Weather, water and air

2024

Czech Hydrometeorological Institute

CHMI operates

29
professional meteorological stations

208
automated meteorological stations

178
rain gauge stations

1
aerological station

2
meteorological radars

2
sodars

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

291
manual rain gauge stations

4
windprofilers

537
surface water limnographic stations

1 522
hydrogeological wells

318
springs

48
automated snow gauge stations

17
automated snow pillows

49
air pollution monitoring stations with manual programme

50
air pollution monitoring stations with automatic programme

55
air pollution monitoring stations with manual and automatic programmes

725
groundwater quality monitoring sites

14
rain water quality monitoring stations

27
phenological monitoring locations

Meteorological stations

Hydrology station network

Air quality monitoring

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.

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, researchers' night, etc.

Mobile application Weather CHMI

Expert assessments and activities in the fields of competence

Content


Photo: Adobe Stock

22

At the end of the year, a strong high-pressure system moved into Central Europe, causing inversion weather and worsening dispersion conditions. This led to increased concentrations of PM_{10}, especially in the north-east of the Czech Republic. Smog situations were declared in the O/K/F-M and Třinec agglomerations, followed by regulations in the O/K/F-M agglomeration.

6

November was the only month of 2024 that was colder than the normal of 1991–2020. However, with the anomaly of monthly mean temperature over the Czech Republic −0.7 °C, it was still assessed as a month with near-normal temperature.

16–17

Between September 11 and 16, 2024, the Boris low-pressure system brought extreme rainfall associated with devastating flooding. On 14 September 2024, the historical record for daily rainfall was broken when the Švýcárna station (Šumperk district) recorded 385.6 mm.

11

On August 1, very intense rainfall was recorded at the stationary cell. The highest hourly rainfall total in 2024 (105.6 mm) was measured at the Kubova Huť station in Šumava.

24

At the end of July, three simultaneous smog situations were declared due to high concentrations of ground-level ozone in the Central Bohemian and Ústí nad Labem regions and in Prague.

22

The cold anticyclonic weather during the second decade of January caused a significant increase in concentrations of PM_{10} suspended particles and the subsequent announcement of a smog situation in the Moravian-Silesian Region.

6

February was exceptionally warm, the warmest February ever recorded in the Czech Republic since 1961, with a record high anomaly (+6.1 °C) relative to the February average from 1991–2020. As a result of extremely above-normal temperatures, above-normal precipitation and improved dispersion conditions, low concentrations of air pollutants were measured in February.

21

The major growing season began between February 9 and March 11, which was three weeks earlier than in 2023.

26–27

The episode of Saharan sand dust passing over the Czech Republic at the turn of March and April 2024 brought the most significant deterioration in air quality due to this phenomenon in the modern history of air quality measurements in our territory.

6

April 7 was the first tropical day of 2024, the earliest on record.

15

The lowest average monthly flow (34% QV) was recorded in May in the Odra River basin.

11

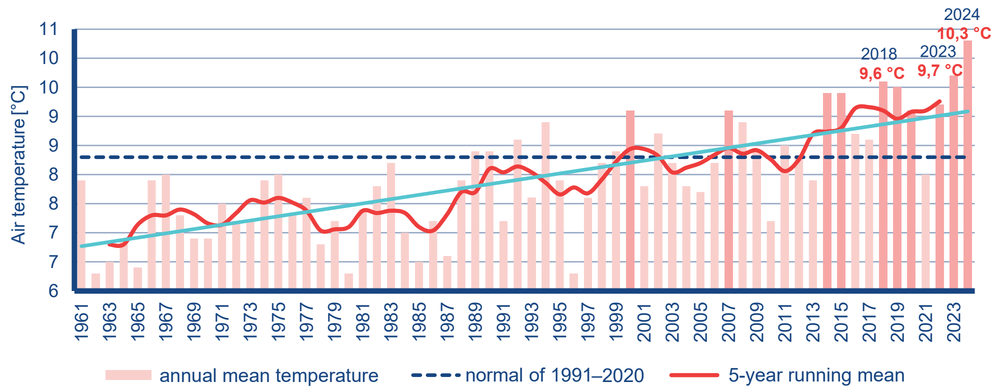
On June 22, a downburst hit the Třinec area and caused extensive damage. However, this storm intensified just before reaching Ostrava and Třinec. A few hours before midnight, a similar, more isolated storm produced a downburst around the village of Studénka, where it caused extensive local damage.

Content

Air temperature

The year 2024 was exceptionally warm. The annual mean air temperature over the area of the Czech Republic (10.3 °C) was 2.0 °C above the normal of 1991–2020. This made 2024 the warmest year on record (since 1961).

2024 was the first year with an annual mean air temperature above 10 °C in the Czech Republic. The mean temperature of the warmest years to date, 2023 (9.7 °C), 2018 (9.6 °C), 2019 (9.5 °C), 2014 and 2015 (9.4 °C), was exceeded by a significant margin.

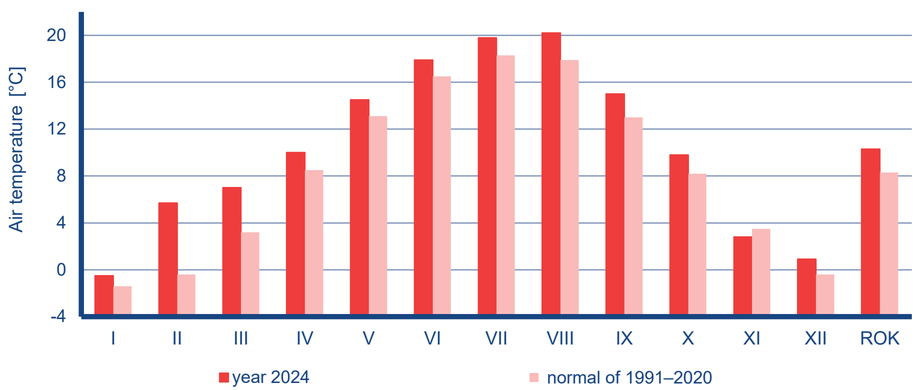


Annual mean air temperature over the area of the Czech Republic [°C] in comparison to the normal of 1991–2020 and fitted linear line (blue) from 1961–2024.

Temperature in the year 2024

All months of 2024, except for November, recorded a positive anomaly of the monthly mean air temperature over the area of the Czech Republic relative to the normal of 1991–2020. February (anomaly +6.1 °C) and March (anomaly +3.8 °C) were exceptionally warm. These months were the warmest February and March in the Czech Republic on record. February also brought a record-high monthly mean temperature anomaly.

April to October were assessed as warm or very warm months with temperature anomalies ranging from +1.4 to +2.3 °C. The first hot day (daily maximum air temperature ≥ 30 °C) of the year occurred on April 7, which was the earliest such day on record in the Czech Republic. Daily maximum temperature greater than 30 °C were measured at the following stations: České Budějovice 30.9 °C, Prague-Komořany 30.6 °C and Čáslav 30.1 °C. January and the final months of the year (November and December) had near-normal monthly mean air temperature.



Annual and monthly mean air temperature over the area of the Czech Republic [°C] in the year 2024 in comparison to the normal of 1991–2020.

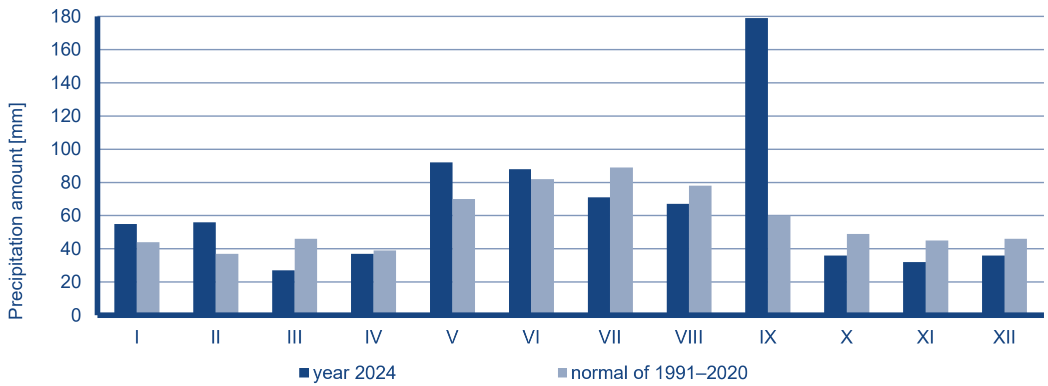
Precipitation

In the year 2024, the Czech Republic received above-normal precipitation amount. The mean annual precipitation amount over the area of the Czech Republic was 776 mm (113% of the normal of 1991–2020).

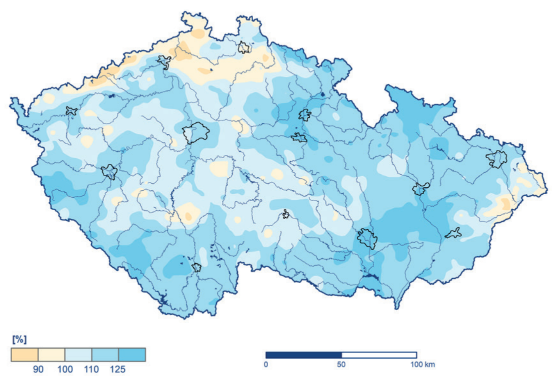
It was the 9th wettest year in a series of the annual precipitation amounts since 1961. The previous higher annual precipitation amount was recorded in 2010 (867 mm, 127 % of the normal) and a slightly lower amount in 2020 (766 mm, 112 % of the normal).

Precipitation in the year 2024

During the year 2024, both precipitation-rich and precipitation-poor months were recorded. In September, an exceptional precipitation amount (179 mm, 298% of normal) was recorded. This was associated with an extreme precipitation event from September 11 to 16, which led to devastating floods. The most extreme rainfall occurred on September 14, especially in the eastern part of the country in the Jeseníky and Beskydy mountains. The highest daily amount (385.6 mm) was recorded at the Švýcárna station (Šumperk district), surpassing the previous record for the highest daily precipitation amount measured in the Czech Republic of 345.1 mm (Bedřichov, Nová Louka, July 29, 1897). Wetter-than-normal months were also January, February and May, with amounts of 55 mm (125% of normal), 56 mm (151% of normal) and 92 mm (131% of normal), respectively. Conversely, March was drier than normal with precipitation amount of 27 mm (59% of normal).



Mean monthly precipitation amount over the area of the Czech Republic [mm] in the year 2024 in comparison to the normal of 1991–2020.



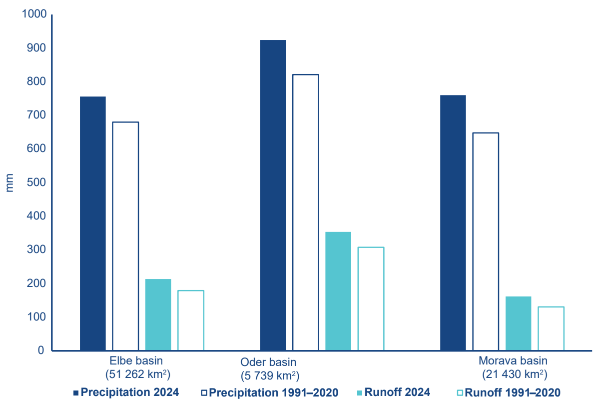
Annual precipitation amount in the year 2024 in % of the normal of 1991–2020.

Spatial distribution of precipitation

In 2024, Bohemia received 758 mm of precipitation (111% of normal), while Moravia and Silesia received 808 mm of precipitation (117% of normal). The annual precipitation amounts were above normal in all regions of the Czech Republic. The wettest regions in comparison to normal were South Moravian and Olomouc regions with precipitation exceeding of 120% of normal. The driest regions compared to normal were the Ústí nad Labem and Liberec regions (less than 105% of normal).

Runoff conditions

Photo: Adobe Stock



Comparison of precipitation and runoff for 2024 with long-term averages for the period 1991–2020 for the main river catchments.

The year 2024 can be assessed as average to above average across the whole territory of the Czech Republic.

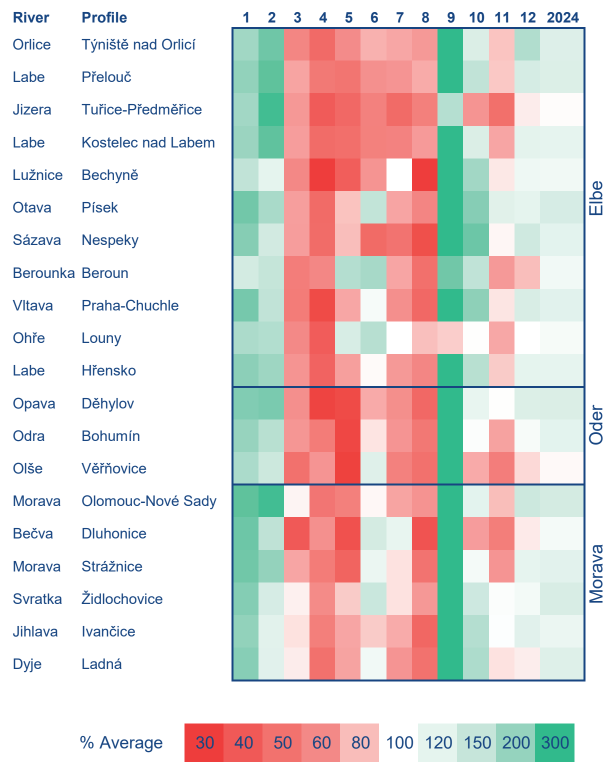
Annual runoff

The annual runoff, in relation to the long-term mean discharges for the period 1991–2020, can be assessed as average to above average. Specifically, 119% of the long-term average discharged from the Elbe basin, 115% from the Oder basin, and 124% from the Morava basin.

Runoff distribution during the year

During the year, average monthly discharges ranged from about 50% (April) to nearly 400% (September) of their long-term values. The greatest fluctuation was recorded on the Opava River at the Děhylov gauge, where discharge was strongly below average in April (36%) and exceptionally above average in September (679%).

In January and February, discharges were above average to significantly above average due to precipitation and snowmelt in mountainous areas. The spring months (March–May) were below average in most basins, except for the Berounka at Beroun and the Ohře at Louny, where heavy May rainfall caused a marked increase. In June, flows were generally average, but much above average on the Berounka and Ohře due to residual runoff from late May precipitation, while remaining below average on the Elbe upstream of the Vltava confluence and on the Sázava and Lužnice. From July onwards, discharges declined until the extreme flood in mid-September. The September flood primarily affected the Oder basin, but also significantly impacted rivers in the Morava basin, the Lužnice basin and tributaries of the Elbe upstream of the Vltava confluence. As a result, average monthly discharges on affected rivers were extraordinarily above average, exceeding 300% of long-term values. The Ohře and its tributaries were largely unaffected. In October, discharges were above average, in November average, and in December slightly above average due to rainfall and snowmelt.



Mean monthly discharges in 2024 in % of long-term monthly mean discharges over the period 1991–2020.

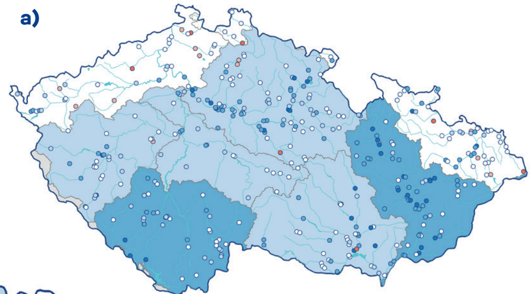
Groundwater levels

Groundwater levels in shallow circulation were overall much above normal in 2024, representing the best condition of the last ten years. In deeper circulation (water--important areas), the condition was normal.

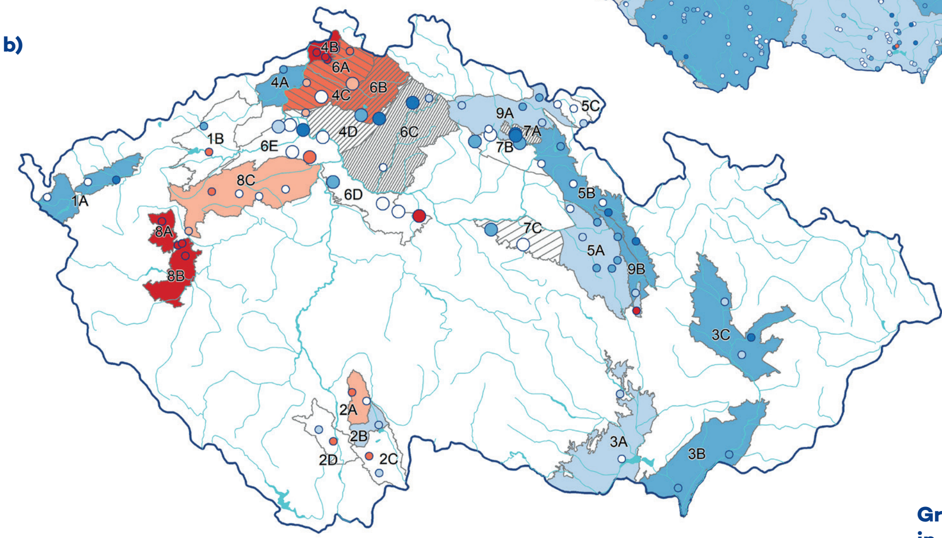
Shallow boreholes

At the beginning of the year, levels were extremely above normal as a result of December floods of the previous year. In February, the level reached the annual maximum, which was extremely above normal. From March onwards, groundwater levels gradually declined, remaining predominantly within the normal range, reaching the annual overall normal minimum in August. An exception was the Lužická Nisa basin, where the condition was extremely and strongly below normal in July and August, respectively. In September and October, groundwater levels rose again to a much above-normal condition. Overall, the level remained moderately to much above normal until the end of the year.

a)



b)



extremely below normal
much below normal
moderately below normal
normal
moderately above normal
much above normal
extremely above normal

HGR – cenoman

extremely below normal
much below normal
moderately below normal
normal
moderately above normal
much above normal
extremely above normal

HGR group

1 – Under the Ore Mountains basins
2 – South Bohemian basins
3 – Moravian Tertiary
4 – North Bohemian Cretaceous basins
5 – East Bohemian Cretaceous basins
6 – Nort Bohemian Cretaceous basins – Cenomanian
7 – East Bohemian Cretaceous basins – Cenomanian
8 – Permocarboniferous basins of the Western and middle Bohemia
9 – Permocarboniferous basins of the Eastern Bohemia

Boreholes

○ HGR – main layer ◯ HRG cenoman

Groundwater levels in 2024 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

In the first quarter, levels were moderately to much above normal, and during the rest of the year they were predominantly within the normal range. However, regional differences were observed. In the North Bohemian Cretaceous basin, groundwater levels were extremely below normal from April until the end of the year, and in the Permocarboniferous of Central and Western Bohemia they were much to extremely below normal throughout the year. In contrast, in the Cenomanian of the East Bohemian Cretaceous basin, levels persisted in a much to extremely above-normal condition throughout the year. In the Moravian Tertiary, high precipitation totals in September and October caused groundwater levels to reach an extremely above-normal condition, and by the end of the year they decreased to a much above-normal level.

Convective season

Photo: Adobe Stock

The year 2024 brought a record number of warnings from the CHMI, particularly in connection with the September floods and a significant convective season. The collection of reports on hail occurrence via social networks was also launched in co-operation with AMS. The results of this cooperation were also used in the following summary of significant storm situations, not only hailstorms.

May 18

Around 5 p.m., a weak tornado appeared near Valtířov (Velké Březno, Ústí nad Labem Region) – the first case this year. It occurred on a weaker line of showers from Saxony, the more significant part of which showed short-term rotation according to Doppler radars. The tornado crossed the Elbe River, which was captured on video by eyewitnesses, and caused minimal damage (slightly damaged paving and minor damage to vegetation). It was a typical example of a short-lived, weak tornado, which is relatively common in our country.

May 19

On this day, the first significant storm situation of 2024 occurred. In the afternoon, several right-moving supercells appeared in the northern and eastern parts of Bohemia, followed later in the evening by a left-moving supercell in the Vysočina region. The most significant of these brought hailstones measuring 3–5 cm to the Nymburk and Poděbrady regions in the evening, which is quite a significant result for mid-May.

June 2

On June 2, we saw just how extremely localised flash floods can be. Slow-moving and relatively "innocent"-looking storms passed through the Starý Plzenec area southeast of Plzeň around noon. The combination of high soil saturation, inappropriate land use, the nature of the local terrain and intense rainfall caused extreme flash flooding in the village of Štěnovice, which flooded the Losinský stream. Štěnovice lies in the lower part of the basin, which is why most of the rainfall concentrated in this small stream, which had been improperly modified decades ago. The rise in the water level occurred so quickly that some people were trapped and a helicopter from Líní had to be called in for evacuation. According to amateur stations, 60–80 mm of rainfall fell. A similar situation occurred in Štěnovice in 1975. This case shows that over time, the same areas are repeatedly affected due to their greater vulnerability to torrential rainfall.

Consequences of flash flooding in Štěnovice on June 2, 2024. Source: iDNES.cz.

June 21

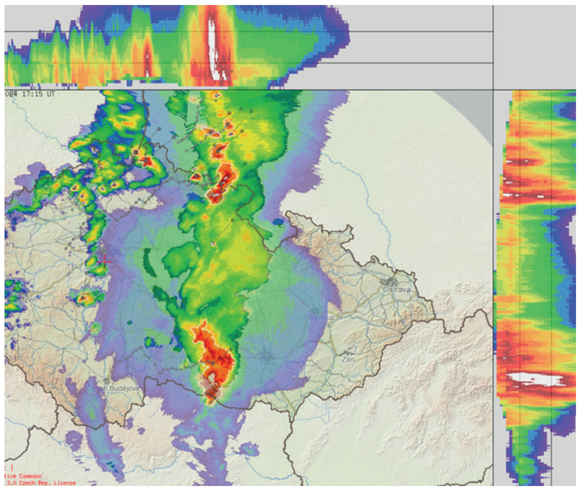
In recent years, the second half of June has been marked by storms. This was no different in 2024, when we recorded the most significant supercell, and especially hail, situation of the year. This was clear from a forecasting perspective; the only question was the influence of Saharan dust in the atmosphere, which could have hindered or slowed down the development of storms. However, this did not happen, and the first very intense supercell storms began to form in the afternoon in the Pošumaví region in an environment with high available convective energy and sufficient wind shear. Within 30 minutes of their formation, the supercells were able to produce hailstones measuring 4 to 7 cm in the Písek area. Another supercell convection also formed during the afternoon in central Bohemia, where we recorded hailstones measuring 4 to 6 cm, mainly in the Mělník, Kladno and Nymburk areas. The most significant hailstones of the day were brought by an embedded supercell at the southern tip of a bow echo convective system, which passed over the Vysočina region towards southern Moravia. In several villages north of Znojmo, hailstones measuring 5 to 7 cm fell around 7:30 p.m., with the largest reaching a diameter of up to 9 cm. Although localised, there was significant damage to houses and cars in the area.

June 22

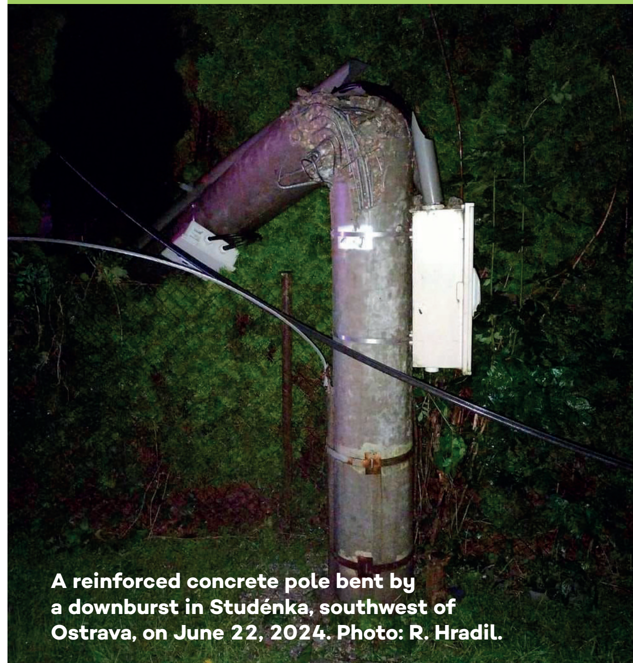
The convective situation continued throughout the night in the Moravia and Silesia regions. In the early hours of the morning, the Třinec area was severely affected by a smaller linear storm system. It was hit by a downburst – an intense drop of cold air in the storm's downdraft, which caused extensive damage. These situations are very difficult to predict from a nowcasting perspective, as most storms tend to be elevated and downdrafts cannot penetrate the stable layer near the Earth's surface. However, this storm intensified just before reaching the Ostrava and Třinec areas. A few hours before midnight, a similar, more isolated storm produced a downburst in the vicinity of the village of Studénka, where it caused extensive local damage. The intensity of the phenomenon is evidenced by a bent reinforced concrete pole.

August

August is usually the main month associated with torrential rainfall. On August 1, we measured a total of 105.6 mm per hour at the Kubova Huť station in Šumava during a stationary cell of intense rainfall. The flood caused major problems, especially in Horní Vltavice. On August 17, the Moravia and Silesia regions were more severely affected, with some stations recording up to 70 mm. On August 18, the centre of precipitation shifted to Bohemia. Stachy in Šumava and Zbiroh were hit the hardest. In Stachy, amateur stations measured over 100 mm, although the CHMI station in Zdíkov recorded "only" 55 mm. In the second half of the day, high totals were also measured in central Bohemia and the Náchod region, where some stations recorded around 70 mm.



The radar image shows an extensive convective system of the bow echo type (curved in the direction of the flow) in the Znojmo area. In its southern part, there is an embedded supercell, which produced the largest hailstones recorded last year. Note the highest radar reflectivities (shown in white in the side view) reaching high vertically in the atmosphere, even above 10 km.



A reinforced concrete pole bent by a downburst in Studénka, southwest of Ostrava, on June 22, 2024. Photo: R. Hradil.

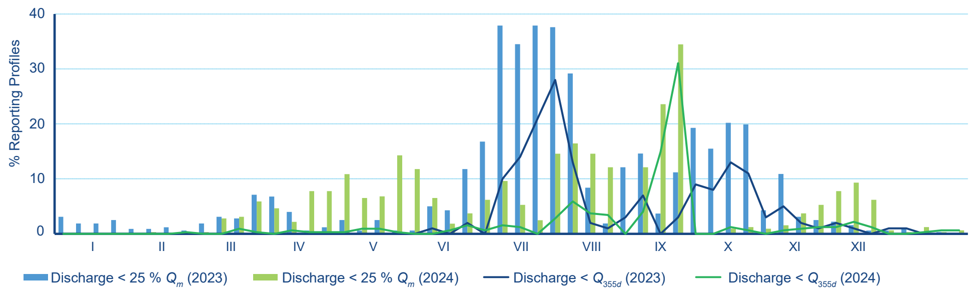
On 21 June 2024, hailstones measuring 9 cm were recorded in the village of Hluboké Mašůvky in the Znojmo region. Photo: E. Procházková.

Drought

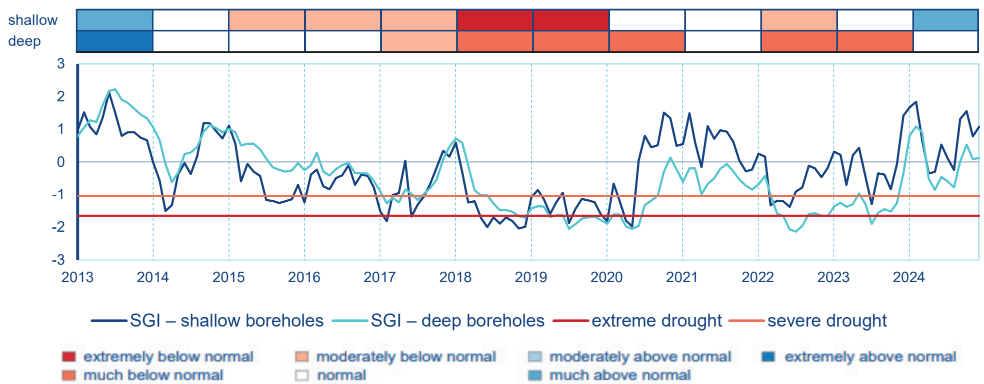
In 2024, drought occurred only sporadically in surface waters and in the shallow groundwater circulation. In the deep groundwater circulation, however, drought persisted in some areas for most of the year.

Surface Water

Compared to the previous year, 2024 was significantly wetter in terms of hydrological drought. From January until mid-July, drought was almost absent across the Czech Republic. From mid-July onwards, the number of profiles with discharges indicating drought (< Q_{355d}) or flows below 25% of Q_m gradually increased. During this period, long-term mean monthly discharges were average or below average in most of the main river basins. The end of August and the beginning of September represented the least watery period of the year. The driest conditions occurred at the end of the first September decade, when drought was recorded at about 30% of profiles. In September, drought was terminated by heavy rainfall and subsequent floods. The remainder of the year was characterised by minimal or only sporadic occurrence of drought.



Weekly drought trend (Q_{355d}*) in 322 reporting profiles in the Czech Republic in 2023 and 2024. Q_m – 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.**

Groundwater

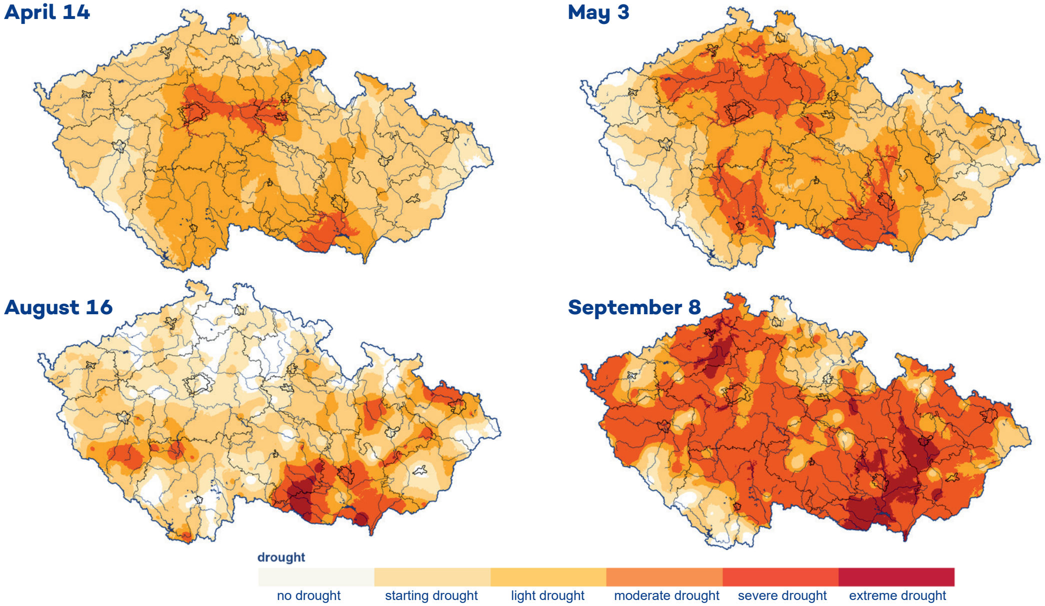
In the shallow circulation, groundwater levels reached the best condition of the past ten years, and drought occurred only sporadically. In the Lužická Nisa basin, however, exceptional drought was observed in July and severe drought in August; in other basins such severe conditions did not occur. In the deep circulation, conditions improved to an overall normal state, but regional differences remained. In some areas, drought from previous years persisted. In the North Bohemian Cretaceous basin, groundwater levels were extremely below normal from April until the end of the year, while in the Permocarboniferous of Central and Western Bohemia, levels were much to extremely below normal throughout the year.

* 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

Soil drought

Soil drought in 2024 can be assessed as moderate compared to previous years. In the 0–40 cm layer, drought occurred only in shorter time intervals. A more significant occurrence was recorded in April and early May, when severe drought appeared in most of the territory, reaching extreme intensity in some areas. Severe to extreme soil drought was also recorded at the turn of August and September.

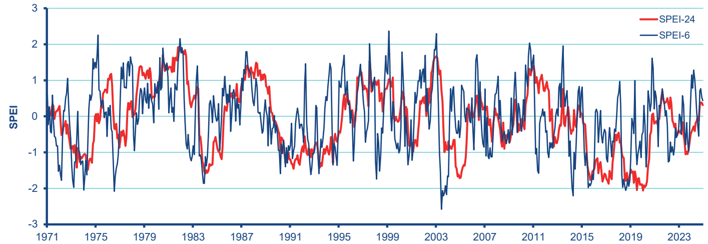


State of soil drought in the surface layer of 0-40 cm on April 14, May 3, August 16 and September 8, 2024.

The state of soil drought in the surface layer of 0–40 cm varied significantly between months and locations within our territory. The growing season began 3–4 weeks earlier than normal, which contributed to the early onset of drought. Soil drought in the surface layer of 0–40 cm occurred as early as the beginning of April, when severe to moderate drought was recorded, especially in Bohemia. In mid-April, severe to moderate drought spread from Bohemia to southern Moravia. The drought peaked in early May, when severe drought occurred over a larger area. At the end of June, only eastern Bohemia was experiencing severe drought. In mid-August, severe drought was recorded exceptional drought, especially in southern Moravia. By the beginning of September, severe to exceptional drought also spread to Bohemia.

Course of the SPEI index*

From January to the end of August 2024, SPEI-24 values were less than 0, indicating persistent drought conditions. The lowest SPEI-24 values, below –0.4, were recorded in April. Negative SPEI-6 values occurred only in July and August.



Course of SPEI indices calculated for 6 and 24 months from 1971–2024 for the region of the Czech Republic. The lower the values, the more intense the drought.

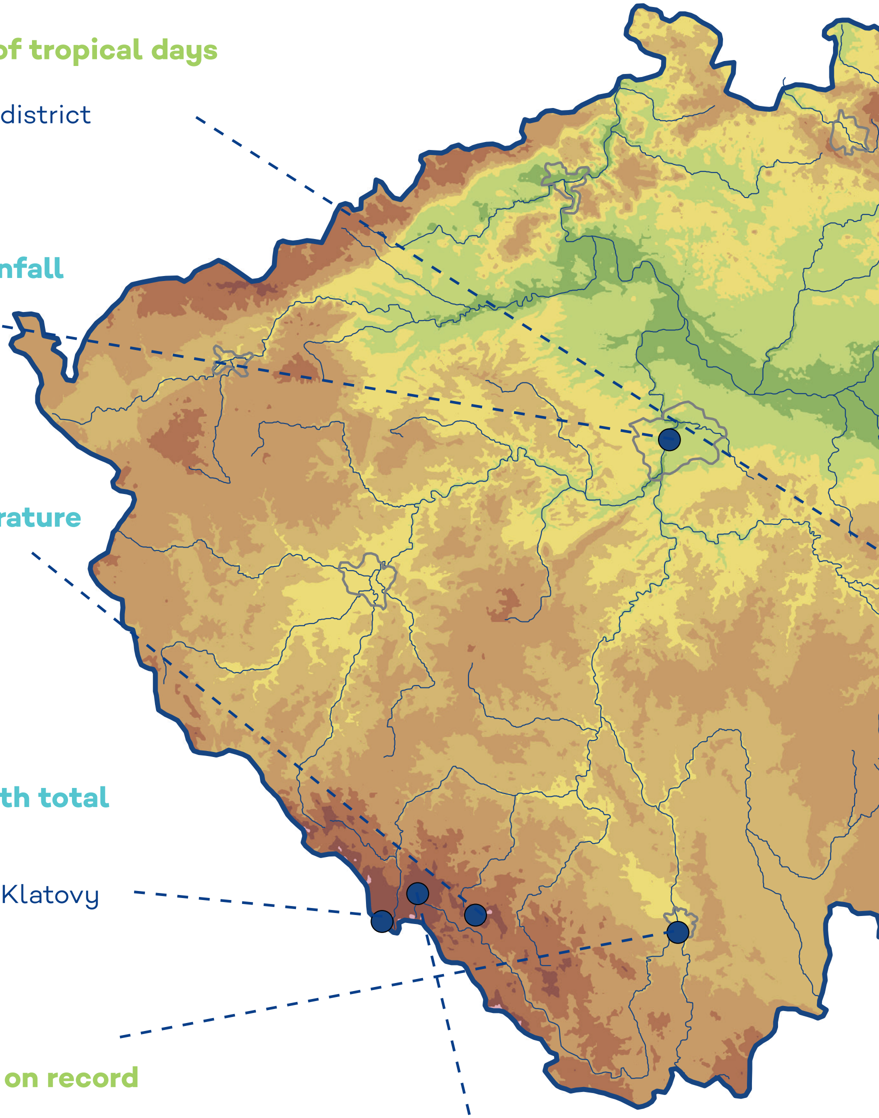
* SPEI index (Standardized Precipitation-Evapotranspiration Index) is based on the difference between precipitation amount and potential evapotranspiration. It is a standardized quantity, which means its values can be compared across various regions and periods.

SPEI can be calculated for periods of various 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.

Map of extreme events

Foto: 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 number of tropical days
47 days
Strážnice, Hodonín district

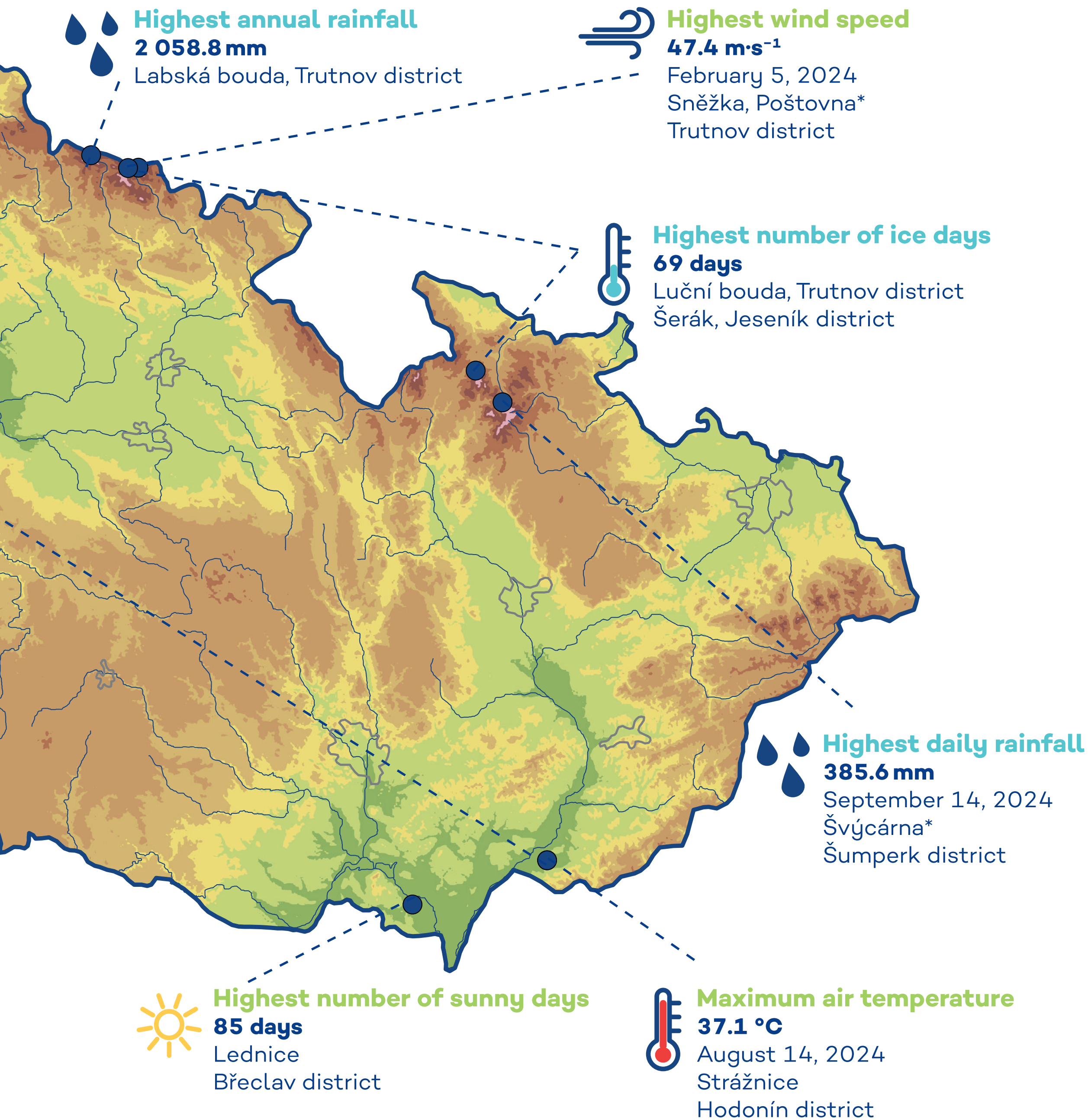
Lowest annual rainfall
474.2 mm
Prague, Karlov
Prague district

Minimum air temperature
−24.0 °C
January 17, 2024
Kvilda-Perla*
Prachatice district

Highest snowdepth total
170 cm
January 17, 2024
Blatný vrch*, okres Klatovy

Earliest tropical day on record
April 7, 2024
České Budějovice

Highest hourly rainfall
105.6 mm
August 1, 2024
Kubova Huť
Prachatice district



Highest values of average monthly discharges in main basins were recorded in September in the Odra basin (546 % Q_{IX}) and Dyje basin (507 % Q_{IX}).

Overall, the lowest average monthly flow (34 % Q_{V}) was recorded in May in the Odra river basin.

The largest water reserves in the snow cover during the winter of 2023/24 were December 4, 2023, with a total amount of 2.122 billion m³, which corresponds to 26.9 mm. This amount was the highest overall for this week in terms of a comparison of winter seasons evaluated since 1980. The greatest snow cover was in the Šumava Mountains, with 35 to 90 cm, the Beskydy Mountains, with 25 to 78 cm, the Jeseníky Mountains, with 25 to 70 cm, and in the Krušné Mountains 30 to 68 cm.

In terms of the number of profiles for which a state of hydrological drought – Q_{355d} – was indicated in 2024, the period of July, August and the first ten days of September was assessed as the most hydrologically dry. The highest total number (200) of profiles indicating hydrological drought was recorded on September 8, 2024.

---

* **Stations not operated by the CHMI**

September 2024 Flood

River channel of the Bělá in the municipality of Mikulovice (Jeseník District) on September 19 2024. Photo: Archive CHMI Ostrava.

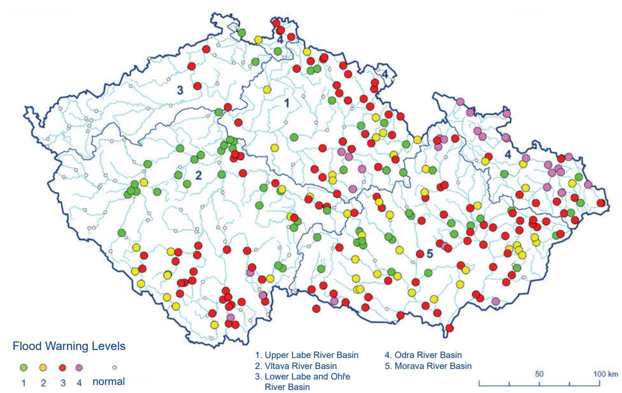
In September 2024, the Czech Republic was affected by extreme precipitation, which caused the most significant runoff situation of the last decade. This flood was exceptional not only in the extent of the affected area but also in the magnitude of peak flows, which in many locations exceeded previously recorded maxima. The most severely affected regions were Moravia and Silesia; however, extreme discharges occurred almost throughout the country, except in western Bohemia.

Causes of the Flood Episode

The primary cause of this extreme event was the enormous precipitation totals that fell during the second decade of September. Precipitation evolved from light and moderate at the beginning to very intense at the end, when rain fell on already saturated soils. The rainfall was further amplified by orographic effects, especially in the Krkonoše and Jeseníky Mountains. The extraordinary rainfall totals resulted from a wavy cold front passing on the night of September 11–12, followed by a low-pressure system affecting the Czech Republic. At some sites, precipitation reached up to 500 mm within five days, particularly in the Krkonoše and Jeseníky. The most significant rainfall occurred between September 12 and 16, with five-day totals ranging from 100 to 300 mm across most of the country, while in western and northwestern Bohemia they remained between 30 and 70 mm.

Runoff Conditions

In response to forecasts of very high precipitation, water management enterprises released water from reservoirs to increase retention capacity. On rivers downstream of major reservoirs, particularly in Moravia, 1st flood warning levels were reached as early as September 12. Subsequent intense precipitation caused rapid rises in river levels, leading to widespread floods across much of the country, with frequent attainment of 3rd flood warning levels. The only major basin not to reach any warning level was the Ohře. The most affected catchment was the Odra, where some sites exceeded the 100-year discharge (Q_{100}). On the Černá Opava at Mnichov, even a flow beyond Q_{100} was recorded on September 15. Q_{100} was also reached on the Bílovka at Velké Albrechtice, the Odra at Svinov, the Opavice at Krnov, the Hvozdnice at Jakartovice, the Opava at Děhylov, the Stonávka at Hradiště and the Bělá at Mikulovice. In the Morava and Dyje basins, extreme levels were also recorded, with Q_{100} reached on several rivers (e.g. the Krupá at Habartice, the Velička at Velká nad Veličkou and the Dyje at Podhradí nad Dyjí). In the upper Elbe basin, warning levels were exceeded from September 12, with peaks generally by September 15. On the Novohradka at Luže and Úhřetice, the 100-year level was reached on September 15. Similar conditions occurred in



Flood warning levels recorded in September 2024.

the Vltava basin, with pronounced rises on the Sázava, Lužnice and Malše; on the Malše at Pořešín and the Lužnice at Pilař, Q_{50} levels were exceeded, while elsewhere mostly Q_{2-10} was reached. In total, the 3rd warning level was reached or exceeded at 180 profiles out of 366 monitored by the ČHMÚ Flood Forecasting and Warning Service, and at 42 profiles, an extreme flood was recorded.

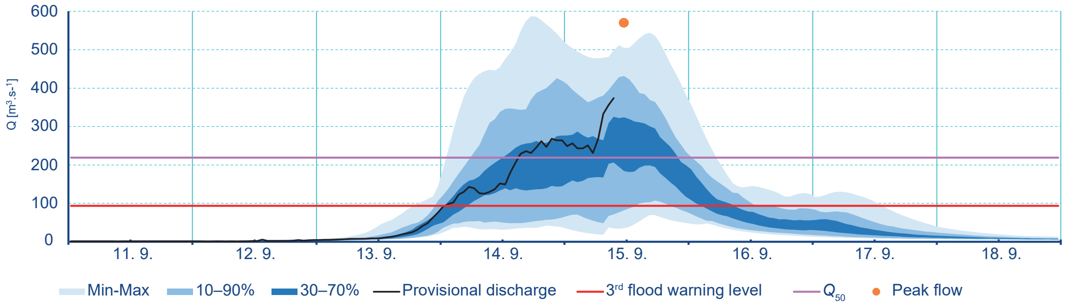
Floodplain of the Lužnice River south of Veselí nad Lužnicí in the municipality of Vlkov.
Photo: September 19 2024, South Bohemian Regional Authority.

Evaluation of the Flood

The most severely affected area was the Jeseník region, particularly the Opava basin, the upper Morava basin (the Morava River and its tributaries such as the Branná, Desná and others), and the catchments of tributaries of the Kladská Nisa (Vidnava, Bělá, etc.), where extreme flood levels were greatly exceeded and in some profiles historical maxima were reached. Evaluation of hydrographs, including peak discharges, has not yet been completed in the most affected basins due to major changes in river cross-sections. Estimates of peak discharges are being carried out using hydraulic models in cooperation with external experts.

Despite the extreme nature of the flood, water management enterprises, based on timely precipitation forecasts, were able to release storage volumes in major reservoirs, which helped mitigate the downstream flood course. Relatively low initial soil saturation also delayed runoff response and, in less affected areas, reduced the overall impacts.

Mikulovice station after the flood on October 1 2024. Photo: Archive CHMI Ostrava.



Probabilistic discharge forecast for the Bělá River from all available meteorological inputs on September 12 2024 at 07:00, supplemented with the evaluated peak discharge.

Surface water quality

In 2024, the most common exceedances in surface waters were for nutrients (especially total phosphorous), organic pollution indicators and polycyclic aromatic hydrocarbons (PAHs). 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

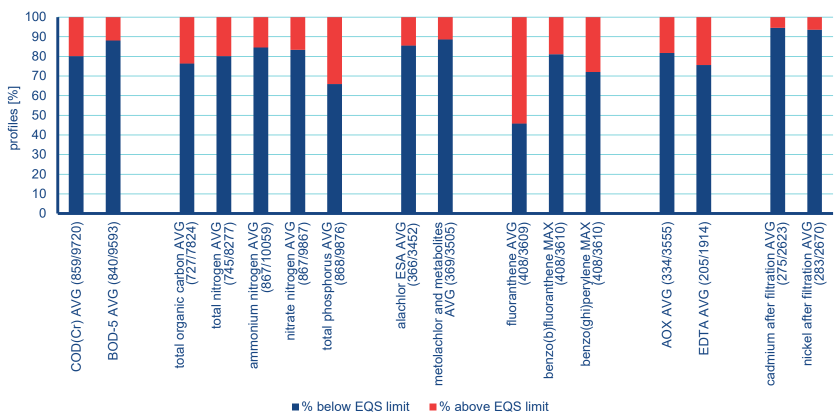
Of the nutrients, total phosphorus was the most frequent to exceed the limit value (34% of the profiles). Total nitrogen, chemical oxygen demand (CODCr) were at concentrations above the limit in less than 20% of the profiles, while approx. 15% of the profiles exhibited concentrations above the limits for ammonium and nitrate nitrogen. The limit for total organic carbon (TOC), which reflects the total organic compounds of the water, was exceeded in 24% of the profiles. The pollution sources are mainly wastewater and agriculture.

Pesticides

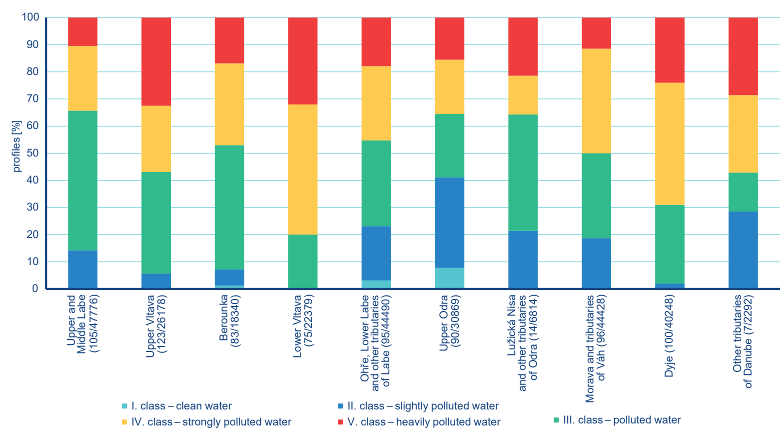
The most frequent pesticides found at above limit levels (> 10% of profiles) were metabolites of herbicides alachlor, especially alachlor ESA (used in rape cultivation) and metolachlor and its metabolites (used in maize cultivation).

Heavy metals, PAHs, other pollutants

Heavy metals (in dissolved form) nickel and cadmium exceeded the limit values in > 5% of profiles and lead and mercury in 1–2% of profiles. Among the PAHs, fluoranthene (< 55% of profiles), benzo[*ghi*]perylene and benzo[*b*]fluoranthene were detected at concentrations above the limit, with combustion identified as the source. Of the other pollutants, ethylendiamintetraacetic acid (EDTA, a component of detergents and washing agents), adsorbable organically bound halogens (AOX) and bisphenol A were 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 2024 (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 2024 (on the X axis in parentheses: number of evaluated profiles/number of samples used for evaluation).

Grounwater quality

In 2024, the most frequently detected pollutants in groundwater were those related to agricultural production – pesticides and nitrogenous substances.

Pesticides, nitrogenous substances

Almost 40% of groundwater samples in 2024 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.

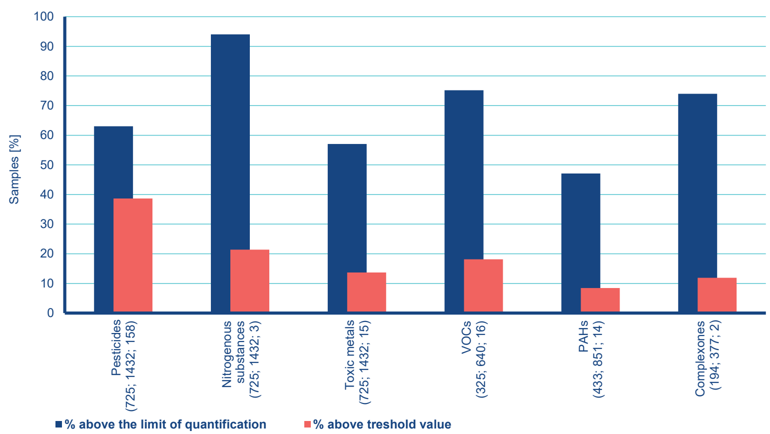
Heavy metals

Arsenic, cobalt 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.

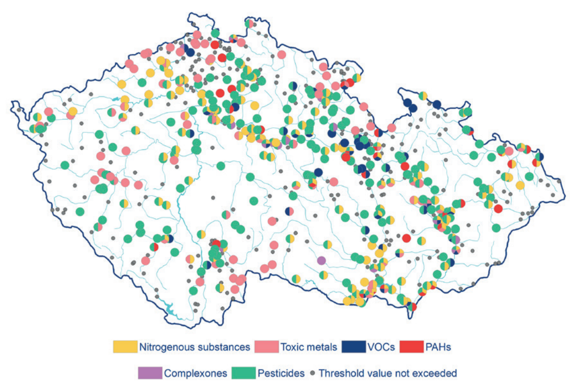
Volatile organic compounds, polycyclic aromatic hydrocarbons, complexones

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, chrysene, naphthalene and pyrene have been detected above the limits. 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 45 samples.

Photo: Adobe Stock



Frequency of values of determinants from the main groups in groundwater samples in 2024. 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 threshold values for pollutants (nitrogenous substances, toxic metals, pesticides, VOCs, PAHs, complexones) in groundwater.

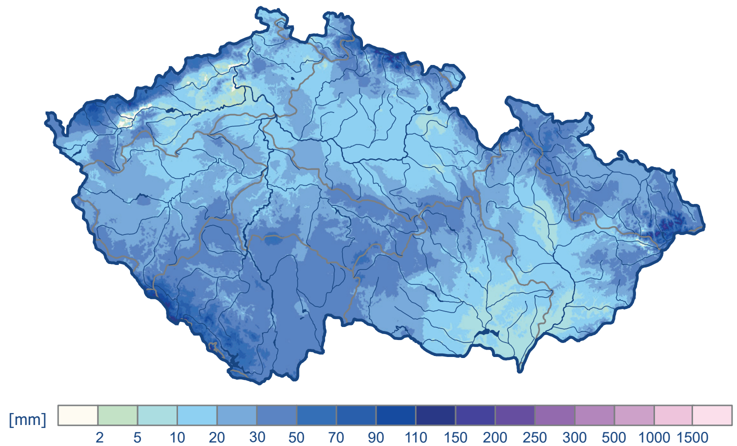
Snow

Snow storage in the winter of 2023/2024 was initially well above average at the beginning of December relative to the 1991–2020 reference period. Due to a major thaw at the end of the year, it dropped to below-average levels and remained significantly below average in the second part of the winter. At the beginning of the 2024/2025 winter, snow storage was slightly above average in mid-December, but following the Christmas thaw it decreased to slightly below average.

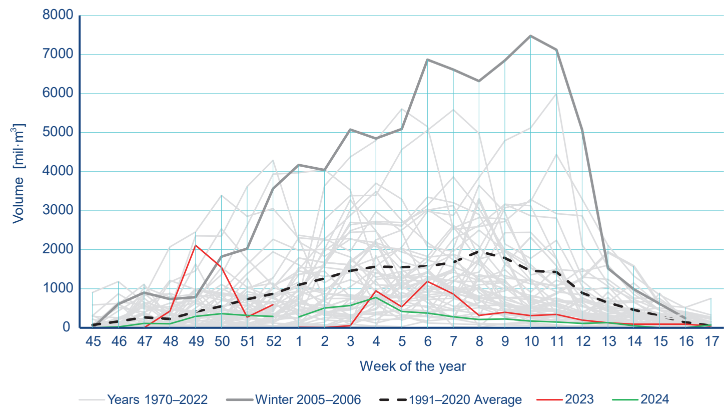
Snow Storage Development

Snow accumulation in the 2023/2024 season began in late November. At the beginning of December, storage was well above average, representing the highest snow storage for week 48 since 1980. The seasonal maximum was reached on 4 December 2023 with 2.122 billion m^3 (26.9 mm). However, after a significant thaw, snow storage decreased to one-eighth of that value by 18 December. In late December, heavy snowfall occurred, followed by another thaw that melted snow cover at all elevations. The 2024 maximum was reached on 22 January, but snow storage was only below average. Snowmelt continued until April, interrupted briefly by snowfall in late April. By then, snow persisted only in the highest parts of the Krkonoše, Šumava and Jeseníky Mountains.

In the 2024/2025 winter, snow accumulation again began in the second half of November. By 16 December 2024, snow storage reached 0.363 billion m^3 (4.6 mm). In most basins, seasonal maxima were reached in mid-December. The Christmas thaw was milder than the previous year.



The maximum snow storage water equivalent on the territory of the Czech Republic in winter 2023/2024 (December 4, 2023, 2.122 billion m^3, runoff 26.9 mm).



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

Photo: Adobe Stock

Phenological progression of wild plants

The start of the long growing season in 2024 was between 9 February and 11 March (three weeks earlier than in 2023); the end of the long growing season was between 6 November and 21 December (one week earlier than in 2023). The growing season lasted 220 to 280 days (in 2023, it lasted 215 to 305 days).

Plants were dormant in January and partly also in February. Thanks to the exceptionally warm February, common hazel (a significant pollen allergen) began to bloom in some locations as early as the first ten days of February. Alder and yew trees also began to bloom in mid-February. Vegetation awoke five weeks early, with snowdrops, snowflakes, lesser celandines and other spring plants blooming in February. At the beginning of March, apricot trees began to bloom in southern Moravia, but they were damaged by frost on 8 March (minimum air temperatures below −6 °C were recorded in some locations). The second wave of frosts during the growing season came in the third decade of April, when other fruit trees (apple, pear and cherry) were already in bloom. This wave lasted almost a week, with the most critical situation occurring on the night of 22–23 April 2024, when temperatures 2 m above the ground ranged between −7 and −1 °C. In addition to fruit trees, forest trees were also damaged (e.g., the flowers of blackthorn, beech and hornbeam froze, as did new shoots on conifers and new leaves on beech, oak and other trees). The head start in vegetation development persisted throughout the territory for almost the entire year, with shorter intervals between phases. Haymaking began in the last decade of May. Strawberries ripened in early June, and the grain harvest began in the second half of June. The ocúny began to bloom at the end of August. From the end of September, the leaves of the trees began to change colour, and leaf fall began at the end of October and continued throughout November. The English oak and European larch lost all their leaves in the last ten days of December.

And finally, a few interesting phenological facts: many plants were observed to flower twice (e.g. dogwood, horse chestnut, blueberry, wild strawberry, magnolia and rhododendron); at the turn of September and October, the second budding and leafing of the common rowan began at the international phenological garden in Doksany (these are typical spring phenological phases, which were recorded in the same location at the end of March and beginning of April), and on 1 December 2024, a cherry tree was observed flowering in a residential area in Brno.

Rhododendron. Photo: Adobe Stock

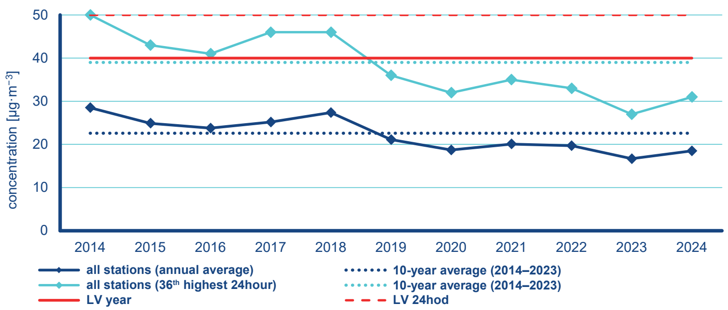
Magnolia. Photo: Adobe Stock

Photo: Adobe Stock

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

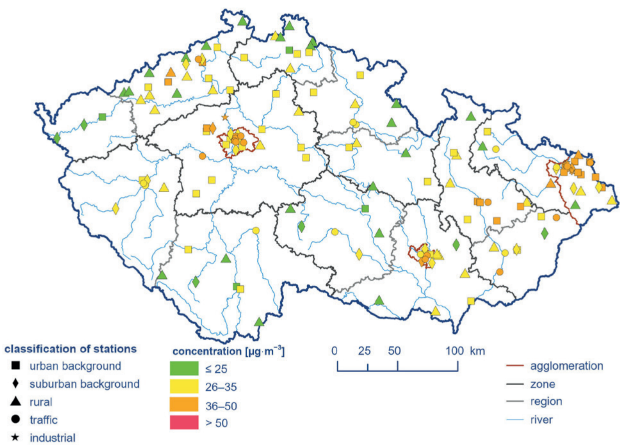
For the first time in the history of measurements, none of the emission limits for suspended particles PM_{10} and $PM_{2.5}$ were exceeded. Particles (a mixture of solid and liquid atmospheric particles with an aerodynamic diameter of less than 10 µm (PM_{10}) or 2.5 µm ($PM_{2.5}$)) have a wide range of effects on the cardiovascular and respiratory systems and are carcinogenic to humans.

nd exceedances 24-hour emission limit (EL) for PM_{10} (50 µg·m^{-3}, maximum 35 exceedances per calendar year) did not occur in 2024. The same situation occurred in 2023, which are the only two years since measurements began in the 1990s when no exceedances occurred. The annual PM_{10} emission limit (40 µg·m^{-3}) has not been exceeded since 2019, which is years 2019–2024 only obperiod without exceeding this limit throughout the entire history of measurements since the 1990s.

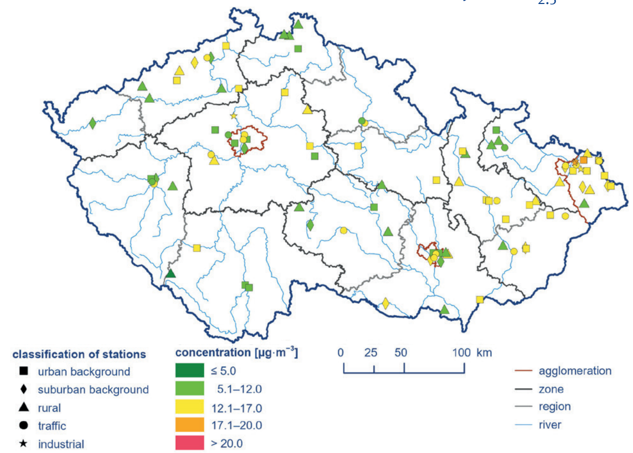


Annual average concentrations of PM_{10} (averages for all automated air pollution monitoring stations (AIM)), 2014–2024.

The emission limit for the annual average concentration of $PM_{2.5}$ (20 µg·m^{-3}) was also not exceeded in 2024. This was the second time (after 2023) in the history of $PM_{2.5}$ measurements since 2005.



36th highest 24-hour average concentration of PM_{10} for the individual ambient air quality monitoring stations, 2024.



Average annual $PM_{2.5}$ concentrations for the individual ambient air quality monitoring stations, 2024.

Between 2014 and 2016, PM_{10} concentrations declined, but rose again in 2017–2018. The most significant decline occurred between 2018 and 2019, since when values have stabilised at lower levels. In the currently assessed year 2024, higher concentrations were recorded compared t o the historical minimum reached in 2023. A similar trend was observed for $PM_{2.5}$.

Benzo[*a*]pyrene

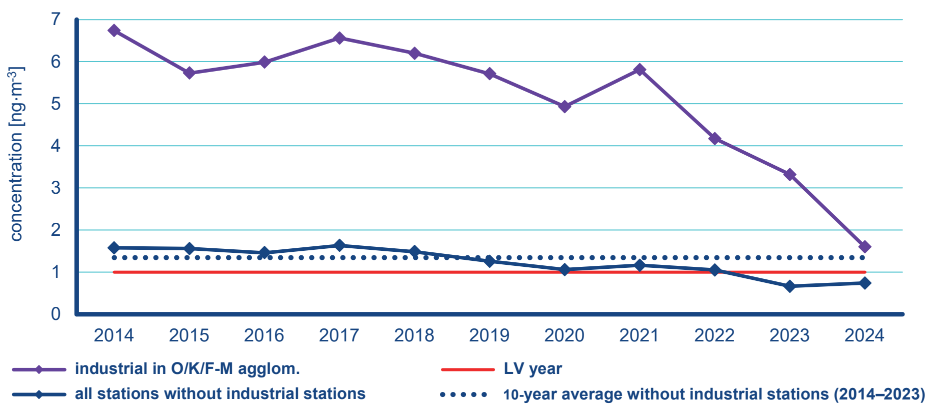
Air pollution caused by benzo[a]pyrene has long been one of the main challenges in the area of air quality in the Czech Republic. Benzo[a]pyrene has proven carcinogenic effects, and its annual emission limit (IL) for health protection (1 ng·m^{-3}) is exceeded every year in many places in the Czech Republic.

According to preliminary data, the annual emission limit for benzo[*a*]pyrene was exceeded at approximately 34% of measuring stations in 2024. Concentrations above the limit were recorded mainly in the Ostrava/Karviná/Frýdek-Místek (O/K/F-M) agglomeration.

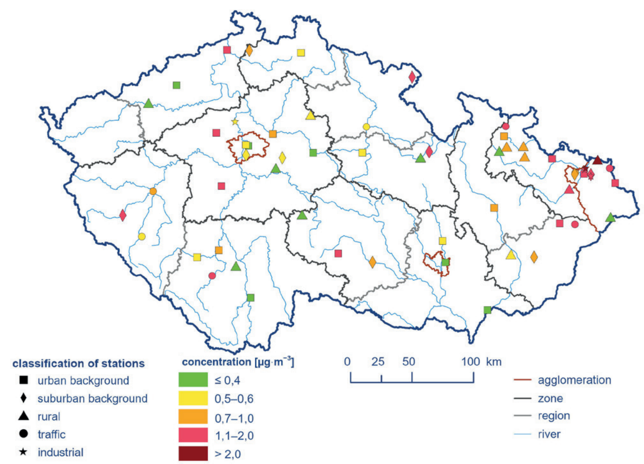
Average annual concentrations of benzo[*a*]pyrene in the assessed period 2014–2024 show a significant decrease at industrial stations in the O/K/F-M agglomeration and a gradual decrease at other types of stations. Since 2021, concentrations at industrial stations have begun to decline significantly, reaching levels in 2024 that are almost comparable to those at background stations. The decline is related to the gradual closure of the Liberty Ostrava, a. s. metallurgical plant.

In 2024, the annual average concentration of benzo[*a*]pyrene from all stations with available data remained at the previous year's level, which was the lowest value since measurements began in 2005.

Although air quality is gradually improving thanks to the measures implemented (e.g. replacement of boilers in households and transition to alternative heat sources), the emission limit for benzo[*a*]pyrene is still being exceeded in some places. Excessive concentrations can be expected mainly in municipalities with a higher proportion of solid fuel heating, which is the main source of benzo[*a*]pyrene in the air. Therefore, the continuation and expansion of measures to improve air quality in the coming years is more than desirable.



Annual average benzo[*a*]pyrene concentrations in the Czech Republic, 2014–2024.



Annual average benzo[*a*]pyrene concentrations in the Czech Republic, 2024.

Ground-level ozone

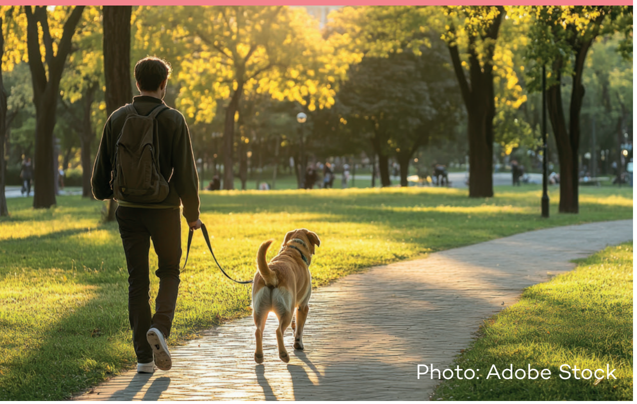


Photo: Adobe Stock

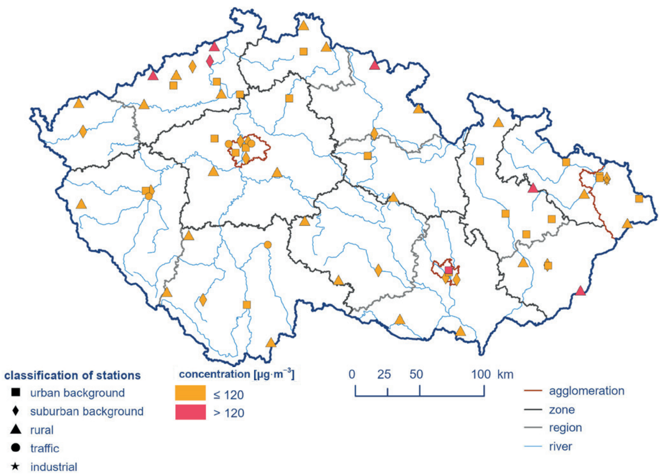
The daily maximum of the 8-hour moving average of ground-level ozone (O_3) has an emission limit of 120 μg·m^{-3}. Legislation allows a maximum of 25 exceedances of the O_3 emission limit per year, averaged over three years. Between 2022 and 2024, this limit was exceeded at 10% of stations, i.e. at 7 out of 68 stations.

In 2024, the emission limit was exceeded at five regional stations (Krkonoše-Rýchory, Červená hora, Rudolice v Horách, Sněžník and Štítná nad Vláří), at one suburban background station Ústí n. L.-Kočkov and at one urban station Brno-Arboretum.

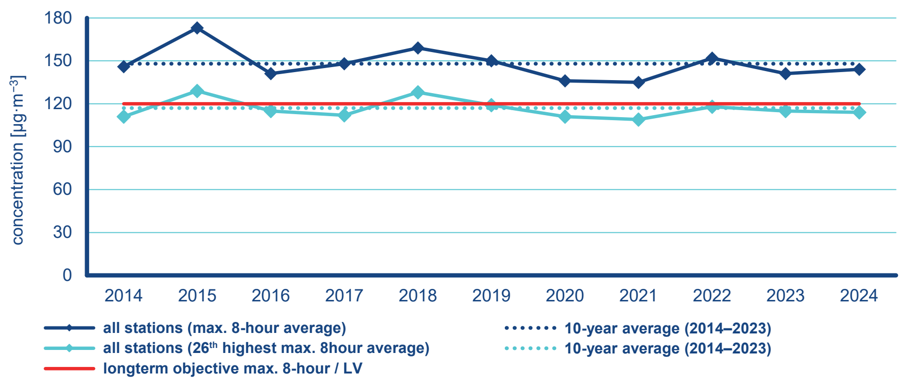
Ground-level ozone does not have its own emission source in the atmosphere. It is a so-called secondary pollutant arising from a whole range of chemical reactions of other substances, known as precursors (especially nitrogen dioxide and volatile organic compounds). Intense solar radiation, high temperatures, low air humidity and periods without precipitation contribute to its formation and accumulation.

Ground-level O_3 concentrations are therefore strongly influenced by meteorological conditions, especially during the warm season (April–September), and unlike other pollutants, they have not shown a significant upward ordownward trend since 2014.

The annual cycle of average monthly O_3 concentrations is characterised by an increase in concentrations in the spring and summer months. Due to high concentrations of ground-level ozone, three smog situations were declared at the end of July.



26th highest values of the maximum daily 8-hour moving average of ground-level O_3 concentrations averaged over 3 years at AIM measuring stations, 2022–2024.



O_3 concentrations (maximum daily and 26th highest maximum daily 8- hour moving average; averages for all AIM stations), 2014–2024.

Nitrogen dioxide

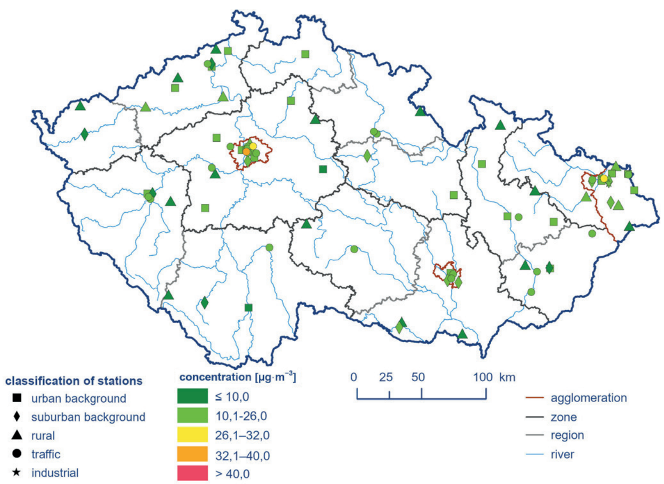
In 2024, the annual emission limit (IL) (40 µg·m⁻³) for nitrogen dioxide (NO_2) was again not exceeded at any station in the Czech Republic. The annual emission limit for NO_2 was last exceeded in 2019.

The highest annual average concentration of NO_2 (36.7 µg/m³) was traditionally recorded at the Prague 2-Legerova traffic hotspot station. This station has long recorded the highest NO_2 concentrations in the Czech Republic due to the high traffic intensity in the immediate vicinity of the station and its location in a street canyon.

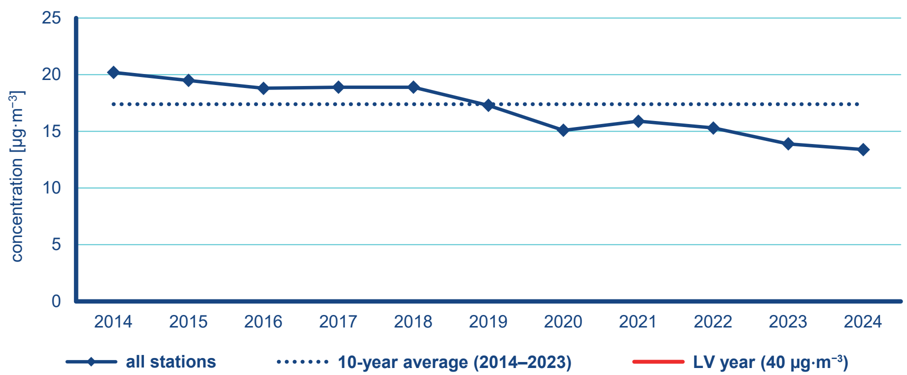
In Prague, higher annual average NO_2 concentrations were recorded at all traffic stations. The situation was similar in other larger cities, such as Brno, Ostrava and Ústí nad Labem. Higher NO_2 concentrations can also be expected near roads in larger cities with heavy traffic, higher building density and a dense local transport network, where traffic flow is often reduced. Conversely, the lowest NO_2 concentrations are found at regional background stations, i.e. in areas far from emission sources.

The hourly concentration limit for NO_2(200 µg·m⁻³) with a maximum permitted number of 18 exceedances per year was not exceeded at any station in 2024. The limit value itself was also not exceeded. In the period under review (2014–2024), the highest NO_2 concentrations were recorded in 2014. Since then, there has been a gradual decline in NO_2, with the most significant reduction occurring between 2018 and 2020. In subsequent years, the decline continued at a slower pace. In 2024, there was a further slight year-on-year decrease in NO_2 concentrations,resulting in the lowest annual average NO_2 concentration for the entire period under review (since the early 1990s).

Photo: Adobe Stock



Annual average concentration of NO_2 at AIM measuring stations, 2024.



Annual average NO_2 concentrations (averages for all AIM stations), 2014–2024.

Saharan sand dust over the Czech Republic at the turn of March and April

At the turn of March and April 2024, large amounts of Saharan sand dust reached Europe, which also had a significant impact on air quality in the Czech Republic. The concentration of suspended particles, especially PM_{10}, increased several times over in a number of locations, which ultimately led to the declaration of a smog situation due to high concentrations of PM_{10} in 13 of 16 zones. This was the first time that a smog situation had been declared for this reason, and in many respects the conditions during this smog situation differed from those normally observed during high concentrations of PM_{10}.

We record the passage of Saharan sand dust across our territory several times a year on average. However, if the particles move higher in the atmosphere, this may not be noticeable in the concentrations of pollutants that we measure at a height of approximately 2 m above the ground. We then observe this phenomenon only as a certain haze in the sky, maximum temperatures decrease, and photovoltaic power plants, for example, have lower production. Sometimes, however, depending on atmospheric conditions, the particles reach the ground layer and affect the level of air pollution.

The episode of Saharan sand dust passing over the Czech Republic at the turn of March and April 2024 brought the most significant deterioration in air quality due to this phenomenon in the modern history of air quality measurement in our country. PM particle concentrations were significantly elevated across virtually all regions, leading to the declaration of a smog situation across almost the entire country due to threshold values being exceeded at more than half of the representative stations in each region.

First, concentrations of PM_{10} suspended particles began to rise sharply in the south-west of our territory, and during 30 March, Saharan sand dust gradually spread across the entire territory. While pollution levels in the south-west of the Czech Republic improved significantly by the evening of 31 March, concentrations

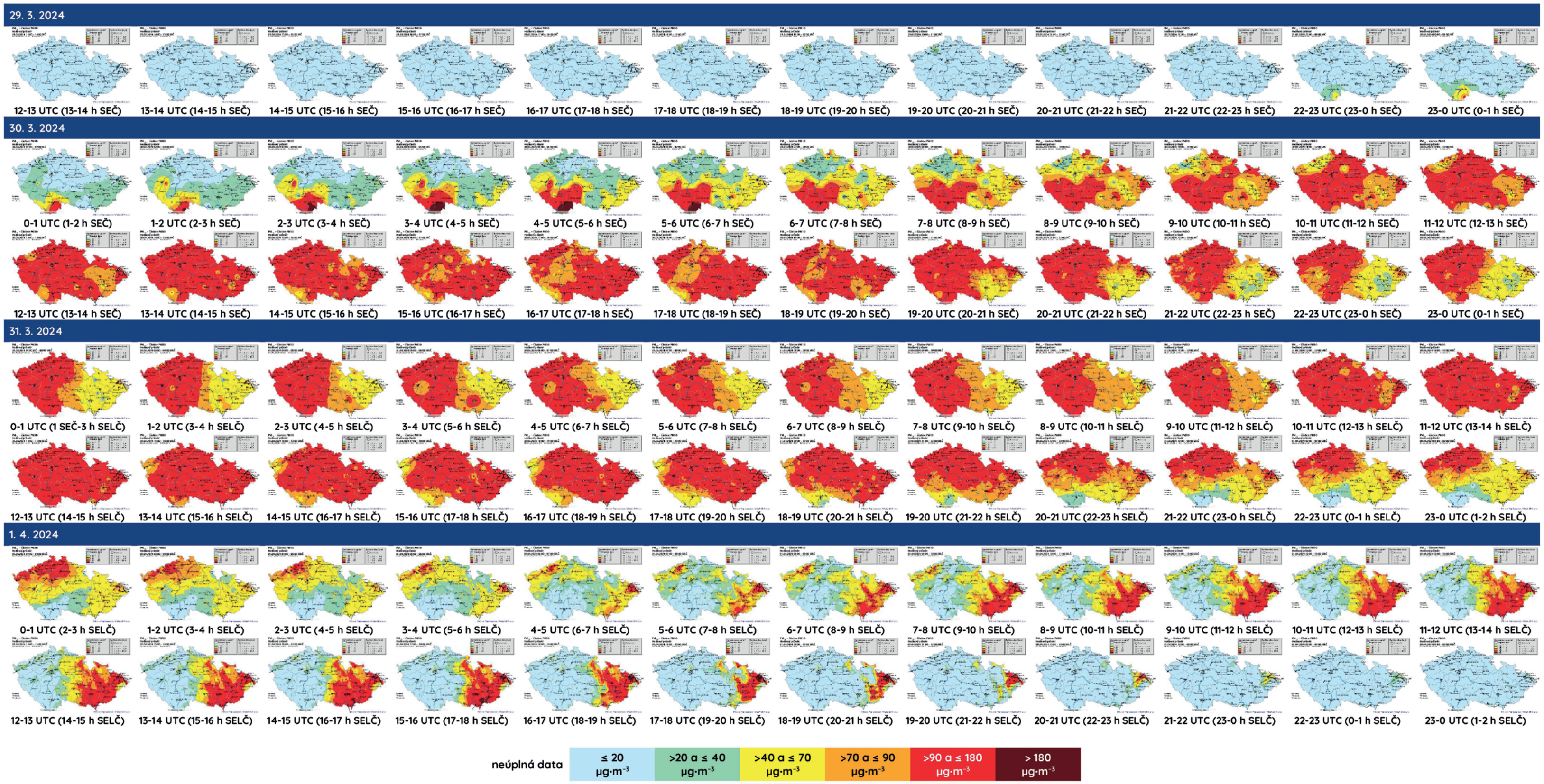
View from the Židlochovice lookout tower in southern Moravia on 1 April 2024 with a clearly visible layer of Saharan sand dust in the atmosphere. Photo: J. Brzezina.

of particles in the south-east PM_{10} remained significantly elevated until the afternoon of the following day, when they fell sharply due to heavier rainfall.

The highest average hourly concentration of PM_{10} particles was measured on 30 March 2024 at 4 a.m. UTC at the Klatovy soud station in the Plzeň Region, at 385.3 $\mu g \cdot m^{-3}$. The second highest average hourly concentration of 375.0 $\mu g \cdot m^{-3}$ was measured at the České Budějovice-Třešňová station in the South Bohemian Region on 30 March 2024 at 3 a.m. UTC.

Typically, smog situations due to high concentrations of PM_{10} particles are observed during the cold season when dispersion conditions are unfavourable. During this episode, however, dispersion conditions were very good, and high wind speeds were one of the causes of the intense swirling of Saharan sand dust. Temperatures were significantly above average for this time of year, which was related to the south to south-westerly flow, when warm air from the south reached us in addition to Saharan sand dust.

Comparison of filters from the Saharan episode from Lovčice in South Moravia. Photo: J. Brzezina.



Average concentrations of PM_{10} particles during the passage of Saharan sand dust over the Czech Republic.

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

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

Branch Brno
Kroftova 2578/43
616 67 Brno

Branch Plzeň
Mozartova 1237/41
323 00 Plzeň

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

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

www.chmi.cz