



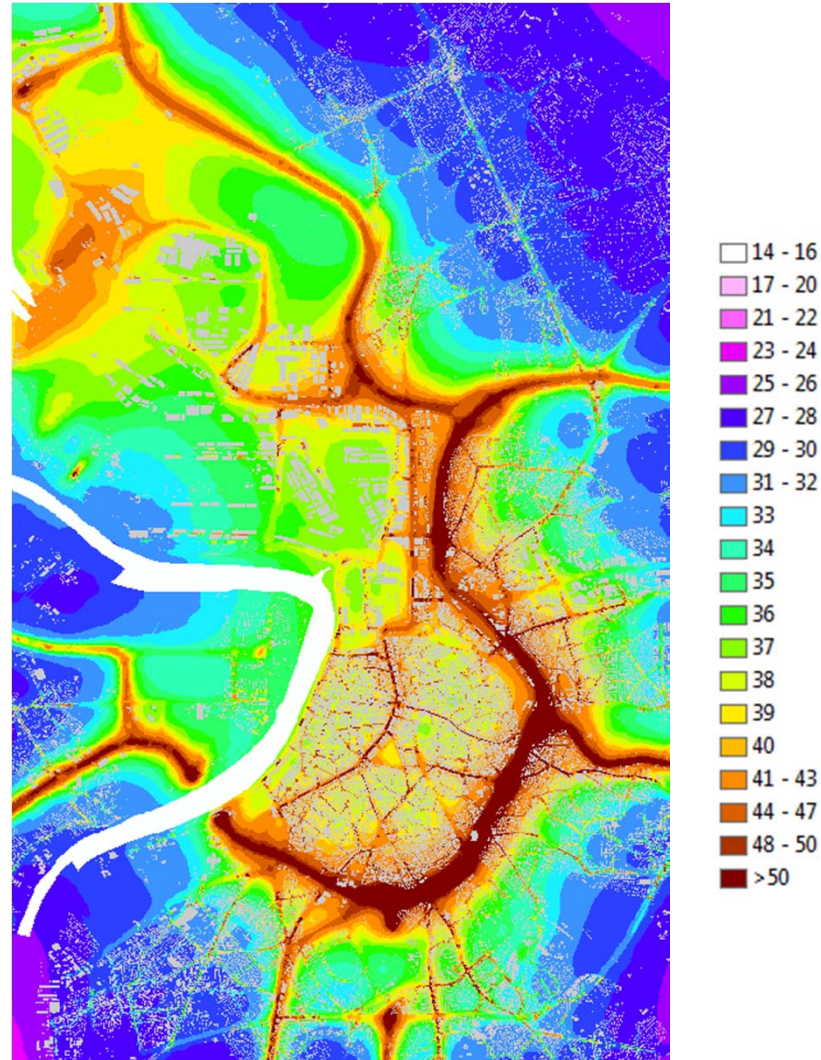
## FAIRMODE SPATIAL REPRESENTATIVENESS: ANTWERP DATASET

*Hans Hooyberghs, Wouter Lefebvre, Stijn Janssen*



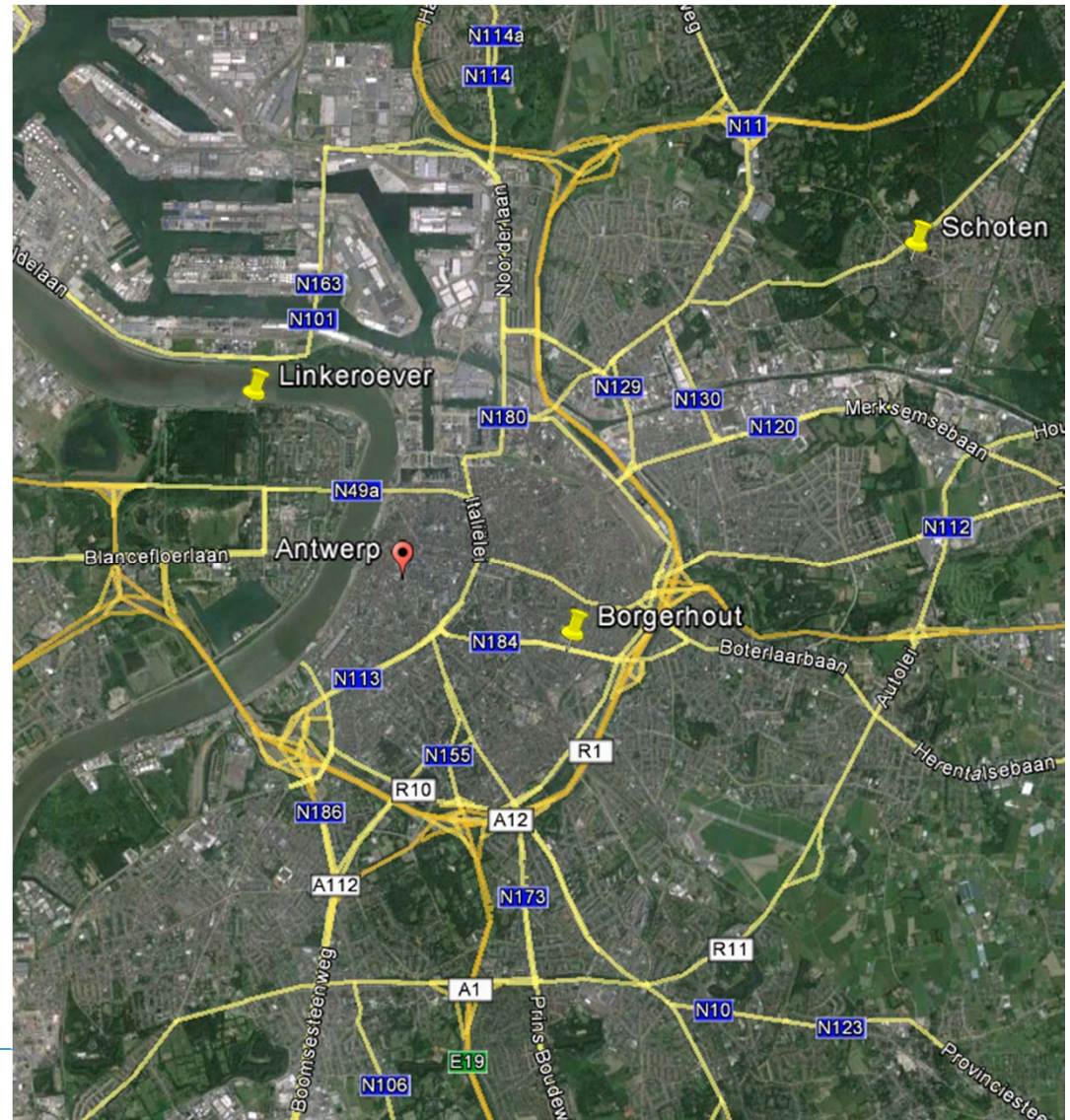
## OVERVIEW

- » Spatial representativeness
- » Data overview
- » Measurements
- » Emissions
- » Model chain
  - » Basic description
  - » Model input
- » Virtual stations
- » Summary



## SPATIAL REPRESENTATIVENESS EXERCISE

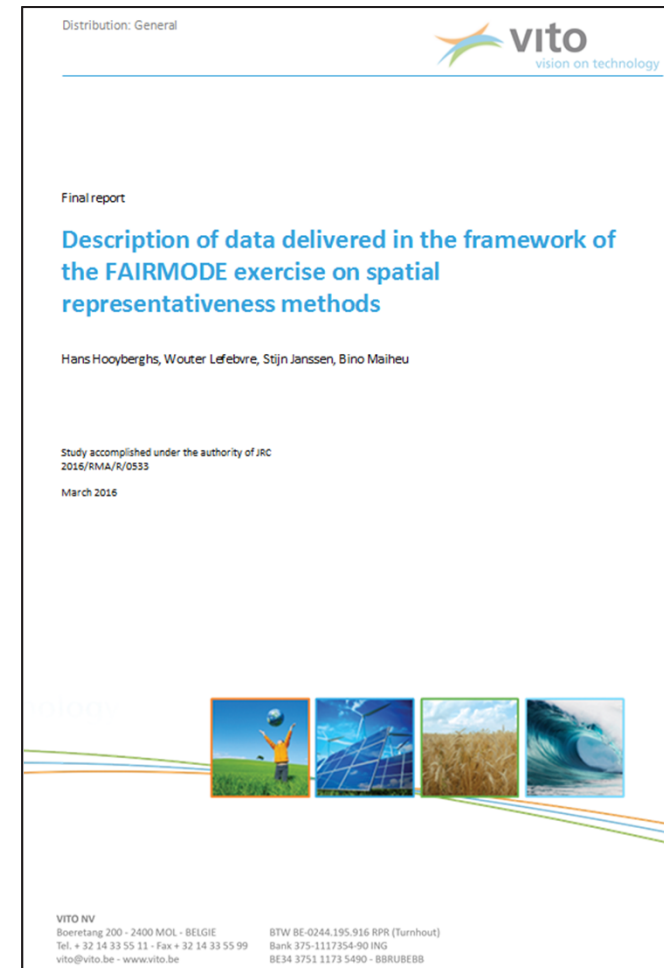
- » Focus on representativeness of three measurement stations in the Antwerp Area
- » Traffic site
  - » Borgerhout II (street canyon location)
- » Urban background sites
  - » Antwerpen-Linkeroever
  - » Schoten



Fairmode intercomparison exercise

## DATA OVERVIEW

- » Measurements
  - » Telemetric stations (2012)
  - » Campaigns with passive samplers and mobile stations (2012)
- » Emissions
- » RIO-IFDM-OSPM modelresults
- » Various
  - » Population density (100m x 100m)
  - » Buildings
  - » Corine Land Use



## MEASUREMENTS

- » 26 telemetric stations, yearlong data (2012)

Industrial	16
Urban / Industrial	1
Urban / Traffic	1
Urban / Traffic street canyon	1
Urban background	6
Urban background / Industrial	1

- » Campaigns with passive samplers and mobile stations (2011 and 2012):
  - » NO<sub>2</sub> and PM
  - » 27 measurement periods of 14 days

Urban Background	2
Street canyon	2
Regional road	2

## EMISSIONS

- » Gridded emission data on 1x1km<sup>2</sup>
  - » CO, NH<sub>3</sub>, NMVOS, NO<sub>x</sub>, PM<sub>10</sub>, PM<sub>2.5</sub>, So<sub>x</sub>
  - » SNAP-sectors
- » Line sources for traffic emissions
  - » Note that these emissions are also included in the 1x1km<sup>2</sup> gridded emissions, this file denotes how these emissions are spread across the roads in the grid cells
- » Point sources
  - » Annual total point source emissions for 2010 reported by the Belgian government in the scope of the CLRTAP-agreement (The 1979 Geneva Convention on Long-range Transboundary Air Pollution).
  - » Since the point source data included in the 1x1km<sup>2</sup> gridded emissions differ slightly from the point source data in this file, one must take care in combining both datasets and apply a suited double counting procedure

Snap sector	Sector Description
1	Combustion in energy production and transformation
2	Non-industrial combustion plants
3	Combustion in manufacturing industry
4	Production processes
5	Extraction and distribution of fossil fuels and geothermal energy
6	Solvent use and other product use
7	Road transport
8	Other mobile sources and machinery
9	Waste treatment and disposal
10	Agriculture



# POINT SOURCES

## Comparison of data sets

### » Total emissions in domain

Ton/year	NO <sub>x</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>
Local dataset (2012)	12488	425	219
CLRTAP (2010)	12589	0	0
E-PRTR (2012)	11422	106	0

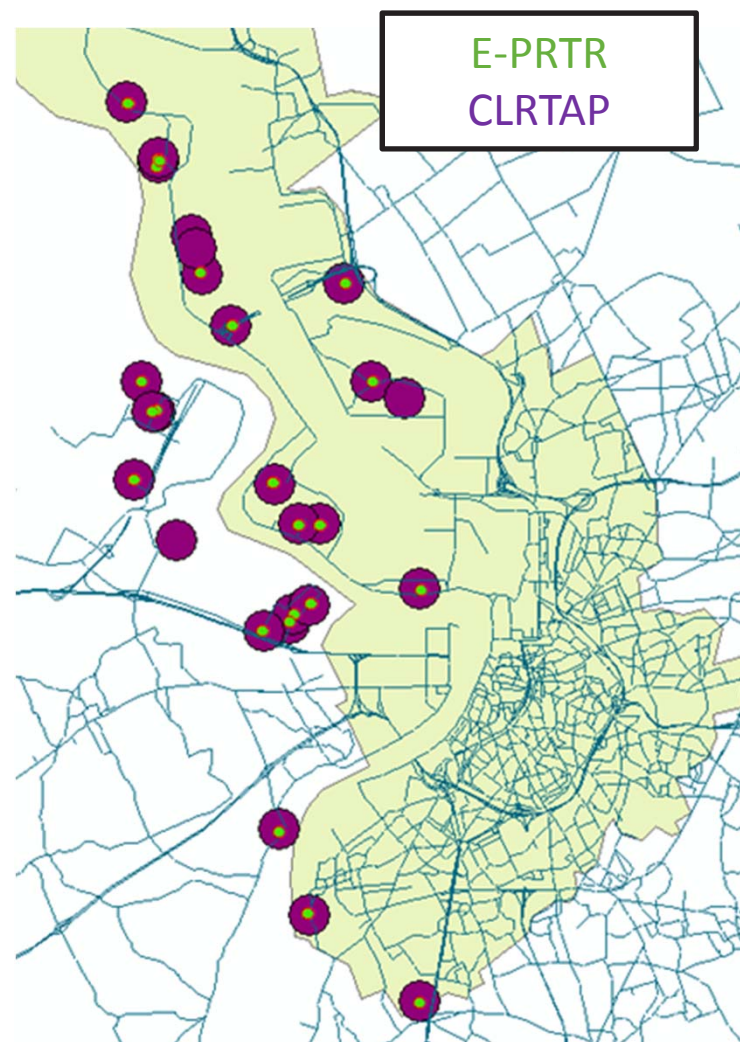
Note: According to our local dataset, only 8% of the PM<sub>10</sub>-emissions are emitted at point sources.

### » Height of emissions

Height category	Local dataset	CLRTAP
1 (h > 45m)	6125	6100
2 (45m < h < 100m)	5530	4590
3 (100m < h < 150m)	700	135
4 + 5 (h > 200m)	60	0
Unknown		1765

### » Additional constraints:

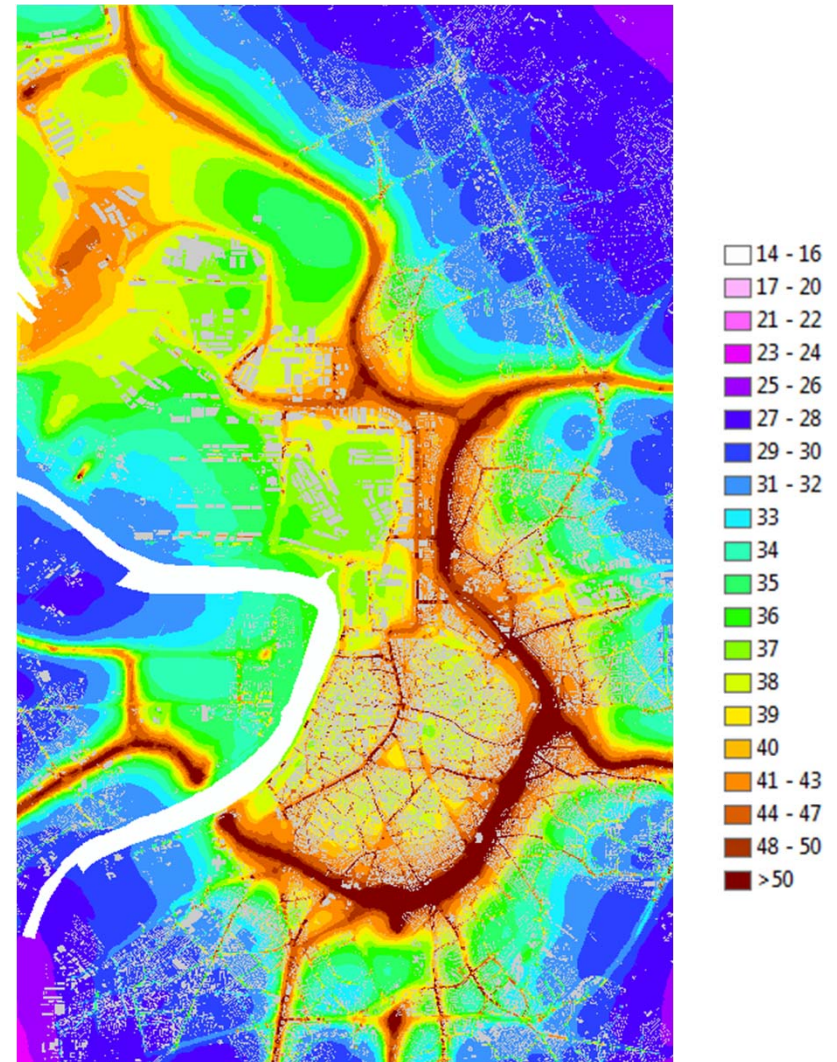
- » No height of stacks in E-PRTR
- » No heat content in E-PRTR and CLRTAP
- » Coordinates in local dataset are confidential



## MODEL RESULTS

### *Description*

- » Model chain: RIO-IFDM-OSPM
- » Year: 2012
- » Pollutants:  $\text{NO}_2$ , BC,  $\text{PM}_{2.5}$ ,  $\text{PM}_{10}$ ,  $\text{C}_6\text{H}_6$ ,  $\text{O}_3$
- » Results
  - » Gridded annual mean concentrations
  - » Time series for 341 (virtual) stations





# MODEL RESULTS

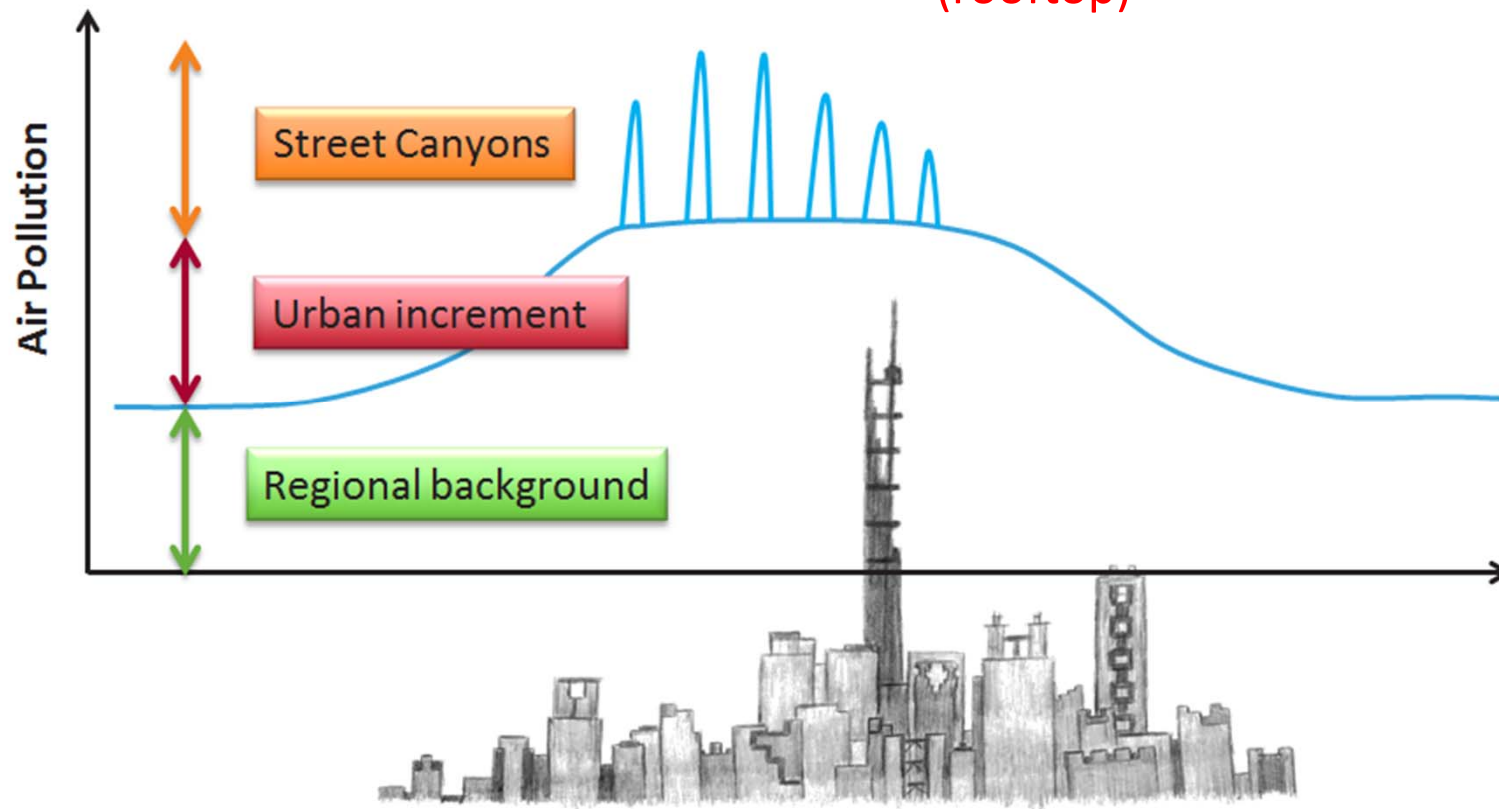
Model Chain

RIO - IFDM - OSPM chain

Regional background

Urban traffic and industrial point sources (rooftop)

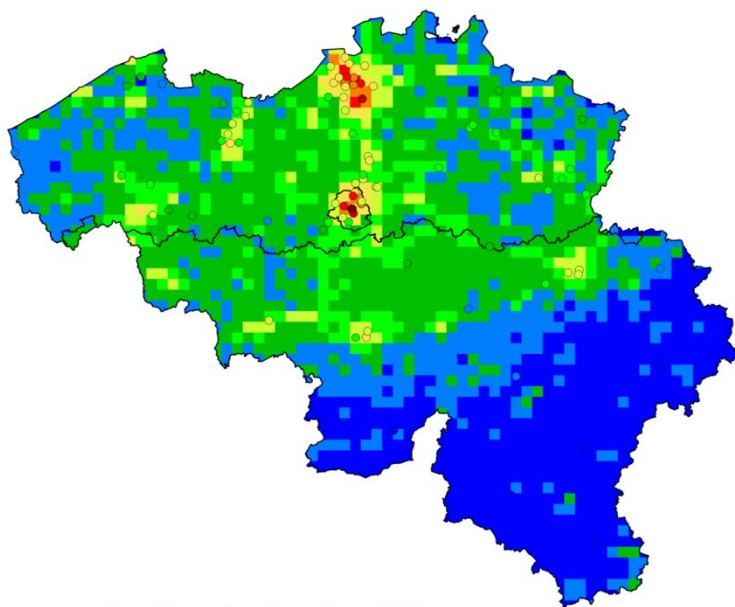
Street-canyon module



# OVERVIEW I

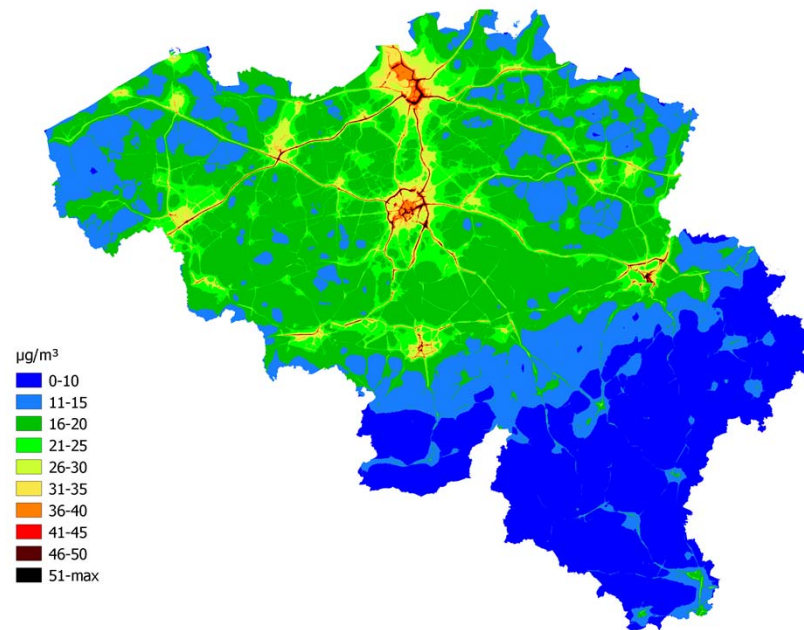
## RIO

Annual mean NO<sub>2</sub> concentrations (Belgium, 2012)



## RIO-IFDM

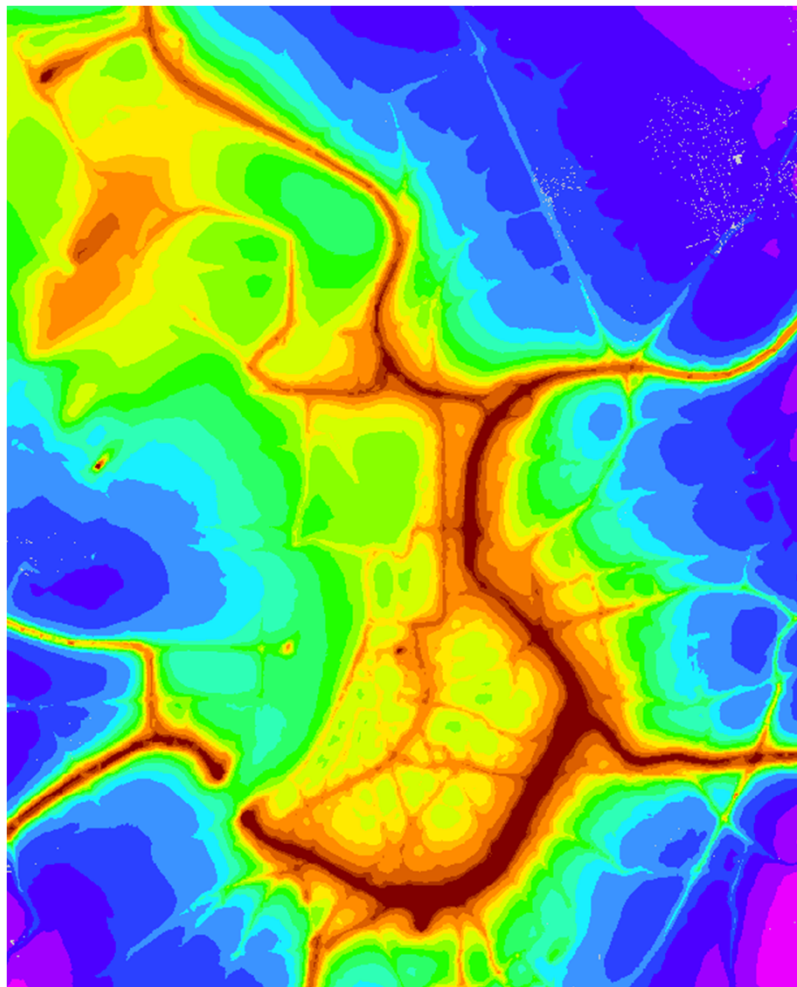
RIO-ifdm NO<sub>2</sub> annual mean 2012



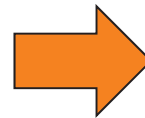
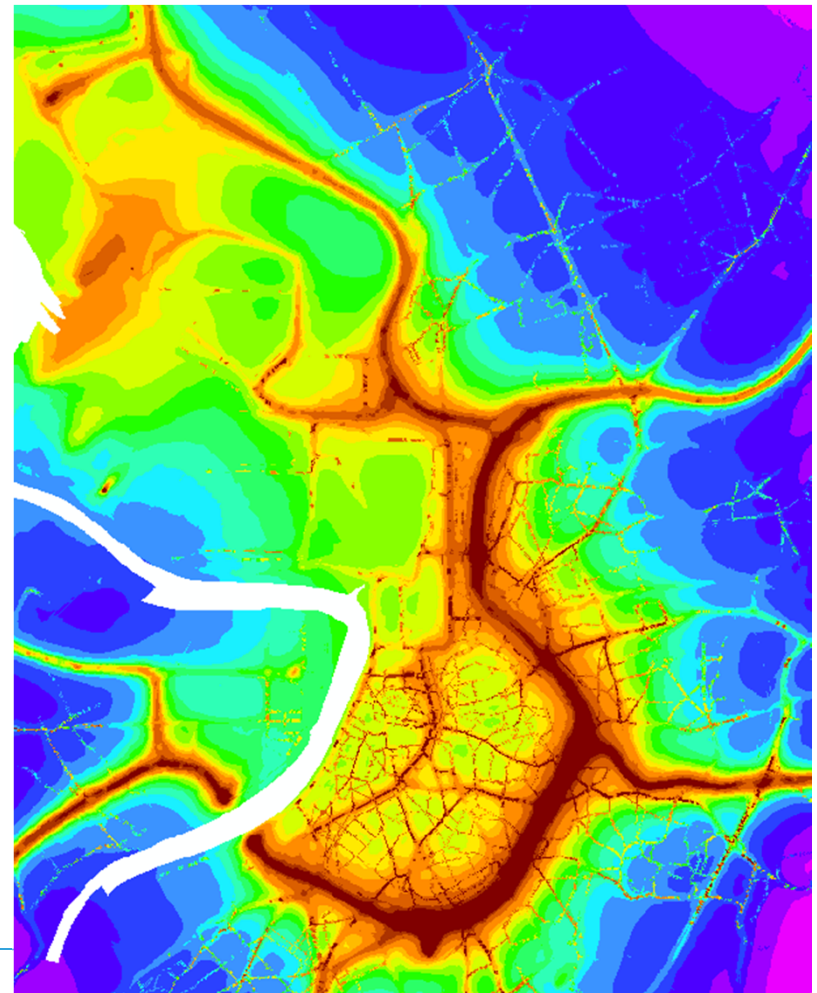
Data source: <http://www.atmosys.eu>

## OVERVIEW II

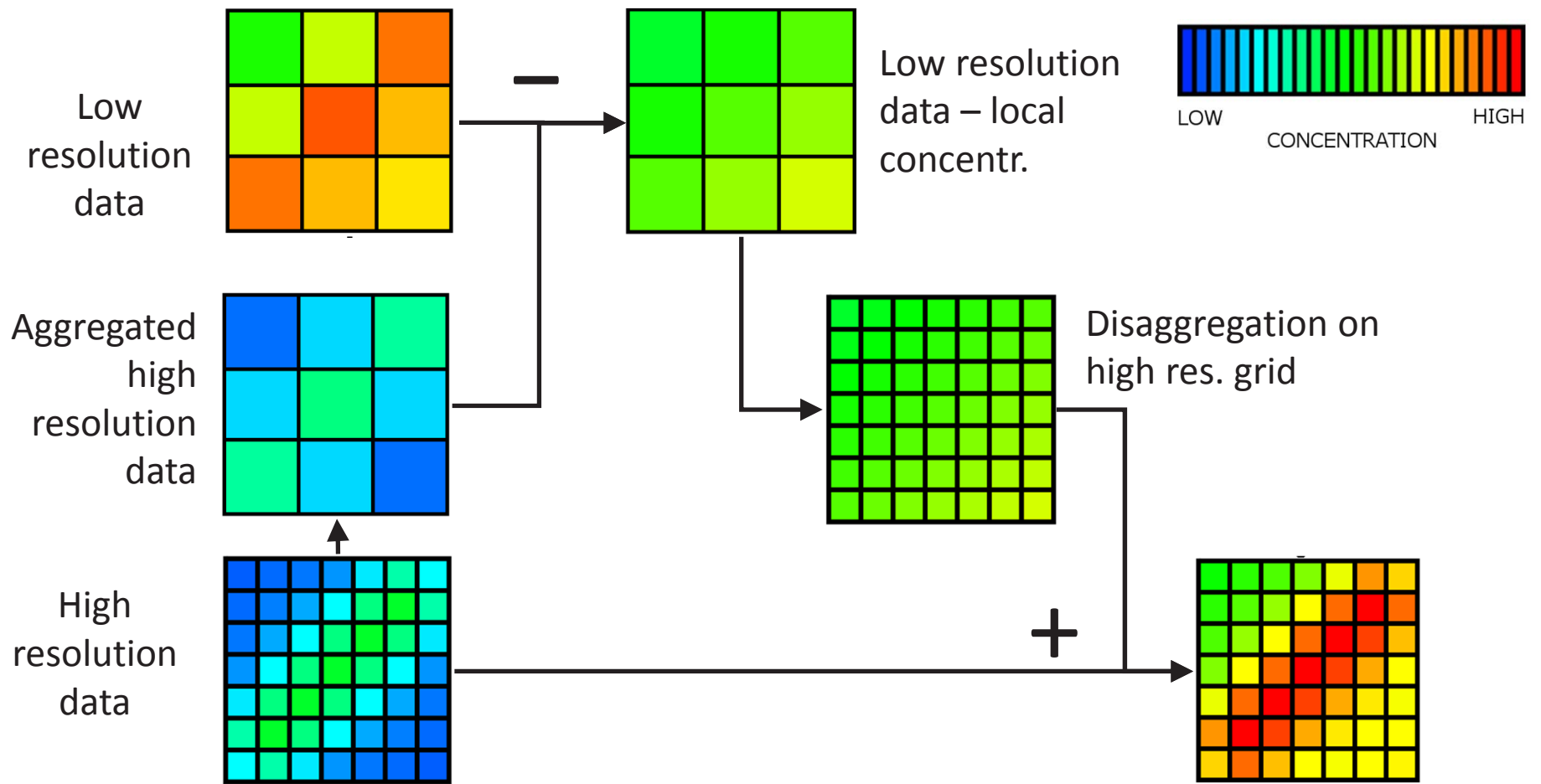
RIO-IFDM



RIO-IFDM-OSPM



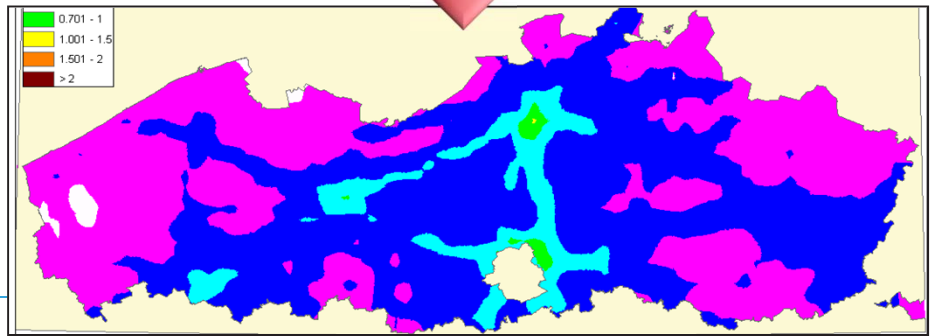
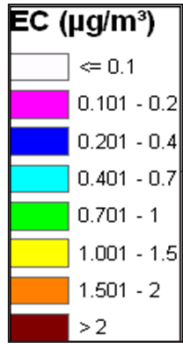
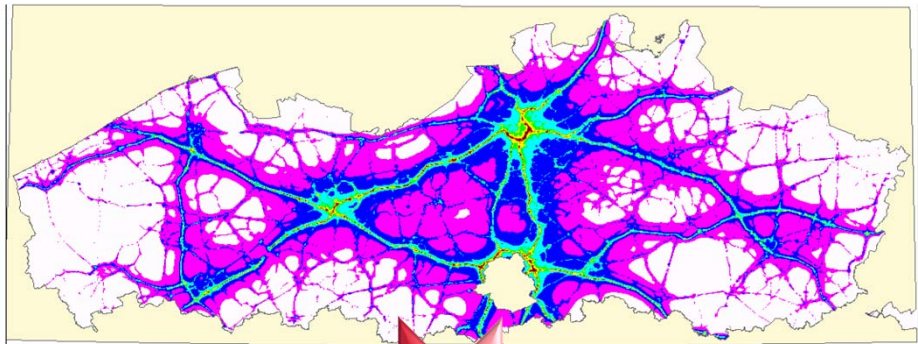
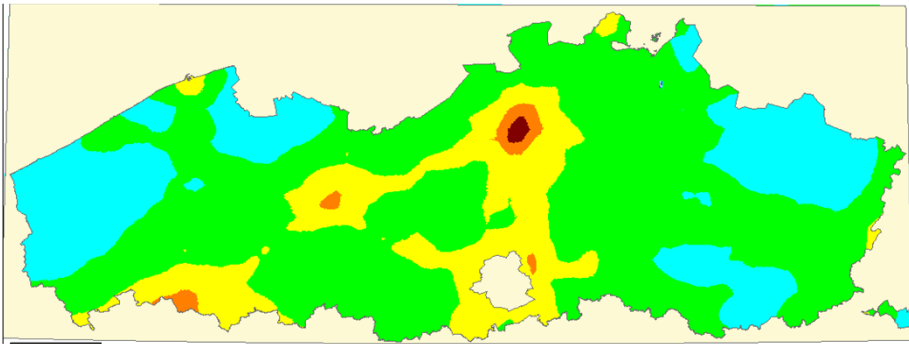
# AVOID DOUBLE COUNTING: THEORETICAL EXAMPLE



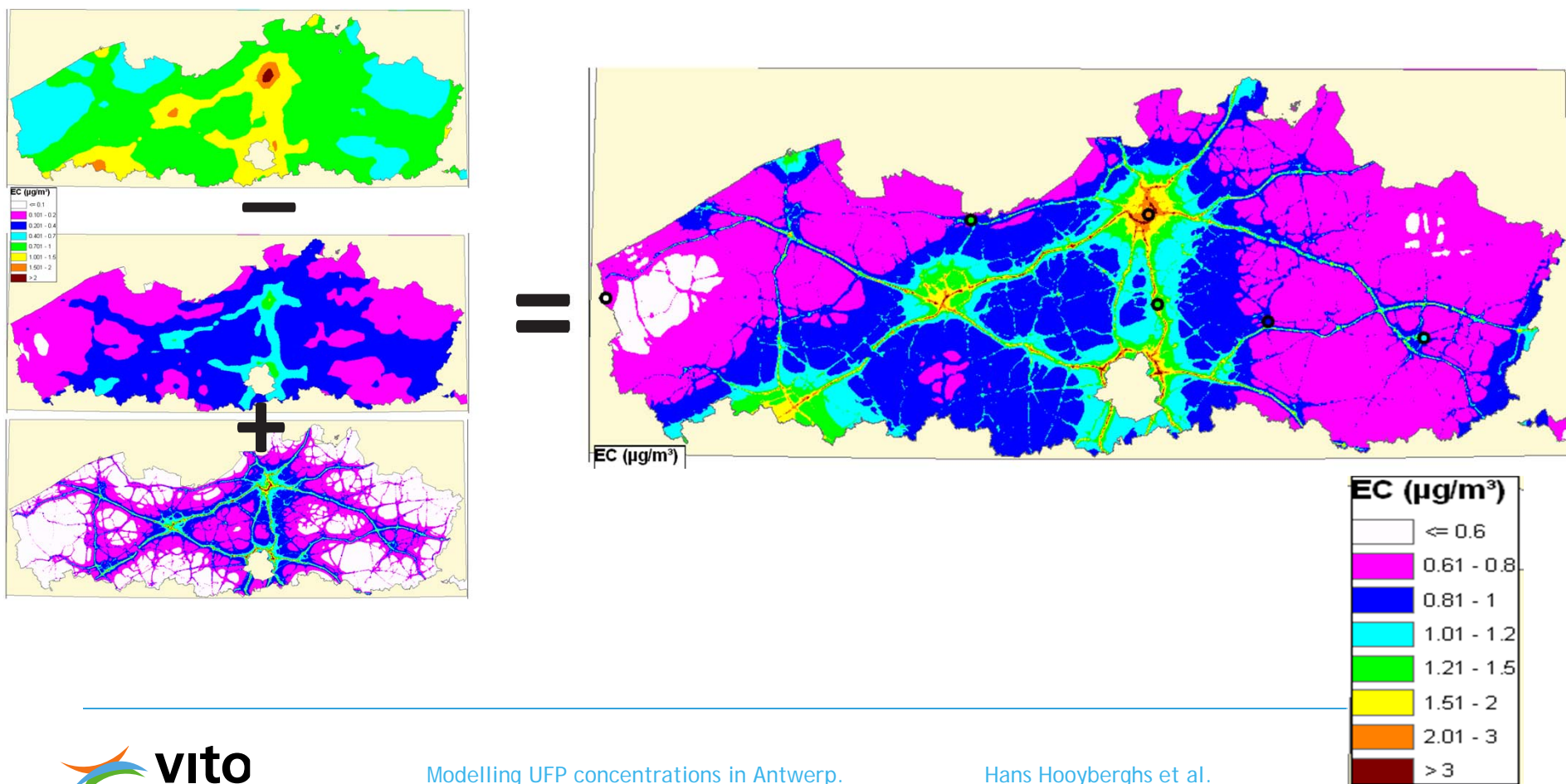
# AVOID DOUBLE COUNTING: REAL WORLD EXAMPLE

EC at regional scale

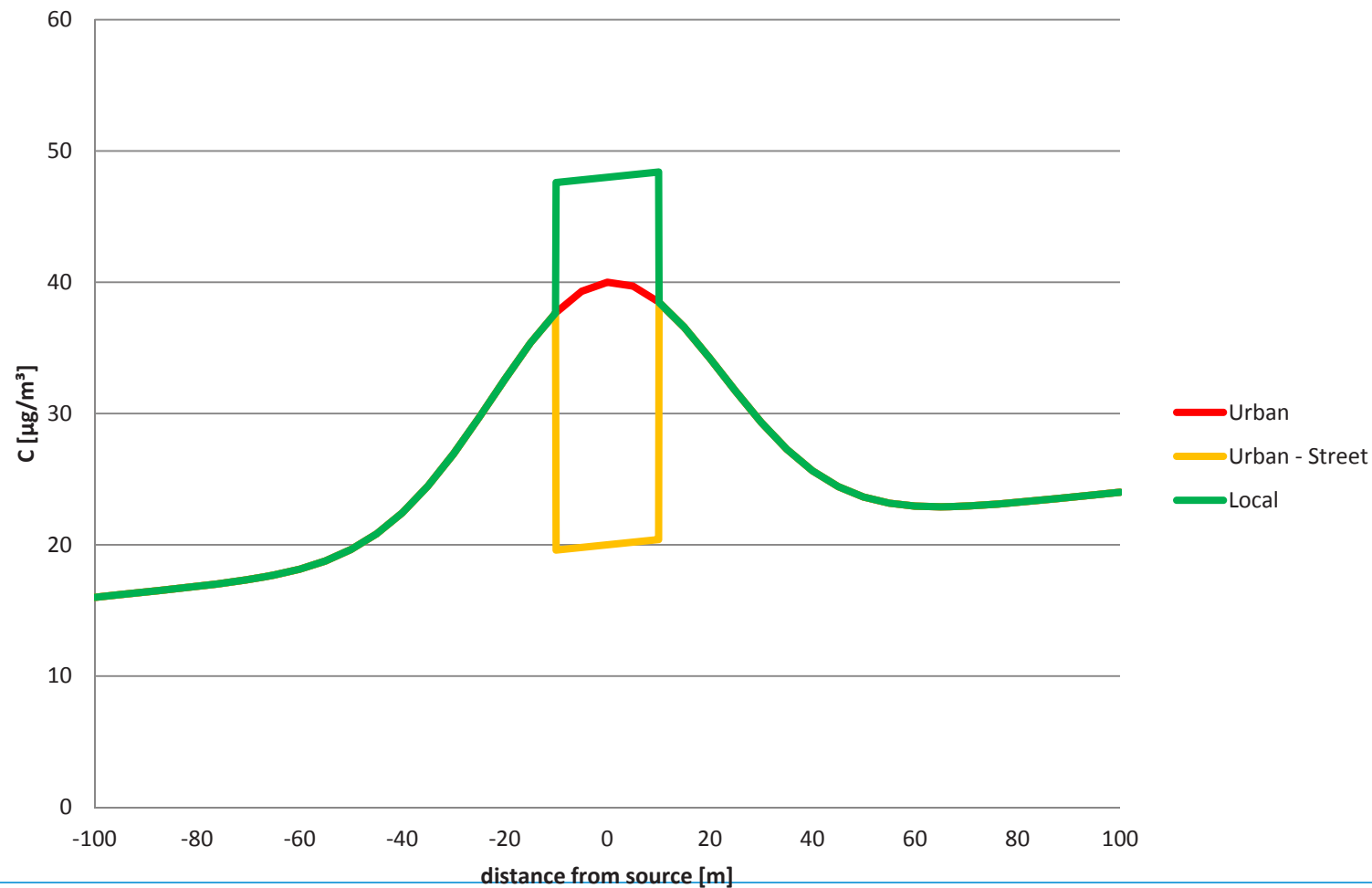
EC from traffic



# AVOID DOUBLE COUNTING: REAL WORLD EXAMPLE

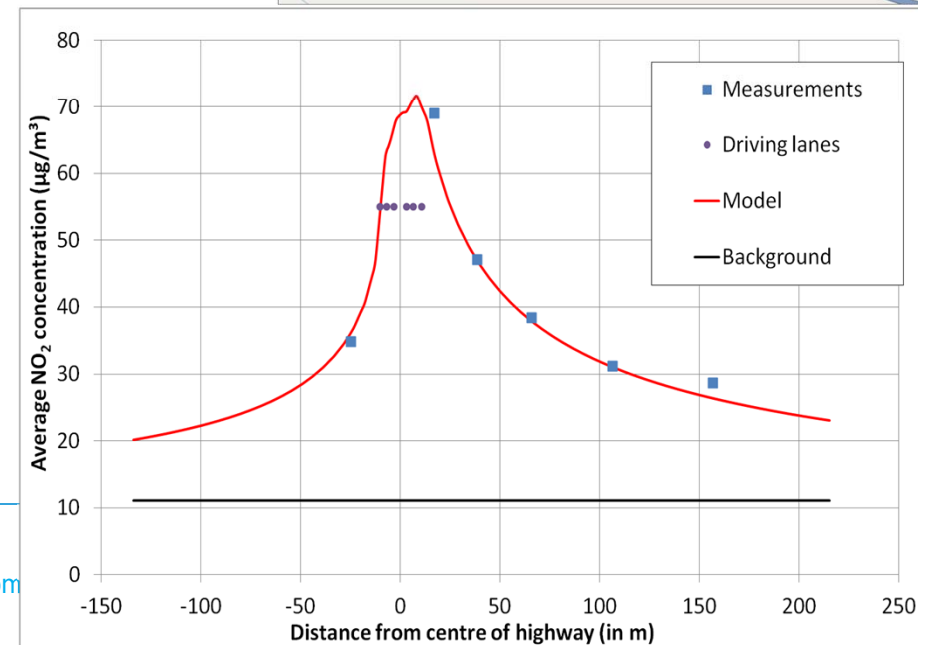
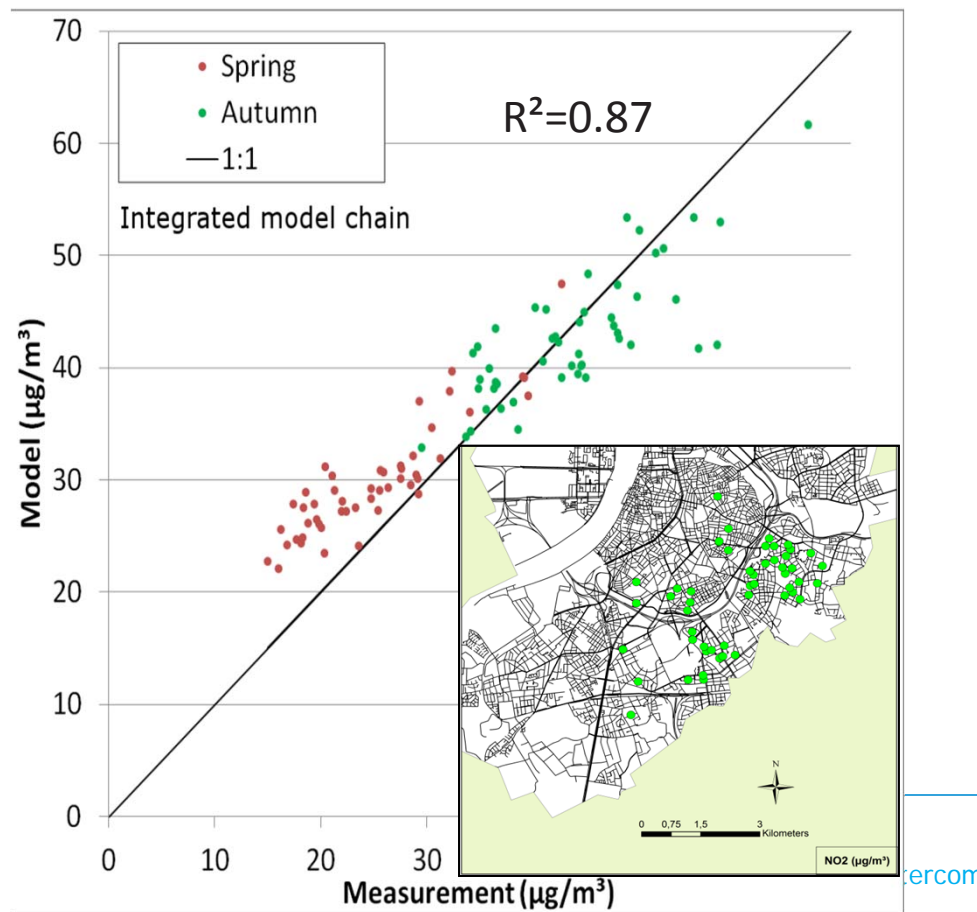


## AVOID DOUBLE COUNTING AT STREET LEVEL



# VALIDATION

- » Model chain has been validated in many campaigns
  - » City wide validation for Antwerp (NO<sub>2</sub>)
  - » Gradient validation close to highway (NO<sub>2</sub>)
  - » 5 chemKar campaigns for particulate matter (PM)



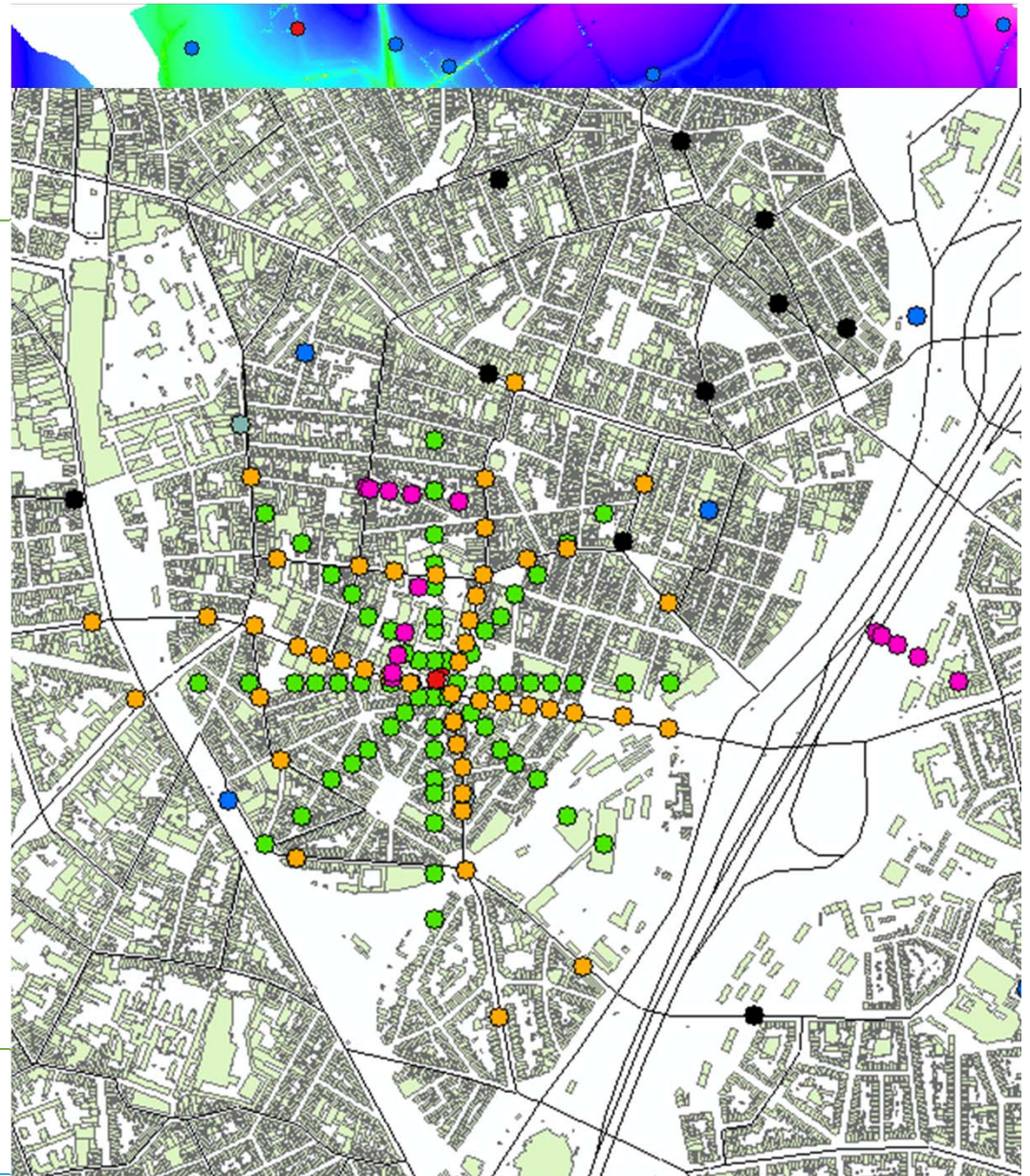


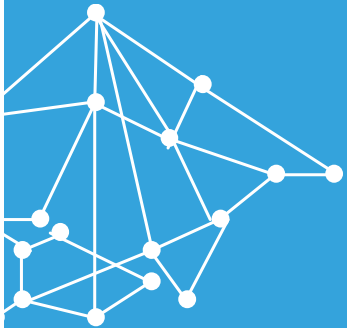
## REMARKS

- » Underestimation of PM concentrations in street canyons (related to multiple resuspension)
- » No street canyon results for ozone (only rooftop concentrations)
- » Due to the lack of benzene measuring stations, there is no RIO-background concentration. Hence, the benzene maps only show the local contribution of traffic and industrial point sources. Measurements at the Borgerhout measuring station indicate that the annual mean background concentration is approximately  $0.7 \mu\text{g}/\text{m}^3$ .
- » The point source dataset used in the modelling exercise and the one provided in the emission data differ slightly. Due to confidentiality agreements, VITO is not allowed to disclose its (high resolution) dataset, but the emissions of this dataset are included in the  $1 \times 1 \text{km}^2$  gridded emissions. A comparison between the CLRTAP dataset and the (confidential) local point source data is provided in the appendix of the report.

## VIRTUAL MONITORING STATIONS

- » Categories:
  - » ATMOSYS campaign locations (6)
  - » **Telemetric stations (26)**
  - » **Randomly chosen locations (117)**
  - » Randomly chosen street canyon locations (47)
  - » Randomly chosen tunnel exit locations (4) [white]
  - » **Non-street canyon locations on concentric circles around Borgerhout stations (33)**
  - » **Street canyon locations on concentric circles around Borgerhout stations (14)**
  - » **Virtual gradient measurement at three locations (30)**
- » Total: 341 stations (100 in street canyon)



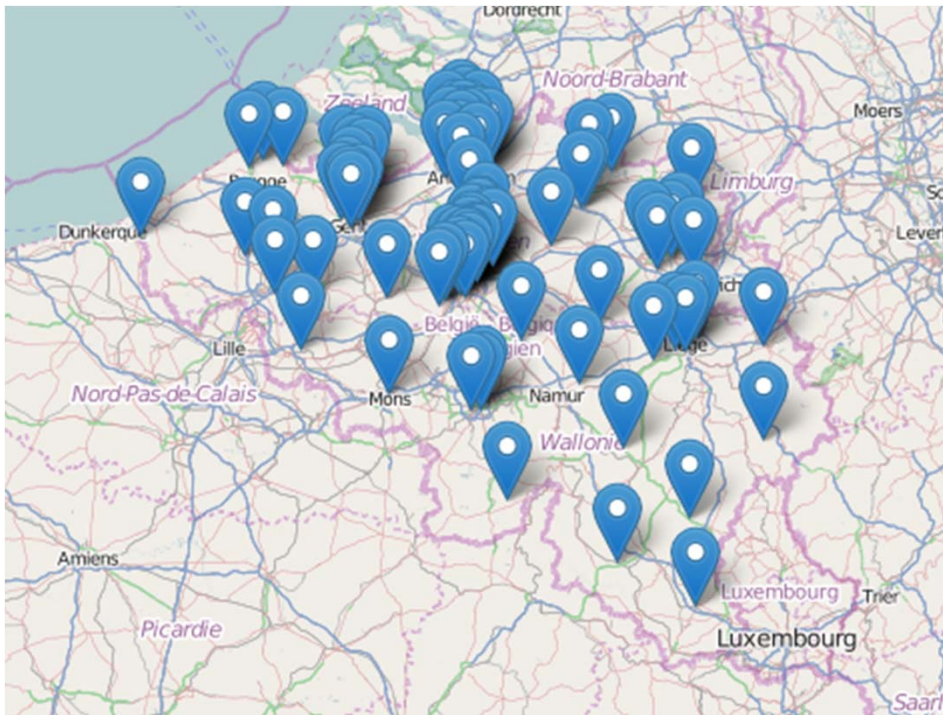


Questions?

EXTRA SLIDES

# REGIONAL MODELLING: RIO

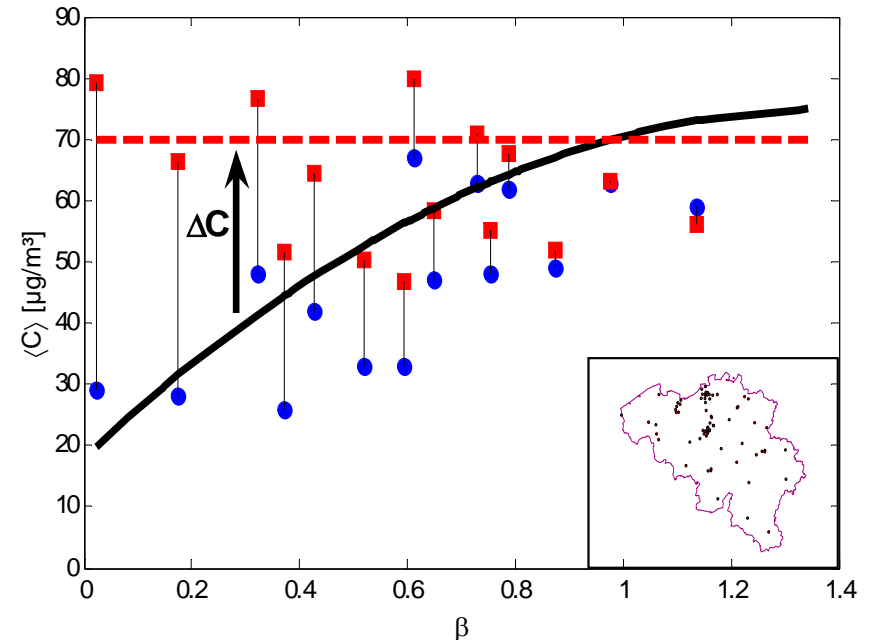
» Modelling technique based upon measurements



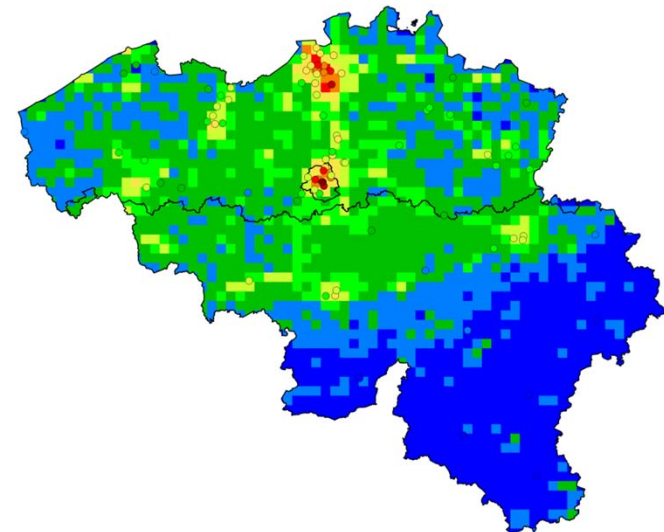
<a href="#">41B004</a>	Brussel (Sint-Katelijne)	Bxl	59	7:00	13:00
<a href="#">41B006</a>	Brussel (EU Parlement)	Bxl	62	3:00	12:00
<a href="#">41B008</a>	Brussel (Belliardstraat)	Bxl	75	11:00	13:00
<a href="#">41B011</a>	Sint-Agatha-Berchem	Bxl	56	1:00	13:00
<a href="#">41MEU1</a>	Neder-Over-Heembeek	Bxl			6:30
<a href="#">41N043</a>	Voorhaven (Haren)	Bxl	61	7:00	13:00
<a href="#">41R001</a>	Sint-Jans-Molenbeek	Bxl	69	7:00	13:00
<a href="#">41R002</a>	Elsene	Bxl	59	3:00	13:00
<a href="#">41R012</a>	Ukkel	Bxl	43	3:00	13:00
<a href="#">41WOL1</a>	Sint-Lambrechts-Woluwe	Bxl	53	7:00	13:00
<a href="#">4.70E+14</a>	Vorst	Bxl	53	2:00	11:00
<a href="#">44M705</a>	Roeselare (Haven)	Via	41	8:00	10:30
<a href="#">44N012</a>	Moerkerke	Via	28	11:00	13:00
<a href="#">44N029</a>	Houtem (Veurne)	Via	18	3:00	13:00
<a href="#">44N052</a>	Zwevegem	Via	52	11:00	13:00
<a href="#">47E714</a>	Dudzele	Via	26	10:00	13:00
<a href="#">47E715</a>	Zuikerkerke	Via	29	3:00	13:00
<a href="#">42R821</a>	Beveren Waas	Via	54	7:00	13:00
<a href="#">42R830</a>	Doel (Schedelmolenstraat)	Via	51	4:00	13:00
<a href="#">42R892</a>	Kallo (sluis Kallo)	Via	61	1:00	13:00
<a href="#">44M702</a>	Ertvelde	Via	46	5:00	13:00
<a href="#">44N051</a>	Idegem	Via	49	9:00	13:00
<a href="#">44R701</a>	Gent	Via	50	6:00	13:00
<a href="#">44R702</a>	Gent (Gustaaf Callierlaan)	Via	56	6:00	13:00
<a href="#">44R710</a>	Destelbergen	Via	49	6:00	13:00
<a href="#">44R721</a>	Wondelgem	Via	51	11:00	13:00
<a href="#">44R731</a>	Evergem	Via	46	8:00	13:00
<a href="#">44R740</a>	Sint-Kruiswinkel	Via	56	5:00	13:00
<a href="#">44R750</a>	Zelzate	Via	49	4:00	13:00
<a href="#">47E703</a>	Oost-Eeklo	Via	43	8:00	13:00
<a href="#">47E704</a>	Wachtebeke	Via	47	4:00	13:00
<a href="#">47E716</a>	Mariakerke	Via	48	9:00	13:00
<a href="#">40AL01</a>	Antwerpen-Linkeroever	Via	60	1:00	13:00
<a href="#">40HB23</a>	Hoboken	Via	65	1:00	13:00
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<a href="#">40LD02</a>	Geel	Via	23	1:00	13:00
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<a href="#">42M802</a>	Antwerpen (Luchtbal)	Via	61	2:00	13:00
<a href="#">42N016</a>	Dessel	Via	36	1:00	13:00
<a href="#">42R801</a>	Borgerhout	Via	66	1:00	13:00

## RIO METHODOLOGY

- » Main question: How to make reliable maps based upon the measurements?
  - » Higher values in urban areas
  - » Lower values in rural areas
  - » Simple interpolation is insufficient
- » Solution: use of Corine land use data
- » Steps
  - » Detrending: removal of land use bias in measurements  
Result: “homogeneous” concentrations at measurements stations
  - » Interpolation  
Result: “homogeneous” map of concentrations
  - » Retrending: re-adding the land use bias  
Result: concentration map

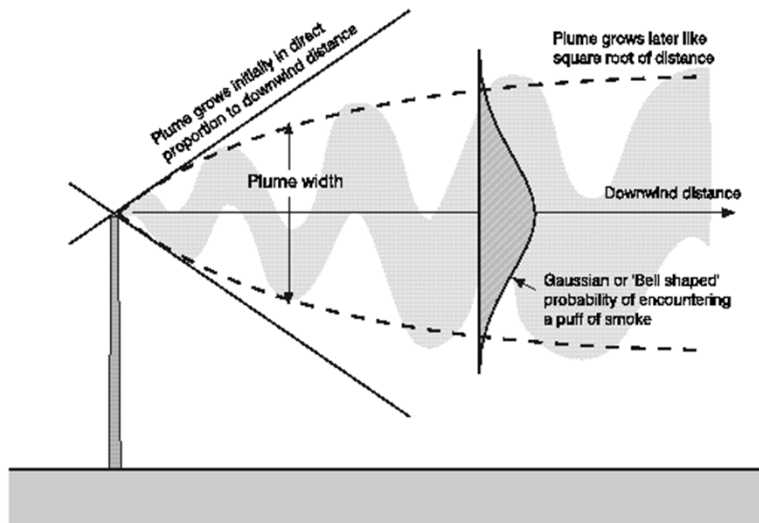


Annual mean NO<sub>2</sub> concentrations (Belgium, 2012)



## LOCAL MODELLING

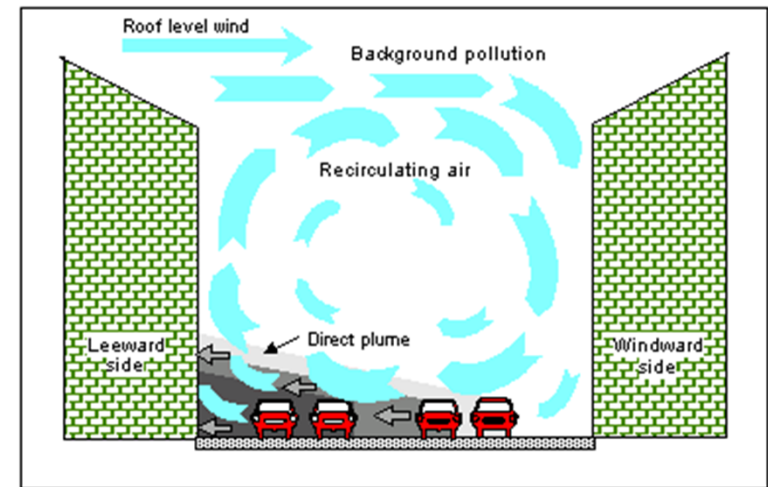
### IFDM Urban scale traffic



Double-counting procedure



### OSPM Street-canyon module



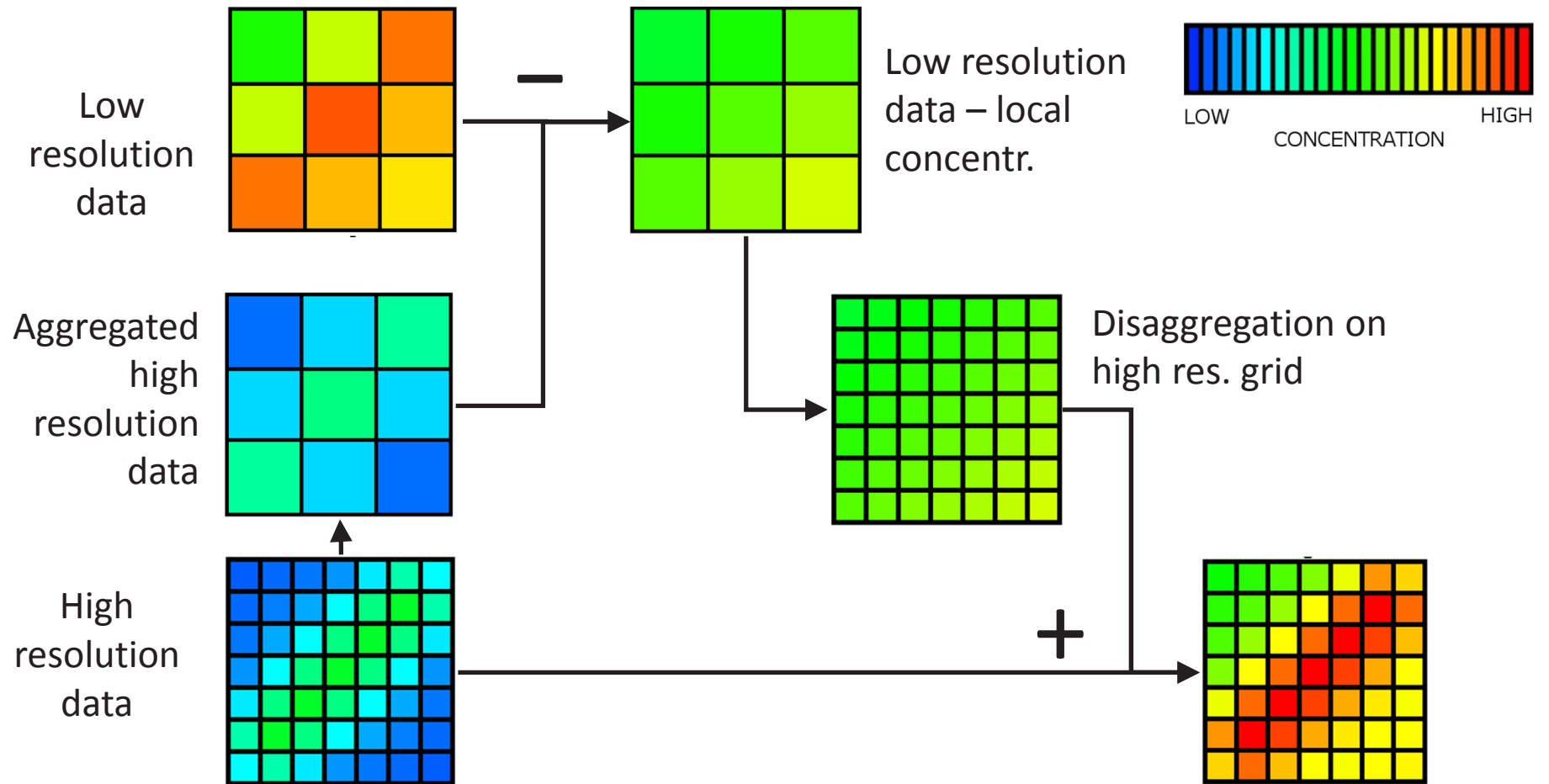
- » Plume model
- » Gaussian dispersion, taking into account the stability of the atmosphere using stability classes (based on meteorological input)
- » Receptor model

- » Box model for the recirculating part of the pollutants in the street canyon (resuspension)
- » For simplicity: asymmetry of street canyon is neglected

What about double  
counting of emissions?

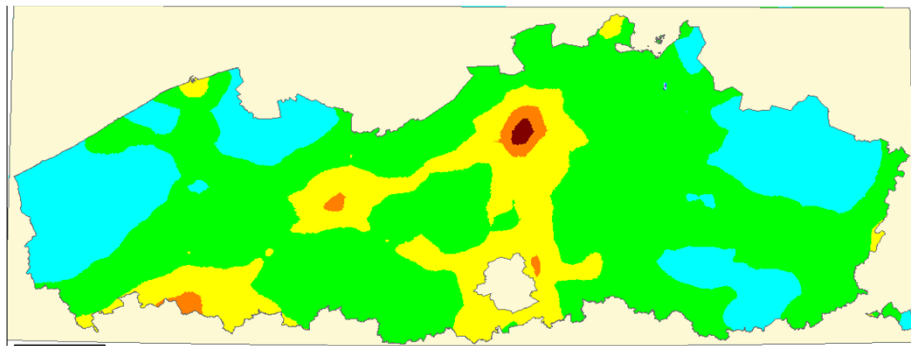


# Avoid double counting: theoretical example

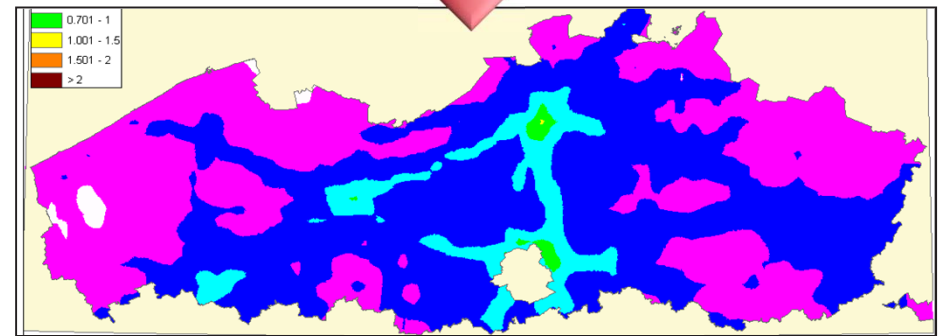
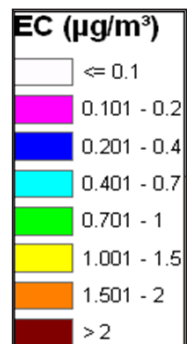
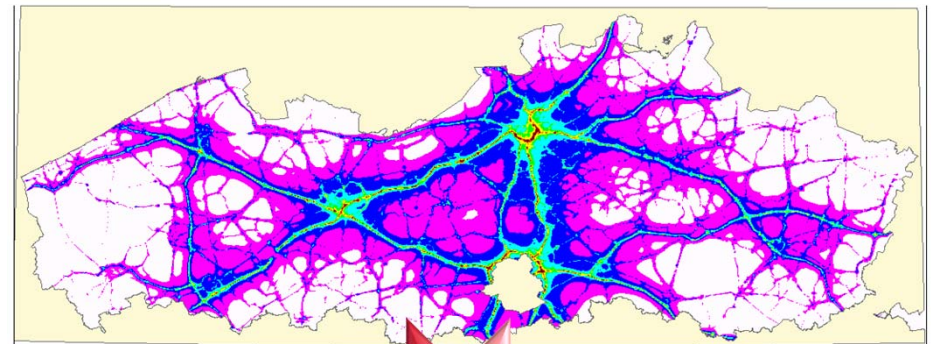


# Avoid double counting: real world example

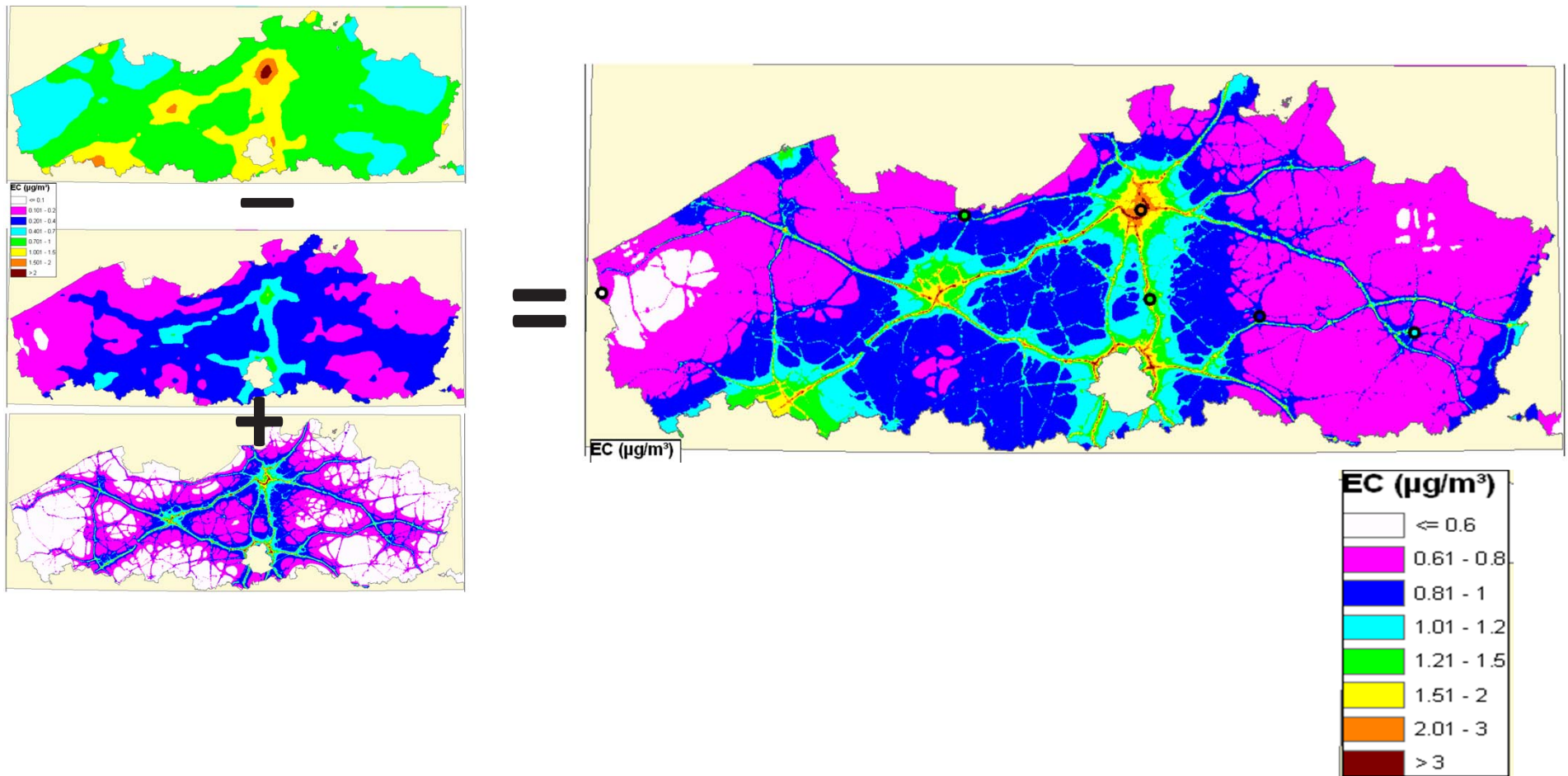
EC at regional scale



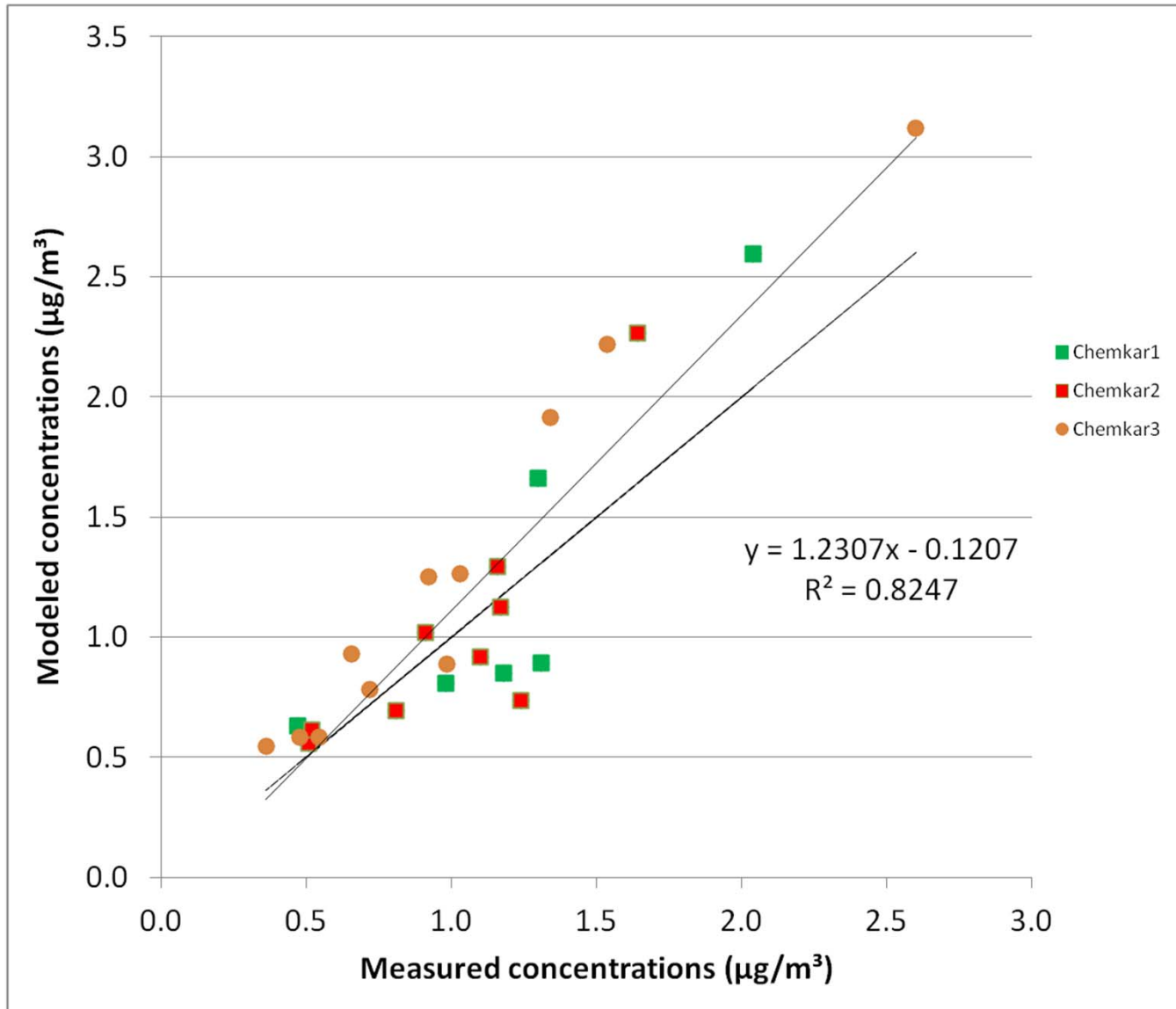
EC from traffic



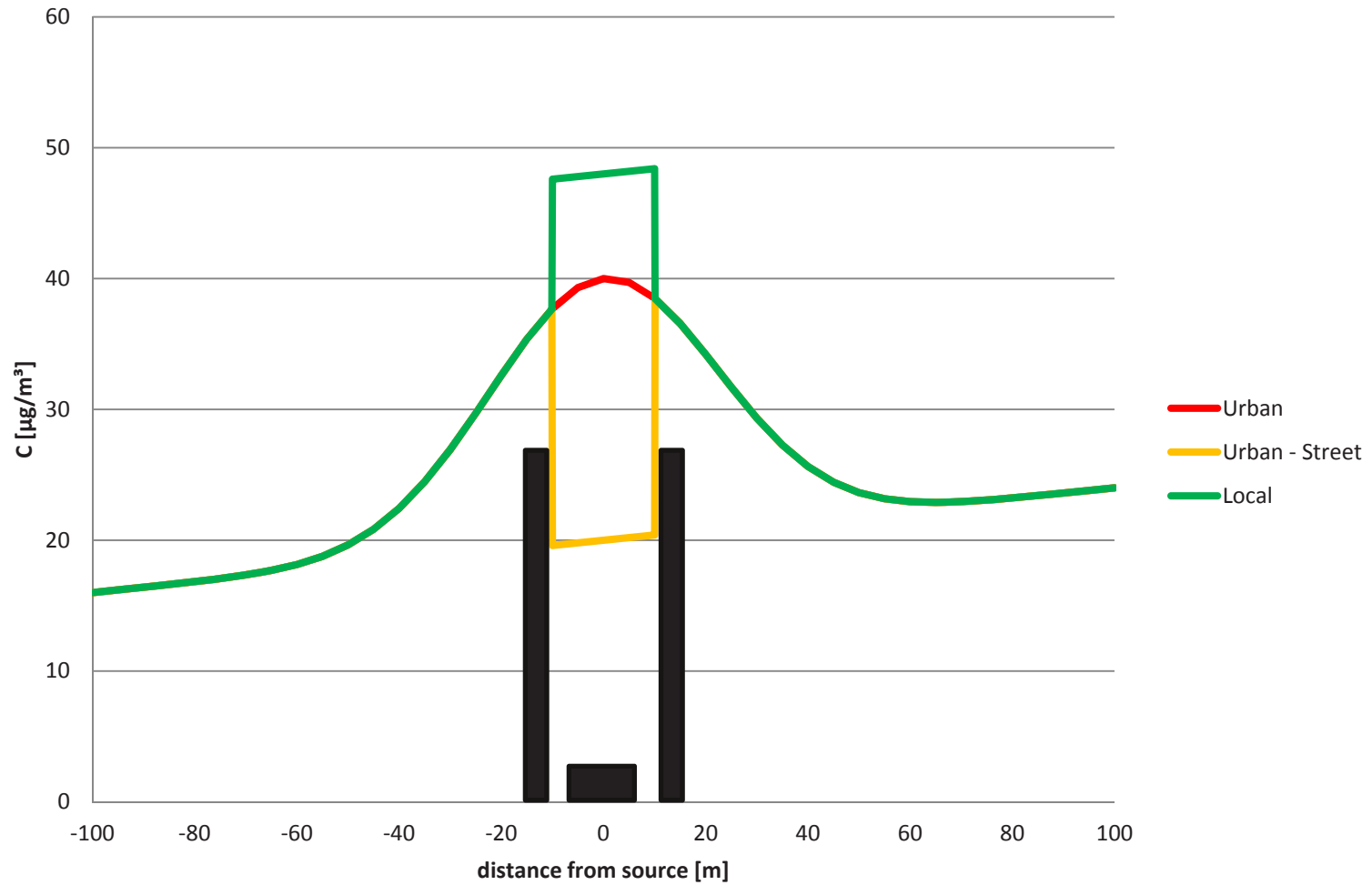
# Avoid double counting: real world example



# Validation with independent measurements

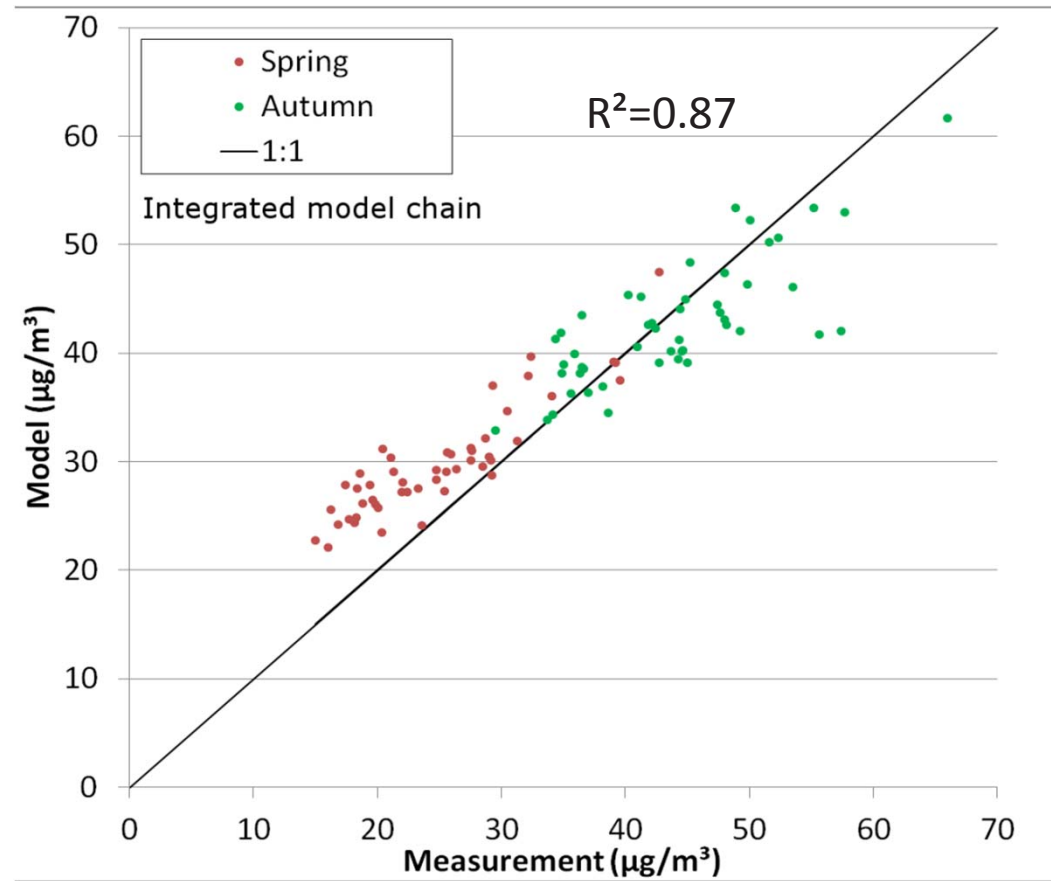
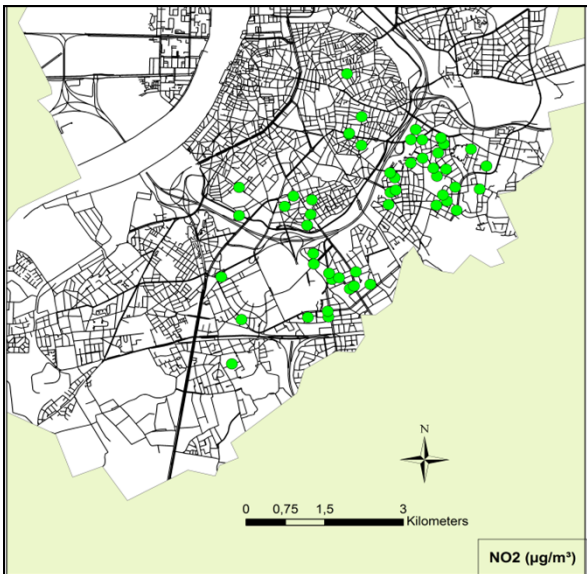
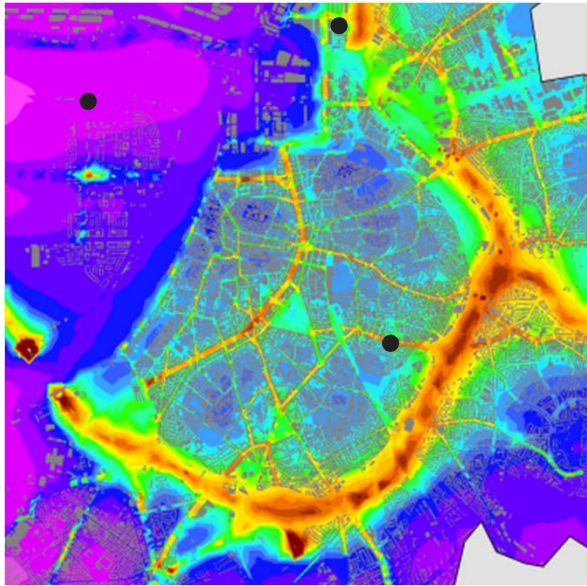


# Avoid double counting: theoretical example



# VALIDATION CAMPAIGNS

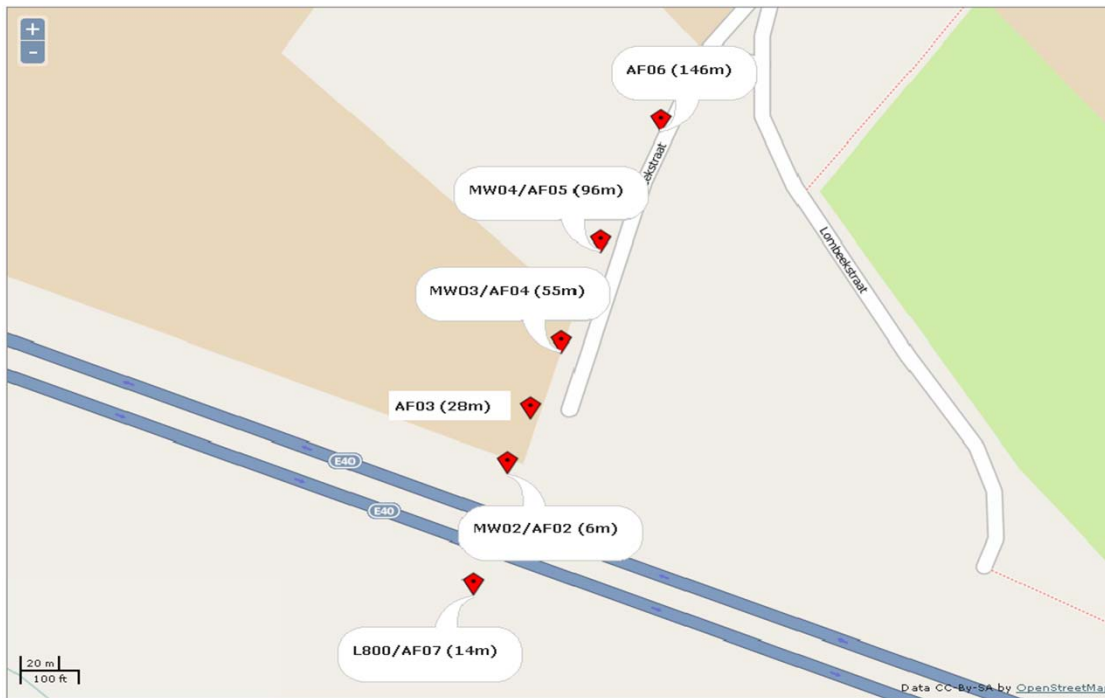
## Urban scale validation campaign



Lefebvre, W. et al. (2013), *Atm. Env.*, 77, p. 325-337

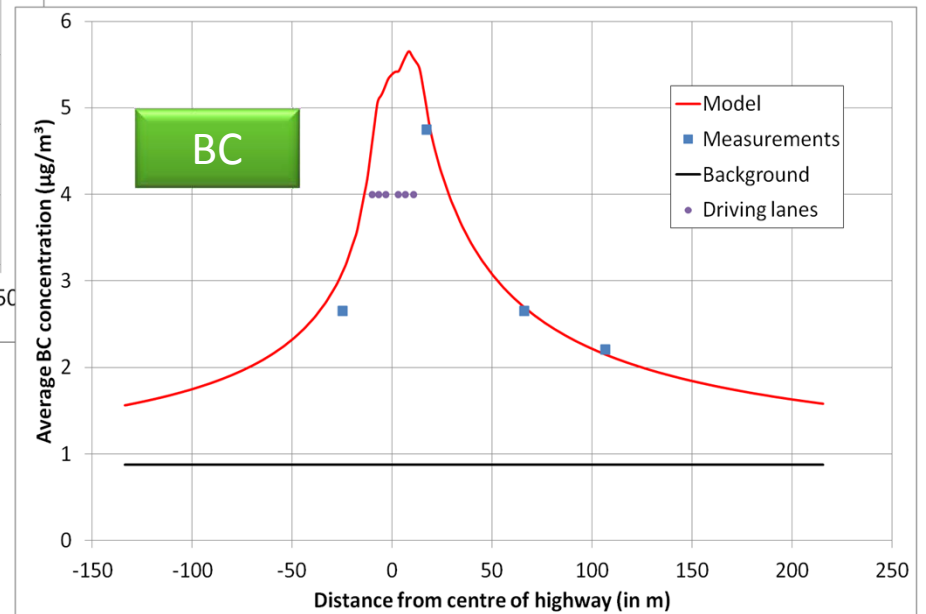
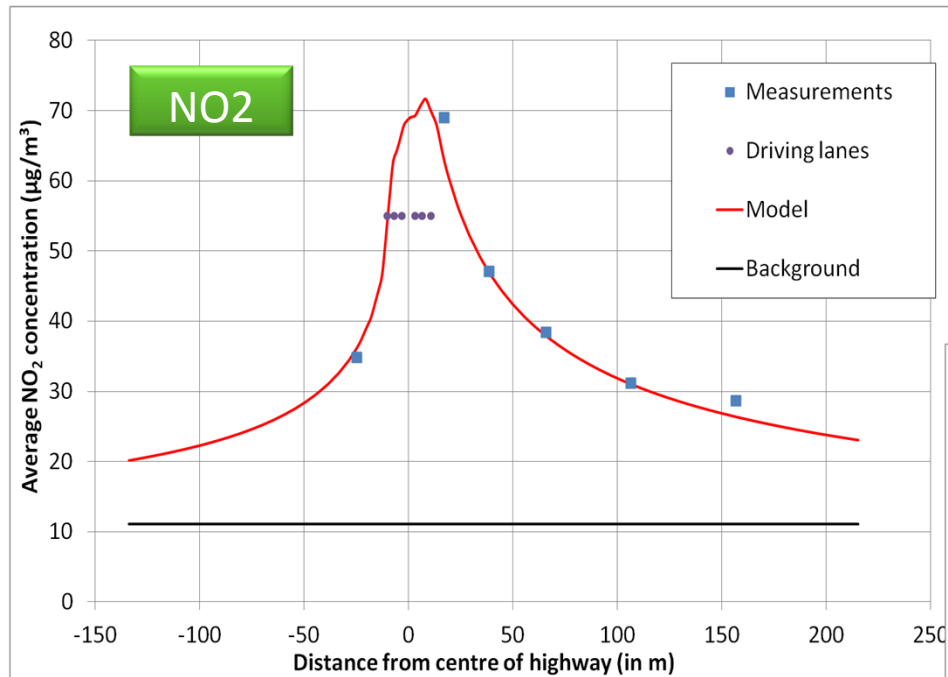
# VALIDATION CAMPAIGNS

## Highway measurement campaign



# VALIDATION CAMPAIGNS

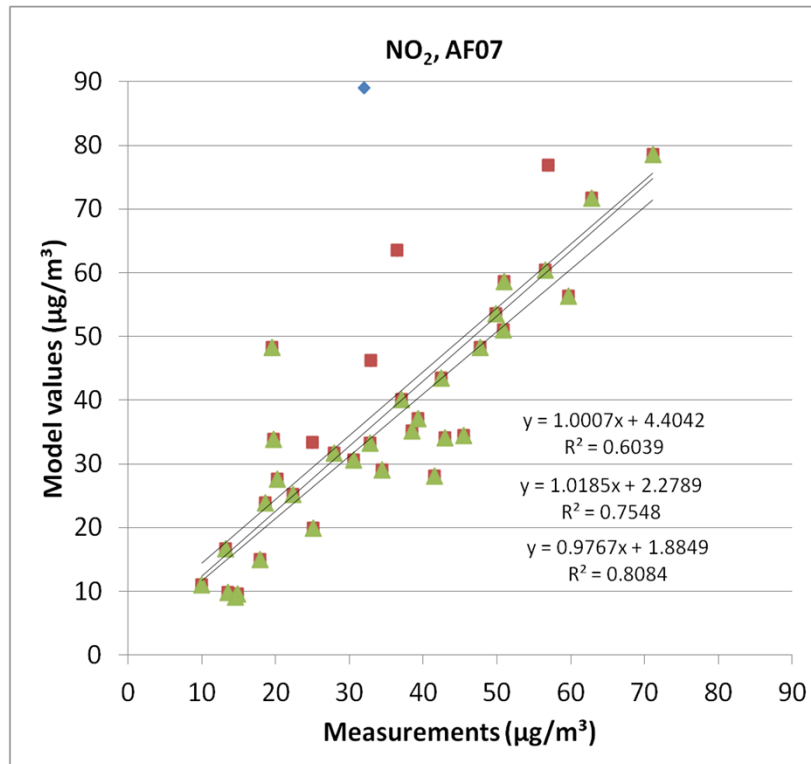
Highway campaign, spatial validation



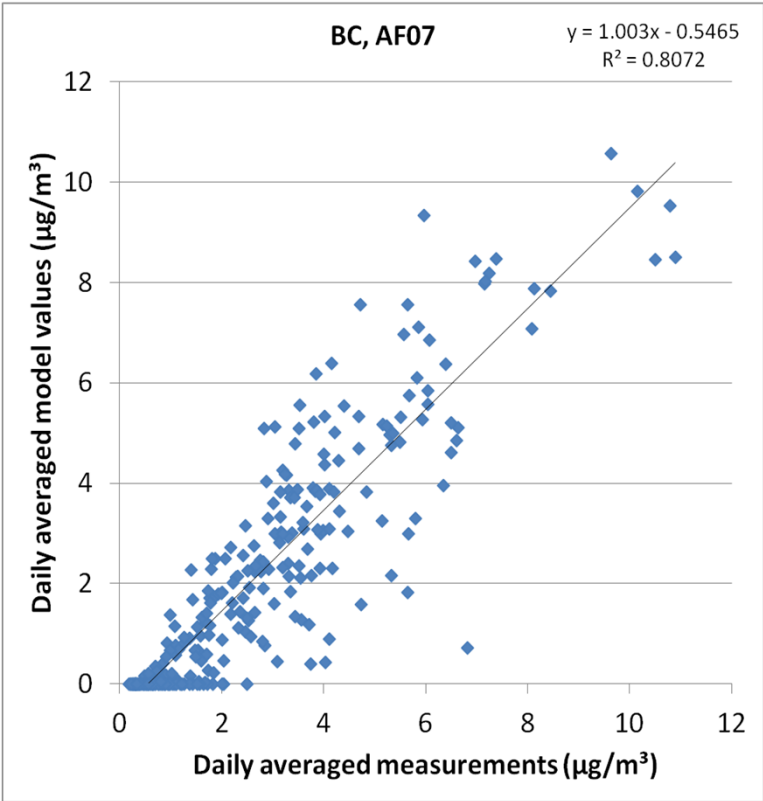


# VALIDATION CAMPAIGNS

Highway campaign, temporal validation



NO<sub>2</sub>, weekly



BC, daily