The state of the air quality in 2009

and the European exchange
of monitoring information in 2010

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See: http://www.hamburger-luft.de/index.jsp , choose "Momentan aktive Stationen", click on "Sternschanze".

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SUMMARY

Current air quality legislation of the European Union (EU), Council Decision (97/101/EC), requires the Commission to prepare yearly a technical report on the meta information and air quality data that have been exchanged among the EU Member States (MS) and the Commission. Besides the EU Member States, other member and cooperating countries of the European Environment Agency, which include EU candidate countries, EU potential candidate countries and European Free Trade Association (EFTA) states, have agreed to follow this reporting procedure as well. The content of AirBase (version5) is available to the public via the European Environment Agency (EEA) website[1]. More information on AirBase can be found on the ETC/ACM website[2]. The results of the reporting cycle presented in this technical report cover data for 2009.

A total of 38 countries, including the 27 EU MS, have provided air quality data for 2009. As in preceding years, a large number of time series have been transmitted, covering, for example, sulphur dioxide (SO_2), nitrogen dioxide (NO_2), nitrogen oxides (NO_x), particulate matter (PM_{10}, $PM_{2.5}$), ozone (O_3), carbon monoxide (CO) and benzene (C_6H_6). In an increasing degree also Volatile Organic Compounds (VOC), Heavy Metals (HM) and Polycyclic Aromatic Hydrocarbons (PAH) have been transmitted. Nearly all the countries that have updated their meta information have used the Air Quality Data Exchange Module (AQ-DEM), made available for this purpose by the European Topic Centre on Air Pollution and Climate Change Mitigation (ETC/ACM).

This technical report not only describes the meta information and the quality of the measurement data but also the state of the air quality for some selected pollutants in 2009.

[1] http://www.eea.europa.eu/themes/air/airbase
[2] http://airbase.eionet.europa.eu/

CONTENTS

INTRODUCTION

The reciprocal exchange of information and data among countries and the European Commission is based on the Air Quality Directive (AQD) 2008/50/EC (EU, 2008)). This Exchange of Information (EoI) Decision 'establishing a reciprocal exchange of information and data from networks and individual stations measuring ambient air pollution within the Member States', was formerly established in the EoI Decision 97/101/EC and annexes (EU 1997, EU 2001a and EU 2001b).

Parallel to dataflow under the EoI, the Member States (MS) of the European Union (EU) provide information on air quality in the context of the former Air Quality (AQ) Framework Directives (FWD) and related daughter directives (DD). These Directives have been merged into the AQD 2008/50/EC (EU, 2008)) except for the fourth DD (4DD, EU 2004a). This information mainly focuses on compliance checking with obligations under the AQ directives, such as limit values. To avoid duplicate reporting by the MS, some of the meta data that is needed for evaluating the reports under the FWD (in particular the meta-information on stations and networks) is only sent under the EoI.

The EoI data submission still follows the Guidance on the revised Annexes of the Decision (Garber *et al.* 2001). Rules for implementing a reporting system under the Directives 2008/50/EC and 2004/107/EC (Implementing Provisions, IPR) are in development.

The EoI requires a large set of meta information and AQ data to be delivered to the Commission. Part of this information is mandatory and the other items are to be delivered to the Commission 'to the extent possible' and 'as much information as feasible should be supplied' (see Annex A).

According to the EoI Decision, the Commission will, each year, prepare a technical report on meta information and AQ data exchanged, and make the information available to EU MS. The decision states that the Commission will call on the European Environment Agency (EEA) with regard to the operation and practical implementation of the information system. The European Topic Centre on Air Pollution and Climate Change Mitigation (ETC/ACM), under contract to EEA, manages the database system, AirBase (see Mol *et al.* 2005). The information submitted under the EoI is stored in AirBase. Statistics based on the delivered information are calculated and also stored in AirBase (see Annex B). In AirBase (version 5) also NO_x values have been derived for stations where NO and NO_2 values have been reported, but no NO_x values. The contents of AirBase are available to the public via the EEA website[1]. Background information on AirBase can be found on the ETC/ACM website[2]

AirBase is the central database for the AQ meta information for the different AQ data flows: EoI, FWD (questionnaire, summer ozone reporting (SOR)), the Near Real Time (NRT) ozone Web site[3].

[1] http://www.eea.europa.eu/themes/air/airbase
[2] http://airbase.eionet.europa.eu/
[3] http://www.eea.europa.eu/maps/ozone/welcome

This report shows information provided by the 27 EU Member States (EU-27). In addition it contains information from the other five EEA member countries and from the six EEA cooperating countries[1], which have agreed to follow the data exchange procedures in the framework of Euroairnet[2].

This report also refers to the QA/QC aspects of the data in AirBase. The procedures and the first QA/QC checks are described in some reports (see Mol 2010). The standard checks on the delivered EoI-data are: outliers, strange statistics, missing data, missing essential meta data, possible overwriting of data already stored in AirBase, possible deletion of stations and measurement configurations with data. In addition to these standard checks also QA/QC checks are performed on questionable station coordinates.

In addition to the more technical aspects of the data submission process, this report will briefly describe the state of the air quality for some selected pollutants. The current (2009) air quality status will be described together with the changes in concentrations during the last years.

The EoI Technical report of last year (EoI2009, 2008-data) is given by Mol *et al.* (2010). EoI Technical Reports of earlier years can be found on the ETC/ACM Website[3]

[1] EU27 Member States: Austria, Belgium, Bulgaria, Denmark, Finland, Germany, Greece, Spain, France, Ireland, Italy, Luxembourg, The Netherlands, Portugal, Sweden, United Kingdom, Czech Republic, Estonia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Romania, Slovenia, Slovakia. Next to the 27 EU Member States the four EFTA Countries (Iceland, Liechtenstein, Norway and Switzerland) and Turkey are EEA member countries (EEA 32 member countries). EEA cooperating countries are: Albania, Bosnia and Herzegovina, Croatia, Former Yugoslav Republic of Macedonia (FYROM), Serbia and Montenegro.

[2] http://acm.eionet.europa.eu/databases/databases/EuroAirnet/index_html

[3] http://acm.eionet.europa.eu/databases/airbase/eoi_reports

1. EXCHANGE OF INFORMATION 2010 (DATA FOR 2009)

1.1. Data delivery

Thirty eight countries, including the EU-27 MS, provided AQ data for the reporting year 2009. In comparison with the previous EoI cycle, Albania and Montenegro have also delivered data (see the status table in http://acm.eionet.europa.eu/country_tools/aq/eoi_to_airbase_status/index_html

The delivery of data was facilitated by the AQ Data Exchange Module (AQ-DEM)[1]. This tool was used by most of the countries. Some countries provided their data in files in the EoI specified formats (DEM and ISO-7168-1: 1999 (extended) format). All data delivered for the reporting year 2009 was loaded into AirBase (version 5). All statistics and exceedances relevant in the DD have been calculated and were also loaded into AirBase. Also NO_x values have been derived and loaded in AirBase for stations where NO and NO_2 values have been reported, but no NO_x values.

1.2. QA/QC feedback actions

Several quality checks have been performed on delivered data and the already available information in AirBase. The quality checks in all steps of the EoI delivery process (the DEM checks and the QA/QC checks on the delivered data) are described in various reports (see Mol 2010). The yearly QA/QC checks on the delivered EoI-data are checks on outliers, strange statistics, missing data, missing essential meta data, possible overwriting of data already stored in AirBase and possible deletion of stations and measurement configurations with data. In addition to these standard checks also QA/QC checks are performed on questionable station coordinates and overlapping stations.

Intensive feedback took place with all reporting countries on these items. The country feedbacks sent to the MS resulted for 36 EoI reports in one or more updates of their original report like:

- revalidation of suspicious data, originally reported as valid;
- resubmission of time series in which suspicious data were detected;
- updating (essential) meta information;
- submission of missing time series

More detailed information on the country feedbacks can be found in Annex C.

1.3. Reporting characteristics

Sulphur dioxide (SO_2), nitrogen dioxide (NO_2), nitrogen oxides (NO_x), ozone (O_3), carbon monoxide (CO), particulate matter (PM_{10}, $PM_{2.5}$), benzene (C_6H_6) and lead (Pb) were the most frequently reported pollutants. Fewer time series were submitted for the less commonly monitored components, i.e. Volatile Organic Compounds (VOC), Heavy Metals (HM) and Polycyclic Aromatic Hydrocarbons (PAH).

The number of reporting countries varied per component ranging from all 38 countries for PM_{10} and O_3 to seventeen for components for VOC- (VOC minus benzene, see Annex D).

The number of reporting stations in 2009 also varied accordingly, being 408 for one or more VOC- and 3268 for NO_2. Differences in the distribution and density of reporting stations are

[1] http://acm.eionet.europa.eu/databases/country_tools/aq/aq-dem/dem_install.html

illustrated for selected pollutants (*Figures 1 through 8)*[1]. The expected EoI stations in these figures are described in Article 3 of the EoI decision (EU 1997). The EoI should cover at least the stations which are used in the FWD and the related DD. Only if the concentrations are below the lower assessment threshold (LAT) it is not necessary to deliver fixed measurement data (EU, 2008 (Annex II)).

Overviews of reporting in 2009 can be seen in *Tables 1 and 2* in this report. For completeness the tables also show the number of stations with NO_x data or if no NO_x data are available with NO_2 + NO data (symbol "NO_x/NO") and the number of stations providing data for one or more O_3 precursors excluding benzene which is listed separately (VOC-) and the number of stations with data for one or more of the heavy metals in the 4th DD (HM4: As, Cd, Hg, Ni) and one or more PAH in the 4th DD (PAH4). Only *lead in aerosol* (Pb_aer) has been taken into account. For a detailed definition of HM4, PAH4 and Pb_aer see Annex D).
The stations in AirBase have a station type: traffic, industrial, background or unknown and a type of area: urban, suburban, rural or unknown. The type of stations in *Table 1* has been defined as follows:

Station classification	Type of station in AirBase	Type of area in AirBase
Traffic	Traffic	Urban, suburban, rural, unknown
Urban background	Background	Urban, suburban
Industrial	Industrial	Urban, suburban, rural, unknown
Rural background	Background	Rural
Other	Background	Unknown
	Unknown	Urban, suburban, rural, unknown

More detailed information on the number and type of stations per pollutant and per country in 2009 can be found in table A "number of stations per pollutant and station type and country in 2009"
http://acm.eionet.europa.eu/databases/airbase/eoi_tables/eoi2009/index_html

All stations with data (stations with raw data with averaging times varying from hour to year and/or statistics) are taken into account in this chapter, regardless of the data coverage[2] at that station[3]. For the gaseous components mostly hourly and daily concentration data have been delivered. The components from the 4th DD (HM4 and PAH4) have also other averaging times than hour and day: weekly, 2-weekly, 4-weekly, monthly, 3-monthly and yearly. If the measurement periods of a component differ more than 25% from a constant averaging time, the averaging time has been defined as "var".

The daily values in AirBase have been calculated by ETC/ACM from the hourly values if available. If a country reports both hourly and daily values, the delivered daily values have been overwritten by the calculated daily values. If 3-hourly data are delivered, these data are aggregated in daily values, which only are reported.

Most countries delivered data for more pollutants than the mandatory list of pollutants defined under the EoI. See table B "number of stations with HM4, VOC, PAH4 and other non-Directive components" in
http://acm.eionet.europa.eu/databases/airbase/eoi_tables/eoi2009/index_html for a summary of these supplementary components.

[1] Note that a number of Frenchstations (Reunion, Guadeloupe, ...) fall outside the maps; these station are however included in the Tables and other graphs.
[2] In the Air Quality Daughter Directives the terms *data capture* and *time coverage* have been defined. The time coverage is the percentage of measurement time in a given period. The data capture is the percentage of valid measurement values in a given data set. For each yearly time series the so called *data coverage* has been calculated in AirBase. The *data coverage* is defined as follows: *Data coverage = data capture * time coverage*.
[3] More specific: stations with data are stations with calculated or defined statistics (annual means).

For most pollutants the number of stations for which data have been reported in 2009 has been increased in comparison with 2008 (see *Table 1)*. Only SO2 (and NO_x /NO slightly decreased. The highest increases are in the number of stations measuring $PM_{2.5}$ (48%) and VOC- (38%). The difference between the number of stations for which NO_2 has been reported and the number of stations for which NO_x /NO has been reported is 914. Most automated monitors measure both pollutants simultaneously, so this difference is still rather big. See table C "number of stations with NO_2 , NO_x and NO" in http://acm.eionet.europa.eu/databases/airbase/eoi_tables/eoi2009/index_html for an overview per country.

Table 1 Number of stations for which 2009 data have been delivered for AQD & 4DD components, specified per station type.

	SO2	NO2	NOx/NO	PM10	PM2.5	Pb_aer	CO	C6H6	O3	VOC-	HM4	PAH4
Reporting EU countries	27	26	25	27	27	24	27	27	27	15	25	23
Total number of stations	2015	3147	2272	2809	798	661	1304	757	2176	402	727	540
Of which												
Traffic	387	894	721	823	180	146	631	297	298	178	147	135
Urban background	825	1322	823	1171	403	270	416	274	1072	108	307	252
Industrial	525	506	393	471	82	142	187	130	265	89	148	71
Rural background	264	399	328	319	123	98	62	53	507	25	120	78
Other	14	26	7	25	10	5	8	3	34	2	5	4
Reporting non-EU countries	10	10	7	11	4	1	8	5	10	2	2	1
Total number of stations	169	121	82	206	28	14	51	18	70	6	18	5
Of which												
Traffic	31	50	37	50	18	2	29	13	20	1	2	1
Urban background	104	39	25	129	8	5	9	3	22	4	5	2
Industrial	19	14	9	17	0	0	11	1	8	0	2	0
Rural background	14	17	11	9	2	7	2	1	20	1	9	2
Other	1	1	0	1	0	0	0	0	0	0	0	0
Total reporting countries	37	36	32	38	31	25	35	32	37	17	27	24
Total number of stations 2009 data	2184	3268	2354	3015	826	675	1355	775	2246	408	745	545
Total number of stations 2008 data	2280	3233	2418	2842	559	624	1348	719	2227	296	637	484
Increase stations 2008/2009 data	-96	35	-64	173	267	51	7	56	19	112	108	61
Perc. Increase stations 2008/2009 data	-4%	1%	-3%	6%	48%	8%	1%	8%	1%	38%	17%	13%

Table 2 Number of stations for which 2009 data have been delivered for AQD & 4DD components, specified per country.

	SO2	NO2	NOx/NO	PM10	PM2.5	Pb_aer	CO	C6H6	O3	VOC-	HM4	PAH4
EU-27 countries												
AUSTRIA	108	155	134	143	13	18	41	22	113	0	18	19
BELGIUM	56	69	69	62	34	51	21	39	40	0	53	23
BULGARIA	27	23	16	41	7	8	16	17	19	7	12	13
CYPRUS	2	2	2	3	5	2	1	1	2	0	2	2
CZECH REPUBLIC	73	89	89	124	33	67	29	29	60	0	67	34
DENMARK	2	0	0	7	7	8	7	3	9	3	8	1
ESTONIA	9	9	9	7	6	2	7	2	9	0	2	2
FINLAND	10	30	28	31	10	1	6	8	19	8	7	6
FRANCE	271	495		384	81	35	91	28	446	0	33	24
GERMANY	162	438	387	450	111	132	134	65	284	64	182	119
GREECE	14	27	19	17	4	0	13	2	24	2	0	0
HUNGARY	24	24	23	25	3	0	21	12	17	12	6	16
IRELAND	12	14	14	17	5	5	6	3	11	1	8	5
ITALY	316	631	622	501	107	38	393	197	355	160	38	36
LATVIA	7	9	1	9	7	5	1	7	9	0	5	3
LITHUANIA	13	10	13	14	7	5	9	5	14	1	5	5
LUXEMBOURG	6	6	6	6	3	5	3	2	6	0	5	5
MALTA	4	3	2	4	3	4	4	3	4	3	4	3
NETHERLANDS	20	59	44	43	29	6	21	8	37	8	8	6
POLAND	211	248	121	222	31	98	67	61	65	1	85	92
PORTUGAL	54	65	65	56	23	0	40	5	48	0	0	0
ROMANIA	69	67	67	54	24	29	78	33	66	0	35	0
SLOVAKIA	12	16	16	31	4	6	10	9	14	0	6	8
SLOVENIA	22	11	10	12	4	4	5	2	12	2	6	3
SPAIN	458	497	387	438	150	92	249	143	394	124	93	80
SWEDEN	9	33	11	37	15	4	4	11	18	0	4	0
UNITED KINGDOM	44	117	117	71	72	36	27	40	81	6	35	35
Total EU-27 countries	2015	3147	2272	2809	798	661	1304	757	2176	402	727	540
non-EU-27 countries												
ALBANIA	3	3	0	2	0	0	0	0	2	0	0	0
BOSNIA - HERZEGOVINA	8	4	2	1	2	0	3	0	5	0	0	0
CROATIA	8	8	0	8	0	0	8	4	2	0	0	0
ICELAND	5	7	6	8	6	0	1	1	1	1	0	0
LIECHTENSTEIN	0	1	1	1	0	0	0	0	1	0	0	0
MACEDONIA, FYRO[1)]	28	15	15	15	0	0	14	0	13	0	0	0
MONTENEGRO	3	4	4	4	0	0	4	0	3	0	0	0
NORWAY	9	29	23	29	15	0	8	9	11	0	4	5
SERBIA	20	18	0	1	0	0	1	1	1	0	0	0
SWITZERLAND	11	32	31	27	5	14	12	3	31	5	14	0
TURKEY	74	0	0	110	0	0	0	0	0	0	0	0
Total non-EU-27 countries	169	121	82	206	28	14	51	18	70	6	18	5
Total number of stations 2009 data	2184	3268	2354	3015	826	675	1355	775	2246	408	745	545
Total number of stations 2008 data	2280	3233	2418	2842	559	624	1348	719	2227	296	637	484
Increase stations 2008/2009 data	-96	35	-64	173	267	51	7	56	19	112	108	61
Perc. Increase stations 2008/2009 data	-4%	1%	-3%	6%	48%	8%	1%	8%	1%	38%	17%	13%

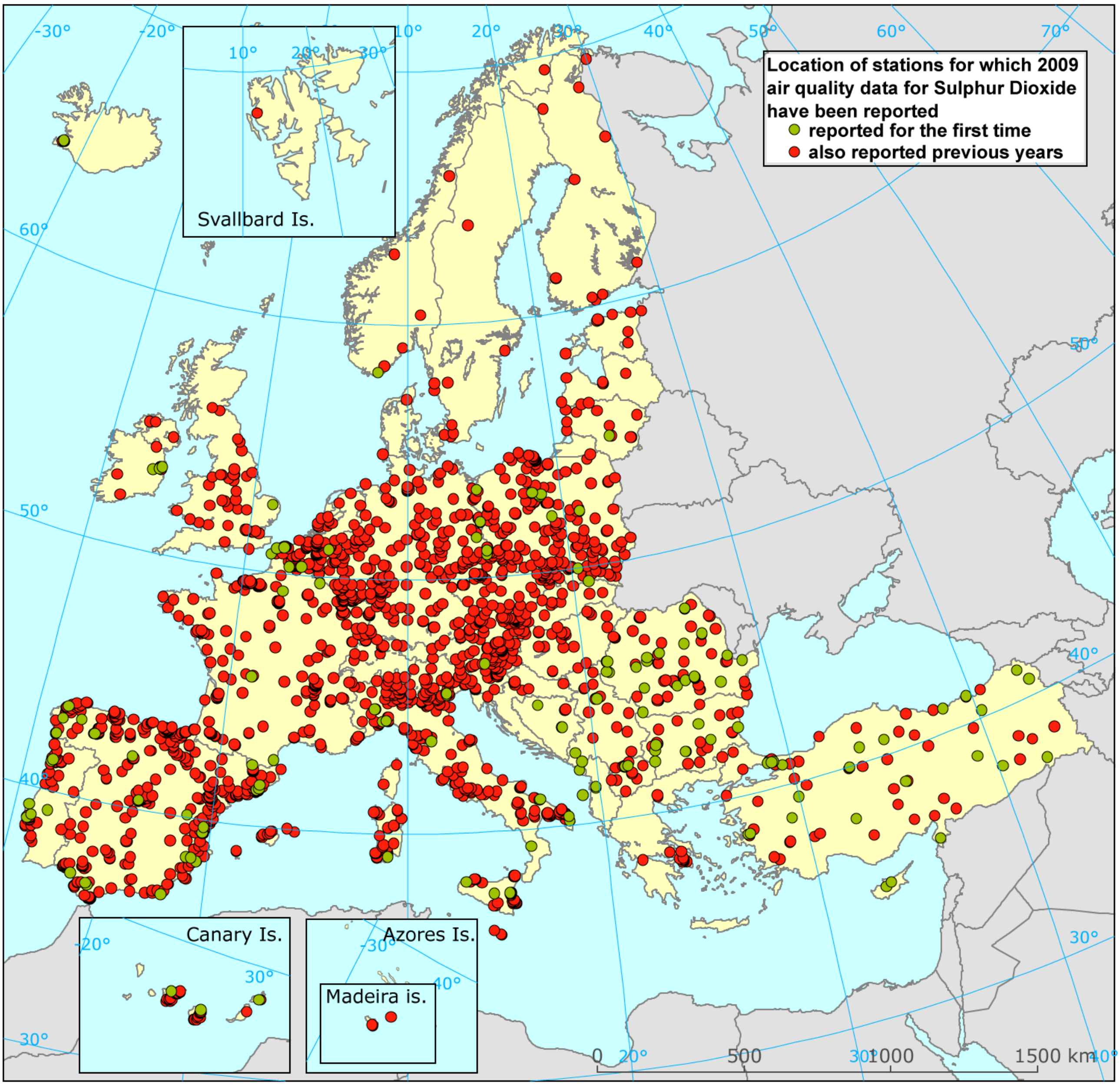


Figure 1 Location of stations for which 2009 air quality data for sulphur dioxide (SO_2) have been reported. The green stations report for the first time (new stations).

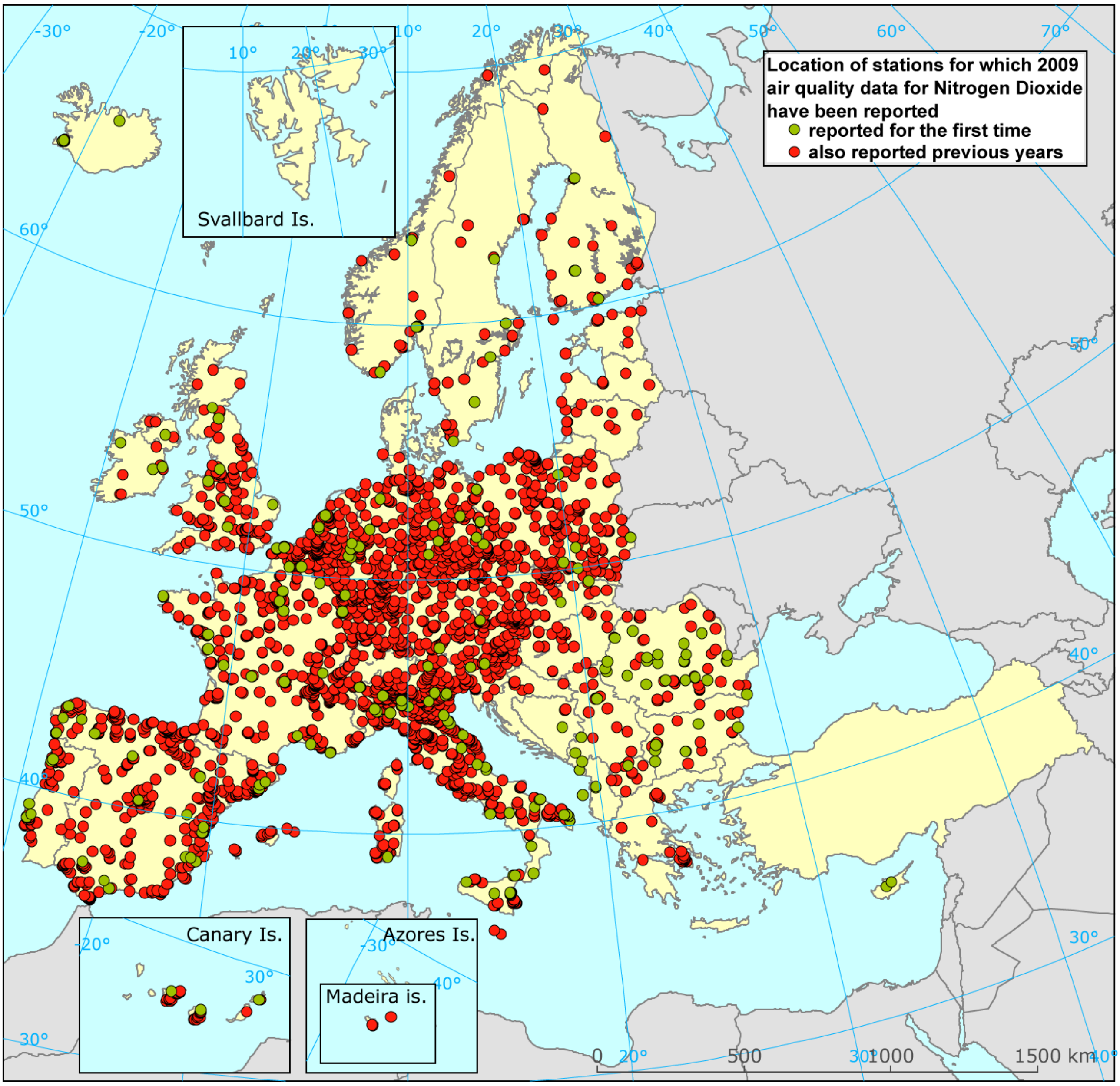


Figure 2 Location of stations for which 2009 air quality data for nitrogen dioxide (NO_2) have been reported. The green stations report for the first time (new stations).

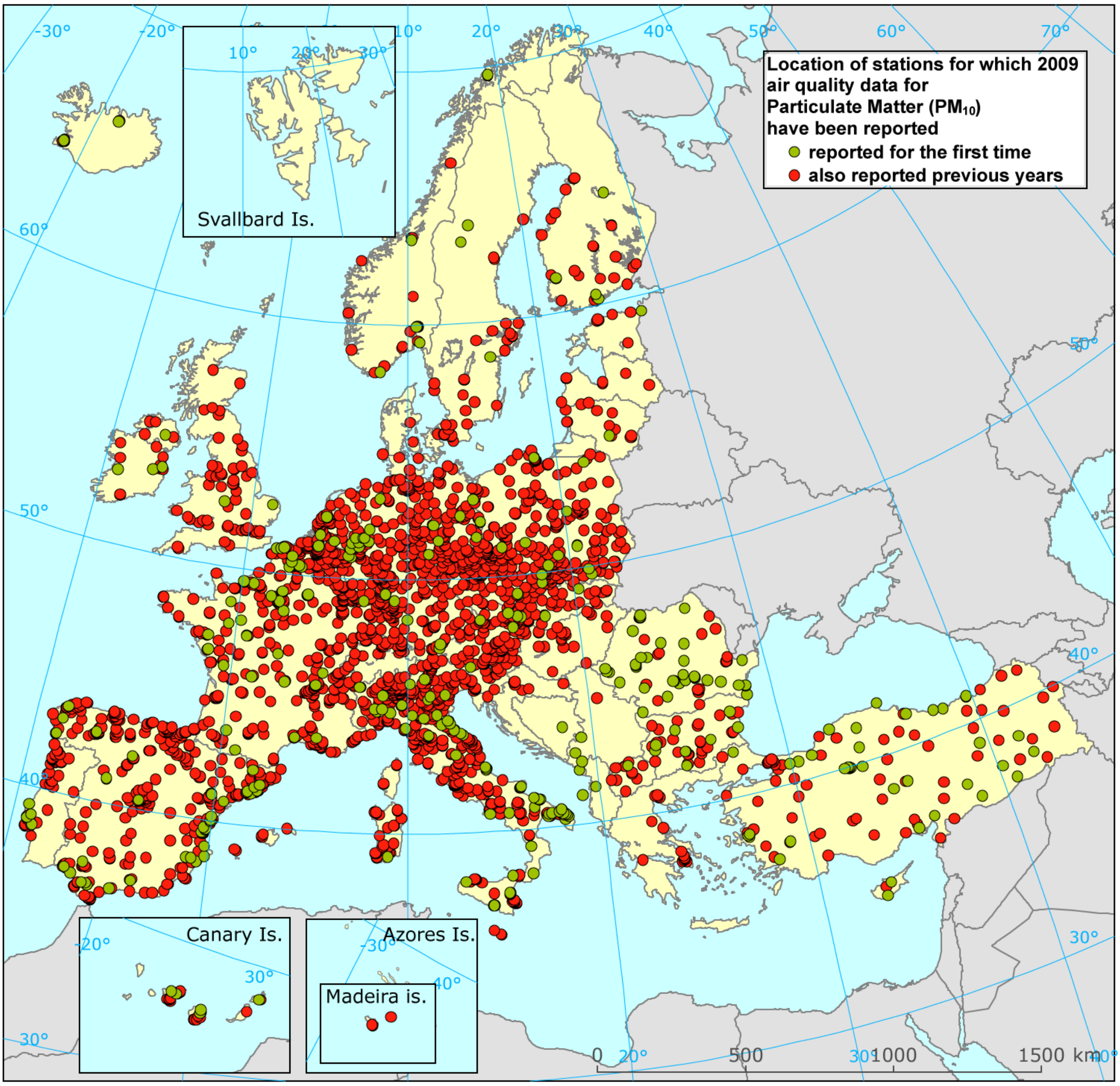


Figure 3 Location of stations for which 2009 air quality data for particulate matter (PM_{10}) have been reported. The green stations report for the first time (new stations).

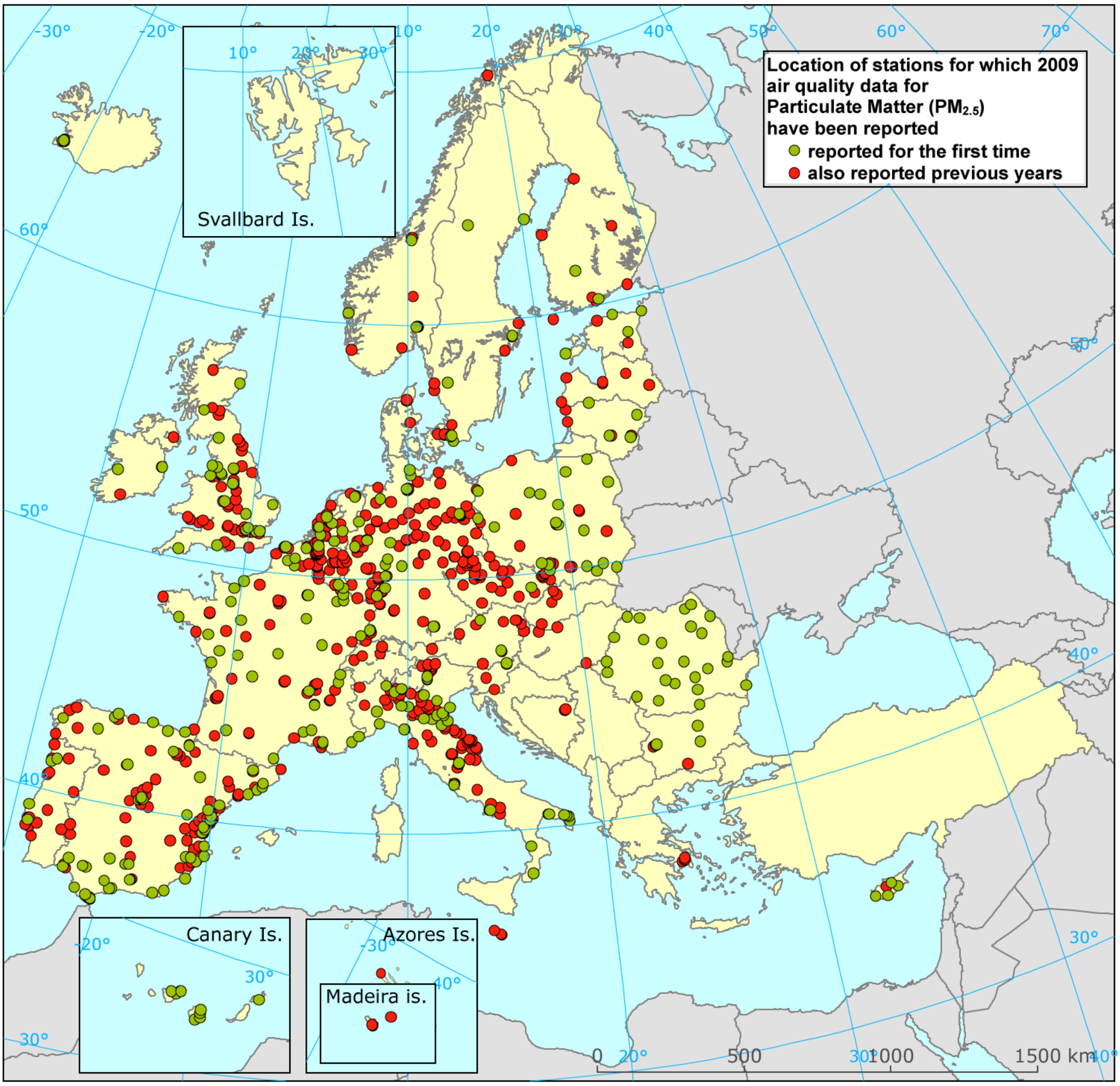


Figure 4 Location of stations for which 2009 air quality data for particulate matter ($PM_{2.5}$) have been reported. The green stations report for the first time (new stations).

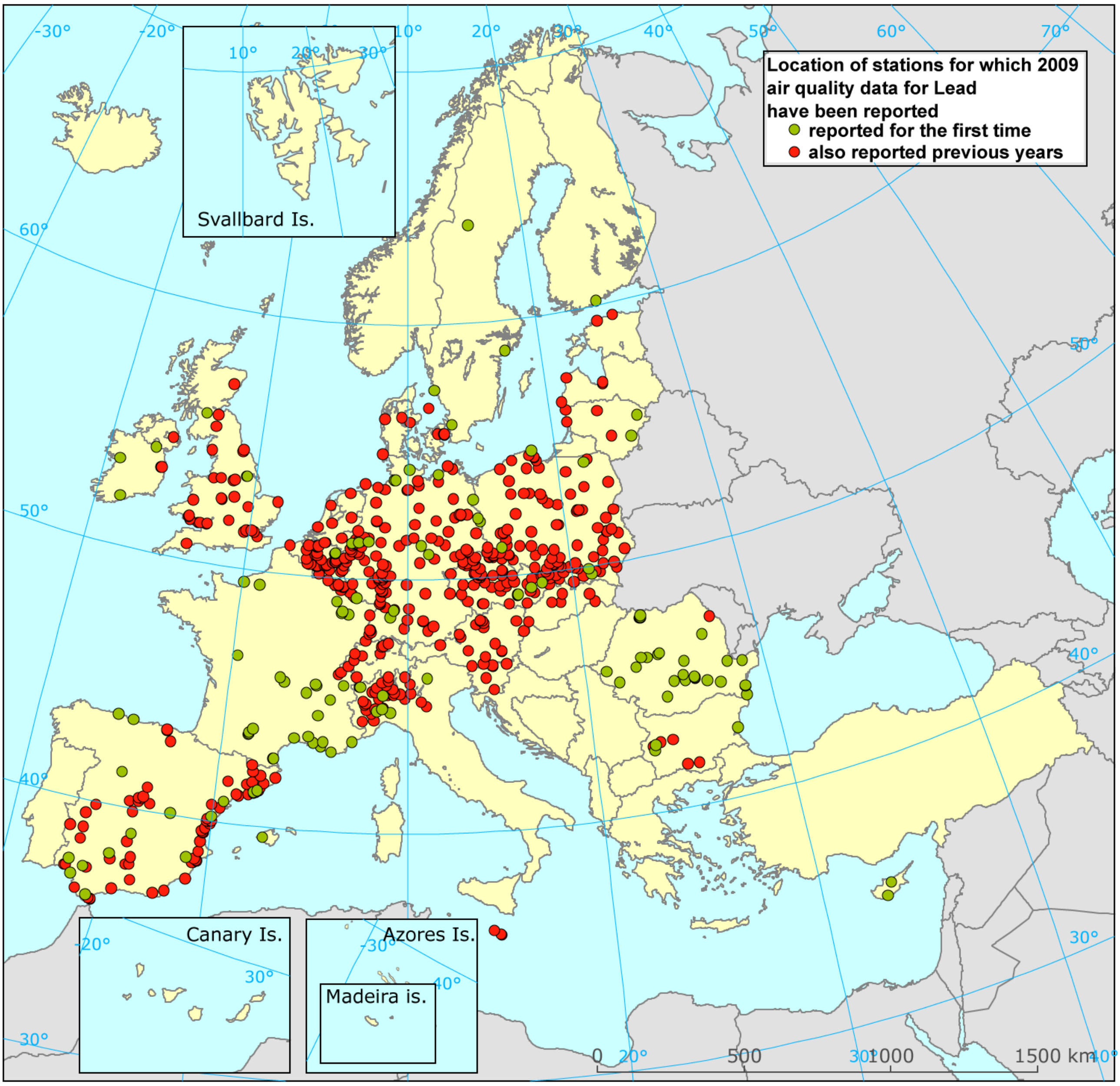


Figure 5 Location of stations for which 2009 air quality data for lead (Pb) have been reported. The green stations report for the first time (new stations).

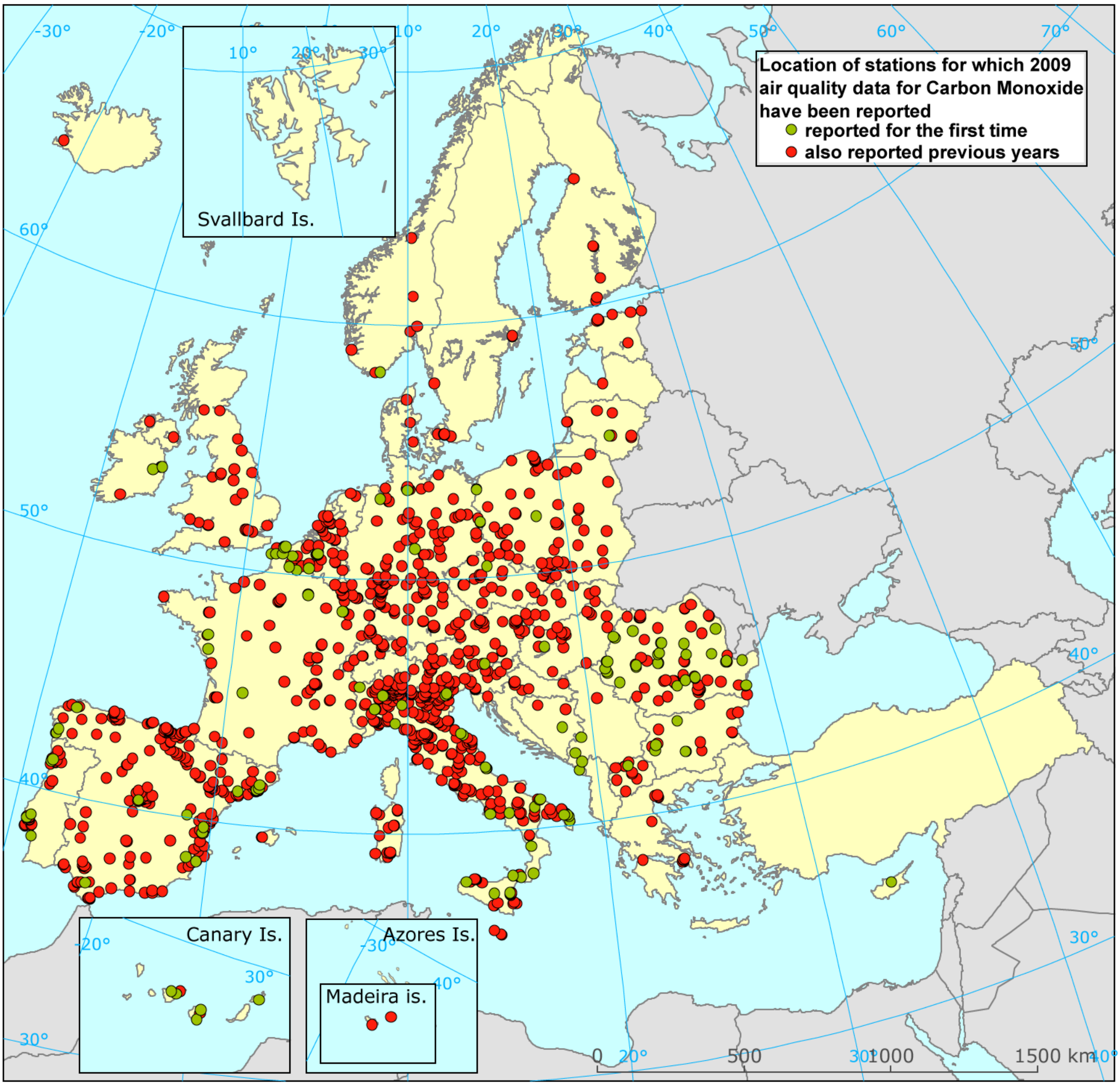


Figure 6 Location of stations for which 2009 air quality data for carbon monoxide (CO) have been reported. The green stations report for the first time (new stations).

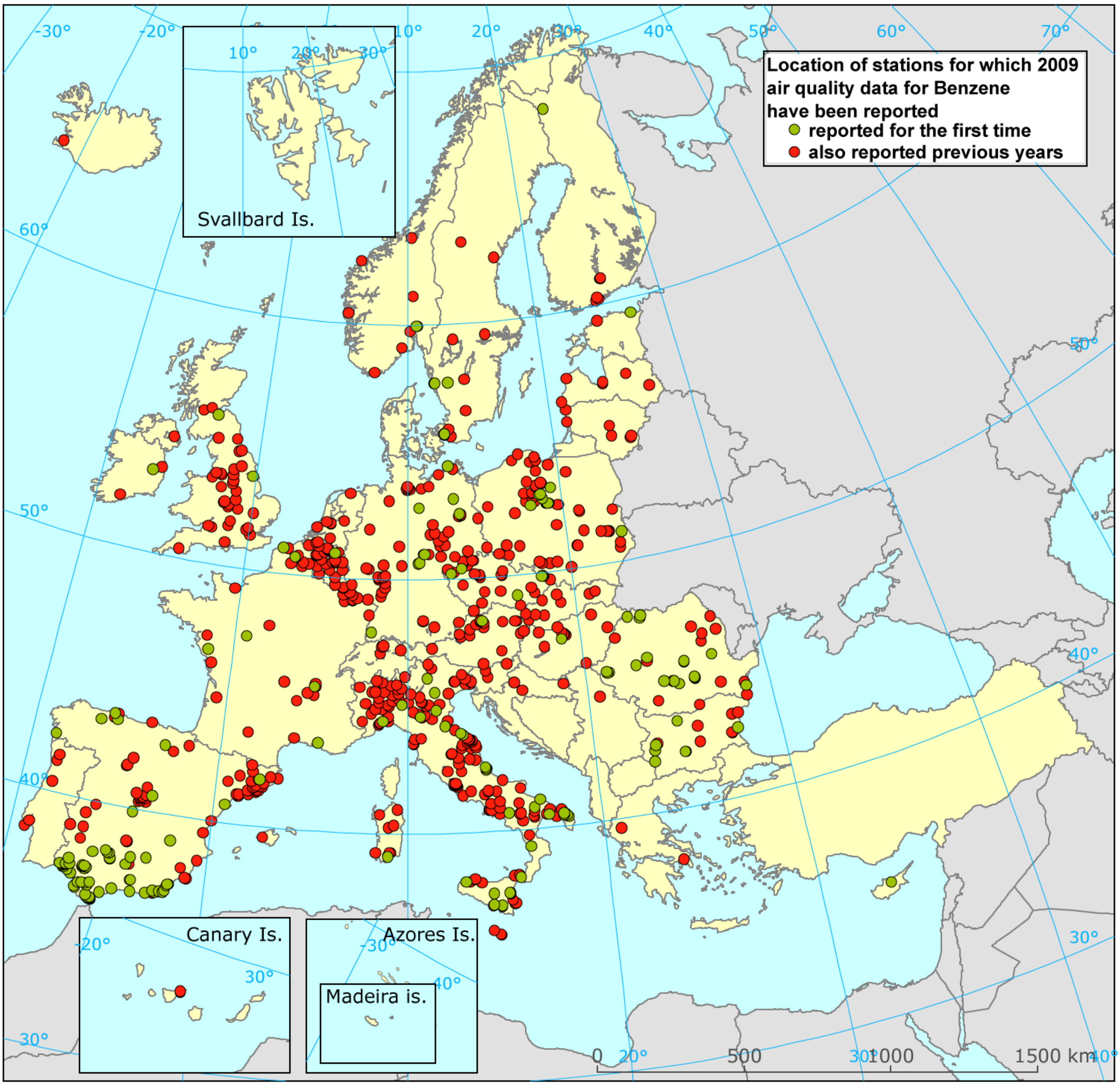


Figure 7 Location of stations for which 2009 air quality data for benzene (C_6H_6) have been reported. The green stations report for the first time (new stations).

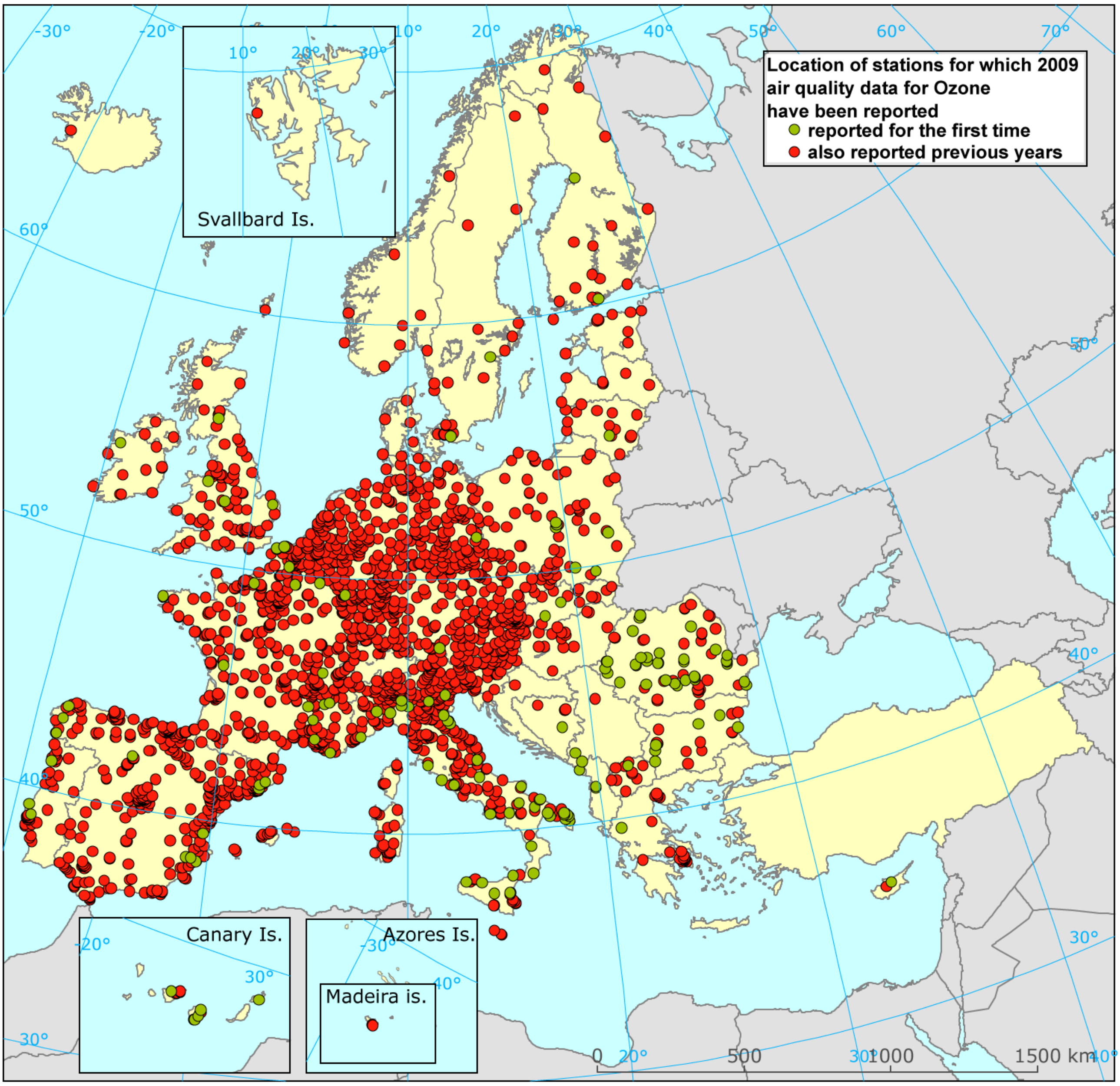


Figure 8 Location of stations for which 2009 air quality data for ozone (O_3) have been reported. The green stations report for the first time (new stations).

1.4. Total number of stations in AirBase

The total number of stations in AirBase is 7734, from which 7091 stations have measurement data (raw data and statistics). 19 stations have only invalid raw data and have therefore no calculated statistics. 178 stations have only reported statistics; no raw data have been delivered. The 446 stations without data are for instance:

- stations for which meta information has been delivered under the EoI but no measurement data;
- stations for which measurement data will be delivered;
- stations reporting NRT ozone[1] to the EEA and stations reporting SOR (3rd FWD/DD)[2] data which have not yet delivered for the EoI

Table 3 gives an overview of the number of station in AirBase 5 (with data until 2009); for comparison also the numbers for AirBase 4 (with data until 2008) have been given.

Table 3. Overview number of stations in AirBase 4 and 5

Selection of stations	Nr. of stations Airbase 4	Nr. of stations AirBase 5
Stations with only invalid raw data	79	19
Stations with only statistics	178	178
Stations with raw data and statistics	6622	7091
Stations without data	500	446
Total stations in AirBase	7379	7734

The EoI should cover at least the stations which are included in the FWD/Questionnaire (EU 2004b). MS are notified when stations and measurement configurations have been reported in NRT, SOR and the FWD/Questionnaire, but are not present in AirBase. They are requested to deliver the meta information of these stations and measurement configurations.

[1] http://www.eea.europa.eu/maps/ozone/welcome
[2] http://www.eea.europa.eu/maps/ozone/compare/summer-reporting-under-directive-2002-3-ec

1.5. Historical data, data coverage and time series

The total number of stations with data which are operational in 2009 is 4711 (see *Table 4*). This is an increase of 41 stations in comparison with the EoI2009. In the EoI2010 also historical data (2008 or earlier years) have been delivered, see *Table 5*.

Figure 9 gives information on the data coverage of the 2009 stations. The number of stations with data coverage >0% (all operational 2009 stations) have been compared with the number of stations with >=75% and >=90% data coverage[1]. In table D you can also find information on data coverage, see “Information on time series in AirBase” http://acm.eionet.europa.eu/databases/airbase/eoi_tables/eoi2009/index_html.

Long-term measurement series provide valuable information for determining, for example, the effect of abatement measures and trend analysis. Keeping in mind that AirBase became operational in 1997, the average length of the time series in AirBase can also be found in table D. Note that the length of the time series in years in table D is calculated regardless of the data coverage in a year. The calculation is also based on any averaging time. If there is a gap of one or more years, the maximum length of time series is taken. For the average length of time series all stations available in AirBase have been included.

The number of stations with continuous time series is visualized in *Figure 10* for several components.

[1] The data quality objectives as laid down in the Daughter Directives require, in general, a data coverage of 90%. For continuous measurements in the assessments presented here (chapter 2) a criterion of 75% data coverage is applied.

Table 4 Summary of periods and number of stations for which data have been delivered.

Country	Air quality reporting Start/end year [1)]	Number of stations for which data have been delivered for at least one year in the whole period [1)]	Number of stations for which 2008 data have been delivered in EoI2009 [1)]	Number of stations for which 2009 data have been delivered in EoI2010 [1)]
EU-27 countries				
AUSTRIA	1981-2009	255	195	193
BELGIUM	1985-2009	341	233	226
BULGARIA	1998-2009	41	32	41
CYPRUS	1993-2009	7	2	6
CZECH REPUBLIC	1992-2009	188	171	174
DENMARK	1976-2009	40	14	14
ESTONIA	1997-2009	11	9	9
FINLAND	1990-2009	92	51	56
FRANCE	1976-2009	1064	725	700
GERMANY	1976-2009	1149	550	545
GREECE	1983-2009	37	29	29
HUNGARY	1996-2009	45	32	32
IRELAND	1973-2009	102	26	29
ITALY	1976-2009	1075	708	707
LATVIA	1997-2009	19	12	12
LITHUANIA	1997-2009	25	17	18
LUXEMBOURG	1976-2009	14	8	8
MALTA	2002-2009	7	3	4
NETHERLANDS	1976-2009	92	68	78
POLAND	1997-2009	474	418	389
PORTUGAL	1986-2009	101	62	67
ROMANIA	1999-2009	154	103	107
SLOVAKIA	1995-2009	56	36	37
SLOVENIA	1996-2009	32	29	30
SPAIN	1986-2009	785	582	601
SWEDEN	1985-2009	77	51	55
UNITED KINGDOM	1969-2009	644	265	270
Total		*6927*	*4431*	*4437*
Non-EU-27 countries				
ALBANIA	2009-2009	3		3
BOSNIA - HERZEGOVINA	1985-2009	21	4	8
CROATIA	2004-2009	8	8	8
ICELAND	1993-2009	12	4	9
LIECHTENSTEIN	2004-2009	2	1	1
MACEDONIA, FYRO [2)]	1997-2009	46	34	30
MONTENEGRO	2009-2009	4		4
NORWAY	1994-2009	57	34	46
SERBIA	2002-2009	26	22	20
SWITZERLAND	1991-2009	47	34	32
TURKEY	2007-2009	116	98	113
Total		*342*	*239*	*274*
Total EU-27 + non-EU-27 countries		*7269*	*4670*	*4711*

1) Irrespective of the component(s) measured
2) FYRO= Former Yugoslavian Republic Of

Table 5 Number of stations delivering historical data (2008 or earlier years) in the EoI 2010

Country	Number of stations for which 2008 data have been delivered in EoI2010 1)	Number of stations for < 2008 data have been delivered in EoI2010 1)
EU-27 countries		
AUSTRIA	14	19
CYPRUS	6	0
CZECH REPUBLIC	4	0
DENMARK	12	0
FINLAND	7	0
LATVIA	2	0
NETHERLANDS	41	35
ROMANIA	1	0
SLOVAKIA	3	0
SLOVENIA	6	0
SPAIN	1	0
Total	*97*	*54*
Non-EU-27 countries		
SWITZERLAND	1	15
Total	*1*	*15*
Total EU-27 + non-EU-27 countries	*98*	*69*

1) Irrespective of the component(s) measured

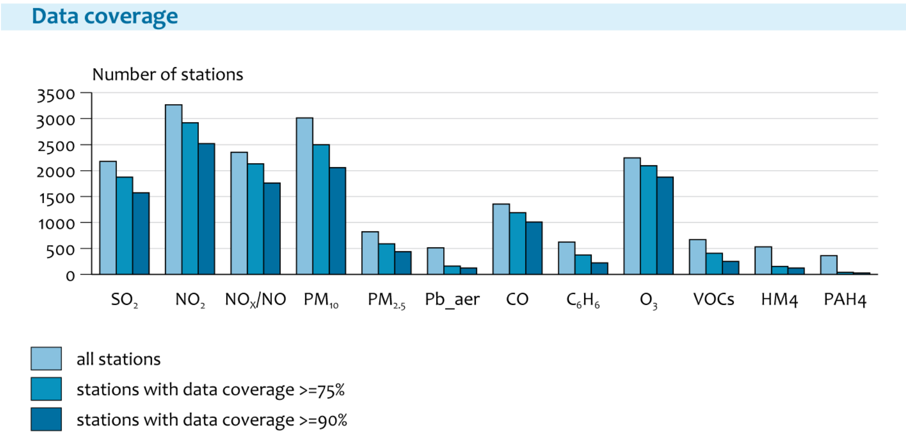


Figure 9 Number of stations with 2009 data coverage >0% (with data), >=75% and >=90%. Data coverage is based on daily averages for SO_2, NO_2, NO_x/NO, PM_{10}, $PM_{2.5}$, Pb_aer, benzene, VOC, HM4 and PAH4 and based on daily running 8h maximum for CO and O_3

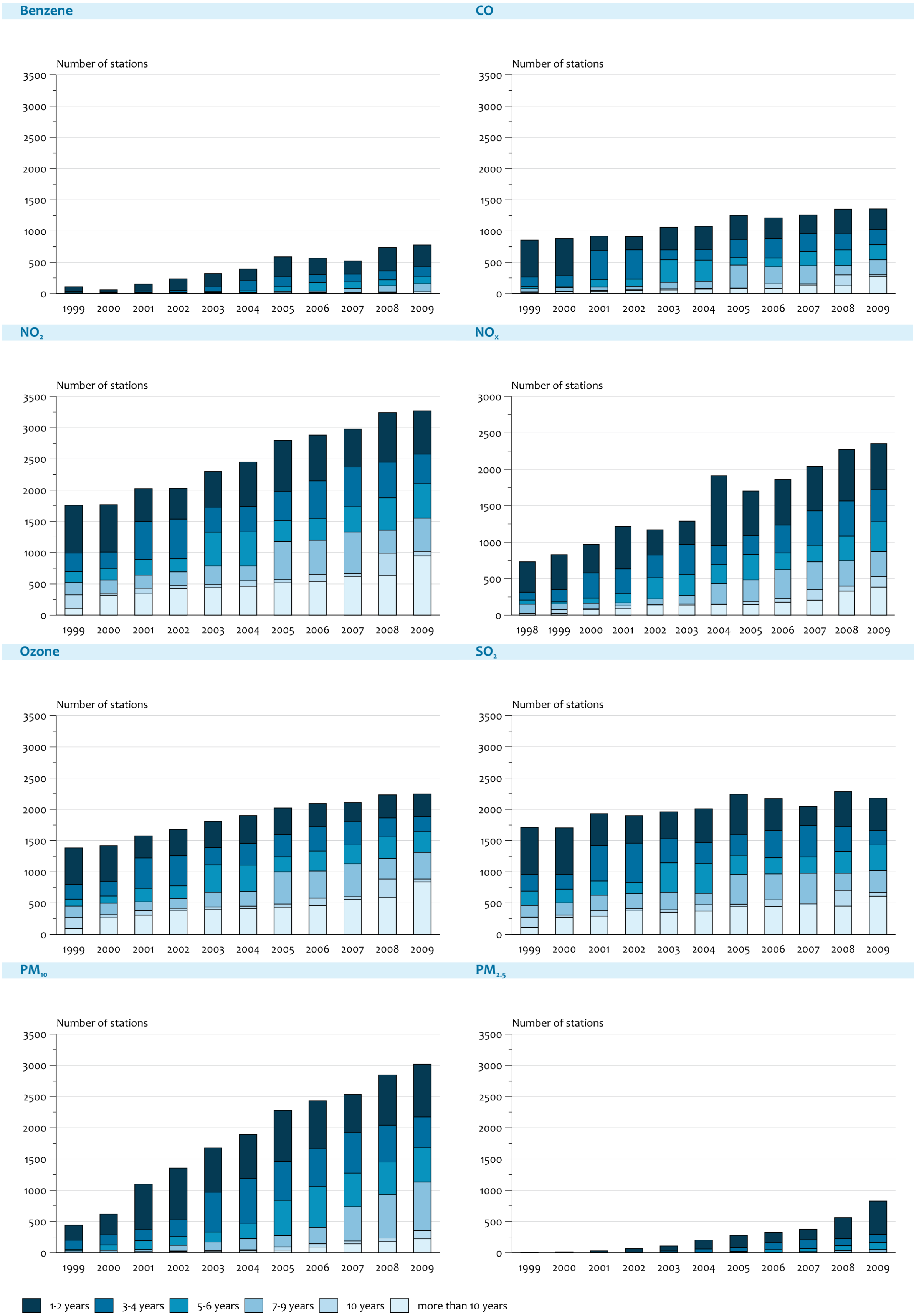


Figure 10 Number of stations with time series of 1-2, 3-4, 5-6, 7-9, 10 and more than 10 year ending in the year on the x-axis for several components.

2. STATE OF THE AIR QUALITY FOR SELECTED POLLUTANTS

2.1. Introduction

In addition to the more technical aspects of the 2009-data submission process, this section will present a preliminary evaluation of the 2009 air quality data. More extensive discussions on the state of the European ambient air has and will be provided in the air pollution and related reports prepared by EEA and ETC/ACM (e.g. as part of the State of the Environment report (EEA 2010) and the forthcoming report on European Air Quality (EEA, 2011 in preparation)).

This section will briefly describe the current (2009) air quality status and the long-term changes in concentrations are also discussed. Focus will be on the pollutants listed in the Air Quality Directive (EU, 2008), that is, SO_2, NO_2, PM_{10} and $PM_{2.5}$, CO, C_6H_6 and O_3. Lead and the other heavy metals listed in the 4th Daughter Directive (EU, 2004a) will only briefly be discussed; an analysis (Barrett *et al.* 2008) has shown that, with the exception of a few (industrial) hotspots, the heavy metal concentrations are well below the limit (LV) or target value (TV). Benzo(a)pyrene (B(a)P) forms a potential risks for human health in various parts of Europe. The concentrations measured in 2009 will be compared with the limit and target values as set in the Directives, see *Table 6*.

The air quality in 2009 is described here in a number of maps showing annual mean concentrations together with availability and geographical distribution of the reporting stations. The air quality in relation to the limit or target values is presented in so-called distance-to-target graphs. In these graphs for each station type the (relative) frequency distribution of concentrations measured at each station type is shown. The station types are: rural (=rural background), urban (= (sub)urban background), traffic and other (which is mainly industrial). In each graph the bin size equals 10% of the limit or target value, for example in the distance-to-target graph of the PM_{10} annual mean value, the concentration bins runs from 0-4; 4-8; 8-12; 12-16 µg/m^3 ; ...etc. In case the limit value is expressed as a maximum allowable number of exceedances (N_{exc}) of a specified threshold value, the (N_{exc}+1)th highest value has been evaluated: the limit value is respected if this concentration is below the threshold level.

In the maps, distance-to-target graphs and in the trend graphs only stations having a data coverage of more than 75% have been included; for benzene the data coverage criterion has been set to 50% (Working Group on benzene, 1998) while for the heavy metals and B(a)P a coverage criterion of 14% is used (Mol *et al*, 2010).

The statistical data presented here has been extracted from the AirBase metadata files by means of an Excel macro. This macro extracts and selects statistical data, aggregated exceedance information and relevant meta information (see Annex B for a description of the available statistical data) for a pollutant, period and countries defined by the user. The macro is available at the ETC/ACM web site[1]; the AirBase metadata is in the form of XML-files available from the EEA data service[2].

[1] See http://acm.eionet.europa.eu/databases/airbase/airbasexml/index_html for the macro and additional documentation.

[2] See http://www.eea.europa.eu/data-and-maps/data/airbase-the-european-air-quality-database-3 ; the most convenient is to download the *all country XML-file*.

Table 6. Limit and target values defined by the EU for SO_2, NO_2, NO_x, PM_{10}, $PM_{2.5}$, lead, benzene, CO, O_3, arsenic, cadmium, nickel and benzo(a)pyrene to be met in 2009 unless indicated otherwise.

Pollutant	Protection target	period	Limit and target values (µg/m3) (d)	No of allowed exceedances	Target date
SO_2	Human health	Hourly average	350 µg/m3	24 hours/yr	
	Human health	Daily average	125 µg/m3	3 days/yr	
	Vegetation	Annual average	20 µg/m3		
	Vegetation	winter average	20 µg/m3		
NO_2	Human health	Hourly average	200 µg/m3	18 hours/yr	1 Jan 2010
	Human health	Annual average	40 µg/m3		1 Jan 2010
NOx	Ecosystems	Annual mean	40 µg/m3 (e)		
PM_{10}	Human health	Daily average	50 µg/m3	35 days/yr	
	Human health	Annual average	40 µg/m3		
$PM_{2.5}$	Human health	Annual average	25 µg/m3		1 Jan 2015 (b)
	Human health	Averaged exposure indicator (AEI)	20 µg/m3	based on 3 year average	2015
	Human health	Exposure reduction target	Percentage reduction (c)	based on 3 year average	2020
lead	Human health	Annual average	0.5 µg/m3		
CO	Human health	8h running average (a)	10mg/m3		
benzene	Human health	Annual average	5 µg/m3		1 Jan 2010
ozone	Human health	8h running average (a)	120 µg/m3 (TV)	25 days/yr	1 Jan 2010
	Vegetation	AOT40 (f)	18 (mg/m3).h (TV)		1 Jan 2010
arsenic	Human health	Annual average	6 ng/m3 (TV)		1 Jan 2012
cadmium	Human health	Annual average	5 ng/m3 (TV)		1 Jan 2012
nickel	Human health	Annual average	20 ng/m3 (TV)		1 Jan 2012
benzo(a) pyrene	Human health	Annual average	1 ng/m3 (TV)		1 Jan 2012

(a) daily maximum of 8h running averaged concentrations
(b) enters into force 1 Jan 2010 as target value
(c) percentage reduction depending on the AEI value in 2010
(d) limit value unless indicated otherwise
(e) measured as NO2
(f) see Annex B for definition and calculation method

2.2. 2009 Air Quality Status

The *Figures 11* until *37* show the observed concentration maps, distance-to-target plots and trend plots/maps for the components mentioned in the AQ directive.

2.2.1. Nitrogen dioxide (NO_2)

The limit value of the annual mean NO_2 concentration is 40 µg/m³ and has to be met in 2010. For 2009 the limit value plus margin of tolerance (MOT) is 42 µg/m³. The annual mean NO_2 concentrations are given in *Figure 11*. Distance-to-target graphs for the long-term NO_2 limit value is given in *Figure 12* and for the short-term NO_2 limit value in Annex E (*Figure E.1*).

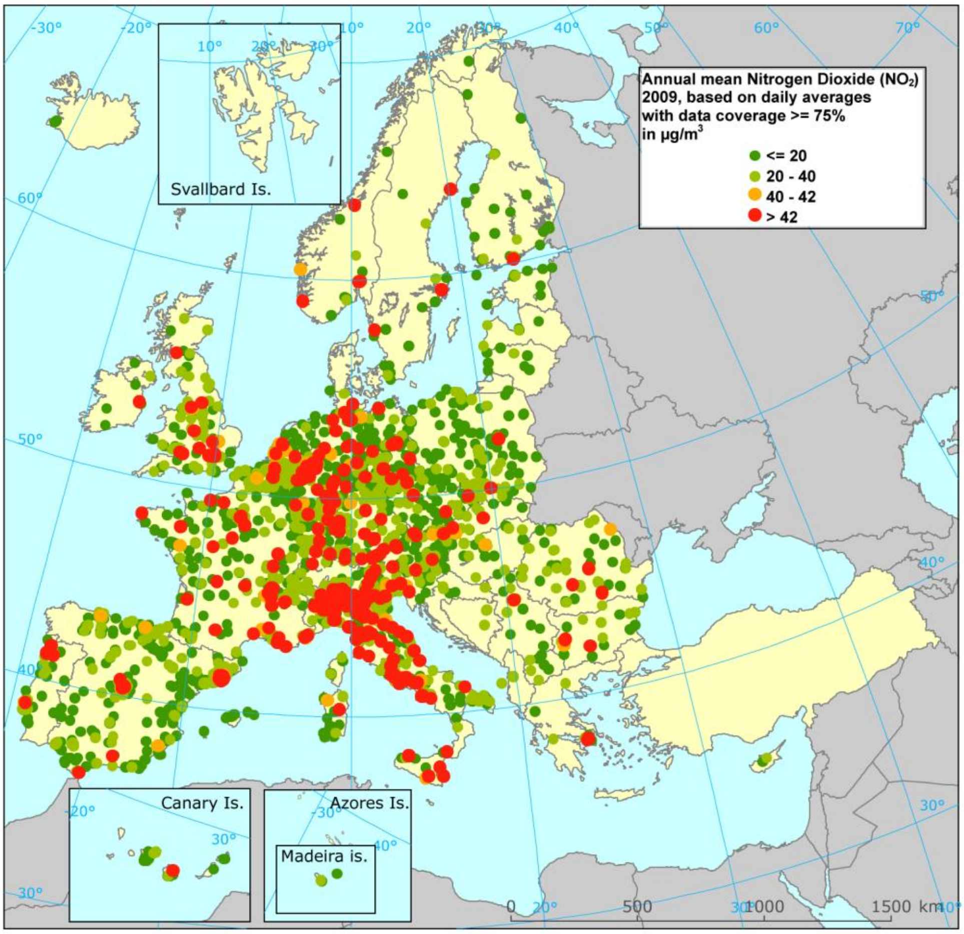


Figure 11. Annual mean concentration map of NO_2 (µg/m³); the two highest concentration classes correspond to the limit value (40 µg/m³) and limit value plus margin of tolerance (42 µg/m³), respectively; reference period 2009.

In nearly all countries at one or more stations exceedances of the LV and of the LV+MOT are observed. Most frequently these exceedances are observed at traffic stations, see the distance-to-target plot (*Figure 12*). The different concentration levels at rural, urban and traffic stations are clearly seen in the distance-to-target plots: while the LV is not exceeded in the rural background, it is exceeded at 47% of the traffic stations with a maximum observed concentration of 112 µg/m³ at a station in Stuttgart. At 57 (sub)urban stations (5%) an

exceedance of the limit values is observed. In 2009 the NO_2 annual limit value plus margin of tolerance has been exceeded at 41% of the traffic stations, see *Figure 12*.
Exceedances are rather persistent: 193 stations operational in the 5-year period 2005-2009 showed each year an exceedance; the number of stations where the limit value has been exceeded uninterruptedly over the past four or three years is 242 and 293, respectively; this corresponds to about 13% of the stations operational during the whole period of three or four years. The increase in number of stations does not necessarily reflect a worsening of air quality but rather an increase in the number of reporting stations: the difference of 51 stations (= 293-241) consists of 46 stations where reporting started in 2007. The long-lasting exceedances are mostly observed at traffic stations. The impact of an increasing number of diesel cars leading to an increased fraction of direct NO_2 emissions might counteract the effect of reductions in the NO_x emissions from road transport. A more extensive discussion on the NO_2 hotspot situations is given by Guerreiro et al (2011).
The hourly limit value of NO_2 is less stringent with exceedances at about 1 and 8% of the urban and traffic stations, respectively (see *Figure E.1*).

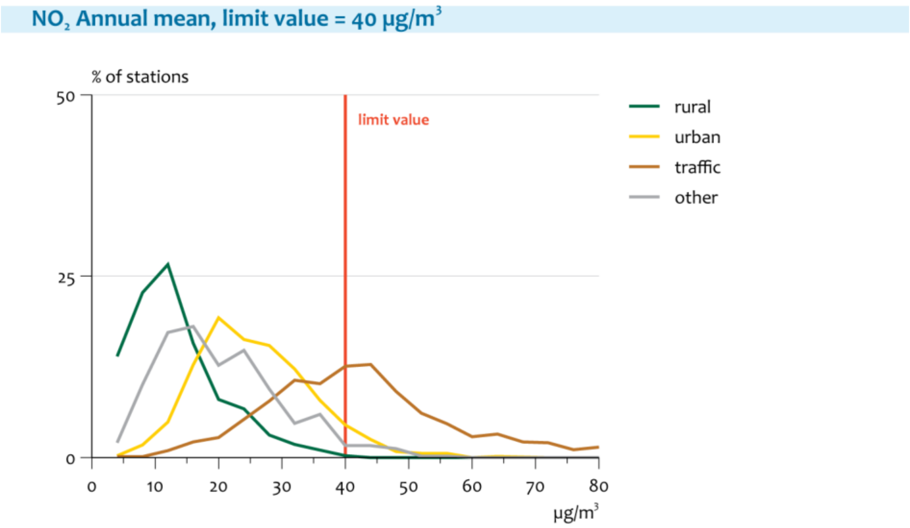


Figure 12. Distance-to-target graphs for the long-term NO_2 limit value, reference year 2009.

The trend in NO_2 and NO_x concentration over the period 1999-2009 is summarized in *Figures 13 and 14*. Although for both pollutants a consistent set of stations (see Annex F for a description of the trend methodology and data selection criteria) is used, the spatial distribution of the stations over Europe differs. This will hamper a direct comparison between the two sets of trend estimates. The top panel shows decreasing NO_2 and NO_x concentrations at all station types but the NO_x reduction is larger than the NO_2 reduction. In the NO_x-case the order of rural-urban-traffic reflects the closeness of the sources. In the NO_2 case the reduction at traffic stations clearly lacks behind the reduction at rural and urban stations. The relative increase in direct NO_2 emissions from diesel cars and chemical non-linearities might form an explanation.
In *figures 13* and *14* the differences in trends at (sub)urban background and (sub)urban traffic stations is compared. At the background level the situation is relatively clear: the NO_2 levels are decreasing at 81% of the stations (at 44% of the stations, there is a significant trend). Similar numbers (80% and 45%, respectively) are estimated for the NO_x stations although annual changes are larger than in case of NO_2. At traffic stations the NO_2 trends are slightly less significant and less downward. At 88% of the traffic locations NO_x is going (strongly) downwards reflecting the changes in emissions from road traffic.
The maps in Figure 14 show the spatial distribution of the stations. Although there are some regions where stations having a upward trend seem to cluster (Austria, Italy), in most areas stations having both upward and downward trends are observed.

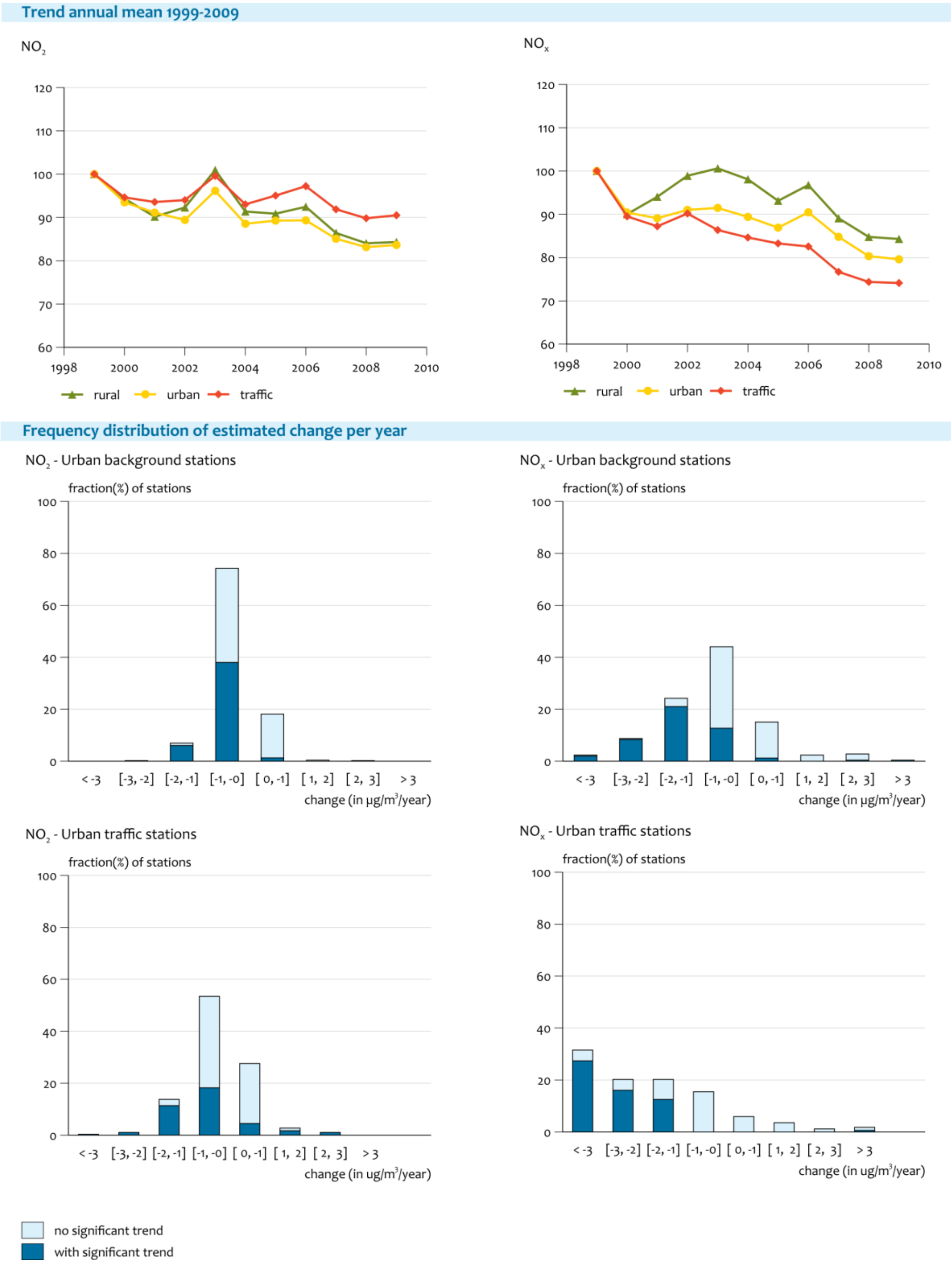
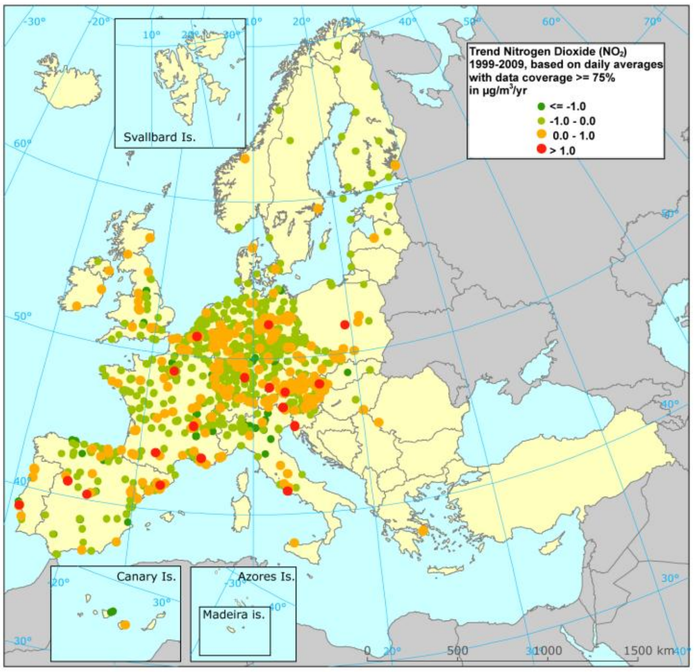


Figure 13. Overview of trend analysis of NO_2 and NO_x concentrations, period 1999-2009. Left part relates to NO_2, right part to NO_x. NO_x concentrations are expressed in µg NO_2/m^3. From top to bottom:

- *indexed trend (reference year 1999) at rural, urban and traffic stations*
- *frequency distribution of estimated change per year (in µg/m³ per year) at (sub)urban background stations; closed bars refer to stations having a significant trend, open bars to station having a non-significant trend*
- *similar but now for urban traffic stations*



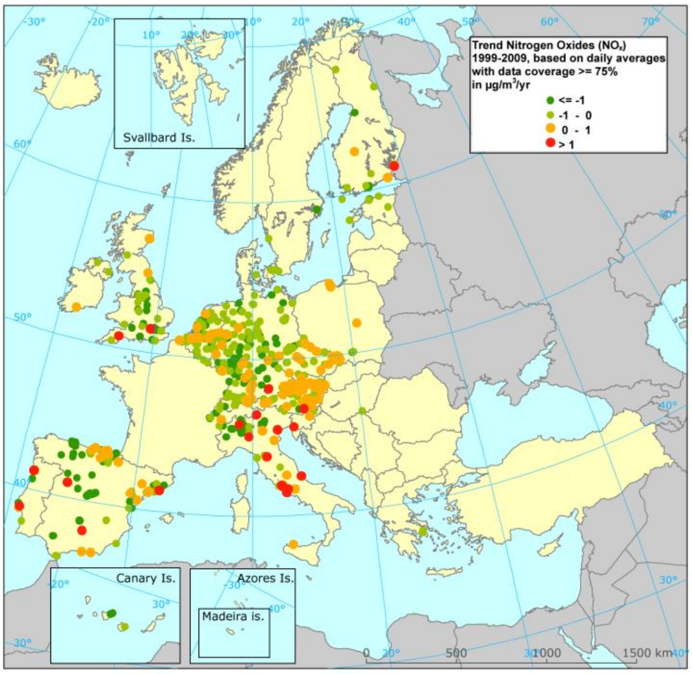


Figure 14. Spatial distribution and estimated trend at all stations used in the trend analysis of NO_2 and NO_x concentrations, period 1999-2009. NO_x concentrations are expressed in µg NO_2/m^3.

2.2.2. Sulphur dioxide (SO_2)

The annual mean SO_2 concentrations are given in *Figure 15*; like in 2008 the highest concentrations are observed in the West Balkan countries and Turkey. The distance-to-target graph for the daily limit value of SO_2 is given in *Figure 16*. The other distance-to-target graphs (for the hourly limit value of SO_2 as well as for the two limit values set for the protection of vegetation (annual mean and winter period mean (October 2008 – March 2009)) are given in Annex E (*Figures E.2, E.3 and E.4*).
The limit value set for the protection of vegetation (20 µg/m³ as annual mean) has been exceeded at 3% of the stations; however, none of the exceedance stations are classified as rural background; the vegetation limit value might not be applicable here. As emissions tend to be higher and dispersion condition are worse during winter periods, the concentrations during the winter 2008/2009 are on the average slightly higher than those during the year 2009. The more stringent limit value for the protection of vegetation set for a winter period (20 µg/m3) is exceeded at one rural station. The hourly and daily limit values set for the protection of human health have been exceeded at 1 and 2 % of the urban stations, respectively.

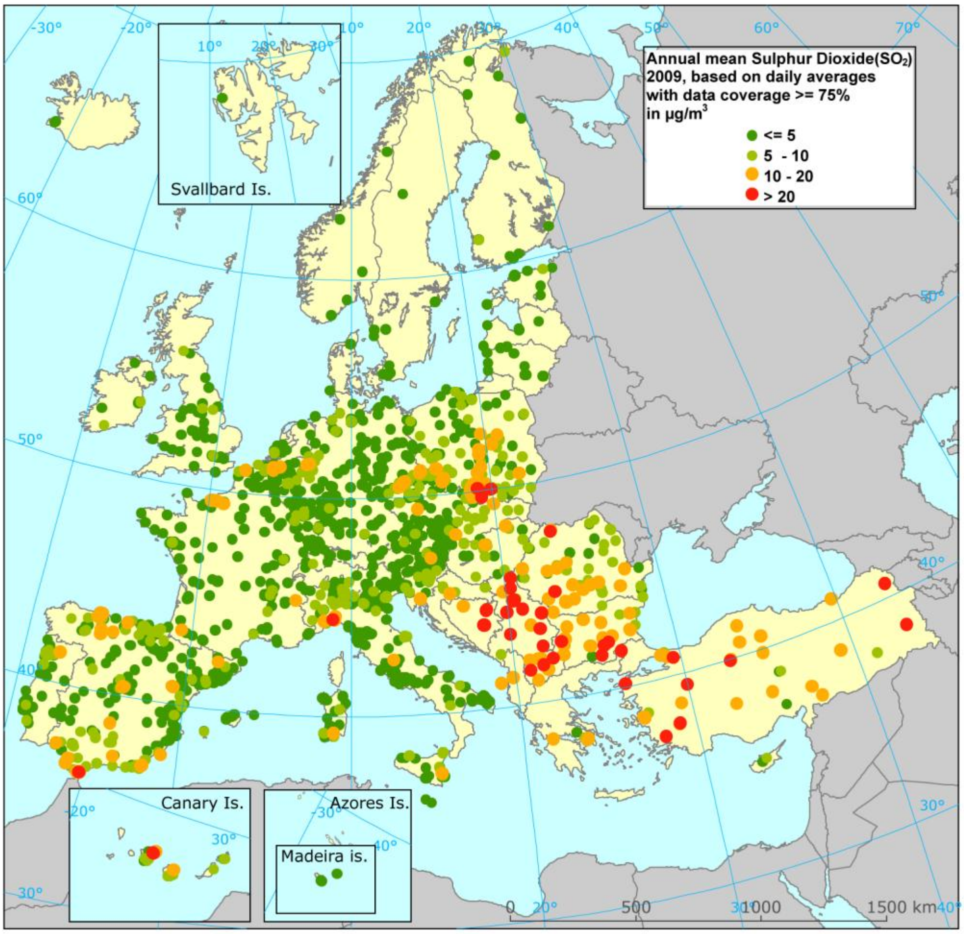


Figure 15: Annual mean concentration map of SO_2 (µg/m³), 2009; the highest concentration class corresponds to the limit value (20 µg/m³) set for the protection of vegetation.

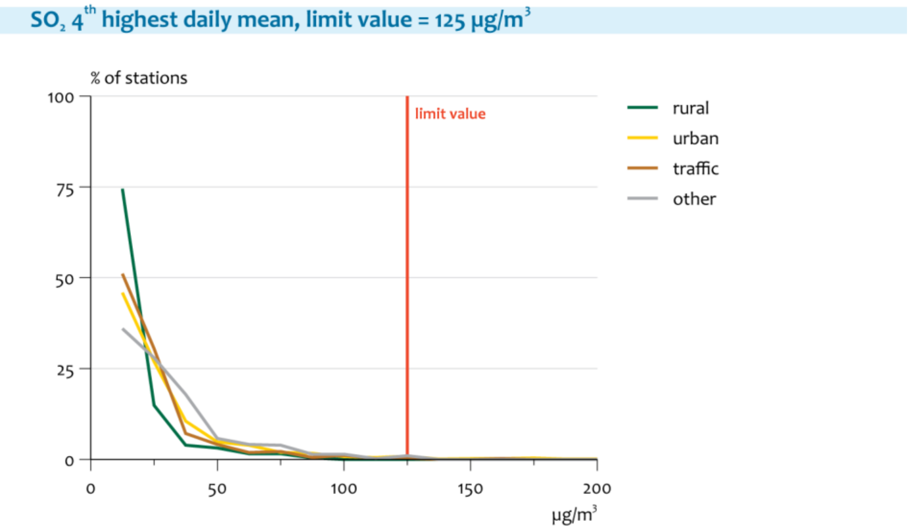


Figure 16: Distance-to-target graphs for the daily limit value of SO_2, 2009.

The SO_2 concentrations show a steady decrease over the period 1999-2009 (see *Figure 17*). At all station types the concentrations decreased by more than 50% over the last 11 years. The average concentration at traffic stations is on average about 1 µg/m³ higher than at the urban background stations. Although the sulphur content in motor fuel is very low, the closeness of traffic stations to the traffic flow and emissions might explain the difference in concentration level.

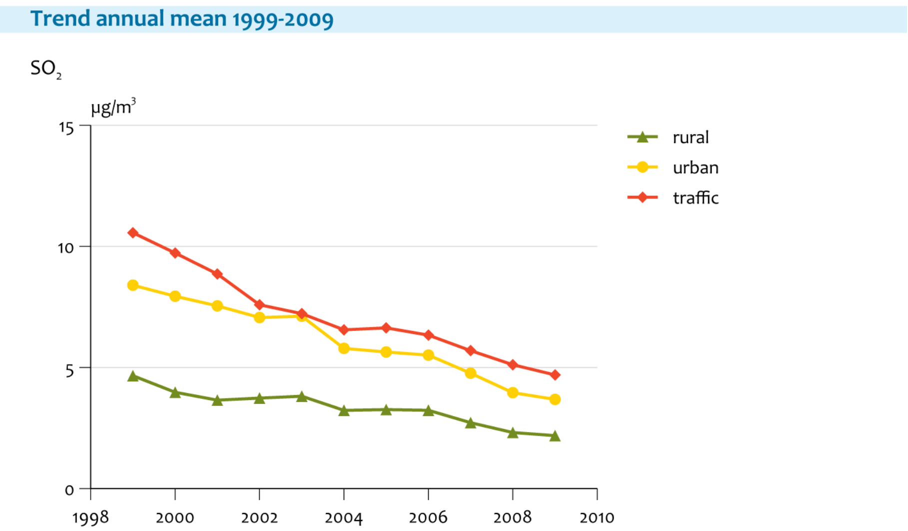


Figure 17: Trend in SO2 concentrations per station type, period 1999-2009. Only stations operational during nine years in the period 1999-2009 have been included.

2.2.3. Particulate Matter

Figure 18 shows the annual mean concentrations of PM_{10}; both the exceedances of the annual limit values as well as stations where most likely the short-term (daily) limit value is exceeded are shown (the daily mean values may not exceed 50 µg/m³ on more than 35 days per year). A statistical analysis of the monitoring data indicated that the daily PM_{10} limit value corresponds to an annual mean of 31 µg/m³ (see e.g.: Buijsman *et al.* 2005; Stedman *et al.*

2007). The map indicates that both limit values have been exceeded in many countries across Europe.

For PM_{10}, the annual limit value was exceeded (red dots) particularly in Poland, Italy, Slovakia, several Balkan states, Turkey and a few regions in Spain. The daily limit value was additionally exceeded (yellow dots) in several more cities in the mentioned countries as well as in many other countries in central Europe and in France. Also cities in Sweden and Latvia had exceedances of the daily limit value. In the UK, exceedances were measured only in London.

The extent of exceedance of the annual and daily limit values of PM_{10} is given in the distance-to-target graphs (see *Figure 19 for the* short-term (daily) limit value of PM_{10} and annex E (*Figure E.5*) for the annual limit value of PM_{10}). Comparing the figures it is clear that the daily limit value is exceeded to a larger extent than the annual limit value. Exceedance of both limit values is observed at all types of stations with increasing numbers from rural to urban to traffic stations. The daily limit value is frequently exceeded at urban background stations (about 28% of stations) and at traffic stations (more than 32% of stations).

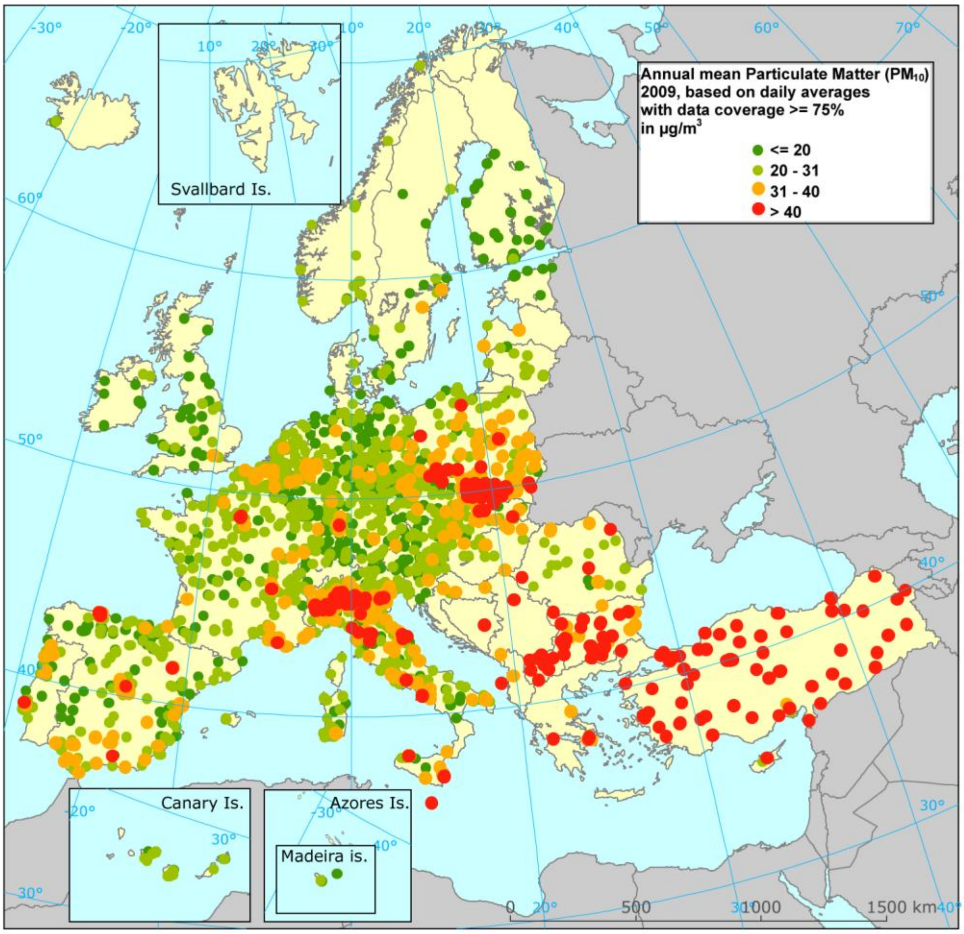


Figure 18: Annual mean concentration map of PM_{10} (µg/m³), 2009; the two highest concentration classes correspond to the annual limit value (40 µg/m³) and to a statistically derived level (31 µg/m³) corresponding to the short-term limit value. The lowest class corresponds to the WHO air quality guideline for PM_{10} of 20 µg/m³ (WHO, 2006).

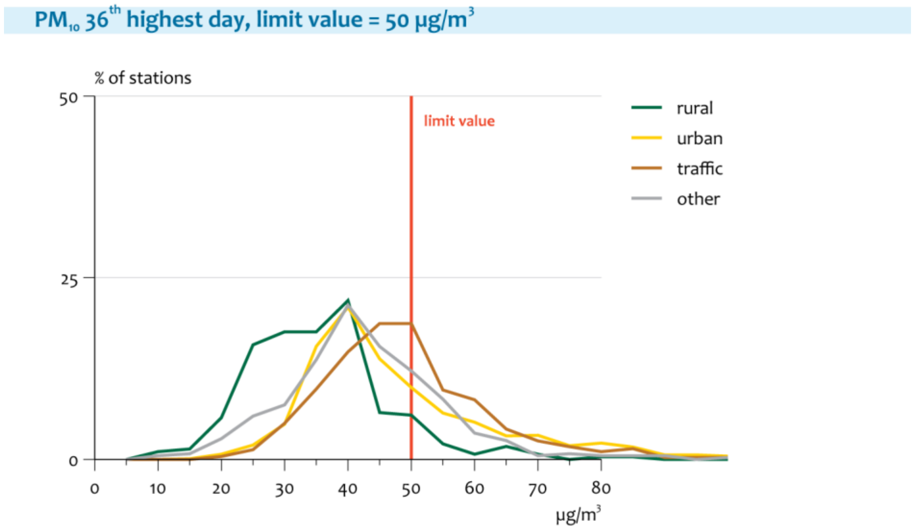


Figure 19. Distance-to-target graph for daily limit value of PM_{10}, reference year 2009.

Figure 20 is presenting the annual mean concentrations of $PM_{2.5}$. For $PM_{2.5}$, the coverage of Europe by monitoring stations is less than for PM_{10} but the number of operational $PM_{2.5}$ stations is still further increasing. For 2009 there are 595 stations fulfilling the criteria of more than 75% data coverage; an increase of more than 250 stations compared to the previous reporting year. The 2009 concentrations were higher than the annual target value to be met by 2010 (red and yellow dots) at several stations in Poland and Italy as well as at a few stations in other countries.
The $PM_{2.5}$ data enables a comparison with the $PM_{2.5}$ target value of 25 µg/m^3 as set in the Air Quality Directive (EU, 2008). The distance-to-target graph in *Figure 21* shows that at 3%, 9% and 8% of the rural, urban and traffic stations the target value has been exceeded. Exceedance is also observed at 6% of the industrial sites.
The new directive introduced an additional $PM_{2.5}$ objective targeting the exposure of the population to fine particles. These objectives are set at the national level and are based on the average exposure indicator (AEI). The AEI is determined as a three-year running annual mean concentration measured at a selected set of stations in urban background locations throughout the territory of a Member State. The AEI reflects the $PM_{2.5}$-exposure of the general (urban) population. Member States provide information on stations and measurement configurations selected for determination of the AEI in the air quality reporting questionnaire (EU, 2004b). However, in the questionnaires reporting over 2009, only 12 Member States provided this information. As a first estimate of the AEI we have calculated here the three-year running mean (2007-2009) as the mean of the annual averaged concentration over all operational (sub)urban background stations in each individual year. The approximated AEI (*Figure 22*) is not based on a stable set of stations. For a number of countries results are based on two or one year only *Figure 22* indicates that in 7 Member States current urban concentrations are above 20 µg/m^3, the level legally binding in 2015.

The change in PM_{10} concentrations since 1999 is presented in *Figure 23*. In the course of 2006 a nation-wide system was introduced in France to correct the PM_{10} measurements from non-reference measuring configurations. In the Mann-Kendall analyses the French data prior to 2007 have been corrected using station-type dependent factors (de Leeuw and Fiala, 2009). In total 459 stations have been operational for at least nine years during the 1999-2009 period. At the majority of the stations (83%) a small negative trend of about 0-1 µg/m^3 per year is observed. The trend is estimated to be significant at 42% of the stations. *Figure 23* shows a steady decrease of the averaged levels at traffic stations while at rural and urban stations an increase is observed in 2009.

The number of PM2.5 stations operational during the last five years is still limited (n=151, *Figure 23*). Concentrations tend to decrease during the first four years and a small increase – similar to PM_{10} – is seen in 2009. Note that the available data is too limited to be conclusive about a possible trend.

In contrast to the PM_{10} data, the overall averaged $PM_{2.5}$ concentrations at urban sites exceed those at traffic sites. As about 9% of the primary $PM_{2.5}$ emissions is caused by road traffic (EEA, 2010) a reversed order is expected. Differences in spatial distribution of the urban and traffic stations over Europe may form an explanation.

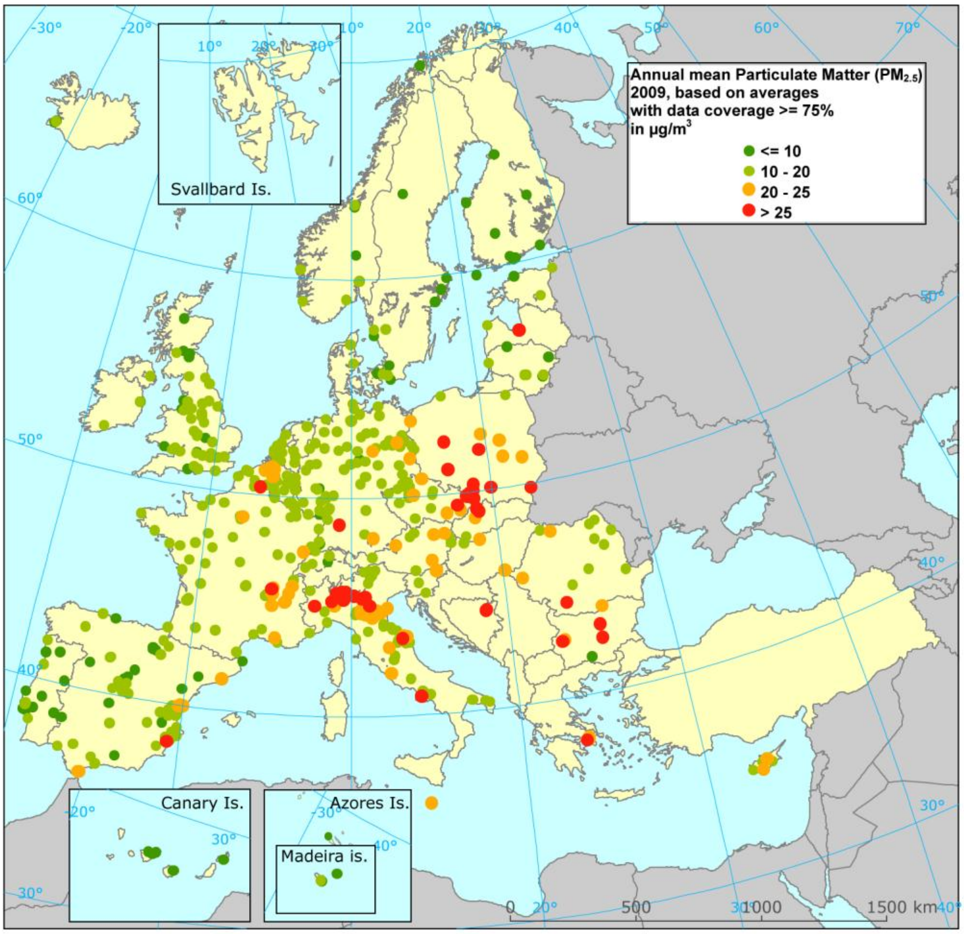


Figure 20: Annual mean concentrations of $PM_{2.5}$, reference year 2009. The lowest class corresponds to the WHO air quality guideline for PM2.5 of 10 µg/m³.

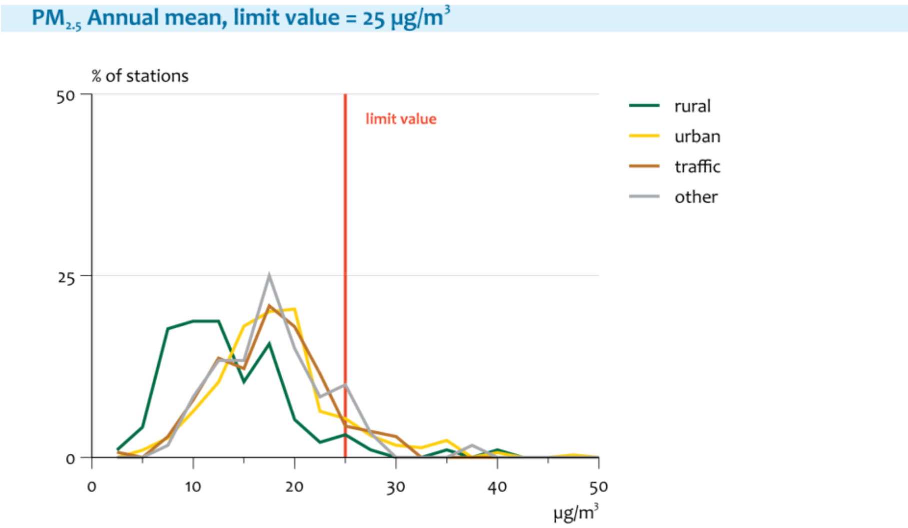


Figure 21 Distance-to-target graph for the annual target value of $PM_{2.5}$, reference year 2009.

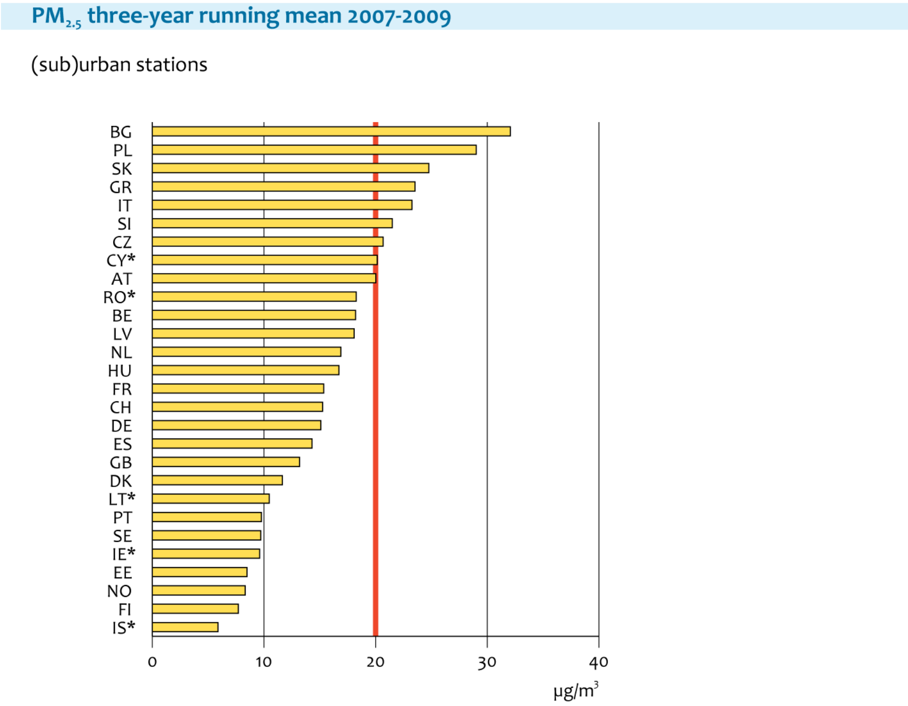


Figure 22 Average Exposure Indicator, three-year running mean (2007-2009) over all operational (sub)urban background stations. Results for countries marked with an asterisk are based on 2009 data only.

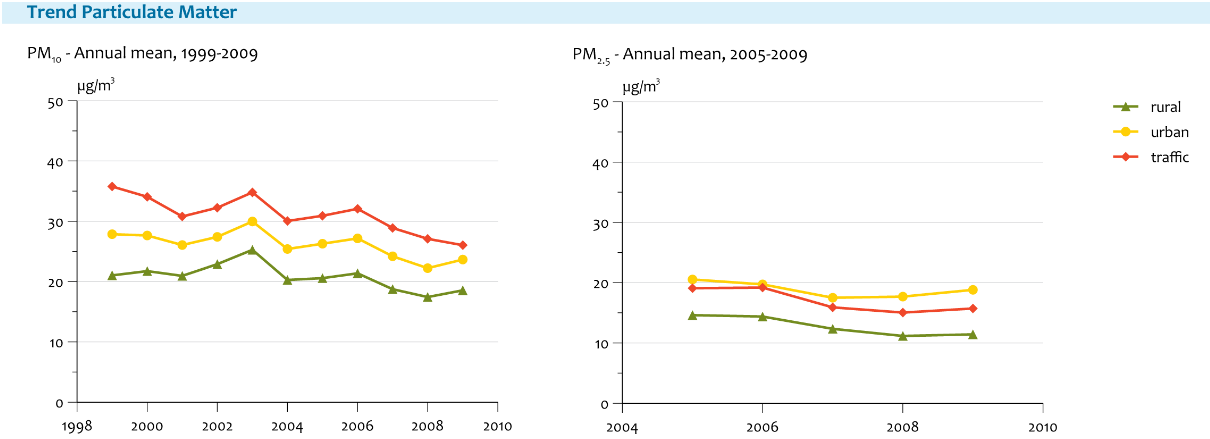


Figure 23 Trend in PM_{10} (left, period 1999-2009) and $PM_{2.5}$ (right, period 2005-2009) concentrations per station type; a consistent set of stations is used.

2.2.4. Carbon monoxide (CO)

In the air quality directive the EU has set a limit value for CO for the protection of human health: the CO maximum daily 8-hour mean values may not exceed 10 mg/m3, see *Figure 25*. Exceedance of the CO limit value is observed at 6 out of 1171 operational stations; exceedances are observed at four traffic, one urban background and one industrial station, located in Italy, Bulgaria and Bosnia and Herzegovina.
The annual averages of the daily maximum of 8-hour means show elevated levels in the same regions, see *Figure 24*. Note that not the maximum value is plotted but the more robust annual mean value of daily maximum 8-hour mean values.

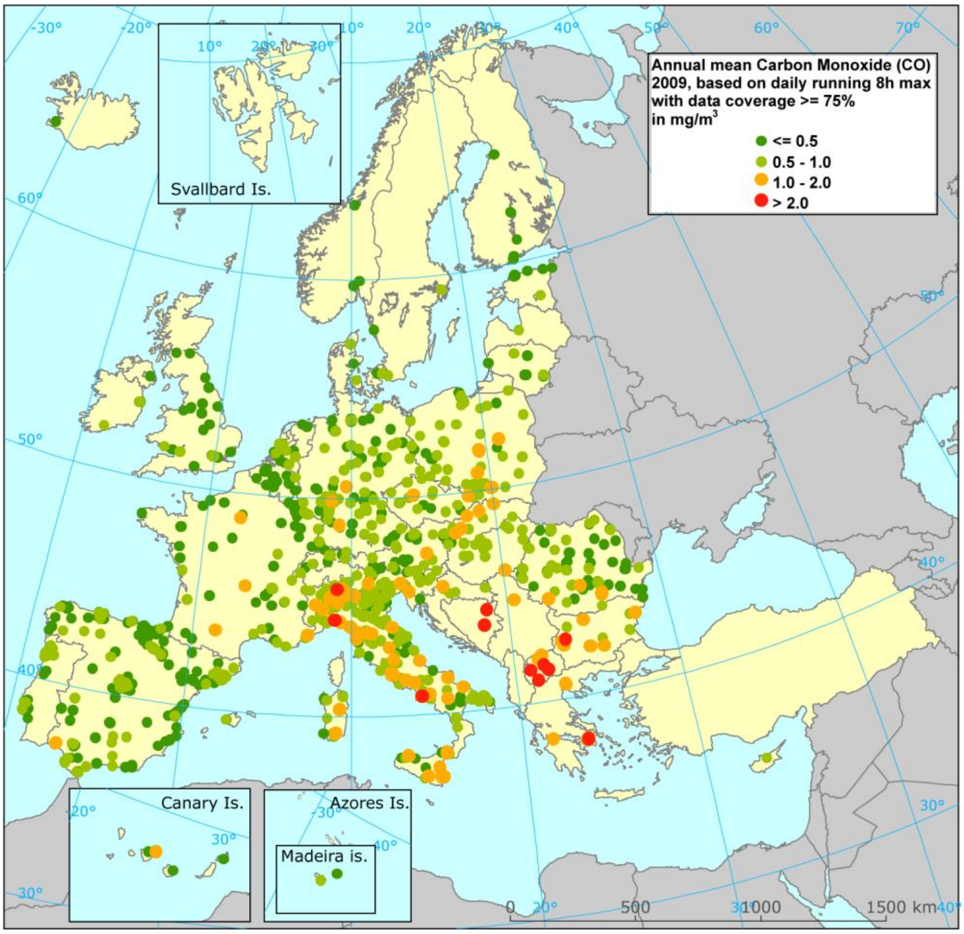


Figure 24: Annual mean concentration of the maximum daily 8-hour mean values of CO (mg/m3), 2009.

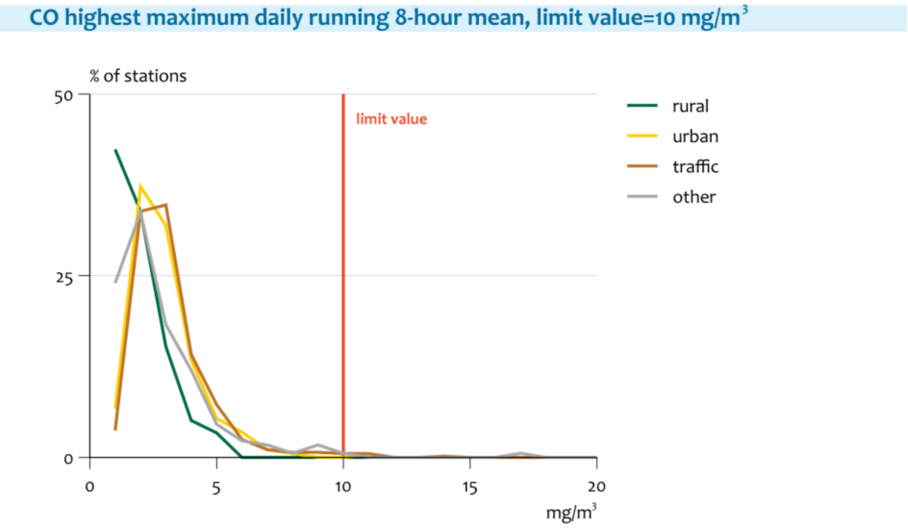


Figure 25: Distance-to-target graph is given for the CO limit value, reference period 2009.

The CO concentrations show a steady decrease over the period 1999—2009 (*Figure 26*). At More than 90% of urban and traffic station show a downward trend which is significant at 72% and 90%, of the urban and traffic stations respectively. At the limited number of rural stations (14 in total) trends are less clear. Uncertainties are introduced by concentrations around and below the detection limit of the monitors and by a large contribution of the hemispheric background. The 2009 concentrations averaged over all rural stations is only 60% above the hemispheric background concentration (0.14 mg/m3, averaged value over 2007-2009) measured at Mace Head, Ireland (WDCGG, 2011).

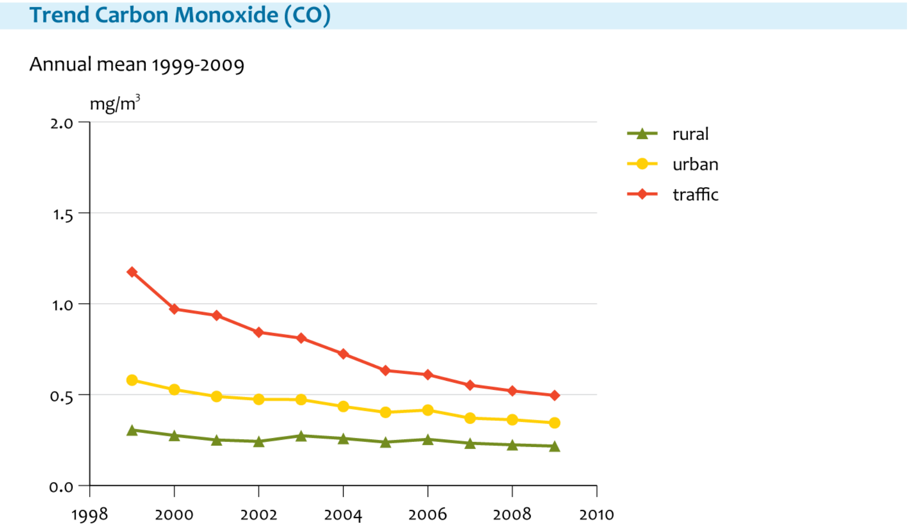


Figure 26. Trend in CO concentrations per station type (consistent station set); period 1999-2009.

2.2.5. Benzene (C_6H_6)

Annual mean concentrations of benzene are at many locations below the lower assessment threshold of 2 µg/m3 (Barrett *et al.* 2008). When concentrations are below the lower assessment threshold the air quality can be assessed by means of indicative or discontinuous measurements. For discontinuous measurements a lower data coverage than 75% will not largely increase the uncertainties in the annual mean values as long as the measurements take place randomly spread over the year (Working group on benzene, 1998). For this reason we have applied here a data coverage criterion of more than 50%.
The Air Quality Directive sets an annual average concentration limit value of 5 µg/m3 for benzene in ambient air, to be met by 2010. Including the margin of tolerance, the annual mean concentrations may not exceed 6 µg/m3 in 2009. The limit value plus margin of tolerance has been exceeded at three stations (in Italy and Poland); concentrations above the limit value are observed at an additional six stations in Czech Republic, Greece, Italy, and Romania(*Figure 28*). Exceedances are observed at urban traffic and urban industrial stations. At rural stations no exceedance of the limit value is observed.
Time series of benzene annual mean levels, averaged for each of the station types, are shown, in *Figure 29*. The concentrations at traffic stations are the highest, benzene in gasoline is still one of the most important sources, but there is a steady decrease until 2007 when concentrations seem to be stable. A similar but less outspoken pattern is seen at the urban stations. Whether a similar stabilisation is also seen in the benzene emissions is not clear; benzene is not included as an individual pollutant in the European emissions inventories.

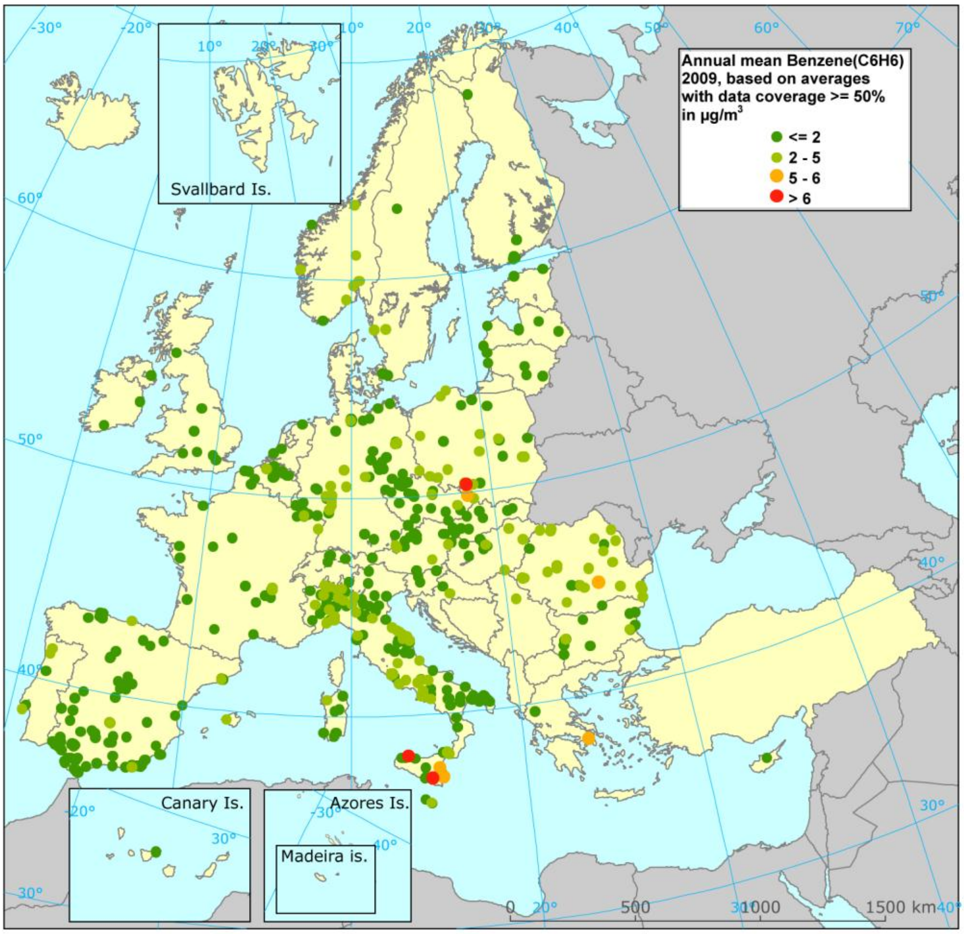


Figure 27: Annual mean value of benzene, 2009. Concentrations of 2, 5, and 6 µg/m3 correspond to the lower assessment threshold, limit value and limit value plus margin of tolerance, respectively.

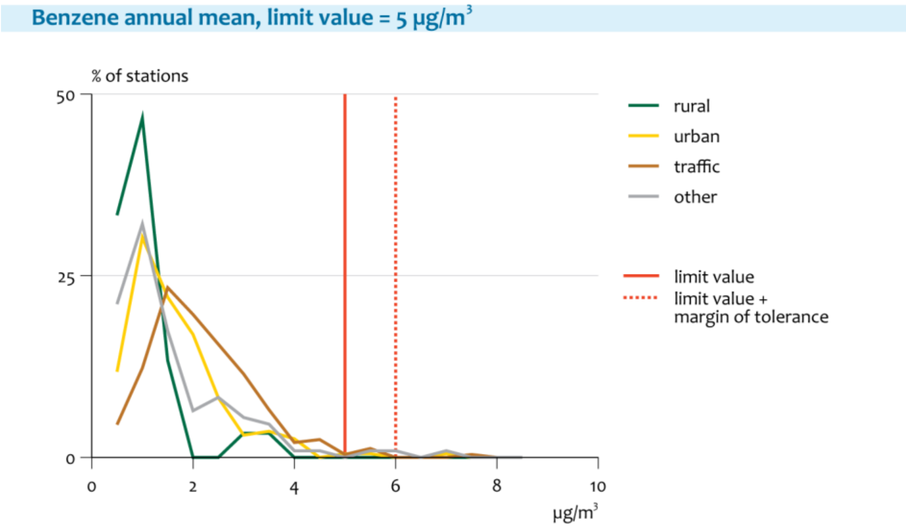


Figure 28: Distance-to-target graph for the benzene limit value; the red dashed line corresponds to the LV plus margin of tolerance (= 6 µg/m3), reference year 2009.

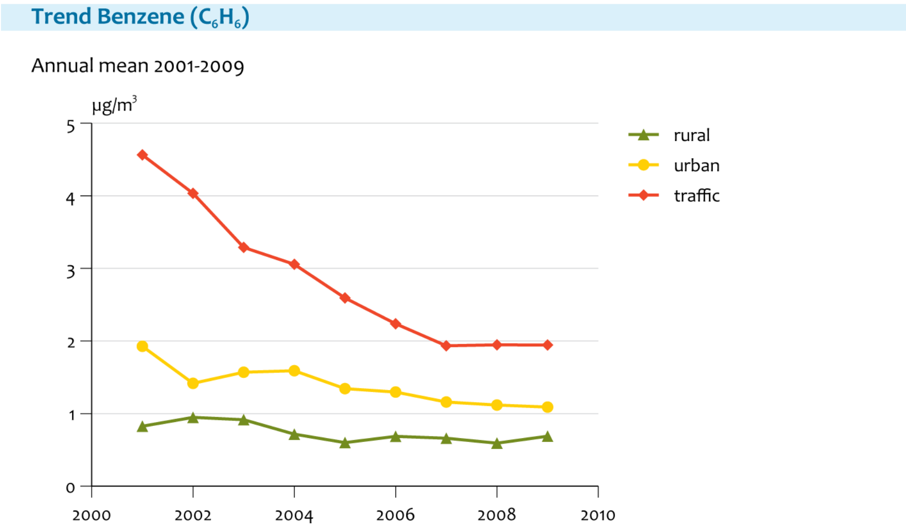


Figure 29 Trend in annual mean benzene concentrations (period 1999-2009) per station type; a consistent set of stations is used.

2.2.6. Ozone (O_3)

In the air quality directive the EU has set target values for the protection of human health (the daily maximum of the running 8-hour mean values may not exceed 120 µg/m3 on more than 25 days per year) and for vegetation (18000 (µg/m3).h as AOT40 value (see Annex B for definition)). *Figure 30* shows the annual mean values of the maximum daily running 8-hour mean concentrations of O_3. Ozone concentrations show a clear north-south gradient with the highest concentrations in the Mediterranean countries. High levels are also observed at mountain stations.

In contrast to the other pollutant the ozone levels are generally the highest at rural locations. Reason for this is that at short distances from NO_x sources – as is the case for urban and

traffic stations – the ozone is chemically quenched by the freshly emitted NO_x. The higher the NOx concentrations (i.e the closer to traffic emissions) the lower ozone concentrations are due to a more complete quenching.

The distance-to-target graphs (for the daily target value given in *Figure 31,* for the AOT40 value given in Annex E , *Figure E.6*) illustrate this general shift towards lower concentrations going from rural to the urban to the traffic sites. The health related target is widely exceeded at 36% of the rural background stations. In urban area the target value is exceeded in about 22% of the background stations. The AOT40 value averaged over all rural background stations is below the target value although at a quarter of the stations an exceedance has been observed.

Trends in ozone concentrations are small, uncertain and may be different for the different station types and for different indicators. The highest concentrations tend to decrease. *Figure 33* shows the change in averaged number of exceedance days of the 120 $\mu g/m^3$ target value between the three-year periods 1991-1993 and 2007-2009. At nearly all stations this number decreases by more than four days per year although at some stations an increase is observed. For more recent years, comparing the periods 1998-2000 and 2007-2009, data for much more stations is available. However, a clear picture is not obtained. Also for this much larger station set covering a larger area in Europe there is a definite decrease in the number of exceedance days at a majority of the stations in most parts of Europe, although there is an increase in exceedance days at some stations scattered across the area, though mainly in southern and some in central Europe.

The temporal changes in annual mean concentrations over the period 1999-2009 are shown in *Figure 32*. This figure first of all reflects the quenching by local NO_x sources: concentrations increases in the order traffic-urban- rural. Ozone background levels increase with altitude, see the difference between rural background stations located at altitudes below 500 m (rural–low) and the mountainous stations at higher altitudes (rural-high).

The figure does not show a clear trend at any of the station types although at both sets of rural stations there is a slight decreasing tendency. Details from the analysis show that at two-thirds of the urban background and traffic stations a (generally not significant) increasing tendency is seen, while 70% of the rural stations have a decreasing tendency.

The short-term indicator (the 26th highest maximum daily running 8-hour mean) which is more representative for the higher ozone levels, shows a slightly different picture: a significant trend is estimated at a smaller number of stations, but for all station types a larger fraction shows a decreasing tendency when compared to the analysis of the annual mean.

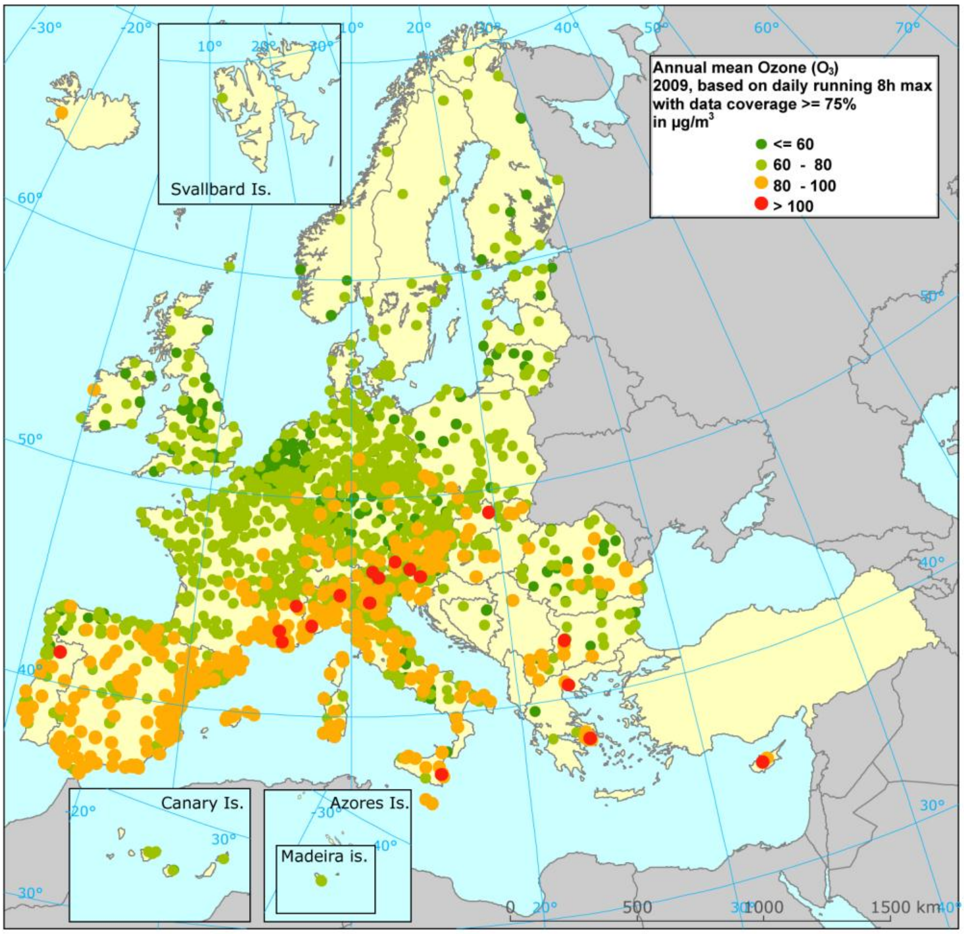


Figure 30: Annual mean value of the maximum daily 8-hour mean values of ozone, 2009.

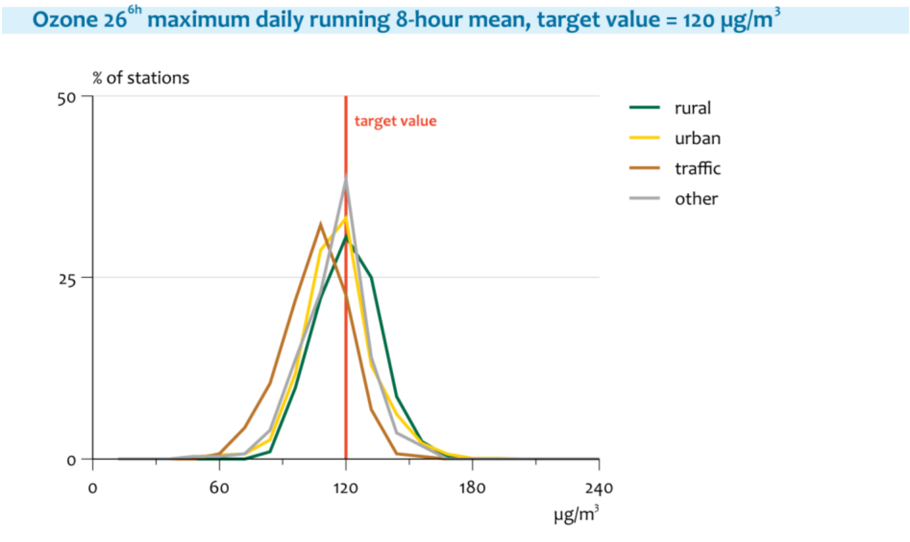


Figure 31: Distance-to-target graph is given for the target values set for the protection of human health

Trend Ozone (O_3)

Annual mean 1999-2009

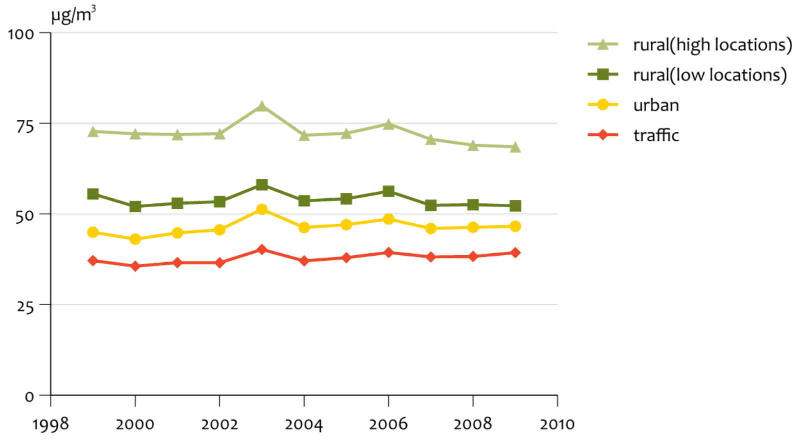


Figure 32 Trend in annual mean ozone concentrations (period 1999-2009) per station type; a consistent set of stations is used.

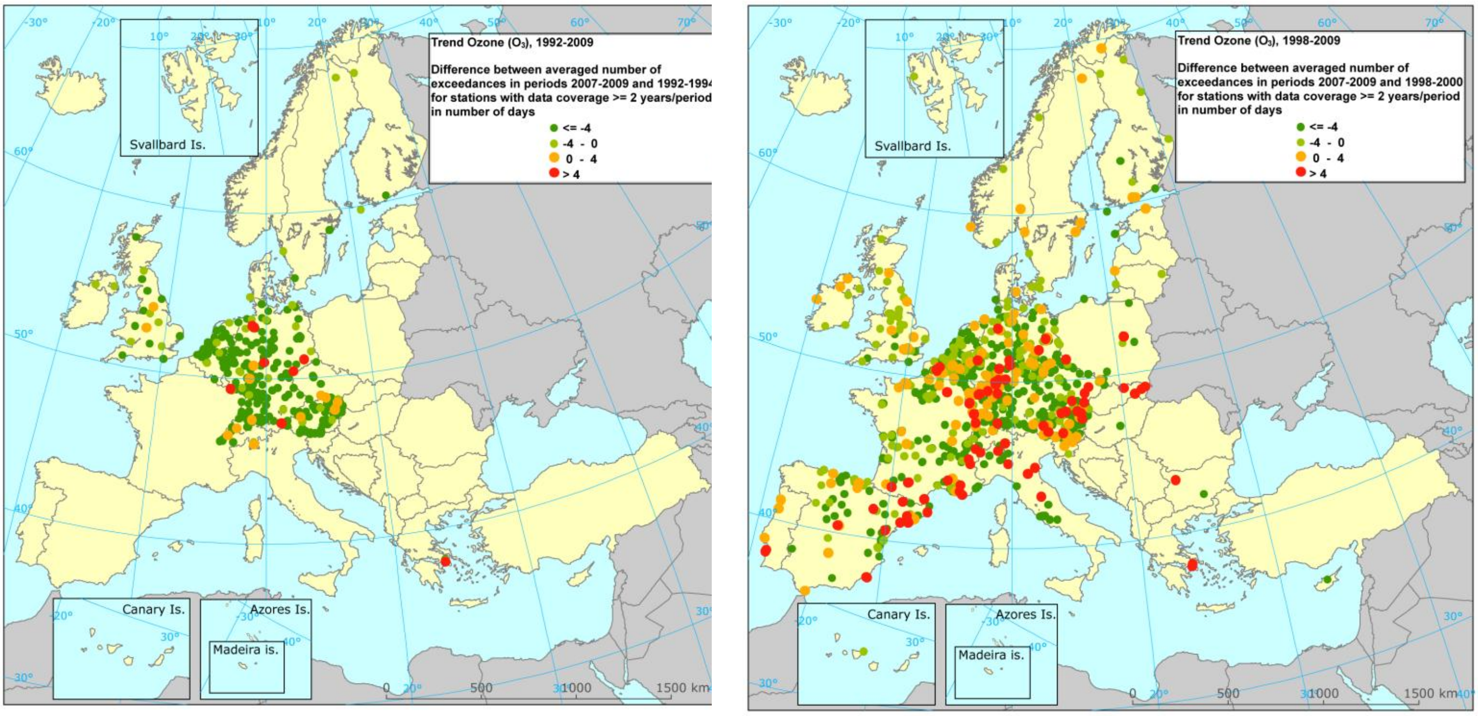


Figure 33. Difference in the number of exceedance days (3-year average) between 2007-2009 and 1991-1993 (left) and between 2007-2009 and 1998-2000 (right). Stations operated over 2 or 3 years in each of the 3-year periods have been included.

2.2.7. Other pollutants

Concentrations of lead and the pollutants covered by the 4th Daughter Directive (arsenic, cadmium, nickel and benzo(a)pyrene) have been reviewed by Barrett *et al.* (2008). The newly submitted 2009 monitoring data are in line with this report. Compared to 2008, the number of reporting stations increased from 120 to 170 stations depending on the pollutant.
As concentrations of these pollutants are frequently below the lower assessment threshold, other techniques than monitoring can be used for assessment of the air quality. This might be the reason that these pollutants are reported for a relatively small number of stations.
Following the data quality objectives set in the air quality directive for indicative measurements, a criterion of data coverage of 14% is applied here on the heavy metal data and benzo(a)pyrene.
With respect to monitoring of heavy metals and BaP, the reference methods as described in the directives are mostly followed for the analytical part. However, when comparing the results of different stations, the problem arises that the fraction of particle sizes sampled is frequently not known. The directive prescribes measuring at PM_{10}. *Figure 34* shows at which fraction of stations HM and BaP is determined on a PM_{10} sample. For the other stations the size fraction of the analyzed aerosol is unknown. It could be larger or smaller than 10 micron.

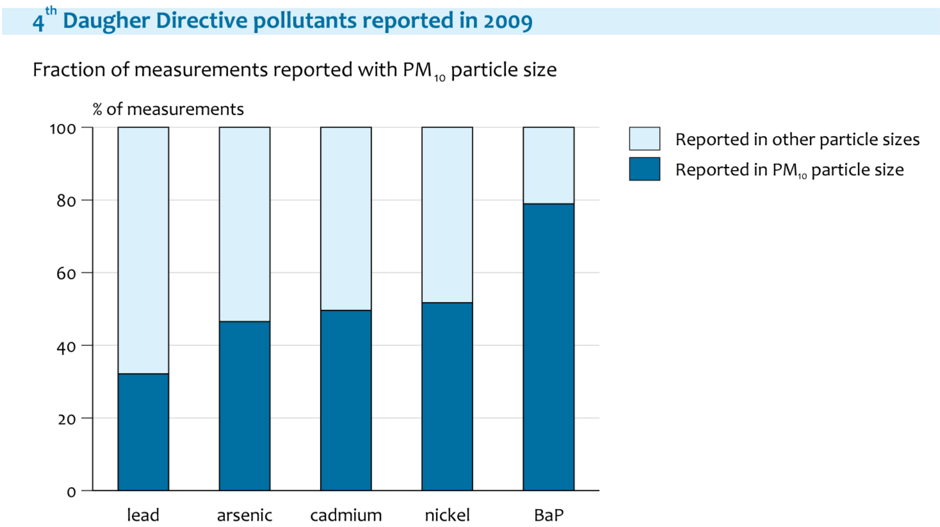


Figure 34. The fraction (%) of HM and BaP measuring stations where the sample represents the PM_{10} particle size fraction.

Summay of the results from the reported 2009 data:

<u>Lead</u>: In France concentrations exceed the limit value at a number of stations. In the AQ questionnaire France reported compliance with the limit value in all of their zones. This discrepancy between the AQQ and EoI data flow is most likely caused by using wrong concentration units in the EoI. Next to the exceedances in these countries, two exceedances (one at an urban industrial station in Romania, the second on a urban background station in Bulgaria) have been reported.
No monitoring data has been received from Greece, Hungary, Norway and Portugal. According to the reporting questionnaire for the air quality directive (EU, 2004b) the concentrations in Greece and Hungary are below the lower assessment threshold (LAT) and other methods than monitoring could be used for assessment. Portugal and Norway did not provide information on the assessment regime but declared that concentrations are below the

limit value. According to the questionnaire there is one station in Portugal measuring lead; data from this station has not been delivered to AirBase.

Arsenic: At about 90% of the stations a concentration below the lower assessment threshold has been reported. However, at 11 (from the 534 operational stations) the observed concentration is above the target value set for 2012. A relatively large number of exceedance is observed in Belgium (6 stations of which 4 are located close to one industrial plant in Hoboken, near Antwerp (VMM, 2009)). The remaining five exceedances are seen in Czech Republic (3 stations), Germany, and Bulgaria, both at industrial (3 stations) and urban sites (2 stations).

Cadmium: Air concentrations are in excess of the target value at 4% of the stations located in two countries (Belgium, 21 stations; Bulgaria, 3 stations). Exceedances are mainly observed at industrial and (sub)urban stations but also at two rural background station in Belgium suggesting a more widespread dispersion of high Cd levels. At the majority of the other stations concentrations are below the lower assessment threshold; the AQ-questionnaire indicates concentrations below the LAT in more than two-third of the zones.

Nickel: Exceedances of the target value are seen at 8 of the 561 operational stations; these stations are located in the eastern part of Belgium, the German Ruhr area, in France and south Norway. Most of the exceedances are related to industry.

Benzo(a)pyrene[1]: Benzo(a)pyrene (BaP) measurements in 2009 were above the target value, (1 ng/m3 as annual average to be met in 2012) at 37% of the monitoring points. This was the case mainly at (sub)urban background stations and, to a lesser extent, at the other stations types (rural, traffic and industrial stations). There is a concentration of impact in central and eastern Europe (NE-SW corridor from the Baltic States, over Poland, Czech Republic, Slovakia, Hungary and Austria, the Po Valley) although exceedances are also observed in the UK (Midlands, Northern Ireland), the German Ruhr area and Bulgaria (see *Figure 35*).
The wide-spread observed exceedances are in agreement with the reports under the Air Quality Directive, where, in addition to the MS mentioned above, Finland and Greece report exceedance of the target value in one or more zones. The assessment for Greece is based on modelling. From the information provided by the AQ questionnaire it is not clear which method has been used to asses the situation in Finland. The total population living in zones reporting an exceedance and potentially exposed to B(a)P concentrations above the target value is estimated as 94 million persons.

Long time series for B(a)P are available for a limited number of stations; 45 stations have reported data for at least four consecutive years since 2005. The time series, averaged per country (*Figure 37*) show that the exceedances of the target value are persistent.

[1] Only BaP *in aerosol* (BaP_aer) has been taken into account. For a detailed definition of BaP_aerosol see Annex D).

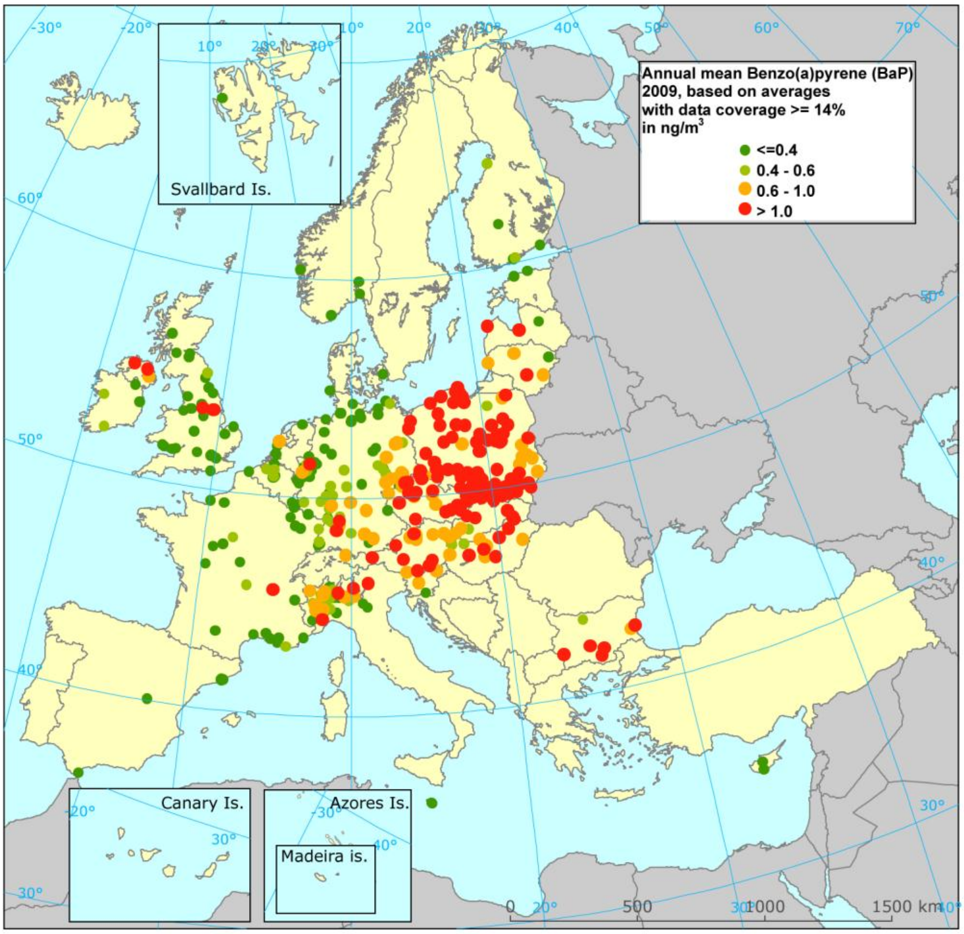


Figure 35: Annual mean concentration of BaP (ng/m3), 2009.

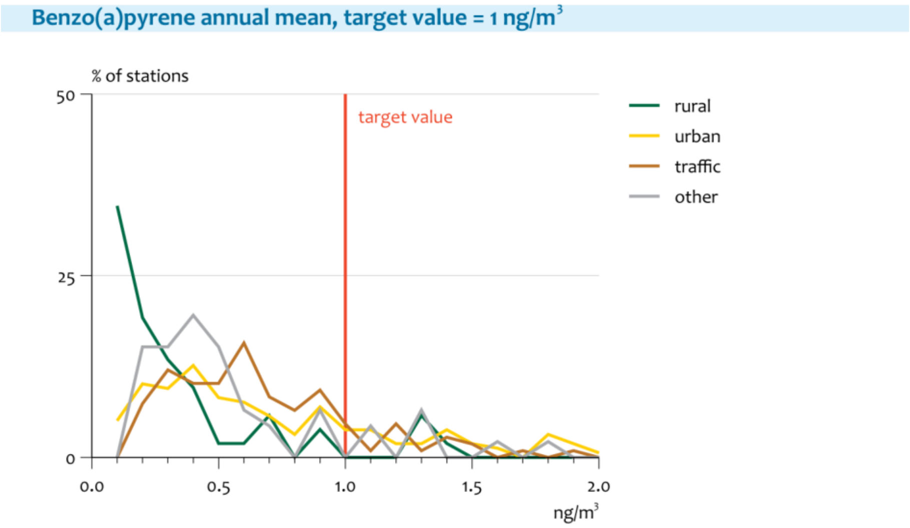


Figure 36: Distance-to-target graph is given for the BaP target value.

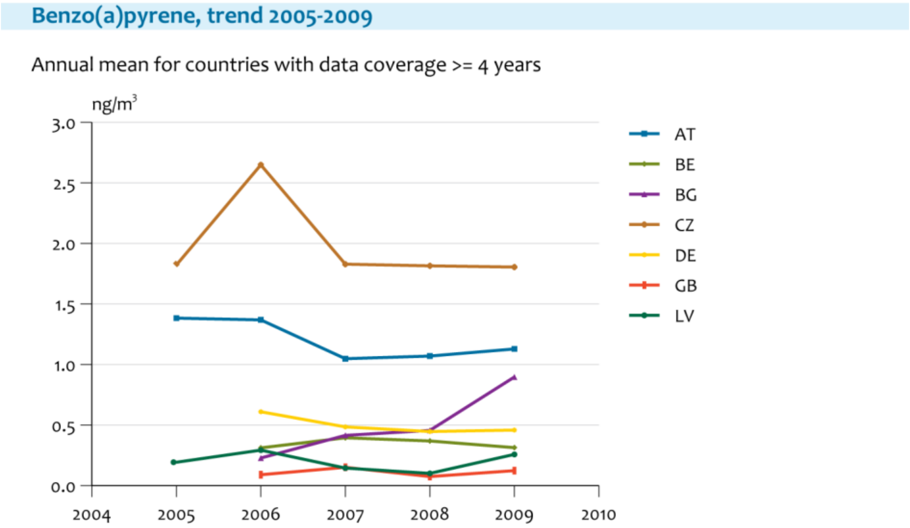


Figure 37: Time series of annual mean B(a)P concentrations in various countries, a consistent set of stations has been used.

3. CONCLUSIONS

A total of 38 countries, including all 27 EU Member States, have provided air quality data for 2009. Measurement data from a total of 4711 stations have been delivered in the EoI2010. For almost all pollutants the number of stations for which data have been reported in 2010 has increased in comparison with 2009. The largest increases are seen in the number of stations reporting $PM_{2.5}$ and VOC (48% and 38% respectively).

In the EoI2009 letter (accompanying the request sent to the Member States in 2010 for submitting 2009 air quality data) mailed to all the data suppliers, the Member States were requested to submit at least two of the three oxidised nitrogen components (NO_2, NO, NO_x).). In spite of this request there is a difference of almost 800 stations (from which about 500 stations of France) between the number of stations for which NO_2 has been reported and the number of stations for which NO (or NO_x) has been reported. As most automated monitors measure both pollutants simultaneously, this difference is unexpectedly large. In AirBase (version 5) NO_x values have been derived for stations where NO and NO_2 values have been reported, but no NO_x values.

The number of stations for the 4DD components is still increasing: the number of stations where one or more heavy metals listed in the 4DD have been reported, has increased by 17% while the number of stations where benzo(a)pyrene or one of the other PAH have been reported has increased by 13%.

Nearly all countries delivered the data in time (before 1st of October 2010). ETC/ACM has produced QA/QC country feedback reports (Mol, 2010). The response on these reports was very good; almost all countries replied to this response within the deadline.
The quality of the meta information, measurement data but also the derived information (statistics, exceedances) in AirBase has been improved considerably.

Concerning the air quality state for the selected pollutants we can conclude the following.

(1) In 2009 the **NO_2** annual limit value plus margin of tolerance has been exceeded at 41% of the traffic stations. The NO_2 and NO_x concentrations over the period 1999-2009 are decreasing, but the NO_x reduction outweights the NO_2 reduction. In the NO_x-case the order of rural-urban-traffic reflects the closeness of the sources. In the NO_2 case the reduction at traffic stations clearly lacks behind the reduction at rural and urban stations. The relative increase in direct NO_2 emissions from diesel cars and chemical non-linearities might serve as possible explanations.

(2) Likewise 2008, the highest **SO_2** concentrations are observed in the West Balkan countries and Turkey. The limit value set for the protection of vegetation (20 µg/m^3 as annual mean) has been exceeded at 3% of the stations; however, none of the exceedance stations are classified as rural background; the vegetation limit value might not be applicable here. As emissions tend to be higher and dispersion conditions are worse during winter periods, the concentrations during the winter 2008/2009 are on average slightly higher than those during the year 2009. The more stringent limit value for the protection of vegetation set for a winter period (20 µg/m3) is exceeded at one rural station. The hourly and daily limit values set for the protection of human health have been exceeded at 1 and 2 % of the stations, respectively. The SO_2 concentrations show a steady decrease over the period 1999-2009. At all station types the concentrations have decreased by more than 50% over the last 11 years.

(3) Both the daily and annual mean limit values of **PM_{10}** have been exceeded in many countries across Europe. Exceedance of the limit values is observed at all types of stations with increasing numbers from rural to urban to traffic stations. The daily limit value is

frequently exceeded at urban background stations (about 28% of stations) and at traffic stations (more than 32% of stations).
The target value for $PM_{2.5}$ has been exceeded for about 10% of the stations.
The PM_{10} concentrations show a deceasing trend since 1999. Concentrations of $PM_{2.5}$ tended to decrease during the first four reporting years, but a small increase – similar to PM_{10} – is seen in 2009.
In contrast to the PM_{10} data, the overall averaged $PM_{2.5}$ concentrations at urban sites exceed those at traffic sites. As about 9% of the primary $PM_{2.5}$ emissions is caused by road traffic (EEA, 2010) a reversed order is expected. Differences in spatial distribution of the urban and traffic stations over Europe may form an explanation.

(4) Exceedances of the **CO** limit value are observed at 6 out of 1171 operational stations; exceedances are observed at four traffic stations, one urban background station and one industrial station. These stations are located in Italy, Bulgaria and Bosnia and Herzegovina. The annual averages of the daily 8-hour maxima show elevated levels in the same regions.

(5) The concentrations of **Benzene** are below the limit value except for a limited number of traffic hotspot situations.

(6) **Ozone** concentrations show a clear north-south gradient with the highest concentrations in the Mediterranean countries. High levels are also observed at mountain stations. In contrast to the other pollutant the ozone levels are generally the highest at rural locations. Reason for this is that at short distances from NO_x sources – as is the case for urban and traffic stations – the ozone is chemically quenched by the freshly emitted NO_x. The health related target is widely exceeded at 36% of the rural background stations. In urban area the target value is exceeded in about 22% of the background stations. In urban area about 22% of the background stations are not in compliance with the target. The AOT40 value averaged over all rural background stations is below the target value although at a quarter of the stations an exceedance has been observed.
Trends in ozone concentrations are small, uncertain and may be different for the different station types and for different indicators. The highest concentrations tend to decrease.

(7) Most Member States have reported **heavy metals** (arsenic, cadmium, nickel) and benzo(a)pyrene regulated under the fourth Daughter Directive. The air pollution by these heavy metals is generally low: at the majority of the stations concentrations are below the lower assessment threshold.

(8) For B**enzo(a)pyrene** the target values are exceeded at 37% of the monitoring points; mainly at (sub)urban background stations and, to a lesser extend, at the other stations types (rural, traffic and industrial stations). There is some concentration of impact in central and eastern Europe (NE-SW corridor from the Baltic States, over Poland, Czech Republic, Slovakia, Hungary and Austria, the Po Valley) although exceedances are also observed in the UK (Midlands, Northern Ireland), the German Ruhr-area and Bulgaria. Long time series for B(a)P are available for a limited number of stations; 45 stations have reported data during at least four years since 2005. The time series, averaged per country show that the exceedances of the target value are persistent.

4. LIST OF ABBREVIATIONS

AEI	Average Exposure Indicator
AOT40	ozone concentrations Accumulated dose Over a Threshold of 40 ppb
AQ	Air Quality
AQD	Air Quality Directive
CAFE	Clean Air For Europe
CDR	Central Data Repository
DD	Daughter Directives
4DD	Fourth Daughter Directive
DEM	Data Exchange Module
DG ENV	Directorate-General Environment
EBM	EuroBoundaryMap
EEA	European Environment Agency
EEA CC	EEA Cooperating Countries
EEA MC	EEA Member Countries
EFTA	European Free Trade Association
EMEP	Co-operative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (European Monitoring and Evaluation Programme)
EoI	Exchange of Information
ETC/ACM	European Topic Centre on Air Pollution and Climate Change Mitigation
ETRS89	European Terrestrial Reference System 1989
EU	European Union
EU MS	The 27 EU Member States
FWD	Air Quality Framework Directive on ambient air quality assessment and Management
GIS	Geographical Information System
IPR	Implementing PRovisions of the Air Quality Directive 2008/50/EC
LAT	Lower Assessment Threshold
LAU	Local Administrative Units
LV	Limit value
MOT	Margin of tolerance
MS	Member State(s)
NRT	Near Real Time
NUTS	Nomenclature des Unités Territoriales Statistiques
LAU	Local Administrative Units
QA/QC	Quality Assurance & Quality Control
SABE	Seamless Administrative Boundaries of Europe
SOR	Summer Ozone Reporting
SOMO35	Sum of Ozone Means Over 35 ppb
TV	Target value

List of components and component groups

As	Arsenic
B(a)P	benzo(a)pyrene
C_6H_6	benzene
Cd	Cadmium
CO	carbon monoxide
Hg	Mercury
HM	Heavy Metals
HM4	Heavy Metals in the 4^{th} DD
Ni	Nickel
NO_2	nitrogen dioxide

NO_x	nitrogen oxides
NO_x/NO	Delivered NO_x and, if no NO_x data available, NO_2 + NO
O_3	ozone
PAH	Polycyclic Aromatic Hydrocarbons
PAH4	Polycyclic Aromatic Hydrocarbons in the 4^{th} DD
Pb	Lead
Pb_aer	Lead in aerosol
$PM_{2.5}$	particulate matter
PM_{10}	particulate matter
SO_2	sulphur dioxide
VOC	Volatile Organic Compounds
VOC-	Volatile Organic Compounds minus benzene

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Annex A Exchange of Information requirements

The MS of the EU should, according to Annex II of the Council Decision on the reciprocal exchange of information, report certain types of meta information (EU, 2001a). Part of the information, as mentioned in Annex II, is mandatory (*Table A1*). The other information should be delivered 'to the extent possible' and 'as much as feasible' (*Table A2)*.

Table A.1 Overview of mandatory meta information to be delivered under the EoI

Item [a]	Description
I.1.	Name of the network
I.4.1.	Name of the body responsible for network management
I.4.2.	Name of person responsible
I.4.3.	Address
I.4.4.	Telephone and fax numbers
I.5.	Time reference basis
II.1.1.	Name of the station
II.1.4.	Station code given under the present decision and to be provided by the Commission
II.1.8.	Geographical co-ordinates
II.1.10.	Pollutants measured
II.1.11.	Meteorological parameters measured
II.2.1.	Type of area

(a) Numbers according to Annex II of the EoI (EU, 2001a)

Table A.2. Overview of non-mandatory meta information to be delivered under the EoI

Item [a]	Description
I.2.	Abbreviation (of the network)
I.3.	Type of networks
I.4.5.	E-mail (of the body responsible for the network)
I.4.6.	Website address
II.1.2.	Name of the town/city of location (of the station)
II.1.3.	National and/or local reference number or code
II.1.5.	Name of technical body responsible for the station
II.1.6.	Bodies or programmes to which data are reported
II.1.7.	Monitoring objectives
II.1.9.	NUTS level IV
II.1.12	Other relevant information
II.2.2.	Type of station in relation to dominant emission sources
II.2.3.	Additional information about the station
III.1.1.	Name (of measurement equipment)
III.1.2.	Analytical principle or measurement method
III.2.1.	Location of sampling point
III.2.2	Height of sampling point
III.2.3	Result-integrating time
III.2.4	Sampling time

(a) Numbers according to the Annex II of the EoI (EU, 2001a).

Table A.3 Overview of mandatory pollutants to be delivered under the EoI

EoI nr.	Formula	Name of pollutant	Units of measurement	Average over
1	SO_2	Sulphur dioxide	µg/m^3	1 h
2	NO_2	Nitrogen dioxide	µg/m^3	1 h
3	PM_{10}	Particulate matter < 10 µm	µg/m^3	24 h
4	$PM_{2.5}$	Particulate matter < 2.5 µm	µg/m^3	24 h
5	SPM	Total suspended particulates	µg/m^3	24 h
6	Pb	Lead	µg/m^3	24 h
7	O_3	Ozone	µg/m^3	1 h
8	C_6H_6	Benzene	µg/m^3	24 h
9	CO	Carbon monoxide	mg/m^3	1 h
10	Cd	Cadmium	ng/m^3	24 h
11	As	Arsenic	ng/m^3	24 h
12	Ni	Nickel	ng/m^3	24 h
13	Hg	Mercury	ng/m^3	24 h
14	BS	Black smoke	µg/m^3	24 h
15	NO_X	Nitrogen oxides	µg NO_2/m^3	1 h

Table A.4 Overview of other pollutants to be delivered under the EoI if available

EoI nr.	Formula	Name of pollutant	Units of measurement	Average over
16	C2H_6	Ethane	µg/m³	24 h
17	$H_2C=CH_2$	Ethene (Ethylene)	µg/m³	24 h
18	HC=CH	Ethyne (Acetylene)	µg/m³	24 h
19	$H_3C-CH_2-CH_3$	Propane	µg/m³	24 h
20	$CH_2=CH-CH_3$	Propene	µg/m³	24 h
21	$H_3C-CH_2-CH_2-CH_3$	n-Butane	µg/m³	24 h
22	$H_3C-CH(CH_3)_2$	i-Butane	µg/m³	24 h
23	$H_2C=CH-CH_2-CH_3$	1-Butene	µg/m³	24 h
24	$H_3C-CH=CH-CH_3$	trans-2-Butene	µg/m³	24 h
25	$H_3C-CH=CH-CH_3$	cis-2-Butene	µg/m³	24 h
26	$CH_2=CH-CH=CH_2$	1.3 Butadiene	µg/m³	24 h
27	$H_3C-(CH_2)_3-CH_3$	n-Pentane	µg/m³	24 h
28	$H_3C-CH_2-CH(CH_3)_2$	i-Pentane	µg/m³	24 h
29	$H_2C=CH-CH_2-CH_2-CH_3$	1-Pentene	µg/m³	24 h
30	$H_3C-HC=CH-CH_2-CH_3$	2-Pentenes	µg/m³	24 h
31	$CH_2=CH-C(CH_3)=CH_2$	Isoprene	µg/m³	24 h
32	$C_{36}H_{14}$	n-Hexane	µg/m³	24 h
33	$(CH_3)_2-CH-CH_2-CH_2-CH_3$	i-Hexane	µg/m³	24 h
34	C_7H_{16}	n-Heptane	µg/m³	24 h
35	C_8H_{18}	n-Octane	µg/m³	24 h
36	$(CH_3)_3-C-CH_2-CH-(CH_3)_2$	i-Octane	µg/m³	24 h
37	$C_6H_5-CH_3$	Toluene	µg/m³	24 h
38	$C_6H_5-C_2H_5$	Ethyl benzene	µg/m³	24 h
39	m,p-$C_6H_4(CH_3)_2$	m,p-Xylene	µg/m³	24 h
40	o-$C_6H_4-(CH_3)_2$	o-Xylene	µg/m³	24 h
41	$C_6H_3-(CH_3)_3$	1,2,4-Trimethylbenzene	µg/m³	24 h
42	$C_6H_3(CH_3)_3$	1,2,3-Trimethylbenzene	µg/m³	24 h
43	$C_6H_3(CH_3)_3$	1,3,5-Trimethylbenzene	µg/m³	24 h
44	HCHO	Formaldehyde	µg/m³	1 h
45	THC (NM)	Total non-methane hydrocarbons	µg C/m³	24 h
46	SA	Strong acidity	µg SO_2/m³	24 h
47	PM1	Particulate matter < 1 µm	µg/m³	24 h
48	CH_4	Methane	µg/m³	24 h
49	Cr	Chromium	ng/m3	24 h
50	Mn	Manganese	ng/m3	24 h
51	H_2S	Hydrogen sulphide	µg/m³	24 h
52	CS_2	Carbon disulphide	µg/m³	1 h
53	$C_6H_5-CH=CH_2$	Styrene	µg/m³	24 h
54	$CH_2=CH-CN$	Acrylonitrile	µg/m³	24 h
55	$CHCl=CCl_2$	Trichloroethylene	µg/m³	24 h
56	C_2Cl_4	Tetrachloroethylene	µg/m³	24 h
57	CH_2Cl_2	Dichloromethane	µg/m³	24 h
58	BaP	Benzo(a)pyrene	µg/m³	24 h
59	VC	Vinyl chloride	µg/m³	24 h
60	PAN	Peroxyacetyl nitrate	µg/m³	1 h
61	NH_3	Ammonia	µg/m³	24 h
62	N-DEP	Wet nitrogen deposition	mg N/(m^2*month)	1 month
63	S-DEP	Wet sulphur deposition	mg S/(m^2*month)	1 month

Annex B Aggregation of data and calculation of statistics and NO_x values in AIRBASE

B.1. Hourly and daily values

Aggregation of data

The air quality statistics in AirBase are based on *hourly values*, *daily (24-hour) average values*, and *daily 8-hour maximum values*. However, most of the reported measurement data are in hourly time episodes. To obtain the daily and 8-hour based statistical parameters the hourly values (if available) are aggregated to derive daily and 8-hourly values. If a country reports both hourly and daily values, the reported daily values will be ignored. The calculated daily values will be used instead for calculating the statistics. If 3-hourly data are delivered, these data are aggregated in daily values.

For the aggregation of hourly data to longer averaging periods (8 hourly, daily) a minimum data capture of 75% is required to calculate a valid aggregated value:

- a *daily averaged* (24-hourly) concentration is calculated when at least 18 valid hourly values are available
- a *8-hourly averaged* concentration is calculated when at least 6 valid hourly values are available
- a *maximum daily 8-hour mean* is calculated when at least 18 valid running 8-hour averages per day are available

For the aggregation of 3hourly data to daily values we have also the 75% data capture rule:

- a *daily averaged* concentration is calculated when at least 6 valid 3-hourly values are available

Statistics calculation on annual basis

The following types of annual statistics are calculated depending on the component:

- *General* concentration statistic: annual mean, 50, 95, 98 percentiles and maximum (only SO_2 also 99.9 percentile based on hourly values).
- *Exceedances*: hours/days with concentration > y µg/m^3 (with y = limit or threshold value) and the kth highest value
- *AOT40*: ozone concentrations accumulated dose over a threshold of 40 ppb (AOT40 definition see below)
- *SOMO35*: ozone concentrations accumulated dose over a threshold of 35 ppb (SOMO35 definition see below)

The annual statistical parameters of the table are routinely calculated and stored in AirBase. The statistical parameters are calculated irrespective of the proportion of valid data (data capture) with one exception: all hourly and daily statistics which are based on one day or less are excluded. So statistics with a data coverage lower than 0.275% aren't calculated.

Table B1. Calculated statistics in AIRBASE

Component	Parameter based on 1 hour values	 daily values	 Maximum daily 8-hour mean
Sulphur dioxide (SO_2)	• annual mean • 50 percentile • 95 percentile • 98 percentile • 99.9 percentile • maximum • hours with c > 350 µg/m3 • 25th highest value	• annual mean • 50 percentile • 95 percentile • 98 percentile • maximum • days with c > 125 µg/m3 • 4th highest value	
Nitrogen dioxide (NO_2)	• annual mean • 50 percentile • 95 percentile • 98 percentile • maximum • hours c > 200 µg/m3 • 19th highest value	• annual mean • 50 percentile • 95 percentile • 98 percentile • maximum	
Nitrogen monoxide (NO)	• annual mean • 50 percentile • 95 percentile • 98 percentile • maximum	• annual mean • 50 percentile • 95 percentile • 98 percentile • maximum	
Nitrogen oxides (NO_x) [b]	• annual mean • 50 percentile • 95 percentile • 98 percentile • maximum	• annual mean • 50 percentile • 95 percentile • 98 percentile • maximum	
Ozone (O_3)	• annual mean • 50 percentile • 95 percentile • 98 percentile • maximum • AOT40	• annual mean • 50 percentile • 95 percentile • 98 percentile • maximum	• annual mean • 50 percentile • 95 percentile • 98 percentile • maximum • days with c >120 µg/m3, • 26th highest value • SOMO35
Carbon monoxide (CO)	• annual mean • 50 percentile • 95 percentile • 98 percentile • maximum	• annual mean • 50 percentile • 95 percentile • 98 percentile • maximum	• annual mean • 50 percentile • 95 percentile • 98 percentile • maximum
Particulate matter (PM_{10})	• annual mean • 50 percentile • 95 percentile • 98 percentile • maximum	• annual mean • 50 percentile • 95 percentile • 98 percentile • maximum • days with c > 50 µg/m3, • 8th highest value • 36th highest value	
other	• annual mean • 50 percentile • 95 percentile • 98 percentile • maximum	• annual mean • 50 percentile • 95 percentile • 98 percentile • maximum	

For each statistic the data coverage[1] percentage is calculated. This is done as follows:

$$Data\ coverage = N_{valid} / N_{year} * 100\ \%$$

where N_{valid} is the number of valid hourly/daily values and N_{year} is the number of hours/days in the year

Calculation of aggregations and statistics

1. **All components**

- **Annual mean**
  The annual mean is calculated as follows:

$$Annual\ mean = \Sigma_i C_i / N_{valid}$$

where C_i is the valid hourly/daily/day8hmax concentration and the summation is over all valid hourly/daily values measured in the year. N_{valid} is the total number of valid hourly/daily values in the year.

- **Percentiles**
  The y^{th} percentile should be selected from the measurement values (valid hourly/daily/day8hmax concentrations). All the values should be listed in increasing order:

$$X_1 \leq X_2 \leq X_3 \leq \ldots \leq X_k \leq \ldots \leq X_{N-1} \leq X_N$$

The y^{th} percentile is the concentration X_k, where the value of k is calculated as follows:

$$k = (q \cdot N)$$

with q being equal to $y/100$ and N the number of valid values. The value of $(q \cdot N)$ should be rounded off to the nearest whole number (values < 0.499999… are rounded to 0, values = 0.5 are rounded to 1).

- **Maximum**
  The (annual) maximum is calculated as follows:

$$Maximum = max\ (C_i)$$

where C_i are the valid hourly/daily/day8hmax concentrations and i is running over all valid hourly/daily/day8hmax values measured in the year.

2. **Only SO_2, NO_2, PM_{10}, O_3**

- **k^{th} highest value**
  The k^{th} highest value should be selected from the valid measurement values. All the values should be listed in decreasing order:

  - $X_1 \geq X_2 \geq X_3 \geq \ldots \geq X_k \geq \ldots \geq X_{N-1} \geq X_N$

The k^{th} highest value is the concentration X_k.

[1] In the Air Quality Daughter Directives the terms *data capture* and *time coverage* have been defined. The time coverage is the percentage of measurement time in a given period. The data capture is the percentage of valid measurement values in a given data set. For each yearly time series the so called *data coverage* has been calculated in AirBase. The *data coverage* is defined as follows: *Data coverage = data capture * time coverage*.

Example: the limit value for the protection of human health for PM_{10} is that the daily average of 50 μg/m³ will not be exceeded on more than 35 days per year. If the 36th highest value is more than 50 μg/m³, the limit value for PM_{10} has been exceeded.

- **Number of hours/days with concentration > y μg/m³**
  The *n* number of hours/days with concentration > y μg/m³ (with y = limit or threshold value) can be calculated from the valid measurement values:

$$X_1 , X_2 , X_3 , \ldots , X_k , \ldots , X_{N-1} , X_N$$

  N is the number of X_k-values for whick $X_k > y$ μg/m³. If $n > 35$ in the example on PM_{10} at the previous bullet, the limit value for PM_{10} has been exceeded.

3. **Only O_3, CO**

- **8-hour running averages**
  The 8-hour running averaged value for each hour is calculated as the average of the values for that hour and the 7 foregoing hours (averaging period). So, the averaging period of $hour_1$ of day_n is $hour_{17}$ of day_{n-1} until $hour_1$ of day_n. The averaging period of $hour_{24}$ of day_n is $hour_{16}$ of day_n until $hour_{24}$ of day_n.

- **Maximum daily 8-hour mean**
  The maximum daily 8-hour mean for a day is the maximum of the 8-hours running averages for that day

4. **Only O_3**

- **AOT40 (crops)**
  (Accumulated dose of ozone Over a Threshold of 40 ppb)
  AOT40 means the sum of the differences between hourly concentrations greater than 80 μg/m³ (= 40 parts per billion) and 80 μg/m³:

$$AOT40_{measured} = \Sigma_i \max(0,(C_i - 80))$$

  where C_i is the hourly mean ozone concentration in μg/m³ and the summation is over all hourly values measured between 8.00 – 20.00 Central European Time[1] each day and for days in the 3 month growing season crops from 1 May to 31 July.

  AOT40 has a dimension of (μg/m³)·hours. AOT40 is sensitive to missing values and a correction to full time coverage has been applied:

$$AOT40_{estimate} = (AOT40_{measured} \cdot N_{period}) / N_{valid}$$

  where N_{valid} is the number of valid hourly values and N_{period} is the number of hours in the period.

- **SOMO35**
  (Sum of Ozone Means Over 35 ppb)
  For quantification of the health impacts the World Health Organisation recommends the use of the SOMO35 indicator.SOMO35 means the sum of the differences between maximum daily 8-hour concentrations greater than 70 μg/m³ (= 35 parts per billion) and 70 μg/m³:

$$SOMO35_{measured} = \Sigma_i \max(0,(C_i - 70))$$

[1] In AirBase the time zone was disregarded. So the values between 8.00 – 12.00 in the reported time have been taken.

where C_i is the maximum daily 8-hour ozone concentration in µg/m³ and the summation is over all days per calendar year.

SOMO35 has a dimension of (µg/m³)·days. SOMO35 is sensitive to missing values and a correction to full time coverage has been applied:

$$SOMO35_{estimate} = (SOMO35_{measured} \cdot N_{period}) / N_{valid}$$

where N_{valid} is the number of valid daily values and N_{period} is the number of days per year.

B.2. Other than hourly and daily values: n-day (n>1), n-week, n-month, year and var[1]

Non automatic measured components (e.g. the components from the 4th DD (Heavy Metals and PAHs) have also other averaging times than hour and day: week, 2-week, 4-week, month, 3-month, year etc.). These measurements consist of samples with a start date/time and an end date/time. The averaging time is the period of the sample (end date/time minus start date/time). If the sample periods of a component differ 25% or more from a constant averaging time, the averaging time has been defined as "var". Example: if all periods of 4week samples are within 21 and 35 days, the averaging time is still 4week. The 100% period for a nmonth sample has been defined as the period starting from the start date/time of the sample and ending on the same day number and time n months later. Example: the sample starts at 5 March at 00:00, the 100% 1-month period is until 5 April at 00:00. Other example: the sample starts at 30 January at 00:00, the 100% 1-month period is until "virtual" 30 February, that is actually 2 March at 00:00 (no leap year). So if the end date/time is between 27 March 18:00 and 22 April 18:00 the sample period has still 1month averaging time.

The only statistics calculated for these averaging times are:

- annual mean
- 50 percentile
- 95 percentile
- 98 percentile
- maximum

All statistics calculations are done in analogy to the hourly/daily statistics calculations except for the annual mean and the data coverage. These quantities are calculated on base of the number of hours in the sample periods.
So the data coverage is calculated as follows:

$$Data\ coverage = \Sigma_i N_{valid,i} / N_{year} * 100\ \%$$

where $N_{valid,i}$ is the number of hours in the valid sample i and N_{year} is the number of hours in the year

The annual means are calculated according to the formula:

$$Annual\ mean = \Sigma_i N_i C_{,i} / \Sigma_i N_i$$

[1] n-hour values are aggregated into daily values. The statistics are based on these daily values.

where C_i is the valid concentration in sample period i and N_i is the number of hours in sample period i. The summation is over all valid periods in the year.
Remark: if a period is partially outside the year, only hourly values are taken into account between 1 January and 31 December of the year.

B.3. Calculation of NO_x values

To obtain a better coverage of NO_x-measurements in AirBase, there are in AirBase version 5 also NO_x-values available which are derived from reported NO- and NO_2-results following the formula :

$$C_{NOx} = C_{NO2} + ((M_{NO2}/ M_{NO}) * C_{NO})$$

where

C_{NOx} = NO_x *concentration in* µg NO_2/m^3
C_{NO2} = NO_2 *concentration in* µg$/m^3$
C_{NO} = *NO concentration in* µg$/m^3$
M_{NO} = *MolecularMass of NO* = 30
M_{NO2} = *MolecularMass of* NO_2 = 46

For defining the measurement configuration of the derived NO_x measurements, the information is used of the measurement configuration of NO.
In case NO, NO_2 and NO_x are all reported, the reported NO_x-values will have priority over the derived NO_x-values.

Annex C. QA/QC feedback actions

Overview of the QA/QC activities undertaken by the data suppliers and ETC/ACM during the EoI2010 reporting cycle is given in *Table B1*. The QA/QC checks are described in "Quality checks on air quality data in AirBase and the EoI data in 2009" (see Mol 2010b).

Table C1. QA/QC actions on EoI2009 data in 2010 and 2011

Date	Processes by data supplier	Processes by ETC/ACM
12 May 2010		Release of the DEMv13
	Modifying meta data in the DEM Checking meta data in the DEM Import raw data into the DEM Checking raw data in the DEM Submit to Central Data Repository (CDR)	Help desk
1 Oct 2010 to 15 Dec 2010		Upload DEM into AIRBASE Checks on outliers, missing essential meta data, missing data, resubmission old data, deletion stations/measurement configurations with data. Send feedback reports to the data suppliers
	Replies on the feedback reports, submitting missing data	
		Processing of the replies
15 December 2010		Release interim version AIRBASE by EEA
15 Dec 2010 to 1 Feb 2011		Upload Malta DEM into AIRBASE
	Replies on the feedback reports, submitting missing data	
		Processing of the (non) replies
1 Feb to 8 Febr 2011		Calculation of statistics and exceedances
8 February 2011		Delivery first version AIRBASE to EEA
8 Febr to 10 Febr 2011		Checks by EEA
21 February 2011		Delivery final AIRBASE to EEA
23 February 2011		Release of AIRBASE on EEA Data Service (see airbase history page)

Most feedback is on the outliers. With the outlier checks also errors in units can be detected. There was no feedback on lack of component reporting on $NO/NO_x/NO_2$ (only one of this three components has been reported), but this will be included in the next feedback of EoI2011.

38 countries have delivered EoI2009 data (see status table http://acm.eionet.europa.eu/databases/country_tools/aq/eoi_to_airbase_status/index_html)
All countries have given response on the feedback.

The feedback has been placed on CDR:
http://cdr.eionet.europa.eu/resultsfeedbacks?obligation=http%3A%2F%2Frod.eionet.eu.int%2Fobligations%2F131&startdate%3Adate%3Aignore_empty=&enddate%3Adate%3Aignore_empty=&country=&sort_on=reportingdate&sort_order=reverse Most countries have placed their responses also on CDR. The responses of AT, BA, GR and SK have been placed on Circa: http://eea.eionet.europa.eu/Members/irc/eionet-circle/airclimate/library?l=/qaqc_country_feedback/eoi_2010_2009_data&vm=detailed&sb=Title. One can also use the status table to find very easily all feedback information.

Information on Circa is not public. For access to this information an Eionet user account and password is needed.

Table C2. Status overview of QA/QC feedback actions on the EoI-2010 reporting cycle

Country		outliers	missing data	missing essential data	resubm. data	deleted meta with data stored
AL	Albania	yellow	yellow	blue	yellow	yellow
AT	Austria	blue	blue	yellow	blue	blue
BA	Bosnia-Herzegovina	blue	blue	yellow	yellow	yellow
BE	Belgium	blue	blue	blue	yellow	yellow
BG	Bulgaria	blue	blue	yellow	yellow	blue
CH	Switzerland	yellow	blue	yellow	yellow	yellow
CY	Cyprus	yellow	blue	yellow	yellow	yellow
CZ	Czech Republic	blue	blue	blue	blue	yellow
DE	Germany	blue	blue	blue	yellow	yellow
DK	Denmark	blue	blue	yellow	yellow	blue
EE	Estonia	yellow	blue	yellow	yellow	yellow
ES	Spain	blue	blue	blue	yellow	blue
FI	Finland	blue	blue	yellow	yellow	yellow
FR	France	blue	blue	blue	yellow	yellow
GB	United Kingdom	blue	blue	blue	yellow	blue
GR	Greece	blue	blue	yellow	yellow	yellow
HR	Croatia	blue	yellow	yellow	yellow	yellow
HU	Hungary	yellow	yellow	yellow	yellow	yellow
IE	Ireland	blue	blue	blue	yellow	blue
IS	Iceland	blue	blue	yellow	yellow	yellow
IT	Italy	blue	blue	blue	yellow	blue
LI	Liechtenstein	yellow	yellow	yellow	yellow	yellow
LT	Lithuania	yellow	blue	yellow	yellow	yellow
LU	Luxembourg	blue	yellow	blue	yellow	yellow
LV	Latvia	yellow	blue	yellow	yellow	yellow
ME	Montenegro	blue	yellow	yellow	yellow	yellow
MK	FYR of Macedonia	blue	blue	yellow	yellow	yellow
MT	Malta	No feedback sent				
NL	Netherlands	blue	blue	blue	blue	blue
NO	Norway	blue	blue	yellow	yellow	yellow
PL	Poland	blue	blue	blue	yellow	yellow
PT	Portugal	blue	blue	blue	yellow	yellow
RO	Romania	blue	blue	yellow	yellow	yellow
RS	Serbia	blue	blue	yellow	yellow	yellow
SE	Sweden	blue	blue	yellow	yellow	yellow
SI	Slovenia	blue	yellow	yellow	yellow	yellow
SK	Slovak Republic	blue	blue	yellow	yellow	yellow
TR	Turkey	blue	blue	yellow	yellow	yellow

Legend:

- (blue) detected in country-report and response processed
- (yellow) not detected in country-report
- (white) no answer

Annex D Component groups VOC, Pb_aer, Heavy Metals 4DD (HM4) and PAHs 4DD (PAH4)

Component group Volatile Organic Compounds (VOC) (VOC- = VOC – Benzene)

CompNmbr	CompShortName	CompName	Matrix
20	C6H6	Benzene	air
21	C6H5-CH3	Toluene	air
24	CH2=CH-CH=CH2	1.3 Butadiene	air
25	HCHO	Formaldehyde	air
32	THC (NM)	Total non-methane hydrocarbons	air
316	(CH3)2-CH-CH2-CH2-CH3	i-Hexane (2-methylpentane)	air
394	H3C-CH2-CH2-CH3	n-Butane	air
428	C2H6	Ethane	air
430	H2C=CH2	Ethene (Ethylene)	air
431	C6H5-C2H5	Ethyl benzene	air
432	HC=CH	Ethyne (Acetylene)	air
441	C7H16	n-Heptane	air
443	C6H14	n-Hexane	air
447	H3C-CH(CH3)2	i-Butane (2-methylpropane)	air
449	(CH3)3-C-CH2-CH-(CH3)2	i-Octane (2,2,4-trimethylpentane)	air
450	H3C-CH2-CH(CH3)2	i-Pentane (2-methylbutane)	air
451	CH2=CH-C(CH3)=CH2	Isoprene (2-methyl-1,3-butadiene)	air
464	m,p-C6H4(CH3)2	m,p-Xylene	air
475	C8H18	n-Octane	air
482	o-C6H4-(CH3)2	o-Xylene	air
486	H3C-(CH2)3-CH3	n-Pentane	air
503	H3C-CH2-CH3	Propane	air
505	CH2=CH-CH3	Propene	air
6005	H2C=CH-CH2-CH3	1-Butene	air
6006	trans-H3C-CH=CH-CH3	trans-2-Butene	air
6007	cis-H3C-CH=CH-CH3	cis-2-Butene	air
6008	H2C=CH-CH2-CH2-CH3	1-Pentene	air
6009	H3C-HC=CH-CH2-CH3	2-Pentenes	air
6011	1,2,4-C6H3(CH3)3	1,2,4-Trimethylbenzene	air
6012	1,2,3-C6H3(CH3)3	1,2,3-Trimethylbenzene	air
6013	1,3,5-C6H3(CH3)3	1,3,5-Trimethylbenzene	air

Component group Lead in aerosol (Pb_aer)

CompNmbr	CompShortName	CompName	Matrix
12	Pb	Lead	aerosol
1012	Pb in PM2.5	Lead in PM2.5	aerosol
3012	Pb in TSP	Lead in TSP	aerosol
5012	Pb in PM10	Lead in PM10	aerosol

Component group BaP in aerosol (BaP_aer)

CompNmbr	CompShortName	CompName	Matrix
6015	BaP	Benzo(a)pyrene	air+aerosol
5029	BaP in PM10	Benzo(a)pyrene in PM10	aerosol
5129	BaP in PM10	Benzo(a)pyrene in PM10	air + aerosol
1029	BaP in PM2.5	Benzo(a)pyrene in PM2.5	aerosol

Component group Heavy Metals in 4DD (HM4)

CompNmbr	CompShortName	CompName	Matrix
13	Hg	Mercury	aerosol
14	Cd	Cadmium	aerosol
15	Ni	Nickel	aerosol
18	As	Arsenic	aerosol
653	Hg-reactive	reactive_mercury	air+aerosol
2013	Hg	Mercury	precip
2014	Cd	Cadmium	precip
2015	Ni	Nickel	precip
2018	As	Arsenic	precip
3013	Hg in TSP	Mercury in TSP	aerosol
3014	Cd in TSP	Cadmium in TSP	aerosol
4013	Hg	Mercury	air+aerosol
4813	Hg0 + Hg-reactive	Total gaseous mercury	air + aerosol
5013	Hg in PM10	Mercury in PM10	aerosol
5014	Cd in PM10	Cadmium in PM10	aerosol
5015	Ni in PM10	Nickel in PM10	aerosol
5018	As in PM10	Arsenic in PM10	aerosol
7013	Hg	Mercury	precip+dry_dep
7014	Cd	Cadmium	precip+dry_dep
7015	Ni	Nickel	precip+dry_dep
7018	As	Arsenic	precip+dry_dep

Component group Polycyclic Aromatic Hydrocarbons in 4DD (PAH4)

29	BaP	Benzo(a)pyrene	precip
6015	BaP	Benzo(a)pyrene	air+aerosol
7029	BaP	Benzo(a)pyrene	precip+dry_dep
5029	BaP in PM10	Benzo(a)pyrene in PM10	aerosol
5129	BaP in PM10	Benzo(a)pyrene in PM10	air + aerosol
1029	BaP in PM2.5	Benzo(a)pyrene in PM2.5	aerosol
609	Benzo(a)anthracene	Benzo(a)anthracene	air+aerosol
610	Benzo(a)anthracene	Benzo(a)anthracene	precip
611	Benzo(a)anthracene	Benzo(a)anthracene	precip+dry_dep
5609	Benzo(a)anthracene in PM10	Benzo(a)anthracene in PM10	air+aerosol
5610	Benzo(a)anthracene in PM10	Benzo(a)anthracene in PM10	aerosol
616	Benzo(b)fluoranthene	Benzo(b)fluoranthene	air+aerosol
617	Benzo(b)fluoranthene	Benzo(b)fluoranthene	precip
618	Benzo(b)fluoranthene	Benzo(b)fluoranthene	precip+dry_dep
5616	Benzo(b)fluoranthene in PM10	Benzo(b)fluoranthene in PM10	air+aerosol
5617	Benzo(b)fluoranthene in PM10	Benzo(b)fluoranthene in PM10	aerosol
759	Benzo(j)fluoranthene	Benzo(j)fluoranthene	precip
760	Benzo(j)fluoranthene	Benzo(j)fluoranthene	precip+dry_dep
762	Benzo(j)fluoranthene	Benzo(j)fluoranthene	air+aerosol
5759	Benzo(j)fluoranthene in PM10	Benzo(j)fluoranthene in PM10	aerosol
5762	Benzo(j)fluoranthene in PM10	Benzo(j)fluoranthene in PM10	air+aerosol
625	Benzo(k)fluoranthene	Benzo(k)fluoranthene	air+aerosol
626	Benzo(k)fluoranthene	Benzo(k)fluoranthene	precip
627	Benzo(k)fluoranthene	Benzo(k)fluoranthene	precip+dry_dep
5625	Benzo(k)fluoranthene in PM10	Benzo(k)fluoranthene in PM10	air+aerosol
5626	Benzo(k)fluoranthene in PM10	Benzo(k)fluoranthene in PM10	aerosol
419	Dibenzo(ah)anthracene	Dibenzo(ah)anthracene	precip
763	Dibenzo(ah)anthracene	Dibenzo(ah)anthracene	air+aerosol
7419	Dibenzo(ah)anthracene	Dibenzo(ah)anthracene	precip+dry_dep
5419	Dibenzo(ah)anthracene in PM10	Dibenzo(ah)anthracene in PM10	aerosol
5763	Dibenzo(ah)anthracene in PM10	Dibenzo(ah)anthracene in PM10	air+aerosol
654	Indeno-(1,2,3-cd)pyrene	indeno_123cd_pyrene	air+aerosol
655	Indeno-(1,2,3-cd)pyrene	indeno_123cd_pyrene	precip
656	Indeno-(1,2,3-cd)pyrene	indeno_123cd_pyrene	precip+dry_dep
5654	Indeno-(1,2,3-cd)pyrene in PM	indeno_123cd_pyrene in PM10	air+aerosol
5655	Indeno-(1,2,3-cd)pyrene in PM	indeno_123cd_pyrene in PM10	aerosol
5655	Indeno-(1,2,3-cd)pyrene in PM	indeno_123cd_pyrene in PM10	aerosol

Annex E Distance-to-target graphs

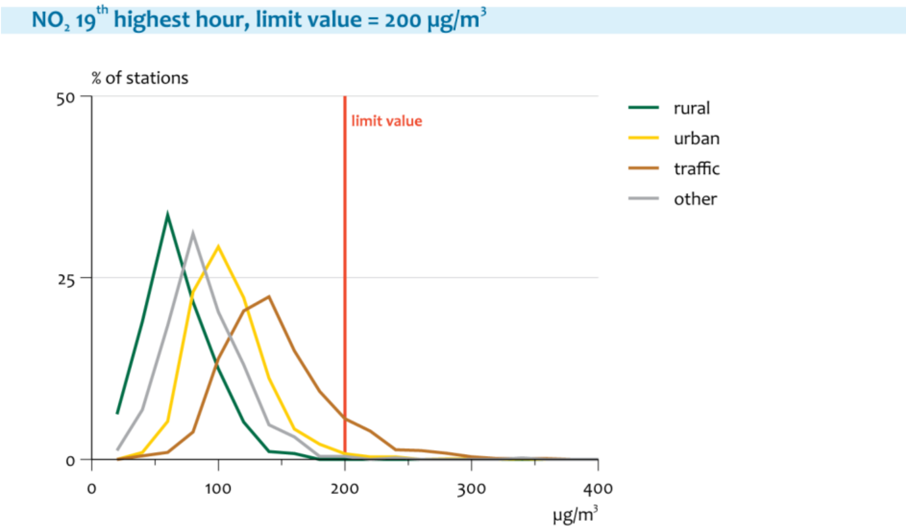

Figure E.1.: Distance-to-target graph for the short-term limit value of NO_2, reference year 2009.

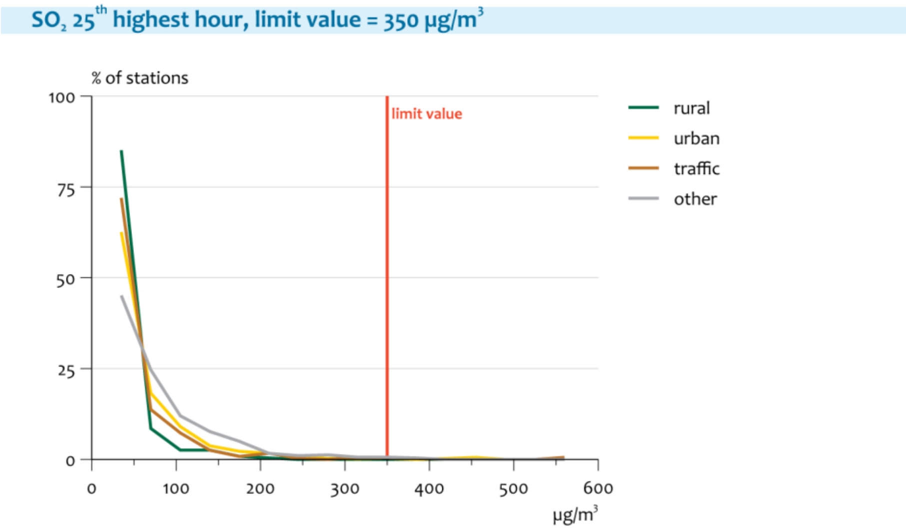

Figure E.2.: Distance-to-target graph for the hourly limit value of SO_2, reference year 2009.

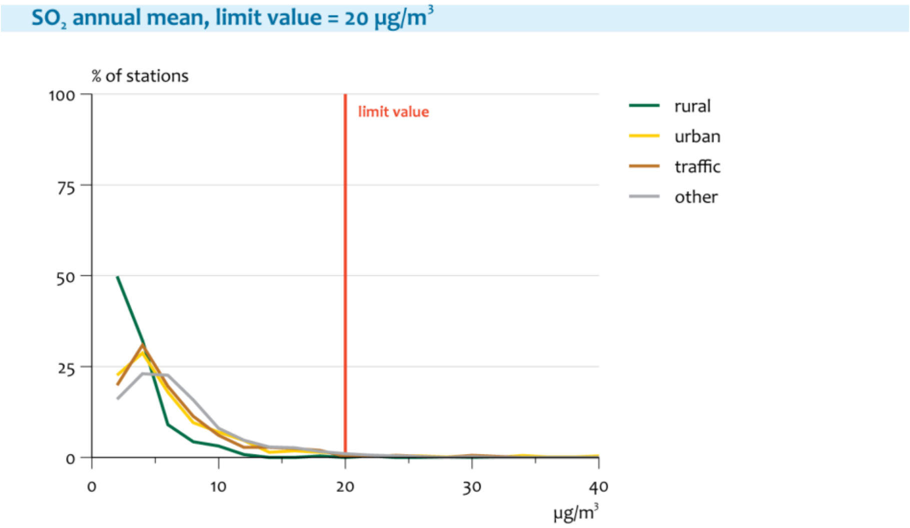

Figure E.3.: Distance-to-target graph for the protection of vegetation (annual mean of SO_2), reference year 2009.

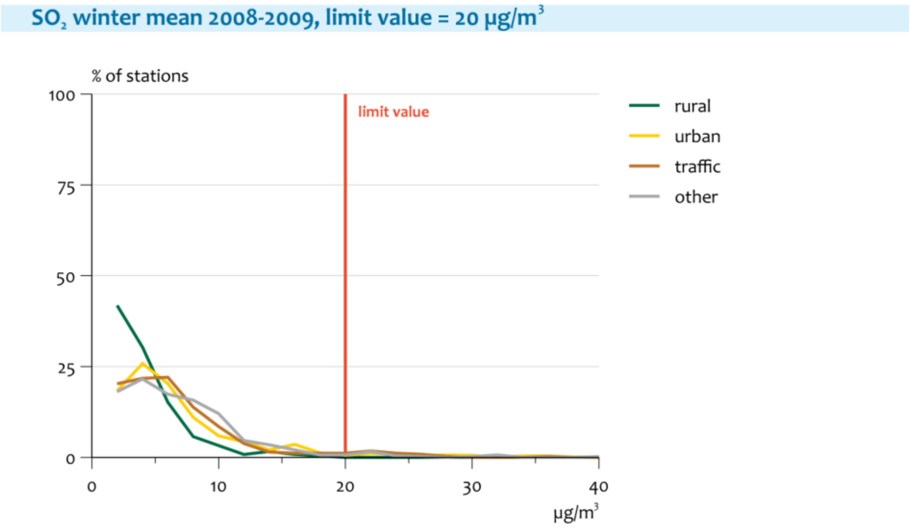

Figure E.4.: Distance-to-target graph for the protection of vegetation (winter period (October 2008 – March 2009) mean of SO_2)

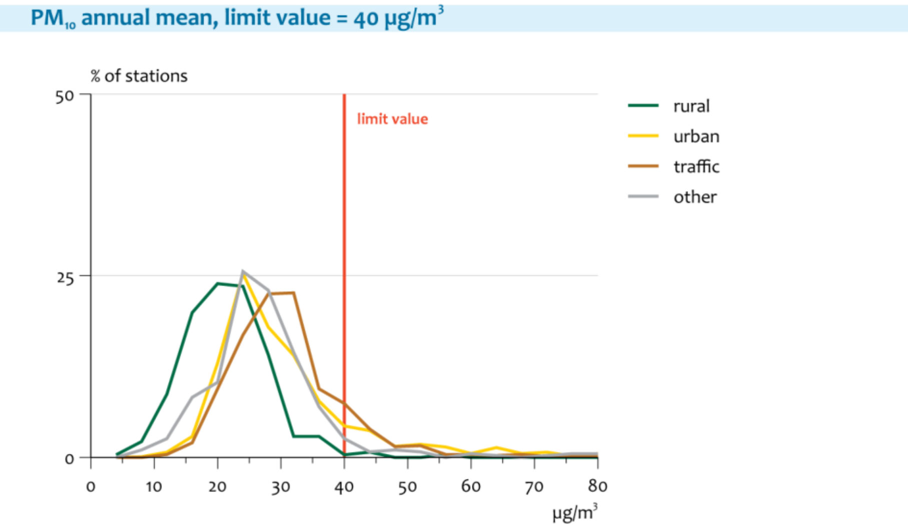

Figure E.5.: Distance-to-target graph for the annual limit value of $PM_{10,}$ reference year 2009.

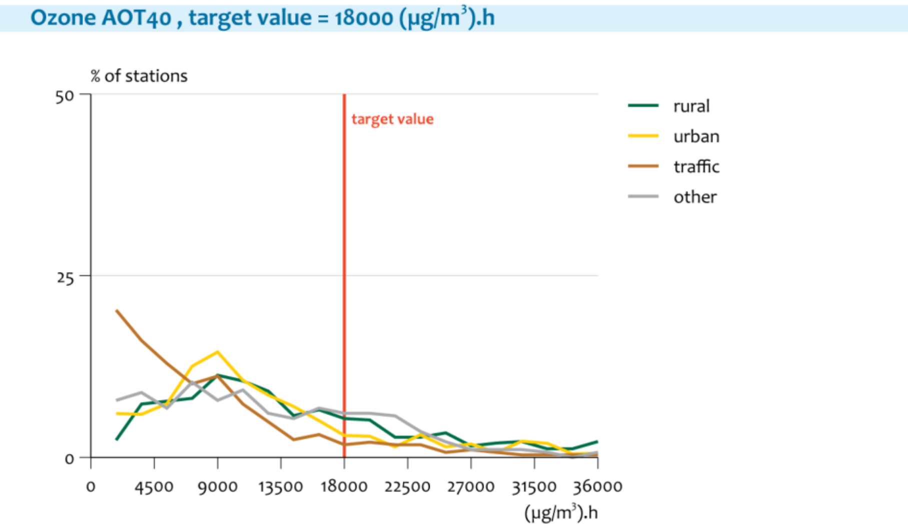

Figure E.6.: Distance-to-target graph for the protection of vegetation (Ozone AOT40), reference period May-July 2009.

Annex F Trend Model

The Mann-Kendall test

For analyzing a possible trend in observed time series the non-parametric Mann-Kendall test (Gilbert, 1987) has been used. This test is particularly useful since missing values are allowed and the data need not to conform to any particular distribution. Moreover, as only the relative magnitudes of the data rather than their actual measured values are used, this test is less sensitive towards incomplete data capture and/or special meteorological conditions leading to extreme values.

In the trend analyses a *consistent set* of stations is used. Requirements for a consistent set are:

- for each year within the time period a minimum data coverage as defined in section 2.1 is required;
- annual data is available for at least 75% of the years within the time period.

In a number of graphs or tables results summarized for the complete consisted set are presented. These results should be interpreted carefully as there might be a bias towards the regions with the highest station density. Similarly, the comparison between the station type might be hampered as the spatial distribution over Europe may differ.

The Mann- Kendall statistic S is defined as:

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} \operatorname{sgn}(x_j - x_k)$$

where

$$\operatorname{sgn}(x_j - x_k) = \begin{cases} 1 & \text{if } (x_j - x_k) > 0 \\ 0 & \text{if } (x_j - x_k) = 0, \\ -1 & \text{if } (x_j - x_k) < 0 \end{cases}$$

x_j is the observable (concentration, number of exceedance days, exposure) in year j; n is the available number of years with a valid measurement. In other words, S is the number of positive differences minus the number of negative differences. If S is a large positive number measurements taken later in time tend to be larger than those taken earlier in time. Similarly, if S is a large negative number, this indicates a downward trend. The Mann-Kendall statistic is only calculated for consistent sets of stations.

If a linear trend is present, the slope is estimated by Sen's non-parametric procedure (Gilbert, 1987). For each time series with n valid measurements a set of slope estimates Q_{jk} is computed for each of the $n(n-1)/2$ data pairs:

$$Q_{jk} = \frac{x_j - x_k}{j - k}$$

Sen's slope estimate equals the median of the $n(n-1)/2$ slope estimates.