simularia

ELISE
ENVIRONMENT LIVE SENSING

# Progetto Elise

## MICRO-SCALE MODELLING OF URBAN AIR QUALITY TO FORECAST $NO_2$ CRITICAL LEVELS IN TRAFFIC HOT-SPOTS

Rossella Prandi, G. Carlino and many others

Air Quality 2016, Milan, 14-18 March

# ELISE - Environment Live SEnsing

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ELISE ENVIRONMENT LIVE SENSING

aizoon TECHNOLOGY CONSULTING

TRUSTECH INNOVATION TECHNOLOGY

CSP innovazione nelle ICT

INSTITUTE FOR SCIENTIFIC INTERCHANGE FOUNDATION

POLITECNICO DI TORINO 1859 1906



POR/FESR Funding

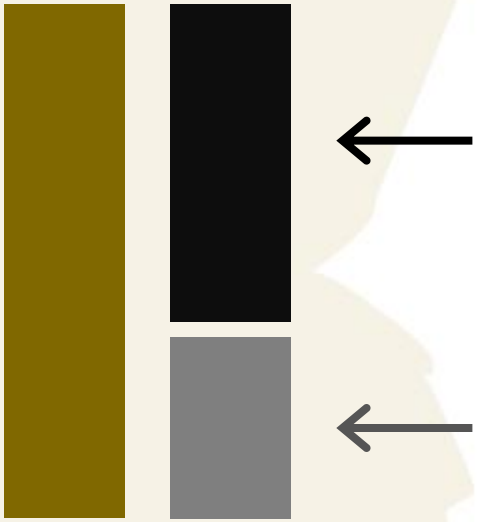
FONDO EUROPEO DI SVILUPPO REGIONALE
P.O.R. 2007 – 2013

REPUBBLICA ITALIANA

REGIONE PIEMONTE

Our task: providing hourly updated and high-resolution $NO_2$ concentration fields in the city of Turin to compare with measures collected by citizens involved in the living lab

Potentially, very high values at kerbside



Roadside increment, microscale model: traffic emissions only

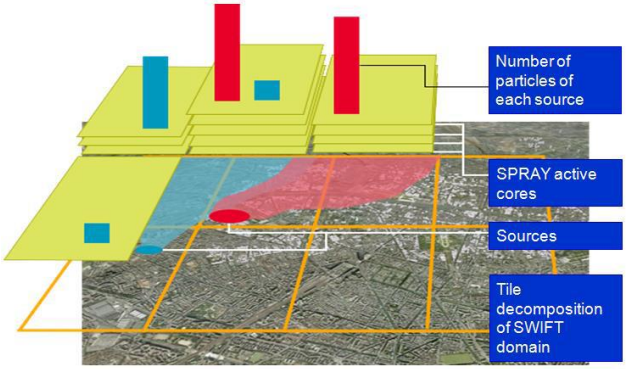
Background, regional scale model: all emissions

# ELISE – Models employed

**PMSS**

Parallel Micro-Swift-Spray, 3D Lagrangian Particle model:

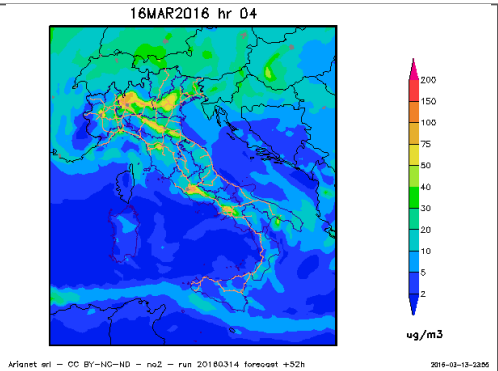
- based on MPI libraries, it allows a multi-tile decomposition of big domains on multicore machines
- computational resources are reallocated dynamically among processes during computation
- obstacles are taken into account at microscale
- meteorological fields are obtained by PSWIFT, a parallelized 3D wind field model for complex terrain which produces a mass- consistent wind field using data from a dispersed meteorological network or a larger scale model.




**QUALEARIA**

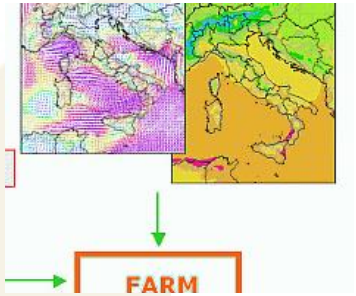
Air quality forecast provided for the current day and up to 120 hours:

- based on FARM (Flexible Air quality Regional Model), a 3D Eulerian CTM model
- downscaling of synoptic weather forecast (GFS by NCEP) with RAMS
- hourly boundary conditions from the global scale forecast by the ECMWF MACC-C-IFS-TM5 (Copernicus)
- national emission inventory (ISPRA) for Italy and the TNO/MEGAPOLI inventory for Europe



# ELISE – Chain


**QUALEARIA (12 km)**




**NOx Traffic emissions (hourly)**

**elise_chain.py**

START (each day at h 00:15)

QualeAria repository

Download meteorological, turbulence and background files (ftp_meteo.py)

Select meteorological file and turbulence data (select_metmin.py)

Compute 3D meteorological fields for 25 hours (execute_pswift.py)

Write background parameters (writebackgroundfields.py)

Get emissions file

Compute 24 hours NOx concentrations fields (00 - 23) (execute_pspray.py)

**elise_postprocess.py**

START (each hour at 05 minutes)

Get sensors data (ftp_sensors.py)

AizoOn server

Get newest available concentration field (selectlasthour.py)

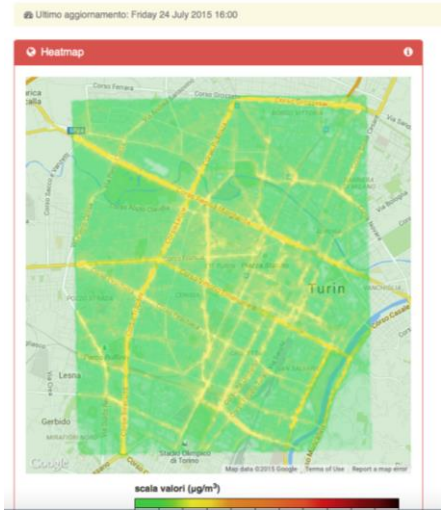
Compute NO2 using background values (sumbackgroundNO2.py)

Data assimilation (dataassimilation.py)

Export CSV file and send it to AizoOn server (sendtoAizoon.py)

Send binary file to SDP (sendbinarytoSDP.py)

$NO_X$ -> $NO_2$ with a photo-stationary box model as in Berkowicz et al. taking into account background NO, $NO_2$ and $O_3$



# Some figures

Horizontal res. 6 m;
1202201 grid points

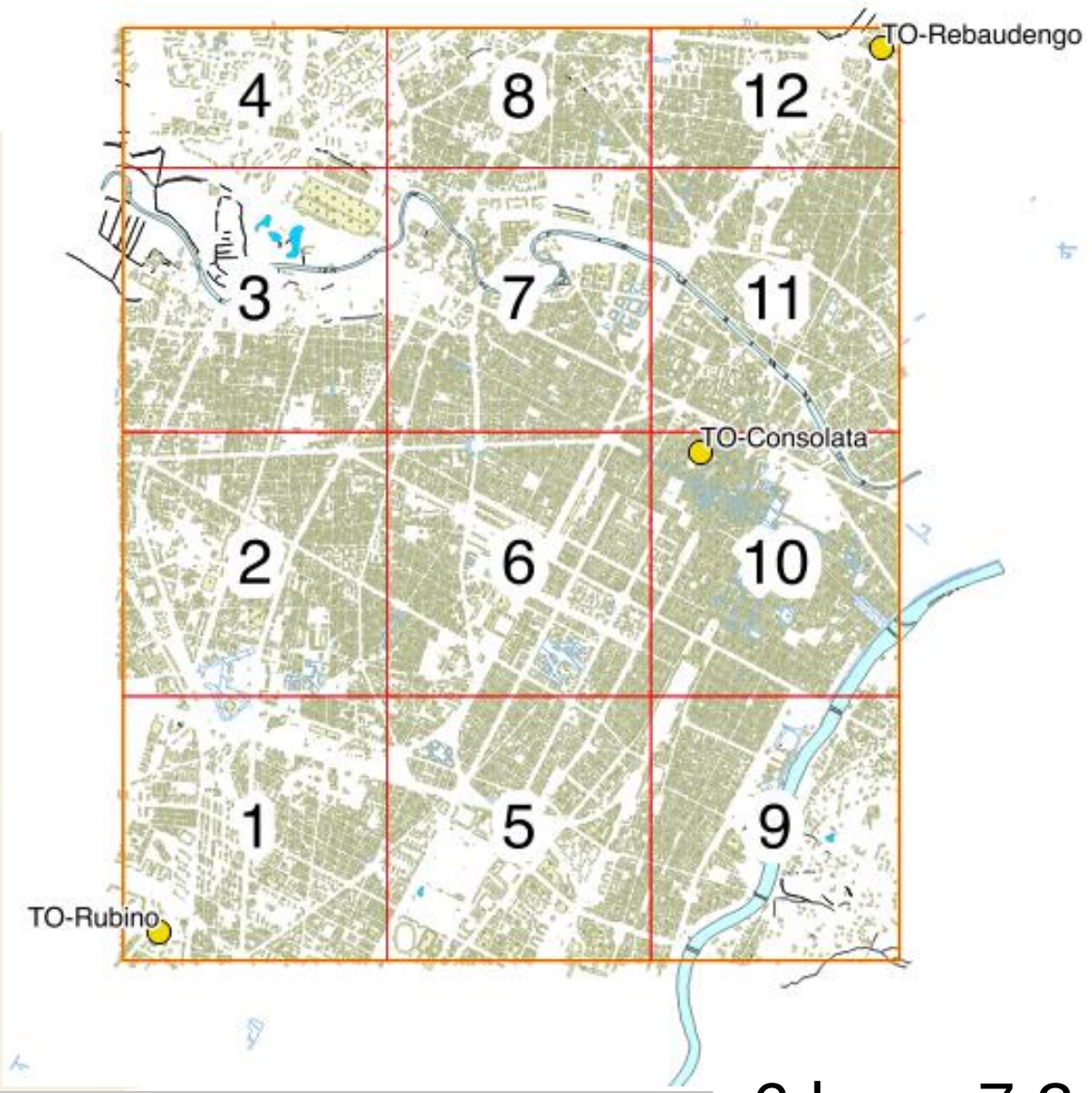
Computation is split on 12 Tiles (16 cores)

26 vertical levels up to 1250 m

Three monitoring sites to compare to

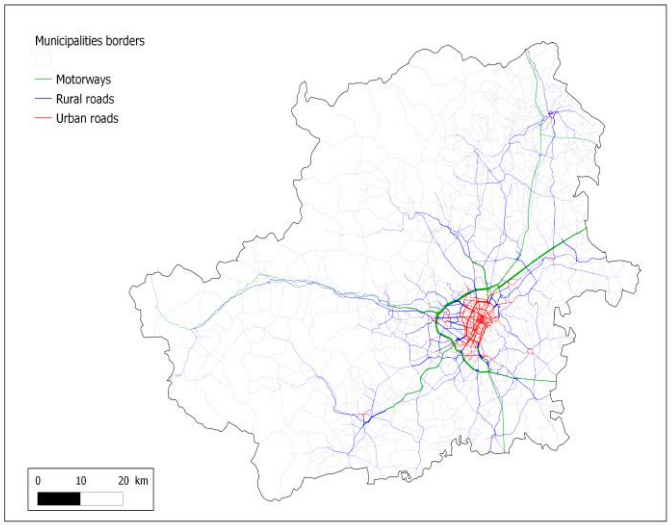
Total number of obstacles: 51982
Average heigth: 12 m
Max. height: 167 m

Only traffic $NO_X$ emissions: 13060 linear sources




6 km x 7.2 km

# Traffic emissions

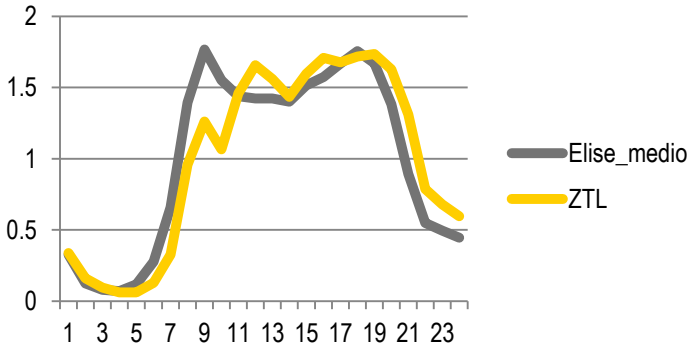



+

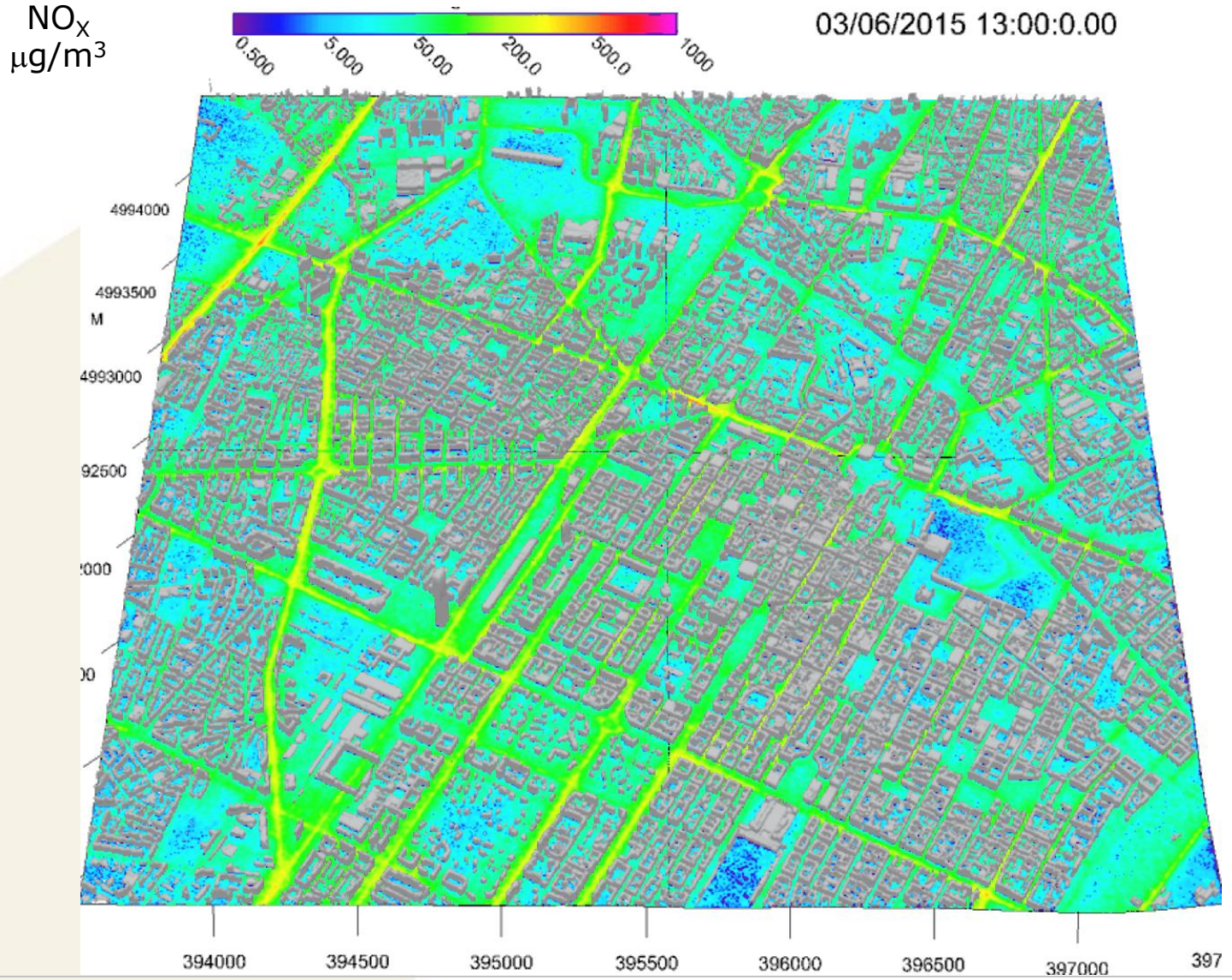

Main road network: bottom-up with COPERT/CORINAIR methodology

Secondary road network: top-down from the regional inventory georeferenced with OpenStreetMap layer

No real-time traffic data but we added some realism in time modulation by taking into account LEZ

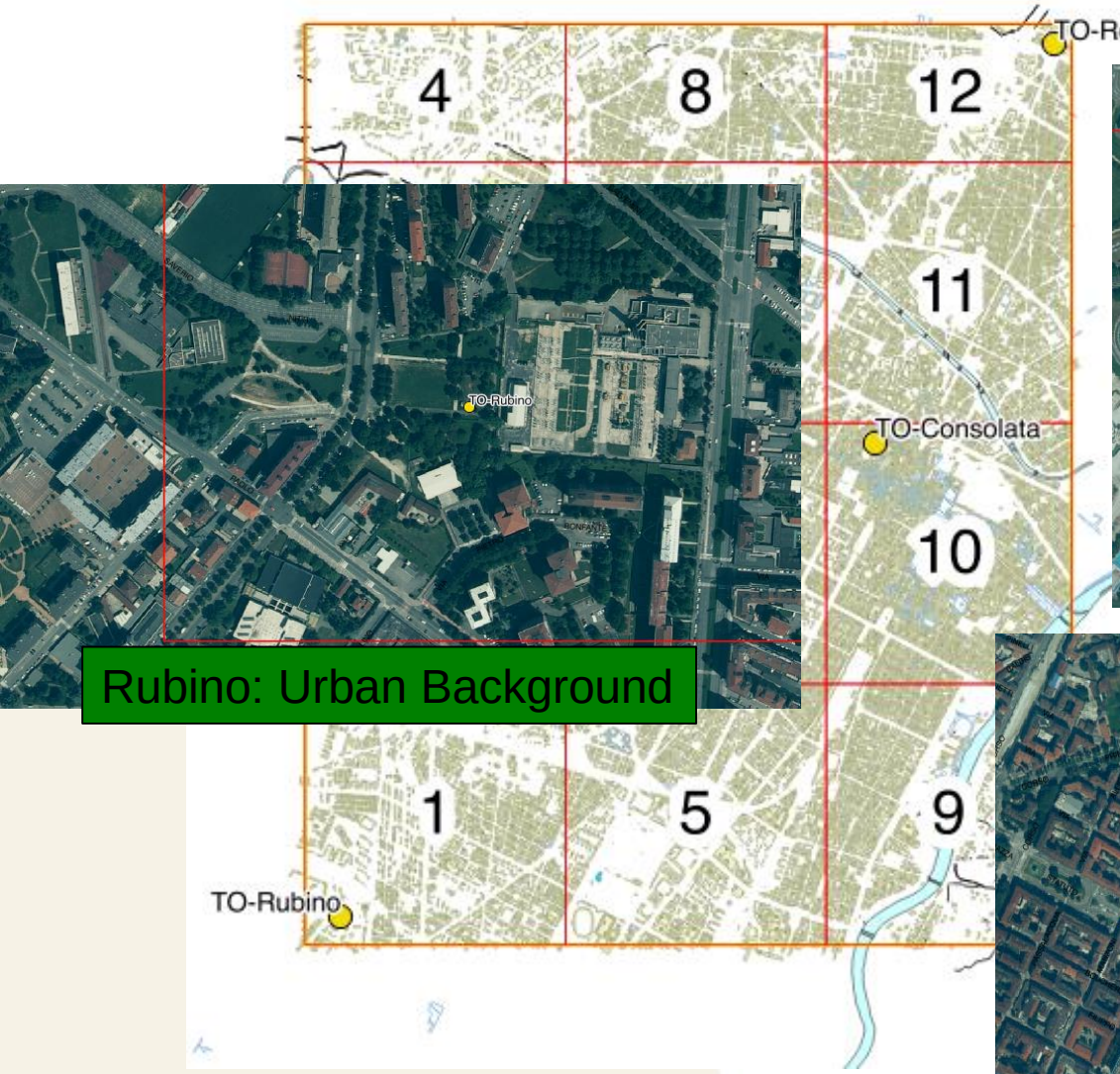


# Traffic $NO_X$ concentrations



# How do we compare to measures?

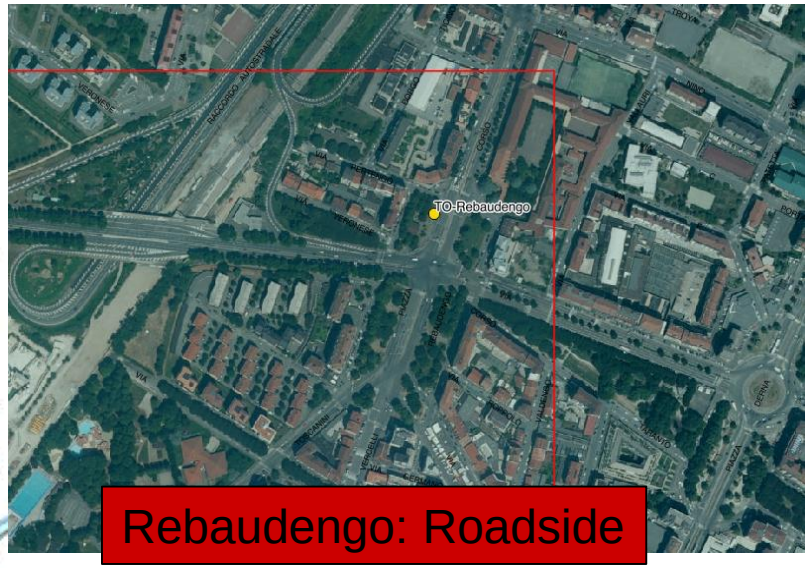
Around 6800 hours, from 15/04/2015 to 8/03/2016







Rubino: Urban Background




Rebaudengo: Roadside


Consolata: Roadside in LEZ

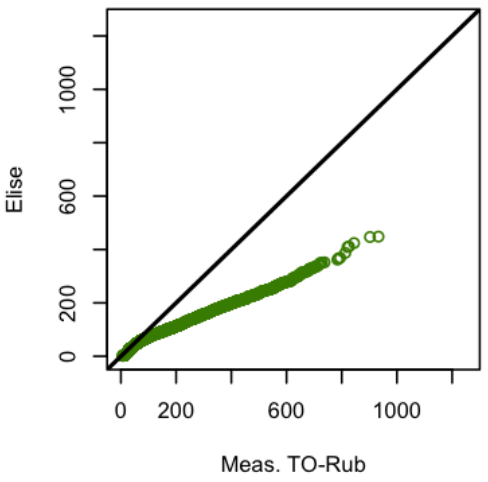
# How do we compare to measures?



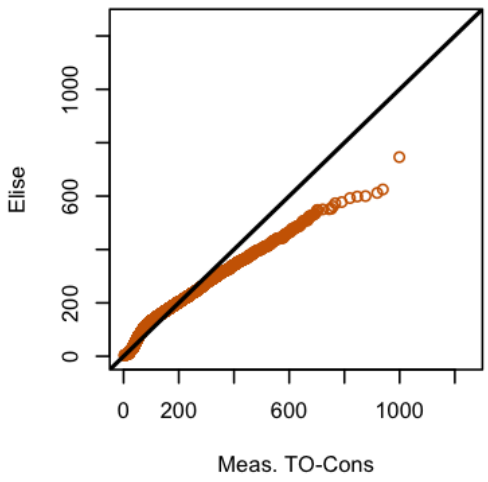
First question: are we exaggerating the amount of traffic related nitrogen oxides?

# Total $NO_X$

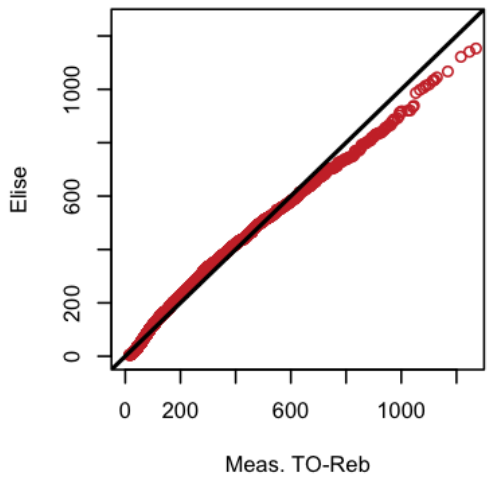
Elise




Urban Background

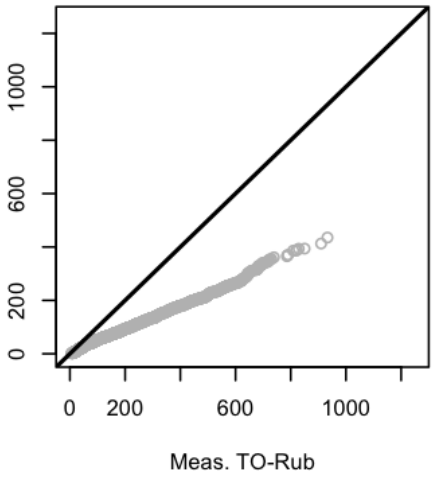


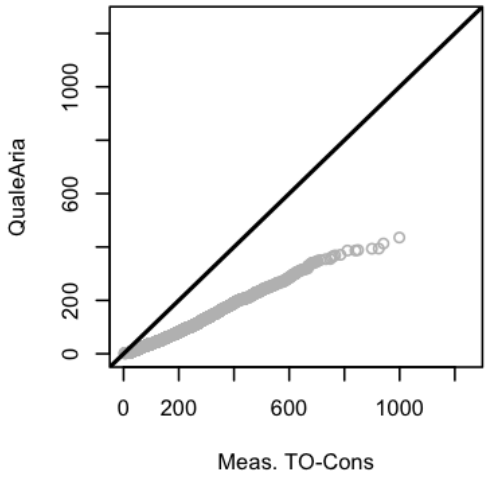

Roadside in LEZ

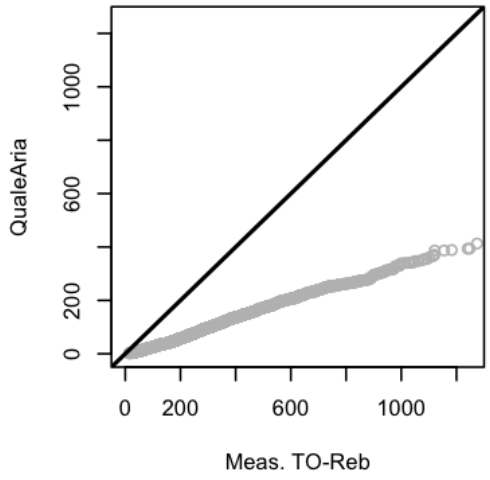



Roadside

Regional background



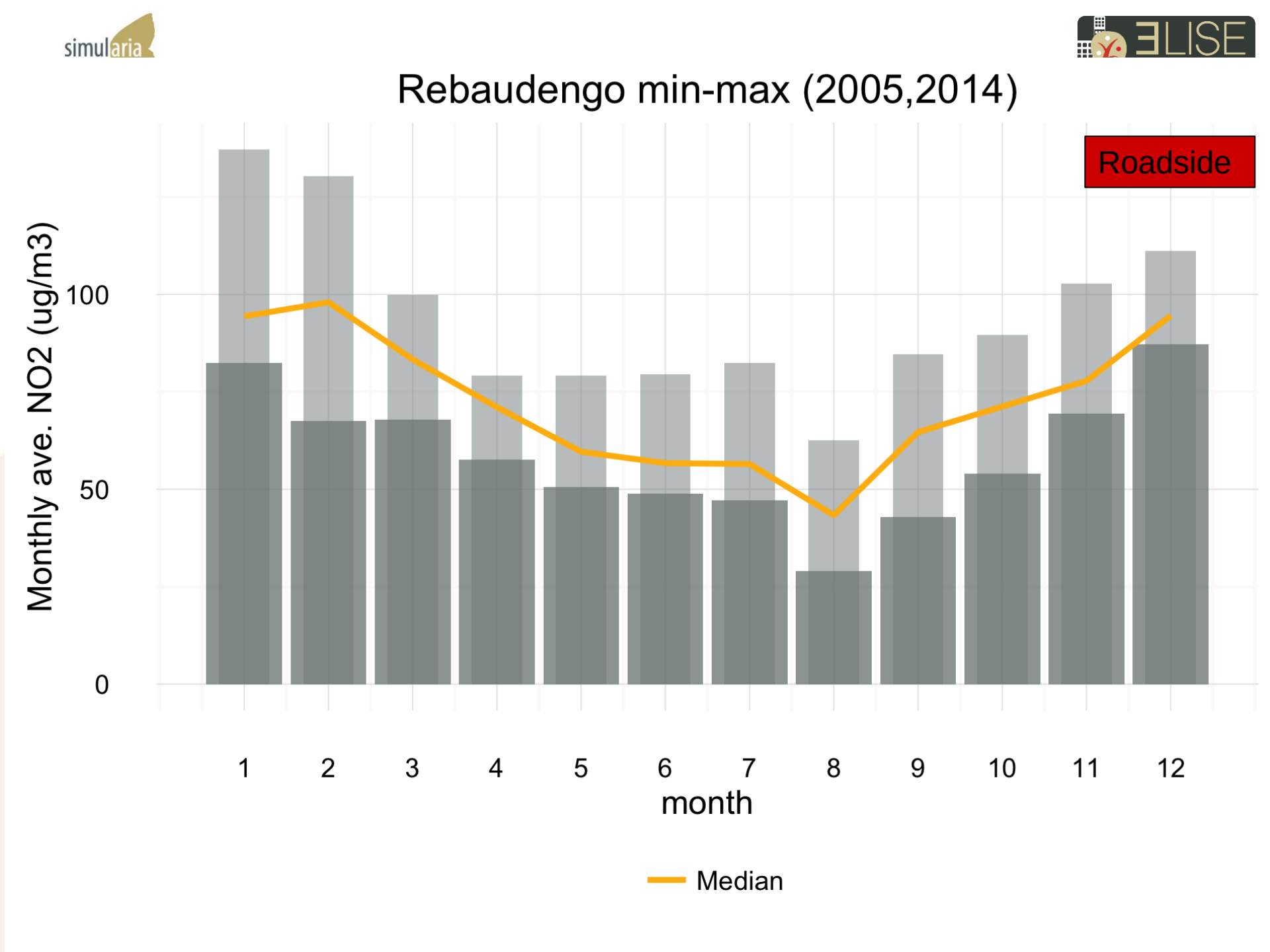



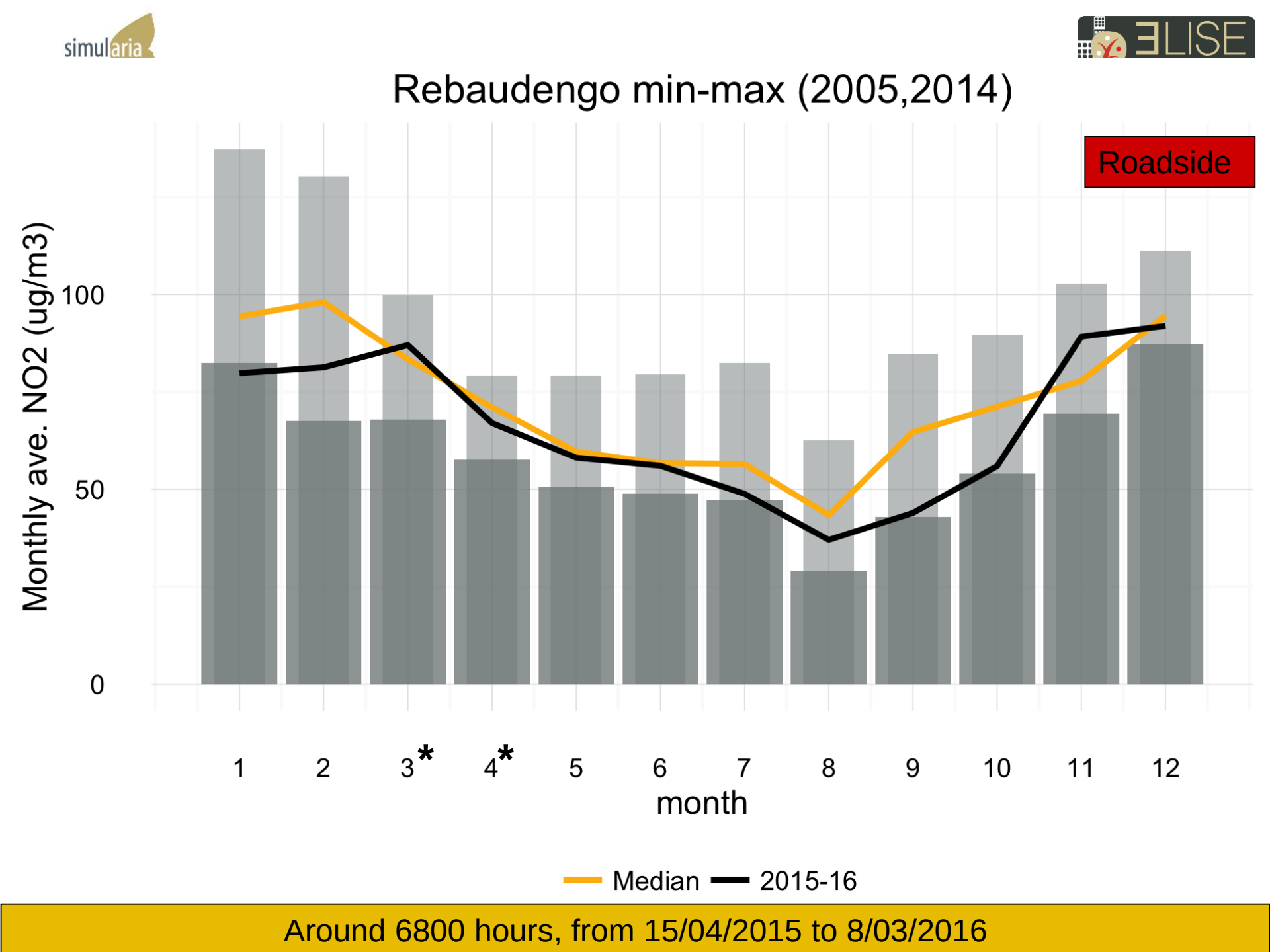
# How do we compare to measures?



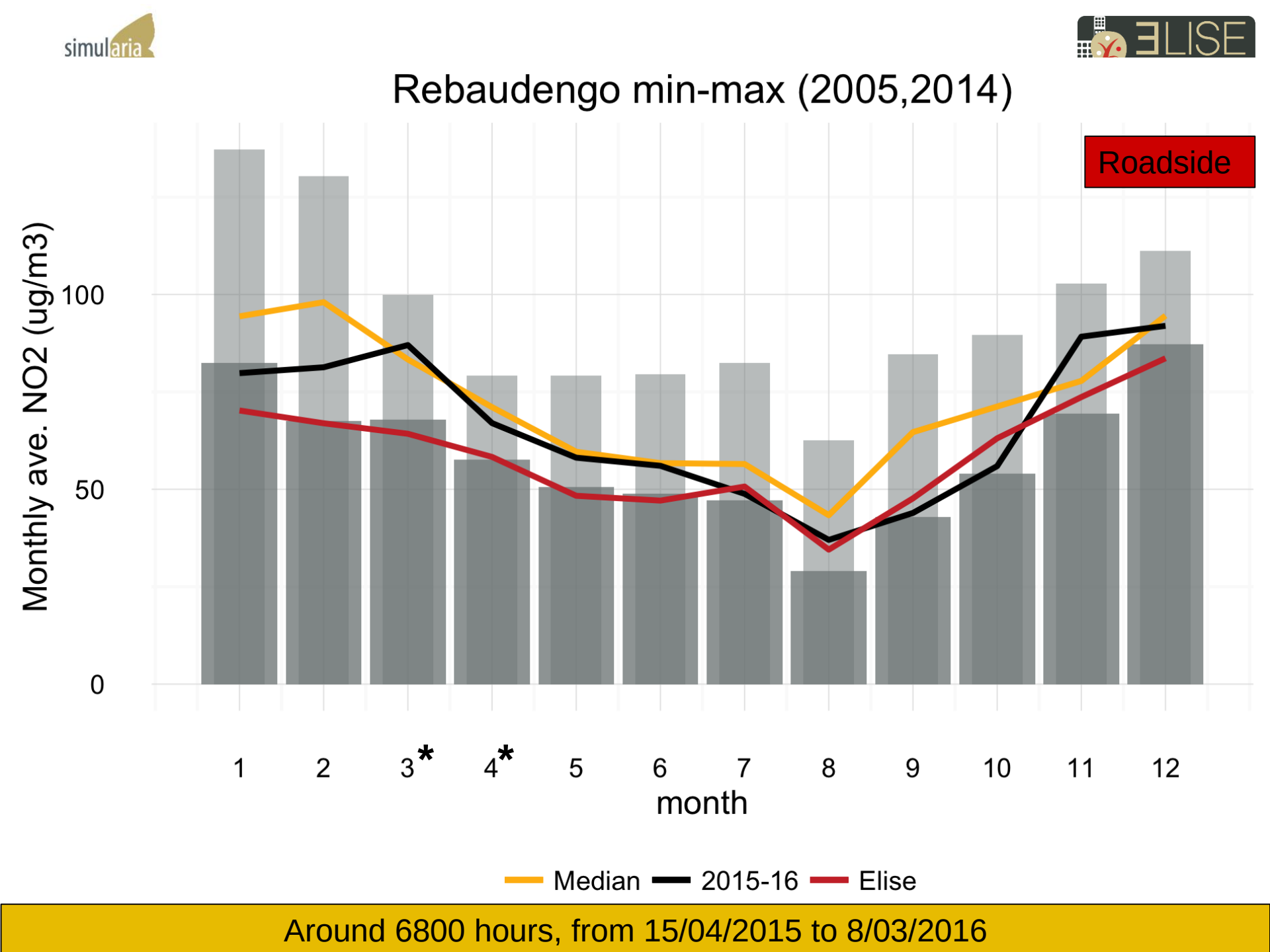
How realistic is our estimate of $NO_2$ hourly concentrations?

- Climatological
- Average behaviour
- Hour vs. hour

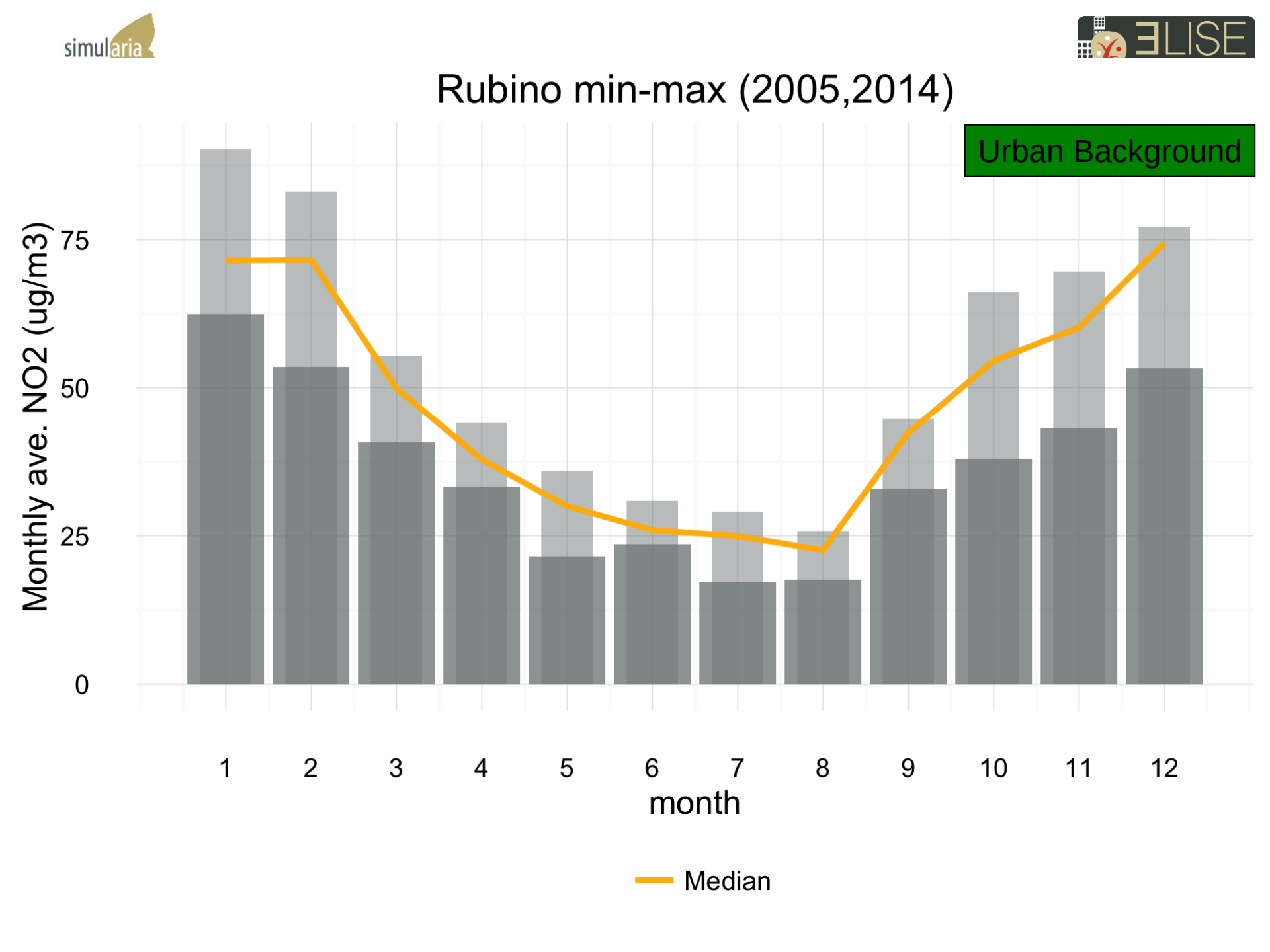

Rebaudengo min-max (2005,2014)
Roadside
Monthly ave. NO2 (ug/m3)
100
50
0
1
2
3
4
5
6
7
8
9
10
11
12
month
Median

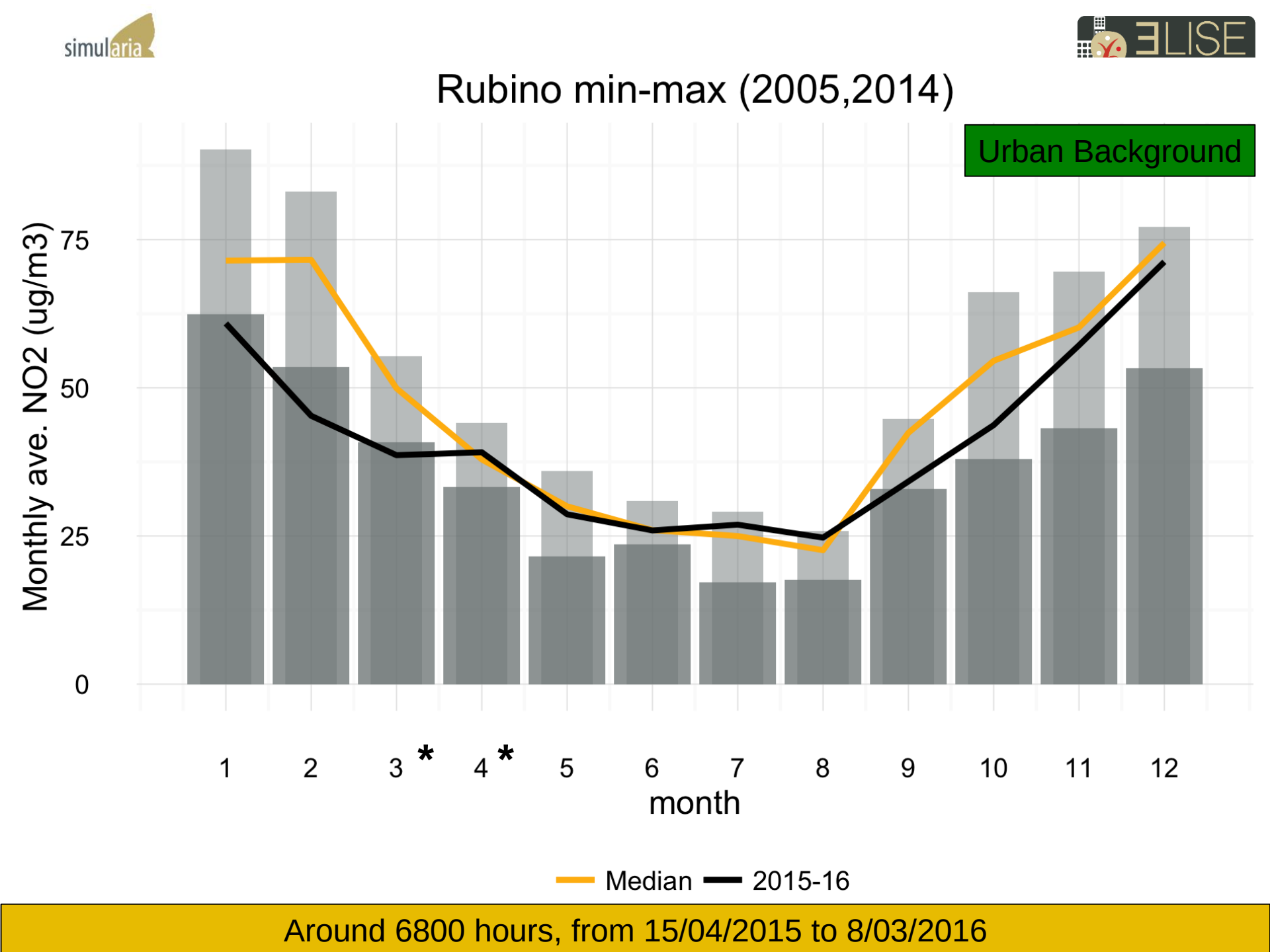



Around 6800 hours, from 15/04/2015 to 8/03/2016

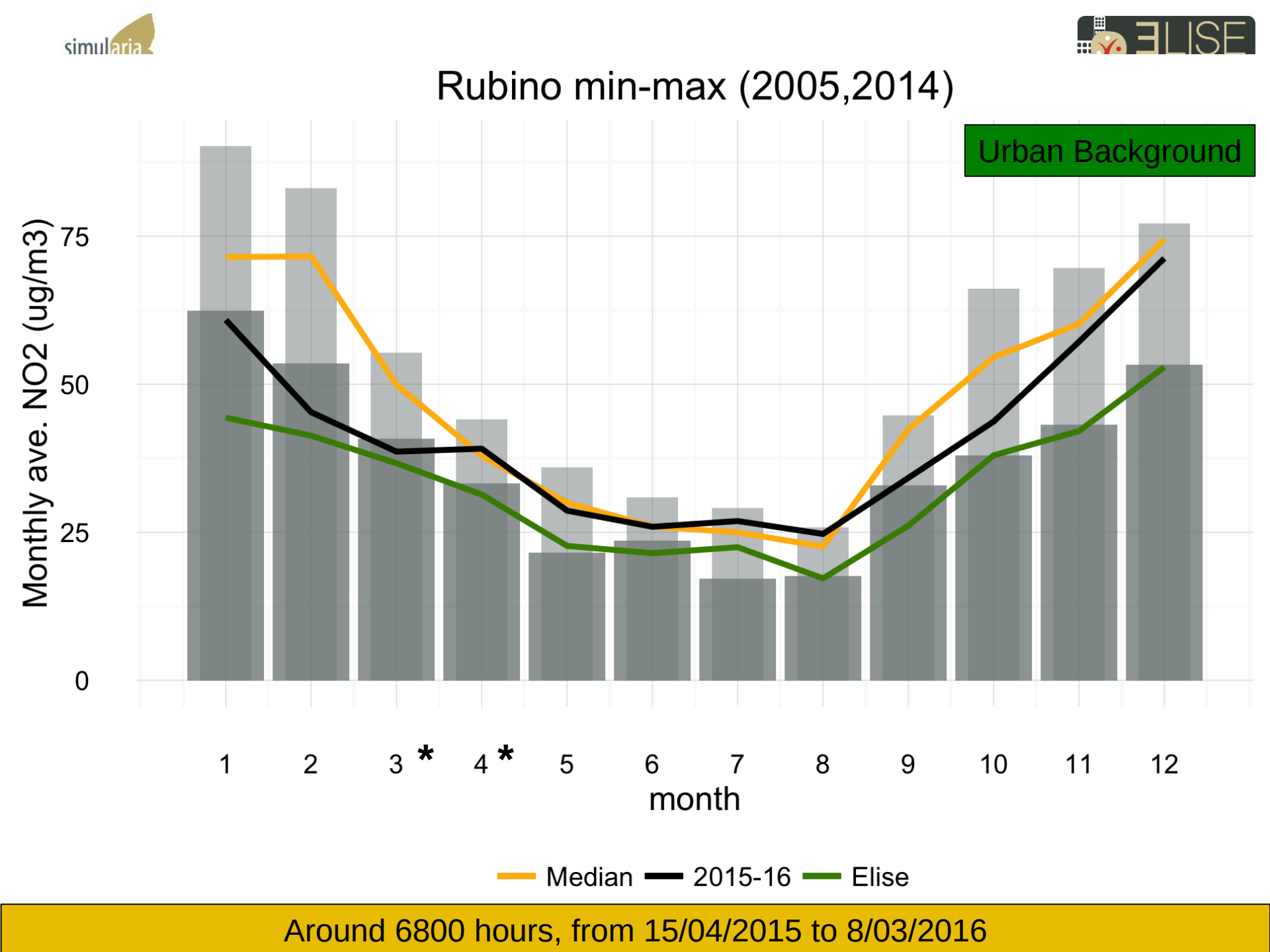



Around 6800 hours, from 15/04/2015 to 8/03/2016


Rubino min-max (2005,2014)
Urban Background
Monthly ave. NO2 (ug/m3)
0
25
50
75
1
2
3
4
5
6
7
8
9
10
11
12
month
Median



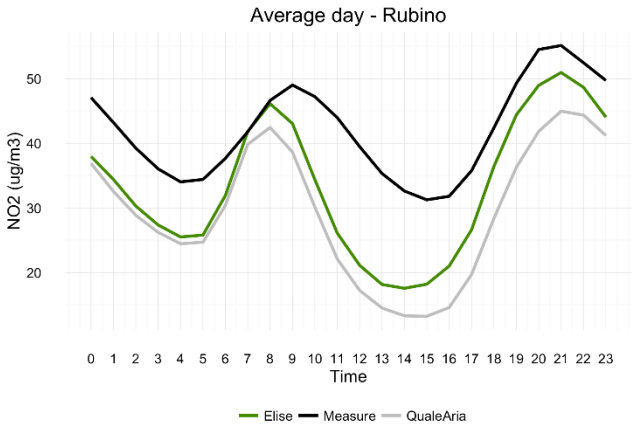

Around 6800 hours, from 15/04/2015 to 8/03/2016

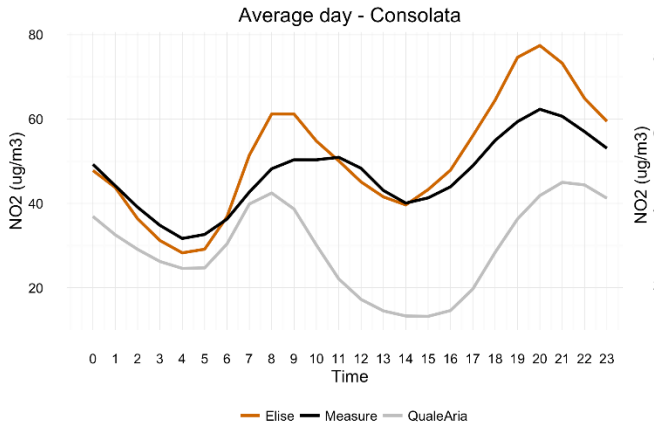


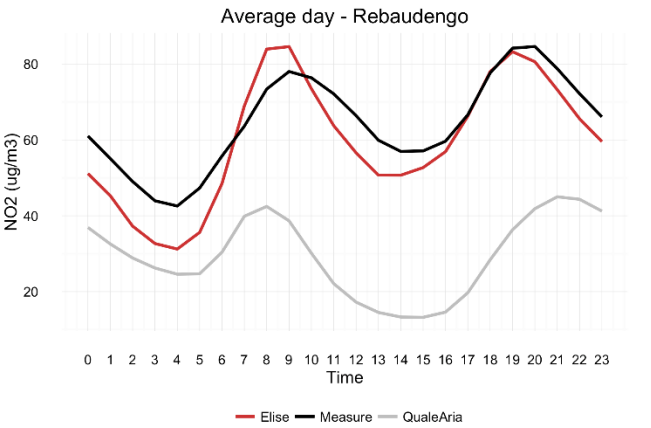

Around 6800 hours, from 15/04/2015 to 8/03/2016

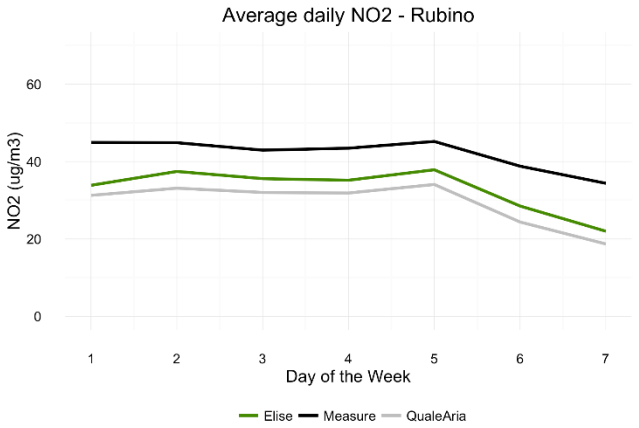
# How do we compare to measures?

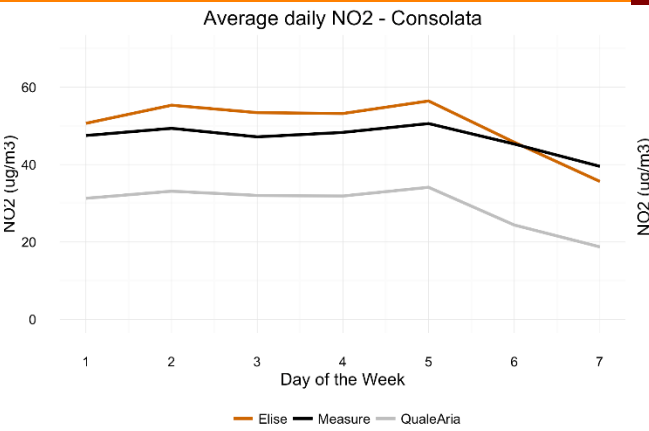
## Average day

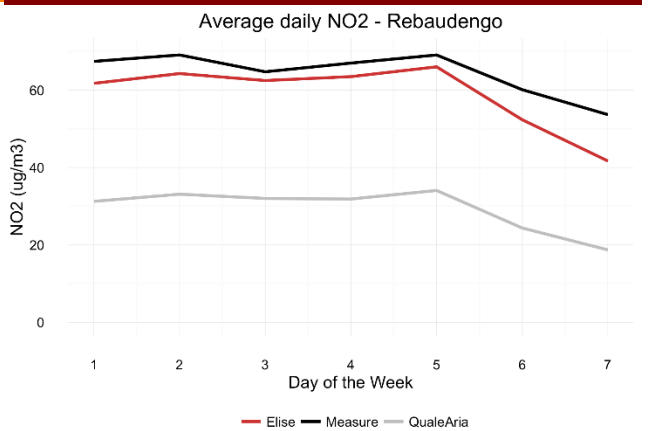


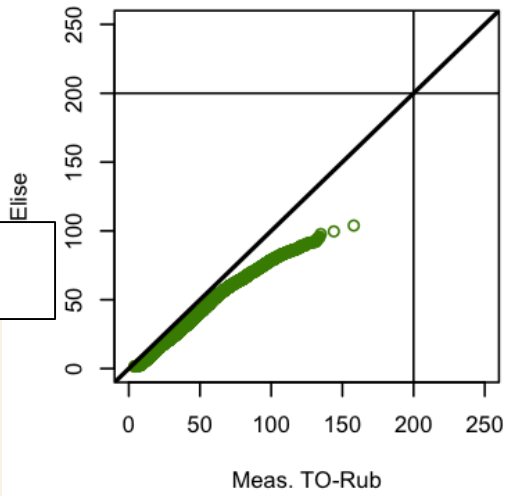



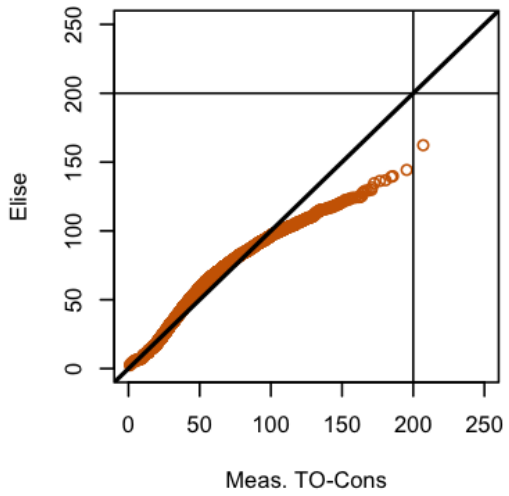

## Average week

# QQ-plot – $NO_2$

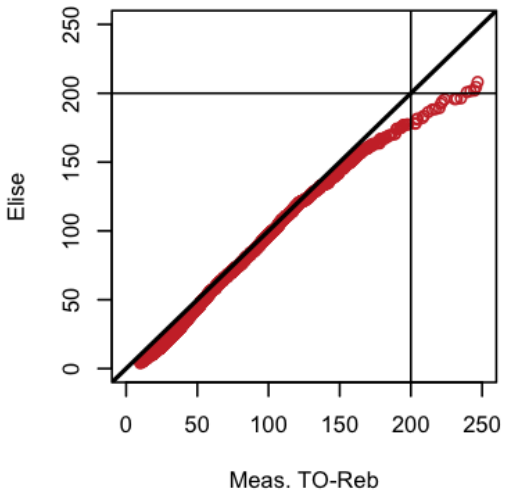
Elise




Urban Background

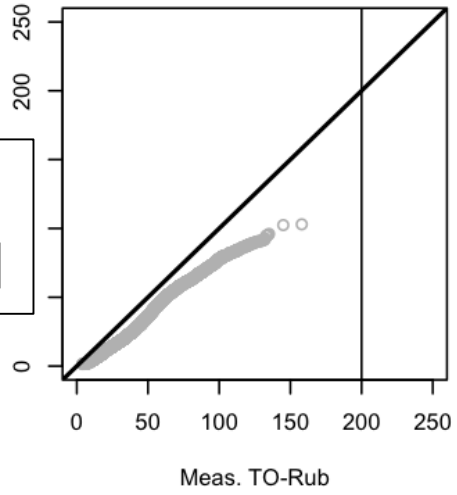


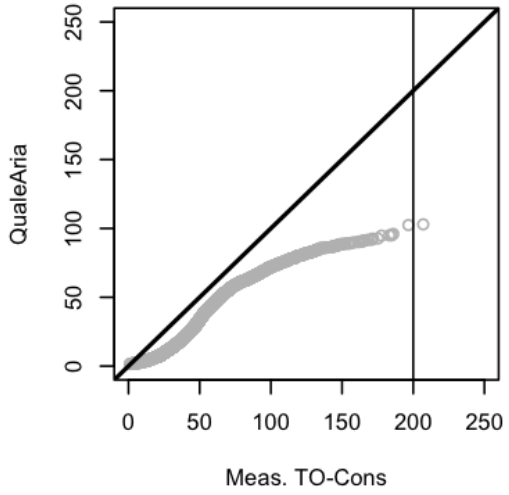

Roadside in LEZ

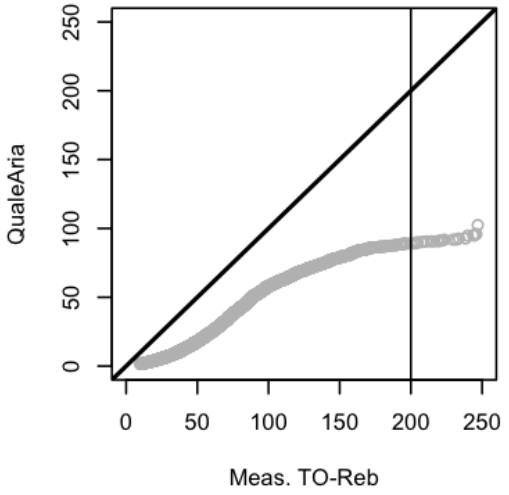



Roadside

Regional background

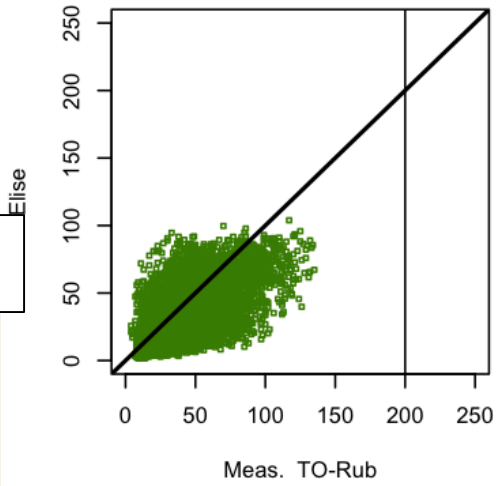


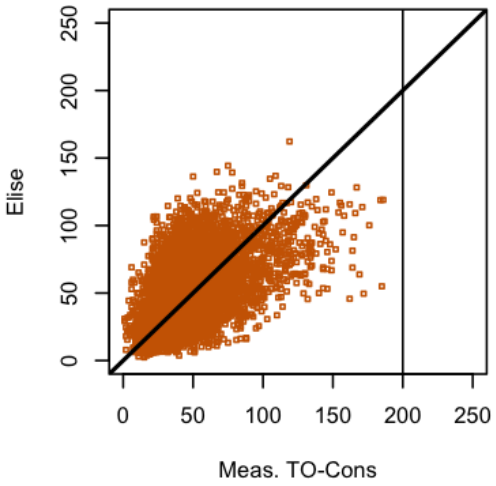



# Scatter plot – $NO_2$

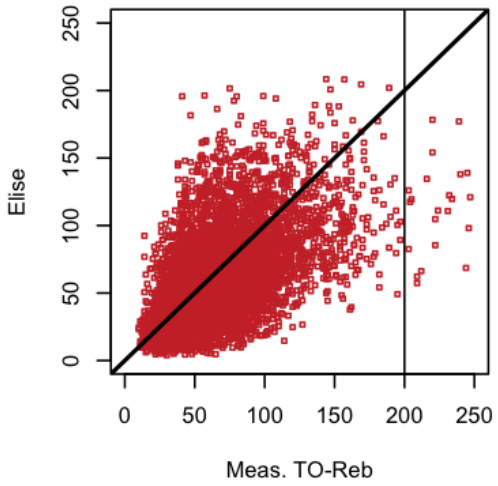
Elise




Urban Background

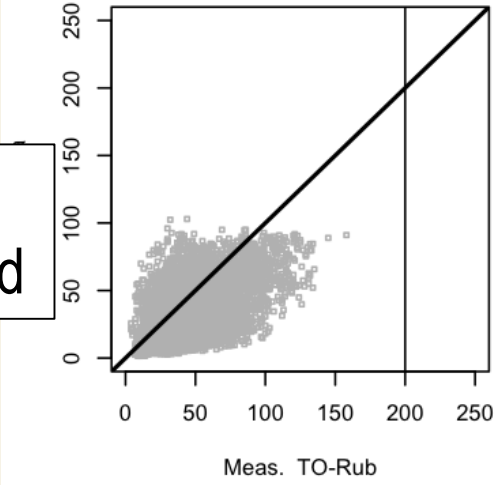


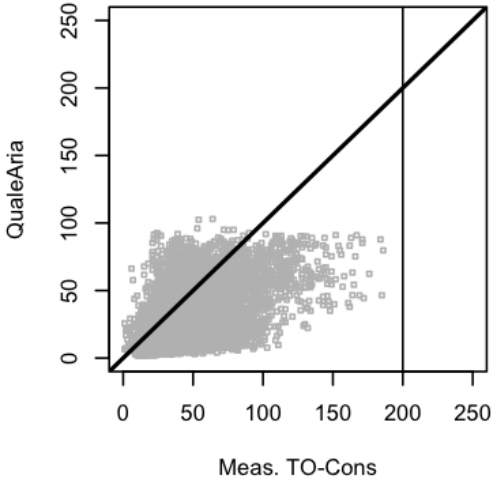

Roadside in LEZ

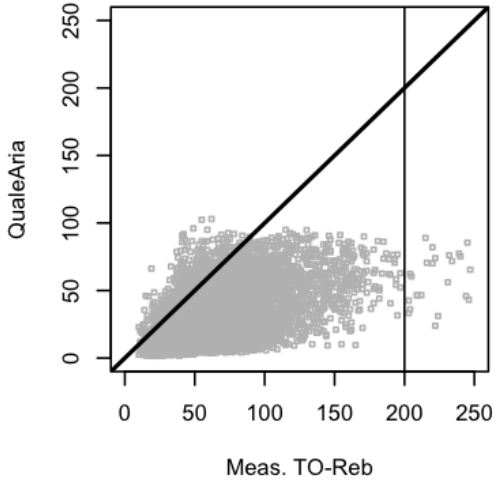



Roadside

Regional background



# Model evaluation $NO_2$ (15/04/2015 – 8/03/2016)

Roadside | Roadside in LEZ | Urban Backgr.

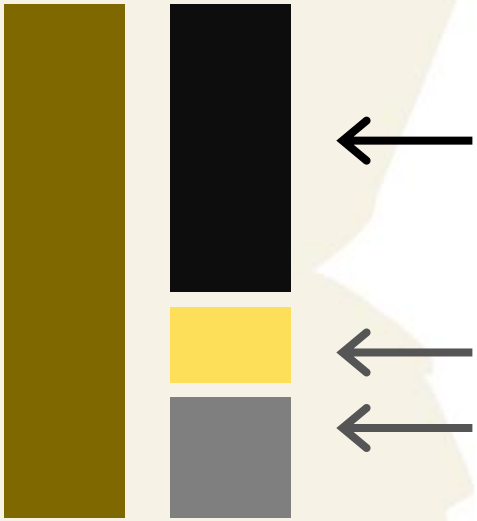
| | | Rebaudengo (UT) | | Consolata (UT) | | Rubino (UB) | |
|---|---|---|---|---|---|---|---|
| | Regional Background | Measure | Model | Measure | Model | Measure | Model |
| **Mean** | 29 | 65 | 59 | 46 | 50 | 42 | 34 |
| **Minimum** | 1 | 10 | 4 | 1 | 2 | 4 | 1 |
| **Maximum** | 95 | 247 | 208 | 186 | 162 | 135 | 104 |
| **1st Quantile** | 13 | 42 | 34 | 29 | 32 | 22 | 17 |
| **Median** | 23 | 59 | 54 | 41 | 48 | 37 | 29 |
| **3rd Quantile** | 42 | 82 | 77 | 56 | 66 | 56 | 48 |
| **Standard Dev.** | 20 | 32 | 33 | 24 | 24 | 24 | 21 |
| **Hours** | | 6673 | | 6734 | | 6473 | |
| **Bias** | | -5.5 | | 4.2 | | -8.1 | |
| **Normalised BIAS** | | -0.08 | | 0.09 | | -0.19 | |
| **AQ Directive Quality Objective [1]** | | -0.14 | | 0.11 | | -0.2 | |
| **Fractional Bias (FB)** | | 0.09 | | -0.09 | | 0.22 | |
| **Root-Mean-Square Error (RMSE)** | | 31 | | 23 | | 21 | |
| **Index of Agreement (IA)** | | 0.73 | | 0.73 | | 0.76 | |
| **Corr. Coeff. (R)** | | 0.55 | | 0.54 | | 0.61 | |

# Conclusions



ELISE has a good capability to reproduce spatial inhomogeneities in $NO_2$ levels typical of the urban environment with a very reasonable amount of resources requested to perform simulations

The model would probably benefit if an urban background were included, especially in winter months

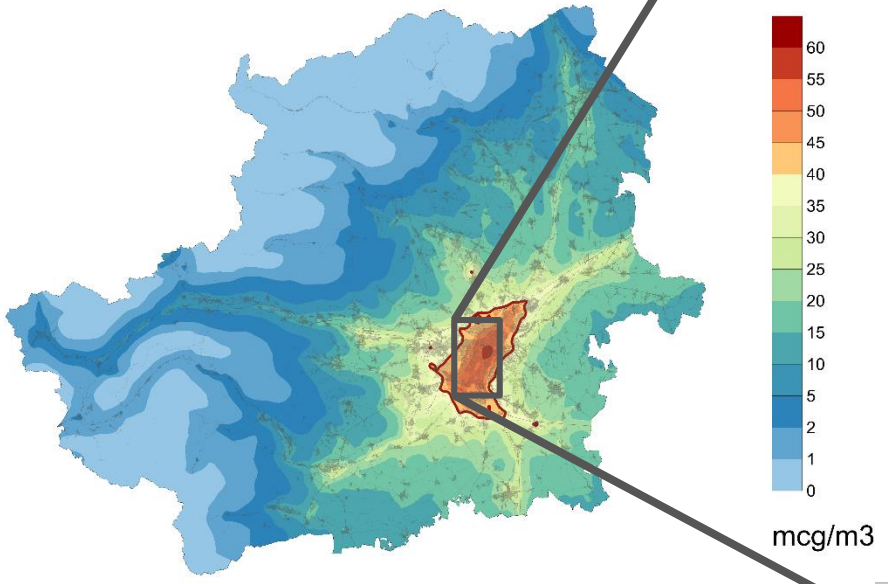


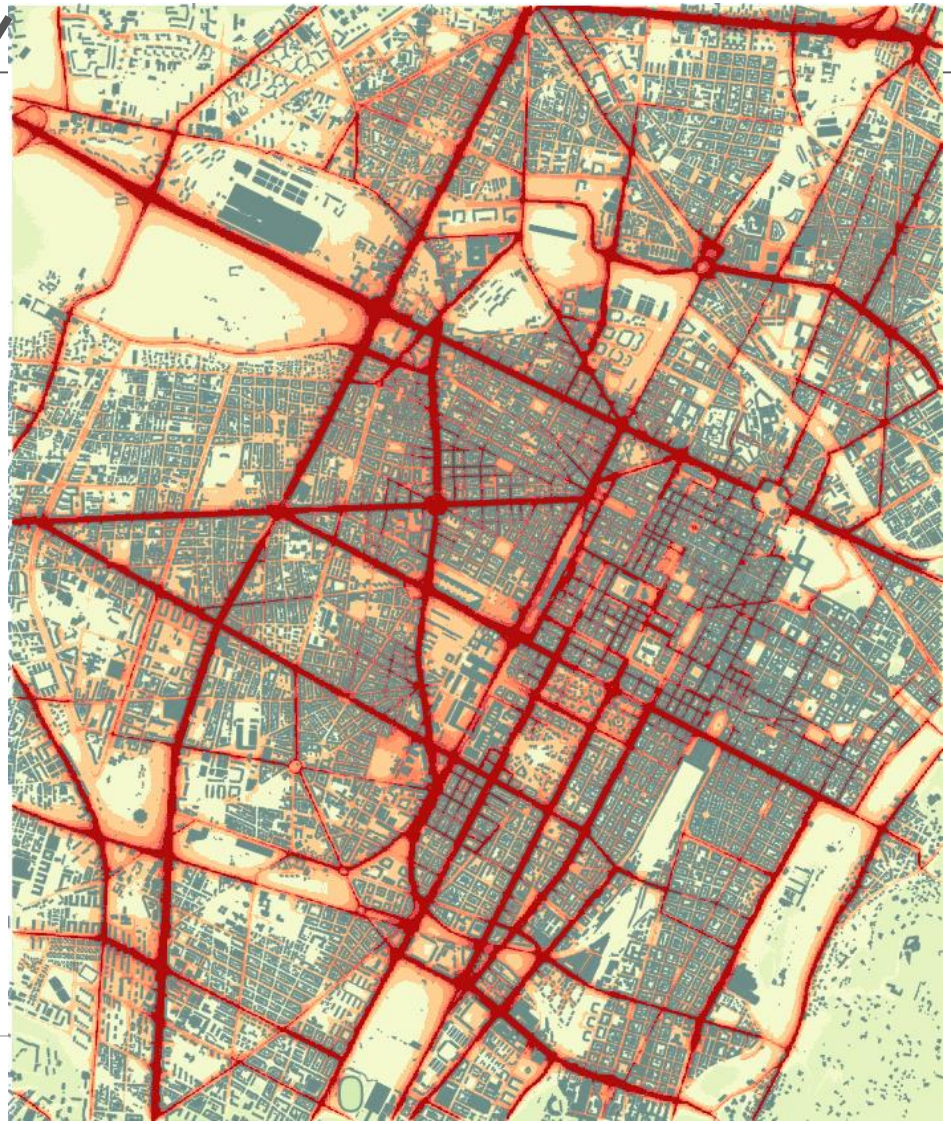
Roadside increment, microscale model: traffic emissions only

Background, URBAN scale model: all emissions

# Conclusions

Even if a sounder sensibility analysis is needed, we can already conclude that microscale modelling is necessary to successfully design air quality plans addressing traffic in cities



Thank you for your attention …

# Decision makers web portal - DDS