Tampere University

Hiukkaslukumääräpitoisuudet ja -kokojakaumat liikenneympäristössä

Topi Rönkkö

Aerosol Physics Laboratory, Faculty of Engineering and Natural Sciences

Tampere University

Content

- Research methods
- Primary exhaust aerosol - Fresh exhaust aerosol - Aged exhaust aerosol
- Ambient aerosol in traffic environments
- Summary

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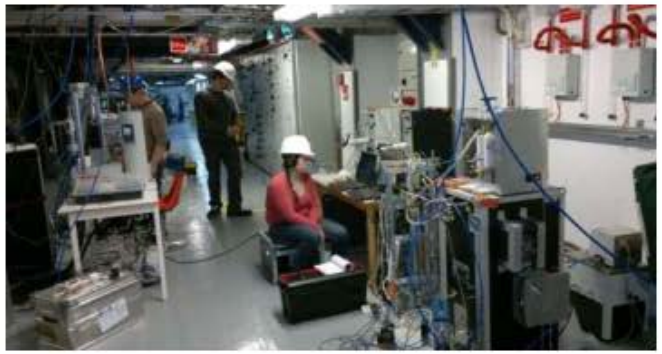
Emission and air quality research conducted by Aerosol Physics Laboratory


- Measurement methods, instrument development, field tests
- Air quality, traffic emissions, stack emissions
- Characteristics of exhaust aerosol
- Transformation of emissions in the atmosphere



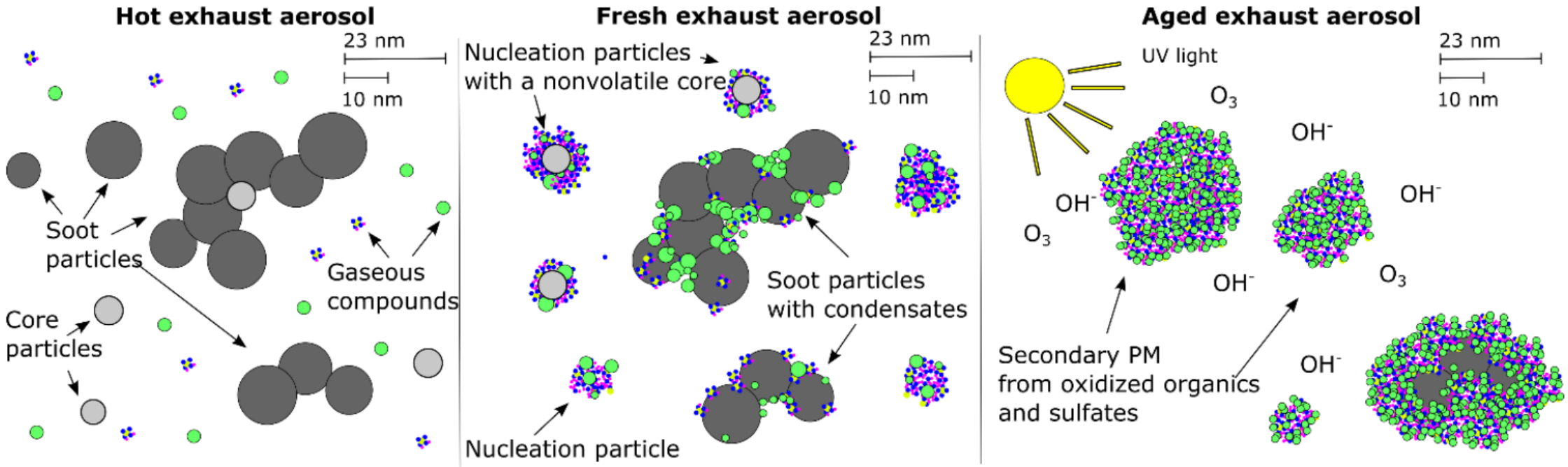



Methods in emission studies

Engine and vehicle laboratories	PEMS	Chasing vehicles on road	Roadside / on-road in traffic	Chamber studies
Highly controlled environment and test conditions, repeatability	Realistic driving conditions	Realistic driving conditions and exhaust dilution and cooling	Emissions of whole vehicle fleet	Atmospheric ageing taken into account

→ Effects of fuels, filtration, catalysts, engine oils, engine loading…

Exhaust aerosol



In hot exhaust

Directly after emission to the atmosphere

After oxidation processes in the atmosphere

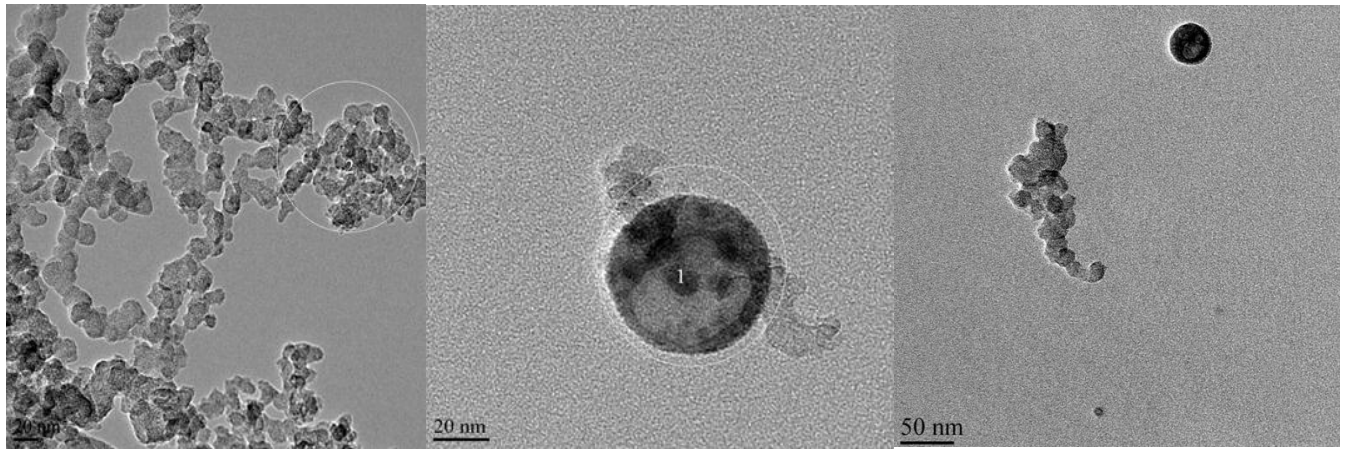
Figure: Panu Karjalainen

Time scale

Seconds | Seconds to minutes | Minutes to hours, hours to days

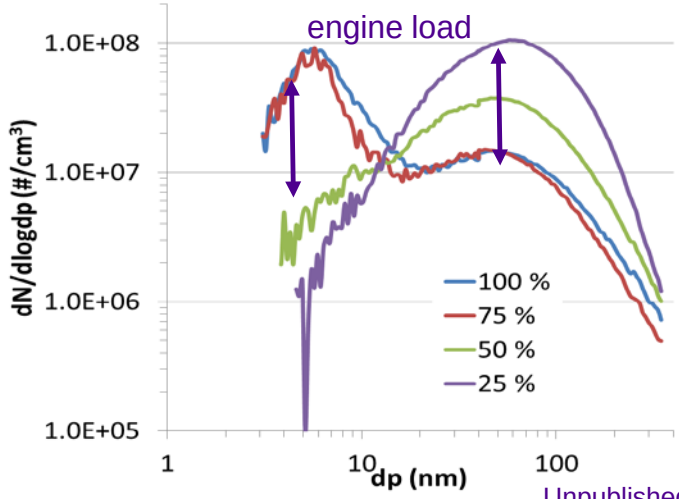
Primary exhaust aerosol

Primary particles from gasoline and diesel engine exhausts



Rönkkö et al., 2014 Kuuluvainen et al., in prep.

Effects of engine load



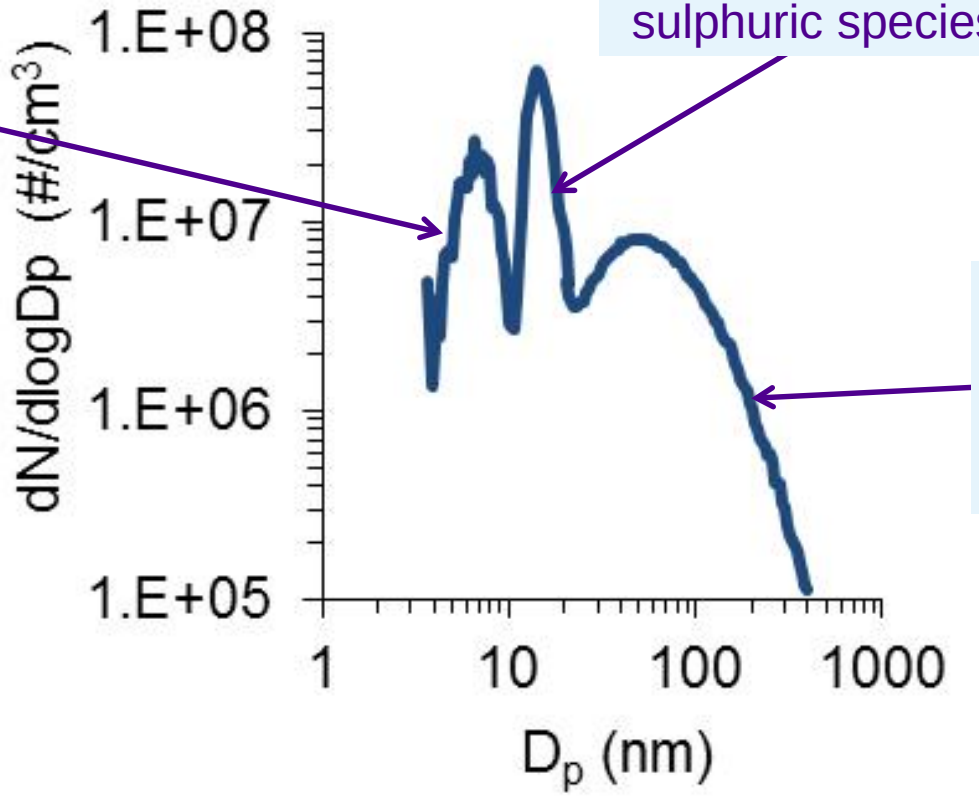
Unpublished results

Fresh exhaust aerosol
= exhaust aerosol after the cooling dilution of exhaust

Fresh exhaust from diesel engine can contain different types of particles

Nanoparticles
-volatile
-formed during cooling dilution
-sulphuric species and…

Nanoparticles
-nonvolatile core, volatile shell
-formed at high T + cooling dilution
-volatile material:
sulphuric species / hydrocarbons



Soot particles
-agglomerated structure
-elemental carbon
-surface species

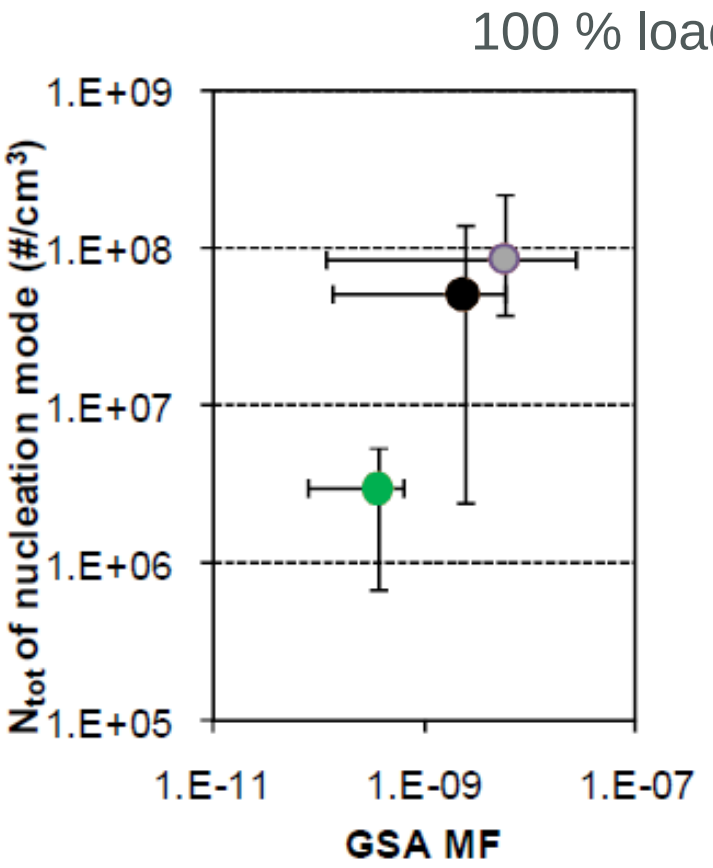
Euro IV heavy duty diesel engine with DOC and pDPF.

Size distribution measured at steady state driving mode (ESC 10)

Rönkkö et al. 2013, EST

E.g. fuel affects nanoparticle emissions (i.e., particle number emissions)

Heavy duty diesel engine
DOC and DPF
Different fuels
Partial flow sampling of exhaust mimicking real-world dilution process
SMPS, CIMS



= different fuels, engine oils, catalysts

Large variations exist both in gaseous sulfuric acid (GSA) and nucleation particle concentrations

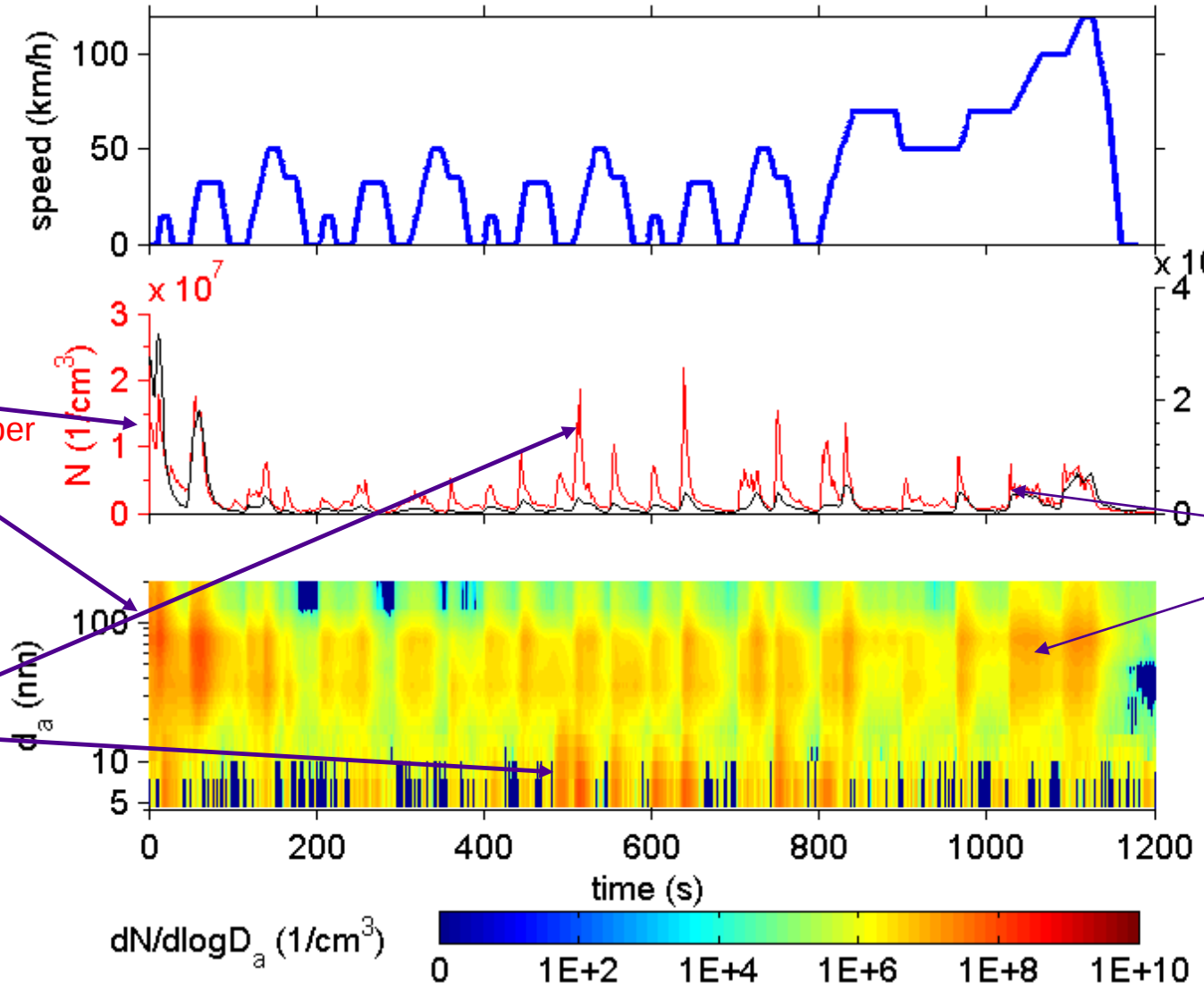
GSA from Arnold et al. 2012

Fresh exhaust aerosol, gasoline car

GDI car
E10 gasoline,
NEDC

Cold start increases particle emissions

High number concentration associated with sub 10 nm nanoparticles

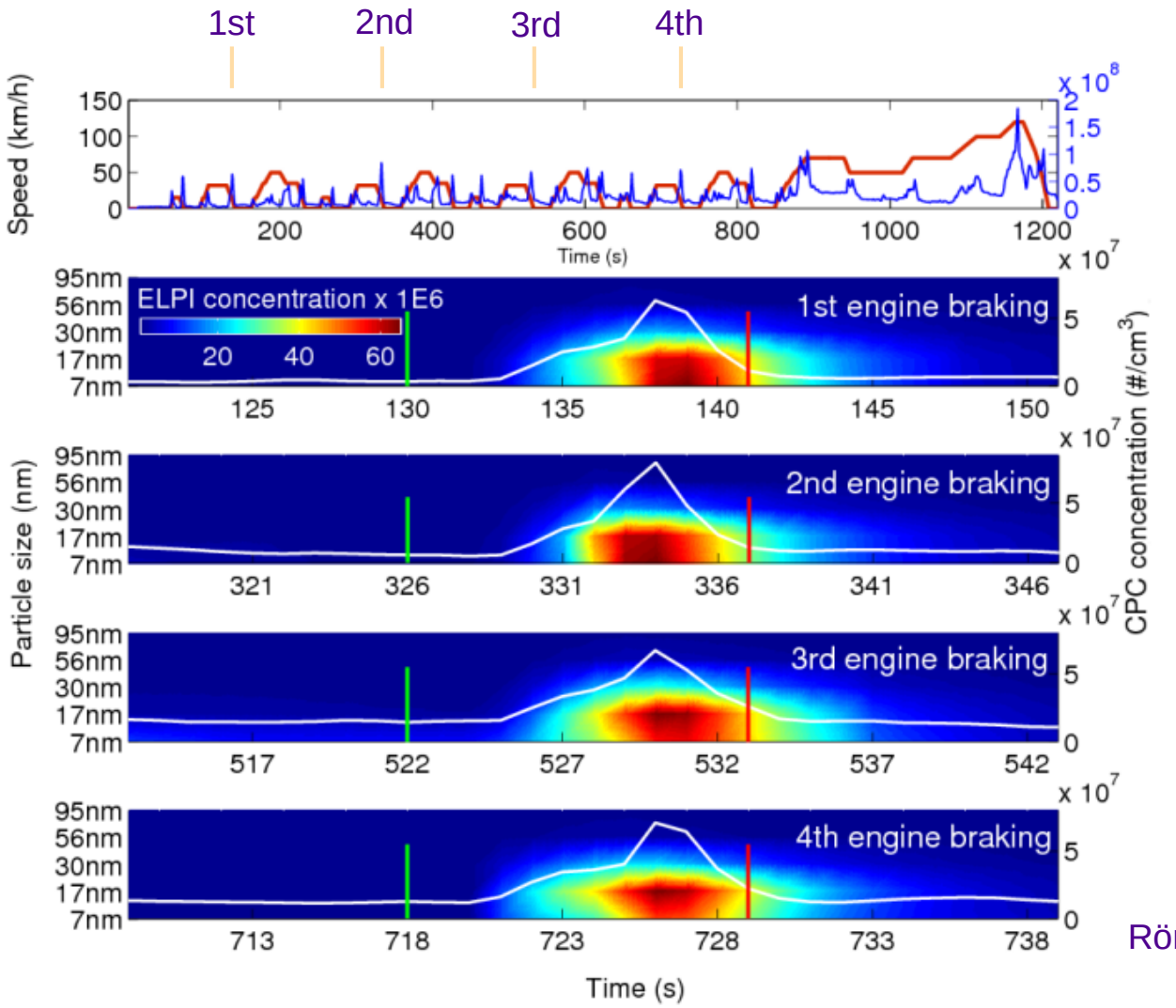


High volume concentration associated with soot mode

Karjalainen et al. 2016

Vehicles emit exhaust particles also during deceleration

GDI car
E10 gasoline
NEDC



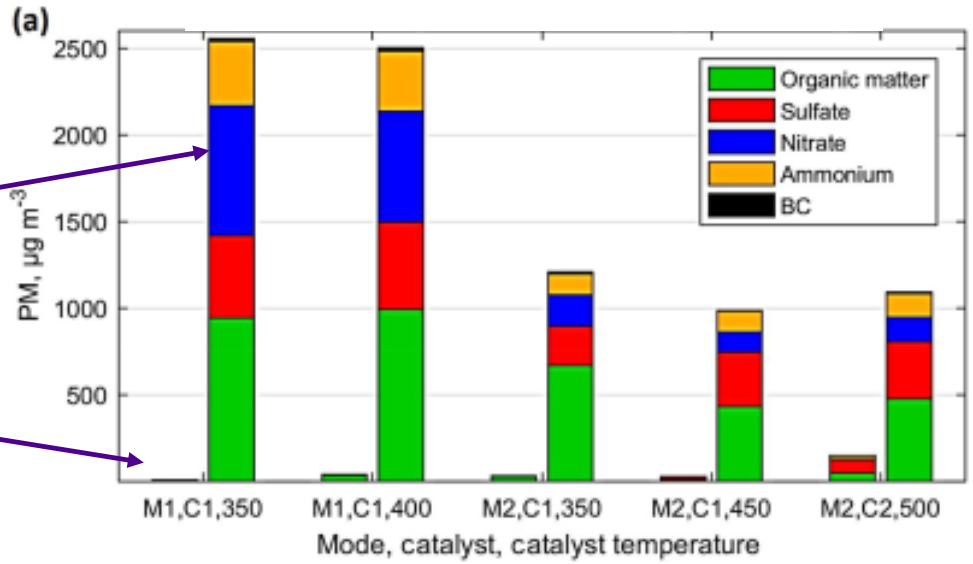
Rönkkö et al. 2013

Aged exhaust aerosol

Comparison of fresh and aged exhaust aerosols, natural gas engine

Aged exhaust

Fresh exhaust



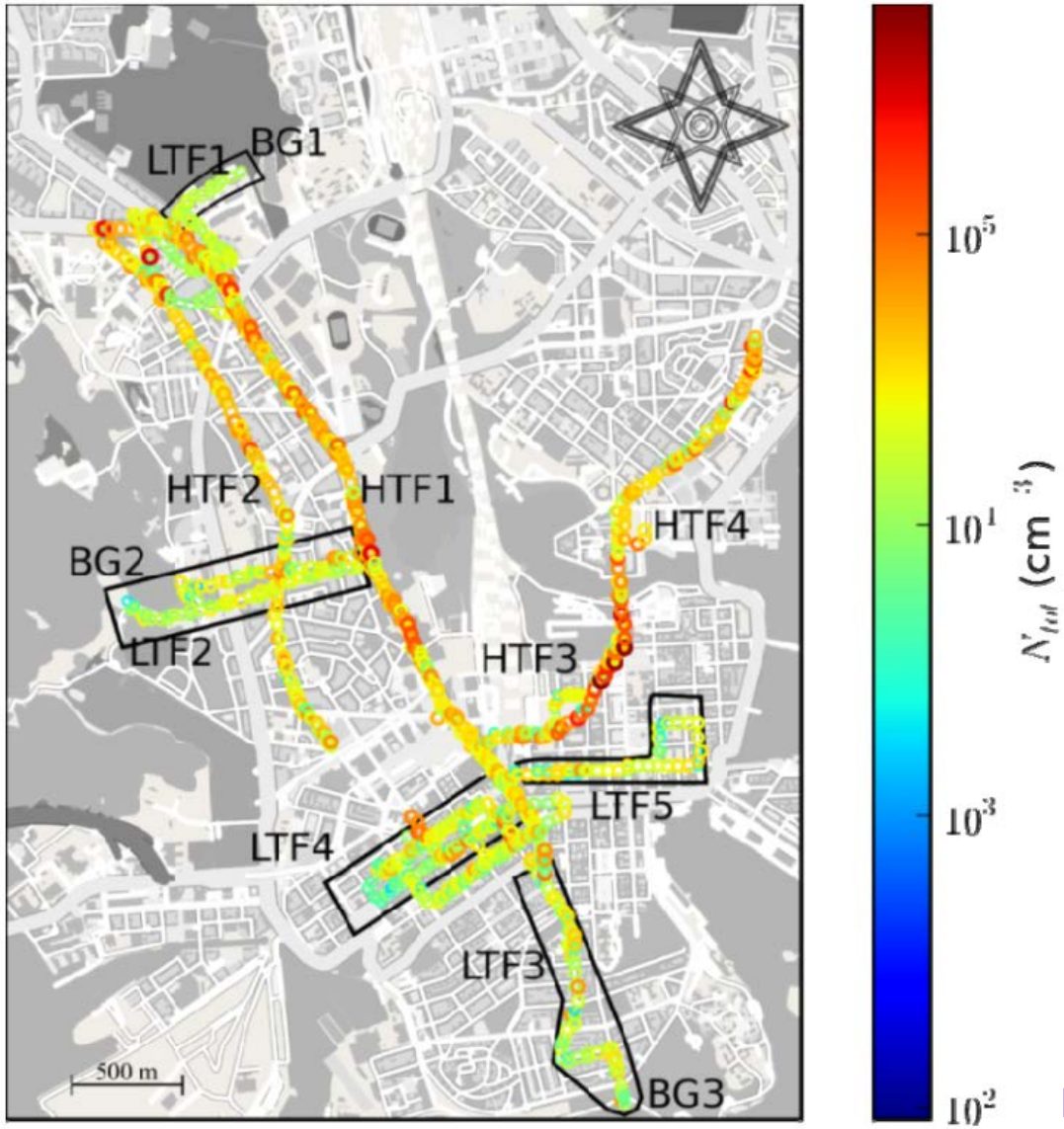
Low emissions levels

Huge difference between fresh and aged exhaust aerosol concentrations

Alanen et al. 2017

Ambient aerosol in traffic environments

Mobile laboratory study in Helsinki



High particle numbers in environments affected by traffic

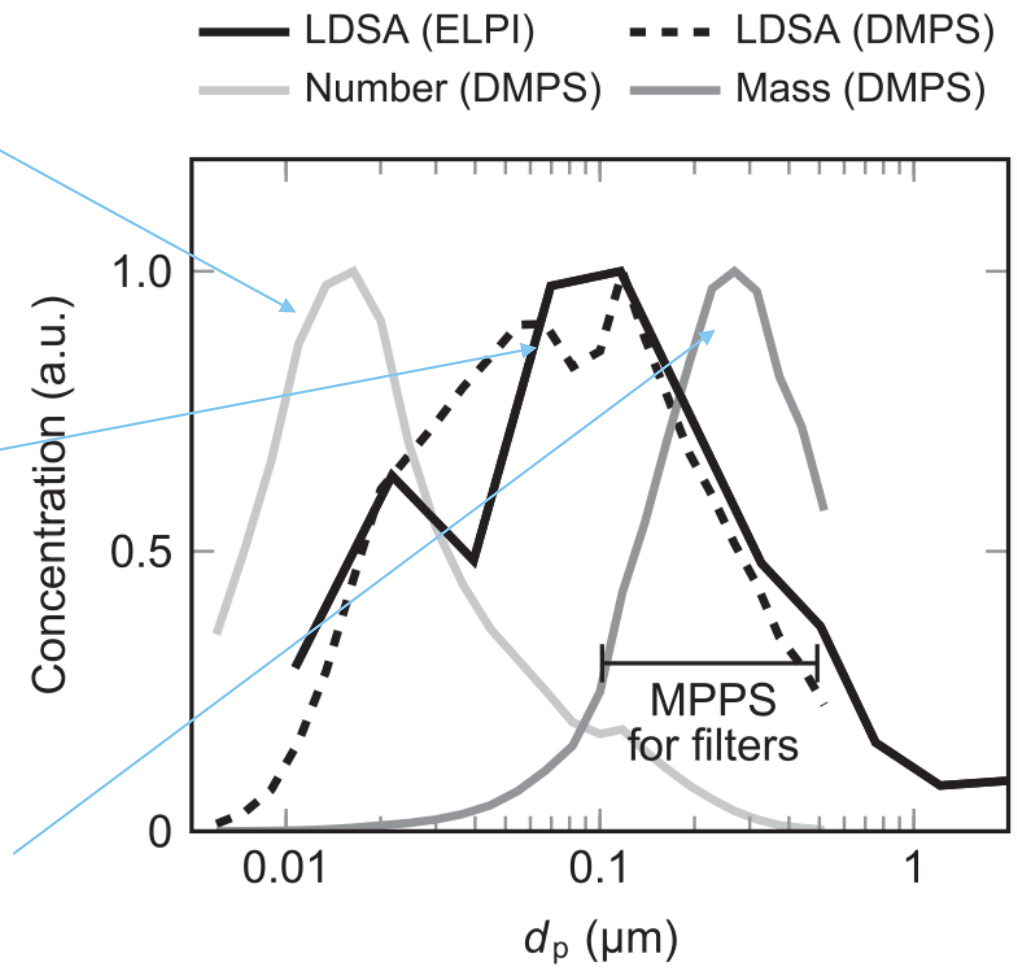
Lähde et al., 2014

Particle size distributions in traffic environments

Small, sub 30 nm particles dominate the number concentration

100 nm is important diameter in respect of lung deposited surface area (LDSA) of particles.

Particulate mass is dominated by particles larger than 100 nm.

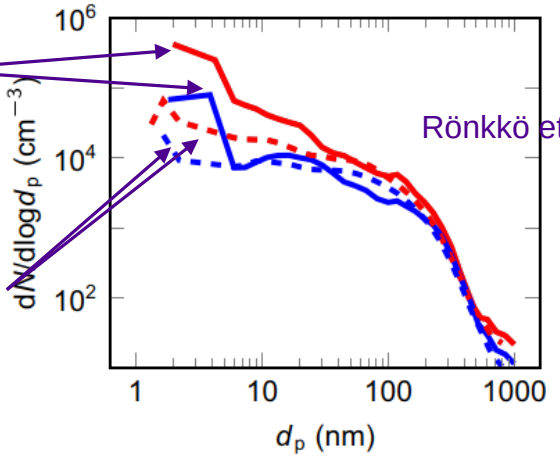


Kuuluvainen et al., 2016

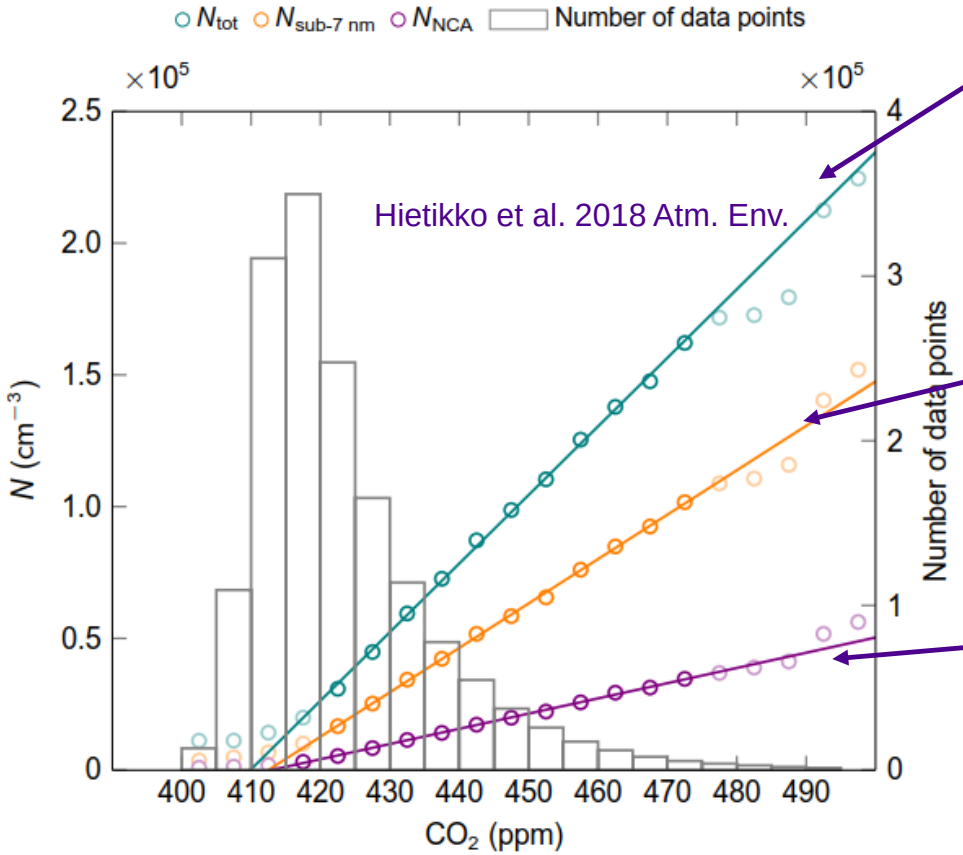
Nanoclusters and determination of particle emission factors of traffic

Road

Urban background



Rönkkö et al., PNAS, 2017



4,22 · 10^{15} particles / kg fuel

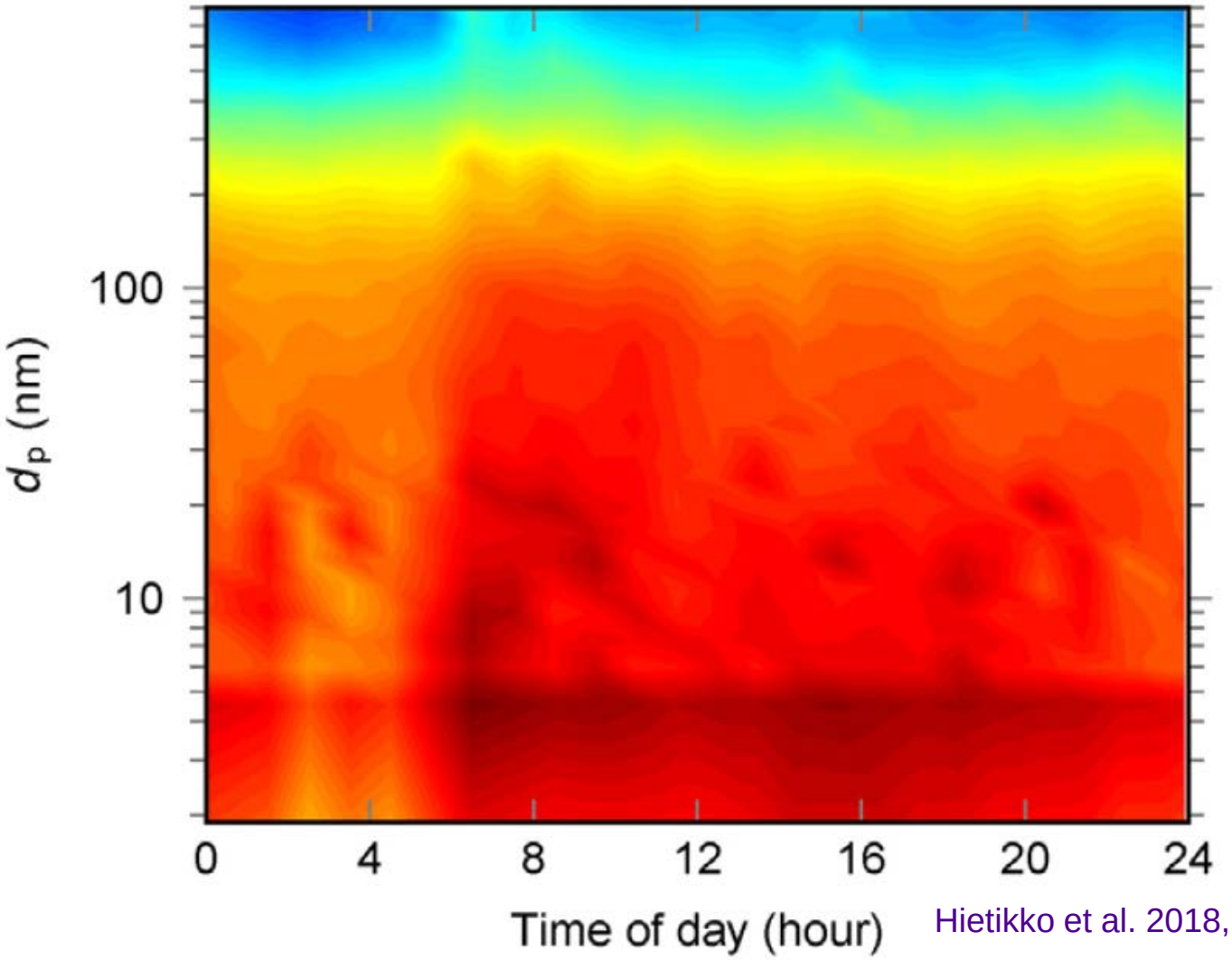
2,73 · 10^{15} sub-7 nm particles / kg fuel

9,36 · 10^{14} sub-3 nm particles / kg fuel

Diurnal variation of particle number size distribution

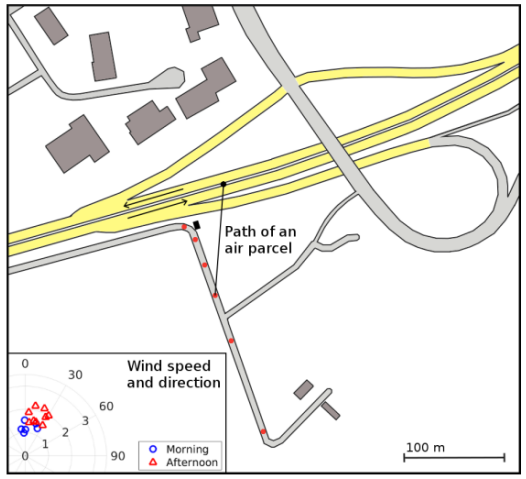
Particle number size distribution in Mäkelänkatu when wind was blowing from road to monitoring station.

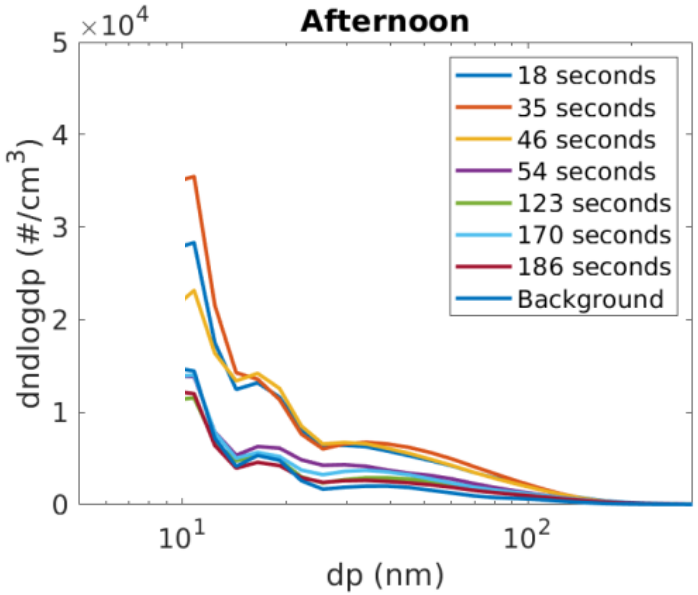
Weekdays, April 2017.

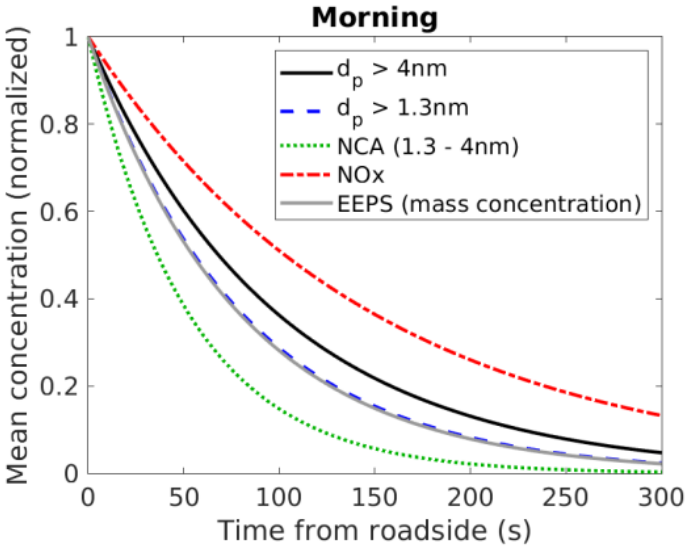


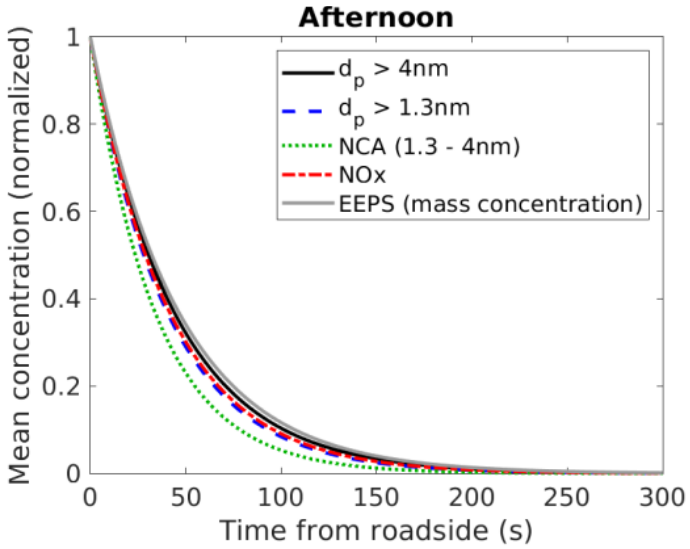
Hietikko et al. 2018, Atm Env

Dispersion of particles in traffic environment



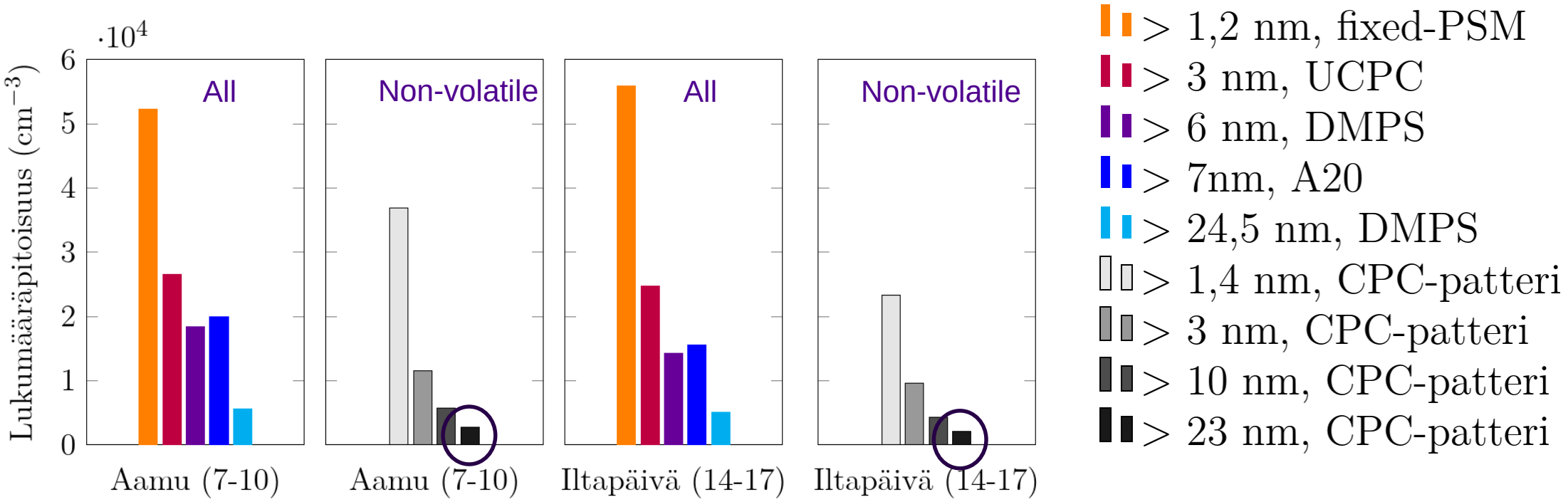






Kangasniemi et al.,
submitted to Atmosphere

Particle number concentrations in street canyon

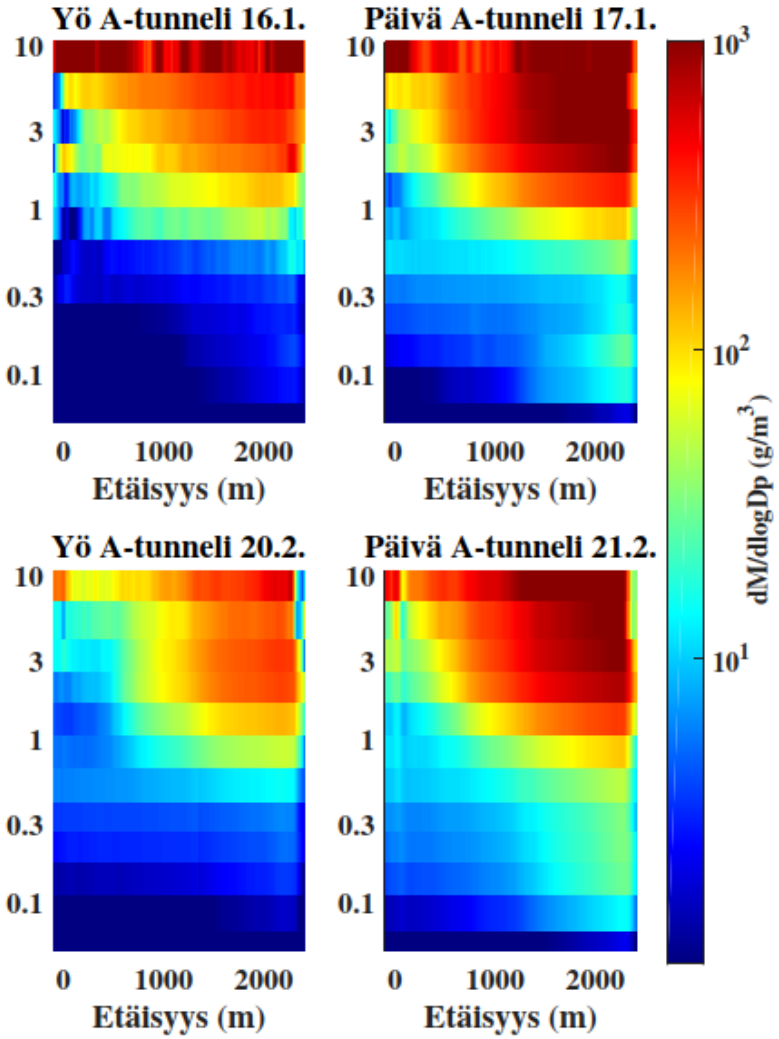


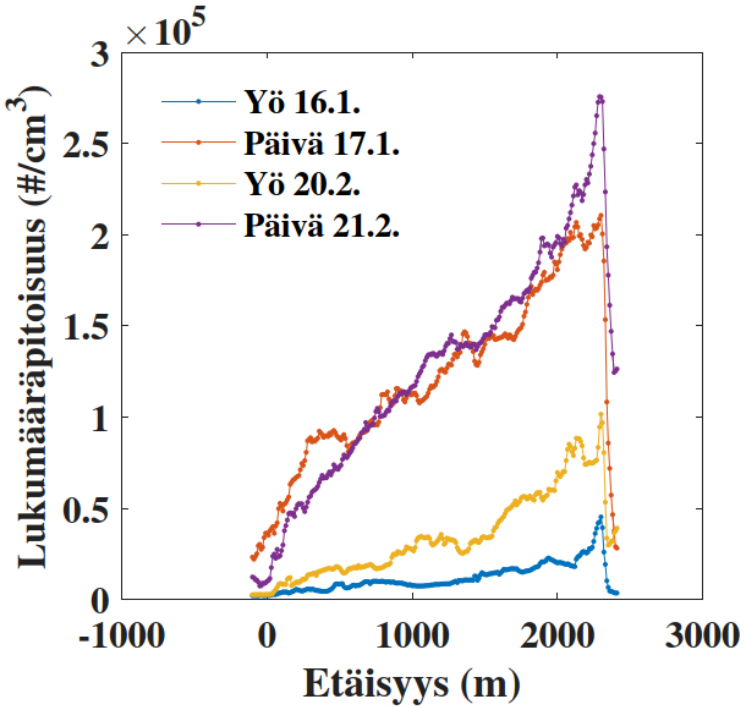
Measured in April-May, 2018

Henna Lintusaari, Diplomityö, 2019

Particles in traffic tunnel

Wintertime particle mass size distributions in Rantatunneli.





Number concentrations of particles larger than 1.2 nm in Rantatunneli, Tampere

Joni Heikkilä, Diplomityö, 2019

Deposition of particles in respiratory tracts

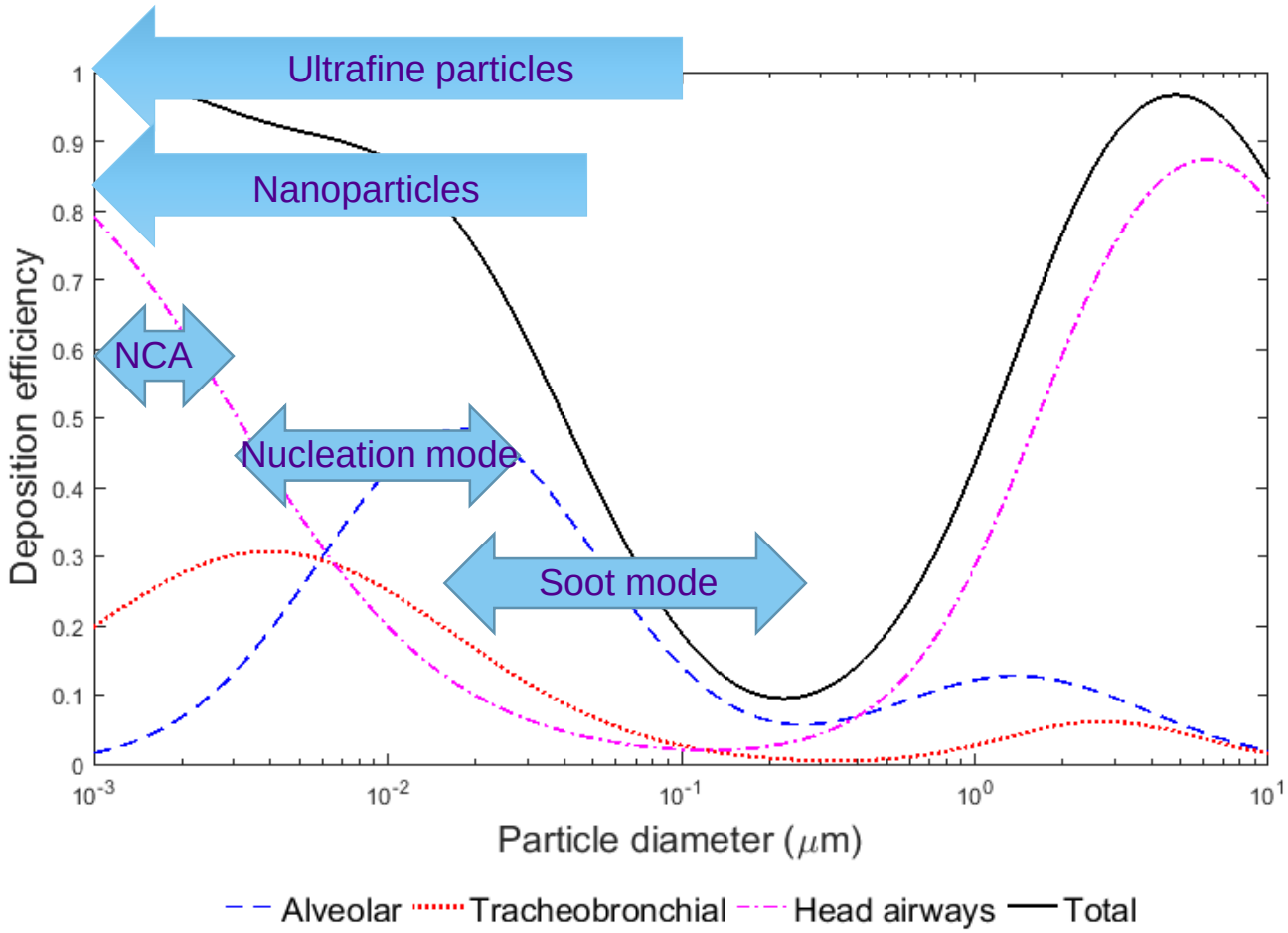


Figure: Teemu Lepistö

Summary

- Exhaust aerosol is a complex mixture of particles and gases
- Exhaust aerosol tranforms during its life cycle
  - Formation of new particles, condensation of semi-volatile compounds; changes of particle size distribution, chemical composition, and volatility
- To monitor particle number, take following into account:
  - Measurement location?
  - Particle size range to be measured, and sampling to be used?
  - Time resolution?
  - All particles or non-volatile fraction only?
  - Trace gas measurements?

Thank you for your attention!

topi.ronkko@tuni.fi

All collaborators and co-authors of following studies are acknowledged:

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