Differences and Similarities in PM Characteristics across Europe:

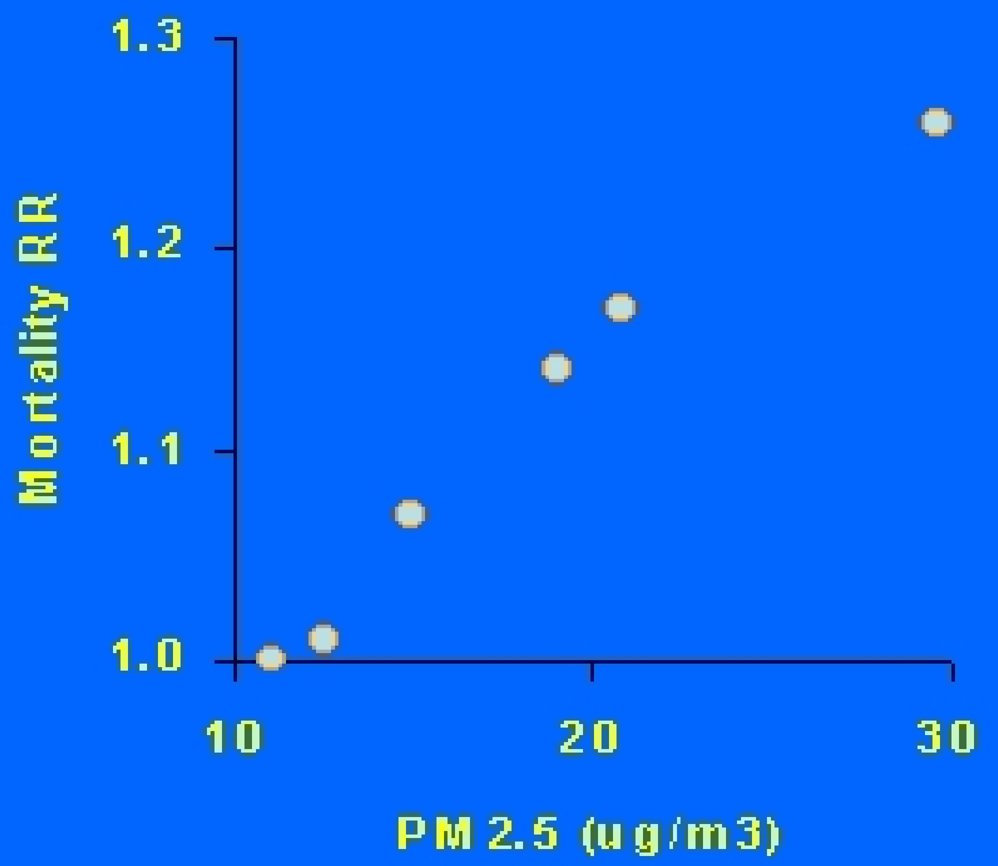
What we learnt and what we might like to know

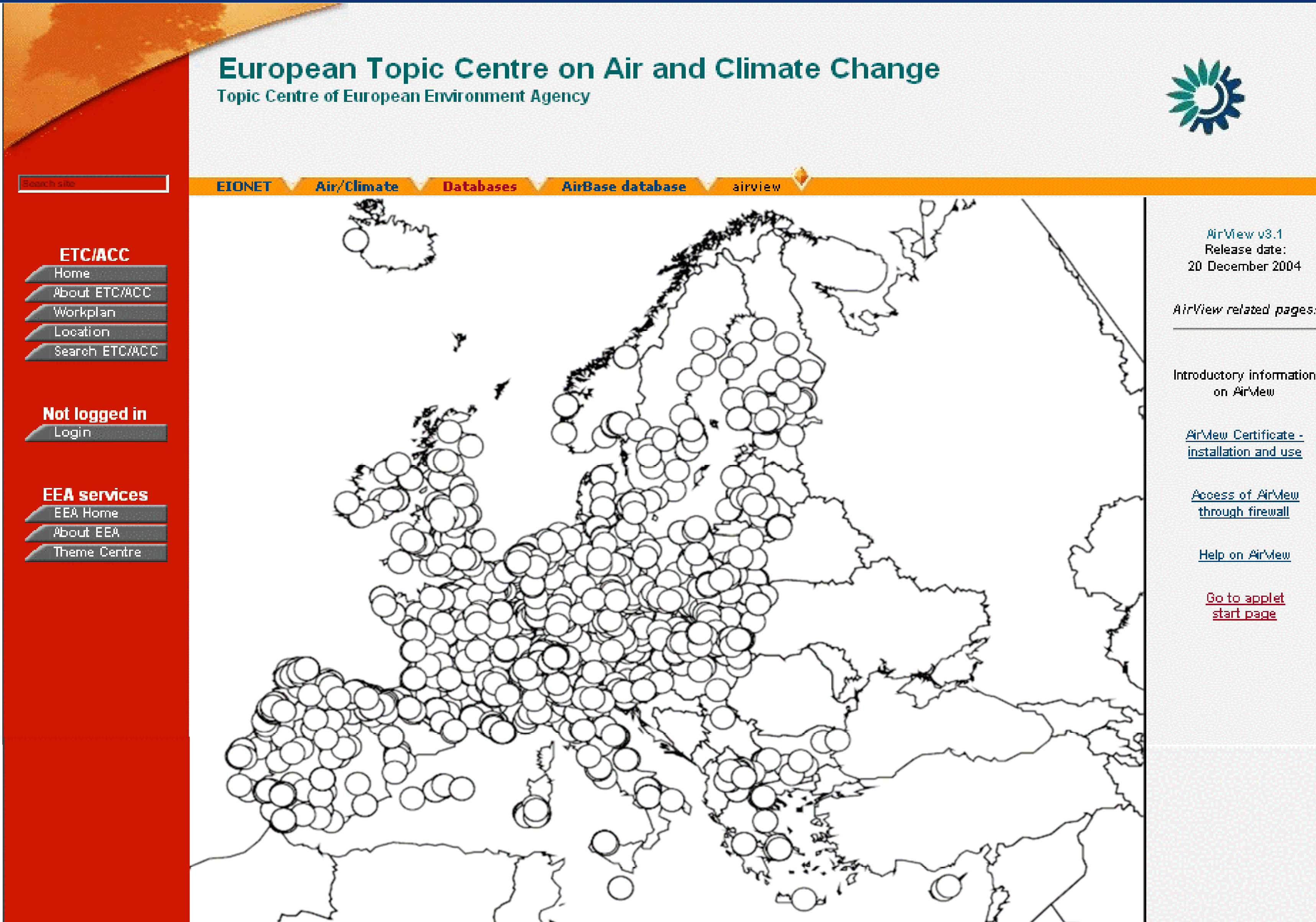
J.P. Putaud

European Commission, DG JRC, Institute for Environment and Sustainability, I-21020 Ispra (Va)

with the COST633 crew

Six Cities Mortality Study




European Topic Centre on Air and Climate Change
Topic Centre of European Environment Agency
EIONET
Air/Climate
Databases
AirBase database
airview
ETC/ACC
Home
About ETC/ACC
Workplan
Location
Search ETC/ACC
Not logged in
Login
EEA services
EEA Home
About EEA
Theme Centre
AirView v3.1
Release date:
20 December 2004
AirView related pages:
Introductory information on AirView
AirView Certificate - installation and use
Access of AirView through firewall
Help on AirView
Go to applet start page

Grahame, Thomas J. and Schlesinger, Richard B. , 'Health Effects of Airborne Particulate Matter: Do We Know Enough to Consider Regulating Specific Particle Types or Sources?', Inhalation Toxicology, 19, 457 – 481, 2007

Green LC, Crouch EAC, Ames MR, Lash TL. 2002. What's wrong with the National Air Quality Standard (NAAQS) for fine particulate matter (PM2.5)? Regul Toxicol Pharmacol 35:327–337

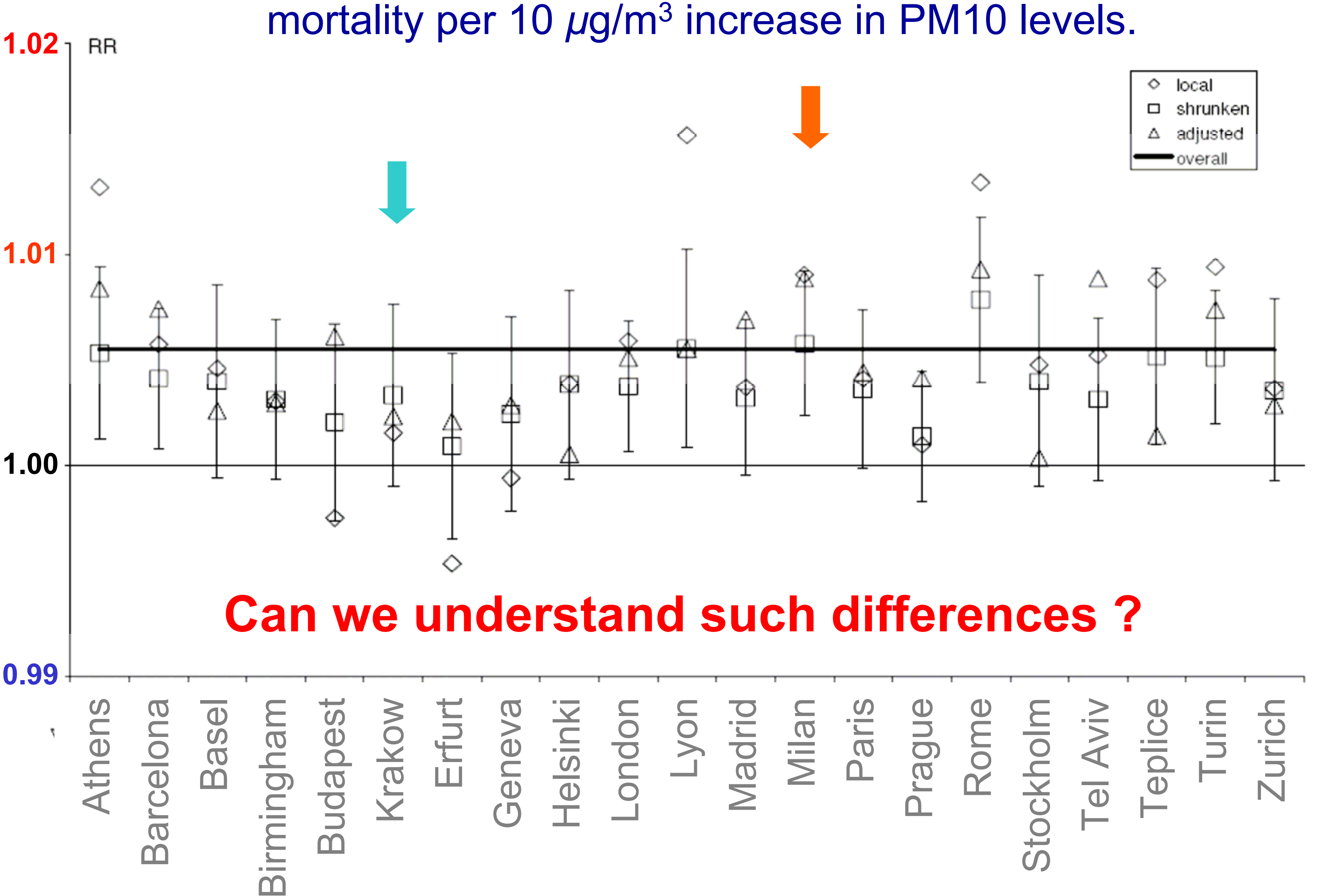
Nygaard U.C., Samuelsen M., Aase A., and Løvik M., The Capacity of Particles to Increase Allergic Sensitization Is Predicted by Particle Number and Surface Area, Not by Particle Mass Toxicol. Sci., 82, 515–524 (2004)

Stoeger T, Reinhard C. Takenaka S, Schroeppel A, Karg E, Ritter B et al. 2006. Instillation of different ultrafine carbon particles indicates surface area threshold dose for acute lung inflammation in mice. Environ Health Perspect.,114:328–333.

Stoeger T., Schmid, O., Takenaka S., Schulz H., Inflammatory Response to TiO2 and Carbonaceous Particles Scales Best with BET Surface Area, Environ Health Perspect. 114:A290–A291, 2007

Wittmaack, K., In Search of the Most Relevant Parameter for Quantifying Lung Inflammatory Response to Nanoparticle Exposure: Particle Number, Surface Area, or What?, Environmental Health Perspect., 115, 187-194, 2007

City-specific estimates (95% CL) of relative risk for mortality per 10 $\mu g/m^3$ increase in PM10 levels.



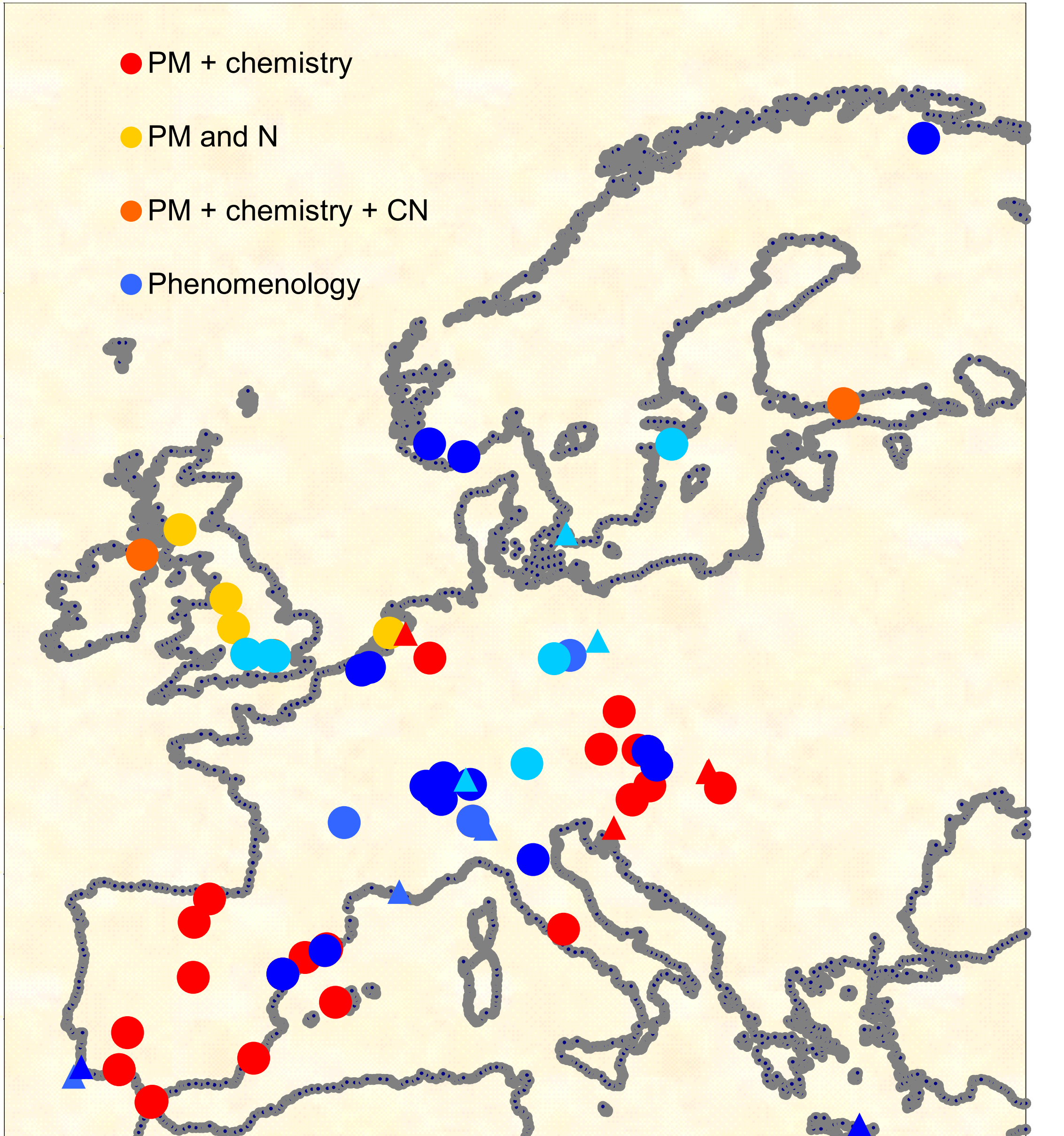
Can we understand such differences ?

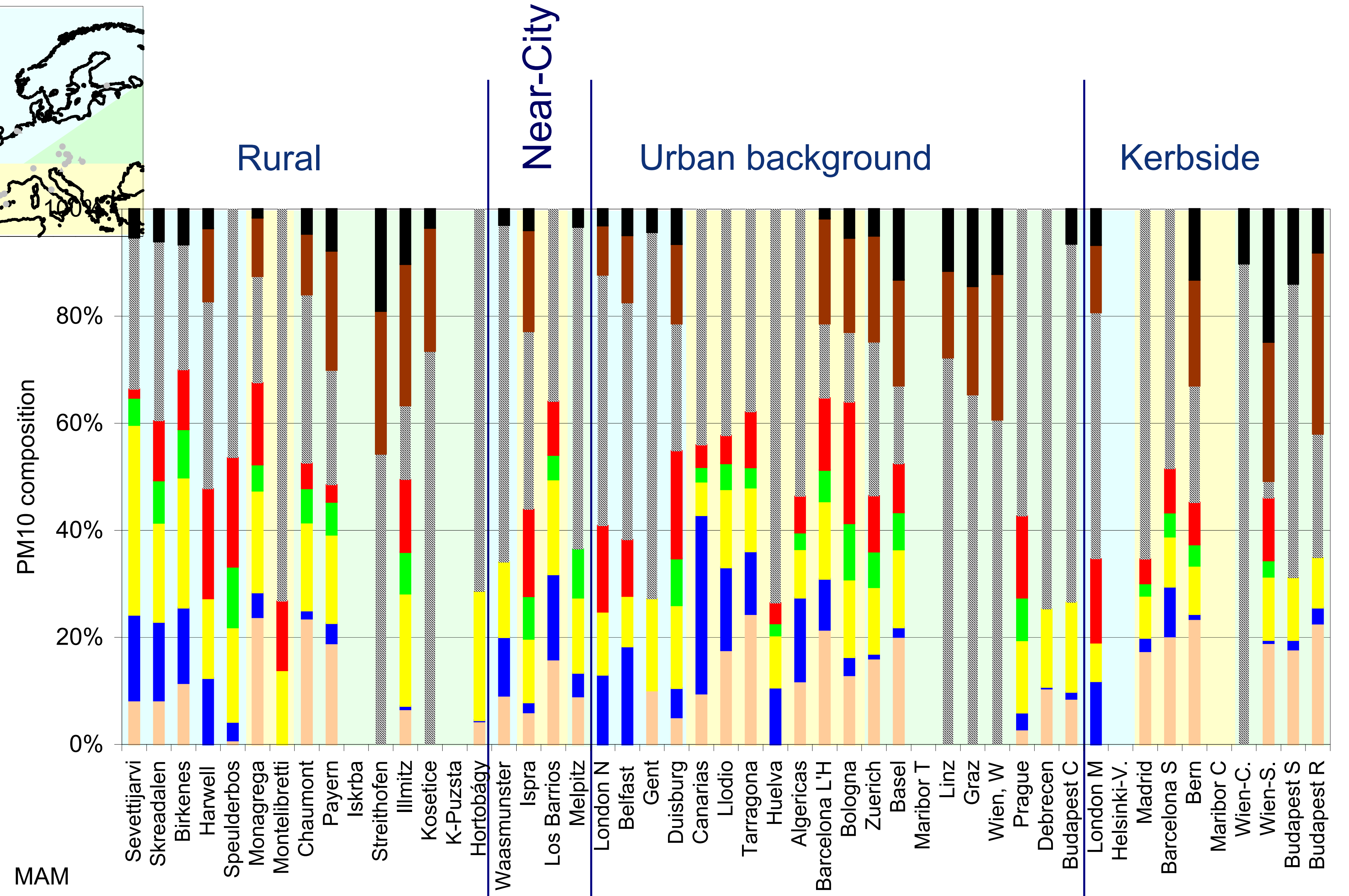
at we learnt

st *Phenomenology*: 34 sites

OST633: 50 original data sets

- 35 with PM and chemistry
- 15 with PM and CN number

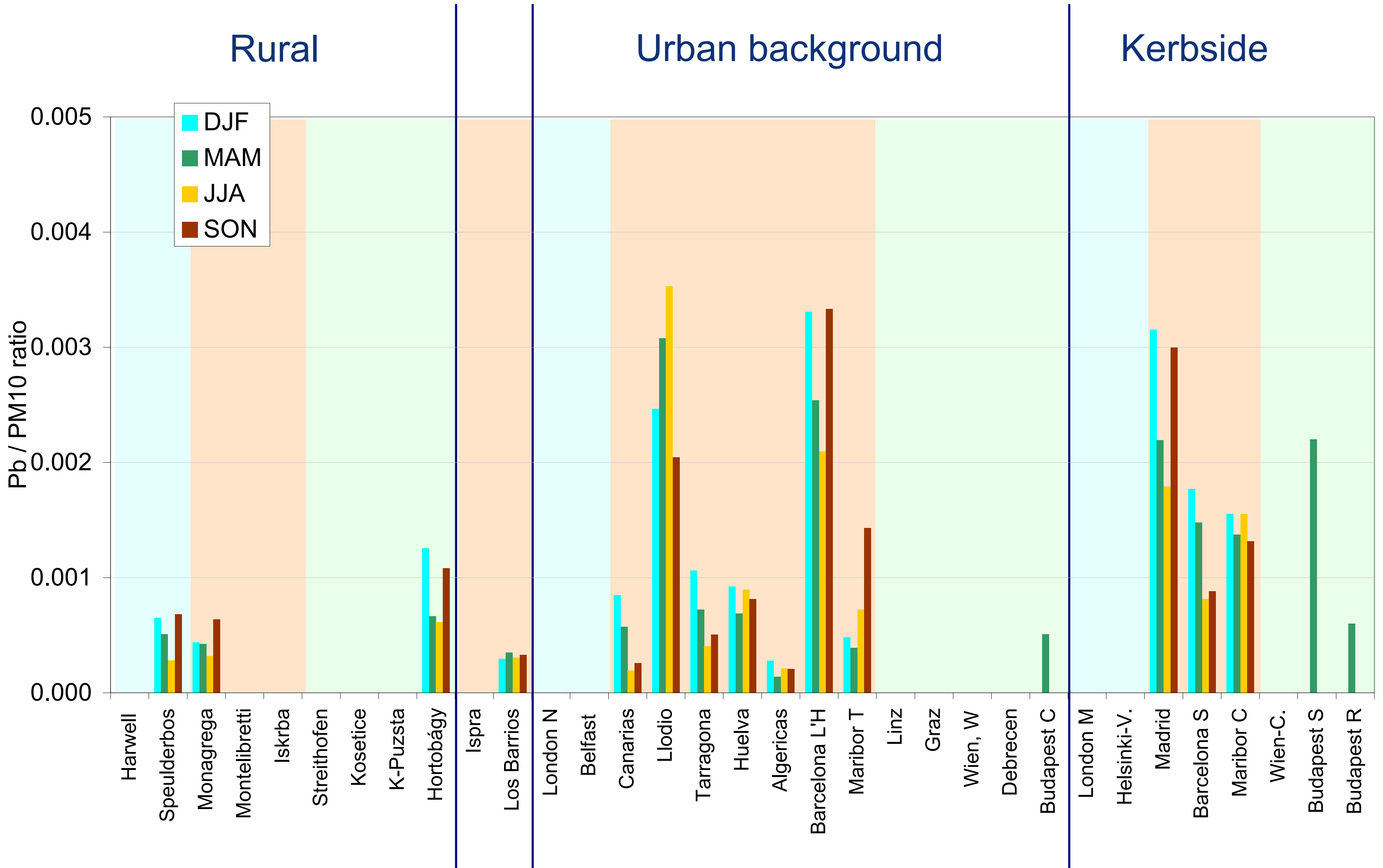


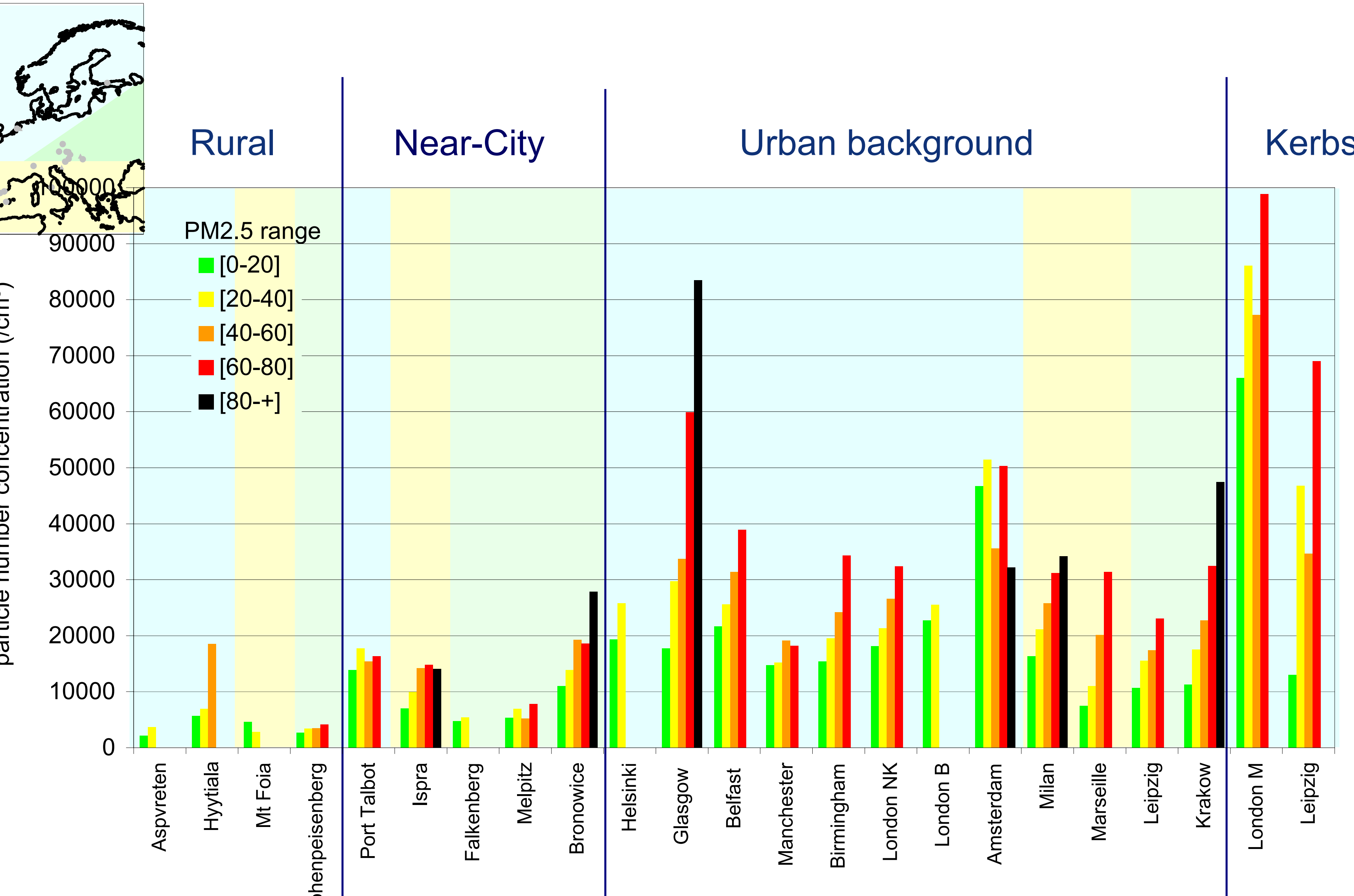

Rural
Near-City
Urban background
Kerbside
PM10 composition
0%
20%
40%
60%
80%
100%
Sevettijarvi
Skreadalen
Birkenes
Harwell
Speulderbos
Monagrega
Montelibretti
Chaumont
Payern
Iskrba
Streithofen
Illmitz
Kosetice
K-Puzsta
Hortobágy
Waasmunster
Ispra
Los Barrios
Melpitz
London N
Belfast
Gent
Duisburg
Canarias
Llodio
Tarragona
Huelva
Algericas
Barcelona L'H
Bologna
Zuerich
Basel
Maribor T
Linz
Graz
Wien, W
Prague
Debrecen
Budapest C
London M
Helsinki-V.
Madrid
Barcelona S
Bern
Maribor C
Wien-C.
Wien-S.
Budapest S
Budapest R
MAM

“Knowing the aerosol chemical composition is essential for determining sources and effects”

Effects? Speciation is not detailed enough.

Sources? Most of the main aerosol constituents are not source-specific.

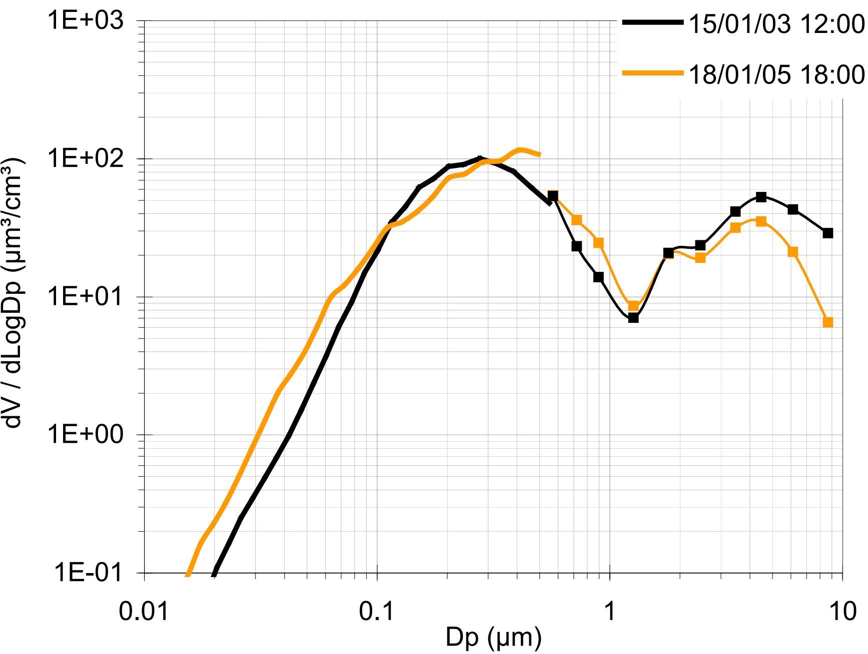

Rural
Urban background
Kerbside
DJF
MAM
JJA
SON
Pb / PM10 ratio
0.005
0.004
0.003
0.002
0.001
0.000
Harwell
Speulderbos
Monagrega
Montelibretti
Iskrba
Streithofen
Kosetice
K-Puzsta
Hortobágy
Ispra
Los Barrios
London N
Belfast
Canarias
Llodio
Tarragona
Huelva
Algericas
Barcelona L'H
Maribor T
Linz
Graz
Wien, W
Debrecen
Budapest C
London M
Helsinki-V.
Madrid
Barcelona S
Maribor C
Wien-C.
Budapest S
Budapest R

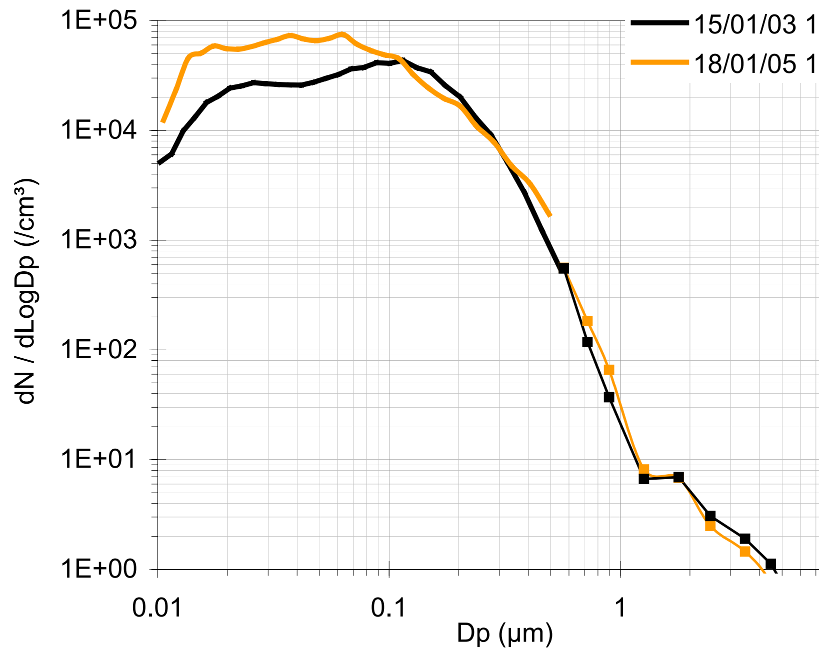


Rural
Near-City
Urban background
Kerbs
PM2.5 range
[0-20]
[20-40]
[40-60]
[60-80]
[80-+]
particle number concentration (/cm³)
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
Aspvreten
Hyytiala
Mt Foia
hohenpeisenberg
Port Talbot
Ispra
Falkenberg
Melpitz
Bronowice
Helsinki
Glasgow
Belfast
Manchester
Birmingham
London NK
London B
Amsterdam
Milan
Marseille
Leipzig
Krakow
London M
Leipzig

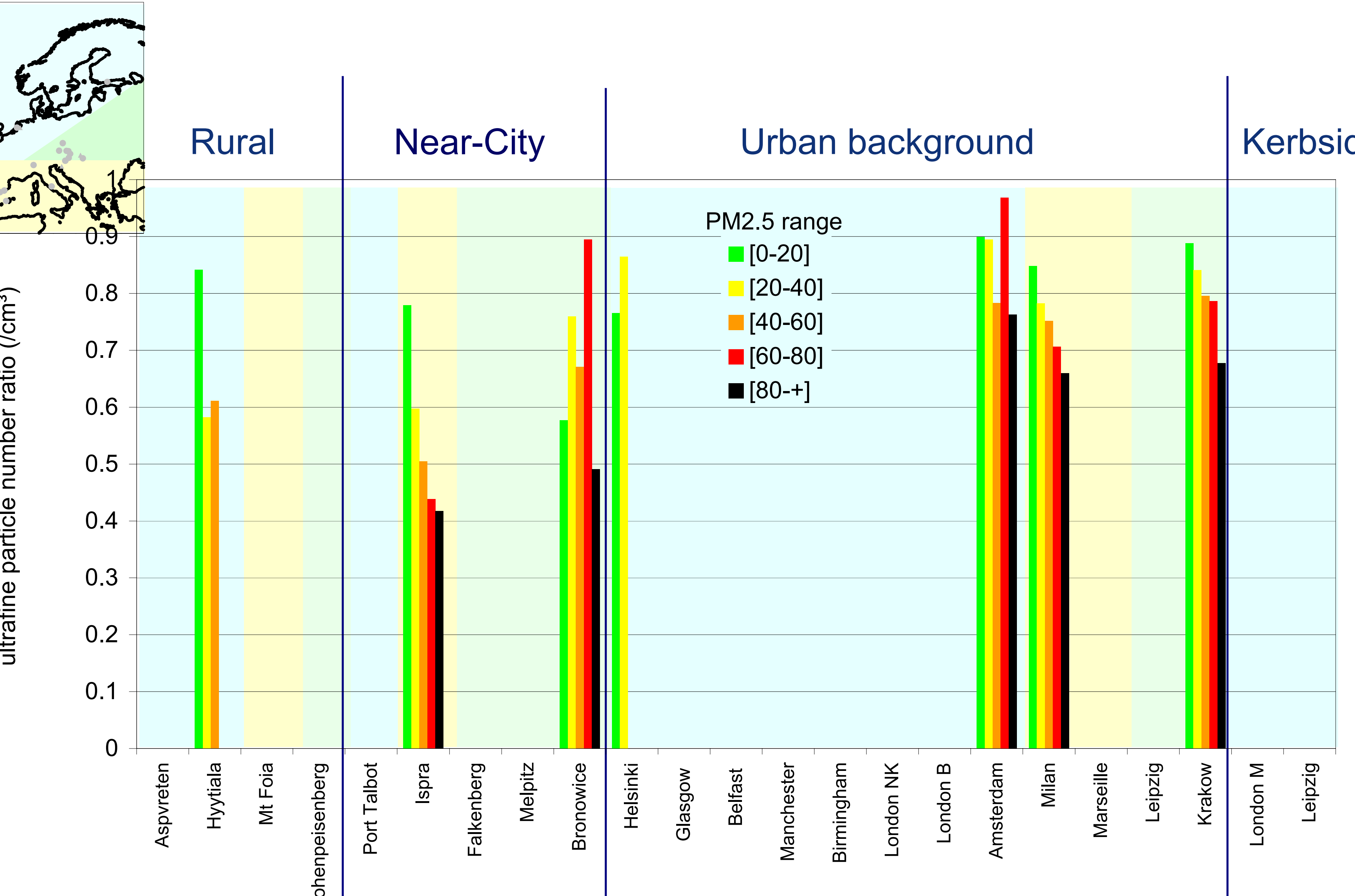
Milan, 15 Jan. 2003 12:00 PM10 = 155 µg/m³

Krakow, 18 Jan. 2005 18:00 PM10 = 158 µg/m³





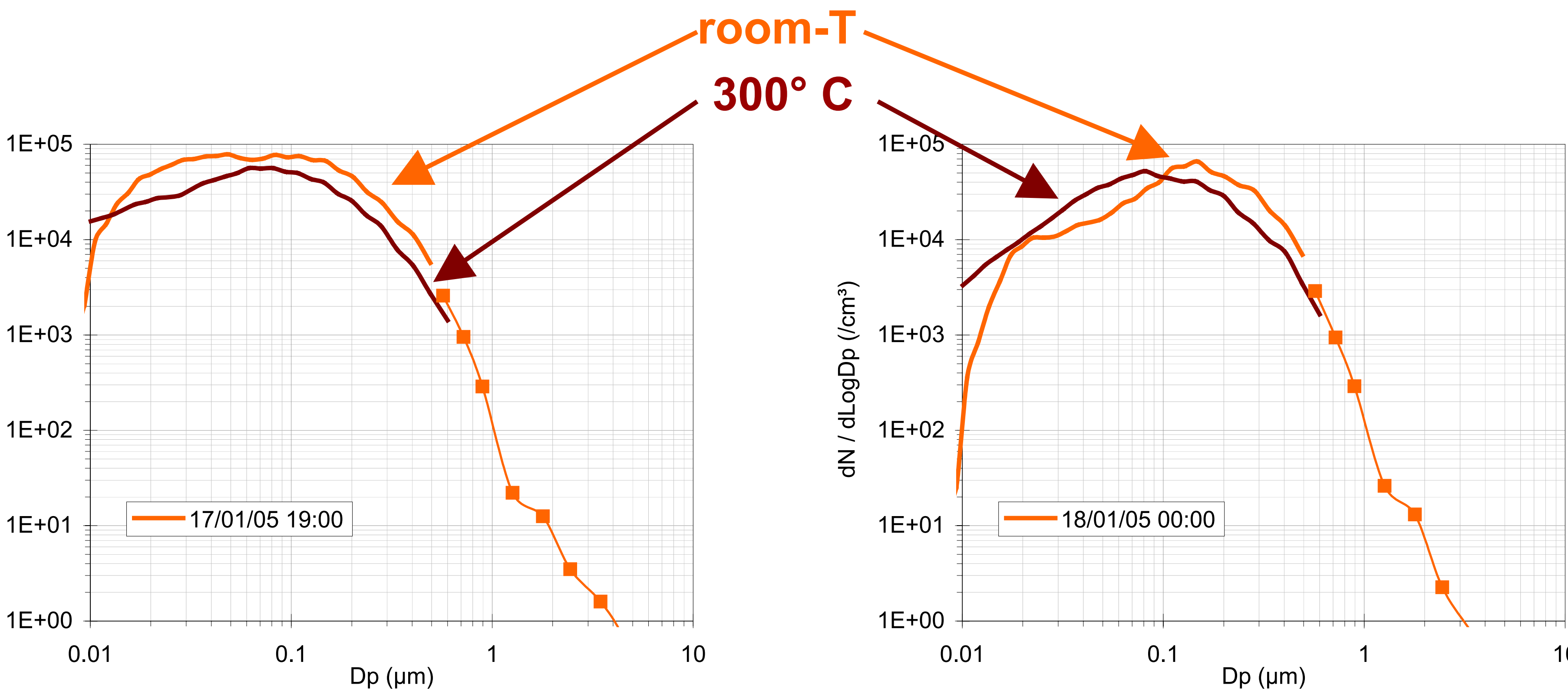
Difference in particle number mainly due to ultrafine particles



Rural
Near-City
Urban background
Kerbsic
ultrafine particle number ratio (/cm³)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
PM2.5 range
[0-20]
[20-40]
[40-60]
[60-80]
[80-+]
Aspvreten
Hyytiala
Mt Foia
ohenpeisenberg
Port Talbot
Ispra
Falkenberg
Melpitz
Bronowice
Helsinki
Glasgow
Belfast
Manchester
Birmingham
London NK
London B
Amsterdam
Milan
Marseille
Leipzig
Krakow
London M
Leipzig

What we might like to know:

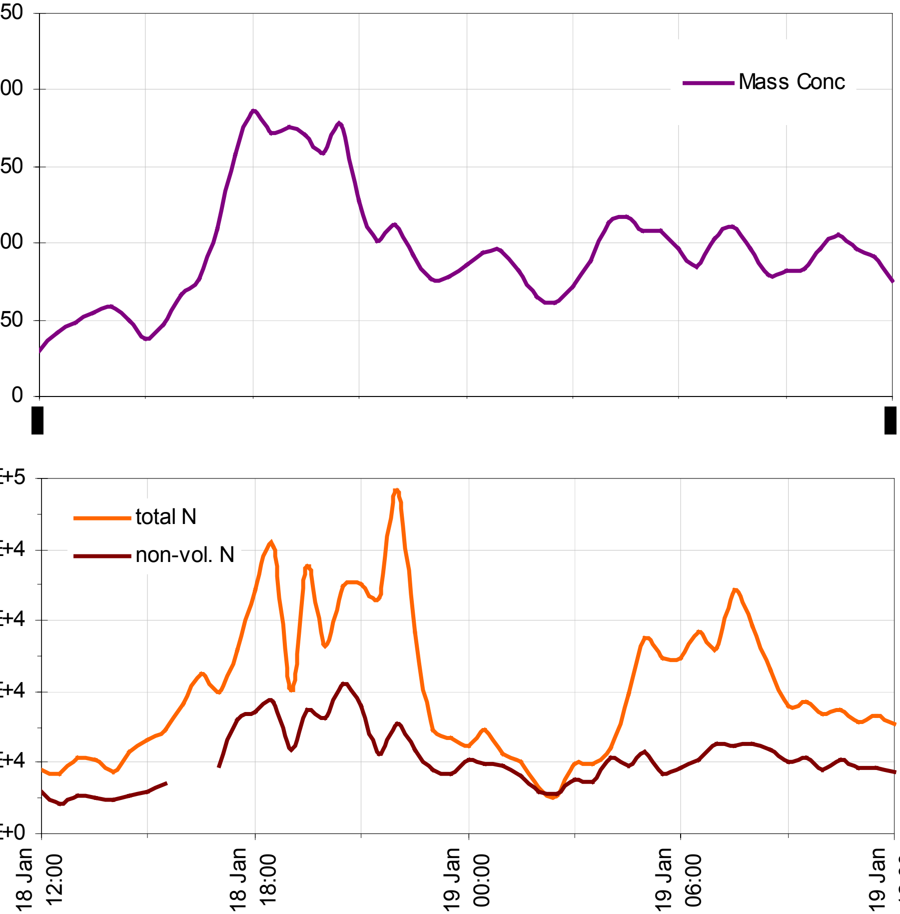
Non-volatile particle number size distribution measurements



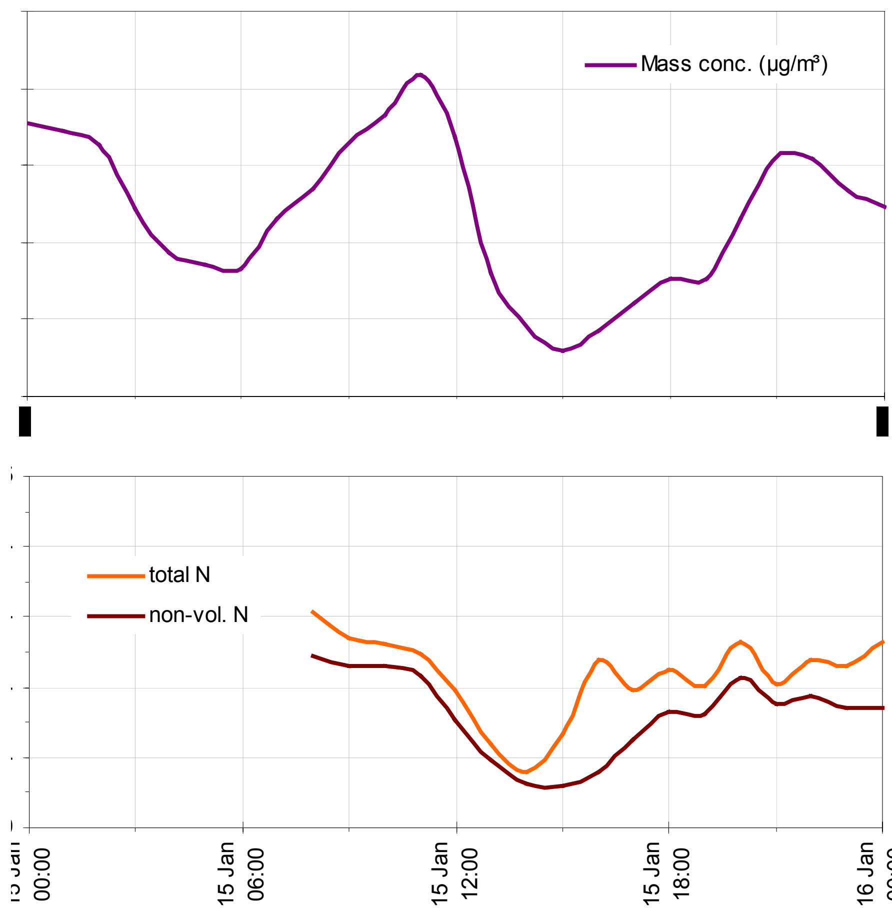
PM10 = 330 µg/m³
room temp.-N = 85000 cm^{-3}
300° C-N = 54000 cm^{-3}

PM10 = 375 µg/m³
room temp.-N = 44000 cm^{-3}
300° C-N = 41000 cm^{-3}

Krakow, 2005



Milan, 2003

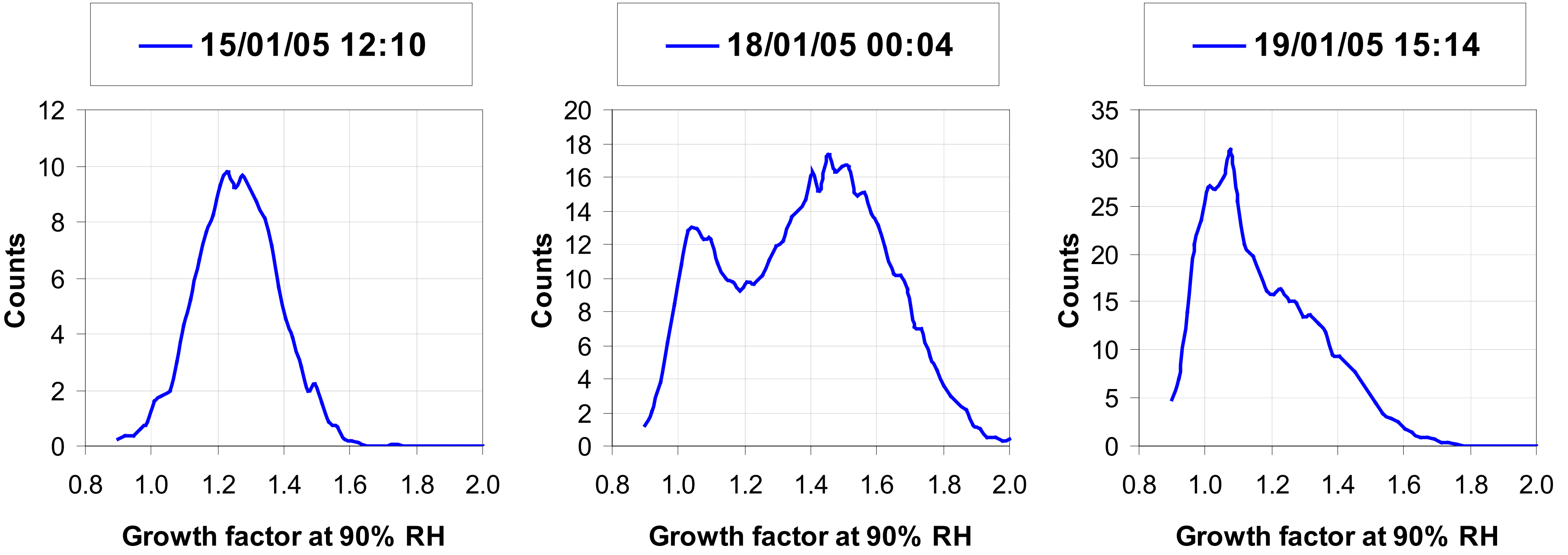


> For comparable mass concentrations, particle number concentration may be much larger in Krakow, but refractory particle number generally smaller

What we might like to know:

Particle hygroscopicity measurements

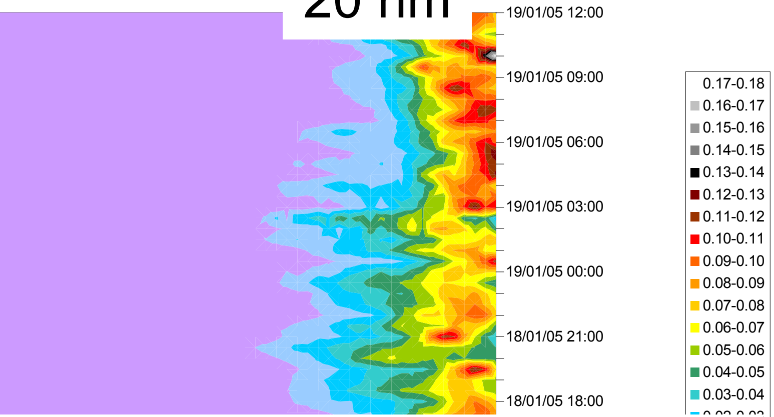
Hygroscopic growth factor of Dp = 50 nm particles (Krakow)



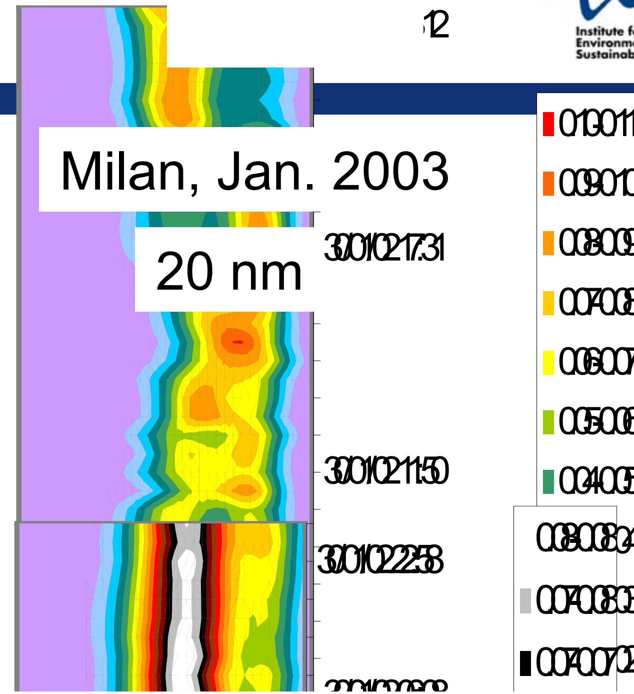
Krakow, Jan. 2005

Milan, Jan. 2003

20 nm

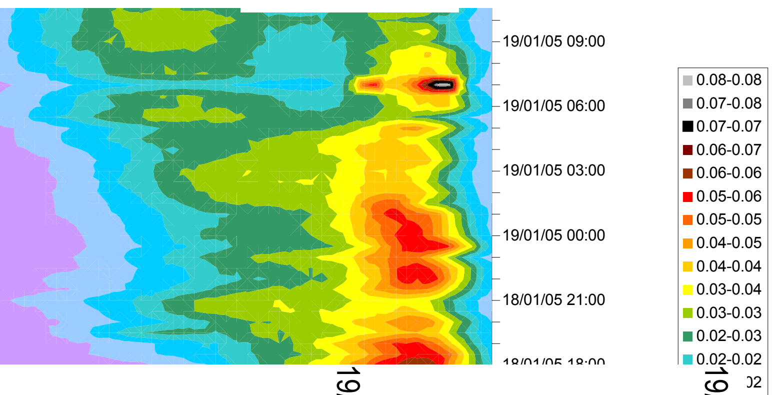


20 nm

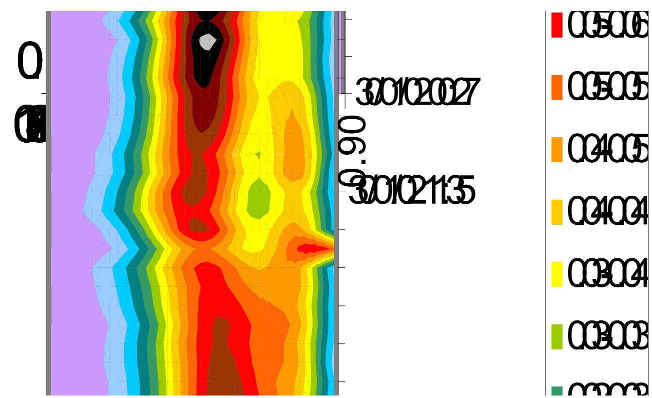


20 nm particles consist of pure C in Krakow, some are soluble in Milan

200 nm



200 nm



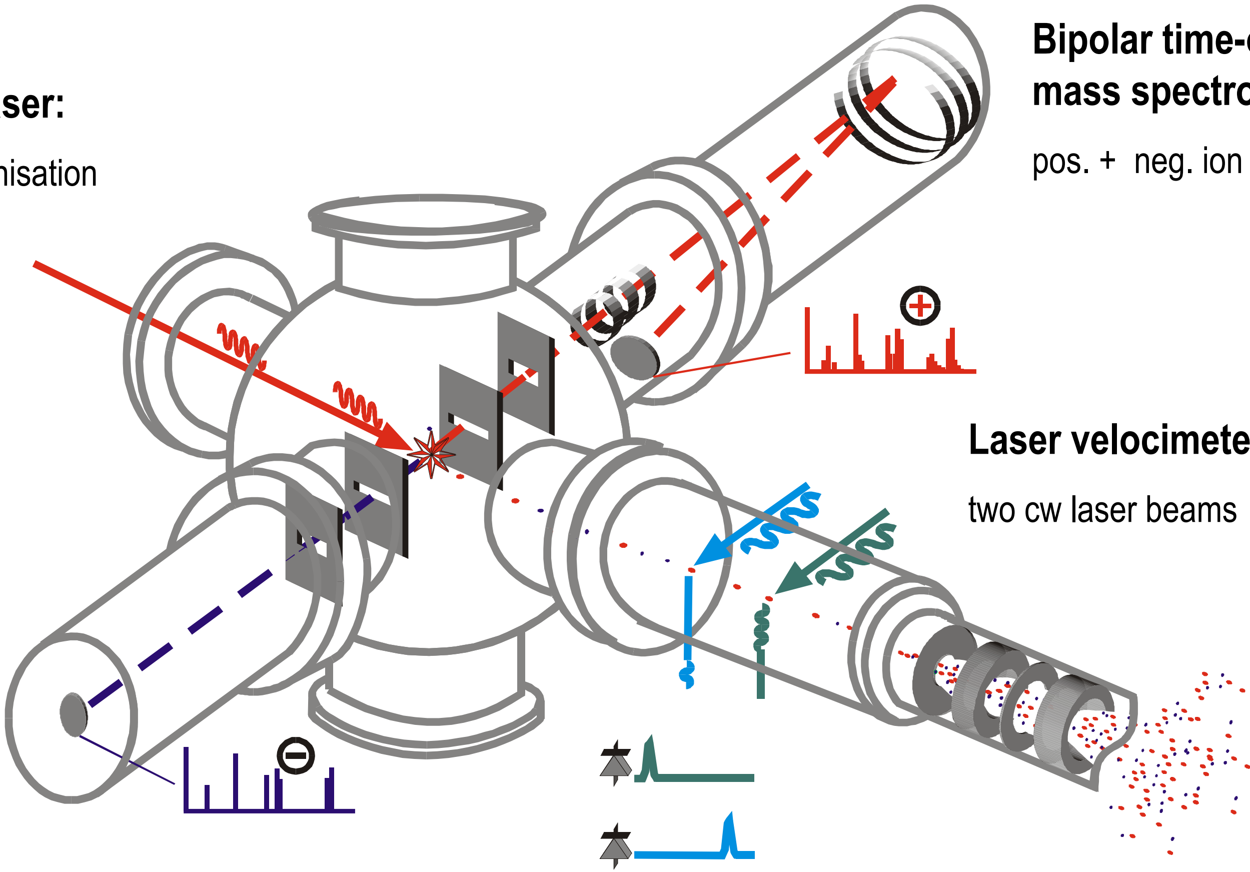
200 nm particles can be soluble in Krakow, generally not in Milan

YAG – laser:

rption / ionisation

Bipolar time-of-flight mass spectrometer:

pos. + neg. ion detection



Laser velocimeter:

two cw laser beams

Aerodynamic lenses:

collimated particle beam

Conclusions (to be discussed):

Relationships between PM mass and health indicators were found
PM mass concentrations across Europe are well known

PM mass closure is rarely achieved
Particle number concentration and size distribution data are scarce

Particle differential mobility – based instruments are available for monitoring article properties that may be confronted with health impact studies

The ideal research task would involve a matrix, "with particle characteristics a ne dimension and health outcomes as the other" (Schlesinger et al., 2006)

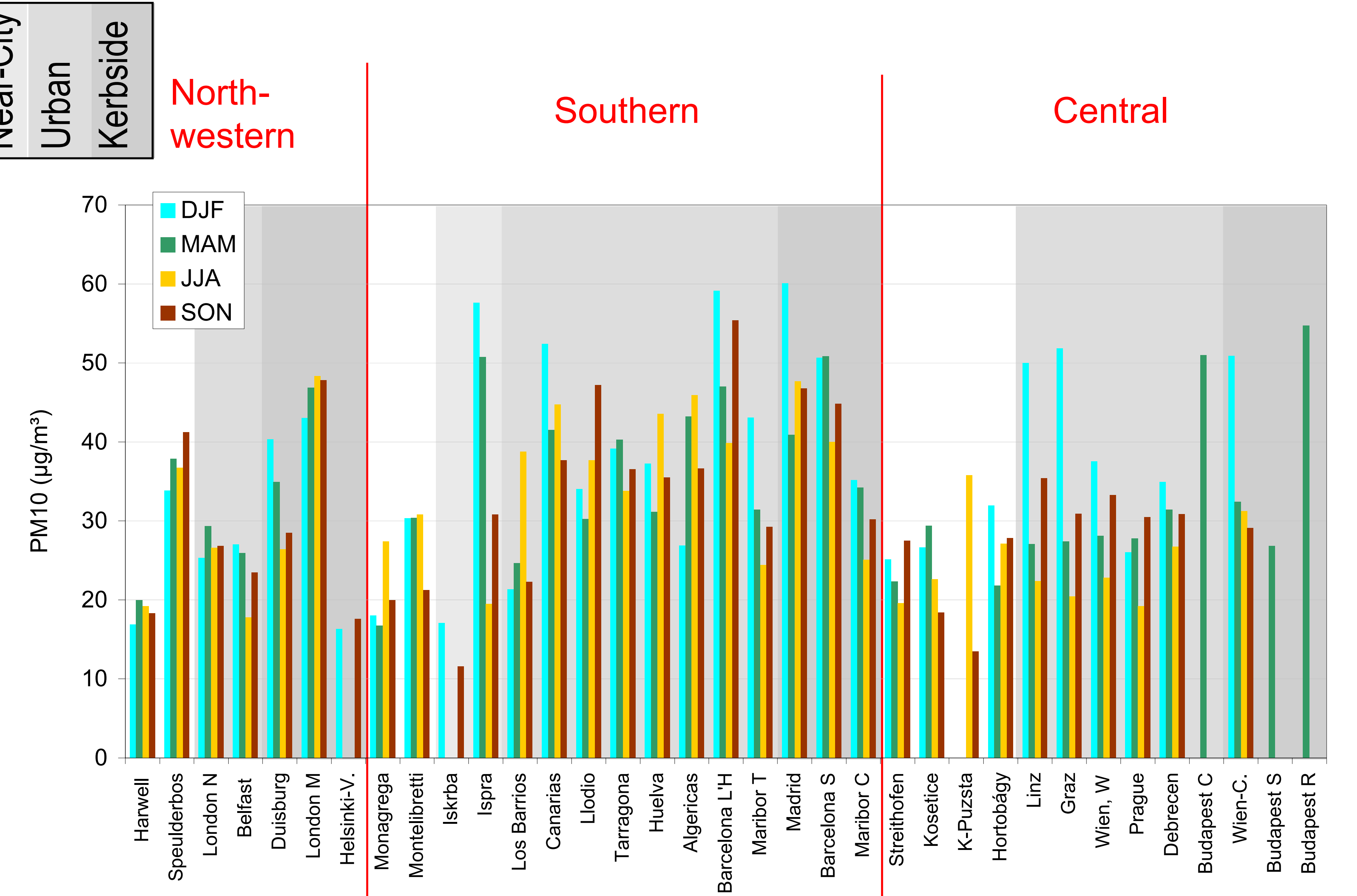
THANK YOU

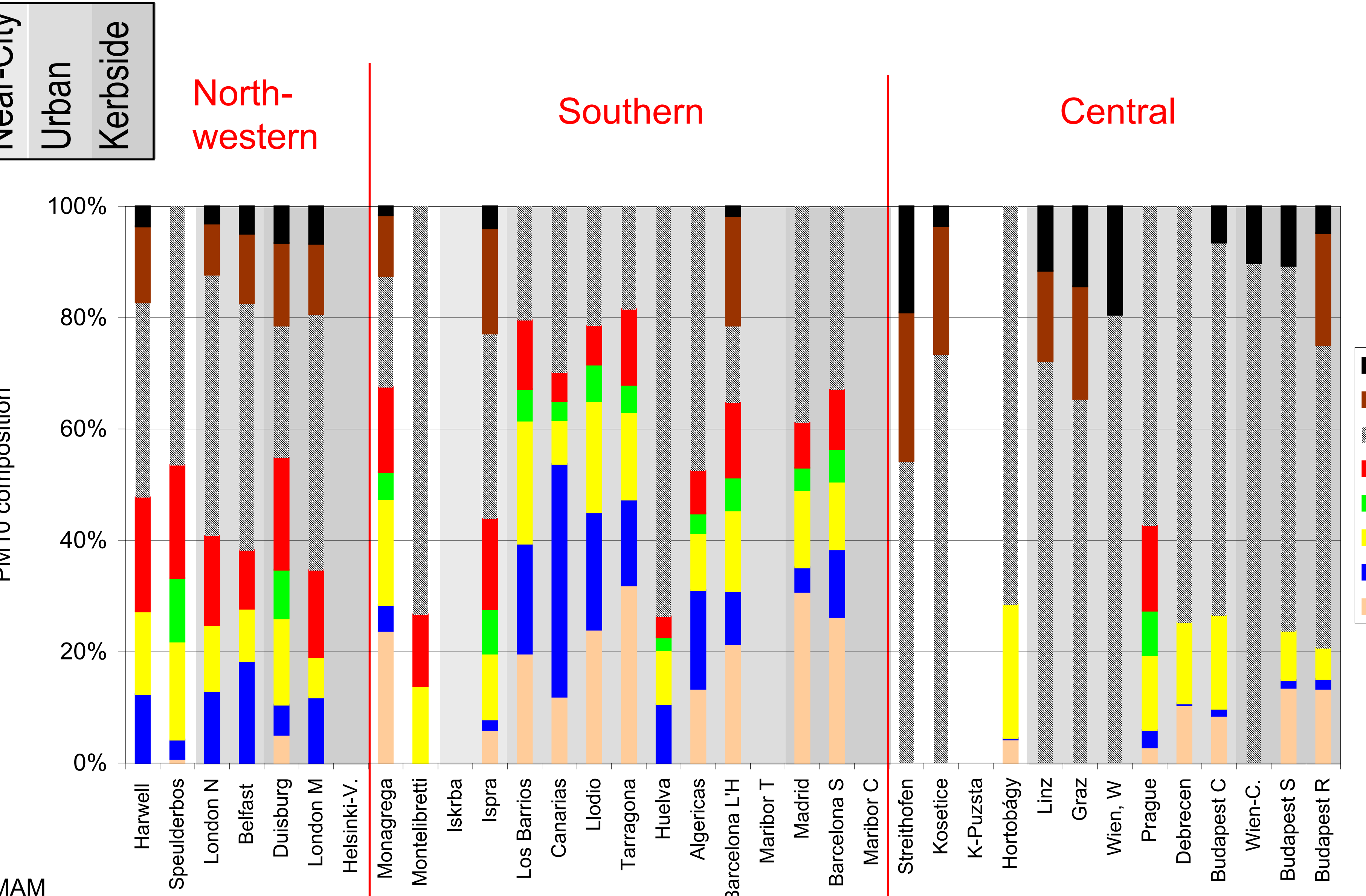
EUROPEAN SCIENCE FOUNDATION
ESF

COST
633

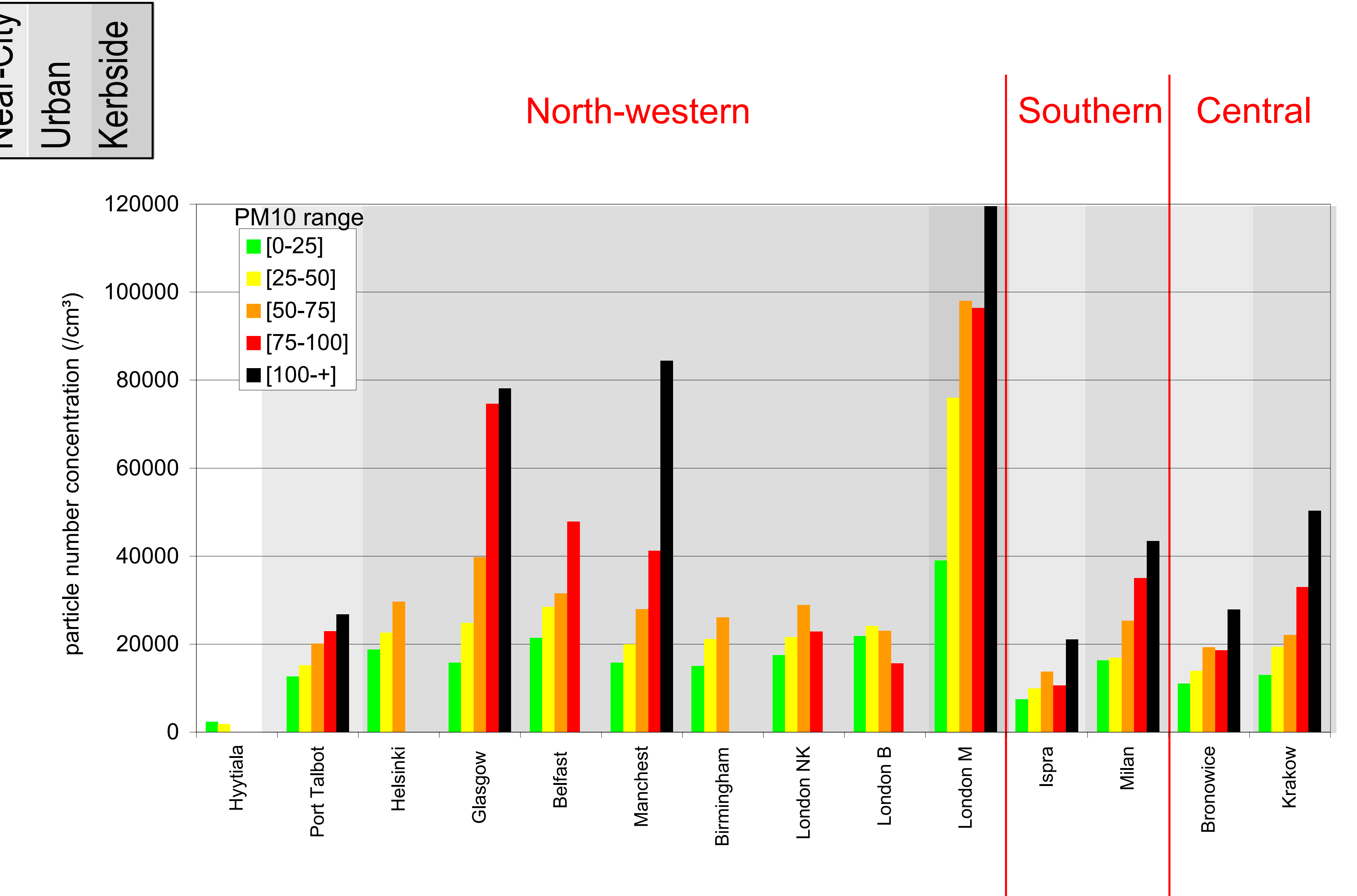
		Number	PM2.5	number/PM2.5
Erfurt (1992)	Wolfgang			227
Erfurt (>1995)	Wolfgang			>600
Milan	Sergio	25800	47	549
Alkmaar	Ruuskanen	25800	27	956
Erfurt	Ruuskanen	25900	42	617
Helsinki	Ruuskanen	20300	9.4	2160

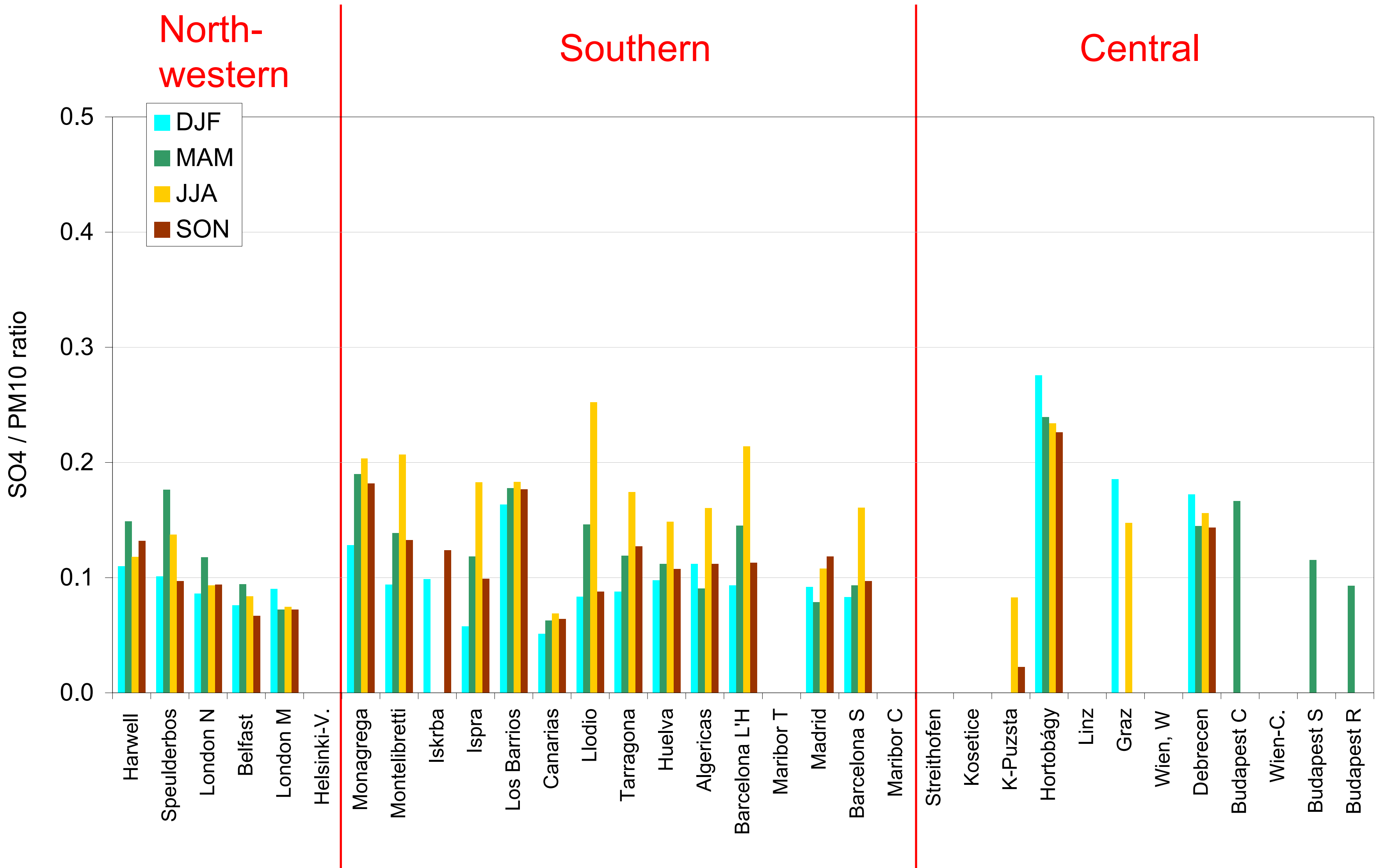
		SO2	NOx	CO	PM10	V(aeD<1µm) / V(aeD<10 µm)	Ntot / PM10	S(non vol uf) / PM10	N uf / Ntot	N non vol / Ntot	SO4+NO3+NH4 / PM10	EBC / PM10
		µg / m^3	µg / m^3	mg / m^3	µg / m^3		10^6 µg^{-1}	mm^2 µg^{-1}				
onal , Bronowice	30-Jan-2005 12:00 - 15:00	29 - 38*	20 - 28*	0.4 - 0.5*	39	0.93	351	1.1	0.73	0.48	0.45	0.10
an , Nowa Huta	15-Jan-2005 12:00 - 21:00	7 - 19*	29 - 51*	0.3 - 0.7*	20	0.80	509	0.8	0.84	0.38	0.34	0.16
derate owa Huta	18-Jan-2005 16:00 19-Jan-2005 09:00	10 - 24*	17 - 200*	0.3 - 1.5*	95	0.88	425	1.1	0.77	0.59	0.20	0.12
	17-Jan-2005 15:00 17-Jan-2005 22:30	13 - 25*	240 - 650*	1.9 - 4.6*	287	0.87	271	1.0	0.67	0.70	0.14	0.14
ere owa Huta	17-Jan-2005 22:30 18-Jan-2005 04:30	13 - 19*	250 - 400*	2.7 - 3.8*	366	0.91	104	1.2	0.33	1.00	0.13	0.12
	18-Jan-2005 04:30 18-Jan-2005 09:00	14 - 30*	250 - 420*	2.5 - 3.9*	353	0.91	170	1.1	0.60	0.72	0.17	0.12
ion episode, 2	30-Jan-2002 09:00 - 18:00	8 - 24[a]	320 - 520[a]	2.7 - 4.2[a]	134	ND	308	ND	0.72	ND	0.34	0.15
ion episode, 3	15-Jan-2003 06:00 - 13:00	6 - 37[a]	320 - 670[a]	2.0 -5.0[a]	142	0.75	307	1.4	0.68	0.83	0.31	0.12

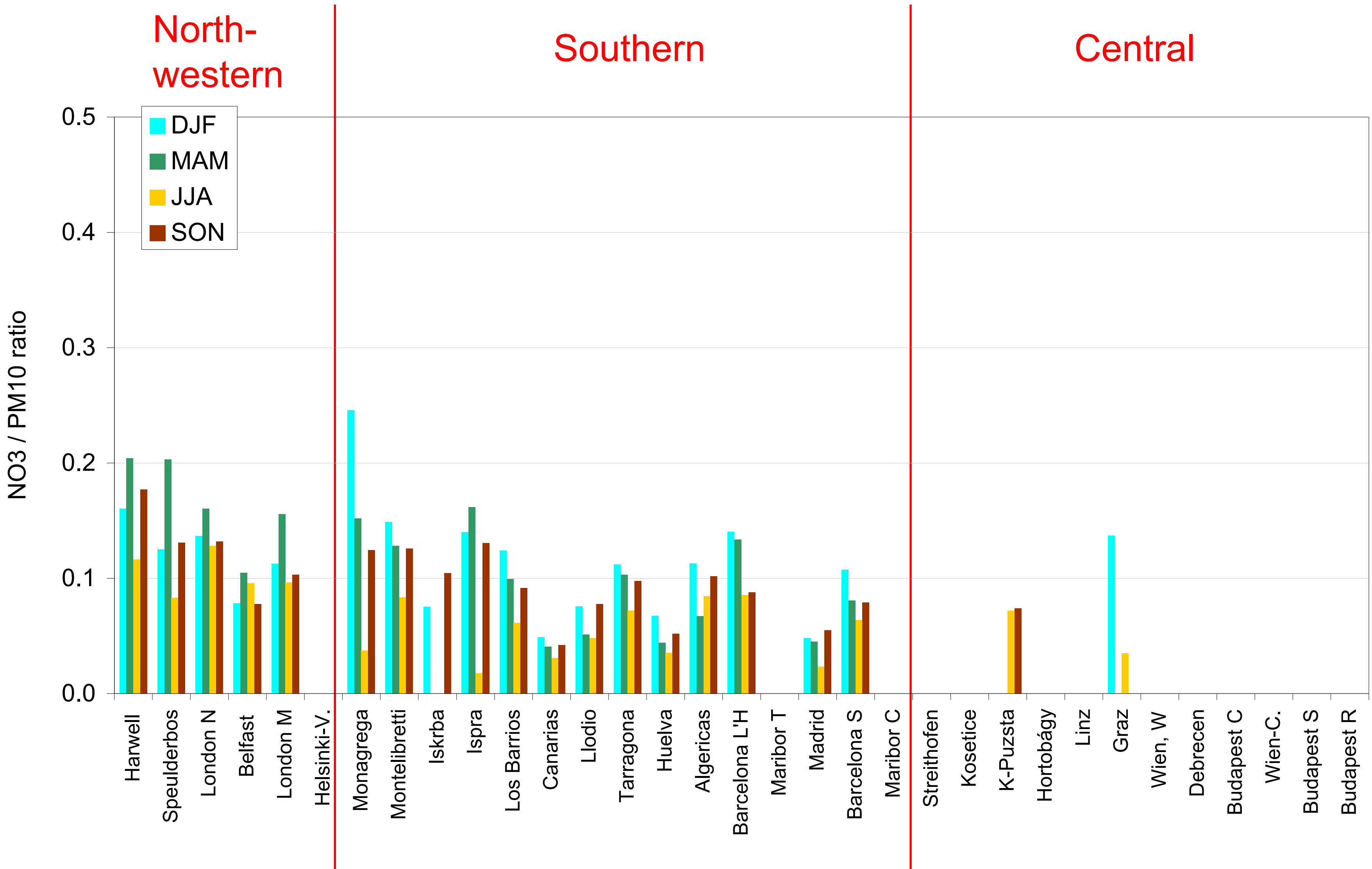

Near-City
Urban
Kerbside
North-western
Southern
Central
DJF
MAM
JJA
SON
PM10 (µg/m³)
70
60
50
40
30
20
10
0
Harwell
Speulderbos
London N
Belfast
Duisburg
London M
Helsinki-V.
Monagrega
Montelibretti
Iskrba
Ispra
Los Barrios
Canarias
Llodio
Tarragona
Huelva
Algericas
Barcelona L'H
Maribor T
Madrid
Barcelona S
Maribor C
Streithofen
Kosetice
K-Puzsta
Hortobágy
Linz
Graz
Wien, W
Prague
Debrecen
Budapest C
Wien-C.
Budapest S
Budapest R

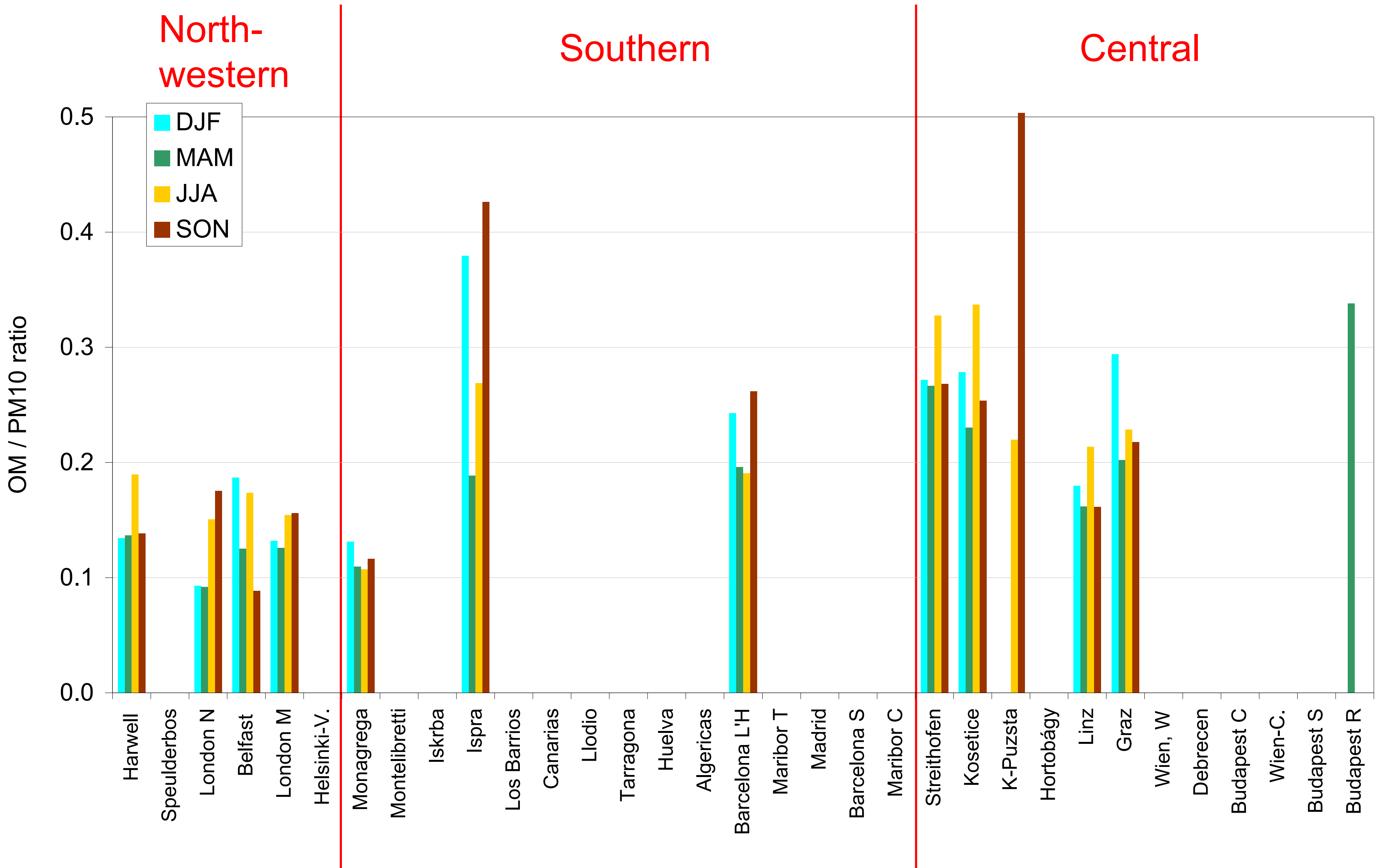

Near-City
Urban
Kerbside
North-western
Southern
Central
100%
80%
60%
40%
20%
0%
PM10 composition
Harwell
Speulderbos
London N
Belfast
Duisburg
London M
Helsinki-V.
Monagrega
Montelibretti
Iskrba
Ispra
Los Barrios
Canarias
Llodio
Tarragona
Huelva
Algericas
Barcelona L'H
Maribor T
Madrid
Barcelona S
Maribor C
Streithofen
Kosetice
K-Puzsta
Hortobágy
Linz
Graz
Wien, W
Prague
Debrecen
Budapest C
Wien-C.
Budapest S
Budapest R

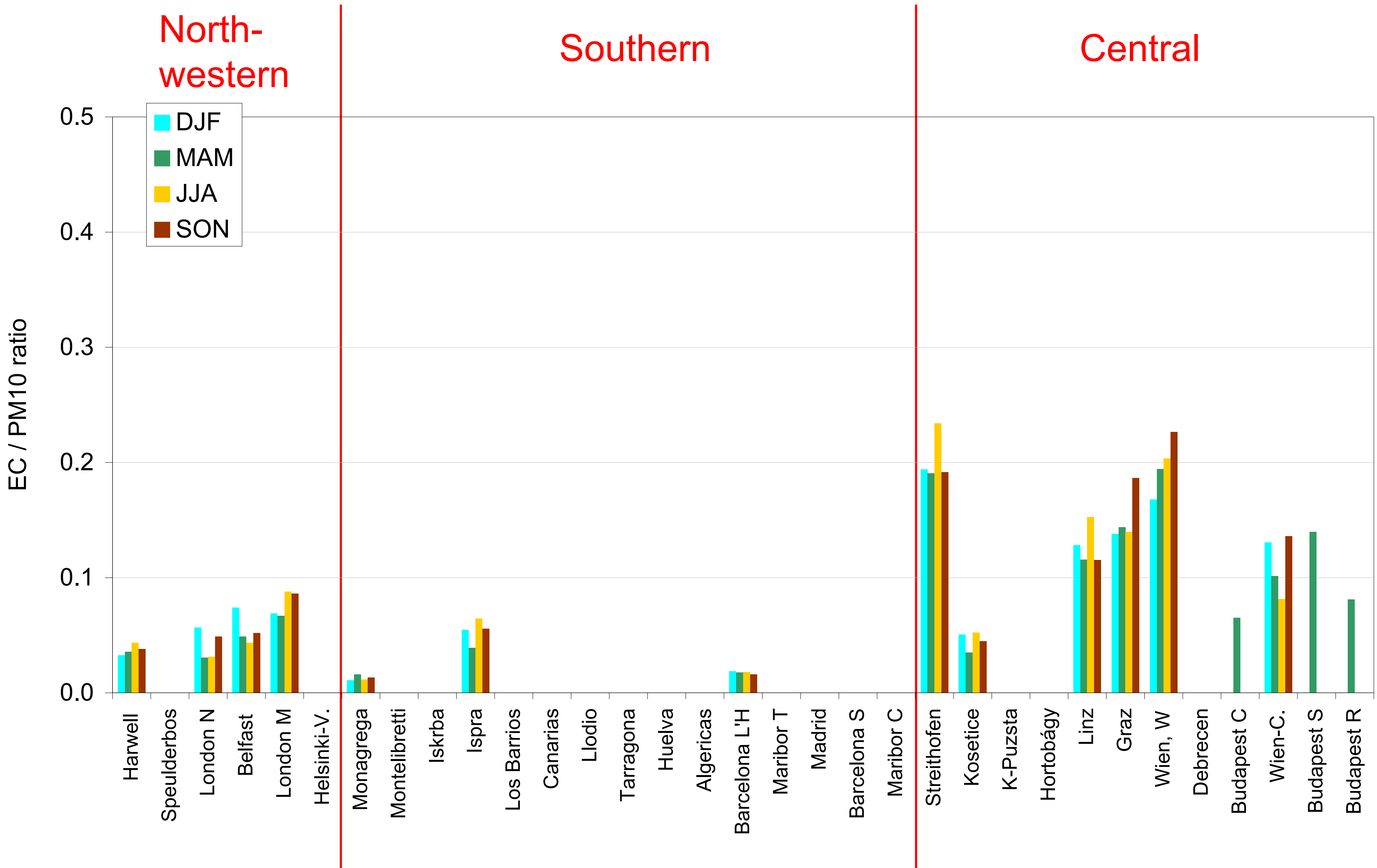
MAM

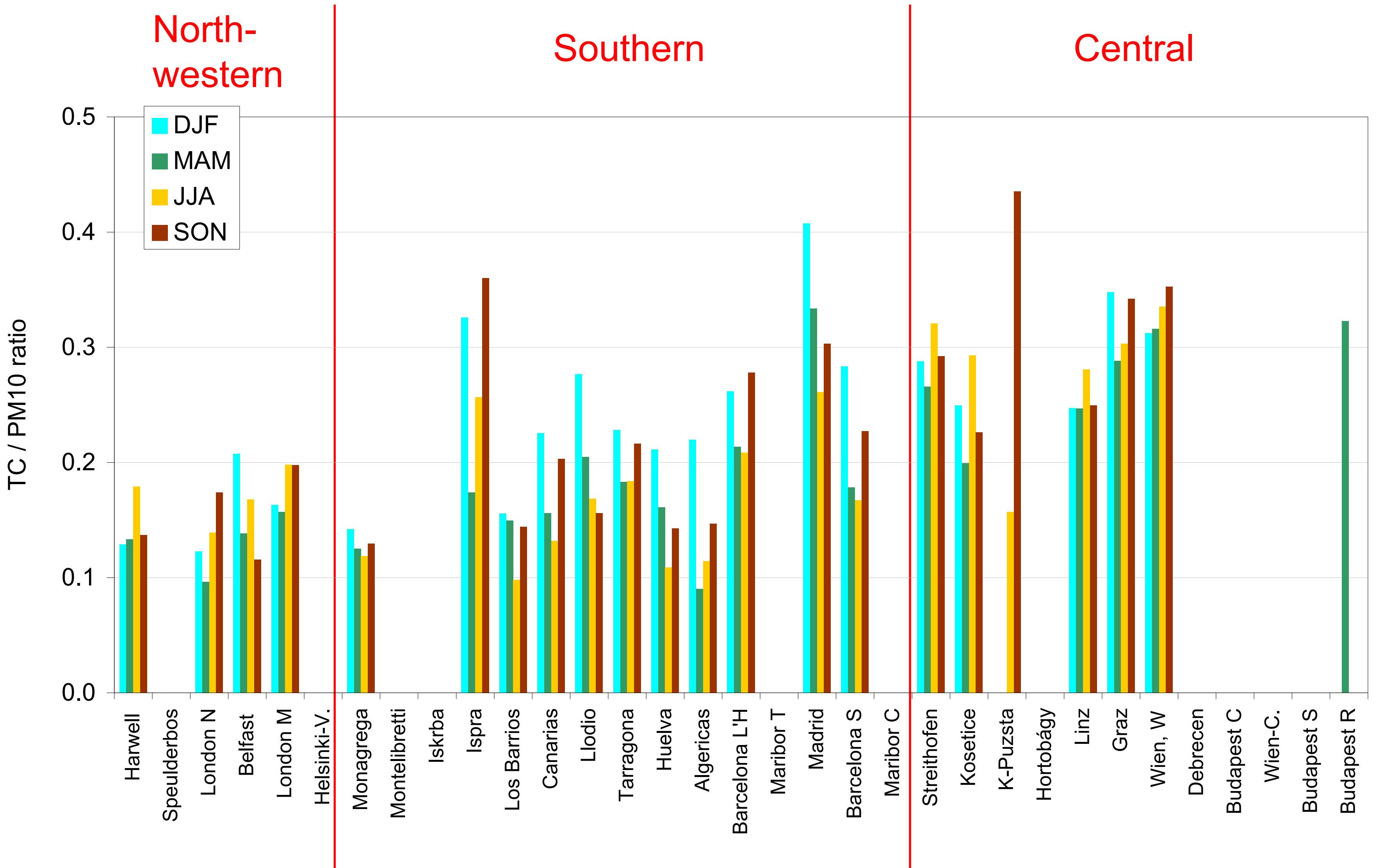

Near-City
Urban
Kerbside
North-western
Southern
Central
PM10 range
[0-25]
[25-50]
[50-75]
[75-100]
[100-+]
particle number concentration (/cm³)
120000
100000
80000
60000
40000
20000
0
Hyytiala
Port Talbot
Helsinki
Glasgow
Belfast
Manchest
Birmingham
London NK
London B
London M
Ispra
Milan
Bronowice
Krakow

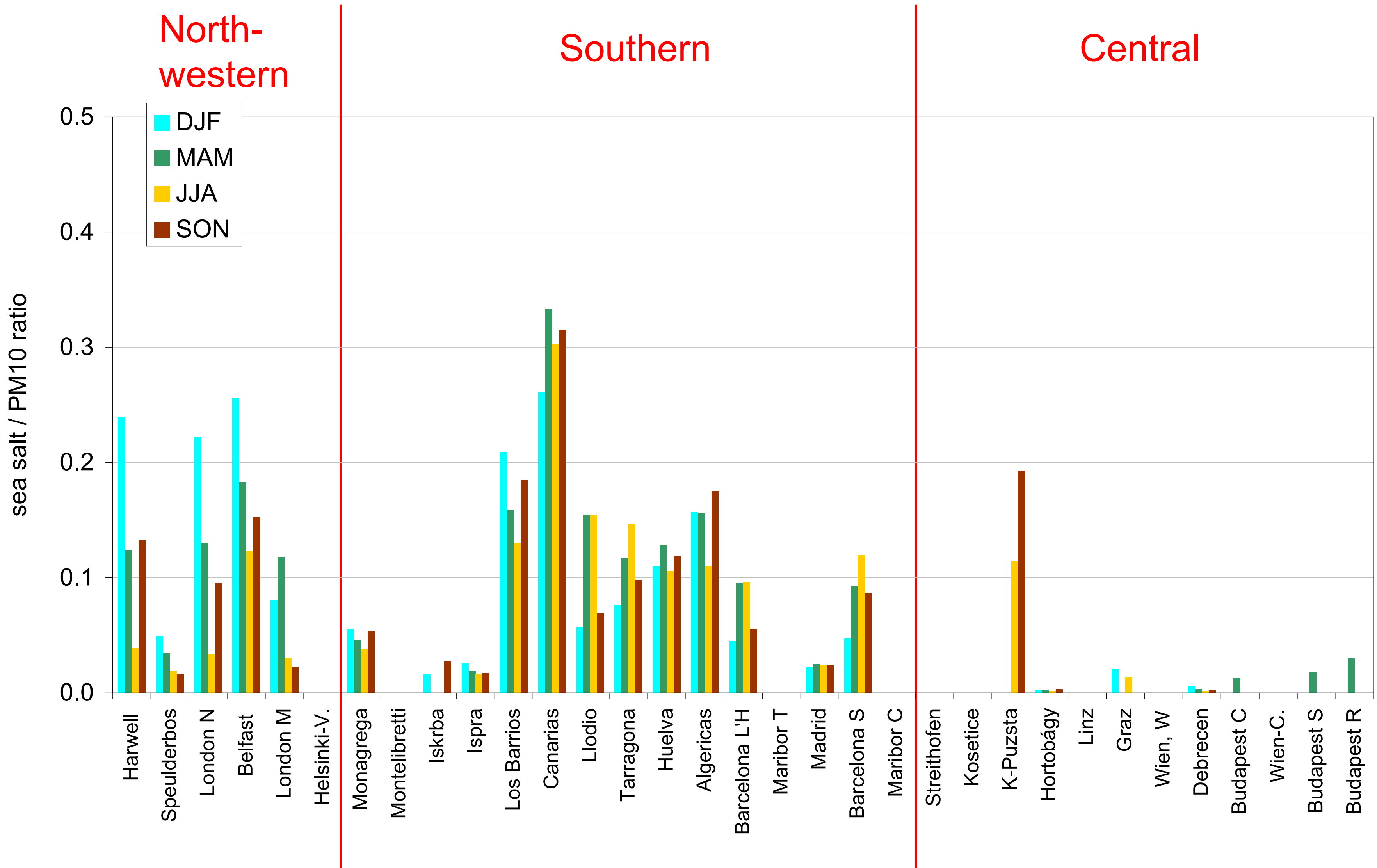

North-western
Southern
Central
DJF
MAM
JJA
SON
SO4 / PM10 ratio
0.5
0.4
0.3
0.2
0.1
0.0
Harwell
Speulderbos
London N
Belfast
London M
Helsinki-V.
Monagrega
Montelibretti
Iskrba
Ispra
Los Barrios
Canarias
Llodio
Tarragona
Huelva
Algericas
Barcelona L'H
Maribor T
Madrid
Barcelona S
Maribor C
Streithofen
Kosetice
K-Puzsta
Hortobágy
Linz
Graz
Wien, W
Debrecen
Budapest C
Wien-C.
Budapest S
Budapest R

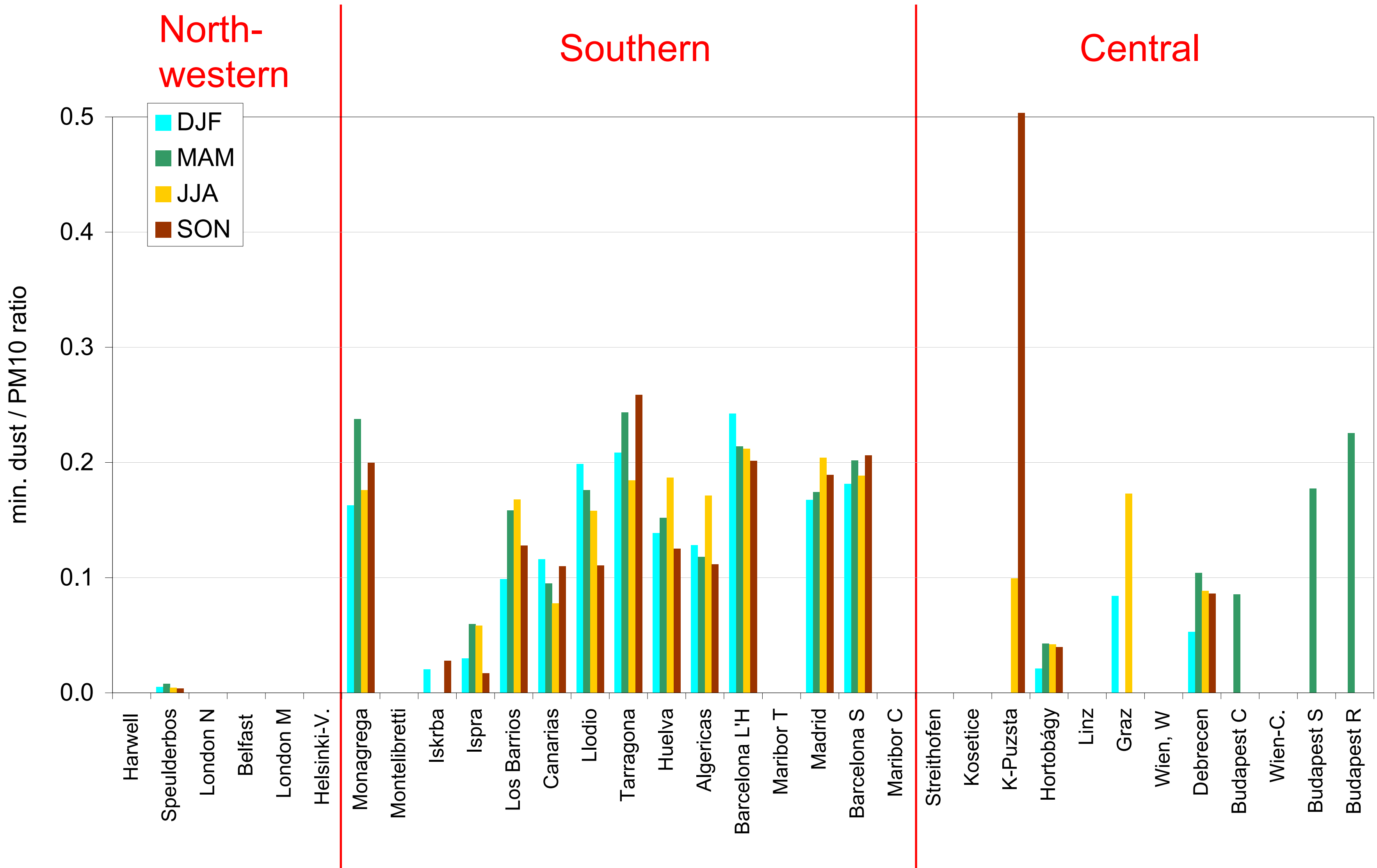

North-western
Southern
Central
DJF
MAM
JJA
SON
NO3 / PM10 ratio
0.5
0.4
0.3
0.2
0.1
0.0
Harwell
Speulderbos
London N
Belfast
London M
Helsinki-V.
Monagrega
Montelibretti
Iskrba
Ispra
Los Barrios
Canarias
Llodio
Tarragona
Huelva
Algericas
Barcelona L'H
Maribor T
Madrid
Barcelona S
Maribor C
Streithofen
Kosetice
K-Puzsta
Hortobágy
Linz
Graz
Wien, W
Debrecen
Budapest C
Wien-C.
Budapest S
Budapest R

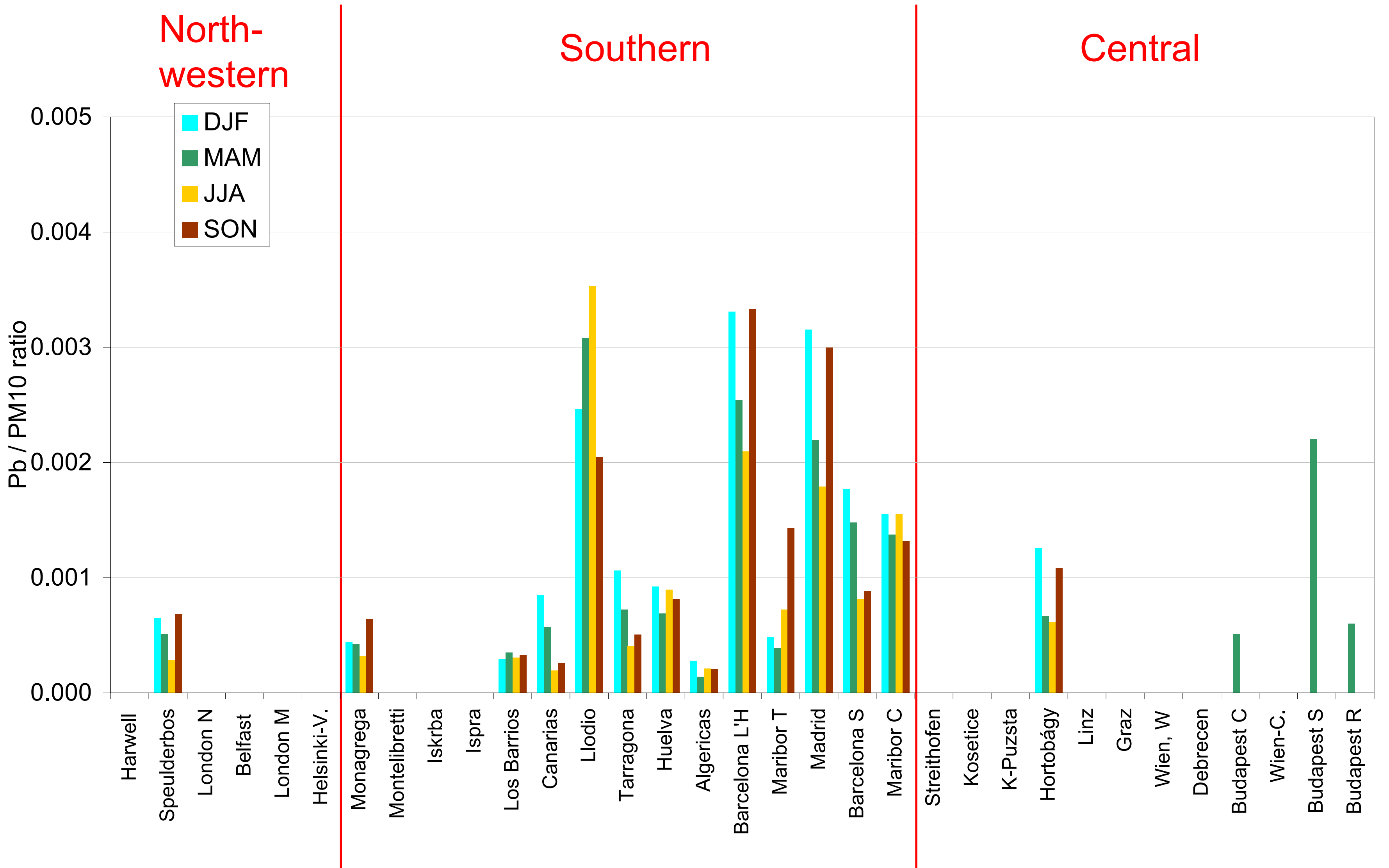

North-western
Southern
Central
DJF
MAM
JJA
SON
OM / PM10 ratio
0.5
0.4
0.3
0.2
0.1
0.0
Harwell
Speulderbos
London N
Belfast
London M
Helsinki-V.
Monagrega
Montelibretti
Iskrba
Ispra
Los Barrios
Canarias
Llodio
Tarragona
Huelva
Algericas
Barcelona L'H
Maribor T
Madrid
Barcelona S
Maribor C
Streithofen
Kosetice
K-Puzsta
Hortobágy
Linz
Graz
Wien, W
Debrecen
Budapest C
Wien-C.
Budapest S
Budapest R


North-western
Southern
Central
DJF
MAM
JJA
SON
EC / PM10 ratio
0.0
0.1
0.2
0.3
0.4
0.5
Harwell
Speulderbos
London N
Belfast
London M
Helsinki-V.
Monagrega
Montelibretti
Iskrba
Ispra
Los Barrios
Canarias
Llodio
Tarragona
Huelva
Algericas
Barcelona L'H
Maribor T
Madrid
Barcelona S
Maribor C
Streithofen
Kosetice
K-Puzsta
Hortobágy
Linz
Graz
Wien, W
Debrecen
Budapest C
Wien-C.
Budapest S
Budapest R


North-western
Southern
Central
DJF
MAM
JJA
SON
TC / PM10 ratio
0.5
0.4
0.3
0.2
0.1
0.0
Harwell
Speulderbos
London N
Belfast
London M
Helsinki-V.
Monagrega
Montelibretti
Iskrba
Ispra
Los Barrios
Canarias
Llodio
Tarragona
Huelva
Algericas
Barcelona L'H
Maribor T
Madrid
Barcelona S
Maribor C
Streithofen
Kosetice
K-Puzsta
Hortobágy
Linz
Graz
Wien, W
Debrecen
Budapest C
Wien-C.
Budapest S
Budapest R

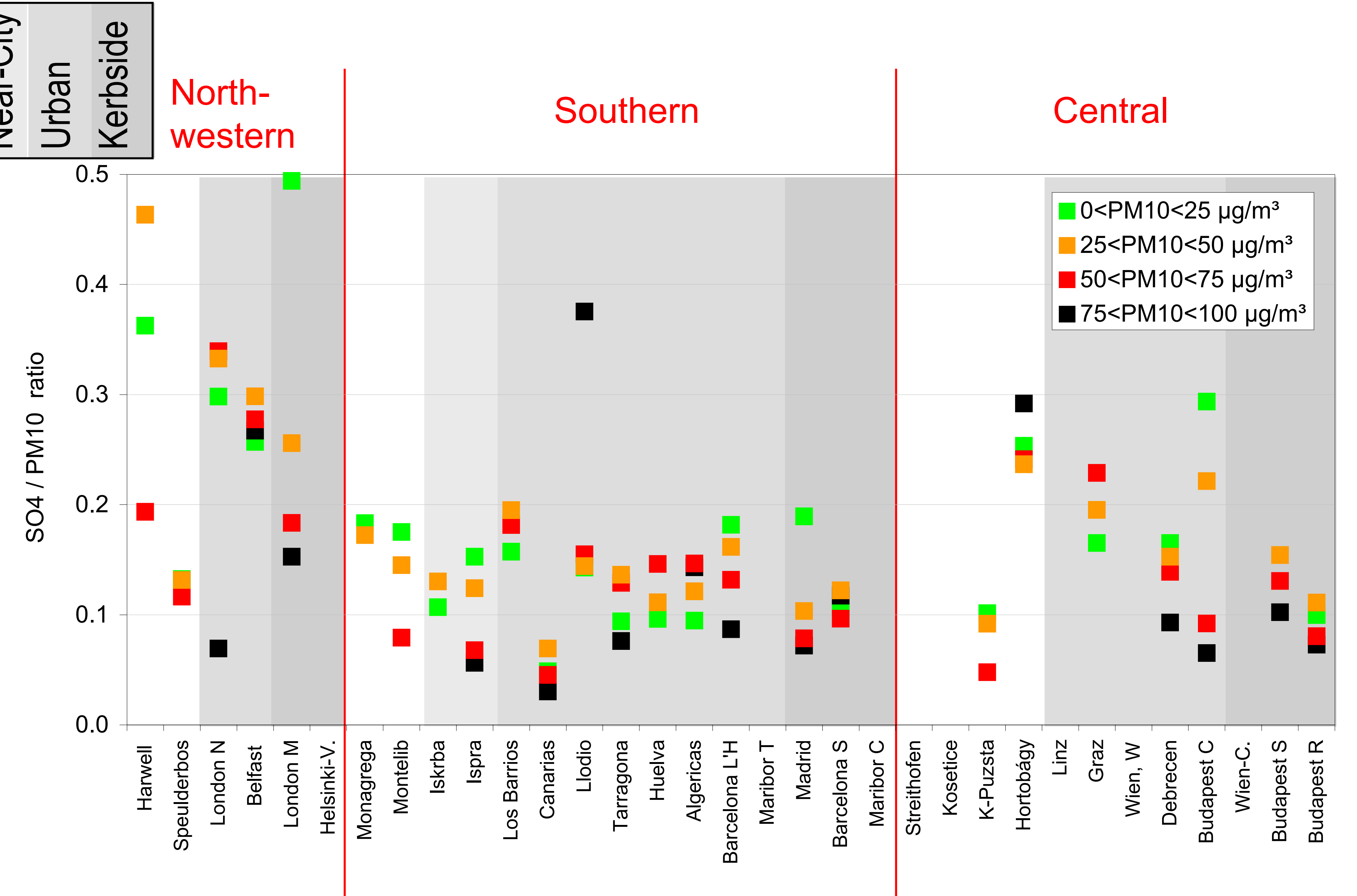

North-western
Southern
Central
DJF
MAM
JJA
SON
sea salt / PM10 ratio
0.5
0.4
0.3
0.2
0.1
0.0
Harwell
Speulderbos
London N
Belfast
London M
Helsinki-V.
Monagrega
Montelibretti
Iskrba
Ispra
Los Barrios
Canarias
Llodio
Tarragona
Huelva
Algericas
Barcelona L'H
Maribor T
Madrid
Barcelona S
Maribor C
Streithofen
Kosetice
K-Puzsta
Hortobágy
Linz
Graz
Wien, W
Debrecen
Budapest C
Wien-C.
Budapest S
Budapest R

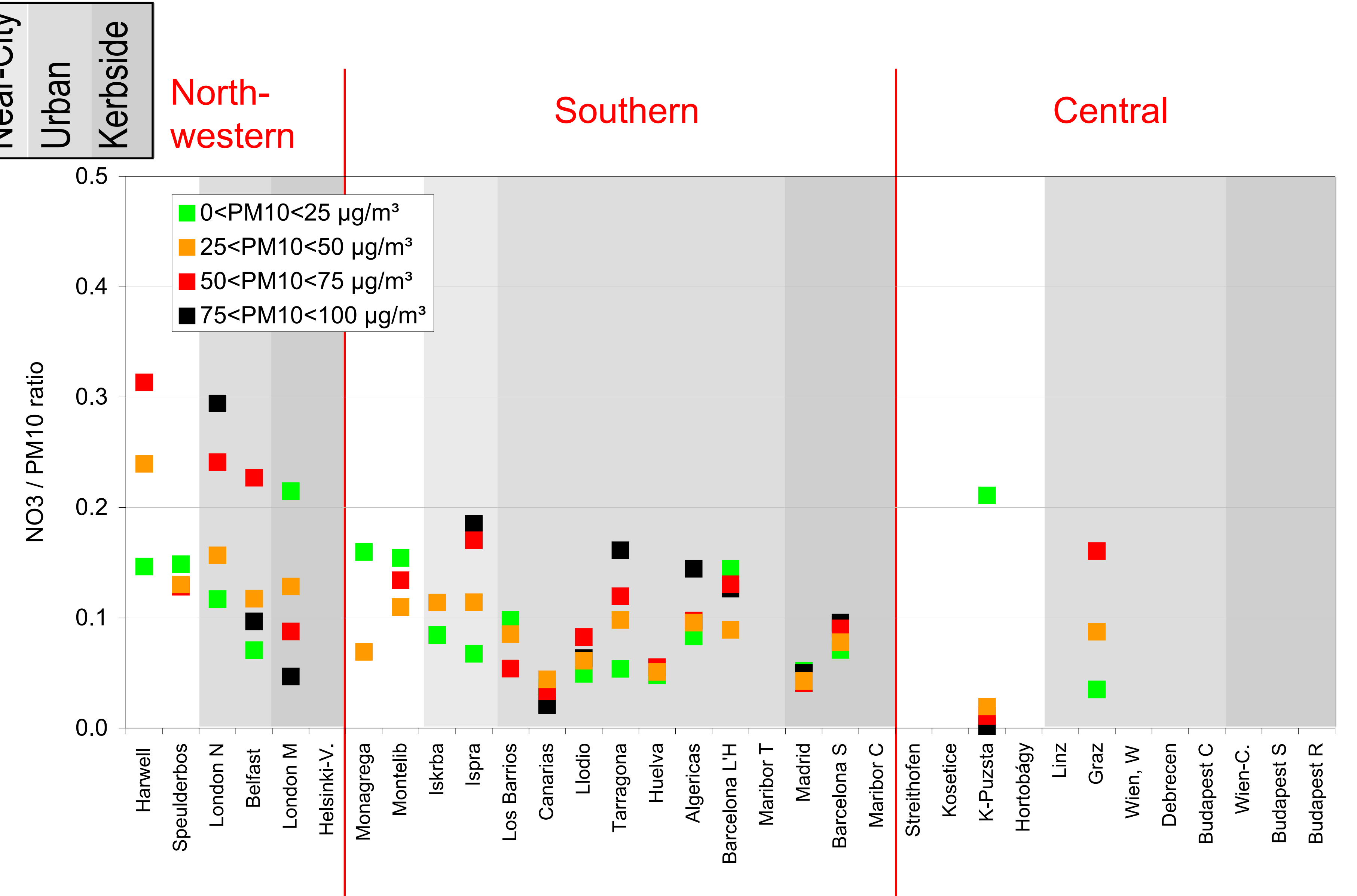

North-western
Southern
Central
DJF
MAM
JJA
SON
min. dust / PM10 ratio
0.0
0.1
0.2
0.3
0.4
0.5
Harwell
Speulderbos
London N
Belfast
London M
Helsinki-V.
Monagrega
Montelibretti
Iskrba
Ispra
Los Barrios
Canarias
Llodio
Tarragona
Huelva
Algericas
Barcelona L'H
Maribor T
Madrid
Barcelona S
Maribor C
Streithofen
Kosetice
K-Puzsta
Hortobágy
Linz
Graz
Wien, W
Debrecen
Budapest C
Wien-C.
Budapest S
Budapest R

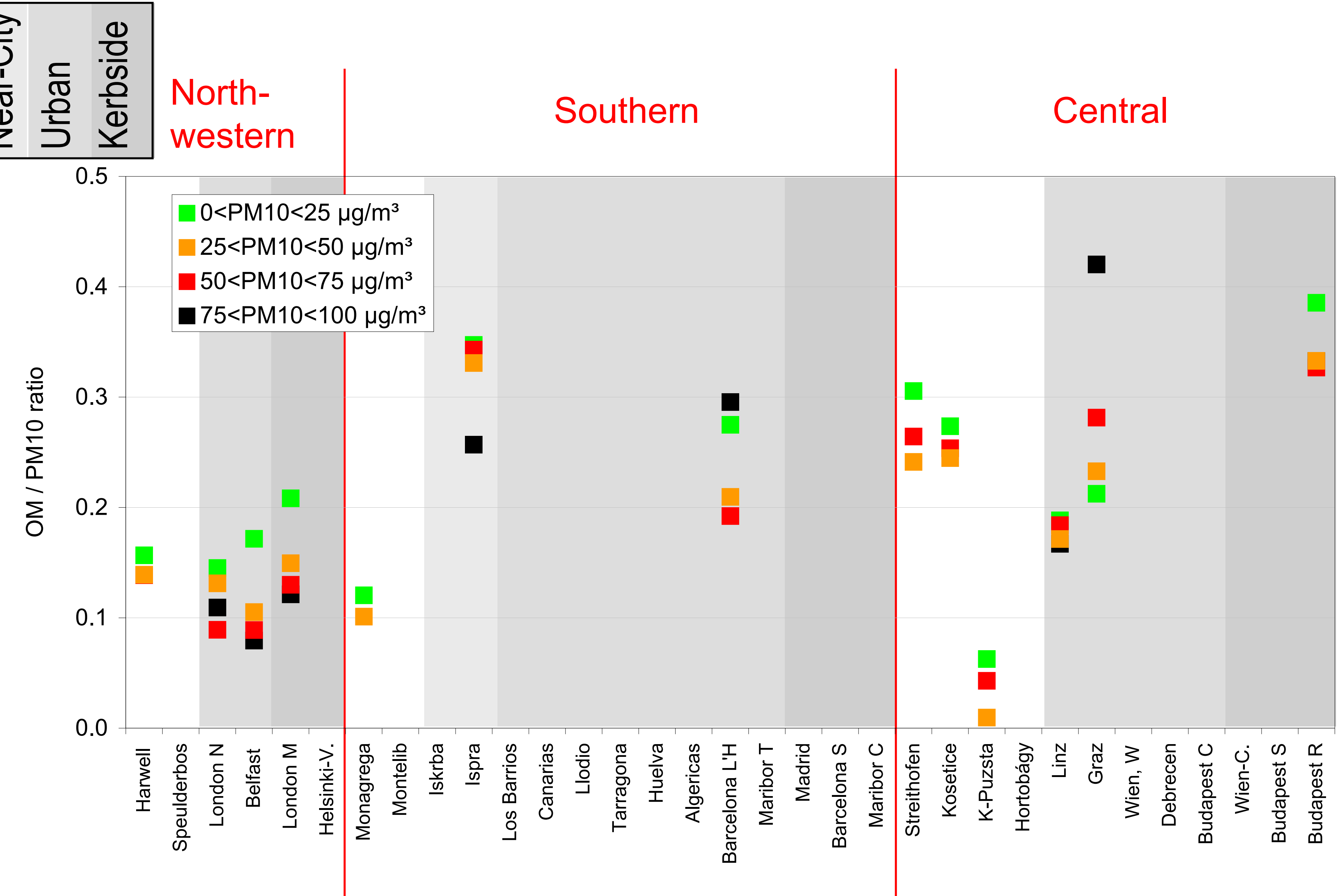

North-western
Southern
Central
DJF
MAM
JJA
SON
Pb / PM10 ratio
0.005
0.004
0.003
0.002
0.001
0.000
Harwell
Speulderbos
London N
Belfast
London M
Helsinki-V.
Monagrega
Montelibretti
Iskrba
Ispra
Los Barrios
Canarias
Llodio
Tarragona
Huelva
Algericas
Barcelona L'H
Maribor T
Madrid
Barcelona S
Maribor C
Streithofen
Kosetice
K-Puzsta
Hortobágy
Linz
Graz
Wien, W
Debrecen
Budapest C
Wien-C.
Budapest S
Budapest R

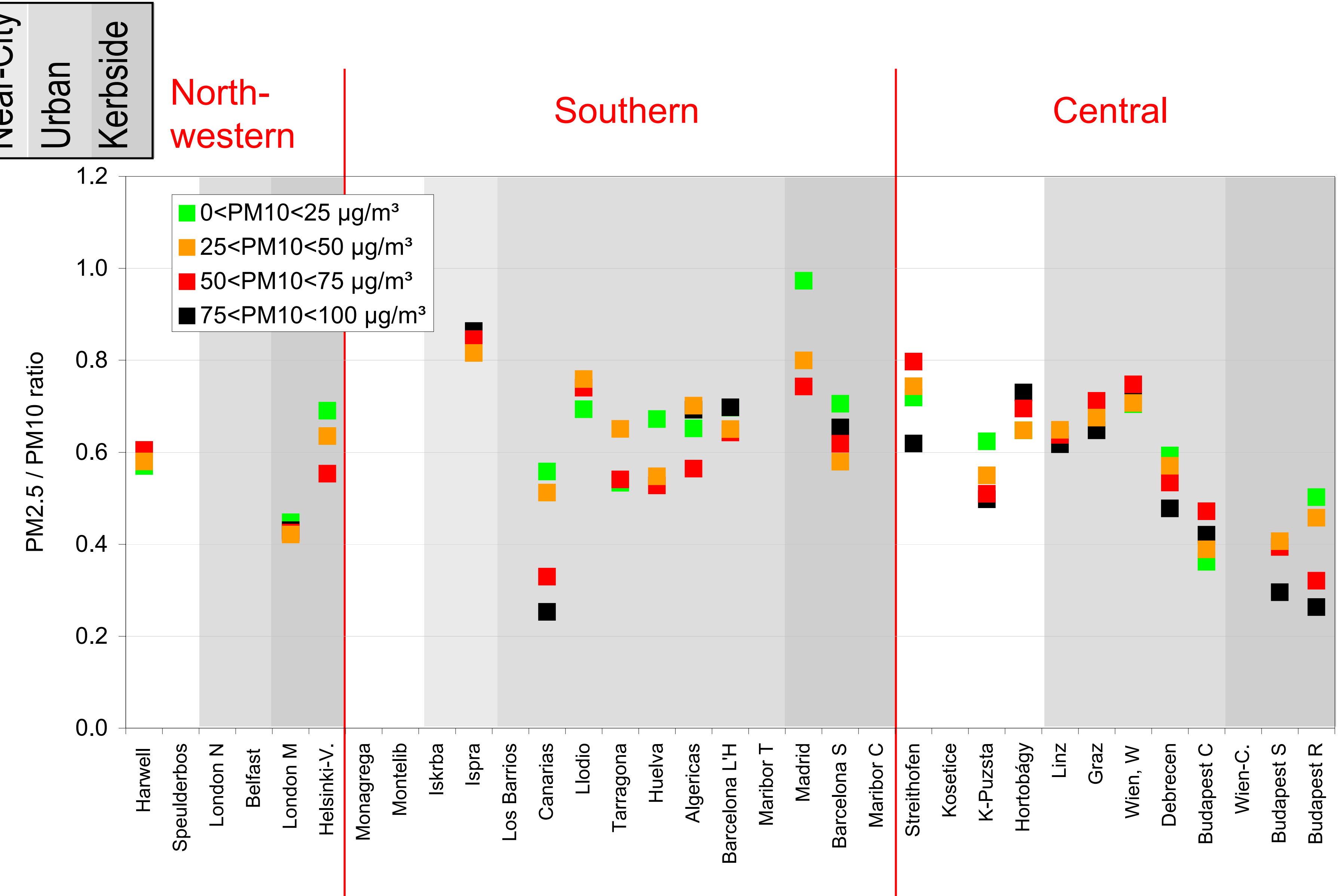
Average contribution of main aerosol constituents to PM10

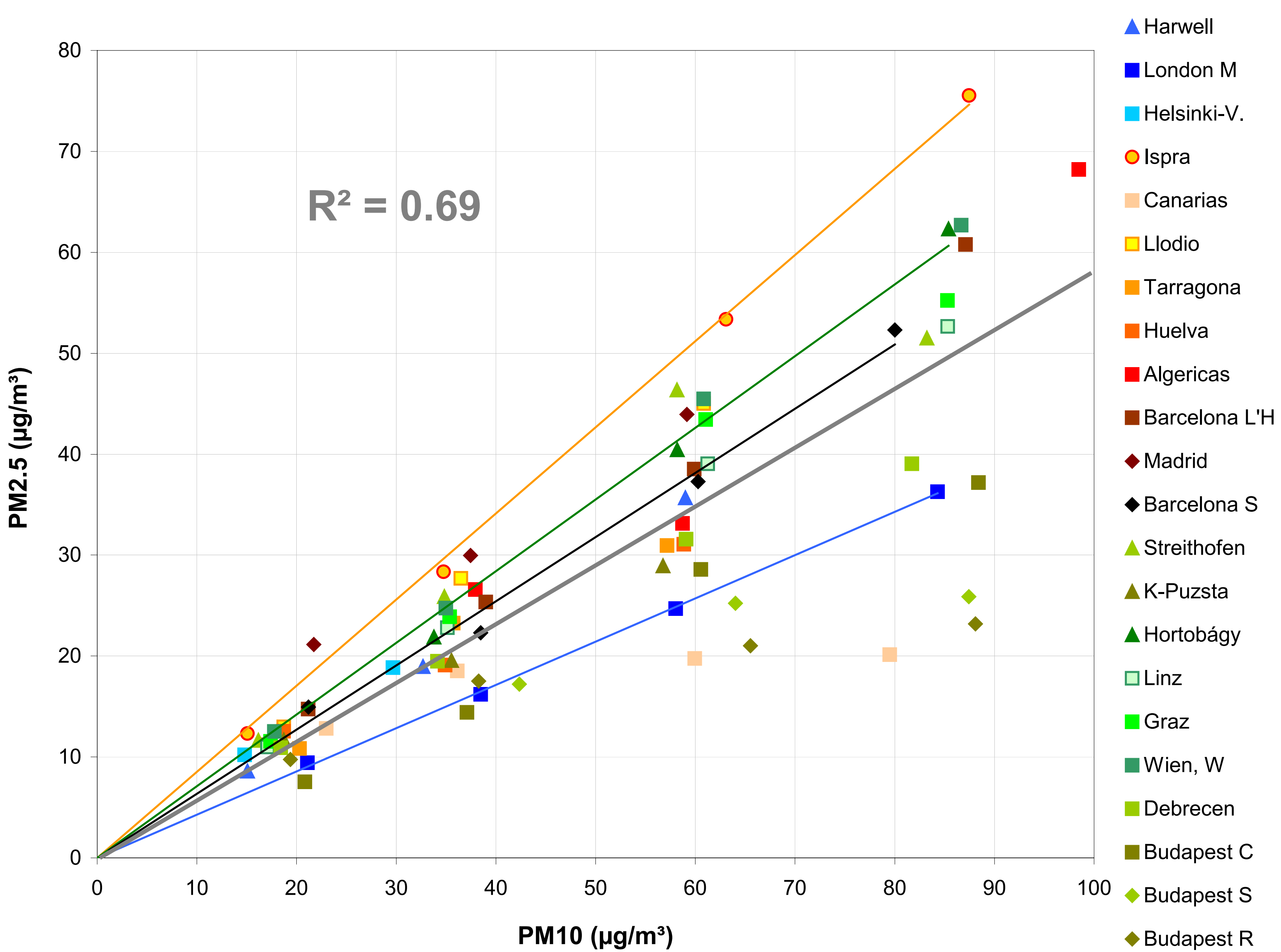
		rural	near-city	urban	kerbside
North Western Europe	min. dust	1%			
	sea salt	8%		15%	6%
	SO4	13%		9%	8%
	NO3	15%		11%	12%
	OM	15%		14%	14%
	EC	4%		5%	8%
	TC	*14%*		*15%*	*18%*
Southern Europe	min. dust	19%	9%	16%	19%
	sea salt	5%	10%	14%	6%
	SO4	16%	14%	12%	10%
	NO3	13%	10%	8%	6%
	OM	12%	32%	22%	
	EC	1%	5%	2%	
	TC	*13%*	*21%*	*19%*	*27%*
Central Europe	min. dust	4%		8%	
	sea salt	0.2%		0.3%	
	SO4	24%		15%	
	NO3				
	OM	28%		21%	
	EC	12%		16%	11%
	TC	*27%*		*30%*	


Near-City
Urban
Kerbside
North-western
Southern
Central
SO4 / PM10 ratio
0.0
0.1
0.2
0.3
0.4
0.5
0<PM10<25 µg/m³
25<PM10<50 µg/m³
50<PM10<75 µg/m³
75<PM10<100 µg/m³
Harwell
Speulderbos
London N
Belfast
London M
Helsinki-V.
Monagrega
Montelib
Iskrba
Ispra
Los Barrios
Canarias
Llodio
Tarragona
Huelva
Algericas
Barcelona L'H
Maribor T
Madrid
Barcelona S
Maribor C
Streithofen
Kosetice
K-Puzsta
Hortobágy
Linz
Graz
Wien, W
Debrecen
Budapest C
Wien-C.
Budapest S
Budapest R


Near-City
Urban
Kerbside
North-western
Southern
Central
0<PM10<25 µg/m³
25<PM10<50 µg/m³
50<PM10<75 µg/m³
75<PM10<100 µg/m³
NO3 / PM10 ratio
0.5
0.4
0.3
0.2
0.1
0.0
Harwell
Speulderbos
London N
Belfast
London M
Helsinki-V.
Monagrega
Montelib
Iskrba
Ispra
Los Barrios
Canarias
Llodio
Tarragona
Huelva
Algericas
Barcelona L'H
Maribor T
Madrid
Barcelona S
Maribor C
Streithofen
Kosetice
K-Puzsta
Hortobágy
Linz
Graz
Wien, W
Debrecen
Budapest C
Wien-C.
Budapest S
Budapest R


Near-City
Urban
Kerbside
North-western
Southern
Central
0<PM10<25 µg/m³
25<PM10<50 µg/m³
50<PM10<75 µg/m³
75<PM10<100 µg/m³
OM / PM10 ratio
0.0
0.1
0.2
0.3
0.4
0.5
Harwell
Speulderbos
London N
Belfast
London M
Helsinki-V.
Monagrega
Montelib
Iskrba
Ispra
Los Barrios
Canarias
Llodio
Tarragona
Huelva
Algericas
Barcelona L'H
Maribor T
Madrid
Barcelona S
Maribor C
Streithofen
Kosetice
K-Puzsta
Hortobágy
Linz
Graz
Wien, W
Debrecen
Budapest C
Wien-C.
Budapest S
Budapest R


Near-City
Urban
Kerbside
North-western
Southern
Central
0<PM10<25 µg/m³
25<PM10<50 µg/m³
50<PM10<75 µg/m³
75<PM10<100 µg/m³
PM2.5 / PM10 ratio
0.0
0.2
0.4
0.6
0.8
1.0
1.2
Harwell
Speulderbos
London N
Belfast
London M
Helsinki-V.
Monagrega
Montelib
Iskrba
Ispra
Los Barrios
Canarias
Llodio
Tarragona
Huelva
Algericas
Barcelona L'H
Maribor T
Madrid
Barcelona S
Maribor C
Streithofen
Kosetice
K-Puzsta
Hortobágy
Linz
Graz
Wien, W
Debrecen
Budapest C
Wien-C.
Budapest S
Budapest R

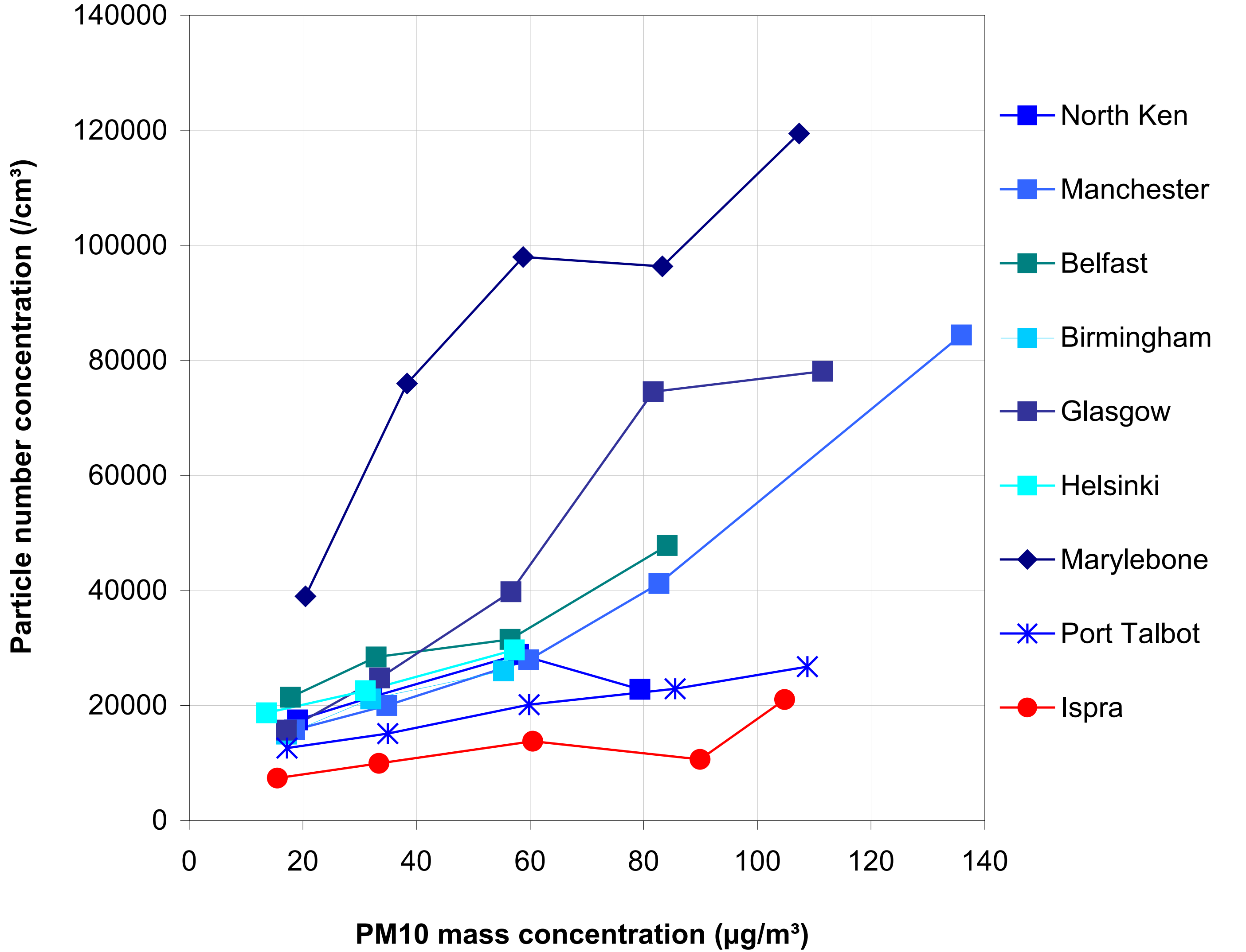

R² = 0.69
PM2.5 (µg/m³)
PM10 (µg/m³)
0
10
20
30
40
50
60
70
80
90
100
Harwell
London M
Helsinki-V.
Ispra
Canarias
Llodio
Tarragona
Huelva
Algericas
Barcelona L'H
Madrid
Barcelona S
Streithofen
K-Puzsta
Hortobágy
Linz
Graz
Wien, W
Debrecen
Budapest C
Budapest S
Budapest R

Urban background

Kerbside

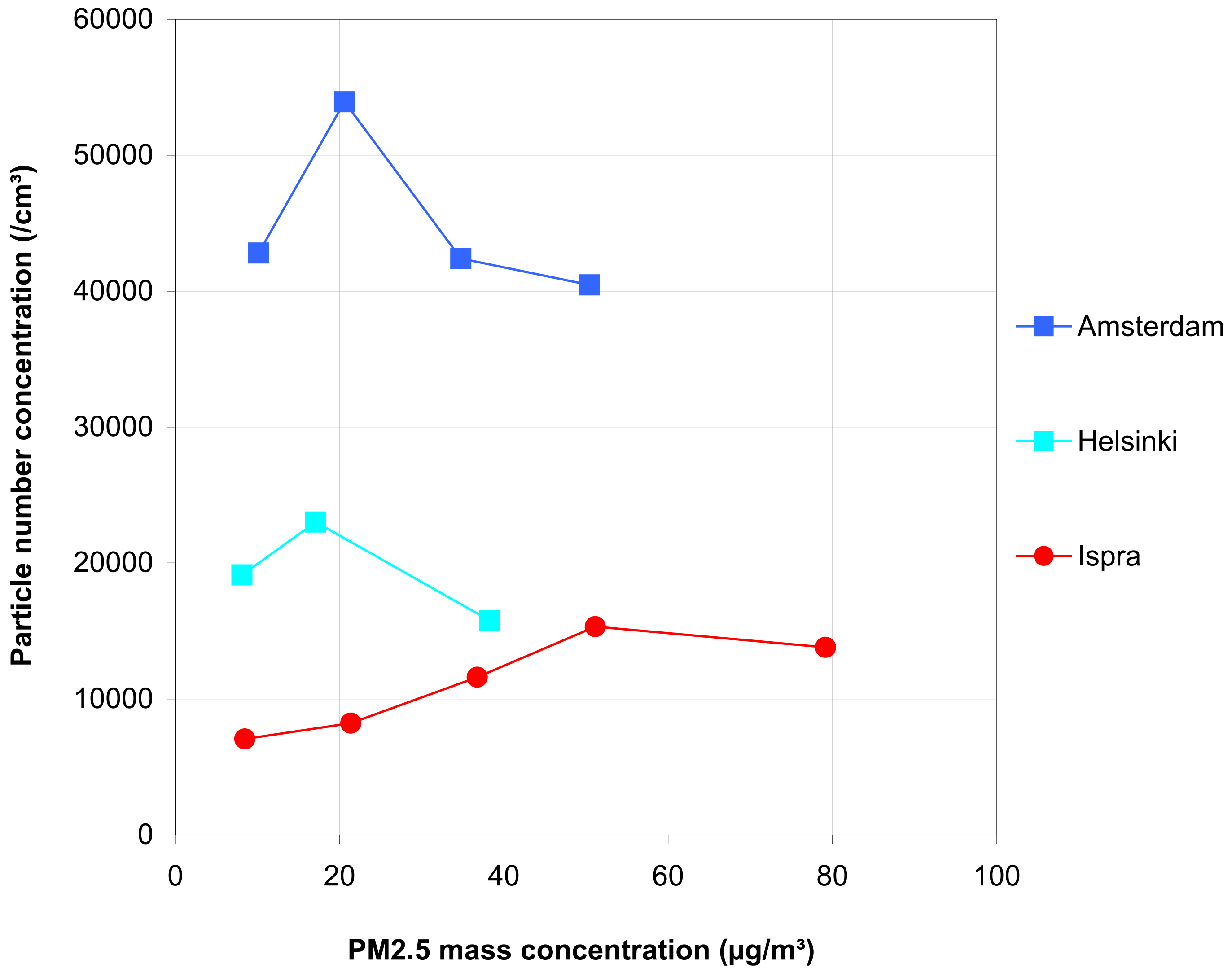
Industrial

Near-City



Urban background

Near-City



nclusions -2

Correlation PM2.5 vs. PM10 ⇨ R^2 = 0.69 (COST633)

⇨ R^2 = 0.95 (*Phenomenolo*

PM2.5 / PM10 is site dependent

⇨ 0.43<ratio<0.85 (COST633)

⇨ 0.58<ratio<0.88 (*Phenomenolo*

sites where PM10 and PM2.5 are not correlated (COST 633)

not observed in *Phenomenology*

lo clear increase in PM2.5/PM10 ratio with PM10 levels

in contrast with *Phenomenology*

nclusions -3

lo correlation between PM2.5 or PM10 and particle number c

confirms *Phenomenology*

'article number / PM10 is rather constant at comparable sites
urban background in NW Europe) for PM10 < 75 µg/m³

new finding

'article number / PM10 increases from near-city to kerbside s

confirms *Phenomenology*

nclusions -4

lain PM10 constituents: <u>generally</u> OM, SO_4^{2-} and NO_3^-

Phenomenology: OM and SO_4^{2-}

lineral dust and sea salt may be major PM10 constituents

new finding

lear gradients in SO_4^{2-}, NO_3^-, and TC contributions to PM10

- from rural to kerbside sites (confirms *Phenomenology*)
- from NW to Central Europe (not shown in *Phenomenolo*

lo clear evidence of PM10 composition change with PM10 le

more complex than in *Phenomenol*