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

COST Action TD1105: WG3-WG4 JOINT SCIENTIFIC MEETING

Duisburg, Germany, 4 - 6 March 2013

Using Mobile Measurements for Air Quality Mapping: Methodological Issues

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WG Member

VITO and Ghent University, Belgium

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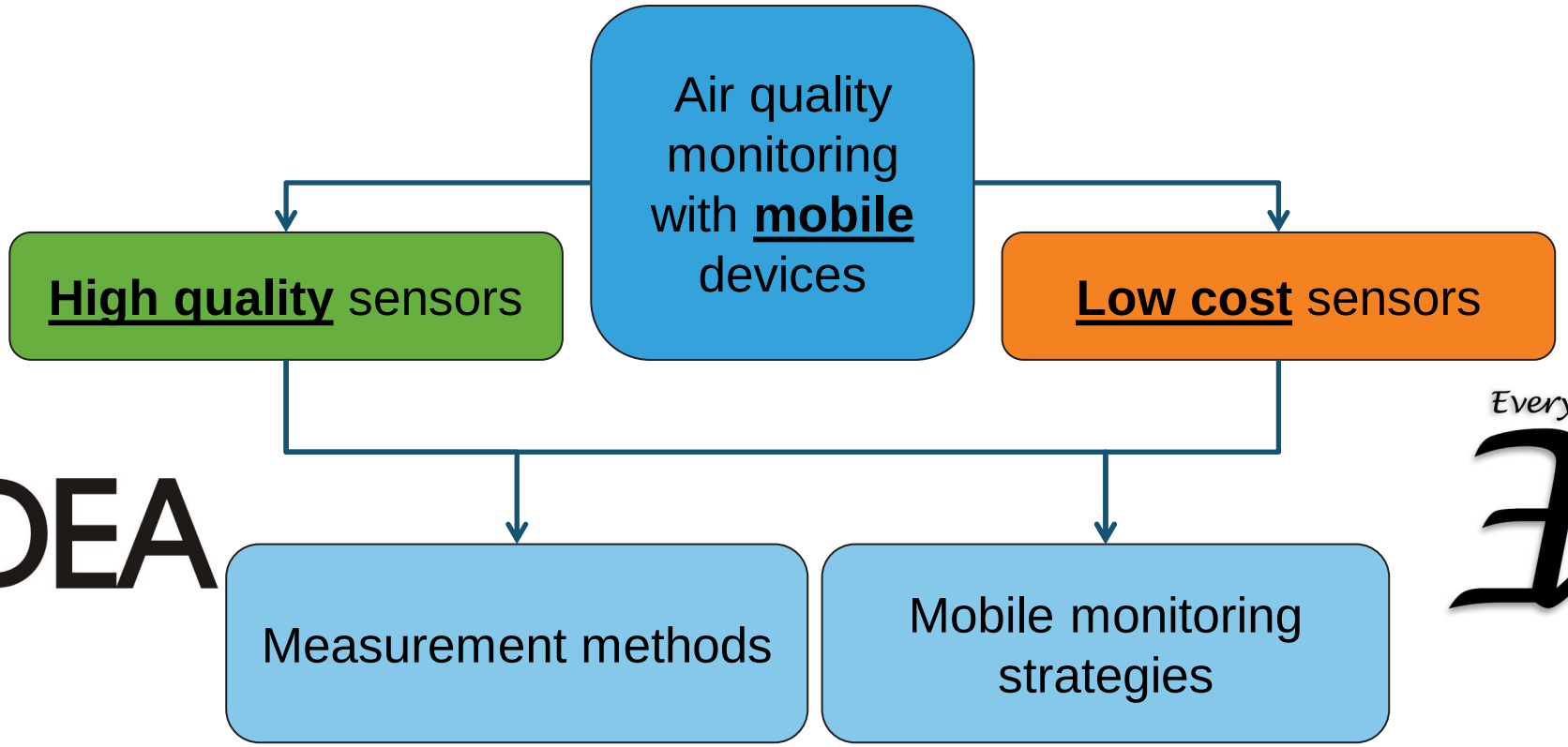
Scientific context and objectives in the Action

- **Brief reminder of MoU objectives:**
  - Assessment of new sensing technologies, including AQC *gas sensors* and wireless *sensors networks*, for environmental management
  - Technical and methodological approach for mapping urban air quality with *portable air quality monitors*

Current research activities of VITO (1/2)

- Dynamic Exposure Assessment



IDEA

Every Aware

Current research activities of the Partner (1/2)

- **IDEA**
  - Extensive mobile monitoring campaign to evaluate methodology
- **EveryAware FP7**
  - Case study with low cost sensorbox
- Own research activities at VITO on dynamic exposure and health

Research Facilities available for VITO (2/2)

- Broad range of stationary and portable monitors for outdoor and indoor PM and ultrafine particles (UFP) monitoring:
  - PM 1, PM2.5 and PM10 - Partisol, Grimm, Dusttrak (portable)
  - Size resolved UFP counts - SMPS – CPC, UFP monitor;
  - UFP counts - Grimm Nanocheck; CPC; P-track(portable)
  - EC/OC reference monitor
  - Black Carbon portable micro-aethalometer.
- Reference outdoor gas monitors for NO, NO_2 and NO_x, CO, O_3, SO_2
- Test gas generation infrastructure and exposure chambers
- Mobile measurement platform (Aeroflex, Black Carbon Mapper)
  - Instruments and ICT indrastructure for data communication and processing

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Mobile monitoring – what's in a name?

- **Scope:**
  - From a mobile laboratory (for eg grid monitoring) ...
  - ... to smartphone add-ons
  - In this context: relatively high-quality or low cost but **portable** devices, by bike or on foot

P-Trak

Micro-aethalometer

Every Aware

Mobile monitoring – what's in a name?

- **Scope:**
  - In this context: relatively high-quality or low cost but **portable** devices, by bike or on foot
- **Objectives:**
  - Obtain spatially and temporally resolved data on air quality
- **Applications:**
  - Personal exposure monitoring
  - Assess (spatial and temporal) variability and dynamics of air pollution
  - Hot-spot identification
  - High resolution mapping in urban environment

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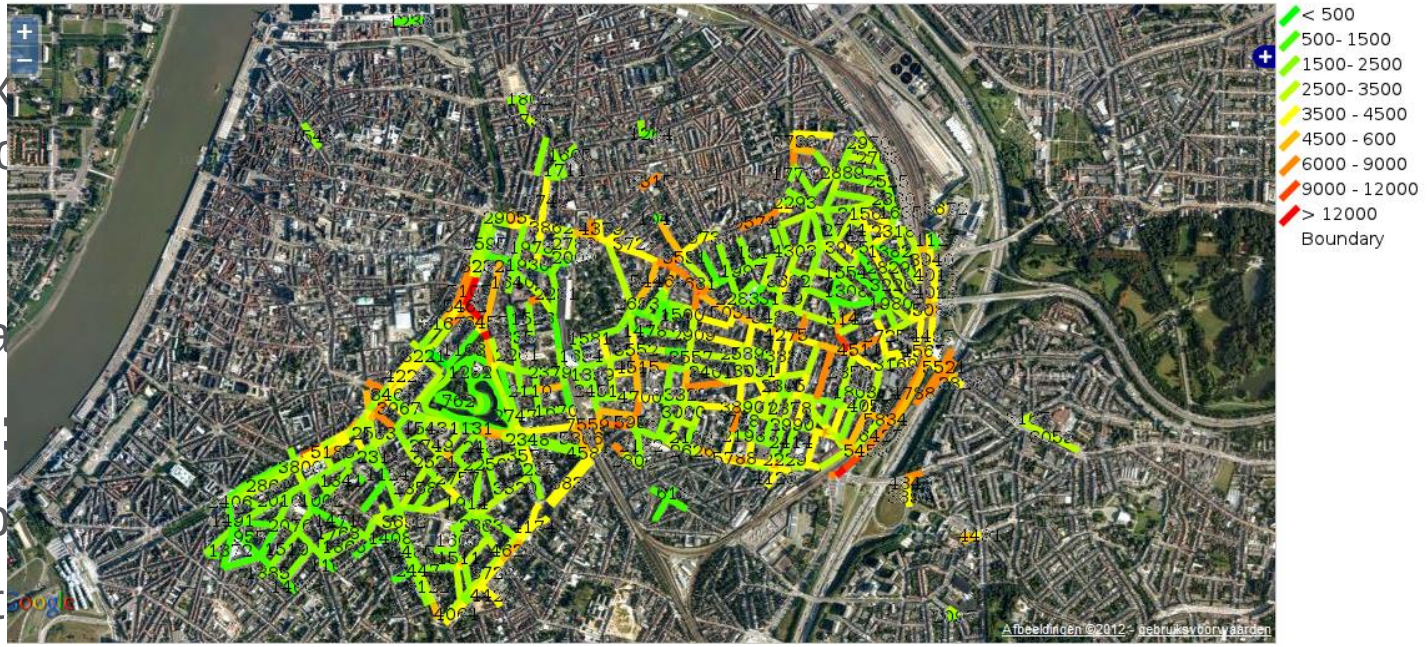

Mobile monitoring – methodology

- Urban air quality (BC) => large variability
- Spatio-temporal data

Mobile monitoring – methodology

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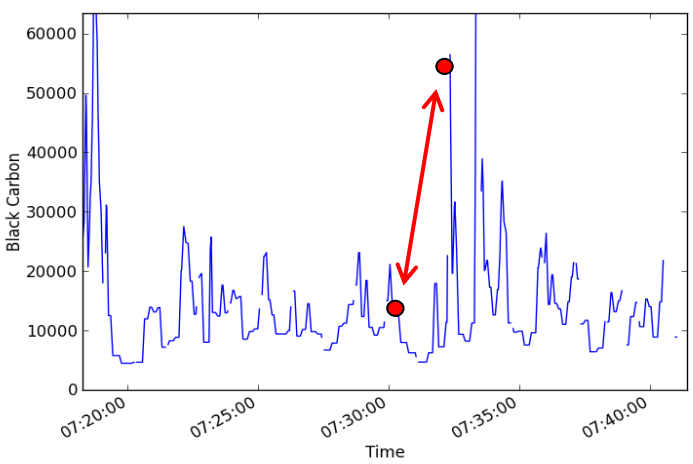
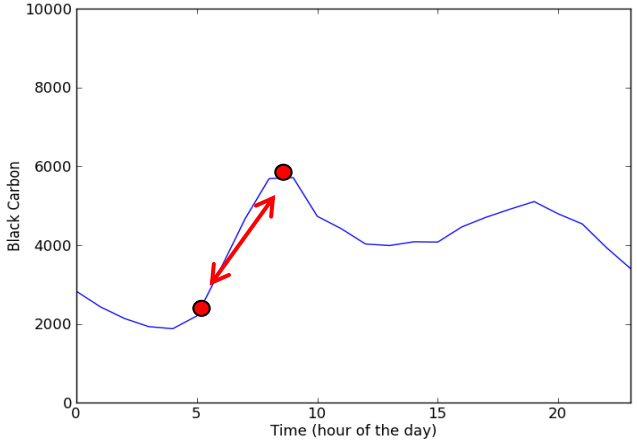
1) Short term



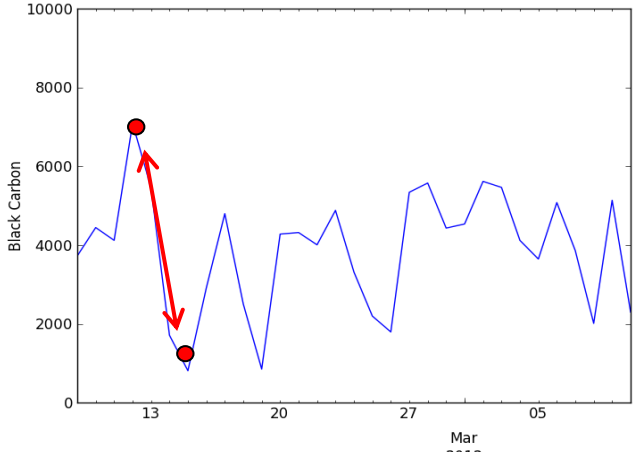
=> Events eg passing car, …

2) Diurnal variation



=> Traffic flow, …

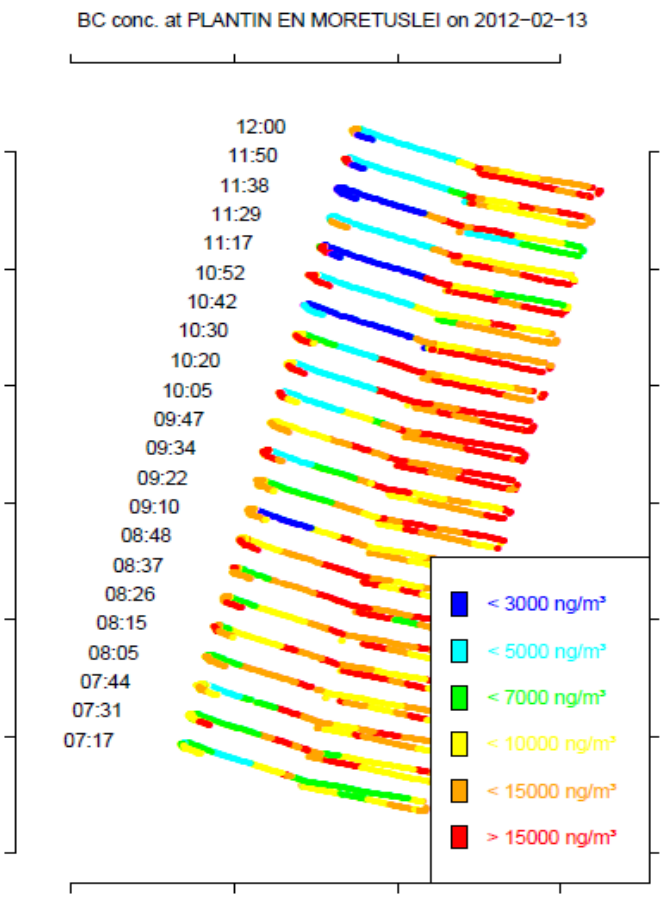
3) Day-to-day



=> Regional variation, meteorological conditions, …

Mobile monitoring – methodology

- Urban air quality (BC) => large variability
- **Spatio-temporal data**
  - (time, location, air quality)
  - Single run = snap shot - Highly influenced by traffic discontinuity and short term incidents



Spatio-temporal series

Repeated measurements: one morning

Mobile monitoring – methodology

- Urban air quality (BC) => large variability
- Spatio-temporal data

=> consequence: large variability in collected data

- Repeated measurements → **How many? Labour intensive**
- Fixed route (in time and/or place)
- Data aggregation
- Background correction → **Decrease number of repetitions?**

→ **Is it possible to map AQ with mobile measurements?**

Achieved RESULTS: measurement campaigns

- Dedicated measurement campaign in Antwerp: 138 hours of bike measurements
- City guards monitoring campaign (opportunistic)
- EveryAware case study: volunteers monitor while commuting

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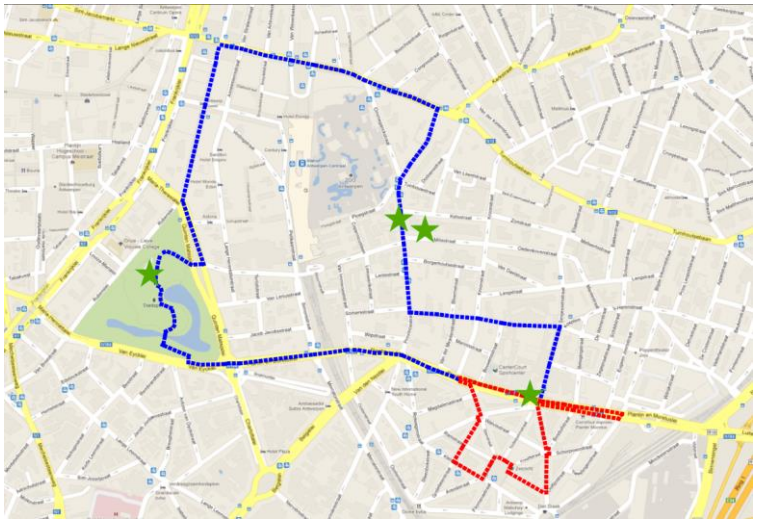
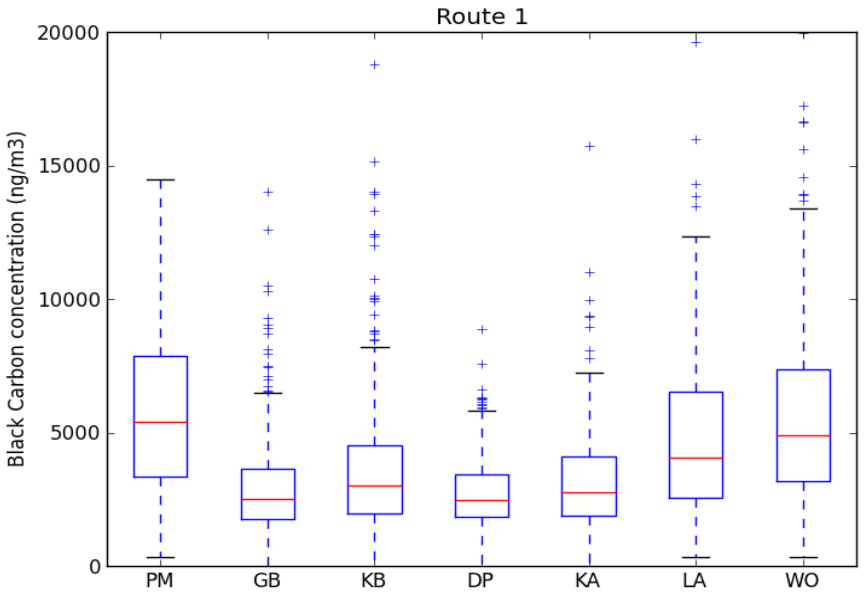
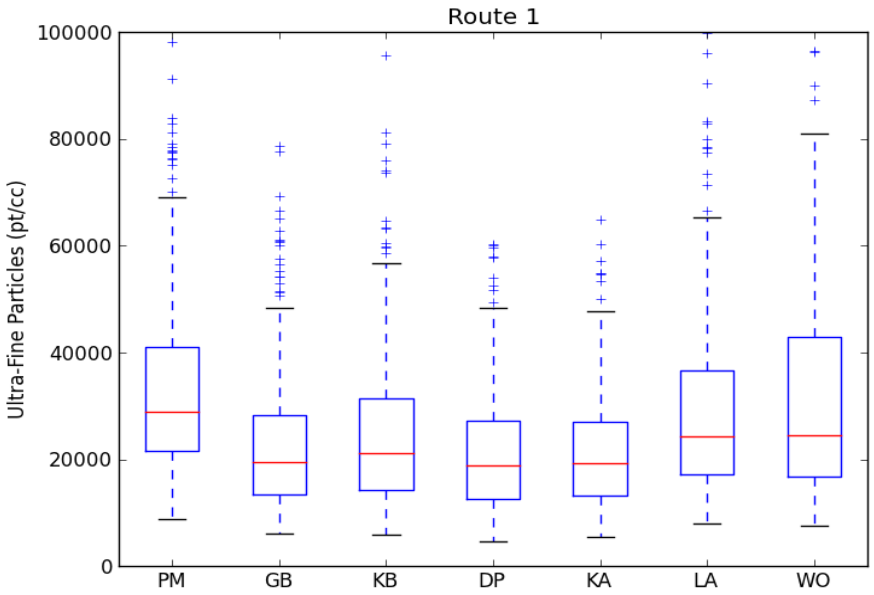


- Bike equipped with a portable UFP (P-Trak, TSI) and BC monitor (micro-aethalometer, MicroAeth, AethLabs) and a GPS
- Two fixed routes (ca. 2 and 5 km long)
- Passing by central monitoring station from the Flemish Environmental Agency (VMM) + stationary measurements at 3 locations, including background locations
- spread over 11 days, ca of bike measurements between 7 am an138 hours d 13 pm, resulting in **256 and 96 repeated runs**, respectively.

Characterizing spatial variation

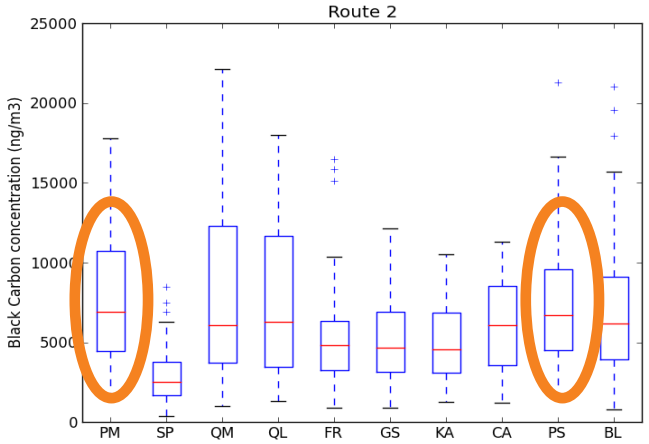




=> Significant differences are found between street level concentrations.

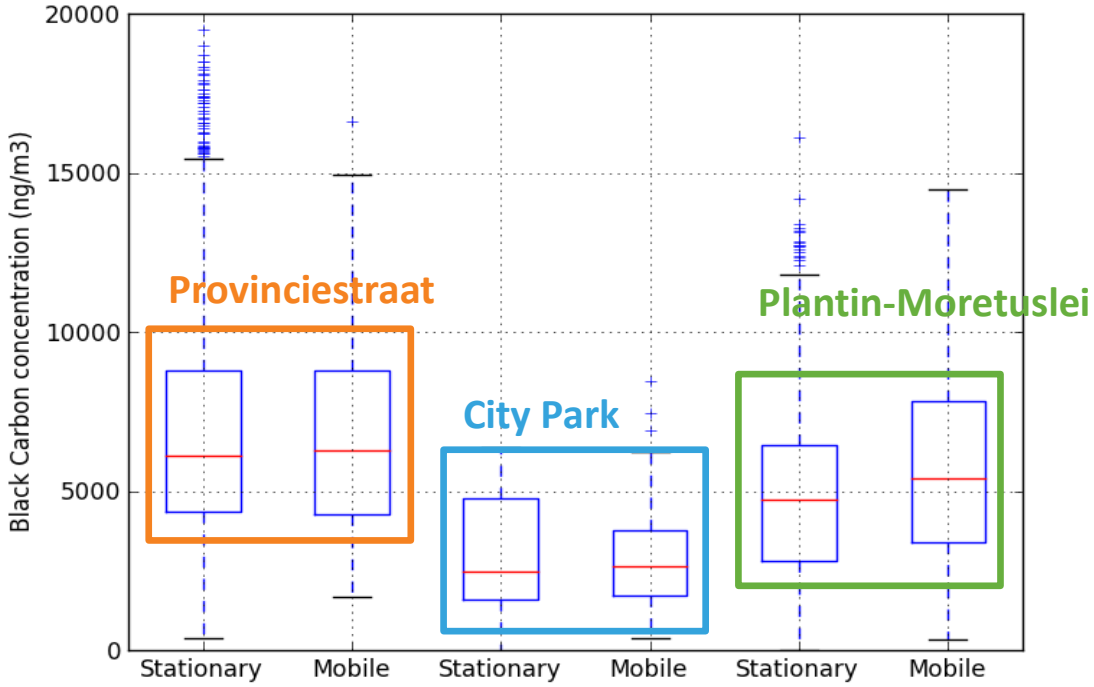
Characterizing spatial variation

- Street canyon
- Distance to traffic



=> Important remark: mobile measurements representative for exposure of cyclist

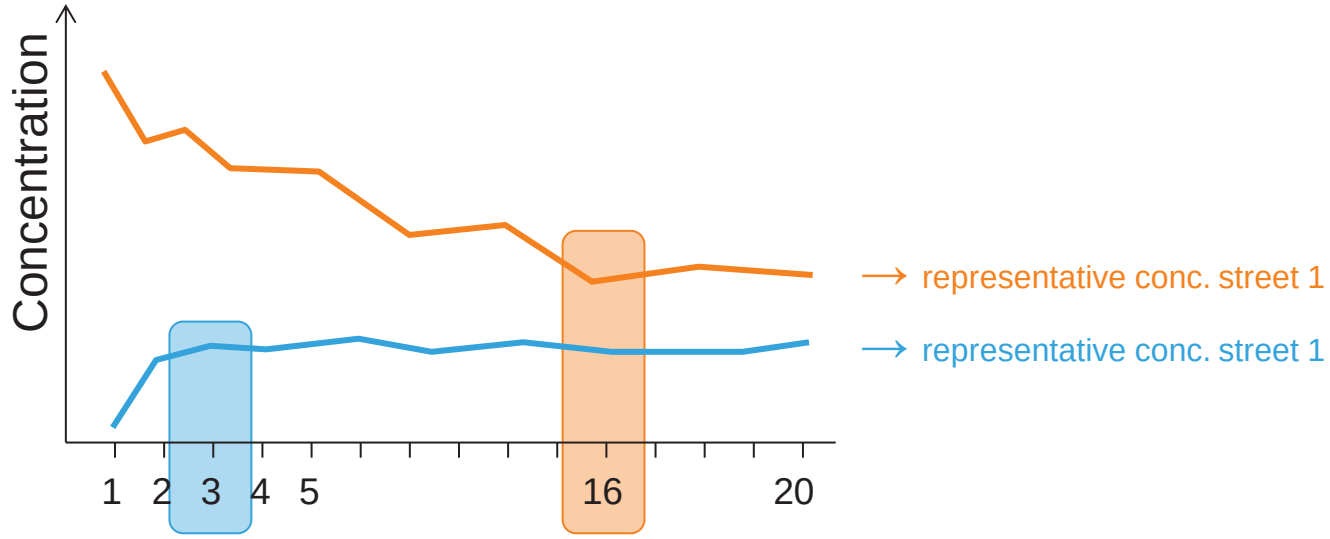
Comparison stationary – mobile measurements



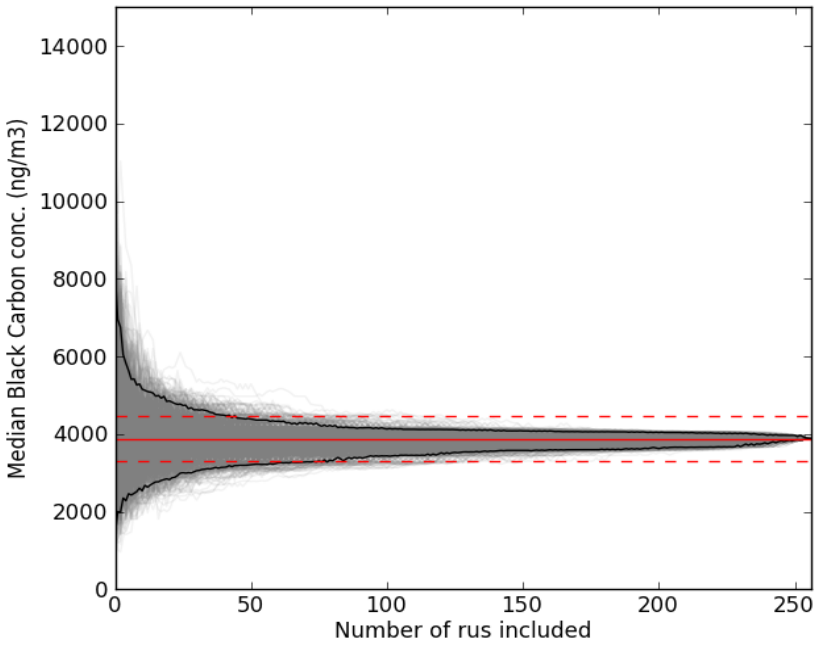
=> Mobile measurements are comparable to the average of stationary measurements in the same street

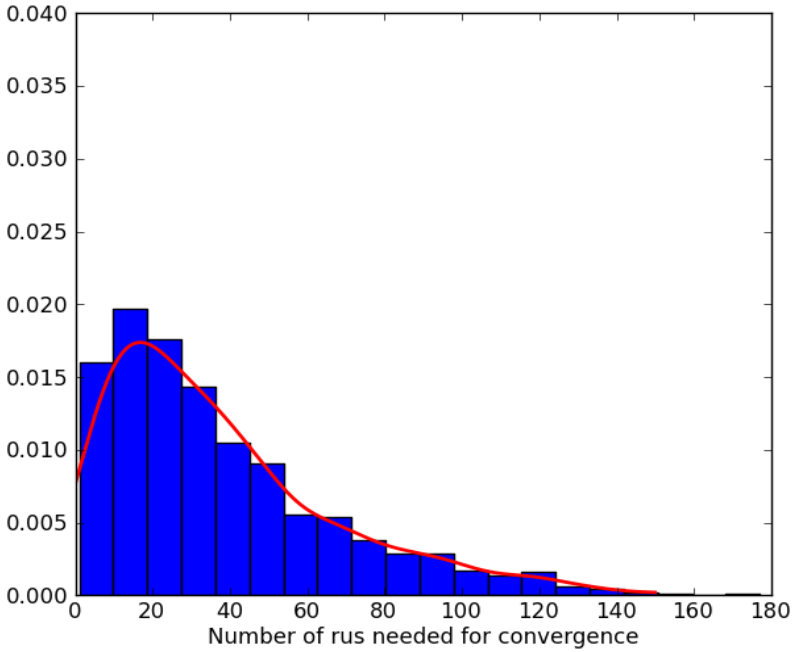
Needed number of repetitions: data experiment

- How sensitive are the results for the number of runs?
- Assumptions:
  - Lack of an absolute reference → **overall median concentration** used as reference
  - Different combinations of runs, **increasing number of runs**
  - **Convergence**? → when the median of the sampled runs deviates less than 15 % from the overall median

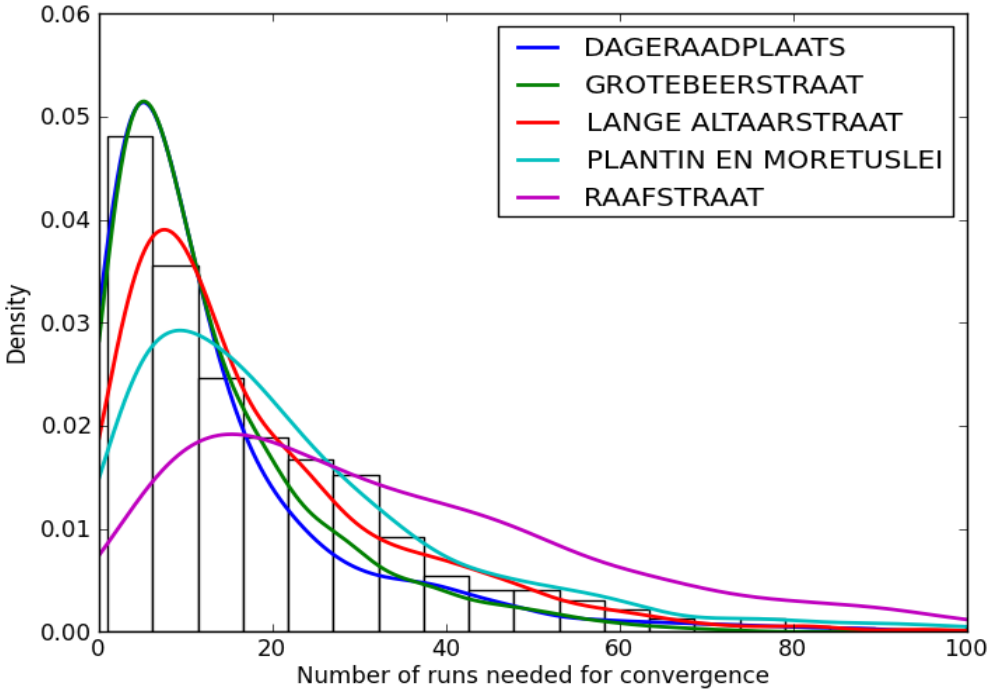


Example for data of all streets



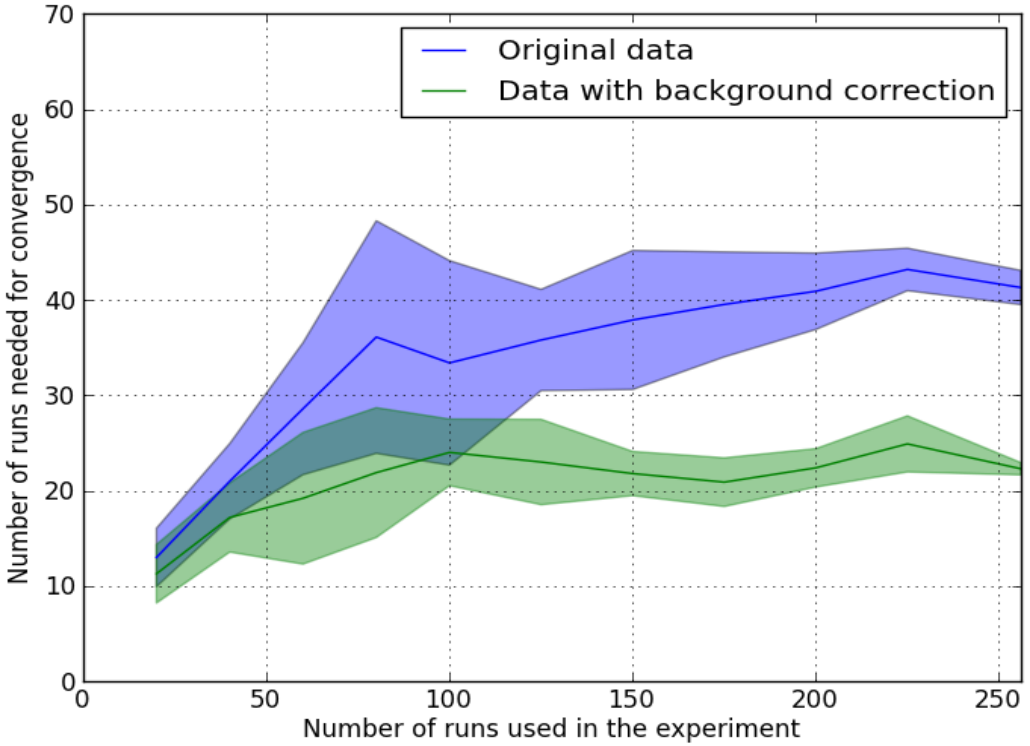


Differences between streets



=> Needed number of runs depends on characteristics of the street

Background correction



=> Background correction reduces needed number of repetitions

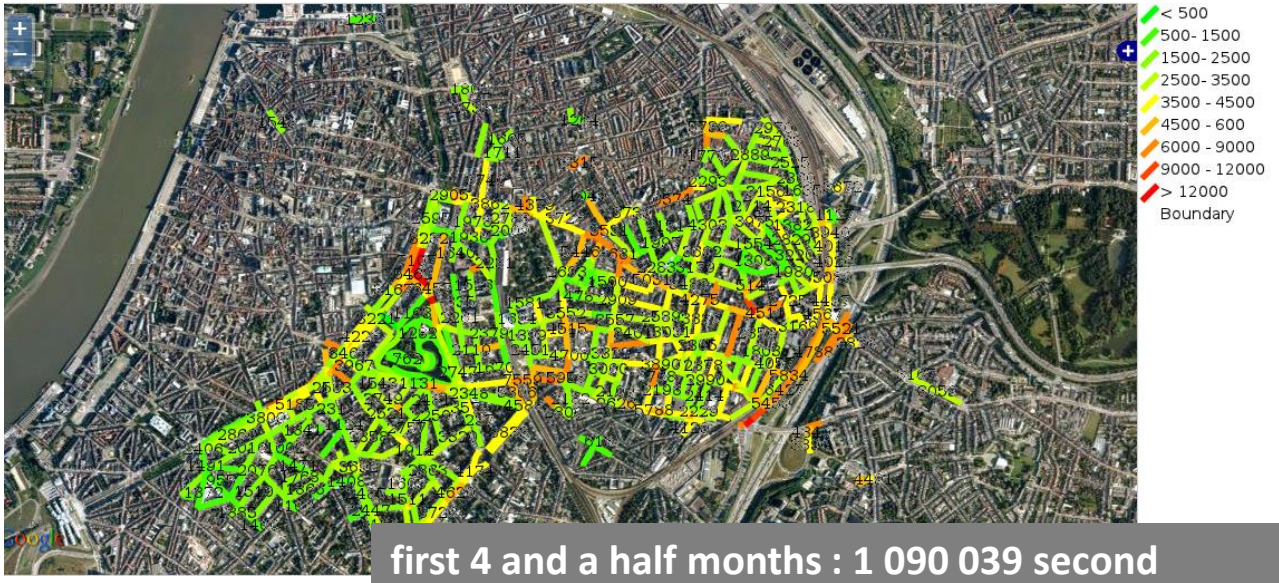
Future planned Activities

- Further validation of methodology with new campaigns
- GPS in the urban environment
- Mobile monitoring: how to collect enough data

  => **Participatory monitoring**

3 teams of 'City Guards' measuring air quality in Antwerp during 12 months

BC Mapper



first 4 and a half months : 1 090 039 second measurements; 302 h of measurements, spread over 53 days; most between 10 am and 16pm during the working week.

Conclusions and Priorities for future research

- Potential of mobile measurement methods to map urban air pollution.
- It is possible to reproducibly **map the air quality** in a specific area using mobile measurements:
  - Significant differences are found between street level concentrations.
  - Mobile measurements are comparable to the average of stationary measurements in the same street.
- but attention has to go to the **methodology**:
  - **Repetitions** are needed to get a representative image.
  - Focus on **specific study area** in space and time.
  - **Background correction** reduces needed number of repetitions
  - Combination with **fixed-site** monitoring station

Conclusions and Priorities for future research

- Number of measurements and repetitions can be increased through volunteers and opportunistic monitoring schemes (**participatory monitoring**)
- Development of **low-cost sensors** => larger deployment becomes possible
- **Extrapolate** using similarity between streets (eg LUR)
- Towards real-time maps

Thank you for your attention!

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