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Overview of exceedances of EC ozone threshold values during April–September 2004

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European Environment Agency

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European Environment Agency
Kongens Nytorv 6
1050 Copenhagen K
Denmark

Tel.: +45 33 36 71 00
Fax: +45 33 36 71 99

Web: www.eea.eu.int
Enquiries: www.eea.eu.int/enquiries

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Libor Černikovský of CHMI, Ostrava coordinated the overall development of the report and was one of its main authors. Other main authors were Frank de Leeuw of RIVM and Pavel Kurfuerst of CHMI, Prague.

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Executive summary

In summer 2004, the levels of ground-level ozone were high in southern Europe with widespread exceedances of the information threshold value (180 µg/m^3), as laid down in the ozone directive (2002/3/EC). The exceedances of the information threshold were similar to earlier years, except for summer 2003, when there was a record number of exceedances. Also the directive's long-term objective to protect human health, 120 µg/m^3 of ozone concentration over 8 hours, was extensively exceeded in the EU and other European countries. The target value to protect human health was also exceeded in southern and part of central Europe. The highest levels were reported from Italy and Spain, with a maximum ozone level of 417 µg/m^3.

Observed ozone trends are in general not statistically significant over the period 1996–2002. More in-depth analysis, e.g. by correcting for meteorological variability is needed, but the data suggest that the decreasing trend in peak values that was observed earlier has levelled off during recent years. Median concentrations show an increasing trend for all station types, although the increase is more pronounced for street and urban stations.

Ground-level ozone is one of the air pollutants of most concern in Europe. Ozone pollution is produced by photochemical processes involving nitrogen oxides and volatile organic compounds in the lower parts of the atmosphere. Ozone levels become particularly high in regions with high emissions and during summer under stagnant meteorological conditions with high insolation and high temperatures. Levels continue to exceed thresholds established in EU legislation to protect human health and to prevent damage to ecosystems, agricultural crops and materials.

This report provides an evaluation of ground-level ozone pollution in Europe during April to September 2004, based on information submitted to the European Commission under Directive 2002/3/EC on ozone in ambient air (European Parliament and Council of the European Union, 2002). Since the submitted data have not yet been finally validated by the Member States, the conclusions drawn in this report should be considered as preliminary.

The ozone directive (2002/3/EC) requires Member States to report exceedances of the information and alert threshold values (see Table 1) to the Commission before the end of the month following an occurrence. Furthermore, by 31 October each year they must provide some additional information, in particular concerning the exceedances of the long-term objective for the protection of human health (daily maximum eight-hour average concentrations of 120 µg/m^3) over the summer period.

Table 1 Ozone threshold values, long-term objective and target value for the protection of human health

Objective	Level (µg/m^3)	Averaging time
Information threshold	180	1 hour
Alert threshold	240	1 hour
Long-term objective	120	8-hour average, daily maximum
Target value	120 (1)	8-hour average, daily maximum

(1) Not to be exceeded on more than 25 days per calendar year averaged over three years.

In order to provide information as soon as possible, summaries of the data as provided monthly by the countries were made available on the website of the European Topic Centre on Air and Climate Change (http://etc-acc.eionet.eu.int/databases/o3excess) when received.

Overview of ozone air pollution in summer 2004

All 25 EU Member States provided information to the European Commission on observed exceedances or indicated by the deadline that no exceedances had been observed. In addition, six other countries provided information upon request of the European Environment Agency.

In summer 2004, exceedances of the long-term objective for the protection of human health for ozone were observed in almost every country, in almost every summer month and at most of the stations. More than 25 occurrences of daily maximum eight-hour average concentrations of ozone higher than 120 µg/m^3 (the target value set in the directive) were observed in Spain, Portugal, France, Germany, Austria, Switzerland, Slovenia and Italy.

However, in summer 2004 there were no long lasting and spatially extensive episodes of high ozone concentrations similar to those that occurred during the extremely warm summer 2003. In fact, summer 2004 was one of the coolest in the past decade. Therefore, the occurrence of exceedances of the information threshold (and other threshold levels) of Directive 2002/3/EC was below average for the decade. The number of exceedances of the high ozone level, 360 µg/m^3 over one hour, corresponding to the warning threshold of the old ozone directive, was close to the average of previous years.

Detailed findings

A total of 1 852 ozone monitoring sites have reported data; 1 792 were located in EU Member States.

The following preliminary conclusions can be drawn for the period April to September 2004.

Exceedance of the information threshold

- The number of exceedances of ozone threshold values in summer 2004 was similar to previous years except for 2003, which showed a much higher number of exceedances. Ozone concentrations higher than the information threshold of 180 µg/m^3 were reported from monitoring sites in 18 EU Member States and four other countries. In total, 2 527 exceedances of the information threshold were counted (11 352 in 2003) at 654 stations (1 220 in 2003). The information threshold was exceeded at about 35 % of all operational stations (68 % in 2003).

- In summer 2004, the spatial extent of the exceedances observed was comparable with previous years, except for summer 2003. Most of western and central Europe was without any recorded exceedances in summer 2004. The most frequent exceedances of the information threshold were observed in southern France, northern Italy and at several locations in Portugal, Spain and Greece.

Exceedance of the alert threshold

- Ozone concentrations higher than the alert threshold of 240 µg/m^3 were reported on 99 occasions in eight EU Member States (Germany, Greece, Spain, France, Italy, Hungary, Portugal and Slovakia) and four other countries (Bulgaria, Switzerland, the Former Yugoslav Republic of Macedonia and Romania). In comparison, 13 of the EU-15 Member States and two other countries reported exceedances of the alert threshold in 2003.

- Most exceedances of the alert threshold occurred in northern Italy, southern France and at several locations in Greece, Spain and Portugal.

Maximum concentrations

- The highest one-hour concentrations were observed in Italy and Spain. The level of 360 µg/m^3 (the former warning threshold) was exceeded three times with the maximum being 419 µg/m^3. This is comparable to summer 2003, when four exceedances of 360 µg/m^3 were recorded with a maximum ozone level of 417 µg/m^3.

Exceedance of the long-term objective for the protection of human health

- Exceedances of the long-term objective for the protection of human health for ozone, i.e. daily maximum eight-hour average concentrations higher than 120 µg/m^3, were observed in almost every country, almost every month and at most of the stations. About 70 % of all stations reported one or more exceedances. Only in one EU Member State, Latvia, were no exceedances reported and none were observed in the Former Yugoslav Republic of Macedonia or Romania.

- For those countries that reported exceedances, the number of exceedance days per country ranged from three (Hungary) to 152 (France). Based on the present data, only one day was without any exceedance in summer 2004. On average, 21 days with exceedances were observed at stations that recorded at least one exceedance.

Exceedance of the target value for the protection of human health

- The target value for protection of human health is that exceedance of 120 µg/m^3 as a daily maximum eight-hour average concentration should not occur more than 25 times (averaged over three years). This occurred at 19 % of all monitoring stations having given reports.

- Belgium (at 11 % of all stations), the Czech Republic (4 %), Germany (24 %), Greece (42 %), France (28 %), Italy (42 %), Cyprus (50 %), Austria (28 %), Portugal (15 %), Slovenia (30 %), Slovakia (19 %) and Switzerland (77 %) reported more than 25 exceedances of the target value. No information was received from Spain, Luxembourg or Poland.

- The target value was exceeded in approximately 23 % of the area for which data were reported.

Main ozone episodes

- The worst ozone episode occurred between 27 July and 6 August 2004. During that period, of the total number of exceedances observed, 38 % were of the information threshold, 9 % of the alert threshold and 20 % of the long-term objective.

- The next worst episode occurred between 8 and 11 June when, of the total observations, 10 % were of the information threshold, 13 % of the alert threshold and 7 % of the long-term objective.

- The largest exceedances of the alert threshold occurred on 22 and 23 July (6 % and 13 % of all observed exceedances respectively).

Trends in ozone statistics

- Over the period 1996–2002, the observed ozone trends are in general not statistically significant. More in-depth analysis, e.g. by correcting for meteorological variability, is needed, but the data suggest that the decreasing trend in peak values (expressed as the 98th or 99.9th percentile of hourly concentrations) observed earlier has levelled off during recent years. Median concentrations show an increasing trend for all types of station, although the increase is more pronounced for street and urban stations.

Disclaimer

The information describing the situation during summer 2004 is partly based on non-validated monitoring data and hence should be regarded as preliminary.

1. Introduction

Ozone is the main product of complex photochemical processes in the lower atmosphere, involving oxides of nitrogen and volatile organic compounds as precursors. Ozone is a strong photochemical oxidant. In elevated concentrations, it causes serious health problems and damage to ecosystems, agricultural crops and materials. The main sectors that emit ozone precursors are road transport, power and heat generation plants, households (heating), industry and petrol storage and distribution.

In view of the harmful effects of photochemical pollution in the lower levels of the atmosphere, the Council adopted, in 1992, Directive 92/72/EEC on air pollution by ozone (Council of the European Communities, 1992). This directive has now been succeeded by Directive 2002/3/EC of the European Parliament and of the Council relating to ozone in ambient air (European Parliament and Council of the European Union, 2002). Directive 2002/3/EC, also known as the third daughter directive to the air quality framework directive (96/62/EC), sets primarily long-term objectives, target values, an alert threshold and an information threshold for ozone to avoid, prevent or reduce harmful effects on human health and the environment. It provides common methods and criteria for the assessment of ozone concentrations in ambient air and ensures that, on the basis of this assessment, adequate information is made available to the public. It also promotes cooperation between the Member States in reducing ozone levels.

Directive 92/72/EEC was repealed on 9 September 2003. Directive 2002/3/EC states that by that date Member States should bring into force the laws, regulations and administrative provisions necessary to comply with the directive. From 2004 onwards, Member States should transfer provisional data on exceedances of the information threshold and the new alert threshold for ozone, as required under Article 10 of Directive 2002/3/EC.

This report is the first under the new ozone directive.

The report gives an overview on the situation during April to September 2004. Chapter 4 provides a comparison over the period 1995–2003. The EEA has prepared similar overviews for the period 1994–2003. Previous reports are available from the Internet site of EEA (http://www.eea.eu.int).

The report does not only cover the EU-25 area; data received from other European countries involved in the EEA European environmental information and observation network (Eionet) are also presented.

The report contains summary information based on data delivered before 9 November 2004 only, i.e. eight days after the deadline set by the directive.

2. Data reporting

2.1. Introduction

Directive 2002/3/EC requires the following data to be provided to the European Commission (and to the EEA).

Monthly data (Article 10(2)(a)(i))
Before the end of the following month, information on exceedances of information and alert thresholds (one-hour average higher than 180 µg/m^3 and 240 µg/m^3). Data submitted in the monthly reports are considered provisional and are to be updated, if necessary, in subsequent submissions.

Summer data (Article 10(2)(a)(ii))
Not later than 31 October, additional provisional data for the foregoing summer period (from April to September) as defined in Annex III to the directive (information on exceedances of alert and information thresholds and of the health protection long-term objective, daily maximum of eight-hour average ozone concentration higher than 120 µg/m^3 and monthly one-hour maximum ozone concentrations) (see Table 1).

Annual data (Article 10(2)(b))
Not later than 30 September of the following year, validated information for ozone and precursors (as defined in Annexes III and VI to the directive). The annual data flow will be included in the questionnaire to be used for annual reporting on air quality assessment in the framework of the air quality framework directive (96/62/EC) and its daughter directives — see Commission Decision 2004/461/EC for details (Commission of the European Communities, 2004).

To manage the monthly and summer data flows, the Member States should use a set of reporting forms as described in the Commission guideline 'Directive 2002/3/EC relating to ozone in ambient air: procedures and formats for the exchange' (ETC/ATC, 2004).

2.2. Data reported over summer 2004

All EU Member States provided, on time, information of observed one-hour exceedances or indicated that no exceedances had been observed. Most of them provided information of observed eight-hour exceedances and one-hour maximums for all stations. In addition, six other countries provided information upon request of the European Environment Agency.

Table 2.1 presents an overview of observed one-hour exceedances and Table 2.2 presents an overview of observed eight-hour exceedances, per country per month.

Ozone monitoring stations were operated throughout the whole period April to September 2004. However, it is possible that some exceedances were not reported if a monitoring station was temporarily out of operation, for example due to maintenance or breakdown. Nevertheless, general experience with current, continuously operated ozone monitors indicate that such situations did not occur frequently.

In this report one-hour exceedances are counted on a daily basis, i.e. a day on which an information/alert threshold is exceeded during at least one hour is counted as one exceedance. Counting of eight-hour exceedances is done in the same way, i.e. a day on which at least one eight-hour average exceeded the long-term objective level is one exceedance.

Ozone monitoring stations were operated throughout the whole period April to

Table 2.1 Overview of observed one-hour exceedances per month per country in 2004

Country	Code (1)	April	May	June	July	August	Sept.
Belgium	BE	–	–	i	i	i	–
Czech Republic	CZ	–	–	–	–	i	i
Denmark	DK	–	–	–	–	–	–
Germany	DE	–	i	i	i	A	i
Estonia	EE	–	i	–	–	–	–
Greece	EL	–	–	A	A	A	A
Spain	ES	i	A	A	A	i	A
France	FR	i	i	A	A	i	i
Ireland	IE	–	–	–	–	–	–
Italy	IT	i	A	A	A	A	A
Cyprus	CY	–	–	–	–	–	–
Latvia	LV	–	–	–	–	–	–
Lithuania	LT	–	–	–	–	–	–
Luxembourg	LU	?	–	–	i	i	?
Hungary	HU	–	–	–	–	A	–
Malta	MT	–	–	–	i	i	–
Netherlands	NL	–	–	i	i	i	–
Austria	AT	–	–	i	i	i	–
Poland	PL	–	–	–	–	–	–
Portugal	PT	i	i	A	A	i	i
Slovenia	SI	–	–	i	i	–	–
Slovakia	SK	–	–	–	A	–	–
Finland	FI	–	i	–	–	–	–
Sweden	SE	–	–	–	–	–	–
United Kingdom	UK	–	–	–	i	i	i
Bulgaria	BG	–	–	–	A	–	–
Switzerland	CH	–	i	A	i	i	–
Liechtenstein	LI	–	–	–	–	–	–
Macedonia, Former Yugoslav Republic of	MK (2)	–	–	i	A	A	i
Norway	NO	–	–	–	–	–	–
Romania	RO	i	–	i	A	i	?

i (yellow): exceedance of the information threshold reported.
– (green): no exceedance reported.
A (red): exceedance of the alert threshold reported.
? (white): no information available.

(1) The countries have been identified using the ISO 3166-1:1997 alpha-2 code in figures, except for Greece (EL) and the United Kingdom (UK).
(2) Provisional code which does not prejudge in any way the definitive nomenclature for this country, which will be agreed following the conclusion of negotiations currently taking place on this subject at the United Nations.

September 2004. However, it is possible that some exceedances were not reported if a monitoring station was temporarily out of operation, for example due to maintenance or breakdown. Nevertheless, general experience with current, continuously operated ozone monitors indicate that such situations did not occur frequently.

In this report one-hour exceedances are counted on a daily basis, i.e. a day on which an information/alert threshold is exceeded during at least one hour is counted as one exceedance. Counting of eight-hour exceedances is done in the same way, i.e. a day on which at least one eight-hour average exceeded the long-term objective level is one exceedance.

A summary of monthly reported data is presented and is regularly updated on the ETC/ACC webpage http://etc-acc.eionet.eu.int/databases/o3excess.

Table 2.2 Overview of observed exceedances of the long-term objective for the protection of human health per month per country during summer 2004

Country	Code (1)	April	May	June	July	August	Sept.
Belgium	BE	+	+	+	+	+	+
Czech Republic	CZ	+	+	+	+	+	+
Denmark	DK	+	+	–	–	–	+
Germany	DE	+	+	+	+	+	+
Estonia	EE	+	+	–	–	–	–
Greece	EL	+	+	+	+	+	+
Spain (2)	ES	?	?	?	?	?	?
France	FR	+	+	+	+	+	+
Ireland (2)	IE	?	?	?	?	?	?
Italy	IT	+	+	+	+	+	+
Cyprus	CY	+	+	+	+	+	+
Latvia	LV	–	–	–	–	–	–
Lithuania	LT	+	+	–	–	–	–
Luxembourg (3)	LU	?	?	?	?	?	?
Hungary	HU	–	+	–	–	+	–
Malta (2)	MT	?	?	?	?	?	?
Netherlands	NL	+	+	+	+	+	+
Austria	AT	+	+	+	+	+	+
Poland (2)	PL	?	?	?	?	?	?
Portugal	PT	+	+	+	+	+	+
Slovenia	SI	+	+	+	+	+	+
Slovakia	SK	+	+	+	+	+	+
Finland	FI	+	+	–	–	–	–
Sweden	SE	+	+	–	–	+	+
United Kingdom	UK	+	+	+	+	+	+
Bulgaria	BG	–	+	–	–	+	–
Liechtenstein	LI	+	+	+	+	+	–
Macedonia, Former Yugoslav Republic of	MK (4)	–	–	–	–	–	–
Norway	NO	+	+	+	–	–	+
Romania	RO	–	–	–	–	–	–
Switzerland	CH	+	+	+	+	+	+

– (green): no exceedance reported.
+ (yellow): exceedance of the long-term objective reported.
? (white): no information available.

(1) The countries have been identified using the ISO 3166-1:1997 alpha-2 code in figures, except for Greece (EL) and the United Kingdom (UK).
(2) Data delivered after the deadline of this report.
(3) No data delivered.
(4) Provisional code which does not prejudge in any way the definitive nomenclature for this country, which will be agreed following the conclusion of negotiations currently taking place on this subject at the United Nations.

2.3. The ozone monitoring network in 2004

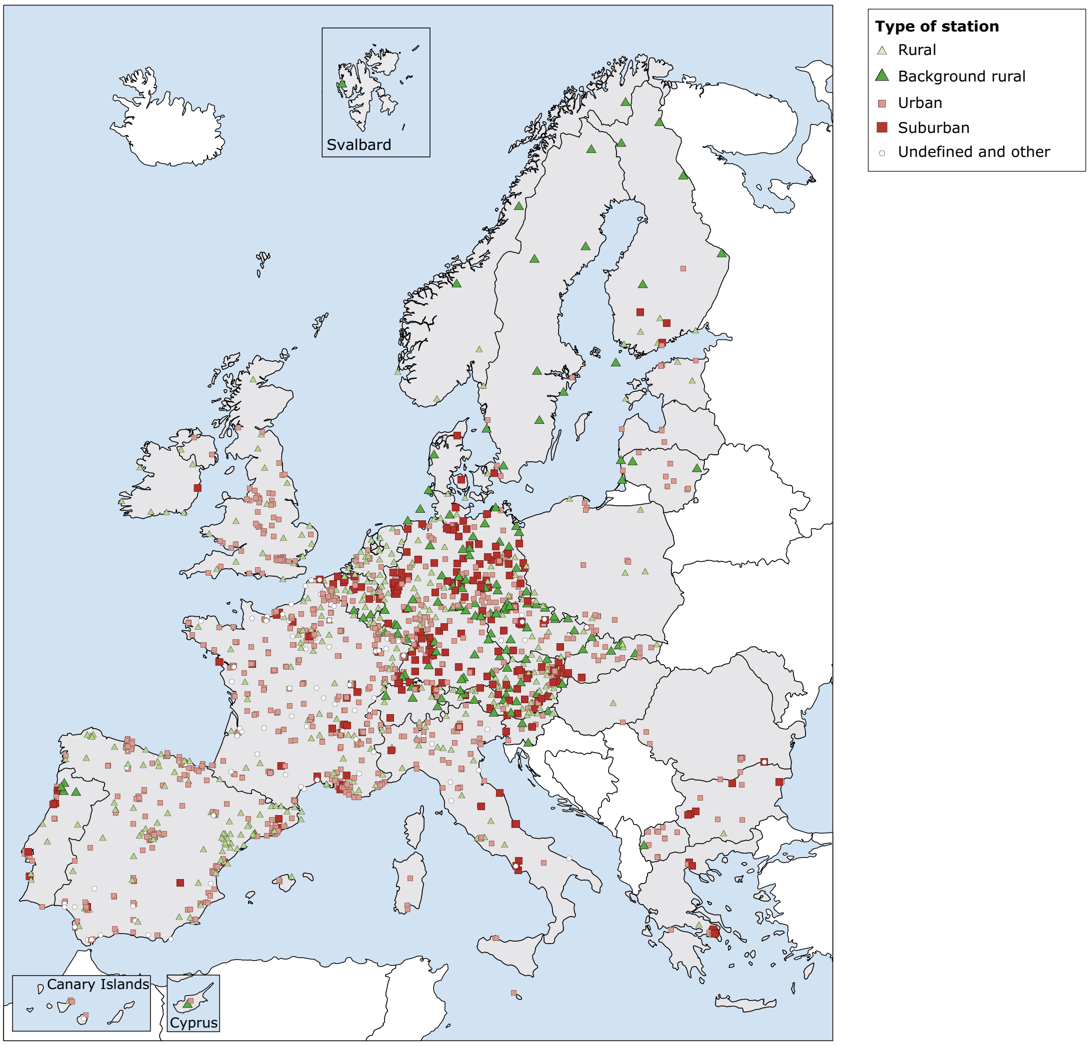
Map 2.1 presents the location of all ozone-monitoring stations assumed to be operational in the reporting countries during the summer season 2004. In total, 1 852 ozone-monitoring sites were operational in summer 2004. Of these stations, 1 792 are located within the EU-25 area. The number of stations reporting during summer 2004 differed only slightly from previous years (1 842 stations in 2001, 1 718 in 2002 and 1 805 in 2003).

A recurring problem is missing or unclear meta-information on monitoring stations. Summer 2004 was no exception.

To guarantee the availability of station meta-information, countries were recommended to use the information available from Airbase for stations currently in operation. For newly established stations not yet registered in Airbase, countries were requested to send station information together with the monthly information. Some countries transmitted information on all currently operated stations with

Map 2.1 Location of ozone monitoring stations as reported by Member States and other European countries in the framework of the ozone directive for summer 2004

Location and type of ozone monitoring stations reporting data
Reference period: summer 2004 (April–September)



Source: Map produced by the European Topic Centre on Air and Climate Change, CHMI.

all information requested by the ozone directive (zone code, type of ozone station); some other countries transmitted only information on newly established stations and several countries did not send any new information at all.

To fill the gaps, station data from summer 2004, summer 2003, annual ozone 2003 reporting and annual 2002 station meta-information reported according to Decision 97/101/EC (EoI) were combined. The main problem remains with the classification of ozone stations as defined in Annex IV to Directive 2002/3/EC, because only a few countries submitted this information. The classification slightly differs from the classification in use under the EoI. In addition to urban and rural types of station, introduced by EoI, Directive 2002/3/EC specifies also suburban and rural background types of station/site and countries have to re-classify their ozone monitoring stations accordingly. However, when the classification of ozone monitoring stations according to Directive 2002/3/EC was not delivered, an EoI station classification from Airbase was applied if available.

3. Overview for summer 2004

In general, air quality with respect to ozone pollution during summer 2004 was much better than during summer 2003. Whereas summer 2003 was one of the warmest summers, summer 2004 was one of the colder ones during the past decade.

3.1. Summary of one-hour exceedances reported

The highest concentrations were observed in Spain and Italy. Surprisingly, Finland reported two exceedances and Estonia one exceedance in 2004 in contrast to no exceedances during the previous years.

The number and size of the highest concentrations were similar to 2003. In 2004, four exceedances of 360 μg/m^3 over one hour (the warning threshold of the old ozone directive) with a maximum of 419 μg/m^3 were observed compared with four exceedances with maximum of 417 μg/m^3 in 2003. However, the countries in which these occurred are different. By comparison, in summer 2002 the 360 μg/m^3 threshold was exceeded in June at one station in France, at one station in Italy and at three stations in Spain. In 2001, the 360 μg/m^3 threshold was exceeded at one French station in March, at one station in Italy in August and at one station in Spain in November. In the annual reports for 2000, only Italy had exceedances of this threshold, on three occasions at two stations.

In spite of the meteorological differences between summer 2004 and summer 2003, when exceptionally long-lasting warm weather affected the whole of southern, western and central Europe, the number of exceedances of the 360 μg/m^3 threshold does not differ substantially between the years. Rather, the poorer conditions in 2003 can be seen by comparing the information threshold exceedances shown in the last two lines of Table 3.1.

Table 3.1 presents a general overview of the observed exceedances of the thresholds during the period for which data were available per country (see Table 2.1 for details). Since the number of stations differs widely from country to country, the absolute number of exceedance days does not offer a suitable comparison of the situation in different countries. Therefore, the concept of 'occurrence of exceedance' has been introduced ([1]). Although this parameter is more comparable between countries, the differences in network, in particular, the ratio between different types of station, limits the comparability. The occurrence of exceedance is included in Table 3.1.

In the EU Member States, no exceedances of the information threshold were observed in Denmark, Ireland, Cyprus, Latvia, Lithuania, Poland or Sweden. Liechtenstein and Norway did not observe exceedance of the information threshold in summer 2004.

For those countries that reported exceedances, the number of exceedance days per country ranged from one (Estonia, Finland) to 76 (Italy). During 128 days within the April to September 2004 period of 183 days, there was at least one station in all reporting countries where an exceedance was observed. About 35 % of all stations reported one or more exceedances. On average 4.3 exceedances were observed at stations which recorded at least one exceedance.

Ozone concentrations higher than the information threshold were reported from monitoring sites in 18 EU Member States and four other countries.

Ozone concentrations higher than the alert threshold of 240 μg/m^3 were reported from

([1]) Occurrence of exceedance is defined as the average number of observed exceedances per country, i.e. the total number of exceedances for all stations divided by the total number of operational stations.

Table 3.1 Overview of exceedances of the one-hour thresholds during summer 2004 on a country-by-country basis

Country	Number of stations (1)	Stations with exceedance (2)					Total number of exceedances		Number of days with exceedance (3)		Maximum observed concentr. (µg/m³)	Occurrence of exceedances (4)				Average duration of exceedance (hours)	
		No.		%		%											
Belgium	37	28	–	76	–	–	70	–	11	–	223	1.9	2.5	–	–	2.6	–
Czech Republic	68	8	–	12	–	–	8	–	2	–	207	0.1	1.0	–	–	2.1	–
Denmark	7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Germany	310	116	1	37	0	1	387	1	21	1	254	1.2	3.3	0.0	1.0	3.0	1.0
Estonia	7	1	–	14	–	–	1	–	1	–	182	0.1	1.0	–	–	1.0	–
Greece	24	12	5	50	21	42	126	11	42	7	352	5.3	10.5	0.5	2.2	2.3	1.7
Spain	302	43	3	14	1	7	233	9	57	8	385	0.8	5.4	0.0	3.0	2.0	1.1
France	448	214	8	48	2	4	691	9	58	6	280	1.5	3.2	0.0	1.1	2.5	1.1
Ireland	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Italy	187	108	22	58	12	20	790	46	76	18	419	4.2	7.3	0.2	2.1	3.3	1.9
Cyprus	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Latvia	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Lithuania	12	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Luxembourg	6	4	–	67	–	–	8	–	5	–	201	1.3	2.0	–	–	2.9	–
Hungary	2	1	1	50	50	100	2	1	2	1	254	1.0	2.0	0.5	1.0	3.0	1.0
Malta	1	1	–	100	–	–	3	–	3	–	233	3.0	3.0	–	–	1.0	–
Netherlands	34	16	–	47	–	–	27	–	8	–	213	0.8	1.7	–	–	2.0	–
Austria	121	20	–	17	–	–	25	–	10	–	209	0.2	1.3	–	–	1.6	–
Poland	21	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Portugal	46	33	5	72	11	15	126	12	29	6	315	2.7	3.8	0.3	2.4	2.3	2.3
Slovenia	10	4	–	40	–	–	11	–	6	–	218	1.1	2.8	–	–	3.5	–
Slovakia	21	3	1	14	5	33	4	1	3	1	312	0.2	1.3	0.0	1.0	1.3	1.0
Finland	16	2	–	13	–	–	2	–	1	–	188	0.1	1.0	–	–	1.5	–
Sweden	12	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
United Kingdom	85	11	–	13	–	–	13	–	4	–	192	0.2	1.2	–	–	1.3	–
EU area	1 792	625	46	35	3	7	2 527	90	120	41	419	1.4	4.0	0.1	2.0	2.7	1.8
Bulgaria	10	2	1	20	10	50	2	1	2	1	249	0.2	1.0	0.1	1.0	1.0	1.0
Switzerland	13	11	2	85	15	18	76	3	22	3	248	5.8	6.9	0.2	1.5	3.5	1.0
Liechtenstein	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Macedonia, Former Yugoslav Republic of	11	7	2	64	18	29	167	4	70	4	274	15.2	23.9	0.4	2.0	3.6	10.8
Norway	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Romania	17	9	1	53	6	11	21	1	18	1	279	1.2	2.3	0.1	1.0	1.4	1.0
Whole area	1 852	654	52	35	3	8	2 793	99	128	46	419	1.5	4.3	0.1	1.9	2.8	2.1
Whole area (summer 2003)	1 805	1 220	326	68	x	27	11 352	720	137	x	417	5.4	x	8.0	x	3.4	x

Grey columns refer to information threshold, white to alert threshold.
x Not evaluated in 2003.

(1) Total number of stations with ozone measurement.
(2) The number and percentage of stations at which at least one threshold exceedance was observed.
Fifth column: percentage of stations with information threshold exceedance at which alert an threshold exceedance was also observed.
(3) The number of calendar days on which at least one exceedance of thresholds was observed.
(4) Left column: averaged over all implemented stations, right figure: averaged over all stations which reported at least one exceedance.

monitoring sites in eight EU Member States (Germany, Greece, Spain, France Italy, Hungary, Portugal and Slovakia) and four other countries (Bulgaria, Switzerland, the Former Yugoslav Republic of Macedonia and Romania) mainly in June and July.

An exceedance of the alert threshold was observed at 8 % of the stations which reported an exceedance of the information threshold (27 % in 2003, 11 % in 2002). In total, 99 exceedances of the alert threshold were counted, that is, during about 3.5 % of the reported exceedances of the information threshold the maximum concentration reached a level above 240 µg/m³ (6 % in 2003). The ratio of the number of exceedances of the information threshold and the number of exceedances of the alert threshold varied strongly across the reporting countries and it is apparently higher for the southern European countries.

Table 3.2 summarises the exceedances on a monthly basis. The largest number of exceedances occurred during June, July and August. An exceedance of the information threshold was observed at at least one of the reporting stations every day in July, and on almost every day in June and August (see Table 3.2 and Figure 3.5).

Figure 3.1 presents the number of days per month on which at least one station in a country recorded an exceedance. This figure reflects for most countries the seasonal behaviour seen in Table 3.2.

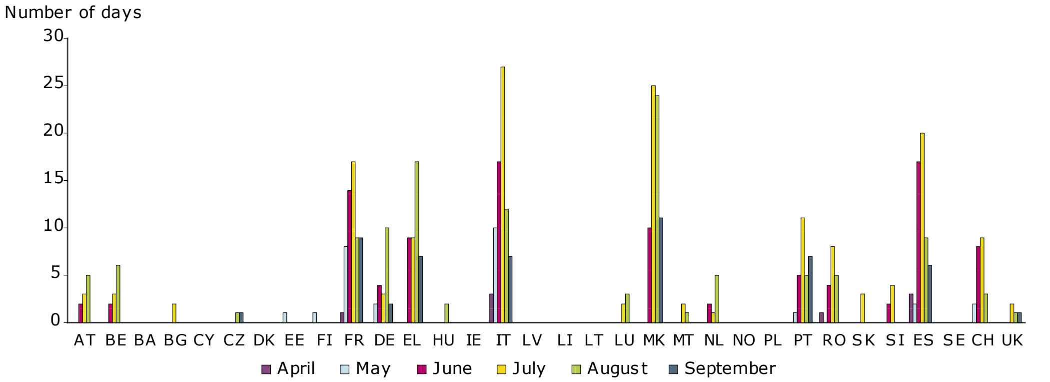
Table 3.2 Overview of exceedances of the one-hour threshold during summer 2004 on a month-by-month basis

Month	Stations with exceedance (1)					Total number of exceedances		Number of days with exceedance (2)		Maximum observed concentr. (µg/m³)	Occurrence of exceedances (3)				Average duration of exceedance (hours)	
	No.		%		%											
April	9	-	0	-	-	9	-	7	-	225	0.0	0.0	-	-	1.6	-
May	76	4	4	0	5	82	6	12	4	419	0.0	0.1	0.0	0.1	2.1	1.0
June	543	24	29	1	4	587	24	26	11	366	0.3	0.9	0.0	0.5	2.7	1.9
July	1 092	56	59	3	5	1 229	58	31	20	352	0.7	1.9	0.0	1.1	3.0	2.4
August	632	7	34	0	1	700	7	28	7	274	0.4	1.1	0.0	0.1	2.7	1.4
September	174	4	9	0	2	186	4	24	4	385	0.1	0.3	0.0	0.1	2.6	1.3

(1) The number and percentage of stations at which at least one threshold exceedance was observed. Fifth column: percentage of stations with information threshold exceedance at which alert an threshold exceedance was also observed.
(2) The number of calendar days on which at least one exceedance of thresholds was observed.
(3) Left column: averaged over all implemented stations, right figure: averaged over all stations which reported at least one exceedance.

Figure 3.1 Number of days on which at least one exceedance of the 1-hour threshold value was observed per country and per month during summer 2004

a) Information threshold exceedances



b) Alert threshold exceedances

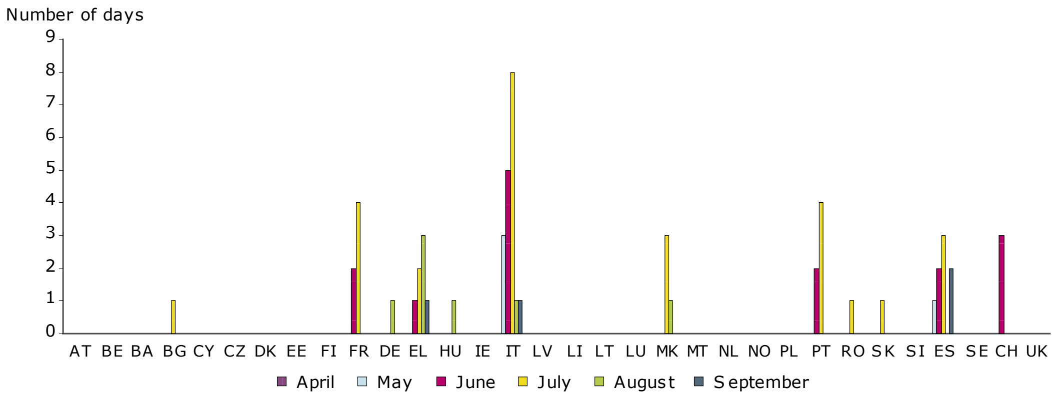
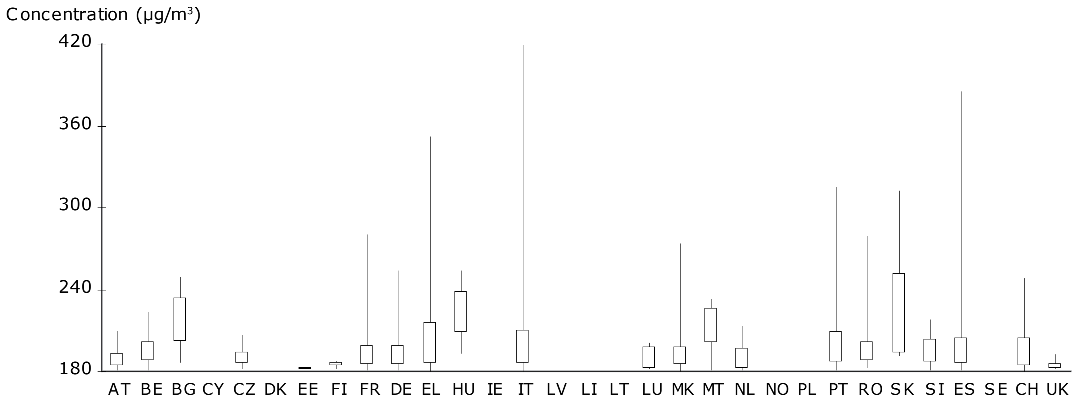


Figure 3.2 shows the frequency distribution of hourly ozone concentrations exceeding the information threshold. At European level, 25 % of maximum hourly concentrations of all the observed exceedances were below 185 µg/m³ (207 µg/m³ in 2003). The highest values of the 75th percentile of all maximum concentrations in a country during exceedances were below 203 µg/m³ (305 µg/m³ in 2003), which is comparable with the maximum 75th percentile value during summers 2002 (219 µg/m³) and 2001 (208 µg/m³).

Figure 3.2 Frequency distribution of concentrations in excess of the 1-hour information threshold



Note: Presented as Box-Jenkins plots indicating the minimum, the 25th percentile, the 75th percentile and the maximum value.

3.2. Overview of long-term objective and target value exceedances reported

Table 3.3 presents a general overview of the observed exceedances of the long-term objective (LTO), i.e. when daily maximum eight-hour average concentrations of ozone were higher then 120 µg/m³, and exceedances of target value (TV), i.e. when daily maximum eight-hour average concentrations of ozone were higher than 120 µg/m³ more than 25 times, during summer 2004 (²).

Daily maximum eight-hour average concentrations of ozone higher than 120 µg/m³ (exceedances of the LTO) were observed in almost every county, almost every month and at most of the stations in summer 2004, even though the summer was mild. In most countries, more than half of the stations reported at least one exceedance. Only in one EU Member State (Latvia) was no exceedance reported. The Former Yugoslav Republic of Macedonia and Romania did not observe exceedance of the LTO.

For those countries that reported exceedances, the number of exceedance days per country ranged from three (Hungary) to 152 (France). Within the period of 183 days in April to September 2004 only one day was reported without any exceedance. Information from some countries is missing and, probably, no day was in reality without exceedance.

About 70 % of all stations reported one or more exceedances. On average, 21 days with exceedance were observed at stations that recorded at least one exceedance.

The TV (i.e. when LTO was exceeded more than 25 times) was passed at 19 % of all stations. Luxembourg, Poland and Spain may well also have had stations with TV exceedance but the information is missing.

(²) Daily maximum eight-hour average concentrations were compared with the legally-set objectives solely for indicative purposes to assess the current situation and its distance from objectives, and not for checking compliance with Directive 2002/3/EC.

Table 3.4 summarises the exceedances on a monthly basis. The largest number of exceedances occurred during July and August. More than half of the stations reported at least one exceedance during May to August.

Figure 3.3 presents the number of days per month on which at least one station in a country recorded an exceedance.

Figure 3.4 shows the frequency distribution of eight-hour ozone concentrations

Table 3.3 Overview of exceedances of the long-term objective for the protection of human health during summer 2004 on a country-by-country basis

Country	Number of stations (1)	Stations with LTO exceedance (2)		Stations with TV exceedance		Total number of LTO exceedances	Number of days with LTO exceedance (3)	Maximum observed concentr. (μg/m³)	Occurrence of LTO exceedances (4)	
		Number	%	Number	%					
Belgium	37	35	95	4	11	658	41	187	17.8	18.8
Czech Republic	68	23	34	3	4	399	65	183	5.9	17.3
Denmark	7	4	57	–	–	4	4	152	0.6	1.0
Germany	310	300	97	74	24	6 089	108	209	19.6	20.3
Estonia	7	5	71	–	–	30	17	167	4.3	6.0
Greece	24	17	71	10	42	693	145	236	28.9	40.8
Spain	302	*	*	*	*	*	*	*	*	*
France	448	433	97	126	28	9 798	152	227	21.9	22.6
Ireland	8	*	*	*	*	*	*	*	*	*
Italy	187	161	86	79	42	5 447	173	250	29.1	33.8
Cyprus	2	2	100	1	50	78	77	145	39.0	39.0
Latvia	5	–	–	–	–	–	–	–	–	–
Lithuania	12	4	33	–	–	5	4	130	0.4	1.3
Luxembourg	6	x	x	–	–	x	x	x	x	x
Hungary	2	1	50	–	–	3	3	203	1.5	3.0
Malta	1	*	*	*	*	*	*	*	*	*
Netherlands	34	32	94	–	–	322	30	187	9.5	10.1
Austria	121	121	100	34	28	2 301	113	177	19.0	19.0
Poland	21	*	*	–	–	*	*	*	*	*
Portugal	46	44	96	7	15	651	113	216	14.2	14.8
Slovakia	21	11	52	4	19	269	99	163	12.8	24.5
Slovenia	10	9	90	3	30	159	59	198	15.9	17.7
Finland	16	4	25	–	–	24	10	164	1.5	6.0
Sweden	12	9	75	–	–	70	28	144	5.8	7.8
United Kingdom	85	54	64	–	–	191	20	171	2.2	3.5
EU area	1 792	1 269	71	345	19	27 191	182	250	15.2	21.4
Bulgaria	10	7	70	–	–	7	6	147	0.7	1.0
Switzerland	13	13	100	10	77	586	107	222	45.1	45.1
Liechtenstein	1	1	100	–	–	20	20	150	20.0	20.0
Macedonia, Former Yugoslav Republic of	11	–	–	–	–	–	–	–	–	–
Norway	8	7	88	–	–	41	22	141	5.1	5.9
Romania	17	–	–	–	–	–	–	–	–	–
Whole area	1 852	1 297	70	355	19	27 845	182	250	15.0	21.5

* Data delivered after the deadline from Ireland, Malta, Poland and Spain.
x No data delivered from Luxembourg.

(1) Total number of stations with ozone measurement.
(2) The number and percentage of stations at which at least one exceedance was observed.
(3) The number of calendar days on which at least one exceedance was observed.
(4) Left column: averaged over all implemented stations.
Right column: averaged over all stations which reported at least one exceedance.

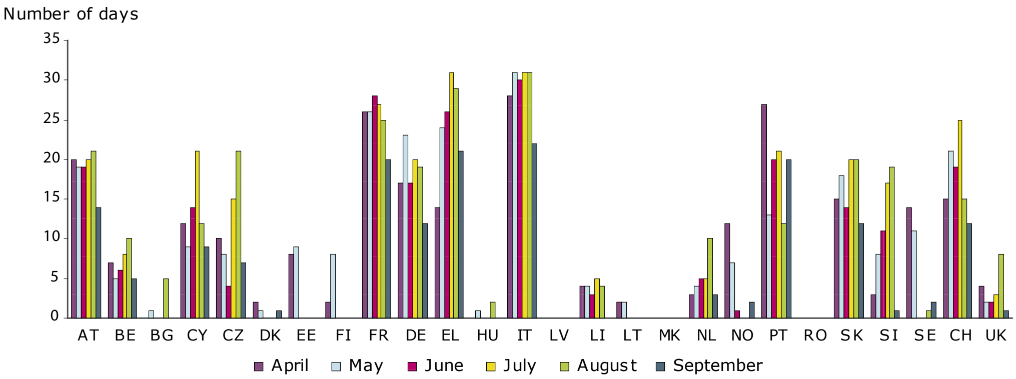
exceeding the long-term objective level. At the European level, 25 % of maximum eight-hour concentrations of all the observed exceedances were below 125 µg/m³. The highest values of the 75th percentile of all maximum concentrations in a country during exceedances were below 143 µg/m³.

Table 3.4 Overview of exceedances of the long-term objective for the protection of human health during summer 2004 on a month-by-month basis

Month	Stations with exceedance (¹)		Total number of exceedances	Number of days with exceedance (²)	Maximum observed concentration (µg/m³)	Occurrence of exceedances (³)	
	Number	%					
April	658	36	2 120	30	178	1.1	1.6
May	979	53	4 395	31	211	2.4	3.4
June	1 006	54	4 498	30	245	2.4	3.5
July	1 122	61	6 804	31	250	3.7	5.2
August	1 131	61	6 816	31	225	3.7	5.3
September	906	49	3 212	29	208	1.7	2.5

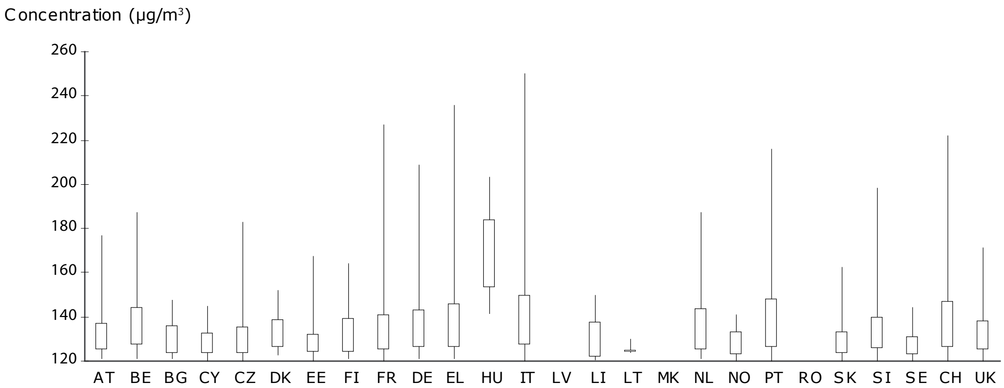
(¹) The number and percentage of stations at which at least one exceedance was observed.
(²) The number of calendar days on which at least one exceedance was observed.
(³) Left column: averaged over all implemented stations.
Right column: averaged over all stations which reported at least one exceedance.

Figure 3.3 Number of days on which at least one exceedance of the long-term objective for the protection of human health was observed per country and per month during summer 2004



Note: Only countries which delivered data are shown.

Figure 3.4 Frequency distribution of concentrations in excess of the long-term objective for the protection of human health



Note: Presented as Box-Jenkins plots indicating the minimum, the 25th percentile, the 75th percentile and the maximum value. Only countries which delivered data are shown.

3.3. Geographical distribution

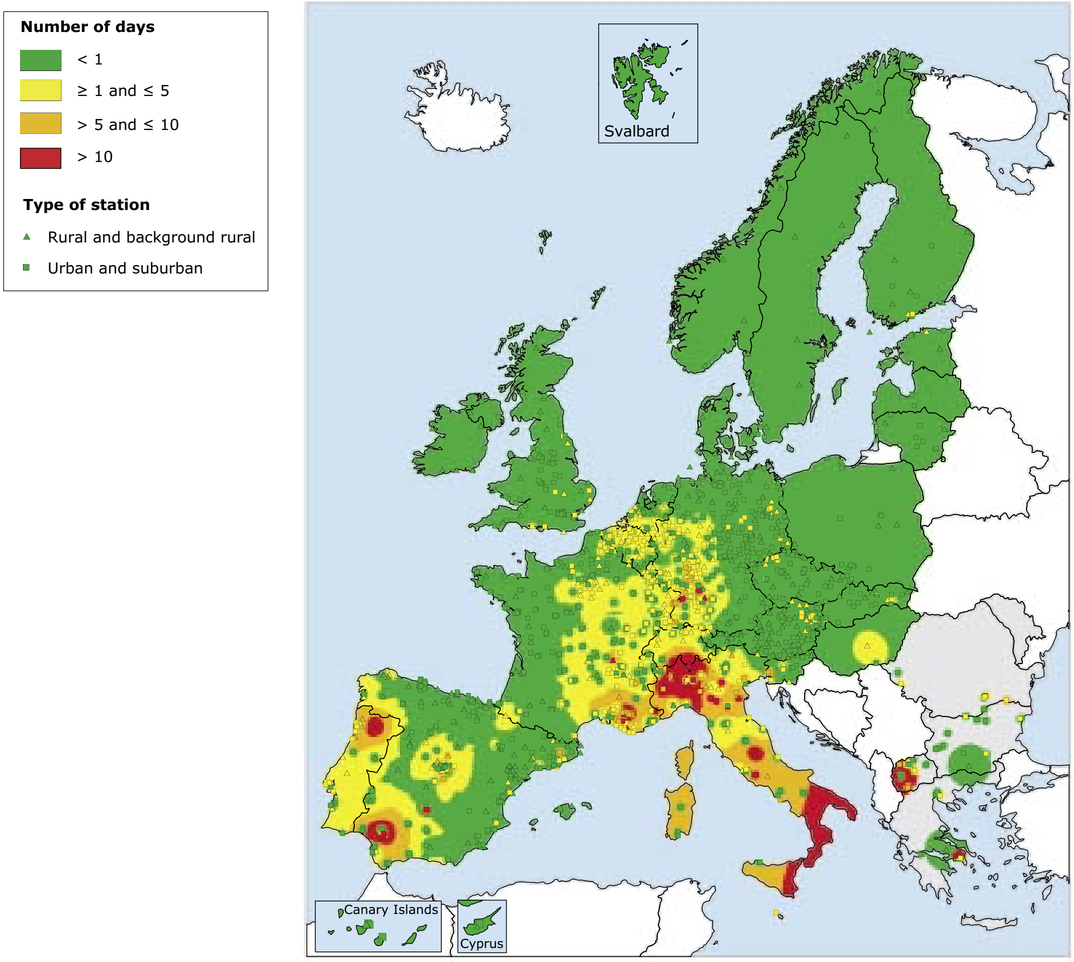
The calculated and measured values were interpolated using inverse distance weighting without distance limitation for rural stations and with an arbitrary radius of representativeness of 20 km for urban and suburban stations for map presentation. Combining rural and urban stations leads to rather homogeneous maps. The colour coding is common for station symbols as well as for interpolated maps. The density of ozone monitoring sites is too low for providing reliable estimates of the spatial distribution by interpolation for the south-eastern part of Europe, and so the data are presented with an arbitrary radius of representativeness of 100 km for rural stations. Note that these radiuses actually might be different for the various regions in Europe.

The spatial distributions were similar between criteria, showing the highest ozone levels in the Mediterranean region. Higher ozone levels also occurred in western parts of Germany and eastern parts of France. The lowest ozone levels occurred in the Baltic States and Scandinavia. Nevertheless, the long-term objective was also often exceeded in these countries.

Map 3.1 shows the geographical distribution of the number of days on which the one-hour information threshold was exceeded. The spatial extent of the exceedances observed in summer 2004 was much smaller than in the hot summer of 2003. Notably, a

Map 3.1 Number of days with exceedance of the information threshold

Exceedance of the 180 µg/m³ ozone information threshold
Reference period: summer 2004 (April–September)



Source: Map produced by the European Topic Centre on Air and Climate Change, CHMI.

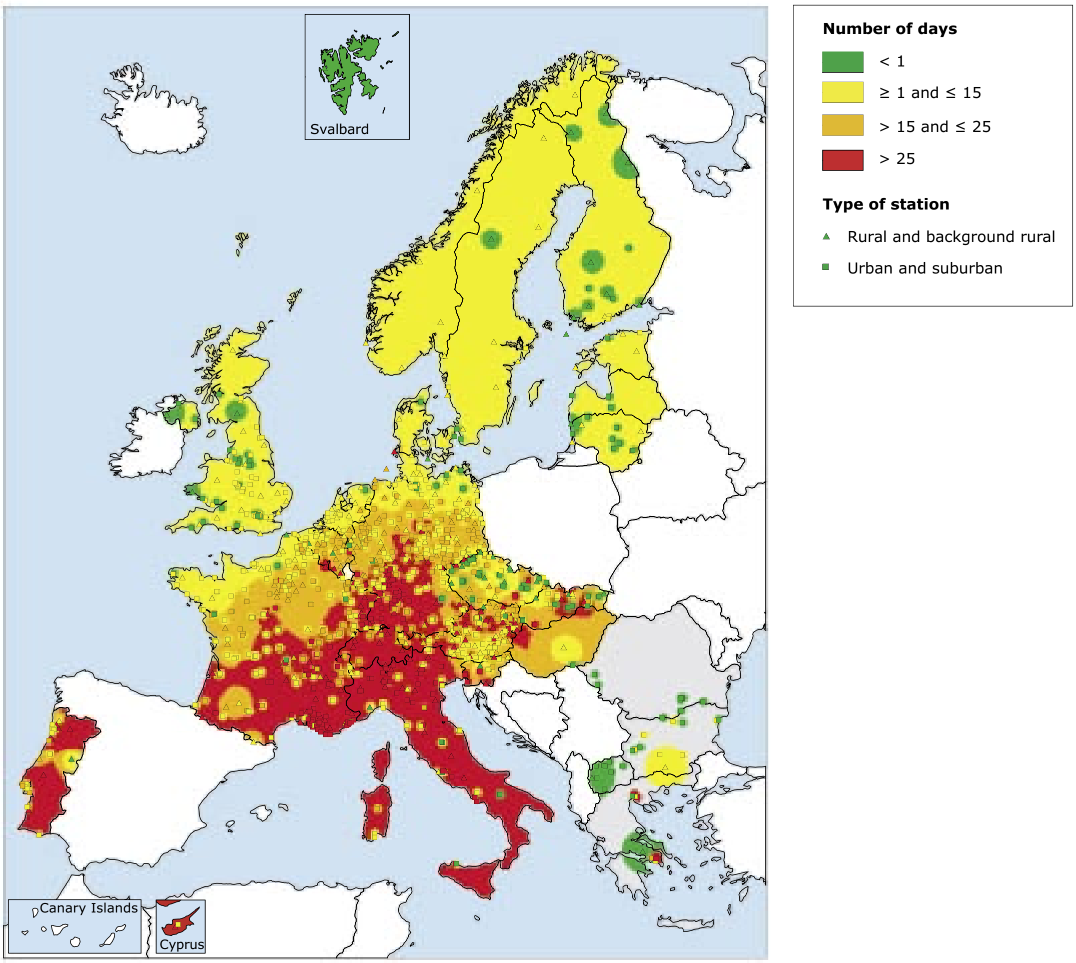
major part of western and central Europe was without any recorded exceedances in 2004. The area with more than five exceedance days in summer 2004 mainly covered part of south-western Germany, southern Switzerland, south-eastern France, most of Italy, northern Portugal, south-western Spain and eastern Greece. The number of days with exceedance was significantly lower than in summer 2003. Scandinavia, the Baltic States and Ireland had no days with exceedance of the information threshold, as in previous years, except for a surprising one day with exceedance in Finland and Estonia on 7 May. No exceedance, or only local exceedances, occurred in the United Kingdom, northern and eastern Spain, western France and central Europe.

The most frequent occurrence of exceedances of alert thresholds was observed in northern Italy, southern France and at several locations in Portugal, Spain and Greece.

Map 3.2 shows the geographical distribution of the number of days on which the long-term objective level (LTO) was exceeded. The United Kingdom, Scandinavia, the Baltic States, the coastline of western Europe and part of central Europe had less than 15 days with LTO exceedance. The number of days with LTO exceedance higher than

Map 3.2 Number of days with exceedance of the long-term objective level

Exceedance of the 120 µg/m³ ozone long-term objective for the protection of human health
Reference period: summer 2004 (April–September)



Note: Data from Ireland, Malta, Poland and Spain were delivered after the deadline.

Source: Map produced by the European Topic Centre on Air and Climate Change, CHMI.

25, i.e. exceedance of the target value for protection of human health (TV), was observed on the Iberian peninsula, southern and central France and Germany, Austria, Switzerland, Slovenia and Italy and at several more isolated areas. This area is very large and represents approximately 23 % of the area, and around 28 % of the population, for which data were reported.

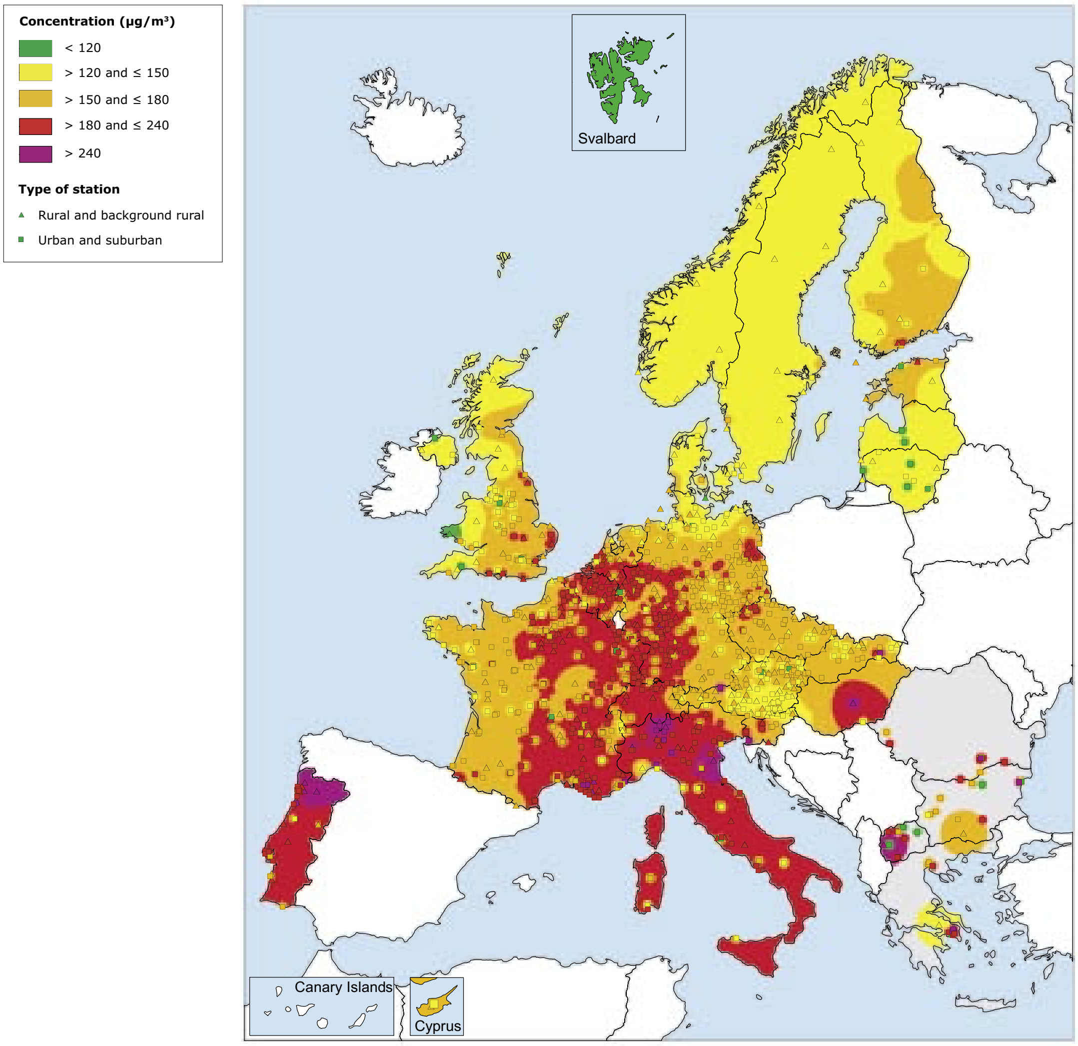
Map 3.3 shows geographical distribution of the measured maximum one-hour concentrations for the whole period April to September 2004. Maximum one-hour concentrations lower than 150 µg/m^3 prevailed in Scandinavia and the Baltic States. Maximum concentrations between 150 and 180 µg/m^3 prevailed in the United Kingdom, western France and central Europe. The area with one-hour concentrations higher than 180 µg/m^3 corresponds to the area with at least one day of exceedance of the information threshold presented in Map 3.1.

In April, one-hour concentrations lower than 150 µg/m^3 were recorded at almost all stations in all countries. Concentrations higher than 180 µg/m^3 were observed at isolated stations in Spain, France, Italy and Romania.

In May, maximum one-hour concentrations higher than 180 µg/m^3 were observed mainly at stations in south-eastern France and northern Italy and at several isolated

Map 3.3 Maximum one-hour concentrations observed during whole summer period

Summer maximum one-hour ozone concentration
Reference period: summer 2004 (April–September)



Source: Map produced by the European Topic Centre on Air and Climate Change, CHMI.

locations in northern Portugal, Spain, south-western Germany and Switzerland, while concentrations remained lower than 150 µg/m³ in most other European stations. The only day with exceedance in Finland and Estonia during summer 2004 was 7 May.

In June, the area with maximum one-hour concentrations higher than 180 µg/m³ extended further to include all of coastal Portugal, northern France, Belgium, the Netherlands, western Germany, Switzerland, Slovenia, central Italy, the Former Yugoslav Republic of Macedonia and eastern Greece.

In July, the area with observed maximum one-hour concentrations higher than 180 µg/m³ grew out from the same areas as in June and extended into the southern part of the United Kingdom, Luxembourg, Slovakia, Malta and Bulgaria.

In August, the affected area remained similar to that of July. Lower concentrations were measured in Slovakia, Slovenia and Bulgaria, and the higher concentrations in the north-western part of the Czech Republic and Hungary.

In September, the situation had returned to a similar situation as in May. Nevertheless, maximum one-hour concentrations higher than 180 µg/m³ were measured in the United Kingdom, the Czech Republic, the Former Yugoslav Republic of Macedonia and eastern Greece, but lower concentrations were observed in Switzerland. The area with concentrations measured between 150 and 180 µg/m³ was larger than it had been in May. In contrast, most of the stations in northern part of the United Kingdom, Scandinavia, the Baltic States and Austria measured maximum concentrations lower than 120 µg/m³, i.e. lower than in May.

3.4. Main ozone episodes

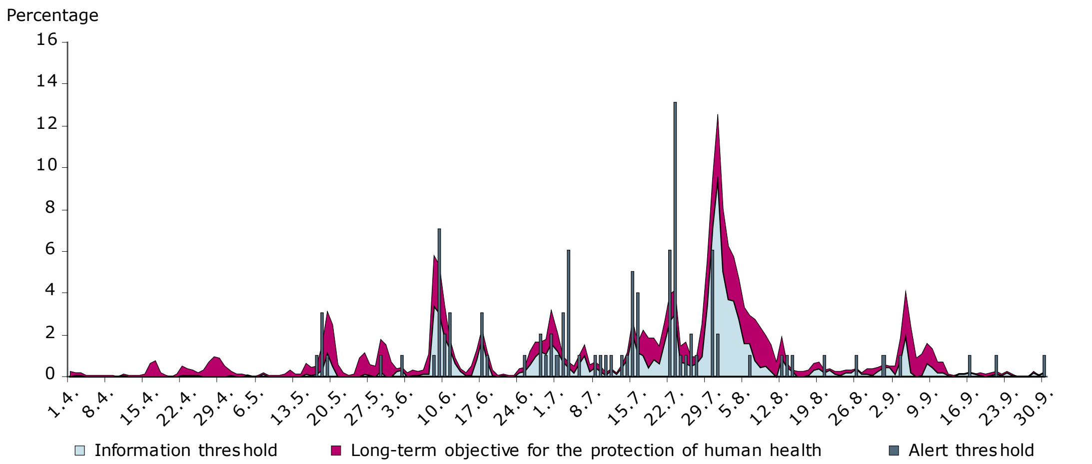
The occurrence of ozone exceedances varies during summer. A summary of exceedances on a monthly basis was given in Tables 3.2 and 3.4. Figure 3.5 shows the distribution of exceedances on a daily basis during summer 2004.

The largest episode occurred between 27 July and 6 August. During that period, 38.4 % of the total number of exceedances of the information threshold, 9.1 % of exceedances of the alert threshold (6.1 % on 30 July) and 20.1 % of exceedances of the long-term objective were observed.

The second strongest episode occurred between 8 and 11 June, during which 9.7 % of the total number of exceedances of the information threshold, 13.1 % of exceedances of the alert threshold (7.1 % on 30 June) and 6.7 % of exceedances of the long-term objective were observed.

Nevertheless, the strongest occurrence of exceedances of the alert threshold was on 22 and 23 July (6.1 % and 13.1 % of all observed exceedances respectively).

Figure 3.5 Distribution of exceedances during summer 2004 on day-by-day basis



4. Comparison with previous years

The ozone levels in 2004 have been compared with the ozone concentrations since 1995. However, this has to be done with caution for several reasons. The data over the period 1995–2002 were extracted from Airbase and therefore refer to a full calendar year; the 2003 and 2004 data are submitted under the previous and current ozone directives and refer to the summer months only. Moreover, the 2003 and 2004 data are only partly validated. Over the years, the networks in Europe have changed. Some of the observed changes might be caused by the changes in location or density of the networks.

As described in the previous chapters, the ozone concentrations over Europe vary strongly, partly as a result of the large variations in climate from the warm Mediterranean, the moist marine climate in the west and the cold, polar-like climate in the north. In the more continental part, the predominantly western winds cause a gradual build-up of precursor emissions. To examine a possible variation in trend of ozone levels over Europe, we have divided Europe into four regions (based on last year's experience, confirmed with this summer's data — see the maps in Section 3.3).

1. Northern Europe (Norway, Sweden, Finland, Estonia, Lithuania, Latvia, Denmark and Iceland).

2. North-western Europe (the United Kingdom, Ireland, the Netherlands, Belgium, Luxembourg and France north of 45° latitude, roughly corresponding to the line Bordeaux–Valence–Briançon).

3. Central and eastern Europe (Germany, Poland, the Czech Republic, Slovakia, Hungary, Austria and Switzerland).

4. Southern Europe (France south of 45 ° latitude, Portugal, Spain, Italy, Slovenia, Greece, Cyprus and Malta).

In region 1, northern Europe, exceedances of the information threshold are exceptional. Even in summer 2003 only one station in Iceland reported one quite unexpected and probably unreliable exceedance in April, which should be verified in EoI data transmission. In summer 2004, in May, two stations in Finland and one in Estonia reported values slightly above the information threshold once. This region is not further included in the trend analysis on exceedances.

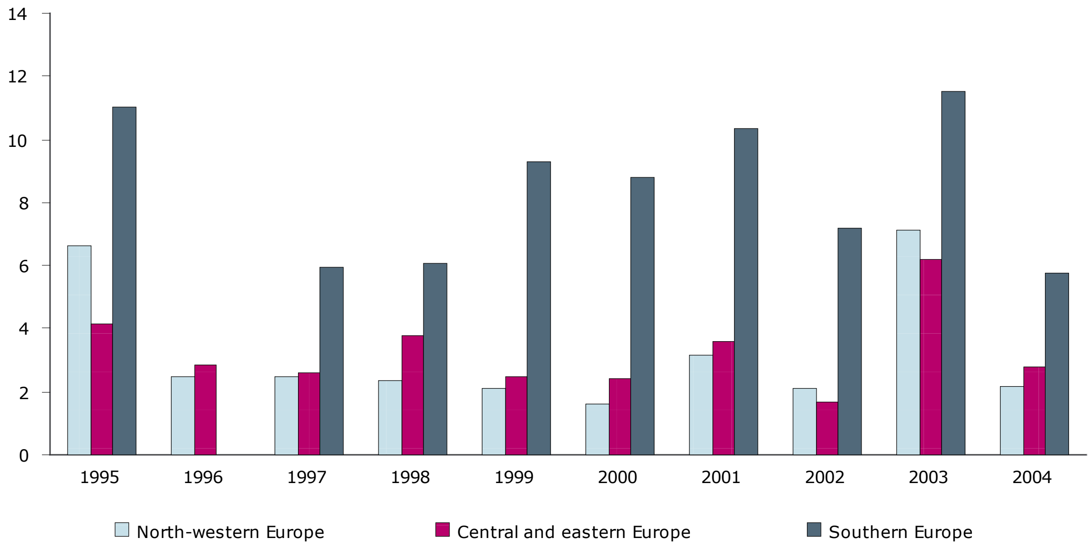
If the information threshold is exceeded, the average duration of such an exceedance shows some variations, but generally it falls in the range of two to three hours for all regions and for all years with the exception of summer 2003. During this extremely hot summer, the exceedance duration is 3.5 hours in the EU-25 region. Surprisingly, in southern Europe the average duration is lower: 2.8 hours. However, the average occurrence for stations which reported at least one exceedance is the highest in southern Europe (see Figure 4.1).

This figure clearly shows that frequent occurrence of exceedance was quite common in southern Europe; indeed, between 1999 and 2001 the number of occurrences was only slightly lower than in the extreme summer of 2003, which resulted in a very large increase in occurrences. The situation during summer 2004 returned to more 'normal' as previously described. The calculations for 2004 are mainly for the period April to July; August data are incomplete due to the deadline of this report.

The analysis of time course/trends is strongly affected by changes in monitoring networks. Over the years, the number of reporting stations, and hence the territorial coverage, has increased significantly. This increase is not consistent over all countries and this may introduce bias. In some years, information from one or two large Member States is missing. Moreover, the ratio between the number of stations located in urban and rural areas has changed over the year; within a country, the configuration of the monitoring network may show a large variation in number or location of stations.

The detection of possible ozone trends therefore calls for a more in-depth analysis using the information on a station-by-station basis while the influence of meteorological parameters has to be taken into account.

Figure 4.1 Average occurrence (the number of exceedance per station) per region for stations, which reported at least one exceedance, observed during the year



Note:
North-western Europe: United Kingdom, Ireland, the Netherlands, Belgium, Luxembourg and France north of latitude 45 °.
Central and eastern Europe: Germany, Poland, the Czech Republic, Slovakia, Hungary, Austria and Switzerland.
Southern Europe: France south of latitude 45 °, Portugal, Spain, Italy, Slovenia, Greece, Cyprus and Malta.
Northern Europe has not been included in this figure because of the low number of exceedances.

4.1. Trends of target values for the protection of human health

In addition to the information and alert thresholds, the ozone directive defines two related target values to be attained by 2010. The target value for the protection of human health is defined as a maximum daily eight-hour mean value of 120 μg/m^3 not to be exceeded on more than 25 days averaged over three years; the target value for protection of vegetation is defined as an AOT40 value of 18 000 (μg/m^3).h calculated from May to July during daylight hours (between 08.00 and 20.00 CET), averaged over five years. A long-term objective for protection of vegetation was introduced as an AOT40 of 6 000 (μg/m^3).h.

To follow the progress towards the 2010 human health target value, the 26th highest daily maximum eight-hour mean concentration is examined. As 25 exceedances per year are allowed, the 26th highest value should drop below 120 μg/m^3 by 2010.

The trend in this parameter over the period 1996–2001 was discussed in the previous ozone report (EEA, 2003). Extending the time series with the 2002 data does not change the finding reached last year: no coherent trend is observed.

For each station operational for six or seven years during the period 1996–2001, a linear trend has been estimated by Sen's non-parametric procedure (Gilbert, 1987). A histogram of all estimated slopes is shown in Figure 4.2. One must be careful in interpretation of this figure as only one out of every six stations has a significant slope at a level of $\alpha = 0.10$. A wide range in estimated slopes is seen: of the rural stations (n = 194), most show a downward trend; but, of the urban stations (n = 262) and, more so, the street stations (n = 117), most show an upward tendency. This can be partly explained by the local impact of decreasing NOx emissions on the concentrations at urban and street locations. Note the very large variation in the slopes at street level; this indicates that street levels are very sensitive to changes in local emissions.

Although the dataset in the trend analysis contains more than 600 stations, the coverage of Europe is relatively poor, since large countries like France and Italy are missing. Shortening the time window to a five-year period (1998–2002) does not solve this problem; the same countries are still missing. After 1999, a substantial coverage is available but this time-series is too short for trend analysis. A Europe-wide trend analysis can only be made when member countries submit, in line with the exchange-of-information decision (Council of the European Union, 1997), historical time-series since 1989.

4.2. Trends of statistics related to population exposure

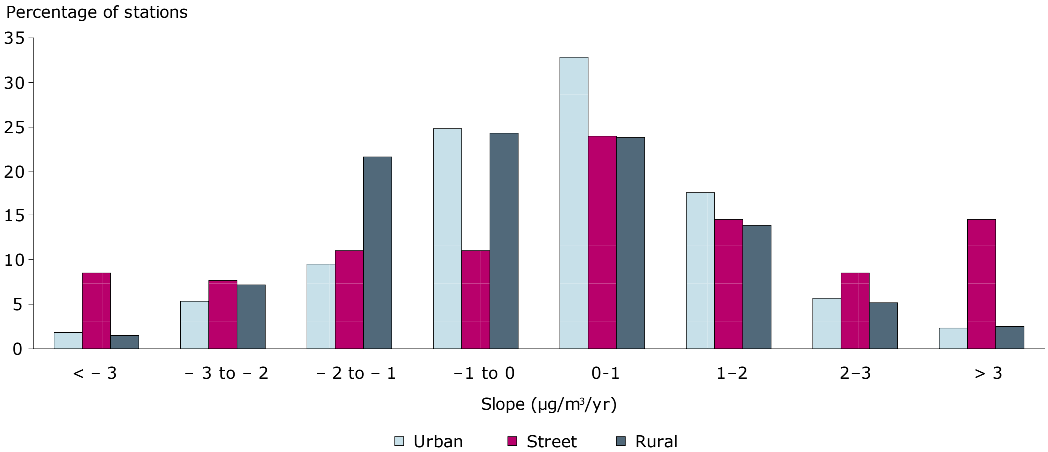
The WHO/CLRTAP Task Force on Health Aspects of Air Pollution has recently recommended a different metric for assessment of policy options. This proposed exposure parameter is defined as the average excess of daily maximum eight-hour means over a cut-off level of 35 ppb (70 μg/m³) calculated for all days in a year. An acronym of SOM35 (sum of means over 35 ppb) has been proposed (3). Results for the period 1996–2002 are presented in Figure 4.3. The characteristic systematic differences between rural–urban–street stations are seen but — as the case for the 26th highest value — no clear trend is seen.

4.3. Trends of target values for the protection of vegetation

The vegetation-related ozone parameter (AOT40) is given in Figure 4.4. The line gives the average AOT40 value for about

Figure 4.2 Frequency distribution of estimated trend (in (μg/m3) per year) in the 26th highest daily maximum 8-hour mean ozone concentration, period 1996–2002

MAX26 1996–2002



Note: Only stations with 6 or 7 operational years are included.

(3) The *SOM35* value is calculated as:

$$SOM35 = \frac{1}{N}\sum_k \max[(C_k - T), 0]$$

where T is the cut-off threshold of 35 ppb (70 μg/m3), N is the number of days with valid measurements and C_k is the maximum daily eight-hour mean at day k.

200 rural stations. The tails of the vertical bars represent the 10th and 90th percentiles. After a period of slow increase, in 2002 the average value drops slightly and remains below the EU target value. However, as meteorological variations are large, again it must be concluded that no coherent trend is seen.

Figure 4.3 **Annual variations of the SOM35-values. Average values over all stations, which reported data over at least six years in the period 1996–2002**

Ozone *SOM35* values

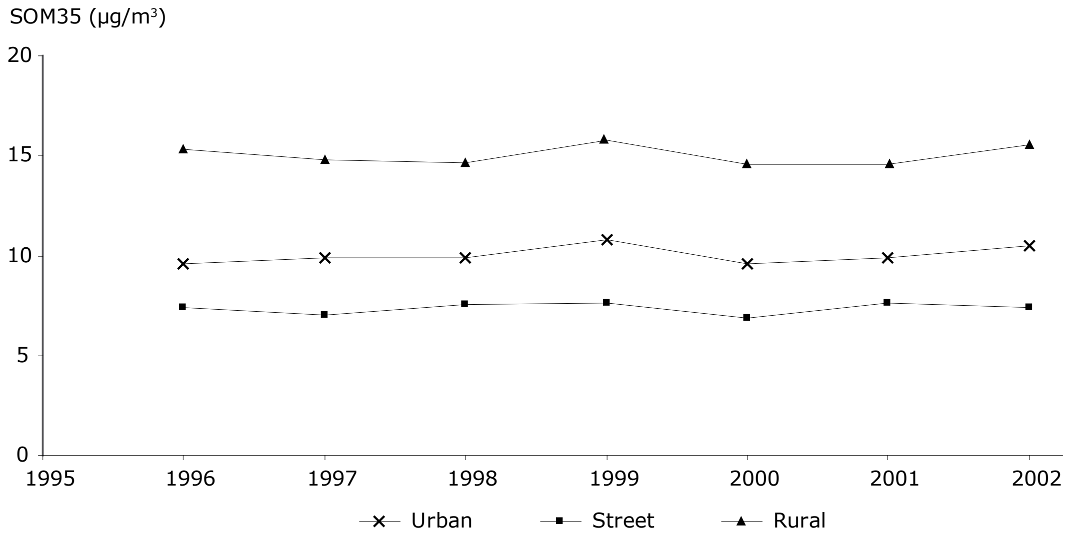
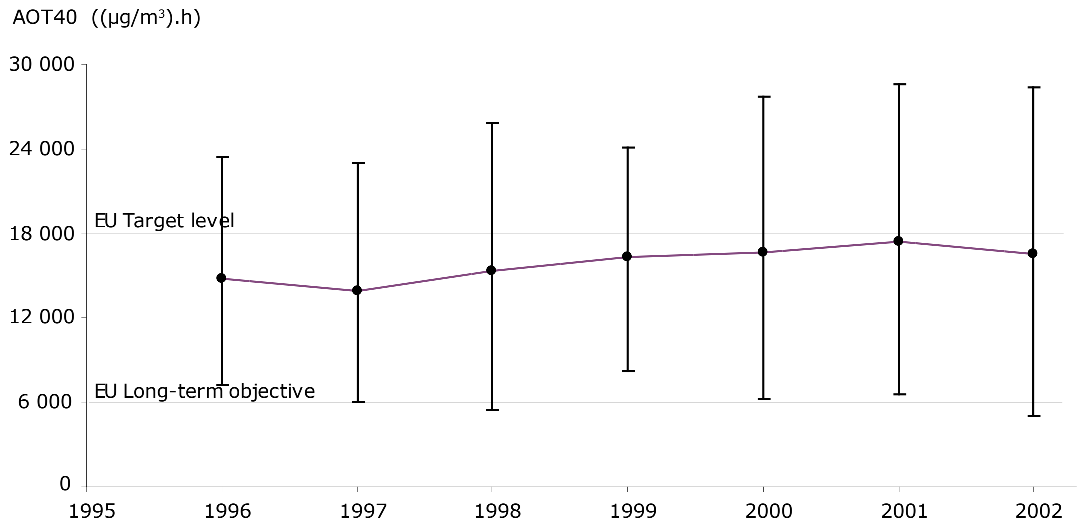


Figure 4.4 **Annual variation in the ozone AT40 value (May–July). Average values over all stations, which reported data over at least six years in the period 1996–2002**

O3 AOT40 (May-July) average of approx. 200 rural stations



Note: The ends of bars indicate the 10th and 90th percentile values.

4.4. Discussion and conclusion on trends

From the above reported findings it must be concluded that none of the effect-related ozone parameters shows a coherent trend. However, in recent literature (see, for example, EMEP, 2004) it is frequently indicated that both model calculations as well as observations show a reduction in peak ozone values during the 1990s. These studies are commonly based on 'old' time series up to 1999. As the current findings and the conclusions from literature seem to be in contradiction, we have re-evaluated the trend in the 50th, 98th and 99.9th percentile values of hourly averaged ozone concentrations. Only stations which were operational during six or seven years in the period 1996–2002 were included in the analysis. The total dataset included 619 stations, of which 263 are classified as urban, 117 as traffic and 195 as rural. The remaining 44 are industrial or unclassified stations. The results are summarised in Figure 4.5. Here the percentile average per station type is given. The variation within a type class is large. For the 98th and 99.9th percentile values, 80 % of the stations fall within a typical range of ± 25 $\mu g/m^3$ around the average. For the 50th percentiles, the range is smaller and is type-dependent: ±10, ±15 and ±20 $\mu g/m^3$ for urban, street and rural stations, respectively.

The 50th percentile shows an increasing trend for all station types although the increase is more noticeable for street and urban stations. The observed trend is significantly upward in one third (urban and street) and one sixth (rural) of the cases. The average slope found here, 0.7 $\mu g/m^3$ per year, is slightly less than the significant positive trend of 0.98 $\mu g/m^3$ per year during the period 1987–2003 observed at the Mace Head background station in Ireland (Simmonds *et al.*, 2004).

The 98th percentiles averaged by station type show no tendency at all. For the individual stations, the 98th percentile tends to increase at a small majority (approx. 60 %) of the street and urban stations; for the rural stations only 40 % show a positive tendency. When indicating 98th percentiles as peak value it cannot be concluded that peak values decreased during the period 1996–2002. Negative trends are observed, however, when the first half of the 1990s is included in the analysis. Airbase contains data over the period 1992–2002 for 136 stations. Over this longer period, again at the street and urban stations, a mixed pattern is seen but a larger fraction of the stations (18 out of 58 rural stations) shows a significant negative trend.

The 99.9th percentile is very sensitive to meteorological conditions but although a wide range in slopes is observed, there is a general tendency to decrease.

In all cases, the observed trends are in general not statistically significant; more in-depth analysis, e.g. by correcting for meteorological variability, is needed, but the data suggest that the decreasing trend in peak values, observed earlier, has levelled off during the most recent years.

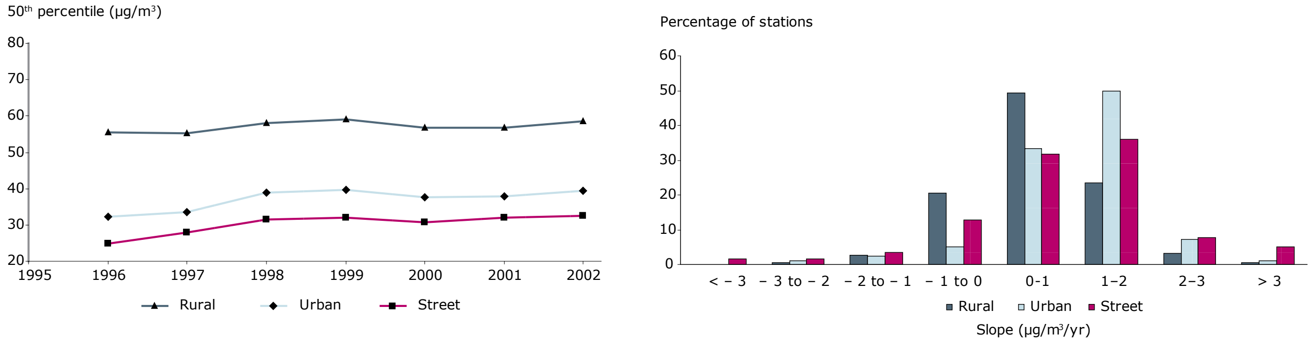
Several reasons can be given for the mixed pattern of ozone trends.

- The steady reduction in ozone precursor emissions seen since 1990 have reduced photochemical production but, at the local scale, reduced NO_x emission may result in higher ozone level caused by less NO titration.
- The hemispheric background concentrations are increasing.
- Increasing temperature may lead to increased photochemistry. Most summers of recent years are in the 'summer top 10'.
- Although total NO_x emissions decrease, there is an increase in direct NO_2 emissions by traffic, as the fraction of diesel engines is increasing. Ozone is produced by photolysis of NO_2. An increasing direct NO_2 therefore leads to increased ozone levels.

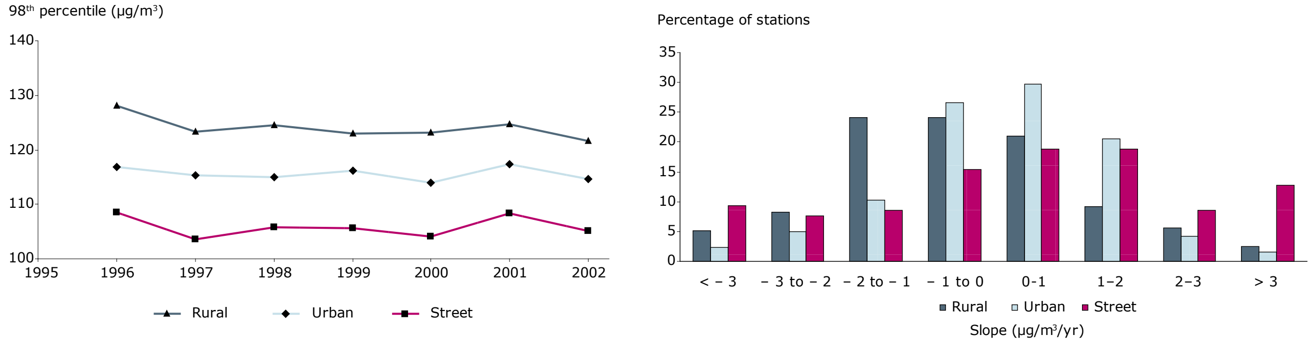
The effects of these processes on ozone trends will have different signs and — depending on the ozone parameter — different magnitude. Further work to reveal ozone trends is needed.

Figure 4.5 Comparison of annual variations in ozone 50th, 98th and 99.9th percentile values (calculated from hourly mean concentrations) and the frequency distribution of estimated trend (in (µg/m³) per year)

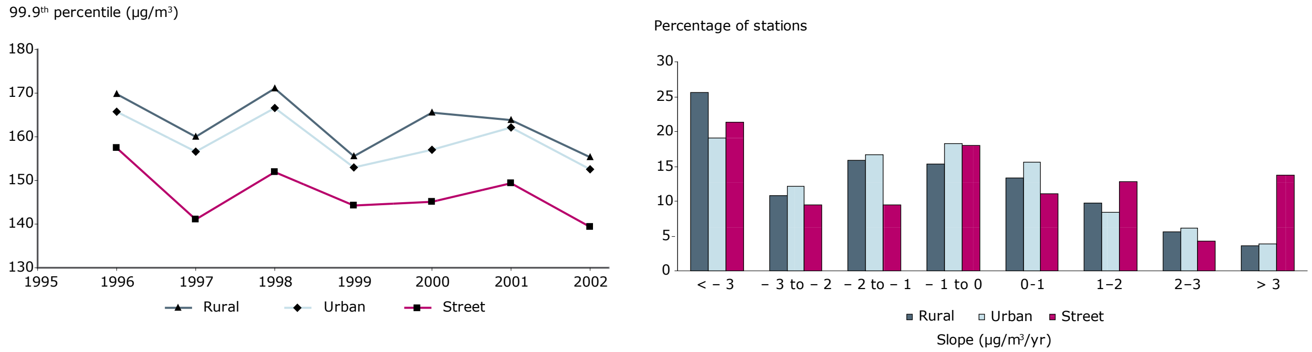
Ozone P50-1h



Ozone P98-1h



Ozone P99.9-1h



Note: Only stations, which reported data over at least six years in the period 1996–2002, are included.

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European Environment Agency
Kongens Nytorv 6
1050 Copenhagen K
Denmark

Tel.: +45 33 36 71 00
Fax: +45 33 36 71 99

Web: www.eea.eu.int
Enquiries: www.eea.eu.int/enquiries

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