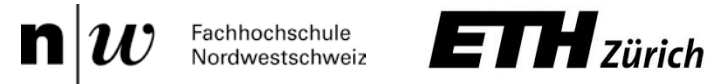


Willkommen
Welcome
Bienvenue



Modelling Ultrafine Particle Number Concentration in Zurich with High Spatio-Temporal Resolution

18th ETH-Conference on Combustion Generated Nanoparticles. June 24, 2014.

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¹Empa, Swiss Federal Laboratories for Materials Science and Technology, Duebendorf, Switzerland.

²ETH Zurich, Computer Engineering and Networks Laboratory, Zurich, Switzerland.

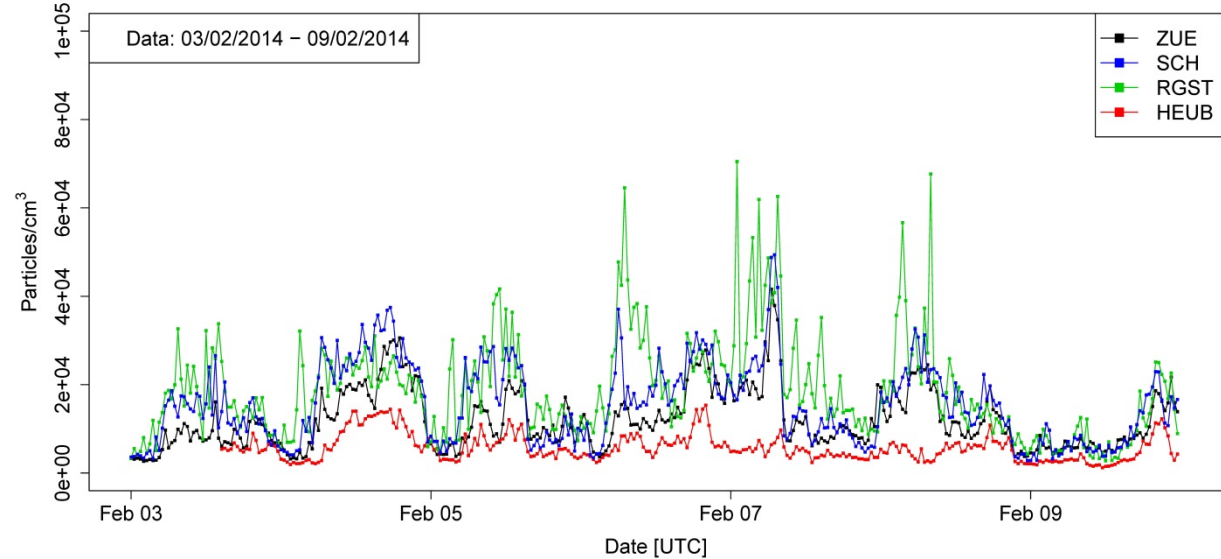
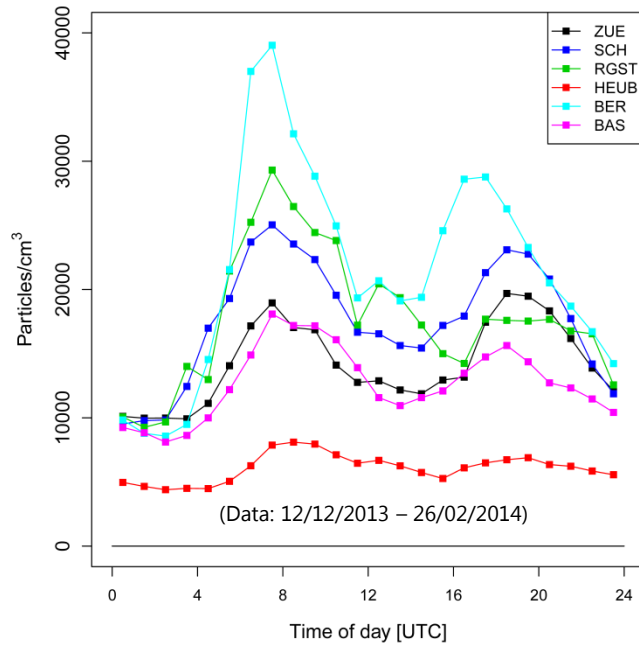
³University of Applied Sciences and Arts Northwestern Switzerland, Windisch, Switzerland.



Ultrafine particle (UFP) number concentration in Zurich

Averaged data, weekdays

30 minutes mean PNC



City of Zurich

Bern-Bollwerk

Basel-Binningen



(~1 month of data)

(UGZ)

(~1 month of data)

(NABEL)

(NABEL)

Ultrafine particles (UFP)

- Diameter < 0.1 μm
- Main emission source: road traffic (urban environments, Switzerland)
- UFP in ambient air are a potential risk to human health

Application fields of highly resolved pollutant concentration maps

- ❖ Investigation of health effects related to air pollutants
 - Improvement of the accuracy of personal exposure estimates
- ❖ Urban management and health protection
 - Impact assessment of traffic management on air quality
 - Settlement development, land-use planning

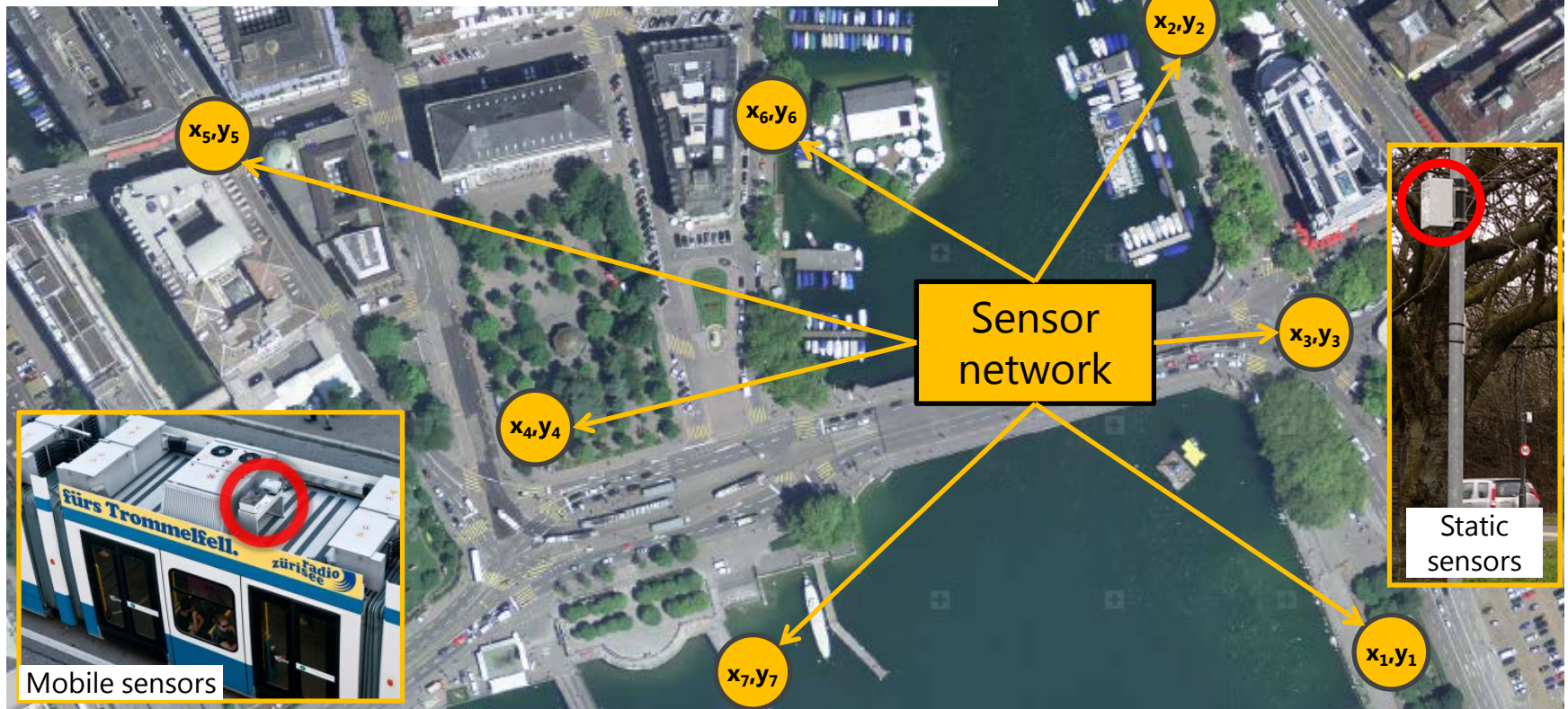
Statistical Modelling

$$P(x, y) = s_1(\text{geo}_1(x, y)) + s_2(\text{geo}_2(x, y)) + \dots + \varepsilon$$

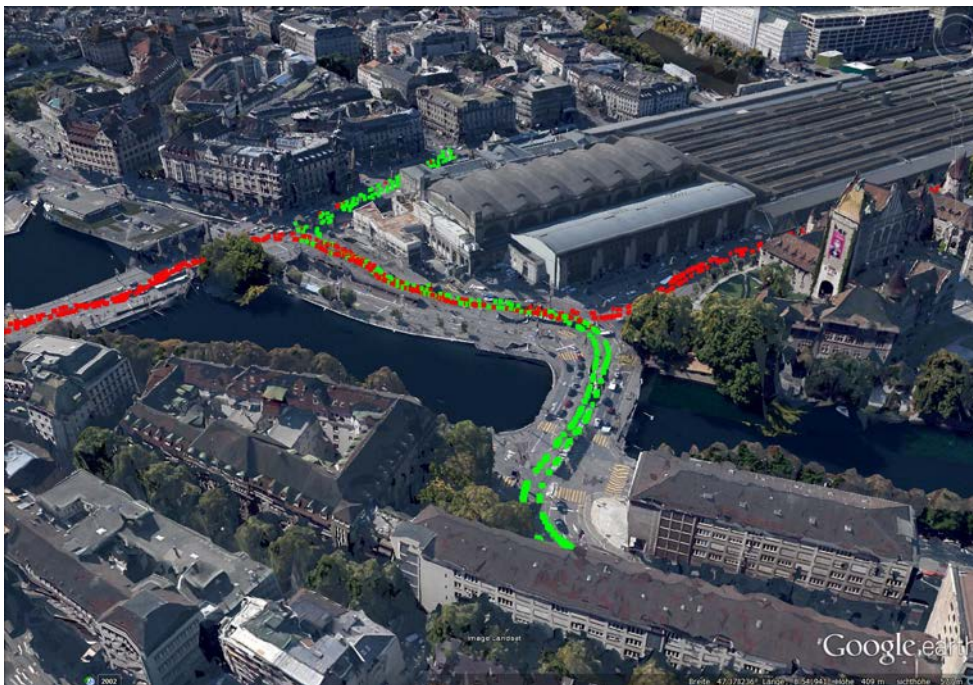
P: Pollutant concentration
s_i: Smooth non-parametric functions
(Generalized Additive Model, GAM)
geo_i: Explanatory variables
ε: Error
x, y: Coordinates

Spatial information

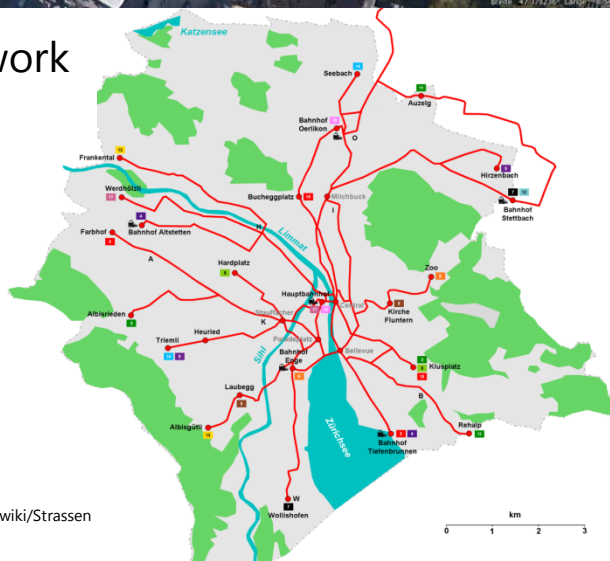
- Traffic
- Building density
- Heating systems
- Elevation
- etc.



OpenSense Mobile Sensor Network



Tram network in Zurich



Source:
http://de.wikipedia.org/wiki/Strassenbahn_Z%C3%BCrich

Sensor boxes on top of 10 trams

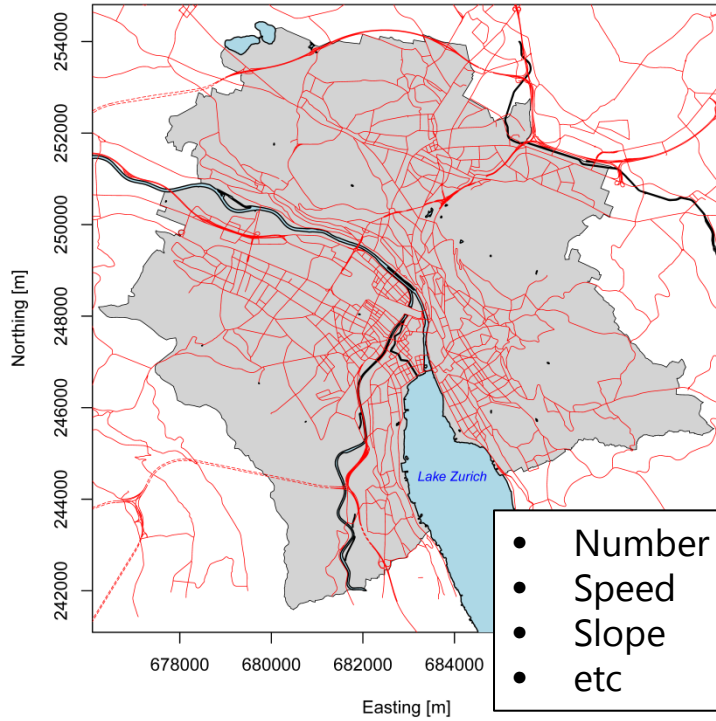
- Particles number concentration
- Ozone
- Temperature
- Humidity
- Position (GPS)



MiniDiSC device

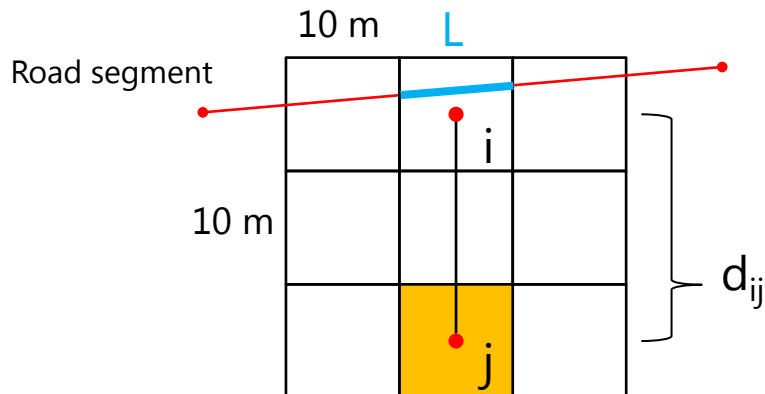
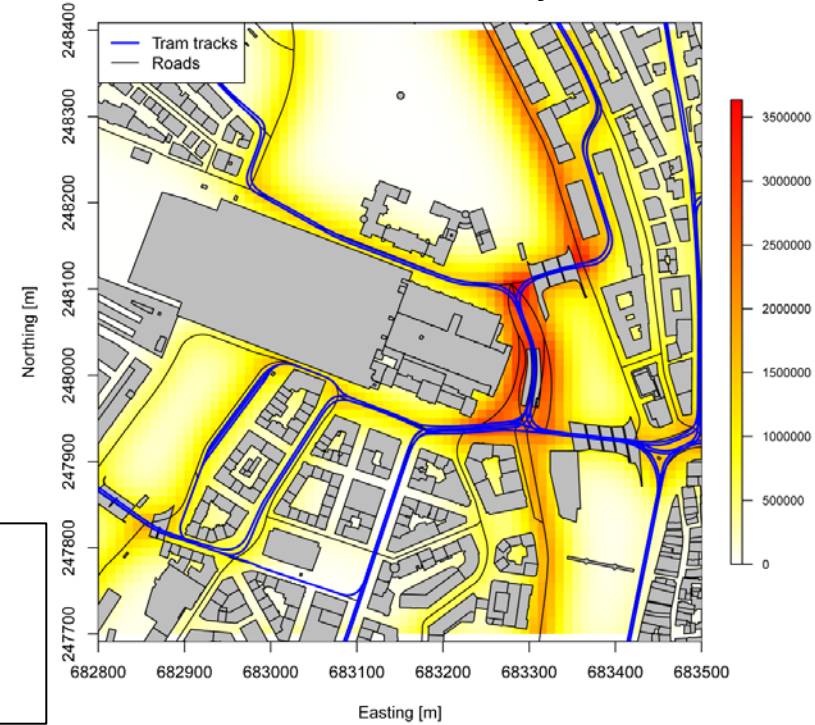
Representation of traffic

Road network



- Number of vehicles / day [Q]
- Speed
- Slope
- etc

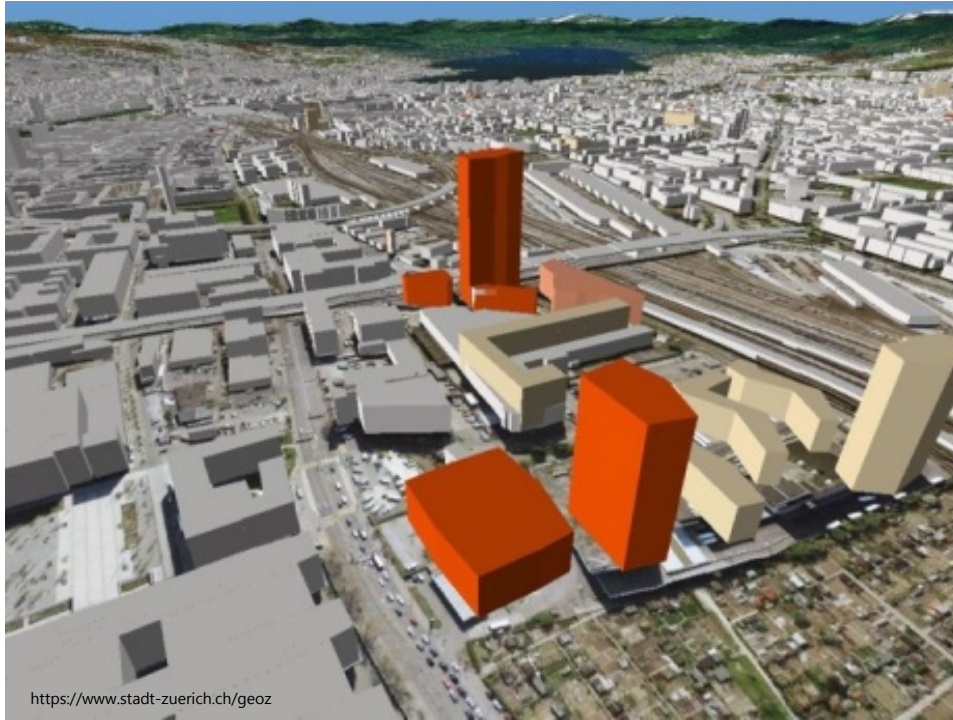
Traffic intensity



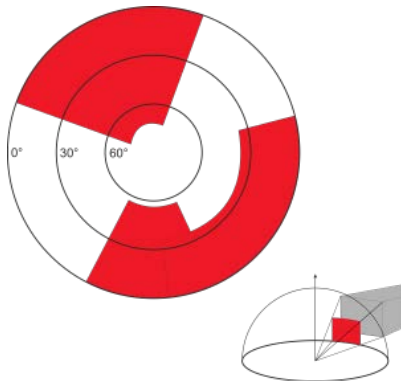
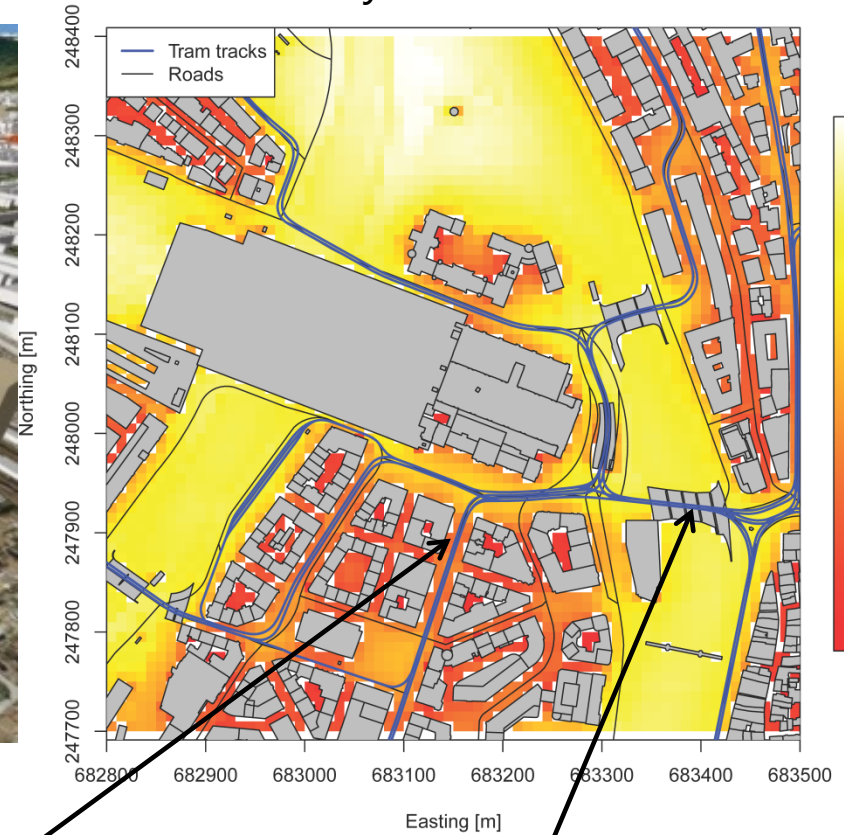
Weighting function

$$T_j = \sum_{i=1}^n Q_i e^{-\frac{d_{ij}}{d_0}}$$

Representation of the built environment



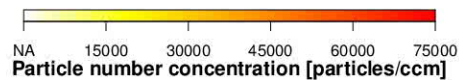
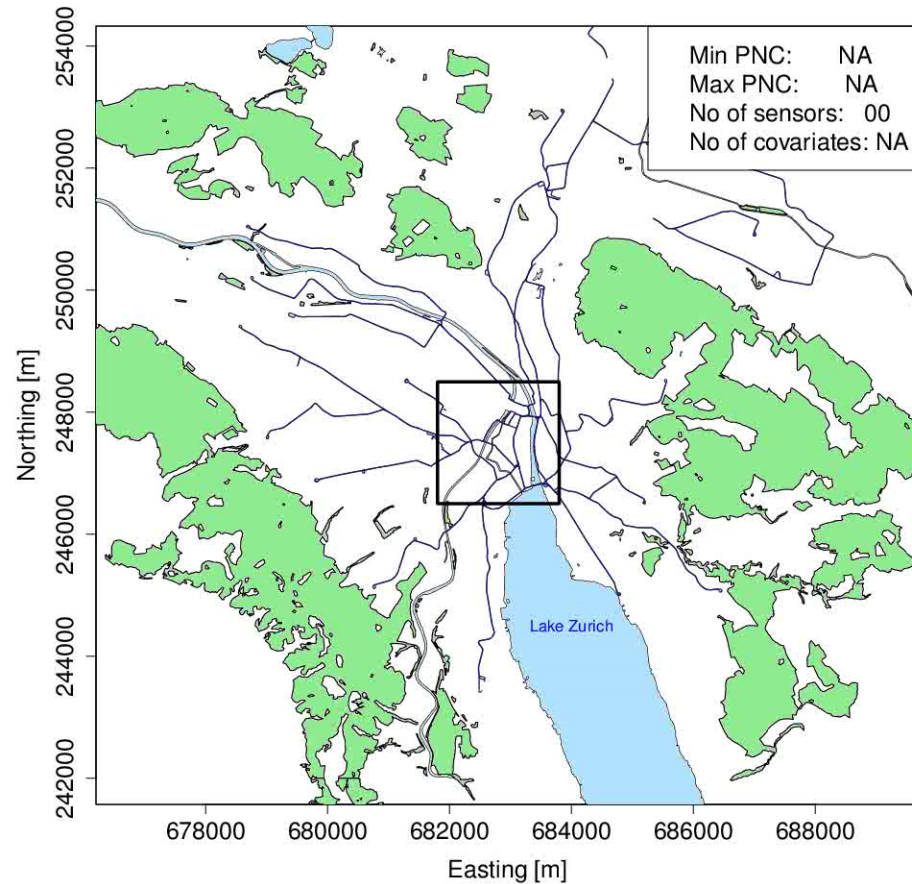
Sky view factors



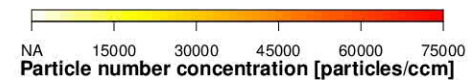
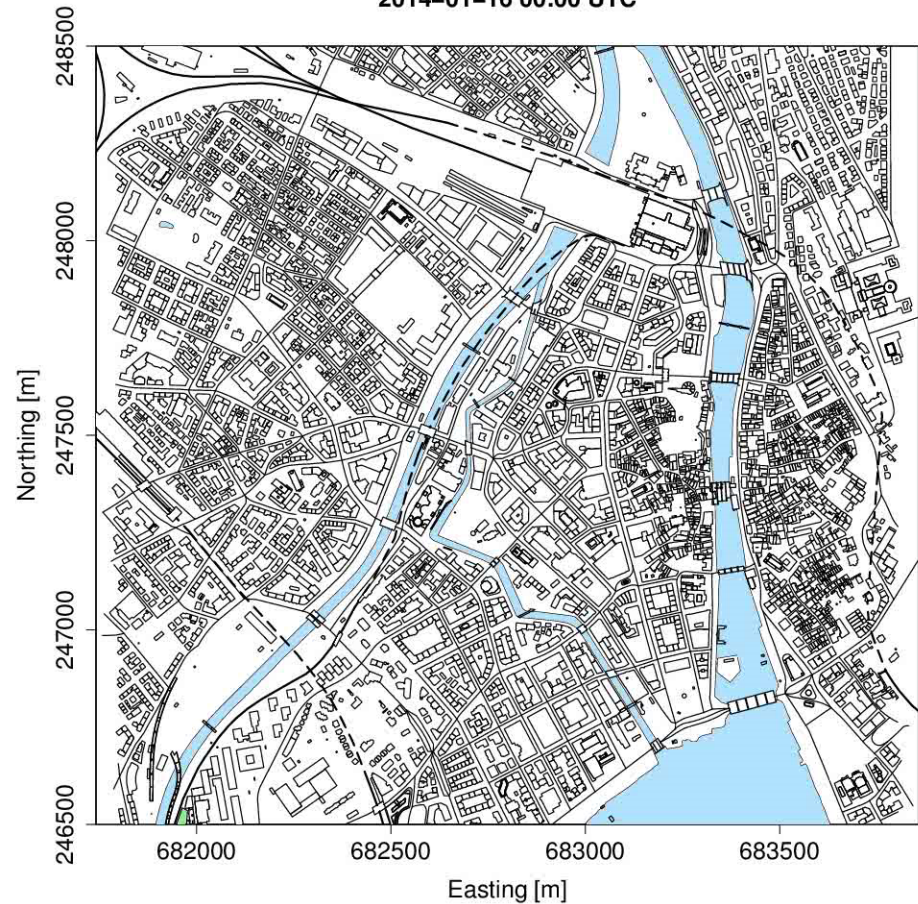
UFP Maps

(Temporal resolution: 30 min)

2014-01-16 00:00 UTC

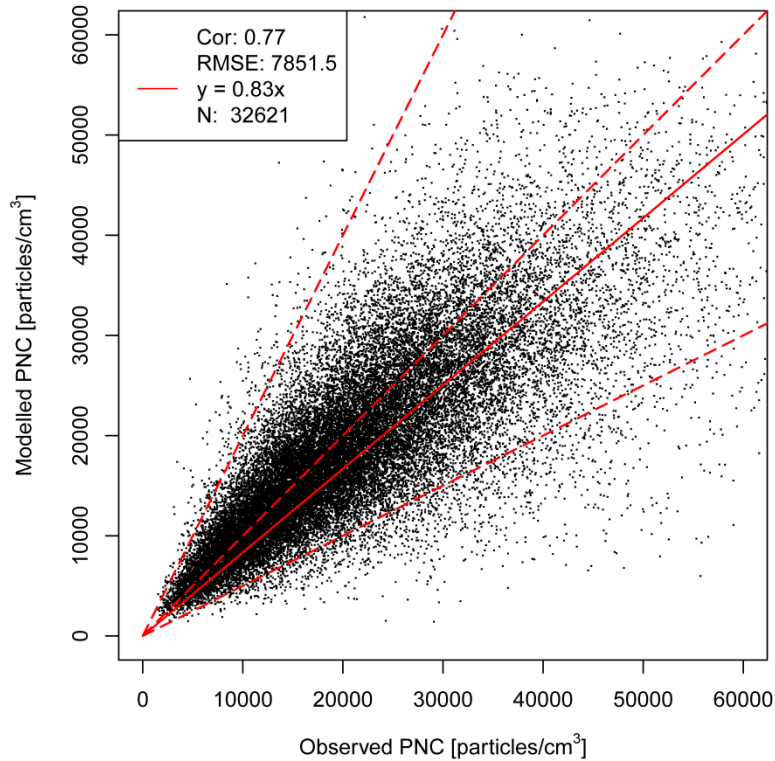


2014-01-16 00:00 UTC

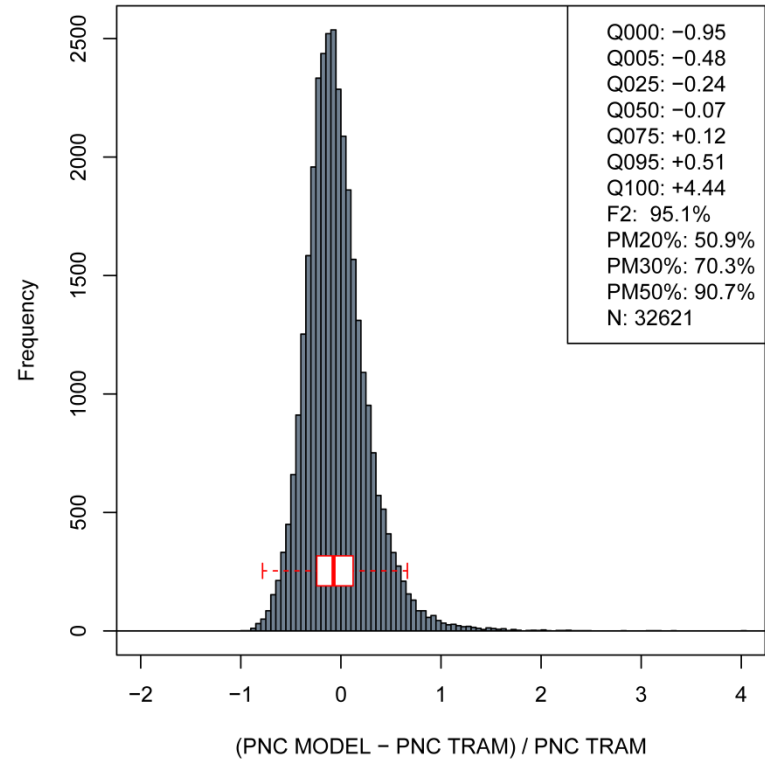


Cross-validation («Leave-one-out»)

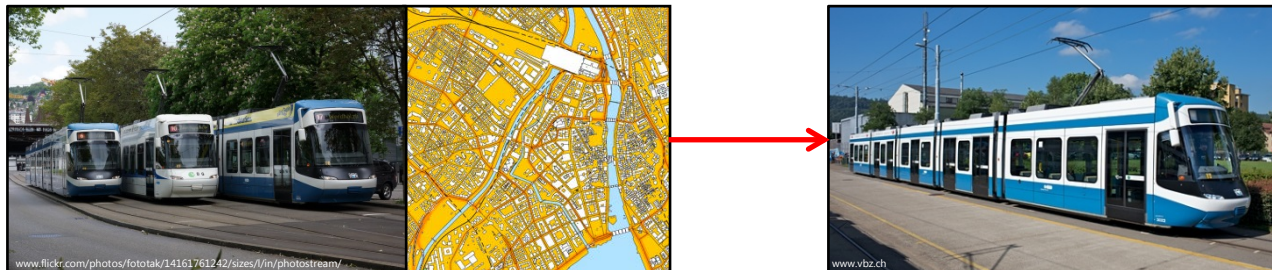
Leave-One-Out Cross-Validation



Leave-One-Out Cross-Validation



PNC: Mean PNC in a 15 min interval with at least 120 observations.

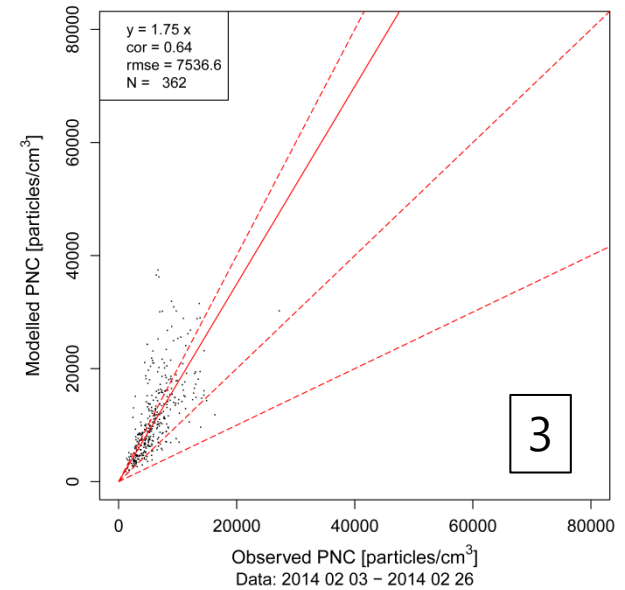
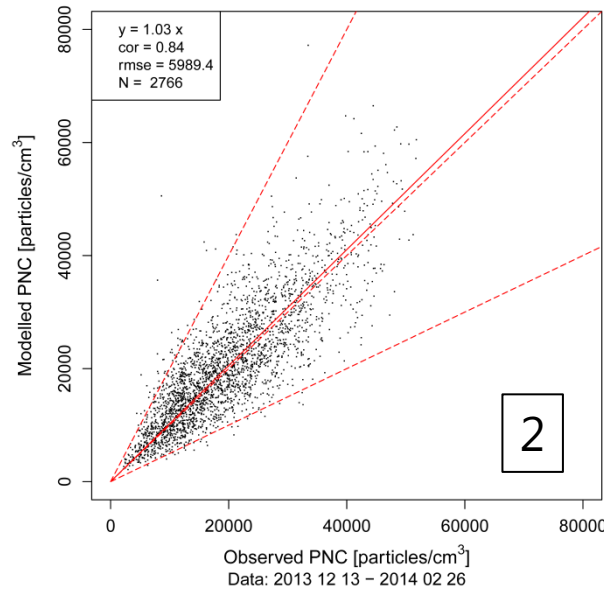
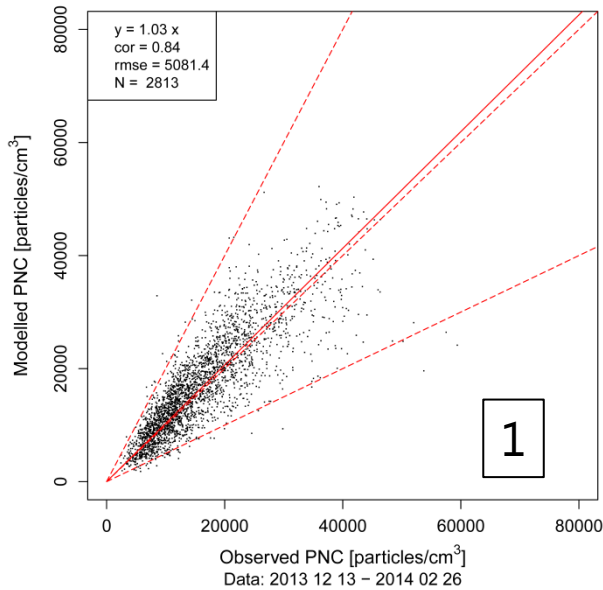


Comparison with measurements of permanent sites

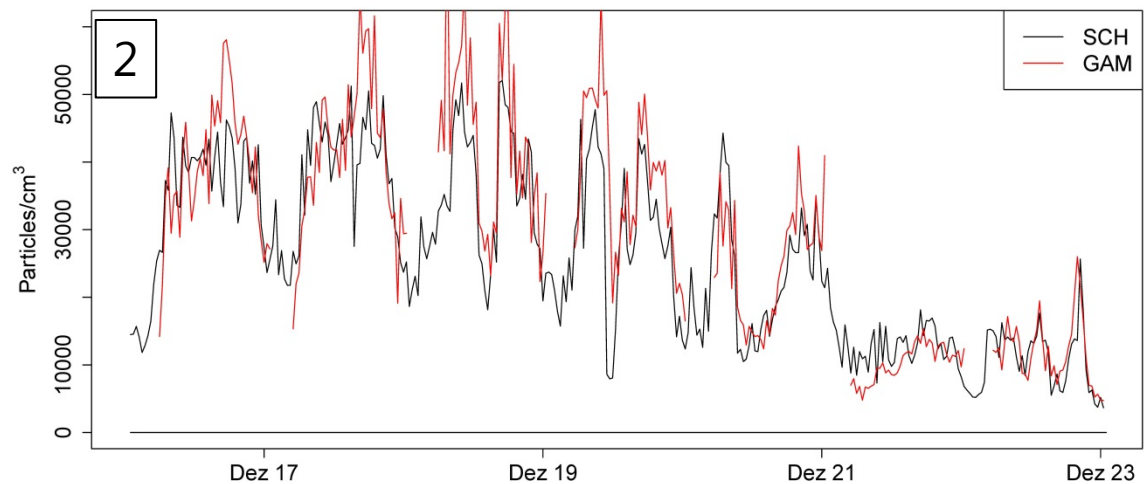
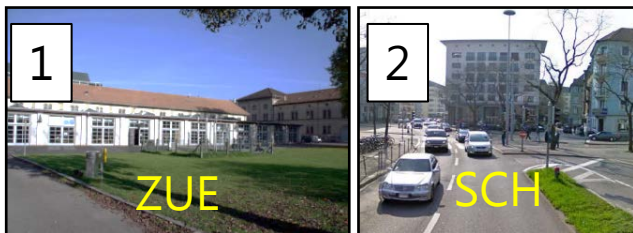
ZUE

SCH

HEUB

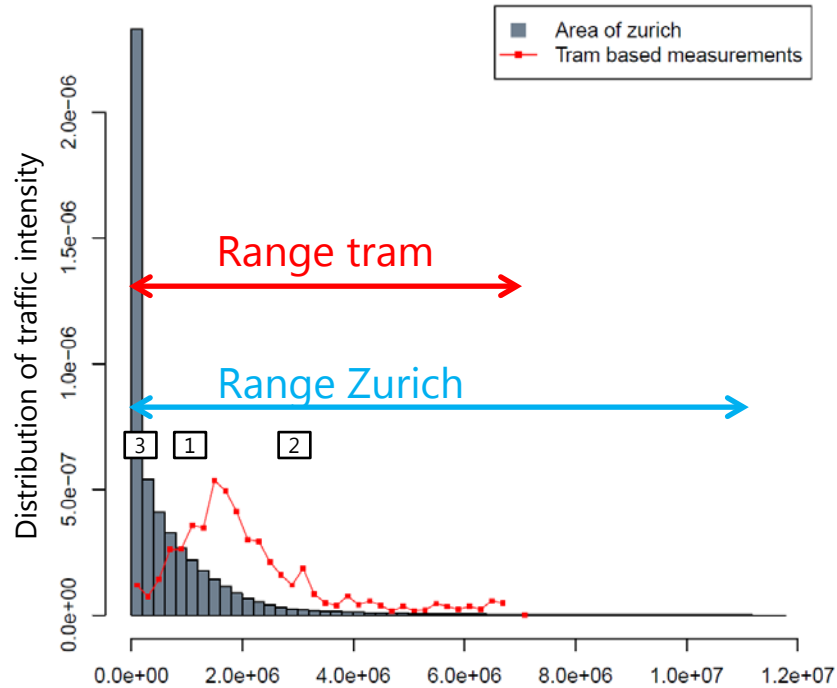


2013/12/16 - 2013/12/22

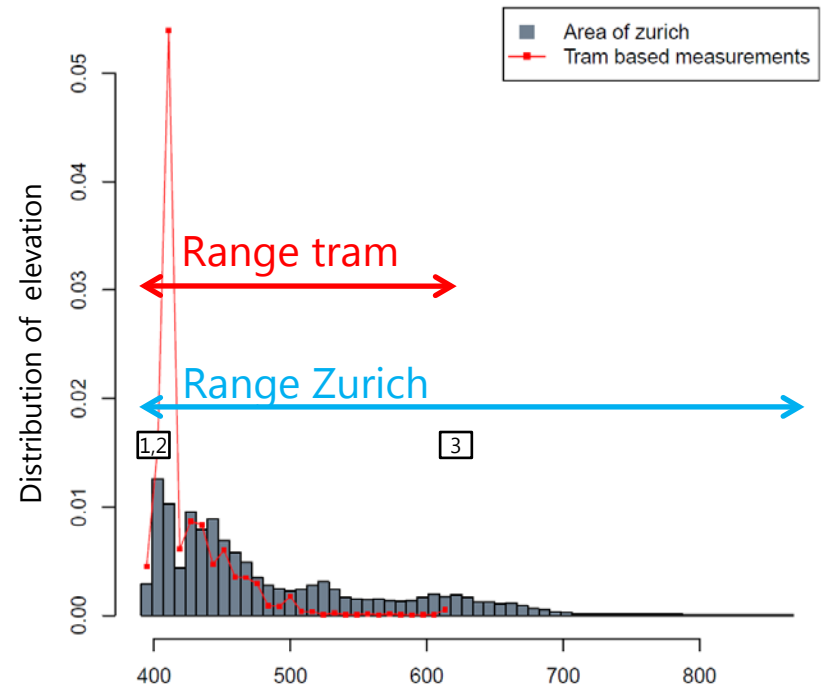


Opensense network characteristics

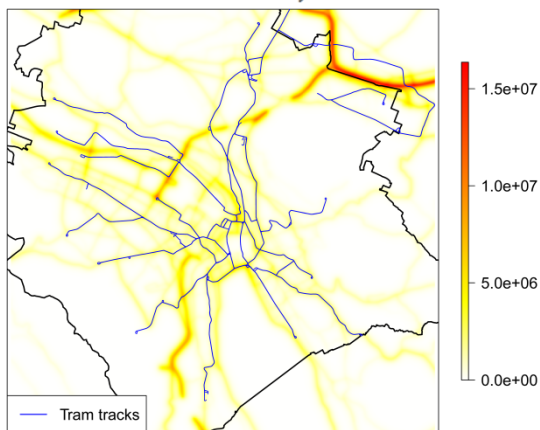
Traffic intensity



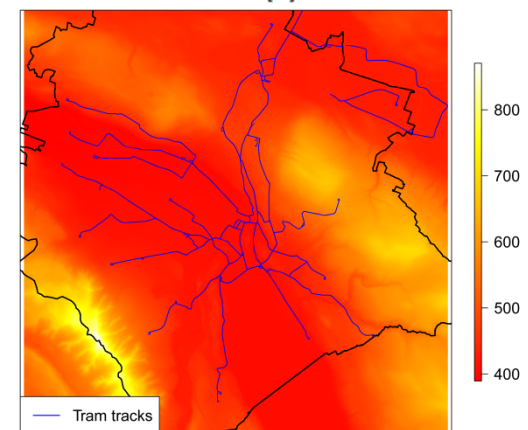
Elevation



Traffic intensity



Elevation



UFP exposure measurements

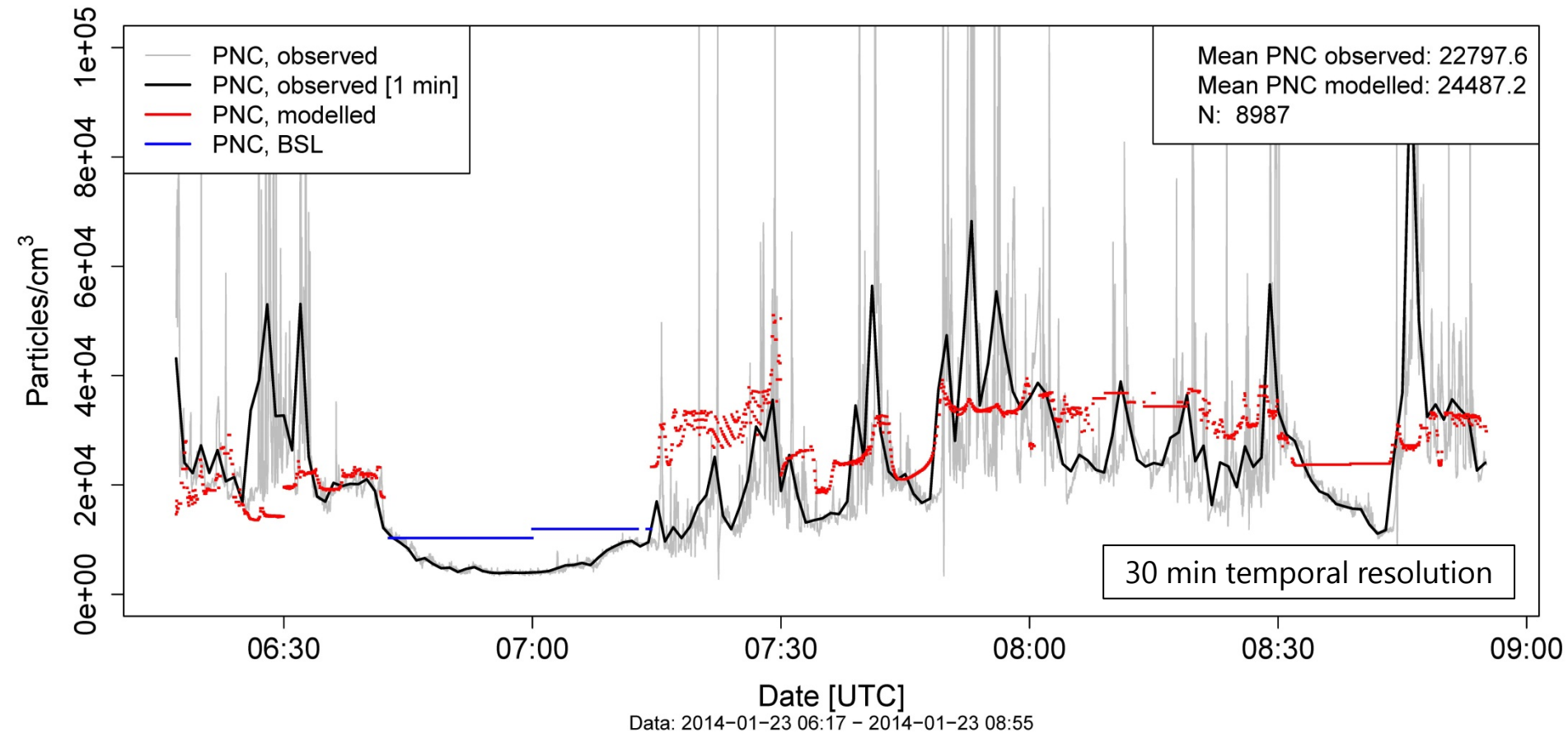


- 17 tours on 11 days in January 2014
- Duration (39 – 172 min)
- 113384 measurements (~1.3 days)



Exposure modelling and UFP map validation

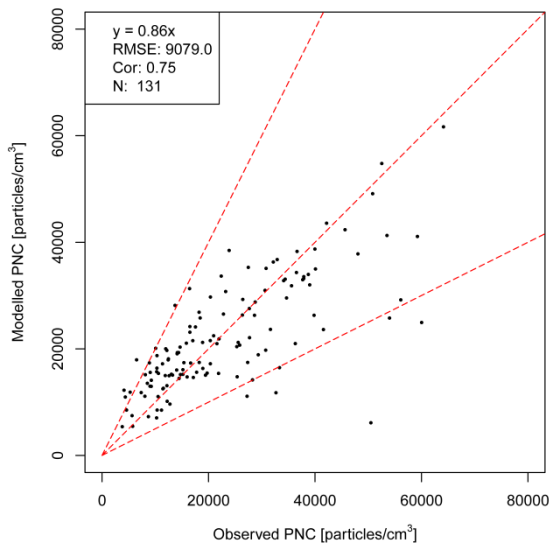
PNC observations and modelling results



Exposure modelling and UFP map validation

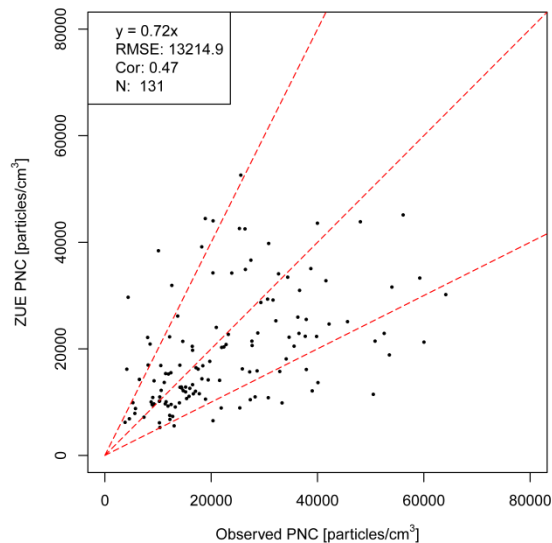
Model

15 minutes intervals



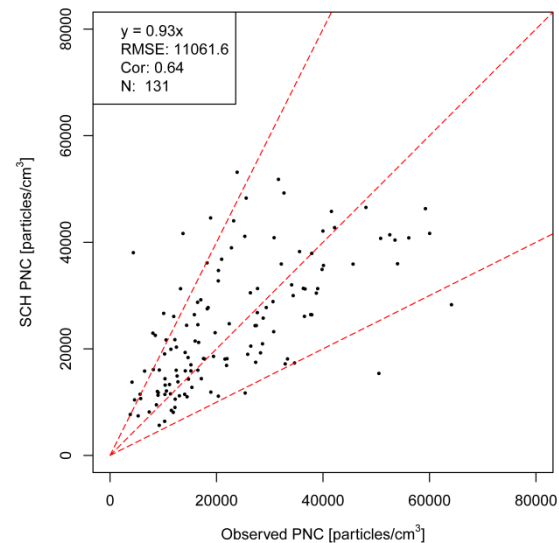
ZUE

15 minutes intervals



SCH

15 minutes intervals



Summary and conclusions

- Opensense UFP data set of good quality
 - MiniDiSCs require periodical maintenance for 24/7 operation.
 - Only few QA/QC routines implemented in the network operation so far.

- Statistical modelling of UFP concentrations
 - Methodology of generating UFP maps developed
 - Further development of predictors ongoing
 - Traffic (e.g. time varying traffic patterns)
 - Improvement of three-dimensional building representation

- Opensense mobile sensor network
 - Uneven distribution of measurements w.r.t. location characteristics
 - Extension of the network by static sensors at distinct locations recommended (e.g. urban background, heavily congested environments)

Thanks for your attention!

Acknowledgments

- Jürg Brunner, Markus Scheller
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- Nano-Tera.ch
 - Strategic action «InUse»
- COST
 - TD 1105 EuNetAir