The state of the air quality in 2008

and the European exchange
of monitoring information in 2009

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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 Member States of the EU (EU MS) and the Commission. Besides the EU MS, 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 contents of AirBase (version 4) is available to the public via the European Environment Agency (EEA) website[1]. More information on AirBase can be found on the ETC/ACC website[2]. The results of the reporting cycle presented in this technical report cover data for 2008.

A total of 36 countries, including the 27 EU MS, have provided air quality data for 2008 . 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 and Climate Change (ETC/ACC).

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 2008 .

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

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INTRODUCTION

The reciprocal exchange among countries and the Commission is based on a series of Council Decisions. The latest Decision (97/101/EC) 'establishing a reciprocal exchange of information and data from networks and individual stations measuring ambient air pollution within the Member States', the Exchange of Information (EoI), was adopted by the European Council in 1997 (EU 1997). The annexes to the Decision have been amended to adapt the list of pollutants covered to changes and requirements on additional information, validation and aggregation (EU 2001a, EU 2001b). Data submission follows the Guidance on the revised Annexes of the Decision (Garber *et al.* 2001).

Parallel to dataflow under the EoI, the Member States of the European Union (EU MS) provide information on air quality in the context of the Air Quality (AQ) Framework Directive (FWD; EU 1996) and related daughter directives (DD; EU 1999, EU 2000, EU 2002, EU 2004a, EU2004b). This information mainly focuses on compliance checking with obligations under the AQ directives, such as limit values. To avoid duplicate reporting by the EU 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 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 and Climate Change (ETC/ACC), under contract to EEA, manages the database system, AirBase (see Mol *et al.* 2005a). 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). The contents of AirBase is available to the public via the EEA website[1]. Background information on AirBase can be found on the ETC/ACC website[2]

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

This report shows information provided by the 27 EU MS. In addition it contains information from other five EEA Member Countries (EEA MC) and from four EEA Cooperating Countries[4] (EEA CC) which have agreed to follow the data exchange procedures in the framework of Euroairnet[5].

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 2009b). The standard checks on the delivered EoI-data are: outliers, missing essential meta data, missing 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.

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

[2] http://airbase.eionet.europa.eu/

[3] http://www.eea.europa.eu/maps/ozone/welcome

[4] 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.

[5] http://air-climate.eionet.europa.eu/databases/databases/EuroAirnet/index_html

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 (2008) air quality status will be described together with the changes in concentrations during the last 10 and 5 years.

The EoI Technical report of last year (EoI2008, 2007-data) is given by Mol *et al.* (2009a). EoI Technical Reports of earlier years can be found on the ETC/ACC Website[1]

[1] http://air-climate.eionet.europa.eu/databases/airbase/eoi_reports/index_html

1. EXCHANGE OF INFORMATION 2009 (DATA FOR 2008)

1.1. Data delivery

Thirty six countries, including the 27 EU MS, provided AQ data for the reporting year 2008 . In comparison with the previous EoI cycle, Croatia, Luxembourg and Turkey have also delivered data (see the status table in http://air-climate.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 2008 was loaded into AirBase (version 4). All statistics and exceedances relevant in the DD have been calculated and were also loaded into AirBase.

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 2009b). The yearly QA/QC checks on the delivered EoI-data are checks on outliers, missing essential meta data, missing 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 the data suppliers on these items. The country feedbacks sent to the EEA MC + EEA CC resulted for 33 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. Results

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 less commonly monitored components.

The number of reporting countries varied per component ranging from 35 countries for SO_2, NO_2, PM_{10} and O_3 to thirteen for components for VOC- (VOC minus benzene).

The number of reporting stations in 2008 also varied accordingly, being 296 for one or more VOC- and 3233 for NO_2. Differences in the distribution and density of reporting stations is illustrated for selected pollutants (*Figures 1 through 8)*. 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.

[1] http://air-climate.eionet.europa.eu/country_tools/aq/aq-dem/index_html

Overviews of reporting in 2008 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 (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, excluding Pb which is listed separately) 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_aerosol 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 2008 can be found in table A "number of stations per pollutant and station type and country in 2008 " http://air-climate.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[1] at that station[2]. 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". If 3-hourly data are delivered, these data are aggregated in daily values, which only are reported.

The daily values in AirBase have been calculated by ETC/ACC 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.

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://air-climate.eionet.europa.eu/databases/airbase/eoi_tables/eoi2009/index_html for a summary of these supplementary components.

For all pollutants the number of stations for which data have been reported in 2008 has been increased in comparison with 2007: SO_2 (+267), NO_2 (+604), PM_{10} (+485), $PM_{2.5}$ (+252), CO(+279), C_6H_6 (+214), O_3 (404), VOC- (+85), HM4 (+274), PAH4 (+272), Pb_aerosol (+193) and NO_x /NO (+512). The main increases come from Spain (NO_2 , NO_x /NO, $PM_{2.5}$,

[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*. The data capture and time coverage and so the data coverage include losses of data due to the regular calibration or the normal maintenance of the instrumentation. In the AQ Directives these losses are excluded.

[2] More specific: stations with data are stations with calculated or defined statistics (annual means).

Pb_aer, CO and O_3), Italy (PM_{10} , C_6H_6 and VOC) and Poland (SO2, HM4 and PAH4). Turkey has also made a valuable contribution with 64 SO_2 and 79 PM_{10} stations.

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 815. 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://air-climate.eionet.europa.eu/databases/airbase/eoi_tables/eoi2009/index_html for an overview per country.

Table 1 Number of stations for which 2008 data have been delivered for DD components, specified per station type.

	Daughter Directive											
	1	1	1	1	1	1	2	2	3	3	4	4
	SO2	NO2	NOx/NO	PM10	PM2.5	Pb_aer	CO	C6H6	O3	VOC-	HM4	PAH4
Reporting EU countries	27	27	25	27	26	20	27	25	27	11	21	19
Total number of stations	2136	3132	2348	2686	540	624	1305	703	2164	289	637	483
Of which												
Traffic	396	870	752	790	138	134	640	310	315	158	135	121
Urban background	883	1333	827	1150	238	278	411	249	1046	61	279	235
Industrial	538	499	407	425	61	116	180	96	257	49	119	58
Rural background	299	392	346	297	101	92	60	44	495	12	100	67
Other	20	38	16	24	2	4	14	4	51	9	4	2
Reporting non-EU countries	8	8	7	8	3		7	5	8	2		1
Total number of stations	144	101	70	156	19		43	16	63	7		1
Of which												
Traffic	24	40	30	39	12		25	11	18	2		
Urban background	91	34	24	96	5		8	3	20	4		
Industrial	17	12	6	13			8	1	6			
Rural background	12	15	10	8	2		2	1	19	1		1
Other												
Total reporting countries	35	35	32	35	29	20	34	30	35	13	21	20
Total number of stations	2280	3233	2418	2842	559	624	1348	719	2227	296	637	484

Table 2 Number of stations for which 2008 data have been delivered for DD components, specified per country.

	Daughter Directive											
	1	1	1	1	1	1	2	2	3	3	4	4
	SO2	NO2	NOx/NO	PM10	PM2.5	Pb_aer	CO	C6H6	O3	VOC-	HM4	PAH4
EU-27 countries												
AUSTRIA	111	154	154	134	12	20	40	22	117		21	19
BELGIUM	61	70	70	62	32	60	21	39	40		61	21
BULGARIA	16	15	15	38	4	7	12	12	13	5	12	12
CYPRUS	1	1	1	2	2	2	1	1	2		2	
CZECH REPUBLIC	88	92	92	121	32	65	34	26	60		65	30
DENMARK	5	12	12	7	8	8	7	2	9	2	8	1
ESTONIA	9	9	9	6	2	3	7	1	9		3	3
FINLAND	10	27	27	28	7		7		17			
FRANCE	312	507		375	35		87	31	461			
GERMANY	185	447	448	450	98	124	153	116	298	77	151	110
GREECE	16	27	26	16	5		14	2	24			
HUNGARY	24	24	23	25	3		20	11	17		6	16
IRELAND	9	10	12	17	1	7	5	2	10	1	3	1
ITALY	337	631	585	454	74	33	416	176	342	140	33	34
LATVIA	7	9	1	9	7	7	1	7	9		7	4
LITHUANIA	12	15	12	13	3	4	8	6	13	1	5	5
LUXEMBOURG	6	6	6	6	1	5	3	2	6		5	5
MALTA	3	3	3	3	3	3	3	3	3	3	3	2
NETHERLANDS	35	55	43	40	20	6	21	8	37	8	8	7
POLAND	260	284	124	239	13	126	65	62	68	1	103	103
PORTUGAL	49	60	60	51	17		38	10	45			
ROMANIA	68	60	60	35	2	13	68	23	47		8	
SLOVAKIA	12	15		27	4	6	11	10	12		6	6
SLOVENIA	21	10	10	10			5		11			
SPAIN	426	446	433	405	92	89	226	81	398	45	92	77
SWEDEN	7	30	9	33	9		4	10	16			
UNITED KINGDOM	46	113	113	80	54	36	28	40	80	6	35	27
Total EU-27 countries	2136	3132	2348	2686	540	624	1305	703	2164	289	637	483
non-EU-27 countries												
BOSNIA - HERZEGOVINA	2	1	1				2		2			
CROATIA	8	8		8			8	4	2			
ICELAND	1	2	2	3	2		1	1	2	1		
LIECHTENSTEIN		1	1	1					1			
MACEDONIA, FYRO[1)]	29	14	14	13			13		12			
NORWAY	7	22	18	22	12		6	7	11			1
SERBIA	21	20	2	1			1	1	1			
SWITZERLAND	12	33	32	29	5		12	3	32	6		
TURKEY	64			79								
Total non-EU-27 countries	144	101	70	156	19	0	43	16	63	7	0	1
Total all countries	2280	3233	2418	2842	559	624	1348	719	2227	296	637	484

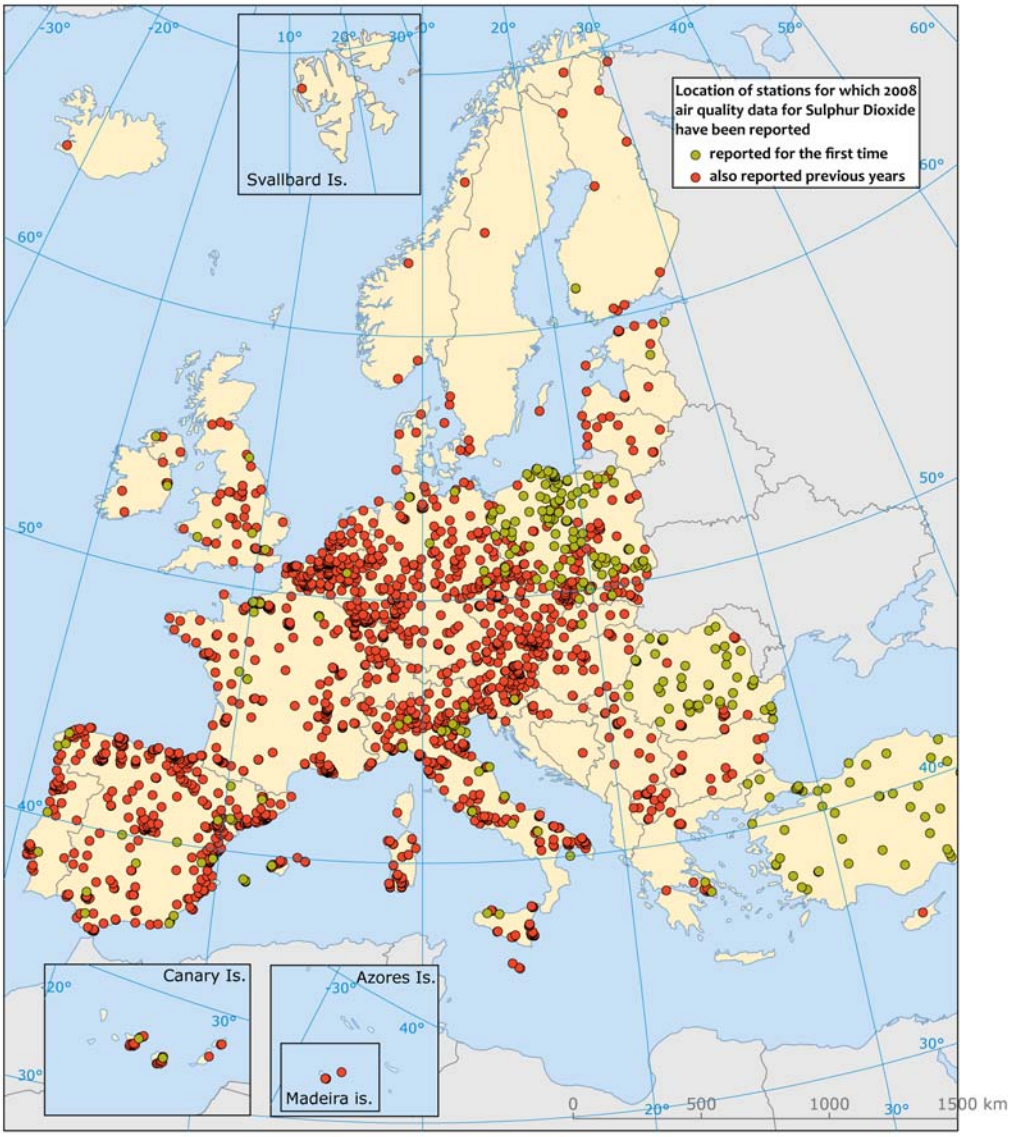

Figure 1 Location of stations for which 2008 air quality data for sulphur dioxide (SO_2) have been reported. The green stations report for the first time (new stations).

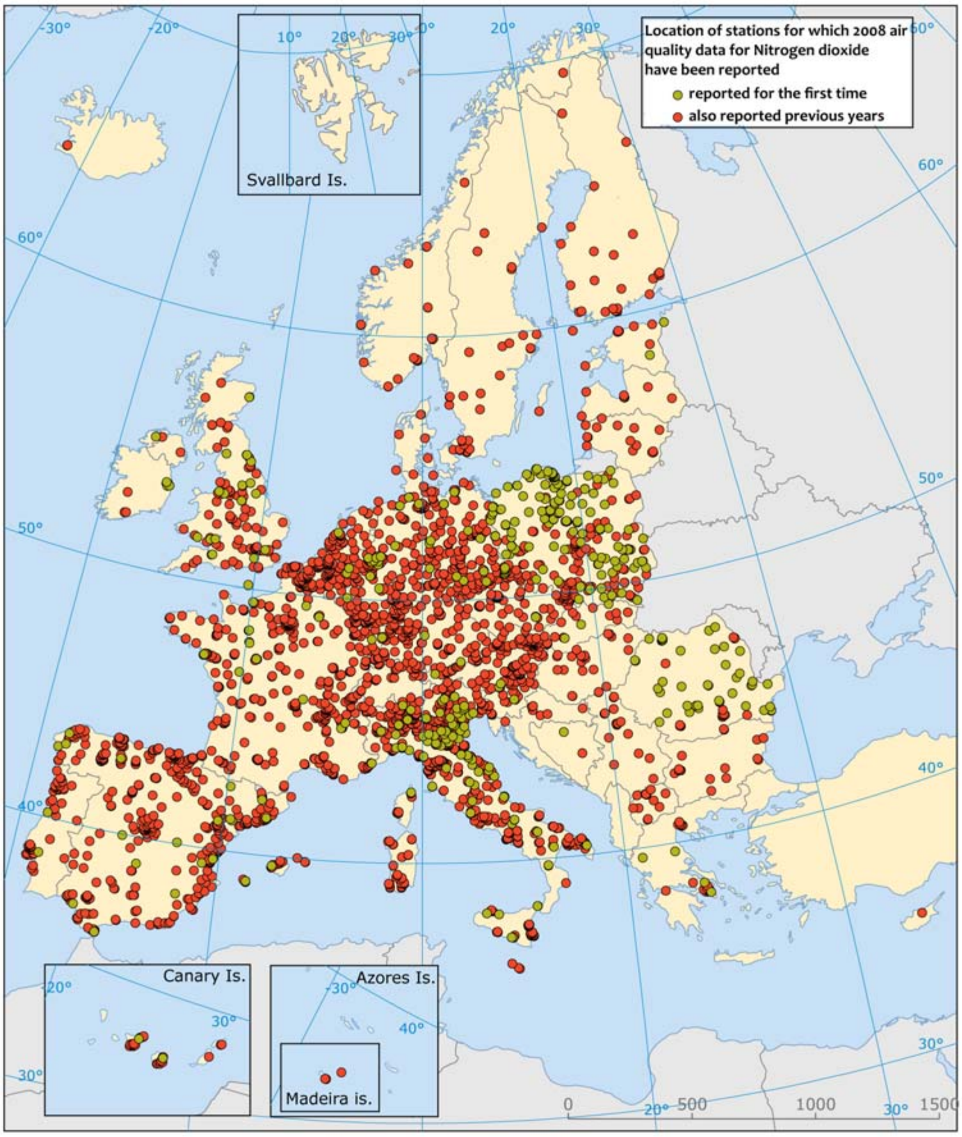

Figure 2 Location of stations for which 2008 air quality data for nitrogen dioxide (NO_2) have been reported. The green stations report for the first time (new stations).

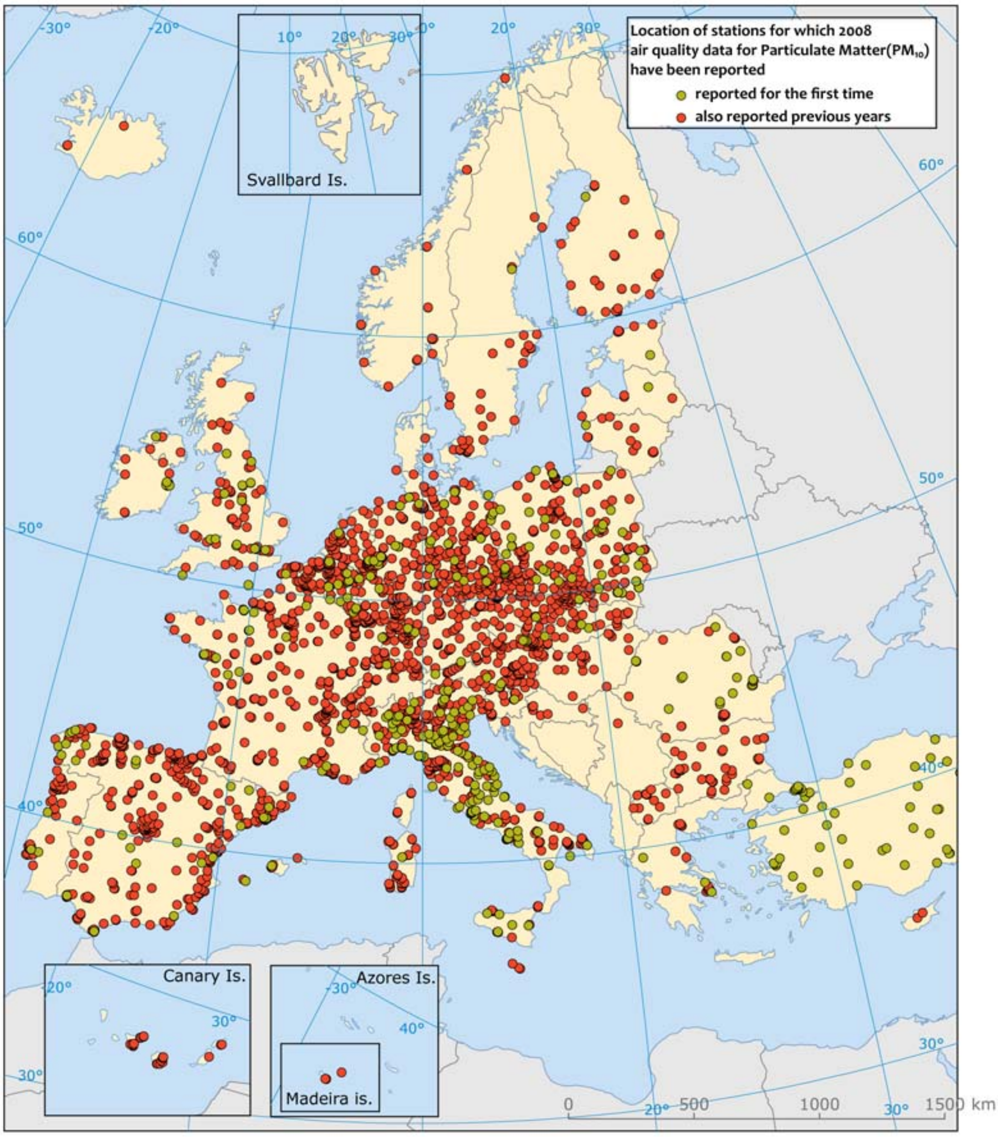

Figure 3 Location of stations for which 2008 air quality data for particulate matter (PM_{10}) have been reported. The green stations report for the first time (new stations).

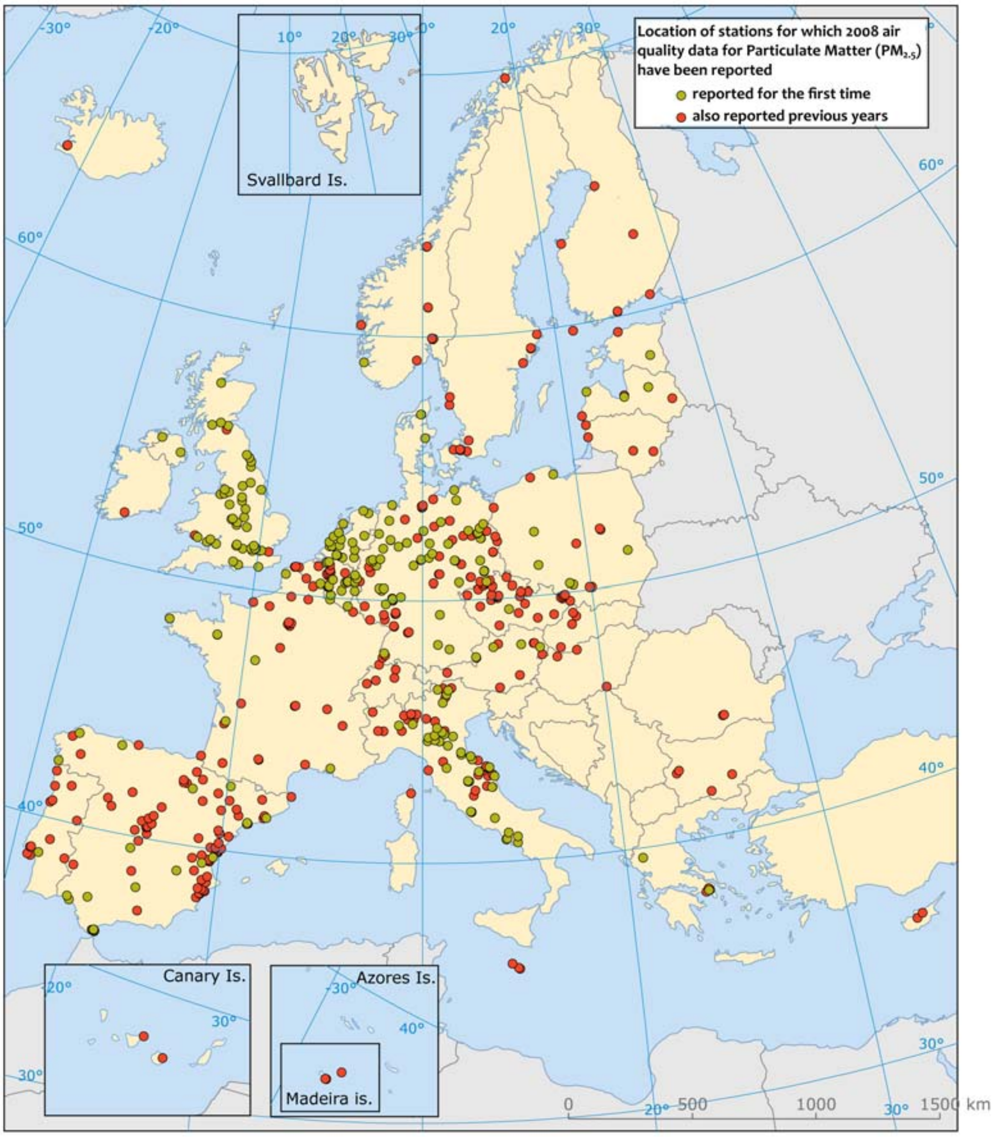

Figure 4 Location of stations for which 2008 air quality data for particulate matter ($PM_{2.5}$) have been reported. The green stations report for the first time (new stations).

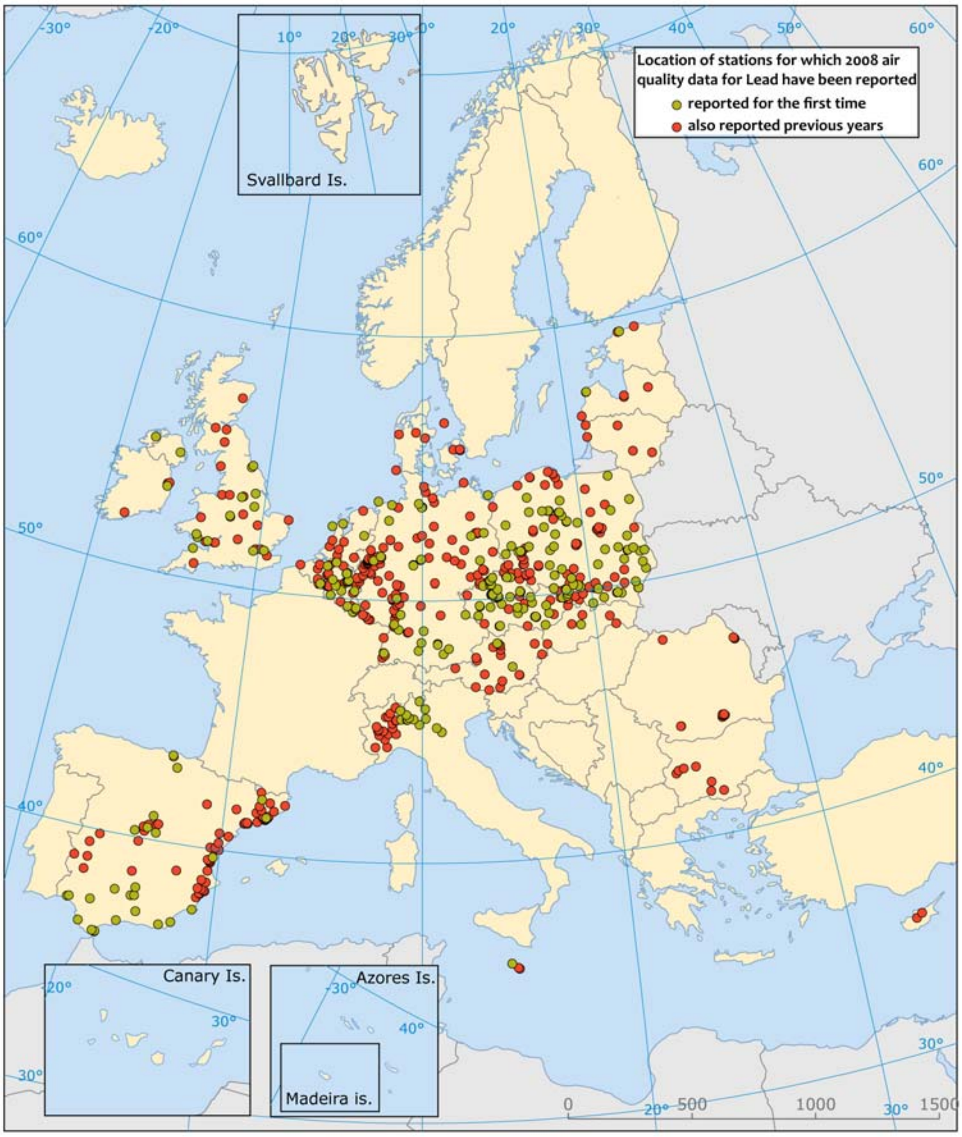

Figure 5 Location of stations for which 2008 air quality data for lead (Pb) have been reported. The green stations report for the first time (new stations).

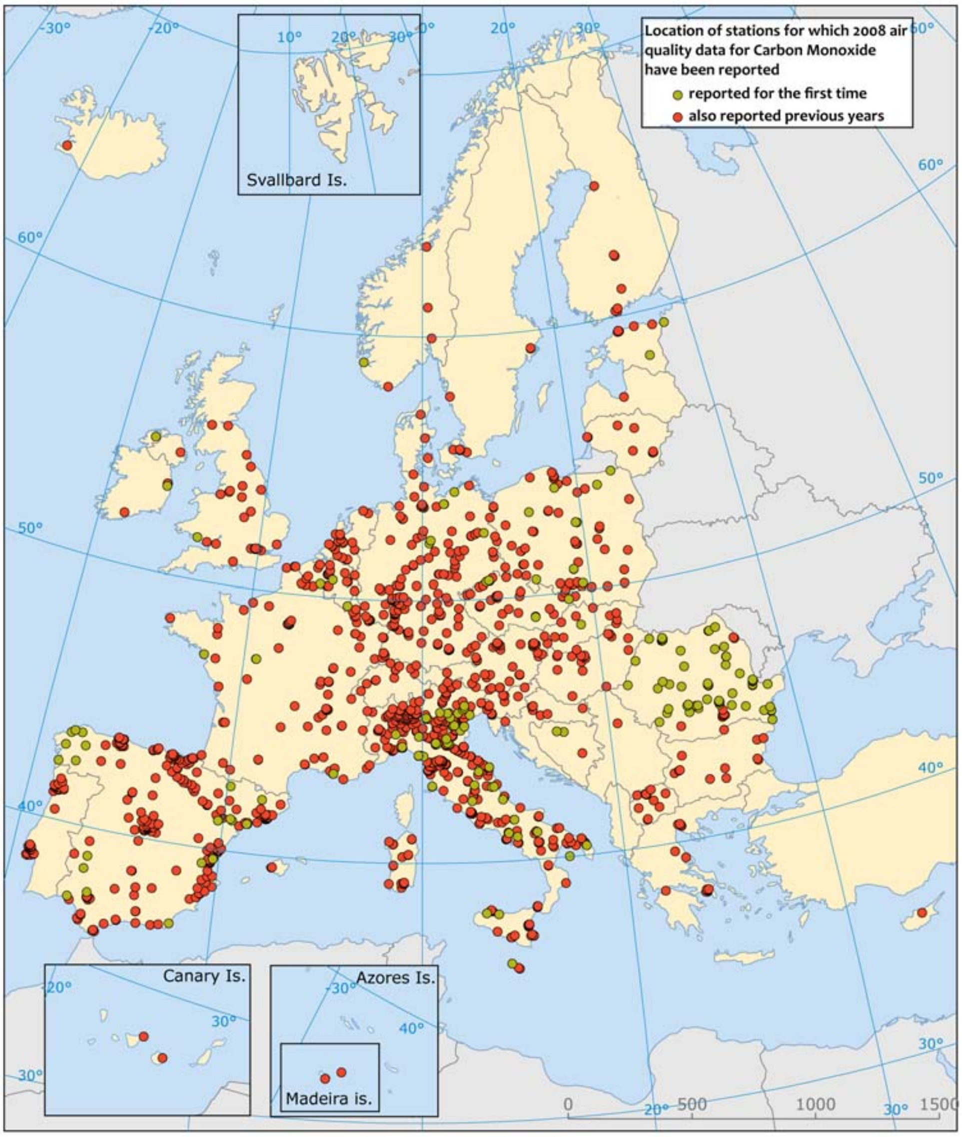

Figure 6 Location of stations for which 2008 air quality data for carbon monoxide (CO) have been reported. The green stations report for the first time (new stations).

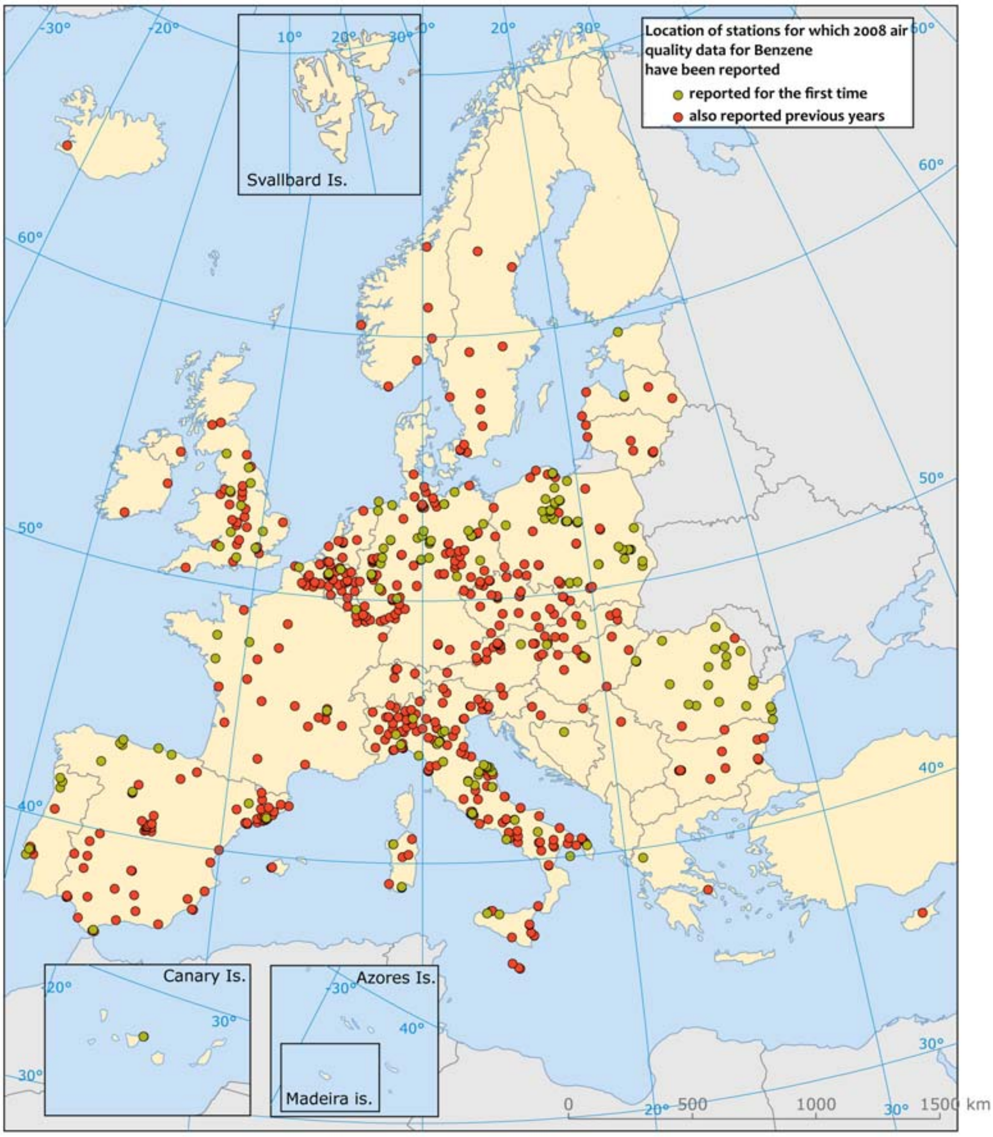

Figure 7 Location of stations for which 2008 air quality data for benzene (C_6H_6) have been reported. The green stations report for the first time (new stations).

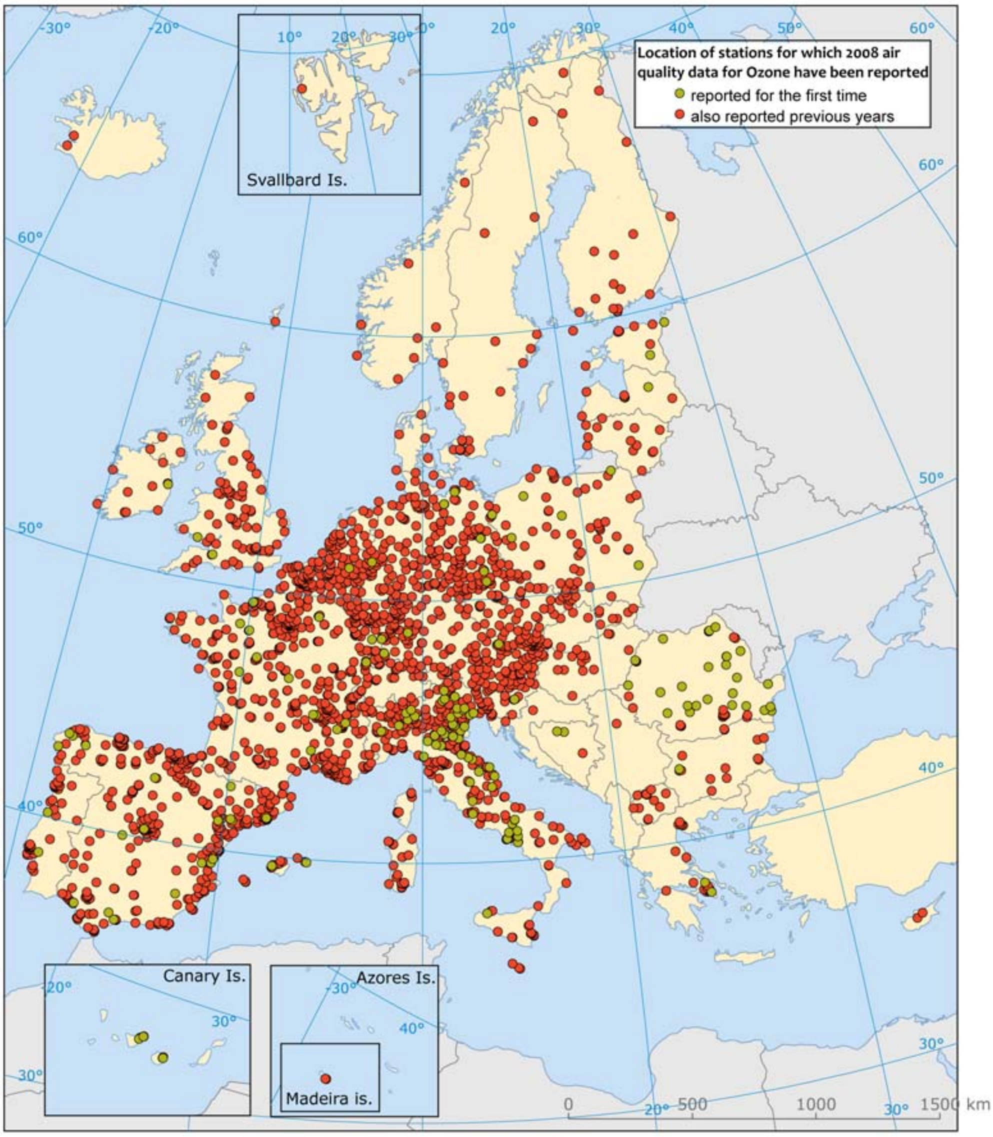

Figure 8 Location of stations for which 2008 air quality data for ozone (O_3) have been reported. The green stations report for the first time (new stations).

1.4. Total number of stations in AirBase

The total number of stations in AirBase is 7379, from which 6622 stations have measurement data (raw data and statistics). 79 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 500 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 near real time (NRT) ozone[1] to the EEA and stations reporting Summer Ozone (3rd FWD/DD)[2] data which have not yet delivered for the EoI

Summarized, in AirBase we have:

Overview nmbr of stations in AirBase	
Selection of stations	Nr. of stations
Stations with only invalid raw data	79
Stations with only statistics	178
Stations with raw data and statistics	6622
Stations without data	500
Total stations in AirBase	7379

The EoI should cover at least the stations which are included in the FWD/Questionnaire (EU 2004b). In the Questionnaire 2009 report (see de Leeuw 2010) the results of this action will be reported.

[1] http://www.eea.europa.eu/maps/ozone/welcome
[2] http://air-climate.eionet.europa.eu/databases/o3excess/index_html

1.5. Historical data, data coverage and time series

The total number of stations with data which are operational in 2008 is 4662 (see *Table 3*). This is an increase of 693 stations in comparison with the EoI2008.

ETC/ACC has generated station lists in which gaps but also potential extensions of time series are indicated. These lists has been send to the countries with the request to deliver these historical data. Several EEA MC have sent historical data (see *Table 4*).

Country	Nr. of components	Nr. of stations
AUSTRIA	5	86
CYPRUS	4	2
CZECH REPUBLIC	3	33
DENMARK	2	5
ESTONIA	1	1
GERMANY	5	856
GREECE	6	14
IRELAND	4	18
LATVIA	4	3
SLOVENIA	5	5
SWEDEN	4	7
SWITZERLAND	9	24
UNITED KINGDOM	6	108

Table 4 Overview historical data delivered in 2009.

Figure 9 gives information on the data coverage of the 2008 stations. The number of stations with data coverage >0% (all operational 2008 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 the average data coverage per country and component, see "Information on time series in AirBase" http://air-climate.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 are 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 requires, 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.

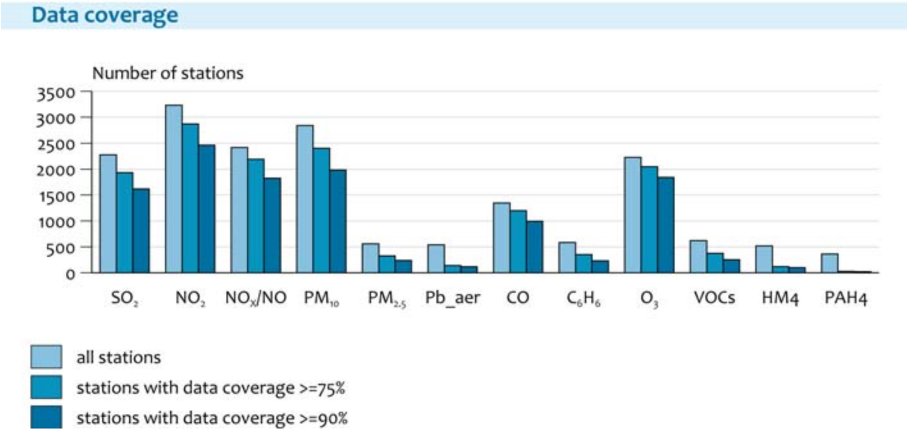

Figure 9 Number of stations with 2008 data coverage >0% (with data), >=75% and >=90%[1]. Data coverage is based on daily averages for SO_2, NO_2, NO_x/NO,PM_{10}, $PM_{2.5}$, Pb_aer, benzene,VOC, HM4 and PAH4 and based on daily running 8h maximum for CO and O_3

[1] The data quality objectives as defined in Daughter Directives requires, in general, a data coverage of 90%. This data coverage do not include losses of data due to the regular calibration or the normal maintenance of the instrumentation and cannot directly be compared with the AirBase data coverage, where these losses are included.

Table 3 Summary of periods and number of stations for which data have been delivered in the whole period and only in 2008.

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 2007 data have been delivered 1)	Number of stations for which 2008 data have been delivered 1)
EU-27 countries				
AUSTRIA	1981-2008	244	191	192
BELGIUM	1985-2008	330	198	233
BULGARIA	1998-2008	38	38	38
CYPRUS	1993-2008	2	2	2
CZECH REPUBLIC	1992-2008	183	129	170
DENMARK	1976-2008	40	14	14
ESTONIA	1997-2008	11	7	9
FINLAND	1990-2008	84	49	49
FRANCE	1976-2008	1030	732	725
GERMANY	1976-2008	985	536	550
GREECE	1983-2008	37	27	28
HUNGARY	1996-2008	44	27	32
IRELAND	1973-2008	99	26	26
ITALY	1976-2008	1027	650	708
LATVIA	1997-2008	19	12	12
LITHUANIA	1997-2008	24	17	17
LUXEMBOURG	1976-2008	14	6	8
MALTA	2002-2008	7	4	3
NETHERLANDS	1976-2008	83	63	68
POLAND	1997-2008	461	269	418
PORTUGAL	1986-2008	96	67	62
ROMANIA	1999-2008	136	45	103
SLOVAKIA	1995-2008	53	34	36
SLOVENIA	1996-2008	26	24	24
SPAIN	1986-2008	748	565	582
SWEDEN	1985-2008	71	53	51
UNITED KINGDOM	1969-2008	626	200	265
Total		*6518*	*3985*	*4425*
Non-EU-27 countries				
ALBANIA				
BOSNIA - HERZEGOVINA	1985-2008	20	4	3
CROATIA	2004-2008	8		8
ICELAND	1993-2008	8	4	4
LIECHTENSTEIN	2004-2008	2	1	1
MACEDONIA, FYRO 2)	1997-2008	44	25	34
MONTENEGRO				
NORWAY	1994-2008	46	36	34
SERBIA	2002-2008	25	23	22
SWITZERLAND	1991-2008	46	32	33
TURKEY	2008-2008	98		98
Total		*297*	*125*	*237*
Total EU-27 + non-EU-27 countries		*6815*	*4110*	*4662*

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

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 2008-data submission process, this section presents a preliminary evaluation of the 2008 air quality data. More extensive discussions on the state of the European ambient air will be provided in the air pollution and related reports prepared by EEA and ETC/ACC (e.g. as part of the State of the Environment report (EEA 2010)).

This section will briefly describe the current (2008) air quality status; the long-term (1999-2008) changes in concentrations are 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 4^{th} Daughter Directive (EU, 2004a) will only briefly be discussed; an analysis on the basis of the available measurements until 2006 (Barrett *et al.* 2008) has shown that, with the exception of a few (industrial) hotspots, the heavy metal concentrations are below the limit or target value. Information until 2008 broadly confirms this conclusion. Benzo(a)pyrene (B(a)P) forms a potential risks for human health in various parts of Europe. The concentrations measured in 2008 will be compared with the limit and target values as set in the Directives, see *Table 4*.

The air quality in 2008 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 industrial. In each graph the bin size equals 25% 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 0-10; 10-20; 20-30; 30-40 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: there is compliance with the limit value 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, 2009).

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/ACC web site[1]; the AirBase metadata is in the form of XML-files available from the EEA data service[2].

[1] See http://air-climate.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-2 ; the most convenient is to download the *all country XML-file.*

Table 4 Limit and target values defined by the EU for SO_2, NO_2, PM_{10}, benzene, CO, O_3, arsenic, cadmium, nickel and benzo(a)pyrene to be met in 2008 unless indicated otherwise.

Pollutant	Protection target	period	Limit and target values (µg/m³) (d)	No of allowed exceedances	Target datae
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. 2008 Air Quality Status

The *Figures 11 until 27* show the observed concentration maps and distance to target plots for a selected 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 2008 the limit value plus margin of tolerance (MOT) is 44 µg/m3. Distance-to-target graphs for 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*).

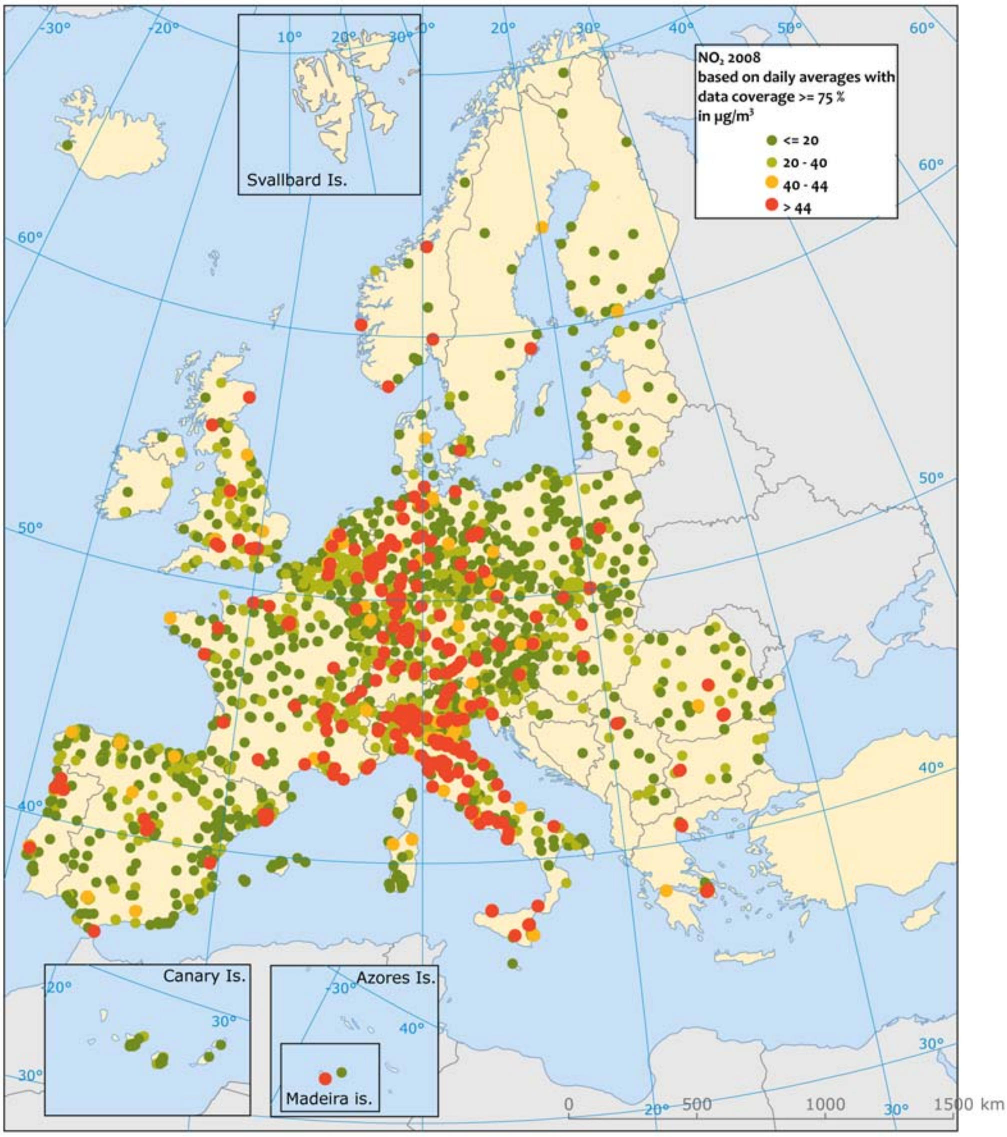

Figure 11. Annual mean concentration map of NO_2 *(µg/m3); the two highest concentration classes correspond to the limit value (40 µg/m3) and limit value plus margin of tolerance (44 µg/m3), respectively.*

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 on traffic stations, see the distance-to-target plots. 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 46% of the traffic stations with a maximum observed concentration of 115 µg/m3. At 50 (sub)urban stations (4%) an exceedance of the limit values is observed. In 2008 the NO_2 annual limit value plus margin of tolerance has been exceeded at 16% of the traffic stations, see *Figure 11*. Exceedances are rather persistence: at more than 420 stations operational in the period 2006-2008, the 3-year averaged concentrations are above the limit value. These long-lasting exceedances are observed in 21 EU MS, mostly on traffic stations (83%) but also at (sub)urban background stations (13%) and industrial stations (4%).

The hourly limit value of NO_2 is less stringent with exceedances at about 1 and 6% of the (sub)urban and traffic stations, respectively. Over the last three years at a limited number of stations (59 traffic, 8 (sub)urban background and 5 industrial) the averaged number of exceedances exceeds the allowed number of 18

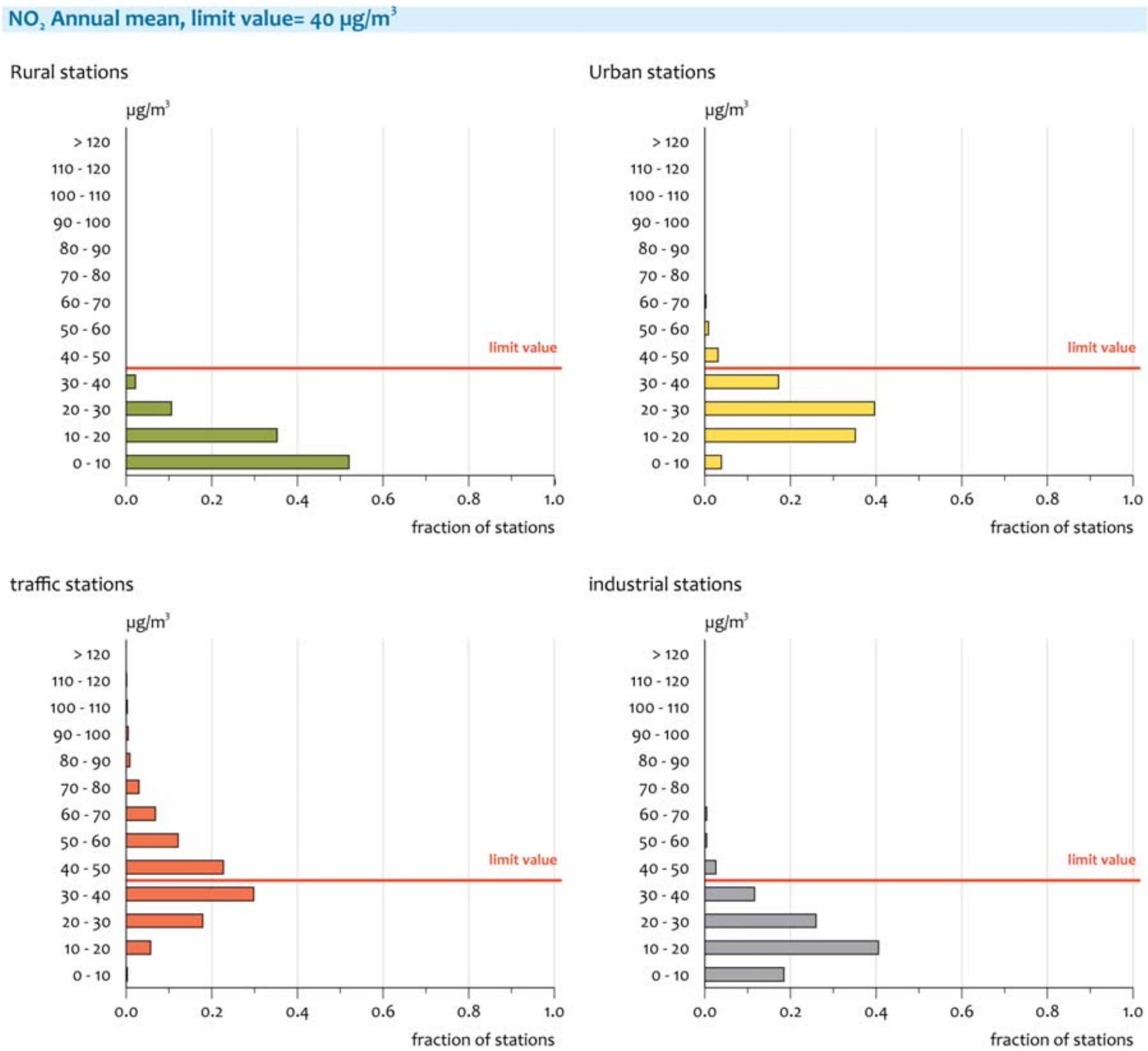

Figure 12. Distance-to-target graphs for the long-term NO_2 limit value.

2.2.2. Sulphur dioxide (SO_2)

The annual mean SO_2 concentrations are given in *Figure 13*. The distance-to-target graph for the daily limit value of SO_2 is given in *Figure 14.* 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 2007 – March 2008)) are given in Annex E (*Figures E.2, E.3 and E.4*). 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 is classified as rural background. As emissions tends to be higher and dispersion condition are worse during winter periods, the concentrations during the winter 2007/2008 are on the average slightly higher than those during the year 2008. The more stringent limit value for the protection of vegetation set for a winter mean (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 1.1 and 1.8% of the stations, respectively.

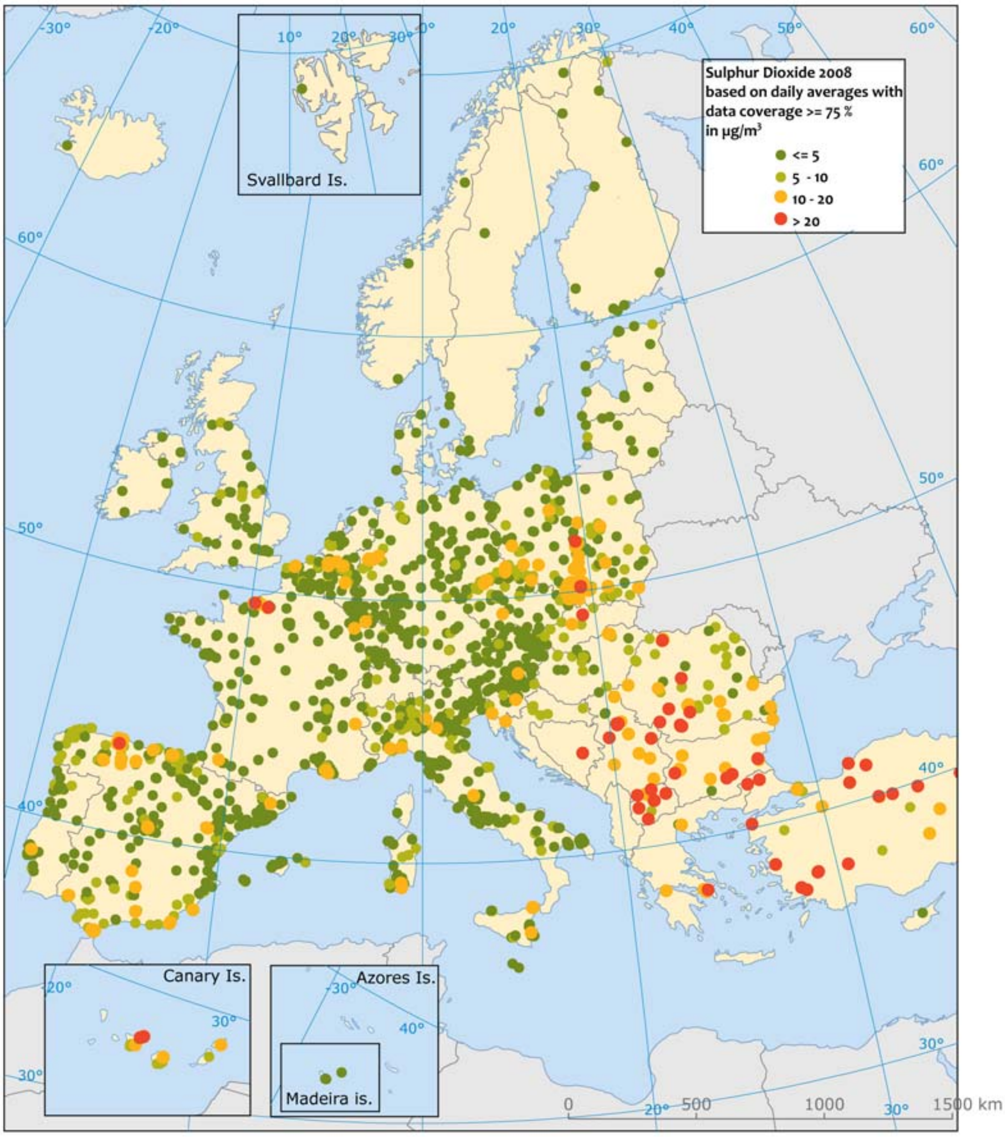

Figure 13: Annual mean concentration map of SO_2 (µg/m^3); the highest concentration classes corresponds to the limit value (20 µg/m^3) set for the protection of vegetation.

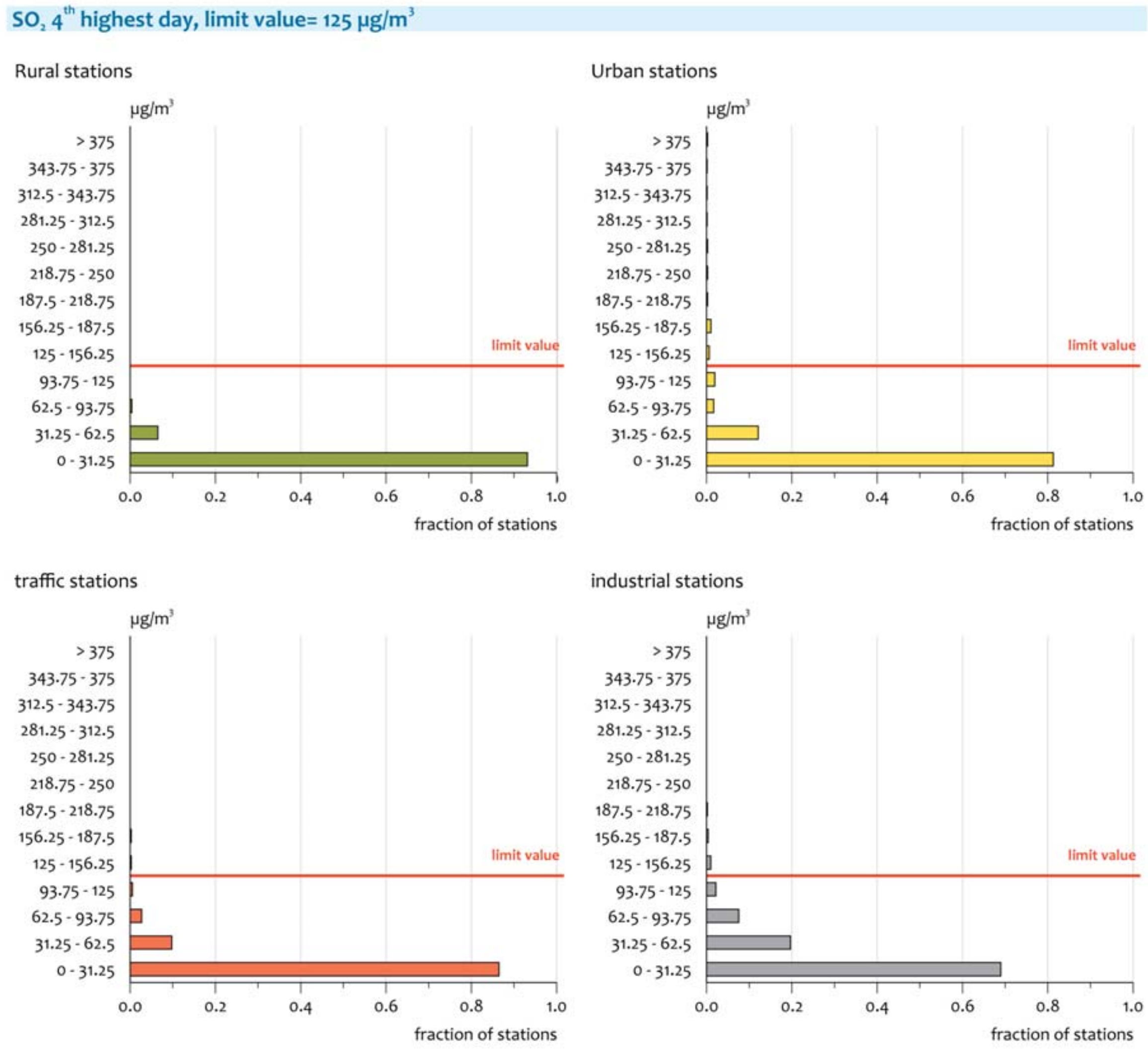

Figure 14: Distance-to-target graphs for the daily limit value of SO_2.

2.2.3. Particulate Matter (PM_{10} and $PM_{2.5}$)

Figure 15 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. A statistical analysis of the monitoring data indicated that the daily PM_{10} limit value corresponds with an annual mean of 31 µg/m³ although regional differences may occur (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.

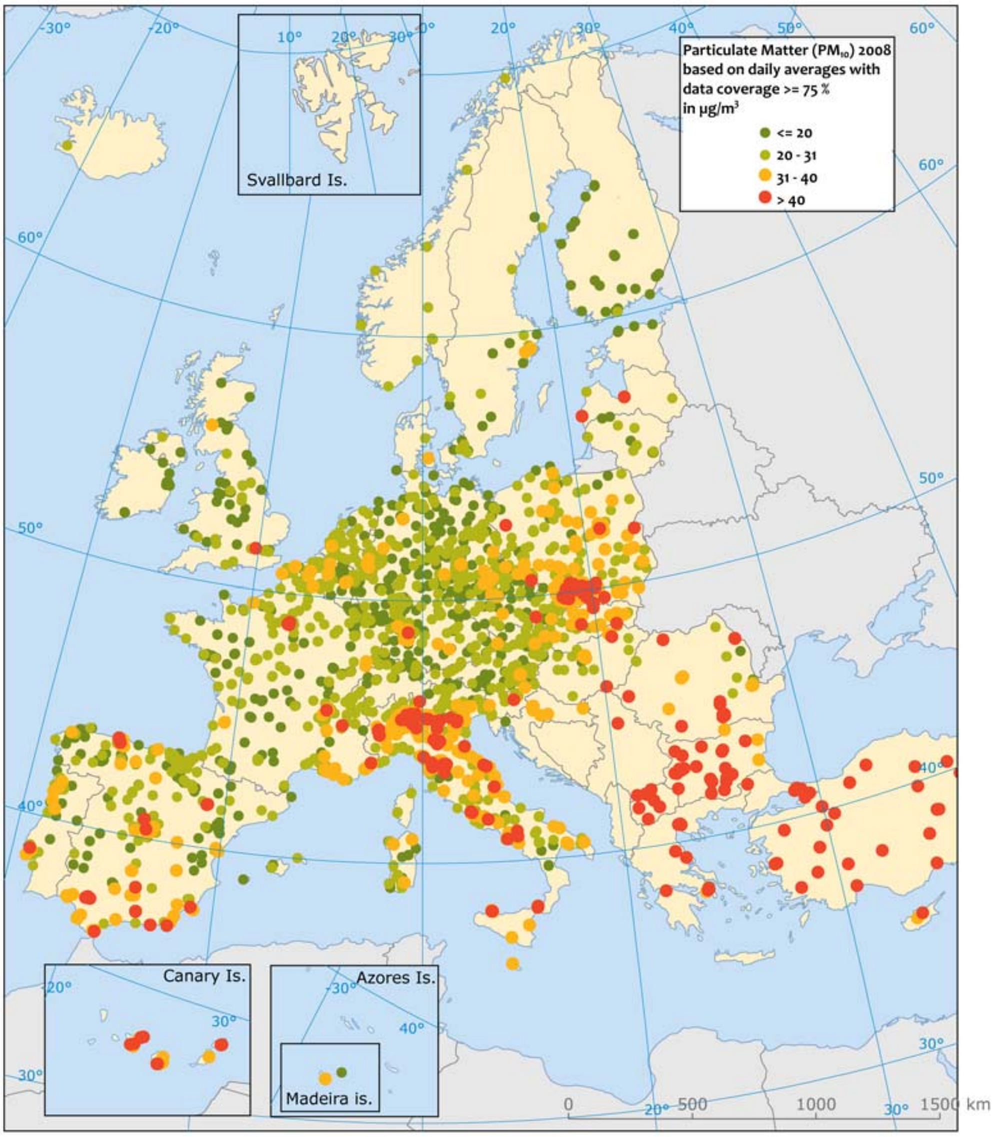

Figure 15: Annual mean concentration map of PM_{10} (µg/m³); the two highest concentration classes corresponds to the annual limit value (40 µg/m³) and to a statistically derived level (31 µg/m³) corresponding to the short-term limit value.)

The extent of exceedance of the annual and daily limit values of PM_{10} is given in the distance-to-target graphs (see *Figure 16 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 background to urban background 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).

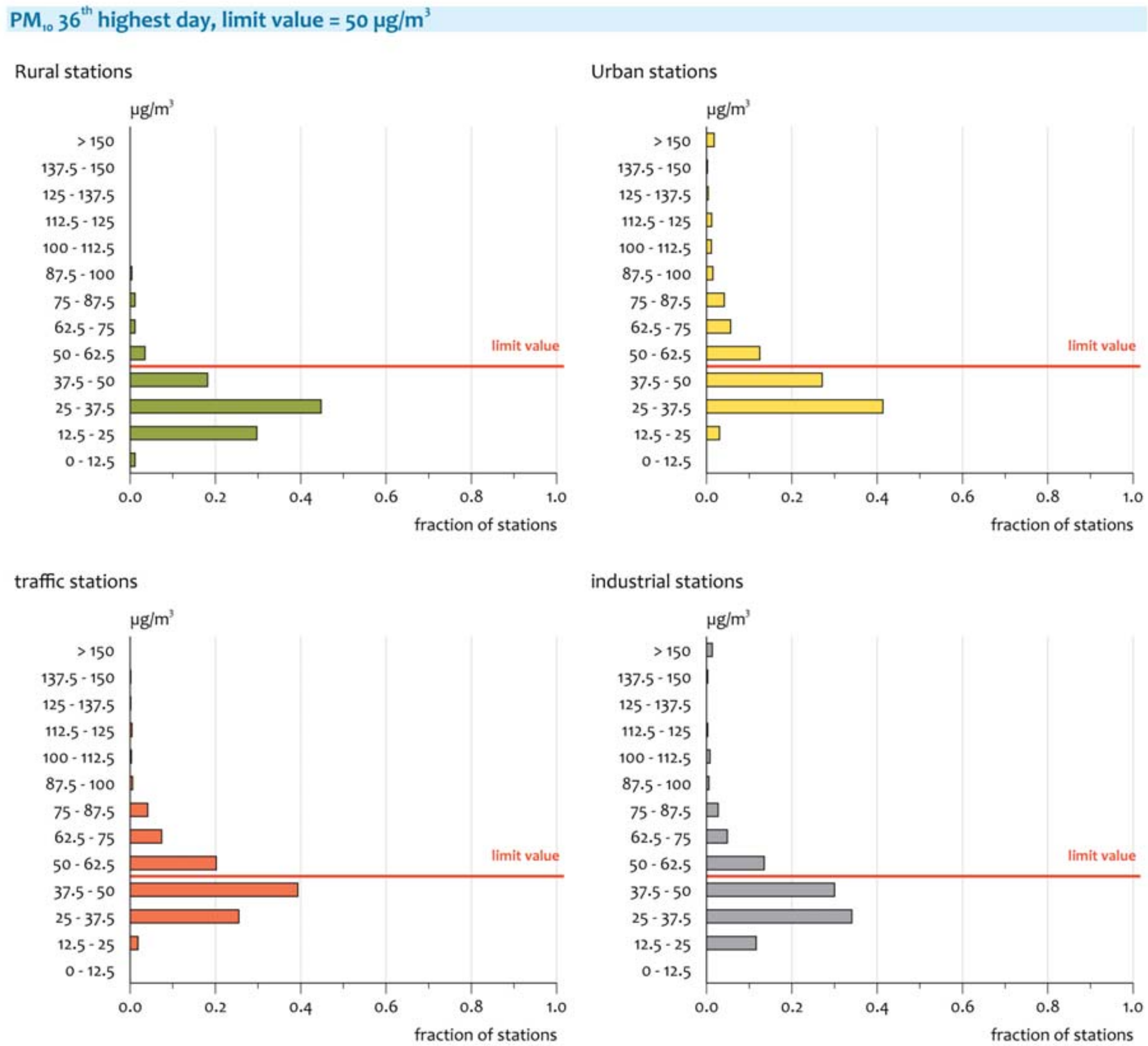

Figure 16 Distance-to-target graph for daily limit value of PM_{10}.

Figure 17 is presenting the annual mean concentrations of $PM_{2.5}$. The number of operational $PM_{2.5}$ stations is still further increasing. For 2008 there are 331 stations fulfilling the criteria of more than 75% data coverage. The spatial coverage and representativeness of the monitoring stations is presently insufficient to assess variations in concentrations across Europe. From the 27 EU MS no data has been received from Slovenia, the data coverage of the two stations in Romania is insufficient.
The $PM_{2.5}$ data enables a comparison with the $PM_{2.5}$ target value of 25 µg/m³ as set in the Air Quality Directive 2008/50/EC with the target of 1 January 2010 (EU, 2008). The distance to target graph in *Figure 18* shows that at 6%, 14% and 5% of the rural, (sub)urban background and traffic stations the target value has been exceeded. Exceedance is also observed at 10% of the industrial sites. The Air Quality Directive 2008/50/EC (EU,2008) 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 the averaged level measured at urban background location throughout the territory of a Member State and it reflects the population exposure. *Figure 19* indicates that in at least 5 Member States current concentrations may be above 20 µg/m³, the level legally binding in 2015.

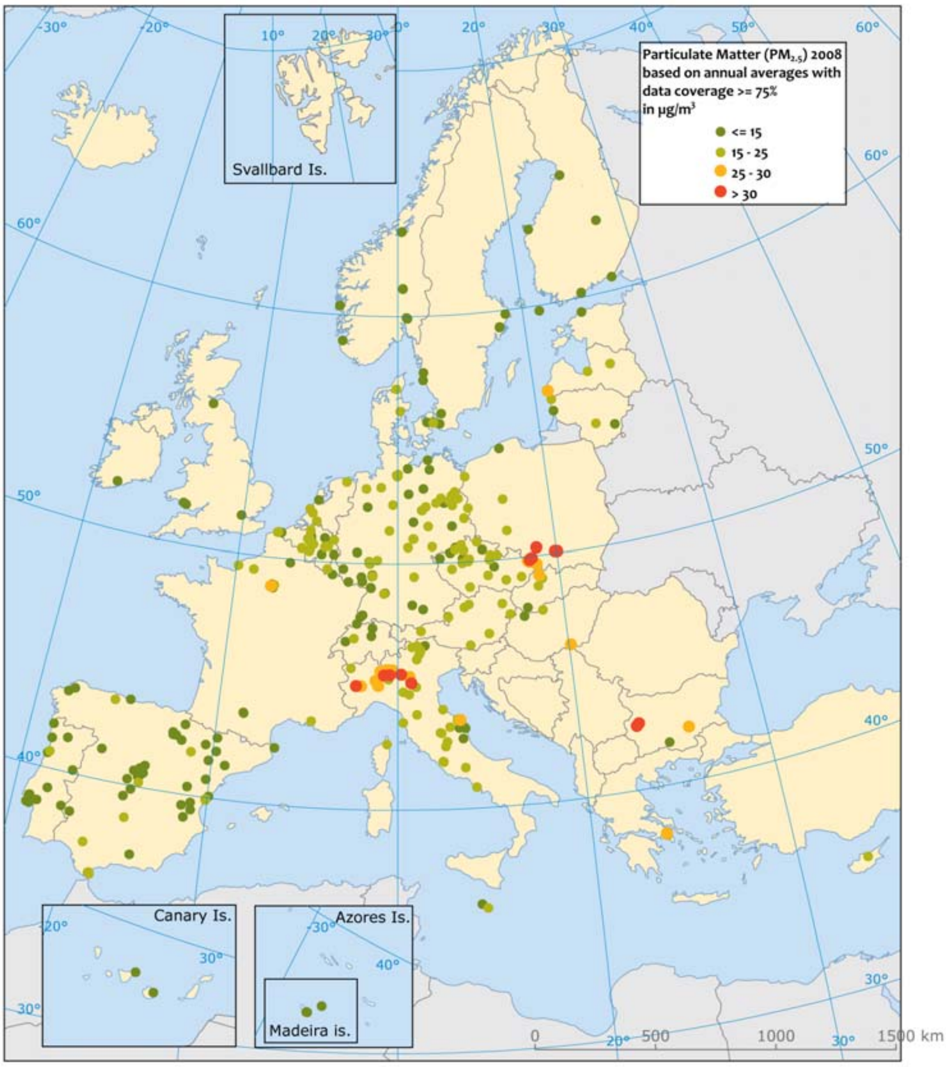

Figure 17: Annual mean concentrations of $PM_{2.5}$

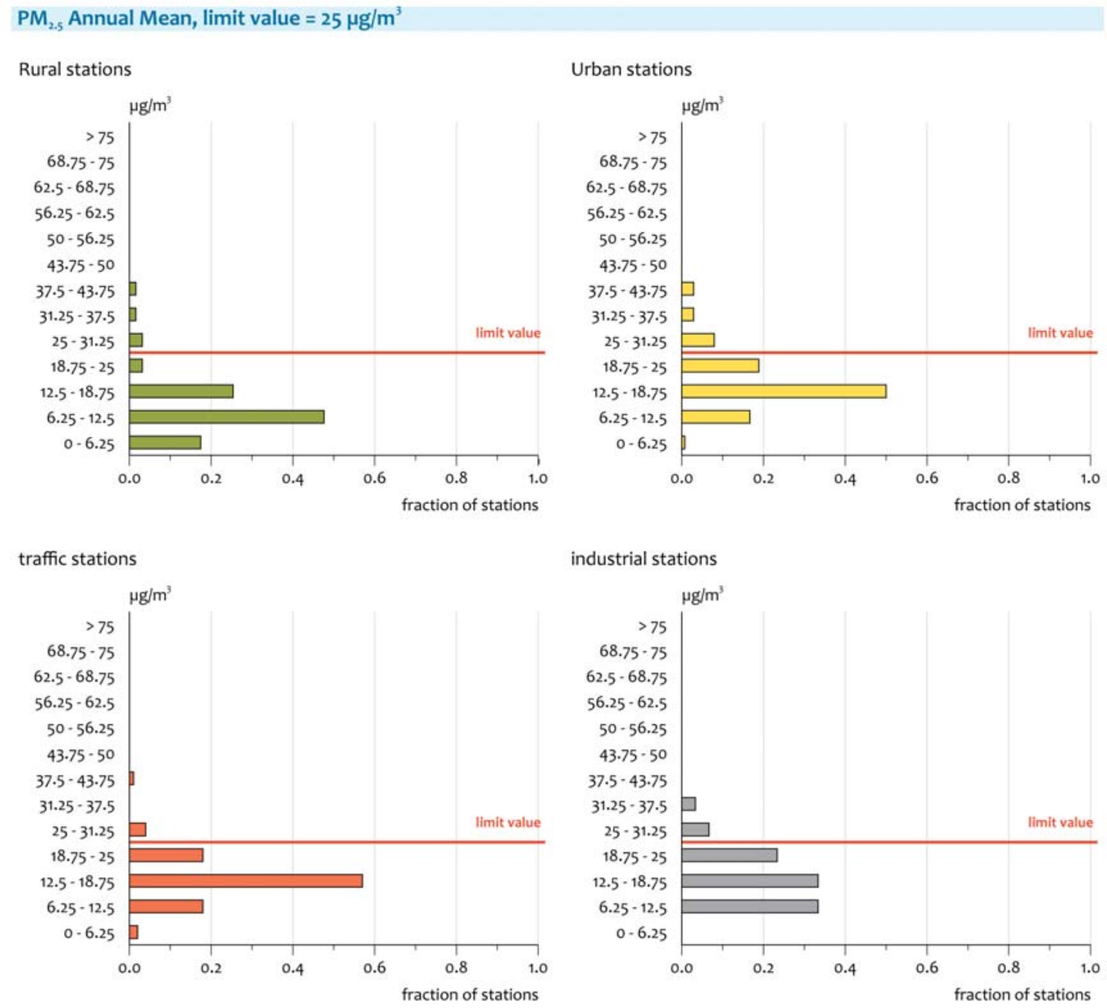

Figure 18 Distance-to-target graph for the annual limit value of $PM_{2.5}$.

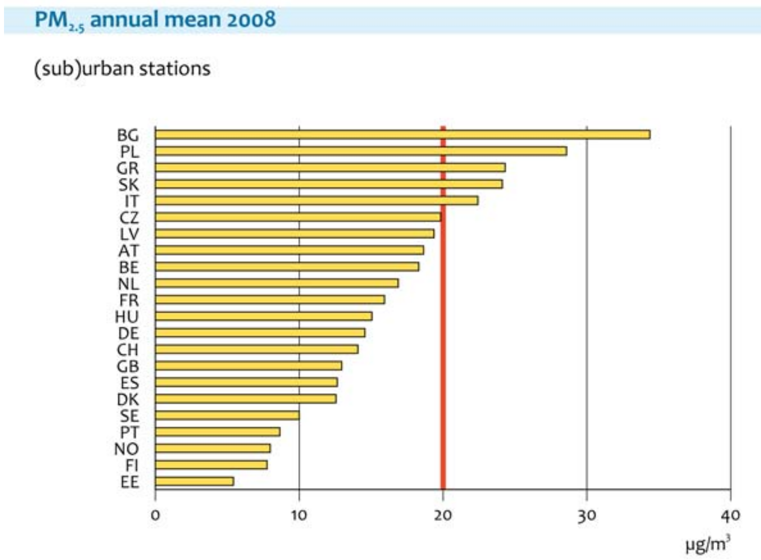

Figure 19 Averaged Exposure indicator averaged over all operational (sub)urban background stations. Note: formal AEI will be based on selection of those stations only.

2.2.4. Carbon monoxide (CO)

In the air quality directive the EU has set limit values for CO for the protection of human health: the CO maximum daily 8-hour mean values may not exceed 10 mg/m³, see *Figure 21*. This level is not exceeded at the 32 operational rural background stations. Exceedances are observed at less than 1% of the (mostly traffic) stations. Exceedances are observed in Italy and the Balkan region (Bulgaria, FYR of Macedonia, Romania). The annual averages of the daily 8-hour maxima show elevated levels in the same regions, see *Figure 20*. Note that not the maximum value is plotted but the more robust annual mean value of daily maximum 8-hour mean values.

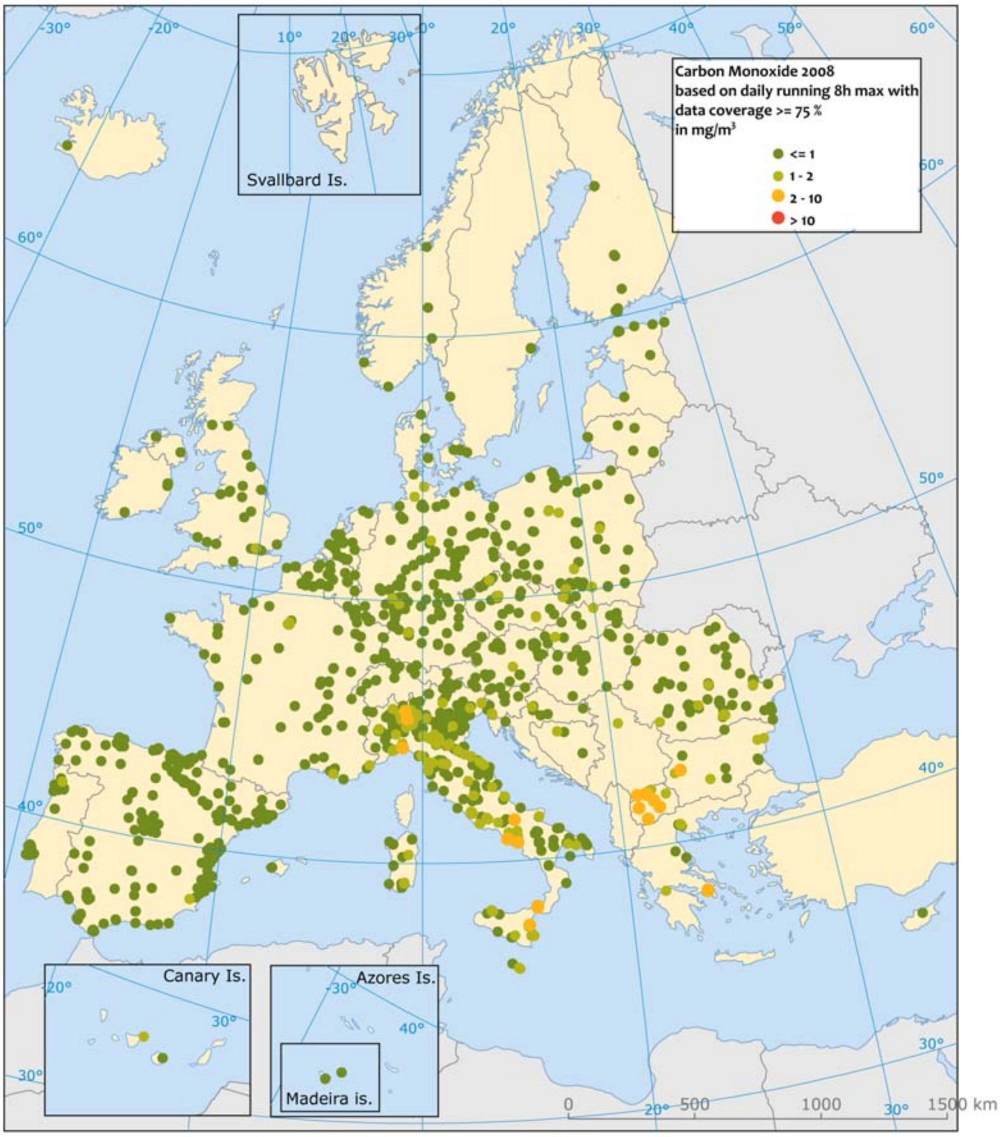

Figure 20: Annual mean concentration of the maximum daily 8-hour mean values of CO (mg/m³).

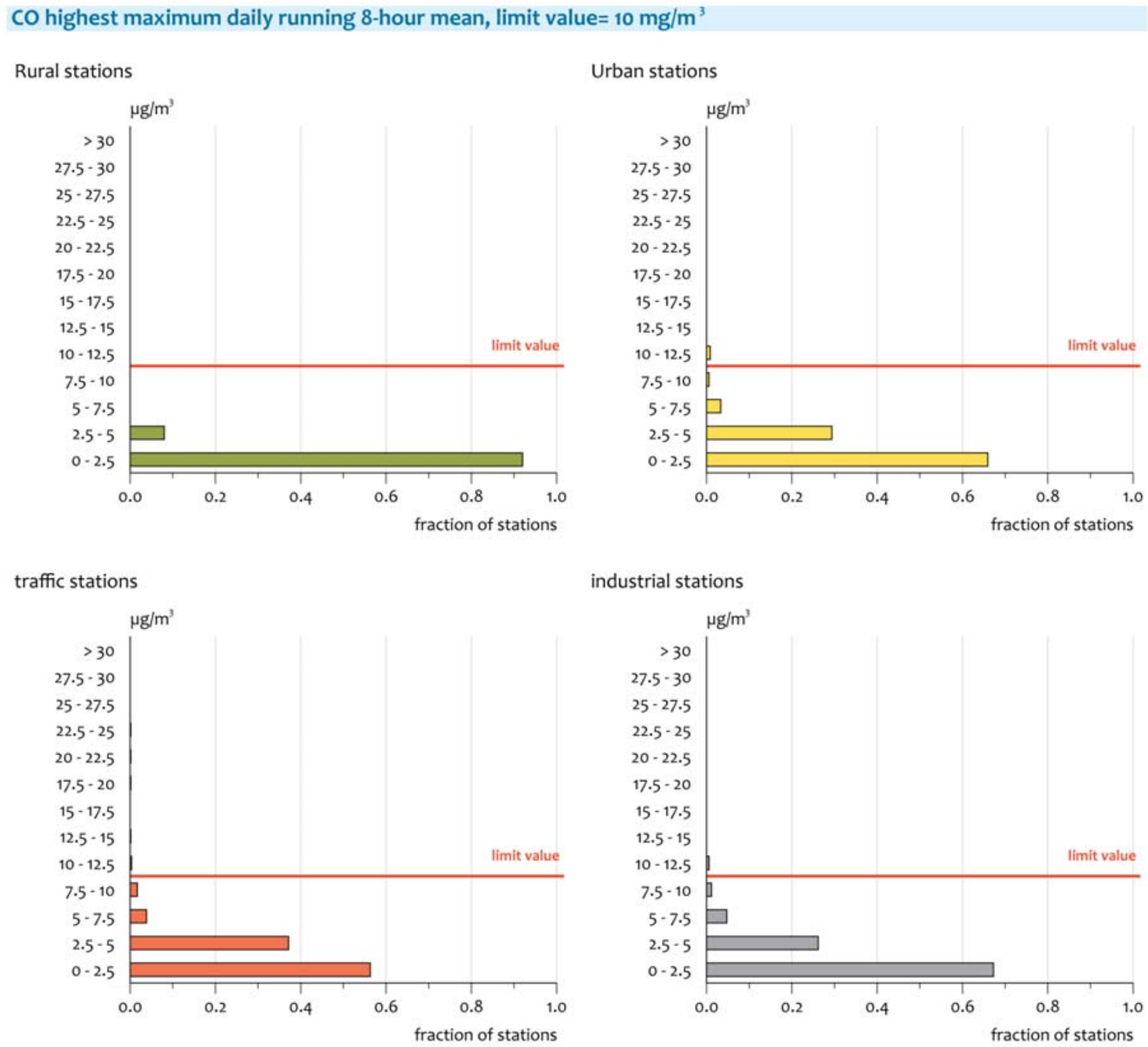

Figure 21: Distance-to-target graph is given for the CO limit value.

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 better than 50%.

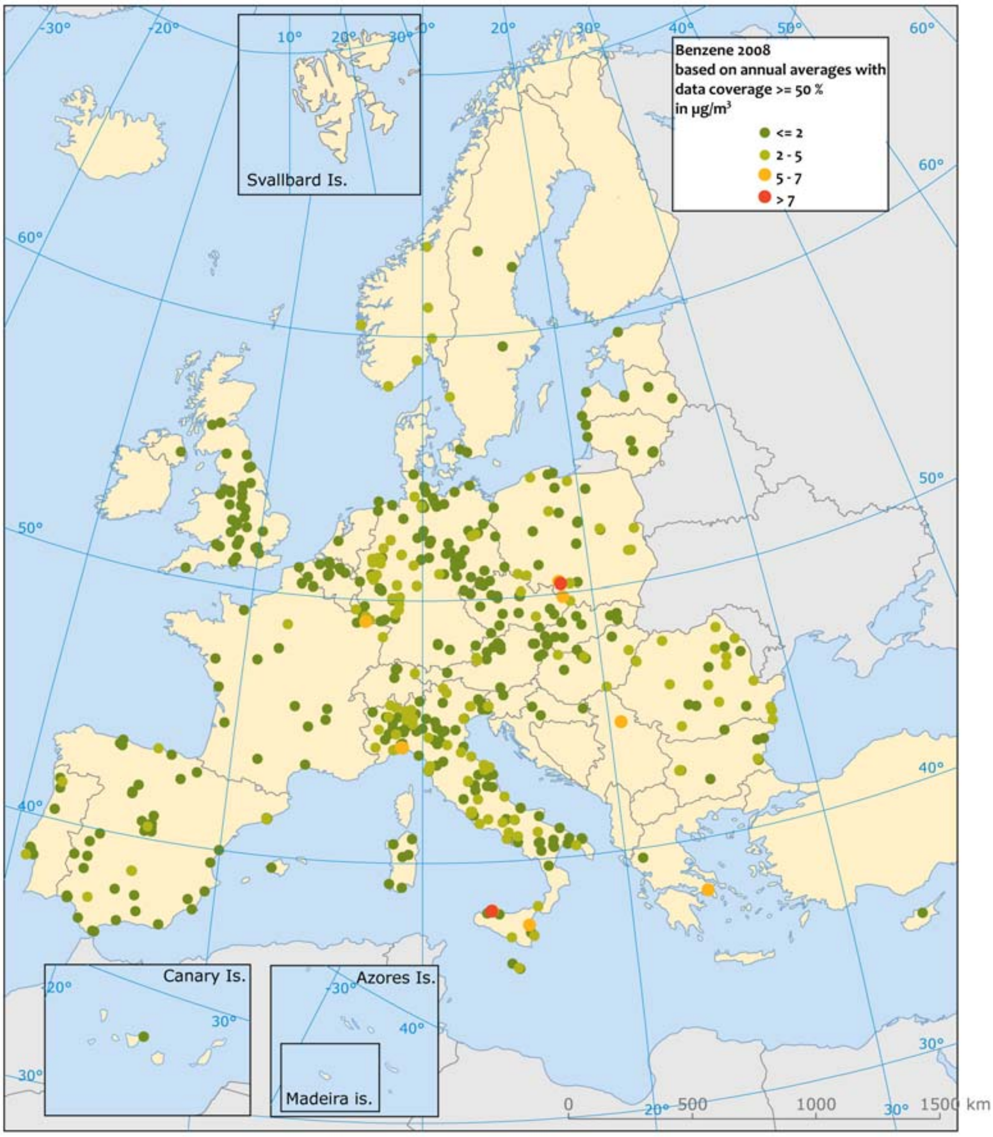

Figure 22: Annual mean value of benzene, 2008. Concentrations of 2, 5, and 7 µg/m³ correspond to the lower assessment threshold, limit value and limit value plus margin of tolerance, respectively. Distance-to-target graph is given for the benzene limit value.

The air quality directive set 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 7 µg/m3 in 2008. At rural background stations no exceedance of the limit value is observed. Exceedance of the limit value is observed at eleven stations. At two of them (one traffic station in Italy and one urban background station in Poland) exceedances of the limit value plus margin of tolerance have been reported.

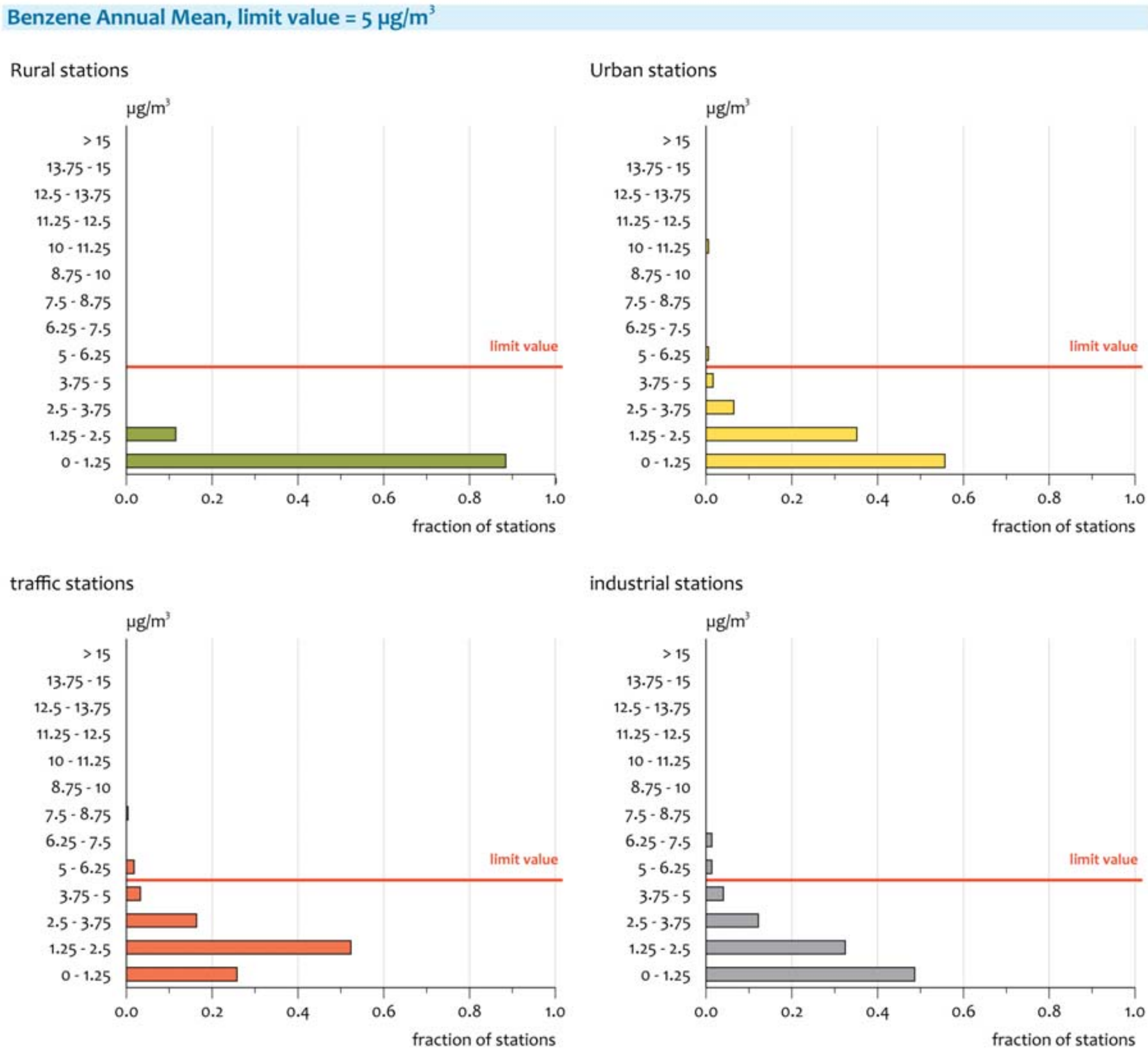

Figure 23: Distance-to-target graph is given for the benzene limit value.

2.2.6. Ozone (O_3)

Figure 24 shows the annual mean concentrations of O_3. The distance-to-target graph for the daily target value of O_3 is given in *Figure 25*. The other distance-to-target graph for the AOT40 value of O_3 is given in Annex E (*Figure E.6*). 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).
The health related target is widely exceeded at 35% of the rural background stations. In urban area about 20% of the stations are not in compliance with the target. The AOT40 value averaged over all rural background stations is below the target value although at nearly half of the stations an exceedance has been observed. In contrast to the other pollutant the ozone levels are generally the highest at rural locations. Reason for this is that at short distances to NO_x sources – as is the case for urban and traffic stations – the ozone is chemically quenched by the freshly emitted NO_x.

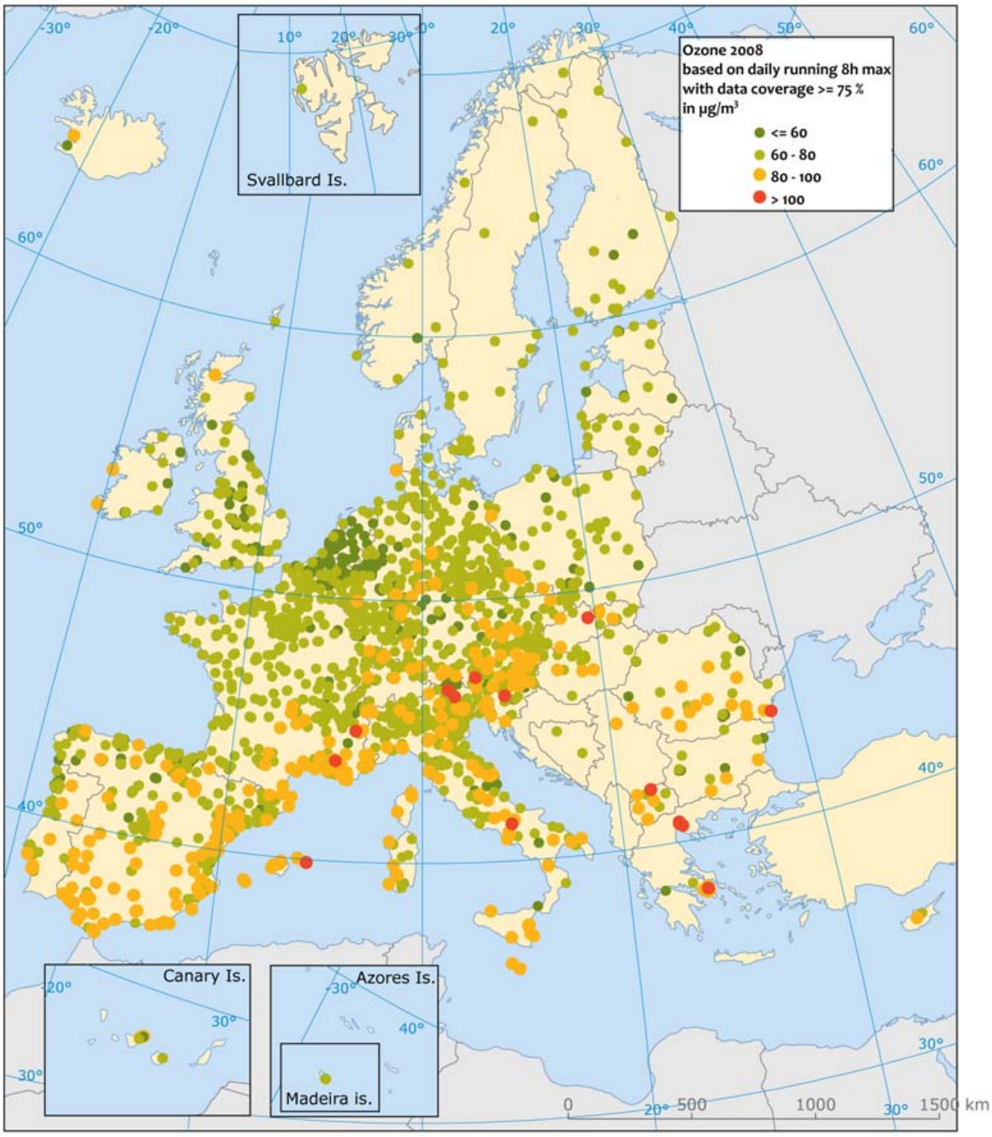

Figure 24: Annual mean value of the maximum daily 8-hour mean values of ozone, 2008.

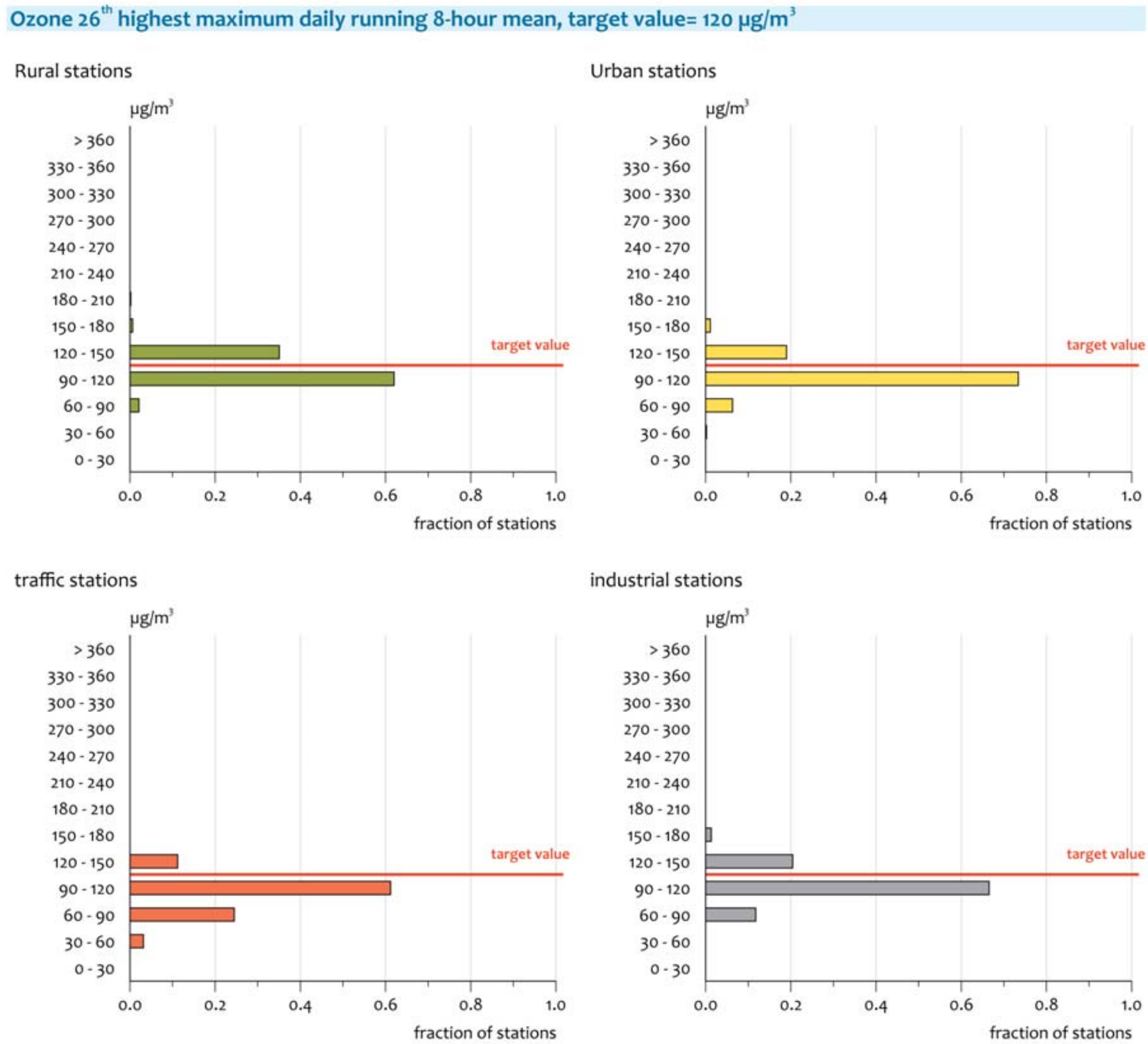

Figure 25: Distance-to-target graph is given for the target values set for the protection of human health

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 2008 monitoring data are in line with this report.
2008 is the first year for which reporting on the components of the 4th DD is mandatory. This is directly reflected in the increase of the number of reporting stations: both for the heavy metals as for PAH there is an increase of about 270 stations.
As concentrations of these pollutants are frequently below the lower assessment threshold, other techniques then 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 on data coverage of 14% is applied here on the heavy metal data and benzo(a)pyrene. A problem in analysing the data of these pollutants is that it is not always known whether the pollutant has been measured on the PM_{10}-fraction (as described in the directives) or on another (undefined) size fraction.

To be more specific on the results in 2008:
Lead: No monitoring data has been received from Finland, France, Greece, Hungary, Portugal, Slovenia and Sweden. According to the reporting questionnaire for the air quality directive (EU, 2004b) the concentrations are below the lower assessment threshold (LAT) and other methods than monitoring could be used for assessment. However, in France and Slovenia the concentration exceeds LAT but monitoring information has not been reported to AirBase although several stations are operational in these countries. Some exceedances of the limit value are observed in Belgium, Bulgaria, Romania and Malta but this appears to be a local issue only.
Arsenic: at the majority of the stations a concentration below the lower assessment threshold has been reported. However, at 16 (from the 381 operational stations) the observed concentration is above the target value set for 2012. A relatively large number of exceedance is observed in Belgium (8 stations of which 5 are located close to one industrial plant in Hoboken, near Anvers (VMM, 2009)). The remaining eight exceedances are seen in Austria, Czech Republic (4 stations), Germany, Spain, and Poland, mainly at industrial sites (6 stations) and urban sites (2 stations).
Cadmium: air concentrations are in excess of the target value at 7% of the stations located in four countries (Belgium, 25 stations; Bulgaria, 4 stations, and at one station in Poland and Romania). Exceedances are mainly observed at industrial and (sub)urban stations but also at two rural background station in Belgium. At the majority of the stations the concentration are below the lower assessment threshold; the FWD-questionnaire indicates concentrations below the LAT in more than two-third of the zones.
Nickel: exceedances of the target value are seen at 7 of the 398operational stations; these stations are located in the eastern part of Belgium, the German Ruhr area and in Gibraltar. Most of the exceedances are related to industry.

Benzo(a)pyrene[1]: target values are exceeded at 37% of the monitoring points mainly at (sub)urban background stations and, to a lesser extend, at traffic and industrial stations. There is some concentration of impact in central Europe (N-S corridor over western Poland, Czech Republic and Austria) although exceedances are also observed in the UK (Midlands, Northern Ireland), the German Ruhr-area and Bulgaria (see *Figure 26*). Long time series for B(a)P are not yet available; a small number of station for which three or more years with data are available show that the exceedances of the target value are persistent.

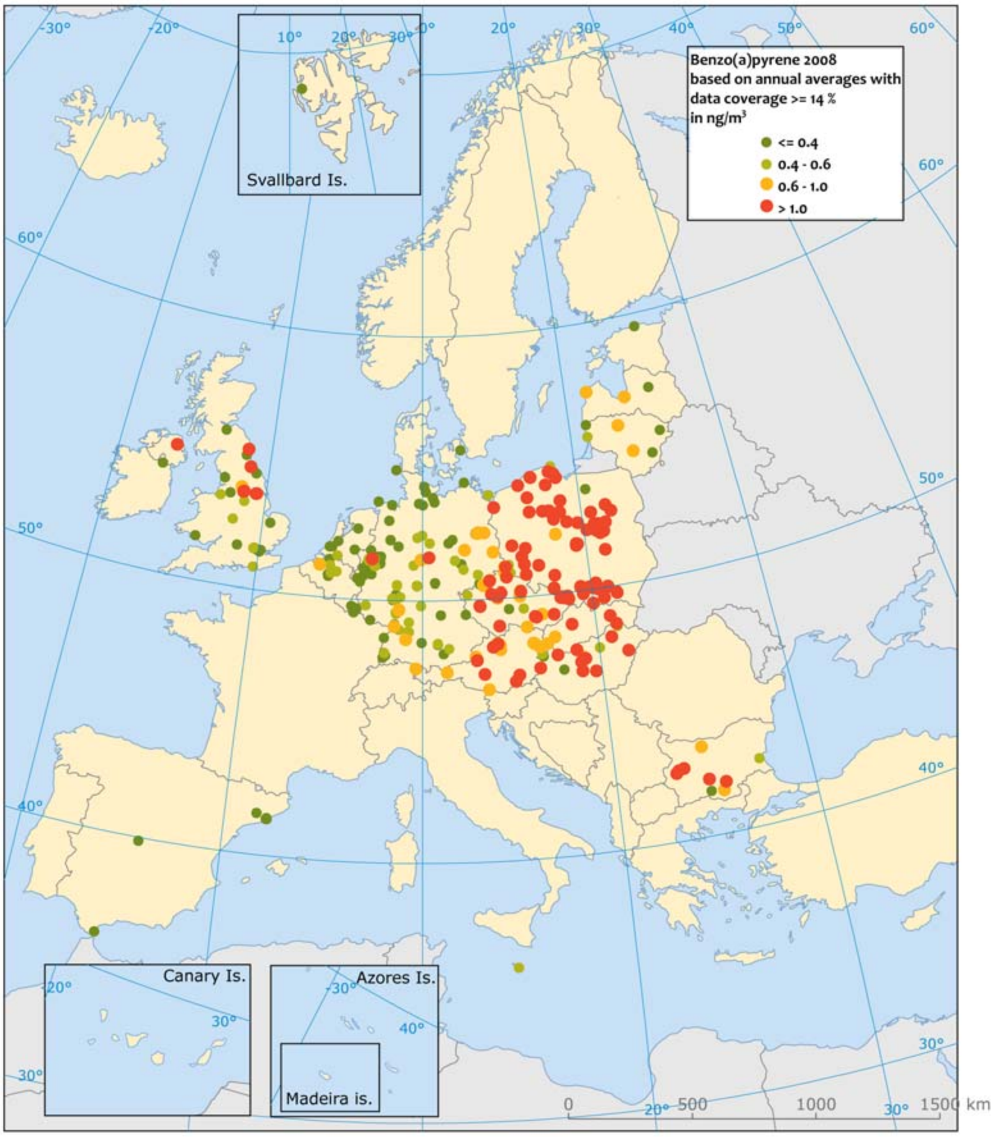

Figure 26: Annual mean concentration of BaP (ng/m³).

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

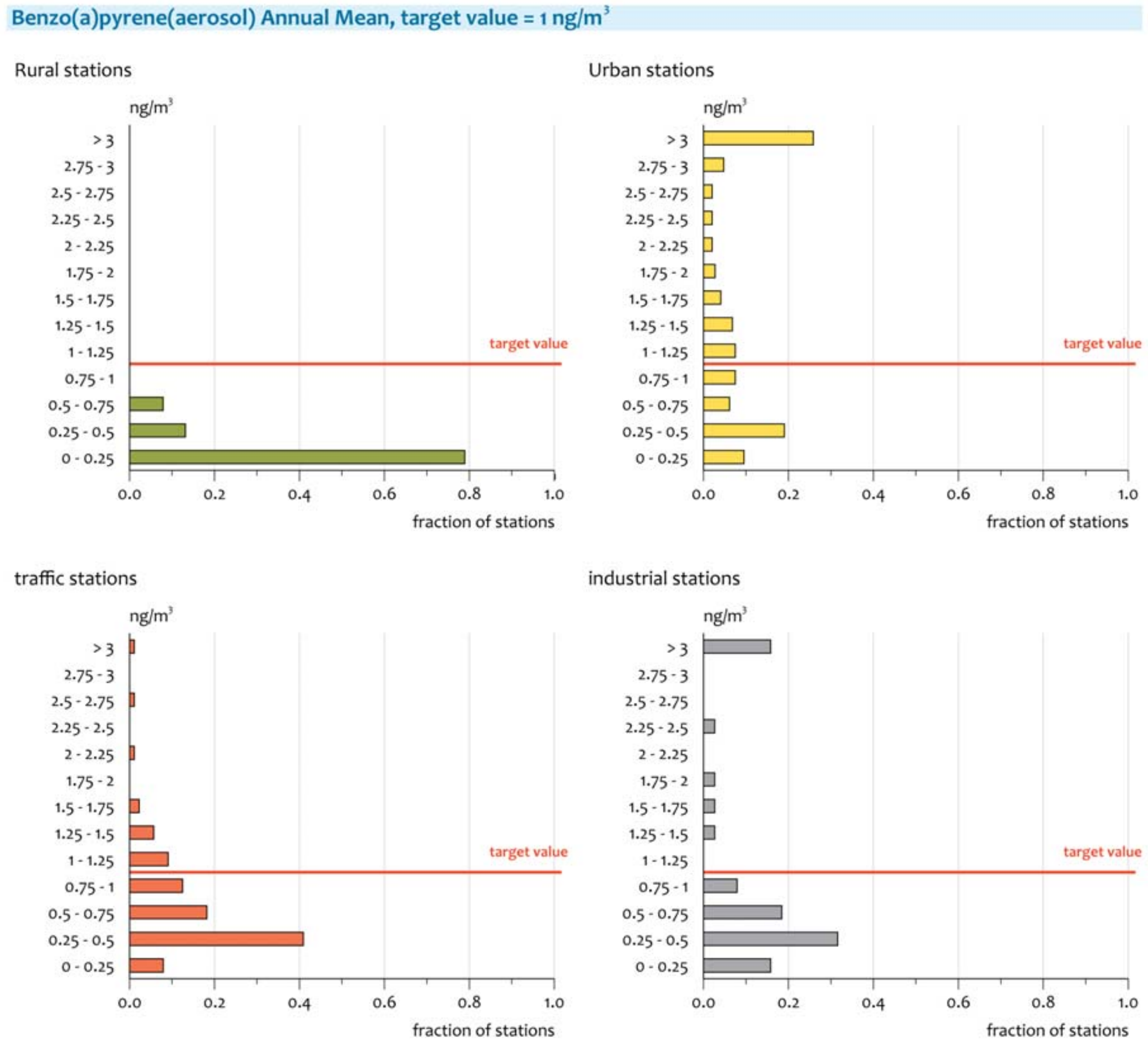

Figure 27: Distance-to-target graph is given for the BaP limit value.

2.3. Changing composition

To analyse possible changes in the chemical composition of the air pollution mix a simple trend model has been applied. The model is applied on monthly mean concentrations and includes a linear trend term and a seasonal correction term; details of the model and the criteria from selecting the stations is given in Annex F. In the discussion below the data on emissions refers to the period 1999-2007; emission data has been taken from EEA (2009).

<u>Sulphur dioxide</u>
SO_2 concentrations show a steady decrease since 1999 at nearly all stations (*Figure 28*). At the majority of the stations a significant decrease is observed; in many cases a downward trend in concentrations of more than 6% per year is found. This exceeds the downward trend of 4.7% per year found in the SO_2 emission in the EU27. At 10 stations (out of 545) a significant increase is noted. There is no clear geographical dependence nor a relation with stations type (the upward trend is observed at urban, rural and traffic stations). Local conditions may play a role here although monitoring artifacts may not be excluded.

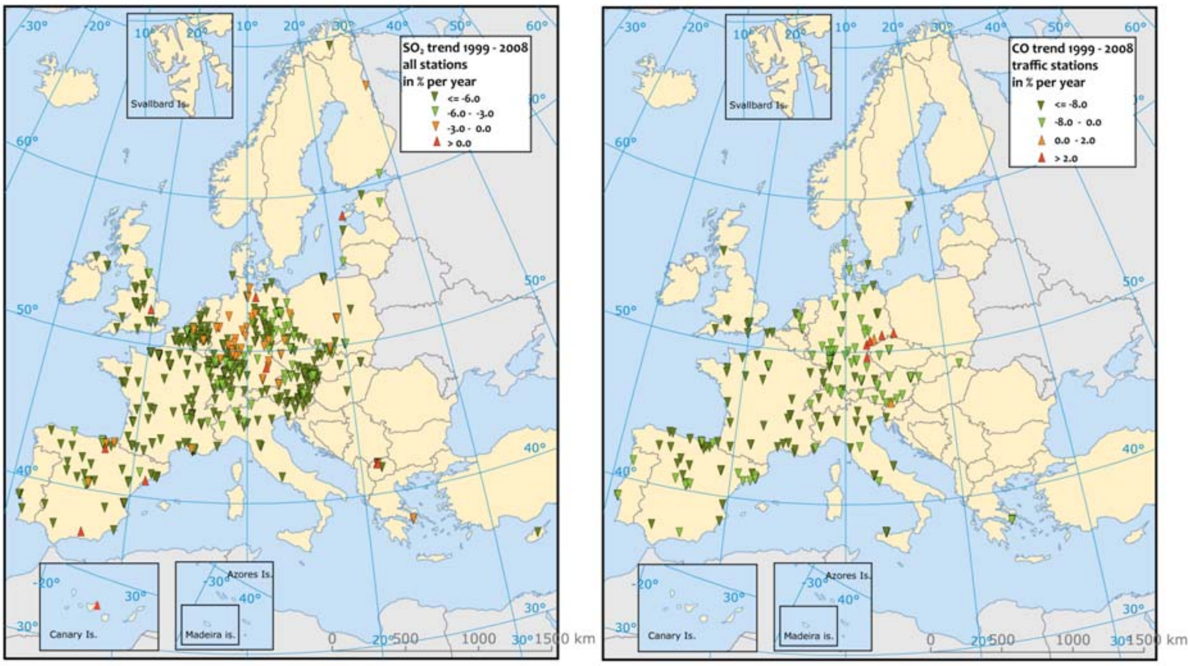

Figure 28. Trend (relative change in % per year) in SO_2 concentrations (left, all station types), and in CO concentration (right, traffic stations only) period 1999-2008.

<u>Carbon monoxide</u>
Like SO_2 the CO concentrations show a steady decrease. At traffic stations a 8.7 % decrease per year is estimated; at the (sub)urban background station the reduction is slightly lower (6.6% per year). These reductions are in line with the changes in CO-emission: for the EU27 the total missions decrease with 4.7 % per year. Road transport emissions decreased even more: the share of road transport emissions in total emissions has reduced from 49% in 1999 to 36% in 2007 for the EU27. *Figure 28* suggests that the decrease in Germany and Austria lacks behind the decreases in United Kingdom and France; this might relate to the differences in emission reduction in the road transport sector (Germany, Austria, 7-9 % reduction per year; United Kingdom, France12-15% reduction per year). In the German Bundesland Saxony a few stations (mainly traffic stations) show an increase in concentration.

The reason is not clear, local conditions may play a role although monitoring artefacts can not be excluded

<u>Nitrogen oxides</u>
The number of long NO_x time series is relatively low: about 50% less than the corresponding NO_2 number. For several EU MS no or only limited information on NO_x concentrations has been submitted nor it was possible to calculate the NO_x levels on the basis of delivered NO and NO_2 concentrations.
Averaged over all available stations a reduction of 2.7% per year is found (see *Figure 29*). However, there are geographical differences: in Switzerland, Germany, Belgium the Netherlands and the United Kingdom there seems to be a systematic decrease at nearly all stations; the downward trend varies between 2.2 (Belgium) to 3.7 % (United Kingdom) per year. In the Czech Republic, Austria increasing concentration are seen at a relatively large number of stations, this increase is seen at any type of station. At the Iberian Peninsula a more mixed picture is seen. To some extent these concentration changes are mirroring the changes in NO_x emissions: European-wide emissions are down with almost 2% per year but at national level the changes varies between +8.5%/yr (Bulgaria) to -4.6%/yr (Germany). In Austria (+1.7%/yr) and Spain (+0.5%/yr) emissions are growing.

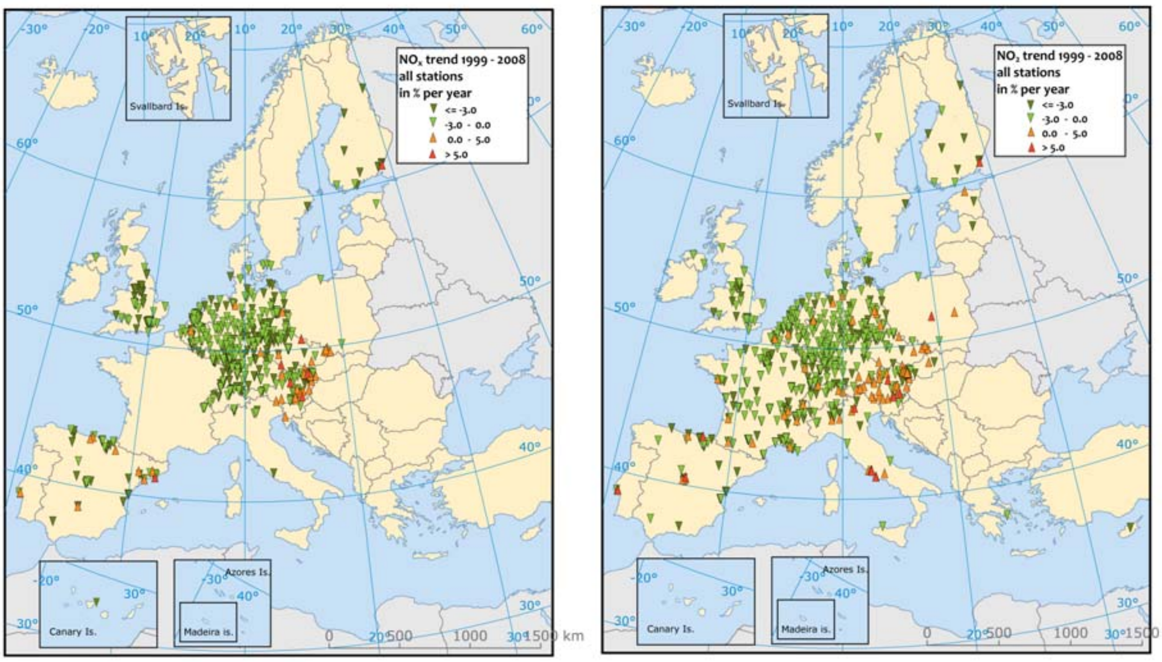

Figure 29. Trend (relative change in % per year) in NO_x concentrations (left, all station types), and in NO_2 concentration (right, all station types) period 1999-2008.

For NO_2 a larger set of time series is available. As *Figure 29* shows there is an overall decreasing trend in NO_2 but this trend is clearly smaller than is the case for NO_x. A decoupling of NO_x and NO_2 trends is to be expected. The ratio of NO_2/NO_x concentrations is largely determined by the photostationary equilibrium

$$NO + O_3 \leftrightarrow NO_2$$

When under constant oxidant concentration (O_x= sum of NO_2 + O_3) the NO_x concentration (NO_x = sum of NO_2 and NO) is reduced, this reduction is not equal for NO and NO2: the equilibrium shift toward the right leading to a smaller reduction of NO_2. This effect is stronger at high NO_x level (e.g. at traffic stations): only a relative small fraction of a NO_x reduction is reflected in a NO_2 reduction. At low NO_x levels (e.g. at rural stations) the changes in NO_x and NO_2 are more equally sized (see *Figure 30* which also demonstrates the increases in ozone when NO_x is lowered). Considering also the findings that due to the increasing number of diesel cars the fraction of NO_2 in total NO_x emissions from road transport is increasing (see Mol *et al*. 2009a and references cited therein for more extensive discussion), an increasing NO_2 trend might be expected at traffic locations especially in region with stable or increasing NO_x emissions. On about 20% of the NO_2 traffic stations an upward trend is seen.

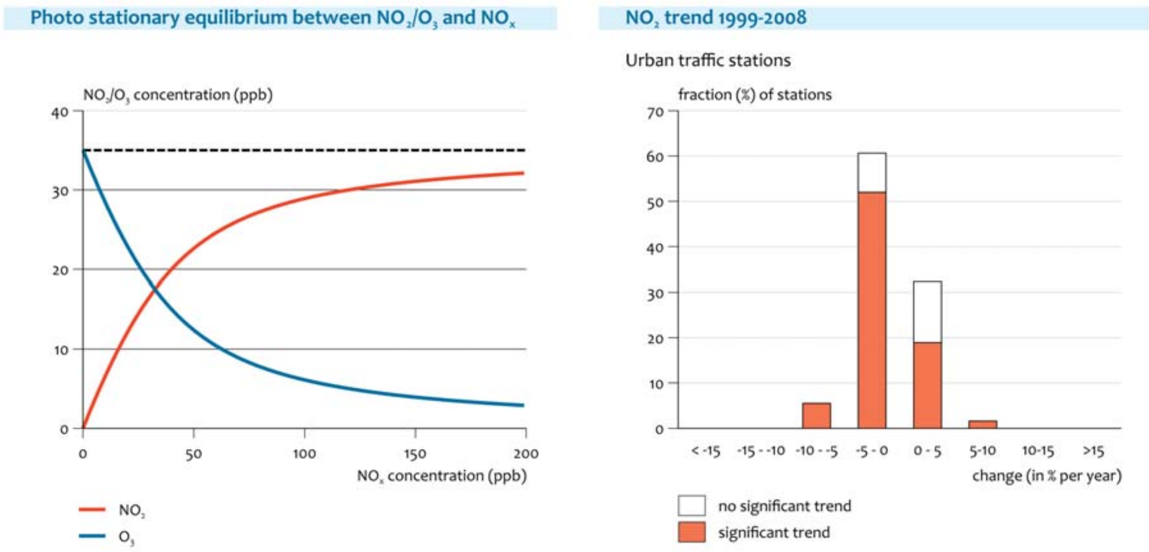

Figure 30. (left) The concentration of NO2 and O3 as function of the NOx concentration as based on the photostationary state (assuming a oxidant level of 35 ppb and a equilibrium constant of 10 ppb).
(right) Frequency distribution of the estimated trend (in % per year) of NO2 at (sub)urban traffic stations. Closed bars correspond to station with a significant trend, open bars to stations where no significant trend is estimated.

<u>Ozone</u>
Ozone trends are small and uncertain: at 60% of the ozone stations being operational in the last 10 years no significant trend in averaged concentrations is seen. Coherent regions with up- or downward ozone trends are difficult to detect (see *Figure 31*). At the limited number of stations in Scandinavia and in the Baltic states decreasing concentrations are observed; the high rural stations (at higher altitudes (above 500m) ozone concentrations tends to decrease. But in continental Europe a scattered pattern is found. Looking at the stations type at the rural station there is a slight bias for a negative trend whereas at urban background and moreover at traffic stations the trend is positive. At the latter station types the change in NO_x emissions will largely contribute to the ozone change (*Figure 31*). Note that the absolute ozone levels at traffic stations are low.

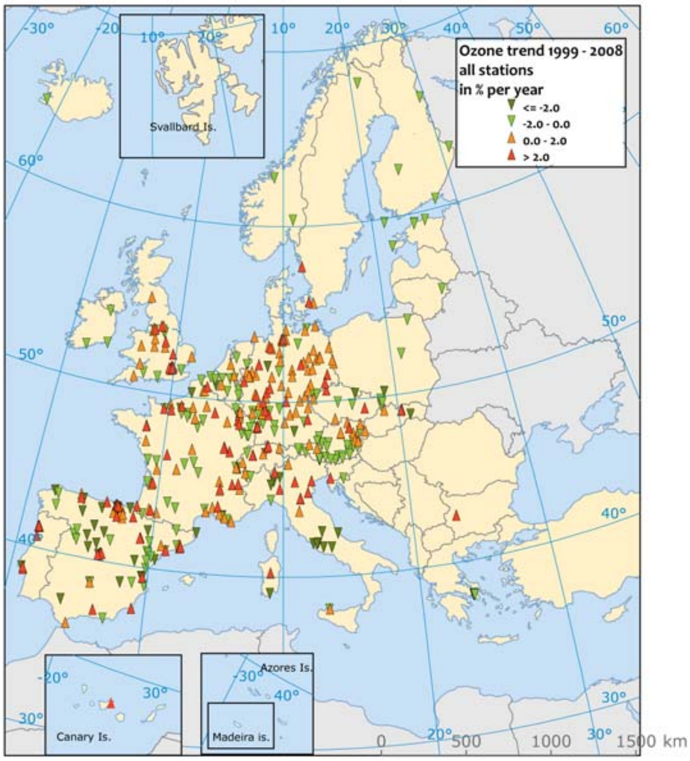

Figure 31. Trend (relative change in % per year) in O_3 concentrations, all station types, period 1999-2008.

<u>*Particulate Matter*</u>
Estimating a trend in PM10 concentration is more cumbersome, partly due to the low number of long time series (499) and partly because the chosen trend model seems less suitable for this pollutant (only for 25% of the time series a correlation of $R^2 > 0.4$ is found). Seasonal variation in PM concentration is less outspoken than in case of, for example, SO_2 or ozone. The increase energy demand in winter time (SO_2) or the enhanced photochemistry in summer time (O_3) result in a distinct annual pattern. For particulate matter a number of sources have different time behaviour: for example, energy-related combustion aerosol, resuspended dust, emission from winter sanding, studded tires, natural sources (sea salt, Sahara dust), photochemical formation of secondary aerosol peaks at different periods in the year. PM-concentration may therefore show a strong monthly variations which cannot be reproduced by the Fourier-model. Another approach, e.g. by including meteorological parameters will be needed. The 105 stations fulfilling the selection criteria as applied here (Annex F) show mostly a decreasing trend. A few stations show an increasing trend (6 station in Spain, 4 in the Czech Republic and one in Poland; the increase is mainly seen on traffic or industrial stations, but also at two rural background stations).
To further test a possible trend in PM_{10} concentration the annual mean values have been analyzed by a Menn-Kendall test (see Annex F). The results of this analysis, based on annual mean values, correspond with the analysis using the Fourier-based time series. Although the set of stations showing a significant trend differs in both approaches, the estimated slopes are very similar. For stations having a significant trend, the concentrations are decreasing with about 4% per year although at 10% of the stations an upward trend is observed. Note that the number of stations with a significant trend is relatively low, 20-30% depending on the method. However, averaged over all stations operational during the last ten years a downward tendency is observed (*Figure 33*); the decrease is particularly observed since 2006.

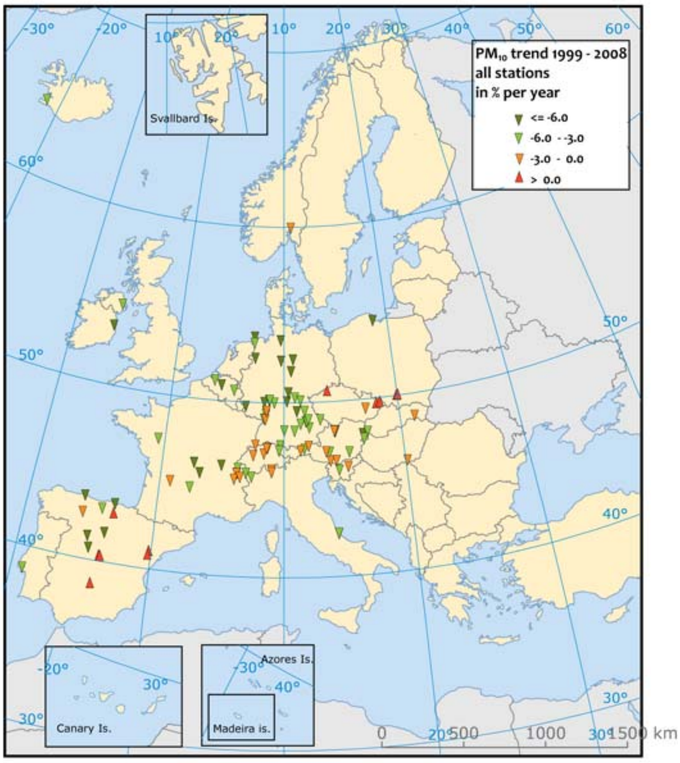

Figure 32. Trend (relative change in % per year) in PM10 concentrations, all stations; period 1999-2008.

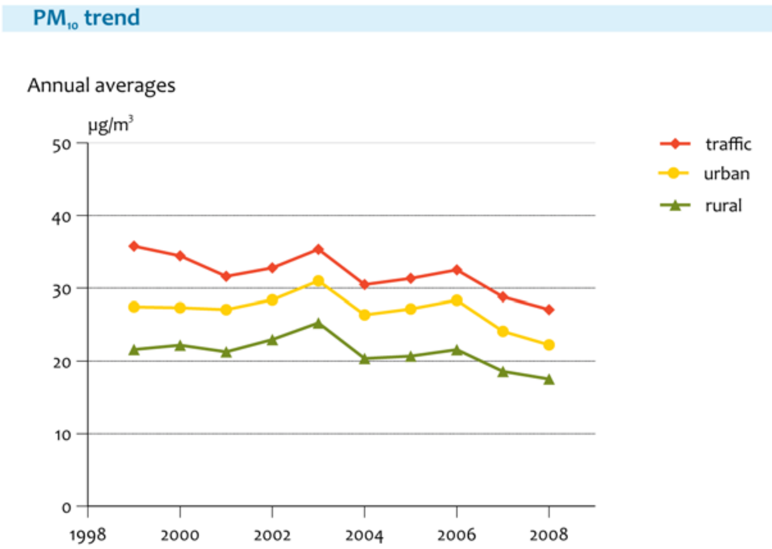

Figure 33. Trend in PM10 concentrations per station type. Only stations operational during 8 years in the period 1999-2008 have been included.

3. CONCLUSIONS

A total of 36 countries, including all 27 EU MS, have provided air quality data for 2008. Measurement data from 4662 stations have been delivered in the EoI2009.
Almost all number of stations for which data have been reported in 2008 has been increased in comparison with 2007. Also the geographical coverage of $PM_{2.5}$ stations has been increased; $PM_{2.5}$ measurement data have been reported from 540 stations, a 50% increase compared to last year. The number of countries delivering $PM_{2.5}$ has been increased to 29; Slovenia is the only EU Member States for which no PM2.5 data is available.
In spite of the request in the EoI2009 letter send to the EoI national data suppliers to deliver at least two of the three oxidised nitrogen components (NO_2, NO, NO_x), there is also still a difference of almost 800 stations 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. Most automated monitors measure both pollutants simultaneously, so this difference should had not been that big.
The number of stations for the 4DD components is still increasing: the number of station where one of more heavy metals listed in the 4DD has increased by 274 while the number of stations where benzo(a)pyrene or one of the other PAH is measured is more than doubled.
Nearly all countries have delivered the data in time before 1st of October 2008. ETC/ACC has produced QA/QC country feedback reports. The response on these reports was very good. 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.
Pollution by SO2 shows an ongoing decreasing trend in the ambient concentrations. Exceedances of the health related limit values are observed at a limited number of stations only. The more stringent limit value for the protection of vegetation set for a winter mean has been exceeded at only one rural station.
NOx concentrations are decreasing in most parts of Europe; in Austria and on the Iberian Peninsula increasing trends are noted at some stations. This is in line with the emission changes. For 57% of the traffic stations a decrease and at 20% an increase in NO2 concentrations is estimated. At the remaining stations no significant trend is seen. Compliance with the NO_2 limit value and limit value + margin of tolerance for annual mean values remains a serious problem in many urban and traffic areas.
The PM_{10} concentrations are reducing slowly. The PM_{10}-limit value for daily values is exceeded frequently at urban background and traffic stations. The daily limit value is exceeded to a larger extent than the annual limit value. The target value for $PM_{2.5}$ has been exceeded for about 10% of the stations.
CO concentrations are reducing in the last 10 years, Some differences in trend are seen over Europe which might be related to the differences in emission reduction trends over Europe. The ambient levels of CO are below the limit value; some incidental exceedances are observed but in these cases measuring artefacts can not be completely excluded at this time.
The concentrations of benzene are in compliance with the limit values except for a limited number of traffic hotspot situations.
At 60% of the ozone stations being operational during the last 10 years no significant trend in mean concentrations is seen. At rural stations, especially those at higher altitudes, seems to have a slight bias towards a negative trend while urban and traffic stations a more positive trend is seen. Ozone concentration shows, more than any of the orther pollutants, a pronounced year-to-year variability which hampers a trend analysis. In 2008 both the health and the ecosystem related target values are exceeded frequently and widely over Europe.
Most EU MS 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 the concentrations are below the lower assessment threshold. For arsenic, cadmium and nickel limited exceedances at 2-7% of the

stations is reported; for benzo(a)pyrene the target values are exceeded at more than one third of the monitoring points.

4. LIST OF ABBREVIATIONS

AEI	Average Exposure Indicator
AOT40	ozone concentrations Accumulated dose Over a Threshold of 40 ppb
AQ	Air Quality
CAFE	Clean Air For Europe
DD	Daughter Directives
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/ACC	European Topic Centre on Air and Climate Change
ETC/LUSI	European Topic Centre Land Use and Spatial Information
ETRS89	European Terrestrial Reference System 1989
EU	European Union
EU27	The 27 EU Member States
EU MS	Member States of the EU
FWD	Air Quality Framework Directive on ambient air quality assessment and Management
GIS	Geographical Information System
LAU	Local Administrative Units
LV	Limit value
MOT	Margin of tolerance
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
SOMO35	Sum of Ozone Means Over 35 ppb
TV	Target value

List of components and component groups

B(a)P	benzo(a)pyrene
C_6H_6	benzene
CO	carbon monoxide
HM	Heavy Metals
HM4	Heavy Metals in the 4th DD
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 4th DD
Pb	Lead
Pb_aer	Lead in aerosol
PM_{10}	particulate matter with an aerodynamic diameter of 10 µm or less
$PM_{2.5}$	particulate matter with an aerodynamic diameter of 2.5 µm or less

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 EU MS 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/m³	1 h
2	NO_2	Nitrogen dioxide	µg/m³	1 h
3	PM_{10}	Particulate matter < 10 µm	µg/m³	24 h
4	$PM_{2.5}$	Particulate matter < 2.5 µm	µg/m³	24 h
5	SPM	Total suspended particulates	µg/m³	24 h
6	Pb	Lead	µg/m³	24 h
7	O_3	Ozone	µg/m³	1 h
8	C_6H_6	Benzene	µg/m³	24 h
9	CO	Carbon monoxide	mg/m³	1 h
10	Cd	Cadmium	ng/m³	24 h
11	As	Arsenic	ng/m³	24 h
12	Ni	Nickel	ng/m³	24 h
13	Hg	Mercury	ng/m³	24 h
14	BS	Black smoke	µg/m³	24 h
15	NO_X	Nitrogen oxides	µg NO_2/m³	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	C2H6	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	$H_3C\text{-}CH_2\text{-}CH_3$	Propane	µg/m3	24 h
20	$CH_2{=}CH\text{-}CH_3$	Propene	µg/m3	24 h
21	$H_3C\text{-}CH_2\text{-}CH_2\text{-}CH_3$	n-Butane	µg/m3	24 h
22	$H_3C\text{-}CH(CH_3)_2$	i-Butane	µg/m3	24 h
23	$H_2C{=}CH\text{-}CH_2\text{-}CH_3$	1-Butene	µg/m3	24 h
24	$H_3C\text{-}CH{=}CH\text{-}CH_3$	trans-2-Butene	µg/m3	24 h
25	$H_3C\text{-}CH{=}CH\text{-}CH_3$	cis-2-Butene	µg/m3	24 h
26	$CH_2{=}CH\text{-}CH{=}CH_2$	1.3 Butadiene	µg/m3	24 h
27	$H_3C\text{-}(CH_2)_3\text{-}CH_3$	n-Pentane	µg/m3	24 h
28	$H_3C\text{-}CH_2\text{-}CH(CH_3)_2$	i-Pentane	µg/m3	24 h
29	$H_2C{=}CH\text{-}CH_2\text{-}CH_2\text{-}CH_3$	1-Pentene	µg/m3	24 h
30	$H_3C\text{-}HC{=}CH\text{-}CH_2\text{-}CH_3$	2-Pentenes	µg/m3	24 h
31	$CH_2{=}CH\text{-}C(CH_3){=}CH_2$	Isoprene	µg/m3	24 h
32	$C_{36}H_{14}$	n-Hexane	µg/m3	24 h
33	$(CH_3)_2\text{-}CH\text{-}CH_2\text{-}CH_2\text{-}CH_3$	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	$(CH_3)_3\text{-}C\text{-}CH_2\text{-}CH\text{-}(CH_3)_2$	i-Octane	µg/m3	24 h
37	$C_6H_5\text{-}CH_3$	Toluene	µg/m3	24 h
38	$C_6H_5\text{-}C_2H_5$	Ethyl benzene	µg/m3	24 h
39	m,p-$C_6H_4(CH_3)_2$	m,p-Xylene	µg/m3	24 h
40	o-$C_6H_4\text{-}(CH_3)_2$	o-Xylene	µg/m3	24 h
41	$C_6H_3\text{-}(CH_3)_3$	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	$C_6H_5\text{-}CH{=}CH_2$	Styrene	µg/m3	24 h
54	$CH_2{=}CH\text{-}CN$	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 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 is required to calculate a valid aggregated value:

- a *daily averaged* (24-hourly) concentration is calculated when at least 13 valid hourly values are available with not more than 6 successive hourly values missing.
- a *8-hourly averaged* concentration is calculated when at least 6 valid hourly values are available (75% data capture)
- a *maximum daily 8-hour mean* is calculated when at least 18 valid running 8-hour averages per day are available (75% data capture)

For the aggregation of3hourly data to daily values we have the following rule:

- a *daily averaged* concentration is calculated when at least 5 valid 3-hourly values are available with not more than 2 successive 3-hourly values missing.

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 k^{th} 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.

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	

Table B1. Calculated statistics in AIRBASE

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 hours/days in the year. N_{valid} is 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**

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

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

[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*. The data capture and time coverage and so the data coverage include losses of data due to the regular calibration or the normal maintenance of the instrumentation. In the AQ Directives these losses are excluded.

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

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:

[1] In AirBase 4 the time zone was disregarded. So the values between 8.00 – 12.00 in the reported time have been taken.

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

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. So if the end date/time is between 27 March 18:00 and 12 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. The only exception is the data coverage calculation for components with “var” averaging time. The data coverage is calculated as follows:

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

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

For calculating n-weekly, n-monthly and variable statistics the concentrations of samples which overlap the calendar year are adjusted. The adjusted concentration = (concentration) * (sample-period within year/ whole sample-period):

$$C_{adjusted,i} = (C_i . P_{wy,i})/P_i$$

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

where $C_{adjusted,i}$ is the adjusted concentration in the overlapping period i, $P_{wj,i}$ is the length of the sample period i within the year, C_i is the valid concentration in the overlapping period i and P_i is the length of sample period i.

Annex C. QA/QC feedback actions

Overview of the QA/QC activities undertaken by the data suppliers and ETC/ACC during the EoI2008 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 2009b).

Table B1. QA/QC actions on EoI2009 data in 2009 and 2010

Date	**Processes by data supplier**	**Processes by ETC/ACC**
1 June 2009		Release of the DEMv12
	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 2009 to 23 Jan 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 (non) replies
23 Jan to 9 Febr 2010		Calculation of statistics and exceedances
9 February 2010		Delivery first version AIRBASE to EEA
9 Febr to 19 Febr 2010		Checks by EEA
19 February 2010		Delivery final AIRBASE to EEA
23 February 2010		Release of AIRBASE on EEA Data Service (see airbase history page)

36 countries have delivered EoI2009 data (see status table http://air-climate.eionet.europa.eu/databases/country_tools/aq/eoi_to_airbase_status/index_html) The response on the feedback reports was very good.

The feedback has been placed on CDR: http://cdr.eionet.europa.eu/ Most countries have placed their responses also on CDR. The responses of BA, BG, DE, FR, GB, GR, HR and IT have been placed on Circa: http://eea.eionet.europa.eu/Members/irc/eionet-circle/airclimate/library?l=/qaqc_country_feedback/eoi_2009_2008_data&vm=detailed&sb=Title . One can also use the status table to find very easily all feedback information.

This information is not public. For access to this information a CIRCA user account and password is needed.

Table B2. Status overview of QA/QC feedback actions on the EoI-2008 reporting cycle

Status	Country feedback						
Country		outliers (extreme/ suspicious)	missing data	missing essential meta inform.	resubmitted data	deletion stations/ meas.conf. with data	reply received
AT	Austria						
BA	Bosnia-Herzegovina						
BE	Belgium						
BG	Bulgaria						
CH	Switzerland						
CY	Cyprus						
CZ	Czech Republic						
DE	Germany						
DK	Denmark						
EE	Estonia						
ES	Spain						
FI	Finland						
FR	France						
GB	United Kingdom						
GR	Greece						
HR	Croatia						
HU	Hungary						
IE	Ireland						
IS	Iceland						
IT	Italy						
LI	Liechtenstein						
LT	Lithuania						
LU	Luxembourg						
LV	Latvia						
MK	FYR of Macedonia						
MT	Malta						
NL	Netherlands						
NO	Norway						
PL	Poland						
PT	Portugal						
RO	Romania						
RS	Serbia						
SE	Sweden						
SI	Slovenia						
SK	Slovak Republic						
TR	Turkey						

Outliers (extreme values,suspicious)
- unknown status outlier(s)
- real outlier(s), still accepted by data supplier as valid
- outlier(s), also rejected by data supplier, unvalid data
- no outlier(s)

Missing data:
- detect. in feedb-report, no reply yet
- additional data submitted
- missing data explained
- no missing data

Missing meta:
- detect. in feedb-report, no reply yet
- missing Information explained and (partly) submitted
- missing Information explained
- no missing meta data

Resubm. data:
- detect. in feedb-report, no reply yet
- restore resubmission
- confirm
- no resubmitted data

Deleted meta with data:
- detect. in feedb-report, no reply yet
- keep meta data in AirBase
- confirmed
- no deleted meta data with data

Reply received:
- expected reply NOT received
- reply: report-modifications
- reply: no report-modifications
- no reply expected

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

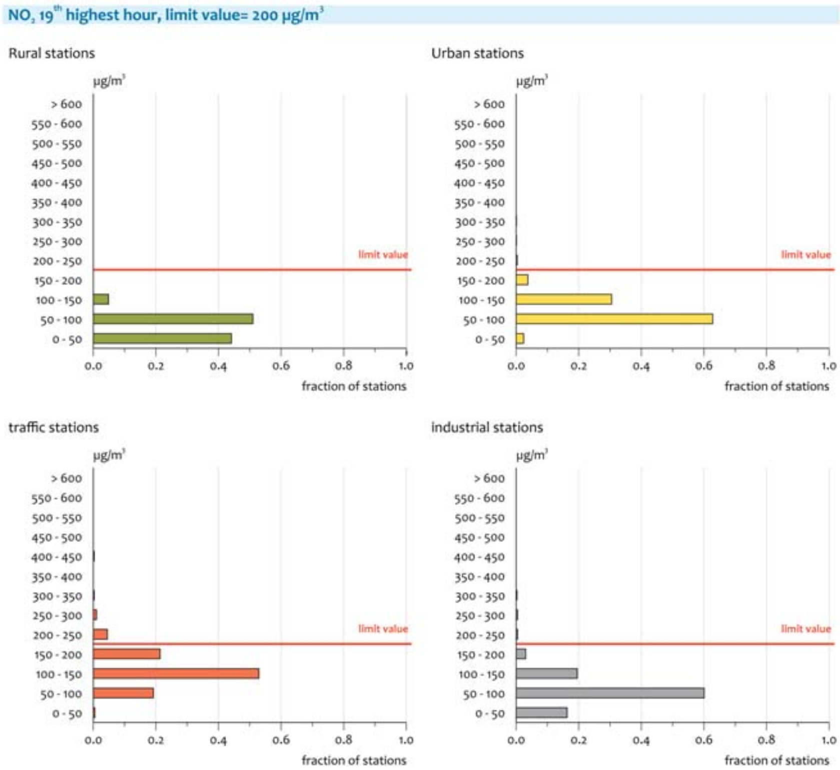


Figure E.1.: Distance-to-target graph for the short-term limit value of NO_2.

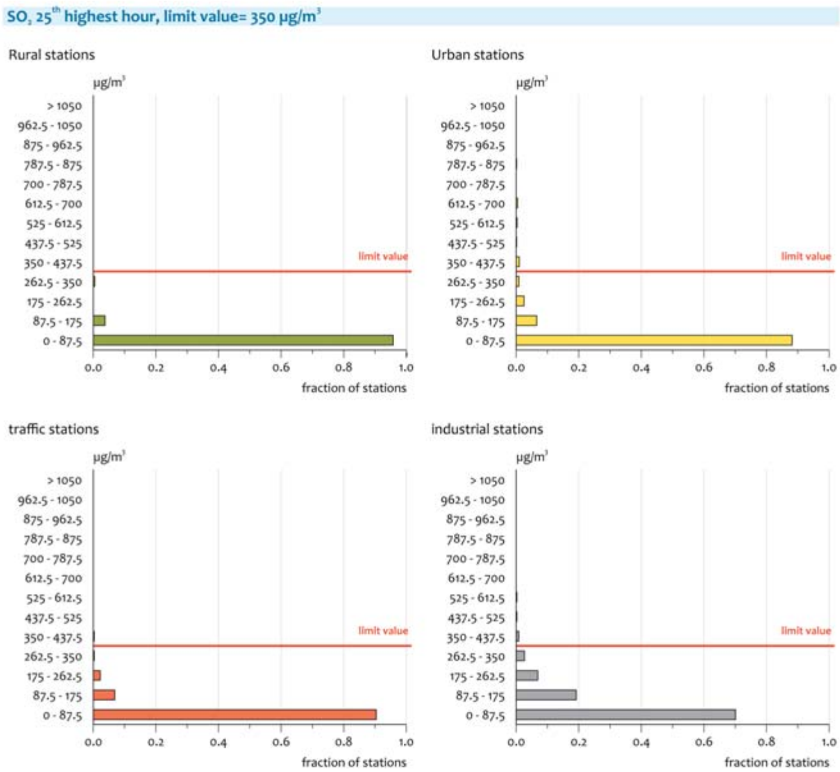


Figure E.2.: Distance-to-target graph for the hourly limit value of SO_2

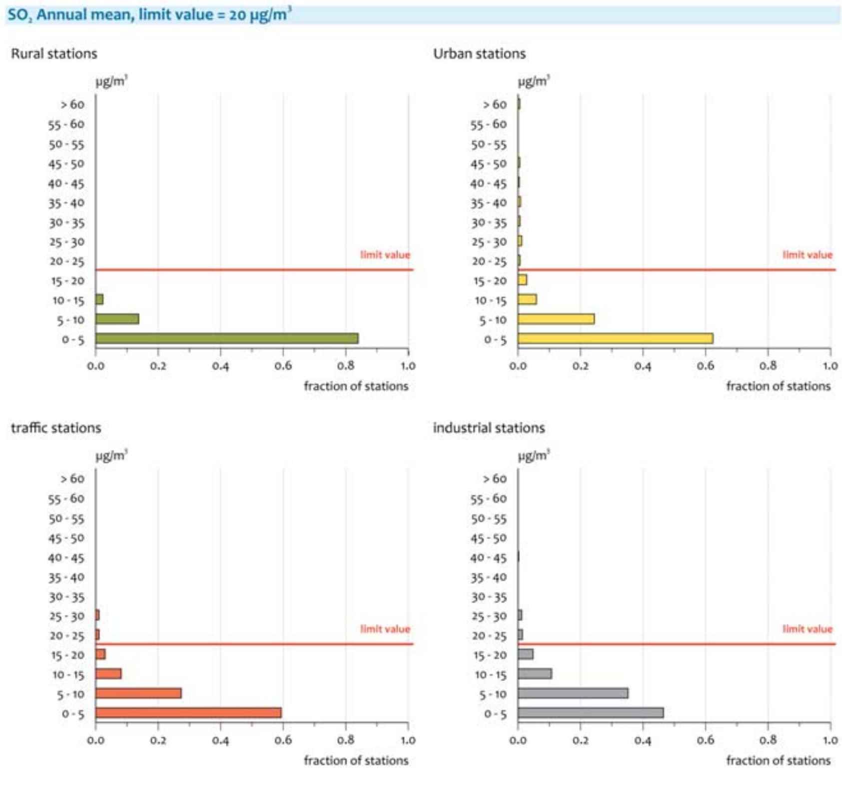


Figure E.3.: Distance-to-target graph for the protection of vegetation (annual mean of SO_2)

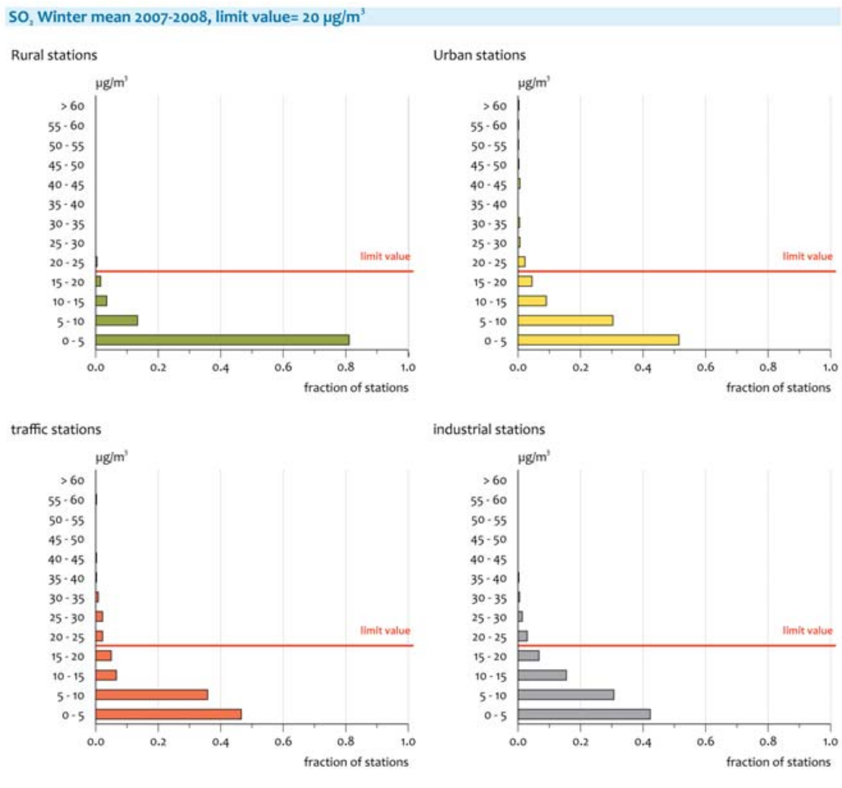


Figure E.4.: Distance-to-target graph for the protection of vegetation (winter period (October 2007 – March 2008) mean of SO_2)

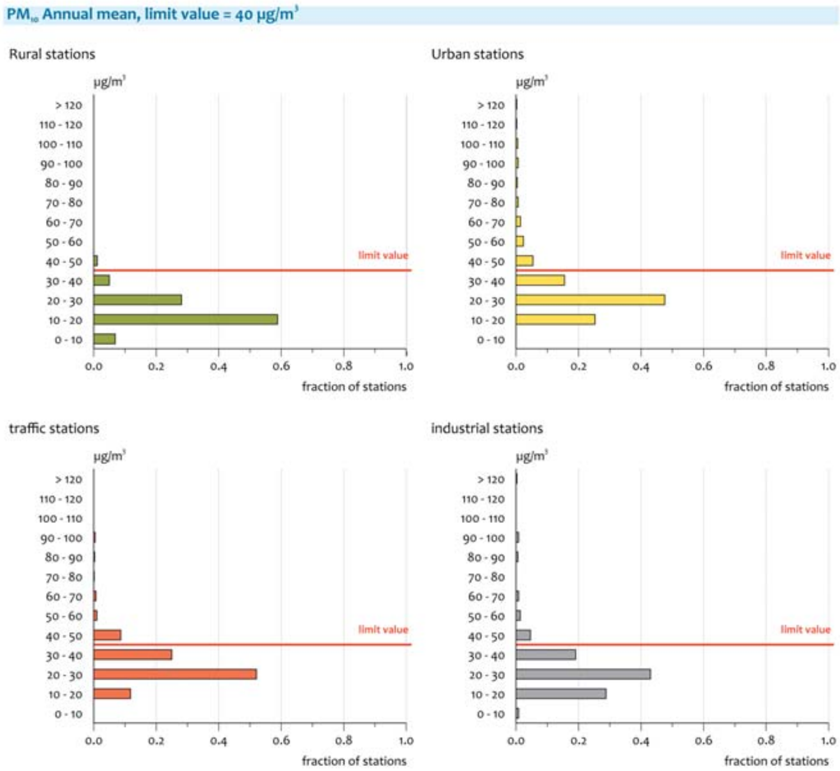


Figure E.5.: Distance-to-target graph for the annual limit value of PM_{10}

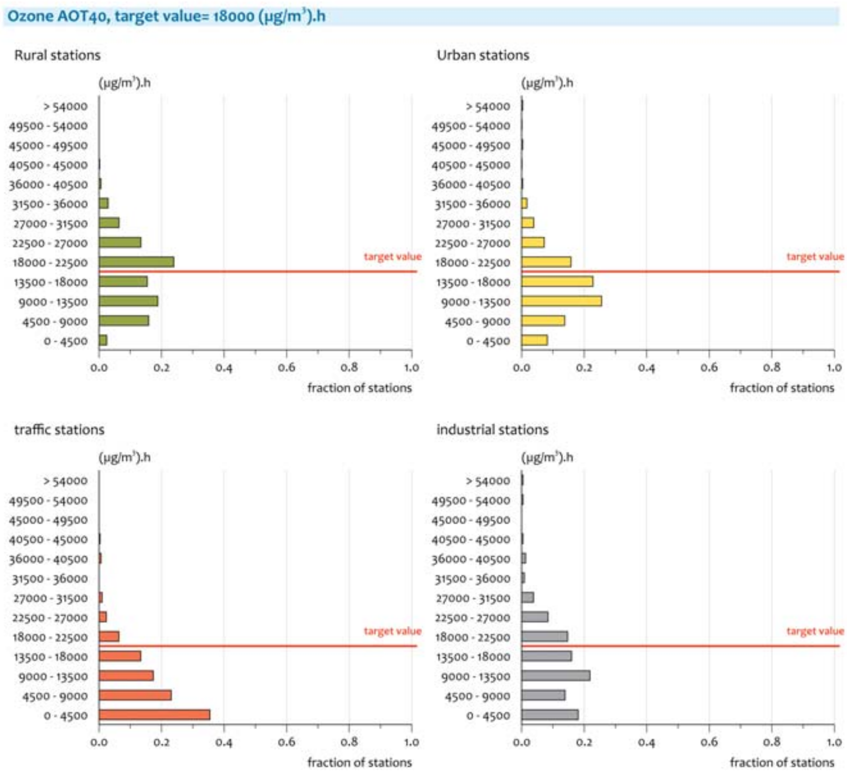


Figure E.6.: Distance-to-target graph for the protection of vegetation (Ozone AOT40)

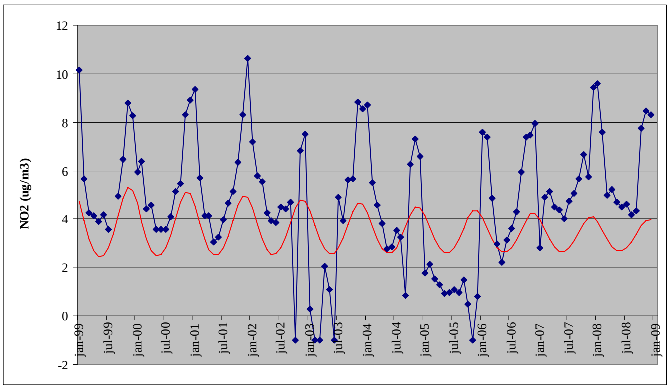
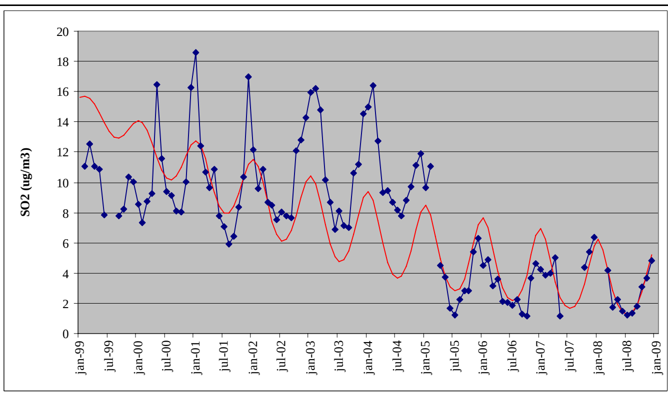
Annex F Trend Model

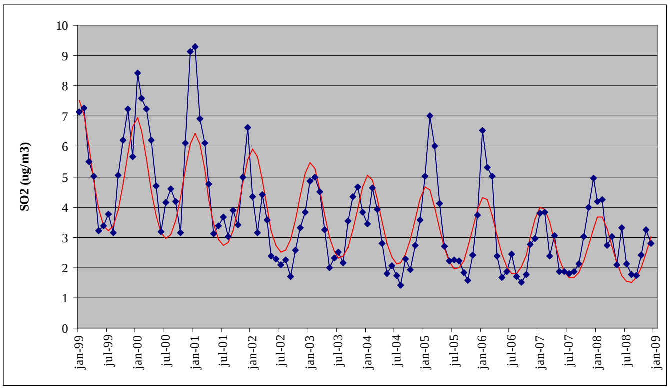
To estimate a temporal trend in the observed data a simple harmonic model has been applied to the monthly means after logarithmic transformation. The seasonal variation is described with a harmonic term allowing for a temporal change both in amplitude and phase angle, the temporal trend is described by a linear term:

$$\ln(C_i) = a_0 + \left(a_1 + b_1\left(\frac{i}{12}\right)\right)\sin\left\{\left(\frac{i}{12}\right)2\pi\right\} + \left(a_2 + b_2\left(\frac{i}{12}\right)\right)\cos\left\{\left(\frac{i}{12}\right)2\pi\right\} + a_3\left(\frac{i}{12}\right) + \varepsilon_i \qquad \text{(F1)}$$

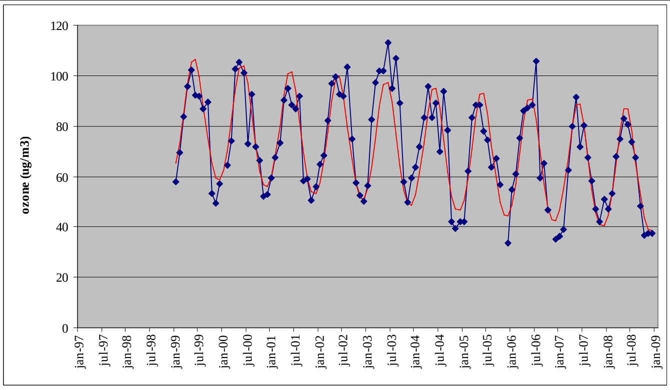
where i is the time in month from January 1999 to December 2008;
C_i is the monthly mean concentration in month i
a_1 *and* a_2 describe the initial seasonal variation
b_1 *and* b_2 describe the temporal trend of seasonal amplitude and phase angle
a_3 is the temporal change in concentration; neglecting the change in the amplitude, the relative change in annual mean concentration is given by $\Delta C/C = (\exp(a3)-1)$.

The coefficient are determined by a routine multiple linear regression methods. The period 1999-2008 has been selected as for most of the main pollutants the number of stations shows a strong increase compared to 1998 and earlier years (see Figure 10). Monthly mean concentrations have been calculated using daily mean values; a monthly mean is considered to be valid if there are more than 75% valid daily values. In the trend analysis only stations having more than 90 valid monthly means (that is, 75% coverage) have been included. Preliminary calculations showed that the fit between observed and modelled concentrations (*Equation F1*) may vary strongly per station. A visual inspection of a few time series having a bad fit showed that frequently the observations show questionable data. Some examples are given below.

<table>
<tr>
<td>
</td>
<td>A large numbers of small negative values (-1.00) have been assigned incorrectly as valid. In the automated data quality checks on the submitted EoI data small negative numbers are not flagged as “suspicious”. Small negative values not exceeding the detection limit may be reported. More sophisticated test (e.g checking on constant values during several consecutive hours/days will be needed.</td>
</tr>
<tr>
<td>
</td>
<td>This plot shows a broken time serie most likely caused by the replacement of the monitor. Similar broken time series are noted for other pollutants and stations. For this particular case the decrease might also be caused by a change in reporting units (initially ug/m3 , later ppb).</td>
</tr>
</table>



Although the correlation between observed data and the calculated data from the trend model is high, there is a notable change in the minimum value around January 2002. A change in detection limit of in the treatment of data below detection limit might be the reason.



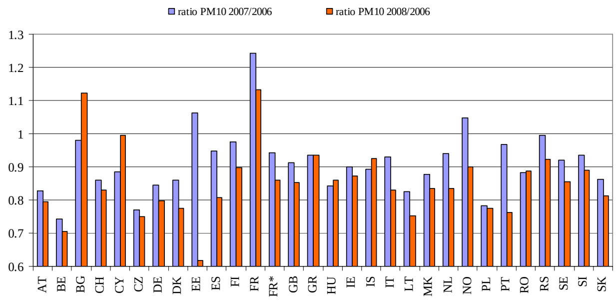
A similar situation as above but now with ozone concentrations: whereas before January 2004 the minimum monthly mean does not falls below 50 ug/m3, the minimum drops after January 2004 frequently below 40 ug/m3.

The automated methods as currently implemented in the quality control procedures of AirBase are not able to detect these irregularities. More refined methods will be needed. A detailed (visual) screening of the time series, preferable using the raw hourly or daily data, and a feedback with the Member States on suspicious data should ideally be done. This, however, is in view of the large number of time series involved, not feasible within the current task. A more pragmatic selection has been applied: only time series with an explained variance of more than 40% ($R^2 > 0.40$) has been included. A summary of the number of time series included in the trend analysis is given in Table F.1.
A special problem arises with the PM10 data. PM mass is measured with different methods and instruments across Europe. Most widely used are gravimetry (the reference method) and automatic instrument based on the beta ray absorption method (BAM) or the tapered element oscillating method (TEOM). It is known that in most part of Europe the results of the automatic instrumental methods need to corrected to make them equivalent to the reference method. Documentation on which correction is where applied and since when is largely lacking although overviews of the applied correction factors in AirBase have been prepared (Buijsman and de Leeuw 2004; de Leeuw 2005). This uncertainty may complicate a trend analysis in particular when information on the adjustment of historical data is not known. When in a Member States correction factors are introduced at different moments in different networks such a change is hardly to detect from the raw data. However, in France the introduction of a correction procedure is well-documented: since January 2007 a nation-wide system has been introduced (MEEDDAT, 2008) which could be noted from the monitoring data (*Figure F1*; see also de Leeuw and Fiala 2009). The correction procedure uses time and place dependent factors but representative national factors per station type can be deduced. These can be used to get a first-order correction of the French data prior to 2006. After correction the results (*Figure F1*) show concentration variations in France which are more in line whith those in neighbouring countries. In the trend analysis (*Equation (A1)*) this correction has been applied to all monthly mean values in France in the period 2001-2006.

Table F.1 Number of stations having (i) a data coverage of more than 75% over the period 1999-2008 and (ii) a correlation between observed and calculated values of $R^2 > 0.40$ and (iii) a significant trend ($\alpha < 0.1$).

Indicator	# stations with > 75% time coverage	of which with R2 >0.4	of which with a significant trend
CO	458	396	369
SO2	936	584	545
NO2	1249	899	661
NOx (a)	803	732	551
O3	1089	1075	416
PM10	499	126	105

(a) NOx concentrations have been calculated from the reported NO and NO2 concentrations where possible complemented with the directly submitted data



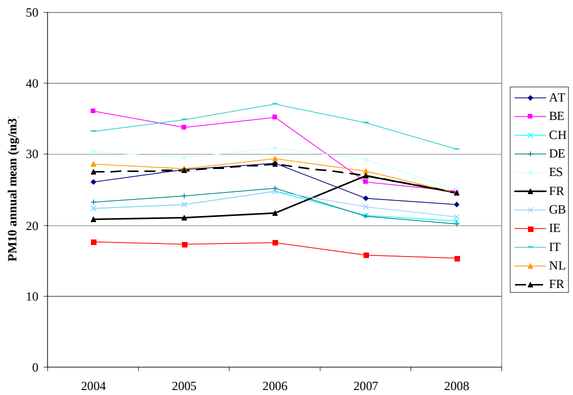


Figure F1. Variation in PM10 concentration during recent years. Left: the ratio of PM10 concentrations in 2007 and 2008 compared to 2006 (all stations operational during he three years). While in most of Europe the ratios for 2007 are below unity and even further decrease in 2008, the French data show an increase of about 25% in 2007 followed by a decrease similar like the other countries. The right-hand figure shows the concentrations since 2004 (limited set of stations operational during the full period). In contrast to the situation in the countries neighbouring France, the French data (black line) show a strong increase between 2006 and 2007. When the French data is corrected for non-equivalence (see text) the data shows a similar behaviour (left: corrected data labelled with FR; right: corrected data is given by the broken black line).*

The Mann-Kendall test

For analyzing a trend in 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. The Mann- Kendall statistic S is defined as:

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

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 stations with at least 75% data coverage, both within each year as over the whole study period.

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 $n(n\text{-}1)/2$ data pairs:

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

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