

## Extended Paper-Abstract

Name of Author **Harish Phuleria**<sup>1,2</sup>

Co-Authors **Ming Yi Tsai**<sup>1,2</sup>, **Martina S. Ragettli**<sup>1,2</sup>, **Elisabetta Corradi**<sup>2</sup>, **Alex Ineichen**<sup>1,2</sup>, **Thierry Rochat**<sup>3</sup>, **Nicole Probst-Hensch**<sup>1,2</sup>, **Martin Fierz**<sup>4,5</sup>, **Nino Künzli**<sup>1,2</sup>

Affiliation <sup>1</sup>**Swiss Tropical and Public Health Institute, Basel, Switzerland;**

<sup>2</sup>**University of Basel, Switzerland;** <sup>3</sup>**University Hospital, Geneva, Switzerland;** <sup>4</sup>**Institute for Aerosol and Sensor Technology, FHNW, Windisch, Switzerland;** <sup>5</sup>**naneos particle solutions gmbh, Windisch, Switzerland**

Mailing address **Socinstrasse 57, 4051, Basel, Switzerland**

Phone / Fax **061 284 8310/ 061 284 8105**, E-mail **harish.phuleria@unibas.ch**

**Title: Spatiotemporal variation of particle number and surface area concentration in four Swiss areas and its relationship with mass measurements**

### Extended Abstract:

**Background:** This study is part of the Swiss Study on Air Pollution and Lung and Heart Diseases in Adults (SAPALDIA), a cohort study initiated in 1990 and spread across eight geographically diverse areas in Switzerland. Innovative exposure modeling has been conducted in SAPALDIA earlier for PM<sub>10</sub> and NO<sub>2</sub>, however, exposure to specific traffic related pollutants such as ultrafine particles and PM constituents has not been assessed.

**Aims:** 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 (PN) and lung-deposited surface area (LDSA) concentration in four study areas: Basel, Geneva, Lugano and Wald.

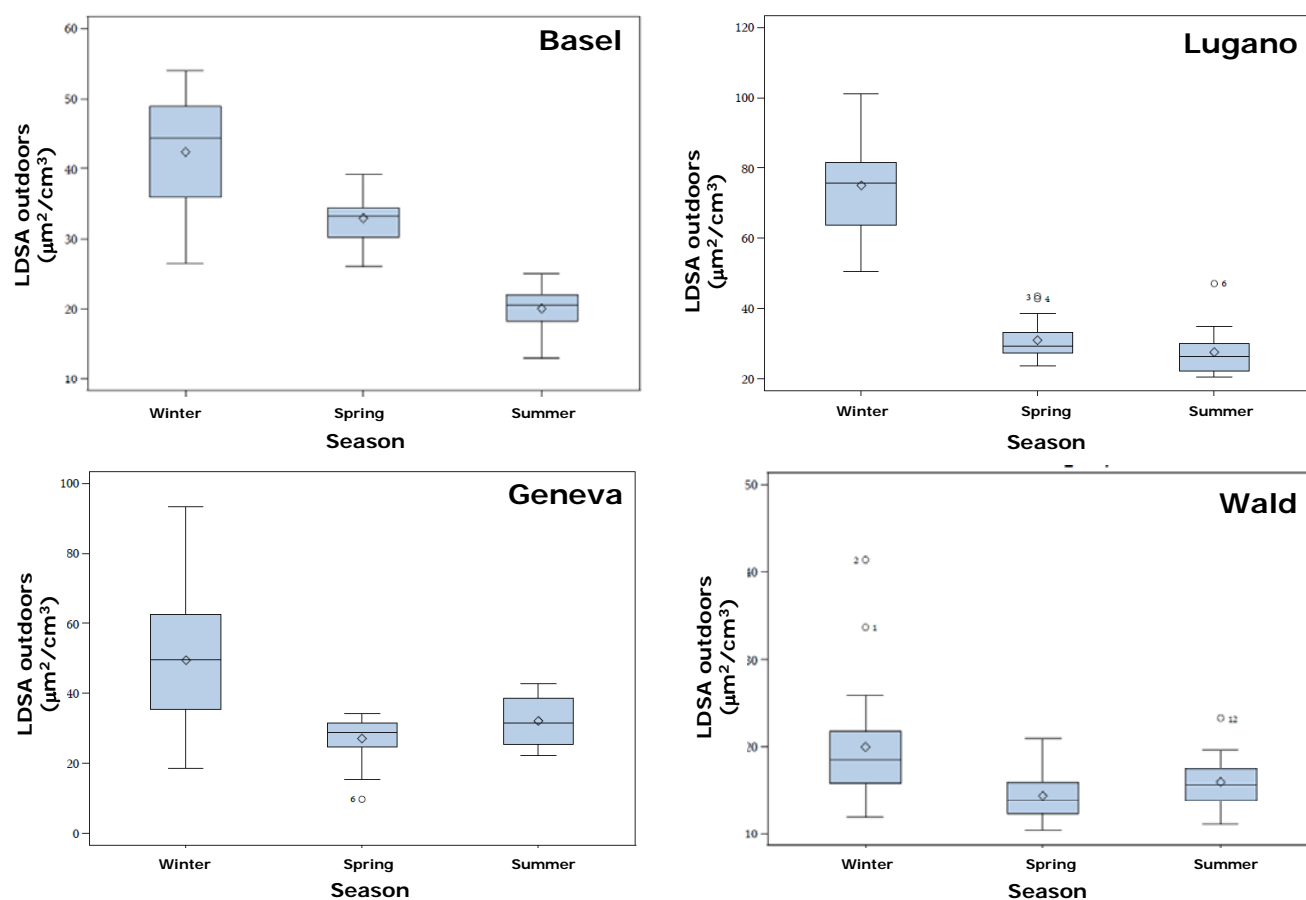
**Methods:** Weekly/biweekly outdoor (as well as indoor) PN and LDSA are measured at 20 residences each in four study areas in three seasons over a period of 2 years, 2011-2012. PN and LDSA are measured using a portable particle counter, miniDiSC (miniature diffusion size classifier). It is a portable diffusion charging based device and measures nanometer sized (10-300nm) particles with a time-resolution of one second.

**Results:** Mean(±SD) weekly outdoor PN levels aggregated across all seasons and sites are 11000±3700, 15400±8300, 15700±7400 and 5600±3500 particles/cm<sup>3</sup> in Basel, Geneva, Lugano and Wald, respectively. Corresponding LDSA values are 31.7±9.5, 36.1±22.2, 44.5±16.5 and 16.7±8.4 μm<sup>2</sup>/cm<sup>3</sup> respectively for the four study areas. As shown in table 1, PN and LDSA are highest in winter and lowest in summer for all study areas/sites (LDSA distribution shown in Figure 1). PN levels show a clear morning and evening rush hour in all seasons in all sites, but more prominently at street sites. PN & LDSA show reasonably moderate to good correlation with NO<sub>2</sub> and soot (measured as black smoke) within all areas but moderate to low correlation with PM<sub>10</sub> and PM<sub>2.5</sub> in all seasons (see Table 2). Summer correlations are generally lower than winter and LDSA, shows higher correlations with all the pollutants than particle number.

**Table 1.** Summary of UFP measurements by season and study area

Pollutant	Area*	Season		
		Winter	Spring	Summer
Particle Number (#/cm <sup>3</sup> )	Basel	13200 ± 2800	12400 ± 1800	7500 ± 1500
	Geneva	21400 ± 6900	11500 ± 3700	13300 ± 2900
	Lugano	21100 ± 6600	12000 ± 3000	9800 ± 2000
	Wald	7000 ± 3100	5400 ± 1300	4400 ± 900
Particle Diameter (μm)	Basel	62.2 ± 7.2	51.0 ± 3.2	51.2 ± 4.7
	Geneva	43.7 ± 9.5	48.8 ± 6.3	47.2 ± 3.2
	Lugano	58.8 ± 7.0	52.0 ± 3.5	55.8 ± 3.7
	Wald	59.0 ± 8.4	52.4 ± 4.2	71.9 ± 11.1
Lung Deposited Surface Area (μm <sup>2</sup> /cm <sup>3</sup> )	Basel	42.4 ± 8.2	32.8 ± 3.5	20.0 ± 3.2
	Geneva	48.5 ± 19.8	27.9 ± 7.3	32.0 ± 6.8
	Lugano	75.0 ± 14.0	30.9 ± 5.7	27.6 ± 6.5
	Wald	19.9 ± 7.3	14.3 ± 2.9	15.9 ± 2.8

\* A maximum of 20 SAP3 households were monitored per each study area/season

**Figure 1:** Outdoor LDSA distribution by season and study areas**Table 2.** Pearson correlations among different measured pollutants

Area	Variable	PM <sub>10</sub>	PM <sub>2.5</sub>	BS <sub>2.5</sub>	NO <sub>2</sub>	PN
Basel	PM <sub>2.5</sub>	0.97	1			
	BS <sub>2.5</sub>	0.92	0.94	1		
	NO <sub>2</sub>	0.69	0.68	0.80	1	
	PN	0.65	0.63	0.72	0.72	1
	LDSA	0.86	0.84	0.87	0.76	0.89
Wald	PM <sub>2.5</sub>	0.87	1			
	BS <sub>2.5</sub>	0.52	0.68	1		
	NO <sub>2</sub>	0.34	0.53	0.91	1	
	PN	0.23	0.30	0.71	0.83	1
	LDSA	0.44	0.55	0.80	0.81	0.85
Lugano	PM <sub>2.5</sub>	0.98	1			
	BS <sub>2.5</sub>	0.89	0.90	1		
	NO <sub>2</sub>	0.71	0.68	0.90	1	
	PN	0.84	0.86	0.92	0.87	1
	LDSA	0.91	0.93	0.94	0.84	0.96
Geneva	PM <sub>2.5</sub>	0.91	1			
	BS <sub>2.5</sub>	0.73	0.82	1		
	NO <sub>2</sub>	0.49	0.52	0.58	1	
	PN	0.26	0.45	0.56	0.67	1
	LDSA	0.49	0.67	0.69	0.60	0.89

**Conclusions:** Our results show significant seasonal and spatial variation in home outdoor ultrafine particles within and between study areas and document the differential impact of traffic on them in Switzerland.

Swiss TPH



Swiss Tropical and Public Health Institute  
Schweizerisches Tropen- und Public Health-Institut  
Institut Tropical et de Santé Publique Suisse

Department of Epidemiology & Public Health  
**Exposure Science Group**

# Spatiotemporal variation of particle number & surface area concentration in four Swiss areas & its relationship with mass measurements

**Harish C. Phuleria, Ming Yi Tsai, Martina S. Ragettli, Elisabetta Corradi, Alex Ineichen, Nicole Probst-Hensch, Nino Künzli**  
Swiss Tropical and Public Health Institute, Basel; University of Basel, Basel

**Martin Fierz** IAST, FHNW, Windisch; naneos particle solutions gmbh, Windisch, Switzerland

**Thierry Rochat** University Hospital, Geneva, Switzerland

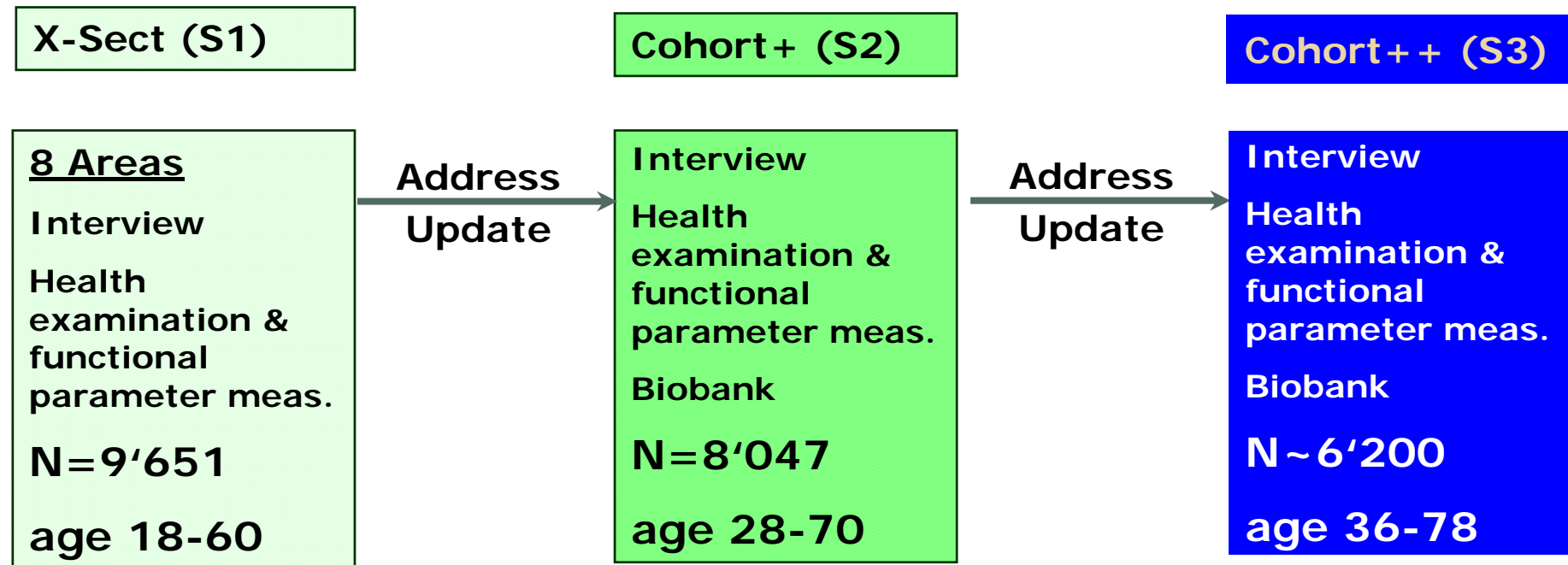


26.June.2013 ETH CGN conference, Zürich, Switzerland

# Swiss Cohort study on Air Pollution and Health in Adults



## SAPALDIA (...a prospective cohort study)



NO<sub>2</sub>, O<sub>3</sub>, CO, SO<sub>2</sub>,  
Meteorological

p NO<sub>2</sub>

p NO<sub>2</sub>

p NO<sub>x</sub>

p NO<sub>2</sub>

TSP

(PM<sub>10</sub>)

PM<sub>10</sub> PM<sub>2.5</sub>

PM<sub>10</sub>/PM<sub>2.5</sub>/PN/

BS+

1992/93

95/97/99

2000

2002/03

2009

2010/11

Dispersion

Dispersion

Dispersion+



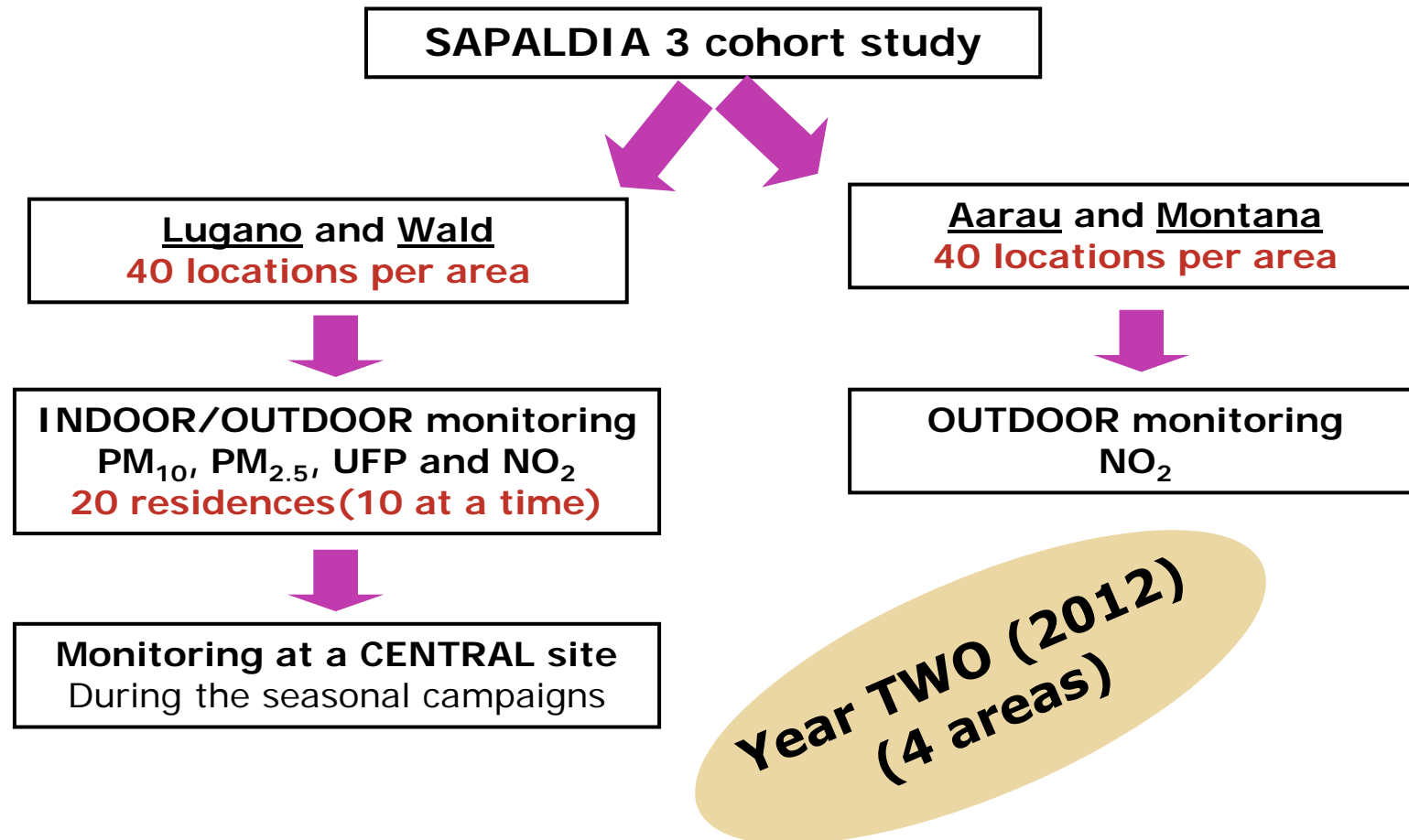


## Specific Research Qs:

- What are the long-term exposure levels to traffic air pollution among general Swiss population?
- How does the traffic PM including UFP, PM<sub>2.5</sub>, and other PM<sub>2.5</sub> components such as soot and trace elements vary within and across the eight SAPALDIA areas?



**SAPALDIA2: 2001-2002 (n=8,047)**

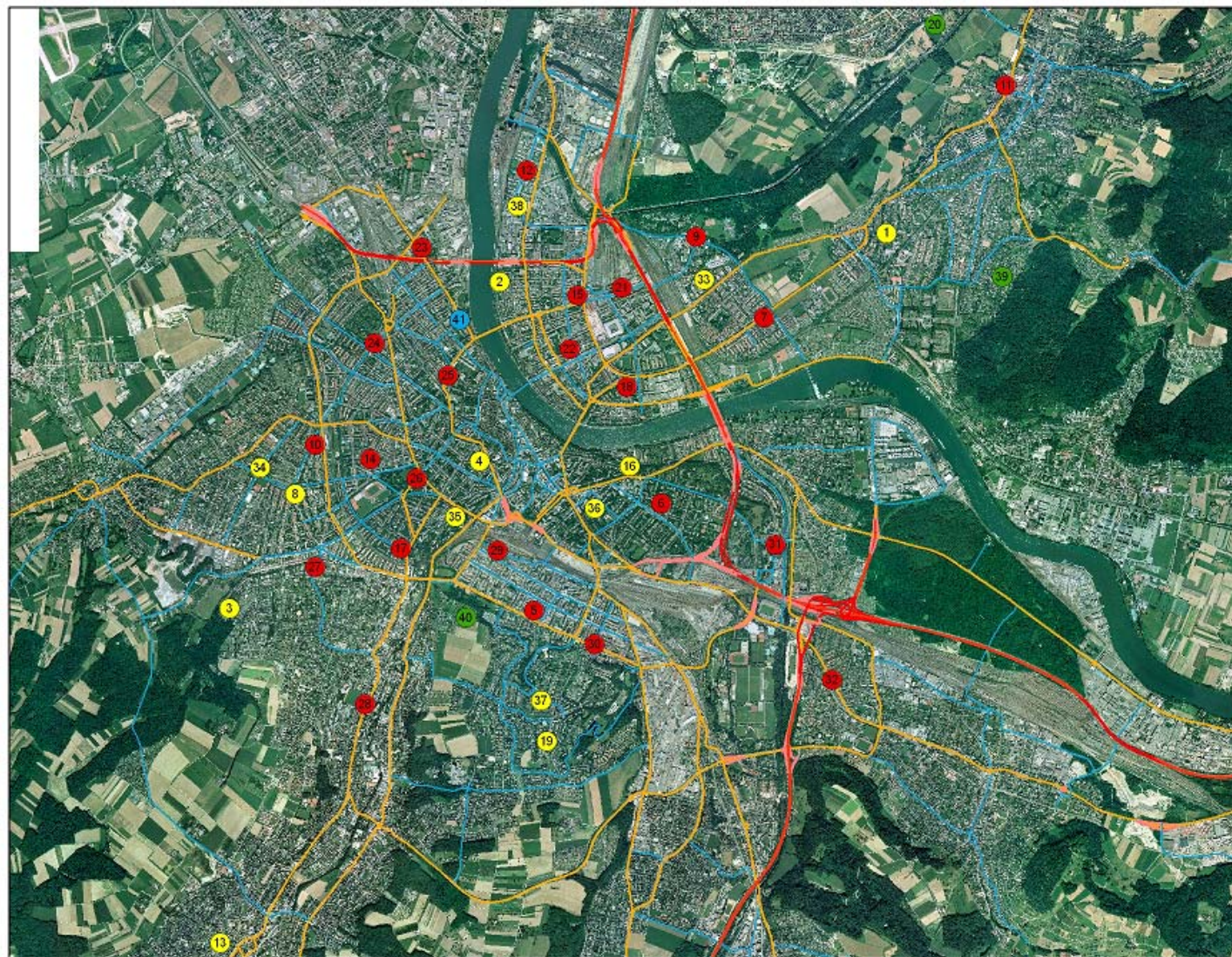


- Year 1 measurements (BS, GE, DA, PA) completed in 2011
- Year 2 measurements (LU, WA, AA, MO) completed in 2012



# Monitoring locations (e.g. Basel)

- 20 sites with  $PM_x$  + UFP +  $NO_2$ , indoors & outdoors
- Additional 20 sites with outdoor  $NO_2$  monitoring
- $PM_x$  sites are SAPALDIA subject homes





# Monitoring Methods

## $\text{NO}_2$

- Passive Passam tubes
- 2-week samples



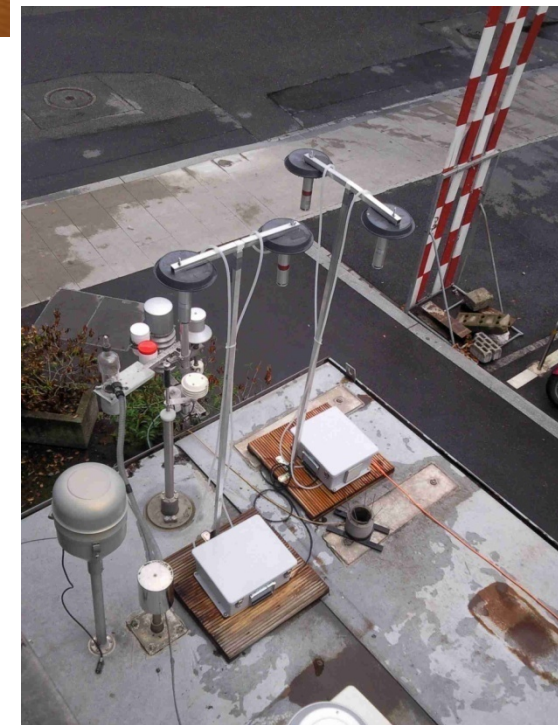
## $\text{PM}_{2.5}/\text{PM}_{10}$

- w/ Harvard Impactors (@ 4 L/min)
- 37mm Teflon filter ( $23 \pm 2$  °C,  $35 \pm 5\%$  RH)
- 2-week samples

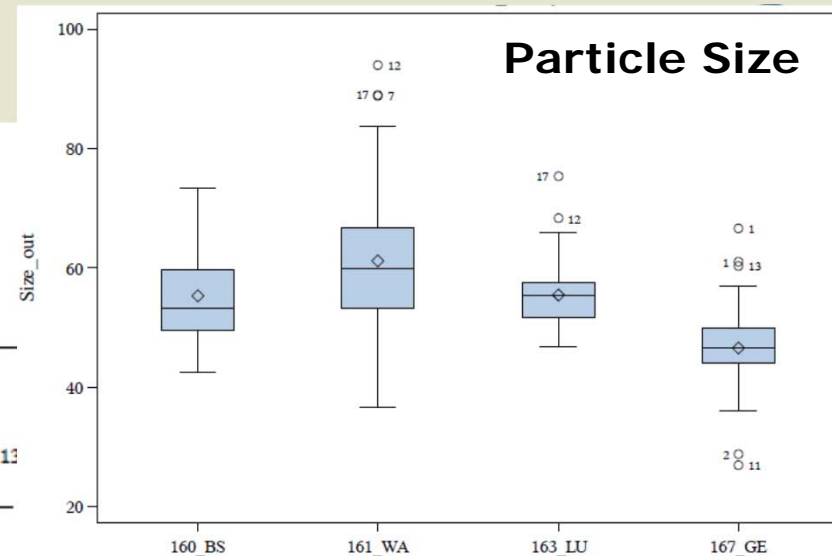
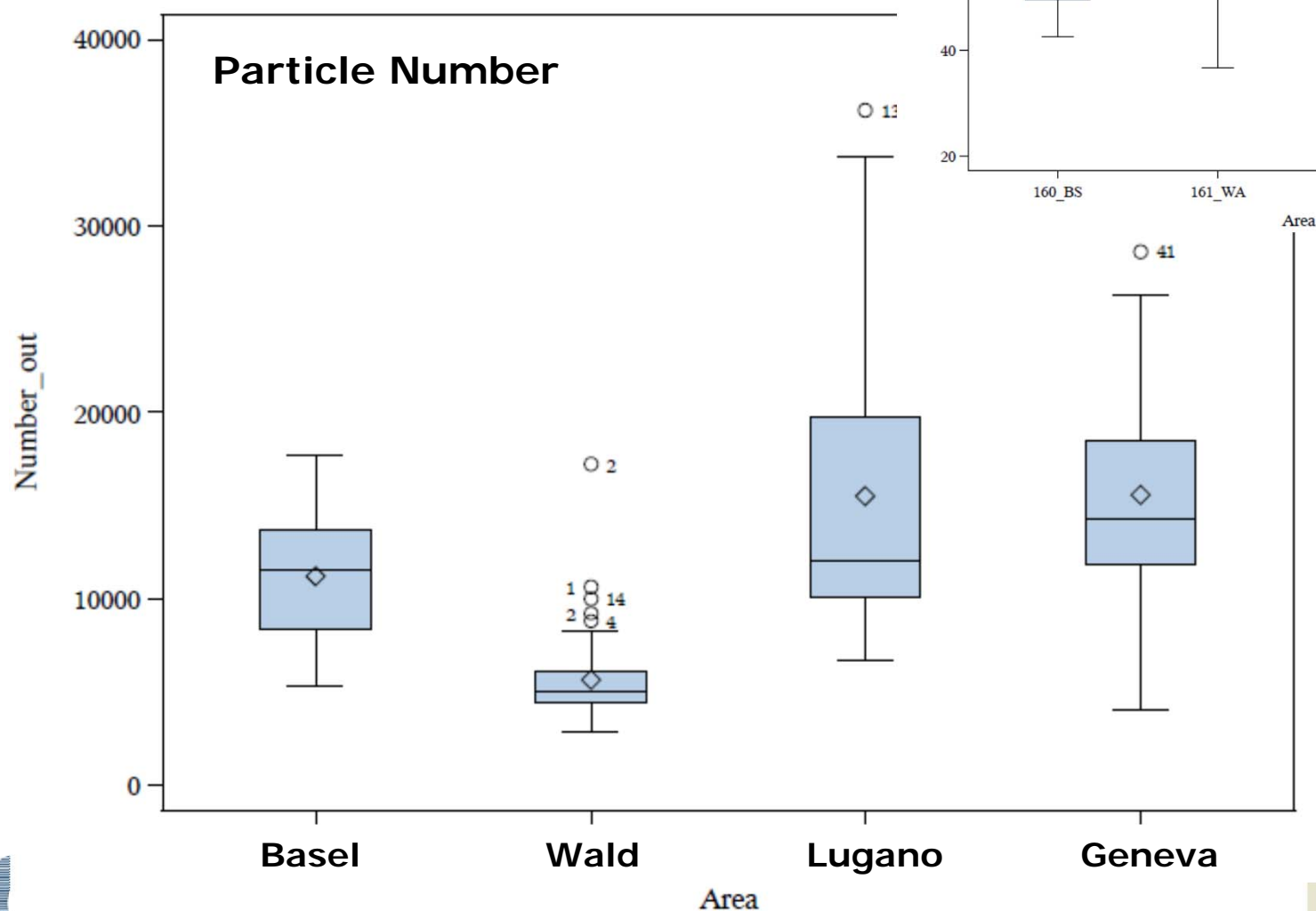


## Particle Number, SA & Size

- miniDiSC (1-sec resolution)
- 1-2 week real-time samples
- $D_p > 12$  nm

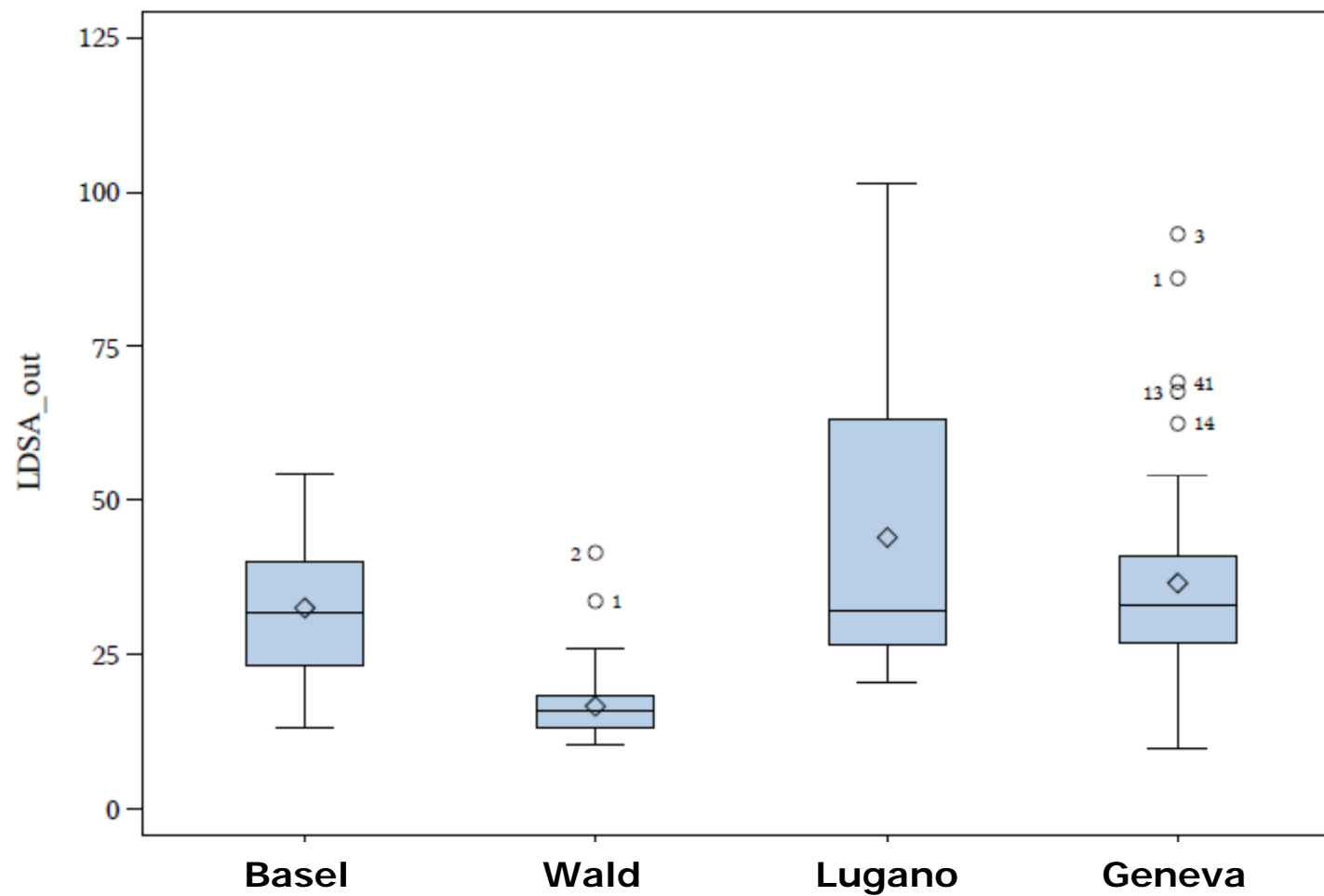


# Overall Outdoor UFP distribution: PN & Dp



# Overall Outdoor UFP distribution: LDSA

Swiss TPH



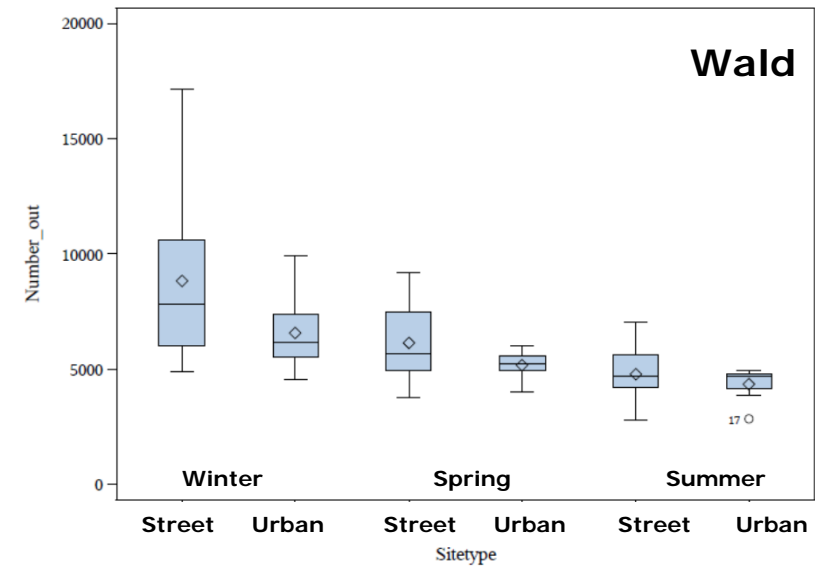
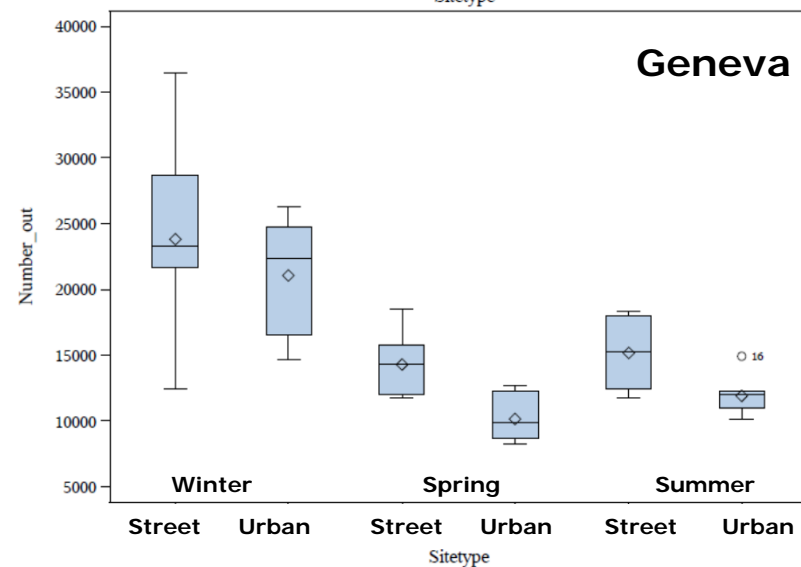
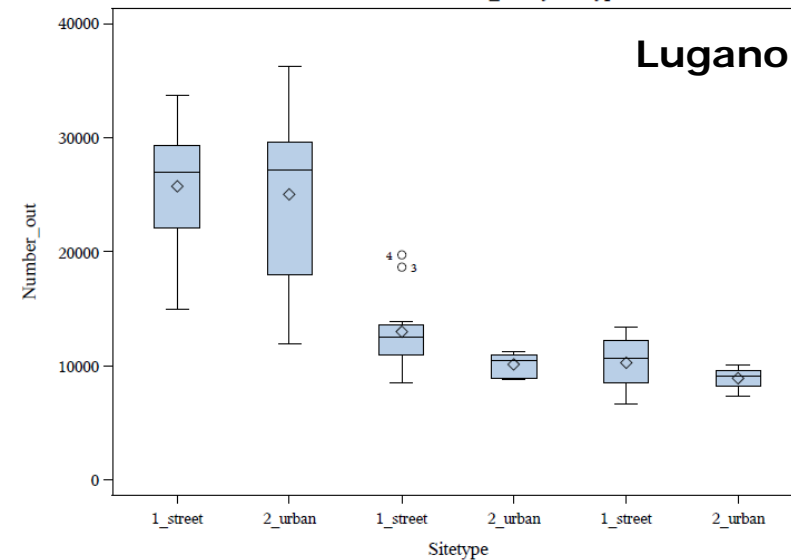
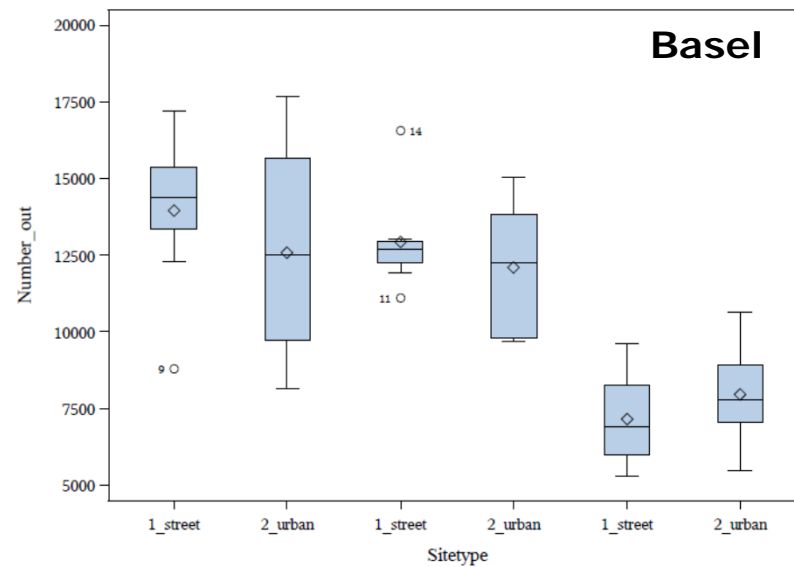
# Outdoor UFP Summary: by Season

Pollutant	Area*	Season		
		Winter	Spring	Summer
Particle Number (#/cm <sup>3</sup> )	Basel	13200 ± 2800	12400 ± 1800	7500 ± 1500
	Geneva	21400 ± 6900	11500 ± 3700	13300 ± 2900
	Lugano	21100 ± 6600	12000 ± 3000	9800 ± 2000
	Wald	7000 ± 3100	5400 ± 1300	4400 ± 900
Particle Diameter (μm)	Basel	62.2 ± 7.2	51.0 ± 3.2	51.2 ± 4.7
	Geneva	43.7 ± 9.5	48.8 ± 6.3	47.2 ± 3.2
	Lugano	58.8 ± 7.0	52.0 ± 3.5	55.8 ± 3.7
	Wald	59.0 ± 8.4	52.4 ± 4.2	71.9 ± 11.1
Lung Deposited Surface Area (μm <sup>2</sup> /cm <sup>3</sup> )	Basel	42.4 ± 8.2	32.8 ± 3.5	20.0 ± 3.2
	Geneva	48.5 ± 19.8	27.9 ± 7.3	32.0 ± 6.8
	Lugano	75.0 ± 14.0	30.9 ± 5.7	27.6 ± 6.5
	Wald	19.9 ± 7.3	14.3 ± 2.9	15.9 ± 2.8

\* A maximum of 20 SAP3 households were monitored per each study area/season



# Outdoor PN: by Season/Sitetype

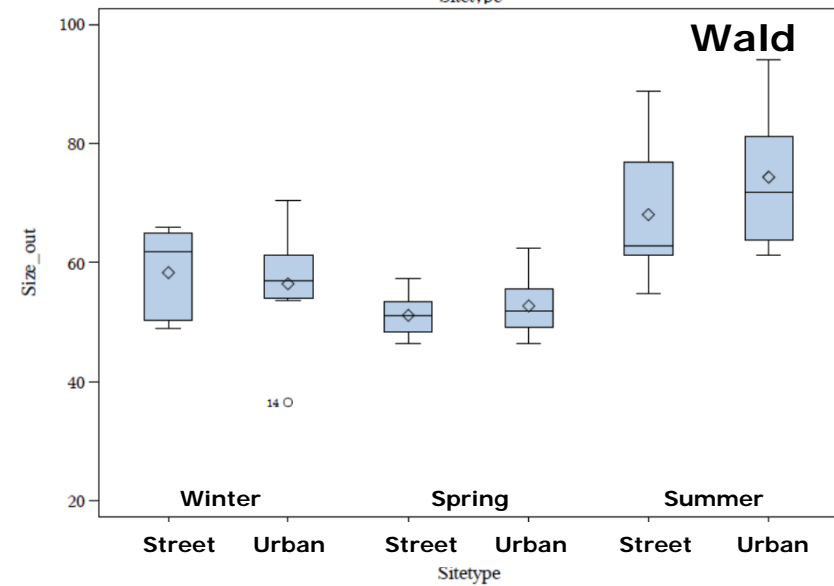
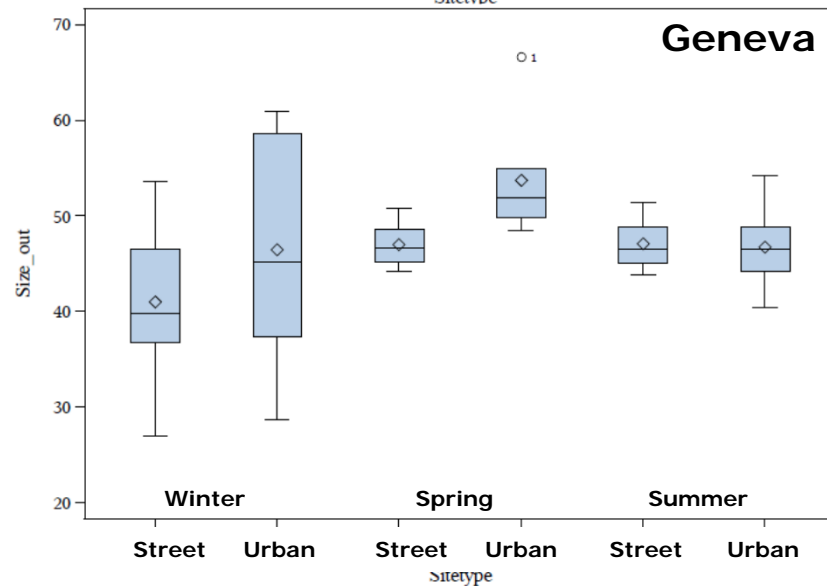
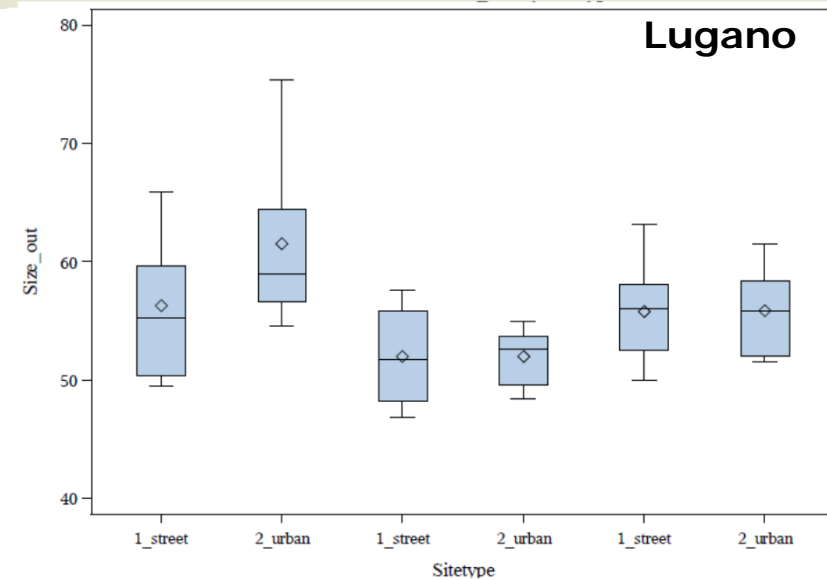
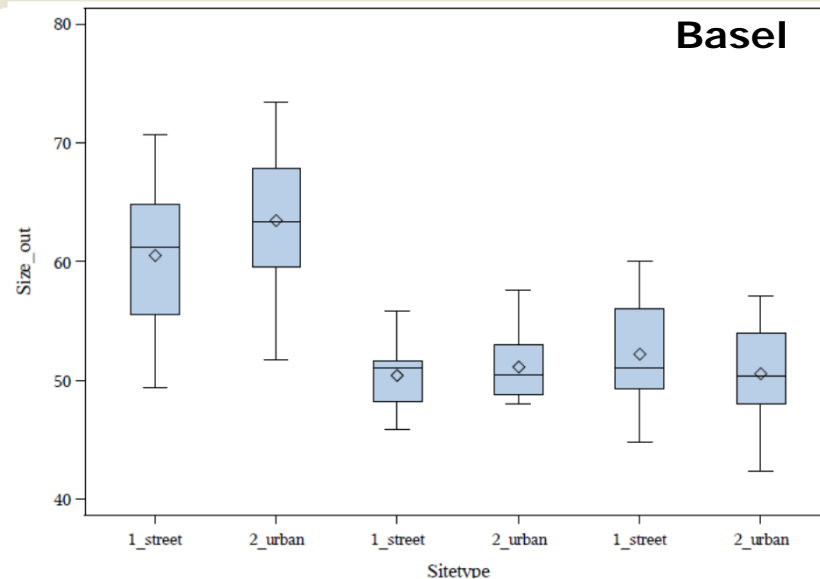


2011

2012



# Outdoor D<sub>p</sub>: by Season/Sitetype

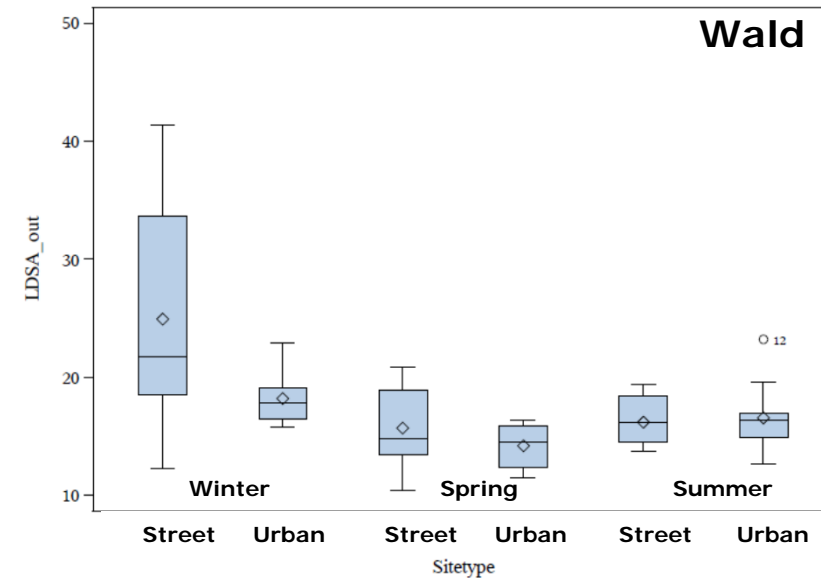
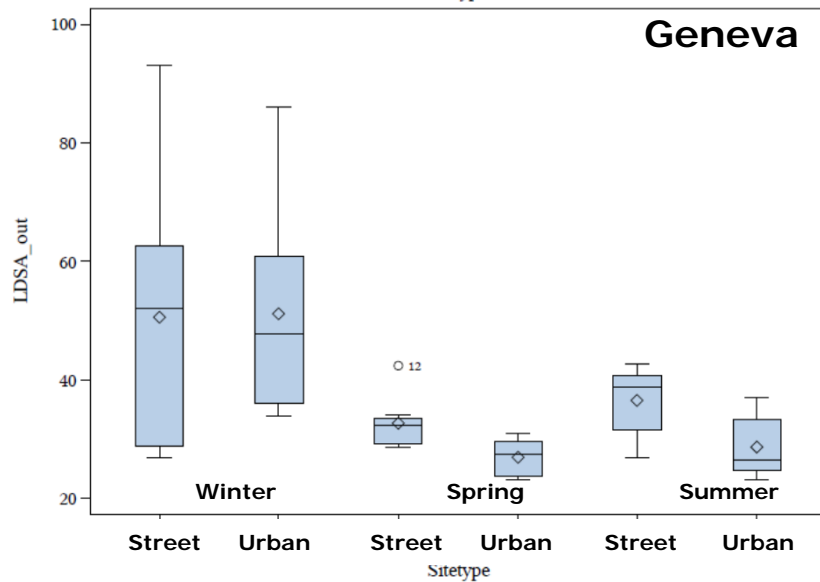
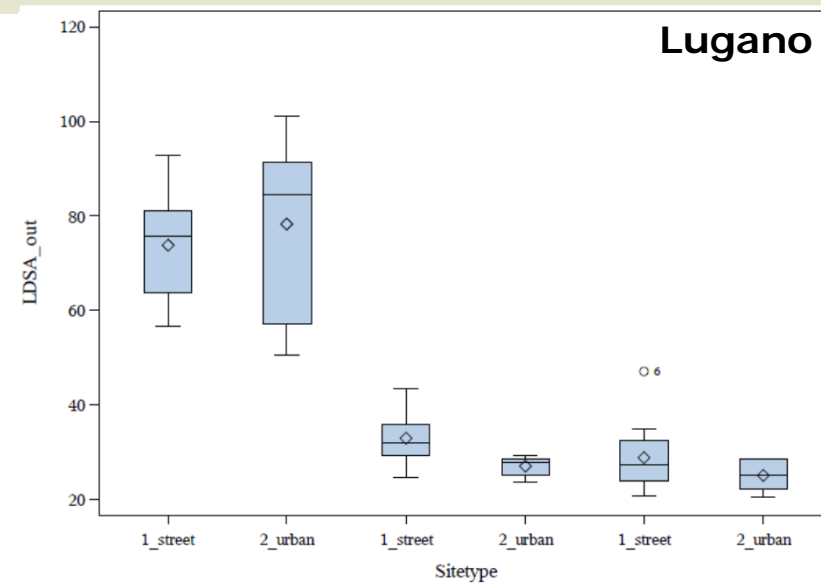
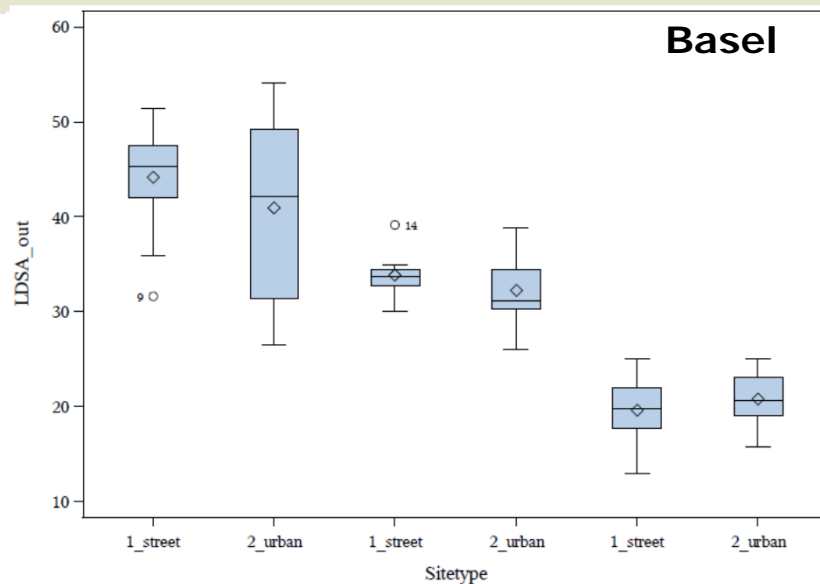


2011

2012



# Outdoor LDSA: by Season/Sitetype

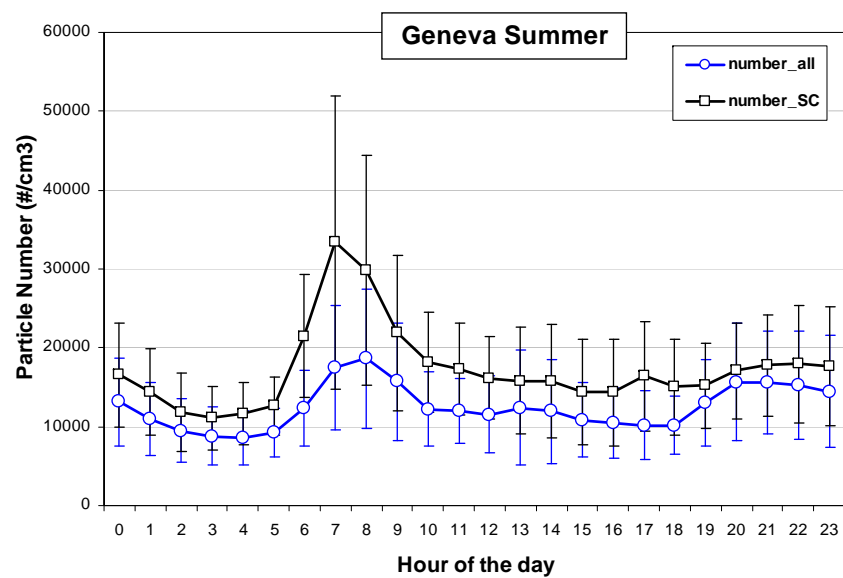
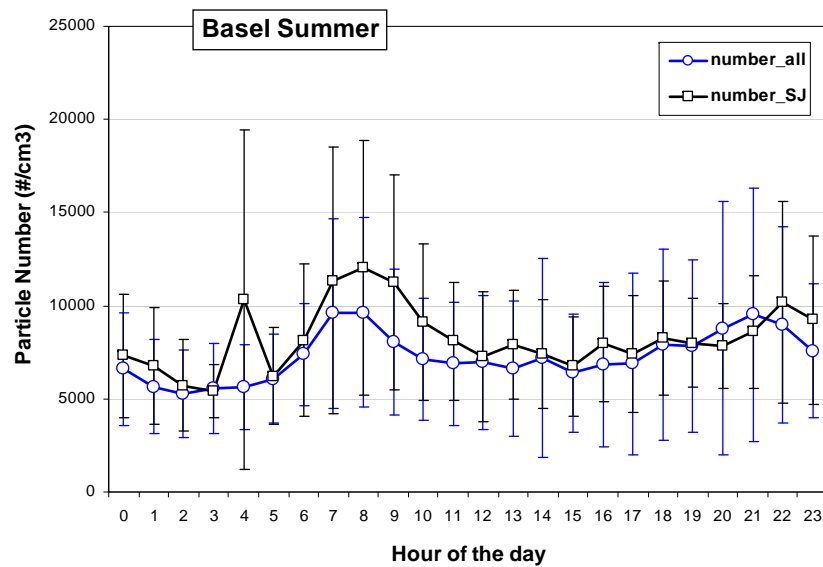
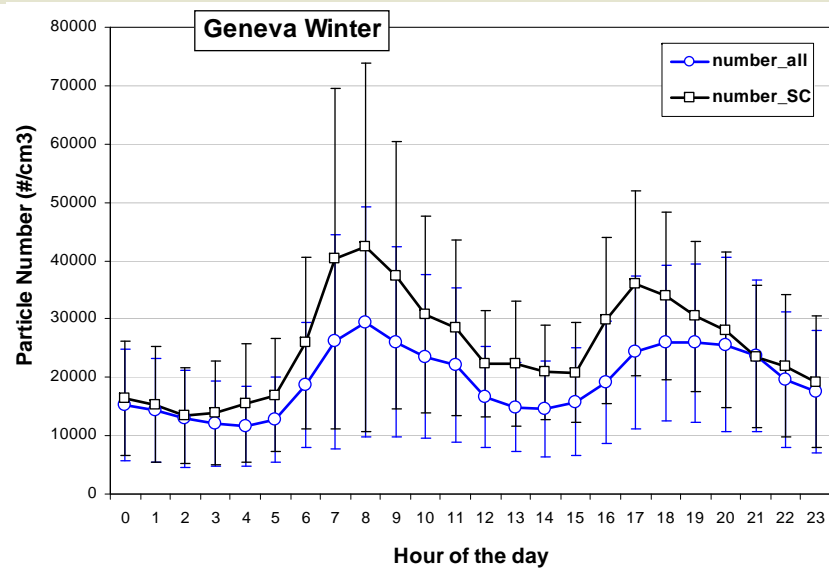
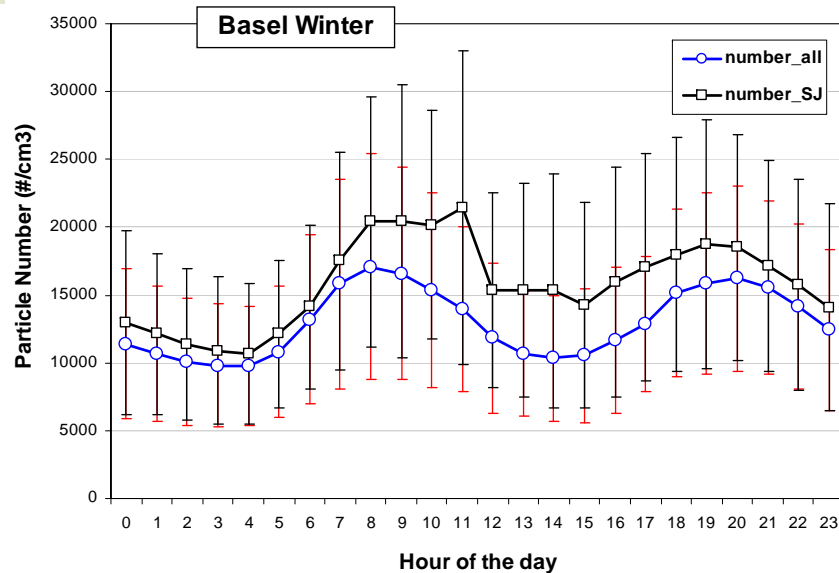


2011

2012

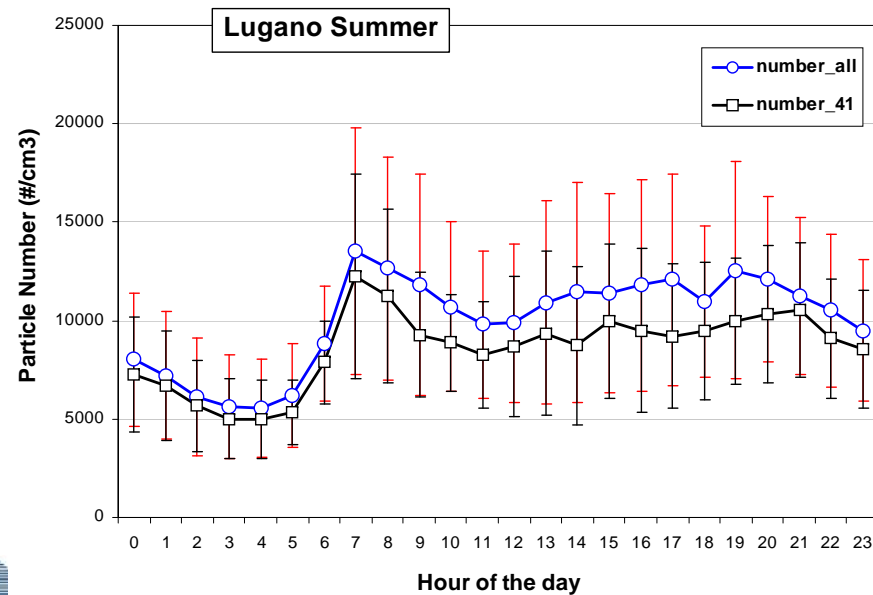
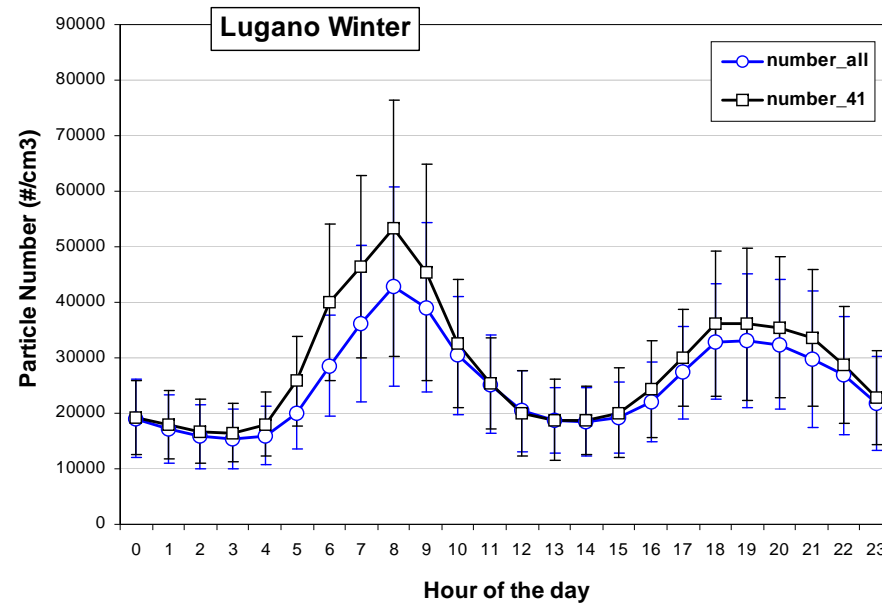


# Outdoor PN: Diurnal variation





# Outdoor PN: Diurnal variation



# Correlation with other pollutants

Area	Variable	PM <sub>10</sub>	PM <sub>2.5</sub>	BS <sub>2.5</sub>	NO <sub>2</sub>	PN
Basel	PM <sub>2.5</sub>	0.97	1			
	BS <sub>2.5</sub>	0.92	0.94	1		
	NO <sub>2</sub>	0.69	0.68	0.80	1	
	PN	0.65	0.63	0.72	0.72	1
	LDSA	0.86	0.84	0.87	0.76	0.89
Wald	PM <sub>2.5</sub>	0.87	1			
	BS <sub>2.5</sub>	0.52	0.68	1		
	NO <sub>2</sub>	0.34	0.53	0.91	1	
	PN	0.23	0.30	0.71	0.83	1
	LDSA	0.44	0.55	0.80	0.81	0.85
Lugano	PM <sub>2.5</sub>	0.98	1			
	BS <sub>2.5</sub>	0.89	0.90	1		
	NO <sub>2</sub>	0.71	0.68	0.90	1	
	PN	0.84	0.86	0.92	0.87	1
	LDSA	0.91	0.93	0.94	0.84	0.96
Geneva	PM <sub>2.5</sub>	0.91	1			
	BS <sub>2.5</sub>	0.73	0.82	1		
	NO <sub>2</sub>	0.49	0.52	0.58	1	
	PN	0.26	0.45	0.56	0.67	1
	LDSA	0.49	0.67	0.69	0.60	0.89

# Correlation with other pollutants: by Season

Area	Season	Variable	PM <sub>10</sub>	PM <sub>2.5</sub>	BS <sub>2.5</sub>	NO <sub>2</sub>	PN
Basel	Winter	PN	0.42	0.56	0.51	0.65	
		LDSA	0.67	0.67	0.71	0.64	0.81
	Summer	PN	0.16	-0.26	0.06	-0.01	
		LDSA	0.04	-0.34	-0.03	0.06	0.86
Wald	Winter	PN	0.56	0.38	0.79	0.92	
		LDSA	0.75	0.52	0.82	0.87	0.89
	Summer	PN	0.24	0.16	0.56	0.71	
		LDSA	0.33	0.51	0.55	0.45	0.70
Lugano	Winter	PN	0.45	0.42	0.43	0.76	
		LDSA	0.72	0.73	0.64	0.58	0.90
	Summer	PN	0.58	0.56	0.81	0.84	
		LDSA	0.78	0.76	0.64	0.62	0.86
Geneva	Winter	PN	0.35	0.40	0.41	0.70	
		LDSA	0.65	0.71	0.65	0.51	0.80
	Summer	PN	0.08	0.03	0.41	0.54	
		LDSA	0.29	0.24	0.63	0.71	0.90

- Weekly outdoor PN levels ranged and  $5600 \pm 3500$  (Wald) to  $15700 \pm 7400$  particles/cm<sup>3</sup> (Lugano)
- LDSA values are  $16.7 \pm 8.4$  (Wald) to  $44.5 \pm 16.5$  μm<sup>2</sup>/cm<sup>3</sup> (Lugano)
- Winter had highest PN levels ((~2 times than summer)
- Clear morning and evening rush hour peaks especially for traffic sites
- Moderate to good correlation with NO<sub>2</sub>, soot (R=0.56-0.92)
- Higher correlation in winter than summer

### Acknowledgements:

Cantonal air monitoring agencies; BAFU; SNF

Field workers; Study participants

**Thank you !**







...additional info



# Gravimetric & Chemical Analysis

## Gravimetric Mass ( $PM_x$ )

Mettler-Toledo microbalance

## Soot (BS)

EEL 43D Black Smoke Reflectometer

## Speciated metals

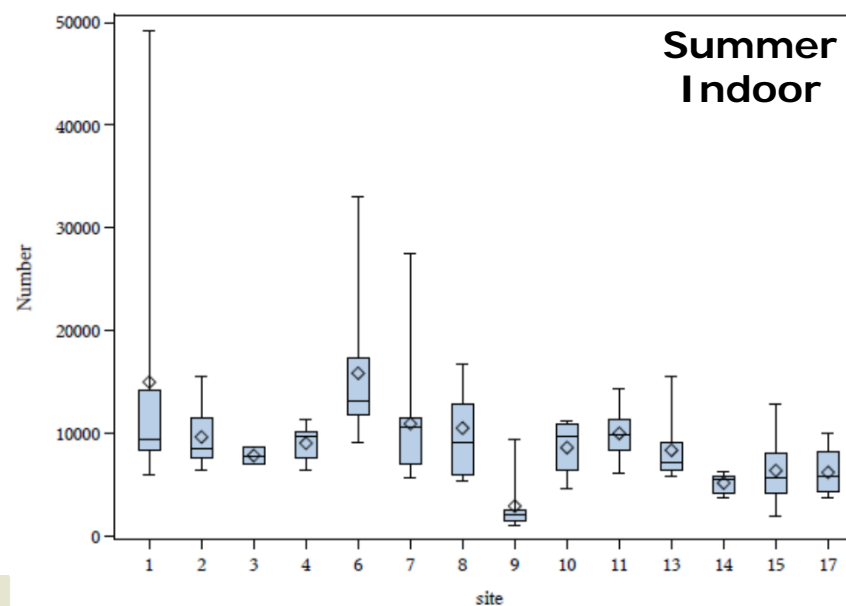
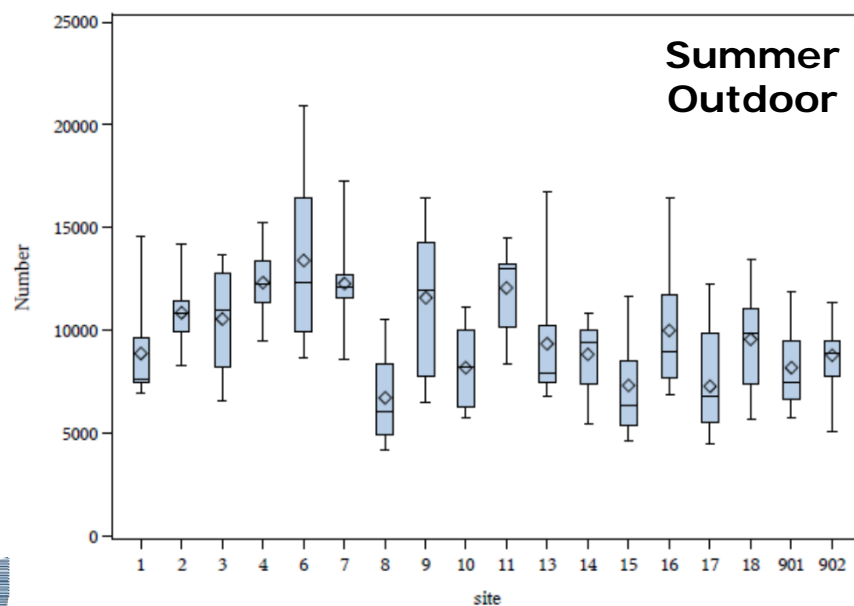
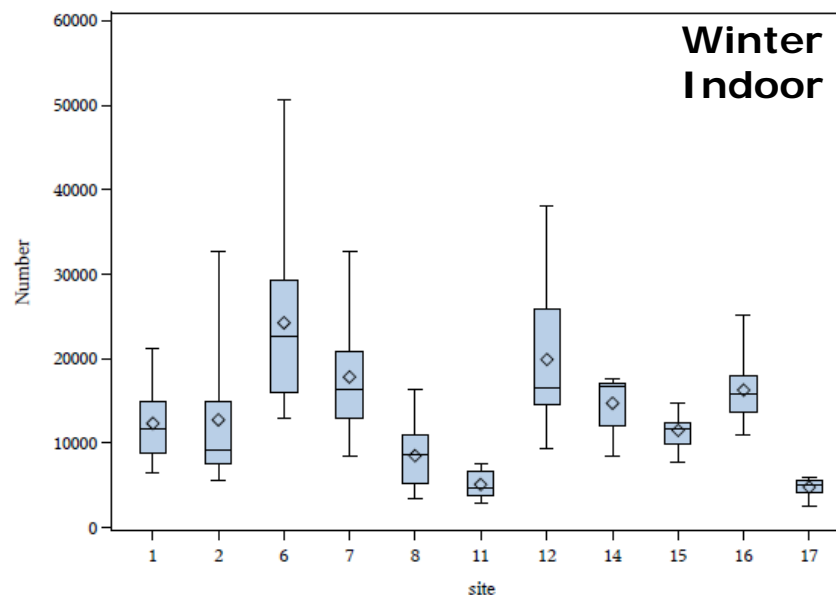
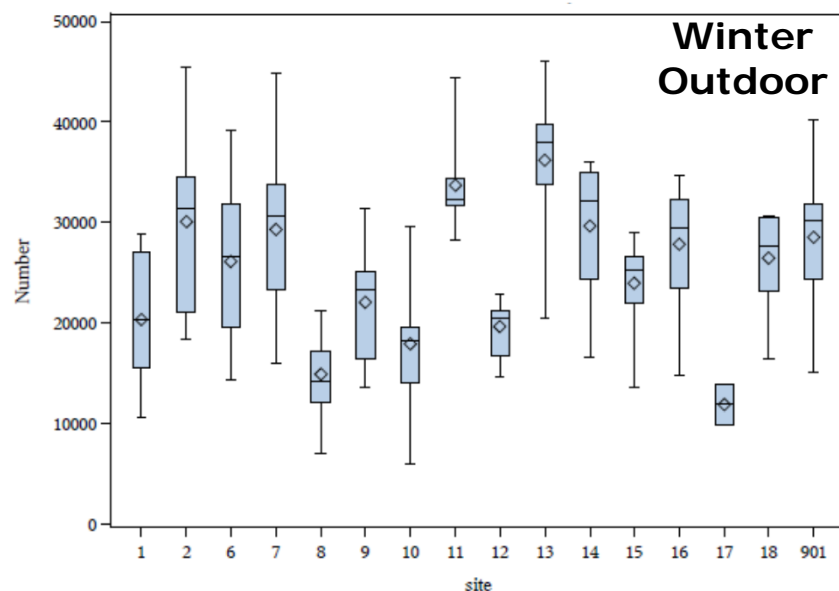
X-ray Fluorescence (for  $PM_{2.5}$  filters)

## Inorganic ions

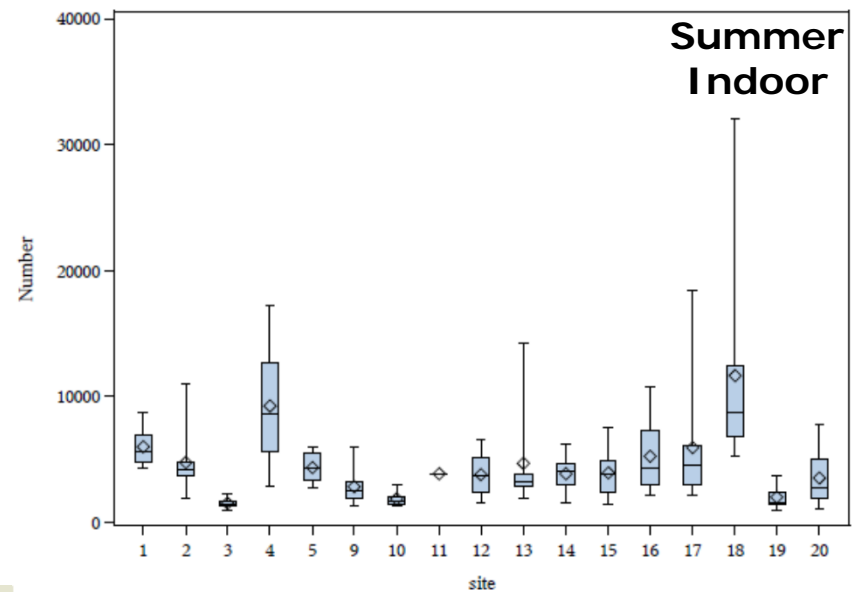
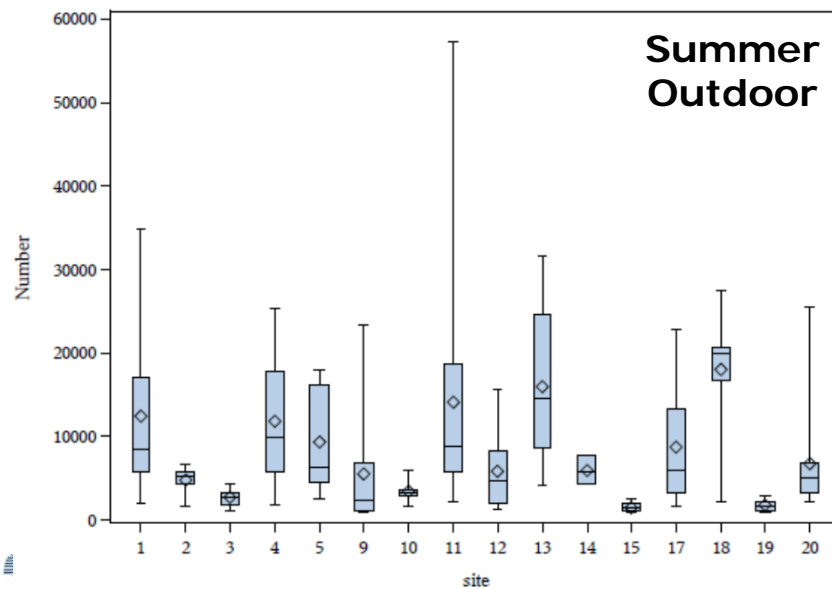
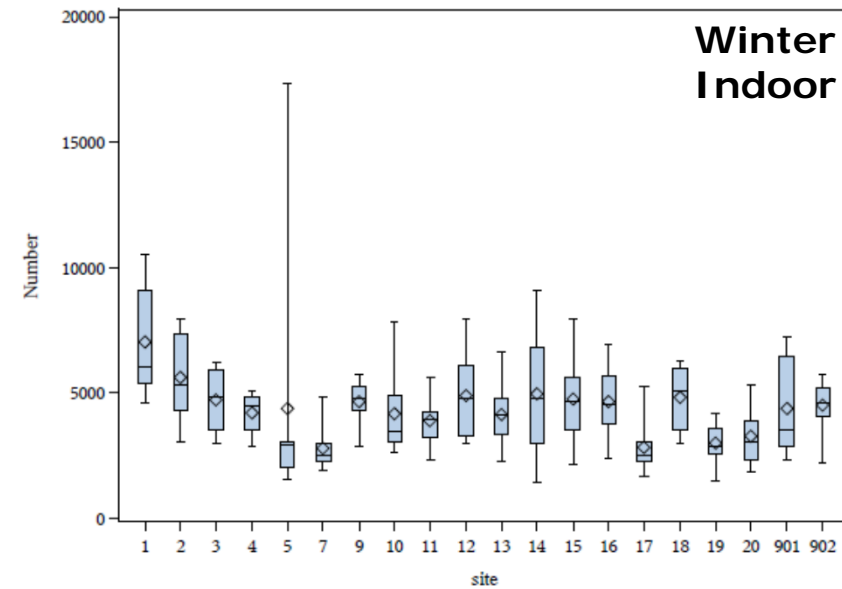
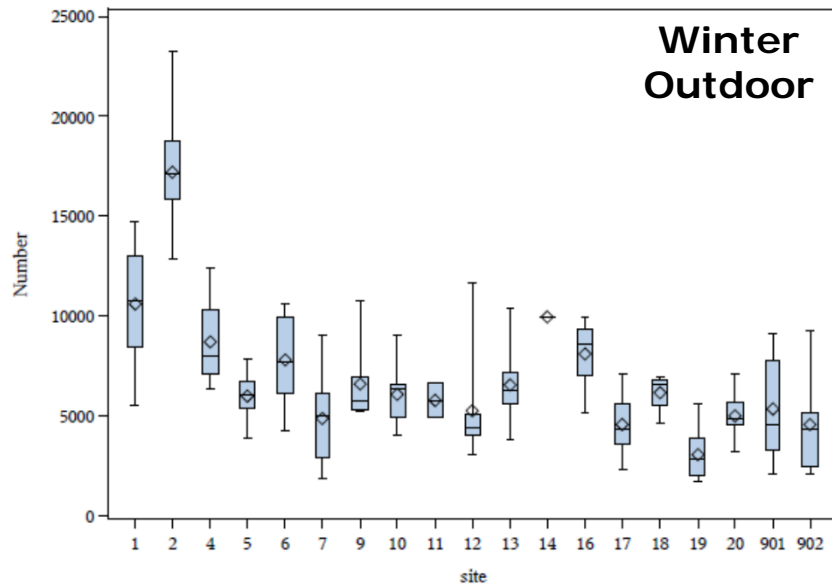
Ion-chromatography (for  $PM_{2.5}$  filters)



# Lugano Indoor-Outdoor UFP: by Season

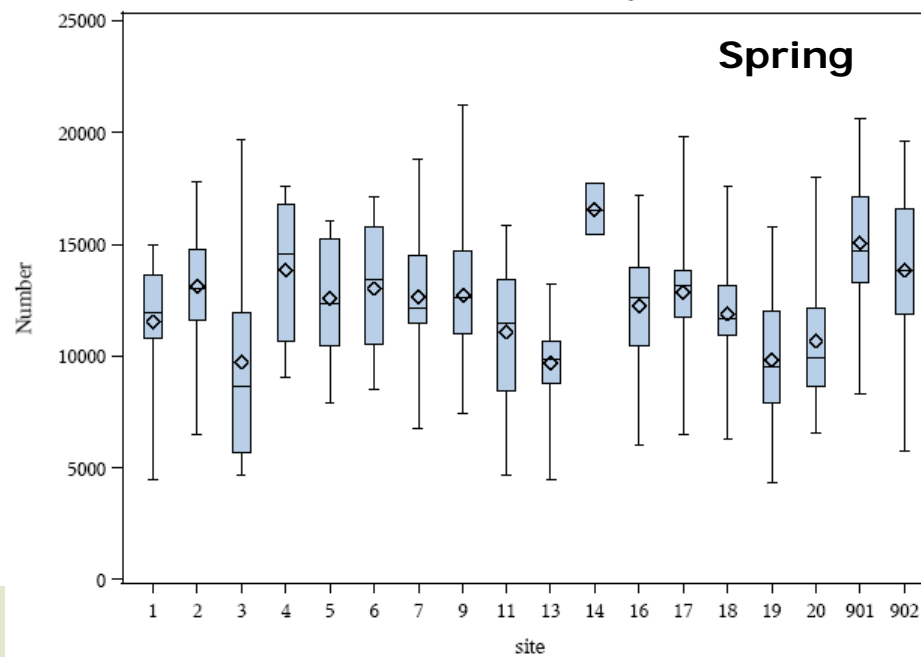
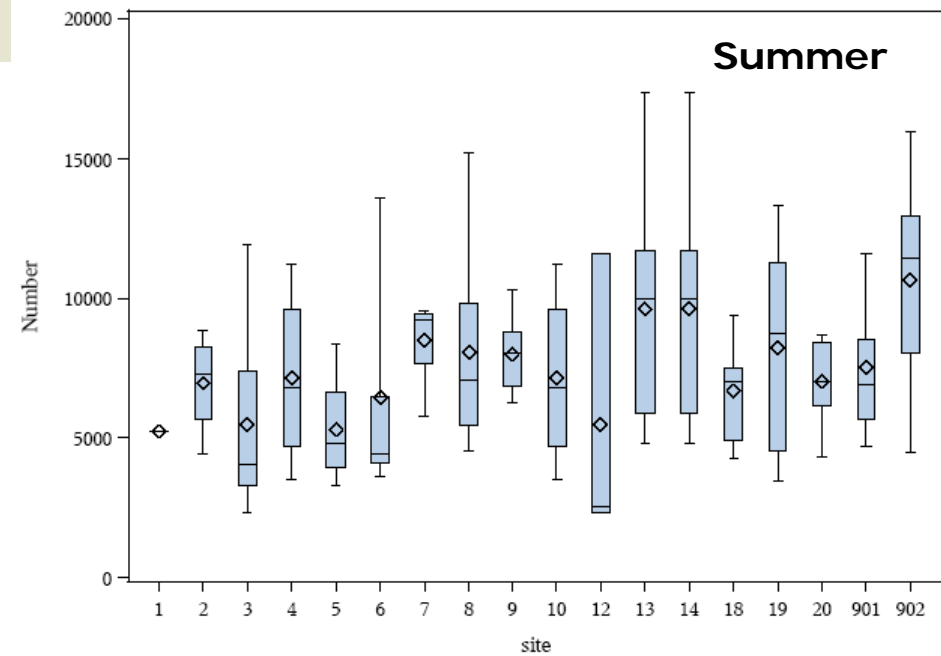
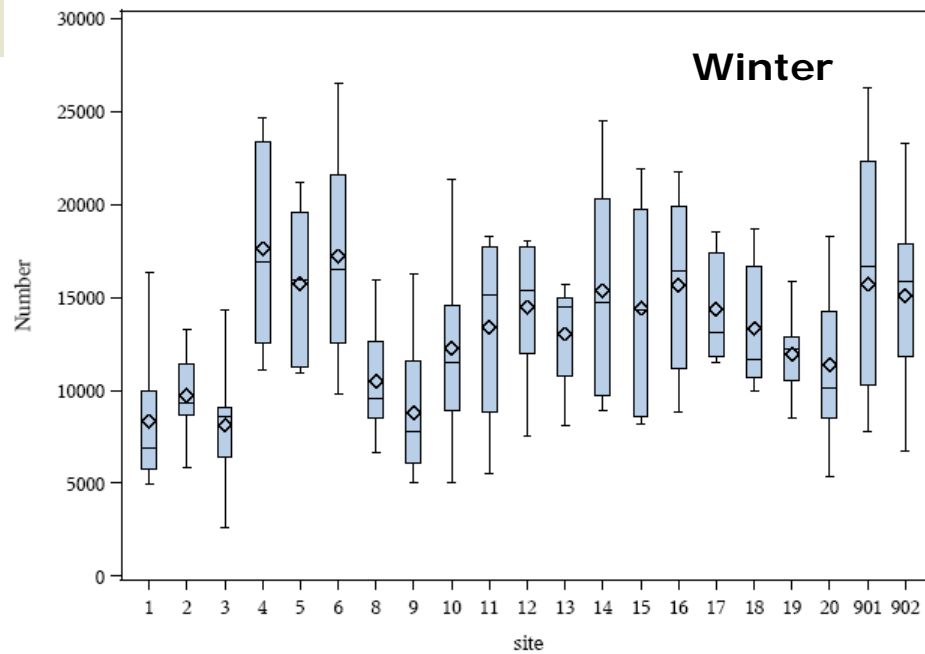


# Wald Indoor-Outdoor UFP: by Season

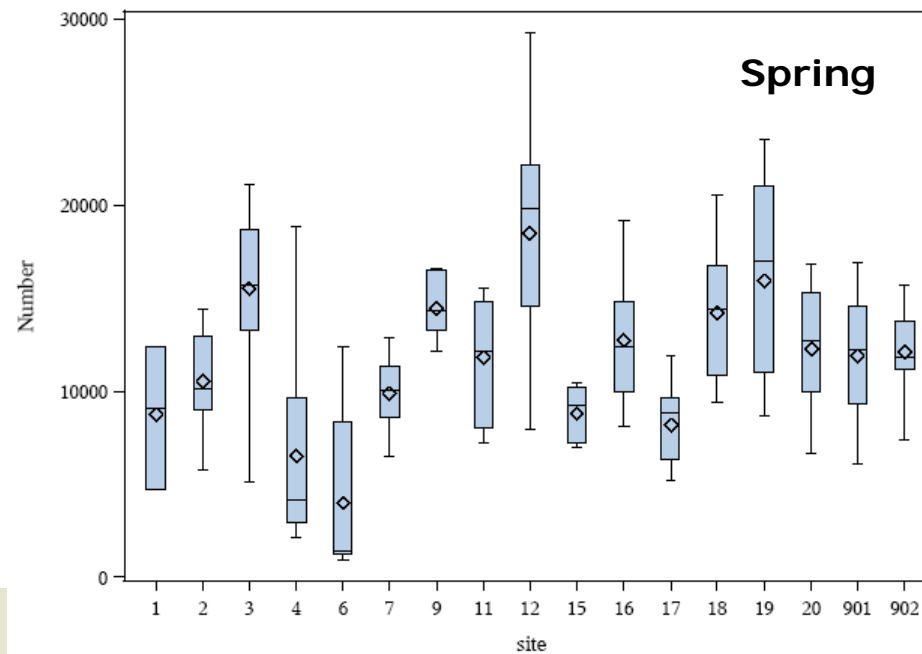
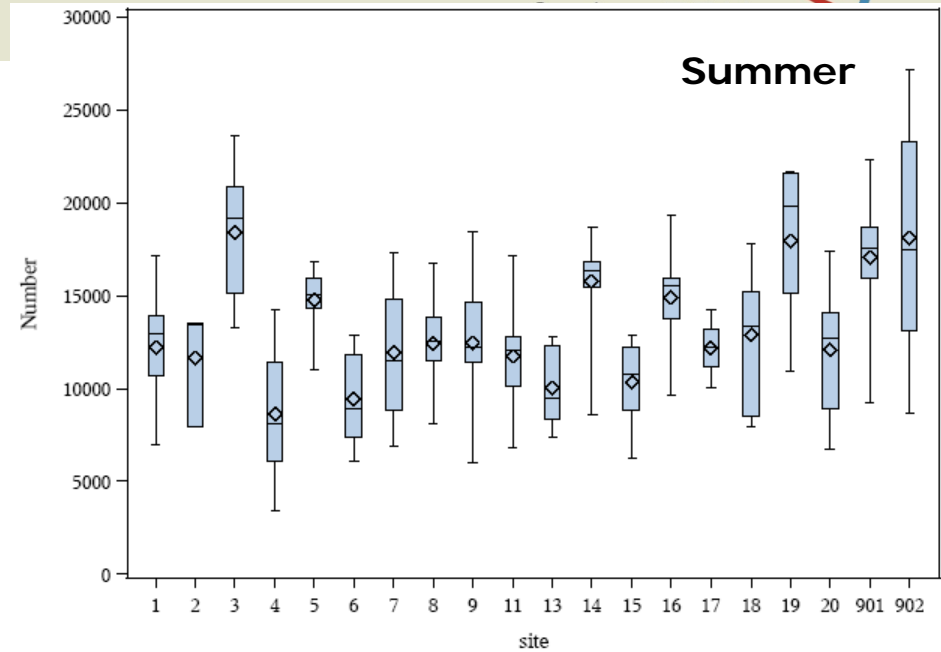
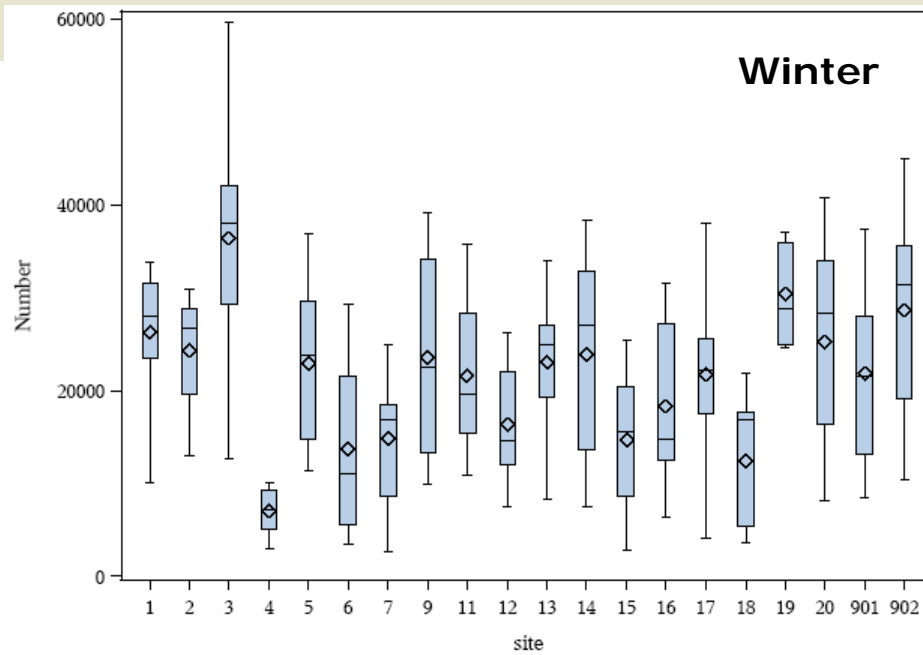




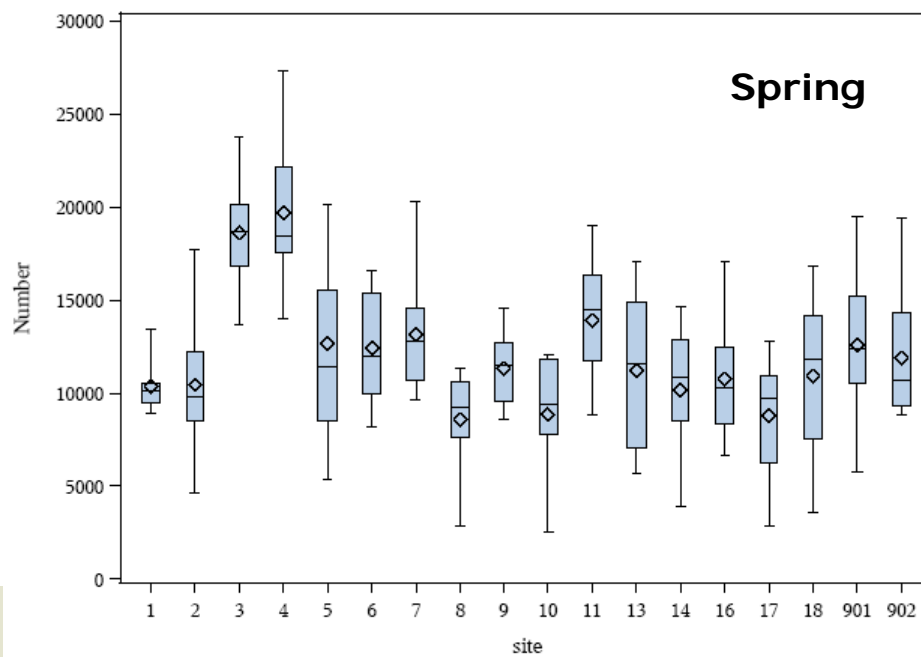
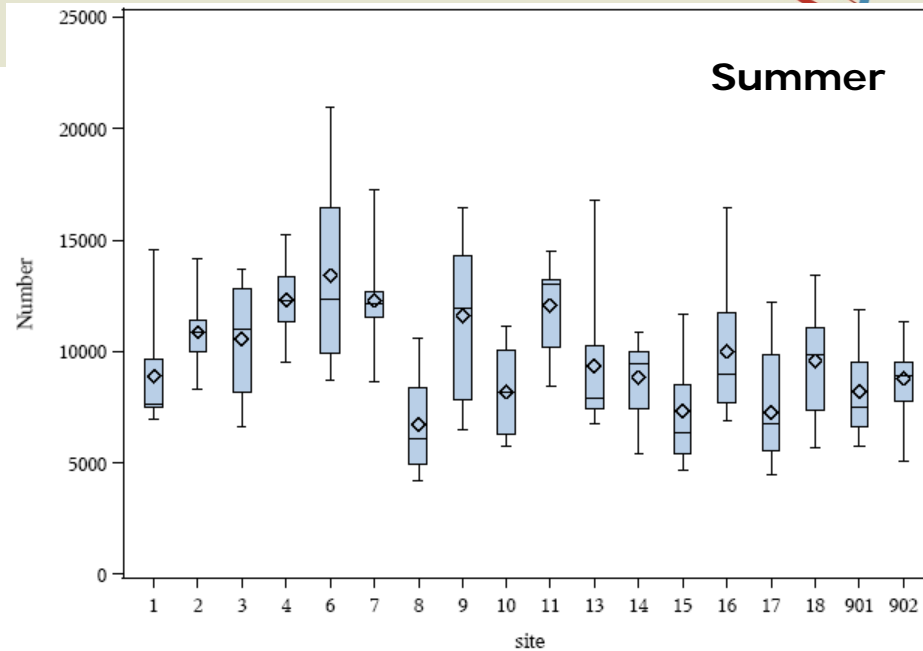
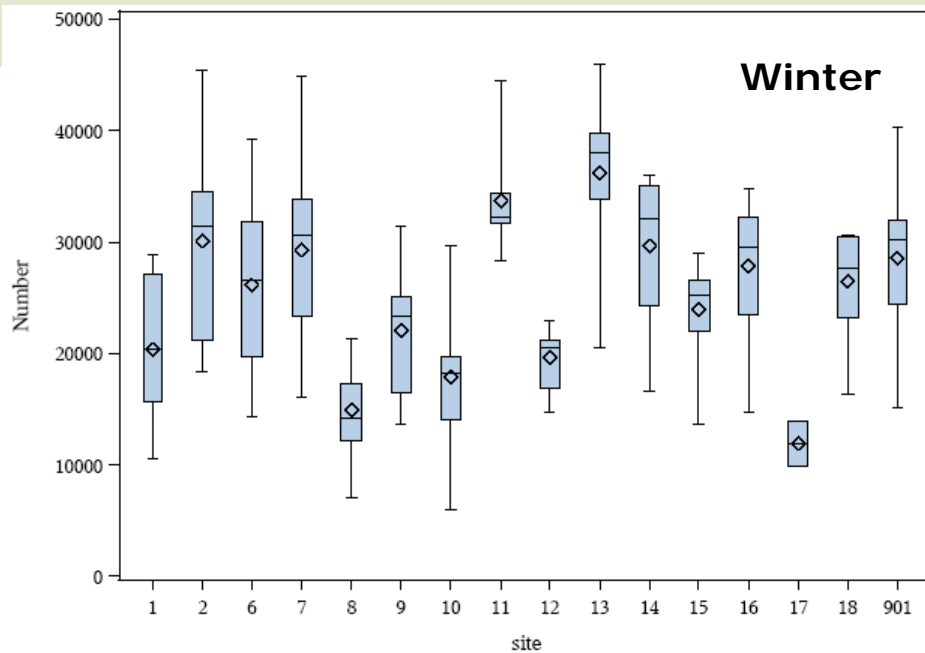
# Outdoor Particle Number: Basel



# Outdoor Particle Number: Geneva



# Outdoor Particle Number: Lugano



# Outdoor Particle Number: Wald

