czech aerosol society

Sborník konference

Ovzduší v ČASe

25. výroční konference
České aerosolové společnosti

9.–11. 11. 2026, Jičín

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SBORNÍK XXV. výroční konference České aerosolové společnosti

OVZDUŠÍ V ČASe

9. – 11. 11. 2026, Jičín

PROCEEDINGS OF 25th Annual Conference of the Czech Aerosol Society

OVZDUŠÍ V ČASe

9. – 11. 11. 2026, Jičín

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PROGRAM

PONDĚLÍ – MONDAY 9.11.2026 DOPOLEDNE – MORNING	
8:00 – 9:00	**Registrace – Registration**
9:00 – 9:15	**Zahájení konference – 25 let ČAS – Opening of the conference – 25 years of ČAS** **Jakub Ondráček**
Soutěž o nejlepší přednášku mladých vědců – Dekati Award (zeleně – in green)	
Session chairwoman	**Naděžda Zíková**
9:15 – 9:30	**LONG-TERM DECLINE IN CLOUD CONDENSATION NUCLEI NUMBER CONCENTRATIONS AT THE KOŠETICE BACKGROUND SITE** Charlie ANDAN
9:30 – 9:45	**RAINWATER CHEMISTRY AS AN INDICATOR OF AMBIENT ICE NUCLEATING PARTICLES?** Joseph DURAT
9:45 – 10:00	**AEROSOL-CLOUD INTERACTIONS AND THEIR EFFECTS ON PRECIPITATION** Natália CHARVÁTOVÁ
Session chairman	**Jakub Ondráček**
10:00 – 11:00	**PLENARY SPEAKER: OXIDATIVE POTENTIAL OF PM: TRANSITIONING FROM RESEARCH TO REGULATION** Gaëlle UZU
11:00 – 11:40	**COFFEE BREAK**
Session chairwoman	**Ludmila Mašková**
11:40 – 11:55	**OXIDATIVNÍ POTENCIÁL PM1 A PM10 S KYSELINOU ASKORBOVOU A DITHIOTHREITOLEM** Hana HLAVÁČKOVÁ
11:55 – 12:10	**EFFECT OF ATMOSPHERIC AGEING AND PAH DERIVATIVES ON AEROSOL OXIDATIVE POTENTIAL (OP)** Puneet Kumar VERMA
12:10 – 12:25	**NMR-OMICS FOR THE ANALYSIS OF WATER-SOLUBLE ORGANIC COMPOUNDS IN ATMOSPHERIC AEROSOL PARTICLES** Eliška RÁDLOVÁ
12:25 – 13:55	**OBĚD – LUNCH**
PONDĚLÍ – MONDAY 9.11.2026 ODPOLEDNE – AFTERNOON	
Session chairman	**Vladimír Ždímal**
13:55 – 14:25	**KEYNOTE: TRENDS IN CZECH OCCUPATIONAL DISEASES CAUSED BY INORGANIC DUSTS** Daniela PELCLOVÁ
14:25 – 14:40	**FROM OCCUPATIONAL NANOPARTICLE EXPOSURE TO EPIGENETIC MEMORY: INVESTIGATING MECHANISMS OF ADAPTIVE RESPONSE** Pavel RÖSSNER

14:40 – 14:55	**MI-TRAP: MITIGATING TRANSPORT-RELATED AIR POLLUTION IN EUROPE – FIRST RESULTS FROM THE PRAGUE 2026 CAMPAIGN** Jakub ONDRÁČEK
14:55 – 15:10	**ROADSIDE VERSUS ROAD-SURFACE POINT SAMPLING OF VEHICLE PARTICLE EMISSION FACTORS** Michal SANETRNÍK
15:10 – 15:25	**ROADSIDE DRIVE-BY DETECTION OF DEFUNCT VEHICLE PARTICLE FILTERS: PRACTICAL DETECTION LIMITS AND REPEATABILITY OF MODERATE COST INSTRUMENTS** Michal VOJTÍŠEK
15:25 – 16:05	**COFFEE BREAK**
Session chairman	**František Lízal**
16:05 – 16:20	**THE NEW PARTICLE FORMATION AT TWO HEIGHTS UNDER DIFFERENT BOUNDARY LAYER AND CLOUD CONDITIONS** Anna ŠPALOVÁ
16:20 – 16:35	**EXPERIMENTAL EVALUATION OF NUCLEATION PHENOMENA IN AN OXIDATION FLOW REACTOR (DOFR™)** Markus NIKKA
16:35 – 16:50	**VERTICAL PROFILING OF ULTRAFINE PARTICLE NUMBER CONCENTRATIONS USING A PORTABLE WATER-BASED CPC** Lucia BUSTIN
16:50 – 17:05	**MEASUREMENT AND CALIBRATION PROCEDURES FOR ULTRAFINE PARTICLES IN EUROPE AND THE EUROPEAN RESEARCH INFRASTRUCTURE ACTRIS** Alfred WIEDENSOHLER
17:05 – 17:20	**AN ULTRAFINE AEROSOL CHARGING MODEL** Oleksandr MOLCHANOV
17:20 – 17:55	**Schůze výboru ČAS – CAS board meeting** Jakub Ondráček
18:00 – 19:00	**VEČEŘE – DINNER**
19:15 – 20:45	**PROHLÍDKA JIČÍNA S PRŮVODCEM (SKUPINA A) – GUIDED TOUR OF JIČÍN (GROUP A)**
20:00 – 21:30	**PROGRAM NA HVĚZDÁRNĚ JIČÍN (SKUPINA B) – PROGRAMME AT JIČÍN OBSERVATORY (GROUP B)**

ÚTERÝ – TUESDAY 10.11.2026 DOPOLEDNE – MORNING	
Session chairwoman	**Petra Růžičková**
9:00 – 10:00	**PLENARY SPEAKER: INDOOR AIR QUALITY AND CHEMISTRY** Šárka LANGER
Session chairwoman	**Petra Vondráková Pokorná**
10:00 – 10:15	**VÝVOJ KVALITY OVZDUŠÍ VE STŘEDNÍ EVROPĚ BĚHEM UPLYNULÝCH DVOU DEKÁD** Radek LHOTKA
10:15 – 10:30	**PROJECT FOCI: NON-CO_2 FORCERS AND THEIR CLIMATE, WEATHER, AIR QUALITY AND HEALTH IMPACTS – FINAL OUTCOMES** Tomáš HALENKA
10:30 – 10:45	**FIRST NATIONAL-SCALE APPLICATION OF NONNEGATIVE MATRIX FACTORIZATION TO PM2.5 SOURCE APPORTIONMENT REVEALS WEST-EAST TRANSBOUNDARY ASYMMETRIES** Radim SEIBERT
10:45 – 11:00	**INTEGRATED SOURCE APPORTIONMENT OF AEROSOL IN THE PORT OF ROTTERDAM USING Q-ACSM, XACT AND AETHALOMETER MEASUREMENTS** Štěpán HORNÍK
11:00 – 11:40	**COFFEE BREAK**
Session chairman	**Radim Seibert**
11:40 – 11:55	**SPATIAL AND TEMPORAL TRENDS OF PERSISTENT ORGANIC POLLUTANTS ACROSS EUROPE AFTER 15 YEARS OF MONET PASSIVE AIR SAMPLING** Petr KUKUČKA
11:55 – 12:10	**WIDESPREAD DISTRIBUTION OF ORGANIC POLLUTANTS IS ENHANCED BY RE-VOLATILISATION FROM SOILS** Gerhard LAMMEL
12:10 – 12:25	**MONITORING ATMOSPHERIC MICROPLASTICS: COMPREHENSIVE ANALYTICAL SOLUTIONS USING PY-GC/MS AND LDIR** Růžena PENÍŽKOVÁ
12:25 – 13:55	**OBĚD – LUNCH**
ÚTERÝ – TUESDAY 10.11.2026 ODPOLEDNE – AFTERNOON	
13:55 – 15:15	**POSTEROVÁ SEKCE S KÁVOU – POSTER SESSION WITH COFFEE**
15:15 – 15:30	**Vyhodnocení soutěže mladých vědců – DEKATI Award announcement** **Jakub Ondráček; Biowell (Dekati)**
15:30 – 16:30	**Členská schůze ČAS – Meeting of the CAS members** **Jakub Ondráček**
19:00	**SPOLEČENSKÝ VEČER – CONFERENCE DINNER**

STŘEDA – WEDNESDAY 11.11.2026 DOPOLEDNE – MORNING	
Session chairwoman	**Iva Hůnová**
9:00 – 9:15	**METEOROLOGICAL EFFECTS ON THE VERTICAL VARIABILITY OF AEROSOL CHEMICAL COMPOSITION AT A RURAL BACKGROUND SITE** Naděžda ZÍKOVÁ
9:15 – 9:30	**VÝSLEDKY DVOULETÉHO MĚŘENÍ VERTIKÁLNÍ DISTRIBUCE AEROSOLŮ AEROSOLOVÝM HMOTNOSTNÍM SPEKTROMETREM NA OBSERVATOŘI KOŠETICE** Petr VODIČKA
9:30 – 9:45	**CHARACTERIZING VERTICALLY RESOLVED FRESH VS. AGED BIOMASS BURNING CARBONACEOUS AEROSOLS BASED ON TALL TOWER MEASUREMENTS** Saliou MBENGUE
9:45 – 10:00	**CHARACTERIZATION OF ATMOSPHERIC BOUNDARY LAYER HEIGHT UNDER VARIOUS ATMOSPHERIC STABILITY AND CLOUDINESS CONDITIONS AT THE NATIONAL ATMOSPHERIC OBSERVATORY KOŠETICE** Kateřina KOMÍNKOVÁ
10:00 – 10:15	**KONCENTRACE V RŮZNÝCH TEPLOTNÍCH TŘÍDÁCH NA NÁRODNÍ ATMOSFÉRICKÉ OBSERVATOŘI KOŠETICE** Jan PACNER
10:15 – 10:55	**COFFEE BREAK**
Session chairman	**Michal Vojtíšek**
10:55 – 11:10	**THE ROLE OF RIME ICE IN ATMOSPHERIC DEPOSITION PROCESSES** Iva HŮNOVÁ
11:10 – 11:25	**LONG-TERM OPERATION AND TESTING OF A STAND-ALONE AUTOMATED MEASURING SYSTEM FOR PM MEASUREMENTS UNDER HARSH METEOROLOGICAL CONDITIONS** Tomáš PROKOP
11:25 – 11:40	**AUTOMATED SEMI-CONTINUOUS DETERMINATION OF GASEOUS NITRIC AND NITROUS ACID IN AMBIENT AIR USING ION CHROMATOGRAPHY** Lukáš ALEXA
11:40 – 11:55	**PŘÍBĚH A VÝHODY REVOLUČNÍHO ŘEŠENÍ PRO FILTRACI VZDUCHU V INTERIÉRU OD NÁVRHU PO KOMERCIONALIZACI** Max FRAENKL
11:55 – 12:10	**Ukončení konference – Closing of the conference** **Jakub Ondráček**
12:10 – 13:40	**OBĚD – LUNCH**

POSTERY – POSTERS

1	**AEROSOLY POD MIKROSKOPEM – POPULARIZAČNÍ PROJEKT V KRAJI VYSOČINA** Adéla HOLUBOVÁ ŠMEJKALOVÁ
2	**ASOCIÁCIA KONCENTRÁCIÍ AEROSÓLU S PREVÁDZKOVOU ČINNOSŤOU V AREÁLI OBAĽOVAČKY ASFALTOVÝCH ZMESÍ** Dušan JANDAČKA
3	**FIELD MEASUREMENTS OF EMISSIONS FROM DOMESTIC SOLID FUEL BOILERS** Kamil KŘŮMAL
4	**FATE OF INHALED THERAPEUTIC AEROSOLS UNDER PATHOLOGICAL RESPIRATORY CONDITIONS: FROM ASTHMA AND DYSPNOEA TO DIGITAL MODELLING OF ARDS** František LÍZAL
5	**INTEGRATED MONITORING OF ORGANIC POLLUTANTS IN THE KOŠETICE OBSERVATORY REGION (1988 – 2025)** Jakub MARTINÍK
6	**HYGROSCOPIC GROWTH OF LACTOSE PARTICLES UNDER PHYSIOLOGICALLY RELEVANT CONDITIONS** Ludmila MAŠKOVÁ
7	**FACTORS SHAPING HOURLY PM10 VARIABILITY IN A COMPACT RURAL SETTLEMENT DURING THE WARM SEASON** Tomasz OLSZOWSKI
8	**FLUXPRISM – AN ATMOSPHERIC GREENHOUSE GAS MONITORING NETWORK** Roman PROKEŠ
9	**PARALELNÍ MĚŘENÍ VE VODĚ ROZPUSTNÝCH LÁTEK V PM1 VE DVOU VÝŠKÁCH** Jaroslav SCHWARZ
10	**FROM LABORATORY TO FIELD MEASUREMENTS: A MOBILE EXPOSURE LABORATORY** Jitka SIKOROVÁ
11	**ATMOSPHERIC FATE OF CURRENT-USE PESTICIDES – TRENDS AND AIR-SOIL EXCHANGE** Puneet Kumar VERMA
12	**MULTI-SITE VS. SUPERSITE AEROSOL SOURCE APPORTIONMENT IN A LIGNITE BASIN AREA** Petra VONDRÁKOVÁ POKORNÁ
13	**VERTICAL GRADIENT OF TOTAL GASEOUS MERCURY IN RELATION TO ATMOSPHERIC CONDITIONS** Gabriela VÍTKOVÁ
14	**EFFECTS OF POST-COMBUSTION AMMONIA AND ASH-FORMING LUBRICATING OIL ADDITION ON TOXICITY OF MARINE ENGINE EMISSIONS AND SECONDARY AEROSOL FORMATION** Táňa ZÁVODNÁ

SPONZOŘI


Altium


ECM ECO Monitoring
Process and environmental monitoring systems


BIOWELL
Specialist for environmental monitoring


DEKATI


TSI
Knowledge
Beyond
Measure.


envitech


PALAS

PŘEDMLUVA

Vážené kolegyně, vážení kolegové, přátelé,

je mi velkou ctí vás jako předseda České aerosolové společnosti (ČAS) přivítat na **jubilejní 25. Výroční konferenci České aerosolové společnosti**, která se letos koná v kraji Rumcajse a Albrechta z Valdštejna, přímo v Jičíně – v **hotelu reSTART**. Čtvrt století našich každoročních setkání je dobrým důvodem se na chvíli zastavit a ohlédnout se zpět; krátké shrnutí naší historie najdete na konci této předmluvy.

Již potřetí se konference Ovzduší a Výroční konference ČAS spojují do společné konference **Ovzduší v ČASe**, pořádané ve spolupráci s velkými výzkumnými infrastrukturami **RECETOX** a **ACTRIS-CZ**. Spojení se jednoznačně vyplatilo: poslední dva ročníky přinesly nejvyšší účast v historii našich konferencí (75 účastníků v Milovech v roce 2024 a 79 v Hustopečích v roce 2025) a **posterová sekce**, zavedená loni, se stala nedílnou součástí programu. Pokud znáte kolegy z výzkumu, státní správy či praxe, pro které by konference mohla být přínosem, vezměte je příště s sebou.

Řada novinek posledních let – včetně posterové sekce – vzešla přímo z vašich odpovědí v **dotazníku** rozesílaném po konferenci. Budu proto rád, když si na něj i letos najdete chvilku.

Výročí je také příležitostí poděkovat těm, kteří společnost i její konferenci vybudovali. Požádal jsem proto oba naše předchozí předsedy, **Jiřího Smolíka** a **Vladimíra Ždímala**, aby se s námi podělili o několik slov o historii ČAS – jejich příspěvky najdete níže. Oběma, stejně jako **všem současným i bývalým členům výboru ČAS**, patří velký dík za jejich práci v uplynulých letech – bez nich bychom dnes neslavili jubilejní 25. Výroční konferenci.

Nové webové stránky ČAS jsou již v provozu na adrese https://www.aerosolscience.cz/ – mimo jiné na nich najdete i sborníky všech konferencí od roku 2003. Nadále také pokračujeme **v přípravách European Aerosol Conference (EAC) 2028 v Praze** a aktivně podporujeme organizátory **EAC 2027 v Lublani**. O všech těchto i dalších záležitostech vás budu informovat **na zasedání členů ČAS v úterý 10. 11. 2026** odpoledne v místě konání konference.

Od roku 2023 patří k našim konferencím plenární přednášky předních zahraničních vědců – prof. Philipa Hopkeho, prof. Alfreda Wiedensohlera, Dr. Martina Gysel-Beera a prof. Gerharda Lammela. Letos s radostí přivítáme další dvě osobnosti. V **pondělí dopoledne 9. 11.** vystoupí **Dr. Gaëlle Uzu** (IRD, Institut des Géosciences de l'Environnement, Université Grenoble Alpes, Francie), která se zabývá **oxidativním potenciálem aerosolových částic** – ukazatelem jejich toxicity, k jehož rozvoji výrazně přispěla. V **úterý ráno 10. 11.** pak **Dr. Šárka Langer** (IVL Swedish Environmental Research Institute, Göteborg, Švédsko) představí svou práci v oblasti **kvality a chemie vnitřního ovzduší** – v domácnostech, školách i na lodích, včetně chemických reakcí iniciovaných ozonem a vzniku sekundárních částic. V **pondělí odpoledne 9. 11.** zazní také zvaná přednáška **prof. Daniely Pelclové** (Klinika pracovního lékařství 1. LF UK a VFN v Praze) o vývoji nemocí z povolání způsobených anorganickým prachem v Česku.

Rád bych vás také povzbudil, abyste se – pokud jím ještě nejste – stali **členy ČAS**. Členové dostávají veškeré informace o dění v oboru, včetně nabídek doktorských a postdoktorských pozic, volných pracovních míst a dalších užitečných zpráv. **Studenti** – členové ČAS – mohou navíc získat **finanční podporu na prezentaci svých výsledků v angličtině na mezinárodních konferencích**. A v neposlední řadě mají členové ČAS

nárok na nižší registrační poplatek na Evropské aerosolové konferenci (EAC). Přihlášku najdete na našich webových stránkách.

Konference by se neobešla bez podpory našich **sponzorů** – firem **Altium, Biowell (Dekati), ECM ECOMONITORING (TSI) a Envitech (Palas)**, kterým tímto upřímně děkuji. Nenechte si ujít příležitost zastavit se během přestávek u jejich stánků a probrat s jejich zástupci novinky z oblasti měřicí techniky. Letos je to také právě **10 let**, co firma **Dekati** poprvé podpořila **soutěž mladých vědců o nejlepší prezentaci (Dekati Award)** – za tuto dlouholetou podporu jí patří zvláštní poděkování.

Zvláštní poděkování patří **Janě Kánské**, která i letos připravila tento sborník.

Těším se na vás v Jičíně. A pokud máte nápad, jak udělat dalších 25 let našich konferencí ještě lepšími, moje dveře (i e-mailová schránka) jsou vám vždy otevřené.

Váš,

Jakub Ondráček (předseda České aerosolové společnosti)

25 let Výročních konferencí ČAS v číslech *(Jakub Ondráček + ČAS)*

Od první výroční konference v roce 2000 (samotná společnost vznikla již 22. dubna 1999, v roce, kdy se v Praze konala EAC 1999, obr. 1) se konference konala celkem 24krát – v 16 městech Česka a Slovenska a jednou, v roce 2006, v Helsinkách v rámci Finsko-českého aerosolového sympozia (obr. 2). Řadu přerušila pouze pandemie covidu-19 v letech 2020–2021. Ve sbornících a dalších dokumentech včetně letošního jsme napočítali **633 příspěvků od 762 autorů ze 176 institucí a 28 zemí**. Z jednodenního setkání s 12 přednáškami a 20 účastníky na ÚCHP v Praze-Suchdole se konference rozrostla na třídenní akci s více než 50 příspěvky a téměř 80 účastníky (obr. 3). Letošní jubilejní ročník přinese 48 příspěvků – 31 přednášek, 2 plenární a 1 zvanou přednášku a 14 posterů – a očekáváme na něm 68 účastníků; na letošních příspěvcích se podílí rekordních 168 autorů z 53 institucí a 15 zemí. Podíl abstraktů v angličtině vzrostl z necelé třetiny v roce 2003 na 86 % v roce 2025 (letos 83 %) a těžiště témat se posunulo od nukleace a teorie aerosolů, které dominovaly prvním ročníkům, k atmosférickému aerosolu, emisím, měřicí technice a zdravotním účinkům. Dvě instituce – Univerzita Karlova a Ústav chemických procesů AV ČR – byly zastoupeny na všech 25 ročnících včetně letošního a jediný autor, Vladimír Ždímal, je spoluautorem příspěvků na všech z nich. Rostla i společnost samotná: počet členů platících příspěvky stoupl z 25 v roce 1999 na 63 v roce 2022 (obr. 3). Další výsledky tohoto ohlédnutí – např. vývoj témat, nejvěrnější instituce či mezinárodní spolupráci – vám ukážu na zasedání členů ČAS v úterý odpoledne.

Z historie ČAS

Českou aerosolovou společnost založil v roce 1999 **Jiří Smolík**, který ji jako její první předseda vedl v letech **1999–2013**. Velkou měrou se zasloužil o to, že se o ČAS brzy vědělo i za hranicemi – již v roce 2002 se stala členem **EAA (European Aerosol Assembly)**, sdružení národních aerosolových společností, a v letech 2010–2012 stál Jiří Smolík v čele EAA jako její prezident. Na jeho práci navázal **Vladimír Ždímal**, předseda ČAS v letech **2014–2022**, který po celou dobu svého působení usiloval o to, aby byla společnost dobře vidět doma i ve světě. Za více než čtvrtstoletí ČAS spojila odborníky z oboru aerosolů i příbuzných disciplín, podpořila rozvoj těchto témat a snaží se přispívat i k řešení společensky důležitých otázek – od kvality ovzduší a změny klimatu až po

informování veřejnosti o šíření aerosolů během pandemie covidu-19. Jak to všechno začínalo a jak se společnost proměňovala, nejlépe vylíčí oba bývalí předsedové sami.

Vznik České aerosolové společnosti *(Jiří Smolík)*

S rozvojem nových technologií a s narůstajícími ekologickými problémy došlo ve druhé polovině minulého století k výraznému rozvoji výzkumu aerosolů. V souvislosti s tím vznikaly v Evropě odborné společnosti, jejichž cílem byla podpora vědeckého výzkumu, vzdělávání a mezinárodní spolupráce v oblasti aerosolů a ochrany ovzduší.

V roce 1992 jsem dostal od Německé akademické výměnné služby (DAAD) grant na studijní cestu po vědeckých pracovištích zabývajících se výzkumem aerosolů. Jedním z pracovišť, která jsem navštívil, byl Fraunhoferův ústav pro toxikologii a výzkum aerosolů v Hannoveru, kde se skupina dr. Holländera zabývala metodami měření aerosolů v reálných systémech. Během pobytu v Hannoveru mě dr. Holländer, který byl tajemníkem Německé společnosti pro výzkum aerosolů (GAeF), přijal za člena GAeF. Jednou z aktivit společnosti byla i příprava Evropské aerosolové konference (EAC). Tady je asi moment, který zapříčinil vznik České aerosolové společnosti. Na jedné ze schůzí společnosti, na které se projednávaly budoucí konference, jsem trochu neuváženě navrhl Prahu. To však nebylo možné, protože pravidlem bylo, že organizátorem konference je příslušná národní společnost. Musím říci, že mě to velice uklidnilo, protože jsem si už uvědomil, jak obtížné je pořádat mezinárodní konferenci bez zkušeností a patřičného zázemí. K mému překvapení mi ale hned příští rok zavolal tajemník GAeF, zda moje nabídka stále platí – pokud ano, mohli bychom konferenci v Praze pořádat pod patronací GAeF. Samozřejmě jsem souhlasil, protože mě už dříve napadlo, že pořádání EAC by mohlo být i vhodnou příležitostí k založení České aerosolové společnosti.

Tento nápad se setkal s pozitivním ohlasem dalších pracovišť, se kterými jsme spolupracovali. Ze zástupců institucí, které projevily zájem (Martin Braniš, PřF UK, Pavel Demo, FZÚ AV ČR, Jiří Smolík, ÚCHP AV ČR, a Zbyněk Večeřa, ÚIACH AV ČR), jsme proto sestavili přípravný výbor. Ten připravil návrh stanov, podal žádost o registraci na Ministerstvo vnitra a požádal Radu vědeckých společností ČR o přijetí do sdružení vědeckých společností. Na základě tohoto procesu vznikla 22. dubna 1999 Česká aerosolová společnost.

Let do vesmíru jménem Aerosoly *(Vladimír Ždímal)*

Od nástupu do Ústavu chemických procesů v říjnu 1989 si připadám jako člověk, který omylem zabloudil do Kennedyho vesmírného střediska na mysu Canaveral, aby se seznámil s tím, co se tam děje, a po třech měsících mu nabídli, aby se stal členem příští výpravy do vesmíru jménem Aerosoly. Od té doby letím v raketě, kterou nastartoval Jirka Smolík, navštívil jsem řadu míst naší aerosolové soustavy a nepřestávám se divit, co všechno je tu k vidění. Podobně jako v Malém princi se na cestách setkáváme s nejrůznějšími bytostmi, které do rakety přistupují nebo z ní vystupují, a řešíme různé komplikované úlohy spojené s tímto letem. Už víc než 35 let se nepřestávám divit množství příležitostí, které náš fascinující obor nabízí.

V tomto smyslu bylo založení České aerosolové společnosti v roce 1999 jen jednou logickou zastávkou na natankování a nabrání nových sil. Každoroční výroční konference společnosti jsou pak příležitostí se zastavit a zbilancovat, co nového se za poslední rok událo. Ani jsme se nenadáli a už slavíme 25. výroční konferenci ČASu – a to jsme si ještě kvůli covidu dali dva roky pauzu. Nic z toho by se ale nestalo, kdyby se Jirka před víc než

35 lety nerozhodl, že budeme dělat aerosoly, a nepřesvědčil mě a Jardu Schwarze, že je to dobrý nápad. Všechno ostatní už je historie.

Díky, Jirko, a díky i vám všem, kolegové z oboru!

PREFACE

Dear colleagues and friends,

It is my great pleasure, as President of the Czech Aerosol Society (ČAS), to welcome you to the **anniversary 25th Annual Conference of the Czech Aerosol Society**, held this year in the land of Rumcajs and Albrecht von Wallenstein, in Jičín itself – at the **reSTART hotel**. A quarter of a century of our annual meetings is a good reason to pause for a moment and look back; you will find a short summary of our history at the end of this preface.

For the third time, the "Ovzduší" conference and the ČAS Annual Conference come together in the joint conference **"Ovzduší v ČASe"**, organised in cooperation with the large research infrastructures **RECETOX** and **ACTRIS-CZ**. The merger has clearly paid off: the last two editions brought the highest attendance in the history of our conferences (75 participants in Milovy in 2024 and 79 in Hustopeče in 2025), and the **poster session** introduced last year has become an integral part of the programme. If you know colleagues in research, public administration or industry who might benefit from the conference, bring them along next time.

Many of the recent changes – including the poster session – came directly from your answers to the **post-conference survey**, so I would be grateful if you could find a moment for it again this year.

The anniversary is also an occasion to thank those who built the society and its conference. I asked our two previous presidents, **Jiří Smolík** and **Vladimír Ždímal**, to share a few words about the history of ČAS – you will find their contributions below. I would like to thank them both, as well as **all present and past members of the ČAS Board**, for their work over the years – without them, there would be no 25th conference to celebrate.

The **new ČAS webpages** are now up and running at https://www.aerosolscience.cz/ – among other things, you will find there the books of abstracts of all conferences since 2003. We also continue our **preparations for the European Aerosol Conference (EAC) 2028 in Prague**, and we are actively supporting the organisers of **EAC 2027 in Ljubljana**. I will update you on these and other topics at the **ČAS Members' Meeting**, which will take place on **Tuesday, 10 November 2026**, in the afternoon at the conference venue.

Since 2023, plenary lectures by leading international scientists have become part of our conference – Prof. Philip Hopke, Prof. Alfred Wiedensohler, Dr. Martin Gysel-Beer and Prof. Gerhard Lammel. This year, we are delighted to welcome two more. On **Monday morning (9 November)**, **Dr. Gaëlle Uzu** (IRD, Institute of Environmental Geosciences, Université Grenoble Alpes, France) will speak about the **oxidative potential of particulate matter**, a health-relevant metric of particle toxicity to whose development she has made major contributions. On **Tuesday morning (10 November)**, **Dr. Šárka Langer** (IVL Swedish Environmental Research Institute, Gothenburg, Sweden) will present her work on **indoor air quality and chemistry** – in homes, schools and ships, including ozone-initiated indoor chemistry and the formation of secondary particles. On **Monday afternoon, 9 November, Prof. Daniela Pelclová** (Department of Occupational Medicine, First Faculty of Medicine, Charles University and General University Hospital in Prague) will give a keynote lecture on trends in Czech occupational diseases caused by inorganic dusts.

I would also like to encourage those of you who are not yet members to **join ČAS**. Members receive all the news from our field, including offers of PhD and postdoctoral

positions, open jobs and other relevant information. **Student members** are also eligible for **financial support for presenting their work in English at international conferences**. Last but not least, ČAS members are entitled to a reduced registration fee at the European Aerosol Conference (EAC). You can find the application form on our webpages.

The conference would not be possible without the support of our **sponsors – Altium, Biowell (Dekati), ECM ECOMONITORING (TSI) and Envitech (Palas)** – to whom I extend my sincere thanks. Do not miss the chance to stop by their stands during the breaks and discuss the latest developments in aerosol instrumentation with their representatives. This year also marks **10 years** since **Dekati** first supported the **competition of young scientists for the best presentation** (Dekati Award) – many thanks for this long-lasting support.

Special thanks go to **Jana Kánská**, who has once again put together **this book of abstracts**.

See you in Jičín! And if you have an idea how to make the next 25 years of our conferences even better, my door (and inbox) is always open.

Yours sincerely,

Jakub Ondráček (President of the Czech Aerosol Society)

25 years of ČAS annual conferences in numbers *(Jakub Ondráček + ČAS)*

Since the first annual conference in 2000 (the society itself was founded on 22 April 1999, the year Prague hosted EAC 1999, Fig. 1), the conference has taken place 24 times – in 16 towns in Czechia and Slovakia and once, in 2006, in Helsinki as part of the Finnish-Czech Aerosol Symposium (Fig. 2). The series was interrupted only by the COVID-19 pandemic in 2020–2021. From the books of abstracts and other records we counted **633 contributions by 762 authors from 176 institutions in 28 countries**, including this year's. What started as a one-day meeting with 12 talks and 20 participants at ÚCHP in Prague-Suchdol has grown into a three-day event with more than 50 contributions and almost 80 participants (Fig. 3). This year's jubilee edition brings 48 contributions – 31 talks, 2 plenary lectures, 1 keynote and 14 posters – and we expect 68 participants; this year's contributions involve a record 168 authors from 53 institutions in 15 countries. The share of abstracts in English rose from less than one third in 2003 to 86 % in 2025 (83 % this year), and the focus has shifted from nucleation and aerosol theory, which dominated the early years, towards atmospheric aerosol, emissions, instrumentation and health effects. Two institutions – Charles University and the Institute of Chemical Process Fundamentals of the CAS – have been represented at all 25 editions including this one, and one author, Vladimír Ždímal, has co-authored contributions at every one of them. The society itself has grown too: the number of fee-paying members rose from 25 in 1999 to 63 in 2022 (Fig. 3). More results of this look back – such as the evolution of topics, the most faithful institutions and international collaboration – I will present at the **ČAS Members' Meeting** on Tuesday afternoon.

From the history of ČAS

The Czech Aerosol Society was founded in 1999 by **Jiří Smolík**, who led it as its first President from **1999 to 2013**. He did much to make ČAS known beyond our borders – as

early as 2002 it became a member of the **European Aerosol Assembly (EAA)**, the association of national aerosol societies, and in 2010–2012 Jiří Smolík served as its President. His work was continued by **Vladimír Ždímal**, President of ČAS from **2014 to 2022**, who throughout his term strove to keep the society visible both at home and internationally. Over more than a quarter of a century, ČAS has brought together experts in aerosol science and related disciplines, supported the development of these topics and tried to contribute to socially relevant issues – from air quality and climate change to informing the public about aerosol transmission during the COVID-19 pandemic. How it all began and how the society has evolved is best told by our two former presidents themselves.

How the Czech Aerosol Society came into being *(Jiří Smolík)*

With the development of new technologies and growing environmental problems, aerosol research expanded considerably in the second half of the last century. In connection with this, professional societies were founded across Europe with the aim of supporting scientific research, education and international cooperation in the field of aerosols and air protection.

In 1992 I received a grant from the German Academic Exchange Service (DAAD) for a study trip to research institutes working on aerosols. One of the places I visited was the Fraunhofer Institute for Toxicology and Aerosol Research in Hannover, where Dr. Holländer's group worked on methods for measuring aerosols in real systems. During my stay in Hannover, Dr. Holländer, who was the secretary of the German Association for Aerosol Research (GAeF), admitted me as a member of GAeF. One of the society's activities was the preparation of the European Aerosol Conference (EAC). This is probably the moment that led to the founding of the Czech Aerosol Society. At one of the society's meetings, where future conferences were being discussed, I rather rashly proposed Prague. That was not possible, however, because the rule was that the conference is organised by the respective national society. I must say this was quite a relief to me, as I had already realised how difficult it would be to organise an international conference without experience and proper background. To my surprise, the very next year the GAeF secretary called me to ask whether my offer still stood – if so, we could organise the conference in Prague under the patronage of GAeF. Of course I agreed, because it had already occurred to me that hosting the EAC could also be a good opportunity to found a Czech Aerosol Society.

The idea was welcomed by other institutions we were collaborating with. From representatives of the institutions that showed interest (Martin Braniš, Faculty of Science, Charles University; Pavel Demo, Institute of Physics of the CAS; Jiří Smolík, ICPF of the CAS; and Zbyněk Večeřa, Institute of Analytical Chemistry of the CAS), we therefore formed a preparatory committee. It drafted the statutes, applied for registration with the Ministry of the Interior and asked the Council of Scientific Societies of the Czech Republic for admission to the association of scientific societies. As a result of this process, the Czech Aerosol Society was established on 22 April 1999.

A space flight called Aerosols *(Vladimír Ždímal)*

Ever since I joined the Institute of Chemical Process Fundamentals in October 1989, I have felt like someone who wandered into the Kennedy Space Center at Cape Canaveral by mistake, just to see what was going on there, and three months later was offered a place

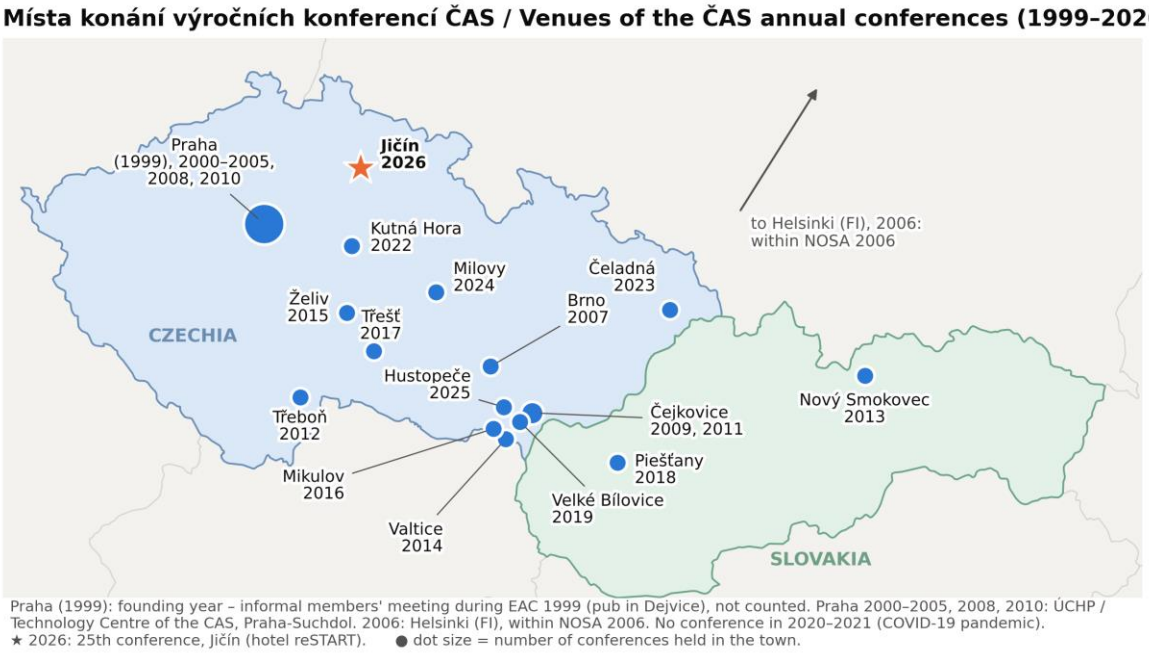
on the next space mission, called Aerosols. Since then I have been flying in the rocket that Jirka Smolík launched; I have visited many places in our aerosol solar system and I never stop being amazed at how much there is to see. As in The Little Prince, on our travels we meet all kinds of beings who board the rocket or get off it, and we solve all sorts of complicated tasks connected with the flight. For more than 35 years now, I have never ceased to marvel at the number of opportunities our fascinating field offers.

In this sense, the founding of the Czech Aerosol Society in 1999 was just one logical stop to refuel and gather new strength. The annual conferences of the society are then an opportunity to pause and take stock of what has happened over the past year. Before we knew it, here we are celebrating the 25th Annual Conference of ČAS – even though we took a two-year break because of COVID. But none of this would have happened if, more than 35 years ago, Jirka had not decided that we would do aerosols and convinced me and Jarda Schwarz that it was a good idea. The rest is history.

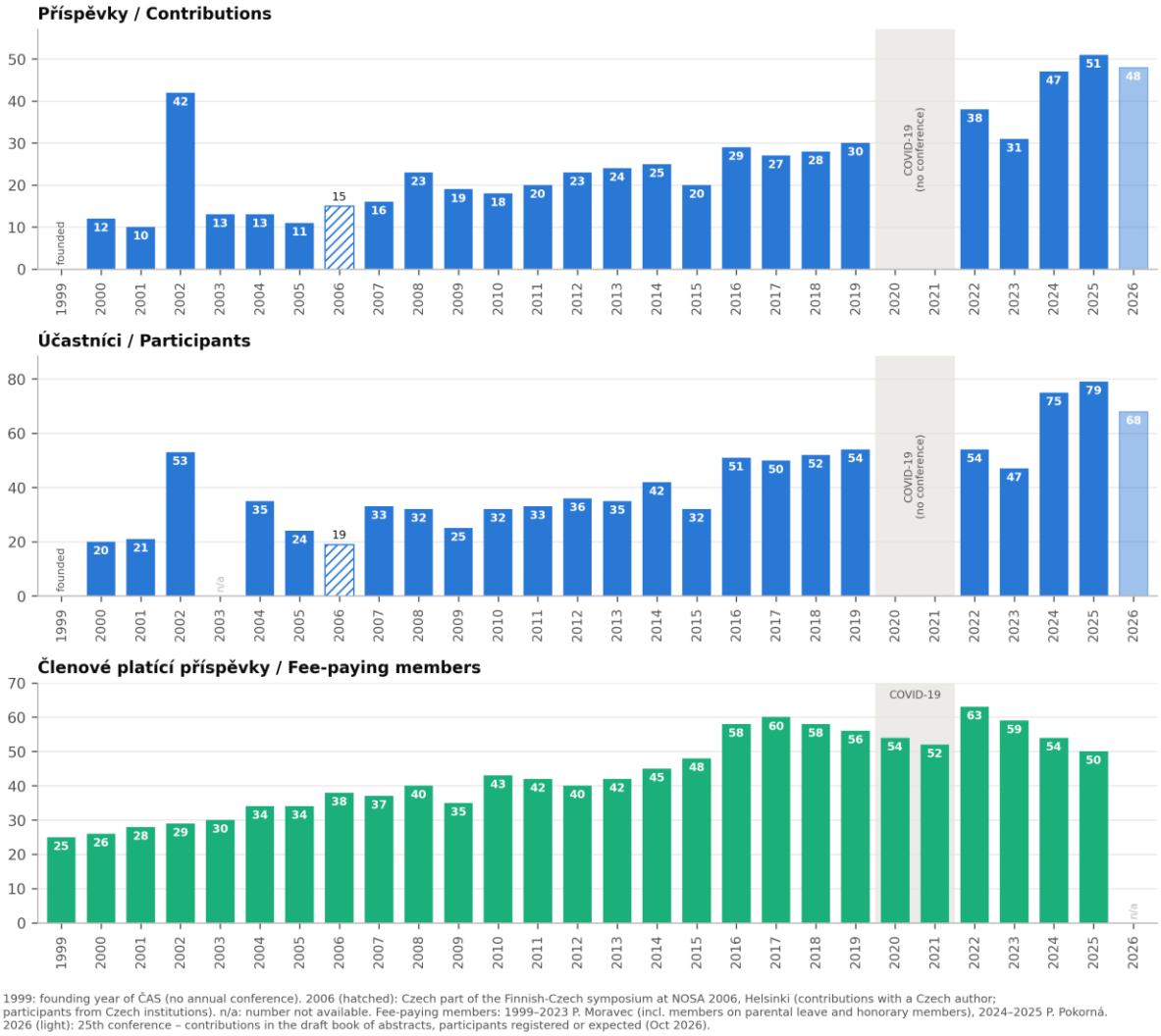
Thank you, Jirka, and thank you all, colleagues in our field!



Obr. 1 / Fig. 1: EAC 1999 v Praze, rok založení ČAS (z archivu J. Smolíka) – nahoře vlevo ukazatel ke konferenci, nahoře vpravo plenární přednáška K. Spurného, dole (zleva) dva bývalí předsedové ČAS V. Ždímal a J. Smolík s kolegou J. Kuglerem / EAC 1999 in Prague, the founding year of ČAS (courtesy of J. Smolík) – top left: the conference sign, top right: plenary lecture by K. Spurný, bottom (from left): two former ČAS presidents V. Ždímal and J. Smolík with our colleague J. Kugler.



Obr. 2 / Fig. 2: Místa konání výročních konferencí ČAS / Venues of the ČAS annual conferences (1999–2026).



Obr. 3 / Fig. 3: Počet příspěvků a účastníků konferencí (2000–2026; 2026 podle návrhu sborníku a registrací) a členů ČAS platících příspěvky (1999–2025; podle P. Moravce a P. Pokorné) / Number of conference contributions and participants (2000–2026; 2026 based on the draft book of abstracts and registrations) and of fee-paying ČAS members (1999–2025; courtesy of P. Moravec and P. Pokorná).

PREZENTACE/PRESENTATION

LONG-TERM DECLINE IN CLOUD CONDENSATION NUCLEI NUMBER CONCENTRATIONS AT THE KOŠETICE BACKGROUND SITE

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Keywords: Cloud condensation nuclei, long-term trends, rural background site.

INTRODUCTION

Cloud condensation nuclei (CCN) are aerosol particles capable of activating into cloud droplets at a given supersaturation. Their abundance depends strongly on particle number concentration and size distribution, while chemical composition and hygroscopicity further influence activation (Paramonov et al., 2015; Schmale et al., 2018). Long-term observations help to distinguish persistent changes in CCN abundance from short-term and seasonal variability. This study examines CCN concentration trends at the National Atmospheric Observatory Košetice, a rural background site in the Czech Republic.

METHODOLOGY

CCN number concentrations from November 2021 to November 2025 were evaluated using monthly distributions and weekly medians. Locally weighted scatterplot smoothing (LOWESS) describes the non-linear temporal evolution of the weekly medians. The Mann–Kendall test assesses the direction and significance of the monotonic trend, and Sen's slope estimates its annual rate of change.

RESULTS, DISCUSSION, CONCLUSIONS

The analysis indicates a statistically significant decrease in CCN number concentration (Mann–Kendall $\tau = -0.26$, $p < 0.001$), with a Sen's slope of -62.20 #·cm^{-3} yr^{-1} (Fig. 1). Monthly medians were approximately 0.5 –1.7 × 10^3 #·cm^{-3}, with substantial variability persisting throughout the record. The LOWESS curve rose to approximately 1.2 × 10^3 #·cm^{-3} in 2022, exhibited subsequent fluctuations, and declined to approximately 0.6 × 10^3 #·cm^{-3} by late 2025.

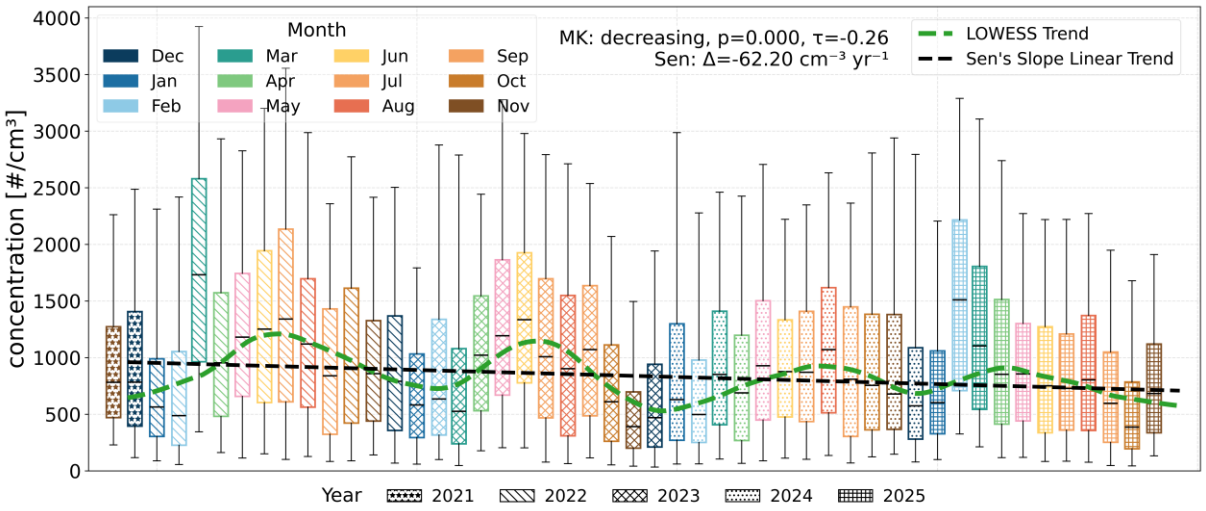


Fig. 1: Monthly CCN concentrations from November 2021 toNovember 2025. Boxes: 25th–75th percentiles; whiskers: 5th–95th percentiles; horizontal lines: medians. Green dashed curve: LOWESS; black dashed line: Sen's slope. The rounded p = 0.000 denotes p < 0.001.

The decline does not establish its cause. Concurrent size distribution, composition, and meteorological observations are needed to explain the Košetice trend. Particle number and size distributions strongly influence CCN abundance, and new particle formation and growth can also contribute to CCN variability (Sihto et al., 2011).

ACKNOWLEDGEMENTS

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RAINWATER CHEMISTRY AS AN INDICATOR OF AMBIENT ICE NUCLEATING PARTICLES?

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Keywords: INP, Clouds, Rainwater

INTRODUCTION

Among the aerosol population, a very small fraction can act as ice nucleation particles (INP), with one potential ice nucleus particle for every 10^5 to 10^3 particles (Murray et al. 2012). Despite their scarcity, they play an important role in cloud formation, lifetime, and precipitation amount (Denman et al., 2007). Recent studies use continuous flow diffusion chambers or expansion chambers to simulate mixed cloud formation conditions and measure the number of ice crystals formed at a set temperature to characterize the ice nucleation ability of an aerosol mix (Moore et al. 2024; Möhler et al. 2021).

Depending on cloud height, type, and synoptic situation, the aerosol population exposed to real mixed cloud formation can differ greatly, and ground aerosol populations may differ from those exposed to ice nucleation (Collaud Coen et al. 2011; Brasseur et al. 2024). Thus, the representativeness of online ground INP measurements needs to be challenged, and rainwater chemistry was tested as one of the possible indicators. In this project, we try to know if rainwater can give us information on the state of aerosols present at the cloud level, the microphysics of the clouds, and whether any link can be made with the aerosols monitored on the ground.

METHODOLOGY

Our current online INP measurement setup at the National Atmospheric Observatory Kosetice (NAOK) consists of a Portable Ice Nucleation Experiment (PINE) measuring INP concentration at 4 meters above the ground. The expansion chamber measures INP at temperatures ranging from -12 to -28°C, with a measurement every 6 min 50 s. We compute an average INP concentration across consecutive measurements at identical temperature settings, thereby reducing the initial concentration detection limit down to 0.125 particles/L.

Alongside PINE, Aerodynamic Particle Sizer (APS), Scanning Mobility Particle Sizer (SMPS), Aerosol Chemical Speciation Monitor (ACSM), Cloud Condensation Nuclei Counter (CCNC), and Swisens Jupiter help characterize the aerosol mix by providing information on the size distribution, the chemical composition, and the hygroscopicity.

We sampled rainwater for 7 precipitation events between May 6th and June 15th, 2026. Collected volumes ranged from 1 to 4 L, depending on the conditions. 7 glass bowls cleaned with ultrapure water were deployed in the field, covering an area of 0.5 m^2. Additional water was provided by the Czech Hydrometeorological Institute (CHMI) automatic rain sampler. We analyzed the water using different methods, depending on the amount available: pH, conductivity, ion chromatography, elemental carbon, water-

insoluble organic carbon analysis, inductively coupled plasma optical emission spectrometry, and cavity ring-down spectroscopy measurements.

Three selected rainwater samples were subjected to additional analysis by NMR aerosolomics, a proton nuclear magnetic resonance spectroscopy-based method developed for molecular profiling of water-soluble organic compounds in atmospheric aerosol (Horník et al. 2021). This approach provides specific information on the compound composition of polar organic material scavenged from the atmosphere during precipitation.

HYSPLIT back trajectory analysis was performed to understand the pathway of the air masses measured at both the ground and cloud levels. The cloud height was retrieved thanks to the CHMI Kosetice ceilometer data.

RESULTS

We present detailed characteristics of the ground aerosol population before, during, and after the different rain events. Thanks to the comparison, we can assess what has been removed from the boundary layer by wet deposition. Deviation in chemical composition from ground level might indicate a different aerosol population at the cloud level. The cavity ring-down spectroscopy, providing data on water isotopes, helps us determine the cloud microphysics and hydrometeor story. We try to link it with INP concentration and the amount and type of aerosol observed at ground level.

ACKNOWLEDGEMENT

This work was supported by the IGA grant project number 028002, and GACR-26-23514S. Special thanks to Charles University LECHAP laboratory for some of the analysis, Jan Sýkora from UCT for access to NMR, and Hornik Stepan for the measurement and expertise. Thanks also to the UCHP research group of membrane separation, bioorganic chemistry, and biomaterials, and fellow PhD students Matyáš Jedlička and Ally for providing some laboratory equipment. Thanks to the Kosetice observatory and CHMI for the accommodation during the sampling period.

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AEROSOL–CLOUD INTERACTIONS AND THEIR EFFECTS ON PRECIPITATION

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Keywords: aerosol–cloud interactions, precipitation, WRF, cloud microphysics

INTRODUCTION

Atmospheric aerosols influence cloud formation and precipitation by acting as cloud condensation nuclei (CCN) and ice-nucleating particles (INPs). Changes in aerosol concentration and properties modify the number of cloud droplets and ice crystals, their subsequent growth, and the conversion of cloud water into precipitation. The resulting precipitation response depends on cloud type, meteorological conditions and background aerosol loading. It may become non-monotonic as increasing particle numbers intensify competition for available water or alter the balance between warm- and ice-phase precipitation processes (Fan et al., 2016). Understanding these dependencies is essential for explaining aerosol–cloud interactions (ACI) and identifying the conditions under which particular microphysical mechanisms dominate. This understanding also supports their representation in numerical models, where simplified parameterisations must capture responses that vary across cloud regimes and aerosol environments. A further application is the assessment of intentional aerosol perturbations through cloud seeding.

The aerosol-aware Thompson–Eidhammer microphysics scheme (TE14; Thompson and Eidhammer, 2014) provides a framework for investigating these dependencies within the Weather Research and Forecasting (WRF) model. It represents two prognostic aerosol categories: water-friendly aerosols (NWFA), which provide particles for cloud droplet activation, and ice-friendly aerosols (NIFA), which contribute to heterogeneous ice nucleation. This study examines how aerosol concentration and activation properties affect simulated precipitation in contrasting winter orographic and summer convective regimes, with emphasis on the microphysical processes underlying the response. It also evaluates the limitations of the default monthly aerosol climatology and tests an offline methodology for replacing it with event-specific aerosol fields derived from WRF-Chem.

METHODOLOGY

Simulations used WRF v4.5.2 with TE14, ERA5 meteorological forcing and two-way nested domains at 9 km and 3 km horizontal spacing. The inner domain covered central Europe and the Alps, with 40 vertical levels and no cumulus parameterisation, allowing precipitation to develop through resolved dynamics and aerosol-aware microphysics. Winter orographic precipitation on 5 January 2019 and deep convection over Berlin on 29 June 2017 were selected to compare contrasting cloud regimes. NWFA and NIFA initial and lateral boundary fields were perturbed separately by factors of 0.01, 0.1, 0.5, 2, 10 and 100 relative to the default climatology.

Additional experiments tested the influence of aerosol activation properties at unchanged initial aerosol number concentrations. The prescribed mean dry radius and hygroscopicity were modified through the CCN activation lookup table: default values of 0.04 μm and $\kappa = 0.4$ were replaced by low-activation (0.01 μm, $\kappa = 0.2$) and high-activation (0.16 μm, $\kappa = 0.8$) variants.

To represent event-specific aerosol conditions, WRF-Chem with the simple GOCART scheme was run for the preceding 24 h, initialised from EAC4 aerosol reanalysis. Aerosol mass mixing ratios were converted into number mixing ratios using assumed lognormal size distributions: dust supplied NIFA, while sulfate, organic carbon and sea salt supplied NWFA. These fields initialised separate TE14 simulations without online chemistry coupling. Paired Berlin metropolitan aerea spin-ups with anthropogenic emissions enabled and disabled assessed their short-term contribution, while the Saharan dust event of 15 March 2022 tested the effect of replacing monthly climatology with an individual dust outbreak.

RESULTS AND DISCUSSION

In the winter case, increasing NIFA produced an almost monotonic increase in domain-integrated precipitation and a shift towards higher precipitation totals. The response was consistent with an INP-limited mixed-phase regime: additional ice nuclei enabled earlier ice formation and more efficient conversion of supercooled cloud water into precipitation. Ice crystals grew by water-vapour deposition and combined through aggregation, enhancing snowfall particularly along the northern Alpine rim. The response nevertheless varied locally. Near Lake Constance, very high NIFA produced more numerous but smaller, slower-falling ice particles. This weakened the downward ice flux through a persistent supercooled liquid-water layer, reducing riming—the collection and freezing of droplets onto falling ice—and therefore precipitation. This local non-monotonic response illustrates how excessive ice initiation can become counterproductive, providing a possible over-seeding mechanism.

Winter NWFA perturbations produced a U-shaped response: both strongly reduced and strongly enhanced NWFA increased total precipitation. At low NWFA, fewer activated droplets promoted collision–coalescence, producing rain earlier and farther upstream. At high NWFA, suppressed warm-rain formation retained cloud water that was transported towards mountain barriers and subsequently released as concentrated heavy precipitation. Changes in aerosol radius and hygroscopicity reproduced the same qualitative behaviour, indicating that both concentration and activation properties act through the activated droplet population.

The summer case was dominated by sensitivity to NWFA and warm-rain formation. Reduced NWFA produced fewer, larger droplets, favouring collision–coalescence and enhancing precipitation. Increased NWFA distributed cloud water among more, smaller droplets, delaying their growth into raindrops and suppressing precipitation. Unlike the winter case, this suppression was not offset by a comparable orographic release of retained cloud water, so the positive high-NWFA response was absent. NIFA effects were approximately an order of magnitude weaker and largely transient. Their spatial pattern mainly reflected shifts in convective-cell location rather than a systematic change in precipitation efficiency. Changing aerosol activation properties produced responses of the same sign as the corresponding NWFA perturbations, consistent with their shared influence on the activated droplet population.

The contrasting aerosol responses also provide a basis for assessing cloud-seeding potential: NIFA enhancement targets ice initiation, as in glaciogenic seeding, while NWFA perturbations offer a limited analogue of hygroscopic seeding, which seeks to promote droplet growth and collision–coalescence.

Figure 1 summarises the enhanced-aerosol experiments over a common 0–18 h period, helping assess which cloud regimes respond favourably to these perturbations. Winter precipitation increased by approximately 1.2% at NIFA ×100, consistent with favourable conditions for glaciogenic seeding. At NWFA ×100, the increase was about 2.4%, but involved a stronger redistribution towards heavy precipitation. Such enhancement may be less desirable for cloud seeding if the additional precipitation is concentrated into local maxima, potentially increasing precipitation-related hazards. Summer NWFA enhancement reduced precipitation by approximately 2–3%, whereas enhanced NIFA caused only small changes. These experiments help identify relevant regimes and microphysical mechanisms, while a more realistic assessment of cloud-seeding effects would require adapting the experiment design to localised aerosol perturbations representative of seeding releases.

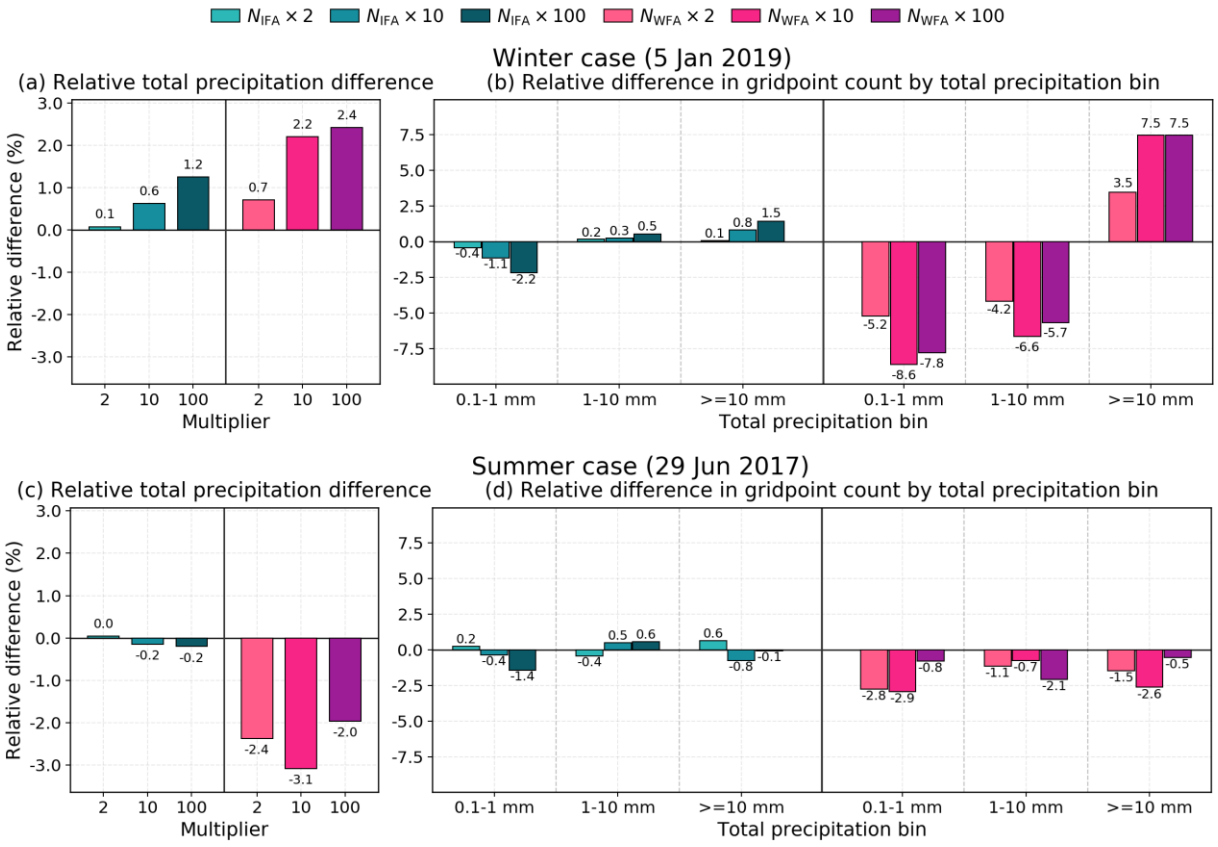


Figure 1. Response to enhanced NIFA and NWFA (×2, ×10 and ×100) in the winter (top) and summer (bottom) cases over a common 0–18 h period in the inner domain. Left: relative change in domain-integrated precipitation. Right: relative change in grid-point counts within accumulated-precipitation bins.

The WRF-Chem experiments highlighted the importance of the assumed aerosol background, consistent with Marelle et al. (2025). For Berlin, both derived NWFA fields were lower than the monthly climatology over much of the domain, and both increased precipitation relative to the climatological control. This response was consistent with fewer activated droplets favouring collision–coalescence and warm-rain formation.

Disabling anthropogenic emissions during spin-up produced the larger increase, while including emissions raised NWFA and partially suppressed precipitation. Thus, replacing the climatology and adding anthropogenic emissions affected precipitation in opposite directions. The disabled-emissions run still retained aerosols from its initial conditions, so the comparison assessed the short-term contribution of emissions rather than a pristine background.

For the Saharan dust case, NIFA within the plume reached approximately 10^9 kg^{-1} at 700 hPa in the parent domain, compared with about 10^6 kg^{-1} in the climatology, while dust-poor regions contained substantially less NIFA. The replacement therefore introduced spatially contrasting perturbations. Although the mechanisms behind the full-day response remain partly unresolved, the methodology developed here provides a basis for further experiments examining how event-specific dust distributions affect cloud microphysics and precipitation.

CONCLUSIONS

The experiments identify contrasting aerosol sensitivities: winter orographic precipitation was predominantly INP-limited, while summer convection responded mainly to CCN and warm-rain processes. Within these cases, TE14 produced physically interpretable responses involving enhanced ice formation, changes in collision–coalescence and delayed precipitation from retained cloud water. Local particle competition and the interaction between cloud-water transport and orographic lifting explain why responses can become non-monotonic or vary within one event. Aerosol effects must therefore be interpreted in relation to the cloud regime and dominant precipitation pathway; increasing aerosol loading does not imply a consistent increase or decrease in precipitation.

Event-specific aerosol initialisation substantially altered both the magnitude and spatial structure of the response, highlighting the importance of the assumed aerosol background. The offline WRF-Chem–TE14 approach offers a practical alternative to monthly climatology for studying anthropogenic aerosol effects and Saharan dust outbreaks, and can be extended through targeted modifications of the experiment design to investigate intentional precipitation modification.

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OXIDATIVE POTENTIAL OF PM: TRANSITIONING FROM RESEARCH TO REGULATION

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INTRODUCTION

Particulate matter (PM) is a major global health challenge, responsible for over 7 million premature deaths each year, with more than 4 million linked specifically to fine particles. Beyond the sheer amount of PM, its toxicity depends on chemical composition and source, but pinpointing the most harmful components is difficult due to their complexity and variability. The oxidative potential (OP) of PM, which measures the particles' ability to produce reactive oxygen species and trigger oxidative stress, has become a key indicator connecting PM chemistry, emission sources, and biological effects. Over the past 20 years, OP has been widely adopted, with over 2,100 studies and 70 research groups regularly measuring it. Its popularity is driven by the ease of acellular OP assays compared to traditional toxicology approaches, and its visibility in recent high-impact publications. Its significance is also recognized in the 2024 European Union Air Quality Directive (EU 2024/2881/CE), highlighting OP as a pollutant of growing concern.

This presentation reviews 10 years of research on PM oxidative potential, focusing on chemical characteristics, source attribution, and the relationship with OP. We examine both traditional and newer source apportionment approaches, including receptor models, and CTM. We also present recent methodological advances from our team for more accurately estimating how different PM sources contribute to ambient OP (Dinh et al., 2024). Finally, we explore how OP-based source attribution is applied in epidemiological studies linking PM exposure to health outcomes, demonstrating its potential to guide targeted air quality management and public health strategies (Tassel et al.,). This policy shift highlights the need for an updated review of OP measurements and their remaining challenges.

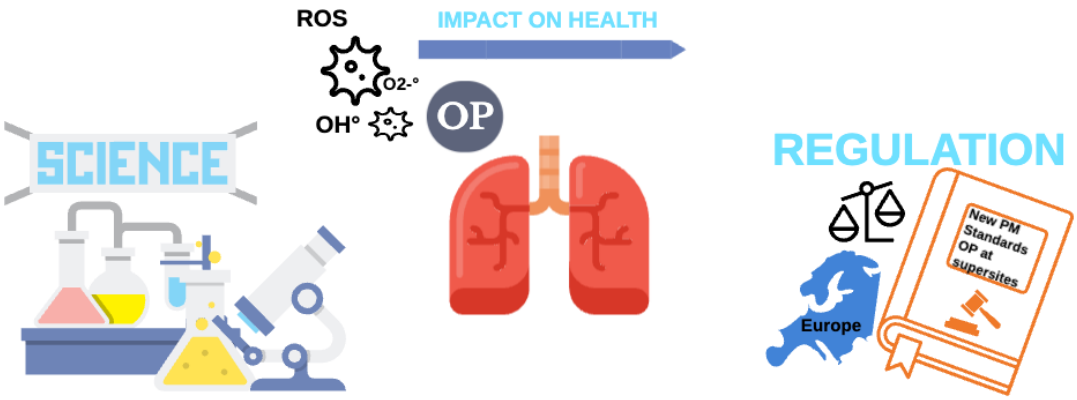


Fig. 1: OP from research to regulation

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OXIDATIVNÍ POTENCIÁL PM1 A PM10 S KYSELINOU ASKORBOVOU A DITHIOTHREITOLEM

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Key words: oxidative potential, ascorbic acid, dithiothreitol, PM1, PM10, simulated lung fluids

SUMMARY

Atmospheric particulate matter (PM) is a complex mixture of chemical compounds that adversely affect human health through mechanisms involving oxidative stress (Novo-Quiza et al., 2024). Oxidative potential (OP), reflecting the ability of particle constituents to promote oxidative reactions and deplete antioxidants, has emerged as a complementary indicator of PM toxicity. Its assessment is influenced not only by particle size and composition but also by the chemical composition of the extraction medium (Cigánková et al., 2021). Simulated lung fluids (SLFs) provide a more physiologically relevant approach for evaluating interactions between inhaled particles and the pulmonary environment. Furthermore, seasonal variations in emission sources and atmospheric conditions may alter aerosol composition and its oxidative activity. This study aims to compare the OP of urban aerosol particles measured using ascorbic acid (AA) assay in three simulated lung fluids—Gamble's solution (GS), simulated alveolar fluid (SAF), and artificial alveolar fluid (AAF)—and to investigate differences between winter and summer sampling campaigns.

METODY MĚŘENÍ

Vzorkování městského aerosolu probíhalo v roce 2023 během dvou odběrových kampaní, zimní (únor–březen) a letní (červenec–srpen). Pomocí velkoobjemového vzorkovače DHA-77 a DHA-80 (Digitel) byly při průtoku vzduchu 30 m^3/h zachycovány částice velikostních frakcí PM_1 a PM_{10} na nitrocelulózové membránové filtry (Sartorius, průměr 150 mm, velikost pórů 3 μm). Každá kampaň zahrnovala 14 vzorků od každé velikostní frakce, přičemž jednotlivé odběry trvaly 48 hodin. Celkem tak bylo získáno 56 vzorků aerosolu.

Po odběru byly filtry rozděleny na čtyři stejné části. Jedna z nich byla určena ke stanovení celkové koncentrace prvků, zatímco ostatní byly po dobu 24 hodin extrahovány v simulovaných plicních tekutinách –GS, SAF a AAF. Získané extrakty byly následně využity k posouzení biodostupnosti prvků a stanovení oxidativního potenciálu (OP) aerosolu.

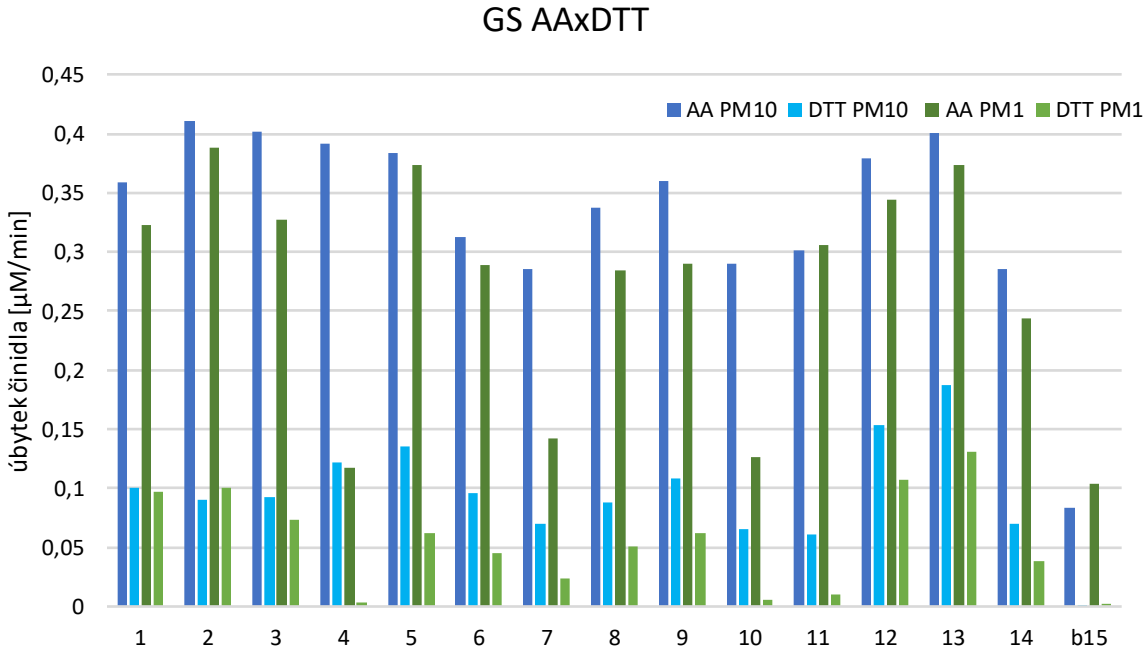
Pro stanovení OP byly použity dvě bezbuněčné metody založené na sledování úbytku redukčních činidel: dithiothreitolový (DTT) test a test s kyselinou askorbovou (AA).

V obou případech probíhala inkubace extraktů při 37 °C. U testu s DTT v předem stanovených časových intervalech byla reakce ukončena a zbytkové množství DTT bylo stanoveno spektrofotometricky při 412 nm po reakci s 5,5´-dithiobis-2-nitrobenzoovou kyselinou (DTNB). Princip AA testu spočíval ve spektrofotometrickém sledování poklesu koncentrace kyseliny askorbové při 265 nm v důsledku její reakce s redoxně aktivními složkami aerosolu ve stejných časových intervalech jako DTT. Rychlosti úbytku DTT a AA byly využity ke kvantifikaci oxidativního potenciálu a následnému porovnání jednotlivých velikostních frakcí, extrakčních prostředí a odběrových období.

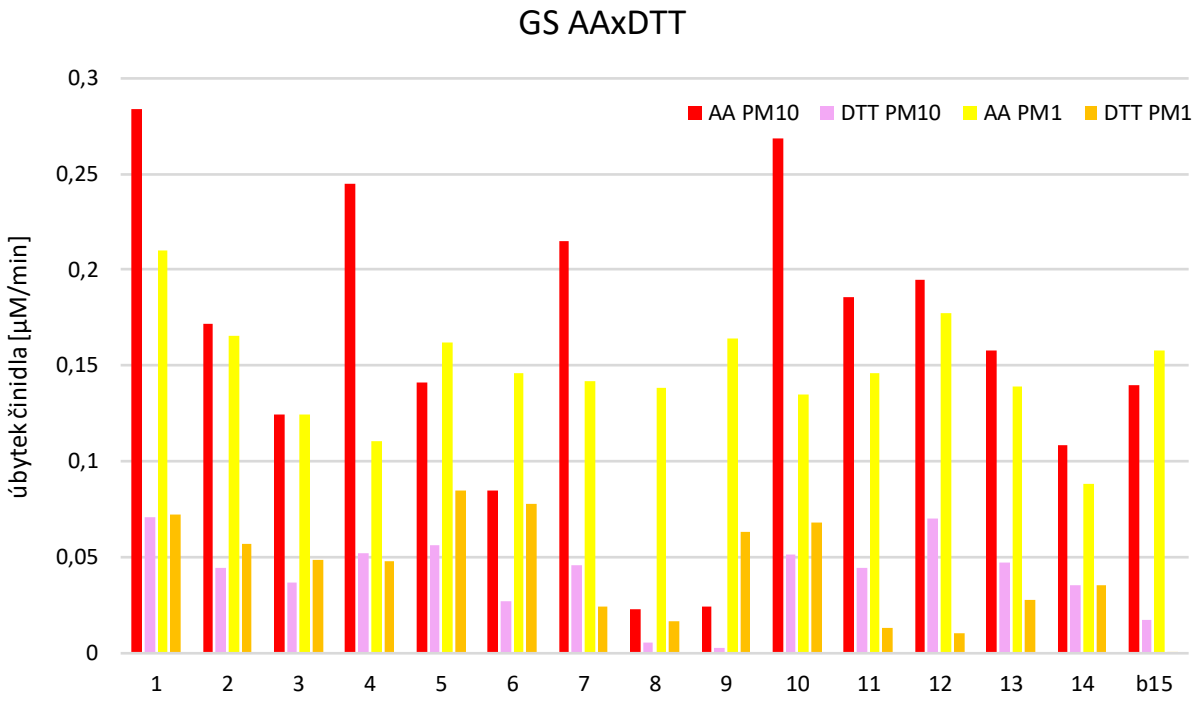
VÝSLEDKY A ZÁVĚR

OP městského aerosolu se lišil v závislosti na použité simulované plicní tekutině, velikostní frakci, odběrovém období a analytické metodě. DTT test vykazoval vyšší průměrné hodnoty OP během zimní kampaně ve všech sledovaných podmínkách, přičemž nejvýraznější sezónní rozdíl byl zaznamenán u PM_{10} v GS, kde byla zimní hodnota přibližně 2,4krát vyšší než letní.

Naproti tomu AA test ukázal vyšší zimní hodnoty v GS a AAF, zatímco v tekutině SAF byl pozorován opačný trend. Významnou roli hrálo také extrakční prostředí. Zatímco nejvyšší průměrné hodnoty DTT-OP byly zpravidla zaznamenány v SAF nebo AAF, u AA testu vykazoval nejvyšší průměrné hodnoty GS ve všech skupinách vzorků. Frakce PM_{10} obecně vykazovala vyšší OP než PM_1, s výjimkou DTT testu v GS během letní kampaně. Výsledky naznačují, že naměřená oxidační aktivita výrazně závisí na složení extrakčního prostředí a použité analytické metodě.



Obr. 1: Porovnání metody AA a DTT v GS pro velikostní frakce PM1 a PM10 v zimě



Obr. 2: Porovnání metody AA a DTT v GS pro velikostní frakce PM1 a PM10 v létě

PODĚKOVÁNÍ

Tato práce byla podporována grantem FCH-S-26-8994 Integrované ekotoxikologické, analytické a syntetické přístupy v environmentální chemii a vývoj environmentálních technologií.

LITERATURA

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EFFECT OF ATMOSPHERIC AGEING AND PAH DERIVATIVES ON AEROSOL OXIDATIVE POTENTIAL (OP)

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Keywords: DTT assay, PAH derivatives, HR-ToF-AMS, Dual Carbon isotopes

INTRODUCTION

Fine particulate matter ($PM_{2.5}$) is a major environmental health risk, associated with respiratory, cardiovascular and neurological disease, and its adverse effects are increasingly attributed to redox-active organic constituents that promote reactive oxygen species (ROS) formation in humans. Polycyclic aromatic hydrocarbons (PAHs), mainly emitted by incomplete combustion of fossil fuels and biomass (traffic, industry, residential burning and fireworks), together with their derivatives, are among the most toxic and widespread organic components of $PM_{2.5}$. Semi-volatile PAHs partition between the gas and particle phases depending on the meteoroloical conditions and their chemical properties: PAHs with five or more aromatic rings are predominantly particle-bound, whereas 3-4-ring species distribute between both phases. Several congeners are recognised carcinogens, mutagens and genotoxicants (Verma et al., 2017).

During atmospheric processing, PAHs undergo oxidation by OH radicals, NO_2, and O_3 and nitration through OH- or NO_3-initiated reactions followed by NO_2 addition, as well as heterogeneous reactions involving NO_2/N_2O_5, leading to the formation of secondary nitro-PAHs (NPAHs) and oxygenated PAHs (OPAHs). These derivatives can also be emitted directly from primary combustion sources. Some NPAHs, notably 1-nitropyrene, are direct-acting mutagens, whereas quinone-containing OPAHs can undergo redox cycling and generate reactive oxygen species (ROS). Polar functional groups in PAH derivatives can increase their water solubility and chemical reactivity, potentially altering their environmental fate and contribution to PM toxicity relative to their parent PAHs.

Oxidative potential (OP) reflects the redox activity of particle-bound constituents and their capacity to generate ROS, providing an integrative metric of PM toxicity (Bates et al., 2019). Although PAHs and quinones (a redox-active subgroup of OPAHs) have been associated with urban $PM_{2.5}$ OP (Pietrogrande et al., 2022), the contributions of parent PAHs and their nitrated and oxygenated derivatives and their dependence on atmospheric ageing remain poorly resolved. Understanding these relationships is essential for identifying the specific chemical characteristics of PAH transformation products that contribute to $PM_{2.5}$ OP and associated toxicological effects.

METHODOLOGY

$PM_{2.5}$ samples (n = 42) were collected on pre-baked (450 °C, 8 h) quartz-fibre filters with a high-volume sampler on the rooftop of the Physical Research Laboratory, Ahmedabad, from 6 November 2020 to 16 March 2021. The site is a central urban location

affected by traffic, domestic combustion and nearby industry. $PM_{2.5}$ mass was determined gravimetrically and filters were stored at −20 °C until analysis.

PAHs and their derivatives. A 6 cm^2 filter punch was extracted ultrasonically (60 min) in 10 mL dichloromethane : *n*-hexane (4 : 1), cleaned on a silica-gel column and concentrated to 1.5 mL. Thirty-nine compounds were quantified: 16 priority PAHs, 13 NPAHs and 10 OPAHs. Analysis used GC-MS (Bruker SCION SQ; Rtx-5MS column, 30 m × 0.25 mm × 0.25 μm) in selected-ion-monitoring mode, with helium at 1.5 mL min^{-1} and a 39.3 min oven programme (70 to 320 °C). Duplicate analyses (~20% of samples) agreed within 10%, and field and laboratory blanks were subtracted. *Carbonaceous fractions* (OC, EC, WSOC), the water-soluble organic composition (HR-ToF-AMS; f_{44}, f_{43}, O/C) and dual carbon isotopes ($\delta^{13}C$; radiocarbon-derived biogenic fraction, $f_{bio,TC}$) are shown in Devaprasad et al. (2025).

Oxidative potential. OP was quantified with the DTT assay (Verma et al., 2024). Filter extracts (1.5 cm^2 punch; methanol : water, 1 : 1) were filtered (0.45 μm) and incubated with 100 μM DTT at 37 °C, and residual DTT was determined with DTNB at 412 nm. OP is reported per unit air volume (OP_v, nmol DTT min^{-1} m^{-3}) and per unit PM mass (OP_m, pmol DTT min^{-1} μg^{-1}).

RESULTS AND DISCUSSION

$PM_{2.5}$ and OP. The mean ambient $PM_{2.5}$ concentration 93.7 ± 36.4 μg m^{-3} (range: 46.8-237 μg m^{-3}), while mean OC and EC concentrations were 22.5 ± 9.3 μg m^{-3} (10.6-55.4 μg m^{-3}) and 2.8 ± 1.4 μg m^{-3} (0.72-6.88 μg m^{-3}), respectively, reflecting pronounced temporal variability. The highest $PM_{2.5}$ concentration (237 μg m^{-3}), coinciding with the maximum EC concentration (6.88 μg m^{-3}), was recorded on 14 November 2020 during Diwali firework emissions. The mean volume-normalised oxidative potential (OP_v) was 12.5 ± 6.4 nmol DTT min^{-1} m^{-3} (5.17-32.8 nmol DTT min^{-1} m^{-3}), and the mean mass-normalised oxidative potential (OP_m) was 145 ± 76 pmol DTT min^{-1} μg^{-1} (67-386 pmol DTT min^{-1} μg^{-1}). These values exceed most of those reported for other Indian and international sites; for instance, OP_v in summertime Delhi was 2.9 ± 1.1 nmol DTT min^{-1} m^{-3} (Verma et al., 2024). Both OP metrics peaked during the Diwali (16 November) and New Year (1 January) episodes (Fig. 1), when $PM_{2.5}$ concentrations increased by a factor of approximately 2.5.

PAHs and their derivatives. Mean PAHs concentrations decreased in the order ΣPAHs (46.6 ng m^{-3}) > ΣOPAHs (6.7 ng m^{-3}) > ΣNPAHs (3.9 ng m^{-3}), together accounting for only ~0.06% of $PM_{2.5}$ mass and ~0.13% of organic matter, despite their potential toxicity. Individual compounds ranged from 0.60 (anthracene) to 7.81 ng m^{-3} (fluorene) for PAHs, 0.24 (4-methoxy-1-naphthaldehyde) to 1.24 ng m^{-3} (9-fluorenone) for OPAHs, and 0.19 (9-nitrophenanthrene) to 0.53 ng m^{-3} (3-nitrofluoranthene) for NPAHs. By molecular weight, particle-bound high-molecular-weight PAHs (25.7 ng m^{-3}) exceeded low- (14.7 ng m^{-3}) and intermediate-molecular-weight PAHs (6.2 ng m^{-3}). The abundance of chrysene, benzo[b]- and benzo[k]fluoranthene, benzo[a]pyrene, and dibenz[a,h]anthracene is consistent with contributions from traffic-related emissions, while the prominence of benzo[b]fluoranthene may reflect diesel combustion. In contrast, lighter PAHs (naphthalene, acenaphthylene, acenaphthene, and fluorene) indicate volatilization of petroleum-derived hydrocarbons associated with nearby fuel stations.

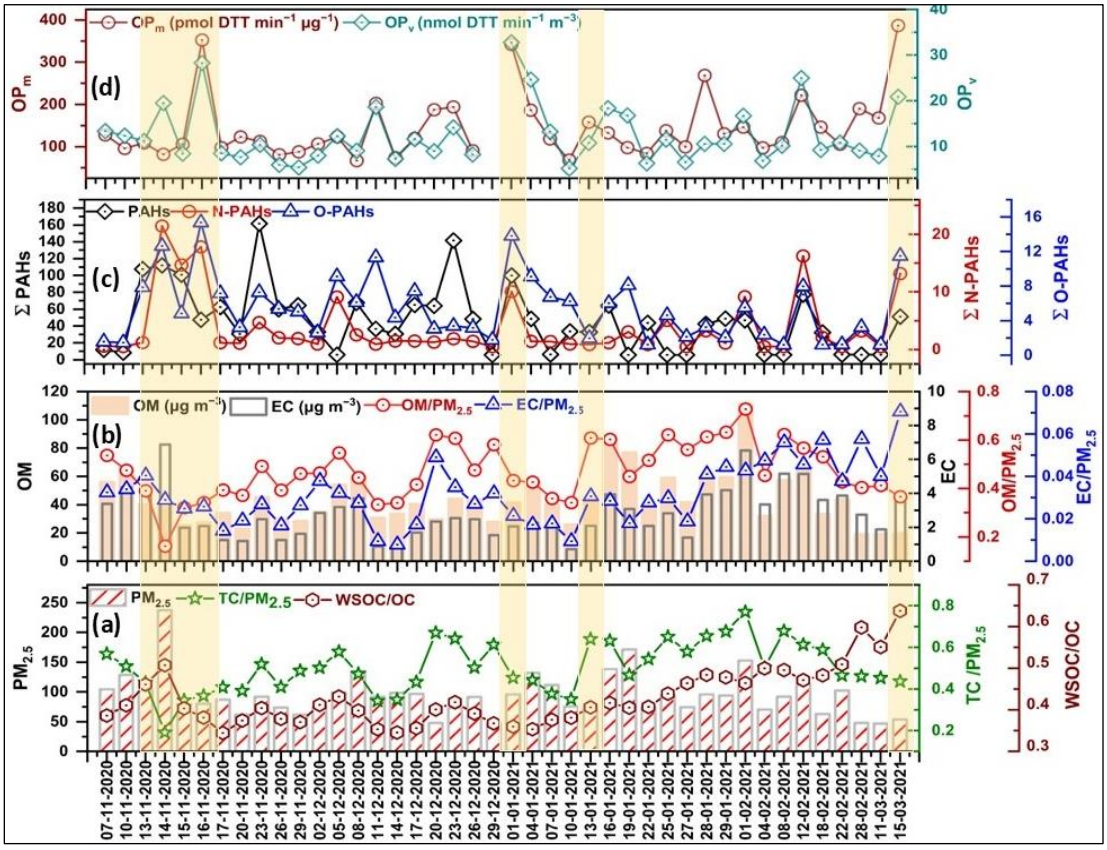


Fig. 1: Time series of (a) $PM_{2.5}$, $TC/PM_{2.5}$ and WSOC/OC, (b) OM, EC, $OM/PM_{2.5}$ and $EC/PM_{2.5}$, (c) ΣPAHs, ΣNPAHs and ΣOPAHs, and (d) OP_m and OP_v; shaded bands mark episodic events

Ageing and OP_v. OP_v was independent of $PM_{2.5}$ mass, indicating that particle composition rather than aerosol loading controlled the redox response (Fig 1). OP_v increased linearly with EC (slope ≈ 5 nmol DTT min^{-1} μg^{-1}) among different aerosol clusters, indicating a consistent EC-associated contribution across samples, whereas regression intercepts varied from +1.87 to −8.79 nmol DTT min^{-1} m^{-3} with ageing state, indicating changes in the EC-independent fraction of OP_v during atmospheric processing. OP_v increased with f_{44}/f_{43} (2.14–6.6) and O/C but decreased with WSOC/OC (0.34–0.64). The strong relationship between OP_v and O/C ($R^2 > 0.85$) among samples of comparable ageing state indicates that greater aerosol oxidation was associated with enhanced redox activity. Collectively, these trends suggest that atmospheric ageing altered the chemical composition of $PM_{2.5}$ in a manner that increased the relative importance of oxidized, redox-active constituents to OP_v.

OPAHs, isotopes, and OP_v. OP_v increased with ΣOPAHs, particularly in samples with $f_{44}/f_{43} > 4.35$, whereas less-aged samples showed associations with both NPAHs and OPAHs. This contrast suggests a progressive shift in the chemical drivers of OP_v during aerosol ageing, from contributions involving both nitrated and oxygenated PAHs toward a stronger association with OPAHs in more aged aerosol. Total-carbon $\delta^{13}C$ (−25.9 ± 0.65‰; range: −27.0 to −23.2‰) and $f_{_bio,TC}$ (0.52–0.68) indicate contributions from mixed fossil-fuel and biomass/biogenic sources.

Functional groups and OP_v. Pearson correlations showed that OP_v was most strongly associated with ΣOPAHs ($R > 0.75$), followed by ΣNPAHs ($R > 0.55$), whereas associations with ΣPAHs were comparatively weak. When normalized to 9,10-phenanthrenequinone (PQN, R value normalized to 1), the relative correlation strengths were 0.96 for ΣOPAHs,

0.77 for ΣNPAHs, and 0.31 for ΣPAHs. Among individual compounds, PQN showed the strongest association with OP_v, followed by 1-nitropyrene (0.85), anthraquinone (0.77), and 1,4-naphthoquinone (0.68). In contrast, unsubstituted PAHs (≤0.46) and OPAHs lacking quinoid groups showed weaker associations. The stronger associations of quinoid- and nitro-substituted aromatic compounds with OP_v are consistent with their greater potential to participate in redox-active pathways and ROS generation. These statistical associations may also reflect contributions from co-varying metals and secondary organics.

CONCLUSIONS

Winter-time $PM_{2.5}$ in Ahmedabad exhibited elevated oxidative potential (OP_v = 12.5 ± 6.4 nmol DTT min^{-1} m^{-3}). While primary combustion emissions (EC) provided a common baseline, OP_v increased with f_{44}/f_{43} and O/C and decreased with WSOC/OC, consistent with increasing contributions from aged, highly oxidised, and less water-soluble organic aerosol. OPAHs showed the strongest association with OP_v, particularly in more-aged samples, with quinones and 1-nitropyrene showing the strongest associations, highlighting the importance of PAH functionalisation rather than parent-PAH mass alone. Dual carbon isotopes indicated mixed fossil-fuel and biomass/biogenic sources. Overall, the results highlight the role of atmospheric ageing and PAH functionalisation in modulating the oxidative potential of wintertime $PM_{2.5}$.

ACKNOWLEDGEMENT

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NMR-OMICS FOR THE ANALYSIS OF WATER-SOLUBLE ORGANIC COMPOUNDS IN ATMOSPHERIC AEROSOL PARTICLES

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Keywords: Atmospheric aerosols, Chemical composition, Seasonal variation, Water-soluble organic compounds, NMR spectroscopy

INTRODUCTION

Aerosol particles as a ubiquitous part of our atmosphere are involved in many processes and their composition has a high variability both in time and geographical location. Studying this variability can help to determine transformation mechanisms of present compounds, as well as transport pathways of aerosol particles. To achieve representative results, we need to describe a wide range of compounds contained in the particles. Regarding organic compounds, the water-soluble fraction is generally less described and needs further study. A method, that could augment that, is NMR spectroscopy, which allows us to measure samples in solution and achieve complementary information to already available data. Even though the method is known to be quite unsensitive, its potential for this application has already been proven (Horník et al., 2021, 2024).

METHODOLOGY

A high-volume Digitel DHA-80 sampler was used for the sampling of PM_{10} aerosol particles at the meteorological observatory Tušimice (Czech Hydrometeorological Institute – CHMI). The samples were collected on quartz fiber filters (diameter 15 cm, Whatman, WHA185315050, Grade QM-H) with the sampling interval of 24 hours. The air flow was set to 500 l/min. There was a summer (June – July 2024) and a winter (January – February 2025) sampling campaign realized.

For the purpose of profiling compounds in measured spectra of real samples, a representative library had to be prepared. In the end, 51 compounds associated with atmospheric aerosols were added to an available commercial library. ^{1}H NMR spectrum was measured for each sample using a 600 MHz NMR spectrometer. The spectra were then used as a template for modelling signals of each compound. Lastly, by analyzing each of the standard spectra, it was confirmed that using the library for profiling yields satisfactory results.

Real PM_{10} samples were first extracted into deionized water and then freeze-dried. Before the measurement, dry samples were redissolved in a small amount of phosphate buffer in D_2O with an NMR standard (TSP) added. ^{1}H NMR spectra were measured under the same conditions as the standard samples, except for the use of 3 mm NMR tubes and the acquisition of 1000 scans.

Each sample spectrum was analysed by the means of NMR aerosolomics and the obtained concentration data was subjected to different statistical methods, both univariate and multivariate, to highlight the seasonal variation in aerosol composition.

RESULTS, DISCUSSION, CONCLUSIONS

There were 62 aerosol samples analyzed in total, of which 31 were collected in summer and 31 in winter. In the acquired spectra, 67 compounds were detected, some appearing in both seasons while others only in one.

The first statistical method used was principal component analysis (PCA). Before the analysis, the data were normalized on the sum of concentrations, and there were 3 scaling approaches tested – no scaling, autoscaling and Pareto scaling. All three approaches to scaling yielded a score plot with clearly separated zones for summer and winter samples (Fig. 1).

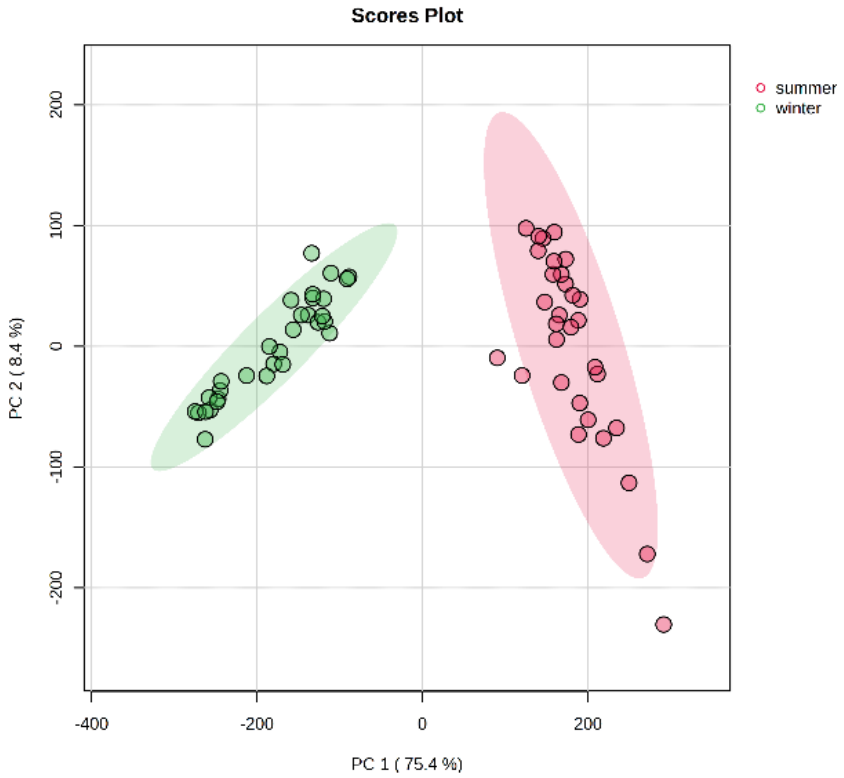


Fig. 1: PCA score plot for normalized data with no scaling. Green dots represent the winter samples, red dots the summer samples.

The PCA loading graphs on the other hand reflected the different scaling methods, with autoscaling coming out as the best at highlighting the impact of compounds present in lower concentration compared to most abundant ones.

Next, univariate statistical methods were used. Volcano plot with the parameters of FC = 5 and p-value = 0.05 after false discovery rate (FDR) correction pointed out 24 statistically significant compounds. Also, correlation matrices were calculated for summer and winter samples individually and the data was then compared with time series graphs to find similar trends in compound concentrations (Fig. 2). The highest values of correlation coefficients were found between levoglucosan, galactosan and mannosan in winter samples which wasn't surprising since all these compounds are known to come from the same source.

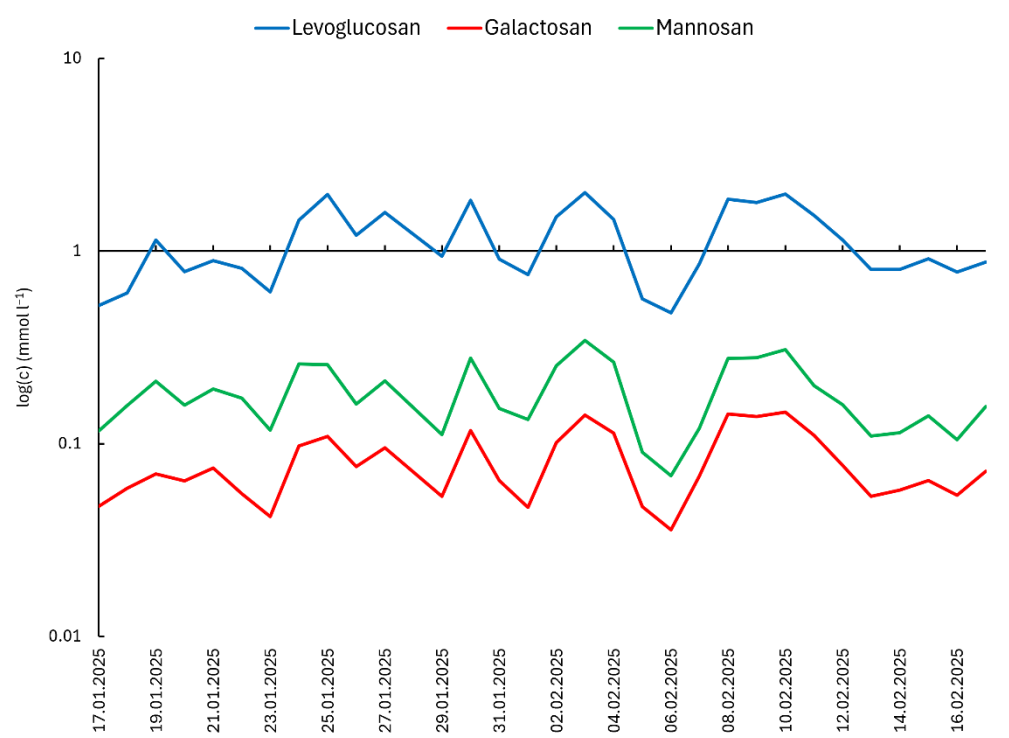


Fig. 2: Time series for concentrations of levoglucosan, galactosan and mannosan in winter samples with a logarithmic scale on y-axis.

Currently, another multivariate statistical method, positive matrix factorization (PMF), is being tested for source apportionment purposes. There is still more optimization needed, but the preliminary results resolved several factors, inluding biomass burning, coal combustion, long-distance transport marine aerosol and one or more biogenic sources.

ACKNOWLEDGEMENT

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TRENDS IN CZECH OCCUPATIONAL DISEASES CAUSED BY INORGANIC DUSTS

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Keywords: Pneumoconioses, Development, Prevention, Statistics

INTRODUCTION

Occupational medicine is an incredibly complex, interdisciplinary field bridging medicine, chemistry, and physics to address a vast spectrum of risks—from physical strain to noise, inhalation risks, skin irritants and allergens, radiation and chemicals exposure, and emerging new technological hazards.

The first In-Patient Clinic of Occupational Medicine in Czechoslovakia, was established at the Emmaus Monastery in the year 1951. It started with 27 beds, and the patients with occupational lung diseases, most frequently silicosis, coal workers pneumoconiosis or asbestosis had to return to the inpatient ward at intervals of 6 to 24 months. However, they often had to come earlier than had been planned due to worsening shortness of breath due to the right hear failure or exacerbation of chronic bronchitis.

Many of them were dyspneic after minimal movement, they depended on oxygen and infusions, which they received up to three times a day. By the end of the 1990s, some of them already had an oxygen concentrator at home with a multi-meter tube to the mask, so that they could lead a bearable life. If they got lung cancer due to silicosis or mesothelioma due to asbestos, they usually died in the clinic after a few weeks (Pelclová 2026).

Their occupational histories included work in underground tunnels or shelters for the government in central Prague, in mineral ore mines for silver and lead in central Bohemia – including Příbram (closed in 1978), Kutná Hora (closed in 1992) and in uranium mines in Jáchymov (closed in 1964) and Příbram (closed in 1991).

The underground black coal mines in Kladno, Central Bohemia, where our patients worked, were closed already in 2002. However, most coal mines were still working in the east of Moravia in Ostrava region, and the last deep black coal mine in the Czech Republic was closed in January 2026.

Uranium mining in Bohemia was strategically important for the USSR, and despite the small size of the Czechoslovak Socialist Republic, it ranked among the world's top ten uranium producers. Such intensive production required a large labor force, which was supplemented by political prisoners and regime opponents sent to labor camps in the uranium mines. Several dozen political prisoners were compelled to extract uranium ore for export to the USSR. By the latter half of the 20th century, Czechoslovakia had effectively become a major uranium powerhouse.

Communist authorities strictly punished any form of dissent and the working conditions for political prisoners were among the harshest. Many of them, including university teachers or lawyers forced to work in the uranium mines, developed lung or skin cancer due to extremely poor hygienic conditions. No respirators or other protective equipment were provided, and they were often required to sleep in soiled work clothes, further compromising their health.

If they developed lung cancer caused by silica, they were not entitled to its compensation until 1997, when the IARC classified silica in group 1, i.e. a human carcinogen causing lung cancer. Until that time, there were not enough studies in non-smokers, and everything was explained by smoking. The insidious thing about diseases caused by these dusts, i.e. pneumoconiosis, is that they develop and worsen even after the worker is removed from the hazardous environment. This progression is proportional to the amount of inhaled dust particles because the dust particles and asbestos fibers permanently provoke a change in the lung structure into non-functional tissue, and the body is unable to eliminate them. Another problem is that workers do not initially experience shortness of breath or a cough, so they feel strong enough to continue their work (Pelclová 2007, 2011). Only a chest X-ray can confirm a dangerous level of damage. If X-rays are not performed on time and workers are not removed from exposure at an early stage, these incurable diseases shorten their lives. This progression can be seen in the X-rays of our patients who stopped working at the initial stage of pneumoconiosis up to the middle of the 20th century.

The most dramatic cases were those of patients who had previously worked with asbestos and were diagnosed with mesothelioma. They were admitted to our Clinic for a dyspnea at rest caused by a fluid that filled sometimes half of their chest cavity. These tumors involved mesothelial cells lining the body cavities, including the pleura, peritoneum, and pericardium. These cells produce fluid that lubricates the space between the layers. Under normal circumstances, it is a tiny amount of fluid to enable the organs to move smoothly. When mesothelioma develops, the amount of fluid reaches liters, which leads to compression of the lung tissue and severe dyspnea at rest.

The patients worked in asbestos processing and eternit producing factories. In the first half of the 20th century, they were not even given personal protective equipment and asbestos was considered an amazing, extremely resistant and useful material. At the time when they worked in an asbestos manufacturing factory or producing asbestos seals, cords or eternit, i.e. asbestos-cement roofs or pipes, their wives commonly had to wash their working clothes at home.

The numbers of occupational lung diseases due to inorganic dusts are decreasing and the Clinic was changed to an outpatient Department in 2011.

METHODOLOGY

The data concerning the Czech Republic were collected from the Registry of Occupational Diseases of the State Institute of Public Health in Prague.

RESULTS, DISCUSSION, CONCLUSIONS

The numbers of occupational pneumoconiosis, acknowledged in the Czech Republic in the past 30 years, are shown in Figures 1, 2, and 3.

It can be seen that the numbers are decreasing in all categories. The only exception is the coal workers' pneumoconiosis in 2025, the increase may be explained by a higher number of health checks that these miners underwent before leaving work in this year.

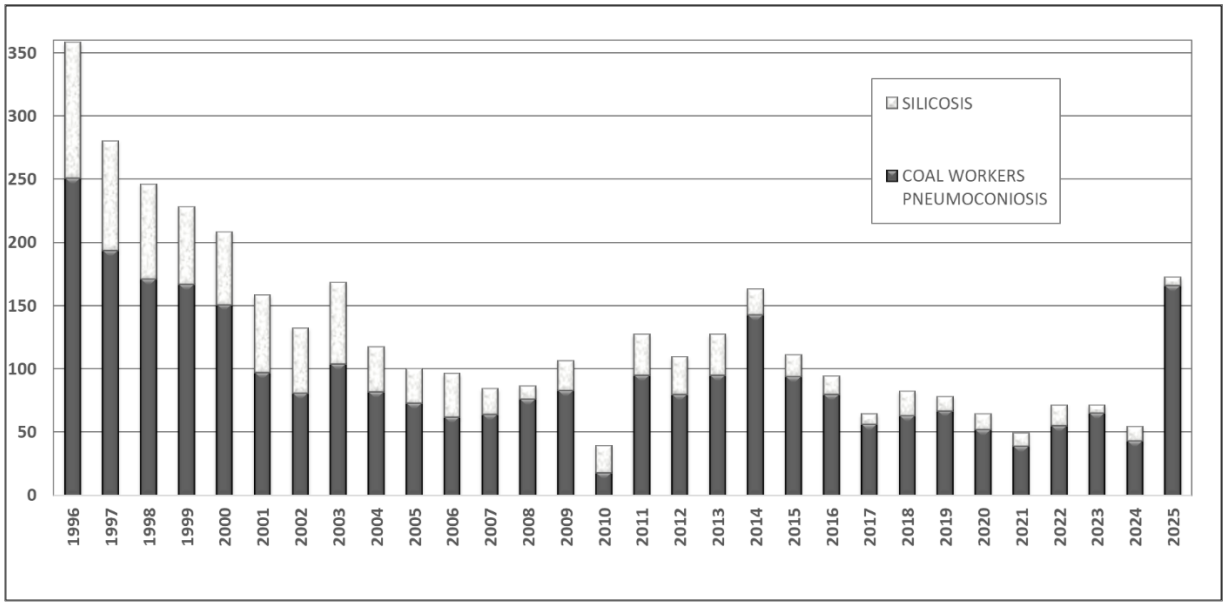


Fig. 1: Acknowledged Silicosis and Coal Workers Pneumoconiosis in past 30 years

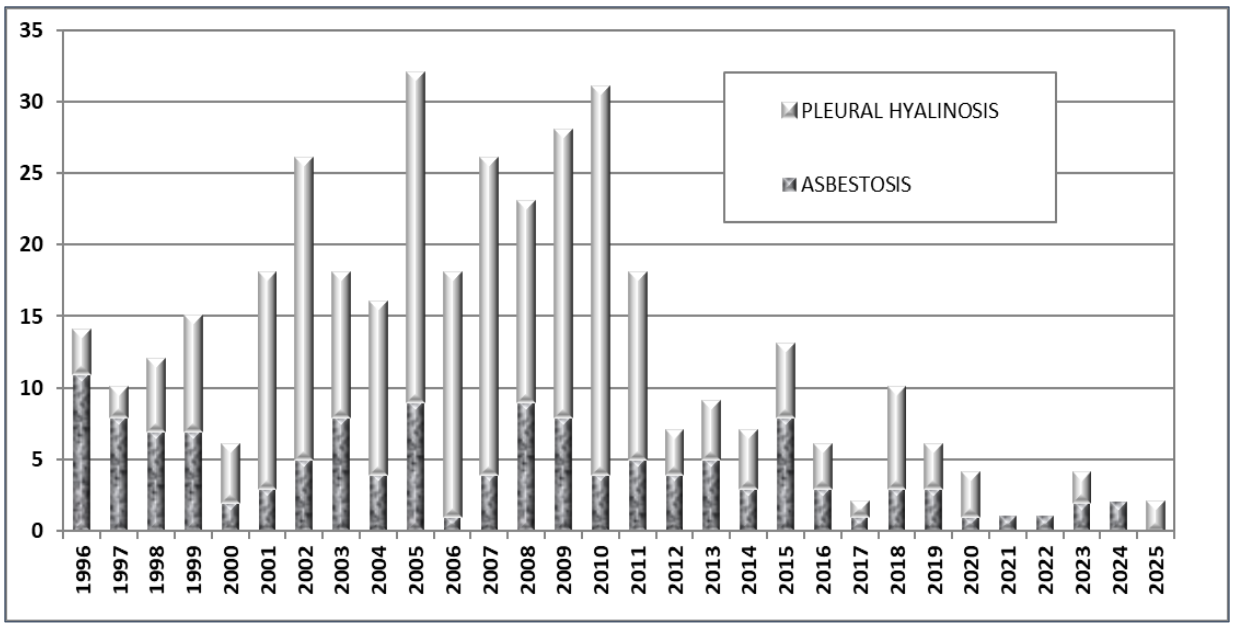


Fig. 2: Acknowledged Benign Diseases due to Asbestos in past 30 years

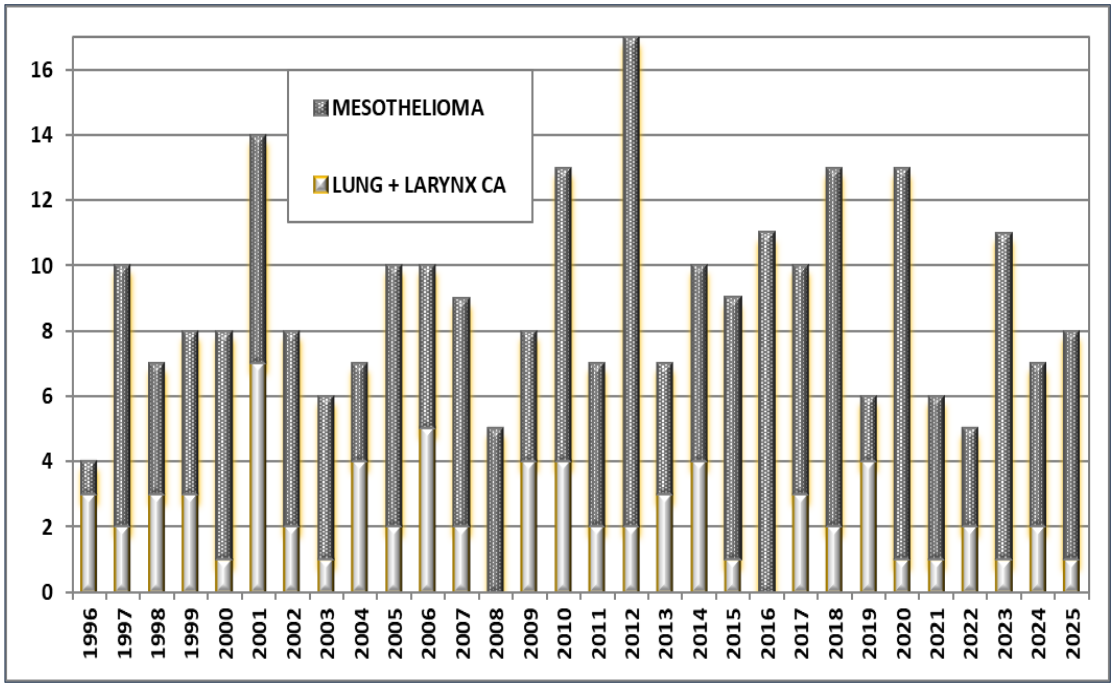


Fig. 3: Acknowledged Malignant Diseases due to Asbestos in past 30 years

Even more importantly, the severity and spectrum of recognized occupational diseases have been changing. The life-threatening pneumoconioses are becoming rare, and asbestosis will not appear as a disease due to recent exposures due to the ban of asbestos and very strict criteria for removing asbestos materials. Asbestos fibers stay in human body until the end of the life. Unfortunately, not all mesotheliomas, that are exclusively caused by asbestos, are acknowledged. Due to the long latency, only about 11 % of these diseases were compensated as occupational (Urban 2022).

However, surprises occur in occupational medicine. A life threatening silicosis from recent exposures was not seen here for decades, but it may occur due to the beautiful artificial SiO_2-containing stone, used in modern kitchens and apartments, with 85% SiO_2 and 7-15% polymeric resin as seen in several countries. This severe disease appeared in the USA, Canada, Israel, Spain, and Australia. In this country, using this material has already been banned, as it led to many lung transplants and lethal cases in young males. Czech Republic did not detect any cases of silicosis caused solely by this exposure yet, but such unwelcome cases could still emerge.

Prevention may sound like a somewhat dry and formal concept. However, it truly changes people's lives and means fewer tragic outcomes, as demonstrated by the history of Occupational Medicine in the Czech Republic.

Great progress in workplace hygiene supervision and in the care of employees exposed to occupational hazards in the past decades has been reflected in a decreasing number of serious occupational diseases and in the gradual reduction of hospital beds dedicated to occupational medicine in the country.

However, sometimes surprises appear, such as the exposure to silica-containing artificial stone. Therefore, it is necessary to inform all pulmonologists and general practitioners and to actively screen for this disease.

ACKNOWLEDGEMENT

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FROM OCCUPATIONAL NANOPARTICLE EXPOSURE TO EPIGENETIC MEMORY: INVESTIGATING MECHANISMS OF ADAPTIVE RESPONSE

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Keywords: Nanoparticles, Inhalation, DNA damage, Adaptive response, Epigenetic memory

INTRODUCTION

Exposure to nanoparticles (NPs) may pose significant health risks depending on their physicochemical properties, exposure route and dose. Although oxidative stress and DNA damage are recognized mechanisms of NP toxicity, repeated exposure may also induce adaptive response that modifies the organism's susceptibility to subsequent challenges. The molecular mechanisms underlying these responses, particularly the potential role of epigenetic memory, remain insufficiently understood.

Previous occupational investigations have provided evidence of adaptive responses in humans exposed to NPs. Building on these observations, the present study investigates potential molecular mechanisms underlying adaptive responses and epigenetic memory following inhalation of iron oxide nanoparticles (FeO NPs), focusing on epigenetic modifications in hematopoietic stem cells (HSCs) and their potential association with immune function and toxicological outcomes.

METHODOLOGY

In a previous occupational study, 21 workers involved in welding metal surfaces and machining nanocomposites and 21 controls without occupational NP exposure were investigated. Blood samples were collected before and after work shifts, and NP exposure was characterized using stationary and personal monitoring. DNA strand breaks (DNA-SB) and oxidative DNA damage in peripheral blood leukocytes were assessed using the comet assay.

In the experimental study, mice are exposed to FeO NPs generated by thermal decomposition of iron(III) acetylacetonate vapor in a hot-wall tube-flow reactor. Particle composition, mass concentration, number-size distribution and morphology are characterized. Systemic toxicity, pulmonary histopathology, inflammatory responses and immune-cell populations are evaluated using biochemical analyses, histology, immunohistochemistry, quantitative PCR, flow cytometry and cytokine assays. DNA strand breaks and oxidative DNA damage are assessed using the comet assay with lesion-specific enzymes. DNA repair proteins, antioxidant enzymes and glutathione levels are also analyzed.

To investigate potential mechanisms of epigenetic memory, HSCs isolated from bone marrow undergo genome-wide DNA methylation profiling using Methyl-Seq technology and analysis of histone modifications by CUT&RUN sequencing. These analyses aim to

identify epigenetic changes potentially associated with immune function and adaptive responses following FeO NP exposure.

RESULTS, DISCUSSION, CONCLUSIONS

In the occupational study, particle monitoring identified machining as the predominant source of NPs. Compared with controls, workers exposed to nanocomposites exhibited significantly increased levels of both DNA-SB and oxidative DNA damage. In machining workers, DNA-SB levels were significantly higher after the work shift than before it, whereas no such difference was observed in welders. Notably, oxidative DNA damage remained comparable between pre- and post-shift samples in both occupational groups.

The absence of an acute increase in oxidative DNA damage, despite evidence of elevated baseline damage in exposed workers, is consistent with the possible induction of adaptive processes associated with chronic NP exposure. However, this interpretation remains tentative, and potential adverse health effects cannot be excluded.

The ongoing experimental investigation will examine whether epigenetic reprogramming of HSCs contributes to adaptive response following FeO NP inhalation. The results are expected to provide further insight into the potential role of DNA methylation and histone modifications in the molecular mechanisms underlying these responses.

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MI-TRAP: MITIGATING TRANSPORT-RELATED AIR POLLUTION IN EUROPE – FIRST RESULTS FROM THE PRAGUE 2026 CAMPAIGN

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Keywords: Traffic emissions, UFP, Black carbon, Volatile particles, Catalytic stripper

INTRODUCTION

Transport – road, air, maritime and rail – is a major source of air pollution in European cities, in particular of ultrafine particles (UFP) and black carbon (BC), as well as of noise (Kumar et al., 2014; Rönkkö and Timonen, 2019). Exhaust emissions contribute mainly combustion-generated UFP and BC, whereas non-exhaust emissions from brake, tyre and road-surface wear and from road-dust resuspension add particles of a wide range of sizes and chemical composition. With increasingly strict exhaust limits and the growing share of electric vehicles, non-exhaust sources already account for a large and rising share of traffic-related PM (Harrison et al., 2021), and the Euro 7 regulation introduces, for the first time, limits for brake particles and tyre abrasion (EU, 2024). Owing to their small size, UFP deposit efficiently deep in the respiratory system and may translocate to other organs; epidemiological studies associate UFP and BC with adverse cardiovascular and respiratory effects (Janssen et al., 2012; Ohlwein et al., 2019), although the independent role of UFP is still debated. Yet neither UFP nor BC is regulated in ambient air, and WHO (2021) issued only good-practice statements for their monitoring. In Prague, the traffic contribution in the ultrafine range was attributed mainly to direct exhaust emissions (Ondráček et al., 2011), and highly time-resolved elemental source apportionment at an urban traffic site identified traffic, soil/road dust and road salt among the local sources of PM2.5 (Windell et al., 2024).

The Horizon Europe project MI-TRAP (MItigating TRansport-related Air Pollution in Europe, 2024–2027), coordinated by NCSR Demokritos and involving 26 partners from 11 countries, focuses on transport-related air-pollution hotspots in ten European cities – busy roads and junctions, but also ports, airports and major railway stations. The project aims to (i) develop and validate advanced online monitoring methods for transport-related pollutants with a focus on UFP, BC and chemical composition, including a methodology of cost-effective (CE) boxes for lower-cost monitoring at hotspots, (ii) operate high time-resolution monitoring of air quality, traffic and noise at these sites, (iii) quantify exhaust and non-exhaust sources, including by near-real-time source apportionment (Manousakas et al., 2025), (iv) propose and assess measures to mitigate pollution from these sources and (v) link exposure to health impacts. The project outputs are intended to serve as a scientific background for future EU air-quality legislation, supporting the mitigation of urban air pollution from all types of transport, and to raise public awareness of transport-related air pollution. Here we introduce the project and give a first look at data from the ongoing Prague campaign.

METHODOLOGY

In each pilot city, MI-TRAP combines one high-resolution (HR) station with two cost-effective (CE) boxes operated in parallel for several months. The HR station hosts research-grade instrumentation – a mobility particle size spectrometer (MPSS), a condensation particle counter (CPC), a filter-based absorption photometer (i.e. aethalometer), an aerosol chemical speciation monitor (ACSM) and a multi-metals online monitor (i.e. Xact); the MPSS, CPC and aethalometer are equipped with a catalytic stripper (CS; Amanatidis et al., 2013) and a three-way valve that switches their sampling between total and solid (non-volatile) particles. The CE boxes use relatively low-cost instruments: a micro-aethalometer (i.e. MA350; BC with fossil/biomass apportionment after Sandradewi et al., 2008), also equipped with a CS and a three-way valve, a sensor of total and solid particle number concentration (TPN and SPN) that also estimates the modal diameter of the size distribution (i.e. NanoDust), an optical particle sizer (i.e. OPS or DustTrak), and CO_2 and RH/T sensors; where applicable, a traffic camera and a noise sensor are added. In Prague, measurements started in July 2026 and continue until mid-October 2026 at three sites with contrasting traffic influence (Fig. 1): the HR station in Holešovice (heavy-traffic site close to the railway station, with a noise sensor), a CE box in Vysočany (roof of a CHMI station at a busy junction, with a traffic camera and a noise sensor) and a CE box in Dobrovíz (village with suburban background near the airport, with a noise sensor). The CE boxes have run since 2 July, the HR station since mid-July. Data are hourly means in UTC.



Fig. 1: Location of the measurement sites. Map © Seznam.cz, a.s., © OpenStreetMap contributors.

FIRST RESULTS

The first weeks of data (July – early August) from the Prague campaign show a clear traffic signal at both urban sites. At Holešovice, total particle number concentrations were typically 5 000–20 000 cm^{-3} and occasionally reached several tens of thousands of particles per cm^3. Aitken-mode particles (25–100 nm) peaked during the morning (05–06 UTC, i.e. 07–08 local time) and evening rush hours, while additional nucleation-mode (6.3–25 nm) maxima appeared later in the morning and in the evening. The catalytic stripper removed roughly 35–50 % of the particles, mostly at 15–25 nm (Fig. 2), a behaviour of semi-volatile traffic nanoparticles known for decades (Kittelson, 1998). At Vysočany, BC was dominated by fossil sources and showed a sharp weekday morning peak at about 06 local time (04 UTC), when traffic builds up while the boundary layer is still shallow, and a second maximum in the late evening, most likely enhanced by the developing nocturnal boundary layer (Fig. 3a); CO_2 followed the same pattern. Solid PN

and BC tracked CO_2, while the volatile PN fraction varied between 0.3 and 0.6 (Fig. 3c). At suburban Dobrovíz, fossil BC was about five times lower (Fig. 3b).

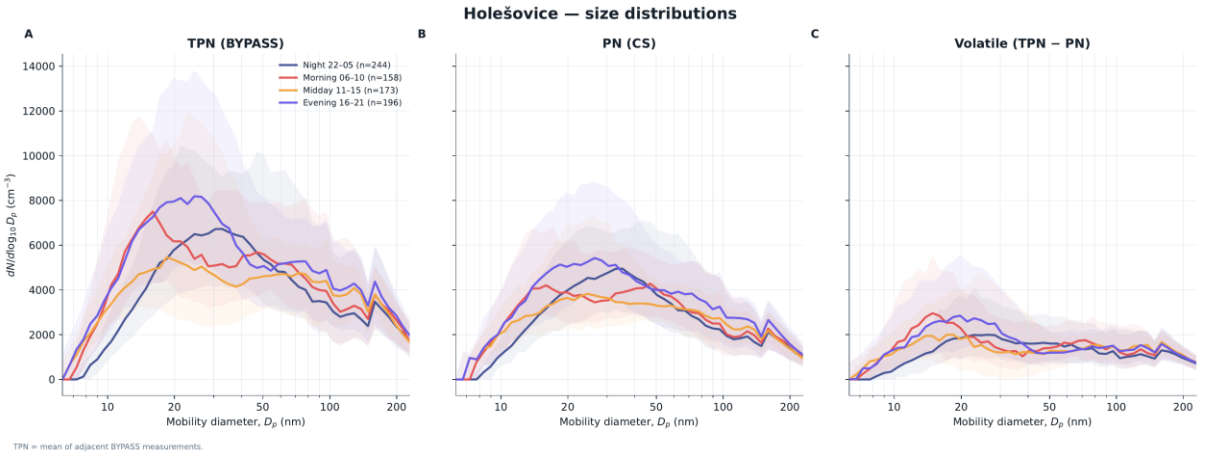


Fig. 2: Mean size distributions at Holešovice by time of day: (A) total particles (bypass), (B) non-volatile particles (catalytic stripper), (C) volatile particles (difference).

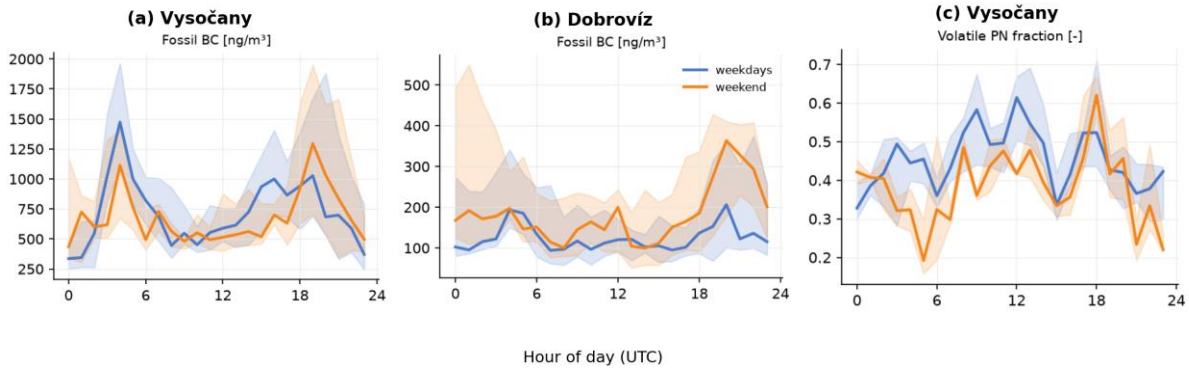


Fig. 3: Diurnal cycles (median and IQR, weekdays vs. weekend) of fossil BC at Vysočany (a) and Dobrovíz (b) and of the volatile PN fraction at Vysočany (c).

CONCLUSIONS AND OUTLOOK

The Prague MI-TRAP campaign captured a clear traffic signal at the urban sites, a strong contribution of volatile particles at the hotspot and a marked BC gradient between urban and suburban sites. The campaign continues until mid-October 2026, extending the dataset to autumn conditions; the combined HR/CE dataset will then be used to evaluate the CE-boxes and to apportion traffic sources.

ACKNOWLEDGEMENT

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ROADSIDE VERSUS ROAD-SURFACE POINT SAMPLING OF VEHICLE PARTICLE EMISSION FACTORS

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Keywords: vehicle emissions, particle number, CO_2, point sampling, remote emission sensing

INTRODUCTION

Fewer than 20 % of the vehicles are estimated to cause 60–90 % of the exhaust particle-number emissions of road traffic (Knoll *et al*., 2024). Point sampling can identify them in real traffic: a fixed inlet near the road draws in the exhaust plumes of passing vehicles, in which concentrations of particles and CO_2 are measured. As long as particles and CO_2 are diluted alike, the ratio of their excess over background does not depend on the dilution; multiplied by the vehicle's CO_2 emission per kilometre, it gives the emission factor in particles per kilometre (Hak *et al*., 2009). An inlet on the road surface in the lane centre resolved individual vehicles in normal traffic (Hak *et al*., 2009) and gave a strong CO_2 signal at a campus gate (Vojtíšek-Lom *et al*., 2025), but it needs access to the road. On the other hand, a roadside inlet is easier to deploy but catches fewer plumes: at nine sites, Knoll *et al*. (2024) obtained a usable CO_2 plume from on average 34 % of the vehicles with an inlet in the road centre, against 25 % and 17 % at the left and right roadside. Whether the two positions give the same factor for the same passage has, to our knowledge, not been measured. Here we compare them.

METHODS

The measurements were made on 12–15 May 2026 at the entrance gate of a campus in Prague-Suchdol, a one-way, single-lane road where every vehicle stops at the barrier and then accelerates away from standstill. Two measuring platforms sampled the same traffic at the same time (Fig. 1).

The centre-line platform had its inlet on the road surface in the lane centre, beneath the vehicles, supplying sample to an FTIR analyser used to measure CO_2 and a condensation particle counter (CPC) to measure total particle number (TPN). The roadside platform had its inlet 1 m above the ground and about 1.5 m from the lane centre, with its own CO_2 sensor and a NanoDust particle counter (TPN mode reported here only). Registration plates were read by a camera. Vehicle type, model year, fuel and type-approval CO_2 emission (g/km) were obtained from the vehicle registry. A passage is detected when a platform's CO_2 rises more than a threshold above its own background (75 ppm at the centre line, 10 ppm at the roadside). Two passages form a pair only when both received the same camera record and their CO_2 maxima agree in time. The factor is the ratio of the particle and CO_2 excess over background integrated over a short window around the CO_2 maximum (9 s for the CPC, 3 s for the NanoDust), converted to particles per kilometre.

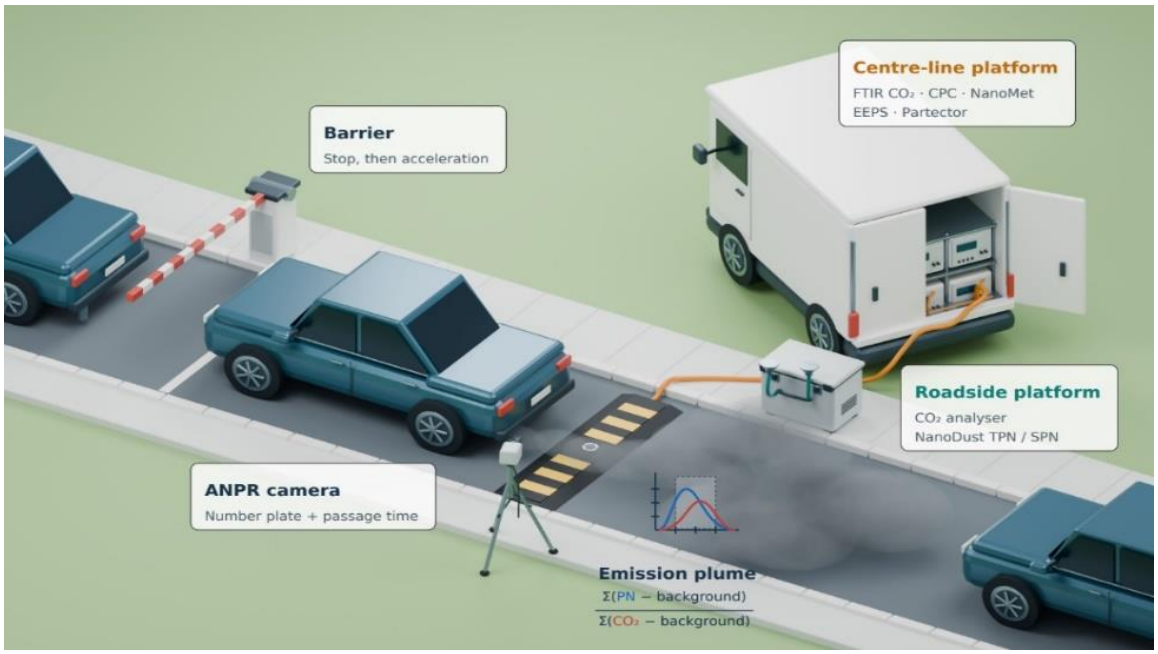


Fig. 1: Sampling arrangement: roadside inlet 1 m above ground, about 1.5 m from the lane centre; centre-line inlet on the road surface; number-plate camera. Not to scale.

RESULTS AND DISCUSSION

The roadside inlet caught about two thirds of the passages detected directly beneath the vehicles. Both platforms identified the same vehicle in 256 passages; 79 of them gave a valid TPN factor on both platforms and 53 a positive one on both. These pairs were ranked by both platforms alike (Spearman 0.81, log–log R^2 0.79), with the roadside factor being typically 2.5 times higher than the centre-line factor (median of the pair ratios), and this ratio varied from passage to passage: 40 % of the pairs agreed within a factor of two and 85 % within a factor of ten. The 2.5-fold difference is systematic and a calibration can remove it; the passage-to-passage variation is what limits a judgement of the technical condition of the vehicle from a single passage. Because each platform also had its own particle counter (CPC vs. NanoDust), both the inlet position and the instruments contribute to this difference.

CONCLUSIONS

A roadside inlet largely reproduces the ranking of high-emitting vehicles obtained directly beneath the vehicle, without access to the road and with about two thirds of the passages captured. What remains is a systematic scale difference that calibration can remove, and a variation from passage to passage, so a decision about an individual vehicle should rest on several passages. Roadside screening can therefore rank vehicles reliably.

ACKNOWLEDGEMENTS

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ROADSIDE DRIVE-BY DETECTION OF DEFUNCT VEHICLE PARTICLE FILTERS: PRACTICAL DETECTION LIMITS AND REPEATABILITY OF MODERATE COST INSTRUMENTS

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Keywords: diesel particle filter, high emitters, particle number, point sampling, detection limit, remote sensing, vehicle emissions

INTRODUCTION

Mobile sources, including motor vehicles, are, along with local heating appliances, principal contributors to fine and ultrafine particles in urban air pollution. Notably internal combustion engines produce carbonaceous nanoparticles which contain carcinogenic semi-volatile organic compounds, efficiently deposit in human lung alveoli and have been reported to penetrate into the bloodstream and, via the olfactory nerve, to the brain. Introduction of diesel particle filters, essentially mandatory from the introduction of particle number (PN) limit in Euro 5b, has greatly decreased diesel engine particle emissions to the point that during certain times, PN concentrations in the exhaust are lower than those in the ambient air ingested by the engine. This and other technical measures aimed to reduce emissions have resulted in an increasingly uneven distribution of emissions within the vehicle fleet: A small number of vehicles with high particle emissions due to defunct or absent filters and/or other defects are responsible for large part of the fleet particle emissions. (It should be noted that a vehicle with a broken, tampered or removed particle filter typically has an additional mechanical problem and therefore has higher particle emissions than an older vehicle without a particle filter, but in good technical condition.) Such high emitters should be, but not always are, identified during the periodic technical inspection (PTI). As an alternative, detection of high emitters using several remote sensing techniques has been demonstrated within the CARES project (Vojtisek-Lom et al., 2025). Of these, PN measurement in a sample extracted from the vehicle travel path (technique called point sampling) at a gated entrance, developed within Horizon Europe projects LENS and MI-TRAP, and described last year at this conference and in Vojtisek-Lom et al., 2025, has shown a very good correlation between emission factor determined from point sampling using laboratory-grade instruments and concentration of non-volatile PN (nvPN) in the tailpipe at idle.

METHODS

During point sampling measurement at a gate, the vehicle stops at the gate, the gate opens, and the vehicle proceeds, leaving behind a diluted plume of exhaust. Sampling line placed at the center of the driving lane or at its edge draws the diluted plume into instruments measuring CO_2 and PN concentrations at fast time resolution. If the CO_2 peak

is sufficiently high (typically 15-100 ppm) above the background concentrations, the emission factor in PN per kg fuel is calculated from the net CO_2 and PN concentrations above the background and assumed carbon content of the fuel.

There are two applicable limits: The type approval limit, applicable to a 30-minute driving cycle (WLTP), of 6e11 particles per km (#/km), and the periodic technical inspection (PTI) limit of 0.25-1.0e6 #/cm^3. Both limits pertain to solid particles, with semi-volatile fraction removed (nvPN), counted at 50% efficiency at 23 nm ($nvPN_{23}$). For diesel engines, at typical fuel consumption of 20 km per kg of fuel and intake air flow of 30 m^3 per kg of fuel, the type approval limit corresponds to 4e5 #/cm^3 in raw exhaust, and to a theoretical 120-800 #/cm^3 roadside peak at CO_2 peak of 15-100 ppm. At exhaust CO_2 concentrations of 1.5-2% (without exhaust gas recirculation) to up to 4% (with exhaust gas recirculation), typical PTI PN limits of 0.25-1.0e6 #/cm^3 correspond, at roadside CO_2 peaks of 15-100 ppm, to a theoretical roadside PN peak of 94-6667 #/cm^3. This applies to $nvPN_{23}$; at $nvPN_{10}$/$nvPN_{23}$ ratios of 1-10 or more, and PN/nvPN ratios from slightly over 1 (old diesel engines) to over 10 (particle filter equipped engines), comparable concentrations for other metrics ($nvPN_{10}$, PN_{10}, ...) are higher.

In this work, several moderate cost instruments were evaluated, and repeated measurements were conducted to assess the consistency of the results among multiple vehicle passages. The measurements took place during morning and mid-day of May 11-15, 2026 at the Czech University of Life Sciences in Prague entrance from Kamýcká street. One set of instruments was located in a van and sampled from the center of the entrance line: CO_2 and other gaseous compounds were measured with a portable FTIR (Bruker Matrix), $nvPN_{10}$ with a portable nvPN counter (NanoMet3, Matter Engineering), PN_{10} with a portable diffusion charger combined with electrical current, induced by particles, detection (Partector2, Naneos), PN_5 with a PTI grade diffusion charger with electrical current detection (ePNC, Dekati), and size distributions with a fast electric mobility sizer (EEPS, TSI). Another set of moderate cost instruments, described in a companion presentation (Sanetrník et al.), was sampling from the side of the road. Vehicle technical information was obtained from the national motor vehicle registry using registration plates automatically read by a camera aimed at the rear of the vehicles. More than 1000 vehicle passages were observed, including tens of vehicles passing three or more times.

RESULTS AND DISCUSSION

Preliminary analysis reveals that during approximately 7 hours of measurement (May 15, 2026), the median spread in 10-second windows, calculated as the difference of maximum and minimum concentrations measured within the window, of $nvPN_{10}$ measured by NanoMet3 (a laboratory grade instrument) was 198 #/cm^3, and of PN_{10} measured by Partector2 (a hand-held moderate cost device) was 1547 #/cm^3. The median concentrations of $nvPN_{10}$ (NanoMet3) were 2836 #/cm^3 and those of PN_{10} (Partector2) were 7343 #/cm^3. The observed variations represent a variety of factors such as instrument noise and artefacts, and variations in background concentrations due, i.e., to presence of diluted plumes from more distant sources such as vehicles on surrounding streets.

Overall, the practical detection limit, accounting for both instrument factors and contributions of other sources to particle and CO_2 concentrations, strongly depends on the exhaust dilution ratio (assessed from peak CO_2 concentration), and on background particle concentration levels and their variation, including interference from previously passed vehicles and other sources. The background concentrations and the threshold

level for a high emitter have implication on the choice of instruments: The benefits of higher precision instruments diminish once the background variability exceeds that of the instrument. The threshold level is a political decision and is likely to be, in reality, dependent on the background concentrations and the prevalence of high emitters, so that the worst of the high emitters are captured while keeping the percentage of failed vehicles to a politically acceptable level. In areas with relatively good air quality, moderate exceedances by a relatively small number of vehicles may be detected with proper care and with repeated measurements, while in relatively polluted areas, moderate cost instruments could be well capable of detecting the worst of the high emitters exceeding the limits by two orders of magnitude or more.

CONCLUSIONS

It is believed that when administered properly, drive-by detection of high emitters at entrance to sensitive places, such as hospital campuses, could serve as a supplementary measure to PTI and as an enforcement of low emission zones, with any single measurement validated either by physical inspection or by repeated measurements.

ACKNOWLEDGEMENTS

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THE NEW PARTICLE FORMATION AT TWO HEIGHTS UNDER DIFFERENT BOUNDARY LAYER AND CLOUD CONDITIONS

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

INTRODUCTION

The Neutral cluster and Air Ion Spectrometer (NAIS) is an electrical-mobility spectrometer designed for measurements of atmospheric ions and nanometer-sized aerosol particles. The instrument measures number size distributions of both positive and negative naturally charged ions, typically in the mobility-equivalent diameter range of approximately 0.8–40 nm, and aerosol particle size distributions from approximately 2–40 nm. Particles and ions are classified according to their electrical mobility and detected using electrometers, allowing the NAIS to resolve the earliest stages of atmospheric new particle formation and subsequent particle growth. (Mirme & Mirme, 2013)

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. (Kulmala et al., 2012)

This study focuses on the vertical development of NPF, examining differences in particle size distributions under varying atmospheric conditions, including cloud occurrence, atmospheric boundary layer height, and precipitation.

METHODS

The measurements were performed at the National Atmospheric Observatory Košetice (NAOK), a rural background station in the Czech Republic. During the summer and autumn campaign of 2025, two Neutral cluster and Air Ion Spectrometers (NAIS) were deployed simultaneously, with one instrument located at ground level and the second installed at the tall tower 230 m above ground level. This configuration enables comparison of particle and ion number size distributions close to the surface and at the upper measurement level. The analysis will focus on the vertical evolution of new particle formation (NPF) in relation to the atmospheric boundary layer height, the occurrence of cloud conditions at the upper measurement level, and precipitation. Meteorological and environmental data, essential for the interpretation of the measurements, are provided under Open Access to the infrastructure ACTRIS-CZ.

RESULTS

NAIS data were collected simultaneously at two different heights (ground and 230 m). The effects of atmospheric boundary layer height, cloud occurrence at the elevated measurement level, and precipitation on the vertical development of NPF were investigated and evaluated on the size distributions of both positive and negative ions in the size range of 0.8–42 nm, and total particles in the size range of 2.5–42 nm.

Aerosol particle and ion size distributions differ between when the tower top is in cloud (as analysed from the ceilometer) and under clear-sky conditions. Both NAIS polarity channels in particle mode show enhanced particle concentrations around 10–15 nm during cloud conditions (Figure 1 bottom), and generally lower ion concentrations (Figure 1 top) compared to clear sky conditions.

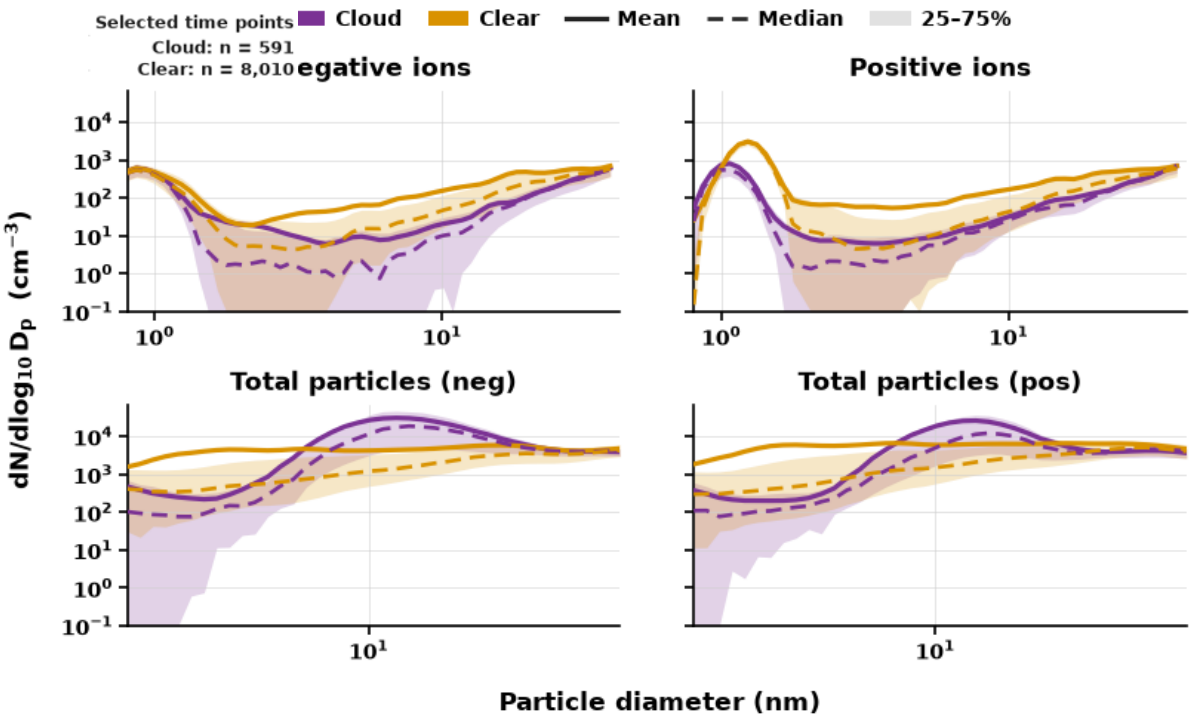


Fig. 1.: Mean (solid lines) and median (dashed lines) particle and ion number size distributions measured by NAIS at 230 m above ground during 18 August–15 October 2025 under in-cloud (purple; n = 591) and clear-sky (orange; n = 8 010) conditions. Shading indicates the 25th–75th percentile range; n denotes the number of selected time points, with valid counts varying by size bin.

ACKNOWLEDGEMENTS

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EXPERIMENTAL EVALUATION OF NUCLEATION PHENOMENA IN AN OXIDATION FLOW REACTOR (DOFR™)

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Keywords: secondary aerosol, DOFR™, SOA, ELPI®+, effective density

INTRODUCTION

Oxidation flow reactors (OFR), such as Dekati® Oxidation Flow Reactor (DOFR™), are aerosol conditioning units designed to simulate atmospheric aging and especially used in studying secondary aerosol formation. DOFR design is similar to previously published OFR TSAR (Tampere University Secondary Aerosol Reactor) (Simonen, 2017). Utilizing high concentrations of OH-radicals and UVC (254 nm) radiation, days-long oxidation processes can be achieved within minutes. The oxidation of volatile vapors, present in the measured aerosol, can make them condensable within the OFR chamber, leading to growth of existing particles or nucleation of new particles. Whether the nucleation takes place depends on the overall process parameters, but more interestingly here, on the ratio between condensable vapor and seed particles of the measured aerosol. So, at the output of the OFR, the condensed particulate mass can end up in its own distribution mode and/or growing the existing seed particle mode. Similar phenomena in which background aerosol influences new particle formation may also happen in real ambient conditions affecting, e.g., pollution formation processes.

METHODOLOGY

In our experiments we varied the ratio between condensable vapor and seed particles around the point where nucleation takes place. Soot seed particles were generated using a Miniature Inverted Soot Generator (MISG). An eDiluter™ Pro along with a catalytic stripper were used to condition and to adjust the concentration of the soot seed particles. As a condensable vapor precursor, toluene, α-pinene, and mixture of their vapors was introduced from a temperature-controlled flow saturator either continuously or in pulses produced with a syringe. The prepared aerosol was then atmospherically aged with a DOFR™ using stable humidity and ozone concentration. The size distribution of the aged aerosol from the DOFR™ was measured with an ELPI®+ and an SMPS (TSI). By combining the information from these two instruments, the effective density (ρ_{eff}) of the generated particles was estimated using the following equation.

$$\rho_{eff} = \rho_0 \frac{C_{aer} Dp_{aer}^2}{C_{mob} Dp_{mob}^2} \quad 1)$$

The aging was controlled by varying the UVC radiation intensity in the oxidation chamber, and a CO gas tracer was used as a marker agent for the aging. A CO analyzer (SICK) monitored the CO concentration after the reactor, and the equations were used to estimate the corresponding aging time.

$$OH_{exp} = \frac{1}{k_{OH,CO}} \ln\left(\frac{[CO]_0}{[CO]_f}\right) = \frac{1}{2.3794*10^{-13}\left[\frac{cm^3}{molec.*s}\right]} \ln\left(\frac{[CO]_0}{[CO]_f}\right) \quad (2)$$

$$t_{eqv} = \frac{OH_{exp}}{1.5*10^6\left[\frac{molec.}{cm^3}\right]} \quad 3)$$

RESULTS, DISCUSSION, CONCLUSIONS

The point where nucleation occurs was found for both the stable and the pulsed vapor cases. Measurements were performed to cover the cases where practically only nucleation or coated soot particles were present, as well as the case where both modes are present. Fig. 1 presents a situation where vapors only condense on top of the soot particles, and nucleation does not occur. Condensation leads to an increase in the aerodynamic size of the soot, while the number concentration stays relatively stable. In Fig. 2, the soot particle concentration is not high enough to work as an efficient sink for condensable oxidation products. Also in this case, the aerodynamic size of the soot particles increases but, due to the nucleation, there is a significant increase in the total number concentration.

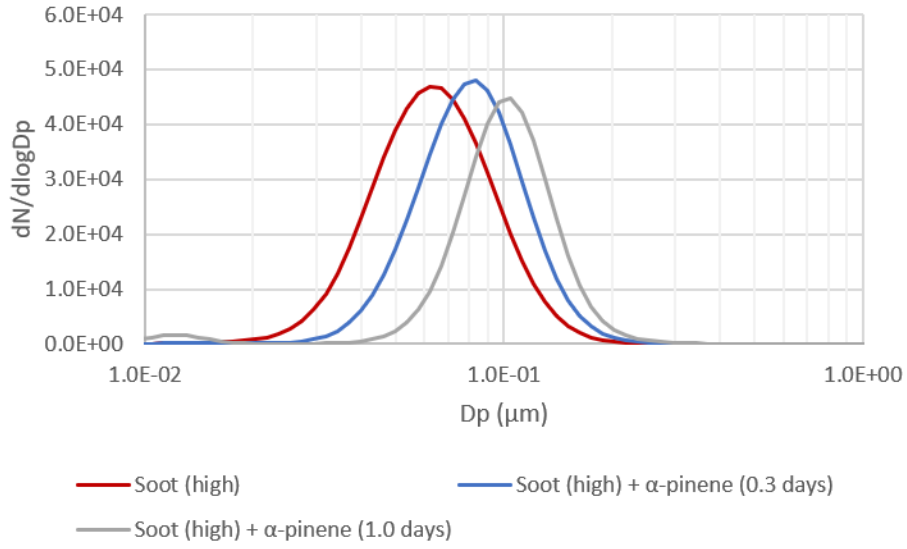


Fig. 1: A high soot particle concentration acts as an efficient condensation sink for α-pinene oxidation products, thereby preventing nucleation.

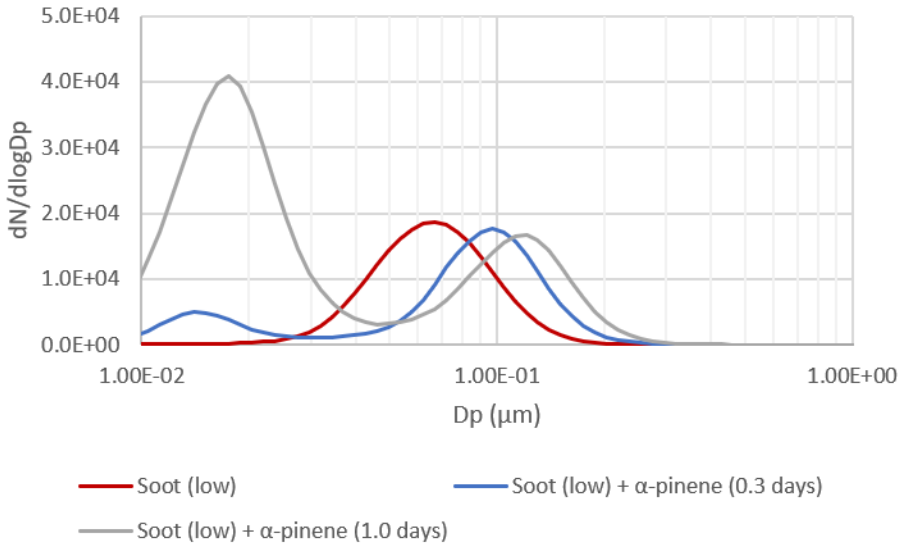


Fig. 2: Low soot concentration can't suppress the nucleation of α-pinene oxidation products.

Clear differences were observed between ELPI®+ and SMPS distributions as the soot seed particles started to grow from the condensing vapor. This indicated changes in the effective density of the measured particles. Further analysis confirmed the observations and showed a significant increase in effective density from 0.4 g/cm^3 to 0.7 g/cm^3.

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VERTICAL PROFILING OF ULTRAFINE PARTICLE NUMBER CONCENTRATIONS USING A PORTABLE WATER-BASED CPC

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Keywords: UFP monitoring; mobile measurement; WCPC; UAV

INTRODUCTION

Water-based condensation particle counters (WCPCs) have been widely adopted since the introduction of a continuous-flow design utilizing water as the working fluid by Hering & Stolzenburg (2004, 2005). Following this milestone, numerous commercial instruments have been developed for the continuous monitoring of ultrafine particles (UFPs). This work introduces a novel, compact, and portable single-channel WCPC (TSI OmniCount™ Model 3001) engineered specifically to facilitate mobile and field-deployable measurements. Furthermore, we evaluate the atmospheric monitoring capabilities of a dual-channel configuration of this platform (Model 3002) integrated onto an unmanned aerial vehicle (UAV) for high-resolution vertical profiling of air quality as shown in Fig.1.



Fig. 1: UAV-integrated OmniCount 3002 condensation particle counter performing vertical profile measurements of aerosol concentration.

METHODOLOGY

The OmniCount™ Model 3001 and Model 3002, Bock et. al (2025), utilize the same core technology as the laboratory-grade TSI Model 3789 Versatile WCPC but in a miniaturized, field-deployable format

The detection efficiency of the single-channel portable WCPC (Model 3001) was evaluated using the experimental configuration illustrated in Fig. 2. Five Model 3001 units were evaluated simultaneously using a monodisperse NaCl aerosol generated via a tube

furnace and classified using a TSI Model 3082 Aerosol Classifier paired with a Model 3085 Differential Mobility Analyzer (DMA). Reference concentration measurements were acquired using a Model 3068B Aerosol Electrometer.

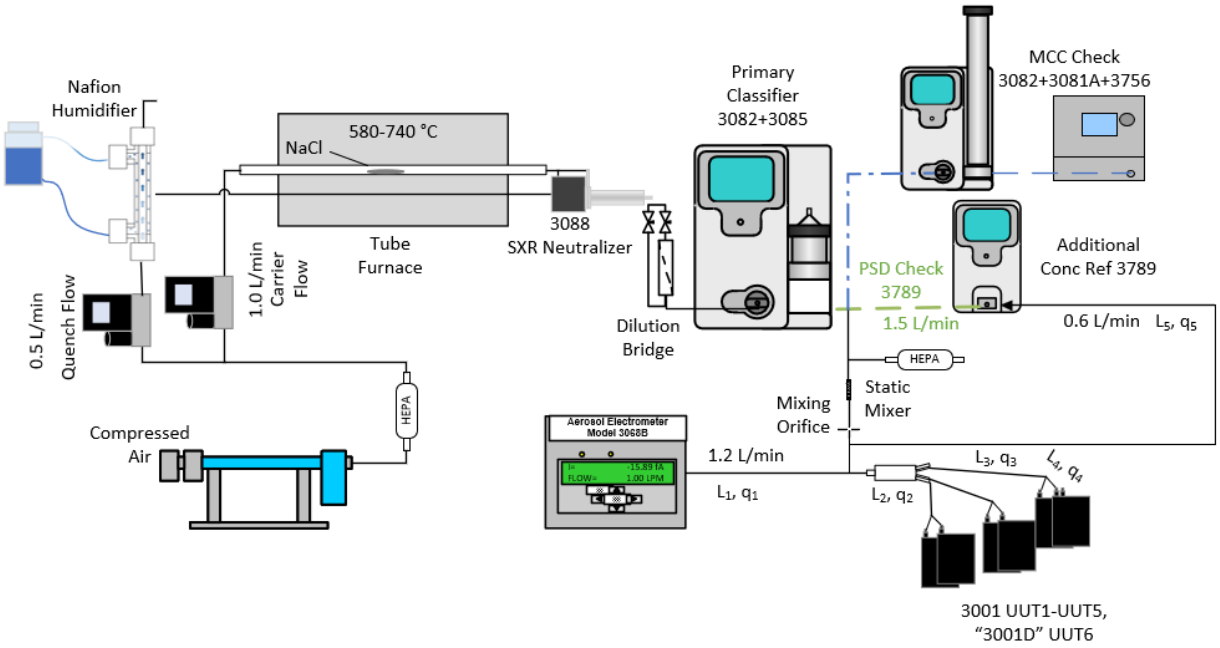


Fig. 2: Schematic of the experimental setup utilized to characterize the counting efficiency of five 3001 OmniCount units using sodium chloride (NaCl) aerosol.

The compiled detection efficiencies and their corresponding curve fits are presented in Fig. 3. All evaluated units demonstrated a detection efficiency exceeding 50% at a particle diameter of 10 nm.

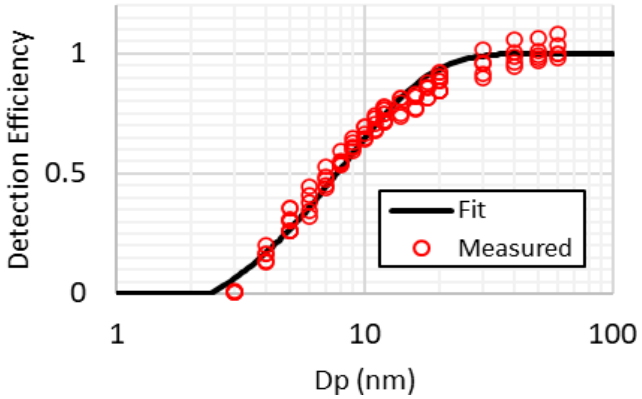


Fig. 3: Particle detection efficiency.

RESULTS, DISCUSSION, CONCLUSIONS

A dual-channel model 3002 particle counter was deployed aboard an unmanned aerial vehicle (UAV) to conduct vertical profile measurements of particle number concentrations (PNC) from ground level up to an altitude of 100 m above ground level (a.g.l.). The flight protocol consisted of a stepwise vertical ascent, with the UAV performing 60-second hovering steps at 5 m intervals to ensure stable sampling. The monitoring site was located on the university campus, directly in front of the main

entrance to the Faculty of Physics and Applied Computer Science (Environmental Physics team) at the AGH University of Krakow.

The raw PNC data initially displayed significant high-frequency fluctuations, which were attributed to the high sampling frequency of 10 Hz. To mitigate this noise, the data resolution was downsampled to 1 Hz and filtered using a median-based rolling window. The processed profiles revealed distinct strata of elevated concentrations at 40 m and 80 m a.g.l., as shown in Fig. 4. Nonetheless, even the peak PNC values remained well below the high-exposure benchmark of 10,000 particles/cm^3 outlined in the WHO Global Air Quality Guidelines (2021) good practice statements for ultrafine particles (UFP).

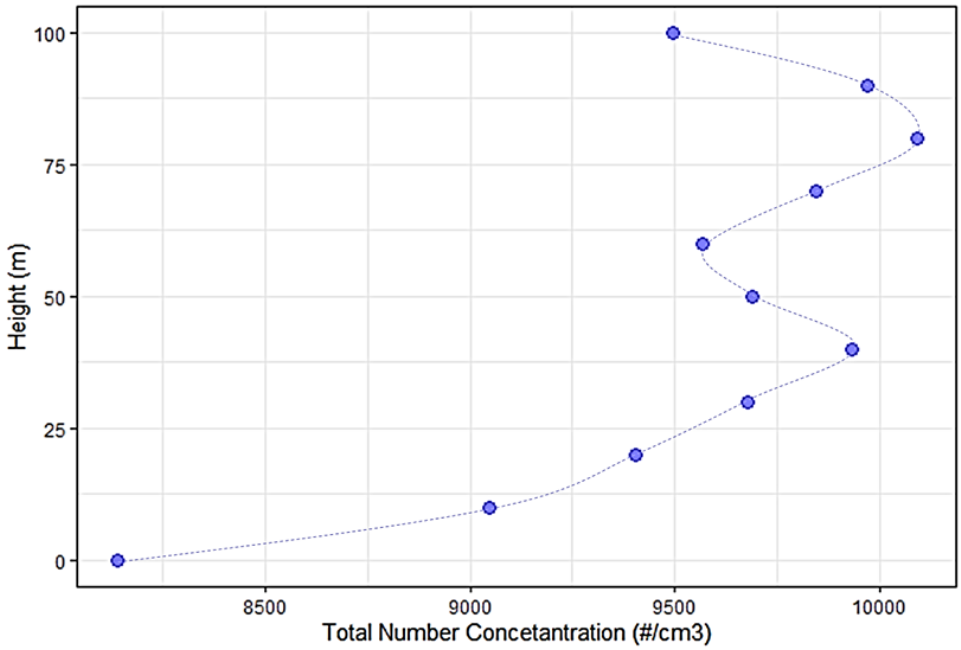


Fig 4. Corrected and smoothened UFP aerosol concentration measured in several heights above ground level.

The vertical distribution of PNC was further validated by simultaneous measurements of PM2.5 and PM10 using UAV-mounted sensors, which showed strong agreement with the hourly particulate mass concentrations recorded at the nearby GIOS reference station on Krasińskiego Avenue (GIOS; October 16, 2025, 14:00).

ACKNOWLEDGEMENT

I would like to express my sincere gratitude to the team from the Faculty of Environmental Physics, the UAV operator, and Maciej Marlega from NG Lab company for organizing the experiment and making it a success, despite the unexpected technical obstacles encountered along the way.

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MEASUREMENT AND CALIBRATION PROCEDURES FOR ULTRAFINE PARTICLES IN EUROPE AND THE EUROPEAN RESEARCH INFRASTRUCTURE ACTRIS

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Keywords: ACTRIS, UFP, Calibration, CPC, MPSS

ABSTRACT

Ultrafine aerosol particles (UFPs) play an increasingly recognized role in air quality, atmospheric processes, and human health, yet their reliable measurement in ambient air remains technically challenging. In Europe, the research infrastructure ACTRIS-ERIC (Aerosol, Clouds and Trace Gases Research Infrastructure) provides a framework for harmonized and traceable in situ observations of short-lived atmospheric constituents. Reliable UFP measurements require standardized measurement procedures, well-characterized instrumentation, and traceable calibrations across observational networks.

Within ACTRIS, quality assurance for particle number concentration and particle number size distribution measurements is supported by the calibration center network, including the World Calibration Center for Aerosol Physics (WCCAP), the Prague Aerosol Calibration Center (PACC), and other units of the Center for Aerosol In-Situ Measurements – European Center for Aerosol Calibration and Characterization (CAIS-ECAC). Measurement and calibration practices are aligned with European standards, in particular EN 16976 for particle number concentration and CEN/TS 17434 for particle number size distributions by mobility spectrometry over a mobility diameter range of approximately 10–800 nm.

The presentation outlines the implementation of these standards in ACTRIS measurement procedures and calibration routines. Instrument calibrations, intercomparisons, and calibration workshops are used to establish and maintain traceability and comparability of particle number concentration and size distribution data across National Facilities, including atmospheric observatories, simulation chambers, and mobile platforms. Recent developments in harmonized documentation, including ACTRIS standard procedures, are also presented.

The ACTRIS approach provides a basis for extending harmonized UFP number concentration and size distribution measurements to routine air-quality monitoring networks. Remaining challenges include the broader implementation of standardized procedures, maintaining traceability across large operational networks, and overcoming technical and organizational barriers to wider uptake. The ACTRIS quality-assurance framework can therefore serve as a blueprint for operational UFP monitoring networks in Europe and beyond.

ACKNOWLEDGEMENT

This work was supported by ACTRIS-ERIC through the ACTRIS Centre for Aerosol In Situ Studies – European Centre for Aerosol Calibration (CAIS-ECAC), which provides calibration, harmonization, and quality assurance activities for aerosol in-situ observations within the ACTRIS research infrastructure.

AN ULTRAFINE AEROSOL CHARGING MODEL

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Keywords: electrostatic precipitator; biomass combustion; DC corona

INTRODUCTION

Ultrafine particles form a substantial part of the number emissions from small-scale biomass combustion, yet electrostatic precipitators (ESPs) collect particles below 50 nm least efficiently: this charging is challenging. The widely used diffusion charging model developed by White is based on kinetic gas theory (White, 1951). It describes the charging of a spherical particle by unipolar ions undergoing thermal motion and diffusion toward the particle surface. The model assumes a continuous ion concentration field and accounts only for the Coulombic interaction between the ions and the charged particle.

This elegant expression is quite simple, but ignores image forces and the dielectric properties of the particle material, which are dominant for particles less than 50 nm, thus resulting in miscalculations. This work proposes an analytical model that retains the comprehensive physics within the simplicity of the White formulation.

METHODOLOGY

The model considers a spherical particle of radius $\boldsymbol{r}$ and relative permittivity $\boldsymbol{\varepsilon}$, and singly charged ions of one polarity with a mean free path $\boldsymbol{\lambda \geq 3r}$.In this free-molecular limit, the charging rate factorises into three physically transparent terms:

$$\frac{dn_n}{dt} = \sigma_{ef}\overline{\langle v_i \rangle} N_0 e^{-\frac{U_c(r)-U_i(r')}{k_b T}} \tag{1}$$

Where $\sigma_{ef} = \pi(r)^2 1 + \frac{U_i(r)}{k_b T}$ is the capture cross-section enlarged by the image force, r′ being the radius at which the image potential reaches the ion thermal energy, $U_c(R) = \frac{nq^2}{4\pi\varepsilon_0 R}$ the Coulomb barrier and the image-force potential $U_i(r) = \frac{(nq)^2}{8\pi\varepsilon_0 r}\frac{\varepsilon-1}{\varepsilon+1}$.; the model contains no free or fitted parameters.

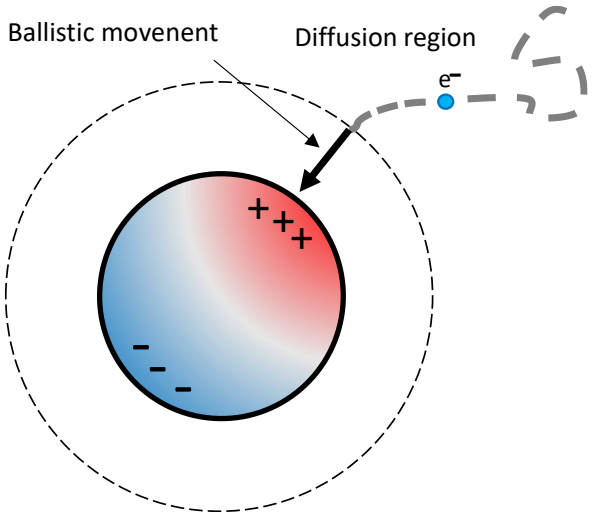


Fig. 1: The ion-particle interaction

The model was validated on a 160 kW automatic pellet boiler with a single-stage honeycomb ESP. Ten regimes combined two thermal outputs (160 and 90 kW) with five discharge currents of 5–40 mA. Fractional efficiencies were determined from ELPI (6–5370 nm) and SMPS (16.8–798 nm) measurements in alternating ESP-on/ESP-off cycles. Charges predicted by the proposed model were used in the Deutsch equation, and the agreement was quantified by Pearson's χ^2 criterion. Detailed information is presented elsewhere (Molchanov and Krpec, 2026).

RESULTS, DISCUSSION, CONCLUSIONS

The largest absolute reduction in particle number occurred at 40–100 nm, where most particles were found, whereas 6–14 nm particles were collected poorly in all regimes: their mean charge remains well below one elementary charge, and 70–90% of them leave the ESP uncharged; ion-induced nucleation may add to their outlet concentration.

The models differ most at low energisation and below 20 nm. White's model underpredicts charge and efficiency throughout ($\chi^2 \gg 0.20$ at $d_p \approx 14$ nm and low Nt), because the neglected image force dominates ion capture while the mean charge is below unity. The proposed model gives a flat error surface without systematic bias ($\chi^2 < 0.02$, locally 0.04–0.06 below 15 nm and $Nt < 2 \times 10^8$ s cm^{-3}) and the lowest total $\Sigma\chi^2$ at every Nt-product, with the largest advantage at 2–4 × 10^8 s cm^{-3}, typical of practical ESP operation. The residual deviation at the lowest energisation is not due to the charging model alone: it also reflects electrohydrodynamic secondary flows (0.1–1.5 m s^{-1}) comparable with the drift velocities of 30–50 nm particles.

The proposed closed-form model factorises the charging rate of particles below 50 nm into the image-enhanced capture cross-section, Maxwellian ion flux and Boltzmann barrier factor, recovering the $\lambda \gg r$ limit without numerical integration or free parameters. It eliminates the underprediction of White's theory and, being computationally trivial, can be applied directly in ESP design or as a charging closure in CFD codes, combined with classical theories above 50 nm.

ACKNOWLEDGEMENT

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INDOOR AIR QUALITY AND CHEMISTRY

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Keywords: Gaseous and particulate pollutants, Chemical reactions and products

INTRODUCTION

People in industrialized countries spend the vast majority (almost 90%) of their time indoors, making indoor environments a dominant contributor to human exposure to air pollutants. Although homes, schools and ships differ substantially in design, occupancy patterns and ventilation strategies, they share common challenges related to indoor air quality (IAQ) and climate including exposure to volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), other gaseous pollutants and airborne particles.

The topics covered in this lecture will be illustrated through examples from own research, international collaborations, and published research rusults which have shown that indoor pollutant concentrations are shaped by a complex interplay between building characteristics, occupant activities, ventilation, material emissions and outdoor pollution sources. Studies in residential buildings (Langer and Bekö, 2013), schools (Cabovska et el., 2022), preschools (Langer et al., 2021), offices (Domhagen et al., 2024) and maritime environments (Langer et al., 2020) have revealed substantial variability in indoor air quality and exposures and highlighted the importance of effective ventilation and building characteristics.

Recent advances in indoor air chemistry have shown that indoor environments are not merely passive recipients of pollutants but active chemical reactors. Ozone transported indoors reacts with building materials, consumer product emissions and human-derived compounds, generating a wide range of oxidation products and secondary particles. Investigations involving ozone chemistry, human emissions and particle formation have demonstrated that reactions between ozone and building materials (Schripp et al., 2012), skin lipids (Salvador et al., 2019; Langer et al., 2024; Wojnowski et al., 2026), personal care product constituents, and ventilation conditions (Langer et al., 2008) can substantially alter indoor air composition and contribute to the formation of ultrafine (Fischer et al., 2015) and nanocluster aerosols (Wu et al., 2024).

Traditionally viewed as passive receptors of outdoor pollution, buildings are now emerging as not only sinks but also sources of urban air contaminants. Ventilation-driven air exchange releases VOCs originating from building materials, consumer products, human occupants and products from indoor chemistry to the outdoor environment, creating localized zones of elevated pollution around buildings – urban air pollution islands (Coggon et al., 2021; Gkatzelis et al., 2021; Wu et al., 2024, Arata et al., 2026).

This plenary lecture will provide an integrated perspective on indoor air quality across homes, schools and ships, highlighting key emission sources, determinants of exposure and emerging knowledge on ozone-initiated indoor chemistry. Particular attention will be given to VOCs, SVOCs, combustion-related pollutants, particles and secondary reaction products, as well as to the role of ventilation and occupants as both sources and drivers of indoor chemistry. The lecture will discuss implications for building operation, ventilation design and exposure assessment.

ACKNOWLEDGEMENT

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VÝVOJ KVALITY OVZDUŠÍ VE STŘEDNÍ EVROPĚ BĚHEM UPLYNULÝCH DVOU DEKÁD

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Klíčová slova: Pozaďová lokalita, Znečištění ovzduší, Zpětné trajektorie, Rozptylové podmínky

SUMMARY

Long-term changes in background air pollution at the National Atmospheric Observatory Košetice were examined using a 20-year dataset covering 2005–2024. Study combined measurements of SO_4, $\sum NO_3$, $\sum NH_4$, PM_{10}, NO_x, CO, O_3, and SO_2 with meteorological measurement and 96-hour backward air-mass trajectories. Most investigated pollutants showed lower concentrations in the more recent decade, whereas O_3 and $\sum NH_4$ exhibited slight increases in median values. Air-mass origin also played an important role, with the highest concentrations associated with transport from southeastern Europe.

ÚVOD

Znečištění venkovského ovzduší má významné dopady jak na zdravotní stav populace, tak na fungování přírodních ekosystémů (Seinfeld a Pandis, 2016). Analýza vychází z měření prováděných v letech 2005–2024 na Národní atmosférické observatoři Košetice (NAOK; 49°34′24″ N, 15°04′49″ E; 534 m n. m.), jejíž venkovský charakter umožňuje sledování regionální pozaďové úrovně znečištění ovzduší střední Evropy.

METODY MĚŘENÍ

Souvislost mezi původem vzdušných hmot a koncentracemi sledovaných polutantů byla posuzována pomocí analýzy zpětných trajektorií v kombinaci s koncentracemi vybraných znečišťujících látek. Hodnoceny byly síranové ionty (SO_4), suma dusičnanových iontů ($\sum NO_3$), suma amonných iontů ($\sum NH_4$), aerosolové částice (PM_{10}), oxidy dusíku (NO_x), oxid uhelnatý (CO), přízemní ozon (O_3) a oxid siřičitý (SO_2). Zpětné trajektorie byly vypočteny pomocí modelu HYSPLIT (Hybrid Single-Particle Lagrangian Integrated Trajectory) s délkou trajektorie 96 hodin. Pro výpočty byla použita meteorologická data GDAS s prostorovým rozlišením 1° × 1°. Počáteční výška trajektorií byla nastavena na 500 m nad úrovní terénu (AGL) a trajektorie byly počítány v šestihodinových intervalech, tj. v 00, 06, 12 a 18 UTC. Na základě vypočtených zpětných trajektorií byly následně identifikovány klastry vzduchových hmot, a to samostatně pro dvě desetiletá období: 2005–2014 a 2015–2024.

Pro statistické zpracování dat byly využity nástroje openair (Carslaw, D. C., a Ropkins., 2012) v prostředí R a ZeFir (Petit a kol., 2017) v programu Igor. Pro kvantifikaci změn v jednotlivých ročních obdobích byl použit Theil-Senův odhad trendu (Theil 1950; Sen 1968). Možný vliv meziroční meteorologické variability byl posuzován prostřednictvím hodnot teploty a relativní vlhkosti vzduchu, rychlosti a směru větru a ventilačního indexu.

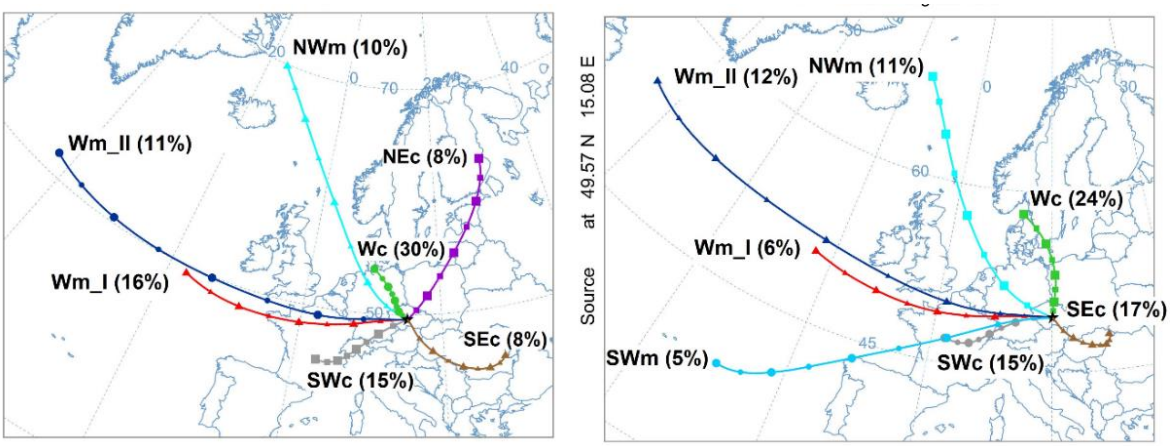
VÝSLEDKY

Porovnání obou desetiletých období ukazuje celkový pokles koncentrací většiny sledovaných znečišťujících látek. Nejvýraznější snížení mediánových koncentrací bylo zaznamenáno u NO_x (přibližně o 50 %) a SO_4 (o 46 %), následované $\sum NO_3$ (o 28 %), PM_{10} a CO (shodně přibližně o 25 %) a SO_2 (o 24 %). Naopak mediánové koncentrace O_3 a $\sum NH_4$ se mezi obdobími mírně zvýšily, přibližně o 4 % respektive o 8 %. Výsledky tak naznačují výrazné zlepšení kvality ovzduší z hlediska většiny primárních a sekundárních znečišťujících látek, zatímco u O_3 tento trend patrný není (Tab. 1).

Tab. 1: Mediánové koncentrace hodnocených veličin v ($\mu g \cdot m^{-3}$) spolu s mezikvartilovým rozpětím mezi roky 2005–2014 a 2015–2024.

$\mu g \cdot m^{-3}$	SO_4	$\sum NO_3$	$\sum NH_4$	PM_{10}	NO_x	CO	O_3	SO_2
2005–2014	2,05 ± 2,25	3,20 ± 2,80	2,57 ± 2,01	16,00 ± 16,00	8,80 ± 6,12	284,24 ± 113,00	59,85 ± 34,91	1,60 ± 1,86
2015–2024	1,11 ± 1,28	2,30 ± 1,97	2,78 ± 2,08	12,00 ± 14,00	4,36 ± 4,40	214,00 ± 72,00	62,40 ± 32,30	1,21 ± 1,31

Koncentrace hodnocených látek byly významně ovlivněny původem vzdušných hmot (Obr. 1). Nejvyšší koncentrace většiny sledovaných látek byly v obou desetiletých obdobích zaznamenány při transportu vzdušných hmot z jihovýchodní Evropy (klastr SEc). Ve druhém sledovaném období se zároveň zvýšil podíl vzdušných hmot přicházejících z tohoto sektoru, což ovlivnilo vývoj kvality ovzduší na NAOK.



Obr. 1: Zpětné trajektorie vzdušných mas na NAOK mezi roky 2005–2014 a 2015–2024.

PODĚKOVÁNÍ

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PROJECT FOCI: NON-CO2 FORCERS AND THEIR CLIMATE, WEATHER, AIR QUALITY AND HEALTH IMPACTS – FINAL OUTCOMES

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

INTRODUCTION

While overall 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, has been 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 have developed new regionally tuned scenarios based on improved emissions to assess the effects of non-CO2 forcers. Mutual interactions between the results and climate services producers and other end-users have provided feedback for 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 implementation in 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.

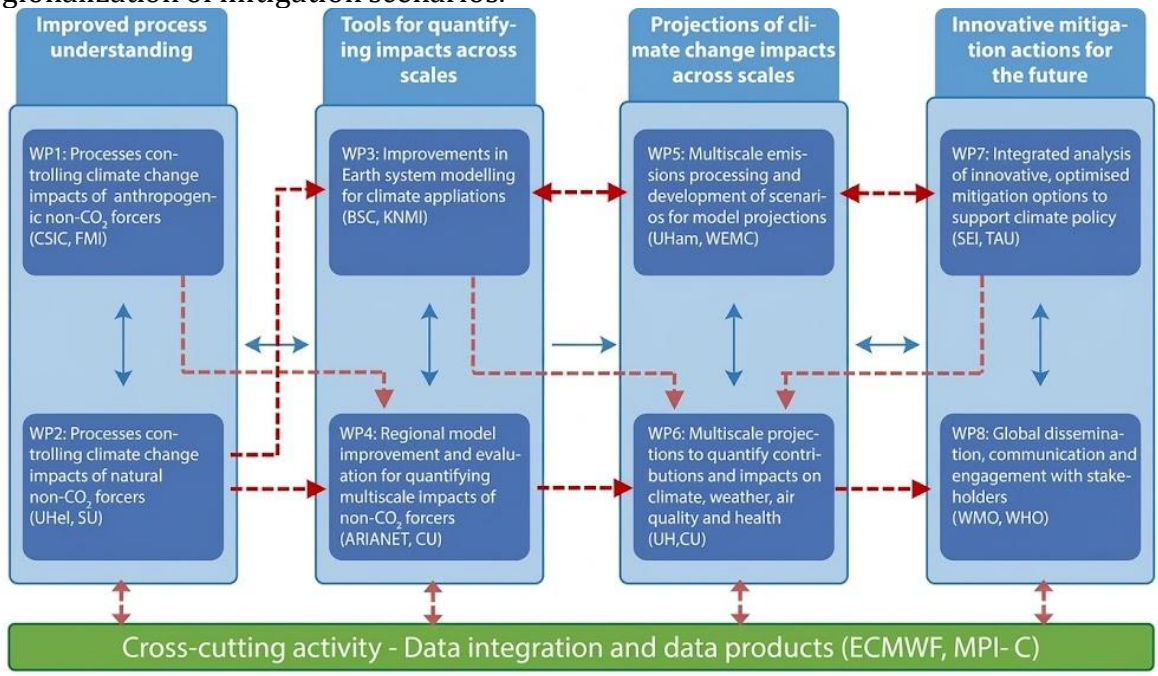


Fig. 1: Scheme of the project.

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 e.g. calculated radiative properties, see example in Fig. 2.

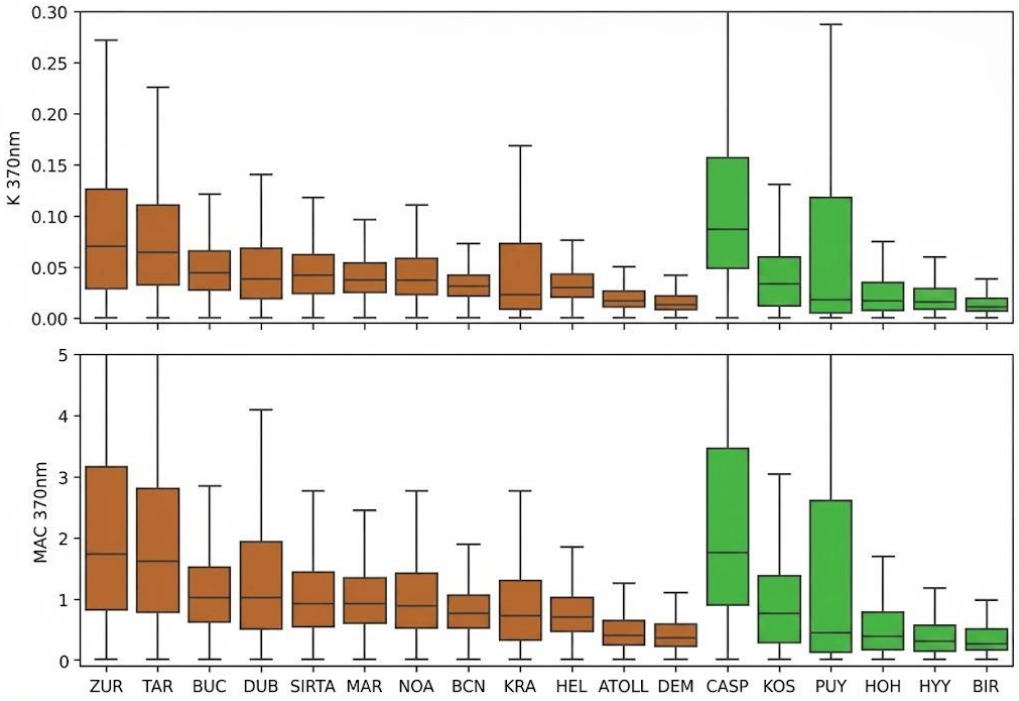


Fig. 2: Imaginary refractive index (k) and mass absorption cross section (MAC) of OA particles at 370 nm for a subset of measuring stations.

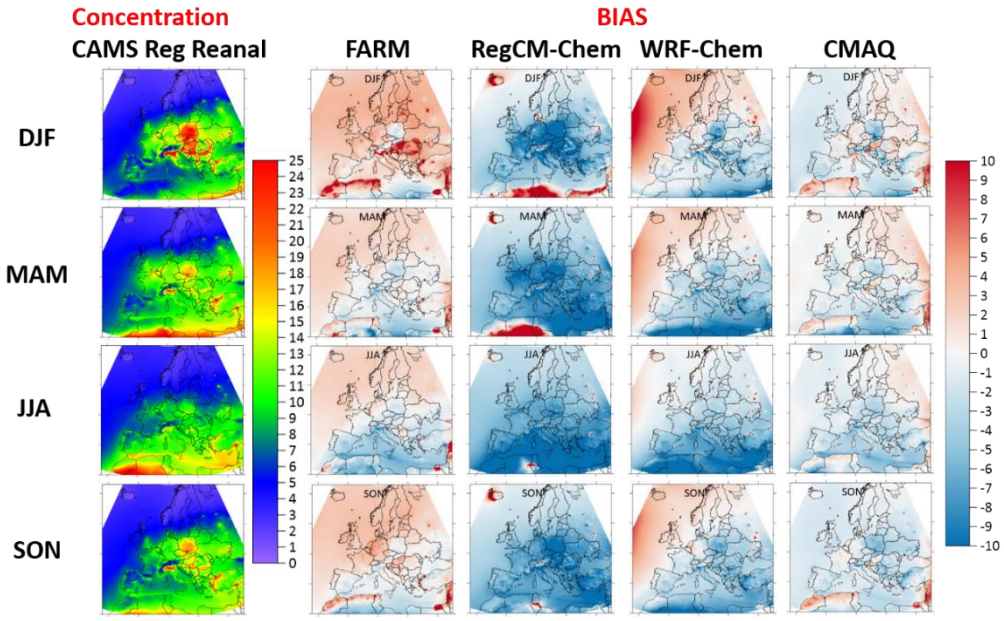


Fig. 3: Seasonal climatology of PM2.5 (μg/m^3) from CAMS European Air Quality Reanalysis (left columns) and the relative seasonal bias (%) of the simulations by the contributing models for the period 2013-2019.

In Fig. 3 the assessment of a historical period in terms of biases against CAMS reanalysis of PM2.5 is provided. In Fig. 4, we can see the development of average temperature over Europe based on observations and global EC-Earth for historical period and for future under scenario SSP3-7.0 and its low-NTCF modification implementing faster reduction of some agents like anthropogenic aerosols. For selected components, annual mean surface concentrations are shown for Europe from the SSP3-7.0 scenario simulations by regional models for the future period. Finally, the project FOCI involved the health effects, which example is presented in Fig. 6, in terms of mean June–August (JJA) Universal Thermal Climate Index (UTCI) over Europe.

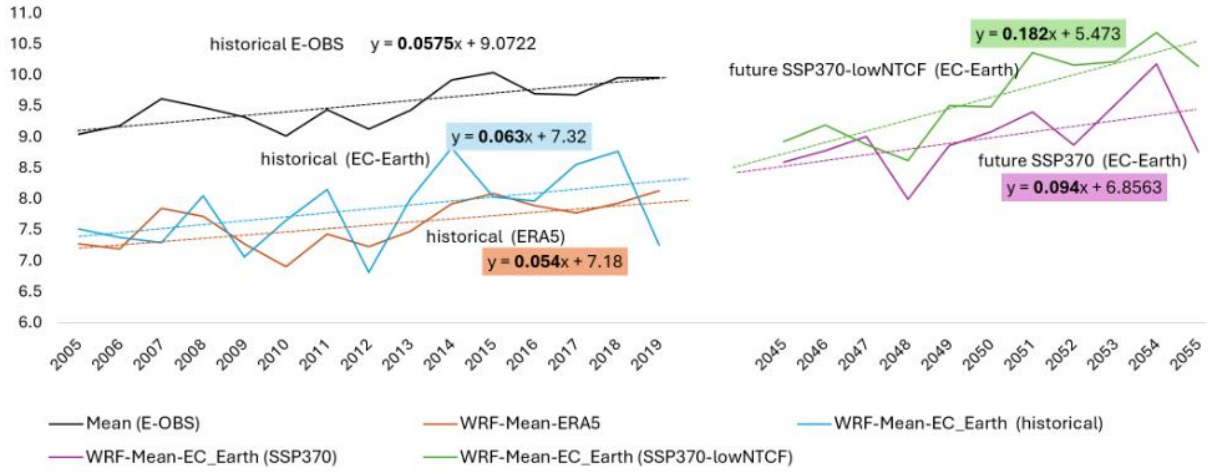


Fig. 4: Annual trends over European domain of T2m annual averaged (°C) for historical period and future under scenarios SSP3-7.0 and SSP3-7.0-lowNTCF.

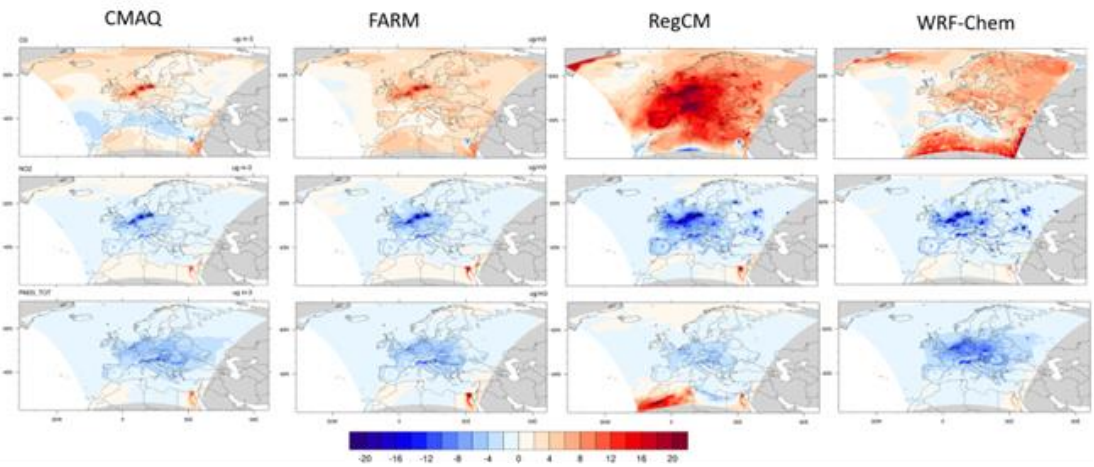


Fig. 5: Changes in annual mean surface concentrations of O_3 (top row), NO_2 (middle), and $PM_{2.5}$ (bottom) under SSP3-7.0 against the historical period (2005–2014) for 2046–2055, by the simulations driven by EC-Earth3-AerChem. In μg m^{-3}, for RegCM (μg kg^{-1}).

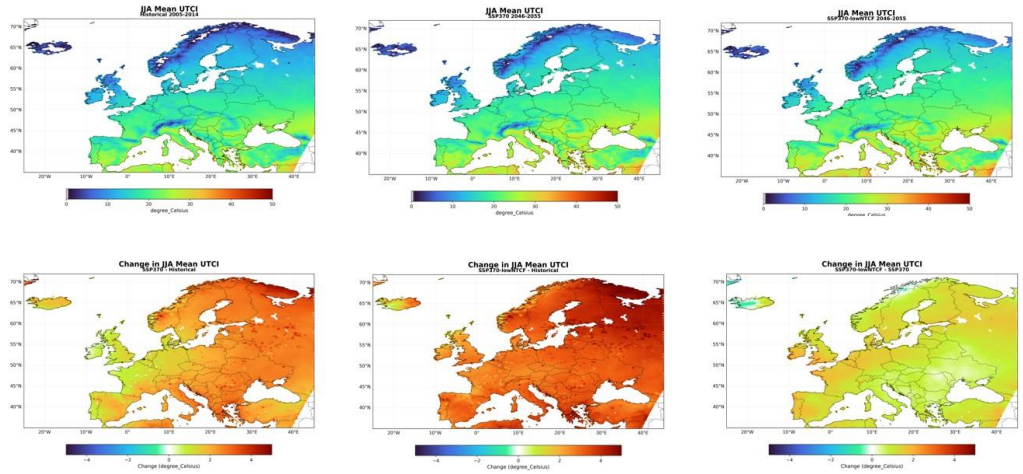


Fig. 6: Mean June–August (JJA) Universal Thermal Climate Index (UTCI) over Europe for the historical period (2005–2014), SSP3-7.0 (2046–2055) and SSP3-7.0-lowNTCF (2046–2055) (top), and corresponding changes for SSP3-7.0 and SSP3-7.0-lowNTCF relative to the historical period and for SSP3-7.0-lowNTCF relative to SSP3-7.0 (bottom).

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FIRST NATIONAL-SCALE APPLICATION OF NONNEGATIVE MATRIX FACTORIZATION TO $PM_{2.5}$ SOURCE APPORTIONMENT REVEALS WEST–EAST TRANSBOUNDARY ASYMMETRIES

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Keywords: $PM_{2.5}$, nonnegative matrix factorization, source apportionment, transboundary transport, HYSPLIT

INTRODUCTION

The Czech Republic lies between western and eastern European emission regions. Although air quality has improved substantially since the 1990s, the recast EU Ambient Air Quality Directive reduces the annual $PM_{2.5}$ limit from 25 to 10 μg m^{-3} by 2030, making regional secondary aerosol and transboundary transport increasingly important.

We combined chemically speciated aerosol measurements from 33 Czech sites sampled during 2021–2025. The objectives were to obtain a nationally consistent source apportionment across urban, rural, industrial and background environments and to test whether pollution arriving at border stations exhibits a systematic differences.

METHODOLOGY

To our knowledge, this is the first application of nonnegative matrix factorization (NMF) to a national-scale, multi-year air-quality source-apportionment problem based on chemically speciated receptor data. NMF was selected because merging the annual campaigns produced step changes associated with changes in laboratory practice, e.g., calibrations and analyzer replacements. These discontinuities affected both estimated analytical uncertainties and, for some trace elements, absolute concentrations. U.S. EPA PMF 5.0 was highly sensitive to these discontinuities and split single pollution types into factors without a physical basis. NMF requires no uncertainty matrix and therefore provided a practical way to integrate the heterogeneous campaigns without propagating inconsistent laboratory uncertainty estimates into the model.

Offline $PM_{2.5}$ or PM_{10} samples were analyzed for thermally resolved organic and elemental carbon, water-soluble ions, anhydrosaccharides, benzo[*a*]pyrene, and elements. The raw, unweighted concentration matrix was decomposed using nonsmooth NMF (ns-NMF; $\theta = 0.25$). Ranks 6–10 and the Brunet algorithm were compared; the selected nine-factor solution used 200 random initializations. Factor-profile and contribution uncertainties were estimated using 100 site-stratified stationary block-bootstrap resamples. Robustness to remaining concentration discontinuities was tested by refitting the model after omitting each campaign year, region, and site-campaign, and separately for the 21 true-$PM_{2.5}$ and 12 PM_{10} sites. Factor contributions were converted to $PM_{2.5}$ mass by intercept-free regression; measured and reconstructed mass agreed with $r^2 = 0.92$ ($n = 4{,}349$). Transport was evaluated using 96 h HYSPLIT back-trajectories driven by ERA5. At eight rural border-background stations, each day was classified as inflow, interior or tangential according to the trajectory arrival bearing relative to the outward border normal. The directional concentration contrast was defined as DCC =

($C_{inflow} - C_{interior}$)/($C_{inflow} + C_{interior}$). Because each contrast is calculated within one station and campaign, site, year, analytical batch, sampling programme and sampled size fraction are held constant.

RESULTS AND DISCUSSION

Nine interpretable pollution types were resolved: Sulfate SIA, Nitrate SIA, Summer OA, Winter OA, residential biomass burning, residential coal combustion, Salt, Crustal and Metallurgy. Four factors—Sulfate SIA, Nitrate SIA, Summer OA and Crustal—were recovered on both aerosol-size subsets with matched profile correlations above 0.91. Leave-one-year, leave-one-region and leave-one-site-campaign refits preserved the spatial rankings of the factors, indicating that the main national patterns were not artifacts of individual campaigns. Regional source mixtures differed markedly: residential combustion and metallurgy dominated the northeast; sulfate-rich secondary aerosol prevailed in the northwest and north; mineral dust was important in surface-mining areas; and the regional secondary aerosol dominated rural elevated sites.

Across the network, Sulfate SIA increased under easterly arrival at all 33 sites, whereas the Atlantic-influenced Salt factor decreased at most. At the border stations, $PM_{2.5}$ and sulfate were lower when air arrived from Germany than from the Czech interior, but higher under outward-sector arrival along the eastern and southeastern borders. At TMJS in the Jablunkov Pass, $PM_{2.5}$ was approximately 60% higher on inflow days. Station-level $PM_{2.5}$ DCC increased by 0.058 ± 0.022 per degree of longitude ($p = 0.039$; permutation $p = 0.037$). After adjustment for season, temperature, mixing depth and transport height, DCC ranged from approximately −0.29 at PPRM on the Bavarian border to +0.17 at TMJS (Fig. 1).

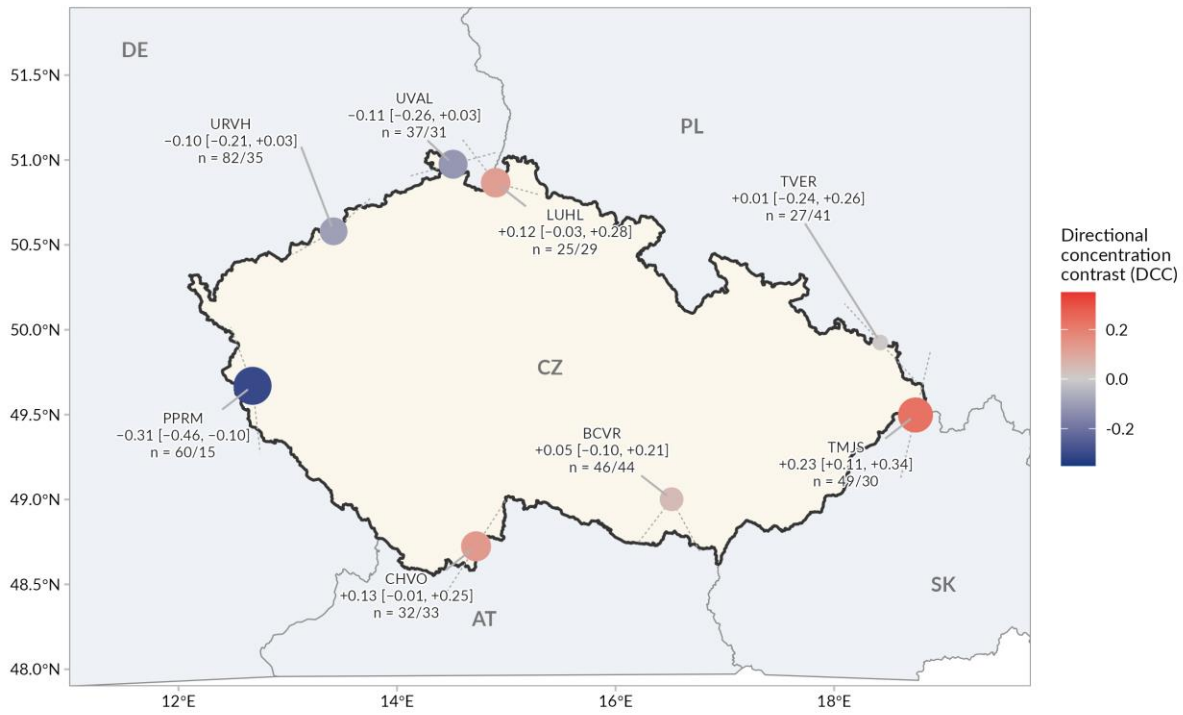


Fig. 1: Directional concentration contrast (DCC) of $PM_{2.5}$ at eight border stations. Red denotes higher concentrations on inflow days and blue lower concentrations; bars give 95% bootstrap confidence intervals.

Across the eight stations, 26–56% of campaign-integrated $PM_{2.5}$ occurred on inflow-classified days (median 38%). Because externally transported material can also arrive on interior and tangential trajectories, this quantity is a trajectory-based lower bound on the transboundary share. Concentration-weighted trajectory fields located the broad sulfate pathway to the east and southeast, with a core over the Pannonian Basin, while Summer OA formed a broad non-directional regional background.

CONCLUSIONS

Nonsmooth NMF enabled a national source-apportionment analysis that could not be performed reliably with uncertainty-weighted PMF because of step changes among and within laboratory campaigns. The method produced stable regional factors and linked the remaining Czech $PM_{2.5}$ burden to distinct local and regional controls. Cleaner German-sector inflow contrasts with sulfate-rich eastern and southeastern transport, forming a significant west–east gradient. The result supports continued international SO_2 and NO_X abatement along these pathways and demonstrates the need for synchronized, multi-year chemical monitoring. The rotating campaign design supports spatial comparison but not a national temporal trend.

ACKNOWLEDGEMENTS

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INTEGRATED SOURCE APPORTIONMENT OF AEROSOL IN THE PORT OF ROTTERDAM USING Q-ACSM, XACT AND AETHALOMETER MEASUREMENTS

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Keywords: Atmospheric aerosol, Source apportionment, Port emissions, Online aerosol measurements

INTRODUCTION

Large port areas are affected by many aerosol sources within a relatively small region. Emissions from ships, heavy duty transport, terminal machinery and industrial activities co-occur with mechanically generated dust or marine and secondary aerosol. These sources often overlap spatio-temporally, which complicates their separation using only a single type of chemical information (Pérez et al., 2016).

Aerosol mass spectrometry provides detailed information on organic and secondary inorganic aerosol, while elemental measurements offer source specific tracers for several combustion and industrial processes. Black carbon adds complementary information on combustion emissions. Combination of the different datasets in one receptor model can therefore improve source separation in complex port-industrial environments (Camman et al., 2024). The aim of this study was to identify the major aerosol sources and processes affecting the western part of the Port of Rotterdam using a combined Q-ACSM, Xact and Aethalometer dataset.

METHODOLOGY

Measurements were performed during the MITRAP campaign at Hoek van Holland in the Port of Rotterdam from July to December 2025. The site is influenced by the North Sea as well as shipping lanes, port terminals and the large industrial areas.

The combined PMF input matrix contained 14 selected Q-ACSM ions selected as specific markers of hydrocarbon-like, biomass burning and oxygenated organic aerosol as well as ACSM nitrate and ammonium, then 16 Xact elements and fossil fuel and wood

burning related black carbon components from AE33 (Manousakas et al., 2025). PMF model configuration was evaluated by testing the weighting of the organic signals, extra modelling uncertainty and the number of factors. The final model contained nine factors.

Factor interpretation was based on chemical fingerprints together with independent measurements of particle mass and number, gaseous pollutants and meteorological parameters. Wind direction and wind speed were used to evaluate possible source regions and to distinguish local, port/industrial and marine influences.

RESULTS, DISCUSSION, CONCLUSIONS

The combined PMF analysis resolved nine chemically distinct factors, which were grouped into four main source/process classes, including combustion related sources, primary marine aerosol, industrial and mechanically generated aerosol and secondary aerosol. Secondary ammonium nitrate was the largest individual factor, contributing 37.0% of the mass integrated within the PMF solution, followed by sulfur rich secondary aerosol (14.4%), port/fossil fuel combustion (12.8%) and marine aerosol (12.6%).

Three factors represented different types of combustion aerosol. Residual oil shipping showed a highly specific V and Ni fingerprint and captured most of these two elements. In contrast, port/fossil-fuel combustion was characterized by a broad hydrocarbon-like organic signature together with BC_{ff} and strong relationships with independently measured BC and NOx. Biomass-burning combustion was distinguished by the combined presence of K, m/z 60 and 73, and BC_{wb}.

The primary marine aerosol factor was dominated by particulate Cl and was associated with marine inflow from the North Sea. Three further factors described different components of industrial and mechanically generated aerosol. The non-ferrous industrial factor was represented by Pb, Cu, Zn and As fingerprint, whereas the ferrous industrial factor contained Fe and Mn. A Ca and Ti dominated factor showed a stronger relationship with coarse particle mass, supporting its interpretation as mineral/material dust with an important mechanical or resuspension contribution.

Two factors represented secondary aerosol. The ammonium nitrate factor contained 82.9% of nitrate and 52.1% of ammonium while the second secondary factor was characterized by a strong sulfur signature. Wind-resolved analyses provided additional support for the factor assignments, separating marine influence from several port-industrial source sectors and showing differences between local and broader source regions.

Overall, the results demonstrate that combining Q-ACSM organic and inorganic composition, Xact elemental data and Aethalometer black carbon can resolve source types and atmospheric processes that would be difficult to distinguish using a single measurement technique. The aerosol at the Rotterdam receptor was controlled by a combination of port-related combustion, marine influence, chemically distinct industrial sources and secondary aerosol, with secondary aerosol representing the largest integrated mass contribution despite the location within a major port-industrial environment.

ACKNOWLEDGEMENT

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SPATIAL AND TEMPORAL TRENDS OF PERSISTENT ORGANIC POLLUTANTS ACROSS EUROPE AFTER 15 YEARS OF MONET PASSIVE AIR SAMPLING

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Keywords: POPs, air monitoring, Stockholm convention, temporal trends

INTRODUCTION

The Stockholm Convention on Persistent Organic Pollutants, entering into force in 2004, aims to protect human health and ecosystems from anthropogenic chemicals characterized by persistence, bioaccumulation, long range transport potential, and toxicity. To verify the efficacy of global phase outs and restrictions, the Global Monitoring Plan (GMP) was established to harmonize POPs air monitoring across United Nations Regional Groups.

Within Europe, implementation and monitoring have traditionally been divided between the Western Europe and Others Group (WEOG) and the Central and Eastern Europe (CEE) Group. Historical disparities in industrial practices, regulatory enforcement, and chemical usage led to elevated atmospheric burdens of specific OCPs and legacy pollutants in CEE countries compared to WEOG nations. (Holoubek *et al.,* 2007)

While active air sampling networks like the European Monitoring and Evaluation Programme (EMEP) and the UK Toxic Organic Micro Pollutants (TOMPs) network have operated since the early 1990s, continuous records exceeding 15 years are restricted to only a handful of stations—predominantly in Northern/Western Europe and the Arctic (EMEP, 2016, AMAP, 2016). To address this geographic bias and build regional capacity, the MONET passive air sampling network was initiated in the Czech Republic in 2003 and subsequently expanded across CEE countries (2006–2008) and WEOG countries (2009). This study evaluates 15 years of harmonized MONET data (2003–2019) to establish the first comprehensive, continent-wide spatial and temporal trend analysis for 20 priority POPs (White *et al.*, 2023).

METHODOLOGY

The MONET network includes 32 long term monitoring stations distributed across 27 European countries, covering diverse environmental characteristis (rural, urban, and background sites). Passive air samplers (Klánová *et al.,* 2007*,* Jurado *et al.,* 2004, Hung *et al.*, 2010) equipped with polyurethane foam (PUF) disks were deployed to capture gaseous and particulate bound POPs. PUF disks provide a cost-effective, electricity free sampling mechanism ideal for long term atmospheric compounds concentrations monitoring and continuous spatial coverage where active high-volume samplers are logistically unfeasible.

Samples were collected, extracted, and analyzed at the RECETOX laboratories (Masaryk University). Target compounds included polychlorinated biphenyls (PCBs)

including dioxin-like PCBs (dl-PCBs), polychlorinated dibenzo-*p*-dioxins and furans (PCDDs/Fs), polybrominated diphenyl ethers (PBDEs) and selected organochlorine pesticides (OCPs).

Data from passive sampling were converted to air concentrations using previously experimentally derived sampling rates.

Long-term temporal trends were evaluated using statistical regression models, accounting for seasonal variability, meteorological factors, and left-censored data (values below method detection limits). Atmospheric halving times ($t_{1/2}$) were derived from first-order decay models fitted to annual median concentrations at individual sites.

RESULTS, DISCUSSION, CONCLUSIONS

As of January 1, 2019, the concentration ranges (pg/m^3) were 1.1–52.8 (PCBs), 0.3–8.5 (dl-PCBs), 0.007–0.175 (PCDDs/Fs), 0.02–2.2 (PBDEs), 0.4–24.7 (BDE 209), 0.5–247 (DDT and metabolites), 1.7–818 (HCHs), 15.8–74.7 (HCB), and 5.9–21.5 (PeCB).

Over the 15 years observation window (2003–2019), atmospheric concentrations of legacy POPs exhibited clear downward trajectories.

Significant Declines: Median annual decreases ranging between −8.0% and −11.5% were observed for PCBs, PCDDs/Fs, HCB, PeCB, and PBDEs.

Halving Times: These annual reduction rates correspond to atmospheric halving times ($t_{1/2}$) of approximately 6 to 8 years, confirming that international regulatory bans and emission controls are effectively translating into declining atmospheric burdens.

Secondary Sources & Resuspension: Compounds with higher persistence and soil-air exchange potential (such as heavier HCHs and DDT metabolites and isomers) exhibited more complex, leveling-off trends at certain agricultural sites, driven by historical soil reservoirs and secondary emission fluxes.

This study validates the MONET passive air sampling network as a powerful, robust instrument for long-term environmental monitoring under the Stockholm Convention's GMP. Over 15 years (2003–2019), significant declines in POPs (halving times = 6–8 years) confirm the effectiveness of international regulatory frameworks. Furthermore, the statistical parity between WEOG and CEE monitoring sites highlights a unified European atmospheric environment. Continued passive monitoring remains essential to track emerging chemicals of concern and ensure sustained compliance with global environmental treaties.

ACKNOWLEDGEMENT

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WIDESPREAD DISTRIBUTION OF ORGANIC POLLUTANTS IS ENHANCED BY RE-VOLATILISATION FROM SOILS

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Keywords: atmospheric aerosols, PAH, pesticides, PFAS

INTRODUCTION

The atmospheric fate and distribution of long-lived and persistent chemicals are of particular interest as many of these substances are toxic and ecotoxic even in very low concentrations, are bio-accumulative and, following atmospheric deposition, resist degradation in soils and surface waters. They are semivolatile (vapour pressures between 10^{-6} and 10^{-2} Pa), hence, may re-volatilise, which means that soils even in remote areas become secondary sources of the pollutant. For banned chemicals, such as the organochlorine pesticides or intentionally produced PCBs, secondary sources are dominating today (AMAP, 2021; UNEP, 2023).

Per- and polyfluoroalkyl substances (PFAS) are emitted from chemical industry or from products' usage. PFAS are globally distributed environmental pollutants, particularly persistent, bio-accumulative, and toxic, raising severe concerns for ecosystems and human health (Cousins et al., 2022). Due to their semivolatile and surface-active characteristics, their atmospheric fate and long-range transport potential is complex and poorly understood. Polycyclic aromatic compounds (PACs) are by-products of all fossil fuel and biomass burning processes and some of them ubiquitous in the global atmosphere.

METHODOLOGY

We studied the air-soil cycling of organic pollutants at a rural grassland site and a boreal forest site by determining their concentrations in air, topsoil and in air equilibrated with soil (Cabrerizo et al., 2009; Lammel et al., 2026). Air and soil samples were analysed by GC-MS/MS, the direction of flux was derived from air fugacity compared with potential and effective soil fugacity (Mwangi et al., 2024), and the flux was quantified using a micrometeorological flux-gradient method (Lammel et al., 2026).

RESULTS, DISCUSSION, CONCLUSIONS

Results for PACs (55 substances) and PFAS (23 substances) are presented.

A much higher level of PFASs in air was found at the northern than at the central European site, namely 62-67 pg m^{-3} vs. 0.05-0.22 pg m^{-3}. At both sites, the dominating species was perfluorobutanoic acid (PFBA) and the particulate mass fraction was only 1% by average. In soil, the concentrations were comparable i.e., 0.6-2.1 ng g^{-1} and 1.0-1.3 ng g^{-1}, respectively. Downward fluxes, indicating deposition were found for some PFAS, whereas the fluxes of the C_4 and C_6 carboxylic acids at both sites and the C_7 and C_8 carboxylic acid at the central European site were upward, suggesting emission from soils, during both day and night-time. These observations confirm the widespread distribution of PFAS in air and soil far from sources. Obviously, some PFCAs' long-range transport potential is enhanced by re-volatilisation, like previously found for chlorinated persistent semivolatile organics.

In soil at the boreal site, oxygenated and nitrated PAHs (OPAH, NPAH) contributed much higher fractions to PAC contamination of air and soil than at the rural site, reflecting the conversion of primary PACs during transport from sources. The same number of PACs in soil have reached equilibrium concentration with air, despite one site being in a polluted and PAC source region and the other in a much less polluted and PAC receptor region. Upward diffusive flux was observed for one PAH, triphenylene, at the rural grassland site, and for three 3-ring PAHs and naphthaldehyde at the boreal forest site. There, emission fluxes were quantified and ranged 0.5–12 ng m^{-2} h^{-1} (Fig. 1). The results indicate that low molecular weight PAH secondary emissions in a receptor region may be of same order of magnitude as domestic primary emissions.

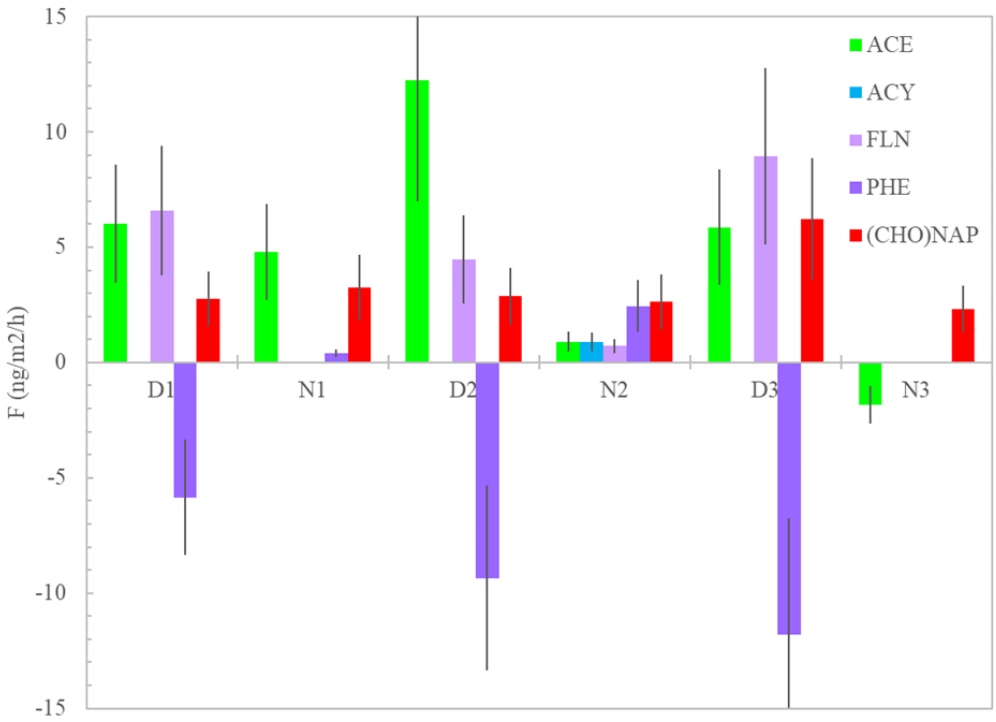


Fig. 1: Vertical flux of PAHs (ng m^{-2} h^{-1}) during day- and night-time (D, N) at the boreal forest site. F > 0 upward, F < 0 downward. Error bars reflect the uncertainty. Only compounds shown with c_g > LOQ at both 3 cm and 2 m above ground.

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MONITORING ATMOSPHERIC MICROPLASTICS: COMPREHENSIVE ANALYTICAL SOLUTIONS USING PY-GC/MS AND LDIR

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Key words: airborne microplastics analysis, GC/MS, LDIR, pyrolyzer

SUMMARY

It is known that microplastic pollution increasingly threatens environmental and human health. Furthermore, in recent years there are also scientific publications which have demonstrated that airborne microplastics can influence weather patterns and potentially alter precipitation and regional climate dynamics. For these reasons, monitoring air pollution caused by microplastics is very important.

INTRODUCTION

Altium International is official distributor of Agilent Technologies and Frontier Lab. The Altium company places great emphasis on the professional development of its staff, which is why all technical specialists are regularly trained at the manufacturers' training centers. Altium also offers its customers application support in the development of analytical methods and in the analytical interpretation of data.

In this presentation the instrumentation used for microplastic pollution measurements will be introduced, specifically an Agilent Technologies GC/MS system coupled with a Frontier Lab pyrolysis unit, as well as the Agilent 8700 LDIR Chemical Imaging System. The combination of these advanced technologies enables both the chemical identification of polymer types and their quantitative analysis, as well as the precise characterization of the size and shapes of their particles. The principles behind both techniques will be discussed, along with the practical aspects of their usage.

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

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Keywords: Dual-height measurements, Vertical gradients, Carbonaceous aerosols, Secondary aerosols, Boundary layer, Synoptic circulation

INTRODUCTION

Most atmospheric aerosol observations are performed close to the ground, although aerosol concentration and chemical composition can vary substantially within the atmospheric boundary layer (Liang et al., 2022). Vertically resolved measurements are therefore important for evaluating the representativeness of surface observations and for understanding the effects of atmospheric stability, turbulent mixing, and regional transport on aerosol distributions (Li et al., 2017).

The 250 m atmospheric tower at the National Atmospheric Observatory Košetice (NAOK), a rural background site in the Czech Republic, provides a unique opportunity to investigate such variability (Dvorská et al., 2015). The aim of this study was to characterize differences in submicron aerosol chemical composition between 4 m and 230 m and to investigate how season, thermal stratification, mixing-layer height (MLH), air-mass history, and synoptic circulation are associated with the observed vertical aerosol structure.

METHODOLOGY

Measurements were performed at NAOK from December 2019 to May 2020, covering winter and spring conditions. Non-refractory PM_1 components, including organics (Org), sulfate (SO_4^{2-}), nitrate (NO_3^-), and ammonium (NH_4^+), were measured using a ToF-ACSM at 4 m and a c-ToF-AMS sampling from 230 m. Equivalent black carbon (eBC) was obtained from optical attenuation measurements of Sunset OCEC analyzers deployed at both heights. Meteorological variables were measured along the tower, and MLH was derived from ceilometer observations.

The vertical distribution was characterized using the concentration ratio ($C_{230\,m}/C_{4\,m}$), where values below 1 indicate higher concentrations near the surface. Vertical gradients were additionally calculated as concentration changes normalized to 100 m. Thermal stratification was described by the temperature difference $\Delta T = T_{230}m - T_{10}m$, where positive values indicate temperature inversion. Air-mass back trajectories were calculated using the HYSPLIT model (Stein et al., 2015) and grouped into six clusters. Synoptic situations were classified using the Czech Hydrometeorological Institute circulation scheme (Racko, 2014).

RESULTS

Aerosol concentrations were generally higher at 4 m than at 230 m. Carbonaceous components showed the strongest near-surface enrichment, whereas secondary inorganic species generally exhibited weaker vertical contrasts. Clear component-specific seasonal differences were observed. In winter, median 230/4 m ratios were approximately 0.50 for Org, 0.85 for SO_4^{2-}, 0.75 for NO_3^-, 0.71 for NH_4^+, and 0.56 for eBC. In spring, the ratios increased to approximately 0.72 for Org and 0.62 for eBC, whereas the SO_4^{2-} ratio decreased to approximately 0.60. Seasonal differences in the daily concentration ratios were statistically significant for Org and SO_4^{2-}, whereas NO_3^-, NH_4^+, and eBC showed no significant seasonal differences.

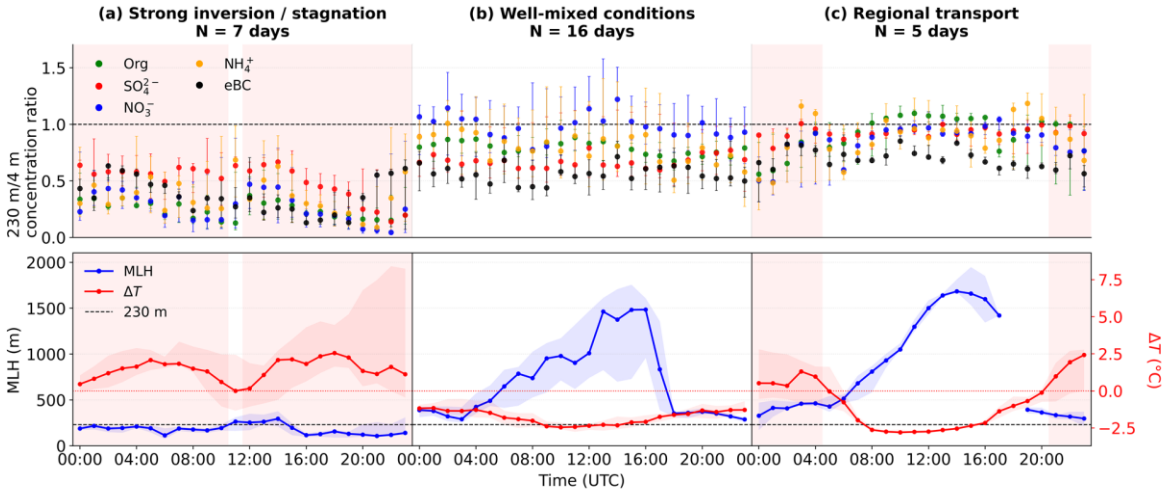


Figure 1. Diurnal variation of vertical aerosol concentration ratios (upper panel) and boundary-layer conditions (lower panel) under (a) strong inversion/stagnation, (b) well-mixed conditions, and (c) regional transport. In the upper panel, the dashed line highlights the ratio of 1; in the lower panel, the thin red line denotes the isothermic conditions (ΔT = 0), while the black dashed line denotes the height of the tower (230 m). The red shading highlights inversion conditions.

Atmospheric stability strongly affected the vertical aerosol distribution (Fig. 1). During well-mixed conditions, the median MLH increased to approximately 667 m and concentration ratios approached unity, indicating substantially stronger vertical coupling between the two measurement heights. During inversion/stagnation periods, the median MLH was approximately 174 m, and 230/4 m ratios remained well below unity. In the strongest adequately sampled inversion category (ΔT = 8 – 10 °C), median concentrations at 4 m and 230 m were 6.22 and 1.27 μg m^{-3} for Org, 1.72 and 0.33 μg m^{-3} for SO_4^{2-}, 2.41 and 0.20 μg m^{-3} for NO_3^-, 1.08 and 0.09 μg m^{-3} for NH_4^+, and 1.36 and 0.25 μg m^{-3} for eBC, respectively. Differences between the two heights were significant for all five components.

HYSPLIT cluster analysis also showed variations in vertical aerosol distributions among different air masses. However, observed cluster-specific differences cannot be attributed exclusively to air-mass origin but instead reflect the combined effects of air mass history, seasonal variability, and associated meteorological conditions.

Synoptic circulation further influenced the vertical composition, with local stability and synoptic-scale dynamics jointly governing vertical aerosol variability, highlighting the limitations of relying solely on surface data to represent aerosol dynamics.

CONCLUSIONS

The findings clarify how meteorological conditions and transport processes shape aerosol vertical structure, and provide context for interpreting ground-based air quality measurements, evaluating transport processes, and improving vertical representation of aerosol in atmospheric models (Julaha et al. 2026). Additionally, the study highlights the value of vertically resolved aerosol measurements for interpreting surface observations and understanding aerosol-boundary-layer interactions.

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VÝSLEDKY DVOULETÉHO MĚŘENÍ VERTIKÁLNÍ DISTRIBUCE AEROSOLŮ AEROSOLOVÝM HMOTNOSTNÍM SPEKTROMETREM NA OBSERVATOŘI KOŠETICE

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Klíčová slova: AMS, vertikální distribuce aerosolů, pozaďová stanice, sezónnost

SUMMARY

Vertical aerosol measurements provide valuable information for the three-dimensional characterization of the atmosphere. This contribution presents preliminary results from detailed online measurements conducted at ground level (4 m) and from a tower (230 m) using an aerosol mass spectrometer. These measurements were conducted from March 2024 to February 2026 and represent a unique dataset showing seasonal vertical changes of basic chemical components in fine aerosols at a rural background site.

ÚVOD

Vertikální měření aerosolů poskytuje důležité informace pro trojrozměrnou charakterizaci atmosféry. První dlouhodobé vertikální online měření chemického rozdělení aerosolů ve výškách 4 m a 230 m na Národní atmosférické observatoři Košetice (NAOK) na přelomu let 2019–2020 ukázalo odlišnou distribuci základních chemických složek v jemné frakci PM_1 během zimy a jara (Julaha a kol., 2026). Z toho důvodu byla mezi lety 2024–2026 provedena následná měření pro detailní sezónní charakterizaci těchto částic. Předběžné výsledky z měření aerosolové hmotnostní spektrometrie během této dvouleté kampaně jsou předmětem tohoto příspěvku.

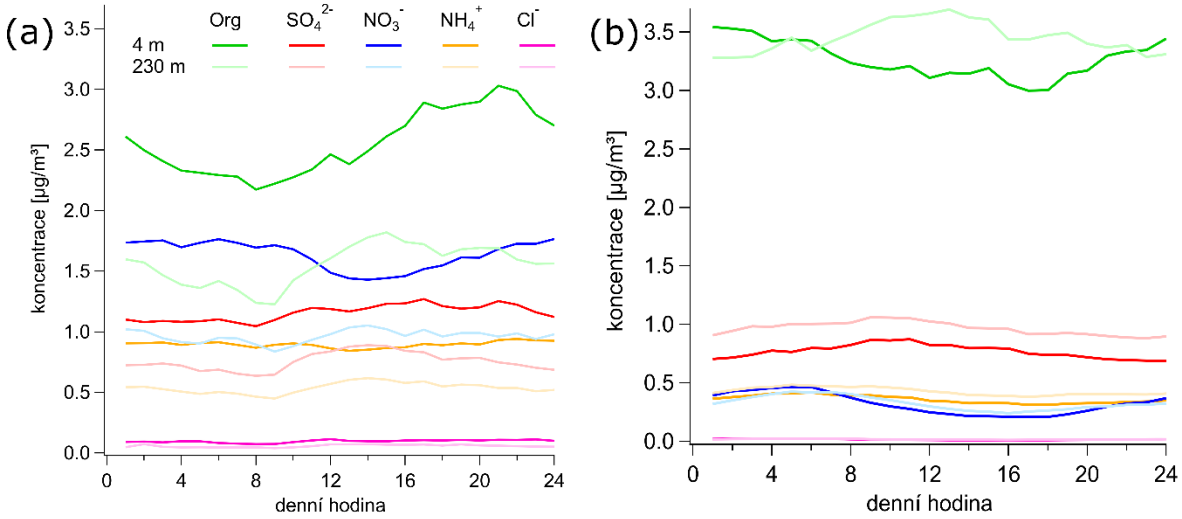
METODIKA

Měření frakce aerosolu PM_1 na NAOK (N 49°35′, E 15°05′; 534 m n. m.) pokrývají období od března 2024 do února 2026. Chemické složení jemných částic bylo měřeno pomocí kompaktního aerosolového hmotnostního spektrometru s ToF detektorem (c-ToF AMS, Aerodyne Research, USA). Pro měření ve výškách 4 m a 230 m nad zemí byl při použití jediného přístroje instalován přepínací ventil, který umožňoval střídání odběru vzorků z obou výšek. Frekvence přepínání byla 15 minut, během kterých byly provedeny vždy tři 5-ti minutové scany, přičemž první scan po přepnutí byl z analýzy vyloučen. Pro některá srovnání byla použita také data koncentrací černého uhlíku měřené aethalometrem (AE33, Magee, Slovenia).

VÝSLEDKY, DISKUSE, ZÁVĚRY

Již první výsledky z jarních měření v roce 2024 ukázaly výrazné denní rozdíly v chodech koncentrací, zejména u organického aerosolu (OA) (Schwarz a kol., 2025).

Analýza dalších sezón formou průměrných denních trendů poskytla srovnání změn od jara 2024 do zimy 2025/26. Během sezón docházelo k postupným změnám nejen v rámci denního cyklu, ale také koncentračního zastoupení jednotlivých složek. Jak ukazuje Obr. 1a, během zimních sezón byly koncentrace všech složek vyšší u země, což bylo v souladu s předpokladem výraznějšího lokálního znečištění a nižší mezní vrstvy atmosféry v tomto ročním období. Oproti očekávání však byly koncentrace některých složek aerosolu v létě vyšší ve 230 m než při zemi (Obr. 1b). Např. koncentrace síranů byla v letním období stabilně vyšší ve 230 m, zatímco koncentrace OA byla v průměru vyšší ve 230 m pouze během dne. Jarní a podzimní sezóny, jakožto tranzitní období, představovaly postupné vyrovnávání těchto výrazných rozdílů mezi zimou a létem. Podrobnější analýza, včetně zaměření na vybrané hmotnostní fragmenty, bude předmětem prezentace.



Obrázek 1: Denní trendy základních chemických látek měřených AMS ve 4 m a 230 m nad zemí na stanici NAOK během (a) zimy 2025/2026, a (b) léta 2025.

PODĚKOVÁNÍ

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CHARACTERIZING VERTICALLY RESOLVED FRESH VS. AGED BIOMASS BURNING CARBONACEOUS AEROSOLS BASED ON TALL TOWER MEASUREMENTS

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Keywords: black carbon, brown carbon, vertical distribution, light absorption, particle size, biomass burning.

INTRODUCTION

Open biomass burning (OBB) is the largest global source of carbonaceous aerosols (CA) which can be divided into black (BC) and brown carbon (BrC) based on their light absorption efficiency at various wavelengths (Bond et al., 2013; Leskinen et al., 2020). The absorption spectral dependency, defined by the absorption Ångström exponent (AAE), depends on aerosol type (BC and BrC) and source and can evoluate during atmospheric aging (Che et al., 2022; Forrister et al., 2015). In this study, we undertake a comparative analysis of light-absorbing CA from fresh and aged OBB smoke plumes detected at the National Atmospheric Observatory Košetice (NAOK, 49°35'N, 15°05'E; 534m a.s.l.), Czech Republic.

METHODOLOGY

Local smoke plumes from the traditional burning of the witches in 2023 - 2025 (BoW_23, BoW_24 and BoW_25) are compared to a 7-10 day-aged smoke from the Canadian wildfire (CaW) in summer 2025. Measurements were conducted simultaneously at 4 m and at 230 m a. g. l. of a tall tower to examine the vertical distribution of the aerosols. The absorption coefficient (δ_{ab}) was obtained with AE33 aethalometers (Magee Scientific, Berkeley, CA, USA) measuring 1-minute equivalent black carbon (eBC) at seven wavelengths (370 - 950 nm). Particle number size distribution (PNSD, 10 – 800 nm) and size-resolved PM_1 organic aerosols (OA) were also obtained with a scanning mobility particle sizer and an aerosol mass spectrometer, respectively, both measuring every 5 min.

RESULTS, DISCUSSION, CONCLUSIONS

All BoW and CaW events led to increased concentrations of CA at NAOK, but they affected differently the vertical gradient. Local BoW smoke plumes led to higher concentration at 4 m, unlike the aged, long range transported CaW smoke which had a stronger influence at 230 m. The two-dimensional AAE approach was adopted ($AAE_{370\text{-}880}$ vs. $AAE_{600\text{-}880}$) to provide insight into the potential sources, aging and mixing state of BC and BrC (Fig. 1). The results describe a pattern between fresh aerosols from fossil fuel combustion with BC dominating δ_{ab} (AAE ~ 1) and fresh BB aerosols from BoW with BrC

dominating δ_{ab} (AAE ~ 2). The aged CaW exhibited lower AAE (< 1.5) lying within background signal represented by winter, spring and autumn when BB is major source of CA at NAOK. During aerosols aging, decrease in AAE may be driven by a combination of factors including bleaching or loss of BrC content, formation of secondary organic aerosols and variations in the aerosols size distribution.

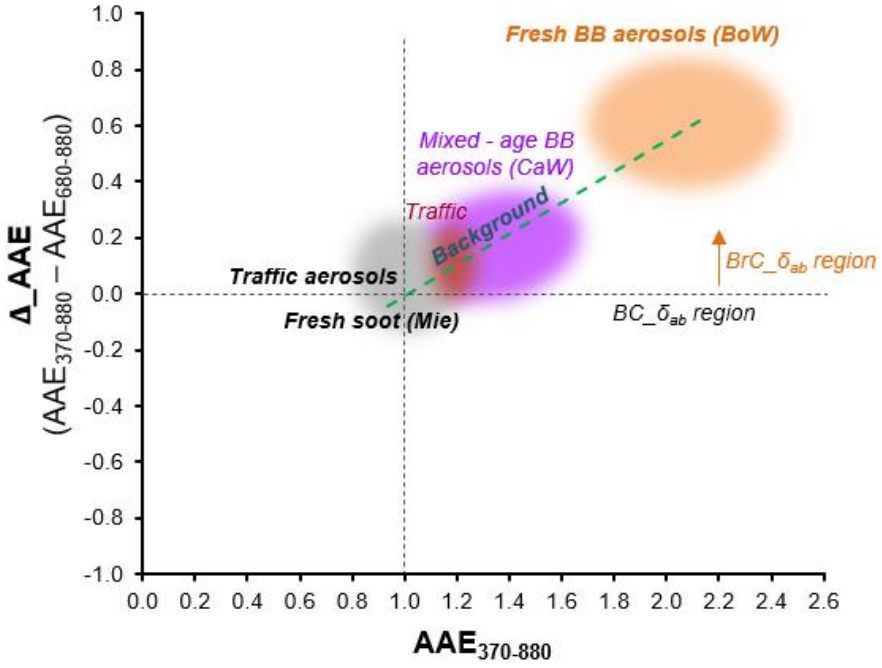


Fig. 1: The two- dimensional AAE approach describing the potential sources, aging and mixing state of BC and BrC measured at NAOK.

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CHARACTERIZATION OF ATMOSPHERIC BOUNDARY LAYER HEIGHT UNDER VARIOUS ATMOSPHERIC STABILITY AND CLOUDINESS CONDITIONS AT THE NATIONAL ATMOSPHERIC OBSERVATORY KOŠETICE

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Keywords: Atmospheric boundary layer, Atmospheric stability, Cloudiness, Ceilometer

INTRODUCTION

The atmospheric boundary layer (ABL) is the lowest part of the troposphere, directly influenced by the Earth's surface through turbulent exchanges of heat, moisture, and momentum. Its height and vertical structure show significant diurnal and seasonal variability, driven primarily by surface heating and cooling and the resulting changes in atmospheric stability. The ABL height is therefore a key parameter that determines the vertical distribution and dispersion of air pollutants and greenhouse gases in the atmosphere.

Atmospheric stability, determined by the vertical temperature stratification, plays an important role in the development of the ABL and the associated dispersion conditions. Stable stratification inhibits turbulent mixing and generally limits vertical exchange, while unstable conditions promote turbulence and facilitate the redistribution of substances present in the atmosphere. In addition to thermal stratification, cloudiness can substantially modify the surface radiation budget and thus influence the development of the ABL. The effects of cloudiness on atmospheric boundary layer height (ABLH) differ between daytime and nighttime conditions.

This study investigates the variability of atmospheric boundary layer height under different atmospheric stability and cloudiness. The attention is paid to the influence of differences between low-, middle-, and high-level clouds, and their potential implications for ABL development and atmospheric dispersion conditions.

METHODOLOGY

The study was conducted at data from the National Atmospheric Observatory Košetice (NAOK), a Central European background station. The analysis covers the period 2019–2021. ABLH was derived from measurements obtained using a Vaisala CL51 ceilometer. The data were processed using Vaisala BL-View software, followed by numerical post-processing in R to select the most suitable ABLH candidate. The procedure was based on the method of Lotteraner et al. (2016), with modifications adapted to the study conditions.

Atmospheric stability was determined from the vertical air temperature gradient calculated using measurements at 10 and 50 m above ground level on the 250-m meteorological mast. Air temperature was measured using Vaisala HMP155 temperature and humidity probes, and observations were classified into seven Pasquill stability classes (Woodward, 1998).

Cloud cover (CC) derived from ceilometer measurements was evaluated following the method of Kotthaus et al. (2018) and classified into cloudy (CC > 20%) and clear conditions. Cloud-base heights were further categorized into low-, middle-, and high-level clouds. The ceilometer-based classification was compared with SYNOP observations to account for differences between cloud detection within the instrument's narrow field of view and reported cloud cover.

RESULTS, DISCUSSION, CONCLUSIONS

The results show a clear relationship between atmospheric stability and ABL height. Higher ABLH values were observed under unstable conditions (Pasquill classes A–C), particularly during daytime in spring and summer, while stable conditions (classes F–G) were associated with lower and relatively constant ABLH during nighttime.

Cloudiness further modified ABLH, with its effect differing between daytime and nighttime conditions. During daytime, ABLH was generally lower under cloudy conditions than under clear skies, particularly in the presence of low- and high-level clouds, while no clear difference was observed for middle-level clouds. At night, cloudy conditions were generally associated with slightly higher ABLH, likely due to reduced radiative cooling of the surface; this pattern was not observed for high-level clouds.

The results confirm the important role of atmospheric stability and cloudiness in controlling ABLH and demonstrate the need to consider their combined effects.

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KONCENTRACE V RŮZNÝCH TEPLOTNÍCH TŘÍDÁCH NA NÁRODNÍ ATMOSFÉRICKÉ OBSERVATOŘI KOŠETICE

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Klíčová slova: Kvalita ovzduší, Teplota vzduchu, PM_{10}, $PM_{2.5}$, NO_2, CO, O_3, Isopren

SUMMARY

Long-term temperature-dependent behaviour of air pollutants at the National Atmospheric Observatory Košetice (NAOK) was examined using a 30-year dataset covering 1994–2025. Daily mean concentrations of 13 pollutants, including PM_{10}, $PM_{2.5}$, SO_2, NO_2, NO_x, CO, O_3, BaP, heavy metals (Pb, As, Cd, Ni), and isoprene. Were combined with daily mean air temperatures stratified into six discrete temperature classes (≤ −5, −5–0, 0–10, 10–20, 20–25, and ≥ 25 °C). Concentrations were normalised using Z-scores computed relative to the full observational record (1994–2025) to enable cross-pollutant comparison while preserving inter-decadal differences. The analysis was further divided into three decadal periods (1994–2004, 2005–2015, 2016–2025). Combustion-related pollutants showed strongly elevated anomalies under cold conditions, while O_3 and isoprene peaked under warm conditions. Decadal analysis revealed a progressive weakening of cold-season signals for combustion species and marked intensification of warm-season isoprene anomalies in the most recent period at NAOK.

ÚVOD

Rostoucí teploty vzduchu spojené s klimatickou změnou ovlivňují atmosférickou chemii, emise znečišťujících látek i podmínky jejich rozptylu (Jacob *et al.*, 2009). Teplota vzduchu zároveň ovlivňuje intenzitu emisních zdrojů. Zejména vytápění domácností a klíčové meteorologické faktory jako výška planetární mezní vrstvy a rychlost fotochemických reakcí (Seinfeld and Pandis, 2016). Analýza vychází z měření prováděných v letech 1994–2025 na Národní atmosférické observatoři Košetice (NAOK; 49°34′24″ N, 15°04′49″ E; 534 m n. m.).

METODIKA

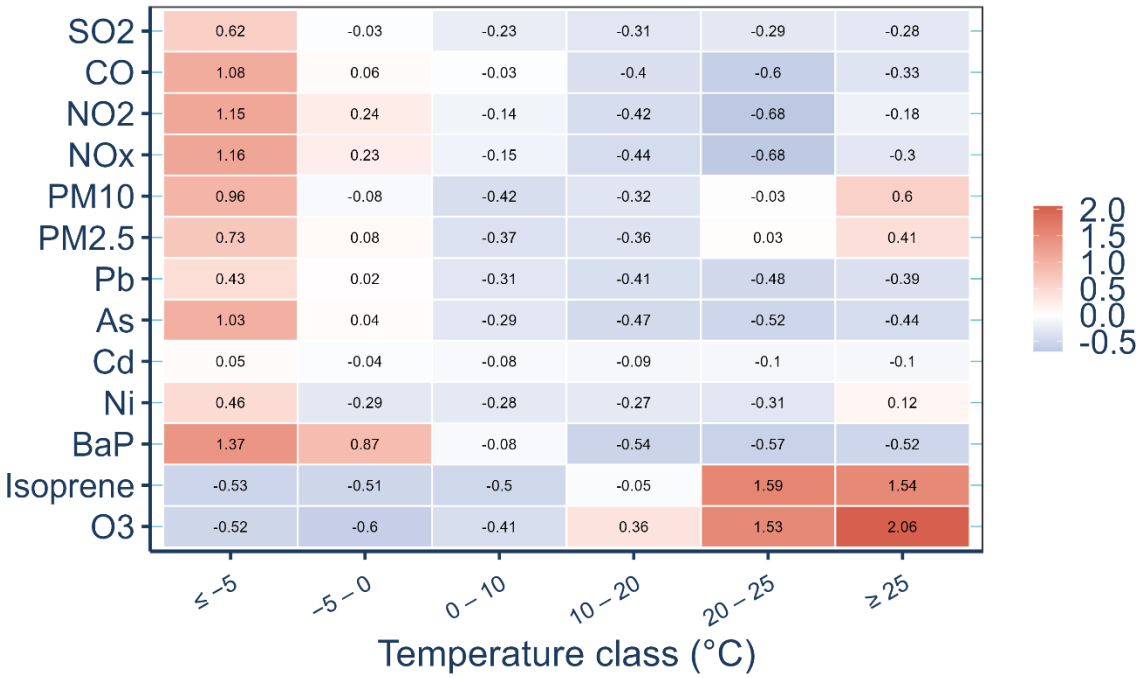
Hodnoceny byly denní průměrné koncentrace PM_{10} a $PM_{2.5}$ (zeslabení beta záření), SO_2 (UV fluorescence), NO_x (chemiluminiscence), CO (infračervená absorpce), O_3 (UV fotometrická absorpce), BaP (odběr na filtr po dobu 72 hodin, analýza GC-MS), těžké kovy Pb, As, Cd, Ni (odběr na filtr po dobu 48 hodin, analýza ICP-MS) a isopren (odběr do nerezových kanistrů, analýza GC). Teplota vzduchu byla měřena přístrojem Vaisala HMP 155 a to kontinuálně po celé hodnocené období.

Denní průměrné koncentrace byly normalizovány pomocí Z-skóre vypočteného vůči celé observační řadě (1994–2025), aby bylo možné srovnání napříč polutanty při zachování rozdílů mezi dekádami. Data byla rozdělena do šesti teplotních tříd (≤ −5, −5–0, 0–10, 10–20, 20–25 a ≥ 25 °C) a tří desetiletých období (1994–2004, 2005–2015, 2016–

2025). Statistické zpracování bylo provedeno v prostředí R s využitím balíčku tidyverse (Wickham *et al.*, 2019), grafy byly vytvořeny v ggplot2 (R Core Team, 2024).

VÝSLEDKY, DISKUSE, ZÁVĚRY

Výsledky mediánových Z-skóre (Obr. 1) ukazují zřetelné teplotní závislosti napříč všemi sledovanými polutanty. Polutanty spojené se spalováním (PM_{10}, CO, NO_2, NOx, SO_2 BaP a stopové kovy) vykazují nadprůměrné koncentrace při nízkých teplotách, zatímco O_3 a isoprén dosahují maxima při teplotách nad 20 °C. Nejvyšší kladné Z-skóre bylo zaznamenáno pro O_3 ve třídě ≥ 25 °C (Z = +2,06), zatímco BaP vykazuje nejsilnější signál při teplotách pod 0 °C (Z = +1,37 ve třídě ≤ −5 °C). Celkový rozsah mediánových Z-skóre od přibližně −0,6 do +2,1 ukazuje, že teplotou podmíněné zvýšení koncentrací výrazně převyšuje jejich pokles. Tento vývoj má přímé důsledky pro hodnocení dopadů klimatické změny na kvalitu ovzduší.



Obr. 1: Mapa mediánových Z-skóre koncentrací sledovaných polutantů v jednotlivých teplotních třídách na NAOK (1994–2025).

Dekádní srovnání odhaluje systematické posuny teplotních spekter. Zimní zvýšené koncentrace polutantů pocházející ze spalovacích zdrojů postupně slábnou. Nejvýraznější změna byla pozorována u NO_2, jehož mediánové Z-skóre ve třídě ≤ −5 °C kleslo z +1,64 v období 1994–2004 na −0,20 v období 2016–2025, a u BaP, který zaznamenal pokles o přibližně 4 jednotky Z-skóre v průběhu jediné dekády. Tyto změny dokládají dlouhodobé snižování emisí v důsledku evropské legislativy v oblasti kvality ovzduší a národních programů podpory modernizace vytápění. Naopak letní koncentrace isoprenu se v nejnovějším desetiletém období výrazně zintenzivnily. Mediánové Z-skóre ve třídě 20–25 °C vzrostlo z −0,17 v letech 1994–2004 na +2,15 v letech 2016–2025, což je největší dekádní změna zaznamenaná mezi polutanty řízené fotochemickou reakcí.

PODĚKOVÁNÍ

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THE ROLE OF RIME ICE IN ATMOSPHERIC DEPOSITION PROCESSES

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Keywords: Rime ice, Loads, Ion concentrations, Hydrological input, Mountains

INTRODUCTION

Rime ice is defined as a deposit of ice generally formed by the freezing of supercooled fog or cloud water droplets on objects the surface temperature of which is lower than or slightly above 0 °C (WMO 2017). It remains so far generally neglected part of atmospheric deposition fluxes however, it is generally accepted that rime ice may play considerable role particularly in regions where its occurrence is frequent (Ahti - Makkonen, 1982). In Central European conditions that is predominantly in mountain regions. Nevertheless, evidence of this is still scarce. We have therefore recently focused on studying the formation, occurrence and behaviour of rime ice using various methods, including the sampling of rime ice and subsequent chemical analyses, field measurements of the mass of formed rime ice loads, and experiments in a climatic wind tunnel. Additionally, we also explored existing long-term measurements carried out by the Czech Hydrometeorological Institute (CHMI) - the data which have not been evaluated before. Our underlying hypothesis was that rime similarly as fog, is an important pathway of atmospheric deposition, and failure to take these hydrometeors into account consistently results in an underestimation of the total true atmospheric deposition fluxes. The aim of this presentation is to show the findings so far obtained by a broader team of researchers of the CHMI, in collaboration with colleagues from the Czech Geological Survey (CGS), the Institute of Theoretical and Applied Mechanics of the Czech Academy of Sciences, the Institute of Informatics of the Czech Academy of Sciences and the Institute of Environmental Studies of the Faculty of Natural Sciences, Charles University.

METHODOLOGY

Different approaches were used to cover this topic in broader context. For analysis of existing dataset of observations of rime ice occurrence and thickness we used advanced atatistical approach based on a semiparametric GAM, Generalized Additive Model, (Wood, 2017). The winter sampling for rime ice at ten mountain tops in the CR provided by the CGS and comparison of contents of sulpur ($S\text{-}SO_4^{2-}$) and nitrogen ($N\text{-}NO_3^-$) in rime ice and snow was described by Hůnová *et a*l. (2022; 2023). For sampling of rime ice in the field, we used plastic model trees (usually used as Christmas decoration) which proved to be very effective (Fig.1) and allowed for comparison of rime ice in the open area and at the forest at three sites at the altitude around 1000 m a.s.l. The results of 2024/2025 field measurements in the Krkonoše mountain tops were summarized by Kučera (2025) in his diploma thesis. To compare the rime ice formation on different devices we used climatic wind tunnel (Fig. 2). Presently we are preparing a manuscript collating our latest findings from field measurements and climatic wind tunnel experiments.



Fig. 1: Plastic model tree used for field rime ice measurements positioned at the Krkonoše mountain tops (photo Lukáš Kučera)

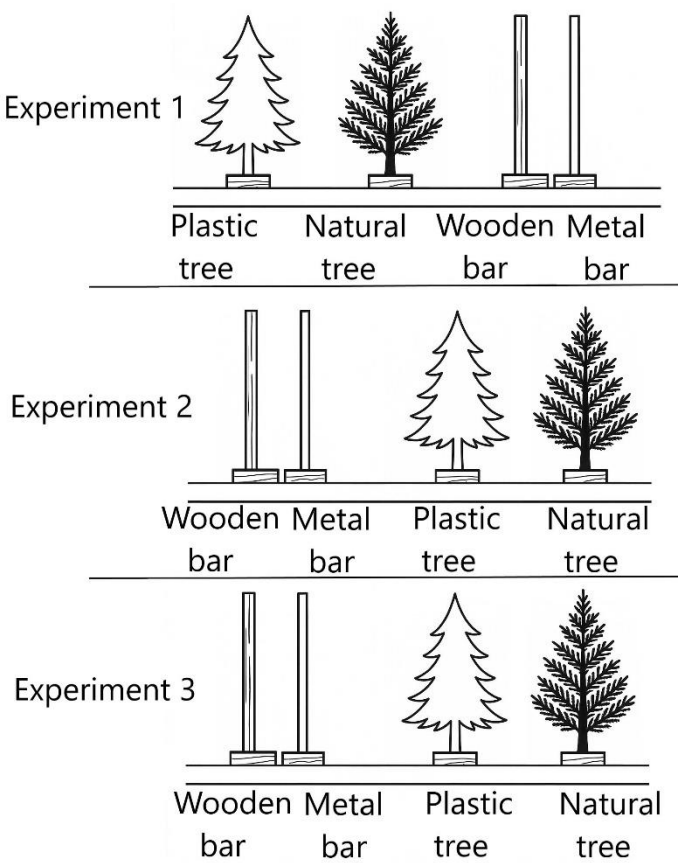


Fig. 2: Scheme of various devices used for quantification of rime ice loads in the climatic wind tunnel experiment (Kučera, 2025)

RESULTS AND DISCUSSION

The long-term trend analysis of observations of rime ice occurrence and measurements of rime ice thickness carried out on a routine basis by the CHMI at 23 professional meteorological stations situated at the altitude range of 250–1322 m a.s.l. during 2002–2023 revealed high year-to-year variability at all sites. The mountain sites yielded significantly higher rime ice loads than sites situated in lowlands or hilly areas. The highest by far rime ice hour and thickness records were observed at the LYSA station in the Beskydy Mts situated at the exposed mountaintop and highly elevated above the surrounding terrain (Hůnová *et al*., 2026).

To understand the role of rime ice in atmospheric deposition processes and to quantify the deposition fluxes of chemical species via the rime ice deposition pathway we perceived two major aspects of this phenomenon: (i) chemistry of the rime ice and (ii) hydrological volume of the rime ice. With respect to chemistry, we have found that rime ice samples were significantly more mineralized than snow samples from the same area. This holds for all Czech bordering mountain top sites and entire winter seasons examined, for major ions (Hůnová *et al*., 2022; 2023) as well as minor ions (Cimova *et al*., 2016). These findings are in line with other similar studies from elsewhere.

Even if the chemical composition of rime ice is known, to calculate the deposition fluxes of certain species over a winter season is a challenge, as the hydrological volume of rime ice formed over the winter is usually unknown. Within a student diploma thesis (Kučera, 2025) the field observations of rime ice formation at the Krkonoše Mts, were carried out at three sites over 2024/2025 winter. Using a plastic model tree 50 cm tall as suitable rime ice sampler we were abke to successfully mimic rime ice formation at a small tree-level. Although it is not possible to extrapolate our findings to a mature tree or even an ecosystem, we were able to get a reasonable indication that such a small plastic tree can collect more than 2.5 kg of rime ice over one of the winters which, according to the CHMI, was among the warmer ones. To put this result into water volume context we can state that the rime ice loads formed on one model plastic tree during our field campaign, equalled some 13% of winter and 3% of annual precipitation amount at mountain tops.

The climatic wind tunnel experiments enabled us to watch rime ice formation live and quantify the difference in rime ice loads formed on various devices differing in material and branching. We used freshly cut spruce tree, plastic model tree, wooden rod and metal rod, all devices being of the same height. Although the time duration of the experiments was limited to 22 min due to technical constraints, the results obtained within controlled experimental conditions complemented nicely our findings from field measurements.

CONCLUSIONS

Although the hydrological volume of rime ice is lower than annual precipitation amount, it forms a non-negligable portion of atmospheric deposition especially in mountan regions. In combination with much higher mineralization of rime ice as compared to snow or rain it may increase the input of contaminants into our environment. Our findings support the hypothesis that rime ice is an important pathway of atmospheric deposition. Even in our conditions, with mere 2–3 winter months suitable for rime ice formation per year, it may add substantially to annual deposition fluxes. If we neglect this fact, the estimated exposure of ecosystems is likely to be underestimated. Therefore, the rime ice should be always considered in quantification of deposition fluxes particularly in sensitive mountain ecosystems.

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LONG-TERM OPERATION AND TESTING OF A STAND-ALONE AUTOMATED MEASURING SYSTEM FOR PM MEASUREMENTS UNDER HARSH METEOROLOGICAL CONDITIONS

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Keywords: particulate matter; air quality monitoring; stand-alone automated measuring system

INTRODUCTION

Automated Measuring Systems (AMS) for PM measurements have shown a high temperature and humidity sensitivity outside a certain range. Best available practice is based on AMS positioning into air-conditioned weather-protective enclosures, where proper sampling and operation conditions still need to be met, i.e. use of heated sampling inlets. Sampling locations need to be chosen and designed to reflect such elevated requirements on infrastructure available onsite, including specific needs related to available space, higher power consumption and reliable data acquisition and transmission (example on Fig. 1). AMS deployment is very difficult or even impossible at many sampling locations due to those specific needs. In combination with higher spatial and temporal resolution of air quality monitoring systems needed, authorities are looking for new alternatives, which would allow them to deal with such challenges, and to meet new legislative requirements. Compact stand-alone AMS could provide required performance, but very often not able to follow data quality objectives as necessary, i.e., like indicative measurement systems. New technological developments of reference grade AMS look promising to be able to bridge a gap but still need to provide clear and transparent evidence of the performance under various operation conditions, what is reachable through long-term testing and comparative campaigns.



Fig. 1: Teppanala Air Quality Monitoring Station, Imatra, South Karelia, Finland

The reference method for measurements of particulate matter (PM) in air, segregated into particles with an aerodynamic diameter smaller than 10 µm (PM10) and smaller than 2.5 µm (PM2.5), is based on 24-hours filter sampling and gravimetric analysis according to the standard EN 12341:2014. However, this method does not provide real-time data, which is useful to interpret current air quality situation and is needed to fulfil the requirement for informing the public on air pollution levels in real time. Thus, the ambient air PM measurements are conducted mostly using automated measurement systems (AMS), i.e., continuous particle monitors, that provide measurement data in real time and with a high time resolution (Saarnio, K. et al., 2025).

Member States may use other methods in case they are able to demonstrate a consistent relationship with the reference method. In Finland, a Demonstration of Equivalence (DoE) of continuous PM10 and PM2.5 Automated Monitoring Systems (AMS) was conducted within the project National quality program for particulate matter measurements: Ongoing verification of suitability of automated measuring systems (Ongoing 2021). AMS representing different instrument types and measurement techniques were compared with the gravimetric reference method according to EN 12341:2014. The verification followed a modified approach based on EN 16450:2017, enabling broader inclusion of instruments over a long-term comparison campaign, where the conducted test procedure could not fully adhere to the ongoing verification of suitability requirements by the EN 16450:2017 (Saarnio, K. et al., 2025).

The present work introduces results of a long-term testing and comparison campaign of two TÜV (EN 16450:2017) certified instruments (Fidas® Smart 100 system, Palas GmbH referred as Device #62 and Device #63) against two gravimetric reference samplers (EN 12341:2014).



Fig. 2: Fidas® Smart 100 During DoE Test in Helsinki/Finland (2022 – 2023)

METHODOLOGY

Teppanala measurement station of Finish Meteorological Institute (FMI) close to city of Imatra hosted the last DoE campaign (urban background with industry influence). This

location has typically a big gradient of temperature and humidity during the seasons. Within an 8-month campaign between September 2024 and May 2025, the temperature variation was between -16°C and +20°C, where relative humidity fluctuated between 50% and 99%, with average value about 84%. It is well known, winter seasons could be challenging in Finland, as observed in previous campaign as illustrated on Fig. 2. (DoE Test at AQMS in Helsinki, 2022-2023).

The Fidas® Smart 100 is aerosol spectrometer specially developed for use in official environmental regulatory monitoring, supporting direct wall, pole, or tripod mounting due to its very compact dimensions, often compared to the size of a 'shoebox', which does not need an air-condition between -20 °C and +50 °C. It continuously analyzes the fine dust particles present in the ambient air in the size range between 0.18 and 18 µm, where a sample humidity is controlled by an intelligent aerosol drying system (Compact-IADS), which is part of the unit. Technology and algorithms were developed based on the EN 16450-certified Fidas® 200 (Palas GmbH), the solution which proven its performance throughout most of EU-operated regulatory monitoring networks. The Fidas® Smart 100 is EN 16450:2017 (https://www.qal1.de/) type approved particulate matter analyzer for continuous and simultaneous measurement of PM2.5 and PM10, which provides additionally also PM1, PM4, TSP total dust, particle number concentration, and their particle size distribution, including pressure, temperature, humidity, and carbon dioxide, in ambient air. The measurement instruments used were regularly maintained and calibrated on-site, as Palas® aerosol spectrometers can be fully calibrated and adjusted against a traceable transfer standard by the user directly at the location of its operation. QA/QC procedures according to EN 16450:2017 were applied. Fidas® Smart 100 features Ethernet, WLAN, and mobile phone network-based connectivity and data transfer. All measured values were processed and recorded directly by the unit itself onsite, by built-in computer, and, alternatively also transferred in parallel to Palas' own data online (cloud) platform MyAtmosphere (https://my-atmosphere.net/) for remote visualization or further data processing.

Finnish reference laboratory for air quality (Reflab-FI) collected 24h-filter samples by the reference method - filter sampling and gravimetric analysis method according to EN 12341:2014. The sampling was conducted using two Leckel SEQ47/50 (Sven Leckel Ingenieurbüro GmbH) samplers, one equipped with PM10 inlet and the other with PM2.5 inlet, and both samplers having an automatic sample exchange system. Polytetrafluoroethylene (PTFE) membrane filters (Millipore Fluoropore FSLW04700 3 µm) were used as sampling substrates. The weighing of empty and sampled filters was made with the accredited (EN ISO/IEC 17025:2017) gravimetric method (ultra-microscale Mettler Toledo XP2U) of the reference laboratory in the condition-controlled weighing cabinet according to EN 12341:2014. Samples were collected as 16-filter batches for each period / season (summer / winter). QA/QC procedures according to EN 12341:2014 were applied. The Finnish National Reference Laboratory at FMI has demonstrated its competence in PM10 and PM2.5 measurements in the interlaboratory comparison organized in 2018 by the European Reference Laboratory for Air Pollution (ERLAP) of the Joint Research Centre (JRC) of the European Commission (Saarnio, K. et al., 2025).

RESULTS, DISCUSSION, CONCLUSIONS

In this section, the measurement results from different AMS are compared against the reference method. The 24-h-averaged AMS data were compared to the reference method

data using the EU-Equivalence Tool (V3.1 020720), based on EN 16450:2017 standard and constructed in the frame of the Working Group 15 (PM10/PM2,5) of the Technical Committee of Air Quality of the European Committee for Standardization CEN (CEN/TC 264/WG 15).

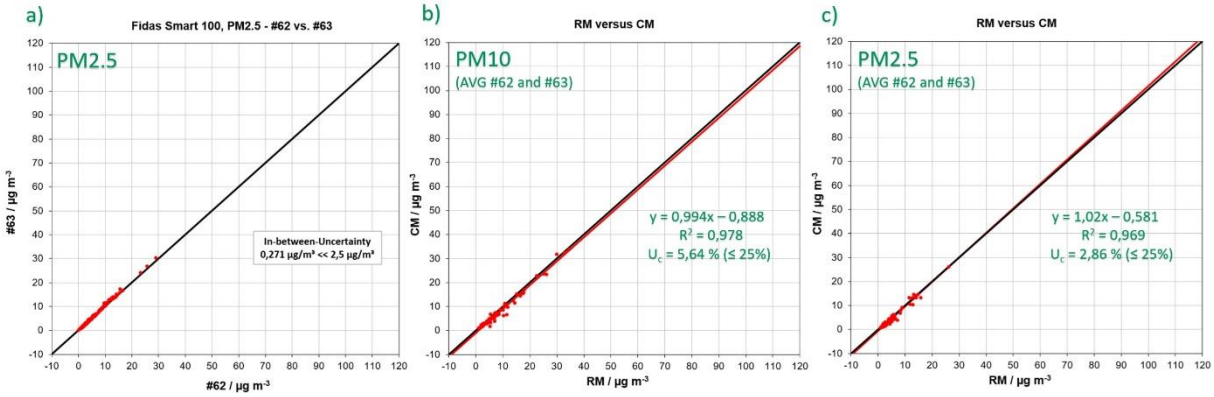


Fig. 3: Intercomparison of Fidas® Smart 100 vs Leckel SEQ 47/50 samplers, where a) inter-unit comparison between candidate units, b) PM10 DoE test results, c) PM2.5 DoE test results, where average values from Device #62 and Device #63 evaluated

Both instruments demonstrated very good agreement with the reference method for PM10 and PM2.5, where no correction factors needed. In all of the evaluated data sets, the candidate instruments achieved a coefficient of determination (R2) values of >= 0.96 compared with the reference instruments, as indicated on Fig. 3. Furthermore, the expanded measurement uncertainty remained below 10% in all evaluations, well below the requirement limit of 25%, under various operation conditions, even if only focused on cold days (when ambient air temperature below 5 °C), as indicated in Tab.1.

Tab. 1: Teppanala DoE Test Data Evaluation, 2024-2025

PM-Fraction	Data Set	Slope	Intercept	R^2	Uncertainty U_c	2024/2881/EU Request 24-h AVG
PM10	All data	0,994	-0,888	0,978	5,64 %	Uc ≤ 25 %
PM10	TEMP < 5 °C	0,968	-0,731	0,965	9,89 %	Uc ≤ 25 %
PM2.5	All data	1,02	-0,581	0,969	2,86 %	Uc ≤ 25 %
PM2.5	TEMP < 5 °C	0,984	-0,521	0,968	7,22 %	Uc ≤ 25 %

Newly developed AMS seems to have overcome limitations of conventional technologies. It could provide an interesting solution at locations and applications, where no AMS could be deployed due to various limitations in the past. Long-term operation stability, reliable performance, and expectable life-time to be further investigated.

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AUTOMATED SEMI-CONTINUOUS DETERMINATION OF GASEOUS NITRIC AND NITROUS ACID IN AMBIENT AIR USING ION CHROMATOGRAPHY

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Keywords: Nitric acid, nitrous acid, wet diffusion denuder, ion chromatography

INTRODUCTION

Nitric acid (HNO_3) and nitrous acid (HONO) are important components of atmospheric reactive nitrogen. HNO_3 acts as an important sink of NO_x, whereas HONO photolysis represents an important source of OH radicals (Seinfeld and Pandis, 2016). Their determination is challenging because both compounds are reactive, water-soluble and susceptible to sampling artefacts (Kleffmann, 2007). Conventional coated filters and dry diffusion denuders generally require long sampling periods, while wet diffusion denuders continuously transfer soluble gases into a renewed liquid film (Simon and Dasgupta, 1995).

This study evaluates a fully automated cylindrical wet effluent diffusion denuder coupled to ion chromatography (CWEDD-IC) for semi-continuous determination of gaseous HNO_3 and HONO.

METHODOLOGY

Ambient air was sampled through a CWEDD at 1.0 L min^{-1} against a counter-current flow of deionised water (1.2 mL min^{-1}). The effluent was transferred through a debubbler to an automated two-column preconcentration system coupled to ion chromatograph (ICS-2100, Dionex, USA). Effective preconcentration lasted 55 min and the chromatographic cycle 60 min, providing a 1 h time resolution. Atmospheric detection limits were 16.4 ng m^{-3} for HNO_3 and 26.5 ng m^{-3} for HONO.

Interferences from NO_2 and NO were evaluated and compared with Na_2CO_3-coated filters and dry diffusion denuders (DDs). The method was subsequently tested during urban field campaigns in Brno in September 2025 and January 2026 against conventional 24 h offline sampling.

RESULTS, DISCUSSION

CWEDD collection efficiencies at 1.0 L min^{-1} were 97.99% for HNO_3 and 99.98% for HONO. NO_2 interference was 0.65% for HNO_3 and 0.19% for HONO, whereas NO interference was only 0.03% for both analytes. For HONO, NO_2 interference increased to 2.11% for coated filters and 3.82% for DDs. NO interference of the offline methods ranged from 1.18 to 1.94%, demonstrating their higher susceptibility to NO_x-derived artefacts.

During the summer campaign (Fig. 1), mean CWEDD-IC concentrations were 0.71 µg m^{-3} HNO_3 and 0.99 µg m^{-3} HONO. Relative to CWEDD-IC, DD results were 45% for HNO_3 and 243% for HONO, whereas coated filters yielded 2% and 125%, respectively. In winter, CWEDD-IC concentrations increased to 1.99 µg m^{-3} HNO_3 and 1.68 µg m^{-3} HONO. DD

results represented 117% and 20% of CWEDD-IC values, and coated filters 10% and 60%, respectively.

The pronounced and season-dependent differences indicate the influence of competing positive and negative sampling artefacts. In CWEDD-IC, the continuously renewed aqueous film and rapid transfer of collected analytes reduce their residence time on the sampling surface and therefore limit the opportunity for such processes.



Fig. 1: Changes in the concentration of HNO_3/HONO (and nitrates/nitrites) in ambient air during the summer campaign (Brno, September 2025)

CONCLUSIONS

The fully automated CWEDD-IC system enables semi-continuous determination of gaseous HNO_3 and HONO with 1 h time resolution, high collection efficiency and low NO_x interference. Compared with conventional 24 h offline methods, it provides substantially higher temporal resolution and reduces the influence of sampling artefacts. The system also represents an independent analytical platform suitable for comparison and validation of rapid continuous-flow analysers.

ACKNOWLEDGEMENT

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PŘÍBĚH A VÝHODY REVOLUČNÍHO ŘEŠENÍ PRO FILTRACI VZDUCHU V INTERIÉRU OD NÁVRHU PO KOMERCIONALIZACI

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Klíčová slova: filtrace vzduchu, čistička vzduchu, rukávový filtr

Účinné odstraňování aerosolových částic v interiéru je důležité pro ochranu zdraví osob a zlepšení kvality vzduchu obecně. Mobilní čističky vzduchu a filtrační systémy běžně využívají vláknité filtry s vysokou filtrační účinností (HEPA). Zde bychom rádi demonstrovali, proč je vysoká filtrační účinnost vhodná pro jednoprůchodovou filtraci, nikoli pro běžné čištění vzduchu v interiéru. To je totiž realizováno vícenásobným průchodem vzduchu filtrem, a proto je vhodné maximalizovat objem vzduchu, který filtrem prochází, při vhodně zvolené filtrační účinnosti. Námi navržené filtrační zařízení jsme dlouhodobě otestovali a ve spolupráci s komerčním partnerem dovedli až k udělení patentu. Nyní je filtrační zařízení komerčně dostupné a vhodné pro využití v kancelářích, nemocnicích, školách, skladech a výrobě.

POSTERY/POSTERS

AEROSOLY POD MIKROSKOPEM – POPULARIZAČNÍ PROJEKT V KRAJI VYSOČINA

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Klíčová slova: elektronový mikroskop, aerosoly, popularizace

SUMMARY

A project focused on popularising air quality in the Vysočina region was carried out in 2025 and 2026. One outcome was an exhibition showcasing a variety of aerosol particles in ambient air. During the summer and winter campaigns, several aerosol particles were sampled and analysed from different sources (residential heating, resuspension, pollen, etc.). Results were presented in posters with adequate explanation of the role of aerosols in ambient air and their impact on human and environmental health.

ÚVOD

V Kraji Vysočina již více než 37 let existuje specializované pracoviště kvality ovzduší a meteorologických měření – Observatoř Košetice, Český hydrometeorologický ústav (ČHMÚ). Observatoř během let rozšiřuje a specializuje měřící program tak, aby v odpovídající kvalitě zajistila měření, která splňují požadavky českých zákonů, evropských směrnic a vybraných mezinárodních projektů a programů. Kromě provozu měření, přípravy datových sad a jejich interpretace patří k práci na observatoři i popularizační aktivity. V roce 2025 a 2026 proběhl ve spolupráci Společnosti pro rozvoj Humpolecka, z.s., Via rustica z.s. a Českého hydrometeorologického ústavu projekt „Klimatické a environmentální dopady změn kvality ovzduší na vybraném území Kraje Vysočina v čase“. Cílem projektu bylo přiblížit veřejnosti téma kvality ovzduší a prohloubit povědomí o tom, jak se ovzduší v regionu mění a co vše jej ovlivňuje. Součástí projektu byly exkurze na Observatoř Košetice, deset vzdělávacích přednášek o kvalitě ovzduší, publikace a výstava snímků aerosolových částic.

METODIKA

Aerosolové částice byly kontinuálně vzorkovány na polykarbonátové filtry po dobu 24 hodin, ve velikostní frakci PM_{10}. Prvková analýza probíhala na elektronovém mikroskopu MIRA3 (Tescan) na pracovišti ČHMÚ, Brno. Vzorkování probíhalo na deseti lokalitách v územním působení Společnosti pro rozvoj Humpolecka, z.s. a Via rustica z.s. v letní a zimní kampani (červen, listopad a prosinec 2025) (Obr.1). Snímky z elektronového mikroskopu byly dále vyhodnoceny a použity pro přípravu výstavy. Připraveno bylo 18 plakátů, snímky byly doplněny textem popisujím vznik částic a jejich vliv na zdraví člověka a životní prostředí.



Obr. 1: Lokality pro odběr vzorků aerosolových částic k analýze na elektronovém mikroskopu, Kraj Vysočina. Ukázka plakátu z výstavy, Humpolec červenec 2026.

VÝSLEDKY

Analýza výsledků ukázala různé zdroje aerosolových částic přírodního i antropogenního původu. Nejčastěji se na filtrech zachytily částice původem z dopravy či vytápění. Nešlo však pouze o aglomeráty sazí, ale i o úlomky z brzdového obložení, částice z resuspenze nebo z pálení trámů či odpadu. V obou kampaních byly zachyceny aerosoly z půdy, spory hub, pyly rostlin a fragmenty ze schránek hmyzu. V některých lokalitách byly součástí aerosolu i částice ze sklářské taveniny, fragmenty železa či dřevěných vláken.

PODĚKOVÁNÍ

Tento projekt „Klimatické a environmentální dopady změn kvality ovzduší na vybraném území Kraje Vysočina v čase“ je spolufinancován Evropskou unií.

ASOCIÁCIA KONCENTRÁCIÍ AEROSÓLU S PREVÁDZKOVOU ČINNOSŤOU V AREÁLI OBAĽOVAČKY ASFALTOVÝCH ZMESÍ

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Kľúčové slová: PM_{10}, $PM_{2,5}$, $PM_{2.5-10}$, asfaltová zmes, prevádzkový hluk

SUMMARY

A two-week campaign at an asphalt mixing plant examined the temporal variability of particulate matter using three collocated sensors corrected against gravimetric measurements. Weekday hourly PM_{10} medians peaked at 24–25 μg/m^3 between 06:00 and 08:00, compared with approximately 12 μg/m^3 at night. PM remained positively associated with noise after adjustment for meteorology and time. The campaign was originally designed to compare PM concentrations during the production of standard asphalt mixture and low-temperature asphalt mixture, with lower process temperatures expected to reduce emissions. However, operational circumstances prevented the two production regimes from being evaluated separately, so the analysis focused on temporal patterns of PM concentrations across site activities.

ÚVOD

Aerosól v areáli obaľovačky vzniká pri manipulácii s kamenivom, jeho doprave a spracovaní, ako aj pri pohybe vozidiel a resuspenzii prachu z povrchov. Súčasťou emisií môžu byť aj produkty spaľovania a kondenzácie organických pár (US EPA, 2004). Časový priebeh koncentrácií preto odráža kombináciu pracovnej činnosti, lokálneho transportu a meteorologických podmienok.

Cieľom práce je opísať denný priebeh PM_{10}, $PM_{2,5}$ a hrubej frakcie $PM_{2,5-10}$, ich hmotnostné zastúpenie a asociáciu s hlukom. Pôvodný zámer porovnať nízkoteplotnú a štandardnú asfaltovú zmes nebolo možné vyhodnotiť pre komplikované meteorologické podmienky a nečakané prevádzkové okolnosti. Predmetom tejto práce je preto hodnotenie aerosólu v prevádzkovom areáli ako celku.

Tri senzory a mobilná monitorovacia stanica kvality ovzdušia (MMSKO) boli umiestnené na jednom meracom mieste v areáli obaľovačky (48°08′31,5″ N; 17°33′47,0″ E). Senzory predstavujú súbežné prístrojové merania, nie tri nezávislé locality.



Obr. 1: Spoločné meracie miesto senzorov a MMSKO v areáli obaľovačky. Fotografia z meracej kampane.

METODIKA

Kampaň prebiehala od 11. 8. 2026 11:00 do 26. 8. 2026 08:40. Spracovaných bolo 2 147 desaťminútových záznamov PM, hluku a meteorológie. Pracovné dni boli definované kalendárne ako pondelok až piatok: 1 571 záznamov z 12 dátumov vrátane dvoch neúplných dní.

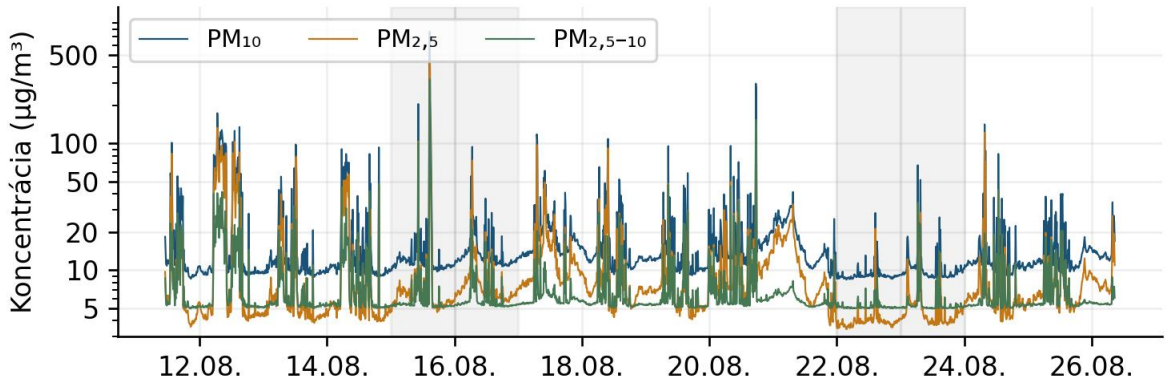
Korekcia každého senzora a frakcie vychádzala zo štyroch porovnávacích kampaní v októbri–novembri 2024 a 2025, februári a marci 2026. Senzorové priemery zodpovedali gravimetrickému odberu od 10:00 do 10:00 nasledujúceho dňa. Dostupných bolo 52 párov pre SM13338 a 56 pre ostatné senzory. Porovnali sme pôvodné údaje, regresiu cez počiatok, pomer súčtov a lineárny model C = a + b.x (x je údaj senzora). Najnižšiu RMSE pri postupnom vynechaní celej kampane dosiahol lineárny model s interceptom vo všetkých šiestich prípadoch (tab. 1).

Tab. 1: Parametre vybraného modelu. RMSE vyjadruje chybu na vynechaných kampaniach; a a RMSE sú v µg/m^3.

Senzor	Frakcia	a	b	R^{2*}	RMSE
13338	PM_{10}	7,661	0,671	0,831	7,75
13338	$PM_{2,5}$	2,889	0,609	0,972	2,20
13340	PM_{10}	7,775	0,673	0,835	7,71
13340	$PM_{2,5}$	2,945	0,600	0,967	2,53
13336	PM_{10}	7,371	0,683	0,832	7,51
13336	$PM_{2,5}$	2,525	0,620	0,969	2,29

** R^2 pri prispôsobení modelu všetkým dostupným párom.*

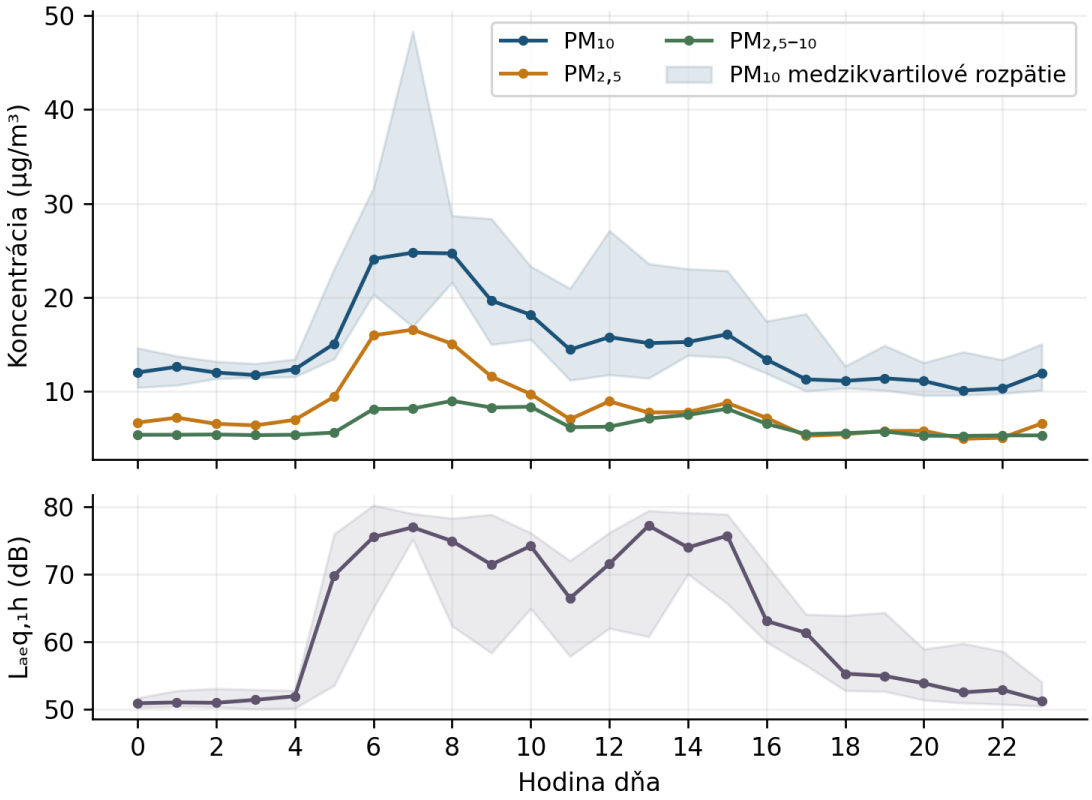
Pre každý interval bol použitý aritmetický priemer troch korigovaných hodnôt; $PM_{2,5-10} = PM_{10} - PM_{2,5}$. PM_1 bez gravimetrickej referencie nebol zahrnutý. Denný profil tvoria mediány úplných hodinových priemerov medzi pracovnými dňami (10–11 hodín pre každý čas dňa). Hluk bol interpretovaný ako LAeq, 10min; hodinové LAeq boli agregované energeticky. Meteorológia MMSKO zahŕňala vietor, teplotu, vlhkosť a zrážky.



Obr. 2: Desaťminútový priebeh korigovaných koncentrácií. Logaritmická os; sivé plochy označujú víkendy.

VÝSLEDKY A DISKUSIA

Za celú kampaň dosiahli priemerné korigované koncentrácie PM_{10}, $PM_{2,5}$ a $PM_{2,5-10}$ hodnoty 17,84; 10,41 a 7,43 µg/m^3. Mediány boli 11,91; 6,40 a 5,41 µg/m^3. Rozdiel medzi priemerom a mediánom poukazuje na epizodický charakter zvýšení; 95. percentil PM_{10} dosiahol 43,83 µg/m^3. Tieto výsledky opisujú jedno miesto v areáli.



Obr. 3: Denný profil pracovných dní. Mediány hodinových hodnôt; pásma označujú 25.–75. percentil PM_{10} a LAeq. Koncentrácie sú priemerom troch korigovaných senzorov.

Najvýraznejší spoločný vzostup PM a hluku nastal ráno. Medián hodinového PM_{10} dosiahol o 6., 7. a 8. hodine 24,11; 24,77 a 24,69 µg/m^3, kým medzi 0. a 4. hodinou bol

11,75–12,63 µg/m³. Jemná frakcia v ranných hodinách dosiahla 15,08–16,58 µg/m³ a hrubá frakcia 8,14–9,01 µg/m³. Ranný medián PM_{10} (6.–8. hodina) prevyšoval nočný medián (0.–4. hodina) vo všetkých 11 dňoch s dostupnými oboma obdobiami. Po 16. hodine koncentrácie aj hluk prevažne klesali.

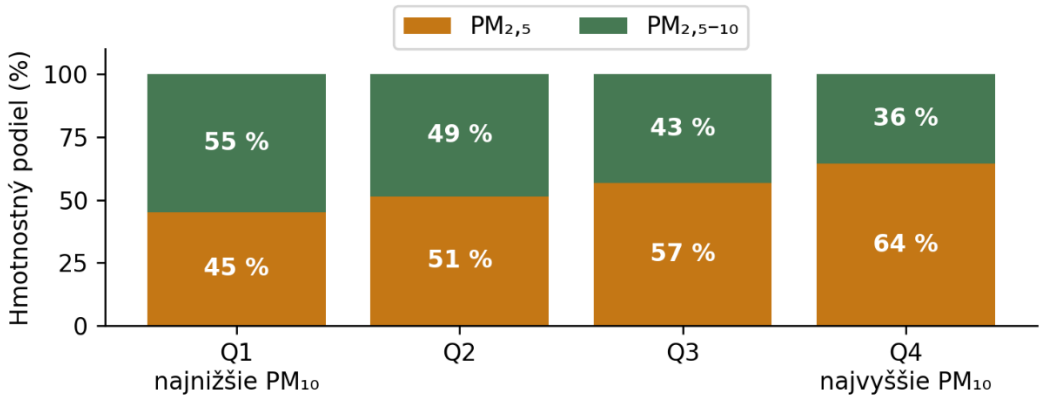
Počas pracovných dní bol Spearmanov korelačný koeficient s desaťminútovým hlukom 0,488 pre PM_{10}, 0,444 pre $PM_{2,5}$ a 0,569 pre hrubú frakciu. Pri LAeq < 55 dB bol medián PM_{10} 11,22 µg/m³ (n = 670), pri LAeq ≥ 75 dB 20,97 µg/m³ (n = 356). Pásma hluku slúžia na opis asociácie, nie ako overené hranice výroby.

V regresii logaritmu koncentrácie na hluk, meteorológiu, hodinu a dátum bolo zvýšenie LAeq o 10 dB spojené s pomerom PM_{10} 1,27 (95 % interval spoľahlivosti 1,11–1,45). Pre $PM_{2,5}$ bol pomer 1,31 (1,11–1,54), pre hrubú frakciu 1,20 (1,11–1,30). Intervaly využívajú robustný odhad so zhlukovaním podľa 12 dátumov; neistotu kalibrácie nezahŕňajú. Po vynechaní 20. 8. 17:20–18:20 zostal pomer PM_{10} 1,25 (1,09–1,44). Výsledok podporuje súvislosť s pracovnou činnosťou, neurčuje však príčinu ani konkrétny zdroj.

HMOTNOSTNÉ FRAKCIE A MIMORIADNE EPIZÓDY

Z pomeru súčtov korigovaných koncentrácií vyplýva hmotnostný podiel $PM_{2,5}$ na PM_{10} 58,4 % a podiel $PM_{2,5–10}$ 41,6 %.

Pri vyššom hluku rástli absolútne koncentrácie oboch frakcií, ale smer zmeny ich podielov závisel od korekcie. V pracovných dňoch bol korigovaný podiel $PM_{2,5}$ pri LAeq < 55 dB 55,7 % a pri ≥ 75 dB 65,8 %. Hluk teda súvisí so zvýšením PM, no zmena relatívneho zastúpenia frakcií nie je voči voľbe korekcie robustná. Optická odozva závisí aj od veľkosti, zloženia a vlhkosti častíc (Hagan a Kroll, 2020).



Obr. 4: Hmotnostné zastúpenie jemnej ($PM_{2,5}$) a hrubej ($PM_{2,5–10}$) frakcie v kvartilových skupinách korigovaných koncentrácií PM_{10}.

Najväčšia epizóda nastala v sobotu 15. 8. o 14:40. Pôvodné PM_{10} jednotlivých senzorov dosiahli 825–1 569 µg/m³; po korekcii bol ich priemer 763,70 µg/m³. Rýchlosť vetra MMSKO bola 1,5 m/s a LAeq 60,2 dB. Vietor ani pracovný zdroj nemožno z týchto údajov potvrdiť. Epizóda nevstupuje do profilu pracovných dní.

Dňa 20. 8. o 17:40 sa zaznamenalo LAeq až 122 dB a priemerné korigované PM_{10} 255,74 µg/m³. Následný dážď, ochladenie a zmena vetra sú zlučiteľné s prechodom búrky. Hromy sú možným vysvetlením hluku.

Korekcia bola overená na 24-hodinových údajoch z iných sezón, nie na desaťminútových špičkách. Extrémy výrazne prekračujú rozsah kalibrácie a ich korigované veľkosti sú extrapoláciou. Vlhkosť môže ovplyvňovať optické PM (Jayaratne et al., 2018); regresné zohľadnenie meteorológie túto meraciu neistotu neodstraňuje. Kalibrácia a časové párovanie sú preto nevyhnutné, ale nemusia zaručovať prenositeľnosť do odlišného aerosólu (US EPA, 2022).

ZÁVERY

Meranie zachytilo opakovaný ranný vzostup jemnej aj hrubej frakcie a výrazné krátkodobé epizódy. Súbeh PM s hlukom podporuje hypotézu príspevku pracovnej činnosti k prašnosti areálu. Presné priradenie zdrojov vyžaduje denník prác a súbežnú referenciu v prevádzke. Porovnanie NAZ a SAZ ani identifikácia chemického zloženia aerosólu z tejto kampane neboli uskutočnené. V budúcnosti sa plánuje rozšírenie meraní za účelom porovnania NAZ a SAZ a odberom väčšieho počtu vzoriek tuhých častíc s cieľom zachytiť rozdiely výrobných procesov.

POĎAKOVANIE

Táto práca vznikla s podporou Vedeckej grantovej agentúry Ministerstva školstva, výskumu, vývoja a mládeže Slovenskej republiky a Slovenskej akadémie vied v rámci riešenia projektu VEGA č. 1/0354/26 „Výskum vzniku a zloženia nevýfukových emisií PM z cestnej dopravy“ a VEGA č. 1/0448/25 „Výskum udržateľných asfaltových technológii z hľadiska prevádzkovej spôsobilosti vozoviek a emisií CO_2“.

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FIELD MEASUREMENTS OF EMISSIONS FROM DOMESTIC SOLID FUEL BOILERS

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Keywords: wood combustion, coal combustion, levoglucosan, hopanes

INTRODUCTION

Exposure to elevated concentrations of atmospheric aerosol particles adversely affects human health. Their health effects depend, among other factors, on particle size and deposition within the respiratory tract. Coarse particles are predominantly deposited in the upper respiratory tract, whereas fine particles (PM2.5), including the submicron fraction (PM1), can penetrate deeper into the lungs, reaching the bronchi and alveoli (Křůmal et al., 2012).

Combustion processes are major sources of atmospheric aerosol particles. One important contributor is the use of small combustion devices (SCDs) for domestic heating during winter. Unlike large industrial facilities, SCDs typically have low chimneys, resulting in emissions being released close to ground level (breathing zone of residents). Furthermore, they are generally not equipped with flue gas cleaning technologies and are subject to less stringent regulatory oversight than large stationary sources.

Emissions from SCDs are mostly concentrated during the heating season, which typically lasts approximately five months in Central Europe. Consequently, their contribution to local air pollution during winter can be considerably greater than their annual average contribution. Outdated combustion technologies, such as over-fire and boilers with down-draft combustion, remain in use, particularly in Central and Eastern Europe, and can produce substantial particulate emissions. In contrast, modern combustion technologies, including automatic boilers, generally produce lower emissions of particulate matter and products of incomplete combustion. These differences have contributed to increasing regulatory and societal pressure to replace outdated heating systems with cleaner alternatives.

METHODOLOGY

In our previous studies, combustion experiments were conducted in an accredited laboratory under standardized conditions (EN 303-5) using different solid fuels, including hardwood (beech), softwood (spruce), and hard and brown coal, at both nominal and reduced heat outputs (Křůmal et al., 2019; 2021; 2023). The experiments covered a range of combustion technologies, from outdated over-fire and boilers with down-draft combustion to modern gasification and automatic boilers.

The present follow-up study investigated emissions under real-world operating conditions in households located in urban and rural areas. The selected households used different fuels (wood or coal) and were equipped with both outdated and modern boilers.

Particulate emissions (total suspended particles, TSP) were collected from boiler flue gases on quartz-fiber filters. The collected 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 can provide valuable information for identifying the contribution of domestic solid fuel combustion to ambient particulate pollution.

RESULTS AND DISCUSSION

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

The highest TSP emission factor was observed during wood combustion in the oldest over-fire boiler (2,320 mg/kg or 140 g/GJ), whereas the lowest was obtained for an automatic wood pellet boiler (223 mg/kg or 13.2 g/GJ). Similar trends were observed for emissions of carbon monoxide (CO) and organic gaseous compounds (OGCs), both of which are associated with incomplete combustion. The highest carbon dioxide (CO_2) emission factors, expressed in mg/kg, were observed for automatic boilers, particularly those burning brown coal. These differences may reflect both combustion conditions and the higher carbon content of brown coal. Overall, the observed emission trends were consistent with those reported in our previous laboratory studies (Křůmal et al., 2019; 2021; 2023). Detailed emission factors for individual organic compounds and markers will be presented.

Particular attention was paid to specific organic markers and their diagnostic ratios, which are used for particulate emission source identification. The levoglucosan-to-mannosan (L/M) ratios, often used to differentiate between softwood and hardwood combustion, were only partially consistent with values reported in the literature and those obtained in our previous laboratory studies. In contrast, the homohopane index determined for brown coal combustion was consistent with previously reported values. Diagnostic PAH ratios, however, differed substantially from literature values, in agreement with observations from our earlier laboratory experiments.

CONCLUSION

The most favorable emission profiles were generally observed for modern automatic boilers, which produced lower particulate emissions and lower emissions of products of incomplete combustion than outdated combustion technologies.

In addition to quantifying toxic PAHs, the study investigated specific organic markers and their potential application to the identification of domestic solid fuel combustion sources in ambient aerosol particles. However, the diagnostic marker ratios obtained under real-world operating conditions did not always agree with literature values or those determined in our previous laboratory experiments. These findings point to potential limitations of applying literature-based diagnostic ratios to emissions from individual domestic heating systems and underscore the importance of characterizing emissions under real-world operating conditions.

ACKNOWLEDGEMENT

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FATE OF INHALED THERAPEUTIC AEROSOLS UNDER PATHOLOGICAL RESPIRATORY CONDITIONS: FROM ASTHMA AND DYSPNOEA TO DIGITAL MODELLING OF ARDS

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Keywords: Therapeutic aerosols, Asthma, Dyspnoea, ARDS, Airway model

INTRODUCTION

Inhalation therapy represents a cornerstone of non-invasive drug delivery, enabling direct targeting of specific regions within the respiratory tract while minimising systemic toxicity (Rudokas et al., 2016). However, the regional deposition of inhaled aerosols is governed by an interplay of particle properties, airway morphology, and breathing kinematics (Tsuda et al., 2013). A critical limitation in the preclinical evaluation of inhaled therapeutics is the reliance on standard Pharmacopoeial testing methods, which fail to replicate the morphological alterations and dynamic, realistic breathing patterns of patients suffering from severe respiratory pathologies (Lizal *et al.*, 2026).

In asthma, chronic inflammation induces airway remodelling, bronchial narrowing, and alterations in bifurcation angles and lobar ventilation distribution (Choi *et al.*, 2015). Delivering anti-inflammatory agents with poor aqueous solubility, such as curcumin encapsulated in liposomal vesicular carriers, requires overcoming these geometric constrictions to reach the lower airways. Conversely, in patients experiencing severe dyspnoea (air hunger), the primary barrier is aerodynamic rather than purely morphological. Inhaled furosemide has been investigated to relieve refractory dyspnoea by sensitising Slowly Adapting Receptors (SARs) located in the smooth muscle of the conducting airways across generations G2–G16 (Sudo *et al.*, 2000). Yet, rapid inspiratory acceleration during dyspnoea promotes the formation of a turbulent laryngeal jet, generating an aerodynamic filter that traps droplets in the upper airways (Lizal *et al.*, 2026). Finally, in Acute Respiratory Distress Syndrome (ARDS), both structural and kinematic extremes converge: diffuse alveolar damage, pulmonary oedema, surfactant dysfunction, and heterogeneous alveolar collapse (atelectasis) severely distort airflow distribution. Within the newly initiated RESPIRE project, we are developing a digital twin of ARDS lungs to optimise targeted regenerative aerosol delivery. The aim of this contribution is to compare how asthma, severe dyspnoea, and ARDS govern the fate of inhaled therapeutic aerosols using in vitro physical replicas and in silico Computational Fluid Dynamics (CFD) modelling.

METHODOLOGY

Two experimental-numerical case studies (asthma and dyspnoea) were conducted and will be compared with the digital ARDS model under development.

1. Asthma case: Two vesicular systems — conventional liposomes composed of dipalmitoylphosphatidylcholine stabilised with 10% DOTAP (DPPC + 10% DOTAP) and ionic pair amphiphiles (Sept-DBS + 10% Septonex) — were prepared via ethanol injection, loaded with curcumin, and modified with hydrophobised hyaluronan (Linolenoyl-HyA). Following nebulisation stability screening, the PARI LC Sprint Star jet nebuliser (PARI GmbH, Germany) was selected. Aerodynamic particle size distribution (APSD) was measured using a Next Generation Impactor (NGI, Copley Scientific, UK) cooled to 5 °C at 15 L/min for 3 min in triplicate and analysed via Fluorescence Correlation Spectroscopy (FCS). Regional deposition was measured in a 3D-printed asthmatic airway replica (cooled to 5 °C, extending from the oral cavity to the 3rd tracheobronchial generation) derived from the realistic geometry of Lizal *et al*. (2012) by modifying cross-sections in segments 3 and 4, bifurcation angles in segments 8 and 13, and progressive narrowing in the upper and middle lobes. The replica was coupled via outlet filters to a five-piston breathing simulator reproducing lobe-specific asthmatic tidal breathing over 150 cycles, and compared against 3D CFD simulations.

2. Dyspnoea case: An aqueous furosemide solution (FUR Kabi 20 mg/2 mL) was nebulised using an Aerogen Solo vibrating mesh nebuliser (Aerogen Ltd., Ireland). APSD was evaluated using a pre-cooled (5 °C) Andersen Cascade Impactor (ACI) at 28.3 L/min with HPLC quantification. Regional deposition was investigated in a segmented 3D-printed realistic human airway replica (generations G0–G7, 22 segments, 10 outlets) connected to the five-piston breathing simulator mimicking severe COPD dyspnoea: tidal volume 1.39 L, breathing frequency 28.6 min^{-1}, inspiratory-to-expiratory ratio 1:4, and mean inspiratory flow ~3.3 L/s over 100 cycles (Lizal *et al*., 2026). Experimental data were compared with Large Eddy Simulation (LES) modelling in Simcenter Star-CCM+.

3. ARDS model: A multi-scale in silico airway model representing ARDS pathophysiology is currently being constructed. The digital model integrates an endotracheal cannula to simulate the mechanically ventilated regimes.

RESULTS AND DISCUSSION

Standard cascade impaction confirmed that both nebuliser-formulation systems generated aerosols within the inhalable range ~ (1–5 μm). For the curcumin-loaded DPPC + 10% DOTAP liposomes, the mass median aerodynamic diameter (MMAD) was ~2.6 μm with a fine particle fraction (FPF < 5 μm) exceeding 87% (and ≤ 10% below 0.5 μm). Similarly, nebulised furosemide exhibited an MMAD of 3.03 ± 0.03 μm, geometric standard deviation (GSD) of 1.80 ± 0.01, and an FPF of 81.2 ± 2.8%. Under standard low-flow Pharmacopoeial assumptions, both aerosols would be predicted to achieve high deep-lung delivery.

However, realistic airway modelling revealed different fates of the inhaled droplets depending on the underlying pathology. In the asthmatic lung replica, the relatively small droplet size (MMAD ~2.6 μm) proved advantageous for bypassing narrowed proximal bronchi. More than 80% of the recovered curcumin dose (91.3% in experiment, 83.6% in CFD) penetrated beyond the 3rd tracheobronchial generation into the individual lung lobes, with only 8.7% (EXP) and 16.4% (CFD) depositing in the upper and proximal airways (G0–G3). The lobar deposition distribution in asthma followed the inhaled volumes of the specific lobes (see Fig. 1)

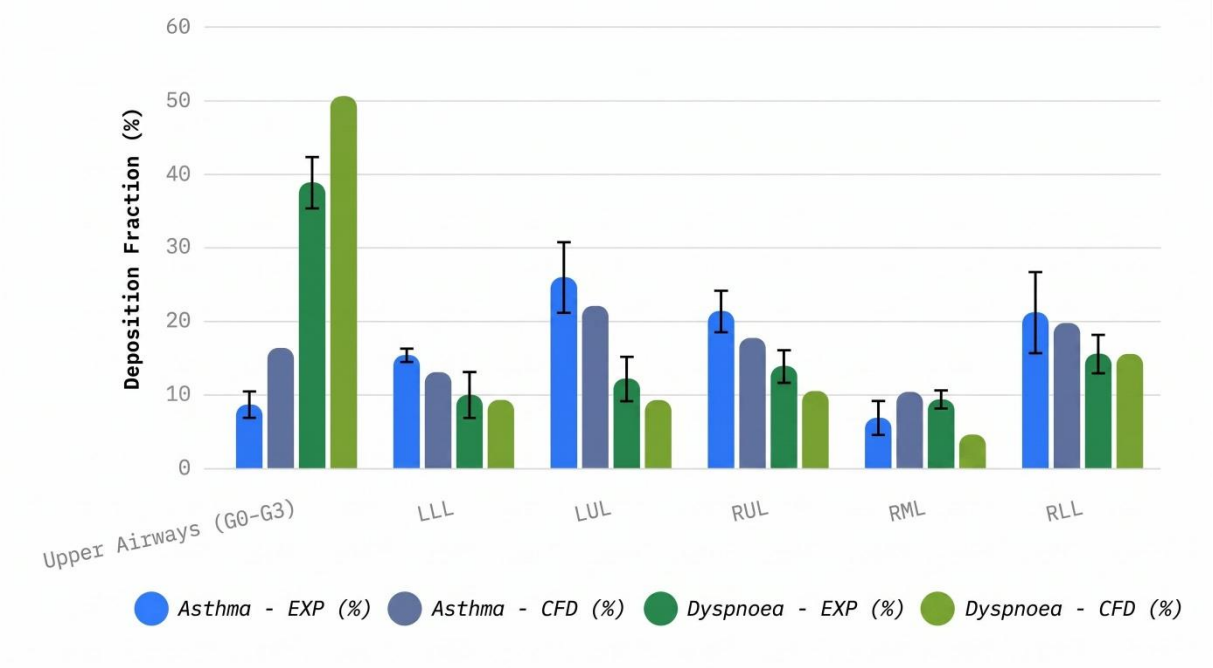


Fig. 1: Comparison of regional and lobar deposition fractions (in vitro experiment vs. 3D CFD simulation) for curcumin liposomes in an asthmatic lung model and nebulised furosemide under severe dyspnoea (error bars represent standard deviations of experimental measurements)

In contrast, under simulated dyspnoea, the rapid inhalation flow (~3.3 L/s) elevated the droplet Stokes number and generated a high-velocity turbulent laryngeal jet, creating a severe aerodynamic barrier. Upstream deposition in G0–G3 reached 38.9% in experiments and 50.6% in LES simulations (with 14.9% EXP and 22.8% CFD lost in the oral cavity alone), while the effective delivered dose rate dropped by more than 50% (from 0.87 ± 0.35 to 0.39 ± 0.15 mg/min) due to the short inspiratory fraction. These findings have direct implications for our ongoing digital modelling of ARDS within the RESPIRE project: because ARDS combines severe ventilation heterogeneity with high local velocities in oedematous airways, 1D models are insufficient and full 3D CFD coupling with lobe-specific impedance is essential to guide regenerative aerosols to injured parenchyma.

CONCLUSIONS

Combining realistic 3D-printed airway replicas with CFD simulations demonstrates that standard Pharmacopoeial impactor tests alone cannot predict clinical aerosol delivery under pathological conditions. While sub-3 µm liposomal curcumin formulations successfully navigate remodelled asthmatic airways (> 90% penetrating beyond G3) in proportion to lobar ventilation, rapid inhalation during severe dyspnoea induces turbulent laryngeal filtration that captures 39–51% of the aerosol in G0–G3 and creates proximal saturation hotspots. Consequently, effective therapy requires tailoring both droplet aerodynamics and flow-governed delivery to the specific mechanics of asthma, dyspnoea, and ARDS.

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INTEGRATED MONITORING OF ORGANIC POLLUTANTS IN THE KOŠETICE OBSERVATORY REGION (1988 - 2025)

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Keywords: Monitoring, Persistent organic pollutants, Long-term monitoring, Košetice observatory, GENASIS database, ACTRIS CZ

INTRODUCTION

The National Atmospheric Observatory Košetice (NAOK) in Czechia is one of the backbone environmental monitoring stations in Central Europe. Since 1988, this station, operated by the Czech Hydrometeorological Institute (CHMI), has served as a base for the Global Monitoring Plan (GMP) for Central and Eastern Europe and is part of the European Monitoring and Evaluation Programme (EMEP) and the International Cooperative Programme on Integrated Monitoring of Air Pollution Effects on Ecosystems (ICP IM, site CZ01).

RECETOX (Masaryk University, Brno, Czechia) has been conducting integrated monitoring of persistent organic pollutants (POPs) and emerging contaminants in air and wet deposition at this site for more than 30 years now. The additionally monitored environmental matrices include, but are not limited to, soils, sediments, surface waters, and biota (pine and spruce needles, mosses) collected at sites surrounding NAOK (Fig. 1) (Holoubek *et al.,* 2007). Samples are collected annually in August and analyzed at the Trace Analytical Laboratories (TAL) of RECETOX for concentrations of polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and organochlorine pesticides (OCPs). Since the start of the monitoring programme, more than 1400 samples have been collected and analysed (Fig. 2). All data from the long-term monitoring is available through GENASIS database (Borůvková *et al.*, 2026).

As a result of high bark beetle activity in the region, sampling of pine and spruce needles, as well as mosses, was discontinued in 2020 due to the severe impact of deforestation on the historical sampling sites (Fig. 1, Fig. 2).



Fig. 1: NAOK region sampling sites (2018 and 2025)

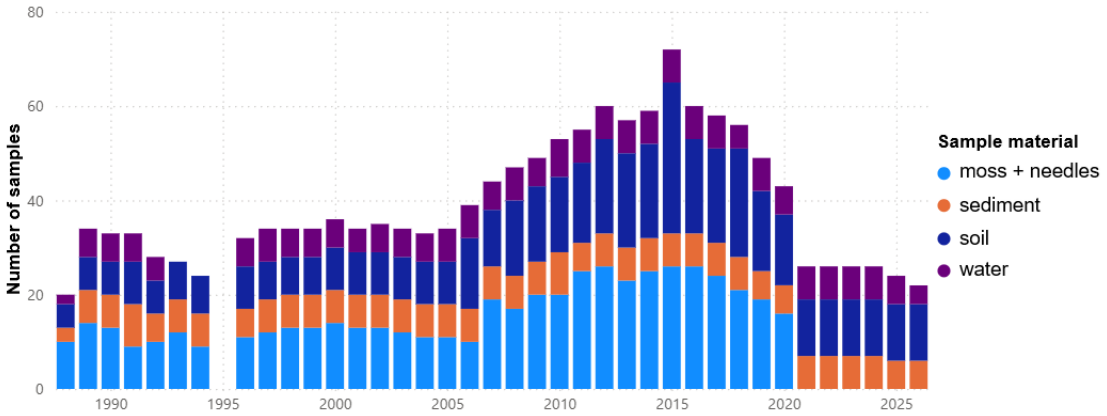


Fig. 2: Number of samples collected yearly for integrated monitoring

METHODOLOGY

Sampling of different materials was done by following techniques:

1) Surface water – spot sampling of ponds and streams into glass bottle.
2) Sediment – spot sampling using grab samplers or shovels.
3) Soil – spot sampling of organic horizont, inorganic horizont and bulk soil surface (10 cm depth) using spade or shovel.
4) Moss – hand picked samples.
5) Pine/Spruce needles – scissor cut of 1- and 2-year shoots, hand picked pine needle litter.

Samples were processed using different techniques depending on the sample matrix and were analysed for concentrations of PAHs, PCBs, and OCPs using GC-MS/MS systems. Soil and sediment samples were also analysed for organic carbon content.

RESULTS

As an example, Figures 3 and 4 compare concentrations of ∑16 EPA-PAHs in moss samples collected at different sampling sites and concentrations of ∑7 indicator PCBs in pine needle litter samples, respectively. Long-term monitoring on this scale provides a unique dataset that can be used to investigate temporal trends in contamination in the region surrounding NAOK. It also highlights the unforeseen challenges associated with long-term monitoring, where some sampling sites or even entire environmental matrices may become unavailable due to the impacts of deforestation (2020) and drought conditions (2026).

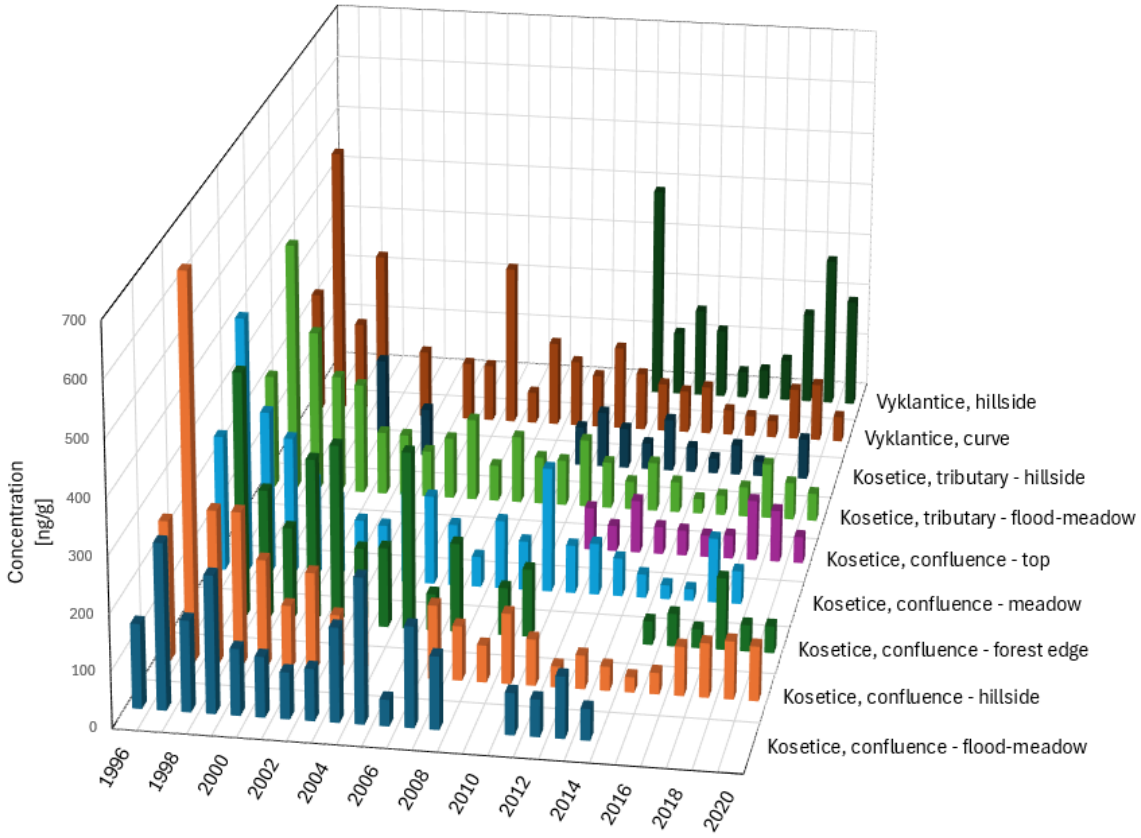


Fig. 3: Yearly concentrations of ∑16 EPA-PAHs in moss samples at different sampling sites from 1996 to 2020

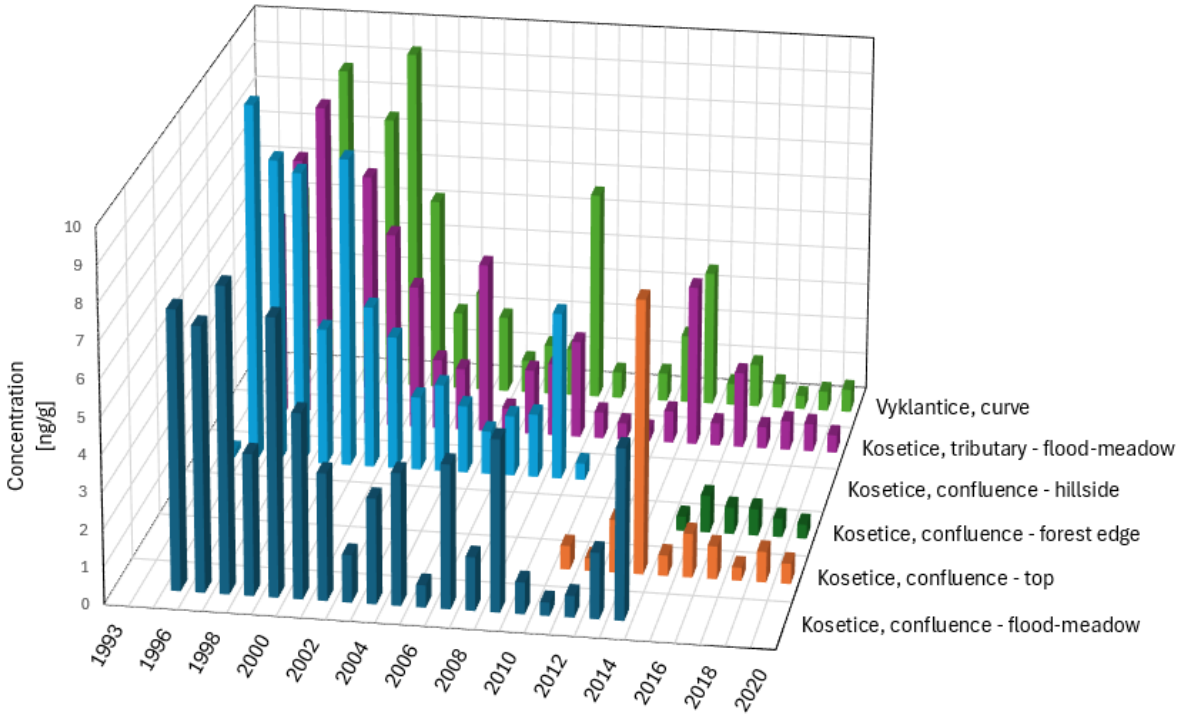


Fig. 4: Yearly concentrations of ∑7 indicator PCBs in samples of pine needle litter at different sampling sites from 1993 to 2020

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HYGROSCOPIC GROWTH OF LACTOSE PARTICLES UNDER PHYSIOLOGICALLY RELEVANT CONDITIONS

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Keywords: Hygroscopic growth, Respiratory tract, Dry powder inhalers, Lactose

INTRODUCTION

Dry powder inhalers (DPIs) are widely used for the treatment of respiratory diseases, including asthma, chronic obstructive pulmonary disease, acute bronchitis, and cystic fibrosis. DPI formulations typically comprise an active pharmaceutical ingredient and an excipient, most commonly lactose, which serves as a carrier for the active ingredient. Upon inhalation, aerosol particles are exposed to the high relative humidity prevailing in the respiratory tract, which may induce hygroscopic growth and consequently affect their deposition (Broday and Georgopoulos, 2001).

METHODOLOGY

This study investigated the hygroscopic growth of size-resolved lactose particles during transport from ambient conditions into the human respiratory tract. Measurements were performed using a developed humidified mouth–trachea mechanistic model under conditions representative of the respiratory environment.

RESULTS, DISCUSSION, CONCLUSIONS

The results demonstrated that particle growth was primarily governed by residence time and relative humidity, whereas the initial particle size had no significant influence on the extent of hygroscopic growth. The observed particle growth indicates that changes in particle size under respiratory tract conditions may alter aerosol deposition and potentially increase deposition in the lower respiratory tract.

ACKNOWLEDGEMENT

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FACTORS SHAPING HOURLY PM10 VARIABILITY IN A COMPACT RURAL SETTLEMENT DURING THE WARM SEASON

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Keywords: elemental composition, rural air quality, positive matrix factorization, HYSPLIT, air-mass transport

INTRODUCTION

Compact rural settlements can be affected simultaneously by local emissions from individual heating systems, resuspension, traffic and other mechanical emissions, nearby anthropogenic activity, and a variable regional aerosol background (Hopke et al., 2020; Olszowski, 2019; Pokorna et al., 2018). At hourly resolution, these influences may overlap and cannot be resolved from the PM10 mass concentration alone. This study aimed to characterise hourly PM10 variability during the warm season and to identify the source-related and transport-related processes responsible for short-term PM concentration changes.

METHODOLOGY

Measurements were performed in the old, compactly built-up part of Kotórz Mały, southern Poland, from 30 June to 1 August 2018. Hourly PM10 mass concentration and elemental composition were measured with a HORIBA PX-375 monitor using energy-dispersive X-ray fluorescence (EDXRF). Meteorological parameters were measured in situ with a Davis Vantage Vue station. Source apportionment was carried out with US EPA PMF 5.0. All calculations and uncertainty analyses were performed in accordance with the PMF 5.0 User Guide (US EPA, 2014). The final six-factor 1 h solution was interpreted as: F1 - Zn-Pb traffic/mechanical; F2 - mixed anthropogenic, Zn-rich; F3 - soil/mineral; F4 - Ca-rich mineral dust; F5 - industrial/mechanical, metal-rich; and F6 - regional, S-rich aerosols.

Air-mass transport was evaluated with NOAA HYSPLIT using GDAS meteorological fields. A total of 128 72 h backward trajectories arriving at 500 m AGL were clustered into four transport types. Differences in PMF-factor contributions among clusters were tested with a permutation Kruskal-Wallis test, and epsilon-squared (ε^2) was used as the effect-size measure.

RESULTS AND DISCUSSION

Figure 1 presents the four trajectory clusters represented northern/Scandinavian inflow (C1; 13 trajectories; 10.2%), eastern to north-eastern inflow (C2; 33; 25.8%), north-western/regional inflow (C3; 58; 45.3%), and western to north-western/marine inflow (C4; 24; 18.8%). C3 was therefore the most frequent transport pathway during the campaign. The trajectories were treated as air-mass pathways rather than direct locations of emission sources.

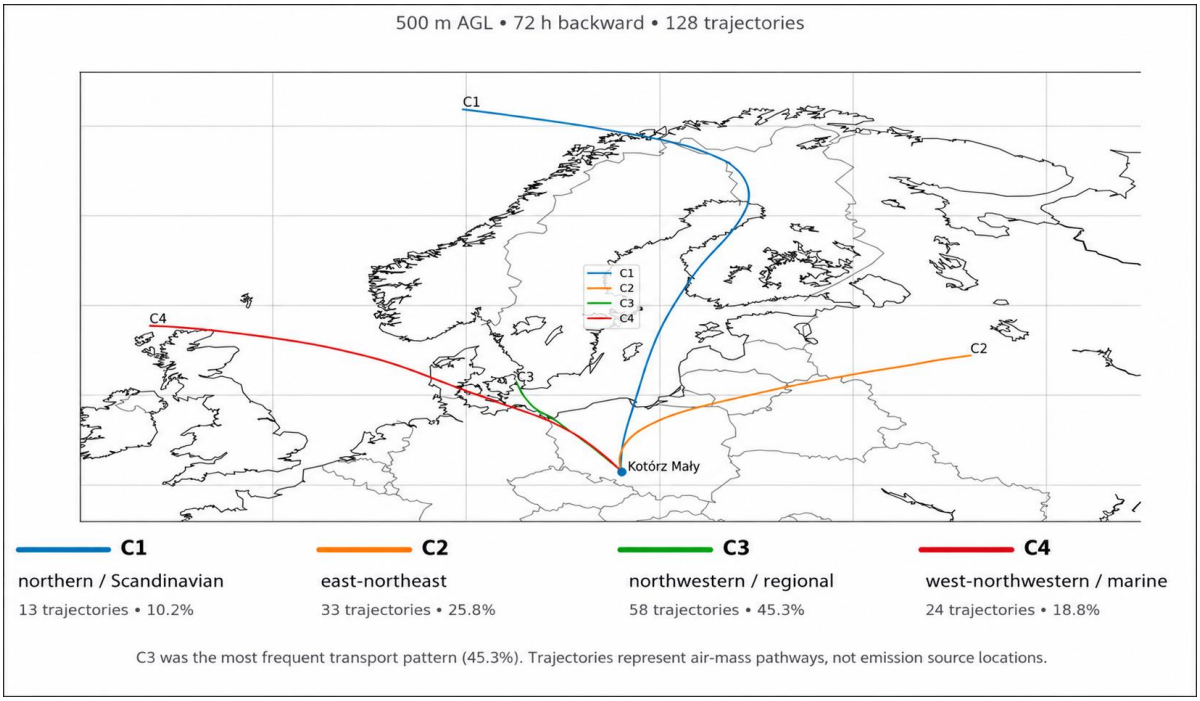


Fig. 1: HYSPLIT cluster-mean 72 h backward trajectories arriving at Kotórz Mały at 500 m AGL (128 trajectories).

The modelled PM10 mass was dominated by F6 regional S-rich aerosol (29.88%), F5 industrial/mechanical metal-rich aerosol (25.11%), and F2 mixed anthropogenic aerosol (22.39%). F3 soil/mineral material contributed 16.50%, F4 Ca-rich mineral dust 5.35%, and the episodic F1 Zn-Pb traffic/mechanical factor 0.78%. Thus, most modelled mass was associated with regional or mixed anthropogenic components, whereas mineral/resuspension factors remained relevant to short-term variability.

The chemical profiles show that distinct elemental associations supported the factor interpretation: F6 was characterised by S; F5 by several metals; F3 by a mineral signature; F4 by Ca; and F1 by Zn and Pb. This separation enabled the hourly PM10 signal to be interpreted as a changing mixture rather than as a single-source response.

Selected episodes show that similar PM10 levels could arise from different source mixtures (Fig. 3). Daily mean PM10 ranged from 7.2 μg m^{-3} on 18 July to 33.3 μg m^{-3} on 22 July; elevated values also occurred on 3-5, 23 and 31 July. The changing factor structure shows that PM10 mass alone did not identify the governing mechanism.

Episode composition indicates two temporal scales: mineral/resuspension factors were associated with short-lived local increases, whereas F6 and F2 were more persistent and altered the background level. Short-term peaks and longer increases, therefore, did not necessarily have the same origin.

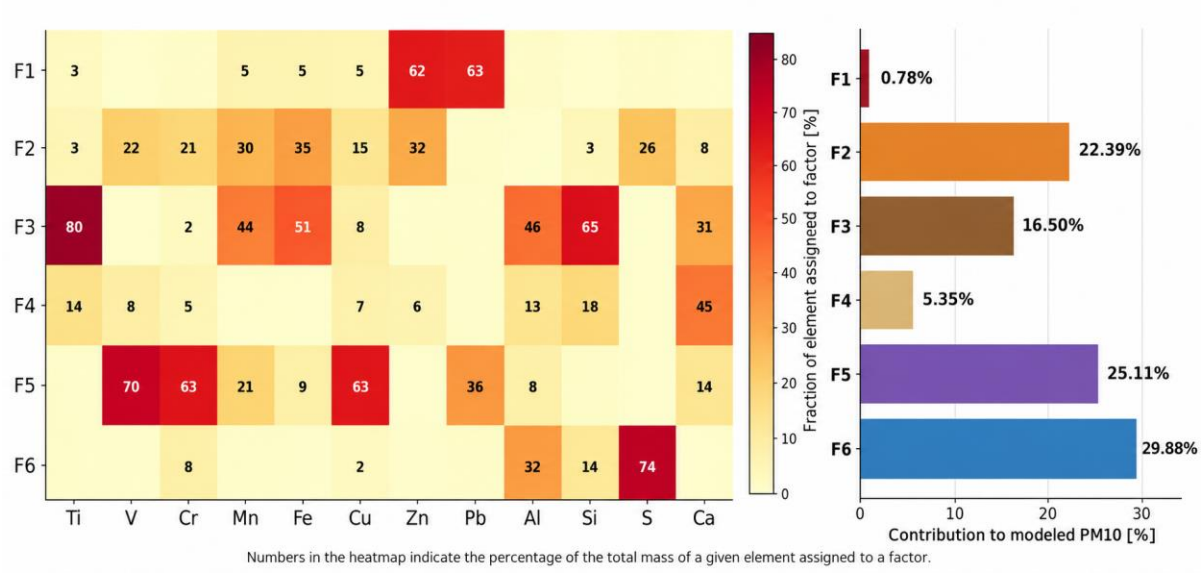


Fig. 2: Chemical profiles of the six PMF factors and their contribution to modeled PM10.

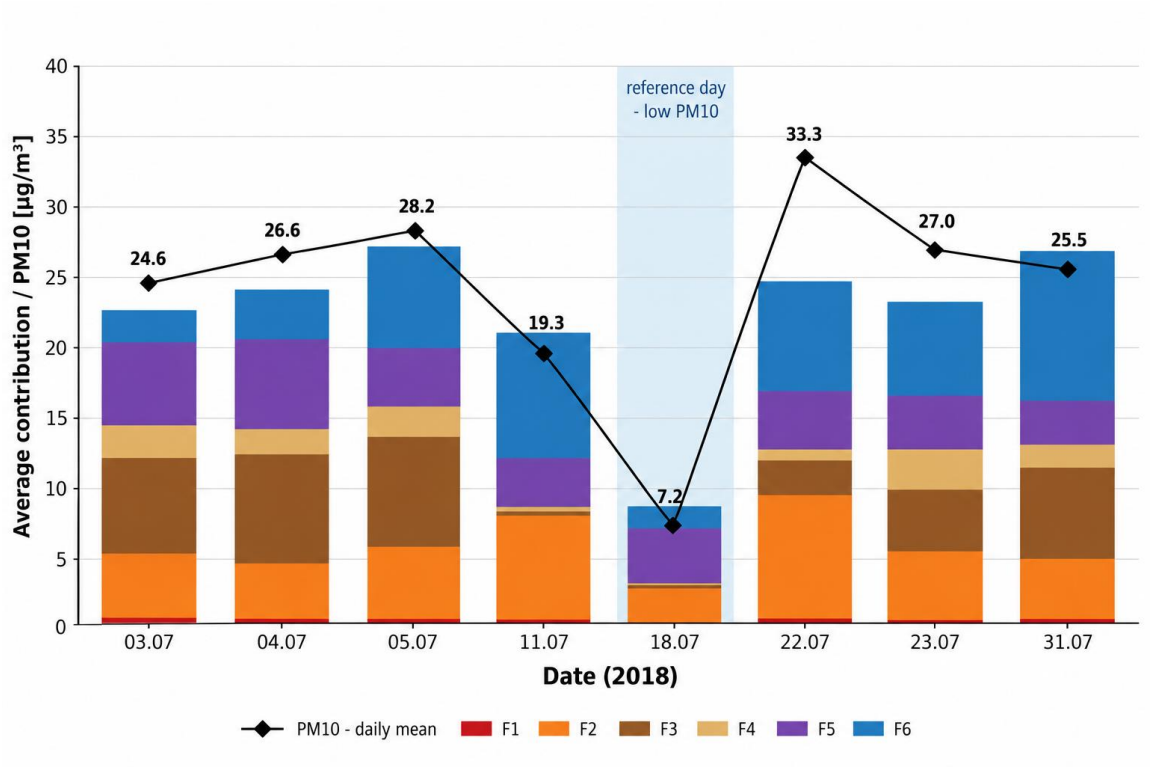


Fig. 3: Source structure of selected PM10 episodes during the measurement campaign.

Air-mass origin significantly differentiated all six PMF factors (Fig. 4). The strongest effects occurred for F6 ($\varepsilon^2 = 0.266$, $p < 0.00001$) and F2 ($\varepsilon^2 = 0.247$, $p < 0.00001$); the weakest was for F3 ($\varepsilon^2 = 0.055$, $p = 0.01804$). Intermediate effects were found for F1, F5 and F4. F6 was lowest under C1 and higher for the remaining transport sectors, while F2 also showed pronounced cluster dependence. Thus, transport primarily modulated the regional and mixed anthropogenic background, whereas mineral processes were less dependent on air-mass origin.

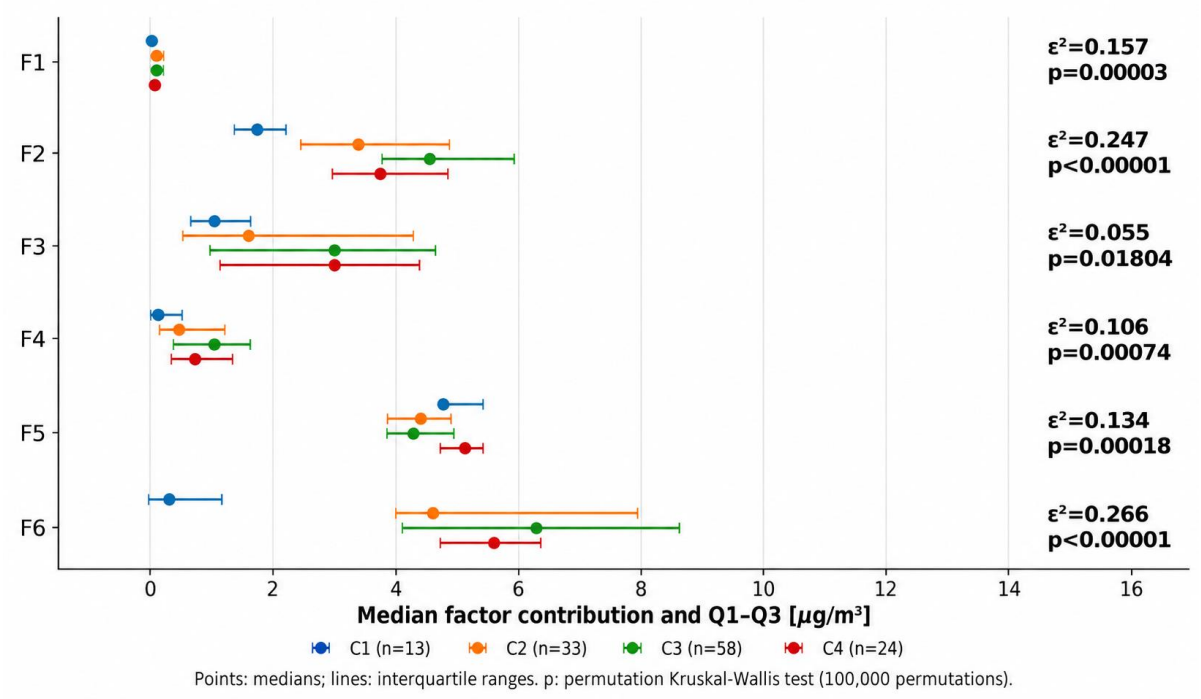


Fig. 4: PMF-factor contributions by HYSPLIT cluster (median and Q1-Q3); p values from permutation Kruskal-Wallis tests and ε^2 effect sizes.

CONCLUSIONS

Hourly PM10 variability resulted from the overlap of local processes and a variable regional background; neither long-range transport nor local sources dominated throughout the campaign. Mineral/resuspension processes mainly affected short-lived variability, whereas the regional S-rich and mixed anthropogenic factors were most strongly associated with air-mass origin. Combining hourly EDXRF data, PMF and HYSPLIT therefore resolved source dynamics that PM10 mass alone could not distinguish.

ACKNOWLEDGEMENT

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FLUXPRISM – AN ATMOSPHERIC GREENHOUSE GAS MONITORING NETWORK

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Keywords: Greenhouse gases, GHG fluxes, FluxPRISM, Atmospheric modeling, ICOS, long-term monitoring, calibration.

INTRODUCTION

FluxPRISM connects greenhouse gas (GHG) measurements from 13 sites across the Czech Republic, capturing the spatial variability of atmospheric CO_2 and N_2O. Measurements at heights above 50 m provide information representative of a wider surrounding area, helping to distinguish local from long-range influences and identify the sources of changes in atmospheric concentrations.

Combining atmospheric observations with modelling approaches improves estimates of greenhouse gas emissions and uptake across agricultural and forest landscapes. Integration with ICOS and ACTRIS places the measurements in a broader European context and supports the transfer of ICOS-based expertise in measurement systems, software development and data processing. The network is supported by a dedicated calibration and measurement laboratory, providing the infrastructure required for high-quality and comparable measurements.

EXPERIMENTAL SETUP

The network comprises 12 newly installed stations, complemented by the Křešín superstation, part of the National Atmospheric Observatory Košetice and an ICOS Class 1 station operating since 2014.

Křešín serves as a calibration and reference point for high-precision GHG measurements, supporting the future integration of European ICOS stations into biospheric flux estimation using Lagrangian particle dispersion models.

The operation of a dedicated calibration station is an integral part of the FluxPRISM network, ensuring the accuracy, traceability and comparability of measurements across all stations. The station also supports GHG measurements from aircraft and other sources, linking atmospheric observations with emission measurements, as well as the determination of the isotopic composition of calibration gases and other samples.

RESULTS AND CONCLUSIONS

The FluxPRISM network integrates continuous GHG measurements, standardized calibration procedures and automated data validation. Measurements are performed at one or two heights at each station, while a comprehensive digital profile records station metadata, equipment, operational events and calibration gas information. Measurement quality and comparability across the network are ensured through regular calibration

using standardized gas cylinders (3× CAL, 1× LTT and 1× REF) together with travelling standards.

The newly developed software supports both automated and manual data validation, including checks of instrument performance, measurement parameters, data stability and data distribution. The processing pipeline calculates hourly mean CO_2 and N_2O concentrations and generates validated data products. Automated reports and graphical outputs provide an overview of measurement time series, target gas measurements, calibration results and calibration cylinder drift, enabling efficient quality control and long-term monitoring of the entire network.

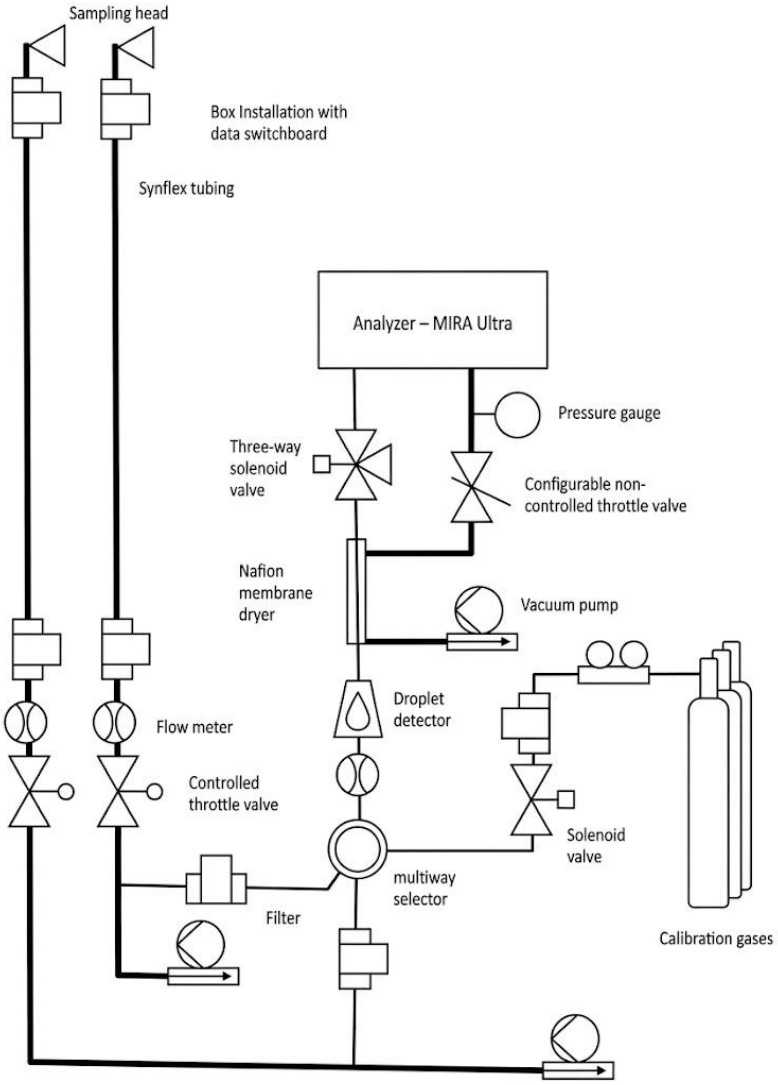


Figure 1: FluxPRISM Station Setup.

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.

PARALELNÍ MĚŘENÍ VE VODĚ ROZPUSTNÝCH LÁTEK V PM1 VE DVOU VÝŠKÁCH

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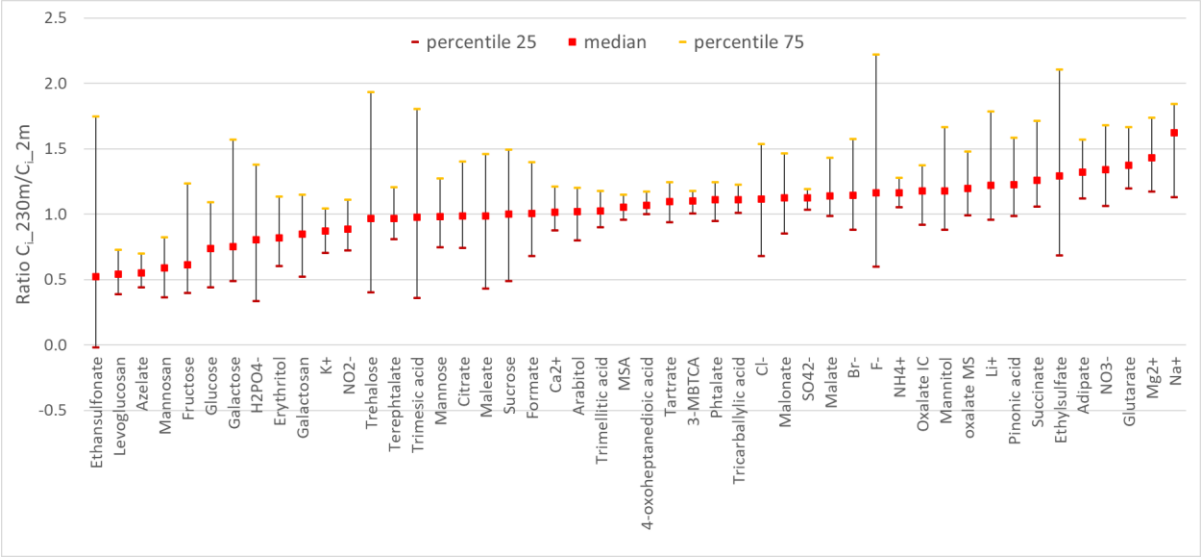
Klíčová slova: Atmosférické aerosoly, Chemické složení, Vertikální rozdíly, PM1

SUMMARY

Aerosol fine fractions were sampled in parallel at 2 m a.g.l. and at 230 m a.g.l. using sequential samplers, Leckel, using PM_1 sampling heads and quartz filters. The ratios between concentrations of individual water-soluble chemical compounds obtained using IC, IC-MS, and HPAE-PAD methods were assessed and reported.

ÚVOD

Dlouhodobé měření atmosférických aerosolů obvykle zůstává přízemní a spoléhá na to, že dynamika mezní vrstvy zajistí jeho dostatečnou reprezentativnost. Naše měření na atmosférické věži pomocí přepínacího ventilu a 230 m dlouhé odběrové trubky ukázalo, že tomu tak vždy není a rozdíly na 230 m vertikálně mohou být značné. Dlouhá vzorkovací trubka však nabízí prostor pro zpochybňování měření nebo některých jeho aspektů. Proto jsme se pokusili kromě jiných měření také zajistit klasický odběr na filtry přímo na platformě ve 230 m a některé předběžné výsledky budou diskutovány v tomto příspěvku.



Obr. 1: Mediány a 25. a 75. percentily poměrů mezi koncentracemi jednotlivých složek ve 230 a 2 m nad zemí.

METODIKA

Vzorkování bylo prováděno na Národní atmosférické observatoři Košetice (NAOK; GPS:N 49°35′, E 15°05′; 534 m n. m.) na křemenné filtry (QM-H Whatmann). Odběry byly zajištěny dvěma sekvenčními odběrovými zařízeními Leckel, přičemž verze použitá ve 230 m byla vybavena klimatizací prostoru pro skladování navzorkovaných filtrů

(T<23°C). Odběry dole i nahoře probíhaly 24 h jednou za dva dny při průtoku 2,3 m^3/h a odběrová hlava byla PM_1 u obou zařízení. Filtry ze 2 m byly odebírány z přístroje co nejdříve po odběru, zatímco filtry ve 230 m zůstávaly až po dobu 1 měsíce v zařízení.

VÝSLEDKY, DISKUSE, ZÁVĚRY

Kromě krátké periody během teplejšího období v roce 2024 byla většina zdařilých měření provedena v období od konce března 2025 do začátku února 2026. Výsledky v abstraktu jsou pak převážně z teplejší části roku, a to od konce března do konce září 2025. Z tohoto pohledu je třeba hodnotit uvedená data.

Ta jsou v obrázku 1 seřazena podle velikosti mediánu poměrů mezi naměřenými koncentracemi dané látky nebo iontu ve výšce 230 m a ve výšce 2 m nad zemí. Některé látky se vyznačují větším rozptylem naměřených hodnot. Jedná se buď o látky, které byly často přítomny v koncentracích kolem jejich detekčního limitu (F-, trimesinová kyselina), nebo o látky, které se pravděpodobně rozkládaly během skladování filtrů v temperovaném boxu v přístroji na věži (ethansulfonová a ethylsírová kyselina).

Zbylá data můžeme zhruba rozdělit do 3 skupin. V první skupině jsou látky, u kterých je medián poměrů koncentrací menší než 0,9. U těchto látek můžeme s velkou pravděpodobností říci, že mají své zdroje převážně uvnitř mezní vrstvy a navíc jsou pravděpodobně spíše lokálního původu. Sem patří zejména tracery spalování biomasy, jako jsou levoglucosan, manosan a galactosan, a dále jednoduché cukry, jako jsou glukóza, fruktóza a galaktóza, které jsou v teplejším období roku zejména biologického původu. Kromě toho sem patřily erythritol a azelaová kyselina a z iontů fosforečnany, dusitany a pak draselné ionty, které i v létě pocházejí částečně ze spalování biomasy.

Druhou skupinu tvoří látky, jejichž medián poměrů kolísá kolem 1 (0,9–1,1) a které tedy mohou být buď střídavě lokálního či regionálního původu nebo jsou vytvářeny v celém objemu atmosféry jako jsou sekundární organické i anorganické sloučeniny. Sem patří většina detekovaných organických kyselin včetně methansulfonové kyseliny, sacharóza z pylů, arabitol a trehalóza jako složky spor hub nebo bakterií, a i vápenaté ionty.

Poslední skupinou jsou látky, které vznikají převážně ve vyšších vrstvách mezní vrstvy nebo v mracích nebo jsou transportovány z větších vzdáleností. Mezi tyto složky patří téměř všechny anorganické anionty (F^-, Cl^-, Br^-, SO_4^{2-}, NO_3^-) z nichž nejvyšší medián poměrů měly dusičnany, u kterých může hrát roli nižší teplota ve větší výšce ale zároveň i přeměněná mořská sůl ($NaNO_3$), která svou přítomnost potvrzuje nejvyšším mediánem poměrů pro hořečnaté a sodné ionty. Z organických kyselin sem patřily kyselina ftalová, tricarbalylová, malonová, malátová, šťavelová, pinonová, jantarová, adipová a glutarová. Překvapivě sem patří i manitol, i když má obecně stejné zdroje jako arabitol.

Celkově toto měření potvrdilo, že v teplejší části roku jsou koncentrace PM_1 většinou vyšší ve výšce 230 m než u země. Domněnky o rozkladu kyselin případně dalších látek v temperovaném boxu jsou nyní ověřovány cíleným experimentem.

PODĚKOVÁNÍ

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FROM LABORATORY TO FIELD MEASUREMENTS: A MOBILE EXPOSURE LABORATORY

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Keywords: Exposure system, Mobile laboratory, Toxicology, Environmental monitoring, Air-liquid interface (ALI), Field studies

SUMMARY

The NanoEnviCz research infrastructure is developing a mobile nanotoxicology laboratory designed to support field-based assessment of airborne pollutants and particles. The laboratory is based on a patented mobile exposure system enabling direct air-liquid interface (ALI) exposure of respiratory cells under realistic environmental conditions. By integrating biological exposure, environmental monitoring, sample processing and on-site analytical capabilities, the platform will provide a comprehensive investigation of the health effects of complex atmospheric mixtures and emerging pollution sources.

INTRODUCTION

Understanding the health effects of airborne pollutants requires experimental approaches that closely reflect real-world exposure conditions. Conventional toxicological studies often rely on collected samples transported to laboratory facilities, which may limit the ability to investigate rapidly changing environmental conditions. To address these challenges, NanoEnviCz is developing a mobile nanotoxicology laboratory that will enable exposure experiments, environmental monitoring and biological sample processing directly in the field.

RESULTS AND CONCLUSIONS

A key component of the planned platform is a mobile exposure system allowing direct air-liquid interface (ALI) exposure of respiratory cell models to ambient air, combustion emissions and other aerosol mixtures. The system is designed to operate close to emission sources and could be combined with real-time characterization of particulate and gaseous pollutants. The exposure system has already been successfully used within the PAREMPI project and supports research activities in the REALCHEM project, demonstrating its potential for investigating the health impacts of emerging emission sources and complex atmospheric mixtures.

The future mobile nanotoxicology laboratory will combine exposure experiments, environmental monitoring, and sample processing directly in the field. This will enable studies of airborne particles and complex atmospheric mixtures under realistic exposure conditions and minimize sample transport between field sites and laboratories. In addition, standardized sample handling across different locations will improve the comparability of results by reducing variability associated with sample transport and processing.

The mobile toxicology laboratory will make it possible to combine environmental monitoring with toxicological studies under real-world conditions. It will provide new opportunities for research on combustion emissions, nanomaterials, urban air pollution and other emerging environmental challenges, and will strengthen the capacity of the NanoEnviCz infrastructure for field-based environmental health research.

ACKNOWLEDGEMENT

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ATMOSPHERIC FATE OF CURRENT-USE PESTICIDES – TRENDS AND AIR-SOIL EXCHANGE

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Keywords: Pesticides, air-soil exchange, long-range transport, aerosol size distribution

INTRODUCTION

Current-use pesticides (CUPs), semi-volatile organic compounds (SVOCs) widely used in modern agriculture, can be transported far beyond their locations of application, reaching background, residential, and industrial areas, the free troposphere, and even the Arctic (Mayer et al., 2024). European pesticide authorisation requires assessment of a compound's long-range atmospheric transport (LRAT) potential (EC, 2009) by focusing on atmospheric transport without accounting for the possibility that, after deposition, compounds can re-volatilise and re-enter the atmosphere.

Legacy organochlorine pesticides (OCPs) exhibit the same process: after deposition, they can re-volatilise and undergo repeated cycles of deposition and release, a process known as *multihopping* or the *grasshopper effect* (Semeena and Lammel, 2005), thereby enhancing their LRAT. Whether present-day CUPs undergo similar multihopping had not previously been assessed directly via field observations. Two further properties govern the atmospheric fate and long-range transport of CUPs once airborne: gas-particle partitioning and particle mass size distribution. Both influence deposition processes, while particle-phase association can also reduce oxidative degradation through the shielding effect(Socorro et al., 2017).

The present study addresses this knowledge gap by combining (i) a multi- year atmospheric record at a rural central European site, used to assess multi-annual trends and the immediate effects of recent pesticide bans (Mayer et al., 2025), with (ii) the first field-based, parallel air–soil study at both a source site (rural grassland) and a receptor site (boreal forest). The study was designed to directly test our hypothesis of CUPs undergoing air–soil cycling and multihopping.

METHODOLOGY

To characterise long-term changes in atmospheric pesticide occurrence, biweekly air samples were collected at the National Atmospheric Observatory Košetice (NAOK), Czech

Republic, a rural background monitoring site adjoining agricultural fields. The dataset comprised 30 legacy OCPs monitored during 2013–2022 and 48 CUPs monitored during 2019–2021, with concentrations determined in the gas and particulate phases using GC-MS/MS and LC-MS/MS. Multi-annual temporal trends were evaluated using multiple regression models accounting for seasonal variability (Mayer et al., 2025).

Air–soil exchange: Parallel field campaigns were conducted at NAOK (14–25 October 2024, autum) and at the SMEAR II boreal forest station, Hyytiälä, Finland (May 2025, spring). At both sites, 52 CUPs were monitored in the gas and particulate phases using high-volume PM_{10} sampling and size-resolved collection with a six-stage cascade impactor covering particle sizes from <0.49 to 10 µm. A low-flow soil-fugacity sampler collected air equilibrated with the soil pore space, providing an effective soil fugacity (fS) for comparison with a potential soil fugacity (f_S') calculated from bulk topsoil concentrations at 0–2.5 and 2.5–5 cm depth. A criterion of $|\log(f_S/f_A)| > 0.5$ was applied to identify deviations from air–soil equilibrium, with the sign indicating the direction of exchange. At Hyytiälä, two 3D sonic anemometers allowed the quantification of eddy diffusivities for the determination of vertical compound mass exchange (flux). HYSPLIT back-trajectories were used to characterize the history and origin of the sampled air masses.

RESULTS & DISCUSSION

Multi-annual trends: Out of the 48 targeted CUPs, 32 were detected above their method detection limits (MDLs), spanning approximately five orders of magnitude (40 fg m^{-3} for 2,4-D to 5 ng m^{-3} for S-metolachlor); chlorpyrifos, S-metolachlor and prosulfocarb were the most abundant compounds. Atmospheric concentrations decreased significantly for 14 CUPs during 2019–2021, including the recently banned chlorpyrifos, fenpropimorph and thiacloprid, with estimated halving times of approximately ≈0.38–0.48 yr for chlorpyrifos and fenpropimorph, and 0.91 yr for thiacloprid, consistent with a rapid response to regulatory changes. Chlorpyrifos and fenpropimorph remained detectable one year after their respective bans, indicating environmental persistence. In contrast, legacy OCPs banned decades ago, including β-/γ-HCH, DDE, DDD, DDT, α-chlordane, and mirex, showed a levelling-off of previously declining atmospheric concentrations, consistent with enhanced secondary sources through reversed air–surface exchange and/or remobilisation from soil and water reservoirs (Mayer et al., 2025).

Air-soil exchange – concentrations: At NAOK, 14 of 52 CUPs were quantified above their MDLs (0.12 pg m^{-3} for spiroxamine to 2.8 ng m^{-3} for pendimethalin); six compounds (chlorpyrifos, chlorotoluron, metazachlor, pendimethalin, prosulfocarb, tebuconazole) occurred in >94% of samples with no significant day-night difference. Chlorpyrifos reached up to 0.9 ng m^{-3} more than four years after its EU authorisation lapsed, consistent with the persistence seen in the trend record above. At Hyytiälä, 12 CUPs were quantified at 2–3 orders of magnitude lower levels (0.09–59 pg m^{-3}). The number of compounds detected tracked air-mass origin, rising from 7 (Arctic/Greenland flow) to 12 (southerly flow via Germany, Poland, the Baltic states), consistent with long-range transport into a receptor region with 3.2% and 5.1% cropland cover within 10 and 100 km, respectively.

Gas–particle partitioning and particle size: Several CUPs were predominantly associated with sub-micrometre particles, with mass median diameters (MMDs) <0.5 µm for, e.g., chlorpyrifos, metazachlor, prosulfocarb, and TBA at NAOK, whereas others (2,4-D, boscalid, and tebuconazole) were associated with coarse particles (MMD >1 µm). For

TBA, MMD increased from 0.06 μm at NAOK to 1.2 μm at Hyytiälä, consistent with atmospheric aging and site-specific partitioning during transport. Chlorpyrifos was predominantly particle-bound at NAOK but was detected only in the gas phase at Hyytiälä, consistent with differences in atmospheric transport and partitioning between the rural and boreal environments.

Air–soil exchange – soil and fugacities: CUPs were detected in topsoil at both sites (Table 1): boscalid, prosulfocarb, and spiroxamine at NAOK, and prosulfocarb, spiroxamine, and four neonicotinoids and three transformation products at Hyytiälä, including clothianidin, imidacloprid, and thiamethoxam, which have not been approved for outdoor use in the EU since 2018. This represents the first evidence of CUPs in forest soils in northern Europe. Soil-to-air fugacity ratios indicated upward exchange for selected compounds, while the potential and effective approaches did not always agree because they represent different soil domains. At Hyytiälä, TBA exchange showed opposite directions during day and night, with net deposition by day (–0.08 ± 0.06 ng m^{-2} h^{-1}) and net emission at night (0.13 ± 0.05 ng m^{-2} h^{-1}; 24-h mean 0.03 ± 0.06 ng m^{-2} h^{-1}), possibly associated with wet deposition of TBA to soil.

Tab. 1: CUPs quantified in topsoil (0–2.5 cm; ng g^{-1} dry weight) at the NAOK and Hyytiälä sites.

Compound / group	**Class**	**NAOK (rural)**	**Hyytiälä (boreal)**
Boscalid	Fungicide	0.37	< MDL
Prosulfocarb	Herbicide	0.05	1.7
Spiroxamine	Fungicide	0.03	0.23
Neonicotinoids + metabolites (7 compounds)	Insecticides/ metabolites	not analysed	0.01–0.45

CONCLUSIONS

A dedicated source–receptor field campaign demonstrated that, similar to OCPs, CUPs undergo air–soil cycling and multihopping, potentially extending their transport to remote boreal forest environments. Declining atmospheric concentrations of chlorpyrifos, fenpropimorph, and thiacloprid were consistent with responses to recent regulatory changes, while the continued detection of chlorpyrifos years after the end of its authorised use, together with evidence of air–soil exchange, indicates its environmental persistence. At the boreal site, the observed long-range transport and air–soil exchange of TBA further demonstrate that atmospheric fate can involve repeated deposition and re-volatilisation. Because particle-bound CUPs may be shielded from OH-radical oxidation, an effect not represented in conventional atmospheric lifetime models, gas–particle partitioning and air–soil exchange should be considered alongside existing LRAT criteria in future pesticide risk-assessment frameworks.

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MULTI-SITE VS. SUPERSITE AEROSOL SOURCE APPORTIONMENT IN A LIGNITE BASIN AREA

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Keywords: PM_{10}, Offline and online techniques, PMF, Pollution origin

INTRODUCTION

The spatial representativeness of an air quality monitoring station is one of the most relevant parameters when interpreting measured concentrations of PM and apportioning its sources (e.g., Kracht et al., 2017; Yatkin et al., 2020). Two approaches, multiple-site and supersite, offer different ways to assess representativeness. The choice of the approach depends on the goals of the monitoring program. The study aims to assess spatial and temporal variations in PM_{10} concentrations across a lignite basin and to compare source apportionment results obtained from different methodological approaches using both multiple monitoring sites and a supersite.

METHODS

The research area was the northwest part of the Czech Republic. Four monitoring sites (Lom, Chomutov, Most airport, and Rudolice v Horách) were used. Three of the four sites were located in relatively flat terrain at the bottom of the Most Basin. The Rudolice site was situated in the mountainous area above the basin and represented a location only slightly affected by local emissions produced within the basin. At all sites, two parallel 12 h PM_{10} (PTFE and quartz filters) samples were collected (Leckel SEQ) every 36 h from 1st January to 31st December 2022 for consequent chemical analysis. At Lom site, additional online measurements as 2 h PM_{10} elemental composition (Xact), 5 min NR-PM1 (C-ToF-AMS), 1 min eBC (AE33) and 5 min particle number size distribution (SMPS and APS) were carried out from 3rd January to 14th July 2022.

PMF was applied to a matrix consisting of either a year-long offline only (from all four sites – multi-site approach), or combined online and offline (Lom site – supersite approach) semi-annual dataset. As the offline and online data differed in temporal resolution, the online data were aggregated to match the offline resolution. The PMF results post-processing, as well as spatial and dispersion variation analysis, followed.

RESULTS AND DISCUSSION

At the Lom supersite, 11 sources were identified. Despite many methodological differences between multi-site and supersite source apportionment, a reasonable factor match was found, along with similar contributions of the major sources to PM_{10}. The most

significant differences between the multi-site and supersite results were observed for regional carbonaceous particles (21 % vs. 14 %, respectively) and residential heating (16 % vs. 11 %, respectively). The identified factors behaved differently across the sites and under varying dispersion conditions (Fig. 1). Long-range transported aerosols (LRT_CARBON and LRT_SALT) contributed most to pollution levels in the Most Basin during favourable dispersion conditions. In contrast, worsened dispersion conditions rather than high wind speed triggered the high mining contributions, outweighing the effect of enhanced particle resuspension during windy episodes. The secondary inorganic aerosol (LRT + REG_SIA) did not exhibit a clear behaviour pattern, suggesting a mixed regional and long-range origin.

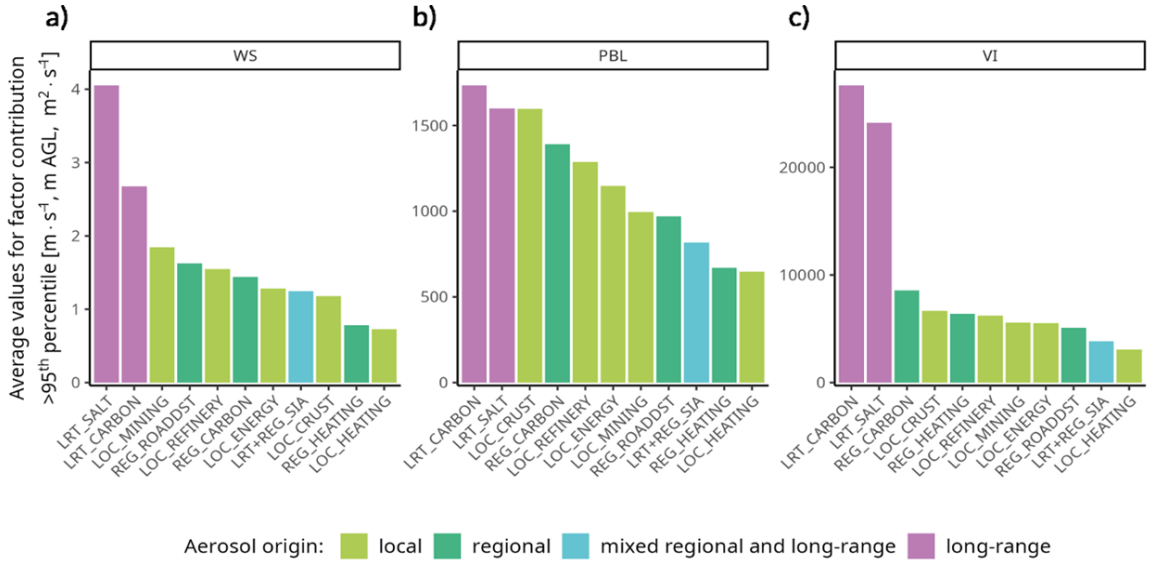


Figure 1: Wind speed (a), planetary boundary layer height (b), and ventilation index (c) for factor concentrations exceeding the 95th percentile at the Lom site.

CONCLUSIONS

Both approaches yielded consistent results on PM_{10} source contributions. Surface coal mining was identified as the dominant contributor, accounting for up to 30 % of PM_{10} mass, followed by secondary inorganic aerosols and residential heating emissions. Since the single site method limited spatial interpretation, the multi-site approach enabled better differentiation of local, regional, and long-range sources. These findings underscore the importance of targeted regional air quality strategies, particularly addressing mining and residential heating emissions. More details are provided by Seibert et al. (2025).

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VERTICAL GRADIENT OF TOTAL GASEOUS MERCURY IN RELATION TO ATMOSPHERIC CONDITIONS

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Keywords: Atmospheric mercury, Atmospheric boundary layer height, Vertical distribution, Long-range transport

INTRODUCTION

Mercury and its compounds are toxic substances that are released into the environment mainly through atmospheric emissions. Total gaseous mercury (TGM), consisting predominantly of elemental mercury (Hg^0), is relatively persistent in the atmosphere and can therefore be transported over long distances. The vertical distribution of atmospheric mercury may be influenced by local meteorological and dispersion conditions, including the development of the atmospheric boundary layer (ABL).

The Atmospheric Station Křešín u Pacova, part of the National Atmospheric Observatory Košetice (NAOK) in the Czech Republic, provides long-term continuous measurements of TGM under background conditions. The combination of measurements at different heights with information on ABL development and meteorological conditions enables the investigation of processes influencing the vertical distribution of atmospheric mercury.

METHODOLOGY

TGM is measured at two height levels, 4 and 240 m above ground level, using Tekran 2537X analyzers. The station is also equipped with a Vaisala CL51 ceilometer, providing information on ABL development and meteorological instruments measuring wind speed and direction.

The analysis builds on a previous comparison of selected winter and summer periods, in which differences in TGM concentrations between the two measurement levels were examined in relation to ABL development and meteorological conditions. The current study extends the analysis to additional time periods and selected meteorological and atmospheric parameters. Particular attention is also given to individual episodes of elevated mercury concentrations, which are investigated in greater detail using backward air-mass trajectories.

RESULTS, DISCUSSION, CONCLUSIONS

The previous analysis indicated a distinct seasonal character of the vertical TGM gradient. During periods with stronger development of the ABL, the concentration

difference between the two measurement levels showed more pronounced diurnal changes, consistent with enhanced vertical mixing. In contrast, more stable conditions were observed during the winter period, corresponding to the invariable diurnal variation of mercury.

The extended analysis provides a broader assessment of the relationships between the vertical distribution of TGM, ABL development, and other selected atmospheric parameters. Detailed analysis of individual episodes with elevated mercury concentrations, supported by backward trajectory analysis, is used to identify potential source regions and provide further insight into the processes contributing to the observed concentration variability.

The results contribute to a better understanding of the temporal and vertical variability of atmospheric mercury at the Křešín u Pacova background station and provide a basis for further investigation of the factors influencing its distribution and potential transport pathways.

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EFFECTS OF POST-COMBUSTION AMMONIA AND ASH-FORMING LUBRICATING OIL ADDITION ON TOXICITY OF MARINE ENGINE EMISSIONS AND SECONDARY AEROSOL FORMATION

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Keywords: Low-Carbon Fuel; Transcriptomics; Air-Liquid interface; Diesel Marine Blend; Maritime emissions; Atmospheric aging

INTRODUCTION

Maritime transport is a major global source of air pollution (Sofie *et al.*, 2018). While sulphur regulations have driven changes in marine fuel composition, toxicological implications of emerging fuel additives are largely unexplored, especially under realistic atmospheric aging conditions (Kangasniemi *et al*., 2025). Ammonia is promoted as a low-carbon solution for maritime decarbonization (Al-Aboosi *et al.*, 2021), and lubricants remain unavoidable contributors to marine exhaust particles (Eichler *et al.*, 2017). Both can substantially alter aerosol chemistry and aging processes. Secondary aerosols formed through atmospheric oxidation may differ strongly from fresh emissions (Offer *et al*., 2022), yet are rarely included in toxicity assessments due to experimental complexity. Here, we present the first integrated in vitro study combining realistic marine engine emissions, simulated atmospheric aging, and on-site air-liquid interface (ALI) toxicology, investigating how ammonia and lubricating oil additives influence secondary aerosol formation and associated biological responses.

METHODOLOGY

A diesel marine blend (DMB) was combusted alone or combined with post-combustion ammonia injection (DMB+NH_3) or 0.8 wt% lubricating oil (DMB+LO) in a single-cylinder diesel engine under controlled laboratory conditions. Aged aerosols were generated using a Potential Aerosol Mass Oxidation Flow Reactor simulating ~2.4 days of atmospheric aging. Aerosol were characterized for total particle number, PM_1 mass, and chemical composition. Human BEAS-2B bronchial epithelial cells were exposed to fresh or aged emissions for 90 minutes, while a 3D human airway epithelium MucilAir™ was exposed for 120 minutes to fresh emissions only, using a portable ALI exposure system. Cytotoxicity (lactate dehydrogenase release), cell layer integrity (transepithelial electrical resistance), DNA damage (Comet assay), oxidative stress (oxidative DNA damage by

Comet assays with FPG and 15-F2t-isopostane as a marker of lipid peroxidation), and whole genome expression changes were assessed after 24h recovery.

RESULTS, DISCUSSION

Ammonia and lubricating oil additives produced distinct changes in emission composition, particle size distribution, aerosol aging and biological responses. Lubricating oil addition increased nucleation-mode particles and reduced black carbon. Post-combustion ammonia injection led to a 14-fold increase in PM_1 mass, driven mainly by formation of secondary inorganic aerosol dominated by ammonium nitrate. No cytotoxicity, genotoxicity, or oxidative stress were detected in any of the exposure scenarios. Transcriptomic responses in BEAS-2B cells remained weak in both fresh and aged DMB and DMB+LO, however, ammonia-derived secondary aerosols elicited pronounced transcriptional responses with 699 differentially expressed genes (DEGs) showing activation of oxidative stress and inflammatory signaling (AP-1/FOS), mitochondrial and ribosomal stress, and chromatin remodelling pathways. The observed responses align with the high inorganic aerosol load and altered redox environment generated during ammonia-driven aging. In MucilAir™, fresh DMB+NH_3 exposure caused a marked and predominantly suppressive transcriptional response (488 DEGs).

CONCLUSIONS

Our study demonstrates that fuel additives can profoundly influence secondary aerosol formation and cellular stress responses. Ammonia strongly enhances secondary aerosol mass and drives transcriptional stress responses, while lubricating oil exerts minimal effects on aging and toxicity. The integration of realistic marine emissions, atmospheric aging, and ALI-based in vitro toxicology represents a major methodological advance and provides critical insight into health-relevant impacts of future marine decarbonization strategies, crucial to avoid unintended consequences of low-carbon fuels in maritime transport.

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