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LAND-USE REGRESSION MODELLING UTILIZING CO MEASUREMENTS OF A LOW-COST, HIGH DENSITY SENSOR NETWORK IN CAMBRIDGE

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Scientific context and objective

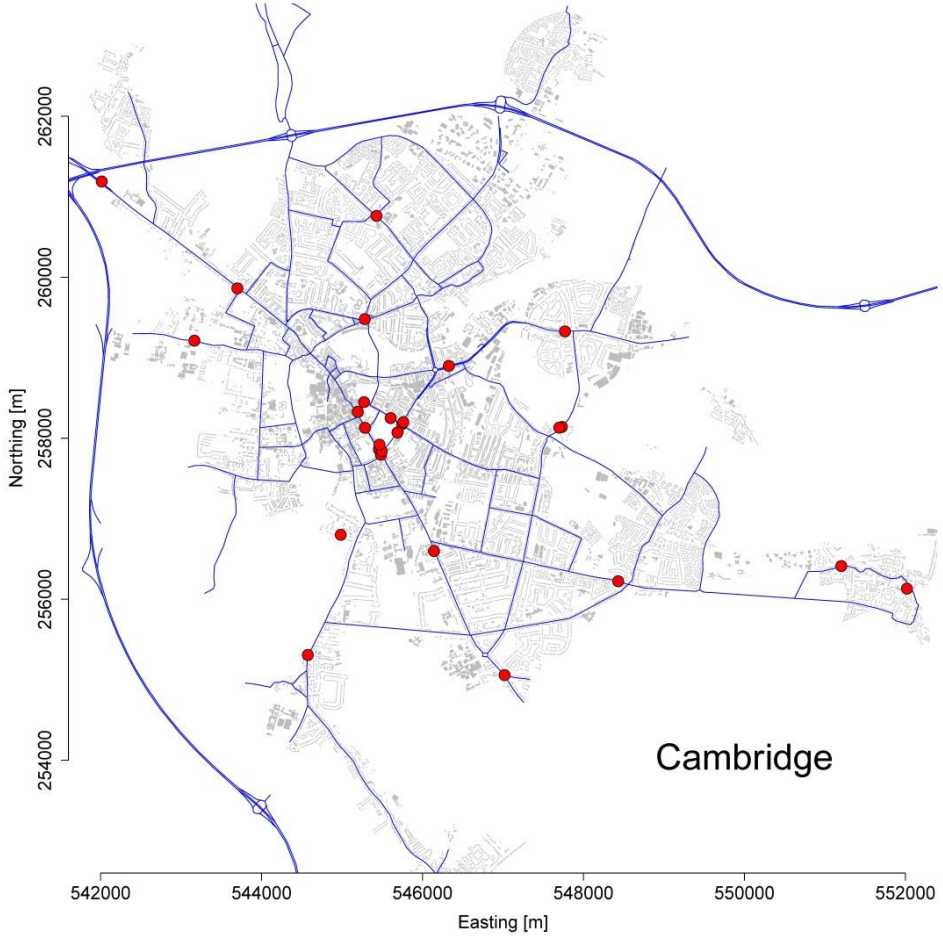
Context

- Increased concentrations of atmospheric pollutants such as CO, NO, NO_2 or O_3 can affect adversely human health
- Limited accuracy of exposure estimations for pollutants with a high spatial and temporal variability (e.g. ultrafine particles, NO_2)
- High density, low cost sensor networks become viable

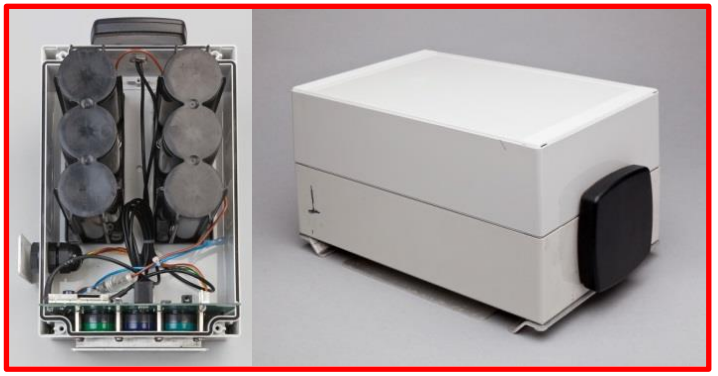
Objective

➢ Development of statistical modelling techniques for the mapping of atmospheric pollution concentrations with high spatio-temporal resolution

Cambridge sensor deployment



- Deployment details
  - 11/03/2010 – 30/05/2010
  - 45 sensor boxes
  - CO, NO, NO_2, T and RH
  - temporal resolution of 10s
- CO input data for statistical models from 26 sensors

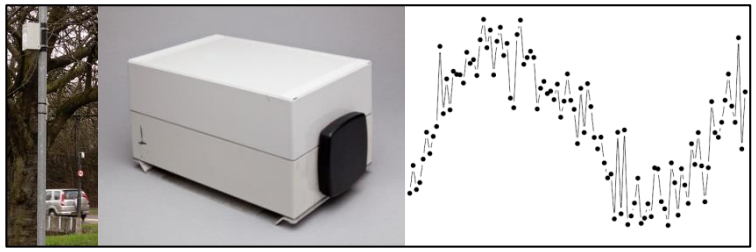


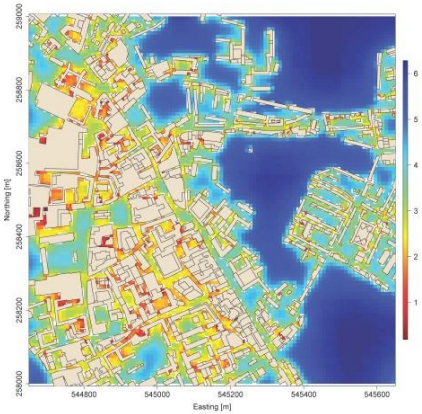
Mead et al., Atmospheric Environment 70 (2013), 186-203.

Statistical modelling of pollutant concentrations in the urban environment

Data from the sensor network

Spatial information





Statistical models

High resolution pollutant concentration maps

Statistical modelling

- Model association between atmospheric pollutant concentration and land use information

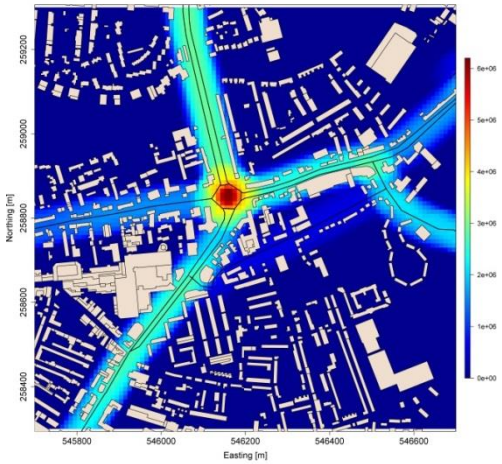
$$Y = f(geo_1) + g(geo_2) + h(geo_3) + \ldots + E$$

Y	atmospheric pollutant concentration
f, g, h, etc.	smooth non-parametric functions (Generalized Additive Model, GAM)
geo_i	road traffic (road network), rail traffic, buildings, street configuration, heating systems used, industries, topography, …
E	residual

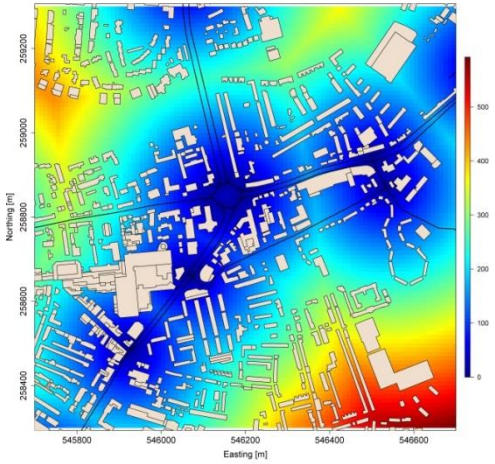
- Use model for prediction of atmospheric pollutant concentration in each grid cell of modelling domain

Explanatory variables: traffic information

Traffic intensity (50 m buffer)

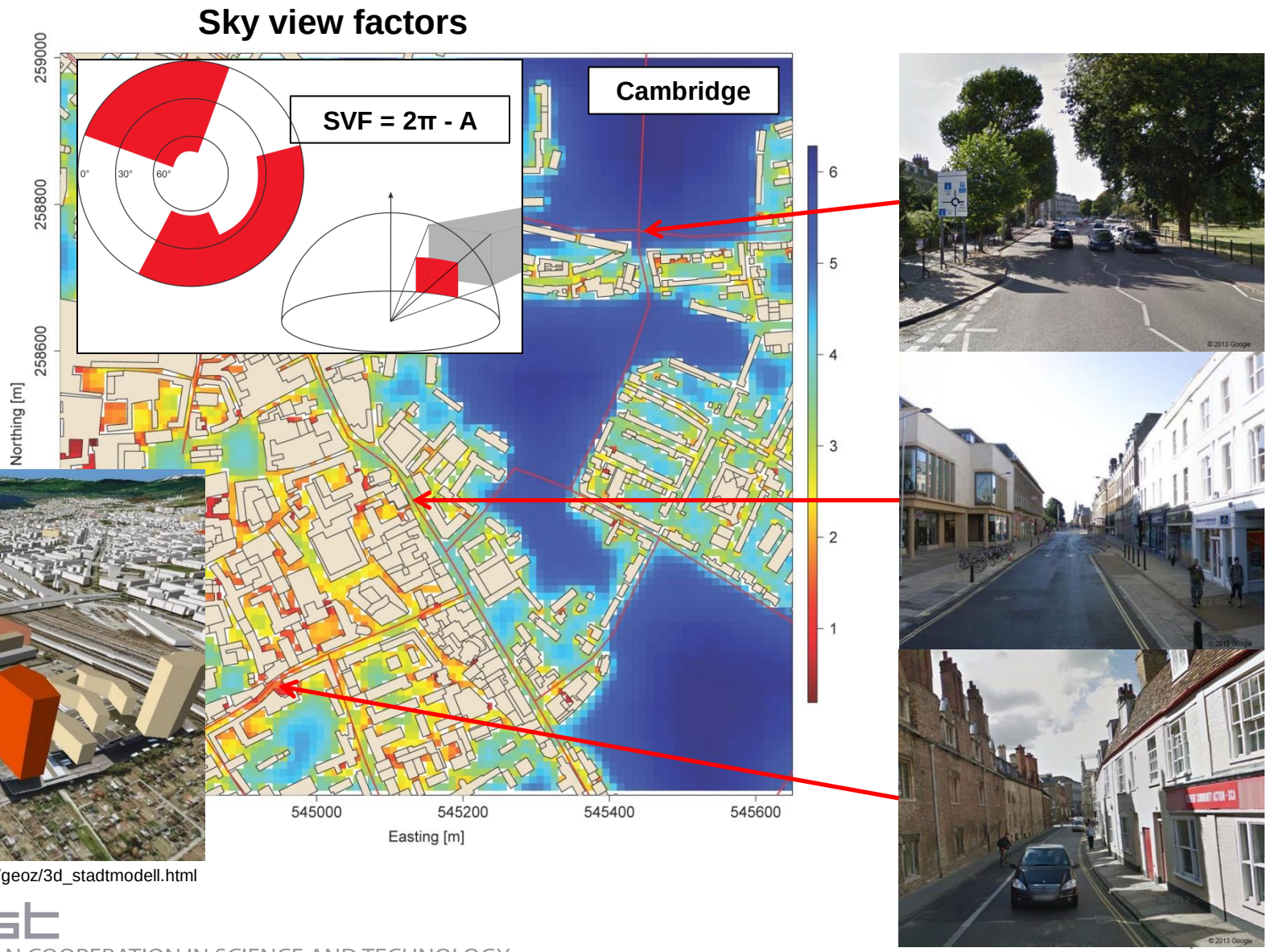


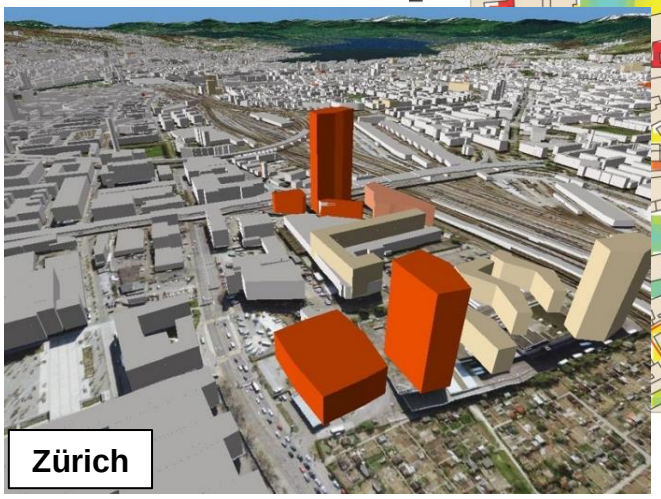
Distance to nearest crossroad



- Traffic information per road
  - Light/heavy traffic
  - Average speed
  - …
- Computation of traffic related variables
  - Traffic intensities using buffers of different sizes
  - Distance to roads
  - Distance to crossroads
  - …

Explanatory variables: building density

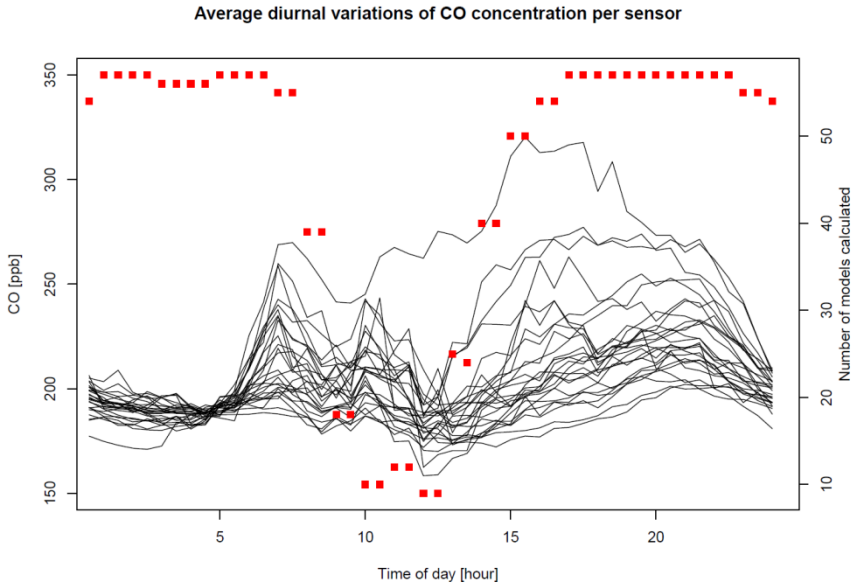




http://www.stadt-zuerich.ch/ted/de/index/geoz/3d_stadtmodell.html

(Image source: maps.google.com)

CO measurements of the deployment



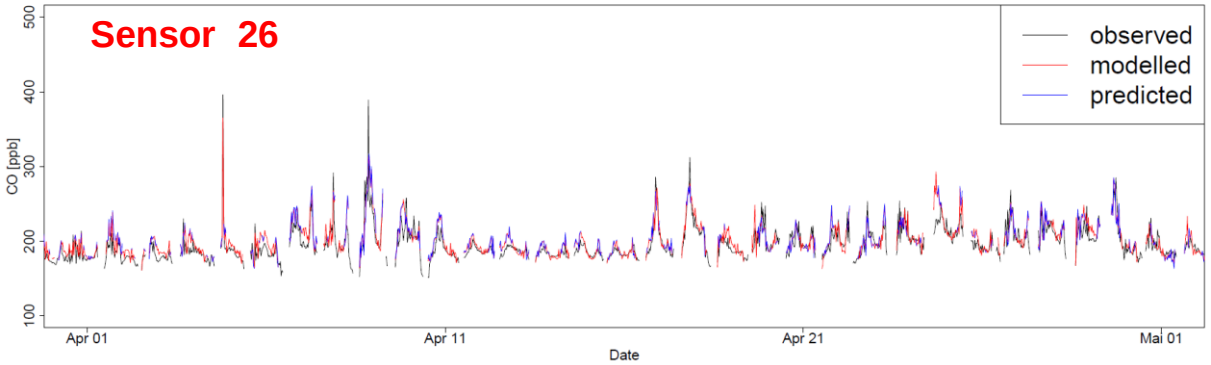
- Data quality
  - Sufficient for model development
  - A large part of the data around noon excluded due to sensor issues

- Network design
  - Only few heavily congested sites
  - Sites not optimally located w.r.t. the range of all spatial information types
  - Reasonable dependence of mean CO concentration on spatial information

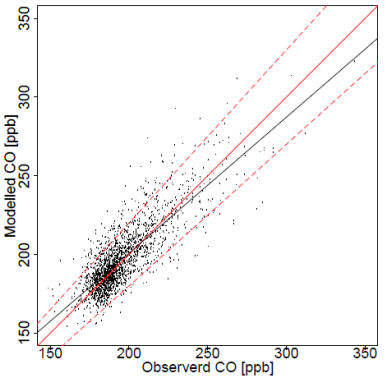
Preliminary results

30 min temporal resolution

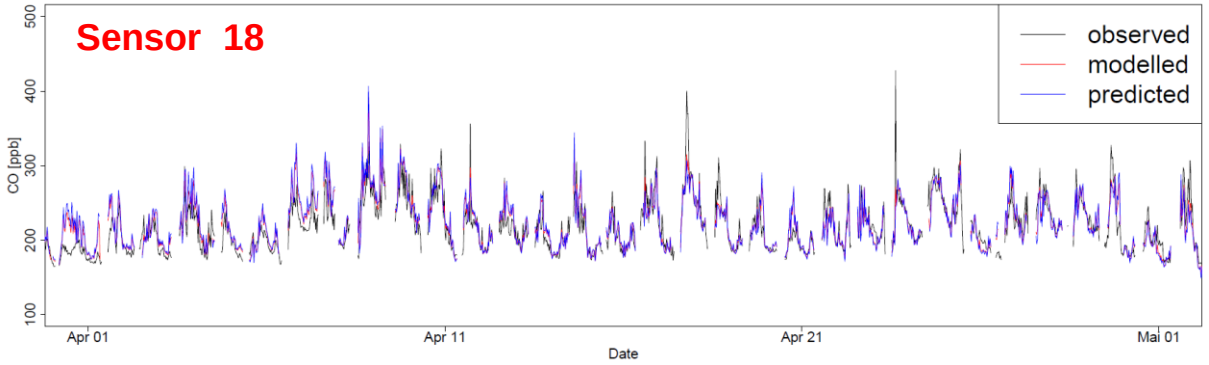
Observed, modelled and predicted CO concentrations



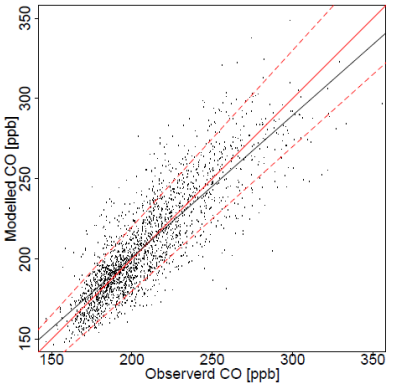
Modelled versus observed CO concentrations



Observed, modelled and predicted CO concentrations



Modelled versus observed CO concentrations



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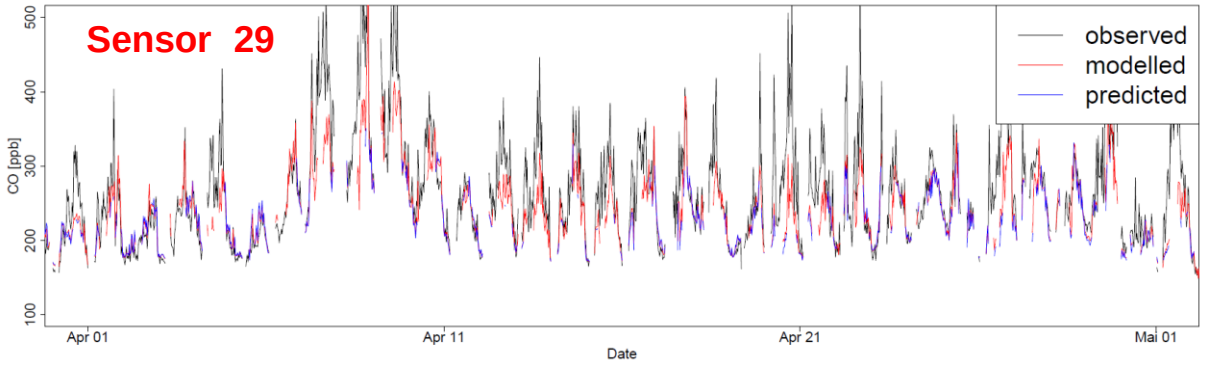
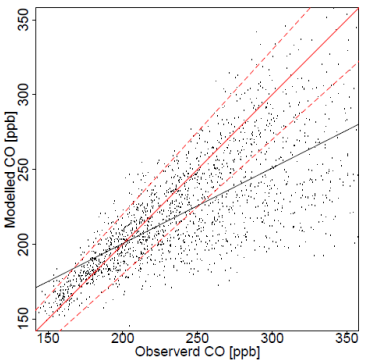
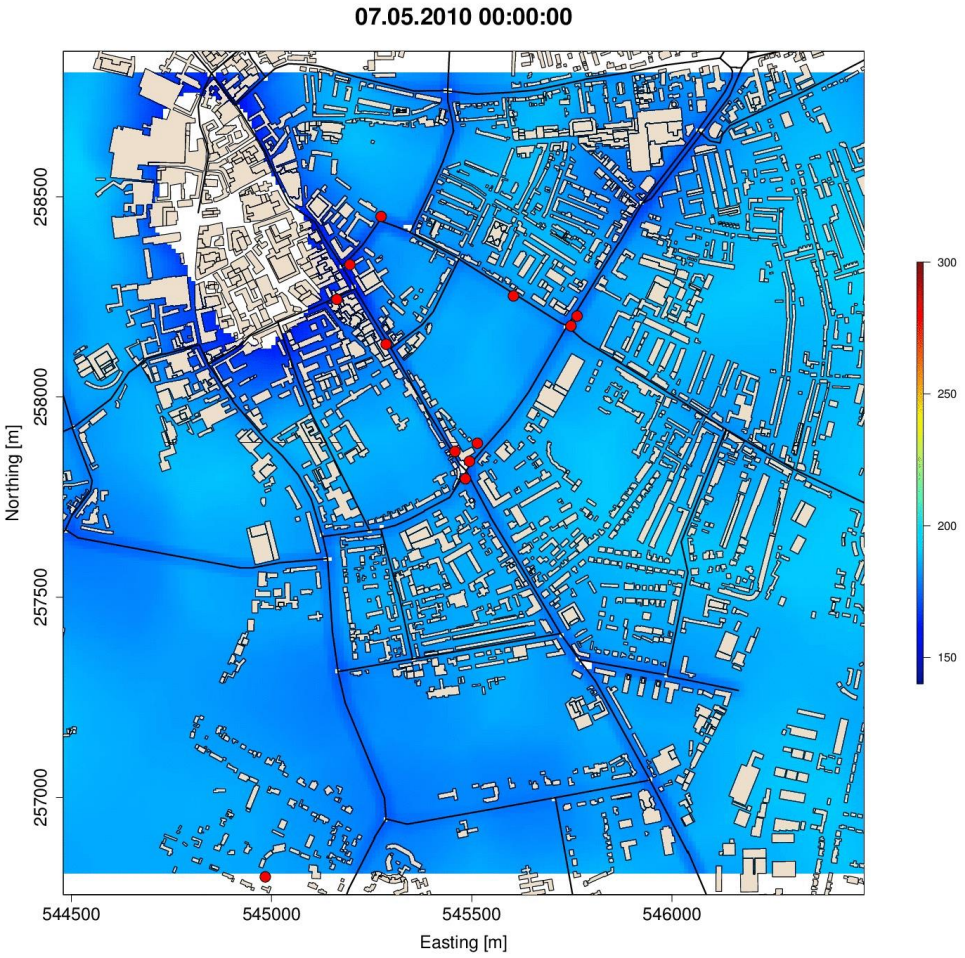


Modelled versus observed CO concentrations



Preliminary results and next steps

- Next steps:
  - Further improvement of the models
  - Modeling NO concentrations
  - Model validation
    - Leave-one-out cross-validation
    - Comparison with data of permanent monitoring sites (NO)
    - Comparison with results of the physical ADMS dispersion model



Conclusions and R&I Needs

- Preliminary results show the applicability of statistical models
- Statistical models make demands on
  - sensor performance
  - sensor network design
  - accuracy, reliability and completness of spatial information
- Further work planned in the fields of
  - statistical modelling techniques
  - development of most selective explanatory variables
  - sensor network design
  - quality assurance and quality control of sensors