Dynamics of urban particle number size distributions in Stockholm, Sweden

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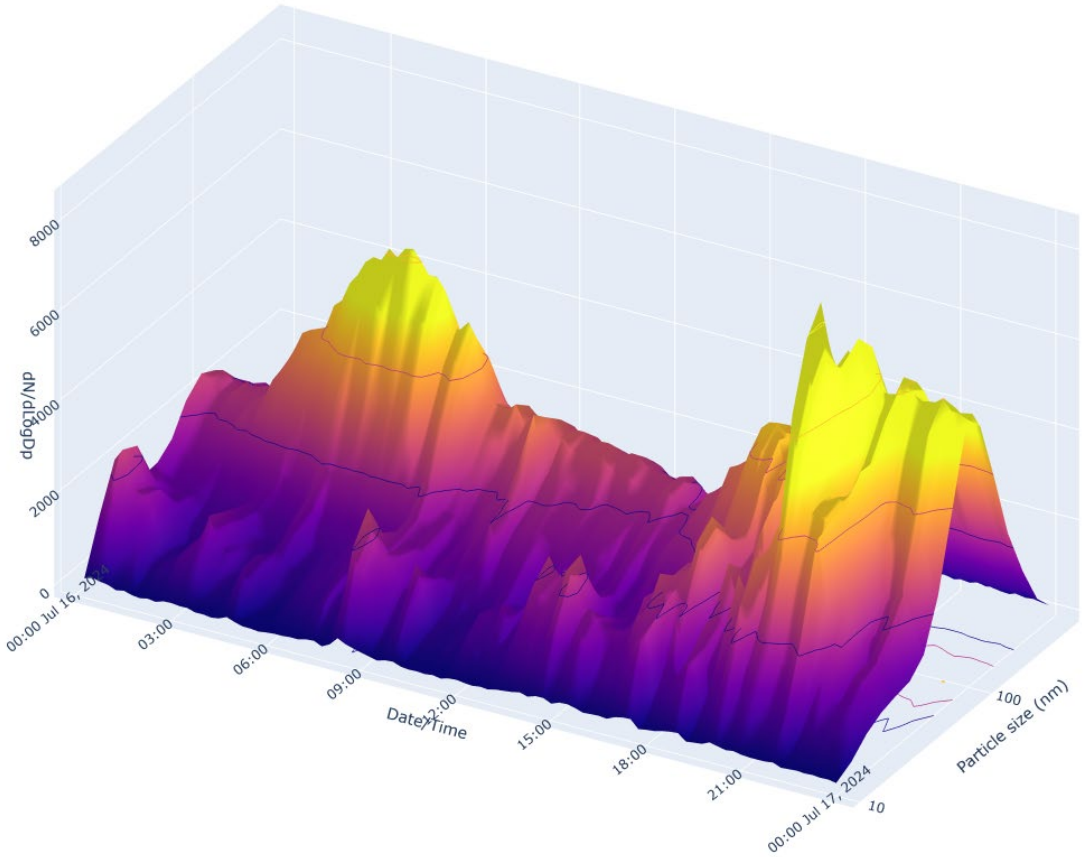

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Motivation

Environment and Health protection

EU air quality directive 2024

- Align 2030 legislation with WHO guidelines
- Urban background: UFP, Size distribution of UFP
- Regional background: UFP (Size distribution recommended)

And:
Want to understand local PNSD dynamics

WHO GLOBAL AIR QUALITY GUIDELINES

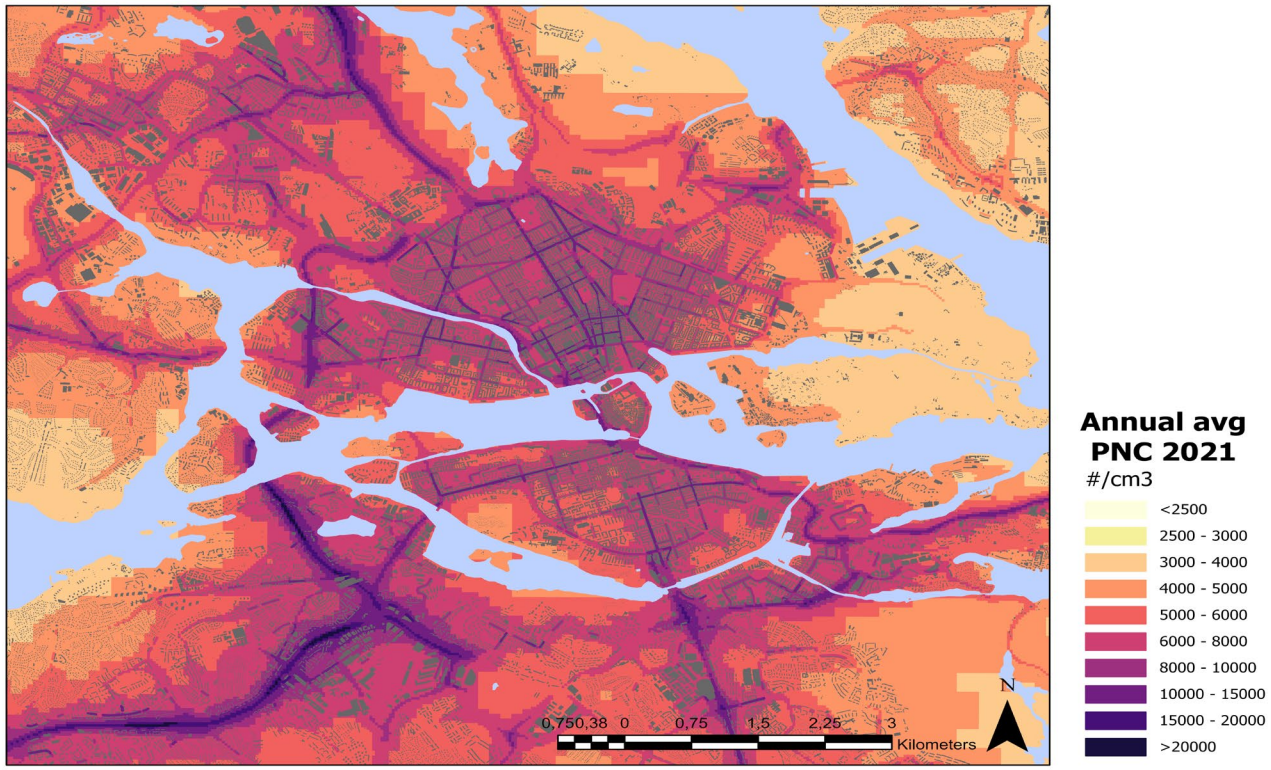
Box 4.2. Good practice statement – UFP

The GDG decided to formulate the following four good practice statements on UFP to guide national and regional authorities and research towards measures to reduce ambient ultrafine particle concentrations.

1. Quantify ambient UFP in terms of particle number concentration (PNC) for a size range with a lower limit of ≤ 10 nm and no restriction on the upper limit.
2. Expand the common air quality monitoring strategy by integration of UFP monitoring into existing air quality monitoring. Include size-segregated real-time PNC measurements at selected air monitoring stations in addition to, and simultaneously with, other airborne pollutants and characteristics of PM.
3. Distinguish between low and high PNC to guide decisions on the priorities of UFP source emission control. Low PNC can be considered < 1000 particles/cm3 (24-hour mean). High PNC can be considered > 10 000 particles/cm3 (24-hour mean) or 20 000 particles/cm3 (1-hour).
4. Utilize emerging science and technology to advance approaches to the assessment of exposure to UFP for application in epidemiological studies and UFP management.

Particle number concentration in Stockholm

Modelled PNC for Stockholm

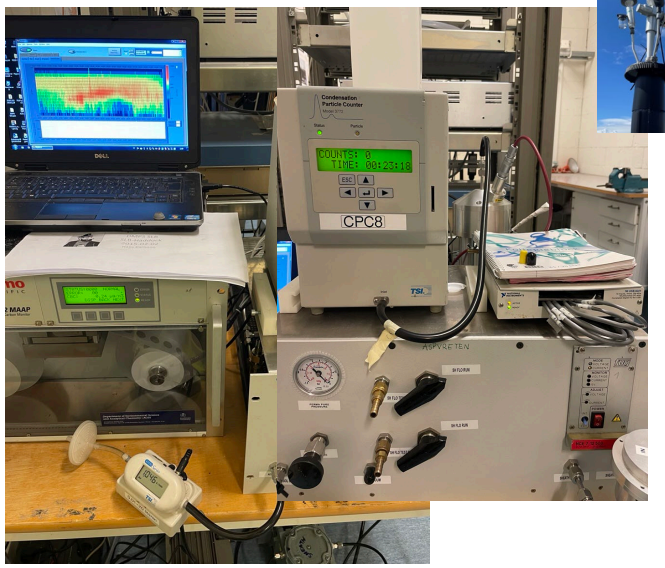


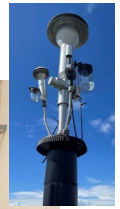
Broman et al., Env. Int. 2025 https://doi.org/10.1016/j.envint.2025.109857

nPETS
nanoParticle Emissions
from the Transport Sector

Urban background monitoring station Stockholm

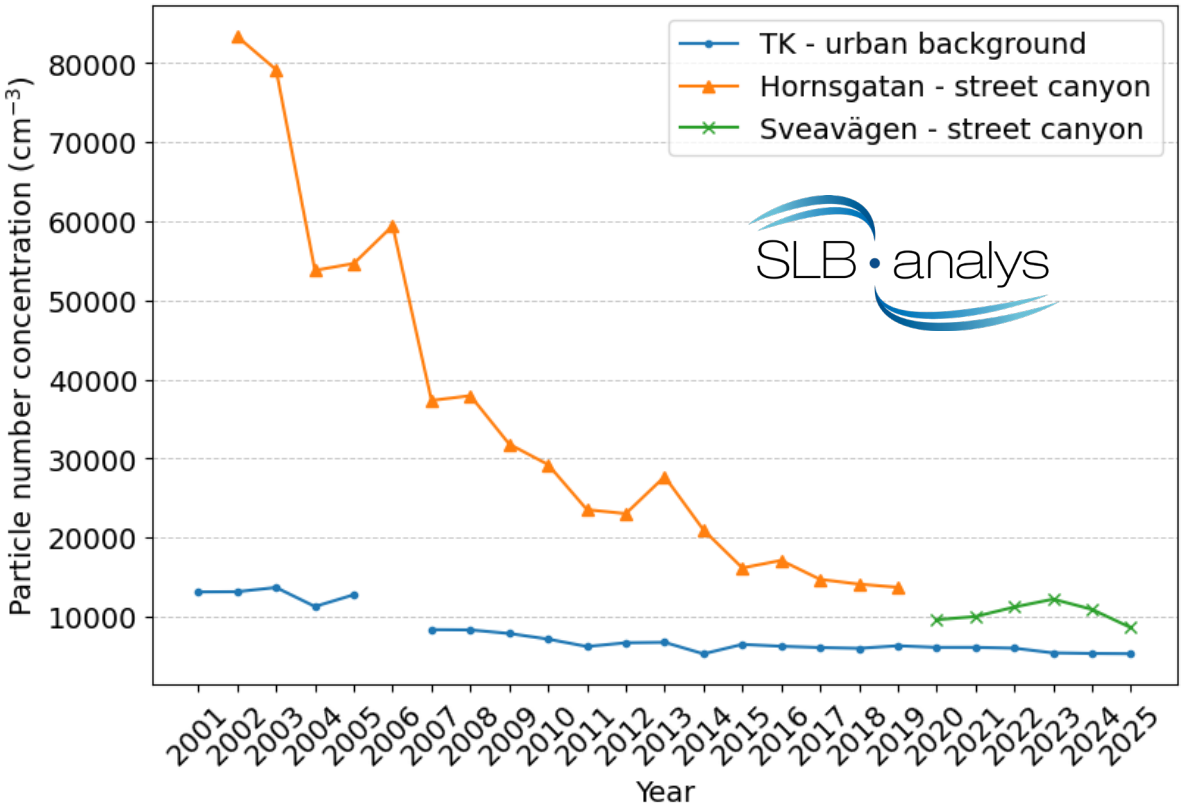
- Two CPCs (D_p > 4 nm), one in urban background, one in street canyon
- Differential Mobility Particle Sizer (DMPS, 10–410 nm) for PNSD in urban background (2022-present)
- Co-located meteorology, OPCs, TEOM, gas monitors

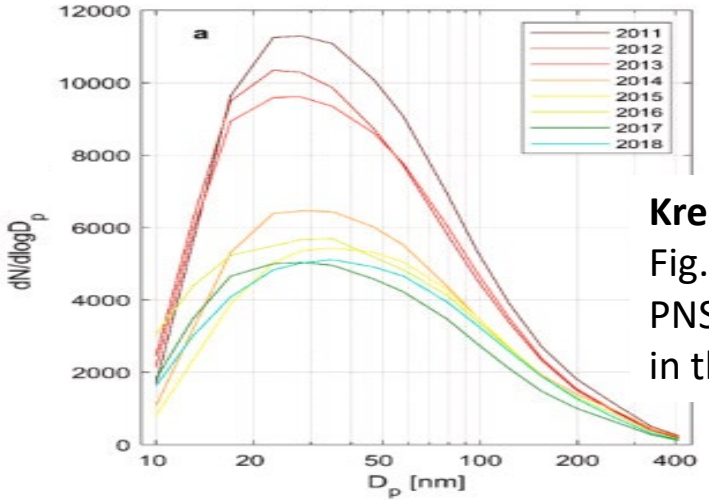




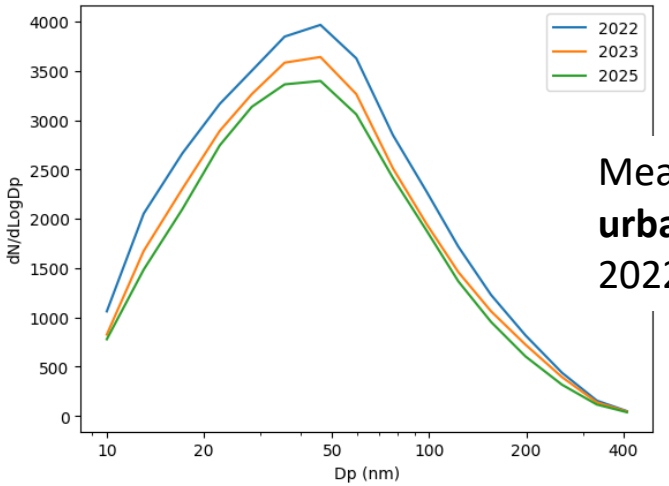
Particle number concentrations and size distributions in Stockholm, annual averages

PNC >4nm





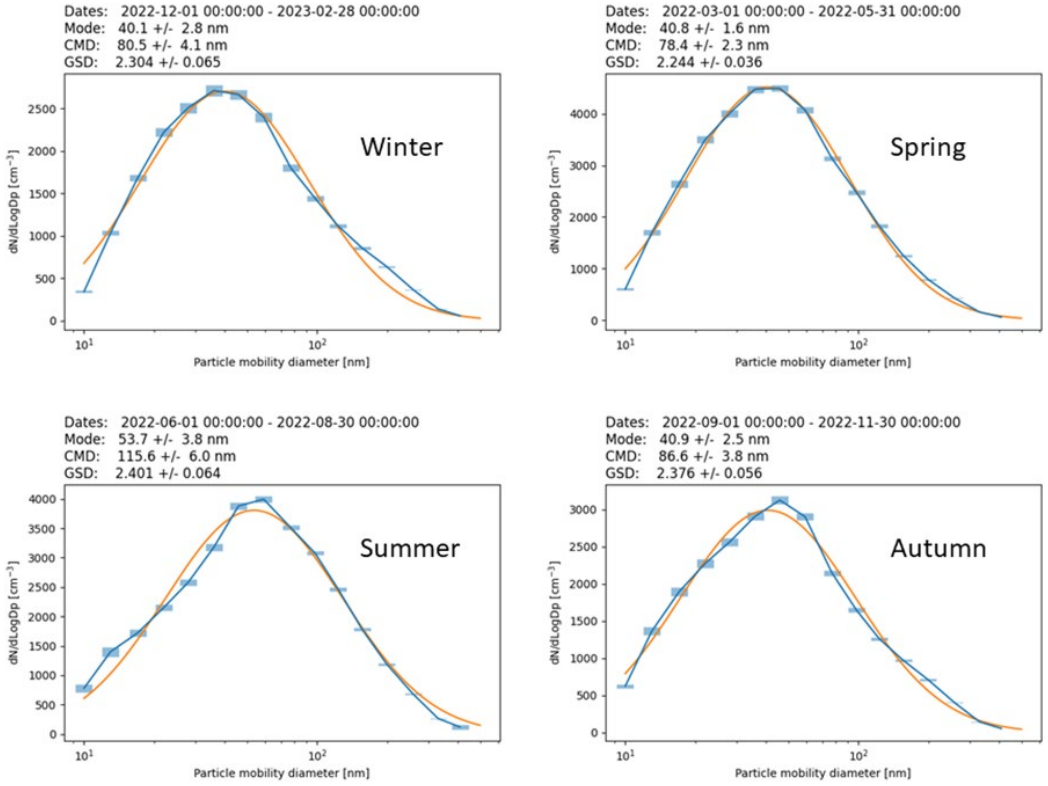
Krecl et al, Env. Poll. 2024: Fig. 3. a) Mean annual PNSD at the **street canyon** in the period 2011–2018.



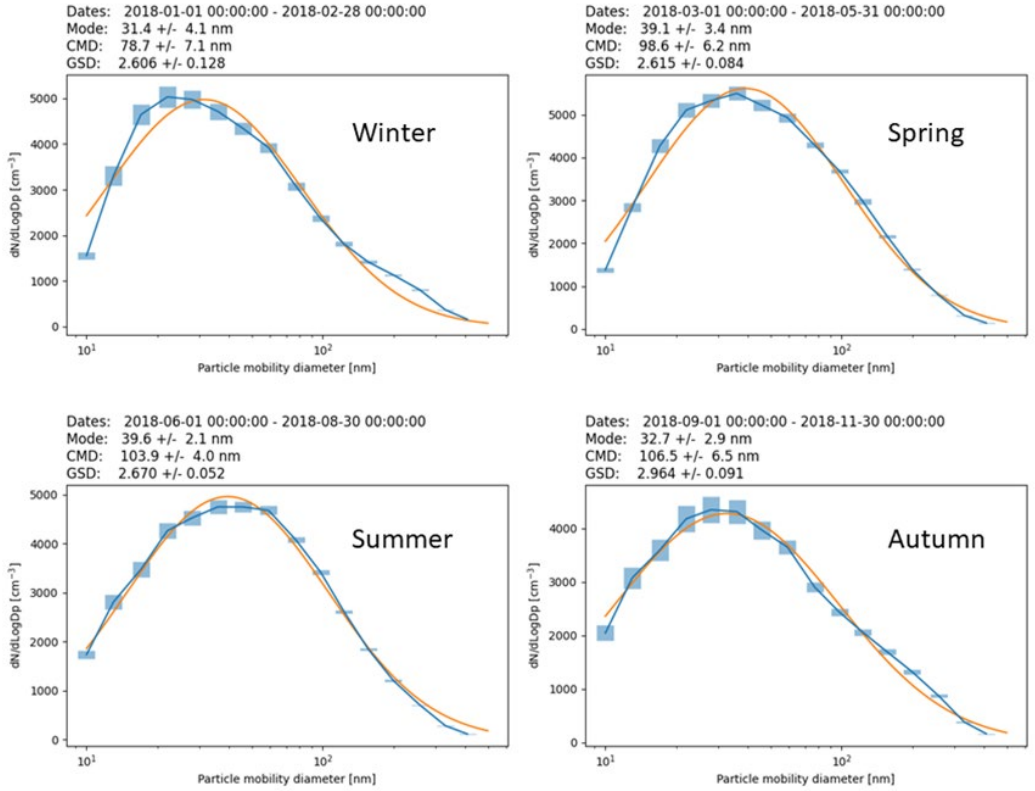
Mean annual PNSD in **urban background** for 2022, 2023, 2025.

Seasonal averages of PNSDs

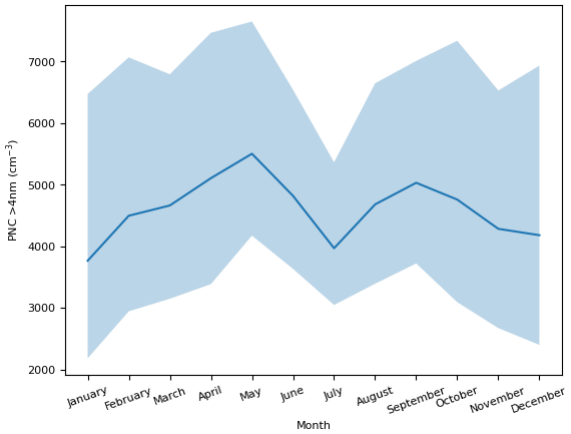
Urban background (TK) 2022/23

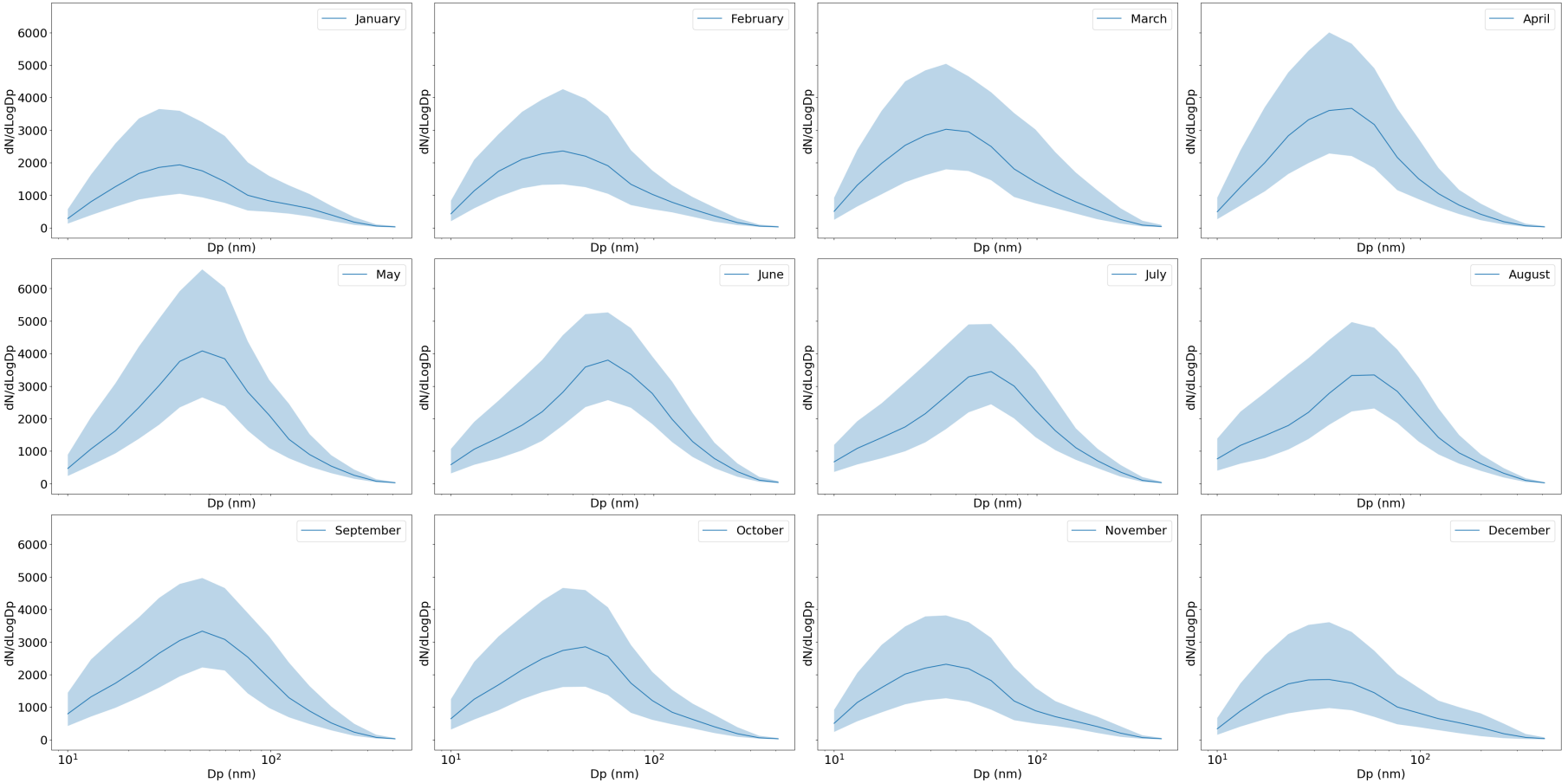


Street canyon (Hornsg) 2018

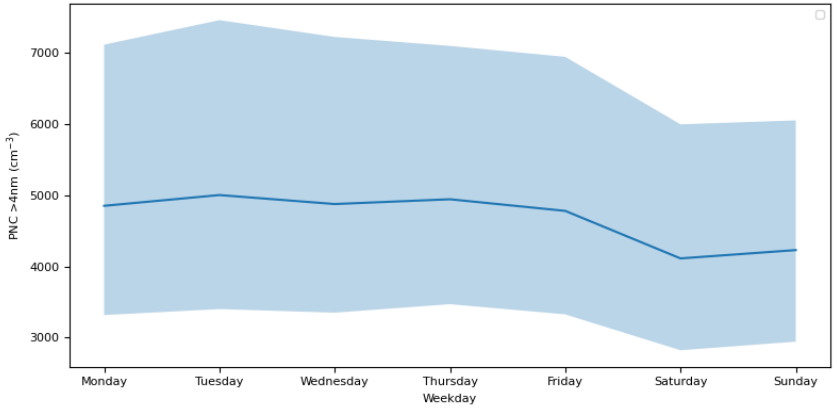


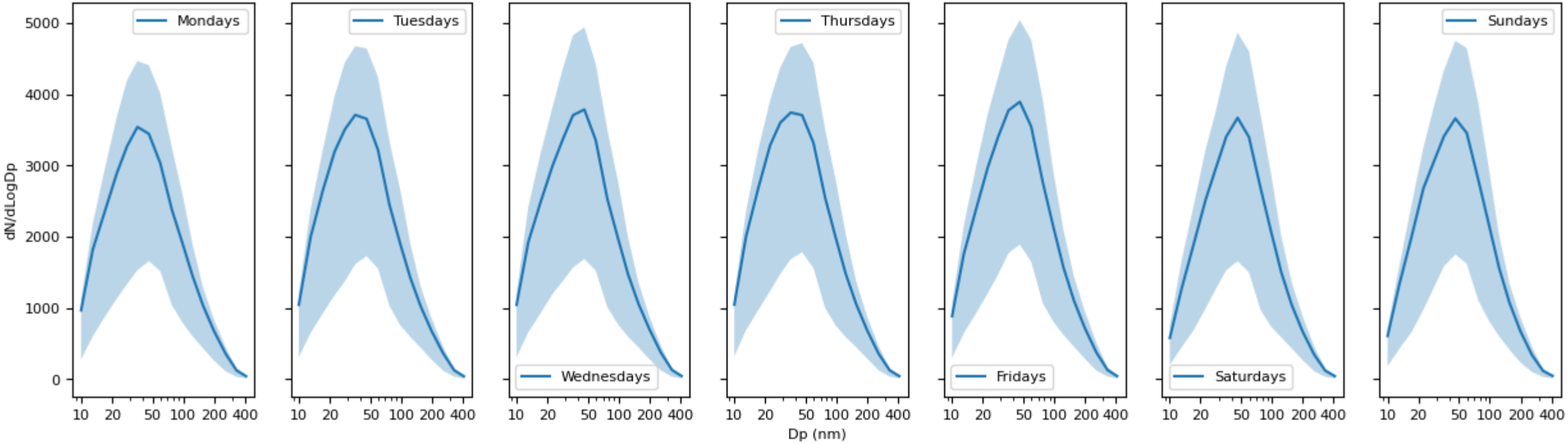
Monthly averages of PNCs and PNSDs



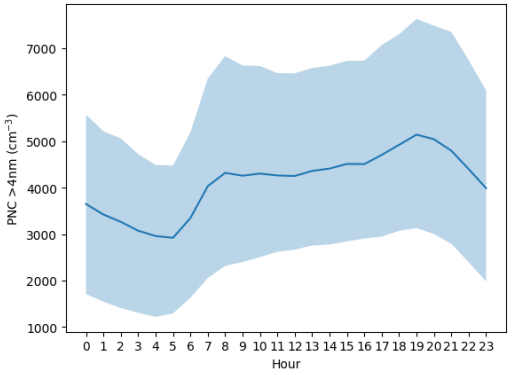


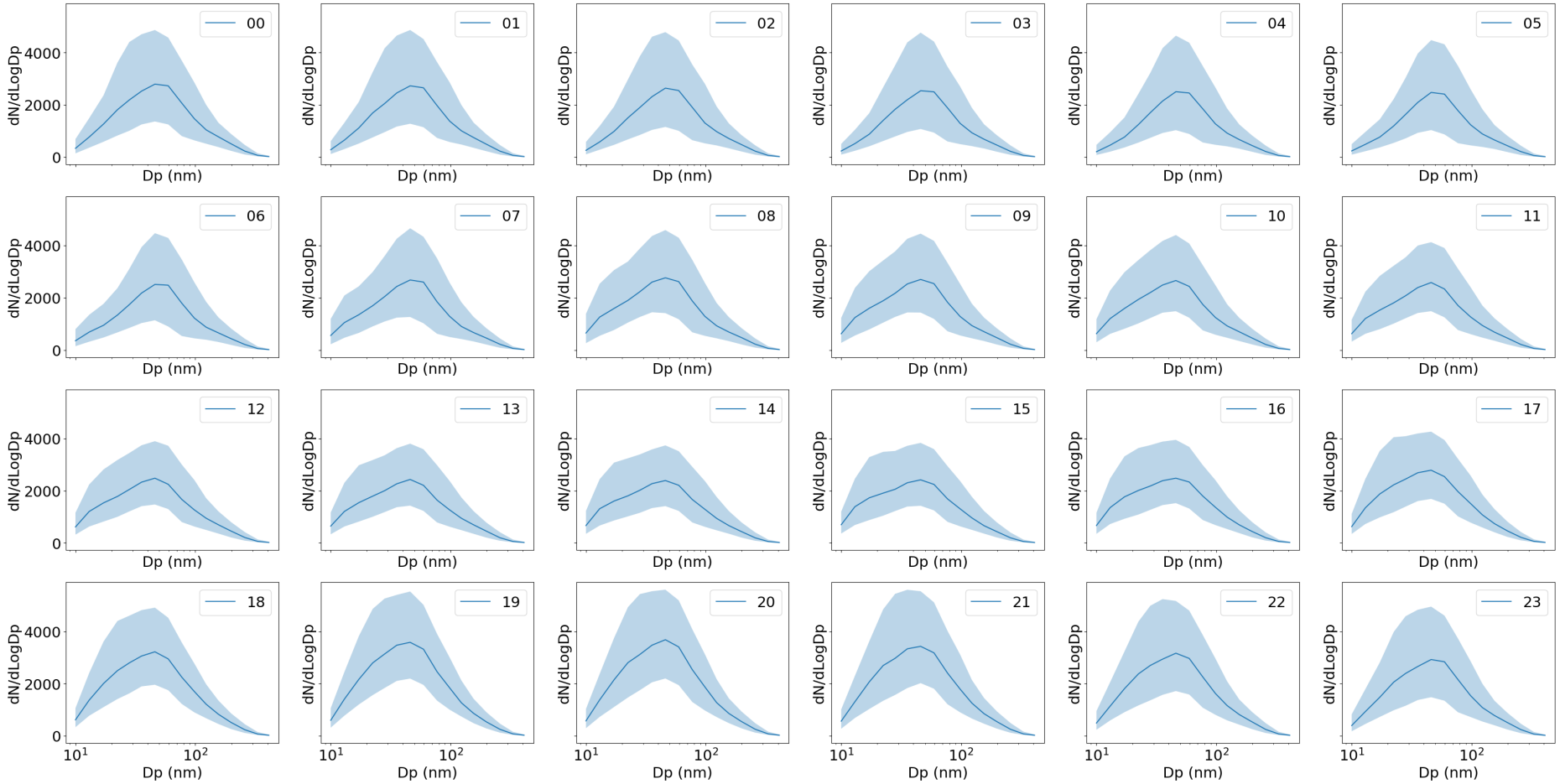
Weekday averages of PNCs and PNSDs





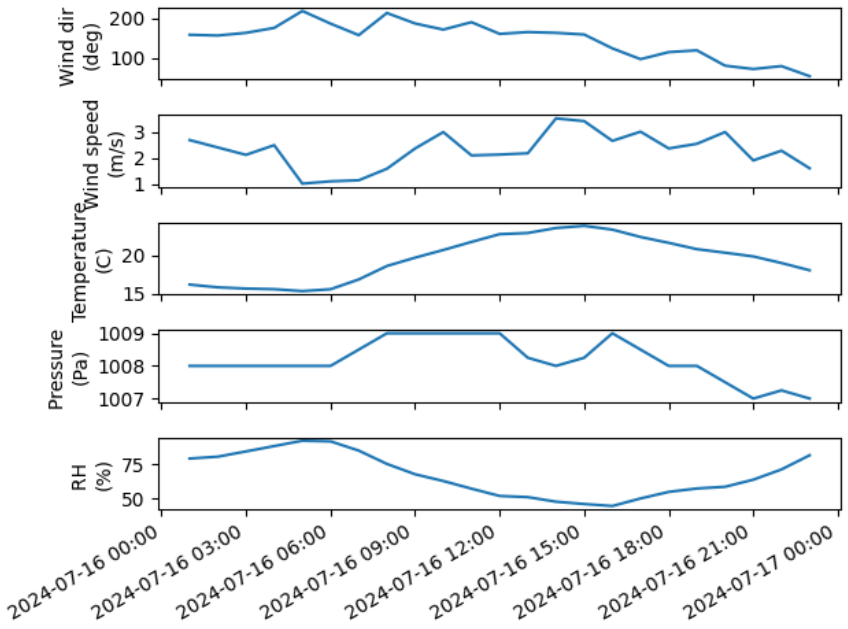
Hourly averages of PNCs and PNSDs

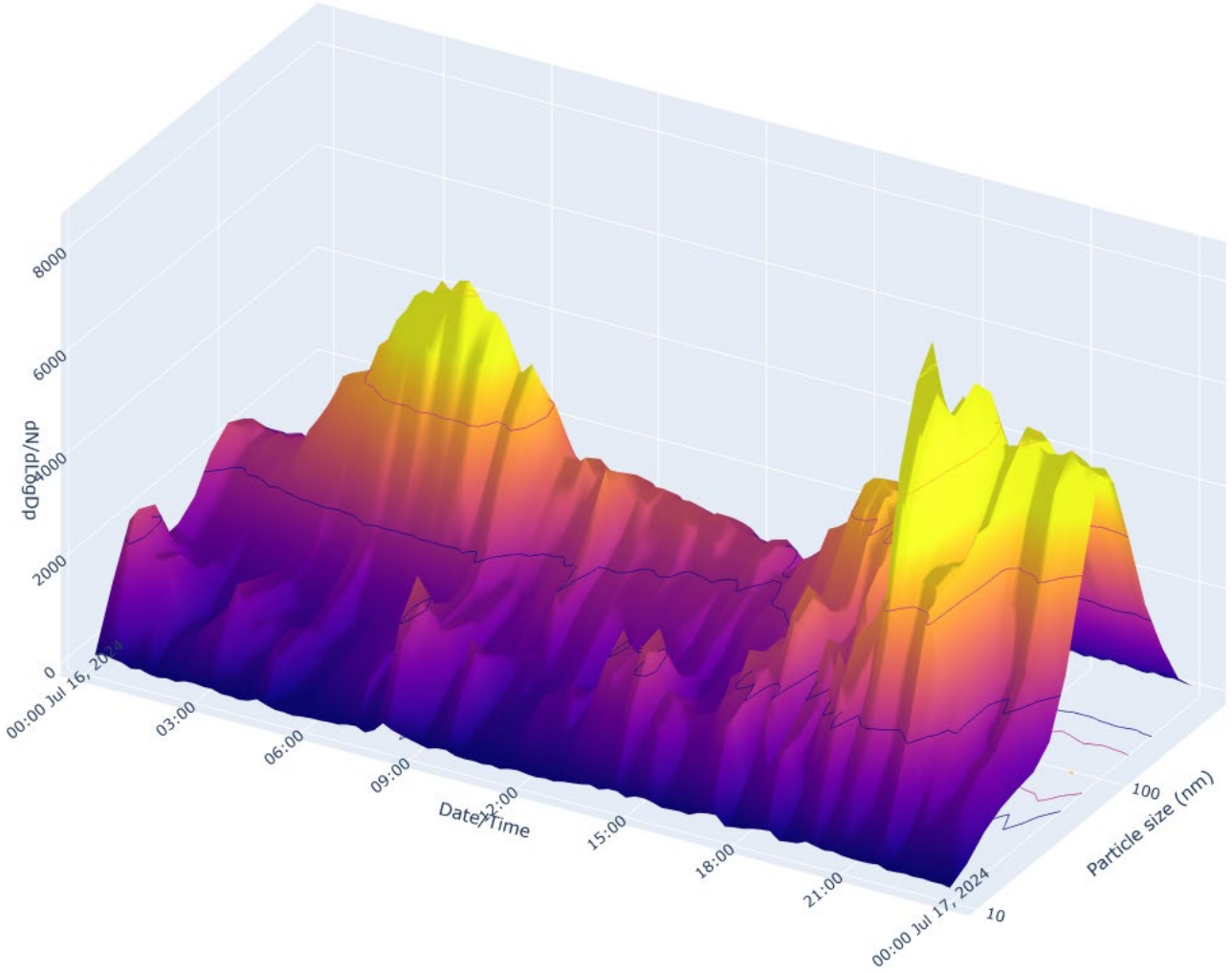




Dynamics: emissions + meteorology

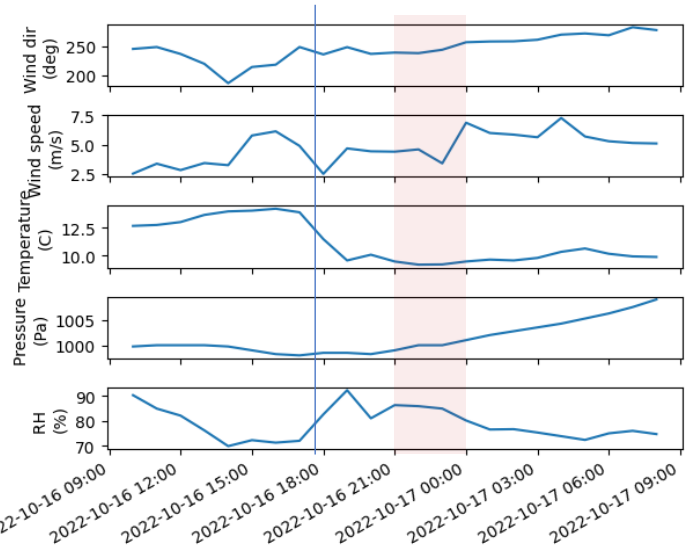
- Build-up of concentrations from exhaust in morning, shallow ABL
- Dilution due to increasing ABL height and mixing
- Afternoon rush hour adds emissions again, ABL height decreasing leading to high concentrations again



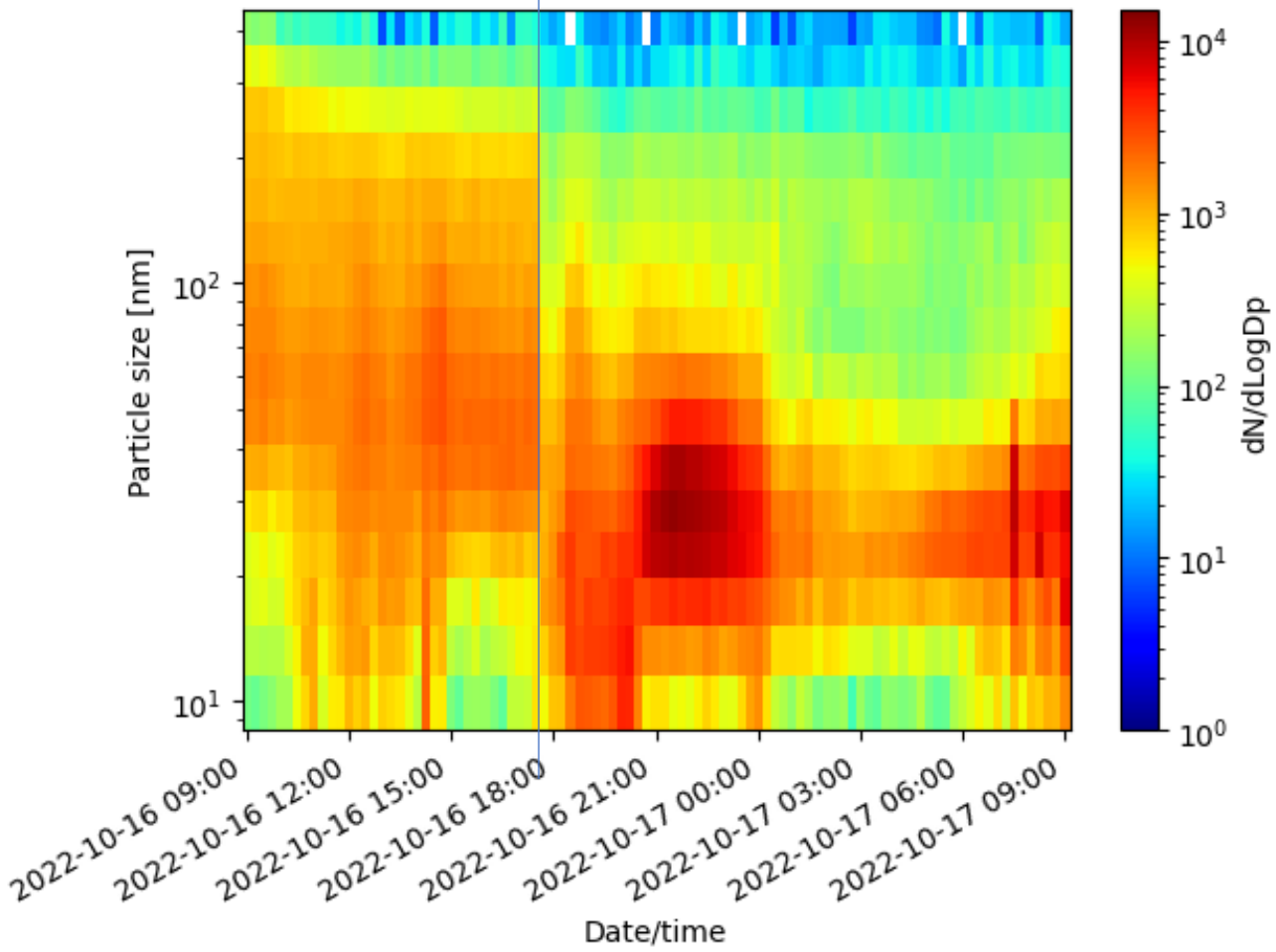


Example: Scavenging event

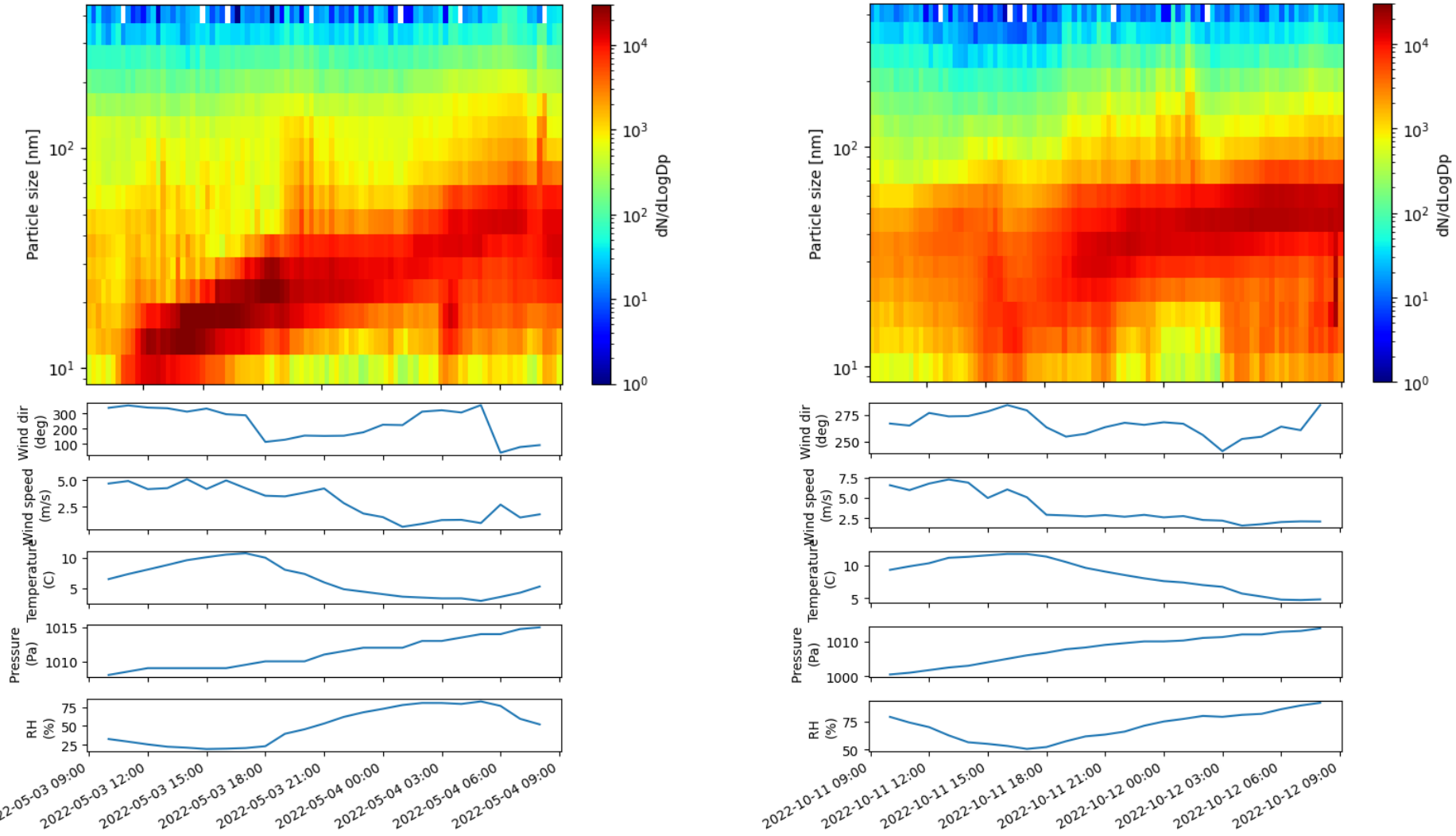
- Sharp change in PNSD coincides with short, heavy rain
- Does the particle 'burst' have anything to do with the rain?



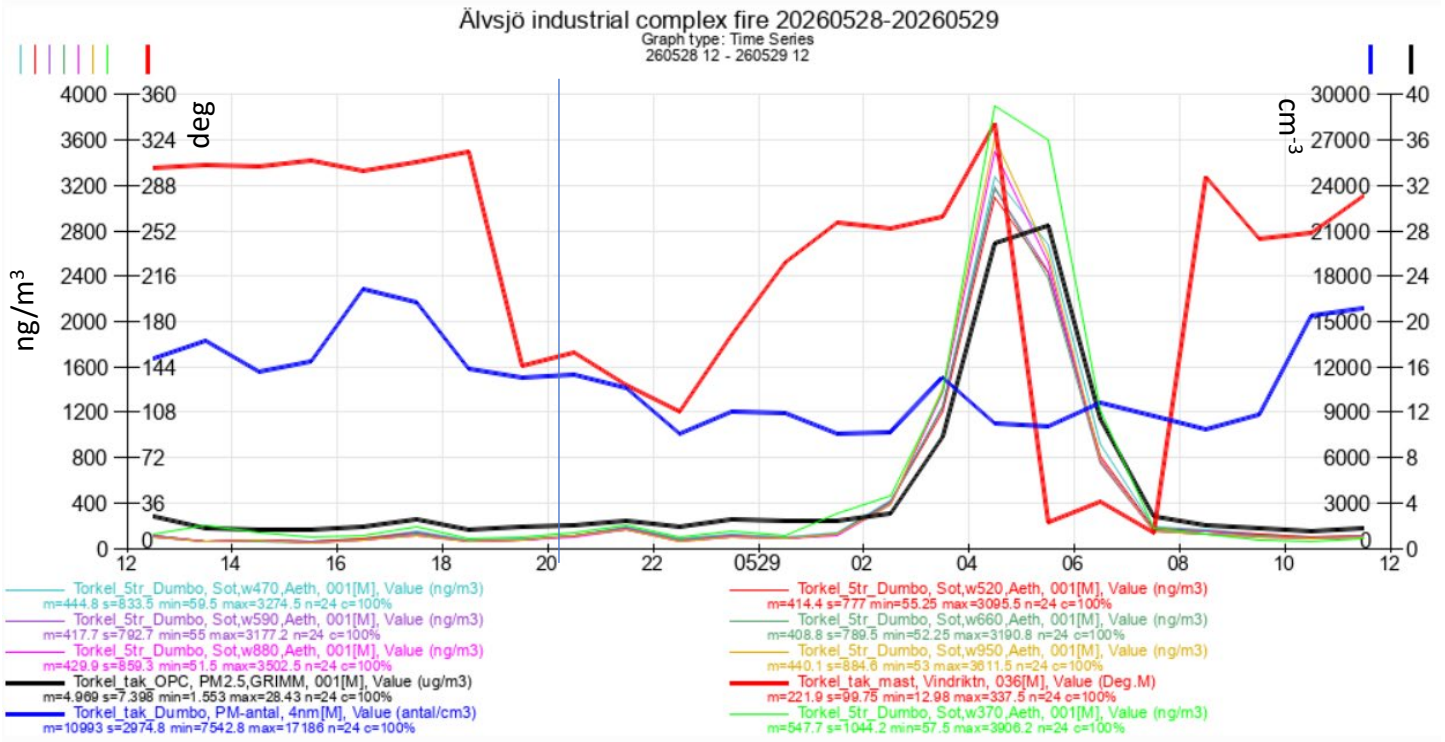
Precipitation intensity ~2.6 mm/h

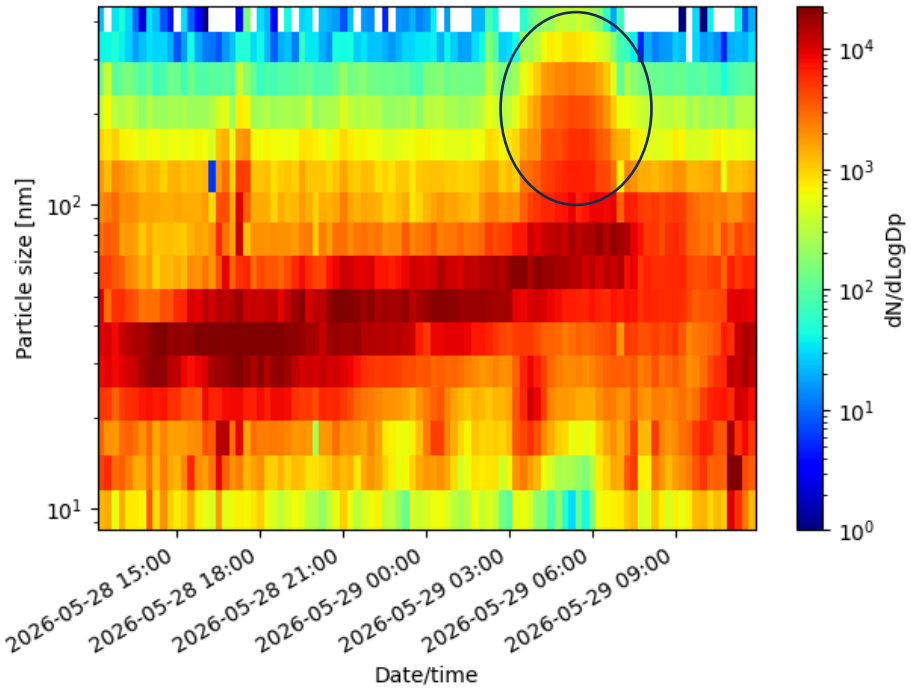


Example: Particle growth events in urban background



Example: Fire in industrial area in southern Stockholm





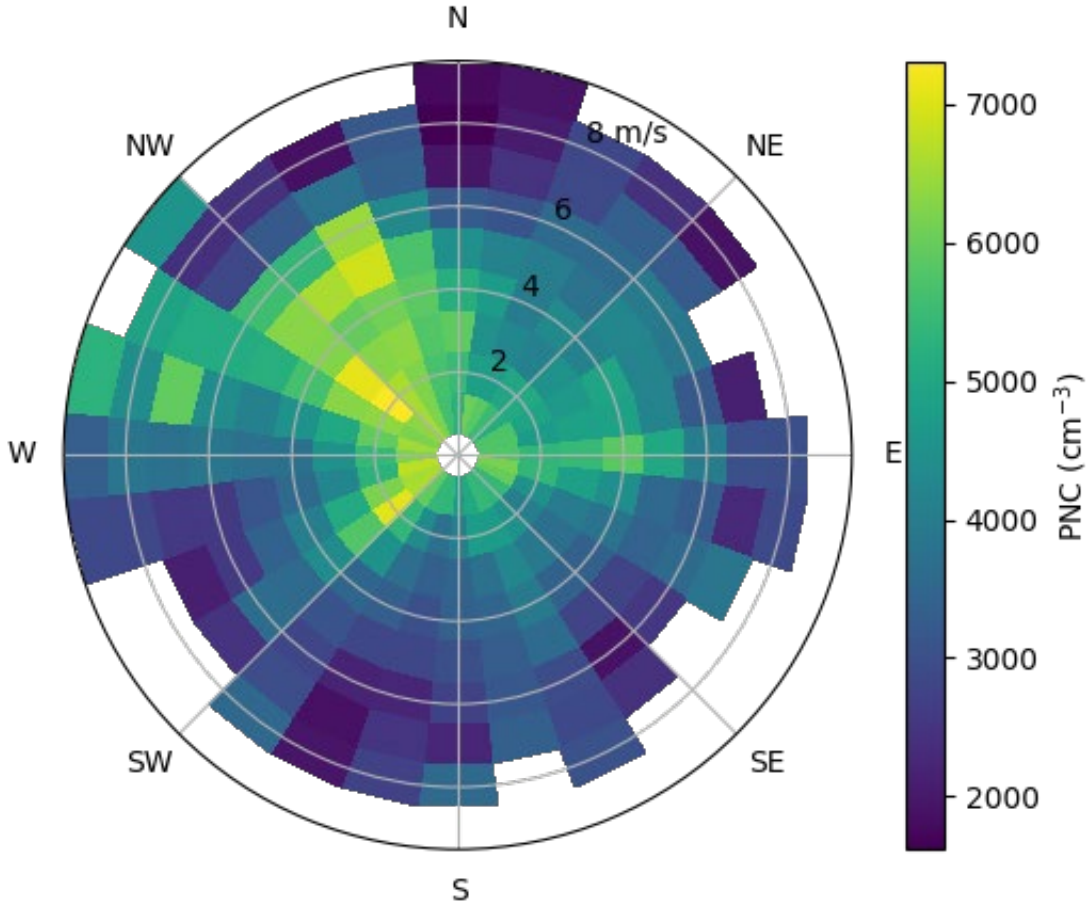
Particles from the fire were contributing to BC and PM2.5 but PNC was uneffected?!

PNC ”footprint” of Stockholm

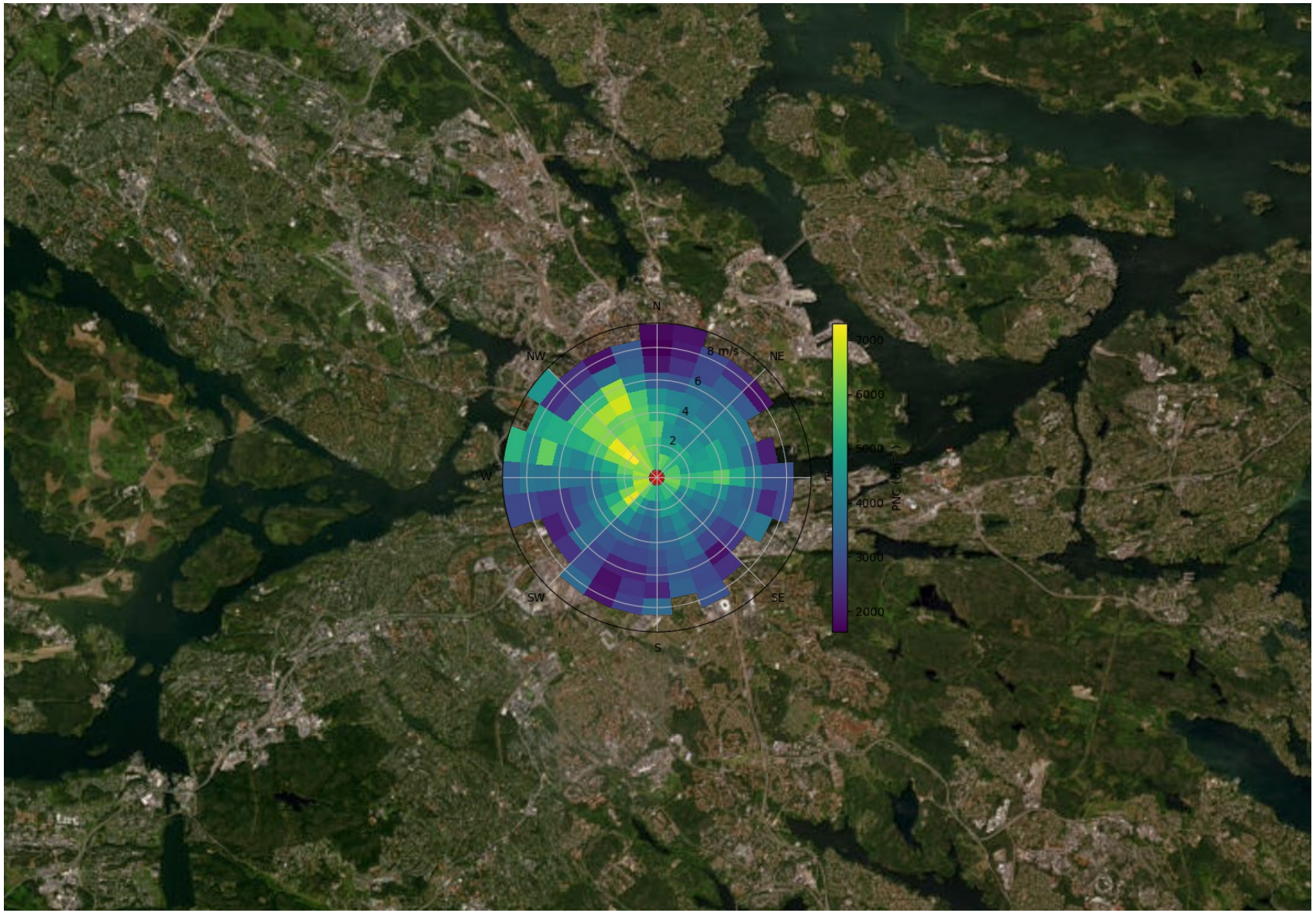
Meteorology is important!

Let’s take a look at PNC for different wind conditions.

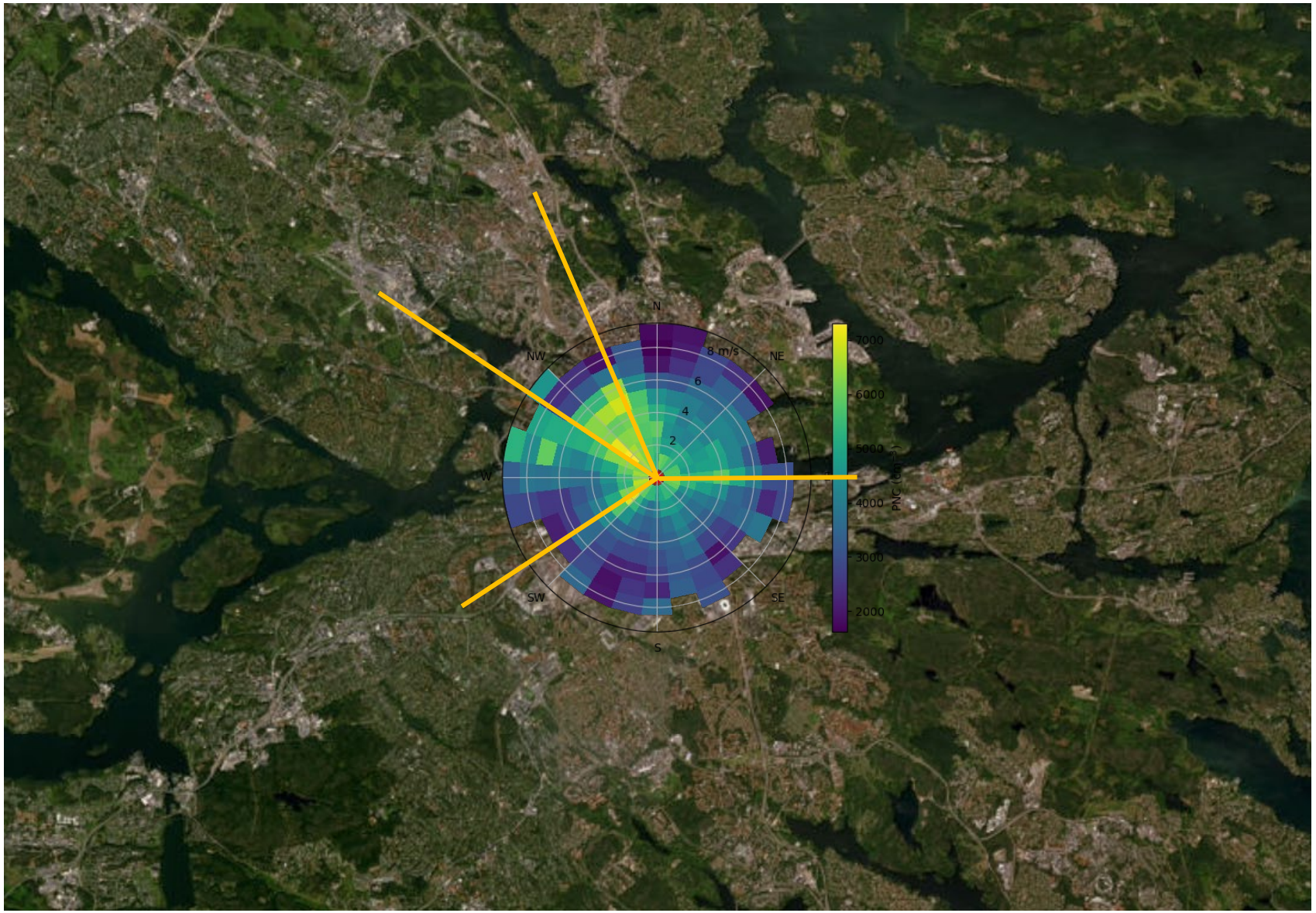
CPC (> 4nm)



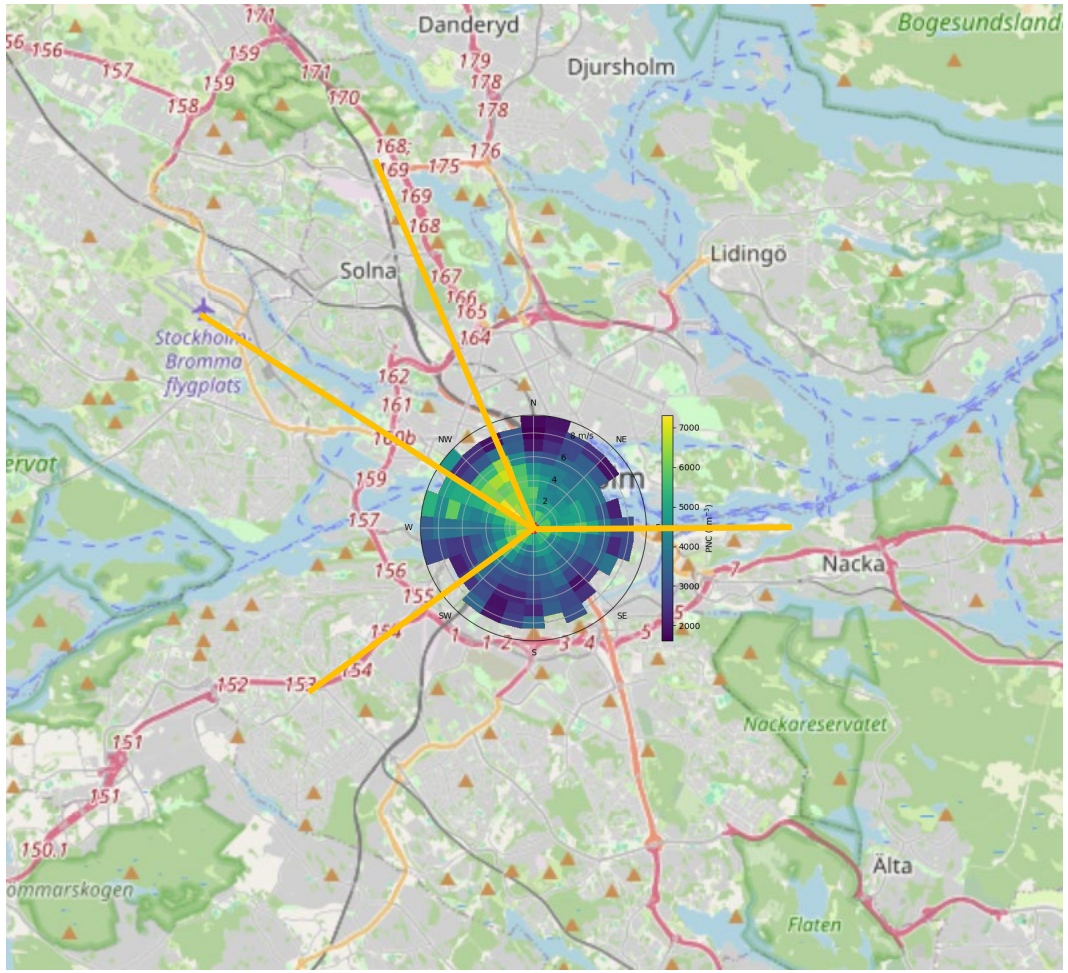
PNC ”footprint” of Stockholm

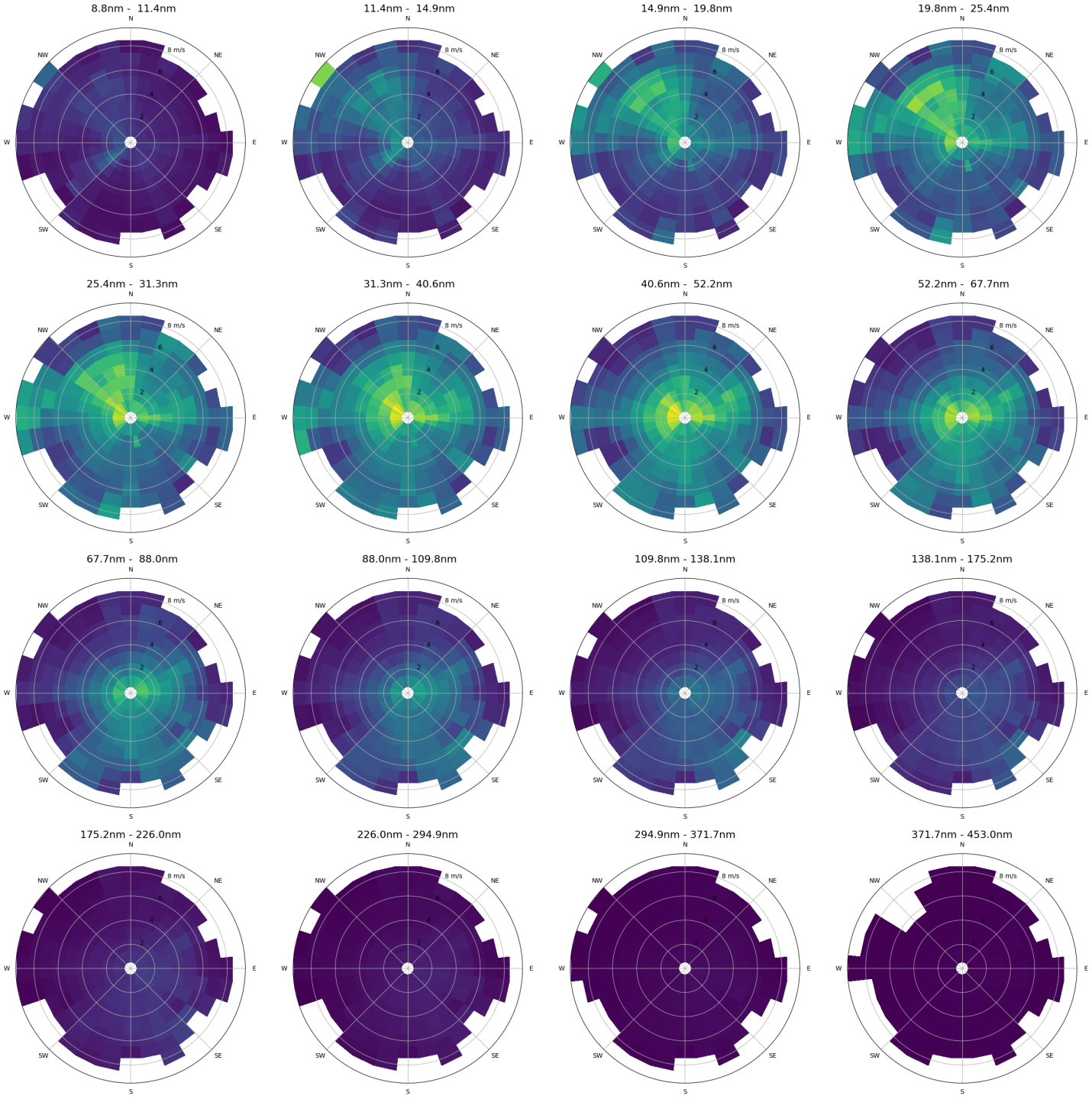


PNC ”footprint” of Stockholm

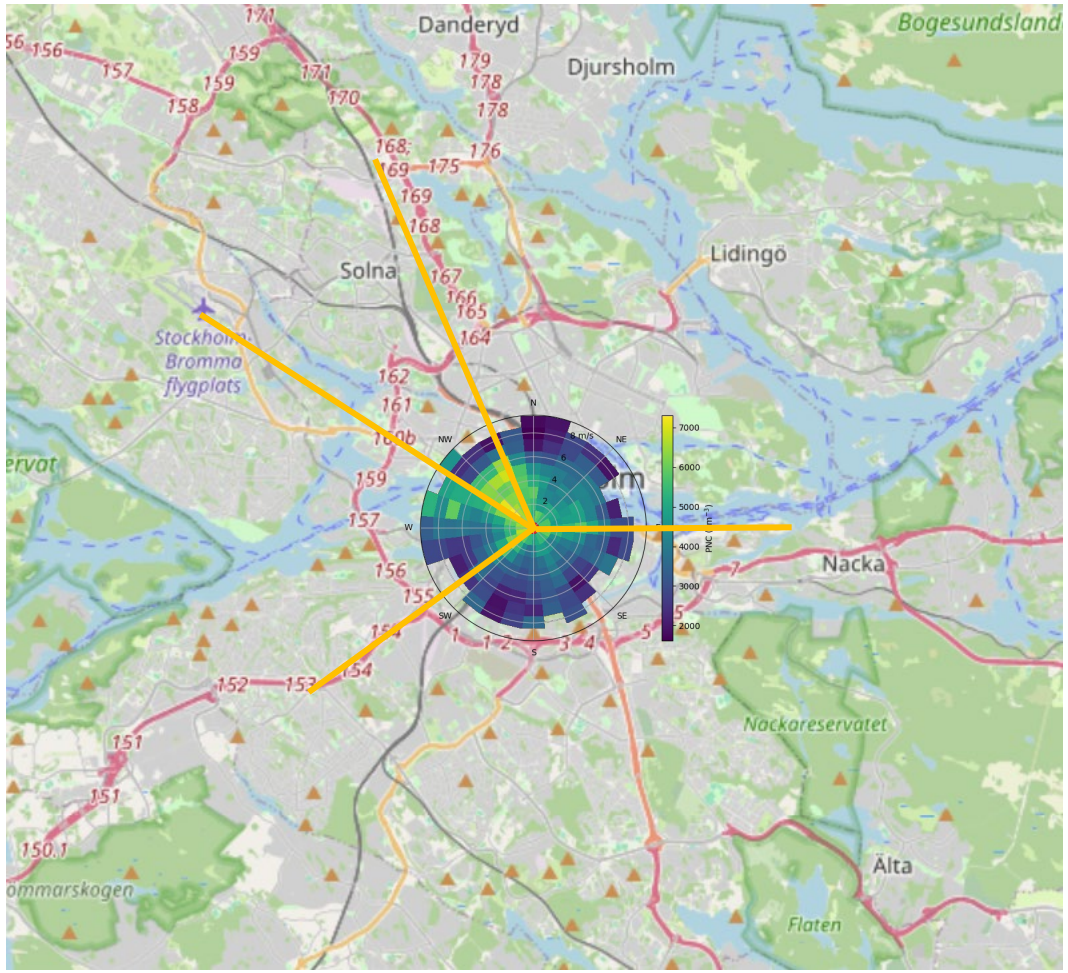


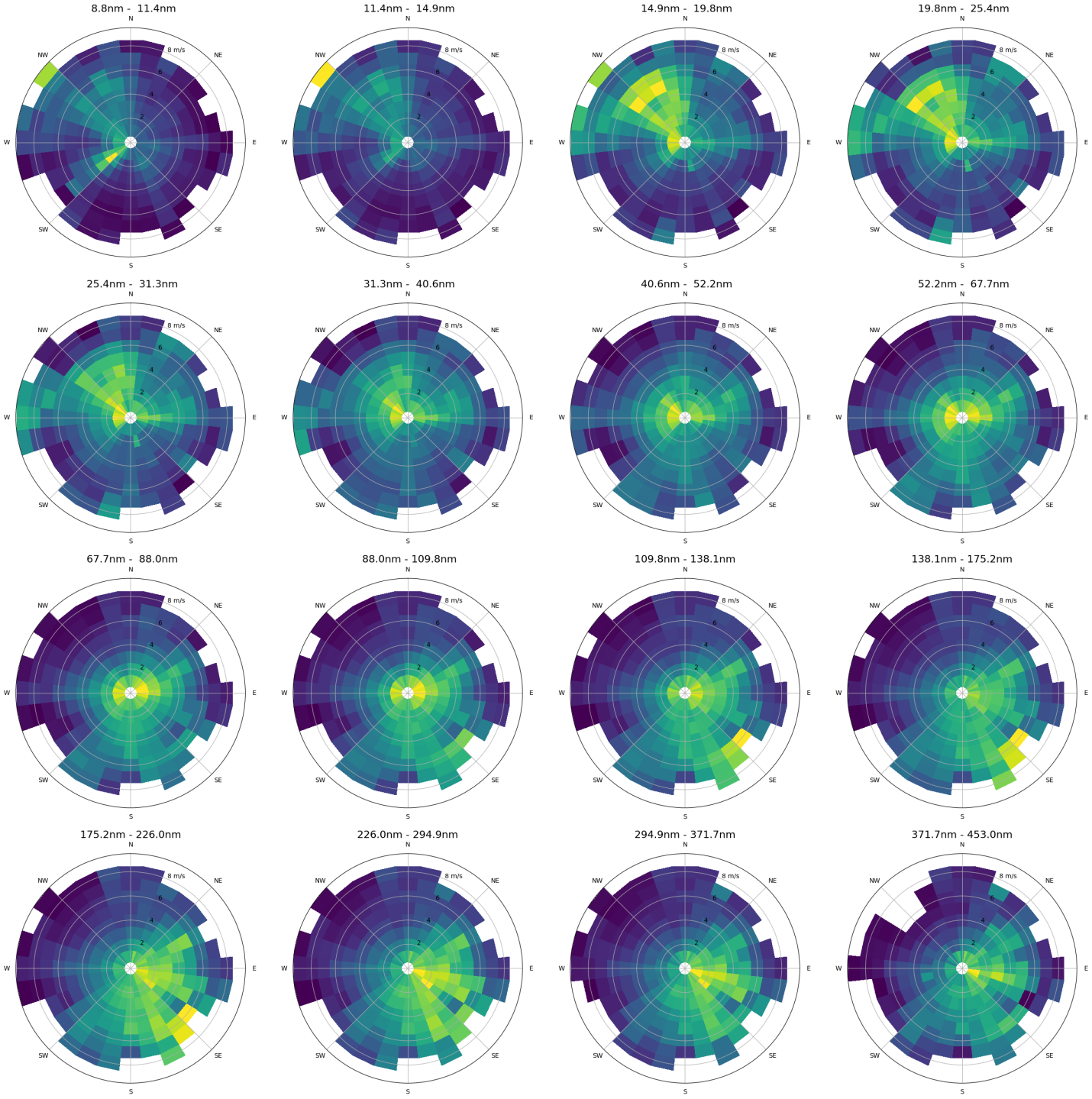
PNSD ”footprint” of Sthlm





PNSD ”footprint” of Sthlm

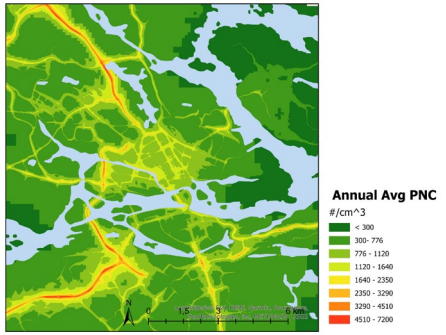


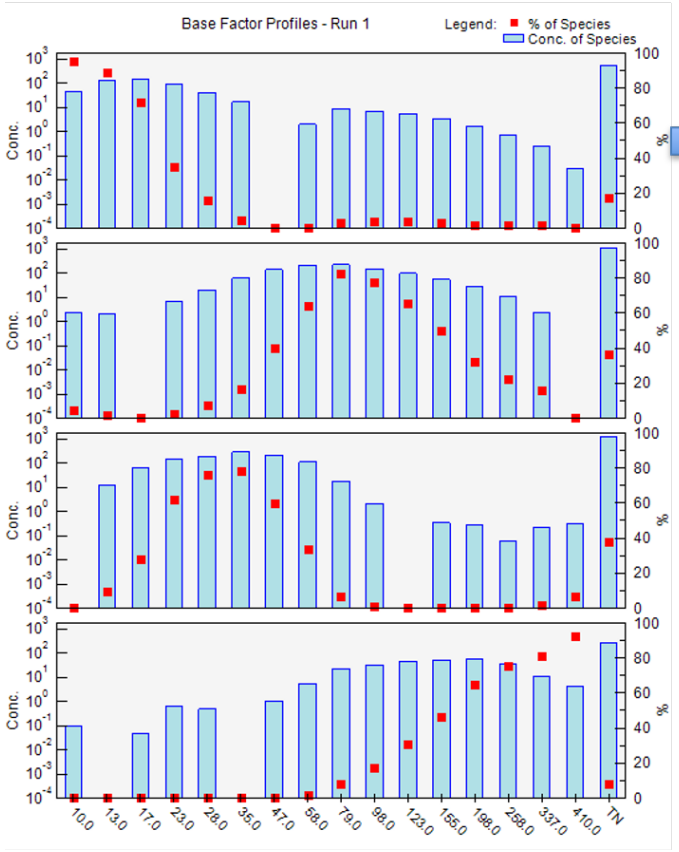


Source apportionment: PMF and dispersion simulations

Revisit Positive Matrix Factorization (PMF) source apportionment for Stockholm by Fulvio Amato (CSIC), nPETS

nPETS
nanoParticle Emissions from the Transport Sector



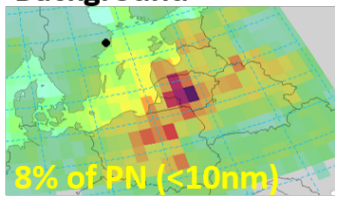


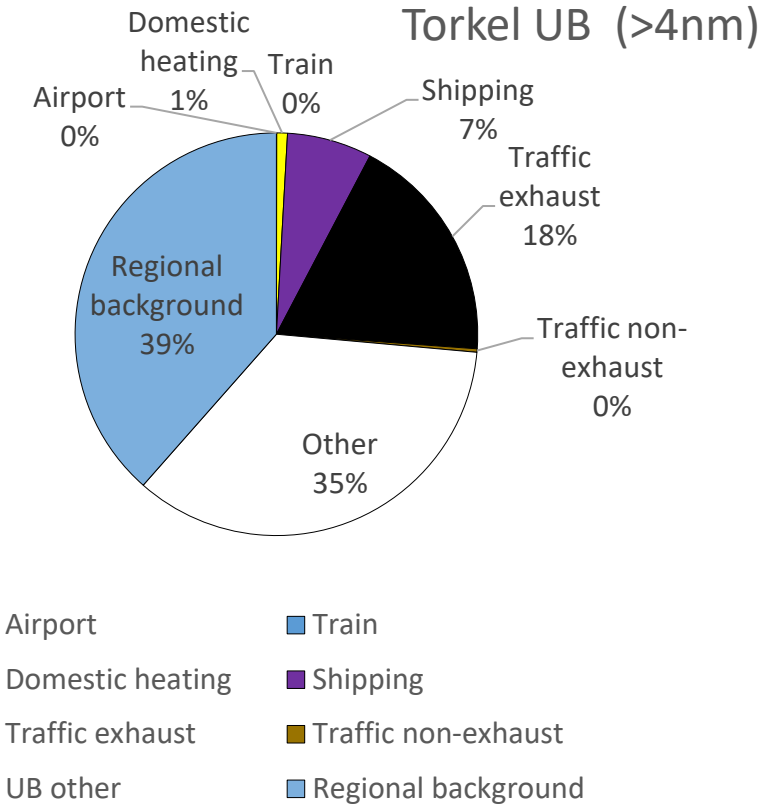
Aviation

Shipping

Road traffic

Background





Conclusions

- Observe clear long-term trends for PNCs and PNSDs in Stockholm
- Rich dynamics in PNC and PNSD in urban environment due to different sources and interplay with meteorology

Further work:

- Revisit Positive Matrix Factorization (PMF) source apportionment analysis by Fulvio Amato done within nPETS
- Revisit Gaussian dispersion modeling for PNC and improve
- Second (mobile?) PNSD measurement in Stockholm

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