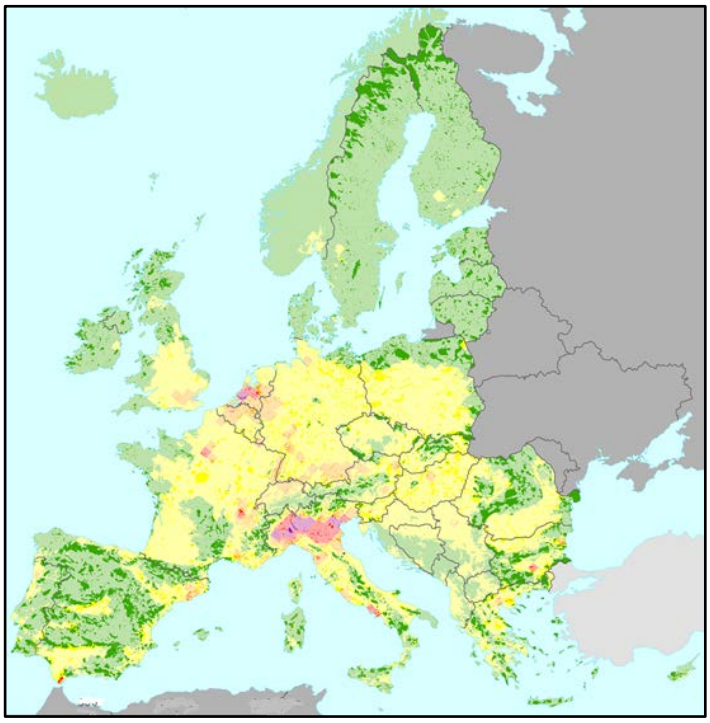
Additional 2011 European air quality maps

NO_2 annual average;

NO_x annual average, SO_2 annual and winter average;

overlays with Natura2000 areas



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Front page picture:
NO_x annual average map of the rural areas overlaid with the map of Natura2000 (Annex 1 of this paper).

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Contents

1 Background

For the analyses done for EEA Report No 5/2014 "Air quality in Europe - 2014 report", the ETC/ACM prepared several maps in addition to those presented in Horálek et al. (2014a). These maps have been calculated for the year 2011, resp. for the winter season 2010/2011. The maps are: health related indicator of NO_2 (annual average), vegetation related indicators of NO_x (annual average) and SO_2 (annual average, winter average) (**Annex 1**). Next to this, the ETC/ACM prepared concentration maps overlaid with NATURA2000 areas for all vegetation related indicators, i.e. for NO_x, SO_2 and ozone (indicators AOT40 for crops and AOT40 for forests as presented in Horálek et al., 2014a) (**Annex 2**), and from these maps NATURA2000 area exposure tables have been derived (**Annex 3**).

The methodology used for the creation of the concentration maps is in principle the same as documented in Horálek et al. (2014a). The mapping method consists of a linear regression model followed by kriging of the residuals produced from that regression model (residual kriging). The map of the health related indicator of NO_2 has been created for the rural and urban background areas separately on a grid at 10x10 km resolution. Subsequently, these rural and urban background maps we merged into one combined air quality indicator map using a population density grid at 1x1 km resolution. For presentational purposes at the European scale, we aggregated the final combined map at 1x1 km grid resolution into maps at a 10x10 km grid resolution. It should be noted that this map refers to background areas only as hotspot and traffic locations are not taken into consideration. The maps of vegetation related NO_x and SO_2 indicators we created on a grid at 2x2 km resolution, based on rural background measurements. These maps are applicable for rural areas only, as vegetation is considered not to occur at (sub)urban areas.

1.1 Data used

For the preparation of the additional indicator maps, we extracted air quality station monitoring data from the European monitoring database *AirBase* and derived the following indicators values: NO_2 annual average for 2011, NO_x annual average for 2011, SO_2 annual average for 2011, and SO_2 winter average for 2010/2011 (**Table 1**). Only data from stations classified by AirBase of the type *background* for the areas *rural*, *suburban* and *urban* are used. *Industrial* and *traffic* station types are not considered; they represent local scale concentration levels not applicable at the mapping resolution employed. Only the stations with annual (resp. winter) data coverage of at least 75 percent have been used.

Table 1 Number of stations selected for additional indicator mapping – rural background stations used for rural areas, urban and suburban background stations used for urban areas

Indicator type	Health	Ecosystems					
	NO_2	NOx				SO_2	
	annual average	annual average				annual average	winter average
	2011	2011				2011	2011/2012
Number of Airbase stations by type		direct	+ derived		= total		
		NO_x	NO & NO_2	NO_2 only	NO_x		
rural background	392	*352*	*+ 21*	*+ 20*	= 393	232	214
urban background	1147						

For NO_2, 392 rural background and 1147 urban/suburban stations are used. For NO_x, 393 rural background stations are used. Out of these stations used in NO_x mapping, for 352 stations just NO_x data are reported in AirBase. For 21 stations, NO_x values are calculated from reported NO_2 and NO data, using the equation $NO_x = NO_2 + (46/30) \cdot NO$. For 20 stations, for which NO_2 data only are reported, NO_x values are estimated from NO_2 data using the quadratic regression, similar to Horálek et al. (2007). For SO_2, 232 rural background stations are used for the annual average, while 214 such stations for the winter areas.

1.2 Supplementary variables used

Next to the air quality monitoring data, a comparable set of supplementary data variables as reported in Horálek et al. (2014a) have been used, namely EMEP MSC-W model output, altitude, wind speed, surface solar radiation, and population density. For EMEP model output the same indicators as for the monitoring data are applied. Next to these supplementary data, also NATURA2000 data have been used (EEA, 2012).

For the actual map creation we applied supplementary variables similar to Table 2.1 of Horálek et al. (2014b). For the health indicator NO_2 annual average the EMEP model output, altitude and wind speed at both rural and urban background areas have been used. For the ecosystem indicator NO_x annual average these are the EMEP model output, altitude, wind speed and surface solar radiation. The supplementary data used for SO_2 is the EMEP model output only.

1.3 Uncertainty

The uncertainty estimations of the maps we based on the cross-validation, see Horálek et al. (2014a). The statistical indicators for the individual maps are, as follows. NO_2 annual average, rural map: RMSE = 5.2 µg.m^{-3}, RRMSE = 49.1%, bias = 0.0 µg.m^{-3}; urban map: RMSE = 6.6 µg.m^{-3}, RRMSE = 28.3%, bias = 0.3 µg.m^{-3}. NO_x annual average: RMSE = 7.5 µg.m-3, RRMSE = 51.3%, bias = 0.1 µg.m-3. SO_2 annual average: RMSE = 1.5 µg.m^{-3}, RRMSE = 58.3%, bias = 0.0 µg.m^{-3}. SO_2 winter average: RMSE = 1.7 µg.m^{-3}, RRMSE = 57.0%, bias = 0.0 µg.m^{-3} (**Table 2**).

Next to the uncertainty estimates, Table 2 shows also the parameters of the linear regression models and of the residual kriging. Supplementary data used are the same as described in Section 1.2. However, altitude was found to be statistically non-significant for the urban background areas at indicator NO_2 annual average. Similar to this, surface solar radiation was found to be statistically non-significant for the rural background areas at indicator NO_x annual average.

Table 2 Statistical parameters and uncertainty estimates of the maps, based on cross-validation

linear regression model + OK of its residuals		NO_2		NO_x	SO_2	
		Annual average		Ann. average	Ann. average	Winter average
		Urban map	Rural map	Rural map	Rural map	Rural map
c (constant)		24.2	11.9	23.7	0.6	0.6
a1 (EMEP model 2011)		2.26	2.30	0.93	1.14	1.03
a2 (altitude GTOPO)		n. sign.	-0.0026	-0.0090		
a3 (wind speed 2011)		-2.26	-1.91	-4.32		
a4 (s. solar radiation 2011)				n. sign.		
adjusted R^2		*0.30*	*0.39*	*0.50*	*0.42*	*0.51*
standard error	*[µg.m^{-3}]*	*7.3*	*5.3*	*7.6*	*1.8*	*2.0*
nugget		26	0	60	1.0	2.2
sill		47	32	67	3.0	4.0
range	[km]	40	40	560	270	250
RSME	**[µg.m^{-3}]**	**6.6**	**5.2**	**7.5**	**1.5**	**1.7**
Relaltive RSME	**[%]**	**28.3**	**49.1**	**51.3**	**58.3**	**57.0**
Bias	**[µg.m^{-3}]**	**0.3**	**0.0**	**0.1**	**0.0**	**0.0**

1.4 Vegetation exposure tables

For the vegetation related indicator maps (NO_x annual average, SO_2 annual and winter average, ozone's AOT40 for forests and for crops), the NATURA2000 area exposure tables have been derived: for each concentration class the total NATURA2000 area in Europe has been determined (**Annex 3**).

References

EEA (2012). NATURA2000. Version 2012 rev. 1. https://sdi.eea.europa.eu/internal-catalogue/srv/eng/search?uuid=c773f1a8-16ed-4f7a-91aa-f7475105f805

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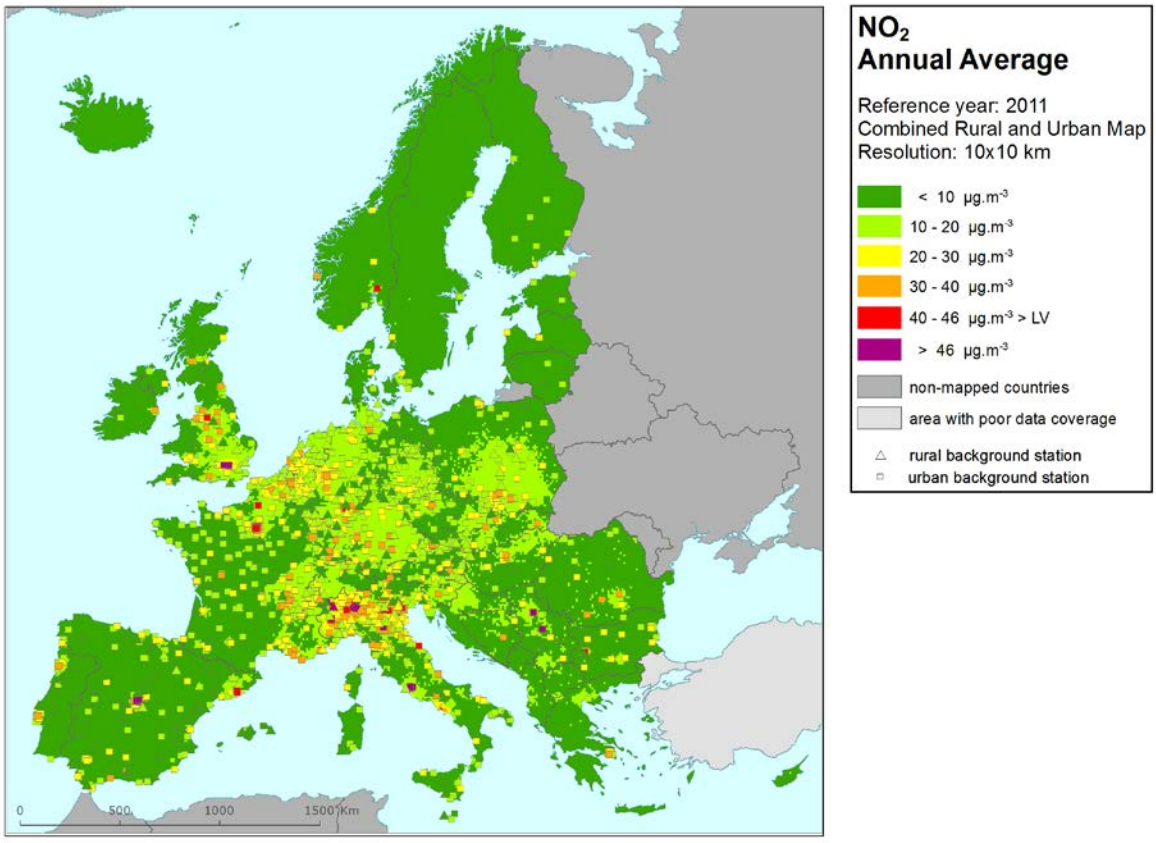
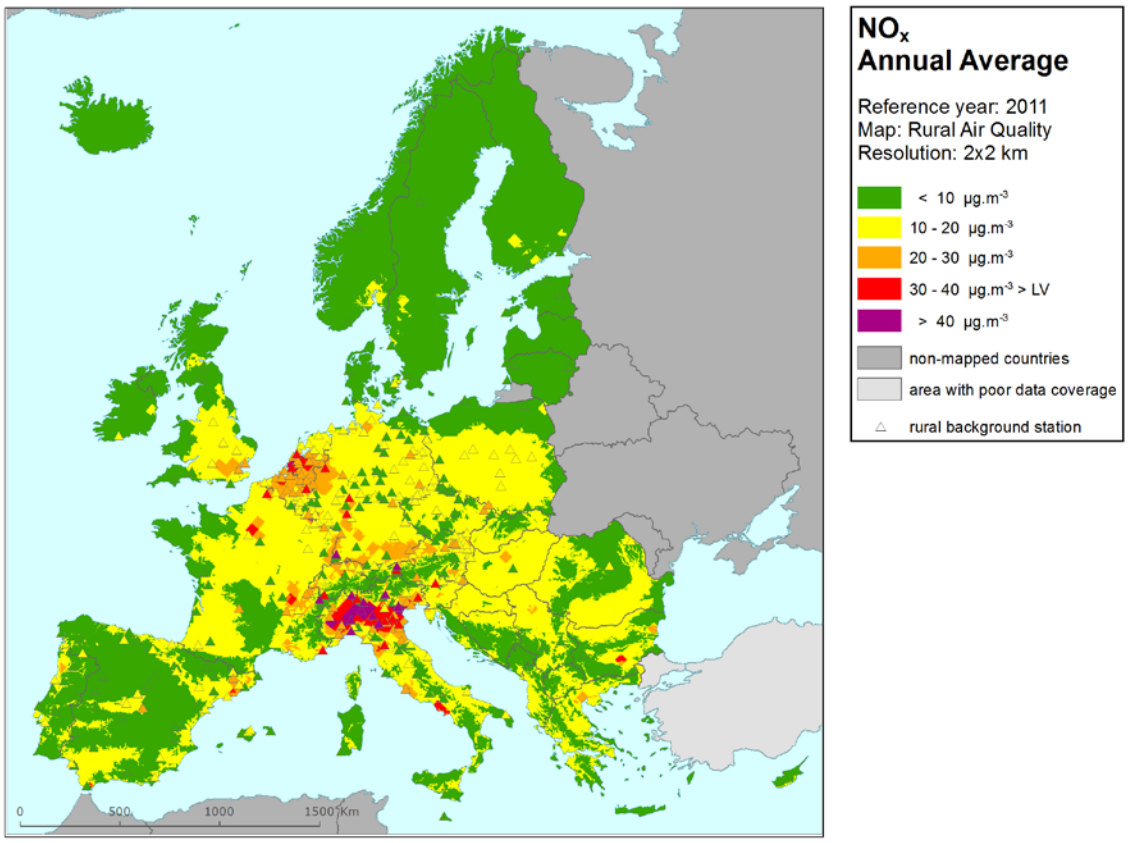
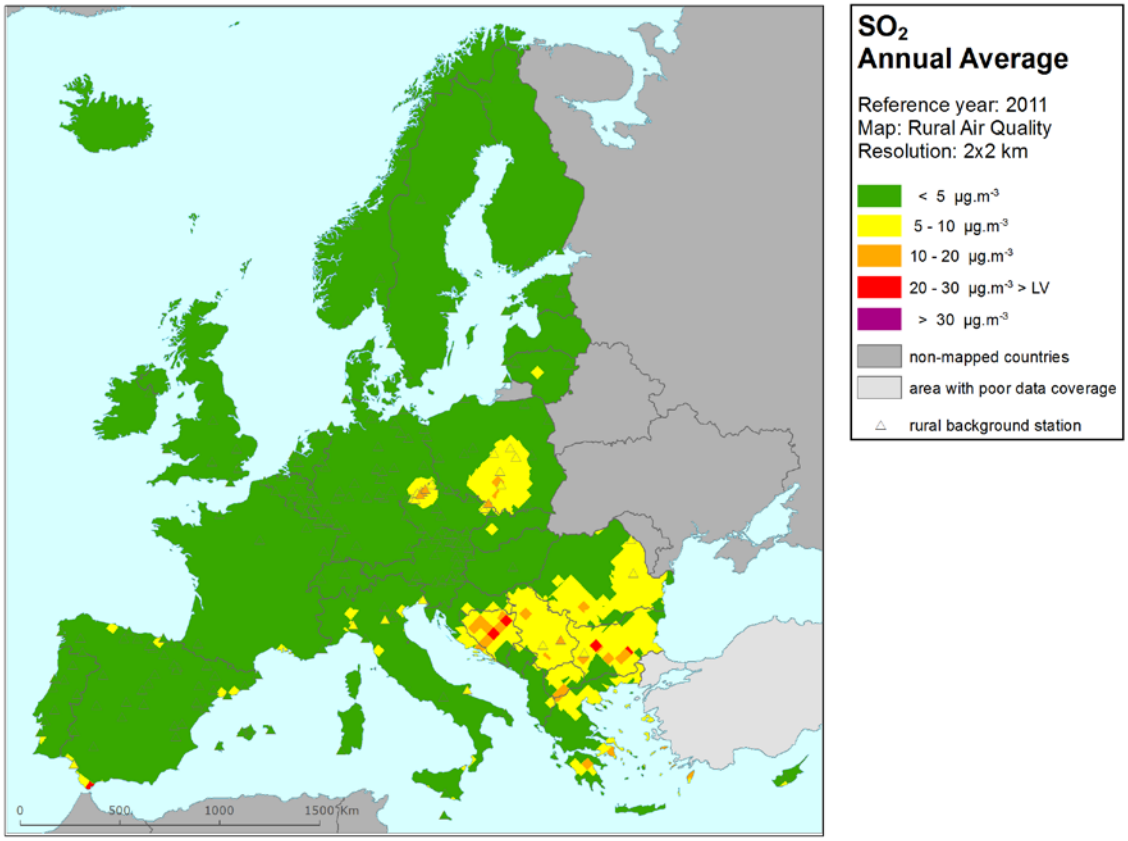
Annexes

Annex 1: Concentration maps



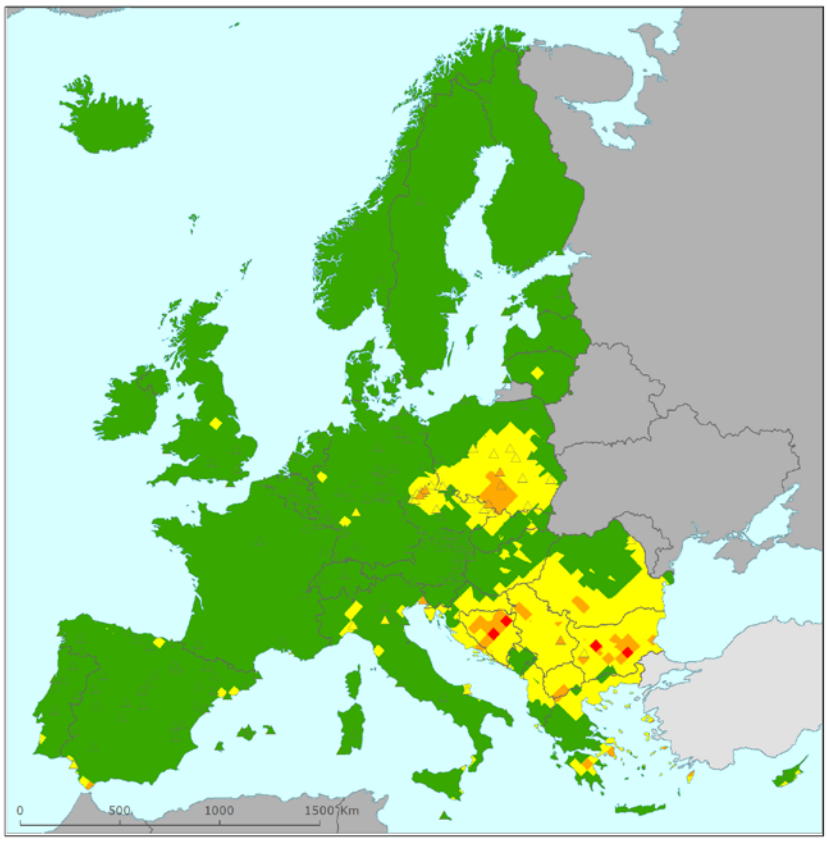




SO_2
Annual Average

Reference year: 2011
Map: Rural Air Quality
Resolution: 2x2 km

- < 5 µg.m^{-3}
- 5 - 10 µg.m^{-3}
- 10 - 20 µg.m^{-3}
- 20 - 30 µg.m^{-3} > LV
- > 30 µg.m^{-3}
- non-mapped countries
- area with poor data coverage
- △ rural background station

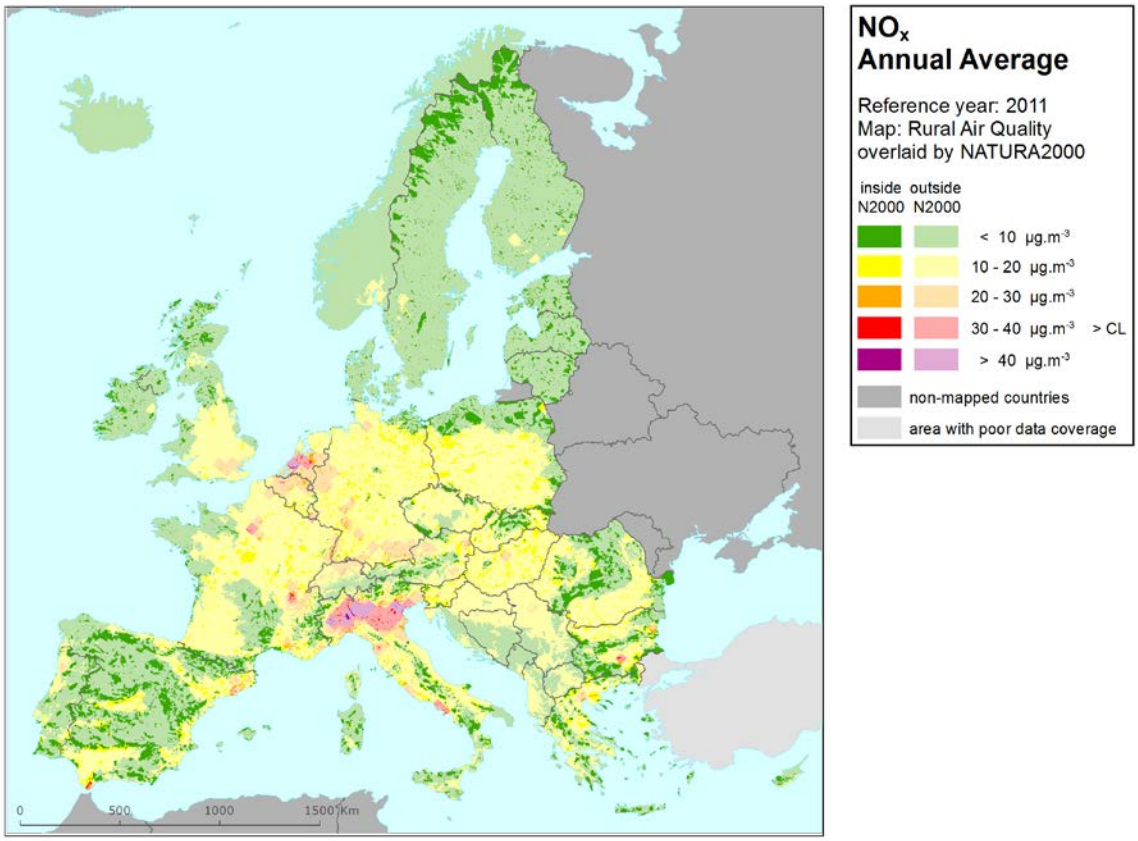


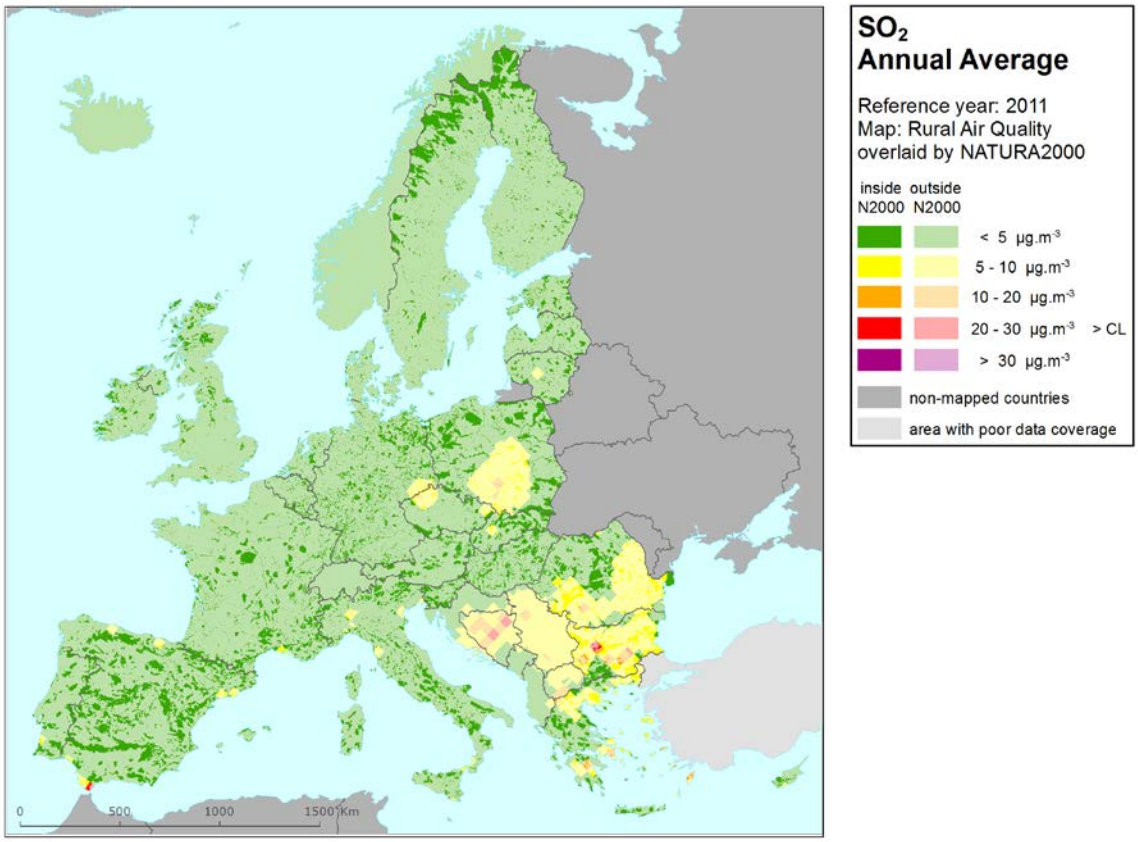
SO_2
Winter Average

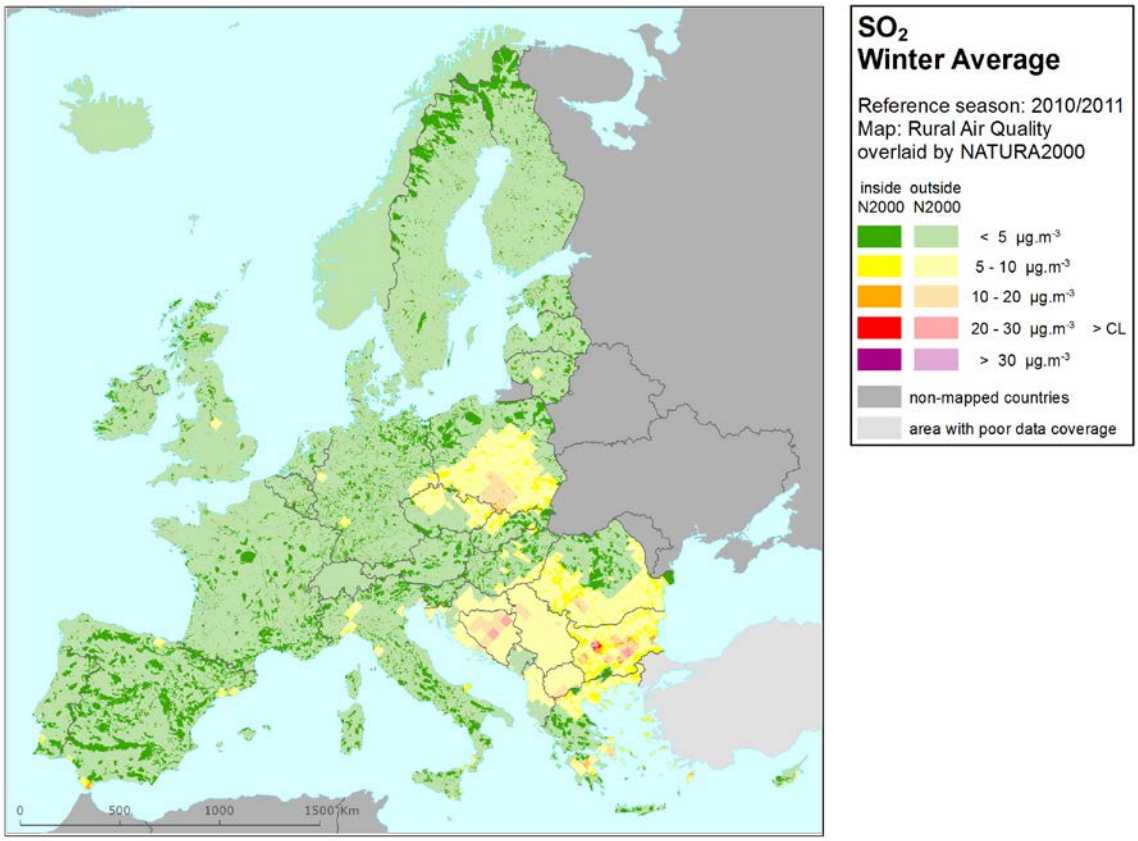
Reference season: 2010/2011
Map: Rural Air Quality
Resolution: 2x2 km

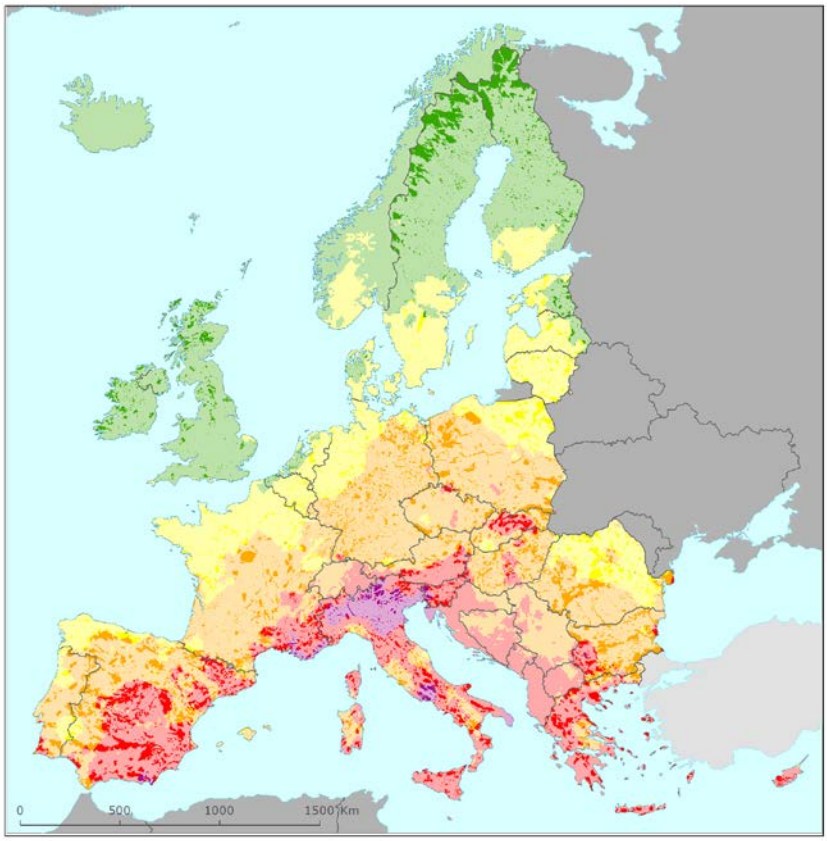
- < 5 µg.m^{-3}
- 5 - 10 µg.m^{-3}
- 10 - 20 µg.m^{-3}
- 20 - 30 µg.m^{-3} > LV
- > 30 µg.m^{-3}
- non-mapped countries
- area with poor data coverage
- △ rural background station

Annex 2: Concentration maps overlaid with NATURA2000




SO_2
Annual Average
Reference year: 2011
Map: Rural Air Quality
overlaid by NATURA2000
inside N2000
outside N2000
< 5 µg.m-3
5 - 10 µg.m-3
10 - 20 µg.m-3
20 - 30 µg.m-3
> CL
> 30 µg.m-3
non-mapped countries
area with poor data coverage
0
500
1000
1500 Km


SO_2
Winter Average
Reference season: 2010/2011
Map: Rural Air Quality
overlaid by NATURA2000
inside N2000
outside N2000
< 5 µg.m-3
5 - 10 µg.m-3
10 - 20 µg.m-3
20 - 30 µg.m-3
> CL
> 30 µg.m-3
non-mapped countries
area with poor data coverage
0
500
1000
1500 Km

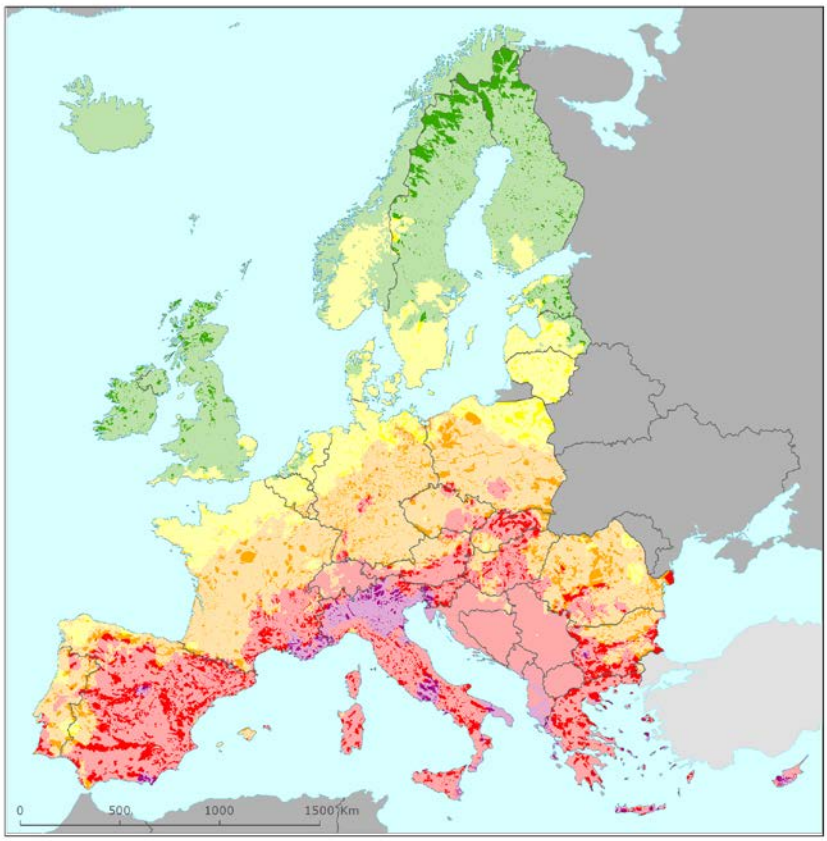


Ozone
AOT40 for crops

Reference year: 2011
Map: Rural Air Quality
overlaid by NATURA2000

inside N2000	outside N2000	
		< 6 mg.m^{-3}
		6 - 12 mg.m^{-3}
		12 - 18 mg.m^{-3}
		18 - 27 mg.m^{-3} > TV
		> 27 mg.m^{-3}

non-mapped countries
area with poor data coverage



Ozone
AOT40 for forests

Reference year: 2011
Map: Rural Air Quality
overlaid by NATURA2000

inside N2000	outside N2000	
		< 10 mg.m^{-3}
		10 - 20 mg.m^{-3}
		20 - 30 mg.m^{-3}
		30 - 50 mg.m^{-3}
		> 50 mg.m^{-3}

non-mapped countries
area with poor data coverage

Annex 3: Vegetation exposure tables for NATURA2000 areas

	NO_x, annual average, 2011									
Area	Area of NATURA2000					Percentage of NATURA2000 [%]				
	Total area	> 10 µg.m^{-3}.h		> CL (30 µg.m^{-3}.h)		< 10 µg.m^{-3}.h	10 - 20 µg.m^{-3}.h	20 - 30 µg.m^{-3}.h	30 - 40 µg.m^{-3}.h	> 40 µg.m^{-3}.h
	[km^2]	[km^2]	[%]	[km^2]	[%]					
NATURA2000	1 278 379	382 917	30.0	7 238	0.6	70.0	27.1	2.3	0.4	0.1

	SO_2, annual average, 2011									
Area	Area of NATURA2000					Percentage of NATURA2000 [%]				
	Total area	> 10 µg.m^{-3}.h)		> CL (20 µg.m^{-3}.h)		< 5 µg.m^{-3}.h	5 - 10 µg.m^{-3}.h	10 - 20 µg.m^{-3}.h	20 - 30 µg.m^{-3}.h	> 30 µg.m^{-3}.h
	[km^2]	[km^2]	[%]	[km^2]	[%]					
NATURA2000	1 278 379	6 972	0.5	1 744	0.1	90.7	8.8	0.4	0.1	0.0

	SO_2, winter average, 2011/2012									
Area	Area of NATURA2000					Percentage of NATURA2000 [%]				
	Total area	> 10 µg.m^{-3}.h)		> LV (20 µg.m^{-3}.h)		< 5 µg.m^{-3}.h	5 - 10 µg.m^{-3}.h	10 - 20 µg.m^{-3}.h	20 - 30 µg.m^{-3}.h	> 30 µg.m^{-3}.h
	[km^2]	[km^2]	[%]	[km^2]	[%]					
NATURA2000	1 278 379	11 927	0.9	863	0.1	85.9	13.2	0.9	0.1	0.0

	Ozone, AOT40 for crops, 2011									
Area	Area of NATURA2000					Percentage of NATURA2000 [%]				
	Total area	> LTO (6 mg.m^{-3}.h)		> TV (18 mg.m^{-3}.h)		< 6 mg.m^{-3}.h	6 - 12 mg.m^{-3}.h	12 - 18 mg.m^{-3}.h	18 - 27 mg.m^{-3}.h	> 27 mg.m^{-3}.h
	[km^2]	[km^2]	[%]	[km^2]	[%]					
NATURA2000	1 278 379	1 060 976	83.0	308 066	24.1	17.0	22.8	36.1	21.6	2.5

	Ozone, AOT40 for forests, 2011									
Area	Area of NATURA2000					Percentage of NATURA2000 [%]				
	Total area	> CL (10 mg.m^{-3}.h)		> RV (20 mg.m^{-3}.h)		< 10 mg.m^{-3}.h	10 - 20 mg.m^{-3}.h	20 - 30 mg.m^{-3}.h	30 - 50 mg.m^{-3}.h	> 50 mg.m^{-3}.h
	[km^2]	[km^2]	[%]	[km^2]	[%]					
NATURA2000	1 278 379	1 073 502	84.0	818 887	64.1	16.0	19.9	26.6	32.9	4.5