SPATIAL REPRESENTATIVENESS OF RURAL BACKGROUND MONITORING STATIONS IN SPAIN

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Outline

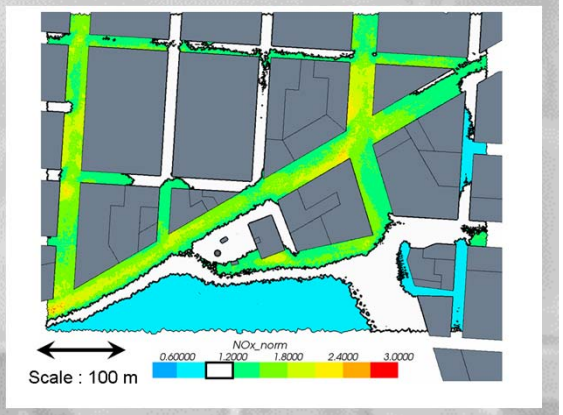
- Introduction
- Objectives
- Methodology
- Results
- Conclusions

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.



Objectives

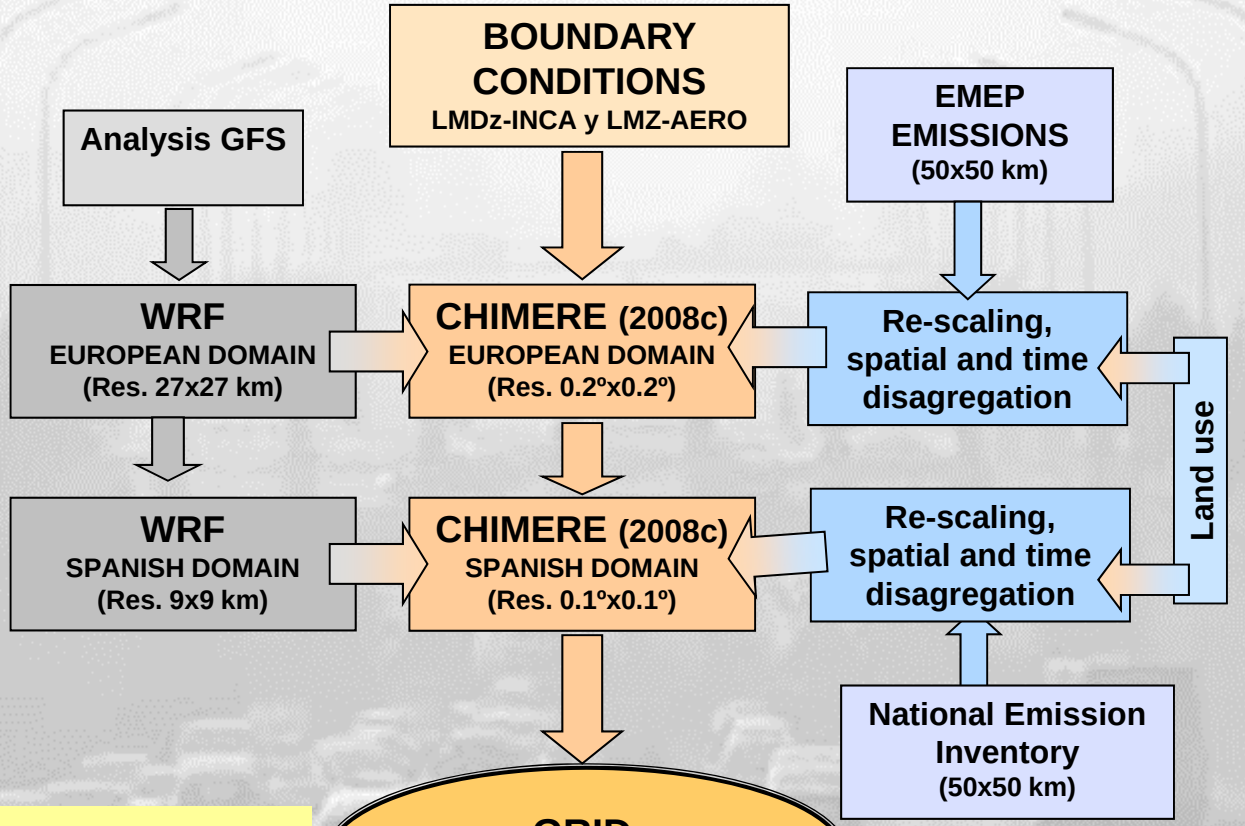
- **To estimate the SR area of the rural background (RB) stations based on the analysis of the pollutant concentration distribution around the stations in the Iberian Peninsula and Balearic Islands** obtained from annual WRF-CHIMERE model simulations combined with measurements of air quality stations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

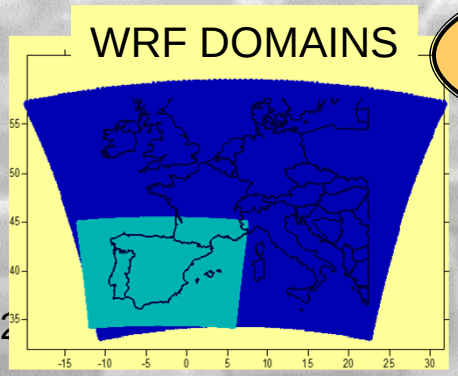
Methodology

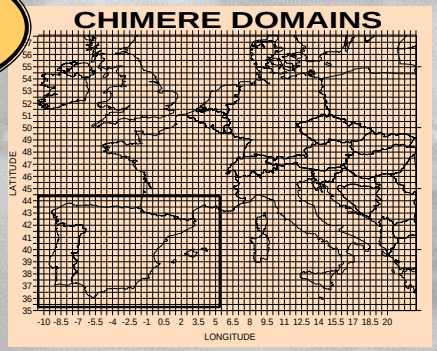
- Analysis of the annual maps of pollutant concentrations of SO_2, O_3, NO_2 and PM_{10} for three years (2008-2010) computed routinely for annual air quality assessment in Spain.
- Maps obtained from annual simulations with the WRF-CHIMERE model system combined with measurements at air quality stations.

	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

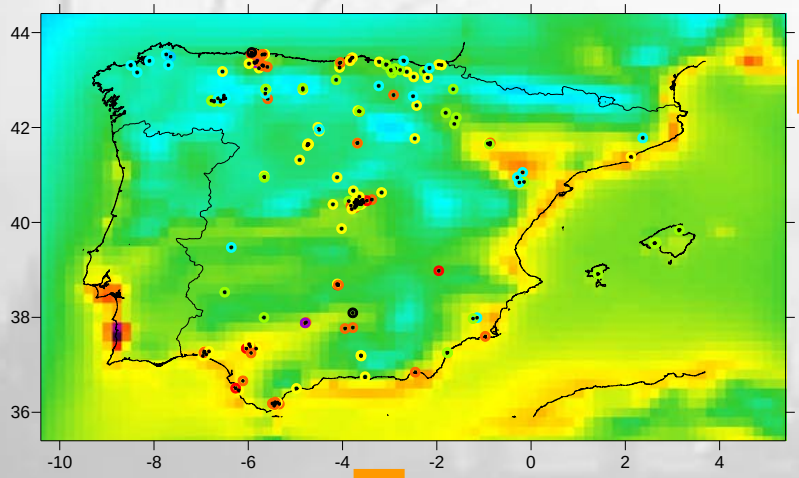






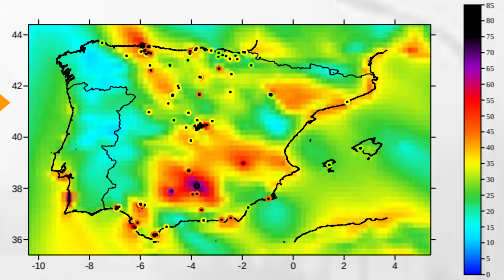
Measurements and modeling combination

Model and measurement



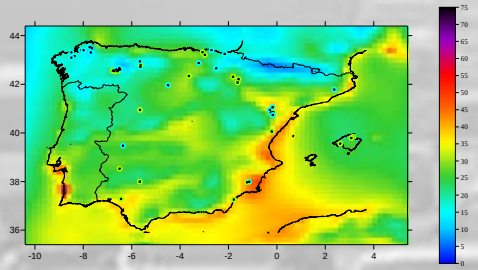
Kriging applied to residuals

URBAN

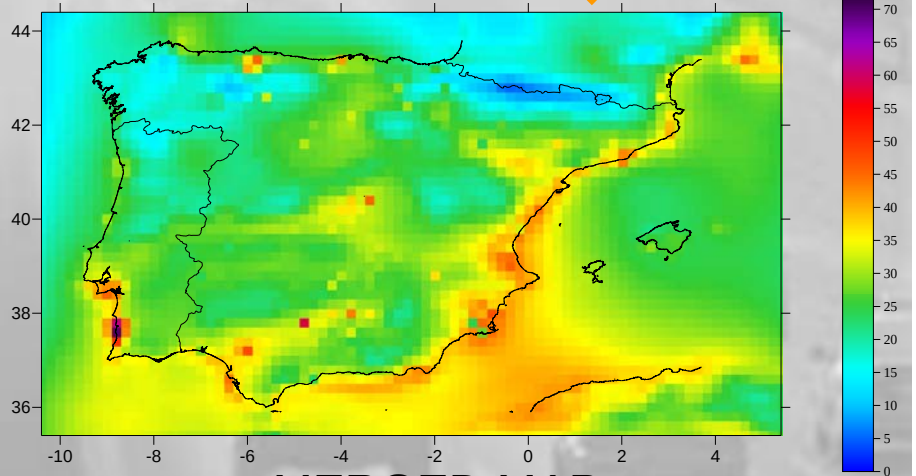


POPULATION

Kriging applied to residuals



RURAL

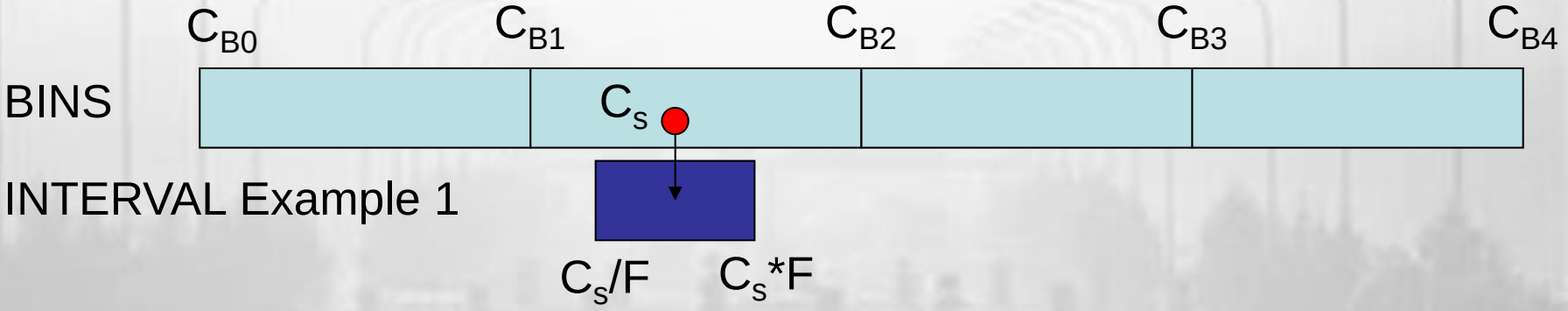


MERGED MAP

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)

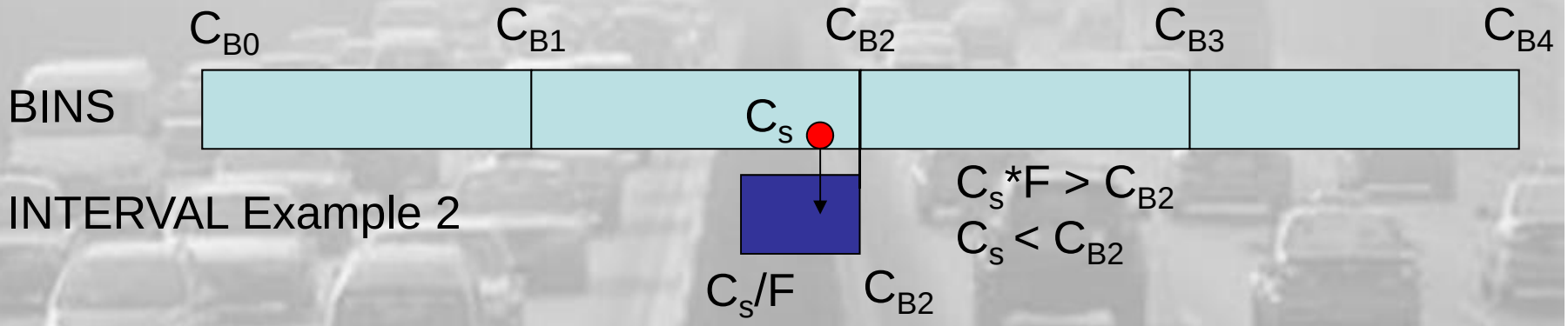


Table 2. Criteria for delimiting the SR of the RB stations for every pollutant and air quality standard. I = bins of concentrations (μgm^{-3}), F = factor applied to set the concentration interval respect to the reference concentration at the station, and L = limits (μgm^{-3}) applied to the upper and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

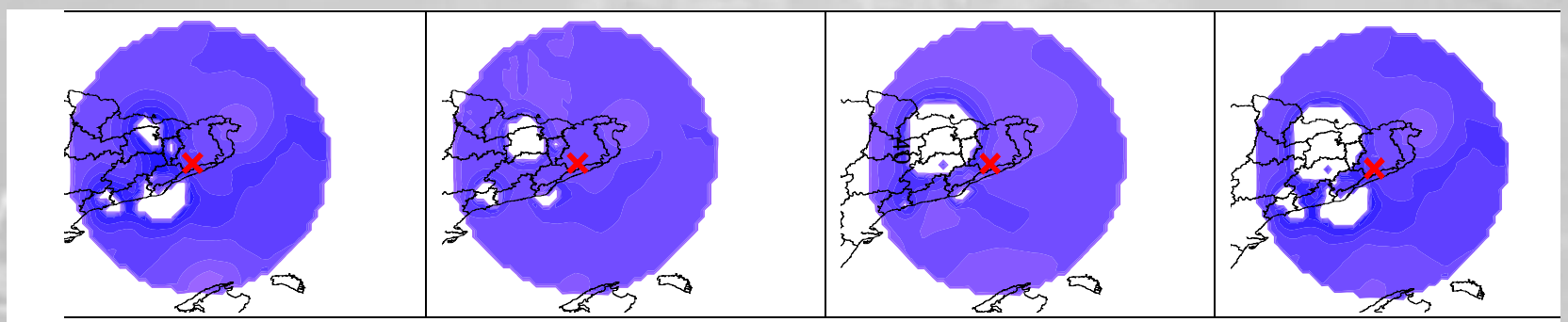
Averaging time	SO_2			O_3			NO_2			PM_{10}		
	I	F	L	I	F	L	I	F	L	I	F	L
Annual mean	<4	2	max≤4				<13	2	max≤13			
	≥4 <8	1.2	min≥4 max≤8				≥13 <26	1.2	min≥13 max≤26	<20	1.2	max≤20
	≥8 <12	1.2	min≥8 max≤12				≥26 <32	1.2	min≥26 max≤32	≥20 <28	1.2	min≥20 max≤28
	≥12 <20	1.2	min≥12 max≤20				≥32 <40	1.2	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).

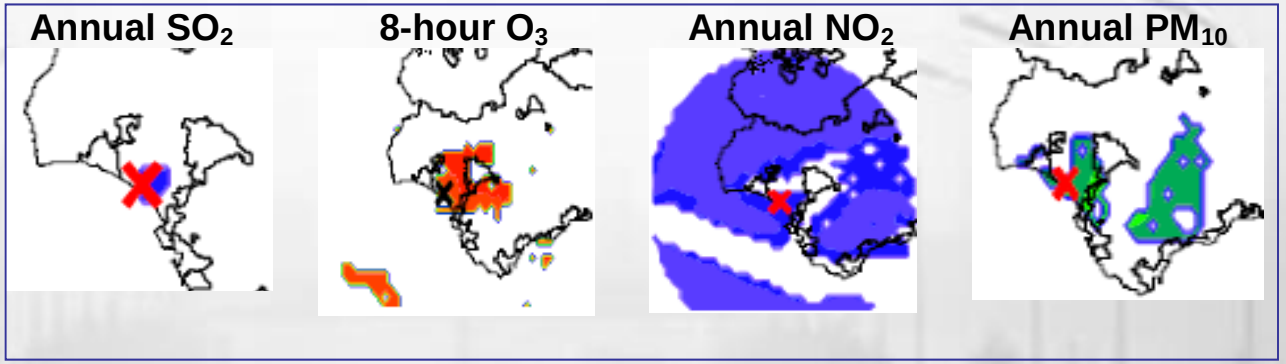
- The multiyear SR area can be estimated computing the intersection of the yearly SR areas.

2008 2009 2010 Intersection

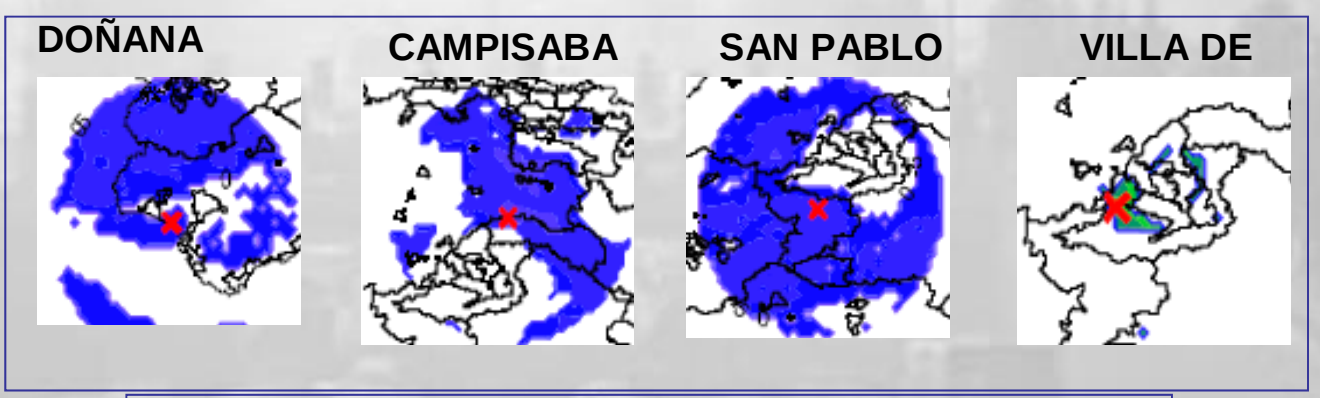


Results

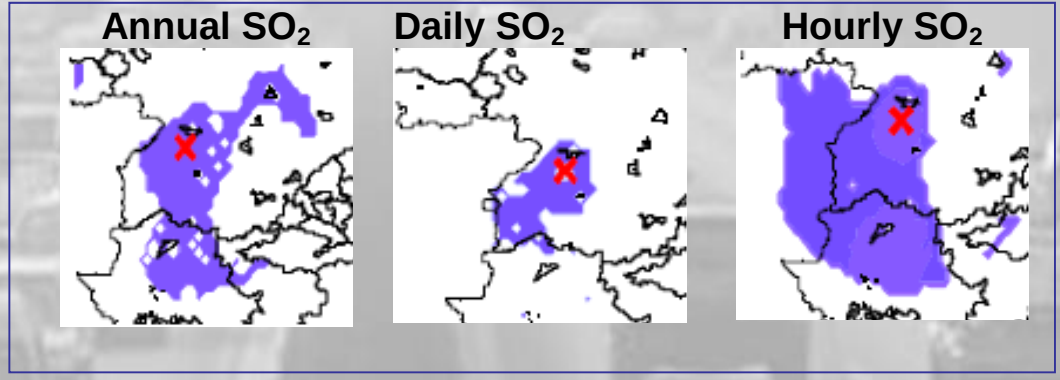
SRs for Doñana station and several pollutants



SR for hourly NO_2 and several stations

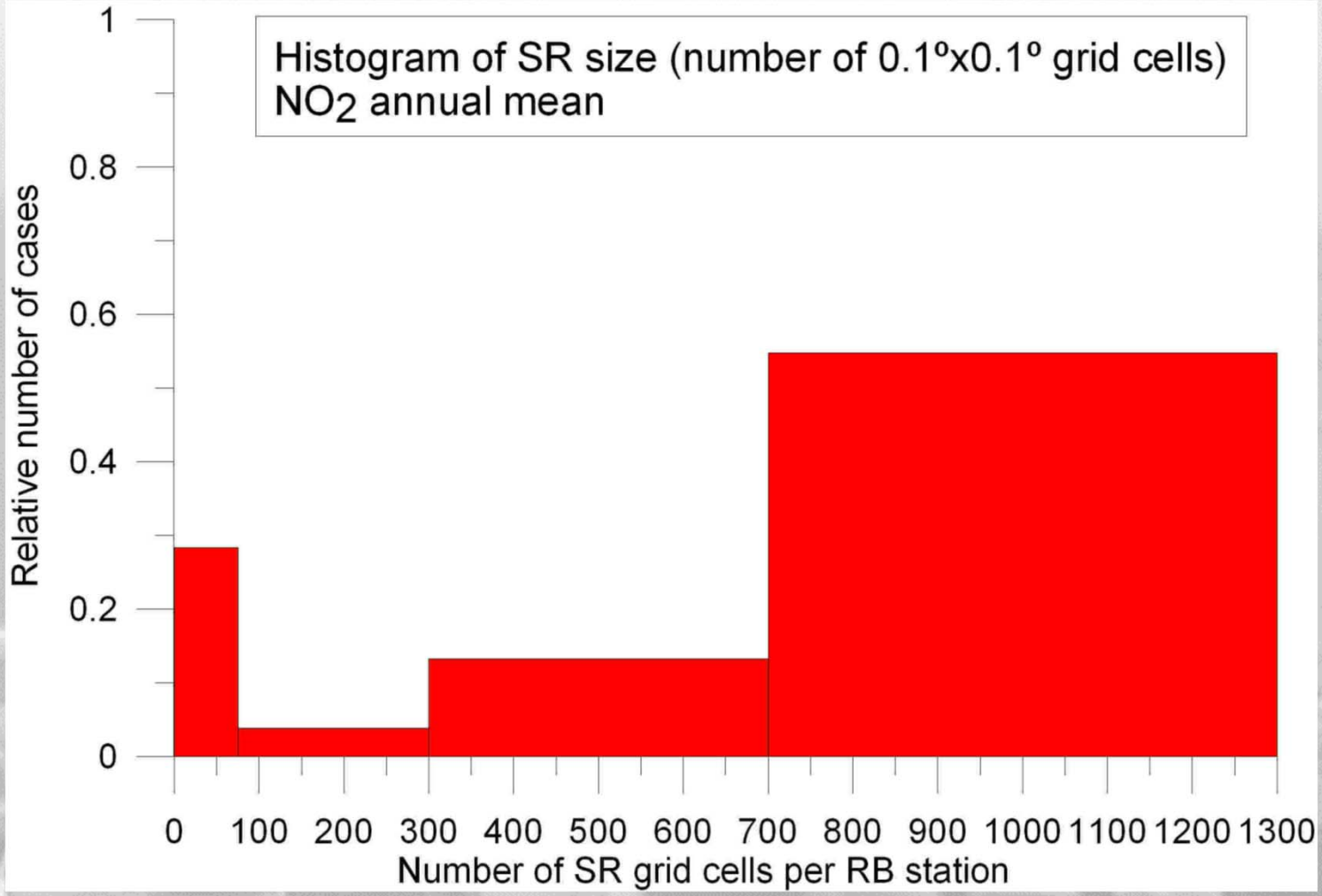


SRs for Peñausende station and SO_2



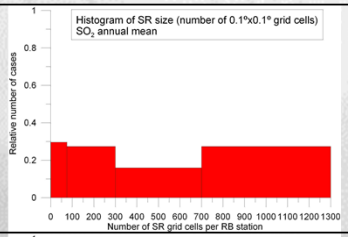
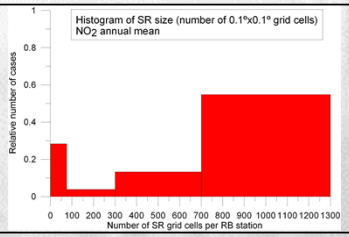
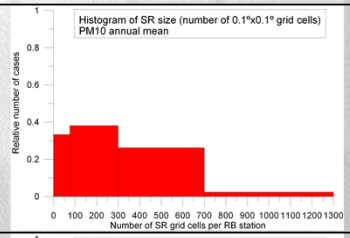
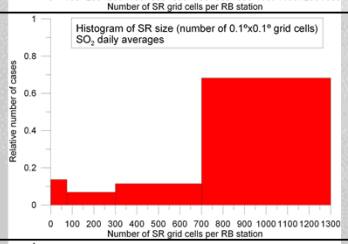
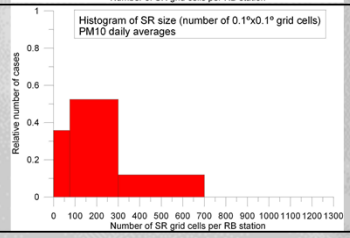
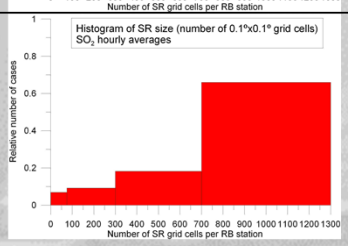
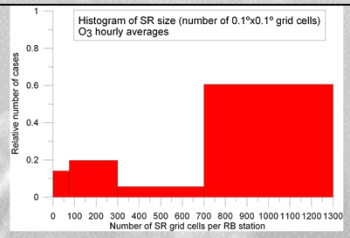
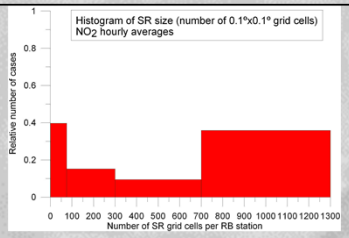
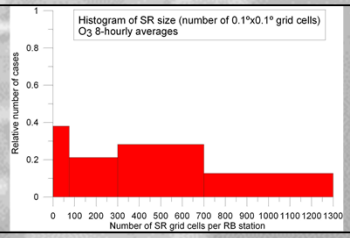
SR size (1)

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)

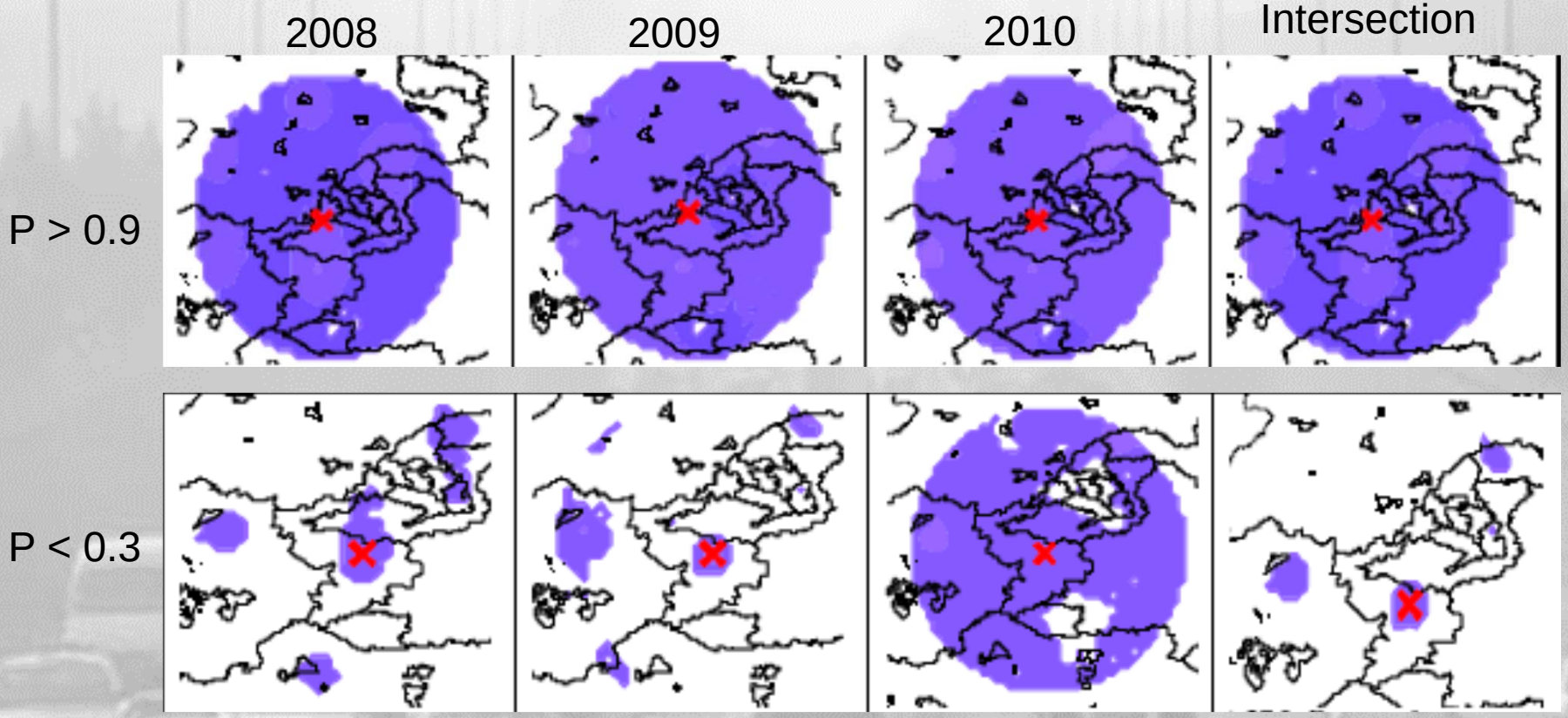
- Interannual variability of the SR areas has been analysed by computing a persistence index *P* defined by:

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

  - 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

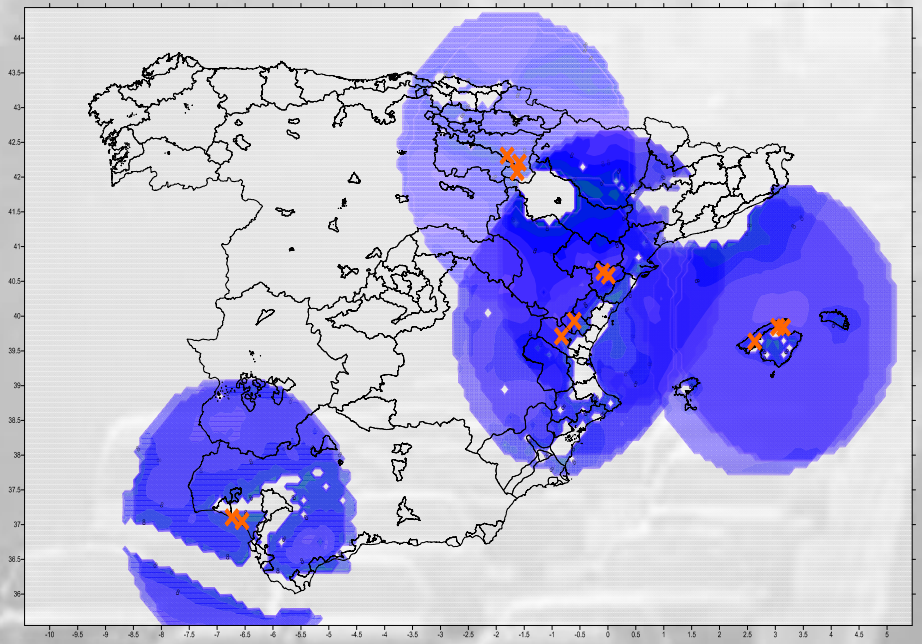
Station redundancy (3)

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

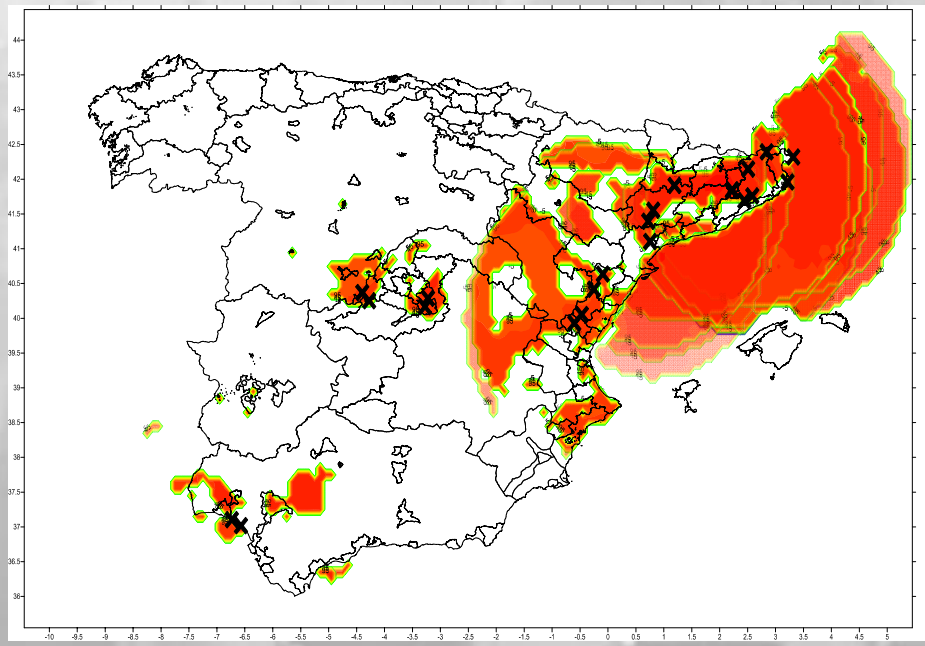
Station redundancy (5)

- Examples of stations with Q > 0.8

NO_2 anual



O_3 8-hourly

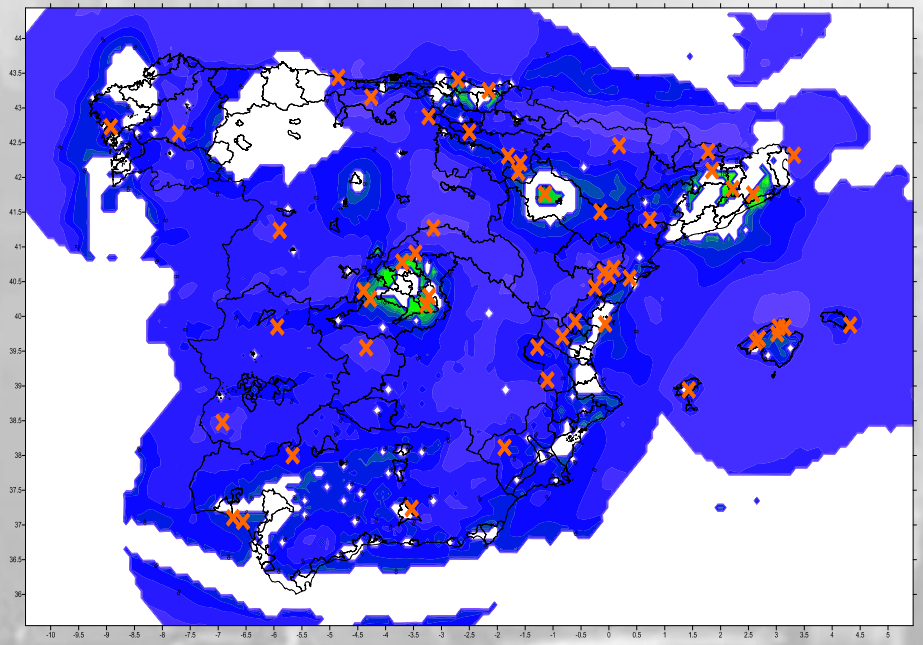


Station redundancy (5)

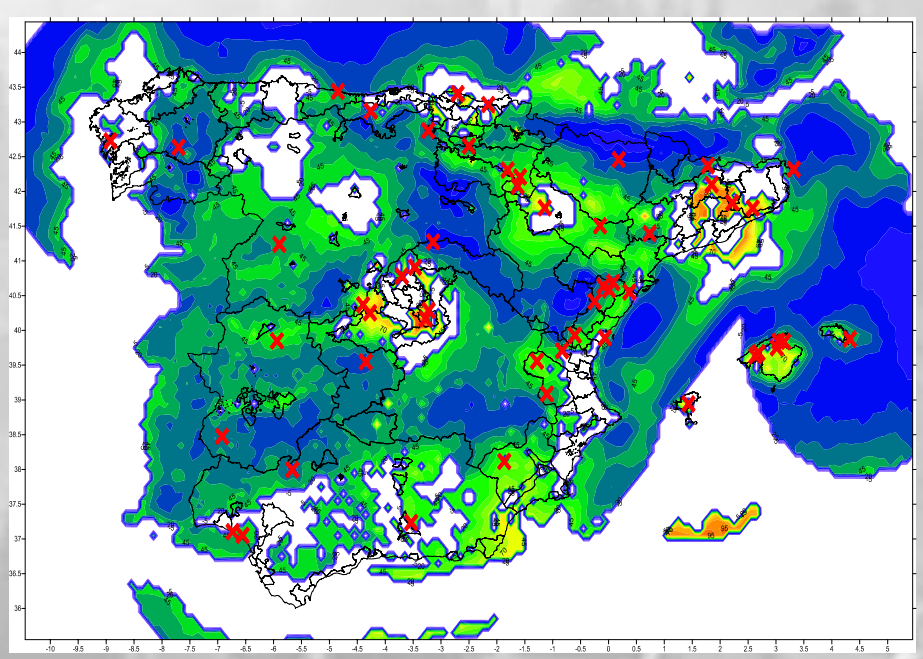
Q = 1	**O_3**	**O_3**	**PM_{10}**	**PM_{10}**
	8-hourly	*hourly*	*annual*	*daily*
	3	2	1	3
Names of RB stations	ParcBit / Hospital	Matalascañas / Doñana	Orusco / Villa_ De	Ctcc-Fun / Ctcc-Arg
Names of RB stations	SanMart / Villade	Tona-zoe / BH Tona		Ctcc-Tud / Ctcc-Arg
Names of RB stations	Orusco / Villarej			Ctcc-Tud / Ctcc-Fun

Network coverage (1)

NO_2 annual

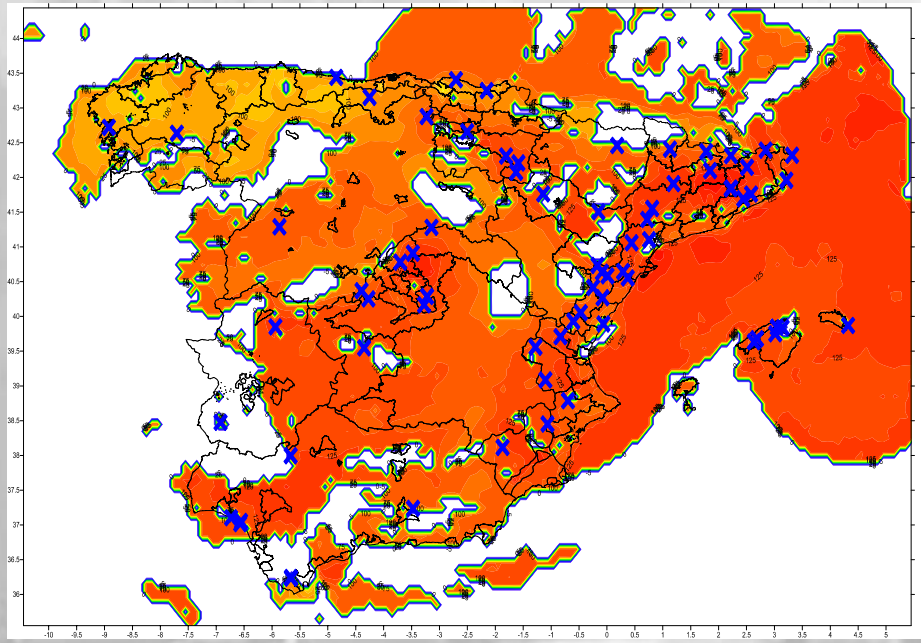


NO_2 hourly

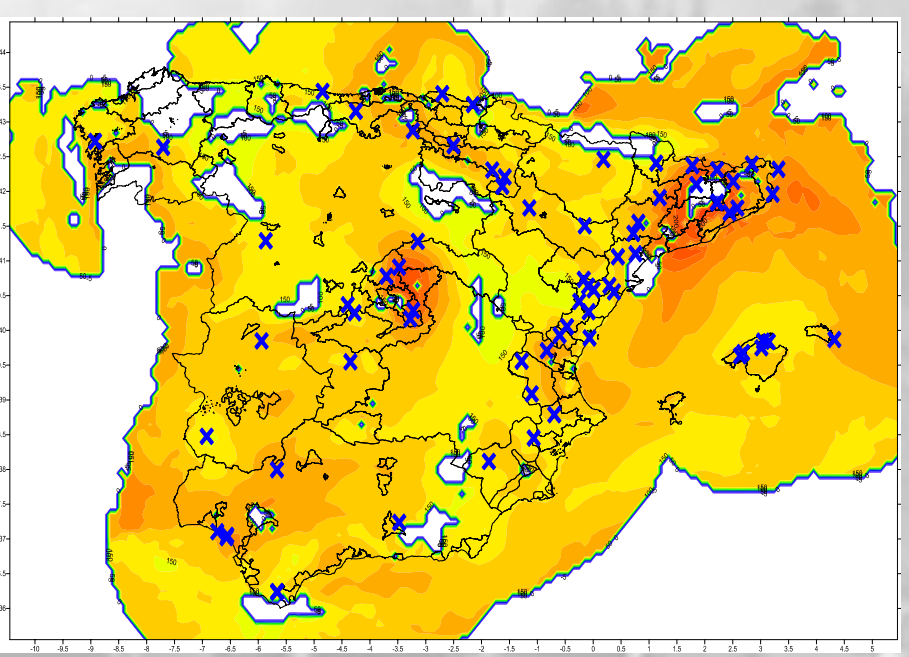


Network coverage (2)

O_3 8-hourly

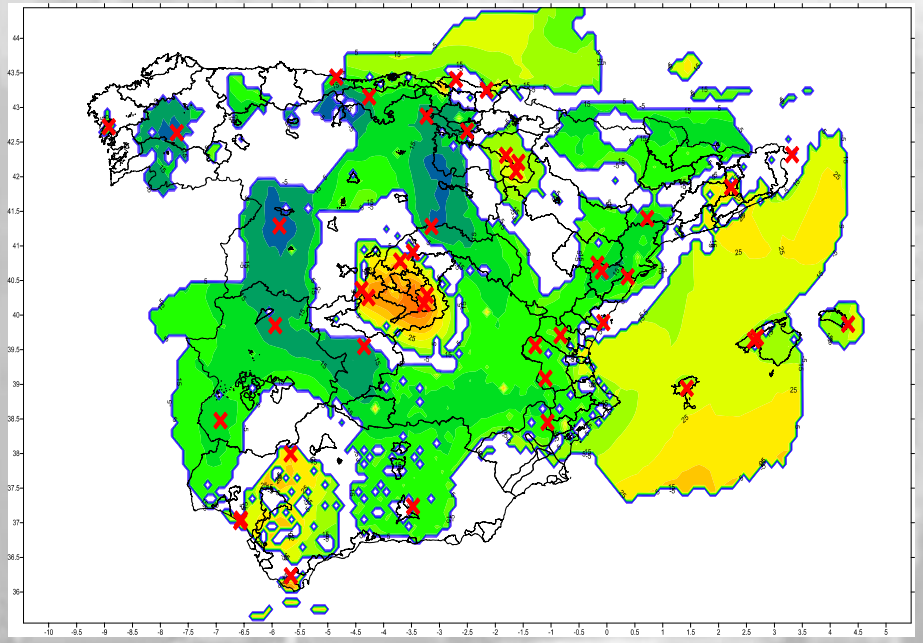


O_3 hourly

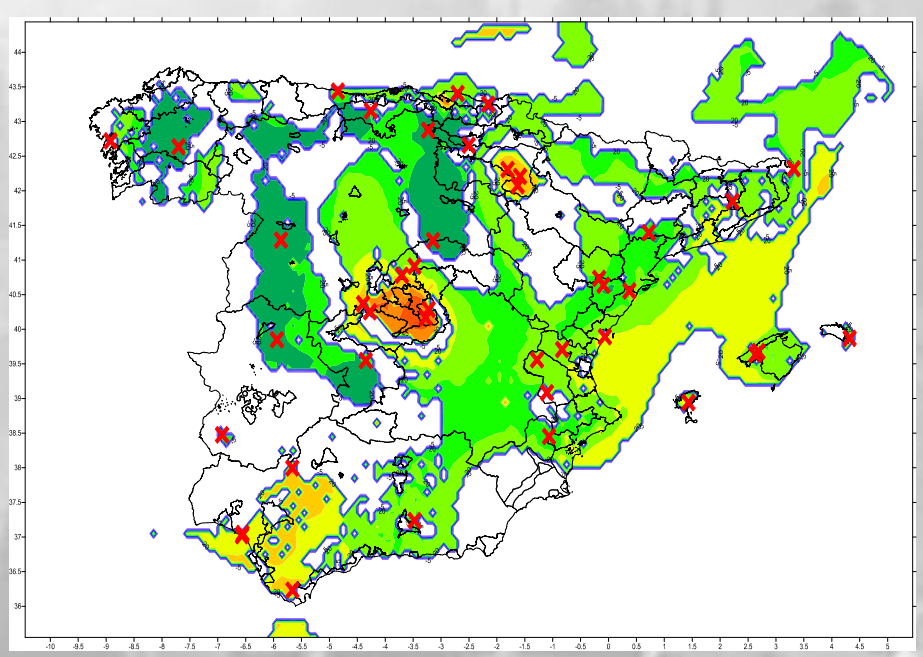


Network coverage (3)

PM_{10} annual

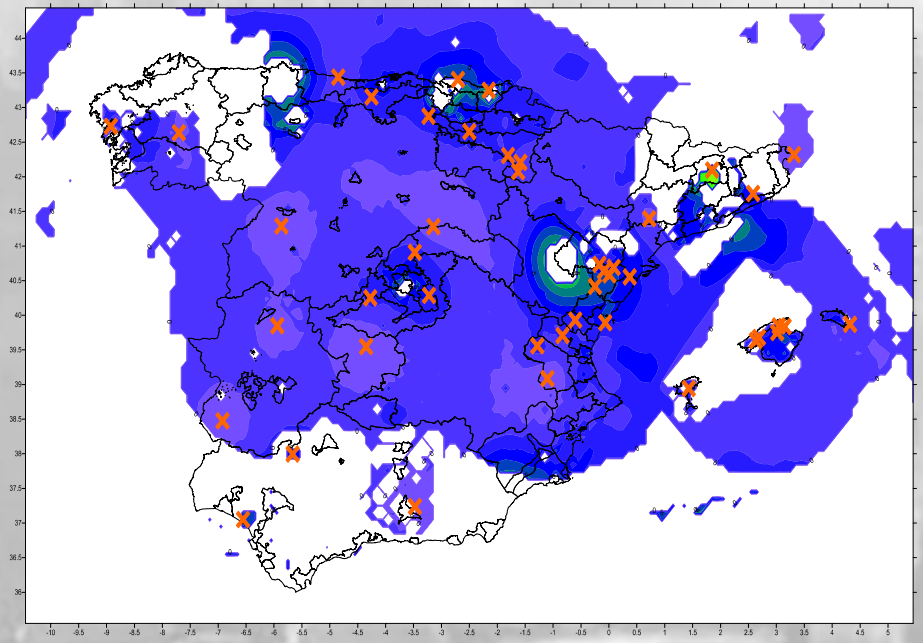


PM_{10} daily

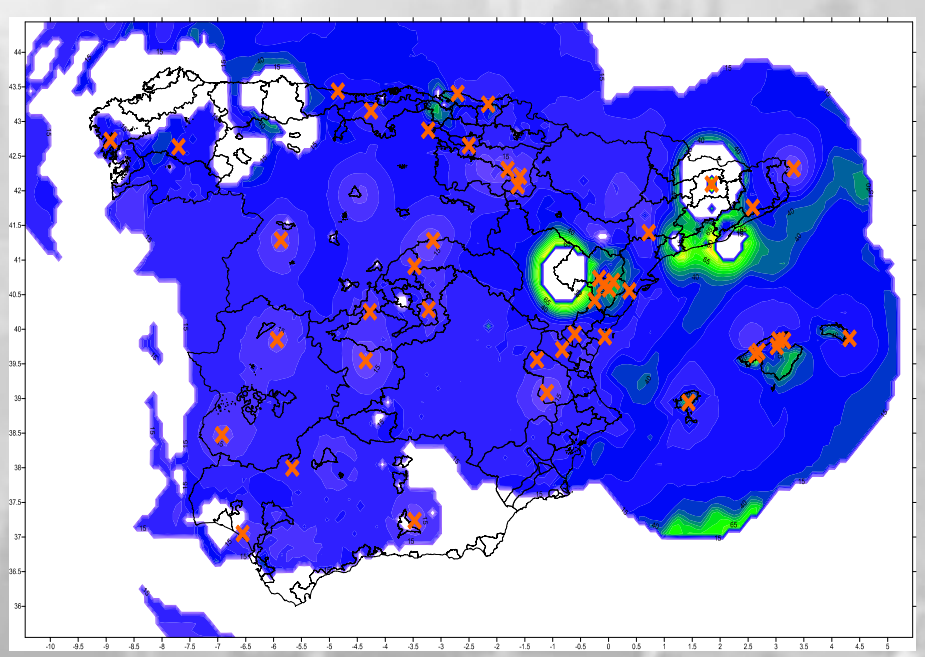


Network coverage (4)

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.