
Czech
Hydrometeorological
Institute

Sources of air pollution and the role of transport, not only during periods of smog

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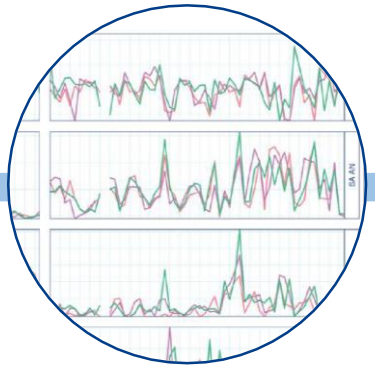
Outlines

- The identification of air pollution sources
- The Impact of Transport on Air Quality
- Smog warning and regulation system

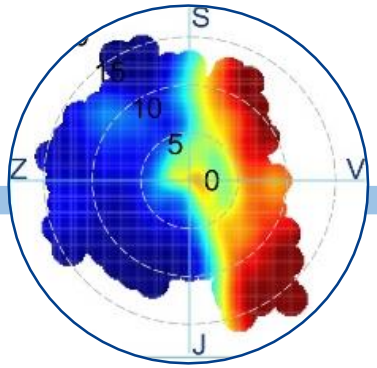
Where and how should we target air quality measures most effectively?

Data analysis - pollution sources

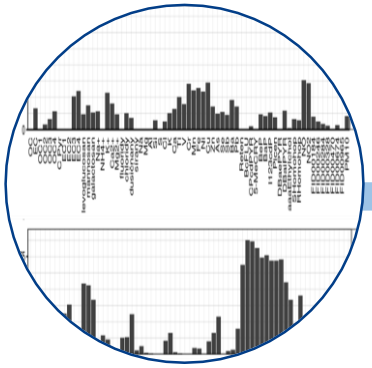
What pollution sources affect the resulting air quality in a given location?



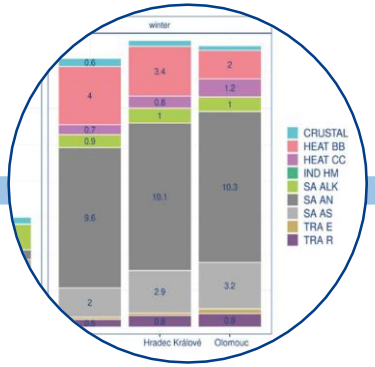
Evolution of pollutant concentrations over time



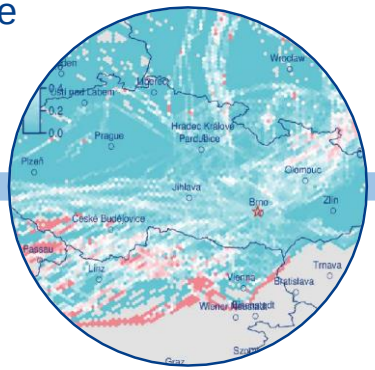
Combination of wind direction and wind speed pollution data over time - concentration roses



"Chemical footprint" of sources - local heating, transport, industry...



Proportions of individual sources of pollution



Contribution to pollution by long-haul transport

It affects the target (receptor) site:

- 60 % domestic heating
- 20 % transport
- 17 % resuspension
- 7 % industry

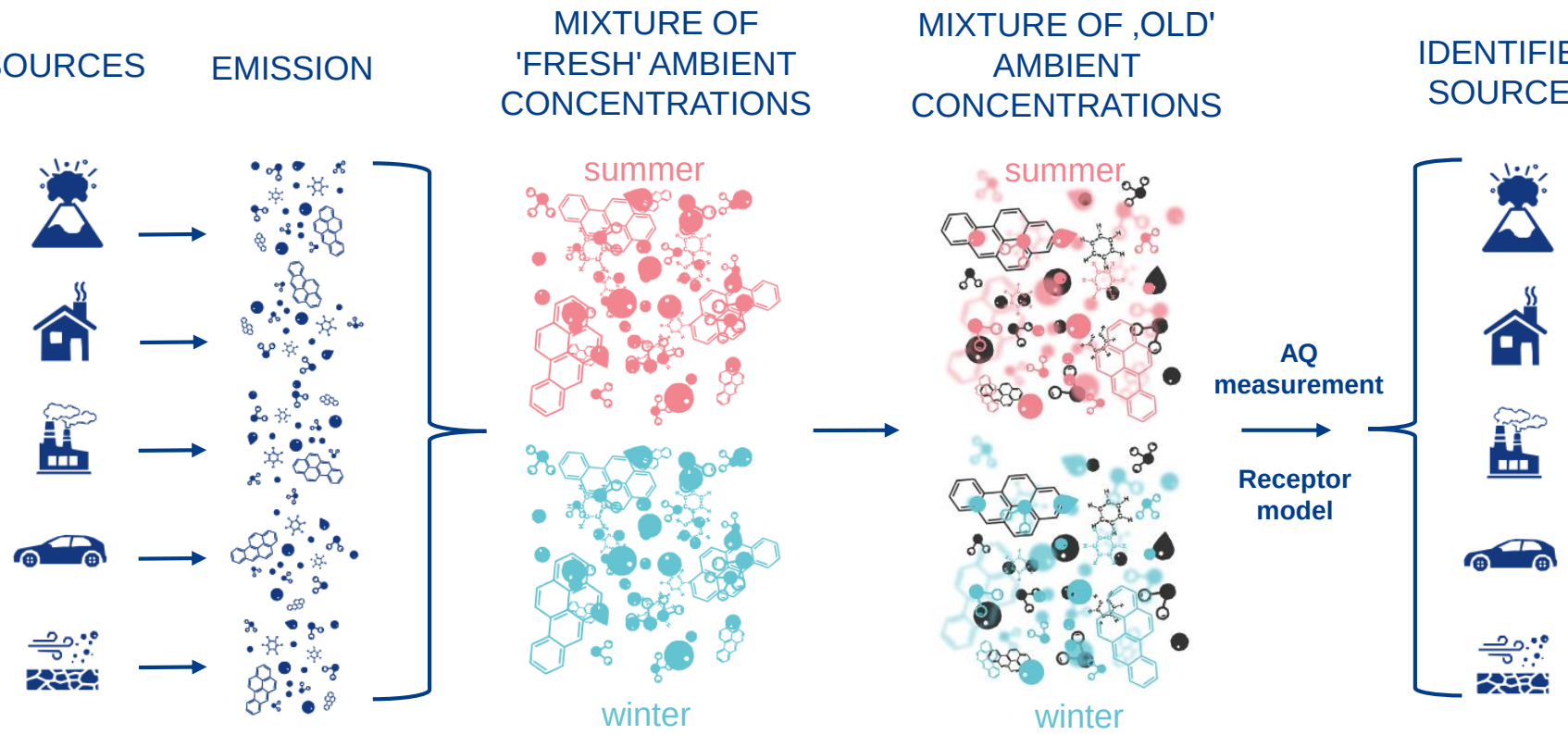
The ongoing identification of air pollution sources at the CHMI

- Positive Matrix Factorization modelling (PMF) is an independent alternative to other methods, some of which do not work well
- The method is considered best available practice within the EU for source identification
- **Air monitoring measures air quality rather than the causes of pollution**
- Factor analysis of time series of samples reveals the factors that explain changes in concentrations
- The identified factors act as fingerprints of the actual pollution sources
- **Quantified factor proportions = proportions of actual pollution sources**

Advantage of PMF: no need for emission data

Disadvantage of PMF: large measurement range

Source identification using the receptor model



The way to identify air pollution sources

- Design a measurement campaign
- Capture the aerosol and its precursors
- Monitor conditions in the surrounding atmosphere
- Determine pollution markers
- Evaluate using multivariate factor analysis to identify groups of pollution sources and their contributions
- Test the validity of the solution
- Interpret the results and propose measures

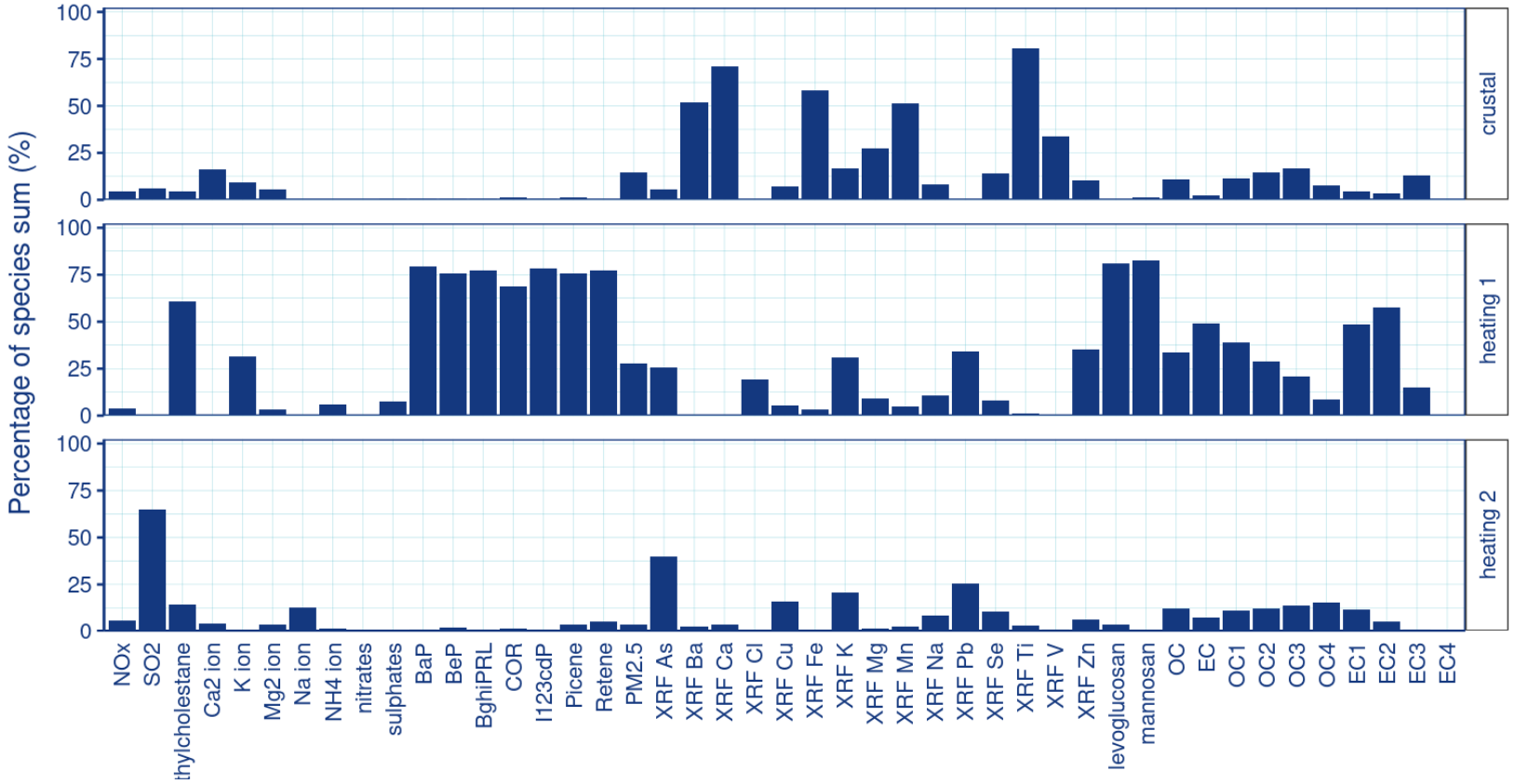
The usability of the PMF source identification

- Verifying and completing transport model results
- Design of air protection measures for specific areas
- Proposing measures for similar sites within larger territorial units (e.g. village centres, transport hubs and industrial areas)

Also suitable for areas where the results of transport models are uncertain:

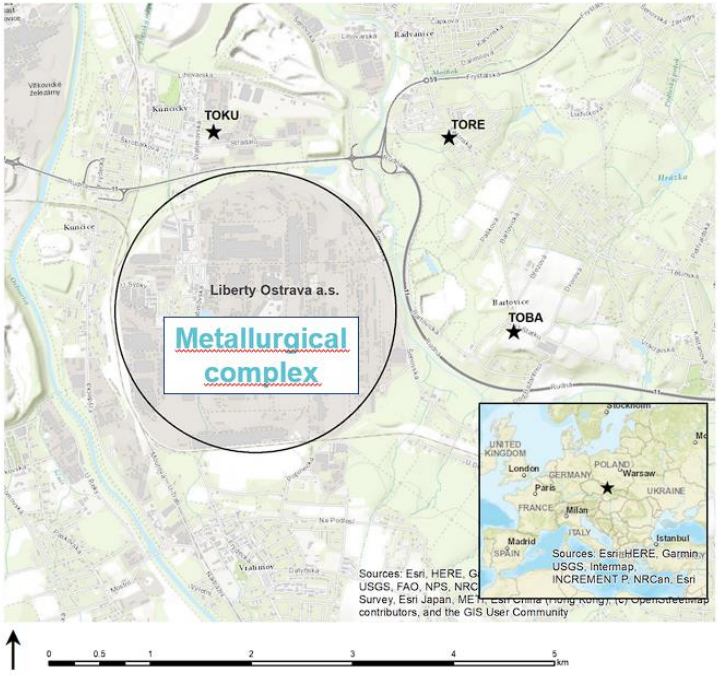
- affected by emissions that can be imprecisely quantified, such as fugitive emissions, particulate resuspension, and emissions from other sources without measurement obligations
- affected by transboundary transport and/or secondary aerosols; ensuring a representative database for the transport model is organisationally, time-consuming and costly

Chemical profiles of factors, examples

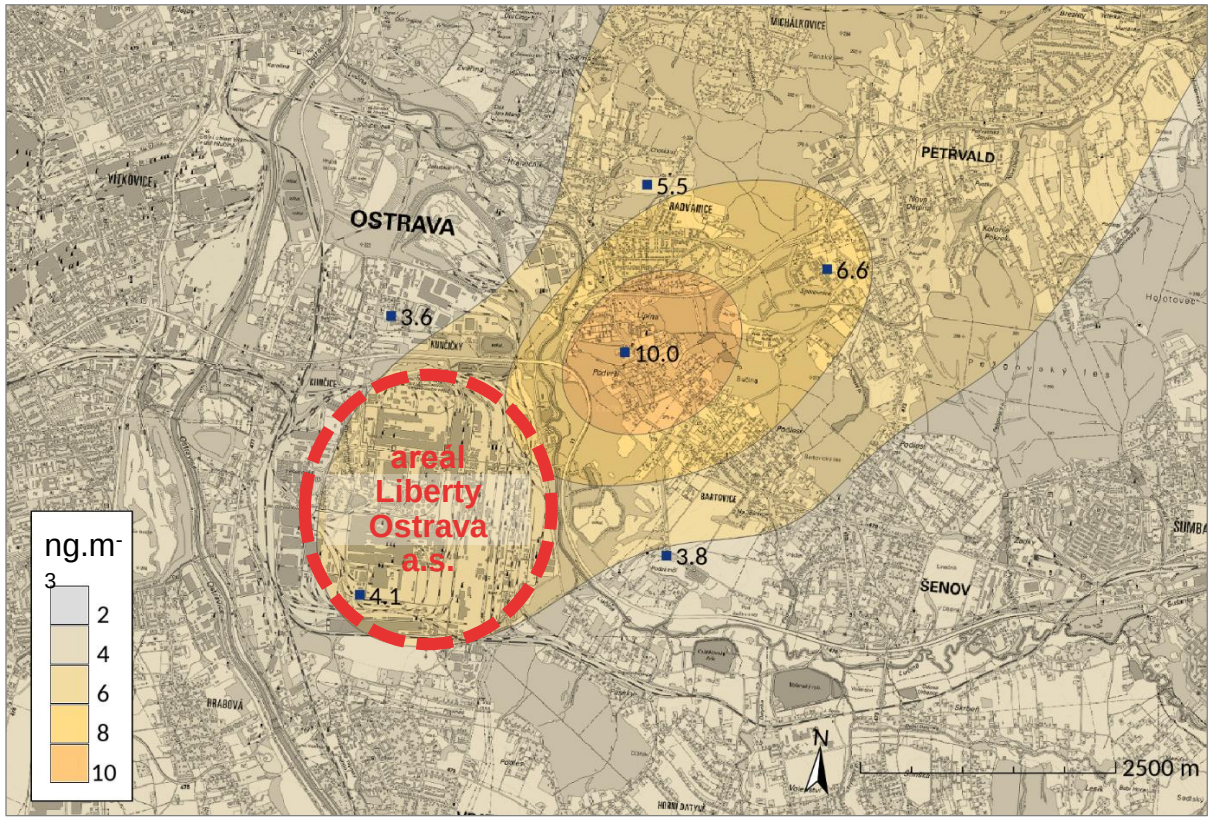


Example study - Identification of the air pollution causes, Ostrava region
Key methods:

- Three-hourly samples of PM_{10} aerosol enabled high temporal resolution of measured benzo[a]pyrene concentrations in winter
- The whole-year measurement allowed to evaluate seasonal variation of concentrations
- Measured concentrations and meteorological data were used for statistical evaluation of industrial contribution to PM_{10}
- The wide spectrum of PM_{10} aerosol components were determined and used for the PM_{10} and benzo[a]pyrene source apportionment utilizing PMF receptor model



Example study - Identification of the air pollution causes, Ostrava region, results



Field of benzo[*a*]pyrene average annual concentration

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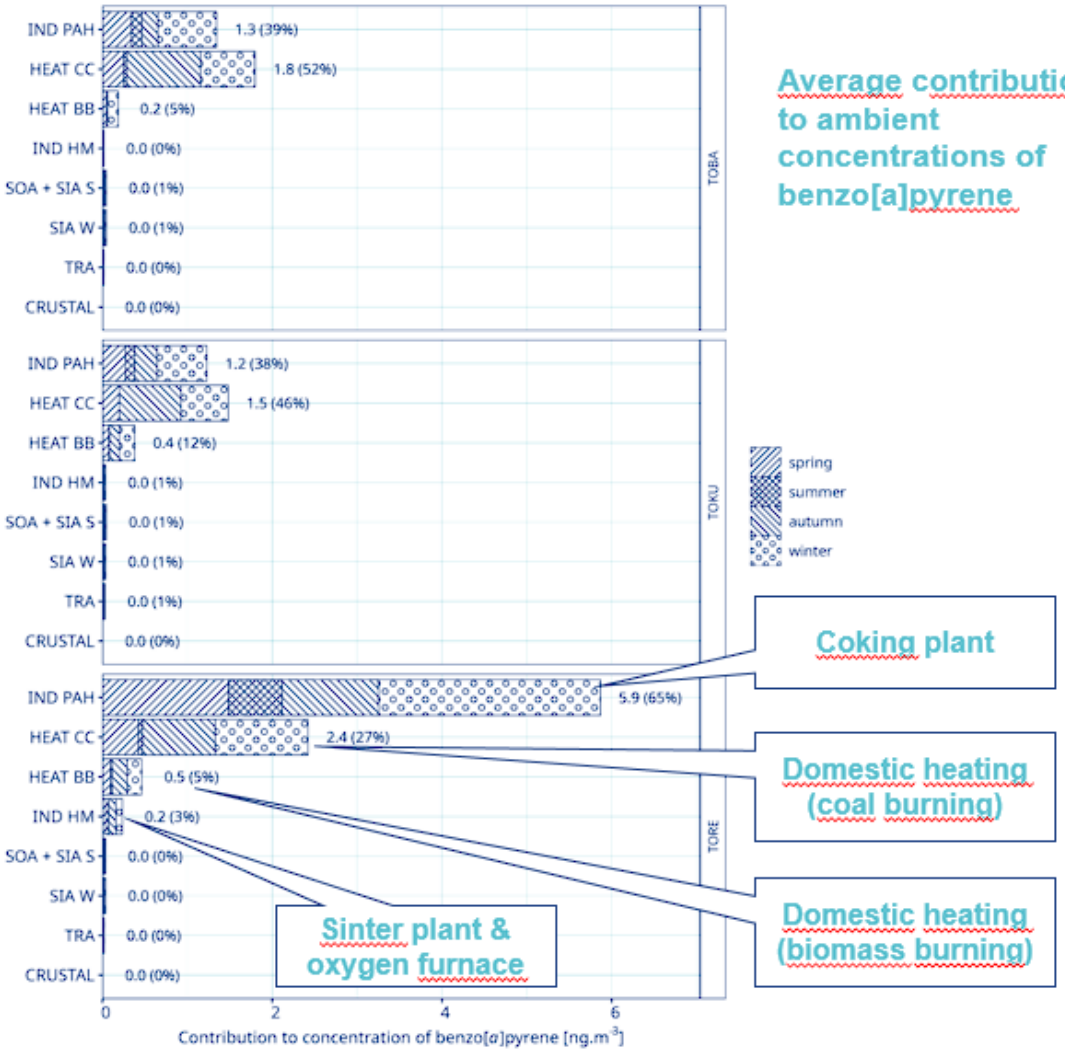
ARAMIS

Example study - Identification of the air pollution causes, Ostrava region, results



In winter, most PM_{10} pollution comes from secondary particles (sulfates and ammonium nitrates); at TORE station, this is about 20%.

The main source of PM_{10} is household heating.

Benzo[a]pyrene pollution mainly originates from coal-based domestic heating (90%), except at the TORE station.

At TORE station, 2/3 of benzo[a]pyrene comes from Liberty Ostrava industrial site; less than 1/3 from local homes.

The TORE station reflects only local industrial surroundings, not the wider Ostrava area – but less than 10,000 residents near TORE are affected by benzo[a]pyrene levels above 5 ng/m³.

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The impact of transport on air quality

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The Impact of Transport on Air Quality

- Road transport contributes significantly to emissions of NO_x, PM_{10}/$PM_{2.5}$, CO, and VOCs in cities
- Not only tailpipe emissions, but also wear of tires, brakes, and road surfaces significantly increase particulate matter levels
- Traffic-related air pollution is linked to respiratory diseases, cardiovascular problems, and premature deaths
- During smog situations, transport restrictions can help reduce pollutant peaks (e.g. low-emission zones, free public transport)

Urban mobility strategies (e.g. promotion of public transport, cycling, walking, electrification of fleets) are essential tools for emission reduction,with potential climate benefits

Emissions from transport

What makes up transport emissions?

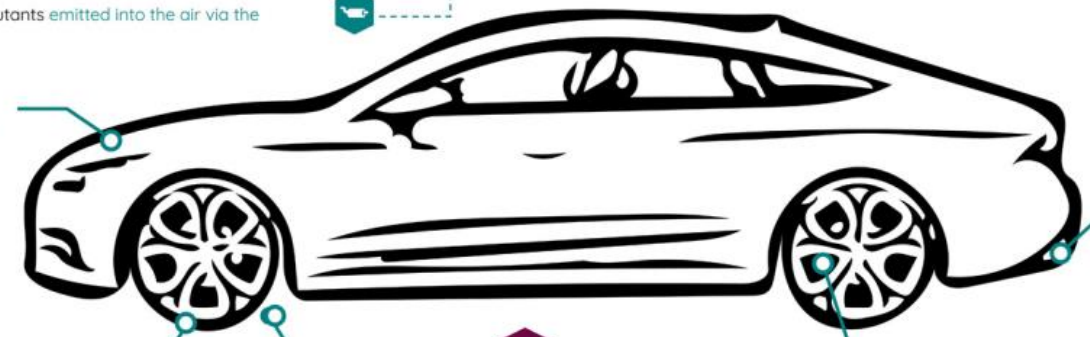
Although transport emissions are significant, their importance is often overestimated. On the other hand, transport emissions are not just what a car emits from its tailpipe.

Non-exhaust emissions – pollution from transport that does not come from the exhaust. This includes for example abrasion of brake pads, tires and road surface, but also for example the so-called resuspension, which is the removal of deposited material from the ground to the atmosphere.

Exhaust emissions – air pollutants emitted into the air via the exhaust system

In modern cars, **non-exhaust emissions account for the majority of the car's total emissions**. Depending on different studies and car types, this can be **up to 90%** of suspended particulates. The higher the emission standard a car meets, the higher the ratio.

Exhaust emissions contain a wide range of pollutants. Transport in general is the main source of **nitrogen oxide (NO_x)** emissions in the Czech Republic. NO_x concentrations are highest in congested locations and in larger cities in general.



Electric vehicles and emissions

Electric vehicles are now the focus of attention in the future of the automotive and transport industries. However, these vehicles are sometimes **incorrectly presented as zero-emission vehicles**. In reality, however, they are only zero exhaust emission vehicles. Moreover, they are higher than equivalent vehicles with internal combustion engines. The amount of pollution from abrasion depends, among other things, on the weight, which tends to be higher in electric vehicles due to the heavy battery. It is also necessary to take into account **how the electricity was actually generated**. If comes from, for example, a coal power station, the emissions from fossil fuel combustion were still emitted just somewhere else.

Electric vehicles are indeed a better alternative to combustion engine vehicles in terms of air pollution, especially if the electricity that powers the car is generated in a renewable energy source. However, when non-exhaust emissions are taken into account, it should be noted that vehicles in general will never be completely zero-emission, because they simply cannot be.

Solution for the future

The ideal solution for the future is to **use road transport only in the most urgent cases** and use **vehicles with zero exhaust emissions** (electric cars, hydrogen fuel cell cars), which also generate fuel (electricity, hydrogen) in a renewable and environmentally friendly way.

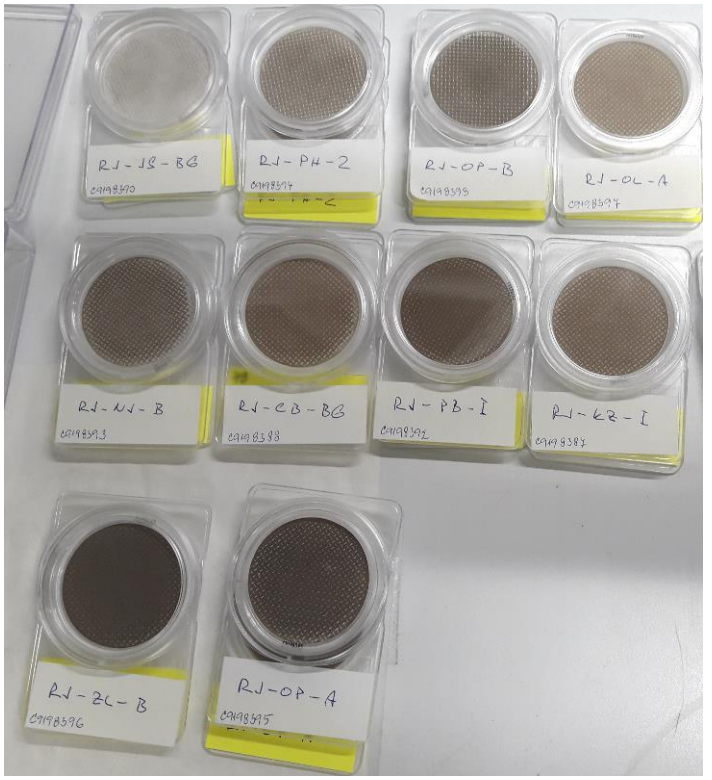
When road transport is reduced, alternatives must be offered, for example in the form of **efficient public transport** and a **network of cycle paths**. Increased use of **car sharing** is a future option, including the use of **autonomous and driverless cars**.

Chemical Profiling and Health Risks: A study of road dust in the Czech Republic

Research of PAH and heavy metals atmospheric deposition health effect in connection with the transport induced particles resuspension
https://starfos.tacr.cz/cs/projekty/SS01010156

Assess the chemical composition of road dust in the Czech Republic, considering regional differences in atmospheric deposition. Evaluate health risks from PAHs and heavy metals in deposited dust. Identify chemical markers of re-suspended road dust specific to Czech conditions and test their use in air pollution source apportionment.

PM_{10} separation



The impact of transport – PM concentrations

- It significantly worsens the air quality situation with regard to PM in cities
- Primary exhaust emissions of PM are of little significance, but a significant area effect is secondary ammonium nitrate in winter
- There is a significant local impact due to particulate resuspension and abrasion
- Transport is a priority in the centres of the most congested urban areas

Smog warning and regulation system

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Smog situations

A smog situation is a state of **short-term significant air pollution**. In this particular case, concentrations of PM_{10} particles, sulfur dioxide, nitrogen dioxide and ground-level ozone are monitored for this purpose in the Czech Republic.

A smog situation is declared when **the conditions for the declaration are met**. This includes both area-wide nature of the pollution and for example in the case of PM_{10} particles the fact that the weather forecast does not make it likely that the situation will get better in the upcoming hours.

*If the concentrations of pollutants are significantly higher than the threshold values for declaring a smog situation, a state of even greater pollution may be declared. In the case of PM_{10}, SO_2 and NO_2 this state is called **regulation**, for ground-level ozone a **warning**.*

Nowadays, smog situations in the Czech Republic are only declared due to high concentrations of PM_{10} (**winter smog, mostly at very low temperatures and poor dispersion conditions**) or ground-level ozone (**summer smog, on very hot, clear days**). SO_2 and NO_2 concentrations no longer reach the values for declaring a smog situation in the long term.

Smog warning and regulation system

According to the Czech Act No. 201/2012 Coll., on Air Protection, a **smog situation** is a state of **extremely polluted air** when the level of pollution by sulphur dioxide, nitrogen dioxide, PM_{10} or tropospheric ozone exceeds one of the threshold values. The CHMI operates the system on the basis of a mandate from the Ministry of the Environment.

This system has been in operation in the Czech Republic since the 1980s.

Information is used to:

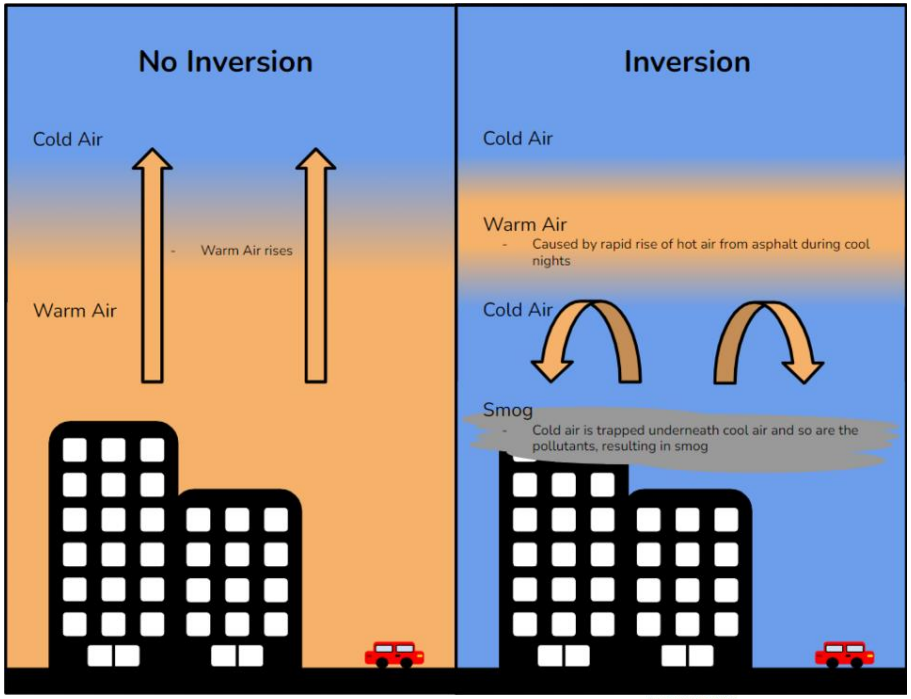
- informing about the occurrence of a situation with elevated concentrations of air pollutants
- to regulate (reduce) the release of pollutants from sources that significantly affect the air quality of a given area

The impact of dispersion conditions on air quality

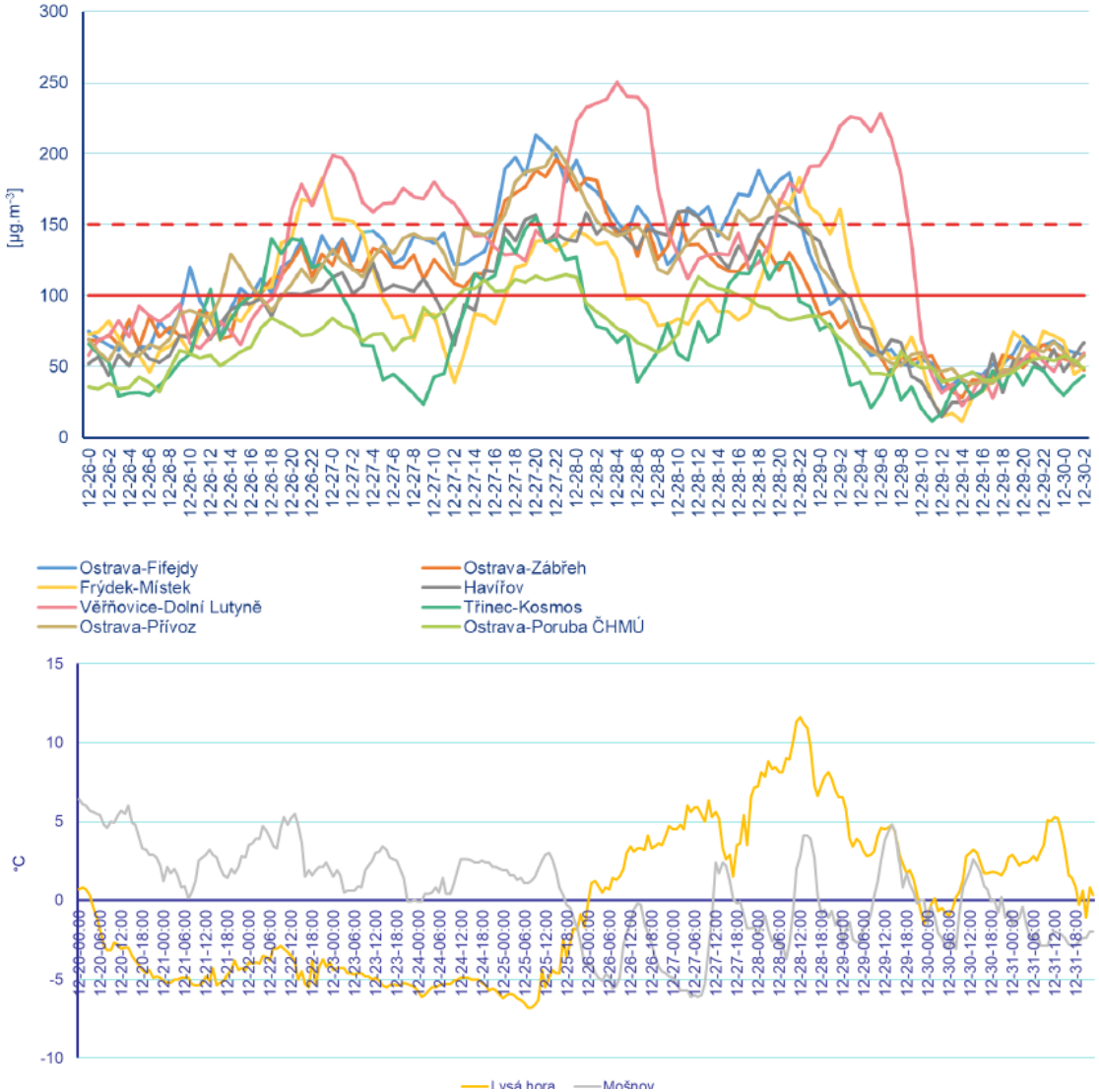
Dispersion conditions represent the extent to which the atmosphere can disperse pollutants emitted by various sources at a given place and time.

These conditions can significantly impact air quality, particularly during the colder months when conditions are generally poorer and emissions from sources such as heating are higher.

Dispersion conditions are mainly influenced by **wind speed**, which determines horizontal dispersion, and the **temperature** stratification of the atmosphere, which determines vertical dispersion. One example of unfavourable dispersion conditions is a **ground temperature inversion**, which occurs when a layer of warmer air forms above the ground. Unlike the warmer air, the cooler air does not tend to rise, significantly reducing vertical dispersion.



Development of pollution and meteorological conditions during the winter smog situation



Hourly concentrations of PM_{10} from 26 to 30 December 2024 at selected automatic stations of the CHMI in the Moravian-Silesian Region of the Czech Republic

Temperature at 1-hourly intervals, 20–31 December 2024, at Lysá Hora (mountain peak) and Mosnov (lowland)

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Smog situations **do not pose an immediate threat to life!** Nevertheless, especially individuals belonging to a group of **more sensitive individuals** should follow some **recommendations** in order to **minimize** any **health complications**.

Who is a sensitive individual?

Children

Children including **infants**.

Pregnant

Sensitive individuals are not just **pregnant women**, but also the **developing fetus.**

Elderly

Chronically ill

Individuals with chronic diseases, especially of the **respiratory** and/or **cardiovascular system** (asthmatics, patients with chronic obstructive pulmonary disease etc.)

Acutely ill

Individuals **acutely ill** or shortly **after being ill**, who are temporarily weakened.

Particularly when the air quality is poor **aim to reduce pollutant emissions**. For example, take public transport instead of car and do not make open fires.

Recommendations for higher levels of air pollution

Limit your stay outdoors

You can still go outdoors (shopping, to school etc) even when pollutant concentrations are higher. However, you should try to minimize the time spent outdoors. Also consider the time of the day you go outside. When ground-level ozone concentrations are high, levels tend to be highest in the afternoon and evening. For the PM particles, highest concentrations tend to be observed during peak traffic and when people heat (morning, evening).

Reduce physical activity outdoors

Increased physical activity leads to more intense breathing, which is not desirable during poor air quality.

Ventilate briefly and intensively

There are a number of air pollution sources indoors as well and thus it is not uncommon for the air quality to be worse inside than outside. Therefore, ventilate even during elevated concentrations of pollutants outdoors! However, ventilate only briefly, but intensively. Ideally 3 to 4 times a day.

Reduce polluting the air indoors

Since prolonged ventilation is not desirable, limit indoor pollution by for example avoiding painting, varnishing, smoking etc. indoors.

Initiate treatment early and be prepared

If you experience difficulties or deterioration of your health, initiate treatment as soon as possible. Chronically ill patients who know that they are particularly sensitive to higher levels of air pollution should carry medicals with them.

The role of municipalities in preventing and managing smog situations

In the event of a smog situation being declared, municipalities can issue a regulatory order to restrict the operation of road vehicles. This may include bans on entering the city centre, speed limits and free use of public transport. Operators of stationary sources with special operating conditions imposed must also take action. The newly proposed concept of regulatory orders extends the power to regulate more areas; for example, regional authorities will have the ability to impose special operating conditions on selected major stationary sources in operating permits.

Long-term measures to improve local air quality:

- Promoting green transport involves developing infrastructure for electric vehicles and encouraging cycling and walking
- Urban greenery: planting insulating greenery along roads can reduce concentrations of suspended particulates
- Construction activity regulation: reducing dust from construction activities through guidelines and measures

Thank you for your attention

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The Impact of Transport on Air Qualitye

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