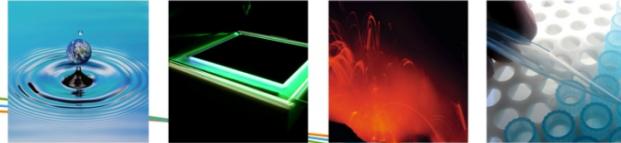




vision on technology



29/03/2012

## Effect of a LEZ on air pollution

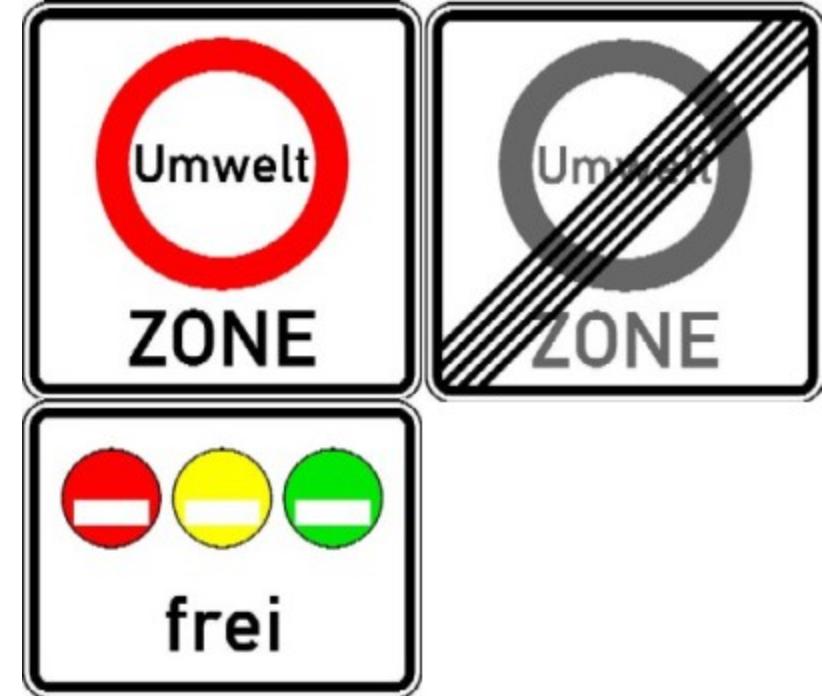
Isaak Yperman (TML) and Wouter Lefebvre (VITO)

# Outline

- » LEZ? Definitions, ...
- » Simple calculation scheme for the effect of an LEZ
- » Several cases in Flanders
- » Congestion charge versus LEZ
- » Detailed case for Antwerp: combining an LEZ and a congestion charge with other measures

# LEZ: definition (wikipedia)

A Low-Emission Zone (LEZ) is a geographically defined area which seeks to restrict or deter access by specific polluting vehicles or only allow low emitting vehicles, such as regular or plug-in hybrids, or zero-emission vehicles, such as all-electric vehicles, with the aim of improving the air quality.



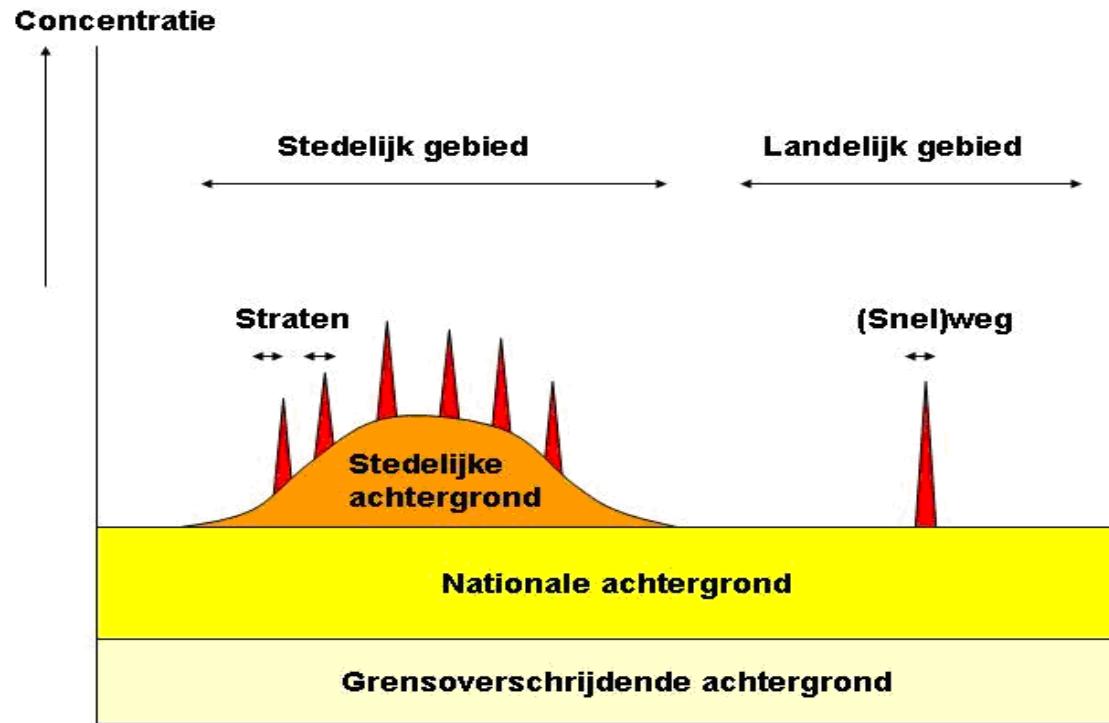
Congestion pricing or congestion charges is a system of surcharging users of a transport network in periods of peak demand to reduce traffic congestion. Examples include some toll-like road pricing fees, and higher peak charges for utilities, public transport and slots in canals and airports. This variable pricing strategy regulates demand, making it possible to manage congestion without increasing supply.

# Therefore...

- » LEZ has an effect on the park: which types of vehicles will drive?
- » CC has mainly an effect on the amount of kilometers driven

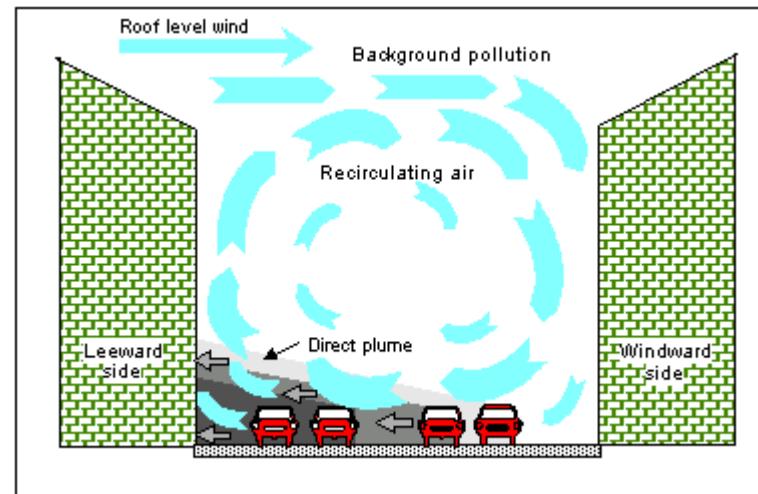
# Simple calculation scheme for the effect of an LEZ

- » Source apportionment of concentrations within a street. Not all concentrations are due to the street!

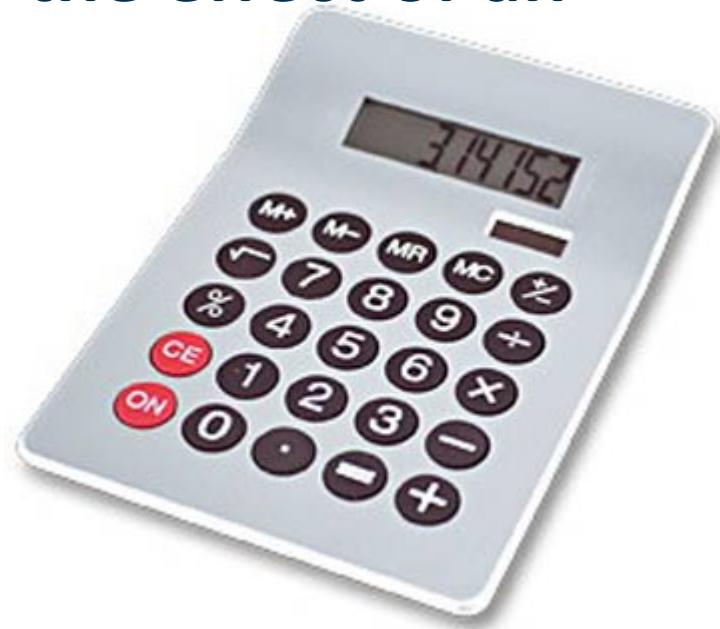


# Simple calculation scheme for the effect of an LEZ

- » Street canyons:
  - » Street canyons have higher concentrations due to the trapping of emissions. => Emission reductions will have an enhanced effect in street canyons!



# Simple calculation scheme for the effect of an LEZ



- »  $\Delta C = C_{bsc} R_c \Delta E + C_{sc} \Delta E$
- » with
  - »  $\Delta C$  = concentration change due to LEZ
  - »  $C_{bsc}$  = concentration without taking into account the street canyon
  - »  $R_c$  = percentage of the concentrations attributable to traffic from within the LEZ
  - »  $\Delta E$  = emission change in the LEZ (in %).
  - »  $C_{sc}$  = concentration change within the street canyon

# Simple calculation scheme for the effect of an LEZ

- » We can try to determine all parameters, but  $R_c$  is difficult. However, we can write it as:
  - »  $R_c = R_{c,VI} L$
  - » With:
    - »  $R_{c,VI}$  the percentage of the concentrations that is linked to the traffic in Flanders
    - »  $L$  a number between 0 and 1, denoting that only the emissions within the LEZ decrease and not all the Flemish emissions.

# Simple calculation scheme for the effect of an LEZ

- » How do we estimate L?
  - » Suppose an LEZ in Antwerp between the river Schelde and the Ring
    - » NO<sub>x</sub> emissions in Antwerp: ~2500 ton/jaar
    - » NO<sub>x</sub> emissions in the LEZ: ~250 ton/jaar
    - » NO<sub>x</sub> emissions on Antwerp highways: ~1300 ton/jaar
  - » 250/2500 => L≈0.1, but ... emissions on roads within the LEZ have a higher impact than emission further away. => Estimation L=0.25
- »  $\Delta C = C_{bsc} R_{c,VL} \Delta E L + C_{sc} \Delta E$ 
  - » NO<sub>2</sub>:  $C_{bsc} = 33 \mu\text{g}/\text{m}^3$ ;  $R_{c,VL} = 45\%$ ;  $\Delta E = 25\%$ ;  $L = 0.25$ ;  $C_{sc} = 7 \mu\text{g}/\text{m}^3$  =>  $\Delta C = 2.68 \mu\text{g}/\text{m}^3$ .
  - » Large and strong LEZ!

# Simple calculation scheme for the effect of an LEZ

- »  $\Delta C = C_{bsc} R_{c,VL} \Delta E L + C_{sc} \Delta E$ 
  - » PM<sub>10</sub>:  $C_{bsc} = 28 \mu\text{g}/\text{m}^3$ ;  $R_{c,VL} = 10\%$ ;  $\Delta E = 10\%$ ;  $L = 0.15$ ;  $C_{sc} = 1 \mu\text{g}/\text{m}^3 \Rightarrow \Delta C = 0.14 \mu\text{g}/\text{m}^3$ .
  - » Small, weak LEZ!
- » How to improve the effectiveness of an LEZ?
  - »  $C_{sc}$  and  $C_{bsc}$  large: in areas with high concentrations
  - »  $R_{c,VL}$ : This we cannot influence easily
  - »  $\Delta E$  : make the LEZ stronger
  - »  $L$  : make the LEZ larger, with a lot of traffic emissions within the LEZ

# LEZ in Flanders

- » 1. Definition of LEZ
- » 2. Geographical area of LEZ
- » 3. Vehicle fleet composition
- » 4. Exemptions & violations
- » 5. Emission factors
- » 6. Effect on traffic volumes
- » 7. Effect on emissions
- » 8. Effect on concentrations
- » 9. Complementary measures
- » 10. Congestion charging vs. LEZ

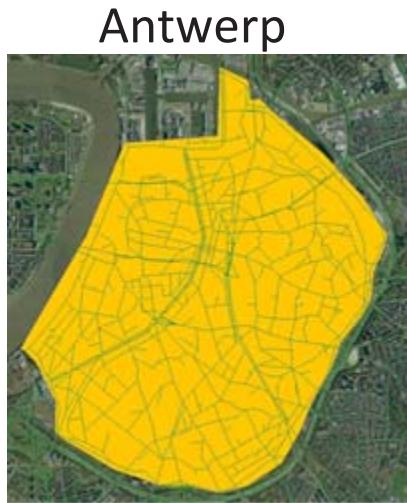
# 1. Definition of LEZ

- » A Low-Emission Zone (LEZ) is a geographically defined area where certain emission standards are required for vehicles to access the zone, with the aim of improving the air quality.
- » Required emission standards:

2015	HDV (trucks)	Euro 4
	PC - gasoline	Euro 1
	PC - diesel	Euro 4
2020	HDV (trucks)	Euro 5
	PC - gasoline	Euro 2
	PC - diesel	Euro 5

## 2. Geographical area of LEZ

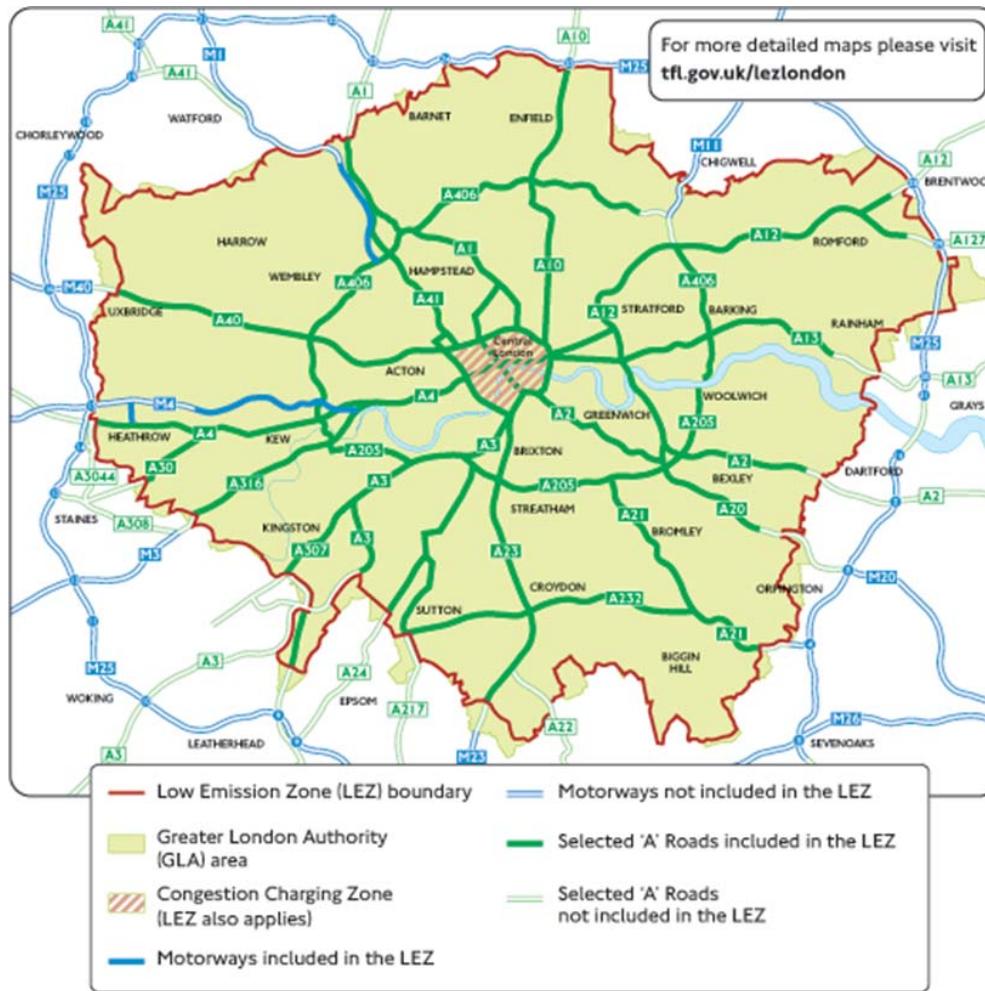
- » LEZ corresponds to inner city zone, bounded by ringroad around city



- » Ideally:
    - small amount of through traffic in LEZ
    - appropriate route for through traffic around LEZ
- minimal re-routing effects

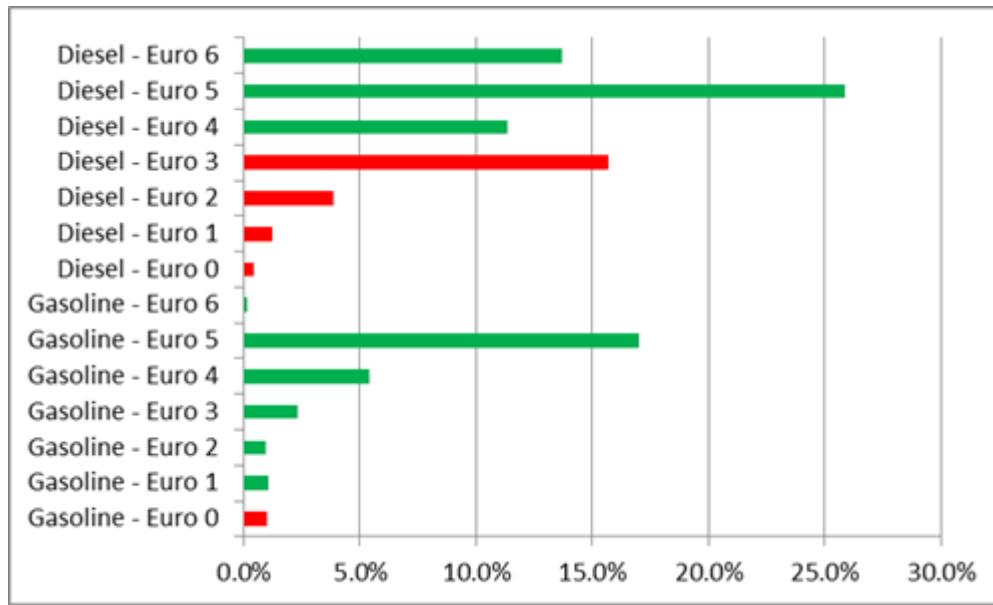
## 2. Geographical area of LEZ

» London:



### 3. Vehicle fleet composition

- » Reference scenario 2015 – Belgian fleet (% vkm in 2015) (TREMOVE v3.4)



- » 2015: 22% of vkm driven by vehicles that are no longer allowed in LEZ
- » LEZ scenario's: non-complying vehicles are replaced by vehicles that are distributed in emission classes the way complying vehicles are distributed

## 4. Exemptions and violations

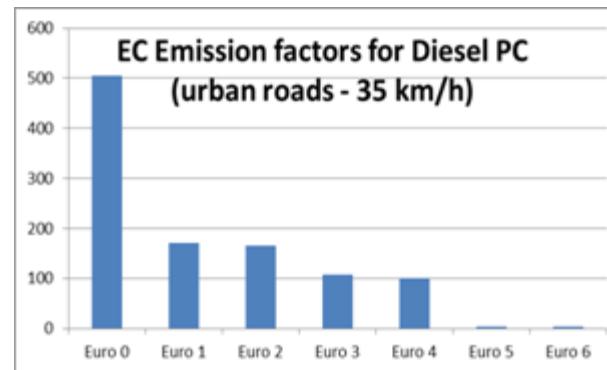
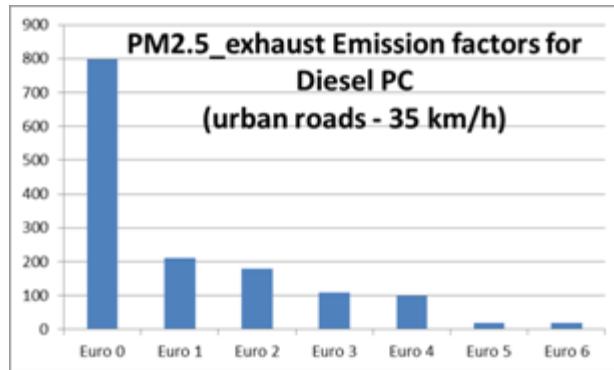
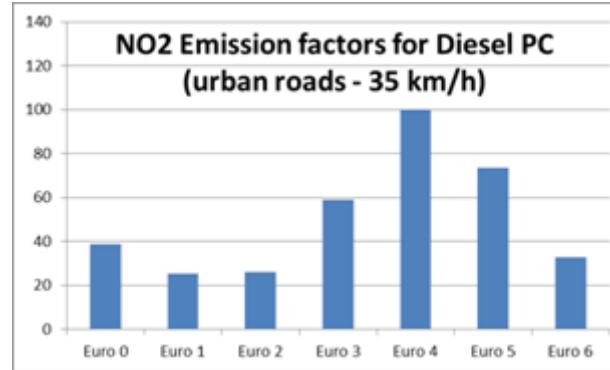
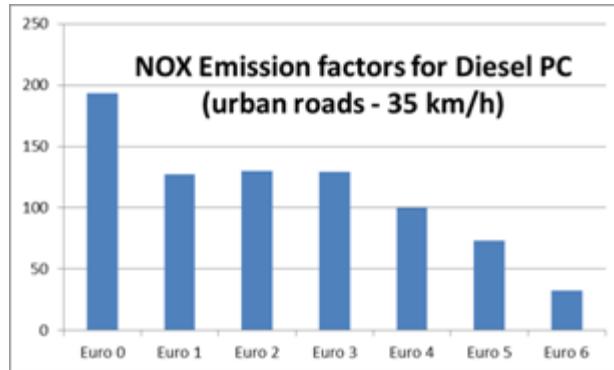
- » Required emission standards:

2015	HDV (trucks)	Euro 4
	PC - gasoline	Euro 1
	PC - diesel	Euro 4
2020	HDV (trucks)	Euro 5
	PC - gasoline	Euro 2
	PC - diesel	Euro 5

- » Assumption: 22% of non-complying PC and 25% of non-complying trucks keep on driving in LEZ (due to exemptions and violations)
- » Exemptions for:
  - » Police / emergency vehicles
  - » Military vehicles
  - » Historic vehicles
  - » Special / agricultural vehicles
  - » Disabled drivers' vehicles
- » Hardship exemptions for marginal businesses and low-income households
- » Violations ~ effective enforcement

# 5. Emission factors

- » Emission factors based on COPERT IV emission functions



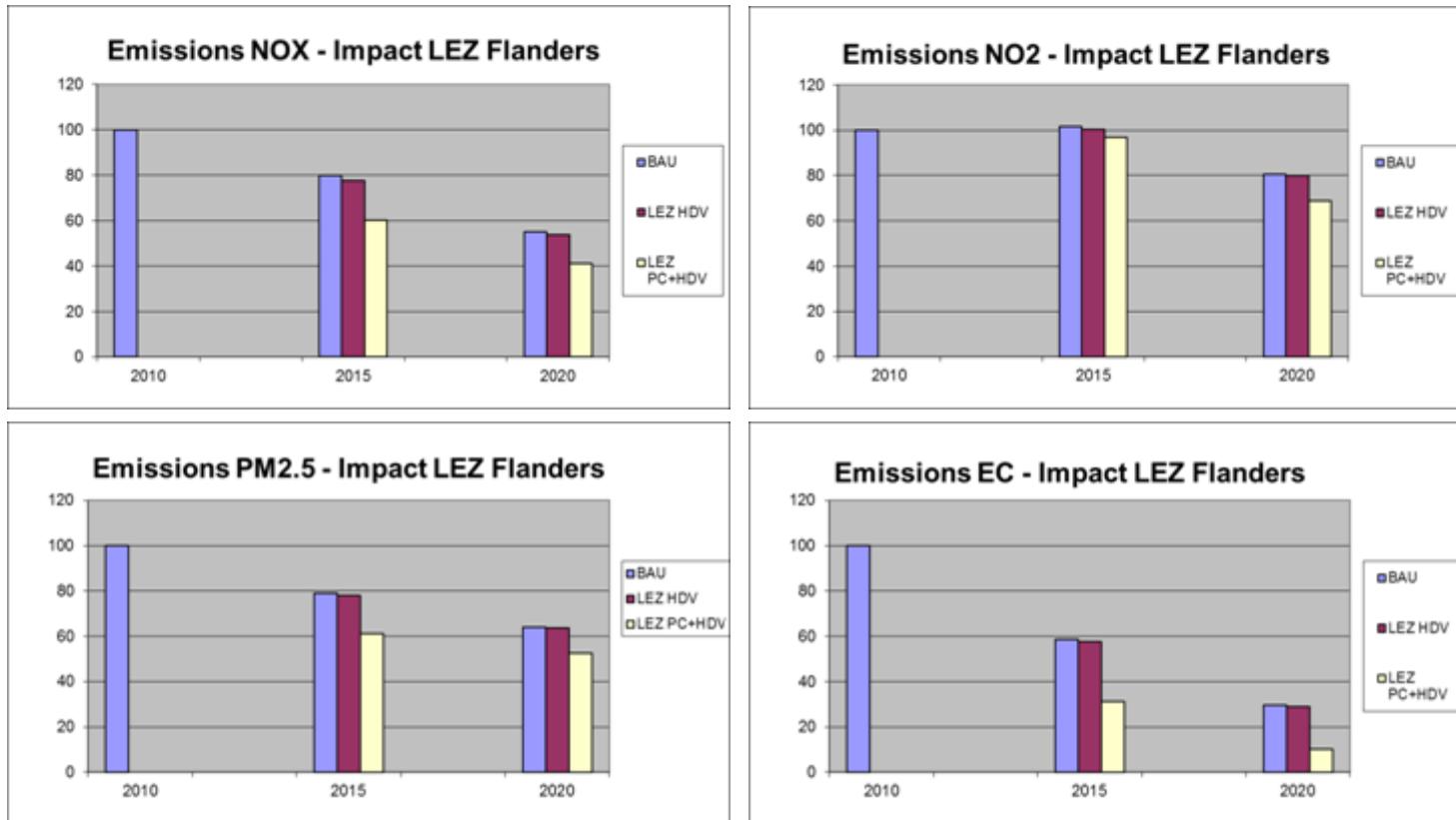
# 6. Effect LEZ on traffic volumes

- » Assumptions:

- » No effect on destination choice
- » No effect on modal choice
- » No effect on total number of trips
- » Small effect on route choice: non-complying vehicles without origin or destination in LEZ will no longer drive through LEZ
  - traffic volumes in LEZ decrease by ± 2%.

# 7. Effect LEZ on emissions

- » Emissions = f (traffic volumes, speeds, vehicle fleet, emission factors)



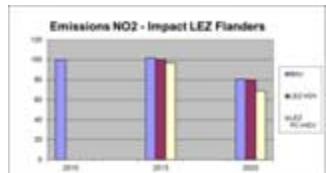
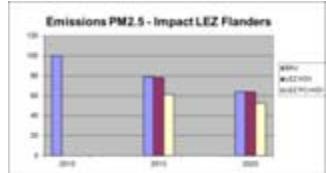
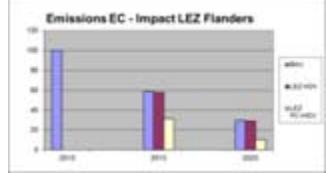
## 8. Effect LEZ on concentrations

» Concentration = background concentration + traffic contribution

'Pluim snelweg' (major roads)

→ 'CAR' (emissions/roadtype/treefactor)

Selected points:

	Δ emissions	traffic contribution / total conc.	Δ concentrations
NO2		30 - 40%	2 - 5%
PM2.5 & PM10		10 - 20%	2 - 4%
EC		40 - 50%	20 - 25%

## 9. Complementary measures

To increase social acceptability:

- » Exemptions
- » Gradual introduction of LEZ
- » Stimulating purchase clean vehicles (tax reduction)
- » Stimulating more efficient urban distribution
- » Stimulating alternative transport modes

# 10. Congestion charging vs. LEZ

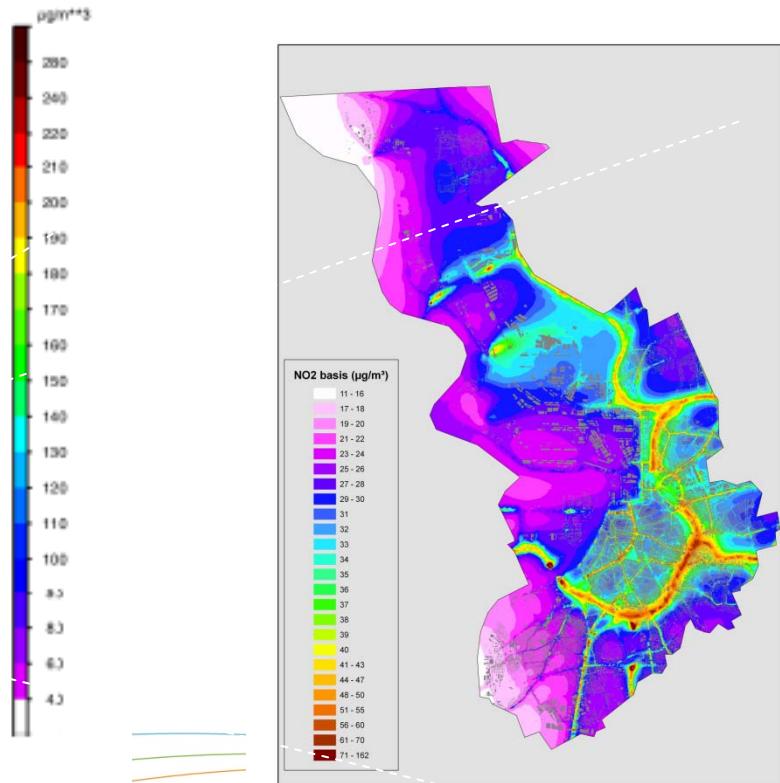
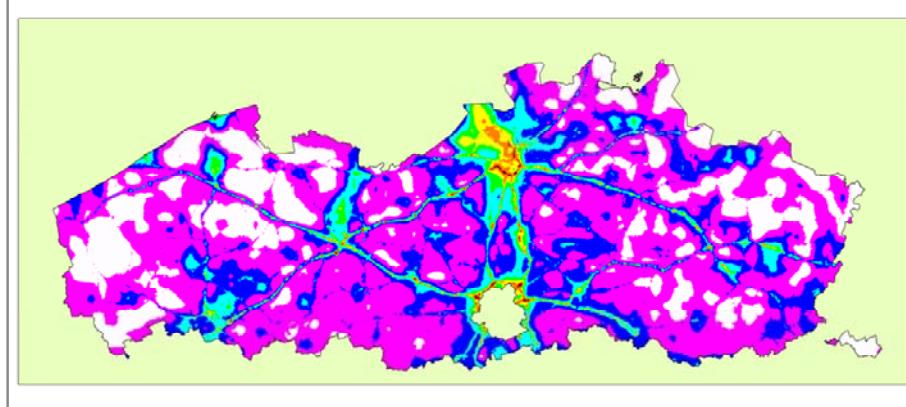
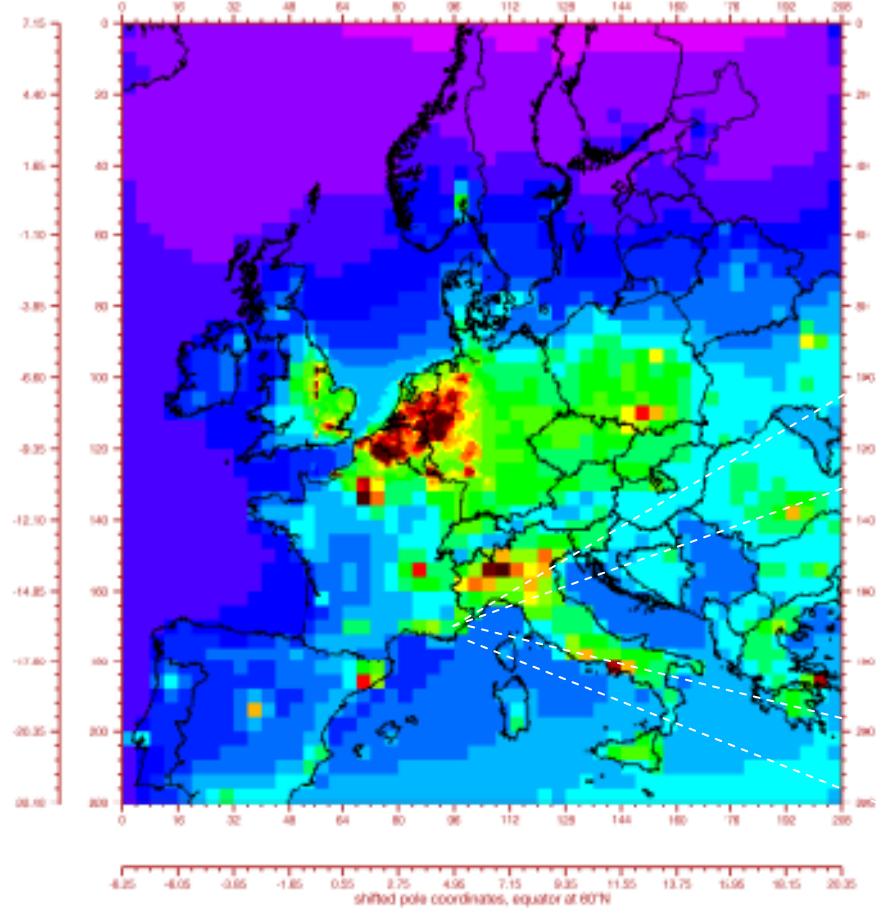
- » LEZ

- » Main effect:  $\Delta$  vehicle fleet composition
- » Small effect on vehicle kilometers driven

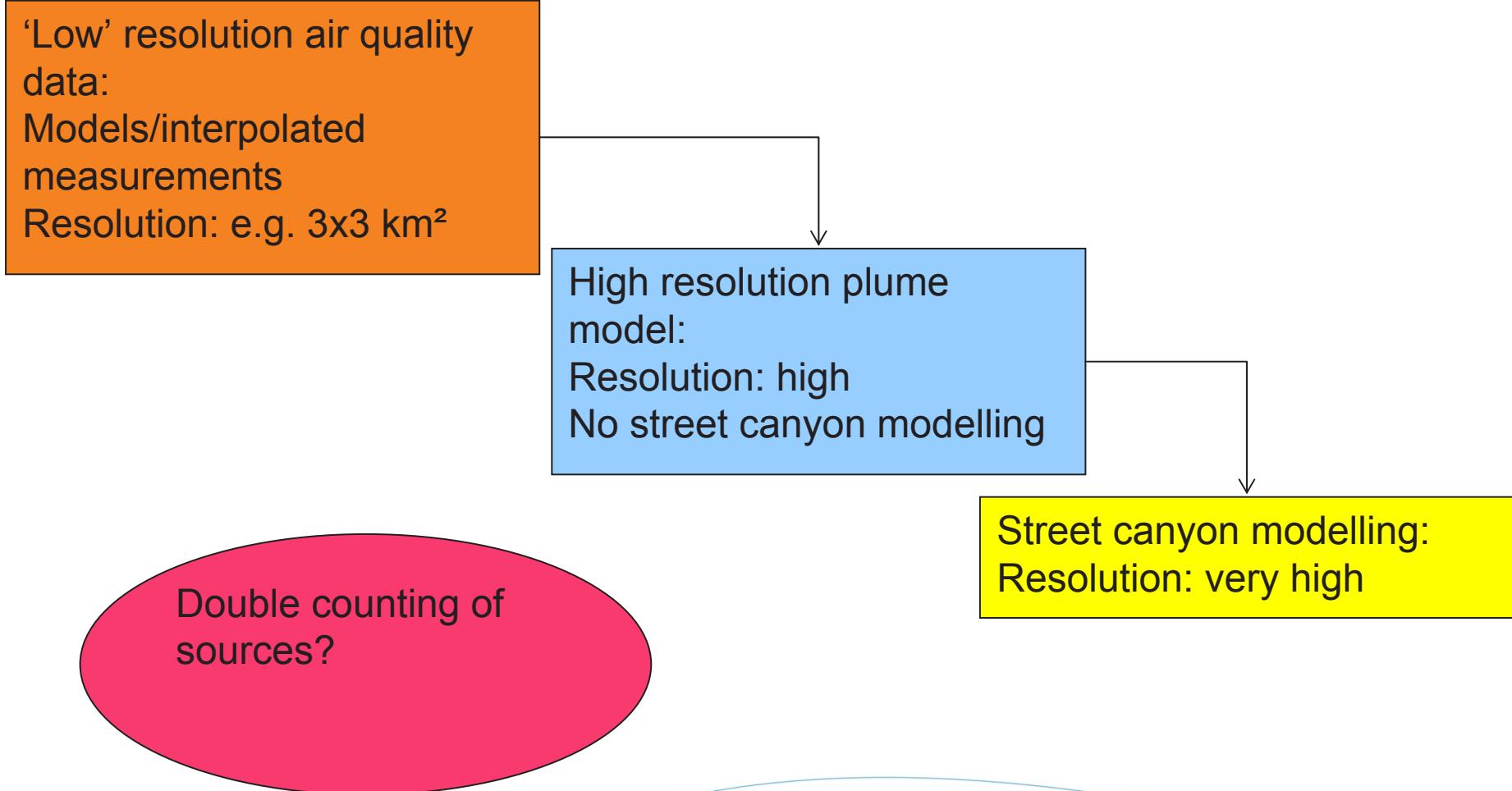
- » Congestion charging

- » Main effect:  $\Delta$  vehicle kilometers driven
- » If there is no effect on vehicle fleet composition
  - $\pm$  -20% vkm needed for same effects on local air quality (NOX, PM)
  - also impact on CO2, liveability, ...

# In Antwerp ...

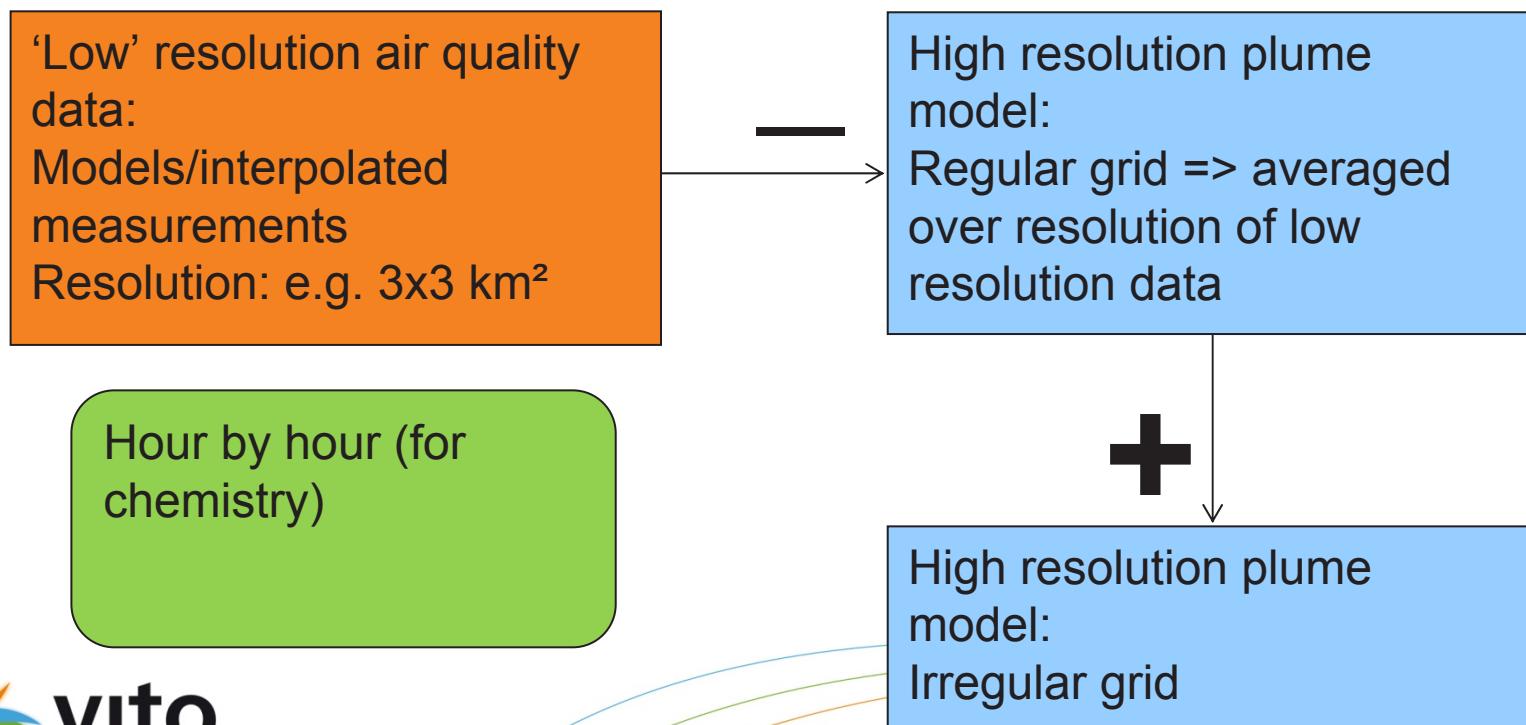


# Combination of models at different scales

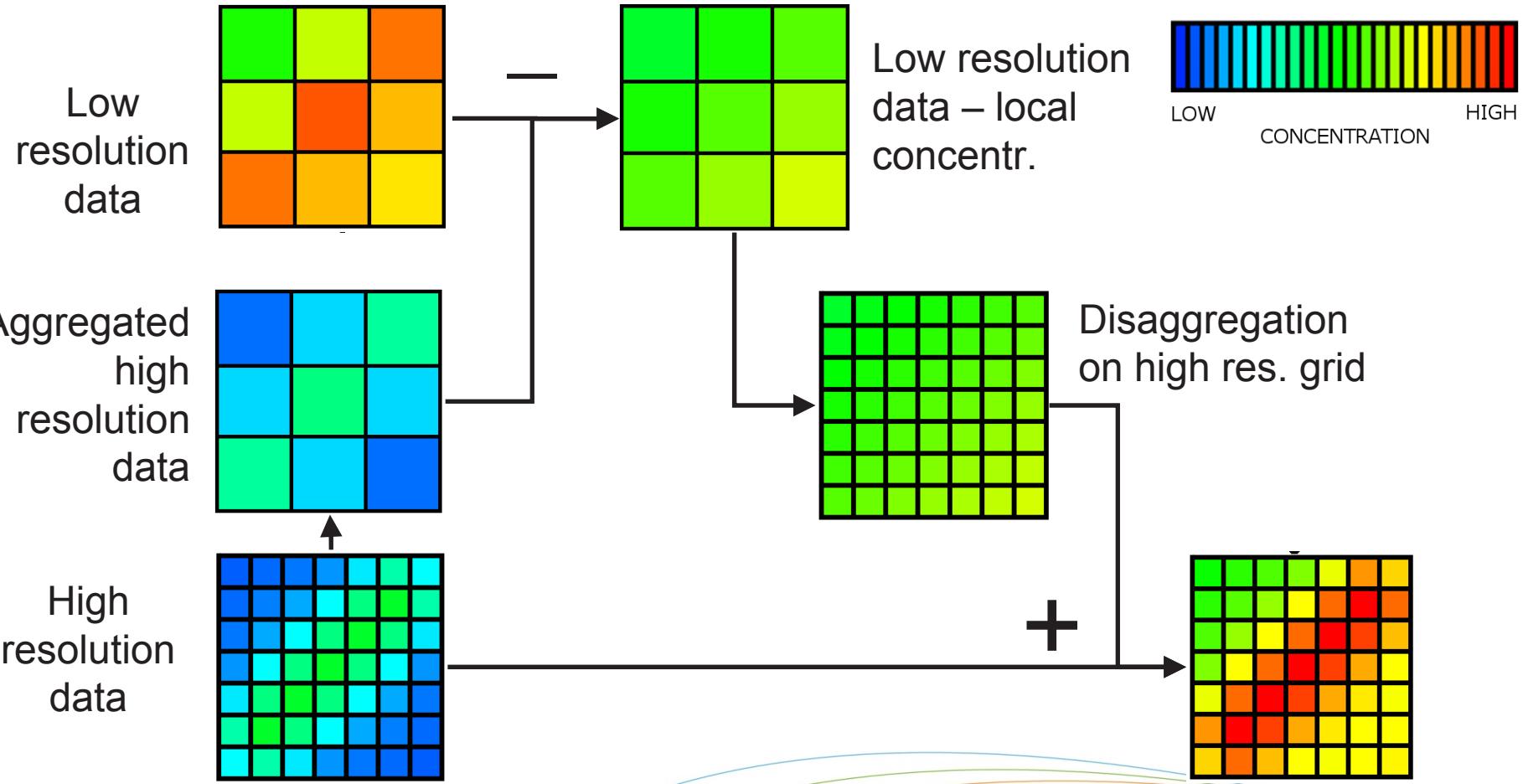


# Avoid double counting

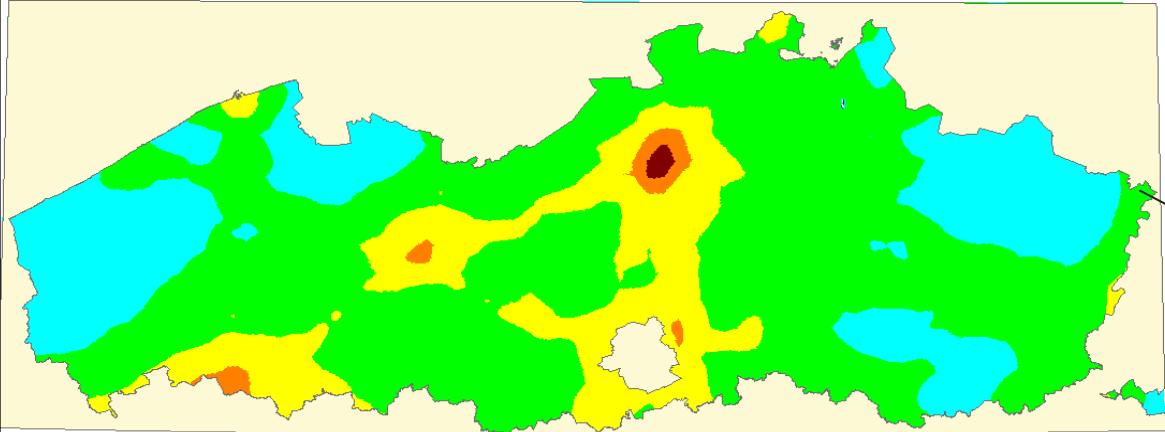
- » In low resolution data: all sources are taken into account



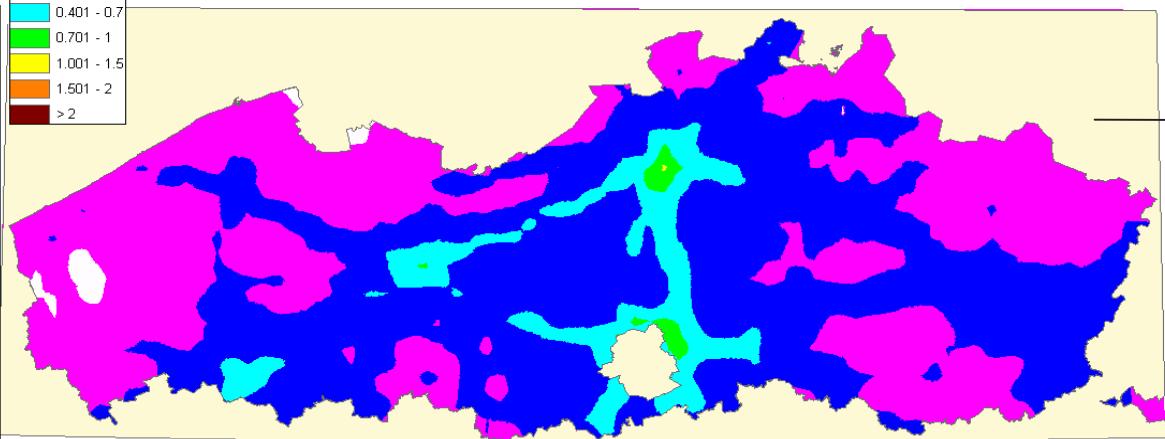
# Avoid double counting: theoretical example



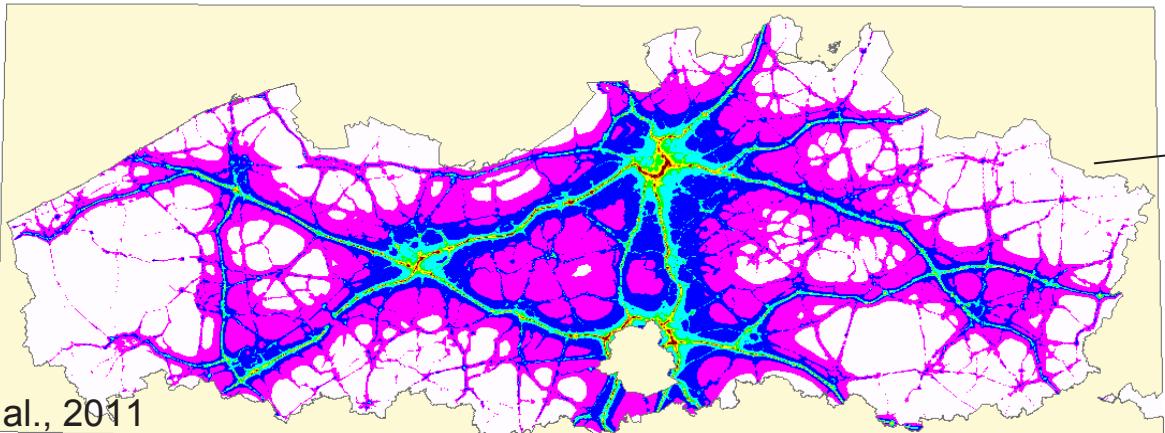
Avoid double counting:  
practical example



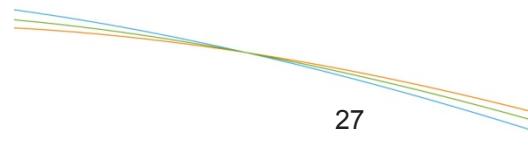
Low resolution data  
(AURORA)



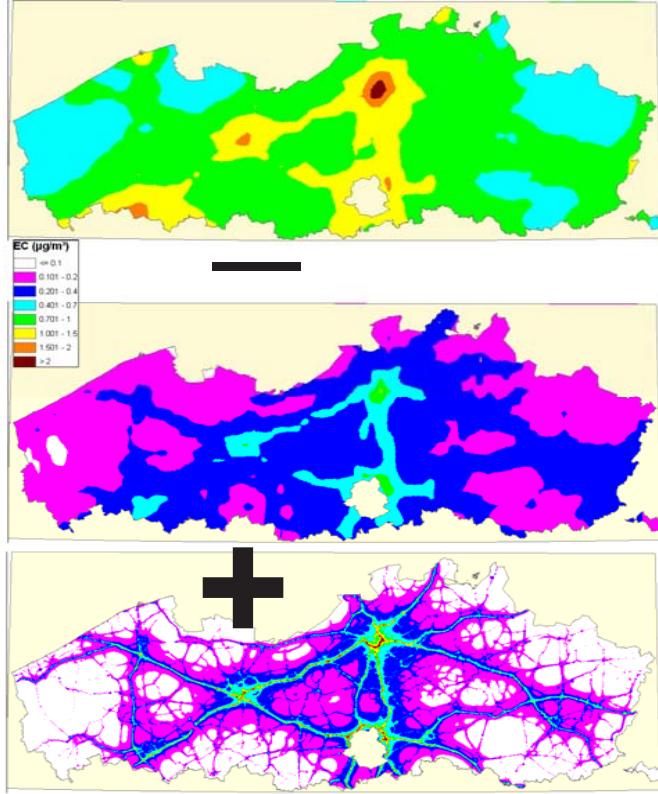
High resolution  
data averaged  
over low  
resolution grid



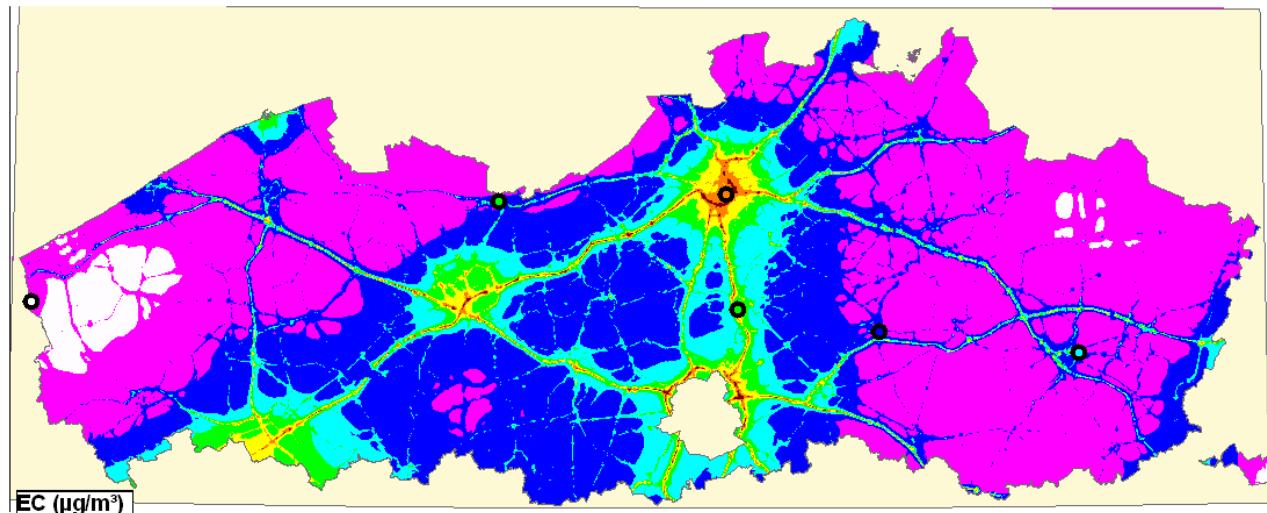
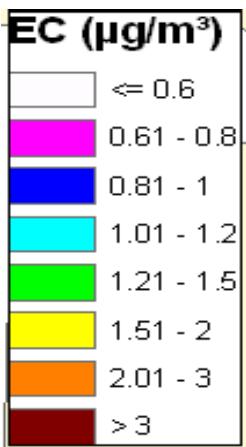
High resolution  
data



## Avoid double counting: practical example

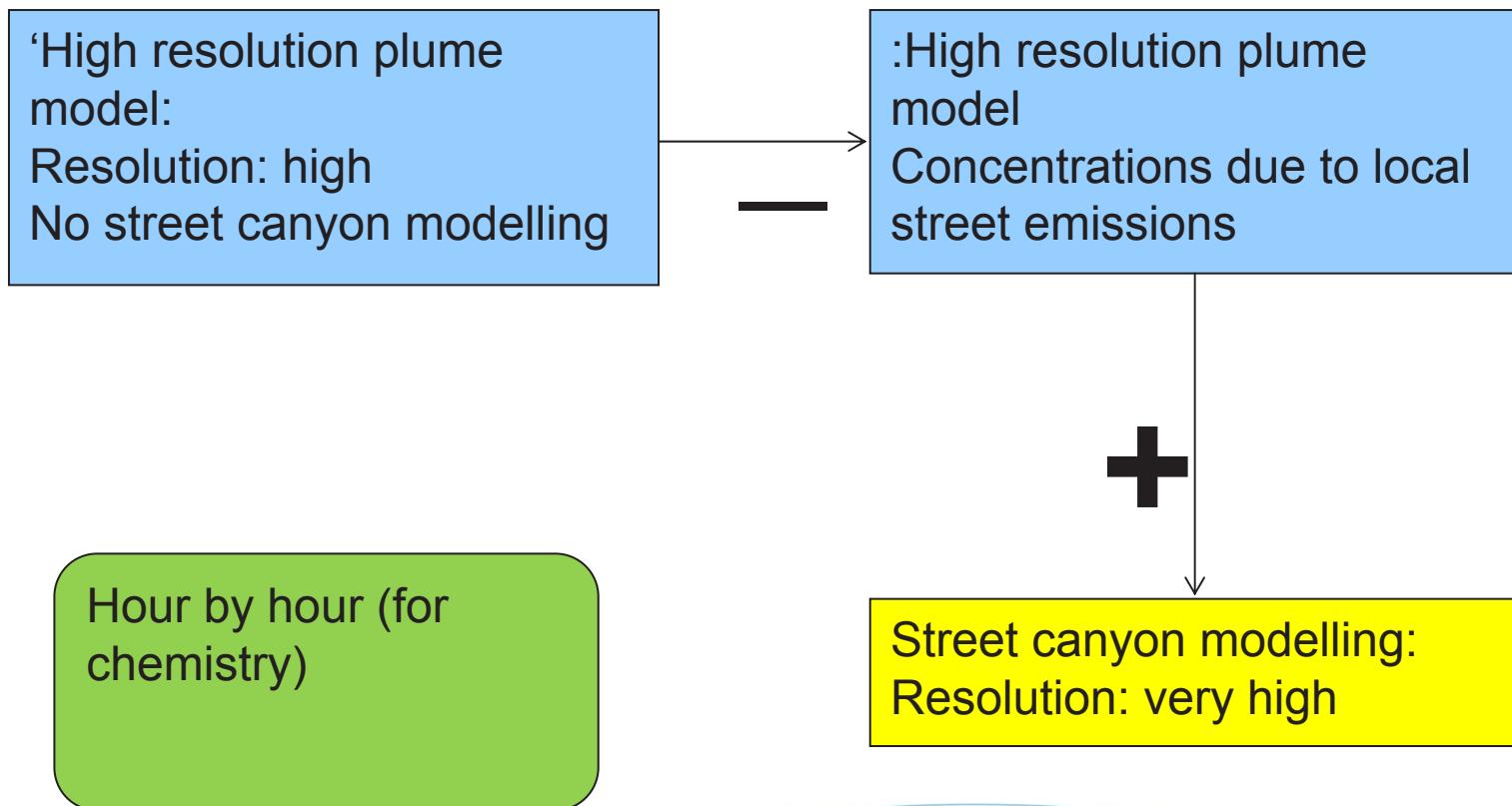


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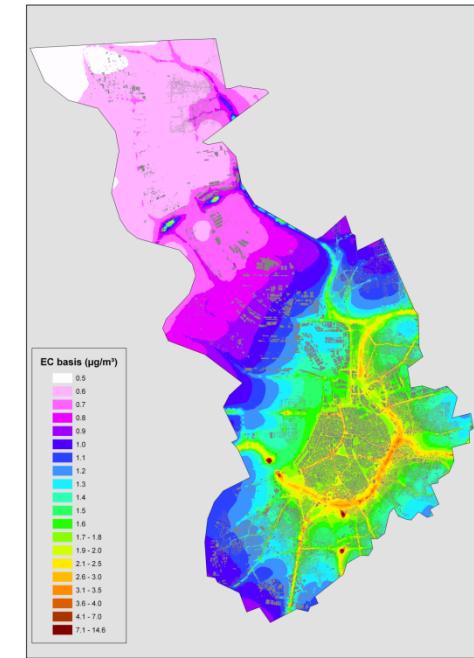
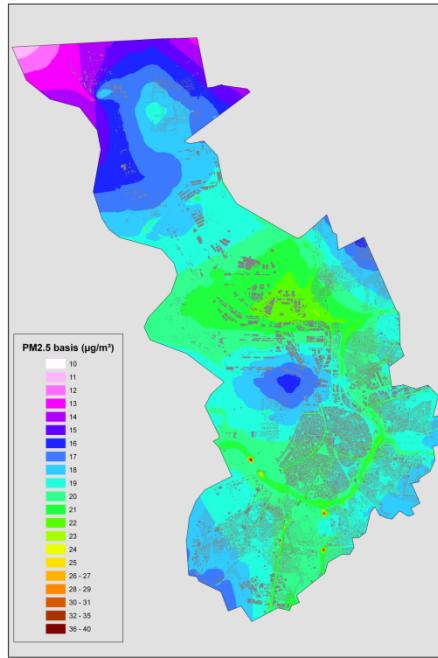
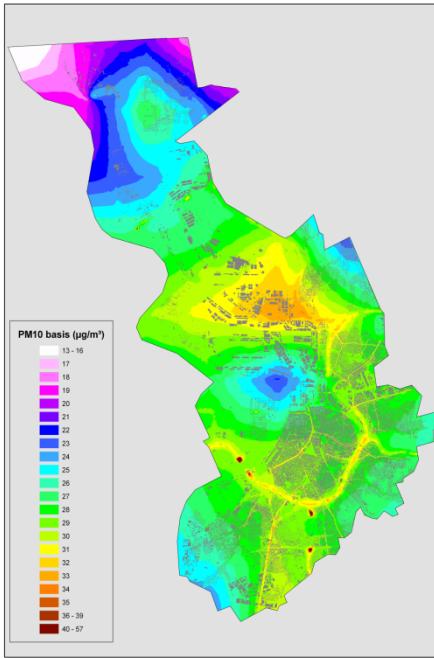
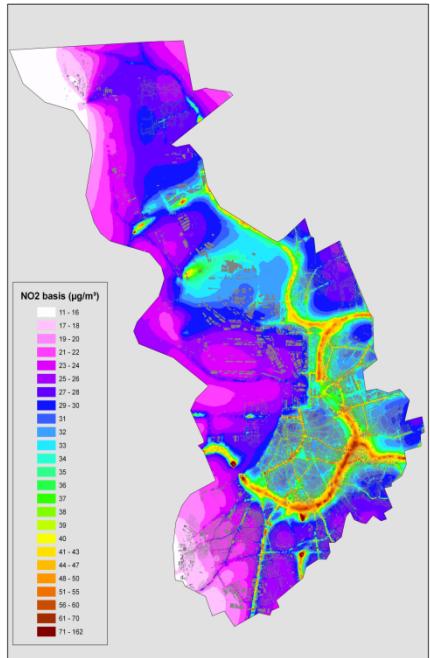


# Analogous methodology for street canyon modelling

- » In low resolution data: all sources are taken into account



# Air quality concentration maps



NO<sub>2</sub>

PM<sub>10</sub>

PM<sub>2.5</sub>

EC

# **3 different scenarios → 3 packages of measures with effects on both air quality and noise**

## **Measure package 1: Measures at city level**

- Deepening local mobility plan
- Changing traffic circulation
- Speed area: 30 km/h in the inner-city
- Defining traffic areas: car free, low traffic...
- Reducing number of heavy duty vehicles in the city
- Expanding and improving public transport: trams + P&R
- Greening the car fleet of the municipality
- Reducing tyre noise
- Ecofriendly and silent busses
- Acoustic barriers/screens
- Reducing road noise
- Lower speed limits
- ...

## **Measure package 2: Low Emission Zone and/or Congestion charge (cfr London, Stockholm)**

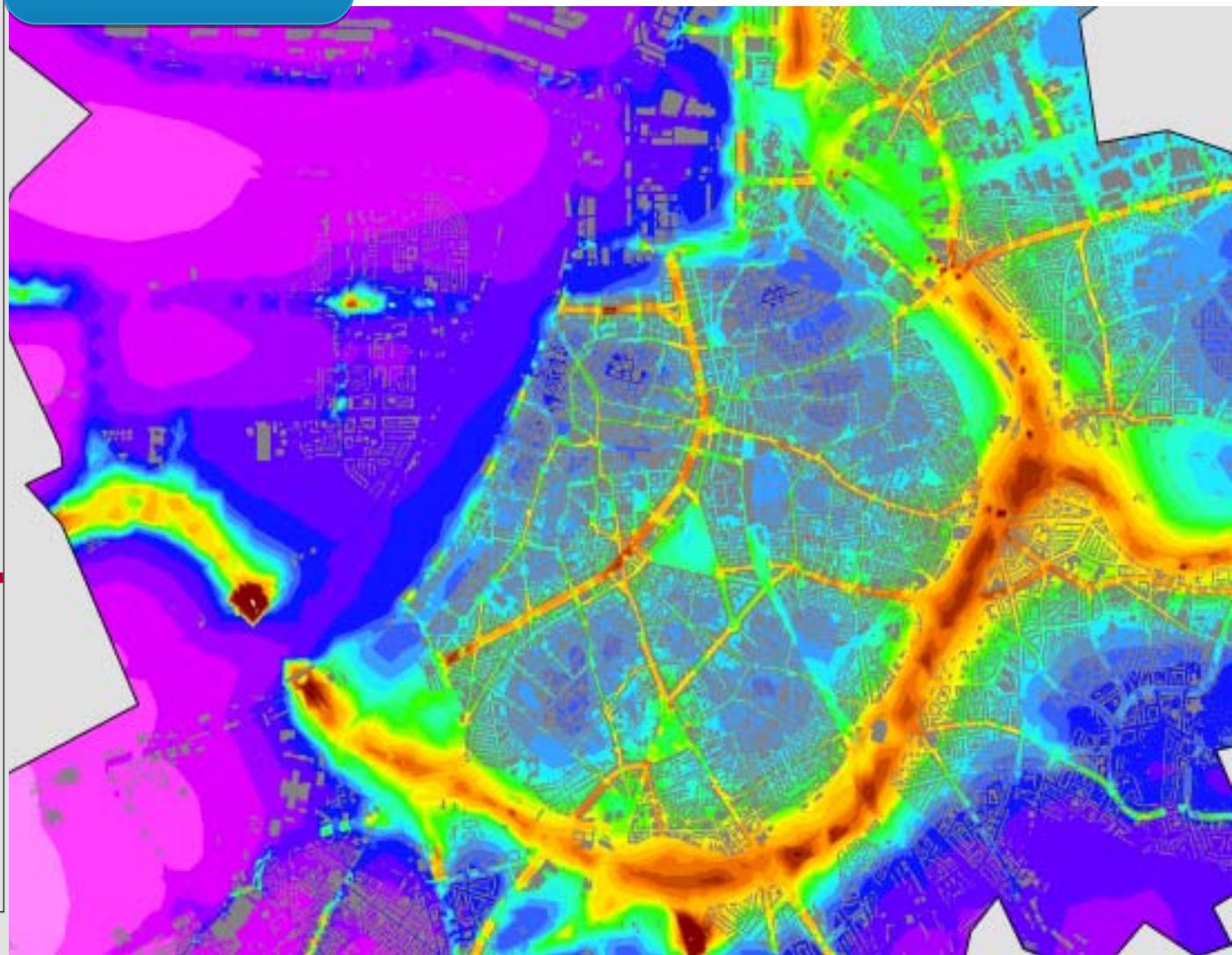
## **Measure package 3: measures in the industrial sector**

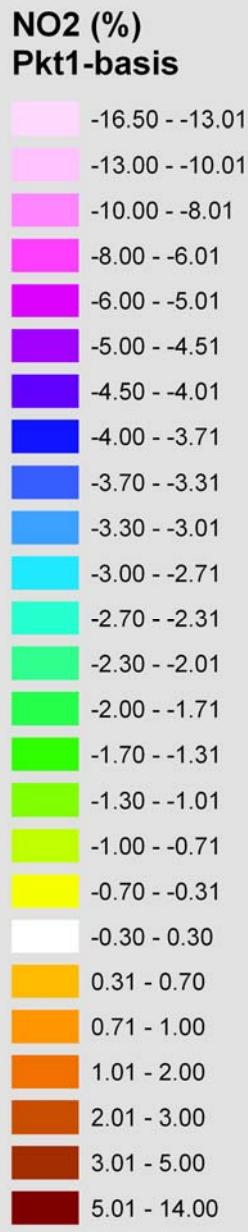
- Strict supervision on sources of particulate matter
- Demanding implementation of best available technologies

NO<sub>2</sub> basis ( $\mu\text{g}/\text{m}^3$ )

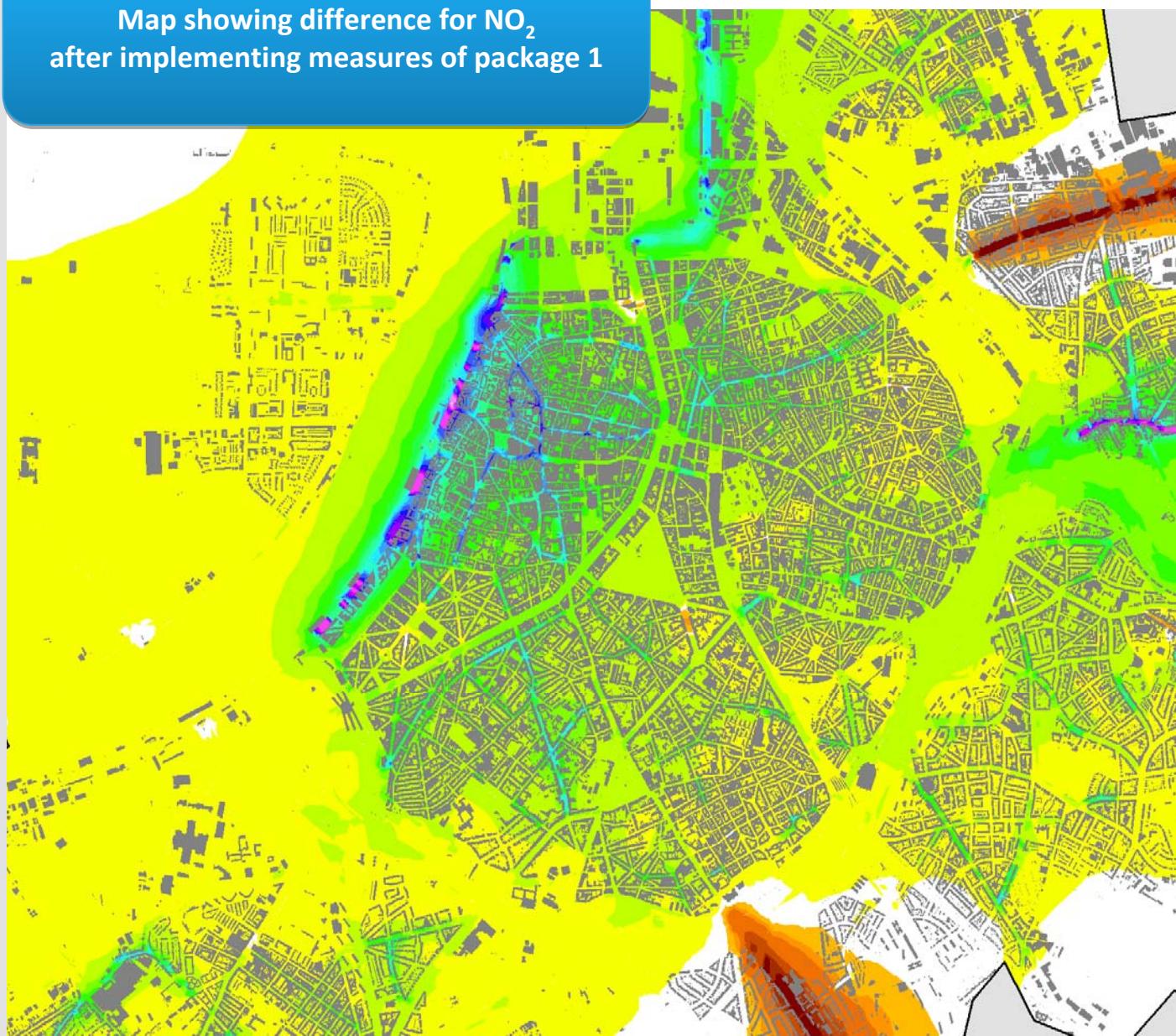
	11 - 16
	17 - 18
	19 - 20
	21 - 22
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	44 - 47
	48 - 50
	51 - 55
	56 - 60
	61 - 70
	71 - 162

Basic scenario  
Situation NO<sub>2</sub>  
2015



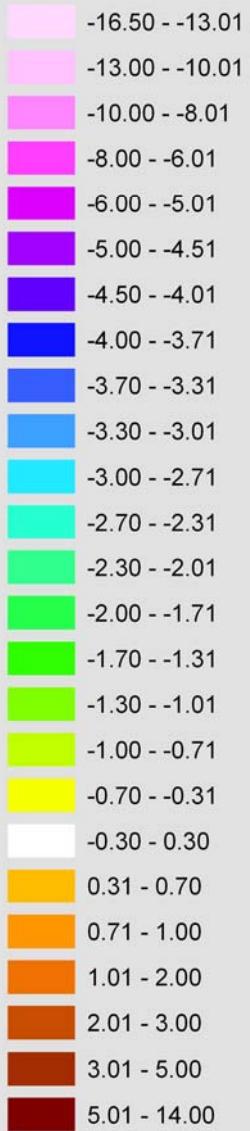


Map showing difference for NO<sub>2</sub>  
after implementing measures of package 1

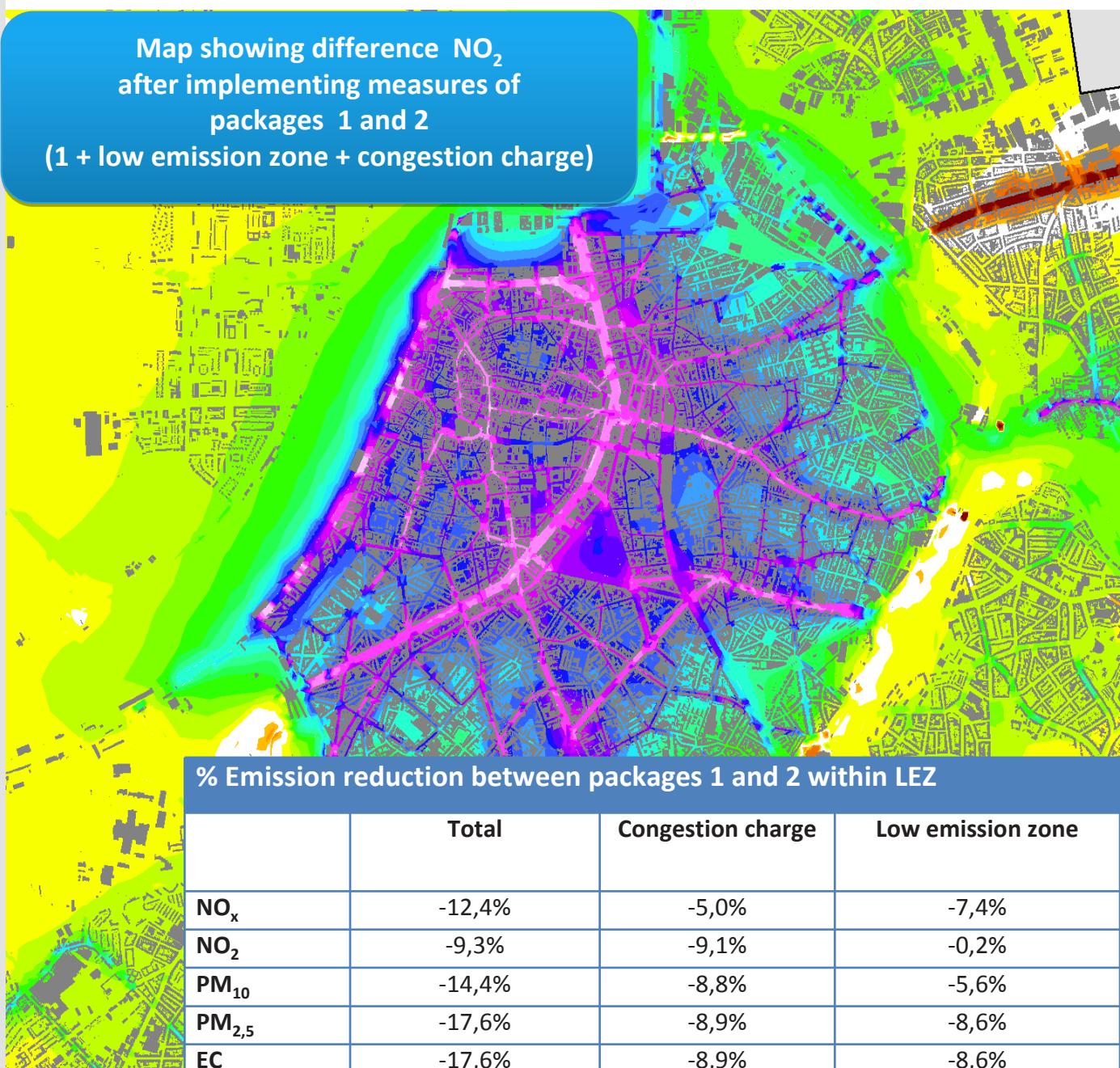




## NO<sub>2</sub> (%) Pkt2-basis

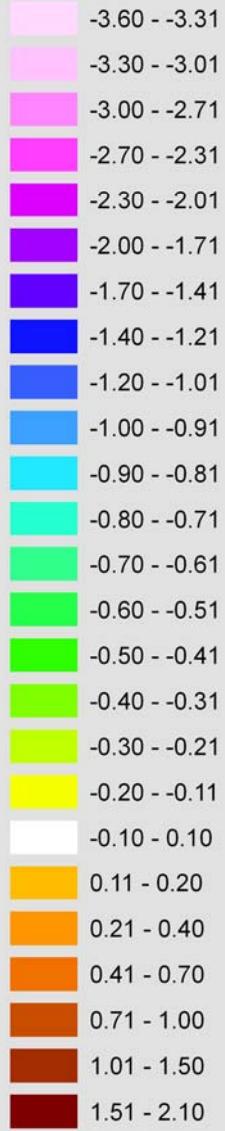


Map showing difference NO<sub>2</sub>  
after implementing measures of  
packages 1 and 2  
(1 + low emission zone + congestion charge)

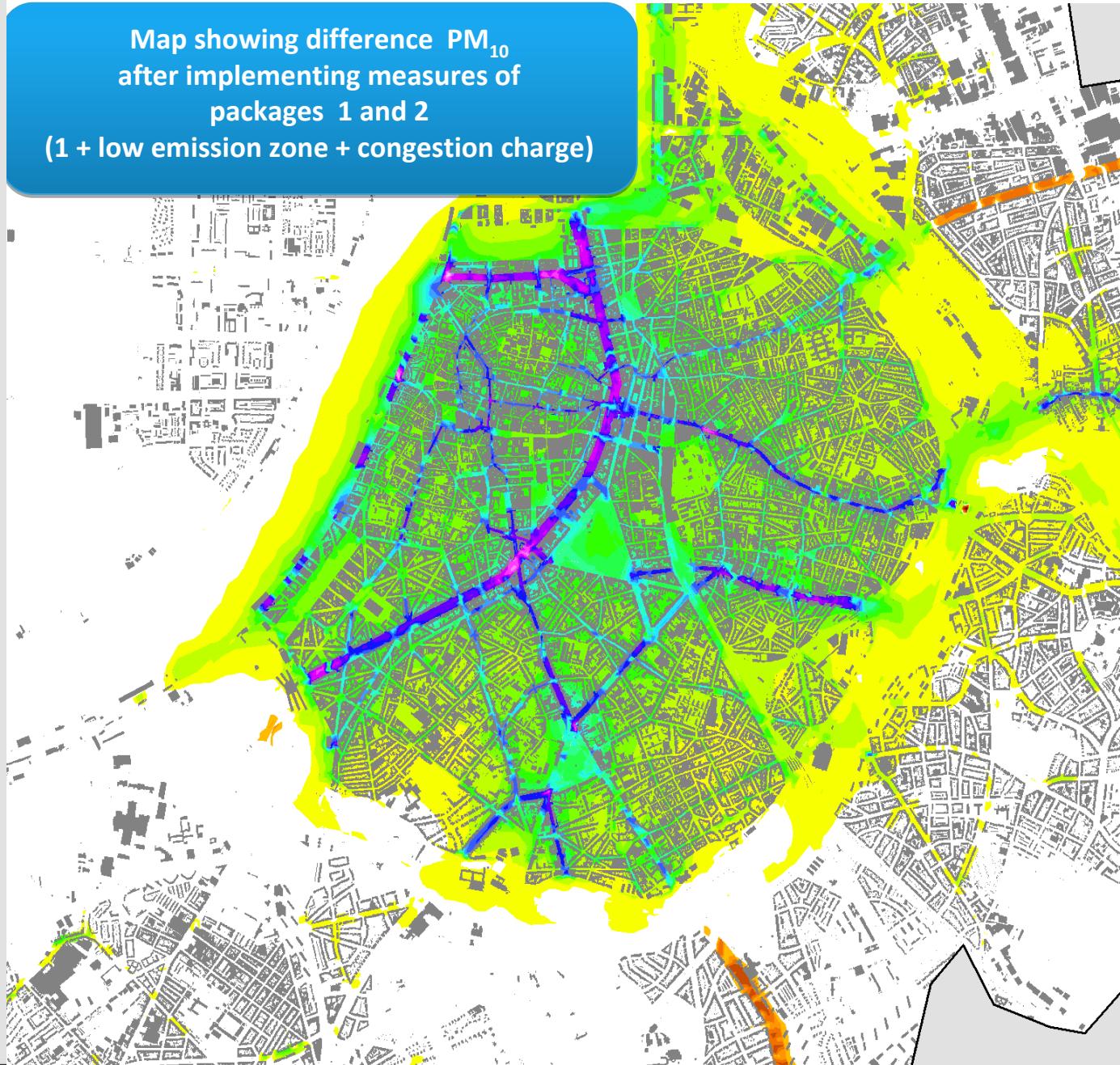




**PM10 (%)  
Pkt2-basis**

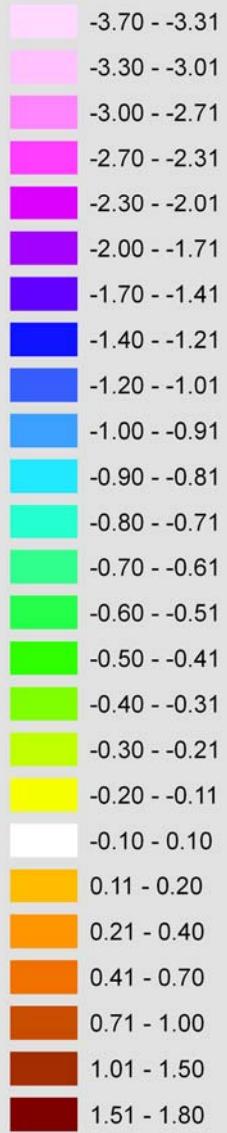


**Map showing difference  $\text{PM}_{10}$   
after implementing measures of  
packages 1 and 2  
(1 + low emission zone + congestion charge)**

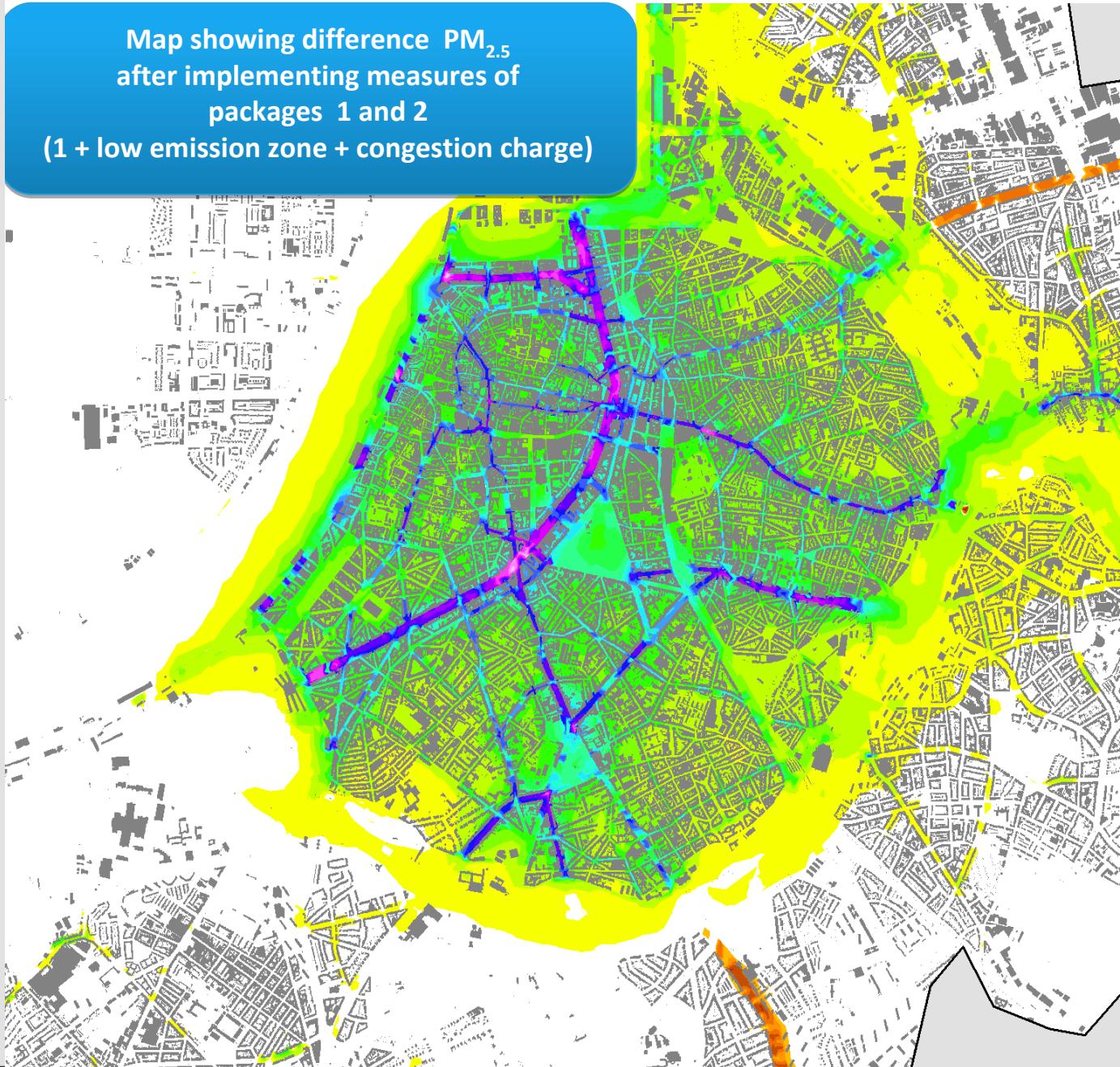




**PM2.5 (%)  
Pkt2-basis**

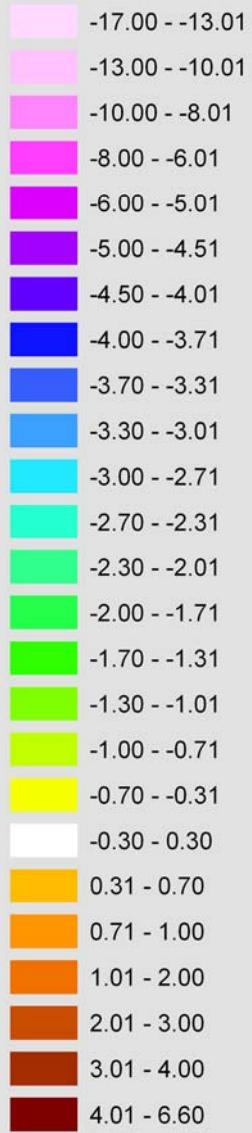


Map showing difference PM<sub>2.5</sub>  
after implementing measures of  
packages 1 and 2  
(1 + low emission zone + congestion charge)

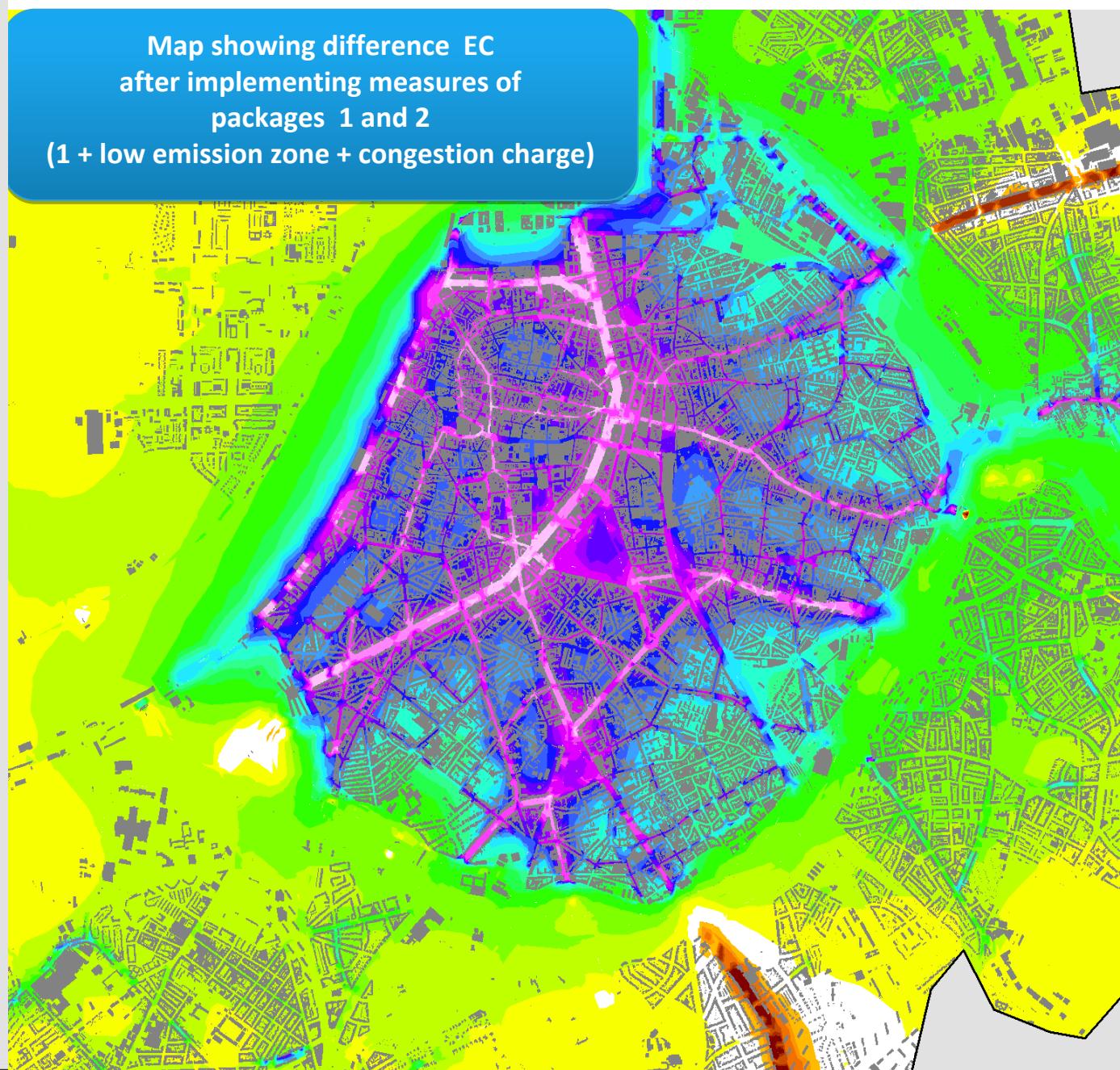




## EC (%) Pkt2-basis



Map showing difference EC  
after implementing measures of  
packages 1 and 2  
(1 + low emission zone + congestion charge)



# General conclusions

- » Impact LEZ – Flanders:
  - » Small effect on traffic volumes
  - » Significant effect on emissions of especially PM and EC
  - » Limited effect on concentrations of NO<sub>2</sub> and PM
  - » Significant effect on concentrations of EC