RIO: a novel approach for air pollution mapping

Stijn Janssen[1], Nele Veldeman[1], Clemens Mensink[1], Gerwin Dumont[2] and Frans Fierens[2]

(1) VITO, Belgium

(2) IRCEL, Belgium

HARMO 12

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Introduction

- Belgium is a rather small country with highly urbanized regions
- Air pollution is a serious problem in some regions
- EU air quality standards are not met everywhere

Introduction

- Air quality is sampled by a dense network of monitoring sites
  - e.g. about 60 to 70 stations for NO_2 and PM_{10} in Belgium
- Real-time measurements are published one-line by IRCEL
- Need for reliable maps to inform the public in near real-time
- How to create an air quality map from point values?
  - ➤ Use a model
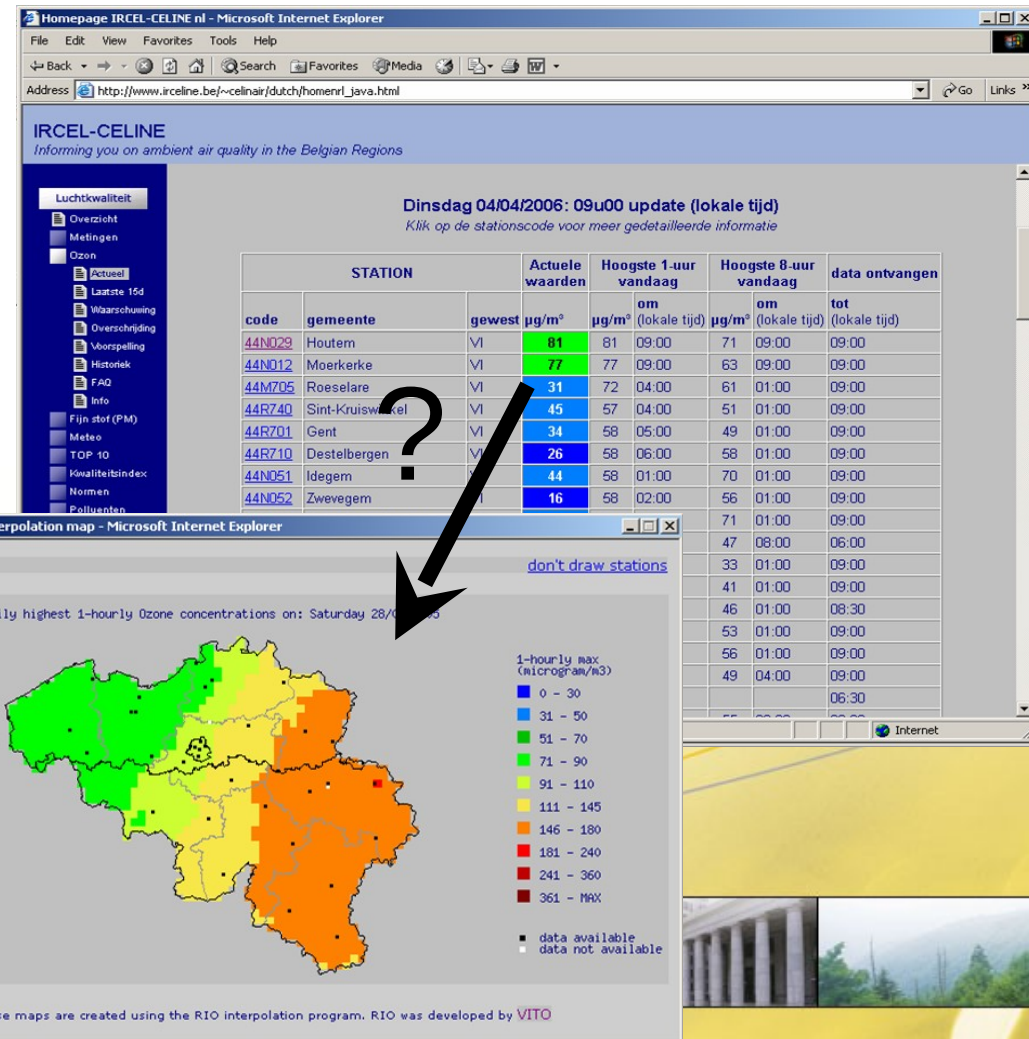
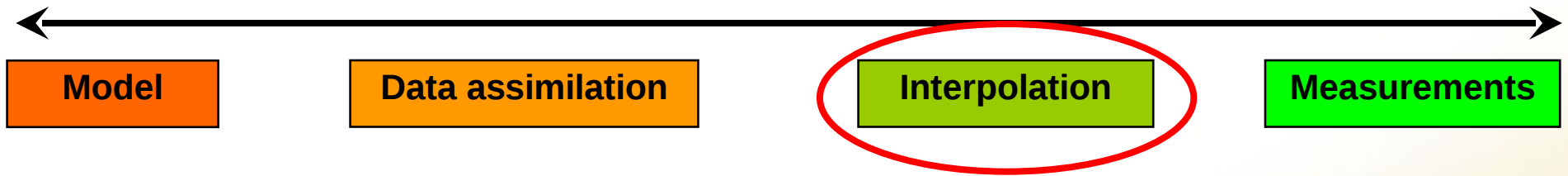# Introduction

- According to EU Directives:
  - Air quality assessment for entire air quality zones
  - Indicator for human exposure
- Need for reliable maps with annual averages and statistics

Introduction

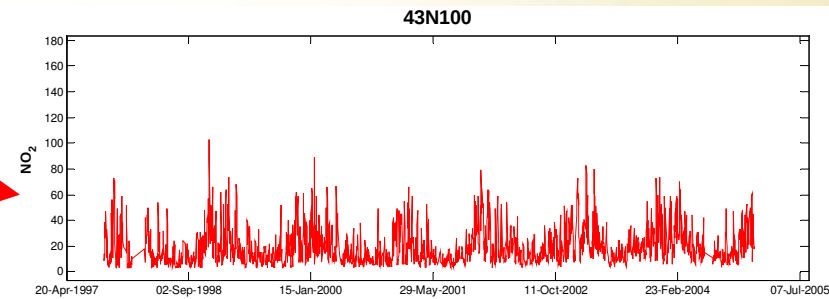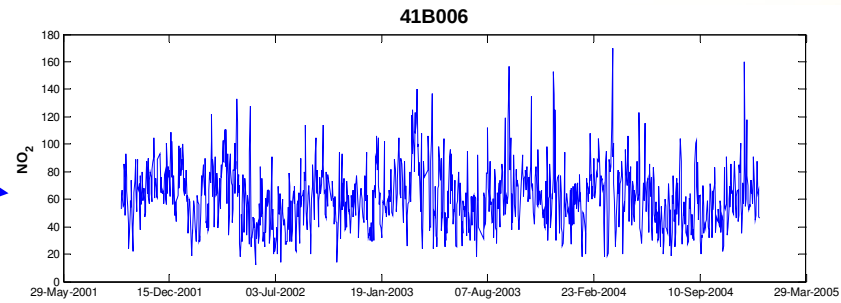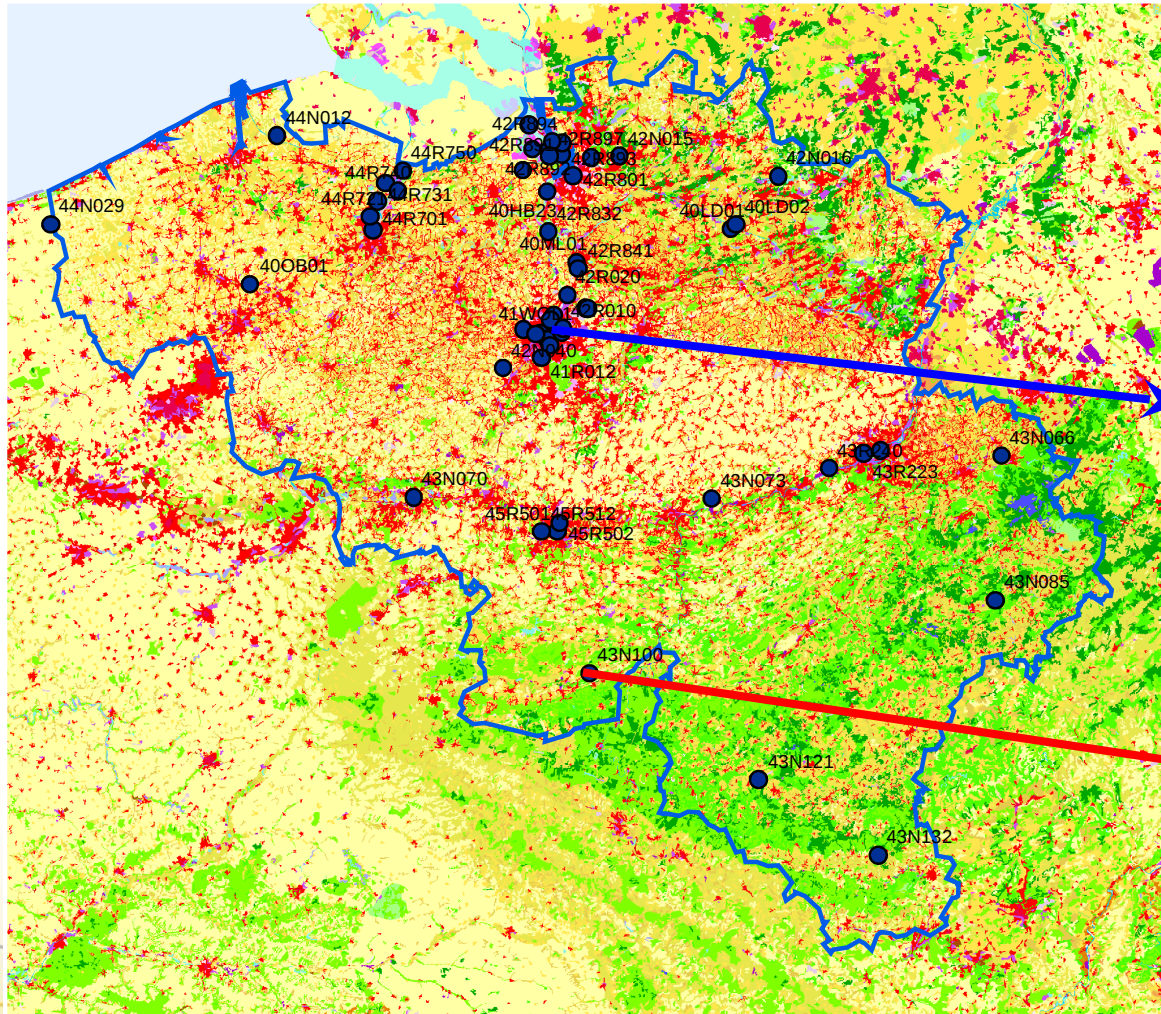- A wide variety of tools is available for an Environment Agency to accomplish these tasks

| Model | Data assimilation | Interpolation | Measurements |

- Interpolation tools are only applicable for a limited set of tasks (assessments, mapping,…)
- Advantages of an (intelligent) interpolation model:
  - Fast (near real-time)
  - Accurate
  - Simple

Introduction

RIO-model: Methodology

- Observation:
  - Sampling values depend on land use in (direct) vicinity of the monitoring site

- Consequence:
  - Interpolation scheme needs to know this relation between land use and air quality levels

- Approach in RIO-model:
  - Create land use indicator to express this relation

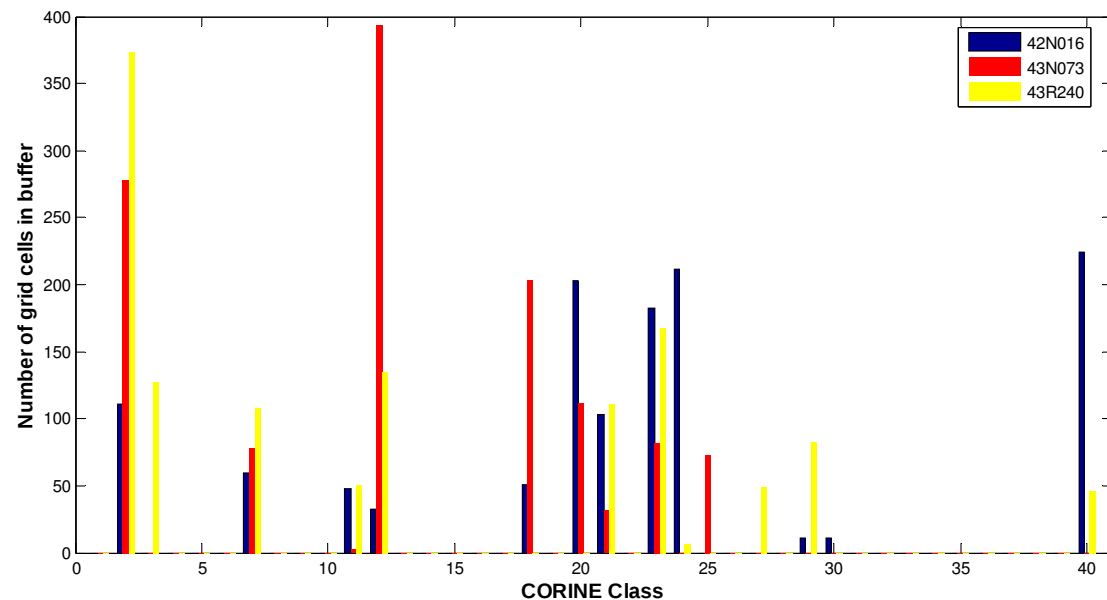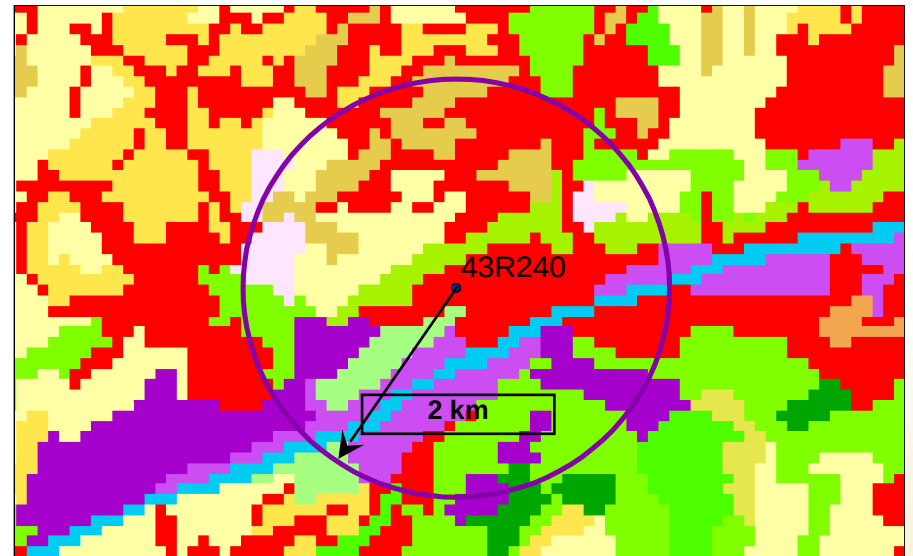# RIO-model: Land use indicator

Land use indicator

For each station:

- Determine buffer (e.g. 2km radius)

- Characterize land use by CORINE class distribution inside buffer
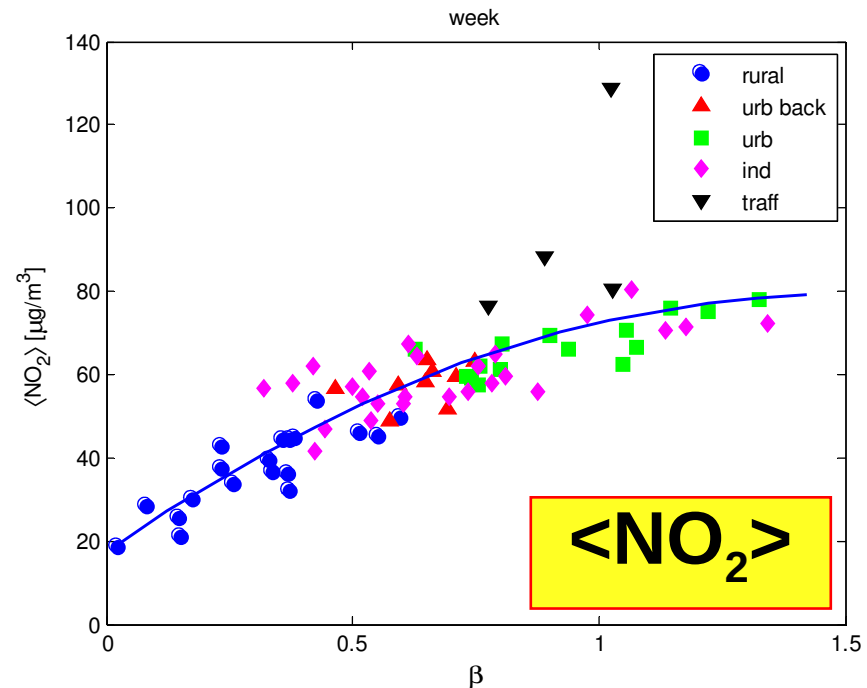
RIO-model: Land use indicator

RIO-model

- Land use indicator is based on CORINE class distribution

$$\beta_{\text{CORINE}} = \log\left[1 + \sum_i \left(a_i.n_{\text{CORINE class } i}\right) \Big/ \sum_i n_{\text{CORINE class } i}\right]$$
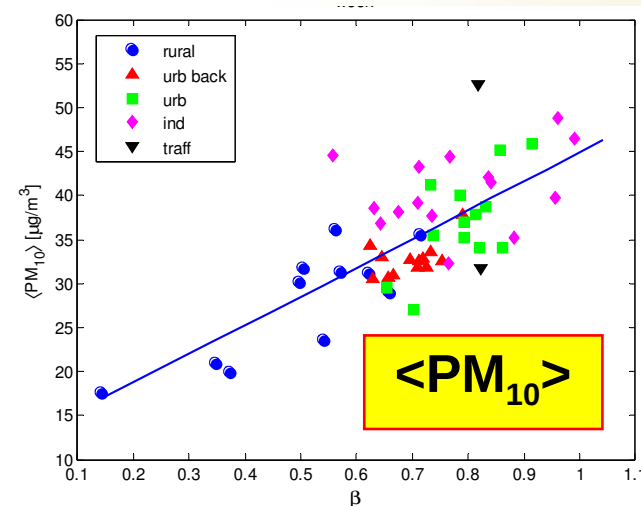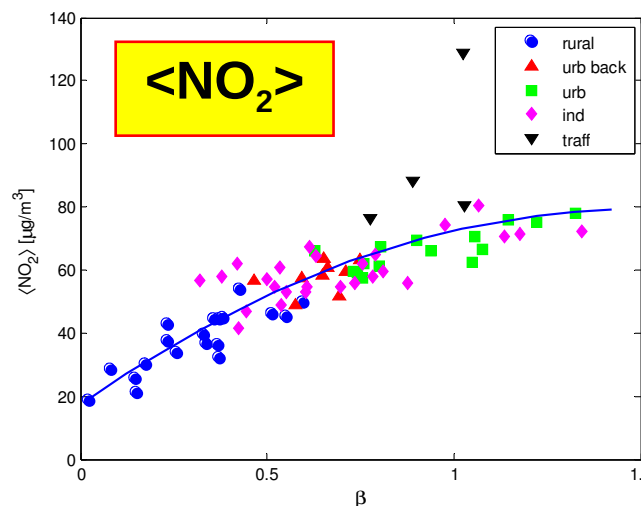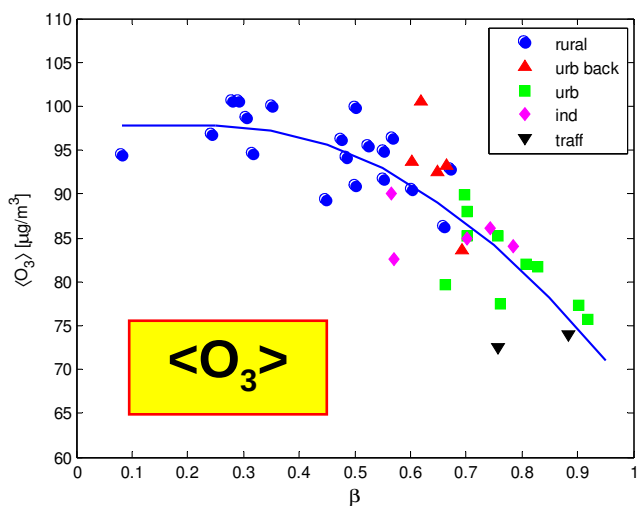
- Calibration of coefficients a_i:

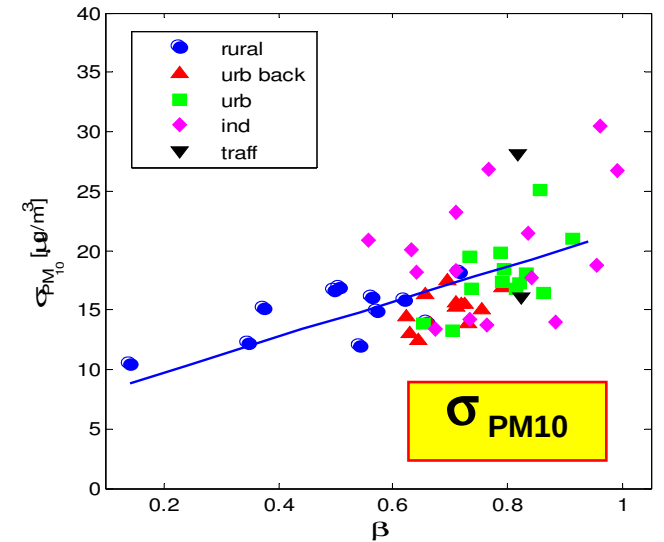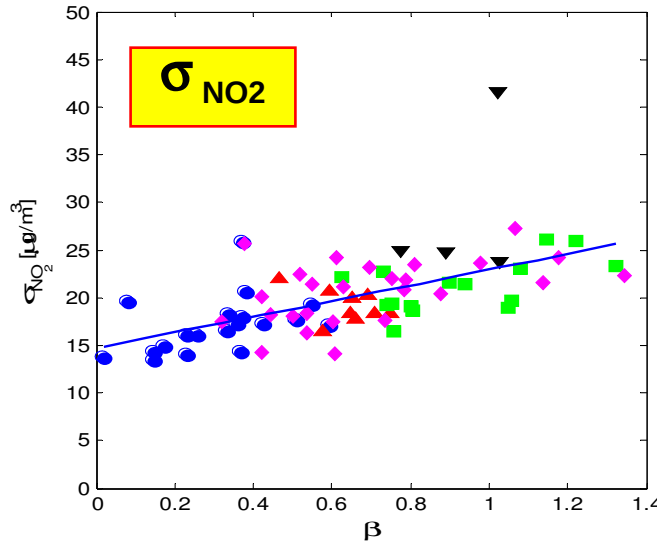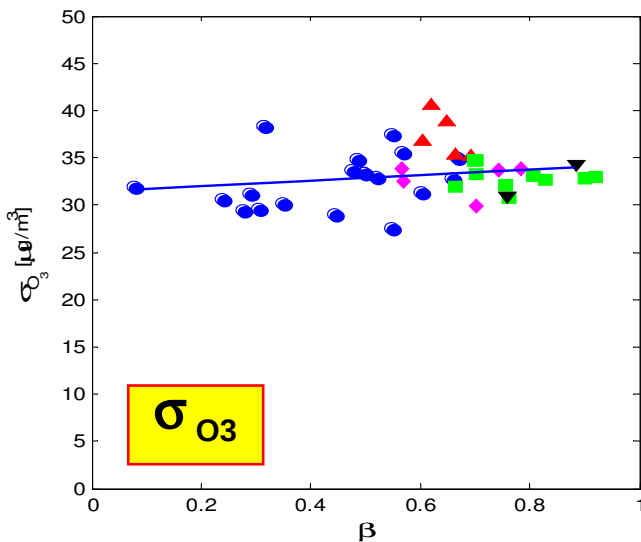 multi-regression to optimize trend for mean and standard dev. of monitoring data

RIO-model: Trend functions

- Trends in long tem mean of sampling values:
  - Relation between land use and average air quality levels
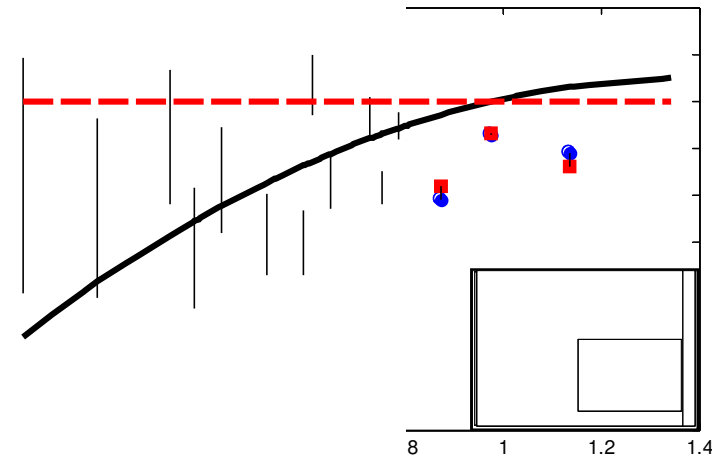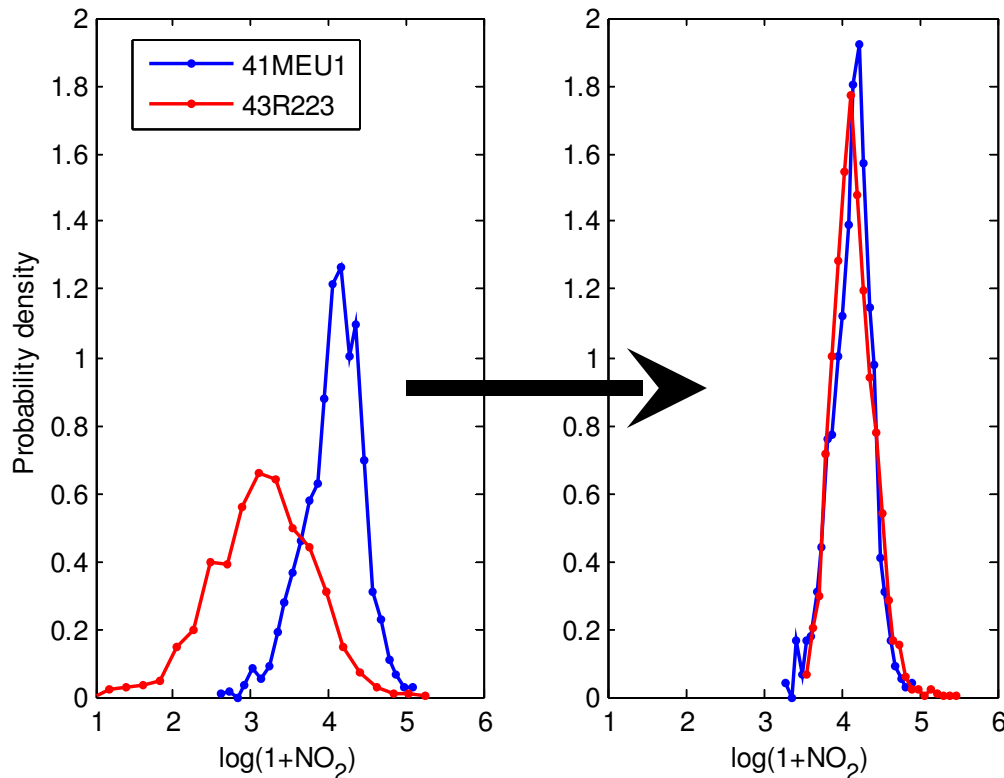 - Smooth transition between rural and urban sites

RIO-model: Trend functions

- Trends also observed in standard deviation of sampling values:

RIO-model: Detrending

- Use relation between land use indicator and AQ statistics to "detrend" monitoring data:
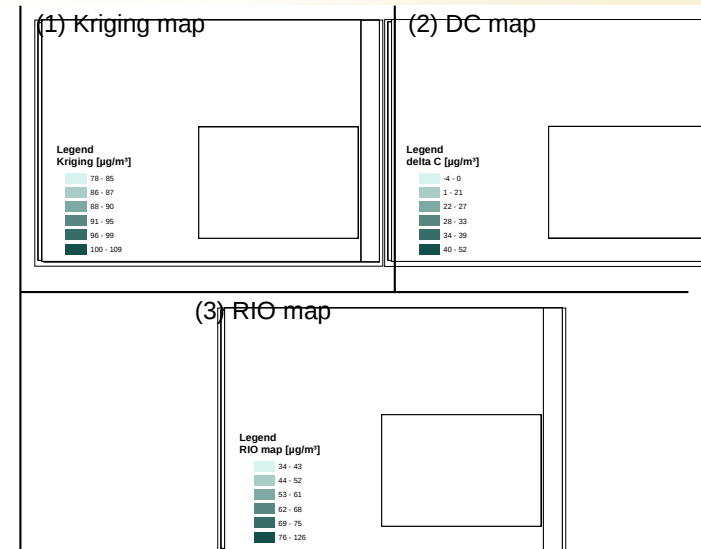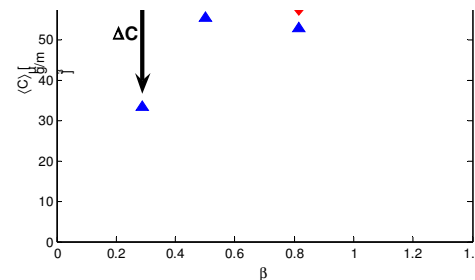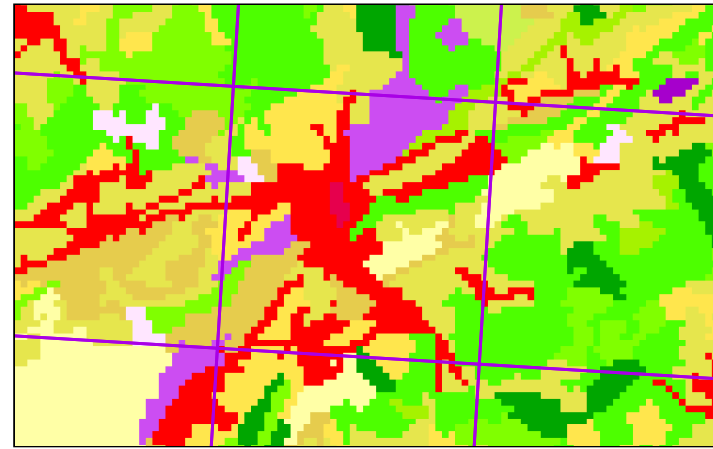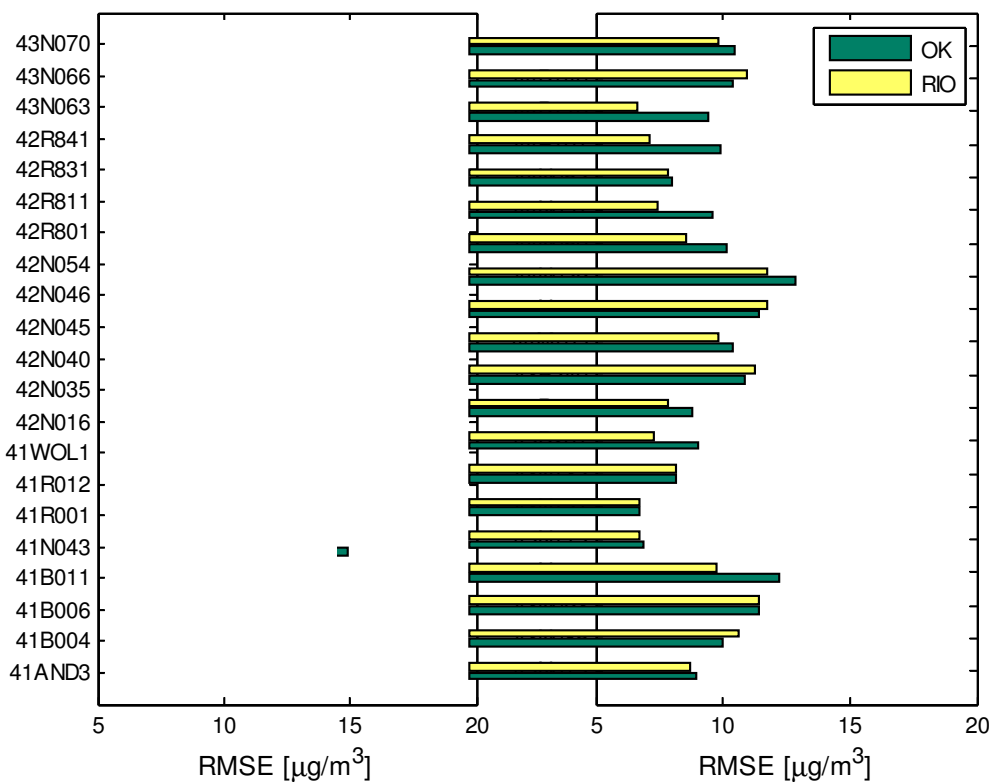 - ➢ Remove local character of sampling values

RIO-model: Methodology

RIO methodology:
- – Detrend sampling values
- – Interpolate detrended values with Ordinary Kriging
- – Determine local β-value
- – Get corresponding trend shift (ΔC)
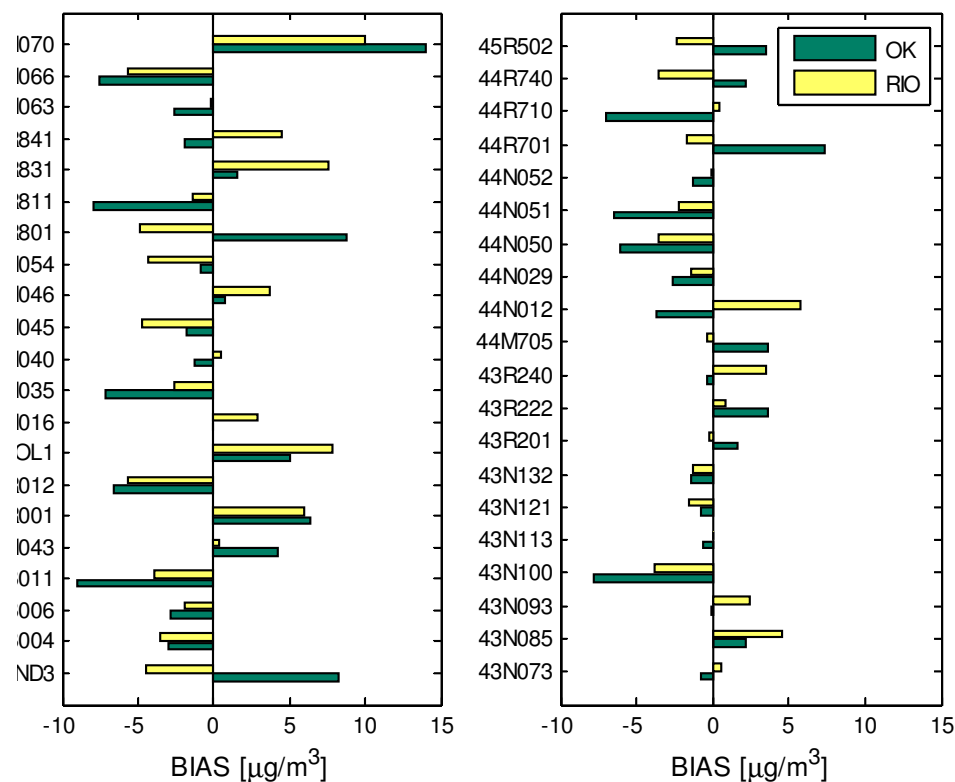- – Add ΔC to interpolation result

(1) Kriging map

Legend
Kriging [µg/m³]
- 78 - 85
- 86 - 87
- 88 - 90
- 91 - 95
- 96 - 99
- 100 - 109

(2) DC map

Legend
delta C [µg/m³]
- -4 - 0
- 1 - 21
- 22 - 27
- 28 - 33
- 34 - 39
- 40 - 52

(3) RIO map

Legend
RIO map [µg/m³]
- 34 - 43
- 44 - 52
- 53 - 61
- 62 - 68
- 69 - 75
- 76 - 126

RIO-model: Validation

Validation: leaving-one-out. Compare with standard OK

RIO-model: Validation

Validation: leaving-one-out. Compare with standard IDW and OK

Model	O_3		NO_2		PM_{10}	
	RMSE	Bias	RMSE	Bias	RMSE	Bias
IDW	10.97	-1.70	18.17	4.74	12.12	1.70
OK	10.37	-0.44	16.85	1.45	11.65	1.22
RIO	9.56	-0.08	14.45	-0.67	9.89	0.01

RIO: Near real-time application

RIO: Annual averages

Annual average NO_2 concentrations for 2006

RIO

OK

Legend
NO2 [µg/m³]

☐	error
■	< 10
■	11 - 12
■	13 - 14
■	15 - 17
■	18 - 20
■	21 - 23
■	24 - 26
■	27 - 29
■	30 - 33
■	> 33
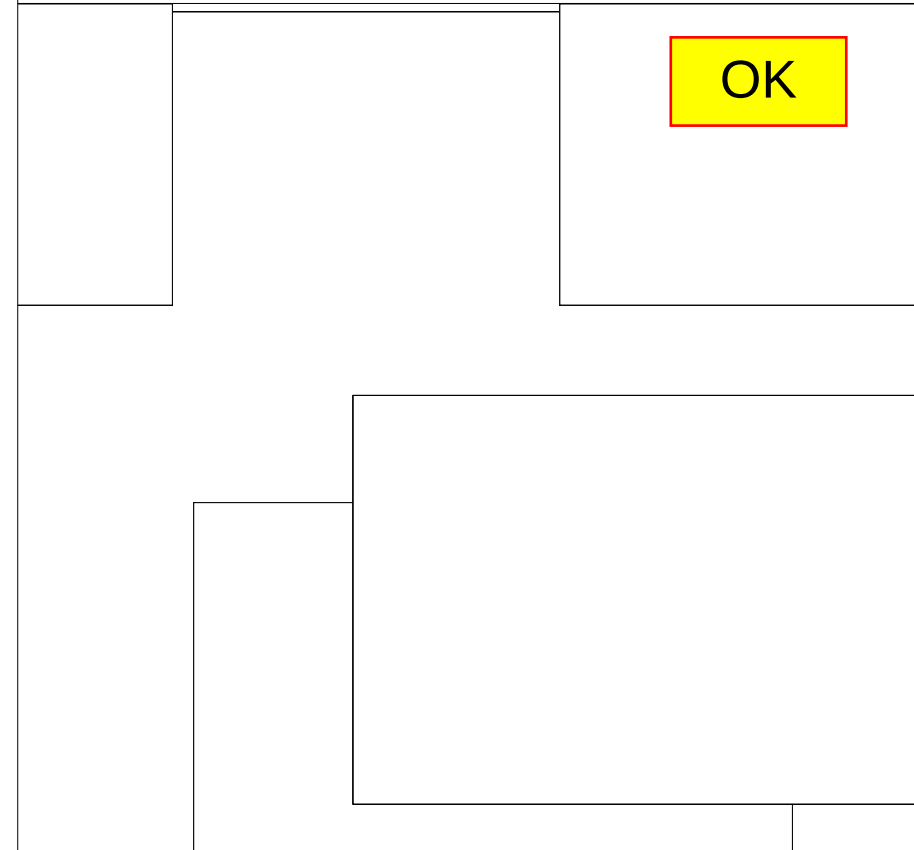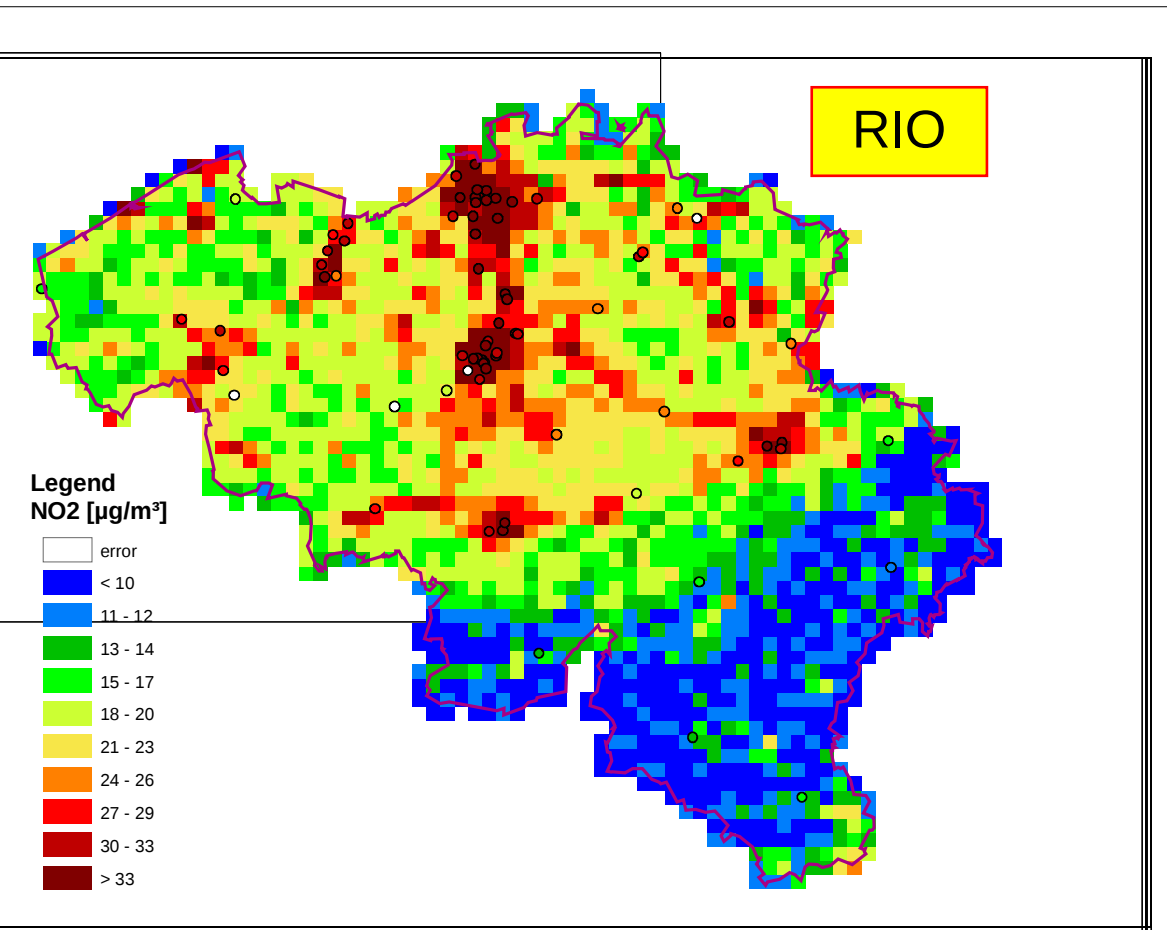
RIO: Annual averages

Annual averaged PM$_{10}$ concentrations for 2006

Number of days exceeding the 50 µg/m³ daily PM$_{10}$ limit in 2003

Legend PM10 [µg/m³]

☐	error
■	< 18
■	19 - 21
■	22 - 23
■	24 - 25
■	26 - 27
■	28 - 29
■	30 - 31
■	32 - 34
■	35 - 38
■	> 38

Number of days (2003) with daily mean PM10 concentration > 50 µg/m³

number of days

■	0 - 5
■	6 - 10
■	11 - 15
■	16 - 20
■	21 - 25
■	26 - 30
■	31 - 35
■	36 - 50
■	51 - 70
■	> 70
●	measuring station

20 0 20 40 60 80 100 Kilometers

IRCEL-CELINE

RIO: New developments

High β_{small}
Low β_{large}

High β

High β_{small}
High β_{large}

High β
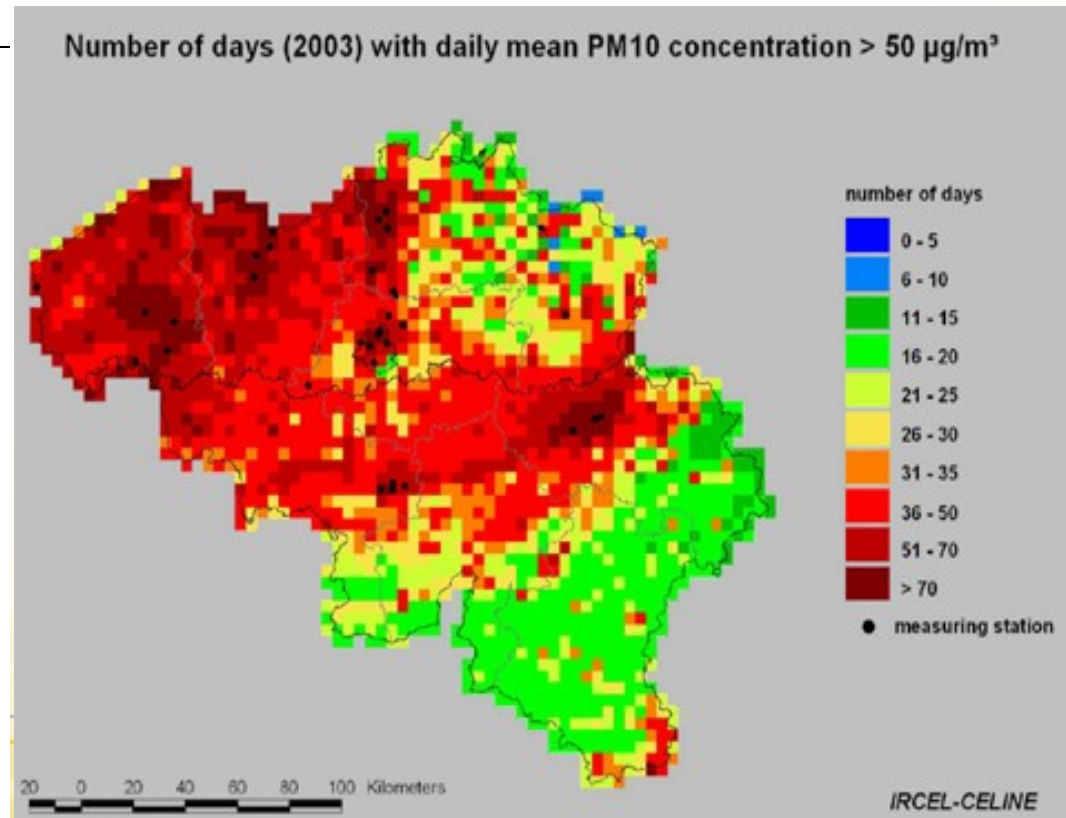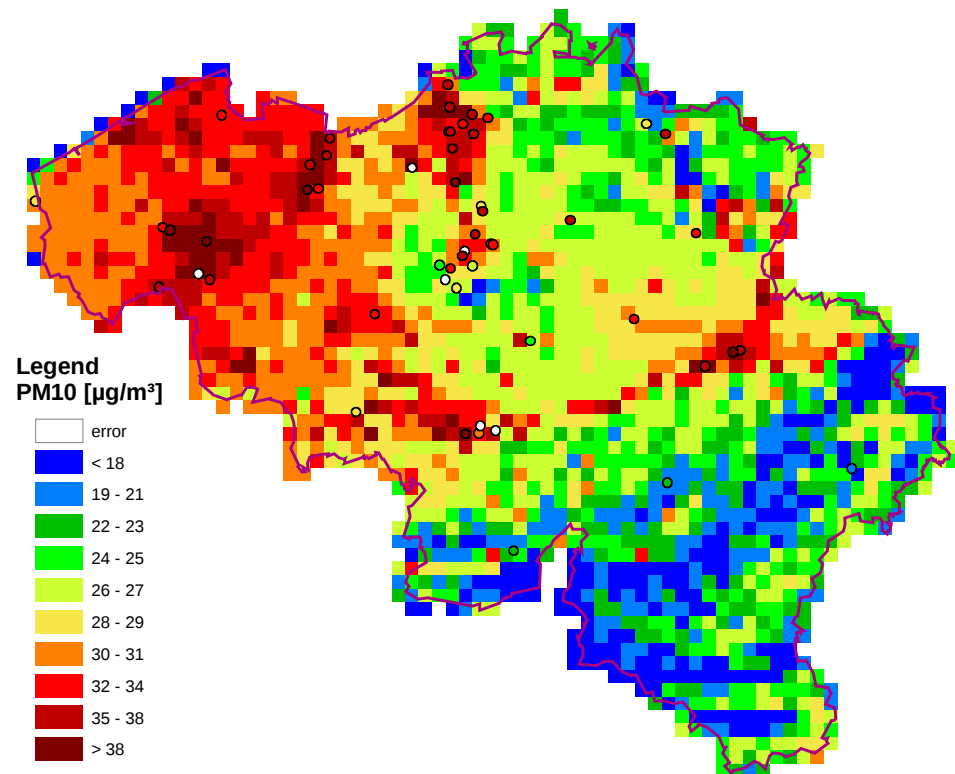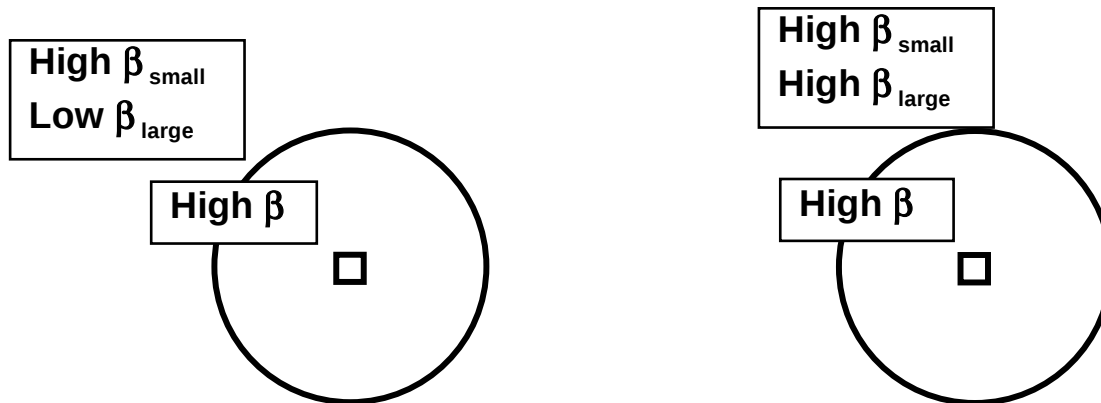
RIO: New developments

- ## Double scale in β parameter
  - ➢ Combined land use information at 1km and 10km spatial scale

1D → 2D

RIO: New developments

Legend
NO2 [µg/m³]

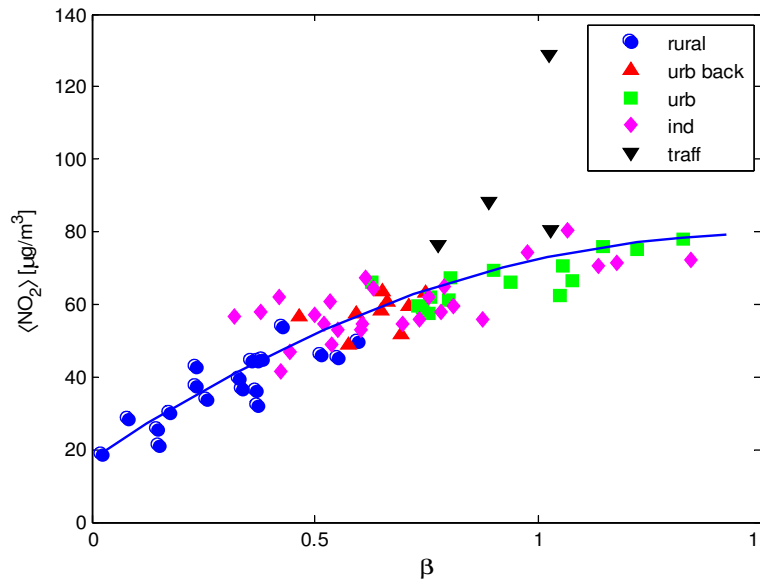|	
	error
	< 10
	11 - 12
	13 - 14
	15 - 17
	18 - 20
	21 - 23
	24 - 26
	27 - 29
	30 - 33
	> 33

no2_grid_belgium_1x1km
NO2_year

	< 10
	11 - 12
	13 -14
	15 -17
	18 -20
	21 -23
	24 -26
	27 -29
	30 -33
	> 33
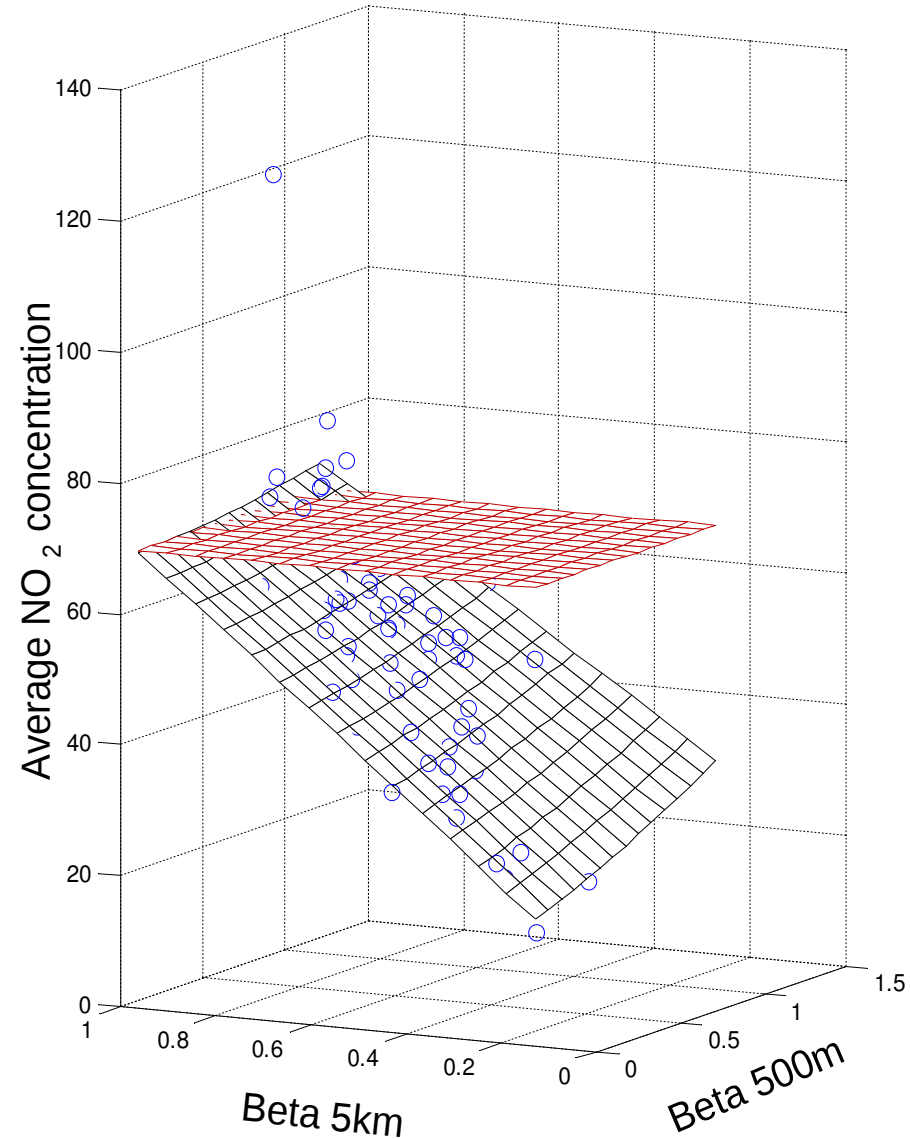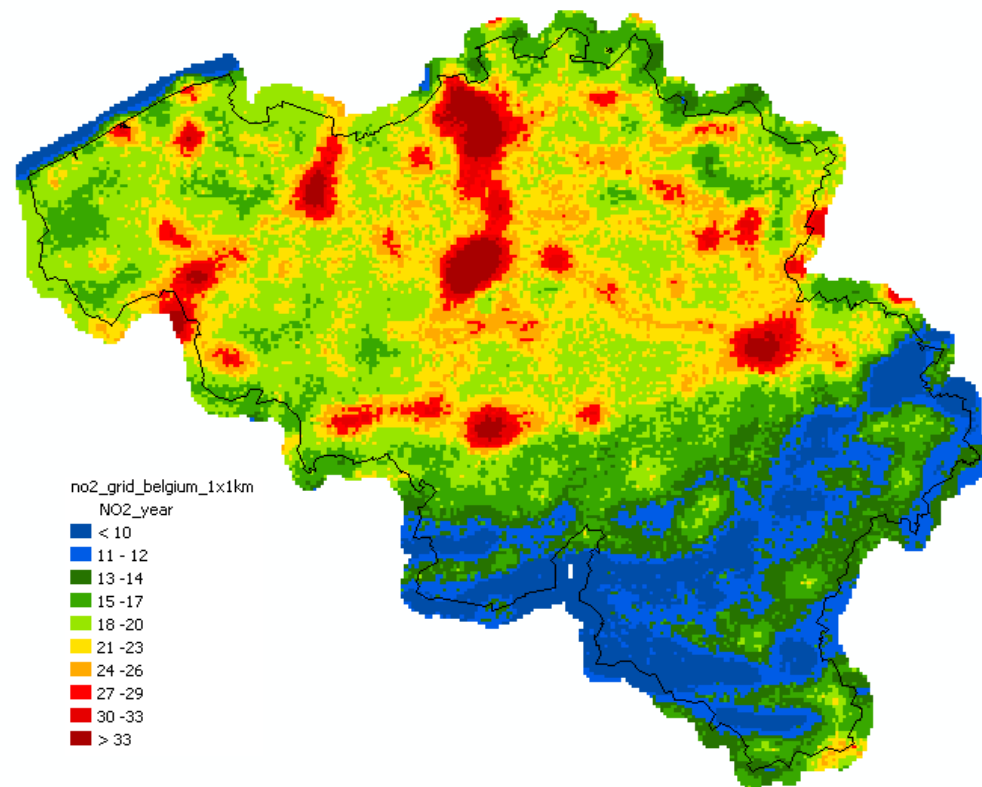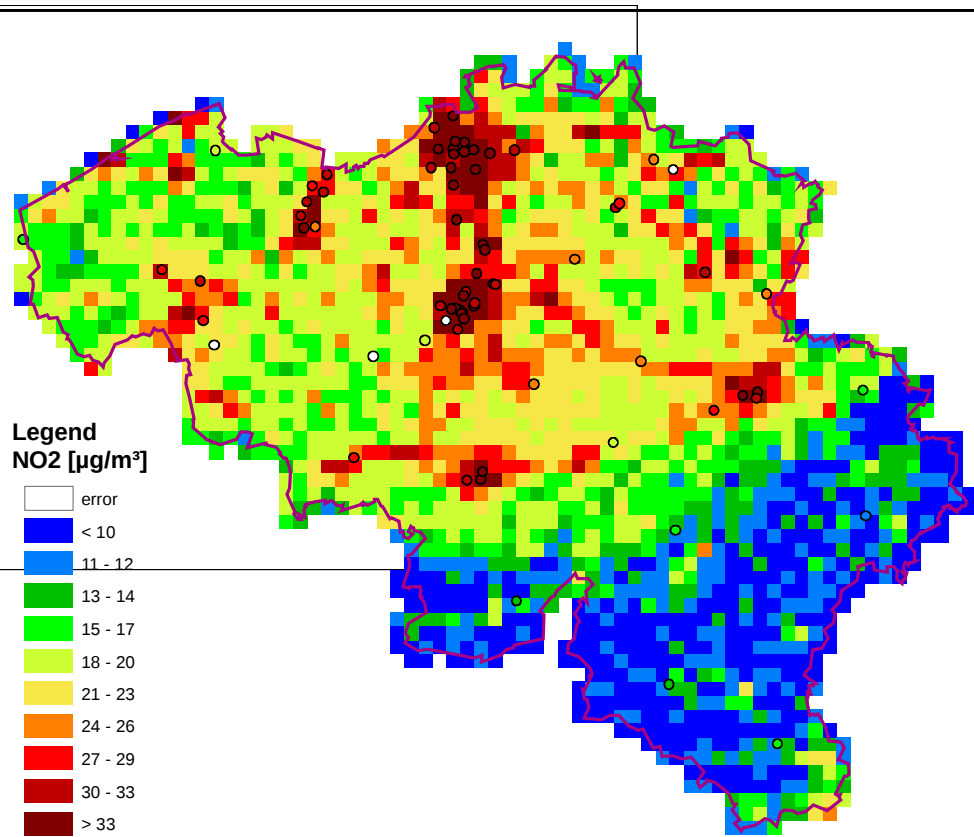
Conclusion

- RIO is an operational interpolation scheme for ambient air pollution (O_3, NO_2, PM_{10}, …)

- Kriging is used as interpolation tool

- A land use model is applied to incorporate local patterns

- Detrending is an essential step for the interpolation of air quality values

- Intelligent interpolation models can be applied as accurate, efficient and fast assessment tools