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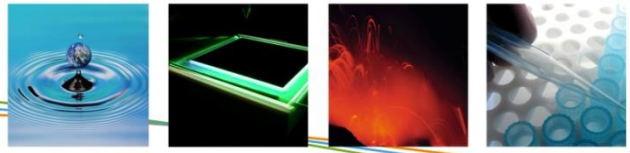


New approaches in outdoor air quality monitoring: mobile sensing, participatory sensing and sensor networks

COST Action TD1105 EuNetAir

First Scientific Meeting, 4 – 6 December, Rome, Italy

Presentation: Jan Theunis

Research team:

Matteo Reggente

Jan Peters

Martine Van Poppel

Evi Dons

Joris Van den Bossche

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

Outline

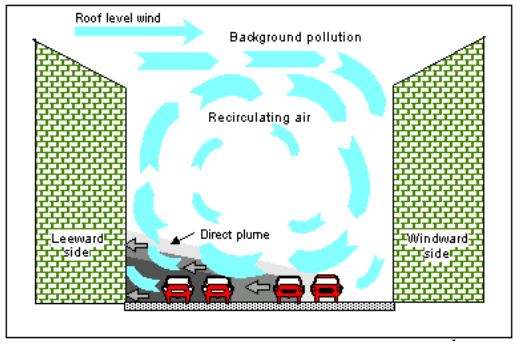
- (Urban) air quality monitoring
- New approaches: focus on exposure and health
- Sensor networks: concept, examples of statistical modelling
- Mobile monitoring
- Participatory monitoring

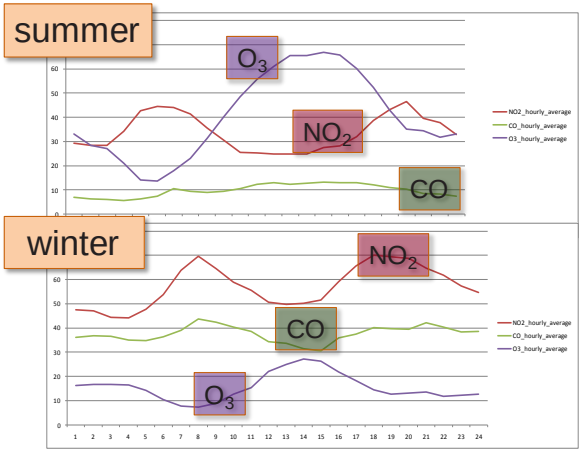
SIG2 Smart Sensors for Urban Air monitoring

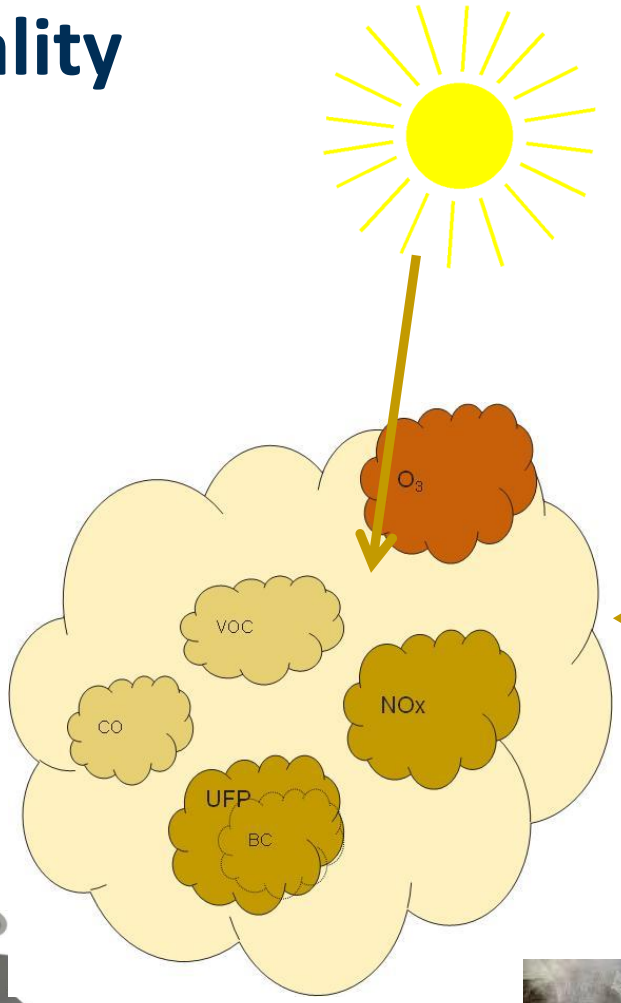
tools and methods

- Sensor array

Urban air quality

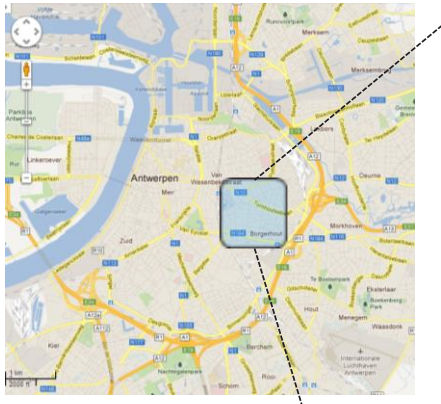


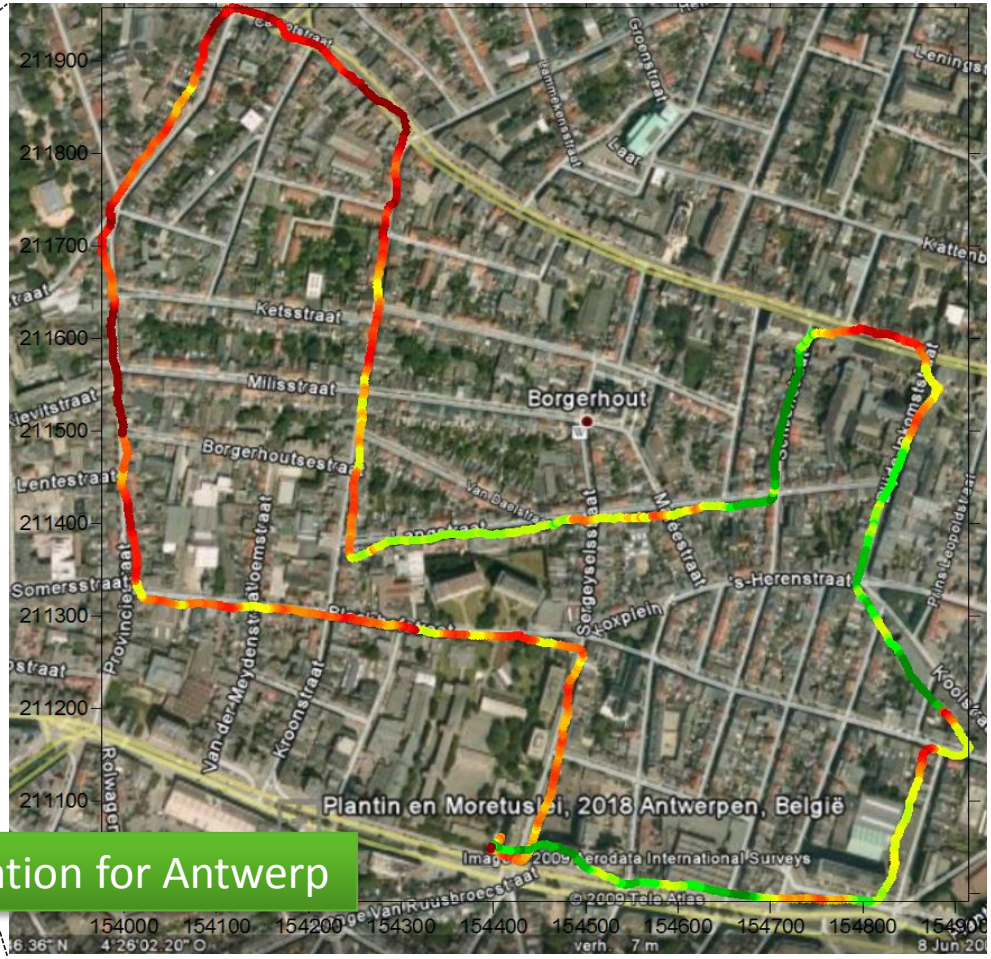




Air quality monitoring

- Conventional: Reference methods
  - Only regulated components
  - “Correct” but poor spatial coverage

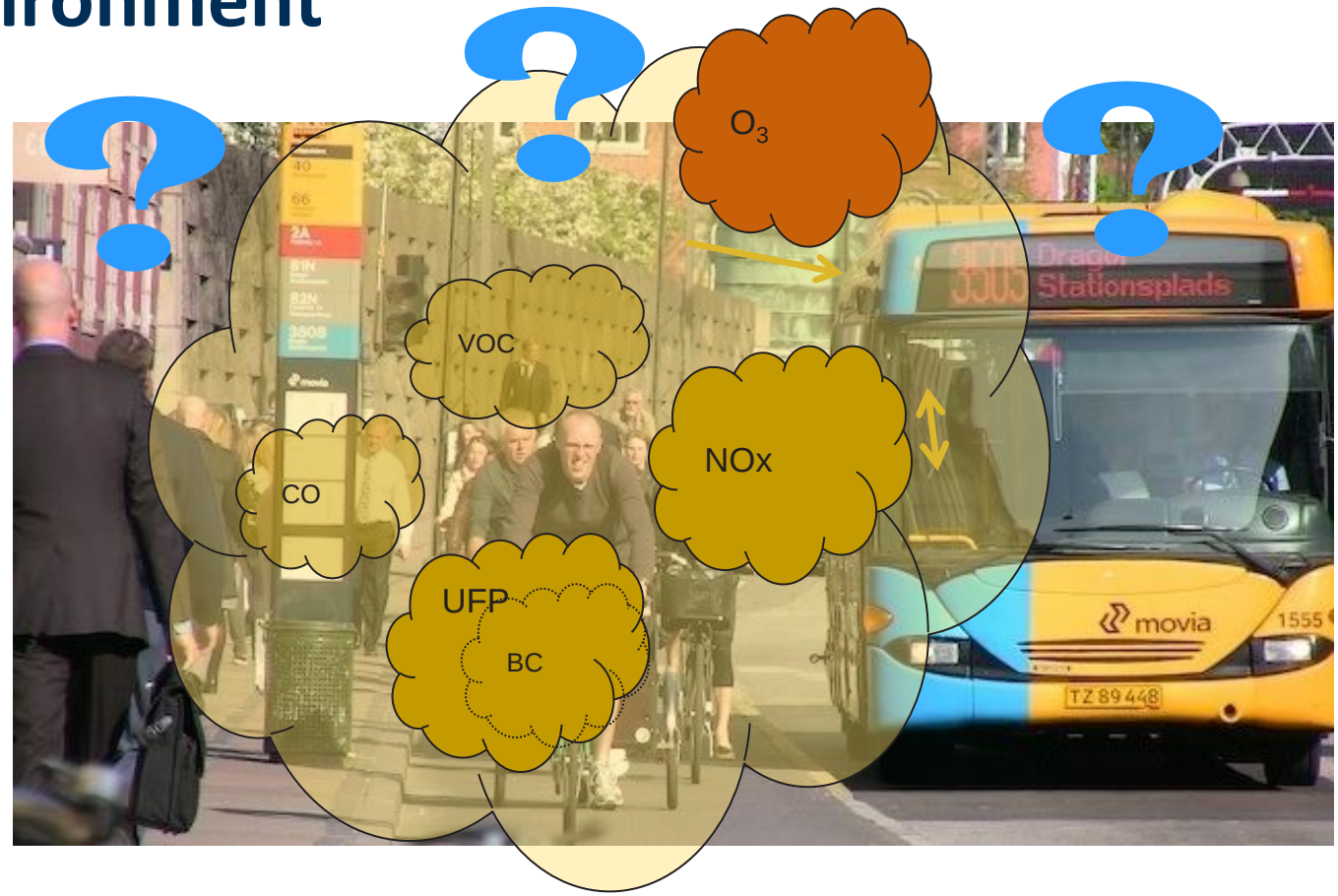




1 Urban air quality station for Antwerp

Air quality is not homogeneous in urban environments!

Exposure: people moving through the environment



- Dynamic Exposure Assessment –micro-environments
- Need for detailed data with high spatial and temporal resolution
- Traffic-related pollution: NOx, Ultrafine Particles (UFP), Black Carbon (BC)

New approaches: focus on exposure and health

Sensor Networks	Mobile Monitoring	Participatory Monitoring

	Low cost sensing devices	
Stationary	*Targeted*	*Opportunistic*
Mobile	High range portable monitors	
	Targeted	*Opportunistic*
	Low cost sensing devices	
	Targeted	*Opportunistic*

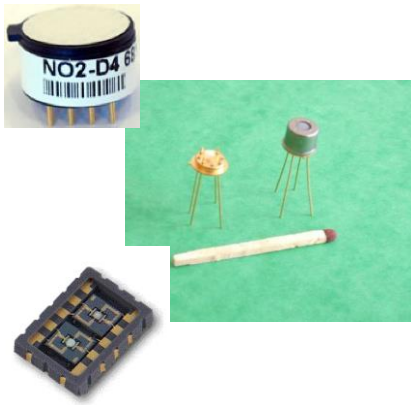
SIG2 Smart Sensors for Urban Air monitoring

» Challenges: sensor quality, data quality, intelligent data processing

Sensor networks: concept

- Heterogeneous networks of low cost sensors and high performance instrumentation
- Lack of accuracy compensated by amount of data
- Making use of network intelligence (incl. learning capabilities) to guarantee overall quality
- Combined measurement of different agents, e.g. different air pollutants, noise, meteo, …
- Making sensors work closely together
  - UFP, NOx, CO, noise → “proxies”
- Data aggregation and mining

Sensor networks: low cost sensors



Basic sensors

- Electrochemical
- Semiconductor metaloxide
- 5 – 80 €

Sensor head

- temperature control
- calibration curve
- correcting for T, RH
- 200 - 300 €

Measuring device

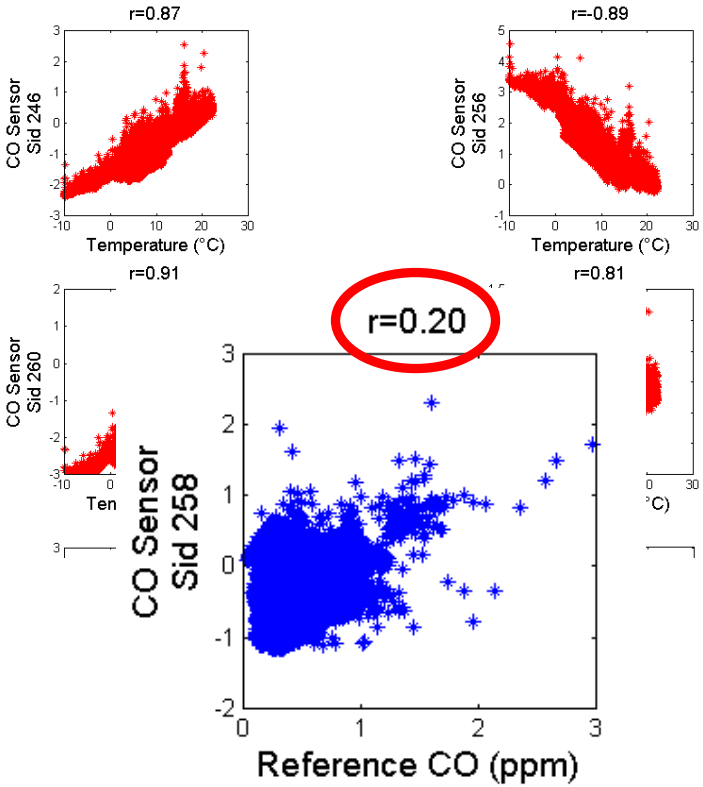
- 1000 - 2000 €

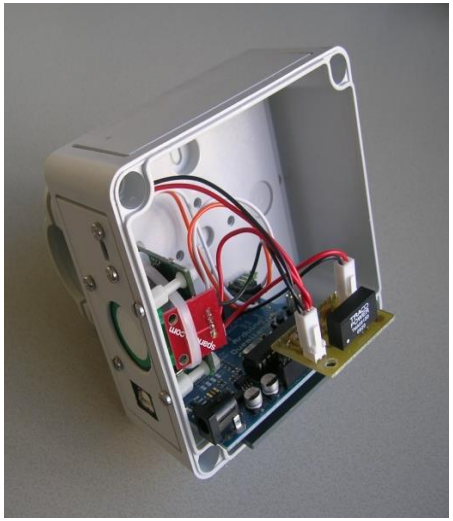
Not designed for / little experience in ppb range

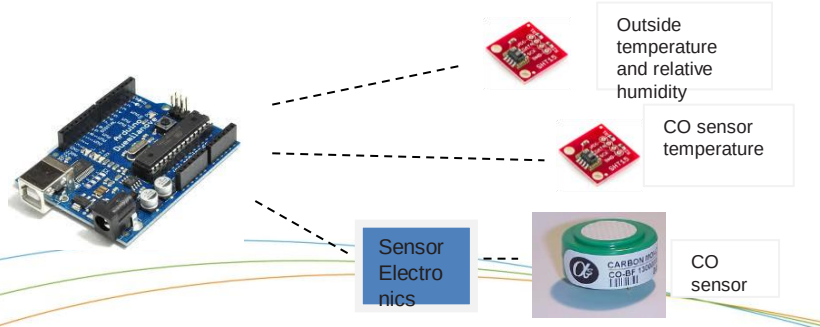
cross-interference, drift, T and Hum effects

Sensor networks: low cost sensors

- Sensor node with low-cost CO sensor:
- → Huge temperature dependence

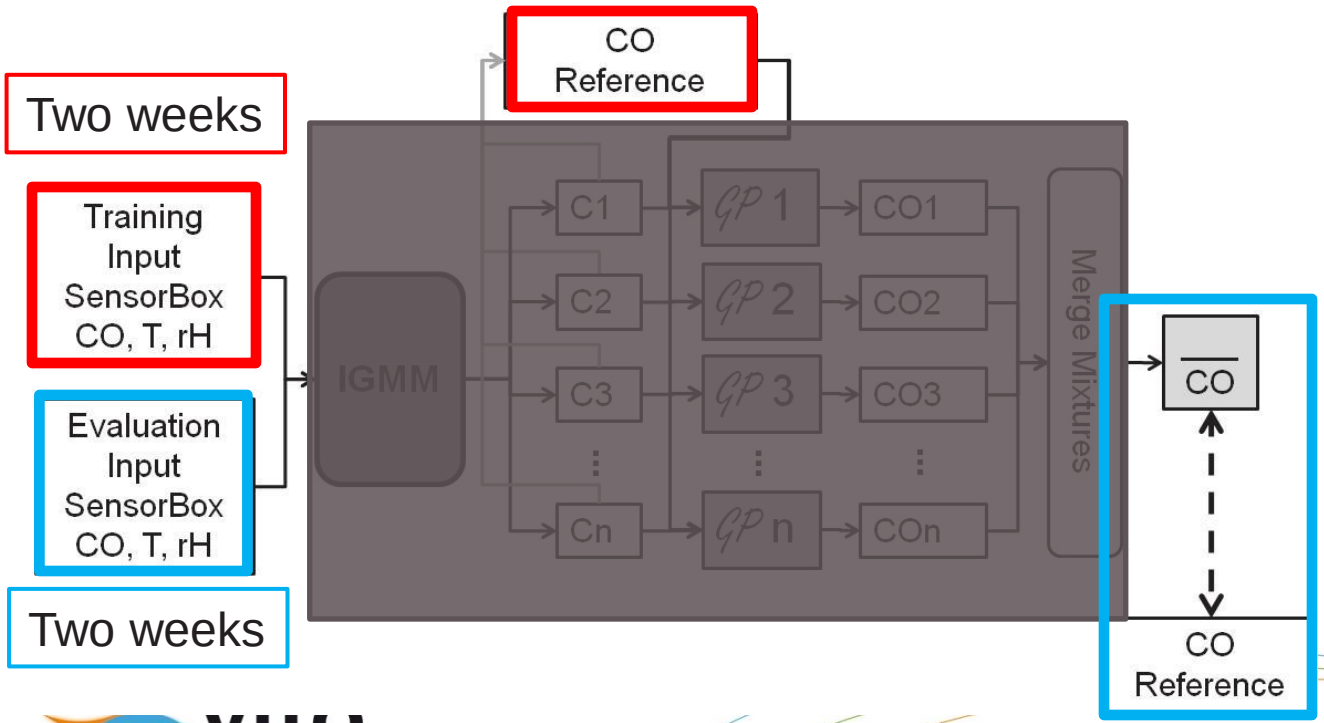






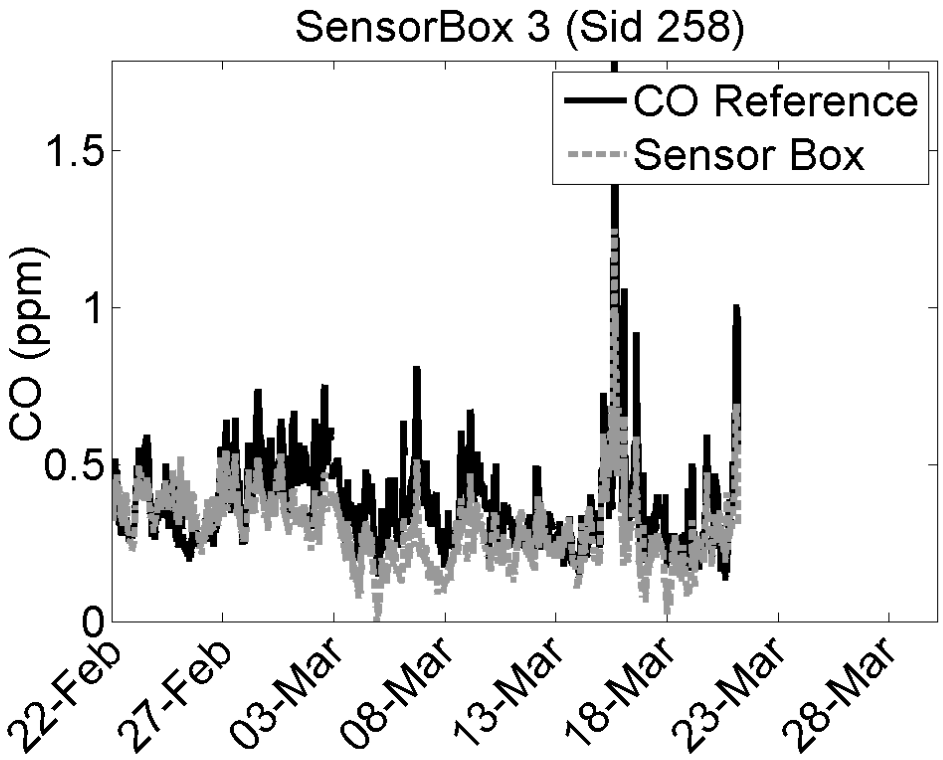
Sensor networks: low cost sensors

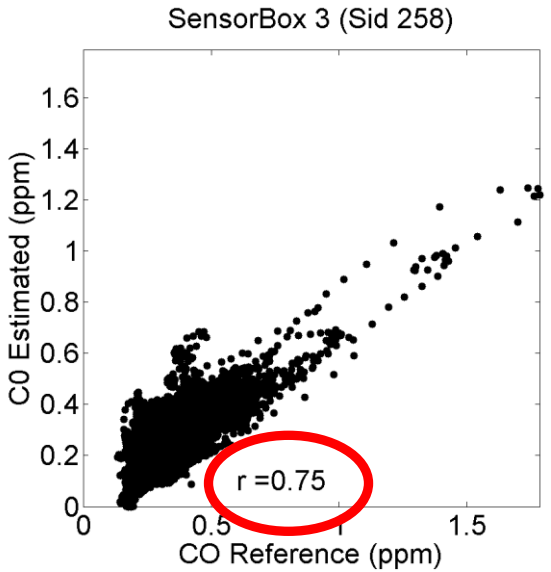
- Sensor node with low-cost CO sensor
  - » correcting interference of environmental factors
  - » Test set-up: sensors collocated with reference CO monitor
  - » Develop statistical model



Sensor networks: low cost sensors

- Sensor node with low-cost CO sensor
  - » correcting interference of environmental factors: result

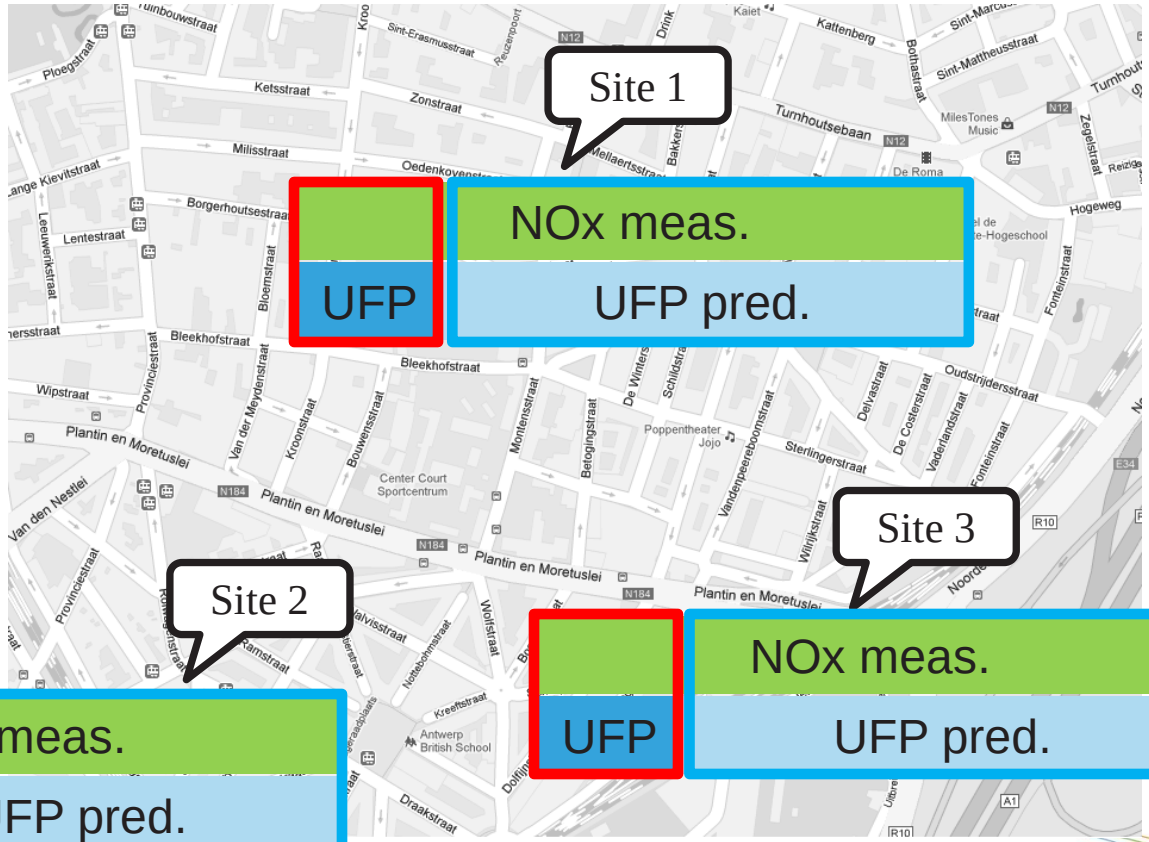




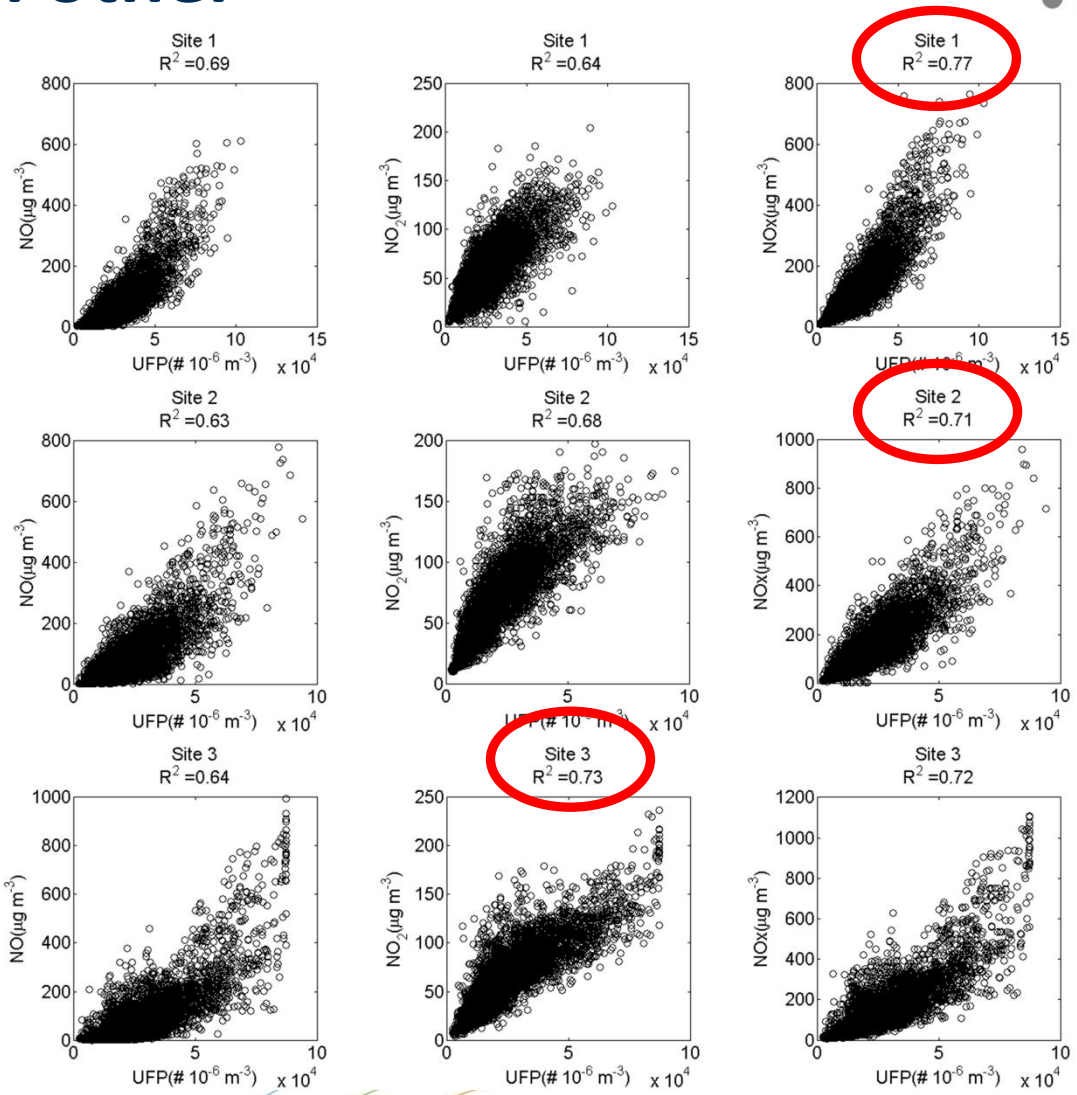
Sensor networks: sensors learning from each other

- Estimating UFP (ultrafine particles)
  - With the help of NO and NO_2 measurements

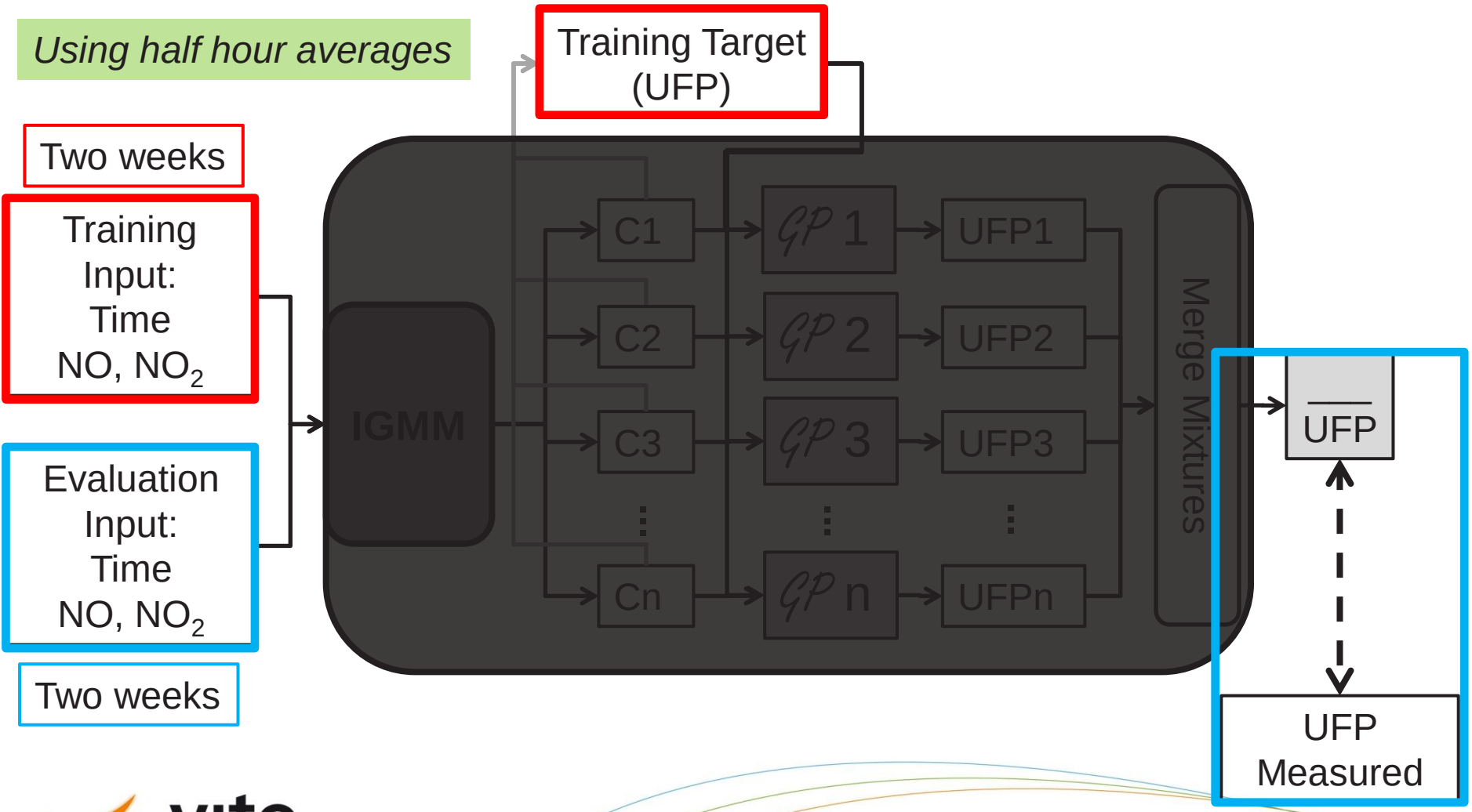
Matteo Reggente, Jan Theunis, et al (submitted to Environmental Modelling and Software) Prediction of Ultrafine Particle Number Concentration in Urban Environments by means of Gaussian Process Regression Based on NO/NO2 Measurements



Sensor networks: sensors learning from each other



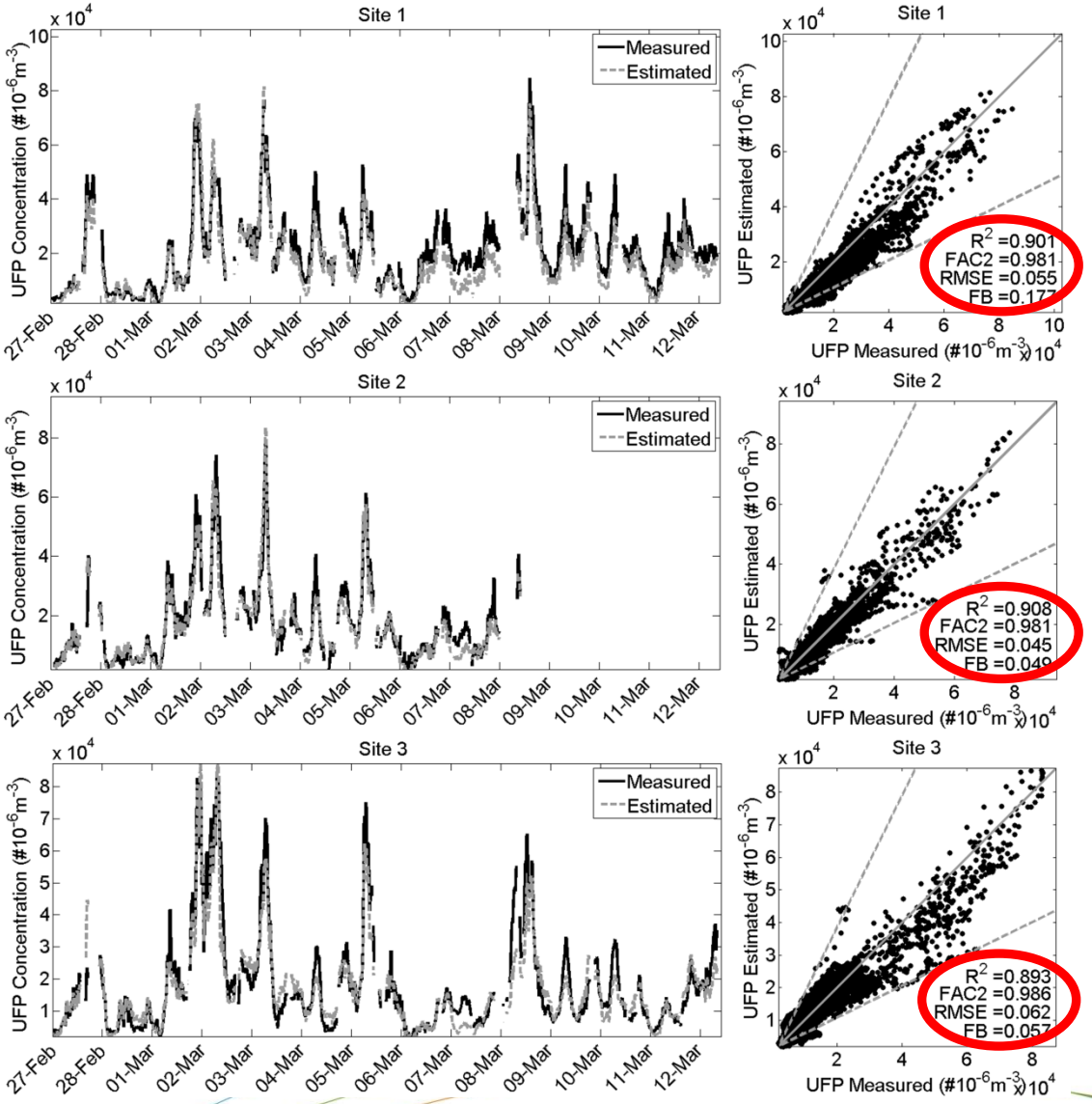
Sensor networks: sensors learning from each other: Statistical Modelling



Statistical modelling: Evaluation

Time Series and Scatter Plot:

Measured versus estimated UFP concentrations



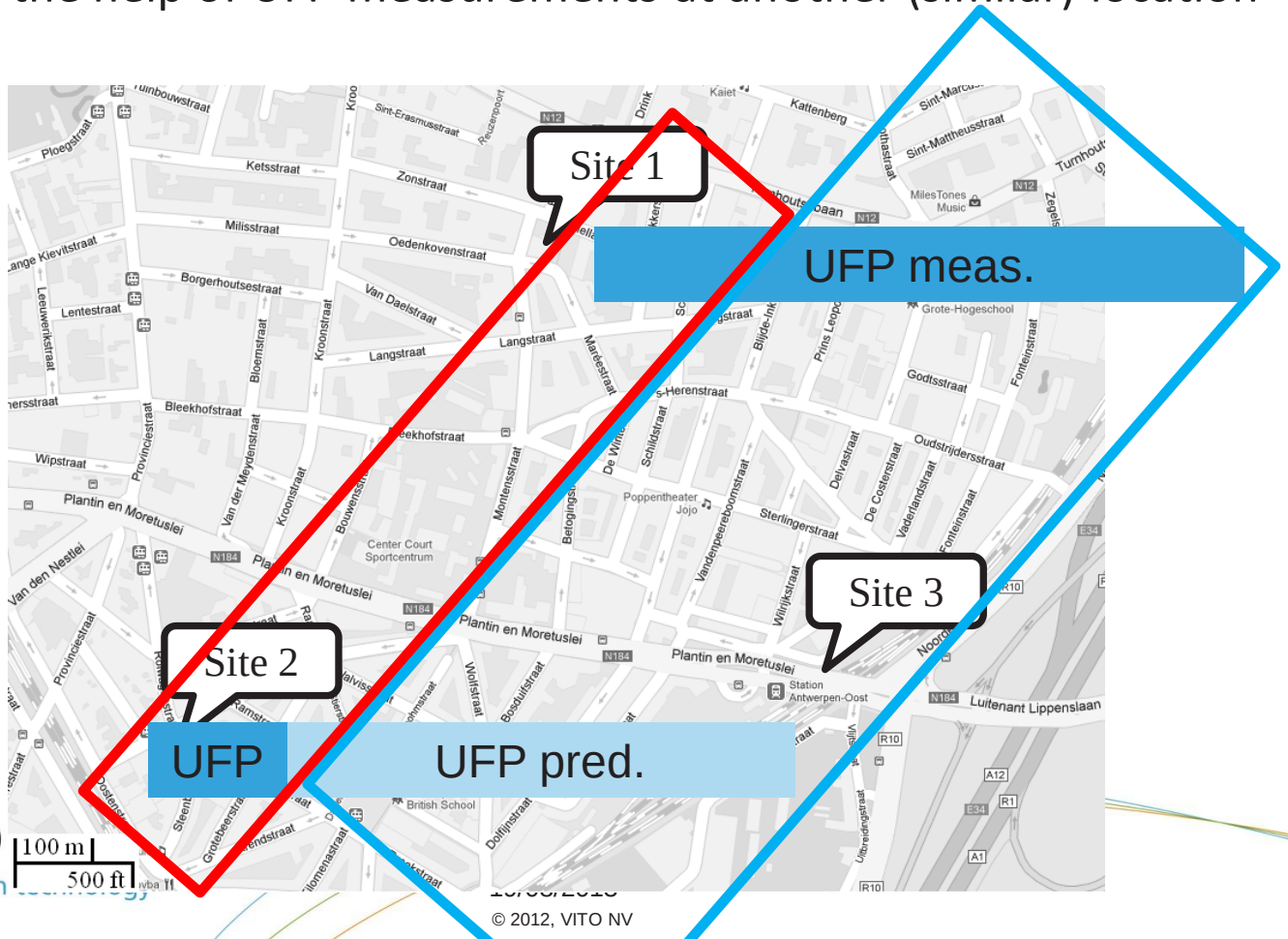
Statistical modelling: Evaluation

Using five minute averages

	Covariates	R^2	RMSE	FAC2	FB
Site 1	Time,NO,NO_2	0.84	0.066	0.94	0.17
	Time,NO	0.79	0.073	0.88	0.17
	Time,NO_2	0.69	0.089	0.90	0.20
Site 2	Time,NO,NO_2	0.82	0.064	0.94	0.46
	Time,NO	0.75	0.074	0.90	0.01
	Time,NO_2	0.73	0.079	0.93	0.08
Site 3	Time,NO,NO_2	0.85	0.072	0.97	0.05
	Time,NO	0.75	0.097	0.81	0.09
	Time,NO_2	0.84	0.085	0.97	0.09

Sensor networks: sensors learning from each other

- Estimating UFP (ultrafine particles)
  - With the help of UFP measurements at another (similar) location

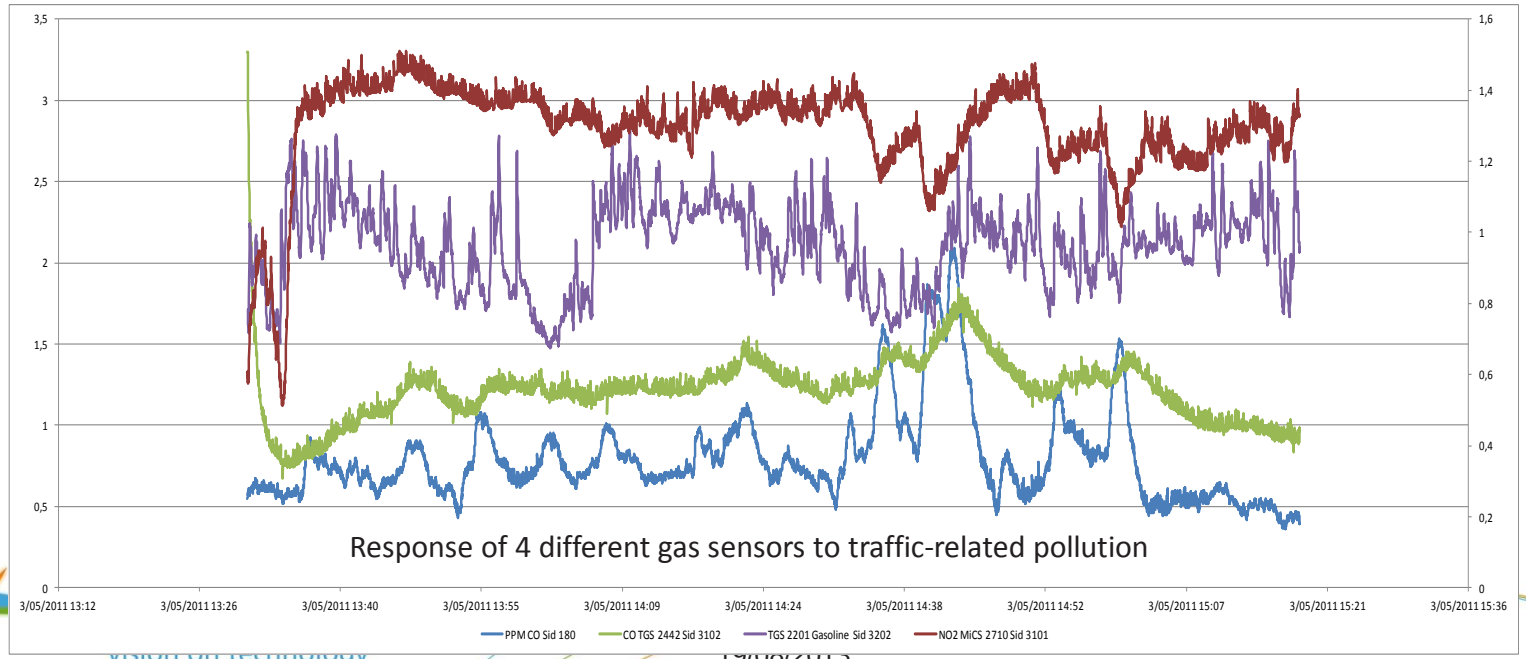


Low cost measurement devices for large scale mobile data collection: EveryAware SensorBox

Individual low-cost sensors → Sensor array (e-nose)

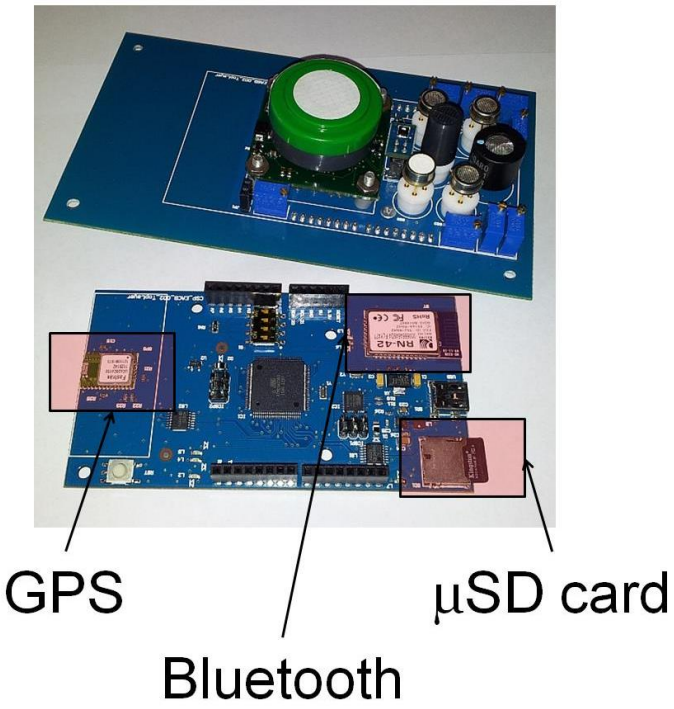
→ poor selectivity
→ cross-interference
→ drift
→ T and humidity effects

→ Exploit partial selectivity towards different gas components using machine learning tools to achieve multivariate calibration



Response of 4 different gas sensors to traffic-related pollution

Low cost measurement devices for large scale mobile data collection: EveryAware SensorBox



Bart Elen, Jan Theunis, Stefano Ingarra, Andrea Molino, Joris Van den Bossche, Matteo Reggente and Vittorio Loreto (2012) The EveryAware SensorBox: a tool for community-based air quality monitoring, paper presented at the Workshop Sensing a Changing World, May 9-11, 2012, Wageningen, The Netherlands. (http://www.geo-informatie.nl/workshops/scw2/papers/Elen_etal_EveryAware_SensorBox.pdf)

10 sensor e-nose
- 7 sensors which react on traffic pollution
-Ozone, Temperature and Relative humidity for sensor correction

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Low cost measurement devices for large scale data collection: Multivariate Calibration

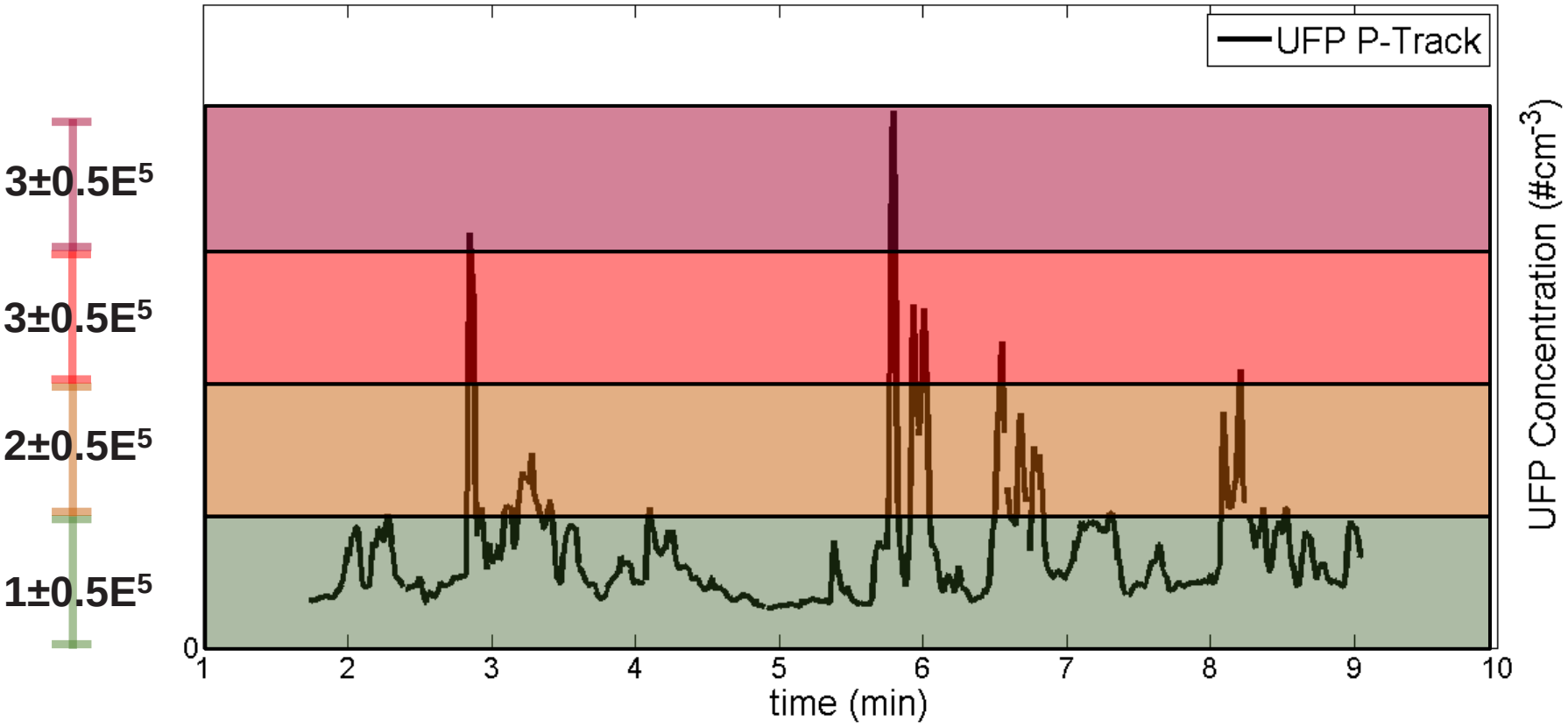
- Deployment of the Sensor Boxes close to a monitor
- Use them both stationary and mobile

Alternative 1 – Continuous Mobile Calibration

- **Deployment of a subset of Sensor Boxes close to portable and “TRUSTABLE” device in a mobile contest**

Alternative 2 – Discrete Mobile Calibration

- Deployment of a subset of Sensor Boxes close to portable and “TRUSTABLE” device in a mobile contest
- **Classification / Ordinal regression**
  - **Target: [BC, UFP]**



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