Ultrafine Particles: What Progress Have We Made and What Questions Remain?

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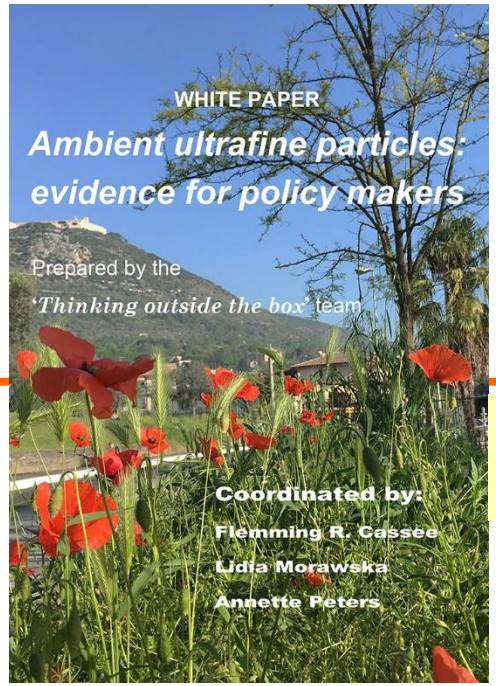

The Team: Thinking outside the box

Ambient ultrafine particle: evidence for policy makers. White paper. Pfintal, Germany: **European Federation of Clean Air and Environmental Protection Associations: 2019** (https://efca.net/files/WHITE%20PAPER-UFP%20evidence%20for%20policy%20makers%20(25%20OCT).pdf,.

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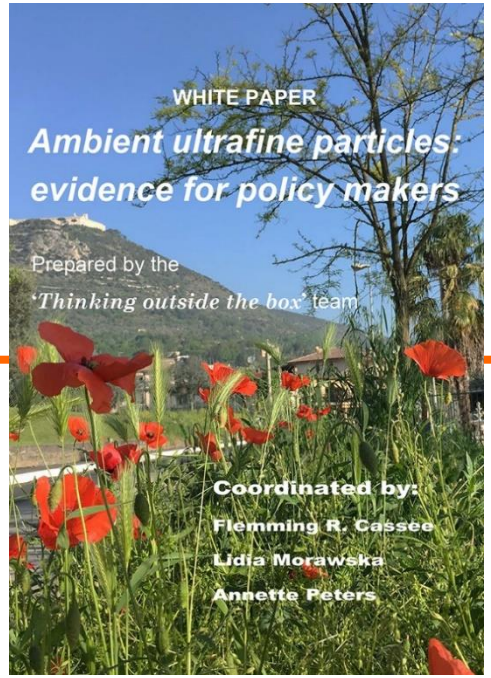
Recommendations: EXPOSURE



Progress:

Recommendations 1, 2 and 3

Future:

Recommendations 4 and 5

Recommendation 1

Recommendation to quantify ambient **quasi-UFP** in terms of particle number concertation (PNC) in a range at least down to 10 nm, with no restriction on the upper limit

From toxicology: For practical reasons, using particle number as a predictor may be preferred above mass and surface area, especially if the particle size distribution is known

Significance

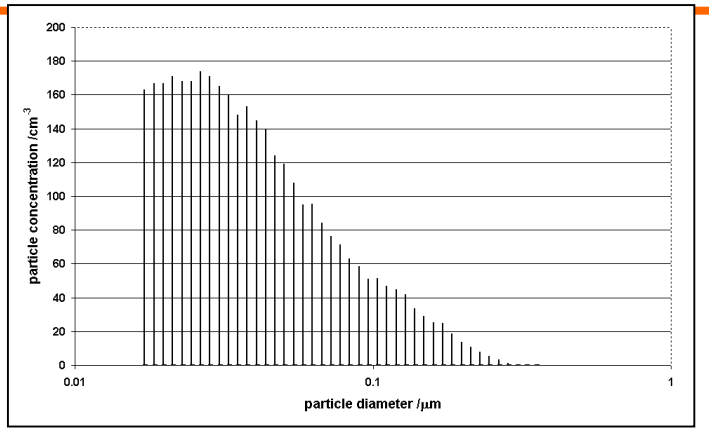
This is an essential criterion for:

- Design of exposure/epi studies
- Carrying out the meta analysis

Background 1a

ISO/TC 146/SC 2/WG1 N 320 defines:

…an **ultrafine particle** as "*A particle sized about 100 nm in diameter or less*"



1. The recommendation means that SMPS and CPC data can be used

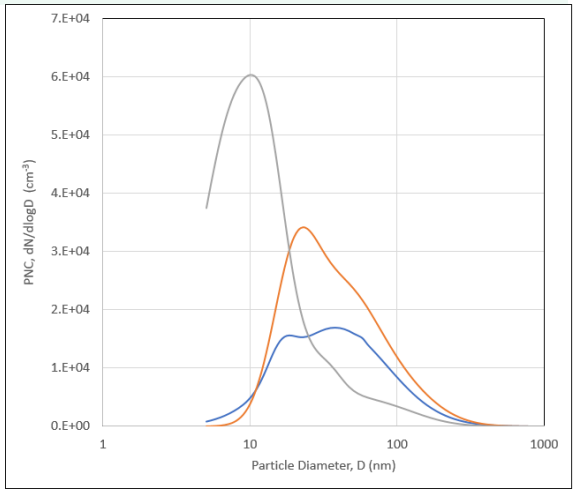
2. An error/uncertainly due to missing the first few nm:
- Could be calculated/corrected for lower size limit up to 10 nm.
- Negligible for lower size limit less than 5-6 nm

Background 1b

The impact of the lower cut off

Number of particles < 10 nm

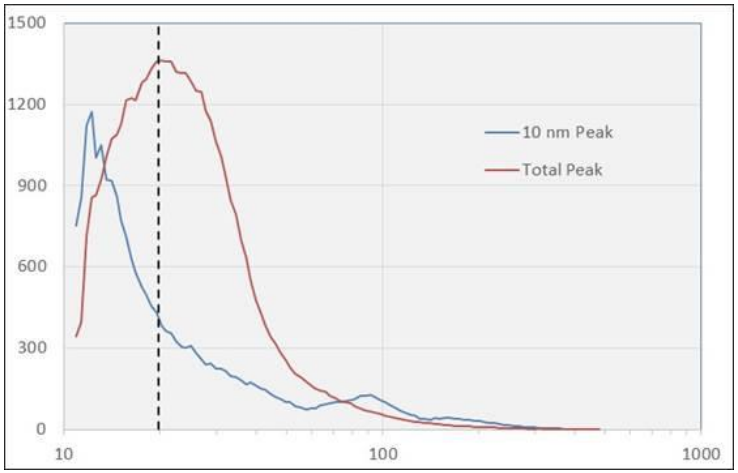
- Morning traffic: ~ 1% (orange)
- During the day: about 4% (blue)
- During NPF: higher (grey)



Number of particles < 20 nm

Initial stages of NPF -blue curve) ⇨ 65%

Fully developed NPF-red curve) ⇨ 42%



Recommendation 2

The following daily (24 hours) mean PNC can be considered as *typical*, based on the scientific literature:

- Clean environments < 10^3 particles cm^{-3}
  (not affected by anthropogenic emissions)
- Urban background < 10^4 particles cm^{-3}

In *typical* clean urban microenvironments hourly mean concentrations < $2x10^4$ particles cm^{-3}

The uncertainty in the calibration of PNC measuring instruments varies:
~ 30% for < 10^3 particles cm^{-3}
~ 10% for ~10^4 particles cm^{-3} (typical urban background concentrations)

Significance

At the moment that are no reference or guideline values for exposure to UFP

"… *the existing body of epidemiological evidence is insufficient to conclude on exposure/response relationship to UFP*". (WHO 2005)

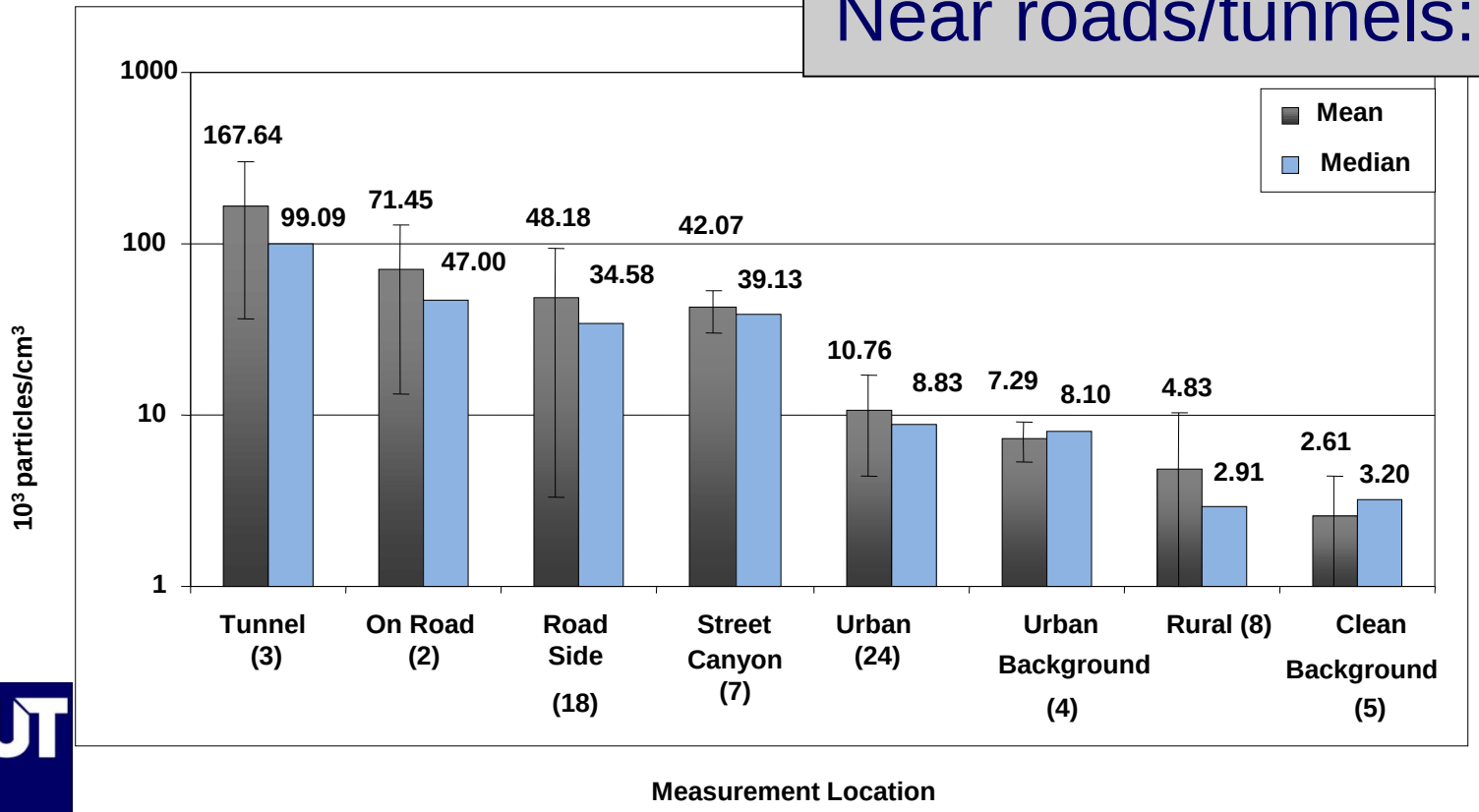
Typical values can serve as a comparative reference

Background 2a

Clean environments: < 10^3

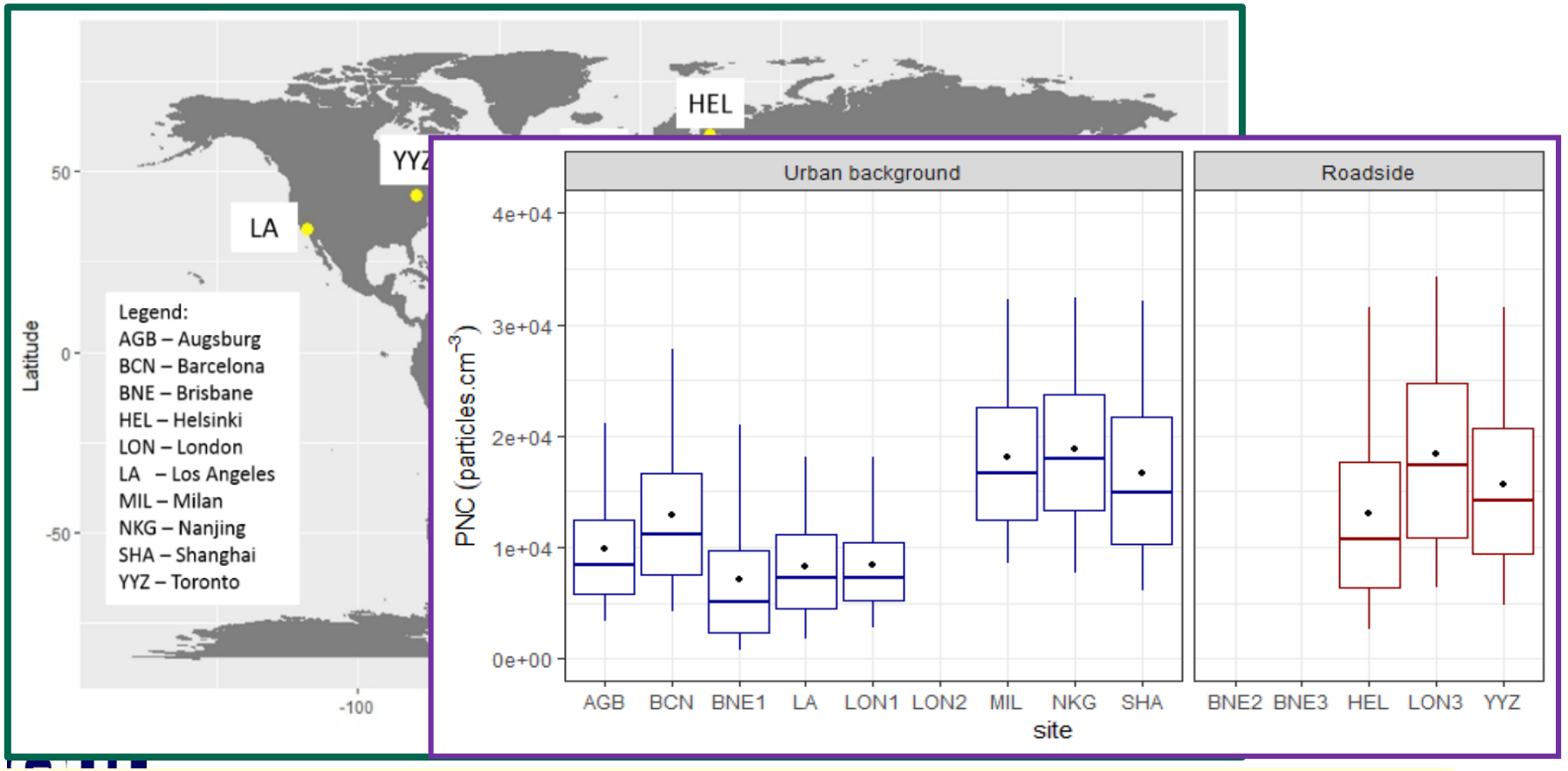
Urban background: ~ 10^4

Near roads/tunnels: > 10^5



Morawska, et al. *Atmospheric Environment,* 42: 8113-8138, 2008

Background 2b



De Jesus et al. *Ultrafine particles and $PM_{2.5}$ in the air of cities around the world: how similar or different are their drivers?* *Environment International, 129, 118-135, 2019*

Recommendation 3

The following should not be used as proxies of UFP:

- $PM_{2.5}$
- CO
- NO_x
- BC

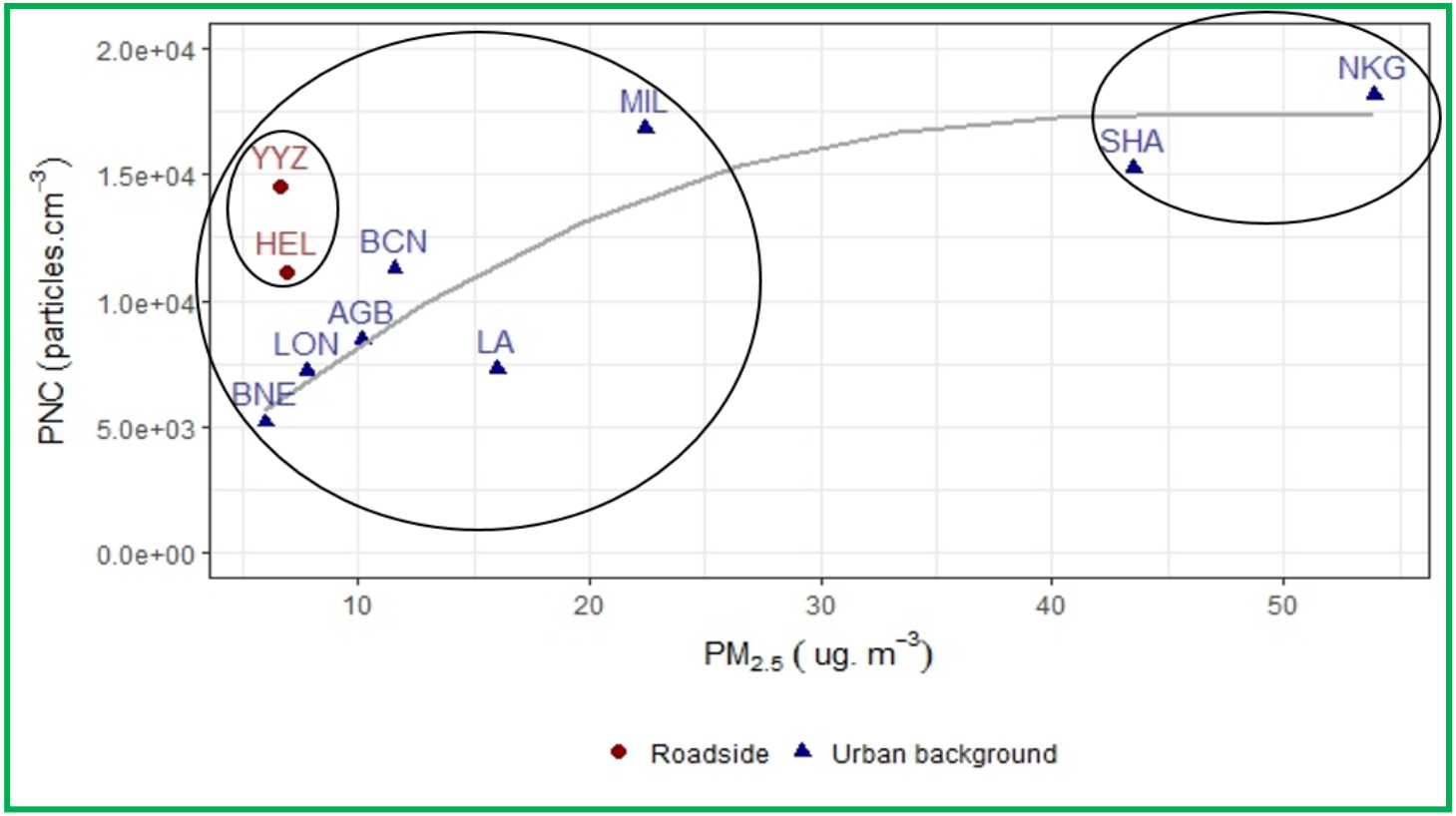
Significance

Using other pollutants as proxies of exposure to UFP leads to exposure misclassification

Very little/no relationship between PNC and $PM_{2.5}$

The existence/degree of the relationship between PNC and traffic emitted gases and BC vary ➔ specific to the environment

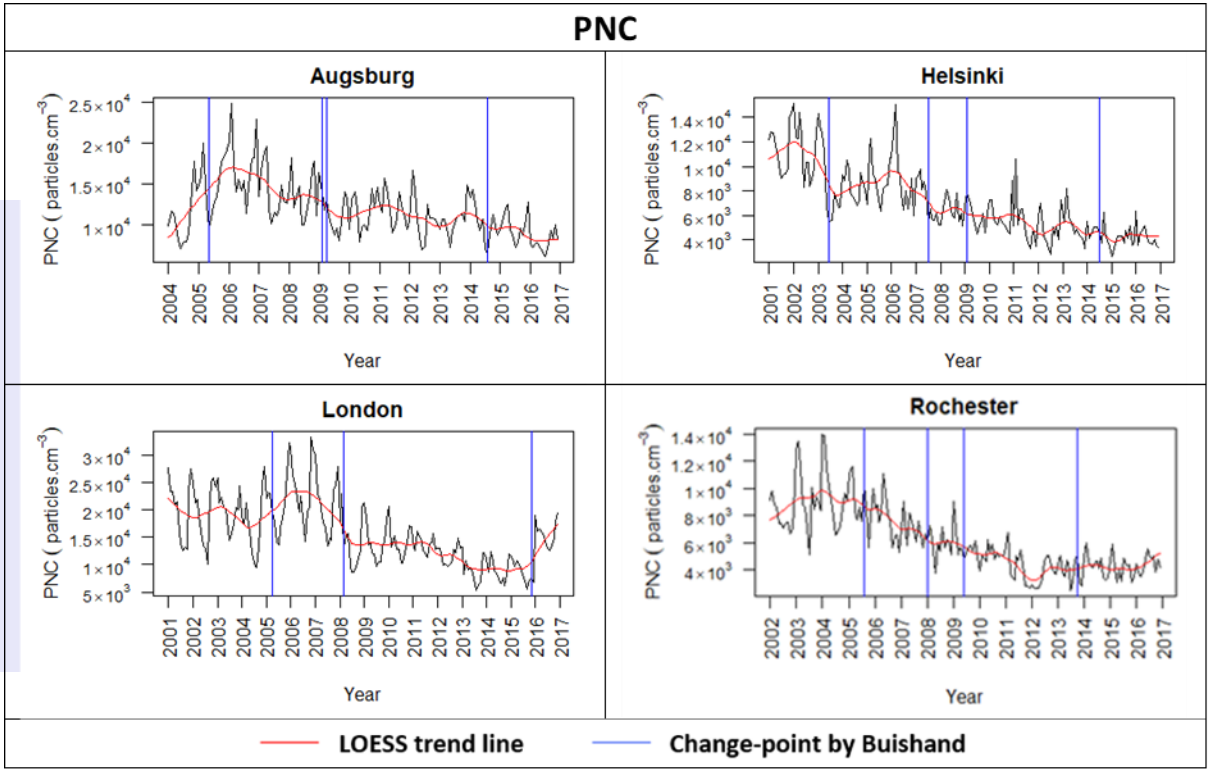
Background 3a



•De Jesus et al. *Ultrafine particles and $PM_{2.5}$ in the air of cities around the world: how similar or different are their drivers?* *Environment International, 129, 118-135, 2019*

Background 3b

- PNC decreased in all cities
- $PM_{2.5}$ to lesser extend
- The years in which the reduction in concentration occurred do not coincide for $PM_{2.5}$ and PNC



De Jesus at al., *Long-term trends in PM2.5 mass and particle number concentrations in urban air: the impacts of mitigation measures and changing climates*. Env Pollution, 263, 114500. doi:10.1016/j.envpol.2020.114500

Recommendation 4

Regulatory air quality monitoring strategy should be extended by integration of UFP for reporting purposes

Parameters monitored should allow quantification and characterization of **primary versus secondary** particles and their source contribution

Background 4

Fig. 1. Geographical location of the three study areas (Barcelona, Huelva, and Santa Cruz de Tenerife).

N = N1 + N2

total

secondary

low BC

primary + nucleating immediately after emission

correlated with BC

- Mean UFP concentration similar in all 3 cities
- BC higher in Barcelona and Tenerife
- Association with daily mortality:
  - In Barcelona and Tenerife with N1
  - In Huelva with N2 *(none were significant)*

Tobias et al,. *Short-term effects of ultrafine particles on daily mortality by primary vehicle exhaust versus secondary origin in three Spanish cities*. Env. International, 111 (2018) 144-151.

Recommendation 5

Efforts should be stepped up to utilize the emerging science and technology to advance approaches to the assessment of exposure to UFP for application in epidemiological studies and management.

- Modelling tools
- Increasing the number of monitors
- Utilise mobile platforms

Not outside of the box yet, but on the way!

Thank you!

Thinking outside the box team, Munich, Germany, February 2019