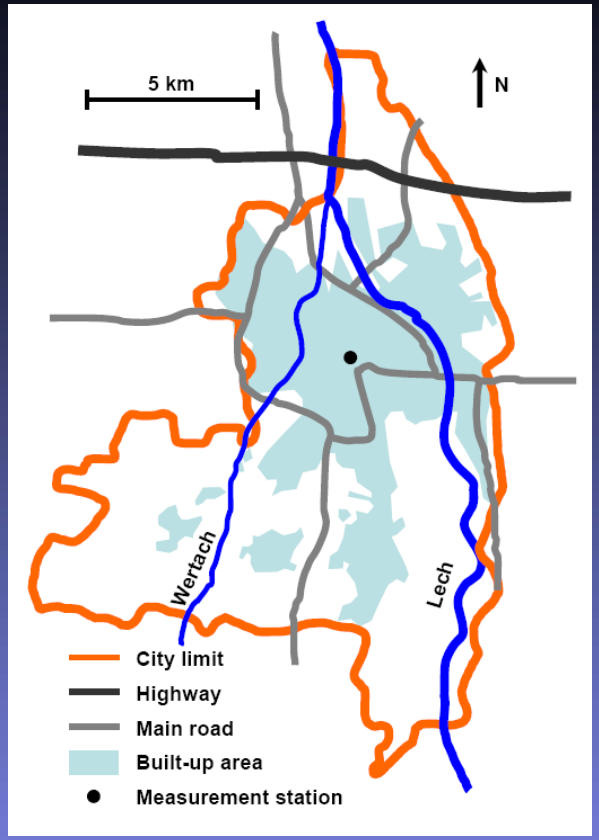
Can we use fixed ambient air monitors to estimate exposure to ultrafine particles?



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International Conference in Dresden "Ultrafine Particles in Urban Air"
October 23-24, 2007

Institute of Epidemiology

Two conclusions coming from recently published papers

- The limited data available (on exposure to ultrafine particles) suggest that central monitoring site may give a somewhat worse proxy for human exposure to ultrafine particles than to fine particles (Pekkanen et al., 2004).

- Exposure assessment for ultrafine particles is still in its initial stage compared to exposure assessment for $PM_{2.5}$ or PM_{10} (Pusstinen et al., 2007).

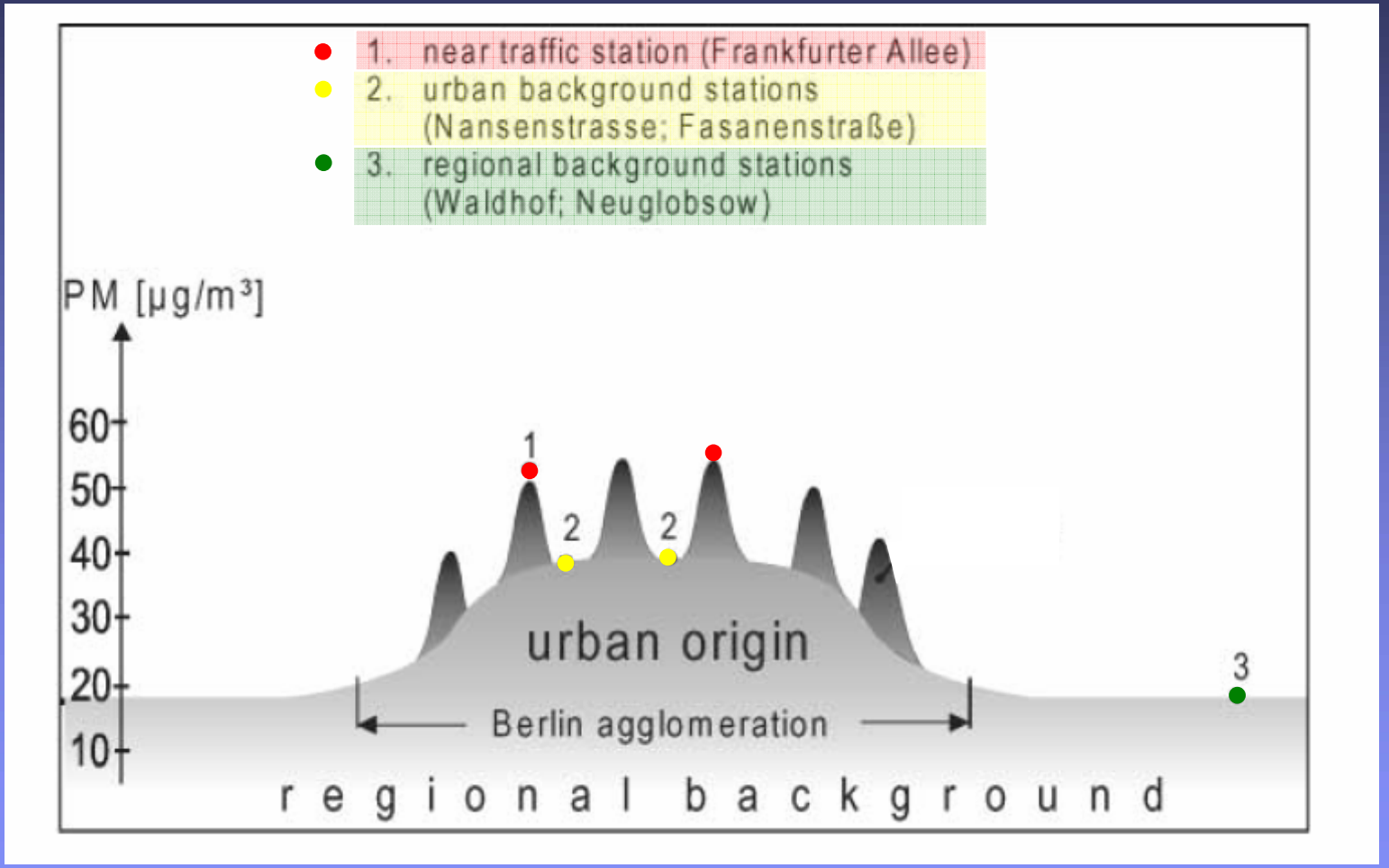
Characteristics of ultrafine particles vs. fine particles ($PM_{2.5}/PM_{10}$)

Fine particles	Ultrafine particles (UFP)
Dominated by long-range transport	Mostly produced by local sources (traffic)
Have lifetimes in the order of days and are transported over long distances	Are rather unstable in the atmosphere and coagulate quickly
Very high temporal correlation and rather small spatial variability across an urban area	UFP are supposed to have a larger spatial and lower temporal variability than fine particles (Monn, 2001, Pekkanen and Kulmala, 2004)
Numerous studies with regard to the temporal and spatial variability of particle mass concentration	Studies on temporal and spatial variability of particle number concentration are rare

Outline

- Exposure assessment using a central monitoring site - some general remarks
- Temporal and spatial variability of ultrafine particles across a city area – results from different studies

Schematic horizontal profile of the ambient particles levels



Lenschow et al., 2001

Criteria on the location of the sampling sites (EU 1996, EU 1999)

Sampling sites directed to the protection of human health should be located:

- closed to the hot spots (where the highest concentrations are expected)
- at urban background (in areas which are representative for the general population)

The inlet sampling point should be between 1.5 m (the breathing zone) and 4 m above the ground

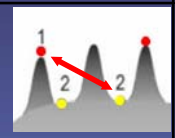
Dresden Nord

Augsburg

Outline

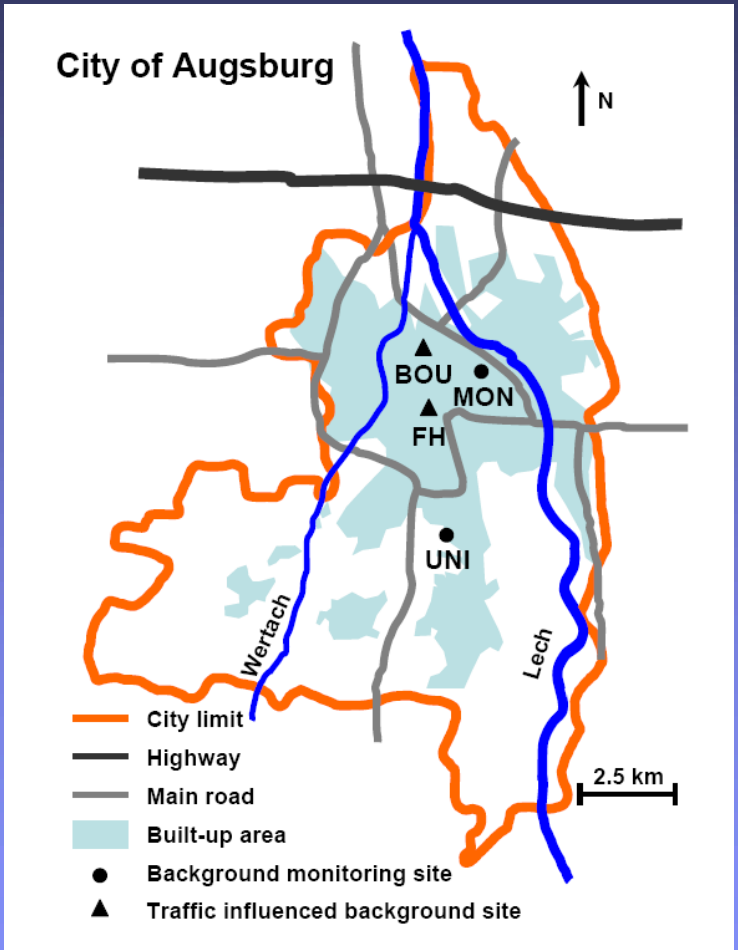
- Exposure assessment using a central monitoring site - some general remarks
- Temporal and spatial variability of ultrafine particles across a city area – results from different studies

Spatial and temporal variation of PNC – current knowledge

Buzorius et al. (1999)	Tuch et al. (2006)
Helsinki 	Leipzig 
Three sites in the vicinity of major roads, one site 22 km north-west of the city center	Two sites (one background and one traffic site (street canyon))
Correlation coefficients: 0.60 - 0.88	Correlation coefficients: 0.35 - 0.46
Highest correlations between the sites mostly affected by traffic (>0.80)	The background site was on a roof about 16 m above the ground

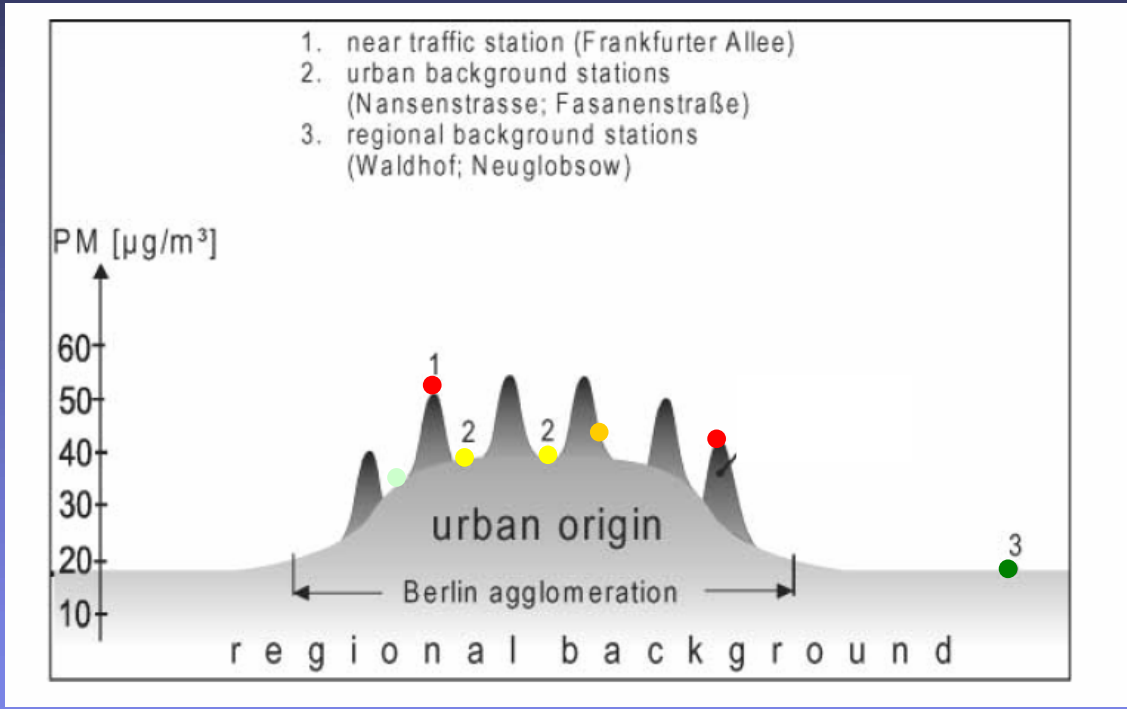
Spatial and temporal variation of PNC at fixed monitoring sites (Augsburg)

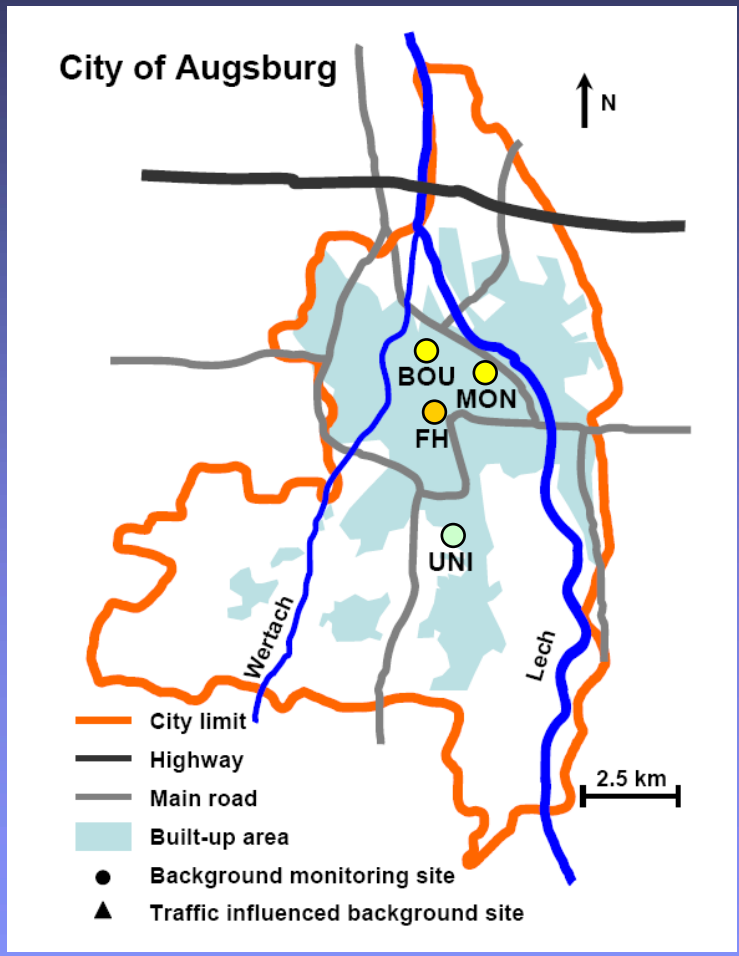
- Two sampling periods:
  1) winter period:
     Dec 2 to Dec 12, 2003
  2) spring period:
     Apr 5 to May 12, 2004
- Four background sites (bs):
  FH, MON, BOU, UNI
- PNC measured by CPC



Cyrys et al., submitted

Spatial and temporal variation of PNC at fixed monitoring sites (Augsburg)





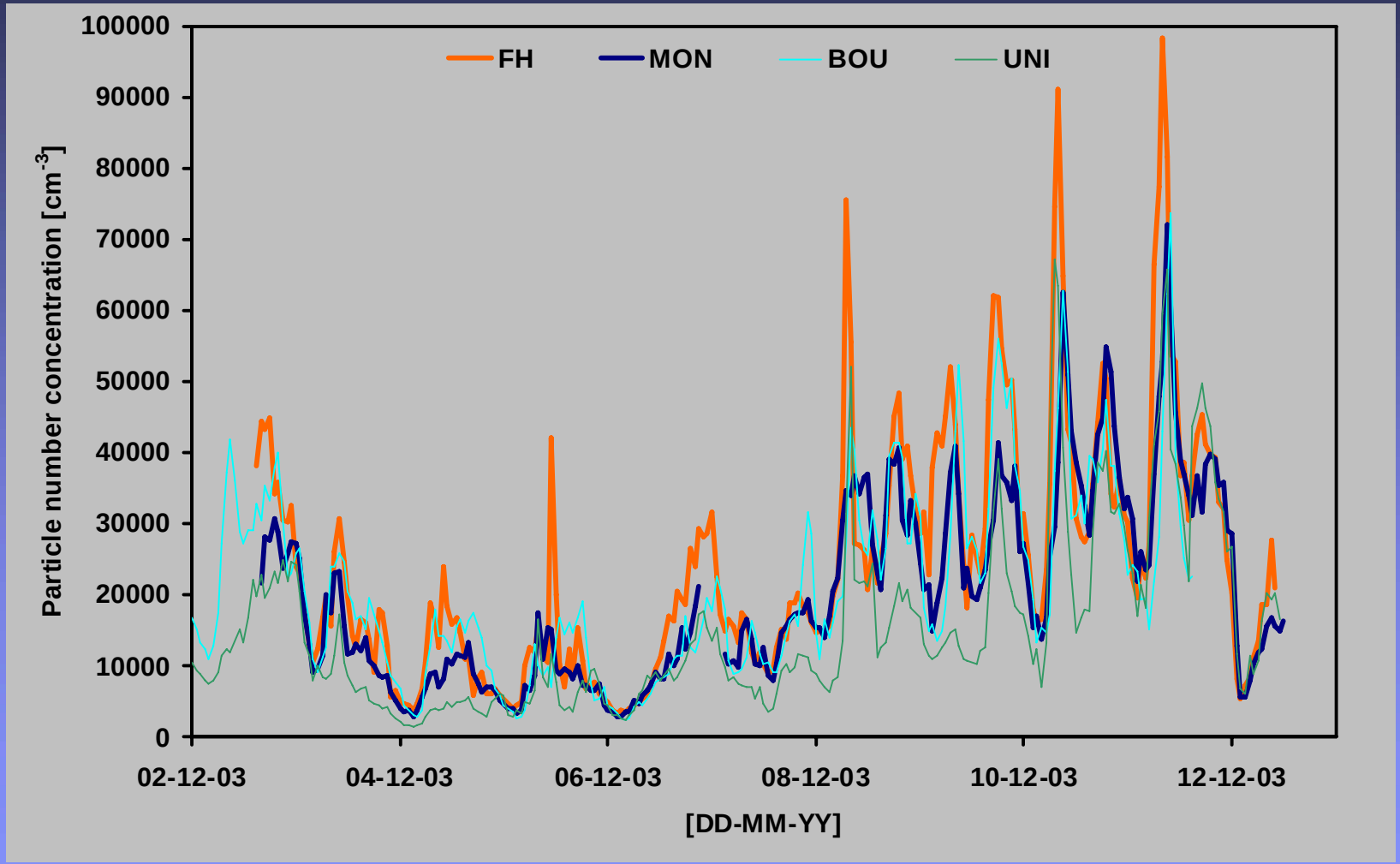
FH: traffic influenced urban bs

MON, BOU: urban bs

UNI: suburban bs

Cyrys et al., submitted

PNC at different monitoring sites during the winter period



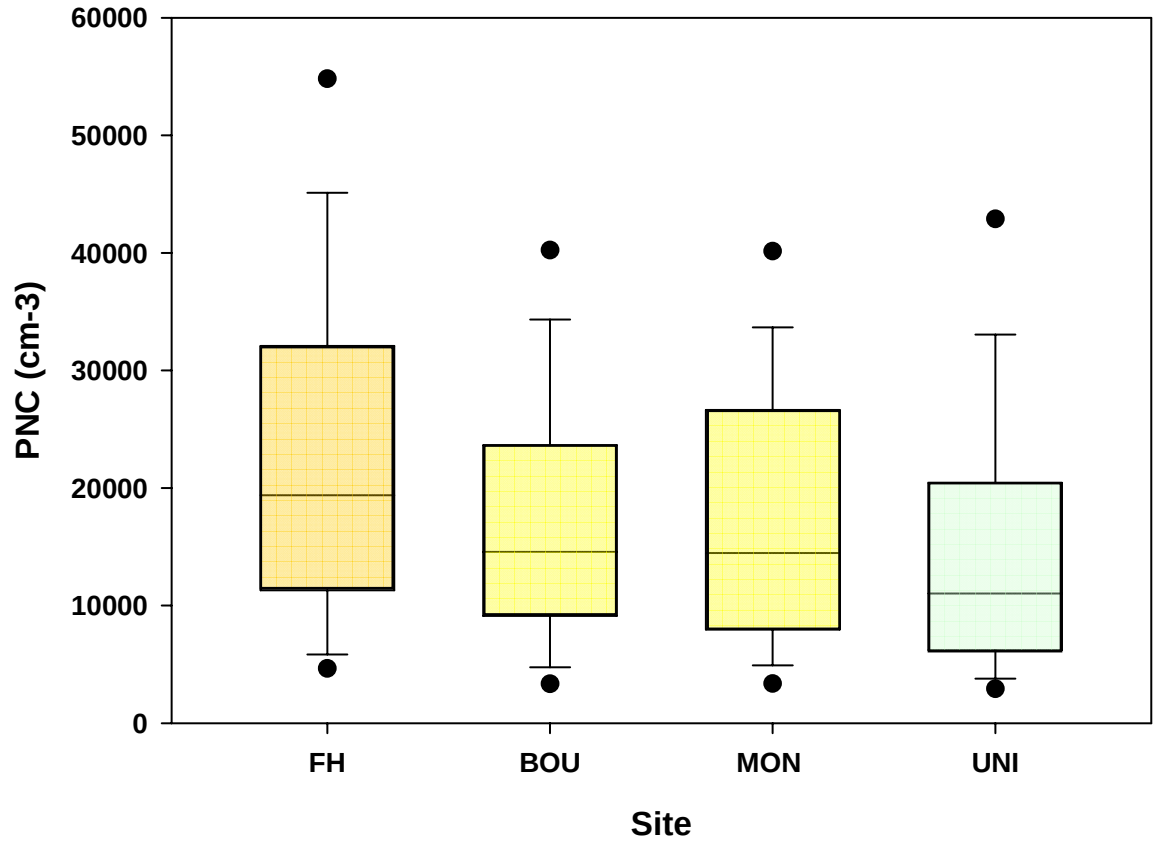
Cyrys et al., submitted

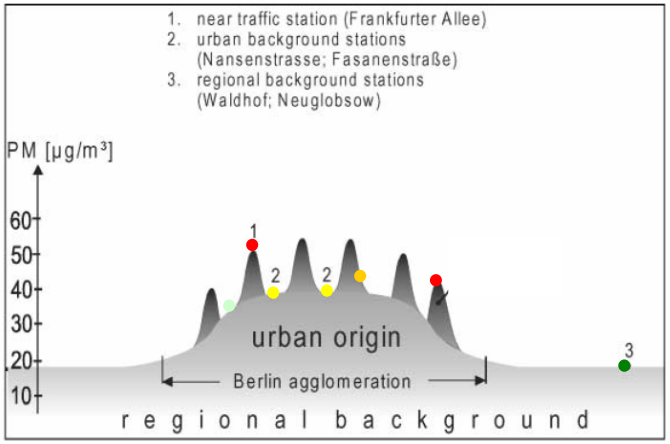
Temporal variability of PNC in Augsburg (winter period)

	MON	FH	BOU	UNI
MON	1	0.92 n=227	0.89 n=239	0.91 n=228
FH	*0.93* *n=9*	*1*	*0.84* *n=236*	0.88 n=236
BOU	*0.89* *n=10*	*0.87* *n=9*	*1*	0.77 n=252
UNI	*1.00* *n=9*	*0.95* *n=9*	*0.89* *n=10*	1

Cyrys et al., submitted

Spatial variability of PNC in Augsburg (winter period)





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Cyrys et al., submitted

RUPIOH study

Relationship between Ultrafine and fine Particulate matter in Indoor and Outdoor air and respiratory Health

- Four cities: Amsterdam, Athens, Birmingham and Helsinki
- In each city:
  - continuously measurements at a central monitoring site
  - additional measurements in and directly outside approx. 35 homes
  - only in one home simultaneously

Map of the study area: Amsterdam

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Puustinen et al., October 2007

RUPIOH study: spatial and temporal variation

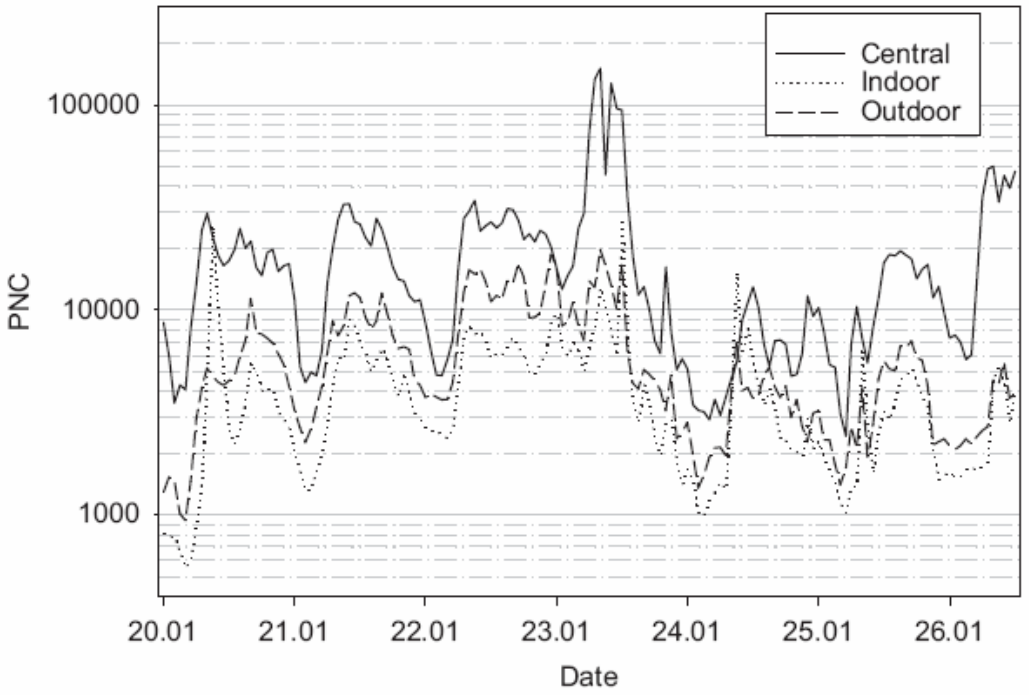
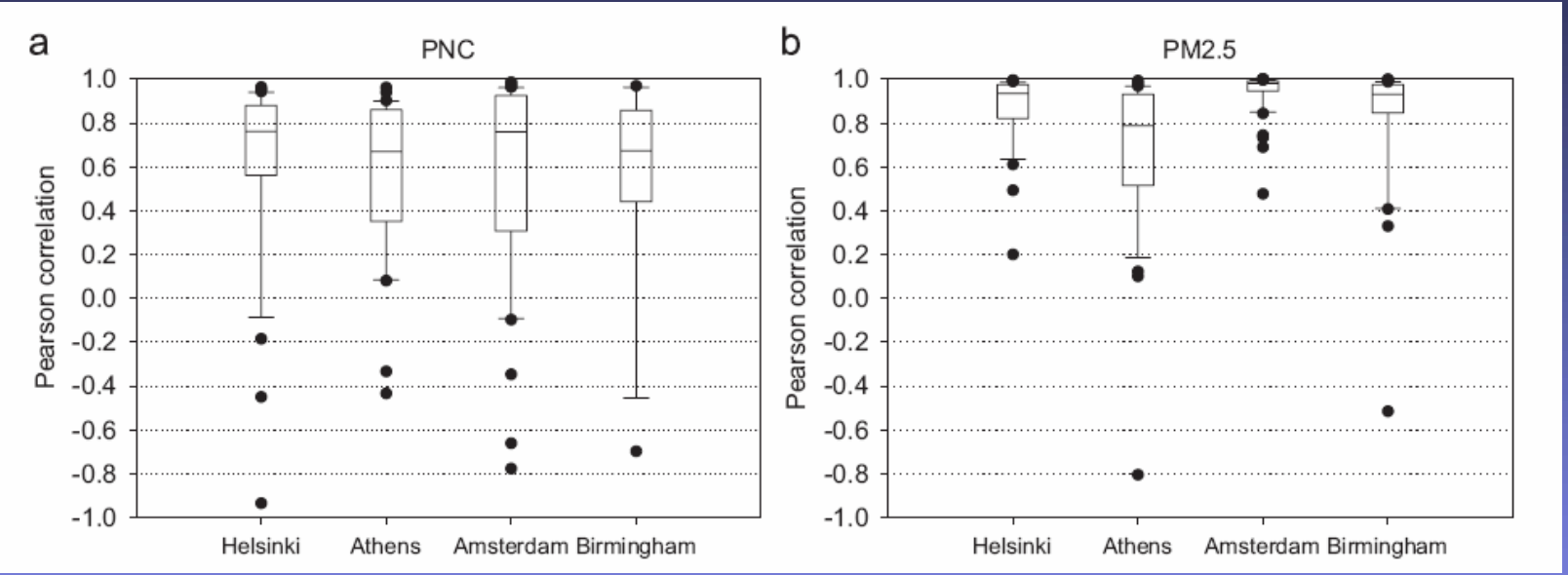


Fig. 2. Example of PNC hourly concentrations in study outdoor site ID 49 for 1 week, in indoor, outdoor and central site. ID 49 was in Helsinki, an urban background site, measured during 20.01–26.01.2004. The residential outdoor/central site correlation was 0.89 and the ratio 0.37.

Puustinen et al., 2007

RUPIOH study: temporal variation



	Helsinki	Athens	Amsterdam	Birmingham
Number of homes	37	35	50	30
Study period	28.10.2002–23.02.2004	23.10.2002–25.03.2004	16.10.2002–23.02.2004	4.11.2002–10.03.2004
Inhabitants metropolitan area (10^6)	1.0	3.2	1.1	2.6
Area (km^2)	745	440	324	902
Population density (km^{-2})	1342	7628	3398	2882
Distance homes to central site (km)[a]	7.6 (2.5–34)	6 (0.7–18.8)	3.3 (0.3–9.5)	7.0 (0.9–29.7)
City centre sites[b]	6 (16%)	9 (26%)	31 (62%)	1 (3%)
Site type[b]				
Background	32 (87%)	22 (63%)	28 (56%)	23 (77%)
Traffic	5 (13%)	13 (37%)	22 (44%)	7 (23%)
Traffic intensity (vehicles per day)[a]	952 (100–8 974)	5046 (100–44 000)	6062 (100–23 446)	2866 (100–19 821)
Canyon street[b]	3 (8%)	11 (31%)	12 (24%)	2 (7%)
Sampling height (m)[a]	3 (0–35)	6 (0–23)	5 (2–25)	2 (2–6)

Puustinen et al., 2007

RUPIOH study: spatial variation

Table 2
Median of ambient particulate air pollution concentrations at central and residential sites in four European cities (October 2002–March 2004)

Pollutant	Location	Helsinki	Athens	Amsterdam	Birmingham
PNC (cm^{-3})	Central	12 490	20 276	18 090	18 787
	Residential	4507	15 234	26 346	16 109
$PM_{2.5}$ ($\mu g\ m^{-3}$)	Central	7.5	22.6	16.5	8.7
	Residential	8.3	20.6	17.6	10.2
PM_{10} ($\mu g\ m^{-3}$)	Central	13.1	51.7	26.9	17.1
	Residential	12.3	46.0	29.9	17.2
PM_{10}–$PM_{2.5}$ ($\mu g\ m^{-3}$)	Central	4.5	28.8	9.4	6.8
	Residential	3.6	23.2	10.9	7.6
Soot ($10^{-5} m^{-1}$)	Central	1.3	3.5	1.9	1.3
	Residential	1.2	3.0	2.4	1.3

Puustinen et al., 2007

Conclusions: temporal variation

- PNC measured at a central site reflect well temporal variation near homes across urban areas, though less than for fine particles.
- Correlations with the central site were similar for background and traffic homes (RUPIOH study, data not shown).
- Using a central site in epidemiological time-series studies does not result in substantially larger measurement errors for PNC than for $PM_{2.5}$ or PM_{10}.

Conclusions: spatial variation

- A fixed monitoring site could either over- or underestimate the absolute NC values over the urban areas, the differences for $PM_{2.5}$ or PM_{10} are smaller.
- It suggests that epidemiological studies assessing health effects related to long-term average exposure should not rely on one central monitoring site.
- To cover the spatial variability across the urban area other approaches should be considered: e.g. increasing the number of monitors or modeling of PNC.

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