Spatial Representativeness of Spanish AQ Stations

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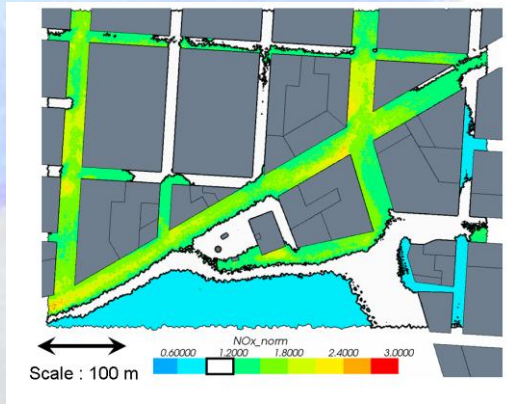
Introduction (1)

- Pollutant concentration data measured at monitoring stations needed for air quality assessment.
- How representative is a station?
- Spatial representativeness (SR) influenced by:
  - topography or obstacles,
  - air flows,
  - distribution of pollution sources,
  - averaging time and pollutant type.
- Methods for estimating the SR area of a station try to find out:
  - how the pollution is distributed around the station
  - which is the area where pollutant concentrations do not differ more than a certain percentage of measured one at the station site.

Introduction (2)

- Methods to estimate SR:
  - **Measurement campaigns** with many **passive samplers** distributed around station.
    - Advantage: Cheap, good pollution map.
    - Disadvantage: Only long term concentration averages.
  - **Surrogate indicators related to emission sources distribution**, but the effect of transport and dispersion of pollutants is not estimated.
  - **Climatic-topographic criteria**, recommended specially for rural background stations.
  - **Air quality models.**
    - Advantage: Effects of the emission sources distribution and atmospheric pollutant processes taken into account ➔ quite realistic pollution map.
    - Disadvantage: Computational burden.

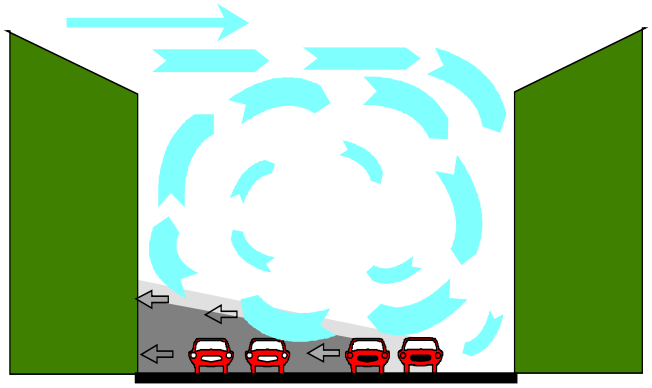


Representativeness studies in CIEMAT

- Station representativeness for air quality assessment.
- Using modelling.
- Two types of stations:
  - **Urban (traffic) stations** using CFD model simulations (for several months) *(Santiago et al, Science of Total Environment, 2013)*
  - **Rural background stations** using annual (2008-2010) CHIMERE simulations combined with observations *(Martín et al., 2013, HARMO15 and submitted for publishing in Atmos. Pol. Research)*

Representativeness of urban stations

- Urban air quality assessment is an important part of urban air quality management.
- Usually based on a network of urban monitoring stations.
- Urban morphology with atmospheric processes:
  - complex flow field
  - strong spatial heterogeneities of pollutant concentration patterns
- Spatial representativeness of point measurements is very limited
- Very difficult to catch this heterogeneity.
- Increase the number of stations:
  - very expensive
  - often not possible in practice.



Representativeness of urban stations

- **To estimate the spatial representativeness of the urban air quality stations.**
  - Maps of areas of similar concentration to that measured in the AQ station.
- How? ➔ Using the **RANS-CFD models**.
  - Disadvantage ➔ computational time that prevents unsteady simulations for large time periods.
- Other option? ➔ Steady-state simulations of representative cases and averaging the results.
  - Less computationally expensive.

Description of Methodology

- Steady simulations for meteorological scenarios: every wind direction (16 wind directions: N, NNE, NE, …) with a passive tracer emitted from each street. (*Parra et al., 2010, Atmospheric Environment*) or for some wind speed cases.
- Averaged tracer concentration maps computed by applying weighted average of steady simulations taking into account how frequent are the scenarios.
- Due to the linearity of the conservation equation of the passive scalar, the concentration at every hour is

$$C(\vec{x}) = \sum_i C_i(sector) \cdot A \frac{N_i}{v_{in}(t)}$$

$$A = f(car_{speed}, car_{emission}, L_{street}, V_{source})$$

Where N_i is the number of cars passing in road i, and $v_{in}(t)$ is the inlet wind speed at that hour.

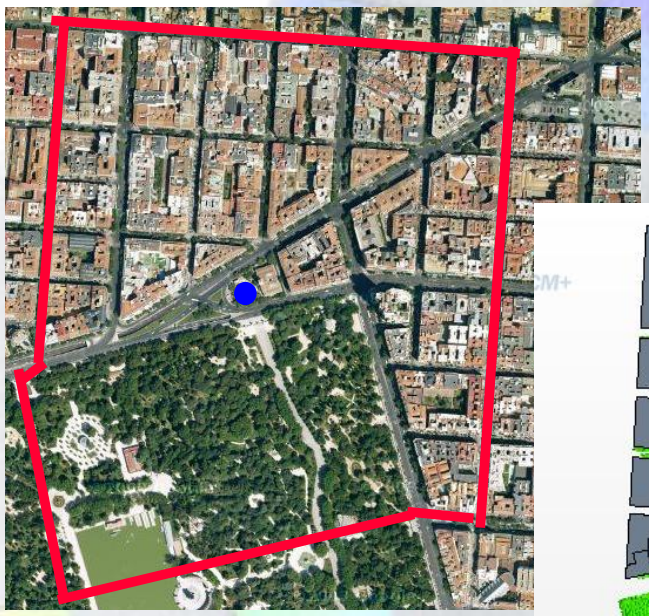
Methodology: Assumptions

- Pollutants must be non-reactive or at least for the time period studied pollutants should be little influenced by atmospheric chemistry
- Thermal effects negligible in comparison with dynamical effects.
- Emissions inside each street at a selected hour proportional to traffic intensity at that hour.
- Emissions modelled as a line source inside each street and several tracers (one for type of street).
- Tracer concentration at certain hour only depending on emissions and meteorological conditions at that hour.

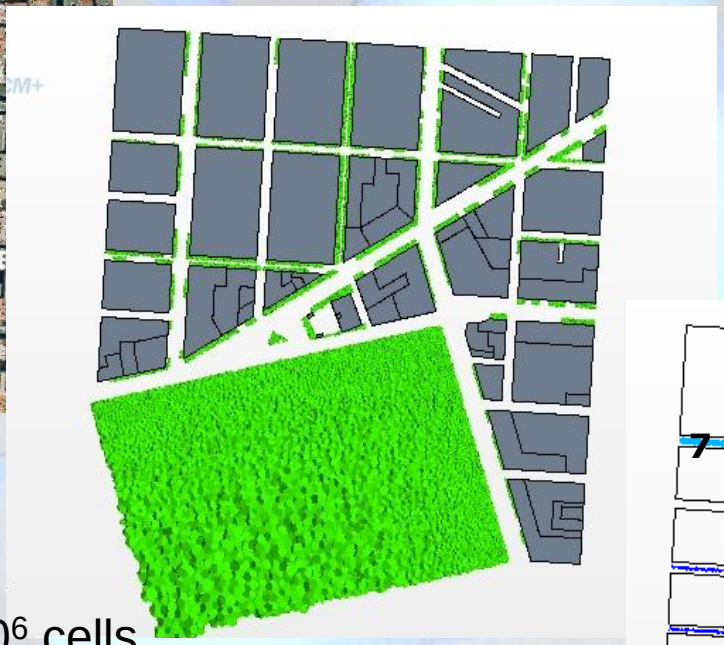
Representativeness of urban stations

- Estimated representativeness area in two traffic oriented stations in Madrid:
  - Escuelas Aguirre (EEAA)
  - Plaza de Castilla (Pza Castilla).
- Other potential locations close to the stations has been explored to get better locations for stations.

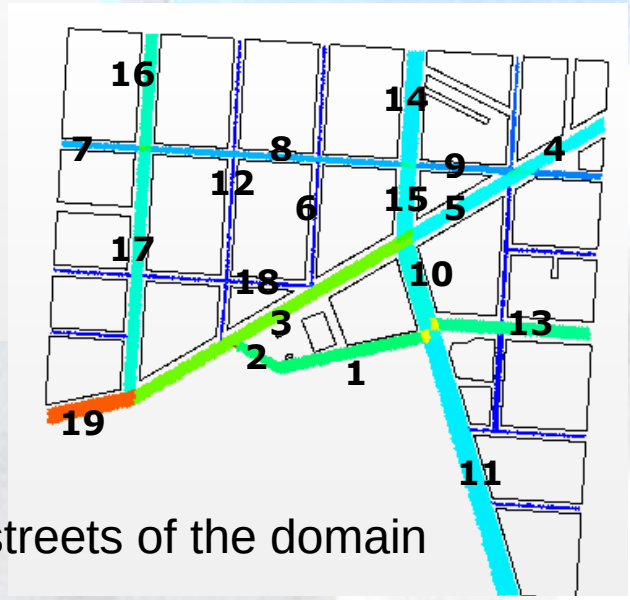
Traffic station - close to an urban park - Madrid



Max high buildings = 90 m
Most between 18-24 m
Size of simulated area 700x800 m^2



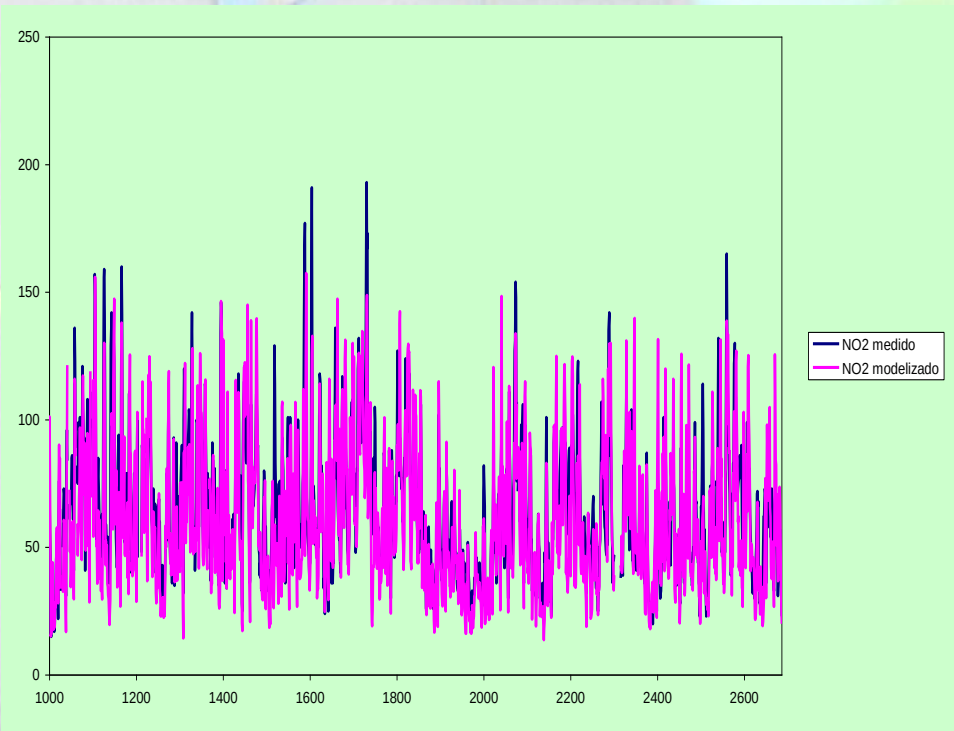
Irregular mesh of $3 \cdot 10^6$ cells
resolution of about 1m-3m close to the buildings

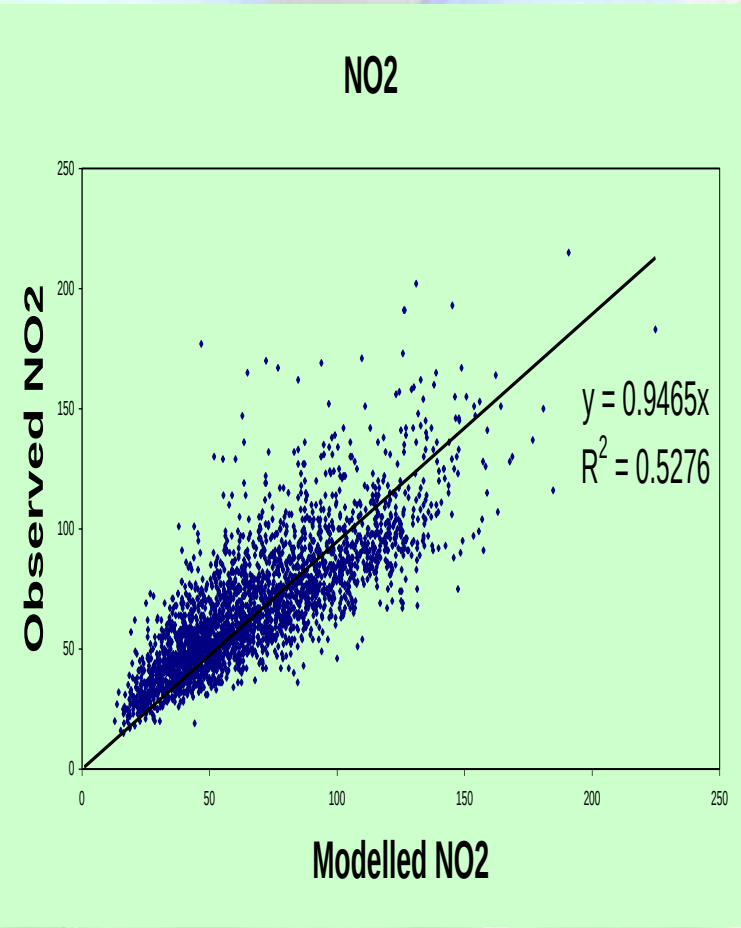


Relative traffic intensity in the main streets of the domain

Traffic station - close to an urban park - Madrid

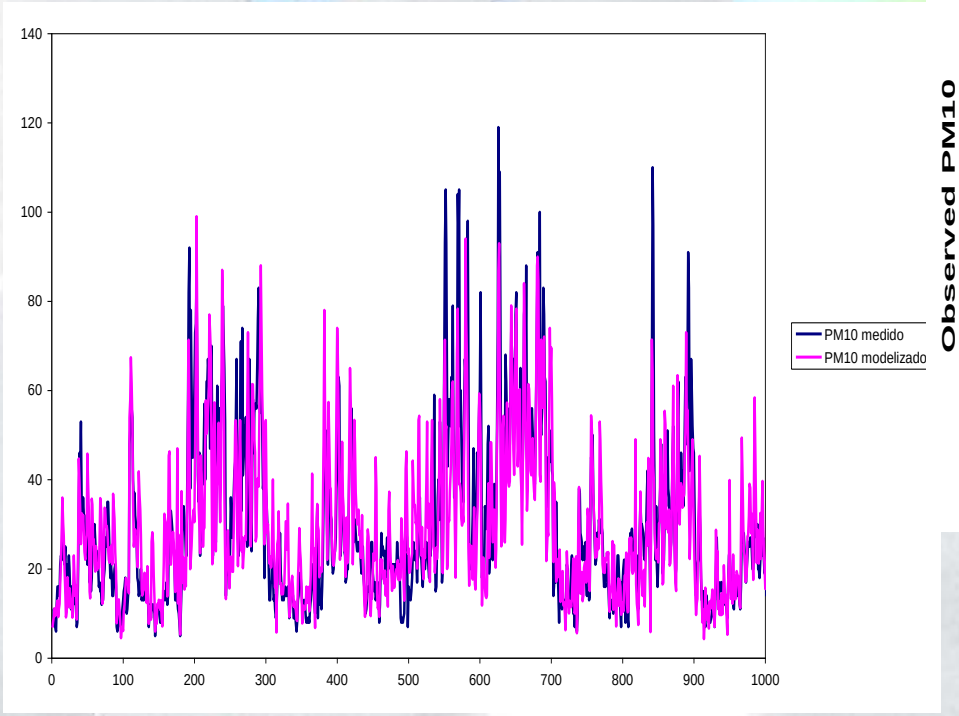
- The simulated period was January-May 2011.
- Comparison with observed data at AQ station for hourly data for NO_2.

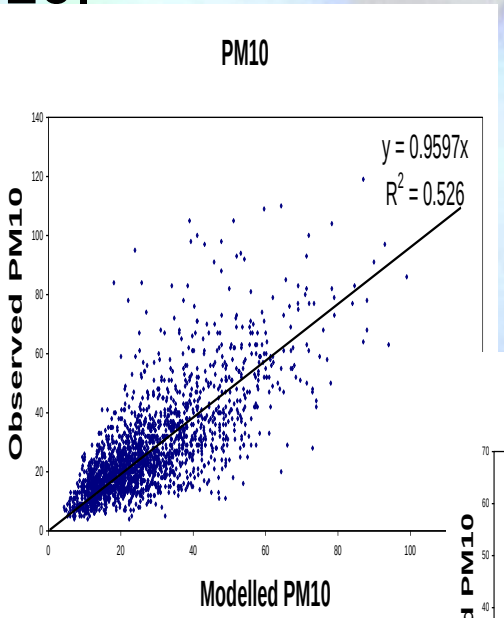


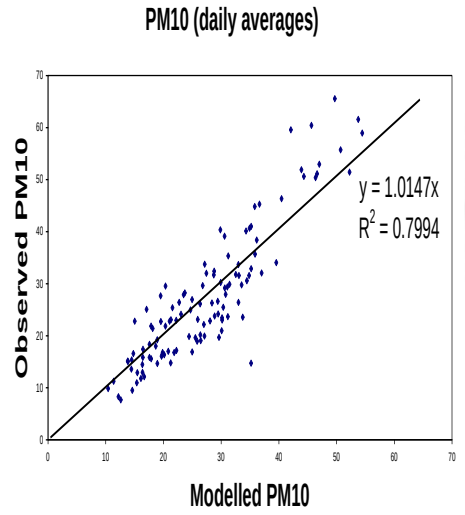


Traffic station - close to an urban park - Madrid

- The simulated period was January-May 2011.
- Comparison with observed data at AQ station for hourly and daily mean data for PM10.



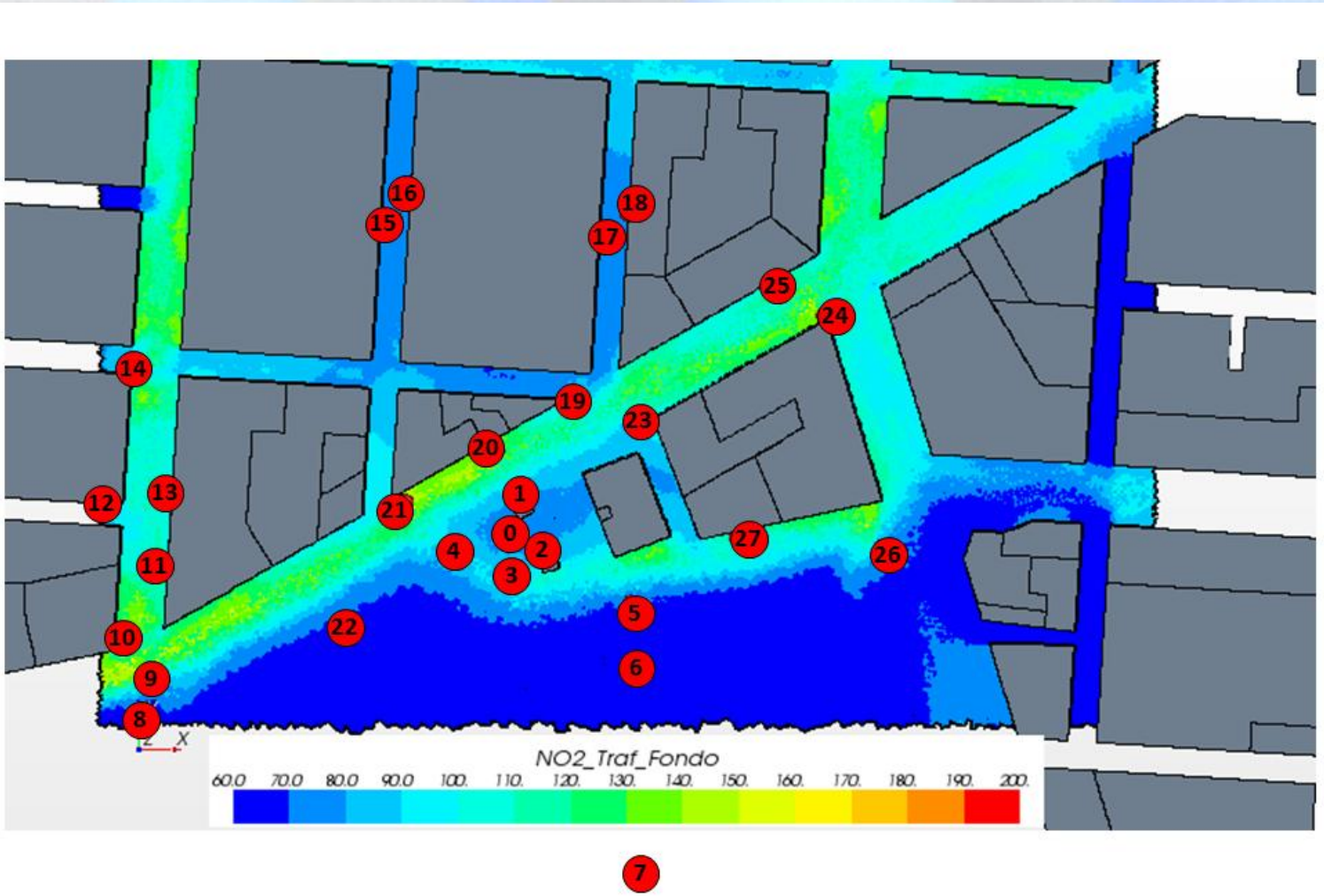




Comparison with data of passive samplers

Deployed by ETSII-UPM-Madrid

NO_2, January 26th – February 16th, 2014



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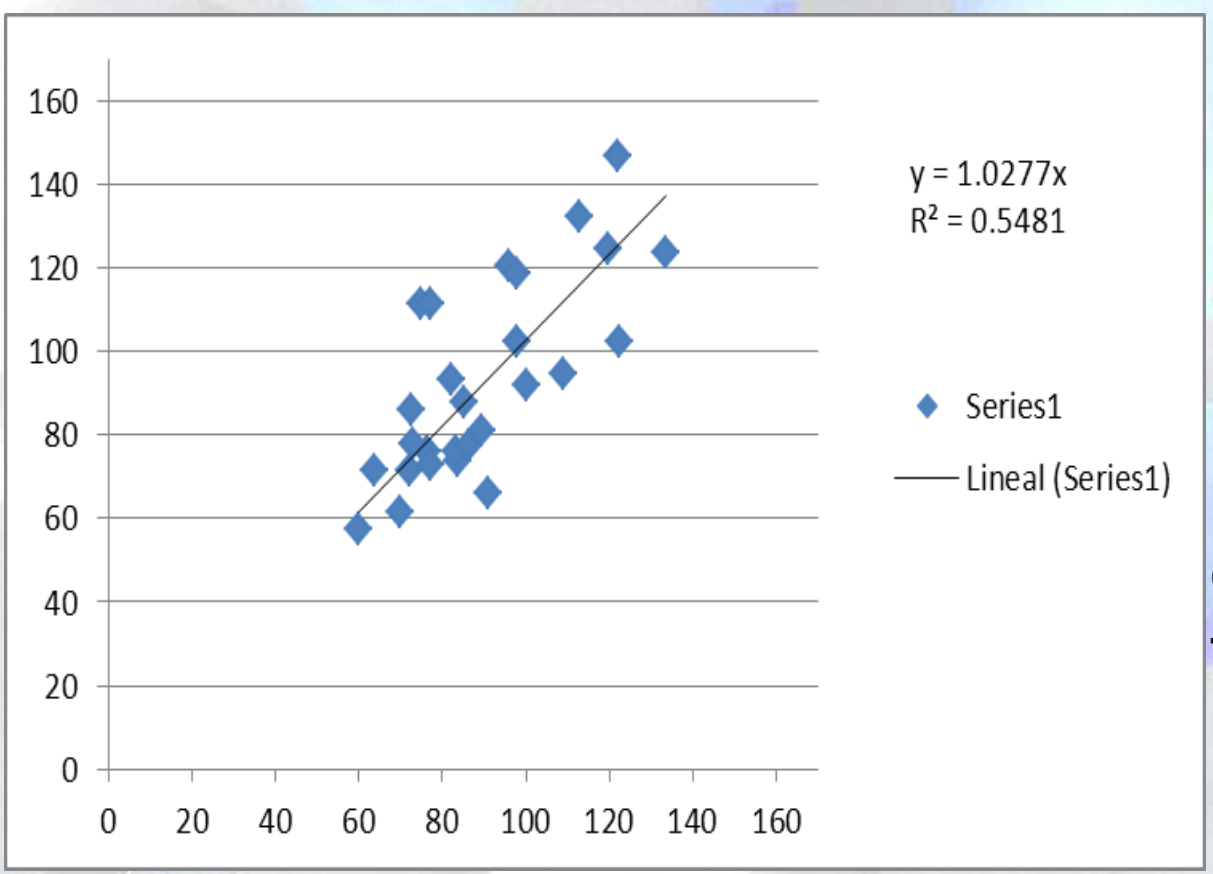
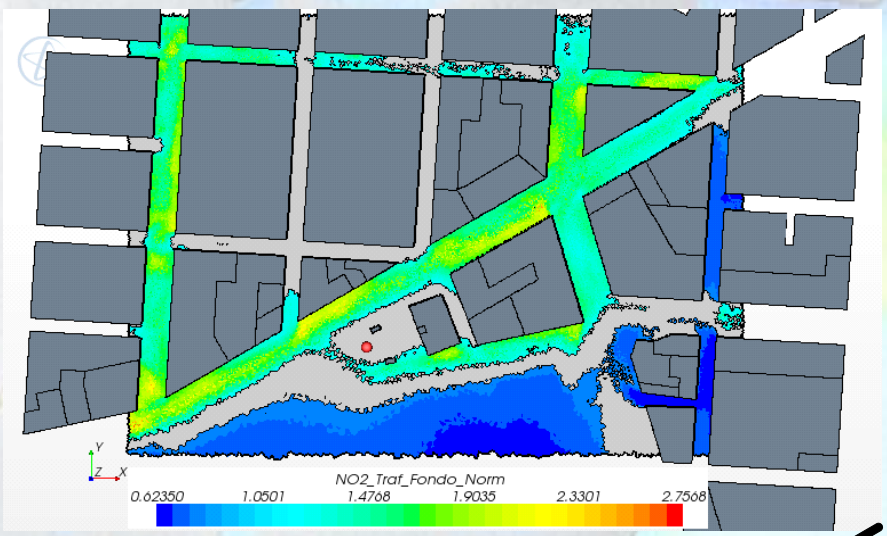


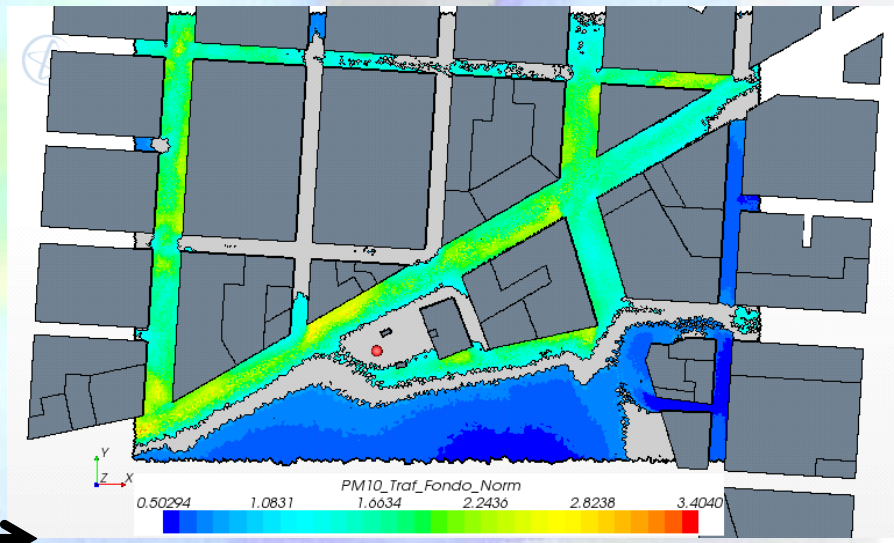
BIAS	**-2,063**
ERROR-ABS	**14,345**
RMS	**21,741**
NMB	**-0,022**
NMAE	**0,155**
MFE	**0,148**
MFB	**-0,025**
CMRSE	**21,643**
TARGET	**0,977**
BNMBF	**-0,023**
ENMAEF	**0,158**
FAC2	**0,963**

Traffic station - close to an urban park - Madrid

Results related to average concentrations January-May 2011:

- Averaged NO_2 and PM10 concentration maps





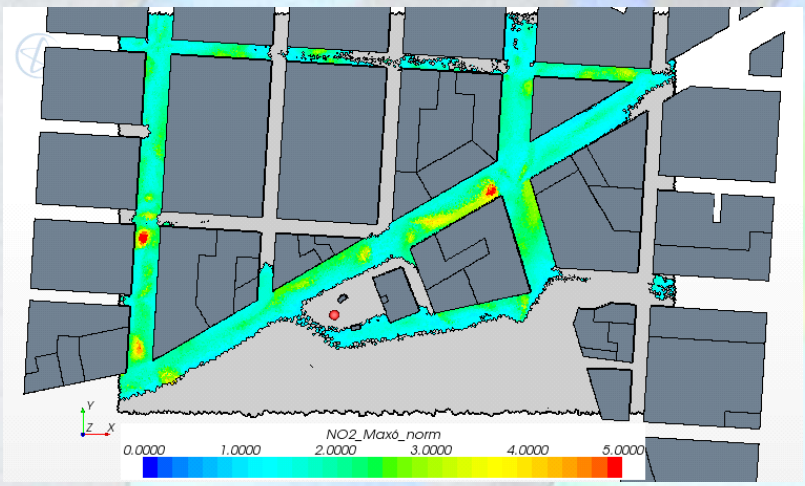
Scale: 100 m

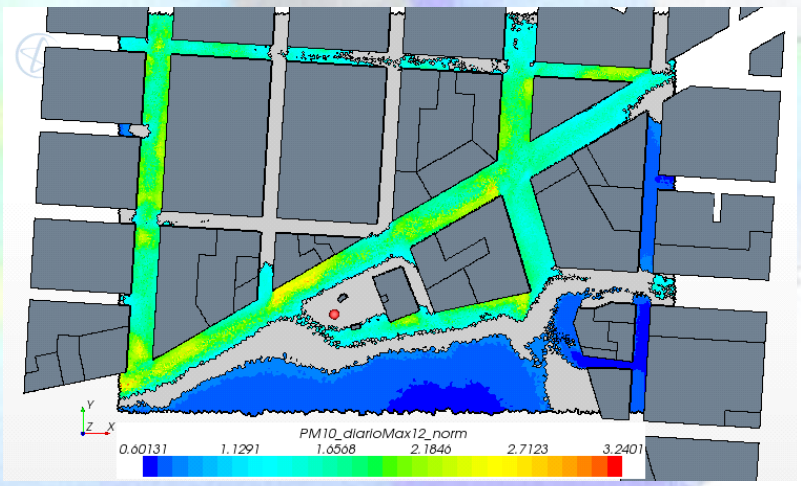
Mean concentration map normalized by concentration at station location (red dot) for NO2 (left) and PM10 (right). Grey shows the area with concentrations into ±20% around the station concentration.

Traffic station - close to an urban park - Madrid

Results related to probability of exceed limit values January-May 2011 :

- Percentile 99.8 hourly NO_2 and 90.4 daily PM10 concentration maps



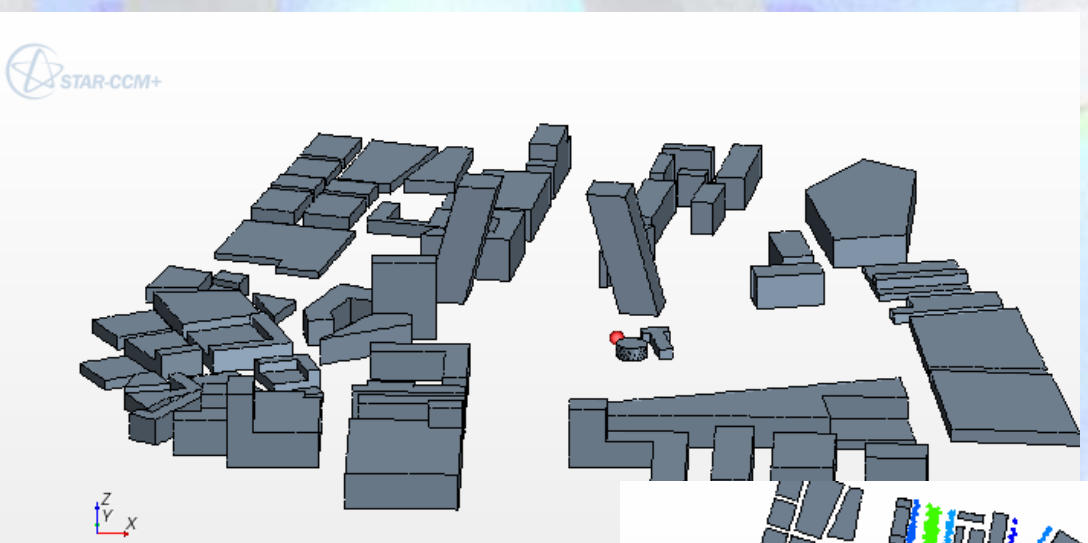


Scale: 100

Concentration map normalized by concentration at station location (red dot) for 99.8 percentile of hourly data of NO2 (left) and 90.4 percentile of daily data of PM10 (right). Grey shows the area with concentrations into ±20% around the station concentration.

Traffic station in a square in Madrid (Plaza Castilla)

Open area with high buildings
Size of simulated area 1km x 1km



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resolution of about 1m-3m close to the buildings

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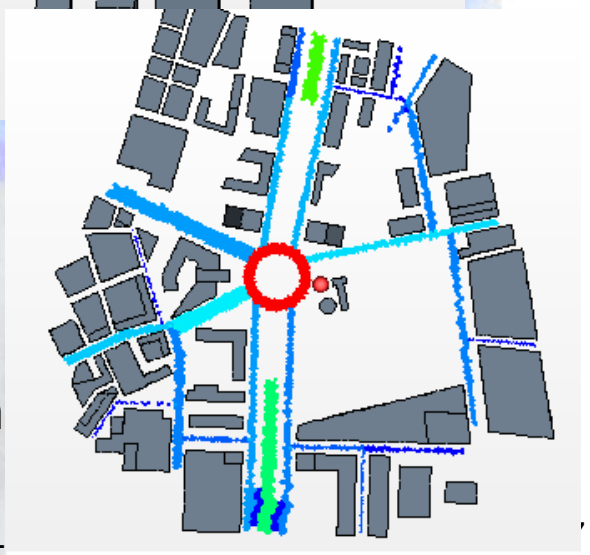

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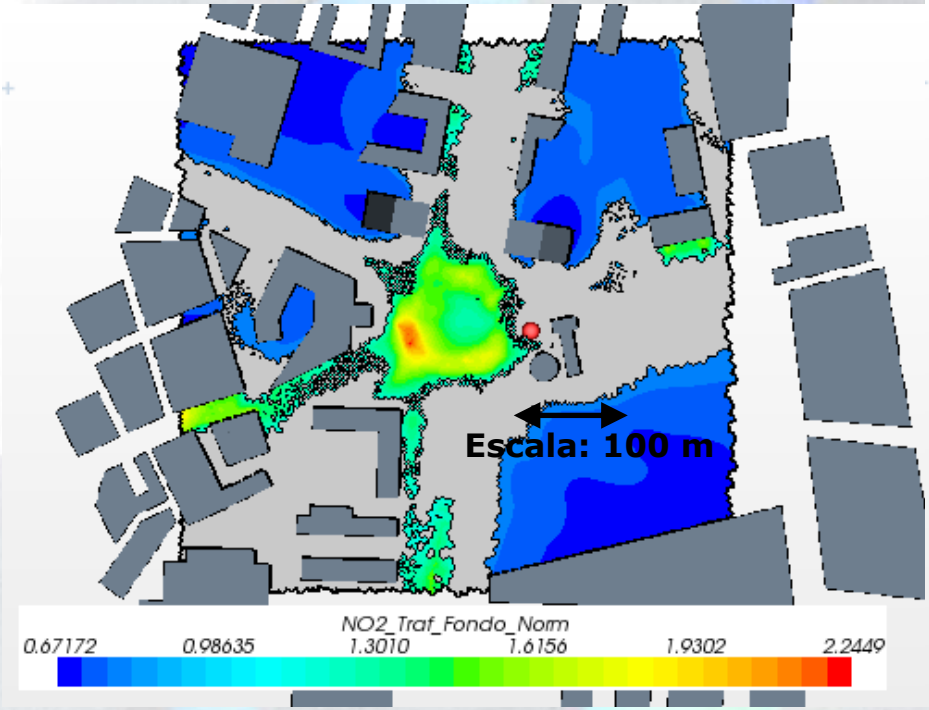
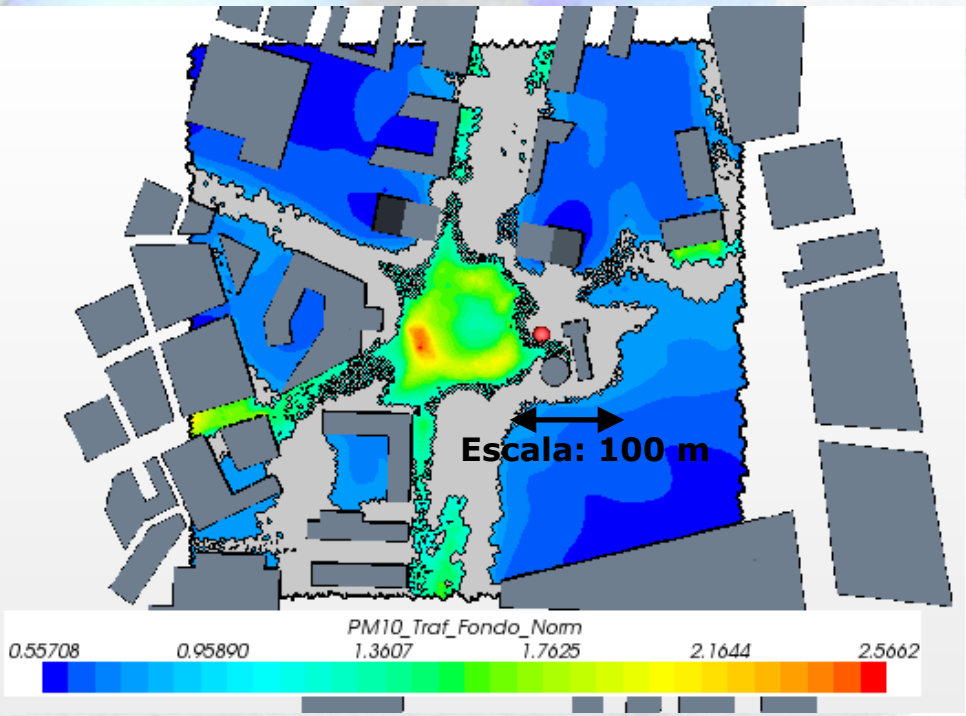
Results related to average concentrations January-May 2011:

- Averaged NO_2 and PM10 concentration maps





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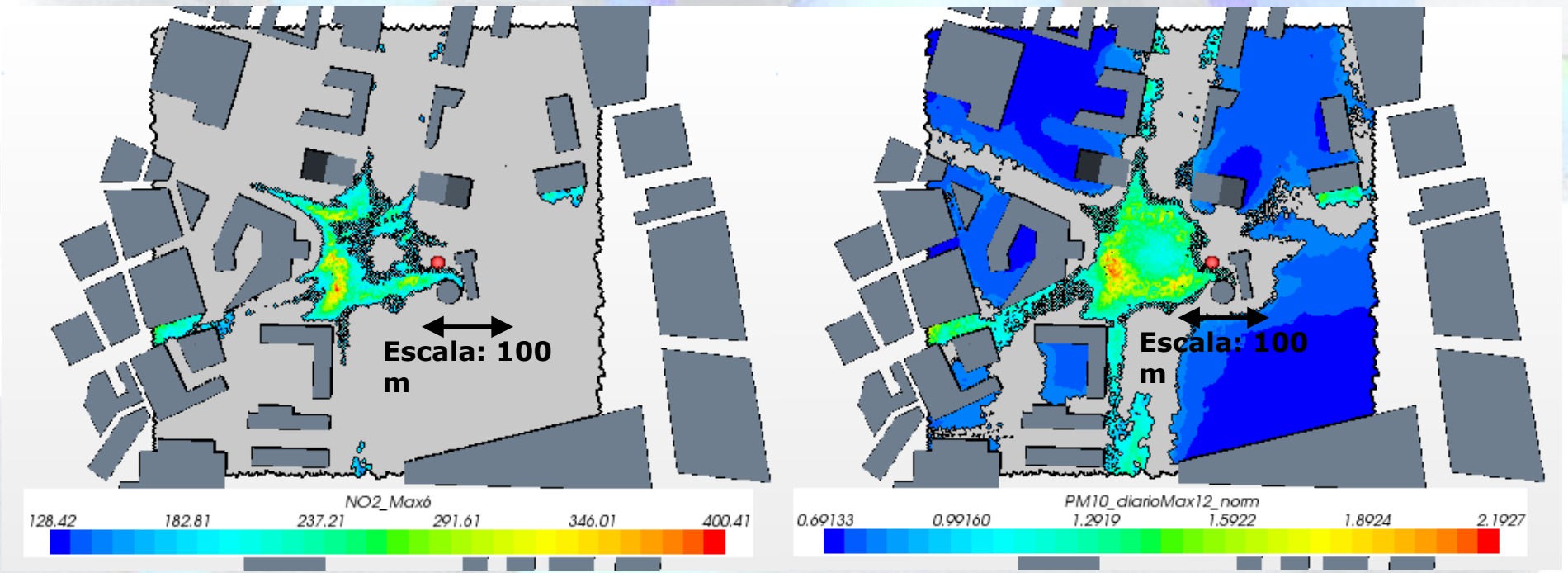

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Macroscale siting of sampling points Directive 2008/50

1. **Protection of human health**

(a) Sampling points directed at the protection of human health shall be sited in such a way as to provide data on the following:

– the areas within zones and agglomerations where the highest concentrations occur to which the population is likely to be directly or indirectly exposed …

– levels in other areas within the zones and agglomerations which are representative of the exposure of the general population;

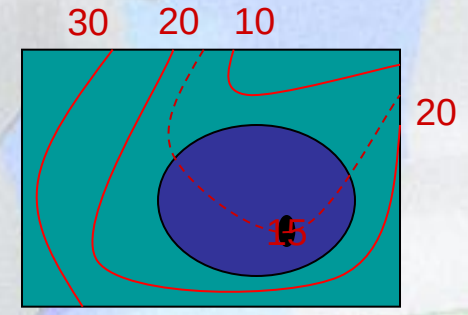
(b) Sampling points shall in general be sited in such a way as to avoid measuring very small micro-environments in their immediate vicinity, which means that a sampling point must be sited in such a way that the air sampled is representative of air quality for a street segment no less than 100 m length at traffic-orientated sites and at least 250 m x 250 m at industrial sites, where feasible;

Representativeness Index

AR=100 (Ra / Da)

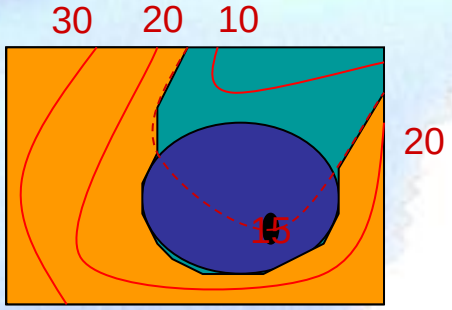
Ra= representativeness area

Da= domain area



ANRmayor= 100 (NRahc /Da)

NRahc = Non-representativeness area with concentration > station concentration



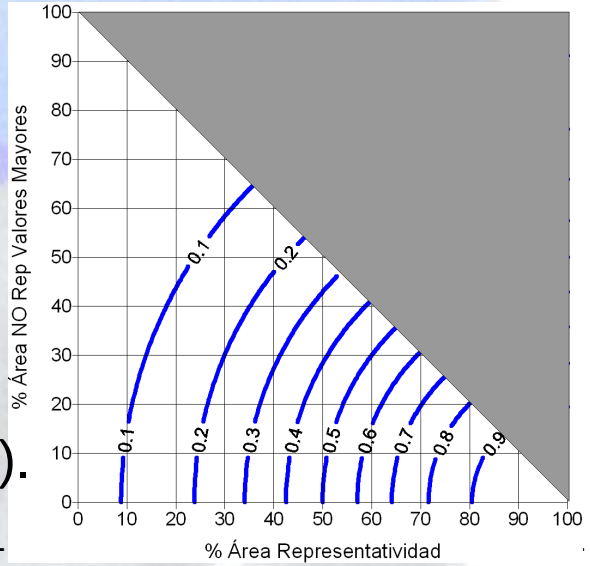
$$IR = e^{-\left[\frac{AR-100}{2\sigma_x}^2 + \frac{ANRmayor}{2\sigma_y}^2\right]}$$

$\sigma x = \sigma y = 42.48$ ➔ circular isolines of *IR*

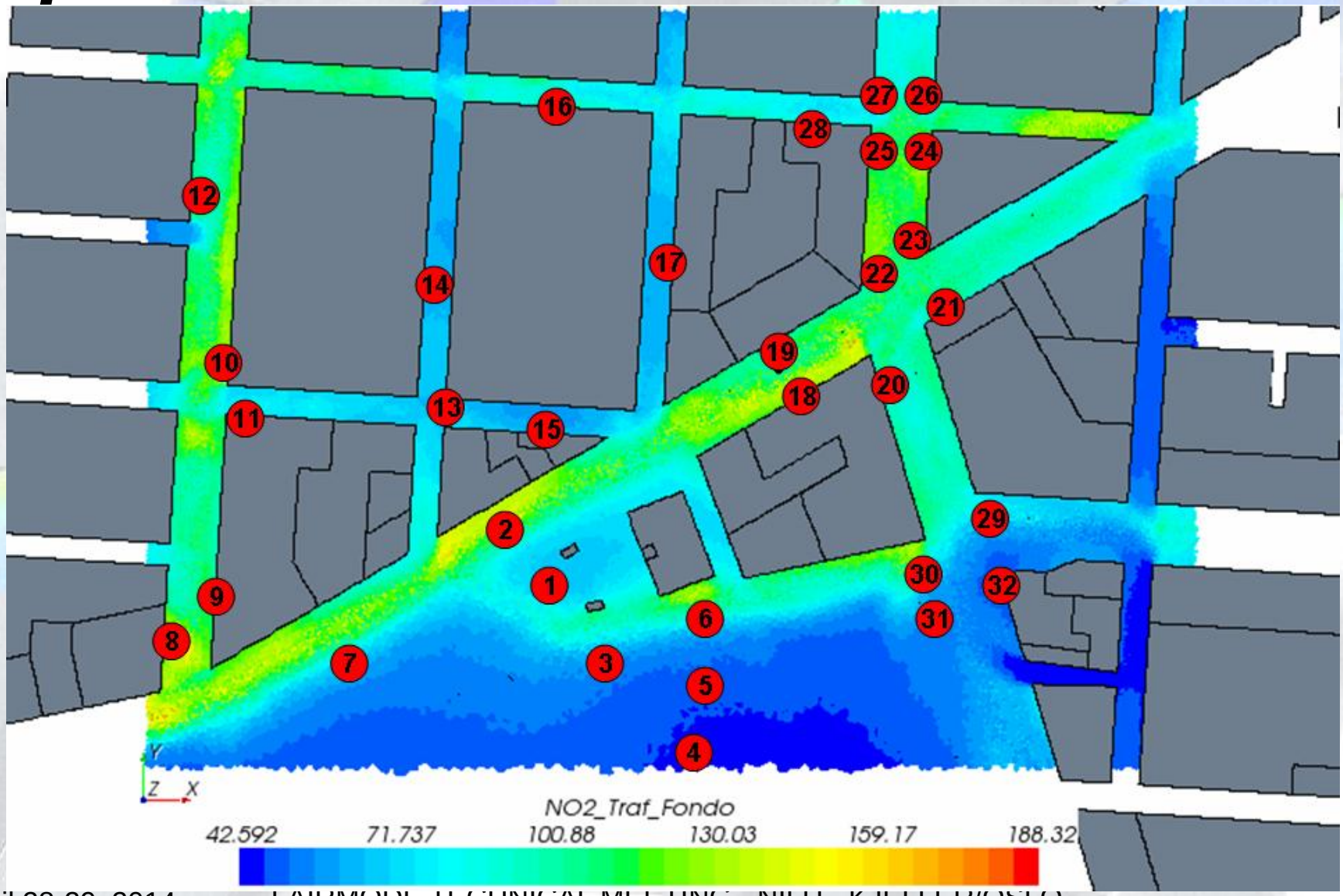
IR ranges 0-1,

AR = 50% and *ANRmayor* = 0% ➔ *IR* = 0.5.

if *IR=1* ➔ *AR=100* and *ANRmayor=0* (perfect station).



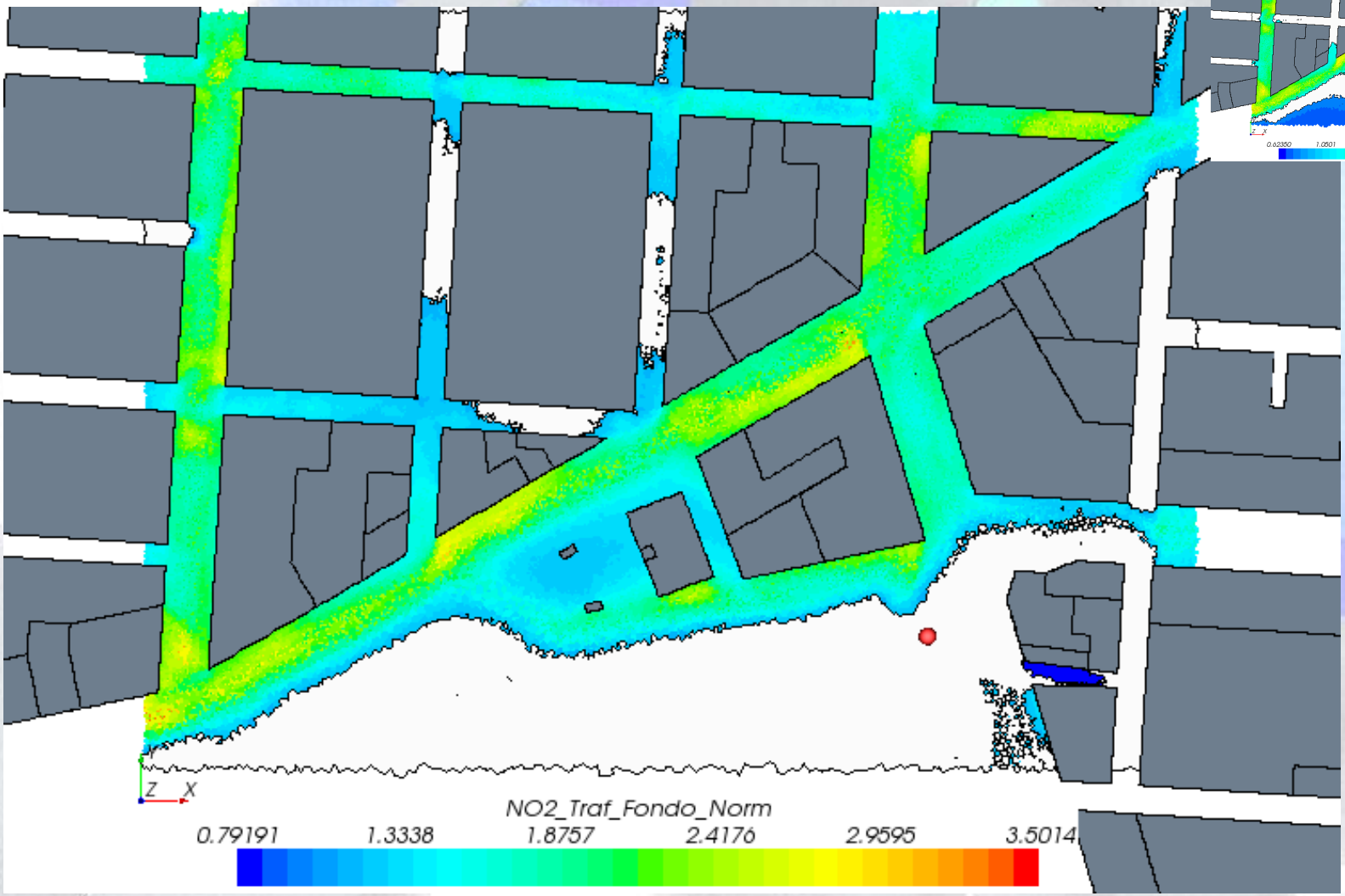
Representativeness of other potencial locations. EEAA Area

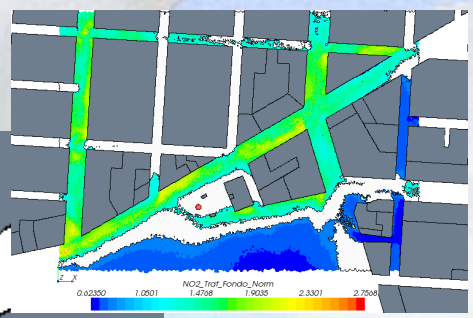


Representativeness of other potencial locations sorted by AR. EEAA area

Posición	Conc	% *AR* rectángulo	% *ANRmayor* rectángulo	% *ANRmenor* rectángulo	*IR*
31	53.8	39	60	0	0.13
3	53.6	39	61	0	0.13
17	62.9	38	48	14	0.18
15	63.2	37	48	15	0.18
14	63.3	37	47	16	0.18
26	96.4	36	10	54	0.31
19	103.4	36	5	59	0.32
20	95.5	36	11	53	0.31
12	103.6	36	53	11	0.15
27	93.7	36	13	52	0.31
21	106.7	35	4	61	0.31
9	108	35	3	62	0.31
30	108.3	35	3	62	0.31
7	65.9	34	45	21	0.17
5	50.3	33	67	0	0.09
29	82	33	26	41	0.24
16	81.8	33	26	41	0.24
25	112.4	33	2	65	0.29
11	79.4	33	29	38	0.22
28	75.9	33	34	34	0.21
1 (estación)	68.3	33	42	25	0.17
32	49.4	32	68	0	0.08
13	69.4	32	41	27	0.17

Location 31. EEAA





Representativeness of other potencial locations sorted by ANRmayor. EEAA area

Posición	Conc	% *AR* rectángulo	% *ANRmayor* rectángulo	% *ANRmenor* rectángulo	*IR*
22	127.2	22	0	78	0.19
8	130.4	19	0	81	0.16
10	130.9	19	0	81	0.16
6	134.9	16	0	84	0.14
2	137.8	14	0	86	0.13
18	138.2	14	0	86	0.13
24	140.4	13	0	88	0.12
23	115	32	1	67	0.27
25	112.4	33	2	65	0.29
30	108.3	35	3	62	0.31
9	108	35	3	62	0.31
21	106.7	35	4	61	0.31
19	103.4	36	5	59	0.32
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11	79.4	33	29	38	0.22
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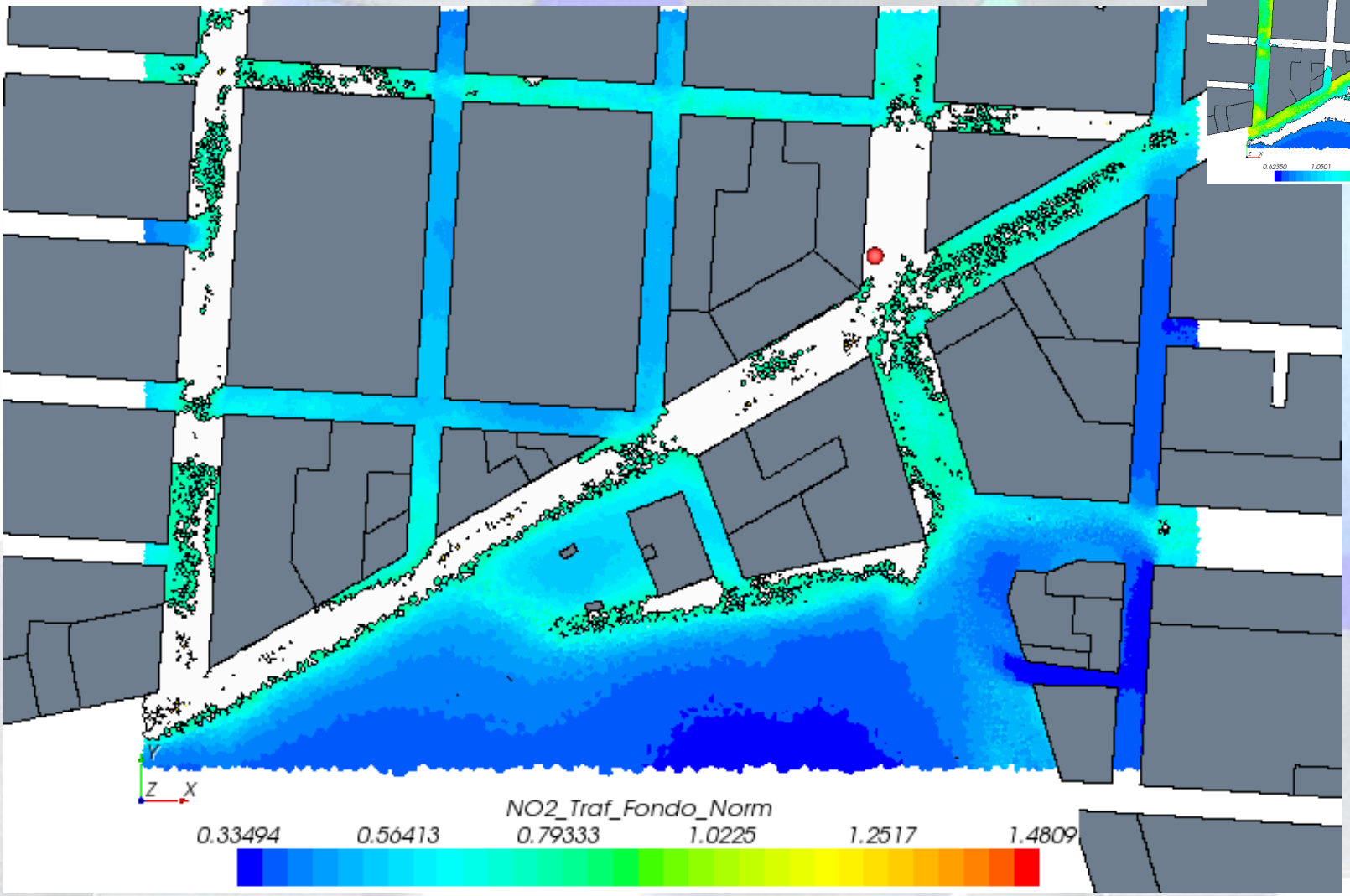
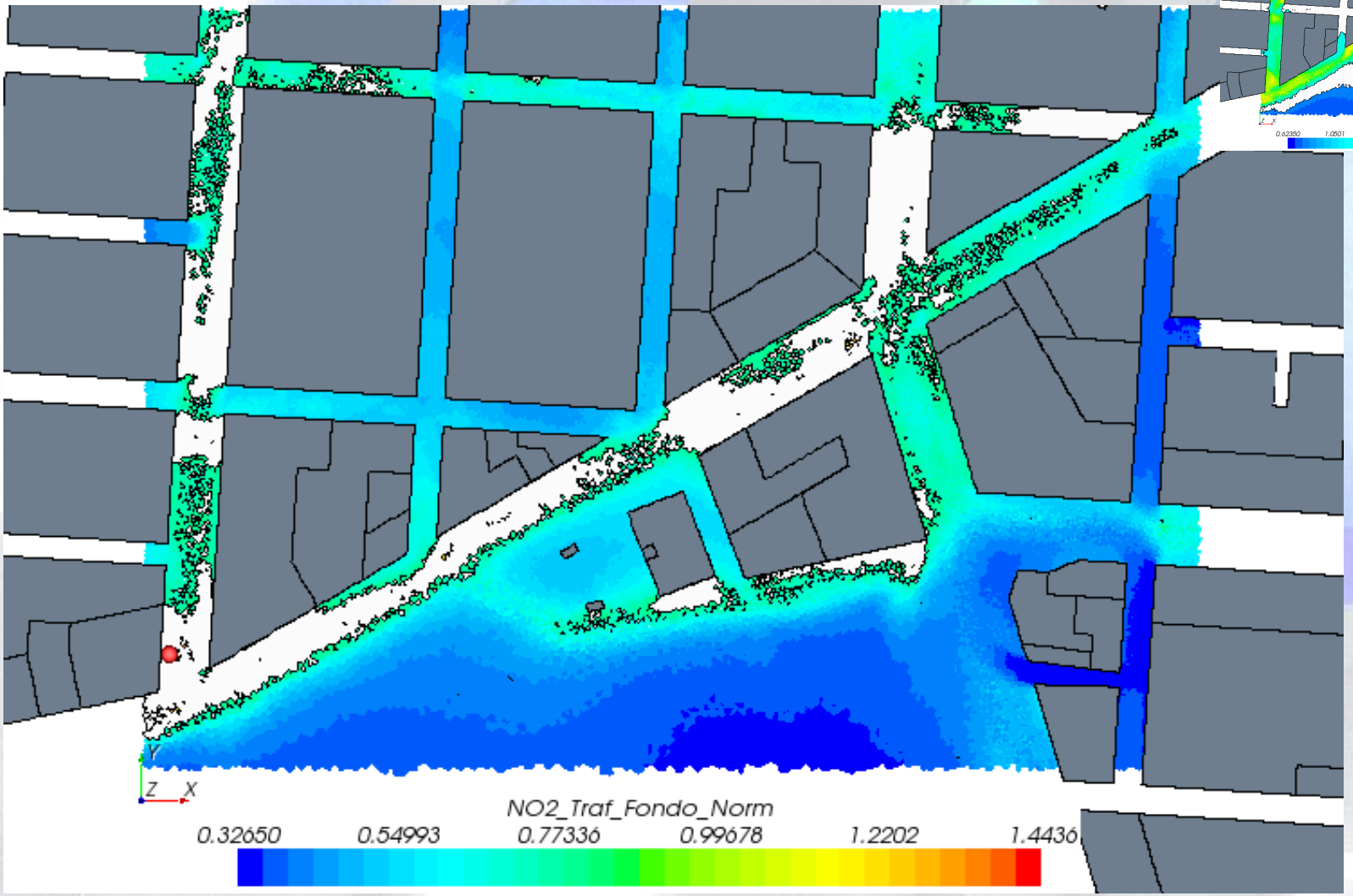
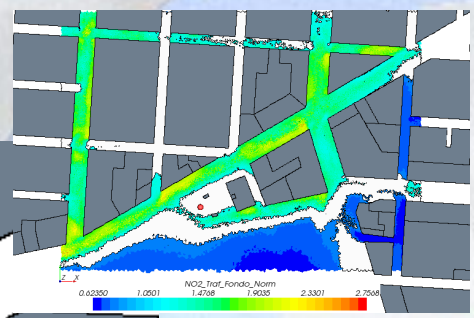
Location 22. EEAA

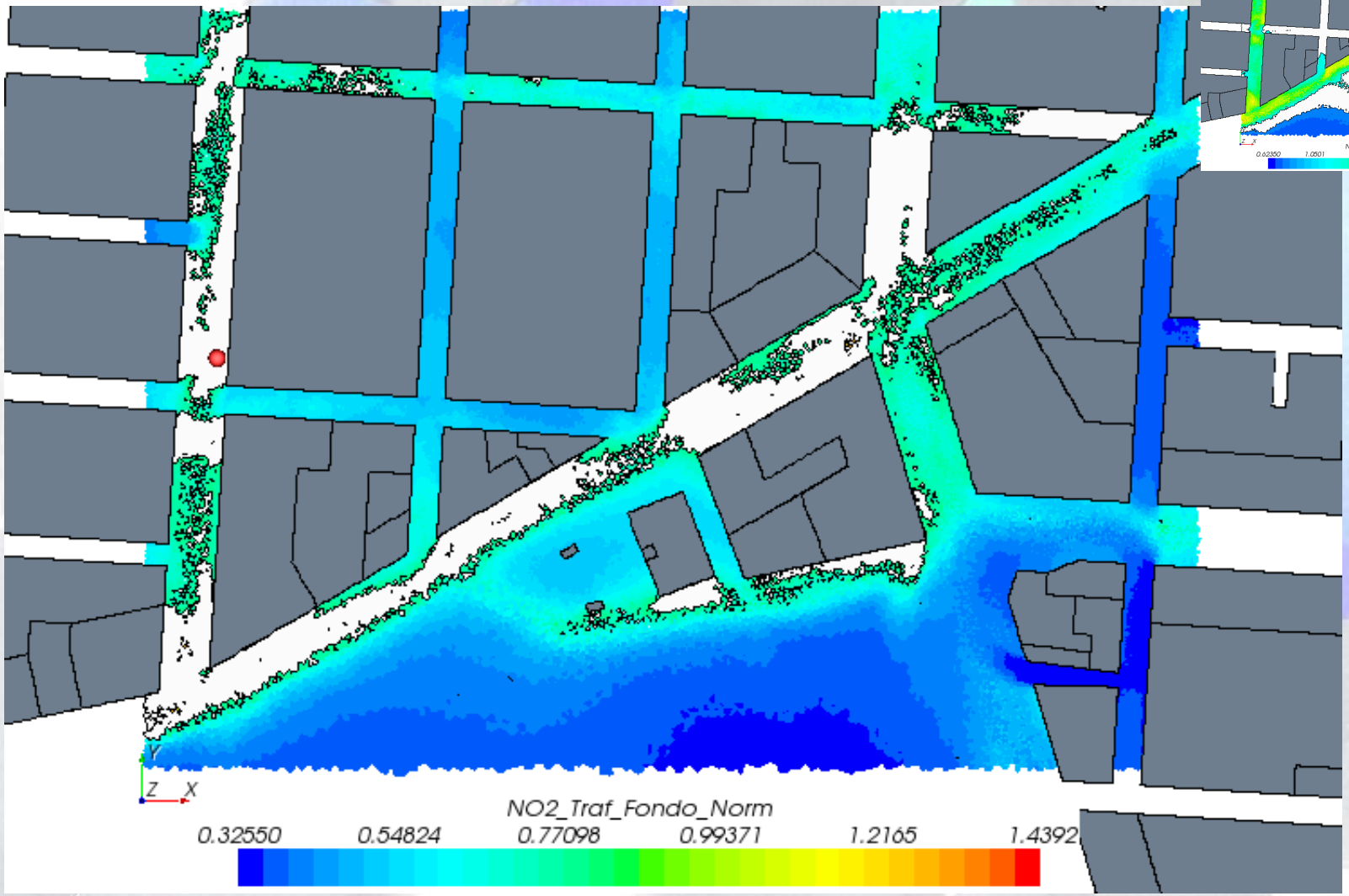


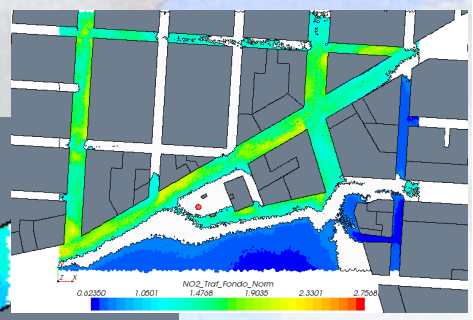
Location 8. EEAA





Location 10. EEAA





Representativeness of other potencial locations sorted by IR. EEAA area

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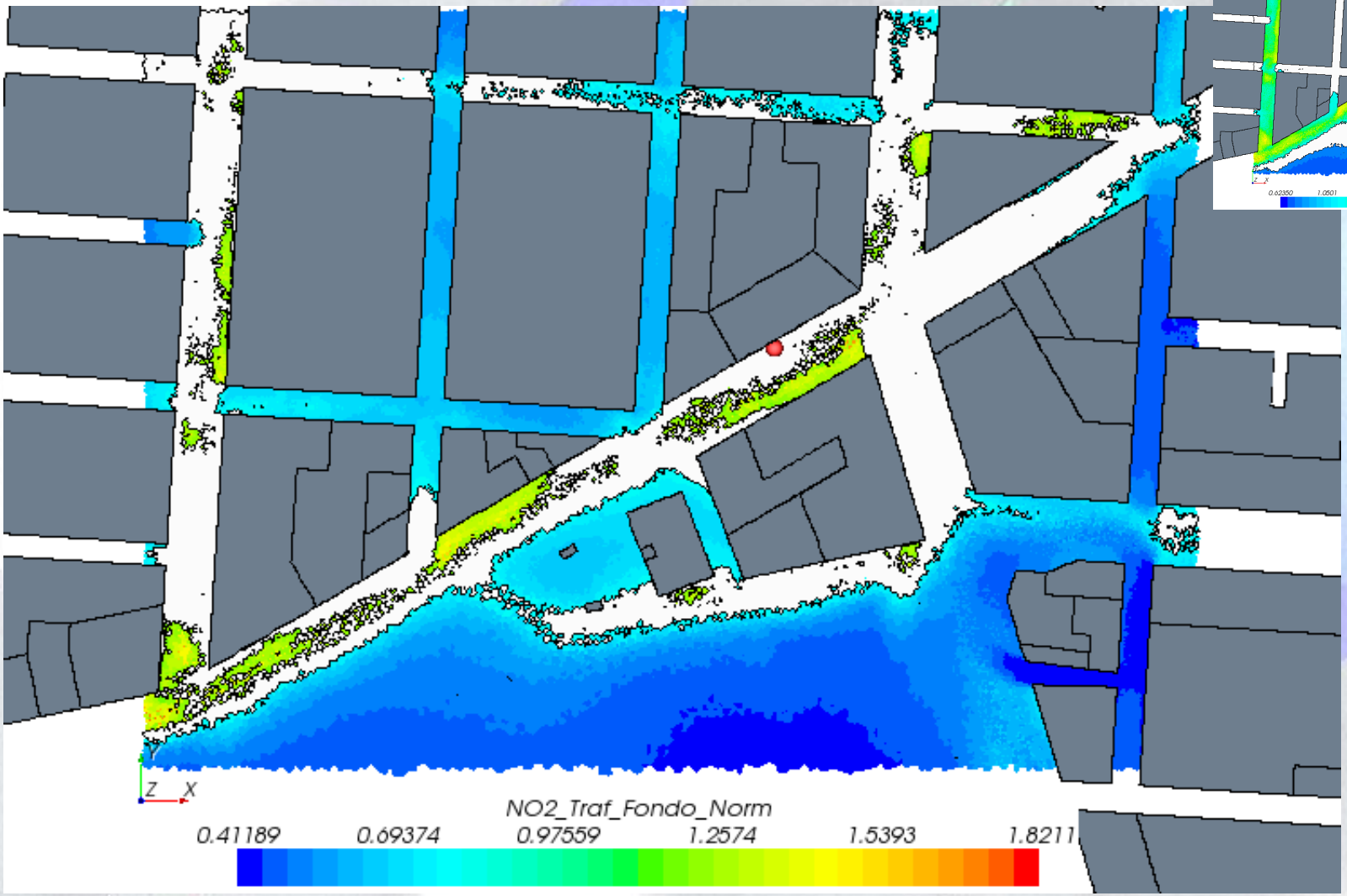
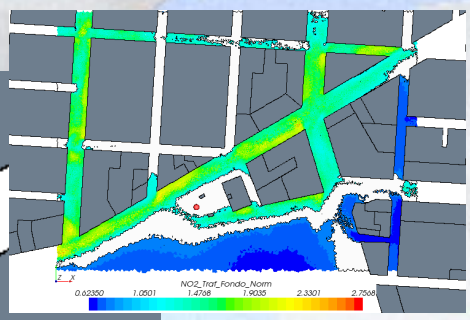
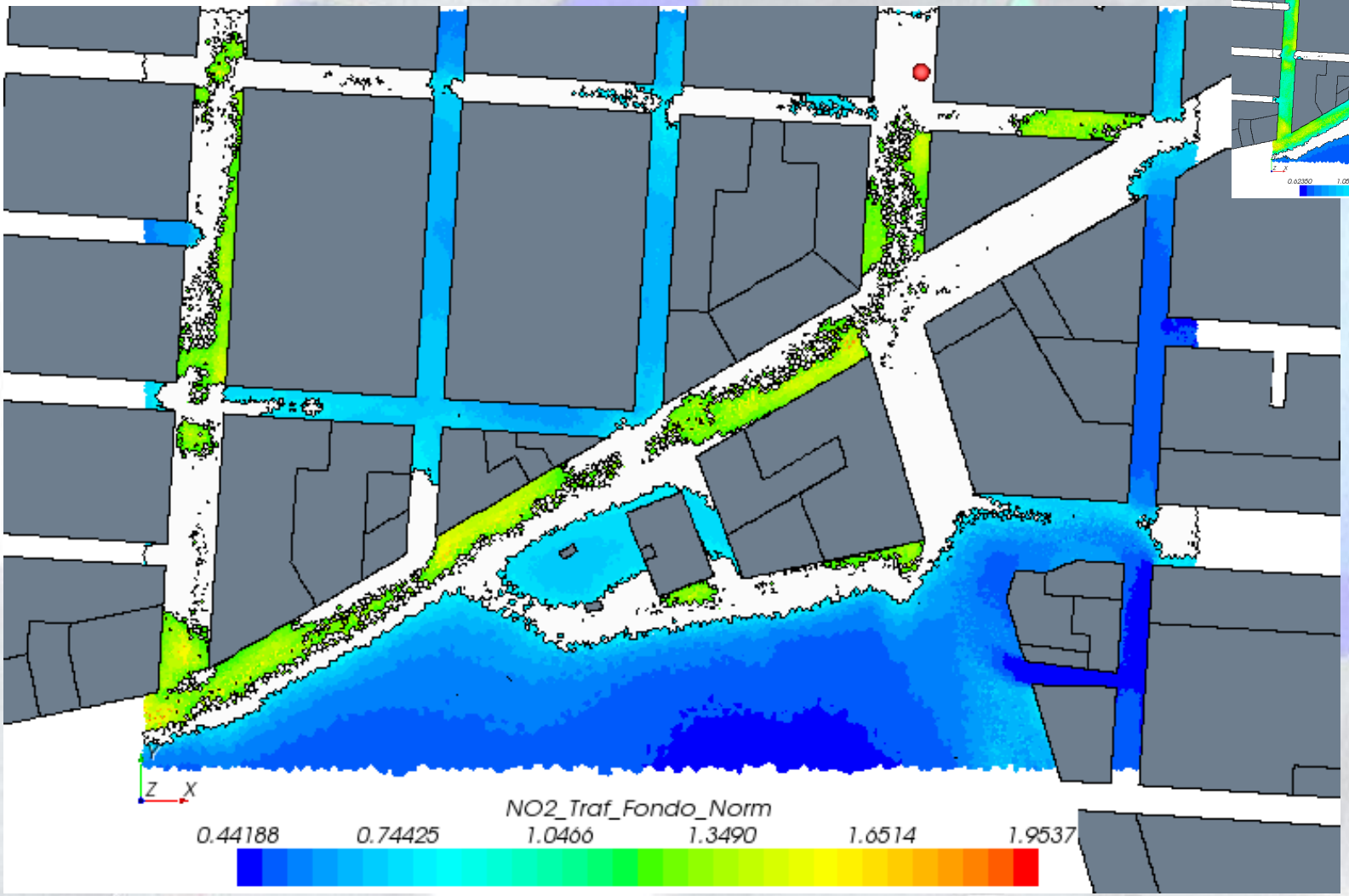
6	134.9	16	0	84	0.14

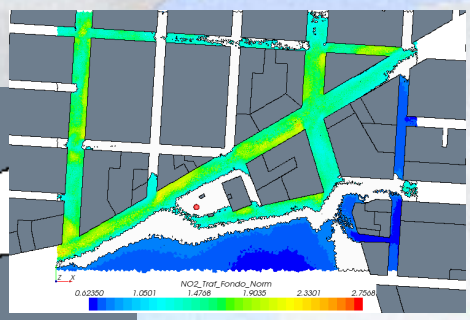
Location 19. EEAA



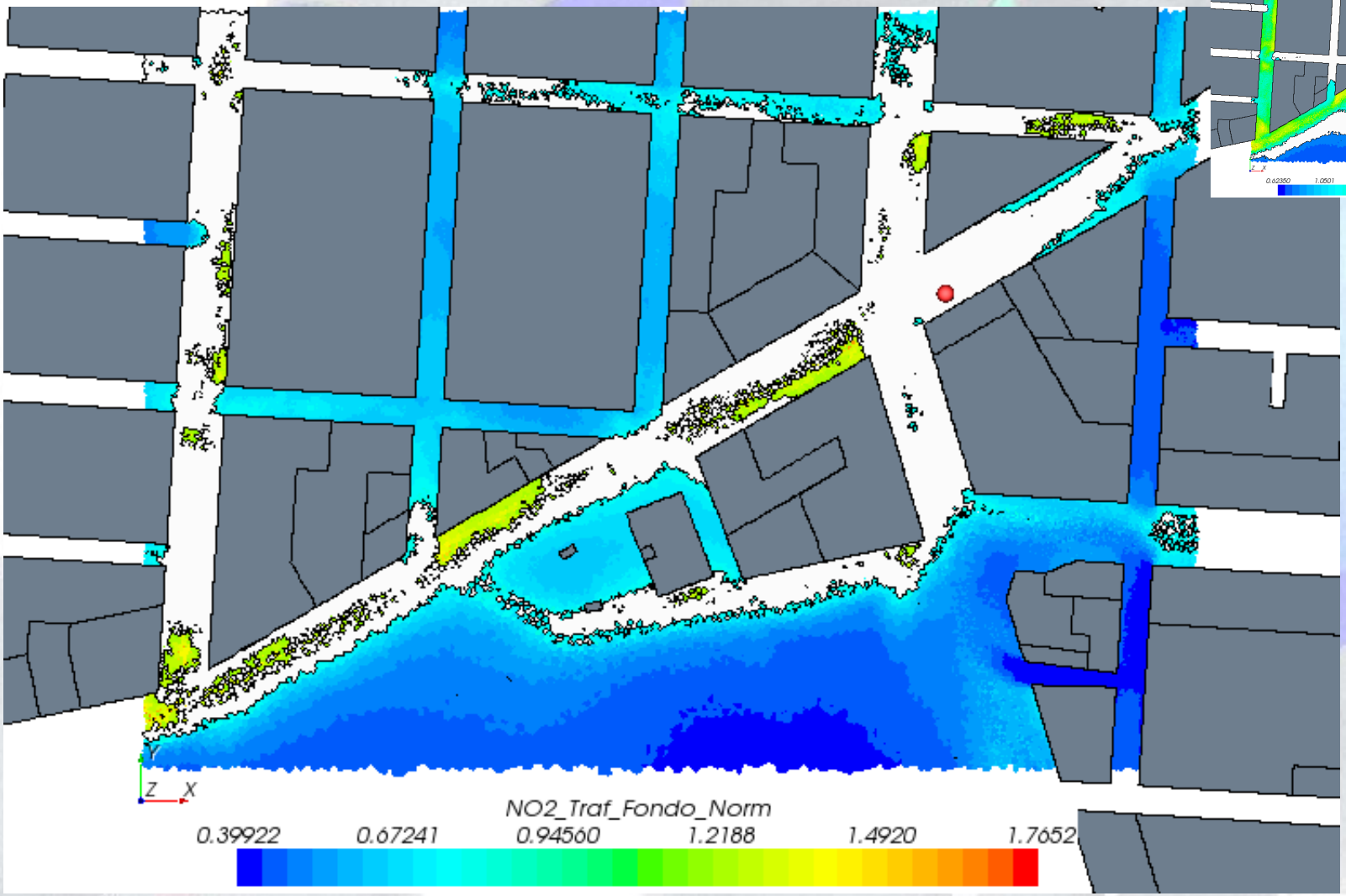


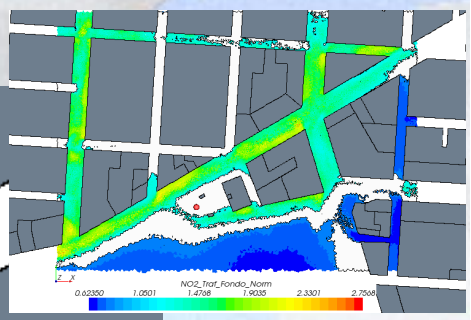
Location 26. EEAA





Location 21. EEAA

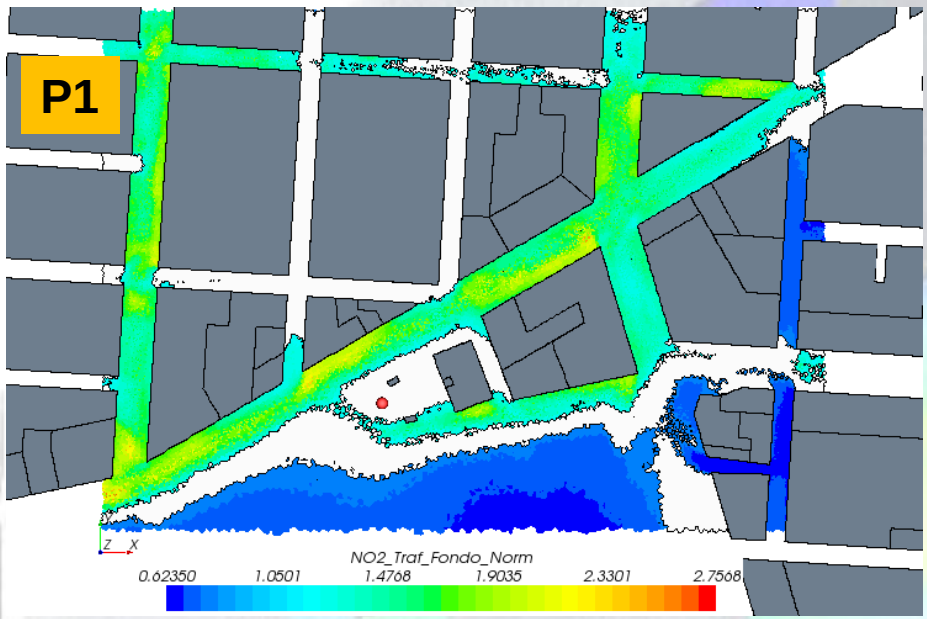


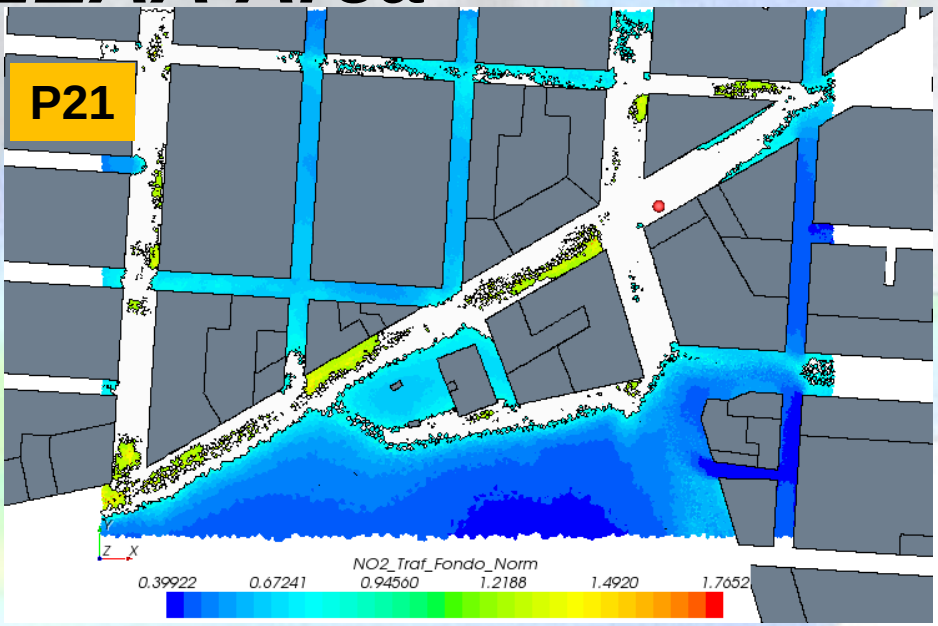


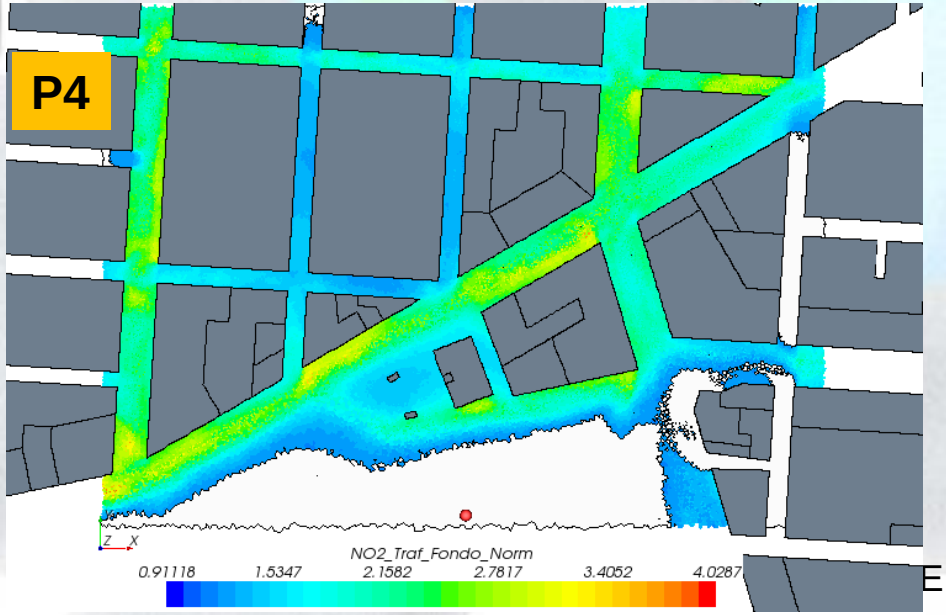
EEAA area: Conclusions

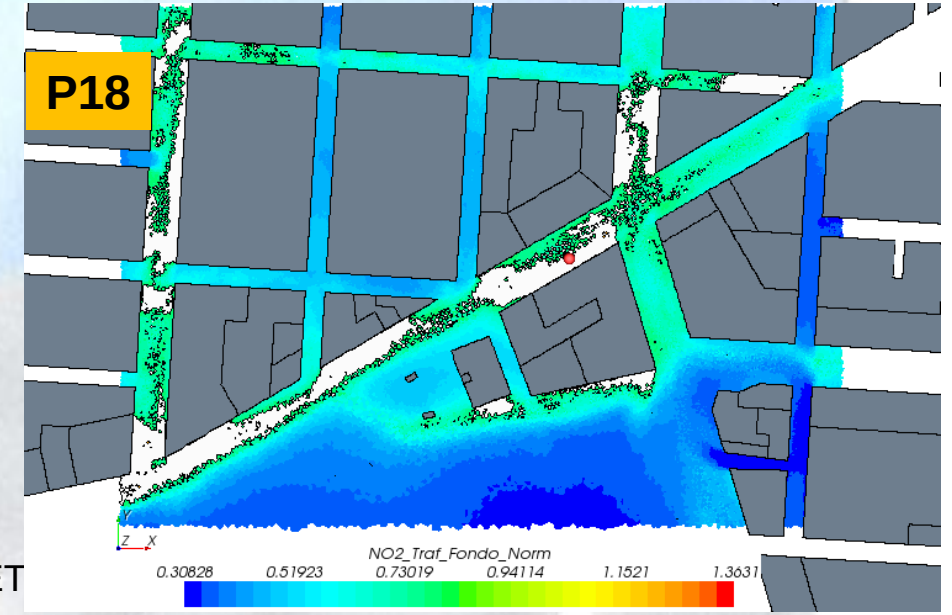
- At least 4 stations needed to cover 100% of area. For example: **P1**, **P21**, **P18** y **P4**.
- Representativeness area (**P1** + **P21**) = 68%.

Representativeness of other potencial locations. EEAA Area



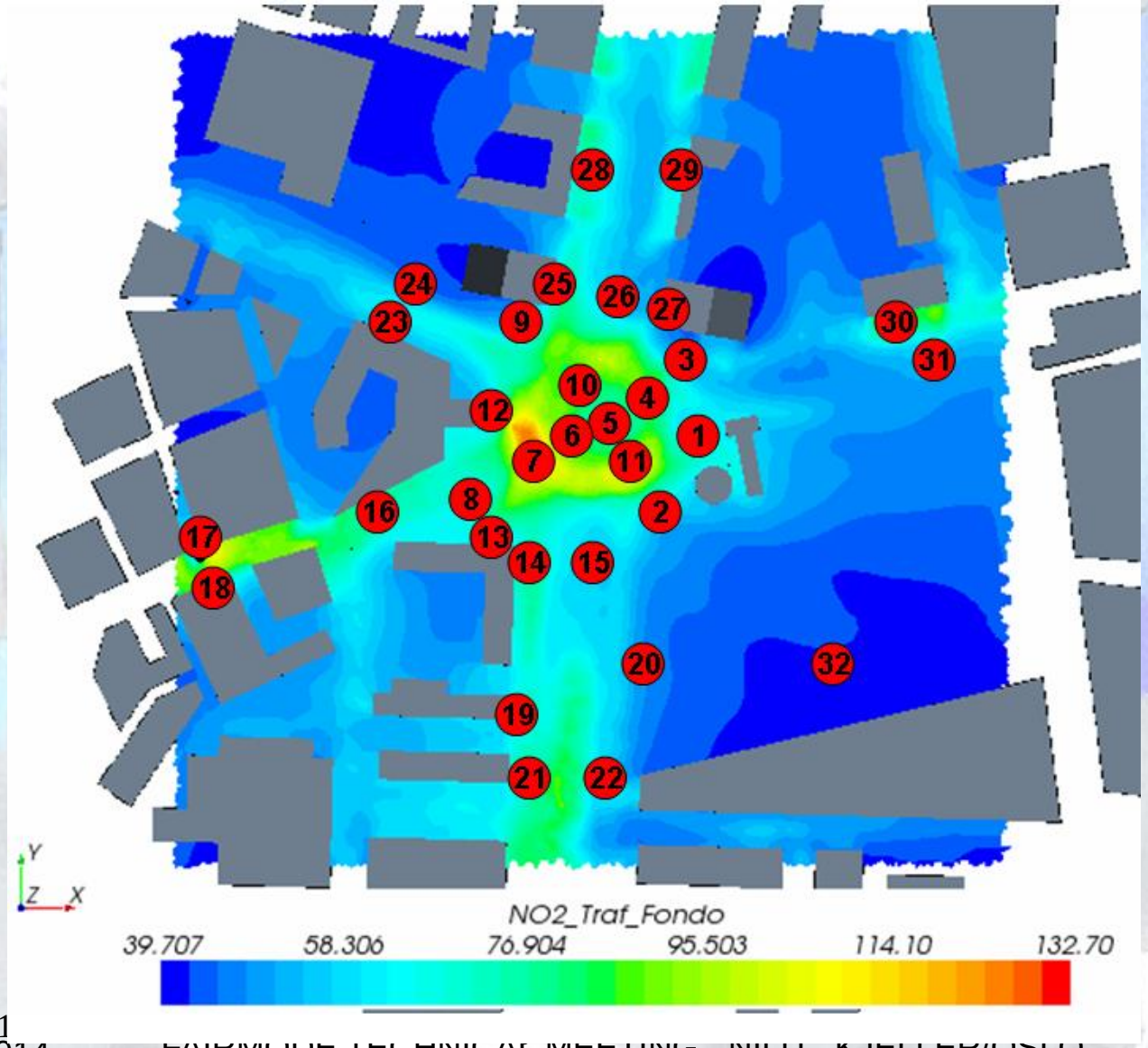






EET

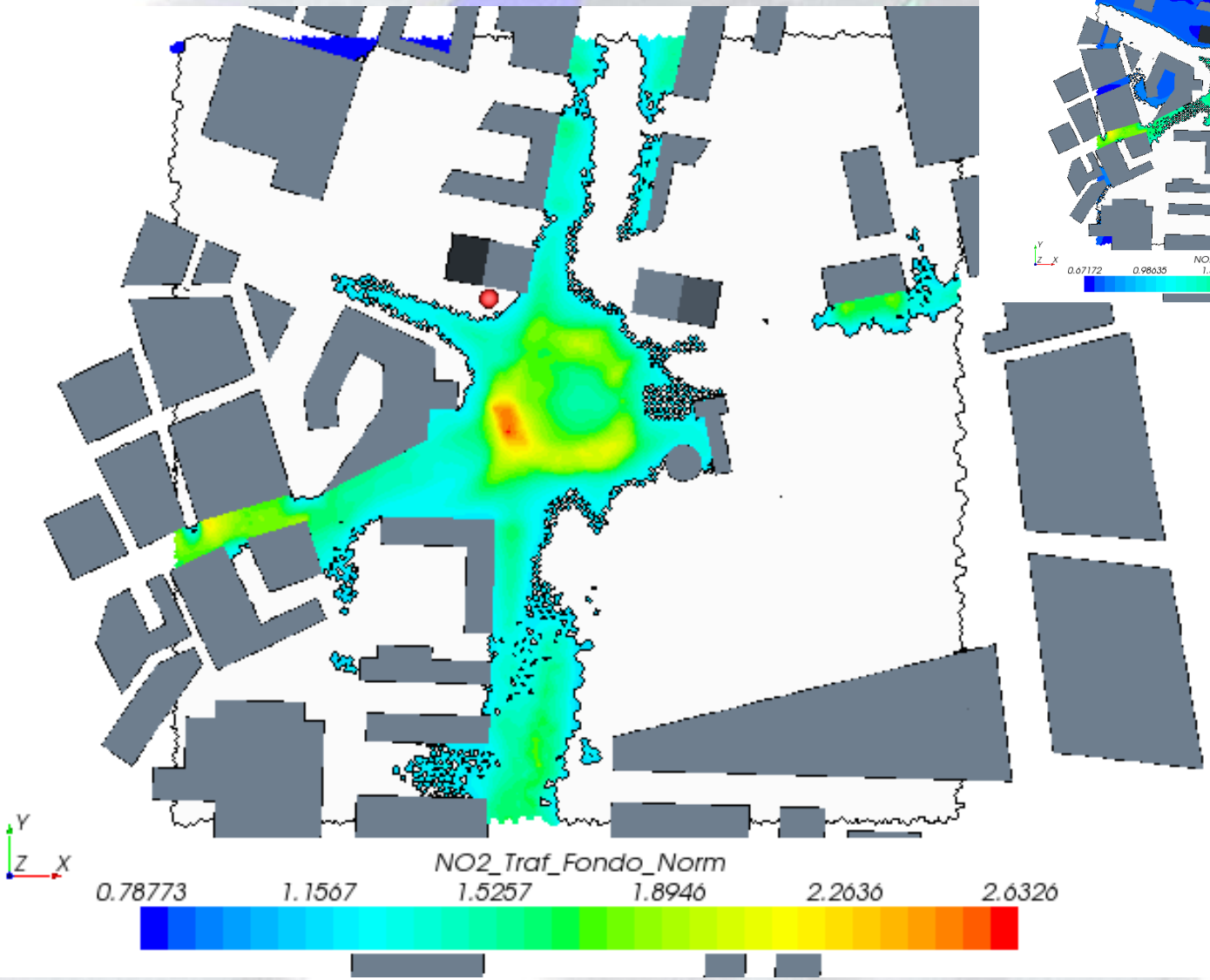
Representativeness of other potencial locations. Pza Castilla Area

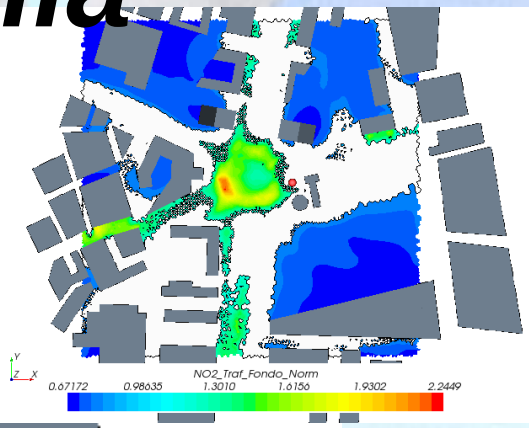


Representativeness of other potencial locations sorted by AR. Pza Castilla area

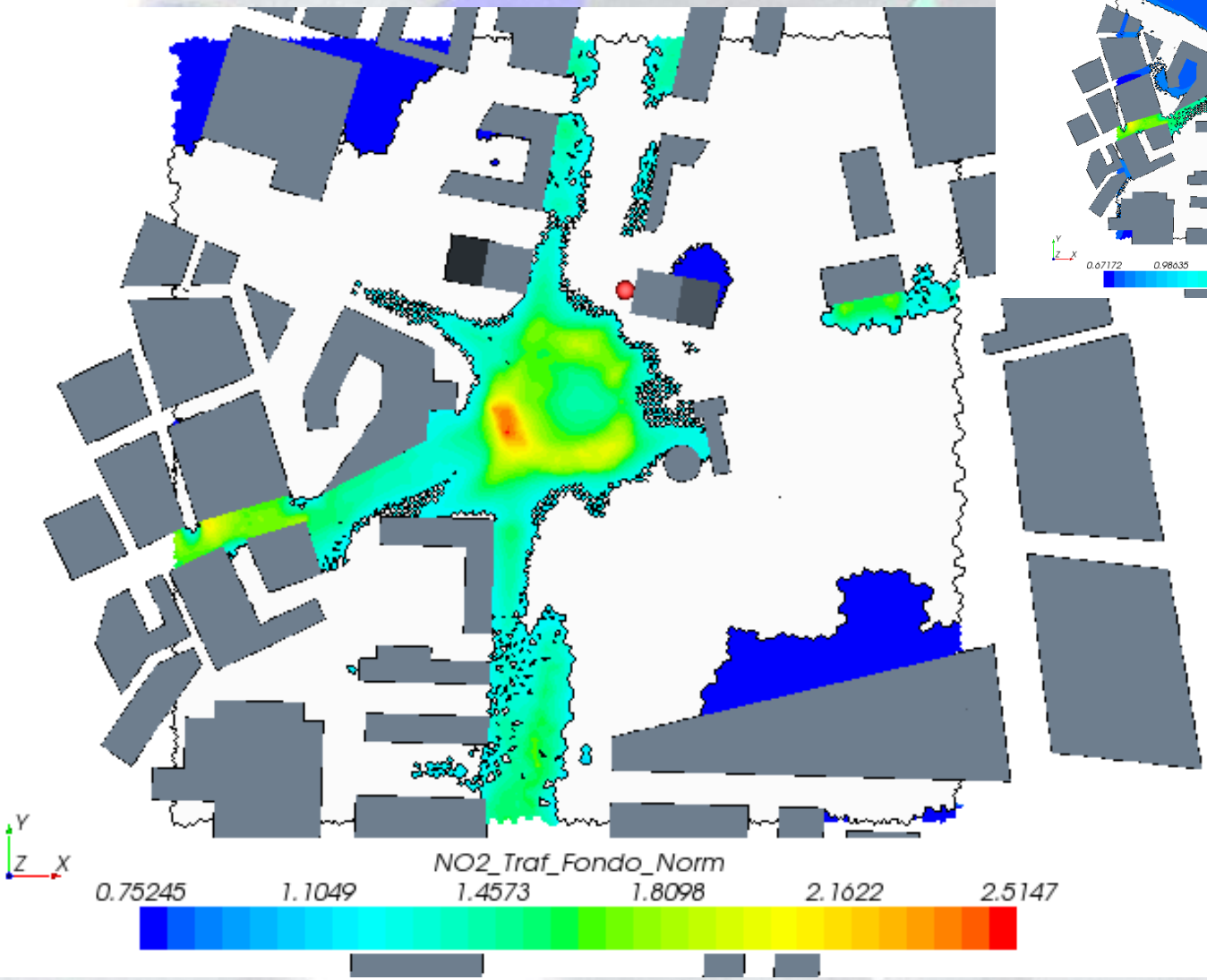
Posición	Conc	% *AR* rectángulo	% *ANRmayor* rectángulo	% *ANRmenor* rectángulo	*IR*
9	50.4	77	23	0	0.75
27	52.8	74	19	7	0.75
20	47.8	71	29	0	0.63
22	47.6	71	29	0	0.62
3	47.4	70	30	0	0.61
24	44	60	40	0	0.41
32	42.4	55	45	0	0.33
29	56.4	55	15	31	0.53
15	57	53	14	33	0.52
26	57.7	52	13	35	0.50
23	58.9	50	12	38	0.48
31	58.9	50	12	38	0.48
1 (estación)	59.1	49	12	39	0.47
2	62.4	39	10	51	0.35
12	62.6	38	9	52	0.34
13	63.9	36	9	56	0.31
8	64.9	34	8	58	0.30
28	66.2	33	7	61	0.28
25	67.6	30	6	64	0.26
19	70.1	27	5	68	0.23
21	73.8	22	3	75	0.18
14	77.5	18	2	79	0.16
4	78.9	17	2	81	0.15

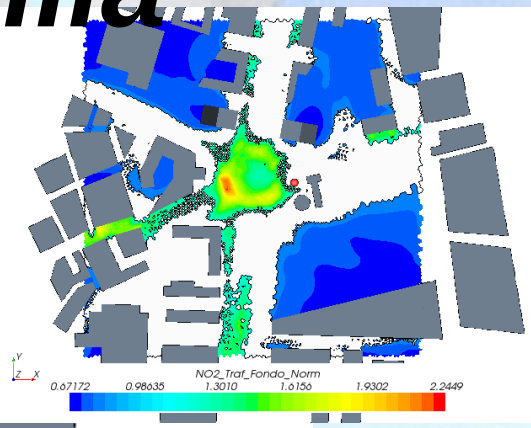
Location 9. Pza Castilla



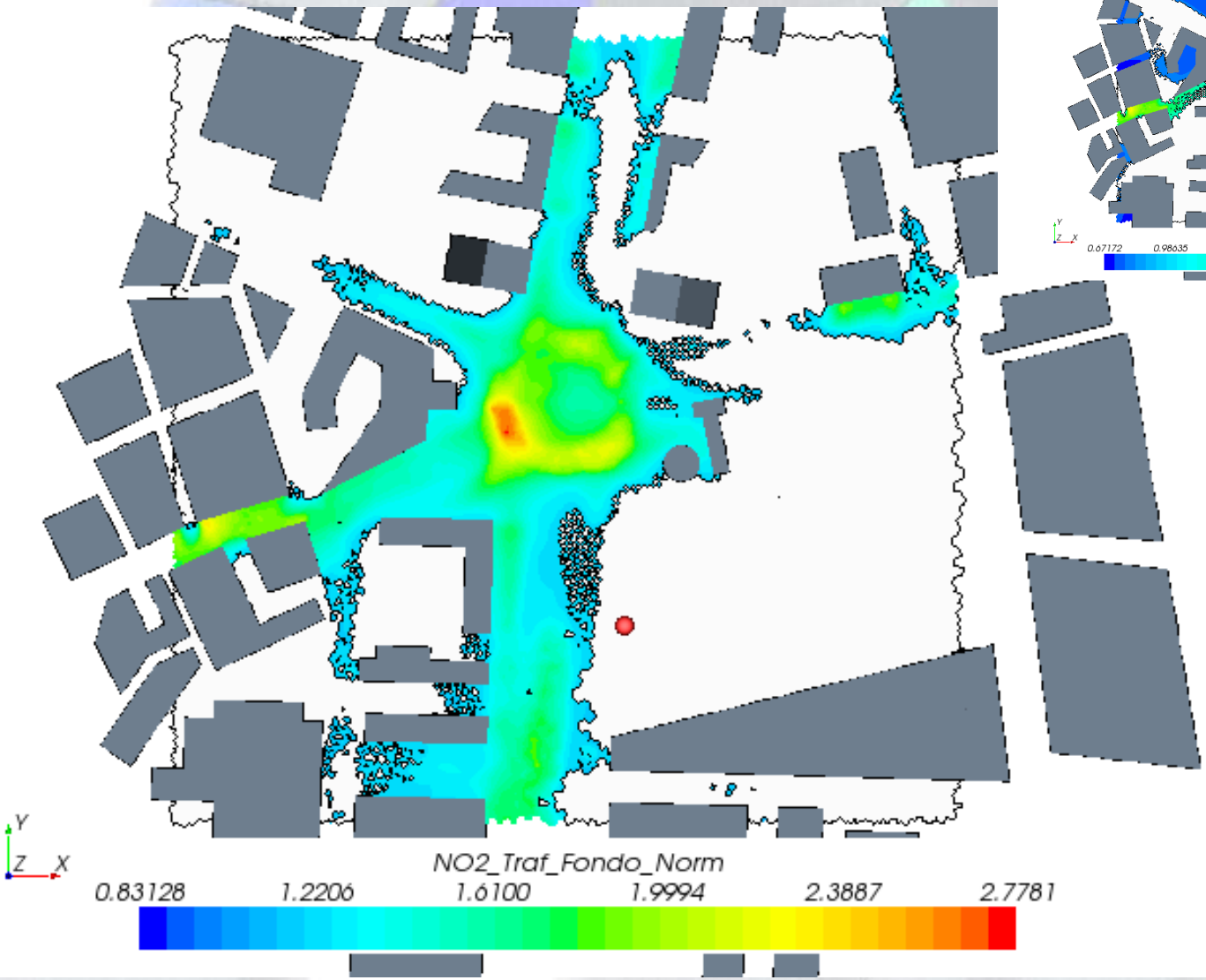


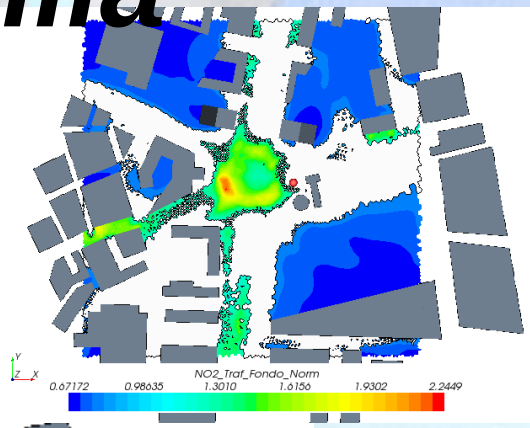
Location 27. Pza Castilla





Location 20. Pza Castilla

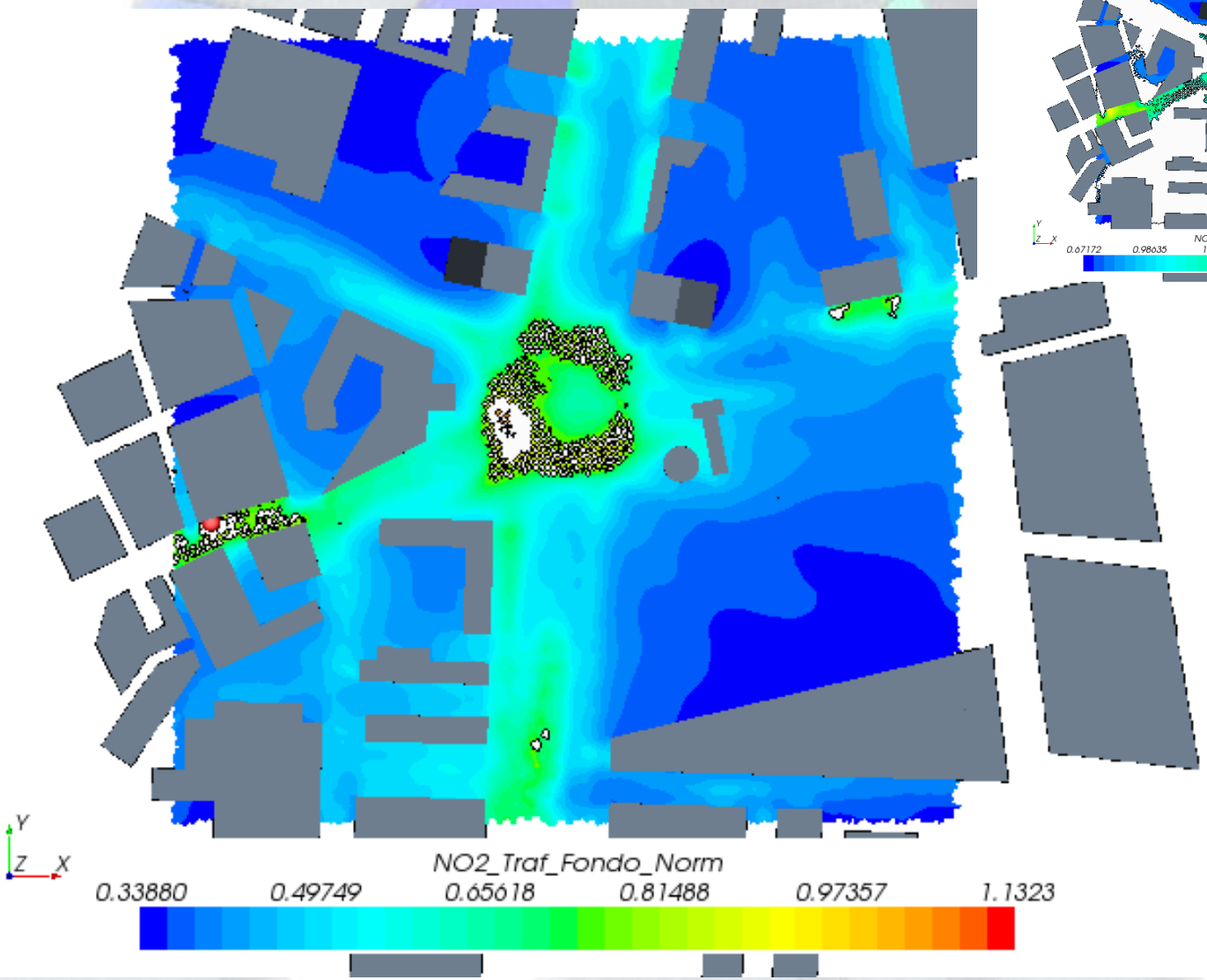


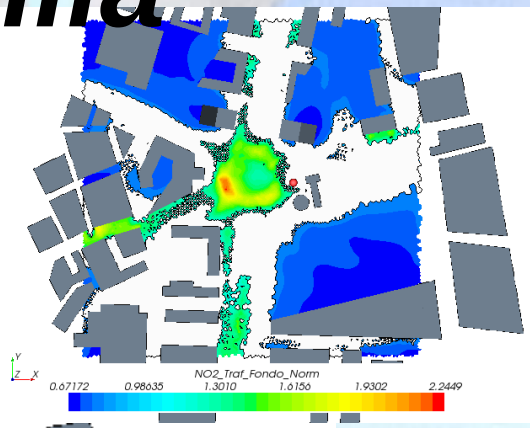


Representativeness of other potencial locations sorted by ANRmayor. Pza Castilla area

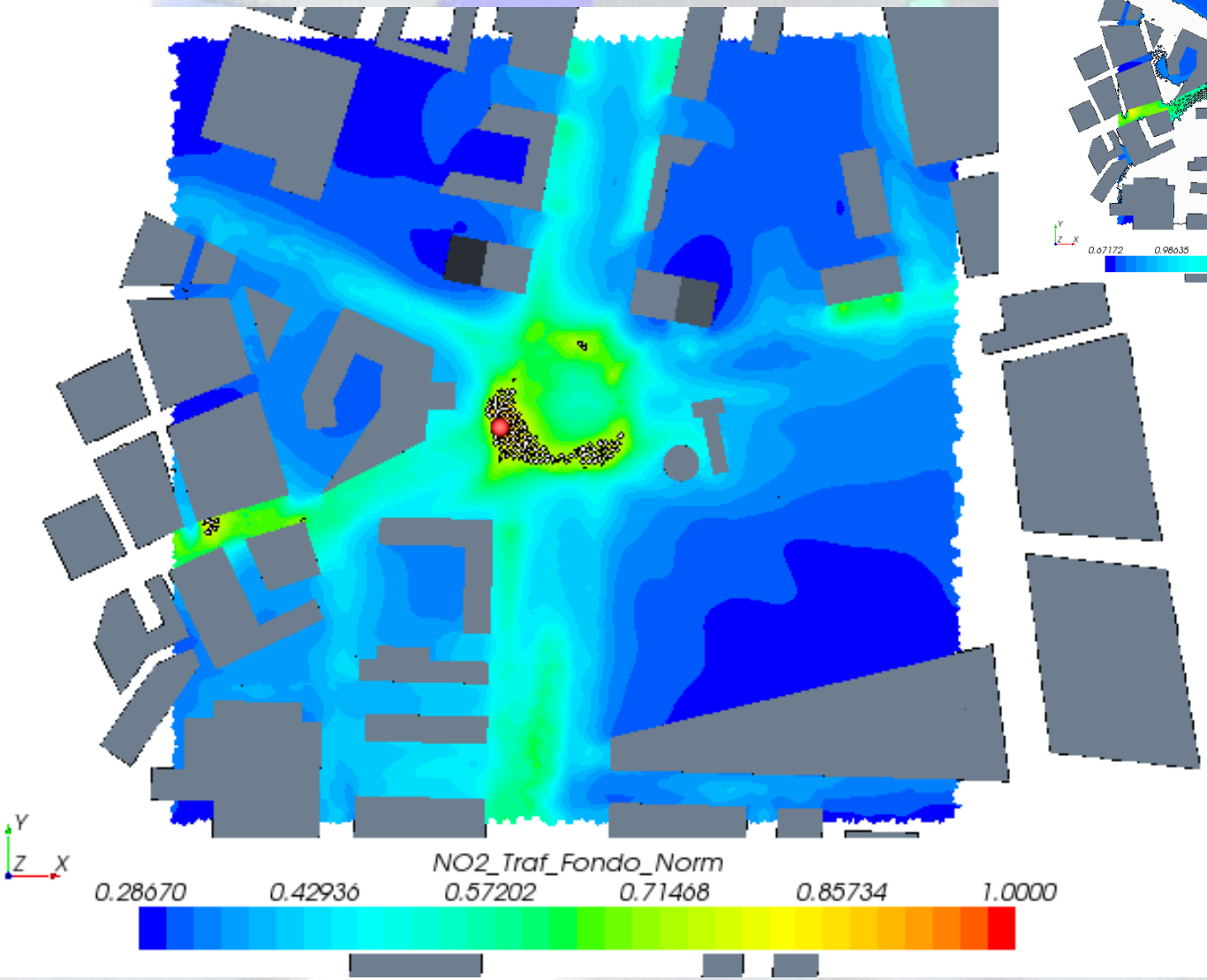
Posición	Conc	% *AR* rectángulo	% *ANRmayor* rectángulo	% *ANRmenor* rectángulo	*IR*
17	117.2	2	0	98	0.07
7	138.5	0	0	100	0.06
18	105	5	0	95	0.08
6	85.4	13	1	86	0.12
30	85	13	1	86	0.12
16	81.8	15	2	83	0.14
11	81.9	15	2	83	0.14
5	80.4	16	2	82	0.14
10	80.6	16	2	82	0.14
4	78.9	17	2	81	0.15
14	77.5	18	2	79	0.16
21	73.8	22	3	75	0.18
19	70.1	27	5	68	0.23
25	67.6	30	6	64	0.26
28	66.2	33	7	61	0.28
8	64.9	34	8	58	0.30
13	63.9	36	9	56	0.31
12	62.6	38	9	52	0.34
2	62.4	39	10	51	0.35
1 (estación)	59.1	49	12	39	0.47
23	58.9	50	12	38	0.48
31	58.9	50	12	38	0.48
26	57.7	52	13	35	0.50
15	57	52	14	32	0.53

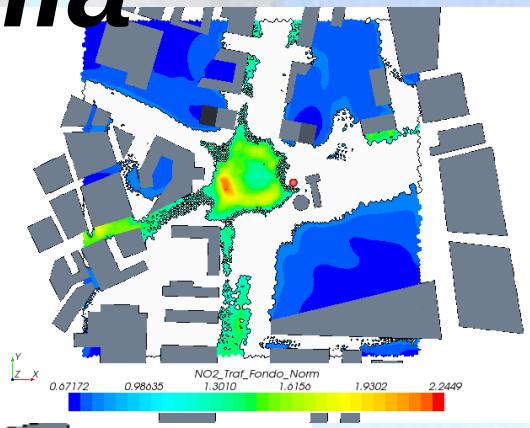
Location 17. Pza Castilla



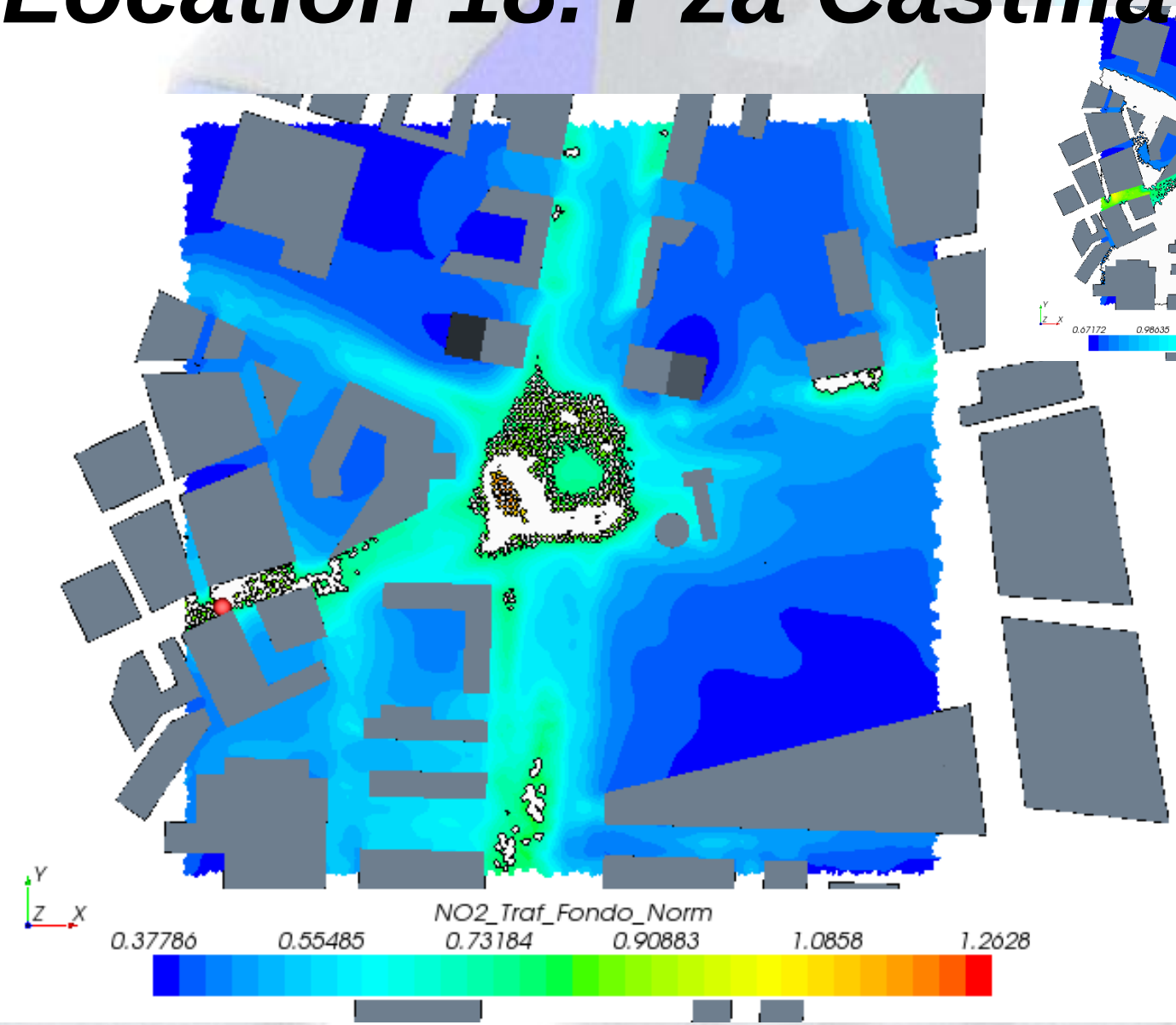


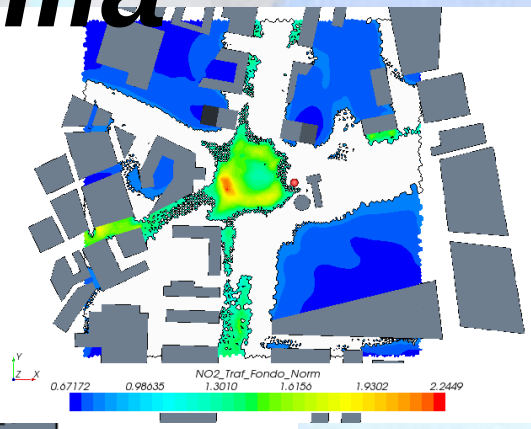
Location 7. Pza Castilla





Location 18. Pza Castilla

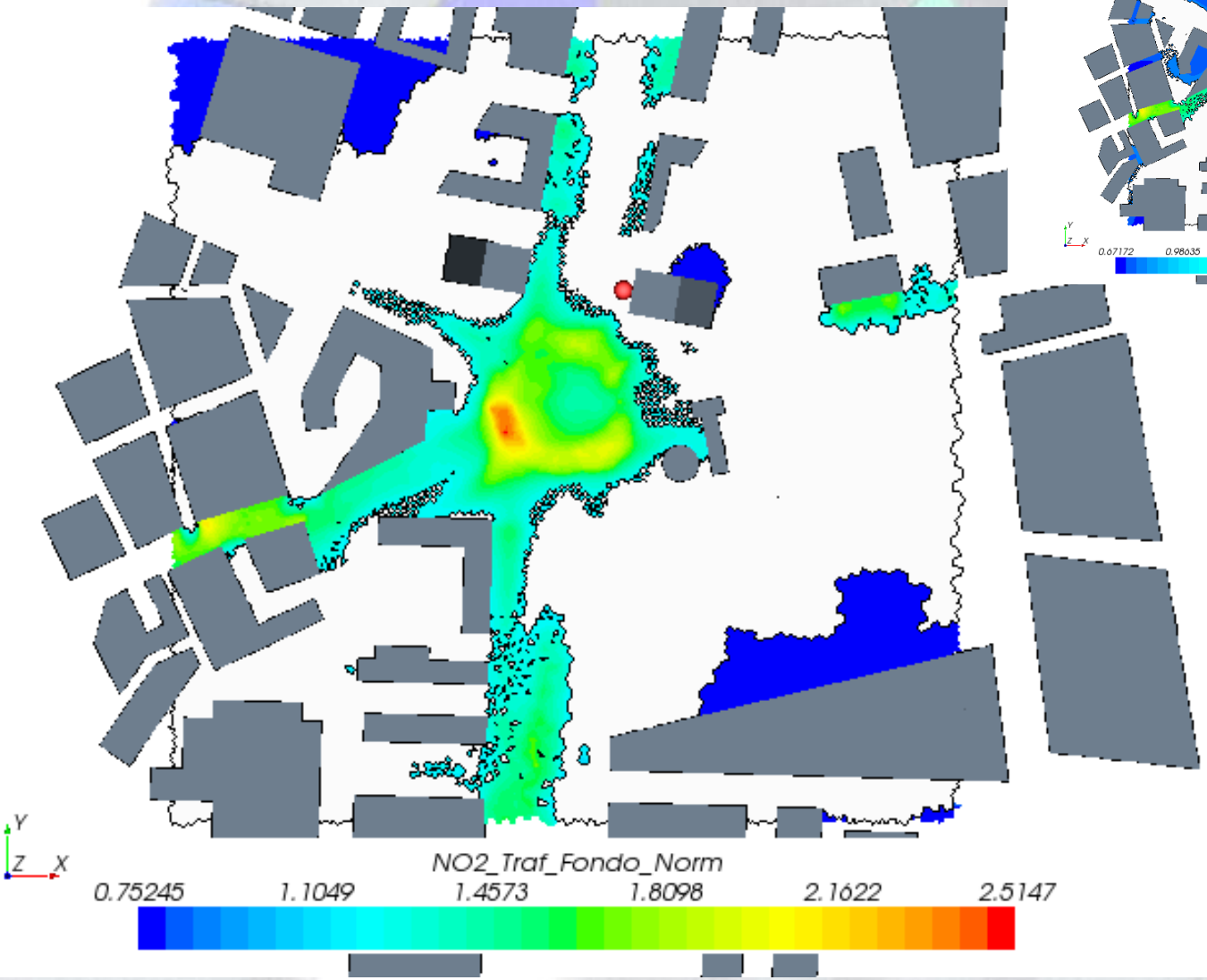


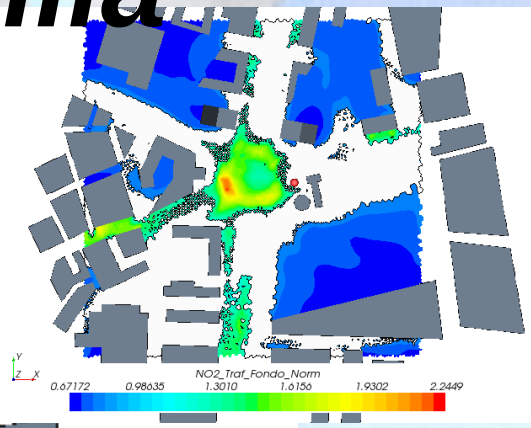


Representativeness of other potencial locations sorted by IR. Pza Castilla area

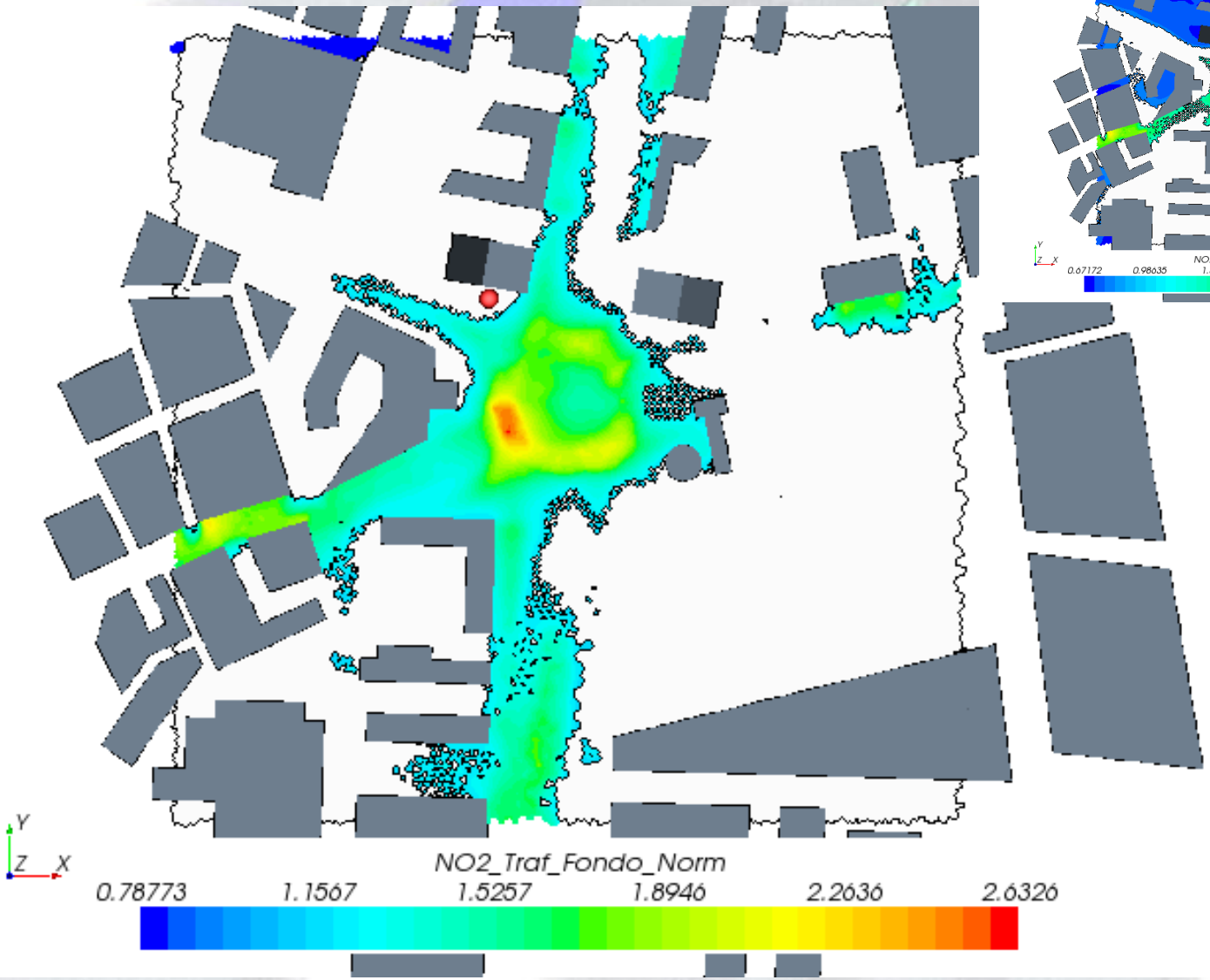
Posición	Conc	% *AR* rectángulo	% *ANRmayor* rectángulo	% *ANRmenor* rectángulo	*IR*
27	52.8	74	19	7	0.75
9	50.4	77	23	0	0.75
20	47.8	71	29	0	0.63
22	47.6	71	29	0	0.62
3	47.4	70	30	0	0.61
29	56.4	55	15	31	0.53
15	57	53	14	33	0.52
26	57.7	52	13	35	0.50
23	58.9	50	12	38	0.48
31	58.9	50	12	38	0.48
1 (estación)	59.1	49	12	39	0.47
24	44	60	40	0	0.41
2	62.4	39	10	51	0.35
12	62.6	38	9	52	0.34
32	42.4	55	45	0	0.33
13	63.9	36	9	56	0.31
8	64.9	34	8	58	0.30
28	66.2	33	7	61	0.28
25	67.6	30	6	64	0.26
19	70.1	27	5	68	0.23
21	73.8	22	3	75	0.18
14	77.5	18	2	79	0.16
4	78.9	17	2	81	0.15

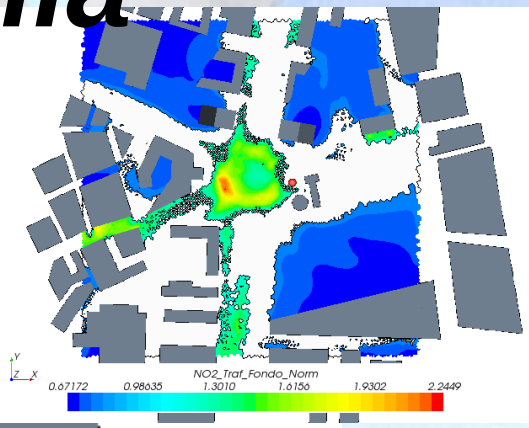
Location 27. Pza Castilla



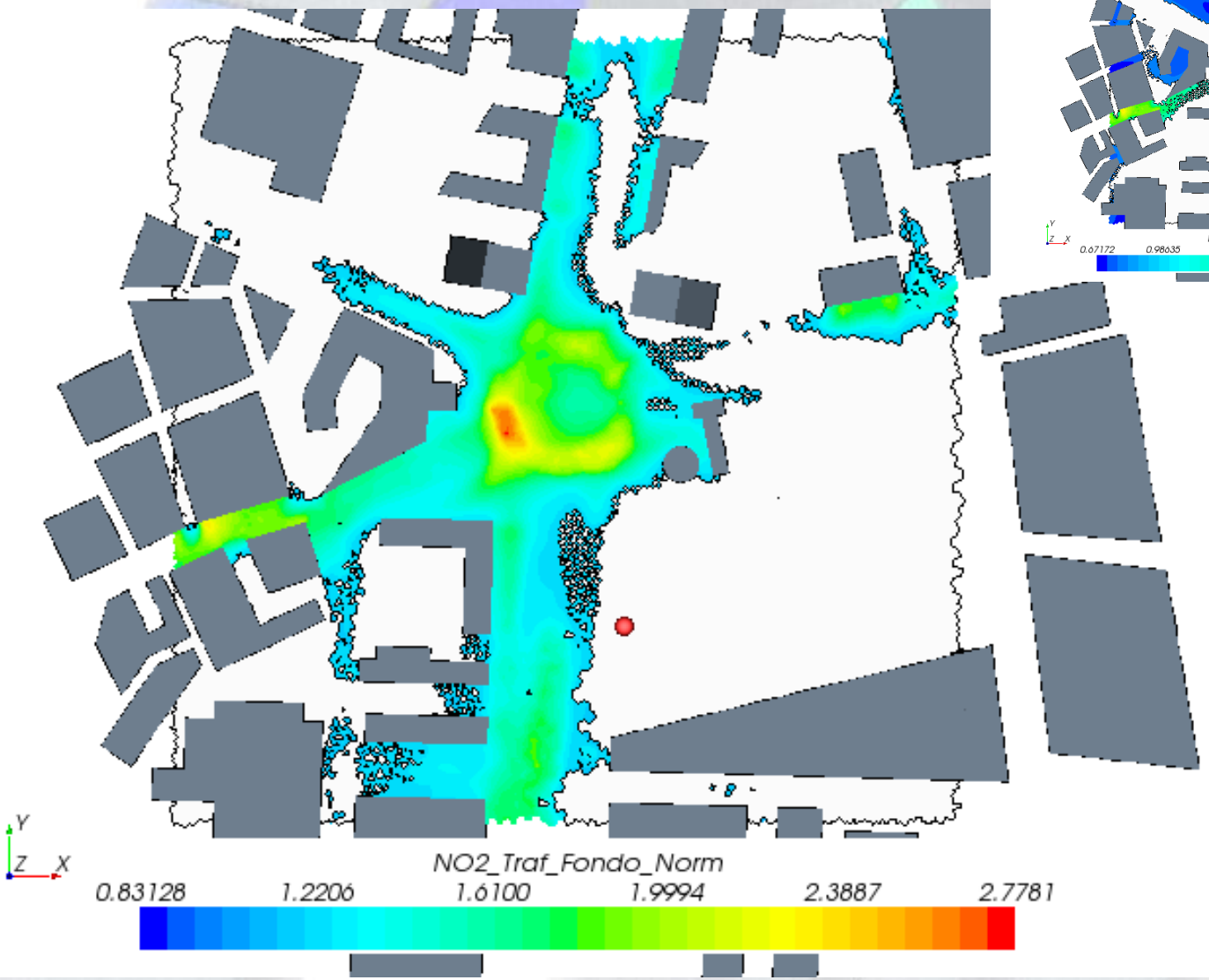


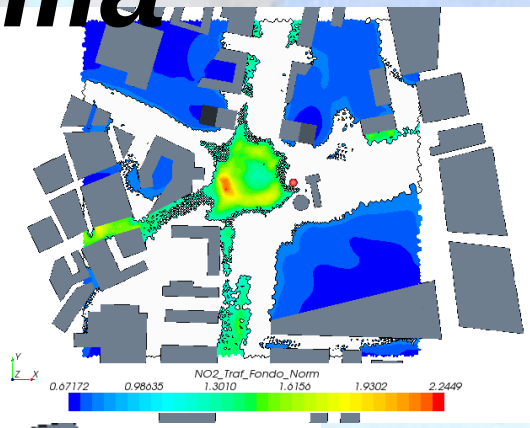
Location 9. Pza Castilla





Location 20. Pza Castilla





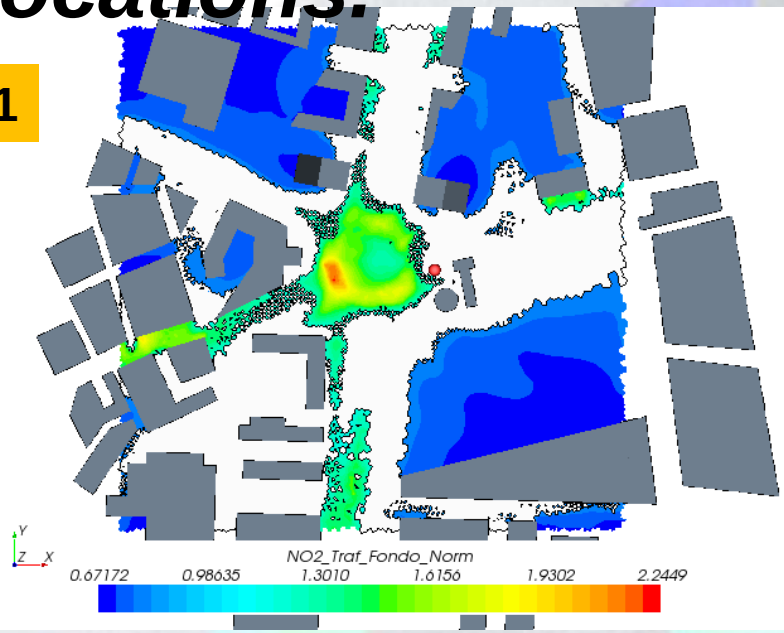
Pza Castilla: Conclusions

- More locations with high AR (*AR* > 70%) and low concentrations due to it is very open area.
- Only two stations needed to cover almost all area:
  - **P1 (station)** and **P20,** *AR* total = 88%
  - **P19 and P20,** AR total = 95%.

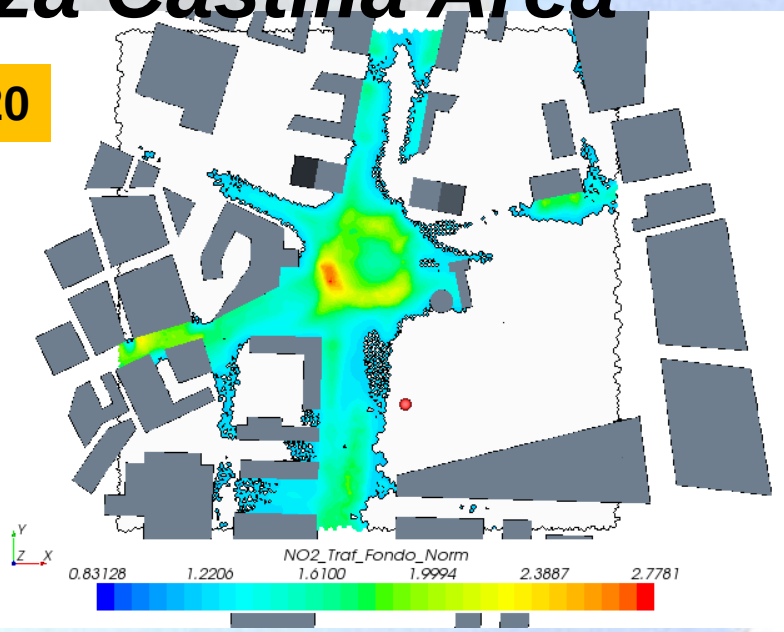
Representativeness of other potencial locations.

Pza Castilla Area

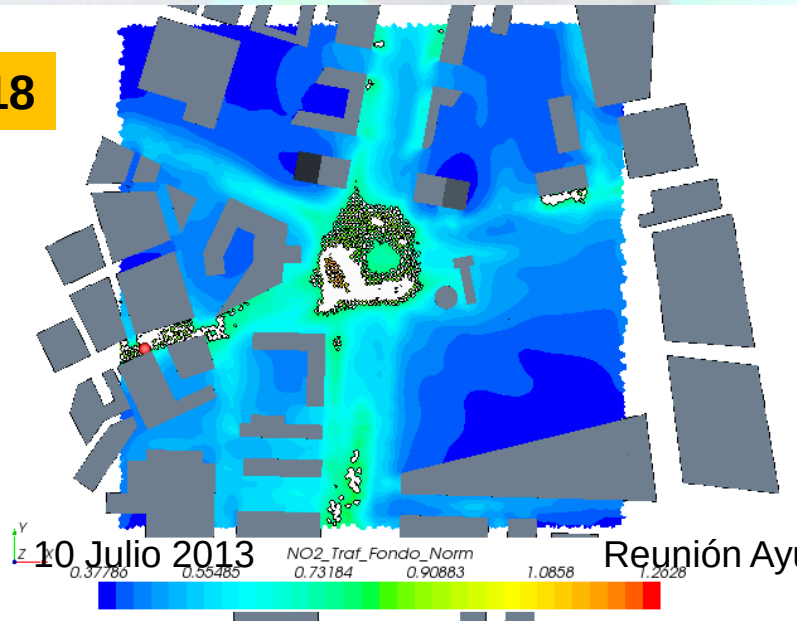
P1



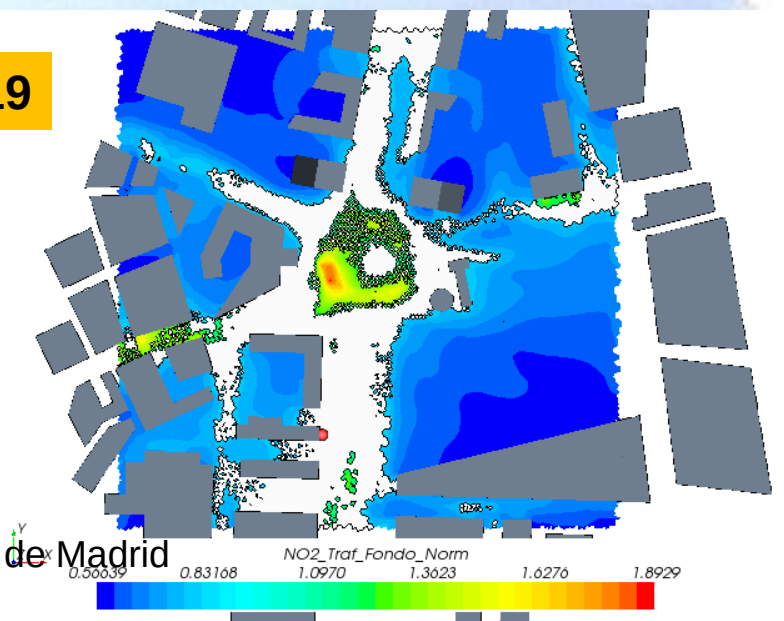
P20



P18



P19



Rural Background Stations

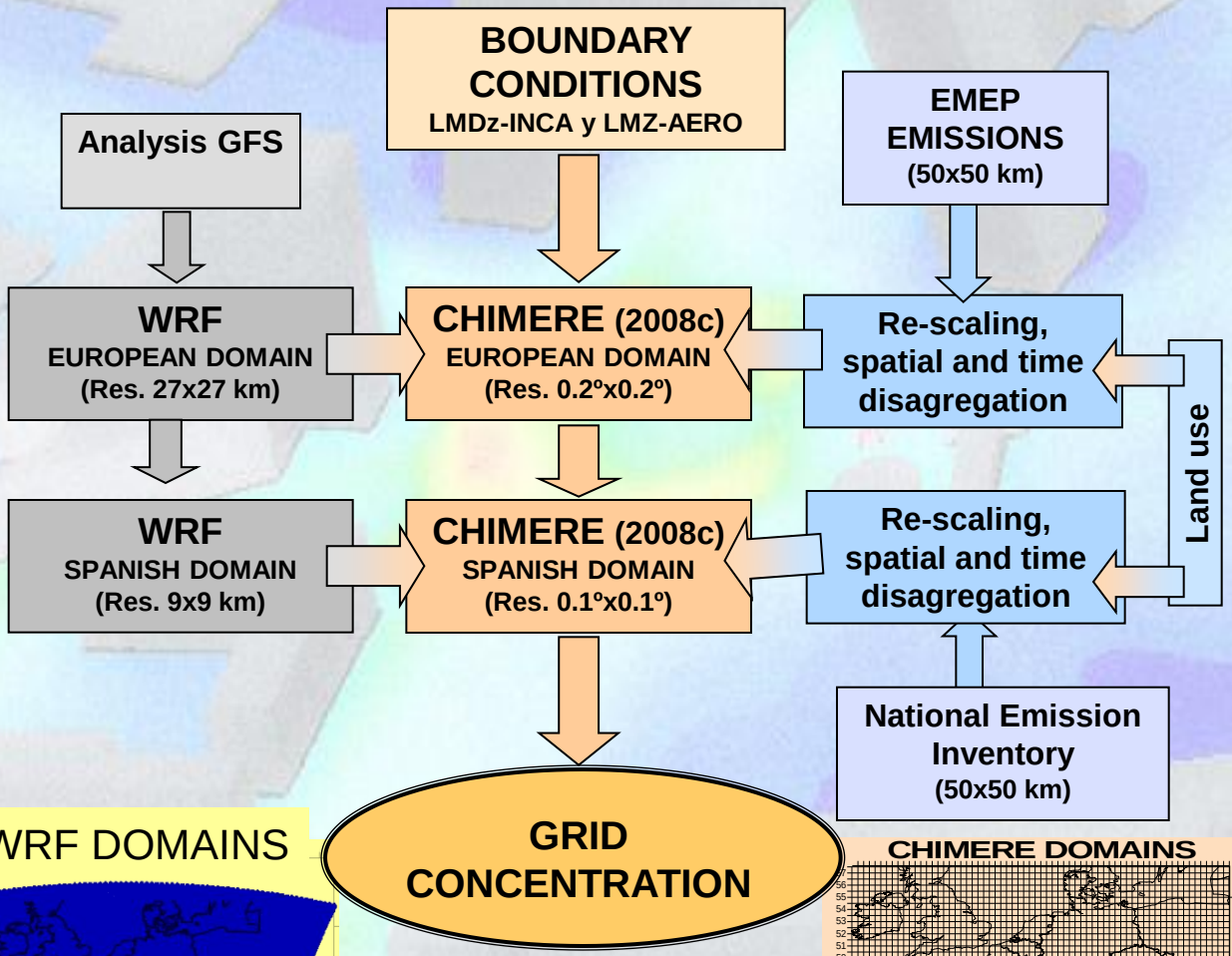
- **To estimate the SR area of the rural background (RB) stations based on the analysis of the pollutant concentration distribution around the stations in the Iberian Peninsula and Balearic Islands** obtained from annual WRF-CHIMERE model simulations combined with measurements of air quality stations for three years (2008-2010).
- The resulted SR areas are analysed and discussed:
  - size distribution
  - interannual variability
  - station redundancy
  - network coverage

Methodology

- Analysis of the annual maps of pollutant concentrations of SO_2, O_3, NO_2 and PM_{10} for three years (2008-2010) computed routinely for annual air quality assessment in Spain.
- Maps obtained from annual simulations with the WRF-CHIMERE model system combined with measurements at air quality stations.

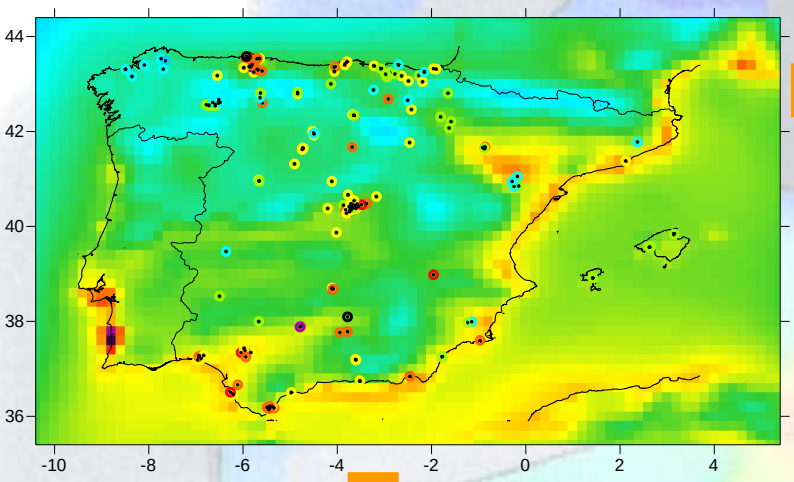
	Annual mean	**Daily limit value (daily average)**	**Hourly limit value (hourly average)**	**Target value (8-hour average)**	**Information threshold (hourly average)**
SO_2	Yes	4^{th} upper value	25^{th} upper value	No	No
O_3	No	No	No	26^{th} upper value	Maximum value
NO_2	Yes	No	19^{th} upper value	No	No
PM_{10}	Yes	36^{th} upper value	No	No	No

Modeling scheme



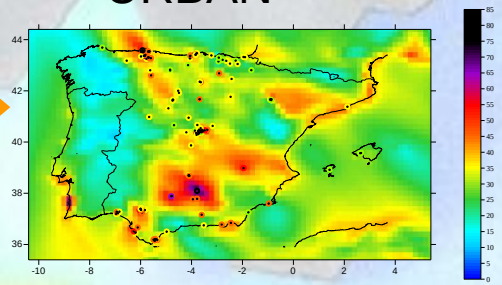
Measurements and modeling combination

Model and measurement



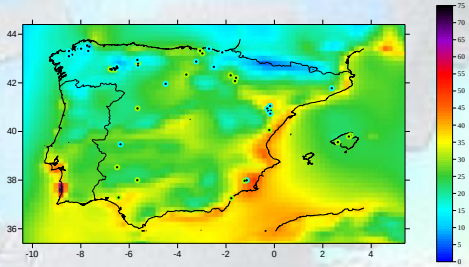
Kriging applied to residuals

URBAN

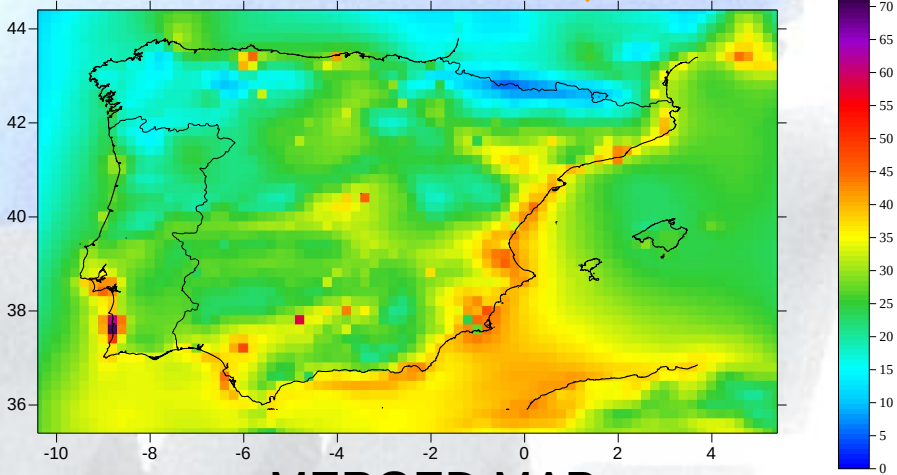


POPULATION

Kriging applied to residuals



RURAL

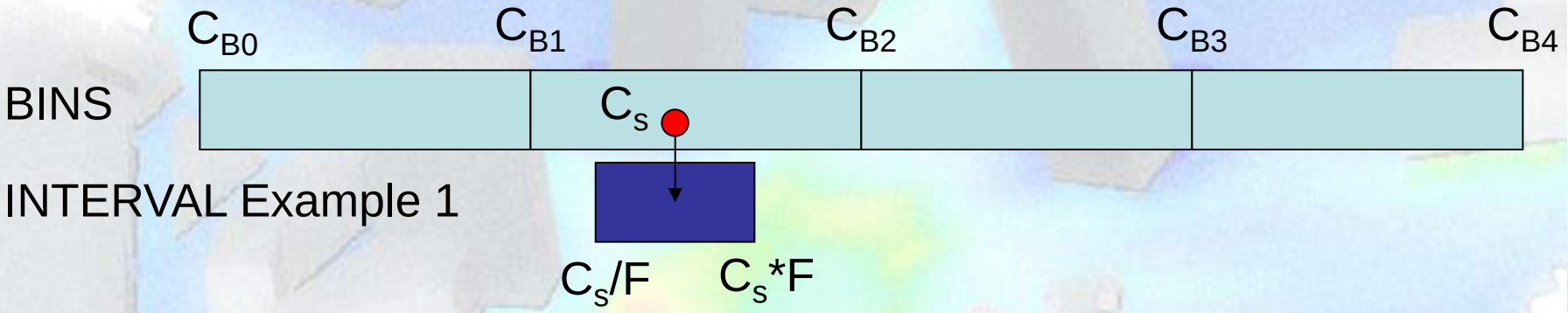


MERGED MAP

SR delimiting criteria

- Criteria for delimiting representativeness area are based on:
  - Concentration does not vary more than a certain percentage or factor (F) of the concentration at the station,
  - Concentration in the SR falls in the same air quality assessment classification (assessment thresholds, limits values).
  - Maximum SR area is a circle of 200 km of radius around the station (area of 125664 km^2). Directive EC 2008/50 states one rural background station per 100000 km^2.
- Procedure:
  1. Several concentration bins were set up for every pollutant and air quality standard (related to LV, TV, UAT, LAT).
  2. When station concentration falls in a bin, limits of concentration interval to comparison with concentrations around station are computed by applying factor F (1.2) to concentration at station site.
  3. SR area of a station will contain all the surrounding grid cells (10x10 Km) in circle of 200 km of radius with concentrations falling into interval.

Setting concentrations intervals



C_{Bi} = bin limits (related to LV, TV, UAT, LAT)
C_s = concentration at station
F = factor for setting intervals (1.2 or 2.0 for very low concentrations)

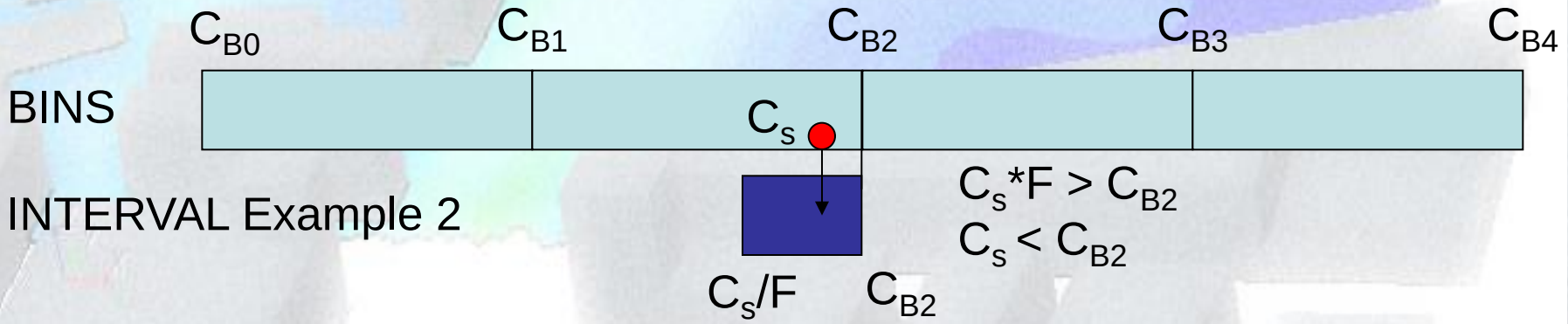


Table 2. Criteria for delimiting the SR of the RB stations for every pollutant and air quality standard. I = bins of concentrations (μgm^{-3}), F = factor applied to set the concentration interval respect to the reference concentration at the station, and L = limits (μgm^{-3}) applied to the upper and lower values of the intervals for each concentration bin.

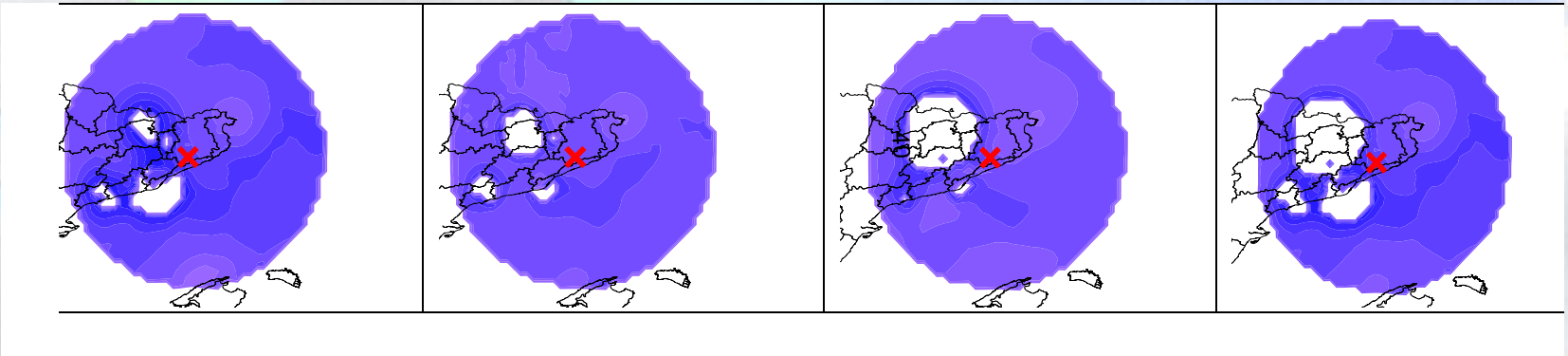
Averaging time	SO_2			O_3			NO_2			PM_{10}		
	I	F	L	I	F	L	I	F	L	I	F	L
Annual mean	<4	2	max≤4				<13	2	max≤13			
	≥4 <8	1.2	min≥4 max≤8				≥13 <26	1.2	min≥13 max≤26	<20	1.2	max≤20
	≥8 <12	1.2	min≥8 max≤12				≥26 <32	1.2	min≥26 max≤32	≥20 <28	1.2	min≥20 max≤28
	≥12 <20	1.2	min≥12 max≤20				≥32 <40	1.2	min≥32 max≤40	≥28 <40	1.2	min≥28 max≤40
	≥20	1.2	min≥20				≥40	1.2	min≥40	≥40	1.2	min≥40
Daily average	<25	2	max≤25									
	≥25 <50	1.2	min≥25 max≤50							<25	1.2	max≤25
	≥50 <75	1.2	min≥50 max≤75							≥25 <35	1.2	min≥25 max≤35
	≥75 <125	1.2	min≥75 max≤125							≥35 <50	1.2	min≥35 max≤50
	≥125	1.2	min≥125							≥50	1.2	min≥50
Hourly average	<70	2	max≤70	<90	1.2	max≤90	<50	2	max≤50			
	≥70 <140	1.2	min≥70 max≤140	≥90 <135	1.2	min≥90 max≤135	≥50 <100	1.2	min≥50 max≤100			
	≥140 <210	1.2	min≥140 max≤210	≥135 <180	1.2	min≥135 max≤180	≥100 <140	1.2	min≥100 max≤140			
	≥210 <350	1.2	min≥210 max≤350	≥180 <210	1.2	min≥180 max≤210	≥140 <200	1.2	min≥140 max≤200			
	≥350	1.2	min≥350	≥210 <240	1.2	min≥210 max≤240	≥200 <400	1.2	min≥200 max≤400			
				≥240	1.2	min≥240	≥400	1.2	min≥400			
8-hour average				<84	1.2	max≤84						
				≥84 <108	1.2	min≥84 max≤108						
				≥108 <120	1.2	min≥108 max≤120						
				≥120 <180	1.2	min≥120 max≤180						
				≥180	1.2	min≥180						

Results

- The SR area of the RB stations was estimated for each of the three years (2008, 2009 and 2010).

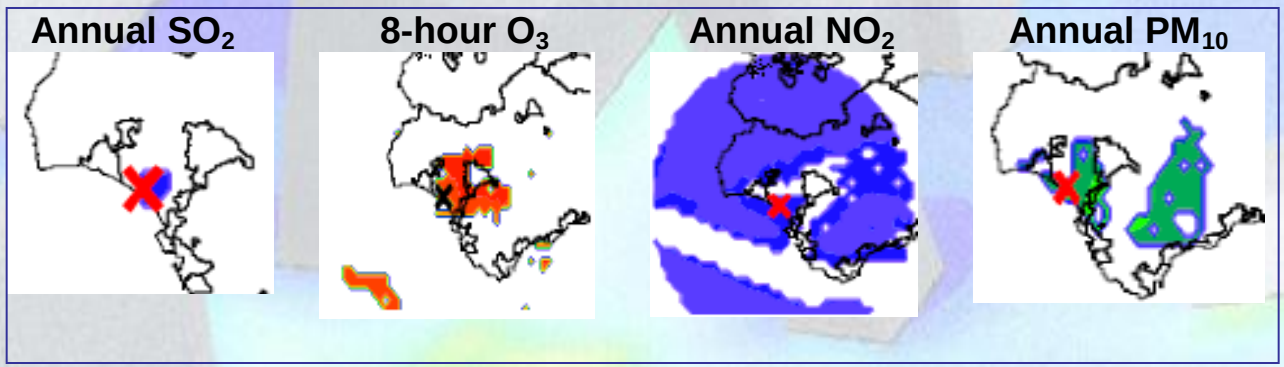
- The multiyear SR area can be estimated computing the intersection of the yearly SR areas.

2008 2009 2010 Intersection

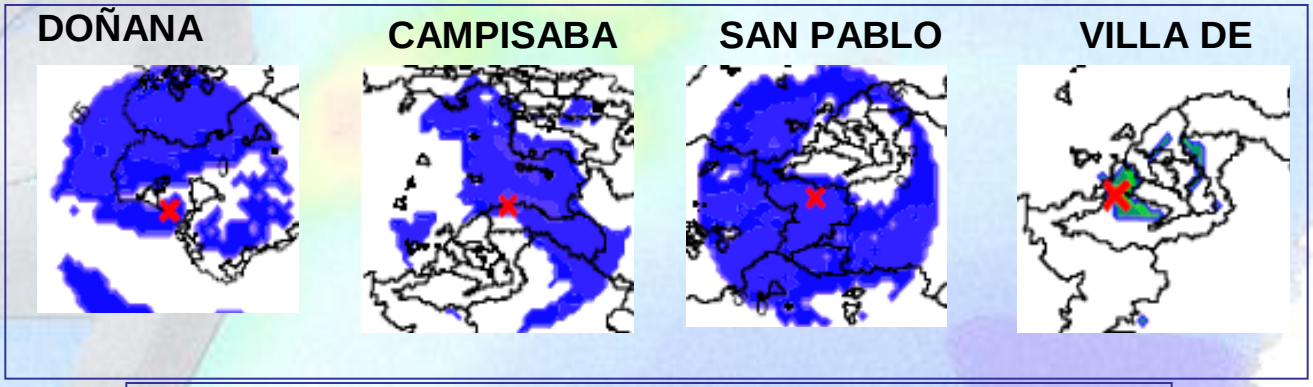


Results

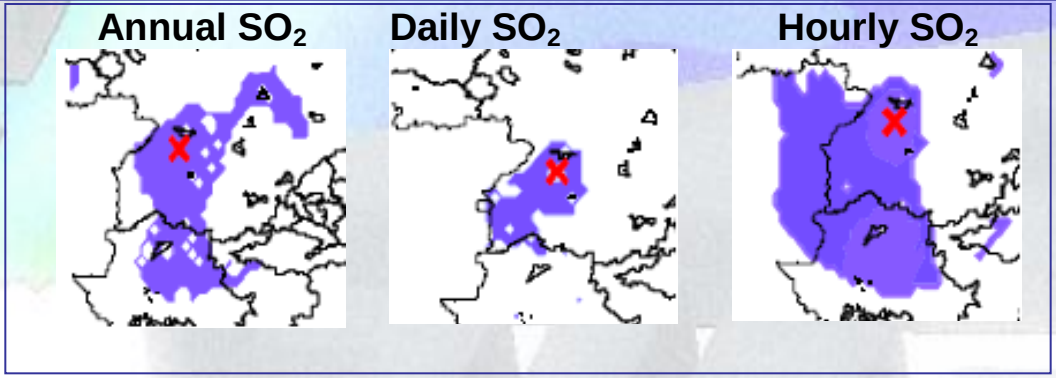
SRs for Doñana station and several pollutants



SR for hourly NO_2 and several stations

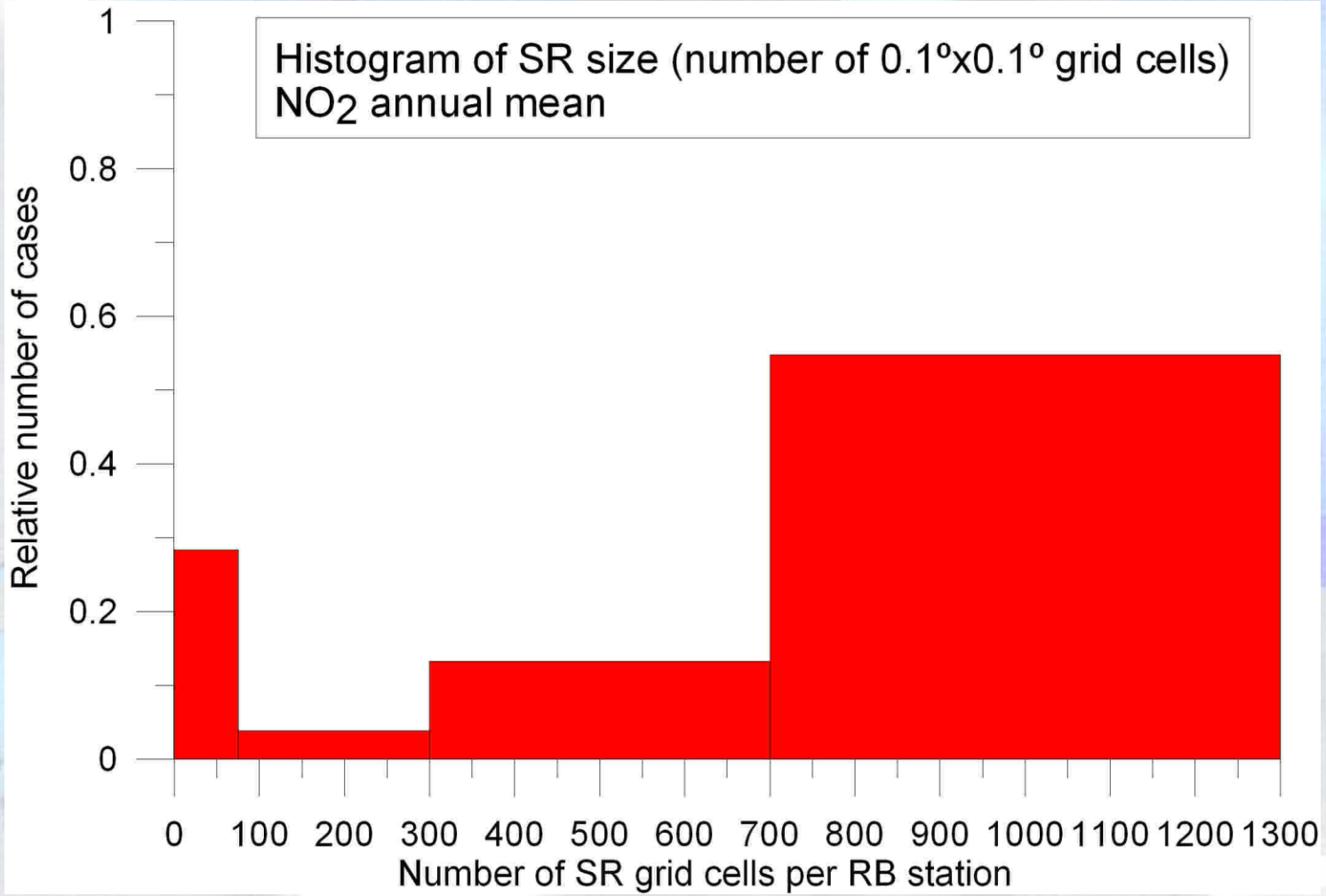


SRs for Peñausende station and SO_2



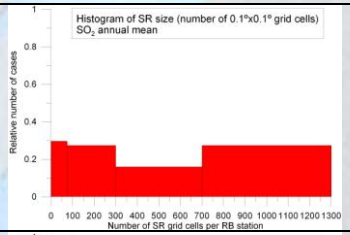
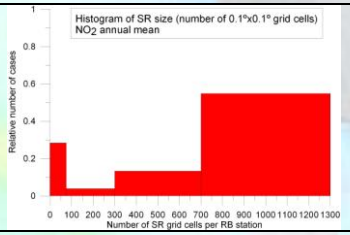
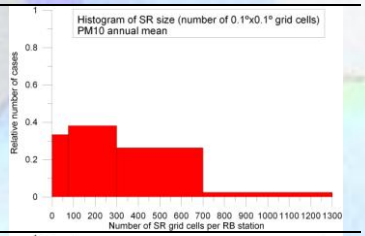
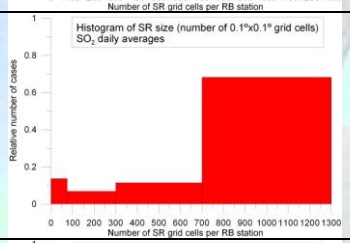
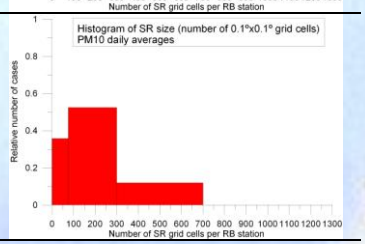
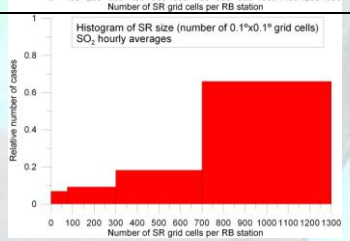
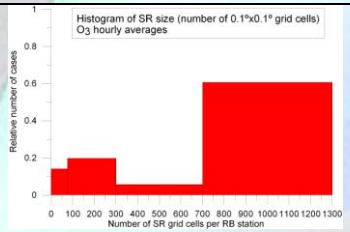
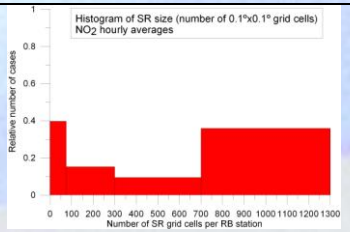
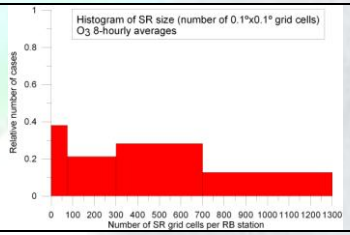
SR size (1)

Bins of grid cell (10x10 km^2) numbers are 0-75, 75-300, 300-700 and 700-1300.



SR size (2)

Bins of grid cell (10x10 km^2) numbers are 0-75, 75-300, 300-700 and 700-1300.

Averaging time	SO_2	O_3	NO_2	PM_{10}
Annual mean				
Daily average				
Hourly average				
8-hour average				

SR size (3)

Bins of grid cell (10x10 km^2) numbers are 0-75, 75-300, 300-700 and 700-1300.

- Large SR areas are more frequent for hourly and daily SO_2, hourly O_3 and annual NO_2.
- More small or medium SR areas for PM_{10} and 8-hourly averages of O_3.
- Generally, the SR areas ranging from 300 to 700 grid cells are less frequent.

Interannual variability (1)

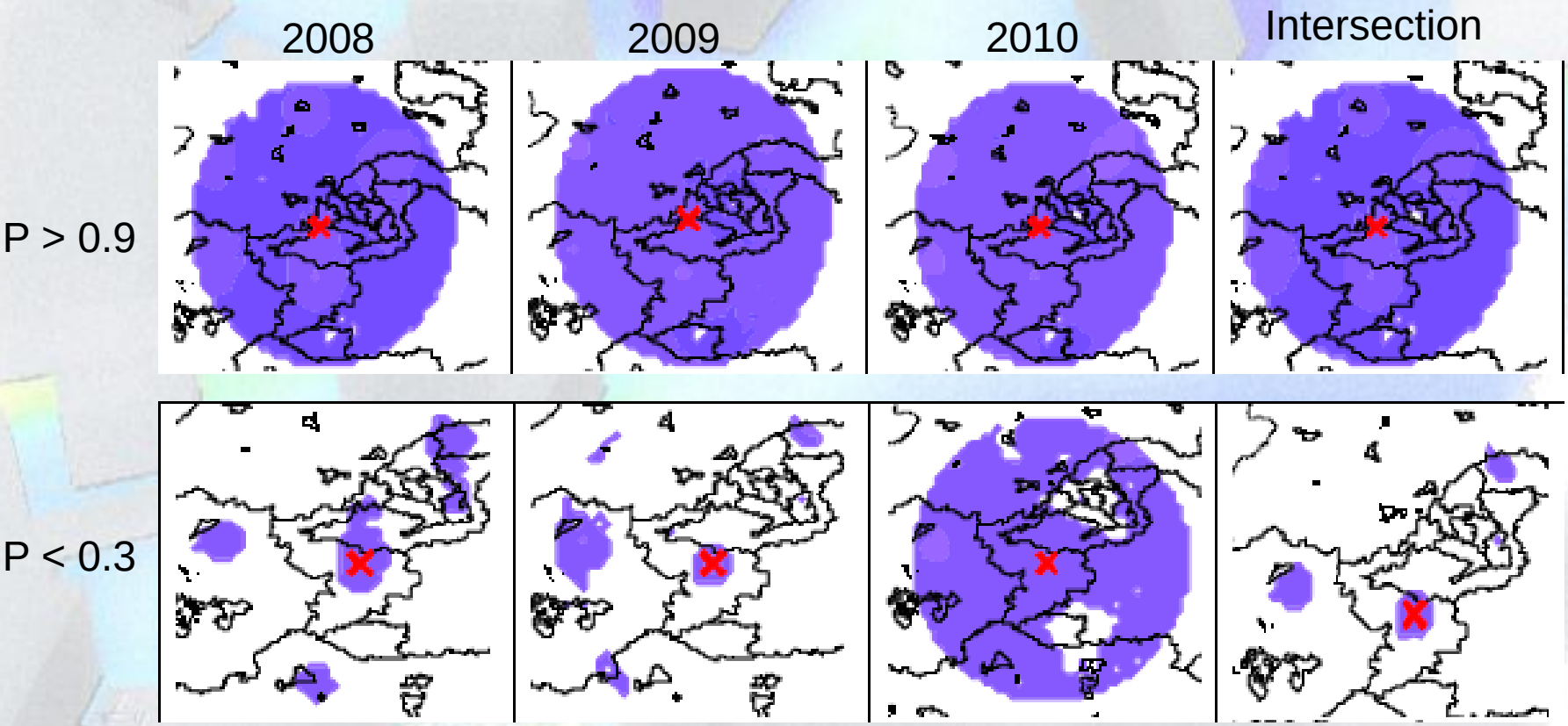
- Interannual variability of the SR areas has been analysed by computing a persistence index *P* defined by:

$$P = \min\left[\frac{SR_T}{SR_Y}\right]$$

  - SR_Y = SR area of a station for a year *Y* (2008, 2009 or 2010)
  - SR_T = multiyear SR area of the same station.
- $P \in [0,1]$, P=0 ➔ no persistency, P=1 ➔ same SR all years.

P	SO_2			O_3		NO_2		PM_{10}	
	annual	daily	hourly	8-hour	hourly	annual	hourly	annual	daily
0.0 - 0.3	23	8	7	34	21	14	21	22	20
0.3 - 0.7	10	7	8	29	11	12	16	17	22
0.7 - 1.0	11	29	29	8	39	27	16	3	0
Total	44	44	44	71	71	53	53	42	42

Interannual variability (2)



SO_2 hourly

Station redundancy (1)

- Redundancy ➔ two or more stations are representative of the same portion of territory.
- *Q* factor = ratio between the common area of two stations and the total area covered by both stations (percentage of redundancy between two stations).

$$Q = I_{ab} / (N_a + N_b - I_{ab})$$

  - I_{ab} = number of cells in common between SR of two stations (A, B)
  - N_a = number of cells in SR of station A
  - N_b = number of cells in SR of station B
- $Q \in [0,1]$
- *Q=0* means no common SR area,
- *Q=1* means that the two stations are totally coincident.

Station redundancy (2)

Q>0.5	NO_2	NO_2	O_3	O_3	PM_{10}	PM_{10}	SO_2	SO_2	SO_2
Intersections	annual	hourly	8-hourly	hourly	annual	daily	annual	daily	hourly
0	32	28	27	14	27	27	35	17	16
1	5	14	21	15	14	12	2	5	7
2	3	6	0	4	1	3	3	4	5
3	6	2	5	4			4	2	3
4	5	3	2	3				13	6
5	1		3	15				1	1
6	1		4	3				3	5
7			3	0					1
8			3	2					
9			0	4					
10			1	1					
11			2	3					
12				2					
13				1					
Total	53	53	71	71	42	42	44	44	44

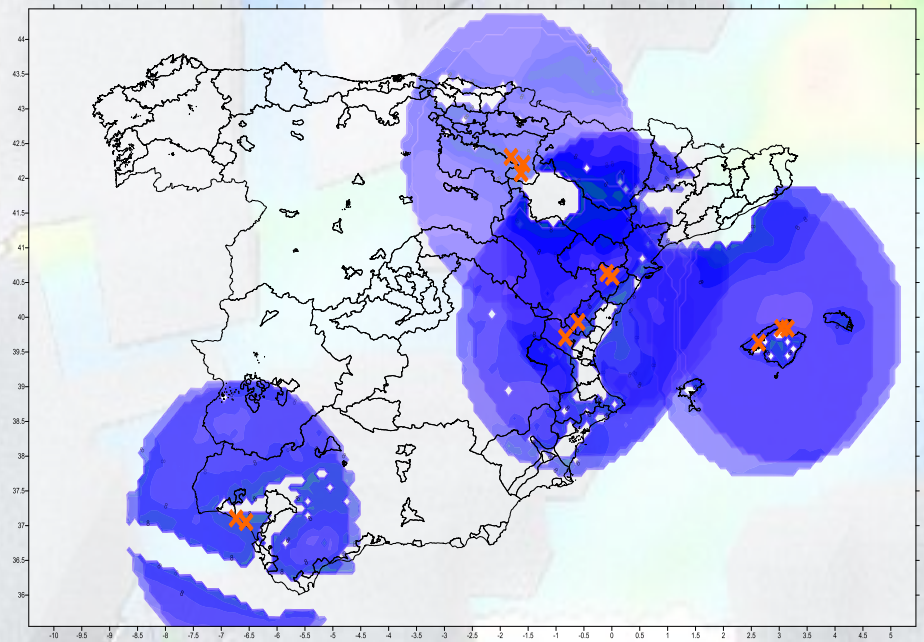
Station redundancy (3)

Q>0.8	NO_2	NO_2	O_3	O_3	PM_{10}	PM_{10}	SO_2	SO_2	SO_2
Intersections	annual	hourly	8-hourly	hourly	annual	daily	annual	daily	hourly
0	41	42	39	30	36	35	41	32	35
1	8	8	20	18	6	4	0	3	2
2	4	3	4	8		3	3	8	5
3			2	3				1	2
4			4	11					
5			2	1					
Total	53	53	71	71	42	42	44	44	44

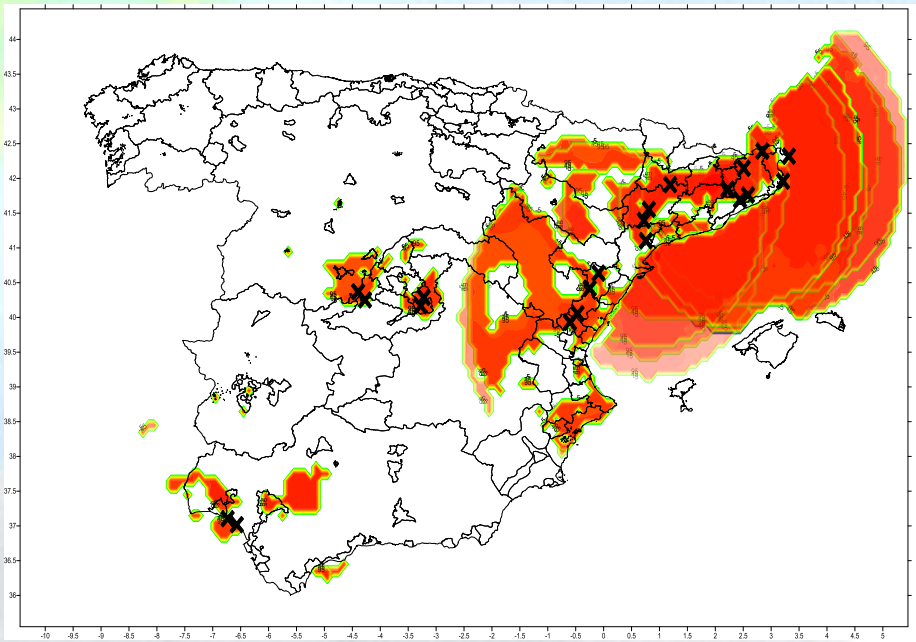
Station redundancy (5)

- Examples of stations with Q > 0.8

NO_2 anual



O_3 8-hourly

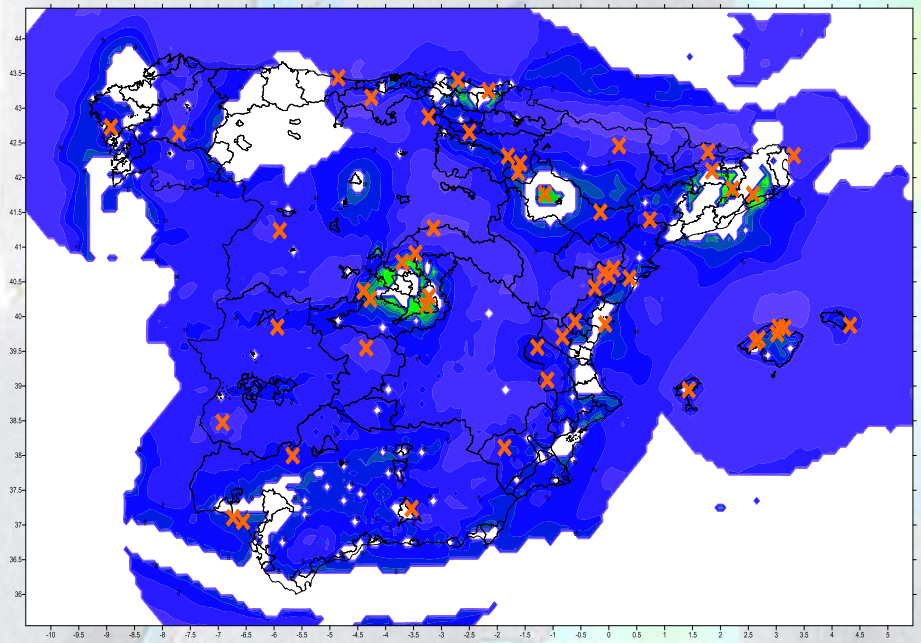


Station redundancy (5)

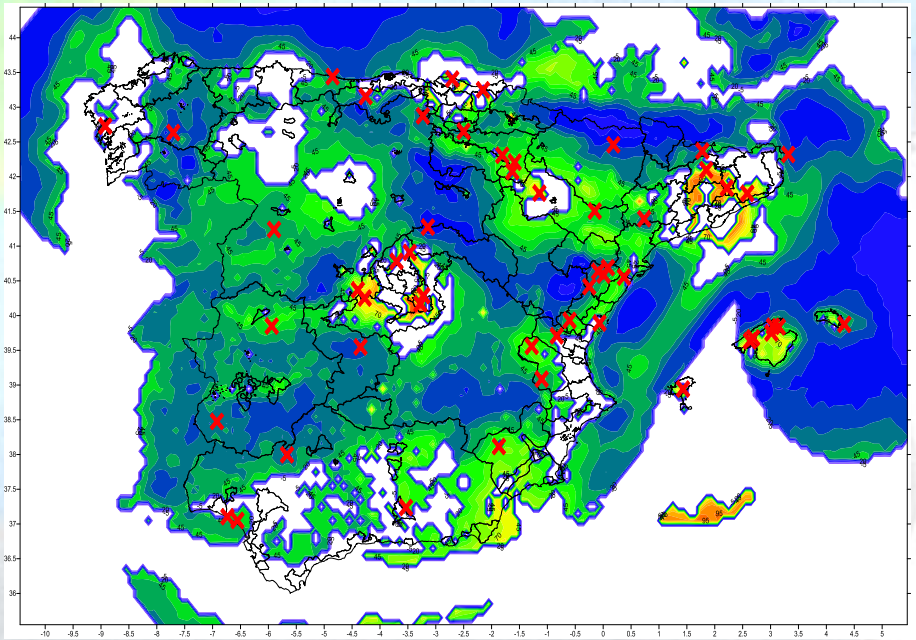
Q = 1	**O_3**	**O_3**	**PM_{10}**	**PM_{10}**
	8-hourly	*hourly*	*annual*	*daily*
	3	2	1	3

Network coverage (1)

NO_2 annual

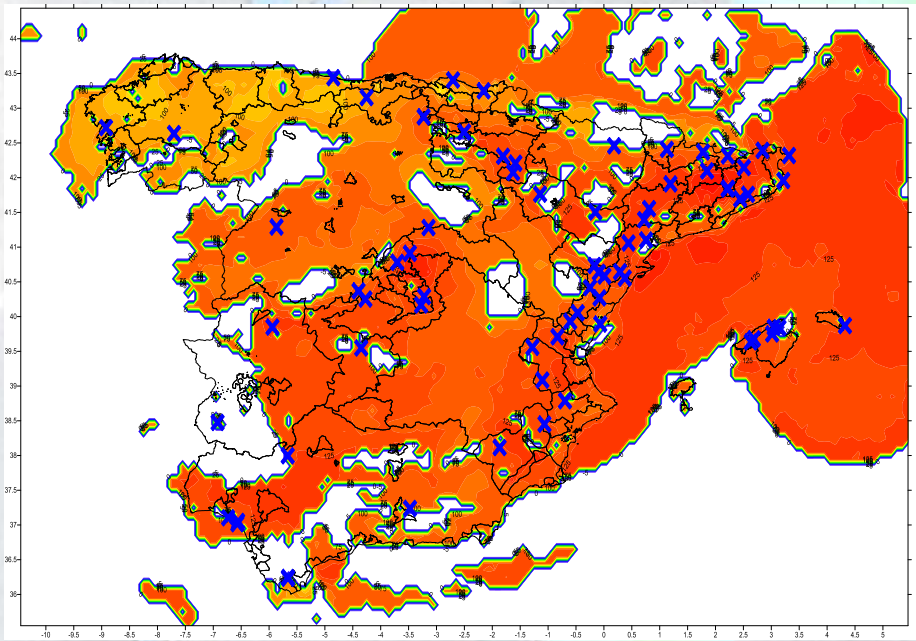


NO_2 hourly

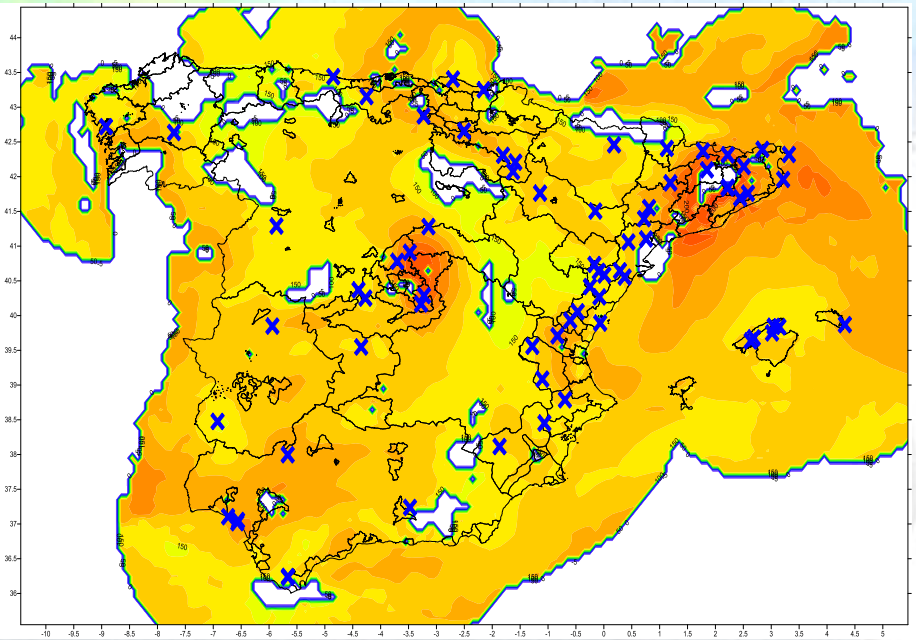


Network coverage (2)

O_3 8-hourly

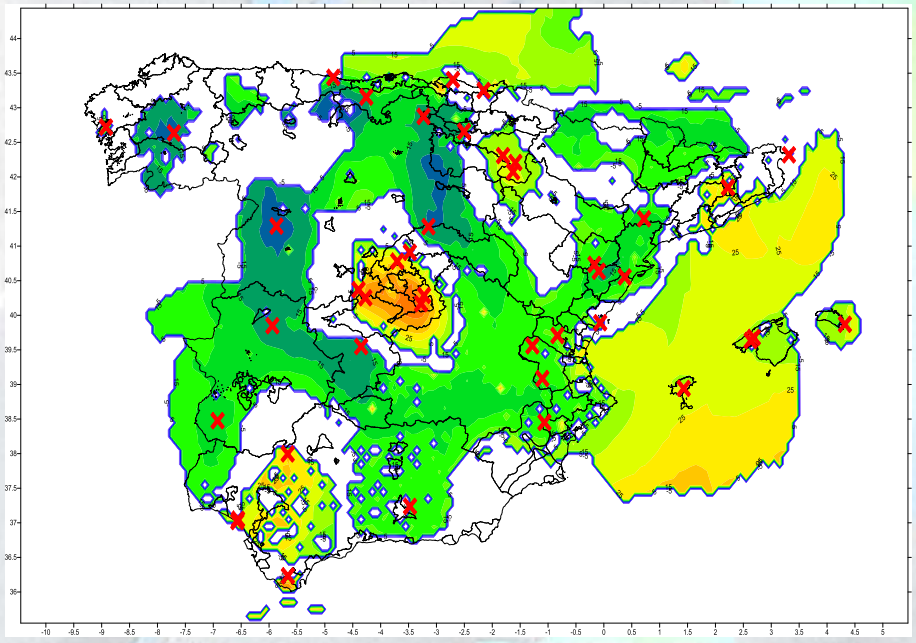


O_3 hourly

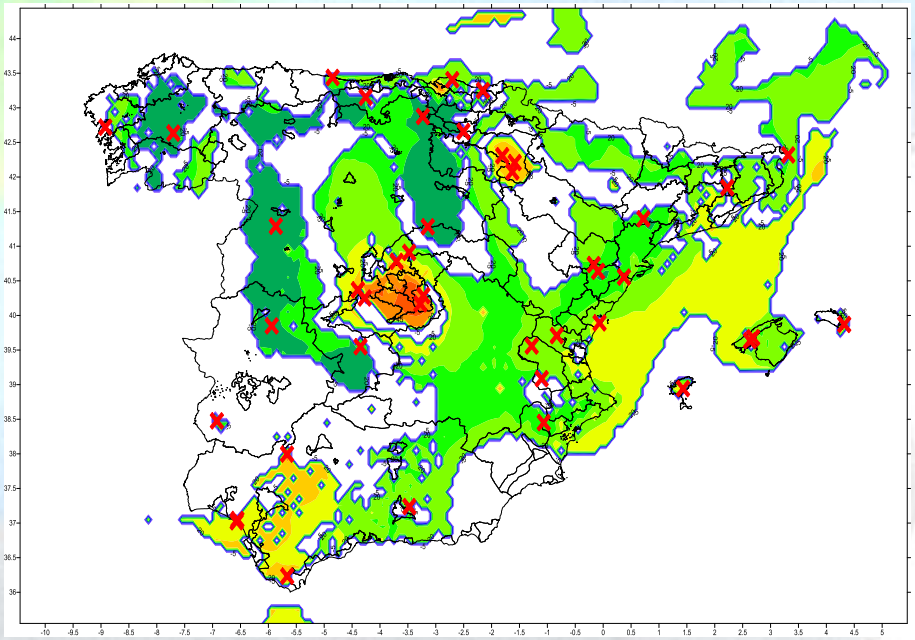


Network coverage (3)

PM_{10} annual

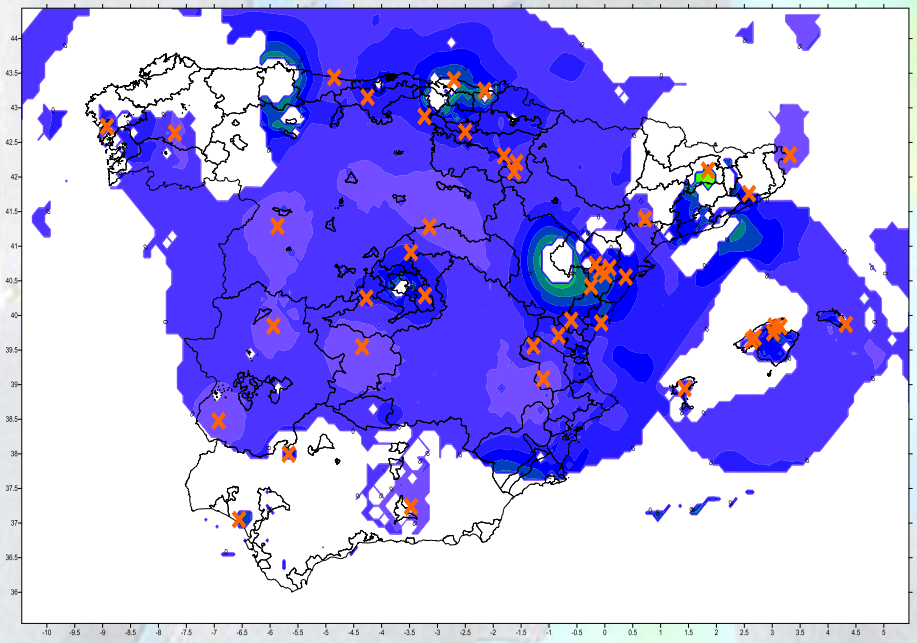


PM_{10} daily

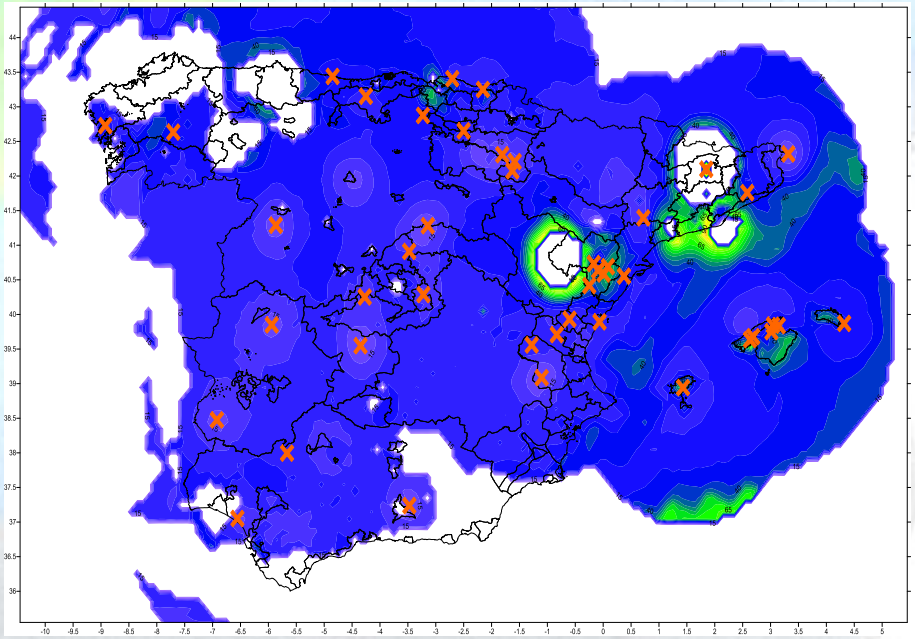


Network coverage (4)

SO_2 annual



SO_2 hourly



Conclusions

- Methodology to estimate spatial representativeness (SR) of rural background (RB) stations using maps from combination of modeling and monitoring.
- Great variability of SR sizes and shapes.
- For same station, different SR depending on pollutant and averaging time.
- High interannual variability of SR except to daily and hourly SO_2, hourly O_3 and annual NO_2.
- A significant number of stations are redundant especially for O_3.
- The coverage of the AQ station network shows some rural areas not well covered.