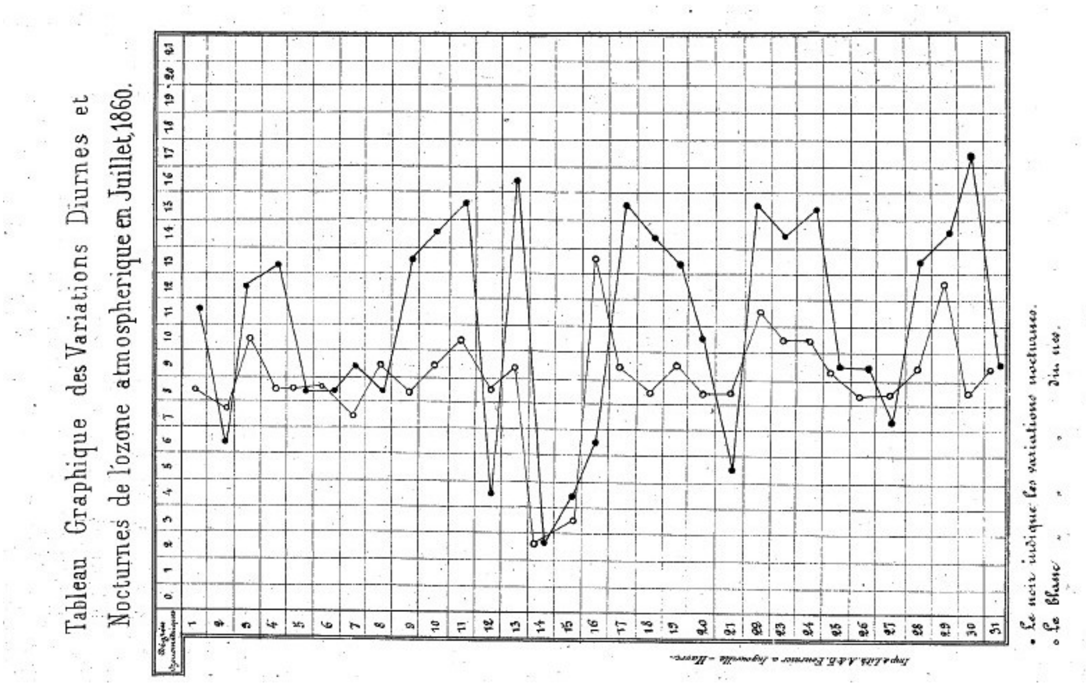
European exchange of monitoring information and state of the air quality in 2007



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Front page picture: Time series of night time and day time measurements of ozone, July 1860 made by M. Bénard in Le Havre, France. For the assessment of changes in the chemical composition of the atmosphere, long time series are needed. The ETC/ACC puts, with the help of the national data suppliers, during the 2009-reporting cycle emphasis on the collection of historical data. The ozone measurements presented here for Le Havre have been made with the so-called Schönbein method. This method is very sensitive for monitoring artefacts which disable a reliable estimate of the ozone levels in the western part of France in the second half of the 19th century.

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SUMMARY

Current air quality legislation of the European Union, 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 European Union Member States and the Commission. Besides the EU Member States, other member and cooperating countries of the European Environment Agency, which include EU candidate countries, EU potential candidate countries and EFTA states, have agreed to follow this reporting procedure as well. The contents of AirBase (version 3) is available to the public via the 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 2007.

A total of 33 countries, including 26 EU Member States, have provided air quality data for 2007. Contrary to last year, Luxemburg[3] and Croatia have not delivered EoI data. 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 2007.

Over the last eleven monitoring years pollution by SO_2, NO_x, PM_{10} and CO shows a decreasing trend in the ambient concentrations. At traffic stations concentrations of NO_2 are nearly constant notwithstanding the NO_x concentration reductions. The reduction of CO on rural stations is very small. The ozone concentrations are constant on the rural level and show increasing levels at urban and traffic stations. Exceedances of the health related limit values are observed at a limited number of stations only for SO_2, CO and benzene. Compliance with the health related limit values of NO_2, PM_{10} and O_3 is a serious problem in many urban and traffic areas.

The lead concentrations have declined considerably with the introduction of unleaded petrol. Several Member States have reported heavy metals (arsenic, cadmium, nickel) and benzo(a)pyrene regulated under the fourth Daughter Directive. The air pollution by these heavy metals is generally low. For arsenic and cadmium the concentrations are below the lower assessment threshold at the majority of the stations. Nickel and benzo(a)pyrene have limited exceedances of the target values. The target value for $PM_{2.5}$ has been exceeded for 10-15% of the stations. In 10 Member States one or more exceedances are observed.

Urban air quality indicators have been defined for PM_{10} and ozone. These indicators reflect population weighted concentrations. For both indicators the time series does not show a clear increasing or decreasing tendency.

[1] http://www.eea.europa.eu/themes/air/airbase
[2] http://airbase.eionet.europa.eu/
[3] Luxembourg has delivered the EoI2008 on 30 March 2009. These data are not included in the latest version of AirBase (version 3) and therefore also not considered in this Technical paper.

CONTENTS

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 EU Member States provide information on air quality in the context of the Air Quality Framework Directive (FWD; EU 1996) and related daughter directives (EU 1999, EU 2000, EU 2002, EU 2004a, EU 2004b). This information mainly focuses on compliance checking with obligations under the air quality directives, such as limit or target values. To avoid duplicate reporting by the Member States, 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 air quality 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 air quality data exchanged, and make the information available to EU Member States. 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 has become more and more the central database for the air quality meta information for the different air quality data flows: EoI, FWD (questionnaire, summer ozone reporting) and the NRT ozone Web site[3].

This report shows information provided by 26 of the EU-27 Member States (Luxembourg is missing[4]). In addition it contains information from other five EEA member countries and from three cooperating countries[5], which have agreed to follow the data exchange procedures in the framework of Euroairnet.

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 several reports (see Mol *et al.* 2005b, Mol 2008b). 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

[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] Luxembourg has delivered the EoI2008 on 30 March 2009. These data are not included in the latest version of AirBase (version 3) and therefore also not considered in this Technical Report.
[5] EU27 Member States: Austria, Belgium, Bulgaria (since 01-01-2007), 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 (since 01-01-2007), 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), Montenegro and Serbia.

measurement configurations with data. In addition to these standard checks also QA/QC checks are performed on questionable station coordinates.

In addition to the more technical aspects of the data submission process, this report will briefly describe the state of the air quality for some selected pollutants. The current (2007) 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 (EoI2007, 2006-data) is given by Mol *et al*. (2008a). 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 2008 (DATA FOR 2007)

1.1. Data delivery

Thirty three countries, including the EU-27 Member States, provided air quality data for the reporting year 2007. The air quality data from Luxembourg has been received six month after the official submission deadline which was too late to include the data in this reporting cycle. They will be included in next year's cycle. In contrast to the previoius cycle, Croatia has not 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 Air Quality 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 2007 was loaded into AirBase (version 3). All statistics and exceedances relevant in the Daughter Directives 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 *et al.* 2005b, Mol 2008b). 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 questionable measurement data.

Intensive feedback took place with the data suppliers on these items. The country feedbacks sent to the member states resulted for 30 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 all 33 countries for NO_2, PM_{10} and O_3 to thirteen for components like PAH and VOC (for definition see Annex D).

The number of reporting stations in 2007 also varied accordingly, being 211 for one or more VOC and 2629 for NO_2. Differences in the distribution and density of reporting stations are illustrated for selected pollutants (*Figures 1 through 8)*. The expected EoI stations in these

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

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 Daughter Directives.

Overviews of reporting in 2007 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; excluding benzene which is listed separately) 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_aerosol) 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 are 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 2007 can be found in table A "number of stations per pollutant and station type and country in 2007" in http://air-climate.eionet.europa.eu/databases/airbase/eoi_tables/eoi2008/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. 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, 4-weekly, monthly, 3-monthly and yearly. If the measurement periods of a component differ more than 25% from a constant averaging time, the averaging time has been defined as "var".

The daily values in AirBase have been calculated by ETC/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/eoi2008/index_html for a summary of these supplementary components.

For nearly all pollutants the number of stations for which data have been reported in 2007 has been decreased in comparison with 2006: SO_2 (-152), NO_2 (-241), PM_{10} (-66), $PM_{2.5}$ (-13), CO(-140), C_{66} (-64), O_3 (-251), VOC excluding benzene (-7). Only HM4 (+23) and PAH4 (+100) have been increased. Also Pb_aerosol (+184), but in 2006 the stations where Pb in

[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*.

PM_{10} had been measured were not included in this component group. The number of stations for which NO_x or NO +NO_2 has been reported has decreased (-189). The difference 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 is 723. Most automated monitors measure both pollutants simultaneously, so this difference is 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/eoi2008/index_html for an overview per country.

Table 1 Number of stations for which 2007 data have been delivered for Daughter Directives 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	26	26	24	26	24	20	26	23	26	11	19	13
Total number of stations	1946	2539	1839	2289	294	431	1036	490	1771	206	363	212
Of which												
Traffic	396	792	650	682	99	113	550	227	249	121	98	70
Urban background	768	1070	650	997	131	173	336	164	912	45	123	90
Industrial	482	335	262	355	13	80	96	61	159	30	74	23
Rural background	291	324	276	244	50	65	37	31	416	10	68	29
Other	9	18	1	11	1		17	7	35			
Reporting non-EU countries	6	7	7	7	2		6	4	7	2		
Total number of stations	67	90	67	68	13	0	33	15	52	5	0	0
Of which												
Traffic	14	33	28	30	9		20	11	13	1		
Urban background	28	32	23	24	4		5	3	16	3		
Industrial	12	11	7	6			6		6			
Rural background	13	14	9	8			2	1	17	1		
Other												
Total reporting countries	32	33	31	33	26	20	32	27	33	13	19	13
Total number of stations	2013	2629	1906	2357	307	431	1069	505	1823	211	363	212

Table 2 Number of stations for which 2007 data have been delivered for Daughter Directives 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	114	152	152	128	9	18	42	23	116	2	20	19
BELGIUM	60	66	66	49	12	44	17	38	38		44	10
BULGARIA	16	15	15	38	4	18	12	11	13	5	17	16
CYPRUS	1	1	1	2	2	2	1	1	2		2	
CZECH REPUBLIC	89	92	92	118	32	22	32	27	60		22	23
DENMARK	5	12	12	11	4	9	7	1	9	1	9	1
ESTONIA	7	7	7	5	1	2	5		7		2	2
FINLAND	11	27	28	29	7	1	7		17			
FRANCE	325	521		355	54		100	32	475			
GERMANY	205	467	437	466	52	119	173	73	301	59	121	71
GREECE	13	25	25	16	3		11	1	24			
HUNGARY	25	25	24	25	3		21	11	17			
IRELAND	8	8	8	17	1	10	7	3	8	2	1	
ITALY	314	549	524	234	38	20	339	124	287	87	20	19
LATVIA	7	9	1	7	4	6	1	6	8		6	2
LITHUANIA	12	15	12	13	3	4	8	5	13		4	4
MALTA	4	4	4	4	3	3	3	3	4	3	3	
NETHERLANDS	35	55	44	39		5	22	8	37	8	5	
POLAND	145	145	94	203	6	68	57	17	59	2	28	20
PORTUGAL	47	63	63	53	17		40	7	46			
ROMANIA	28	32	21	31	3	22	16	6	26		2	
SLOVAKIA	12	13		27	4	6	11	10	13		6	
SLOVENIA	21	10	10	10			5		11			
SPAIN	398	141	136	298	14	28	58	56	120	30	23	5
SWEDEN	8	31	9	35	11		4	12	15			
UNITED KINGDOM	36	54	54	76	7	24	37	15	45	7	28	20
Total EU-27 countries	1946	2539	1839	2289	294	431	1036	490	1771	206	363	212
non-EU-27 countries												
BOSNIA - HERZEGOVINA	4	2	2	2			1		1			
ICELAND	1	2	2	3	1		1	1	3	1		
LIECHTENSTEIN		1	1	1					1			
MACEDONIA, FYRO[1)]	21	15	15	14			14		13			
NORWAY	7	25	21	24	12		7	10	10			
SERBIA	23	22	3	1			1	1	1			
SWITZERLAND	11	23	23	23			9	3	23	4		
Total non-EU-27 countries	67	90	67	68	13	0	33	15	52	5	0	0
Total all countries	2013	2629	1906	2357	307	431	1069	505	1823	211	363	212

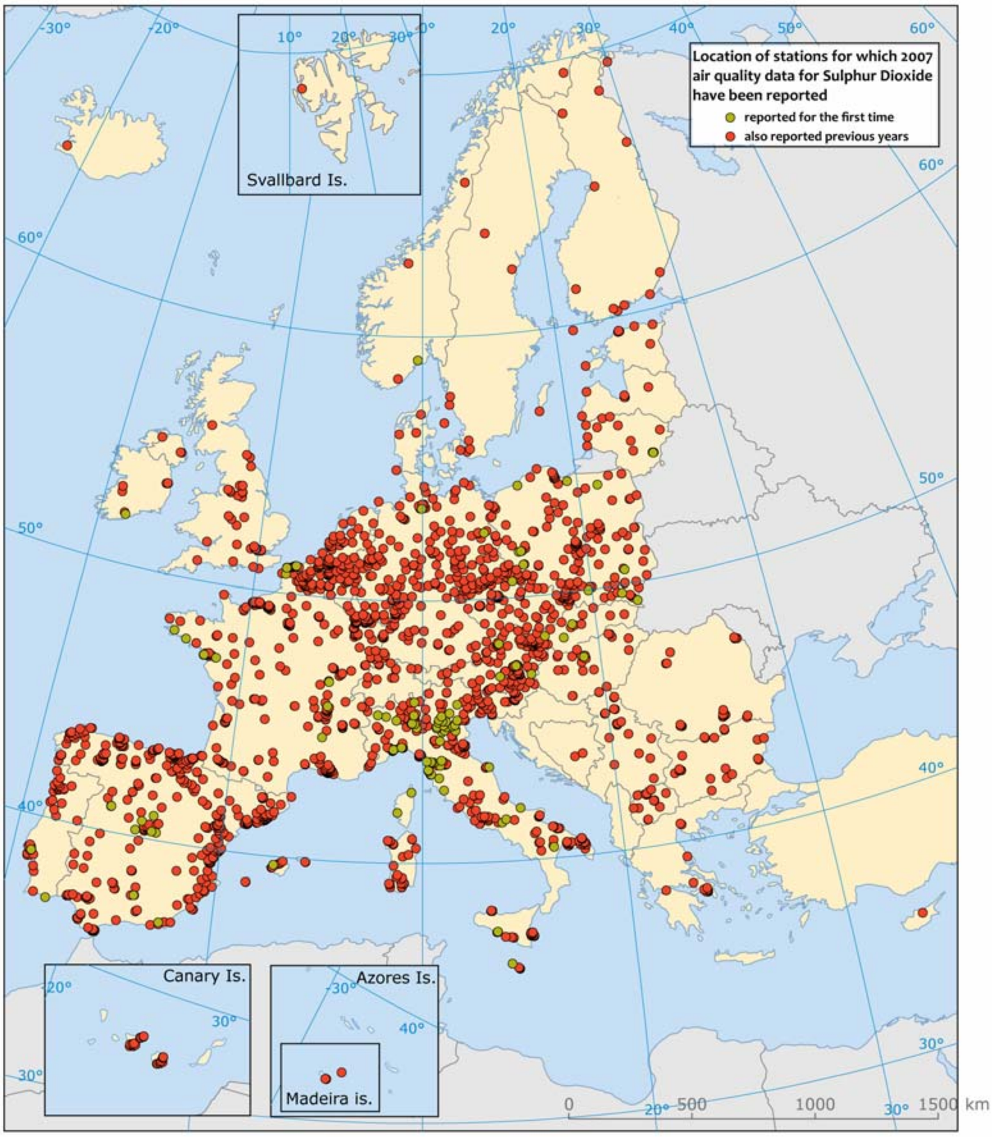


Figure 1 Location of stations for which 2007 air quality data for sulphur dioxide (SO_2) have been reported. The green stations report for the first time (new stations).

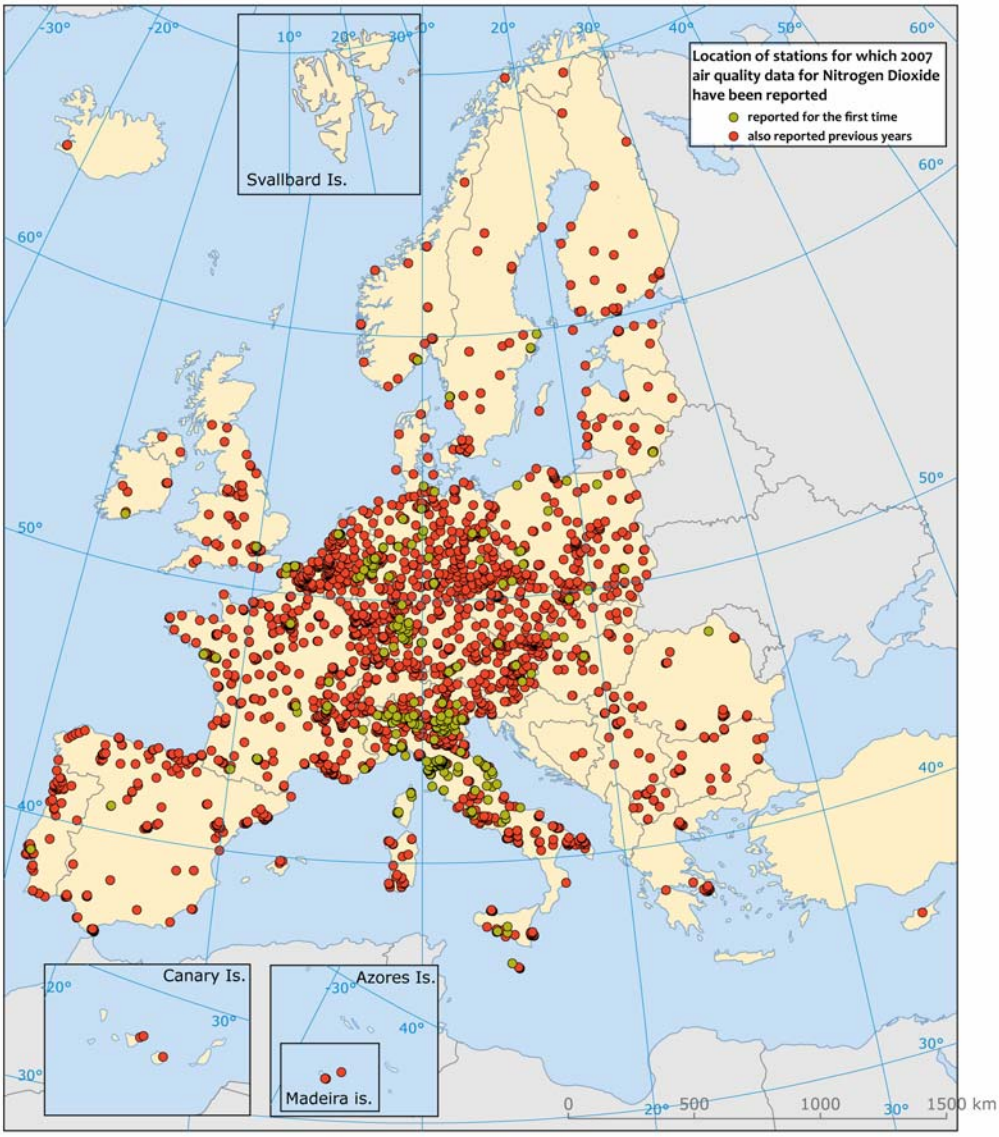


Figure 2 Location of stations for which 2007 air quality data for nitrogen dioxide (NO_2) have been reported. The green stations report for the first time (new stations).

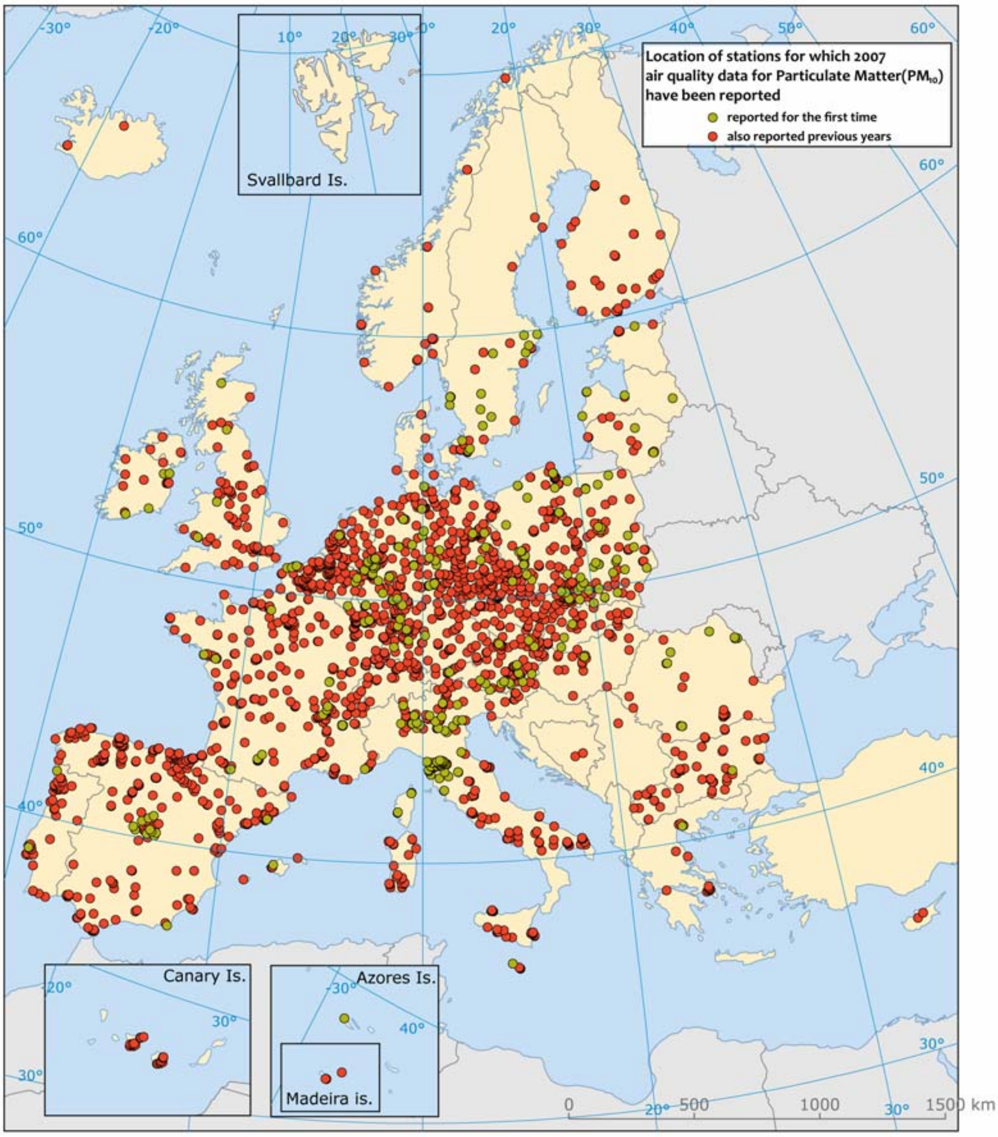


Figure 3 Location of stations for which 2007 air quality data for particulate matter (PM_{10}) have been reported. The green stations report for the first time (new stations).

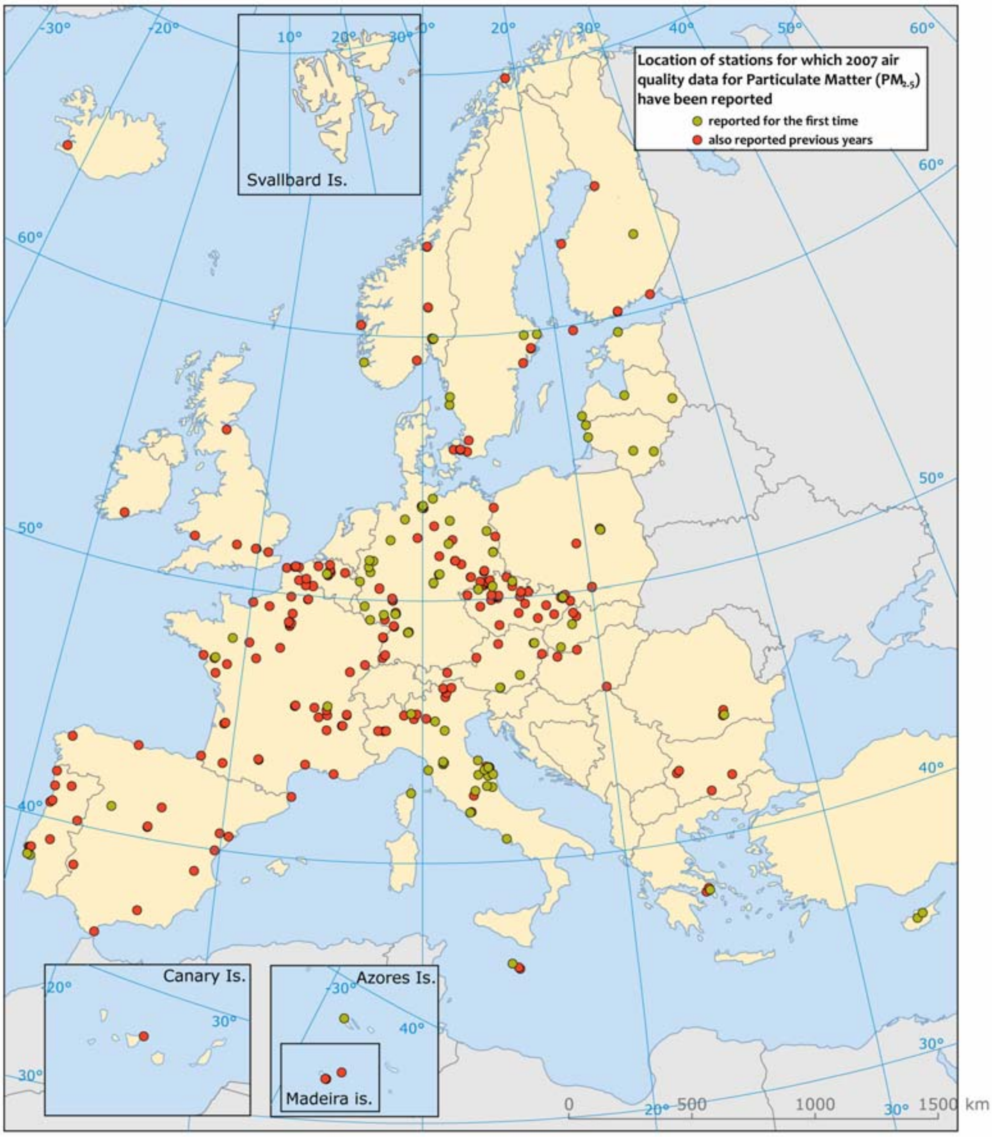


Figure 4 Location of stations for which 2007 air quality data for particulate matter ($PM_{2.5}$) have been reported. The green stations report for the first time (new stations).

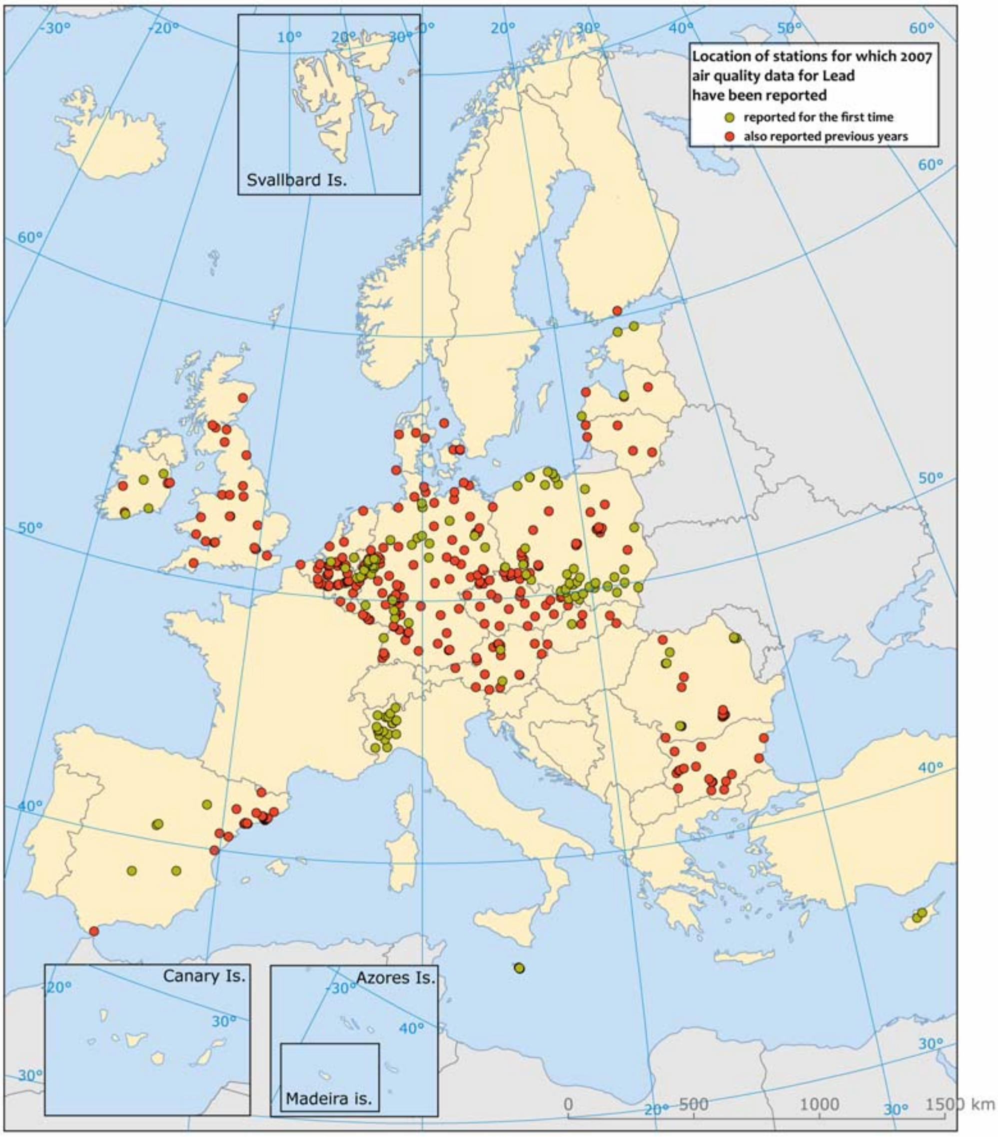


Figure 5 Location of stations for which 2007 air quality data for lead (Pb) have been reported. The green stations report for the first time (new stations).

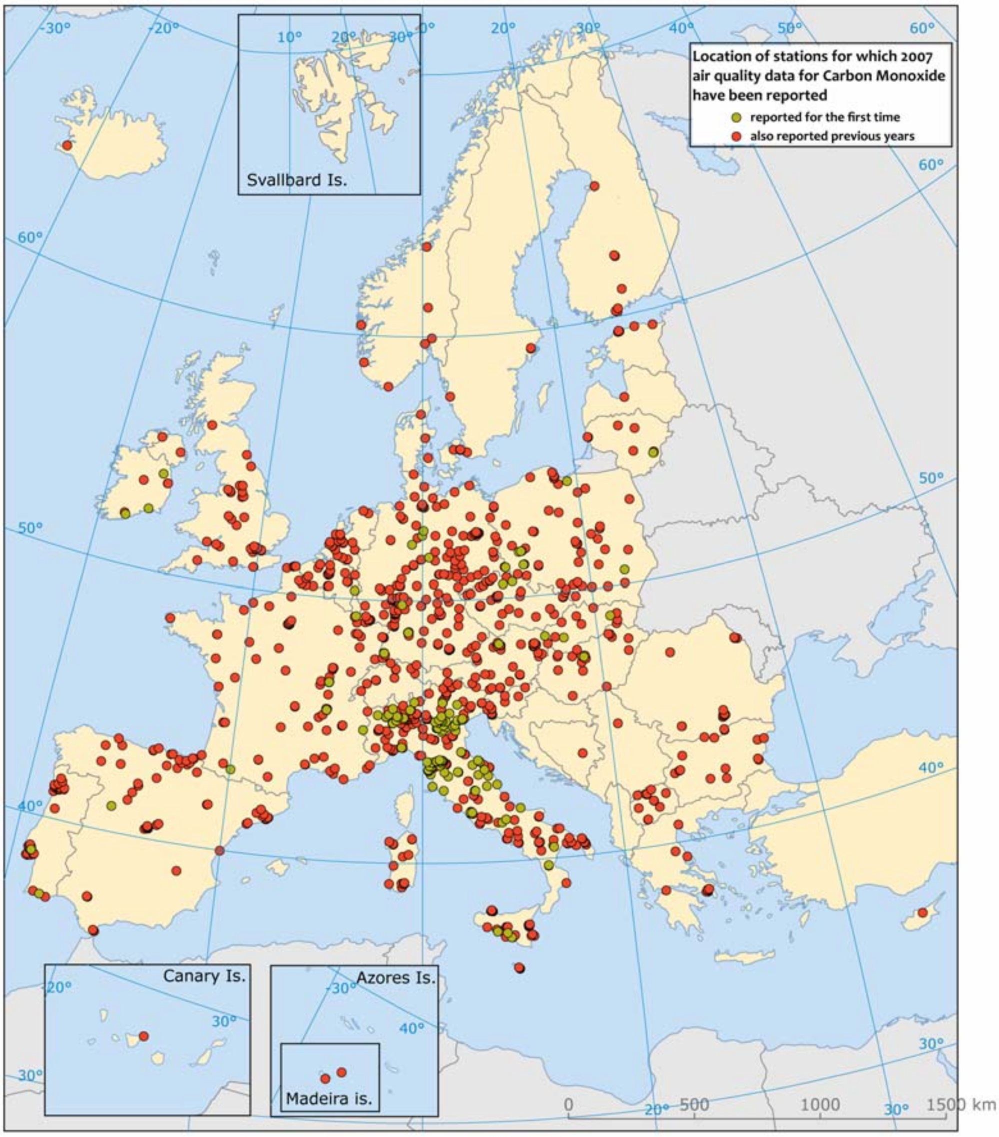


Figure 6 Location of stations for which 2007 air quality data for carbon monoxide (CO) have been reported. The green stations report for the first time (new stations).

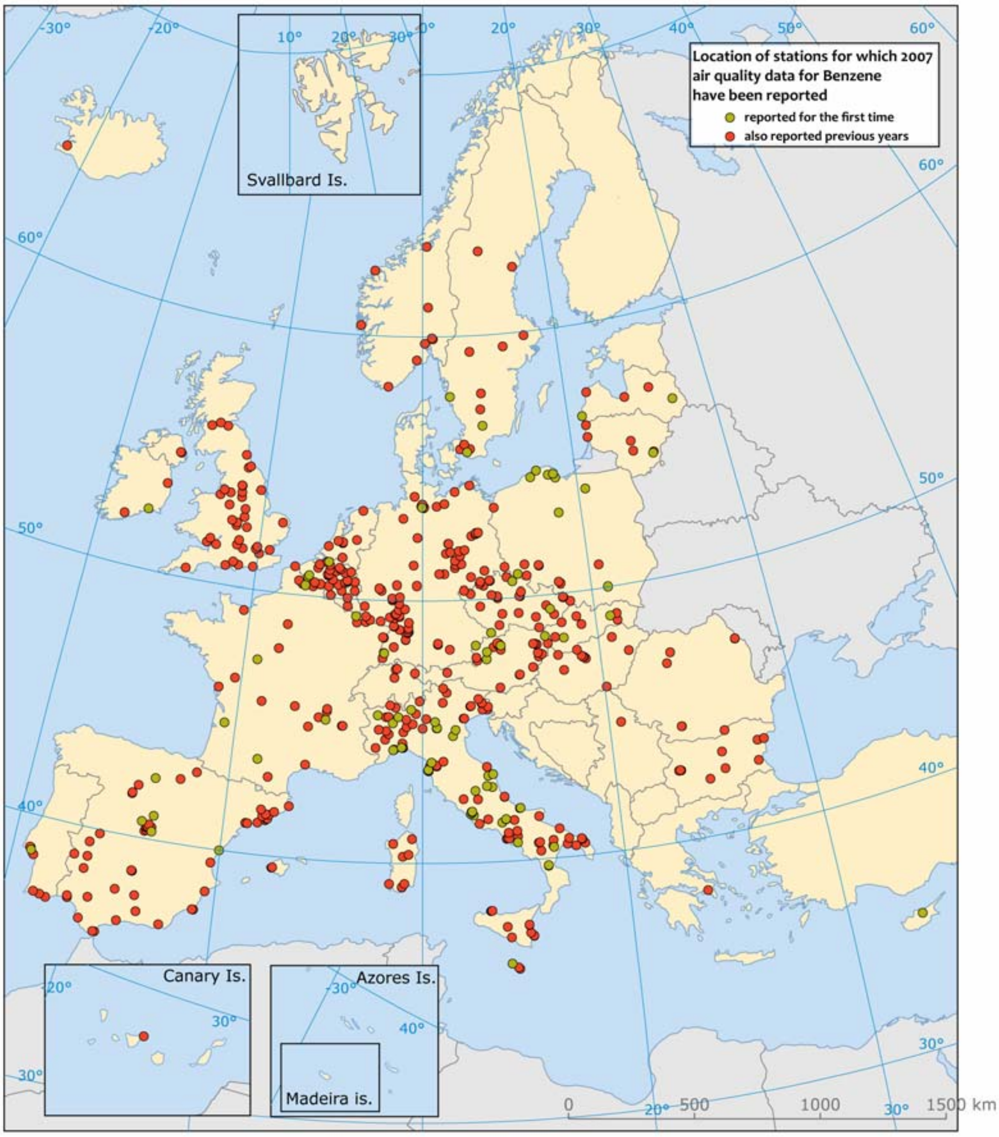


Figure 7 Location of stations for which 2007 air quality data for benzene (C_6H_6) have been reported. The green stations report for the first time (new stations).

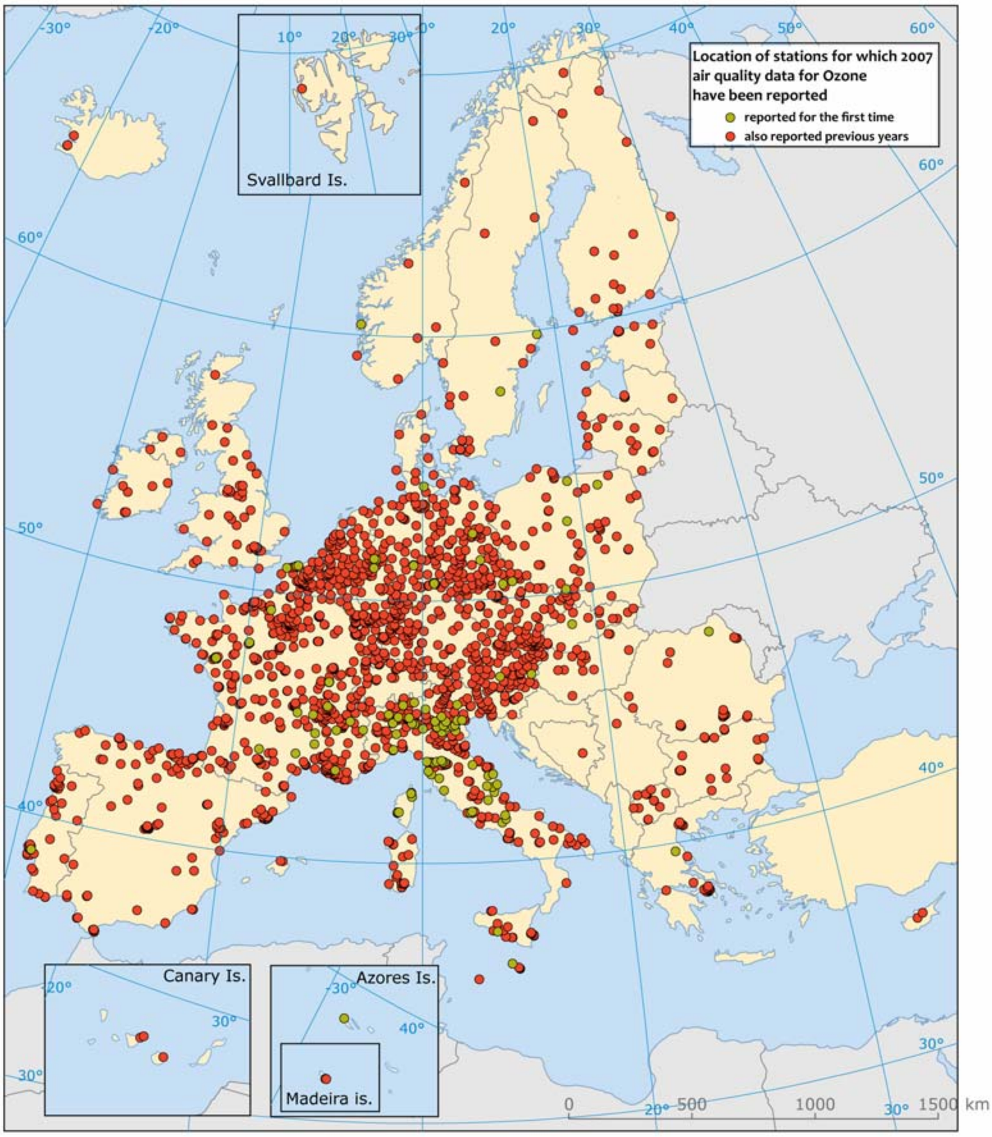


Figure 8 Location of stations for which 2007 air quality data for ozone (O_3) have been reported. The green stations report for the first time (new stations).

1.4. Total number of stations in AirBase

The total number of stations in AirBase is 6745, from which 6136 stations have measurement data (raw data and statistics). 42 stations have only invalid raw data and have therefore no calculated statistics. 183 stations have only reported statistics; no raw data have been delivered. The 567 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	42
Stations with only statistics	183
Stations with raw data and statistics	5953
Stations without data	567
Total stations in AirBase	6745

The exchange of information should cover at least the stations which are included in the FWD/Questionnaire (EU 2004b). Last year (2008) ETC/ACC has send a list of Questionnaire stations which are not in AirBase to the EoI data suppliers with the request to deliver both meta data and measurement data for these stations. In the Questionnaire 2008 report (see Vixseboxse and de Leeuw 2009) 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. Data coverage and time series

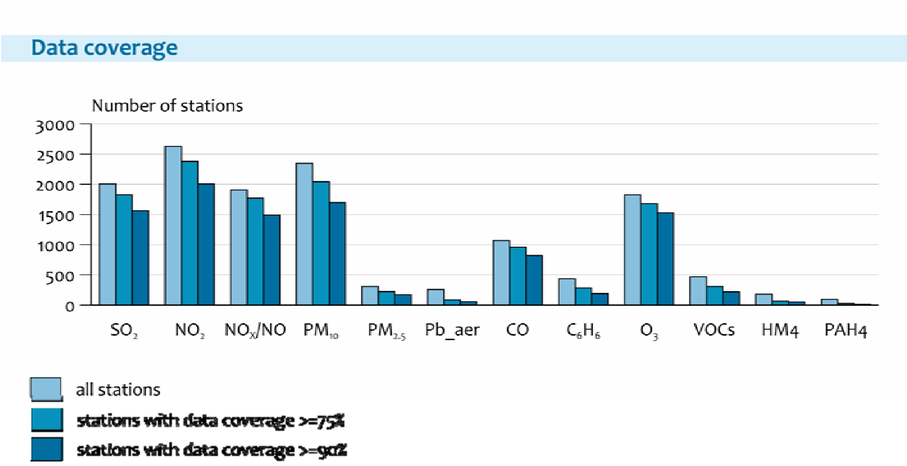
The total number of stations with reporting data in 2007 is 3969 (see *Table 3*).

Figure 9 gives information on the data coverage of the 2007 stations. The number of stations with data coverage >0% (all operational 2007 stations) have been compared with the number of stations with >=75% and >=90% data coverage[1]. In table D you can also find information on data coverage, see "Information on time series in AirBase" in http://air-climate.eionet.europa.eu/databases/airbase/eoi_tables/eoi2008/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. For the next AirBase version we expect a considerable improvement in the number of time series. ETC/ACC has generated station lists in which gaps but also potential extensions are indicated. These lists will be send to the countries with the request to deliver these historical data.

Figure 9 Number of stations with 2007 data coverage >0% (with data), >=75% and >=90%. Data coverage is based on daily averages for SO_2, NO_2, NO_x/NO,PM_{10}, $PM_{2.5}$, Pb_aer, benzene,VOC, HM4 and PAH4 and based on daily running 8h maximum for CO and O_3



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

Table 3 Summary of periods and number of stations for which data have been delivered in the whole period and only in 2007.

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 2006 data have been delivered [1)]	Number of stations for which 2007 data have been delivered [1)]
EU-27 countries				
AUSTRIA	1990-2007	241	193	191
BELGIUM	1985-2007	296	204	196
BULGARIA	1998-2007	61	38	38
CYPRUS	2003-2007	2	2	2
CZECH REPUBLIC	1992-2007	141	129	129
DENMARK	1976-2007	40	14	14
ESTONIA	1997-2007	9	7	7
FINLAND	1990-2007	82	56	50
FRANCE	1976-2007	1004	747	732
GERMANY	1976-2007	928	588	536
GREECE	1983-2007	34	27	27
HUNGARY	1996-2007	38	26	27
IRELAND	1973-2007	92	27	24
ITALY	1976-2007	971	689	629
LATVIA	1997-2007	19	9	12
LITHUANIA	1997-2007	24	18	17
LUXEMBOURG	1976-2006	12	6	
MALTA	2002-2007	7	5	4
NETHERLANDS	1976-2007	82	62	63
POLAND	1997-2007	308	278	269
PORTUGAL	1986-2007	94	69	66
ROMANIA	1999-2007	63	51	45
SLOVAKIA	1995-2007	50	39	34
SLOVENIA	1997-2007	25	25	24
SPAIN	1986-2007	687	552	474
SWEDEN	1993-2007	70	59	53
UNITED KINGDOM	1969-2007	565	224	189
Total		*5945*	*4144*	*3852*
Non-EU-27 countries				
ALBANIA				
BOSNIA - HERZEGOVINA	1985-2007	19	5	4
CROATIA	2004-2006	8	8	
ICELAND	1993-2007	9	5	4
LIECHTENSTEIN	2004-2007	2	1	1
MACEDONIA, FYRO [2)]	1997-2007	44	41	25
MONTENEGRO				
NORWAY	1994-2007	46	36	36
SERBIA	2002-2007	25	24	23
SWITZERLAND	1992-2007	38	27	24
TURKEY				
Total		*191*	*147*	*117*
Total EU-27 + non-EU-27 countries		*6136*	*4291*	*3969*

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 will present a preliminary evaluation of the 2007 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 (see, e.g. EEA 2009).
This section will briefly describe the current (2007) air quality status; the long-term (1997-2007) and short-term (2003-2007) changes in concentrations are discussed. Focus will be on the pollutants listed in the Air Quality Directive (EC, 2008), that is, sulphur dioxide, nitrogen dioxide, PM_{10} and $PM_{2.5}$, carbon monoxide, benzene and ozone. The concentrations measured in 2007 will be compared with the limit and target values as set in the Directives, see *Table 4*. Lead will only briefly be discussed; a recent analysis (Barrett *et al.* 2008) has shown that with the exception of a few (industrial) hotspots lead concentrations are well below the limit value.
The air quality in 2007 is described here in a number of maps showing annual mean concentrations and the 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 (rural background, (sub)urban background and traffic stations; industrial stations, stations with an unknown station type and background stations with un unknown type of area have not been included) the concentration averaged over all stations, the average concentration calculated only for stations where the limit (or target) value (LV; TV) is exceeded and the maximum observed value is presented. The number of stations in each category is given above the bars. Each graph is scaled in such a way that the concentration axis runs from zero to three times the limit or target value.
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%.
The 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 aggregated data) for a period and a set of 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://dataservice.eea.europa.eu/dataservice/metadetails.asp?id=1079 ; the most convenient is to download the *all country XML-file*.

Table 4 Limit and target values defined by the European Union for SO_2, NO_2, PM_{10}, benzene, CO, O_3, arsenic, cadmium, nickel and benzo(a)pyrene to be met in 2007 unless indicated otherwise.

Parameter (1)	period	Limit and target values (µg/m3)	No of allowed exceedances	Target data
SO_2 (1999/30/EC)				
Human health protection	Hourly average	350 µg/m3	24 hours/yr	
Human health protection	Daily average	125 µg/m3	3 days/yr	
Vegetation protection	Annual average	20 µg/m3		
Vegetation protection	winter average	20 µg/m3		
NO_2 (1999/30/EC)				
Human health protection	Hourly average	200 µg/m3	18 hours/yr	1 Jan 2010
Human health protection	Annual average	40 µg/m3		1 Jan 2010
PM_{10} (1999/30/EC)				
Human health protection	Daily average	50 µg/m3	35 days/yr	
Human health protection	Annual average	40 µg/m3		
$PM_{2.5}$ (2008/50/EC)				
Human health protection	Annual average	25 µg/m3		1 Jan 2015 (b)
Human health protection	Averaged exposure indicator (AEI)	20 µg/m3	based on 3 year average	2015
Human health protection	Exposure reduction target	Percentage reduction(c)	based on 3 year average	2020
Pb (1999/30/EC)				
Human health protection	Annual average	0.5 µg/m3		
CO (2000/69/EC)				
Human health protection	8h running average[a]	10mg/m3		
Benzene (2000/69/EC)				
Human health protection	Annual average	5 µg/m3		1 Jan 2010
Ozone (2002/3/EC)				
Human health protection	8h running average[a]	120 µg/m3	25 days/yr	1 Jan 2010
Vegetation protection	Hourly averaged (growing season)	18 (mg/m3).h		1 Jan 2010
Arsenic (2004/107/EC)				
Human health protection	Annual average	6 ng/m3		1 Jan 2012
Cadmium (2004/107/EC)				
Human health protection	Annual average	5 ng/m3		1 Jan 2012
Nickel (2004/107/EC)				
Human health protection	Annual average	20 ng/m3		1 Jan 2012
Benzo(a)pyrene (2004/107/EC)				
Human health protection	Annual average	1 ng/m3		1 Jan 2012

(1) Reference to the daughter directives under the framework directive have been given; the first three daughter directives have been include din the new Air Quality Directive 2008/50/EC.
(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

2.2. 2007 air quality status

The figures 11 until 16 show the observed concentration maps and distance to target plots for selected components mentioned in the Air Quality directive.

2.2.1. Nitrogen dioxide (NO_2)

The limit value of the annual mean NO2 concentration is 40 µg/m3 and has to be met in 2010. For 2007 the limit value plus margin of tolerance (MOT) is 46 µg/m3. In nearly all countries exceedances of the LV and of the LV+MOT are observed. Most frequently these exceedances are observed on traffic stations, see also the distance-to-target plots. At more than 50% of the traffic stations the 40 µg/m3 limit value is exceeded, for traffic stations with an exceedance the concentration is on the average 35% above the LV. At 5% of the (sub)urban stations an exceedance of the limit values observed, at non-compliance stations the concentrations are 17% too high. The NO_2 annual limit value plus margin of tolerance is in 2007 46 µg/m3; this level has been exceeded at 3% of the (sub)urban background stations and at about 35% of the traffic stations, see Figure 11.
The hourly limit value of NO2 is less stringent with exceedances at less than 1 and 8% of the (sub)urban and traffic stations, respectively.

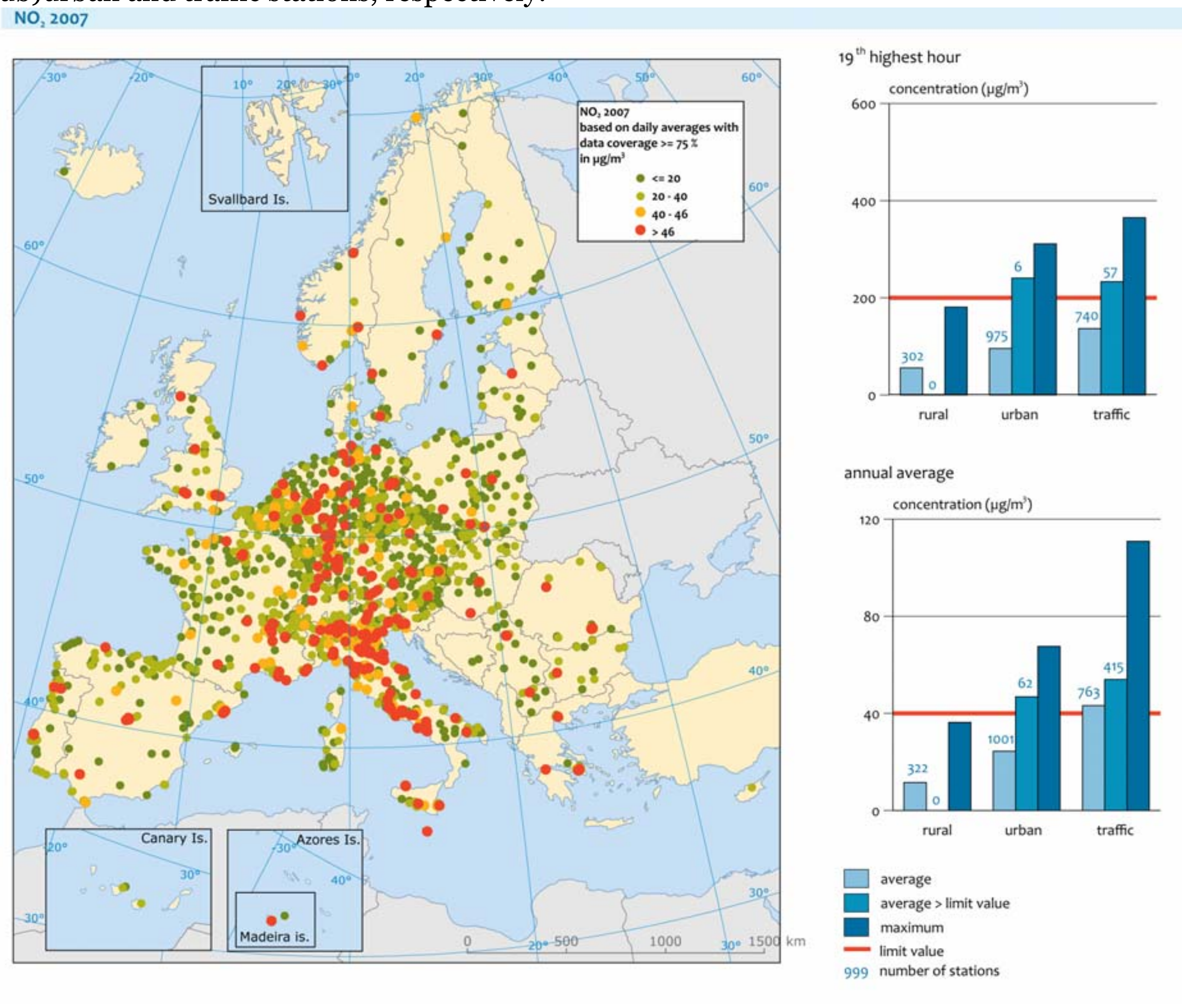


Figure 11. Annual mean concentration map of NO_2 (µg/m3); the two highest concentration classes correspond to the limit value (40 µg/m3) and limit value plus margin of tolerance (46 µg/m3), respectively. Distance-to-target graphs for the short-term and long-term NO_2 limit value.

2.2.2. Sulphur dioxide (SO_2)

The annual mean SO_2 concentrations are given in Figure 12. The limit value set for the protection of vegetation (20 µg/m3 as annual mean) has been exceeded at one out of every 30 stations; most of these stations, however, are classified as urban, traffic or industrial. At two out of 227 rural stations an exceedance is observed. As emissions tends to be higher and dispersion condition are worse during winter periods, the concentrations during the winter 2006/2007 are on the average slightly higher than those during the year 2007. However, the more stringent limit value for the protection of vegetation set for a winter mean (20 µg/m3) is exceeded at only one rural station. The hourly and daily limit values set for the protection of human health have been exceeded at 0.8 and 1.3% of the stations, respectively.

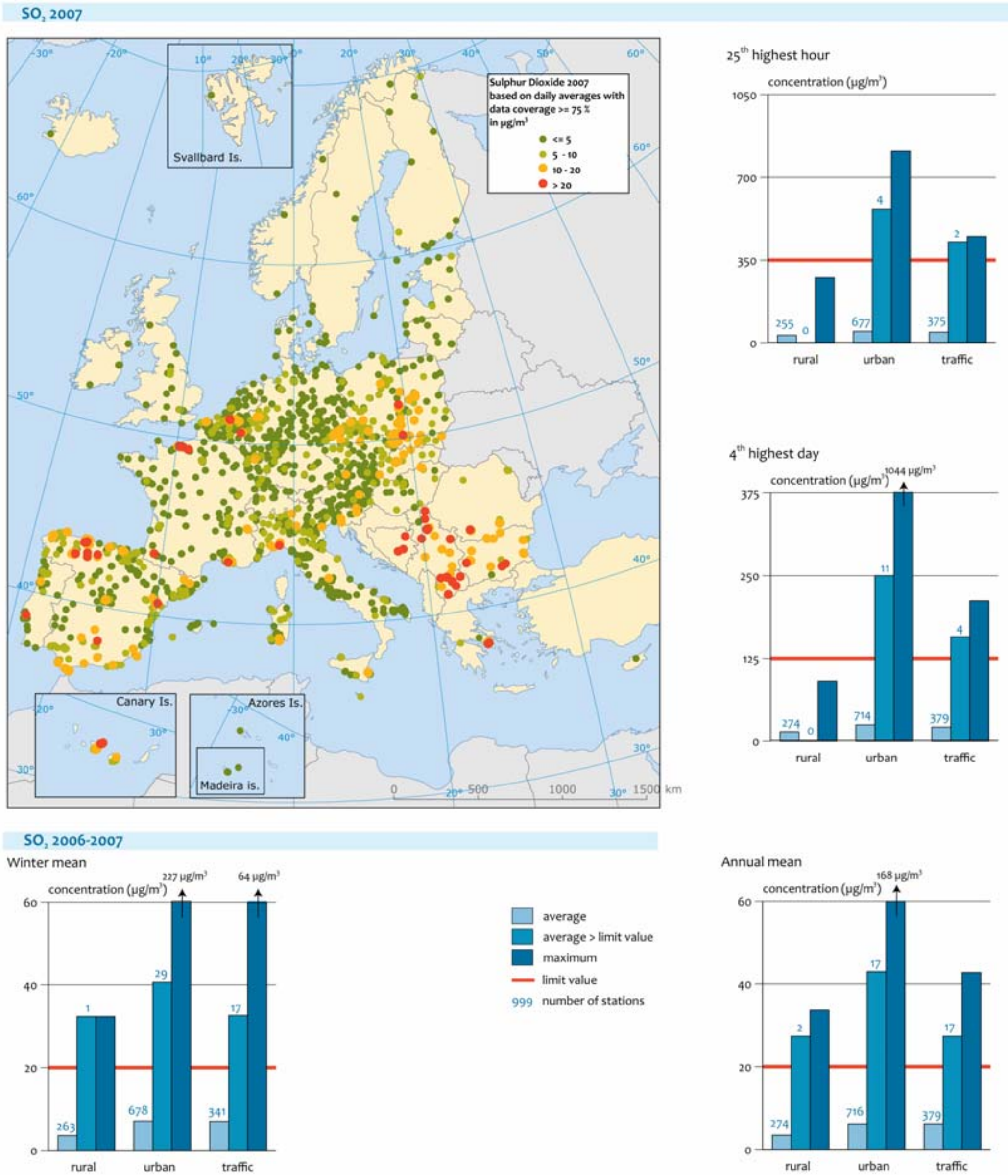


Figure 12: Annual mean concentration map of SO_2 (µg/m3); the highest concentration classes corresponds to the limit value (20 µg/m3) set for the protection of vegetation. Distance-to-target graphs are given for the hourly and daily limit value of SO_2 as well as for the two limit values set for the protection of vegetation (annual mean and winter period mean (October 2006 – March 2007).

2.2.3. Particulate Matter PM_{10}

Figure 13 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 is equivalent with an annual mean of 31 µg/m³ (see e.g.: Buijsman *et al.* 2005; Stedman *et al.* 2007). The map indicates that both limit values have been exceeded in many countries across Europe. The extent of exceedance of the annual and daily limit values of PM10 is given in the distance-to-target graphs. 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 (more than 28% of stations) and at traffic stations (more than 38% of stations).

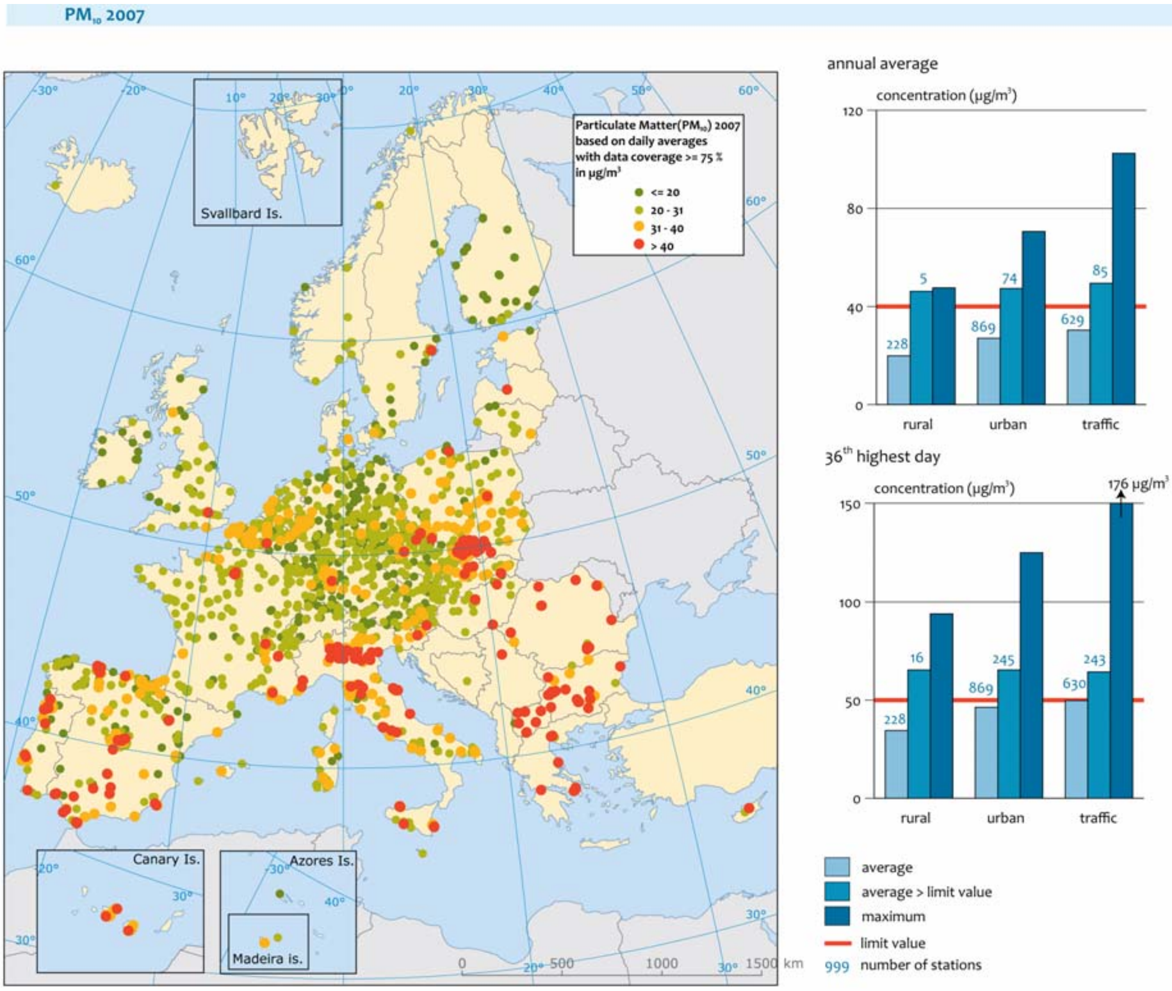


Figure 13: Annual mean concentration map of PM10 (µg/m³); the two highest concentration classes corresponds to the annual limit value (40 µg/m³) and to a statistically derived level (31 µg/m³) equivalent to the short-term limit value.) Distance-to-target graphs are given for the annual and daily limit value of PM10.

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 daily maximum 8-hour mean values may not exceed 10 mg/m3, see Figure 14. This level is not exceeded at the 32 operational rural background stations. Exceedances are observed at less than 1% of the urban background stations and at 2-3% of the traffic and industrial stations. Exceedances are observed in Italy and the Balkan region (Serbia, Bulgaria, FYR of Macedonia, Romania). The annual averages of the daily 8-hour maxima show elevated levels in the same regions, see Figure 14. Note that not the maximum value is plotted but the more robust annual mean value of daily maximum 8-hour mean values.

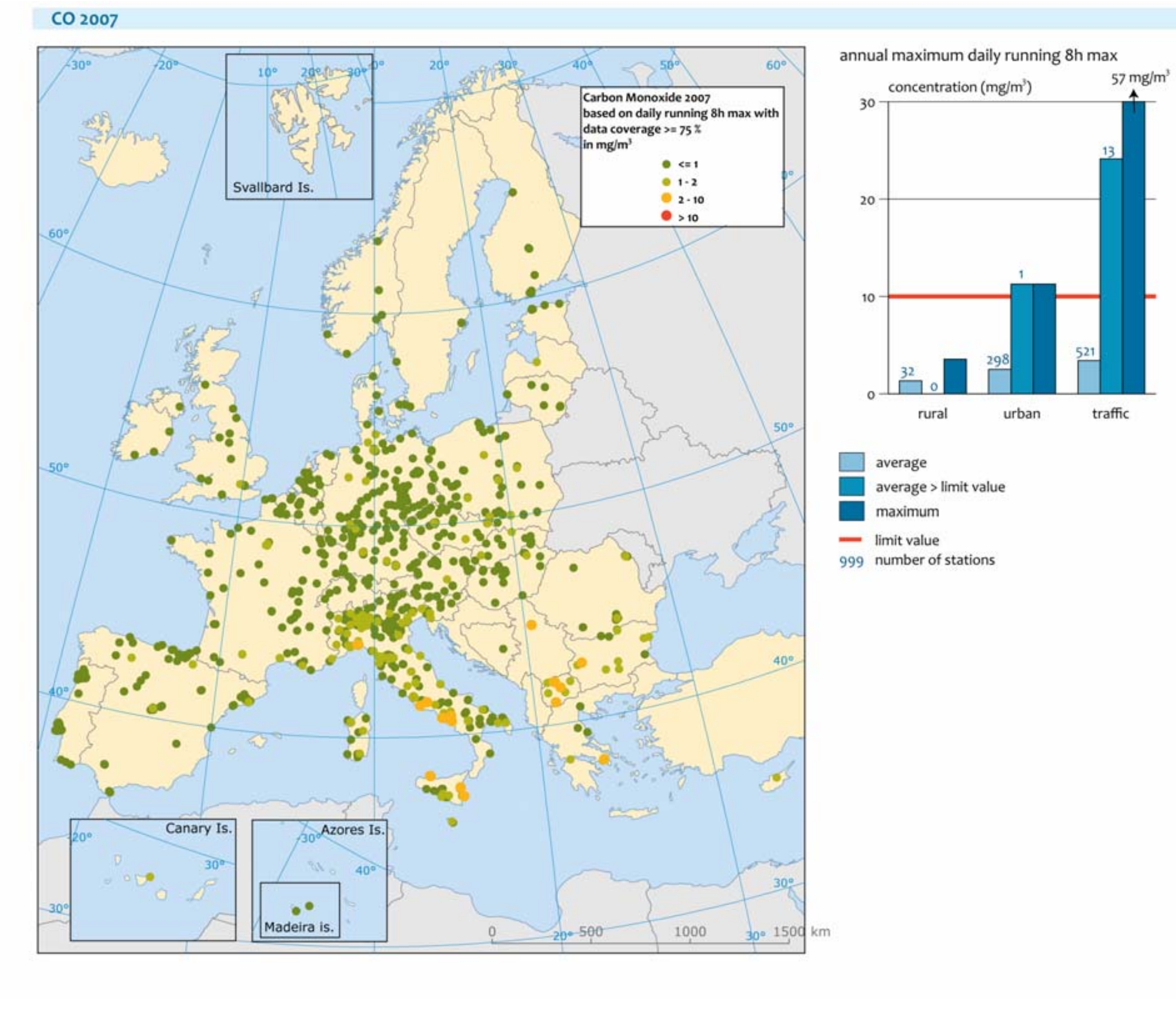


Figure 14: Annual mean concentration of the daily maximum 8-hour mean values of CO (mg/m3). Distance-to-target graph is given for the CO limit value.

2.2.5. Benzene

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 a data coverage criterion of better than 50%.
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 8 µg/m³ in 2007. At rural and (sub)urban background stations no exceedance of the limit value is observed. Exceedance of the limit value is observed at four traffic stations and at two industrial stations. At two of them (one industrial station in Czech Republic and one traffic station in Serbia) exceedances of the limit value plus margin of tolerance have been reported.

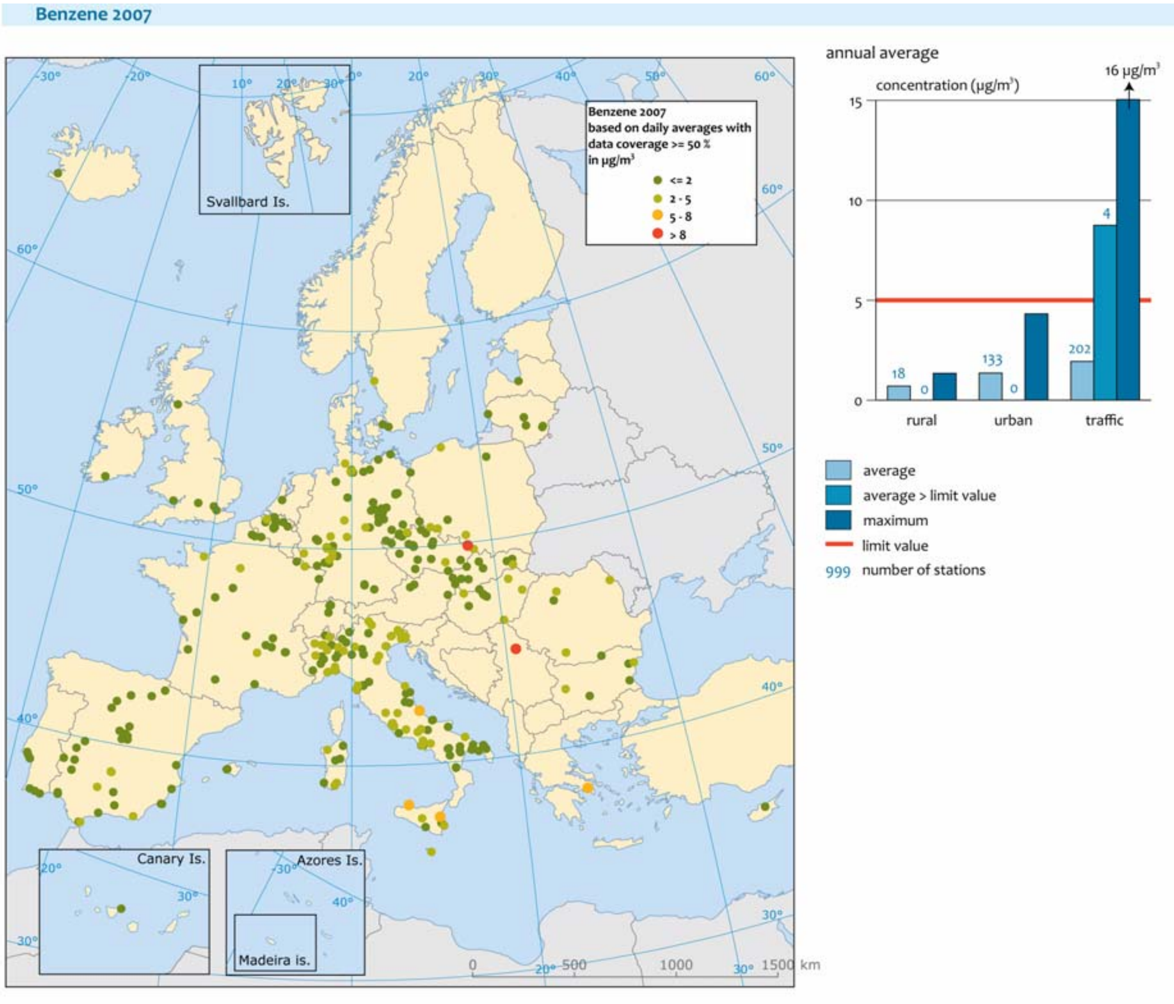


Figure 15: Annual mean value of benzene, 2007. Concentrations of 2, 5, and 8 µg/m³ correspond to the lower assessment threshold, limit value and limit value plus margin of tolerance, respectively. Distance-to-target graph is given for the benzene limit value.

2.2.6. Ozone (O_3)

In the air quality directive the EU has set target values for the protection of human health (the daily maximum of the running 8-hour mean values may not exceed 120 µg/m3 on more than 25 days per year) and for vegetation (18000 (µg/m3).h as AOT40 value).
The health related target is widely exceeded at 45% of the rural background stations. In urban area about 30% 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 one third of the stations an exceedance has been observed. In contrast to the other pollutant the ozone levels are generally the higheswt at rural locations. Reason for this is that at short distances to NOx sources – as is the case for urban and traffic stations – the ozone is chemically quenched by the freshly emitted NOx.

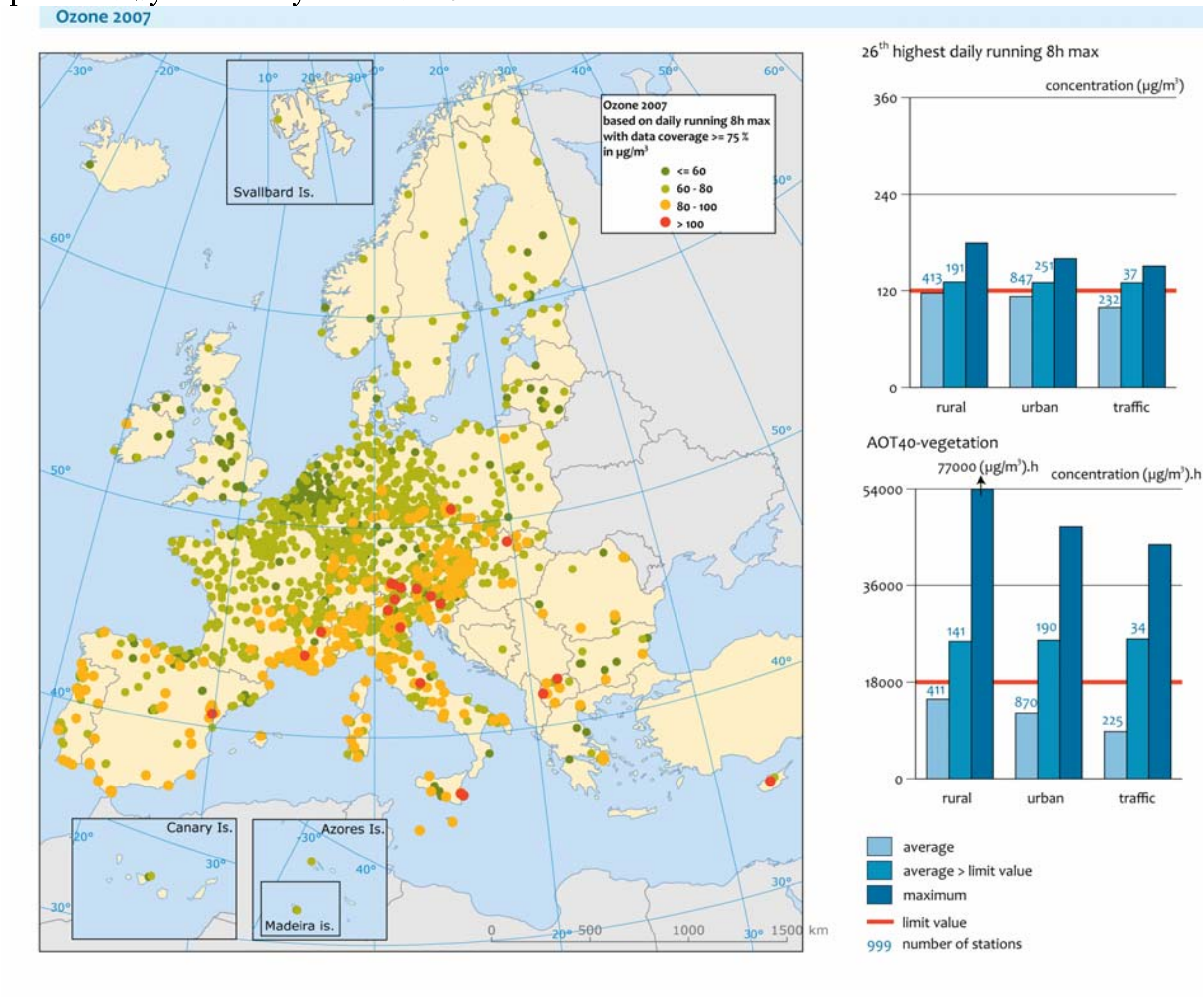


Figure 16: Annual mean value of the daily maximum 8-hour mean values of ozone, 2007. Distance-to-target graph is given for the target values set for the protection of human health and vegetation.

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 2007 monitoring data are in line with this report.
Reporting on the components of the 4th DD is still limited. The first reporting year under the 4th daughter directive is 2008, reports of all Member States are to be expected by October 2009. However, a large number of Member States provided information for 2007 on a voluntary basis which has been reviewed by de Leeuw and Vixseboxse (2008). A brief update on the basis of the AirBase data will be presented here.
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. 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. This might be the reason that these pollutants are reported for a relatively small number of stations. 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 2007:
Lead: concentrations have declined considerably with the introduction of unleaded petrol. Some exceedances of the limit value continue in Bulgaria, Romania and Estonia but this appears to be a local issue only.
Arsenic: at the majority of the station a concentration below the lower assessment threshold has been reported. However, at 11 (from the 274 operational stations) the observed concentration is above the target value set for 2012. Exceedances are mainly seen at industrial sites (8 stations) and urban sites (3 stations).
Cadmium: air concentrations are in excess of the target value at 9% of the stations located in three countries (Belgium, Romania and Bulgaria). At the majority of the stations the concentration are below the lower assessment threshold.
Nickel: a limited exceedance at 5% of the stations located in Italy, Belgium, the German Ruhr area and the United Kingdom. Most of the exceedances are related to industry.
Benzo(a)pyrene: target values are exceeded at around a quarter of the monitoring points, mainly urban background, 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 Lithuania.

Particulate matter, PM2.5
The number of operational $PM_{2.5}$ stations is only slightly higher than in 2006. For 2007 there are 224 stations fulfilling the criteria of more than 75% data coverage. Although the spatial coverage and representativeness of the monitoring stations is presently insufficient to assess variations in concentrations across Europe, the data enables a comparison with the $PM_{2.5}$ target value of 25 $\mu g/m^3$ as set in the new Air Quality Directive (EU 2008). The distance to target graph shows that at 10%, 15% and 10% of the rural (sub)urban background and traffic stations the target value has been exceeded. Exceedance is also observed at 5 of the 9 industrial sites.
In the period 2003-2007, 34 stations (of which 14 station in France, the remaining in 8 other countries) are operational during the full five years[1]. These stations do not show a significant trend during this period although the graph suggests a downward tendency on these stations. The start year 2003 was from an air quality point of view an exceptional year; due to

[1] One monitoring-year (station BE0371A, year 2005) has been excluded from this analysis as strongly deviating data have been reported.

unfavourable meteorological situations air pollution levels were in 2003 much higher than in "normal" years.

Figure 18 shows for each of the reporting countries the averaged concentration for each of the station type and the highest concentration measured at any of the stations within a Member State. In 10 Member States one or more exceedances are observed.

The new directive introduced an additional $PM_{2.5}$ objective targeting the exposure of the population to fine particles. These objectives are set at the national level and are based on the average exposure indicator (AEI). The AEI is the averaged level measured at urban background location throughout the territory of a Member State and it reflects the population exposure. Although the network to measure the AEI is not established fully in all countries, the graph indicates that in at least 7 Member States current concentrations are above 20 µg/m^3, the level legally binding in 2015. The targets set to reduce the population exposure in 2020 depend on the three-year running mean AEI level observed in 2010. Based on the 2007 data alone a reduction target of 20% or 15% is estimated for 12 and 3 Member States, respectively, see de Leeuw and Horalek (2009) for a more detailed discussion.

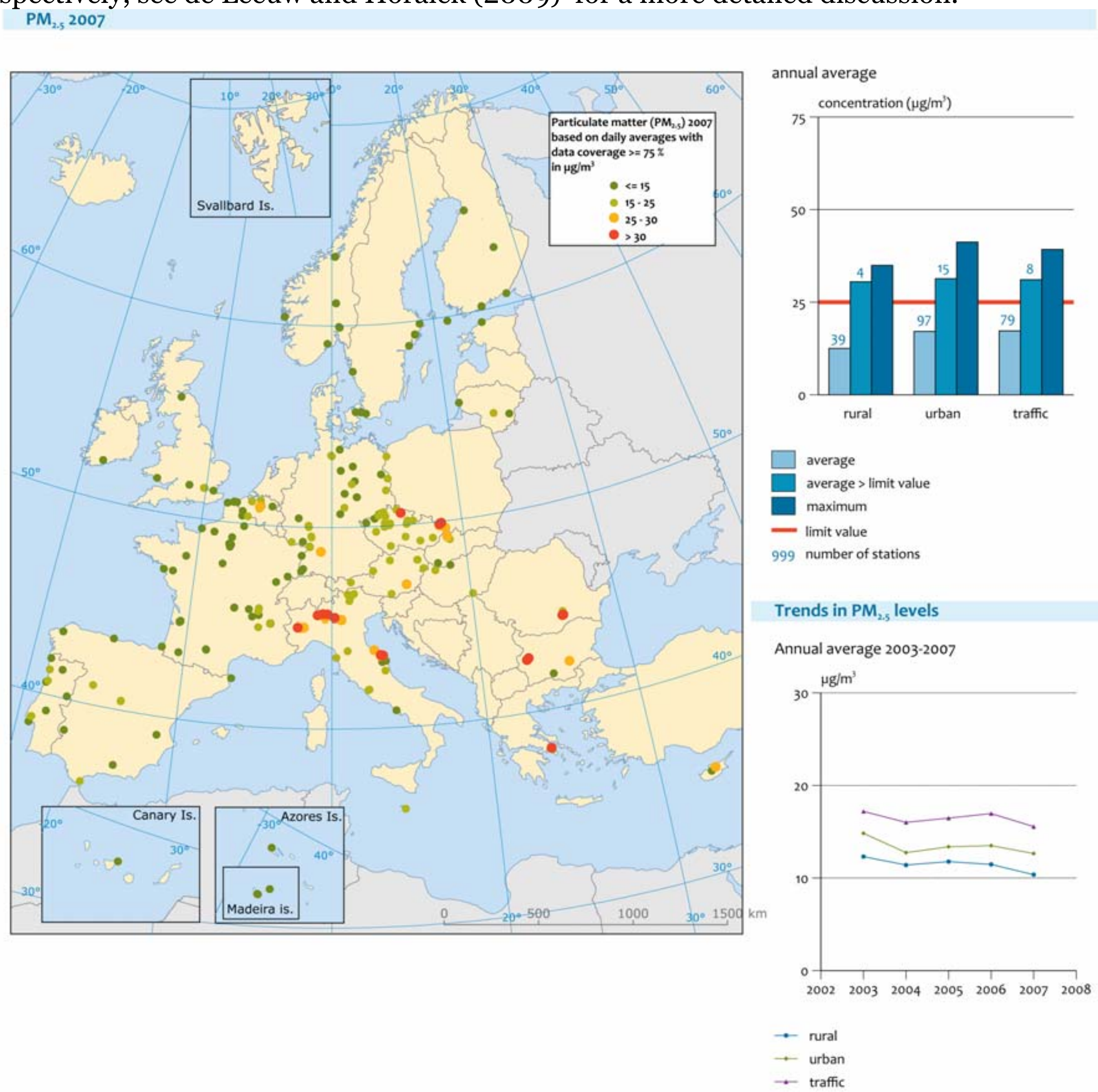


Figure 17. Annual mean concentrations of PM2.5, 2007; distance-to-target graph and the variation of PM2.5 concentrations over the last five years. Only stations operational during the full five-year period have been included.

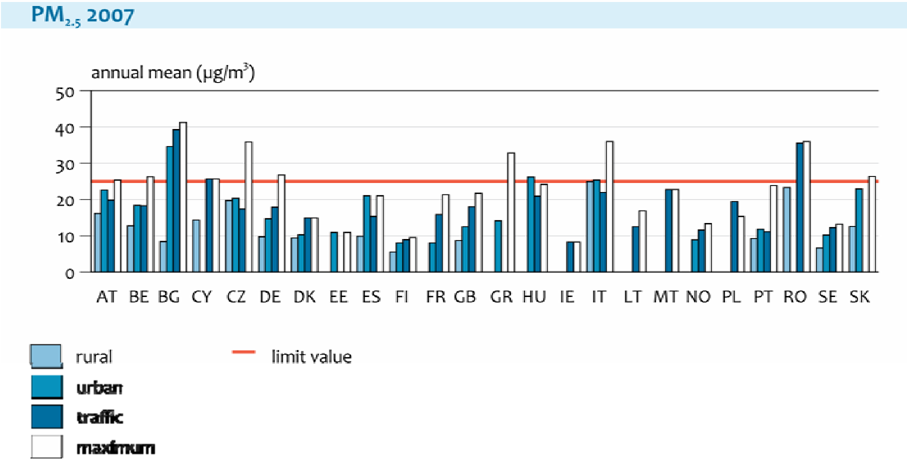


Figure 18. Annual mean PM2.5 concentration, averaged per Member State and per station type and the highest annual mean concentrations measured at any station type in a Member State.

2.3. Trend in air quality

Estimating a European wide trend in air quality is hampered by the fact that number and type of stations may differ widely between the European countries. In general terms, it can be stated that the stations included in the time series starting in 1997 are located largely in the central -western part of Europe (Austria, Belgium, the Czech Republic, Switzerland, Germany, the Netherlands, and the UK) and in Spain. The time series for the shorter period (2003-2007) cover almost all countries delivering data to AirBase. The Balkan region, however, is not well covered.
In the trend analysis only stations having a data coverage of at least 75% per year for at least 9 years in the period 1997-2007 have been included. The short-term analysis considers only stations operational during the whole period 2003-2007 and having a data coverage of 75% for each year.
In the discussion below the data on emissions refers to the period 1997-2006; emission data has been taken from EEA (2008).

Change in concentrations 1997-2007

The indexed changes in concentrations for each of the station types are given in Figure 19. For SO2 a clear picture is seen: at each station type concentrations are down with about 65 index points. In the EEA32 countries emissions have been dropped slightly less: by 44% in the period 1997-2006. A comparison of modelled trends using annual specific meteorological and emission data with observations (Denby et al., 2008) also indicates a stronger trend in observed than in modelled data. Meteorological variation, spatially biased location of the monitoring stations and a (chemical) interaction with other pollutants may explain this difference.

The total anthropogenic and traffic emissions of CO are reduced with 35% and 55% , respectively. On the rural stations a very small (10%) reduction in concentration is seen. This small reduction may partly be explained by the fact that the hemispheric contribution to the rural CO background concentrations is comparable to the contribution from European emissions: on an averaged rural background of 0.36 mg/m3 the hemispheric contribution is estimated as about 0.15 mg/m3 (Derwent *et al.,* 2006; Meszaros *et al*., 2005;Pochanart et al., 2003). Additionally, measuring artefacts may play a role here. The CO monitors as installed in air quality monitoring networks have a typical detection limit of 0.05 mg/m3 (Umweltbundesamt, 2008; Hans Berkhout, RIVM, personal communication, 2009); the current levels are approaching this detection limit. At urban and traffic stations a reduction of 50-60% in the concentrations is found.

At all station types the concentrations of oxidant (Ox = sum of ozone and NO_2) are virtually constant in period 1997-2007; the ozone concentrations are constant at the rural level and show increasing levels at urban and traffic stations. The increases in ozone at urban and traffic stations could be explained by chemical interaction between ozone the freshly emitted NOx. Emissions of NOx are largely in the form of NO which in a very fast chemical reaction consumes ozone under formation of NO_2. So, close to NOx source a dip in ozone and an increase in NO_2 concentration are expected. When NOx emissions are reduced this will result in less NO-titration (higher ozone) at the local scale. Away from local sources in the rural background the NO-titration is less important.
Although NOx and VOC precursors emissions have been declined the ozone concentrations are not declining. Other processes like increasing hemispheric ozone

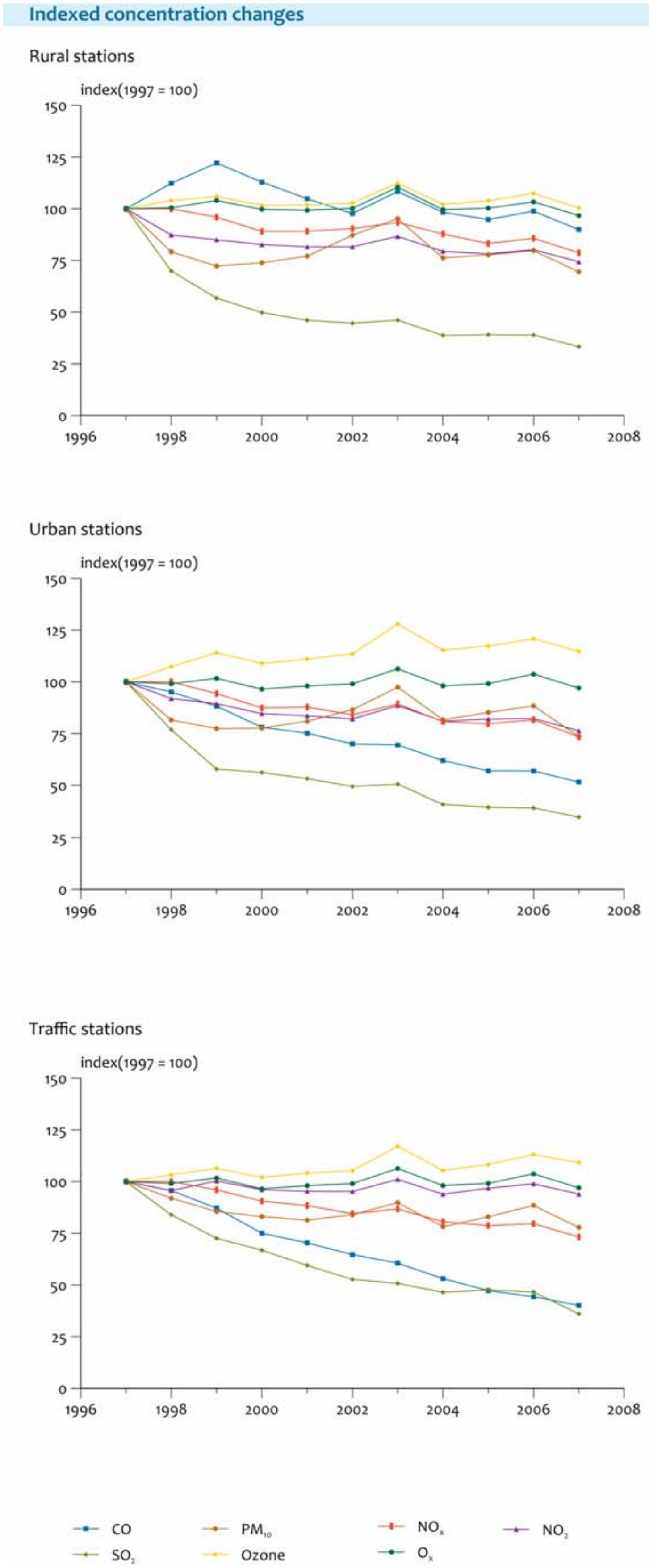


Figure 19. Indexed changes in annual mean concentrations (in case of CO the annual mean of daily maximum 8-hour mean values) per stations type, 1997-2007.

background concentrations (Derwent *et al.,* 2007), changes in weather patterns (Andersson *et al.,* 2007) or changes in biogenic isoprene emissions or emissions from forest fires and biomass burning may play a role.

In the EEA32 countries the NOx emission have decreased with 18% in the period 1997-2006; traffic related emissions showed an even larger decrease: -28%. In line with this, the decrease in ambient NOx concentrations[1] is about 22% at rural stations and 27% at urban/traffic stations. At traffic stations the reduction in NO_2 concentration is small (minus 6%) notwithstanding the NOx reductions. This can be explained by two processes which do not play such an important role at urban and rural level (reductions in NO_2 and NOx are very similar here). Firstly, at a constant oxidant level the NO_2/NOx ratio increases with lowering NOx concentration due to the NO-titration. Secondly there are clear indications that the fraction of directly emitted (primary) NO2 in the total NOx emission from road transport is increasing. Oxidation catalyst and particle filters on diesel cars are mainly causing this increase (Carslaw and Beevers, 2004; Carslaw, 2005; Hueglin *et al*., 2006; Carslaw *et al*., 2007; Alvarez *et al*., 2008).
The monitoring data in AirBase confirm this increase. The difference in daily oxidant concentrations measured at a traffic station and a close-by located (sub)urban background station is evaluated against the difference in NOx concentrations (NOx = sum of NO and NO_2). Selecting only winter periods, it can be assumed that the difference in oxidant levels between the two stations is caused by the direct emissions of NO2 and not by photochemical formations. The number of suitable traffic/(sub)urban background stations pairs is limited, partly because ozone is frequently not measured at a traffic site, partly because of the incomplete reporting of NO (or NOx) concentrations. Completing historical time series on NO and other pollutants will be a major task of the ETC/ACC and the national data suppliers.
Two station pairs have been identified: the traffic station in Marylebone Road (EoI station code GB0682A) and the urban background station Bloomsbury (GB0566A) at a distance of 2.5 km and the Danish stations Copenhagen/1257 (DK0030A) and Copenhagen/1259 (DK0045A) at a distance of 0.5 km. Results are presented in Figure 20 and Table 5. At the end of the last century, for the London stations the slope which is equivalent to the fraction of directly emitted NO_2, is estimated as 0.085. For the period 1998-2002, Carslaw and Beevers (2004) estimate a direct NO_2 fraction of 9.3%. In traffic models a typical value of 5% direct NO_2 emission was used during the nineties (Eerens et al, 1993; Wesseling and Sauter, 2007).

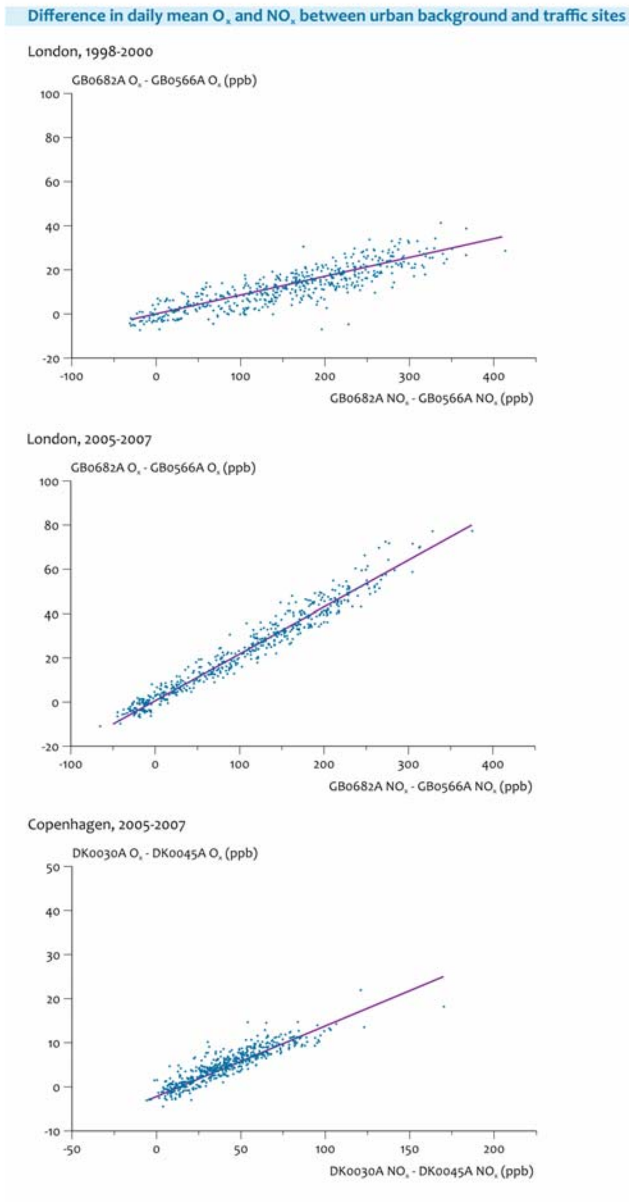


Figure 20 Differences in daily mean oxidant and NOx concentration between a traffic and an urban background station, winter periods; top: London, 1998-2000; middle: London, 2005-2007; bottom Copenhagen, 2005-2007.

[1] For the year 1997 the number of reporting NOx stations is too low to include this year in the trend analysis. For NOx the indexed changes are calculated using 1998 as reference year. This might underestimates the estimated decrease over the period 1997-2007.

Table 5, Relation between daily averaged oxidant and NOx concentrations at traffic/(sub)urban background station pairs; winter periods only.

Traffic station	Urban station	Period	Slope	Standard error	Corr. Coef (R^2)
GB0682A	GB0566A	1998-2000	0.085	0.002	0.73
GB0682A	GB0566A	2005-2007	0.209	0.002	0.96
DK0030A	DK0045A	2005-2007	0.149	0.003	0.82

Seven years later the direct NO_2 emission has increased to 21% in the London case. (Table 5). The data for Copenhagen result in a slightly smaller direct NO_2 fraction (15%) which might indicate the differences in car fleet. Along a Swiss highway a direct NO2 fraction of 23% is observed (Heuglin *et al.*, 2006). As modern Euro 3 and Euro 4 diesel cars have a direct NO_2 emission of 40-70% where the upper end is estimated for Euro 4 diesel cars equipped with original equipment manufacturer particle filter (Alvarez *et al.*, 2008), a further increase is to be expected. Risks to exceed the EU limit values for NO2 at hot-spot locations will be increasing (Carslaw et al., 2007, Jablonska, 2008, Velders and Diederen, 2009).

Recent trends 2003-2007

A quick look at the recent trends (2003-2007, Figure 21) suggest downwards tendencies. However, a closer look shows that the decrease is mainly realized in the first year; due to the meteorological circumstances concentrations of most pollutants reached high levels in 2003. During the last four years most of the pollutants do not show any systematic changes. Exceptions are formed by CO, benzene and SO_2 which continue to decline at urban and traffic stations.

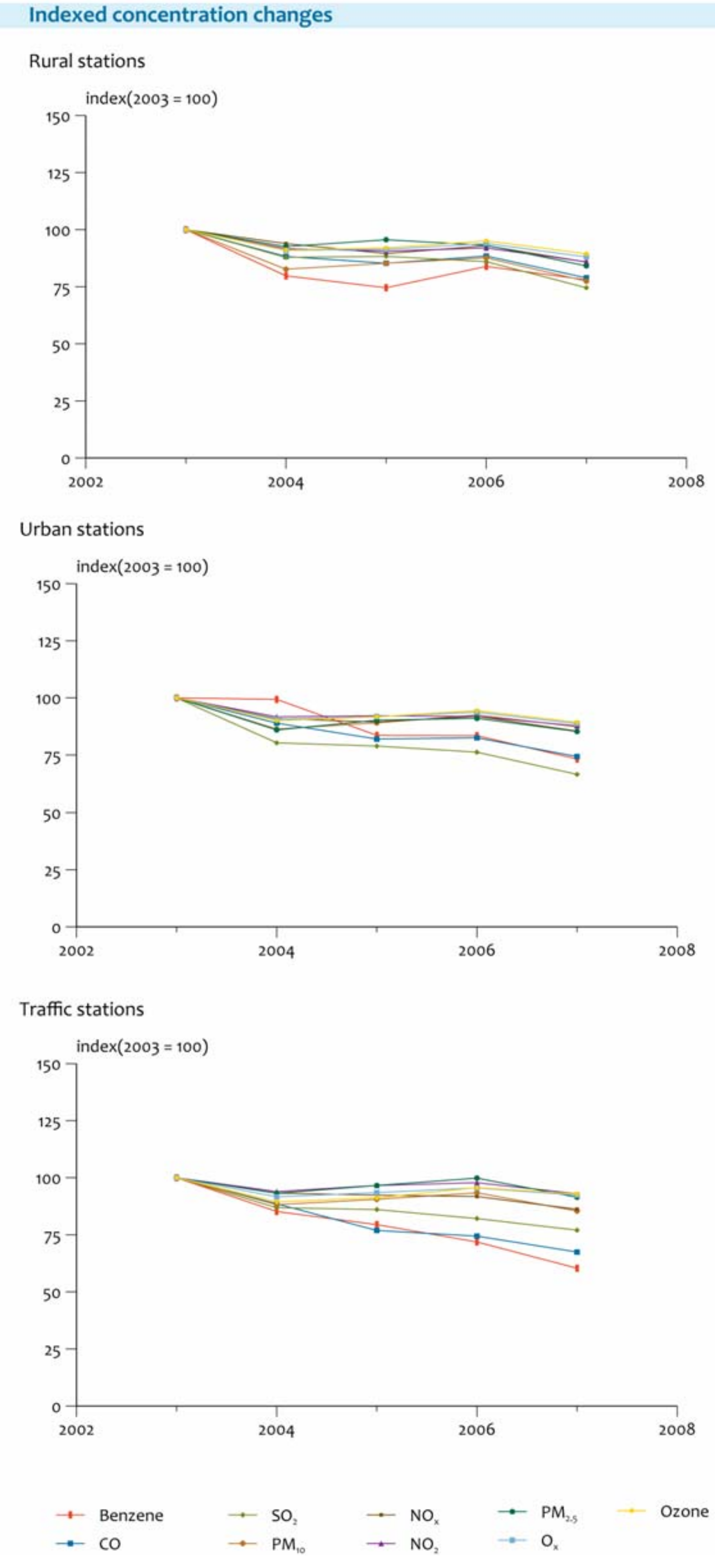


Figure 21. Indexed changes in annual mean concentrations (in case of CO the annual mean of daily maximum 8-hour mean values) per stations type, 2003-2007.

2.4. Urban air quality

Urban air quality is of major concern. The high density of population and of economic activities in urban areas result in increased emissions, ambient concentrations and exposure. Here we present an urban air quality indicator which is one of the ten environment-related indicators that highlight trends relevant to the Sixth Environment Action Programme's priority areas[1]. The urban air quality indicator is also one of the Structural Indicators developed by Eurostat[2]. The indicator focuses on the exposure to particulate matter and ozone, the components most relevant for health impacts

Health effects of fine particulates are caused by their inhalation and penetration into the lungs, where chemical and physical interactions with tissues can induce irritation or damage. Since finer particles are more able to penetrate, the size of the particles is of significance. Current and growing scientific understanding is that the mortality effects of PM are mainly associated with the $PM_{2.5}$ fraction, i.e. particles with diameters of 2.5 μm and below. In the new Air Quality Directive (EU 2008) standards for $PM_{2.5}$ (a.o. a population exposure indicator, AEI) have been set. However, at this moment, the availability of $PM_{2.5}$ data is insufficient to be included in the Structural Indicator. The WHO (2006) recommends an air quality guideline for PM_{10} of 20 $\mu g/m^3$ as annual mean (10 $\mu g/m^3$ for $PM_{2.5}$). These are the lowest levels at which total, cardiopulmonary and lung cancer mortality have been shown to increase significantly in response to $PM_{2.5}$.
Particulate matter is both directly emitted into the atmosphere (primary PM) as well as formed in atmospheric-chemical processes (secondary PM). PM precursors are sulphur dioxide (SO_2), nitrogen oxides (NO_x) ammonia (NH_3) and volatile organic compounds that are partly transformed into particles by (photo-) chemical reactions in the atmosphere.

Ozone (O_3) is the most important photochemical oxidant in the troposphere. It is formed by photochemical reactions in the presence of sun light and precursor pollutants such as nitrogen oxides (NO_x) and volatile organic compounds (VOC). There is evidence from controlled human and animal exposure studies of the potential for ozone to cause adverse health effects. In short-term studies of pulmonary function, lung inflammation, lung permeability, respiratory symptoms, increased medication usage, morbidity and mortality, O_3 does appear to have an independent effect (especially in summer). Lung function changes and effects on asthma incidence, consistent with experimental studies, have been found, but independence from effects of classical pollutants has not been fully determined. The WHO recommends an air quality guideline of 100 $\mu g/m^3$ as daily maximum 8-hour mean. This concentration will provide adequate protection of public health though some health effects may occur below this level.
In addition to health effects, ozone causes damage to ecosystems, agricultural crops and materials.

Methodology

The indicator is based upon measurements of particulate matter (PM_{10}) and ozone as reported under the Air Quality Framework Directive 96/62/EC, its daughter directives and on the Council Decision 97/101/EC on the exchange of information and data on ambient air quality within the Member States.
According to the recommendations of World Health Organisation (UN ECE, 2003), the annual mean concentration is the best indicator for PM-related health effects. The structural indicator value for PM_{10} is given by:

[1] http://ec.europa.eu/environment/indicators/index_en.htm
[2] http://epp.eurostat.ec.europa.eu/portal/page/portal/structural_indicators/indicators/environment

$$SI_{PM} = \frac{\sum_i C_i \times Pop_i}{\sum_i Pop_i}$$

where C_i is the annual mean PM_{10} concentration averaged over all (sub)urban background monitoring stations in an agglomeration *i* having a population of Pop_i. The summation is over all agglomerations in a Member State or – in the case of the aggregated EU27 structural indicator - in the whole EU27.

The principle metric for assessing the effects of ozone on human health is, according to WHO's recommendations (UN ECE, 2004), the daily maximum 8-hour mean. Ozone effects should be assessed over a full year. Current evidence is insufficient to derive a level below which ozone has no effect on mortality. However, for practical reason is recommended to consider an exposure parameter which is the sum of excess of daily maximum 8-h means over the cut-off of 70 µg/m3 (35 ppb) calculated for all days in a year. This exposure parameter has been indicated as SOMO35 (sum of means over 35, see Annex B for definition), and is extensively used in the health impact assessments[1], including the Clean Air for Europe (CAFE) Programme leading to the Commission Communication on the Thematic Strategy on Air Pollution.

The ozone structural indicator is given by:

$$SI_{Ozone} = \frac{\sum_i SOMO35_i \times Pop_i}{\sum_i Pop_i}$$

where $SOMO35_i$ the averaged SOMO35 value over all (sub)urban background station in an agglomeration *i* having population of Pop_i. The summation is over all agglomerations in a Member State or in the whole EU27.

Data collection & handling

Information on agglomerations has been extracted from the annual reporting questionnaire under the air quality directives following the the Commission Decision 2004/461/EC (EU 2004). A preliminary report evaluating the questionnaire for the reporting year 2007 has been prepared by de Leeuw and Vixseboxse (2008); analyses of earlier years are given by van den Hout (2006) and Vixseboxse and de Leeuw (2008). The air quality data has been extracted from AirBase.

From AirBase stations fulfilling the following criteria have been selected:

1. stations classified as *urban background* or *suburban background*; the stations classified as "traffic" or "industrial" are influenced by local (traffic) emissions and might not be representative for the concentrations in more residential areas and are therefore excluded from the indicator calculations;
2. stations having a data coverage of at least 75% per calendar year (that is with more than 274 valid daily values per calendar year);
3. (sub)urban background stations used for compliance checking under the FWD (that is, stations for which a positive match is made between questionnaire and AirBase, see above) and assigned to an agglomeration.

The 2007 information has been applied for the whole period 1999-2007. As the definition of the zones and agglomerations by the Member States may differ from year to year, (for example, in 2004, 1095 zones and agglomerations have been defined, in 2007 this numbers

[1] The general methodology has been endorsed in the Summary report prepared by the joint Task Force on the Health Aspects of Air Pollution of the World Health Organization/European Centre for Environment and Health and the Executive Body of the UN Convention on Long Range Transboundary Air Pollution http://www.unece.org/env/documents/2004/eb/wg1/eb.air.wg1.2004.11.e.pdf

was reduced to 904), some uncertainties are introduced here. No attempts have been made to introduce year-specific population numbers.

After selection, for each agglomeration a representative mean concentration is obtained by averaging over all operational stations within the agglomeration. National and European aggregation is done by using the weighting procedure described above.

Results

Figure 22 shows the population weighted mean concentrations of PM_{10} and ozone in urban agglomerations, averaged over the EU27 Member States. Over the years the PM_{10} concentrations show variations between 27-31 µg/m³, that is, more than 50% above the WHO recommended guideline of 20 µg/m³. Concentrations below the WHO-guideline are observed in the Scandinavian countries and Ireland; about 10% of the population in agglomerations is exposed to averaged levels below the WHO guideline. Urban concentrations close to or above the current EU-limit value (40 µg/m³) are observed in agglomerations in Bulgaria, the Czech Republic, Greece, Hungary, Italy, Poland, Romania and Slovenia. 10% of the population lives in agglomeration with an averaged concentration above the LV. Although the emissions of primary PM and of the precursors are declining, the indicator does not show any upward or downward tendency.
The ozone SOMO35 values vary between 3000 and 6000 (µg/m³).day. The strong increase in ozone levels in 2003 has to be accounted to the weather condition: 2003 was a year favouring ozone production in the most parts of Europe. Ozone precursor emissions are steadily decreasing over the years. This is, however, not reflected in the ozone level: The ozone indicator does not show a clear increasing or decreasing tendency.

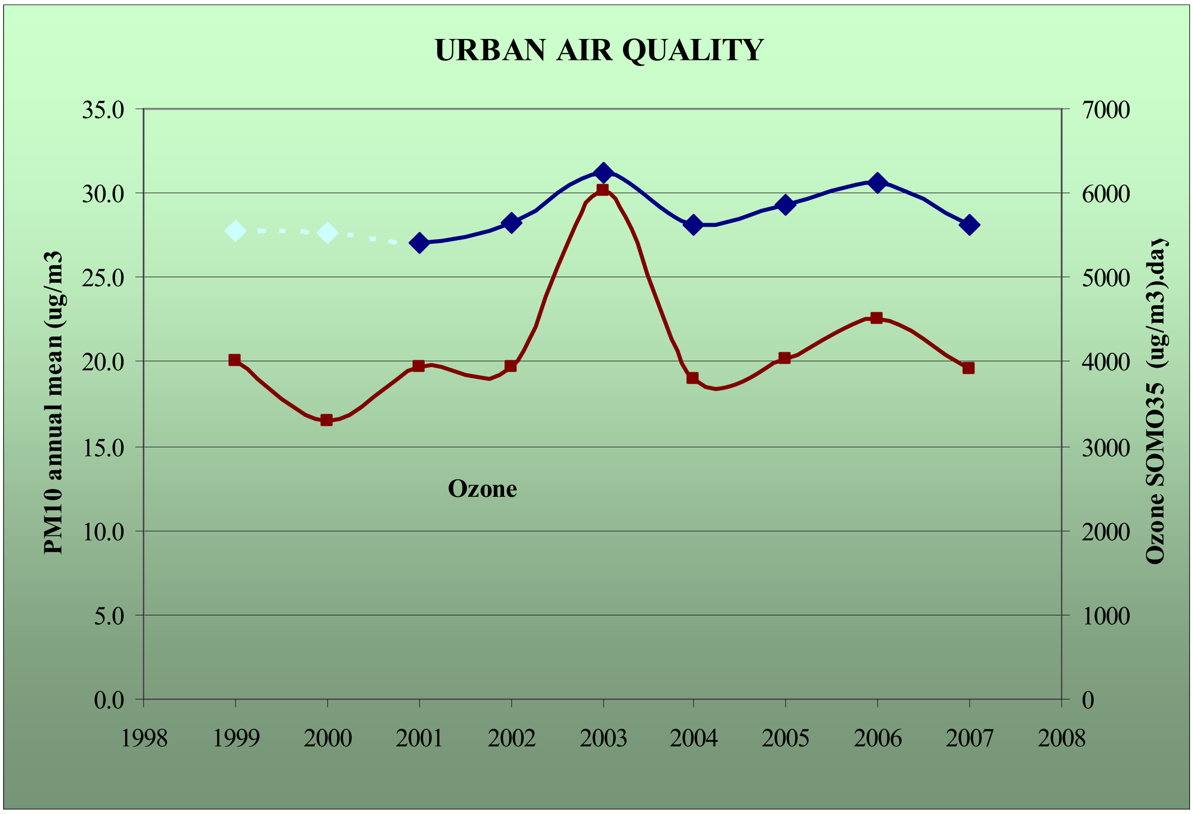


Figure22. Population weighted concentrations of PM10 and ozone in urban agglomerations in EU27.

Uncertainties

This indicator covers the population in urban agglomerations as defined under the Framework Directive (de Leeuw and Vixseboxse 2008). Air quality data fulfilling all the stringent criteria set here is not available in each of the agglomerations. The fraction of the total population living in agglomerations (177 million) for which ozone data is available at urban background locations is steadily increasing from 68% in 1999 to 91% in 2006. In 2007 it decreases to 77% mainly caused by a very low number of Spanish stations reporting ozone. PM_{10} data is available for a population fraction increasing from 54 % (2001) to 80% (2007). In the year 1999 and 2000 for a population fraction of 27% and 34%, respectively PM_{10} data is available. The indicator values for these years should not be seen as representative.

The rural population and the population living in smaller town and villages is not included. As PM_{10} tends to be higher and ozone tends to be lower in urban areas, the urban PM_{10} level will be an overestimation and the urban ozone level will be an underestimation for the exposure of the total population.

The uncertainty in the individual air quality measurements is assumed to be within the quality objectives set in the Daughter directives (for PM_{10}: 25%, for ozone: 15%). However, different methods are in use from the routine monitoring of PM_{10}. Some of these methods are very sensitive for measuring artefacts. The first daughter directive states that when a non-reference method is applied, equivalence with the reference method has to be ensured, if necessary, by applying a correction factor. However, it can not be excluded that incidentally the data obtained by a non-reference method has not been or is not properly corrected prior to submission to AirBase. This may lead to a systematic underestimation for the stations concerned. Overview of PM measuring methods and correction factors are available from the ETC/ACC web site (Buijsman and de Leeuw, 2004; de Leeuw, 2005).

For interpretation of the AQ data it is essential to have information on the direct surroundings of the station as local sources may influence the concentrations. Though guidance is provided on how to classify the stations, difference in the interpretation of the guidance within the countries can not be ruled out. This might introduce differences between countries.

3. CONCLUSIONS

A total of 33 countries, including 26[1] of the 27 EU Member States, have provided air quality data for 2007. Measurement data from 3969 stations have been delivered in the EoI2008. Almost all number of stations for which data have been reported in 2007 has been decreased in comparison with 2006. Also the spatial station coverage of $PM_{2.5}$ has been decreased. $PM_{2.5}$ measurement data have been reported from only 307 stations, 13 stations less than in the EoI2007. The number of countries delivering $PM_{2.5}$ has been increased: 26.
In spite of the request in the EoI2008 letter to send at least two of the three NO components (NO_2, NO, NO_x), there is also still a difference of 723 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 is still rather big.
Only the number of stations for the 4DD components has been increased: for heavy metals except lead 23 stations and for PAH 100 stations more than in the EoI2007. 19 countries have reported heavy metals except lead and 13 countries have reported PAH.
Nearly all countries have delivered the data in time before 1st of October 2007. 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 SO_2 shows a 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. At traffic stations NO_2 concentrations are nearly constant notwithstanding the NO_x concentration reductions. This is partly caused by the NO-titration process, but there are also clear indications that the fraction of directly emitted (primary) NO_2 in the total NO_x emission from road transport is increasing. This report gives some examples using AirBase data to demonstrate this. Compliance with the NO_2 limit value and limit value + margin of tolerance for annual mean values is 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.
CO concentrations are reducing in the last 10 years, but the reduction on rural stations is very small. This small reduction may partly be explained by hemispheric background contributions. The ambient levels of CO are below the limit value; some incidental exceedances are observed but in these cases measuring artifacts can not be excluded.
Benzene concentrations are declining in the last five years, also on urban and traffic stations. The concentrations are in compliance with the limit values except for a limited number of traffic hotspot situations.
In the last 10 years, the ozone concentrations are constant on the rural level and show increasing levels at urban and traffic stations. One of the reasons could be NO-titration, but increasing hemispheric ozone background concentrations, changes in weather patterns, changes in biogenic isoprene emissions or emissions from forest fires and biomass burning may play also a role. Both the health and the ecosystem related target values are exceeded frequently and widely over Europe.
The lead concentrations have declined considerably with the introduction of unleaded petrol. Several Member States have reported heavy metals (arsenic, cadmium, nickel) and benzo(a)pyrene regulated under the fourth Daughter Directive. The air pollution by these

[1] The delivery of Luxembourg has been received too late (30 March 2009) to be included in this Technical paper.

heavy metals is generally low. For arsenic and cadmium the concentrations are below the lower assessment threshold at the majority of the stations. Nickel has a limited exceedance at 5% of the stations and for benzo(a)pyrene the target values are exceeded at around a quarter of the monitoring points.
The target value for $PM_{2.5}$ has been exceeded for 10-15% of the stations. In 10 Member States one or more exceedances are observed. Urban air quality indicators have been defined for PM_{10} and ozone. These indicators reflect population weighted concentrations. The trend for both indicators does not show a clear increasing or decreasing tendency.

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
EMEP	Co-operative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe
EoI	Exchange of Information
ETC/ACC	European Topical 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
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
MS	Member State(s)
NRT	Near Real Time
NUTS	Nomenclature des Unités Territoriales Statistiques
SABE	Seamless Administrative Boundaries of Europe
SOMO35	Sum of Ozone Means Over 35 ppb
TV	Target value

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Annex A Exchange of Information requirements

The Member States of the European Union 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 Exchange of Information (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 Exchange of Information (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 Exchange of Information (EU, 2001a).

Table A.3 Overview of mandatory pollutants to be delivered under the Exchange of Information (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 Exchange of Information (EoI) if available

EoI nr.	Formula	Name of pollutant	Units of measurement	Average over
16	C2H$_6$	Ethane	µg/m^3	24 h
17	$H_2C=CH_2$	Ethene (Ethylene)	µg/m^3	24 h
18	HC=CH	Ethyne (Acetylene)	µg/m^3	24 h
19	$H_3C-CH_2-CH_3$	Propane	µg/m^3	24 h
20	$CH_2=CH-CH_3$	Propene	µg/m^3	24 h
21	$H_3C-CH_2-CH_2-CH_3$	n-Butane	µg/m^3	24 h
22	$H_3C-CH(CH_3)_2$	i-Butane	µg/m^3	24 h
23	$H_2C=CH-CH_2-CH_3$	1-Butene	µg/m^3	24 h
24	$H_3C-CH=CH-CH_3$	trans-2-Butene	µg/m^3	24 h
25	$H_3C-CH=CH-CH_3$	cis-2-Butene	µg/m^3	24 h
26	$CH_2=CH-CH=CH_2$	1.3 Butadiene	µg/m^3	24 h
27	$H_3C-(CH_2)_3-CH_3$	n-Pentane	µg/m^3	24 h
28	$H_3C-CH_2-CH(CH_3)_2$	i-Pentane	µg/m^3	24 h
29	$H_2C=CH-CH_2-CH_2-CH_3$	1-Pentene	µg/m^3	24 h
30	$H_3C-HC=CH-CH_2-CH_3$	2-Pentenes	µg/m^3	24 h
31	$CH_2=CH-C(CH_3)=CH_2$	Isoprene	µg/m^3	24 h
32	$C_{36}H_{14}$	n-Hexane	µg/m^3	24 h
33	$(CH_3)_2-CH-CH_2-CH_2-CH_3$	i-Hexane	µg/m^3	24 h
34	C_7H_{16}	n-Heptane	µg/m^3	24 h
35	C_8H_{18}	n-Octane	µg/m^3	24 h
36	$(CH_3)_3-C-CH_2-CH-(CH_3)_2$	i-Octane	µg/m^3	24 h
37	$C_6H_5-CH_3$	Toluene	µg/m^3	24 h
38	$C_6H_5-C_2H_5$	Ethyl benzene	µg/m^3	24 h
39	m,p-$C_6H_4(CH_3)_2$	m,p-Xylene	µg/m^3	24 h
40	o-$C_6H_4-(CH_3)_2$	o-Xylene	µg/m^3	24 h
41	$C_6H_3-(CH_3)_3$	1,2,4-Trimethylbenzene	µg/m^3	24 h
42	$C_6H_3(CH_3)_3$	1,2,3-Trimethylbenzene	µg/m^3	24 h
43	$C_6H_3(CH_3)_3$	1,3,5-Trimethylbenzene	µg/m^3	24 h
44	HCHO	Formaldehyde	µg/m^3	1 h
45	THC (NM)	Total non-methane hydrocarbons	µg C/m^3	24 h
46	SA	Strong acidity	µg SO_2/m^3	24 h
47	PM1	Particulate matter < 1 µm	µg/m^3	24 h
48	CH_4	Methane	µg/m^3	24 h
49	Cr	Chromium	ng/m3	24 h
50	Mn	Manganese	ng/m3	24 h
51	H_2S	Hydrogen sulphide	µg/m^3	24 h
52	CS_2	Carbon disulphide	µg/m^3	1 h
53	$C_6H_5-CH=CH_2$	Styrene	µg/m^3	24 h
54	$CH_2=CH-CN$	Acrylonitrile	µg/m^3	24 h
55	$CHCl=CCl_2$	Trichloroethylene	µg/m^3	24 h
56	C_2Cl_4	Tetrachloroethylene	µg/m^3	24 h
57	CH_2Cl_2	Dichloromethane	µg/m^3	24 h
58	BaP	Benzo(a)pyrene	µg/m^3	24 h
59	VC	Vinyl chloride	µg/m^3	24 h
60	PAN	Peroxyacetyl nitrate	µg/m^3	1 h
61	NH_3	Ammonia	µg/m^3	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

Aggregation of data

The air quality statistics in AirBase are based on *hourly values*, *daily (24-hour) average values*, *daily 8-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 have been overwritten by the calculated daily values.

For the aggregation of hourly data to longer averaging periods (8 hourly, daily) at least a 75% availability of raw measurement data (i.e. 75% data coverage) is required to calculate a valid aggregated value.
That is, starting with hourly concentrations:

- 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
- a *maximum daily 8-hour mean* is calculated when at least 18 valid running 8-hour averages per day are available

Statistics calculation on annual basis

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

- *General* concentration statistic: annual mean, 50, 95, 98, 99.9 percentiles, maximum and y^{th} highest value
- *Exceedances*: hours/days with concentration > y µg/m^3 (with y = limit or threshold 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 coverage). The data coverage percentage is given.

Component	Parameter based on		
	1 hour values	daily values	Daily 8h maxima
Sulphur dioxide (SO_2)	• annual mean • 50 percentile • 95 percentile • 98 percentile • 99.9 percentile • maximum • hours with c > 350 $\mu g/m^3$ • 25th highest value	• annual mean • 50 percentile • 95 percentile • 98 percentile • maximum • days with c > 125 $\mu g/m^3$ • 4th highest value	
Nitrogen dioxide (NO_2)	• annual mean • 50 percentile • 95 percentile • 98 percentile • maximum • hours c > 200 $\mu g/m^3$ • 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 $\mu g/m^3$, • 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 $\mu g/m^3$, • 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

Calculation of specific aggregations and statistics

- **Hourly running 8-hour averaged values**
  The running 8-hour 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.

- **Daily 8-hour maximum**
  The daily 8-hour maximum is the maximum of the daily 8-hours means taken from the hourly running 8-hour averages.

- **Percentiles**
  The y^{th} percentile should be selected from the measurement values. 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 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).

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

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

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

  Example: the limit value for the protection of human health for PM_{10} is that the daily average of 50 µg/m^3 will not be exceeded on more than 35 days per year. If the 36^{th} highest value is more than 50 µg/m^3, the limit value for PM_{10} has been exceeded.

- **Number of hours/days with concentration > *y* µg/m^3**
  The n number of hours/days with concentration > y µg/m^3 (with y = limit or threshold value) can be calculated from the 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 which $X_k > y$ µg/m^3. If $n > 35$ in the example on PM_{10} at the previous bullet, the limit value for PM_{10} has been exceeded.

- **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/m^3 (= 40 parts per billion) and 80 µg/m^3:

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

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

AOT40 has a dimension of (µg/m^3)·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/m^3 (= 35 parts per billion) and 70 µg/m^3:

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

where C_i is the maximum daily 8-hour ozone concentration in µg/m^3 and the summation is over all days per calendar year.

SOMO35 has a dimension of (µg/m^3)·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.

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 “QA/QC checks on air quality data in AIRBASE and on the EoI2004 data – Procedures and results” (see Mol *et al.* 2005b).

Table B1. QA/QC actions on EoI2008 data in 2008 and 2009

Date	**Processes by data supplier**	**Processes by ETC/ACC**
1 June 2008		Release of the DEMv11
	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 2008 to 15 Jan 2009		Upload DEM into AIRBASE Checks on outliers, missing essential meta data, resubmission old data, deletion stations/measurement configurations with data. Send feedback reports to the data suppliers
	Replies on the feedback reports add response rate(s)	
		Processing of the (non) replies
15 Jan 2009		Calculation of statistics and exceedances
End Jan 2009		Checks by EEA
26 February 2009		Delivery AIRBASE to EEA (see airbase history page)
March 2009		Release of AIRBASE on EEA Data Service

33 countries have delivered EoI2006 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 DE, EE, FR, GR, MT and NL have been placed on Circa: http://eea.eionet.europa.eu/Members/irc/eionet-circle/airclimate/library?l=/qaqc_country_feedback/eoi_2008_2007_data&vm=detailed&sb=Title

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	Country feedback	outliers (extreme/ suspicious)	missing data	missing essential meta inform.	resub mitted data	deletion stations/ meas.conf. with data	reply received
AL	Albania						
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						
ME	Montenegro						
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 outliers
- one or more real outliers
- no outlier

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

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

Resubmitted data
- detect. in feedb-report, no reply yet
- restore resubmission
- confirm

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

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

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

Component group Volatile Organic Compounds (VOC)

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 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