Ultrafine particle exposure from individual aircrafts approaching Innsbruck airport

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Project
ATEMLUFT

UFP exposure of students during their way to and from schools

BORG
Mittersill

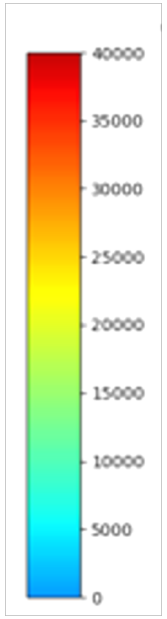
rural

Mittersill

Gymnasium Ursulinen
Innsbruck

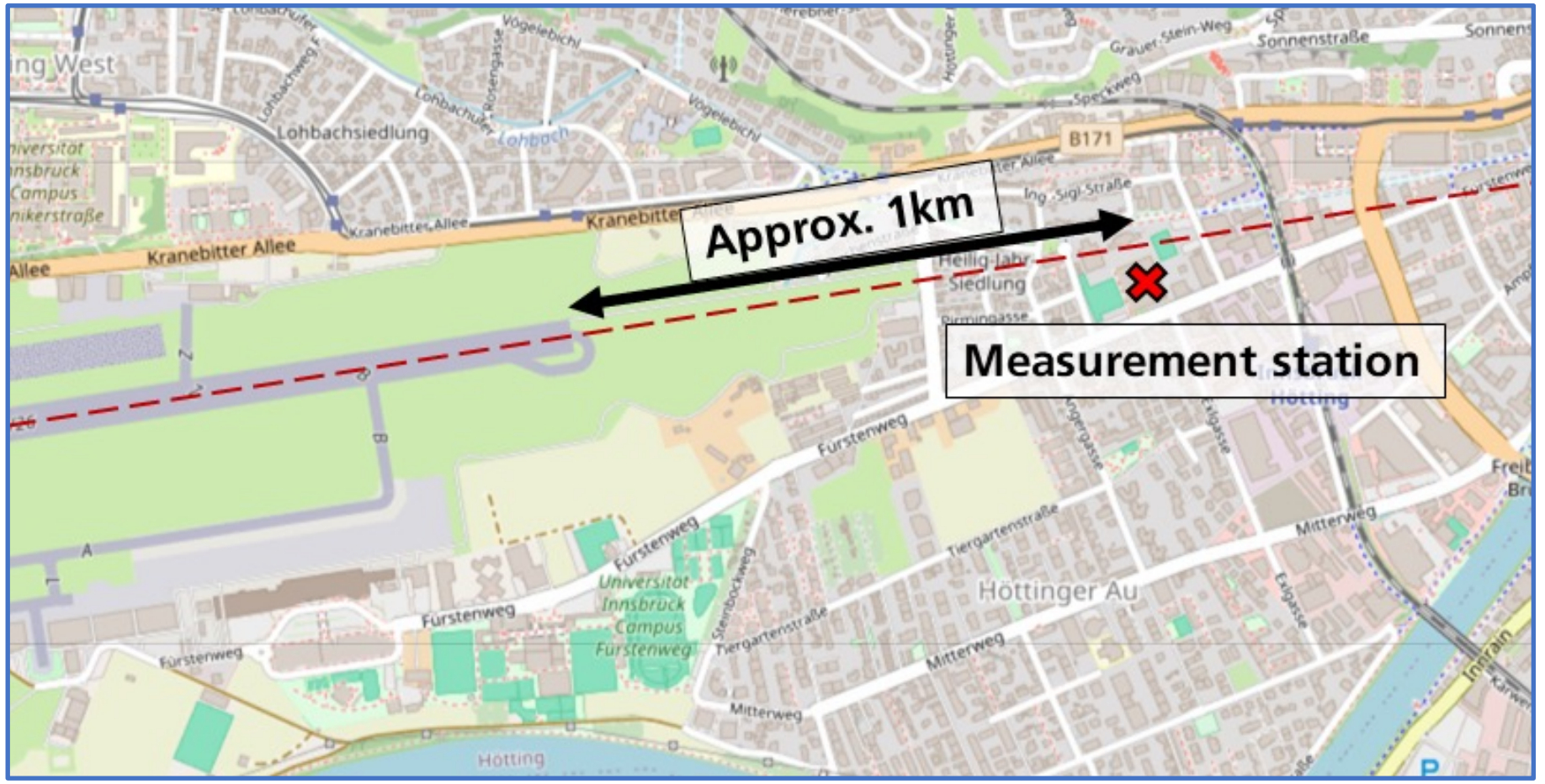
urban

Innsbruck



PNC
cm^{-3}

Location of the measurement station at the roof of the school building



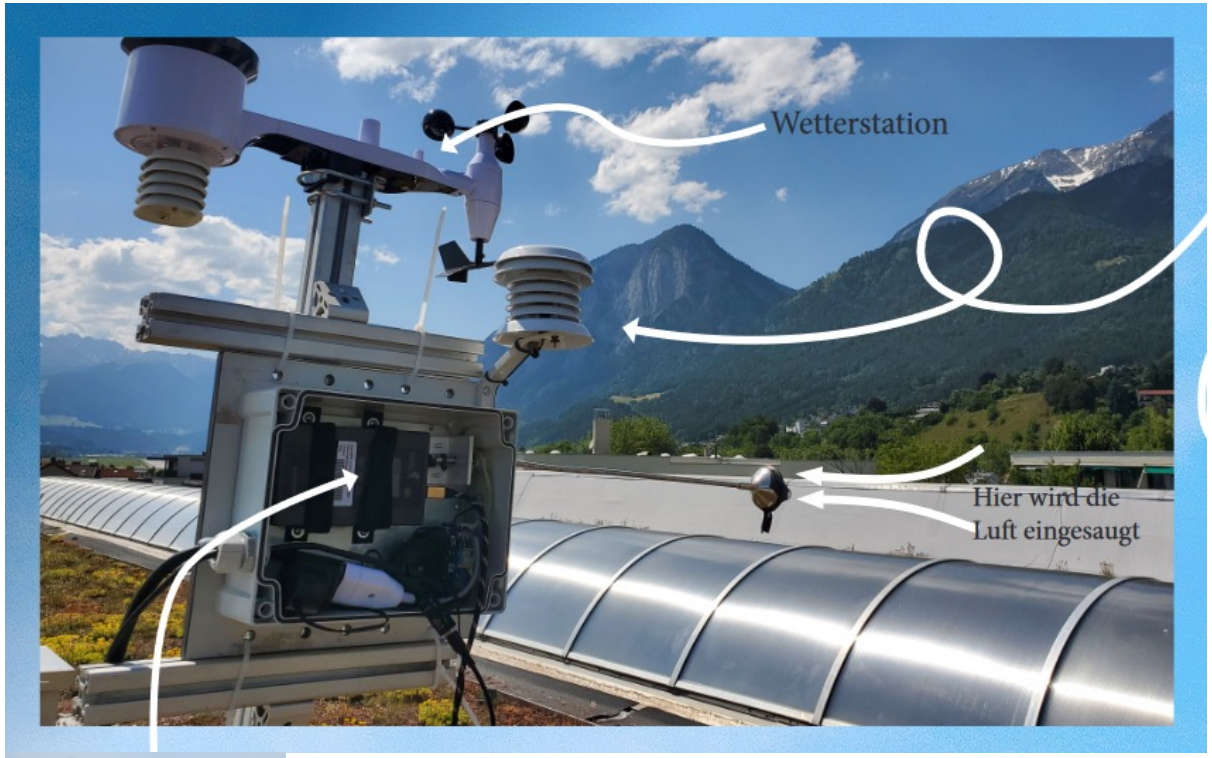
Measurement station at the roof of the school

Instruments

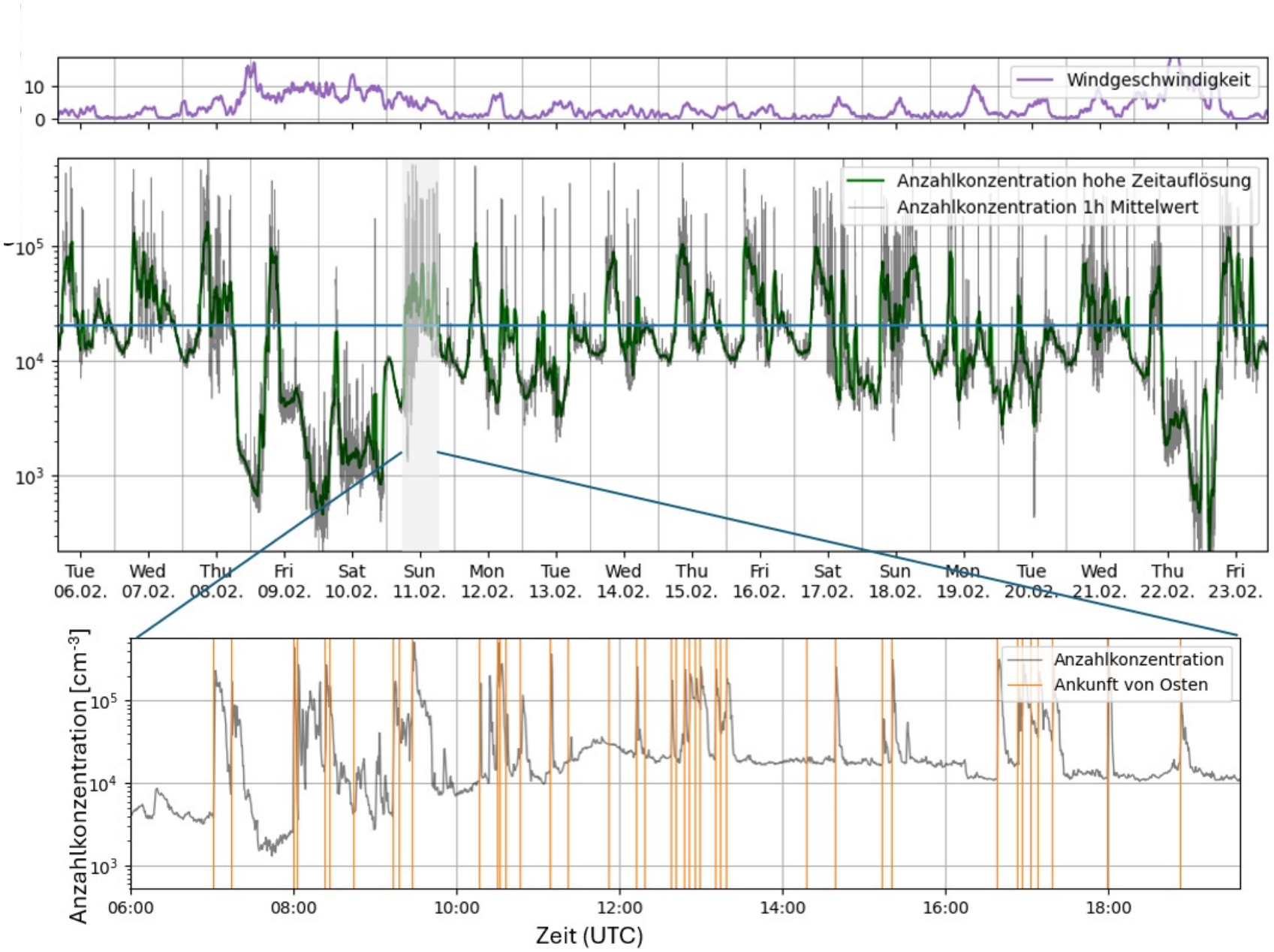
- Weather station

- Partector2 Naneos — PNC every 1s
- Partector2 Pro Naneos — PNC every 4 s
- LI-850 LI-COR — CO_2 every 1s
- Microphone — Volume < 1s

Individual aircraft data from Flightaware

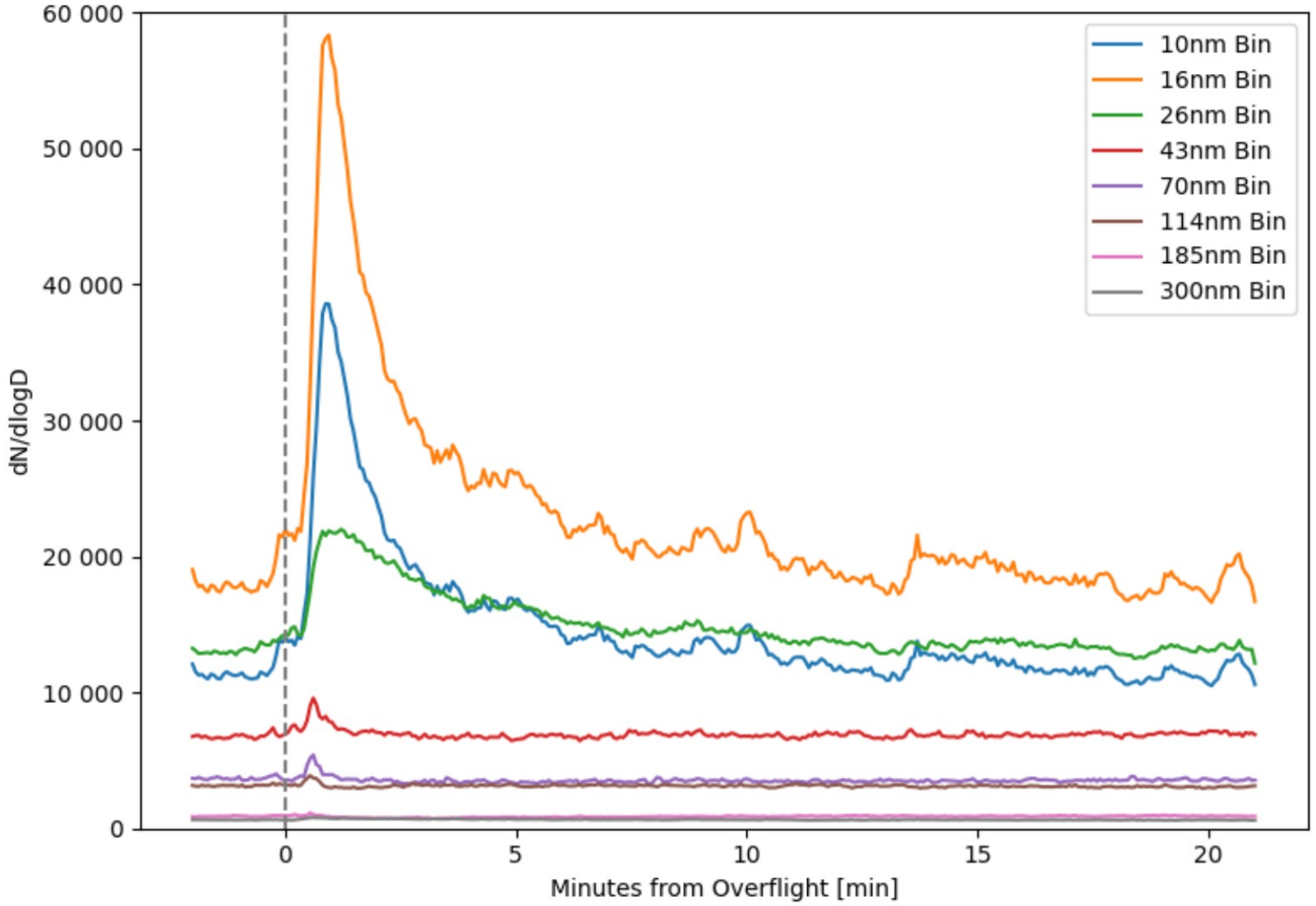


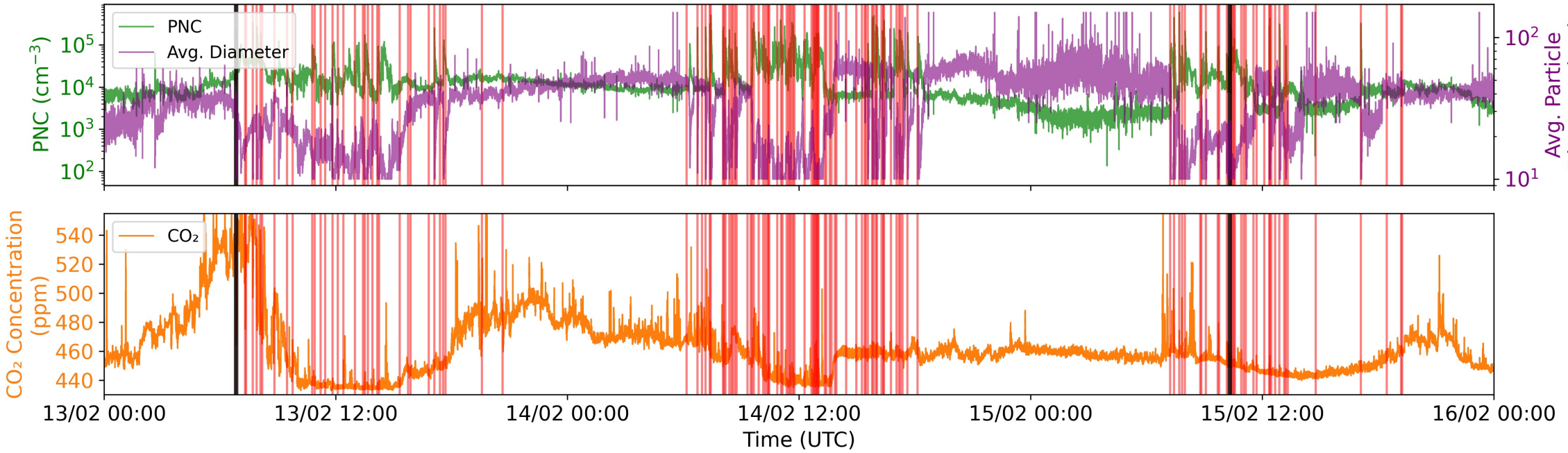
UFP exposure during Feb. 2024 at the roof of the school

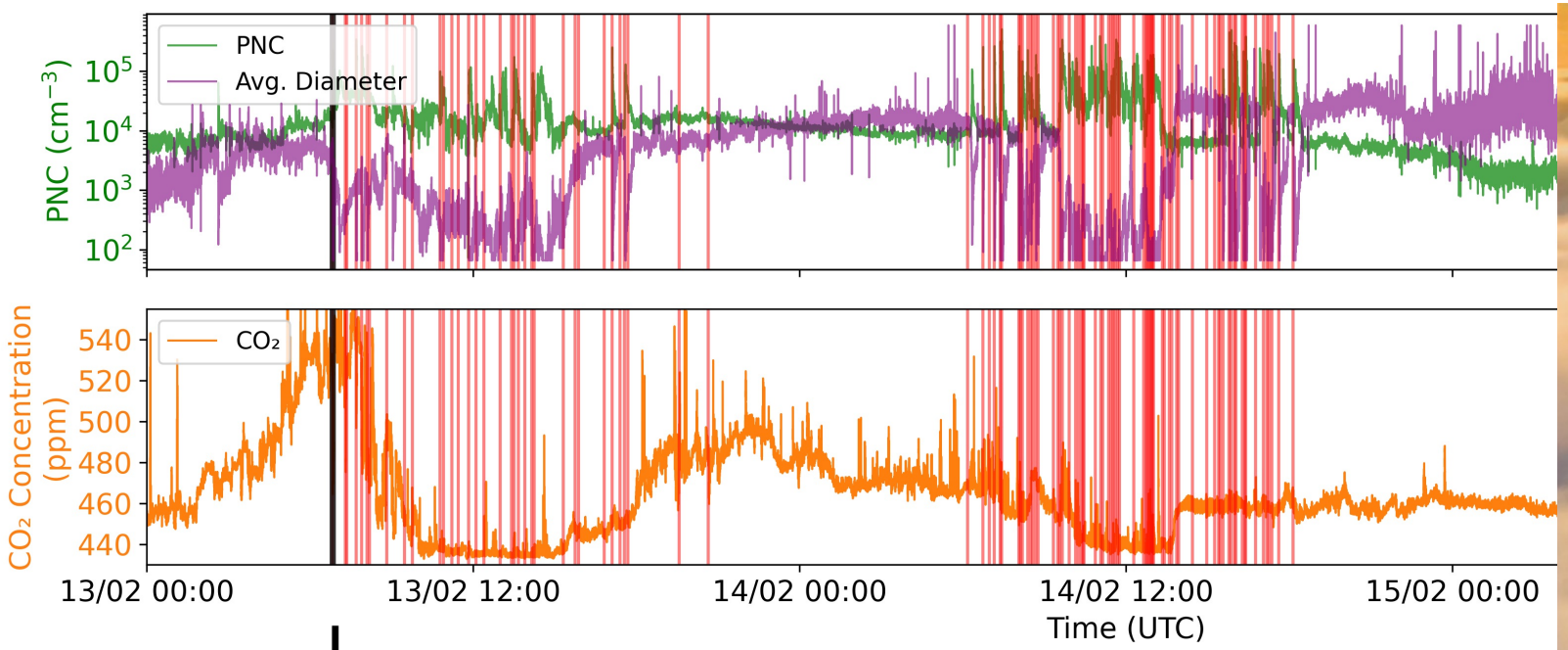


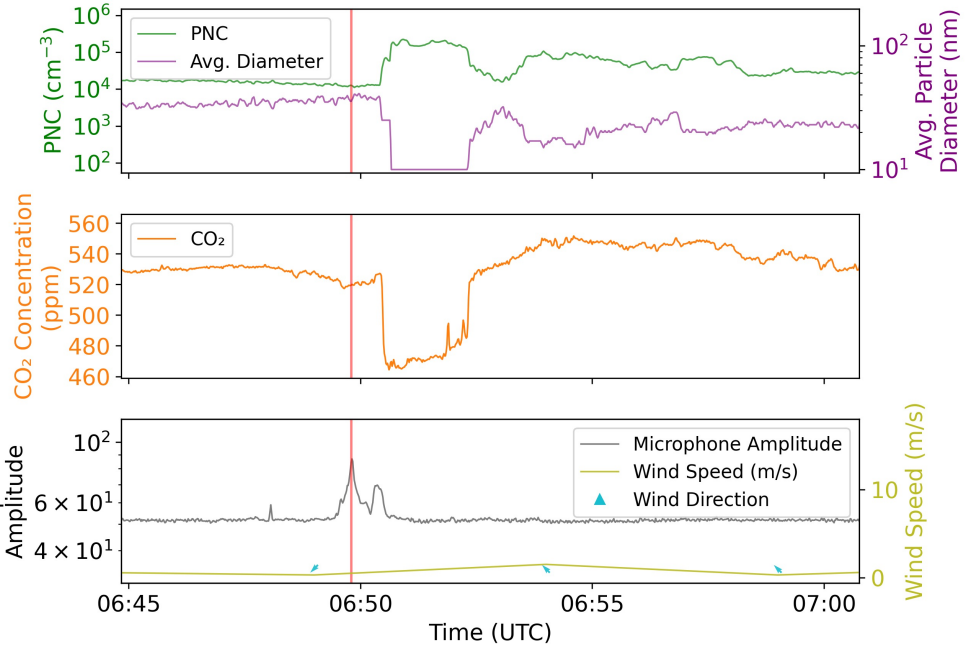
UFP “high” WHO

Size resolved PNC of 304 arriving aircrafts during March 2025

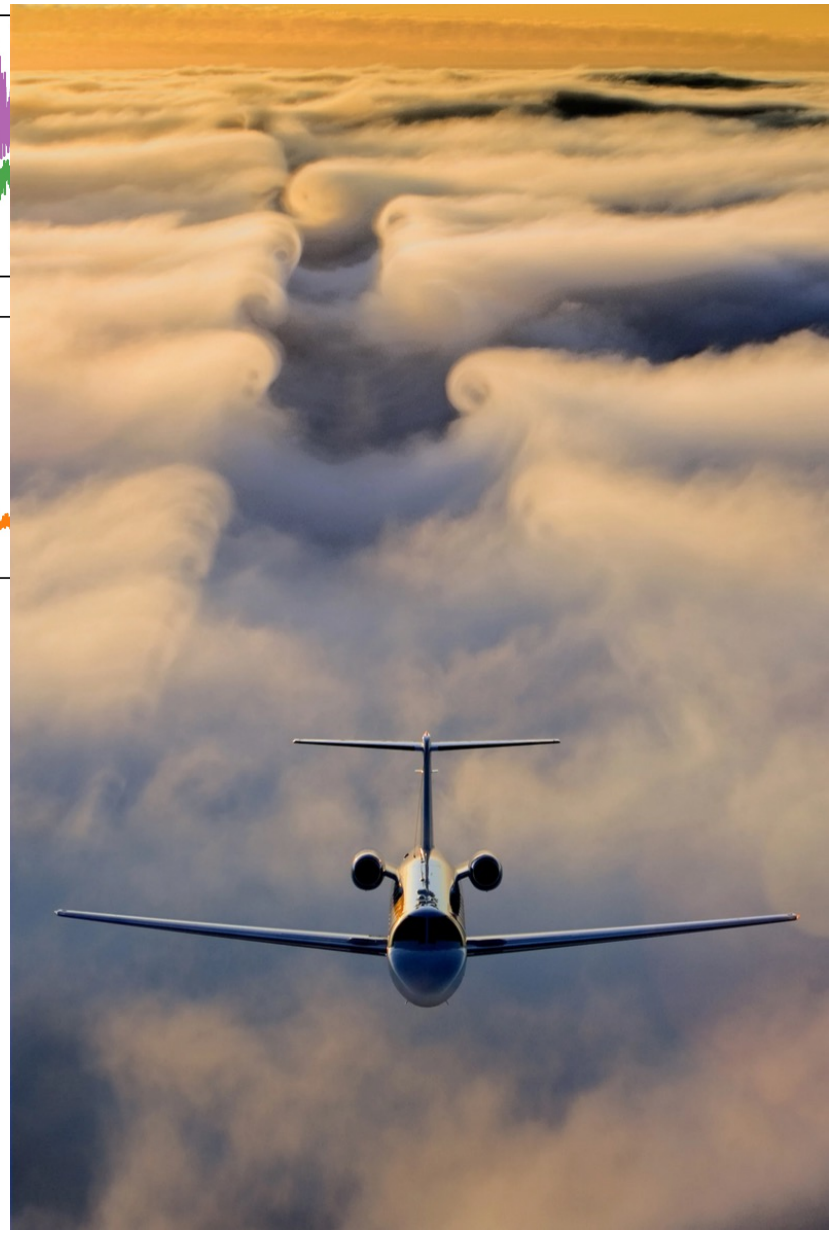



PNC
Avg. Diameter
PNC (cm^{-3})
10^5
10^4
10^3
10^2
10^2
10^1
Avg. Particle Diameter (nm)
CO_2
CO_2 Concentration (ppm)
540
520
500
480
460
440
13/02 00:00
13/02 12:00
14/02 00:00
14/02 12:00
15/02 00:00
15/02 12:00
16/02 00:00
Time (UTC)

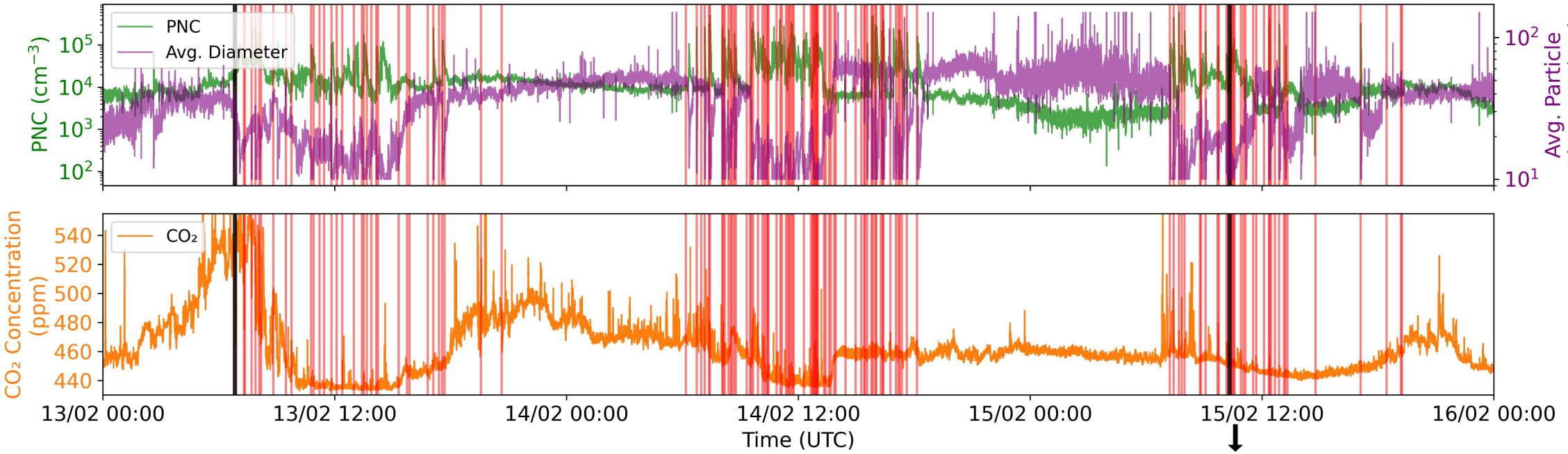




A plane „parting clouds“ with its **wingtip vortices**

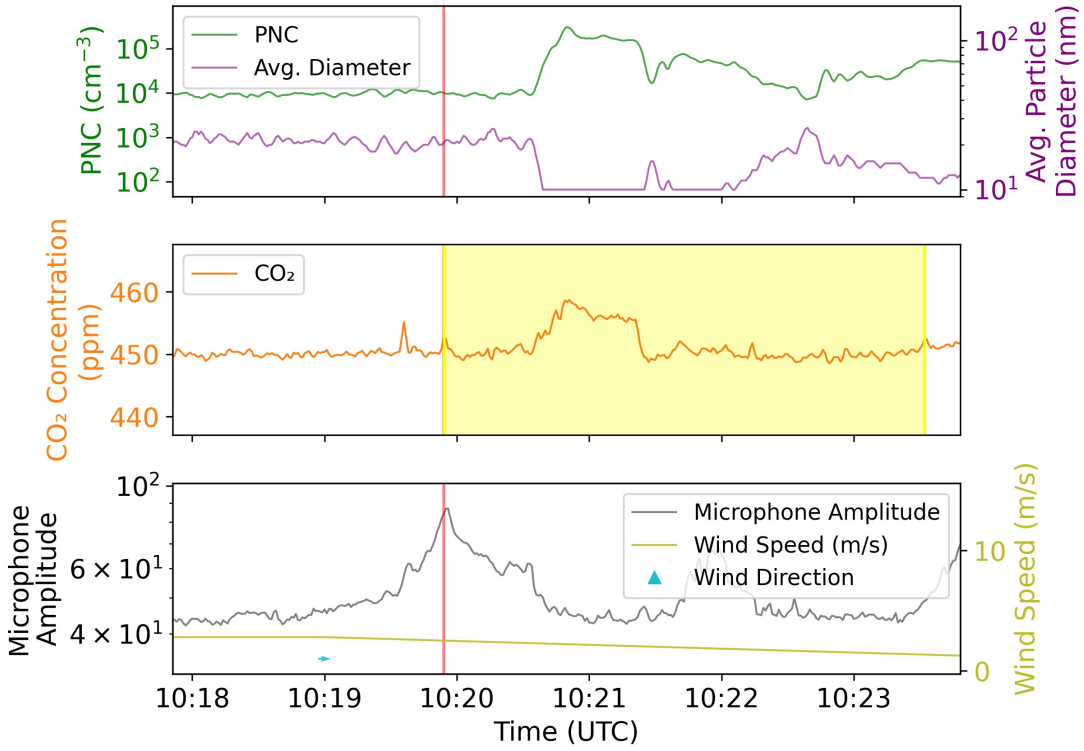


Paul Bowen / Courtesy photo



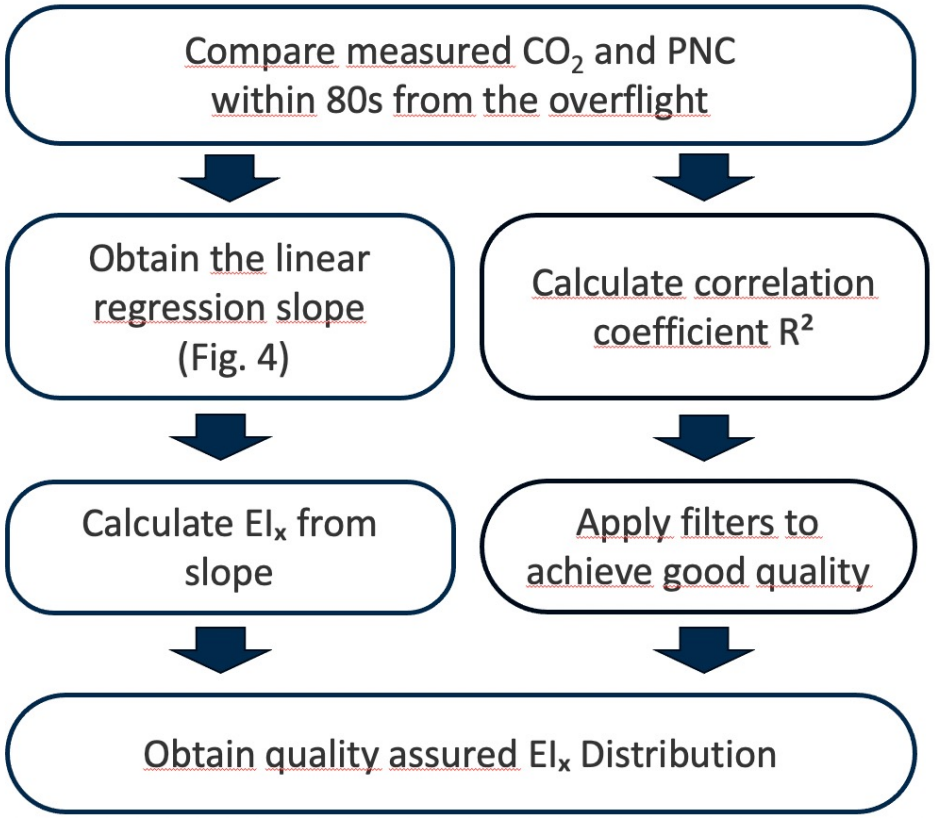
A mixed layer develops during the sunny morning, removing the **vertical CO_2 gradient** between the measurement station and the approaching aircraft trajectory

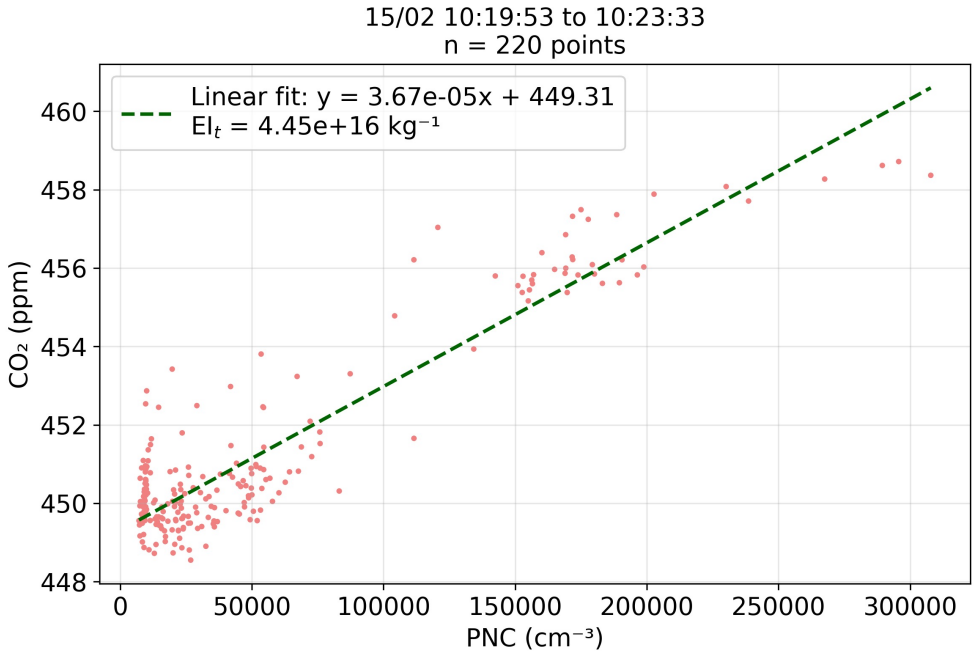
The exhaust plume is mixed-down by **wake vortices** reaching the station 35 s after the aircraft overflight showing a **positive CO_2** and **PNC correlation**



Jet engines emit large amounts of UFP as quantified by the particle number **E**mission **I**ndex (EI_x)

➪ PNC produced per kg fuel (3.16 kg CO_2[1]) burned (see **Poster** by **P. Küssner, C. Ruth, T. Wittler et al.**)



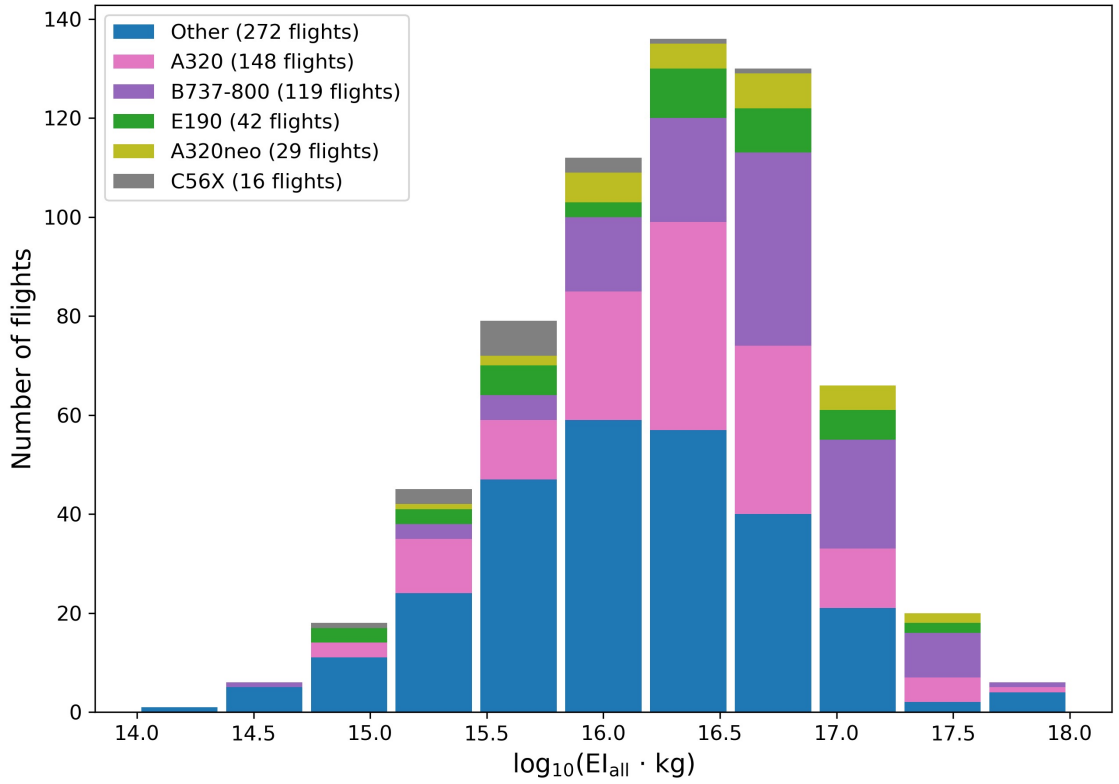


Linear regression of CO_2 vs PNC for the flight from Schiphol

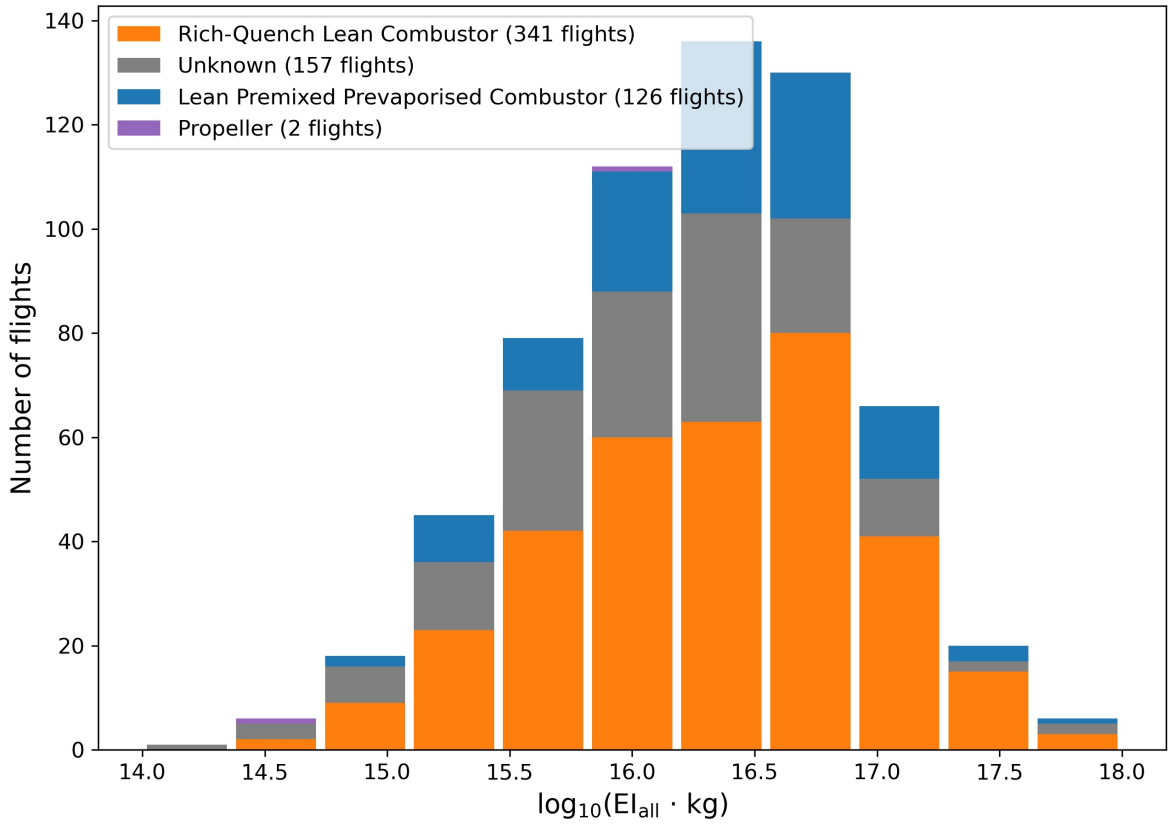
[1] European Environment Agency, EMEP/EEA air pollutant emission inventory guidebook 2019 - Technical Guidance to Prepare National Emission Inventories (2019)

Estimated emission index (EI_{all}) for 626 arriving aircrafts (see Poster by P. Küssner et al.)

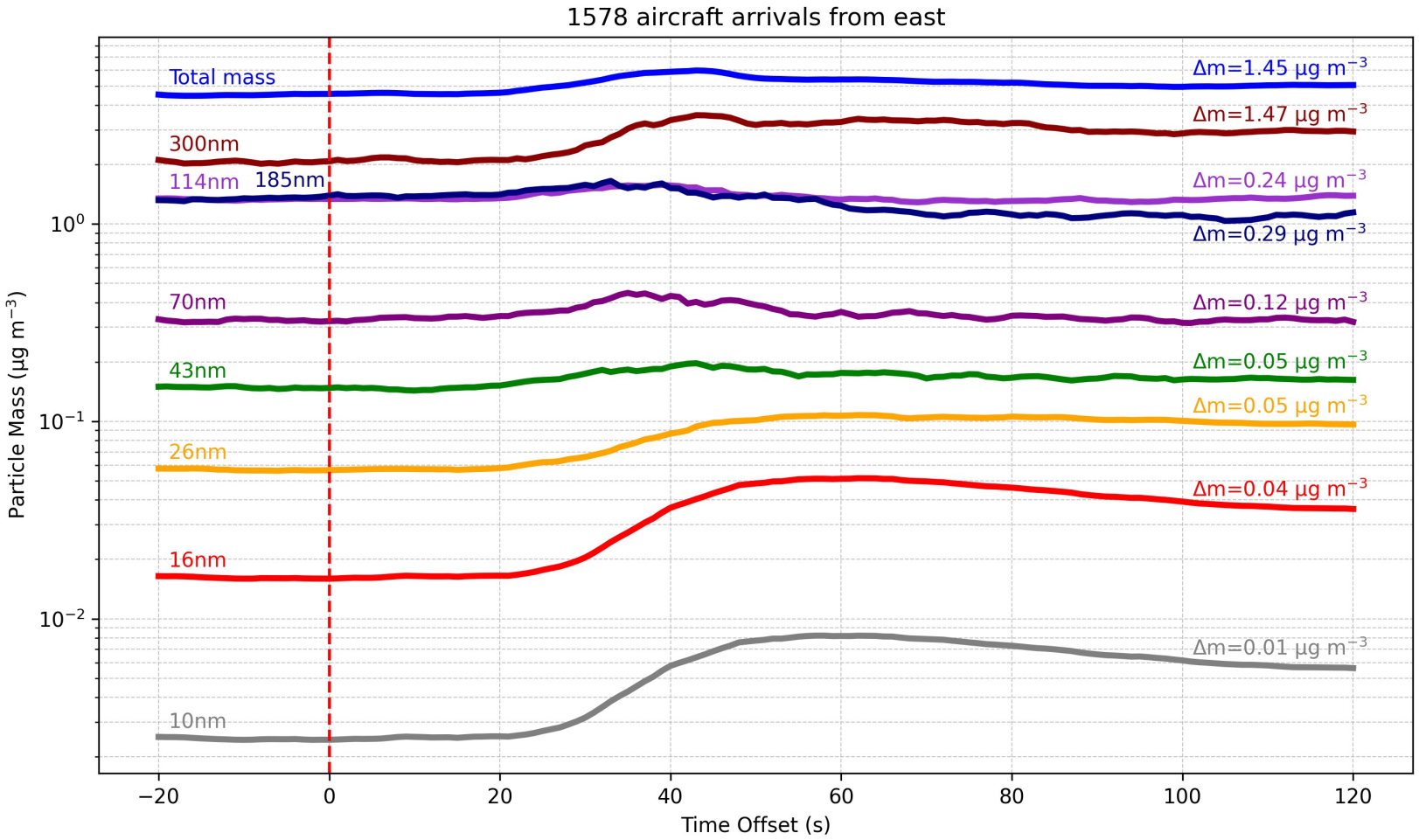
A) coloured by aircraft type



B) coloured by engine type



Size resolve UFP Mass exposure from landing Airplanes



Average mass increase for each size bin (Partector2 Pro)

- Δm maximum increase from background average - 20s before to 20s after closest approach (red dashed line)

Summary

- Wake vortices cause efficient down-mixing of aircraft exhaust plumes along the landing corridor
- Landing aircrafts cause PNC exposure of $10^{16 \pm 1}$ (particles / cm^3) per kg fuel burned
- PNC not really correlate to aircraft types or engine types

Future Outlook

- While high PNC are a first indication of UFP exposure, a chemical analysis of individual plumes is needed to better assess the toxicity of UFP exposure from individual aircraft overflights
- Due to the low mass load of UFP and the short plume duration real-time chemical characterization is challenging
- High-resolution (Orbitrap) mass spectrometry seems feasible for real-time ambient measurements

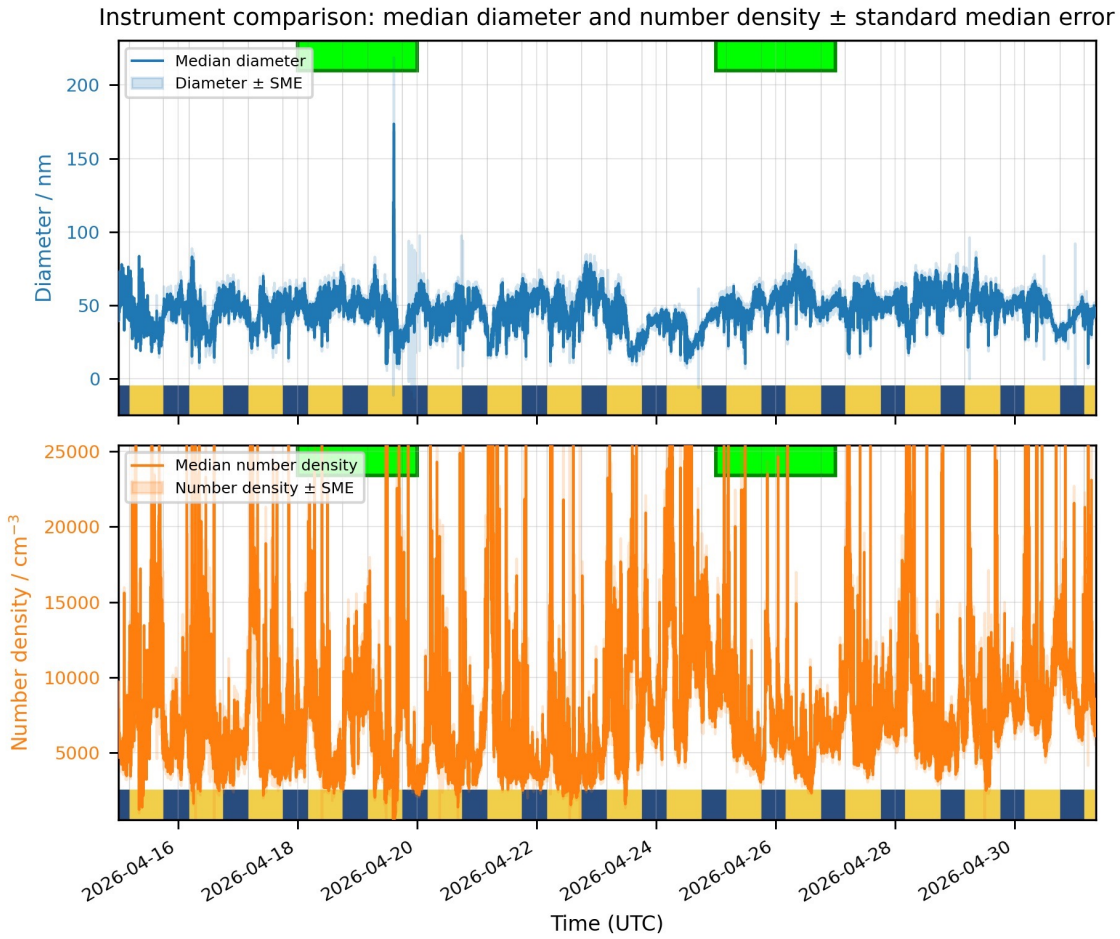
Acknowledgements

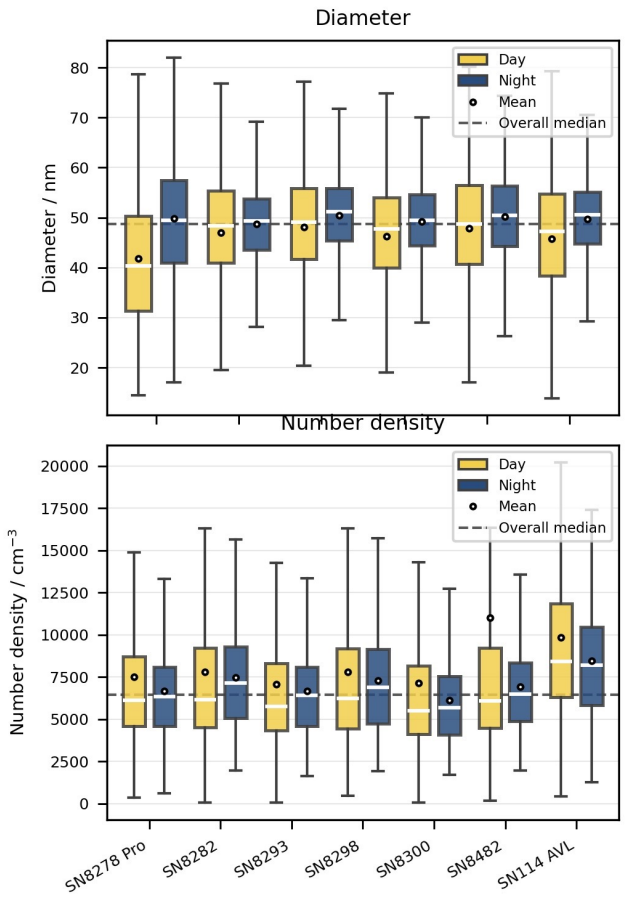
This Work was supported by OeAD Sparkling Science (Project Atemluft)

Intercomparison

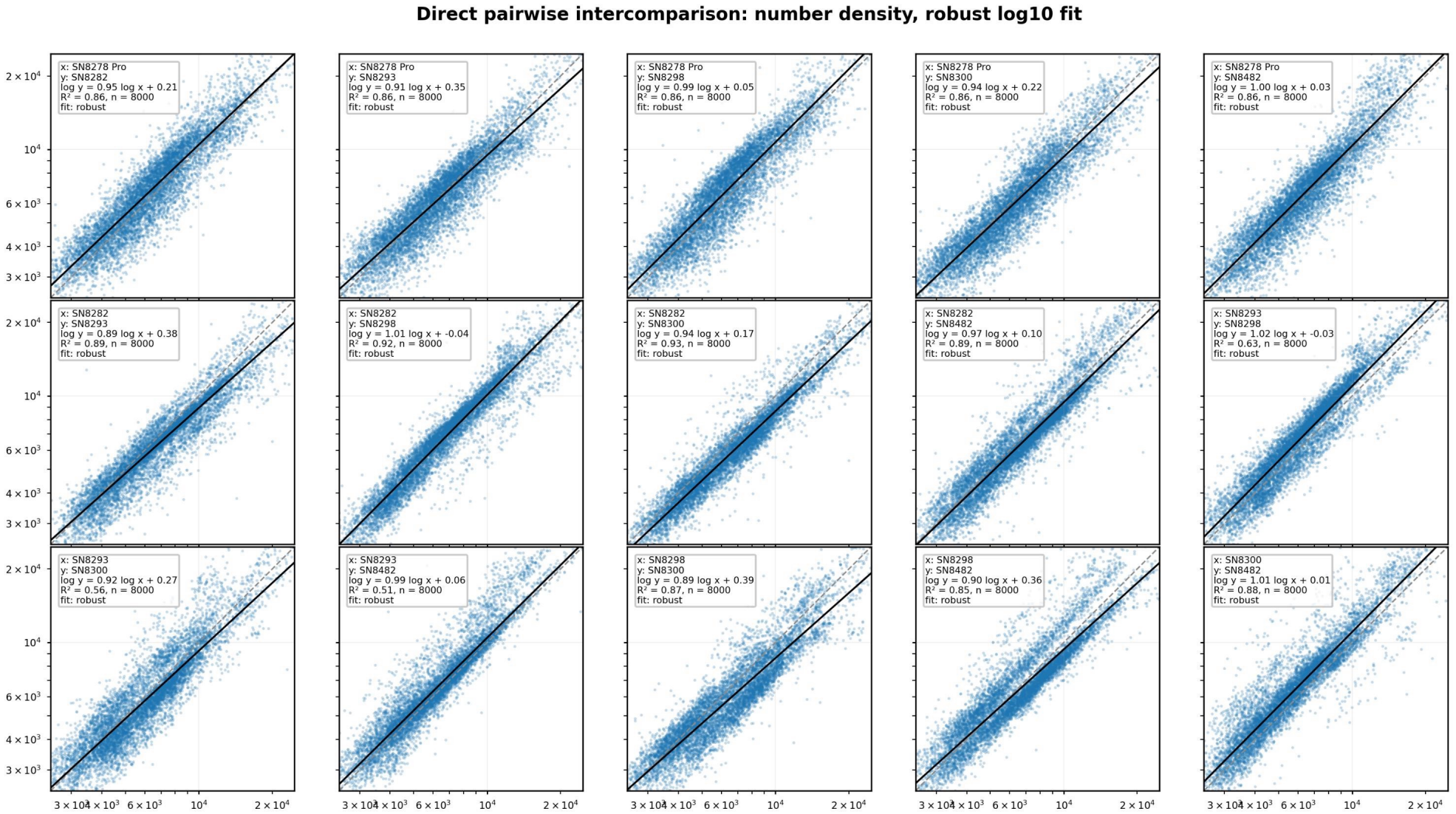
Partector2, Partector2 Pro & AVL UFP

Intercomparison
Partector2, Partector2 Pro & AVL UFP

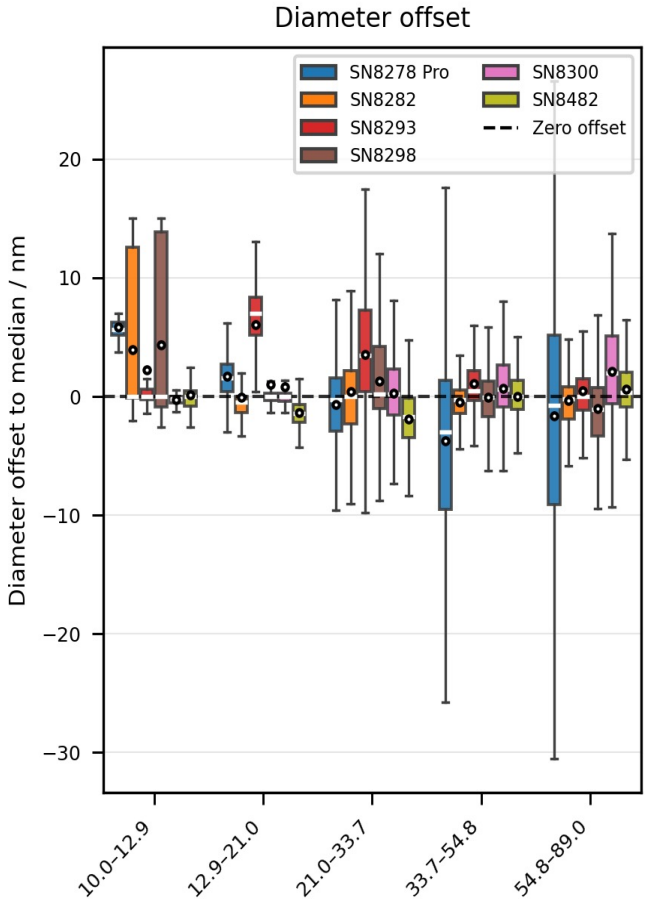


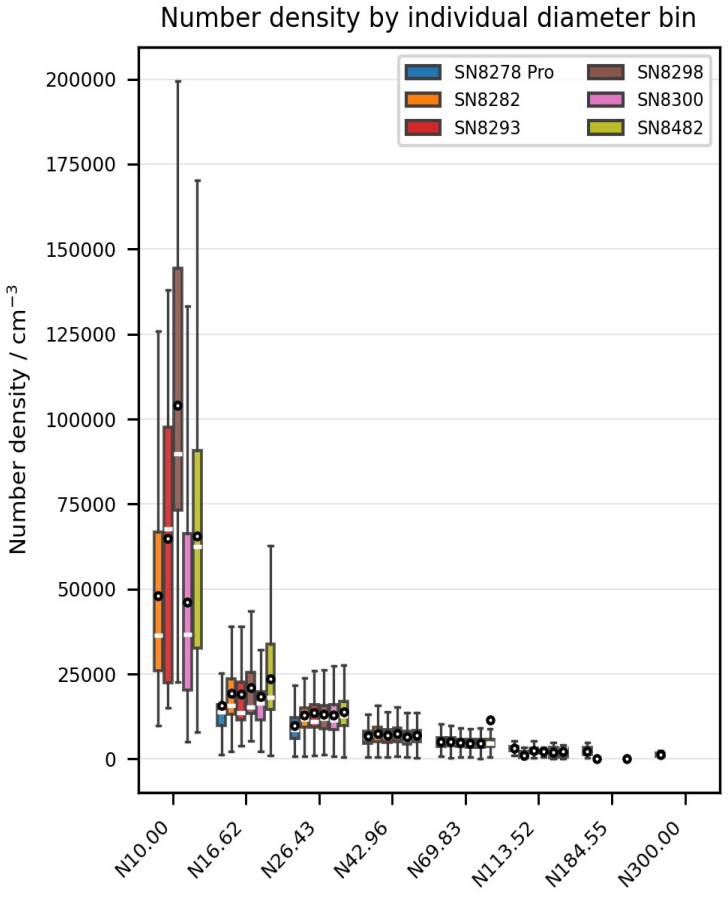


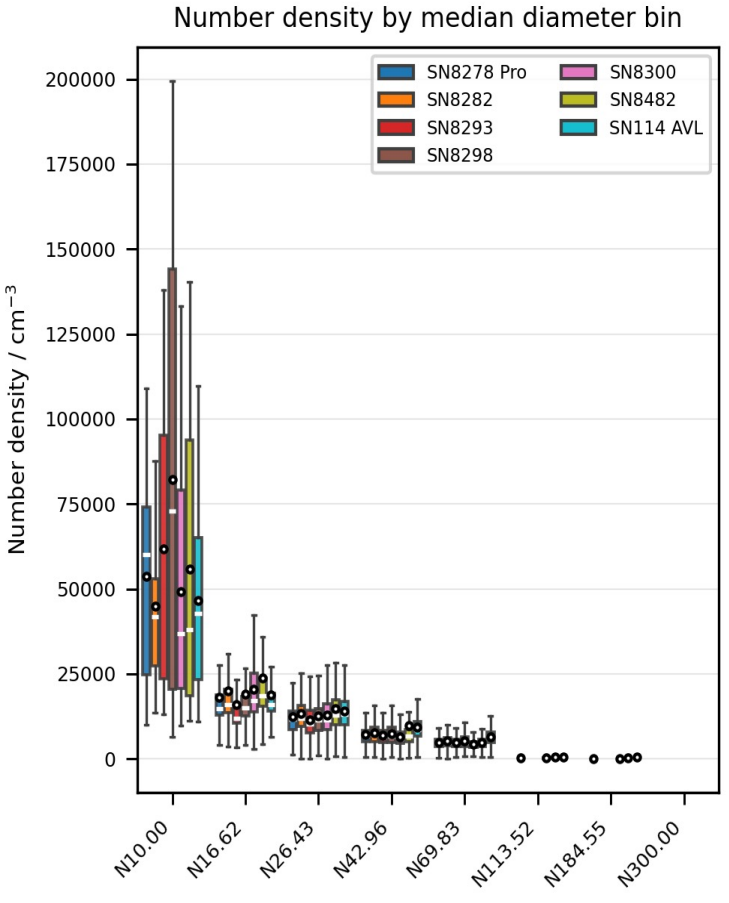
Intercomparison
Partector2, Partector2 Pro & AVL UFP

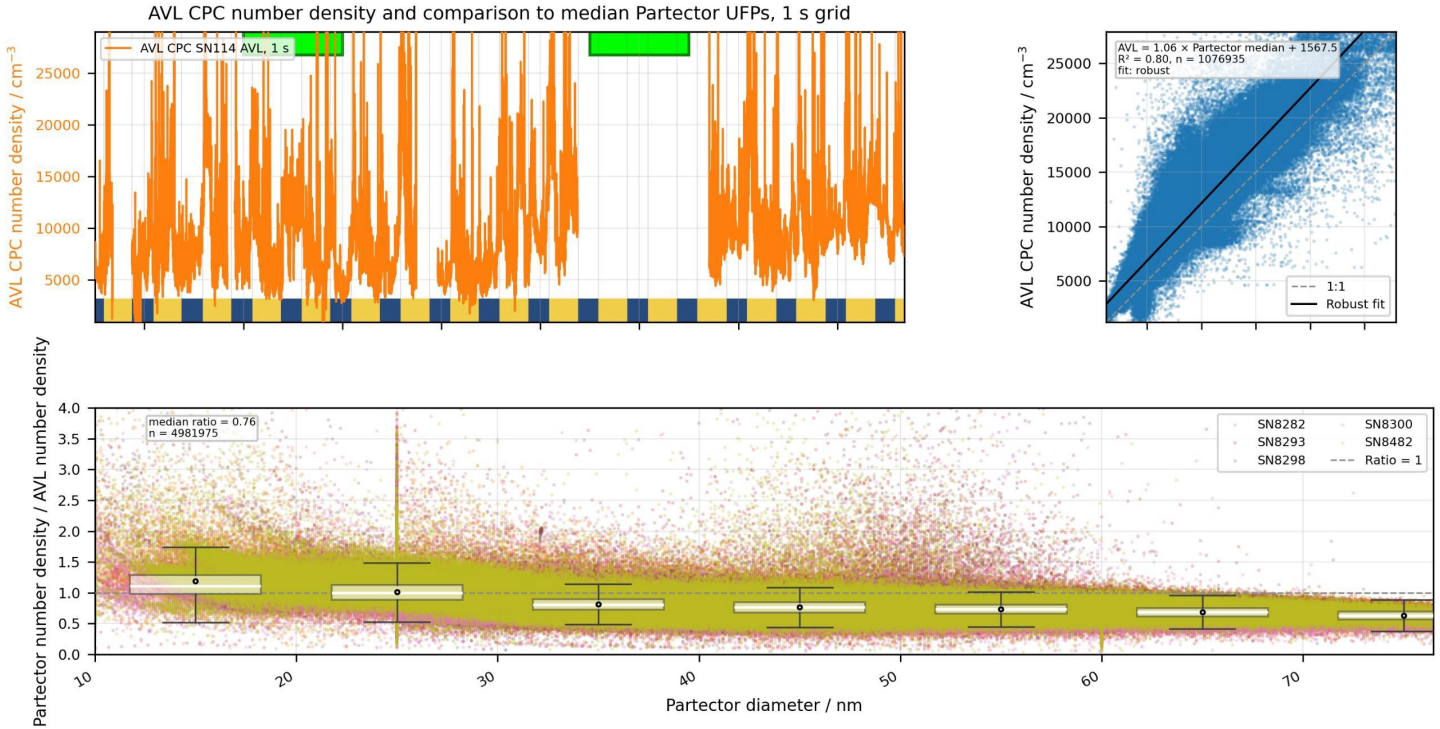


Intercomparison
Partector2, Partector2 Pro & AVL UFP



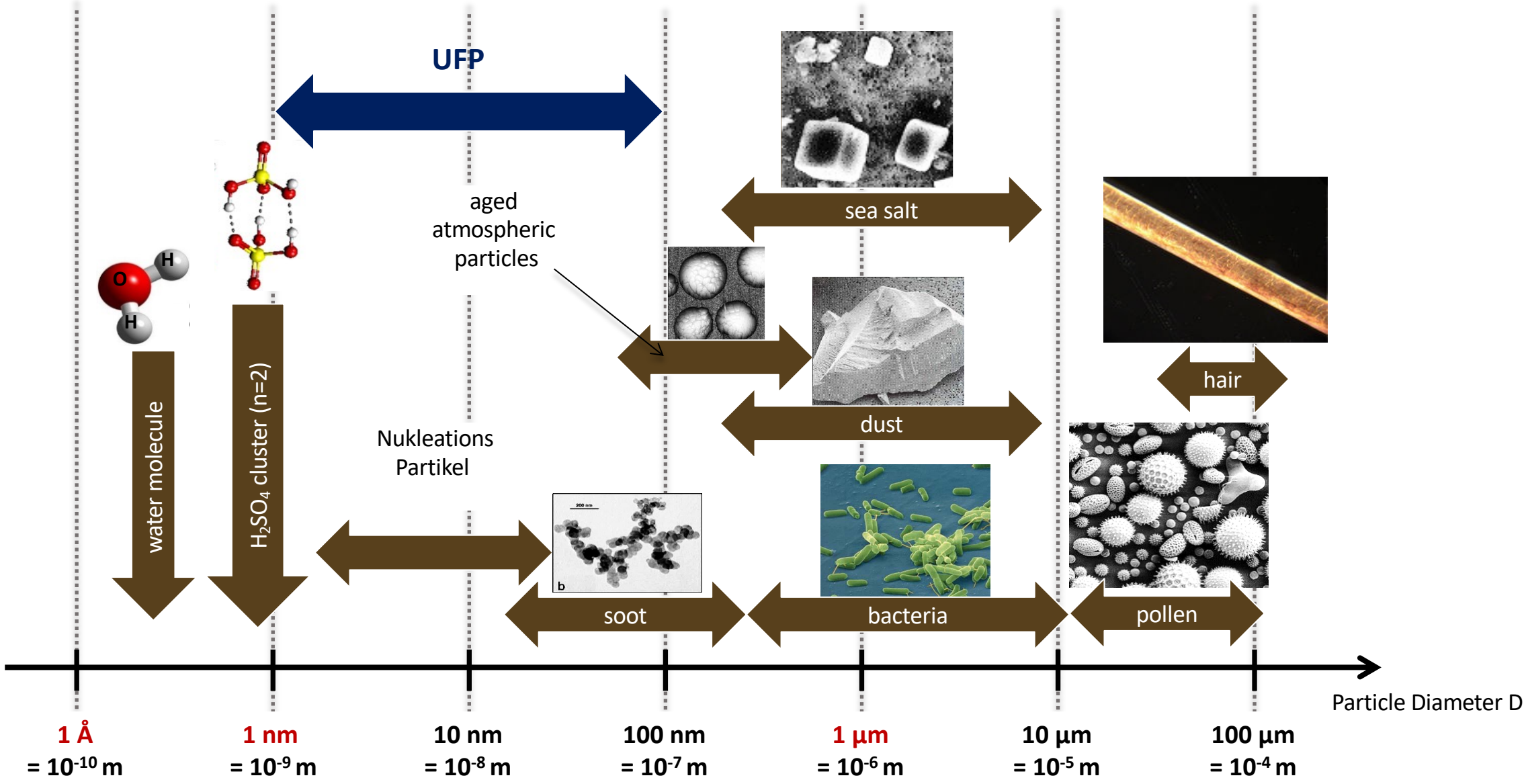




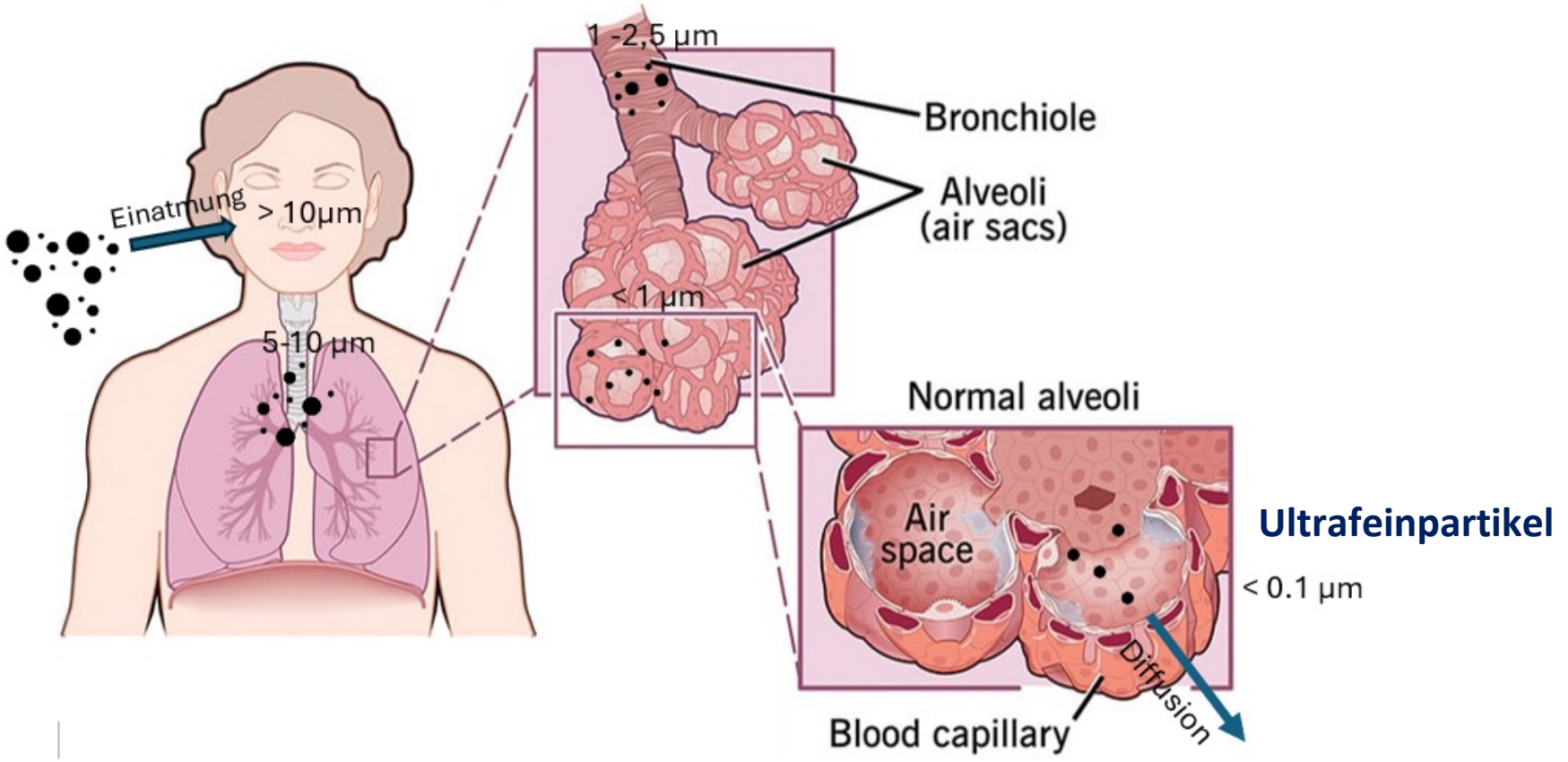


The lower panel highlights that the deviation between the Partector instruments and the AVL CPC is diameter-dependent. At small particle diameters, the Partector-to-AVL number-density ratio is close to or above unity, indicating comparable or even higher Partector concentrations. With increasing diameter, the ratio systematically decreases, falling below unity for larger particles. The overall median ratio of 0.76 should not be interpreted as a constant concentration offset, but rather as the result of a size-dependent biases between the instruments.

Grössenbereiche Atmosphärischer Aerosolpartikel



Eindringtiefe von Partikeln unterschiedlicher Größen



Ultrafeinpartikel

< 0.1 µm

Partector2 PRO am 07.10.24

UFP Anzahl

Größenverteilung UFP