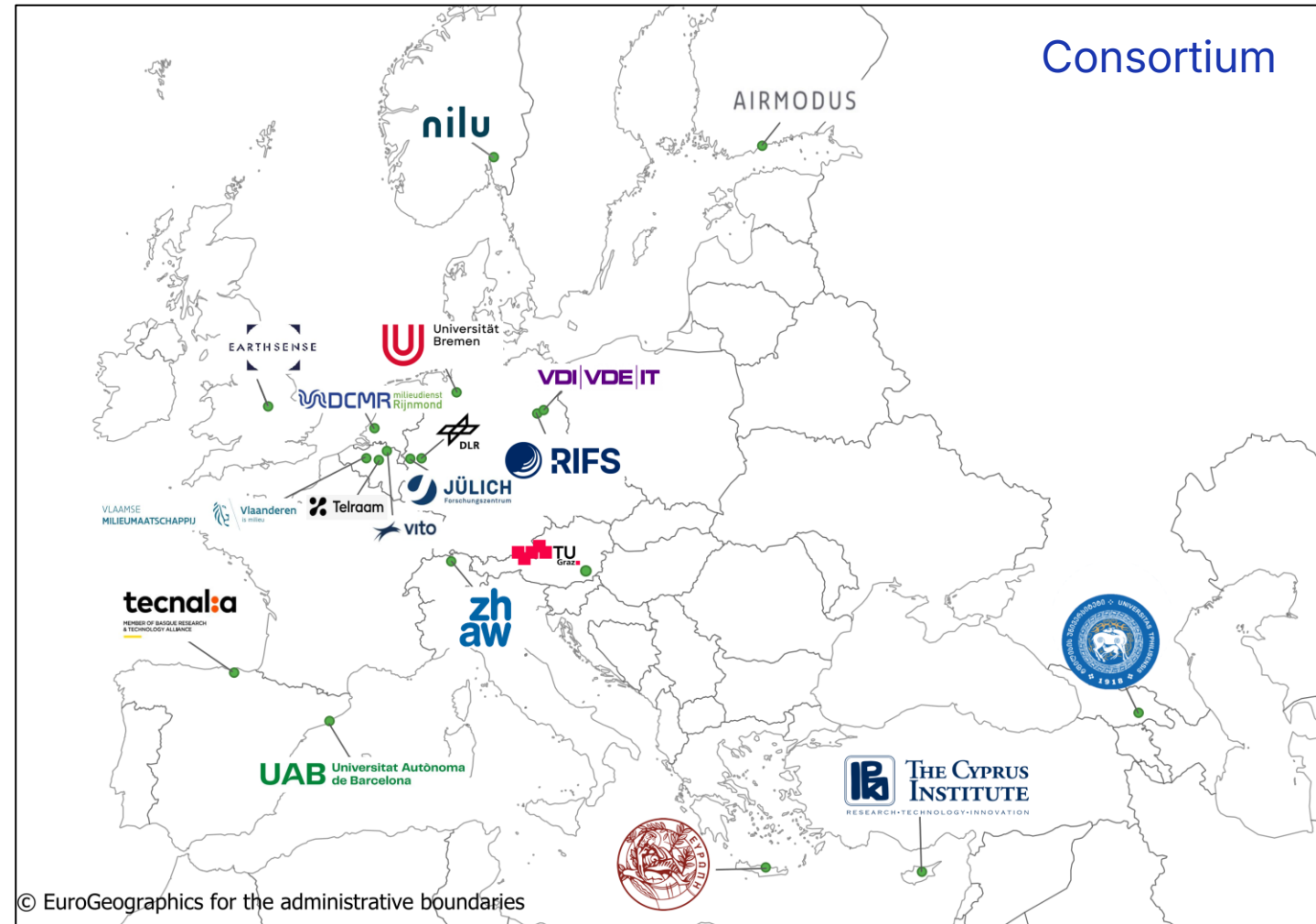


Net4Cities: Longer-term monitoring of UFP at transport locations in European cities

Erika von Schneidemesser, Seán Schmitz, Lorena Vega Garcia, Himanshu Setia, Aki Pajunoja (ENVEA), Saskia Drossaert van Dusseldorp (ZHAW), Martine Van Poppel (VITO), Michael Pikridas (Cyl) + Net4Cities Consortium

Aim / Consortium

The **overall aim of Net4Cities is to facilitate the realization of the EU Green Deal's Zero Pollution Action Plan** by advancing air and noise pollution monitoring infrastructure and providing **evidence-based support for implementing effective transport policies** via the Net4Cities Studio products and thereby improving air quality and mitigating noise pollution.



Project Context - UFP



Official Journal
of the European Union

EN
L series

2024/2881

20.11.2024

DIRECTIVE (EU) 2024/2881 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 23 October 2024

on ambient air quality and cleaner air for Europe

(recast)

THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty on the Functioning of the European Union, and in particular Article 192(1) thereof,

Having regard to the proposal from the European Commission,

After transmission of the draft legislative act to the national parliaments,

Having regard to the opinion of the European Economic and Social Committee ⁽¹⁾,

Having regard to the opinion of the Committee of the Regions ⁽²⁾,

Acting in accordance with the ordinary legislative procedure ⁽³⁾,

Whereas:

(1)

Directives 2004/107/EC ⁽⁴⁾ and 2008/50/EC ⁽⁵⁾ of the European Parliament and of the Council have been substantially amended. Since further amendments are to be made, those Directives should be recast in the interest of clarity.

(2)

The Commission set out in its communication of 11 December 2019 entitled 'The European Green Deal' an ambitious roadmap to transform the Union into a fair and prosperous society, with a modern, resource-efficient and competitive economy; that aims to protect, conserve and enhance the Union's natural capital, and to protect the health and well-being of citizens from environment-related risks and impacts. Specifically on clean air, the Commission committed itself to further improving air quality and to aligning Union air quality standards more closely with the recommendations of the World Health Organisation (WHO). The Commission also announced in the European Green Deal a strengthening of provisions on air quality monitoring, modelling and planning.

(3)

In its communication of 12 May 2021 entitled 'Pathway to a Healthy Planet for All – EU Action Plan: Towards Zero Pollution for Air, Water and Soil', the Commission established a 'Zero Pollution Action Plan' that, inter alia, addresses pollution aspects of the European Green Deal and further commits to reducing, by 2030, the health impact of air pollution by more than 55 % and the Union ecosystems where air pollution threatens biodiversity by 25 %.

(4)

The Zero Pollution Action Plan also sets out a vision for 2050, where air pollution is reduced to levels no longer considered harmful to health and natural ecosystems. To that end, a staged approach towards setting current and future Union air quality standards should be pursued, establishing air quality standards for 2030 and beyond, and developing a perspective for alignment with the most up-to-date WHO Air Quality Guidelines at the latest by 2050 based on a regular review mechanism to take into account the latest scientific evidence. Given the links between pollution reduction and decarbonisation, the long-term objective to achieve the zero pollution ambition should be

(5)

OJ C 146, 27.4.2023, p. 48.

(6)

OJ C 2023/251, 26.10.2023, EUL: <http://data.europa.eu/eli/C/2023/251/oj>.

(7)

Position of the European Parliament of 24 April 2024 (not yet published in the Official Journal) and decision of the Council of 14 October 2024.

(8)

Directive 2004/107/EC of the European Parliament and of the Council of 15 December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons to ambient air (OJ L 23, 26.1.2005, p. 3).

(9)

Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe (OJ L 152, 11.6.2008, p. 1).

EL: <http://data.europa.eu/eli/dir/2024/2881/oj>

1/70



EUROPEAN STANDARD

EN 16976

NORME EUROPÉENNE

EUROPÄISCHE NORM

June 2024

ICS 13.040.20

Supersedes CEN/TS 16976:2016

English Version

Ambient air - Determination of the particle number concentration of atmospheric aerosol

Air ambiant - Détermination de la concentration en nombre de particules de l'aérosol atmosphérique

Außenluft - Bestimmung der Partikelanzahlkonzentration des atmosphärischen Aerosols

This European Standard was approved by CEN on 19 May 2024.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

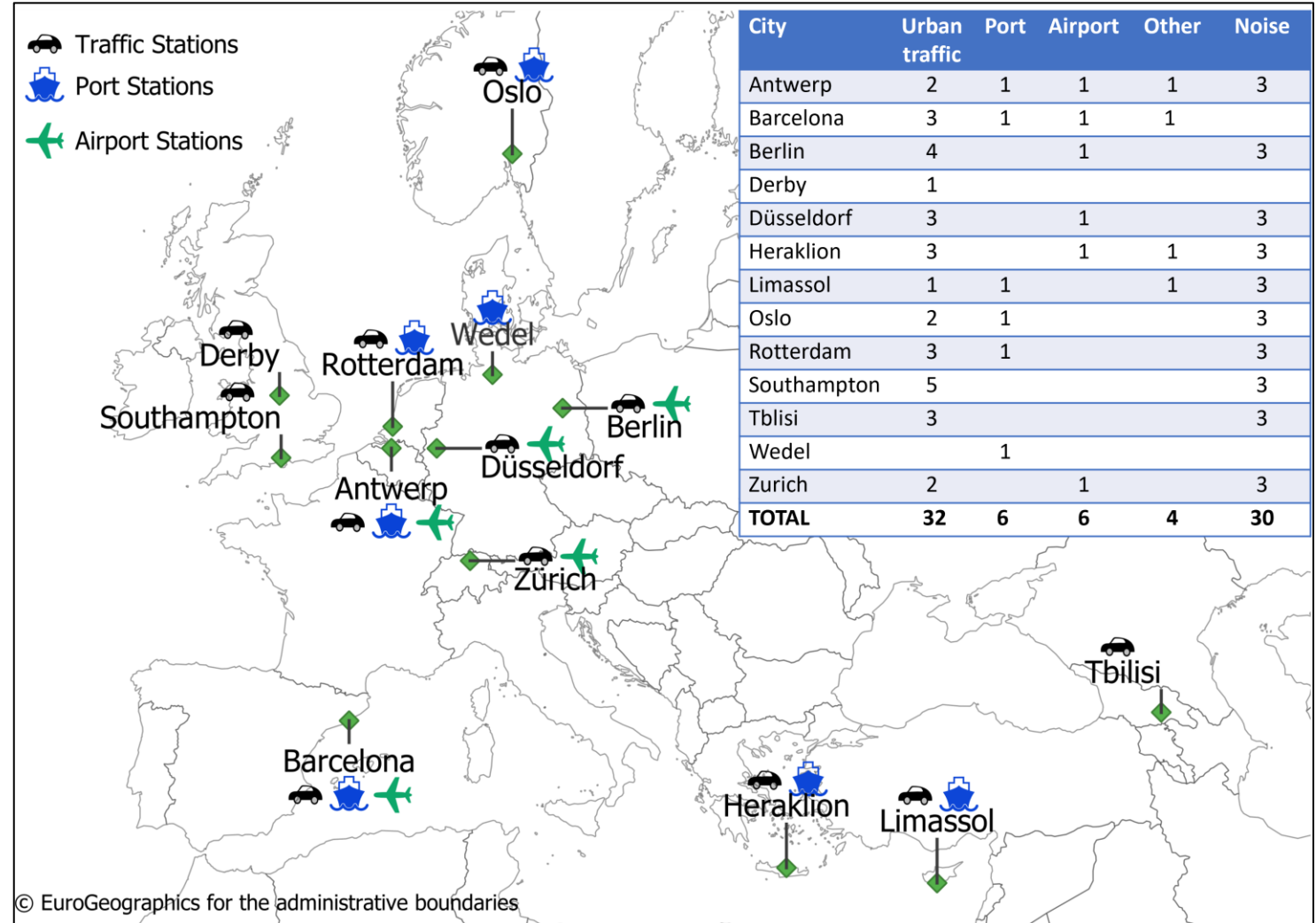
CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

© 2024 CEN All rights of exploitation in any form and by any means reserved worldwide for CEN national Members.

Ref. No. EN 16976:2024 E

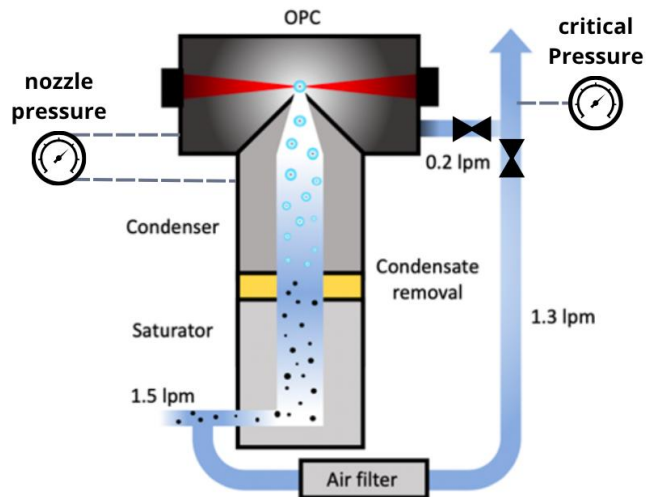
Project Context

- Revised EU AAQD
 - pollutants of emerging concern should be monitored (e.g., Ultrafine particles ($\leq 0.1 \mu\text{m}$), Ammonia, Black carbon)
- EU Action Plan: Towards a Zero Pollution for Air, Water and Soil (adopted May 2021)



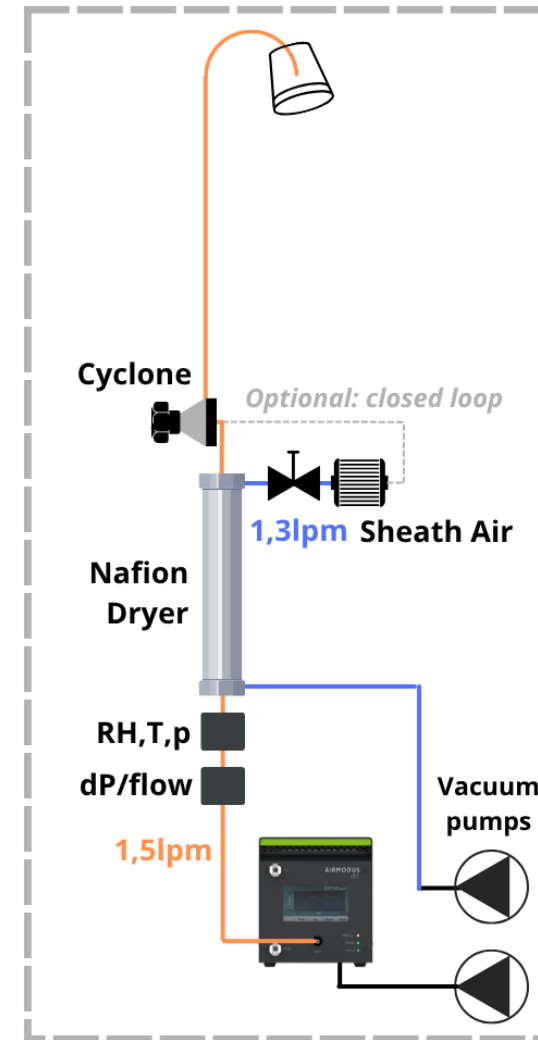
The Net4Cities UFP (CPC) network*

- 25 counters, first installations in January 2025 – end of 2027
- 21x A30 (propylene glycol), 4x A20 (butanol)
- 1Hz data, 24/7 total
PNC ~ 10 nm - 2.5 μ m
particles/cm³



CPC measurement system

- Full-flow CPC to EN 16976 - smallest reliable footprint
- EN 16976 full-flow CPC · D50 = 10 nm · RH < 40%
- Mini cyclone - removes coarse particles, protects the CPC for contamination
- 12" Nafion dryer + RH/T/p monitor (drying has been reliable network-wide)
- Small dedicated pumps, no large bypass pump -> lower cost & power
- Logger, cloud connection, automatic data pipeline to NILU data hub.



Lung Deposited Surface Area (LDSA)

- **Definition:** Measures *lung-deposited particle surface area concentration* in $\mu\text{m}^2/\text{cm}^3$

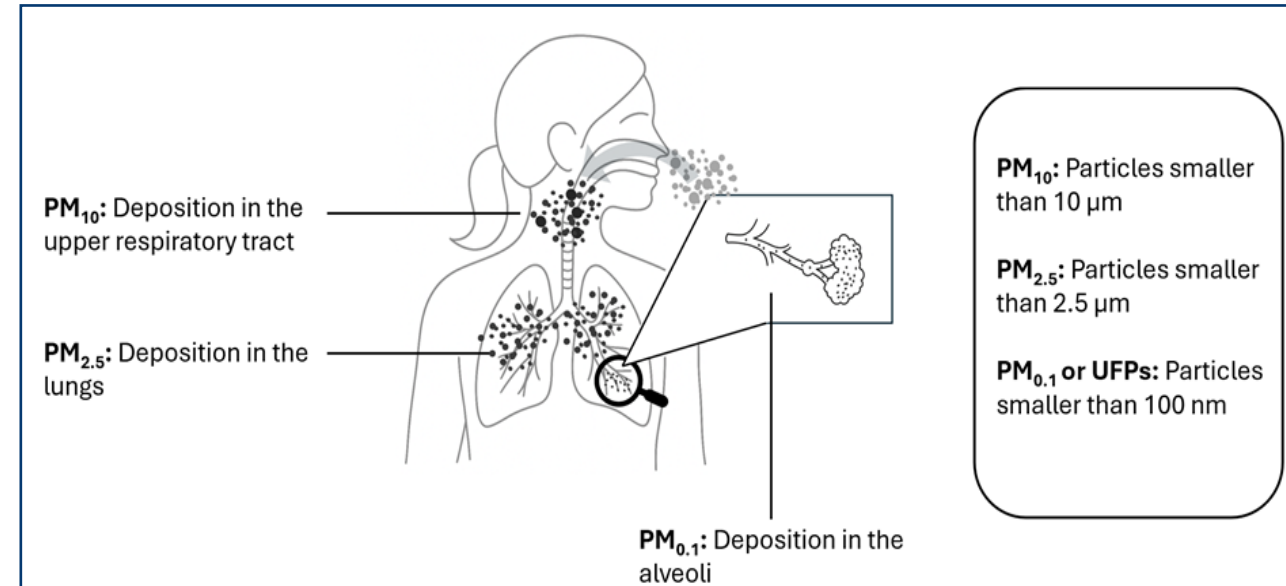
- **Health Impact:** Recognized as a highly effective *metric for nanoparticle toxicology*^[1,2]

- **Data Gap:** Scarcity of long-term, large-scale environmental measurements globally.

- **EU Levels:** Averages of $15\text{--}85\mu\text{m}^2/\text{cm}^3$ episodic peaks can exceed $200\mu\text{m}^2/\text{cm}^3$ ^[3,4]

- **Variability:** Significant *spatiotemporal fluctuations* with distinct winter-time peaks.

- **Drivers:** Concentrations are highly influenced by proximity to local sources.



Slide: S. Drossaart van Dusseldorp

¹Schmid and Stoeger 2016

²Kwon et al. 2020

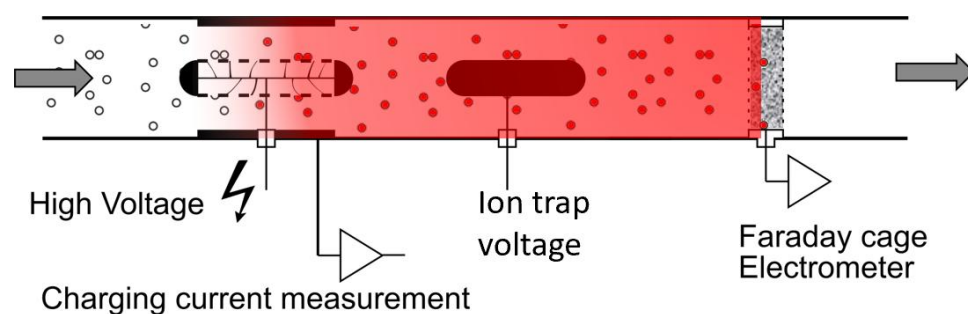
³Edebali et al. 2003

⁴Liu et al. 2023

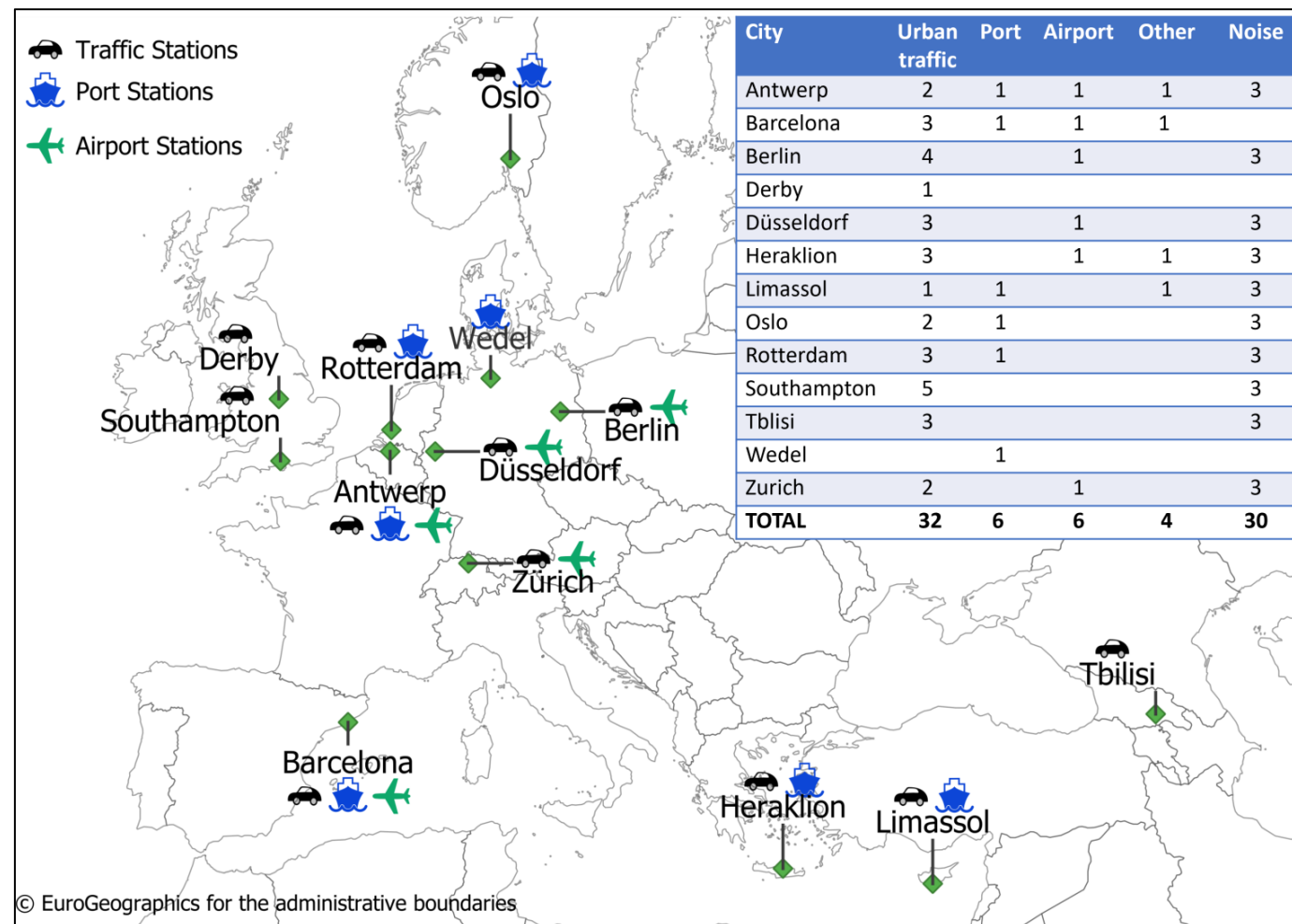
Net4Cities Network



- 33 European measurement sites
- naneos LDSA devices
- Continuous 24/7 operation with 2-second recording intervals
- Indirect surface area measurement utilizing the principle of diffusion charging



Picture courtesy: Martin Fierz



Slide: S. Drossaert van Dusseldorp

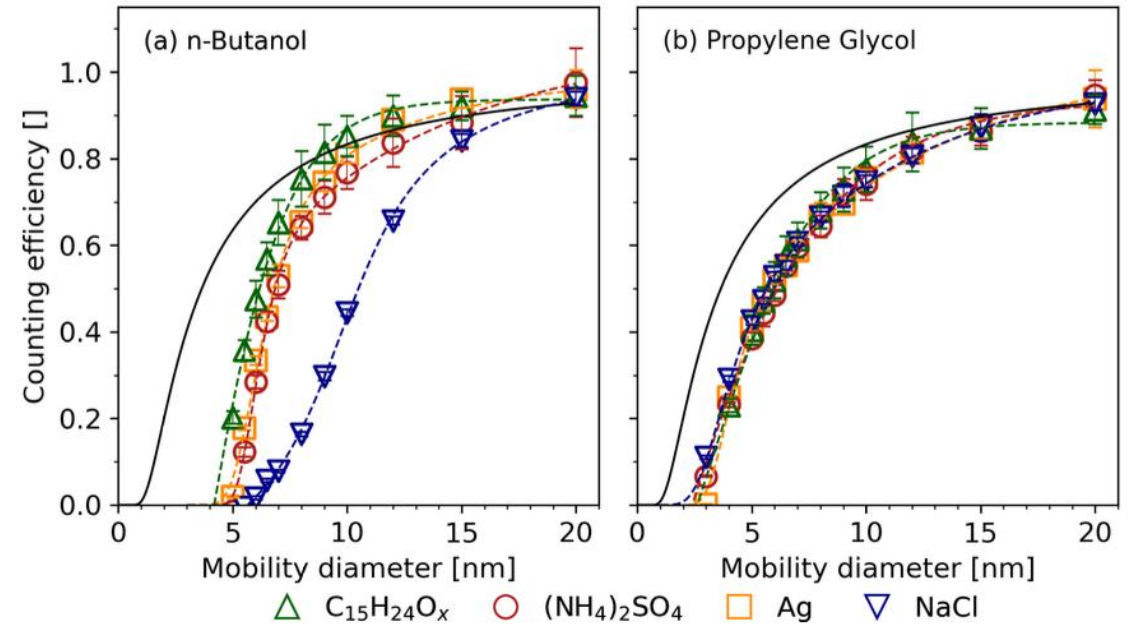
Propylene glycol – equivalence & approval

Building the long-term evidence base

- Butanol vs. PG equivalence & composition-insensitivity already demonstrated (Wlasits et al., 2024)
- PG ACTRIS approval - pending; this network is part of the field evidence and important user experience project.

In Net4Cities project:

- Calibration before / during / after -> quantify long-term drift
- Helsinki ACTRIS station: parallel butanol vs PG, >6 months, with SMPS to test the size-distribution effect on N_{tot}
- All cut-off and linearity calibrations during the project compared and analyzed (>50 calibrations done already)



Wlasits et al.; Aerosol Res., 2, 199–206, 2024

PG vs Butanol



PROPYLENE GLYCOL

- + No butanol-removal system needed
- + Refill every 4-6 months
- + Odorless, user-friendly fluid
- + Very low consumption - liquid level a non-issue

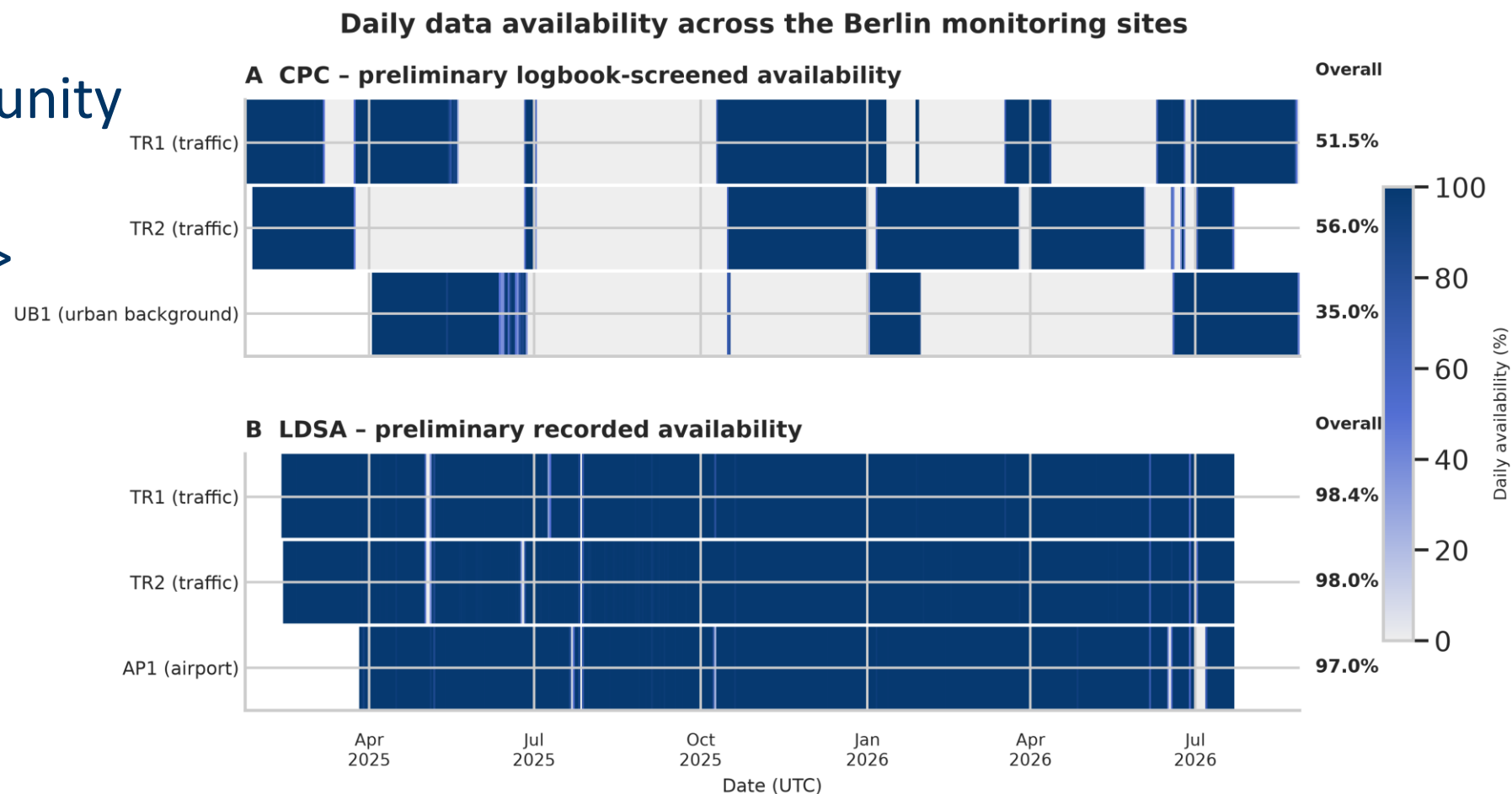
BUTANOL

- Butanol-removal system required
- Refill / site visit ~every 23 days
- Odorous; harder for host sites
- Frequent visits - tough for remote stations
- Some gas monitors (and users ;)) sensitive to butanol vapor

Save EUR 5,000-10,000 / system upfront + up to EUR 1,200 / year / system

Data coverage

- N4C network -> learning opportunity
- Transport environments -> higher concentrations



CPC: complete minutes retained after preliminary logbook screening; suspect periods included. LDSA: positive numeric measurements; device-status codes not yet interpreted.

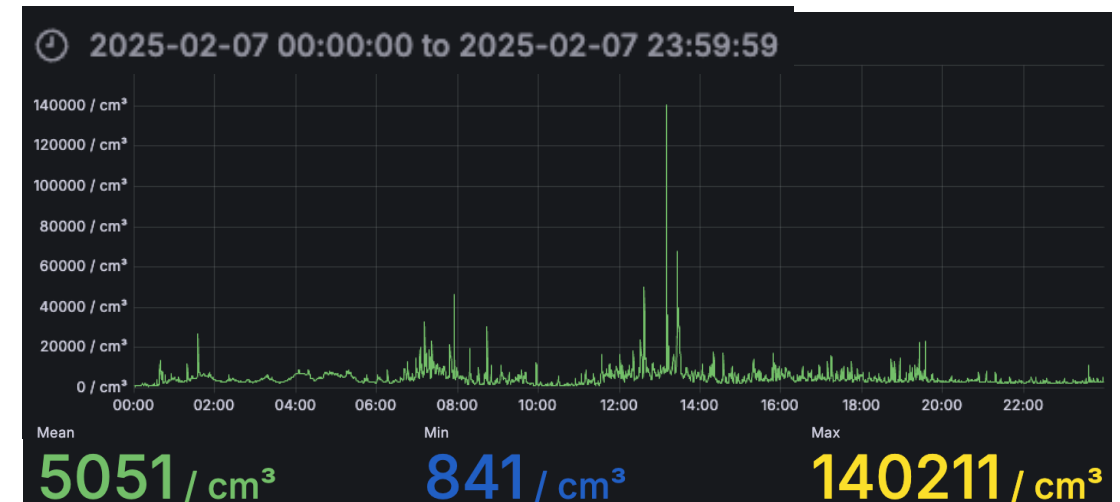
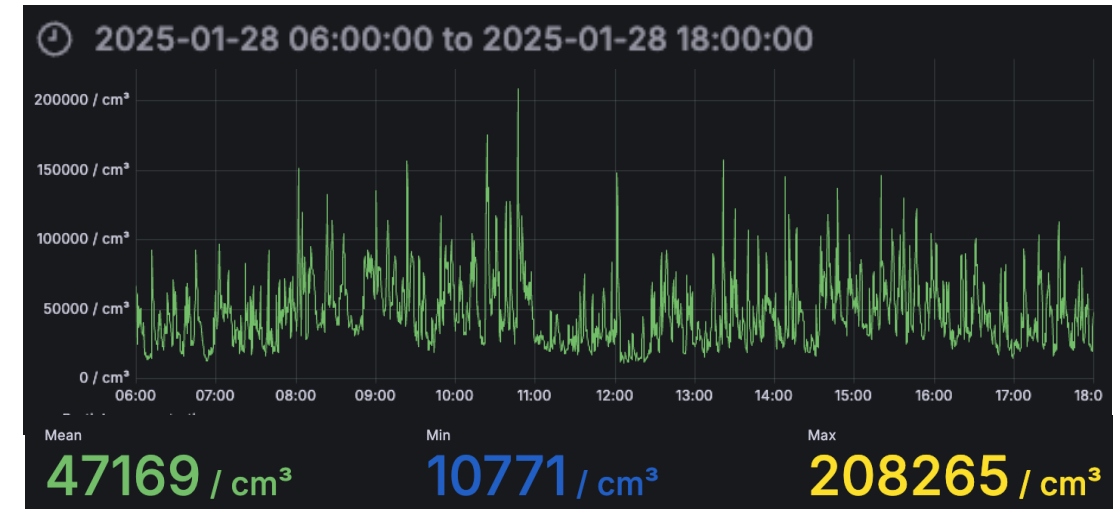
Lessons from the field

Urban peaks far exceed the calibration range

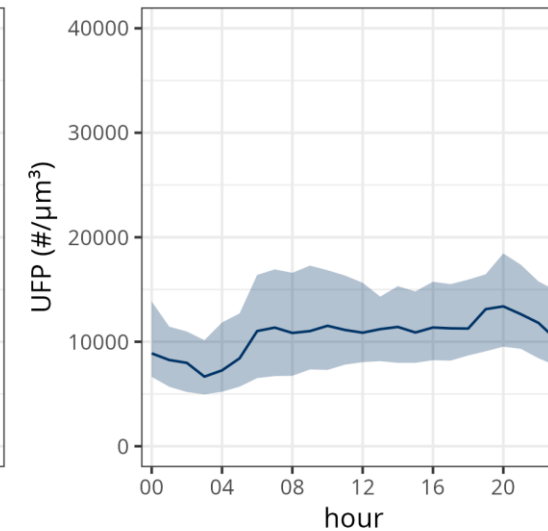
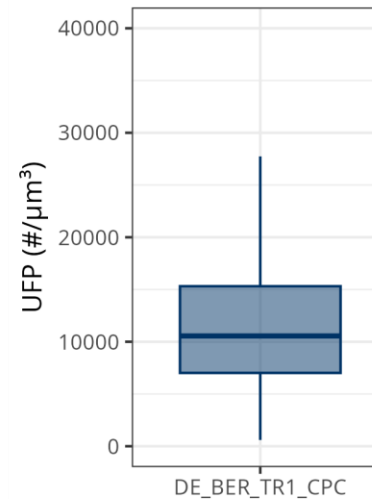
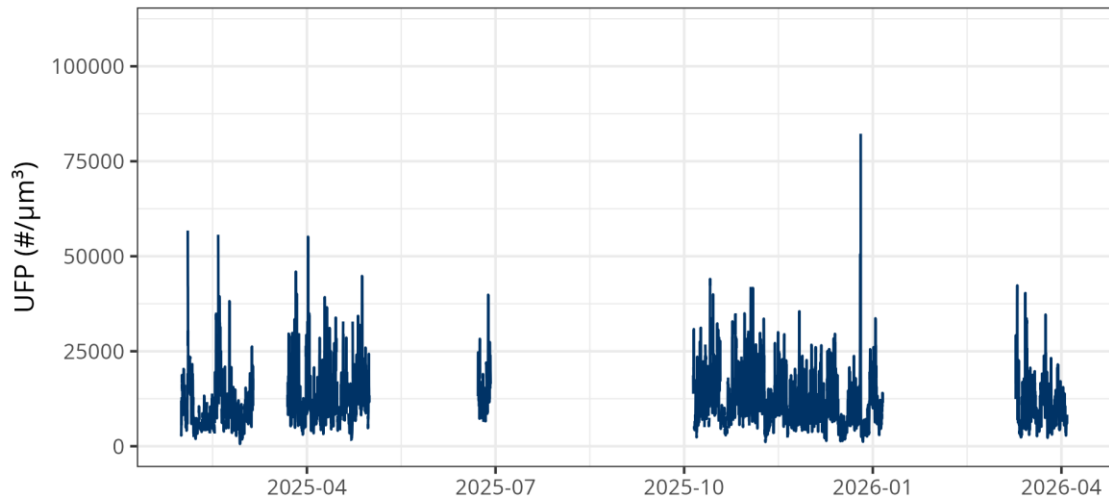
- Peaks of **300,000-500,000 #/cc** near traffic & local sources
- ACTRIS calibration only to 50,000 #/cc -> these sites would need a dilutor
- Main issues: nozzle contamination (tiny optics aperture) & critical-orifice contamination - both cleanable
- Cyclone cut-off ran high -> bypass flow added to survive extreme loads

1 day examples – HIGH and LOW – (1 minute avg data)

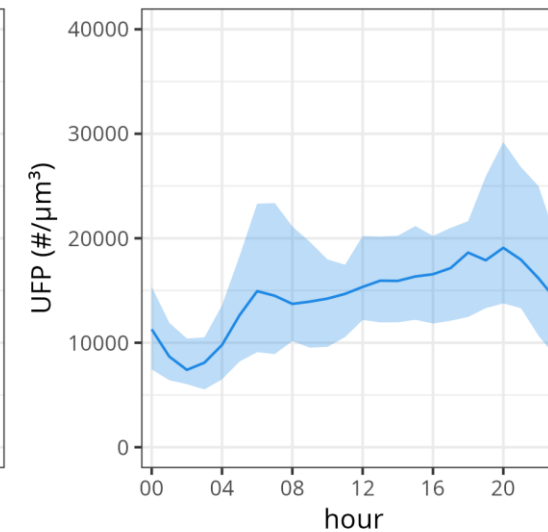
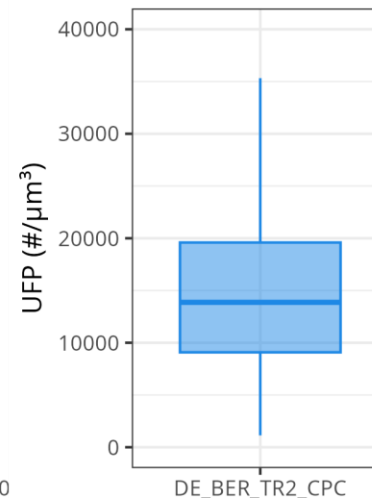
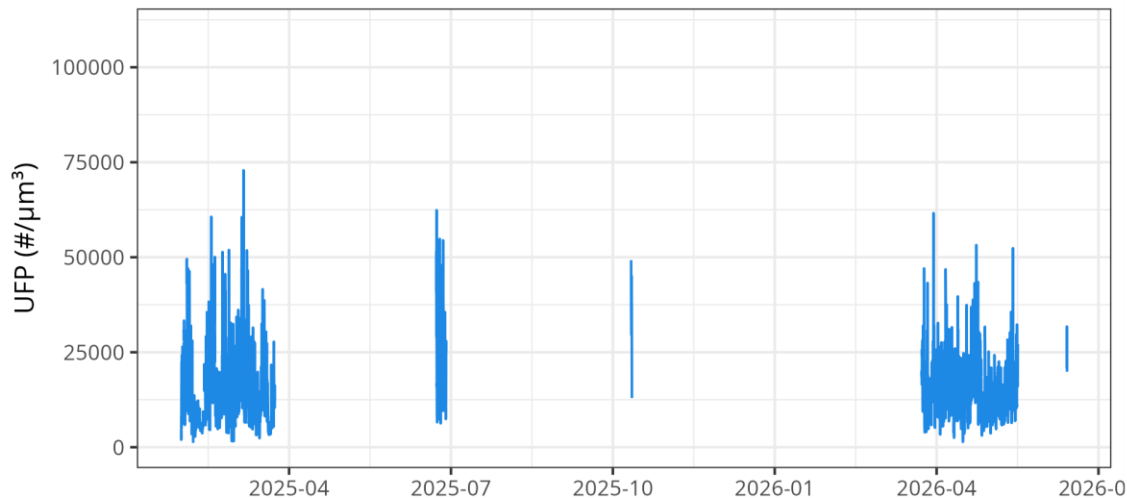
- Note: the min/max values are 1minute min/max, not 1Hz
- High peaks in CPC data are not outliers or noise, they are real data!



Initial results CPC – example Berlin

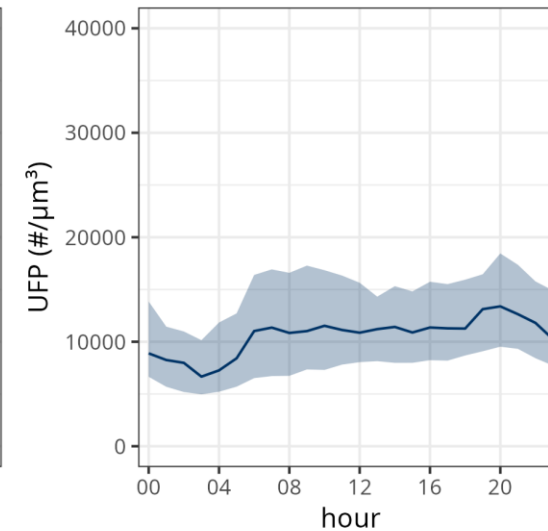
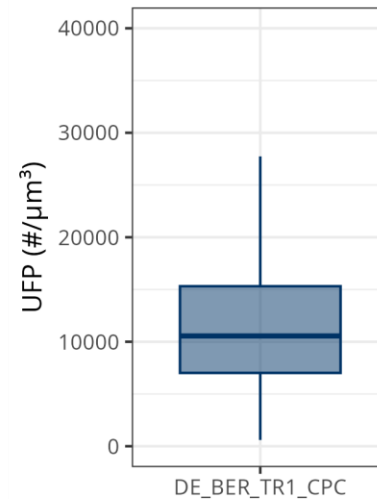
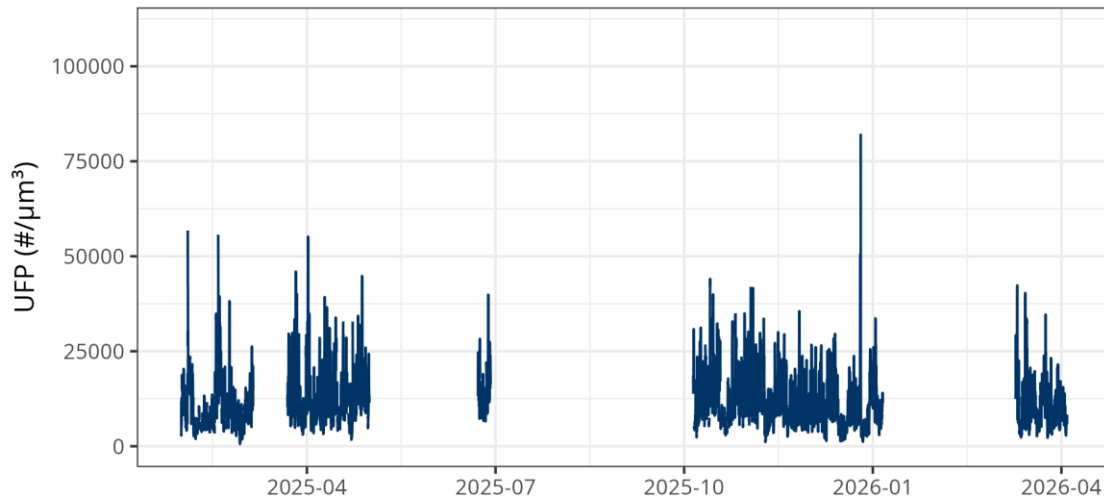


Berlin
Frankfurter
Allee
(MC174)

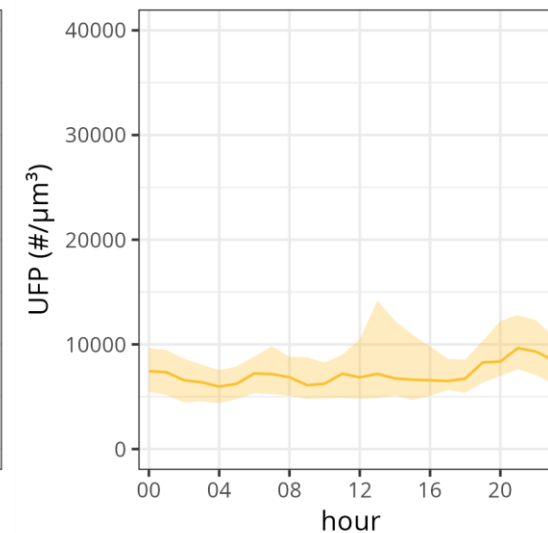
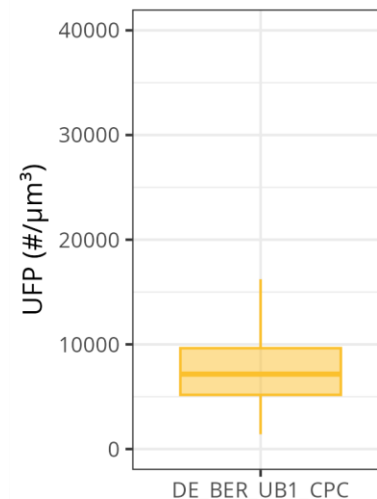
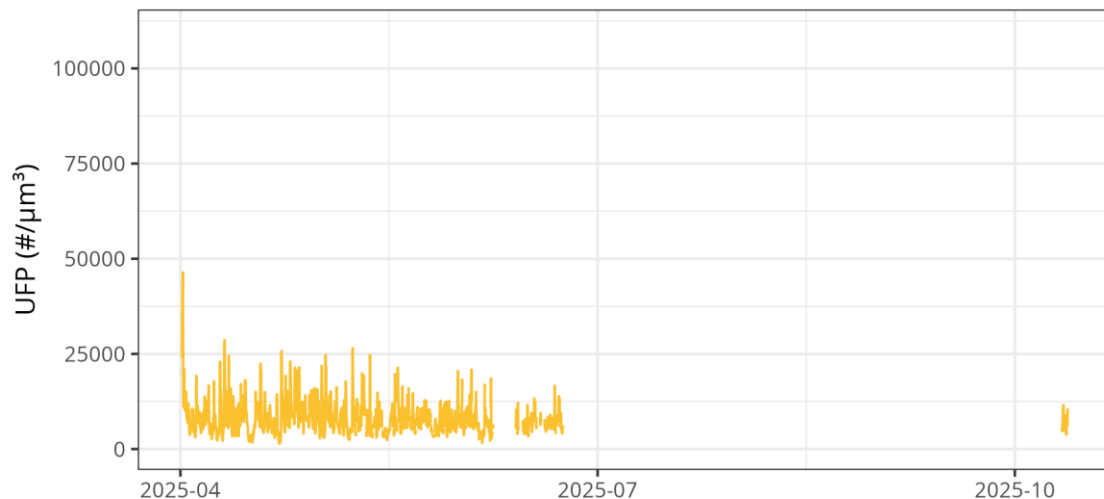


Berlin
Mariendorfer
Damm
(MC124)

Initial results CPC – example Berlin

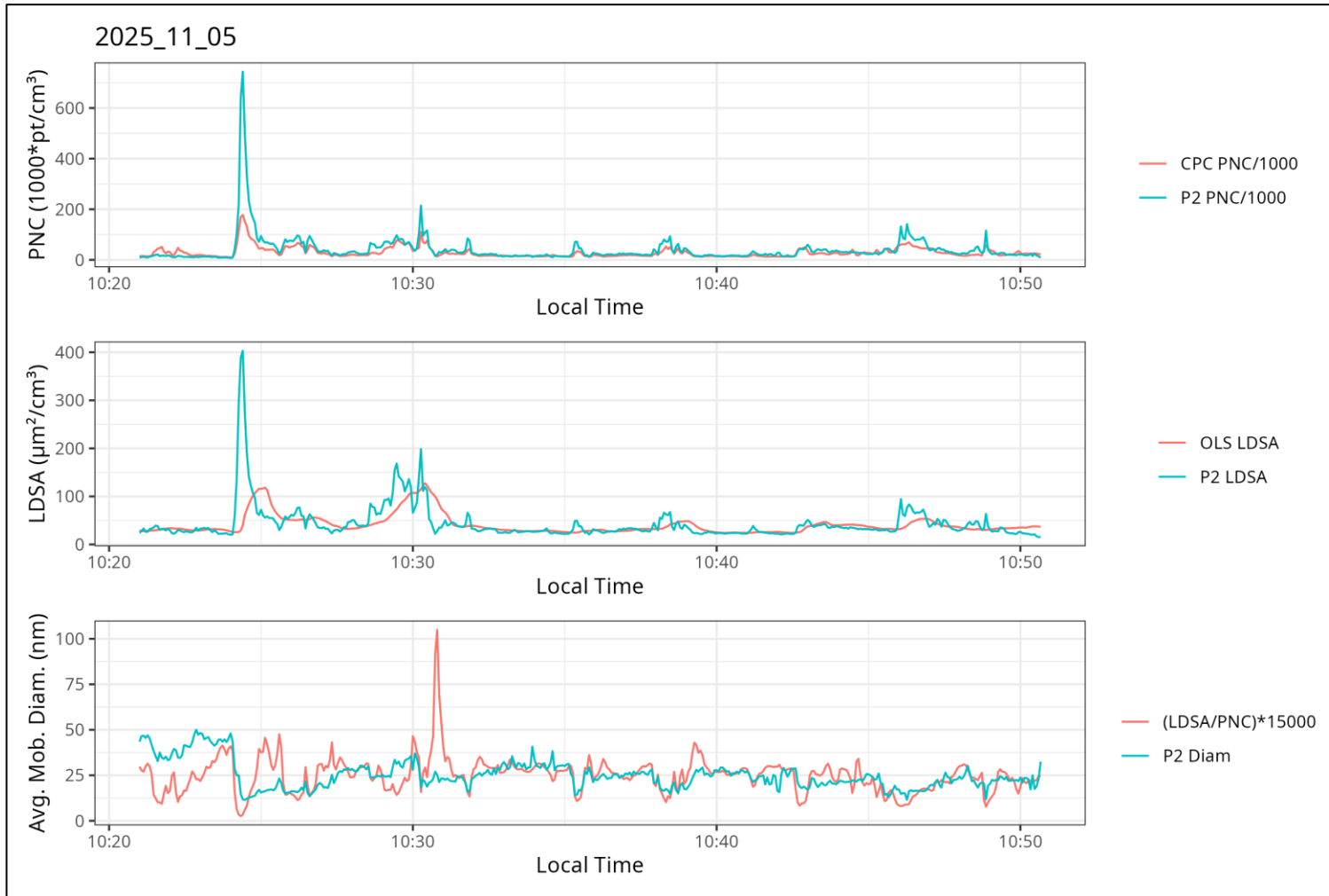


Berlin
Frankfurter
Allee
(MC174)



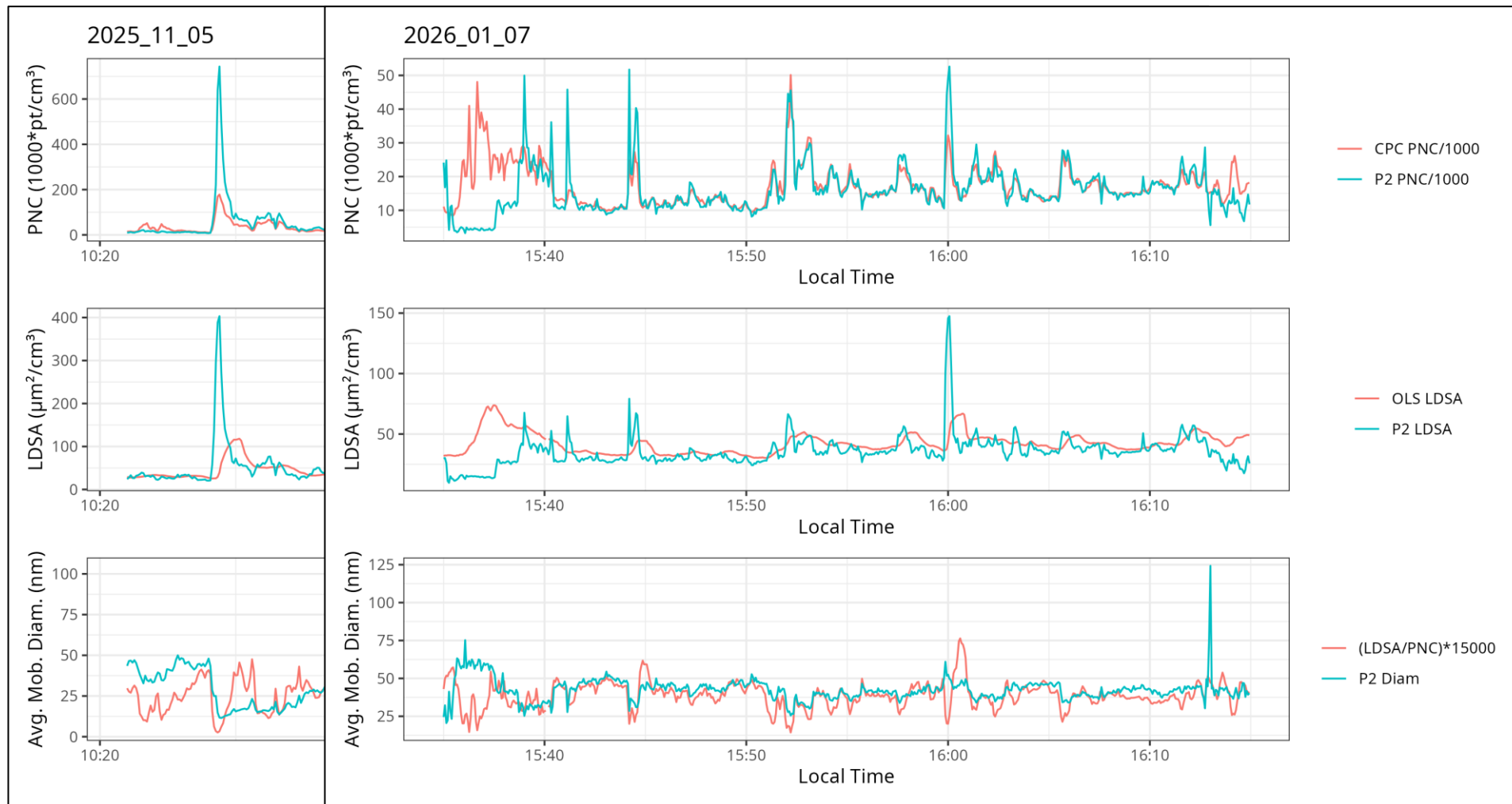
Berlin
Nansenstr.
(MC042)

LDSA – Partector 2 Co-Locations

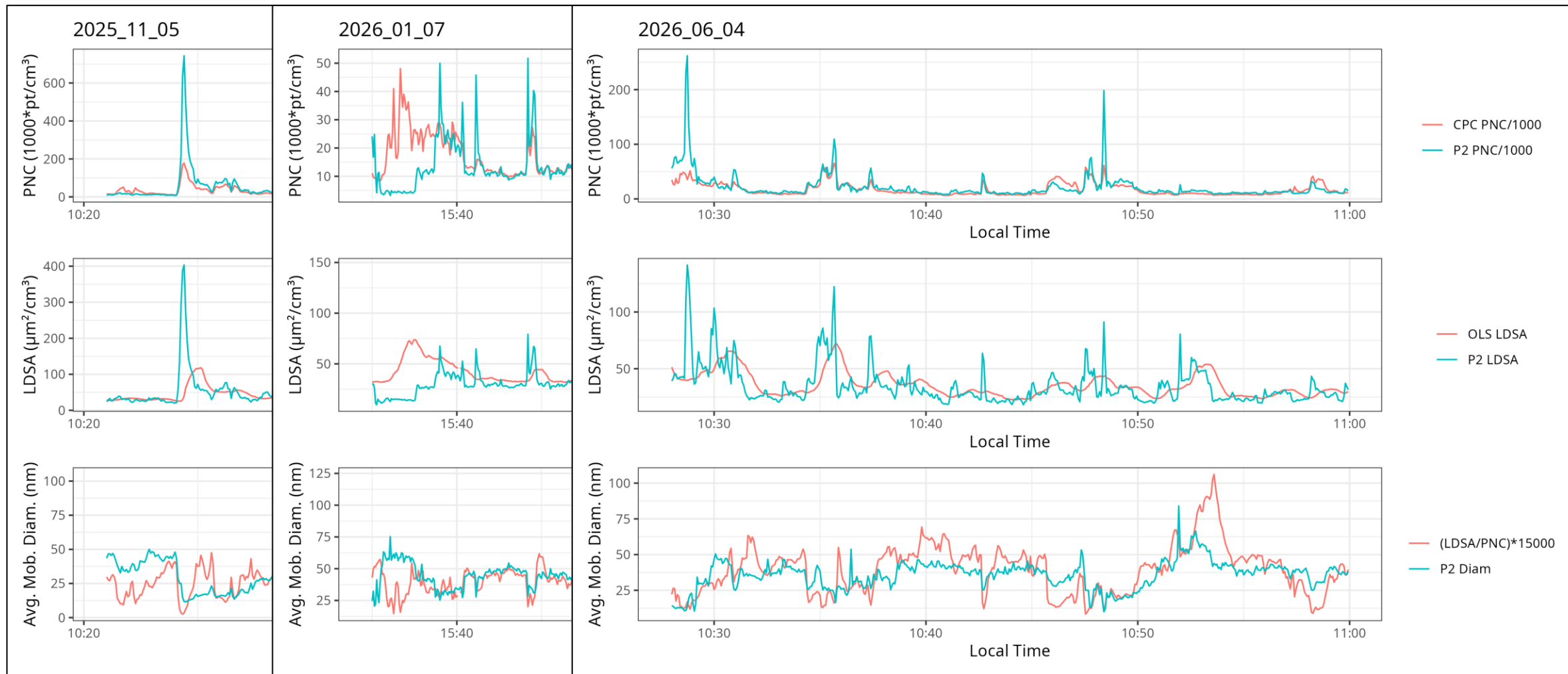


- Regular performance checks
-> colocation with Partector2
- Good agreement with CPC and LDSA
- 4 sec resolution all instruments
- At Berlin TR2 (MC124)

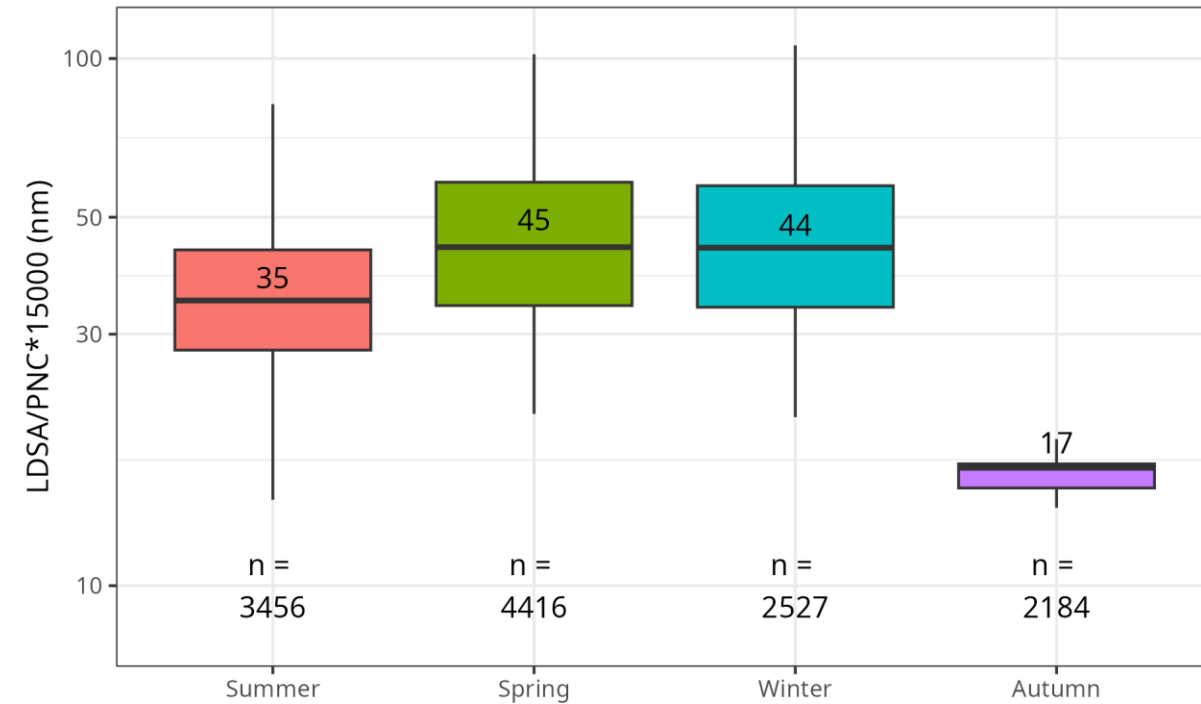
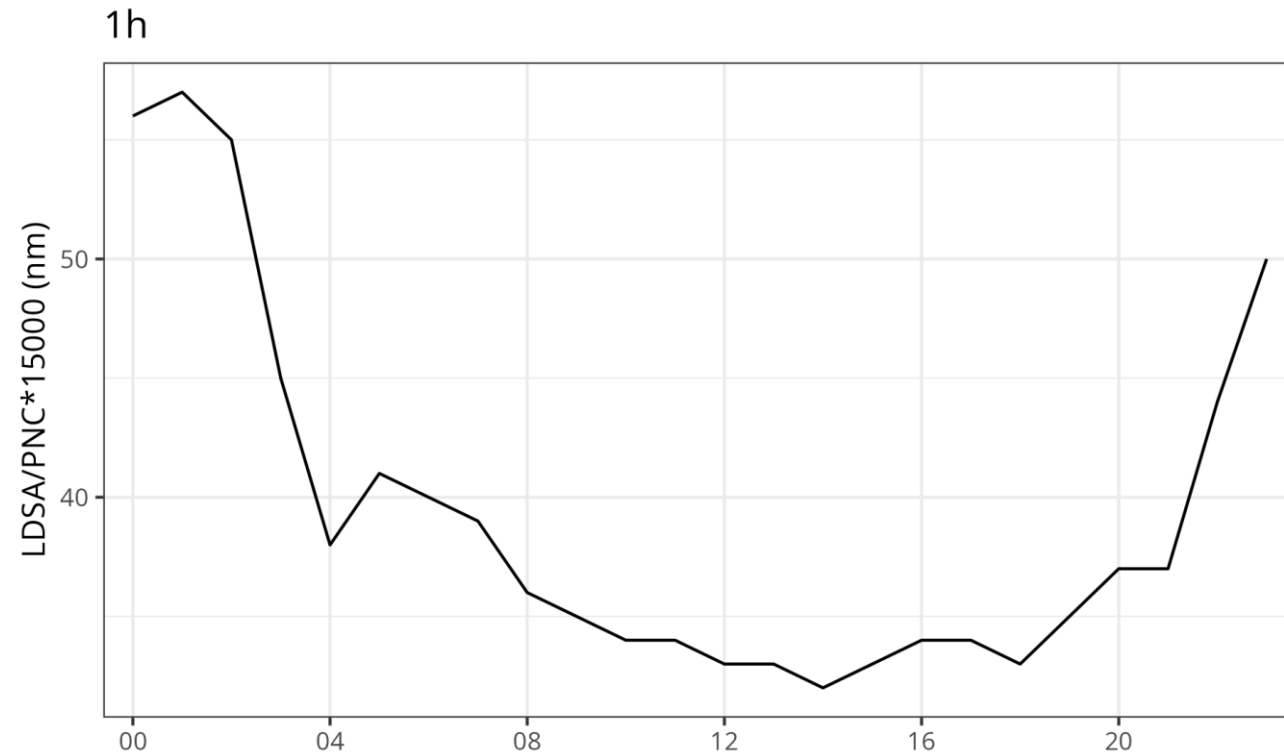
LDSA – Partector 2 Co-Locations



LDSA – Partector 2 Co-Locations



Initial results PNC vs LDSA



Outlook



- Project continues through end of 2027
- Digging into analysis
- Putting together lessons learned -> Net4Cities Studio

Erika von Schneidemesser
evs@rifs-potsdam.de

Research Institute for Sustainability | at GFZ
Berliner Straße 130
D — 14467 Potsdam
T: +49 (0) 331-28822-407
www.rifs-potsdam.de



LinkedIn

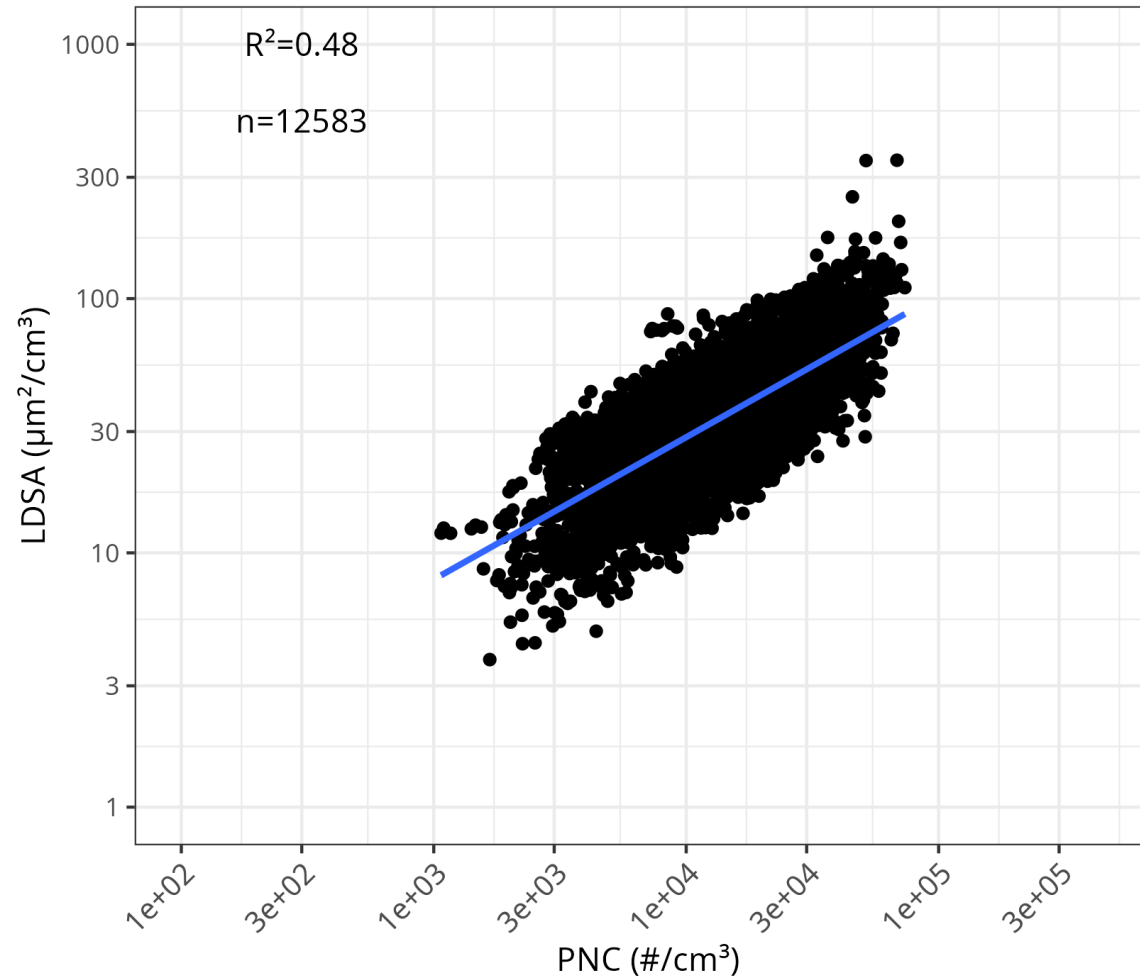


www.net4cities.eu

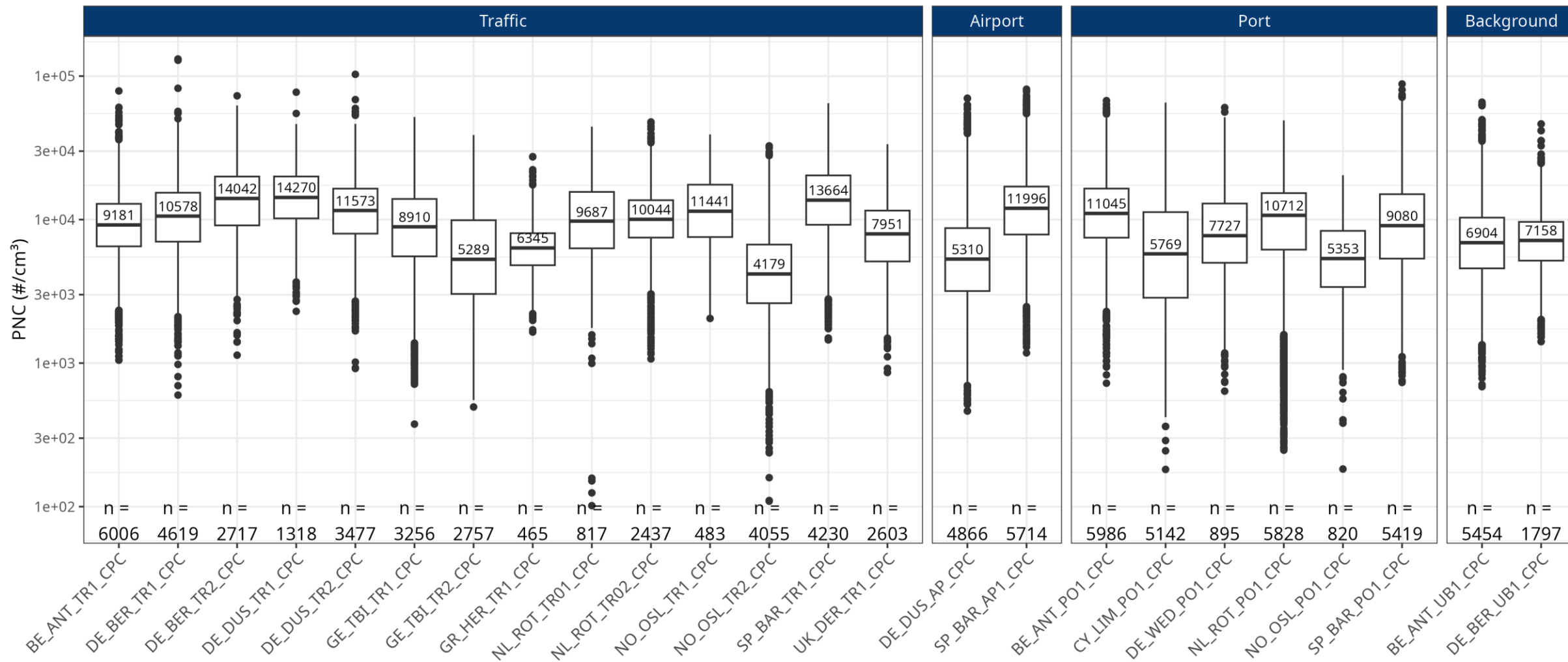
Initial results PNC vs LDSA

- Linear regression
- Hourly resolution
- Berlin TR2 (MC124)
- Jan 2025 – Jul 2026

- Airmodus A30 CPC with PG
- naneos OLS LDSA
- naneos Partector 2



Initial results CPC



Initial results LDSA

