

Supplementary Material: Size-resolved condensation sink as an approach to understand pathways how gaseous emissions affect health and climate

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Effect of ambient temperature and pressure on the ELPI+ CS response

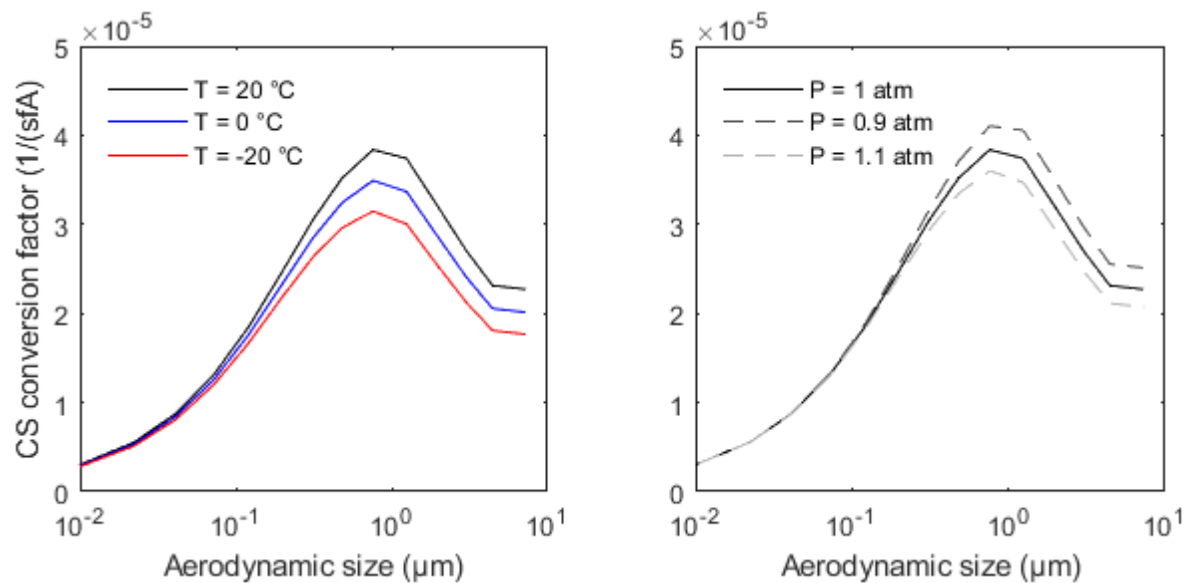


Figure S1: The ELPI+ CS response coefficient (i.e. conversion factor) as a function of particle size with varying ambient temperature and pressure.

The ELPI+ and DMPS comparison campaign

Table S1: Average measured concentrations during different pollution episodes of the DMPS and ELPI+ comparison campaign in Helsinki.

	Helsinki: No episode	Helsinki: Inversion	Helsinki: LRT
PN (1 cm^{-3})	7 700	16 200	9 700
PM _{2.5} ($\mu\text{g m}^{-3}$)	3.4	9.9	15.4
NO ($\mu\text{g m}^{-3}$)	16.1	29.8	22.2
BC ($\mu\text{g m}^{-3}$)	0.58	1.11	1.01
ρ_{eff} (g cm^{-3})	1.1	1.3	1.7

Description of the measurement campaigns

Table S2: Description of the measurement campaigns and utilised data.

Campaign	Location	Description
Helsinki, ELPI+ and DMPS comparison (01-02/2022)	Urban traffic	The measurements were conducted on a kerbside in a street canyon, including 3+3 driving lanes. The DMPS measured in an air quality monitoring station, and the ELPI+ in a mobile laboratory right next to the station. The measurements were carried out daily between 06:30 and 19:30. The weather conditions were typical wintertime conditions in Helsinki. During the inversion episode, temperature was below -5°C , reducing the dilution and dispersion of pollutants. During the LRT episode, air masses in Helsinki had travelled through Central and Eastern Europe.
Helsinki, Summer (08/2019) (see [2])	Urban traffic	The measurements carried out in the same street canyon as the ELPI+ and DMPS comparison. The measurement were conducted with a mobile laboratory. The utilised data was measured between 6 am and 6 pm.
	Highway	The measurement site was next to Länsiväylä highway in Espoo (Helsinki metropolitan area), approximately 20 meters from the road. The average weekday traffic on the highway was 70 000 vehicles in 2019. The measurement were conducted with a mobile laboratory. The utilised data was measured between 6 am and 6 pm.
	Shipping	The data was measured in the Harbour B location of the corresponding publication (Lepistö et al. 2022) in Helsinki. The measurement were conducted with a mobile laboratory. Harbour B location was relatively far away from other pollution sources like road traffic, and, therefore, it can be better considered to represent the emissions from the ships. During the measurements, dominating wind direction was from the sea (and harbour area) to the measurement location.
Helsinki, Winter (03/2021) (see [3])	Urban traffic	The measurements carried out in the same street canyon as the ELPI+ and DMPS comparison and Helsinki, Summer 2019. The measurement were conducted with a mobile laboratory. The utilised data is based on measurement on 2 nd and 8 th March when there was not a LRT-episode affecting the results.
	Airport	The measurements were conducted with a mobile laboratory next to Helsinki-Vantaa airport, approximately 200 m away from the closest (and the most active) runway. Due to the SARS-CoV-2 outbreak, air traffic was significantly reduced during the campaign, and the measurements were targeted on times, when the wind was from the airport, and the airport activity was high (take-offs approximately every 5 min).
	Residential area	The measurements were conducted with a mobile laboratory in a detached-housing residential area in Vantaa (Helsinki metropolitan area). The utilised data was measured during the evening when the effects of residential wood combustion was the clearest (cold Friday evening, March 5th).

Tampere (04-05 2020)	Highway	The measurements were conducted by driving the mobile laboratory back-and-forth an busy arterial road and a motorway. The utilised data was measured between 6 am and 6 pm.
Raahe (01-02/2021) (see [1])	Residential area	The data was measured with a mobile laboratory in detached-housing residential area. Only evening data considered as the effects of residential wood combustion were the clearest during the evenings. Only the data measured when the wind was not from the nearby steel factory considered.
	Industrial	The data was measured with a mobile laboratory in an background site when the wind was from the nearby steel factory (approximately 2 km away from the factory).
Düsseldorf (03/2022)	Urban traffic	The measurement site located next to an arterial road in a low emission zone, allowing only the use of vehicles that fulfil EURO 4 emission standard. The measurement were conducted with a mobile laboratory. The utilised data was measured between 6 am and 6 pm.
	Highway	The measurements were done by driving on motorways near Düsseldorf airport. The utilised data was measured between 6 am and 6 pm.
	Airport	The measurements were done in a residential area near Düsseldorf airport (2 – 3 km away). Only the data measured when the wind was from the airport were considered.
	Riverside	The measurements were done in a residential area right next to river Rhine (50 – 300 m away from the passing ships). Only the data measured when the wind was blowing from the river were considered.
Prague (03-04/2022)	Urban traffic	The site located in a preschool yard next to a two-lane street having two tramlines in the middle. The measurements were carried out with a mobile laboratory. The utilised data was measured between 6 am and 6 pm.
	Highway	The measurements were done with a mobile laboratory right next to a busy six-lane arterial road in-and-out the city. The utilised data was measured between 6 am and 6 pm.
Delhi-NCR (11-12/2018) (see [4])	Urban traffic	The measurement site was along a busy road with two lanes in both directions. The ambient temperature varied between 8 °C to 20 °C during the period. All the data reported by Salo et al. (2021) were utilised.

[1] Barreira, et al. (2023). Comprehensive characterization of wintertime submicron aerosol in a Nordic town influenced by residential wood combustion, traffic and industrial sources. *Atmospheric Pollution Research*, 14, 8. DOI: 10.1016/j.apr.2023.101835

[2] Lepistö, et al. (2022). Connection between lung deposited surface area (LDSA) and black carbon (BC) concentrations in road traffic and harbour environments. *Atmospheric Environment*, 272. DOI: 10.1016/j.atmosenv.2021.118931.

[3] Lepistö, et al. (2023). Snapshots of wintertime urban aerosol characteristics: Local sources emphasized in ultrafine particle number and lung deposited surface area, *Environmental Research*, 231, 1. DOI: 10.1016/j.envres.2023.116068.

[4] Salo, L., et al. (2021). The characteristics and size of lung-depositing particles vary significantly between high and low pollution traffic environments. *Atmospheric Environment* 255, 118421. <https://doi.org/10.1016/j.atmosenv.2021.118421>

The size distributions results of the simulations

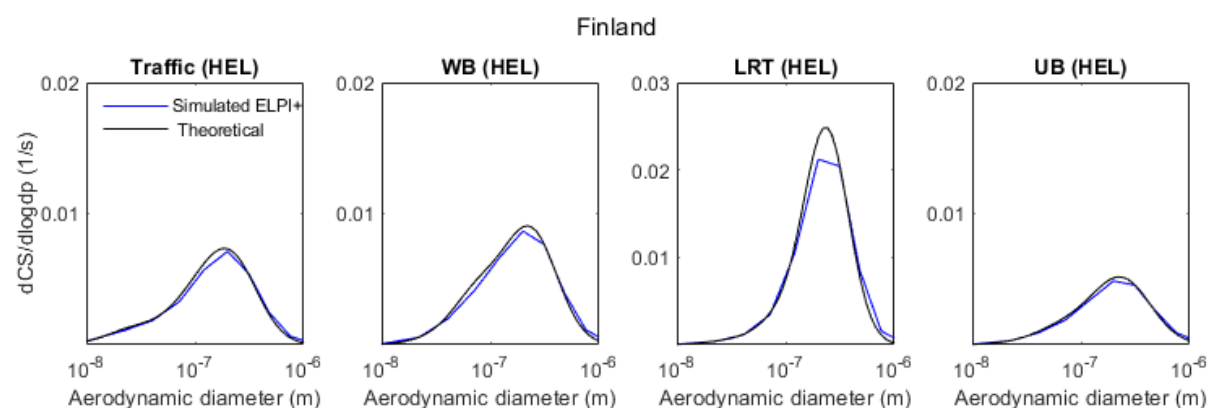


Figure S2: The simulated and theoretical CS size distributions based on the size distributions reported from Finland (Table 2). WB = Wood burning, LRT = long-range transported, UB = Urban background.

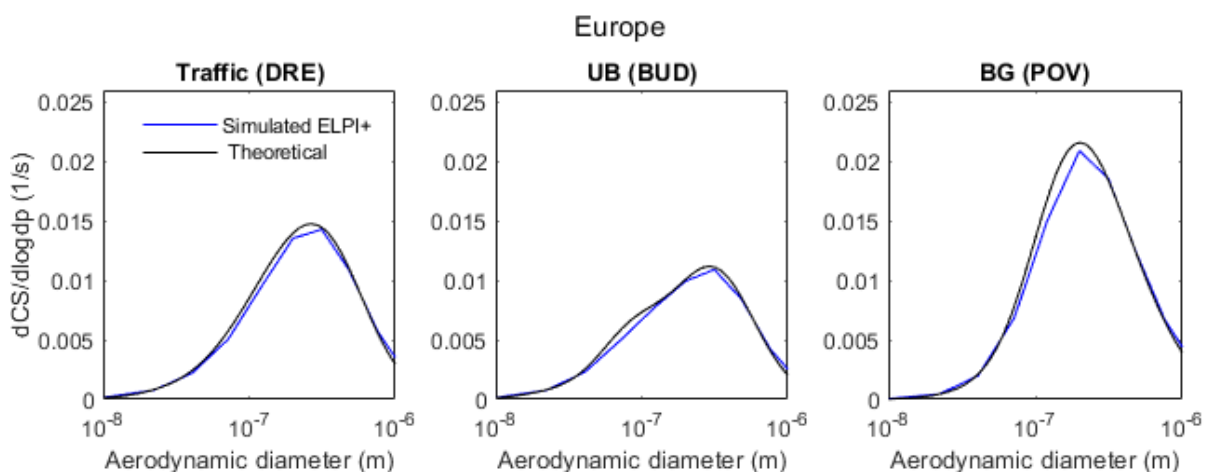


Figure S3: The simulated and theoretical CS size distributions based on the size distributions reported from Europe (Table 2). UB = Urban background, BG = Background, DRE = Dresden, BUD = Budapest, POV = Po Valley.

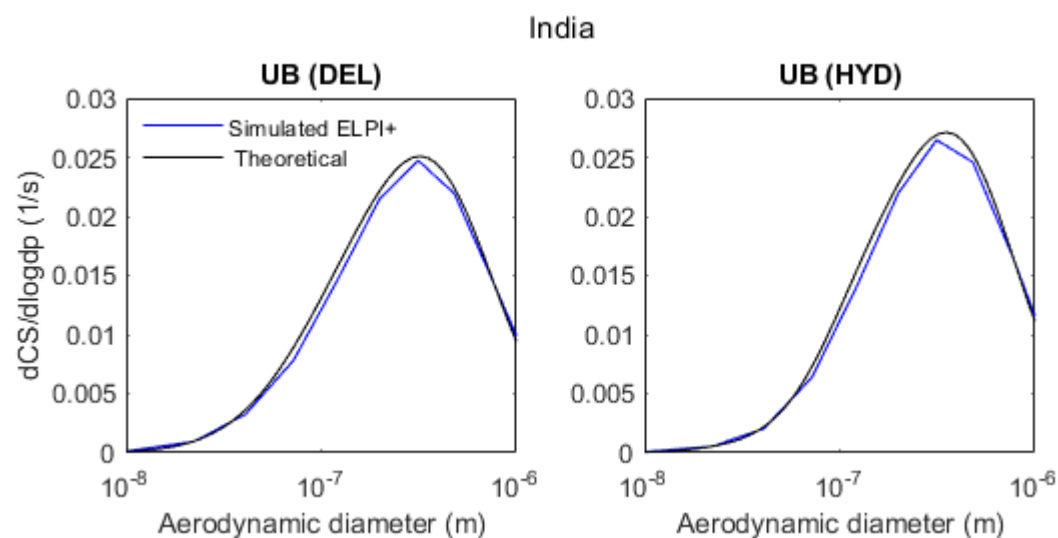


Figure S4: The simulated and theoretical CS size distributions based on the size distributions reported from India (Table 2). UB = Urban background, DEL = Delhi, HYD = Hyderabad.

The measured CS with different assumed particle effective densities

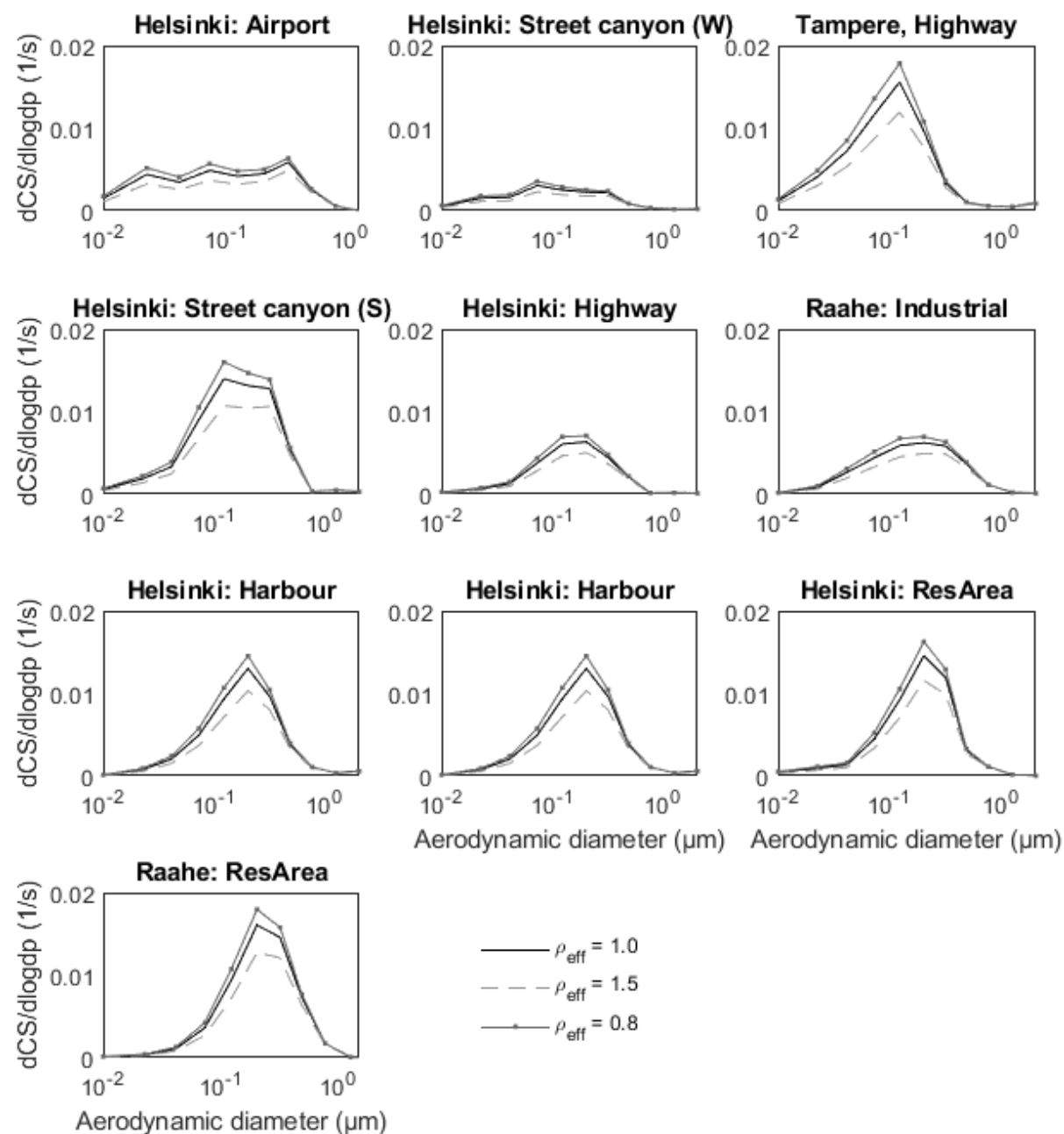


Figure S5: Average CS size distributions measured in Finland with assumed effective densities of 1.0, 1.5 and 0.8 g/cm³.

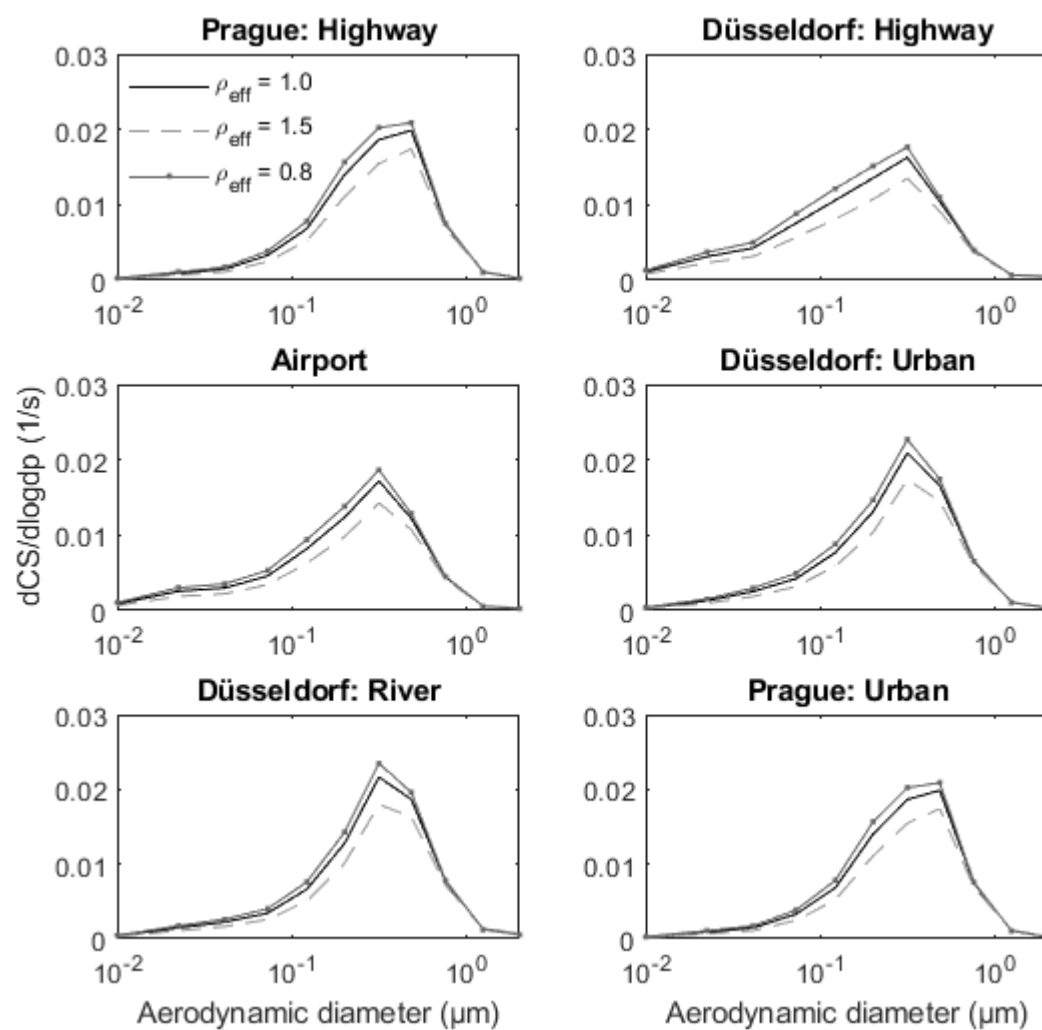


Figure S6: Average CS size distributions measured in Central Europe with assumed effective densities of 1.0, 1.5 and 0.8 g/cm³.

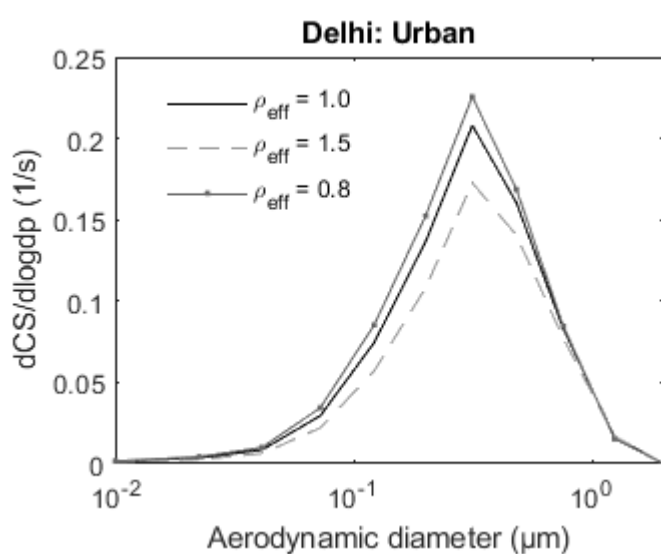


Figure S7: Average CS size distribution measured in Delhi-NCR with assumed effective densities of 1.0, 1.5 and 0.8 g/cm³.

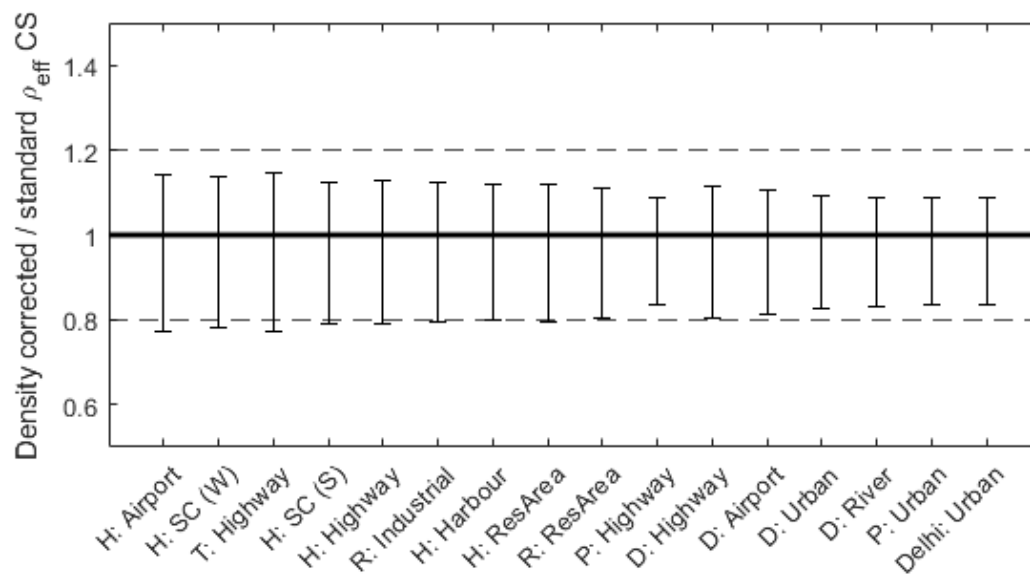


Figure S8: The density corrected ELPI+ CS (with ρ_{eff} 0.8–1.5 g/cm³) compared to the standard ρ_{eff} assumed measurement.

CS attributable to ultrafine particles ($\text{CS}_{0.1}$)

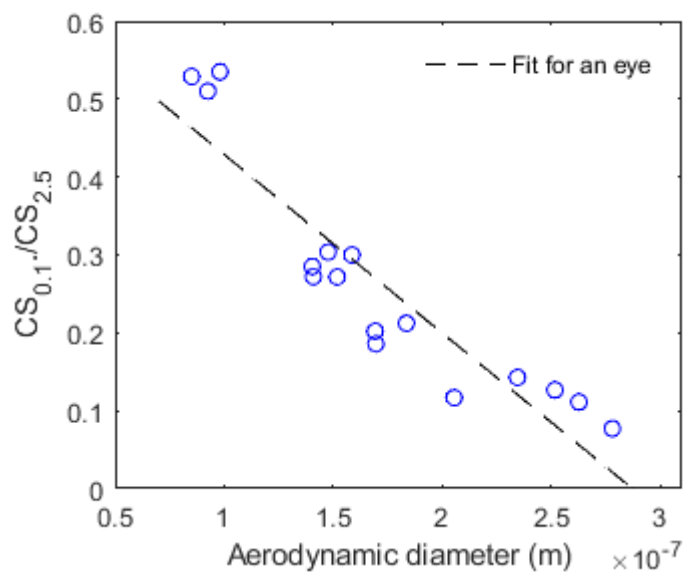


Figure S9: The connection between CS attributable to ultrafine particles ($\text{CS}_{0.1}$) and total CS (of particles smaller than 2.5, $\text{CS}_{2.5}$) as a function of GMD size of CS size distribution in the studied environments.

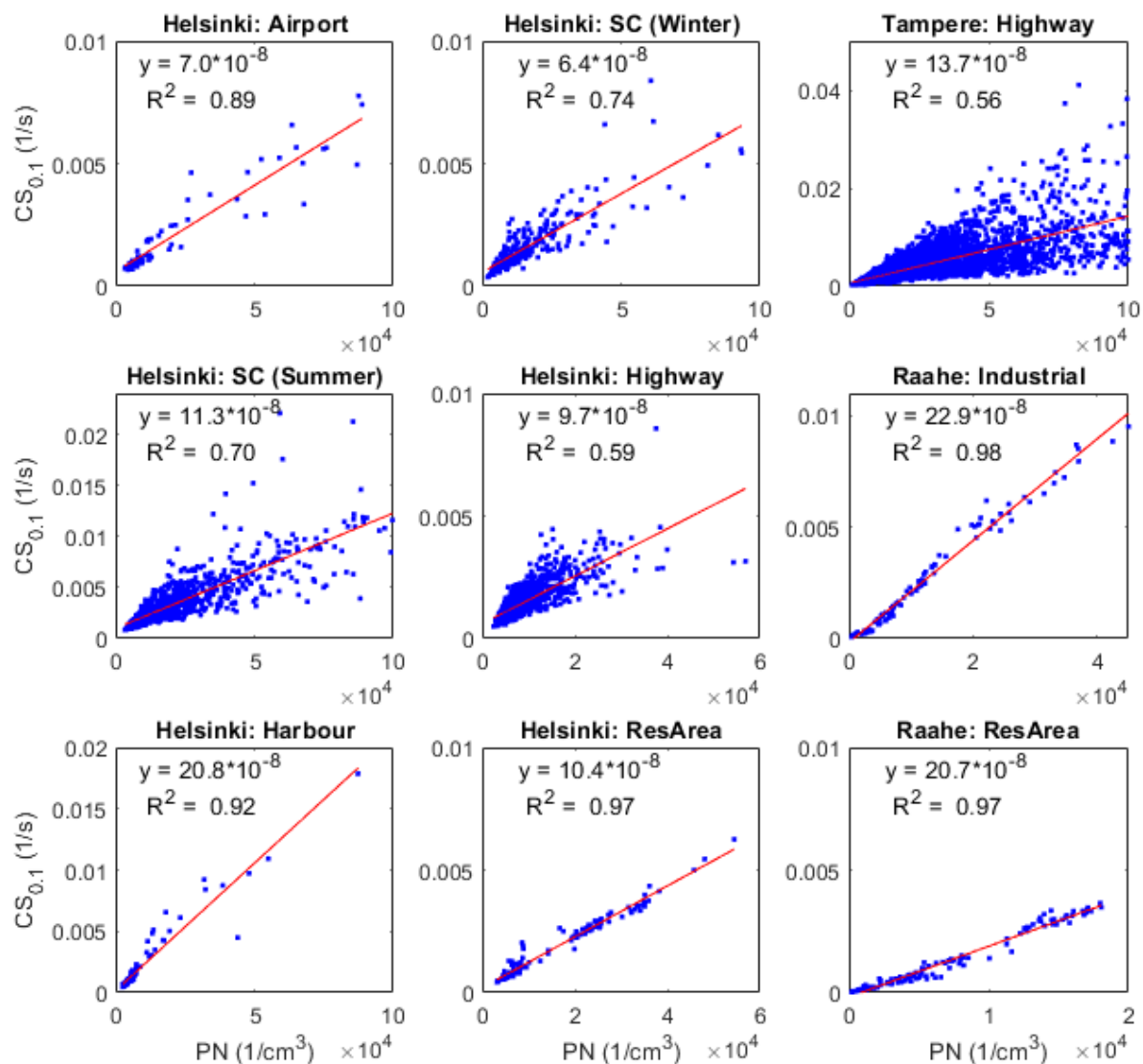


Figure S10: Linear fits between CS attributable to ultrafine particles ($CS_{0.1}$) and PN concentration in the studied environments in Finland. Here, outliers of $PN > 10^5$ 1/cm³ were neglected.

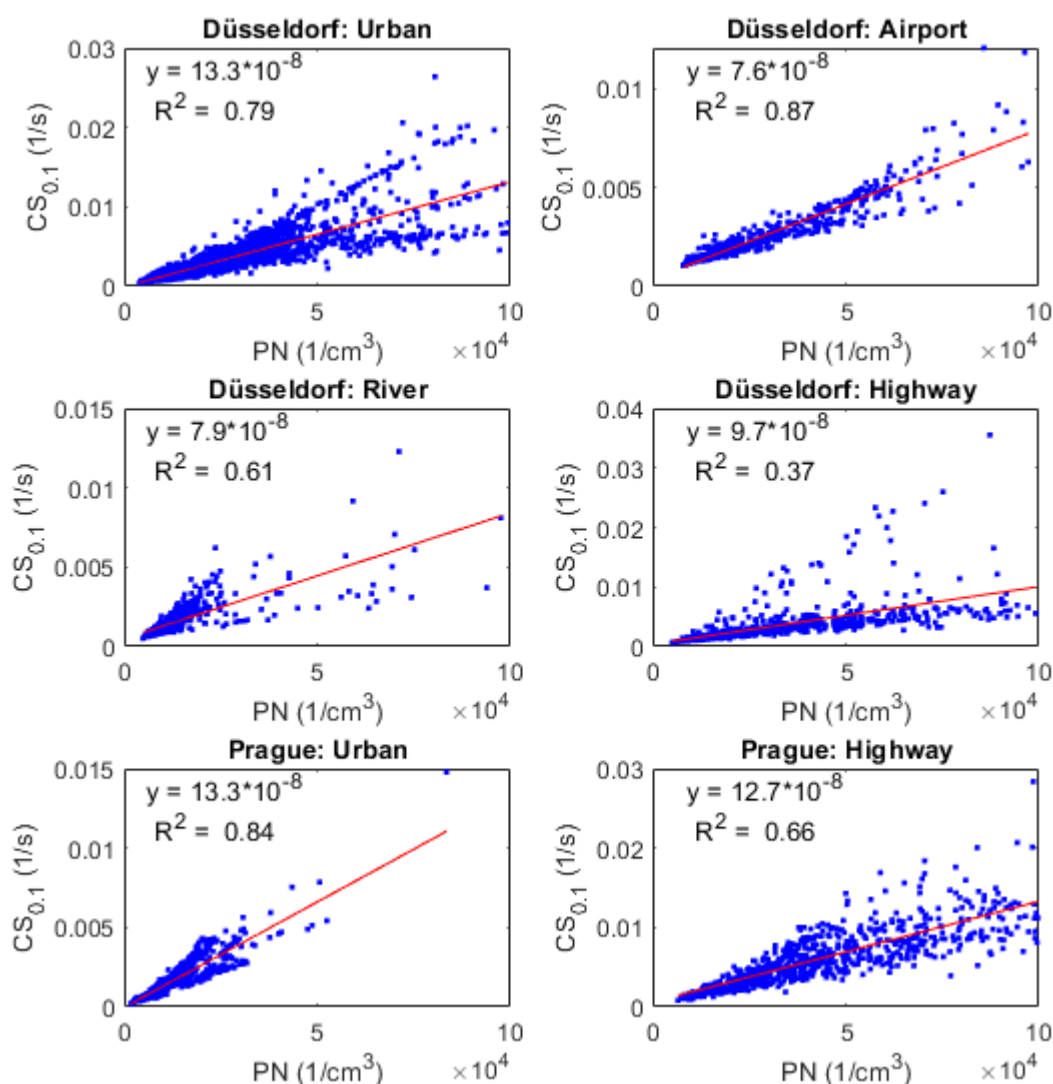


Figure S11: Linear fits between CS attributable to ultrafine particles ($CS_{0.1}$) and PN concentration in the studied environments in Central Europe. Here, outliers of $PN > 10^5$ $1/cm^3$ were neglected.

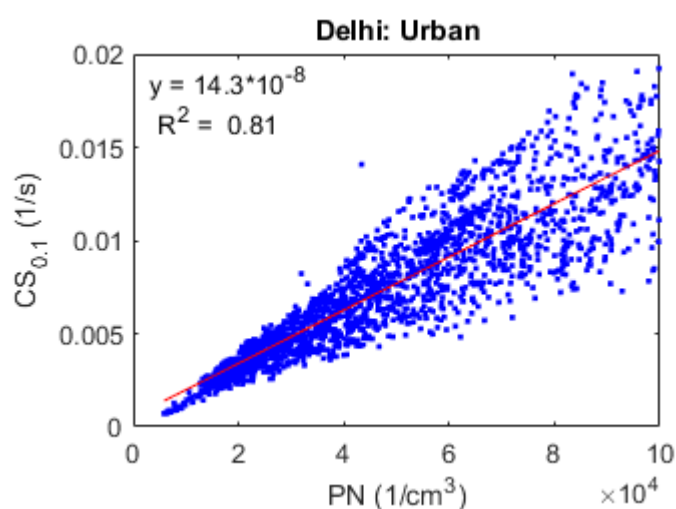


Figure S12: Linear fit between CS attributable to ultrafine particles ($CS_{0.1}$) and PN concentration in Delhi-NCR. Here, $PN > 10^5$ $1/cm^3$ results were neglected to keep the same criteria as in Fig. S10-11.

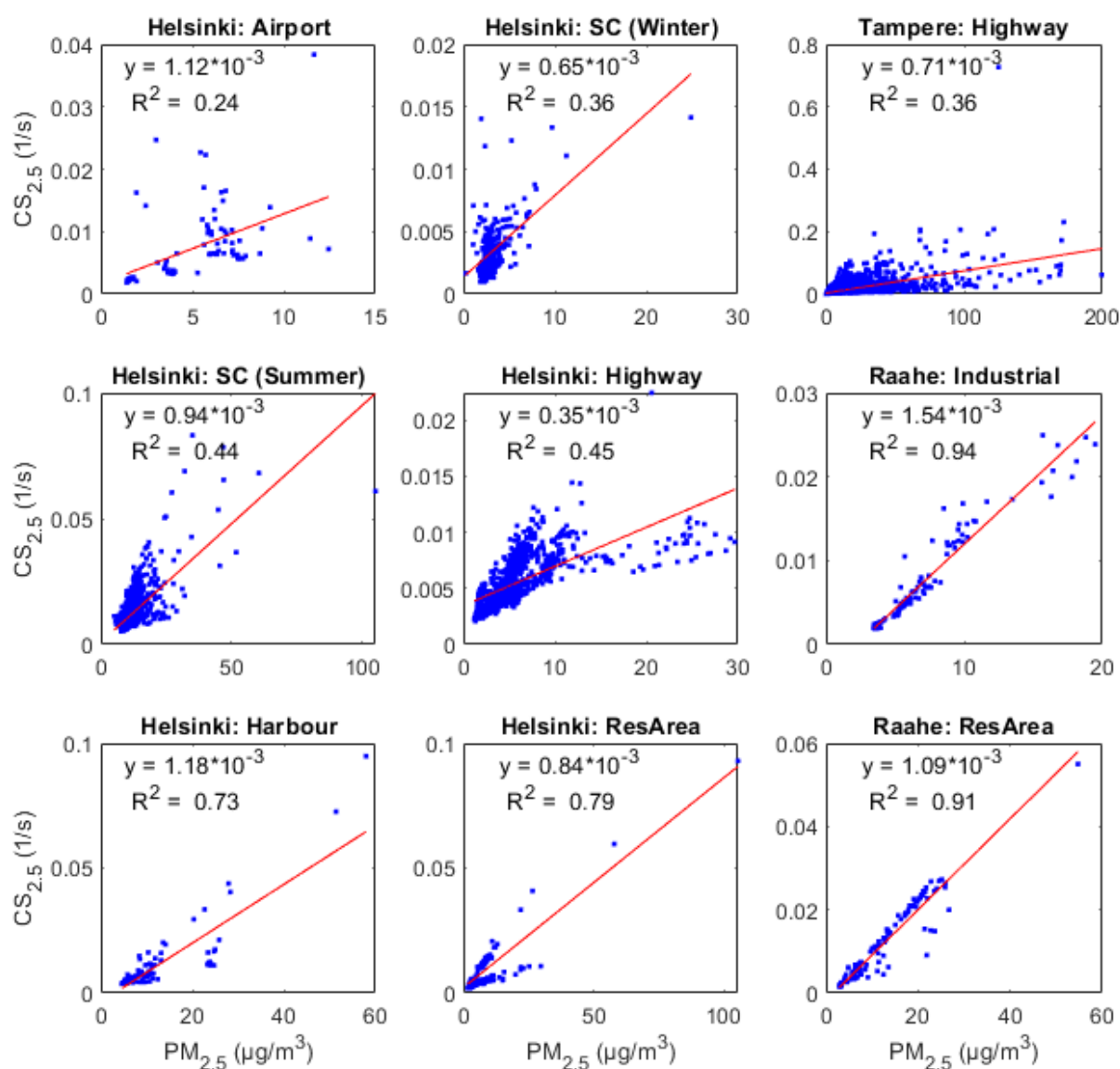


Figure S13: Linear fits between CS particles smaller than 2.5 μm ($CS_{2.5}$) and $PM_{2.5}$ in the studied environments in Finland. Here, outliers of $PM_{2.5} > 200 \mu g/m^3$ were neglected.

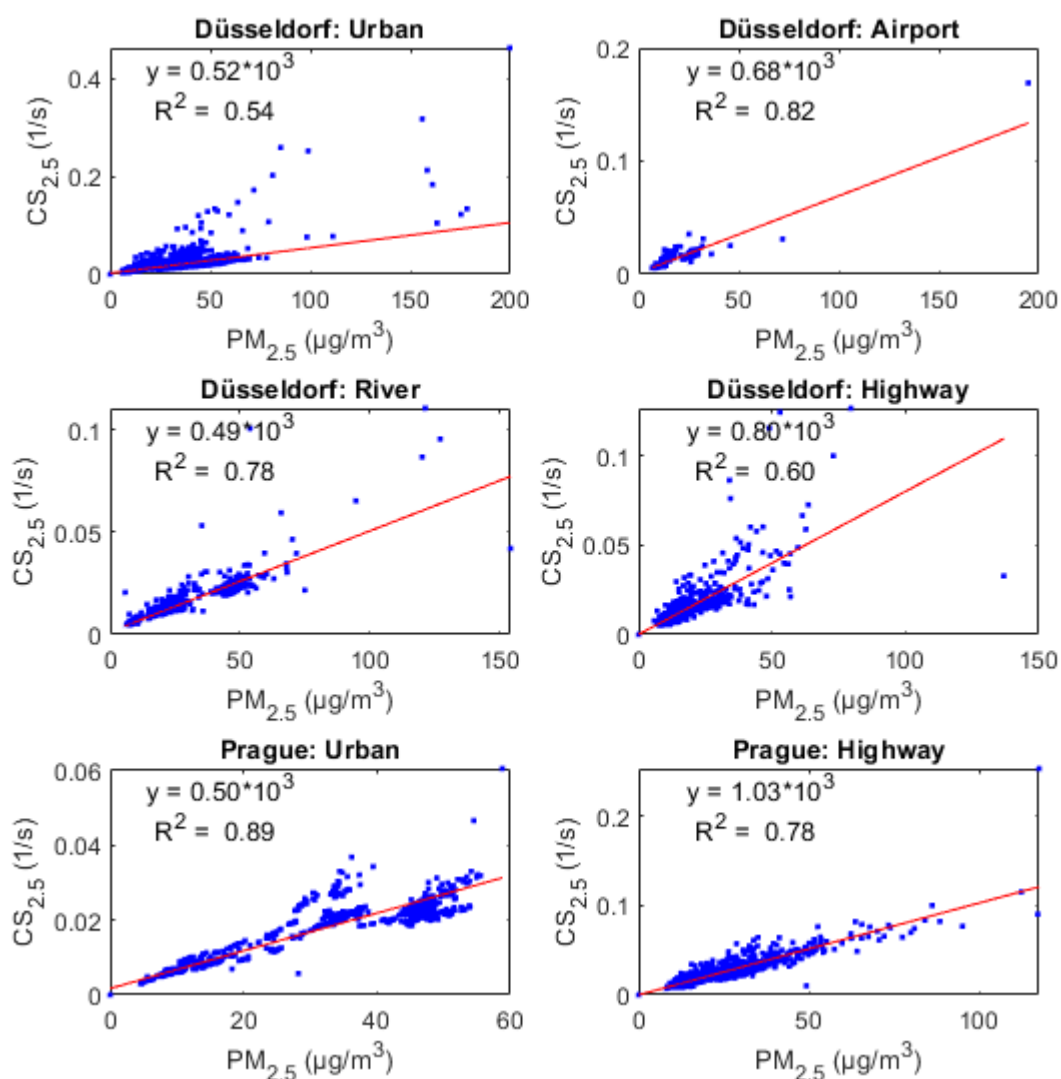


Figure S14: Linear fits between CS particles smaller than 2.5 μm ($\text{CS}_{2.5}$) and $\text{PM}_{2.5}$ in the studied environments in Central Europe. Here, outliers of $\text{PM}_{2.5} > 200 \mu\text{g}/\text{m}^3$ were neglected.

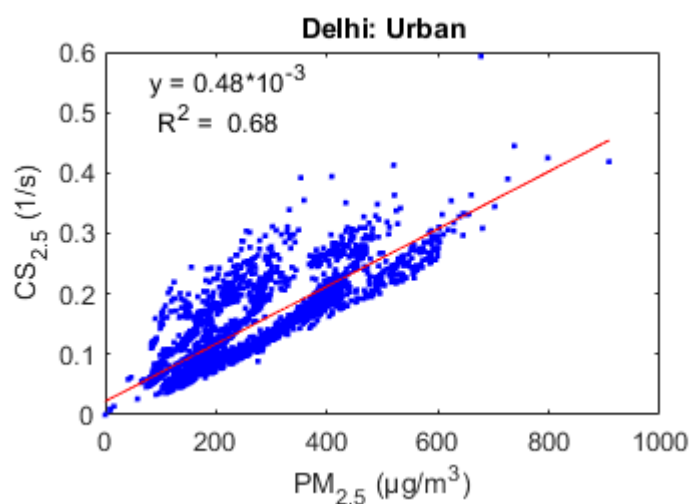


Figure S15: Linear fit between CS particles smaller than 2.5 μm ($\text{CS}_{2.5}$) and $\text{PM}_{2.5}$ in Delhi-NCR. Here, outliers of $\text{PM}_{2.5} > 1000 \mu\text{g}/\text{m}^3$ were neglected.