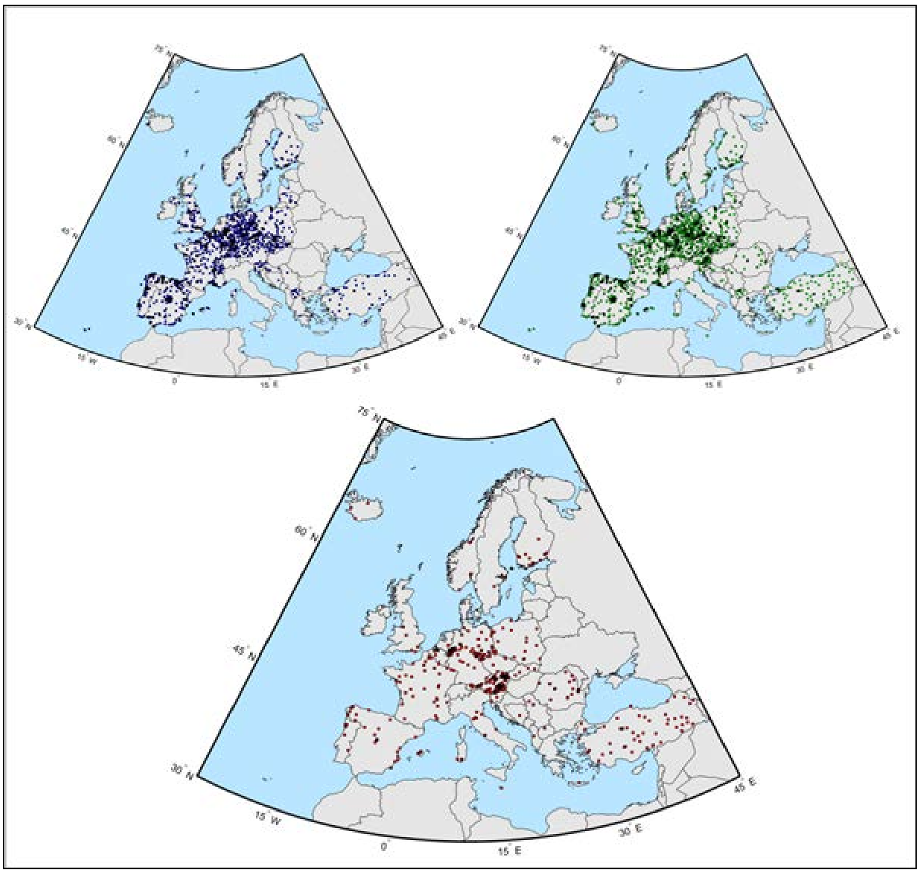
Analysis of station classification and network design in Europe



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Front page picture:
Figure 3 of this paper. Top left: PM10 monitoring stations classified with AirBase v6 in 2012 study; top right: PM10 monitoring stations classified with AirBase v7 in this study; bottom: PM10 monitoring stations which were additionally classified with AirBase v7 but were missing in the v6 classification.

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1 Introduction

The enforcement of European and national legislations on air quality, the development of air quality monitoring in the new EU Member States and increased data exchange among countries have led to a growing amount of available information about air quality in Europe. However, while much effort is dedicated to data quality assurance and control through European programmes, a recent position paper (JRC-AQUILA, 2013), written at the request from the European Commission Directorate-General for the Environment (DG ENV), points out a lack of information regarding the monitoring strategies underlying site selection and the fitness for purpose of the chosen monitoring locations. Furthermore, it recommends that the current station classification schemes be refined or supplemented by other approaches in combination with metadata describing the station surroundings.

In that context, the first part of this study discusses various aspects of the current air quality monitoring networks:

- Have there been major changes in the monitoring strategy since the publication of the Air Quality Framework Directive in 1996, e.g. has this strategy been more directed to population exposure or does it rather focus on locations where the highest concentrations can be expected (“hot spot situations”)?
- Are the networks in line with the EUROAIRNET criteria? Those criteria had been set in 1999 in a EEA report with a view to establishing a monitoring network with sufficient spatial coverage, representativeness and reliability to support and facilitate air quality assessments.
- Do they meet the criteria set in the AQ Directive as regards the number of measurement points per pollutant?

However, discussion in this first section only compares the mandatory requirements or complementary design criteria, such as those from EUROAIRNET, with the station classification as reported by the countries. There is no independent tool yet for checking if the stations are properly classified or if their characteristics meet the monitoring target.

In the second part of this report, a supplementary classification system recently developed by Joly and Peuch (2012) is therefore discussed and analysed in relation to the methods currently in use for station classification, namely the definition of the type of station and type of area according to the Decisions regarding the exchange of information and reporting (EoI, EC 1997; IPR, EC 2011) and the classification scheme provided for ozone by the Air Quality directive (EC 2008). The last two methods are based on the land occupation and economic activities in the surroundings of the station while the methodology from Joly and Peuch (2012) is based on the temporal behaviour of observed concentrations and allows specific classification for every targeted pollutant. This section updates and completes a previous ETC/ACM document (2013) dedicated to that methodology. A European-wide analysis is first carried out to highlight the main characteristics of this supplementary classification (robustness, spatial coverage) in relation to the usual classification schemes. Unexpected classification results – referred to as outliers – and specific situations interesting for study are then pointed out. An analysis of station classification on the city scale is given as example.

It is recognized that the choice of a classification scheme depends on the objectives of the air quality assessments: for model validation a different set of stations might be used than in trend analyses, in mapping activities or in assessing the impact of a specific source category. To assist users in making the right choice, a template for classification is proposed as additional material. This spreadsheet can also help data providers in identifying monitoring stations which require further investigation. It is presented in the annex VI.

2 Analysis of the air quality monitoring network

This section provides an insight into the way European monitoring networks have developed over the last fifteen years. It first provides an analysis of the station classification in the networks. In a second step, the monitoring network design is described in terms of representativeness for exposure assessment and compliance with the legal requirements. The analyses are based on information about stations and assessment zones reported by countries under the Air Quality Directives (EC, 1996; EC, 2008) and the Exchange of Information (EoI) Decision (EC, 1997).

2.1 Data collection

2.1.1 Considered period

The study is about PM, NO_2, O_3 and SO_2 monitoring network, with main focus on PM and NO_2, and specifically on 4 selected years: 1996, 2004, 2007 and 2011.

1996: it should represent the situation before adoption of the Framework Air Quality Directive (EC, 1996) and is the first year for which AirBase contains information for the majority of EU15 Member States. It should be mentioned, however, that for a number of Member States 1996 data is incomplete or missing. Although required by the EoI Decision (EC, 1997), Member States have not always submitted additional information over the 1990-1997 period. Missing information for some Member States in 1996 may hamper the comparison between the years.

2004: this year marks the point of the largest single enlargement in terms of people and number of countries. Ten new countries (Czech Republic, Cyprus, Estonia, Latvia, Lithuania, Hungary, Malta, Poland, Slovakia and Slovenia) joined the EU to form EU25

2007: two more countries from Eastern Europe, Bulgaria and Romania joined the EU, bringing the number of Member States to 27 countries.

2011: this is the most recent year available in AirBase.

2.1.2 Station information

For each of the four years, all stations, which have submitted raw data, have been selected from AirBase. No further selection criteria on data capture have been applied, resulting in an upper limit of the number of operational stations. In practical applications, a number of stations will not pass the test on minimal data coverage of 75% or 90%. For 1996 information from several Member States (3 to 6, depending on the pollutant) is missing; for 2004, 2007 and 2011 for all Member States information is available.

Following the EoI Decision, stations are classified according to a ***type of area*** and a ***type of station***. The type of area defines the wider surroundings of the station (Garber et al, 2002):

- *Urban area: continuously built-up urban area meaning complete (or at least highly predominant) building-up of the street front side by buildings with at least two floors or large detached buildings with at least two floors. With the exception of city parks, the built-up area is not mixed with non-urbanised areas.*
- *Suburban area: largely built-up urban area. 'Largely built-up' means contiguous settlement of detached buildings of any size with a building density less than for 'continuously built-up' area. The built-up area is mixed with non-urbanised areas (e.g. agricultural, lakes, woods). It must also be noted that 'suburban' as defined here has a different meaning than in every day English i.e. 'an outlying part of a city or town' suggesting that a suburban area is always associated to an urban area. In our context, a suburban area can be suburban on its own without any urban part.*
- *Rural area: all areas that do not fulfil the criteria for urban or suburban areas are defined as rural areas.*

The type of station is defined in relation to the dominant emission sources influencing the concentration at the station. The following types of station have been defined in the EoI guidance[1] (Garber et al, 2002):

- *Traffic station: Located such that its pollution level is determined predominantly by the emissions from nearby traffic (roads, motorways, highways).*
- *Industrial station: Located such that its pollution level is influenced predominantly by emissions from nearby single industrial sources or industrial areas with many sources. Industry source is here taken in its wide meaning including sources like power generation, incinerators and waste treatment plants.*
- *Background station: Located such that its pollution level is not influenced significantly by any single source or street, but rather by the integrated contribution from all sources upwind of the station (e.g. by all traffic, combustion sources etc. upwind of the station in a city, or by all upwind source areas (cities, industrial areas) in a rural area).*

Note that each type of area can be combined with each type of station, for example the combination urban/traffic and suburban/traffic defines a traffic-station in the (inner)city; the combination rural/traffic defines a station close to a intercity motorway or highway.

According to the EoI Guidance (Garber et al, 2002), submission on the type of area was mandatory; information on type of station should be provided "to the

[1] These definitions have been rephrased in the last IPR guidance (2013). However, the formulation in use during the studied years is kept in this report.

extent possible". Both items, however, provide information essential for a proper evaluation of the observed concentrations. The need for information on both points can be illustrated in the best way with an example: Figure 1 gives the annual mean NO_2 concentration at three stations in Vienna. The stations AT90MBA and AT9STEF are by their type of area both classified as *urban*; the distance between the two stations is about 5 km. The marked difference in behaviour - at AT90MBA (Hietzinger Kai) the NO_2 concentrations are systematically higher - can only be explained by the type of station: Hietzinger Kai is an *urban-traffic* station while AT9STEF (Stephansplaz) is an *urban background* station. Like station AT9STEF, the station AT9SCHA is a background station. However, AT9STEF is an urban while AT9SCHA is a suburban background station, which explains its lower NO_2 concentrations.
Thanks to an intensive interaction between ETC and the national data suppliers the essential meta-information on type of station and type of area is nearly complete in AirBase.

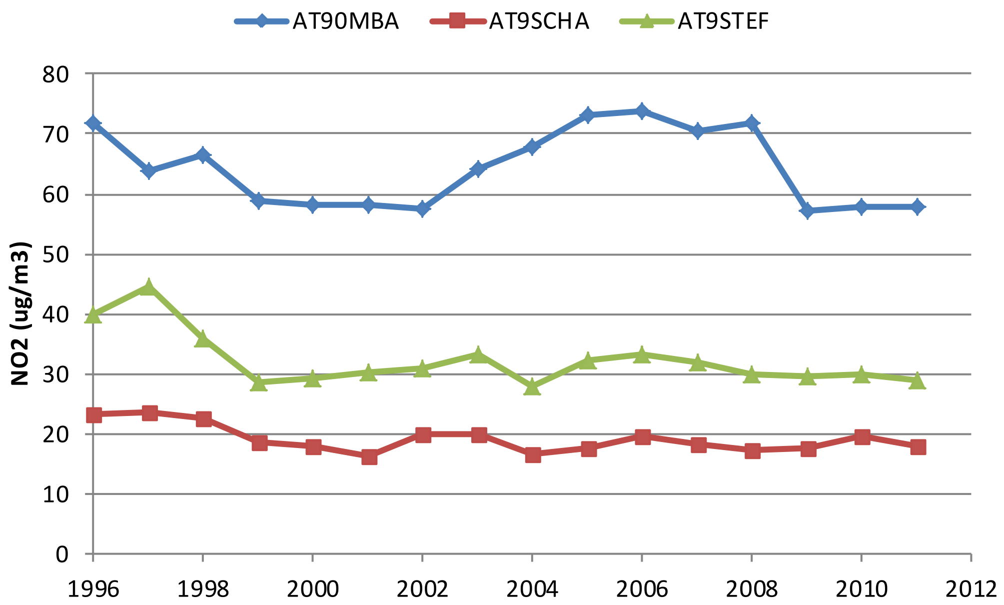


Figure 1. Annual mean NO_2 concentration at three stations (AT90MBA, urban traffic, AT9SCHA, suburban background and AT9STEF, urban background) in Vienna.

Based on type of area/type of station combination all stations have been grouped into four classes according to the scheme given in Table 1. In the remaining of this chapter stations are indicated by their class unless explicitly stated.

Table 1. Classification scheme of stations based on type of area and type of zone.

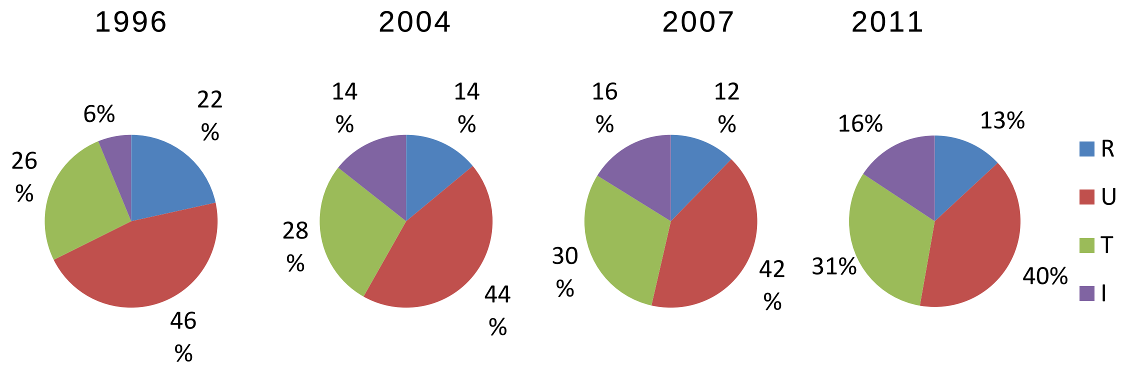
class	type of area	type of station
(sub)urban background (U)	urban	background
	suburban	background
traffic (T)	urban	traffic
	suburban	traffic
	rural	traffic
	unknown	traffic
regional background (R)	rural	background
industrial (I)	urban	industrial
	suburban	industrial
	rural	industrial
	unknown	industrial
unknown (O)	unknown	background
	urban	unknown
	suburban	unknown
	rural	unknown
	unknown	unknown

2.2 Analysis of station classification in the EU Member States´ networks

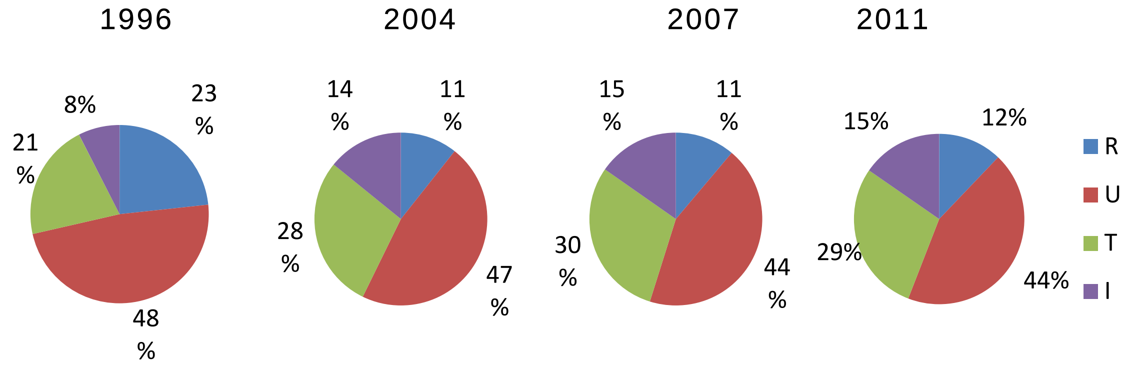
In general the largest changes are seen between 1996 and 2004. Partly these changes were caused by the ill representativeness of the 1996 data, but also the networks have evolved following the accession of more Member States to the European Union. As mentioned above, for some (large) Member States, there is no information available for 1996. Large changes are particularly observed for PM_{10}, however, the 1996 data is not representative as in most countries a systematic monitoring of PM_{10} started around 1996. For typically traffic-related pollutants (NO_2, PM_{10}, CO) a large fraction of traffic stations can be observed.

The assumption that the Directive introduced a shift towards more (sub)urban stations is not supported by the information in AirBase. Although there is an increase in the absolute number of stations (except SO_2) the relative distribution of station types barely changed from 1996 to 2004 and is stable between 2004 and 2011 (Figure 2, Table 2). The number of SO_2 stations is nearly constant since 2004. In large parts of Europe the SO_2 concentrations are below the upper or below the lower assessment threshold and a less dense network or no fixed monitoring network is required. For $PM_{2.5}$ the fraction of (sub)urban background stations is high, reason here might be the requirements on monitoring the Averaged Exposure Indicator.

NO_2



PM_{10}



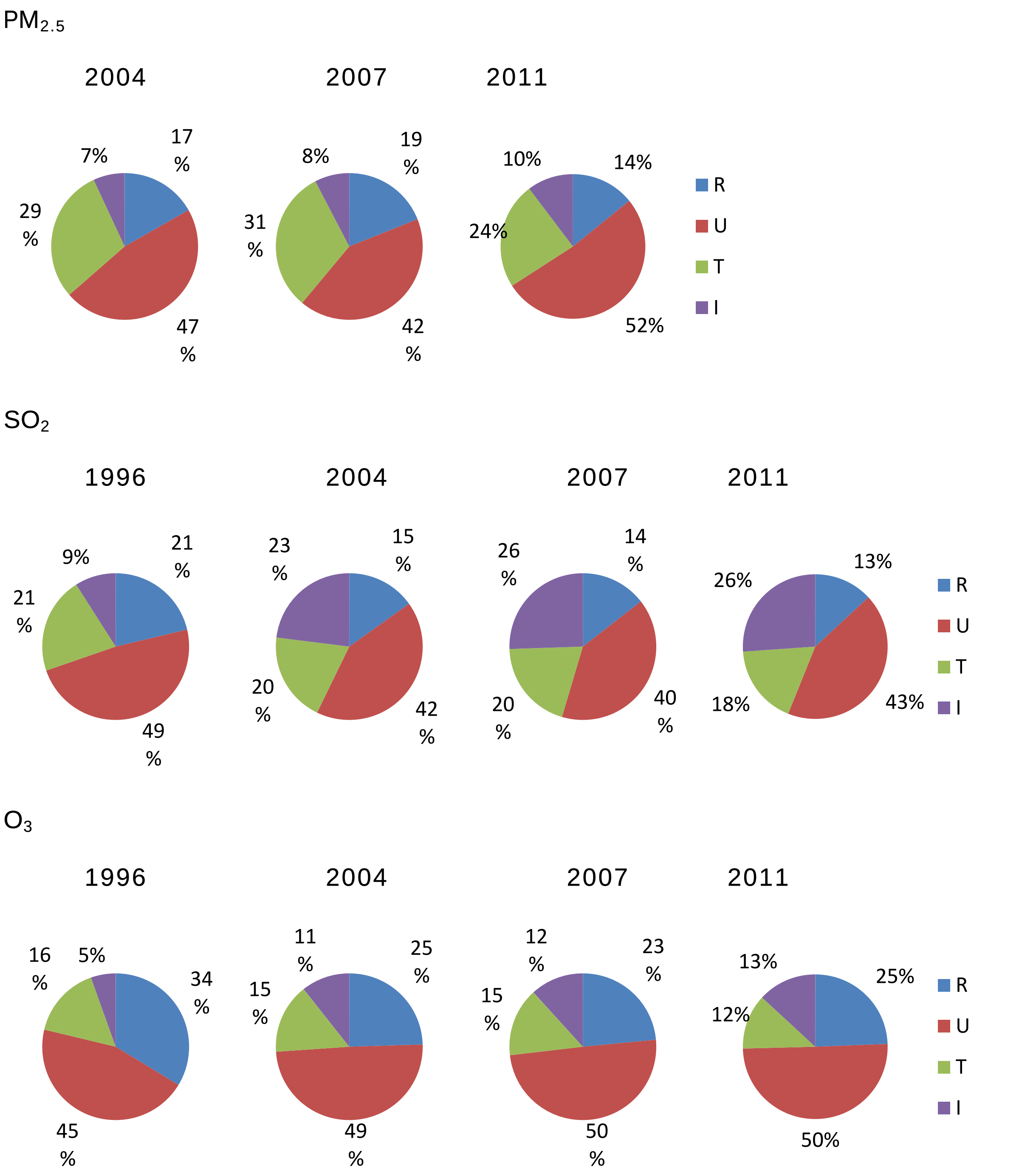


Figure 2. Pie-charts showing the distribution of station classification (NO_2, PM_{10}, $PM_{2.5}$, SO_2 and ozone, monitoring stations) in EU Member States for the years 1996, 2004, 2007 and 2011. Stations classified as unknown (O) are not included in the pie-charts. In 1996 $PM_{2.5}$ measurement data at only one (traffic) station have been reported to AirBase.

Table 2. Distribution of station classification (PM_{10}, $PM_{2.5}$, ozone, NO_2 and SO_2 monitoring stations) in EU Member States for the years 1996, 2004, 2007 and 2011. These include stations classified as unknown (O).

number of stations	PM_{10}				$PM_{2.5}$				Ozone			
	1996	**2004**	**2007**	**2011**	**1996**	**2004**	**2007**	**2011**	**1996**	**2004**	**2007**	**2011**
regional bck (R)	31	204	291	368	0	34	72	155	241	464	494	538
urban bck (U)	64	892	1 139	1 329	0	95	160	567	322	935	1 045	1 107
traffic (T)	28	547	779	873	1	60	119	261	113	292	318	271
industrial (I)	10	271	398	466	0	14	29	113	39	202	247	289
unknown (O)	0	1	1	12	0	0	0	2	0	1	0	8
total	133	1 915	2 608	3 048	1	203	380	1098	715	1 894	2 104	2 213

	NO_2				SO_2			
	1996	**2004**	**2007**	**2011**	**1996**	**2004**	**2007**	**2011**
regional bck (R)	205	340	365	418	203	300	295	264
urban bck (U)	439	1 074	1 227	1 265	462	836	819	866
traffic (T)	249	667	898	1 005	203	393	406	358
industrial (I)	59	349	480	501	86	457	521	526
unknown (O)	0	1	0	9	0	2	0	5
total	952	2 431	2 970	3 198	954	1 988	2 041	2 019

2.3 Monitoring criteria and its application

2.3.1 EUROAIRNET criteria

Larssen et al (1999) recommend a set of criteria on selecting stations for a representative monitoring network for assessment of population exposure (Table 3).

Table 3. Assessment of population exposure: Criteria for selection of areas/ stations to be fulfilled by each state as far as possible (Larssen et al 1999).

Type of area	Criteria	
	Area selection	Station selection
Agglomerations >0.5 mill	All cities	All stations, for up to 20 stations in the agglomeration. When subset is selected (when >20 stations), the selection must contain all station categories represented in the city, and must be spatially distributed in the agglomeration to cover the whole population.
0.25-0.5 mill	At least 25% of the cities	The selected areas (cities) must represent high, medium and low levels of industrialisation, as occurring in the country.
0.05-0.25 mill	At least 10% of the cities	The selected areas (cities) must represent high, medium and low levels ofindustrialisation, as occurring in the country.
Rural areas	1)	
Industrial areas outside cities	All areas with air pollution above the WHO AQ Guidelines	All existing monitoring stations in these areas.

1) Monitoring needs and network/station selection to be done by each country. At least 50% of the rural population should be covered in terms of being reasonably well represented by monitoring stations.

When 2011 monitoring stations are checked on EUROAIRNET criteria using the set of Urban Audit[2] cities as reference, nearly all of the large cities have been included, exceptions being Napoli for PM_{10} and NO_2, and all big cities in Turkey for NO_2. Table 4 shows that at the European level the criteria have been met for the rest of smaller cities. An analysis for PM_{10} and NO_2 at the national level is given in Annex I. With a few exceptions, PM_{10} and NO_2 are monitored in all large and medium sized cities. With respect to small cities monitoring is performed in more cities than the EUROAIRNET criteria requires. Notable exception is Turkey and some of the Balkan countries where no urban NO_2 stations are reporting to AirBase.

This analysis shows that the density of PM_{10} and NO_2 monitoring networks is in line with the EUROAIRNET criteria. However, for a final conclusion on its representativeness for population exposure, the station classification and spatial distribution need to be considered.

[2] http://epp.eurostat.ec.europa.eu/portal/page/portal/region_cities/city_urban

Table 4. Coverage of the EUROAIRNET criteria in European cities, 2011

	PM_{10}	NO_2
all large cities (>500 000)	72 of 73 (99%)	59 of 73 (81%)
medium cities (250 000-500 000)	93 of 116 (80%)	92 of 116 (79%)
small cities (50 000-250 000)	555 of 750 (74%)	528 of 750 (70%)

2.3.2 Air Quality Directive requirements

The criteria as given by the Air Quality Directive (EC, 2008) set the number of stations in an agglomeration/zone depending on population and current air quality status for a specific component. As an example in Table 5 the minimum numbers of PM stations required by the Air Quality Directive criteria are given.

Table 5. Minimum required PM (PM_{10} and $PM_{2.5}$) stations, depending on population and current AQ status (>UAT meaning maximum concentrations above the upper assessment threshold and L-UAT meaning between the lower and upper assessment threshold)

Population in agglomeration/zone (thousands)	>UAT	L-UAT
0- 249	2	1
250 – 499	3	2
500- 749	3	2
750 – 999	4	2
1 000 – 1 499	6	3
1 500 – 1 999	7	3
2 000 – 2749	8	4
2 750 - 3 749	10	4
3 750 – 4 749	11	6
4 750 - 5 999	13	6
≥6 000	15	7

Checking against these criteria results in zones where monitoring seems to be "insufficient". Results for PM_{10} and NO_2 are given in Table 6 and Table 7. Density is too low for about 20% of the PM and 10% of the NO_2 zones. However, the above-mentioned criteria may be loosened by as much as 50% when countries also use modelling as supplementary assessment tool and this could be the case for some of these zones with low station density. From the Air Quality Questionnaires (EC 2004) information on which zones modelling has been applied to for assessing the air quality could be extracted. No information is available on which models were used, but we can only assume that they meet the criteria as described in article 7.3, points a and b in the AQ Directive (EC, 2008).

Table 6. PM monitoring, 702 zones/agglomerations common to 1996, 2004, 2007 and 2011. Agreement with AQD requirements considering the assessment regimes applicable in 2011:

Number of zones	1996	2004	2007	2011
$N_{stations} = N_{min}$	32	108	102	113
$N_{stations} > N_{min}$	6	193	306	423
$N_{stations} < N_{min}$	664	401	294	166

Table 7. NO_2 monitoring, 702 zones/agglomerations common to 1996, 2004, 2007 and 2011. Agreement with AQD requirements considering the assessment regimes applicable in 2011:

Number of zones	1996	2004	2007	2011
$N_{stations} = N_{min}$	211	174	132	105
$N_{stations} > N_{min}$	15	337	462	516
$N_{stations} < N_{min}$	476	191	108	81

In addition to requirements on the number of stations the Directive requires from 2008 on that the number of PM_{10} and $PM_{2.5}$ stations do not differ more than by a factor of 2. A first check on this criterion is shown in Table 8.

When the ratio is between 0.5 and 2 it is in agreement (yellow cells) with the Air Quality Directive requirements, when <0.5 or >2 it is in non-agreement (red cells).

Table 8. $PM_{10}/PM_{2.5}$ measuring stations ratio on country level (should be between 0.5 and 2 from 2008 on).

	1996	2004	2007	2011
AL				1.0
AT		37.3	15.6	7.0
BA		0.0		
BE		3.5	4.1	1.5
BG			16.0	4.4
CH		5.8	5.6	3.5
CY			2.0	0.6
CZ		3.3	3.8	2.8
DE		27.7	9.4	2.9
DK		7.0	3.3	0.9
EE			5.0	1.1
ES		7.1	4.9	2.2
FI		4.7	4.0	2.1
FR		6.9	6.6	3.7
GB		18.5	13.7	0.9
GR			5.7	4.5
HR				
HU		5.5	8.7	3.1
IE		4.7	17.0	2.4
IS	2.0	1.0	3.0	1.5
IT		21.0	8.0	3.6
LI				
LT			4.3	3.5
LU		2.0	3.0	1.5
LV			1.8	1.8
ME				
MK				
MT			1.3	1.3
NL				1.7
NO		2.2	2.0	1.6
PL		52.5	33.8	2.9
PT		3.9	3.1	2.6
RO			10.3	2.4
RS				
SE		3.5	3.3	2.3
SI				3.5
SK		6.5	6.8	1.2

3 Analysis of a supplementary station classification

3.1 Context

To complement AirBase classification (see section 2.1.2) and get further insight into the behaviour and representativeness of the station measurements, a supplementary classification based on the monitoring data itself was developed within MACC[3] project (Joly & Peuch, 2012). In a recent ETC/ACM study (ETC/ACM, 2013), referred to as the “2012 study” in what follows, this classification was computed according to the same methodology and the results were examined, with both an overall analysis on the European scale and a focus on the cities involved in the Air Implementation Pilot project (EEA, 2013). The 2012 study demonstrated the added value of this classification which does not replace AirBase one but offers the possibility of making an objective, quantitative and pollutant specific comparison of the stations based on the temporal variability of concentrations. It thus provides helpful information to interpret air quality data and increases existing knowledge about monitoring networks.

Considering the possible benefits from this additional classification, it was decided to go further with this approach and the interpretation of the classes. The objectives of the work carried out for the present report were therefore to:

- implement the classification methodology with the latest release of AirBase (v7) so as to enlarge the available dataset, extend the training period and have more stations classified;
- confirm the robustness of the methodology;
- have a closer look at the classification results corresponding to particular situations.

The analysis was carried out for PM_{10}, NO_2 and O_3 taking into account possible different users. Analysis over the whole European domain of the classification might benefit those who tend to use the classification for data assimilation or validation procedure. Local scale analysis at station level might benefit those users dealing with stations and air quality on city level. The updated results for the cities involved in the Air Implementation Pilot project are then provided in Annex V.

3.2 Update of the classification with AirBase v7

The principles of the classification methodology according to Joly & Peuch (2012) are not repeated in this report. The reader is invited to refer to the previous ETC/ACM document (2013). It is only recalled that the methodology has been conceived to best discriminate between rural background sites and sites influenced by urban and traffic sources.

[3] http://www.gmes-atmosphere.eu/

The classification was remade with **AirBase v7**, including an additional year in the training period (from **2002 to 2011)** (old classification was with AirBase v6 and 2002-2010 training period).

The quality criteria set by Joly and Peuch (2012) were strictly applied to calculate the Fisher axis through linear discriminant analysis (LDA) and define the ten classes for each pollutant. In Joly and Peuch (2012) and ETC/ACM (2013), a station which did not participate to the construction of the axis (for example a suburban background site[4]) had to meet the same requirements to be projected on it. In this update, the quality objectives defined for projection were lowered to a reasonable extent (Table 9) so that a significantly higher number of stations could be classified (Table 10). Those newly classified stations (see Figure 3 and additional figures in Annex II) are spread over most of Europe (for any pollutant) and over Turkey (for PM_{10}).

Table 9. Quality requirements which measurement stations should comply with for the linear discriminant analysis (LDA) and subsequent projection on the Fisher axis

Quality objectives	2012 study LDA and projection	This study LDA	This study Projection
Minimum number of hourly data	365*24	365*24	273*24
Maximum proportion of missing data to calculate an hourly value of the moving diurnal cycle (window=31 days)	0.2	0.2	0.7
Minimum number of values to calculate the monthly average of the diurnal amplitude	20	20	10

Table 10. Number of stations classified in the ETC/ACM previous 2012 study and in this study

	Number of stations classified in 2012 study (AirBase v6, 2002-2010)	Number of stations classified in this study (AirBase v7, 2002-2011)
NO_2	2697	3136
PM_{10}	1822	2248
O_3	2098	2349

[4] In the methodology from Joly and Peuch (2012), the stations used to calculate the Fisher axis are the rural background, the urban background and the suburban or urban traffic ones.

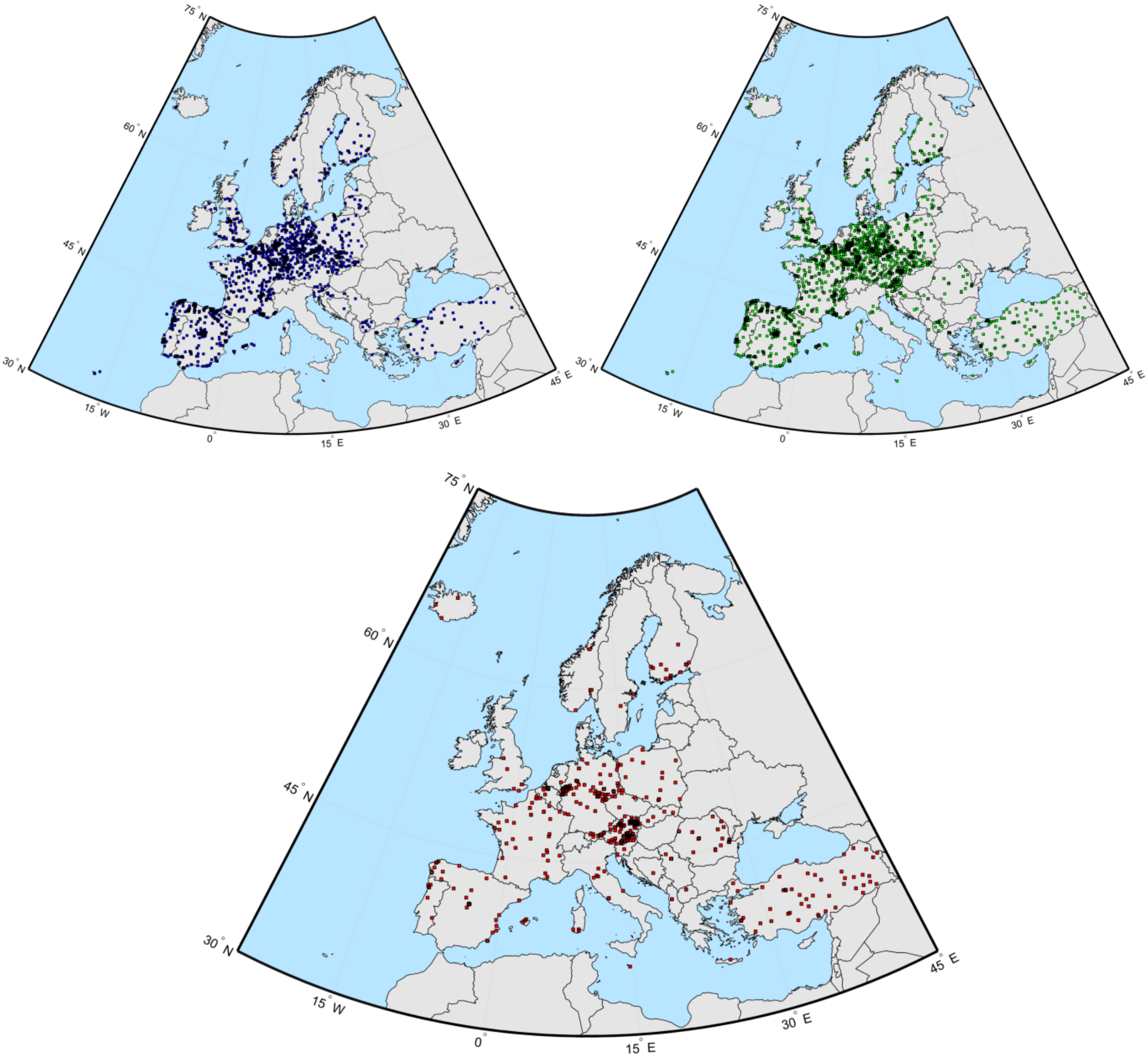


Figure 3. Top left: PM_{10} monitoring stations classified with AirBase v6 in 2012 study; top right: PM_{10} monitoring stations classified with AirBase v7 in this study; bottom: PM_{10} monitoring stations which were additionally classified with AirBase v7 but were missing in the v6 classification

For those stations which could be classified in both studies, the classes obtained with AirBase v6 (period 2002-2010) and AirBase v7 (period 2002-2011) are compared. The difference is zero or small (NO_2 : +/- 1 class, PM_{10} and O_3: +/- 2) in most cases (Table 11). Larger differences requiring closer inspection are observed for a limited number of stations listed in Annex II. Some of them can be explained looking at the time series. For example, a drop of 7 classes occurs for two Belgian PM_{10} monitoring stations: the time series clearly show a change in the reported data flow during the year 2011. Before April 2011, daily data were reported and expressed as hourly values, each one being repeated 24 times in the day; since 2011, actual hourly values have been made available for both sites. The new classes (3 and 2 vs. 10 and 9 respectively) are much more consistent with AirBase classification (rural background).

Table 11. Comparison between the classes obtained in the ETC/ACM previous 2012 study and in this study. Number (#) and percentage (%) of stations for which the difference (calculated as class_ABv7 – class_ABv6) is -9, -8, …0, …, +9.

	NO_2 [#]	PM_{10} [#]	O_3 [#]	NO_2 [%]	PM_{10} [%]	O_3 [%]
-9	0	0	0	0	0	0
-8	0	0	0	0	0	0
-7	0	2	0	0	0.11	0
-6	0	0	0	0	0	0
-5	0	0	0	0	0	0
-4	0	1	2	0	0.055	0.096
-3	0	1	1	0	0.055	0.048
-2	0	18	17	0	0.988	0.813
-1	**236**	**312**	**267**	**8.79**	**17.1**	**12.8**
0	**2251**	**1198**	**1450**	**83.8**	**65.8**	**69.3**
1	**196**	**267**	**341**	**7.30**	**14.7**	**16.3**
2	2	17	13	0.074	0.934	0.621
3	0	3	0	0	0.165	0
4	0	2	1	0	0.110	0.048
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0

3.3 Overall analysis of the station classes

As in the previous 2012 study (ETC/ACM, 2013), the classes obtained for each pollutant are studied by comparison with AirBase classification and auxiliary variables describing the station environment (population density, land use). The spatial distribution of the classes is also examined.

The graphs and maps supporting this analysis are very similar to those obtained in the previous 2012 study. The extension of the training period (with inclusion of 2011) and the classification of a larger set of stations (between 250 and 450 stations depending on the pollutant, cf. Table 10), even with relaxed quality requirements, have minor impact on the class distributions and statistics. This confirms the robustness of the classification methodology that has already been highlighted.

The main conclusions coming out from this new analysis are presented hereafter and illustrated for PM_{10}. The figures relating to the three pollutants are provided in Annex III (NB: the figures displayed in this section and in Annex III for PM_{10} are the same.)

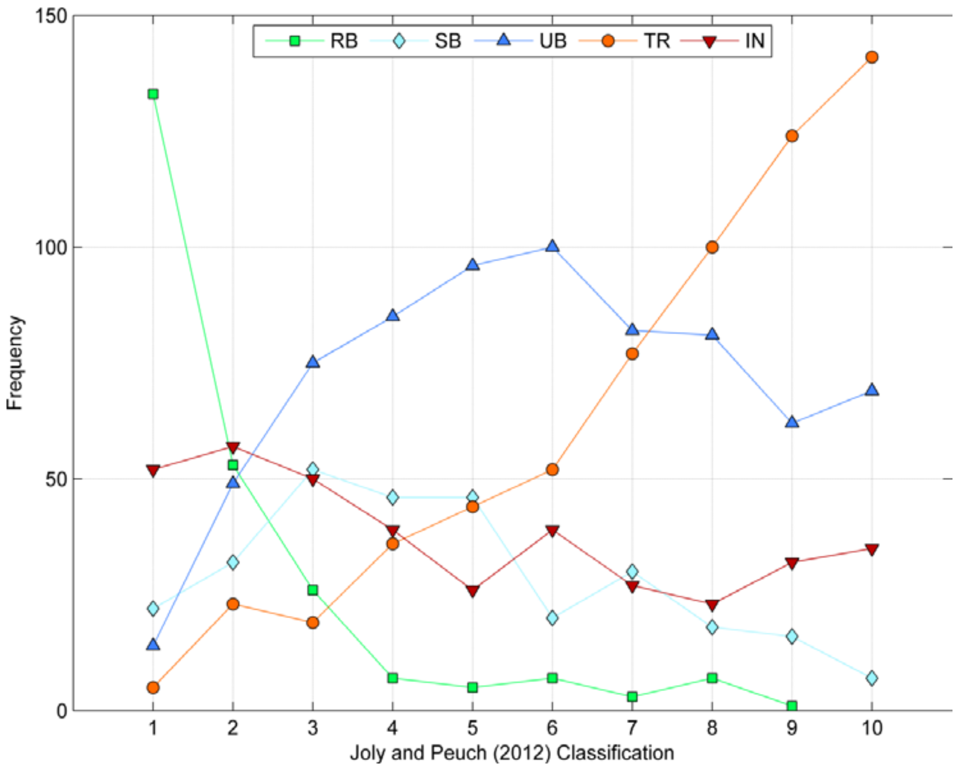


Figure 4. Distribution in frequency of the new PM_{10} station classification, categorized by AirBase metadata. RB = Rural background, SB = Suburban background, UB = Urban background, TR = Traffic (all types of area), IN = Industrial (all types of area).

The classification algorithm manages to separate rural background stations (classes 1 to 3) from traffic oriented sites (8 to 10) (Figure 4, Figure 19, Figure 31). The frequency distributions for the other AirBase categories are more widely spread throughout the classes. This is especially the case for ozone, which might be related to the higher proportion of background sites in the ozone training dataset (i.e. the set of stations used to compute the Fisher axis) and the influence of long-range transport.

As illustrated by the boxplots (Figure 5, Figure 20, Figure 32), rural background stations have the lowest median class in Joly & Peuch classification for the three pollutants (1-2). Urban traffic stations show the highest median class (8-9). The other categories display intermediate median classes in a coherent order: in particular, the median is 4 for suburban background sites (exception: 6 for ozone) and 6 for urban background stations (exception: 5 for NO_2).

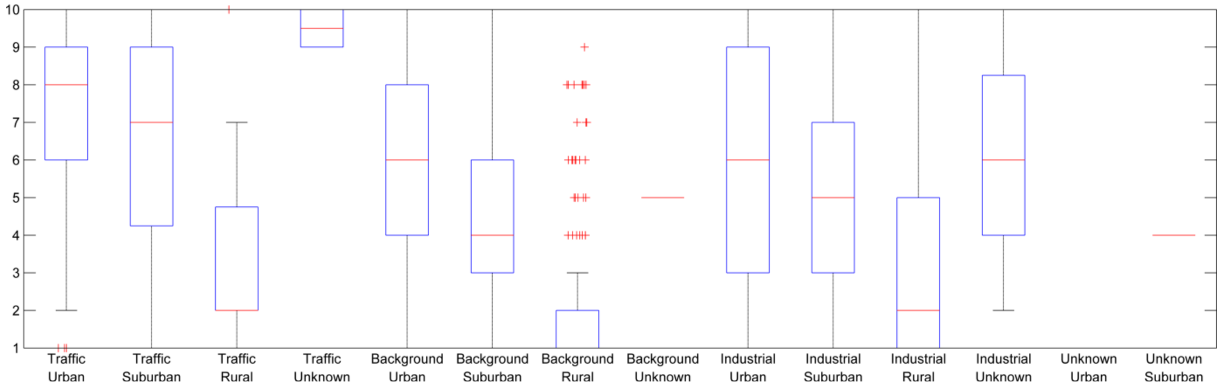


Figure 5. Box plot showing the median (red line), 25th and 75th percentiles (top and bottom of blue rectangle), the extreme values excluding outliers (black whiskers), as well as outliers (red crosses) of the new classification system for PM_{10}, categorized by AIRBASE station metadata

Although no direct link can be established between the station class and the characteristics of the station environment (population density[5], land use[6]), some tendencies appear, indicating that the class number is usually higher in urbanised and densely populated areas.

As would be expected, low classes are associated with lower population densities (Figure 6, Figure 21, Figure 33). From class 1 to class 7, the population density tends to increase, as highlighted by Figure 7 (Figure 22, Figure 34).

The percentage of each of the 44 CORINE Land Cover classes in a 1 kmx1km rectangle around the station is a good indicator of the more or less urbanized or rural nature of the station location. Particularly interesting are the classes CLC111 (continuous urban fabric) and CLC112 (discontinuous urban fabric) as

[5] For this analysis, the population density was derived from the Global Rural-Urban Mapping Project, GRUMPv1 (http://sedac.ciesin.columbia.edu/data/collection/grump-v1), which builds upon the Gridded Population of the World (GPW) version 3 dataset. The GRUMPv1 dataset provides global gridded data on population density for the year 2000 at a spatial resolution of 30 arc-seconds. For each station stored in AirBase, the corresponding latitude and longitude were extracted and the value of the closest grid cell in the GRUMPv1 dataset was obtained.

[6] Corine Land Cover is an inventory of land cover in 44 classes, operationally available for most areas of Europe. A description of the 44 classes can be found at http://www.eea.europa.eu/publications/COR0-landcover. The CORINE Land Cover data set at 100 m spatial resolution (2006) was used. For each station, a 1 km x 1 km rectangle centred on the location of the station was extracted from the land cover raster and the fraction of each land cover class was computed for this area.

well as some classes related to agricultural areas (2.X.X) and forest and semi-natural areas (3.X.X).The CLC112 dominates for most station classes, except for class 1 (and class 10 for ozone). However, some association is observed as well between the station class and the type of land use: for example, the environment of stations classified as 1 is mainly composed of CLC211 (arable land) and CLC312 (conifer forest) which are mostly found in rural areas. The environment of stations classified as 5 to 10 is mainly composed of CLC111 (continuous urban fabric) and CLC112 (discontinuous urban fabric) which are mostly found in urban areas.

In addition, Figure 6, Figure 21 and Figure 33 point out specific sites surrounded by very high population densities, above $2x10^4$ persons/km^2. Such stations may be interesting for study: this point is addressed in section 3.4.3.

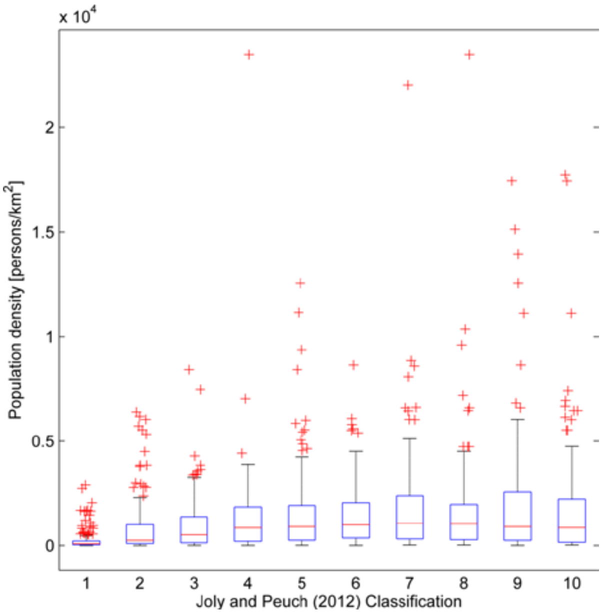


Figure 6. The relationship between the categories of the new PM_{10} station classification and population density, at the station. This boxplot shows the median (red line), 25th and 75th percentiles (upper and lower limits of the blue box), extreme values excluding outliers (black whiskers), and outliers (red crosses) of population density, categorized by Joly and Peuch (2012) classification

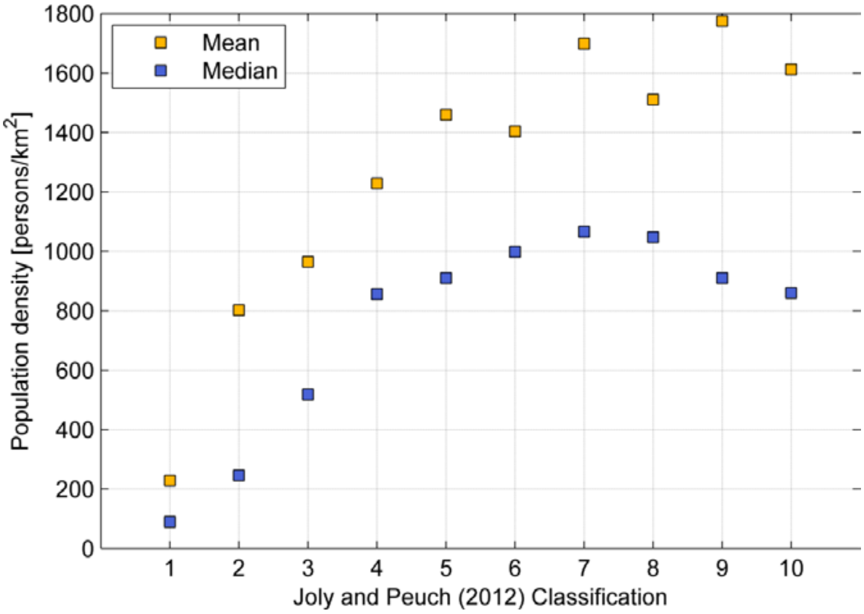


Figure 7. Similar to Figure 6 but only showing the median and mean of population density (outliers included) for each of the ten classes

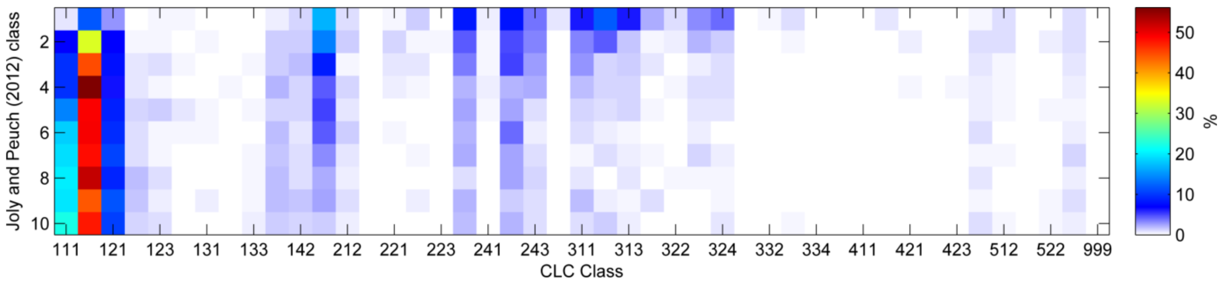
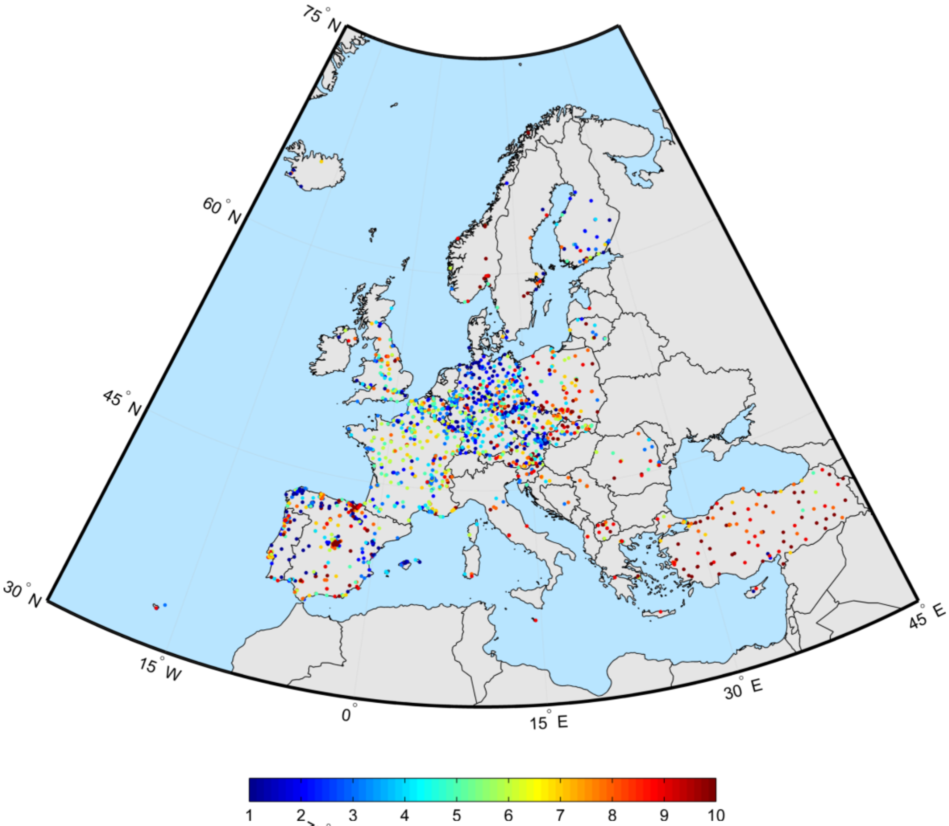


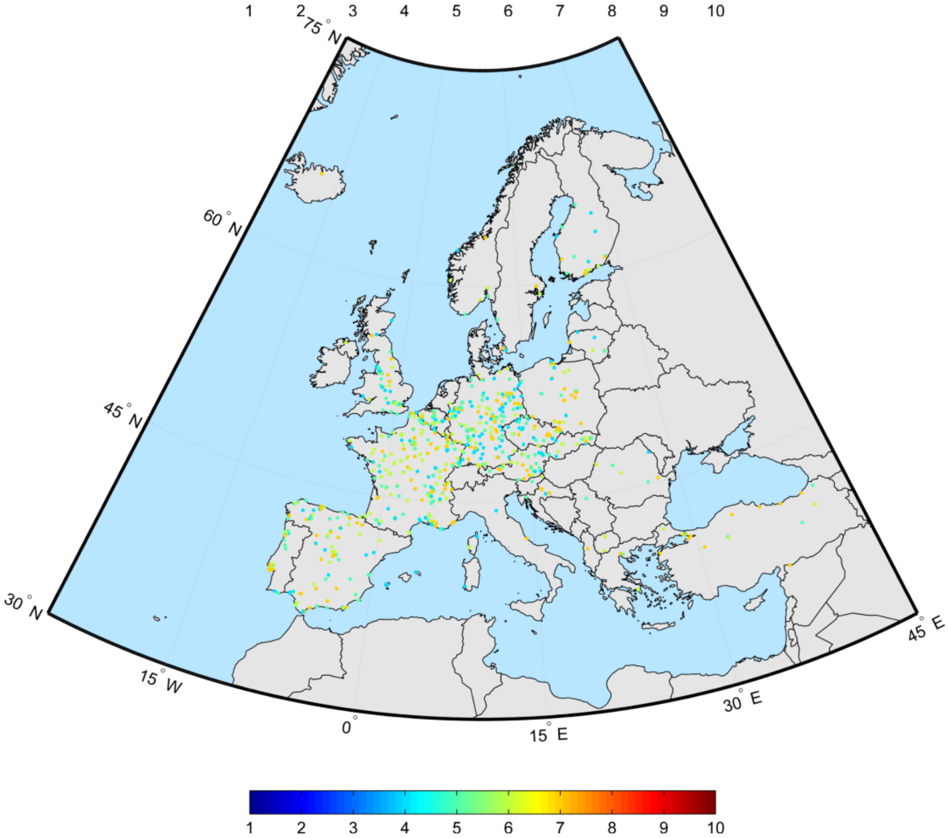
Figure 8. Average percentage of CORINE land cover classes for each of the 10 classes of the Joly and Peuch (2012) scheme that have been assigned to PM_{10} monitoring stations. This was computed over all 2248 stations that were studied here. Note that only every second CLC class was labelled here for clarity.

Regarding the spatial distribution of the classes over Europe (Figure 9, Figure 24, Figure 36), a few remarks can be done:

- Stations with medium classes are distributed over all Europe. For PM_{10} and O_3 the density of such stations is lower in the Eastern part of Europe.
- Stations with low classes are distributed over all Europe, with an especially high density in the centre of Europe (mostly Germany).
- Stations with high classes are distributed over all Europe as regards NO_2 and PM_{10}. Concerning O_3, they are almost absent from Northern Europe.
- In some countries (e.g. the Netherlands, Switzerland) PM_{10} monitoring stations could not be classified. This may be due to the type of

measurement, e.g. gravimetric measurements in Switzerland (the methodology works only for hourly values), or to insufficient data coverage (so that one or some of the requirements indicated in Table 9 were not met). Providing a precise explanation for each station requires further investigation. Stations with available data but no class assigned have been identified and highlighted in the spreadsheet which is provided as supplementary material (see Annex VI).


75° N
60° N
45° N
30° N
15° W
0°
15° E
30° E
45° E
1 2 3 4 5 6 7 8 9 10


75° N
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45° N
30° N
15° W
0°
15° E
30° E
45° E
1 2 3 4 5 6 7 8 9 10

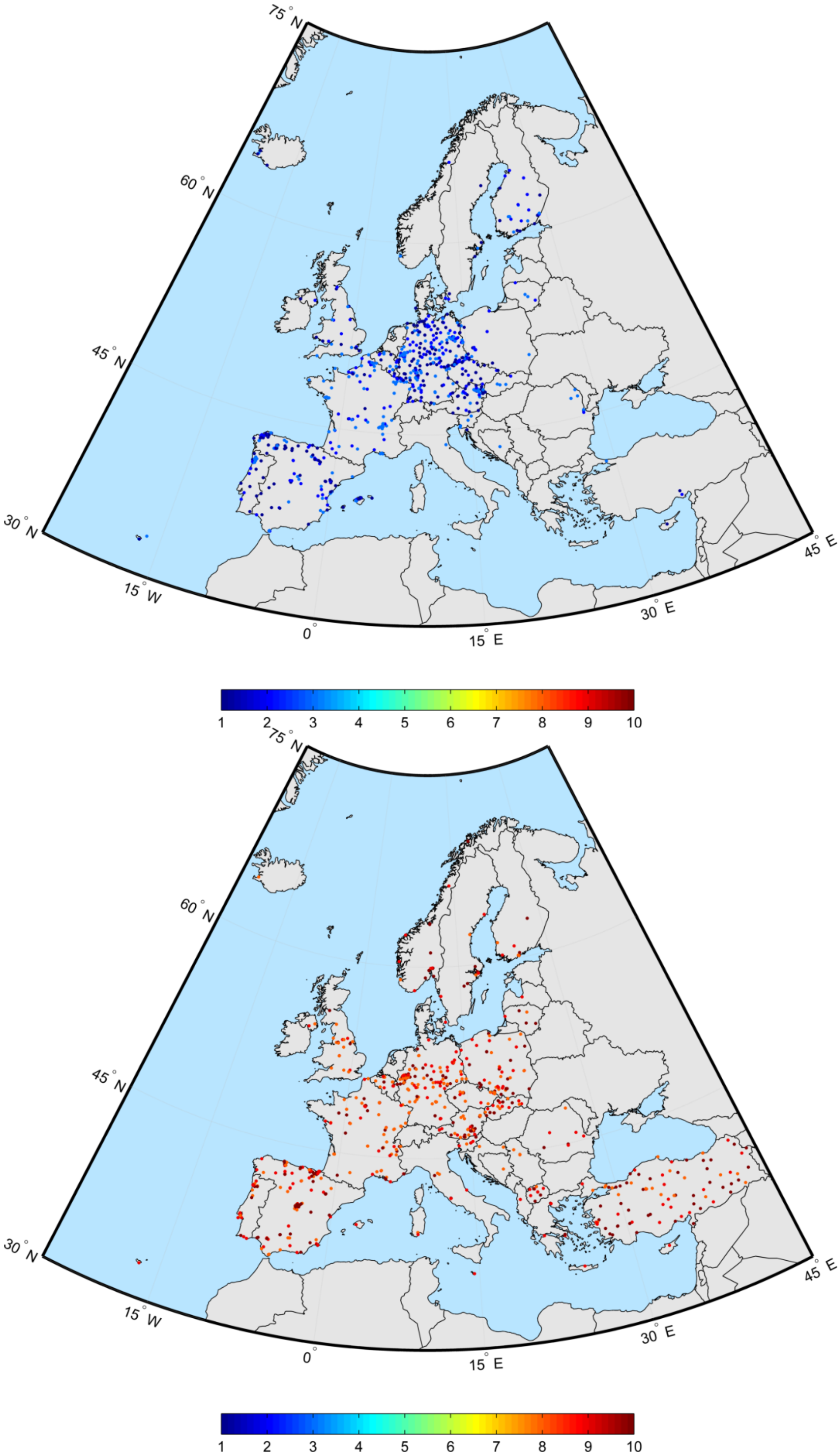

Figure 9. Overview map of PM_{10} monitoring stations. From top to bottom: 2248 stations, all classes together; 869 stations with medium classes (4, 5, 6, 7); 662 stations with low classes (1, 2, 3); 717 stations with high classes (8, 9, 10).

3.4 Identification of specific situations

Among the classified stations, three types of situations, with possible overlap between them, have been identified:

- stations for which the classification according to Joly & Peuch methodology (2012) does not well match the types of area and site provided in AirBase (Figure 10);
- stations displaying very different classes according to the measured pollutant;
- stations located in specific environment such as densely populated areas (Figure 6).

The following subsections give an insight into those three categories of situations, referred to as “outliers”. They do not aim at explaining each particular case, which requires the knowledge and local expertise from data providers. The idea is rather to illustrate how the supplementary classification can help in bringing out unusual and interesting study cases.

Finally, to illustrate the use of the supplementary classification at local scale, an example is provided analysing the case of Berlin, a participant city in the Air Implementation Pilot (EEA, 2013).

3.4.1 Outliers compared to AirBase classification

Section 3.3 (see Figure 4 and Annex III, Figure 19 and Figure 31) shows that rural background stations mostly fall into the lowest classes (below 3) whereas suburban and especially urban traffic stations mostly fall into the highest classes (above 6). It means that the eight indicators describing the temporal variability of concentrations succeed in differentiating rural background stations from stations influenced by traffic. However there is no strict correspondence between both classification systems: for one or several pollutants, high classes have thus been assigned to some rural background stations and low classes to a few (sub)urban traffic sites.

The upper map in Figure 10 displays rural background stations with PM_{10} class of 4 or more. Similar maps are provided in Annex IV for the three pollutants (Figure 37, Figure 38 and Figure 39, Figure 38 being the same as Figure 10). This type of situation mostly concerns O_3 monitoring stations (Table 12). As was explained in ETC/ACM (2013) report, this can be related to the characteristics of the ozone monitoring network and the classification methodology. Ozone pollution is mainly a regional issue and the Air Quality Directive (2008/50/EC) only requires O_3 monitoring at rural, suburban and urban background sites. As a consequence, the training dataset used to define the ten classes for O_3 contains a higher proportion of background sites and a lower proportion of traffic sites than for NO_2 and PM_{10}. Ozone background stations have therefore a larger weight in the construction of the Fisher axis and the definition of the classes, including the upper ones.

The lower map in Figure 10 displays suburban and urban traffic stations with PM_{10} class of 4 or lower. Similar maps are presented in Annex IV for the three pollutants (Figure 37, Figure 38 and Figure 39, Figure 38 being the same as Figure 10). This type of situation mostly concerns PM_{10} monitoring stations (Table 13). This is in line with experimental studies[7] suggesting that regional background pollution has a significant contribution to PM_{10} levels in urban areas and road traffic a less marked influence at local scale compared to NO_2.

Table 12. Number of stations that are classified as rural background within the Airbase database but were assigned classes of 4 or higher by the Joly and Peuch (2012) algorithm.

	Class ≥ 4	**Class ≥ 6**	**Class ≥ 8**
NO_2	28	14	3
PM_{10}	30	18	8
O_3	173	96	47

Table 13. Number of stations that are classified as suburban or urban traffic within the Airbase database but were assigned classes of 4 or lower by the Joly and Peuch (2012) algorithm.

	Class ≤ 4	**Class ≤ 3**	**Class ≤ 2**
NO_2	32	14	6
PM_{10}	75	40	22
O_3	40	18	8

[7] VMM (2013), Life+ ATMOSYS snelwegcampagne: Luchtkwaliteit nabij de E40-snelweg in Affligem.
Freutel et al. (2013), Aerosol particle measurements at three stationary sites in the megacity of Paris during summer 2009: meteorology and air mass origin dominate aerosol particle composition and size distribution, Atmos. Chem. Phys., 13, 933–959.
Beauchamp et al. (2011). Variabilité spatiale des concentrations de PM10 autour de sites de proximité automobile: mise en oeuvre et exploitation de campagnes de mesure, rapport LCSQA.

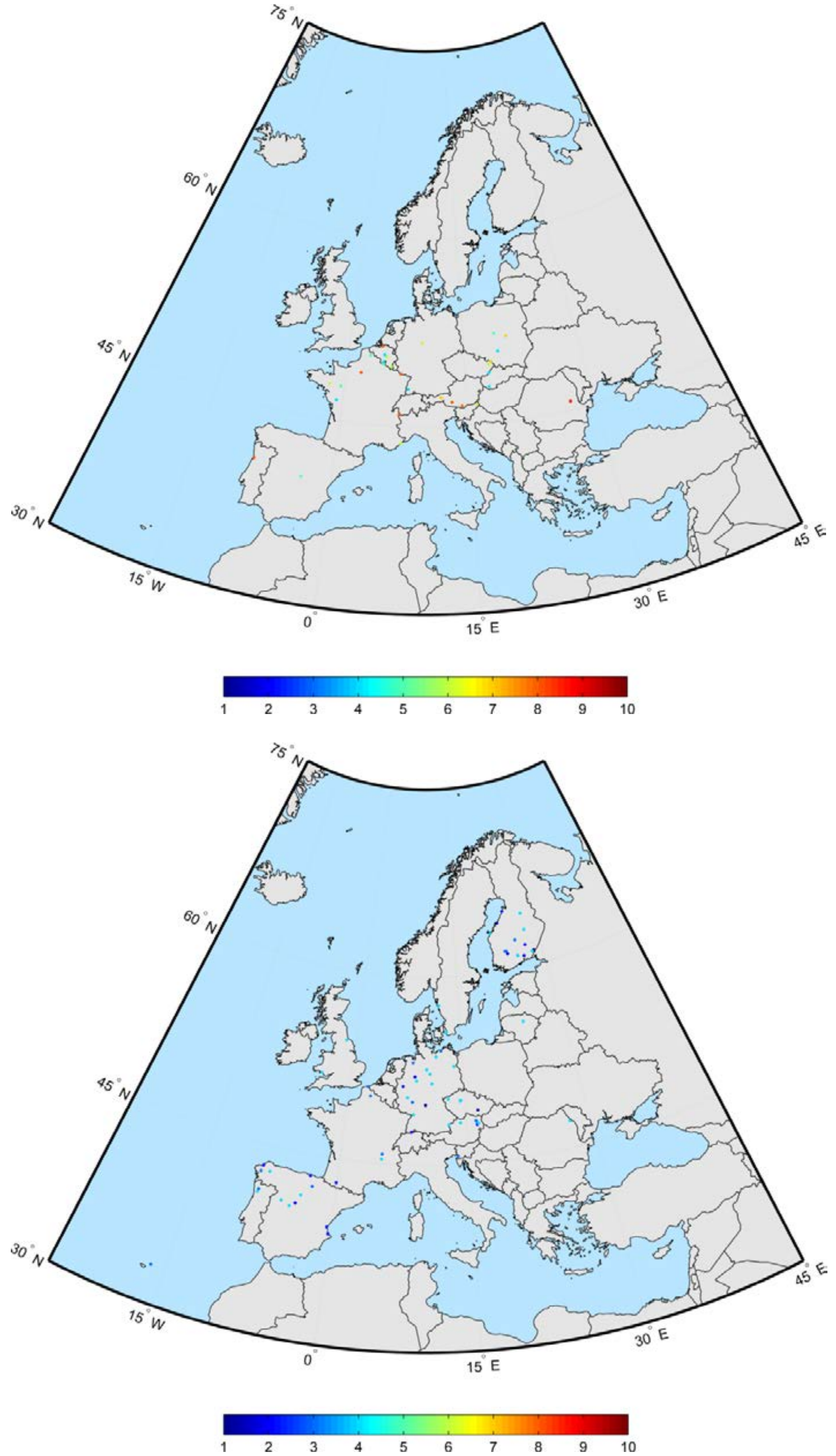

Figure 10. Top: Outliers in the new PM_{10} classification of rural background stations. These are stations that are classified as rural background within the Airbase database but were assigned classes of 4 or higher by the Joly and Peuch (2012) algorithm. Bottom: Outliers in the new PM_{10} classification of (sub)urban traffic stations. These are stations that are classified as suburban or urban traffic within the AirBase database but were assigned classes of 4 or lower by the Joly and Peuch (2012) algorithm.

3.4.2 Stations displaying different classes according to the pollutant

The differences between the classes assigned to NO_2, PM_{10} and O_3 have been calculated for all stations measuring at least two compounds. The histogram of the differences between NO_2 and PM_{10} classifications has a Gaussian shape with a maximum frequency at zero, i.e. a null difference between the classes (Figure 11). The histogram of the differences between NO_2 and O_3 classifications is skewed, with still a maximum at zero but a larger proportion of negative differences (Figure 11), which is also illustrated by the boxplots in Figure 12. This result can partly be explained by the specificities of the ozone monitoring network (see above section 3.4.1): for ozone, background stations (in particular suburban ones, see Figure 32 vs. Figure 26) are thus shifted towards higher classes. Further explanations have to be looked for by considering geographical and meteorological factors (mountains, sea, as highlighted in the ETC/ACM (2013) report), long range transport and other local features. The maps of the differences between NO_2, PM_{10} and O_3 classifications are shown below (Figure 13, Figure 14).

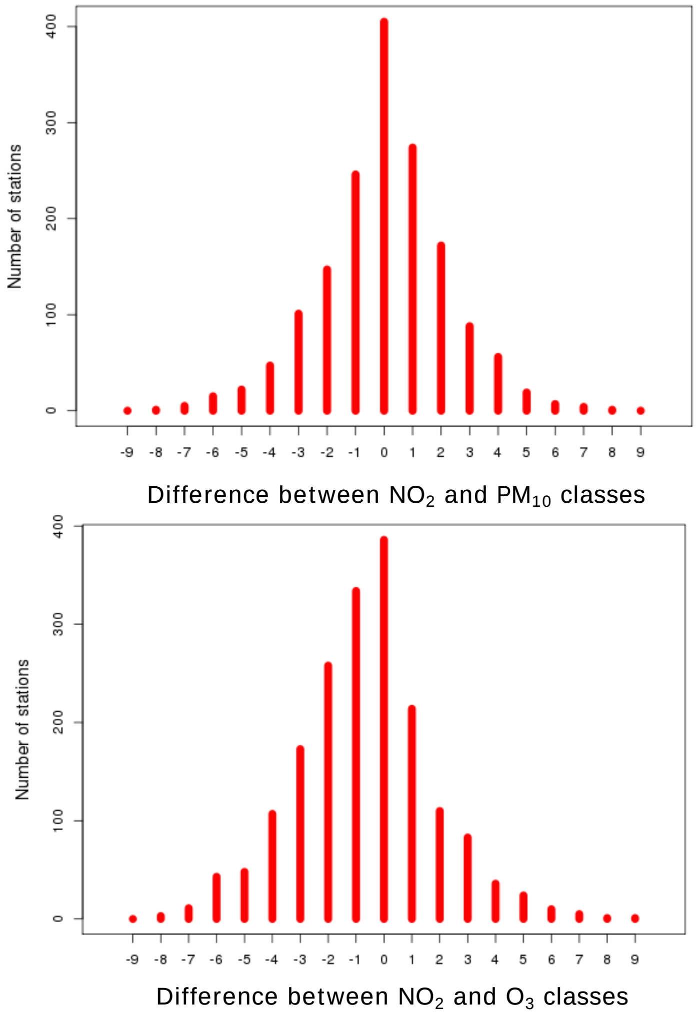

Figure 11. Statistical distribution, of the differences between NO_2 and PM_{10} classifications (top), NO_2 and O_3 classifications (bottom), categorized by AIRBASE station metadata. Differences calculated as (NO_2 class – PM_{10} class) and (NO_2 class - O_3 class) respectively.

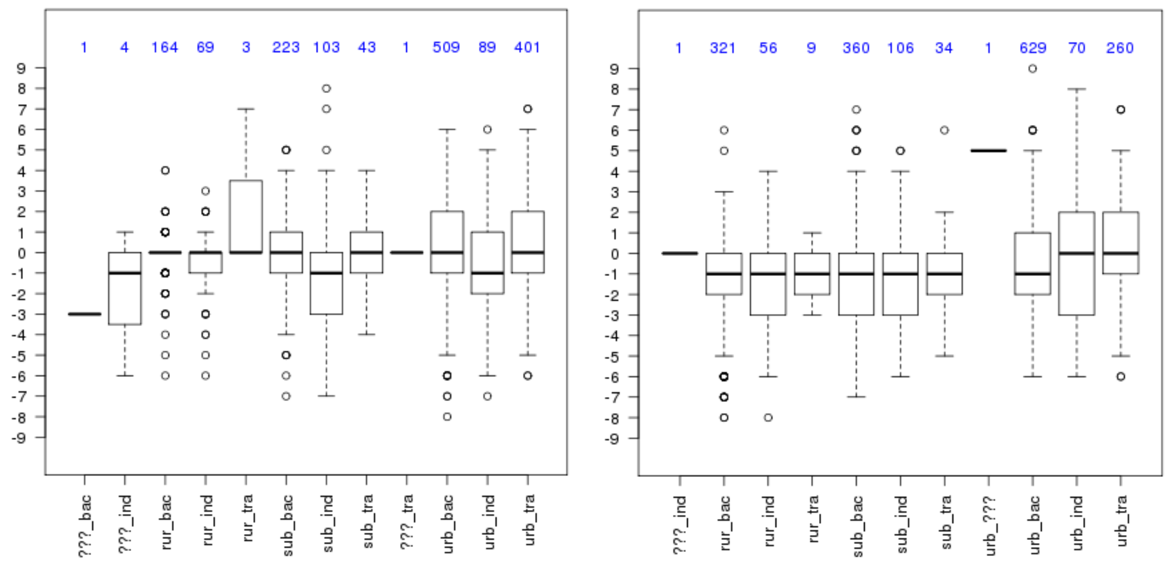

Figure 12. Boxplot of the differences between NO_2 and PM_{10} classifications (left), NO_2 and O_3 classifications (right), categorized by AIRBASE station metadata. It shows the median (horizontal bold line), 25th and 75th percentiles (upper and lower limits of the box), extreme values excluding outliers (black whiskers), and outliers (circles) of the differences. The number of stations per AIRBASE category is indicated in blue. Differences are calculated as (NO_2 class – PM_{10} class) and (NO_2 class - O_3 class) respectively.

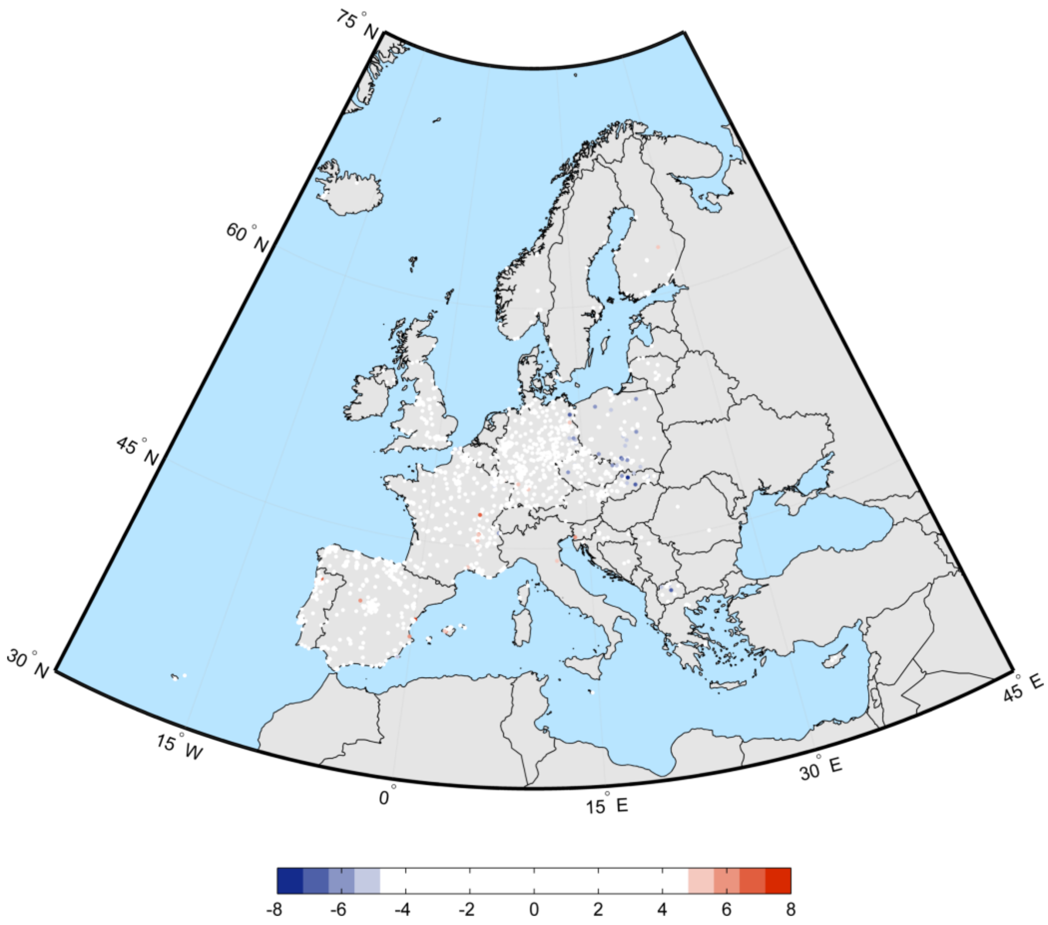

Figure 13. Map of the differences between NO_2 and PM_{10} classification. The differences are calculated as (NO_2 class – PM_{10} class).

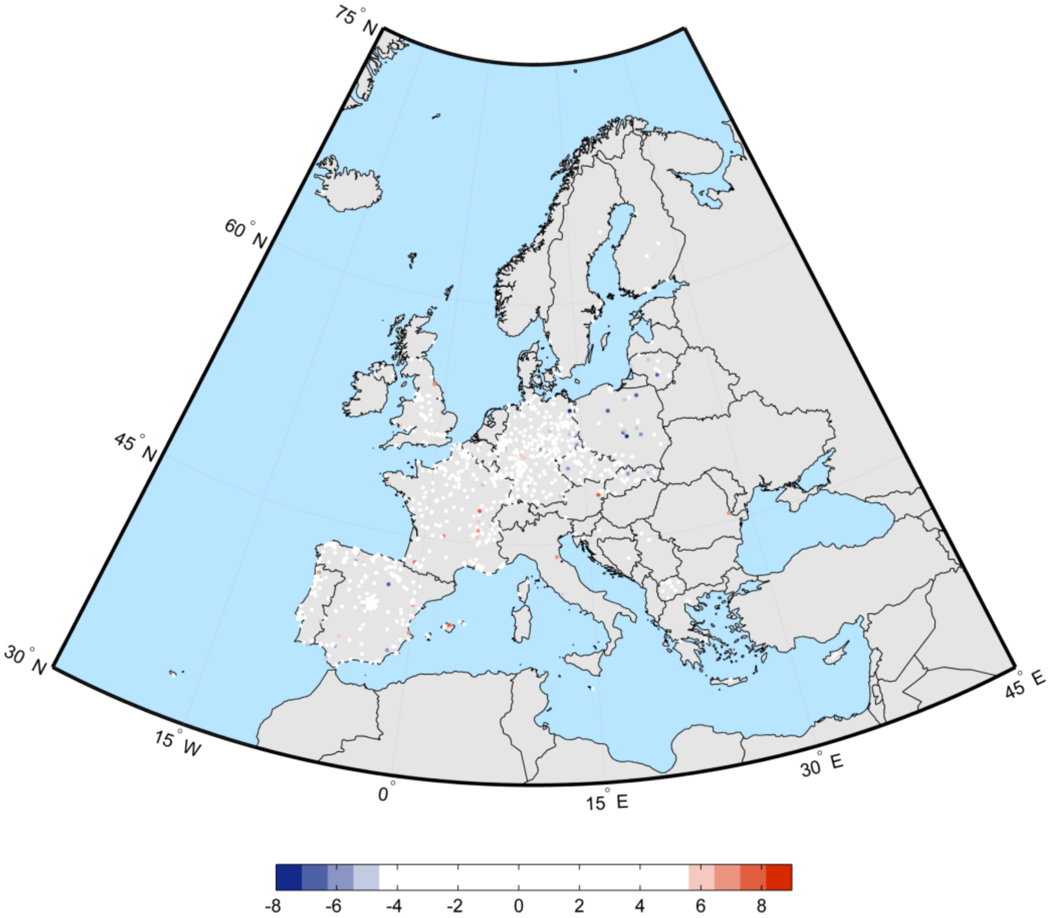

Figure 14. Map of the differences between NO_2 and O_3 classification. The differences are calculated as (NO_2 class - O_3 class).

3.4.3 Stations located in specific environment

In section 3.3, Figure 6, three stations can clearly be distinguished: stations with more than 20 000 inhabitants/km^2. Those stations with very high population density are located in the same area: Paris area. In Paris and its region, the local air quality monitoring association (Airparif) manages more than 25 PM_{10} monitoring stations. The three identified stations with more than 20 000 inhabitants/km^2 are then in minority and really specific of the local zone. The Parisian station classified as 4 is characterized in AirBase as an urban background site (code FR04055, Paris 1er Les Halles) and was closed in November 2011. This station is classified as 8 for O_3 and 7 for NO_2. The other two stations, also labelled as "urban background", show relatively high classes (7 to 8) for all pollutants (Table 14). Further analysis could be undertaken by the local data provider (Airparif) to understand those results.

Table 14. Example of three Parisian stations located in densely populated areas.

EoI code	Type of area	Type of station	NO_2	PM_{10}	O_3	Population density (inhab./km^2)
FR04055	urban	background	7	4	8	23482.37
FR04143	urban	background	8	8	(*)	23482.37
FR04004	urban	background	7	7	7	22032.06

(*) the station could not be classified for this pollutant

3.4.4 Focus on one city

As an example of possible analysis on a local scale, the case of Berlin - one of the twelve cities involved in the Air Implementation Pilot Project (EEA, 2013), see Annex V - is presented (Figure 15).

There is an overall good correspondence between the supplementary classification and AirBase metadata, especially as regards NO_2 and PM_{10}:

- Rural background stations are classified between 2 and 3 (1 to 4 for O_3);
- Suburban background stations are classified between 2 and 4;
- Most urban background stations are classified between 3 and 6;
- Most suburban or urban traffic stations are classified between 7 and 10.

Those last two categories include a few exceptions:

- NO_2: three traffic stations display rather low classes: 3 (DEBE011), 5 (DEBE043), 5 (DEBE045);
- PM_{10}: two stations located in an urban background environment are classified quite differently: 3 (DEBE018) and 7 (DEBE010).

As for the industrial station located in the south of Berlin, its behaviour is more typical of a rural background location, with a class of 2 for the three pollutants.

To analyse and explain such results, local factors (not necessarily reflected by the population and land use variables) need to be considered. For instance the difference of PM_{10} class between DEBE018 and DEBE010 seems consistent with the description of the monitoring sites provided by Berlin municipality (http://www.stadtentwicklung.berlin.de/umwelt/luftqualitaet/de/messnetz/index.shtml): DEBE018 is located in a residential and commercial area. The environment of DEBE010 is similar but the presence of two main traffic streets in the neighbourhood of the station is mentioned.

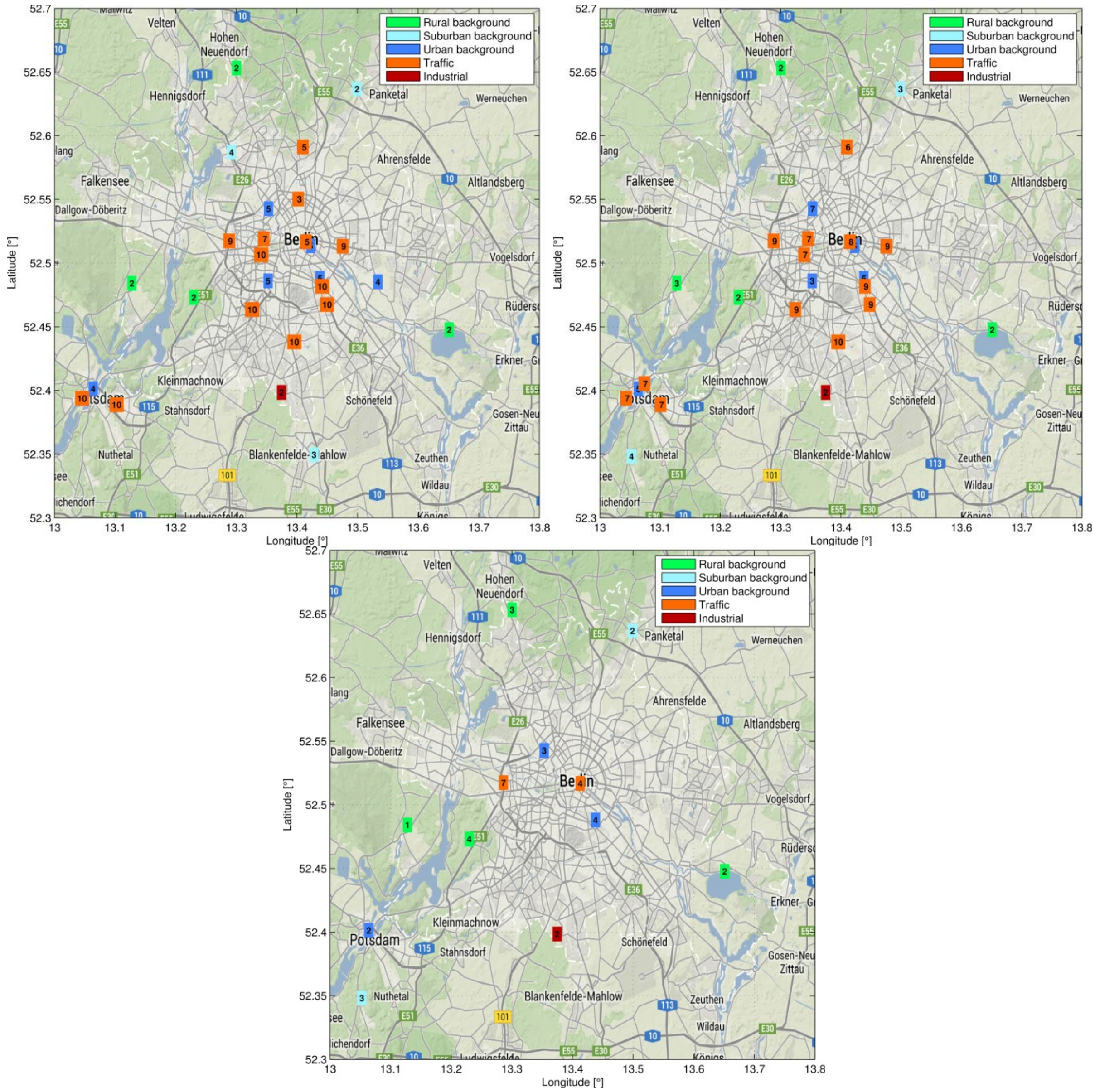

Figure 15. Spatial comparison of the two classification systems in the air quality zone of Berlin. The traditional AirBase metadata classification is shown as coloured boxes whereas the Joly and Peuch (2012) classification is given as a number from 1 to 10. Top left: NO_2; top right: PM_{10}; bottom: O_3

4 Conclusions

After more than fifteen years since the entry into force of the Air Quality Framework Directive (EC, 1996) and considering the fast development of air quality measurement across Europe (from EU15 to EU28 and other European countries), this report makes an assessment of the European monitoring network. Using historical meta-information from AirBase, the main evolutions of the network are examined. One significant result is that the relative distribution of the different types of sites (according to the EoI classification) is stable between 2004 and 2011.

Different criteria are then considered to evaluate to which extent the monitoring network is appropriate for assessing population exposure and meeting the Air Quality Directive (EC, 2008) requirements. This analysis shows that the density of PM_{10} and NO_2 monitoring networks is in line with the EUROAIRNET criteria set in 1999 by the EEA to establish a representative European monitoring network. However, for a final conclusion on its representativeness for population exposure, the classification and spatial distribution of the stations need to be considered. Regarding agreement with the directive requirements, an encouraging trend is observed, with an increasing, respectively decreasing, number of air quality assessment zones being above, respectively below, the minimum requirements in terms of measurement points.

To go more in depth with the characterization of the stations, the second part of this report focuses on the update of the classification according to Joly & Peuch (2012) methodology and highlights new findings. AirBase v6 was replaced by AirBAse v7 and the training period used to compute the Fisher Axis and subsequently classify the stations was extended to 2002-2011. Furthermore quality requirements on missing data were relaxed so that a significant number of unclassified stations could be projected afterwards on the same Fisher axis and get a class number. To analyse the results, all graphics and statistics included in the previous report (ETC/ACM, 2013) were updated according to a homogeneous format. One main conclusion is that the methodology is stable from Airbase v6 to Airbase v7 with an additional year. All graphs and statistics remain similar.

Thanks to examples, it is then shown how this methodology, complemented by other auxiliary variables, can help to enhance specific monitoring situations which could require further analysis.

As an additional product of this work, a spreadsheet compiling information on monitoring stations has been prepared. It should enable the data users or data providers to select the optimum classification for their application and/or perform quality check on the consistency of meta data.

5 References

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ANNEX I

Analysis of the network design according to EUROAIRNET criteria.

Table I.a. PM_{10} monitoring coverage in cities with a population over 500,000 for the years 1996, 2004, 2007 and 2011.

Row Labels	#cities>500k	1996	2004	2007	2011	difference	% coverage
AT	**1**	0	1	1	1	0	100%
BE	**1**	1	1	1	1	0	100%
BG	**1**	0	1	1	1	0	100%
CZ	**1**	1	1	1	1	0	100%
DE	**13**	0	13	13	13	0	100%
ES	**6**	0	6	5	6	0	100%
FI	**1**	1	1	1	1	0	100%
FR	**8**	0	7	8	8	0	100%
UK	**5**	5	5	5	5	0	100%
GR	**1**	0	1	1	1	0	100%
HR	**1**	0	0	0	1	0	100%
HU	**1**	0	1	1	1	0	100%
IT	**6**	0	5	6	5	-1	83%
LT	**1**	0	1	1	1	0	100%
LV	**1**	0	1	1	1	0	100%
NL	**2**	2	2	2	2	0	100%
NO	**1**	1	1	1	1	0	100%
PL	**5**	0	5	5	5	0	100%
PT	**1**	0	1	1	1	0	100%
RO	**1**	0	1	1	1	0	100%
RS	**1**	0	1	1	1	0	100%
SE	**1**	0	1	1	1	0	100%
TR	**13**	0	0	0	13	0	100%
Grand Total	**73**	**11**	**57**	**58**	**72**	-1	99%

Table I.b. PM_{10} monitoring coverage in cities with a population between 250,000 and 500,000 for the years 1996, 2004, 2007 and 2011.

Row Labels	500k≥#cities>250k	1996	2004	2007	2011	difference	% coverage
AL	**1**	0	0	0	1	0	100%
BA	**1**	0	0	1	0	-1	0%
BE	**2**	1	2	2	2	0	100%
BG	**2**	0	2	2	2	0	100%
CH	**1**	0	1	1	1	0	100%
CY	**1**	1	1	1	1	0	100%
CZ	**2**	2	2	2	2	0	100%
DE	**14**	0	13	14	14	0	100%
DK	**2**	0	2	2	2	0	100%
EE	**1**	0	1	1	1	0	100%
ES	**9**	0	8	9	9	0	100%
FR	**14**	0	14	14	14	0	100%
UK	**25**	10	15	15	8	-17	32%
GR	**1**	0	1	1	1	0	100%
IE	**1**	0	1	1	1	0	100%
IT	**6**	0	4	5	6	0	100%
LT	**1**	0	1	1	1	0	100%
MK	**1**	0	1	1	1	0	100%
NL	**2**	2	2	2	2	0	100%
PL	**7**	0	7	7	7	0	100%
PT	**2**	0	0	0	1	-1	50%
RO	**7**	0	1	5	3	-4	43%
SE	**2**	0	2	2	2	0	100%
SI	**1**	0	1	1	1	0	100%
SK	**1**	0	1	1	1	0	100%
TR	**9**	0	0	0	9	0	100%
Grand Total	**116**	**16**	**83**	**91**	**93**	**-23**	**80%**

Table I.c. PM_{10} monitoring coverage in cities with a population between 50,000 and 250,000 for the years 1996, 2004, 2007 and 2011.

Row Labels	250k≥#cities>50k	1996	2004	2007	2011	difference	% coverage
AL	**6**	0	0	0	0	6	0%
AT	**5**	0	5	5	5	0	100%
BA	**4**	0	0	0	0	4	0%
BE	**6**	1	3	3	3	3	50%
BG	**14**	0	4	11	13	1	93%
CH	**7**	1	7	7	6	1	86%
CY	**1**	0	0	0	1	0	100%
CZ	**15**	9	15	15	15	0	100%
DE	**93**	0	74	76	76	17	82%
DK	**2**	0	2	2	1	1	50%
EE	**1**	0	0	0	2	-1	200%
ES	**81**	0	49	62	76	5	94%
FI	**8**	0	8	8	8	0	100%
FR	**107**	0	75	86	87	20	81%
UK	**88**	8	26	26	25	63	28%
GR	**8**	0	3	4	4	4	50%
HR	**4**	0	0	0	2	2	50%
HU	**9**	0	5	7	6	3	67%
IE	**3**	0	1	2	2	1	67%
IS	**1**	1	1	1	1	0	100%
IT	**61**	0	31	45	52	9	85%
LI	**1**	0	0	0	0	1	0%
LT	**2**	0	3	3	3	-1	150%
LU	**1**	0	0	1	1	0	100%
LV	**3**	0	0	1	1	2	33%
ME	**2**	0	0	0	2	0	100%
MK	**4**	0	3	3	3	1	75%
MT	**1**	0	1	1	1	0	100%
NL	**25**	4	10	10	11	14	44%
NO	**5**	1	3	4	5	0	100%
PL	**55**	0	29	43	44	11	80%
PT	**25**	0	15	16	19	6	76%
RO	**25**	0	3	5	10	15	40%
RS	**10**	0	0	0	2	8	20%
SE	**10**	0	3	7	9	1	90%
SI	**1**	0	1	1	1	0	100%
SK	**7**	0	6	7	7	0	100%
TR	**49**	0	0	0	49	0	100%
Grand Total	**750**	**25**	**386**	**462**	**555**	**195**	74%

Table I.d. NO_2 monitoring coverage in cities with a population over 500,000 for the years 1996, 2004, 2007 and 2011.

Row Labels	#cities>500k	1996	2004	2007	2011	difference	%
AT	**1**	1	1	1	1	0	100%
BE	**1**	1	1	1	1	0	100%
BG	**1**	0	1	1	1	0	100%
CZ	**1**	1	1	1	1	0	100%
DE	**13**	13	13	13	13	0	100%
ES	**6**	2	6	6	6	0	100%
FI	**1**	1	1	1	1	0	100%
FR	**8**	0	8	8	8	0	100%
UK	**5**	5	5	5	5	0	100%
GR	**1**	1	1	1	1	0	100%
HR	**1**	0	0	0	1	0	100%
HU	**1**	0	1	1	1	0	100%
IT	**6**	0	5	6	5	-1	83%
LT	**1**	0	1	1	1	0	100%
LV	**1**	0	1	1	1	0	100%
NL	**2**	2	2	2	2	0	100%
NO	**1**	1	1	1	1	0	100%
PL	**5**	0	4	5	5	0	100%
PT	**1**	0	1	1	1	0	100%
RO	**1**	0	1	1	1	0	100%
RS	**1**	0	1	1	1	0	100%
SE	**1**	0	1	1	1	0	100%
TR	**13**	0	0	0	0	-13	0%
Grand Total	**73**	**28**	**57**	**59**	**59**	**-14**	**81%**

Table I.e. NO_2 monitoring coverage in cities with a population between 250,000 and 500,000 for the years 1996, 2004, 2007 and 2011.

Row Labels	500k≥#cities>250k	1996	2004	2007	2011	difference	%
AL	**1**	0	0	0	1	0	100%
BA	**1**	0	1	1	1	0	100%
BE	**2**	2	2	2	2	0	100%
BG	**2**	0	1	2	2	0	100%
CH	**1**	1	1	1	1	0	100%
CY	**1**	0	1	1	1	0	100%
CZ	**2**	2	2	2	2	0	100%
DE	**14**	11	13	14	14	0	100%
DK	**2**	1	2	2	2	0	100%
EE	**1**	0	1	1	1	0	100%
ES	**9**	0	8	9	9	0	100%
FR	**14**	0	14	14	14	0	100%
UK	**25**	11	19	8	14	-11	56%
GR	**1**	0	1	1	1	0	100%
IE	**1**	0	1	1	1	0	100%
IT	**6**	0	5	5	6	0	100%
LT	**1**	0	1	1	1	0	100%
MK	**1**	0	1	1	1	0	100%
NL	**2**	2	2	2	2	0	100%
PL	**7**	0	6	7	6	-1	86%
PT	**2**	0	0	0	1	-1	50%
RO	**7**	0	2	4	5	-2	71%
SE	**2**	1	2	2	2	0	100%
SI	**1**	0	1	1	1	0	100%
SK	**1**	1	1	1	1	0	100%
TR	**9**	0	0	0	0	-9	0%
Grand Total	**116**	**32**	**88**	**83**	**92**	**-24**	**79%**

Table I.f. NO_2 monitoring coverage in cities with a population between 50,000 and 250,000 for the years 1996, 2004, 2007 and 2011.

Row Labels	250k≥#cities>50k	1996	2004	2007	2011	difference	%
AL	**6**	0	0	0	0	6	0%
AT	**5**	5	5	5	5	0	100%
BA	**4**	0	1	0	0	4	0%
BE	**6**	2	3	3	4	2	67%
BG	**14**	0	2	5	8	6	57%
CH	**7**	7	7	7	6	1	86%
CY	**1**	0	0	0	0	1	0%
CZ	**15**	9	15	15	15	0	100%
DE	**93**	78	75	76	85	8	91%
DK	**2**	2	2	2	2	0	100%
EE	**1**	0	0	0	2	-1	200%
ES	**81**	0	54	72	77	4	95%
FI	**8**	2	7	8	8	0	100%
FR	**107**	0	93	98	96	11	90%
UK	**88**	11	31	12	37	51	42%
GR	**8**	1	3	2	3	5	38%
HR	**4**	0	0	0	2	2	50%
HU	**9**	0	7	7	7	2	78%
IE	**3**	0	1	2	2	1	67%
IS	**1**	1	1	1	1	0	100%
IT	**61**	0	34	51	52	9	85%
LI	**1**	0	0	0	0	1	0%
LT	**2**	0	3	3	3	-1	150%
LU	**1**	0	1	1	1	0	100%
LV	**3**	0	0	1	1	2	33%
ME	**2**	0	0	0	2	0	100%
MK	**4**	0	3	3	1	3	25%
MT	**1**	0	1	1	1	0	100%
NL	**25**	5	9	10	11	14	44%
NO	**5**	1	1	4	5	0	100%
PL	**55**	0	18	38	37	18	67%
PT	**25**	0	17	19	19	6	76%
RO	**25**	0	6	3	12	13	48%
RS	**10**	0	7	8	8	2	80%
SE	**10**	0	8	8	8	2	80%
SI	**1**	1	1	1	1	0	100%
SK	**7**	3	6	7	6	1	86%
TR	**49**	0	0	0	0	49	0%
Grand Total	**695**	**128**	**422**	**473**	**528**	**167**	**76%**

ANNEX II

Station classification according to Joly & Peuch (2012) methodology:

comparison between AirBase v6 (2002-2010) and AirBase v7 (2002-2011) classification results

NO_2

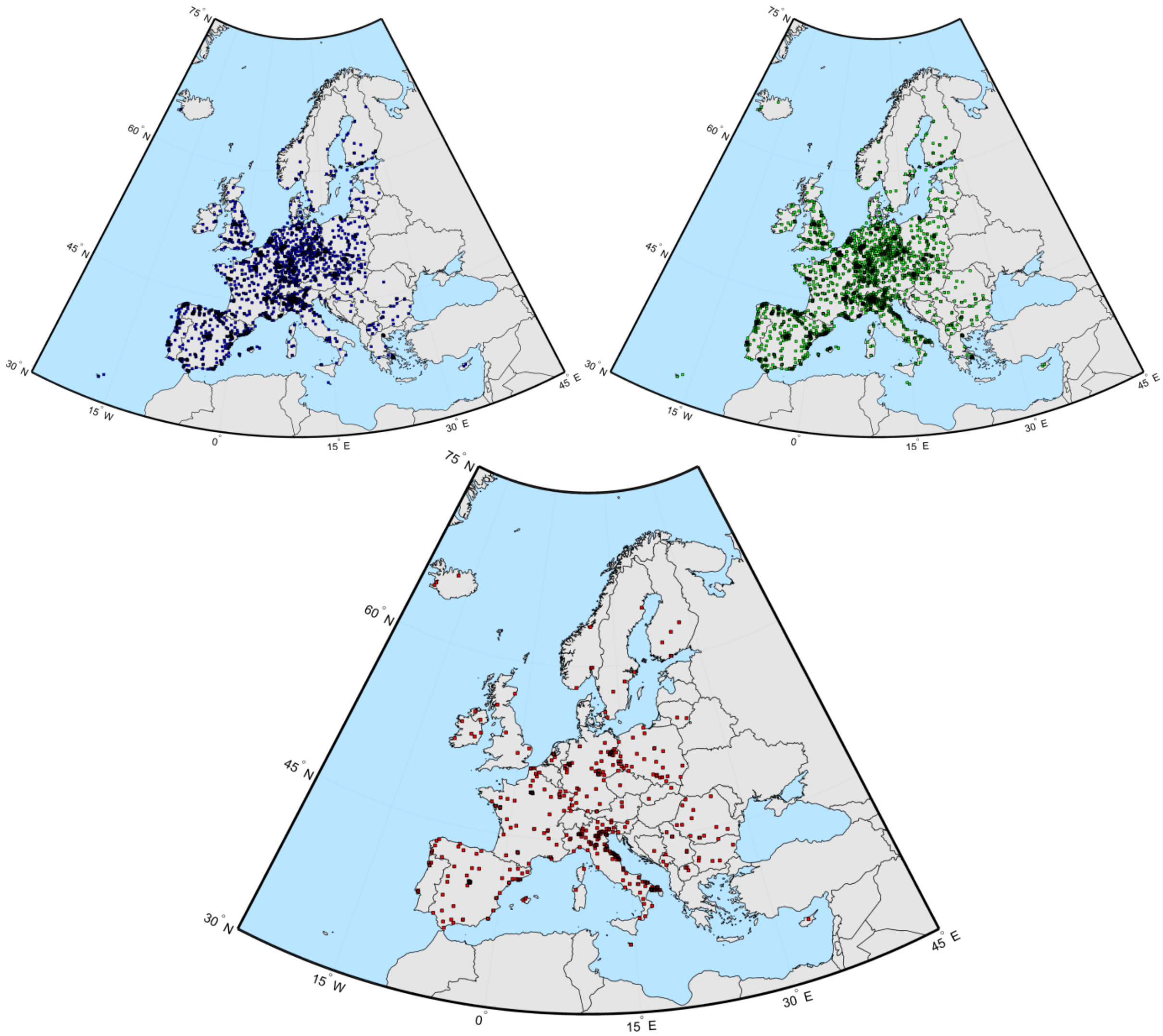


Figure 16. Top left: NO_2 monitoring stations classified with AirBase v6 in 2012 study; top right: NO_2 monitoring stations classified with AirBase v7 in this study; bottom: NO_2 monitoring stations which were additionally classified with AirBase v7 but were missing in the v6 classification

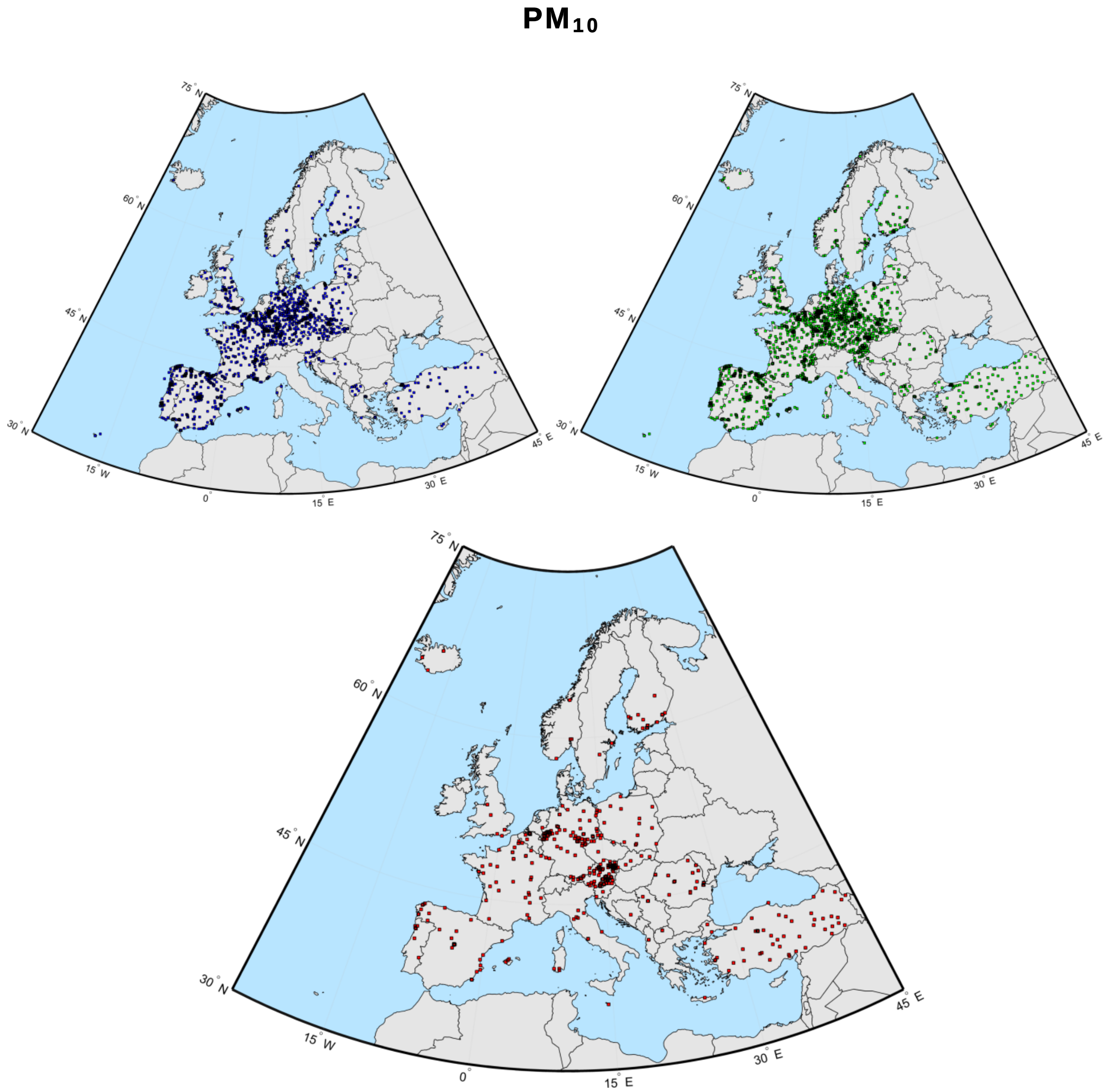


Figure 17 (identical to Figure 3). Top left: PM$_{10}$ monitoring stations classified with AirBase v6 in 2012 study; top right: PM$_{10}$ monitoring stations classified with AirBase v7 in this study; bottom: PM$_{10}$ monitoring stations which were additionally classified with AirBase v7 but were missing in the v6 classification

O_3

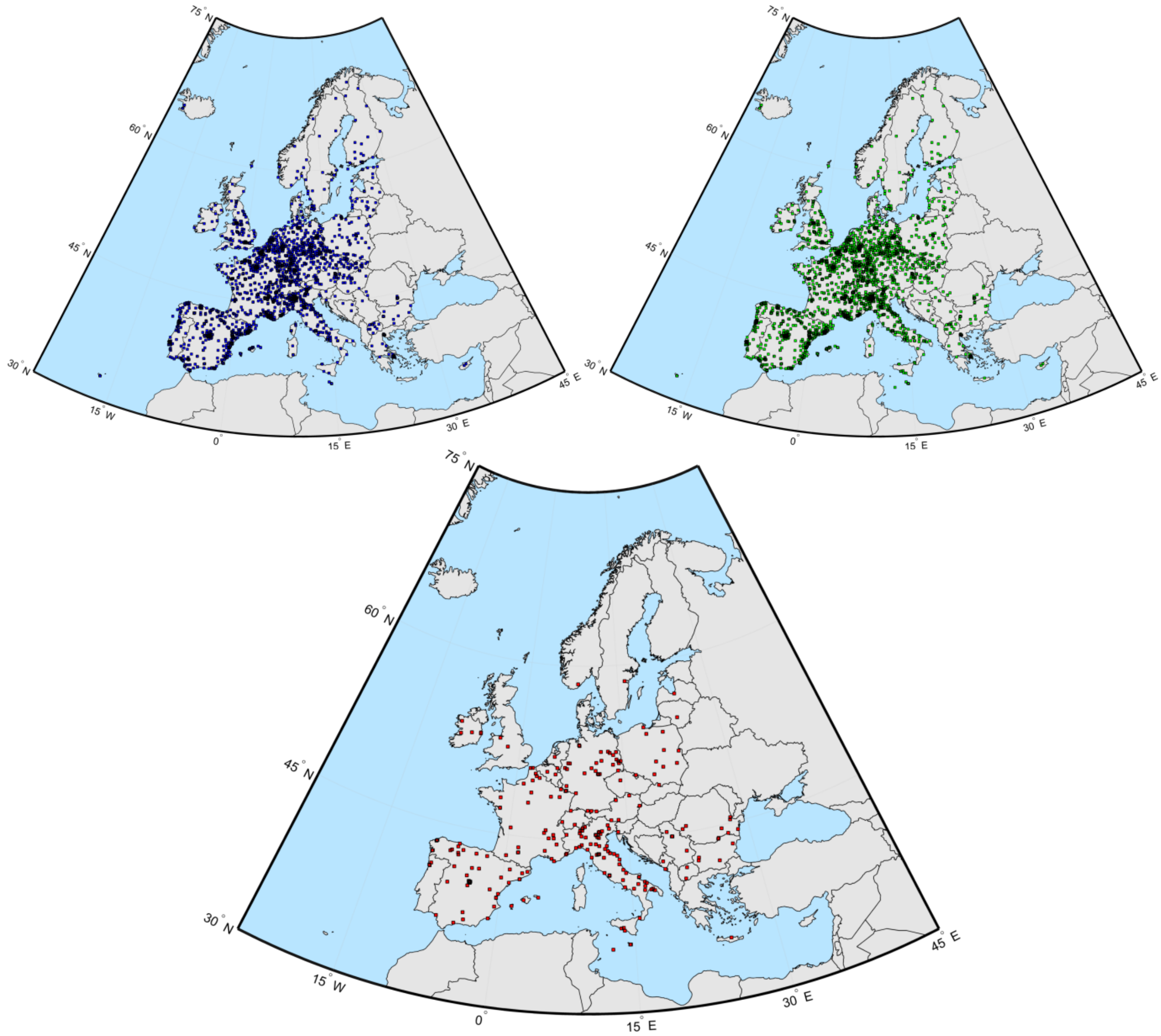


Figure 18. Top left: O_3 monitoring stations classified with AirBase v6 in 2012 study; top right: O_3 monitoring stations classified with AirBase v7 in this study; bottom: O_3 monitoring stations which were additionally classified with AirBase v7 but were missing in the v6 classification

List of stations showing the largest differences between AirBase v6 (2002-2010) and AirBase v7 (2002-2011) classification results

NO_2

- (differences from -1 to +2)

PM_{10}: stations with a difference of 3 or more

code	site	area	lat	lon	class_v6	class_v7	diff_v7_v6
DEST103	tra	urb	52.1209	11.6328	4	8	4
RS0008A	bac	urb	44.8169	20.4703	4	8	4
ES1953A	bac	urb	28.1075	-15.43	1	4	3
FR17016	bac	urb	46.6713	5.55681	3	6	3
FR31016	bac	urb	43.4797	-1.48806	3	6	3
GB0841A	ind	urb	53.5863	-0.636811	5	2	-3
BETN073	bac	rur	50.5033	4.98714	10	6	-4
BETN113	bac	rur	50.0276	5.59173	10	3	-7
BETN121	bac	rur	49.8777	5.20111	9	2	-7

O_3: stations with a difference of 3 or more

code	site	area	lat	lon	class_v6	class_v7	diff_v7_v6
GR0230A	bac	sub	39.62	20.85	6	10	4
BETN012	bac	rur	51.2551	3.36129	6	3	-3
BETR740	ind	rur	51.1507	3.80748	8	4	-4
DEBB065	bac	rur	52.1942	12.5614	6	2	-4

ANNEX III

Station classification according to Joly & Peuch (2012) methodology:

analysis of the results on the European scale

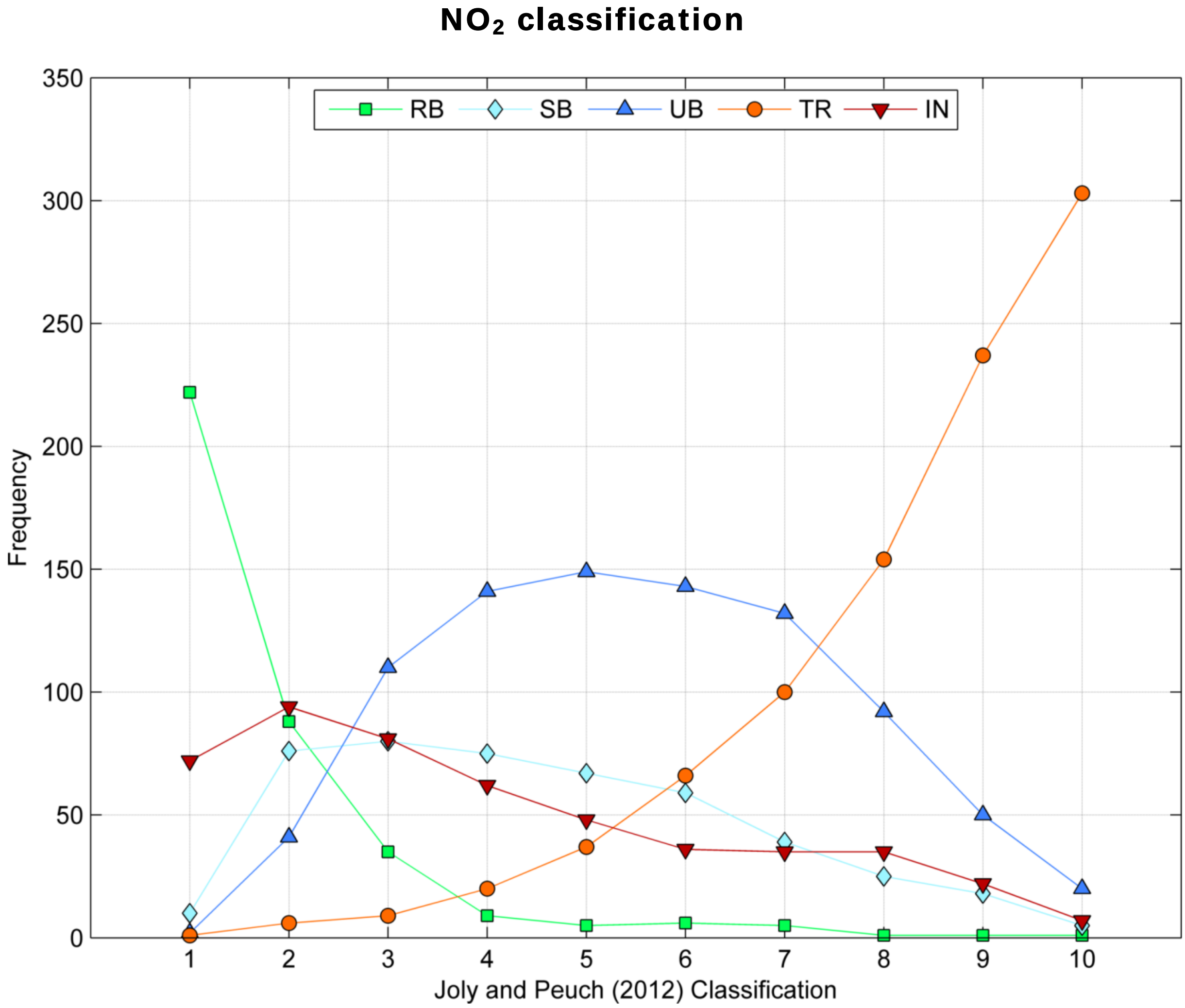


Figure 19. Distribution in frequency of the new NO_2 station classification, categorized by AirBase metadata. RB = Rural background, SB = Suburban background, UB = Urban background, TR = Traffic (all types of area), IN = Industrial (all types of area).

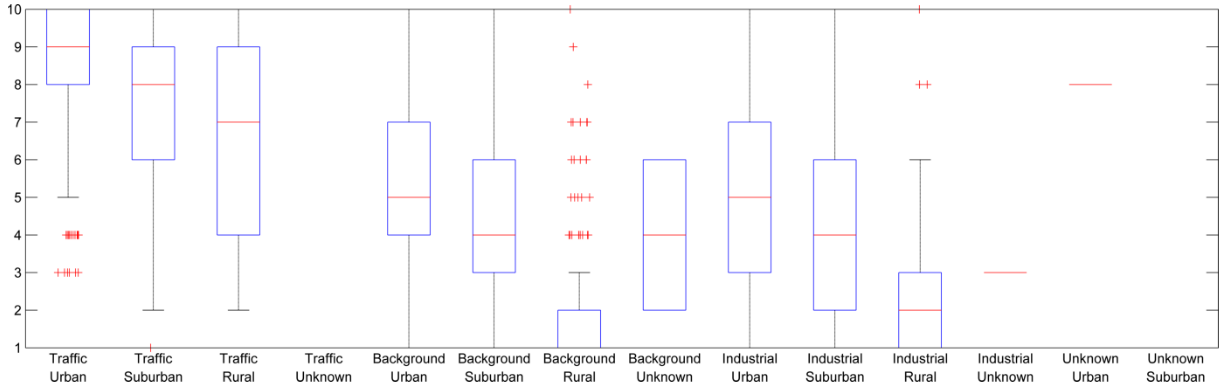


Figure 20. Box plot showing the median (red line), 25th and 75th percentiles (top and bottom of blue rectangle), the extreme values excluding outliers (black whiskers), as well as outliers (red crosses) of the new classification system for NO_2, categorized by AIRBASE station metadata

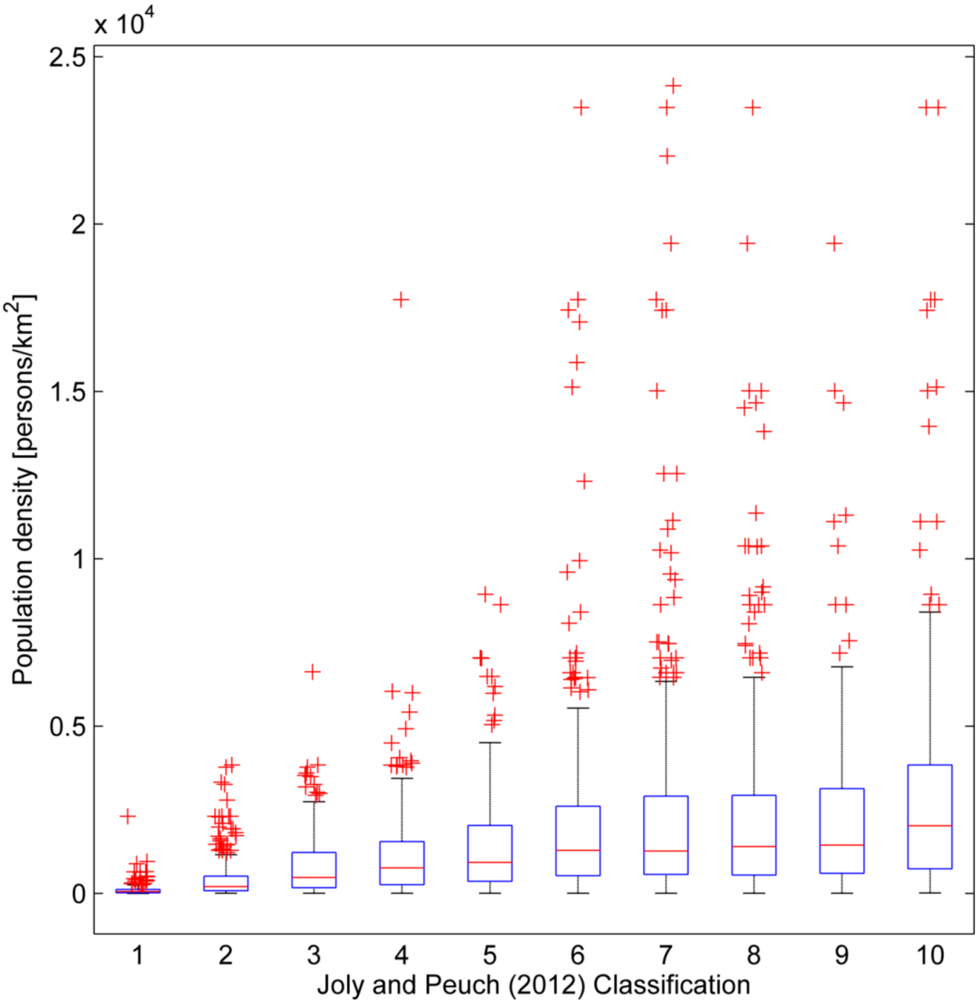


Figure 21. The relationship between the categories of the new NO_2 station classification and population density at the station. This boxplot shows the median (red line), 25th and 75th percentiles (upper and lower limits of the blue box), extreme values excluding outliers (black whiskers), and outliers (red crosses) of population density, categorized by Joly and Peuch (2012) classification

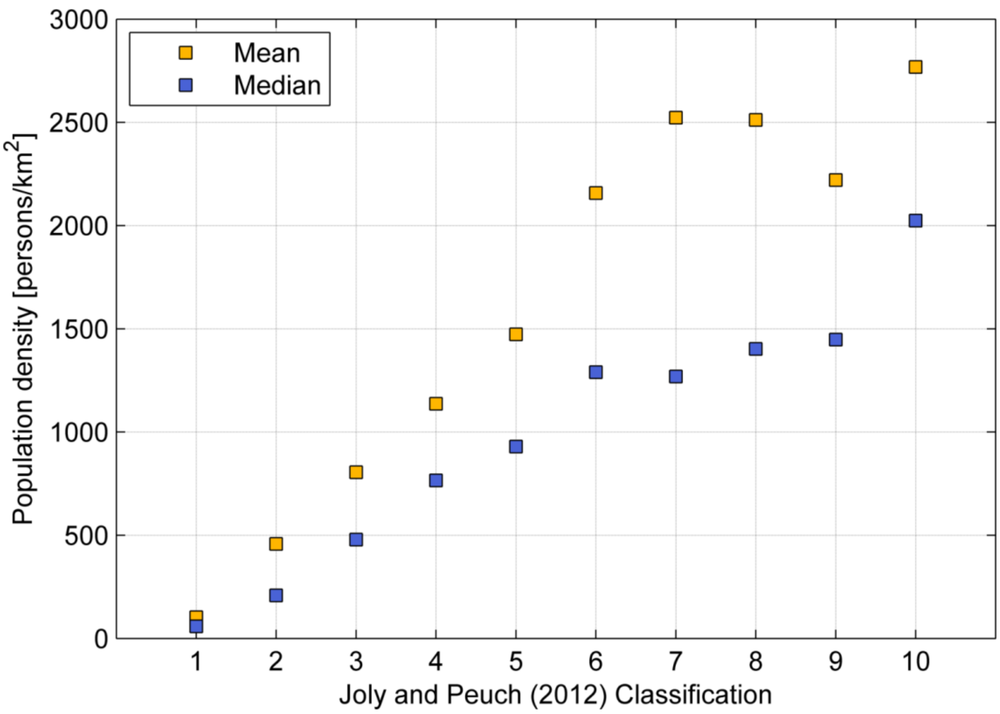


Figure 22. Similar to Figure 6 but only showing the median and mean of population density (outliers included) for each of the ten classes

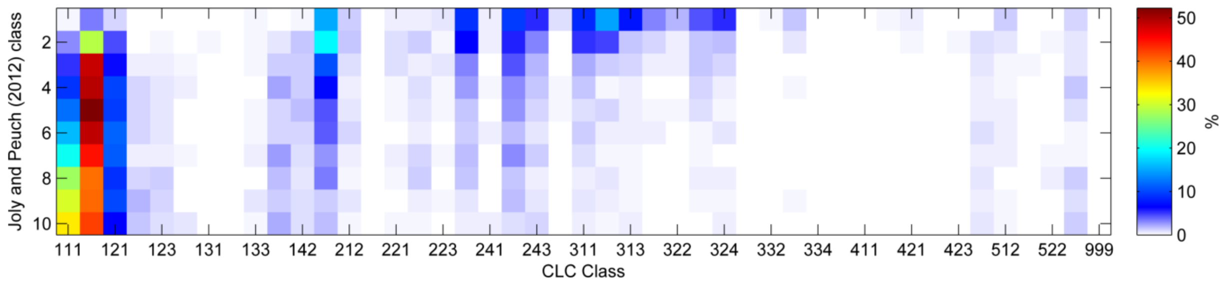
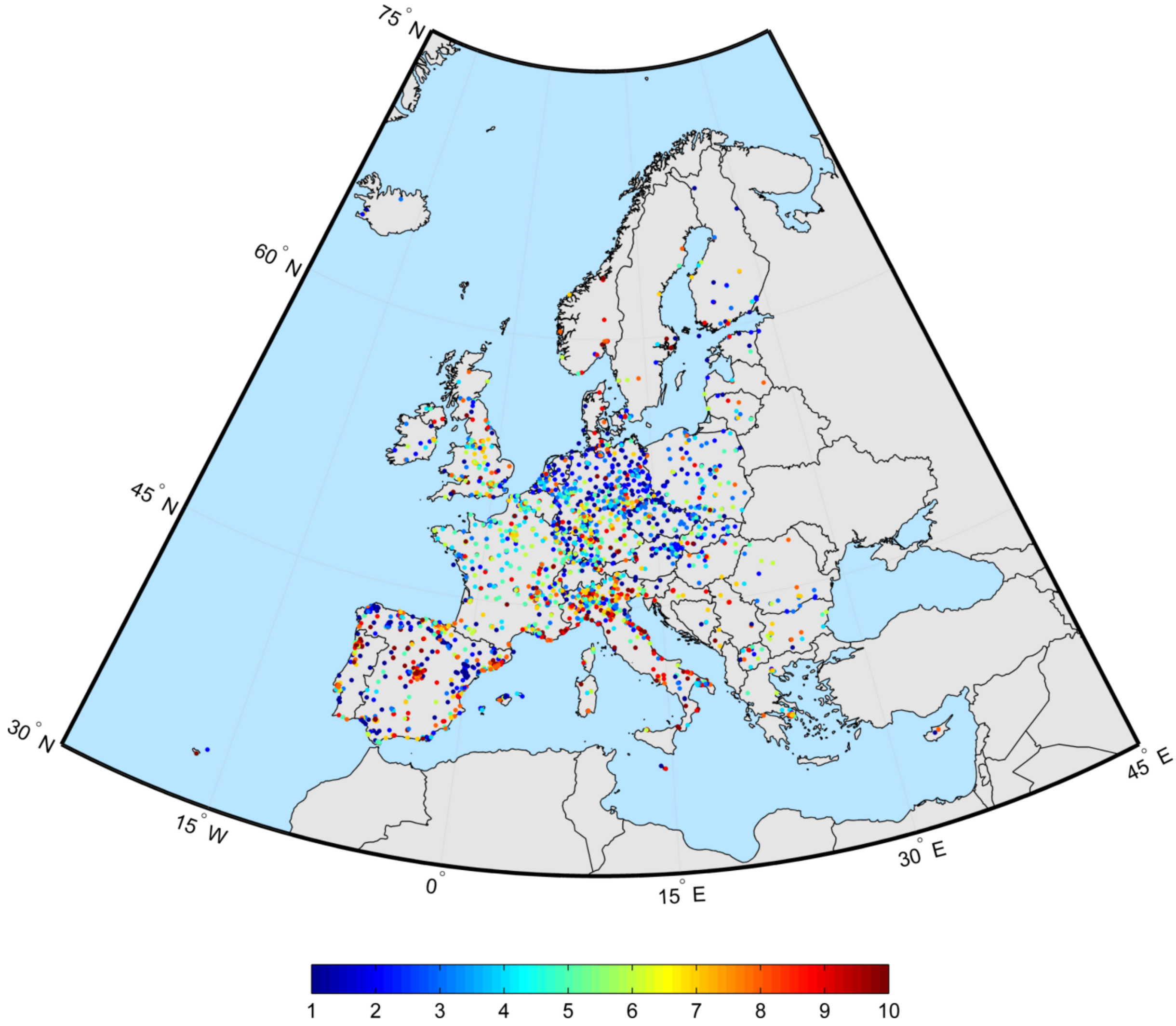


Figure 23. Average percentage of CORINE land cover classes for each of the 10 classes of the Joly and Peuch (2012) scheme that have been assigned to NO_2 monitoring stations. This was computed over all 3136 stations that were studied here. Note that only every second CLC class was labelled here for clarity.


75° N
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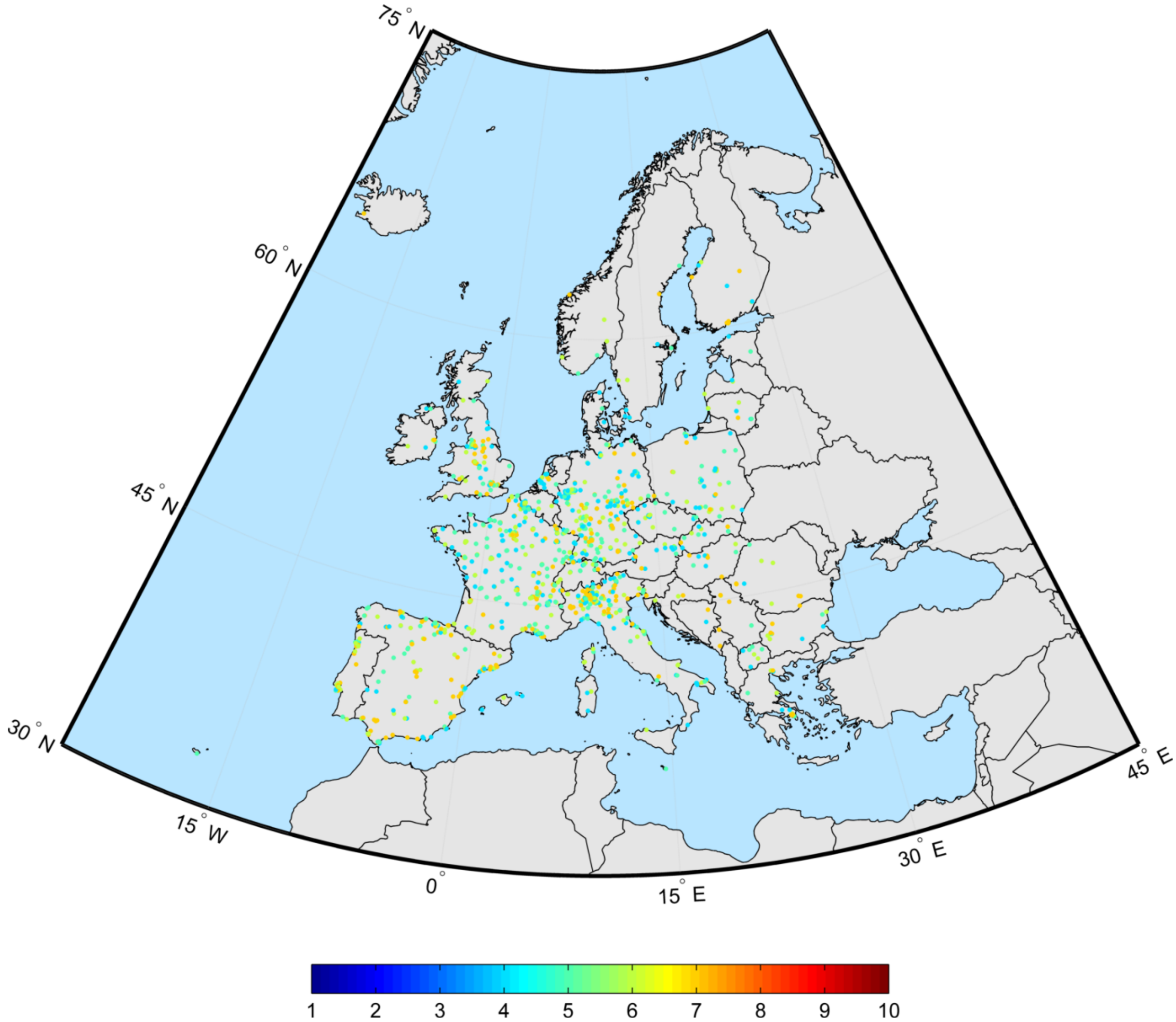
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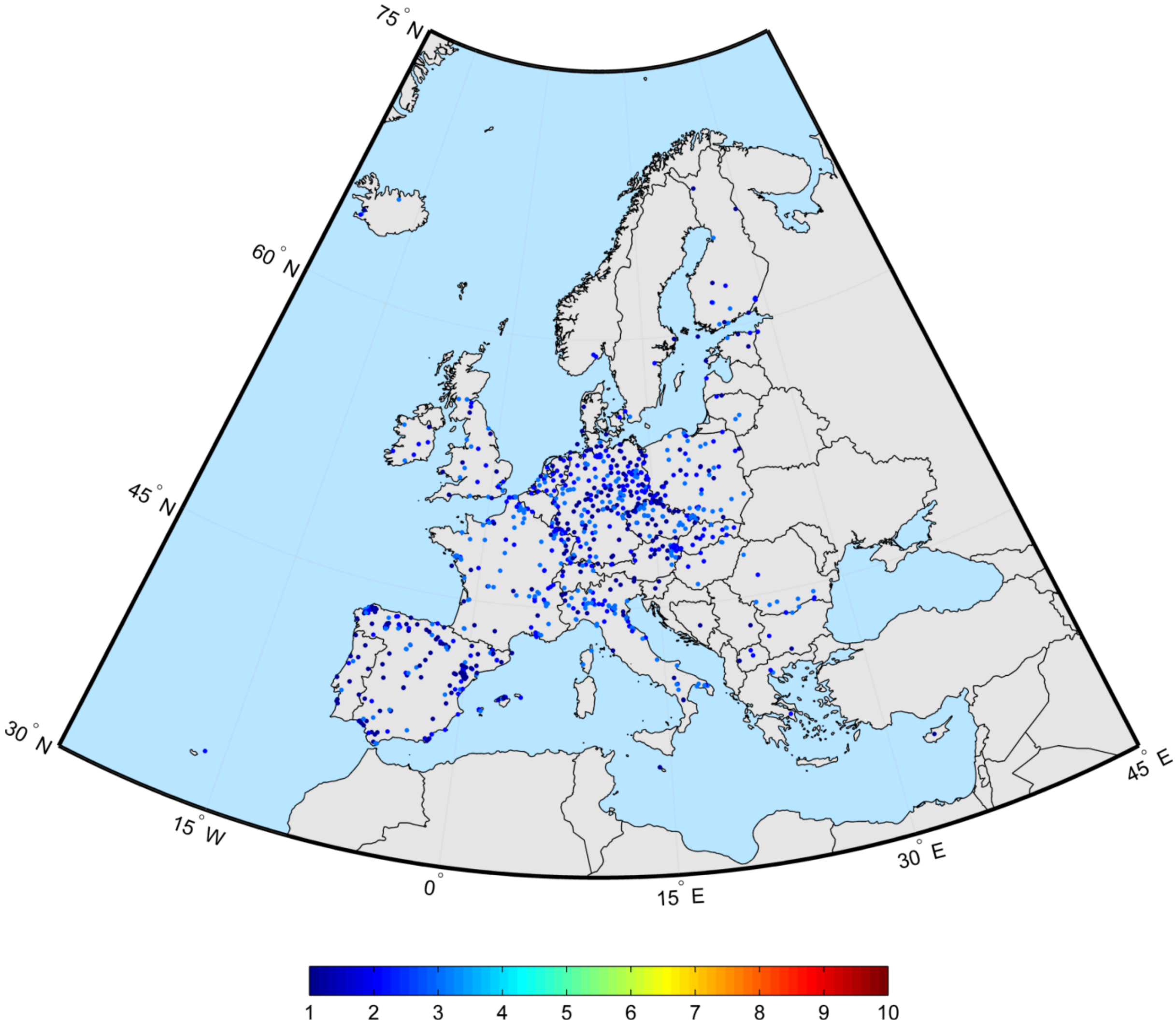

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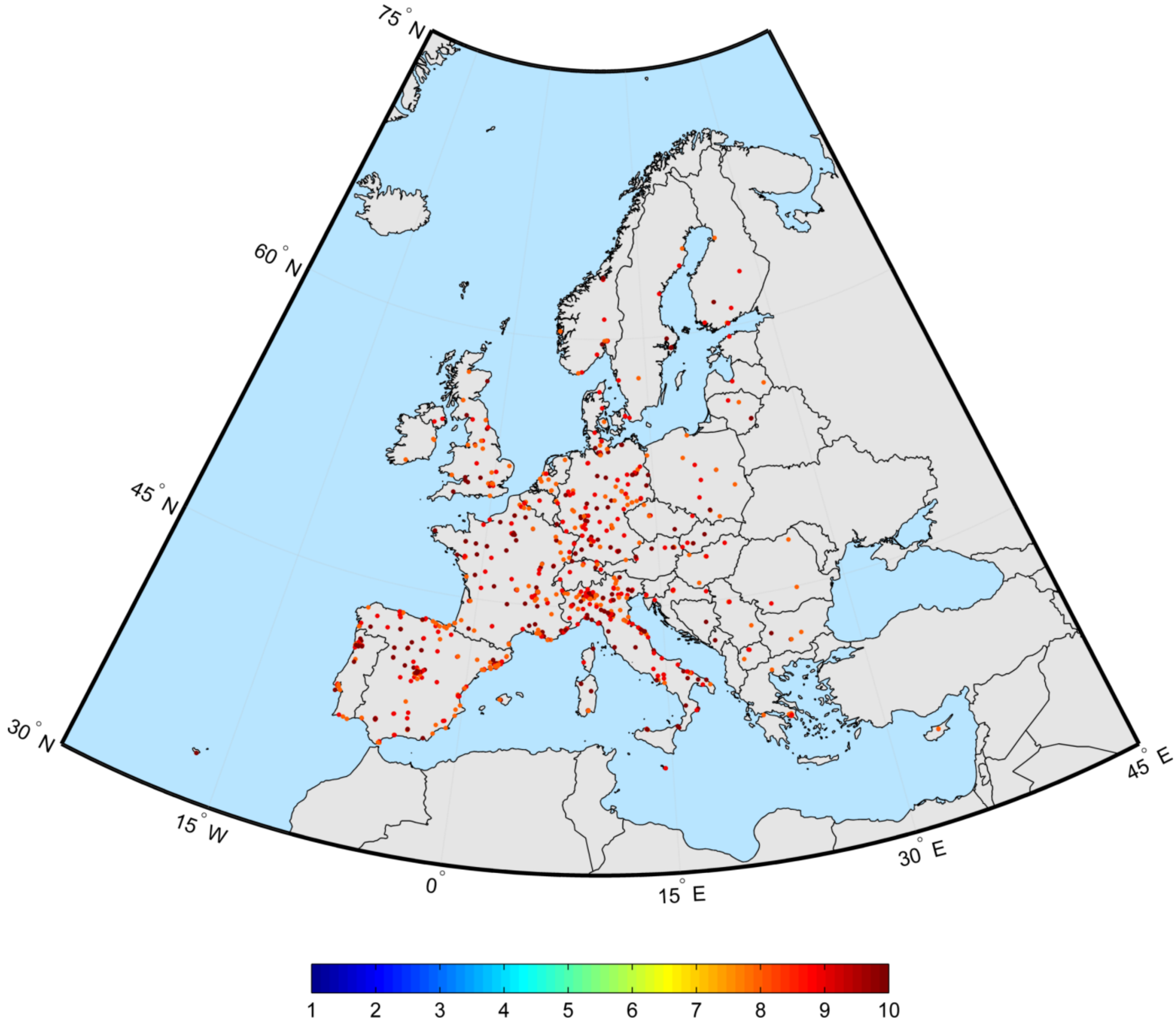


Figure 24. Overview map of NO_2 monitoring stations. From top to bottom: 3136 stations, all classes together; 1235 stations with medium classes (4, 5, 6, 7); 928 stations with low classes (1, 2, 3); 973 stations with high classes (8, 9, 10).

PM_{10} classification

(NB: Figure 25 to Figure 30 are the same as Figure 4 to Figure 9 in the main body text)

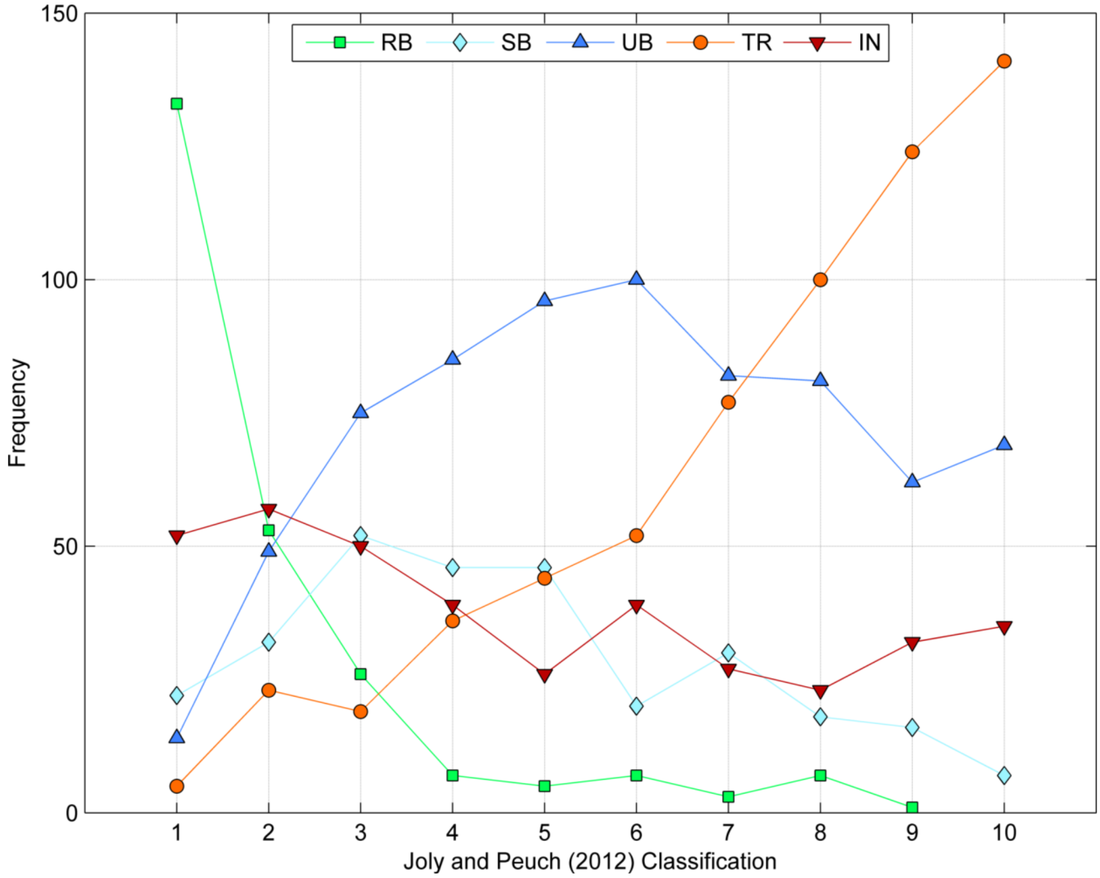


Figure 25. Distribution in frequency of the new PM_{10} station classification, categorized by AirBase metadata. RB = Rural background, SB = Suburban background, UB = Urban background, TR = Traffic (all types of area), IN = Industrial (all types of area).

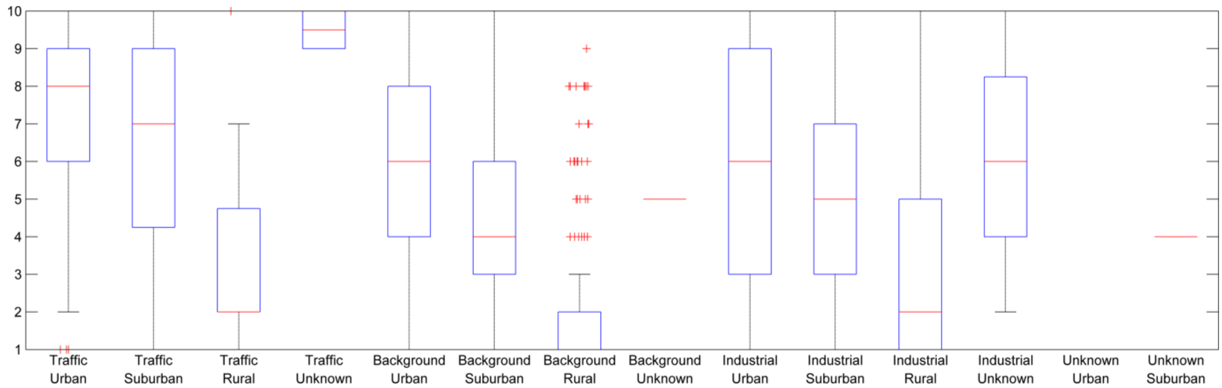


Figure 26: Box plot showing the median (red line), 25th and 75th percentiles (top and bottom of blue rectangle), the extreme values excluding outliers (black whiskers), as well as outliers (red crosses) of the new classification system for PM_{10}, categorized by AIRBASE station metadata

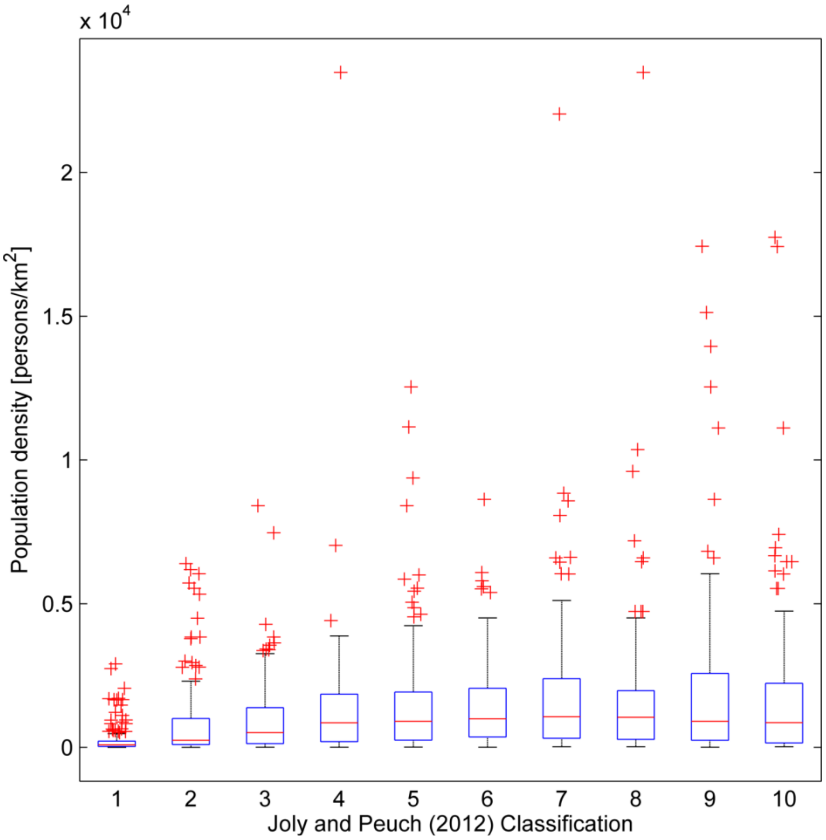


Figure 27. The relationship between the categories of the new PM_{10} station classification and population density at the station. This boxplot shows the median (red line), 25th and 75th percentiles (upper and lower limits of the blue box), extreme values excluding outliers (black whiskers), and outliers (red crosses) of population density, categorized by Joly and Peuch (2012) classification

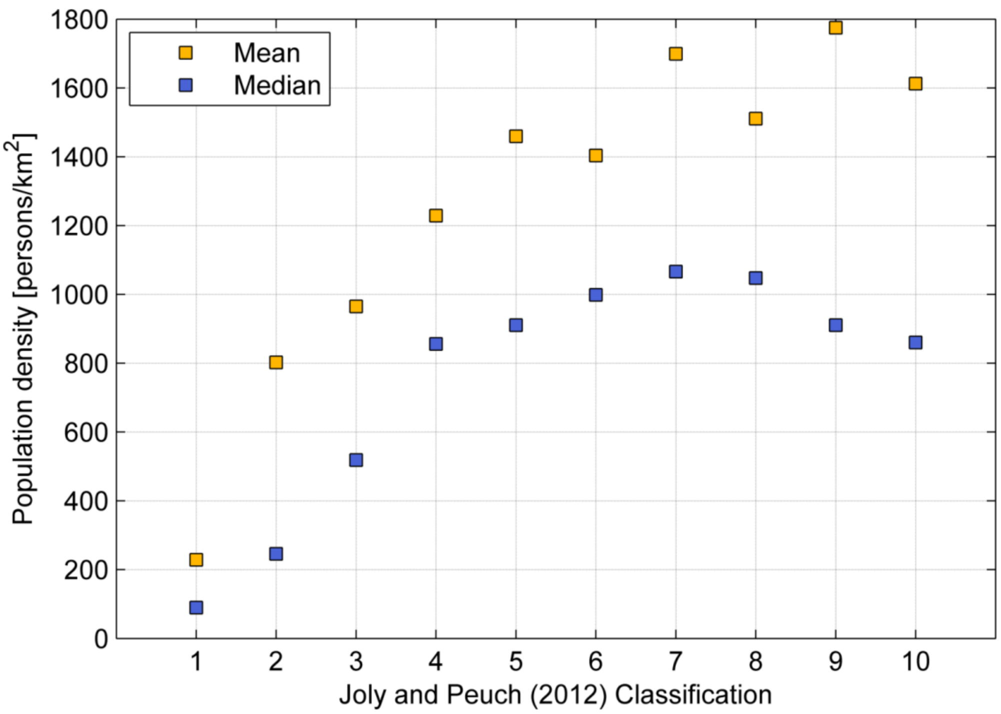


Figure 28. Similar to Figure 27 but only showing the median and mean of population density (outliers included) for each of the ten classes

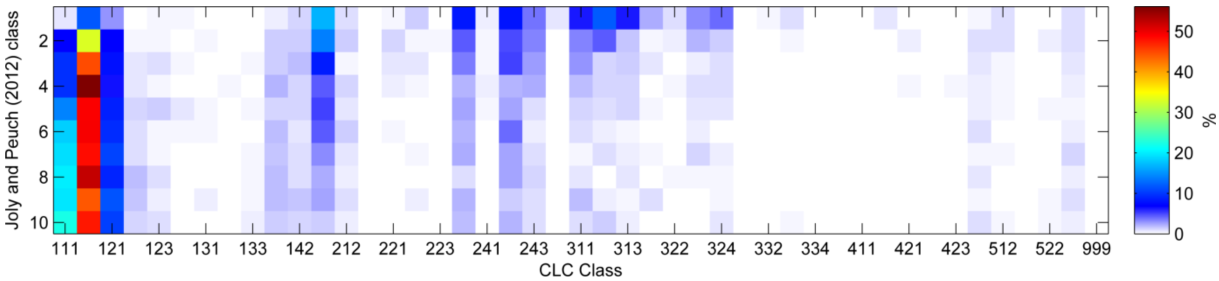
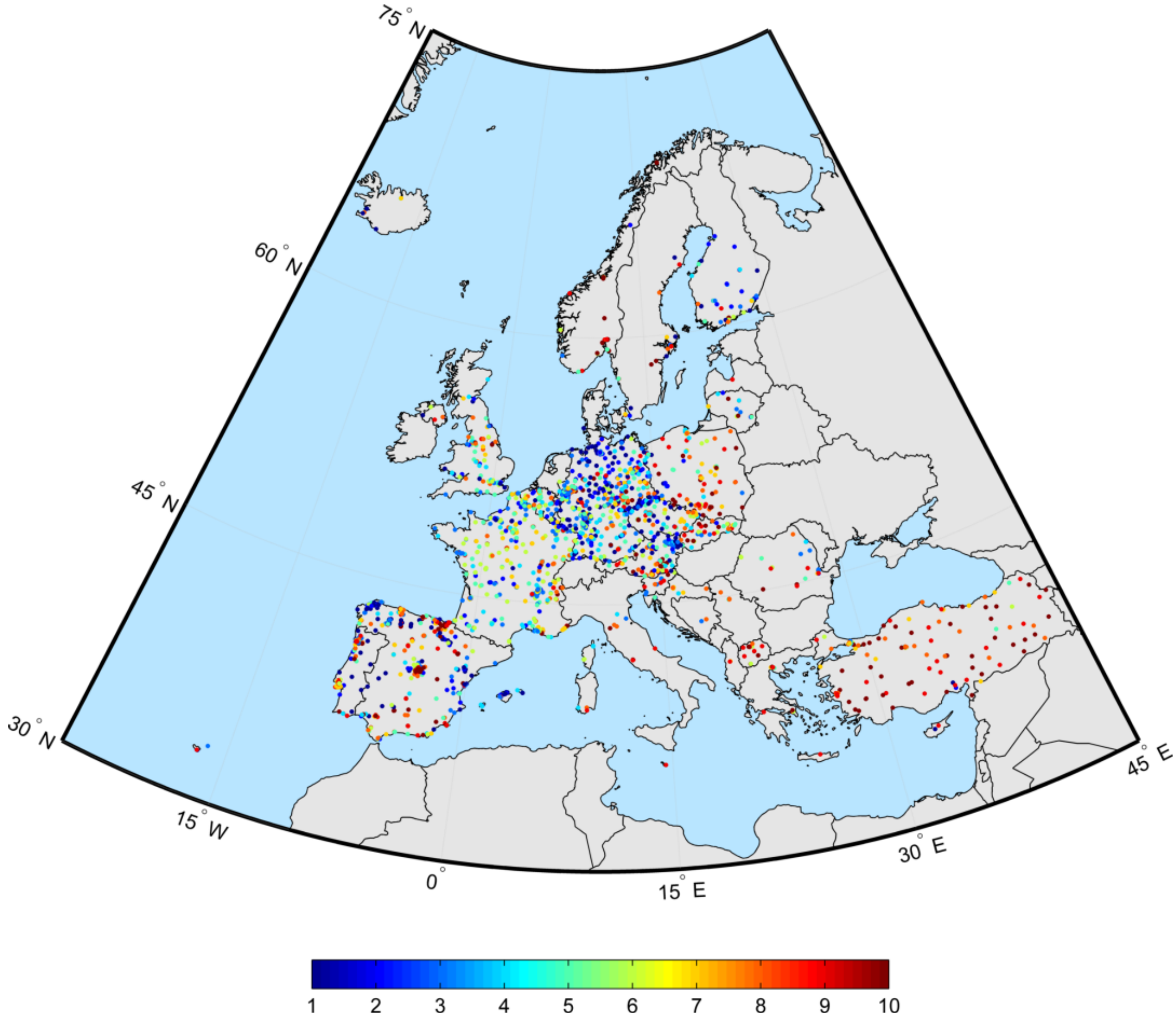


Figure 29. Average percentage of CORINE land cover classes for each of the 10 classes of the Joly and Peuch (2012) scheme that have been assigned to PM_{10} monitoring stations. This was computed over all 2248 stations that were studied here. Note that only every second CLC class was labelled here for clarity.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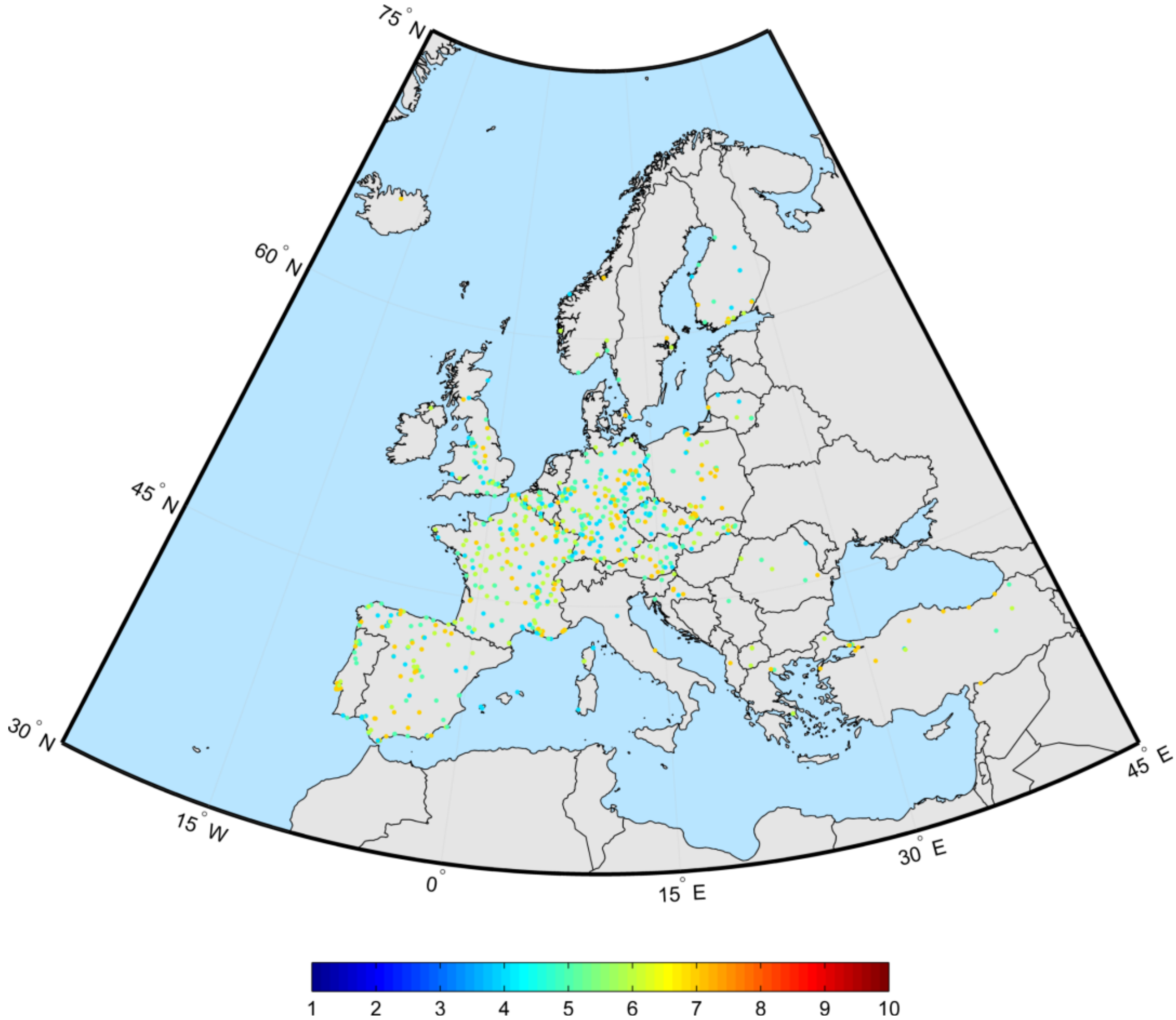

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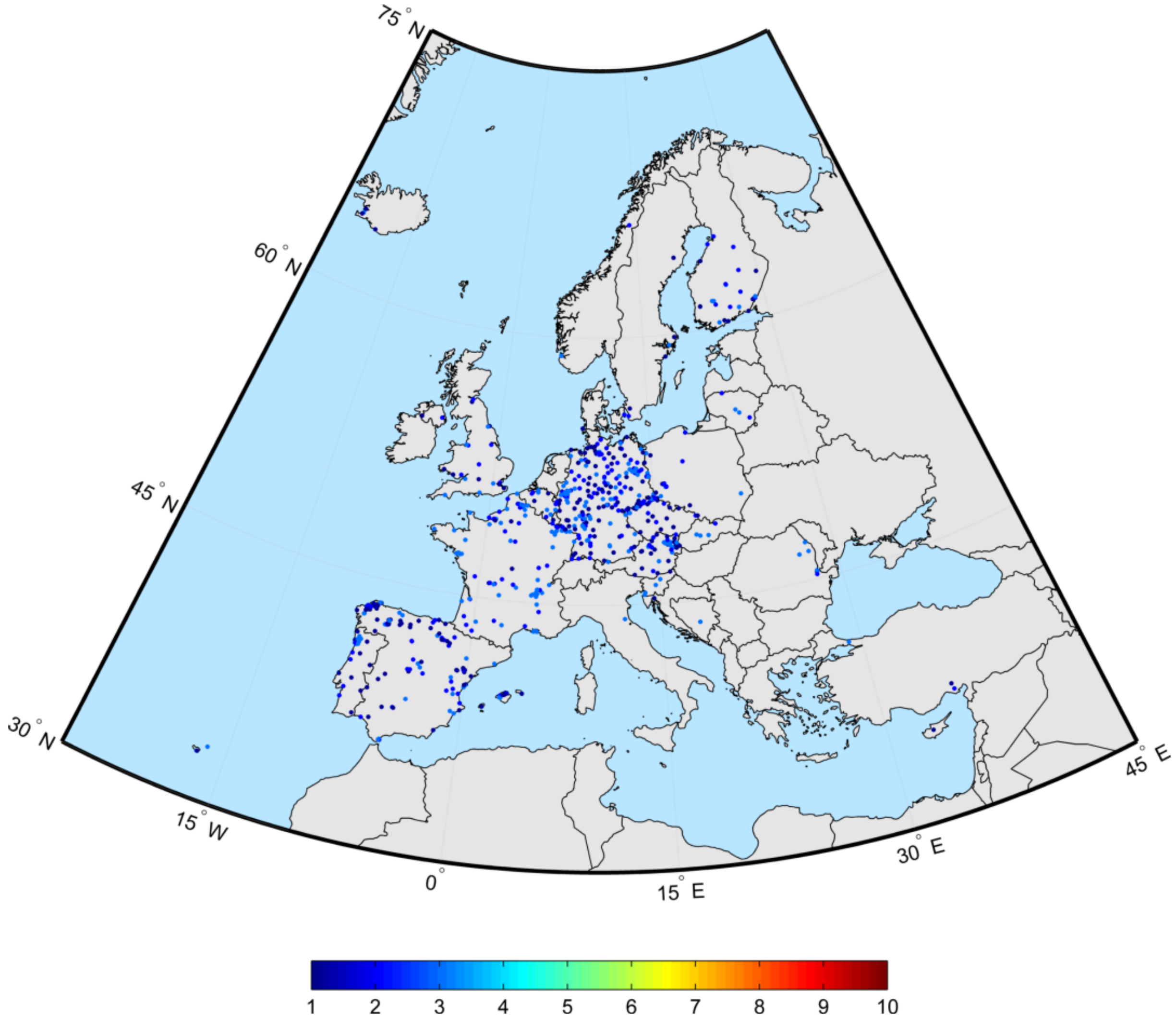

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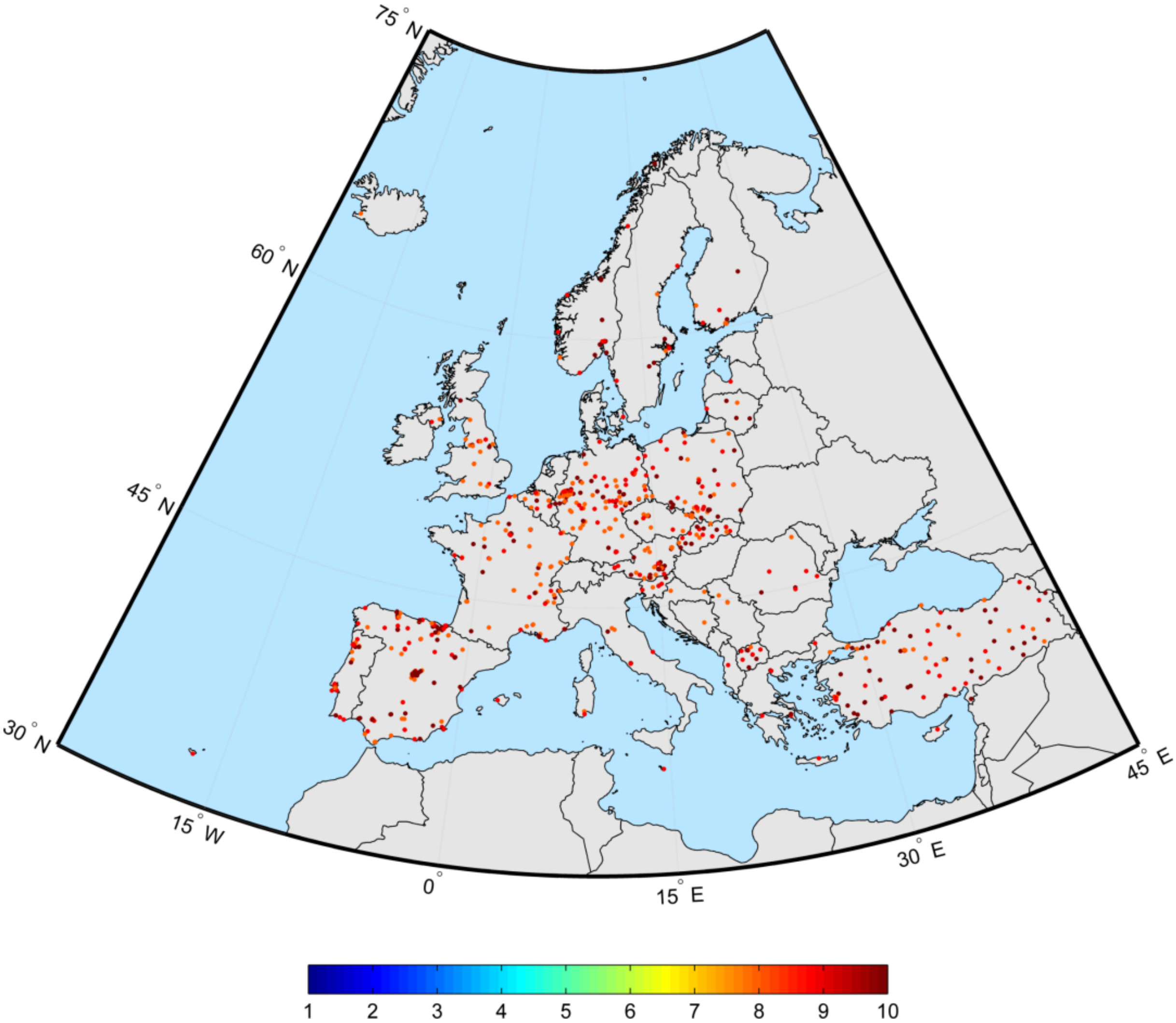


Figure 30. Overview map of PM_{10} monitoring stations. From top to bottom: 2248 stations, all classes together; 869 stations with medium classes (4, 5, 6, 7); 662 stations with low classes (1, 2, 3); 717 stations with high classes (8, 9, 10).

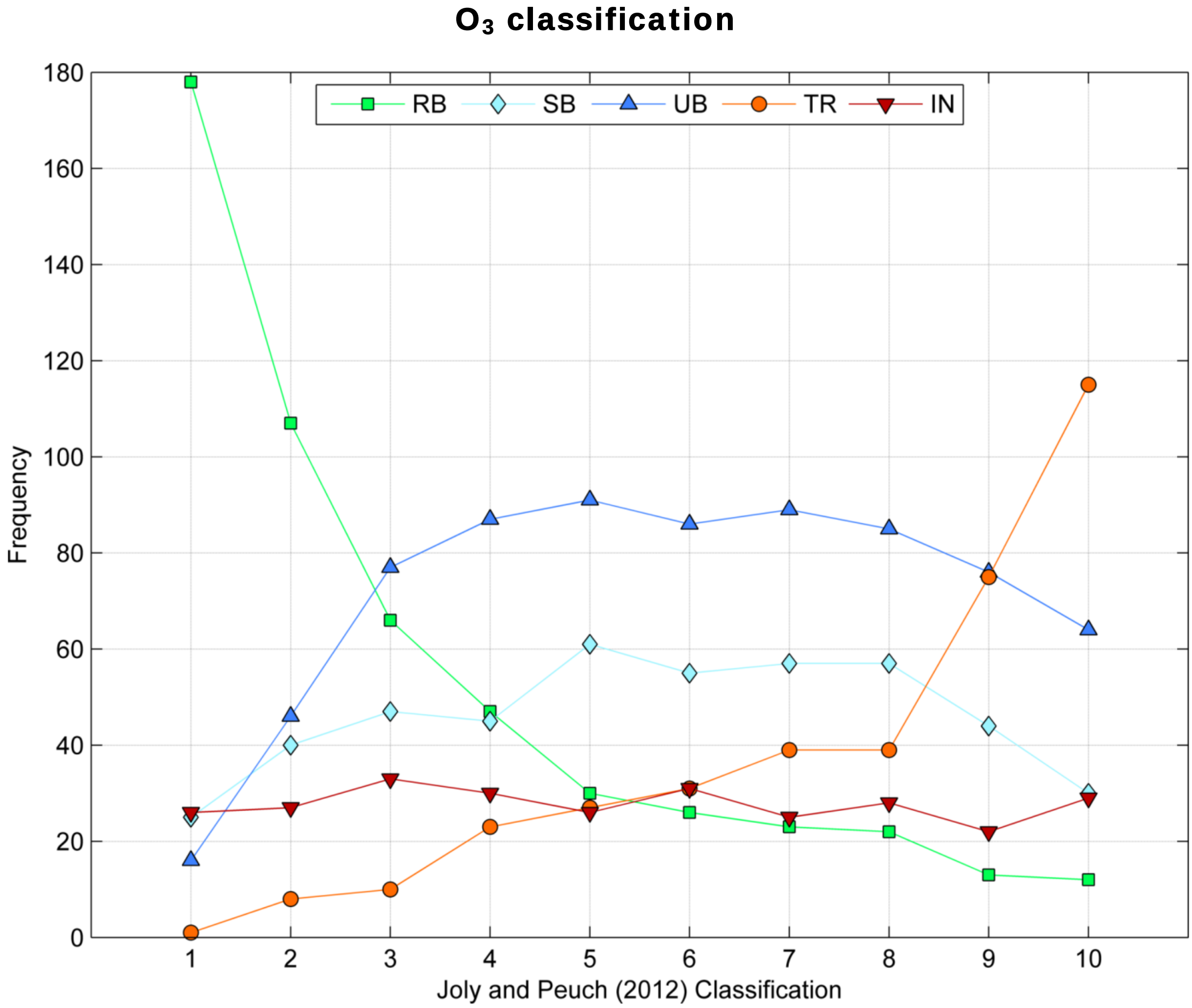


Figure 31. Distribution in frequency of the new O_3 station classification, categorized by AirBase metadata. RB = Rural background, SB = Suburban background, UB = Urban background, TR = Traffic (all types of area), IN = Industrial (all types of area).

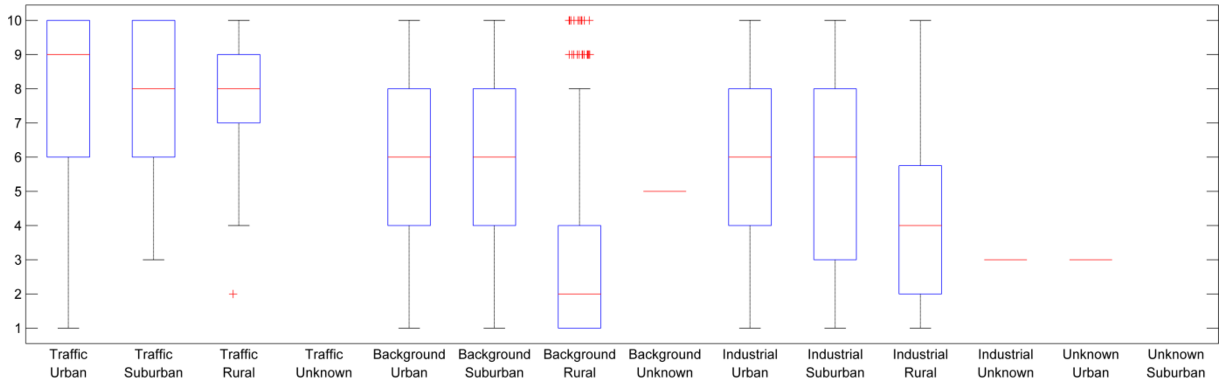


Figure 32. Box plot showing the median (red line), 25th and 75th percentiles (top and bottom of blue rectangle), the extreme values excluding outliers (black whiskers), as well as outliers (red crosses) of the new classification system for O_3, categorized by AIRBASE station metadata

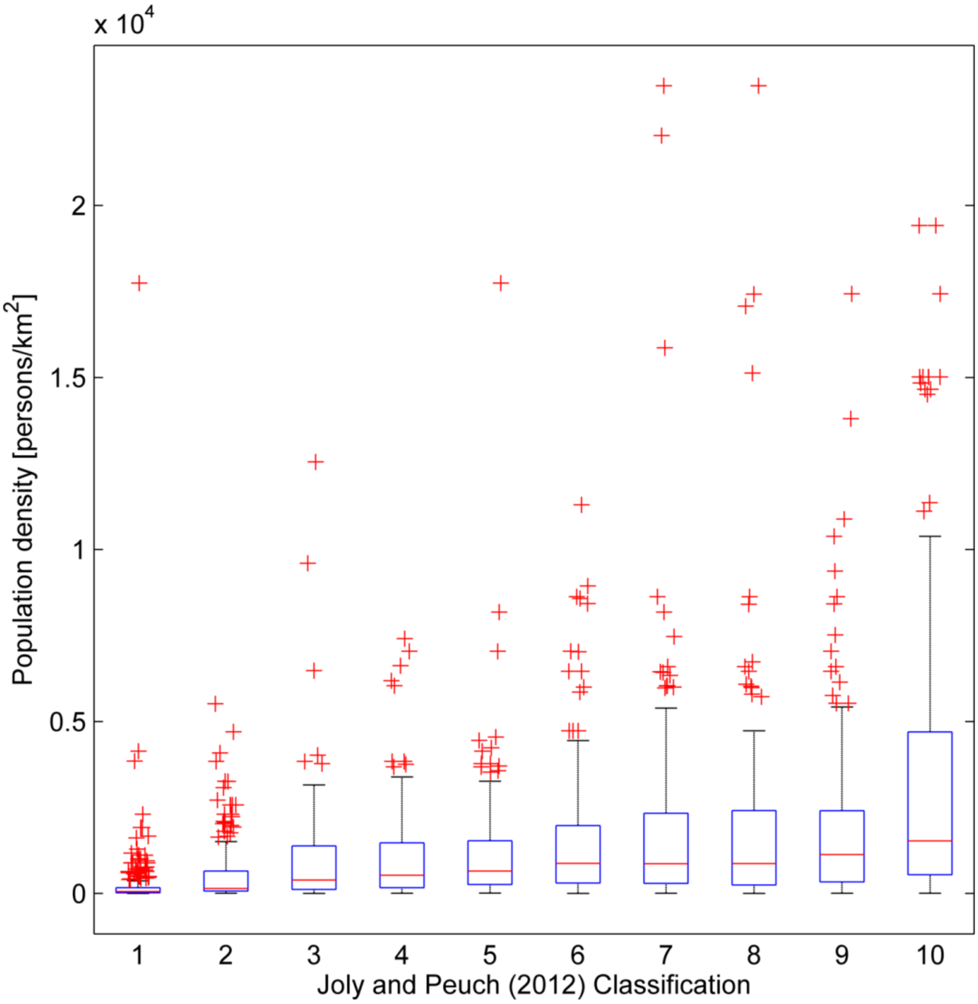


Figure 33. The relationship between the categories of the new O_3 station classification and population density at the station. This boxplot shows the median (red line), 25th and 75th percentiles (upper and lower limits of the blue box), extreme values excluding outliers (black whiskers), and outliers (red crosses) of population density, categorized by Joly and Peuch (2012) classification

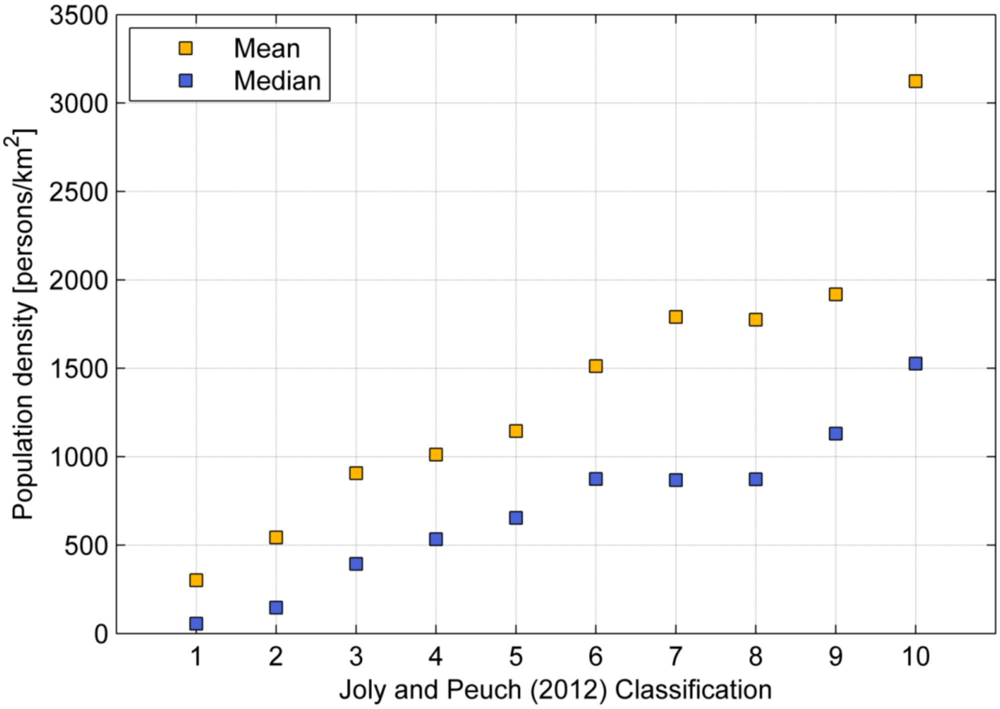


Figure 34. Similar to figure 33 but only showing the median and mean of population density (outliers included) for each of the ten classes

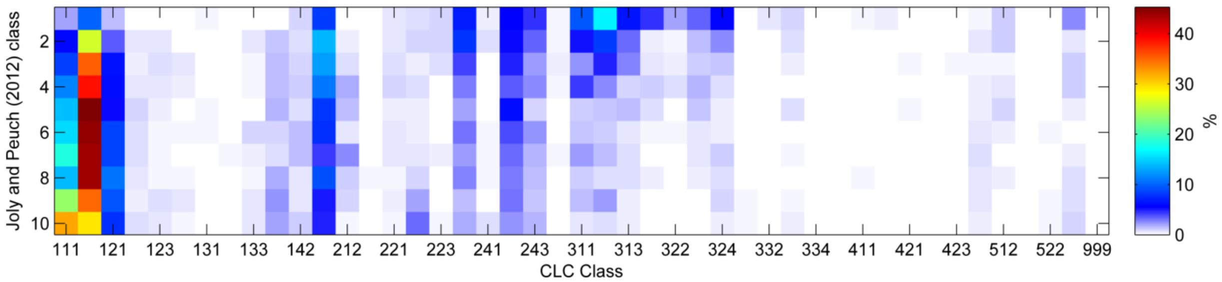
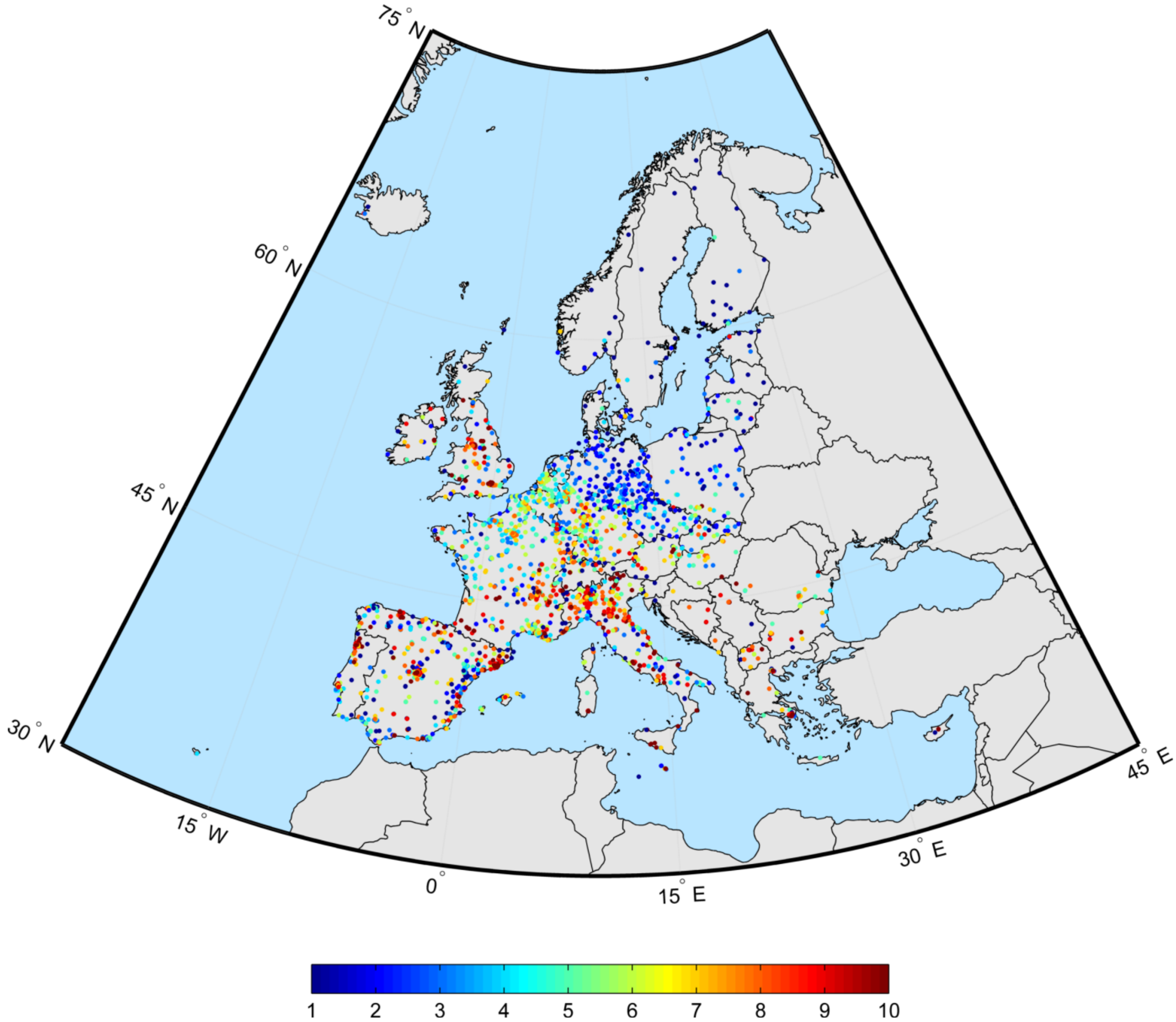


Figure 35. Average percentage of CORINE land cover classes for each of the 10 classes of the Joly and Peuch (2012) scheme that have been assigned to O_3 monitoring stations. This was computed over all 2349 stations that were studied here. Note that only every second CLC class was labelled here for clarity.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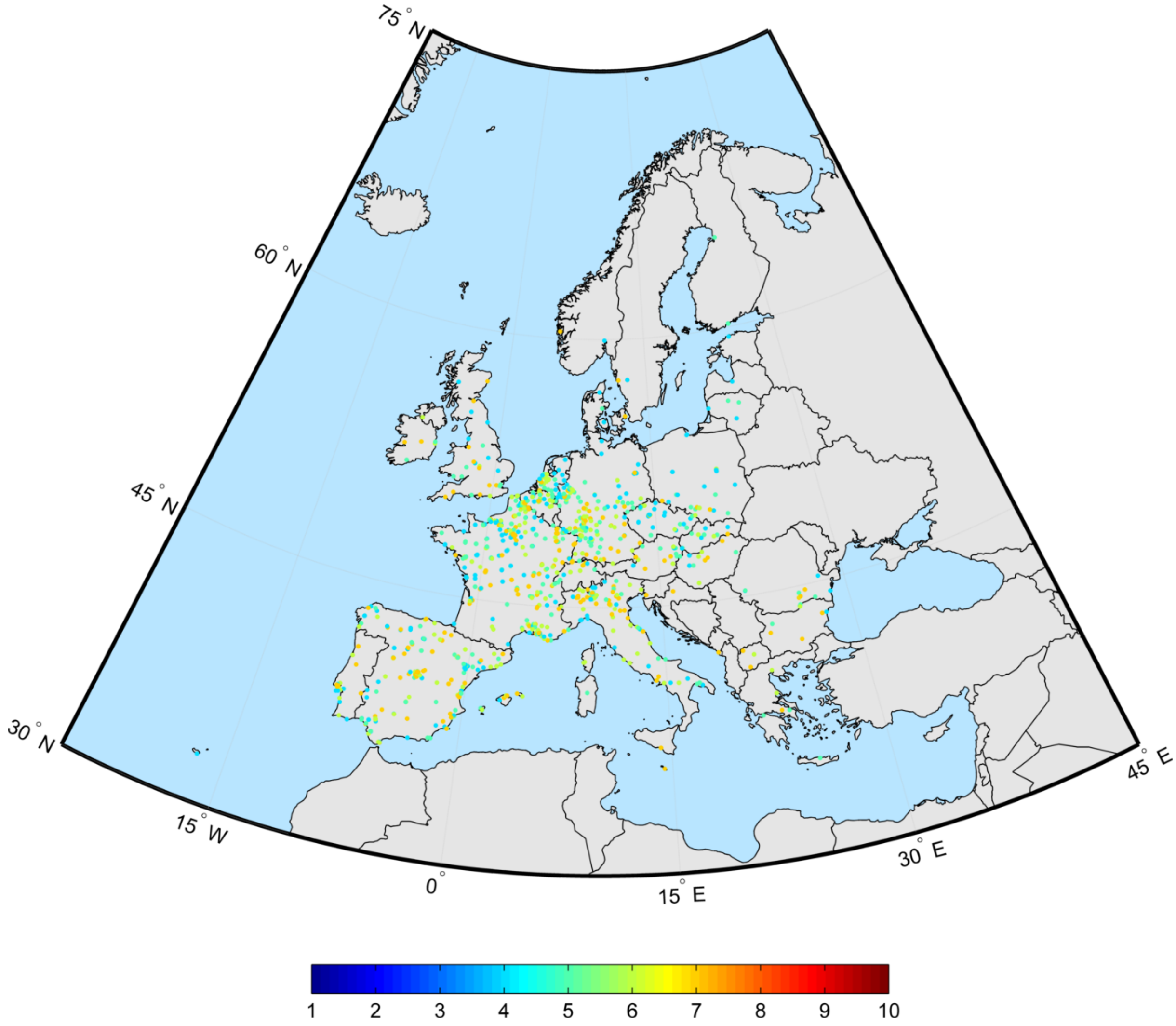
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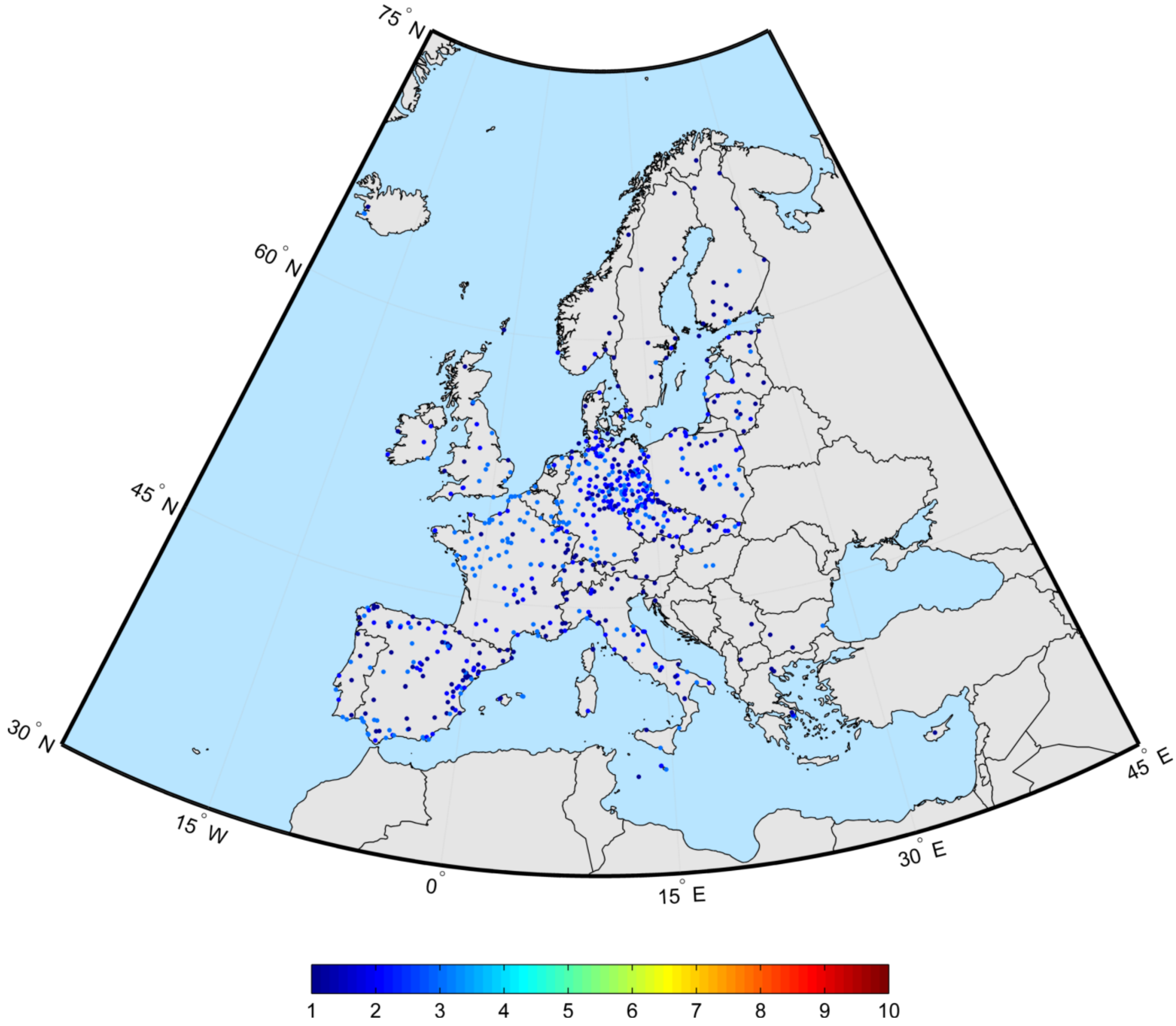

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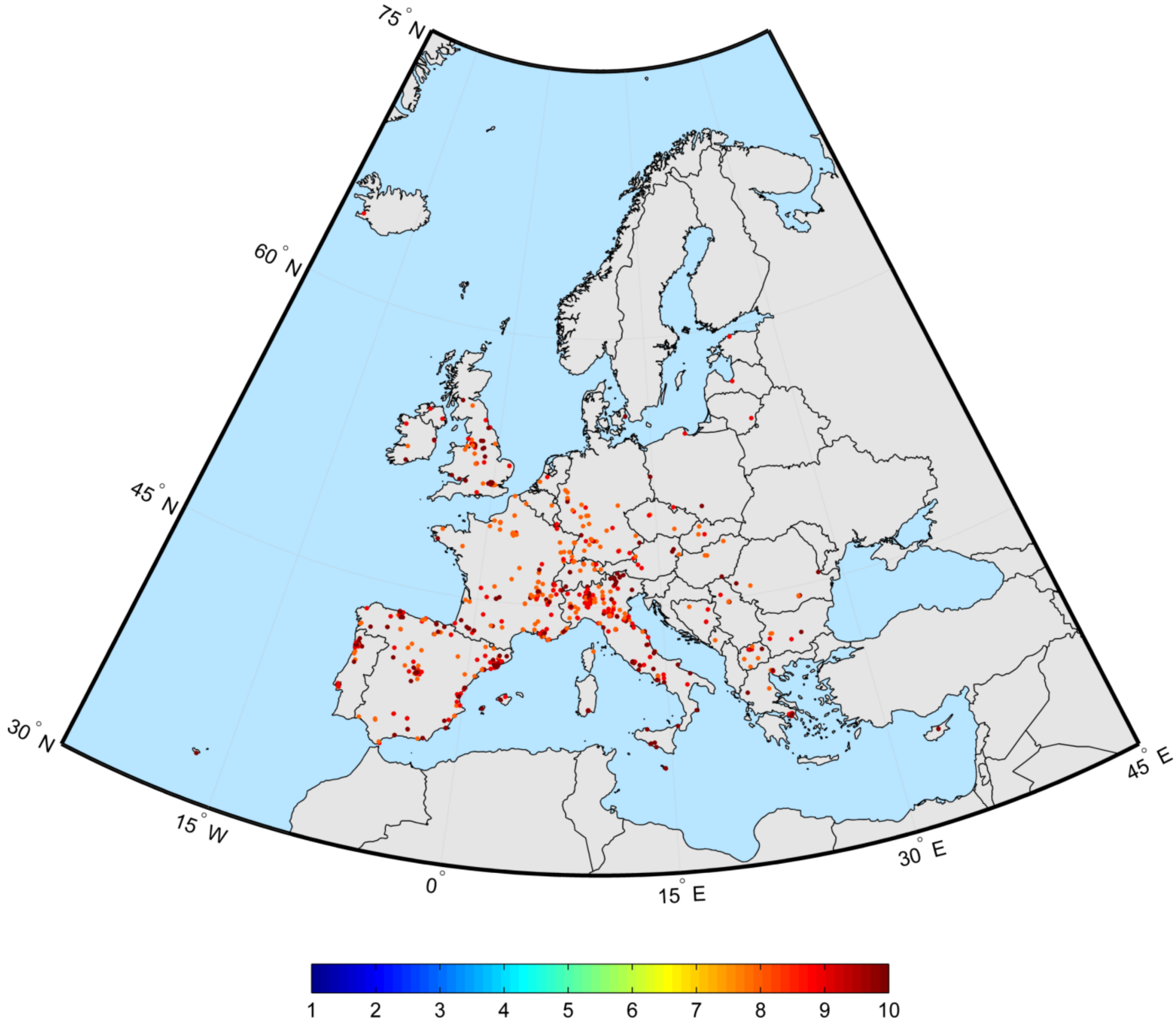

Figure 36. Overview map of O_3 monitoring stations. From top to bottom: 2349 stations, all classes together; 930 stations with medium classes (4, 5, 6, 7); 708 stations with low classes (1, 2, 3); 711 stations with high classes (8, 9, 10).

ANNEX IV

Station classification according to Joly & Peuch (2012) methodology:

specific situations (outliers)

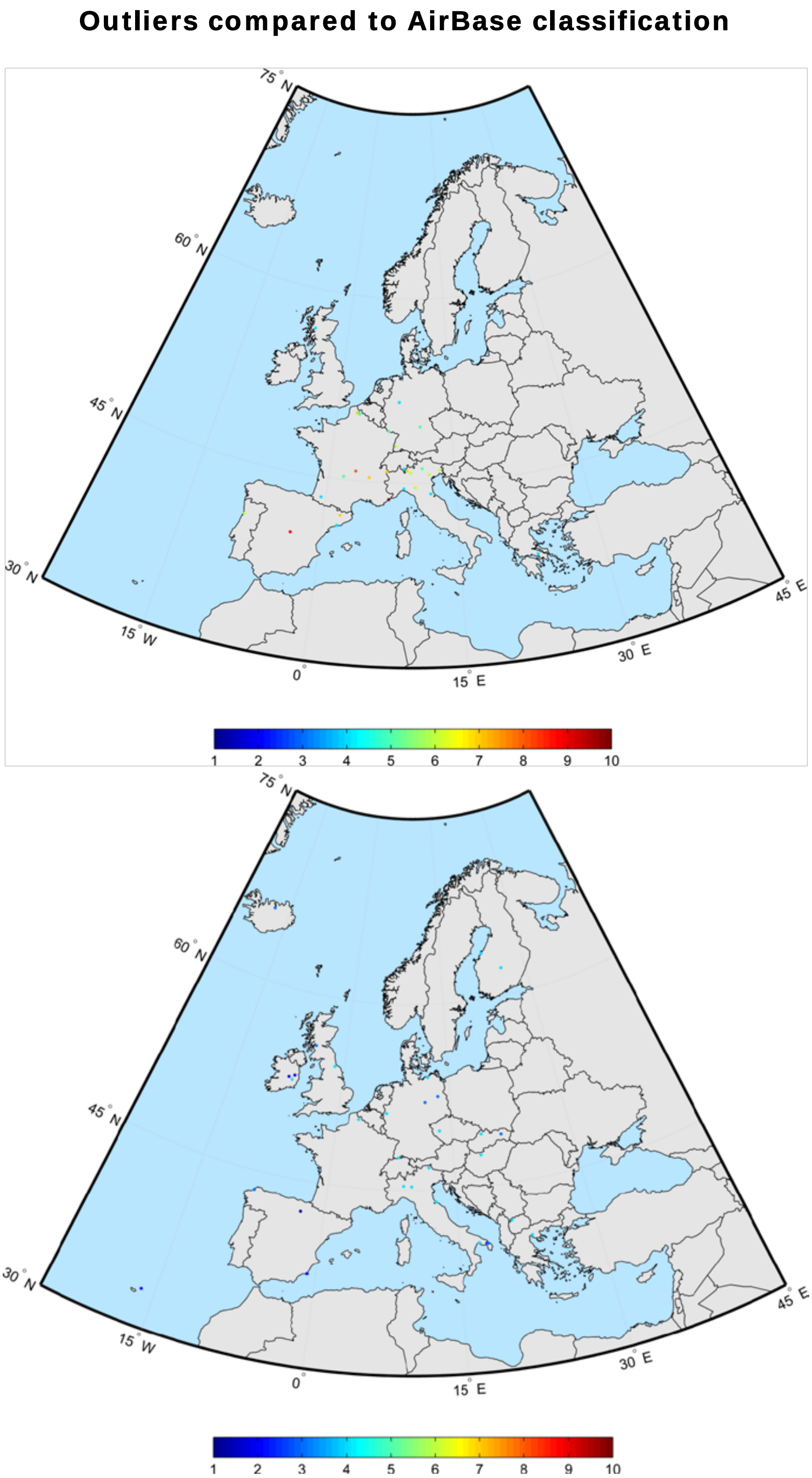

Figure 37. Top: Outliers in the new NO_2 classification of rural background stations. These are stations that are classified as rural background within the Airbase database but were assigned classes of 4 or higher by the Joly and Peuch (2012) algorithm. Bottom: Outliers in the new NO_2 classification of (sub)urban traffic stations. These are stations that are classified as suburban or urban traffic within the AirBase database but were assigned classes of 4 or lower by the Joly and Peuch (2012) algorithm.

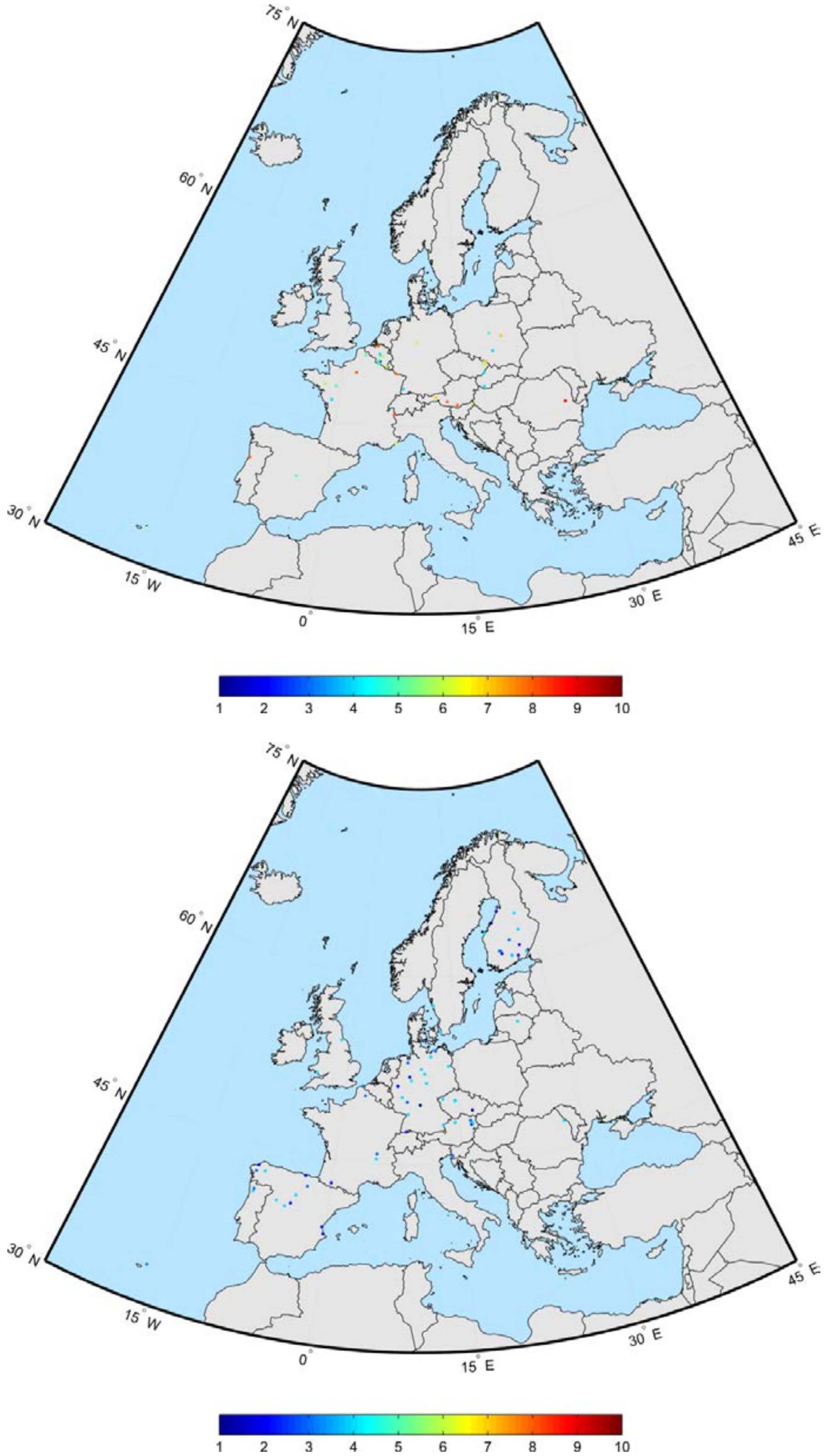

Figure 38. Top: Outliers in the new PM_{10} classification of rural background stations. These are stations that are classified as rural background within the Airbase database but were assigned classes of 4 or higher by the Joly and Peuch (2012) algorithm. Bottom: Outliers in the new PM_{10} classification of (sub)urban traffic stations. These are stations that are classified as suburban or urban traffic within the AirBase database but were assigned classes of 4 or lower by the Joly and Peuch (2012) algorithm.

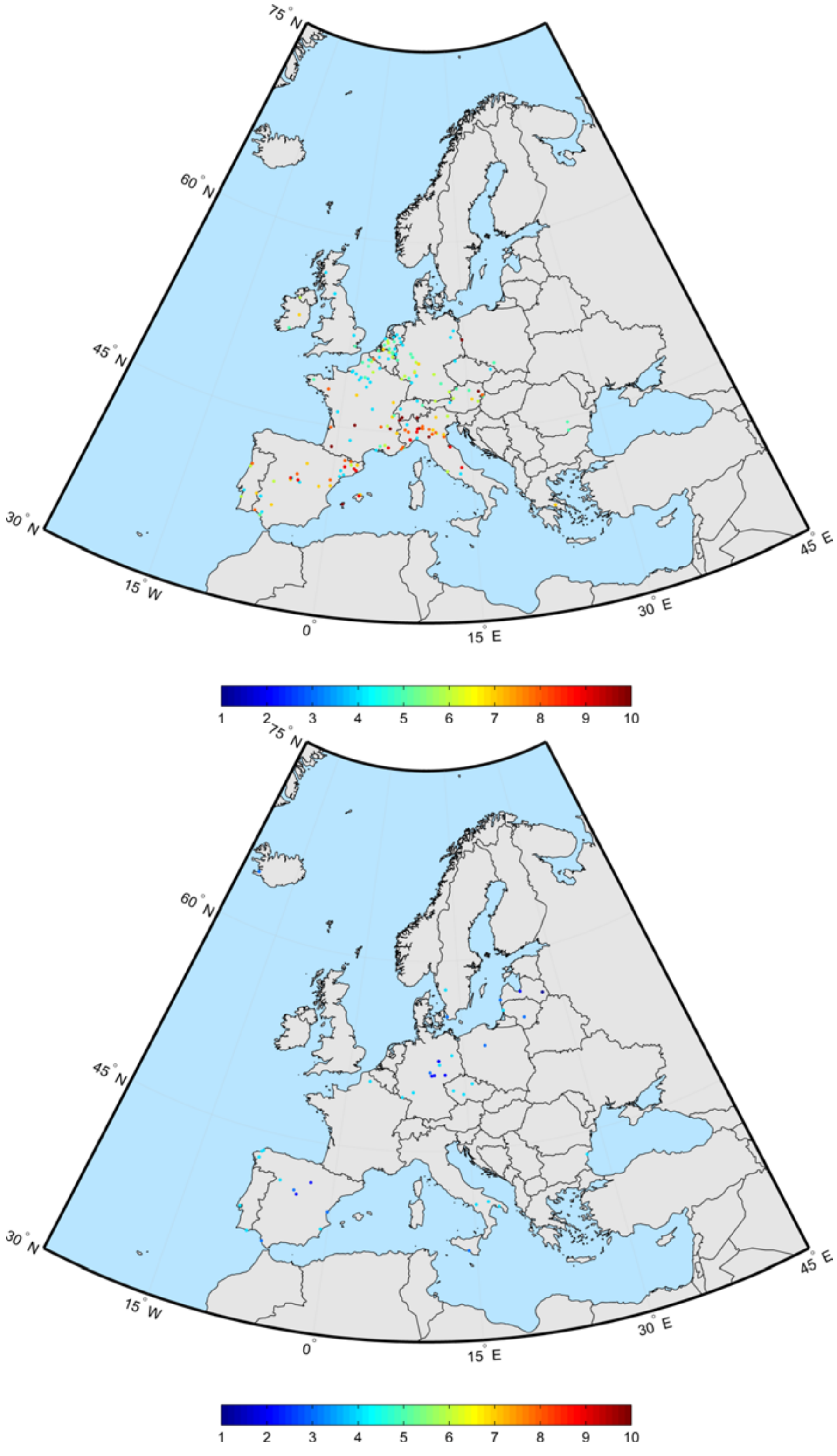

Figure 39. Top: Outliers in the new O_3 classification of rural background stations. These are stations that are classified as rural background within the Airbase database but were assigned classes of 4 or higher by the Joly and Peuch (2012) algorithm. Bottom: Outliers in the new O_3 classification of (sub)urban traffic stations. These are stations that are classified as suburban or urban traffic within the AirBase database but were assigned classes of 4 or lower by the Joly and Peuch (2012) algorithm.

Stations displaying different classes according to the pollutant

Table 15. Stations with a difference of 5 or more between NO_2 and PM_{10} classes.

code	station type	area type	NO_2_class	PM_{10}_class	O_3_class	Diff. NO_2-PM_{10}	Diff. NO_2-O_3
ES1687A	ind	sub	9	1	-	8	
ES1995A	ind	sub	10	3	10	7	0
FR20003	tra	urb	10	3	10	7	0
FR26018	tra	rur	9	2	10	7	-1
PT01046	tra	urb	10	3	-	7	
ES1182A	tra	urb	8	2	9	6	-1
ES1296A	tra	urb	10	4	8	6	2
ES1742A	tra	urb	8	2	5	6	3
ES1756A	ind	urb	8	2	-	6	
IT0873A	tra	urb	9	3	7	6	2
PT01043	tra	urb	10	4	-	6	
PT01050	bac	urb	8	2	10	6	-2
DEBB060	tra	urb	9	4	-	5	
DEBW001	tra	urb	9	4	-	5	
DEBW026	bac	sub	9	4	10	5	-1
DEHH070	tra	urb	10	5	-	5	
DERP029	tra	urb	10	5	-	5	
DESL012	bac	urb	7	2	4	5	3
ES1604A	bac	sub	8	3	4	5	4
ES1942A	bac	urb	10	5	-	5	
ES1986A	tra	urb	9	4	5	5	4
FI00363	bac	urb	7	2	3	5	4

code	station type	area type	NO_2_class	PM_{10}_class	O_3_class	Diff. NO_2-PM_{10}	Diff. NO_2-O_3
FR08020	ind	sub	7	2	-	5	
FR20002	tra	urb	8	3	-	5	
FR27002	bac	sub	8	3	9	5	-1
FR36003	tra	urb	10	5	-	5	
FR38011	bac	urb	7	2	9	5	-2
HR0005A	ind	urb	6	1	1	5	5
IT1048A	bac	urb	8	3	10	5	-2
PT01044	bac	urb	8	3	10	5	-2
PT06006	bac	urb	8	3	10	5	-2
CZ0SKLS	bac	urb	3	8	-	-5	
CZ0TBOM	bac	sub	3	8	-	-5	
CZ0TVER	bac	rur	2	7	-	-5	
DEBB006	bac	urb	3	8	2	-5	1
DEBB043	bac	sub	2	7	2	-5	0
ES0651A	ind	sub	4	9	7	-5	-3
ES1297A	ind	sub	4	9	3	-5	1
ES1650A	ind	sub	4	9	-	-5	
ES1952A	bac	sub	2	7	3	-5	-1
FR01015	ind	sub	2	7	6	-5	-4
FR10005	ind	sub	3	8	6	-5	-3
FR10012	ind	rur	2	7	-	-5	
MK0041A	tra	urb	4	9	7	-5	-3
MK0046A	ind	sub	2	7	-	-5	
PL0046A	bac	urb	2	7	-	-5	

code	station type	area type	NO_2_class	PM_{10}_class	O_3_class	Diff. NO_2-PM_{10}	Diff. NO_2-O_3
PL0070A	ind	sub	2	7	-	-5	
PL0104A	ind	urb	5	10	3	-5	2
PL0106A	bac	urb	4	9	1	-5	3
PL0119A	bac	urb	5	10	-	-5	
PL0126A	bac	urb	3	8	-	-5	
PL0256A	bac	urb	3	8	-	-5	
SK0005A	bac	urb	4	9	9	-5	-5
CZ0PPLA	tra	urb	4	10	4	-6	0
CZ0TOPR	ind	urb	3	9	5	-6	-2
CZ0TOVK	bac	urb	2	8	-	-6	
DEBB001	bac	sub	1	7	3	-6	-2
DETH065	ind	rur	1	7	1	-6	0
FR10027	ind	???	3	9	3	-6	0
FR33220	bac	urb	4	10	9	-6	-5
PL0008A	bac	urb	3	9	6	-6	-3
PL0014A	bac	rur	1	7	2	-6	-1
PL0123A	ind	urb	3	9	-	-6	
PL0187A	bac	urb	4	10	-	-6	
PL0296A	bac	urb	2	8	1	-6	1
PL0574A	ind	urb	3	9	-	-6	
SK0019A	tra	urb	4	10	-	-6	
SK0046A	bac	urb	3	9	4	-6	-1
DEBB038	bac	sub	2	9	1	-7	1
DEBB085	ind	sub	2	9	-	-7	

code	station type	area type	NO_2_class	PM_{10}_class	O_3_class	Diff. NO_2-PM_{10}	Diff. NO_2-O_3
MK0039A	ind	urb	2	9	6	-7	-4
PL0020A	bac	urb	2	9	-	-7	
SK0022A	bac	urb	2	9	6	-7	-4
SK0008A	bac	urb	2	10	4	-8	-2

bac: background; tra: traffic; ind: industrial
rur: rural; sub: suburban urb: urban
???: unknown
"-": The station could not be classified for O_3 according to the methodology in Joly & Peuch (2012)"

Table 16. Stations with a difference of 5 or more between NO_2 and O_3 classes.

code	station type	area type	NO_2_class	PM_{10}_class	O_3_class	Diff. NO_2-PM_{10}	Diff. NO_2-O_3
FR24015	bac	urb	10	-	1		9
ES2000A	ind	urb	9	10	1	-1	8
ES1613A	tra	urb	9	6	2	3	7
ES1643A	tra	urb	9	9	2	0	7
ES1759A	ind	urb	9	-	2		7
IT0902A	bac	sub	9	-	2		7
LV00RZ1	tra	urb	8	-	1		7
ES1548A	bac	sub	8	-	2		6
ES1578A	bac	urb	8	5	2	3	6
ES1623A	bac	urb	8	-	2		6
ES1975A	ind	urb	7	-	1		6
IT0854A	bac	urb	9	-	3		6
IT1602A	bac	sub	9	-	3		6
IT1818A	tra	sub	10	-	4		6
IT2014A	bac	rur	7	-	1		6
IT2020A	bac	sub	10	-	4		6
IT2028A	bac	urb	9	-	3		6
DESL020	tra	urb	9	7	4	2	5
DESN017	bac	urb	8	-	3		5
DETH032	tra	urb	7	8	2	-1	5
ES0822A	ind	urb	8	4	3	4	5
ES1280A	tra	urb	10	9	5	1	5
ES1751A	bac	sub	8	8	3	0	5
ES1811A	bac	rur	9	5	4	4	5
ES1823A	bac	sub	8	7	3	1	5
ES1886A	ind	sub	7	3	2	4	5
ES1897A	ind	sub	7	-	2		5
ES1980A	ind	urb	7	-	2		5
FR09011	bac	urb	9	-	4		5
FR18006	tra	urb	10	-	5		5
FR19010	???	urb	8	-	3		5
FR38008	bac	urb	8	-	3		5
FR41002	bac	urb	6	4	1	2	5
HR0005A	ind	urb	6	1	1	5	5
IT0856A	bac	urb	8	-	3		5
IT1076A	bac	sub	6	-	1		5
IT1593A	bac	urb	9	-	4		5
IT1683A	tra	urb	9	-	4		5
LV00RP5	bac	urb	9	-	4		5

PL0252A	tra	urb	8	10	3	-2	5
PT03097	tra	urb	9	9	4	0	5
BA0029A	bac	urb	4	-	9		-5
CH0001A	bac	sub	3	-	8		-5
CH0008A	bac	sub	2	-	7		-5
CH0051A	bac	rur	2	-	7		-5
DEBY079	bac	sub	4	-	9		-5
DEBY088	ind	sub	4	3	9	1	-5
DEBY113	bac	sub	2	3	7	-1	-5
DEHE034	bac	rur	2	1	7	1	-5
DEHE048	bac	rur	2	-	7		-5
DERP013	bac	rur	1	1	6	0	-5
ES0893A	ind	urb	3	-	8		-5
ES1129A	ind	rur	1	-	6		-5
ES1517A	bac	rur	2	1	7	1	-5
ES1518A	bac	rur	1	1	6	0	-5
ES1616A	bac	rur	1	1	6	0	-5
ES1771A	ind	sub	3	3	8	0	-5
ES1779A	ind	rur	2	2	7	0	-5
ES1805A	bac	rur	3	3	8	0	-5
FR12017	bac	sub	4	-	9		-5
FR16060	bac	sub	4	5	9	-1	-5
FR20047	bac	sub	3	4	8	-1	-5
FR29427	ind	sub	3	-	8		-5
FR33220	bac	urb	4	10	9	-6	-5
FR35004	bac	urb	5	5	10	0	-5
FR35006	bac	rur	5	3	10	2	-5
GB0034R	bac	sub	3	-	8		-5
GB0051A	bac	urb	4	-	9		-5
GB0616A	bac	urb	5	4	10	1	-5
GB0649A	bac	sub	4	-	9		-5
GR0019A	tra	sub	4	-	9		-5
GR0230A	bac	sub	5	-	10		-5
HU0032A	bac	sub	2	-	7		-5
HU0038A	bac	sub	3	-	8		-5
IT0507A	tra	urb	5	-	10		-5
IT0898A	tra	urb	5	-	10		-5
IT0903A	bac	sub	4	-	9		-5
IT1121A	bac	rur	3	-	8		-5
IT1203A	bac	sub	3	-	8		-5
IT1418A	bac	rur	3	-	8		-5
IT1875A	bac	urb	4	-	9		-5
IT1921A	bac	rur	1	-	6		-5
MK0034A	tra	urb	5	9	10	-4	-5

NL00235	bac	rur	2	-	7		-5
PT02018	bac	sub	3	5	8	-2	-5
PT02019	bac	rur	1	2	6	-1	-5
PT04002	bac	rur	1	2	6	-1	-5
SK0005A	bac	urb	4	9	9	-5	-5
SK0018A	ind	sub	2	4	7	-2	-5
CH0033A	bac	rur	4	-	10		-6
ES0824A	ind	sub	4	8	10	-4	-6
ES1348A	bac	rur	2	-	8		-6
ES1378A	ind	rur	2	4	8	-2	-6
ES1432A	ind	sub	3	4	9	-1	-6
ES1433A	ind	sub	4	3	10	1	-6
ES1445A	ind	sub	4	3	10	1	-6
ES1572A	bac	urb	2	3	8	-1	-6
ES1654A	bac	rur	1	1	7	0	-6
ES1810A	bac	rur	1	1	7	0	-6
ES1878A	bac	rur	1	-	7		-6
ES1991A	bac	rur	1	-	7		-6
FR10015	bac	sub	2	-	8		-6
FR15012	ind	rur	3	-	9		-6
FR15013	bac	sub	3	-	9		-6
FR15044	bac	sub	3	-	9		-6
FR19051	bac	urb	4	4	10	0	-6
FR27003	ind	sub	2	-	8		-6
FR27005	bac	rur	2	-	8		-6
FR31021	bac	rur	4	2	10	2	-6
FR37002	tra	urb	3	-	9		-6
GB0583A	ind	urb	4	3	10	1	-6
GB0679A	bac	sub	3	1	9	2	-6
GB0998A	bac	sub	2	-	8		-6
IE0118A	bac	sub	3	-	9		-6
IT0499A	bac	sub	4	-	10		-6
IT0508A	tra	urb	4	-	10		-6
IT0741A	bac	rur	2	-	8		-6
IT1174A	bac	rur	3	-	9		-6
IT1179A	bac	rur	1	-	7		-6
IT1233A	bac	rur	3	-	9		-6
IT1288A	bac	rur	2	-	8		-6
IT1464A	bac	rur	2	-	8		-6
IT1519A	bac	rur	3	-	9		-6
IT1522A	bac	rur	2	-	8		-6
IT1696A	bac	urb	4	-	10		-6
IT1697A	bac	urb	4	-	10		-6
IT1736A	bac	rur	3	-	9		-6

IT1865A	bac	rur	2	-	8		-6
IT1914A	bac	rur	2	-	8		-6
IT1928A	bac	sub	2	-	8		-6
PT01052	bac	urb	4	5	10	-1	-6
PT04006	bac	rur	1	1	7	0	-6
AT30201	bac	sub	3	2	10	1	-7
AT31496	bac	rur	3	-	10		-7
CH0024A	bac	rur	3	-	10		-7
ES1543A	bac	rur	1	1	8	0	-7
ES1774A	bac	rur	2	-	9		-7
FR15007	bac	rur	3	-	10		-7
FR31008	bac	rur	1	-	8		-7
FR37001	bac	sub	3	-	10		-7
FR37003	bac	sub	3	-	10		-7
IT1292A	bac	rur	3	-	10		-7
IT1927A	bac	rur	1	-	8		-7
ES0296A	bac	rur	1	1	9	0	-8
ES1831A	bac	rur	2	1	10	1	-8
IT0921A	ind	rur	1	-	9		-8

bac: background; tra: traffic; ind: industrial
rur: rural; sub: suburban urb: urban
???: unknown
"-": The station could not be classified for PM_{10} according to the methodology in Joly & Peuch (2012)"

Stations located in specific environment

List of stations located in densely populated areas

The following table contains an indicative (but not exhaustive) list of stations surrounded by a high density of population. The spreadsheet which is proposed as a supplement to this report (see Annex VI) provides more detailed description of all monitoring sites included in AirBase.

Table 17. Indicative list of stations located in densely populated areas (above 15.10^3 inhabitants/km^2)

code	station type	area type	NO_2_class	PM_{10}_class	O_3_class
FR04014	bac	urb	7	-	-
FR04055	bac	urb	7	4	8
FR04071	tra	urb	10	-	-
FR04141	tra	urb	10	-	-
FR04143	bac	urb	8	8	-
FR04160	bac	urb	6	-	7
FR04004	bac	urb	7	7	7
GR0002A	tra	urb	7	-	10
GR0003A	tra	urb	9	-	-
GR0032A	tra	urb	8	-	10
FR04031	tra	urb	10	-	-
FR04057	bac	sub	6	-	5
FR04060	bac	urb	7	-	-
FR04131	tra	urb	10	10	-
FR04299	bac	urb	4	-	1
GR0018A	tra	urb	7	9	10
GR0044A	tra	urb	6	-	9
FR04018	bac	urb	7	-	8
FR04123	tra	urb	10	10	-
FR04017	bac	urb	6	-	8
FR04037	bac	urb	6	-	7
FR04008	bac	urb	6	-	8
FR04012	tra	urb	10	9	-
ES0691A	tra	urb	8	-	10
ES1396A	tra	urb	8	-	-
ES1438A	tra	urb	9	-	10
ES1480A	tra	urb	10	-	10
ES1587A	ind	sub	-	-	10
ES1679A	bac	urb	7	-	10

bac: background; tra: traffic; ind: industrial
rur: rural; sub: suburban urb: urban
"-": The station could not be classified for the corresponding pollutant according to the methodology in Joly & Peuch (2012)"

ANNEX V

Station classification according to Joly & Peuch (2012) methodology:

results for the Air Implementation Pilot Cities

NB: for a more comprehensive view of the monitoring networks, all the stations that could be classified, and not only those strictly selected for the Air Implementation Pilot project (EEA, 2013), have been plotted on the city maps.

For some cities, classification results are missing for one or several pollutants. Possible reasons are: no data are available in AirBase over the considered period; the time series have too many gaps or missing values; no hourly PM_{10} data (only daily average values) are available in AirBase.

Antwerp

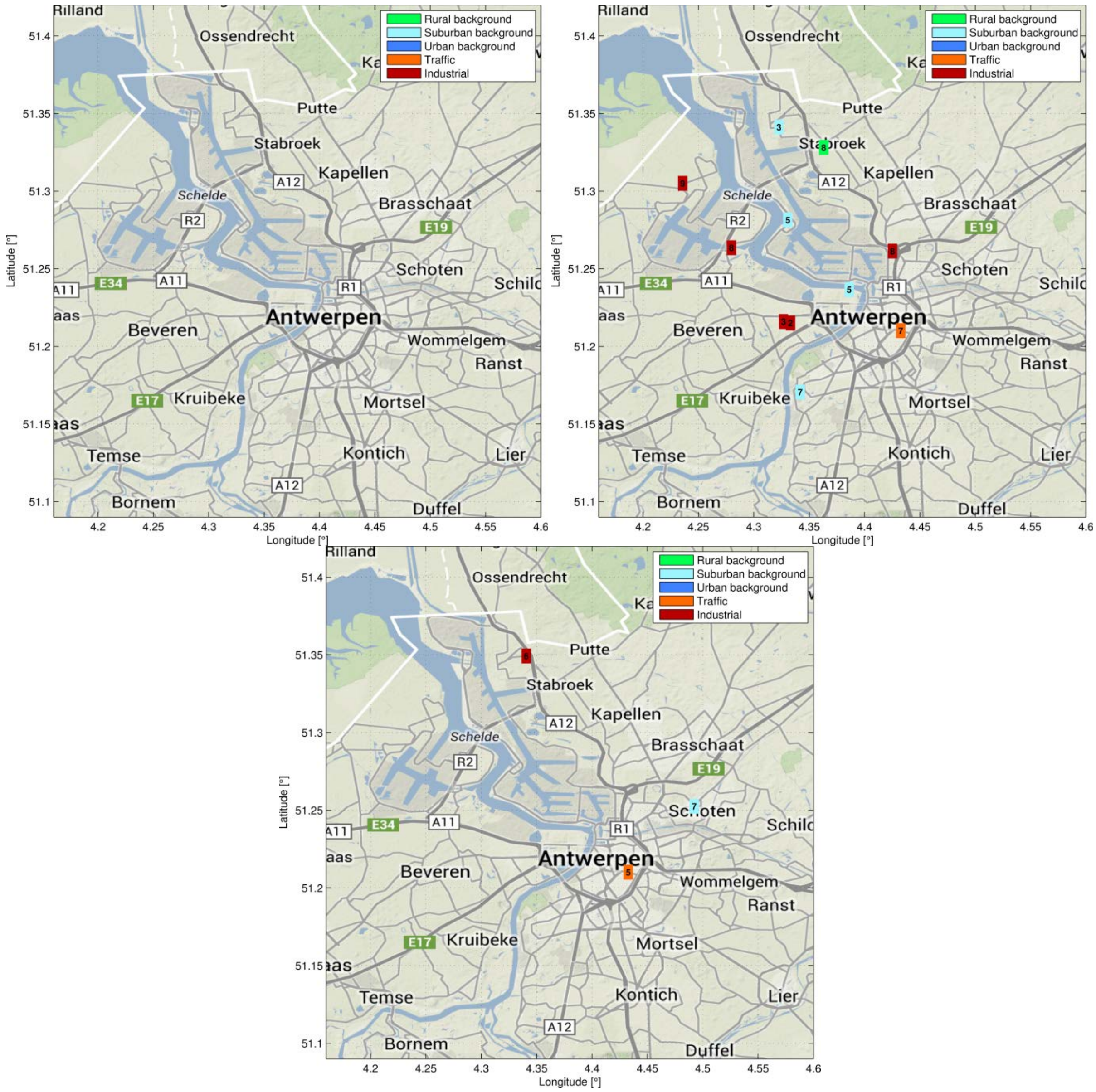

Figure 40: Spatial comparison of the two classification systems in the agglomeration of Antwerp. Top left: NO_2; top right: PM_{10}; bottom: O_3. The traditional AirBase metadata classification is shown as coloured boxes whereas the Joly and Peuch (2012) classification is given as a number from 1 to 10.

Berlin

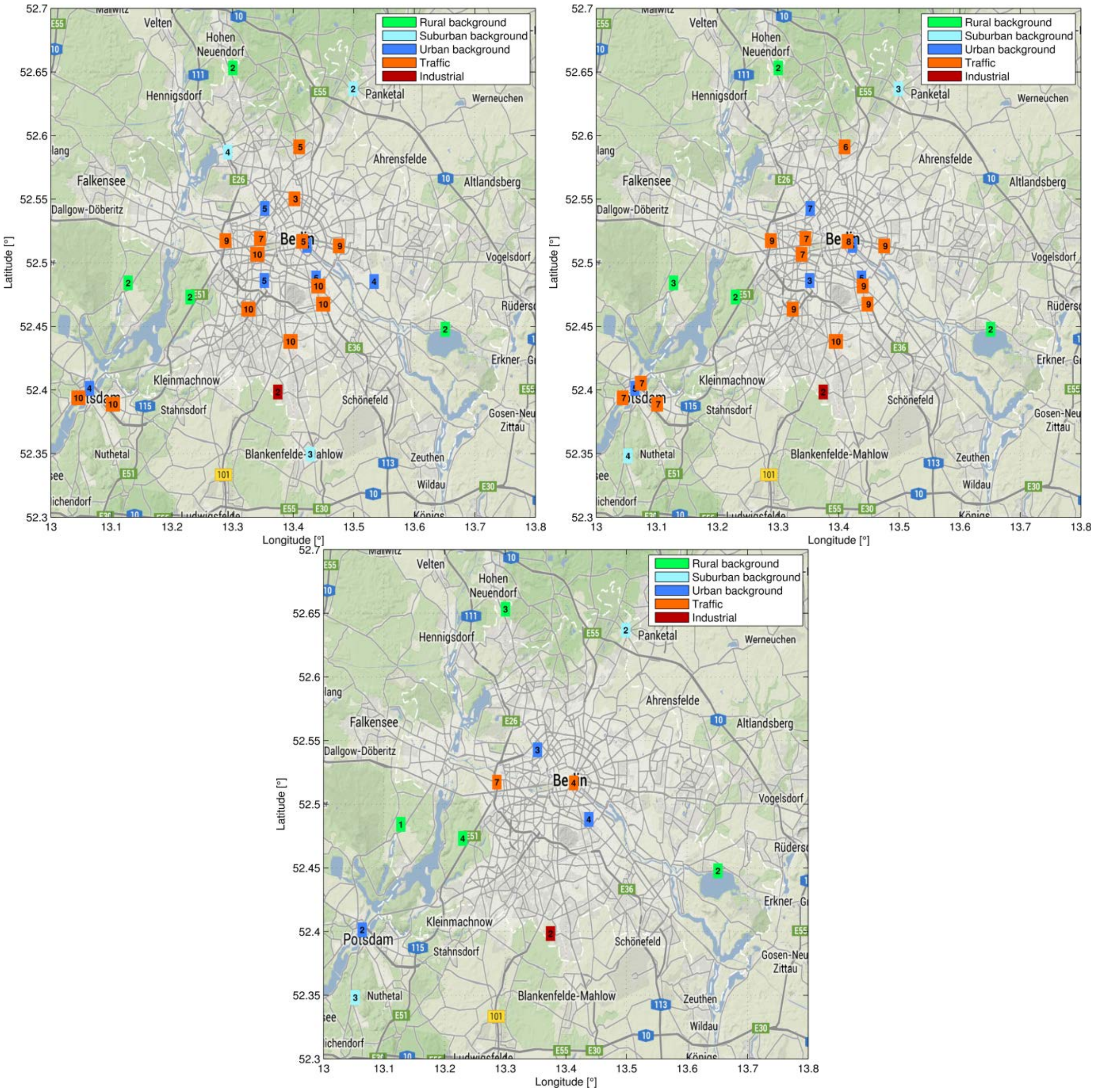

Figure 41: Spatial comparison of the two classification systems in the agglomeration of Berlin. Top left: NO_2; top right: PM_{10}; bottom: O_3. The traditional AirBase metadata classification is shown as coloured boxes whereas the Joly and Peuch (2012) classification is given as a number from 1 to 10.

Dublin

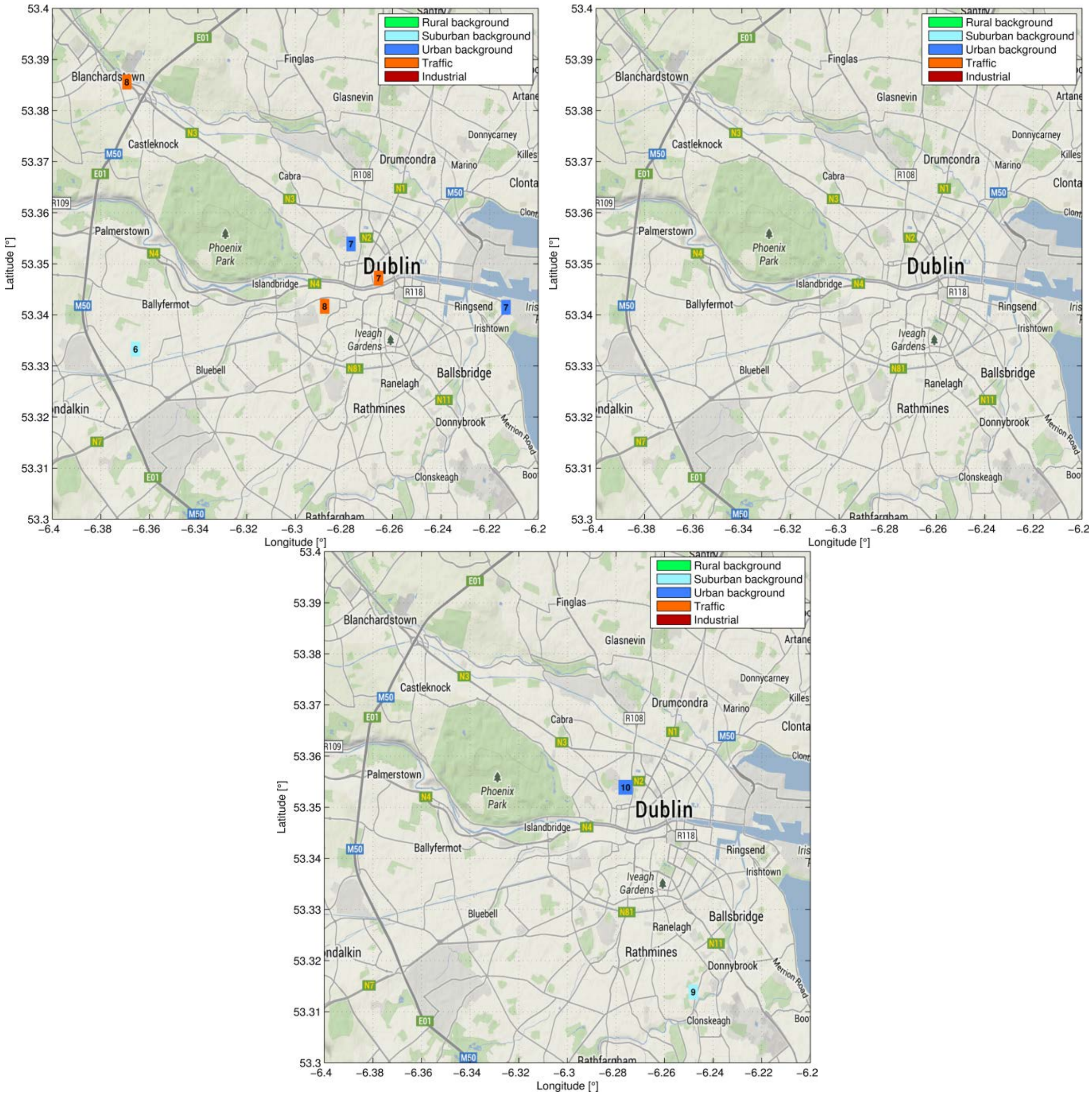

Figure 42: Spatial comparison of the two classification systems in the agglomeration of Dublin. Top left: NO_2; top right: PM_{10}; bottom: O_3. The traditional AirBase metadata classification is shown as coloured boxes whereas the Joly and Peuch (2012) classification is given as a number from 1 to 10.

Madrid

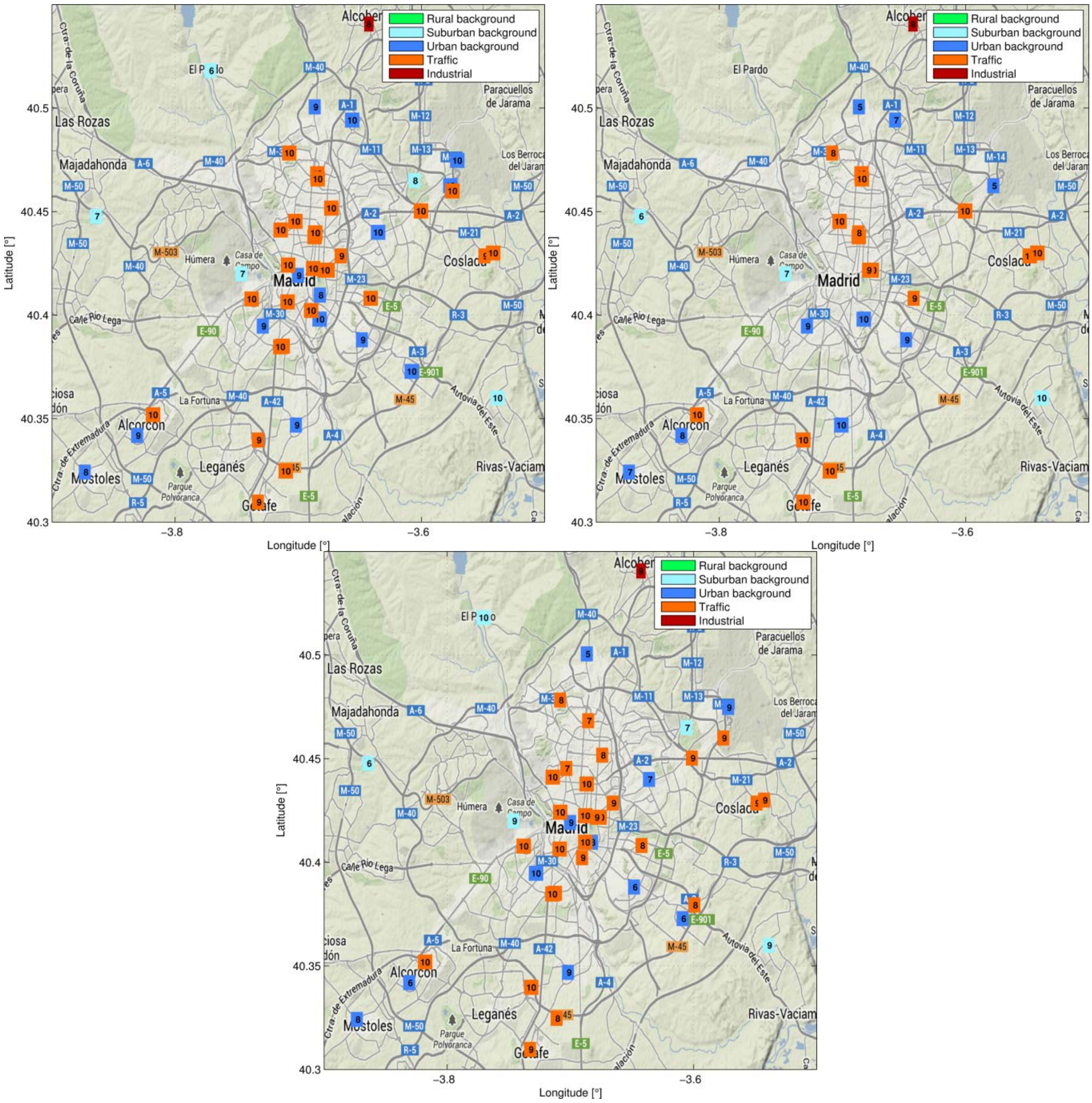

Figure 43: Spatial comparison of the two classification systems in the agglomeration of Madrid. Top left: NO_2; top right: PM_{10}; bottom: O_3. The traditional AirBase metadata classification is shown as coloured boxes whereas the Joly and Peuch (2012) classification is given as a number from 1 to 10.

Malmö

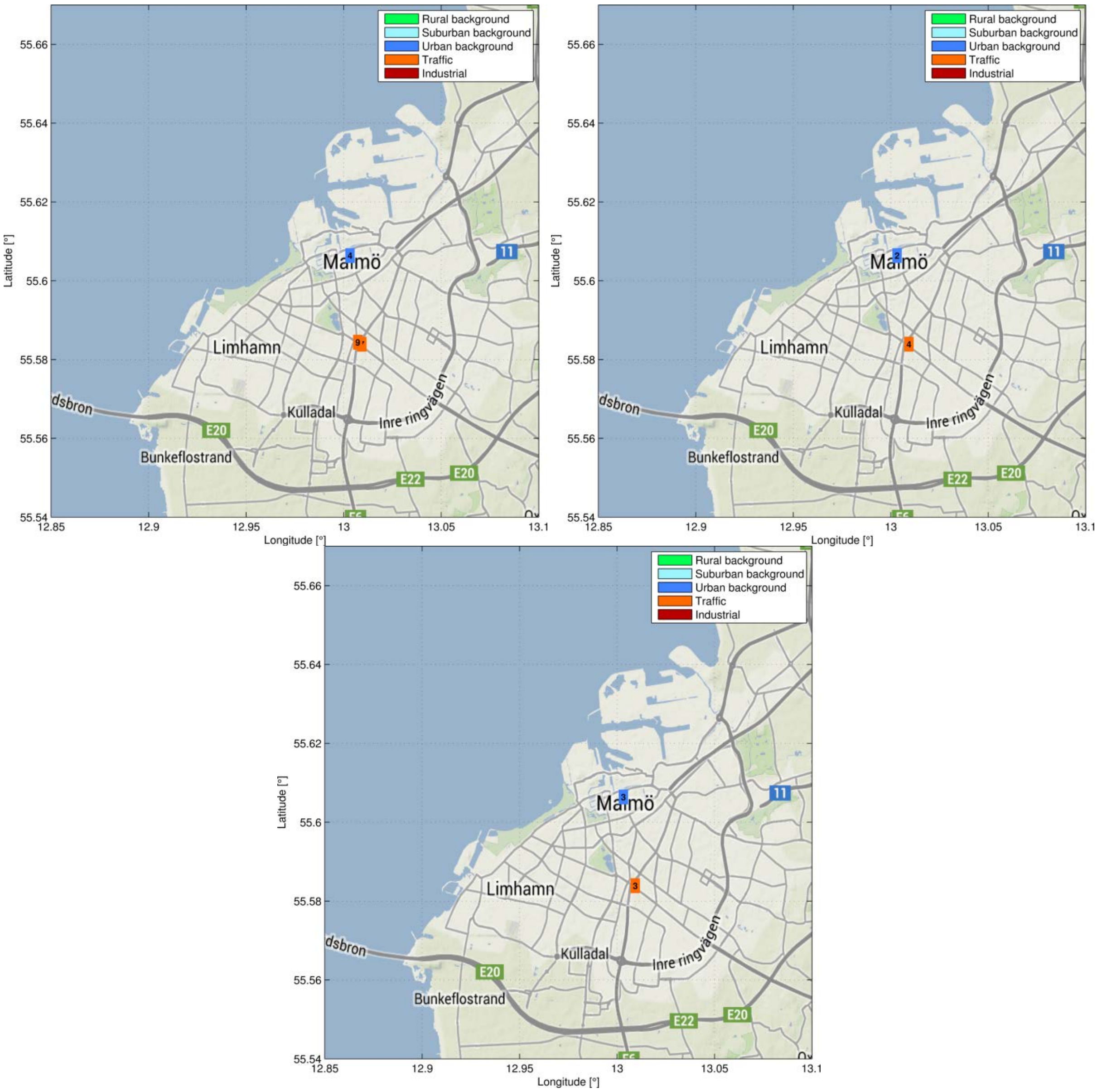

Figure 44: Spatial comparison of the two classification systems in the agglomeration of Malmö. Top left: NO_2; top right: PM_{10}; bottom: O_3. The traditional AirBase metadata classification is shown as coloured boxes whereas the Joly and Peuch (2012) classification is given as a number from 1 to 10.

Milan

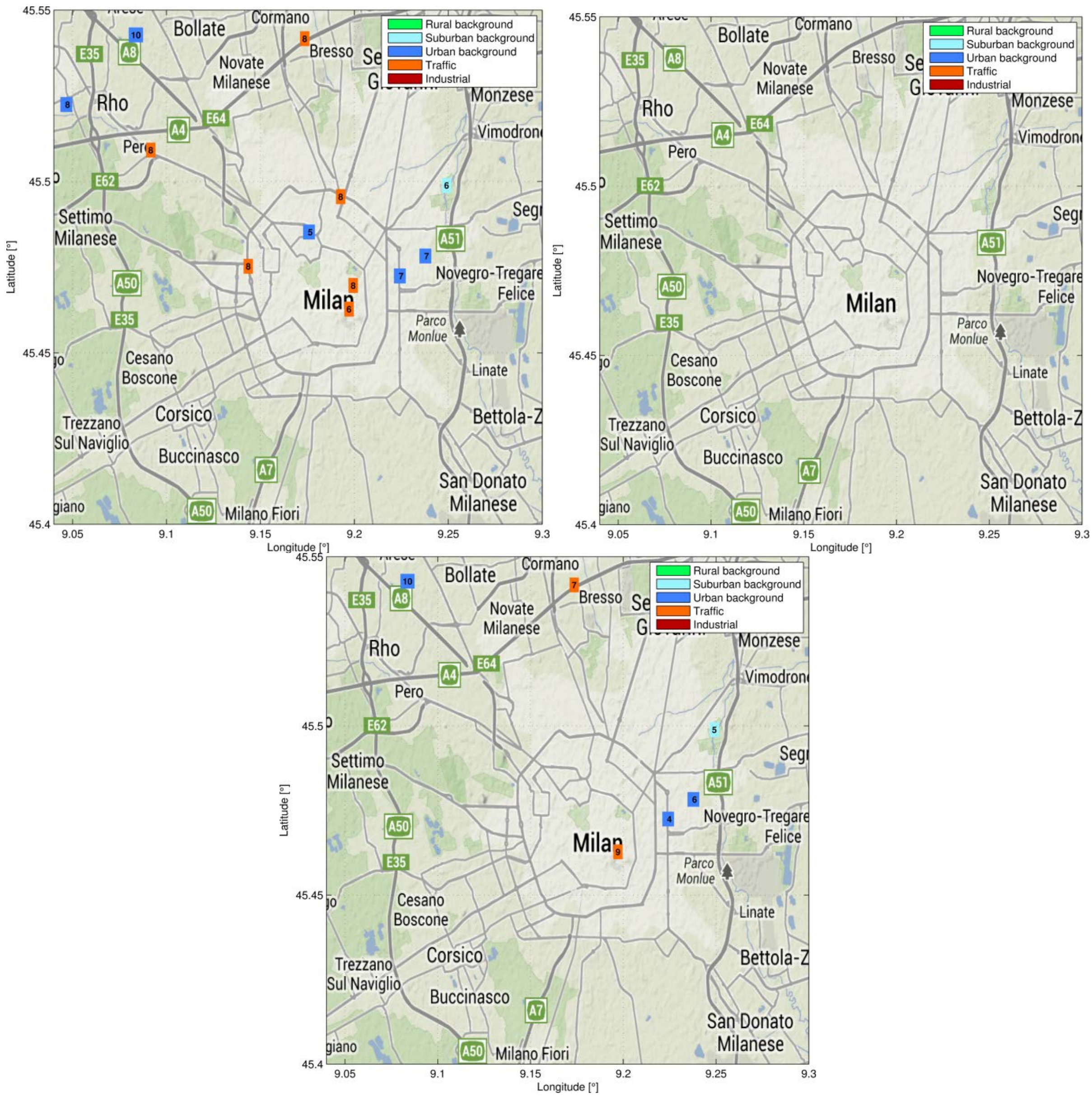

Figure 45: Spatial comparison of the two classification systems in the agglomeration of Milan. Top left: NO_2; top right: PM_{10}; bottom: O_3. The traditional AirBase metadata classification is shown as coloured boxes whereas the Joly and Peuch (2012) classification is given as a number from 1 to 10.

Paris

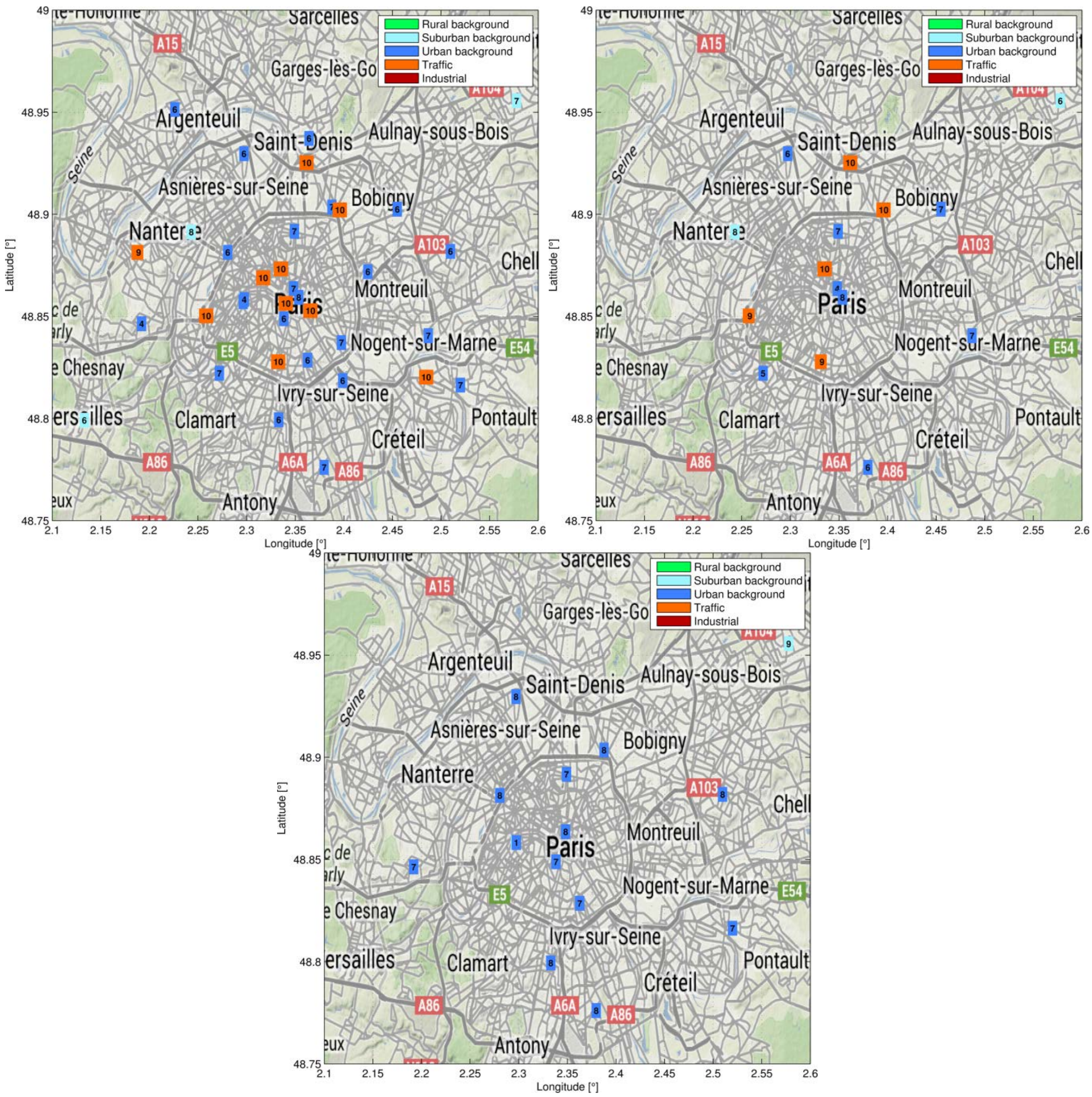

Figure 46: Spatial comparison of the two classification systems in the agglomeration of Paris. Top left: NO_2; top right: PM_{10}; bottom: O_3. The traditional AirBase metadata classification is shown as coloured boxes whereas the Joly and Peuch (2012) classification is given as a number from 1 to 10.

Ploiesti

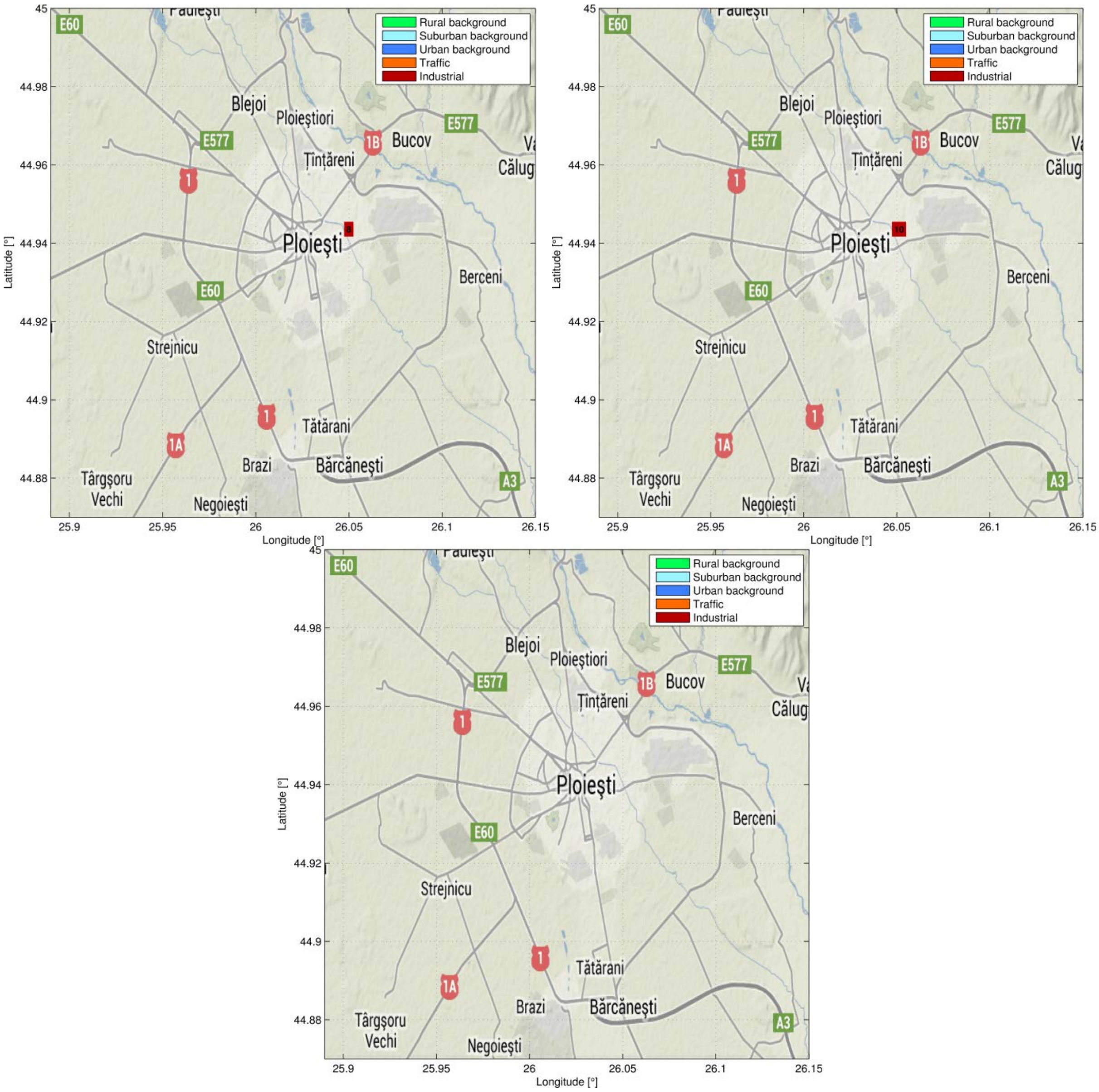

Figure 47: Spatial comparison of the two classification systems in the agglomeration of Ploiesti. Top left: NO_2; top right: PM_{10}; bottom: O_3. The traditional AirBase metadata classification is shown as coloured boxes whereas the Joly and Peuch (2012) classification is given as a number from 1 to 10.

Plovdiv

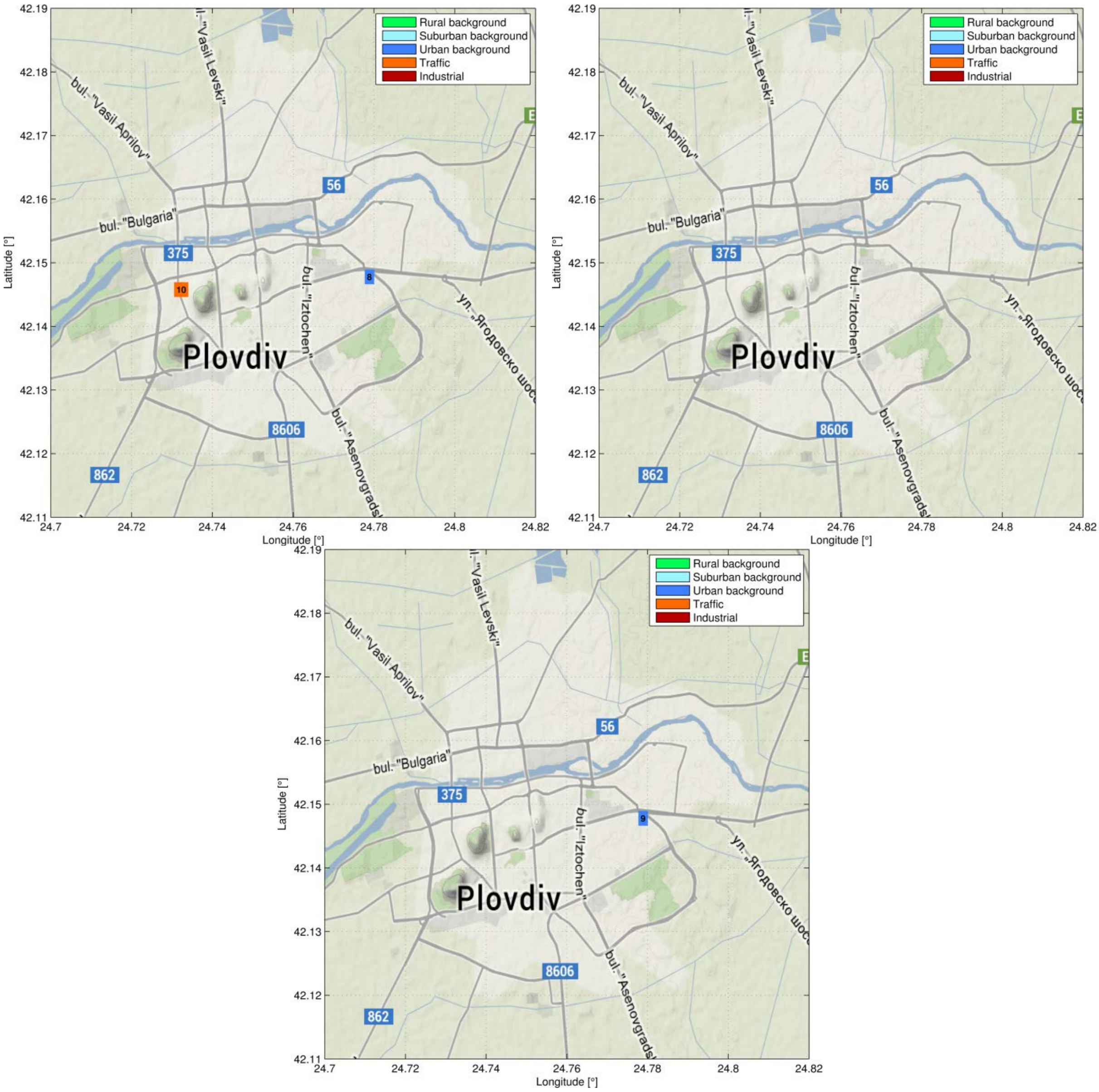

Figure 48: Spatial comparison of the two classification systems in the agglomeration of Plovdiv. Top left: NO_2; top right: PM_{10}; bottom: O_3. The traditional AirBase metadata classification is shown as coloured boxes whereas the Joly and Peuch (2012) classification is given as a number from 1 to 10.

Prague

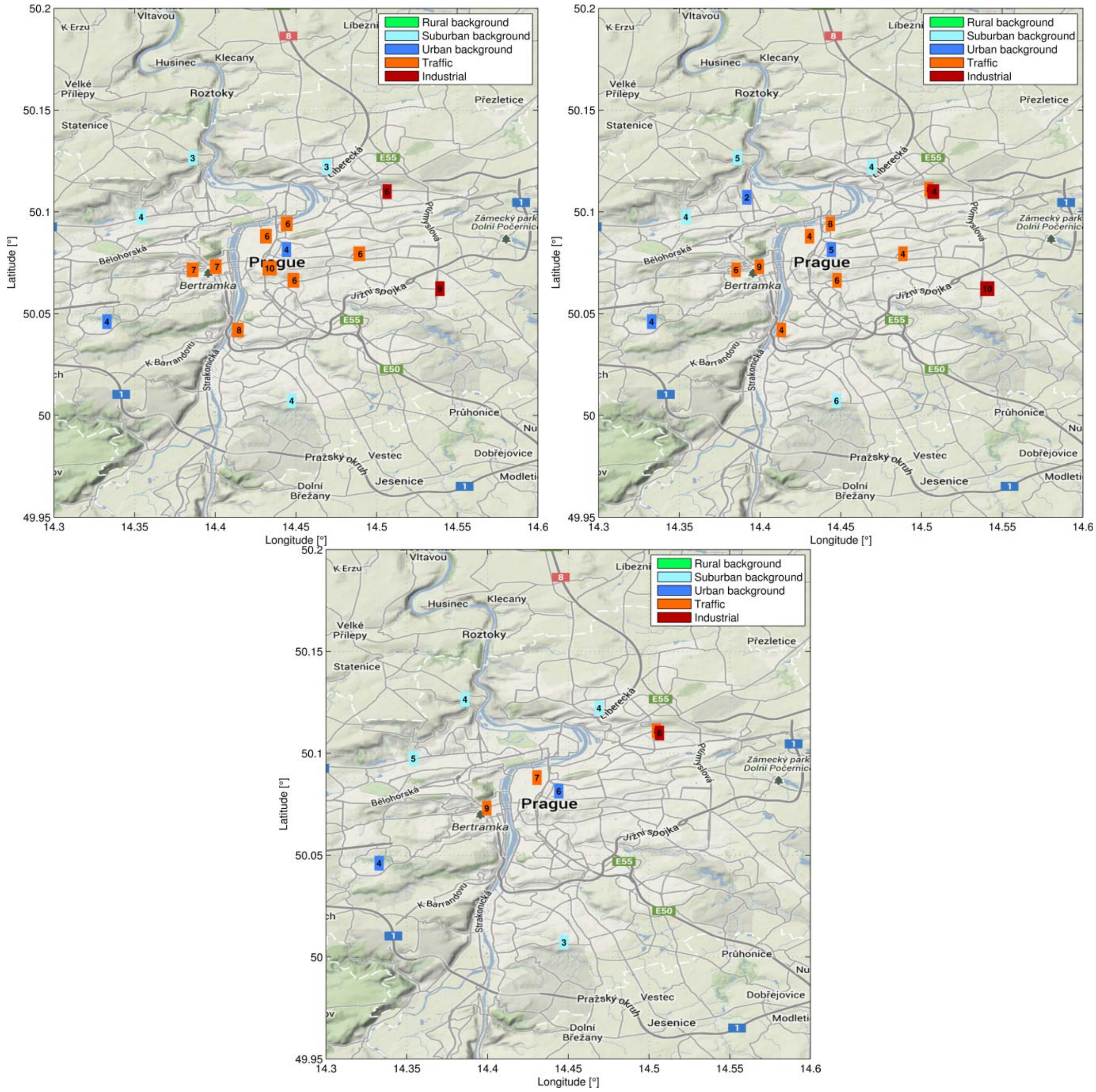

Figure 49: Spatial comparison of the two classification systems in the agglomeration of Prague. Top left: NO_2; top right: PM_{10}; bottom: O_3. The traditional AirBase metadata classification is shown as coloured boxes whereas the Joly and Peuch (2012) classification is given as a number from 1 to 10.

Vienna

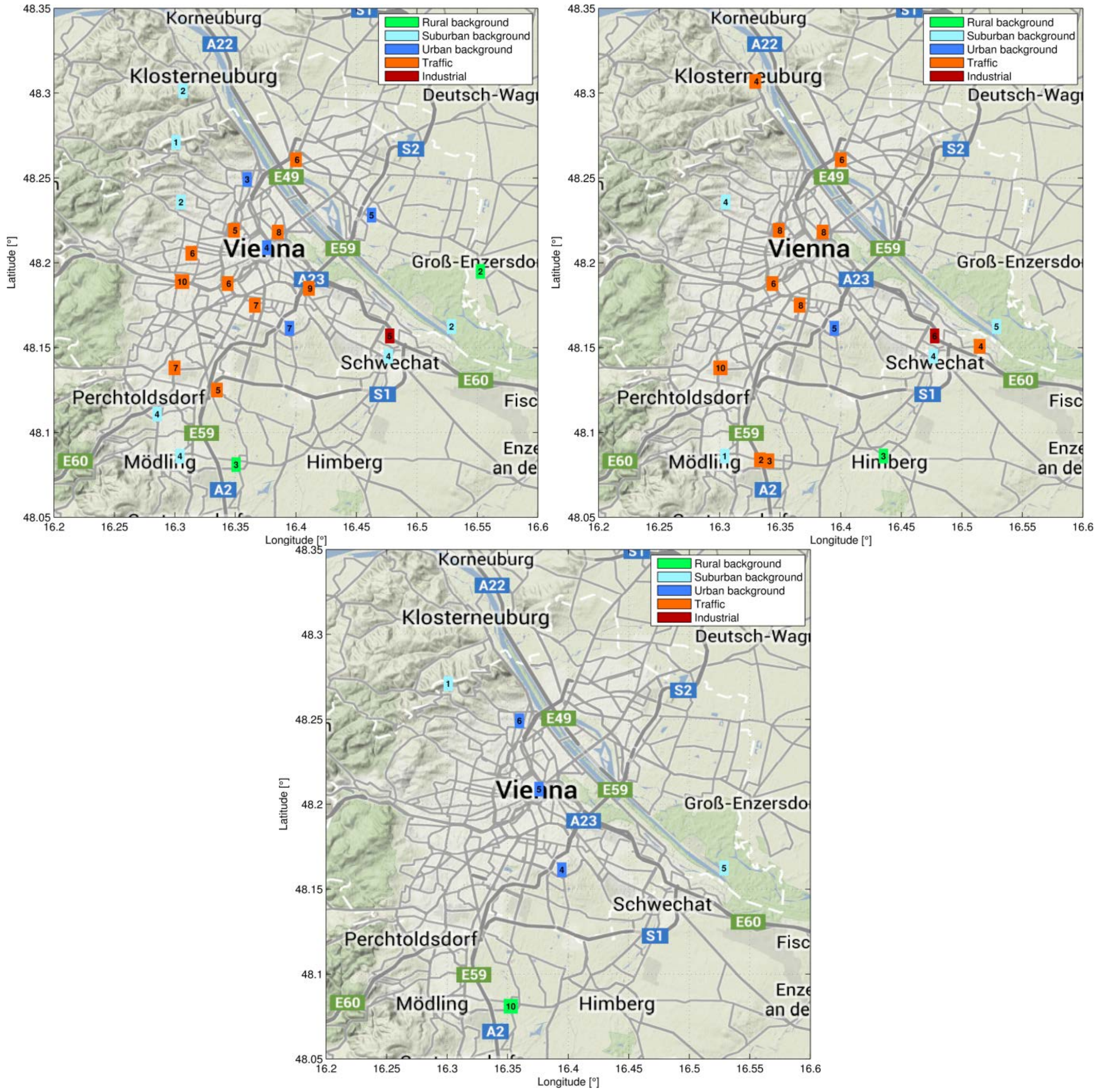

Figure 50: Spatial comparison of the two classification systems in the agglomeration of Vienna. Top left: NO_2; top right: PM_{10}; bottom: O_3. The traditional AirBase metadata classification is shown as coloured boxes whereas the Joly and Peuch (2012) classification is given as a number from 1 to 10.

Vilnius

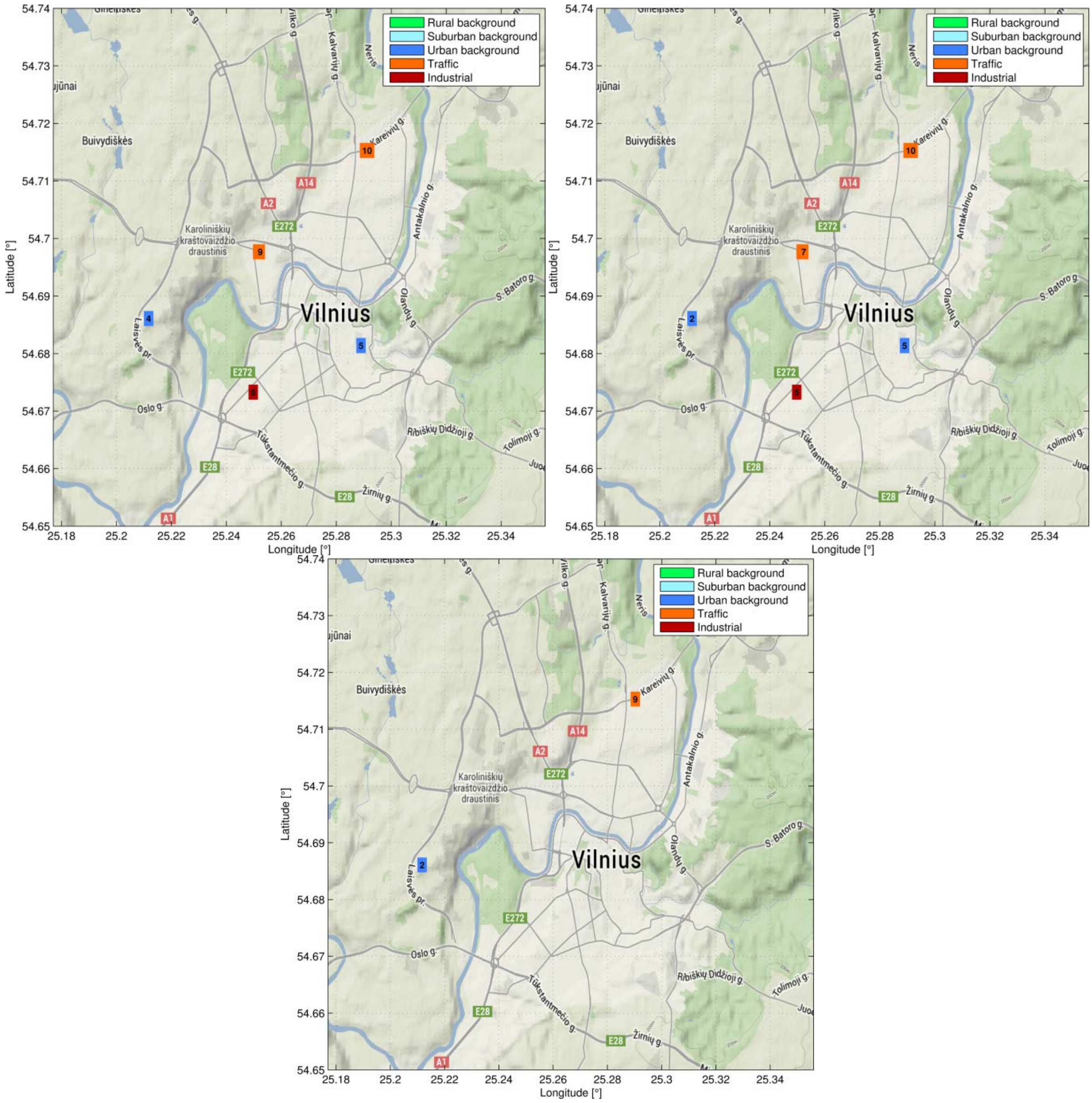

Figure 51: Spatial comparison of the two classification systems in the agglomeration of Vilnius. Top left: NO_2; top right: PM_{10}; bottom: O_3. The traditional AirBase metadata classification is shown as coloured boxes whereas the Joly and Peuch (2012) classification is given as a number from 1 to 10.

ANNEX VI

Template for classification

This spreadsheet contains the following data:

- Station codes and name
- Coordinates
- *Ozone classification (if applicable)*
- EoI classification: type of station
  type of area
  characteristics of zone
- Dominant emission sector(s) (voluntary info EoI)
- City name (when available)
- LAU2 code and name
- NUTS3 code and name
- Closing date (in case the station is no longer operational)
- Classification according to Joly and Peuch methodology (class 1-10) for:
  PM_{10}
  NO_2
  O_3
- Population density (within 1 km radius) (JRC database completed –in blue - by ORNL database)
- Dominant land cover classes (proportion within 1 km radius) (CORINE Land Cover database). In the sheet LC_code a definition of the aggregated land cover classes has been given.

In the columns R-T a dash "-" indicates that the pollutant is not measured at this station, grey shade cells indicate that recent data (period 2007-2011) is available, a plus "+" indicates that older data, before 2007 is available in AirBase.

A red shade highlights apparent discrepancies between the EoI classification and information on the station environment (main emission sources, population density).