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Paper/Poster-Abstract Form

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Title: Spatiotemporal variation of particle number concentration in urban area of Basel, Switzerland and relationship with mass measurements

Abstract: (extended)

The abstracts for papers and posters must contain unpublished information on the research subject: background, investigation methods, results and conclusions. Graphs and references are very welcome. Acronyms should be avoided. Abstracts with < 300 words can not be considered. General information on products which are already commercially available can not be accepted as presentations for the conference but are very welcome at the exhibition of particle filter systems and nanoparticle measurement instruments.

Background: This study is part of the Swiss Cohort Study on Air Pollution and Lung and Heart Diseases in Adults (SAPALDIA), a nearly 20-year old cohort study spread in 8 geographically diverse areas in Switzerland. Innovative exposure modeling has been conducted in SAPALDIA earlier for PM_{10} and NO_2, however, exposure to specific traffic related pollutants such as ultrafine particles and PM constituents has not been assessed.

Aim: The overarching aim is to provide the estimates of individual long-term outdoor traffic-related air pollution exposures of the cohort participants. This paper focuses on the spatial and temporal variation of home outdoor particle number concentration (PN) and its relationship with other PM mass metrics in one of the SAPALDIA area, Basel.

Methods: The PN measurements are being conducted at 20 residences each in four of the eight SAPALDIA areas in three seasons over a period of 2 years, 2011-2012. Indoors and outdoors monitoring will be carried out biweekly for $PM_{2.5}$, PM_{10}, NO_2 and weekly for PN. Particle counts are measured using a particle counting device, miniDiSC (miniature diffusion size classifier), a portable diffusion charging based device and measures nanometer sized (10-300nm) particles with a time-resolution of one second.

Results: Mean weekly averaged PN levels are observed 14529±3296, 13659±1878 and 11545 particles/cm^3 at street, urban and regional background locations respectively. Median correlation coefficient for all sites is 0.70 (range 0.36-0.91) and 0.83 (range 0.39-0.99) for hourly and daily PN respectively. Median coefficient of divergence, a measure of spatial heterogeneity, for all site pairs is 0.15 (range 0.05-0.27), showing a low to mid spatial heterogeneity of daily PN in Basel. All sites show the typical traffic rush hour peaks in the diurnal profiles but the heterogeneity in sites is more apparent in spring season than the winter (Figure 1). Comparison of these 1-week averaged PN measurements with concurrent $PM_{2.5}$, PM_{10} and NO_2 measurements showed reasonable spatial agreement with NO2 but low to poor correlation with PM2.5 and PM10 (Figure 2).

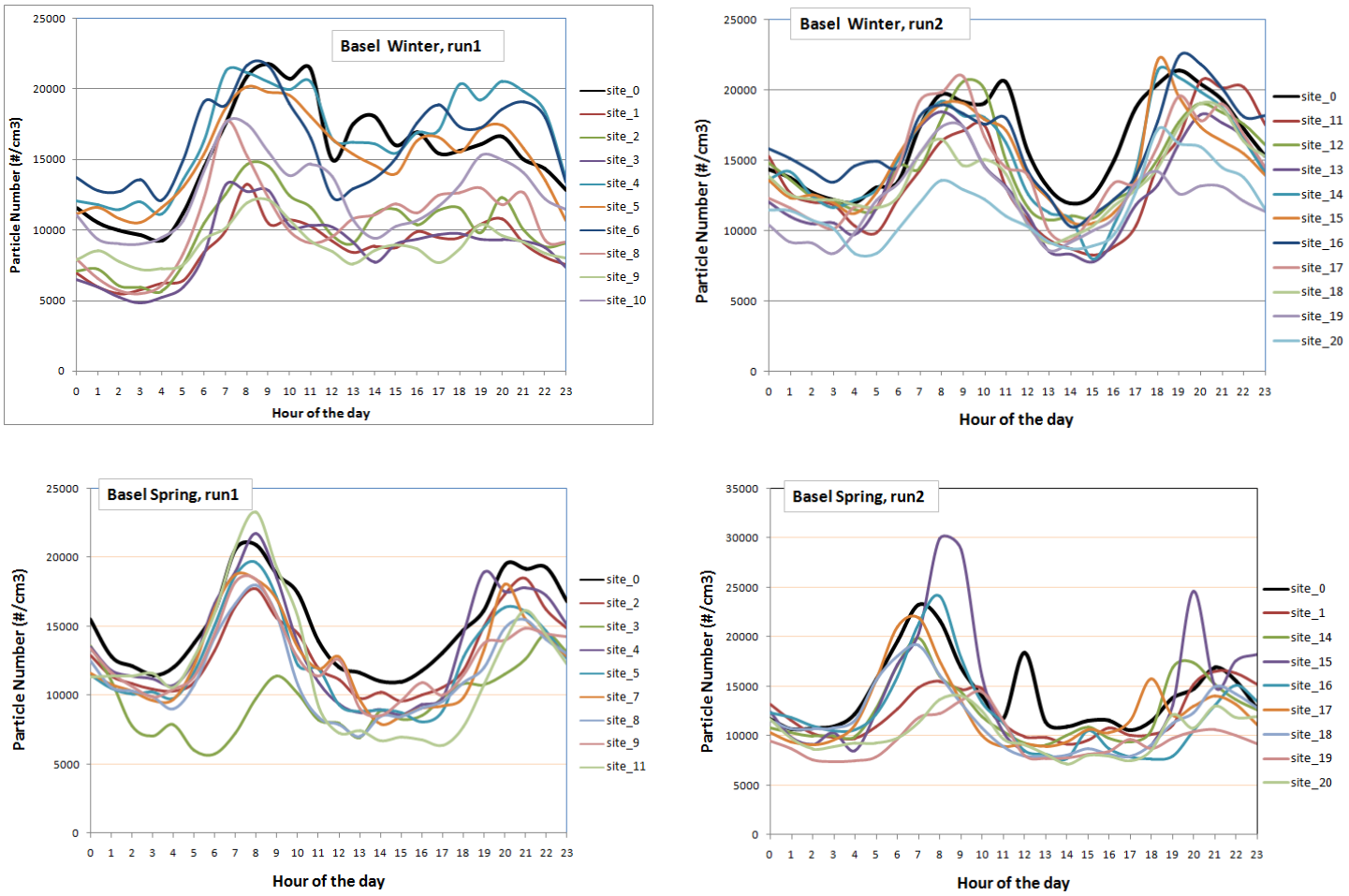

Figure 1: Diurnal variation in particle number concentrations in Basel in winter (top panel) and spring (lower panel). Note: Site_0 represents the continuously monitored urban background site and run 1 and 2 correspond to two consecutive fortnights in each season.

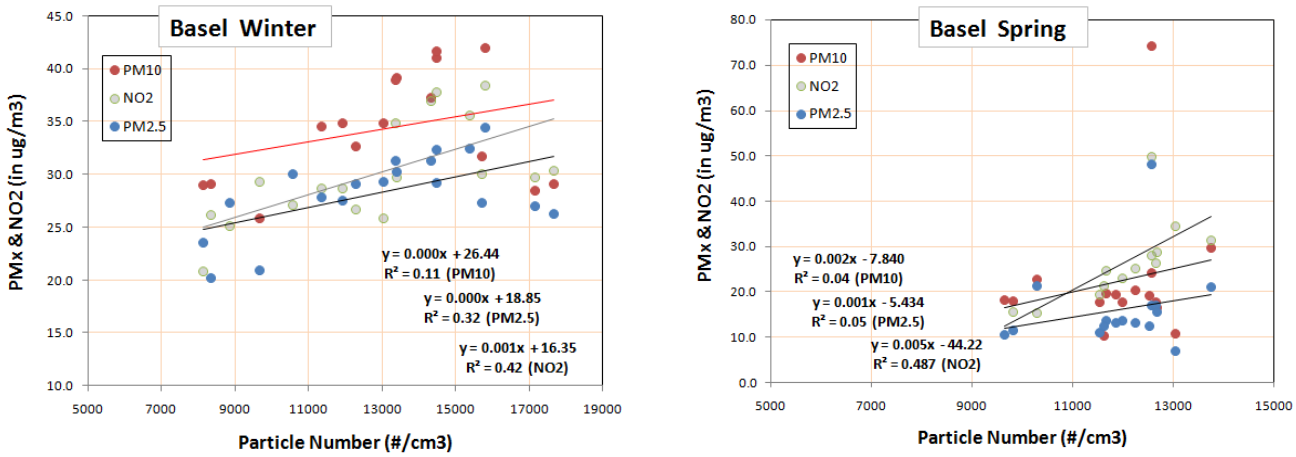

Figure 2: Comparison of 1or 2 week particle number concentrations with concurrent PM2.5, PM10 and NO2 measurements in Basel in winter and spring seasons.

Conclusions: Our first results show significant differences in particle number concentrations in home outdoor locations and document the differential impact of traffic on PN levels in the city of Base. We observed the sites to be moderately heterogeneous in terms of spatial UFP distribution. Daily spatial correlations are higher than hourly ones with overall low to moderate correlations. Long-term (weekly or biweekly) UFP show a poor correlations with PM mass metrics but moderate to high association with $NO_{2.}$

Short CV: I am currently a postdoctoral researcher at Swiss Tropical and Public Health Institute, Basel focusing on environmental exposure and air quality assessment. I started working in Basel since Dec 2007, at that time with University of Basel. I have obtained PhD in Environmental Engineering from University of Southern California, Los Angeles, CA in 2007 where my work was primarily on organic tracer emissions from on-road vehicle fleets. Prior to joining PhD, I completed MS in Chemistry and MS in Environmental Engineering from Indian Institute of Technology (IIT), Delhi, India (1999) and IIT Bombay, India (2001) respectively.

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Department of Epidemiology and Public Health/ Environmental Exposure Sciences Unit

Spatiotemporal variation of particle number concentration in urban area of Basel, Switzerland and relationship with mass measurements

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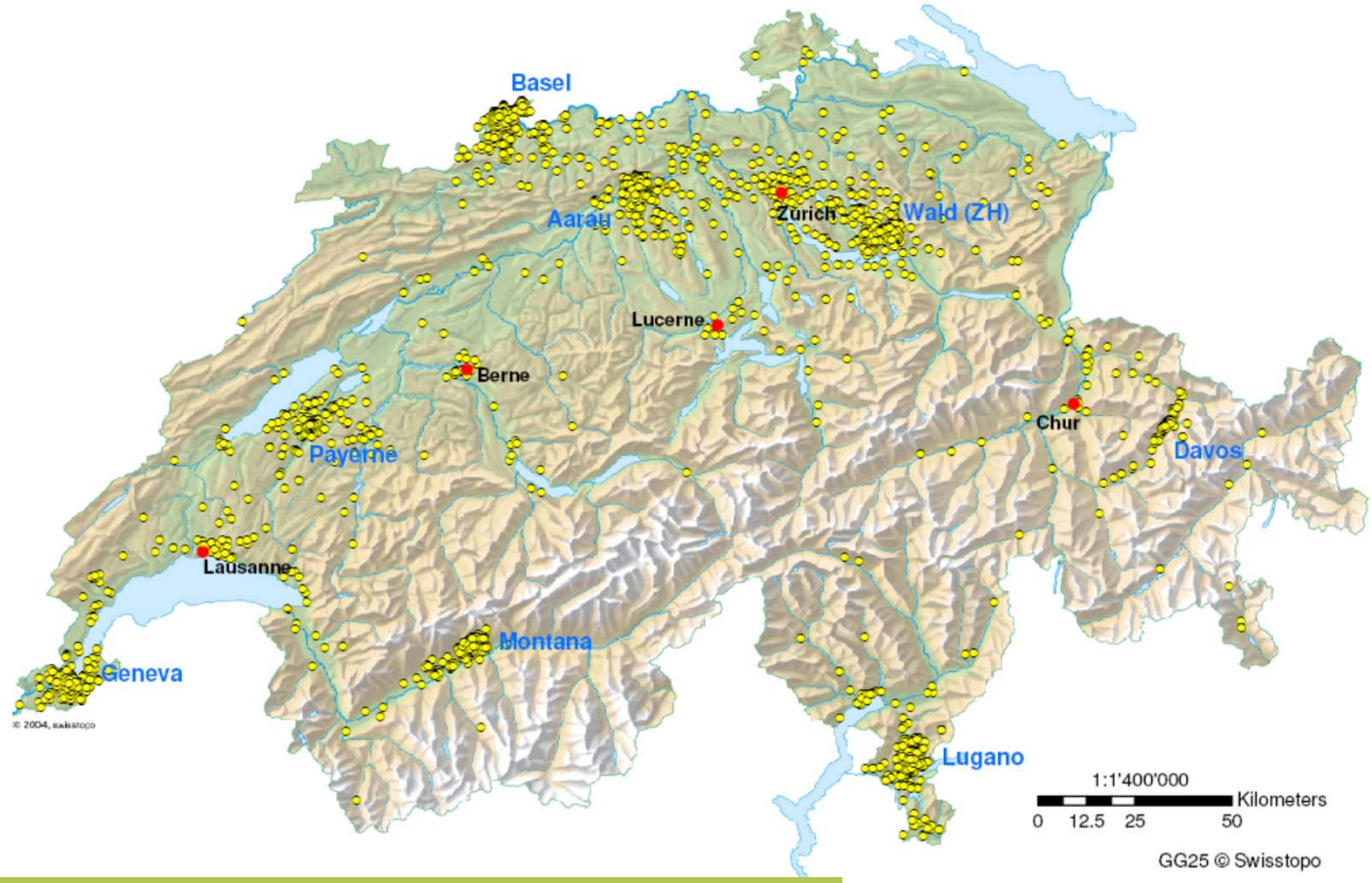
15th ETH-CGN Conference, June 26-29 2011, Zürich

SAPALDIA2: Subjects distribution



SAP 2: 2001-2002 (n=8,047)

Swiss TPH

SAPALDIA: a prospective cohort study

X-Sectional (SAP1)

8 Areas

Interview
Lung function
Methacholine
Skin-prick test
IgE
Exhaled CO

9‘651

age 18-60

Address Update

Cohort + (SAP2)

Interview
Lung function
Methacholine
Total+spec. IgE
Biobank
Heart rate var.
Blood pressure
Exhaled CO

8‘047

age 29-70

Address Update

Cohort ++ (SAP3)

Interview
Lung function
Methacholine
Total+spec. IgE
Biobank
Heart rate var.
Blood pressure
CIMT, PWV

~6000

age 36-78

NO_2, O_3, CO, SO_2, Meteorological

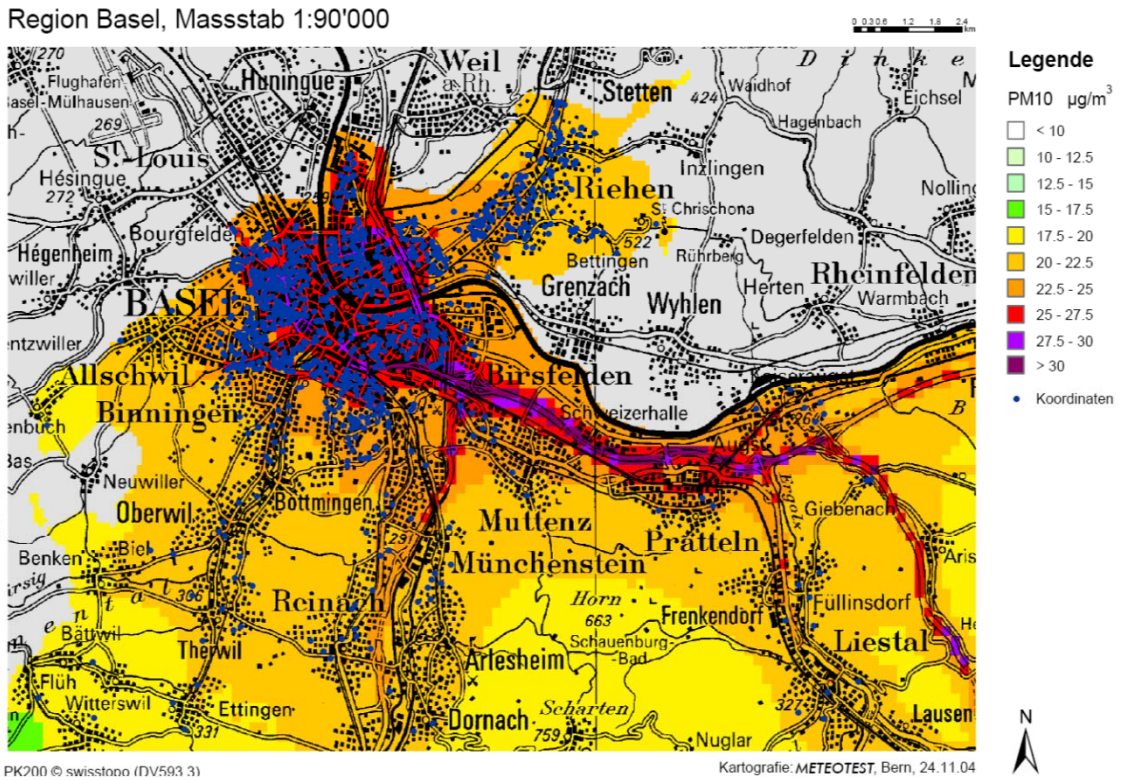
Dispersion Pollen	p NO_2	Dispersion	p NO_2	p NO/NO_2 Dispersion+
TSP	(PM_{10})	PM_{10} $PM_{2.5}$	Pollen	PM_{10}/$PM_{2.5}$/PN/ BS+
1991	1992/93	95/97/99	2000 2002	2010/11

Individual air pollution exposure estimates in SAPALDIA 1 & 2

NO_2 hybrid model – Basel
(using dispersion as well as GIS/land-use variable)

Variable	Estimate	SE	p-v
Intercept	1.94	0.25	<0
Dispersion/central NO_2 ratio	0.37	0.05	<0
T*cos(t)	0.01	0	<0
T*sin(t)	-0.01	0	<0
(Dist to Class1)²	1.1E-06	1.4E-07	<0
log(Dist to Class 1)	-0.12	0.02	<0
Length w/in 500m	2.0E-04	6.8E-05	<0.01
(Length w/in 500m)²	-1.9E-08	8.2E-09	0.03
(cars w/in 100m)²	-3.6E-08	7.4E-09	<0.001
(population 25)²	3.2E-09	1.8E-09	0.07
building_1	-0.01	0	<0.001
Z	-3.9E-03	6.7E-04	<0.001

Adj R^2 = 0.75



PM_{10} dispersion model – Basel
(Liu et al., EHP, 2007)

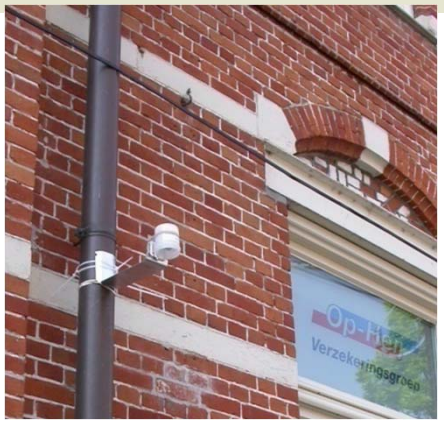
(Liu et al., AE, revised manuscript submitted, May 2011)

Exposure assessment objectives / aims

Overarching aim is to provide the estimates of individual long-term outdoor traffic-related air pollution exposures (e.g. for ultrafine particles) of the cohort participants

- To investigate spatio-temporal variation of ultrafine particles within urban areas
- To explore the long-term spatial relationship with other PM mass metric and co-pollutants (e.g. NO_2)
- To investigate indoor ultrafine exposure in typical Swiss homes

Monitoring Methods



NO_2
- Passive Passam tubes
- 2-week sampling period

Gravimetric $PM_{2.5}$ / PM_{10}
- $PM_{2.5}$ & PM_{10} w/ Harv Impactors (at 4 L/min)
- 2-week sampling periods

PN counts
- miniDiSC (1-sec resolution)
- 1 or 2 week sampling periods

Black smoke (BS)
- EL43D reflectometer

- **2 week sampling / 10 sites simultaneously**
- **~ 40 locations**
- **3 seasons / year**

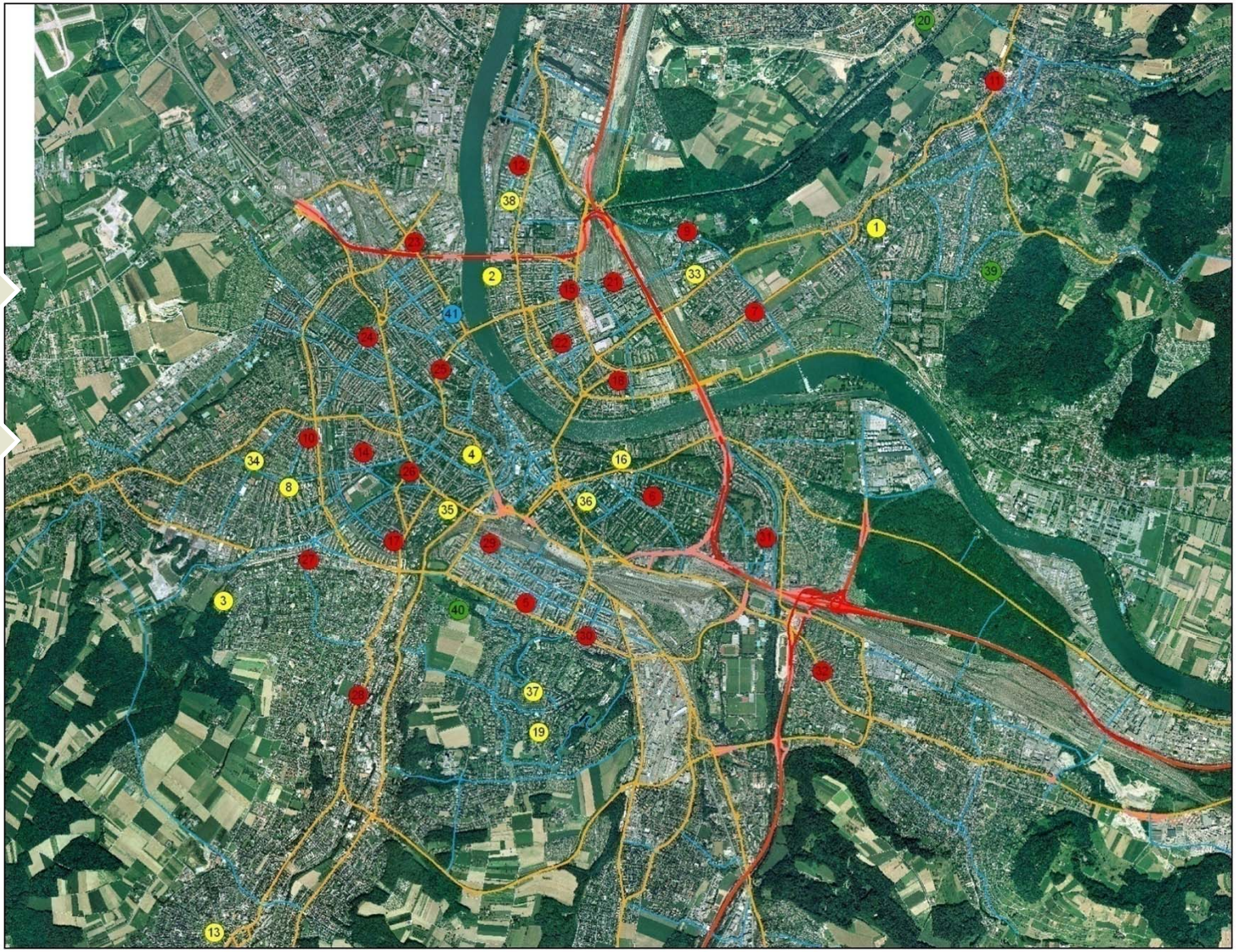
Basel monitoirng sites

Swiss TPH

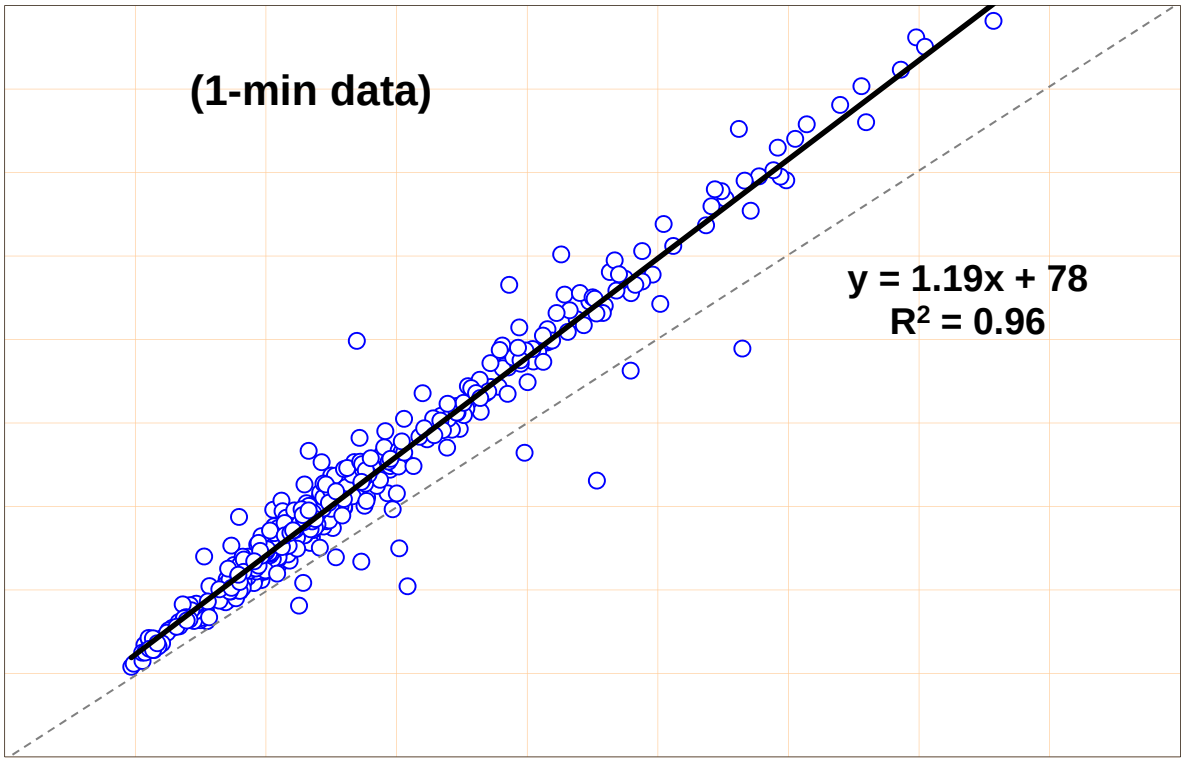
21 PM_x + NO_2 sites

20 NO_2 sites

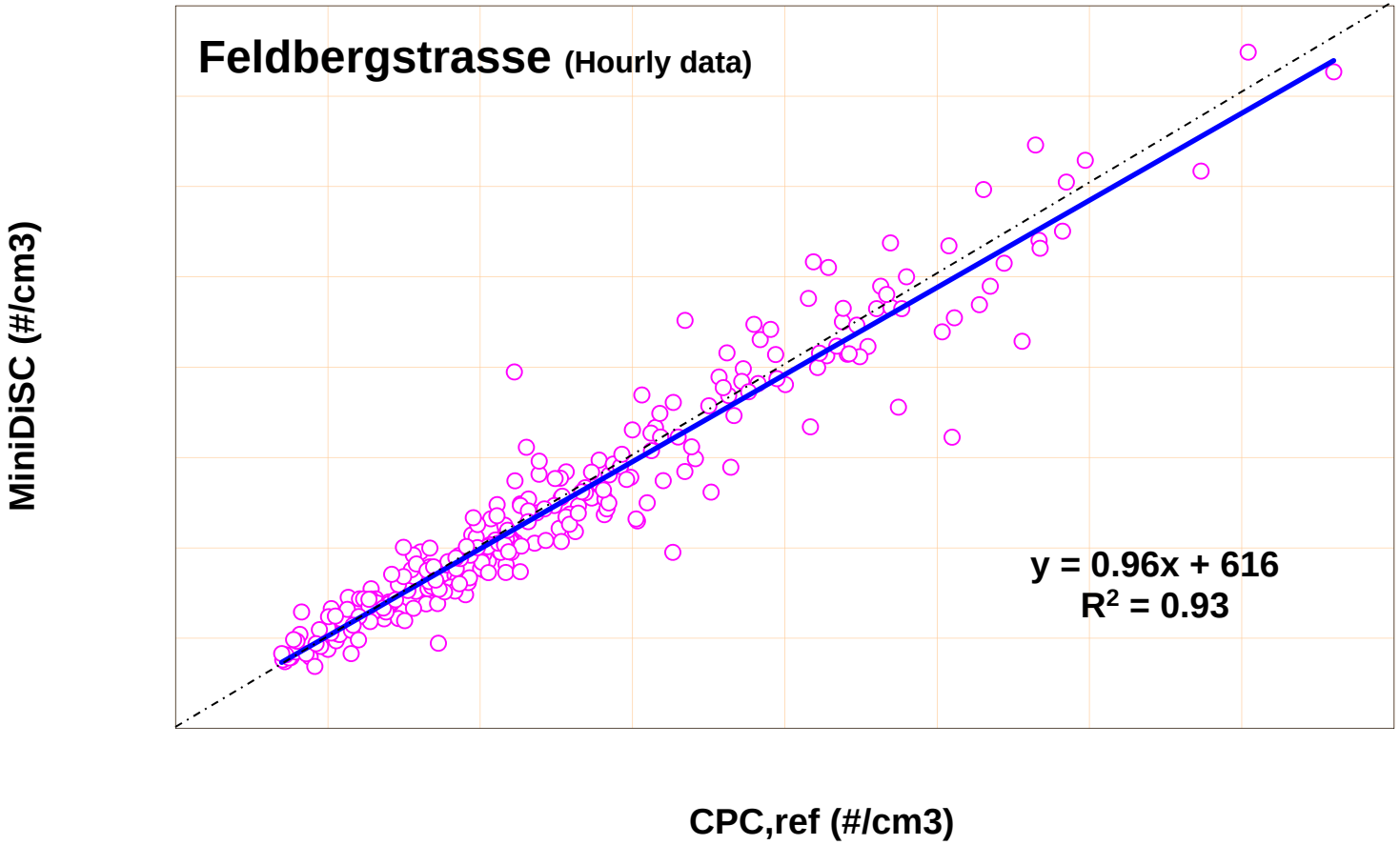
PM sites are subject homes



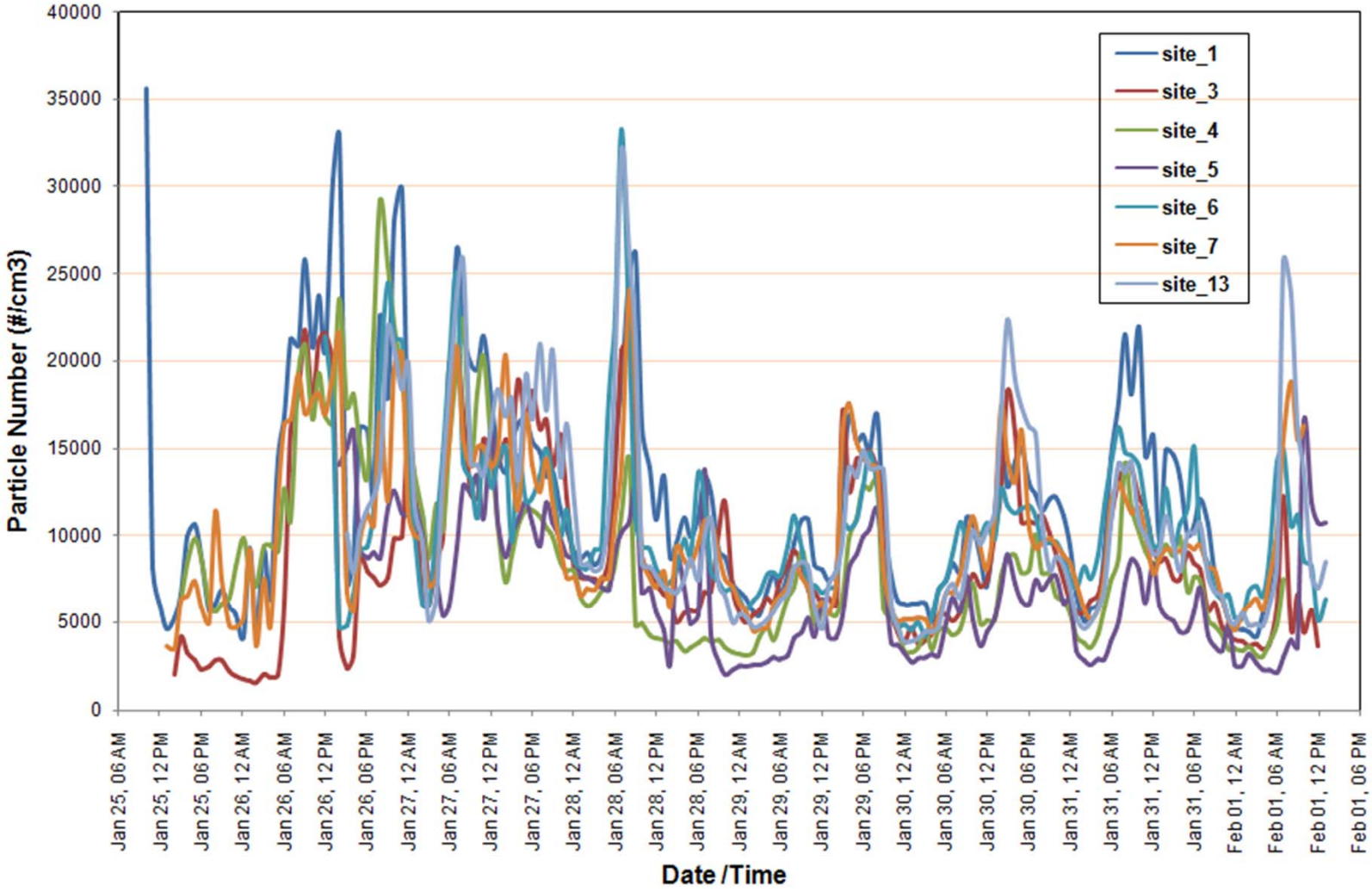
Comparison w/ other handhelds (Ptrak, TSI Inc.)



Comparison w/ standard CPC (3022 TSI Inc.)



Basel Winter: Hourly time series



Correlations between sites: Basel Winter

Hourly data (min N= 139)

	PN_1	PN_3	PN_5	PN_6	PN_7	PN_9	PN_10	PN_12
PN_3	0.70							
PN_5	0.73	0.80						
PN_6	0.68	0.54	0.73					
PN_7	0.58	0.36	0.52	0.56				
PN_9	0.84	0.72	0.81	0.70	0.62			
PN_10	0.55	0.48	0.69	0.67	0.77	0.64		
PN_12	0.91	0.66	0.83	0.78	0.59	0.90	0.70	
PN_13	0.80	0.50	0.75	0.72	0.72	0.80	0.79	0.81

Daily data (min N= 7)

	PN_1	PN_3	PN_5	PN_6	PN_7	PN_9	PN_10	PN_12
PN_3	0.96							
PN_5	0.99	0.97						
PN_6	0.95	0.89	0.97					
PN_7	0.57	0.52	0.53	0.60				
PN_9	0.94	0.98	0.96	0.91	0.49			
PN_10	0.69	0.56	0.73	0.86	0.68	0.62		
PN_12	0.85	0.86	0.89	0.85	0.59	0.94	0.69	
PN_13	0.77	0.59	0.81	0.84	0.65	0.86	0.80	0.89

All weeks data

PN	1-hour	1-day
Median	0.70	0.83
Mean	0.68	0.79
Min	0.36	0.39
Max	0.91	0.99

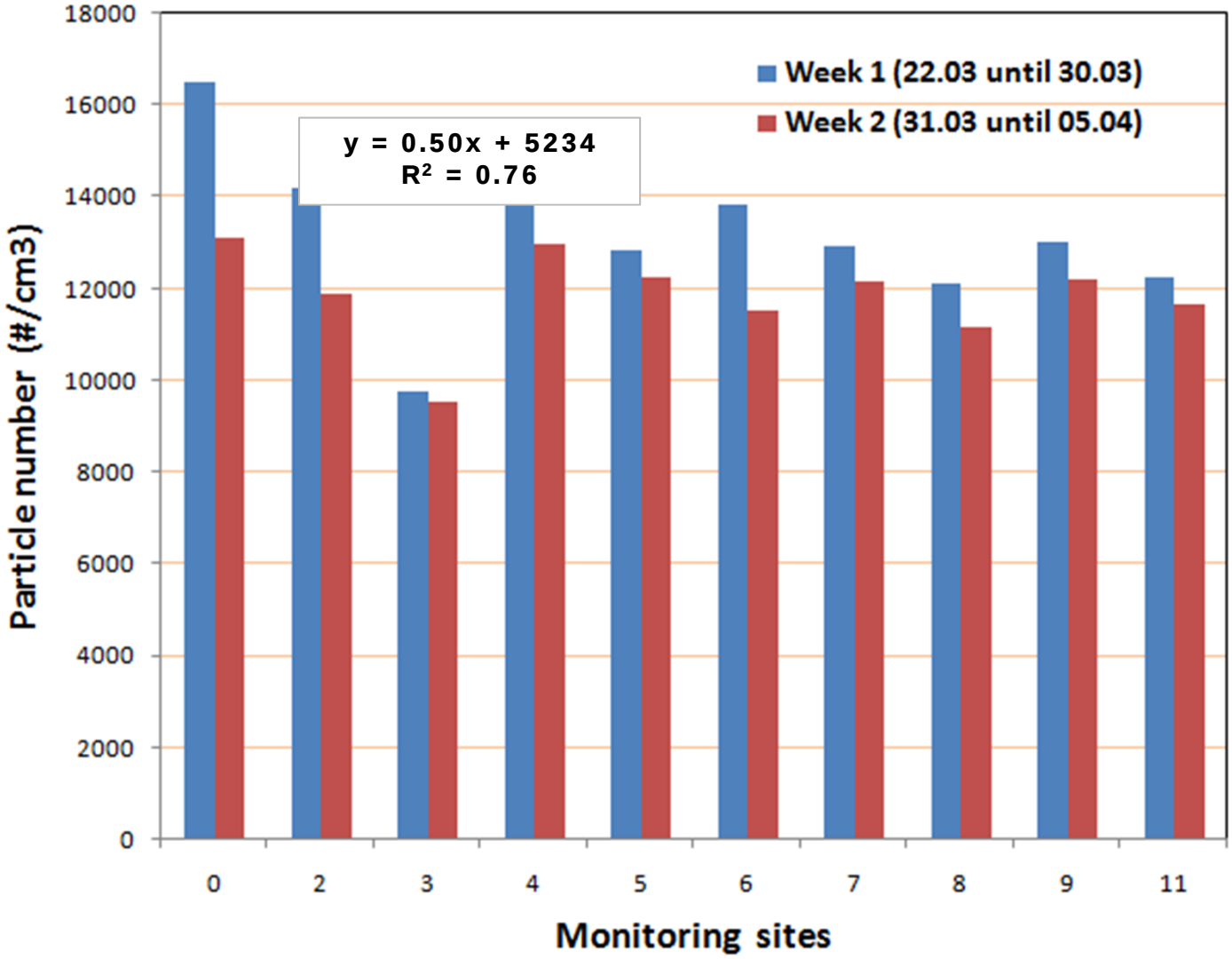
Spatial heterogenity: Basel Winter

	# 1	# 2	# 3	# 4	# 5	# 6	# 8	# 9	# 10
Particle number conc.									
# 0	0.21	0.13	0.25	0.11	0.13	0.14	0.09	**0.27**	0.11
# 1		0.19	0.22				0.21	0.13	0.19
# 2			0.20				**0.05**	0.20	0.08
# 3							0.15	0.18	0.13
# 4					0.06	0.06		0.23	0.14
# 5						0.05		0.19	0.13
# 6								0.23	0.16
# 8								0.21	0.08
# 9									0.20

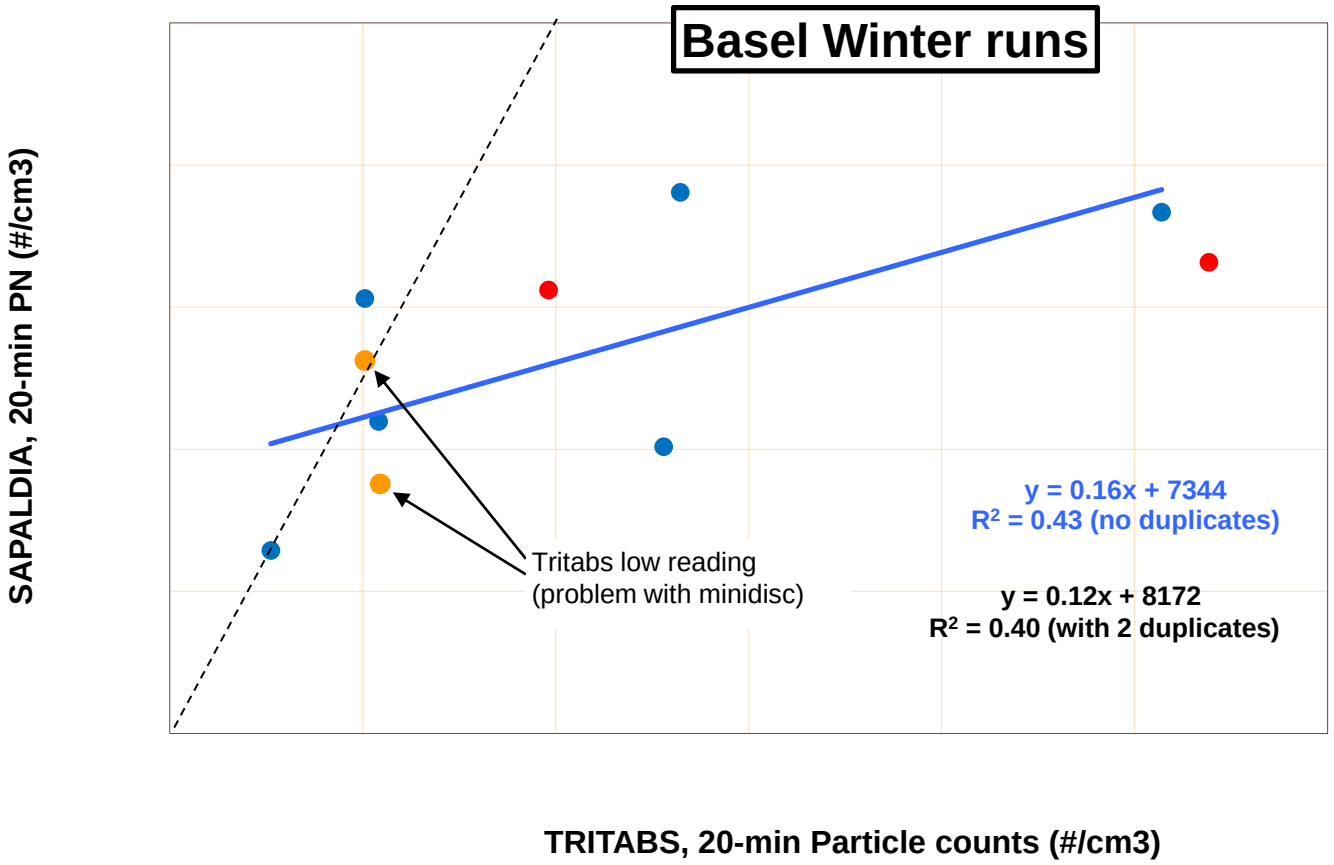
	# 1	# 2	# 3	# 4	# 5	# 6	# 8	# 9	# 10
Mean particle size diam.									
# 0	0.12	0.06	0.09	0.04	0.03	0.03	0.04	0.13	0.04
# 1		0.10	0.11				0.12	0.05	0.11
# 2			0.08				0.04	0.12	0.04
# 3							0.08	0.11	0.05
# 4					0.02	0.03		0.07	0.02
# 5						0.01		0.09	0.01
# 6								0.10	0.02
# 8								0.14	0.06
# 9									0.10

COD	PN	Dp
Median	0.15	0.06
Mean	0.15	0.07
Min	0.05	0.01
Max	0.27	0.14

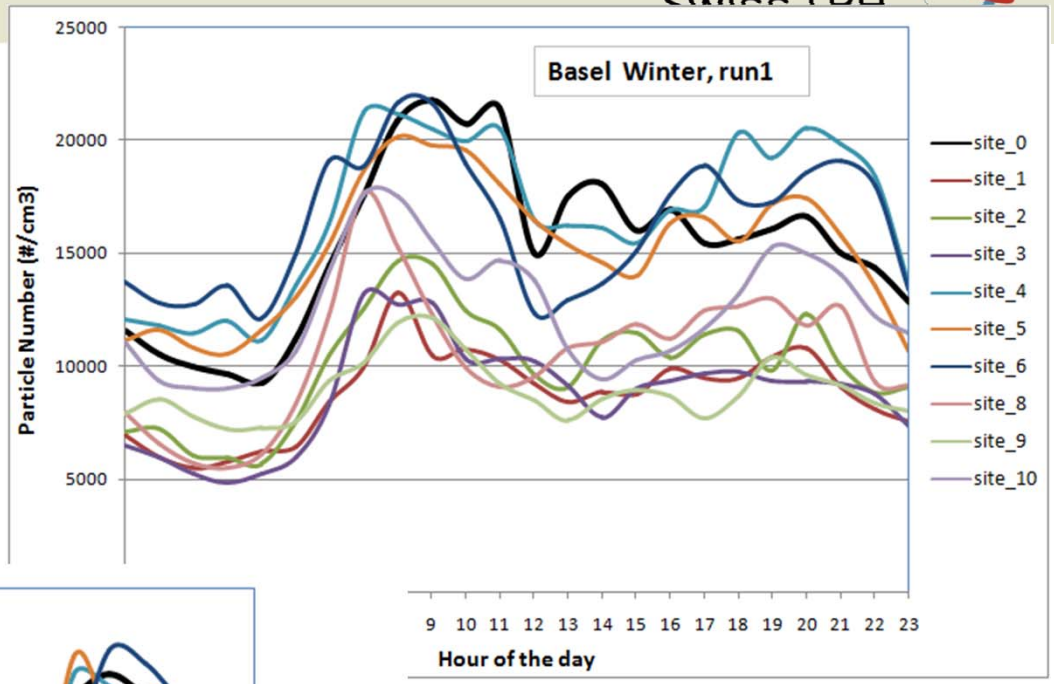
1 week vs 2 week meas.: Basel Spring, run 1

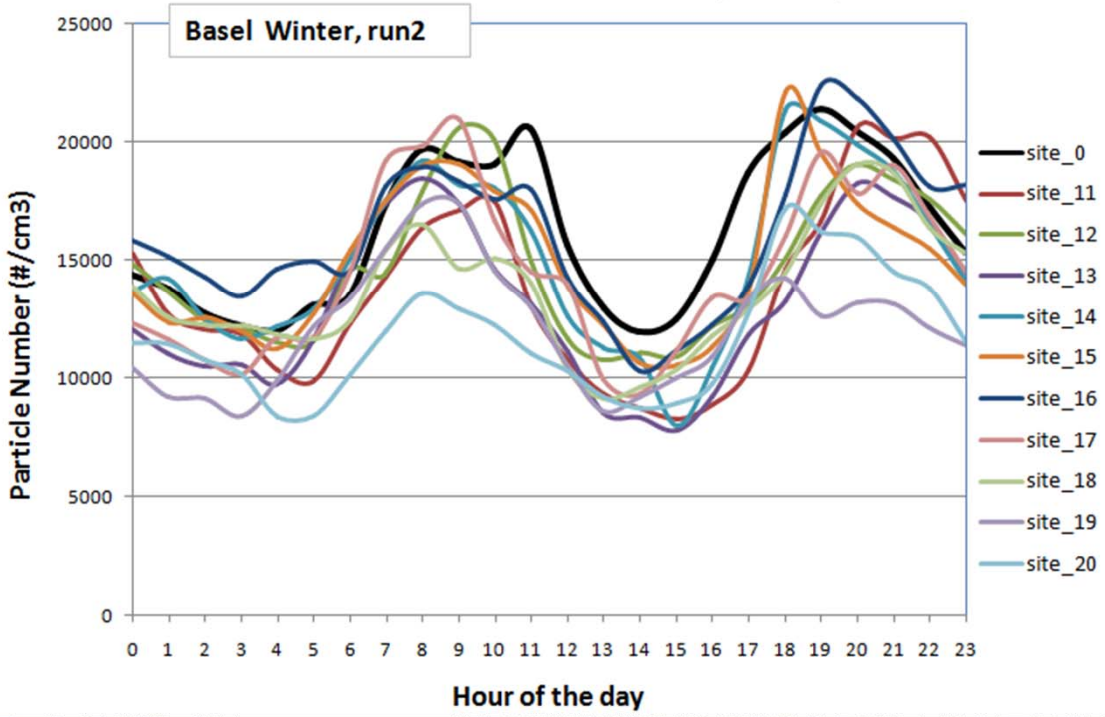


Locations matters !: Comparison w/ TRITABS

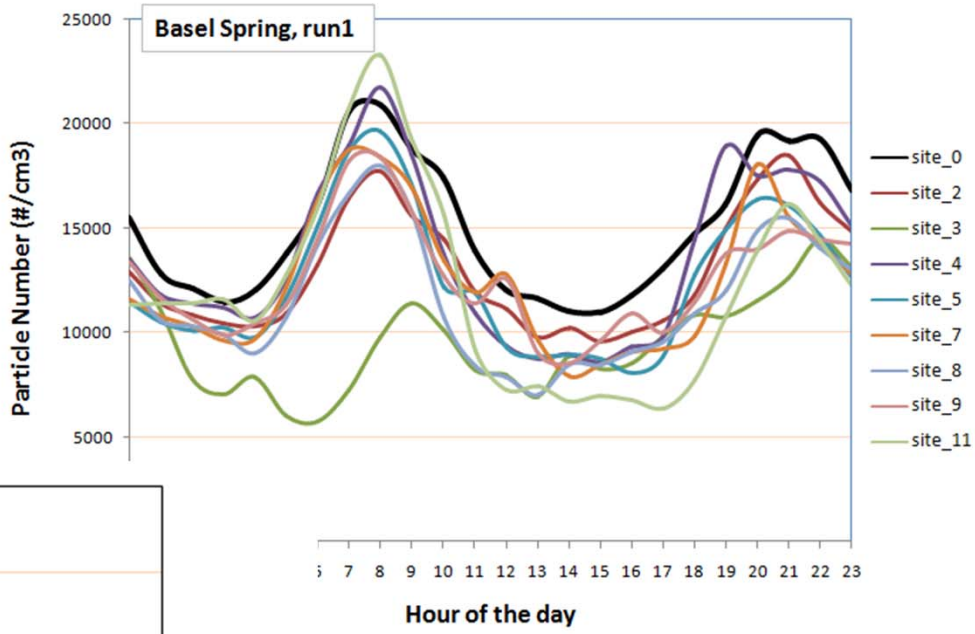


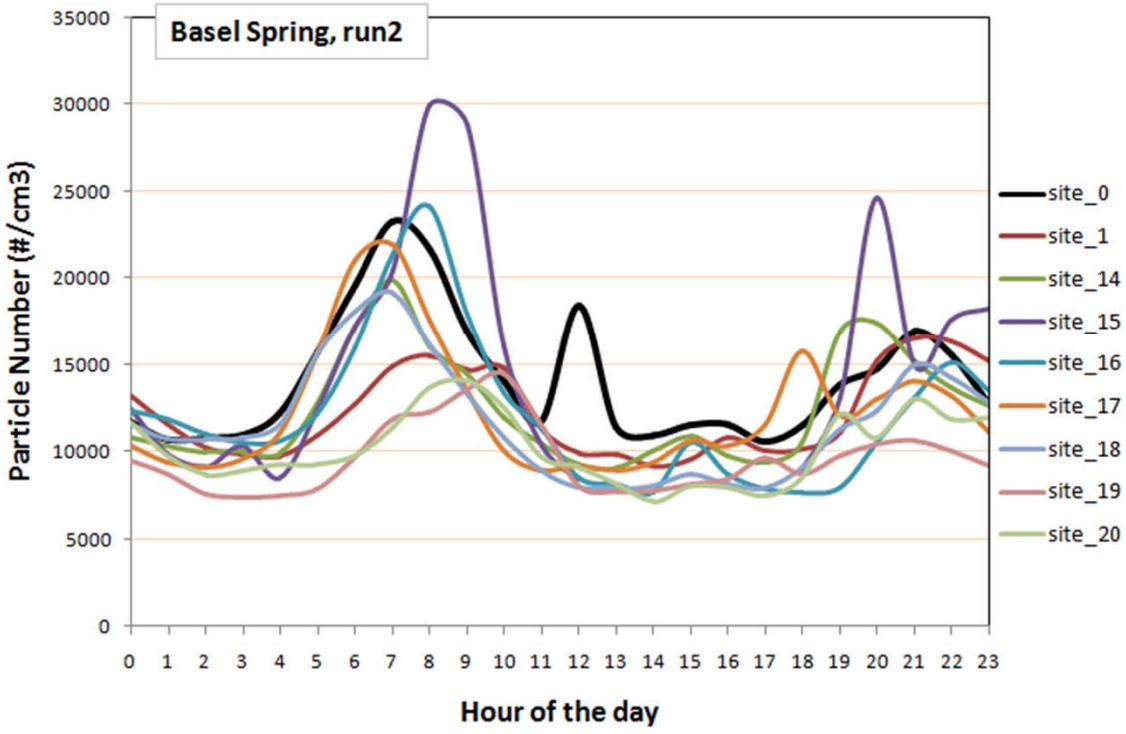
Diurnal variation: Basel Winter



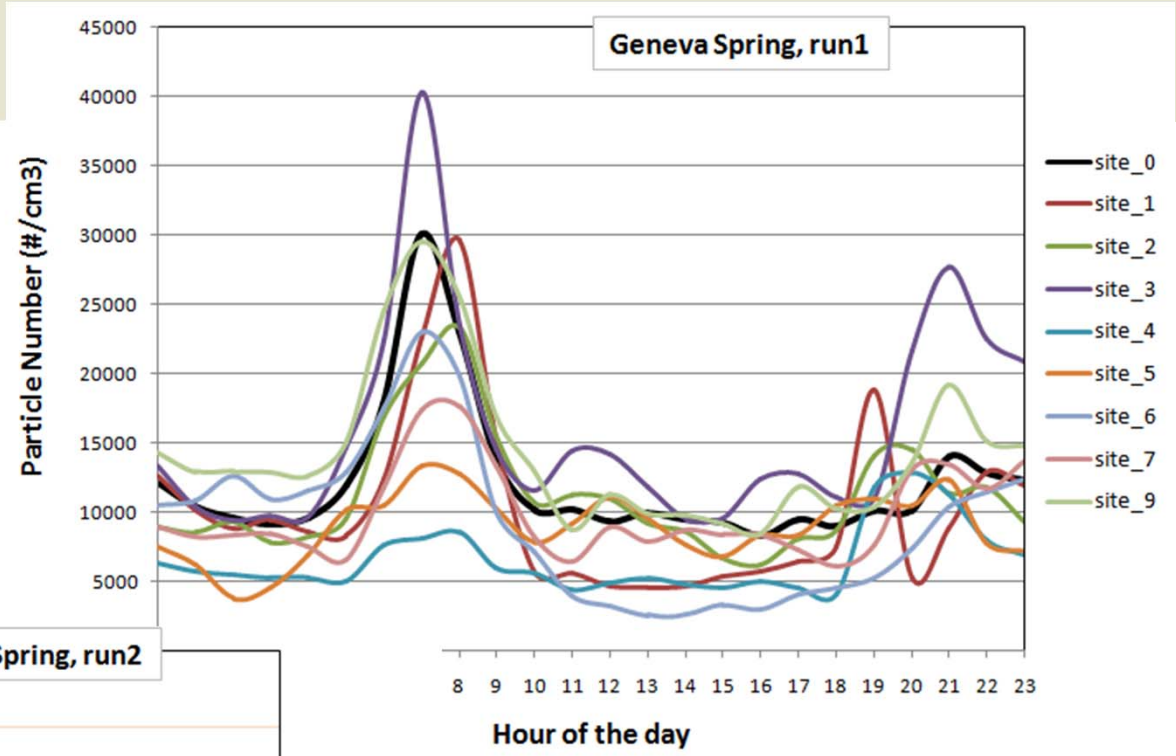


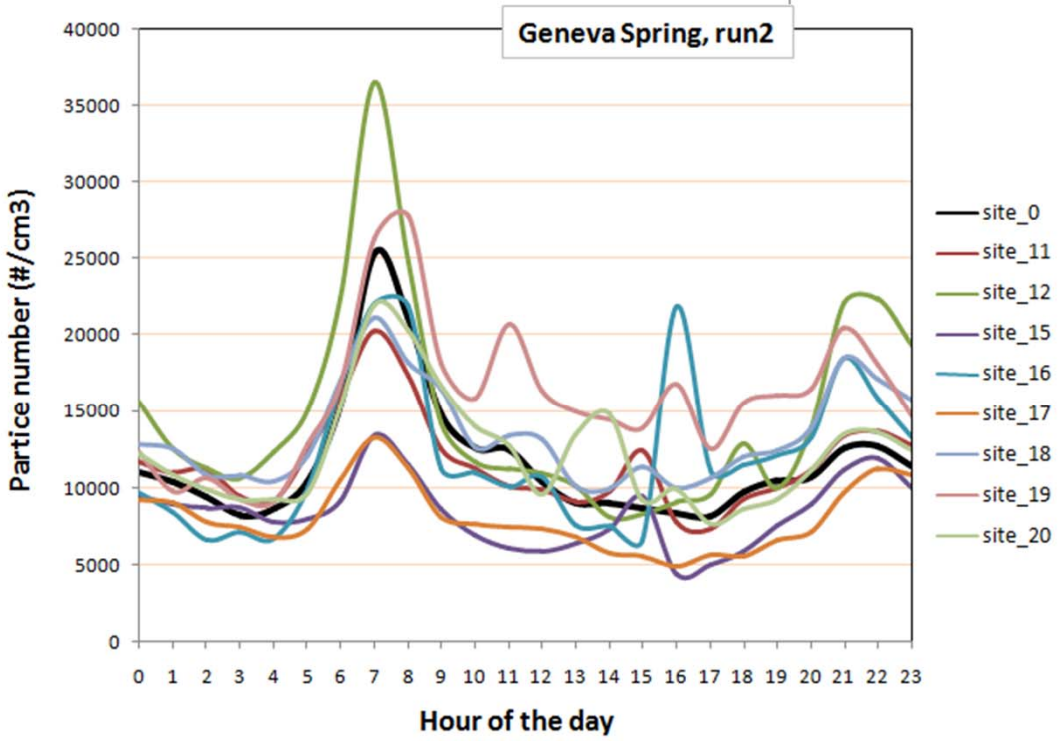
Diurnal variation: Basel Spring



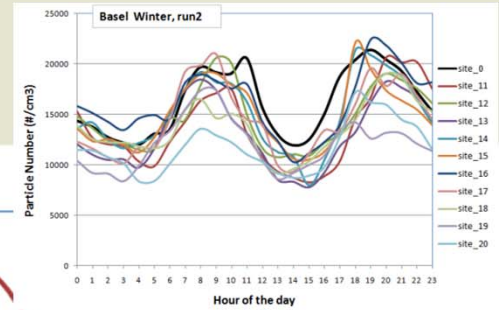


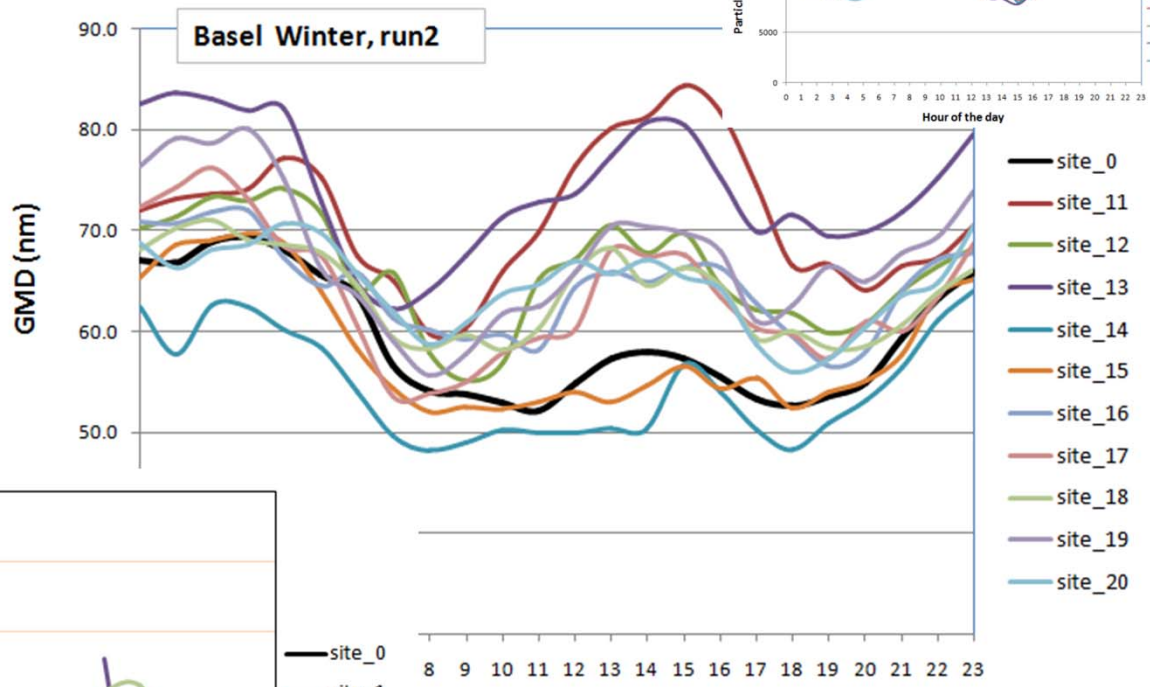
Diurnal variation: Geneva Spring

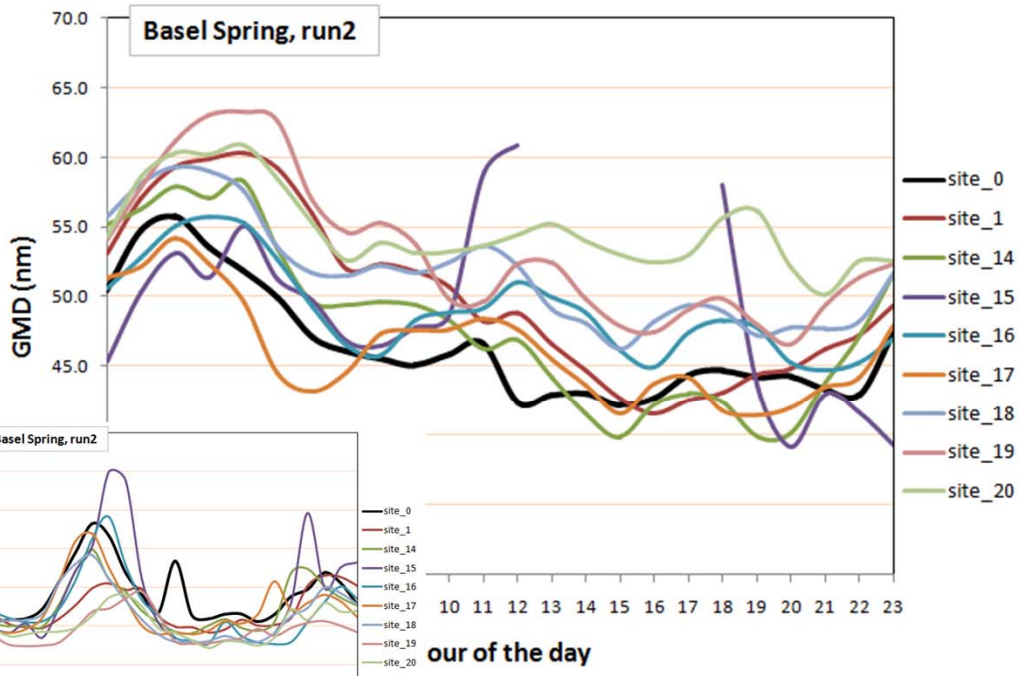




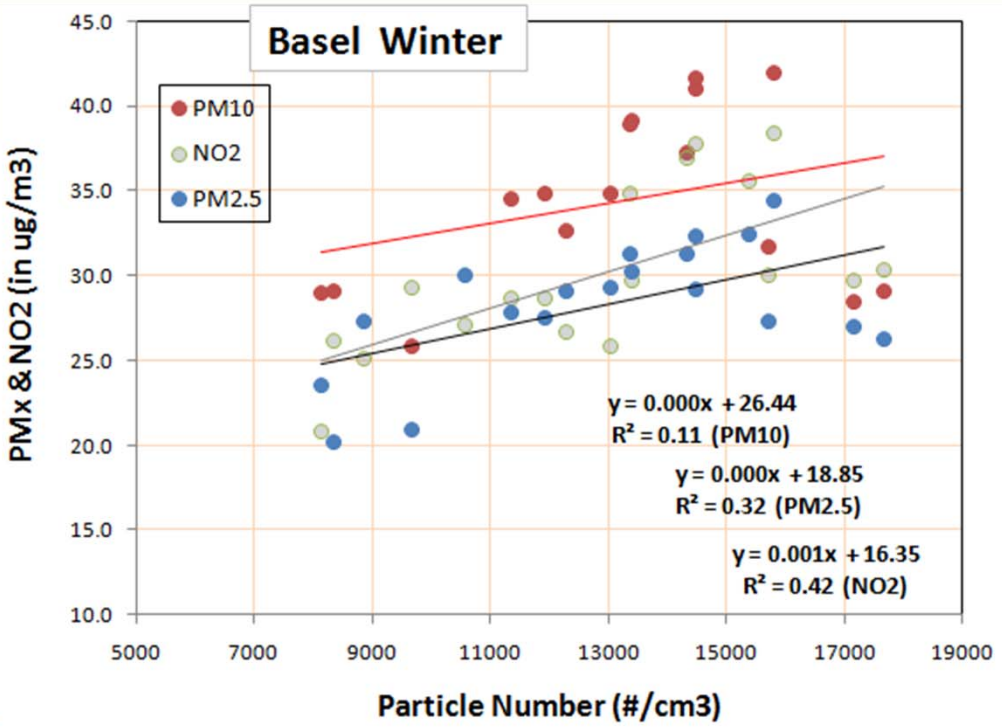
Particle size distribution: Winter vs Spring

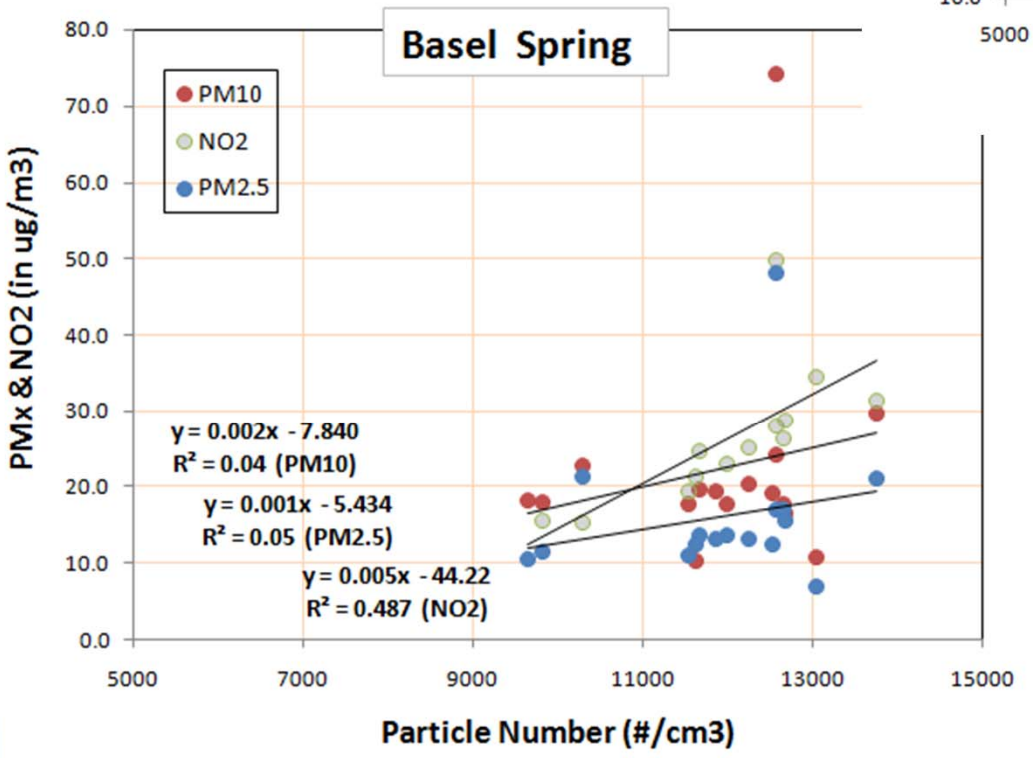




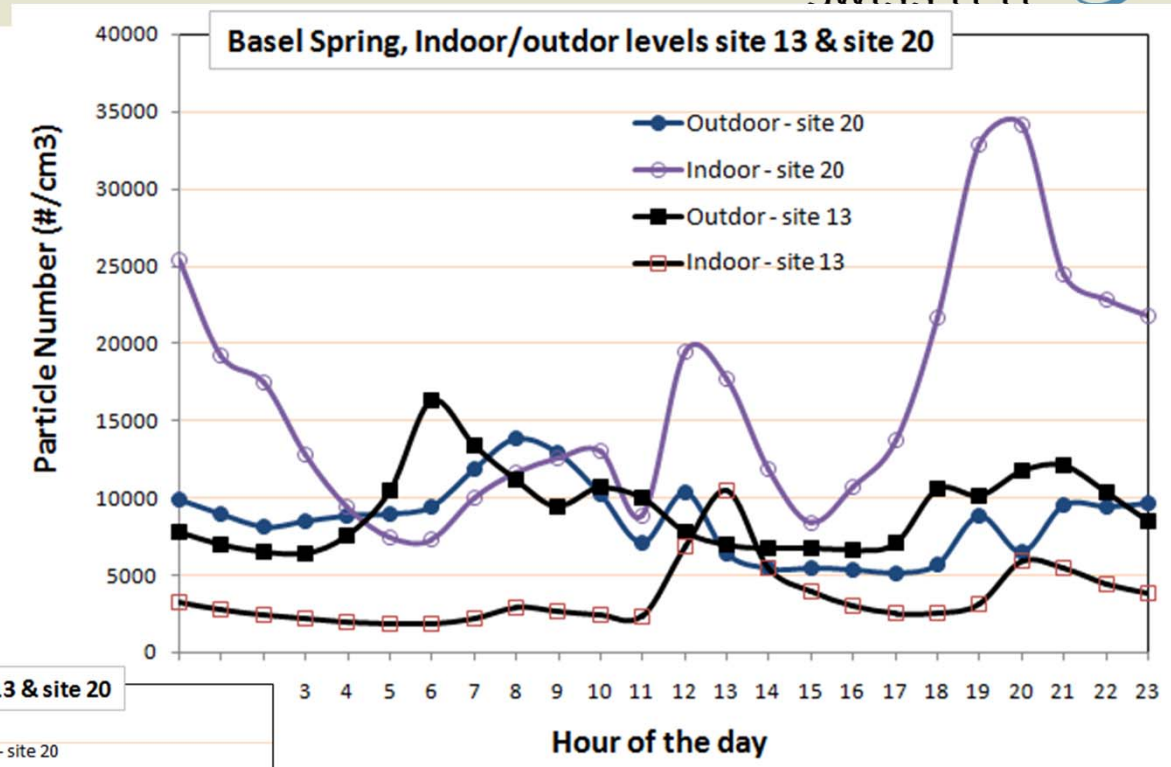


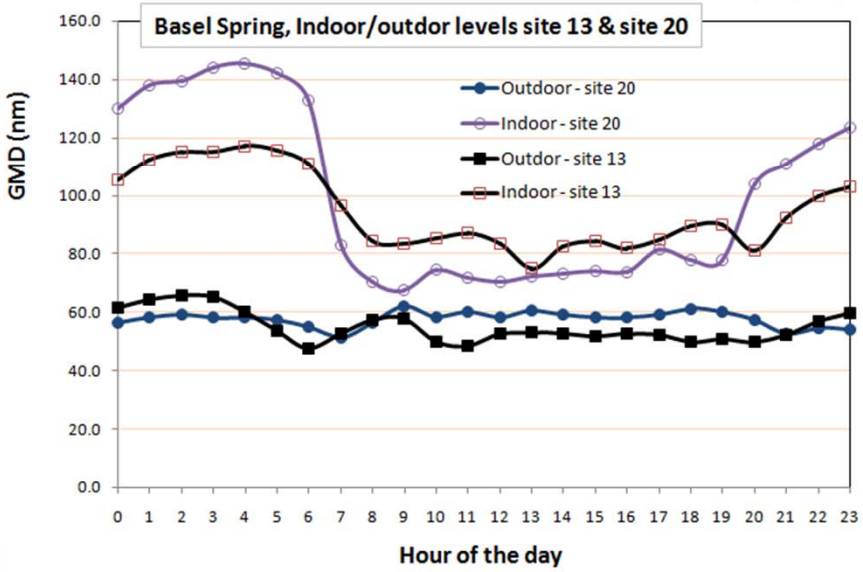
Association between PN & PMx, NO_2: Basel



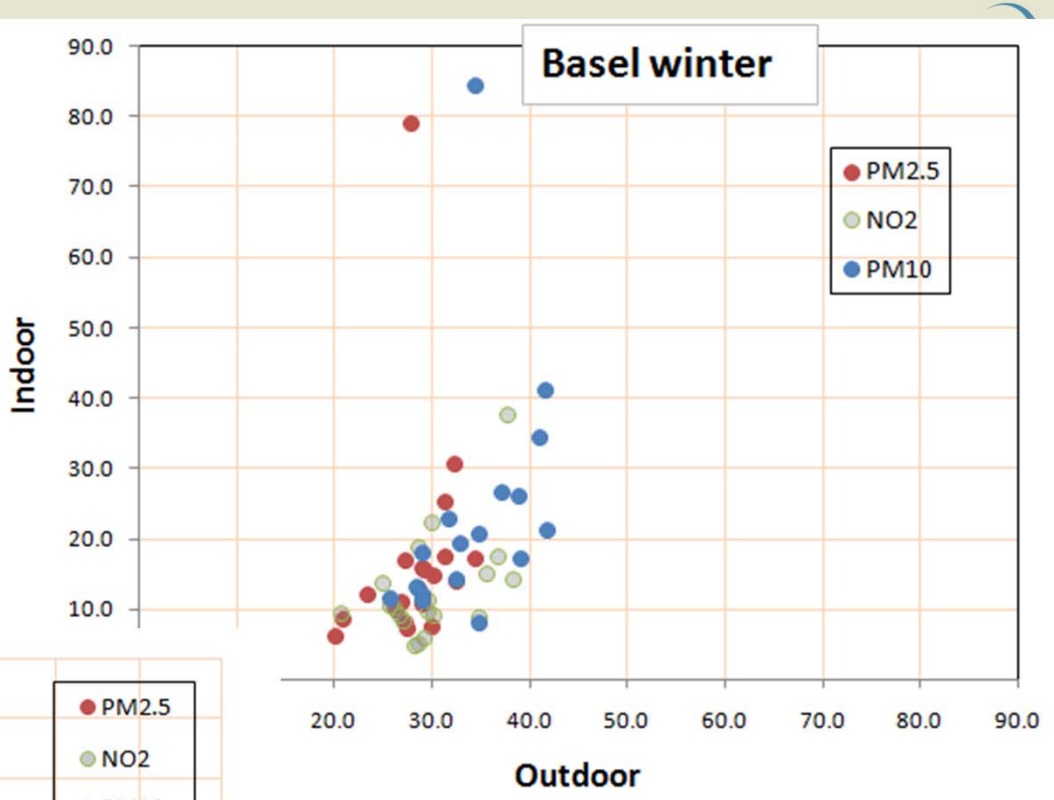


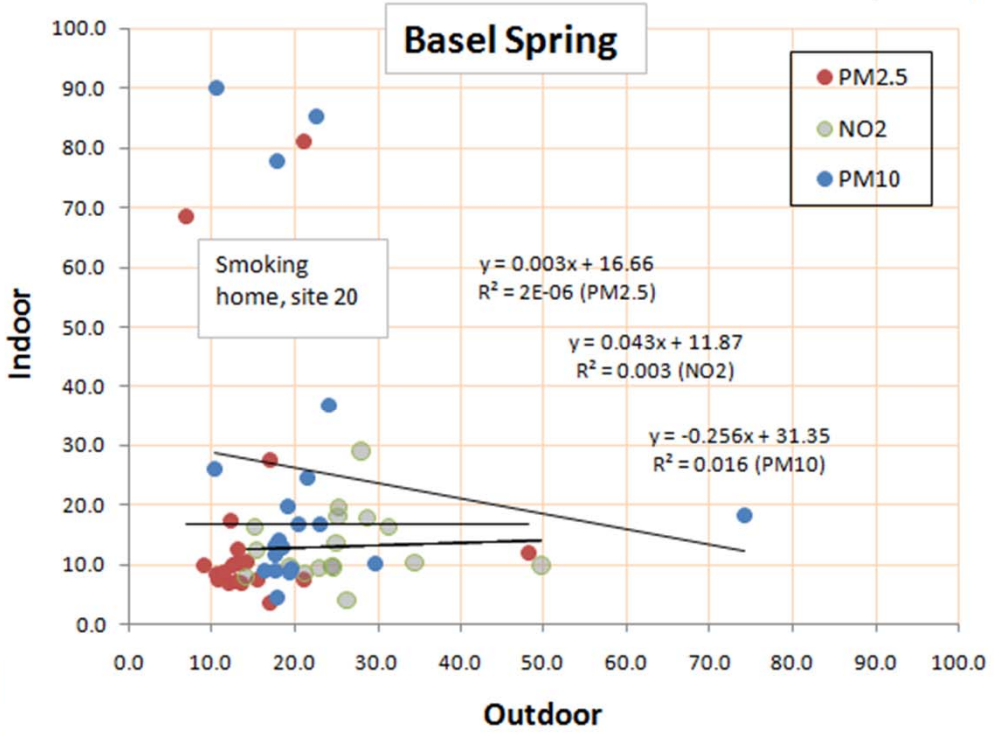
Indoor UFPs: Basel Spring





Indoor PMx, NO_2: Basel





Preliminary conclusions / findings !

- **Moderately heterogeneous in terms of spatial UFP COD 0.06-0.27)**
- **Daily spatial correlations higher than hourly ones, low to moderate correlations**
- **Long-term (weekly or biweekly) UFP has a poor correlations with PM mass metrics but moderate to high association with NO_2**
- **Indoor ultrafine particles are generally very low compared to outdoors; however smoking dominates the situation in indoor smoking homes**

Long road to go…

- Dispersion model validation using large measurement dataset
- Outdoor exposure modeling using GIS (LUR methods)
- Indoor models based on elemental tracers analysis

Funding: SNF, BAFU and cantonal air monitoring, Switzerland

Thank you !