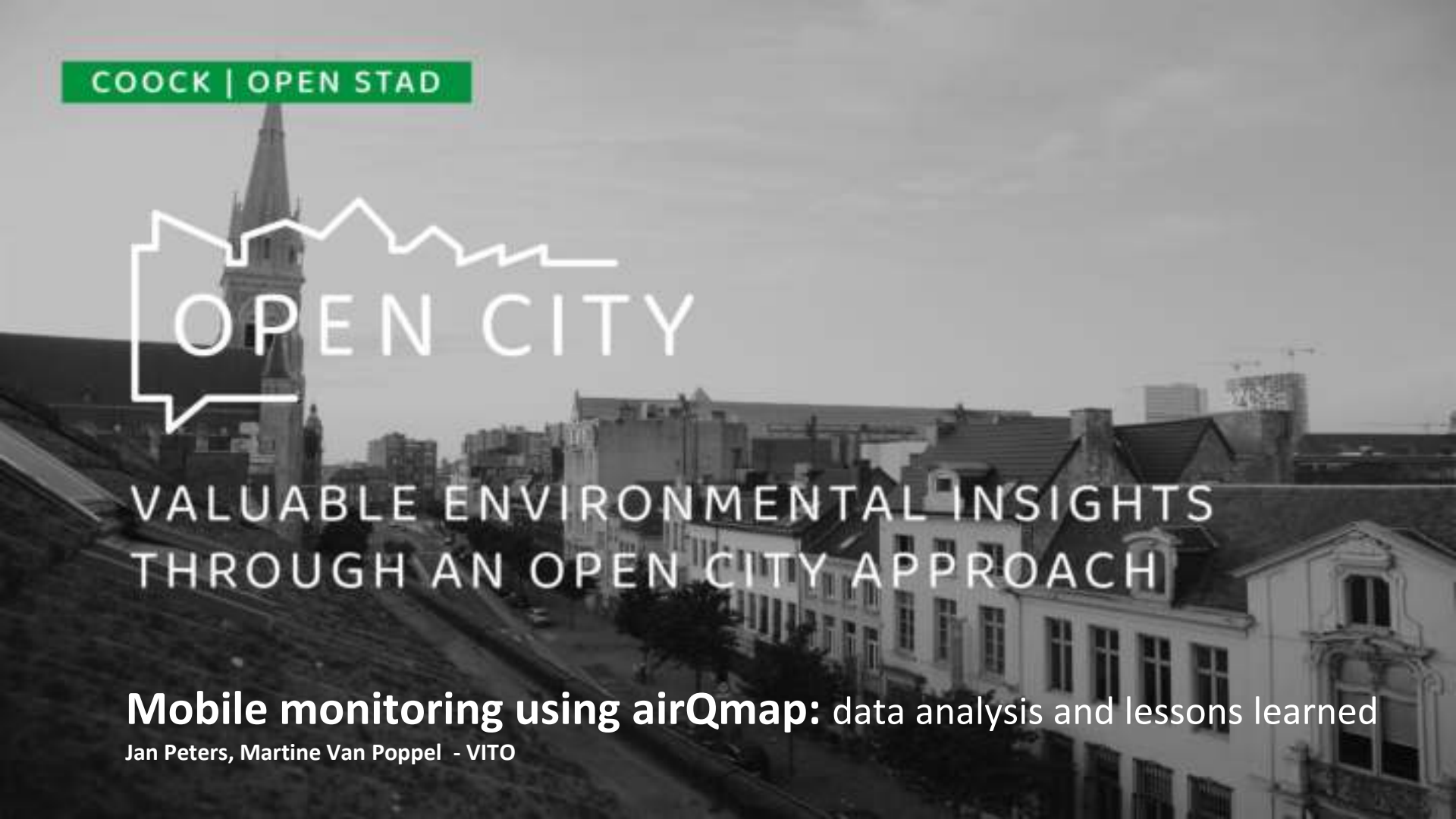
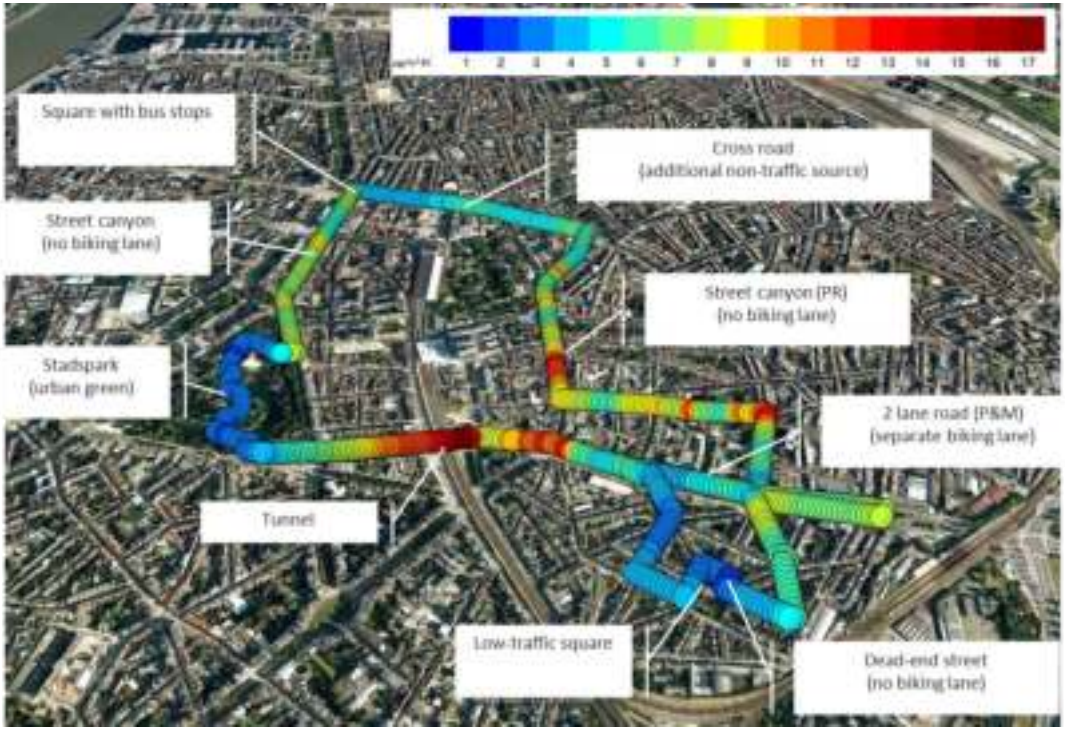


Mobile monitoring using airQmap: data analysis and lessons learned

Jan Peters, Martine Van Poppel - VITO

SPATIAL VARIABILITY OF AQ



Traditional measurement stations:

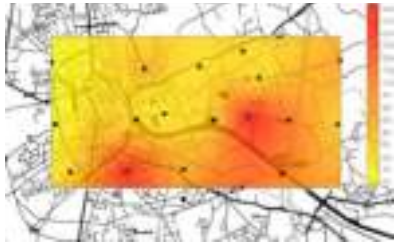
- Reference measurements
- Limited locations

Large spatial variability in a city

COOCK | OPEN STAD

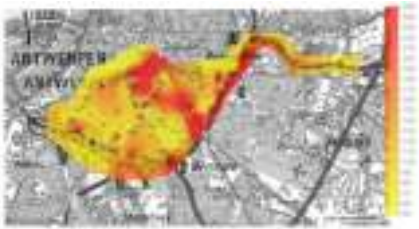
SOME HISTORY OF MOBILE MONITORING AT VITO

2003



5-min measurements + interpolation

2005



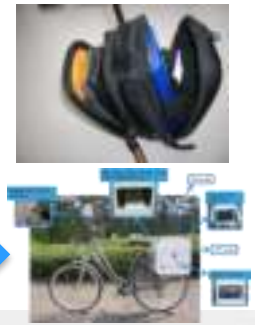
Car as platform + GPS

1s + bike as platform

2010

BC + data processing

Automatic data proc. and volunteers



airQmap
Aeroflex

today...

useability
data processing
methodology
Visualisation
flexible

THE AIRQMAP APPROACH

AIRQMAP

airqmap is a tool to collect large amounts of mobile BC data and process them into street-level BC exposure maps.

Measurement devices: GPS and microAeth

Easy-to-use software

Web application BC maps

www.airqmap.com

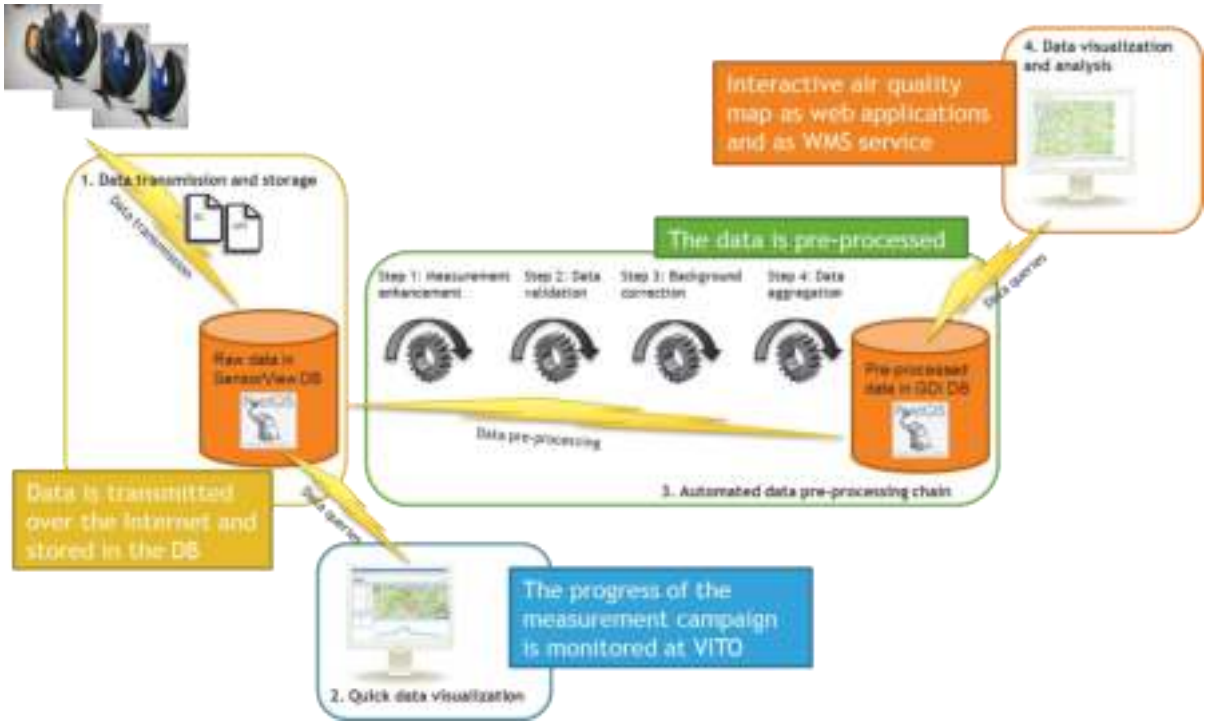
Scientific Methodology

Automated dataprocessing

AIRQMAP MEASUREMENT DEVICE AND POLLUTANT

- Black Carbon (BC)
  - Indicator for combustion-related aerosol
  - Associated with cardiovascular and cardiopulmonary health effects
  - WHO claims: "Studies of short-term health effects suggest that BC is a better indicator of harmful particulate substances from combustion sources (especially traffic) than undifferentiated particulate matter (PM) mass."
- MicroAeth
  - Not a sensor but a 'medium range' (portable) instrument
  - 1sec time resolution (signal noise – postprocessing)

AIRQMAP DATA PROCESSING



AIRQMAP **STANDARD** METHODOLOGY

- BC measurements
  - Algorithm for noise reduction, outlier removal
- Trajectory
  - Fixed route by bike or foot: representative for exposure of cyclist or pedestrians
- Repeated measurements at fixed times
  - Dependent of the research question e.g. hot spots at peak hours
- Data aggregation over time and space
  - 30m spatial resolution
  - Visualisation of result (no interpolation) : min # of datapoints
- Result
  - Spatial variability, no evaluation of limit values

NUMBER OF REPETITIONS

Table 2
Results of the data experiments: required number of repetitions using a deviation of 25 and 50% at different levels of spatial aggregation: the entire route (route 1), different streets (for abbreviations see Table 1) and 20 and 50 m segments (10th, 50th and 90th percentiles are given), and using different processing methods: arithmetic mean ("standard"), trimmed mean ("trimmed"), with a background normalisation ("background") and the combination of both ("both"). The minimum for each spatial level and for 25 and 50% is shown in italics.

	25%				50%			
	Standard	Trimmed	Background	Both	Standard	Trimmed	Background	Both
Route	17	18	*11*	12	4	5	3	4
Street level								
PM	18	20	*13*	14	5	6	3	4
DP	18	19	*14*	*14*	5	5	4	4
WO	63	61	60	57	16	11	15	9
KE	82	68	75	61	21	10	20	9
GI	66	50	62	42	18	8	18	7
KA	44	34	40	25	12	7	12	5
20 m segments								
10%	31	30	26	24	8	6	7	5
50%	59	54	52	48	15	10	13	8
90%	164	112	156	108	44	13	43	*12*
50 m segments								
10%	33	31	29	24	8	7	6	5
50%	57	52	50	42	14	10	13	8
90%	143	102	141	94	39	13	40	*11*

25% and 50% Standard deviation

=>Data processing

=>Spatial resolution

AIRQMAP

- The airQmap approach can be used to analyze mobile data in smart city context

- Other pollutants
  - Some tests performed with PM sensors, UFP

- Other platform
  - Some tests with a car/mobile van

- Opportunistic measurements
  - Some tests with city guards
- …

CHALLENGES OF MOBILE MEASUREMENTS

IMPACT OF DAY

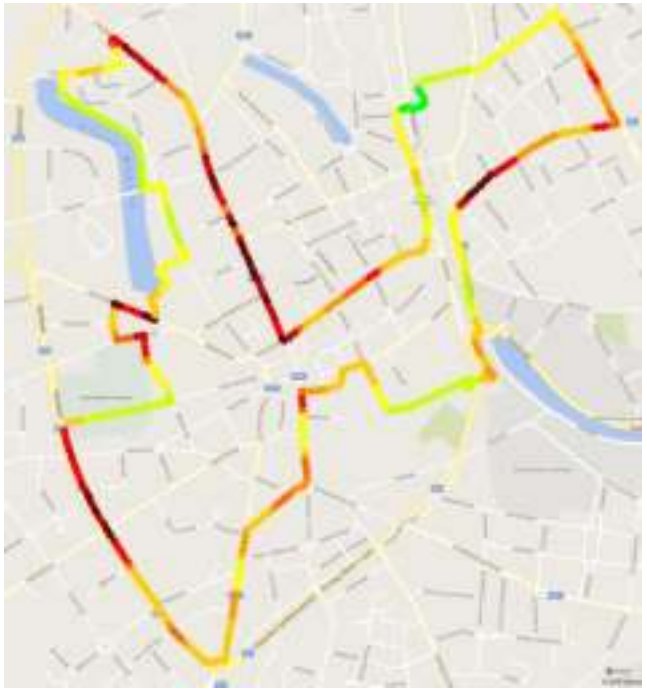
25/10 (weekday)

7/11 (weekday)

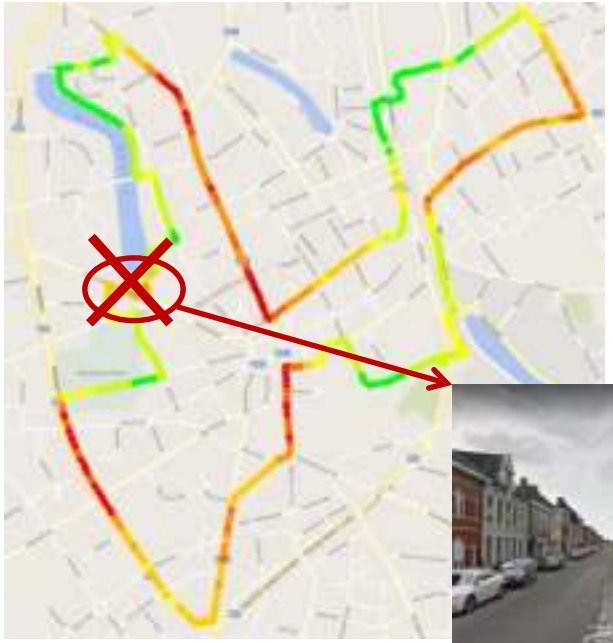
IMPACT OF TIME OF DAY

before noon

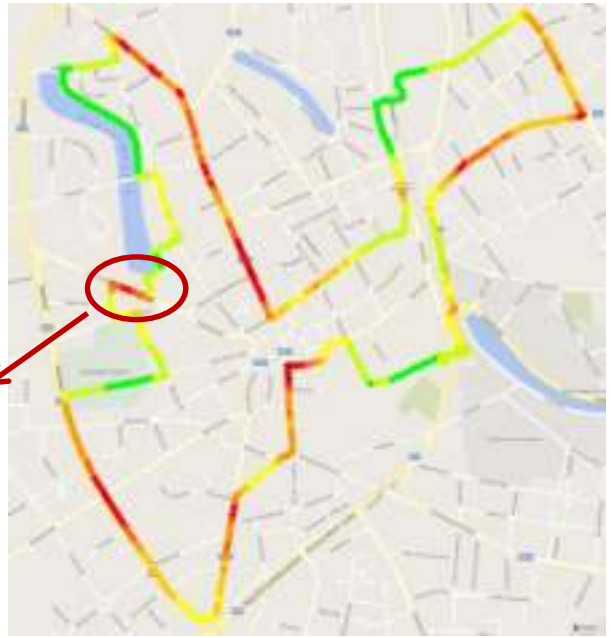
afternoon



TIME-SPACE SYNCHRONIZATION, RESPONSE OF SENSORS



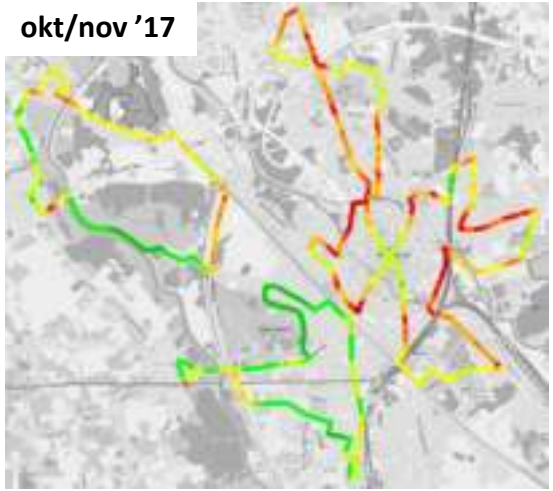
Aggregated map (#: 25 runs)



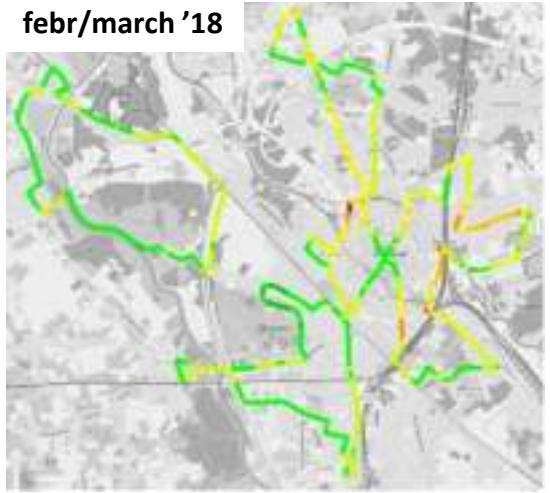
COOCK | OPEN STAD

SEASONAL DIFFERENCES

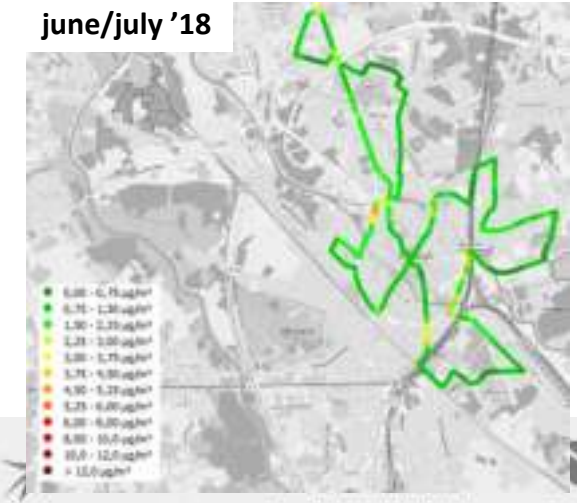
okt/nov ’17



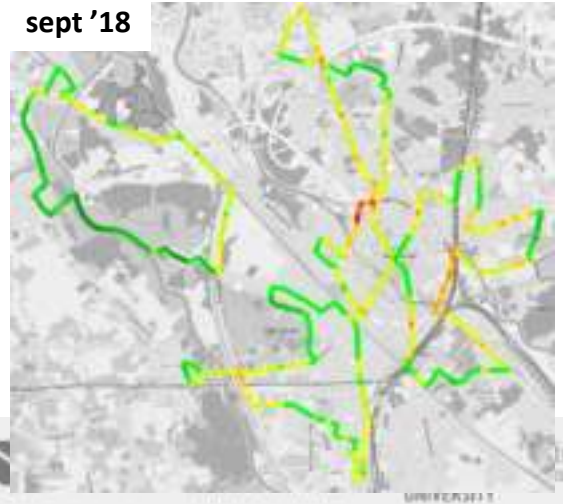
febr/march ’18



june/july ’18



sept ’18



SEASONAL DIFFERENCES

- Summary statistics per campaign and BC concentrations at fixed monitoring stations

	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	VMM virtual Traffic station
Campaign 1	1.0	2.4	3.3	3.7	4.7	12.4	3.3
Campaign 2	1.3	2.0	2.3	2.5	2.9	10.5	2.4
Campaign 3	0.5	0.9	1.2	1.4	1.7	6.2	1.4
Campaign 4	0.5	1.8	2.5	2.5	3.1	8.3	2.5

Yearly average 2017: 1.9

→ Max concentration

→ Min concentration

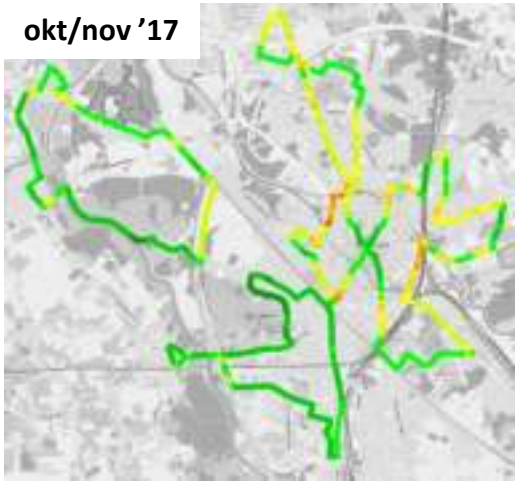
- **Rescaling** based on data on 'virtual' traffic station

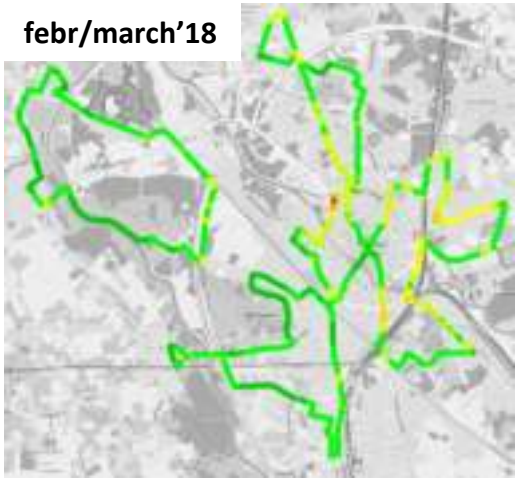
ratio = yearly average/campaign average @VMM traffic station

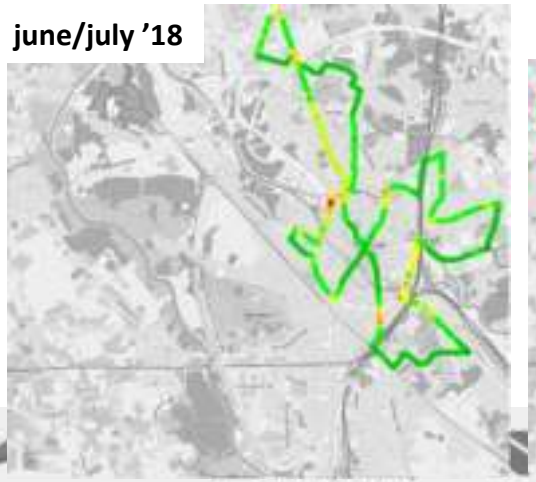
- **Aggregation** of different campaigns based on weighed average

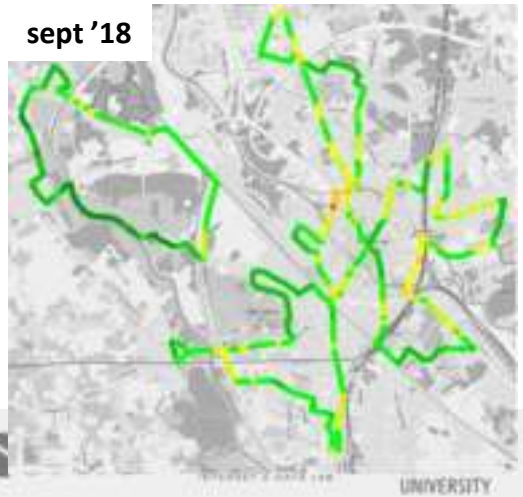
(weighing factor ~ frequency of occurrence of the average BC concentration)

SEASONAL DIFFERENCES









MEASUREMENT SET-UP
OPPORTUNISTIC VERSUS DEDICATED MEASUREMENTS

DEDICATED MEASUREMENTS VERSUS OPPORTUNISTIC APPROACH

- Dedicated measurement set-up
  - Measurement route is defined (in function of question)
  - At specific time(s) of day
  - Gives a representative picture of these moments in time
  - Easy to compare different locations
  - Additional effort to collect data

- Opportunistic measurements
  - Measurements are performed using a ‘platform’
  - Collection of spatio-temporal data
  - Additional effort/attention to data processing
  - Risk of sampling bias

DATA PROCESSING OF OPPORTUNISTIC MEASUREMENTS

- Data collection and aggregation
  - Based on opportunistic measurements (city wardens)
  - 50 m road segments, 1h time

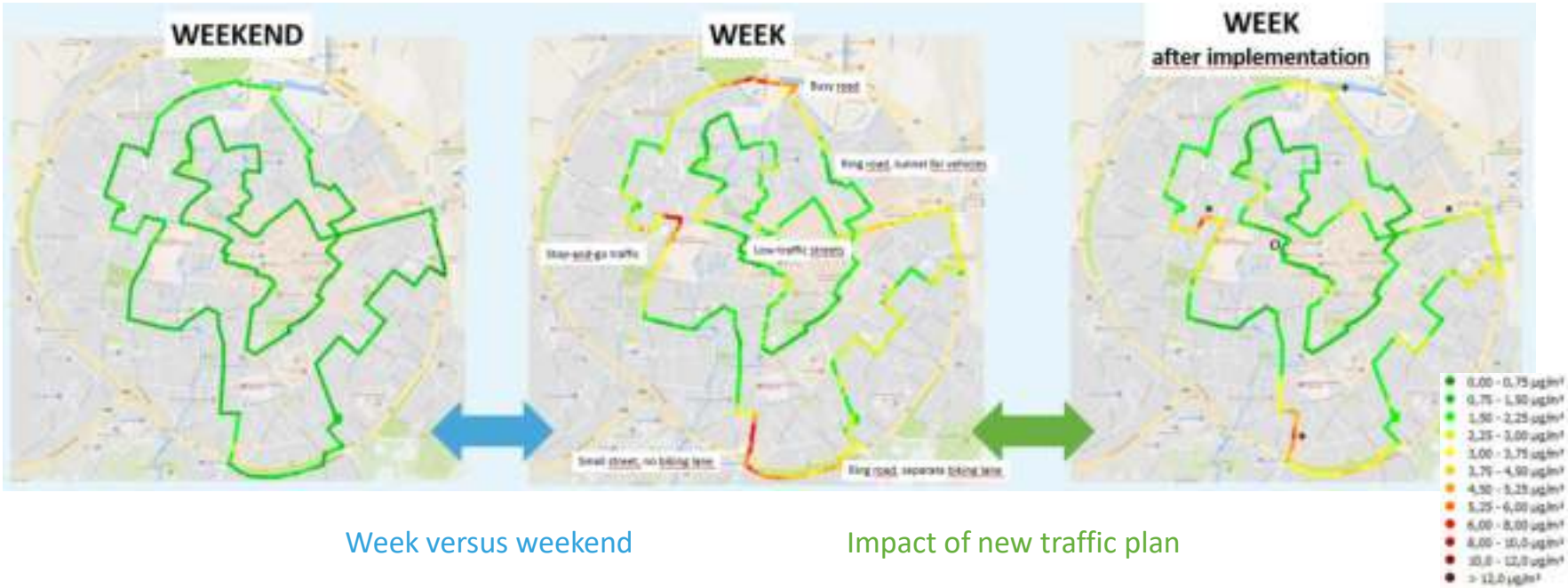
- Land Use Regression model (annual average)
  - Spatial predictor variables: traffic, land use, street geometry,…
  - Temporally adjusted BC values (annual average) additive and multiplicative method

- Spatio-temporal Land Use Regression model
  - Time-dependent variables as predictor variables
  - Real time dynamic pollution map: model update based on recent collected data

WHAT CAN WE DO WITH MOBILE MEASUREMENTS: SOME CASE STUDIES

IMPACT OF NEW TRAFFIC PLANS

Impact of traffic plans, evaluated with airQmap *by citizens in Leuven*

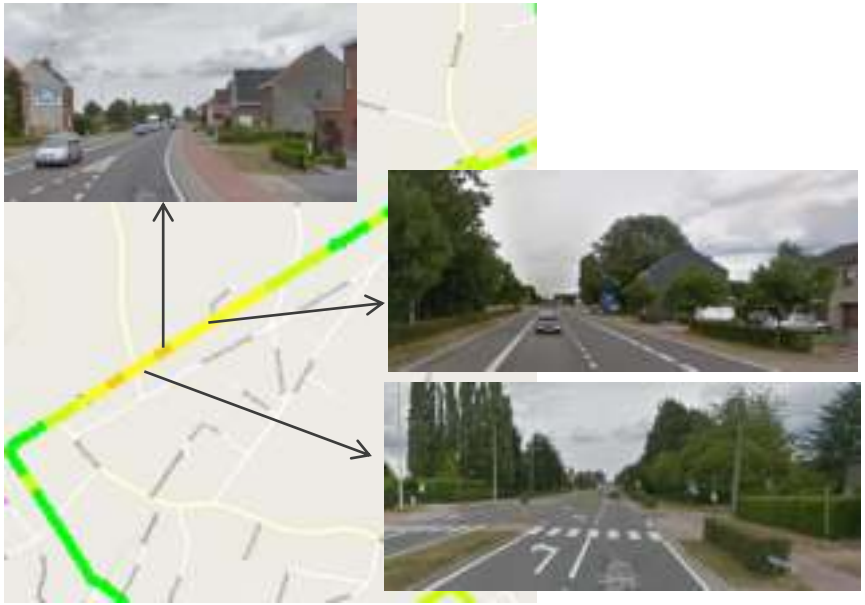


Week versus weekend

Impact of new traffic plan

IMPACT OF STREET INFRASTRUCTURE ON EXPOSURE

Impact of orientation of biking path

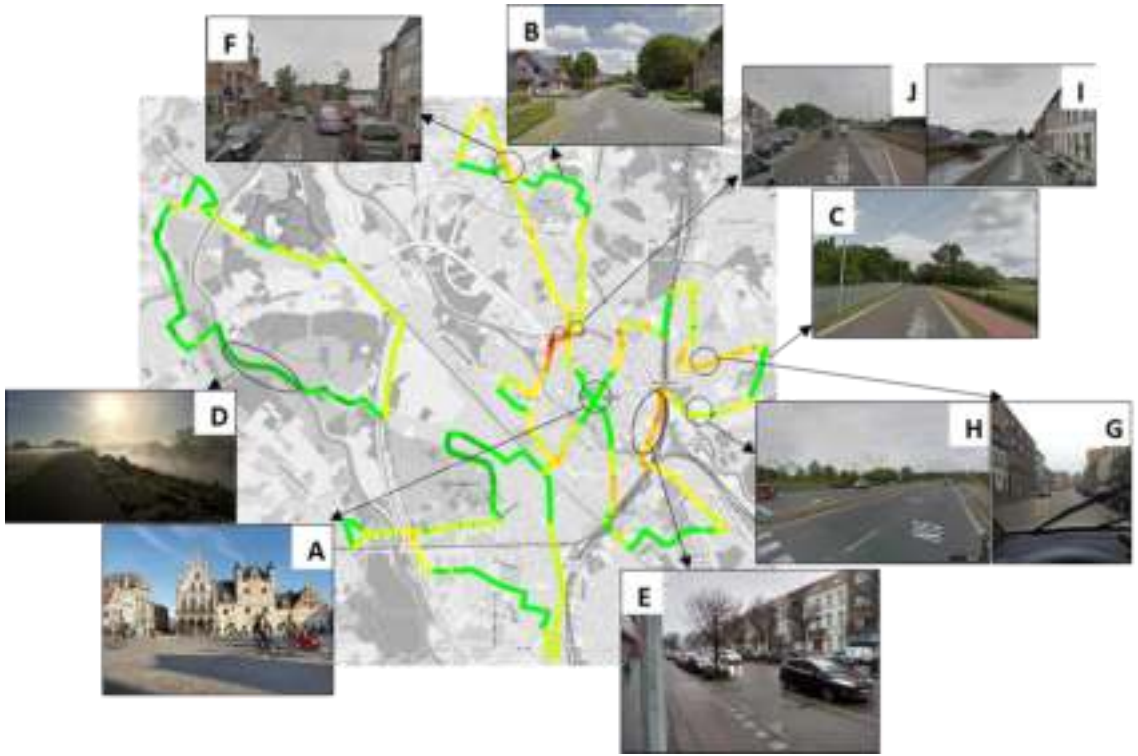


Impact of street characteristics: ventilation and distance

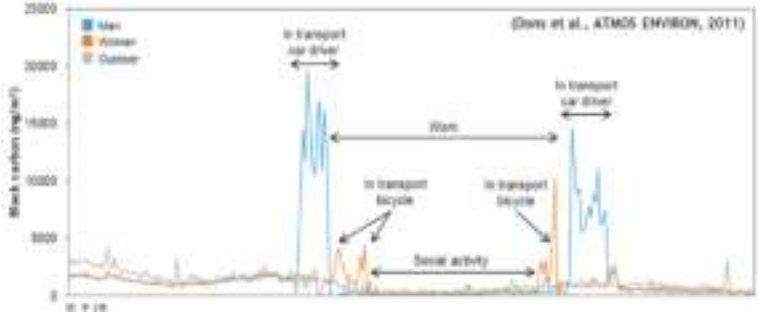
INTERACTIONS WITH CITIZENS

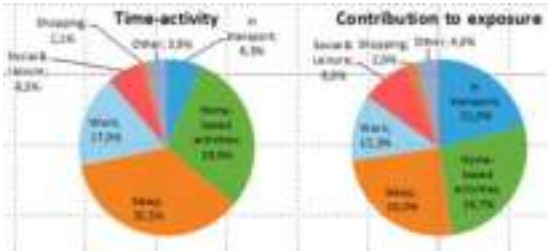
- Citizen Observatory (CO) “Meet Mee Mechelen”
- As part of two Citizen science projects GroundTruth 2.0 and Flamenco
- Involve citizens in AQ measurements and management
- A good data interpretation and feedback is needed
  - Low concentrations are easier to explain than high ones ☺ ?
  - It’s all about the scale!

DETECTION OF HOT SPOTS/IMPACT OF TRAFFIC ON AQ



PERSONAL EXPOSURE TO AIR POLLUTION





IMPACT OF WOOD BURNING

Impact of wood burning on AQ by mobile measurements:

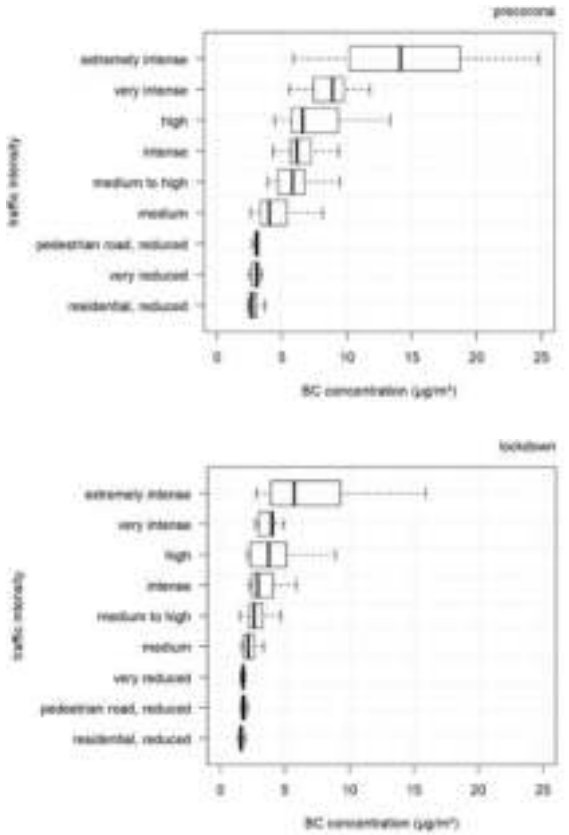
- BC at different wavelengths:
  - BC(WB) : wood burning
  - BC(FF) : fossil fuel

Result show:

- different patterns for wood burning compared to fossil
- Sources identified

IMPACT OF REDUCED TRAFFIC DUE TO COVID19

- Impact of traffic due to COVID-19
- Case study Romania
- Background correction
  - Concentration at park



CONCLUSIONS

- A mobile measurement approach can be used to assess local differences in air quality
- Repeated measurements are needed to get representative results
- Data processing needs to take into account different background concentrations
  - When collecting data at different time at different locations
  - When comparing scenarios
- Data collection process needs attention
- Setting up ICT infrastructure and Apps is important in data-collection and processing
- Selection of sensors and parameters
  - Different sensors with different performance, calibration
  - What are we looking for? What do we want to measure?

NEXT STEPS

- Expertise of airQmap and methodology can be applied in smart city mobile applications

- Apply knowledge for use cases:
  - Set-up
  - Data processing
  - Data interpretation
  - Calibration

- Contact:

martine.vanpoppel@vito.be – jan.peters@vito.be