SBORNÍK XXIV. výroční konference České aerosolové společnosti

OVZDUŠÍ V ČASe

10. 11. – 12. 11. 2025, Hustopeče

PROCEEDINGS OF 24th Annual Conference of the Czech Aerosol Society

OVZDUŠÍ V ČASe

10. 11. – 12. 11. 2025, Hustopeče

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SPONZOŘI/SPONSORS

PŘEDMLUVA

Vážené kolegyně, vážení kolegové, přátelé,

Rád bych vás všechny přivítal, z pozice předsedy České aerosolové společnosti (ČAS), na **24. výroční konferenci České aerosolové společnosti**, v srdci jižní Moravy v Hustopečích – v hotelu **Wine Wellness Hotel Amande.**

Minulý ročník byl ve znamení **pilotního spojení VK ČAS a konference Ovzduší, Ovzduší v ČASe**, které jsme uspořádali ve spolupráci s **VI RECETOX** a pod záštitou **VI ACTRIS**. Tento koncept v loňském roce přinesl zvýšenou účast na konferenci a přítomnost kolegů, kteří se v minulých letech VK ČAS pravidelně neúčastnili. Nicméně, protože je vždy prostor ke zlepšení, rádi bychom ve snaze motivovat i kolegy z blízkých oborů, případně i zástupce legislativních orgánů, v našem úsilí pokračovali. V tomto ohledu bych na vás rád apeloval, abyste, pokud uznáte za vhodné, **informace o konferenci šířili dále** v řadách svých kolegů a spolupracovníků. A to i v případě, že nejsou přímo odborníky ve vašem oboru, ale jejich expertíza by mohla pomoci nahlédnout naši problematiku z jiné perspektivy či přinést zajímavou spolupráci či partnerství.

Jak jste si mohli jistě všimnout, letošní konference doznala dalších **změn**, a to především **po stránce organizační**. V letošním roce byl zaveden **nový online registrační formulář** a také, v návaznosti na dotazník zaslaný po skončení loňského ročníku, vyzkoušíme v **pilotní verzi posterovou sekci**. V této souvislosti bych vás rád i letos požádal o součinnost a apeloval na vaši hojnou účast při **vyplnění dotazníku**, který obdržíte po skončení letošní konference. Pomáhá nám to vylepšovat organizaci a průběh konference tak, aby vše fungovalo k vaší spokojenosti.

Od začátku letošního roku také začal pracovat **nový výbor ČAS** (jeho složení je k dispozici na webových stránkách společnosti), který jste si minulý rok na zasedání členů ČAS odhlasovali. Výbor ČAS je v neustálém kontaktu a všichni jeho členové se snaží přispět k hladkému chodu společnosti, k jejímu zviditelnění a prosperitě. Tímto bych rád **všem členům výboru poděkoval za skvělou spolupráci** v uplynulém roce a těším se na další výzvy, které máme společně před sebou.

Jednou z hlavních změn je práce na **nových webových stránkách ČAS**. Výbor ČAS také v uplynulém roce intenzivně pokračoval v **přípravách na pořádání European Aerosol Conference v roce 2028 v Praze**. V rámci příprav došlo k drobným změnám, především, co se týče místa pořádání EAC2028. O všech těchto záležitostech bych vás rád krátce informoval v rámci **zasedání členů ČAS**, které se bude konat v **úterý 11.11.2025** těsně po skončení programu konference.

Jak se již stalo tradicí v průběhu minulých dvou ročníků, i letos přivítáme **vzácné hosty**, kteří se nám postarají o plenární přednášky. Ano, letos budou **plenární přednášky dvě**, jedna v **pondělí dopoledne 10.11.2025** a druhá **v úterý ráno 11.11.2025**. V návaznosti na předchozí vážené hosty, prof. Philipa Hopkeho a prof. Alfreda Wiedensohlera, se v letošním roce ujmou role plenárních mluvčích **Dr. Martin Gysel-Beer (PSI, Švýcarsko)** a **prof. Gerhard Lammel (Max-Planck Institut, Německo)**. Martin se zabývá především fyzikálními (optickými) vlastnostmi aerosolových částic ve vztahu k lepšímu porozumění vlivů aerosolových částic na klima (snížení nejistot měření a předpovědí) a lidské zdraví (zlepšení kvality životního prostředí). Gerhard se zabývá především chemií stopových organických látek, jejich výměnou mezi vzduchem, vodou a půdou, a v neposlední řadě expozicí těmto sloučeninám v životním prostředí a následným negativním vlivům na lidské zdraví.

Tradiční poděkování patří závěrem **všem sponzorům** konference Ovzduší v ČASe – **Altium, Biowell (Dekati), ECM ECOMONITORING a TSI**. Zástupci těchto firem budou přítomni v průběhu konference a bude tak dost příležitostí s nimi probrat vše, co by vás mohlo zajímat. Někteří kolegové zastupující výše zmíněné firmy obohatí program konference i svými odbornými příspěvky.

A samozřejmě nemohu opomenout letošní **editorku tohoto sborníku Janu Kánskou**. Děkujeme!

Těším se na osobní setkání v Hustopečích a jako vždy všechny **náměty, podněty, výtky a pochvaly jsou vítány**.

Váš,

Jakub Ondráček (předseda České Aerosolové Společnosti)

PREFACE

Dear colleagues and friends,

It is my great pleasure, as the President of the Czech Aerosol Society (ČAS), to welcome you all to the **24th Annual Conference of the Czech Aerosol Society**, held in the heart of South Moravia, in Hustopeče – at the **Wine Wellness Hotel Amande**.

Last year's event marked the **pilot joint conference of the ČAS Annual Conference and the "Ovzduší" (Air) Conference, titled *"Ovzduší v ČASe"*,** which we organized in collaboration with **RECETOX Research Infrastructure** and under the auspices of **ACTRIS Research Infrastructure**. This new format resulted in a higher attendance and the participation of colleagues who had not regularly taken part in previous ČAS conferences. However, as there is always room for improvement, we would like to continue our efforts to motivate participation from colleagues in related fields and possibly even representatives of legislative bodies. In this regard, I would like to **encourage you to share information about the conference** with your colleagues and collaborators, even if they are not directly involved in your field. Their expertise may offer valuable perspectives or foster interesting collaborations and partnerships.

As you have surely noticed, this year's conference also comes with several **organizational updates.** We have introduced **a new online registration form** and, following feedback from last year's post-conference survey, we are **piloting a poster session** for the first time. I would again like to ask for your cooperation and encourage you to **fill out the post-conference survey** you will receive after the event. Your feedback helps us improve the organization and overall experience to better meet your expectations.

Since the beginning of this year, **a new ČAS Board** (its composition is available on our website) has been working, as elected during last year's members' meeting. The board maintains continuous communication, and all its members actively contribute to the smooth operation, visibility, and growth of the society. I would like to take this opportunity to **thank all board members for their excellent cooperation** over the past year and to express my enthusiasm for the challenges that lie ahead of us.

One of the major ongoing projects is the **development of new ČAS webpages**. The committee has also continued its **intensive preparations for hosting the European Aerosol Conference (EAC) 2028 in Prague**. During these preparations, some adjustments were made, particularly concerning the conference venue. I will briefly update you on these topics during the **ČAS Members' Meeting**, which will take place on **Tuesday, November 11, 2025**, immediately after the conference program concludes.

Following the tradition of the past two years, we will again welcome **distinguished guests delivering plenary lectures**. This year, there will be **two plenary talks** — one on **Monday morning (November 10, 2025)** and another on **Tuesday morning (November 11, 2025)**. Continuing the line of previous esteemed speakers, Prof. Philip Hopke and Prof. Alfred Wiedensohler, we are honored this year to host **Dr. Martin Gysel-Beer (PSI, Switzerland)** and **Prof. Gerhard Lammel (Max Planck Institute, Germany)**.

Dr. Gysel-Beer focuses primarily on the physical (optical) properties of aerosol particles in relation to better understanding their impacts on climate (reducing measurement and prediction uncertainties) and human health (improving environmental quality). Prof. Lammel specializes in the chemistry of trace organic compounds, their

exchange between air, water, and soil, and their environmental exposure pathways and health impacts.

Finally, I would like to **extend my sincere thanks to all sponsors** of the *"Ovzduší v ČASe"* conference – **Altium, Biowell (Dekati), ECM ECOMONITORING, and TSI**. Representatives of these companies will be present throughout the conference, providing opportunities to discuss topics of mutual interest. Some of them will also contribute with technical presentations as part of the program.

And of course, I must not forget to thank this year's **proceedings editor, Jana Kánská** – thank you!

I look forward to meeting you all personally in Hustopeče. As always, **your ideas, feedback, comments, and praise are most welcome**.

Yours sincerely,

Jakub Ondráček (President of the Czech Aerosol Society)

CAS members participating at EAC 2025 in Lecce, Italy.

PREZENTACE/PRESENTATIONS

DLOUHODOBÝ VLIV DÁLKOVÉHO TRANSPORTU NA POZAĎOVOU ÚROVEŇ ZNEČIŠTĚNÍ VE STŘEDNÍ EVROPĚ

Radek Lhotka[1], Jan Pacner[1], Adéla Holubová Šmejkalová[1]

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Klíčová slova: Atmosférické aerosoly, Plynné polutanty, Hysplit, Theil-Senova metoda

SUMMARY

Influence of long-range transport on air quality measurements at the rural background station in Central Europe, the National Atmospheric Observatory Košetice was investigated over 20 years. Concentrations of selected air pollutants (SO_2, NO_X, CO, O_3, PM_{10}, SO_4, $\sum NO_3$, $\sum NH_4$) were analysed in conjunction with basic meteorological parameters, the evaluation of trend was utilised by the Theil-Sen method. Results indicate significant negative trends for the prevailing number of air pollutants, with exceptions such as tropospheric ozone, which remained either unchanged or exhibited increasing concentrations.

ÚVOD

Kvalita ovzduší je klíčovým faktorem ovlivňujícím lidské zdraví a udržitelnost ekosystémů (Seinfeld a Pandis, 2016). Tato studie analyzuje 20letou časovou řadu dat (2005–2024) kvality ovzduší na Národní atmosférické observatoři Košetice (NAOK – 49°34´24"N, 15°4´49"E, 534 m n. m., venkovská stanice), která reprezentuje pozaďovou úroveň znečištění ovzduší ve střední Evropě.

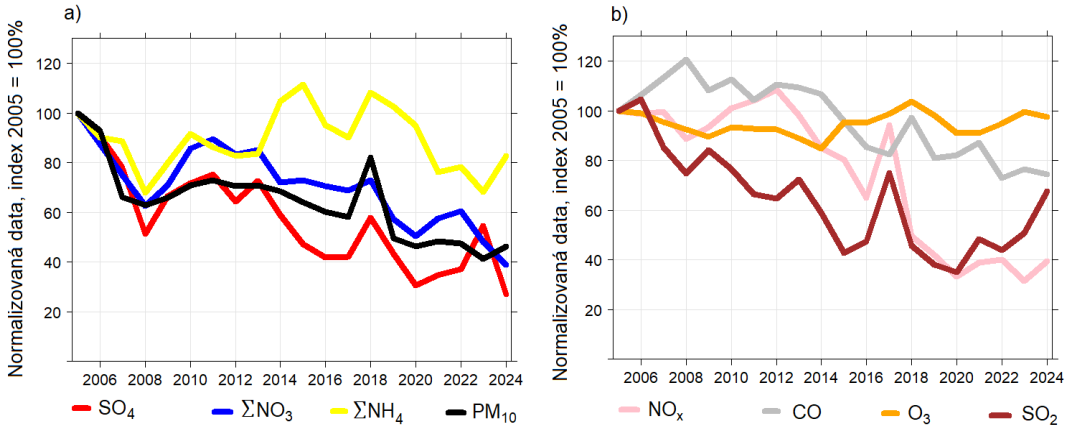
METODY MĚŘENÍ

Vliv dálkového transportu na měřené výsledky byl hodnocen s využitím zpětných trajektorií vzduchových hmot společně s koncentracemi vybraných znečišťujících látek - oxidu siřičitého (SO_2), oxidů dusíku (NO_X), oxidu uhelnatého (CO), přízemního ozonu (O_3) a aerosolových částic PM_{10} (PM_{10}), síranových iontů (SO_4), sumy dusičnanových iontů ($\sum NO_3$) a sumy amonných iontů ($\sum NH_4$). Výpočet zpětných trajektorií pomocí Hybrid Single Particle Lagrangian Integrated Trajectory model (HYSPLIT) byl nastaven v rozlišení: 96hodin, GDAS, 1° × 1°, 500 m AGL, 6hodinové intervaly (00, 06, 12, 18 UTC). Získaná data byla využita k určení klastrů vzduchových hmot pro dvě desetiletá období (2005–2014 a 2015–2024) a pro jednotlivá roční období. Analýzy a výpočty byly provedeny v programech R (balíček openair) a Igor (balíček ZeFir). K výpočtu vývoje sezónních trendů byla použita Theil-Senova metoda (Theil 1950; Sen 1968). Pro hodnocení celkových trendů a jejich změn byly zohledněny také meteorologické parametry, konkrétně teplota vzduchu (T), relativní vlhkost vzduchu (RH) a rychlost a směr větru (ws a wd).

VÝSLEDKY

Největší pokles koncentrací byl zaznamenán u SO_4^{2-}, jejichž průměrné roční koncentrace poklesli o 70 %. Významný pokles byl dále zjištěn u NO_x, $\sum NO_3^-$, shodně

o 60 %, PM_{10} o 50 %, SO_2 o 35 % a CO o 25 %. U pěti z těchto hodnocených látek byl prokázán statisticky významný sestupný trend ($p< 0,001$) platný napříč všemi ročními obdobími. U SO_2 byl sestupný trend zaznamenán pouze v jarním a zimním období ($p< 0,05$), to bylo pravděpodobně ovlivněno zvýšením koncentrací SO_2 mezi lety 2020 a 2024 o 25 %. Koncentrace $\sum NH_4^+$ poklesly o 20 % se statisticky významným negativním trendem pro léto a zimu ($p< 0,05$). Koncentrace O_3 byly časově a prostorově proměnlivé, přičemž celkové hodnoty zůstaly bez významnějších změn (Obr. 1 a Tab. 1). U většiny hodnocených veličin byl zaznamenán významnější pokles v koncentracích ve druhé polovině hodnoceného období (2015–2024).



Obr. 1: Vývoj koncentrací a) SO_4, $\sum NO_3$, $\sum NH_4$, PM_{10}, b) NO_x, CO, O_3, a SO_2 mezi roky 2005 a 2024 na NAOK.

Tab. 1: Průměrné koncentrace hodnocených veličin v ($\mu g \cdot m^{-3}$) v letech 2005 a 2024.

$\mu g \cdot m^{-3}$	SO_4	$\sum NO_3$	$\sum NH_4$	PM_{10}	NO_x	CO	O_3	SO_2
2005	3,7	4,6	3,2	27,0	10,4	270,0	66,9	3,0
2024	1,0	1,8	2,6	12,6	4,1	200,7	65,2	2,0

PODĚKOVÁNÍ

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RESOLVING SEASONAL DYNAMICS OF AEROSOL SOURCES IN A FINE PARTICULATE MATTER FRACTION AT A CENTRAL EUROPEAN RURAL BACKGROUND STATION

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Keywords: PM1.15-0.35, Elemental Composition, Source Apportionment, Temporal Variability

INTRODUCTION

Fine particulate matter (PM) has been a key domain of investigation in atmospheric research due to its complex chemical composition, transport potential, and ability to penetrate environmental and biological systems, thereby influencing ecosystem stability and human health (Pope and Dockery, 2006; Pöschl, 2005). Varying size fractions within fine particles are of particular concern as their physicochemical properties, sources, and atmospheric transformation processes vary considerably with particle size and meteorological conditions (Seinfeld and Pandis, 2019). Seasonal variability further modulates their composition through changes in emission patterns, boundary layer dynamics, and secondary formation pathways (Querol et al., 2004). In this study, we investigate elemental concentrations in the fine aerosol sub-fraction (1.15-0.35 µm) sampled at a Central European rural background site across summer and winter, followed by source apportionment analysis.

METHODOLOGY

Ambient aerosol samples were collected at the National Atmospheric Observatory Košetice (49°35′N, 15°05′E; 534 m a.s.l) during summer (July – August 2019) and winter (December 2019 – February 2020). A Rotating-drum Uniform-size-cut Monitor – 3DRUM (DELTA Group, UC Davis, USA) was used to isolate the fine particulate fraction of the size range 1.15 - 0.35 µm.

Elemental analysis was performed using X-ray fluorescence spectrometry (XRF) at UC Davis, California, USA. Enrichment factors (EFs) were calculated using titanium (Ti) as the reference to distinguish crustal and anthropogenic contributions. Source apportionment was conducted using Positive Matrix Factorisation (PMF, EPA PMF 5.0) to resolve seasonal variability in dominant aerosol sources.

RESULTS, DISCUSSION, CONCLUSIONS

Elemental concentrations in the fine aerosol fraction (1.15-0.35 µm) exhibited clear seasonal variability, with elevated levels during winter compared to summer for several elements (Fig. 1). Enrichment factor (EF) analysis, revealed pronounced deviations from

crustal baselines for elements such as sulfur (S), zinc (Zn), bromine (Br), and lead (Pb), indicating strong anthropogenic influence.

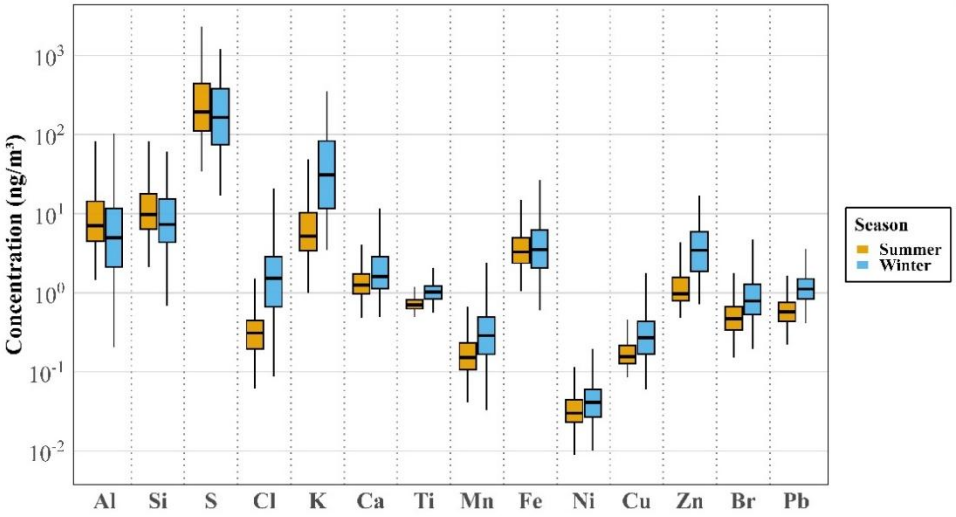

Fig. 1: Variation of elemental concentration across summer and winter.

PMF resolved distinct source profiles across seasons. Crustal sources were among the dominant contributors during summer, alongside other influencing factors, while winter showed enhanced signatures of biomass burning as one of the major sources. Factor stability and elemental fingerprints support robust attribution to regional combustion and mechanical resuspension.

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WHEN ASHES BECOME AEROSOLS: (CRYPTO)TEPHRA AS A TRACER OF VOLCANIC FALLOUT AND LONG-RANGE TRANSPORT

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Keywords: Flying ash, Volcanic aerosols, Sedimentary record, Paleoenvironment

INTRODUCTION

Volcanic eruptions are among the most powerful natural sources of atmospheric aerosols. During explosive events, large volumes of gases and ash, so called “tephra”, are injected into the atmosphere and dispersed over vast areas. These fine volcanic particles interact with climate, ecosystems, and human societies, both in the immediate aftermath and over long timescales (Lowe, 2011). A prominent case is the Late Pleistocene eruption of the Laacher See volcano in the East Eifel Volcanic Field (Germany), which occurred ~13,000 years ago. This eruption dispersed ca. 150 Mt of sulfur and ca. 20 km^3 of tephra across much of Central and Eastern Europe and had wide-ranging effects on landscapes, ecosystems, and human populations: Its fallout disrupted vegetation, altered water chemistry, and impacted Late Ice Age hunter-gatherer groups across the region (Baales et al., 2002; Baldini et al., 2018; van den Bogaard and Schmincke, 1985). While coarse ash deposits near the source have been extensively studied, detecting the fine ash fraction (<100 μm), particularly at long distances, remains a challenge. These aerosol particles become embedded in lake sediments, peat bogs, and other natural archives, where they serve as both stratigraphic markers invisible to the naked eye and proxies for atmospheric transport (Davies, 2015). Mapping their distribution helps to reconstruct eruption dynamics and assess the potential reach and impact of volcanic aerosols on past environments. In the case of the above-mentioned eruption, mapping is particularly important as the Laacher See volcano is still active and another major eruption would have catastrophic consequences (Hensch et al., 2019; Leder et al., 2017). This contribution outlines the fundamentals of cryptotephra research and highlights the significance of fine volcanic ash detection for understanding both past and future eruption scenarios.

EXPERIMENTAL SETUP

Cryptotephra analysis relies on the detection of fine volcanic ash particles which are preserved in sedimentary archives (e.g., lake beds and peatlands). Tephra consists primarily of volcanic glass shards and crystalline minerals, both of which can be preserved as microscopic solid particles, often down to only a few microns in size. The

workflow begins with the retrival of undisturbed sediment cores, typically obtained using gravity or piston coring systems. In our study, cryptotephra layers of the LST were identified in Plansee, an alpine lake in the Eastern Alps (Austria), as well as in sediments from paleolakes and lakes in the Bohemian Forest region (Germany and Czech Republic). These cores are then sampled at high resolution for both non-destructive and destructive analyses. Initial screening often involves X-ray fluorescence (XRF) and/or μ-XRF core scanning, complemented by computed tomography (CT) imaging to detect subtle stratigraphic structures. Suspected tephra-bearing layers are subsequently investigated using density separation techniques to concentrate volcanic glass. Isolated particles are mounted on slides and analyzed by scanning electron microscopy with energy-dispersive spectroscopy (SEM-EDS) to determine their major element composition. Electron probe microanalysis (EPMA) is used for more accurate and standardized glass geochemistry. In some cases, for even higher resolution or trace element data, laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) is applied. In cases where glass is scarce or altered, characteristic minerals are analyzed to support the identification. Automated scanning approaches, such as with a TIMA (TESCAN Integrated Mineral Analyzer) device, allow for high-resolution characterization of glass shards and minerals, further enhancing detection of cryptotephras at very low concentrations. The geochemical fingerprints of these shards and/or minerals are compared to reference data from other deposits, allowing researchers to correlate cryptotephra layers across regions and assign them to specific eruptions. This method is particularly useful for identifying widespread ash from large explosive eruptions, such as the Laacher See volcano, hundreds to over a thousand kilometers from the source (Lowe, 2011). In the case of the Laacher See tephra (LST), a highly distinctive phonolitic composition (silica-rich volcanic glass with elevated K and Na) provides a robust fingerprint that allows distal deposits to be confidently assigned to this eruption, even at sites hundreds to over a thousand kilometers from the source (van den Bogaard and Schmincke, 1985).

RESULTS AND CONCLUSIONS

Our recent cryptotephra investigations in the Alps and adjacent regions have led to the discovery of LST deposits at several distant sites over 400 km from the eruption source. These findings challenge earlier assumptions that the dispersal of LST was largely confined to the northeast and southwest of the Laacher See caldera. Instead, our results indicate a broader and more complex fallout pattern, including previously undocumented deposition to the east of the volcano (e.g., in the Bohemian Forest; Meier et al., 2025) and even in the Eastern Alpine lake Plansee (Austria, Tyrol). A compiled distribution map (Fig. 1) highlights both confirmed LST detections and current gaps in spatial coverage. While some of the new sites such as Plansee exhibit glass concentrations near detection limits, their geochemical fingerprints match the LST reference composition.

Cryptotephra layers are valuable chronological markers in environmental archives. Their precise geochemical fingerprint allows researchers to correlate sedimentary sequences across vast regions and across different settings, from continental over marine to ice core deposits, enabling the synchronization of paleoclimate- and paleoenvironmental records (e.g., Warken et al., 2025). However, understanding the spatial distribution of tephra deposition, especially the long-range transport of the fine tephra fraction, remains a major challenge, and is critical for improving the temporal resolution and reliability of these reconstructions. In this context, methods and models from atmospheric aerosol science offer promising opportunities. Better characterization

of particle transport and fallout dynamics, informed by aerosol modeling approaches, could significantly enhance cryptotephra studies and support more robust interpretations of past volcanic events. Our findings so far indicate that the Laacher See eruption may have caused environmental changes over a larger area than previously thought.

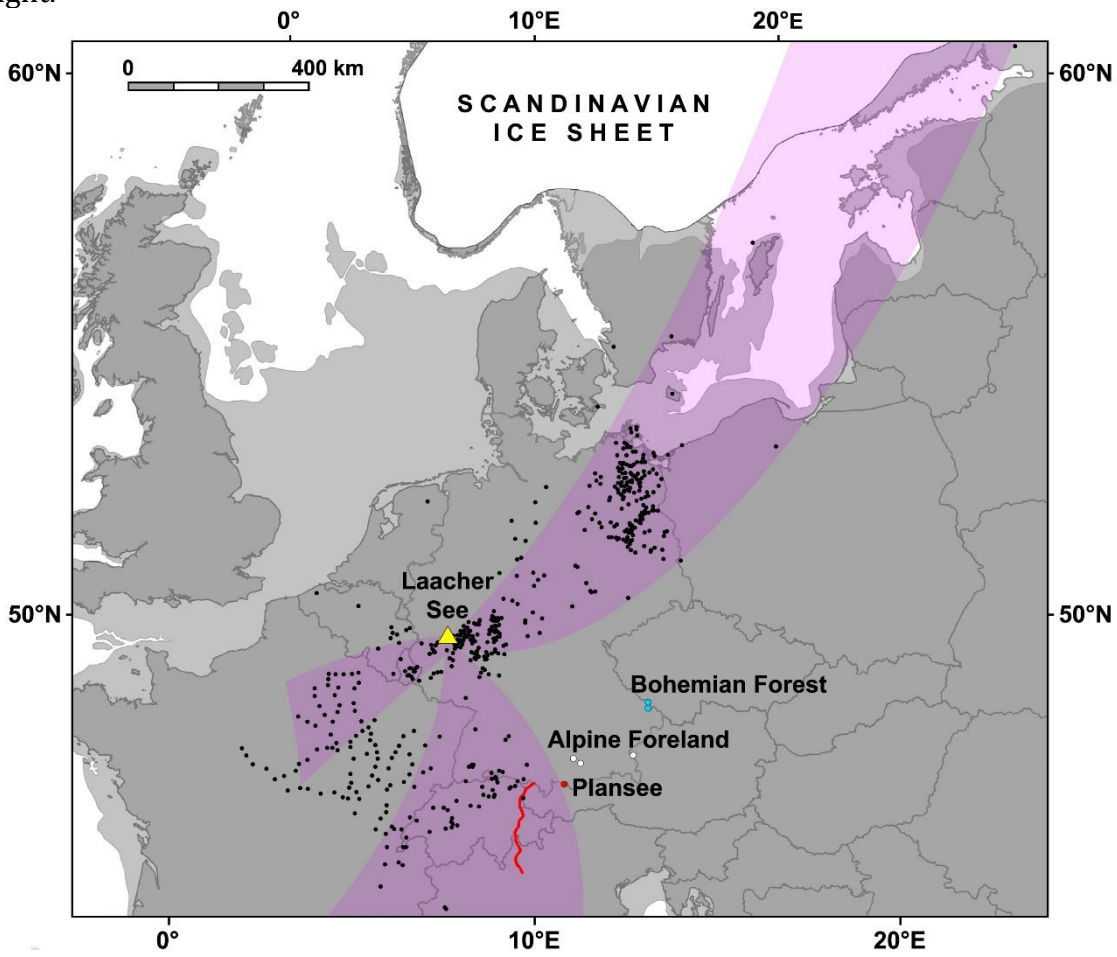

Fig. 1: LST distribution map based on the tephrabase website data (Riede et al., 2011), the outer detection limits of the distal fallout estimated by van den Bogaard and Schmincke (1985) (shown in purple), our results, and a reconstructed Late Ice Age palaeogeography (Riede, 2016). Yellow triangle: the Laacher See volcano; black dots: LST air-fall deposits; blue dots: LST air-fall deposits in the Bohemian Forest; white dots: LST air-fall deposits in the Alpine Foreland; red dot: LST air-fall deposit in the Eastern Alps; red curve: the border between the Western Alps and Eastern Alps.

ACKNOWLEDGEMENT

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INFLUENCE OF AEROSOL CHEMICAL COMPOSITION AND AIR MASS ORIGIN ON CLOUD ACTIVATION AT A BACKGROUND SITE

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Keywords: Cloud Condensation Nuclei, Hygroscopicity, Aerosol-Cloud Interaction

INTRODUCTION

Atmospheric aerosol particles play a crucial role in cloud formation by acting as cloud condensation nuclei (CCN), influencing the Earth's radiative balance and hydrological cycle. The ability of aerosols to serve as CCN depends not only on their number concentration but also on their physical and chemical properties, as well as their mixing state (Mochida et al., 2010). Hygroscopicity, which describes a particle's ability to absorb water, is a fundamental property that governs aerosol behavior in the atmosphere. Since aerosol hygroscopic properties evolve throughout their atmospheric lifetime, understanding these changes is essential for assessing their role in cloud activation. This study presents a comprehensive analysis of aerosol physical, chemical, and activation properties measured at the ACTRIS (Aerosol, Clouds, and Trace Gases Research Infrastructure, http://www.actris.eu/) background site in Košetice (NAOK), Czech Republic. Our primary objective is to improve the understanding of aerosol activation processes and ambient hygroscopic properties, with a particular focus on how chemical composition influences CCN activity.

EXPERIMENTAL SETUP

Atmospheric aerosol measurements were conducted at the National Atmospheric Observatory Košetice (NAOK; 49◦ 35' N, 15◦ 05' E; 534 m a.s.l.), a rural background site in the Bohemian-Moravian Highlands region. This study focuses on aerosol particles' physicochemical properties and activation ability using the data collected at NAOK from December 2022 to November 2023.

A compact time-of-flight aerosol chemical speciation monitor (ToF-ACSM, Aerodyne) was used to measure the chemical compositions of the non-refractory submicron aerosol particulate matter (nitrate, sulfate, chloride, ammonium, and organics). The mass concentration of equivalent black carbon (eBC) was measured using the Aethalometer (AE33, Magee). The condensation particle counter (CPC, model 3775, TSI) was used to measure the total number concentration (NCPC) of atmospheric aerosol and the cloud condensation nuclei counter (CCNC, model 200, Droplet Measurement Technologies) was used to measure the CCN number concentration (NCCNC).

The total activated fraction was obtained by getting the ratio of NCCNC over NCPC at every supersaturation (SS) level. At fully stabilized CCNC conditions, five different SS levels were set in the CCNC instrument (0.1 %, 0.2 %, 0.3 %, 0.5 %, and 1.0 %). A complete SS cycle lasted ~ 1 hour.

The hygroscopicity (κ) was derived from the ACSM chemical composition measurements using the Zdanovskii–Stokes–Robinson (ZSR) mixing rule combined with κ-Köhler theory (Petters and Kreidenweis, 2007). A simple ion-pairing scheme (Gysel et al., 2007) was used in this study, with the κ and ρ values of chemical species adopted by Wu et al. (2015). A κ of 0.1 was used for particulate organics (Gunthe et al., 2011). For black carbon, a κ of 0 was used (Schmale et al., 2018). The GDAS (Global Data Assimilation System) meteorological data in 1°x1° spatial resolution were downloaded and back trajectories were calculated and clustered using the Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model (Stein et al., 2015).

RESULTS AND CONCLUSIONS

The CCN activation ratios (AR) increase with increasing supersaturation (SS) across all clusters of air masses (Fig. 1). Higher SS allows a broader range of particle sizes and compositions to activate into cloud droplets. However, at low SS (0.1 – 0.3 %), clusters originating from the Atlantic region (Cluster 3) exhibit slightly higher AR, while Eastern European clusters (Cluster 1) show the lowest activation efficiency. This suggests that particles from Eastern Europe are less hygroscopic or smaller, requiring higher SS to activate. In contrast, oceanic air masses contain more hygroscopic aerosol species, caused by more oxidized (and therefore more polar) organic aerosol, which activate more readily at lower SS.

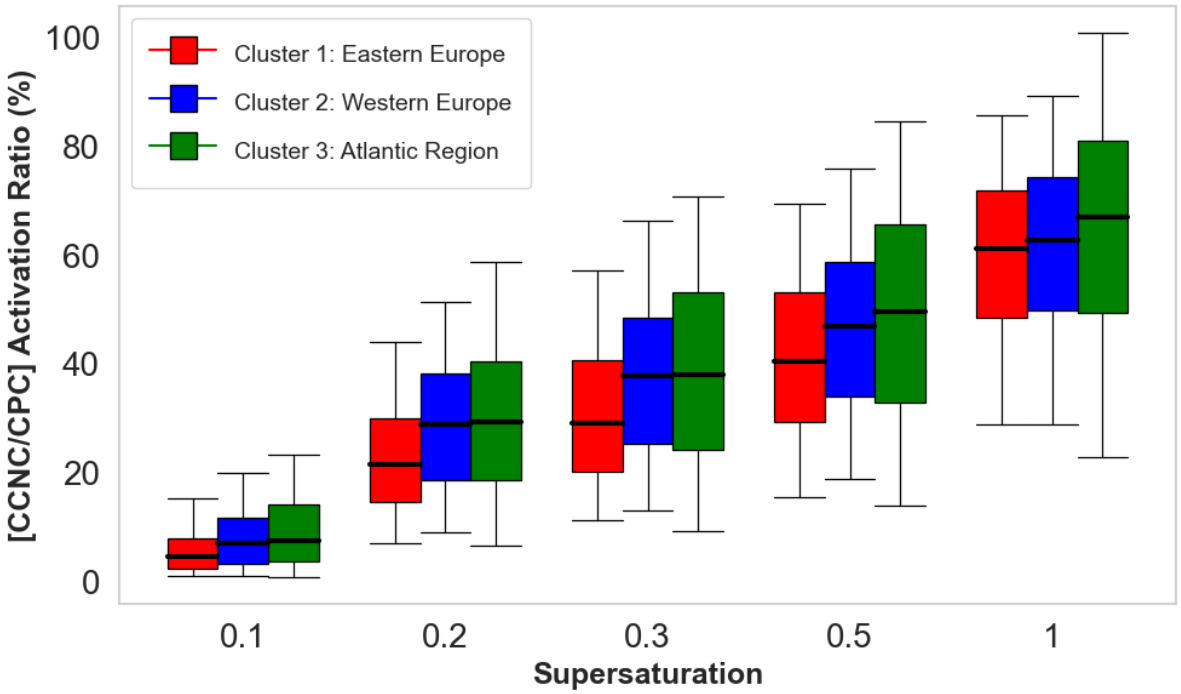

Fig. 1: CCN activation ratio as a function of supersaturation for different clusters. Each box represents the interquartile range (IQR: Q1–Q3), the median (Q2), and whiskers (5th and 95th percentiles).

At higher SS (0.5 to 1.0 %), the differences among clusters become less pronounced, as more particles across all sizes and compositions reach activation. Nonetheless, oceanic air masses still trend slightly higher in activation efficiency, which aligns well with the higher κ values (Fig. 2). Hygroscopicity plays a key role in CCN activation, as higher κ values generally reflect a greater fraction of soluble inorganic species, such as sulfates and nitrates, which readily take up water. The κ values, derived from aerosol chemical composition, indicate that Cluster 3 has the highest average κ, followed by Cluster 2 (Western Europe), and the lowest in Cluster 1.

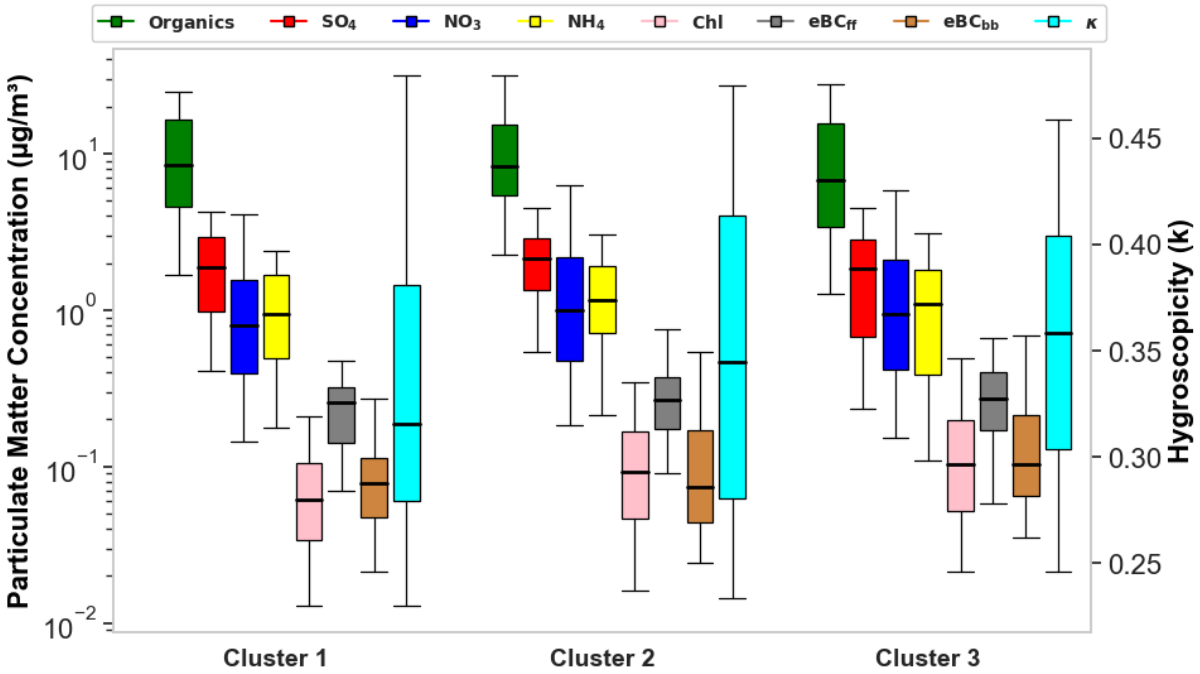

Fig. 2: Particulate matter composition and hygroscopicity across clusters. Each box represents the interquartile range (IQR: Q1–Q3), the median (Q2), and whiskers (5th and 95th percentiles).

In Cluster 1, the dominance of organic matter (which is typically less hygroscopic) and a lower proportion of inorganics contributes to the reduced κ and, consequently, lower CCN activation efficiency. Additionally, Cluster 1 shows relatively higher variability and contributions from combustion-related species, as equivalent black carbon from fossil fuel combustion (eBC_{ff}) and biomass burning (eBC_{bb}), which further reduce the particles' ability to act as CCN.

In contrast, Cluster 3 is influenced by marine or cleaner air masses, which are often enriched with more hygroscopic inorganic aerosols and have lower concentrations of organics and black carbon. This composition enhances CCN activation, especially at lower SS, indicating the presence of larger and more soluble particles.

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AN EXPERIMENTAL APPROACH TO THE LIFE-CYCLE AND ATMOSPHERIC IMPACTS OF BLACK CARBON

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Keywords: Black Carbon, scavenging, radiative impact, polarimetric retrieval

INTRODUCTION

Black carbon (BC) typically contributes around 5-10% to atmospheric aerosol. BC is of major relevance for several reasons: first, BC is associated with adverse health impacts (Janssen *et al.*, 2012); second, BC is the main contributor to absorption of incoming visible solar radiation (Bond *et al.*, 2013) thus exercting radiative forcing and affecting atmospheric dynamics and precipitation (Samset *et al.*, 2022); third a major portion of BC originates from anthropogenic sources (Zhang *et al.*, 2025).

Here we address experimental approaches to quantify different properties of black carbon which are relevant to its lifecycle and the magnitude of its atmospheric impacts. This includes the effects of changes in morphology and mixing state on its efficiency to absorb solar radiation (Romshoo *et al.*, 2021) and to act as cloud condensation nuclei (Juranyi *et al.*, 2013). A major focus will be put on the inverse problem of aerosol polarimetry, illustrated in Fig. 1, for two reasons. First, detection of angular distribution of light scattered by an aerosol is essentially the only approach which allows remote sensing of aerosol properties in a more comprehensive manner including light absorption (Dubovik *et al.*, 2013). Second, light absorption retrieval is known to be prone to systematic bias (Schuster et al., 2019). These topics will be presented based on experimental work in laboratory and field studies.

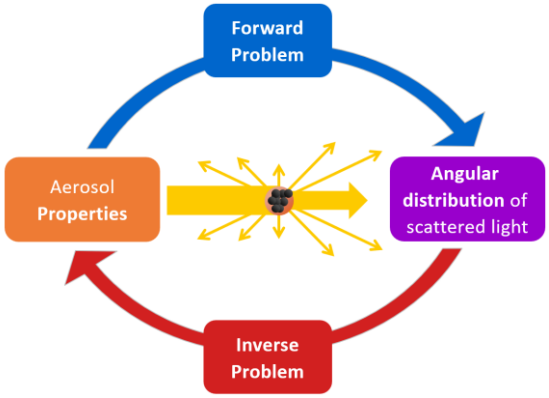

Fig. 1: The inverse problem of aerosol polarimetry is about retrieving aerosol properties from measurement of angular and polarisation dependence of light scattered by this aerosol.

METHODOLOGY

Several aspects of experimental and numerical methods will be addressed. This includes methods to measure BC mass concentration, mixing state and light absorption, which

serve to determine its mass specific light absorption coefficient (MAC). In context of nucleation scavenging of BC to form cloud droplets, the value of applying methods based on quantitative single particle detection will be demonstrated. Instruments enabling in-situ aerosol polarimetry will obtain particular attention (e.g. Moallemi *et al.*, 2023, and references therein). Classification of light absorbing carbonaceous particulate matter (PM) will also be touched upon (Fig. 2; Corbin *et al.*, 2019), given this is crucially important for a consistent framework to interpret experimental data and to simulate light absorption by an atmospheric aerosol.

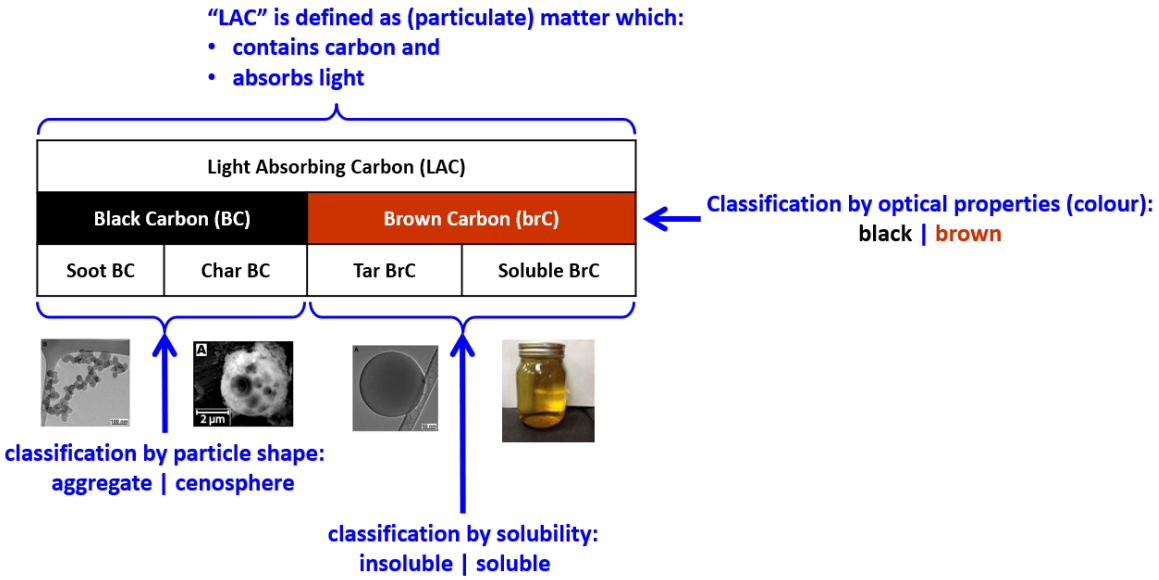

Fig. 2: Classification of light absorbing carbonaceous particulate matter (LAC-PM) following Corbin *et al.* (2019).

RESULTS, DISCUSSION, CONCLUSIONS

The interaction of a particle with light depends strongly on its size, shape and internal morphology. Light scattering is very sensitive to these properties. By contrast, light absorption is less sensitive to these properties, which makes it possible to approximate the light absorption coefficient as product of mass concentration times MAC. However, this only is an approximation. This is, for example, reflected in enhancement of the MAC of BC as it becomes internally mixed with non-absorbing PM during its atmospheric lifecycle. Results from field and laboratory studies demonstrating that this effect indeed occurs in line with theoretical expectations will be presented (Yuan *et al.*, 2021).

The mixing state of black carbon also is crucially important for its ability to act as cloud condensation nuclei given the combined effect of larger size and increased hygroscopicity due to coatings with at least partially water-soluble PM. Results from laboratory and field experiments demonstrating these effects will be presented (Motos *et al.*, 2019). This includes a discussion based on a recent field study of the importance of the actual cloud formation regime on resulting BC scavenged fraction, i.e. CCN limited versus cooling rate limited regime (Reutter *et al.*, 2009),

Inverse problems are often ill-posed for different reasons. However, this limitation does not apply for the inverse problem of aerosol polarimetry in case of simple aerosols, i.e. if all particles have the same composition, a unimodal size distribution and spherical shape. This has been demonstrated with theoretical information content analyses

(Moallemi *et al.*, 2022). Furthermore, a recent study by Xu *et al.* (2025) demonstrated that this also applies for bare BC aggregate particles and retrieval of their light absorption, when considering the effects of aggregate morphology in the optical kernel of the retrieval algorithm. However, atmospheric aerosols are quite complex ensembles containing particles of different shape, composition, and mixing state. The hypothesis put down here is that making an optimal choice for the aerosol model and optical kernel will make it possible to retrieve aerosol properties more reliably when solving the inverse problem of aerosol polarimetry (Fig. 3). Results from controlled laboratory as well as unconstrained field measurements will be used to presetend where we currently stand in this endavor.

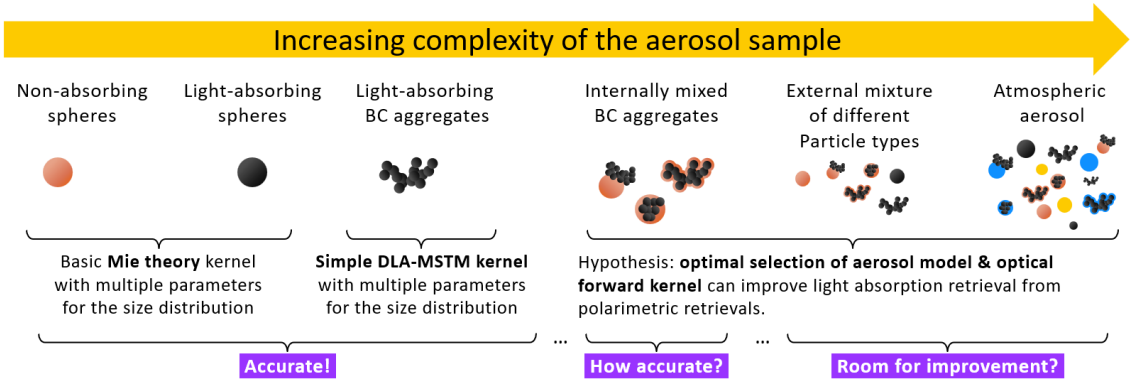

Fig. 3: Aerosol polarimetry is a very powerful tool for indirect measurement of aerosol properties through light scattering for spherical particles. However, optimal choice for aerosol parameters and optical forward kernel becomes critical for accurate property retrieval of atmospheric aerosols, which are an ensemble of particles with varied size, shape, composition and mixing state.

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WATER TO RULE THEM ALL: A MEASUREMENT OF THE HYGROSCOPIC LIGHT SCATTERING ENHANCEMENT USING A NOVEL SINGLE-NEPHELOMETER SETUP SYSTEM AT URBAN BACKGROUND SITE

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Keywords: Aerosol optical properties, Hygroscopicity, Aerosol climate effects

INTRODUCTION

International monitoring programmes recommend measuring aerosol optical properties at relative humidities (RH) below 40% to ensure comparability between atmospheric stations worldwide (WMO/GAW, 2016). However, aerosol hygroscopicity — the ability of particles to take up and retain water vapor — significantly alters their physical, chemical, and optical properties, thereby influencing their climate impacts (Burgos et al., 2019; Zieger et al., 2015). The light scattering enhancement factor, f(RH > 80%), quantifies the increase in aerosol scattering under humidified conditions relative to dry conditions (Titos et al., 2021).

METHODOLOGY

In this study, we introduce a novel single-nephelometer setup designed to reduce measurement uncertainty and reliably detect changes in aerosol light backscattering under elevated RH, $f(\mathrm{RH} > 80\%)_{bsp}$. Ambient aerosols were sampled through a PM_{10} inlet, dried (<40% RH), and split into two streams: one remained dry, while the other was humidified (>80% RH) using a Nafion membrane. The Integrating Nephelometer TSI 3563 alternately measured dry and humidified samples every 60 min to obtain total and backscattering coefficients at three wavelengths. The system was deployed at the ACTRIS urban background site in Prague (50°07′N, 14°23′E) from November 2022 to August 2023. The derived f(RH > 80%) and $f(\mathrm{RH} > 80\%)_{bsp}$ values were analyzed together with meteorological parameters, estimated chemical composition, particle number size distributions (PNSD), air mass back trajectories, and new particle formation (NPF) events to assess hygroscopic behavior in an urban European environment.

RESULTS, DISCUSSION, CONCLUSIONS

Both f(RH > 80%) and $f(\mathrm{RH} > 80\%)_{bsp}$ exhibited some of the lowest values reported in the literature, indicating modest hygroscopic growth of aerosol light scattering at the site. Water uptake by particles increased the single scattering albedo (SSA; Fig. 1B), reflecting enhanced total light scattering. Conversely, a decrease in the backscattering fraction (b; Fig. 1A) with increasing RH suggested stronger forward scattering due to particle growth. Both effects are critical for accurate estimation of the aerosol direct radiative effect.

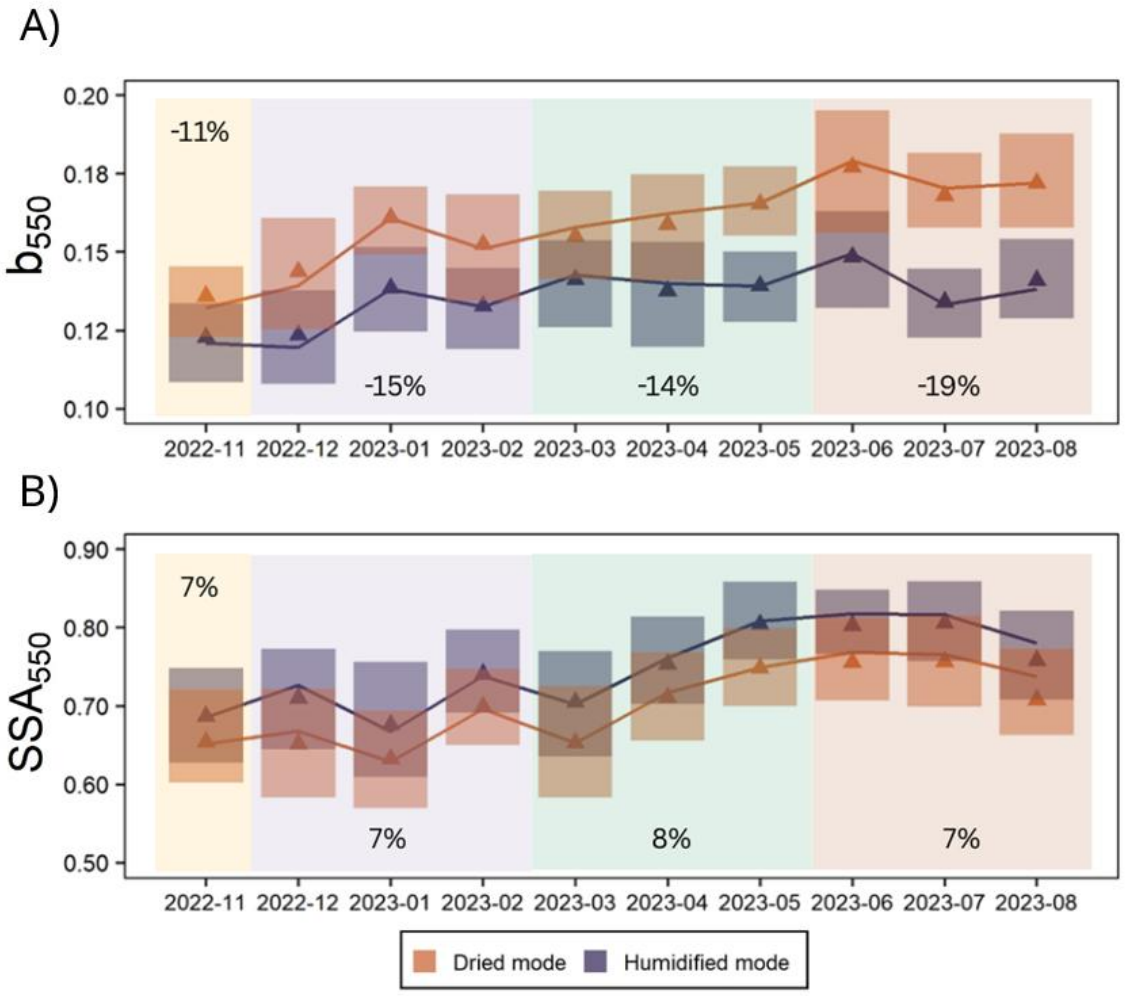

Fig. 1: The monthly variation of A) hemispheric backscattering ratio (*b*) and B) single scattering albedo (SSA) at dry and humidified conditions at 550 nm. The lines with shaded areas and triangles represent median values with interquartile range and mean values, respectively. A colored background depicts individual seasons with relative change between humidified and dry median values.

The weak hygroscopic response was attributed to a dominant carbonaceous aerosol mixture, primarily black (BC) and brown (BrC) carbon, with occasional dust or marine aerosol influence. Both $f(\mathrm{RH} > 80\%)$ and $f(\mathrm{RH} > 80\%)_{\mathrm{bsp}}$ were positively correlated with the ratio of secondary organic carbon (SOC) to total OC. Principal component (PCA) and PNSD analyses revealed the relative contribution of NPF to the observed hygroscopic scattering enhancement.

In conclusion, the single-nephelometer system was proven to reliably quantify RH-dependent changes in aerosol light scattering in the ambient atmosphere. Its main limitations were the reduced temporal resolution and the absence of simultaneous dry/humidified measurements, restricting its use for detailed humidogram analyses.

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FROM BOUNDARY LAYER TO FREE TROPOSPHERE: AEROSOL AND ICE NUCLEATION PARAMETERIZATION

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Keywords: Atmospheric aerosols, Planetary Boundary Layer, Vertical Profile

INTRODUCTION

Atmospheric aerosols (AAs) have a wide range of sizes, are emitted by various sources, and can have very different physical and chemical properties (Calvo et al. 2013; Colbeck 2008), making them one of the most uncertain components for climate models and weather forecasts (IPCC 2021). One of their roles is to act as condensation nuclei for water droplets (Cloud Condensation Nuclei, CCN) and ice crystals (Ice Nucleation Particles, INP) (Tao et al., 2014; Liu et al., 2021) during cloud formation. This process can occur near the ground in cases of fog, as well as at higher altitudes in the troposphere and stratosphere.

We aim to establish new INP parameterizations for central Europe based on online INP measurements at the National Atmospheric Observatory Kosetice (NAOK) to better estimate the solid fraction of hydrometeors in the clouds. The presented study serves as a preliminary work and investigates the vertical distribution and representativeness of aerosol number size concentration, chemical composition, as well as parameterized INP concentration.

METHODOLOGY

We measured the aerosol number size distribution by Mobility and Aerodynamic Particle Sizer Spectrometers (MPSS and APSS), covering aerosol with mobility diameters from 10 to 800 nm and aerodynamic diameters from 0.5 to 10 μm. Aerodynamic diameters determined by APSS were then converted to mobility diameters assuming a particle density of 1.5 g·cm^{-3}. Two pairs of those instruments were installed at NAOK, sampling at 4 m and 230 m above the ground. The four instruments were able to measure simultaneously for 770 hours during December 2024, April, and May 2025. Data sets from MPSS and APSS were combined to calculate the total number concentration of aerosols, as well as the number concentration of aerosols with a mobility diameter greater than 0.5 μm. From the aerosol concentration, INP concentration was calculated through the parameterization from DeMott et al. (2010), as:

$$n_{IN,T_k} = a(273.16 - T_k)^b * n_{aer,0.5}^{(c(273.16-T_k)+d)}, \quad (1)$$

with constants a, b, c, and d being 0.0000594, 3.33, 0.0264, and 0.0033, T_k the temperature in Kelvin, n_{IN,T_k} the INP number concentration in std L^{-1}, and $n_{aer,0.5}$ the concentration of aerosol with mobility diameter > 0.5 μm in std cm^{-3}.

The boundary layer height (BLH) from ERA5 reanalysis was used to retrieve free troposphere measurement periods from the tower top, resulting in 407 hours of free tropospheric measurements out of 770 hours. We also used 72-hour HYSPLIT backtrajectory analysis to get insight into air mass origins.

RESULTS

The total particle number concentration is 44 % higher near the ground (Figure 2a), while the difference for large particles is 162% (Figure 2b). At 230 m above ground, total and large particle number concentrations decrease by 7 % and 13 % when measured in the free troposphere. Near the ground, concentrations react differently to the lowering of the BLH. The total particle number concentration is lower by 15 % when the BLH is higher, while the concentration of large particle numbers is 22 % higher. The number concentration of INP follows the behavior of large particle concentration, as specified in the parameterization input.

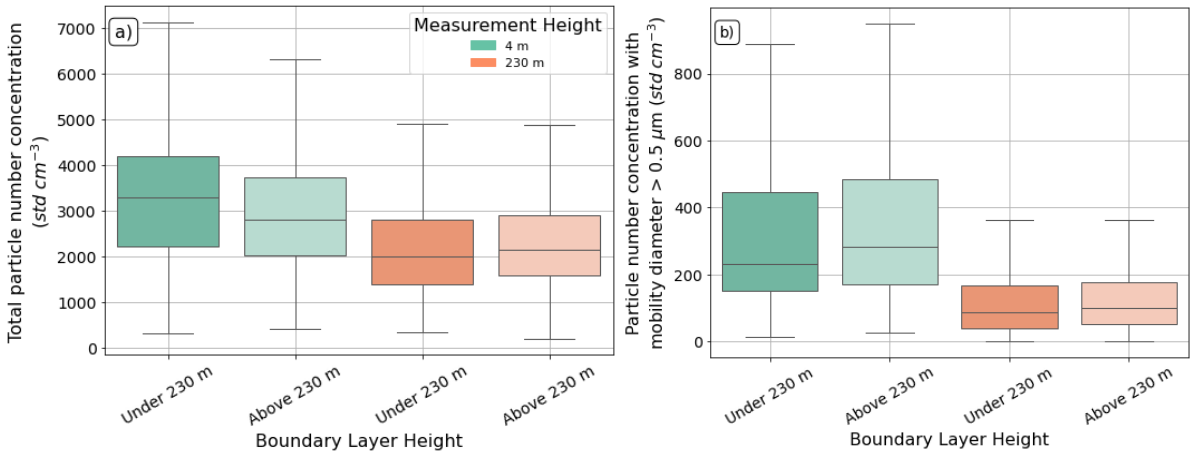

Figure 2: a) Total particle number concentration box plot at different heights depending on the boundary layer height. b) Idem for particle number concentration with a mobility diameter > 0.5 µm.

We observe, depending on the T_k used, INP number concentrations between 47% and 160% higher at the bottom of the tower compared to the tower top. At both heights, the INP number concentration decreases for lower BLH (between 8 and 20 % at 4m and between 5 and 12 % at 230m).

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METEOROLOGICAL EFFECTS ON VERTICAL VARIABILITY OF AEROSOL CHEMICAL COMPOSITION AT A RURAL BACKGROUND SITE

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Keywords: atmospheric aerosols, vertical distribution, chemical composition, AMS, ACSM, EC, OC, Boundary layer

INTRODUCTION

Atmospheric aerosols affect climate, visibility, human health, and ecosystems (Dockery et al., 1993; Charlson et al., 1992; Ackerman et al., 2000). Their impacts strongly depend on chemical composition and vertical distribution within the boundary layer. Most studies remain surface-focused, limiting understanding of vertical variability. This study addresses this gap through dual-height chemically resolved aerosol observations at a rural background observatory located in the Czech Republic.

METHODOLOGY

Simultaneous measurements were conducted at 4 m and 230 m on a 250 m tall tower at the National Atmospheric Observatory Košetice (NAOK) (Dvorská et al., 2015) between December 2019 and May 2020. Aerosol chemical composition was quantified using a compact Time-of-Flight Aerosol Mass Spectrometer (AMS, 230 m) and a Time-of-Flight Aerosol Chemical Speciation Monitor (ACSM, 4 m). The key aerosol components analyzed are organics (Org), sulfate (SO_4^{2-}), nitrate (NO_3^-), ammonium (NH_4^+), and chloride (Chl). Additional elemental, organic, and equivalent black carbon (EC, OC, eBC, respectively) were obtained from semi-continuous Sunset OCEC analyzers at both heights. Meteorological parameters, mixing layer height, and synoptic circulation types were integrated to analyse the factors influencing vertical variability.

RESULTS

The findings reveal that while the boundary layer is generally well-mixed, most aerosol components show higher concentrations near the surface (4m), with vertical ratios (230m/4m) typically between 0.5 and 0.8 (Figure 1). However, episodes of elevated concentrations at 230m highlight the role of atmospheric dynamics and vertical transport mechanisms. The carbonaceous aerosols (Org, EC, OC, eBC) consistently exhibited strong surface dominance, especially in winter under shallow boundary layers and thermal inversions. Secondary inorganic species (SO_4^{2-}, NO_3^-, NH_4^+) showed weaker vertical gradients and episodes of higher concentrations aloft during spring, indicating enhanced photochemical formation and regional-scale transport. Chloride was episodic, occasionally enriched at 230 m, suggesting the influence of biomass burning or long-range

transport. Vertical ratios and gradients highlighted the key role of mixing layer height and temperature gradient in shaping distributions. At the same time, air-mass clusters and synoptic regimes also modulated the relative importance of local versus transported aerosol.

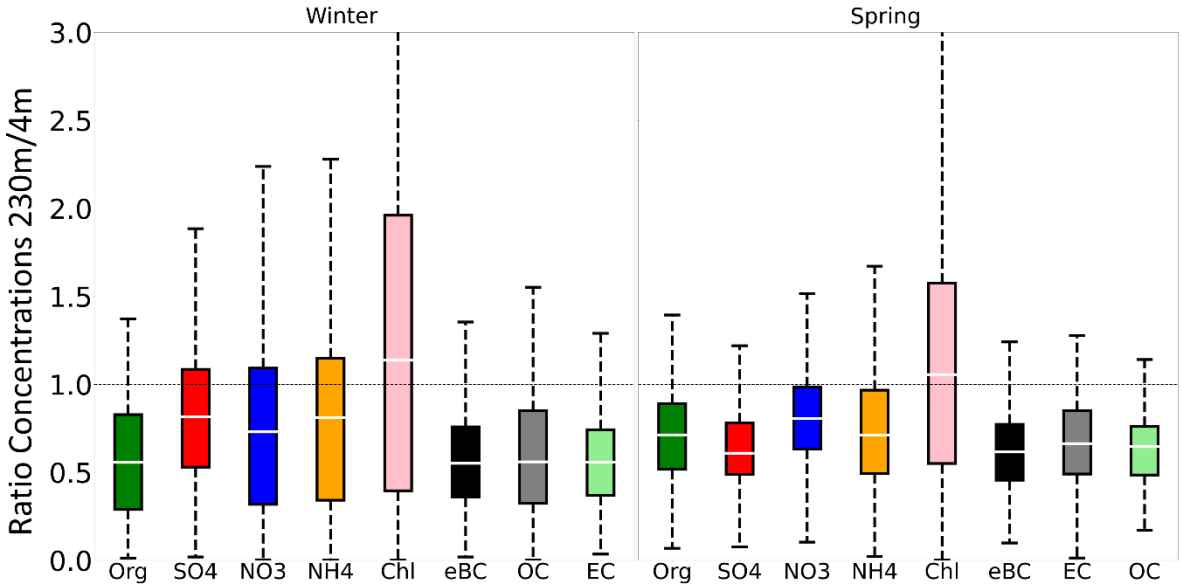

Fig. 1: Seasonal boxplots of vertical concentration ratios (230 m / 4 m) for major aerosol components during winter (left) and spring (right). The dashed line at 1.0 indicates equal concentrations at both heights.

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MEASUREMENT OF NEW PARTICLE FORMATION USING NAIS AT TWO DIFFERENT HEIGHTS

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Keywords: new particle formation, NAIS, clusters, vertical profile

INTRODUCTION

During a new particle formation (NPF) event, gas molecules cluster, stabilize, and grow into aerosol particles. To investigate its mechanisms, it is crucial to study NPF from the very beginning, when particles are only a few nanometers in size (Manninen et al., 2016).

The Neutral Cluster and Air Ion Spectrometer (NAIS) is one instrument capable of measuring such small particles. This multichannel aerosol instrument measures charged particles and cluster ions of both polarities in the electric mobility range of 3.2 to 0.0013 $cm^2 \cdot V^{-1} \cdot s^{-1}$, as well as the distribution of aerosol particles in the size range from 2 to 40 nm. (Mirme & Mirme, 2013)

METHODS

Measurements are conducted at the National Atmospheric Observatory Košetice (NAOK), a rural background site. An important component of this facility is a 250-meter high atmospheric tower, which enables continuous observations across different levels of the atmospheric vertical profile. For our study, two Neutral cluster and Air Ion Spectrometers (NAIS) have been installed at the site—one at ground level and the other at 230 meters above ground level. This setup allows for a direct comparison of particle and ion concentrations near the surface and in the upper part of the atmospheric boundary layer (ABL), providing deeper insight into new particle formation dynamics. In addition, the top of the tower occasionally extends above the ABL, which makes it possible to observe differences between the air within the ABL and in the free troposphere.

Complementary meteorological and environmental data, essential for the interpretation of the measurements, are provided under Open Access to infrastructure ACTRIS-CZ. These include air temperature, humidity, precipitation, wind speed and direction, solar radiation, and carbon monoxide (CO) concentrations. Together, these data enable a comprehensive evaluation of the influence of meteorological conditions and atmospheric composition on the observed processes.

RESULTS

The data collected by the NAIS instruments over several weeks have been measured, processed, evaluated, and compared to meteorological parameters. Based on this comparison, new particle formation (NPF) events were identified and evaluated, focusing on the atmospheric conditions that influence their initiation and subsequent development.

ACKNOWLEDGEMENTS

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TOXICITY OF TRANSPORT EMISSIONS UNDER SUBFREEZING CONDITIONS

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Keywords: transport emissions, toxicity, air-liquid interface, real driving emissions

INTRODUCTION

Vehicle exhaust remains a major source of urban particulate matter (PM), yet the toxicological effects of cold-start emissions under subfreezing conditions are insufficiently understood. Low ambient temperatures impair combustion efficiency, increase unburned hydrocarbons and nitrogen-containing species, and alter particle composition. Recent toxicological work (Hakkarainen *et al.*, 2020, 2024) demonstrated that fuel aromatic content, exhaust after-treatment, and operating temperature remarkably influence emission toxicity. Using a thermophoresis-based air-liquid interface exposure of A549/THP-1 co-cultures, they showed that higher aromatic content and colder engine operation enhance the toxic potential of exhaust aerosols.

Within the Horizon Europe project PAREMPI we build on this research to investigate how subfreezing cold-start emissions from light-duty vehicles affect human airway epithelial cells (3D MucilAir™ model), comparing toxicity at +23 °C and −9 °C.

METHODOLOGY

Five vehicles with different Euro classes and exhaust after-treatment systems were tested under Real Driving Emission (RDE) simulation cycle (Tab. 1). Complete exhaust was delivered directly to MucilAir™ 3D human bronchial epithelial cultures using a portable toxicity incubator (Vojtisek-Lom *et al.*, 2019, 2025). The RDE cycle lasted 72 minutes per exposure, with two consecutive exposures per test vehicle, followed by a 24-hour recovery period before analysis. Clean-air and blank controls were included in each experimental batch to account for background effects.

After exposure, cellular endpoints were evaluated to characterise multiple levels of toxicity. Cytotoxicity was determined by adenylate kinase and lactate dehydrogenase assays in cell culture medium, while barrier integrity was measured as transepithelial electrical resistance (TEER). Oxidative stress was assessed via isoprostane levels, and genotoxicity was evaluated using the Comet assay and phosphorylation of the histone variant H2AX.

For transcriptomic profiling, total RNA was isolated and analysed by RNA sequencing, followed by differential expression analysis. The transcriptomic data were analysed in

three complementary ways to capture both vehicle-specific and temperature-related effects. First, each vehicle was compared individually to its corresponding control to evaluate the overall transcriptional impact of exhaust exposure. Second, data from all vehicles were combined to test the collective effect of different temperature conditions, comparing emissions generated at +23 °C and −9 °C. Finally, two technologically contrasting vehicles (V1 (Euro 6 gasoline PHEV) and V6 (Euro 4 diesel without DPF)) were directly compared between temperature conditions to identify common molecular responses characteristic of subfreezing operation.

Tab. 1: Description of vehicles used for toxicity testing

ID	**Fuel**	**Specificity**	**Euro class**
V1	Gasoline	PHEV[1]	6d
V3	Gasoline	-	6d
V4	Diesel	-	6d
V5	Gasoline	No GPF[2]	6b
V6	Diesel	No DPF[3]	4

([1]Plug-in hybrid electrical vehicle; [2]gasoline particulate filter; [3]diesel particulate filter)

RESULTS, DISCUSSION, CONCLUSIONS

Cytotoxicity was generally low under all conditions (cell viability > 80 %), but cold-conditions exhaust caused more pronounced cellular effects than emissions at +23 °C. A small but consistent decrease in TEER was seen for diesel vehicles (V5 and V6) at −9 °C, indicating a mild disturbance of epithelial barrier function. Oxidative stress increased at lower temperature, particularly for gasoline vehicles (V3 and V5) and one of the diesels (V4). Genotoxicity remained low overall, but the older Euro 4 diesel (V6) showed a mild DNA damage signal under cold conditions.

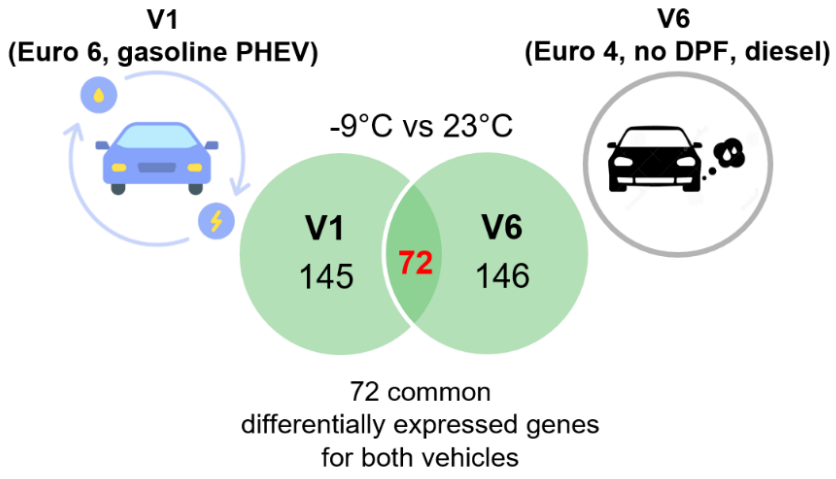

Fig. 1: Comparison of transcriptomic responses to subfreezing operation (−9 °C vs +23 °C) for two vehicles representing opposite technologies: V1 – Euro 6 gasoline plug-in hybrid electric vehicle (PHEV) and V6 – Euro 4 diesel vehicle without diesel particulate filter (DPF). Seventy-two genes were commonly regulated in both vehicles, indicating a shared molecular response.

Transcriptomic analysis clearly reflected the temperature effect. When all vehicles were considered together, 1 563 genes were upregulated and 916 downregulated at −9 °C compared to +23 °C. Two vehicles at the technological extremes (the Euro 6 hybrid (V1) and Euro 4 diesel (V6)) shared a set of 72 differentially expressed genes, mostly related to interferon signalling and antiviral defence (Fig. 1). This pattern suggests that the MucilAir™ model recognized the exposure as a viral-like challenge, activating immune stress pathways.

Altogether, these findings indicate that subfreezing operation enhances the biological impact of vehicle emissions, even for cars with advanced emission controls. The activation of antiviral and stress-response pathways points to a potential link between cold-season emissions and increased respiratory vulnerability observed in epidemiological studies. Incorporating low-temperature testing into toxicological and regulatory evaluations is therefore essential for a more realistic assessment of health risks associated with real-world traffic emissions.

ACKNOWLEDGEMENT

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CHARACTERIZATION OF ROAD DUST AT URBAN INTERSECTION AND ITS DEPENDENCE ON TRAFFIC INTENSITY DURING THE SUMMER SEASON

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Keywords: air pollution, particulate matter, vehicles, immission

INTRODUCTION

Air pollution is one of the significant ongoing environmental challenges. According to European Environment Agency, almost 240 000 premature deaths in Europe are attributable to exposure to fine particulate matter (PM) (EEA, 2024). The new European Union air quality legislation, effective from 2030, will pose a major challenge for member states, including the Czech Republic, to meet the updated standards. Based on data from 2023, only about 59% of monitoring stations are expected to comply with the future EU limits. This highlights an urgent need to reduce air pollution levels, particularly in urban areas (EEA, 2025).

The main sources of these pollutants are anthropogenic activities. Approximately 45% of urban PM originates from traffic and residential heating (Karagulian et al., 2015). Road dust represents a major component of non-exhaust particulate emissions from traffic. It consists of accumulated particles on road surfaces that are resuspended into the ambient air under dynamic conditions such as vehicle movement, wind, and other mechanical disturbances (Chen et al., 2023). The properties and concentrations of road dust are strongly influenced by traffic flow, road surface characteristics, meteorological conditions, and other external factors.

The aim of this study was to characterize road dust at an urban intersection during the summer period. For this purpose, ambient air concentrations of selected pollutants were measured, together with traffic intensity and meteorological parameters. Based on these data, the influence of traffic and seasonal conditions on road dust levels was evaluated.

METHODOLOGY

Sampling of ambient air pollutants was conducted in Brno, at the intersection of Sportovní and Pionýrská streets (49.209311, 16.609059). This intersection is located near the city center, in a predominantly residential area. It connects two four-lane roads and is surrounded by diverse urban features: a large city park on the Pionýrská side, residential buildings and a school on two sides, and a parking area on the fourth side.

Concentrations of gaseous pollutants (NO_2, CO, SO_2) and particulate matter fractions (PM_{10}, $PM_{2.5}$, and PM_1), as well as meteorological parameters (wind direction and speed, temperature, humidity, and soil temperature), were measured using a specialized monitoring vehicle operated by the City of Brno. The vehicle is equipped with standard instrumentation for air quality monitoring.

Particulate matter concentrations were determined by an optoelectronic method using a calibrated Palas device, with the sampling inlet positioned approximately three meters above ground level. The sampling frequency was set to 10 minutes. The

measurement vehicle was positioned in the courtyard of the *Střední průmyslová škola chemická* (49.209356, 16.608090), approximately 70 meters from the center of the intersection. In addition, two low-cost EnviDust sensors were installed on the vehicle to test their performance under real urban conditions.

Traffic intensity and trajectory-based monitoring were evaluated using the TrafficCamera and FLOW software frameworks developed by DataFromSky. These tools enable detailed analysis of traffic scenes, including vehicle classification, counting, and trajectory tracking. The monitoring was based on video footage obtained from cameras installed at the intersection.

Data from both pollutant measurements and traffic monitoring were processed and statistically evaluated using Microsoft Excel and Python.

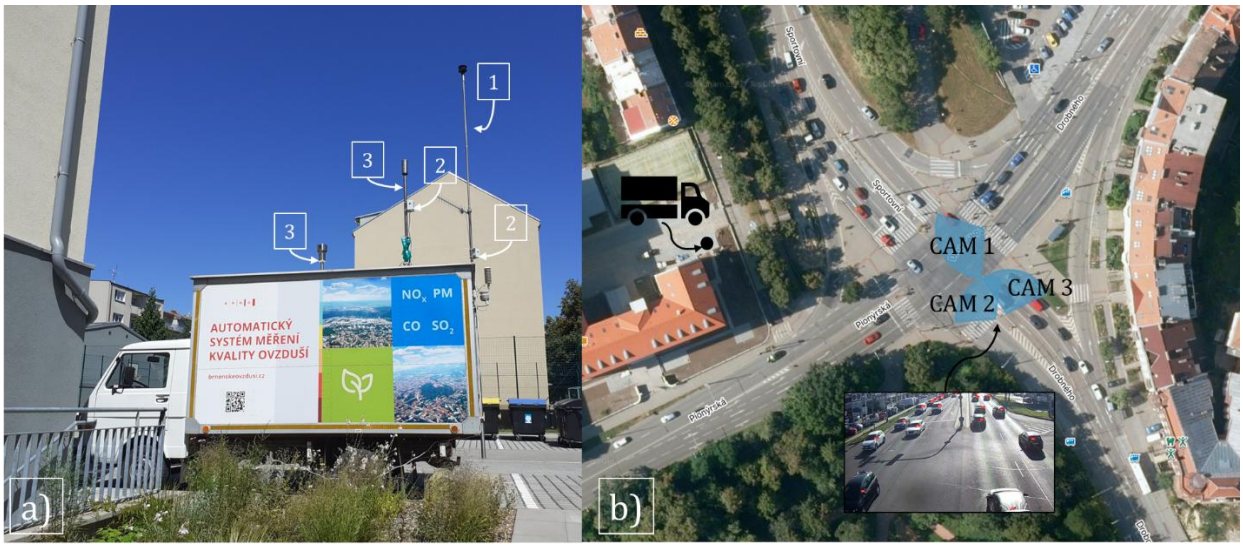

Fig. 1: a) Specialized air quality monitoring vehicle operated by the City of Brno: (1) meteorological sensors, (2) EnviDust low-cost sensors, and (3) instruments for gaseous pollutants and particulate matter measurements. b) Schematic representation of the intersection of Sportovní and Pionýrská streets.

RESULTS, DISCUSSION, CONCLUSIONS

Long-term monitoring data were collected to determine PM_x and NO_x concentrations. Each period of the day was averaged from 10-minute intervals to enable interpretation of the daily cycle. Figure 2 shows a bimodal distribution, with peaks corresponding to morning and afternoon rush hours.

NO_x concentrations, primarily influenced by exhaust emissions, showed a significant correlation with PM_x levels, which originate from a wider range of sources. As the measurements were conducted during the summer season, it can be assumed that NO_x concentrations mainly reflect traffic emissions, with minimal contribution from residential heating. This relationship was consistent throughout the week (see Fig. 3).

Lower NO_x concentrations were observed during weekends, whereas particulate matter levels remained relatively stable. This may be attributed to emissions from outdoor grilling and recreational activities in the nearby park located close to the intersection.

A slight shift in rush-hour dynamics was also observed during the summer period. While the highest traffic peaks in winter typically occur around 15:00 and 18:00 (Linda et

al.), during summer the maxima shifted to later hours, between 19:00 and 21:00. This change is likely associated with increased evening activities, such as concerts and public events, held in the adjacent park.

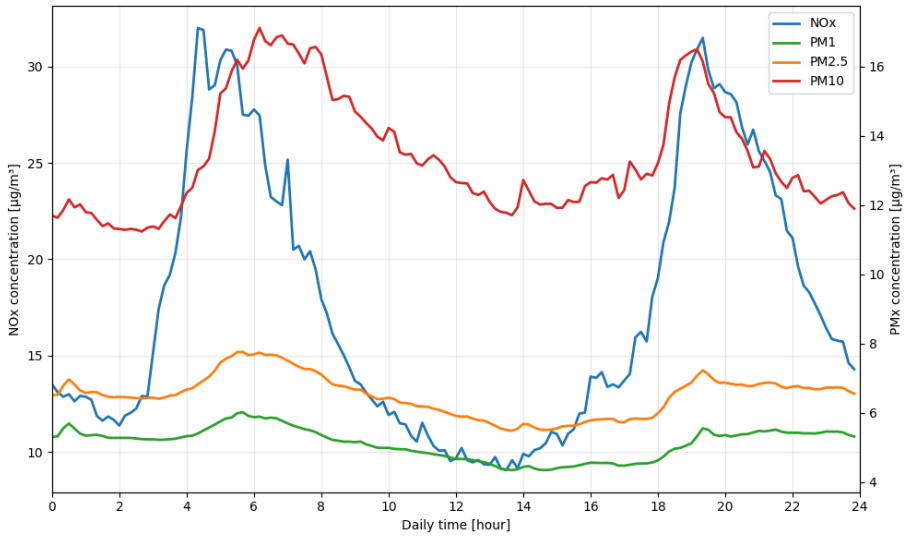

Fig. 2: Correlation between NOx and PM fraction concentration during a summer day.

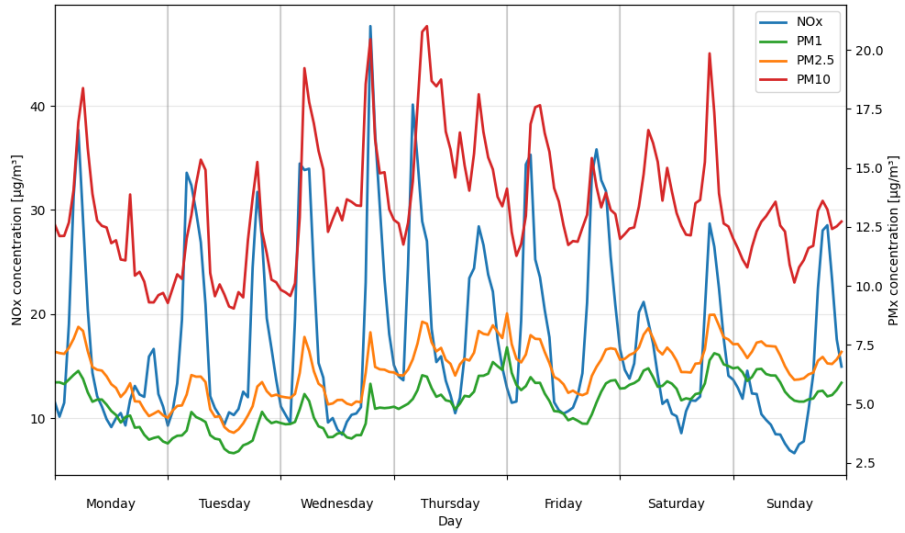

Fig. 3: Correlation between NOx and PM fraction concentration during a summer week.

This study examined the behavior of road dust during the summer season, with a focus on the influence of traffic on particulate matter (PM) concentrations. The findings indicate a strong correlation between traffic intensity and PM levels, accompanied by a shift in rush-hour peaks characteristic of the summer period.

ACKNOWLEDGEMENT

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SUSPENDED PARTICLES FROM THE PERSPECTIVE OF SEM/EDX

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Keywords: Czech Hydrometeorological Institute, Air Pollution, Particulate Matter (PM), SEM/EDX.

INTRODUCTION

Alongside pollutant monitoring, the Air Quality Department of the Czech Hydrometeorological Institute's Brno branch also focuses on research activities. An example of this is the use of the SEM/EDX method for the morphological and elemental analysis of suspended particles (Particulate Matter, PM). PM consists of a mixture of solid and liquid organic and inorganic particles of various chemical compositions, sizes, and origins (Harrison, 2020). They are classified as air pollutants and are subject to ambient air pollution limits (Czechia, 2012, § 5). Although the SEM/EDX method has limitations, such as low sensitivity to light elements or lower spatial resolution of EDX, it is a powerful tool for identifying air pollution sources by combining scanning electron microscopy with energy-dispersive X-ray spectroscopy. It can be simplified that each major source produces particles with a characteristic combination of shape and chemical composition (Bora et al., 2021). The concentration and composition of PM depend on many factors, such as meteorological and dispersion conditions, terrain relief, or the type and intensity of air pollution sources. This study presents a methodological approach for the analysis of suspended particulate matter.

METHODOLOGY

For the purpose of PM analysis using the SEM/EDX method, our laboratory utilizes polycarbonate filters (Isopore™, Merck, s.r.o.) to collect particles from the air. This type of filter is used for its flat surface, as fibrous filters pose challenges: particles can become trapped between individual fibers, making analysis difficult. Sampling is conducted with a low-volume sampler (Baghirra s.r.o), usually over a 24-hour period. The samples are then processed in the scanning electron microscopy laboratory. In the first step, the samples are coated with gold nanoparticles using a sputter coater (Quorum Technologies Ltd.) to ensure electrical conductivity. The samples are then placed in the MIRA3 microscope chamber (TESCAN GROUP, a.s.). This is followed by the adjustment and optimization of the microscope and measurement parameters for the specific sample type (accelerating voltage, working distance, beam current, etc.) and the selection of the detector. Typically, we use a secondary electron (SE) detector primarily for observing the detailed topography of the sample. We also use a backscattered electron (BSE) detector to display contrast based on atomic number, and an EDX detector (Oxford Instruments plc) to detect characteristic X-rays for elemental composition analysis. In some cases, a scanning transmission electron microscopy (STEM) detector is also used to visualize the internal structure of the particles. In the case of electron beam-sensitive samples, the LVSTD detector is used.

A fundamental step in the analytical process is the morphological characterisation of PM, including shape, size, and structure. Another no less critical part of the process

involves point analysis, which is evaluated using AZtec software (Oxford Instruments plc). This technique operates by targeting the sample with a focused electron beam at a defined point, generating element-specific characteristic X-ray radiation. The output provides weight percentages (wt%) representing the mass contribution of each element within the analyzed area.

This is followed by a more comprehensive Feature Analysis, a method based on image segmentation. In this process, a BSE image of the sample is captured, and the software analyzes the image‘s brightness histogram to separate particle pixels from background pixels based on a set threshold, which provides a more thorough overview of the particles in the sample. Based on the input file exported from the Aztec software, the Airity 8.0 web application (proprietary software) is then used to perform further graphical and data analyses. The collected data and analysis outputs are stored in a database created using the freely available and open-source object-relational database system PostgreSQL with the phpPgAdmin extension.

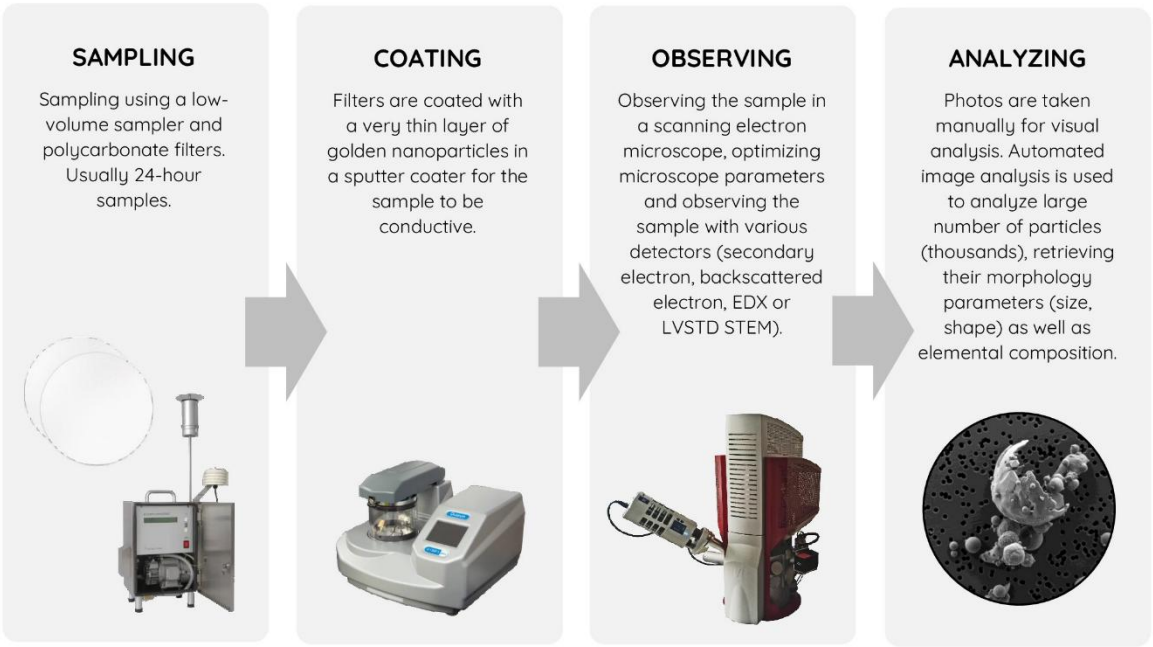

Fig. 1: Workflow of sample preparation and analysis using SEM/EDX

CONCLUSIONS

The SEM/EDX method offers great potential for the analysis of suspended particles, primarily due to its high resolution and its ability to analyze both particle morphology and elemental composition. It provides qualitative and semi-quantitative data. However, it is necessary to consider the limitations of this method, such as the limited detection of light elements or the interaction volume.

It is desirable to synergistically combine this method with other analytical techniques to obtain a more comprehensive picture of the analyzed particles. It is also always necessary to analyze a high number of samples to increase the statistical accuracy and representativeness of the measurements and to contextualize the results with the meteorological and dispersion conditions of the given locality at the time of sampling.

Apart from statistical analyses of semi-quantitative data from feature analyses, one can also process the actual microscope images and use image analysis to identify unique features of specific sources, in combination with morphology and chemical composition data. This task is well-suited for AI and could significantly improve the overall success rate of source apportionment in the future.

ACKNOWLEDGEMENT

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CHARACTERIZATION OF THE EFFICIENCY OF NAFION AIR DRYING UNDER VARIOUS OPERATING CONDITIONS

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Keywords: Nafion, relative humidity, aerosol sampling

INTRODUCTION

In atmospheric research, it is common practice to dry aerosol samples to minimize measurement artifacts caused by water uptake (hygroscopic growth), condensation, coagulation, and changes in optical properties. International networks such as ACTRIS and GAW recommend maintaining the relative humidity of aerosol samples below 40 % (ACTRIS, 2024; GAW, 2016 Swietlicki et al., 2008; Tang et al., 2019).

This humidity level can be achieved by several methods, most commonly by chemical sorption using hygroscopic materials (e.g., $CaCl_2$, P_2O_5, silica gel). However, this approach is not recommended within the ACTRIS framework due to increased diffusive particle losses. An alternative is membrane drying, among which Nafion is widely used (Tuch and Haudek, 2009).

Nafion is a copolymer of tetrafluoroethylene (TFE), which forms a hydrophobic protective backbone, and perfluoro-3,6-dioxa-4-methyl-7-octene-sulfonic acid, which ensures selective permeability of the membrane to water. Strongly hydrophilic acidic sulfonic groups (SO_3^-) at the ends of the side chains spontaneously cluster within the polymer matrix into larger domains and channels. These channels create a structure that enables the physical transport of water molecules by diffusion without any chemical reactions, while other components of the sample—both gaseous and particulate—practically do not pass through the membrane.

Nafion can operate in two basic modes: in the mode of dry, clean air, or in the vacuum mode. In the first case, the sampled air flows inside the capillaries, and on the other side there is a countercurrent of dry gas. In the second mode, the water vapor partial pressure is reduced by applying a vacuum to the outer surface of the capillaries. Both processes are continuous and, when operated under appropriate conditions, do not require sorbent regeneration as in conventional chemical drying methods such as silica gel.

Another advantage of Nafion drying is the ability to achieve the desired relative humidity even at relatively high flow rates.

The permeability of Nafion, and thus its drying efficiency, increases with the diameter and length of the fibers, temperature, and with the purge-to-sample flow ratio or the applied vacuum level (Paul et al., 2020; Leckrone & Hayes, 1997; Perma Pure, 2014; Ye & LeVan, 2003).

The aim of this study is to describe the efficiency of Nafion under various operating flow conditions and to provide optimal adjustable parameters for achieving the desired sample relative humidity.

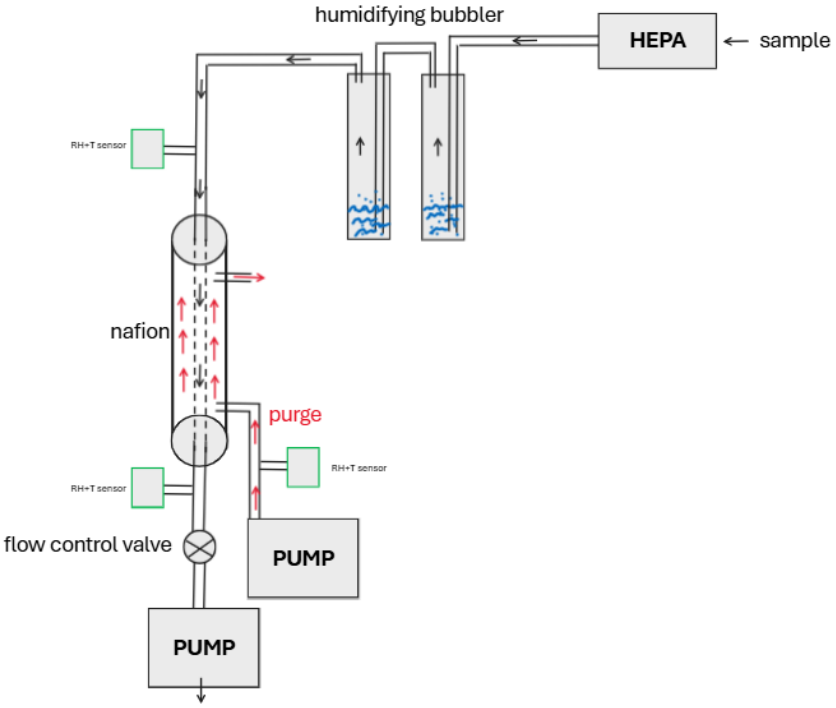

Fig. 1: Nafion drying experiment scheme – purge flow regime

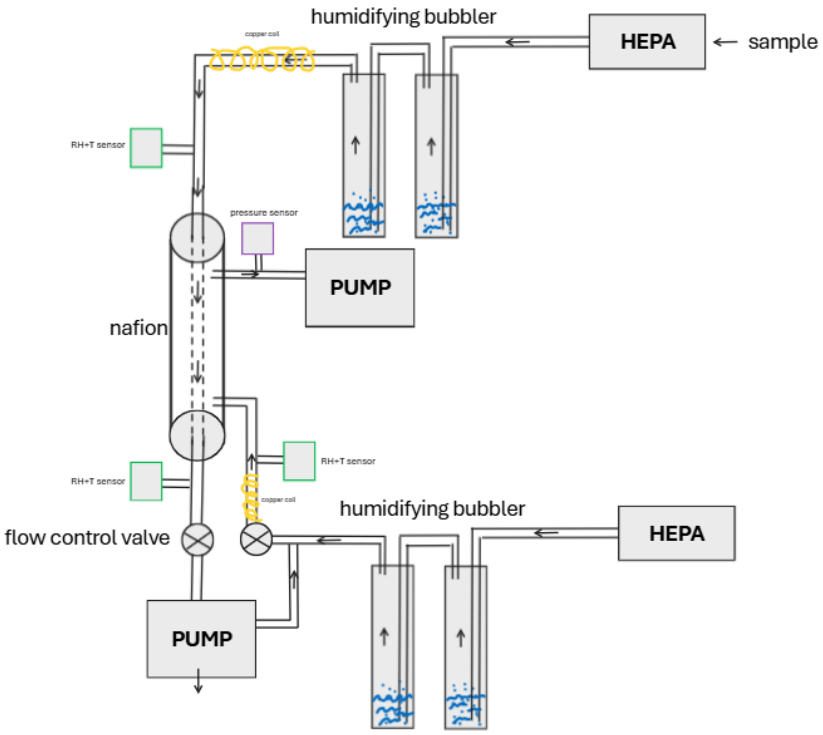

Fig. 2: Nafion drying experiment scheme – vacum régime

METHODS

To characterize the drying efficiency of Nafion (MD-700-24F-1), an experiment was designed covering both operating modes.

First, measurements were performed in the dry air flow mode (see Fig. 1) at sample flow rates of 1, 3, 5, 7, and 9 $L \cdot min^{-1}$ and at 1-, 2-, and 3-fold ratios of the outer air flow to the sample flow.

Subsequently, the efficiency was measured in the vacuum mode at absolute pressures of 0.75, 0.5, 0.25, and 0.05 bar. In both modes, each measurement lasted 3 minutes.

The relative humidity (RH) and temperature at both the inlet and outlet were measured using combined RH + T sensors at one-second intervals. To ensure uniform and comparable conditions, the air entering the Nafion was humidified to approximately 93 % RH. The sample and outer air flow rates were measured using a mass flow meter, and the vacuum level was monitored with a pressure sensor.

The efficiency measurements in the vacuum mode were further conducted separately at RH levels of 0 % and 50 %. The entire experiment was carried out in an air-conditioned laboratory at a stable temperature of 22 °C. To equalize the temperature between the dried air (sample), the outer air, and the ambient environment, copper coils were incorporated into the experimental setup.

ACKNOWLEDGEMENTS

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A STEP TOWARD PERSONALIZED AND DEVICE-SPECIFIC INHALATION THERAPY WITH NEBULISERS

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Keywords: Nebuliser, Aerosol, Breathing profile, Inhalation, Airways, Deposition

INTRODUCTION

The purpose of this study was to analyse how the pressure drop of nebulisers affects patient's breathing profile. Special attention was also given to breathing profiles with and without a nebuliser under different breathing instructions in ten male volunteers. Such knowledge is crucial for improving the prediction of the aerosol drug deposition.

METHODOLOGY

The pressure drop of one jet nebuliser (Pari LC Sprint Star) and two mesh nebulisers (eFlow Rapid and Aerogen Ultra) was measured using an Airflow Meter (Fluke 922).

Separately, ten male volunteers breathed through each nebuliser, and their breathing profiles were recorded using a spirometer (SpiroSonic Smart). Two approaches were tested: instruction to breathe normally or breathe slowly and deeply, which is mostly recommended in the instructions for the use of nebulisers (Mišík et al., 2025).

The measurement results were used as boundary conditions for the simulation of particle deposition for particle sizes of 1, 2.5, 5 and 10 μm. The simulations were carried out in Star-CCM+ using a lung replica as the computational domain.

RESULTS, DISCUSSION, CONCLUSIONS

In the case of spontaneous breathing, pressure drops of the nebuliser affected breathing profiles. These effects were most substantial for the jet nebuliser Pari LC Sprint Star by decreasing the flow rate. During breathing slowly and deeply, the variations between breathing profiles of the volunteers were larger than the influence of the nebuliser's pressure drop. According to the simulation, the reduced flow rate in the jet nebuliser allowed particles of 5 - 10 μm to penetrate deeper into the lung regions. More detailed results will be shown in the presentation.

These findings highlight the importance of considering patient differences as well as the pressure drop of each nebuliser for aerosol drug delivery (Mišík et al., 2025).

ACKNOWLEDGEMENT

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ORGANIC POLLUTANTS IN THE GLOBAL ATMOSPHERE – NEW TRENDS

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Keywords: pesticides, PCB, PAH, soil pollution, air pollution, aerosol

INTRODUCTION

Persistent organic pollutants (POPs) have been distributed in the global atmosphere, because they are only slowly reacting in atmospheric chemistry and resist biodegradation in surface waters, soils and sediments. Following global or regional abatement efforts, the levels in air of organochlorine pesticides (OCPs), polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs) and polycyclic aromatic hydrocarbons (PAHs) have been declining in mid latitudes of the northern hemisphere. In recent years, many more contaminants of emerging concern (CECs) have been identified or anticipated, such as flame retardants, modern pesticides, personal care products and industrial chemicals. CECs are substances which have been released into the environment only recently, or are only now recognized as environmental pollutants despite having been released since long. Many of the particularly persistent synthetic chemicals containing perfluorinated carbon atoms (PFAS) have both hydrophilic and hydrophobic properties. This feature allows for additional environmental fate processes, at least in aquatic environments. As being semivolatile, most POPs and many CECs stored in surface waters and soils may return to the atmosphere triggered by variation of atmospheric levels or following a usage ban (secondary pollutant sources). This feature is enhancing the long-range transport potential (LRTP) of pollutants (grasshopper effect). Large scale distributions and environmental fate processes of POPs and CECs are tpoics of great scientific interest and relevance for the environment and human health.

METHODOLOGY

Spatial distributions in air and surface seawater, air-sea and air-soil exchange of OCPs, PCBs, PAHs including nitrated and oxygenated derivatives (polycyclic aromatic compounds, PACs) and PFAS have been studied in the Mediterranean and Middle East seas, in the Atlantic Ocean, and at central and northern European continental sites, based on air, surface water and soil sampling and off-line trace substance analysis. Long-term trends in air were analysed based on monitoring data from the Czech National Atmospheric Observatory Košetice.

RESULTS AND DISCUSSION

The long-term negative trends of some OCPs banned since long, DDT, chlordane and mirex, besides others, are observed to have been levelling off in recent years in central Europe. While the industrial chemical PCB has been declining following ban since decades, strong sources of PCB are on the rise related to unintentional production in industries worldwide. The return of the banned insecticides DDT and endosulfan, and of

PACs, some of them carcinogenics, from sea surfaces to the atmosphere is on-going in the Mediterranean Sea and Atlantic Ocean. PAHs are found to volatilize from soils not only in source areas, like central Europe, but depending on day-time and season also in receptor areas. Carcinogenicity of air is found to be carried by numerous PACs, most of them usually not monitored or even unidentified.

CONCLUSIONS

New secondary sources of POPs, some of them influenced by global warming, are indicated. Urgent knowledge gaps to better understand POP and CEC cycling in the global environment are degradation rates in air and surface compartments, chemical pathways in air and soil, spatial variability of the chemodynamics in soils and primary emission fluxes. As CECs cover a vast chemical space, understanding their environmental fate is only in the early stages.

ACKNOWLEDGEMENTS

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IMPACTS OF ENVIRONMENTAL POLLUTANTS ON A 3D LUNG CELL MODEL GROWN IN THE AIR-LIQUID INTERFACE

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Keywords: Air pollution, Complex mixtures, Air-liquid interface, Toxicity

INTRODUCTION

Polluted air consists of a complex mixture of gaseous pollutants, particulate matter (PM) of various size and compounds bound to it, and metals. The size of the particles, along with the chemical composition of the complex mixture, determines possible adverse health effects of air pollutants on human health. For comprehensive *in vitro* evaluation of biological effects of ambient air toxic compounds, treatment of cell models consisting of mixtures of relevant cell types grown at the air liquid interface with a complete mixture of pollutants is crucial. However, a limited number of studies evaluated impacts of real-world atmospheric pollution using such approach.

METHODOLOGY

We have developed a mobile exposure system suitable for direct exposure to complex mixtures of ambient air pollutants in the field conditions. Using the system, we exposed cells models of the lungs and olfactory mucosa (a proxy to brain effects) to the ambient air in four localities of the Czech Republic differing in the quality of air pollution (characterized by concentrations of PM, ozone, nitric oxides, volatile organic compounds, and polycyclic aromatic hydrocarbons). We analysed concentrations of these pollutants and correlated them with a panel of relevant biomarkers, including parameters of general toxicity, markers of oxidative stress and inflammatory response, as well as global mRNA and miRNA expression analysis. Specifically, we measured lactate dehydrogenase and adenylate kinase production and transepithelial electrical resistance (TEER), analysed 15-F2t-isopostane and a panel of 20 immune response-related parameters (cytokines/chemokines/growth factors).

RESULTS, DISCUSSION, CONCLUSIONS

In the locality burdened with heavy traffic, we found very high concentrations of ultrafine particles and NOx and observed low TEER values in the exposed samples, indicating significant traffic-related toxicity of the ambient air. In the urban locality, sampled in winter, we observed high PM and benzo[a]pyrene levels. In the samples from the industrial locality, sampled in summer, we detected higher concentrations of TNFα, MIP-1α, Eotaxin, GROα, GM-CSF, IL-6 and IL-7 than in the urban locality samples. We hypothesize that pollen or other plant-related components of the ambient air were responsible for this response. In summary, our system proved to be a suitable approach to monitor direct biological effects of ambient air in the field conditions, reflecting not only the levels of toxic compounds, but also season-specific parameters.

ACKNOWLEDGEMENTS

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GENOME RESPONSE TO THE OCCUPATIONAL AND NON-OCCUPATIONAL ENVIRONMENTAL EXPOSURE TO NANOPARTICLES

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Keywords: Nanoparticles, Exposure, Cytogenetics, Epigenetics, Transcriptomics

INTRODUCTION

Nanoparticles (NPs) have become an important part of everyday life during the last years. Aside from their undoubted benefits, questions regarding the risk of inhalation exposure to human health, and/or genome still need to be addressed. Despite these facts, human biomonitoring studies relevant to the consequences of the chronic and acute inhalation exposure to NPs on the molecular processes in cells as well as health effects are still rare. The Czech biomonitoring research plays the dominant role in this field due to the systematic sampling of the chronically and acutely exposed groups during the nanocomposite materials processing in research phase and/or in their application, as well as due to broad collaboration of the experts across the various scientific fields. During the last years, effects of NPs exposure on the molecular mechanisms by cytogenetic, epigenetic and transcriptomic markers have been studied in the group of nanoparticles research workers as well as in volunteers with exposure simulated that in stomatology.

METHODOLOGY

The following methodological approaches were used for mapping the structural and functional changes in the genome of peripheral blood lymphocytes of males and females: (i) micronuclei analysis (MN) in combination with fluorescent centromere staining for identification of clastogenic and aneuogenic effects of exposure; (ii) chromosomal aberration analysis for identification of structural and numerical rearangements; (iii) genom wide DNA methylation profiling utilizing the array approach for identification up to 850K CpG loci across the whole genome; (iv) comprehencive transcriptomic analysis by Next Generation Sequencing approach for identifications of mRNA and miRNA gene expression changes.

RESULTS, DISCUSSION, CONCLUSIONS

Cytogenetic results revealed that chronic exposure to NPs does not affect the frequency of total MN in contrast to the effect of increased acute exposure. Moreover, gender related DNA damage differences were observed by MN analysis (Rossnerova, 2019). Detailed pattern of chromosomal abberations in acutely exposed females revealed significant increase of monosomies related to X gonosome (Rossnerova, 2024). Opposite to micronuclei analysis, DNA methylation profiling identified more than 700 signnificantly differently methylated CpG loci in a group of chronicaly exposed nanocomposites research workers (Rossnerova, 2020a, 2021). Additionally, transcriptomic profiling revealed 90/50 significantly deregulated mRNA in

acutely/chronicaly exposed groups, respectively. *FKBP5* and *DDIT4* genes with relevance to immune system and cancer respectively, were downregulated repeatedly in both cohorts independently of the type of exposure. Opposite to mRNA, deregulation of miRNA was minimal, related to time frame of sampling, but delayed post-exposure changes are presumed (Simova, 2024, 2025).

All the detected changes point to the induction of processes in the human body to adapt (Rossnerova, 2020b) to the new or chronic exposure conditions with the aim of reducing possible negative consequences of the NPs exposure (e.g., DNA damage level, or risk of various cancers). Obtained data also indicates different consequences of NPs exposure by gender and reveals the risk of significant increase of aneuploidies in females.

In conclusion, personal protection equipment for reducing exposure, and sufficient ventilation systems are highly recommended to limit negative effects of NPs exposure.

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ELPI VS. MPSS/APSS: PERFORMANCE ASSESSMENT WITH WELL-CHARACTERIZED AEROSOLS

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Keywords: ELPI, MPSS/APSS, well-characterized aerosols

INTRODUCTION

There are multiple techniques available for quantifying aerosol particle number and size. Among the most widely used instruments for obtaining high time-resolution data across the nanometer to micrometer scale are aerosol spectrometers such as Mobility Particle Size Spectrometers (MPSS) and Aerodynamic Particle Size Spectrometers (APSS). Cascade impactors remain a central tool in gravimetric analyses of atmospheric aerosols, offering the benefit of size-resolved chemical composition, though they operate with comparatively low temporal resolution.

A more advanced variant is the electrical cascade impactor — in our implementation, the Electrical Low-Pressure Impactor (ELPI, Dekati) (Marjamaki et al., 2000). This instrument combines the conventional gravimetric collection on individual stages with an electrical measurement mode: when particles impinge on a stage, the induced current is recorded in near real time. This dual mode provides both direct mass (or deposit) sampling and instantaneous electrical signals (Eckenberger et al., 2025).

The ability to conduct real-time (up to ~10 Hz), size-resolved (14 stages) measurements alongside chemical composition analysis makes the ELPI approach particularly powerful. Nevertheless, converting the measured currents into meaningful physical quantities (e.g., number, volume, or mass) is nontrivial, in part due to artifacts such as particle bounce, image-charge effects, or incomplete charge transfer. These biases can depend on particle size, shape, composition, or morphology (e.g. bounce behavior under different humidity or particle types) (Fischer & Petrucci, 2021).

METHODOLOGY

In this study, we compare electrical-mode measurements from two ELPI units (each outfitted with different impaction plate designs) against reference instruments — MPSS, APSS, and CPC — across a series of well-controlled aerosol types differing in composition, size, and morphology. The measurement setup employed a variety of aerosol generators (tailored to each particle type) and, for monodisperse aerosols, a size selector (electrostatic classifier). The generated aerosol stream was mixed with clean, dry air to maintain adequate flow to all instruments and, when needed, to dilute concentrations. All

instruments were fed through a shared sampling manifold using isokinetic splitting, with careful flow-path design to minimize particle losses after splitting and/or having equivalent lengths of sampling lines (in order to have the same potential particle losses).

The test aerosol suite comprised both solid (S) and liquid (L) particles and included monodisperse (M) and polydisperse (P) number size distributions ($PSL^{S,M/P}$, ammonium $sulphate^{S,M/P}$, $Sn^{S,M/P}$ and $DEHS^{L,M/P}$ with NaCl cores).

Additionally, we benchmarked the ELPI units against a calibrated reference MPSS from the ACTRIS calibration lab (PACC) and the reference MPSS used during the intercomparison on well-characterized aerosols during ambient aerosol observations over a weekend.

RESULTS, DISCUSSION, CONCLUSIONS

The performance of both ELPI units was evaluated for all generated aerosols as well as for atmospheric aerosol, with comparisons made to the reference instruments.

In general, there was a difference between the ELPI loaded with sintered stages and the ELPI filled with smooth stages covered with greased aluminium foils. The stages with aluminium foils were more vulnerabvle to particle bounce especially for solid challenging particles and larger sizes (e.g. Fig.1 for PSL 100 and 200 nm). This effect was not so much

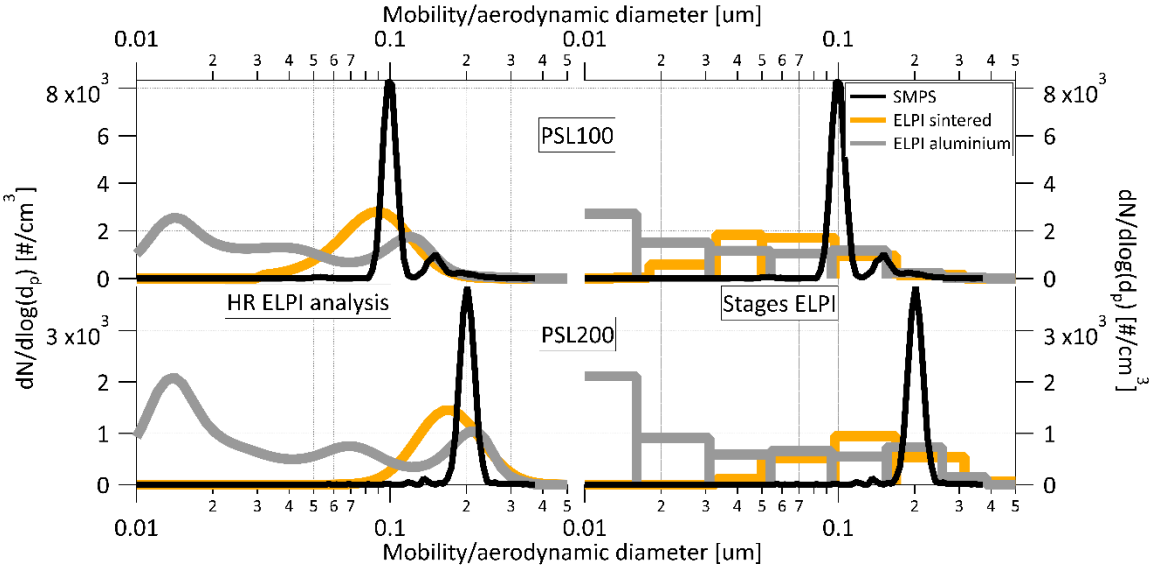

Fig. 1: ELPI impactors with sintered (orange) and smooth (grey) impaction plates against reference MPSS (black) for monodisperse PSL particles (100/200 nm)

pronounced for smaller challenging particles (even solid ones) and in general for liquid particles. This artifact causes bounce of the larger particles to much lower stages of the cascade impactor than they should belong to based on their aerodynamic behavior. Also lower concentration (hundreds of particles per cm^3) measured with the ELPI impactors were causing troubles, because of the threshold of the electometers for the noise level.

For the longer intercomparison on the atmospheric aerosol, both impactors were equipped with smooth stages and greased aluminium foils. The results (see Fig. 2) showed that it is complicated to retrieve the exact shape of the number size distribution measured by the reference MPSS due to lower concentrations in some size bins and the ambient aerosol is also more complex in chemical composition and particle morphology, so it is

more challenging to obtain the fine structure of the size distribution using the High Resolution ELPI analysis from the originally measured 14 impactor stages.

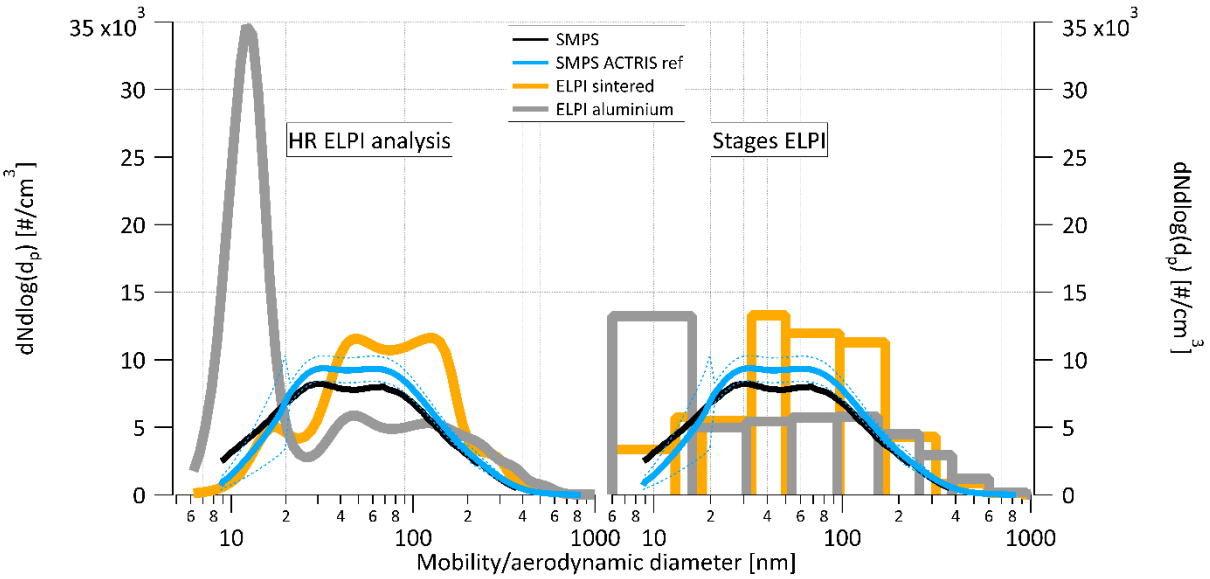

Fig. 2: ELPI impactors with smooth (orange/grey) impaction plates against reference MPSS (black) and ACTRIS reference MPSS (blue) for ambient atmospheric aerosol

Furthermore, one of the two ELPI impactors was still showing much larger deviation and an artifact for the smallest sizes. The reason for this was not fully understood and additional analysis/characterization would be needed.

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AEROSOL SIZE DISTRIBUTION RETRIEVED FROM POLAR-INTEGRATING NEPHELOMETER MEASUREMENTS

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Keywords: Atmospheric aerosols, Polar-integrating nephelometer, GRASP-OPEN

INTRODUCTION

Among optical measurement techniques, nephelometry stands out as a particularly promising method for aerosol characterization. Nephelometers are generally divided into two main types: polar nephelometers (e.g. Martins et al., 2017; Lienert et al., 2003), which measure light scattering at discrete angles, and integrating nephelometers (e.g. Anderson – Ogren, 1998), which determine the total scattering coefficient over a broad angular range. While polar nephelometers have been widely studied for aerosol size distribution retrieval due to their rich angular information (e.g. Moallemi et al., 2022), integrating nephelometers remain comparatively underexplored in this regard. This study focuses on a polar-integrating nephelometer measurements to assess their capability for retrieving fine and coarse aerosol mode properties, aiming to fill this gap in aerosol optical retrieval research.

METHODOLOGY

The presented analysis is based on data collected at the Racibórz Observatory in southern Poland during 2023 and 2024. The station operates both in-situ and remote-sensing instruments dedicated to atmospheric aerosol measurements. All measurements follow the strict quality assurance and control guidelines of the ACTRIS research infrastructure, ensuring the highest data quality and reproducibility.

The in-situ instrumentation includes an AUTORA 4000 polar-integrating nephelometer for scattering measurements and two aerosol size spectrometers — TSI APS and TSI SMPS 3082, providing particle size distributions across a wide diameter range (10 nm–10 μm). Aerosol sampling is performed with an aerodynamic cutoff at 10 μm at the inlets, and the sample air is subsequently dried to below 40% relative humidity using Nafion membrane dryers.

A nephelometer is an optical instrument capable of near-real-time (NRT) measurements of elastic light scattering by aerosol particles. The Ecotech AURORA 4000 polar-integrating nephelometer measures the integrated scattering intensity at three visible wavelengths. The instrument features a variable-position shutter that enables measurements across different angular sectors. With the shutter fully retracted, the integration range extends from approximately 7° to 170°, thus covering almost the entire polar angle except for narrow regions near the exact forward and backward scattering directions. The shutter can be positioned at any angle between 0° and 90°, progressively obscuring up to half of the detector's field of view. This configuration allows integrated measurements from the selected shutter angle up to 170°. By calculating the differences between measurements obtained at successive shutter positions, the integrated scattering signals for individual angular sectors can be derived

The nephelometer data was analysed with the use of the GRASP-OPEN software (Dubovik et al., 2014). GRASP is a single dimensional inversion algorithm providing highly accurate information on microphysical aerosol properties based on a wide range of data sources. It can be used to process in-situ nephelometric data to retrieve aerosol size distributions. The algorithm also incorporates a forward model that can effectively simulate instrument data (including noise) based on the assumed microphysical parameters. This makes GRASP a versatile tool for not only data processing but also simulations of instrument performance and sensitivity studies. In this study we employ the algorithm for simulating nephelometer signals for various aerosol distributions observed at the station by the size spectrometters, investigating the sensitivity of the instrument in these conditions.

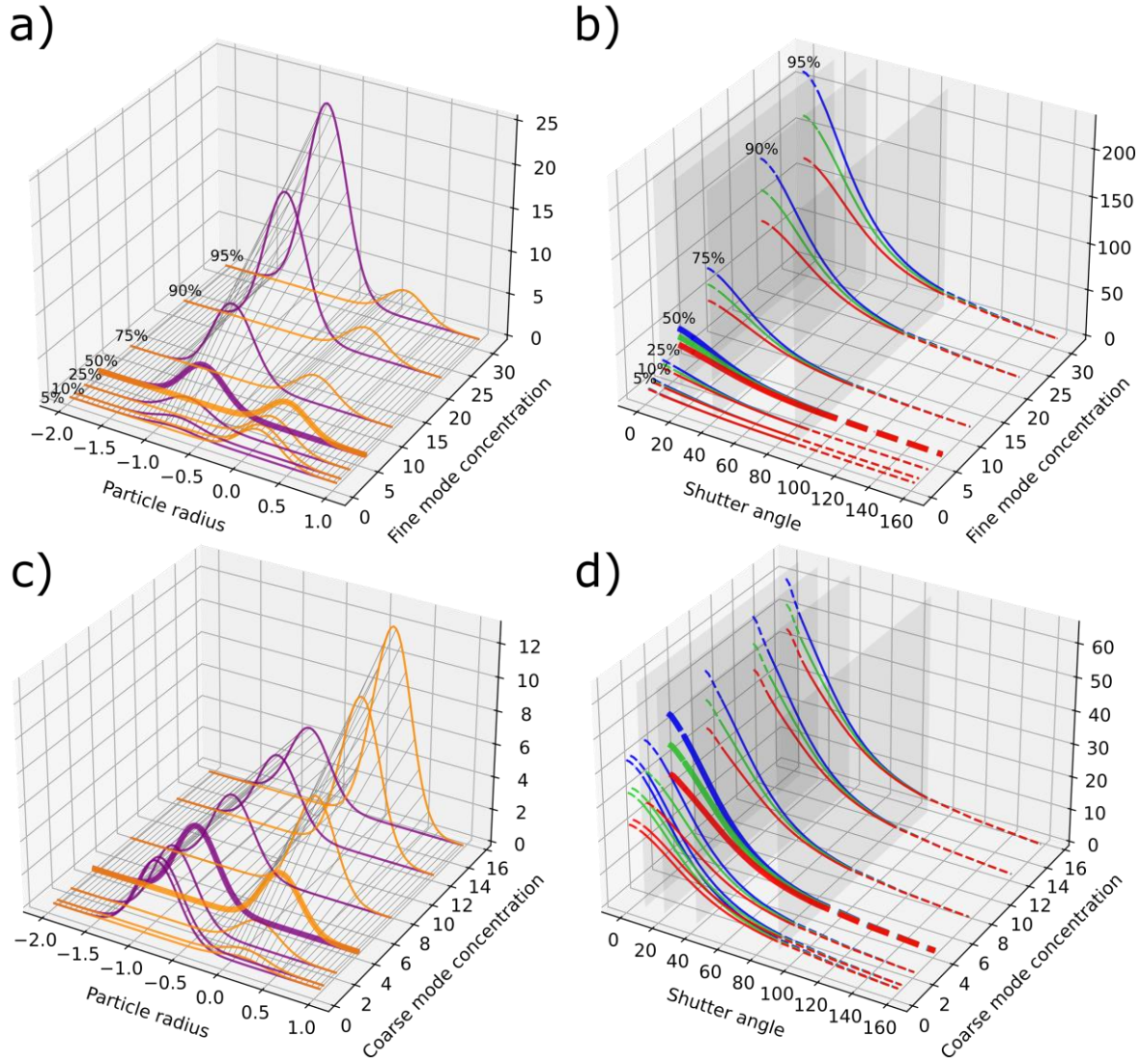

Fig. 1: A theoretical simulation of scattering measured with a polar integrating nephelometer. On the left-hand-side volume size distributions for different fine a) and coarse c) particle concentrations are given. The concentrations are varied between 5th and 95th percentile of concentrations observed at the Racibórz station. On the right-hand-side corresponding simulated measurements for changing concentrations of fine b) and coarse d) particles are shown with the solid part of the lines indicat-ing angular observation range of the AURORA 4000 nephelometer

RESULTS, DISCUSSION, CONCLUSIONS

These results show that a polar integrating nephelometer is significantly more sensitive to the variability in the concentration of the fine aerosol fraction as opposed to coarse. Note that the simulations were performed for a wider range of scattering angles than can be observed by the physical instrument (the values outside of the nephelometers angular range were depicted with a dashed lines in Figure 1). The poor sensitivity to the large particles is a well-known issue in nephelometric studies, stemming from the inability of the instruments to observe the foreword scattering at low polar angles, typically below 7-8 degrees. According to the Mie theory the larger the scattering particle compared to the light wavelength, the more the scattering phase function is dominated by its foreword scattering component. Consequently a significant portion of the light scattered at the coarse aerosol fraction is not registered by the polar integrating nephelometer. This can be seen in the subplot d) of the Figure 1, where the largest differences in the simulated signals are visible for the lowest shutter angles, outside other the nephelometer's detection range. This not only makes it challenging for any inversion algorithm to retrieve coarse aerosol concentration from nephelometer data but also can lead to improper differentiation between fine and coarse aerosol's contribution to the observed angular signals.

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DRIVE-THROUGH DETECTION OF DEFUNCT DIESEL PARTICLE FILTERS: POTENTIAL OF MODERATE COST SENSORS AND „CITIZEN SCIENCE“

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Keywords: Nanoparticles; soot; diesel emissions; diesel particle filter; high emitter; periodic technical inspection; transportation; citizen science; remote sensing

INTRODUCTION

It’s surely long reckoned that modern vehicles with internal combustion engines rely on sophisticated engine controls and on advanced exhaust aftertreatment to achieve low emissions levels. Inadequate design or manufacture, excessive wear, malfunctions, repairs of sophisticated systems with duct tape and baling wire, improper maintenance or deliberate tinkering, tuning and tampering can produce emissions that sure are one or more orders of magnitude higher compared to the typical intended (and type-approved) operation. So, a relatively significant reduction in emissions can be achieved relatively quickly and at low cost by targeting excess emitters. We reckon that on-board diagnostic systems present on newer vehicles and periodic technical inspections are helpful but do not effectively address deliberate tampering or avoiding repairs. Remote sensing (RS) of emissions by open-path spectrometry across the vehicle travel path and sampling of exhaust plume from a moving instrumented chase vehicle or from roadside (point sampling) have been developed and proposed for high emitter detection in the field. Since high emissions episodes can occur even on properly operating vehicles, all RS approaches have been used as an indicative tool for selecting vehicles for subsequent inspection.

In all RS approaches, measurement is done on the plume of vehicle exhaust left behind the passing vehicle, which must be differentiated from other plumes and the background. So, vehicles are tested in a single lane with sufficient spacing. To avoid high emissions due to cold start, transients or very high load, the engine and catalysts should be warm and the engine should be at a moderate and steady load to produce sufficient volume of exhaust. These constraints require a careful choice of the sampling location.

In RS, CO_2 or other tracer is measured alongside with the pollutant of interest. From the ratio of incremental (relative to background) concentrations of pollutant and CO_2, and assumed yield of CO_2 per 1 kg of fuel, emissions per kg fuel are calculated. Making some assumptions about fuel consumption per kWh of power or per km driven, emissions per km or per kWh can be estimated, and these compared with the legislative limits.

This work targets remote measurement of excess particle emissions, with the focus on detecting absent or defunct diesel particle filters, by point sampling measurement. Two novel approaches were explored: Measurement at an entrance gate to a restricted area and exploring the potential of moderate and low cost instrumentation.

We have chosen to target diesel vehicles, as there is a large gap, often several orders of magnitude, between working and defunct particle filter, and there are two readily

established inspection procedures – free acceleration smoke opacity test and the measurement of the number concentration of non-volatile particles during engine idle. Particle emissions from positive ignition engines (of which essentially all are spark ignition engines, and of these, most run on petrol, with a minority operating on gaseous fuels) have been regulated only recently, and despite ongoing efforts, and to date, there is no legislative method or limit for periodic inspection tests. Gaseous emissions can be readily measured by (commercially available or research grade) open-path spectrometry. Optical methods are, however, insensitive to combustion generated nanoparticles and respond only to their visible agglomerates, representing extreme cases of high emitters.

EXPERIMENTAL

The main vehicular entrance to the Czech University of Life Sciences campus has been used, featuring license plate recognition, card reader, and remote contact to a receptionist. The sampling point has been placed on the road surface, in the middle of the travel lane, several meters before the gate, at which the vehicle has to stop or come nearly to a standstill to secure a permission to enter. The campaign setup is shown in Fig. 1

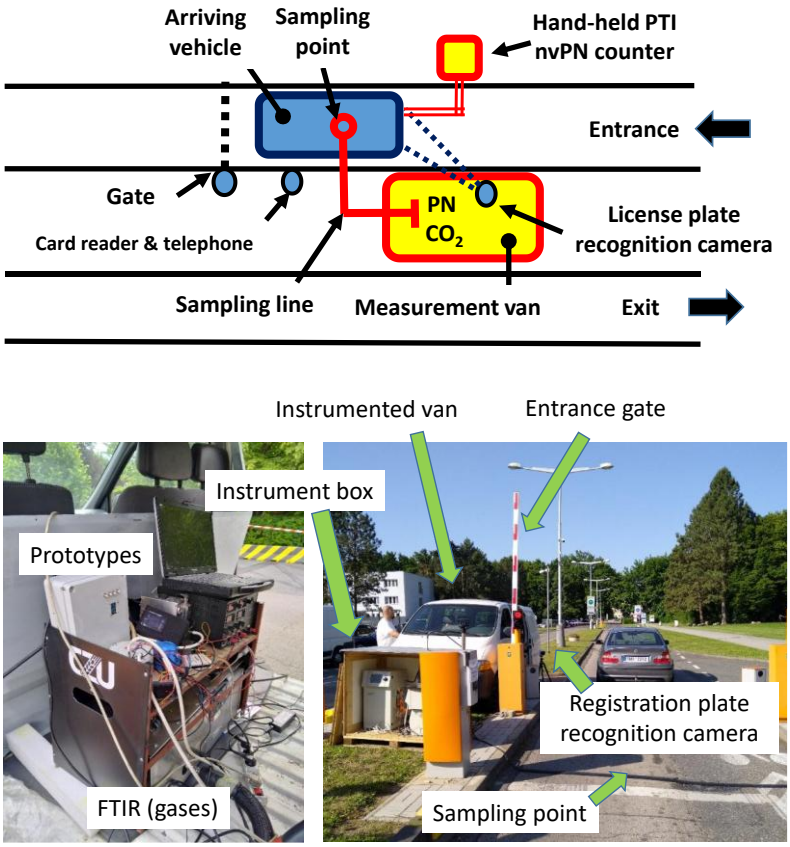

Fig. 1: Diagram and photo of the setup at the campus entrance gate

The first campaigns were done with laboratory-grade non-volatile particle (nvPN) counter (NanoMet3, Matter Engineering) and fast electric mobility sizer (EEPS, TSI). Mobile FTIR analyzer (Bruker/CreaTech) was used to measure the concentrations of CO_2, used to calculate emissions in particles per kg fuel, and CO and NO to assess gaseous high emissions. In a subsequent campaign, two "moderate cost" instruments for total particle number concentrations, Partector (Naneos) and ePNC (Dekati), and a TU Liberec prototype of a low-cost sensor of lung deposited surface area, were used in parallel.

RESULTS AND DISCUSSION

For validation, a total of 50 vehicles were subjected to a shortened (10-15 seconds) tailpipe idle nvPN test, analogous to the one used for the periodic technical inspection in Switzerland, Belgium and Germany. The comparison of emissions factor in nvPN per kg of fuel, determined by remote sensing, with the nvPN idle test, shown in Fig. 2, shows a nearly perfect (> 90 %) success rate of remote sampling at a gate at differentiating diesel vehicles with and without a functional particle filter. A 100 % success rate was obtained considering only measurements yielding peak concentration of more than 100 ppm CO_2 above the background. As an additional check, technical data for vehicles were obtained from the national motor vehicle register based on recorded registration plate numbers.

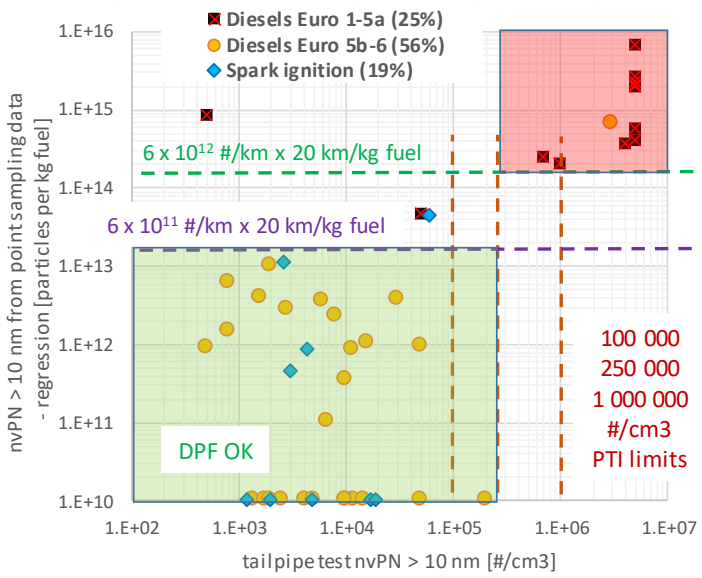

Fig. 2: Correlation of nvPN concentrations measured in the tailpipe during a 10-second idle test (horizontal axis) with nvPN emissions factor from remote sensing

Assuming light-duty vehicle emission limit of 6 x 10^{11} particles per km (#/km) and fuel consumption of 5 kg (6 liters) of diesel fuel per 100 km, vehicles with particle emissions up to 2 x 10^{13} #/kg fuel were considered low emitters. These vehicles had nvPN at idle of 1-200 thousands #/cm^3, with all but one vehicle being below 10^5 #/cm^3. All vehicles with nvPN at idle greater than 0.5 x 10^6 #/cm^3 had emission levels above 2 x 10^{14} #/kg fuel; these were considered to be positive high emitters, leaving out one order of magnitude "tolerance band" or "forbidden gap".

Further, careful analysis of data shows that the very high efficiency of diesel particle filters combined with a robust sampling location offers room for lower cost instruments to be used. (Note that optical sensors sold at tens of Euros are not sensitive to nanoparticles, and low-cost instruments considered here are primarily diffusion chargers and condensation particle counters costing several thousands of Euros, compared to one to two orders of magnitude more expensive laboratory instruments.)

The threshold of 100 ppm CO_2 corresponds to about 0.2 µg CO_2/cm^3 or about 6.2 x 10^{-11} kg fuel per cm^3. At 100 ppm CO_2, a PN detection limit of 1000 #/cm^3 above ambient corresponds to 2 x 10^{13} #/kg fuel, which is, at 20 km per kg fuel, comparable to the 6 x 10^{11} #/km Euro 6 limit. If only vehicles producing at least 100 ppm CO_2 above background are considered, which was 60 % of passing vehicles, the relatively strong signal allows for use of instruments with a detection limit of 1000 #/cm^3, which may be fulfilled by some

moderate cost periodic technical inspection grade nvPN analyzers and diffusion chargers commercially available for ambient monitoring (measuring all particles including volatiles), both with cost on the order of 10 thousands EUR per instrument, one order of magnitude less than laboratory instruments. Also, additional analysis has shown that for peaks at least 100 ppm CO_2, reasonably valid conclusions were even without removing volatile particles (measurements by EEPS), and even using solely the particle concentration, without calculating the ratio of particles to CO_2.

Example results for the moderate cost instruments are given in Fig. 3. Partector, a moderate cost commercial ambient DC sensor, and Dekati ePNC, prototype PTI-grade particle counter (DC sensor) are in general agreement with nvPN readings by NanoMet3, a commercial nvPN instrument, despite not removing volatile particles. Low-cost ionization chamber detected some, but not all, high emitters, typically ones with higher detectable PN concentrations.

Overall, sampling at a gate, where vehicles have to stop and accelerate, is reckoned to be an improvement over classical roadside measurement, as the location inherently provides adequate separation of traffic, a major limitation of point sampling. Also, at many gated entrances, vehicles are already warmed up, and are accelerating at a moderate pace. This location has also yielded rather strong CO_2 peaks, decreasing the requirement for the detection limit of the instruments. Follow-up preliminary measurements suggest that the use of low and moderate costs instruments is possible, albeit possibly at a lower yield.

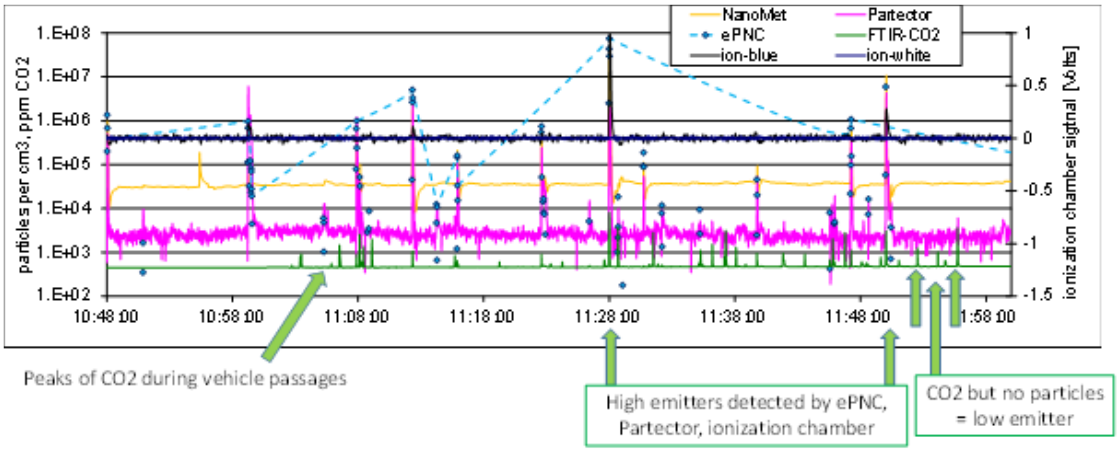

Fig. 3: Particle concentrations measured by moderate and low-cost instruments

ACKNOWLEDGEMENT

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HIGH-RESOLUTION WIND-TUNNEL INVESTIGATION OF POLLUTANT DISPERSION AND FLOW FIELD IN LEGEROVA STREET, PRAGUE

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Keywords: Pollutant dispersion, Street canyon, Urban air quality, Wind tunnel

INTRODUCTION

Air pollution in so-called street canyons is one of the key environmental problems in densely built-up urban areas, where limited ventilation and intense emissions from traffic can lead to high concentrations of pollutants in the breathing zone of residents (Fenger, 1999). The complex interaction between building geometry, wind direction, and atmospheric turbulence significantly affects the transport and dispersion of pollutants, making it challenging to predict air quality in such environments. Among these factors, the aspect ratio (the ratio of building height to the street width) of the canyon, roof geometry, and street orientation relative to the prevailing wind direction have been shown to significantly influence pollutant removal efficiency and flow patterns within the canyon (Kluková et al., 2021; Nosek et al., 2025).

Experimental studies conducted in wind tunnels that model the interaction of the atmospheric boundary layer with urban topography play a crucial role in understanding these mechanisms, as they enable a detailed investigation of flow and dispersion processes under controlled conditions representative of actual urban geometries (Schatzmann & Leitl, 2011). The ability to measure velocities and concentrations at high spatial and temporal resolutions provides valuable data for model validation and for improving our understanding of pollutant transport in complex urban environments.

This study focuses on Legerova Street in Prague, one of the busiest urban corridors characterised by street canyons and heavy traffic pollution. A 1:500 scale model of the street and surrounding buildings was tested under neutral atmospheric boundary layer conditions for two different wind directions. The primary objective is to illustrate the complexity of pollutant concentration distribution in a real street canyon, which is primarily influenced by the geometry of the street canyons and wind direction.

METHODOLOGY

The experiments were conducted in the wind tunnel of the Environmental Aerodynamics Laboratory in Nový Knín. This is an open-circuit wind tunnel with a cross-section of 1.5 x 1.5 m and a length of 30 m. Based on digital data provided by IPR Prague, a 3D-printed model of Legerova Street and its surroundings was produced on a scale of 1:500 and placed in the measuring section of the tunnel (Fig. 1). The incoming boundary layer was created using roughness elements and so-called spires placed along a length of 10 m in front of the model to achieve a logarithmic velocity profile and the required turbulence scales representative of the urban atmospheric boundary layer under neutral stratification. By rotating the model in the measuring section of the tunnel, two wind directions were tested: west and east.

The dispersion of pollutants was simulated using a 1 m long line source from which a tracer gas (ethane) or passive particles (approx. 1 μm) were emitted at a volume flow rate of 18 ml/s. The line source was located at the bottom of the tunnel and in the middle of Legerova Street (Fig. 1c). Ethane concentrations were measured using a fast flame ionisation detector (FFID) mounted on a computer-controlled traversing system, which allows point mapping of average concentration fields with high time resolution (500 Hz). Particle image velocimetry (PIV) from Dantec Dynamics was used to capture instantaneous and average velocity fields, as well as the spatiotemporal structures of particle concentrations at a rate of 500 Hz. This combined approach enabled a detailed analysis of the interaction between flow dynamics and pollutant dispersion mechanisms as well as the measurement of the planar turbulent pollution fluxes in the street canyon (Owolabi & Nosek, 2025) .

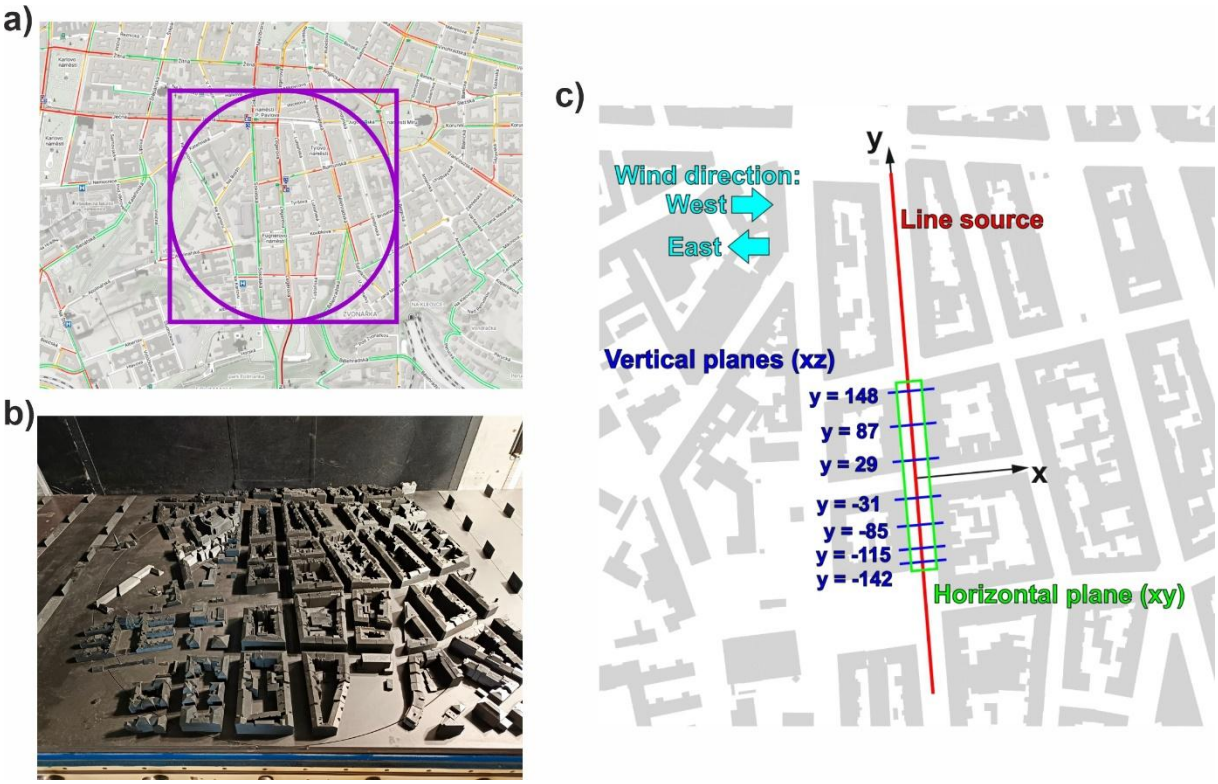

Fig. 1: (a) Selected area (magenta square and circle) for the model of Legerova street; (b) the model of Legerova street in the wind tunnel; (c) positions of the measured vertical (dark blue) and horizontal (green) planes with the marked position of the line-source model (red) and wind orientation (light blue). The positions are in mm according to the scale (1:500).

RESULTS, DISCUSSION, CONCLUSIONS

Fig. 2 shows the mean dimensionless concentrations (C*) and velocity vectors (arrows) at the horizontal planes at a height of 7 mm (corresponding to 3.5 m at full scale) for the west (Fig. 2a) and (Fig. 2b) east wind directions in the investigated section of Legerova street. Here, $C^* = CU_{ref}BL/Q$, where C is the ethane concentration in ppm, U_{ref} is

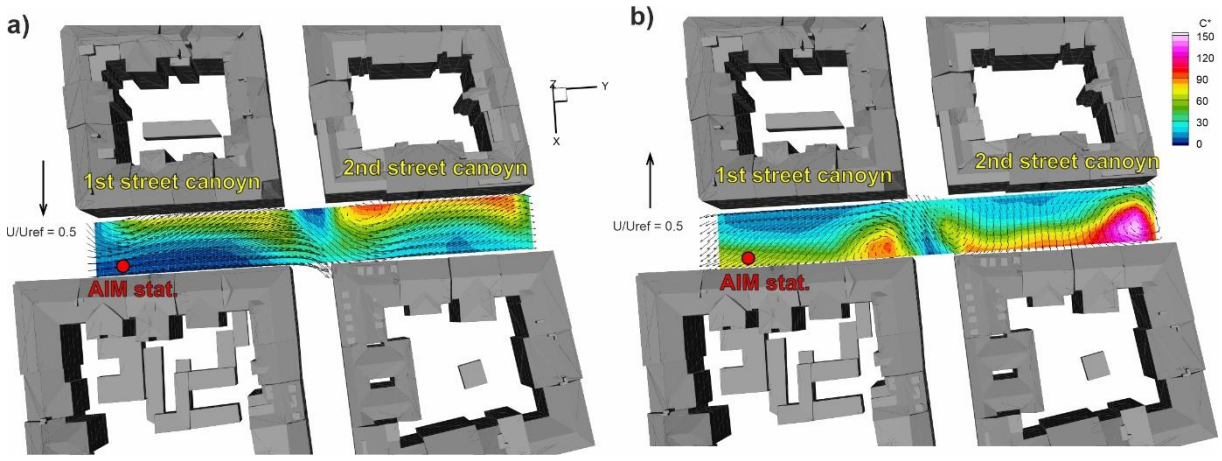

Fig. 2: Mean dimensionless concentrations (C^*) and velocity vectors (arrows) at horizontal fields at height 3.5 m for a) west and b) east wind of the investigated part of the Legerova street. The reference dimensionless velocity vector (U/U_{ref}) is depicted on the left, and the red circle represents the position of the AIM station.

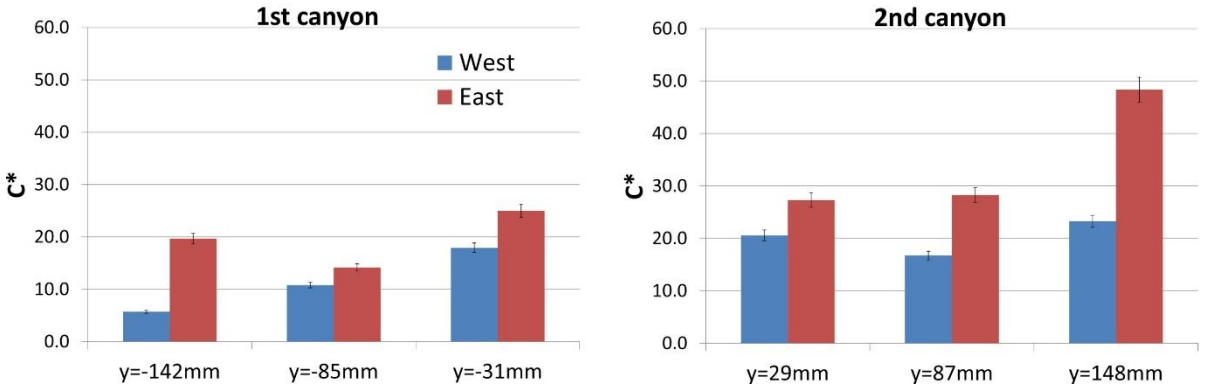

Fig. 3: Spatially averaged dimensionless concentrations (C*) of each of the vertical plane in the first (left) and second (right) street canyon, for the west (blue bars) and east (red bars) wind direction.

the reference freestream velocity in the wind tunnel, B is the average Legerova street width, L is the length of the line source, and Q is the volumetric flow rate of ethane from the line source. The real pollutant concentration, C, can be then recalculated from C^* using the known parameters (U_{ref}, L and Q) from real-scale conditions.

For the west wind (Fig. 2a), a strong lateral flow from south to north is observed within the first investigated street canyon. This is primarily caused by the asymmetry of the buildings, where the longer windward-facing façade deflects the incoming flow from the west toward the south. This lateral motion generates a helical vortex (not shown here), which enhances street-canyon ventilation. Consequently, the lowest concentration levels are found not only at this horizontal plane but also at all three analyzed vertical planes within the first canyon (see blue bars in Fig. 3). Pollutants from this canyon are transported either upward through the roof-level opening or laterally toward the intersection, occasionally entering the second canyon. The second canyon therefore exhibits higher concentration levels, also associated with the development of a quasi-steady horizontal vortex near the intersection.

In contrast, for the east wind (Fig. 2b), both investigated canyons exhibit higher concentration levels compared to the west wind case. This is mainly due to the absence of the "wind-catching" wall and the formation of strong horizontal vortices at the lateral ends of the canyons. As shown in Fig. 3b, at the lateral end of the second canyon (red bar at y = 142 mm, corresponding to 71 m from the intersection center), the mean concentration increases by a factor of approximately 3.5 relative to the west-wind case.

These results clearly demonstrate that building geometry and wind direction play a decisive role in pollutant transport and accumulation within urban street canyons. Both parameters must therefore be carefully considered when assessing urban air quality or conducting pollution source identification in complex urban environments.

ACKNOWLEDGEMENT

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PŘÍSTROJ SYFT TRACER A TECHNOLOGIE SIFT-MS: NOVÉ MOŽNOSTI V ANALÝZE OVZDUŠÍ

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Klíčová slova: Sift-MS, SYFT, real-time analýza ovzduší

SUMMARY

The commercial presentation will focus on the Syft Tracer analytical instrument, which uses SIFT-MS (Selected Ion Flow Tube Mass Spectrometry) technology for real-time detection of trace gases and volatile organic compounds (VOCs). Syft Tracer enables gas analysis with high selectivity, sensitivity (at ppt levels), and operational stability, without the need for chromatographic separation or sample pretreatment.

ÚVOD

Komerční přednáška: Společnost Altium se nově stala oficiálním distributorem přístrojů Syft Technologies, a přináší tak na český trh unikátní přístroje nejen pro real-time analýzy ovzduší.

Přednáška bude věnována analytickému přístroji Syft Tracer, který využívá technologii SIFT-MS (Selected Ion Flow Tube Mass Spectrometry) pro real-time detekci stopových plynů a těkavých organických látek (VOCs). Syft Tracer umožňuje analýzu plynů s vysokou selektivitou, citlivostí (v hladinách ppt) a provozní stabilitou, a to bez nutnosti chromatografické separace nebo předúpravy vzorku.

V rámci prezentace bude detailně představen přístroj jako celek a jeho klíčové technické a provozní parametry, včetně možností konfigurace, a také konkrétní aplikace v oblasti monitoringu kvality ovzduší, mobilního měření či sledování VOCs ve vnitřním prostředí.

HANDHELD ULTRAFINE PARTICLE SIZE DISTRIBUTION MEASUREMENT

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Key words: Detektor, Ultrafine particles, LDSA, AMS, PM1

INTRODUCTION

Many particle detectors work with optical detection and cannot detect particles smaller than about 300 nm. The handheld ultrafine particle detector Partector 2 Pro produced by naneos particle solutions gmbh can measure down to a size of ~10 nm. Ultrafine particles have a very low mass. That's why the Partector 2 Pro ouputs health-relevant metrics, such as lung-deposited surface area (LDSA), particle count, particle diameter and eight-channel particle size distribution. The Partector 2 Pro provides a wide concentration range, is battery-powered, requires no working fluids and works in any orientation.

The Partector 2 Pro is designed mainly for personal exposure monitoring, workplace monitoring and environmental monitoring.

Fig. 1: Partector 2 Pro

MEASUREMENT PRINCIPLE

The Partector 2 Pro measures nanoparticles using a pulsed unipolar diffusion charging method with an ion trap and electrometers. Particles are charged by a corona discharge, which is pulsed on and off and creating clouds of charged particles. These charged particles flow down the instrument and pass through two empty Faraday cages equipped with electrometers. The electrometers detect changes in the charge inside the cages. In between the two electrometer stages, there is an electrostatic precipitation, which preferentially removes small particles so that you get a smaller signal on the second stage, which gives us information on the particle diameter.

The Partector 2 Pro uses standard data inversion algorithm to calculate an 8-channel size distribution (10-300 nm). Time resolution depends on integration time; typically 6 s for one voltage = full scan takes 24 seconds.

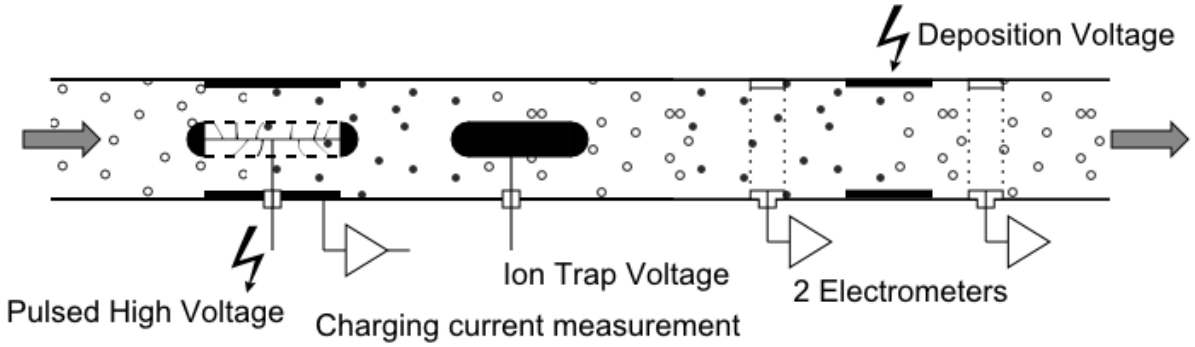

Fig. 2: Measurement principle scheme

PERFORMANCE AND APPLICATIONS

The performance example is not from the lab but from a Swiss monitoring station (Zürich Kaserne), where an SMPS is continuously operated. The Partector 2 operated for one month in the station and in the Fig. 3 is shown how well this works with "real world" aerosols. In particular, the concentrations were quite low, as it was quite clean air in Switzerland; so the issue with small signal differences and noise is larger than in the laboratory tests. The average particle number in this month was just a bit above 5000 particles/cm^3 but the general shape of the size distributions is well reproduced even at those low concentrations.

The main applications for the Partector 2 Pro are personal exposure monitoring, workplace monitoring and environmental monitoring.

The Partector 2 Pro measures all nano-particles – so this can be used to measure exposure to engineered nanoparticles, environmental tobacco smoke, welding fumes, traffic-related nanoparticles or anything else. The Partector 2 Pro is ideally suited for occupational health and safety studies.

The Partector 2 Pro can be used to monitor nanoparticle levels in a laboratory or nanoparticle production facility 24/7. It can sound an alarm and, with its data log, the operator can quickly check when high concentrations occurred.

Small, light and cheap – the Partector 2 Pro is the ideal instrument for studies where nanoparticle concentrations need to be measured with high spatial resolution. By using multiple instruments simultaneously, it can be measured transport phenomena and particle concentration distributions. By combining Partector 2 Pro data with GPS data, it can be easily visualized the measurement in Google Earth.

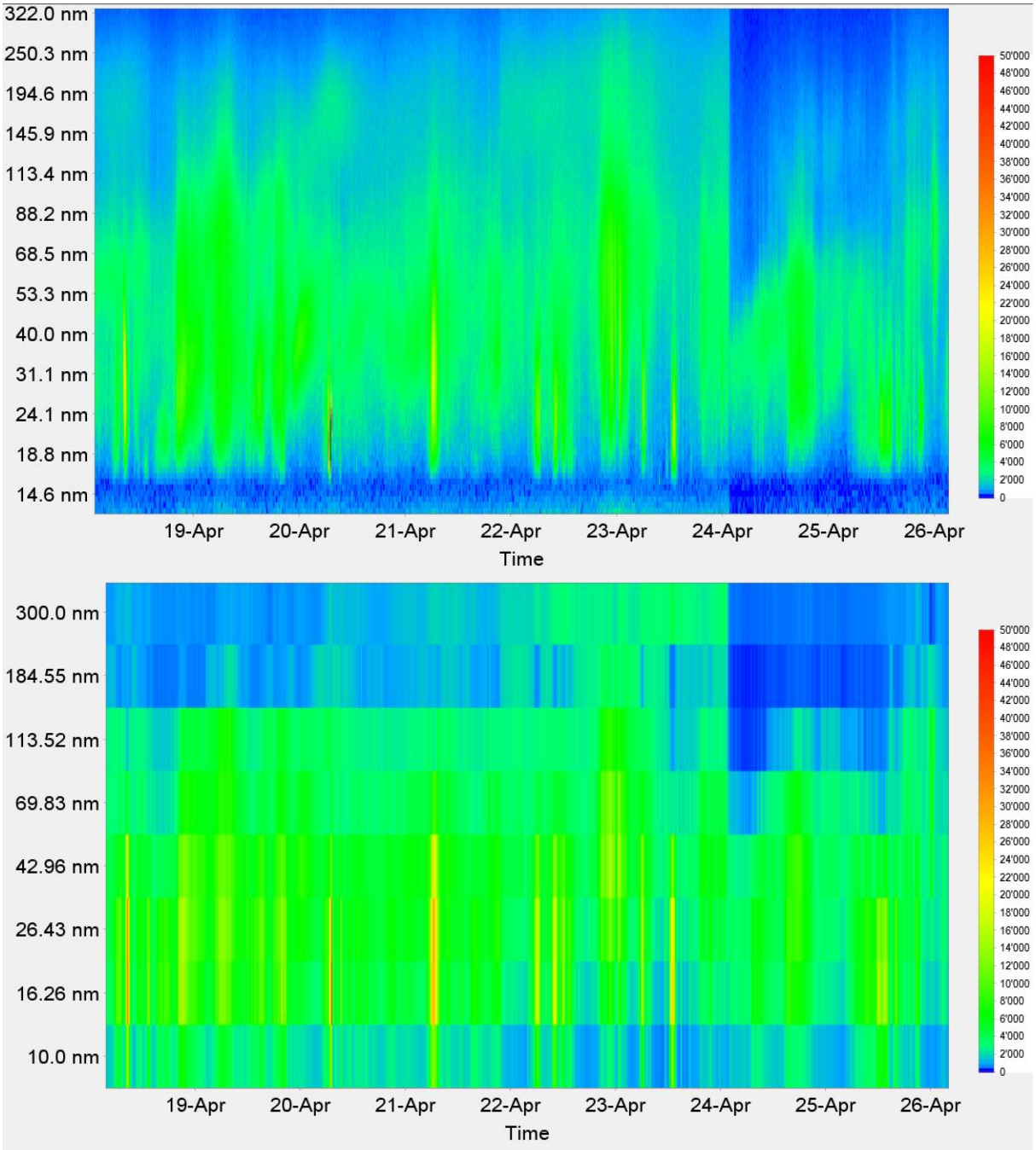

Fig. 3: 4 week comparison at Swiss monitoring station Zürich-Kaserne (showing 1 week only to reduce clutter)

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CHARACTERIZATION AND FIELD TESTING OF THE DEKATI OXIDATION FLOW REACTOR (DOFR)

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Keywords: secondary aerosol, OFR, TSAR, SOA, ELPI

INTRODUCTION

The atmospheric ageing of gases released by different sources can form low vapor pressure compounds that condense to aerosol particles called secondary aerosols. The oxidation flow reactors (OFR, introduced by Kang et al. (2007)) are used for simulating the atmospheric ageing in a short time scale for studying the potential of different pollution sources to form secondary aerosols and also for producing secondary organic test aerosols for different applications. OFRs are particularly useful tools in studying the aging of transient emissions sources owing to their high time resolution compared to environmental chambers and compact size (see e.g. Kuittinen 2021). The high time resolution stems from the short aerosol physical residence time (~1 min) compared to environmental chambers (~hours). Despite the short physical residence time of the OFRs, the equivalent photochemical aging time can be in the order of several days accomplished by the high concentration of oxidants compared to atmospheric conditions. Despite the fact that accelerated photochemistry of OFR has some limitations on how accurately they simulate atmospheric aging (Peng, 2020), OFRs provide properly used a joint metrics that can be used to compare the potential of different emission sources to produce secondary aerosols.

In this study, we present characterization results of a new commercially available OFR called Dekati Oxidation Flow Reactor (DOFR) and its sampling unit. The DOFR design is similar to the previously introduced Tampere University Secondary Aerosol Reactor (TSAR) by Simonen et al. (2017). The main oxidizer in the DOFR is OH-radical that is formed by UV-C (254 nm) photolysis of externally injected O_3 and H_2O. The characterizations performed for the DOFR include the determination of the photochemical ageing range, the gas and the particle residence time distributions (RTD), and the SOA yield from toluene precursor. In addition, the DOFR was used to measure secondary aerosol formed by passenger cars (gasoline and diesel) running in idle, and the results were compared with previous studies.

METHODOLOGY

Particle size distribution measurements were conducted using the ELPI+ and SMPS instruments. The particle RTDs were measured using two CPCs with polydisperse solid particles. The photochemical age was determined by oxidizing the CO gas tracer as in Simonen et al. (2017). Gaseous toluene precursor ageing inside the DOFR was also modelled with a simple time dependent model based on the model presented by Li et al. (2015). The photochemical ageing range was determined for several relative humidities (RH) and UV-light intensities as a function of O_3 concentration.

RESULTS, DISCUSSION, CONCLUSIONS

The ageing range was found to be in 1 – 35 days with the CO tracer and was varied by switching the no. of UV lamps on (the ozone was 50 ppm and RH 50%). The toluene precursor oxidation experiments showed comparable results to previous studies showing 0.1 – 0.3 yields for tested toluene concentrations.

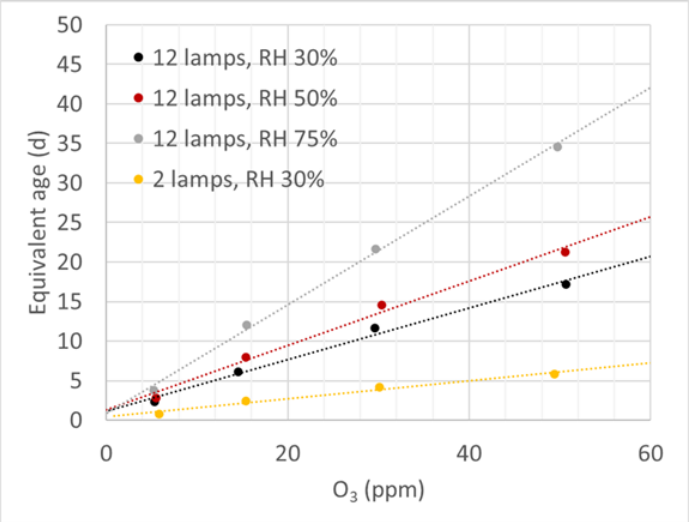

Fig. 1: Measured photochemical age as a function of number of DOFR UV lamps on.

The measured exhaust emission results showed that tested gasoline vehicles could produce 1 to 4 orders of magnitude more secondary aerosol mass compared to primary mass with a cold engine.

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SIZE-RESOLVED MONITORING OF MINERAL DUST EMISSIONS

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Keywords: Dust Emissions, Atmospheric aerosols, Mineral Dust, Particle Size Distribution, J-WADI, FRAGMENT, HiLDA

INTRODUCTION

Mineral dust is a crucial yet still underestimated factor in the global climate system. It influences air quality, cloud formation, Earth's radiation balance, and even precipitation. It is not only determined by the amount, shape, and mineralogical composition of the particles, but also by their particle size distribution (PSD, Mahowald et al., 2014). For dust, the PSD is divided into different size ranges: fine dust with a diameter smaller than $dp < 2.5\mu m$, coarse dust with $2.5 \leq dp < 10\mu m$, super-coarse dust with $10 \leq dp < 62.5\mu m$, and giant dust with $dp \geq 62.5\mu m$. Fine dust tend to cool the atmosphere while Coarse dusttend to warm it, much like greenhouse gases it (Adebiyi et al., 2023). Particle size is also important for cloud microphysics and precipitation processes (Kok et al., 2023). Three international research projects — J-WADI, FRAGMENT, and HiLDA — have in recent years made decisive contributions to sharpening this picture.

The J-WADI project focused on the question of how much super-coarse and giant dust particles contribute to total dust emission. In September 2022, extensive field campaign was carried out in the Jordanian desert near Wadi Rum, coordinated by the Barcelona Supercomputing Center (BSC) together with Institute of Meteorology and Climate Research (IMK-TRO) at the Karlsruhe Institute of Technology (KIT).

While J-WADI highlighted the importance of particle size, the FRAGMENT project focused on dust composition and its effects upon climate. In September 2019, measurements were conducted in Morocco's Lower Drâa Valley, a hotspot for freshly emitted dust. The aim was to characterize not only size distributions but also mineralogy and physical properties in detail.

Arctic regions are often seen as pristine and free of major aerosol sources. Yet recent research shows that significant amounts of mineral dust also arise here and can be transported over long distances. Iceland plays a key role: with its volcanic sediments, melting glaciers, and strong winds, the country is one of the largest dust sources in the Arctic. The Iceland Dust Project was launched as part of the international FRAGMENT initiative (doi: 10.3030/773051)as well as HiLDA project (https://gepris.dfg.de/gepris/projekt/417012665).

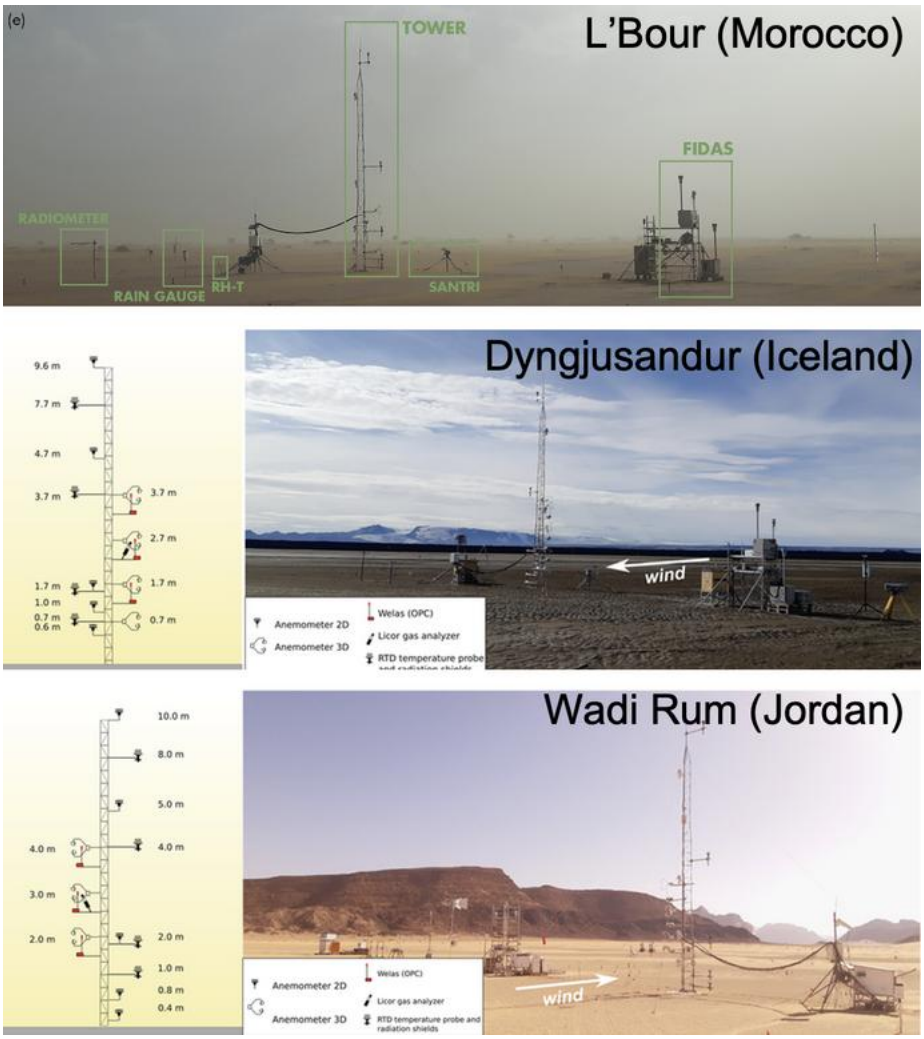

Fig. 1: Field Set-ups (FRAGMENT) - Lower Drâa Valley, Dyngjusandur, Wadi Rum

METHODOLOGY

A multi-instrument strategy was applied to cover the full spectrum of particles from ultrafine to very large sizes (see Table 1). The aerosol spectrometer suite included the UCASS (Universal Cloud and Aerosol Sounding System, designed at the University of Hertfordshire; Smith et al., 2019), the saltation particle counter SANTRI2 (Standalone AeoliaN Transport Real-time Instrument, 160 second edition, designed at the Desert Research Institute; Etyemezian et al. 2017; Goossens et al. 2018). Extended by an EN 16450-certified fine dust monitoring device (Fidas® 200S, Palas GmbH) providing high-resolution real-time data for PM1, PM2.5, and PM10. As an EN 16450-certified reference instrument, which is used worldwide in official monitoring networks and provides validated, regulatory-grade data.

Tab. 1: Characteristics of the instruments used

Instrument	Principle	Light	Inlet	Diameter	Scattering	Position	Resolution
UCASS	light scatt.	Laser 658nm	Nearly open path	1-20µm 2-80µm	16-104°	rotat. mast	16 bins
Welas	light scatt.	Xenon	Directional	1-100µm	90°	scaffolding	256 bins
Fidas	light scatt.	LED	Directional	0.4-37µm	90°	scaffolding	256 bins
CDA	light scatt.	White	Sigma-2	0.75-100µm	90°	scaffolding	256 bins
SANTRI2	shadowing	Diode 890nm	Open path	85-200µm	none	rotat. mast	7 bins

It was complemented by the high-resolution aerosol spectrometers (Promo® 2000 with welas® 2300/2500 aerosol sensors, Palas GmbH) to measure airborne dust concentration per size class at 1 Hz, measuring size distributions between 0.2 and 40 µm directly at the source, which provided time-resolved measurements that captured dynamic changes in particle fluxes. Samples were collected with impactors and samplers, then analyzed in the laboratory using scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDX). Set-up was also combined with the Cloud Droplet Analyzer (CDA, Palas GmbH), which made large spherical particles and droplets measurable, and meteorological sensors and eddy covariance systems, this yielded a comprehensive picture of emission processes.

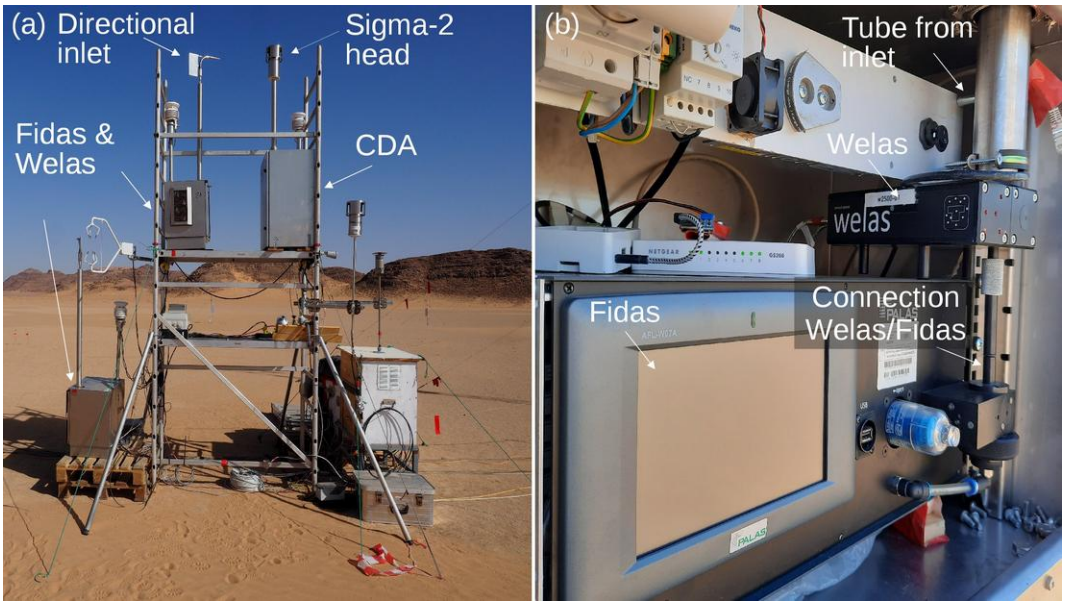

Fig. 2: (a) J-WADI - Welas, Fidas, and CDA

RESULTS, DISCUSSION, CONCLUSIONS

The measurements demonstrated that particles larger than ten micrometers can account for up to 90 percent of total dust mass. Particularly striking was a maximum at around 60 µm — a size class rarely considered in climate models. Moreover, particles

larger than 60 µm were still detectable at several meters above ground, indicating that such large particles can be transported by strong winds across several kilometers — significantly farther than previously assumed.

Another key finding was the role of dry deposition: Large particles are removed from the atmosphere very quickly. Even particles just 5 µm in diameter are deposited at rates of around 65 percent near the source (González-Flórez et al., 2023). This means that measurements taken far from emission points systematically underestimate the share of large particles — one of the main reasons why many climate models have so far represented the true effects of mineral dust at its source only inadequately.

The results shown that dust emissions in Iceland are spatially variable, in contrast to those in hot deserts. In the Dyngjusandur region, dust concentrations of more than 10,000 µg/m^3 PM10 were measured during several events. The particles exhibited a wide size distribution, with mass median diameters of about 12 µm for freshly emitted dust plumes (González-Romero et al. 2024). To contextualize the findings, results were compared with previous research on mineral dust size distributions. The avg J-WADI data aligns well with the avg "SOURCE" dataset from Formenti and Di Biagio (2024), with larger proportion of larger particles.

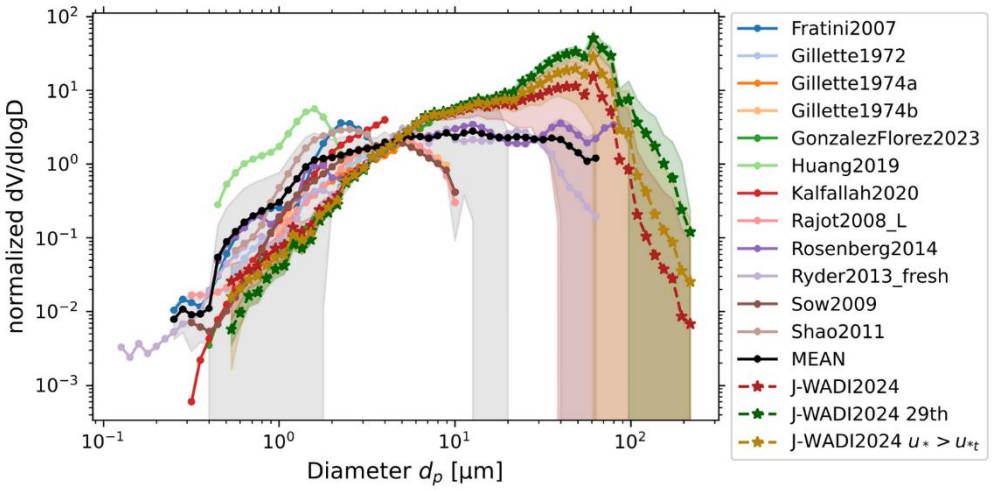

Fig. 3: PSDs from different field campaigns within one day after emission (Meyer et al. 2025)

ACKNOWLEDGEMENT

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MODELING THE SOURCES AND UNCERTAINTIES OF SECONDARY AEROSOLS OVER CENTRAL EUROPE

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Klíčová slova: Secondary aerosol modeling, CAMx, Central Europe

INTRODUCTION

Modeling secondary aerosols using chemical transport models (CTMs) has remained a major challenge for several decades. The concentrations of secondary aerosols predicted by CTMs are subject to uncertainties arising from several factors. These include (1) missing emissions in the inventories used for CTM simulations, (2) simplifying assumptions in the model representation of secondary aerosol formation and processes, and (3) uncertainties in the gas-phase chemical mechanisms that control the concentrations of aerosol precursors. Here, we present selected results from our study of the sources and uncertainties of secondary aerosols in the Central European region, previously published in Bartík *et al.* (2021, 2024) and in the preprint by Bartík *et al*. (2025).

METHODOLOGY

In all three papers, we employed an offline-coupled modeling framework comprising the Comprehensive Air Quality Model with Extensions (CAMx), the Weather Research and Forecasting (WRF) model, and the Model of Emissions of Gases and Aerosols from Nature (MEGAN). The simulations were performed over the Central European domain with a horizontal resolution of 9 km for the years 2018–2019.

In Bartík *et al*. (2021), we studied, among other aspects, the impact of applying two different thermodynamic equilibrium models governing the evolution of inorganic aerosols in CAMx, namely ISORROPIA and EQSAM4clim.

In Bartík *et al.* (2024), we applied two complementary approaches: the first quantified the contributions of emissions from individual GNFR (Gridded Nomenclature for Reporting) sectors to total $PM_{2.5}$ and its major secondary components (ammonium, nitrate, sulfate, and secondary organic aerosol, SOA), while the second assessed the impacts of their complete removal. Specifically, to determine source contributions, we used the Particulate Source Apportionment Technology (PSAT), which is directly implemented in CAMx. To assess the impacts of emission removal, we applied the zero-out method. In the PSAT experiment, secondary organic aerosol (SOA) was modeled using the SOAP module, as this is the only available option in current versions of CAMx. In contrast, for the impact assessment, we conducted two series of experiments—SOAP and VBS—in which SOA was simulated using both built-in modules, SOAP and the 1.5-D VBS, respectively.

In Bartík *et al.* (2025), we investigated the effects of various emission parameterizations, chemical mechanisms, and chemical boundary condition (CBC) treatments on modeled primary organic aerosol (POA) and SOA concentrations through

two sensitivity analyses. The first analysis examined the influence of different approaches to estimating emissions of semi-volatile organic compounds (SVOCs) and intermediate-volatility organic compounds (IVOCs), combining two gas-phase chemical mechanisms (CB6r5 and SAPRC07TC) with two organic aerosol (OA) chemistry schemes (SOAP and the 1.5-D VBS) and including additional chemical aging in the 1.5-D VBS. The second analysis evaluated the role of large-scale transport of OA by replacing the CBCs of two reference configurations from the first analysis, which did not include aerosol species, with those derived from the CAMS EAC4 reanalysis.

Detailed descriptions of the individual model experiments are provided in the respective articles.

RESULTS AND CONCLUSIONS

In Bartík *et al.* (2021), we compared seasonal concentrations of sulfate, nitrate, and ammonium simulated by ISORROPIA and EQSAM4clim for 2018. For sulfate, the concentrations simulated by EQSAM4clim were very similar to those from ISORROPIA, with domain-mean seasonal relative percentage differences (RPDs, calculated as (EQSAM4clim – ISORROPIA) / ISORROPIA) ranging from 0.3 % in spring to 1.6 % in winter. For ammonium, EQSAM4clim generally produced lower concentrations than ISORROPIA, with domain-mean seasonal RPDs ranging from –0.5 % in winter to –10 % in summer. The largest differences were found for nitrate: domain-mean seasonal RPDs were –3 % in winter, –3 % in spring, and –8 % in autumn, but reached –32 % in summer. Locally, underestimations reached up to –70 % in Slovakia, Hungary, southern Austria, and Slovenia, while overestimations of about 15 % occurred in the Alps during winter.

The results of Bartík *et al.* (2024) provide detailed information on the dominant seasonal sources of $PM_{2.5}$ and its components in Central Europe, as well as on the expected effects of sector-specific emission reductions. In general, the results showed marked spatial and seasonal variability in both contributions and impacts across the region. Table 1 summarizes the emission sectors with the highest mean seasonal contributions to $PM_{2.5}$ in the PSAT experiment and the highest seasonal impacts on $PM_{2.5}$ in the SOAP experiment.

In winter, the mean seasonal contributions to $PM_{2.5}$ were dominated by other stationary combustion, boundary conditions, road transport, agriculture–livestock, industrial sources, and agriculture–other, while in summer, biogenic sources were dominant, followed by road transport, industrial sources, boundary conditions, and other stationary combustion. In winter, the highest impacts in the SOAP experiment were associated with other stationary combustion, agriculture–livestock, road transport, agriculture–other, and industrial sources, and in summer with agriculture–livestock, road transport, industrial sources, other stationary combustion, and shipping.

Table 1: Emission sectors with the highest mean seasonal contributions to $PM_{2.5}$ in the PSAT experiment and the highest seasonal impacts on $PM_{2.5}$ in the SOAP experiment. Values in parentheses represent domain-averaged contributions/impacts in $\mu g.m^{-3}$.

Season	Contribution in PSAT	Impact in SOAP
Winter	Oth. stationary combustion (3.2)	Oth. stationary combustion (3.4)
	Boundary conditions (2.1)	Agriculture–livestock (2.9)
	Road transport (1.4)	Road transport (1.4)
	Agriculture–livestock (0.9)	Agriculture–other (1.1)

	Industrial sources (0.6)	Industrial sources (0.6)
Summer	Biogenic emission (0.57) Road transport (0.31) Industrial sources (0.28) Boundary conditions (0.27) Oth. Stationary combustion (0.25)	Agriculture–livestock (0.46) Road transport (0.45) Industrial sources (0.34) Oth. stationary combustion (0.29) Shipping (0.20)

The differences between the contributions and impacts were almost entirely attributable to secondary aerosol components. The most pronounced differences were linked to emissions from agriculture–livestock through their indirect influence on particulate nitrate formation.

The comparison between the SOAP and VBS experiments showed that the use of the 1.5-D VBS scheme, together with IVOC and SVOC emissions, led to increased impacts from other stationary combustion and road transport in winter, and from road transport in summer.

The first sensitivity analysis in Bartík *et al.* (2025) showed that source-specific and non-source-specific IVOC and SVOC emission estimates significantly affect the modeled POA and SOA concentrations. The best agreement with the observed daily organic carbon (OC) concentrations was obtained when the OA chemistry was represented by the 1.5-D VBS scheme with aging of POA and SOA from all anthropogenic sources and SOA from biogenic sources. This setting most strongly reduced the OC underestimation present in all experiments. Model performance was generally better in winter than in summer, with variations by station location.

The second analysis examined the impact of OA from outside the domain via CBCs, highlighting uncertainties linked to the unknown POA:SOA split at the boundaries. Incorporating OA into the CBCs improved model predictions at all stations, with the magnitude of improvement increasing with the POA share in OA. The largest gains in FAC2 occurred in the summer, indicating a strong influence of OA transport during this season.

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STATISTICKÉ MODELOVÁNÍ POČETNÍCH KONCENTRACÍ ČÁSTIC

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Klíčová slova: Atmosférické aerosoly, SMPS, GAM, semiparametrické modely

SUMMARY

In this work, we will introduce a general statistical framework for analysis of multivariate time series of count concentrations of particles monitored simultaneously for several size intervals. We will demonstrate its use for two concrete analysis types: i) decomposition of the series into several interpretable components: annual trend, seasonality, weekly and daily periodicity in hourly resolution, ii) structured modeling of potentially nonlinear influence of direction, speed of the wind and PBLH upon the count concentrations. Both model types will be illustrated on unique and long SMPS time series with aggregation to the size intervals [10,25]; (25,50]; (50,200]; (200,500] nm, measured over many years in Praha Suchdol at ICPF. Models we will be illustrating are respecting basic distributional properties of the count concentrations and hence are multivariate normal, with components based on complexity penalized splines. We will show interpretation of individual terms and fundamentally different behavior of different size intervals. Important role is played not only by marginal nonlinearity, but also interaction between different components (e.g. weekly and daily periodicity pattern is deformed during a year, or windspeed effect is substantially modified by wind direction due to different sources) modeled via tensor product splines.

SOUHRN

V příspěvku představíme obecnou statistickou metodologii pro analýzu vícerozměrných časových řad početních koncentrací částic měřených simultánně v několika velikostních třídách. Ukážeme její konkrétní použití pro dva typy analýz: i) dekompozici řad do několika snadno interpretovatelných složek: meziročního trendu, sezónní složky uvnitř roku, týdenní a denní periodicity v rozlišení po hodinách, ii) strukturované modelování potenciálně nelineárního vlivu směru, síly větru a PBLH na početní koncentrace, a to diferencovaně pro různé velikostní třídy. Oba typy modelů ilustrujeme na unikátních, dlouhých SMPS časových řadách s agregací do velikostních tříd [10,25]; (25,50]; (50,200]; (200,500] nm, naměřených v ÚCHP na v Praze Suchdole. Modely, které pro analýzu formulujeme a používáme respektují základní rysy distribuce početních koncentrací, a jsou tedy formulované jako vícerozměrně lognormální, s komponentami založenými na splinech s penalizací na komplexitu. Ukážeme interpretaci jednotlivých složek i odlišné chování různých velikostních tříd. Podstatná je přitom nejen výrazná nelinearita, ale i interakce vlivu různých složek (například týdenní a hodinová složka se v průběhu roku výrazně deformuje, podobně vliv síly větru interguje se směrem vzhledem k prostorové distribuci zdrojů) modelované s pomocí tensor product splinů.

LONG-TERM CHANGES IN PRECIPITATION CHEMISTRY IN CENTRAL EUROPE

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Keywords: Atmospheric deposition, Chemical composition, Precipitation, Sulphates, Nitrates, Ammonium ions

SUMMARY

Atmospheric deposition is a key environmental process (Seinfeld - Pandis, 2006). On the one hand, it substantially contributes to the self-cleaning of our atmosphere; on the other hand, it introduces water, nutrients and pollutants into our environment. Of the three pathways of real atmospheric deposition (wet, dry and occult), wet deposition is the most well understood. For many decades, precipitation chemistry networks have measured the wide range of substances in rain and snow at global (BAPMON), regional (EMEP, NADP/NTN, CAPMON) and local scales (nation-wide). In the Czech Republic, the chemistry of precipitation has been measured since the 1970s, and several institutions (Czech Hydrometeorological Institute, Czech Geological Service, Research Institute of Forestry and Game Management, Czech Academy of Sciences) currently contribute their results to the nation-wide ISKO database (Information System of Ambient Air Quality), which is operated by the Czech Hydrometeorological Institute (CHMI). These data are evaluated on a yearly basis by the CHMI, and spatial maps of atmospheric deposition fluxes of environmentally important substances with a spatial resolution of 1 x 1 km are provided to both researchers, governmental bodies and interested public (CHMI, 2025). These maps, which visualise deposition fluxes of sulphur, nitrogen and hydrogen, and toxic metals (lead, cadmium, nickel) are freely available at www.chmi.cz.

Reliable data on precipitation chemistry are needed not only in themselves, but also as relevant and extremely important practical information on the input of substances into forest, semi-natural and agricultural ecosystems, as well as into water bodies, with respect to their negative effects. Furthermore, this information is indispensable for extended scientific studies of biogeochemical cycles and global change.

This contribution aims to present long-term changes in precipitation chemistry in the Czech Republic, as evidenced by long-term monitoring efforts. These changes are expressed not only as increases or decreases of individual pollutants, but also as time trends of the ratios of these pollutants. The results clearly show important changes in the relative proportions of the major pollutants, i.e. sulphates. nitrates and ammonium ions (see Fig. 1), which: (i) reveal substantial changes in the composition of the atmosphere with respect to changing emission levels, (ii) suggest changes in atmospheric chemistry and (iii) indicate potential impacts on ecosystems and the environment. Further detailed information can be found for example in Hůnová et al. (2024) and Hůnová – Škáchová (2025).

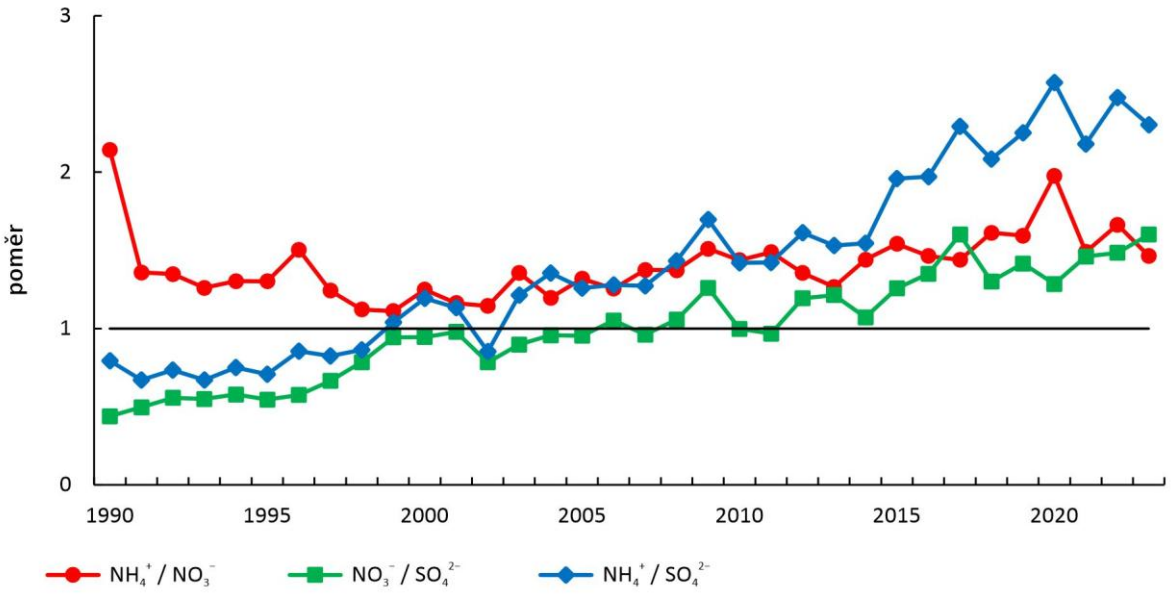

Fig. 1: Long-term changes in NH_4^+/NO_3^-, NO_3^-/SO_4^{2-} and NH_4^+/SO_4^{2-} in precipitation in the CR in 1990–2024 (Hůnová-Škáchová, 2025)

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DETECTION OF BIOGENIC SOA USING TWO CONVENTIONAL OPTICAL INSTRUMENTS

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Keywords: PM1, SOA, PMF, NMF, FLEXMIX

INTRODUCTION

Due to the decline in ambient air concentrations in the EU over the last decades, the relative contribution of natural particle sources has been increasing and is becoming more important for air protection, particularly with a view to 2030, when new emission standards under Directive 2024/2881 will come into force. In addition to mineral dust, biogenic particles can represent a significant fraction of PM. Apart from biogenic primary particles, biogenic secondary organic aerosols (BSOA) formed from biogenic volatile organic compounds (BVOCs) can also play a significant role in some areas, especially in the submicron range. Although freshly formed particles from biogenic VOCs contribute only a minor fraction to PM mass concentrations, particle accumulation and aggregation make them more significant during pollution transport. Moreover, the sequential transformation of BSOA in the atmosphere alters aerosol properties, including their impact on human health (Mahilang et al., 2021).

For BSOA measurements and characterization, state-of-the-art offline and online methods are usually employed. In this study, we tested the detection of BSOA using two conventional optical instruments—the AE33 aethalometer and the FIDAS 200—as signals from BSOA could potentially influence the measured values and complicate their interpretation during PM source apportionment, particularly in areas with high BVOC emissions.

EXPERIMENTAL SETUP

The monitoring site was located in the Jeseníky Mountains in the northern part of the Czech Republic, where high BVOC emissions were expected due to the extensive spruce and beech forest cover. At the same time, the long distance from urban areas and roads ensured a low contribution of anthropogenic sources. Measurements at the Dlouhé Stráně site (GPS: 50.0787678N, 17.1623108E; 1305 m a.s.l.) were conducted from 18 June to 25 September 2024 using the automatic analyzer FIDAS 200 for PM and the AE33 aethalometer for BC. In addition, automatic analyzers were employed to monitor NO, NO_2, NO_x, SO_2, CO, and O_3, along with air temperature, wind speed, and wind direction. As a complement to the online measurements, $PM_{2.5}$ sampling on filters was carried out from 21 June to 22 September 2024. Twenty-four-hour samples were collected every third day using a low-volume sampler (2.3 m^3/h) on quartz filters for laboratory determination of organic and elemental carbon by the thermo-optical EUSAAR_2 method.

The identification of BSOA was based on correlations among measured chemical and meteorological parameters, as well as mixture regression analysis using the FLEXMIX model. To estimate the BSOA contribution to PM, PMF and NMF receptor models were applied to distinguish aerosol sources based on particle size distribution.

RESULTS

The polar plots showed that the sources of particles smaller than 300 nm substantially differed from those of larger particles. This suggested an influence from a local source, presumably SOA formation. The FIDAS number concentrations for the smallest assessed bin (184 nm) were strongly positively correlated with OC1 (after aggregating hourly online measurements to the 24-hour sample resolution) and ozone (Fig. 1), and negatively correlated with air humidity.

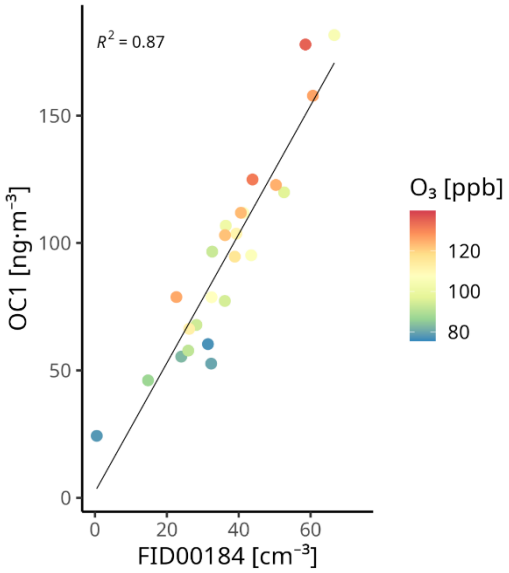

Fig. 1: Relationship among FIDAS200 channel 184 nm, OC1, and ozone

For the online measurements, two data populations were revealed in the ΔBC vs. FIDAS 184 nm scatter plot, classified into two clusters using the FLEXMIX mixture regression model. These clusters differed substantially not only in the slope of the ΔBC vs. FIDAS 184 nm regression line but also in wind speed and temperature. Similarly, two FLEXMIX clusters, differing in their relationships to ozone, EC, wind speed, and particle size, were identified for the ΔBC vs. OC1 offline data. This indicated that small particles (FIDAS 184 nm) consisted of thermally labile organic carbon (OC1), suggesting fresh SOA.

Using the PMF and NMF models, the same three stable factors of distinct time series were obtained by processing the FIDAS volume concentrations data, with peaks at approximately 184–264, 328–543, and >700 nm. The factor representing the smallest particles exhibited a well-pronounced diurnal variation, with concentrations increasing during the first half of the day and peaking between 12:00 and 18:00 (Fig. 2).

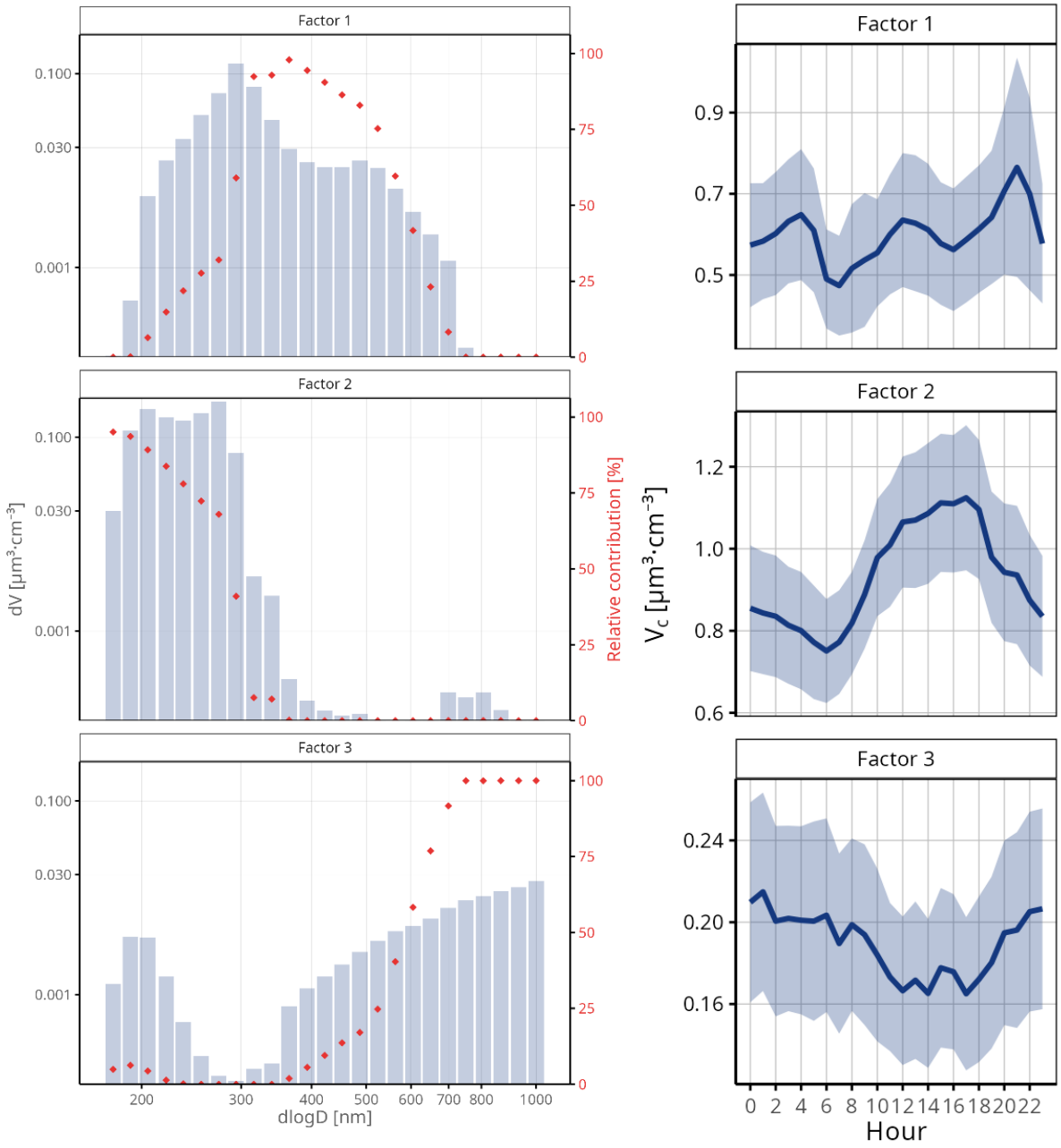

Fig. 2: NMF factors and their diurnal patterns

Processing this photochemically induced NMF factor (Factor 2) in the same way as for the FIDAS 184 nm channel revealed similar but even more distinct clusters, with stronger relationships to meteorological parameters, ozone, EC, and OC1 (Fig. 3). This supports the interpretation that this factor predominantly represents local BSOA.

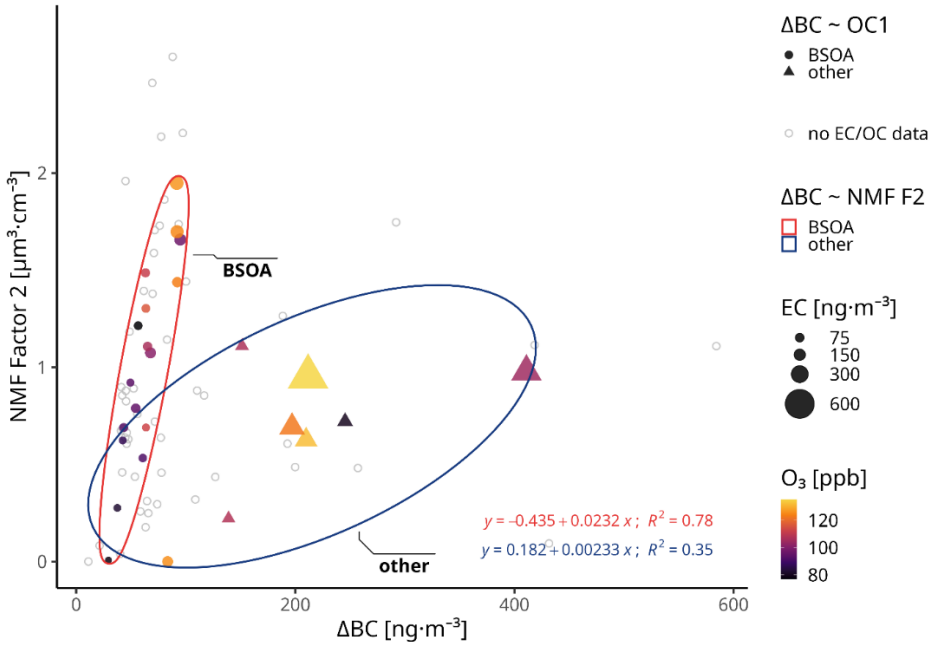

Fig. 3: FLEXMIX clusters for the ΔBC vs. BSOA NMF factor (24-hour values)

Due to the limitations of FIDAS measurements in the submicron range, the particle densities derived from measured mass and volume concentrations were unrealistically high and did not correspond to reasonable values. Nevertheless, we assumed that the factor peaking at 328–543 nm represented ammonium sulfate, as it showed high contributions and its polar plot was consistent with the expected source areas. Based on this assumption, particle density corrections were applied using the same coefficient for all factors. After this adjustment, particle densities of 1.8, 1.4, and 2.8 corresponded well to the expected values for ammonium sulfate, biogenic SOA, and mineral dust, respectively. Using these values, the estimated mean mass contribution of biogenic SOA was 45% for PM_1 and 36% for $PM_{2.5}$.

CONCLUSIONS

Biogenic SOA yields a significant signal in both FIDAS 200 and AE33 measurements, and this should be taken into account in source apportionment studies, particularly at low-pollution sites. Due to the limitations of optical measurements for particles smaller than 1 µm, advanced methods statistical analyses are required for biogenic SOA quantification. At forested mountain background sites, BSOA may represent the main summer PM_1 source and may contribute more than one third to $PM_{2.5}$.

ACKNOWLEDGEMENT

This work was financially supported by the Technological Agency of the Czech Republic (TAČR), Joint Grant No SS 02030031 ARAMIS.

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APPLICATION OF GAS CHROMATOGRAPHY ATMOSPHERIC PRESSURE CHEMICAL IONIZATION MASS SPECTROMETRY FOR ANALYSIS OF CONTAMINANTS IN ENVIRONMENTAL SAMPLES

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Key words: Chemical analysis, gas chromatoraphy, mass spectrometry, PAHs derivates, pesticides, flame retardants

SUMMARY

Detailed sample characterization is important for proper assessment of toxicity and risks posed with contaminant presence in environmental samples. Proper evaluation of toxicity in compound mixtures requires quantification of low-level contaminants. Compound ionization plays an important role in compound quantitation and identification. Electron ionization (EI) and negative chemical ionization (NCI) are the most common ionization techniques used in gas chromatography mass spectrometry (GC-MS), but show certain disadvantages. For example, EI is a hard ionization technique which often causes unwanted in-source fragmentation. On the other hand NCI, a soft ionization technique, may lead to the production of unwanted adducts as a result of using a modifier to lower the fragmentation. Recent development in GC-MS has commercially introduced various atmospheric pressure chemical ionization (APCI) systems. The principle of APCI has been mostly applied in the field of liquid chromatography mass spectrometry (LC-MS). GC-APCI-MS is a soft ionization technique that produces higher abundance of molecular ions without the use of a modifier, thus decreasing production of adducts. APCI is highly advantageous when combined with tandem mass spectrometry (MS/MS), as it provides a highly sensitive detection technique that is able to correctly identify compounds.

GC-APCI-MS/MS was applied for the analysis of polycyclic aromatic hydrocarbons (PAHs) and their derivates, nitro- and oxy- PAHs in environmental samples (air, soil, water). Lower detection and quantitation limits of PAHs, nitro- and oxyPAHs were obtained when analyzed on the GC-APCI-MS/MS compared to the previously used GC-NCI-MS or GC-EI-MS/MS. Further GC-APCI-MS/MS was applied also for determination of organochlorine pesticides (OCPs), such as aldrin, dieldrin, endosulafan, chlordanes; alternative flame retardants (AFRs) in environmental samples.

SOURCE-SPECIFIC ABSORPTION ANGSTROM EXPONENT AND AEROSOL SIZE DISTRIBUTIONS AT A RURAL BACKGROUND SITE

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Keywords: black carbon, brown carbon, light absorption, particle size, biomass burning, fossil fuel.

INTRODUCTION

Black carbon (BC) absorbs very effectively radiation over the entire visible spectrum (from near-UV to near-IR), while brown carbon (BrC) absorbs predominantly in the ultraviolet (UV) band and the short visible wavelength (Bon et al., 2013; Drinovec et al. 2015; Leskinen et al., 2020). The absorption Ångström exponent (AAE) describes the wavelength dependence of light absorption by aerosols and can be used to differentiate between different aerosol types (black and brown carbon) and sources (fossil fuel and biomass burning). This study investigates the size dependence of AAE of aerosols from different sources at a rural background site.

EXPERIMENTAL SETUP

Ground-based (4 m a.g.l.) measurements were carried out from April 25 to May 5, 2023, at the National Atmospheric Observatory Košetice (NAOK; 49°35'N, 15°05'E), Czech Republic. The 1-minute spectral absorption coefficient (δ_{ab}) was obtained with an AE33 aethalometer (Magee Scientific, Berkeley, CA, USA) measuring equivalent BC at seven wavelengths (370, 470, 520, 590, 660, 880, and 950 nm). Particle number size distribution (PNSD, 10 – 800 nm) and size-resolved PM_1 organic aerosols (OA) were also measured with a collocated scanning mobility particle sizer and an aerosol mass spectrometer, respectively, both measuring every 5 min.

RESULTS AND CONCLUSIONS

AAE was computed using a power law fit in logarithmic space of the 7 δ_{ab} versus the corresponding wavelengths, and optimized AAE for fossil fuel (AAE_{ff}) and biomass burning (AAE_{bb}) were determined from the 5^{th} and 95^{th} percentile, respectively. The overall AAE during our survey (1.39 ± 0.20) is consistent with that observed at NAOK during spring (Mbengue et al., 2020). The AAE_{ff} of 1.12 ± 0.09 is close to that of fresh BC particles, consistent with those reported by Savadkoohi et al. (2025) at regional background (RB), urban traffic (UBT), and suburban (SUB) sites in Europe (Fig. 1). The higher AAE_{bb} compared to European RB, UBT, and SUB sites could be attributed to the influence of fresh emissions from the traditional Burning of the Witches, a large-scale biomass burning event in the Czech Republic. AAE_{bb} was strongly correlated with δ_{ab}_BrC_{370} (r = 0.89) and was more sensitive to particle size, unlike AAE_{ff} (0.86 – 1.20).

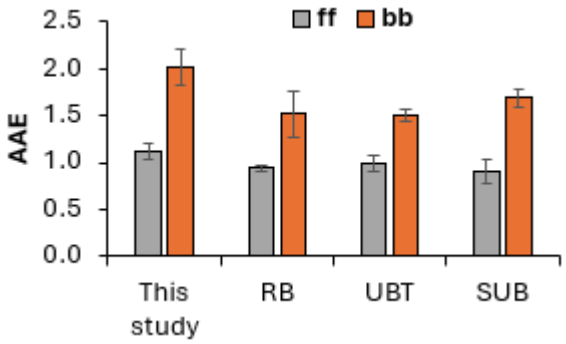

Figure 1: Mean (± std) AAE_{ff} and AAE_{bb} measured at NAOK and those measured at regional background (RB), urban traffic (UBT) and suburban (SUB) sites in Europe (Savadkoohi et al., 2025).

The overall PNSD shows the prevalence of particles < 100 nm. Although higher in number, ultrafine particles smaller than 80 nm were not correlated with AAE_{bb}. Conversely, the higher correlation with AAE_{bb} was observed for particle number concentration in the size range 100 – 400 nm ($r \geq 0.86$). This aligns with the stronger correlation between AAE_{bb} and mass concentration of organic aerosol > 100 nm, with the highest value observed for particles in the 200 – 400 nm range ($r = 0.90$).

ACKNOWLEDGEMENT

The research leading to these results was supported by the Ministry of Education, Youth and Sports of the Czech Republic within the Large Research Infrastructure Support Project - ACTRIS Participation of the Czech Republic (ACTRIS-CZ LM2023030), within the CzeCOS program, grant number LM2023048, and through the Czech Science Foundation grant 24-10768S.

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REGIONAL AND SEASONAL DRIVERS OF METALS AND PAHS CONCENTRATIONS IN ROAD DUST AND THEIR HEALTH IMPLICATIONS IN THE CZECH REPUBLIC

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Keywords: Atmospheric aerosols, PAH, health impact assessment

INTRODUCTION

While exhaust emissions from cars in the EU are clearly declining, the future of non-exhaust emissions looks more pessimistic. The relative importance of these emissions is therefore expected to increase in terms of air quality and human health.

Road dust samples were collected in all regions and seasons. Based on subsequent laboratory and statistical processing, the spatiotemporal distribution of elements and PAHs was evaluated. Furthermore, the contribution of road dust resuspension to air concentrations was estimated and the associated health impacts were assessed. Significant regional and seasonal differences in PAHs and metals were found. Air quality, leading to atmospheric deposition, was the most important factor contributing to these differences. In contrast, traffic intensity played only a minor role in influencing metal and PAH concentrations in road dust.

The aim of this part of the study was to assess regional and seasonal differences in the chemical composition of road dust in the Czech Republic and to evaluate the potential health impacts of resuspension, with a particular focus on polycyclic aromatic hydrocarbons and metals.

The following indicators were evaluated:

- the estimated premature mortality rate;
- the estimated annual number of hospitalizations in the emergency room for heart patients;
- the estimated annual number of emergency respiratory hospitalizations;
- the number of days of bronchodilator in children aged 5 to 14;
- the number of days of bronchodilator use in adults aged 20 to 64;
- number of days with respiratory symptoms per child aged 5 to 14;
- post-neonatal infant (aged 1 to 12 months) mortality from all causes;
- prevalence of bronchitis in children aged 6 to 12 (6 to 18 years);
- prevalence of bronchitis in adults aged 18+;
- incidence of asthma symptoms in asthmatic children;
- estimate of the number of additional cases for individual monitored carcinogenic components

RESULTS, CONCLUSIONS

1. Estimation of the impact of atmospheric deposition of PM_{10} fraction on public health in connection with particle resuspension due to traffic

Tab. 1. Average of measured PM_{10} concentrations [μg/m^3] and estimate of premature mortality

Location	autumn	summer	"summer + autumn"
Praha – Libuš	17.8	14.4	16.3
Ústí n/L – Prokopa Diviše	26.0	17.4	21.6
Zlín – Velké kino	21.1	17.2	19.1
Estimate of premature mortality in % for "autumn and summer" - represents the calendar year			
Praha – Libuš		2.5	
Ústí n/L – Prokopa Diviše		4.6	
Zlín – Velké kino		3.6	

Tab. 2. Average PM_{10} concentrations in resuspesion [μg/m^3] and estimate of premature mortality

Location	Contribution from resuspesion	Premature mortality estimate in %
Praha – Libuš	1.9	0.8
Ústí n/L – Prokopa Diviše	2.4	1.0
Zlín – Velké kino	2.7	1.1

The estimated premature mortality rate by 0.8% (Prague) to 1.1% (Zlín)

2. Estimation of the impact of atmospheric deposition of PAHs (Benzo[*a*]pyrene - BaP) and selected metals on public health in connection with the resuspension of particles due to traffic. The assessment of carcinogens is based on the theory of no threshold effect.

This theory assumes that there is no concentration below which the effect of a given substance is zero. Any exposure poses a certain risk, and the magnitude of this risk increases with increasing exposure. The degree of carcinogenic potential of a given substance is expressed by the cancer risk guideline. The UCR/ICR, i.e., the carcinogenic risk unit/inhalation carcinogenic risk (the risk of developing cancer as a result of lifelong inhalation of air with a concentration of the evaluated substance equal to 1 μg/m^3), is used for the assessment.

Tab. 3. Average of measured BaP, As, Cd and Ni concentrations [ng/m^3]

Location	BaP [ng/m^3]	As [ng/m^3]	Cd [ng/m^3]	Ni [ng/m^3]
Praha – Libuš	0.051	0.059	0.133	0.013
Ústí n/L – Prokopa Diviše	0.048	0.069	0.100	0.028
Zlín – Velké kino	0.079	0.086	0.195	0.029

Note: The higher Cd values in resuspensions are somewhat unexpected.

- BaP – the carcinogenic health risk from resuspension is approximately 100 times lower than in outdoor air at all three locations evaluated. The values there are between 4.2 x 10^{-6} to 6.9 x 10^{-6}.
- As – the carcinogenic health risk from resuspension is approximately 10 times lower than in outdoor air at all three locations. The values there are between 8.9 x 10^{-8} to 1.3 x 10^{-7}.
- Cd – the carcinogenic health risk from resuspension is approximately comparable to the values measured in outdoor air at all three locations. The values there are between 4.9 x 10^{-8} to 9.6 x 10^{-8}.
- Ni - the carcinogenic health risk from resuspension is approximately 10 times lower at all three locations than in outdoor air. The values there are between 5.5 x 10^{-9} to 1.1 x 10^{-8}.

The conversion to population risk is not performed here because the measured locations are not representative of the entire urban population. There is obviously high local variability, which complicates interpretation.

ACKNOWLEDGEMENT

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ONLINE VS. OFFLINE AEROSOLOVÁ HMOTNOSTNÍ SPEKTROMETRIE: URČENÍ STAVU AEROSOLŮ NA ZÁKLADĚ LETNÍCH DAT Z POZAĎOVÉ STANICE KOŠETICE

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Klíčová slova: Uhlíkaté aerosoly, PM_1, AMS, Online vs. offline, Receptorové modelování

SUMMARY

Understanding the origin and type of organic aerosol (OA) is essential for determining its impact on air quality, climate, and health. In this study, we focus on determination of the source/state of OA analyzed using aerosol mass spectrometry. This was performed both online, directly at the station, and offline in the laboratory using analyses of fine aerosol (PM_1) collected on filters. Parallel sampling for online and offline analysis allows us to subsequently assess the validity of given methods.

ÚVOD

Porozumnění původu a typu organického aerosolu (OA) je podstatné pro zjištění jeho vlivu na kvalitu ovzduší, klima i zdraví. V této práci se zaměřujeme na určení zdroje/stavu OA analyzovaného pomocí aerosolové hmotnostní spektrometrie, která byla prováděna jak online, přímo na stanici, tak offline v laboratoři pomocí analýz jemného aerosolu (PM_1) odebraného na filtry. Paralelní odběr pro online a offline analýzu umožňuje následně posoudit validitu daných metod.

METODIKA

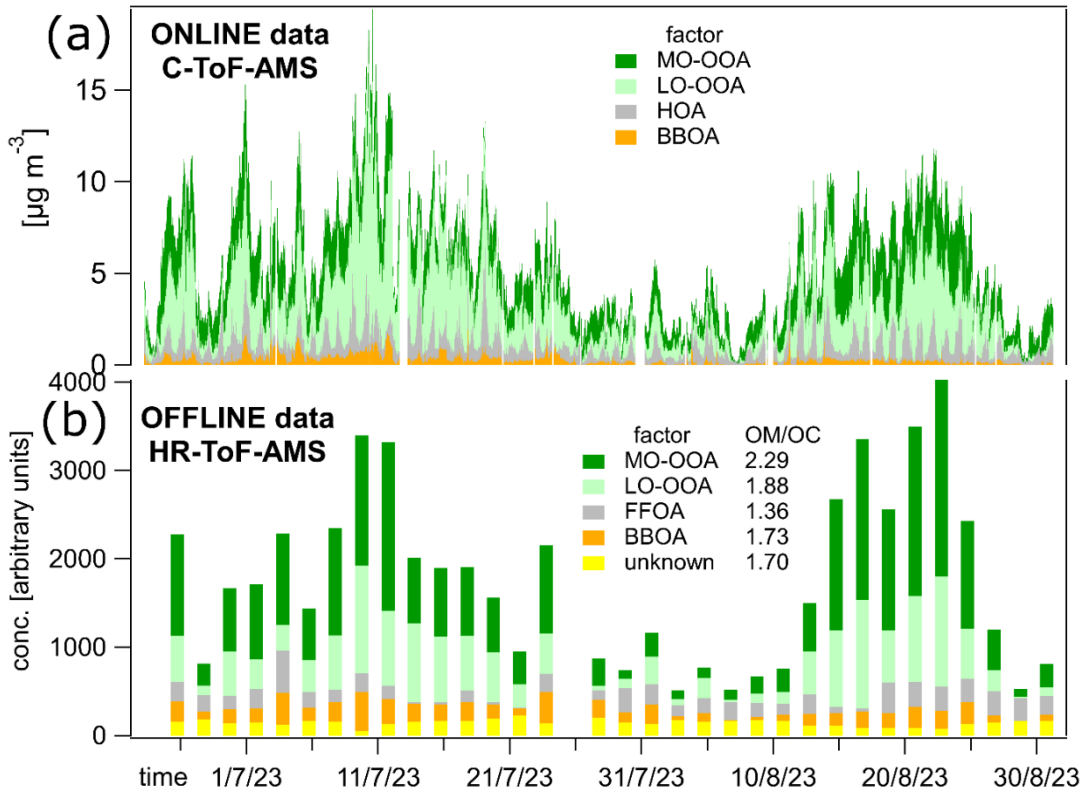
Měření PM_1 byla prováděna během léta (23. června – 30. srpna) 2023 na Národní atmosférické observatoři Košetice (NAOK, N 49°35′, E 15°05′; 534 m n. m.)

Pro online analýzy byla použita 5-ti minutová data z aerosolového hmotnostního spektrometru (AMS), konkrétně typ C-ToF-AMS, doplněná o koncentrace ekvivalentního černého uhlíku (eBC) měřené v 1 minutovém rozlišení pomocí aethalometru (typ AE33, Magee Scientific) a měření elementárního a organického uhlíku (4-h rozlišení).

Pro offline měření byly každý druhý den prováděny 24-h odběry aerosolů na křemenné filtry, na kterých byla provedena gravimetrie, analýza vodou rozpustných iontů a také analýza vysokorozlišovacím hmotnostním spektrometrem (typ HR-ToF-AMS). Soubor dat byl doplněn o meteorologické parametry a klastrové analýzy převládajících směrů větru.

VÝSLEDKY, DISKUSE, ZÁVĚRY

Z hlediska složení letního PM_1 převládal OA následovaný sírany (SO_4^{2-}), amonnými ionty (NH_4^+), eBC a dusičnany (NO_3^-). Pomocí pozitivní maticové faktorizace (PMF) s multilineární engine (ME-2) došlo k rozdělení OA do různých faktorů z hlediska jejich hmotnostních spekter a časových řad pomocí programu Source Finder (SoFi). Obrázek 1 ukazuje výsledky PMF analýzy jak pro online tak pro offline měření. Online data poskytla nejsmysluplnější 4-faktorové řešení, přičemž valnou většinu tvoří oxidované OA (OOA). Relativně podobný výsledek ukazuje i PMF analýza offline dat (Obr.1b), ve které také převažují OOA, ale analýza zároveň poskytla o jeden neznámý faktor více, jehož specifické určení bude dále diskutováno. Obecně ukazují obě metody dobrou shodu ve variacích i množství jednotlivých faktorů. Výhodou online dat je možnost určit denní chody jednotlivých faktorů. Naopak, přidanou hodnotou offline měření je možnost určení původu faktoru buď ve vodě rozpustném, nebo vodě nerozpustném aerosolu. Detaily budou diskutovány během přednášky.



Obrázek 1: Příspěvek faktorů z online (C-ToF-AMS) a offline měření (HR-ToF-AMS). Legenda: OM/OC – poměr organické hmoty a organického uhlíku, faktory MO-OOA a LO-OOA – více oxidované a méně oxidované organické aerosoly, BBOA – organické aerosoly za spalování biomasy, HOA – čerstvé organické aerosoly, FFOA – organické aerosoly ze spalování fosilních paliv, „unknown“ – nepřiřazený faktor.

PODĚKOVÁNÍ

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WHAT ARE THE MAIN CHALLENGES IN BUILDING A NEW GREENHOUSE GAS MEASUREMENT NETWORK WITHIN THE ADAGRIF PROJECT?

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Keywords: Greenhouse gases, Atmospheric modeling, GHG fluxes, ICOS

INTRODUCTION

Advanced methods for greenhouse gas (GHG) emission reduction and sequestration in agricultural and forest landscapes for climate change mitigation are the focus of the AdAgriF project. The structure of this project is divided into three main thematic areas. The first (FluxBASE) focuses on understanding key GHG cycles from the molecular to the landscape level and developing methods for their mitigation. The second work package (FluxPRISM) focuses on developing a high-resolution system that integrates in-situ measurements, ecosystem modeling, and atmospheric modeling for real-time attribution and prediction of GHG fluxes, while the third FluxCOMM, involves the development of a mechanism that maximizes GHG emission reductions without compromising key ecosystem services.

EXPERIMENTAL SETUP

The topic of this presentation is the development of a new precision GHG measurement system within FluxPRISM. The system includes the development of a measurement system and its installation at a specific location, as well as the development of control and evaluation software. The complete measurement network consists of 12 newly installed stations across the Czech Republic, complemented by the superstation Křešín (part of the National Atmospheric Observatory Košetice), which has been operational since 2014 and **is classified as an** ICOS station class 1. Our superstation will serve as a calibration and reference point for accurate GHG measurements, enabling the integration of any European ICOS station into the estimation of biospheric fluxes using Lagrangian particle dispersion models in the future.

RESULTS AND CONCLUSIONS

The GHG fluxes obtained are further analyzed through backward recalibration of process-based models, integration with weather forecasts for GHG flux prediction, regional carbon balance assessments, and spatial disaggregation using remote sensing down to the field scale. This enables attribution of observed fluxes to specific land management practices and their impact on the GHG balance.

The system is currently under intensive development, with gas analyzers being installed or activated on telecom towers, and the first simulations already completed. This conference contribution presents the system's core principles and initial results of spatially distributed, country-wide CO_2 flux estimates.

The expected outcome is a significantly improved understanding of GHG fluxes in the Czech Republic, with much finer spatiotemporal resolution than currently offered by national inventories, global or European inversions, or machine-learning-based eddy covariance estimates.

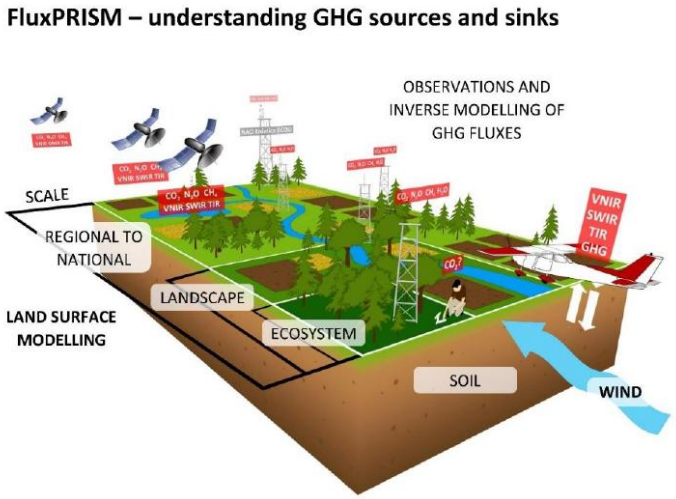

Figure 1: Scheme of the FluxPRISM network.

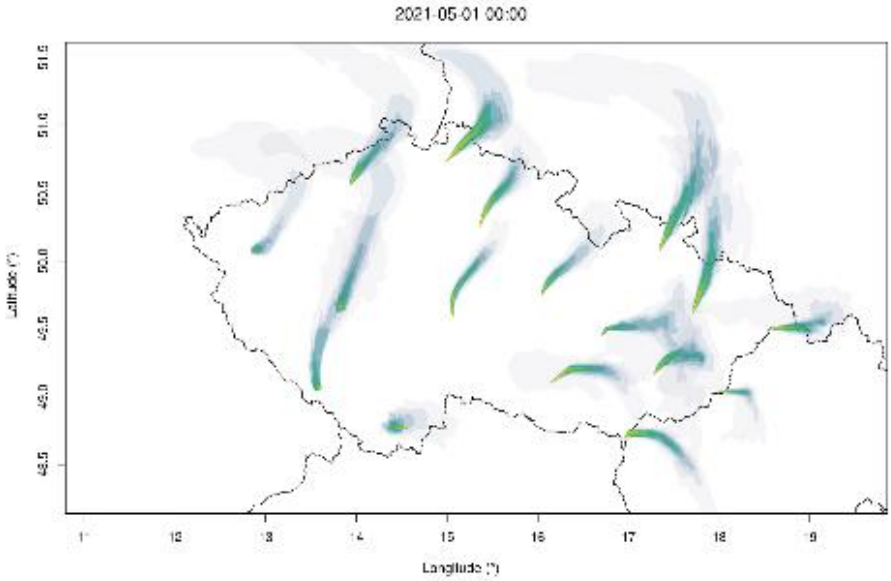

Figure 2: The map showing the location of measuring stations including GHG flux modeling.

ACKNOWLEDGEMENT

Authors acknowledge support from AdAgriF - Advanced methods of greenhouse gases emission reduction and sequestration in agriculture and forest landscape for climate change mitigation (CZ.02.01.01/00/22_008/0004635). The research was also supported by the Ministry of Education, Youth and Sports of the Czech Republic within the Large Research Infrastructure Support Project - ACTRIS Participation of the Czech Republic (ACTRIS-CZ LM2023030), within the CzeCOS program.

HEAT WAVE EFFECTS ON ISOPRENE CONCENTRATIONS AT KOŠETICE AND LIBUŠ OBSERVATORIES

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Keywords: Air Quality, Heat Wave, Temperature, VOC, Isoprene, Terpenes
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INTRODUCTION

Climate change is expected to increase the frequency and intensity of extreme weather events in Central Europe, including heat waves (HWs). These events can strongly affect air quality by enhancing atmospheric stagnation, leading to elevated ozone and particulate matter concentrations (Wu et al., 2019). Higher temperatures also stimulate emissions of biogenic volatile organic compounds (BVOCs) such as isoprene and terpenes, which contribute to the formation of secondary pollutants (Churkina et al., 2017). Since HWs are projected to become more common in the future (Corrêa, 2025), their role in BVOC emissions deserves closer attention. For this reason, we investigated the effect of HWs on isoprene and terpene levels at two Czech observatories.

METHODS

This study was conducted at two Czech observatories operated by Czech Hydrometeorological Institute with contrasting environments. The National Atmospheric Observatory Košetice (NAOK, 49.57°N, 14.79°E, 534 m a.s.l.) represents a rural background site in the Vysočina region, while the Libuš Observatory (Prague, 50.0°N, 14.44°E, 302 m a.s.l.) is a suburban site in the southern part of the capital with stronger anthropogenic influence. Isoprene has been monitored since 1995 by canister sampling according to the EMEP manual and analyzed by gas chromatography at both observatories. During summer 2023, a case study using PTR-TOF-MS to measure isoprene and monoterpenes was peformed at NAOK. Anthropogenic isoprene was estimated using 1,3-butadiene as a tracer, following the methodology described by Reimann et al. (1999). Air temperature data at both sites were obtained from Vaisala HMP sensors. Heatwaves (HWs) were defined in this study as periods of at least three consecutive days with daily maximum temperature equal to or exceeding the 95th percentile of the long-term temperature distribution (1988–2024) at NAOK. For the Košetice observatory, this threshold corresponds to 26.7 °C, while the long-term temperature distribution (1988–2024) at the Libuš observatory set this threshold to 29.3 °C.

RESULTS AND DISCUSSION

At Libuš, median isoprene concentrations during days with median temperatures reached 0.20 $\mu g \cdot m^{-3}$, while during HWs they increased to 1.00 $\mu g \cdot m^{-3}$. At NAOK, the respective values were 0.03 $\mu g \cdot m^{-3}$ and 0.75 $\mu g \cdot m^{-3}$. The long-term dataset from NAOK further showed that from 2018 onwards, HW-related median isoprene concentrations regularly exceeded 1 $\mu g \cdot m^{-3}$, whereas between 1995 and 2017 this occurred only occasionally. Correlation analysis indicated that the overall relationship between

isoprene and temperature was moderate (R = 0.47), but strengthened substantially during HWs (R = 0.71).

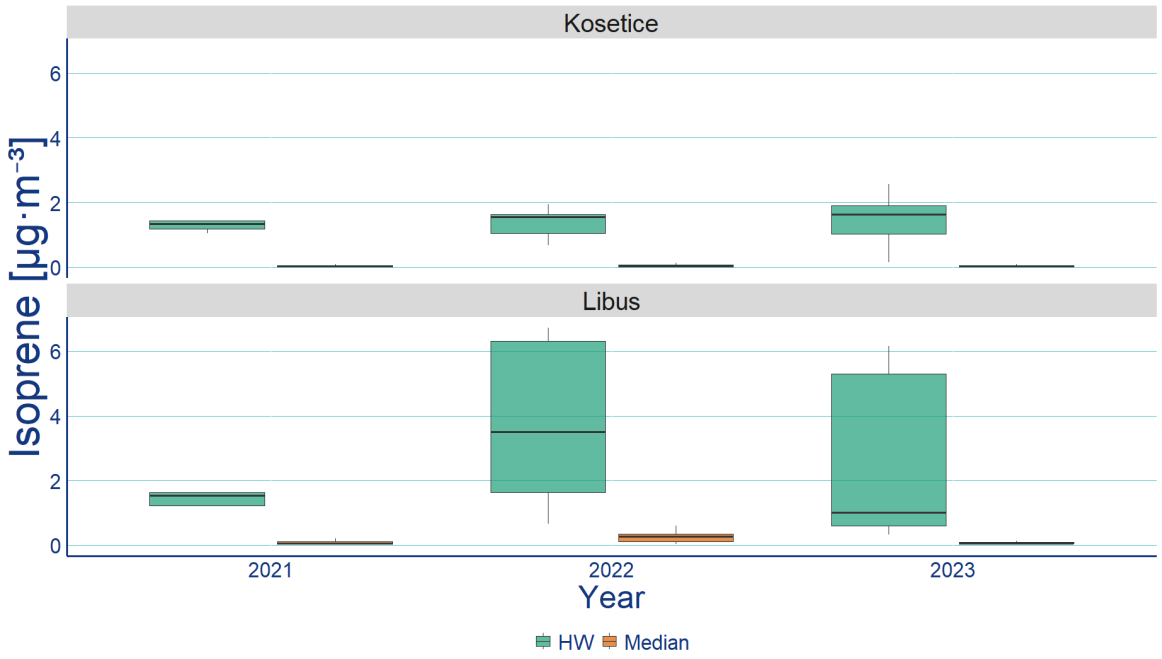

Fig. 1. Annual overview of Isoprene concentrations during regular day temperatures and HW events (2021–2023) from NAOK and Libuš Observatories.

CONCLUSIONS

The comparison of rural and suburban environments confirms that HWs strongly enhance isoprene concentrations, due to site-specification. While NAOK showed lower baseline levels, the relative increase during HWs was more pronounced, highlighting the sensitivity of biogenic sources. In contrast, Libuš exhibited higher absolute concentrations, reflecting the influence of both biogenic and anthropogenic contributions.

ACKNOWLEDGEMENTS

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NABÍJENÍ ULTRAJEMNÝCH AEROSOLŮ PŘI ELECTROSTATICKÉM ODLUČOVÁNÍ

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Klíčová slova: Aerosoly, Nabíjení částice, Electrostatické odlučování

SUMMARY

Corona discharge in electrostatic precipitators (ESPs) ionises gases, charging suspended particles for collection. Accurate charging models are essential for predicting particle behaviour and optimising ESP design. At discharge electrode edges, the electric field generates non-thermal plasma that triggers reactions leading to the removal of NOx and VOCs. The reactions‘ products nucleate in the ionised environment into new nanometre-scale aerosols, which must also be collected to prevent secondary pollution. Current charging calculations for ultrafine particles are inaccurate, and these inaccuracies compromise ESP design and increase combustion emissions. This work proposes a robust charging model for particles up to 50 nm in corona discharge fields, suitable for practical engineering applications.

ÚVOD

Typický korónový výboj v elektrostatických odlučovačích (EO) ionizuje plyny, čímž se suspendované částice nabíjejí a následně odlučují. Vzhledem k tomu, že nabíjení je základním krokem, je přesné modelování tohoto procesu nezbytné pro správný popis chování částic v poli EO a tvoří základ pro návrh optimální konstrukcí EO.

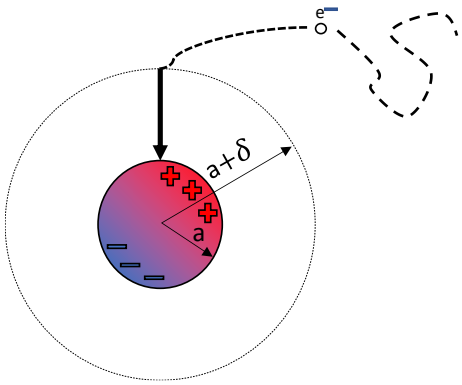
Je známo, že v břitkosti sršících elektrod, elektrické pole generuje netermální plazma, které nevyhnutelně spouští řadu chemických reakcí vedoucích k dekontaminaci NOx volatilných organických látek. Produkty těchto reakcí v ionizovaném prostředí korónového výboje nukleují do nových aerosolů s velikostí v nanometrovém měřítku. Tyto nanočástice představují významný zdroj potenciálního znečištění ovzduší, pokud nejsou efektivně odstraněny. Přesná predikce jejich nabíjení je proto klíčová pro minimalizaci emisí.

Stávající metody výpočtu náboje při elektrostatickém odlučování částic o velikosti pouhých několika desetin nanometrů často poskytují nepřesné výsledky: například metody uvedené v pracích (White, 1951), (Yoo et al., 1997),(Fuchs, 1947) vedou k podhodnoceným hodnotám, zatímco některé metody vyvíjené pro modelování atmosférických aerosolů, například (Fuchs and Sutugin, 1971) vykazují nadhodnocené nabití částic při vysokých koncentracích iontů. Tato mezera může způsobit suboptimální návrh ESP, a – následně – zvýšené emise během provozu spalovacích jednotek (Mukherjee et al., 2024).

Cílem této prací je navrhnout metodu modelovaní nabíjení jemných částic o průměru do50 nm v poli korónového výboje, která bude dostatečně robustní a přesná pro aplikaci v podmínkách běžné inženýrské praxe.

METODIKA

Navržená metoda zohledňuje nabíjení částic po srážkách s chaotický pohybujícími ionty a bere v úvahu obrazové síly (image forces) – vznikající při přiblížení iontu k neutrální částici, kdy je v částici indukován dipólový moment – které vytvářejí přítažný potenciál ovlivňující trajektorii iontu.



Obr. 1: Vznik obrazové síly

Potenciál této sily $\boldsymbol{U_i}$na povrchu částice o poloměru $\boldsymbol{a}$ lze vyjádřit takto (Lushnikov and Kulmala, 2005)

$$U_i(a) = -\frac{(qe)^2}{16\pi\varepsilon_0 a}\frac{\varepsilon-1}{\varepsilon+1} \qquad (1)$$

Kde $\boldsymbol{\varepsilon_0}$- elektricka konstanta, $\boldsymbol{e}$ – náboj elecktronu, $\boldsymbol{\varepsilon}$ - relativní permitivita materialu.

Namísto čistě náhodných Brownových srážek jsou ionty přitahovány k částicím již z větších vzdáleností. Efektivní průřez zachycení iontů částicí se tedy zvyšuje o některou délku $\boldsymbol{\delta}$ (víz Obr.1) a lze jej vyjádřit následovně

$$\sigma_{ef} = \pi a^2\left[1 + \frac{U_i(a)}{k_b T}\right] \qquad (2)$$

Adsorbovaný částici náboj tvoří Coulombovu která odpuzuje ionty stejné polarity. Tento Coulombův potenciál lze vyjádřit takto:

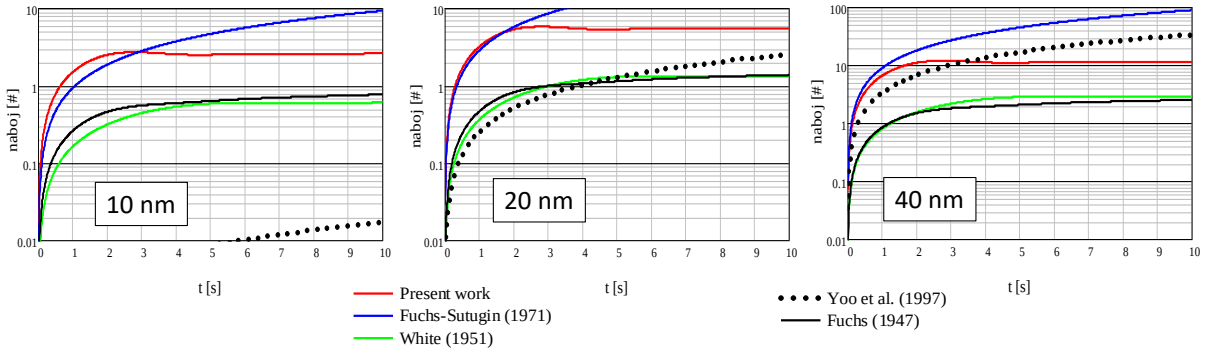
$$U_c(a) = -\frac{(qe)^2}{4\pi\varepsilon_0 a} \qquad (3)$$

Dynamika nabíjení částice muže byt vyjádřena touto rovnicí

$$\frac{dq}{d\tau} = e\sigma_{ef} N_\infty \langle\overline{v}\rangle exp\left[\frac{U_i(a)+U_c(a)}{k_b T}\right] \qquad (4)$$

VÝSLEDKY A DISKUSE

Pro posouzení platnosti metody a porovnání její přesnosti s jinými výše uvedenými metodami byla provedena simulace nabíjení částic v poli koronového výboje s koncentrací iontů přibližně 10^7 iontů/cm^3 a teplotou 100 °C. Dynamika nabíjení po dobu 10 sekund je znázorněna na Obr.2.



Obr. 2: Predikce náboje částic

Metody (White, 1951) a (Yoo et al., 1997), které byly primárně vyvinuty pro větší částice, systematicky podhodnocují náboj u ultrajemných aerosolů. Důvodem je zanedbání obrazových sil, které mají u částic s průměrem pod 50 nm podstatný vliv na efektivní průřez zachycení iontů. Naproti tomu metoda (Fuchs and Sutugin, 1971), ačkoli zahrnuje obrazové síly, byla optimalizována pro atmosférické podmínky s nízkými koncentracemi iontů, což vede k nadhodnocení náboje při vysokých iontových koncentracích typických pro korónový výboj v ESP.

Při koncentraci iontů 10^7 cm^{-3}, která odpovídá reálným podmínkám v elektrostatických odlučovačích, se projevuje důležitá rovnováha mezi obrazovými silami podporujícími zachycení iontů a Coulombovým odpuzováním již nabité částice.

ZÁVĚRY

Navržená metoda kombinuje vliv obrazových sil a Coulombova potenciálu a poskytuje přesnější predikci nabíjení ultrajemných aerosolů než tradiční přístupy používané v oblasti ESP.

Metoda je formulována tak, aby byla použitelná v běžné inženýrské praxi. Vyžaduje pouze základní vstupní parametry (velikost částic, koncentrace iontů, teplota), které jsou v provozu ESP běžně měřitelné nebo odhadnutelné. Výpočetní náročnost je přiměřená pro implementaci do návrhových algoritmů.

Budoucí výzkum by měl zahrnovat experimentální validaci metody v reálných provozních podmínkách ESP a rozšíření modelu o vliv vlhkosti spalin a přítomnosti různých typů iontů vznikajících při koronovém výboji v různých atmosférách spalin.

PODĚKOVÁNÍ

Práce byla realizována v rámci projektu TAČR, programu Životní prostředí pro život, SS07010272, s názvem Výzkum vhodných a nevhodných postupů vytápění pevným palivem.

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POSTERY/POSTERS

BIOACCESSIBILITY OF ELEMENTS AND OXIDATIVE POTENTIAL OF PM1 USING SIMULATED LUNG FLUIDS

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Key words: Atmospheric aerosol, PM1, Simulated lung fluid, Oxidative potential

SUMMARY

Air pollution represents a serious environmental issue with significant impacts on both the environment and human health (Liu et al., 2019). In urban areas, where emissions from traffic, industry, and other anthropogenic activities are more concentrated, aerosols form a complex mixture of solid and liquid particles with potentially harmful effects. Inhaled particles, especially those with smaller aerodynamic diameters, can penetrate deep into the lungs and affect human health depending on their size, chemical composition, and bioavailability (Liu et al., 2021). One of the key parameters that can be used to assess the toxicological impact of aerosol particles is the oxidative potential (OP), which describes the ability of particles to generate reactive oxygen species (ROS) in the body. The OP is often associated with the presence of heavy metals and organic compounds in atmospheric aerosols (Schiavo et al., 2023).

EXPERIMENTAL SETUP

Urban aerosol in the PM1 size fraction was collected using a high-volume aerosol sampler DHA-77 (Digitel, air flow rate 30 m^3/h) onto nitrocellulose membrane filters (diameter 150 mm, pore size 3 μm, Sartorius) over a 48-hour period. During the winter campaign (late February to early March), 7 samples were collected, and the same number was obtained during the summer campaign (August) of 2020.

The collected filters were divided into quarters. One quarter was used for the analysis of total elemental content. The remaining three quarters were subjected to extraction in three types of simulated lung fluids (SLFs) for 24 hours in order to determine the bioaccessibility of particle-bound elements and their oxidative potential (OP).

The OP of PM1 aerosol was assessed using the dithiothreitol (DTT) assay. Filter extracts were incubated with DTT at 37 °C, and the reaction was quenched at defined time intervals. The residual amount of DTT was quantified via reaction with DTNB, forming a

colored product whose concentration was measured by UV–VIS spectrophotometry at 412 nm.

RESULTS AND DISCUSSION

The average mass concentrations of the PM1 fraction were 8.22 ± 1.9 μg/m^3 during the winter campaign and 12.8 ± 3.1 μg/m^3 during the summer campaign.

Urban PM1 aerosol was analyzed for the content of 21 elements (Na, K, Ca, Sr, Ba, Ti, V, Cr, Mo, Mn, Fe, Co, Ni, Cu, Cd, Al, Sn, Pb, As, Sb, Se). In general, the concentrations of elements were lower in winter compared to the summer period.

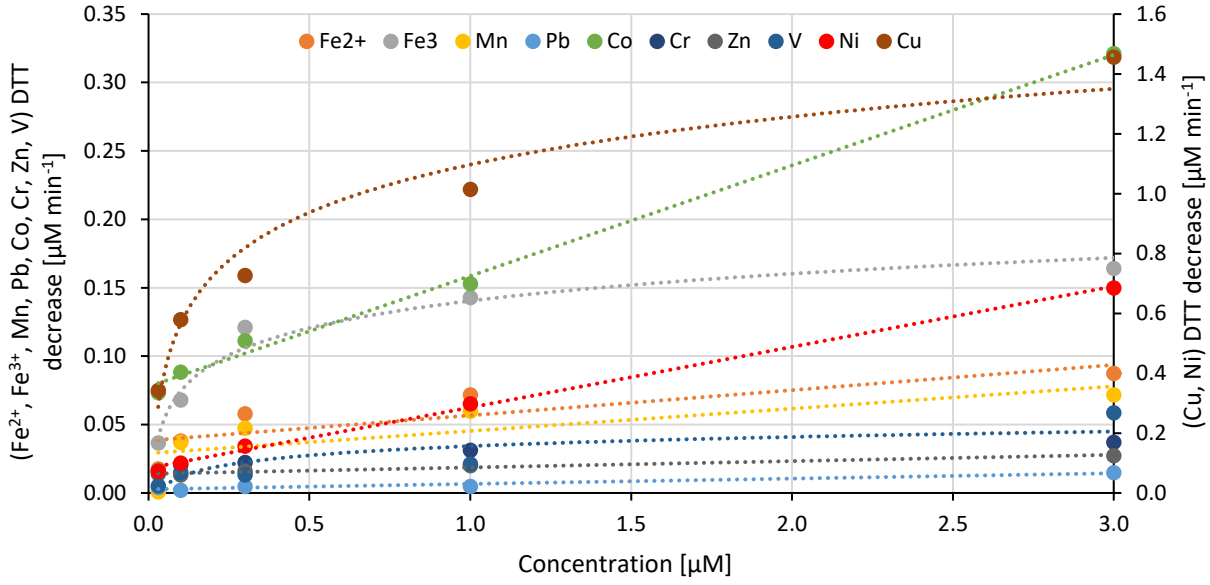

Fig. 1: OP of standards by DTT in Gamble solution

The depletion of DTT in SLFs was measured for standards of 11 elemental cations (Cu^{2+}, Ni^{2+}, Fe^{2+}, Fe^{3+}, Pb^{2+}, Zn^{2+}, Sr^{2+}, V^{4+}, Cr^{3+}, Co^{2+}, Mn^{2+}). More detailed results of the aerosol oxidative potential will be presented at the conference.

ACKNOWLEDGEMENTS

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SUPERLOKALITY DLE SMĚRNICE *2024/2881*

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Klíčová slova: Air Quality, Supersites, New pollutants

SUMMARY

According to the new EU Air Quality Directive 2024/2881, which came into force in December 2024, monitoring Supersites must be prepared in each EU member state. Two supersites will be built in the Czech Republic to fulfil the monitoring requirements (including new pollutants).

ÚVOD

Legislativní omezení směřující ke zlepšení kvality ovzduší jsou v ČR od roku 1990 periodicky vydávány (např. Zákon č. 309/1991 Sb., Zákon č. 201/2012 Sb.) a novelizovány (Zákon č. 172/2018 Sb., Zákon č. 42/2025 Sb.). Platná zákonná opatření jsou v souladu se směrnicí EU 2008/50/ES (aktualizace některých příloh směrnicí 2015/1480). V roce 2024 vstoupila v platnost nová směrnice EU 2024/2881 o kvalitě vnějšího ovzduší a čistším ovzduší pro Evropu. Dle obvyklých pravidel pro implementaci směrnic mají členské státy lhůtu dvou let od účinosti směrnice pro přijetí odpovídajících zákonů a předpisů. ČR není výjimkou, a proto v současné době probíhá intenzivní příprava nového zákona o ochraně ovzduší. Článek 10 Směrnice 2024/2881 nově definuje koncept specializovaných stanic – SUPERLOKALIT.

POŽADAVKY NA MĚŘICÍ PROGRAM

Superlokalitou jsou monitorovací stanice v městské a venkovské pozaďové lokalitě. Jejich počet je podmíněn počtem obyvatel a rozlohou státu. Na každých 10 milionů obyvatel je nutno zřídit jednu městskou superlokalitu. Zřízení jedné venkovské superlokality je podmíněno rozlohou 10 000–100 000 km^2, státy s větší rozlohou musí zřídit jednu venkovskou superlokalitu na 100 000 km^2. Monitorovací supelokality v ČR budou spravovány a provozovány Českým hydrometeorologickým ústavem a to s využitím stávajících stanic Státní sítě imisního monitoringu. Dle požadavků směrnice budou superlokality monitorovat i nové znečišťující látky - ultrajemné částice, černý uhlík, elementární uhlík, amoniak. Příloha VII Směrnice 2024/2881 uvádí seznam požadovaných a doporučených měření. Rozsahem měření na pozaďové venkovské lokalitě z velké části odpovídá současný soubor měření na Národní atmosférické observatoři Košetice. Zejména díky zapojení stanice v programu spolupráce při monitorování a vyhodnocování dálkového přenosu látek znečišťujících ovzduší v Evropě (EMEP) a výzkumné infrastruktury Aerosol, Clouds and Trace Gases Research Infrastructure (ACTRIS). Městskou pozaďovou superlokalitou bude pravděpodobně stanice Ostrava-Poruba, kde bude nutné rozšířit stávající měřicí program pro naplnění zákonných požadavků superlokality (Tabulka 1).

Tab. 1: Přehled povinných měření na superlokalitách v ČR.

Komponent	Městská pozaďová superlokalita	Venkovská pozaďová superlokalita
PM_{10}	✓	✓
$PM_{2,5}$	✓	✓
Těžké kovy (As, Cd, Ni, Pb)	✓	✓
Černý uhlík	✓(N)	✓
Chemické složení $PM_{2,5}$	✓(N)	✓
Velikostní distribuce částic UFP	✓(N)	✓
Počet částic UFP	✓(N)	✓
NO_2 , NO, NO_X	✓	✓
přízemní O_3	✓ (N)	✓
SO2	✓	✓
CO	✓ (N)	✓
Benzen	✓	✓
benzo[a]pyren	✓	✓
NH_3	X	✓ (N)
VOC online	X	✓ (N)
Celková plynná rtuť	X	✓
Celková depozice BaP, PAH	✓ (N)	✓
Celková depozice As, Cd, Ni, Pb	✓ (N)	✓
Depozice Hg	✓ (N)	✓

*(N) nově zavedené měření

PODĚKOVÁNÍ

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LITERATURA

Směrnice Evropského parlamentu a rady (EU) 2024/2881. (2024). https://eur-lex.europa.eu/eli/dir/2024/2881/oj

REAL EMISSIONS FROM THE COMBUSTION OF SOLID FUELS DURING DOMESTIC HEATING

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Keywords: wood combustion, coal combustion, levoglucosan, hopanes

INTRODUCTION

High concentrations of aerosol particles in ambient air negatively affect human health. The harmfulness of aerosols depends largely on where they deposit in the respiratory tract. Coarse particles are mostly trapped in the upper airways, while fine particles (PM2.5) penetrate deeper into the lungs, reaching bronchi and alveoli, where they can cause significant damage (Křůmal et al., 2012).

Combustion processes are one of the main sources of aerosol particles in the atmosphere. A significant example is the use of small combustion devices (SCDs) for household heating in winter. Unlike large industrial plants, SCDs are particularly problematic because their chimneys are low, causing emissions to remain within the breathing zone of residents, and they are typically not equipped with exhaust cleaning technologies. Moreover, they are not subject to the same level of regulatory oversight as large sources of air pollution.

Most emissions from SCDs occur during the heating season, which typically lasts about five months. This means that the contribution of SCDs to local air pollution in winter is considerably higher than the annual average values. Outdated combustion technologies, such as over-fire boilers and boilers with down-draft combustion, are still widely used, particularly in Central and Eastern Europe, leading to substantial emissions of aerosol particles during the heating season. In contrast, modern combustion technologies, such as automatic boilers, produce significantly fewer pollutants. For this reason, there is growing regulatory and social pressure to replace old equipment with cleaner alternatives.

METHODOLOGY

In our previous studies, combustion tests were carried out in an accredited laboratory with standardized procedures (EN 303-5) using different fuels, i.e. hardwood (beech), softwood (spruce), and black and brown coal, under both nominal and reduced output conditions (Křůmal et al., 2019; 2021; 2023). The experiments covered a range of combustion devices, from outdated (over-fire boilers and boilers with down-draft combustion) to modern gasification and automatic boilers.

A follow-up study focused on emissions from real households in both urban and rural areas. These households used different fuels (wood or coal) and a mix of old and modern boilers. Combustion products (TSP fraction) were collected behind the boilers on quartz

filters. The samples were analyzed for organic compounds, including toxic and carcinogenic polycyclic aromatic hydrocarbons (PAHs), as well as specific organic markers such as monosaccharide anhydrides, diterpenoids, and hopanes. These markers are particularly useful for identifying the contribution of SCDs emissions to urban aerosol pollution.

RESULTS AND DISCUSSION

The field study included nine households equipped with different boiler types and fuels: two over-fire boilers (spruce wood), one boiler with down-draft combustion (beech wood), two gasification boilers (beech and spruce wood), and four automatic boilers (wood pellets and brown coal).

The highest particulate matter (TSP) emission factors were found for wood combustion in the oldest over-fire boiler (1,825 mg/kg), whereas the lowest values were obtained for the automatic wood pellet boiler (233 mg/kg). Similar trends were observed for carbon monoxide and organic gaseous compounds emissions, both indicators of incomplete combustion. The highest carbon dioxide emission factors, an indicator of complete combustion, were observed during combustion in automatic boilers, especially when burning brown coal. This is a result of the higher combustion efficiency of modern boiler technologies and also the higher carbon content of brown coal. These findings are consistent with previously published laboratory data (Křůmal et al., 2019; 2021; 2023). Detailed emission factors for individual organic compounds and markers will be presented.

Among organic compounds, emphasis was focused on specific organic markers and characteristic ratios used for source identification of particulate emissions. The levoglucosan/mannosan ratios, which distinguish softwood from hardwood combustion, only partially matched literature values and results from our previous laboratory studies. The homohopane index for brown coal combustion, however, was clearly consistent. In contrast, diagnostic ratios for PAHs differed substantially from literature data. This fact was also observed in our previous laboratory studies.

CONCLUSION

Overall, the most favorable emission profiles were observed for combustion in modern automatic boilers. In addition to quantifying toxic PAHs, the study focused on organic markers that can be used for identification of emission sources of aerosol particles at the monitored sites. However, the calculated marker ratios, used as alternative indicators of emission sources, did not fully correspond to literature values or our previous laboratory findings. Combustion tests were performed in real households that use these boilers for their own heating.

ACKNOWLEDGEMENT

The contribution has been supported by the programme of Regional Cooperation of the Czech Academy of Sciences in 2025-2027 (R200312501); by the Technology Agency of the Czech Republic (project no. SS07010272); and by the Institute of Analytical Chemistry of the Czech Academy of Sciences under an institutional support RVO:68081715.

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CLEANING OF SUBMICRON PARTICLES FROM PAPER USING A COMBINATION OF CO_2 BLASTING AND PLASMA

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Keywords: Submicron particles, CO_2 snow jet, Plasma jet

INTRODUCTION

The aim of this study was to determine if the combination of CO_2 snow particles and plasma is a suitable tool for removing submicron particles from paper. The main requirement was to remove surface contamination without degradation of the material.

METHODOLOGY

The tests were performed using a Particle-Plasma device (CleanLogix), which is based on a patented system of two mutually coordinated jets of low-temperature atmospheric plasma and a CO_2 snow spray (Jackson and Endres, 2016). The streams are mixed immediately before they contact the treated surface (Fig. 1).

Fig. 1: Mixing of the plasma spream and the CO_2 snow spray

RESULTS, DISCUSSION, CONCLUSIONS

The results revealed that, under selected conditions, the cleaning method performed good results, particularly in removing of organic submicron particles. This method therefore has a potential to become an alternative to traditionally used techniques.

ACKNOWLEDGEMENT

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CHOLESTEROL AND CHOLESTERYL ESTERS CHANGES IN THP-1 CELLS AND MICE LUNG TISSUE AFTER EXPOSURE TO PBO NANOPARTICLES

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Keywords: PbO nanoparticles, cholesterol, cholesteryl esters, lungs, THP-1 cells

INTRODUCTION

Exposure to lead oxide nanoparticles (PbO NPs), which are emitted to the environment by high-temperature technological processes, have adverse health effects to human heavily impairing target organs. These nanoparticles pass through the lung barrier and are distributed via the blood into secondary target organs, where they cause numerous pathological alterations (Dumková et al., 2017; Tulinská et al., 2022).

The effect of PbO NPs exposure on the lungs as a primary target organ and on macrophages as specialized cells involved in the innate and adaptive immune response was investigated in detail in this study. Attention was focused on the effect on processes potentially leading to the alteration of metabolism of lipids (especially cholesterol). Cholesterol is an essential compound for normal cell function. Abnormal quantitative or qualitative changes in various forms of cholesterol (free cholesterol, cholesteryl esters or cholesterol bound in lipoproteins) may be useful biomarkers revealing the molecular mechanism of disease.

EXPERIMENTAL SETUP

PbO NPs were generated continuously in situ in a hot wall tube flow reactor using an evaporation–condensation–oxidation technique. Adult female mice (ICR strain) were continuously exposed to PbO NPs (geometric mean diameter 31.1 nm, number concentration 1.64×10^6 particles/cm^3, mass concentration 75.5 μg PbO/m^3) in whole-body inhalation chambers for 11 weeks (24 h/day, 7 days/week). Control animals were exposed to the same air as exposed animals without the addition of NPs. At the end of the exposure period, lungs and other organs were collected for chemical, histological and electron microscopic analyses.

Macrophages of human THP-1 cell lines were exposed to commercial PbO NPs (Nanochemazone; 70 nm diameter, concentration 1 and 5 μg/mL) for 48 h.

Cholesterol and cholesteryl esters were analysed using a UHPLC-ESI-triple quadrupole MS/MS method (Agilent 1290 Infinity II UHPLC System coupled with an electrospray ion source and Agilent 6470 TripleQuadrupole mass spectrometry system).

RESULTS AND DISCUSSION

A significant increase in Pb content in the lungs of mice exposed to PbO NPs was found. The presence of inhaled PbO NPs in lung tissue was confirmed by TEM. Inhalation of PbO NPs revealed chronic inflammation in lung tissue and a significant increase in the

number of total and foam macrophages with numerous cholesterol crystals in lung tissue. Understanding the cellular processes associated with the exposure of cells to PbO NPs could help design new tools involved in enhancing tissue clearance capacity. Consequently, THP-1 cell lines were exposed to PbO NPs. Exposed THP-1 cells showed altered morphology and adhesive behaviour compared to control cells. The comparison of the profile of lipids extracted from the control cell line and cells exposed to elevated concentrations of PbO NPs showed that the levels of most cholesteryl esters (*e.g.* CE 18:1; CE 18:2, CE 22:6, CE 24:5; CE 24:6) were increased after exposure to PbO NPs.

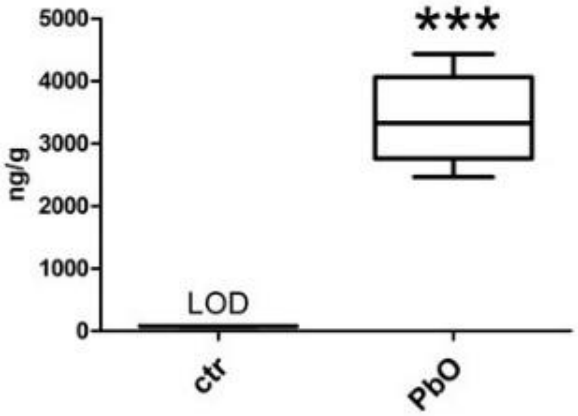

Fig. 1: Pb concentration (ng/g) in mice lungs following 11 weeks of PbO NPs inhalation. The limit of detection of Pb in the lungs is 75 ng/g.

CONCLUSIONS

PbO NPs exposure lead to the accumulation of Pb in the lungs, stimulation of the immune system of exposed mice and caused changes in cholesteryl ester levels in macrophage cells.

ACKNOWLEDGEMENT

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COMPARISON OF AEROSOL CONCENTRATIONS AT TWO NATIONAL MONITORING STATIONS

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Keywords: particulate matter; heavy metals; B-a-P; OC; EC, Košetice; Osieczów

INTRODUCTION

The main aim of atmospheric background monitoring stations is to measure basic pollution levels and track long-term changes in the troposphere (EEA Glossary). Fine dust emitted or formed in the atmosphere can be transported over long distances – hundreds of kilometres from the source of emission (Degórska, Śnieżek, 2012). This study discusses research results on the concentrations of particulate matter and its selected components in two atmospheric background stations situated in Czech Republic (NAOK Košetice) and Poland (DS Osieczów).

The scope and conditions of the observations allowed for the verification of the hypotheses that, with almost identical air mass flow originating (Wd):

1. The concentration levels of elements and compounds related to PM_{10} are identical regardless of the study area;
2. The concentration levels of PM_{10} and $PM_{2.5}$ are identical regardless of the study area.

EXPERIMENTAL SETUP

The analysed results were obtained from: LRI ACTRIS ERIC (NAOK Košetice, meteorological and aerosol data), Chief Inspectorate for Environmental Protection (Osieczów, aerosol data) and Regional Directorate of State Forests in Wrocław (Osieczów, meteorological data). Records from the period between 1 January 2024 and 31 December 2024 were analysed, taking into account data on wind direction and speed, temperature and precipitation, as well as concentrations of PM_{10}, $PM_{2.5}$ and PM_{10}-bound As, Cd, Ni, Pb, B-a-P (Benzo-alpha-Pyrene), OC (Organic Carbon) and EC (Elemental Carbon). NAOK Košetice is in the central Czech Republic (N49°34’24” E15°4’50”, 530 AMSL). DS Osieczów is located almost 200 km north in Lower Silesia in Poland (N51°19’3” E15°25’54”, 177 AMSL).

RESULTS AND CONCLUSIONS

Analysis of the meteorological data showed no significant statistical differences between the two locations for wind direction, precipitation and temperature (p-value from Mann-Whitney test 0.05, 0.16 and 0.06, respectively). There was a significant difference only for wind speed - more than twice as much was recorded in Košetice than in Osieczów. Average mass concentration of PM_{10} and $PM_{2.5}$ in Osieczów and Košetice was almost identical at both sites (median for $PM_{2.5}$ and PM_{10} did not exceed 6% and 1%, respectively). The air quality in terms of aerosol at both sites can be considered very good

(WHO, 2021). The $PM_{2.5}/PM_{10}$ ratio was also lower than in highly urbanised areas (Spandana et al., 2021). For all data it was 0.67 and 0.63 in Košetice and Osieczów, respectively. A higher $PM_{2.5}/PM_{10}$ ratio (>0.75) is mainly associated with primary pollution from anthropogenic activities and the formation of secondary particles that may contain nitrates, sulfates, ammonium, and organic substances (Cabello-Torres et al., 2024). At the same time, in both locations, the ratio is greater than 0.5, which means that natural sources don't dominate, and these anthropogenic influences become important.

Figure 1 presents selected data for sixty days, with almost the exact wind origin at both sites (±5%). The graphical interpretation indicates that the mass concentrations of both PM_{10} and $PM_{2.5}$ were at similar levels. PM_{10}'s median location is practically identical (10.0 Osieczów vs. 10.5 Košetice), while the finer fractions show a greater difference (5.75 Osieczów vs. 6.94 Košetice). For both sites, the $PM_{2.5}/PM_{10}$ ratio decreased slightly to 0.58 O and 0.66 K, confirming the impact of anthropogenic and natural sources.

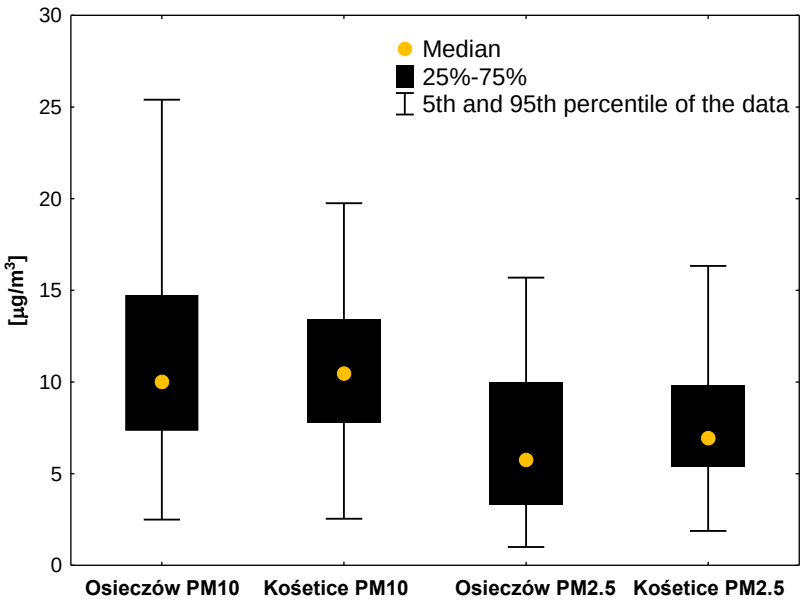

Fig. 1. PM_{10} and $PM_{2.5}$ mass concentrations in Košetice and Osieczów for conditions of almost identical air masses inflow direction.

The analysis showed that the concentration of As, Cd, Ni, Pb and B-a-P in the aerosol fraction under consideration is significantly higher in Osieczów (Figure 2). Of course, the mass concentration of none of the pollutants exceeded the permissible or safe levels for human health (in Poland: As – 6, Cd – 5, Ni – 20, Pb – 500, B-a-P – 1 [ng/m^3]). The observed differences result primarily of emmision characteristics of a given country (here, Poland unfortunately leads Europe in emissions of aersol). Another reason is that the atmospheric background station in Osieczów is located on flat terrain surrounded by forests, which, unlike the topography of Košetice station, hinders the dispersion of pollutants. Higher concentrations in Osieczów may also be influenced by the combustion of fuels for energy purposes in nearby (12 km) ceramic plants in Bolesławiec.

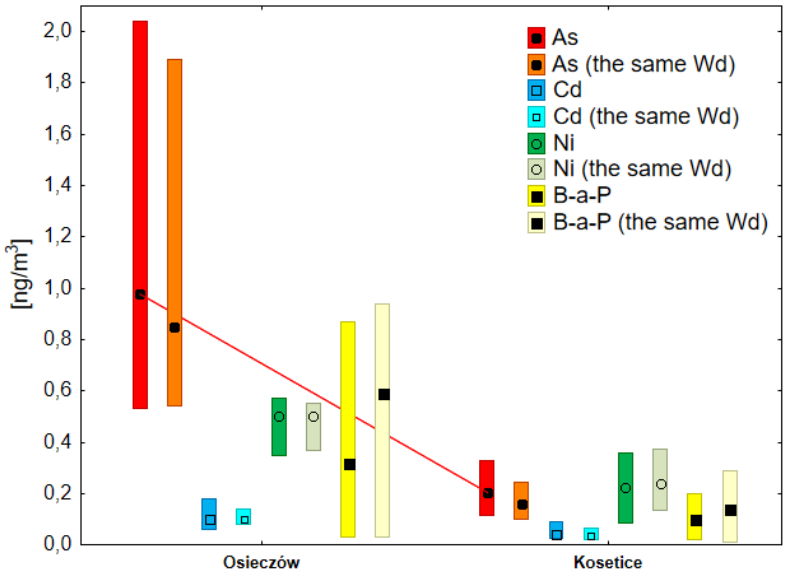

Fig. 2. Collected data of selected elements and B-a-P bound in PM_{10} for both analysed sites.

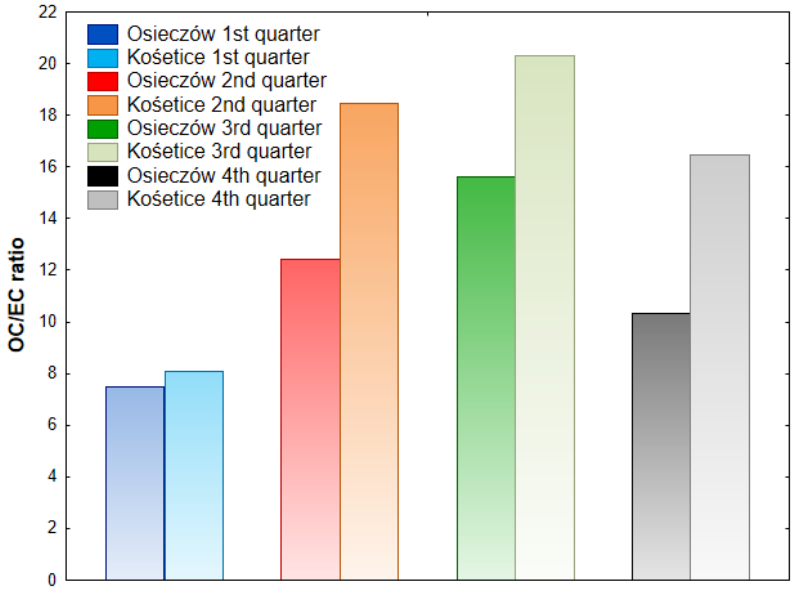

Fig. 3. Quarterly OC/EC ratio for Košetice and Osieczów.

Figure 3 shows quarterly OC/EC ratio for Košetice and Osieczów. It is known that for all sectors except transport, the ratio of elemental carbon emissions to organic carbon emissions is below 1, so it can be concluded that this source is not significantly responsible for pollution in both sites. The graph shows that intensive plant vegetation increases the OC/EC ratio. At the same time, it can be ventured that in the case of Košetice, natural sources are more responsible for the 'pollution profile'.

Table 1. Osieczów-Košetice *p-values* of Mann-Whitney test for all data and records collected during the same wind direction (wd) at both locations. Probability values; significance level □ = 0.05.

	PM_{10}	**$PM_{2.5}$**	**As**	**Cd**	**Ni**	**Pb**	**B-a-P**	**OC**	**EC**
all data	0.20	0.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00
the same wd	0.98	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00
in PM_{10}	**As**	**Cd**	**Ni**	**Pb**	**B-a-P**	**OC**	**EC**		
all data	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
the same wd	0.00	0.00	0.00	0.00	0.01	0.00	0.00		
	As/Cd	**As/Ni**	**As/Pb**	**Cd/Ni**	**Cd/Pb**	**Ni/Pb**			
all data	0.00	0.00	0.04	0.11	0.00	0.00			

The verification of research hypotheses is presented in Table 1. In summary, hypothesis No. 1 was not upheld. Hypothesis 2 can be considered valid only for PM's mass concentration.

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Minister Nauki | Regionalna Inicjatywa Doskonałości | Ministerstwo Nauki i Szkolnictwa Wyższego

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QUALITY ASSURANCE OF MEASUREMENT OF PM_{10} AND $PM_{2,5}$ SUSPENDED PARTICLE FRACTIONS IN OUTDOOR AIR USING PROFICIENCY TESTING

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Keywords: Suspended particles, PM_{10}, $PM_{2,5}$, gravimetry, proficiency testing

INTRODUCTION

Interlaboratory comparative tests have been organized by the air hygiene expert group since 1997. Participation of a workplace in the laboratory proficiency testing program (PT) will allow it to practically demonstrate the quality of its work, at the same time it serves to reveal a possible source of errors in the analytical procedures used and, with properly functioning feedback, will subsequently enable improvement of the quality of work.

In 2001, a joint workplace was created at the NIPH, which provides PT in the field of water and air analysis. This Expert Group for Proficiency Testing (ESPT) was accredited by the ČIA in 2002 according to ČSN EN ISO/IEC 17025 (ČSN EN ISO/IEC 17025, 2001) as the first "Accredited Organizer of Proficiency Testing Programs No. 7001" in the Czech Republic.

In 2023 were organized by NIPH two PTs focused on measuring defined fractions of suspended particles PM_{10} and $PM_{2.5}$, namely PT#O/8/2023 and PT#O/9/2023. Both programs were organized and evaluated in accordance with the ČSN EN ISO/IEC 17043 (ČSN EN ISO/IEC 17043, 2010). The results were also evaluated according to the ČSN ISO 5725-2 (ČSN ISO 5725-2, 2018).

METHODOLOGY

PT#O/9/2023 included taking a sample of outdoor air and determining the mass concentration of suspended particles of the PM_{10} fraction and the $PM_{2,5}$ fraction. Its aim was to verify the accuracy of the sample collection and gravimetric determination procedures.

The PT#O/9/2023 program included two independent 12-hour outdoor air samplings. Each participant randomly selected the location of the sampling system or systems in a prepared 6 * 6 meter field, where each sampling system was allocated a field of size 1 m^2. The collection systems that could not be released from the mobile systems were placed on the edge of this field.

The reference value was evaluated using the Horn's procedure (Meloun, 1994). This allows evaluation for the number of participants even in the range n < 20. The method consists in determining the so-called pivots - values determined by the depth of the pivots, which depends on the size of the set.

Horn's procedure:

1. The elements are sorted from smallest to largest. For n values, the pivot depth is calculated using the formula:

$$H = int\frac{(n+1)/2}{2}\ (n \text{ is odd}) \qquad \text{and} \qquad H = int\frac{\frac{n+1}{2}+1}{2}\ (n \text{ is even}) \qquad (1)$$

2. Select the lower - "X_{Low}" and upper pivot „X_{Upp}“
$$X_{Low} = X_H \quad X_{Upp} = X_{(n+1-H)}$$
3. The pivot half-sum is determined
$$P_L = \frac{X_{Low} + X_{Upp}}{2}$$
4. The pivot range is determined:
$$R_L = X_{Upp} - X_{Low}$$
5. The relative uncertainty of the data set is determined:
$$U_A = \frac{P_L * T_{L1-\alpha_1 n}}{P_L}$$
6. Determination of the probability interval of the correct value:
$$X = (P_L \pm u_A)$$

The reference value is determined by Horn's pivot half-sum (P_L) from the set of measured values, and the standard deviation of the data set corresponds to Horn's relative uncertainty value of the set (u_A).

Success criteria for PT#O/9/2023

The success criterion for the test was the ratio of the measured value to the reference value, expressed as a percentage. The permissible error was based on the sensitivity of the method and was as follows for the measured mass concentration:

Tab. 1: Succes criteria for PT#O/9/2023

Value	Error
Up to 10 µg/m^3	< ± 50 %
10 – 20 µg/m^3	< ± 25 %
Over 20 µg/m^3	< ± 10 %

The criterion for non-evaluation was wind speeds above 10 m/s.

PT#O/8/2023 included, among other parameters, the determination of suspended particles of the PM_{10} and $PM_{2.5}$ fractions in outdoor air using automated measuring systems. Its aim was to cover the basic spectrum of methods used in automated measuring systems, methods using the principles of direct analysis after sampling for continuous measurement (procedures – β-absorption, optical methods and microbalances).

In the form of a 12-hour comparison of real ambient air, 30-minute simultaneously measured concentrations of suspended particles of the PM_{10}/$PM_{2.5}$ fraction were compared with calculated 30-minute reference values.

The reference value was evaluated using Horn's procedure (see above).

Success criteria for PT#O/8/2023

Given that the test combines different measurement methods, the success criterion in the PT is the average value of the ratio of the measured and reference values expressed as a percentage of the reference value.

Value	Error
Up to 10 µg/m³	≤ 100 %
10 – 20 µg/m³	≤ 75 %
20 – 50 µg/m³	< ± 25 %
Over 50 µg/m³	< ± 10 %

RESULTS

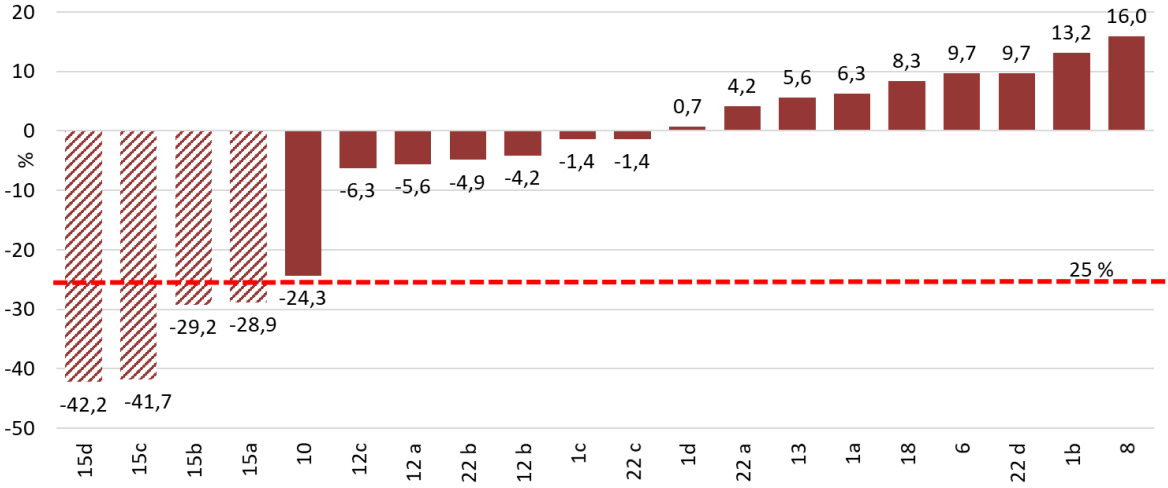

Fig. 1: Gravimetry of PM_{10} fraction – measured values as a percentage of the reference value

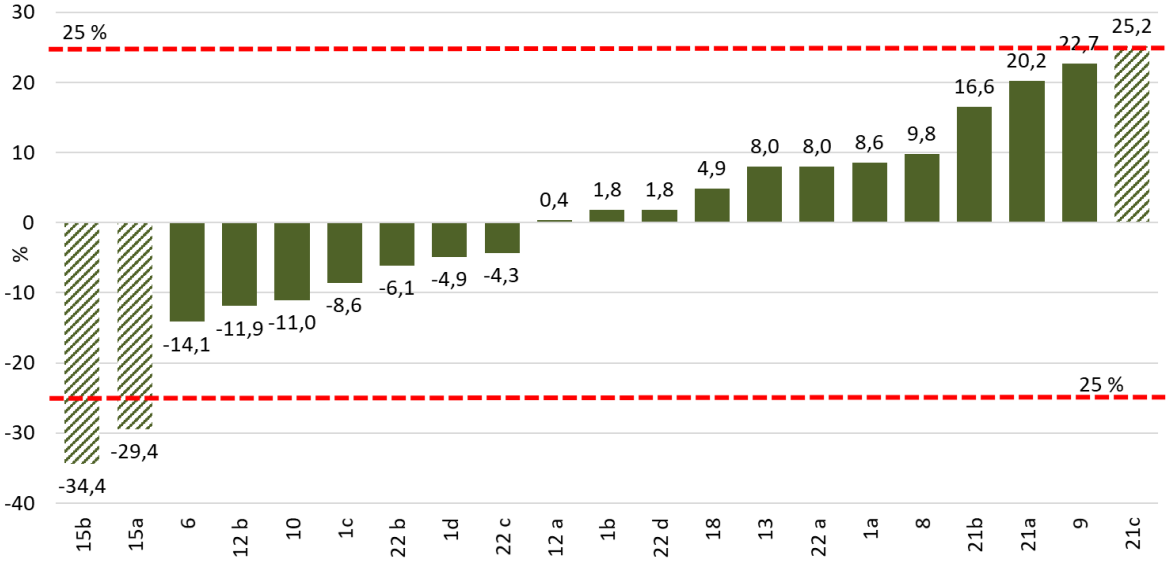

Fig. 2: Gravimetry of $PM_{2,5}$ fraction – measured values as a percentage of the reference value

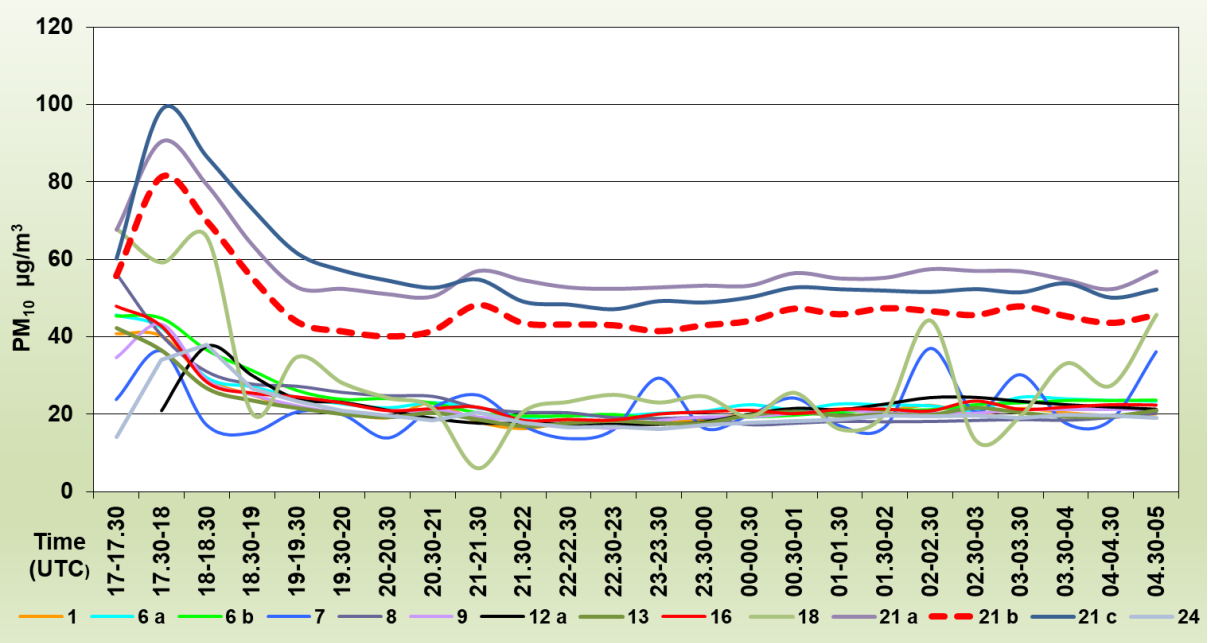

Fig. 3: 30 – minute values of suspended particles of the fraction PM_{10}

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WINTER AIR POLLUTION AT A RURAL BACKGROUND SITE SITUATED IN THE LIGNITE BASIN AREA IN THE VICINITY OF TUŠIMICE POWERPLANT

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Keywords: Speciated PM_{10}, Reactive trace gases, High-time resolution, Temporal and spatial variability, Vertical measurement, Mixing layer height

INTRODUCTION

Rural background sites, representative of a wider area, are important for investigating the influence of regional and long-range transport, and long-term trends in PM concentrations (Putaud et al., 2010). However, during periods with a shallow atmospheric boundary layer, even rural background sites are significantly affected by local sources on the ground. Therefore, data measured at the ground may, in certain situations, not be representative of the wider area. For these reasons, measurements at higher elevations above ground are needed to assess the representativeness of conventional ground-based measurements to distinguish the air pollution origin. The presented study aims to examine and describe the temporal and spatial variations of speciated PM_{10} and reactive trace gases, and their origin, at a rural background situated in the lignite basin area.

METHODS

The campaign was conducted at the meteorological observatory Tušimice (50°35'N, 13°39'E; altitude 322 m), a rural background site, from 20th January to 20th March 2025. PM_{10} elemental composition was measured at the ground (4 m above ground) every 4 h by the Xact625i (13 tracers; Cooper Environmental Services, USA), an online ED-XRF ambient metals monitor. Also, 1 h PM_{10} mass concentrations (Environnement SA, MP101M) along with gas concentrations (SO_2, NO_x, O_3) were recorded at the ground. Additionally, wind speed (WS) and direction (WD) by a 3D and 2D anemometer (10 min; uSonic-3/2, Metek) in four heights (in 10 m, 20 m, 40 m, and 80m) and by a SODAR (Doppler-SODAR-PCS.2000-64, Metek) from 40 m to 600 m, along with other meteorological parameters, were recorded. Finally, the mixing layer height (MLH) by a ceilometer (1 h; CL31, Vaisala) was measured.

The statistical data treatment was performed using R, version 4.5.1 (R Core Team, 2019) with the Openair package (Carslaw and Ropkins, 2012).

RESULTS AND DISCUSSION

The campaign was characterized by an average PM_{10} concentration of 32.8 ± 21.5 μg/m^3, prevailing W-SW-SE wind of average low wind speed (WS < 2 m/s), average temperature of 1.4 ± 5.1 °C and negligible precipitation.

The spatial variation analysis (polarPlots and CPF plots at 75th and 90th percentile) of PM_{10}, PM_{10} elements, and gases indicates slight differences between the methods (polarPlot vs CPF plot) and distinct differences between the heights not only for 10 and 80 m, but also for 10 and 20 m. The biggest result differences of spatial distribution at four heights were for PM_{10}, SO_2, K, Fe, Zn, As, and, in contrast to NO_x, S, Cu, and Se (Fig. 1).

Inversions lasting several hours to days with different starting and ending times of the day were selected in two steps: first, PM_{10} > 29.0 μg/m^3 (campaign median) and second, MLH to 600 m (SODAR upper range). Finally, the data set was divided into "below" and "above" MLH subsets. During the two longest inversions lasting days (18.2.25 20:00 – 21.2.25 10:00 and 5.3.25 17:00 – 7.3:25 14:00), the MLH median was 230/425 m and PM_{10} was 62.0/48.1 μg/m^3, respectively. A similar concentration pattern is expected for PM_{10} elements as well as for reactive trace gases. Inversions duration, MLH and prevailing wind WSWD mainly influenced the pollution origin within the periods of inversion conditions.

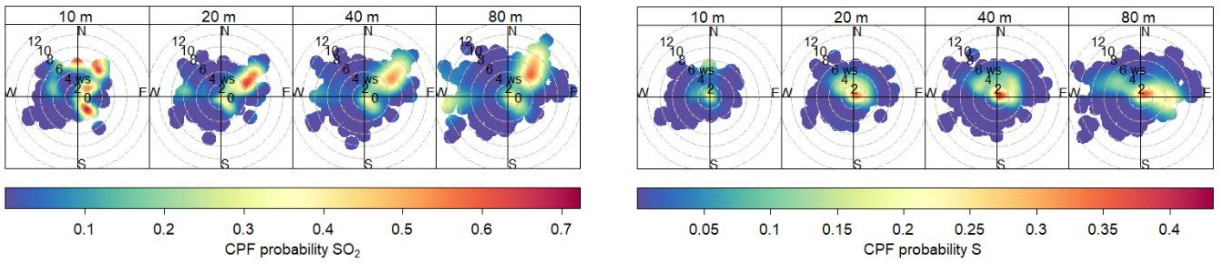

Figure 1: Temporal variation of SO_2 and S concentration using ground-based data and wind measurement at tower (CPF plot at 75th pctl., SO_2 = 5.3 μg/m^3 and S = 1.6 μg/m^3).

CONCLUSIONS

The spatial analysis revealed differences not only in applied methods, an expected result, however also within the heights in the range 10 to 80 m. The inversions of different characteristics (MLH and duration) significantly influenced the temporal variation and origin, local vs. regional, of PM_{10}, PM_{10} elements, and reactive trace gases concentrations. Further, more complex data analysis is needed to fully assess the influence of meteorological parameters on air pollution and its origin at the Tušimice observatory.

ACKNOWLEDGEMENT

The work was financially supported by TA CR within the project „ Air Quality Research Assessment and Monitoring Integrated System", project number SS02030031.

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RECETOX, ACTRIS_CZ RESEARCH INFRASTRUCTURES

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Keywords: research infrastructure, ACTRIS CZ, RECETOX RI, monitoring, GENASIS database, open-access

INTRODUCTION

ACTRIS-ERIC is a European research infrastructure dedicated to observing and analysing aerosols, clouds, and trace gases better to understand their role in climate and air quality. The Czech node, ACTRIS-CZ, is a national consortium comprising Masaryk University (RECETOX), the Czech Hydrometeorological Institute, the Institute of Chemical Process Fundamentals, and the Global Change Research Institute of the Czech Academy of Sciences. RECETOX/ Masaryk University contributes with its advanced laboratory capacities and expertise in organic pollutants and toxic metals, supporting long-term atmospheric monitoring at the National Atmospheric Observatory in Košetice. Through ACTRIS-CZ, RECETOX actively participates in European-scale interdisciplinary research, fostering integration within ACTRIS-ERIC and advancing knowledge on environmental exposures and their health and climate impacts.

RECETOX provides comprehensive **sampling and monitoring of persistent organic pollutants** (POPs) to support international environmental agreements such as **CLRTAP and the Stockholm Convention**. At the National Atmospheric Observatory Košetice—part of the **EMEP network** as a Central European background station—RECETOX delivers high-quality data on POPs in ambient air and atmospheric deposition. Monitoring includes both active and passive sampling through international programs such as **MONET and GAPS**. Integrated environmental assessments cover multiple matrices including air, deposition, water, soil, sediments, enabling in-depth studies of pollutant fate, transport, and removal processes. These efforts are supported by the accredited RECETOX Trace Analytical Laboratory and the **GENASIS database** (www.genasis.muni.cz), which provides open access to curated environmental data for the scientific community.

Monitoring activities and GENASIS database:

The GENASIS database is a comprehensive data repository developed and maintained by RECETOX, offering environmental data collected through long-term monitoring programs. It integrates high-quality datasets from the MONET (Monitoring of Environmental Toxicants) program and the National Atmospheric Observatory in Košetice, which provides continuous measurements of persistent organic pollutants (POPs), toxic metals, and atmospheric contaminants. GENASIS enables researchers to access harmonized, validated data essential for environmental, exposome and environmental health studies. The database supports open access principles, facilitating collaboration and data sharing among national and international partners.

- Data collection and harmonization
- Data hosting and visualization

- Data integration and analysis
- Transport, fate, pharmacokinetic modelling
- Services to UNEP, WHO, government and authorities

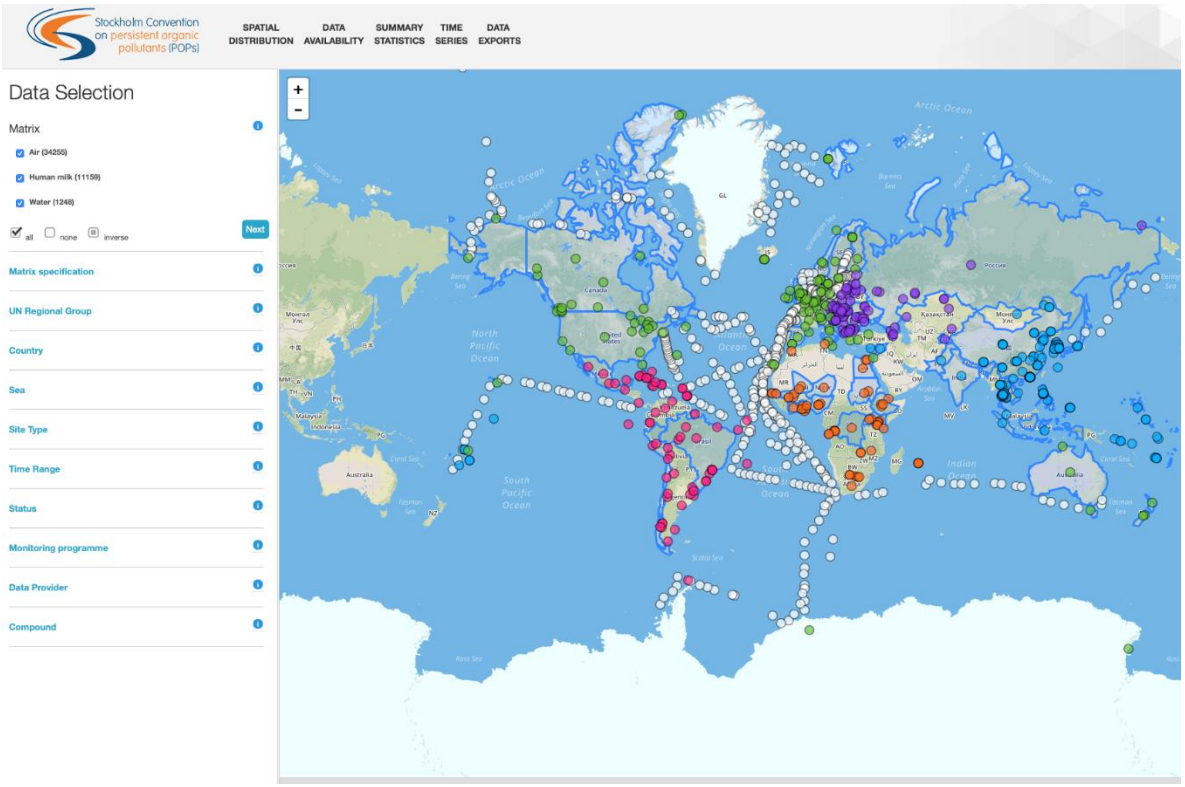

Fig. 1: Example view of the GENASIS online portal, illustrating the user interface

The **sampling services** focused on organic pollutant measurements in air (particles and air fractions) with the following instrumental techniques:

- **Active air samplers** Low/High volumes including particles (PM distribution since 0.5 µm – 10 µm), cascades impactors
- **Multi-directional active air samplers**; Sampling media – compounds dependent: PUF, XAD, or sandwich (PUF/XAD/PUF) according to the compounds of interests
- **Passive air samplers** based on the polyurethane foam disk
- **Biota sampling** like the Bio-passive air samplers – tree needles and moos
- Dry and wet **deposition samplers**

Preparation of a sampling plan and design of the ideal sampling technique according to the customer's needs are a matter of course.

List of analysis available for the air matrices:
Organic pollutants:

- Polychlorinated dibenzo-p-dioxins/furans (PCDDs/Fs)
- Polychlorinated biphenyls (PCBs) – indicator and dioxin-like
- Brominated and organophosphorus flame retardants
- Organochlorine, cyclodiene, and polar pesticides
- Polycyclic aromatic hydrocarbons (PAHs), NOx-, and oxy-PAHs, hopanes
- Perfluorinated compounds (PFAS)

Trace elements, heavy metals, carbon analysis

List of analysis the instruments available:

- Gaseous chromatography connected to mass spectrometric detectors: GC-MS, GC-MS/MS, GC-HRMS, GC-APCI-MS/MS
- Liquid chromatography connected to mass spectrometric detectors: LC-MS/MS
- Inductively coupled plasma coupled with mass spectrometric detection: ICP-MS, ICP-MS/MS
- Single-purpose mercury analyzer
- Carbon analysis: EC/OC

Sampling and training activities – in the Czech Republic or abroad according to customer needs (long term experiences from the Central and Eastern region CEE)

Technology transfer and Capacity building under Stockholm convention not only for CEE region

Services support offered to the projects: ACTRIS, ATMO-ACCESS, IRISCC, EIRENE

Access to ACTRIS-CZ

ACTRIS-CZ offers an Open Access scheme enabling users to engage with its infrastructure via physical, virtual, or remote access modes. Physical access allows users to conduct projects or training directly at the National Atmospheric Observatory in Košetice, following approval by the ACTRIS-CZ expert council. Virtual access provides remote retrieval of data generated at ACTRIS-CZ monitoring sites. Remote access permits the use of ACTRIS-CZ facilities for field measurements, with users responsible for transporting equipment. Additionally, instrument calibration services are available through the Prague Aerosol Calibration Center (PACC).

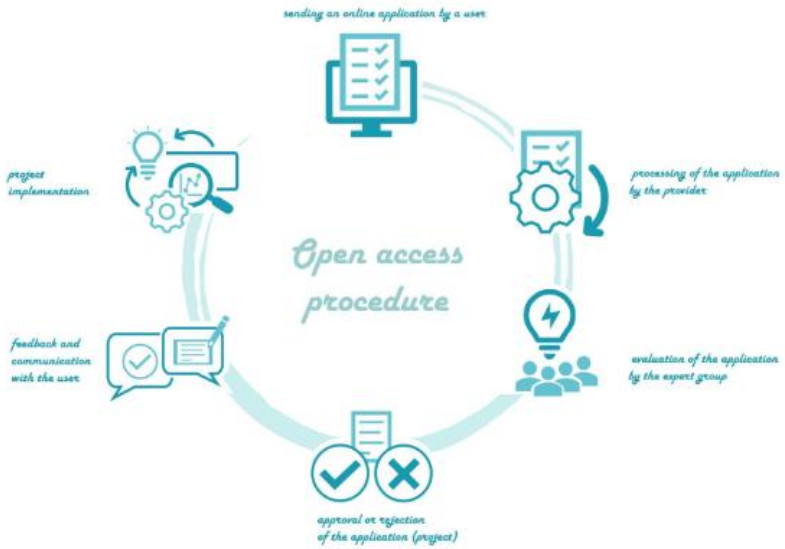

Fig. 2: Overview of the open access workflow

ACKNOWLEDGEMENT

This work is part of a project supported by the European Commission under the Horizon 2020 Research and Innovation Framework Programme, through the ATMO-ACCESS Integrating Activity (grant agreement No 101008004). The work was carried out with the support of the core facilities of the RECETOX Research Infrastructure (project No LM2023069) and ACTRIS-CZ (project No LM2023030), both funded by the Ministry of Education, Youth and Sports of the Czech Republic under the programme "Projects of major infrastructures for research, development and innovations".

RECETOX RESEARCH INFRASTRUCTURE SERVICES OFFER – CORE FACILITY OF THE CENTRAL LABORATORIES

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Keywords: research infrastructure, core facility, open-access, central laboratories, services, training

INTRODUCTION

The **RECETOX Research Infrastructure** is a leading European research infrastructure focused on understanding the complex interactions between environmental exposures, particularly to persistent organic pollutants (POPs), and human health. Its mission is to build a sustainable platform that integrates cutting-edge technologies and interdisciplinary expertise to advance exposome research. Key components include CELSPAC Population Studies, central RECETOX laboratories, and data services, each subdivided into specialized units.

RECETOX RI collaborates with other national and European research infrastructures across environmental, health, and social science domains. As a key partner in ACTRIS-CZ and ICOS-CZ, RECETOX contributes analytical expertise and long-term POPs monitoring to atmospheric research at the Košetice Observatory. RECETOX integrates into BBMRI-CZ and co-leads data management efforts within the H2020 EHEN cluster through its biobanking infrastructure. Strategic cooperation with the Czech e-Infrastructure and ELIXIR enables the development of bioinformatics pipelines and data integration tools, deployed via Galaxy and supported by EBI/EMBL. Additionally, RECETOX partners with SHARE-ERIC, contributing biomarker data and expertise to pan-European ageing and health studies.

RECETOX RI coordinates **EIRENE**, a new ESFRI research infrastructure dedicated to comprehensive environmental exposure assessment within exposome research. EIRENE brings together over 50 institutions from 19 EU countries and affiliated UK and US hubs, aiming to understand the interplay between environmental, lifestyle, and social factors in chronic disease development. EIRENE emphasises strategic interdisciplinarity and forms synergies with other RIs such as BBMRI-ERIC, ACTRIS-ERIC, and SHARE-ERIC.

User Access and Capacity Utilisation at RECETOX RI – RECETOX RI provides a variety of services across multiple access modes—physical, remote, and virtual—under a transparent and merit-based open-access policy. Users include academic researchers, public authorities, private sector clients, and educational participants. Access is offered to laboratories, datasets, biobank samples, and analytical expertise.

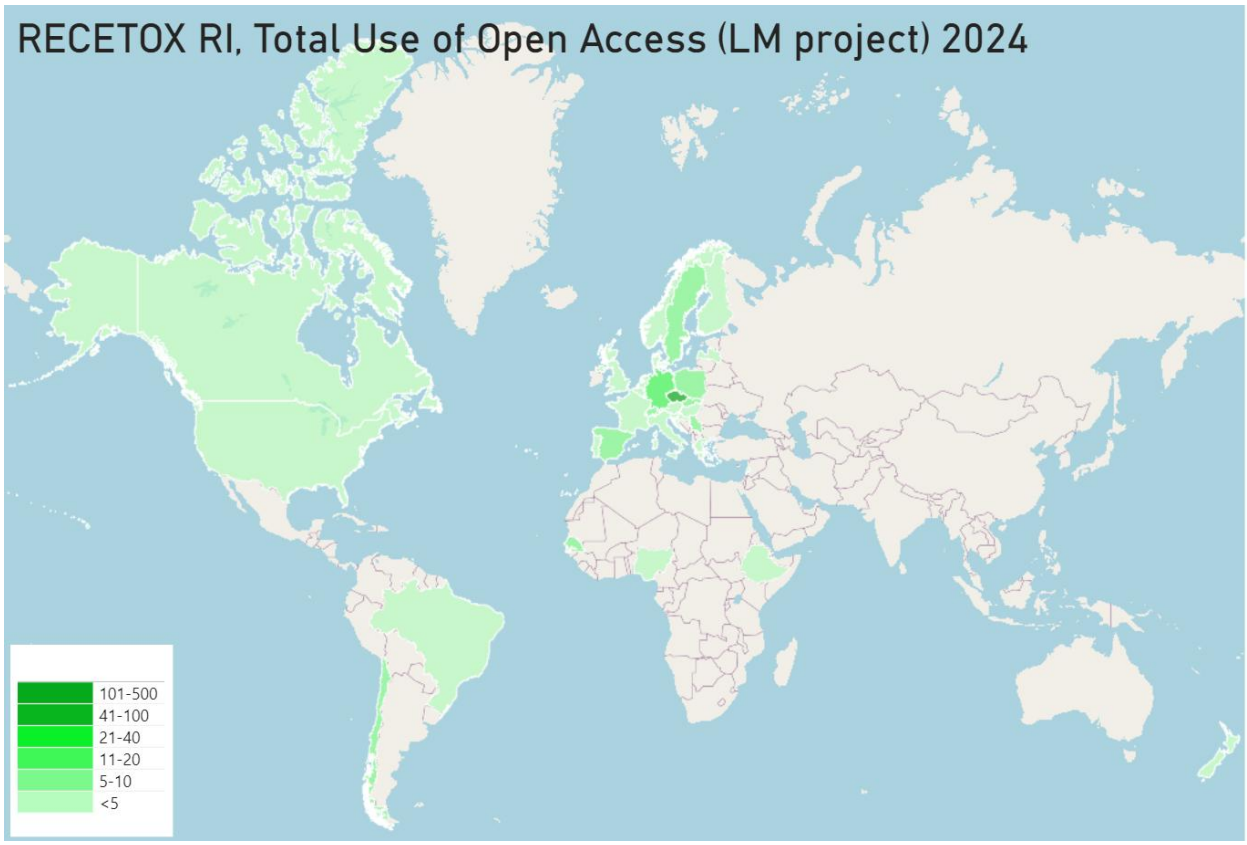

Fig. 1: Open Access Activity at RECETOX RI (LM Project 2024)

Transparent Open-Access System and User Support at RECETOX RI – RECETOX RI operates a centralized open-access system with a two-stage evaluation process that ensures both technical feasibility and scientific excellence of submitted proposals. A newly implemented online platform enables efficient application management and provides detailed project support throughout the entire access lifecycle. Successful applicants receive assistance from dedicated technical staff and local supervisors during project implementation. All outcomes are closely monitored, and mandatory user feedback is collected via structured questionnaires.

Fig. 2: Application Process Step-by-Step

RECETOX provides access to its core facility Central laboratories also through **European Transnational Access** schemes such as IRISCC and ATMO ACCESS. These initiatives enable European researchers to benefit from state-of-the-art analytical instrumentation and expert support for environmental, atmospheric, and human

contaminant analysis and provide the strategic use of their capacities in addressing current environmental and health challenges.

Central Laboratories of the Research Infrastructure (consist of three main facilities)

Trace Analytical Laboratory (TAL) accredited under **ISO/IEC 17025:2018** offers the complete analytical services: the sampling of environmental matrices, the analytical method development across various domains upon customer request, the sample preparation and analysis, techniques for analysing pollutants in environmental and human matrices including quality control, organizing short and long term monitoring studies.

Organic pollutants:

- Polychlorinated dibenzo-p-dioxins/furans (PCDDs/Fs)
- Polychlorinated biphenyls (PCBs) – indicator and dioxin-like
- Brominated and organophosphorus flame retardants
- Organochlorine, cyclodiene, and polar pesticides
- Polycyclic aromatic hydrocarbons (PAHs), NOx-, and oxy-PAHs, hopanes
- Perfluorinated compounds (PFAS)
- Bisphenols
- Plasticizers
- Thyroid hormones
- UV filters – benzophenone
- Mycotoxins

Metabolites:

- OH-PAHs
- Phthalates metabolites + DINCH
- Pesticides metabolites

Trace elements, heavy metals, and species

Microbiome laboratory provides the bacterial and mycobial profiles in various samples using the 16S rRNA gene and ITS gene sequencing. It also performs whole metagenome sekvenci, in which all DNA in the sample is sequenced.

The biomarker analysis laboratory focuses on methods of targeted and non-targeted analyses of biologically important molecules (metabolites, proteins, lipids) as potential biomarkers of effects associated with chemical exposure.

The Atmospheric and Environmental Research Infrastructure Online Training, held from 6 to 10 November 2023 as part of the ATMO-ACCESS project, focused on strengthening atmospheric and environmental research expertise. The **course was organised by the National Atmospheric Observatory Košetice (NAOK) together with RECETOX, Masaryk University**, and was aimed at early-career researchers, advanced students, and technical staff. It addressed key topics including the operation of major research infrastructures such as ACTRIS and ICOS, atmospheric components (aerosols, trace gases, clouds), greenhouse gas fluxes, persistent organic pollutants (POPs), and remote sensing applications. Participants were also introduced to the roles and services of research infrastructures in which NAOK is actively involved, namely ACTRIS, ICOS, and EIRENE.

The training was delivered online using a flexible format that combined expert lectures, video demonstrations, case studies, and interactive quizzes. Its interdisciplinary approach connected atmospheric sciences with environmental chemistry and ecosystem research, highlighting the importance of integrated solutions for environmental challenges. The course attracted 137 participants from 39 countries, with 84 % attending for the first time. Gender representation was balanced (52 % male, 48 % female), and the participants mainly included postgraduate students (69), engineers and technicians (23), and expert scientists (15), demonstrating broad interest across different career stages and expertise levels.

ACKNOWLEDGEMENT

This work is part of a project supported by the European Commission under the Horizon 2020 Research and Innovation Framework Programme, through the ATMO-ACCESS Integrating Activity (grant agreement No 101008004) and was carried out with the support of the RECETOX Research Infrastructure (project No LM2023069) and ACTRIS-CZ (project No LM2023030), both funded by the Ministry of Education, Youth and Sports of the Czech Republic under the programme “Projects of major infrastructures for research, development and innovations”.

PROGRESS AT THE ACTRIS STATION MILEŠOVKA

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Keywords: Low-level clouds, Atmospheric aerosols, In-situ measurements, Observatory Milešovka, ACTRIS

INTRODUCTION

Observatory Milešovka (837 m a.s.l.), operated by the Institute of Atmospheric Physics of the Czech Academy of Sciences, is joining ACTRIS (Aerosol, Clouds and Trace gases Research InfraStructure), specifically its topical section Cloud In Situ (CIS) Measurements (Sedlák and Pešice, 2024). Related adaptations at Milešovka, a new instrument and open access activities will be presented.

CURRENT PROGRESS

When the new roof covering of the observatory building was finished in early summer 2025, adaptations followed to make the installation of measuring instruments on the roof easier. Then we fixed our Particulate Volume Monitor PVM-100 in the selected permanent position for measurement of the liquid water content and the effective radius of cloud droplets within ACTRIS.

We purchased the PINE (Bilfinger, Germany) instrument for automatic measurement of the ice nucleating particles. To test the instrument in accordance with our plan, PINE began its operation at the National Atmospheric Observatory Košetice (NAOK, Fig. 1). PINE should be moved to Milešovka next year, and start regular measurements for ACTRIS there. We will have new carriages for our cableway made, which will enable us to transport bulky objects to the station.

Fig. 1: PINE instrument in the ICPF container at NAOK, June 2025.

OPEN ACCESS TO MILEŠOVKA

We offer an open access to Milešovka facilities. An example is the joint CIS measurement campaign at the station in the period end of October 2024 – early March 2025. Three instruments measuring the cloud droplet size distribution were brought from the Finnish Meteorological Institute (FMI) and from ICPF (see Zíková *et al*., 2025, in these Proceedings).

Within the second FMI open access initiative, one of the instruments mentioned above, namely the probe AQT530 from Vaisala, was installed at Milešovka in May 2025 for all year round measurements (Fig. 2).

We look forward to receiving proposals for open access activities at Milešovka from next potential users.

Fig. 2: Instrument AQT530 from Vaisala on the tower top of Milešovka observatory.

ACKNOWLEDGEMENT

This work was supported by the MEYS of the Czech Republic (project ACTRIS-CZ, code LM2023030).

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ROZDÍLY VE SLOŽENÍ ATMOSFÉRICKÉHO AEROSOLU NR-PM1 V RŮZNÝCH VÝŠKÁCH

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Klíčová slova: Měření na stožárech, NR-PM$_1$, Chemické složení, AMS.

SUMMARY

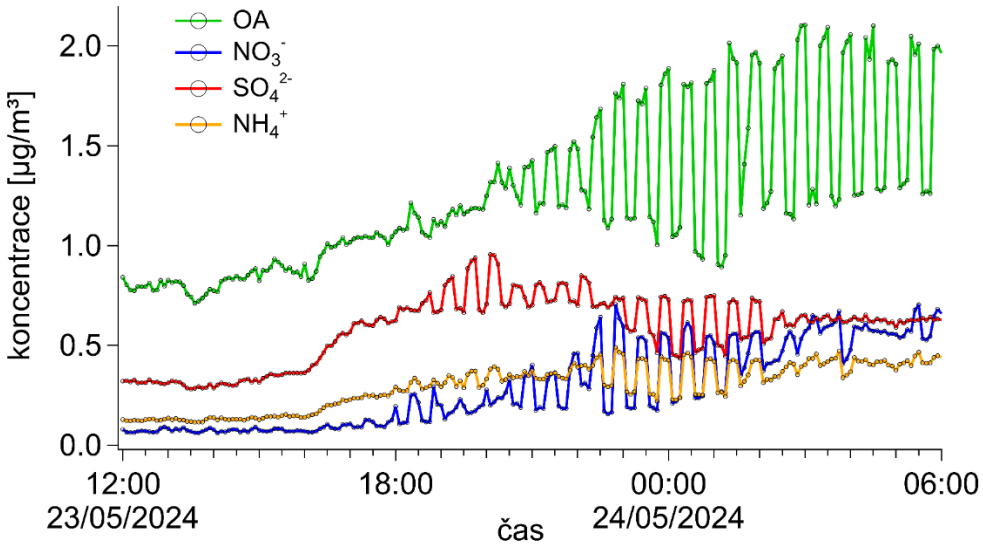
Vertical variations in the composition of atmospheric aerosol NR-PM1 were studied and significant differences were found especially at night, when atmospheric mixing is often limited. Each major NR-PM1 component studied (Organics, sulphates, nitrates, ammonium) had a different behavior, with organics showing the highest differences at night.

ÚVOD

Atmosférické aerosoly se většinou měří několik metrů nad zemí. Měření ve větších výškách jsou obvykle buď krátkodobá s využitím různých typů letů, nebo dlouhodobá s využitím dálkového průzkumu Země, který nemůže přímo posoudit chemické složení aerosolů. K překonání tohoto nedostatku znalostí lze použít měření na stožárech. My jsme využili 250 m vysoký stožár na Národní atmosférické observatoři Košetice (NAOK) v České republice.

METODY

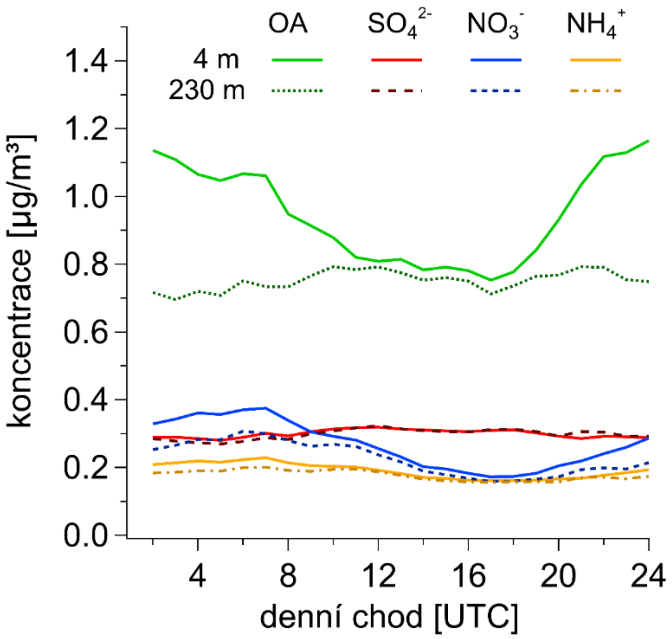
Chemické složení NR-PM1 bylo měřeno pomocí kompaktního aerosolového hmotnostního spektrometru s ToF detektorem (C-ToF AMS, Drewnick a kol. 2005). Pro měření ve výšce 4 m a 230 m nad zemí při použití jen jednoho přístroje byl v měřícím kontejneru instalován přepínací ventil, takže tři po sobě jdoucí vzorky byly odebrány z inletu ve výšce 4 m a tři vzorky z druhého inletu ve výšce 230 m. Vzorek byl do přístroje dopraven 230 m dlouhou trubkou. Příklad časové řady získané tímto přístupem je znázorněn na obr. 1. Toto měření bylo doplněno několika dalšími přístroji, včetně aethalometru AE33, který poskytuje koncentraci ekvivalentního černého uhlíku (eBC), nejdůležitější nevypařitelné složky PM1.



Obr. 1. Příklad časových řad hlavních chemických látek NR-PM1 (nekorigovaných pomocí CE) měřených s C-ToF AMS s použitím přepínacího ventilu. Vyšší koncentrace se obvykle nacházejí v blízkosti země.

VÝSLEDKY

Obecně platí, že rozdíly v koncentracích atmosférického aerosolu po výšce silně závisí na vertikálním promíchávání. Při nedostatečném promíchávání se ale mění nejen koncentrace ale i chemické složení, jak je vidět již na Obr. 1, zejména brzy ráno 24. 5. 2024. Tyto změny jsou zapříčiněny především polohou zdrojů jednotlivých sloučenin, ale také rozdíly v chemické termodynamice v různých výškách, které mohou způsobovat změny ve složení aerosolu. To platí zejména pro dusičnan amonný kvůli jeho tepelné nestabilitě, která může být ovlivněna i různou relativní vlhkostí. Ačkoli časové řady kratší než 24 hodin zobrazené na Obr. 1 nereprezentují delší období, ve skutečnosti se dobře shodují s průměrným denním průběhem všech složek během jarního období, jak je znázorněno na Obr. 2. Ten ukazuje jasný rozdíl v denním průběhu organických látek měřených v blízkosti země a ve výšce 230 m. Zatímco ve 4 m vykazují organické látky minimum odpoledne a nejvyšší koncentraci v noci, ve výšce 230 m mají plochý denní profil s malým maximem před polednem. Chování dusičnanů je poněkud odlišné. Mají také vyšší koncentraci v blízkosti země, ale v obou výškách mají maxima brzy ráno a minima pozdě odpoledne. Na druhou stranu sírany mají v obou výškách podobné koncentrace a denní profily s malými maximy během poledne. Konečně, výsledky pro amonné ions se nacházejí mezi hodnotami dusičnanů a síranů, a to díky jejich převažujícímu obsahu v dusičnanových a síranových solích.



Obr. 2. Průměrné denní koncentrace chemických látek NR-PM1 (nekorigované pomocí CE) ve výšce 4 m a 230 m nad zemí během jarního období.

ZÁVĚRY

Byly studovány vertikální rozdíly ve složení atmosférického aerosolu NR-PM1 a významné rozdíly byly zjištěny zejména v noci, kdy je promíchávání atmosféry často omezené. Každá hlavní studovaná složka NR-PM1 měla odlišné chování, nejvyšší rozdíly vykazovala organika v noci.

PODĚKOVÁNÍ

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REAL-WORLD EMISSIONS OF GASEOUS AEROSOL PRECURSORS FROM MOPEDS AND MOTORCYCLES USING A PORTABLE, RIDER-WORN FTIR ANALYZER

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Keywords: Reactive nitrogen species; Real-world emissions; Motorcycles; FTIR; Aerosol precursors; Unregulated pollutants; Vehicle Emissions

INTRODUCTION

Nano-size particles from combustion and other high-temperature processes are often emitted together with gaseous pollutants, which may substantially contribute to the overall effects of emissions on human health and/or to the formation of secondary aerosols in the atmosphere. Ammonia, formed in three-way catalysts of petrol engines under fuel-rich conditions, may contribute, along with nitrogen oxides (NOx), to the formation of ammonium nitrate particles. Various volatile and semi-volatile organic species emitted by motor vehicles participate in photochemical reactions. Semi-volatile species are often present in, and alternate between, gaseous and aerosol form.

Fourier-transform infra-red (FTIR) spectrometers have been commonly used to analyze engine exhaust for gaseous pollutants, many of which are precursors to secondary aerosols. Several FTIR have been adopted, including three by M.V., M.P. and L.D., for the use in moving vehicles, which is challenging due to the effects of vibrations on precision multipath low-volume optical cells used to achieve a fast response time.

In this work, we have undertaken the challenge of using a mobile FTIR analyzer to analyze exhaust gases of a total of 22 mopeds, motorcycles and other L-category vehicles during typical on-road operation.

EXPERIMENTAL

A Bruker Matrix Fourier-transform infra-red (FTIR) analyzer with a 5-meter optical path length multipass heated cell, Michelson moving mirror interferometer, and liquid nitrogen cooled MCT detector, providing spectra at 5 Hz and 0.5 cm^{-1} optical resolution with a t_{90} time response under 2 seconds, has been extensively modified into a road ready, self-contained 70x35x35 cm, 35 kg package including heated sampling line, filter and pump, consuming <300 W when operating at -9°C ambient temperature. For motorcycle tests, the FTIR has been fitted into an in-house fabricated external frame backpack worn by the motorcycle rider, with bulk of the weight resting on the motorcycle passenger seat.

Absorption spectra of exhaust have been collected during on-road operation from a range of L-category vehicles, including 50cc mopeds, enduro bikes and quads at ambient temperatures 0-30°C, and analyzed for all gaseous pollutants set or proposed to be regulated in major markets - greenhouse gases CO_2, CH_4 and N_2O; reactive nitrogen species NO, NO_2, NH_3; and reactive gases CO and formaldehyde, with an option to analyze ex-post for additional gases. Exhaust flow has been calculated from measured fuel injector pulse width or using a speed-density method.

Fig. 1: Mobile FTIR analyzer in the test cell (left) and mounted on a motorcycle (right).

RESULTS

The validation of on-road FTIR instruments typically consists of parallel measurement with reference instruments in the laboratory for all measured pollutants and on the road for those pollutants that can be reliably measured on the road. A set of dynamic chassis dynamometer tests on six petrol, diesel and natural gas powered vehicles has been run at -9, +23 and +35°C at Bosmal laboratories within the PAREMPI project and on two motorcycles at Emisia laboratories within the LENS project, with laboratory instruments as a reference.

The system has then been mounted into an external frame backpack worn by the test rider during on-road tests of 22 L-category vehicles, with the weight of the instruments resting on the passenger seat. The vehicles were subjected to one cold-start and several hot-start runs of a 2 km urban route, followed by a 50 km route with primarily rural and motorway sections. Exhaust gases were analyzed for principal greenhouse gases CO_2, CH_4 and N_2O, for principal reactive nitrogen species NO, NO_2 and NH_3, and for CO, CO_2, formaldehyde, comprising together all gases regulated under existing or proposed major emissions regulations.

Selected results of comparison tests and motorcycle tests will be presented as preliminary data.

ACKNOWLEDGEMENT

The development of the mobile FTIR, the rider-worn frame for the instrument, and exhaust gas flow inference, and the motorcycle tests, have been funded by Horizon Europe project No. 101056777 (LENS, L-vehicles Emissions and Noise Mitigation Solutions). Comparison tests at Bosmal laboratories were funded by Horizon Europe project No 101096133 (PAREMPI: Particle emission prevention and impact: from real world emissions of tra□c to secondary PM of urban air).

CLOUD DROPLET SPECTRA MEASUREMENTS: COMPARISON IN LOW STRATIFORM CLOUDS

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Keywords: Cloud droplets, Fog monitor, CDA, PVM

INTRODUCTION

Atmospheric aerosol (AA) and its interactions with atmospheric water are of great importance (Neuberger *et al.* 2025); however, they are still connected to considerable uncertainties. To improve our knowledge of aerosol-cloud interactions, in situ field measurements are needed to understand how AA from different sources influences cloud micro and macrophysics, and to provide data for models.

To address such a need, a standardized measurement technique must first be established for cloud droplet spectra (CDS) and liquid water content (LWC).

METHODOLOGY

To provide comparison measurements for CDS and LWC, a three-month intensive in-situ campaign was conducted at Mount Milešovka in the Czech Republic (50.55°N, 13.93°E, 837 m a.s.l.). At the station, low stratus clouds, coded as fog, appear on 55% of the days (Fišák, Tesař, and Fottová 2009). During autumn and winter, up to 90% of days with fog appearance can be expected, based on the 1961-1990 data.

From 30. 10. 2024 to 22. 1. 2025, four online instruments measuring cloud water properties were installed side-by-side: Fog Monitor (FM-120, DMT), Cloud Droplet Analyzer (CDA, Palas GmbH), Cloud in-situ monitor based on Vaisala AQT530 (AQT), and Particulate Volume Monitor (PVM 100, Gerber Scientific)(Fig. 1).

Figure 1. Measurement set-up at the Milešovka station: CDA, FM-120, and PVM.

RESULTS

From the data, apart from CDS and LWC, the Effective Diameter (ED) was also compared from all instruments. Droplet concentrations varied significantly among instruments, due to different counting efficiencies and losses; at the same time, CDS were almost overlapping (Fig. 2).

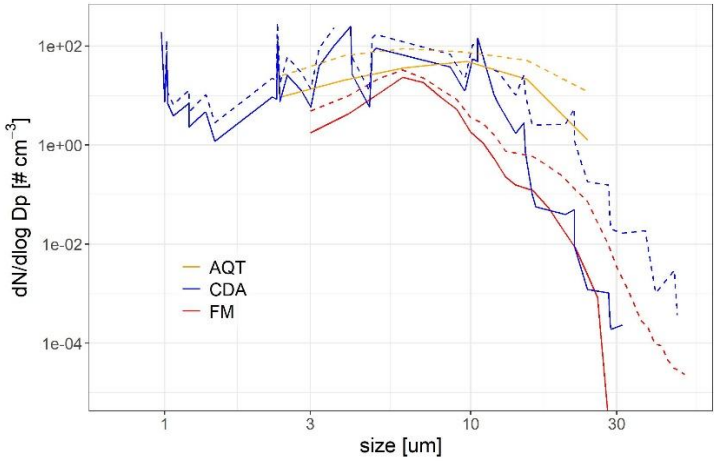

Figure 2. Mean and median CDS during in-cloud periods measured by AQT, CDA, and FM-120.

The median ED varied from 7.1 to 11.8 μm (except for PVM, which reached an ED of 15.0 μm). The measured LWC values of 0.25 g/m^3, as determined by FM-120, agreed well with previous measurements at the station (Zíková et al., 2020). The agreement within the tested instruments, however, was within ± 100 % range.

ACKNOWLEDGEMENT

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PROJECT FOCI: NON-CO2 FORCERS AND THEIR CLIMATE, WEATHER, AIR QUALITY AND HEALTH IMPACTS: WHERE WE ARE AND WHERE WE ARE GOING

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Keywords: Non-CO2 climate forcers, Atmospheric aerosols, Chemical-Climate interactions, emissions

INTRODUCTION

While overall the global warming with the causes and global processes connected to CO2, and its impacts on global to continental scales are well understood with a high level of confidence, there are knowledge gaps concerning the impact of many non-CO2 radiative forcers leading to low confidence in the conclusions. This relates mainly to specific anthropogenic and natural precursor emissions of short-lived GHGs and aerosols and their precursors. These gaps and uncertainties also exist in their subsequent effects on atmospheric chemistry and climate, through direct emissions dependent on changes in e.g., agriculture production, waste managements and technologies based on scenarios for future development as well as feedbacks of global warming on emissions, e.g., permafrost thaw. In addition to the atmospheric radiative forcing (gaseous or aerosols), albedo changes connected to land-use and land-cover can play a role, depending on the adaptation or mitigation measures included in different scenarios.

Thus, the main goal of the EC Horizon Europe project FOCI, is to assess the impact of key non-CO2 radiative forcers, where and how they arise, the processes of their impact on the climate system, to find and test an efficient implementation of these processes into global Earth System Models and into Regional Climate Models, and finally to use the tools developed to investigate mitigation and/or adaptation policies incorporated in selected scenarios of future development targetted at Europe and other selected regions of the world. We will develop new regionally tuned scenarios based on improved emissions to assess the effects of non-CO2 forcers. Mutual interactions of the results and climate services producers and other end-users will provide feedback for the specific scenarios preparation and potential application to support the decision making, including climate policy.

METHODOLOGY

The methods used within the project can be clearly seen from the overall scheme of the project shown in Fig. 1. Basically, there are two parts seen, fundamental science of both the anthropogenic and natural climate forcers (in addition to aerosols other selected gaseous forcers, land use, etc.), dealing with the processes undergone (WP1,2) and their modelling (WP3,4), the second part rather applied considering the emission and their

scenarios, with simulations of their impacts and potential regionalization of mitigation scenarios.

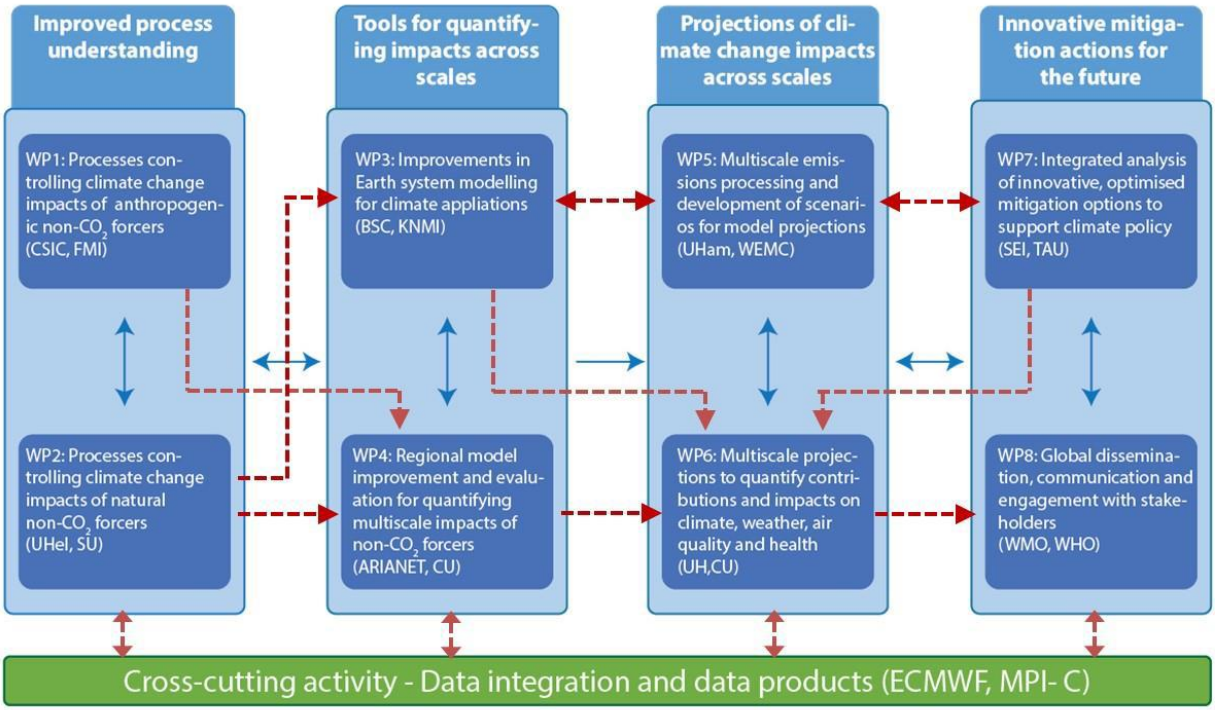

Fig. 1: Scheme of the project.

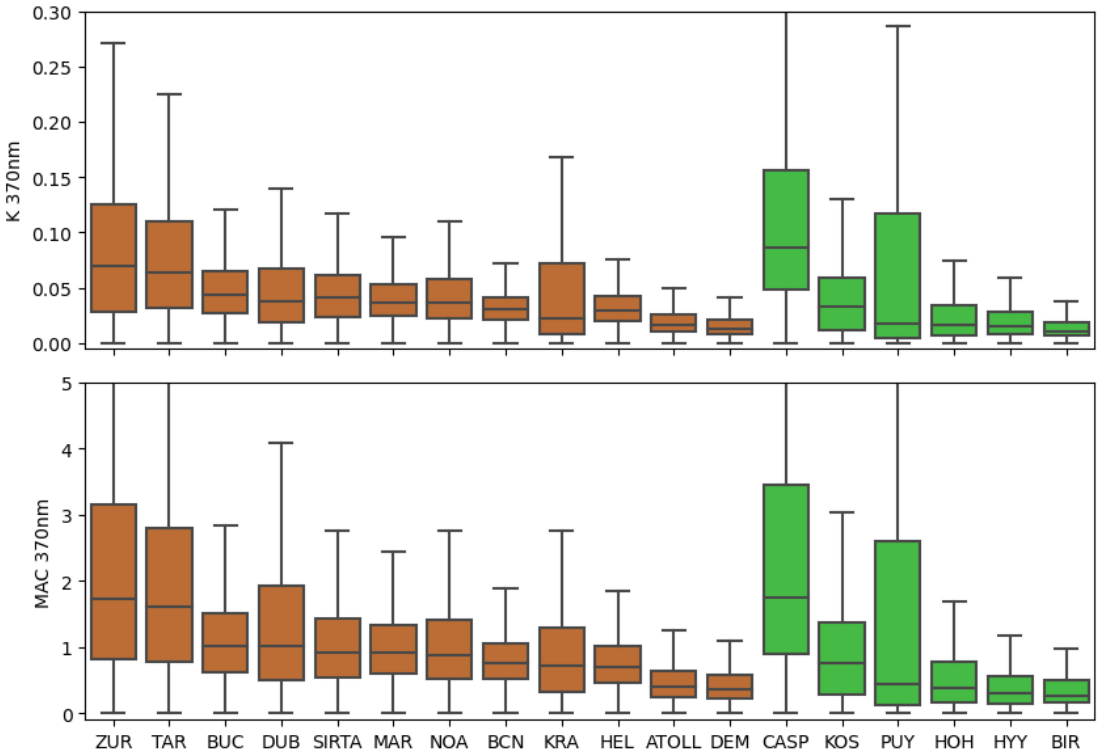

Fig. 2: Imaginary refractive index (k) and mass absorption cross section (MAC) of OA particles at 370 nm for a subset of measuring stations.

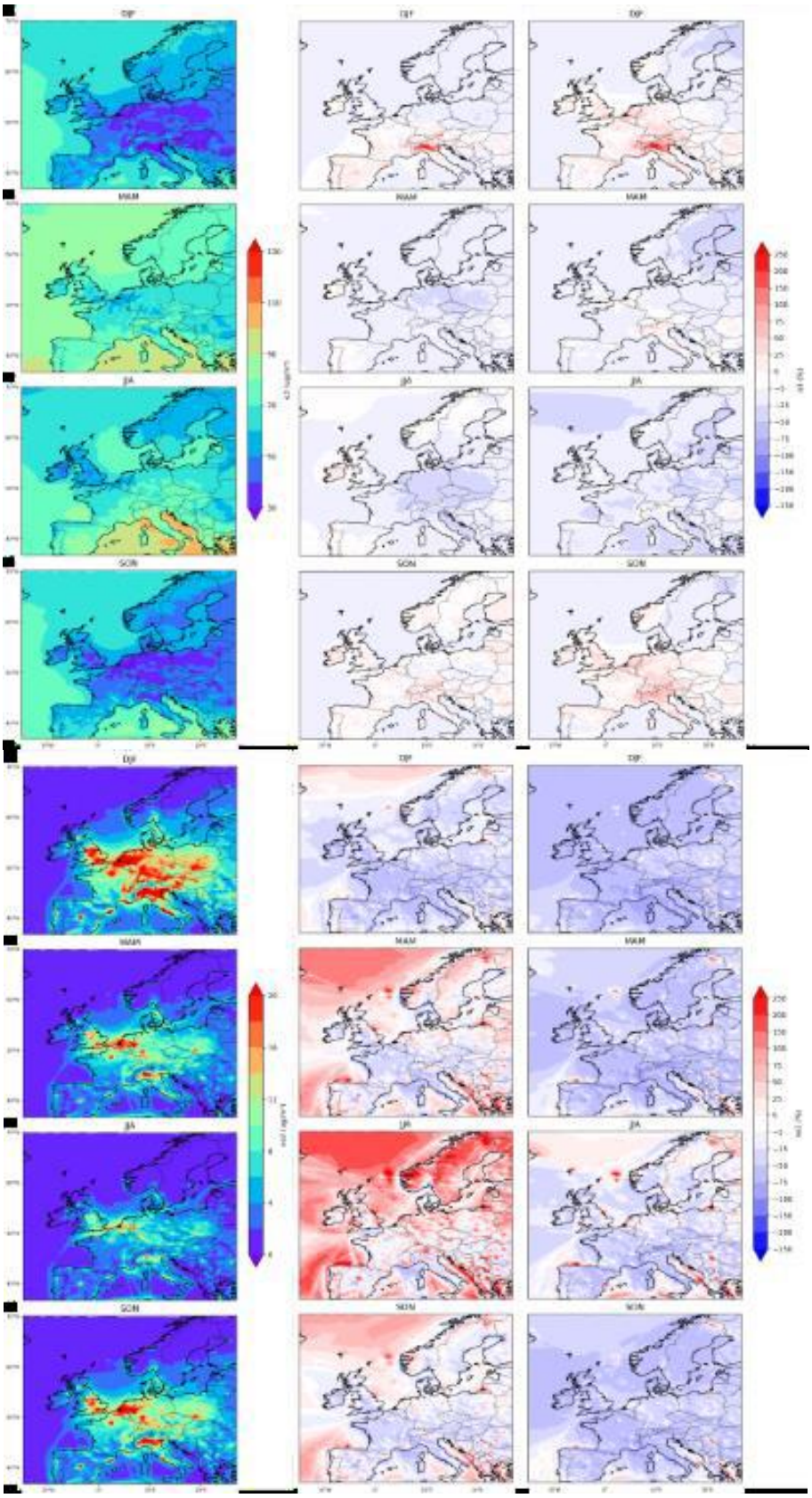

Fig. 3: Seasonal climatology of O3 (left panel) and NO2 (right panel) (μg/m^3) from CAMS European Air Quality Reanalysis (left columns) and the relative seasonal bias (%) of the simulations by RegCM-Chem (middle columns) and WRF-Chem (right columns) for the period 2013-2019.

RESULTS, DISCUSSION, CONCLUSIONS

One of the first results of the FOCI project came from the aerosols properties analysis, resulting in comprehensive GHOST database (https://doi.org/10.5281/zenodo.10637449), collecting the info from many other databases and providing the recalculated radiative properties, see example in Fig. 2.

In Fig. 3 preliminary assessment of a part of historical period in terms of O3 and NO2 is provided.

Present status of the project will be further described, with preliminary results relevant to the conference themes briefly shown. Future selected directions will be discussed.

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