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InUse Strategic action

FNSNF

# Statistical Modelling of Ultrafine Particles Number Concentration in the Urban Environment at High Spatio-temporal Resolution

*Michael Mueller[1], David Hasenfratz[2], Olga Saukh[2], Martin Fierz[3], Christoph Hueglin[1]*

(1) Empa, Swiss Federal Laboratories for Materials Science and Technology, Duebendorf, Switzerland.
(2) ETH Zurich, Computer Engineering and Networks Laboratory, Zurich, Switzerland.
(3) FHNW, University of Applied Sciences and Arts Northwestern Switzerland, Windisch, Switzerland.

EMPA Materials Science & Technology

n|w Fachhochschule Nordwestschweiz

ETH Zürich

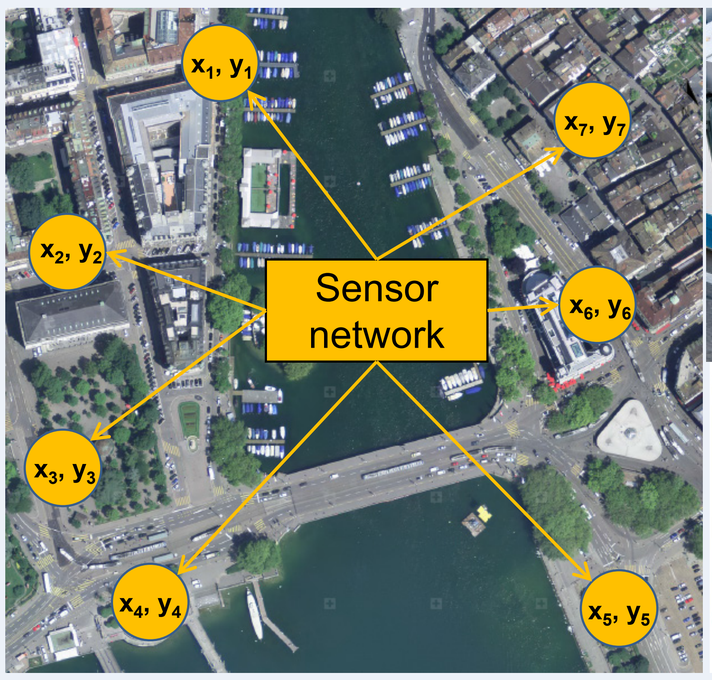
## InUse Project

The strategic action *InUse* focused on the development of methods to generate pollution concentration maps based on measurements of the Opensense mobile sensor network in Zurich [1]. The Opensense network started in 2012 and consists of 10 sensor nodes installed on the rooftop of streetcars. Each node is equipped with sensors measuring ultrafine particles concentration, ozone, carbon monoxide, temperature and humidity as well as a GPS receiver and wireless communication devices [2].

## Ultrafine particles (UFP)

Ambient UFP (diameter < 100 nm) number concentrations depend on the presence of emission sources and the conditions for dispersion. The UFP concentration is highly variable, especially in the urban environment. Inhaled UFPs have the ability to translocate from the alveolar space into tissues and to reach many organs [3]. However, epidemiological evidence for adverse health effects caused by ambient UFP concentration has not completely been established yet. Highly resolved UFP concentration maps might substantially contribute to corresponding research.

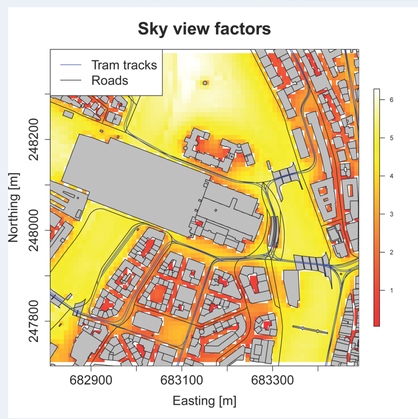
## Sensor network

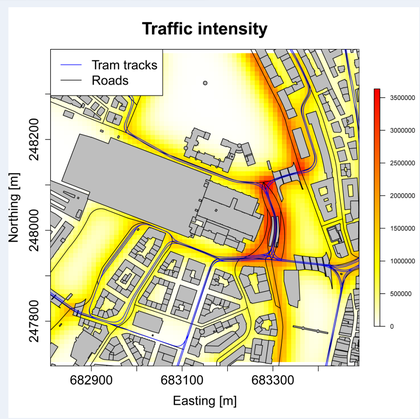




MiniDiSC device for measuring UFP concentration.

## Information with spatial reference




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

## Statistical modelling

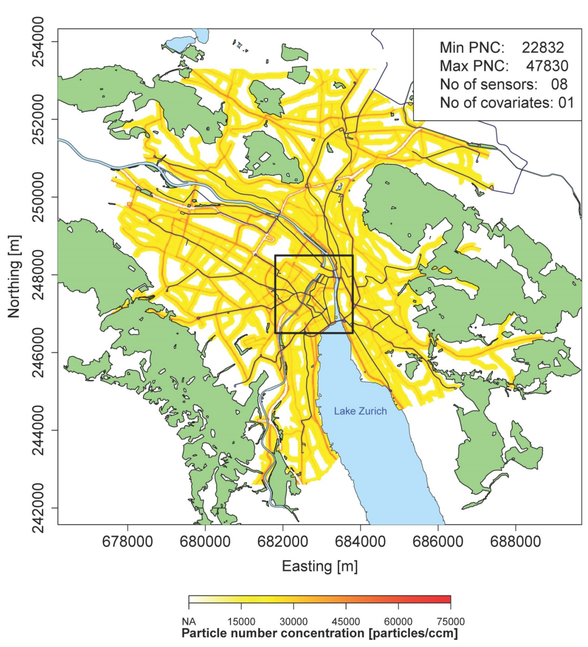
$$P(x,y) = s_1(geo_1(x,y)) + s_2(geo_2(x,y)) + \cdots + \varepsilon$$

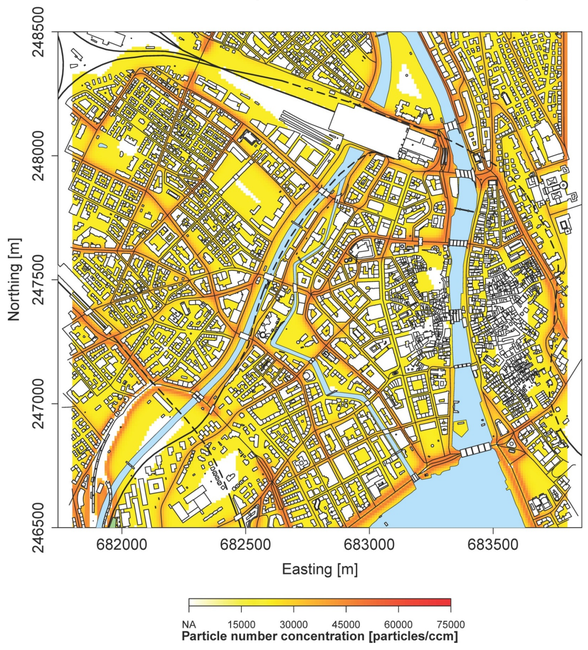
P: Pollutant concentration
$s_i$: Smooth non-parametric functions (Generalized Additive Model)
$geo_i$: Predictor variable
ε: Error
x,y: Coordinates

## Methodology

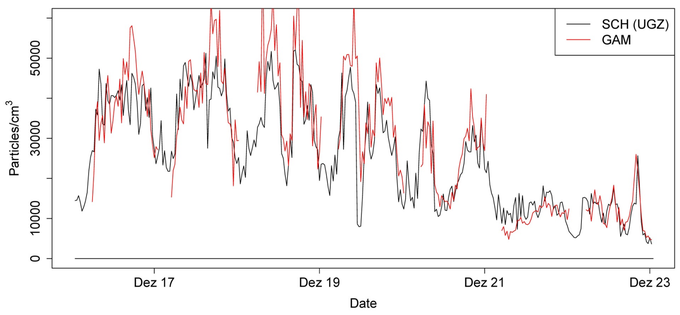
- Modelling of UFP concentration by using statistical models. These rely on UFP measurements and predictor variables as input data.
- Predictor variables are derived based on spatial information. Several representations are computed for each spatial topic in order to account for different emission situations and dispersion conditions. The predictors cover the whole city of Zurich in a 10x10 m resolution.
- Generation of UFP concentration maps for the city of Zurich based on the estimated models.

## UFP concentration map for 2014-01-16 07:00 UTC (30 min resolution)

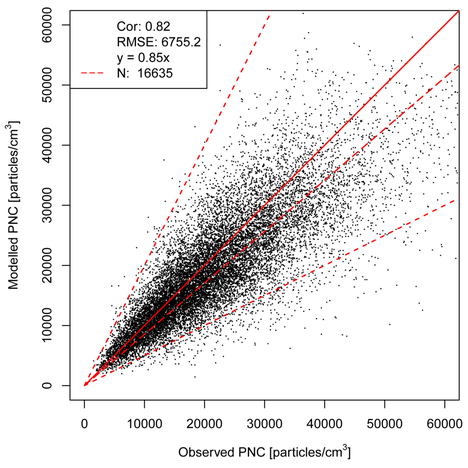


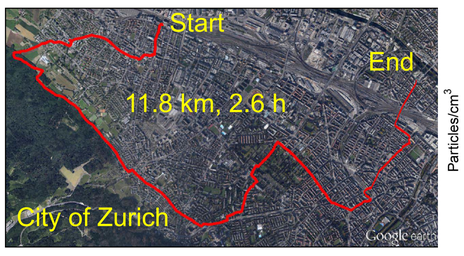

## Model validation

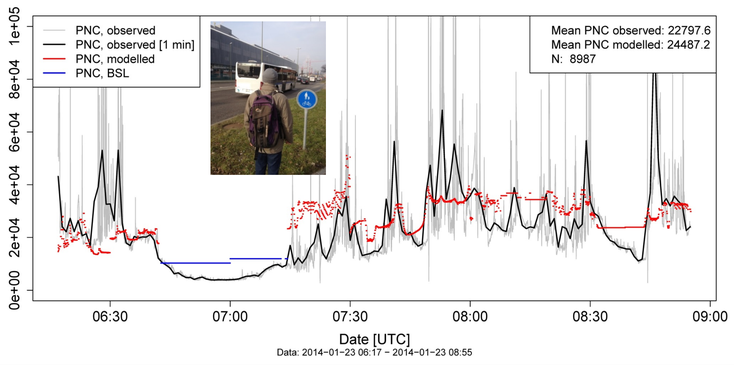



The derived models were validated against measurements of permanent monitoring sites (top), exposure measurements and by performing leave-one-out cross-validation (right).




## Exposure estimates and measurements (example for 2014-01-23)




## Results and conclusions

- Generalized Additive Models are feasible for modelling UFP concentrations at high spatio-temporal resolution.
- UFP concentration maps with 30 min temporal and 10 m spatial resolution were computed for the period December 2013 to February 2014.
- As an example of use and for validation purposes the exposure of pedestrians to UFP was computed for 15 walking tours based on the derived maps.
- The comparison between model values and measurements at permanent monitoring sites points to weaknesses of the sensor network design (e.g. lack of measurements at background locations).

**References**

[1] Li, J., Faltings, B., Saukh, O., Hasenfratz, D. and Beutel, J., 2012. Sensing the Air We Breathe — The OpenSense Zurich Dataset. *Proceedings of the Twenty-Sixth AAAI Conference on Artificial Intelligence.*

[2] Hasenfratz, D., et al., 2014. Pushing the Spatio-Temporal Resolution Limit of Urban Air Pollution Maps. *Proceedings of the 12th International Conference on Pervasive Computing and Communications (PerCom 2014).*

[3] Cassee, F. R., Héroux, M., Gerlofs-Nijland, E. and Kelly, F. J., 2013. Particulate matter beyond mass: recent health evidence on the role of fractions, chemical constituents and sources of emission. *Inhalation Toxicology, 25*, 802-812.