

# European Network on New Sensing Technologies for Air Pollution Control and Environmental Sustainability - *EuNetAir*

COST Action TD1105

**WGs and MC Meeting at LINKOPING, 3 - 5 June 2015**

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Year 3: 1 July 2014 - 30 June 2015 (*Ongoing Action*)

## Highly resolved UFP number concentration maps in Zurich based on data from a mobile sensor network

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Materials Science & Technology



Fachhochschule  
Nordwestschweiz

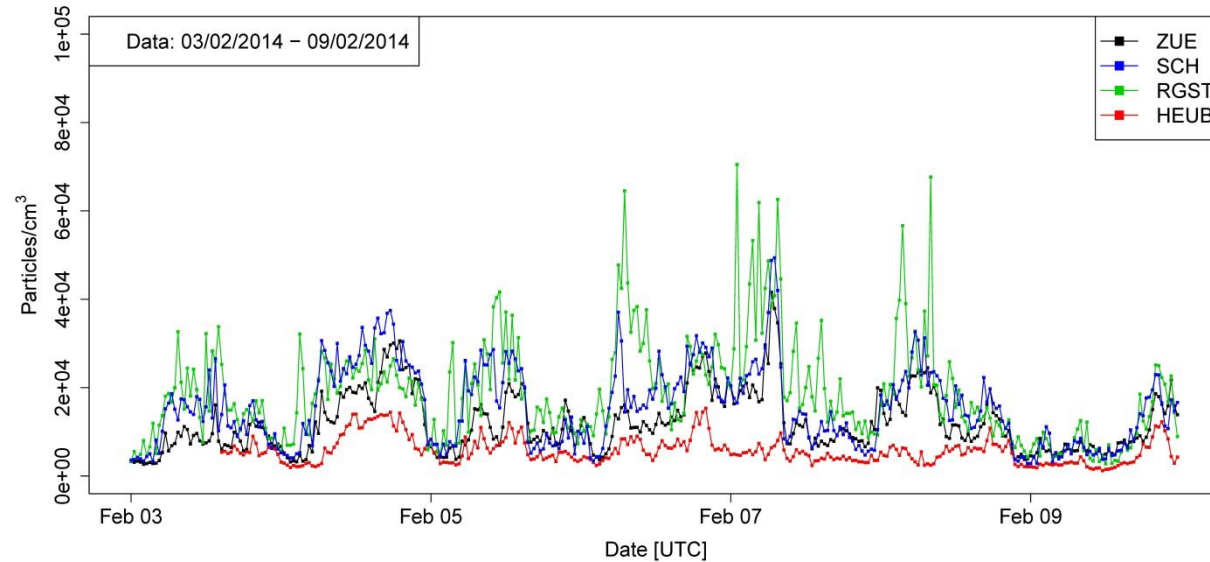


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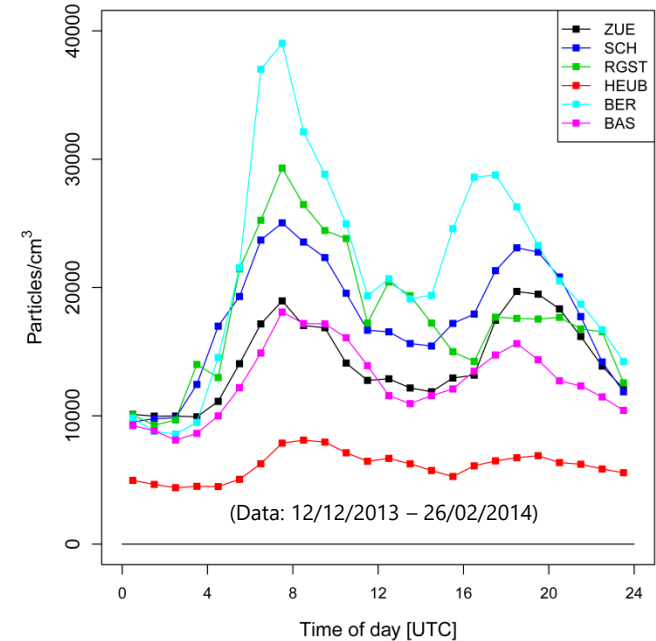
- Introduction: UFP number concentration in the city of Zurich
- OpenSense mobile sensor network
- Statistical modelling
- Application fields of highly resolved PNC maps
- Summary and conclusions

# Ultrafine particle (UFP) number concentration in Zurich

30 minutes mean PNC



Averaged data, weekdays



## City of Zurich



(~1 month of data)

(Source: UGZ)

(~1 month of data)

## Bern (roadside)



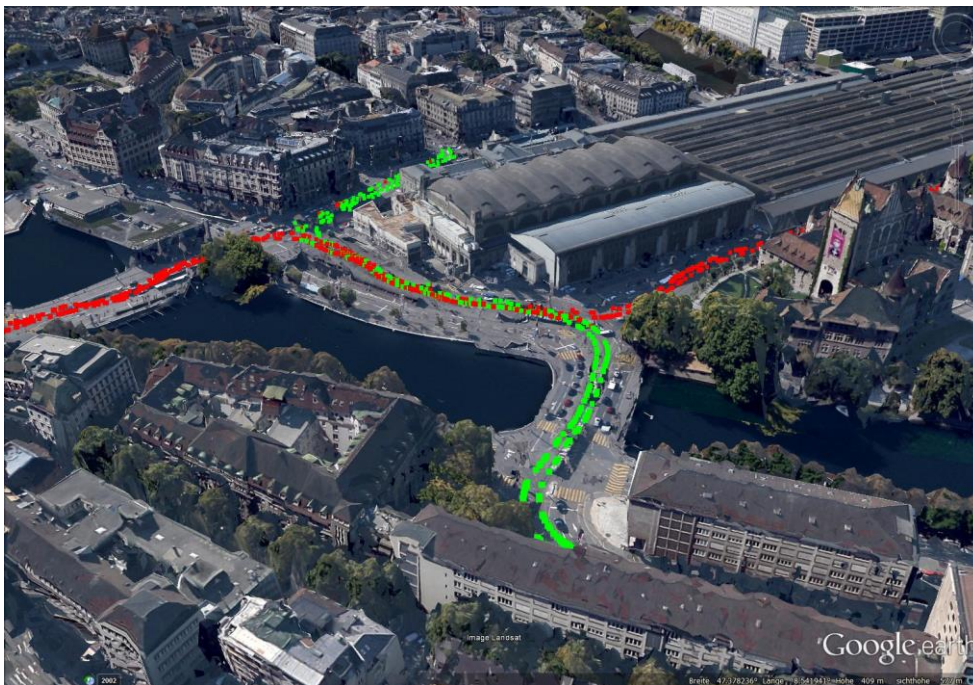
(Source: NABEL)

## Basel (suburban)

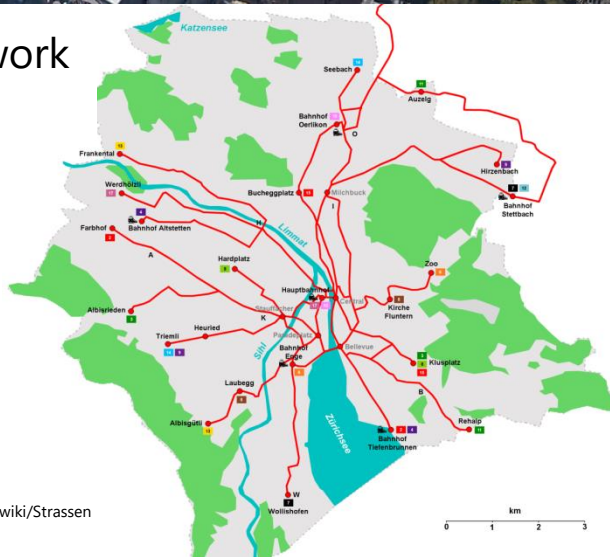


(Source: NABEL)

# OpenSense Mobile Sensor Network



Tram network in Zurich



Source: [http://de.wikipedia.org/wiki/Strassenbahn\\_Z%C3%BCrich](http://de.wikipedia.org/wiki/Strassenbahn_Z%C3%BCrich)

Sensor boxes on the roof of 10 trams

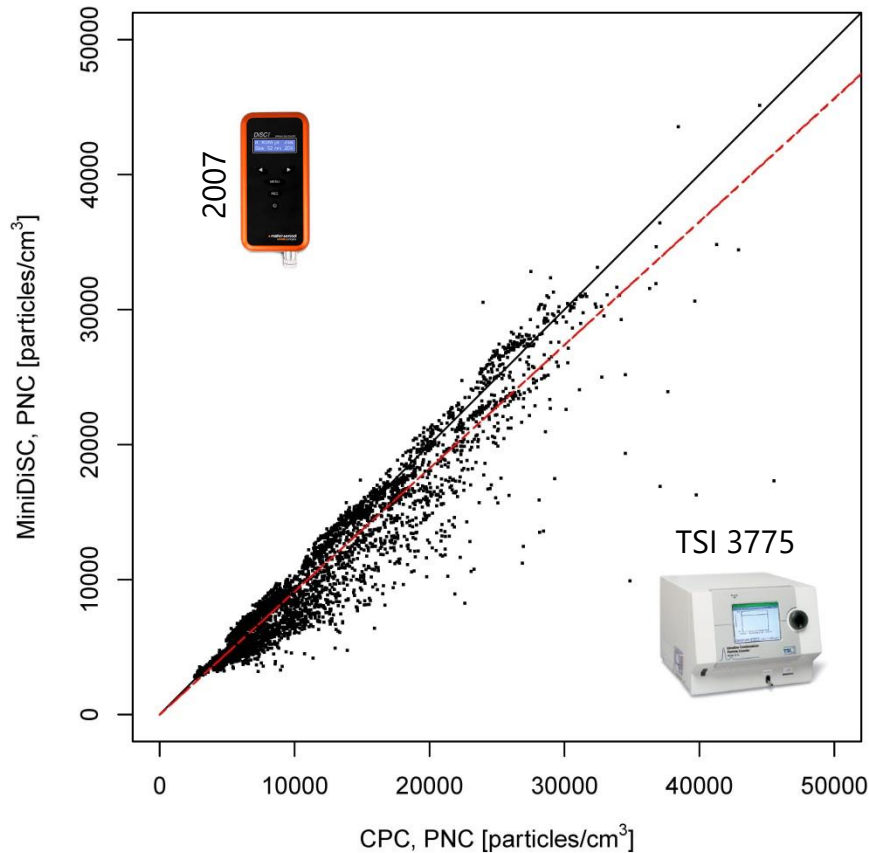
- Particles number concentration
- Ozone
- Temperature
- Humidity
- Position (GPS)



MiniDiSC device

# Mobile measuring platforms

MiniDiSC 2007 (1 min mean values)



Threshold of particle size:

- TSI 3775 ~ 4 nm
- MiniDiSC ~ 10 nm

## Demands of mobile measuring platforms

- Temporal resolution
- Autonomous operation
- Accuracy of measurements

## MiniDiSCs

- Not designed for 24/7 operation
- Instruments require periodical maintenance
- Data from periods without instrument maintenance (2-3 months) are of good quality

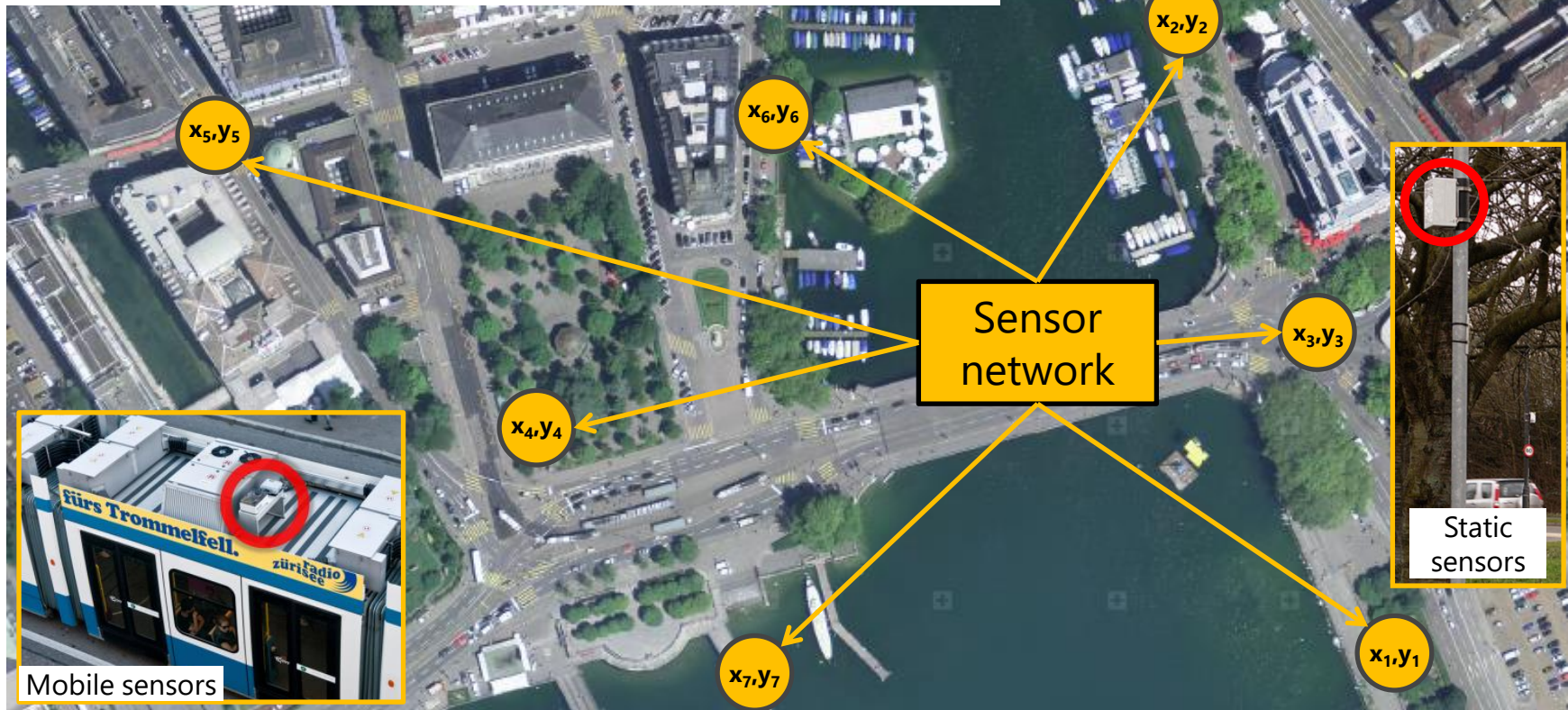
# Statistical Modelling

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

P: Pollutant concentration  
s<sub>i</sub>: Smooth non-parametric functions  
(Generalized Additive Model, GAM)  
geo<sub>i</sub>: Explanatory variables  
ε: Error  
x, y: Coordinates

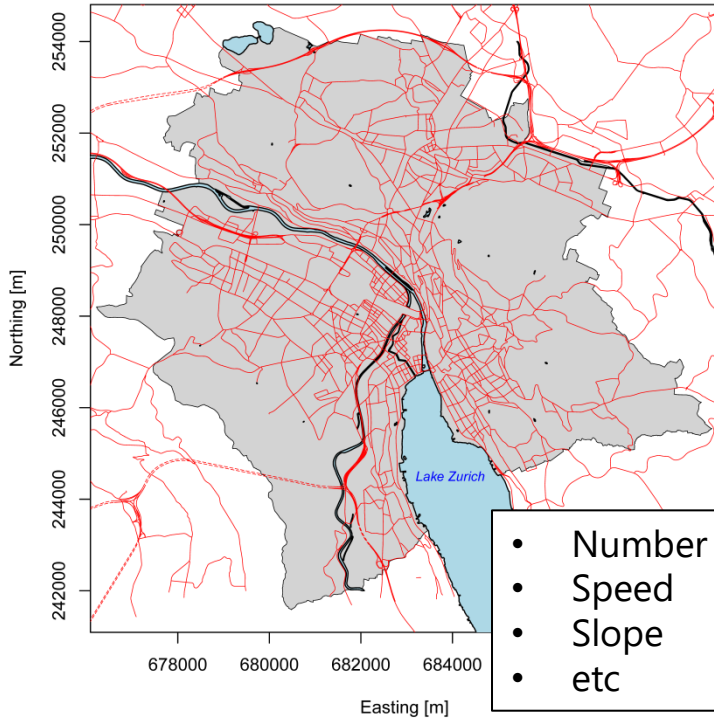
## Spatial information

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



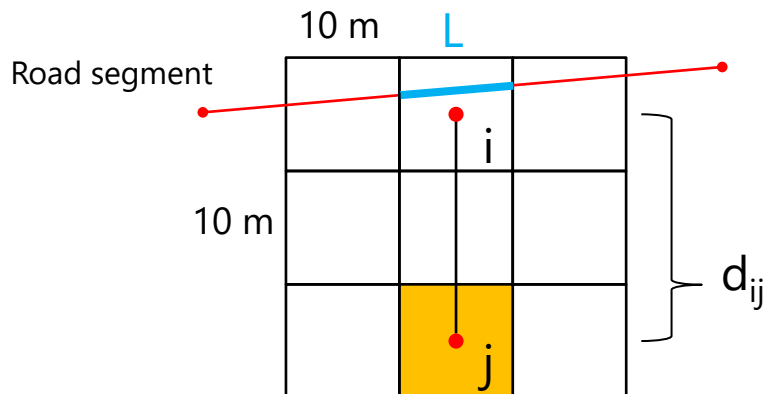
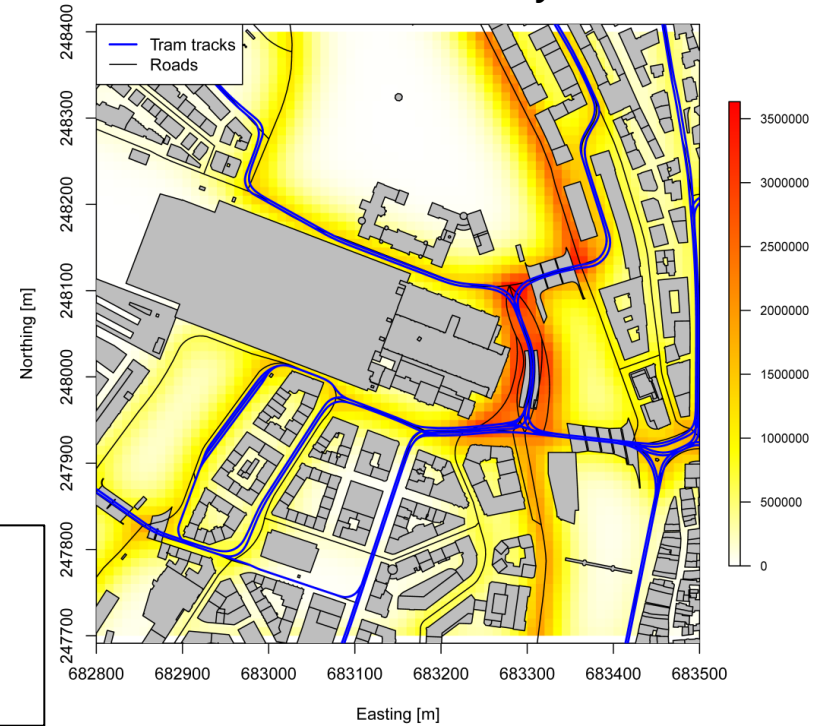
# Representation of traffic

## Road network



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

## Traffic intensity



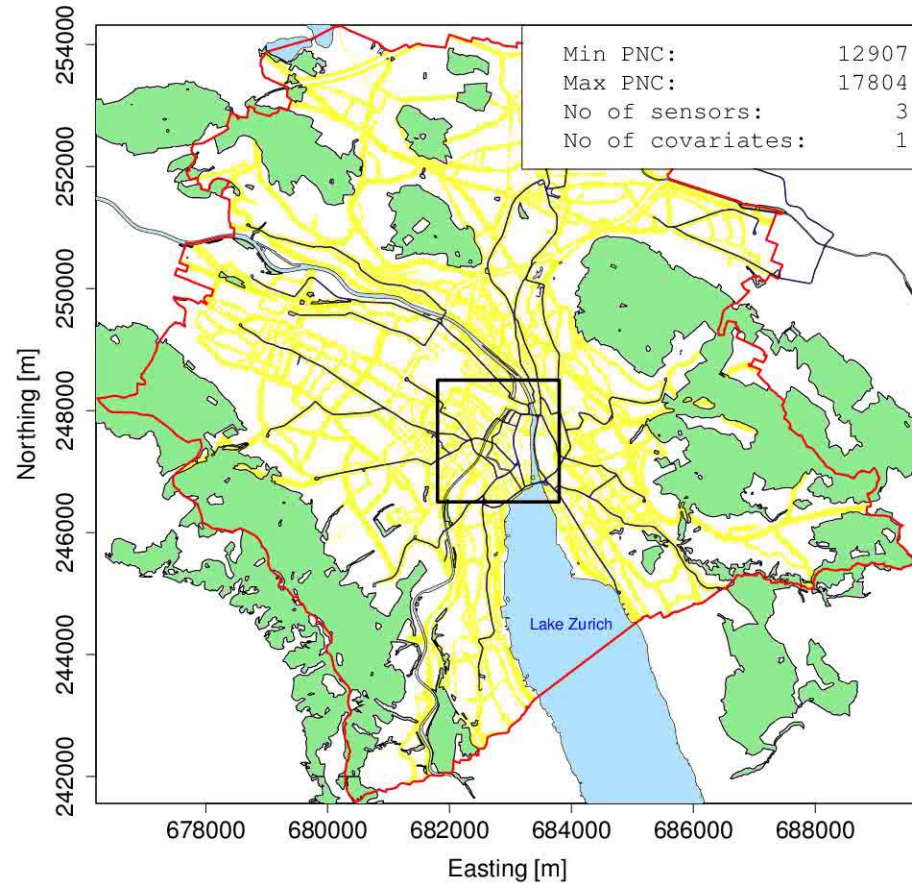
Weighting function

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

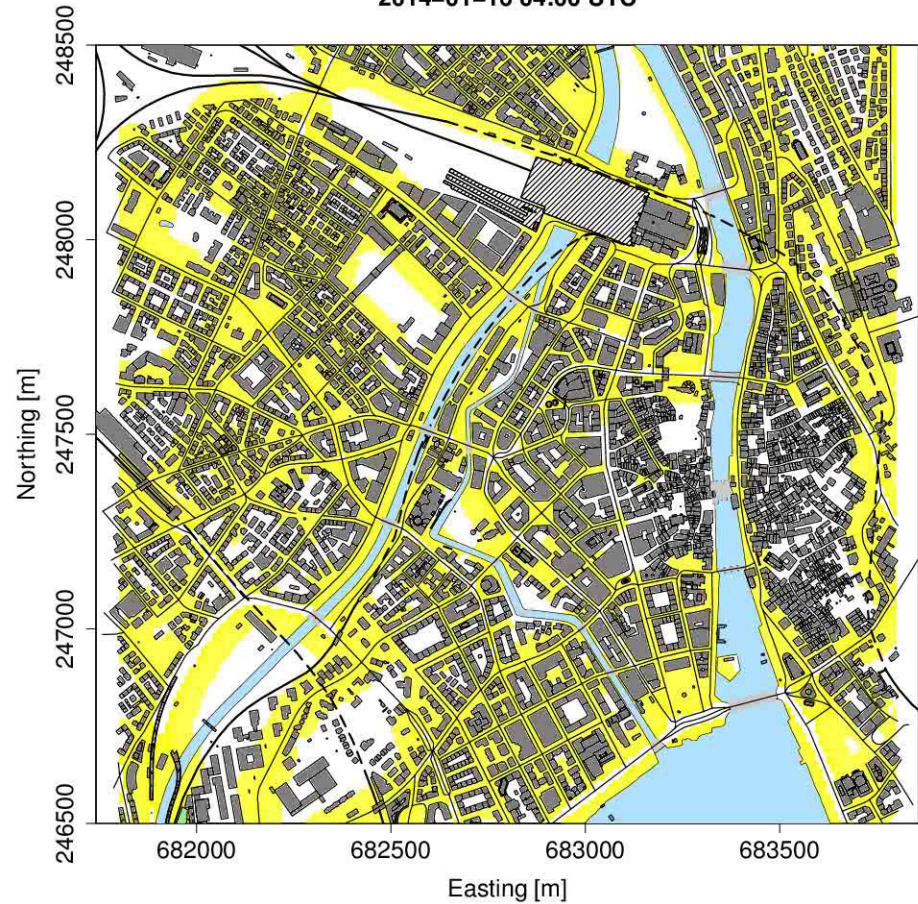
# UFP Maps

(Temporal resolution: 30 min)

2014-01-16 04:00 UTC

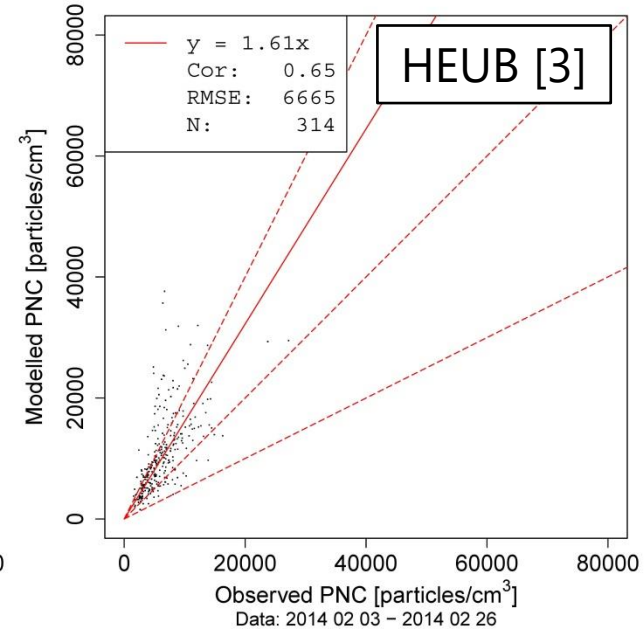
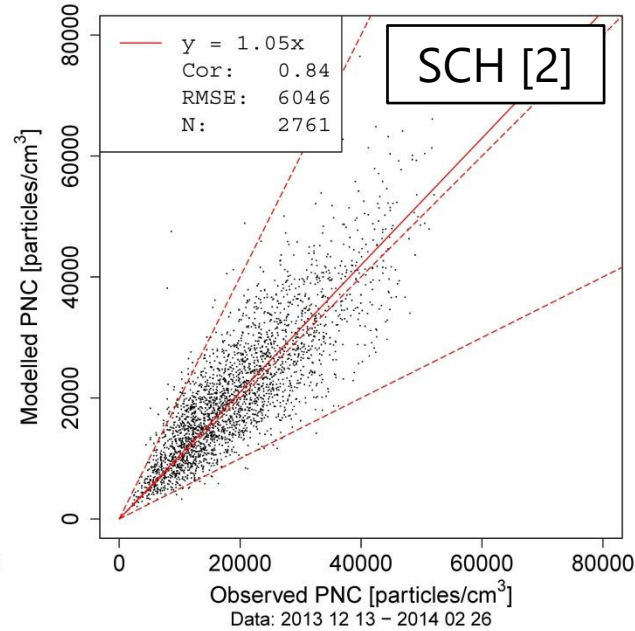
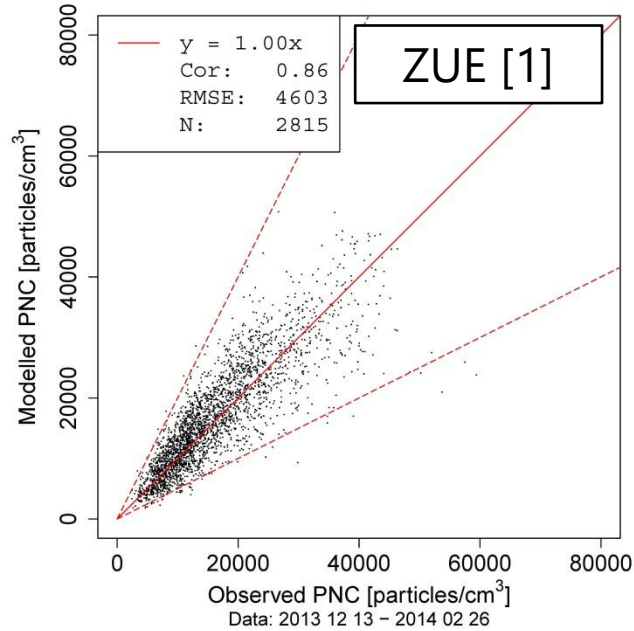


2014-01-16 04:00 UTC

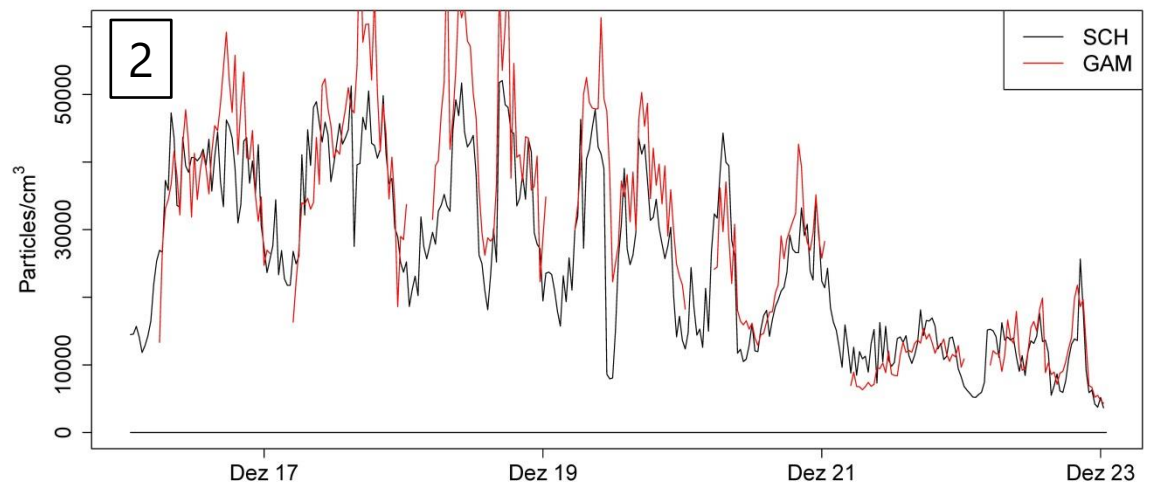
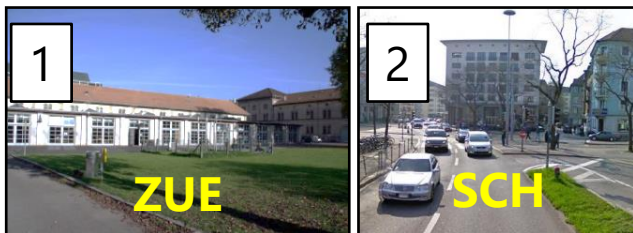




# Comparison with measurements of permanent monitoring sites

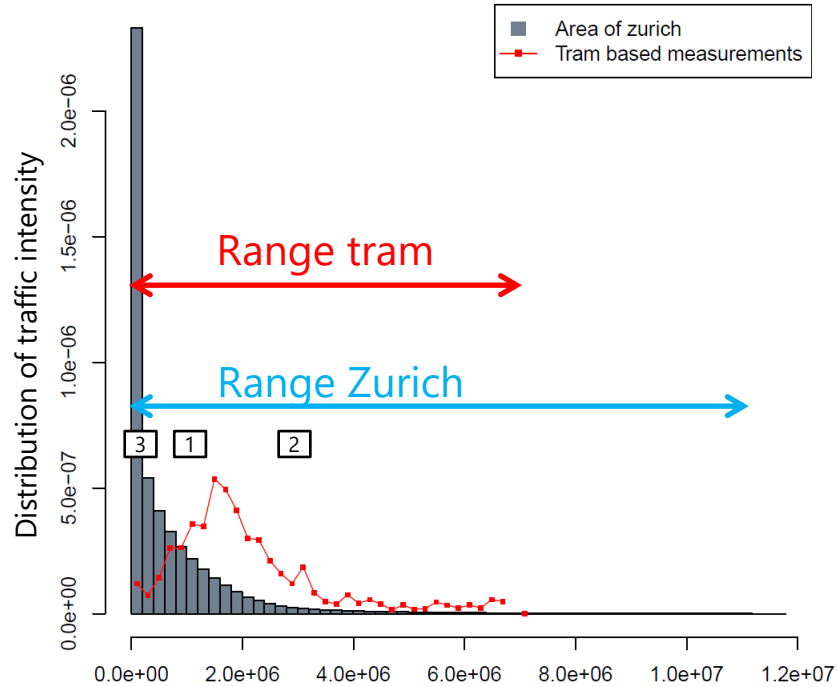


2013/12/16 – 2013/12/22

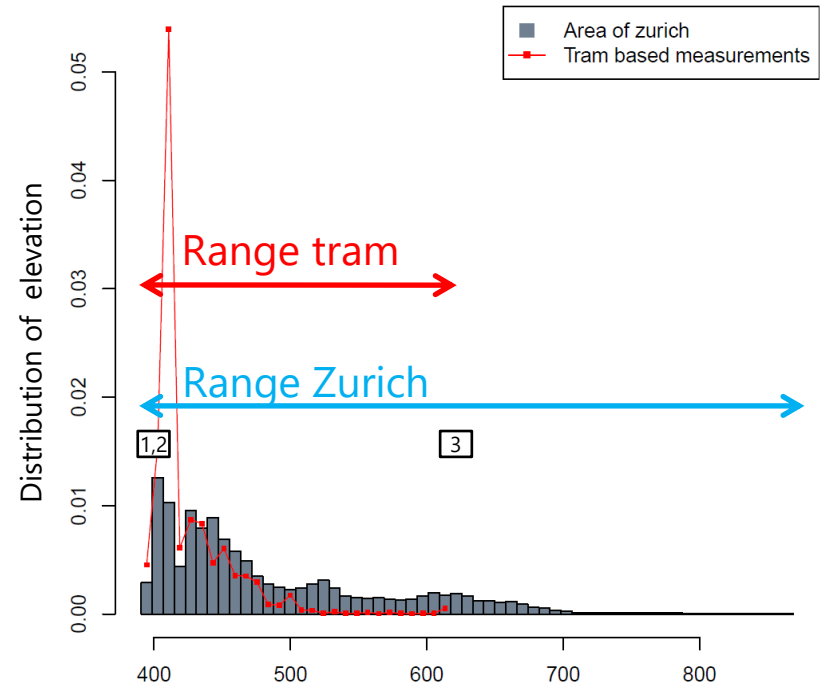


# Opensense network characteristics

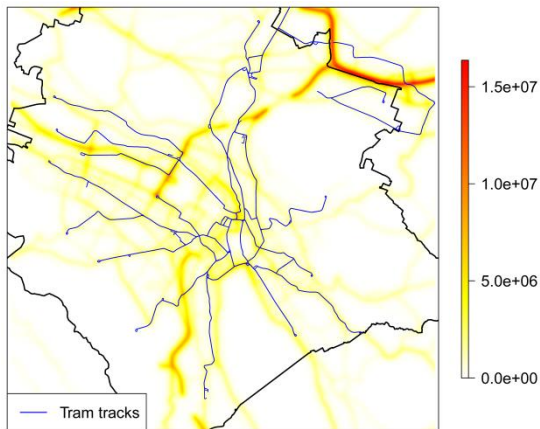
## Traffic intensity



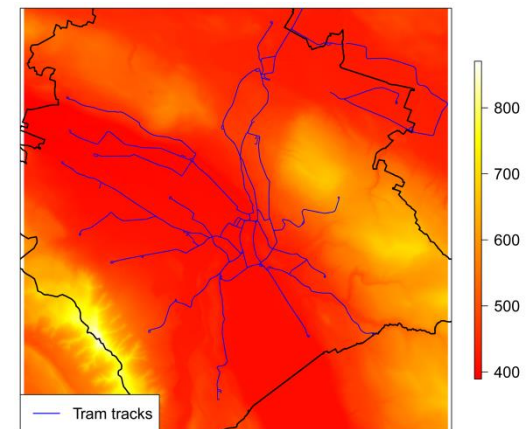
## Elevation



### Traffic intensity

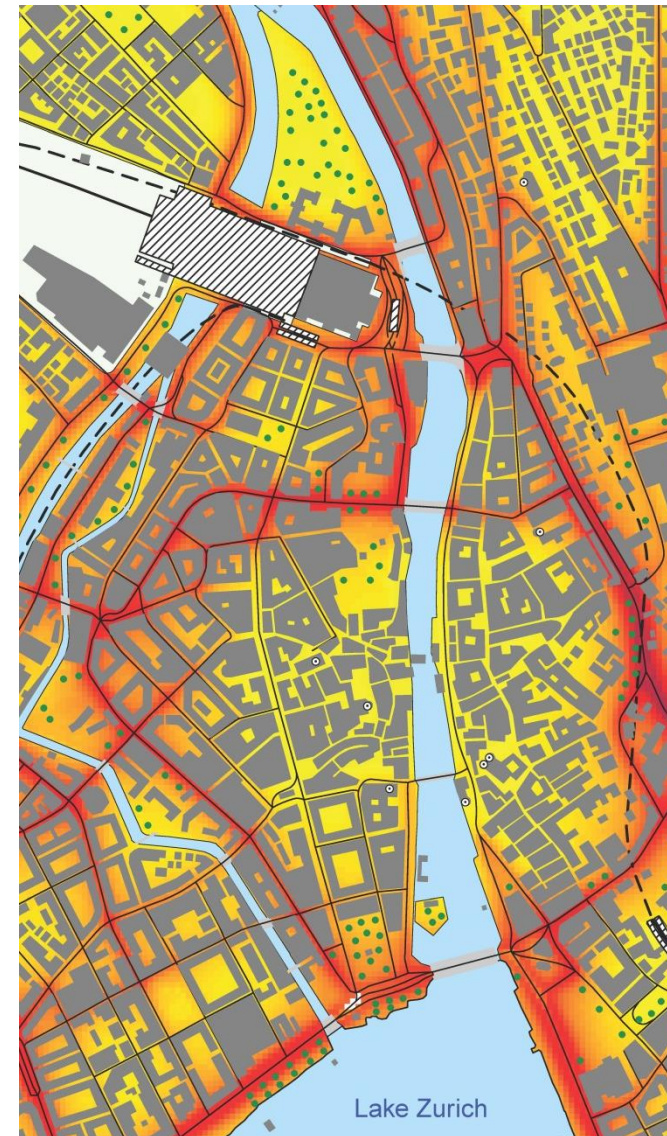


### Elevation

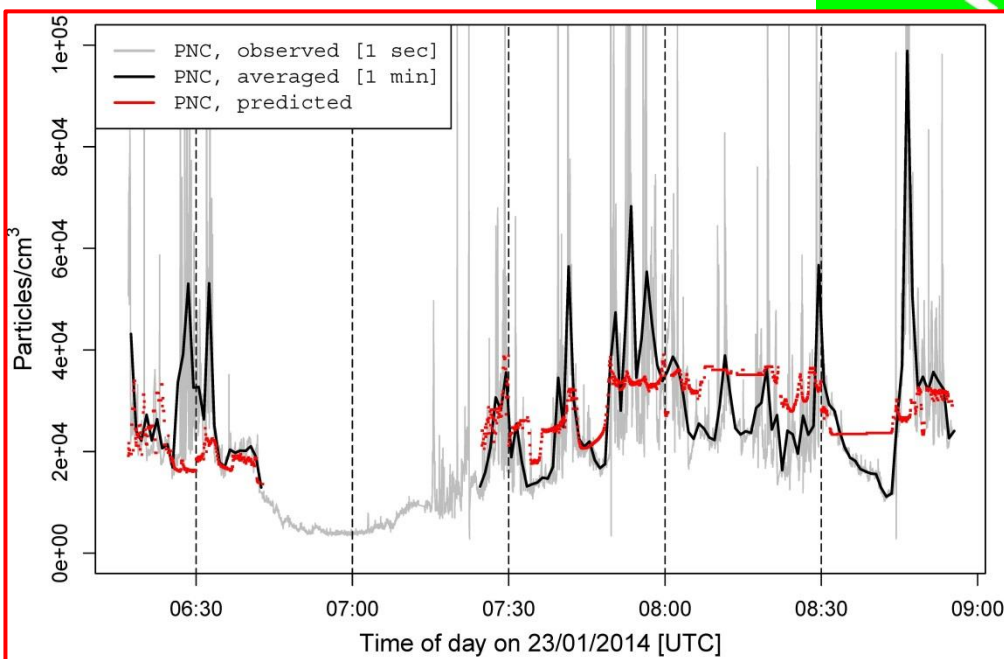
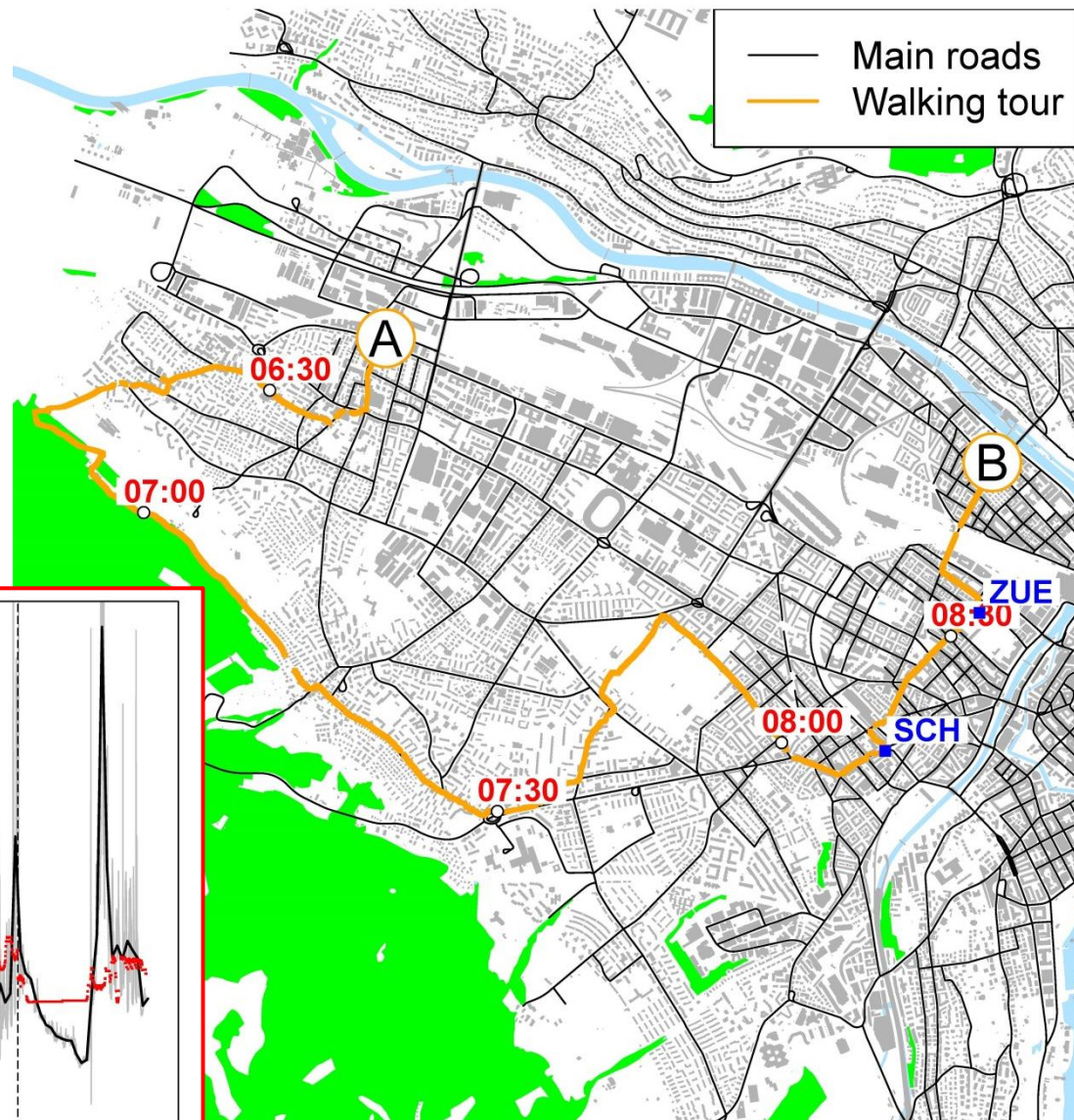


# Application fields of highly resolved pollutant concentration maps

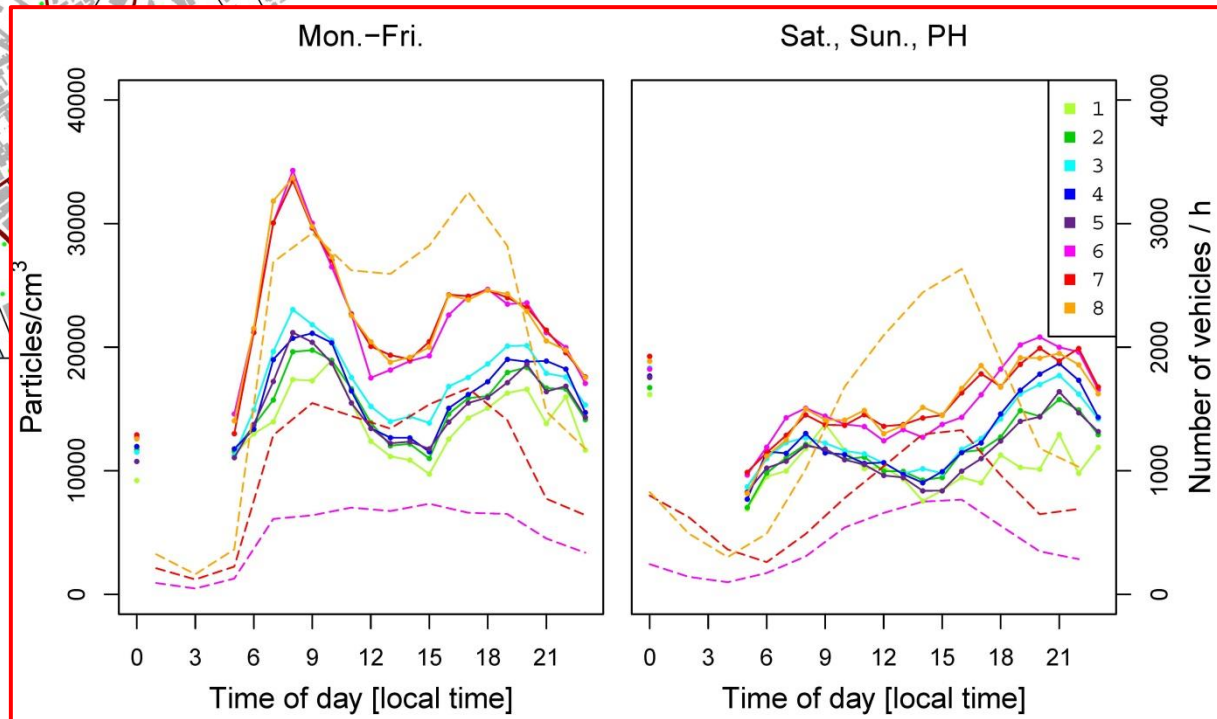
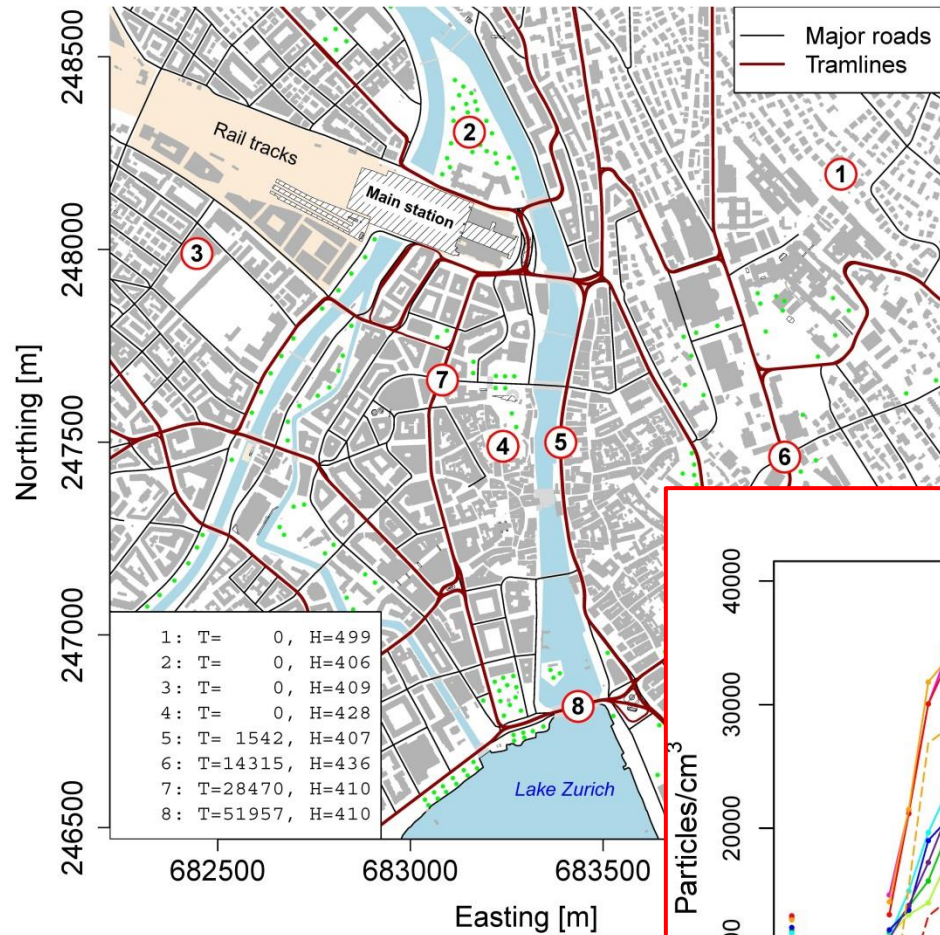
- Investigation of health effects related to air pollutants
  - Accurate PNC concentrations as base for outdoor exposure estimations
- Urban management
  - Air quality monitoring
  - Settlement development, land-use planning
  - Information for the public and policy makers
- Health protection
  - Part of tools used to derive recommendations for the public



# PNC concentration encountered by pedestrians

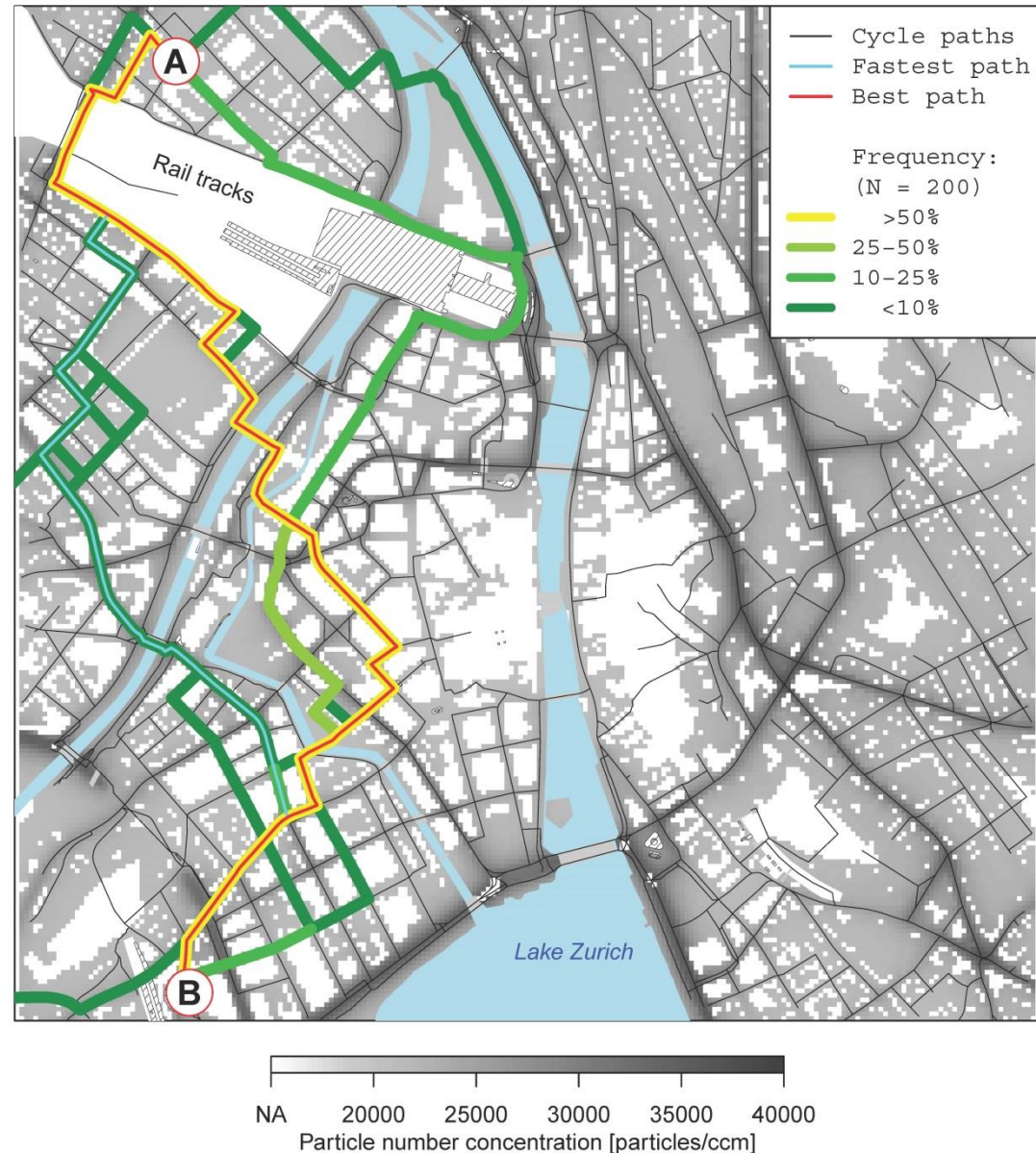


# Pollution levels at different locations



# Recommendations for routing

- Weight of an edge  $\sim$  PNC
- Route finding algorithm minimizes the number of encountered particles (no absolute exposure estimation)
- Set of computations for specified criteria (time/day of week/season) provides recommendations for the optimal route



# Summary and conclusions

- OpenSense UFP data set of good quality
  - Potential in the optimization of the sensor network design
  - MiniDiSCs can provide reliable data during 2-3 months of autonomous operation
  
- Statistical modelling of UFP concentrations
  - Methodology developed for generating UFP maps
  - Model results reasonably agree with measurements at fixed sites
  
- Potential tool in widespread application fields
  - Urban planning
  - Exposure estimation
  - Public health

# Thanks for your attention!

## Acknowledgments

- Jürg Brunner, Markus Scheller  
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