# Insights into the Spatial and Temporal Distribution of UFP from Swiss Health Studies


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

Ming-Yi Tsai, Reto Meier, Marloes Eeftens, Medea Imboden, Inmaculada Aguilera, Alex Ineichen, Mark Davey, Martin Fierz, Regina Ducret-Stich, Martina Ragettli, Christian Schindler, Harish Phuleria, Nino Künzli, Nicole Probst-Hensch

contact: m.tsai@unibas.ch


# Questions?

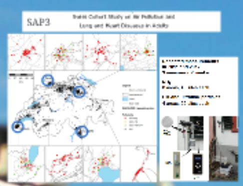
## The Studies in brief

Nearly all our work is done with Martin Fierz's MiniDisc
- Studies done at cohort subjects' homes (24-hr, 1-2weeks)
- Personal measurements (24-hr)
- "Mobile Measurements" (20-30mins) on sidewalks
- Different commute modes

Much higher levels in Geneva & Lugano
Highest in winter, generally lowest in summer

### The SAPALDIA study

SAPALDIA3: Home-Outdoor & Home-Indoor measurements




### TRITABS & TAPAS study

"Mobile" and Personal measurements

Tri-Tabs study
- Basel 2011 (simultaneous to SAP3)

TAPAS study
- Substudies in Basel (2011)

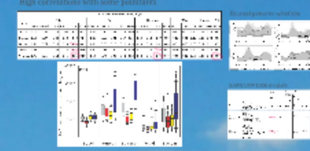
### EXPOsOMICS study

Personal, Home-outdoor, & "Mobile" measurements

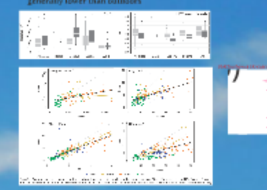
## Several Insights

**Insight #1** (point of view of exposure measurements)
- UFP as a pollutant is not as different (spatially & temporally) from other pollutants as one would first expect
  - seasonally higher in winter vs summer
  - expected diurnal pattern
  - longer-term levels can be well modelled (LUR)

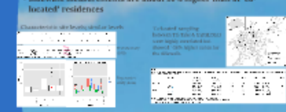
High correlations with some pollutants



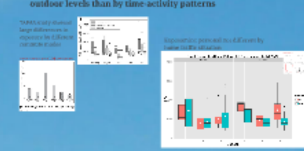
**Insight #2**
- Indoor UFP levels are (as with other pollutants) generally lower than outdoors



**Insight #3**
- Short-term sidewalk measurements (20-30mins) appear to capture the different site types
- Basel sidewalk levels are similar between 2011 & 2014
- Sidewalk measurements are about 20% higher than at 'co-located' residences



**Insight #4**
- Personal UFP measurements are less influenced by home-outdoor levels than by time-activity patterns



### Next Steps

- OMICs analyses with UFP data to ID marker of exposure
  - Real-time data offers a wealth of parameters
  - will be done within a year+
- Build seasonal LUR models (EXPOsOMICs)
  - 30-min @ 160 sites * 3 seasons per area
- Explore possibilities for other UFP modelling (eg, GRAMM/GRAL)
- UFP has been characterized in 3 large Swiss cities + 1 suburb
  - but need to extend to 4 other SAPALDIA areas
  - extend nationally


### Acknowledgments

- Swiss TPH
- SAPALDIA Team
- EXPOsOMICs Consortium
- BAFU - Bundesamt für Umwelt
- EMPA - Eidgenossiche Materialprüfungs-Forschungsanstalt - NABEL network
- Cantonal air monitoring agencies (LHA Beider-Basel, SP-Air Geneva, OstLuft, SP-Environment Valais, InLuft, Abteilung fuer Umwelt des Kantons Aargau, ANU-Graubuenden, SPAAS-Ticino)
- FHNW Schweiz - University of Applied Sciences
- SNF - Schweiz Nationalfonds
- EU Framework Programme 7 grant #308610


*Thank you for your attention!*

*Key is the delivery of the most important results where indeed the key points of the METHODS will easily be popping up and understood: e.g. " the seasonaly adjusted long-term means of UFP home outdoor were stongly predicted by X.... and well correlated with the means of PM10"....   or "from the parallel indoor/outdoor campaigns we conclude.... "*

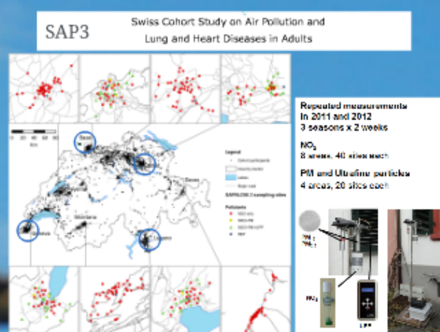
# The Studies in brief

Nearly all our work is done with Martin Fierz's MiniDisc
- Studies done at cohort subjects' homes (24-hr, 1-2weeks)
- Personal measurements (24-hr)
- "Mobile Measurements" (20-30mins) on sidewalks
- Different commute modes

Much higher levels in Geneva & Lugano
Highest in winter, generally lowest in summer

## The SAPALDIA study

SAPALDIA3: Home-Outdoor & Home-Indoor measurements




## TRITABS & TAPAS study

"Mobile" and Personal measurements

Tri-Tabs study
- Basel 2011 (simultaneous to SAP3)

TAPAS study
- Sub-studies in Basel (2011)

## EXPOsOMICs study

Personal, Home-outdoor, & "Mobile" measurements


# Questi

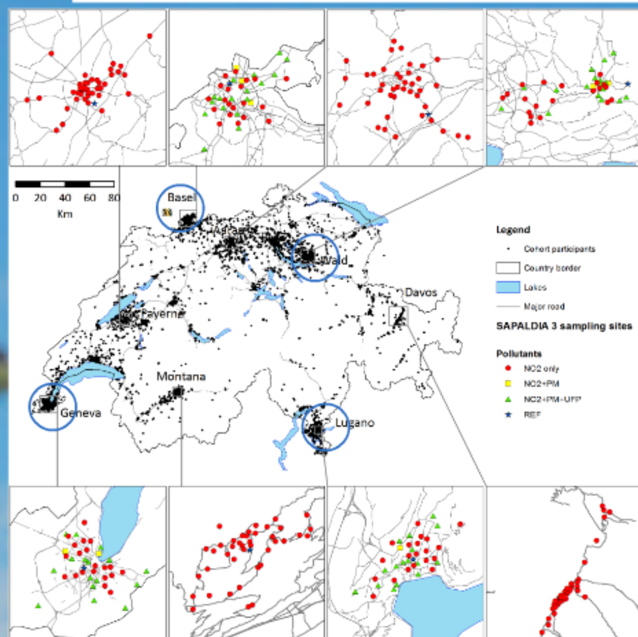
Nearly all our work is do
- Studies done at cohor
- Personal measuremen
- "Mobile Measuremen
- Different commute m
- 

Much higher levels in Ge
Highest in winter, genera

# The SAPALDIA study

## SAPALDIA3: Home-Outdoor & Home-Indoor measurements

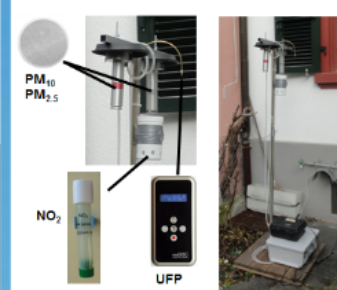
SAP3 — Swiss Cohort Study on Air Pollution and Lung and Heart Diseases in Adults




**Repeated measurements in 2011 and 2012**
**3 seasons x 2 weeks**

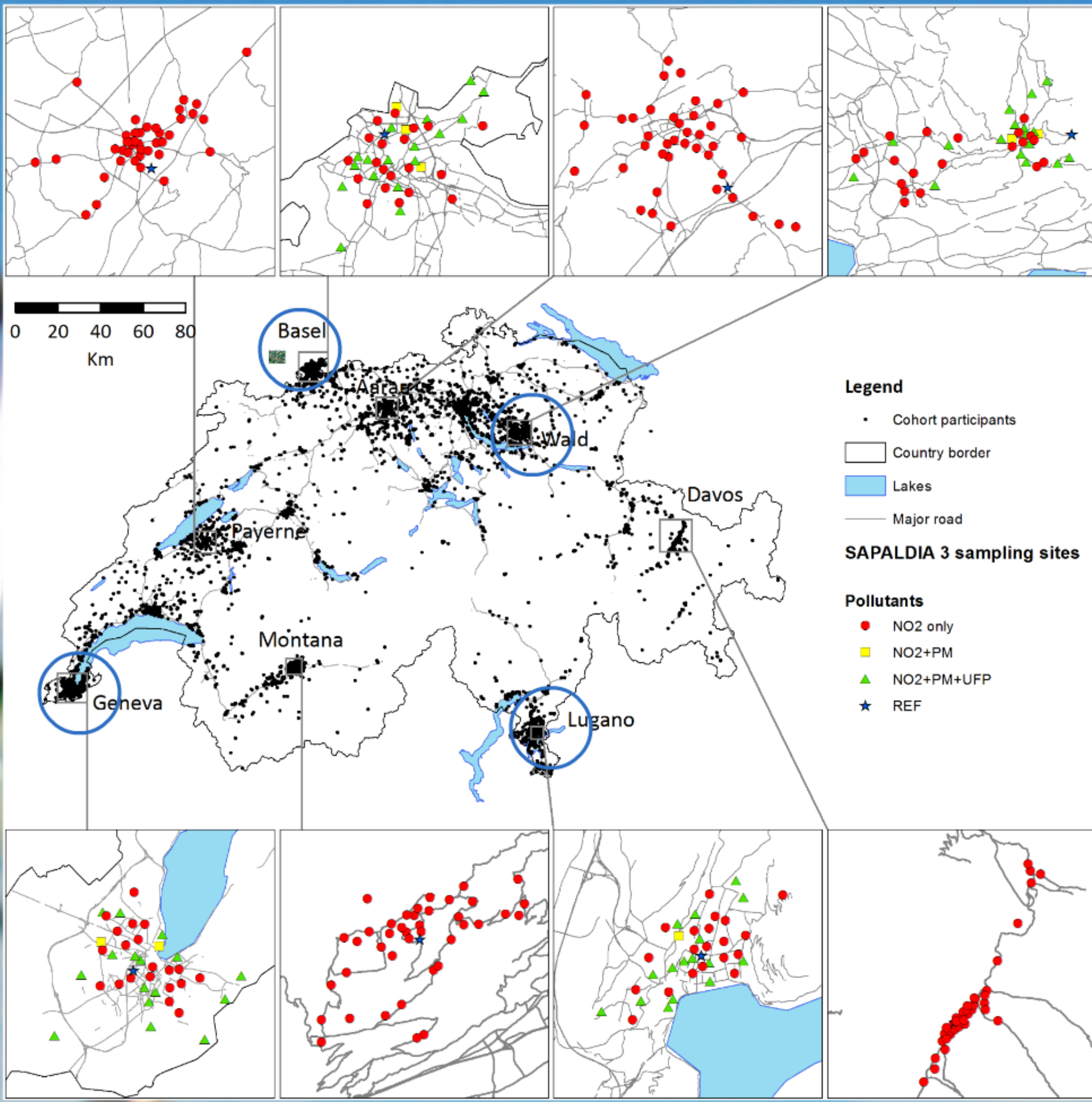
**$NO_2$**
8 areas, 40 sites each

**PM and Ultrafine particles**
4 areas, 20 sites each



# SAP3

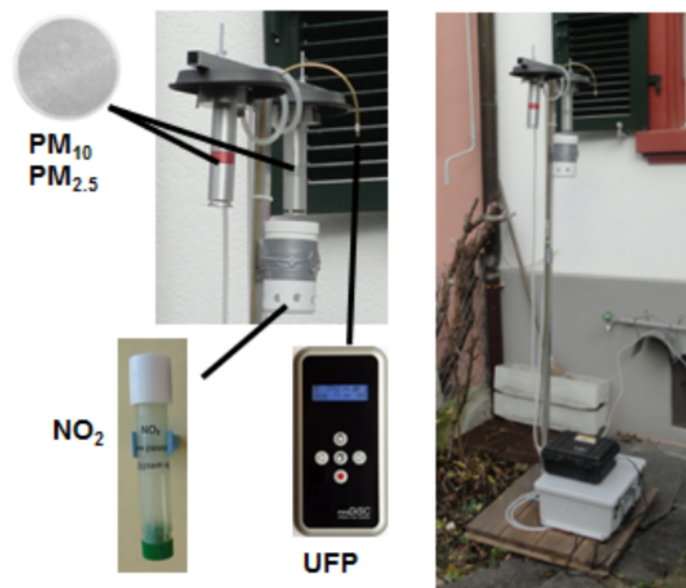
## Swiss Cohort Study on Air Pollution and Lung and Heart Diseases in Adults




**Repeated measurements in 2011 and 2012**
**3 seasons x 2 weeks**

**$NO_2$**
8 areas, 40 sites each

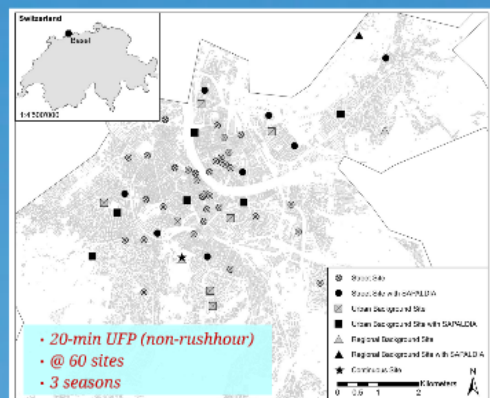
**PM and Ultrafine particles**
4 areas, 20 sites each



evels in Geneva & Lugano
ter, generally lowest in summer

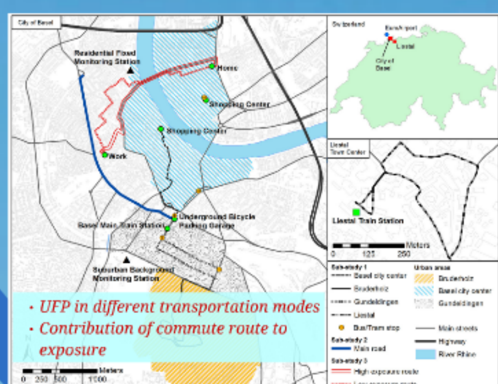
# TRITABS & TAPAS study

## "Mobile" and Personal measurements




Tri-Tabs study

- Basel 2011 (simultaneous to SAP3)

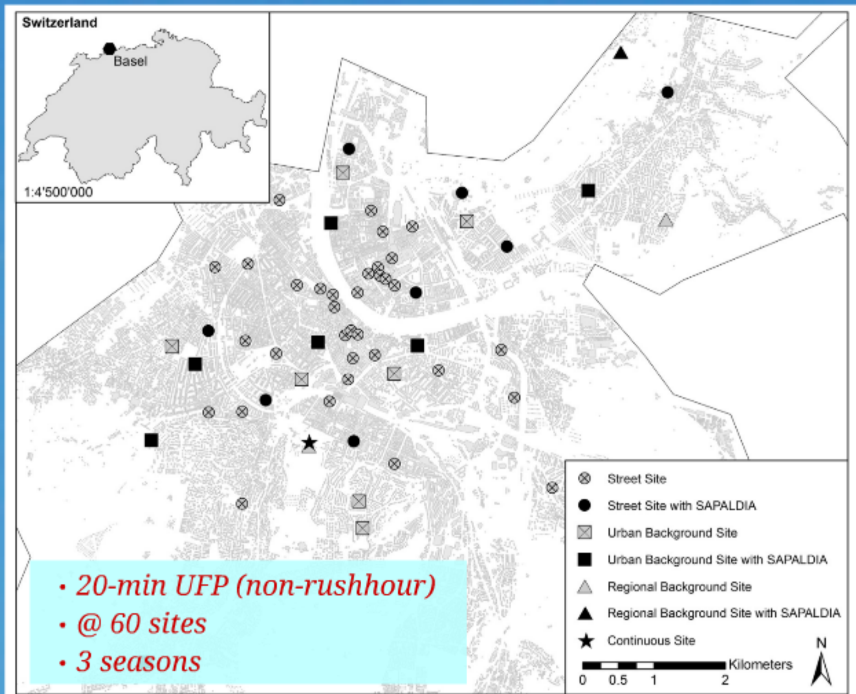



TAPAS study

- Sub-studies in Basel (2011)

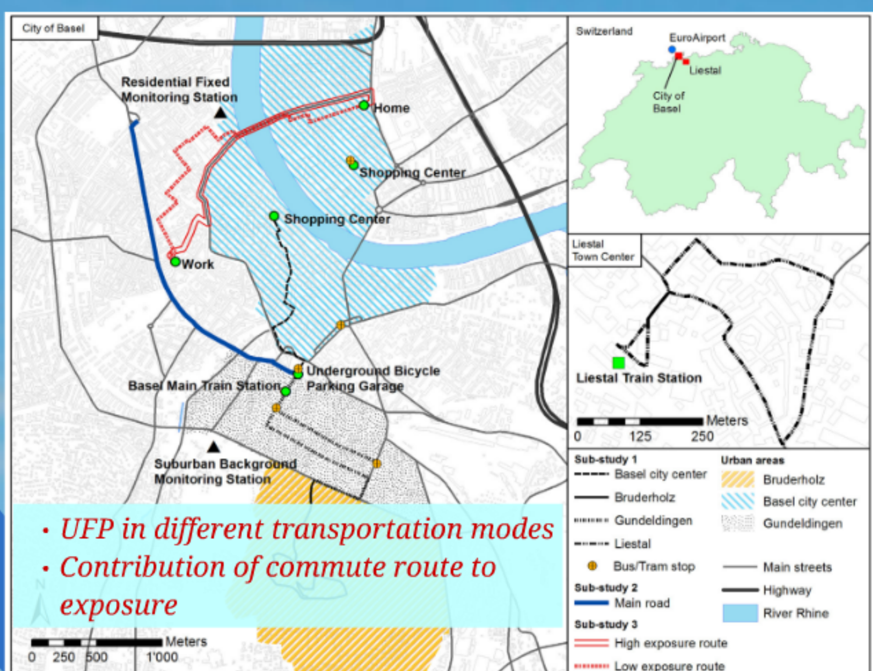
# Tri-Tabs study

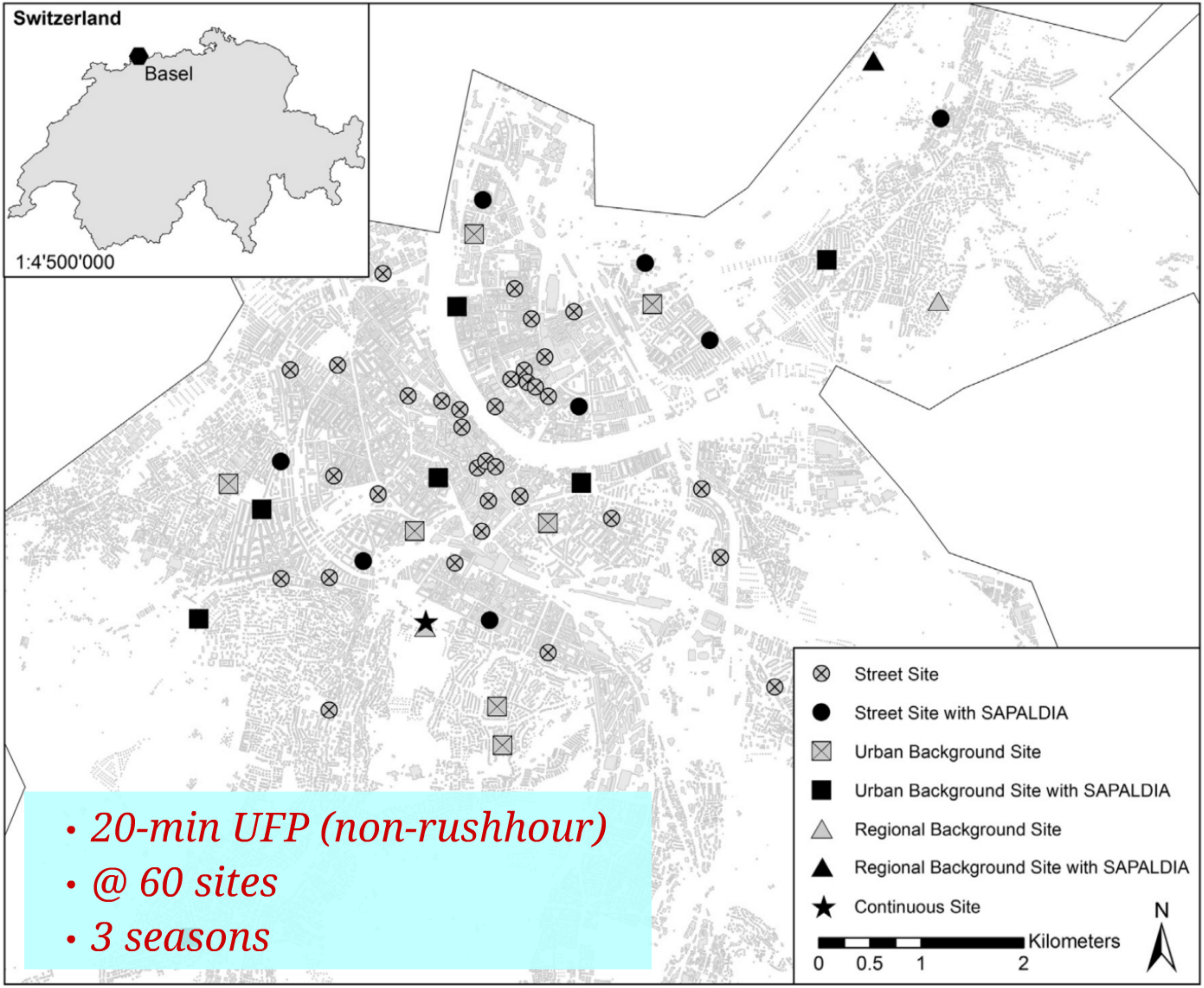
- Basel 2011 (simultaneous to SAP3)



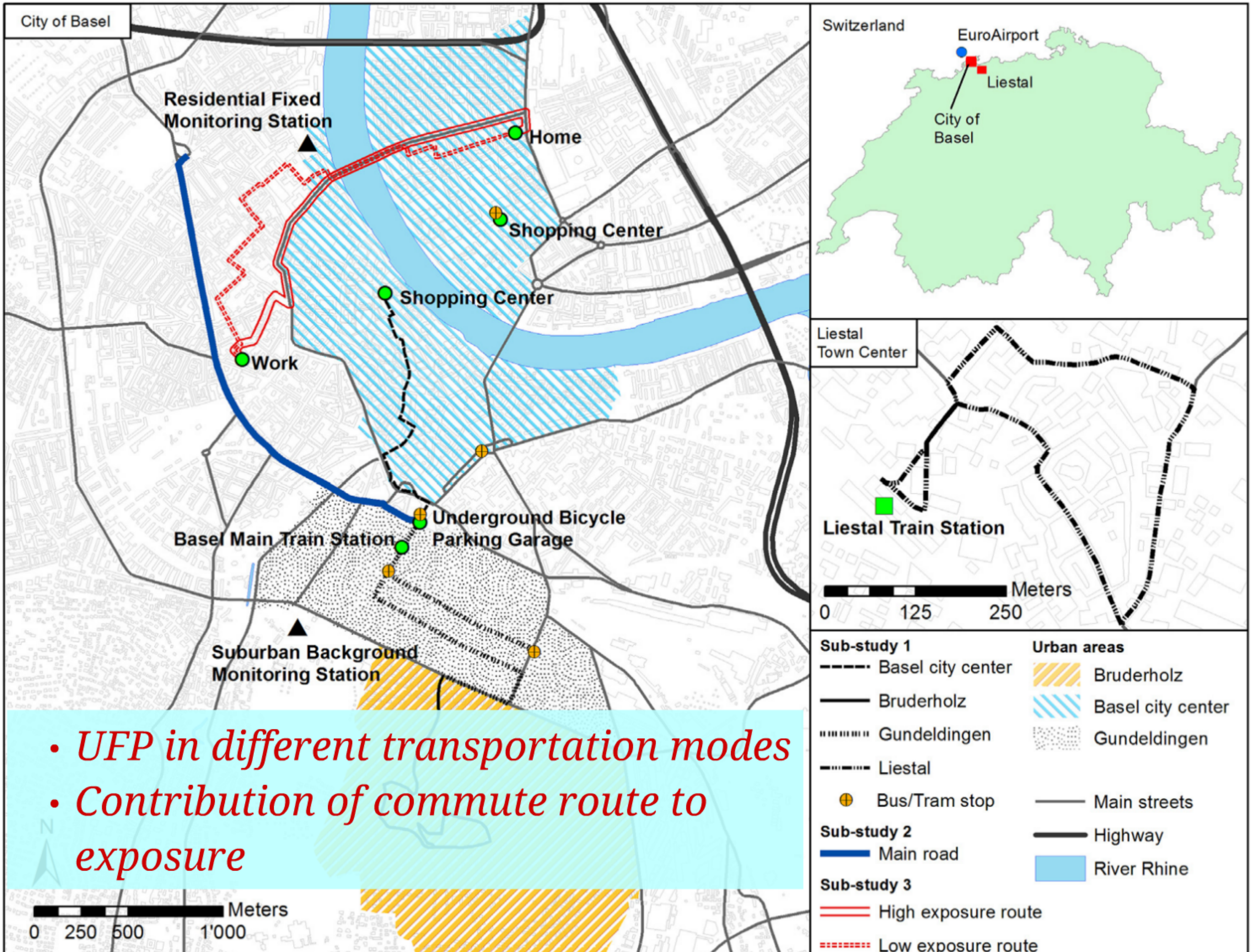

# TAPAS study

- Sub-studies in Basel (2011)

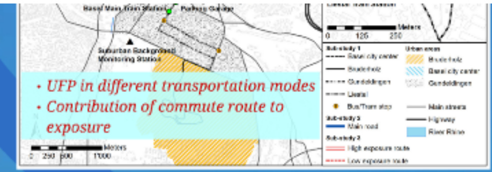





- 20-min UFP (non-rushhour)
- @ 60 sites
- 3 seasons

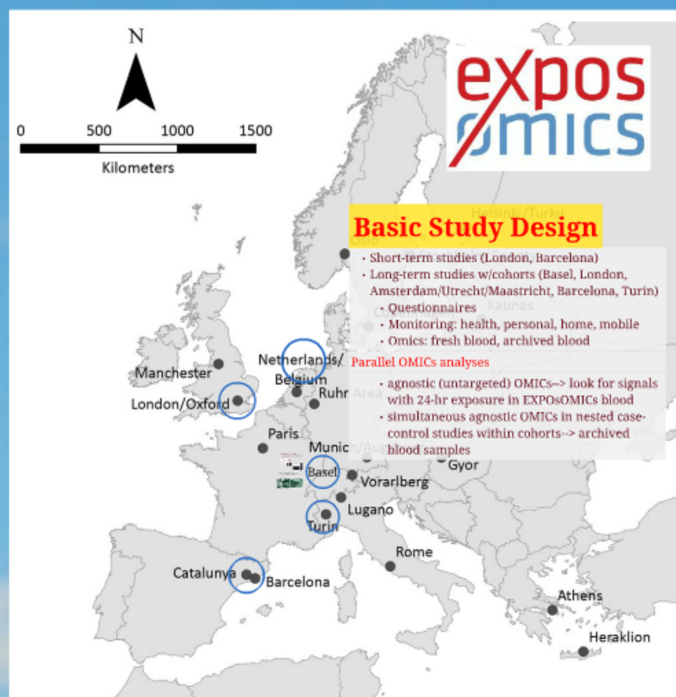



- *UFP in different transportation modes*
- *Contribution of commute route to exposure*

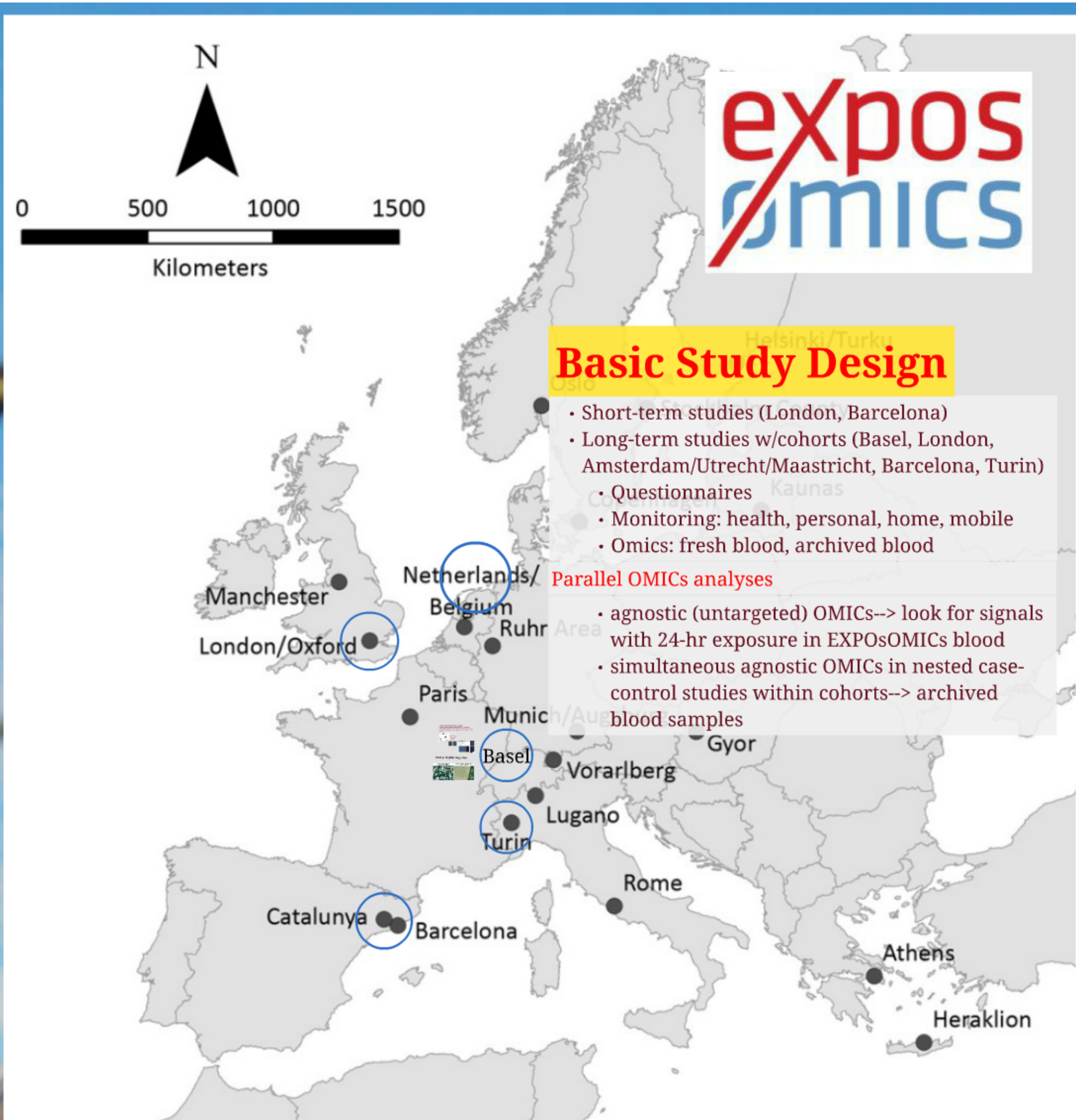



# EXPOsOMICs study

## Personal, Home-outdoor, & "Mobile" measurements




**EXPOsOMICs consortium:**




# Basic Study Design

- Short-term studies (London, Barcelona)
- Long-term studies w/cohorts (Basel, London, Amsterdam/Utrecht/Maastricht, Barcelona, Turin)
  - Questionnaires
  - Monitoring: health, personal, home, mobile
  - Omics: fresh blood, archived blood

Parallel OMICs analyses

- agnostic (untargeted) OMICs--> look for signals with 24-hr exposure in EXPOsOMICs blood
- simultaneous agnostic OMICs in nested case-control studies within cohorts--> archived blood samples

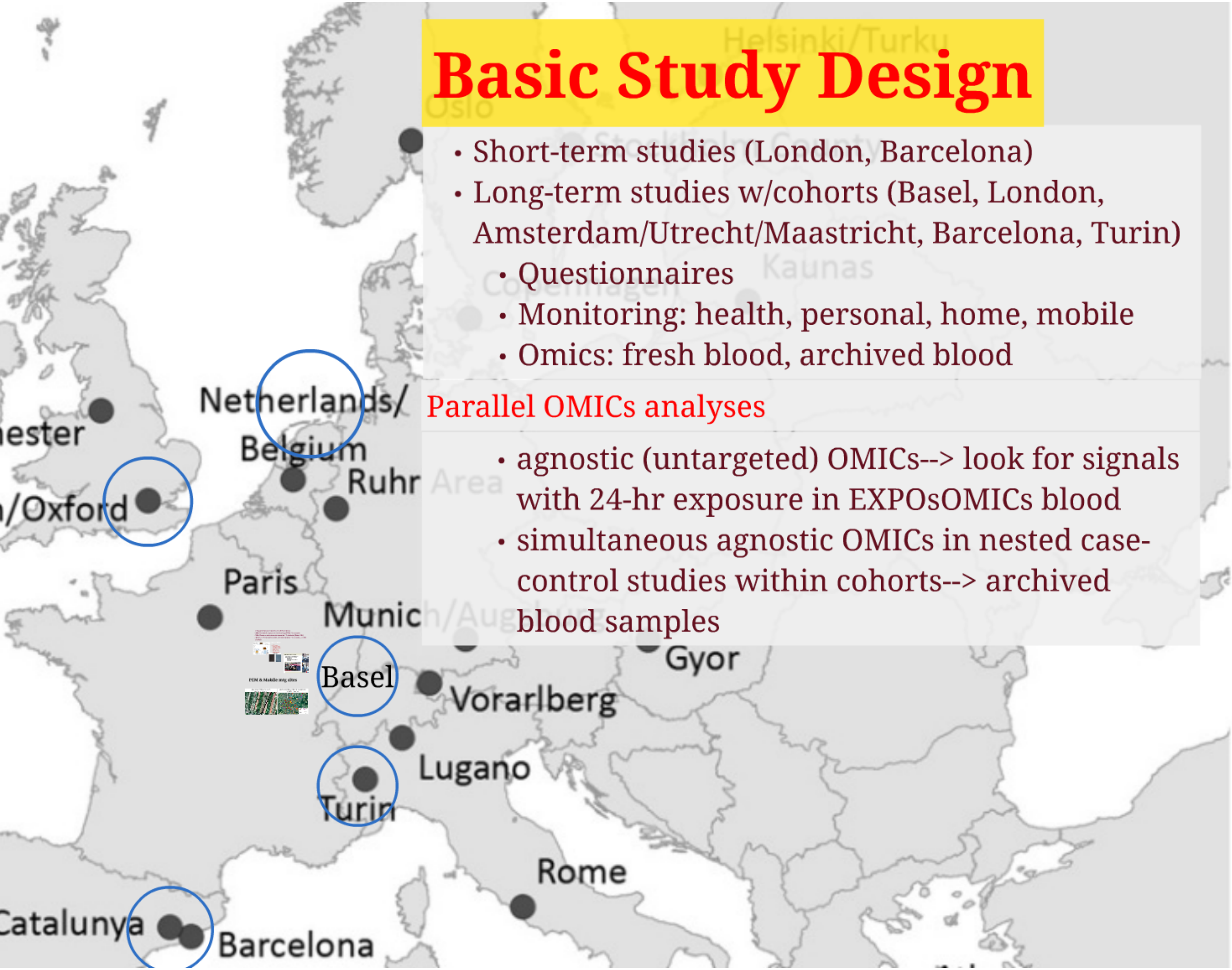
**EXPOsOMICs consortium:**

# Basic Study Design

- Short-term studies (London, Barcelona)
- Long-term studies w/cohorts (Basel, London, Amsterdam/Utrecht/Maastricht, Barcelona, Turin)
  - Questionnaires
  - Monitoring: health, personal, home, mobile
  - Omics: fresh blood, archived blood

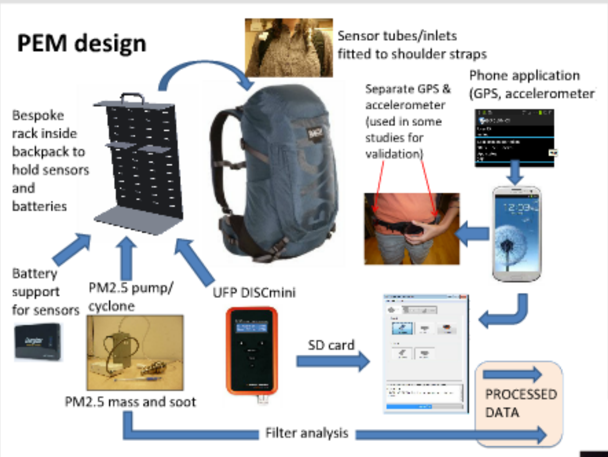
Parallel OMICs analyses

- agnostic (untargeted) OMICs--> look for signals with 24-hr exposure in EXPOsOMICs blood
- simultaneous agnostic OMICs in nested case-control studies within cohorts--> archived blood samples



## Exposure Measurements (in all 5 centers):

- 24hr Personal exposure monitoring (PEM) * 3 seasons
- 24hr Home-outdoor measurements * 3 seasons (Basel+NL)
- 30min UFP measurements at 160 locations * 3 seasons --> LUR models




## 24hr PEM:

*Health metrics*

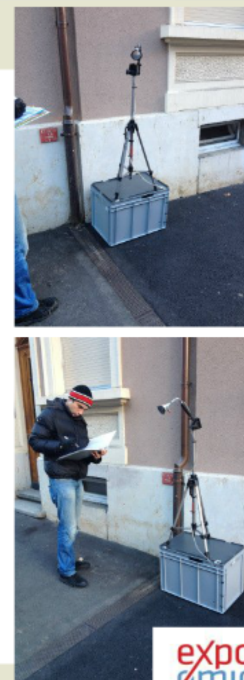
- *Blood pressure*
- *Height & weight*
- *Spirometry*
- *Buccal swab*
- *Blood sample*

**PEM Backpack**

### UFP Mobile Monitoring:

-160 locations in Basel and surrounding areas
-30 min measurements at each location:

- $PM_{2.5}$ (DustTrak)
- BC (MicroAeth)
- Particle numbers (CPC & MiniDisc)
- Traffic counts

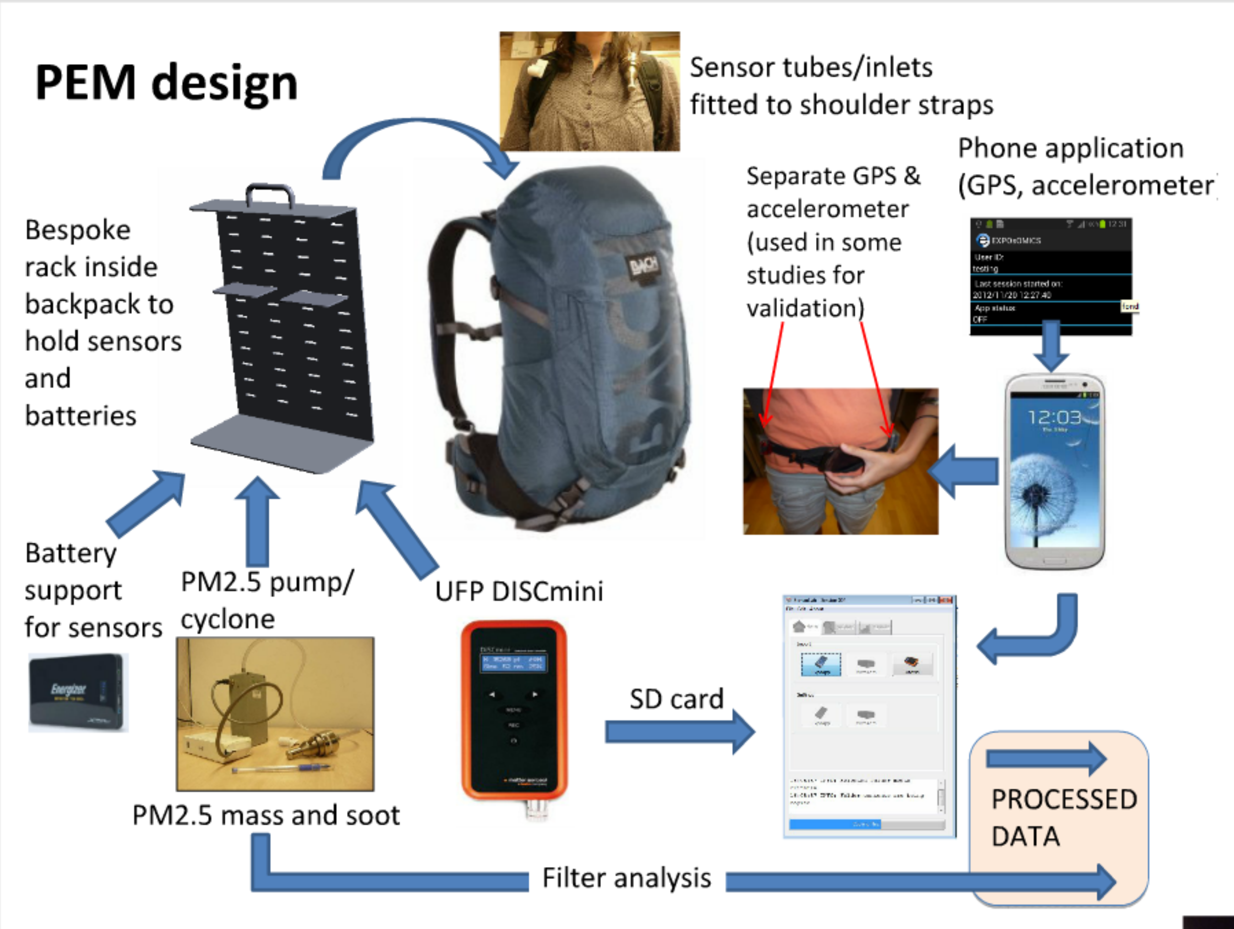


expos omics

# 24hr PEM:

*Health metrics*

- *Blood pressure*
- *Height & weight*
- *Spirometry*
- *Buccal swab*
- *Blood sample*




**PEM Backpack**

# PEM Backpack

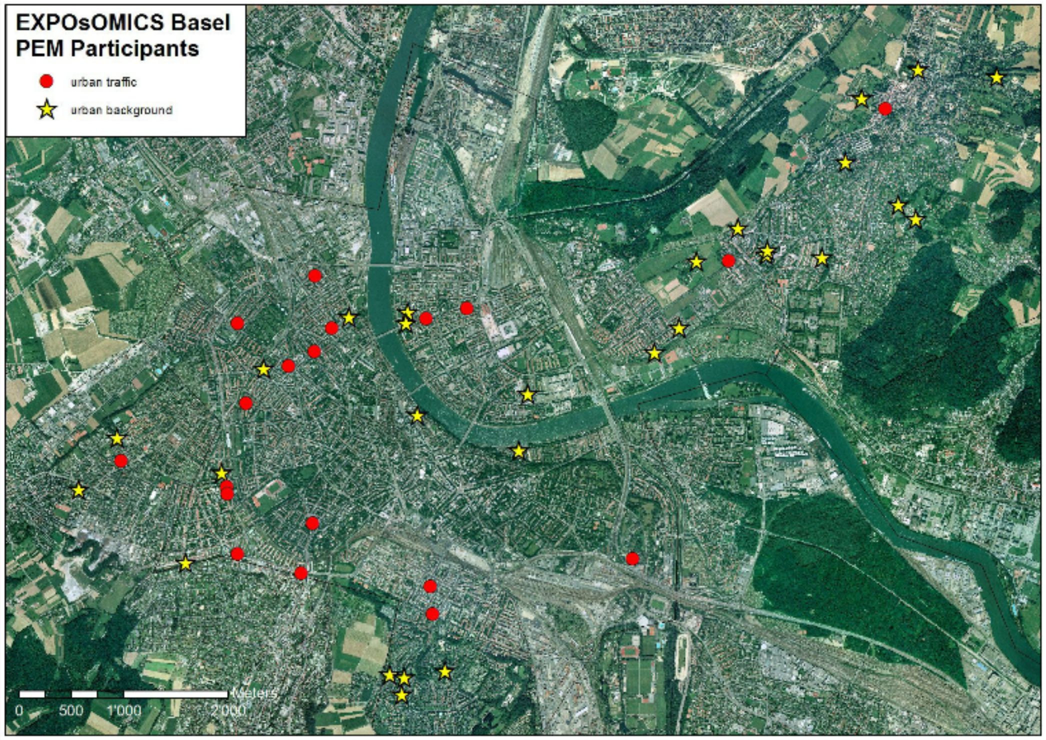

# UFP Mobile Monitoring:

-160 locations in Basel and surrounding areas
-30 min measurements at each location:

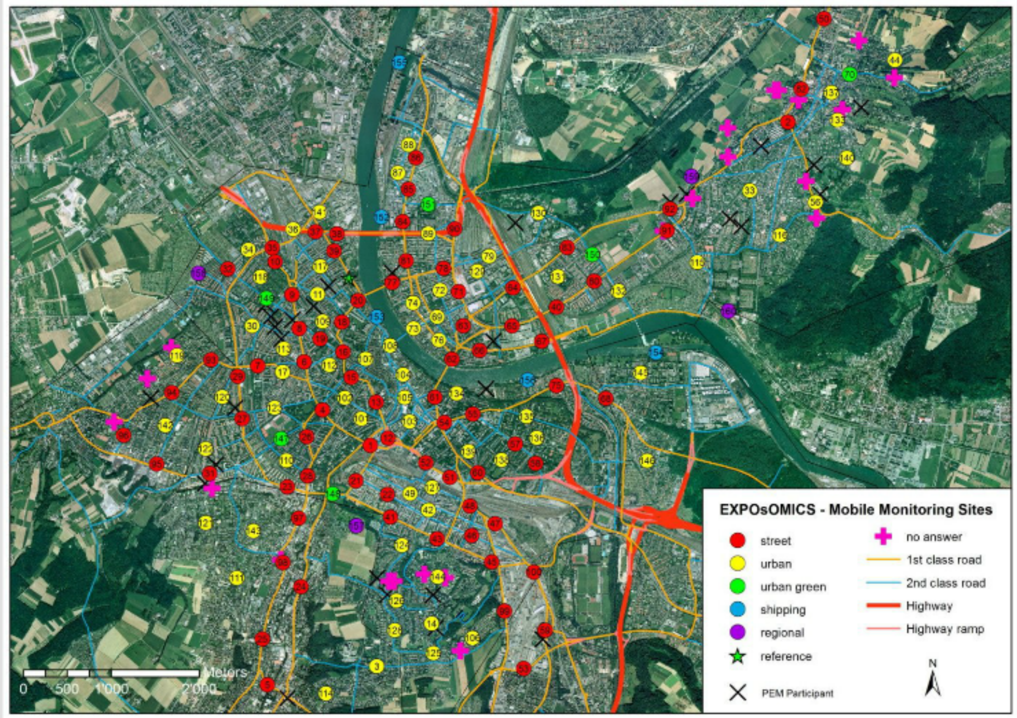
- $PM_{2.5}$ (DustTrak)
- BC (MicroAeth)
- Particle numbers (CPC & MiniDisc)
- Traffic counts

# PEM & Mobile mtg sites

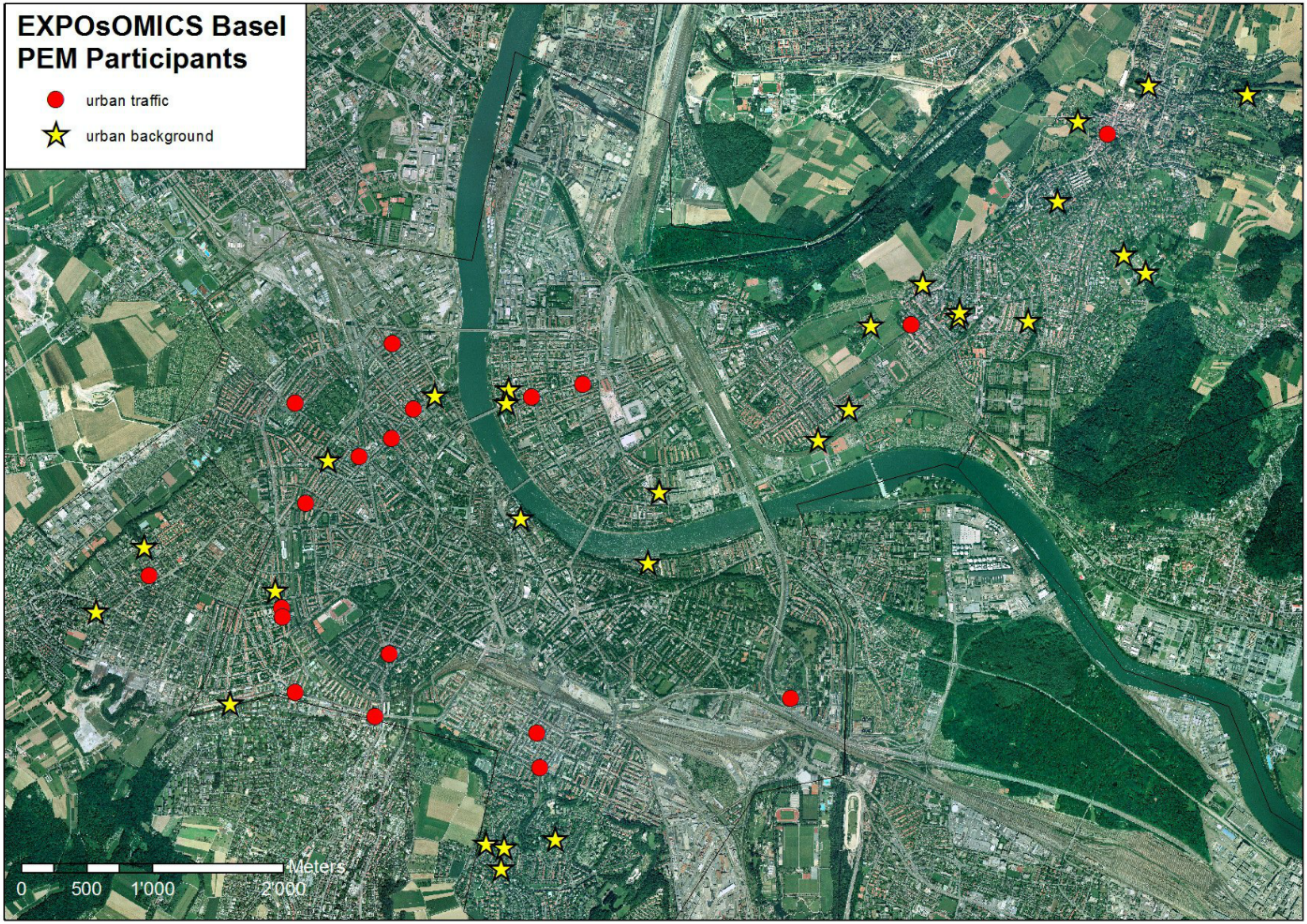
Location of PEM participants
Basel, SAPALDIA cohort



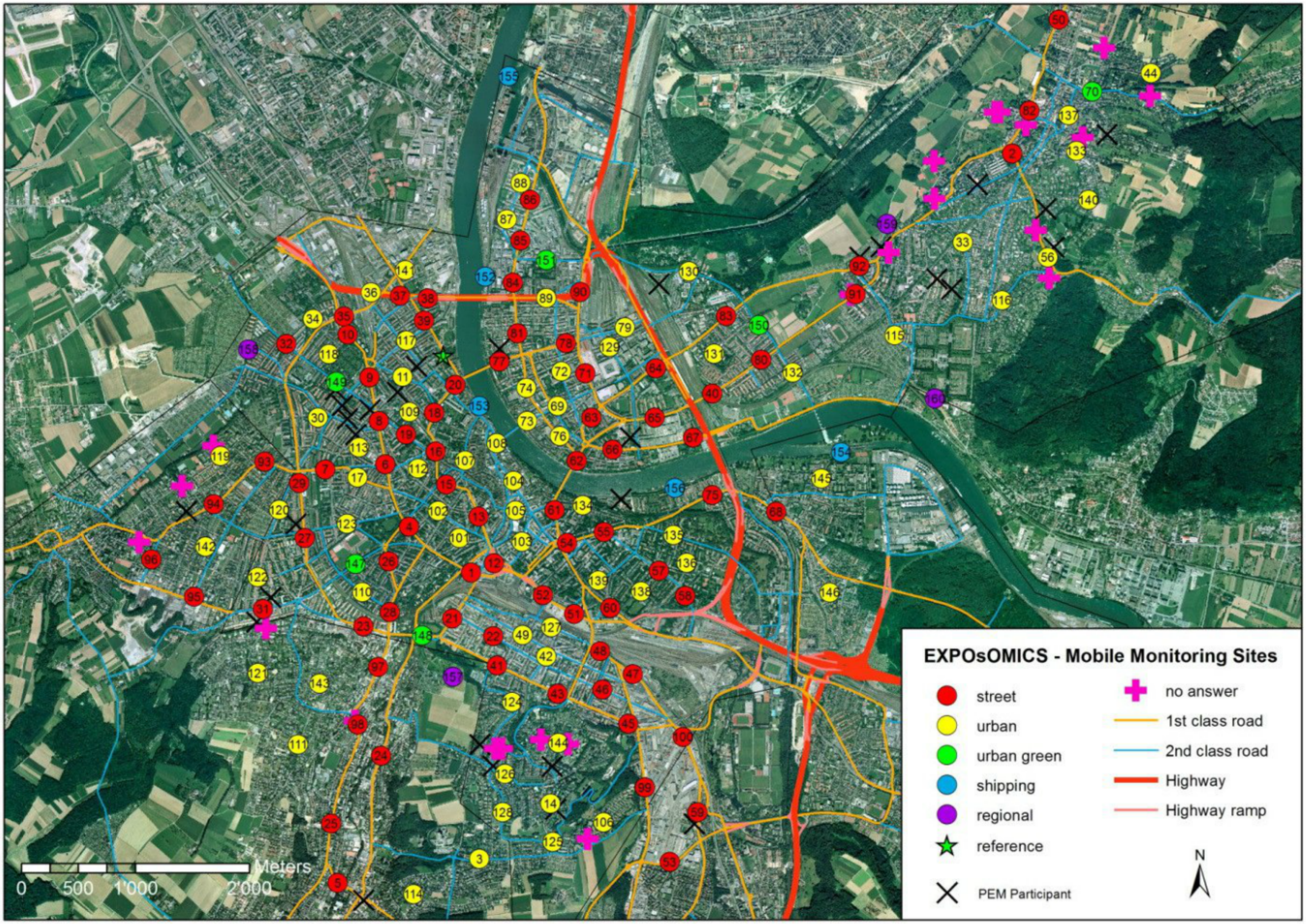

Location of Mobile Monitoring locations
(n=160) Basel, CH



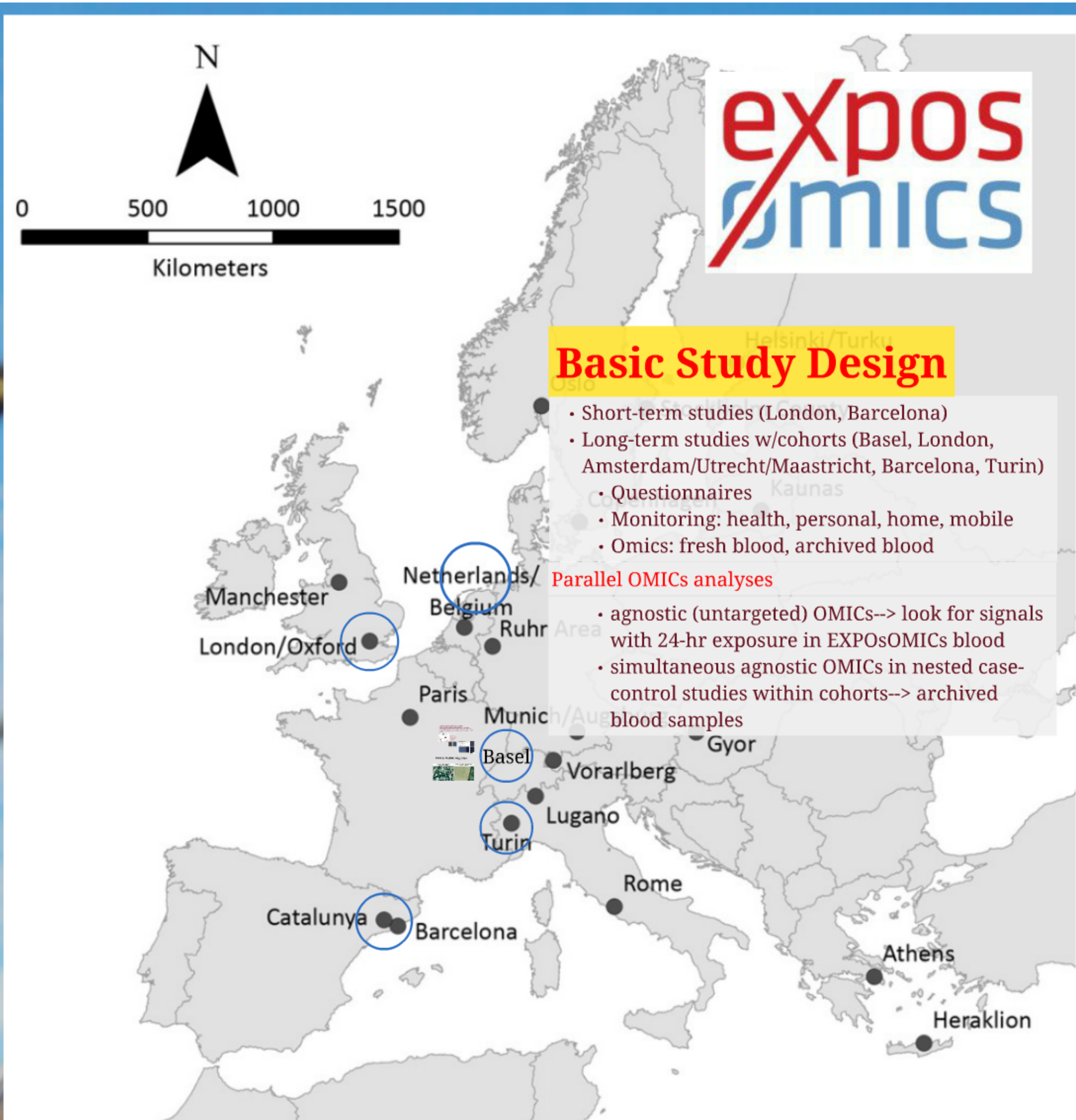
# Location of PEM participants
## Basel, SAPALDIA cohort



# Location of Mobile Monitoring locations (n=160)     Basel, CH



EXPOsOMICs consortium:




# Basic Study Design

- Short-term studies (London, Barcelona)
- Long-term studies w/cohorts (Basel, London, Amsterdam/Utrecht/Maastricht, Barcelona, Turin)
  - Questionnaires
  - Monitoring: health, personal, home, mobile
  - Omics: fresh blood, archived blood

Parallel OMICs analyses

- agnostic (untargeted) OMICs--> look for signals with 24-hr exposure in EXPOsOMICs blood
- simultaneous agnostic OMICs in nested case-control studies within cohorts--> archived blood samples

# The Studies in brief

# Questi

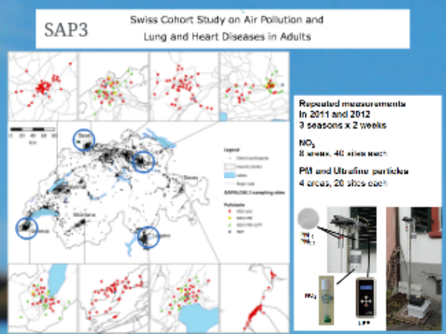
Nearly all our work is done with Martin Fierz's MiniDisc

- Studies done at cohort subjects' homes (24-hr, 1-2weeks)
- Personal measurements (24-hr)
- "Mobile Measurements" (20-30mins) on sidewalks
- Different commute modes

Much higher levels in Geneva & Lugano
Highest in winter, generally lowest in summer

## The SAPALDIA study

SAPALDIA3: Home-Outdoor & Home-Indoor measurements




## TRITABS & TAPAS study

"Mobile" and Personal measurements

Tri-Tabs study
- Basel 2011 (simultaneous to SAP3)

TAPAS study
- Sub-studies in Basel (2011)

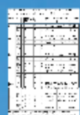
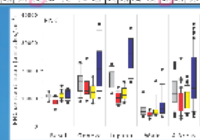
## EXPOsOMICs study

Personal, Home-outdoor, & "Mobile" measurements

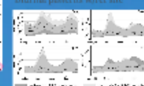

# Questions?

# Several Insights

**Insight #1** (point of view of exposure measurements)
- UFP as a pollutant is not as different (spatially & temporally) from other pollutants as one would first expect
  - seasonally higher in winter vs summer
  - expected diurnal pattern
  - longer-term levels can be well modelled (LUR)

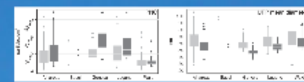
High correlations with some pollutants



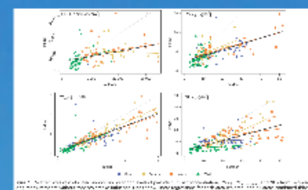
Diurnal patterns wrt site



SAPS UFP LUR models

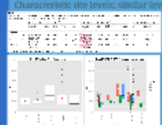
**Insight #2**
- Indoor UFP levels are (as with other pollutants) generally lower than outdoors



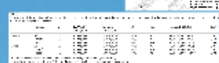


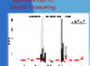
**Insight #3+**
- Short-term sidewalk measurements (20-30mins) appear to capture the different site types
- Basel sidewalk levels are similar between 2011 & 2014
- Sidewalk measurements are about 20% higher than at 'co-located' residences

Characteristic site levels; similar levels



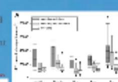
'Co-located' sampling between Tri-Tabs & SAPALDIA3 were highly correlated but showed ~20% higher concs for the sidewalk.

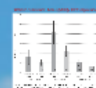




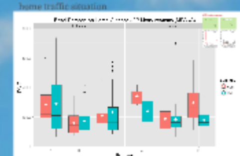
**Insight #4**
- Personal UFP measurements are less influenced by home-outdoor levels than by time-activity patterns

TAPAS study showed large differences in exposure by different commute modes





Exposomics: personal not different by home traffic situation



## Next Steps

- OMICs analyses with UFP data to ID marker of exposure
  - Real-time data offers a wealth of parameters
  - will be done within a year+
- Build seasonal LUR models (EXPOsOMICs)
  - 30-min @ 160 sites * 3 seasons per area
- Explore possibilities for other UFP modelling (eg, GRAMM/GRAL)
- UFP has been characterized in 3 large Swiss cities + 1 suburb
  - but need to extend to 4 other SAPALDIA areas
  - extend nationally


## *Acknowledgments*

- Swiss TPH — Colleagues: Co-authors, Marianne Rutschi, Gregor Fessler, Aliocha Schaffner, Sivi Jeyachchandren, Helen Graf, Tobias Heckelmann, Evelyn Fischer, Kevin Estermann, Benjamin Flückiger, Susanna Nussbaumer, Andreas Schwärzler, Gregor Juretzko, Katja Stähli, Sandra Okorga
- SAPALDIA Team
- EXPOsOMICs Consortium
- BAFU - Bundesamt für Umwelt
- EMPA - Eidgenossiche Materialprüfungs-Forschungsanstalt - NABEL network
- Cantonal air monitoring agencies (LHA Beider-Basel, SP-Air Geneva, OstLuft, SP-Environment Valais, InLuft, Abteilung fuer Umwelt des Kantons Aargau, ANU-Graubuenden, SPAAS-Ticino)
- FHNW Schweiz - University of Applied Sciences
- SNF - Schweiz Nationalfonds
- EU Framework Programme 7 grant #308610


*Thank you for your attention!*

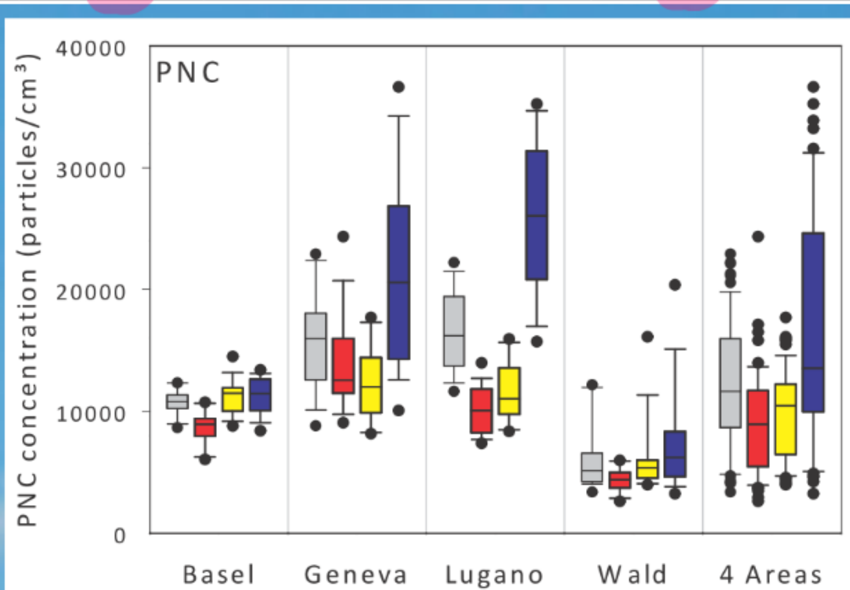
*Key is the delivery of the most important results where indeed the key points of the METHODS will easily be popping up and understood: e.g. " the seasonaly adjusted long-term means of UFP home outdoor were stongly predicted by X.... and well correlated with the means of PM10" .... or "from the parallel indoor/outdoor campaigns we conclude..... "*

# Insight #1 (point of view of exposure measurements)

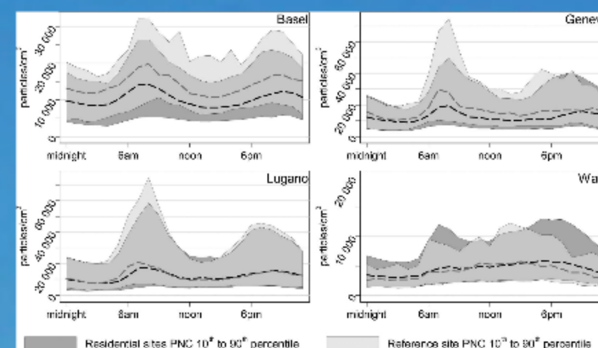
- UFP as a pollutant is not as different (spatially & temporally) from other pollutants as one would first expect
  - seasonally higher in winter vs summer
  - expected diurnal pattern
  - longer-term levels can be well modelled (LUR)

## High correlations with some pollutants

| Coefficient of determination, $R^2$ (n) | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Area | $NO_2$ | | | | | | $PM_{2.5}$ | | | | | $PM_{2.5}$ abs | | | | $PM_{10}$ | | | $PM_{coarse}$ | | PNC |
| | $PM_{2.5}$ | $PM_{2.5}$ abs | $PM_{10}$ | $PM_{coarse}$ | PNC | LDSA | $PM_{2.5}$ abs | $PM_{10}$ | $PM_{coarse}$ | PNC | LDSA | $PM_{10}$ | $PM_{coarse}$ | PNC | LDSA | $PM_{coarse}$ | PNC | LDSA | PNC | LDSA | LDSA |
| Basel | 0.21 | 0.35 | 0.18 | 0.03 | 0.47 | 0.32 | 0.63 | 0.49 | 0.32 | 0.43 | 0.50 | 0.25 | 0.25 | 0.35 | 0.36 | 0.01 | 0.71 | 0.59 | 0.08 | 0.19 | 0.63 |
| Geneva | 0.21 | 0.44 | 0.39 | 0.32 | 0.60 | 0.64 | 0.18 | 0.63 | 0.24 | 0.17 | 0.33 | 0.22 | 0.13 | 0.07 | 0.19 | 0.83 | 0.10 | 0.17 | 0.02 | 0.03 | 0.92 |
| Lugano | 0.11 | 0.82 | 0.25 | 0.13 | 0.74 | 0.61 | 0.16 | 0.75 | 0.16 | 0.10 | 0.38 | 0.28 | 0.14 | 0.61 | 0.48 | 0.51 | 0.27 | 0.50 | 0.17 | 0.12 | 0.75 |
| Wald | 0.35 | 0.90 | 0.62 | 0.37 | 0.82 | 0.80 | 0.51 | 0.45 | 0.20 | 0.34 | 0.30 | 0.71 | 0.44 | 0.86 | 0.84 | 0.30 | 0.69 | 0.72 | 0.33 | 0.34 | 0.98 |
| All areas | 0.42 | 0.80 | 0.63 | 0.41 | 0.81 | 0.80 | 0.51 | 0.74 | 0.21 | 0.40 | 0.58 | 0.68 | 0.41 | 0.74 | 0.79 | 0.59 | 0.62 | 0.76 | 0.42 | 0.40 | 0.90 |




## Diurnal patterns w/ref site

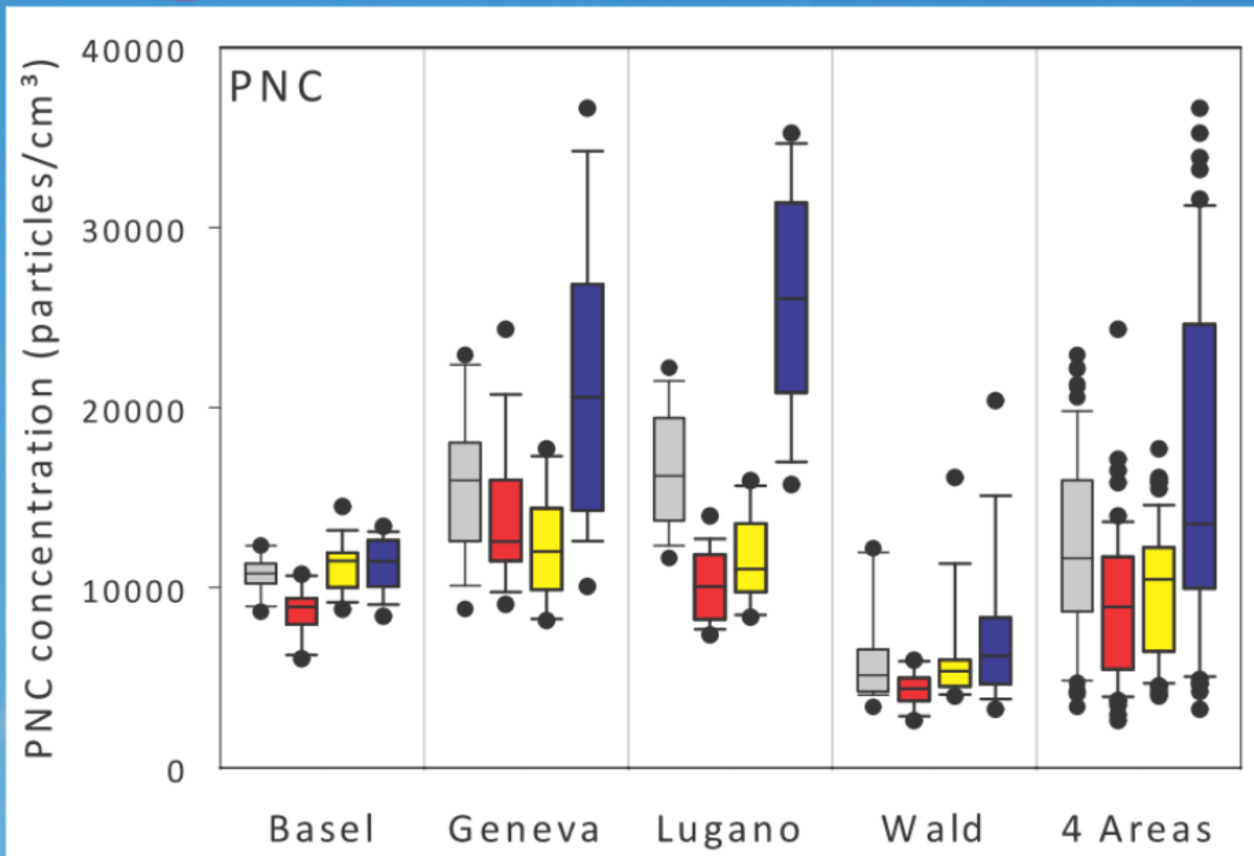



## SAP3 UFP LUR models

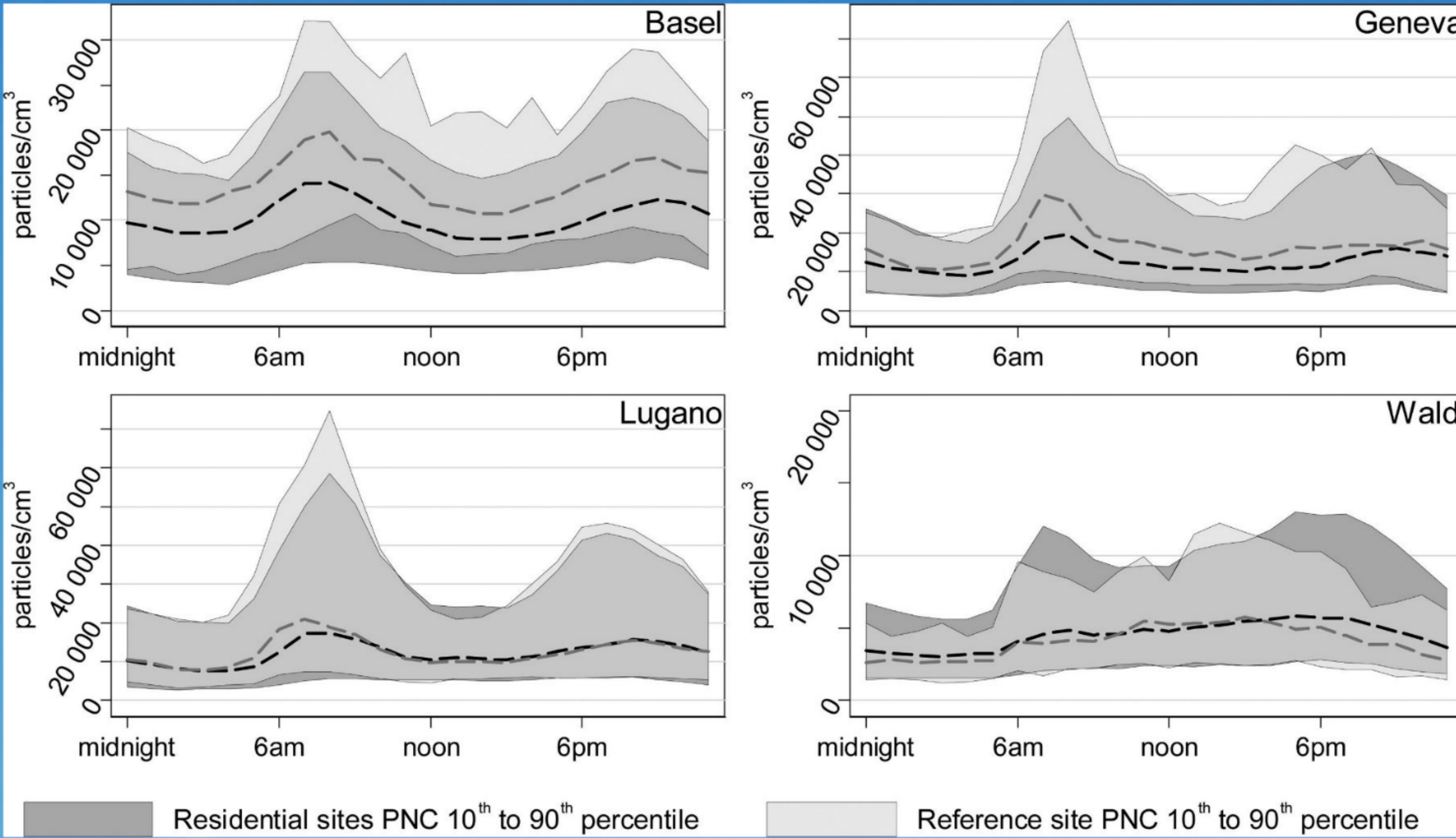
| Pollutant | N | Model | Model | | | Measures of spatial autocorrelation | | LOOCV | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Adj $R^2$ | $R^2$ | RMSE | P-value of association of residuals with area | Moran's I (p-value) | $R^2$ | RMSE |
| $PM_{2.5}$ ($\mu g/m^3$) | 74 | PM2.5 = -13.2 +<br>PM25_2010 * 1.81 +<br>MAJROADLENGTH_25 * 0.0478 +<br>URBGREEN_5000 * 0.000000521 +<br>TRAFMAJOR * 0.0000515 | 0.55 | 0.57 | 2.0 | 0.4530 | -0.0558 (0.7222) | 0.50 | 2.2 |
| PNC (particles/cm³) | 67 | PNC = 7805 +<br>Area_GE * 4270 +<br>Area_LU * 5895 +<br>Area_WA * -2388 +<br>TRAFLOAD_250 * 0.000110 +<br>ROADLENGTH_100 * 4.26 +<br>MAJROADLENGTH_50 * 19.9 +<br>HGNL_1000 * -0.00273 | 0.85 | 0.87 | 1991 | 1.0000 | -0.0663 (0.7059) | 0.82 | 2255 |
| LDSA (µm²/cm³) | 67 | LDSA = 29.9 +<br>Area_GE * 9.17 +<br>Area_LU * 17.3 +<br>Area_WA * 0.503 +<br>MAJROADLENGTH_250 * 0.00817 +<br>ROADLENGTH_100 * 0.0094 +<br>TRAFNEAR * 0.000199 –<br>ALT * -0.0257 | 0.89 | 0.91 | 3.8 | 1.0000 | -0.0434 (0.8349) | 0.87 | 4.2 |

# High correlations with some pollutants

| Coefficient of determination, $R^2$ (n) | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Area | $NO_2$ | | | | | | $PM_{2.5}$ | | | | | $PM_{2.5}$ abs | | | | $PM_{10}$ | | | $PM_{coarse}$ | | PNC |
| | $PM_{2.5}$ | $PM_{2.5}$ abs | $PM_{10}$ | $PM_{coarse}$ | PNC | LDSA | $PM_{2.5}$ abs | $PM_{10}$ | $PM_{coarse}$ | PNC | LDSA | $PM_{10}$ | $PM_{coarse}$ | PNC | LDSA | $PM_{coarse}$ | PNC | LDSA | PNC | LDSA | LDSA |
| Basel | 0.21 | 0.35 | 0.18 | 0.03 | 0.47 | 0.32 | 0.63 | 0.49 | 0.32 | 0.43 | 0.50 | 0.25 | 0.25 | 0.35 | 0.36 | 0.01 | 0.71 | 0.59 | 0.08 | 0.19 | 0.63 |
| Geneva | 0.21 | 0.44 | 0.39 | 0.32 | 0.60 | 0.64 | 0.18 | 0.63 | 0.24 | 0.17 | 0.33 | 0.22 | 0.13 | 0.07 | 0.19 | 0.83 | 0.10 | 0.17 | 0.02 | 0.03 | 0.92 |
| Lugano | 0.11 | 0.82 | 0.25 | 0.13 | 0.74 | 0.61 | 0.16 | 0.75 | 0.16 | 0.10 | 0.38 | 0.28 | 0.14 | 0.61 | 0.48 | 0.51 | 0.27 | 0.50 | 0.17 | 0.12 | 0.75 |
| Wald | 0.35 | 0.90 | 0.62 | 0.37 | 0.82 | 0.80 | 0.51 | 0.45 | 0.20 | 0.34 | 0.30 | 0.71 | 0.44 | 0.86 | 0.84 | 0.30 | 0.69 | 0.72 | 0.33 | 0.34 | 0.98 |
| All areas | 0.42 | 0.80 | 0.63 | 0.41 | 0.81 | 0.80 | 0.51 | 0.74 | 0.21 | 0.40 | 0.58 | 0.68 | 0.41 | 0.74 | 0.79 | 0.59 | 0.62 | 0.76 | 0.42 | 0.40 | 0.90 |



# Diurnal patterns w/ref site

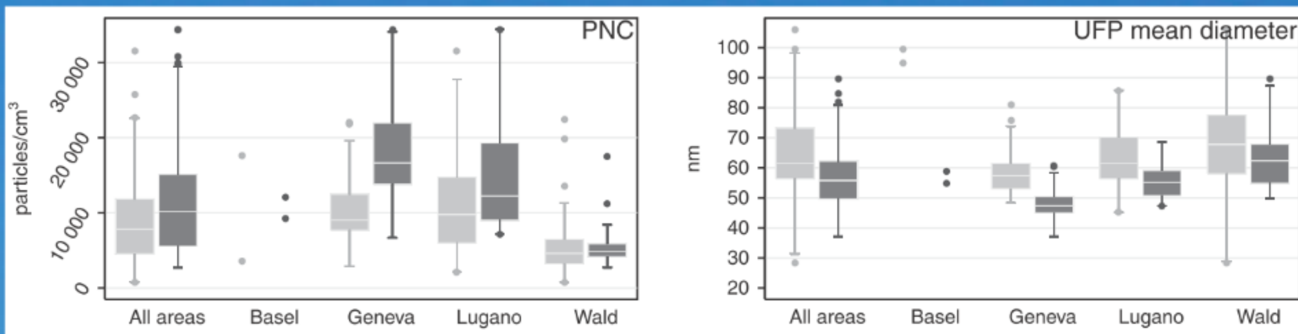


# SAP3 UFP LUR models

| Pollutant | N | Model | Model | | | Measures of spatial autocorrelation | | LOOCV | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Adj $R^2$ | $R^2$ | RMSE | P-value of association of residuals with area | Moran's I (p-value) | $R^2$ | RMSE |
| $PM_{2.5}$ ($\mu g/m^3$) | 74 | PM2.5 = -13.2 +<br>PM25_2010 * 1.81 +<br>MAJROADLENGTH_25 * 0.0478 +<br>URBGREEN_5000 * -0.000000521 +<br>TRAFMAJOR * 0.0000515 | 0.55 | 0.57 | 2.0 | 0.4530 | -0.0558 (0.7222) | 0.50 | 2.2 |
| PNC (particles/$cm^3$) | 67 | PNC = 7805 +<br>Area_GE * 4270 +<br>Area_LU * 5895 +<br>Area_WA * ‘2388 +<br>TRAFLOAD_250 * 0.000110 +<br>ROADLENGTH_100 * 4.26 +<br>MAJROADLENGTH_50 * 19.9 +<br>UGNL_1000 * -0.00273 | 0.85 | 0.87 | 1991 | 1.0000 | -0.0663 (0.7059) | 0.82 | 2255 |
| LDSA ($\mu m^2/cm^3$) | 67 | LDSA = 29.9 +<br>Area_GE * 9.17 +<br>Area_LU * 17.3 +<br>Area_WA * 0.502 +<br>MAJROADLENGTH_250 * 0.00317 +<br>ROADLENGTH_100 * 0.0094 +<br>TRAFNEAR * 0.000199 +<br>ALT * -0.0257 | 0.89 | 0.91 | 3.8 | 1.0000 | -0.0434 (0.8349) | 0.87 | 4.2 |

# Insight #2

- **Indoor UFP levels are (as with other pollutants) generally lower than outdoors**



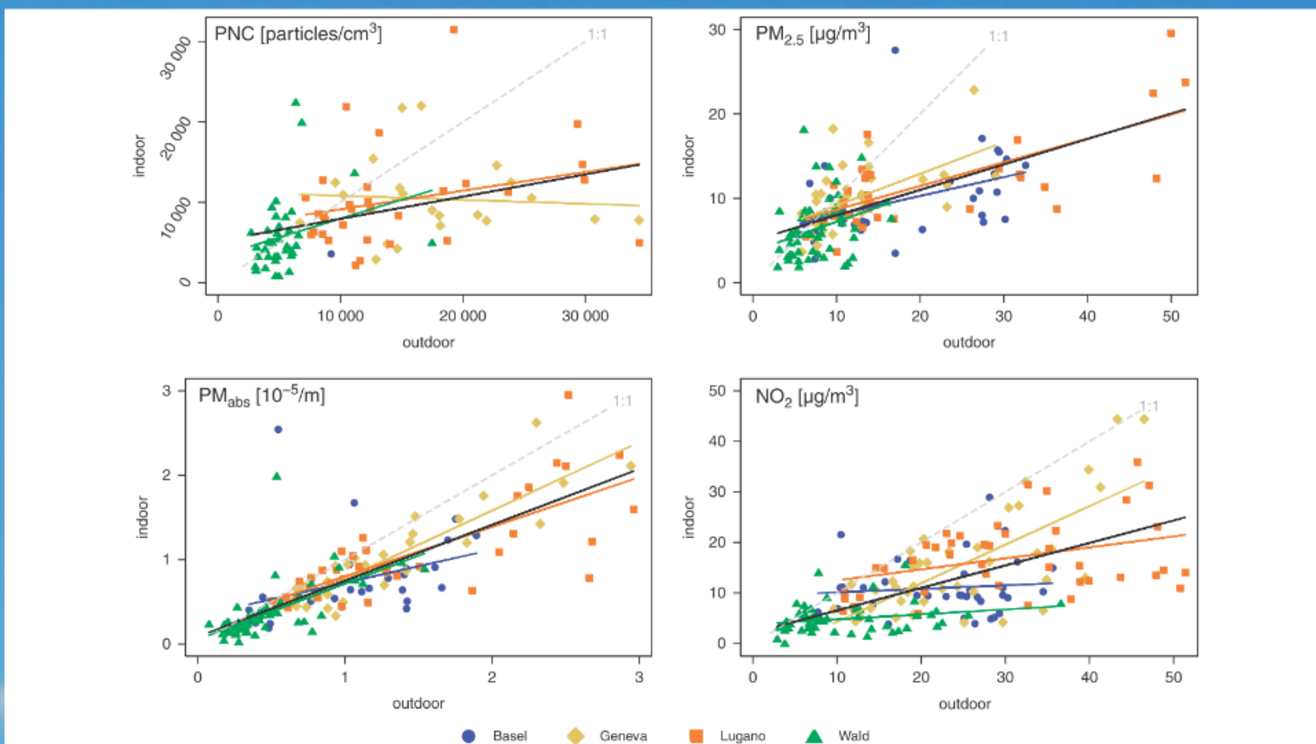
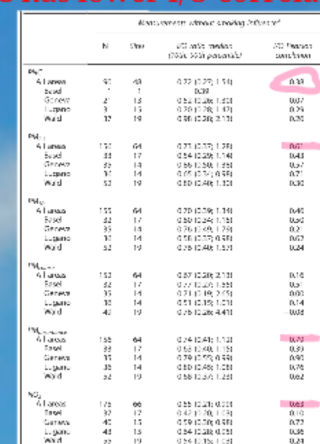



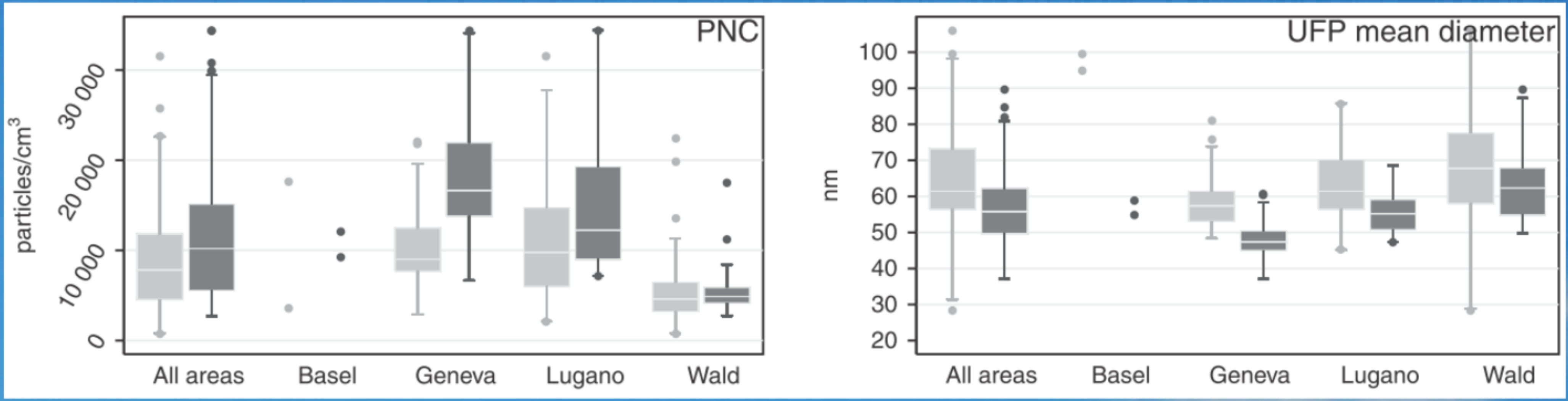

**Figure 2.** Scatter plots of co-located indoor and outdoor levels of particle number concentration, $PM_{2.5}$, $PM_{absorbance}$ and $NO_2$ from 1–2-week-long measurements without tobacco smoke influence. Lines show linear regressions for each area (colored) and all areas combined (black).

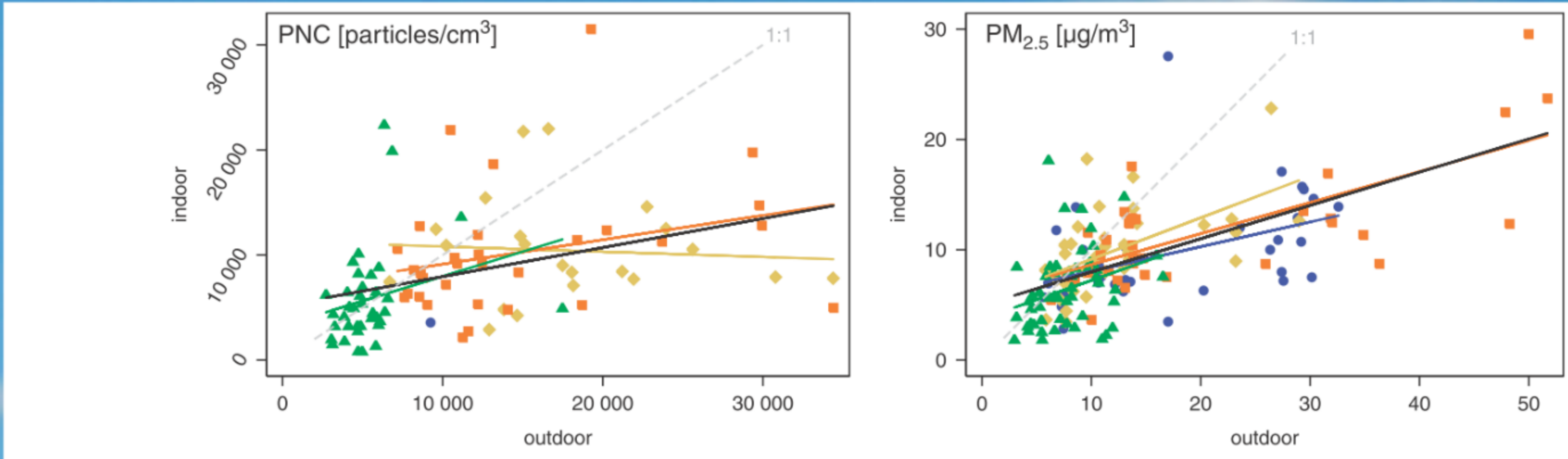
PNC has lower I/O correlation

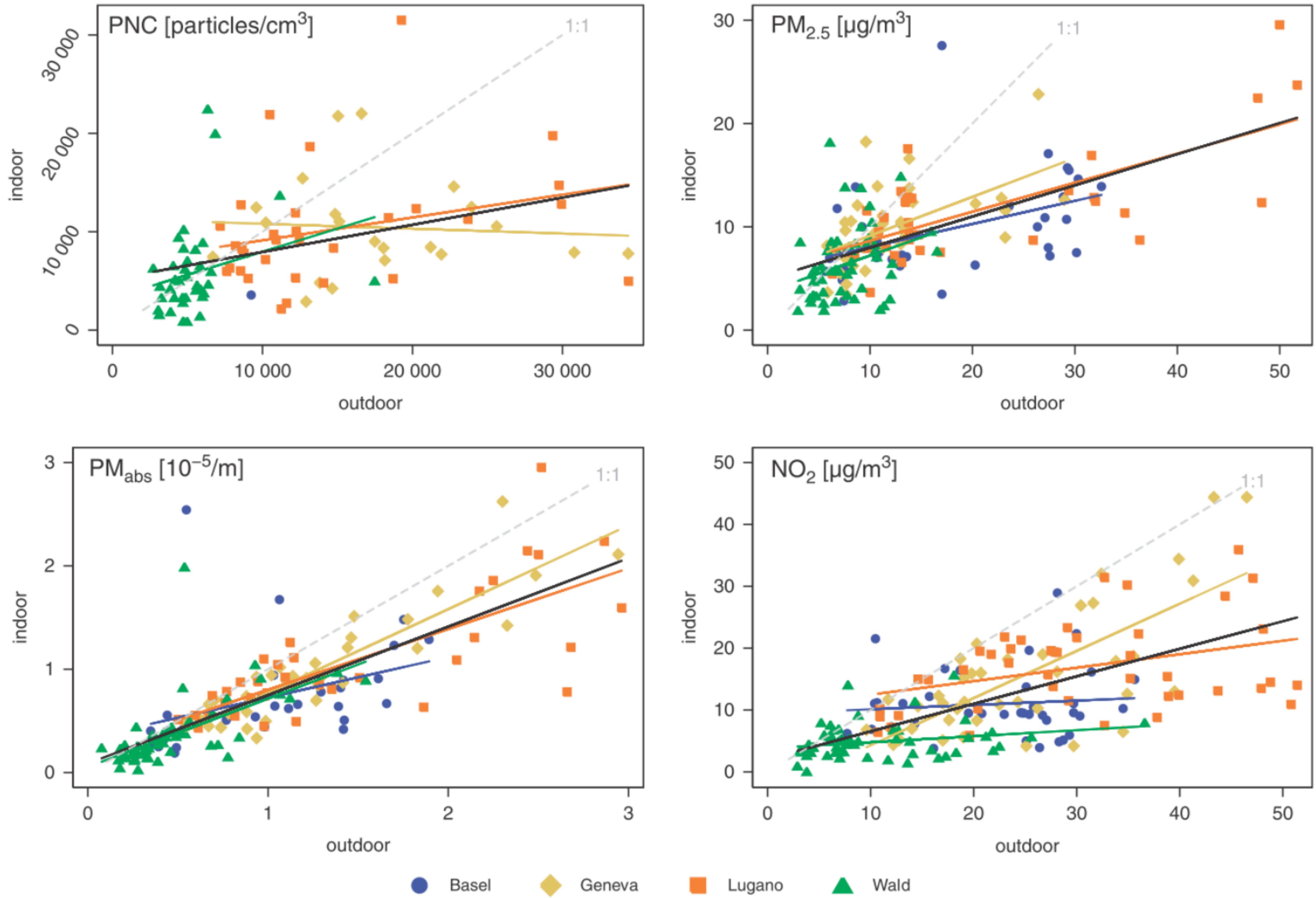


# Insight #2

- **Indoor UFP levels are (as with other pollutants) generally lower than outdoors**






atter plots of co-located indoor and outdoor levels of particle number concentration, $PM_{2.5}$, $PM_{absorbance}$ and $NO_2$ fro

# PNC has lower I/O correlation

| | Measurements without smoking influence[a] | | | |
|---|---|---|---|---|
| | N | Sites | I/O ratio median (10th; 90th percentile) | I/O Pearson correlation |
| *PNC* | | | | |
| All areas | 90 | 48 | 0.72 (0.27; 1.54) | 0.38 |
| Basel | 1 | 1 | 0.39 | |
| Geneva | 21 | 13 | 0.52 (0.26; 1.30) | −0.07 |
| Lugano | 31 | 15 | 0.70 (0.28; 1.47) | 0.29 |
| Wald | 37 | 19 | 0.98 (0.28; 2.13) | 0.26 |
| *$PM_{2.5}$* | | | | |
| All areas | 156 | 64 | 0.73 (0.37; 1.28) | 0.61 |
| Basel | 33 | 17 | 0.54 (0.29; 1.14) | 0.43 |
| Geneva | 35 | 14 | 0.86 (0.50; 1.38) | 0.57 |
| Lugano | 36 | 14 | 0.65 (0.34; 0.98) | 0.71 |
| Wald | 52 | 19 | 0.80 (0.40; 1.30) | 0.30 |
| *$PM_{10}$* | | | | |
| All areas | 155 | 64 | 0.70 (0.39; 1.34) | 0.46 |
| Basel | 32 | 17 | 0.60 (0.34; 1.15) | 0.50 |
| Geneva | 35 | 14 | 0.76 (0.49; 1.79) | 0.21 |
| Lugano | 36 | 14 | 0.58 (0.37; 0.98) | 0.62 |
| Wald | 52 | 19 | 0.76 (0.40; 1.57) | 0.24 |
| *$PM_{coarse}$* | | | | |
| All areas | 152 | 64 | 0.67 (0.20; 2.13) | 0.16 |
| Basel | 32 | 17 | 0.77 (0.27; 1.55) | 0.51 |
| Geneva | 35 | 14 | 0.71 (0.19; 2.65) | 0.00 |
| Lugano | 36 | 14 | 0.51 (0.15; 1.01) | 0.14 |
| Wald | 49 | 19 | 0.76 (0.26; 4.41) | −0.08 |
| *$PM_{absorbance}$* | | | | |
| All areas | 156 | 64 | 0.74 (0.41; 1.12) | 0.79 |
| Basel | 33 | 17 | 0.63 (0.40; 1.15) | 0.39 |
| Geneva | 35 | 14 | 0.79 (0.55; 0.99) | 0.90 |
| Lugano | 36 | 14 | 0.80 (0.45; 1.08) | 0.76 |
| Wald | 52 | 19 | 0.68 (0.37; 1.23) | 0.62 |
| *$NO_2$* | | | | |
| All areas | 175 | 66 | 0.55 (0.21; 0.99) | 0.63 |
| Basel | 37 | 17 | 0.42 (0.20; 1.03) | 0.10 |
| Geneva | 40 | 15 | 0.59 (0.30; 0.98) | 0.72 |
| Lugano | 43 | 15 | 0.64 (0.28; 0.95) | 0.36 |
| Wald | 55 | 19 | 0.54 (0.15; 1.03) | 0.24 |

# Insight #3+

- Short-term sidewalk measurements (20-30mins) appear to capture the different site types
- Basel sidewalk levels are similar between 2011 & 2014
- Sidewalk measurements are about 20% higher than at 'co-located' residences

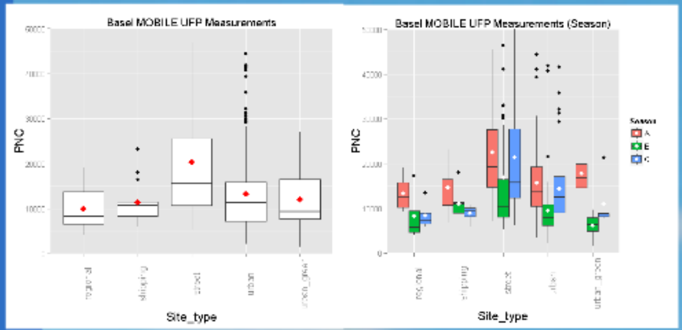
Characteristic site levels; similar levels

**Table 2**
Summary statistics for median and mean 20-min UFP measurements and total traffic counts by season and site type. The mean UFP concentration of the suburban background station, taken during the same 20-min periods, is shown in italics.

| | N | 20-min median UFP (particles cm$^{-3}$) | | | | | 20-min mean UFP (particles cm$^{-3}$) | | | | | 20-min total traffic counts | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean (SD) *suburban* | Min | 25th | 75th | Max | Mean (SD) *suburban* | Min | 25th | 75th | Max | N | Mean (SD) |
| **Site type** | | | | | | | | | | | | | |
| Street | 122 | 14,700 (9100) *12,000 (7700)* | 1600 | 7800 | 20,100 | 53,100 | 17,800 (10,500) *12,300 (7700)* | 1700 | 8700 | 24,900 | 57,500 | 124 | 101 (113) |
| Urban | 45 | 9900 (8000) *10,300 (6700)* | 1100 | 5200 | 12,100 | 30,500 | 11,300 (10,000) *10,200 (6700)* | 1600 | 5900 | 12,100 | 50,500 | 45 | 29 (34) |
| Regional | 8 | 9000 (5300) *11,400 (6000)* | 2200 | 5200 | 12,000 | 17,800 | 9800 (5700) *11,600 (6300)* | 2400 | 5300 | 14,300 | 18,000 | 9 | 5 (6) |

SD: standard deviation; Min: minimum; 25th: 25th percentile. 75th: 75th percentile; Max: Maximum.

Tri-Tabs study (2011)




Exposomics study (2014)

'Co-located' sampling between Tri-Tabs & SAPALDIA3 were highly correlated but showed >20% higher concs for the sidewalk.

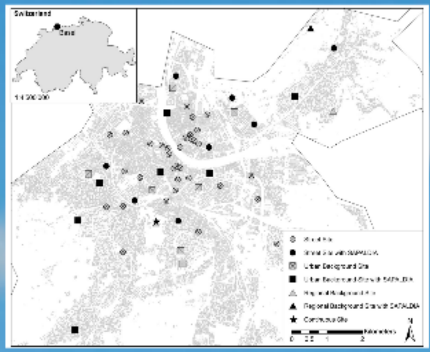
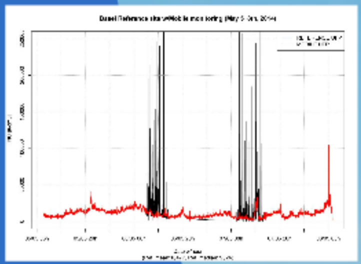



**Table 3**
Comparison of the median and mean 20-min UFP concentrations from SAPALDIA home outdoor measurements with the 20-min median and mean UFP concentrations measured on the sidewalk nearby.

| | Site type | n | SAPALDIA average (sd) | Sidewalk average (sd) | $R^2$ | Slope | Intercept (95% CI) | t-test[a] |
|---|---|---|---|---|---|---|---|---|
| Median | All | 18 | 8500 (3800) | 10,100 (4800) | 0.84 | 0.73 | 1100 (−700, 3000) | <0.01 |
| | Urban[b] | 10 | 8400 (3800) | 9400 (4900) | 0.89 | 0.73 | 1600 (−500, 3800) | 0.14 |
| | Street[b] | 6 | 8100 (3000) | 10,700 (4000) | 0.71 | 0.64 | 1300 (−5100, 7600) | 0.03 |
| Mean | All | 18 | 8700 (3600) | 11,100 (4500) | 0.78 | 0.71 | 900 (−1500, 3300) | <0.01 |
| | Urban[b] | 10 | 8700 (3700) | 10,400 (4900) | 0.88 | 0.70 | 1400 (−1000, 3900) | 0.02 |
| | Street[b] | 6 | 8200 (2700) | 11,600 (3500) | 0.47 | 0.54 | 2000 (−7500, 11,500) | 0.02 |

13 and 5 concurrent measurements were collected in spring and summer, respectively.
[a] p-value of paired t-test for the difference between sidewalk and home outdoor concentrations.
[b] Data for the two regional background sites are not shown.

*Reference Site w/ Mobile Monitoring*



Acknowle

Colleagues: Co-authors, M

- Swiss TPH

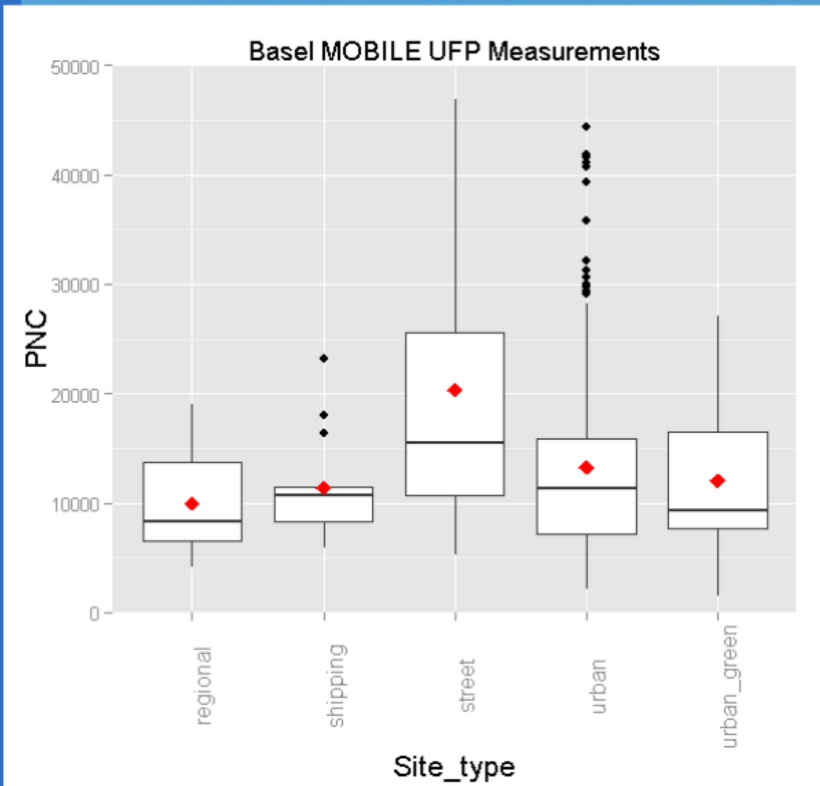
# Characteristic site levels; similar levels

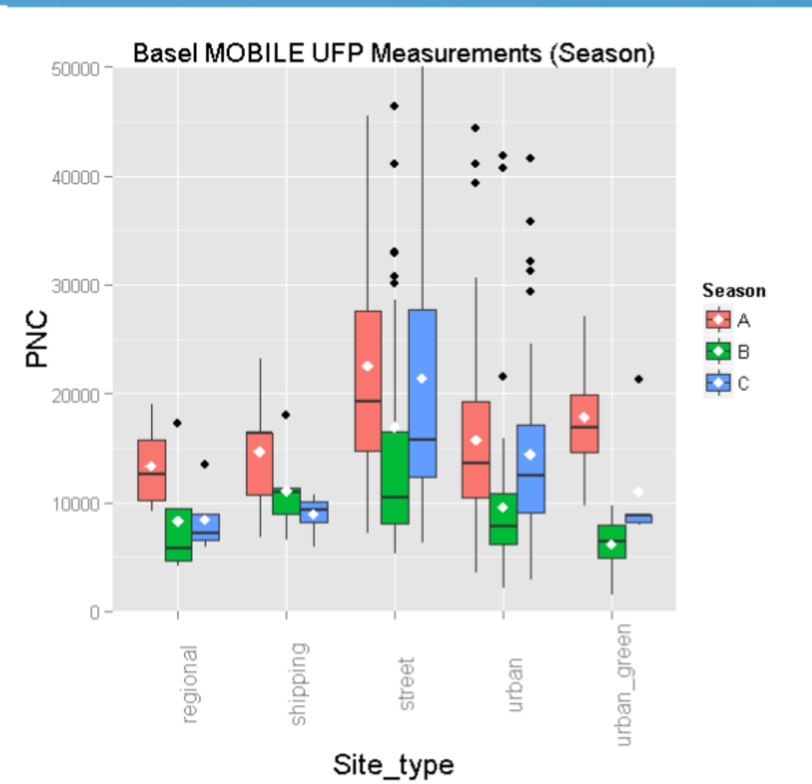
**Table 2**
Summary statistics for median and mean 20-min UFP measurements and total traffic counts by season and site type. The mean UFP concentration of the suburban background station, taken during the same 20-min periods, is shown in italics.

| | *N* | 20-min median UFP (particles cm$^{-3}$) | | | | | 20-min mean UFP (particles cm$^{-3}$) | | | | | 20-min total traffic counts | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean (SD) *suburban* | Min | 25th | 75th | Max | Mean (SD) *suburban* | Min | 25th | 75th | Max | *N* | Mean (SD) |
| **Site type** | | | | | | | | | | | | | |
| Street | 122 | 14,700 (9100) *12,000 (7700)* | 1600 | 7800 | 20,100 | 53,100 | 17,800 (10,500) *12,300 (7700)* | 1700 | 8700 | 24,900 | 57,500 | 124 | 101 (113) |
| Urban | 45 | 9900 (8600) *10,100 (6700)* | 1100 | 5200 | 12,100 | 50,500 | 11,300 (10,000) *10,200 (6700)* | 1600 | 5900 | 12,100 | 50,500 | 45 | 29 (34) |
| Regional | 8 | 9000 (5300) *11,400 (6000)* | 2200 | 5200 | 12,600 | 17,800 | 9800 (5700) *11,600 (6300)* | 2400 | 5300 | 14,300 | 18,000 | 9 | 5 (6) |

SD: standard deviation; Min: minimum; 25th: 25th percentile; 75th: 75th percentile; Max: Maximum.

Tri-Tabs study (2011)

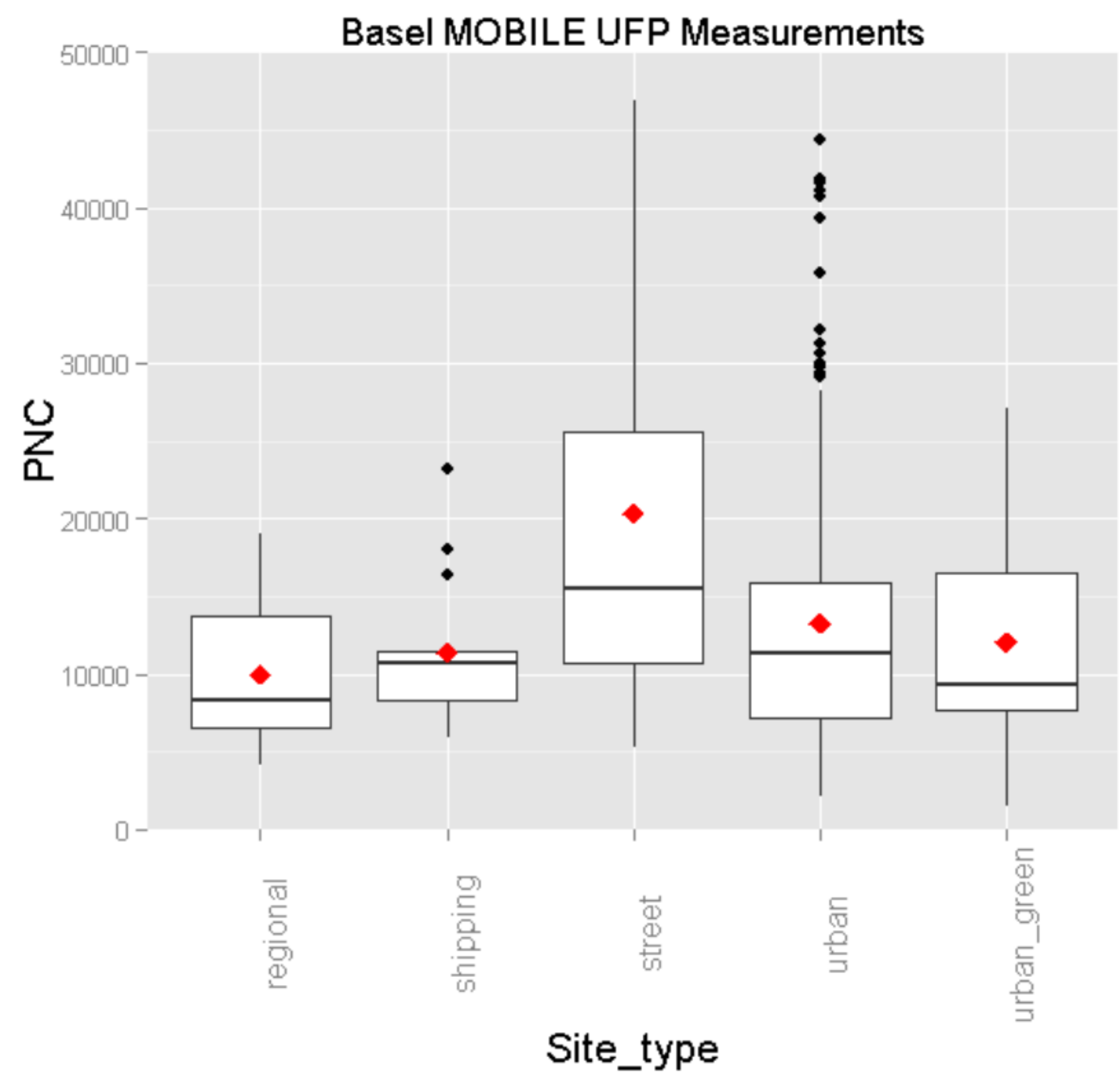


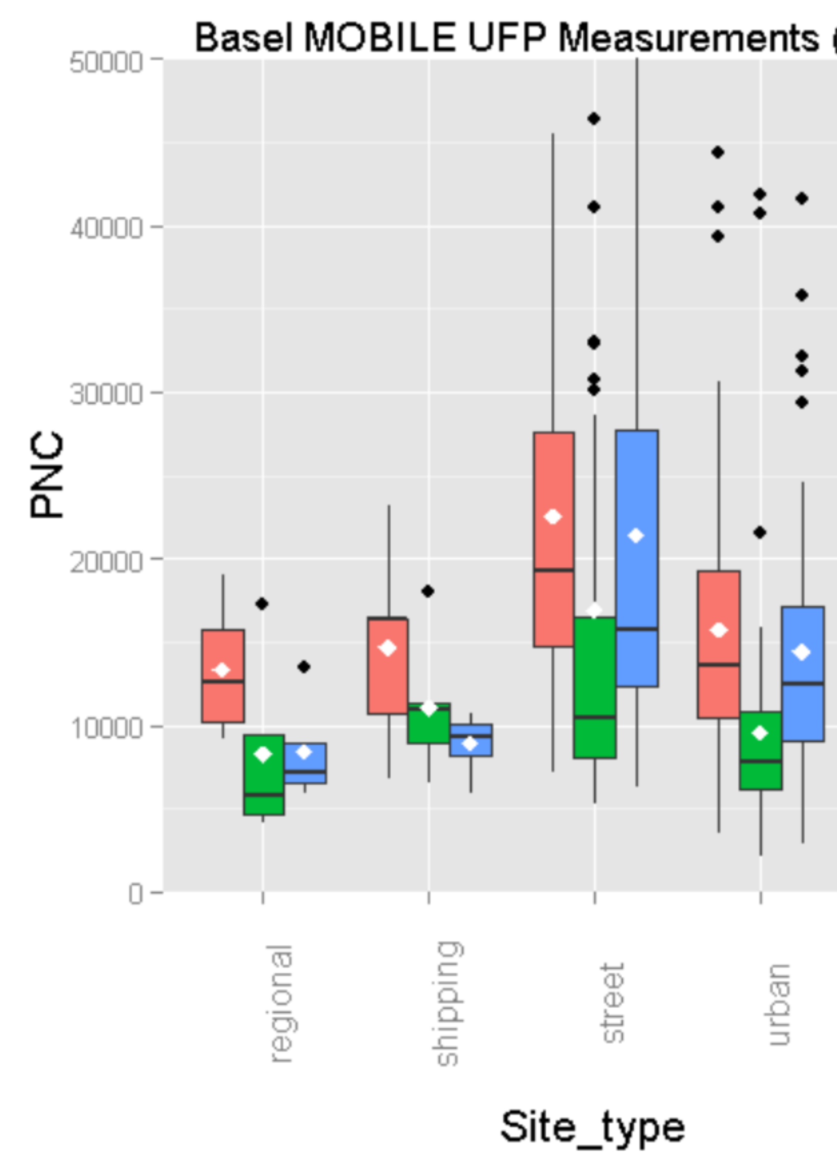




Exposomics study (2014)

| Site type | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Street | 122 | 14,700 (9100)<br>*12,000 (7700)* | 1600 | 7800 | 20,100 | 53,100 | 17,800 (10,500)<br>*12,300 (7700)* | 1700 | 8700 | 24,900 | 57,500 | 124 |
| Urban | 45 | 9900 (8600)<br>*10,100 (6700)* | 1100 | 5200 | 12,100 | 50,500 | 11,300 (10,000)<br>*10,200 (6700)* | 1600 | 5900 | 12,100 | 50,500 | 45 |
| Regional | 8 | 9000 (5300)<br>*11,400 (6000)* | 2200 | 5200 | 12,600 | 17,800 | 9800 (5700)<br>*11,600 (6300)* | 2400 | 5300 | 14,300 | 18,000 | 9 |

SD: standard deviation; Min: minimum; 25th: 25th percentile; 75th: 75th percentile; Max: Maximum.



'Co-located' sampling between Tri-Tabs & SAPALDIA3 were highly correlated but showed >20% higher concs for the sidewalk.

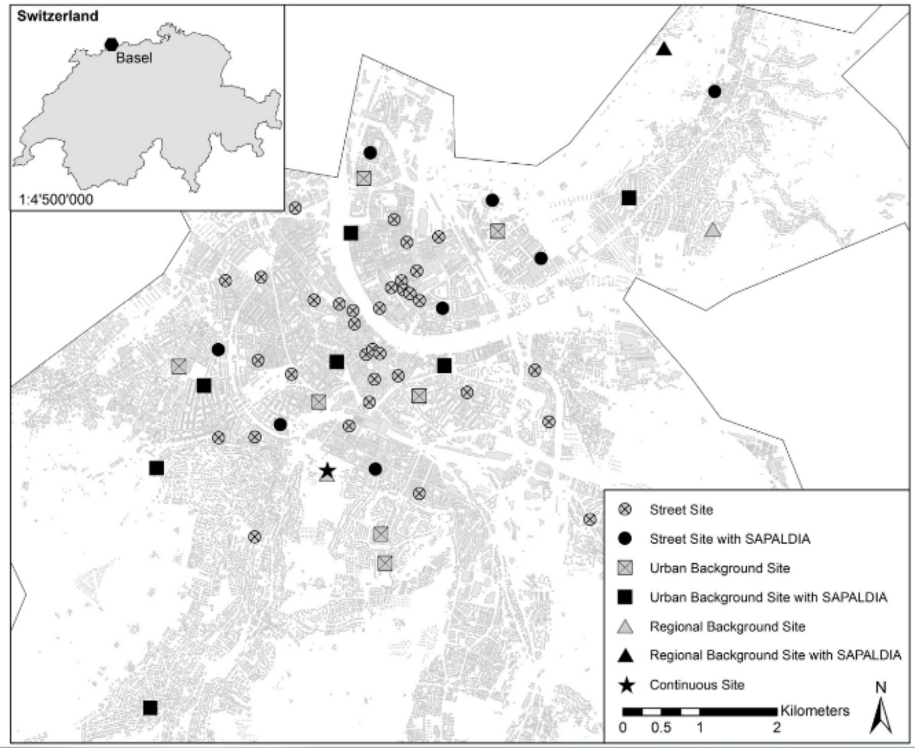



**Table 3**
Comparison of the median and mean 20-min UFP concentrations from SAPALDIA home outdoor measurements with the 20-min median and mean UFP concentrations measured on the sidewalk nearby.

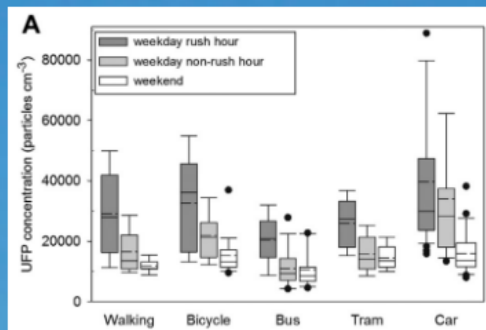
| | Site type | *n* | SAPALDIA average (sd) | Sidewalk average (sd) | $R^2$ | Slope | Intercept (95% CI) | *t*-test[a] |
|---|---|---|---|---|---|---|---|---|
| Median | All | 18 | 8500 (3800) | 10,100 (4800) | 0.84 | 0.73 | 1100 (−700, 3000) | <0.01 |
| | Urban[b] | 10 | 8400 (3800) | 9400 (4900) | 0.89 | 0.73 | 1600 (−500, 3800) | 0.14 |
| | Street[b] | 6 | 8100 (3000) | 10,700 (4000) | 0.71 | 0.64 | 1300 (−5100, 7600) | 0.03 |
| Mean | All | 18 | 8700 (3600) | 11,100 (4500) | 0.78 | 0.71 | 900 (−1500, 3300) | <0.01 |
| | Urban[b] | 10 | 8700 (3700) | 10,400 (4900) | 0.88 | 0.70 | 1400 (−1000, 3900) | 0.02 |
| | Street[b] | 6 | 8200 (2700) | 11,600 (3500) | 0.47 | 0.54 | 2000 (−7500, 11,500) | 0.02 |

13 and 5 concurrent measurements were collected in spring and summer, respectively.
[a] *p*-value of paired *t*-test for the difference between sidewalk and home outdoor concentrations.
[b] Data for the two regional background sites are not shown.

# Insight #4

- **Personal UFP measurements are less influenced by home-outdoor levels than by time-activity patterns**

TAPAS study showed large differences in exposure by different commute modes




*Winter commute: 20% of daily UFP exposure*

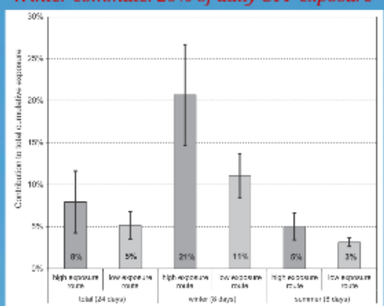
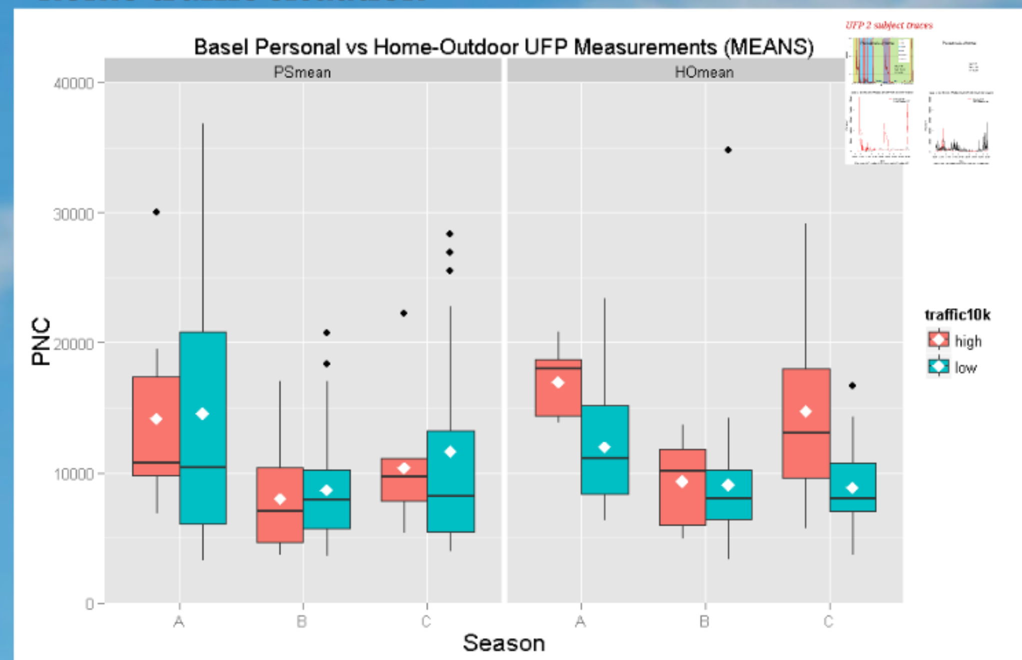
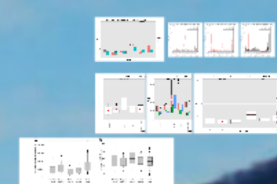



**Fig. 5.** Contribution of commute to total daily ultrafine particle number exposure. Error bars represent 95% confidence intervals derived using bootstrap with 100 replications.

Exposomics: personal not different by home traffic situation

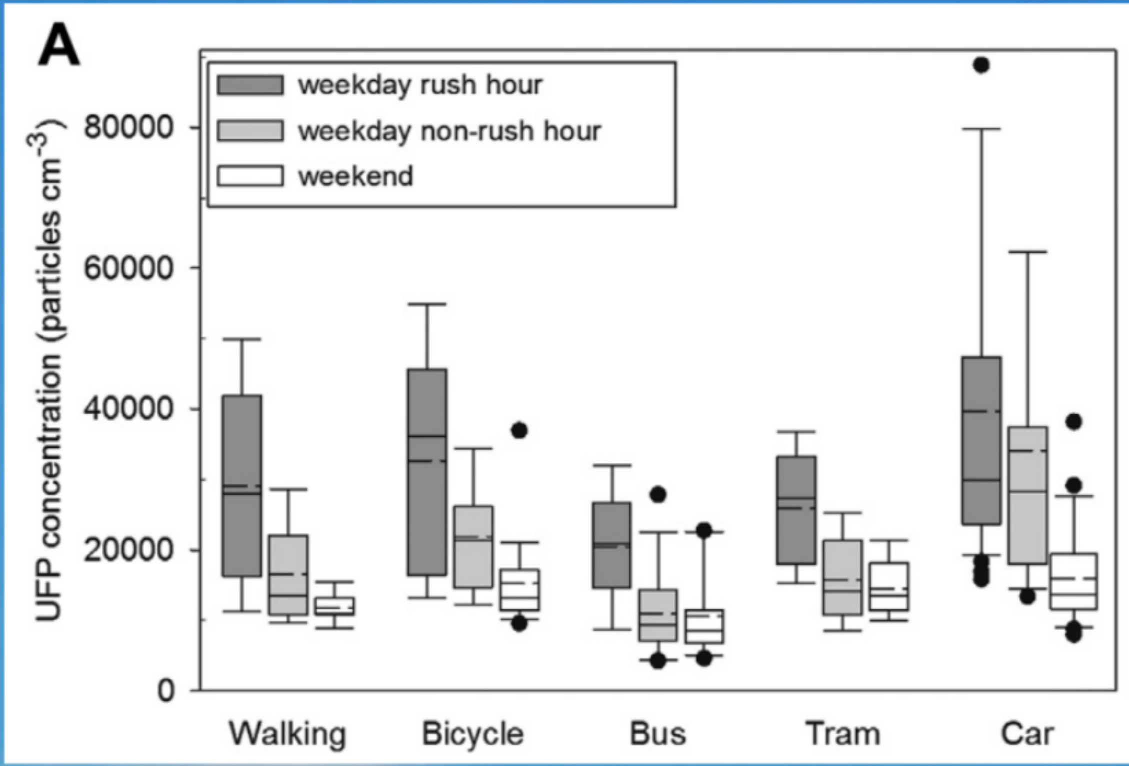


# *dgments*

anne Rutschi, Gregor Fessler, Aliocha

# TAPAS study showed large differences in exposure by different commute modes




*Winter commute: 20% of daily UFP exposure*

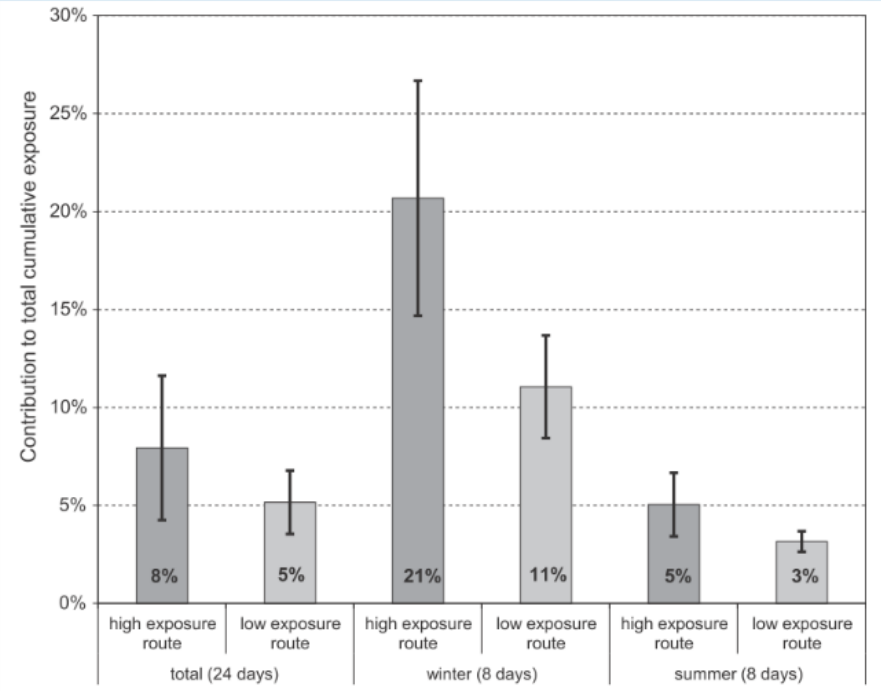
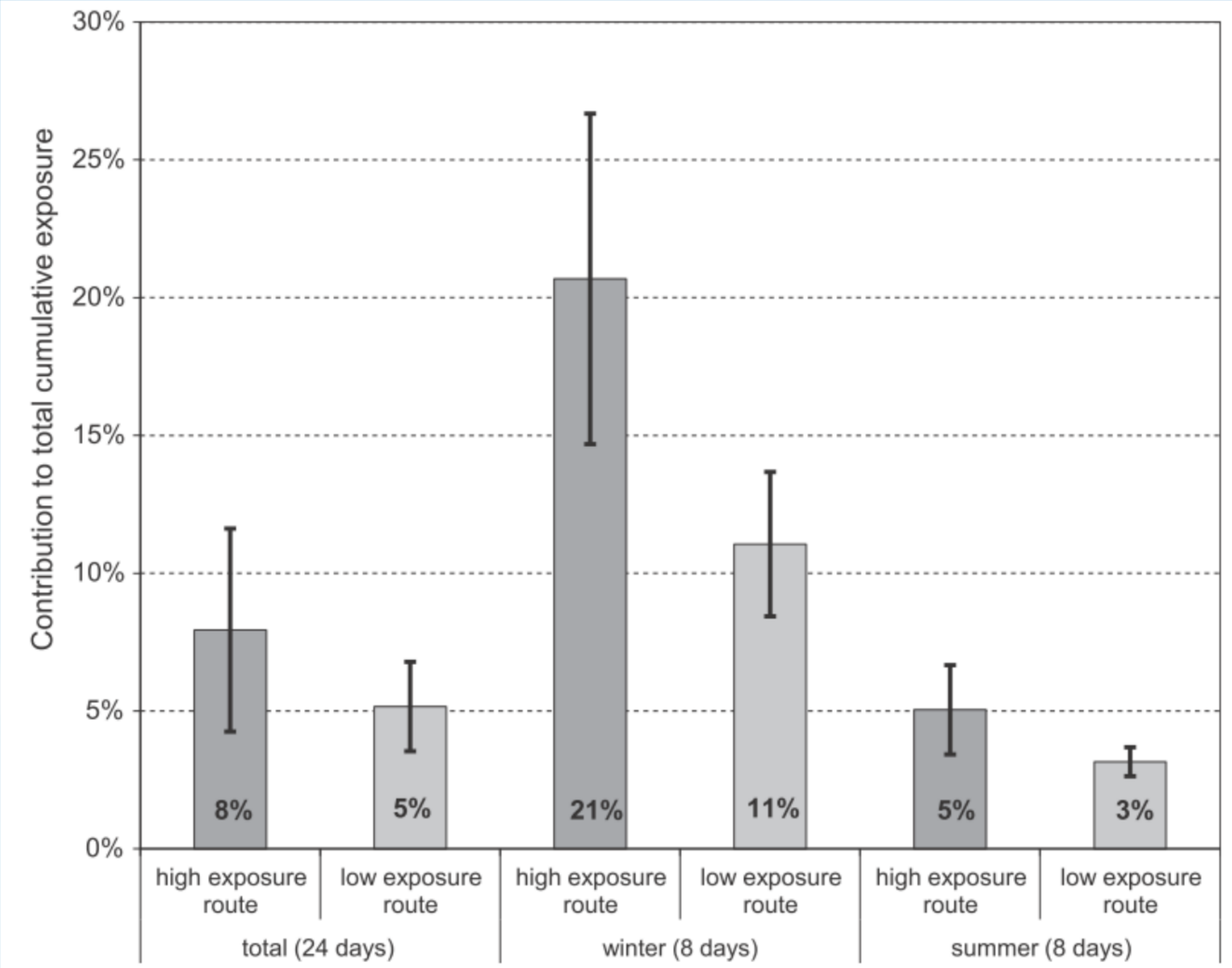
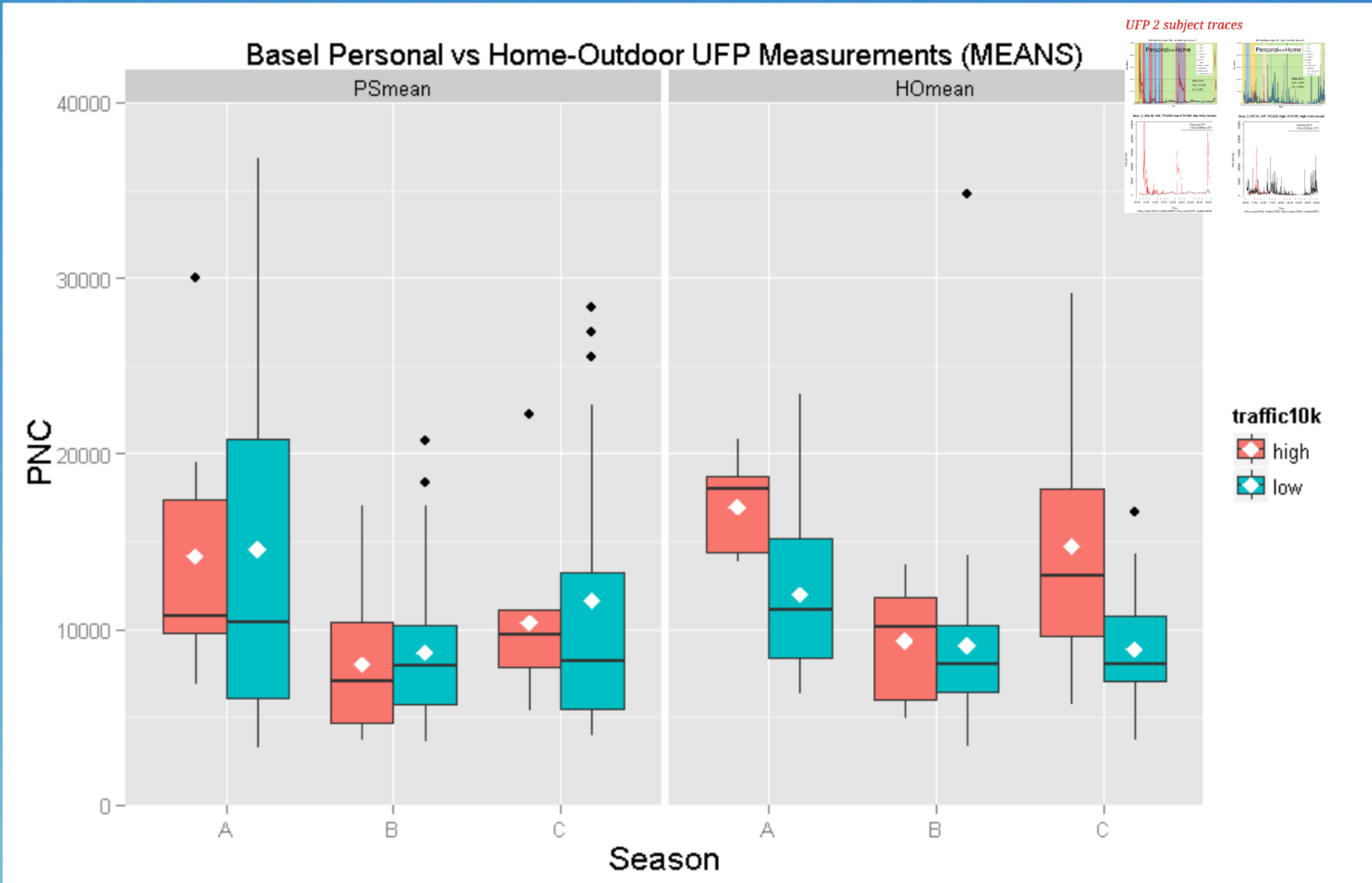



**Fig. 5.** Contribution of commute to total daily ultrafine particle number exposure. Error bars represent 95% confidence intervals derived using bootstrap with 100 replications.

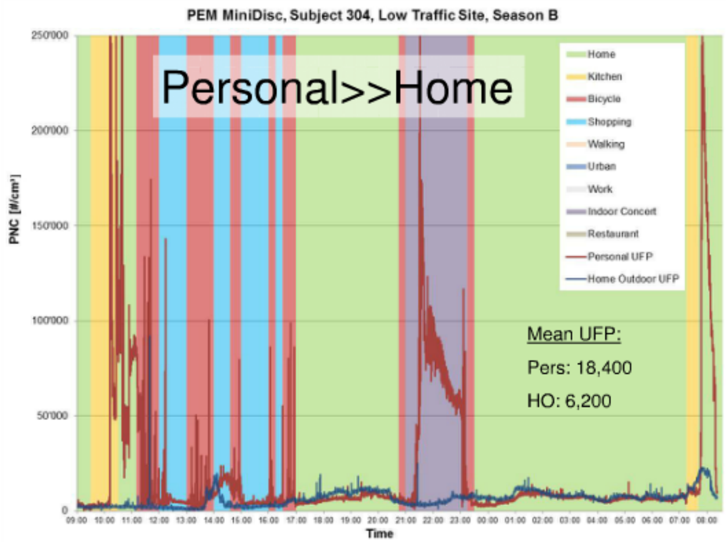
# *Winter commute: 20% of daily UFP exposure*

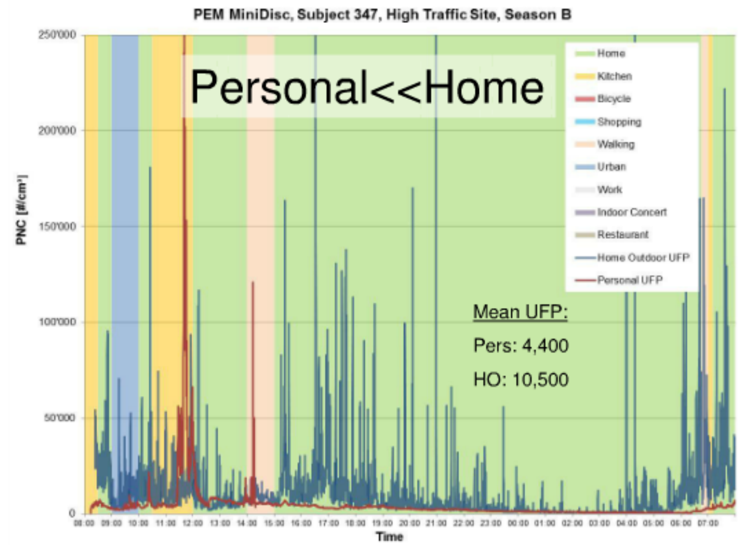


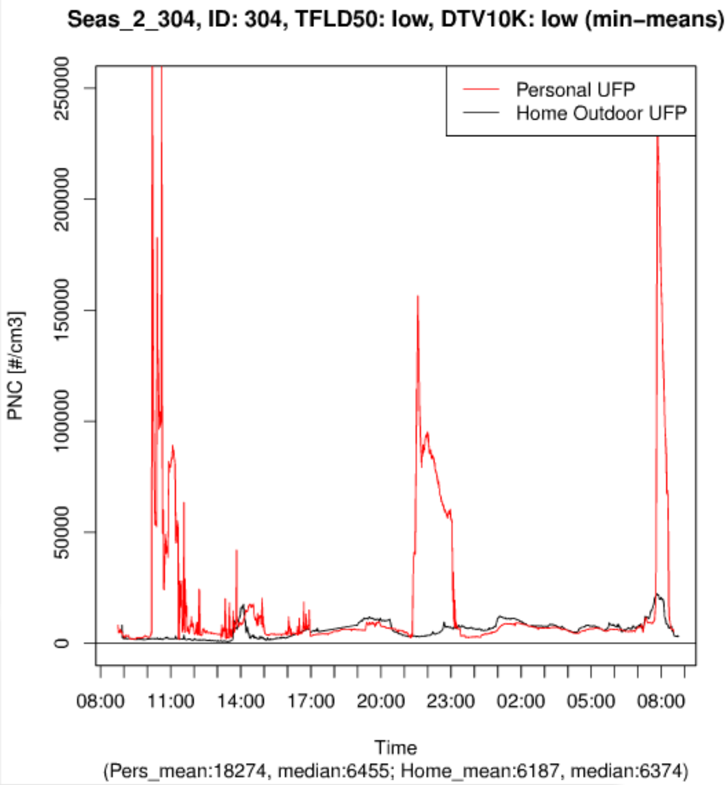
# Exposomics: personal not different by home traffic situation

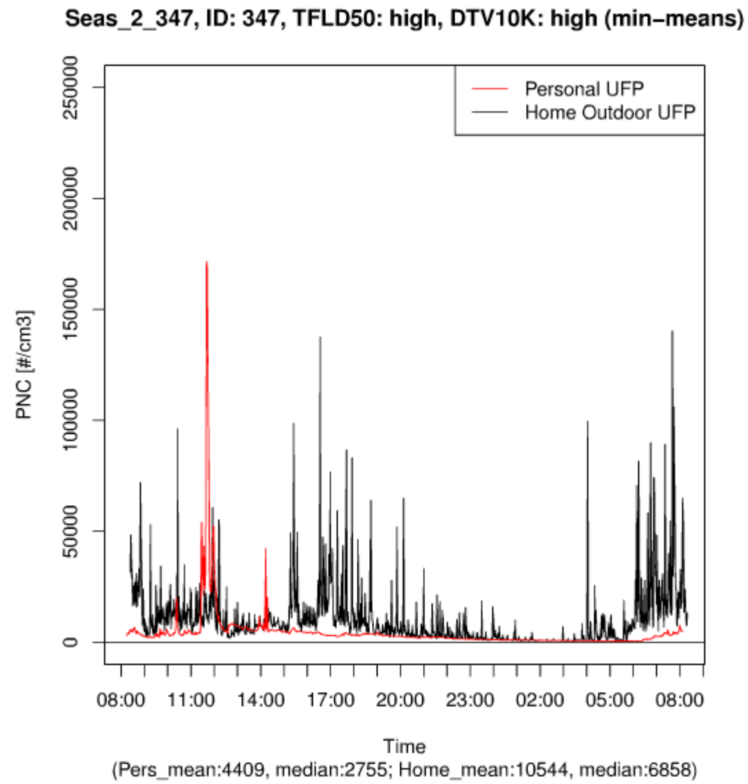


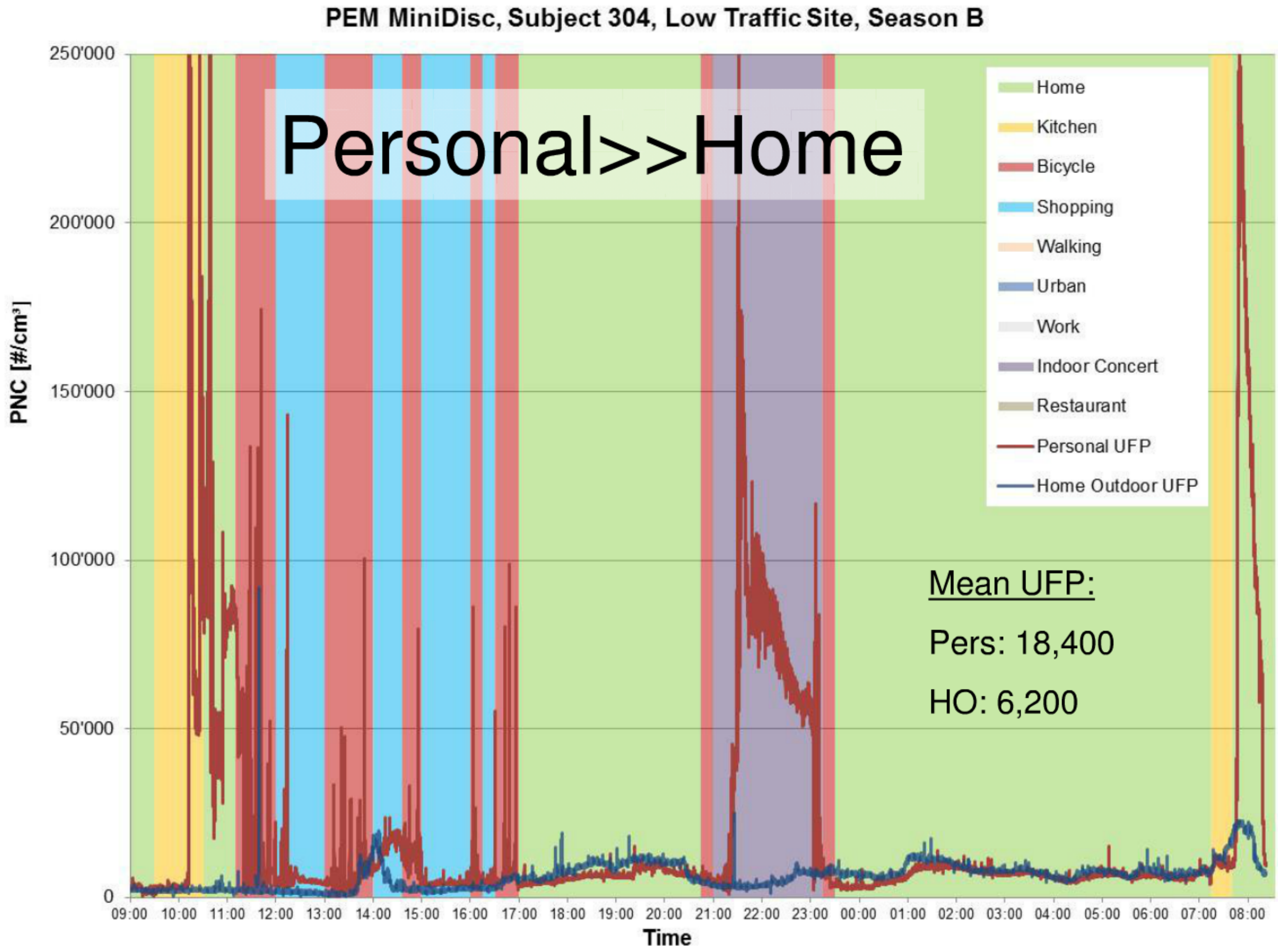
# UFP 2 subject traces

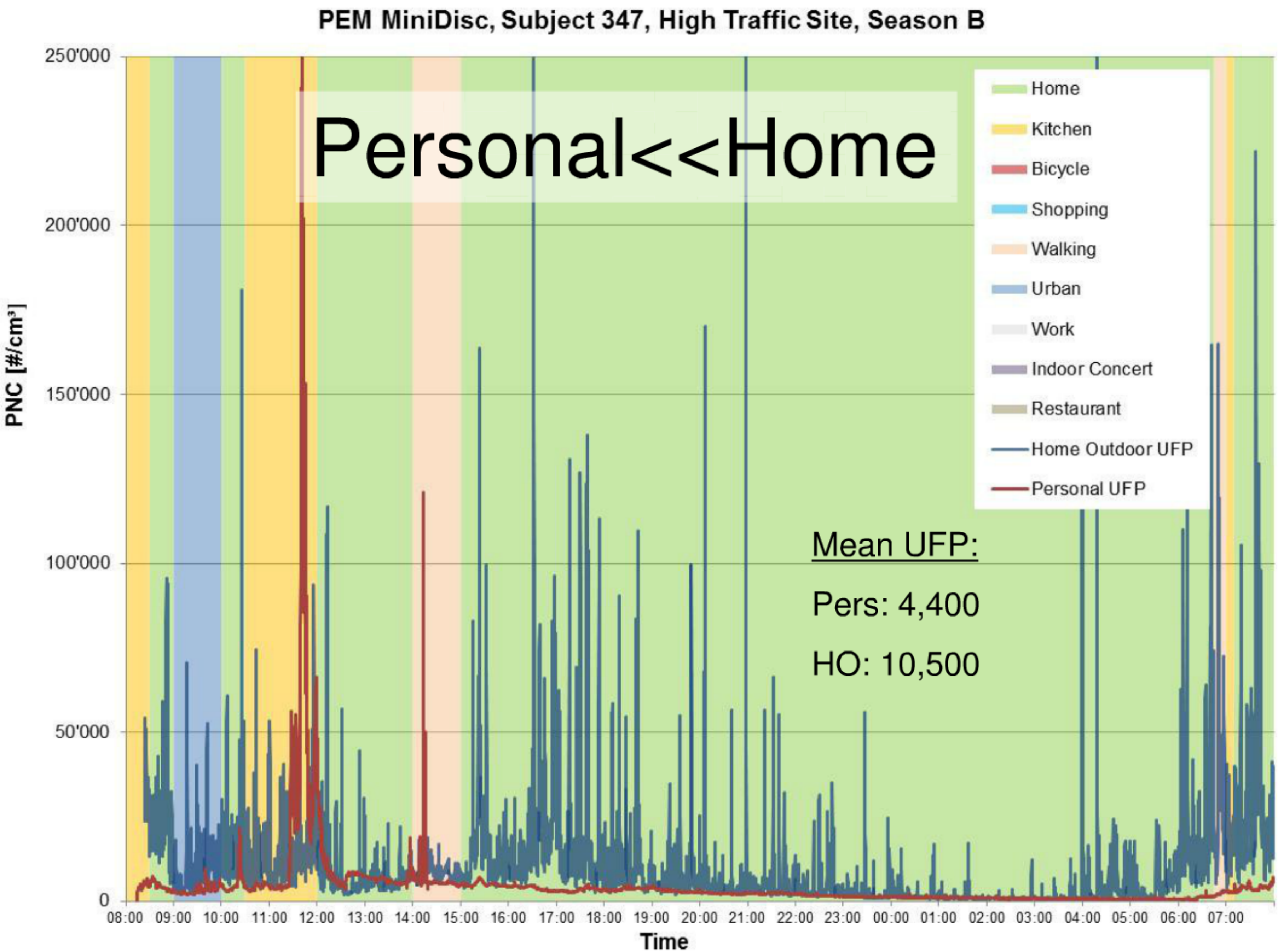



PEM MiniDisc, Subject 304, Low Traffic Site, Season B
Personal>>Home
PNC [#/cm³]
250'000
200'000
150'000
100'000
50'000
0
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
Time
Home
Kitchen
Bicycle
Shopping
Walking
Urban
Work
Indoor Concert
Restaurant
Personal UFP
Home Outdoor UFP
Mean UFP:
Pers: 18,400
HO: 6,200


PEM MiniDisc, Subject 347, High Traffic Site, Season B
Personal<<Home
Home
Kitchen
Bicycle
Shopping
Walking
Urban
Work
Indoor Concert
Restaurant
Home Outdoor UFP
Personal UFP
Mean UFP:
Pers: 4,400
HO: 10,500
PNC [#/cm³]
250'000
200'000
150'000
100'000
50'000
0
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
Time

# Next Steps

- OMICs analyses with UFP data to ID marker of exposure
  - Real-time data offers a wealth of parameters
  - will be done within a year+
- Build seasonal LUR models (EXPOsOMICs)
  - 30-min @ 160 sites * 3 seasons per area
- Explore possibilities for other UFP modelling (eg, GRAMM/GRAL)
- UFP has been characterized in 3 large Swiss cities + 1 suburb
  - but need to extend to 4 other SAPALDIA areas
  - extend nationally

# *Acknowledgments*


- Swiss TPH — Colleagues: Co-authors, Marianne Rutschi, Gregor Fessler, Aliocha Schaffner, Sivi Jeyachchandren, Helen Graf, Tobias Heckelmann, Evelyn Fischer, Kevin Estermann, Benjamin Flückiger, Susanna Nussbaumer, Andreas Schwärzler, Gregor Juretzko, Katja Stähli, Sandra Okorga
- SAPALDIA Team
- EXPOsOMICs Consortium
- BAFU - Bundesamt für Umwelt
- EMPA - Eidgenossiche Materialprüfungs-Forschungsanstalt - NABEL network
- Cantonal air monitoring agencies (LHA Beider-Basel, SP-Air Geneva, OstLuft, SP-Environment Valais, InLuft, Abteilung fuer Umwelt des Kantons Aargau, ANU-Graubuenden, SPAAS-Ticino)
- FHNW Schweiz - University of Applied Sciences
- SNF - Schweiz Nationalfonds
- EU Framework Programme 7 grant #308610


*Thank you for your attention!*

# Insights into the Spatial and Temporal Distribution of UFP from Swiss Health Studies


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

Ming-Yi Tsai, Reto Meier, Marloes Eeftens, Medea Imboden, Inmaculada Aguilera, Alex Ineichen, Mark Davey, Martin Fierz, Regina Ducret-Stich, Martina Ragettli, Christian Schindler, Harish Phuleria, Nino Künzli, Nicole Probst-Hensch

*contact: m.tsai@unibas.ch*


# Questions?

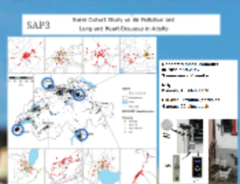
## The Studies in brief

Nearly all our work is done with Martin Fierz's MiniDisc
- Studies done at cohort subjects' homes (24-hr, 1-2weeks)
- Personal measurements (24-hr)
- "Mobile Measurements" (20-30mins) on sidewalks
- Different commute modes

Much higher levels in Geneva & Lugano
Highest in winter, generally lowest in summer

### The SAPALDIA study

SAPALDIA3: Home-Outdoor & Home-Indoor measurements



### TRITABS & TAPAS study

"Mobile" and Personal measurements

### EXPOsOMICS study

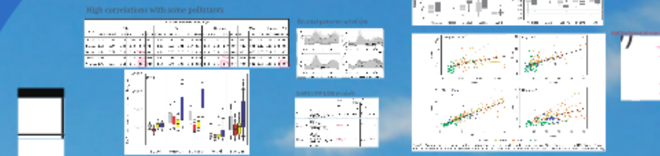
Personal, Home-outdoor, & "Mobile" measurements

## Several Insights

**Insight #1** (point of view of exposure measurements)
- UFP as a pollutant is not as different (spatially & temporally) from other pollutants as one would first expect
  - seasonally higher in winter vs summer
  - expected diurnal pattern
  - longer-term levels can be well modelled (LUR)

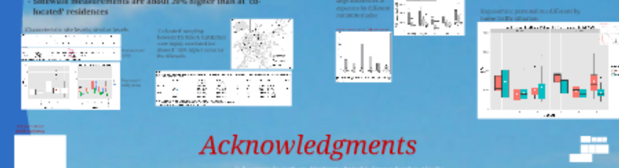
High correlations with some pollutants

**Insight #2**
- Indoor UFP levels are (as with other pollutants) generally lower than outdoors



**Insight #3:**
- Short-term sidewalk measurements (20-30mins) appear to capture the different site types
- Basel sidewalk levels are similar between 2011 & 2014
- Sidewalk measurements are about 20% higher than at 'co-located' residences

**Insight #4**
- Personal UFP measurements are less influenced by home-outdoor levels than by time-activity patterns



### Next Steps

- OMICs analyses with UFP data to ID marker of exposure
  - Real-time data offers a wealth of parameters
  - will be done within a year+
- Build seasonal LUR models (EXPOsOMICs)
  - 30-min @ 160 sites * 3 seasons per area
- Explore possibilities for other UFP modelling (eg, GRAMM/GRAL)
- UFP has been characterized in 3 large Swiss cities + 1 suburb
  - but need to extend to 4 other SAPALDIA areas
  - extend nationally


### *Acknowledgments*

- Swiss TPH
- SAPALDIA Team
- EXPOsOMICs Consortium
- BAFU - Bundesamt für Umwelt
- EMPA - Eidgenossiche Materialprüfungs-Forschungsanstalt - NABEL network
- Cantonal air monitoring agencies (LHA Beider-Basel, SP-Air Geneva, OstLuft, SP-Environment Valais, InLuft, Abteilung fuer Umwelt des Kantons Aargau, ANU-Graubuenden, SPAAS-Ticino)
- FHNW Schweiz - University of Applied Sciences
- SNF - Schweiz Nationalfonds
- EU Framework Programme 7 grant #308610


*Thank you for your attention!*

*Key is the delivery of the most important results where indeed the key points of the METHODS will easily be popping up and understood: e.g. " the seasonaly adjusted long-term means of UFP home outdoor were stongly predicted by X.... and well correlated with the means of PM10".... or "from the parallel indoor/outdoor campaigns we conclude..... "*