

Particle number concentration and lung-deposited surface area in Berlin:

Initial results from Net4Cities

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Net4Cities in Berlin

Berlin monitoring stations

Net4Cities CPC and LDSA measurements

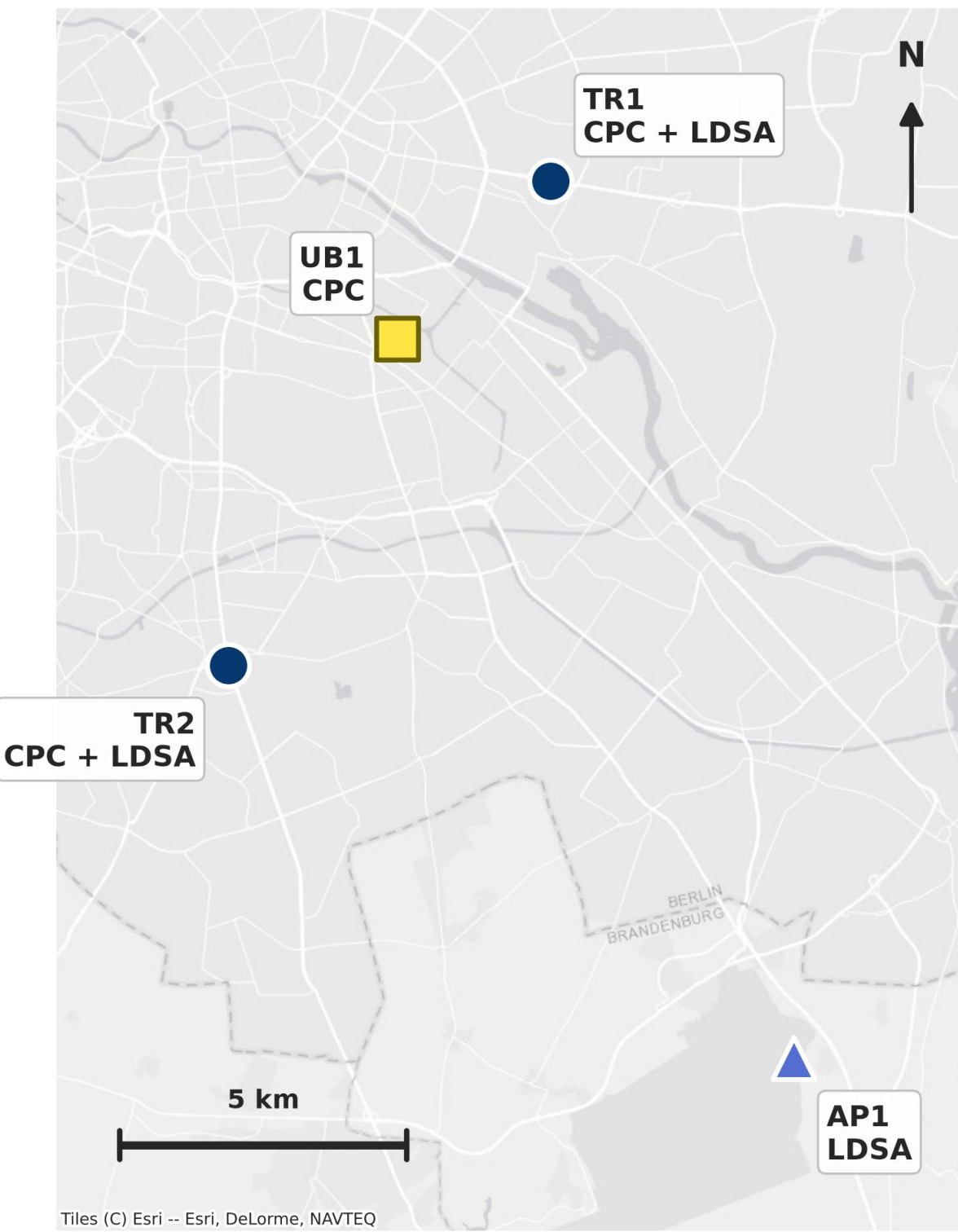


Fig. 1: Net4Cities monitoring locations in Berlin. TR1 and TR2 are traffic sites equipped with CPC and LDSA instruments; UB1 is an urban-background site with a CPC; and AP1 is an airport site with a LDSA.

Net4Cities is a Horizon Europe project (2024–2027) expanding long-term monitoring of transport-related air and noise pollution across 13 European cities. The project aims to improve understanding of emerging pollutants and support evidence-based urban and transport policies.

- The network includes 33 nanos OLS sensors and 24 Airmodus CPCs deployed across traffic, port, airport, and background sites.
- Berlin has 6 monitoring locations, this study focuses on 4 sites with CPC and/or LDSA instruments.
- Collocated instruments at TR1 and TR2 enable comparisons between PNC and LDSA.

Why measure both PNC and LDSA?

Why monitor ultrafine particles (UFPs)?

- Beyond particle mass:** UFPs (<100 nm) contribute little to PM mass despite their high particle numbers and surface area.
- Health impact:** UFPs can reach the alveoli and potentially cross into the blood-stream. LDSA recognized as a highly effective metric for nanoparticle toxicology^[1,2]
- Data Gap:** Long-term, spatially distributed measurements remain scarce, limiting the assessment of exposure patterns and potential health impacts.
- Levels:** LDSA hourly averages <15 $\mu\text{m}^2/\text{cm}^3$ are considered low and >40 $\mu\text{m}^2/\text{cm}^3$ are considered high (no consensus), episodic peaks can exceed 200 $\mu\text{m}^2/\text{cm}^3$ [3,4]. PNC <1,000 pt/cm³ are considered low, with concentrations >10,000 pt/cm³ considered high^[5].

Airmodus condensation particle counter (CPC)

- A30 / A20 CPC (Fig. 2) measure PNC at 1 Hz after condensational growth and optical counting.
- Stainless-steel inlet, ~2.5 μm cutoff cyclone, PermaPure 12" Nafion dryer, and RHTP module (<40% RH).
- Condensation fluid:** Primarily propylene glycol; butanol at selected sites. Tests for ACTRIS compliance ongoing.
- Operational limitations:** Missing data mainly resulted from hardware failures, reduced flow or inlet clogging, connectivity problems and installation logistics.

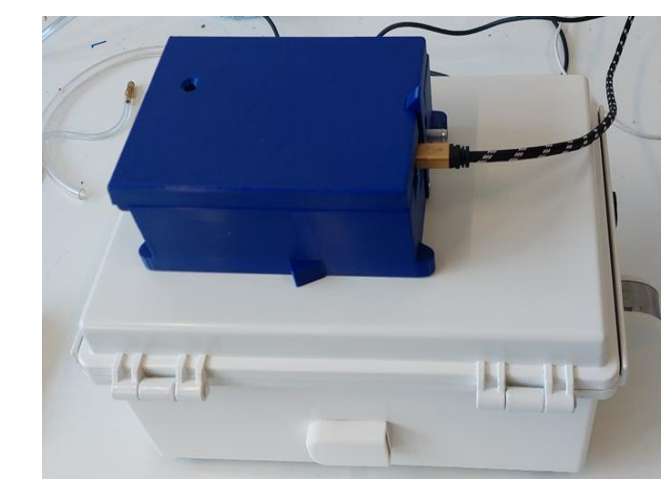


Fig. 3: nanos OLS

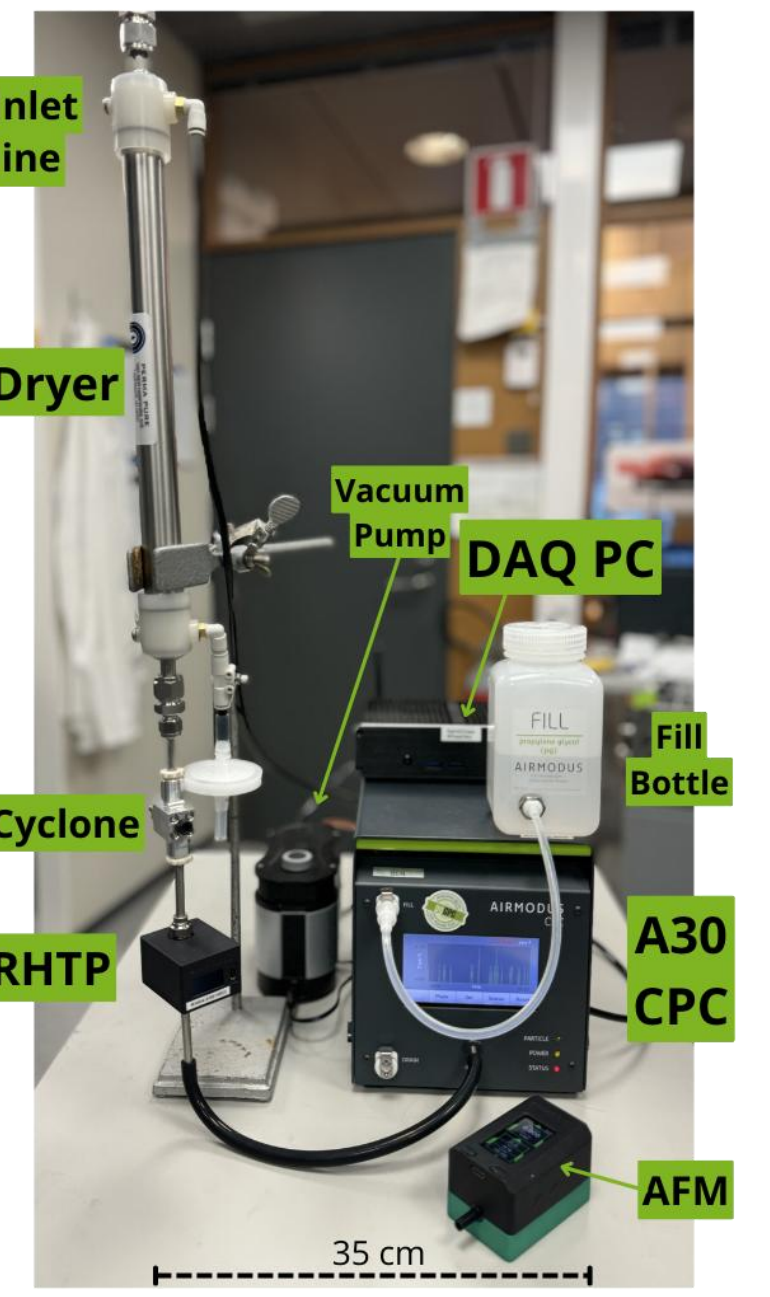


Fig. 2: Airmodus A30.

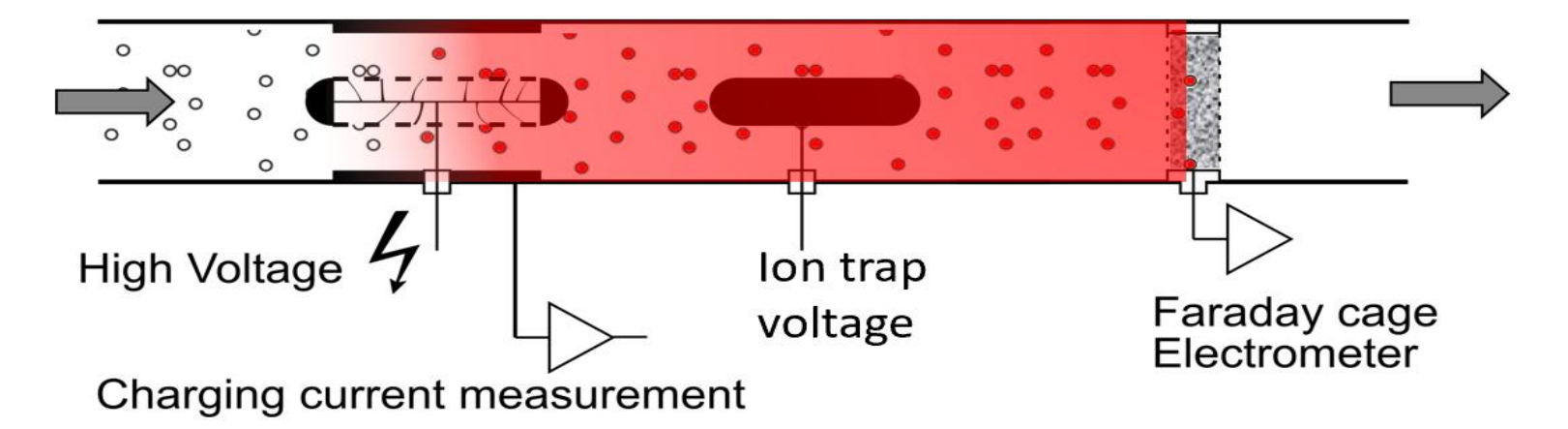


Fig. 4: Diffusion charging measurement principle.

OEM Nanos LDSA sensors (OLS) (Fig 3.)

- Use diffusion charging principle (Fig. 4) as in the nanos Partector instruments.
- Measuring **only LDSA**, not size distribution or PNC, but ~20 co-located with CPCs.
- Initial quality checks indicate **excellent performance**. High data availability (>95%) across all sites.
- Initial results exhibit heterogeneity amongst cities, but similar concentrations between site-types with transport-related emissions.

Preliminary Results

Data availability

LDSA availability exceeded 97%, while CPC availability ranged from 35% to 56%

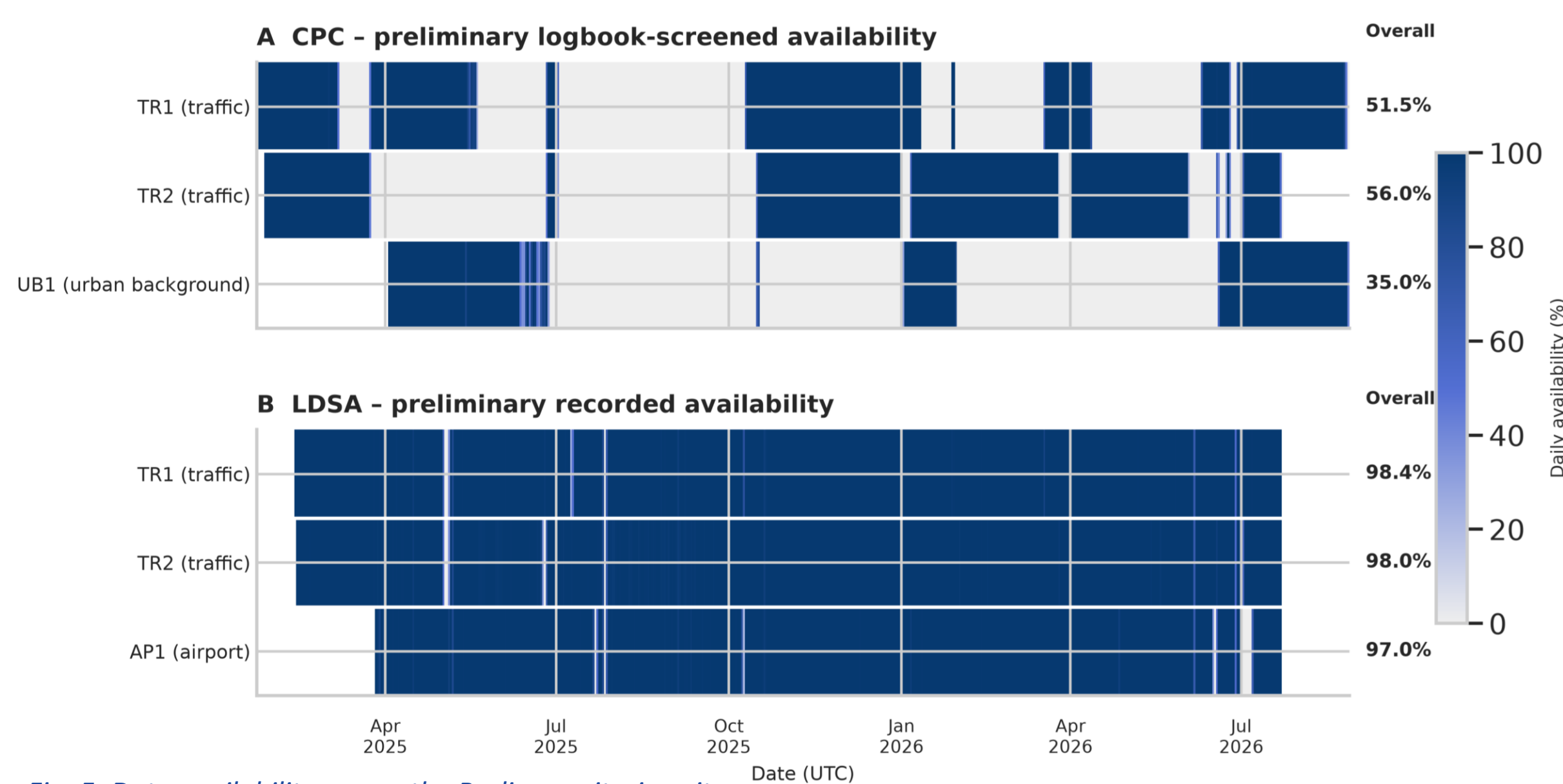


Fig. 5: Data availability across the Berlin monitoring sites.

Concentration distributions

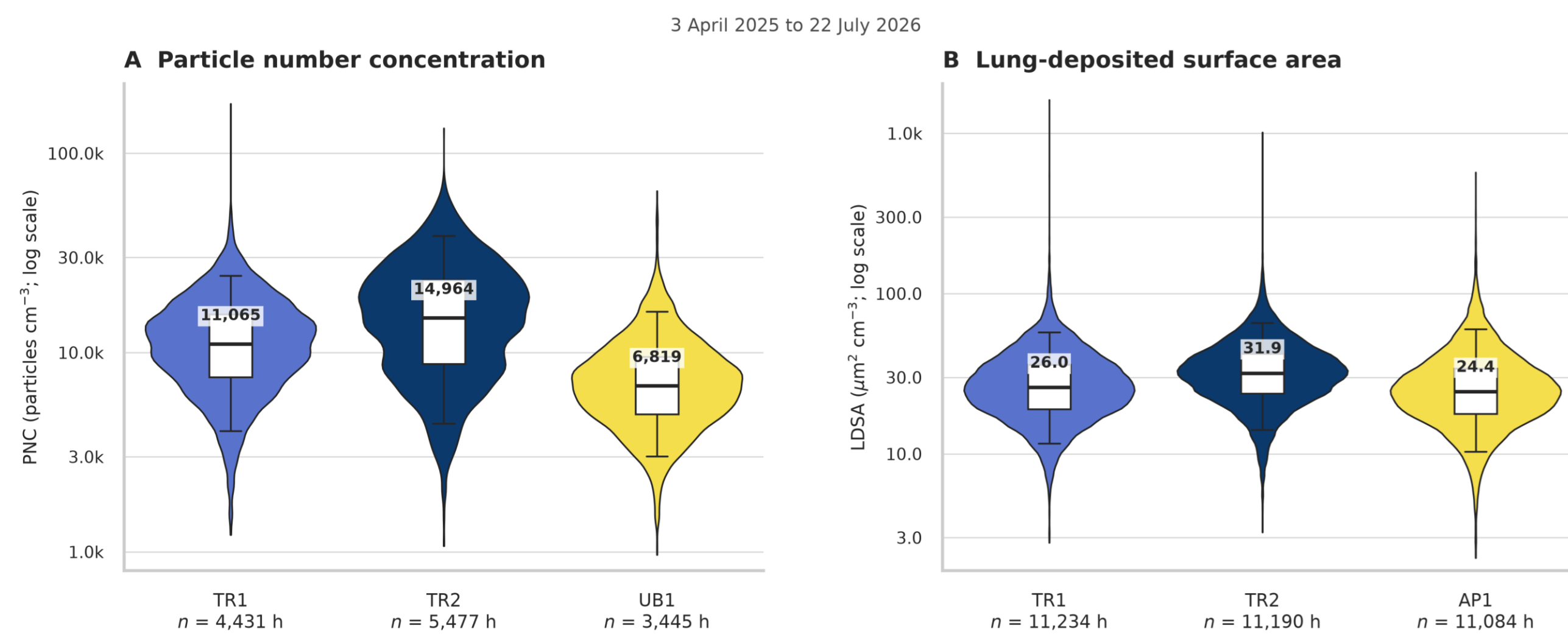


Fig. 6: Hourly PNC and LDSA distributions across the Berlin monitoring sites during the common monitoring period.

TR2 showed the **highest median PNC** (14,964 particles cm⁻³) and **LDSA** (31.9 $\mu\text{m}^2 \text{cm}^{-3}$), while UB1 and AP1 had the lowest medians.

All distributions were around typical concentrations, with occasional high-concentration episodes.

Diurnal concentration profiles

Traffic-site PNC and LDSA rose sharply after 05:00, with the highest daytime concentrations observed at TR2.

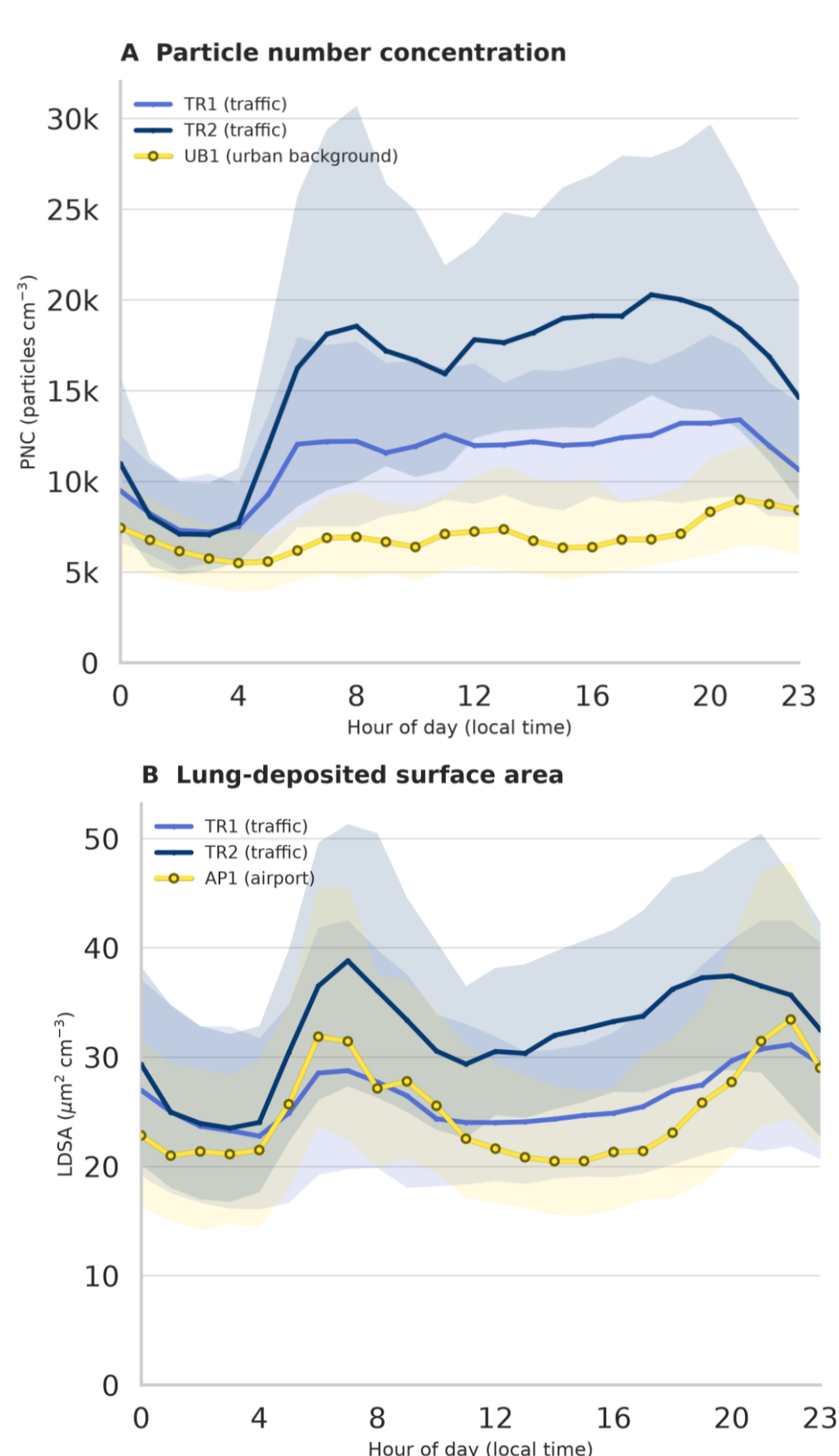


Fig. 7: Median diurnal PNC (Panel A) and LDSA (Panel B) profiles based on all valid hours during the common monitoring period. Shading indicates the interquartile range.

CPC-LDSA association

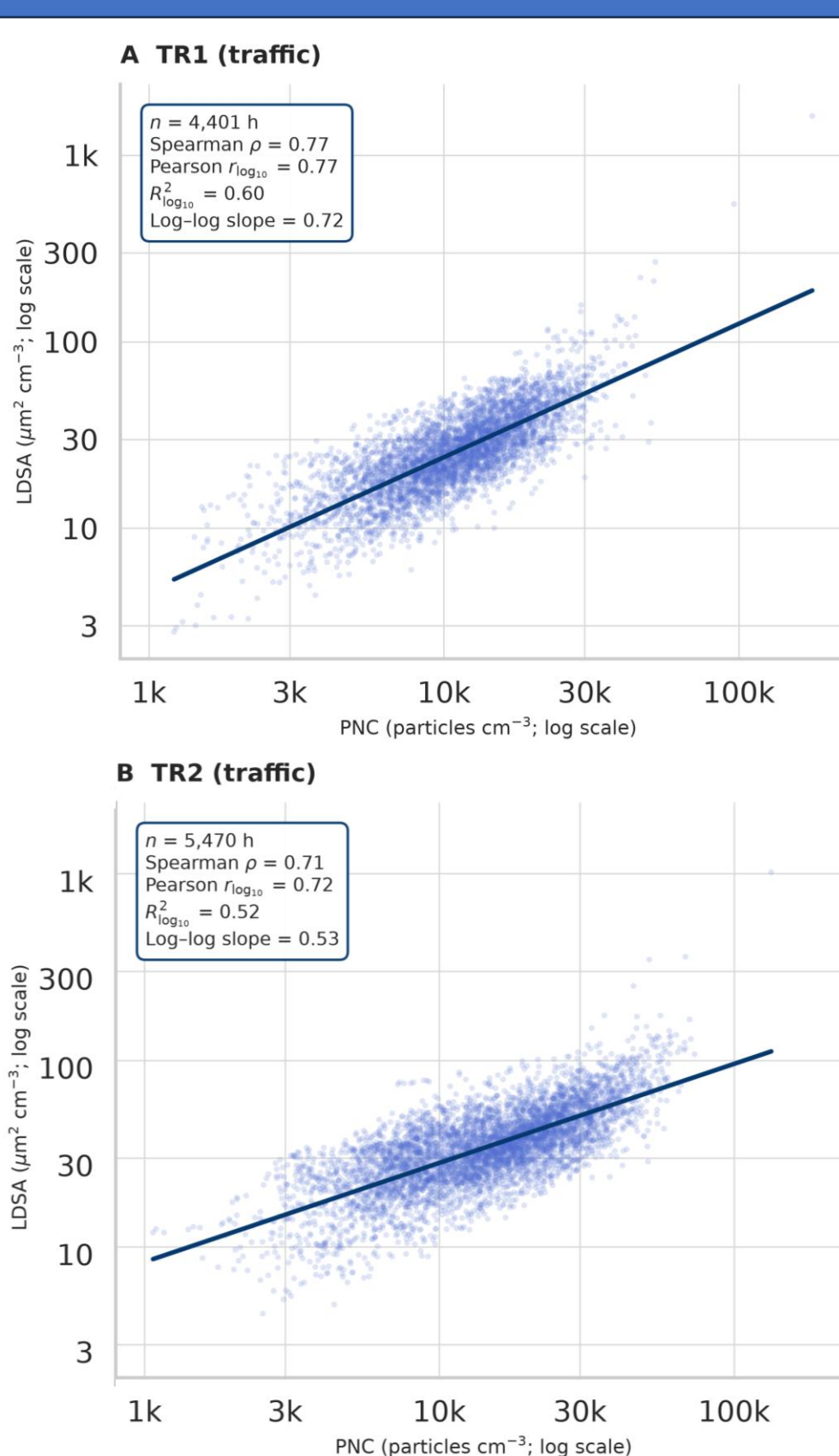


Fig. 8: Same-site, same-hour PNC and LDSA observations at TR1 and TR2. Lines show descriptive log-log regressions.

Pollution roses

Most matched observations occurred under westerly winds, although the concentration-class composition differed among sites.

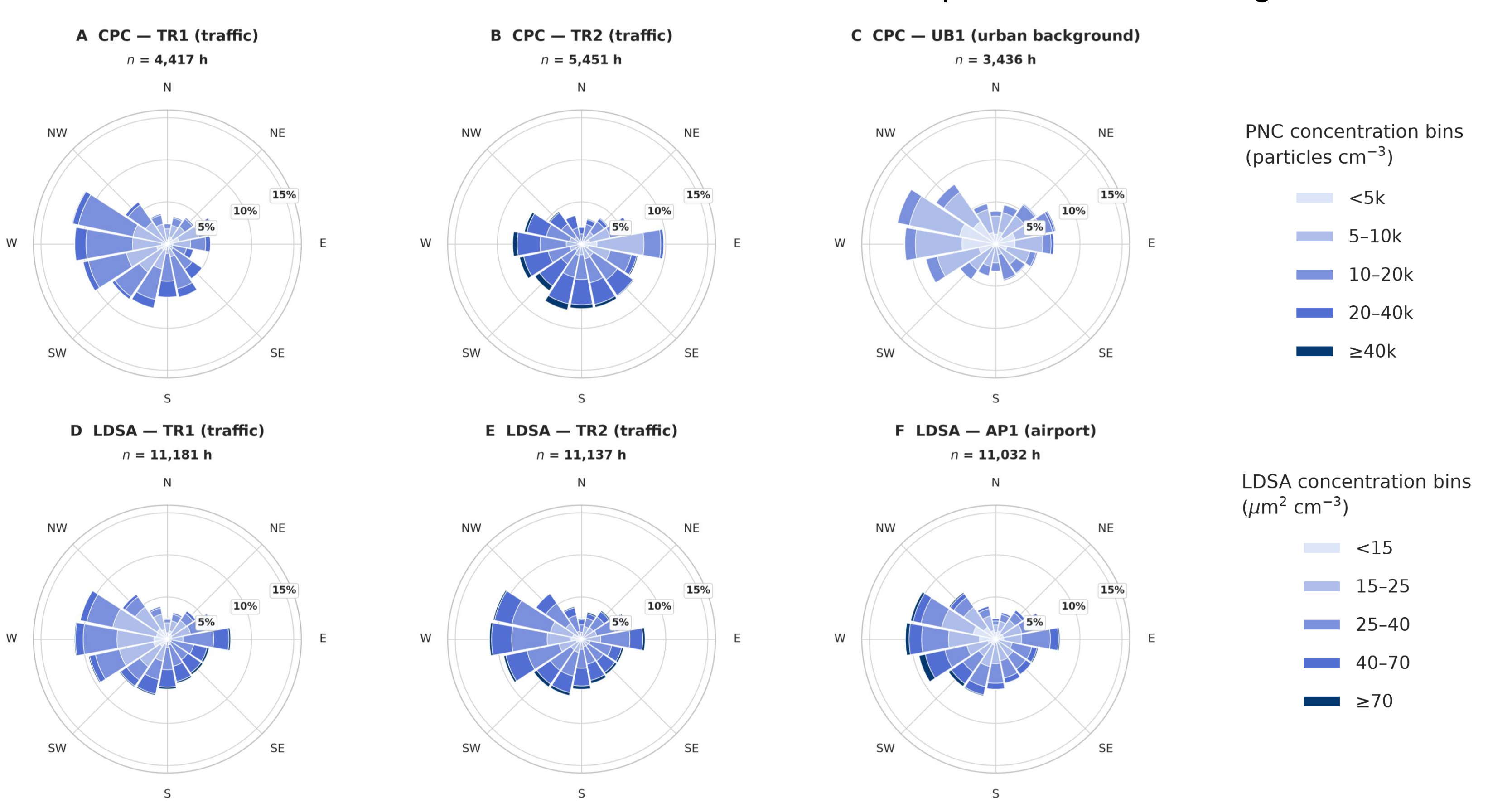


Fig. 9: Pollution roses based on hourly PNC and LDSA observations paired with ERA5 10-m winds. Radial length represents the percentage of matched non-calm hours in each wind sector, while colours show concentration classes. All sites used the same ERA5 grid point; winds below 0.5 m s⁻¹ were excluded.

Next steps

The remaining 18 months of the project will focus on improving data quality, conducting detailed analysis across all sites, and providing policy-relevant recommendations on air pollution and transport policy to stakeholders. The Net4Cities Studio (currently under development) will host all project results, publications, and deliverables, and will serve as a platform for accessing open-access long-term datasets.

References:

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