



Spatial and temporal variation of ultrafine particles in the Bavarian centres of the NAKO health study: Augsburg and Regensburg

J. Cyrys, K. Wolf, M. Dallavalle, S. Breitner, A. Schneider, R. Pickford, S. Kecorius, S. Sues, J. Soentgen, A. Peters

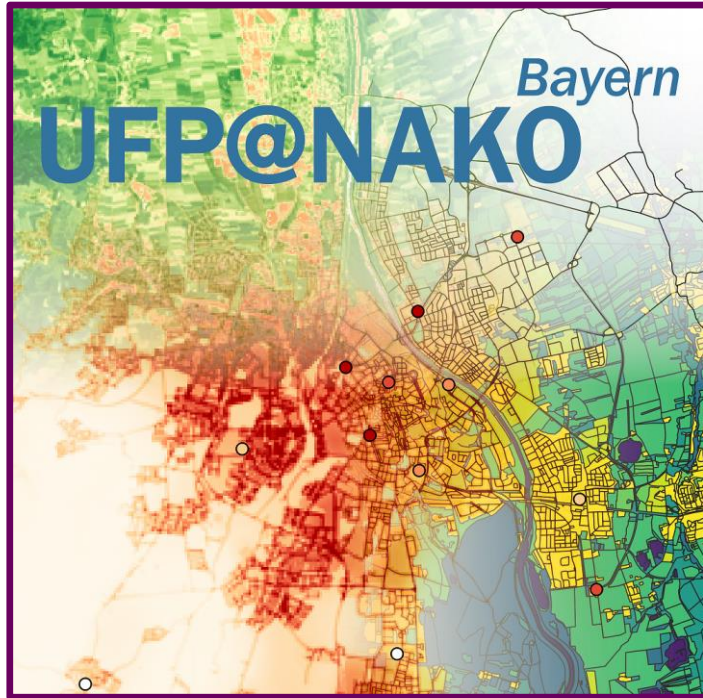
Helmholtz Munich / Ludwig-Maximilians-University München / WZU University Augsburg



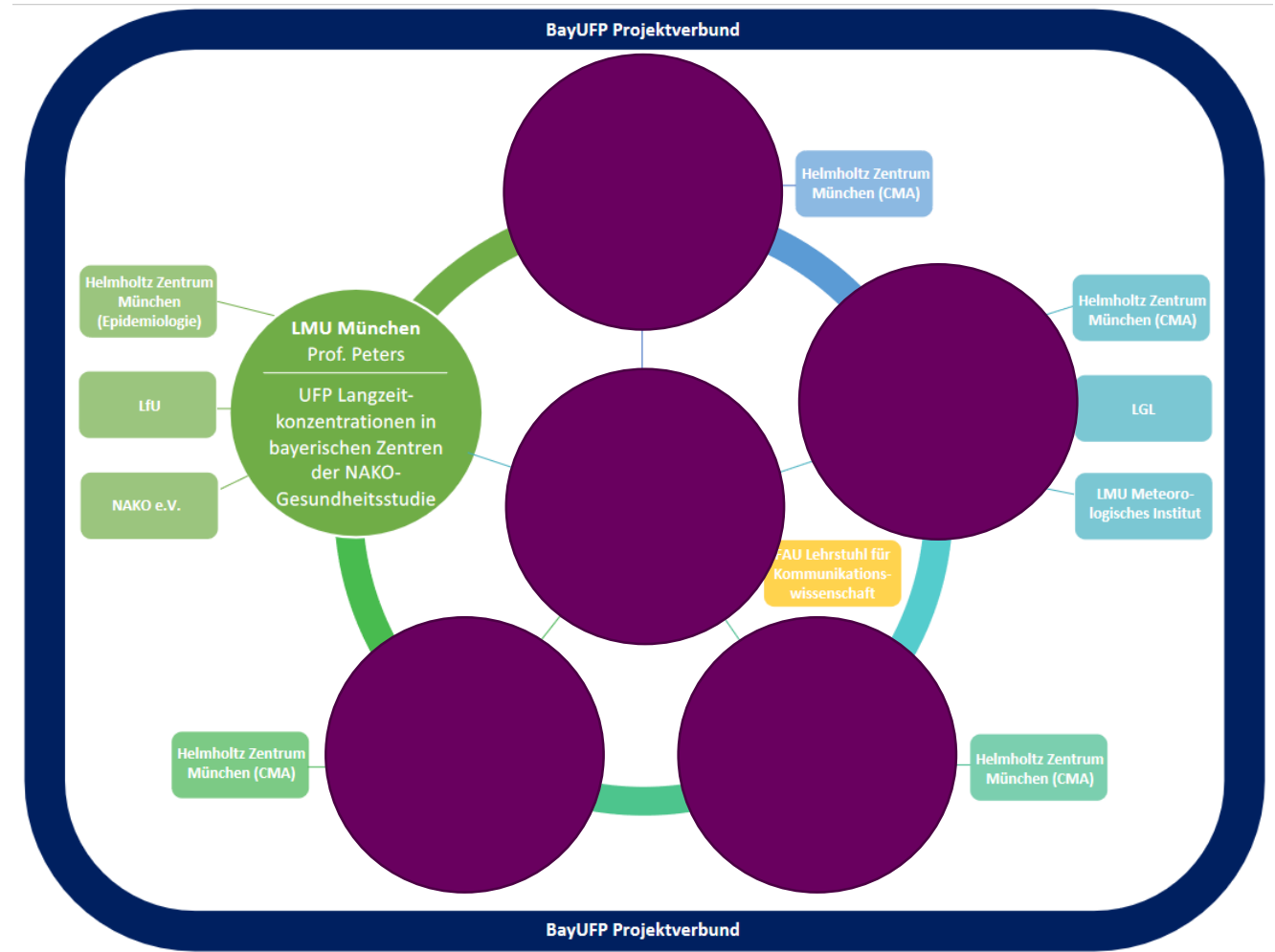
**BAY
UFP**

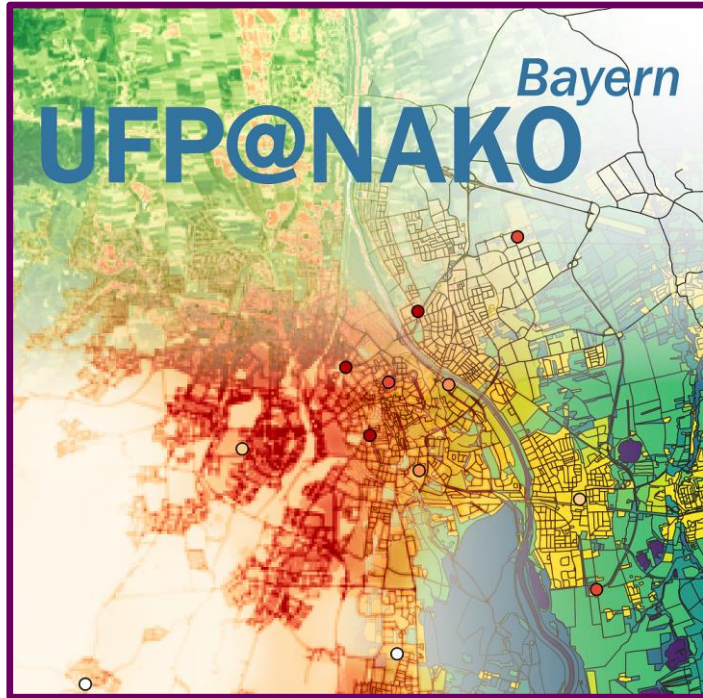
BAYERISCHER
PROJEKTVERBUND
ULTRAFEINE PARTIKEL



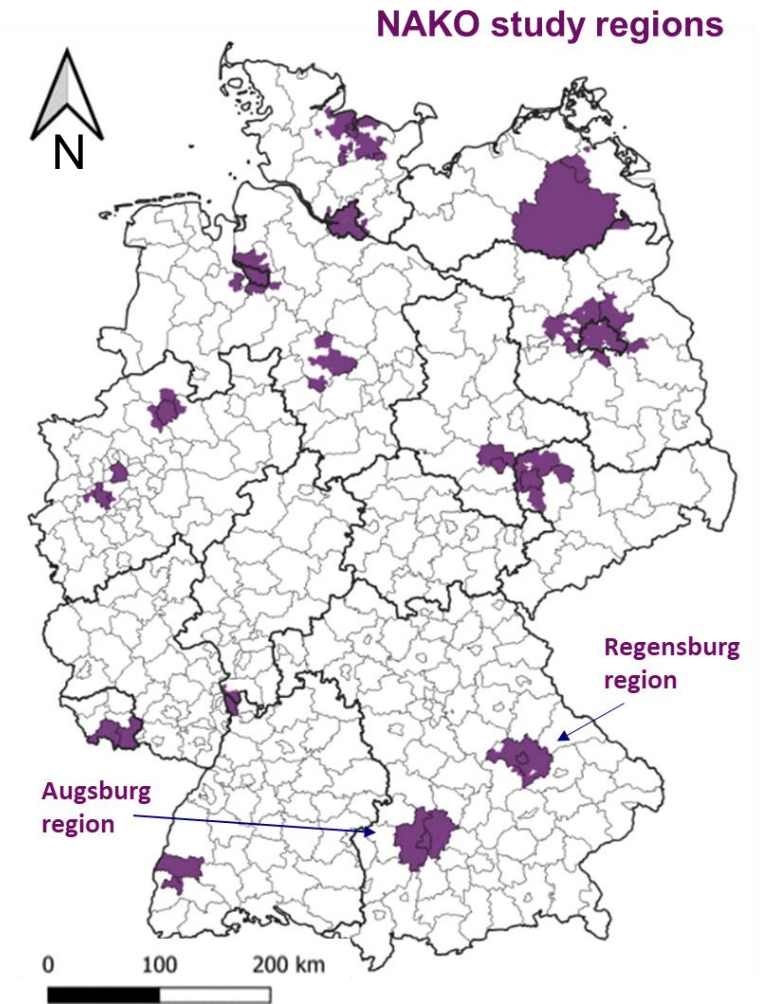


! Studies on long-term health effects of UFP are rare !

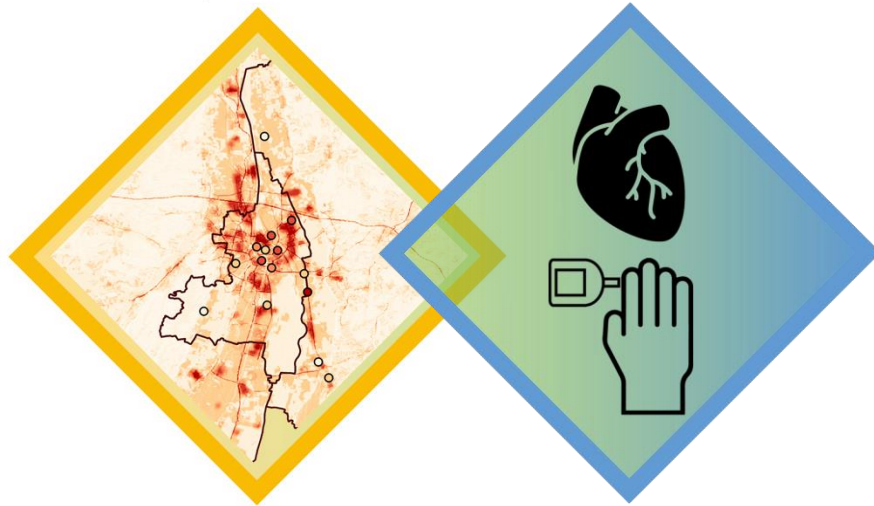




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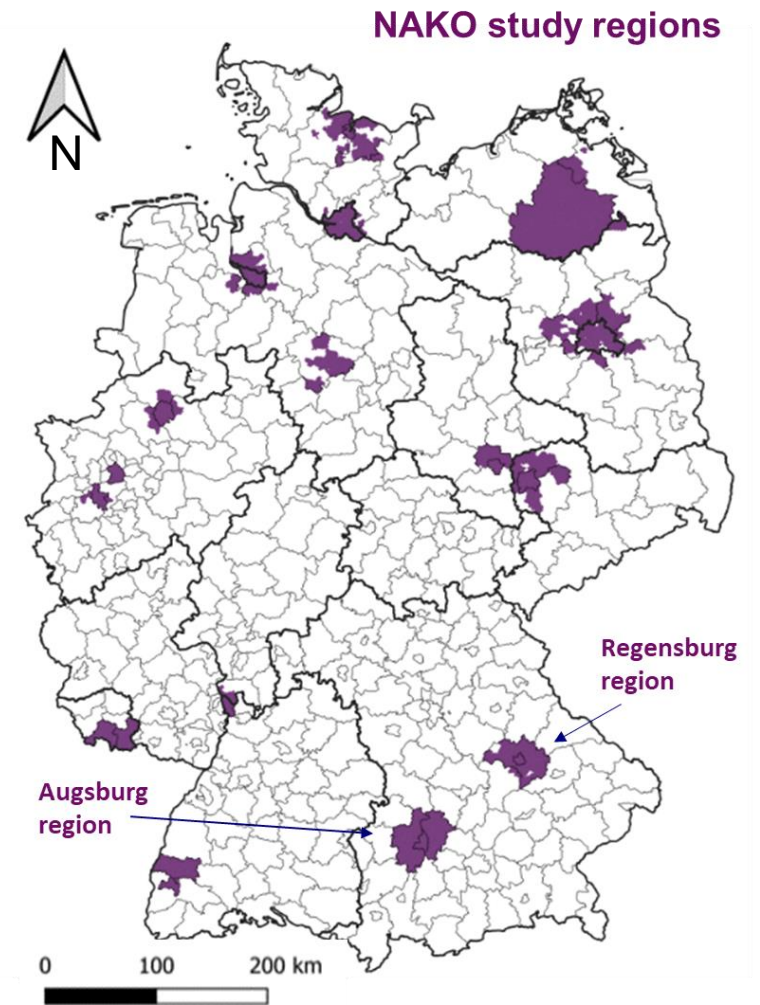


WP1: Exposure **WP2: Health effects**



WP1: Modelling of **long-term exposure** to UFP in Augsburg and Regensburg by LUR (land use regression)

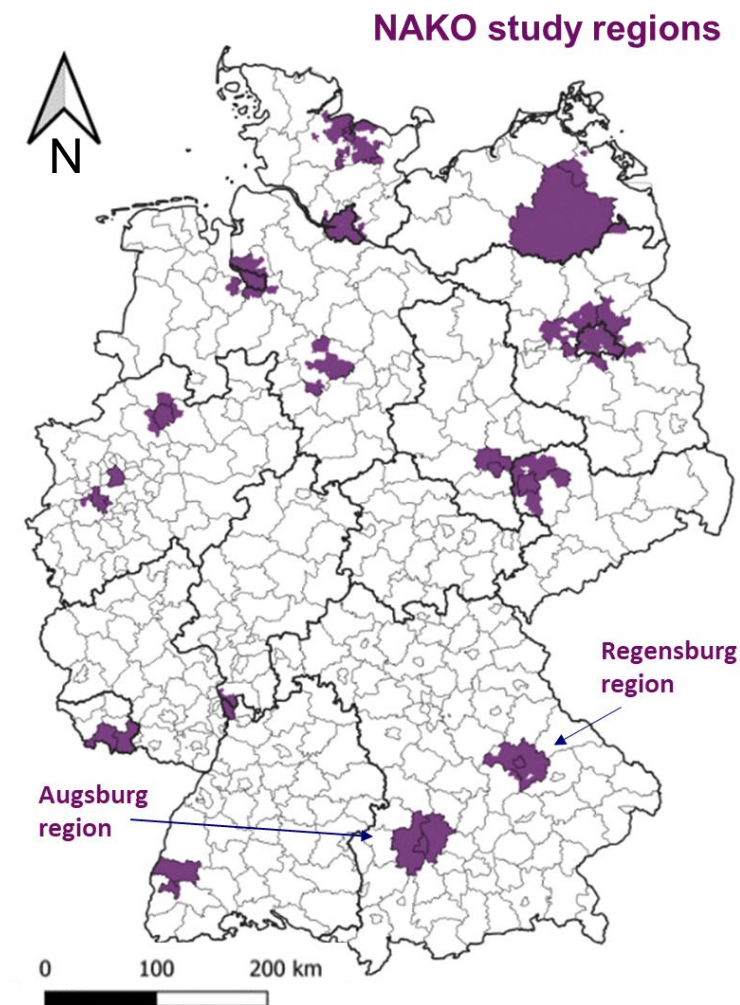
WP2: Estimation of the association between **long-term exposure** to UFP and cardiometabolic risk markers and the prevalence of cardiometabolic diseases



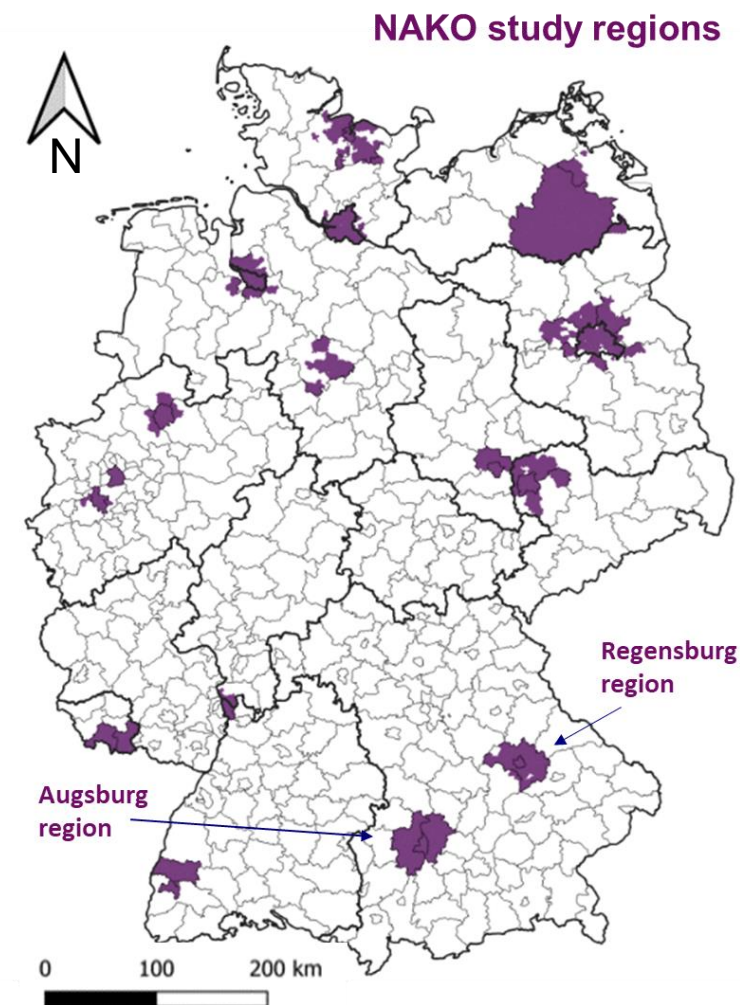
- To update and refine our land use regression (LUR) model for particle number concentration (PNC) as indicator for UFP for Augsburg, Germany
 - based on previous measurements
 - ULTRA III: 2014/15, 20 monitoring stations + model
 - LfU project: 2017, 6 monitoring stations

ULTRA III*: "ENVIRONMENTAL NANOPARTICLES AND HEALTH: Exposure, Modeling and Epidemiology of Nanoparticles and their Composition within KORA"

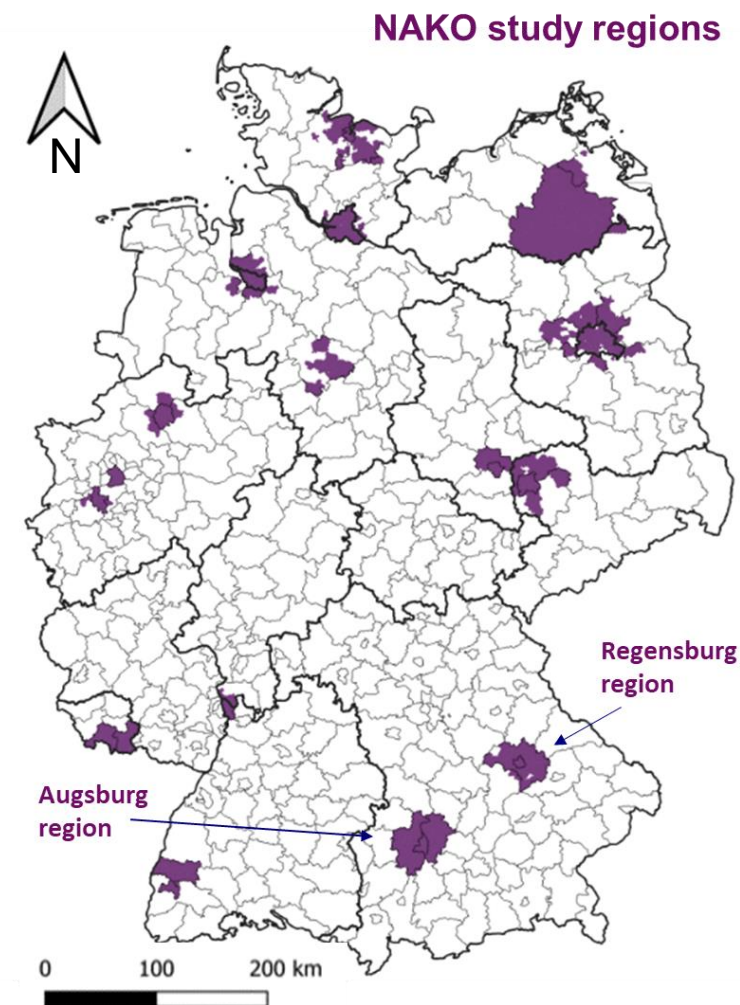
LfU project:** Influence of Local Sources and Meteorological Parameters on the Spatial and Temporal Distribution of Ultrafine Particles in Augsburg, Germany



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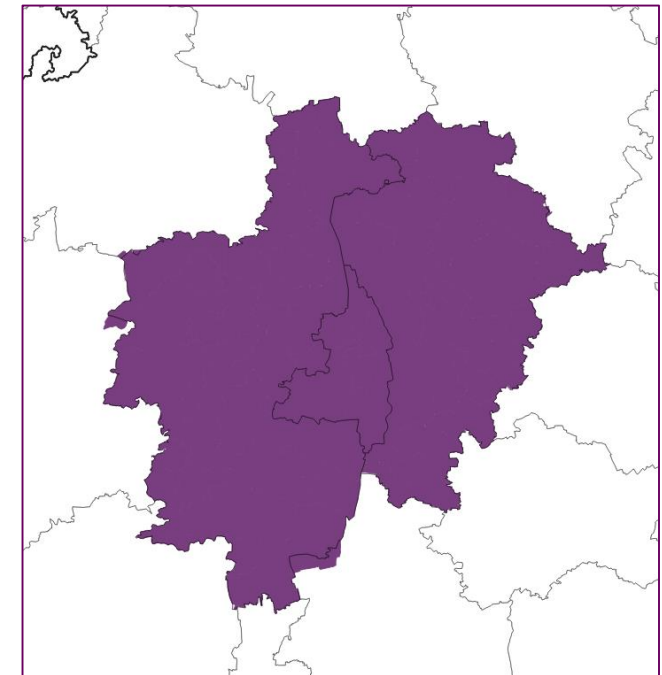


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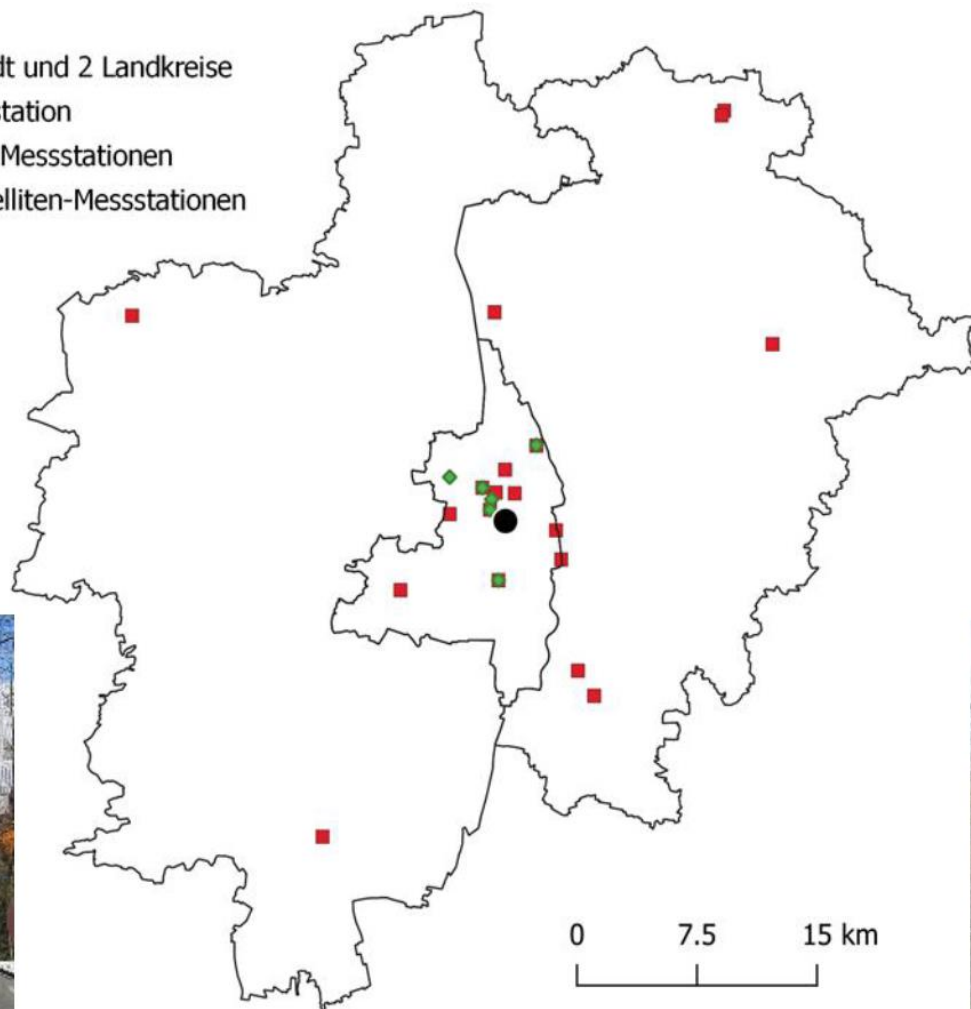


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Augsburg region

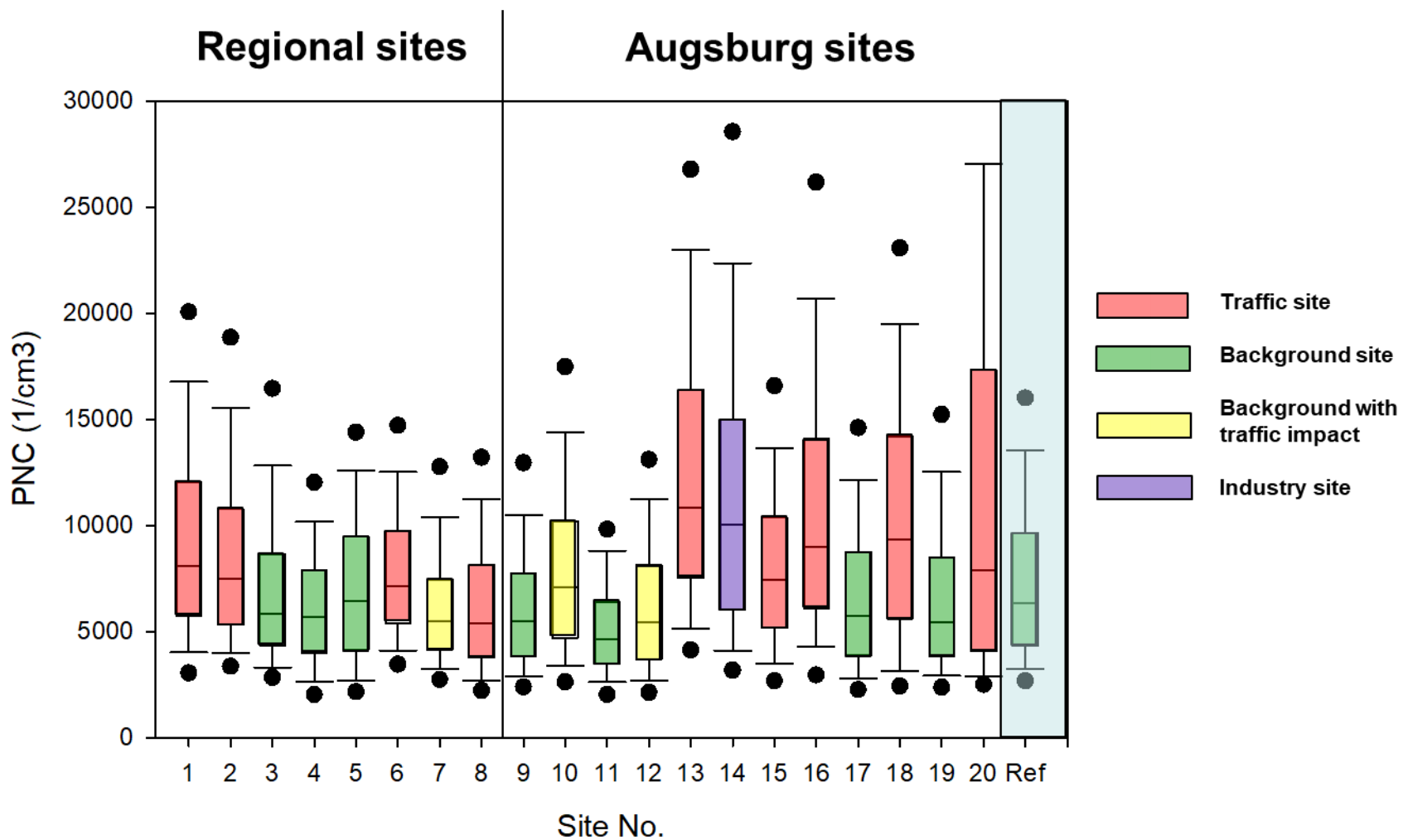


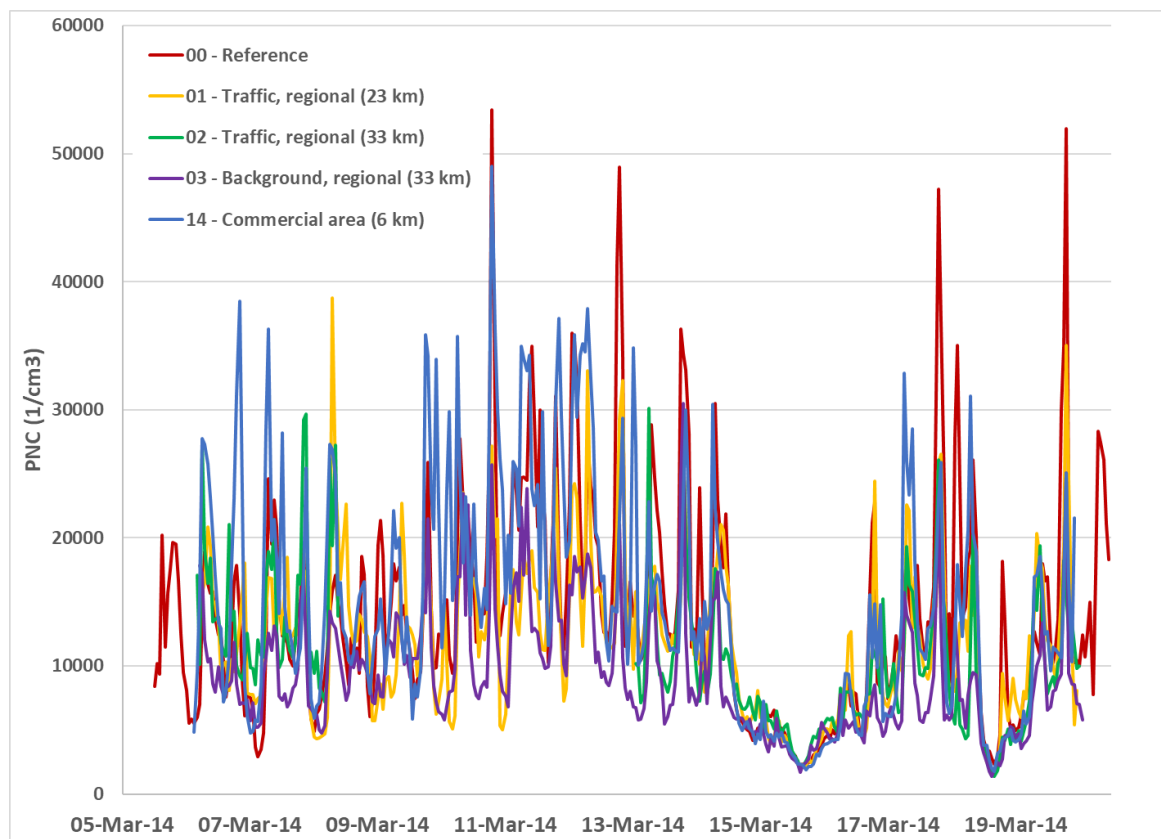
- Augsburg Stadt und 2 Landkreise
- Aerosol-Messstation
- ◆ LfU Satelliten-Messstationen
- ULTRAIII Satelliten-Messstationen



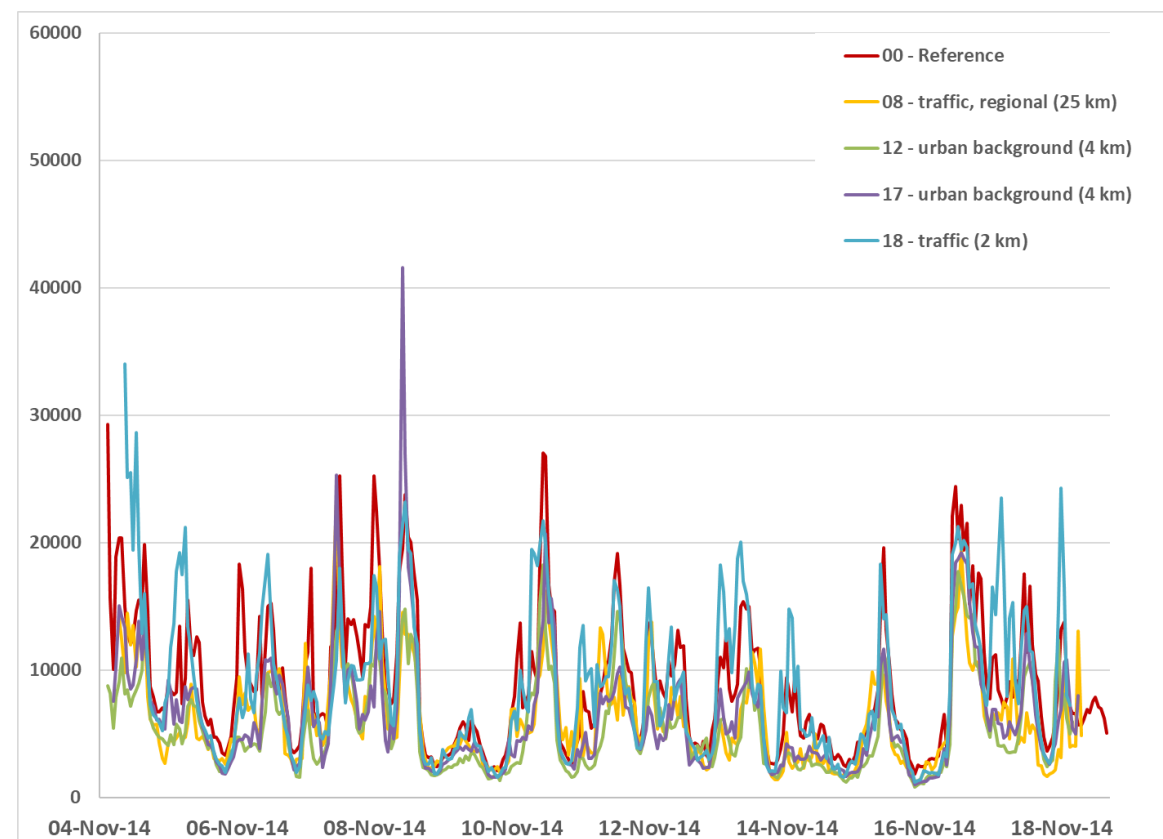
- 20 sites in 2014/15 (ULTRA III)
- 6 sites in 2017 (LfU project)
- 1 continuous site (reference site)







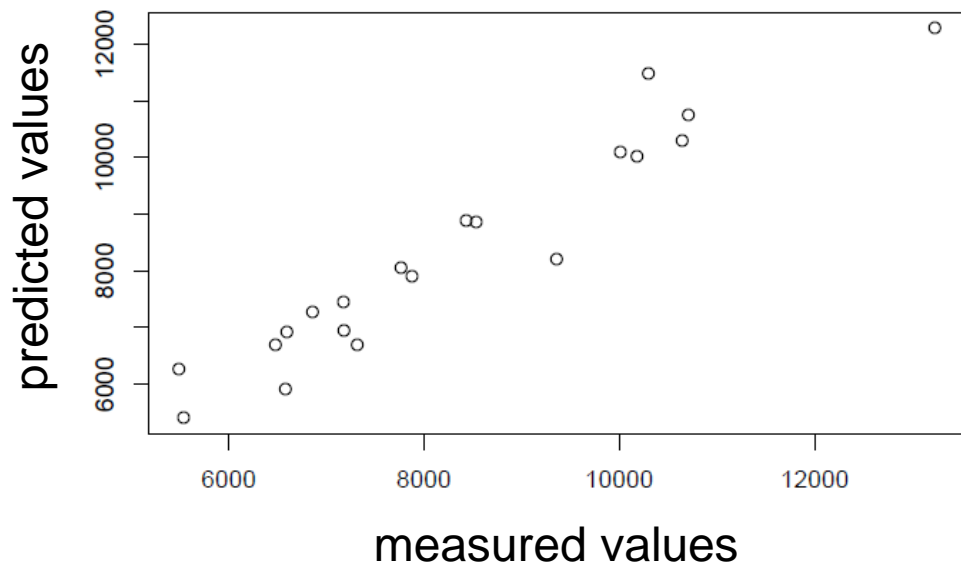
Reference vs.	01 - Traffic, regional	02 - Traffic, regional	03 - Background, regional	14 - Commercial area
Pearson r	0.78	0.74	0.75	0.75



Reference vs.	08 - Traffic, regional	12 - urban background	17 - urban background	18 - traffic
Pearson r	0.79	0.91	0.90	0.83

Pollutant	LUR model	R ²	Adj R ²	LOOCV R ²	LOOCV Adj R ²	Moran's I (p-value)
PNC	6845 + 0.0023 * trafloadm_50 + 75.88 * industry_300 + 52.99 * seminatt_100_neg + 44.86 * green_500_neg + 2.49 * abld_25	0.92	0.89	0.83	0.82	-0.05 (0.99)

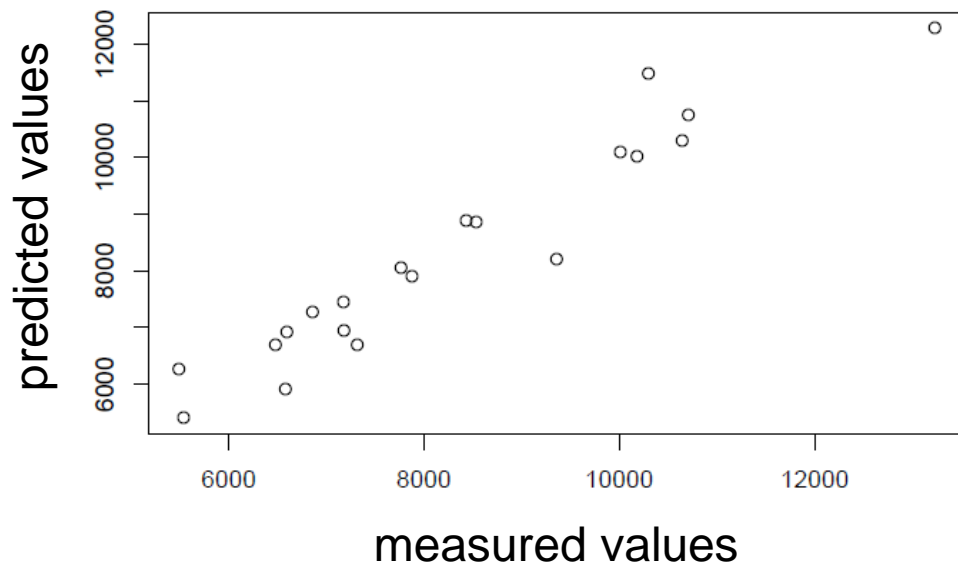
PNC



Wolf et al., 2017

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NO ₂	12.57 + 0.22 * industry_5000 + 0.015 * roadlm_100 + 0.10 * seminat_1000_neg + 0.15 * industry_1000	0.95	0.94	0.90	0.89	-0.10 (0.64)

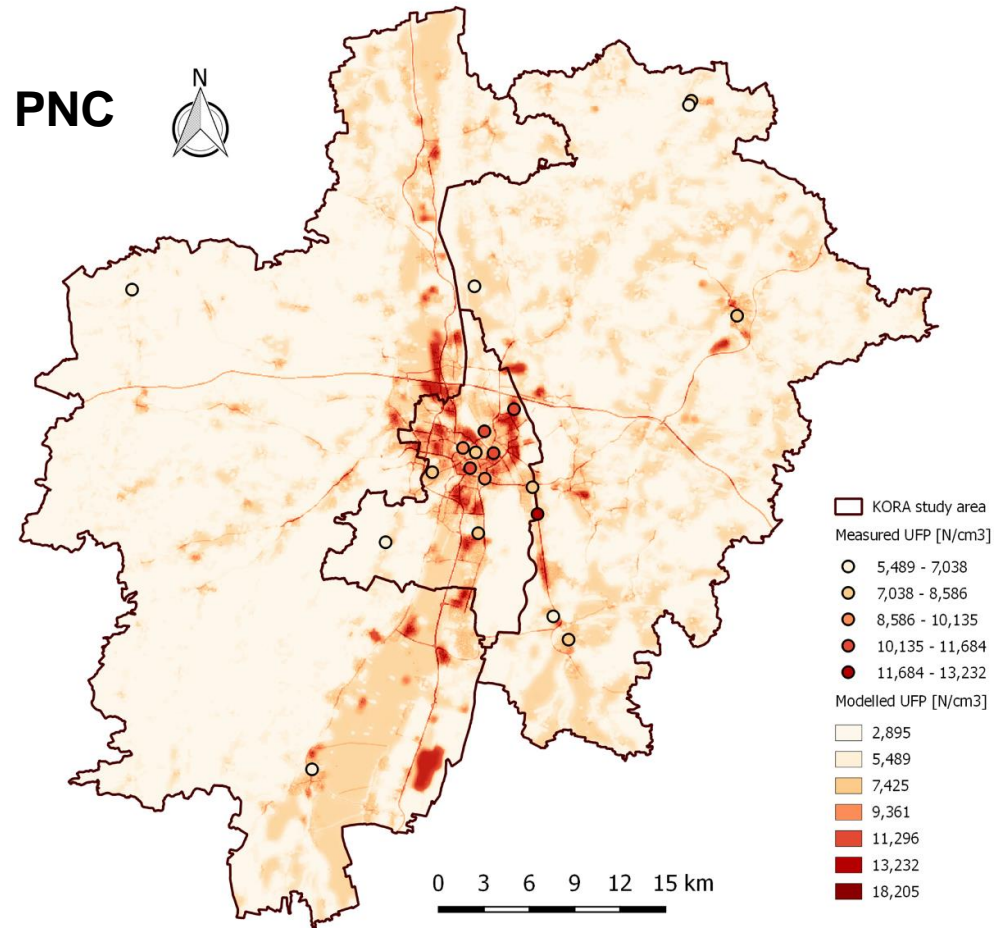
PNC



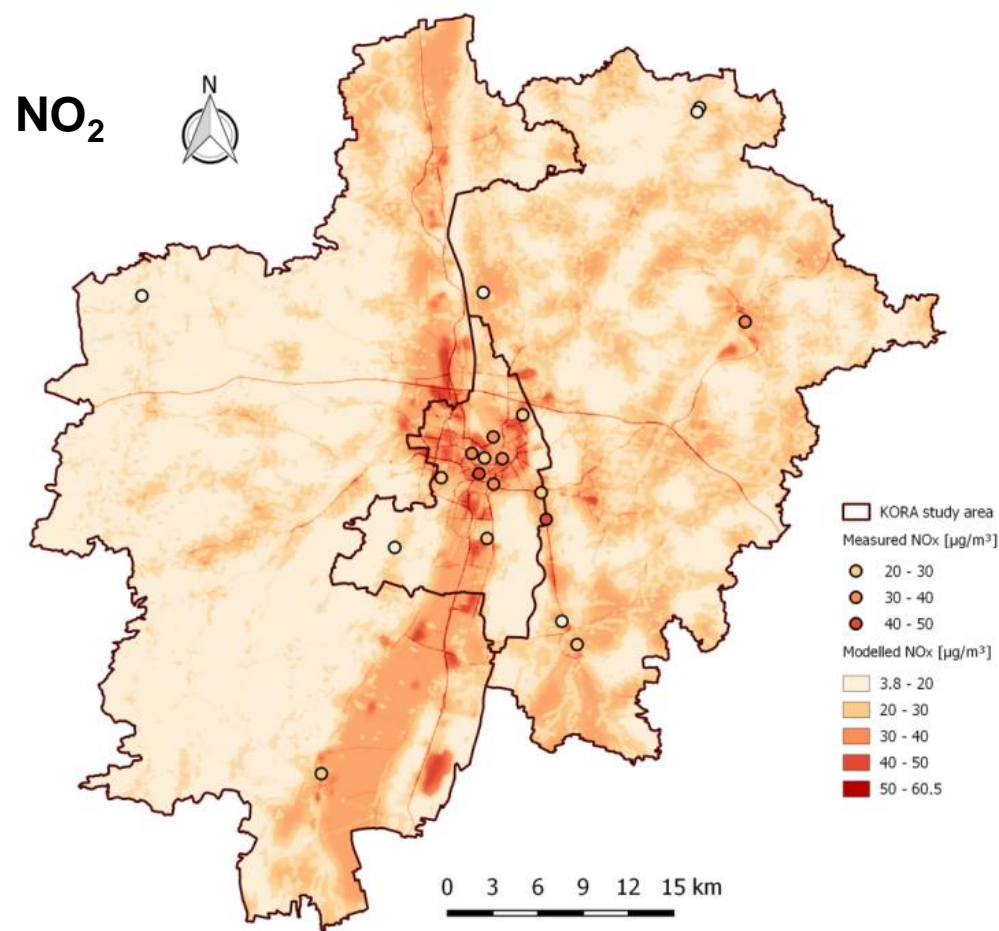
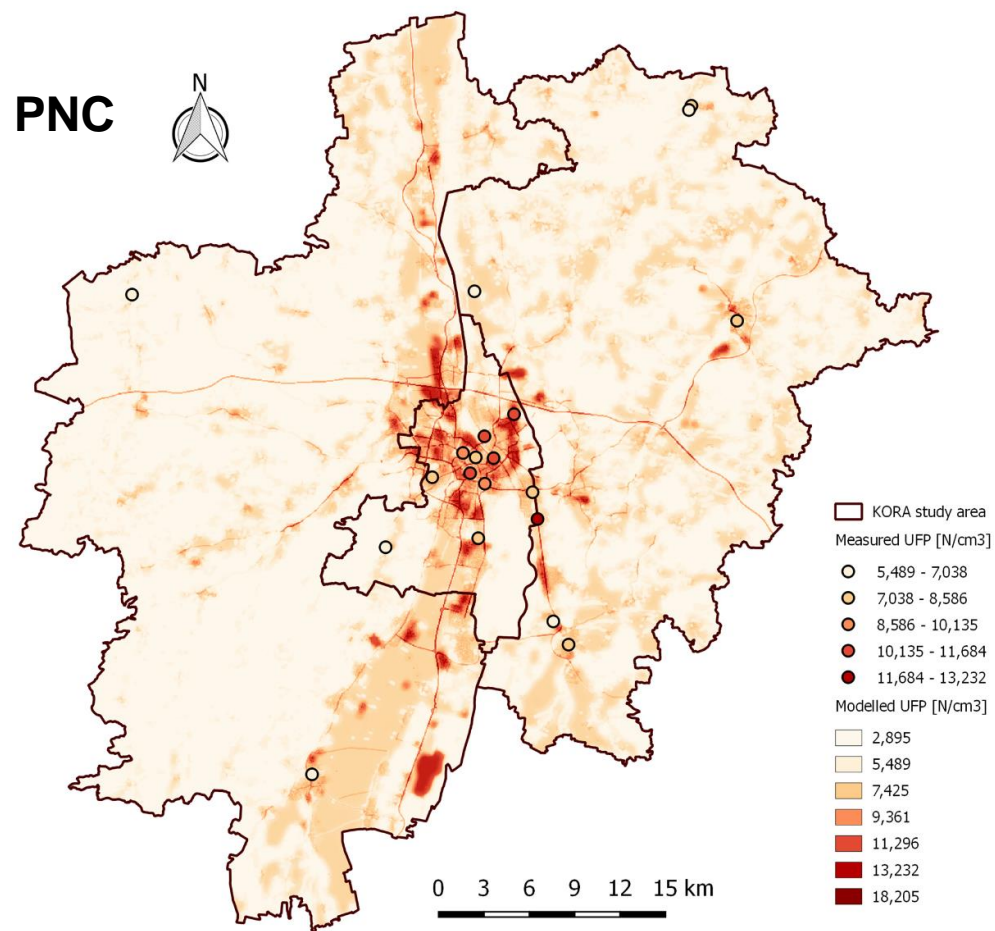
	Predicted	PNC _{mean}	PNC _{median}	Ozone	PM ₁₀	PM _{coarse}	PM _{2.5}	PM _{2.5abs}	NO ₂	NO _x
Measured										
PNC _{mean} (particles/cm ³)			0.98	-0.47	0.75	0.71	0.58	0.61	0.71	0.91
PNC _{median} (particles/cm ³)		0.96		-0.43	0.80	0.75	0.65	0.65	0.78	0.95
Ozone (µg/m ³)		-0.46	-0.41		-0.18	0.08	-0.51	-0.42	-0.26	-0.34
PM ₁₀		0.71	0.78	-0.17		0.84	0.69	0.76	0.68	0.74
PM _{coarse}		0.52	0.57	0.10	0.86		0.33	0.52	0.75	0.77
PM _{2.5} (µg/m ³)		0.64	0.71	-0.45	0.74	0.30		0.79	0.49	0.55
PM _{2.5abs} (10 ⁻⁵ m ⁻¹)		0.81	0.78	-0.39	0.75	0.49	0.77		0.57	0.55
NO ₂ (µg/m ³)		0.88	0.90	-0.32	0.76	0.64	0.58	0.65		0.88
NO _x (µg/m ³)		0.91	0.93	-0.28	0.78	0.65	0.63	0.76	0.95	

Pearson correlations coefficients

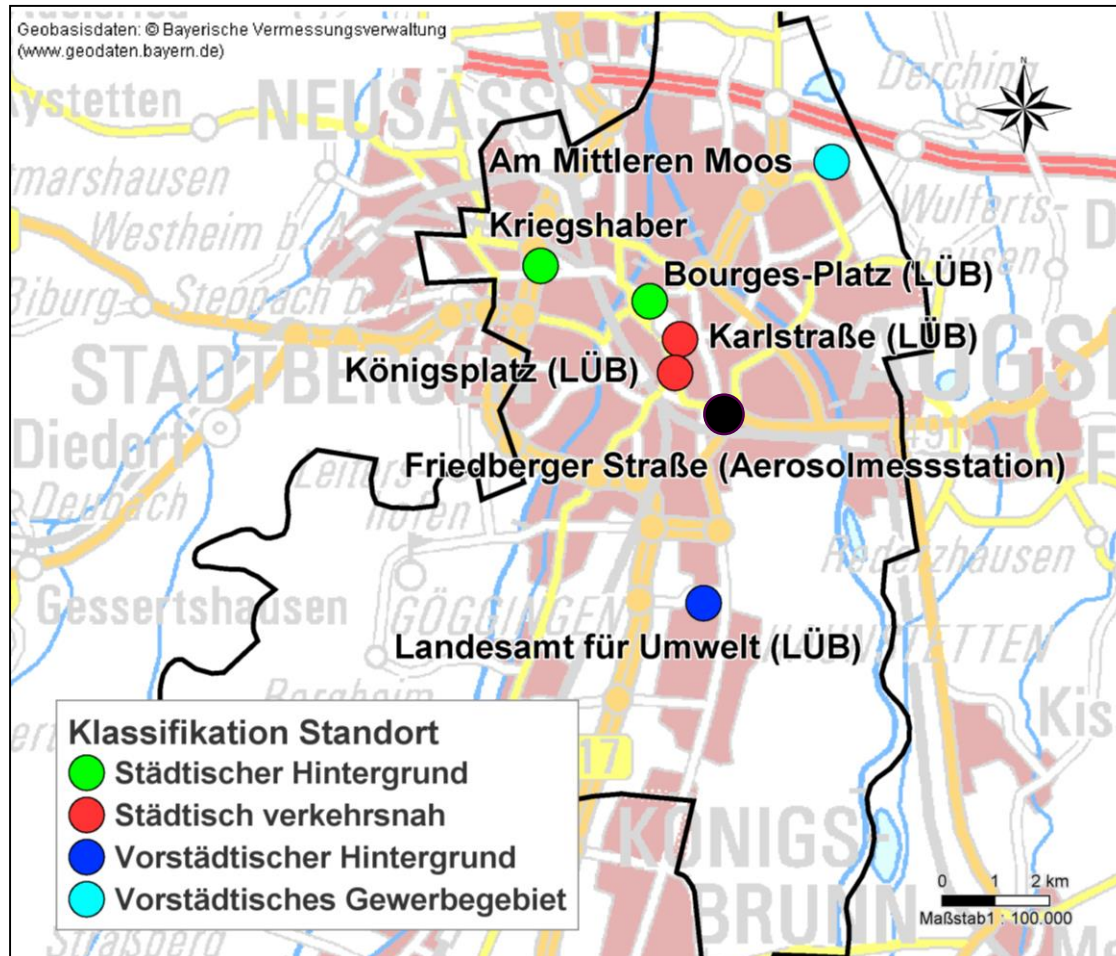




Data sources: © GeoBasis-DE / BKG 2016 (<http://www.bkg.bund.de>)
 Cartography: Kathrin Wolf, Helmholtz Zentrum München, 2016



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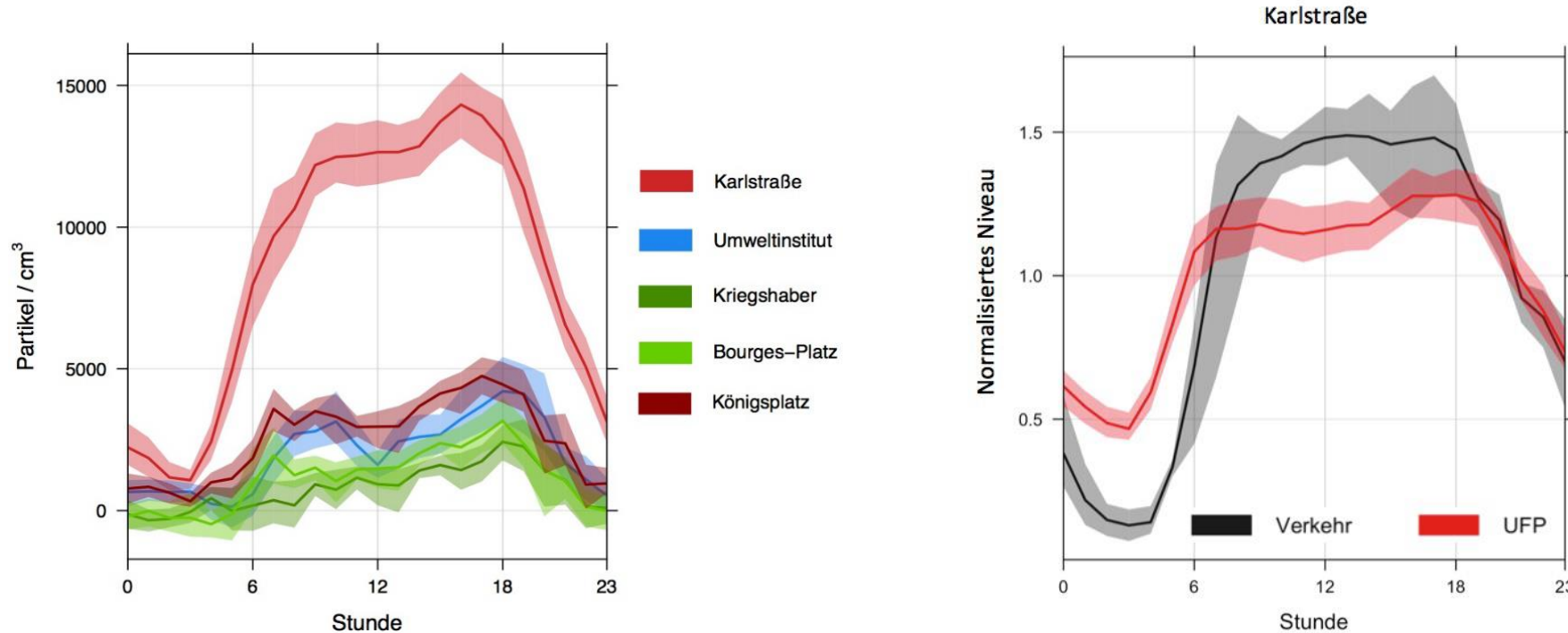


6 monitoring sites

- 2 urban background sites
- 2 traffic sites
- 1 regional background site
- 1 commercial area
- Reference site (urban background)



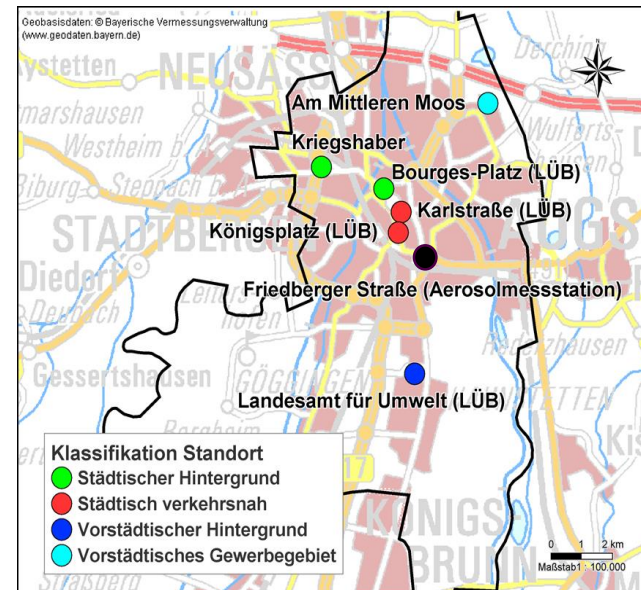
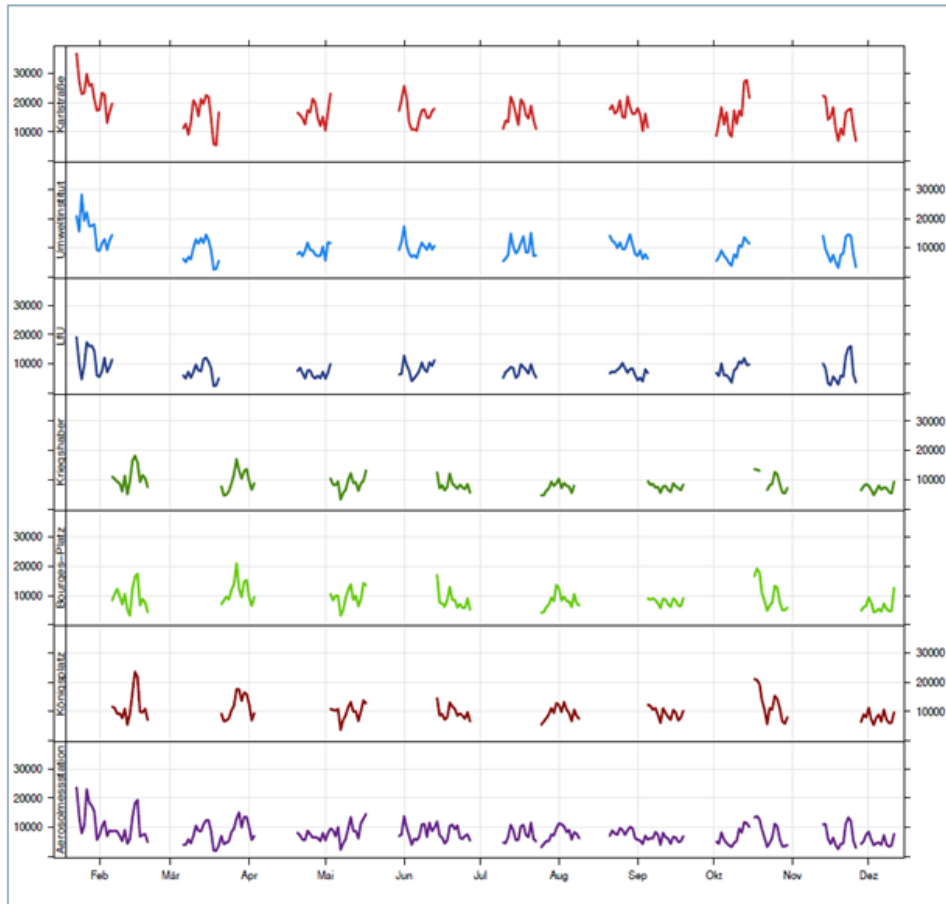
The PNC is strongly determined by local sources (road traffic, industry, combustion plants)



Diurnal variations at different measurement locations (left panel) and comparison with the traffic volume (diurnal variation) at Karlstraße (right panel)



Strong temporal correlation between the measurement sites



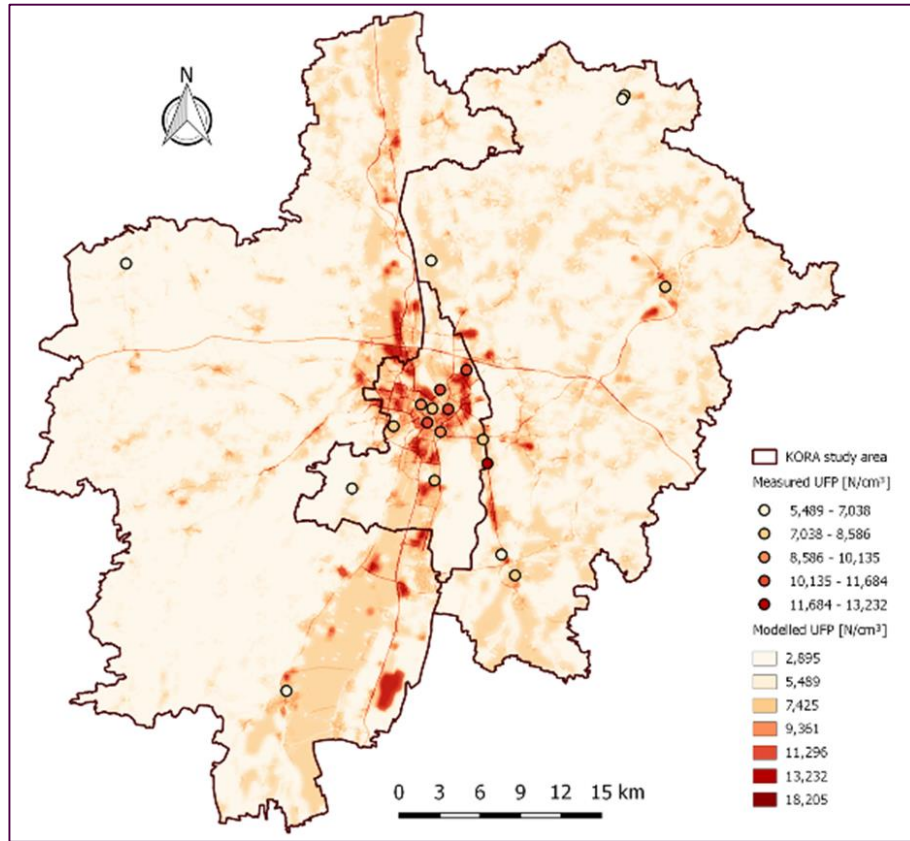
Königsplatz	75
Bourges-Platz	71
Kriegshaber	72
LfU	83
Umweltinstitut	69
Karlstraße	57

Spearman correlation coefficients between the reference measuring station (black) and the satellite measuring stations (for hourly means of PNC concentrations)

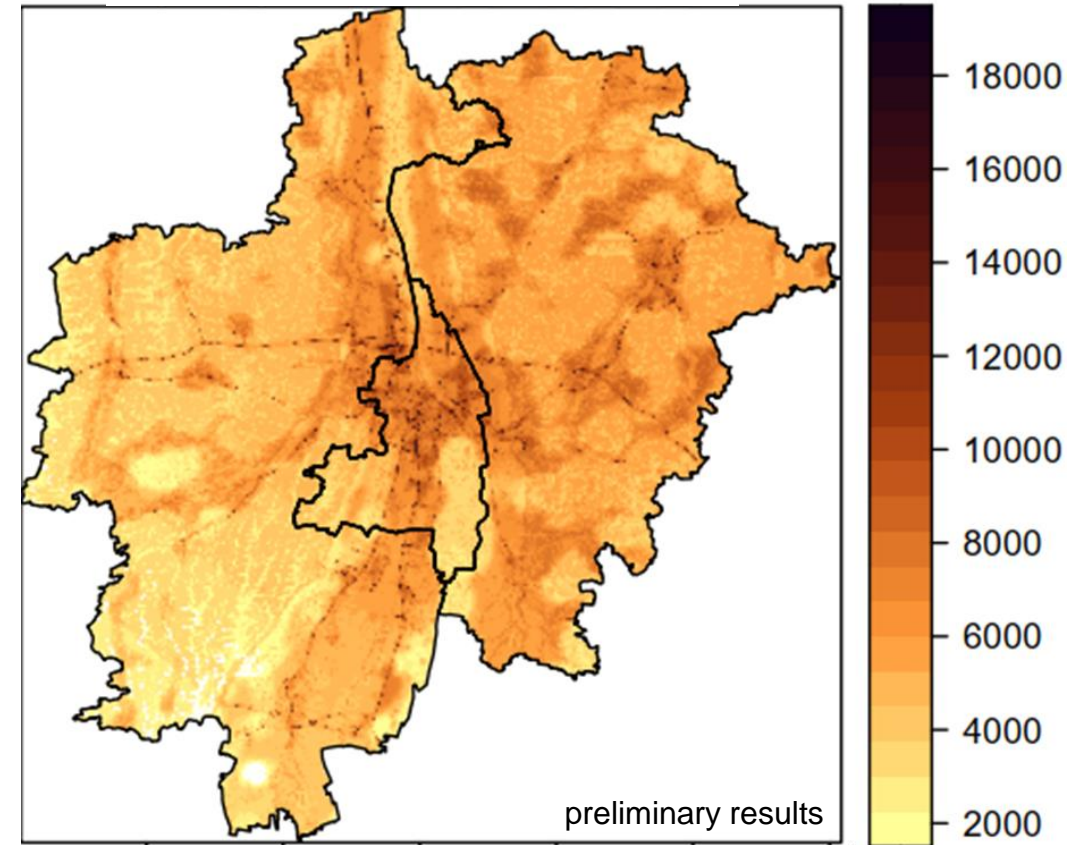


Giemsa et al., 2021

ULTRA III

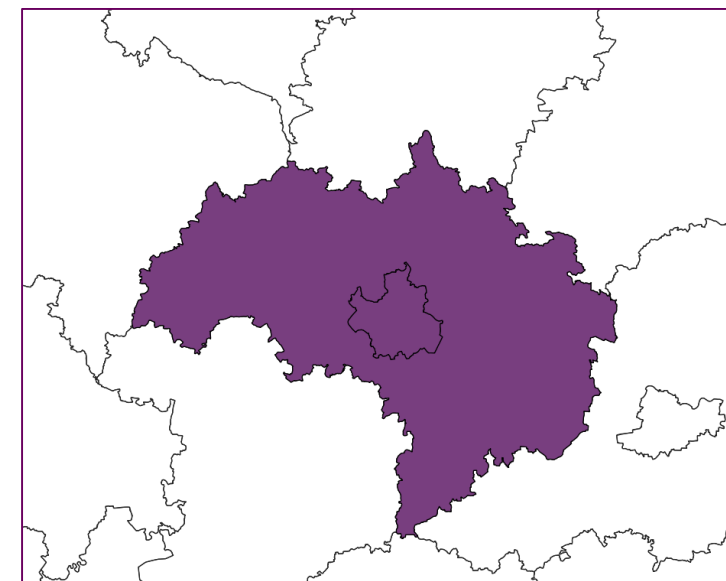


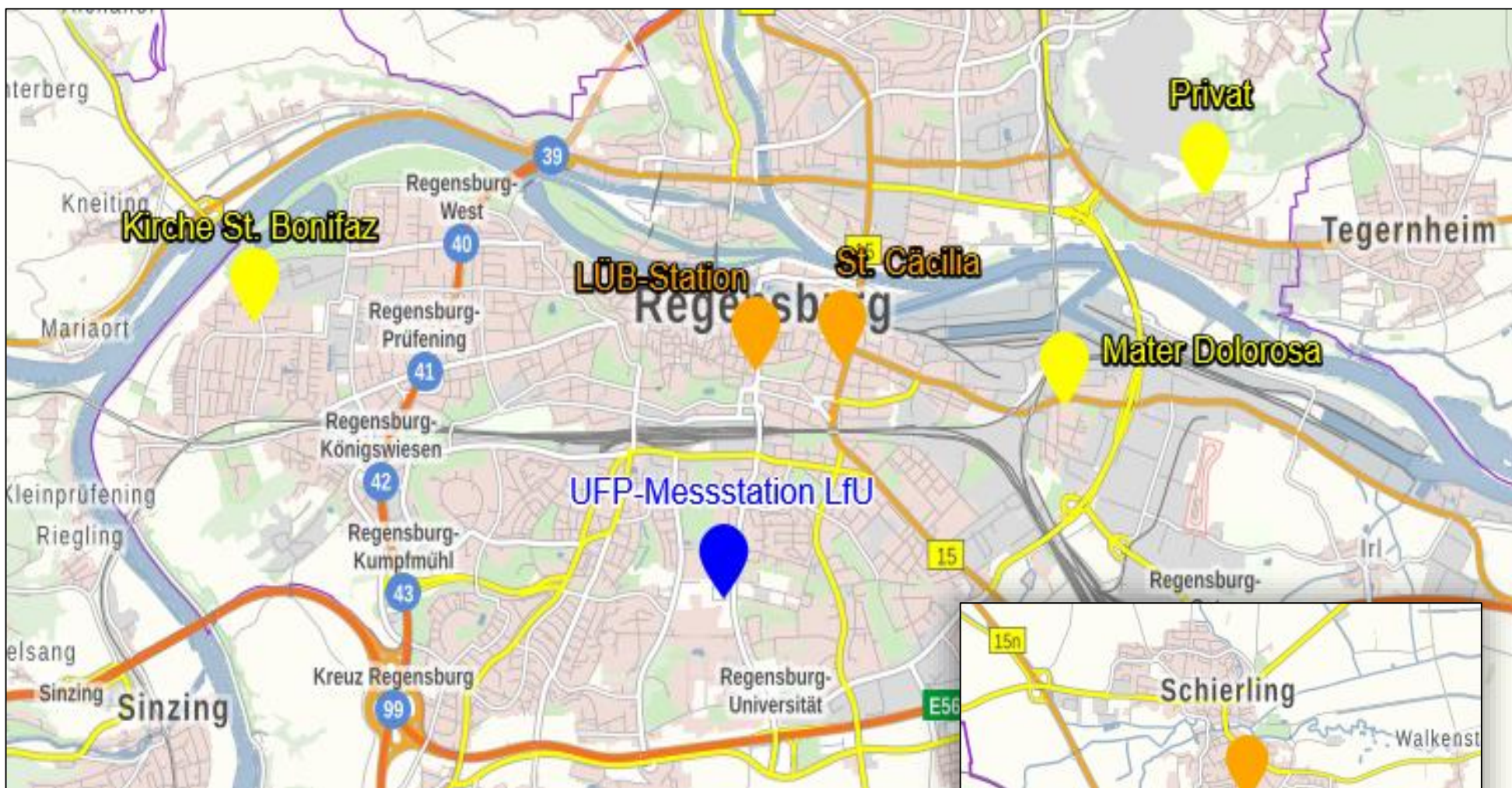
ULTRA III + LfU Project



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Regensburg region



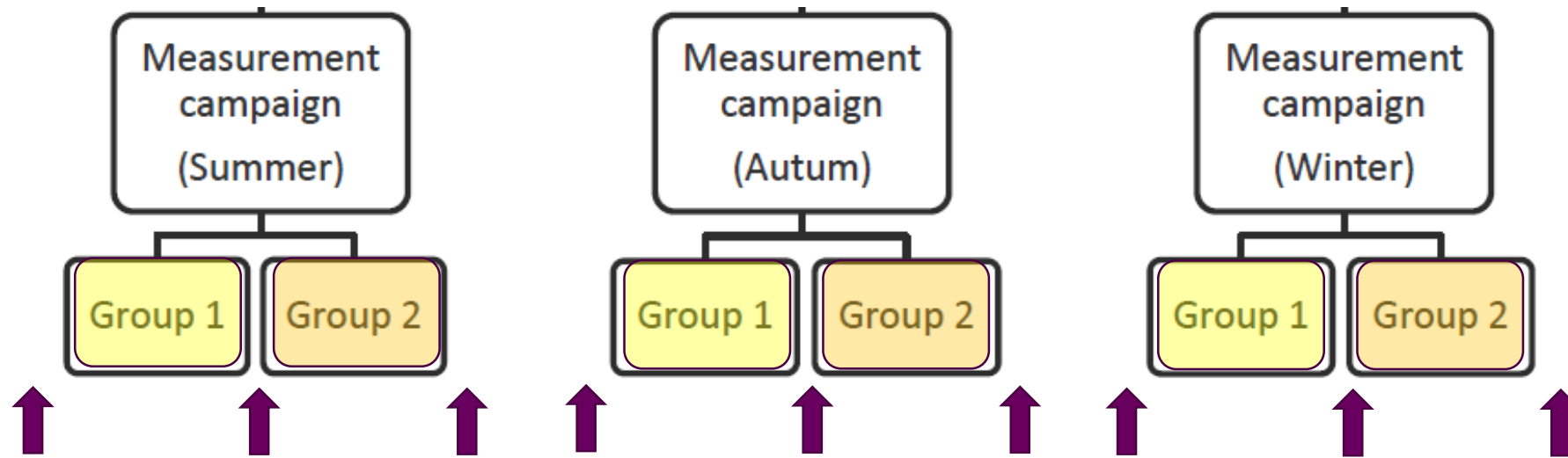


Group 1

Group 2

Reference site
(UFP measurement
station of LfU)





Each measurement campaign consists of:

- Comparison measurements at the beginning of each measurement campaign (approx. 1 week)
- Measurement round group 1 (2 weeks)
- Comparison measurements between the measurement rounds (approx. 1 week)
- Measurement round group 1 (2 weeks)
- Comparison measurements at the end of the measurement campaign (approx. 1 week)



All three CPCs in the grid box next to the UFP measurement station of the Bavarian State Agency for Environment (University of Regensburg)



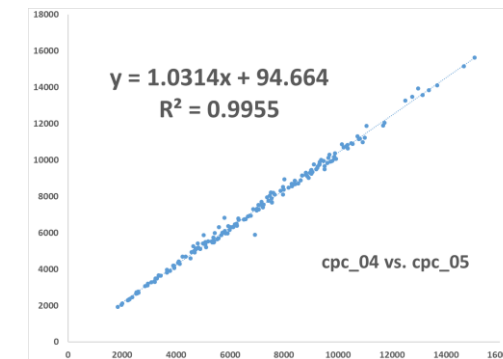
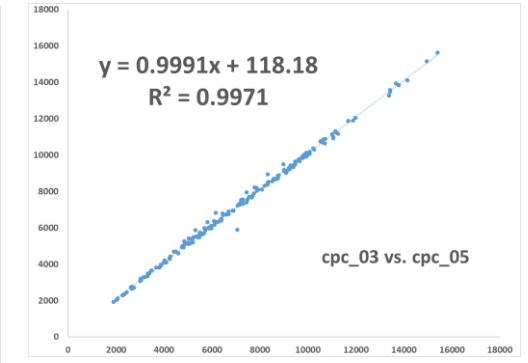
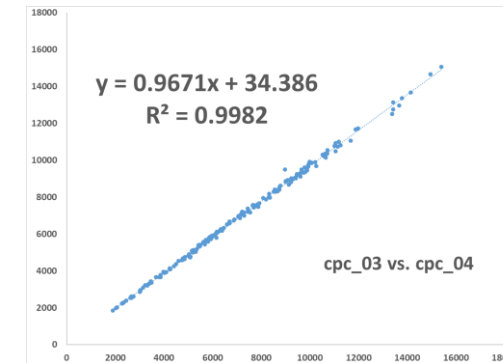
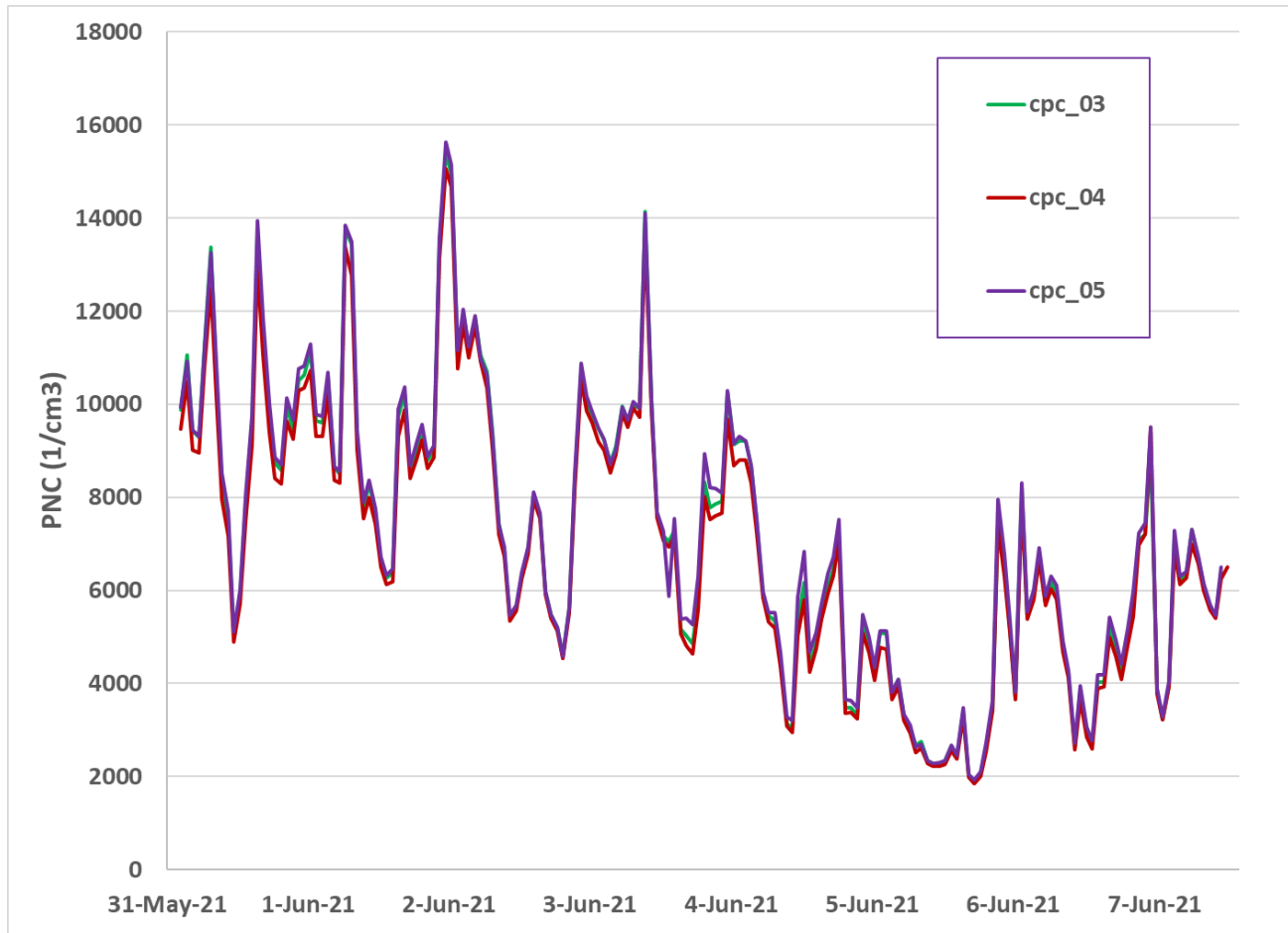
On the roof of the network station (LfU) in city center of Regensburg



All three CPCs in the grid box. Left: at the place of the aerosol-measurement station in Augsburg | Right: next to the UFP measurement station of the Bavarian State Agency for Environment (University of Regensburg)

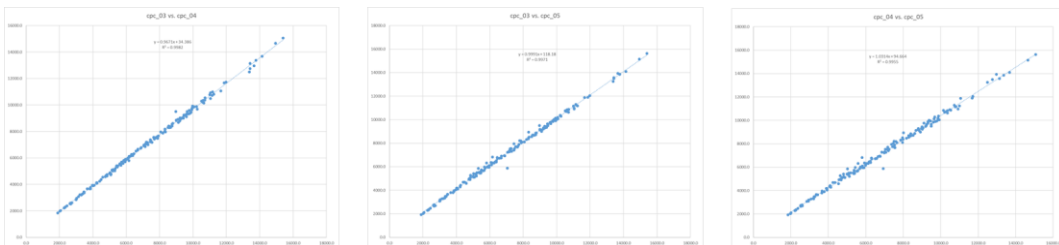
On the roof of the network station (LfU) in city center of Regensburg

Summer measurement campaign – comparison measurements 01 (as an example)



Comparison measurements 1 to 3 (summer) and 7 to 9 (winter)

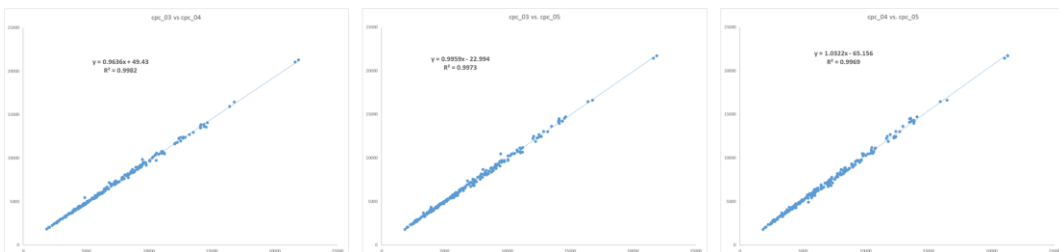
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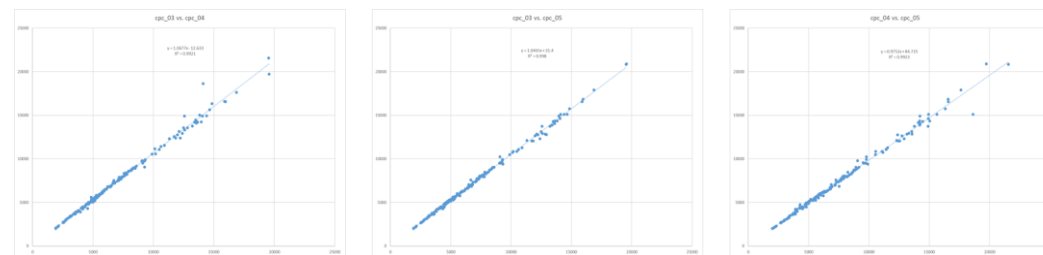
7



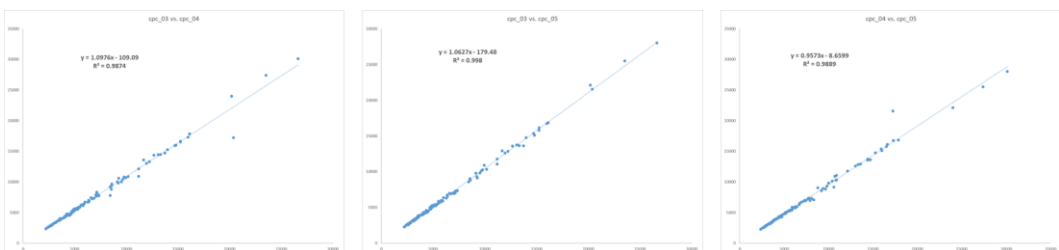
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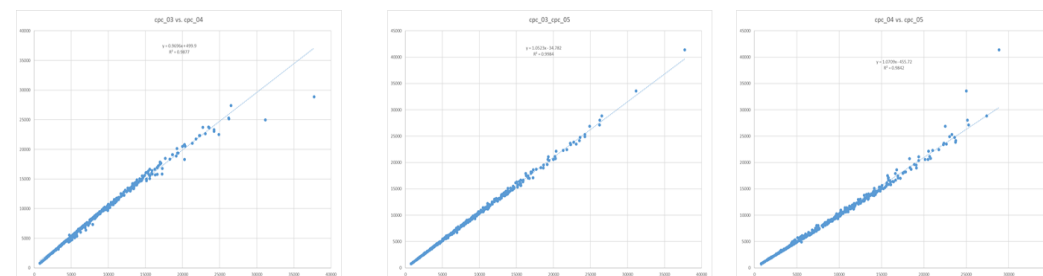
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3

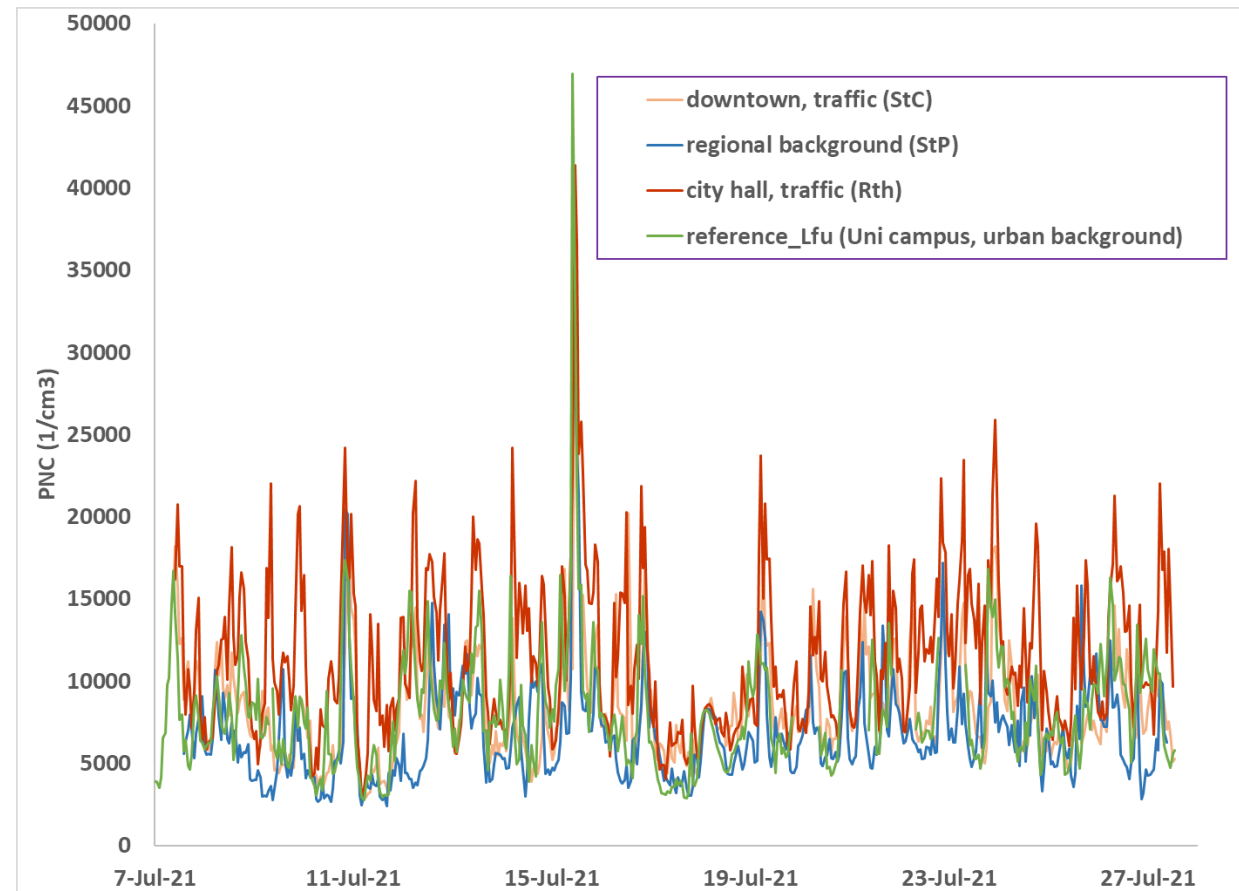
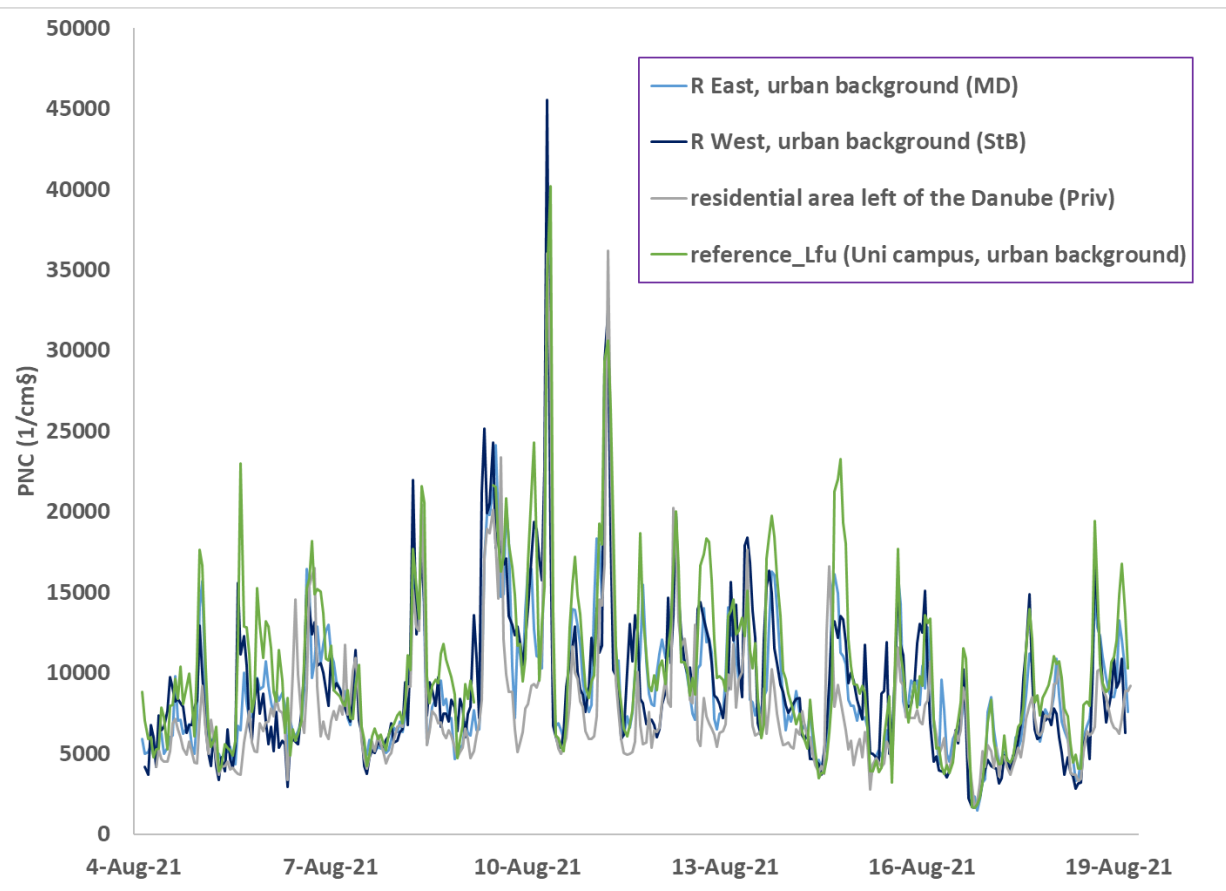


9



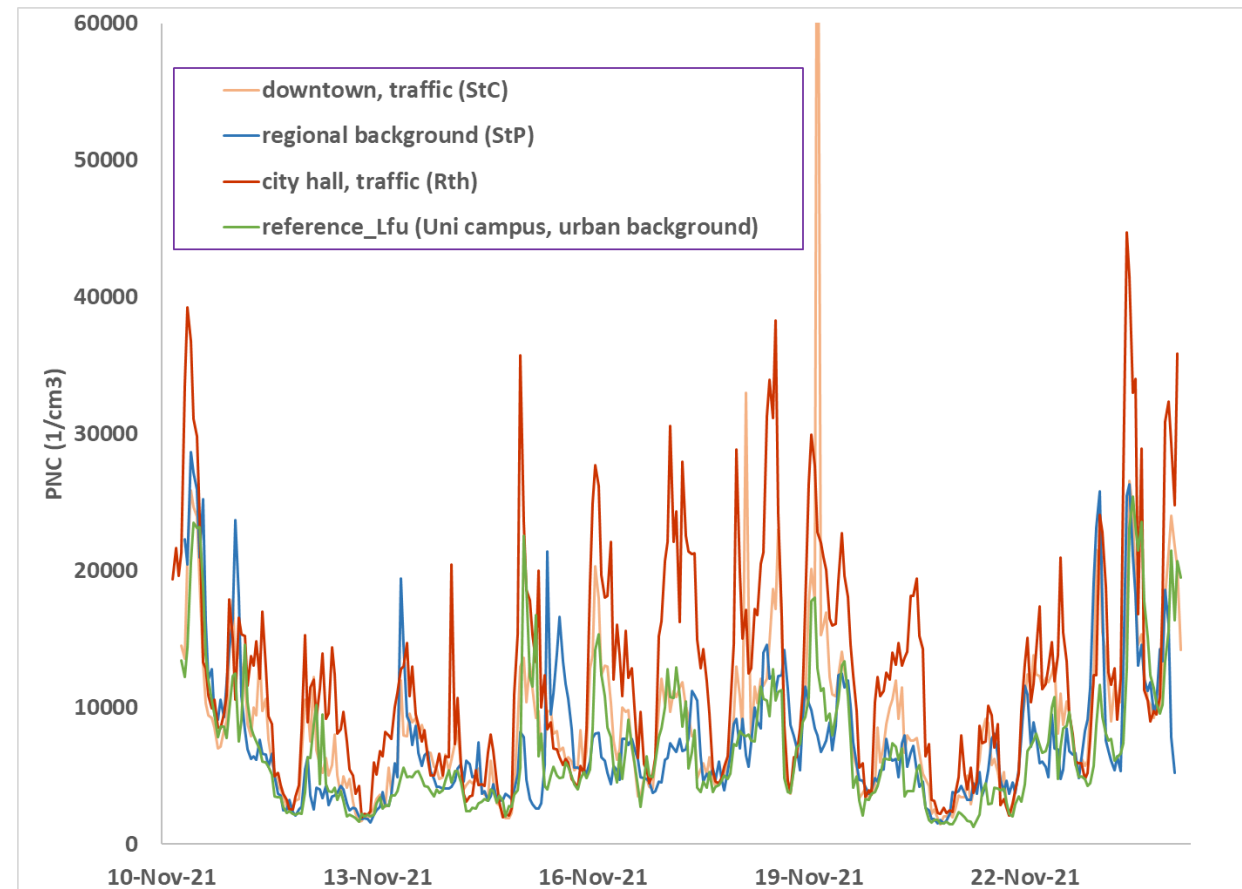
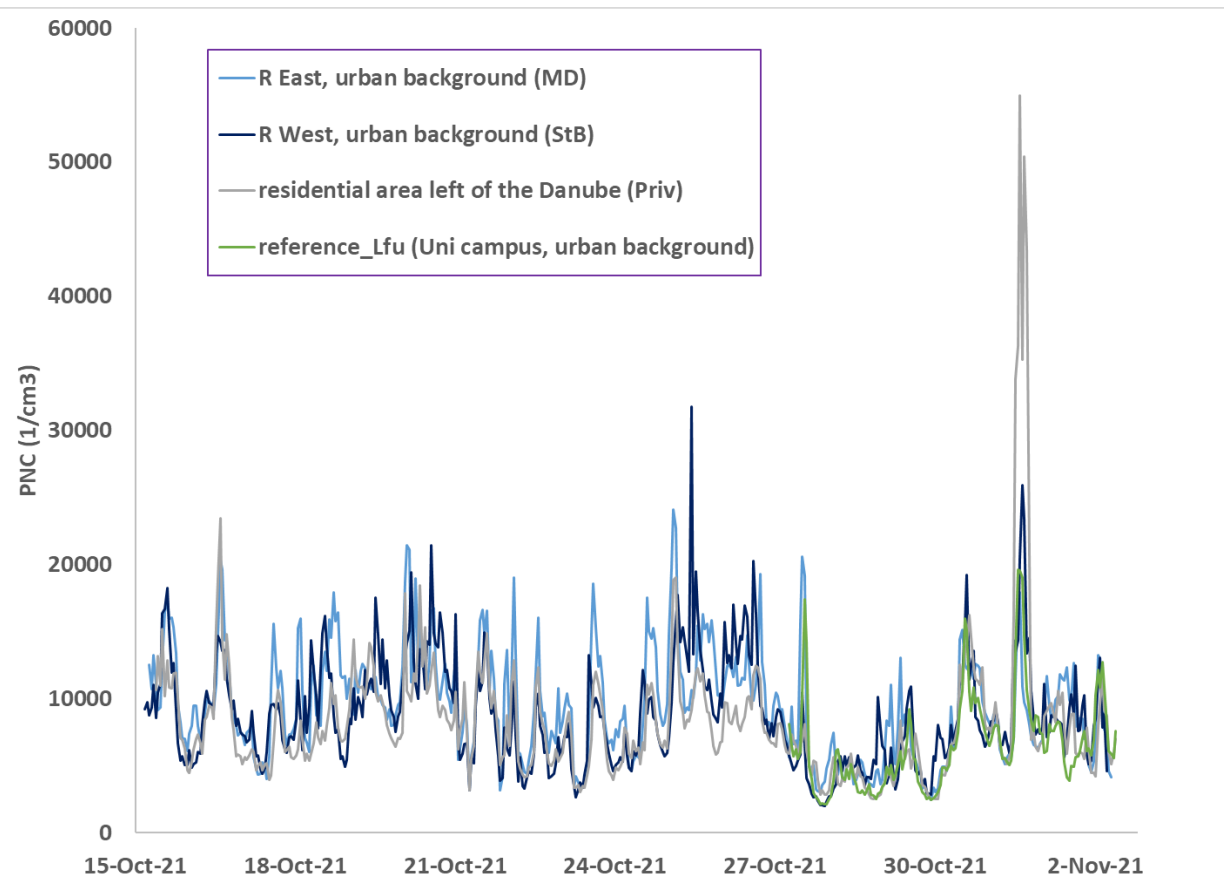
Group 1

Group 2



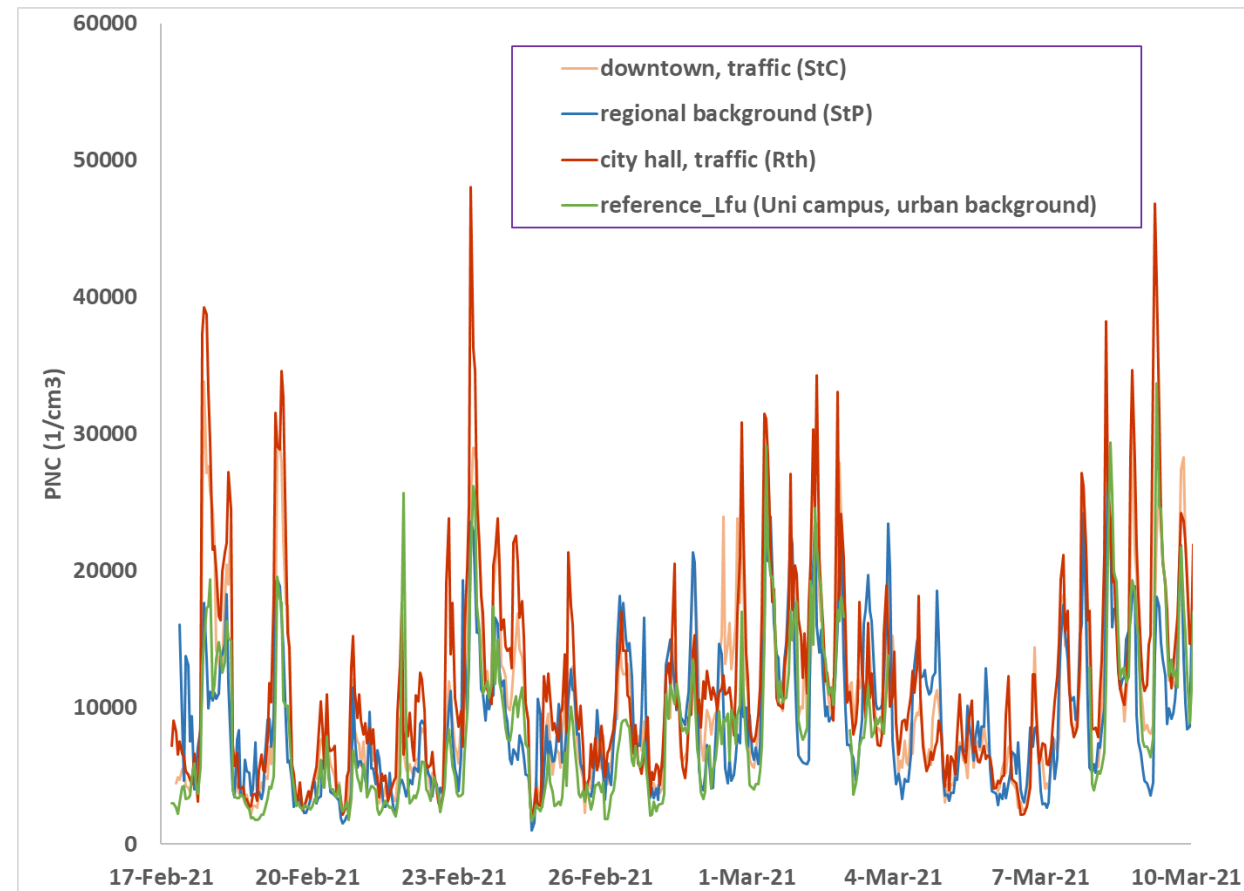
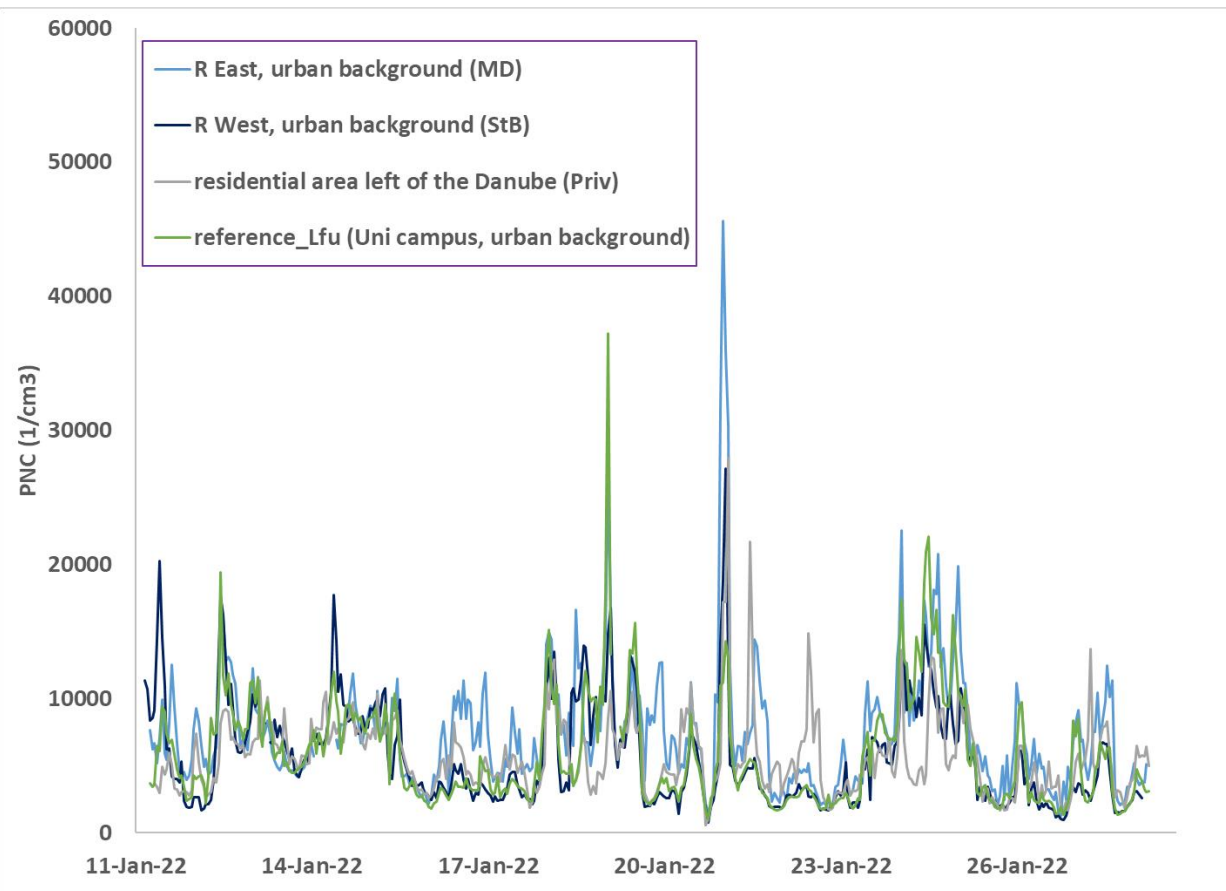
Group 1

Group 2

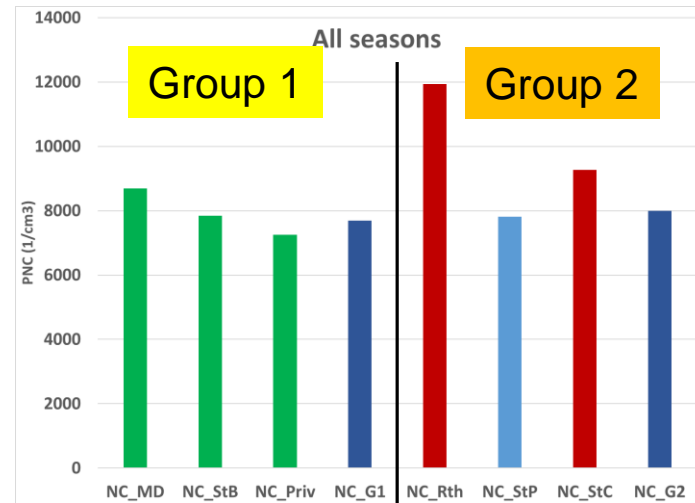
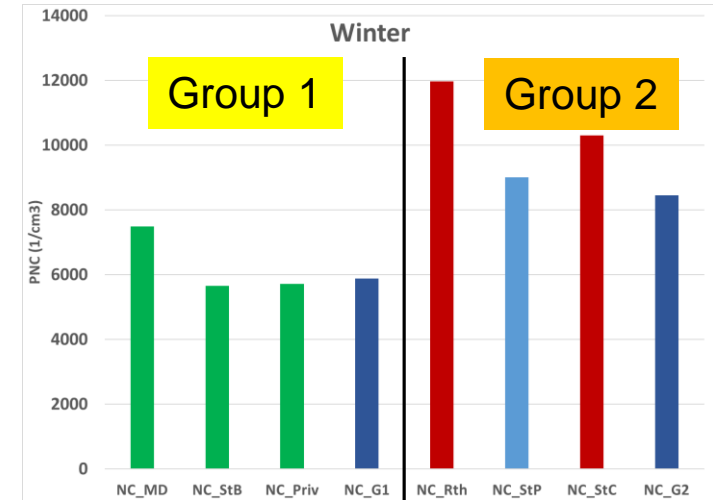
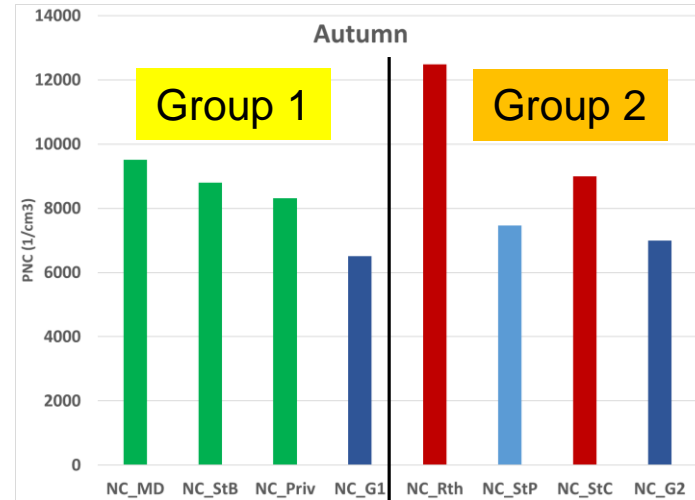
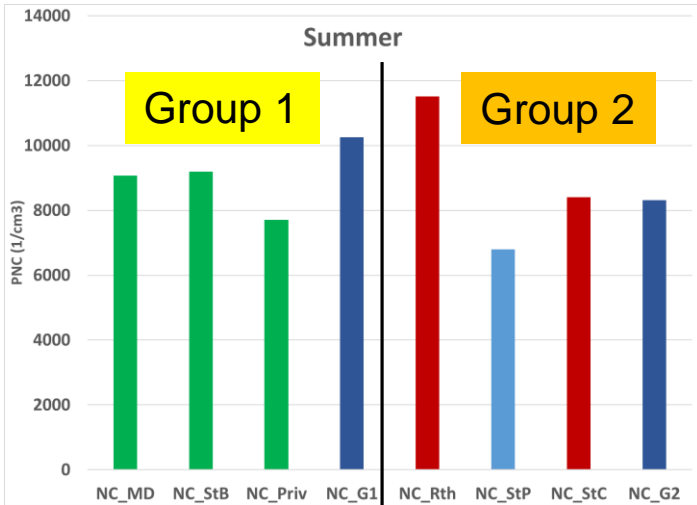


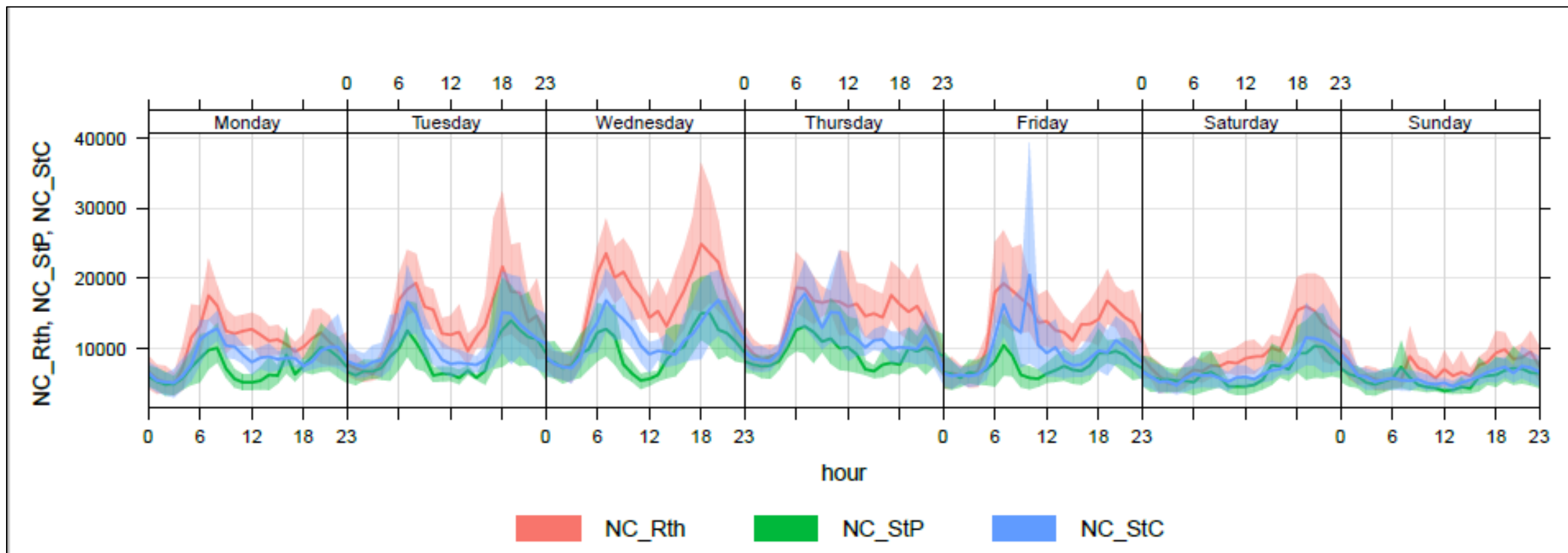
Group 1

Group 2



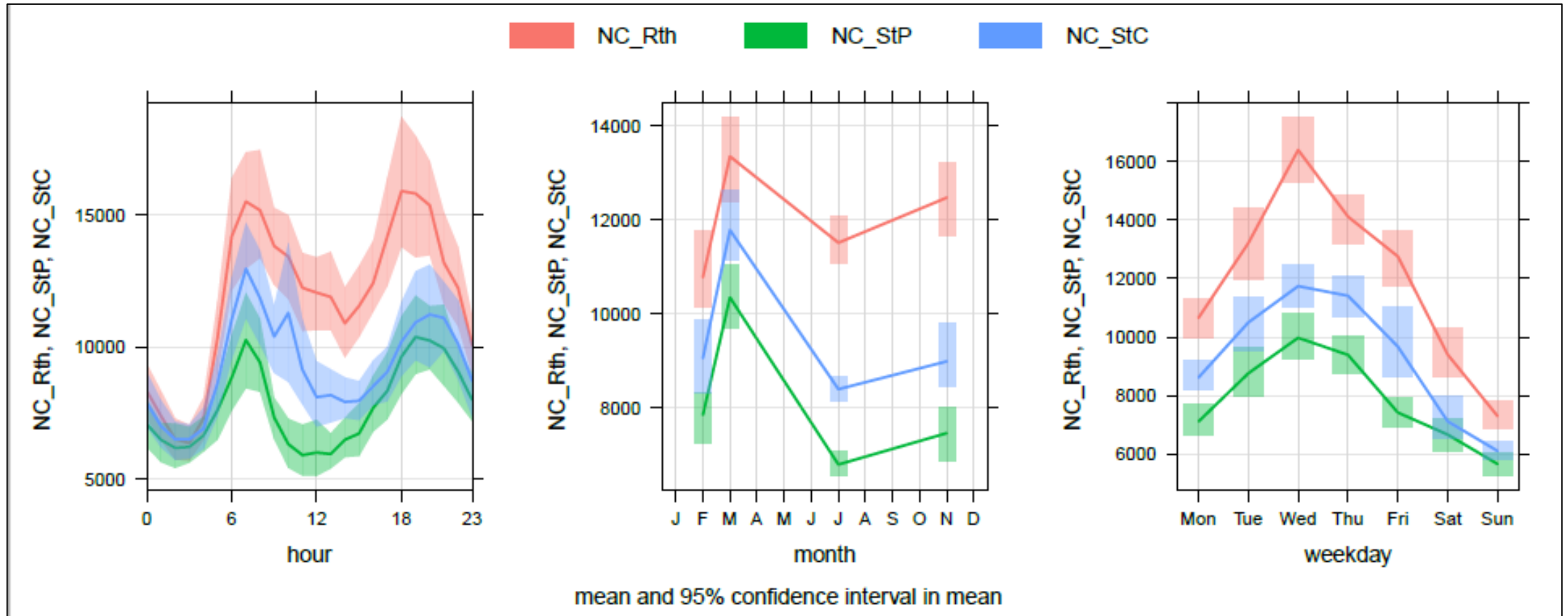
PNC at 6 + 1 sites in Regensburg (by seasons and for all seasons)

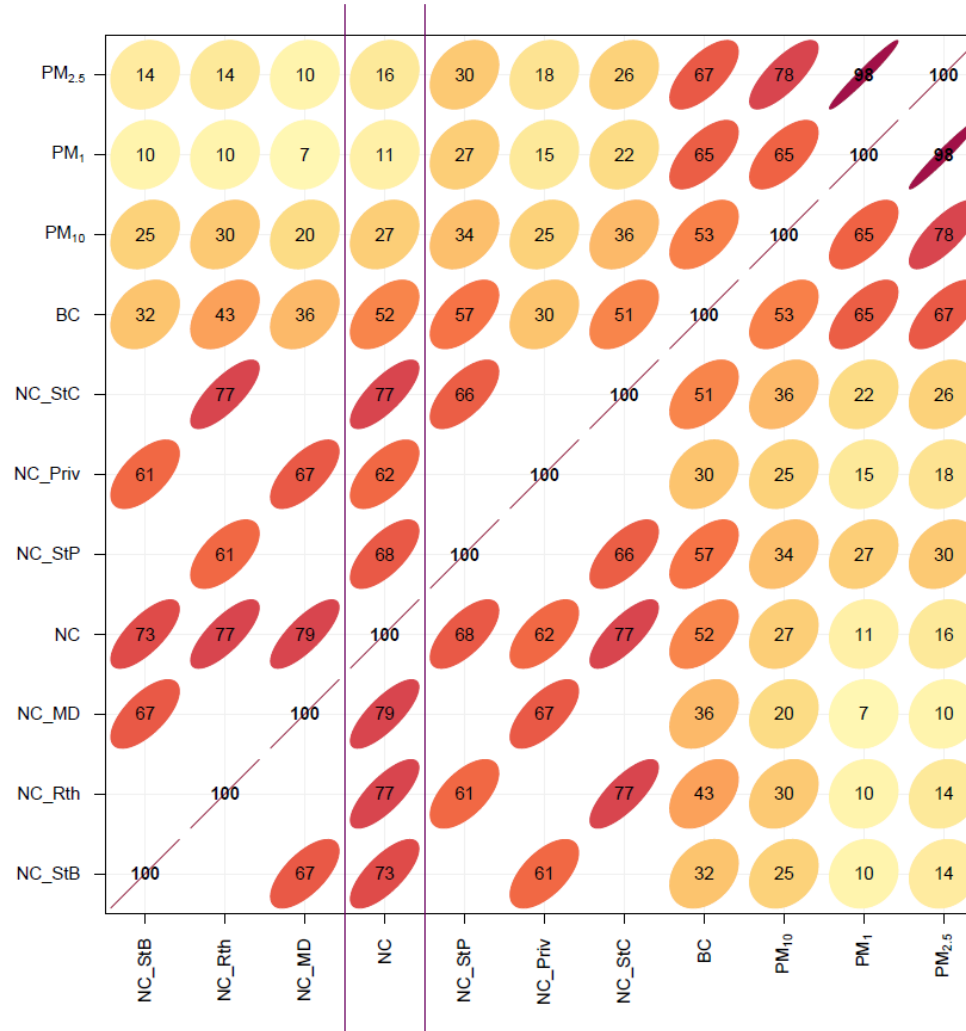




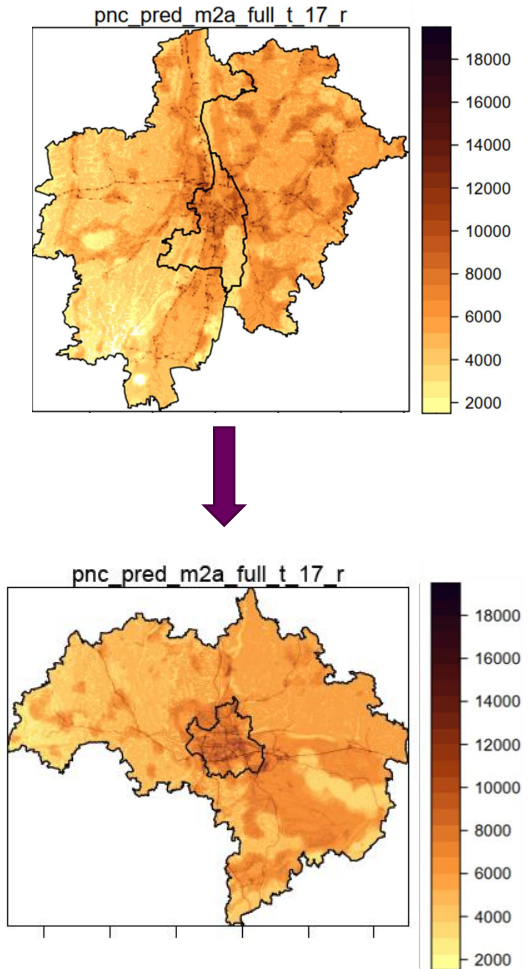
City hall, traffic regional background downtown, traffic

City hall, traffic regional background downtown, traffic





- To correct the values for the difference between the instruments and to adjust the measurements for seasonal variability
- To calculate the annual means for 6 + 1 sites
- To transfer the final LUR model from Augsburg to Regensburg
- To validate the LUR model with the measured annual means
- To assign UFP concentrations to Bavarian participants of the NAKO study (Augsburg, Regensburg) for subsequent epidemiological analyses



Very preliminary!!!

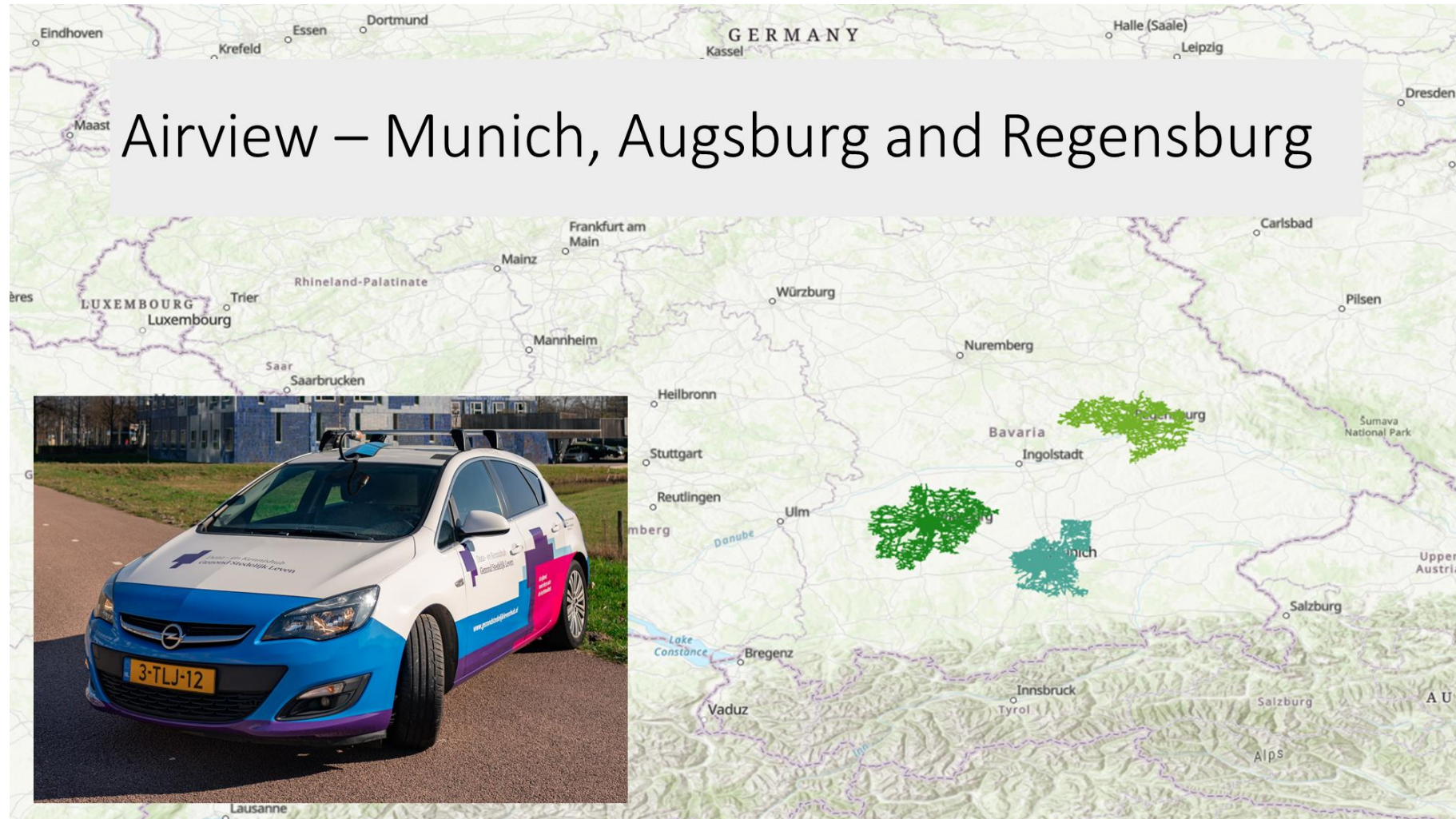
Further information about the spatial and temporal variability of PNC (as indicator for UFP) and other pollutants (PM₁₀, PM_{2.5}, NO₂, O₃) in urban areas

First detailed information on long-term exposure to UFP in urban and rural areas of two Bavarian regions.

Contribution to closing the worldwide research gap regarding missing data on long-term health effects of UFP

Statements on the disentangle of the possible health effects of UFP in comparison to the regulated air pollutants such as PM₁₀, PM_{2.5}, NO₂ and O₃

Future activities - new methods for development of LUR models



Mobile measurement campaigns in European Cities (Rotterdam, Basel, Rome, Barcelona, Athens, Munich, Regensburg and Augsburg)

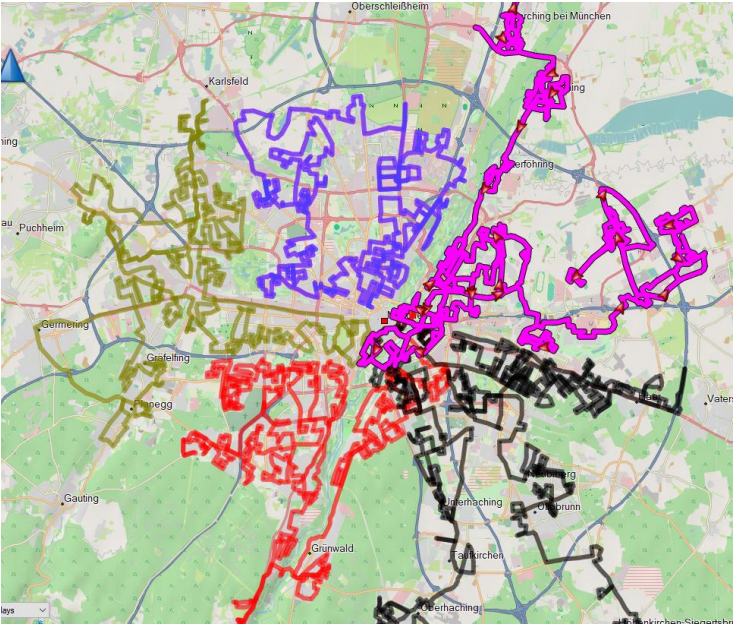
Airview Car



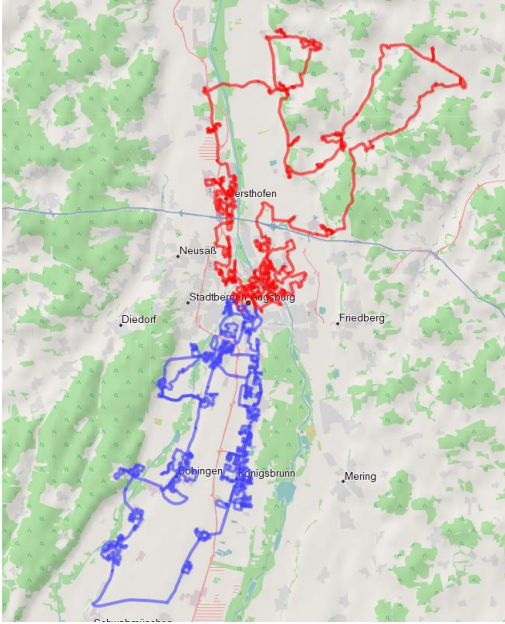
Device	Pollutants
GPS	Location
EPC	Ultrafine Particles
AE33	Black Carbon
DRX DustTrack	PM2,5
LiCOR	CO2
MiniDisc	Ultrafine Particles
2BTech	NOx
Aerodyne	NO2



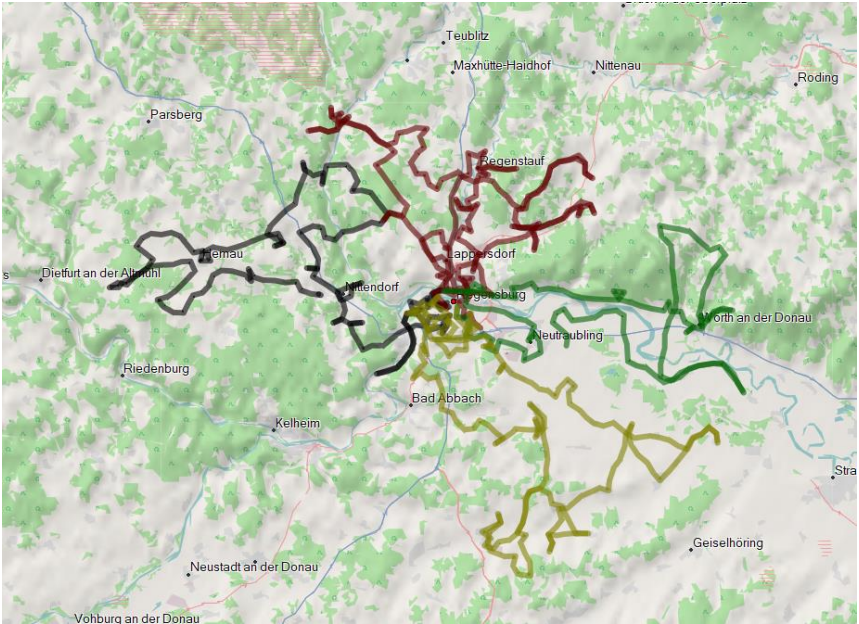
Ongoing mobile measurement campaign in Munich, Regensburg and Augsburg



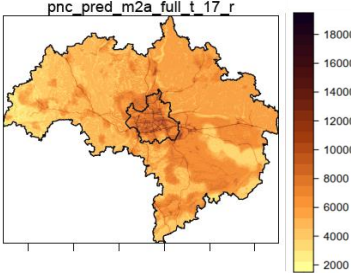
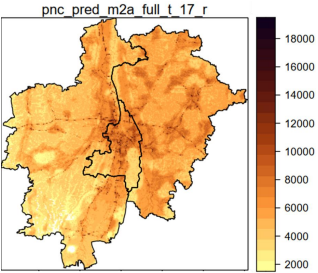
Munich

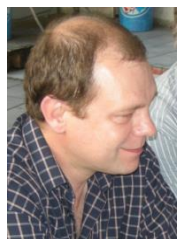


Augsburg



Regensburg





T. Kusch
ULTRA III



U. Hartz



J. Gu



T. Kusch



E. Giemsa

LFU Project



S. Sues



S. Kecorius

UFP@NAKO *Bayern*



M. Kowalski

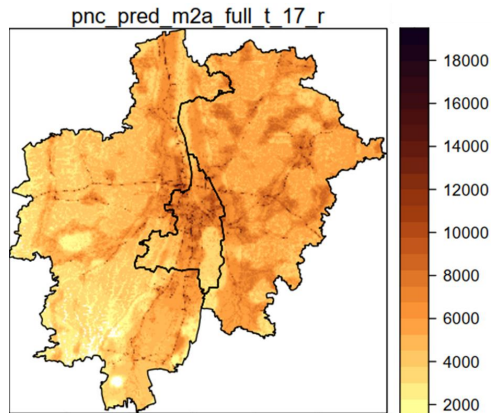




Kathrin Wolf



Marco Dallavalle



LMU München:

Susanne Breitner-Busch

Gabriele Kölbl

Marco Dallavalle

Annette Peters

Helmholtz Munich, EPI:

Simonas Kecorius

Regina Pickford

Alexandra Schneider

Kathrin Wolf

University Augsburg, WZU

Jens Soentgen

Susanne Sues



Thank you.

Sampling Campaign

- 12 sites in Augsburg: 5 traffic, 5 background, 2 background with traffic impact
- 8 sites in the Region of Augsburg: 4 traffic, 2 regional background, 1 background with traffic impact, 1 rural
- Measurements were conducted simultaneously at four sites and the reference site (20/4 = 5 measurement rounds)
- At each monitoring site three measurement periods of two weeks were conducted; in the cold, warm and one intermediate temperature season
- The reference site is used to adjust for temporal variation

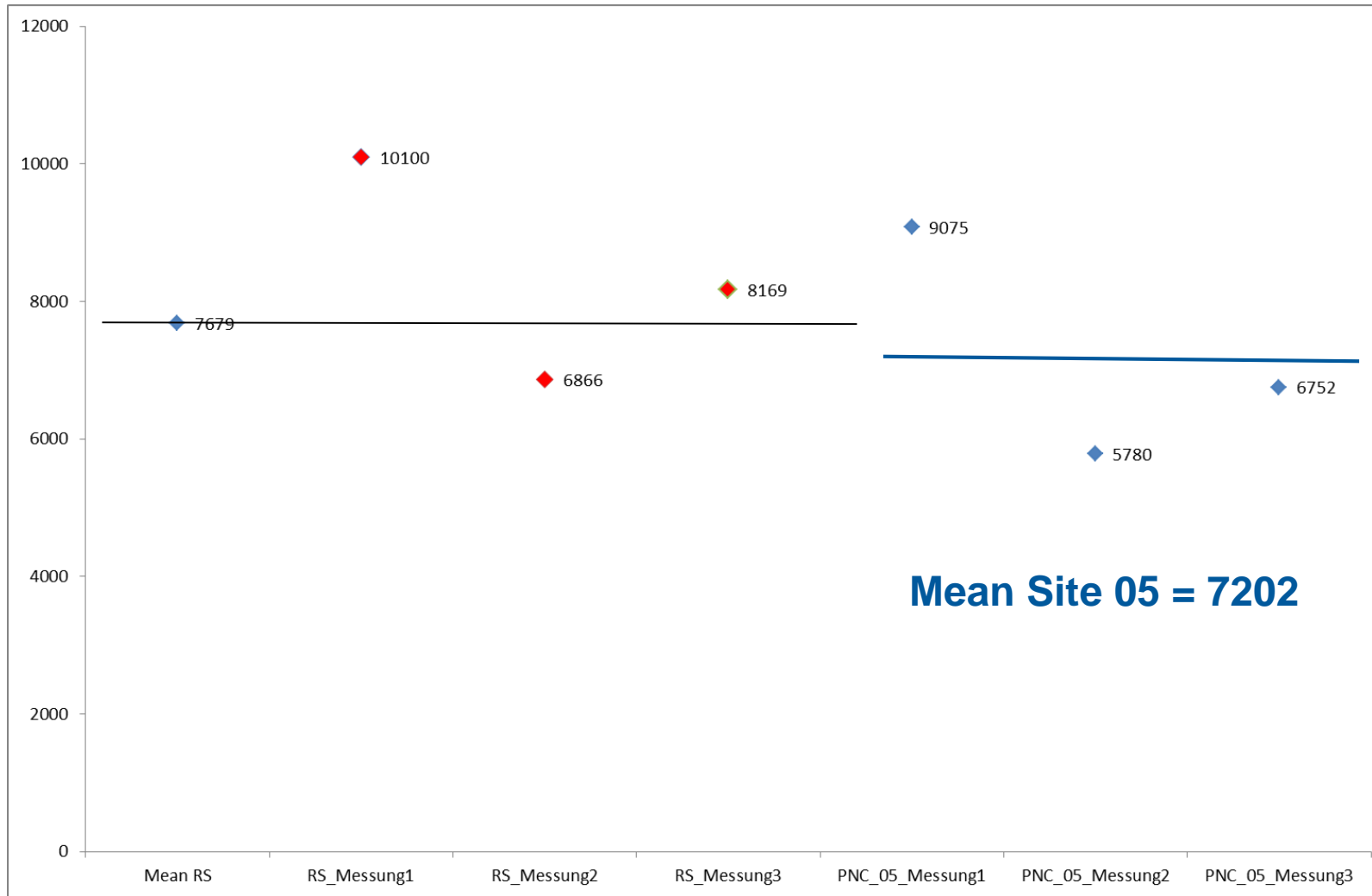
Sampling campaign

- Similar as the ESCAPE campaign but **in a smaller region**
- Conducted between **March 2014 and April 2015**
- **12 sites in Augsburg**: 6 traffic, 5 background, 1 industrial
- **8 sites in the Region of Augsburg**: 4 traffic, 4 background
- **Simultaneous measurements at 4 sites** and the **reference site** (5 measurement rounds)
- At each monitoring site: **3 measurement periods of 2 weeks** spread over the year
- The **reference site** was used to adjust for **temporal variation** (with the difference method)

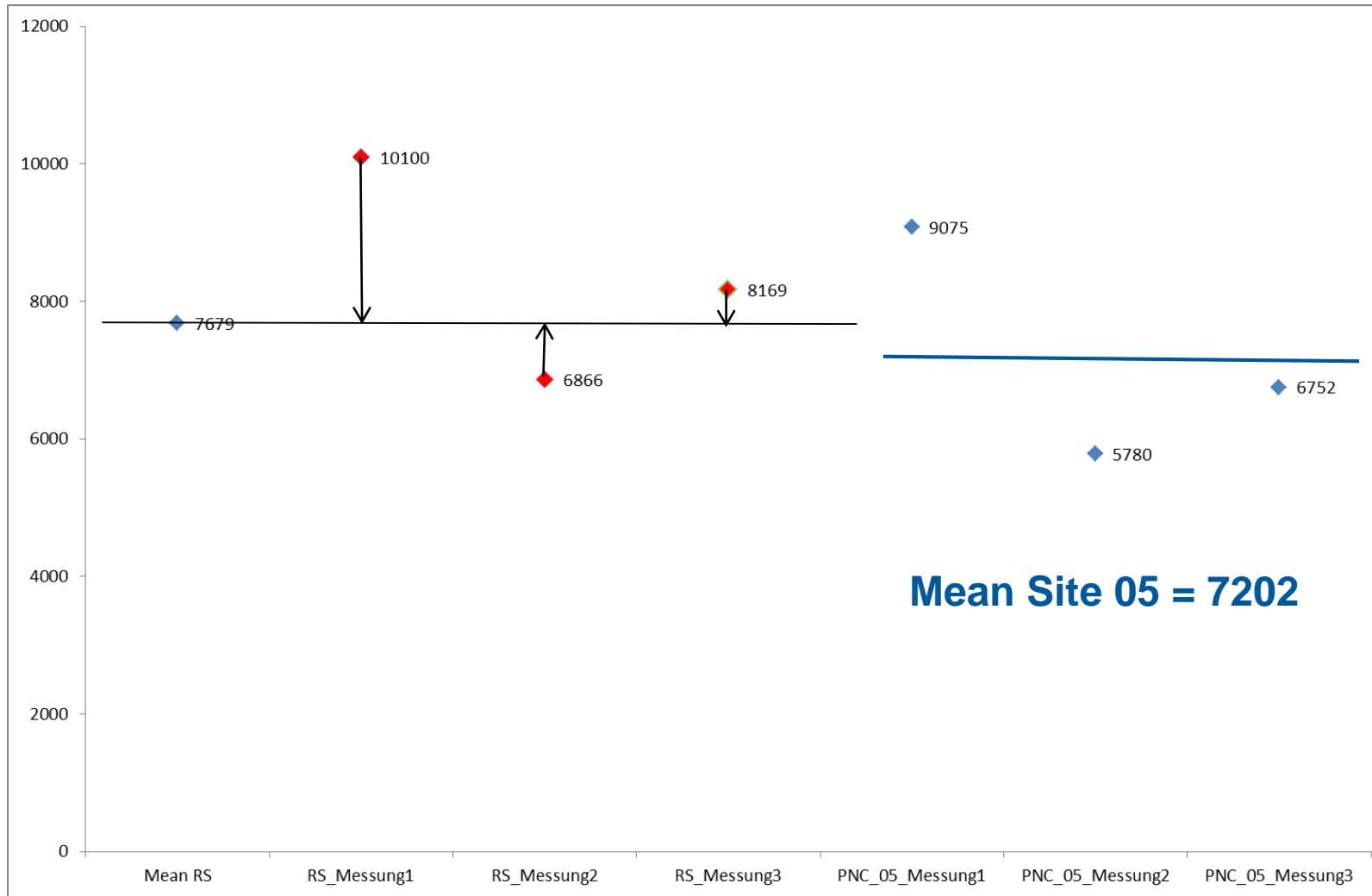
Adjustment on temporal variation (site 05)



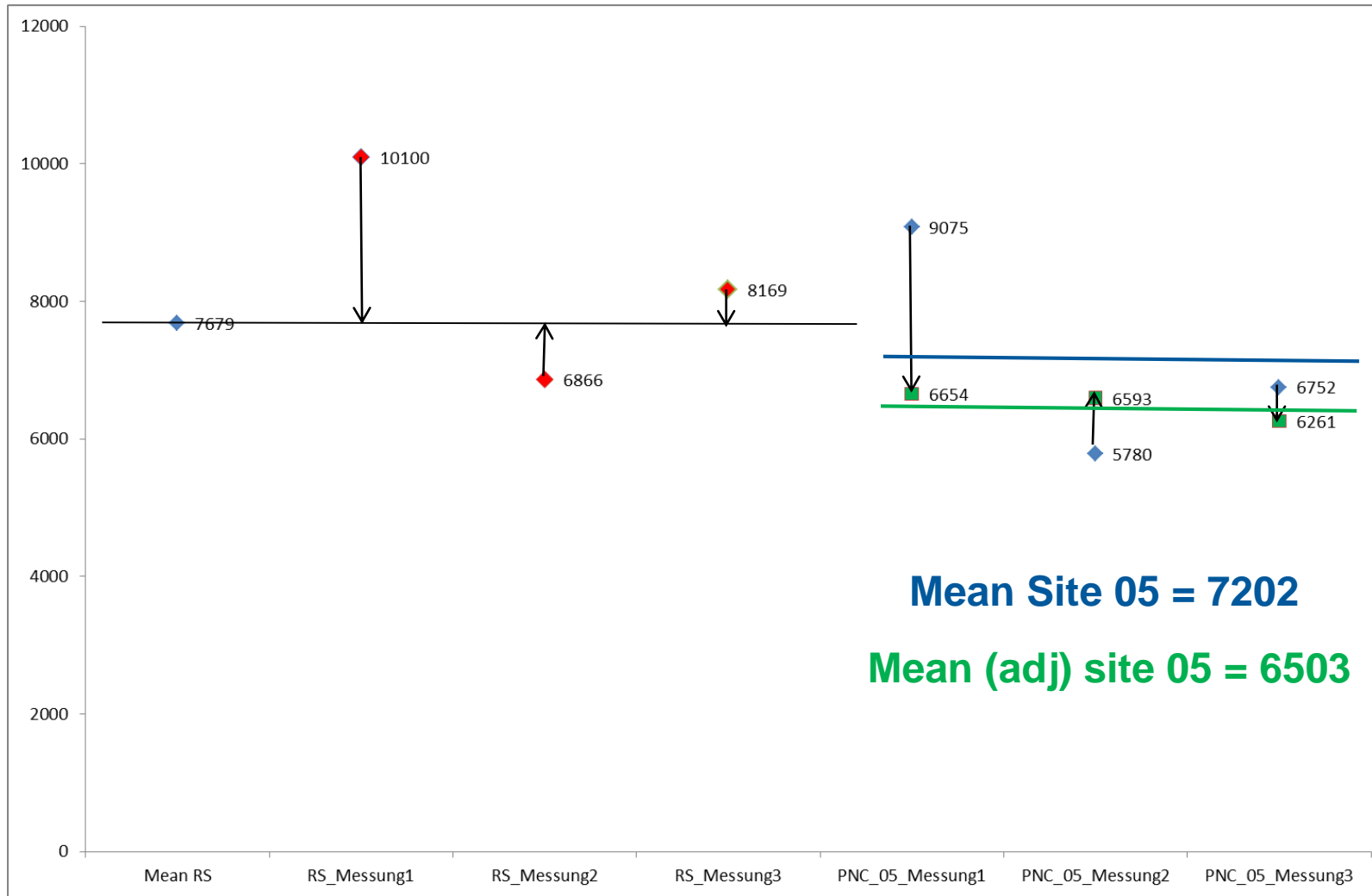
Adjustment on temporal variation (site 05)



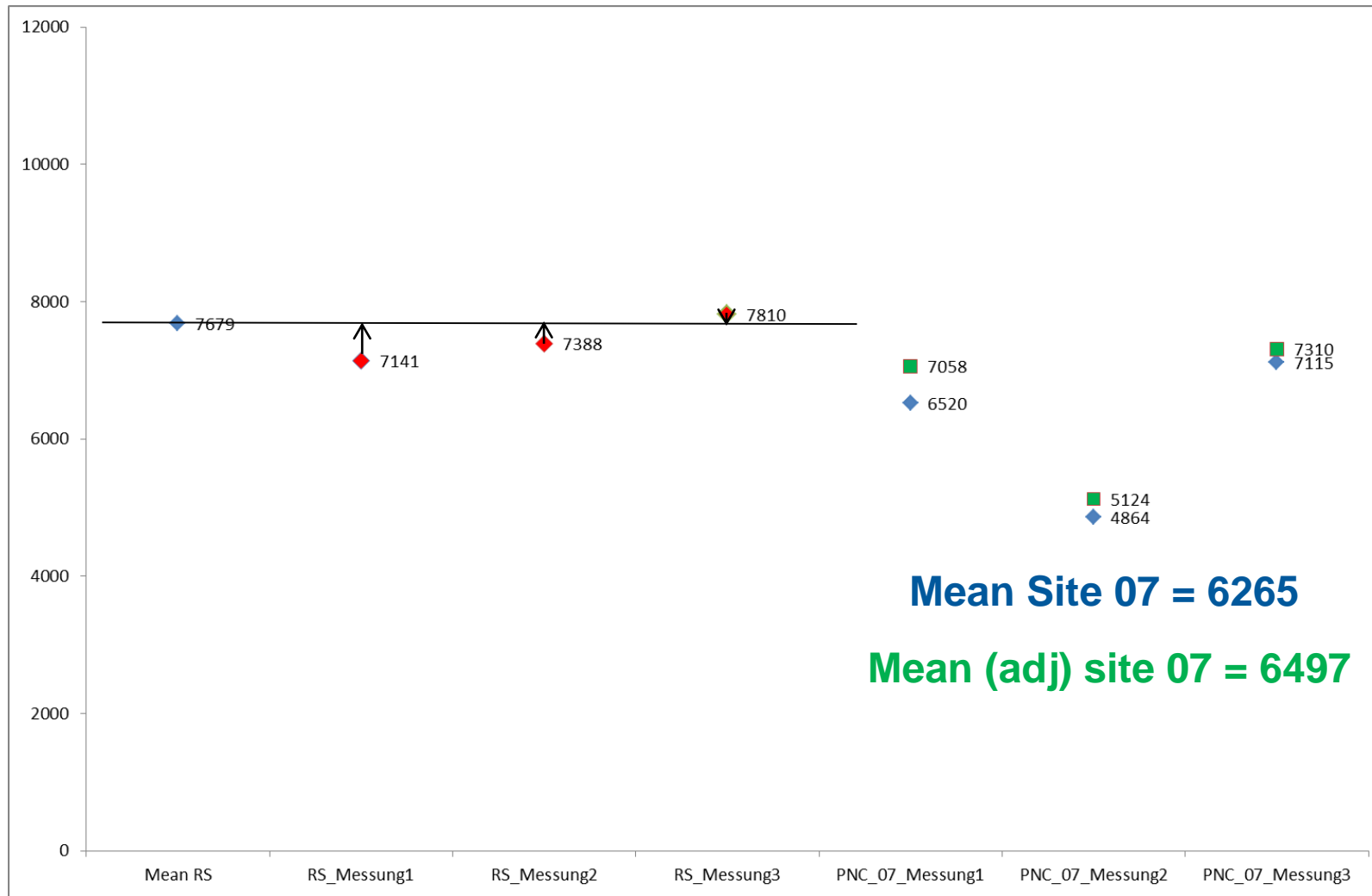
Adjustment on temporal variation (site 05)



Adjustment on temporal variation (site 05)



Adjustment on temporal variation (site 07)



Land use regression modelling I

1. Calculate **annual average concentration** per monitor
2. For **PNC**, in addition **annual median** and **seasonal mean** concentration (also seasonal median?)
3. Calculate **GIS predictor variables** for each monitor:
 - Landuse (residential land, industry, forested areas, ...)
 - Population, household and building density
 - Altitude
 - Traffic (intensity at nearest (major) road, distance to nearest (major) road, roadlength, ...)

Land use regression modelling II

1. Calculate **annual average concentration** per monitor
2. For **PNC**, in addition **annual median** and **seasonal mean** concentration (also seasonal median?)
3. Calculate **GIS predictor variables** for each monitor:
 - Landuse (residential land, industry, forested areas, ...)
 - Population, household and building density
 - Altitude
 - Traffic (intensity at nearest (major) road, distance to nearest (major) road, roadlength, ...)

Land use regression modelling III

4. Develop **regression models** based on average concentrations at monitors **for each pollutant separately**
 - a) Run **univariate regression** for all potential predictors
-> chose predictor with **highest R^2**
 - b) Sequentially **add further predictor variables** which **maximize adjusted R^2** if
 - increase in adjusted $R^2 > 1\%$
 - direction of the effect is as expected
 - no change in the direction of other predictor estimates
 - c) Sequentially **remove predictor variables** with
 - p-value > 0.1 starting with the least significant one
 - variance inflation factor > 3 starting with the highest one (?)

Land use regression modelling IV

- d) Examine **influential observations** by Cook's $D > 1$:
- Rerun model without the corresponding site
 - If changes in the model coefficients, p-values or model R^2 are large
 - ⇒ excluded the variable from the set of eligible predictors
 - ⇒ repeat the whole model development
- e) Assess **independence assumption**: Examine heteroscedasticity, normality and spatial autocorrelation (Moran's I) of residuals
5. Evaluate the **model performance** by leave-one-out cross-validation (LOOCV)
6. Apply **final LUR model** to **cohort addresses** to estimate individual air pollution concentrations