–2020 reference period, and significantly below average in the second part (2023). The beginning of winter 2023/2024 was well above average in the middle of the first decade of December, then well below average due to a major thaw at the end of the year.

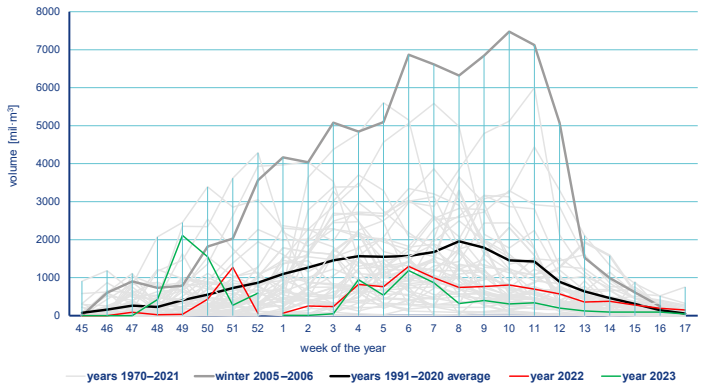
Development of Snow Storage

The start of the 2022/2023 season (from the end of November) was well below average, with the exception of the second and the beginning of the third decade of December, when snow storage reached a seasonal high of 1.277 billion m³ on December 19 and were above average. The Christmas thaw then led to a reduction to well below average levels at the end of the year. In 2023, snow storage was well below average, with increases occurring only in the second half of January. There ,was a gradual snowmelt during February to April 2023, interrupted only by a short-term increase in March. The last assessment of the amount of water in the snowpack during the 2022/2023 winter season was made at the end of April (April 24, 2023). Snow residues were only present in the highest parts of the Krkonoše, Šumava and Jeseníky mountains.

In late November and early December 2023, snow storage reached 2.122 billion m³ on December 4, a seasonal high (2023/2024) and the largest value for week 48 since 1980. However, a thaw at year-end brought snow storage down to average or slightly below.



The maximum snow storage water equivalent on the territory of the Czech Republic in winter 2022/2023 (December 19, 2022, 1.277 billion m³, runoff 16.2 mm).



Development of snow storage on the territory of the Czech Republic in individual winter periods since 1970.

Phenological progression of wild plants

The start of the major growing season occurred in 2023 between March 1 and March 31 (one week earlier than in 2022); the end of the major growing season was between November 16 and December 1 (one week later than in 2022). The major growing season lasted from 215 to 305 days (in 2022 it was from 220 to 250 days).

The plants were in dormancy in January and February. Only common hazel (an important pollen allergen) started to bloom in some locations in mid-January (a month earlier than the previous year). However, due to the cooling at the beginning of February, flowering slowed down and full flowering did not occur until February 15. The snowdrop began to bloom in mid-February.

In March, the plants woke up from dormancy. Although it was still relatively cold, the vegetation was developing ahead of time. Unfortunately, there were frosts in March and April and some fruit tree flowers have frozen. At the end of April, the development of vegetation returned to normal, only in the mountains its development was still slightly delayed.

During May and June, the vegetation was changing before our eyes, the pollen season was at its peak (conifers, beeches, oaks, grasses and other pollen allergens bloomed). In the first decade of May, most of the trees were partially or almost completely leafy. At the beginning of June, haymaking and strawberry harvesting began. At the end of June, grain was already ripening in some locations. In July and August, new shoots of woody plants gradually became woody. At the end of August, the fruits of elderberries, rowanberries and dogwoods ripened, and the hop harvest began. In September, the fruits of other tree species ripened, e.g. hazel, hornbeam, acacia, oak and beech. In October, blackthorns mostly ripened, but their harvest was very weak in some places.

We could enjoy the colors of the leaves for a longer time than usual, the interval between the phenological phase of leaf yellowing 10% and leaf yellowing 100% was longer than a month in many locations. Leaf fall started in November, and the larch did not fall completely at many stations until December.

And finally, one interesting phenology fact: in Plzeň, Bolevec station, the second ripening of blueberries was recorded at the end of October. The above mentioned facts prove that every year is "phenologically" different, and extreme weather significantly affects the development of vegetation.

Black Elder. Photo: Adobe Stock.

White Locust. Photo: Adobe Stock.

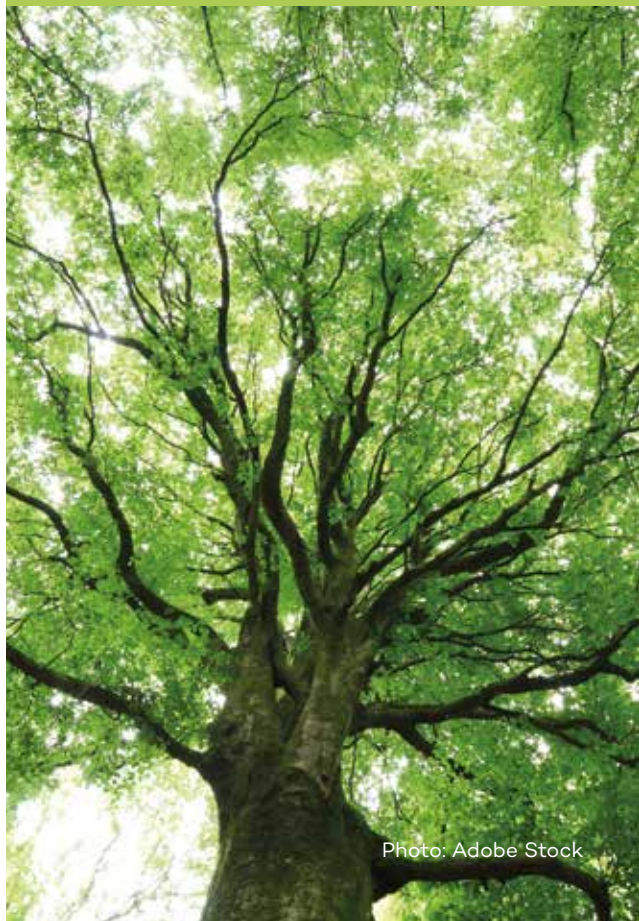


Photo: Adobe Stock

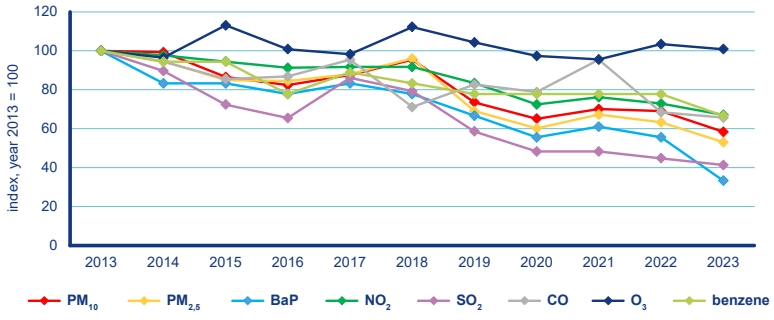
Exceptional Air Quality

The year 2023 was exceptionally favorable in terms of air quality. It extended the period from the year 2020, since when the concentrations of air pollutants are significantly lower than in the previous period. The concentrations of some of the pollutants (suspended particles PM_{10} and $PM_{2.5}$, nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO) and benzo[*a*]pyrene (BaP)) reached the lowest values in 2023 over the whole monitoring period.

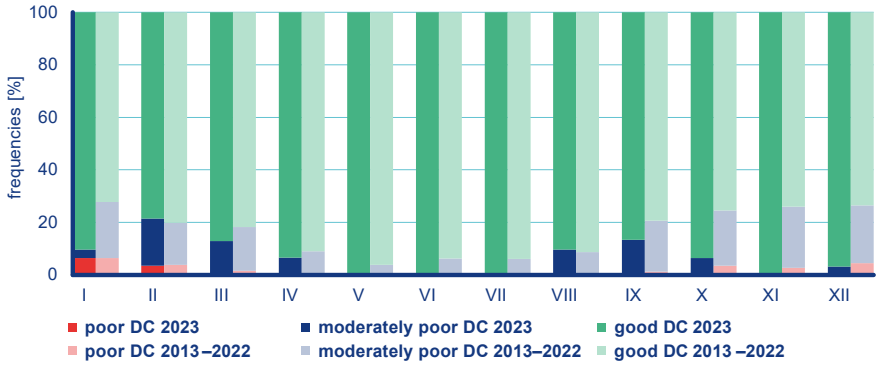
For the first time in the history of measurements, none of the ambient air quality limits for suspended particles PM_{10} and $PM_{2.5}$ were exceeded. In addition, as in previous years, the ambient air quality limits for NO_2, SO_2, CO and benzene were also not exceeded in 2023.

The relatively good air quality in the Czech Republic in the case of the above-mentioned pollutants (with the exception of ground-level ozone) in 2023 was mainly due to their lower concentrations during the winter period, when meteorological and dispersion conditions were favorable from an air quality perspective. Significant decreases in concentrations relative to the long-term average were observed in January and November. The low concentrations in January were due to above-normal air temperatures associated with a lower need for heating and thus lower emissions from local domestic heating. In November, dispersion conditions were unusually good throughout the month and there was also frequent rain, which is important for the so-called self-cleaning of the atmosphere.

Ongoing measures to improve air quality (replacement of old boilers in households, measures at large air pollution sources and renewal of the vehicle fleet) also contribute to the long-term improvement of air quality in the Czech Republic.



Trends in concentrations of selected air pollutants, 2013–2023.

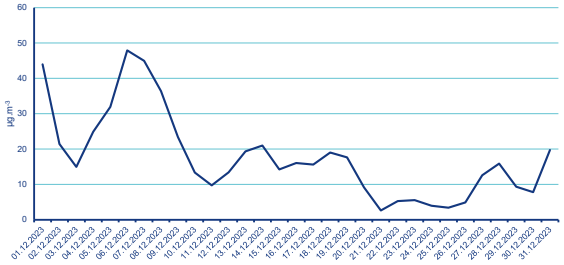


Frequency distribution of dispersion conditions in 2023 compared to 10-year average 2013–2022.

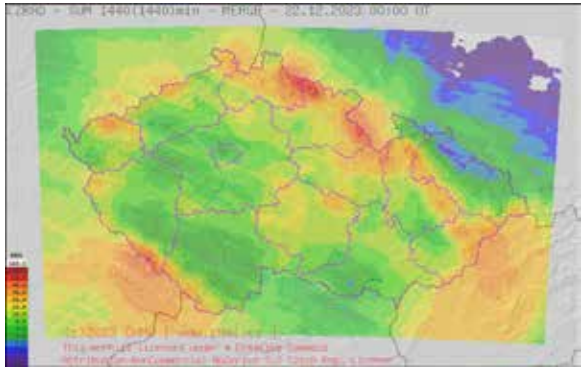
Record Low Particle Concentrations

Due to the long-term decreasing PM emissions in the Czech Republic and very favorable meteorological and dispersion conditions, historically lowest average daily PM_{10} concentrations were measured in the Czech Republic around Christmas 2023.

The lowest PM concentrations ever were measured on December 21, 2023. On December 20, 2023 it rained in most of the territory of the Czech Republic and concentrations dropped significantly, and on December 21, 2023 it rained heavily throughout the Czech Republic and was relatively windy. At the same time, the air temperatures were high for this time of year, reaching up to +8 °C in the lowlands. The very favorable dispersion and meteorological conditions, combined with the high temperatures and therefore low heating intensity, allowed PM concentrations to fall to unprecedentedly low values throughout the entire country. Daily average PM_{10} concentrations were up to a maximum of 3 $\mu g \cdot m^{-3}$ at most stations, with $PM_{2.5}$ concentrations falling to even lower values. The national average PM_{10} concentration on December 21, 2023 was only 2.6 $\mu g \cdot m^{-3}$. Only about 2 weeks earlier, it was almost 50 $\mu g \cdot m^{-3}$ mostly as a result of unfavorable meteorological and dispersion conditions, including significantly lower air temperatures.

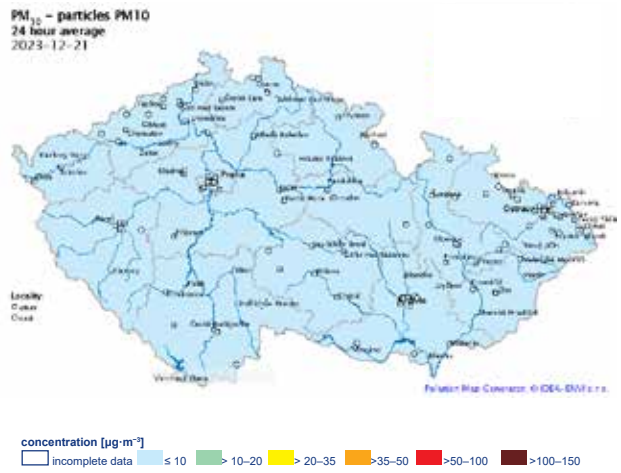


Average daily PM_{10} concentrations in the Czech Republic in December 2023.



Daily precipitation in the Czech Republic. December 21, 2023.

A more detailed analysis of the days with the lowest average PM concentrations ever in the Czech Republic reveals that these are primarily days in the colder half of the year, despite the fact that PM concentrations are in long-term highest in the coldest months. A potential explanation for this phenomenon is the fact that in the summer, at higher wind speeds, a higher amount of particulate matter may enter the air, e.g. through soil resuspension. Thus, although concentrations are overall lower in the summer, the very lowest ever minima are observed under exceptionally favorable conditions in the winter.



24-hour average PM_{10} concentrations, December 21, 2023.

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


Photo: Archive CHMI

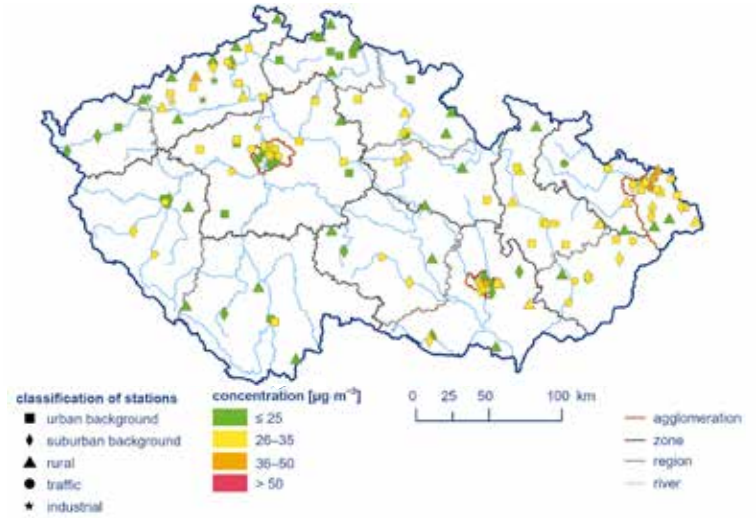
For the first time in the history of measurements, none of the ambient air quality limits for suspended particles PM_{10} and $PM_{2.5}$ were exceeded.

Suspended particles (or atmospheric aerosol) consist of a mixture of solid and liquid atmospheric particles with an aerodynamic diameter of less than 10 μm (PM_{10}) and 2.5 μm ($PM_{2.5}$) respectively. The abbreviation PM stands for *Particulate Matter*. Particulate matter has a wide range of effects on the cardiovascular and respiratory systems and is carcinogenic to humans, with $PM_{2.5}$ having more severe effects.

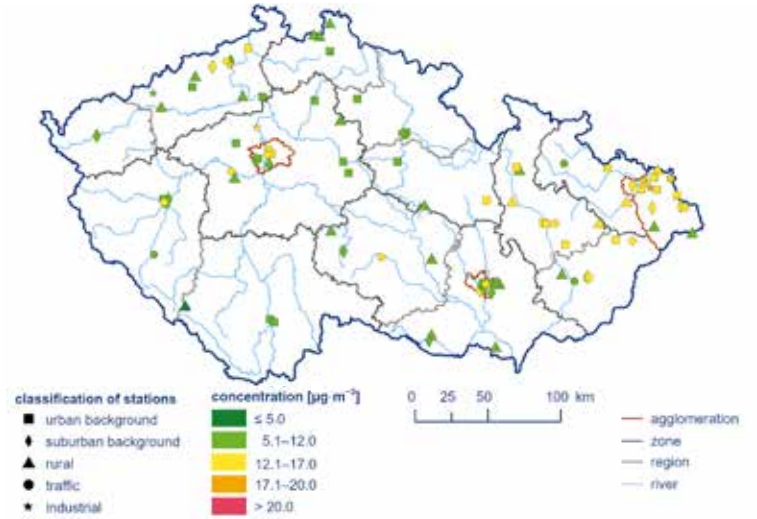
The 24-hour PM_{10} ambient air quality limit (50 $\mu g \cdot m^{-3}$, max. 35 exceedances per calendar year) was not exceeded in 2023. This marks the first year in the history of PM_{10} measurements since the 1990s that the 24-hour ambient air quality limit has not been exceeded. Exceedances of the limit value occurred most frequently in February, March and December. In December, three smog situations with a total duration of 4.4 days were declared in the Czech Republic.

The ambient air quality limit for the annual average concentration of PM_{10} (40 $\mu g \cdot m^{-3}$) was not exceeded in 2023, the fifth time in a row since 2019 in the entire history of PM_{10} measurements since 1993. The emission limit for the annual average concentration of $PM_{2.5}$ (20 $\mu g \cdot m^{-3}$) was not exceeded at any of the measurement stations in 2023. This is the first time this has happened in the history of $PM_{2.5}$ measurements since 2005.

Particle concentrations are highest in the cold season of the year. Higher air pollution during this period is related to both higher levels of particulate emissions from local domestic heating and transport (cold starts) and more frequent occurrence of poor dispersion conditions.



36th highest 24-hour average concentration of PM_{10} for the individual ambient air quality monitoring stations, 2023.



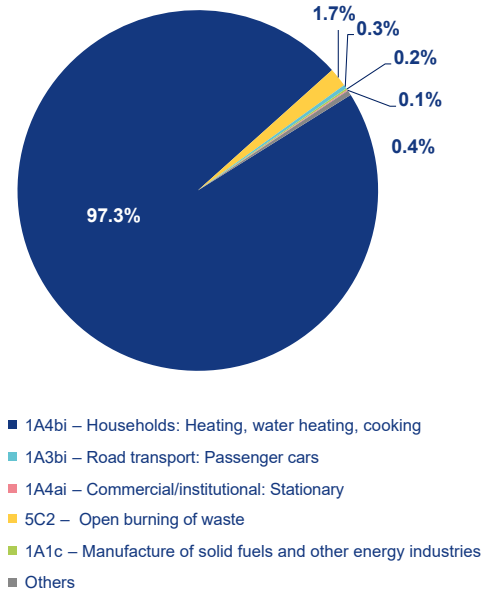
Average annual $PM_{2.5}$ concentrations for the individual ambient air quality monitoring stations, 2023.

Benzo[a]pyrene

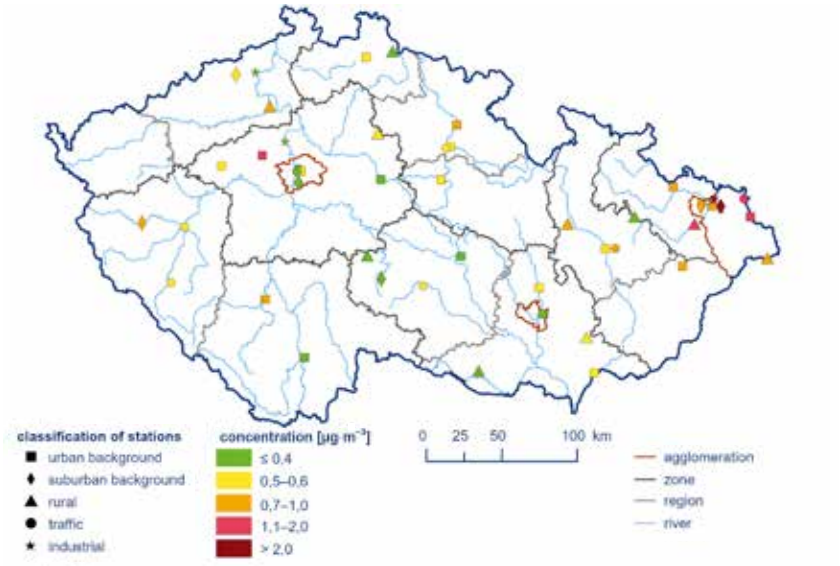
Benzo[*a*]pyrene air pollution has been one of the main air quality challenges in the Czech Republic for a long time. Benzo[*a*]pyrene has proven carcinogenic effects and its annual ambient air quality limit for health protection (1 μg·m^{-3}) is exceeded every year in many places in the Czech Republic.

Source of this air pollutant is predominantly local domestic heating, which accounts for over 97% of total benzo[*a*]pyrene emissions nationwide.

Preliminary data show a significant decrease in the number of stations with benzo[*a*]pyrene levels above the annual ambient air quality limit in 2023. Above limit concentrations of benzo[*a*]pyrene were measured at approximately 16% of the stations. The highest annual average concentrations of benzo[*a*]pyrene are in long-term being observed in the Ostrava/Karviná/Frýdek-Místek agglomeration. High above-limit concentrations of benzo[*a*]pyrene occur here in association with the highest emission load within the Czech Republic and the influence of long-distance transboundary transport from Poland. Higher values can also be expected in other municipalities with a higher proportion of household heating with solid fuels, where benzo[*a*]pyrene is not routinely measured. Concentrations of benzo[*a*]pyrene, like suspended particles, show a significant annual variation with highest values in winter due to higher heating intensity and emission production combined with the occurrence of adverse meteorological conditions during this period.



Sector share for total benzo[*a*]pyrene emissions, 2021.



Annual average benzo[*a*]pyrene concentrations in the Czech Republic, 2023.

Ground-level ozone

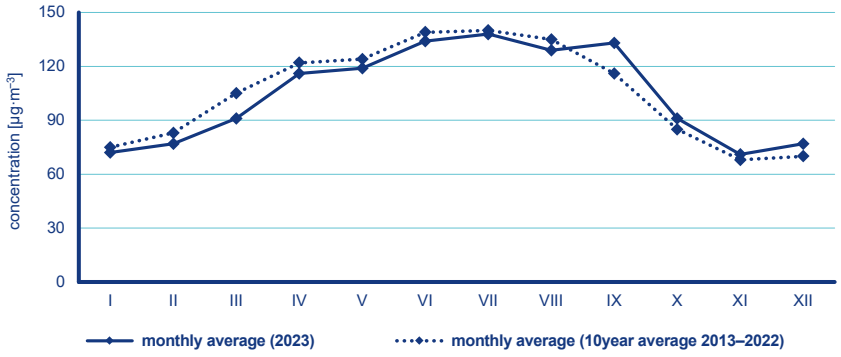

Photo: Adobe Stock

Ambient air quality limit for ground-level ozone (120 µg·m^{-3}, daily maximum 8h moving average, maximum allowed number of exceedances 25 per calendar year in 3-year average) was exceeded at 6% of stations (4 out of 68) in the period of 2021–2023.

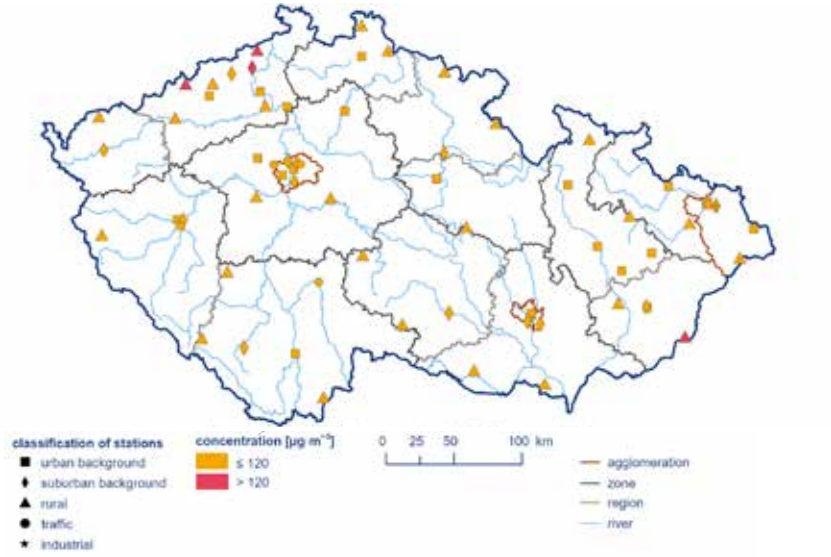
The limit was exceeded at three regional stations (i.e. far from emission sources; Sněžník, Štítná nad Vláří and Rudolice v Horách) and one suburban background station (Ústí n. L.-Kočkov). These stations are all located at higher elevations and/or in Ústecký region, where higher ground-level ozone concentrations are common.

Ground-level ozone does not have a direct emission source. It is a so-called secondary pollutant, which is created in various chemical reactions of other substances, so-called precursors (especially nitrogen dioxide and volatile organic compounds). Conditions favorable for the formation and accumulation of ground-level ozone in the ambient air are intense solar radiation, high air temperature, low relative air humidity or dry periods.

The annual course of monthly ground-level concentrations is characterized by increase in concentrations in spring and summer months. Average monthly concentrations of ground-level ozone between April and August of 2023 were slightly below the average value of the 10-year average for these months. In September the concentrations were above average as a result of meteorological conditions that were observed in September 2023 – exceptionally high temperatures and very low precipitation amount. One smog situation has been declared due to high ground-level ozone concentrations, specifically it was in September in Ústecký region, lasting 16 hours.



Annual course of monthly O_3 concentrations (max. daily 8h moving average), 2023.



26th highest values of maximum daily 8-hour moving average concentration of ground-level ozone as a 3-year average, 2021–2023.

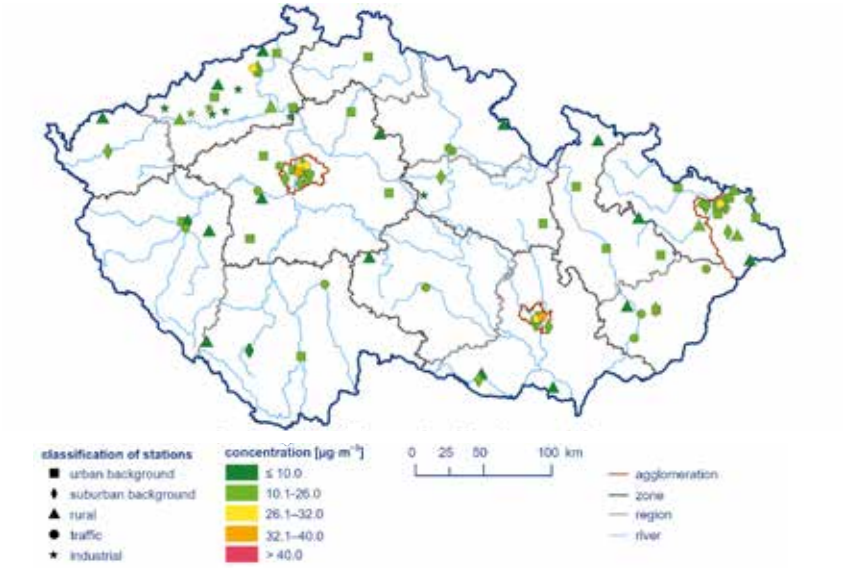
Nitrogen dioxide

The annual ambient air quality limit (40 µg·m^{-3}) for nitrogen dioxide (NO_2) has again not been exceeded at any station in the Czech Republic in 2023. Last limit exceedance has been observed in 2019.

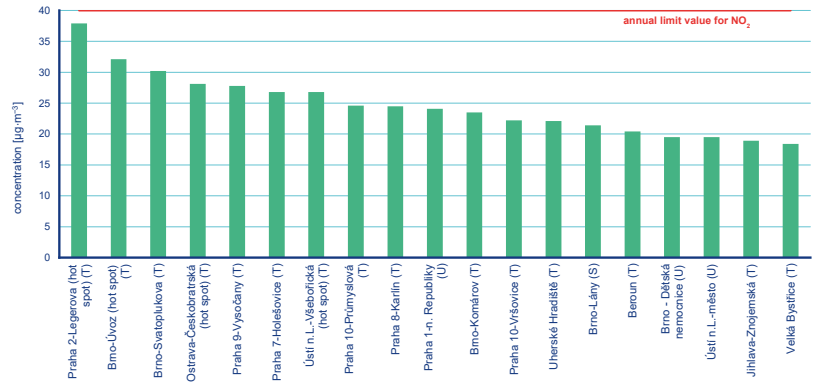
The highest annual average NO_2 concentration (37.9 µg·m^{-3}) was traditionally recorded at the Prague 2-Legerova hot-spot station. Highest NO_2 concentrations in the Czech Republic are for a long time being observed at this station due to the high traffic intensity in the immediate vicinity of the station and its location in a street canyon where ventilation is significantly reduced. High values of annual average NO_2 concentrations were recorded at traffic stations of the large cities of Prague and Brno. Higher NO_2 concentrations can also be expected near roads in larger cities with heavy traffic, higher density development and dense local traffic networks, where traffic flow is often reduced. Conversely, the lowest NO_2 concentrations are at regional background stations, i.e. in areas far from emission sources.

The ambient air quality limit for hourly NO_2 concentration (200 µg·m^{-3}) with a maximum of 18 allowed exceedances per calendar year, was not exceeded at any station in 2023. In fact, the hourly threshold value has not been exceeded a single time at any station.

Annual course of monthly average NO_2 concentrations is related to the varying intensity of emission sources and the effect of meteorological conditions throughout the year. Highest NO_2 concentrations are observed in the colder part of the year due to more frequent poor dispersion conditions as well as higher emissions from local domestic heating and vehicle cold starts.



Annual average NO_2 concentrations at the individual ambient air quality stations, 2023.



Annual average NO_2 concentrations at the individual stations (20 stations with highest concentrations (predominantly traffic stations)), 2023.


Photo: Adobe Stock

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