



# Monitoring black carbon concentrations with mobile devices in the city of Liège

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<http://193.190.182.213/WebAirQuality/MicroParticules.aspx>

## Int 1/6

### Walloon BC data, April 2011 to end 2014

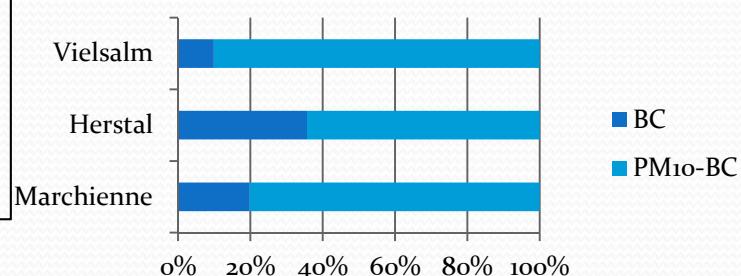
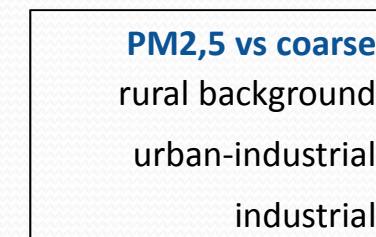
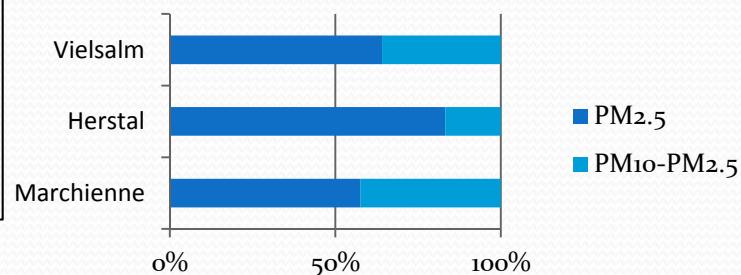
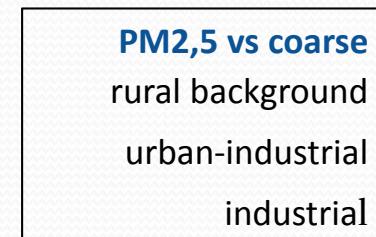
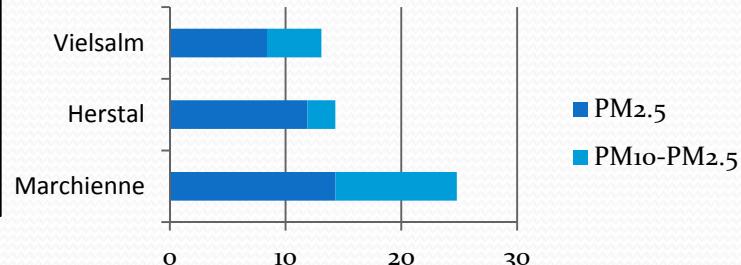
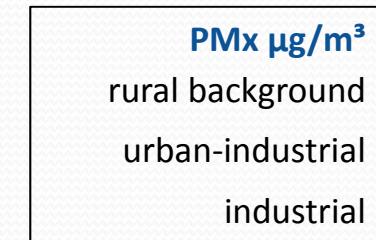
#### CONTEXT

Initiative of ISSeP

Interaction sought  
with city of Liège  
(nb: streetcar to  
partly replace buses)

EC encourages BC  
monitoring

Wallonia/ISSeP:  
3 analysers (fixed  
network) + mobile  
analysers in trailers



## Int 2/6

### Black Carbon

- Definition :

form of particulate matter which captures most efficiently solar energy [EPA]

- Source :

Incomplete combustion of fossil fuels [EEA]

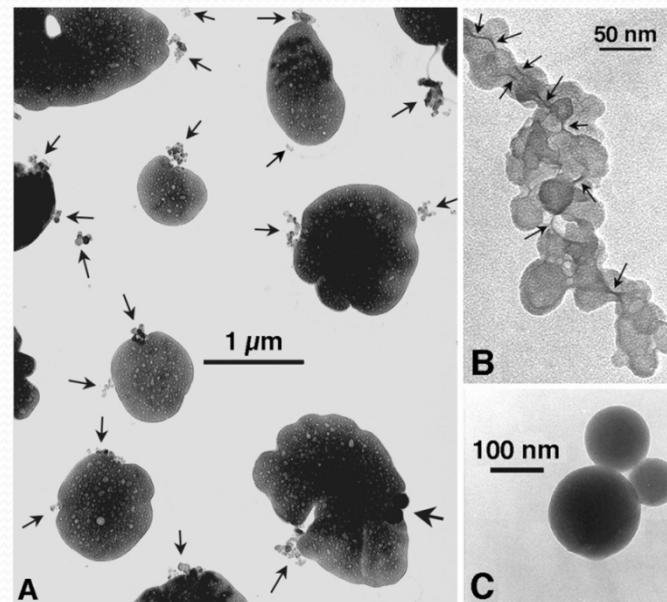
- Noxiouness :

Hazard at least as important as that of PM2,5 [WHO]

- Measurement (in Wallonia)

AE 22 aethalometers

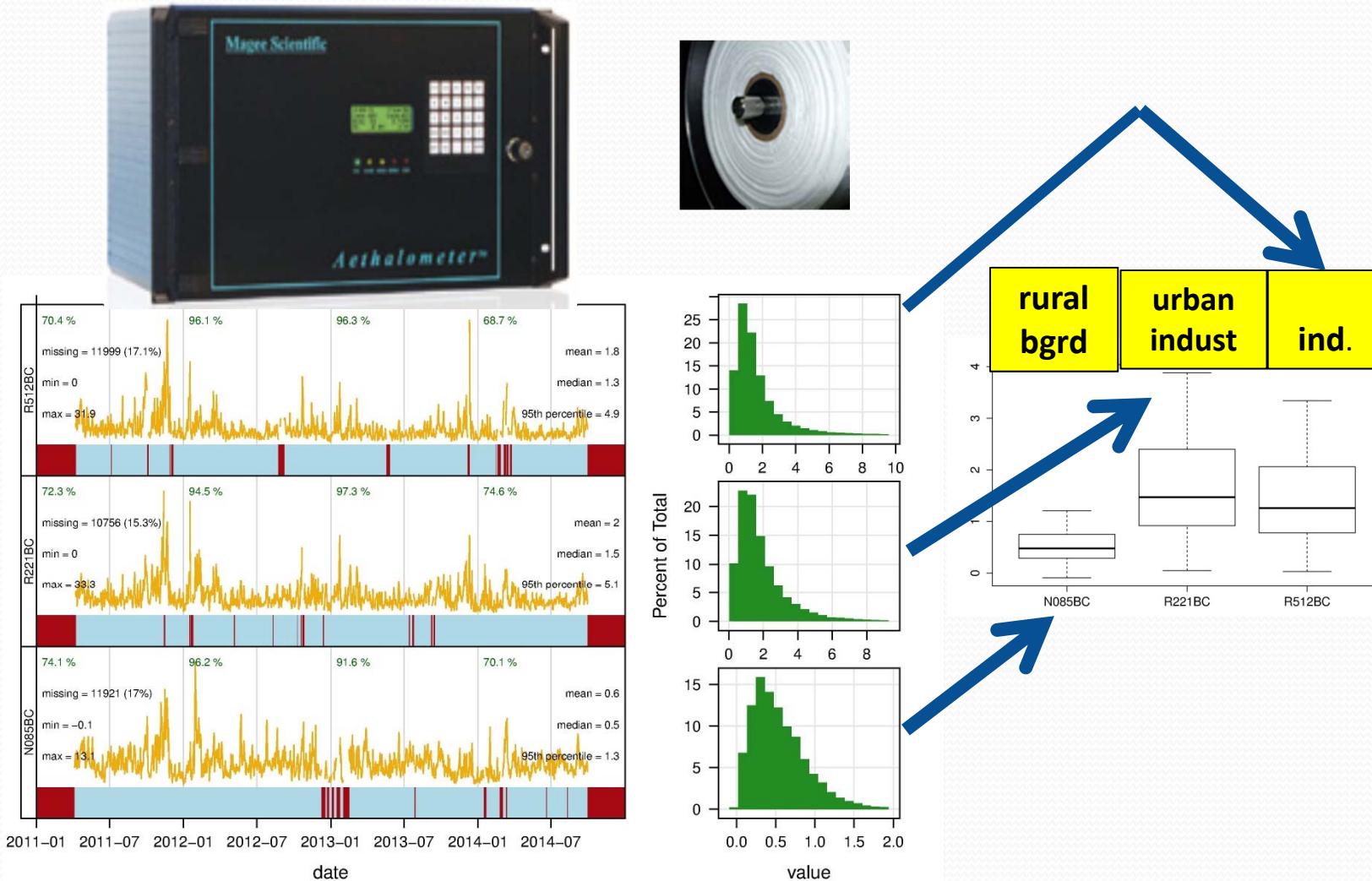
AE51 aethalometers



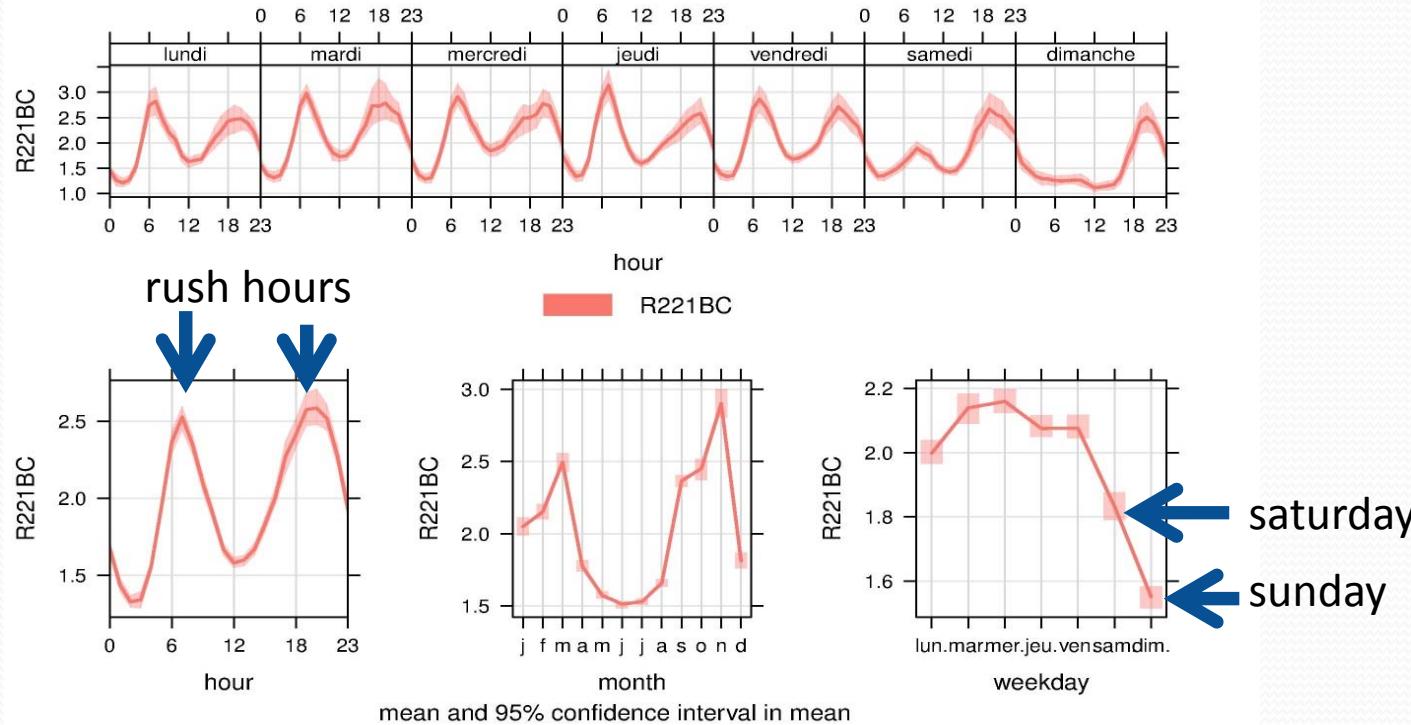
Transmission electron microscopy (TEM) images of aerosol particles, including black carbon from [Posfai et al. \(1999\)](#). In panel A, the black carbon particles (denoted by the small arrows) are mixed with inorganic ammonium sulphate particles. In panel B, a typical chain-like black carbon aggregate is shown with the arrows pointing to a film of carbon that connects the individual spherules within the aggregate. In panel C, fly-ash spheres are shown, which are particles that are often associated with black carbon particles.

## Int 3/6

### Analysers in use: Magee scientific AE22 Aethalometer – 2 wavelengths



## Int 4/6 BC patters at urban-industrial station $\mu\text{g}/\text{m}^3$



- peaks correspond to traffic (rush hours)
- higher values in winter months

## Int 5/6

### Components of the ExTraCar project

- Measurement, mapping, spatial and temporal characterisation of BC levels in the city of Liège . . .(cf issues in Liège, streetcar on track)
- Modelling of BC levels :  
    towards decision oriented tools for local authorities
- Assesment of Exposure of commuters during their trip  
(greater Liège area)

## Int 6/6

### team within ISSeP

#### Core from Air Quality Unit

F. Lenartz, L. Bertrand

F. Detalle, Fernemont

#### Application developpers

A. Caprioli (DB), P. Crespin (GIS)

#### Extra bikers and commuters

5 colleagues

### partners/assistance

#### Brussels-Environment

O. Brasseur, P. Declerck,

#### University of Liège- Geomatics

Y. Cornet

#### Universiteit Hasselt- IMOB

D. Janssens

#### Students

S. Tchiaye-Dongmo (IMOB)

C. Louis (ULg)

I. Elghazi (Univ-Meknès)

## Methods 1/6

6 Black Carbon AE51	GPS GlobalSat DG-200	Grimm 1109
		
1 wavelength 880 nm	Doesn't send Data downloaded	PM10-PM2,5- PM1
		

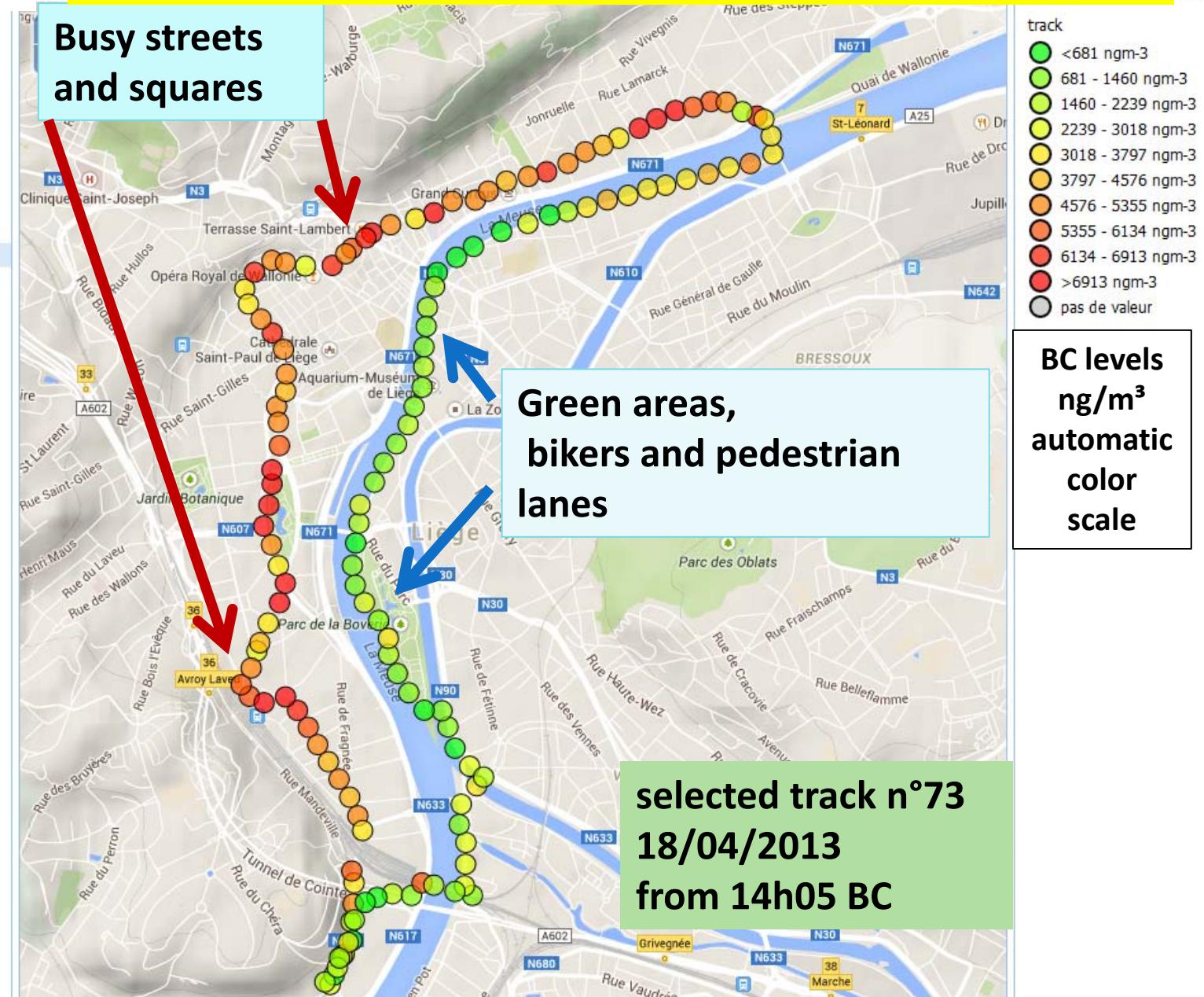
## ExTraCar: mobile equipment: bikers



## Methods 2/6

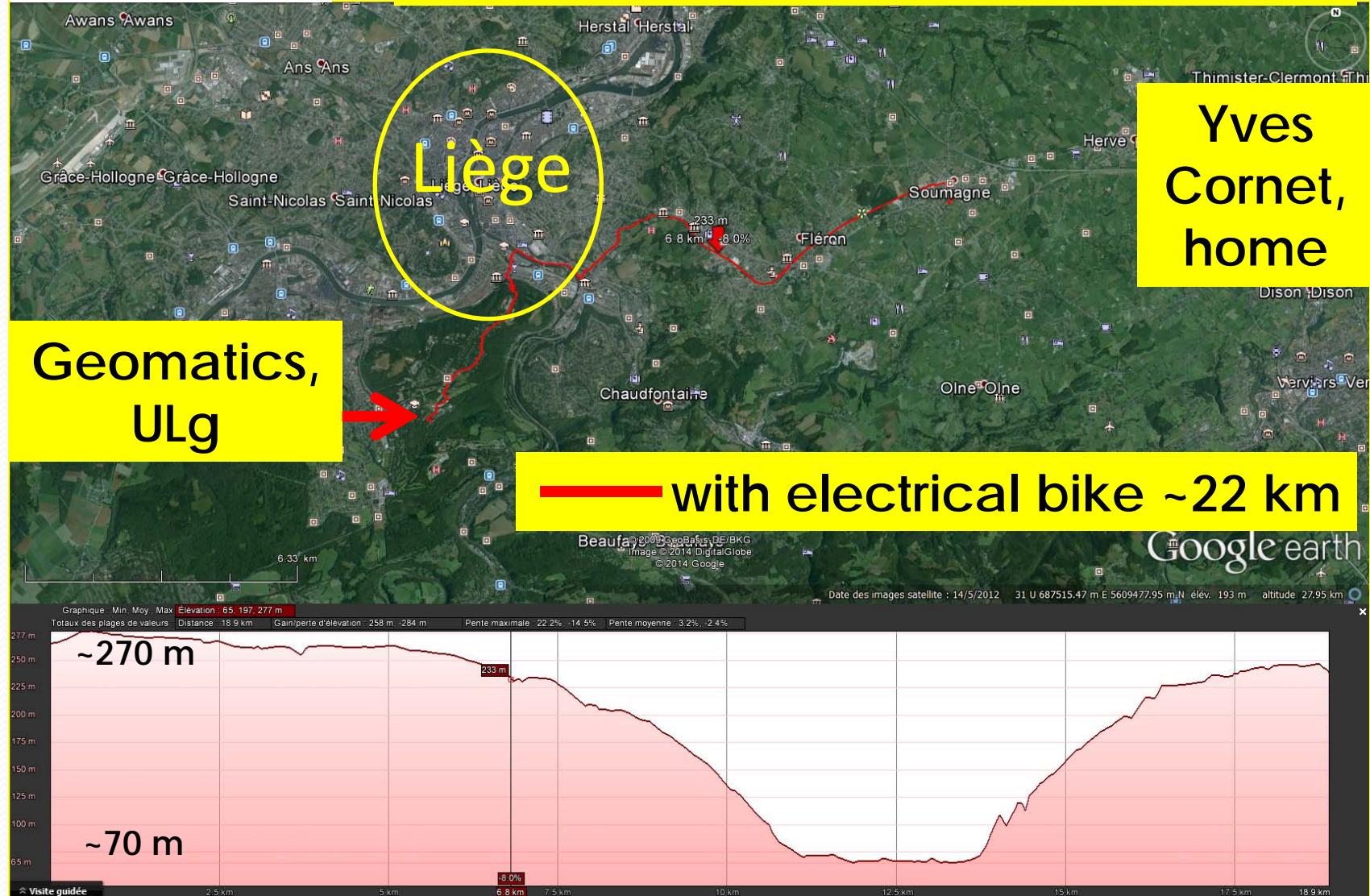
# web-gis application, one loop to begin with

- theoretical paths
- Liège: Ravel et Centre (2013-03-27)
  - track63 (2013-04-25 10:56:00)
    - BC880
    - PM10
    - PM2.5
    - PM1
    - PMinhalable
    - PMthoracic
    - PMrespirable
  - track73 (2013-04-18 14:05:00)
    - BC880
    - PM10
    - PM2.5
    - PM1
    - PMinhalable
    - PMthoracic
    - PMrespirable
- track74 (2013-03-27 13:41:00)
- track75 (2013-04-19 09:06:00)
- track76 (2013-04-22 13:49:00)
- track77 (2013-04-23 16:06:00)
- track78 (2013-04-24 12:39:00)
- track79 (2013-04-25 07:31:00)
- track80 (2013-04-27 14:04:00)
- track81 (2013-08-01 14:15:00)
- track82 (2013-08-02 12:35:00)
- track119 (2014-04-02 09:04:00)
  - BC880
- track120 (2014-04-02 09:09:00)
  - BC880
- track122 (2014-04-03 08:07:00)
  - BC880
  - PM10
  - PM2.5
  - PM1
  - PMinhalable
  - PMthoracic
  - PMrespirable
- track123 (2014-04-03 17:09:00)
  - BC880



## Methods 3/6

### Actual commuting track



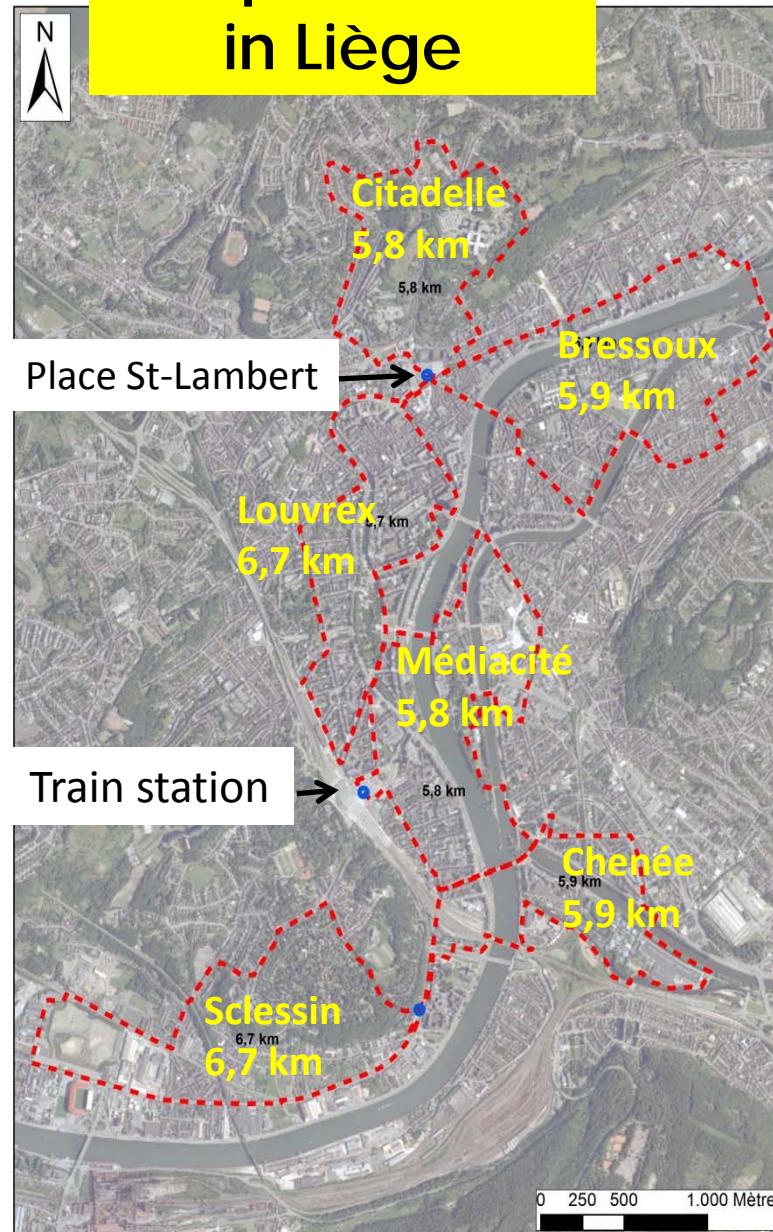
## Methods 4/6

6 loops chosen to map concentrations in the city

5 of 6 pass either in front of train station or at Saint-Lambert

In each loop both busy/canyon streets and open/green parts

## Loops chosen in Liège

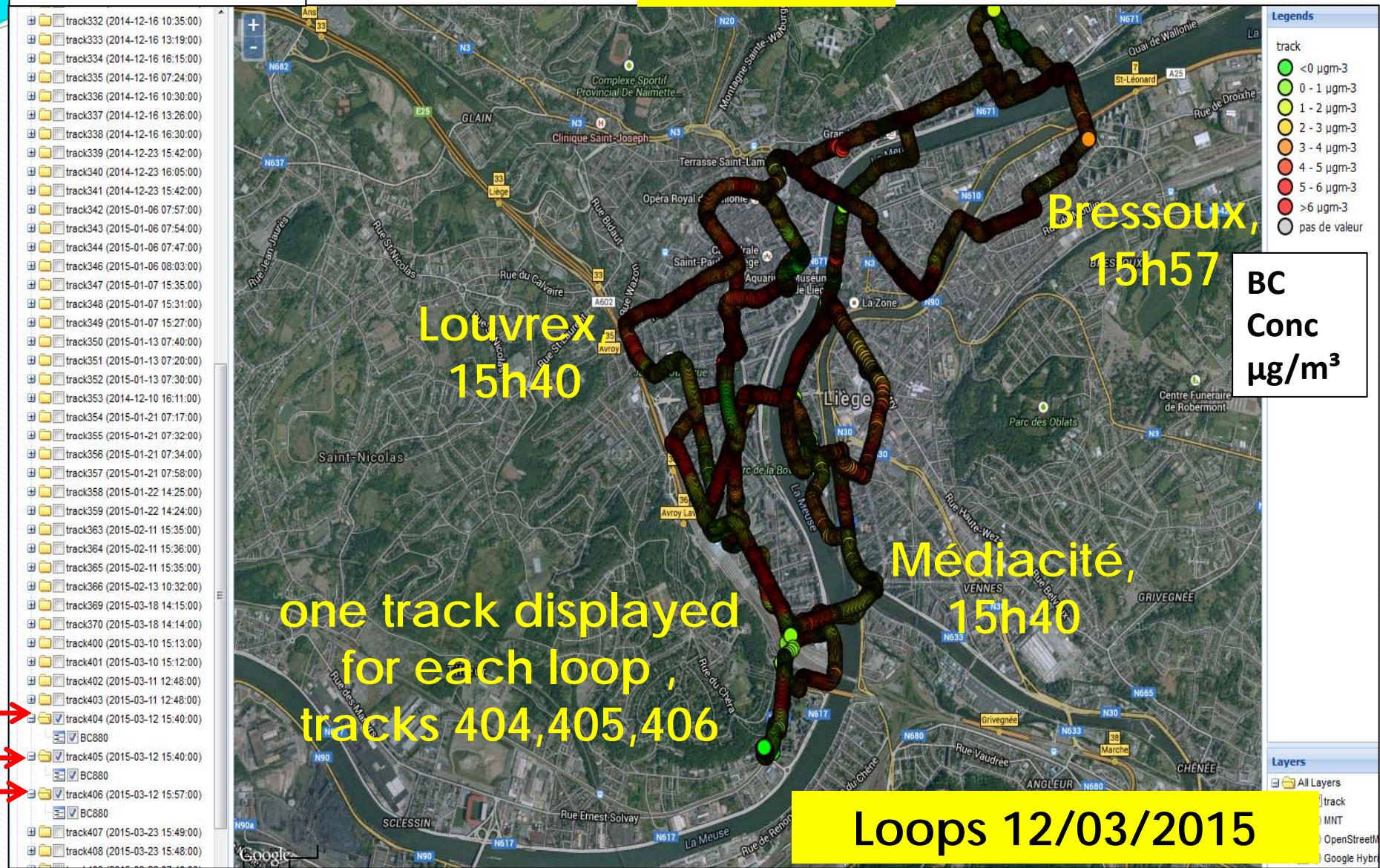


biker:  
3 to 4 times  
a loop

[Measurements  
morning of  
afternoon  
rush  
Hours,  
mainly]

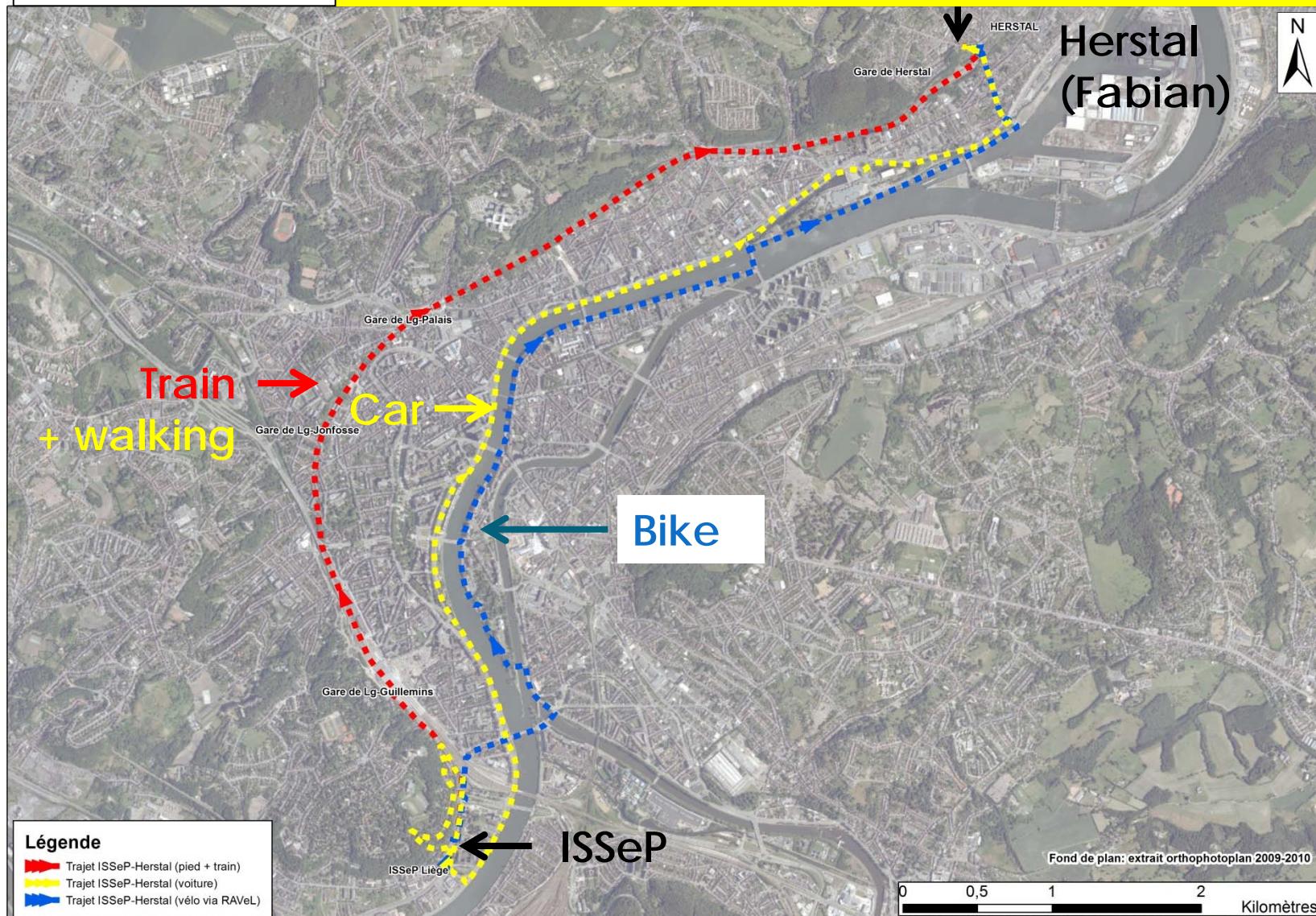
## Methods 5/6

**web-gis**



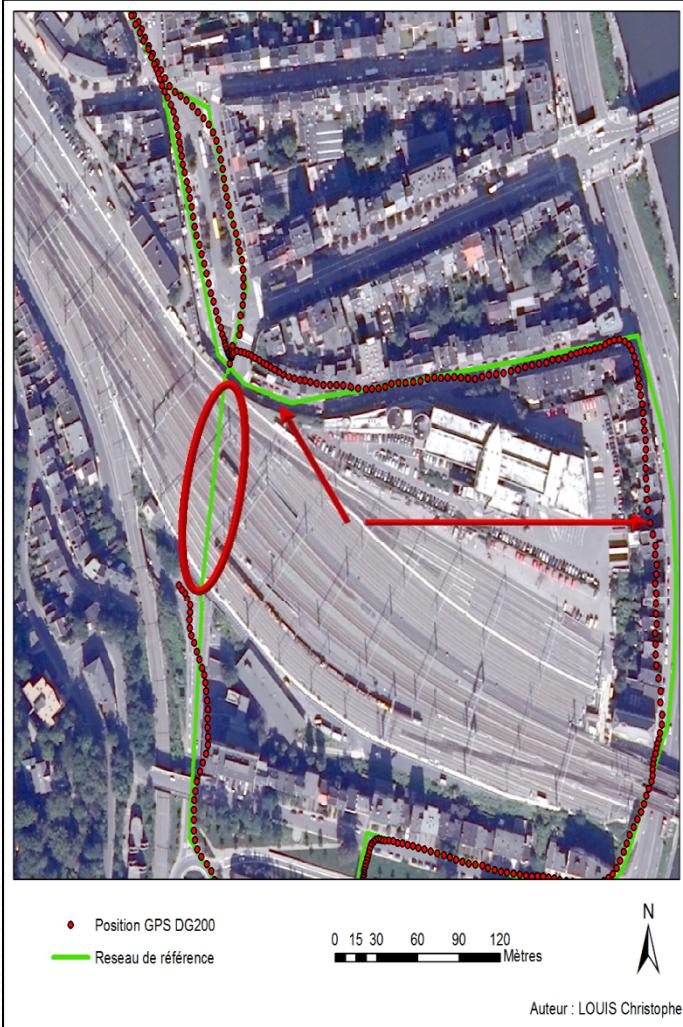
## Methods 6/6

## Commuter's exposure: Train, Car, Bike



Data 1/7

# Gps data processing

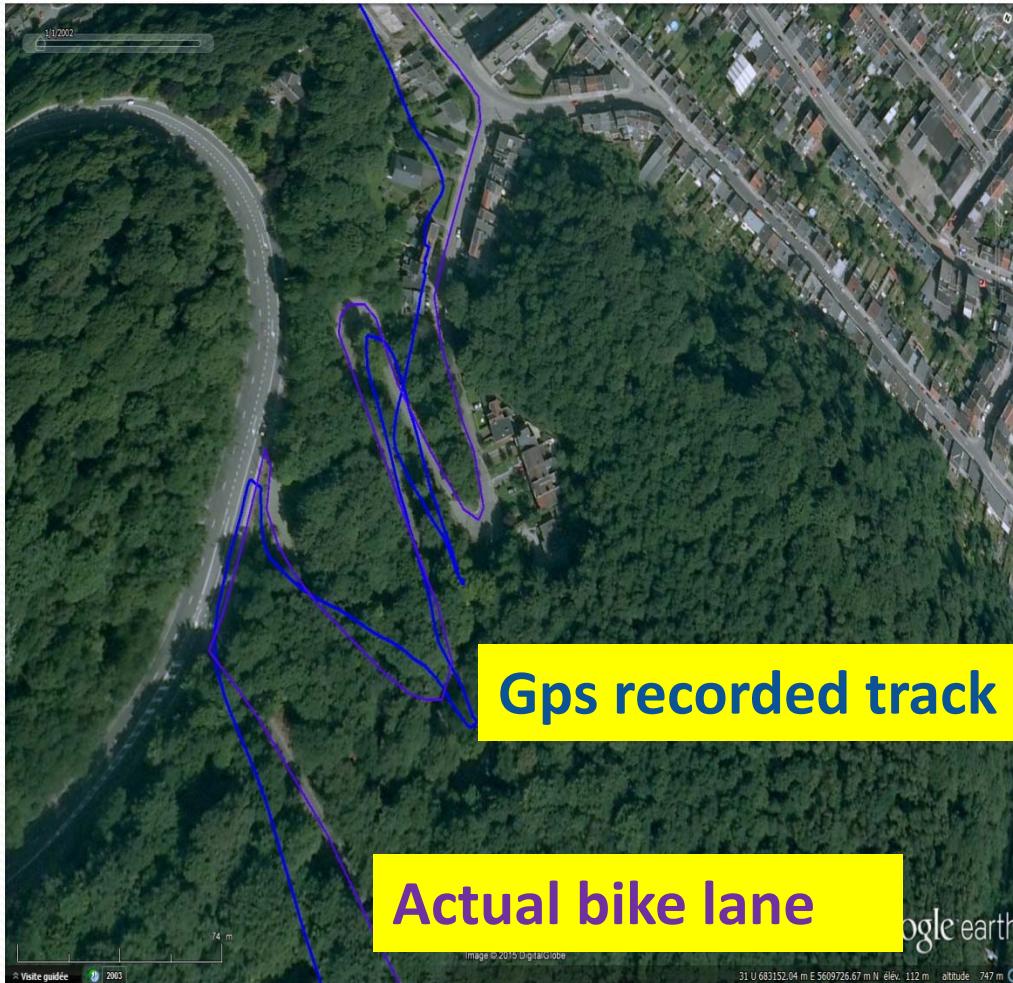


Observed errors in tracker's records

- Wrong positioning away from track and along track
- no records (signal loss)

**Simple cases  
Student's master  
thesis**

Data 2/7



Gps

Université  
de Liège



More  
complex case

Data 3/7

## Gps trackers



Université  
de Liège



Loop done with  
→ expensive GPS  
→ our six DG200

sophisticated /Expensive gps . . .

the six DG 200

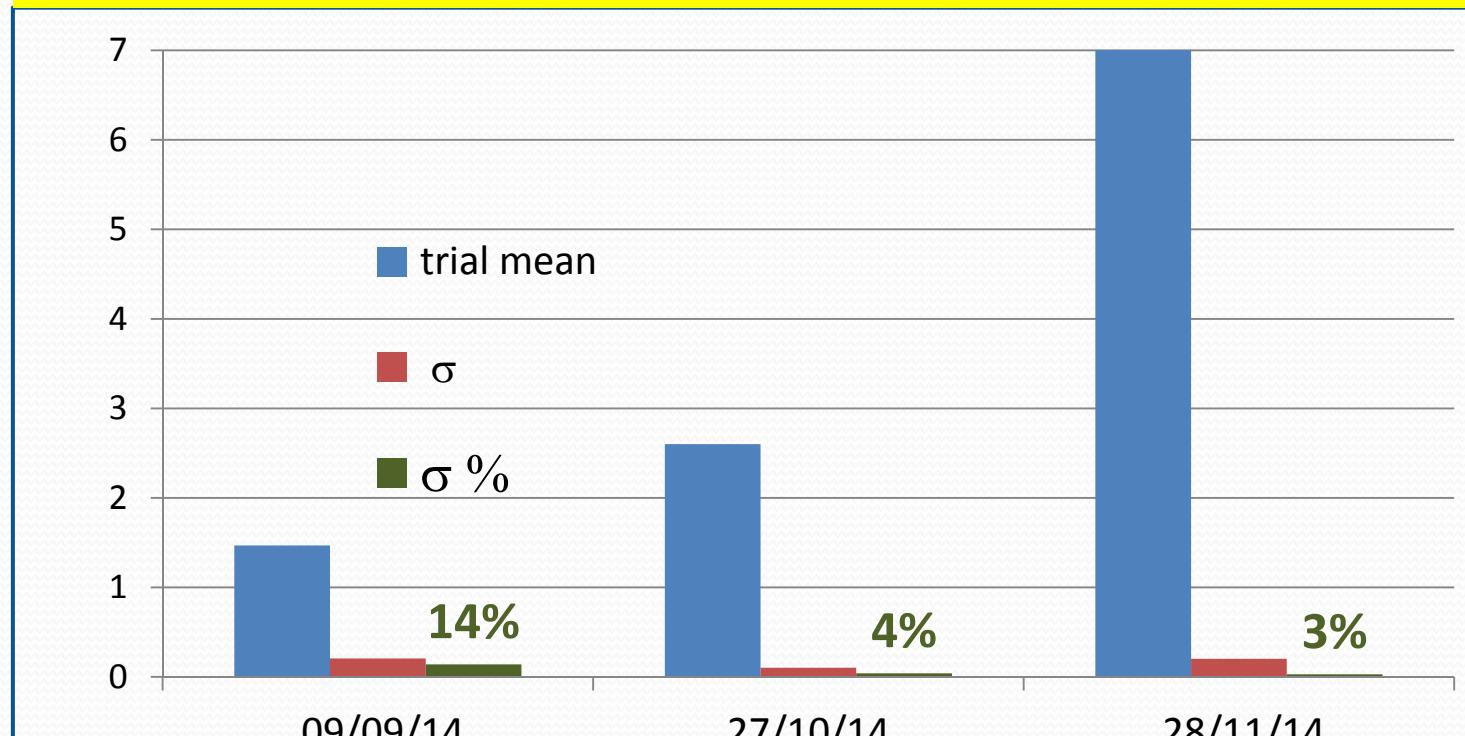
- no benefit from using other device for the data correction procedures
- the project will stick with the simple tracker chosen

**UNCERTAINTIES, 1 sec synchronisation error**  
(analyser versus gps tracker) :

- walking: discrepancy **1.11 m** ( $4 \text{ kmh}^{-1}$ )
  - biking: discrepancy : **5.55 m** ( $20 \text{ kmh}^{-1}$ )
  - car.....
- tracker precision: typically 10 m

## Data 4/7

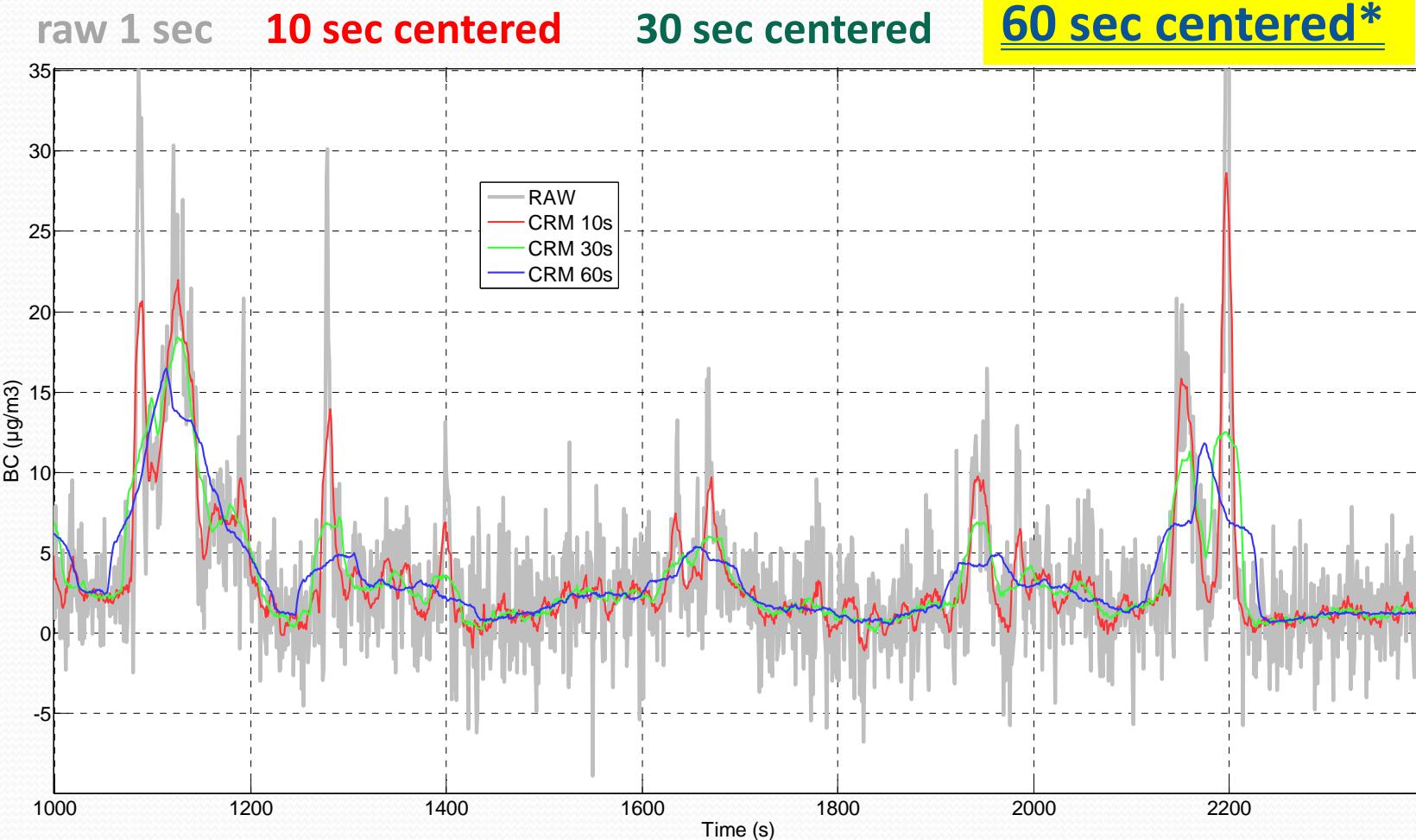
### Comparisons of the six AE51 ( $\mu\text{g}/\text{m}^3$ ) at the Herstal automatic station



→ The precision improves with higher concentrations

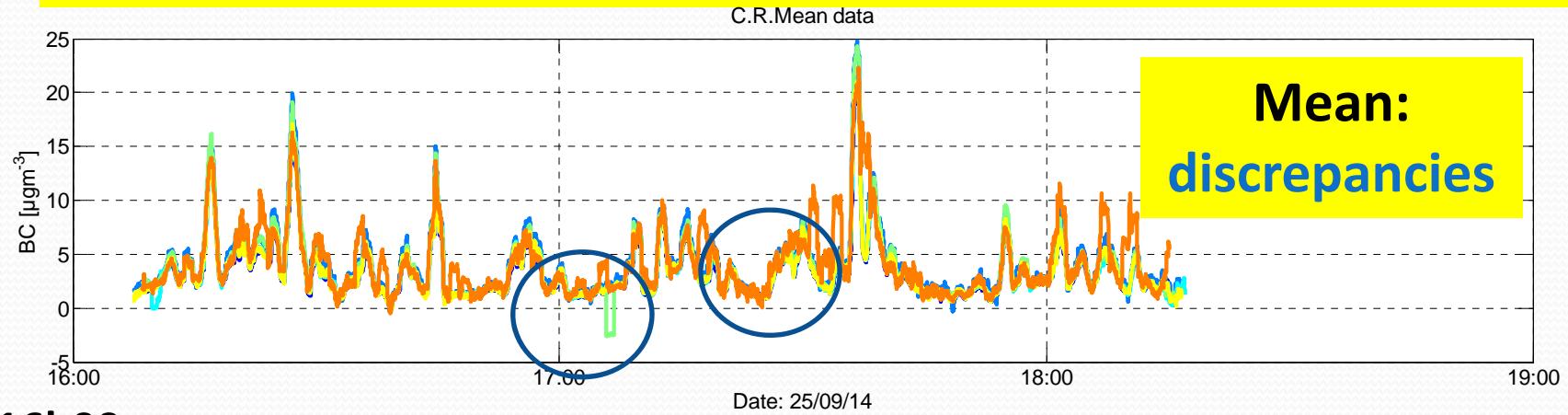
Data 5/7

## how to best process AE51 1 sec results ?



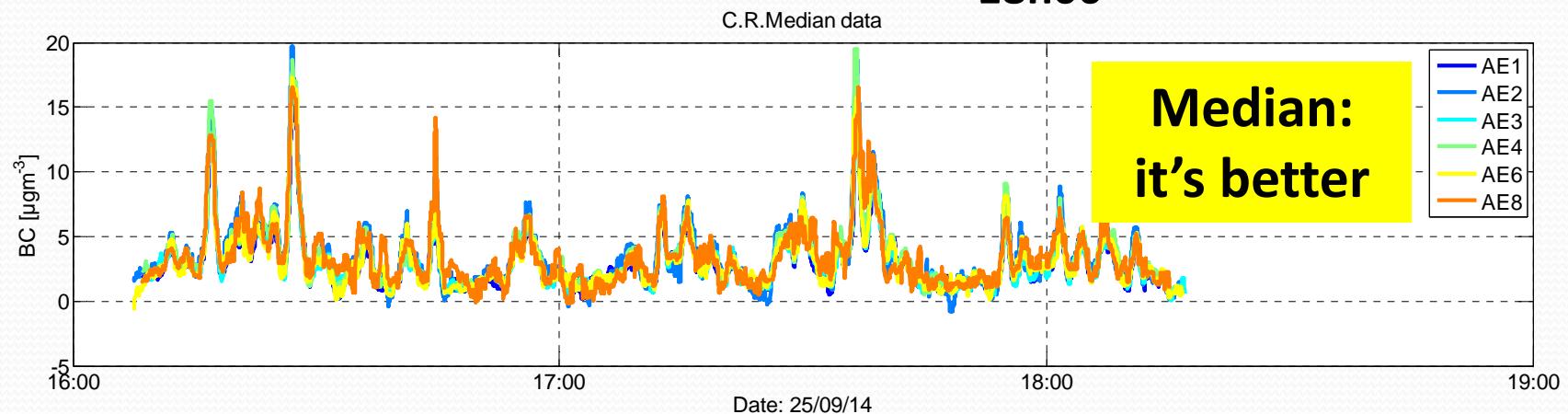
## Data 6/7

SIX moving AE51 compared, running mean or rather running median ?



16h00

18h00



→running median chosen, less inter-instrument discrepancies

## Data 7/7

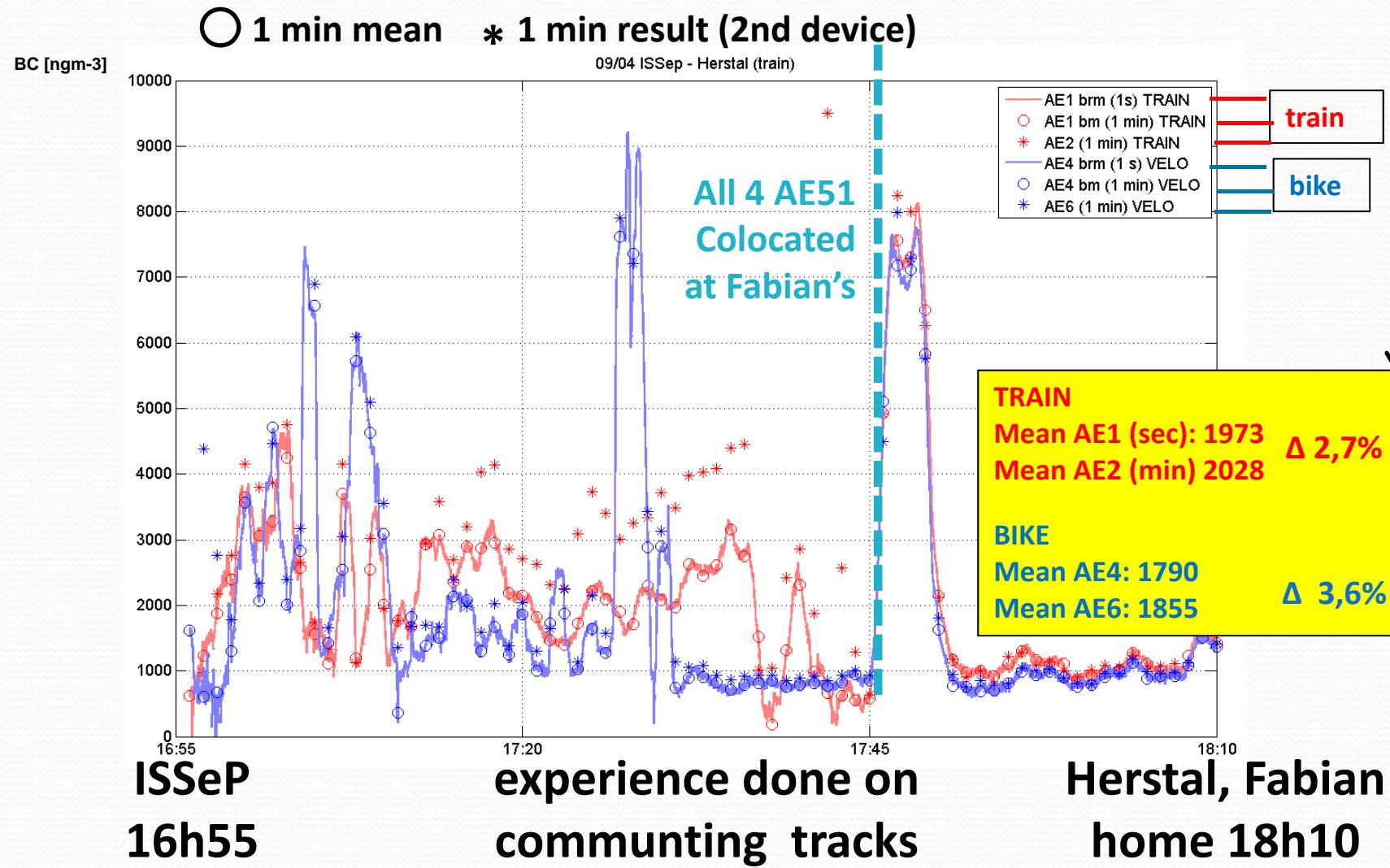
Biker  
Train passenger

each

1<sup>st</sup> AE51: 1 sec time step

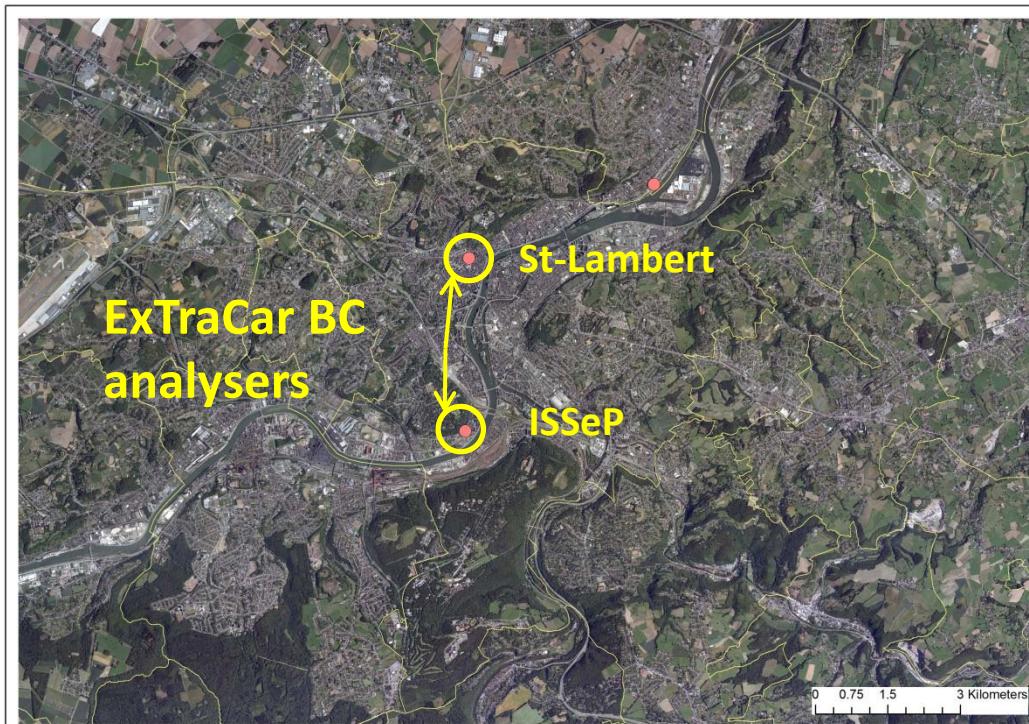
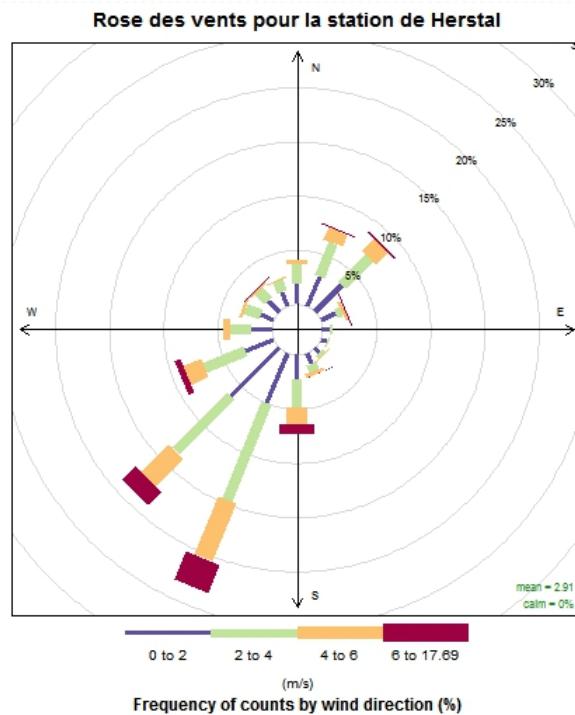
2<sup>nd</sup> AE51: 1 min time step

reasonable agreement between  
1 min mean and 1 min result



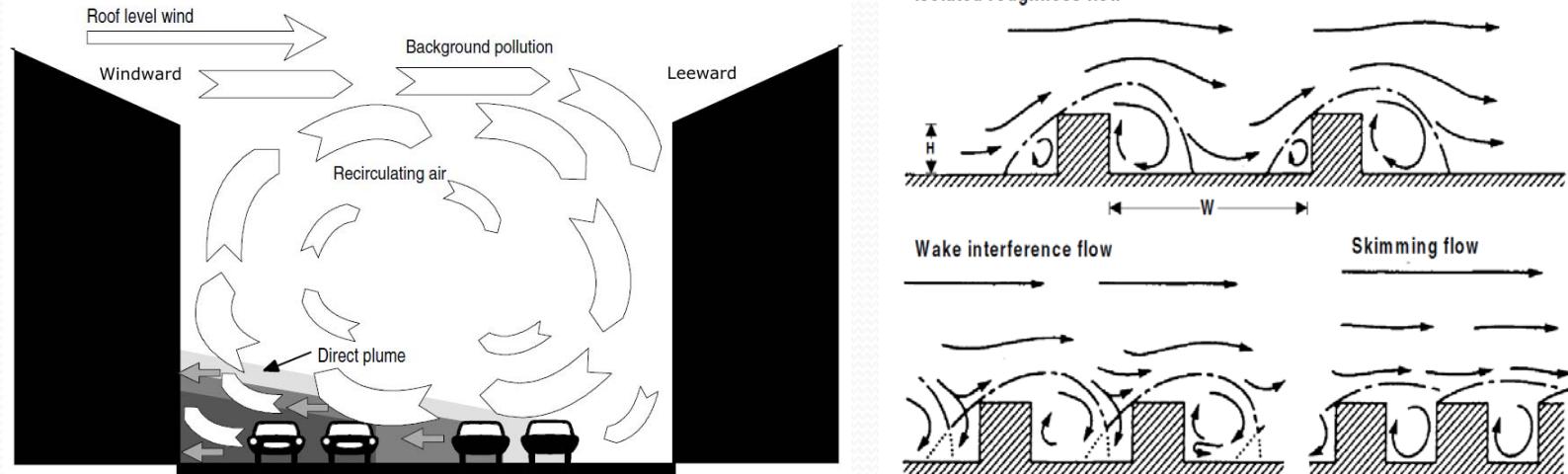
## Modelling 1/7

Needs for regional model; meteo data, continuous monitoring



## Modelling 2/7

### Street Model : application planned for 6 streets



Figures drawn from the report Modelling traffic pollution in streets published by the Danish National Environmental Research Institute and the Ministry of Environment and Energy

**Use of the model adapted for BC by partner Brussels-Environment**  
~ algorithms similar to OSPM

## Modelling 3/7

# Trafic source

- TRAFIC DATA
  - → 2010-2011 annual km, city area,  
Highway/Urban/(rural) – Long/Short vehicles  
From AwAC (Walloon inventories)
  - → Noise study of 2012 : ~ 70 sites , one day data (1 hour resolution)
  - → Buses: data from bus operator TEC-Liège
  - → ExTraCar oswn counts: 6 chosen streets (application of street model)
- EMISSION FACTORS (BC now available (EEA/EMEP +HBEFA)
  - → official 2015 walloon factors
  - → adjustment related to measurements foreseen

#### References:

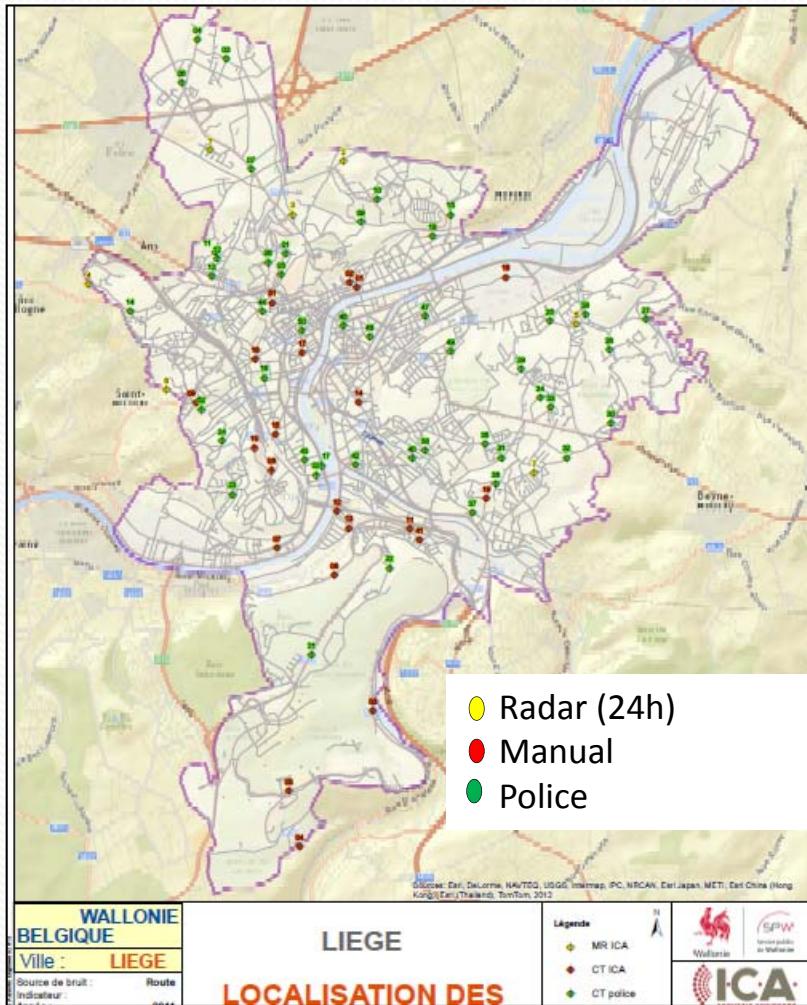
Modelling black carbon concentrations in two busy street canyons in Brussel using CANBC

Atmosenv, 101 (2015),, O. Brasseur and al + + mail O. Brasseur 17/03/2015

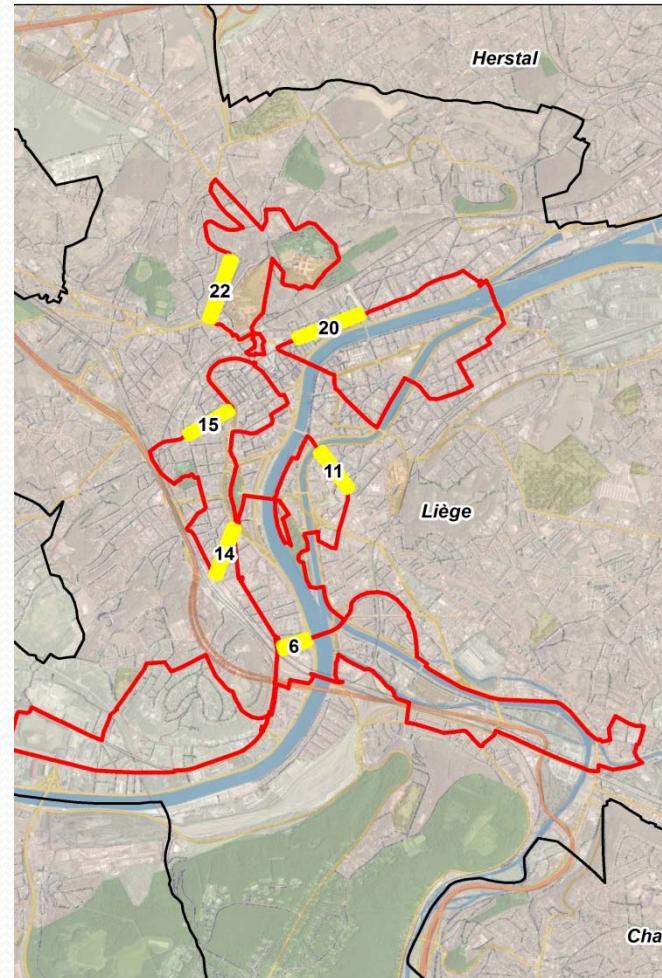
Modelling the effect of speed limit reduction on traffic related elemental carbon (EC) concentrations and population exposure to BC, Wouter Lefebvre and al, Atmoasenv, 45 (2011)

## Modelling 4/7

2012 counting sites (noise study)

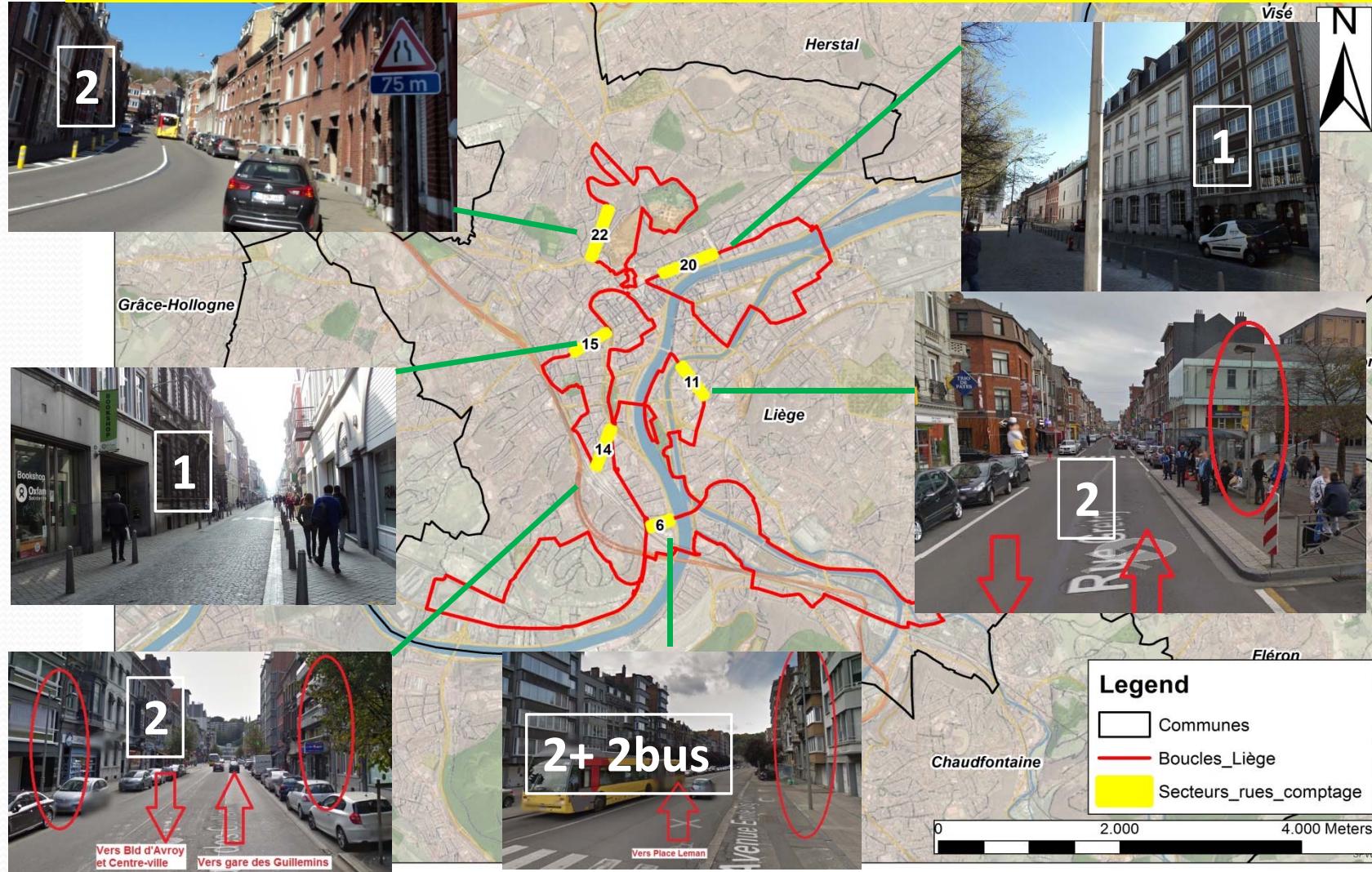


ExTraCar counting sites



## Modelling 5/7

The 6 ExTraCar counting sites + number of ways/lanes



## Modelling 6/7

### ExTraCar counting

- use of two radar TMS-SA4 lent by DGO1-52 of SPW
- began 27/04/2012
- cross check with manual countings (at rush hours)

→ BC measurement boths by bikers and counters during the manual counting sessions



Pictures:  
manufacturer

also consistency check with received existing data

## Modelling 7/7

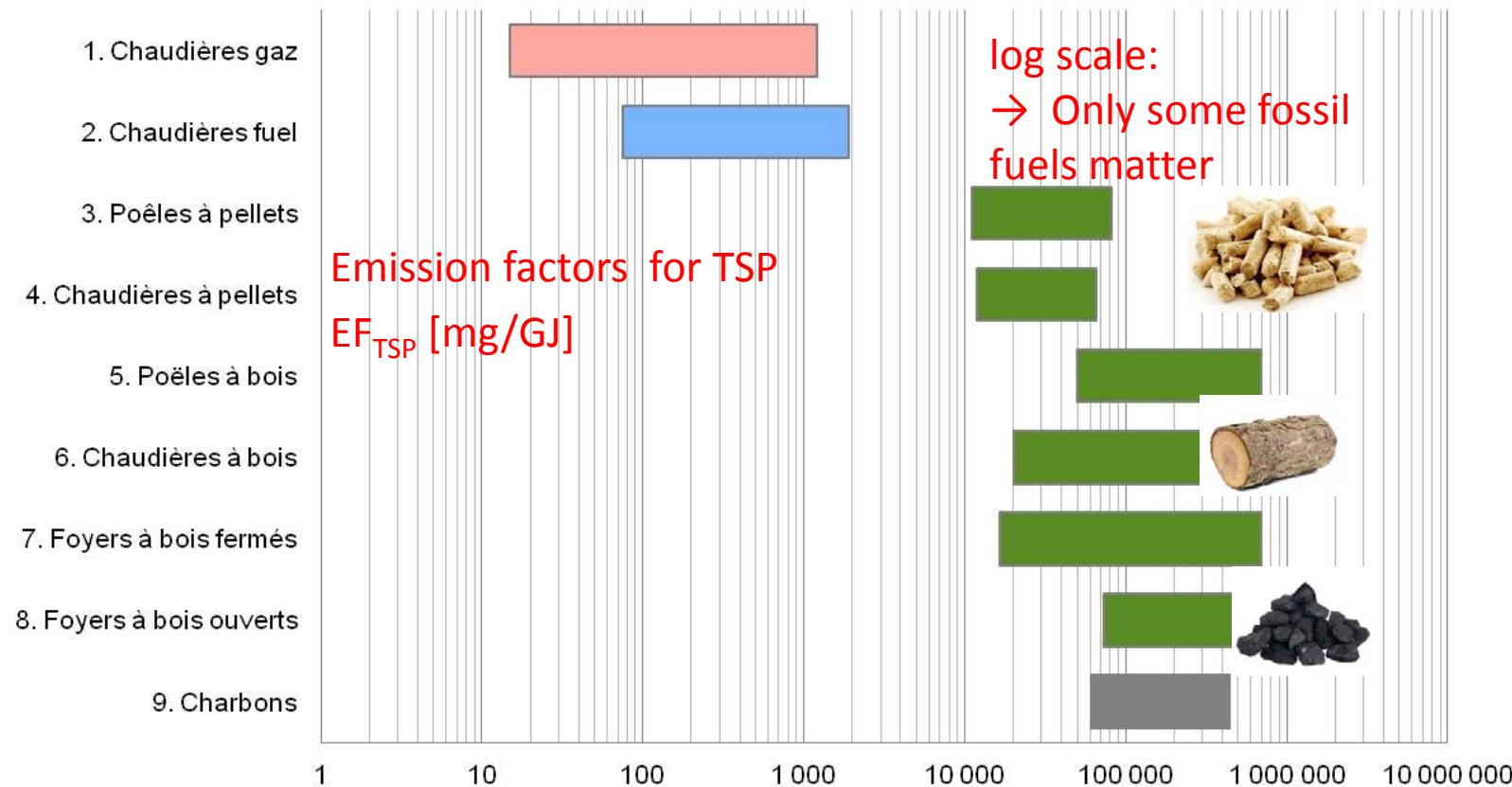
# Domestic heating

From AwAC, performing Walloon Emission inventories

- Number of households using the various fossil fuels

From PIC: space disaggregated volume of dwellings, service activites

Time desagregation taking outdoor temperatures into account



Sources : P. Théate, D. Derriks and X. Frippiat from AwAC (*Agence wallonne de l'Air et du Climat*)  
EMEP/EEA emission inventory guidebook 2013

## Advancement 1/3

### Meteo representativeness: loops

Stability class	Morning rush						Evening rush						Other times					
	Stable		Neutral		Unstable		Stable		Neutral		Unstable		Stable		Neutral		Unstable	
Loops as 03/04/2015	T	G	T	G	T	G	T	G	T	G	T	G	T	G	T	G	T	G
Chênée	?	8	?	0	?	0	?	4	?	10	?	0	/	0	/	4	/	0
Bressoux	?	9	?	11	?	0	?	7	?	26	?	0	/	0	/	13	/	0
Citadelle	?	10	?	3	?	0	?	4	?	11	?	0	/	0	/	1	/	0
Louvrex	?	18	?	11	?	0	?	3	?	34	?	0	/	0	/	16	/	0
Médiacité	?	13	?	3	?	0	?	4	?	36	?	0	/	0	/	11	/	0
Sclessin	?	11	?	3	?	0	?	4	?	15	?	0	/	0	/	1	/	0

T = target; G: results actually got

The purpose is to get for each loop data , data spread as evenly as possible in the three main stability classes and between morning and evening rush  
As April 3rd, 2015, we hadn't yet encountered Unstable conditions for the loops

## Advancement 2/3

### Meteo representativeness: commuting trips

Stability class	Morning rush						Evening rush					
	Stable		Neutral		Unstable		Stable		Neutral		Unstable	
Trips as 03/04/2015	T	G	T	G	T	G	T	G	T	G	T	G
Herstal - ISSeP bike-train-car	3	3	3	3	3	0						
ISSeP – Herstal bike-train-car							3	0	3	2	3	2
Herstal – ISSeP bike-train-car+bus	3	2	3	0	3	0						
ISSeP – Herstal bike-train-car+bus							3	0	3	1	3	0
Soumagne – ISSeP bike-bus-car	3	1	3	1	3	2						
ISSeP – Soumagne bike-bus-car							3	0	3	2	3	1

T = target; G: results actually got

Unstable conditions encountered, yet underrepresented

## Advancement 3/3

## Stability classes, issues

from <http://www.ready.noaa.gov/READYpgclass.php>

Surface wind speed (m/s)	Daytime insolation			Night-time conditions	
	Strong	Moderate	Slight	Thin overcast or > 4/8 low cloud	<= 4/8 cloudiness
< 2	A	A - B	B	E	F
2 - 3	A - B	B	C	E	F
3 - 5	B	B - C	C	D	E
5 - 6	C	C - D	D	D	D
> 6	C	D	D	D	D

Pasquill Class	Sigma Theta (degrees)	Delta T/Delta Z (Deg C/100 m)
A	25	-1.9
B	20	-1.9 to -1.7
C	15	-1.7 to -1.5
D	10	-1.5 to -0.5
E	5	-0.5 to 1.5
F	2.5	1.5 to 4.0
G	1.7	>4.0

A: Extremely unstable  
B: Moderately unstable

D: Neutral  
E: Slightly stable

F: Moderately stable  
G: Extremely stable

### Clarification on this needed, to precise results still needed

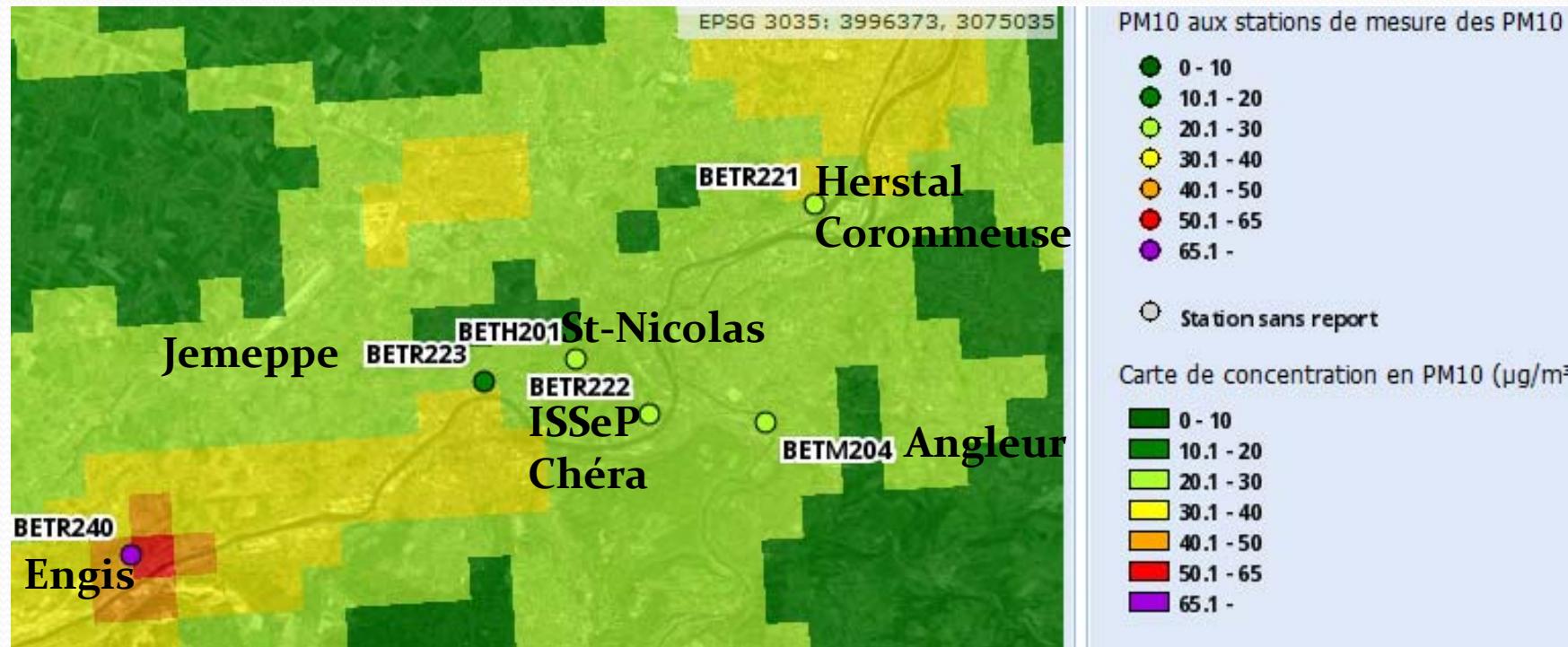
The spread of stabilities in each scheme is large and sometimes it covers the entire range of stabilities for a given Pasquill class. However, it has been observed that the schemes based on Monin-Obukov length and Richardson number gives (more\*) reasonable comparison than the rest of the schemes. (...) The implications of this on estimated distance to maximum ground level concentrations are great and could affect the overall outcome of conventional Gaussian models for industrial siting, planning and management.

Manju Mohan and T.A. Siddiqui (1998), Analysis of various schemes for the estimation of atmospheric stability classification, Atmospheric Environment, Vol. 32, No. 21, pp. 3775-3781

## Exposure 1/8

Compliance  
Monitoring Network

→ Theoretical Exposure



<http://pmlab.irceline.be>

Mean PM10 24h au 3 octobre 2014 at 5H00

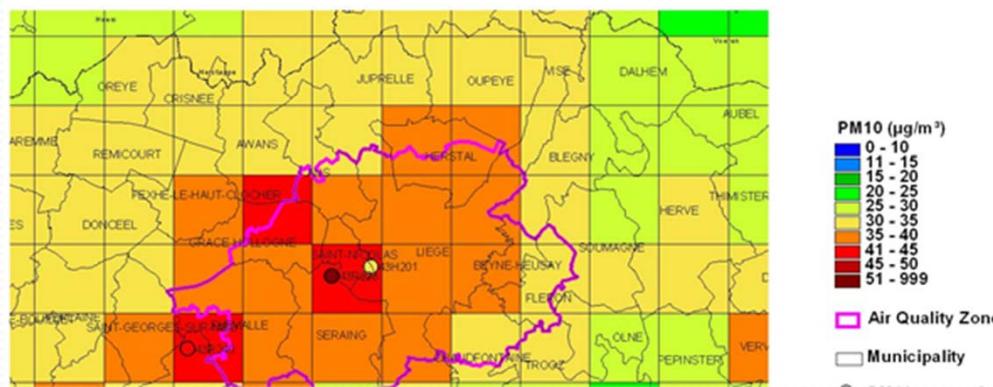
Values at monitoring sites + sophisticated interpolation 1 km grid

Exposure of somebody who would stay in front of home

## Exposure 2/8

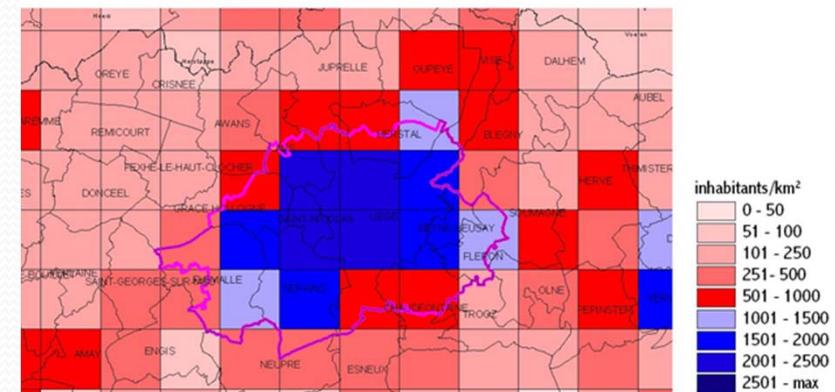
### APHEIS study, Public Health Impact of PM10 Brussels + Antwerp + Liège by ISSeP + KUL

Annual mean PM10 (2004)



+

Liège : Population Density

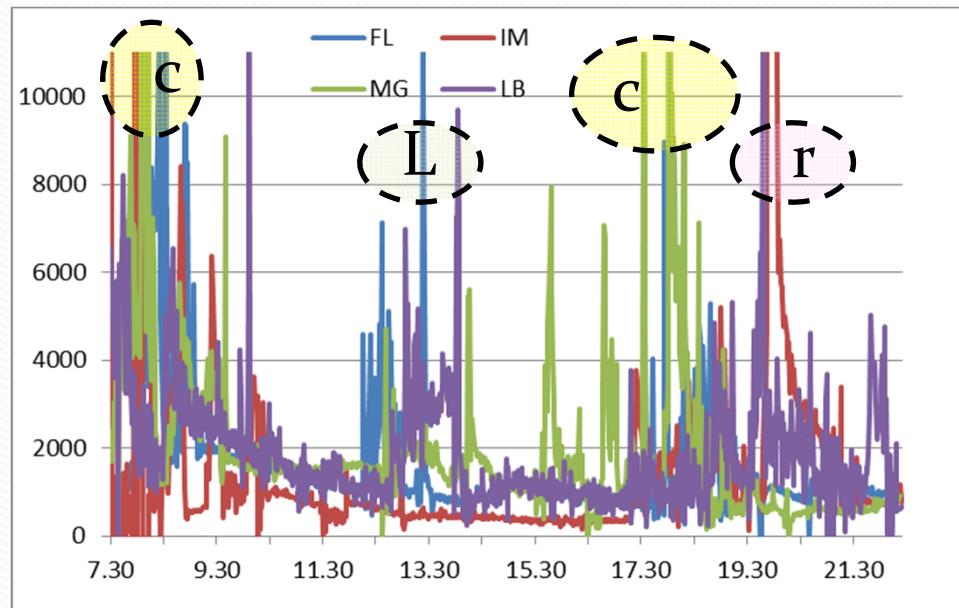


Theoretical PM10  
Exposure, reference year 2004  
Population density taken into  
account, Estimation of health  
effects

## Exposure 3/8

4 ISSeP persons (3 Lg, 1 Colf) Black Carbon (ng/m<sup>3</sup>)  
means of each person, 3+4 juin 2014

Brussels-Environment procedure with activity diaries

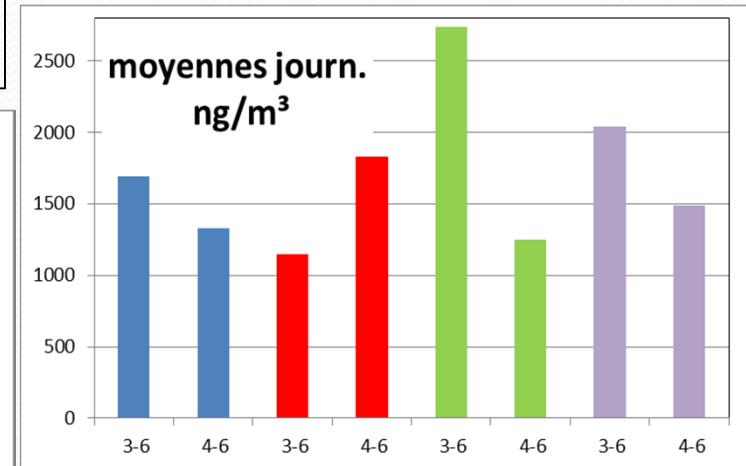


### Peaks

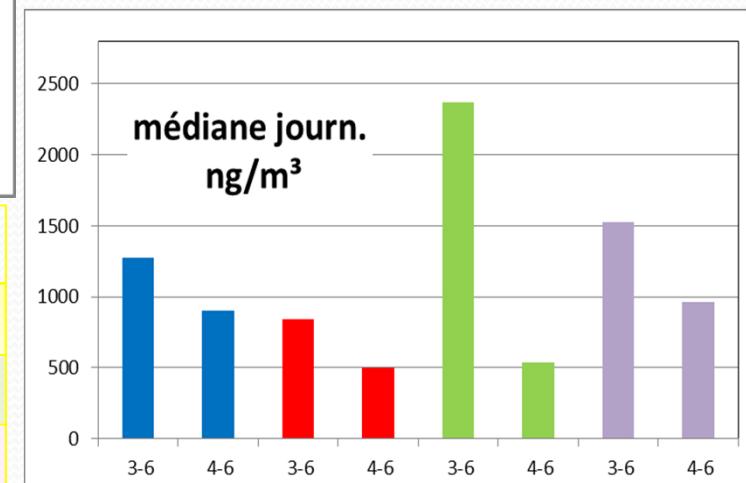
c commuting to, from work

L leaving ISSeP during lunchtime

r riding in the car in the evening



Fabian Isabelle Marie Luc



## Exposure 4/8

### BC Exposure, one day details

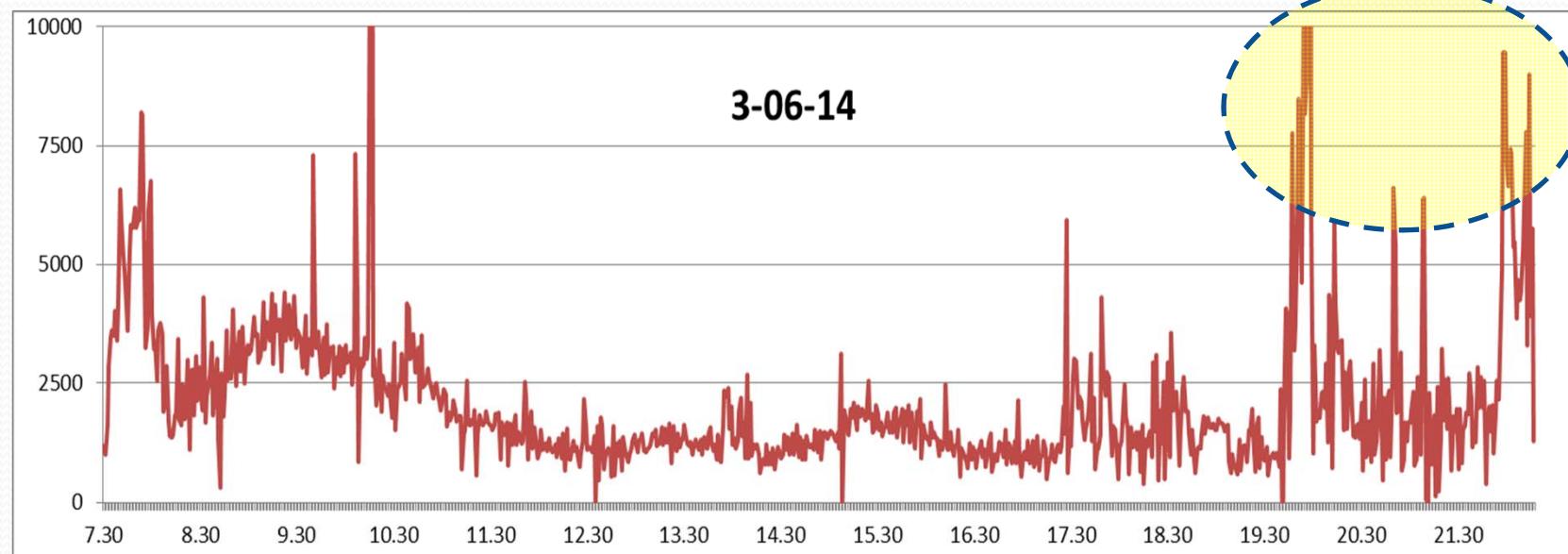
Train + walking,  
Flémalle to Liège

at ISSeP out of buildings

Train + walking,  
Liège to Flémalle

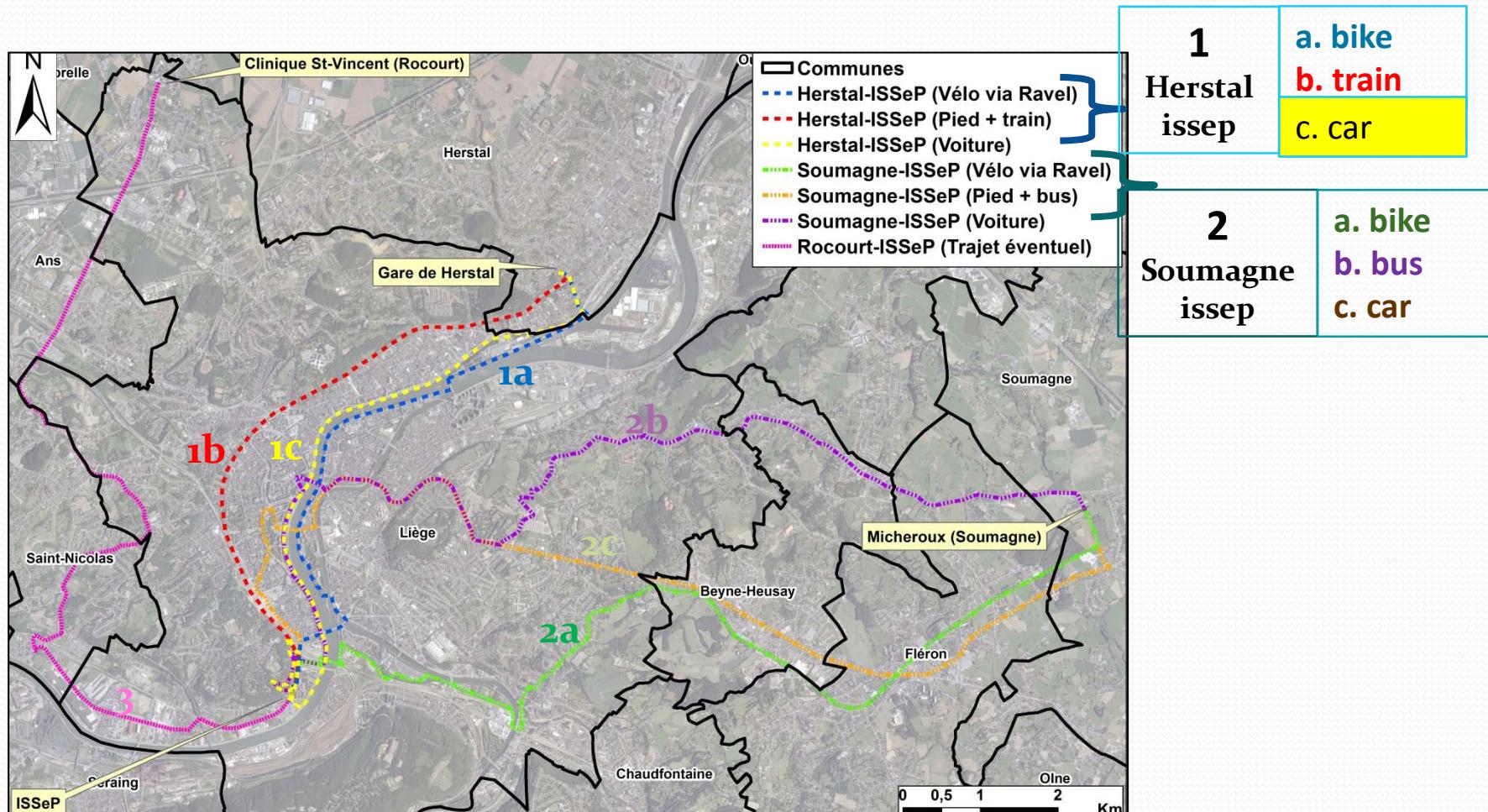
Highway tunnel  
E25-E40

Visit Grivegnée car



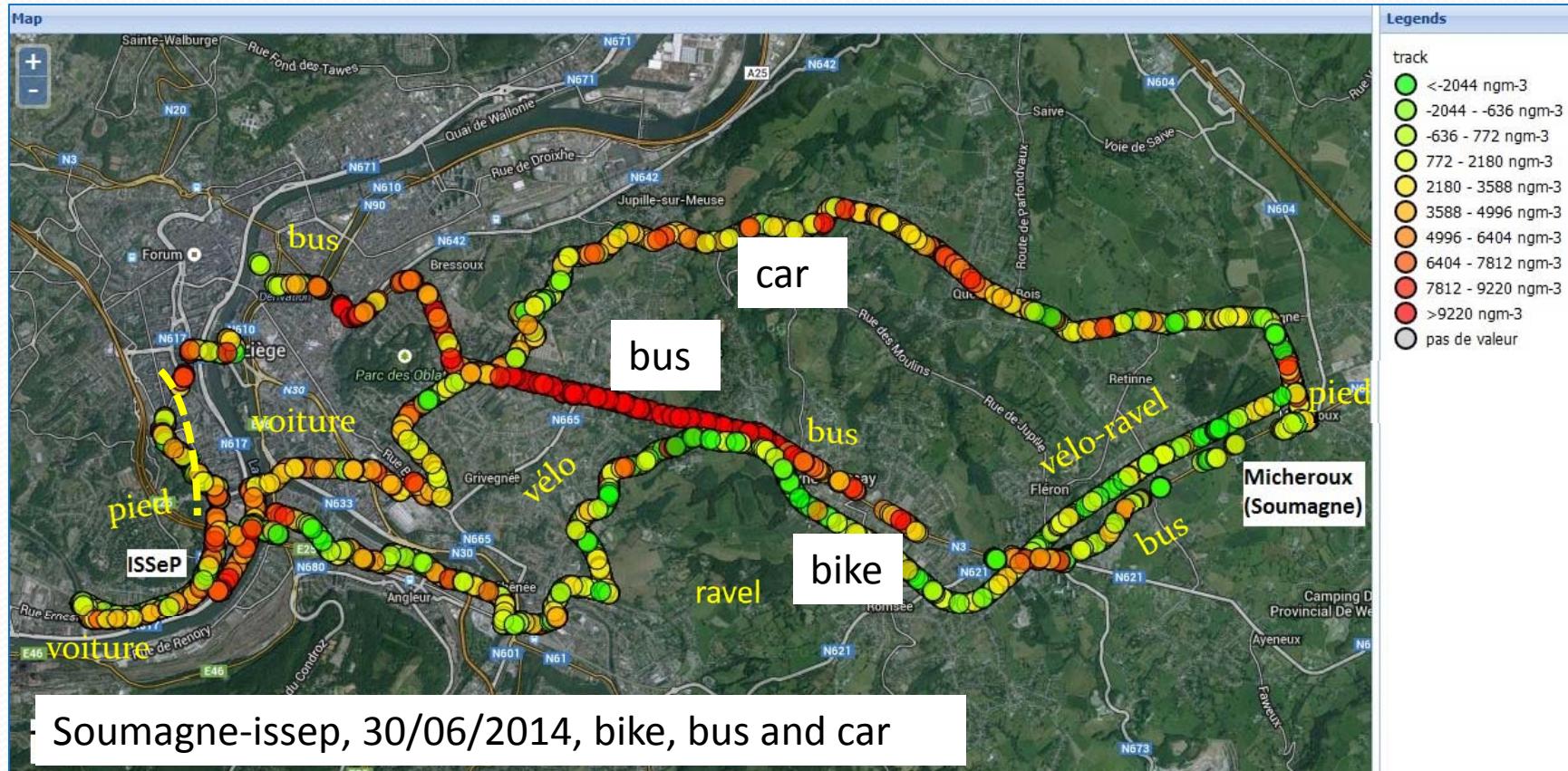
## Exposure 5/8

### Exposure of subjects while commuting



## Exposure 6/8

### BC exposure while commuting



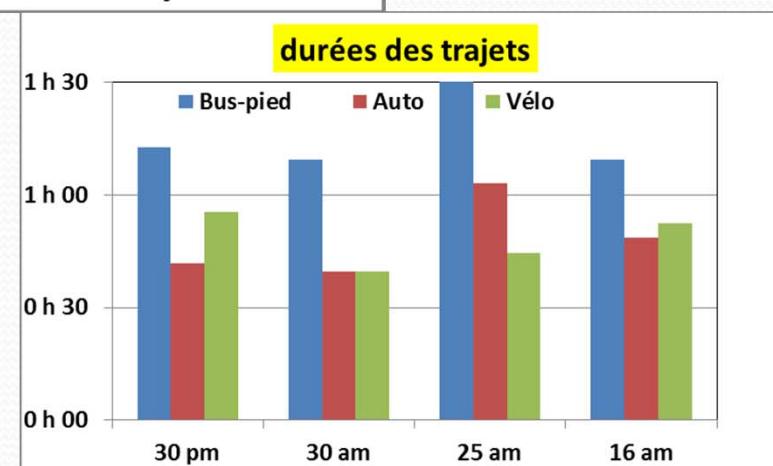
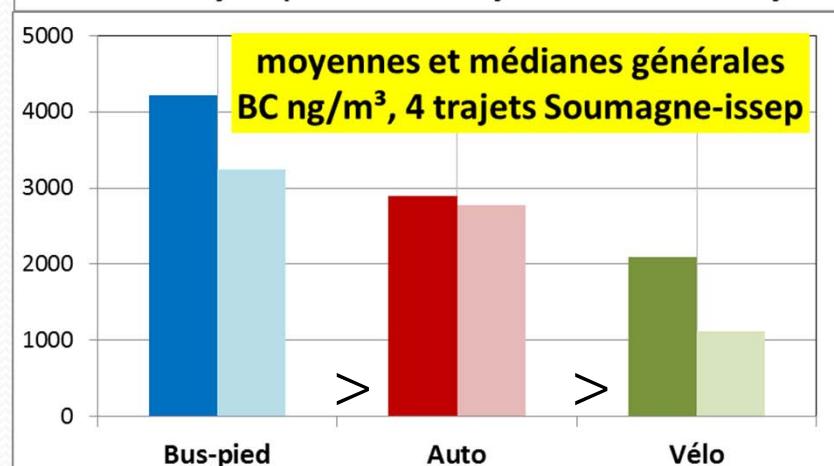
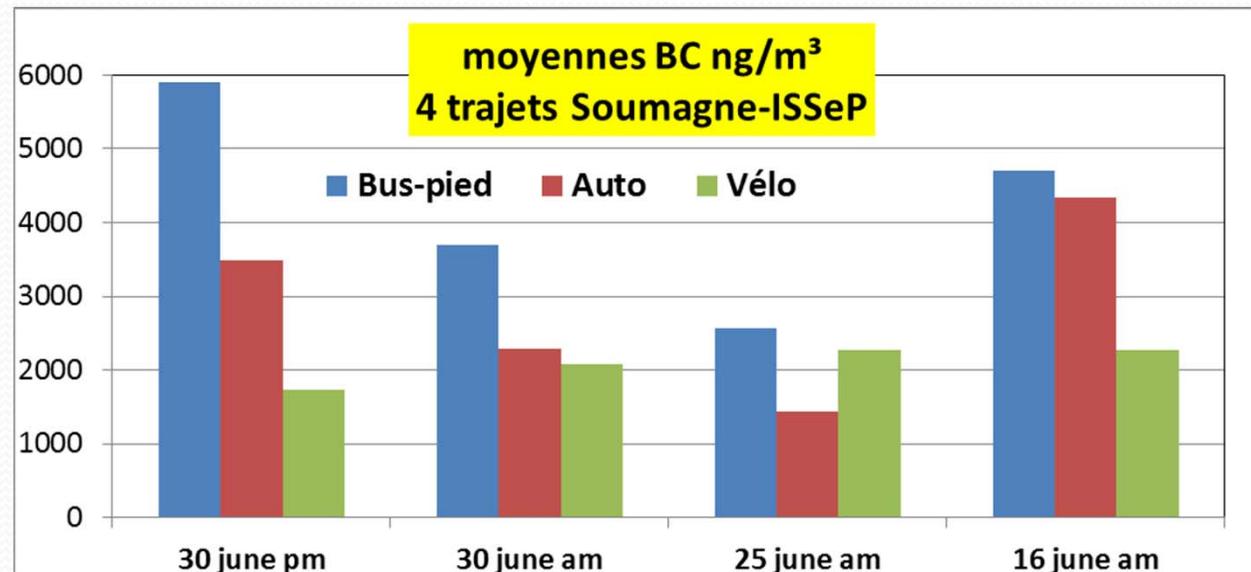
ravel= completed separate bike route

Losses of gps signal for the bus passenger

Hot spots are visible

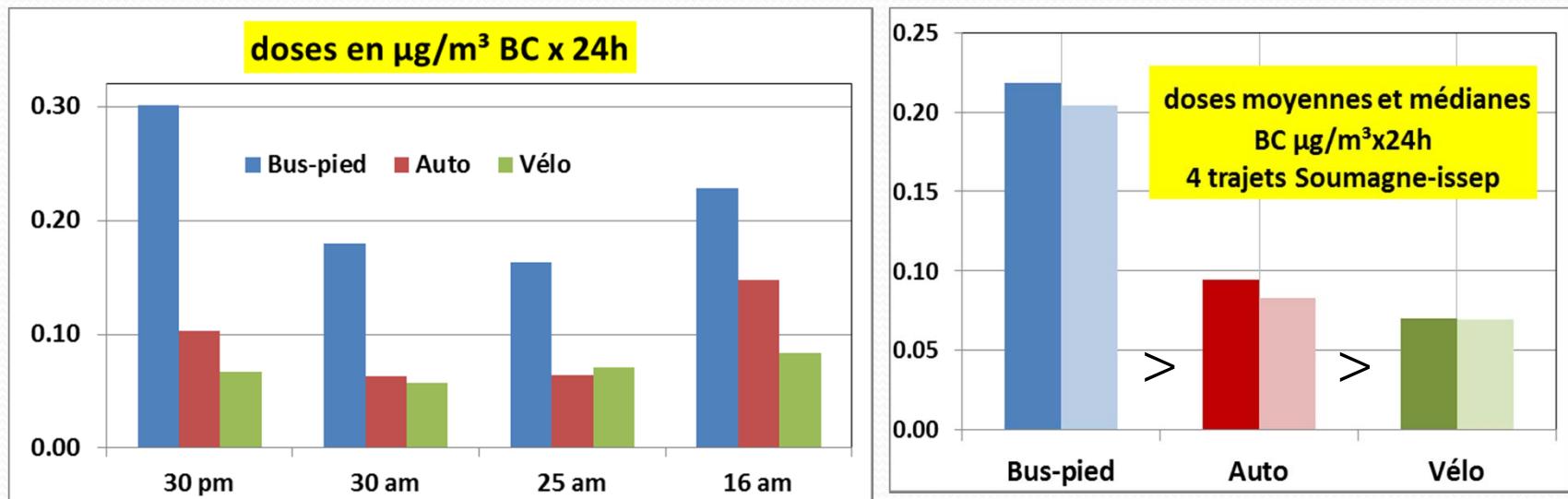
## Exposure 7/8

### BC Exposure while commuting



## Exposure 8/8

### BC Exposure while commuting



! Here 3x Soumagne-issep et 1x issep-Soumagne

Exemple favourable for the biker

- separated bike route for a significant part of the trip
- 3 x downhill, 1 x uphill