Topic report | 13/2001

# Air pollution by ozone in Europe in summer 2001

## Overview of exceedances of EC ozone threshold values during the summer season April–August 2001

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Report to the Commission by the European Environment Agency, European Topic Centre on Air and Climate Change, based on data provided by Member States in the framework of the Council Directive 92/72/EEC on air pollution by ozone by 17 September 2001.

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Luxembourg: Office for Official Publications of the European Communities, 2001

ISBN 92-9167-406-0



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# Contents

# Executive summary

This report gives a first evaluation of the observed exceedances of the ozone public information and warning thresholds during summer 2001 (April–August). According to Council Directive 92/72/EEC on air pollution by ozone, EU Member States have to provide information on ozone levels (statistical parameters, number and duration of exceedances of specified threshold values) on an annual basis before 1 July of the next year. Additionally, exceedances of the threshold values for population information and warning, as set in the directive, must be reported to the Commission within one month after occurrence.

For this report on summer 2001, the deadline for transmitting data was set at 17 September 2001. Nearly all EU Member States provided information on the observed exceedances in time, or indicated that no exceedances had been observed. In addition, 10 other European countries (Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Norway, Poland, Slovakia and Switzerland) provided information on observed exceedances upon the request of the European Environment Agency.

From an evaluation of the exceedances, the following conclusions are drawn for the situation during summer 2001.

- Exceedances of the threshold value for providing information to the population (180 $\mu g/m^3$ for hourly values) have been reported by 11 EU Member States and in five other countries. About 35 % of all stations reported one or more exceedance. The average maximum hourly concentration during an exceedance was 200 $\mu g/m^3$.

- In the reporting period April–August 2001 no exceedance of the threshold value for warning of the population (360 $\mu g/m^3$ for hourly values) has been reported. However, on 21 March 2001 the French station Marignane Ville (a city on the border of Etang de Berre, near Marseille) reported an hourly value above the warning threshold. On the same day various other stations in its direct surrounding reported exceedances of the information threshold.

- Within the European Union and other reporting countries, 1 842 ozone monitoring stations were operational.

An analysis of information on ozone exceedances submitted in the period 1994–99 clearly shows a decreasing trend in the peak values of ozone but an increasing trend in the median concentrations. These findings suggest that European-wide reductions of ozone precursor emissions in the same period lead to a reduction in high ozone concentrations and to a reduced short-term exposure to high ozone values. On the other hand, the increasing median concentrations lead to an increased long-term exposure of the population to ozone.

**Disclaimer**
The information describing the situation during summer 2001 is partly based on non-validated monitoring data and hence should be regarded as preliminary

# 1. Introduction

Ozone is a strong photochemical oxidant, which causes serious health problems and damage to ecosystems, agricultural crops and materials. Human exposure to elevated ozone concentrations can give rise to inflammatory responses and decreases in lung function. Symptoms observed are cough, chest pain, difficulty in breathing, headache and eye irritation. Ozone exposure of ecosystems and agricultural crops results in visible foliar injury and in reductions in crop yield and seed production. For vegetation, a long-term growing season average exposure rather than an episodic (short-term) exposure is of concern. Adverse effects on vegetation can be noted at relatively low ozone levels.

In view of the harmful effects of photochemical pollution in the lower levels of the atmosphere, the European Council adopted Directive 92/72/EEC on air pollution by ozone in 1992. The directive came into force in March 1994. It established procedures for harmonised monitoring of ozone concentrations, exchange of information, communication with and alerting of the population regarding ozone and to optimise the action needed to reduce ozone formation.

Article 6 of the directive specifies how the information on monitoring results must be provided by the Member States to the Commission. Regarding the time frame, two main types of reporting can be distinguished. Information on exceedances of the so-called information threshold (Article 6 sub 2) and warning threshold (Article 6 sub 3) for ozone concentrations is to be provided within one month after occurrence. Information on exceedances of all threshold values given in Article 6 must be provided within six months following the annual reference period (Article 6 sub 1). Article 7 of the directive stipulates that the Commission shall at least once a year evaluate the data collected under the directive. The present report gives an overview on the situation during summer 2001. Similar overviews for the period 1994–2000 have been prepared by the former European Topic Centre on Air Quality (previous reports are available from the EEA website: http://www.eea.eu.int/).

Ozone concentrations, potentially harmful for human health or ecosystems, are observed over the whole of Europe. Formation of ozone takes place at various spatial and time scales: the high emission density of reactive precursors in urban areas might lead to high ozone levels within the city or at short distances downwind. But ozone precursors may also be transported over distances of hundreds to thousands of kilometres, resulting in ozone formation far from the sources. To improve the insight on current ambient ozone concentrations over Europe, countries outside the European Union have been requested by the European Environment Agency (EEA) to provide information on ozone exceedances in line with the ozone directive.

The data reported here does not cover all ozone monitoring stations in the European Union. To be included in this report, the data must satisfy certain criteria stipulated in the directive, concerning *inter alia* measuring methods, sampling methods, station siting, quality assurance and documentation. Formats on the transfer of data have been defined by the expert group on photochemical pollution. This group, established by the Commission following Article 7 of the directive, had several meetings to coordinate the work within the Member States and the Commission.

A revision of the ozone directive is in preparation. In this proposed directive (EU, 2001) target values and long-term objectives for protection of human health and vegetation have been defined which differ from the values set in the current directive. In the 1997 annual report under the directive (De Leeuw et al., 1999) an attempt was made to evaluate the ozone data submitted under the current directive against the targets and long-term objectives proposed in the new ozone directive. This analysis showed that, due to the differences in the definition of the thresholds, the information collected under the current directive is not adequate to assess exceedances of the newly proposed ozone thresholds (1). In the proposed directive the information threshold is defined similar to the current directive as 1h average values of 180 $\mu g/m^3$. The proposed directive further defines an alert threshold of 240 $\mu g/m^3$ as 1h average and stipulates that for the implementation of short-term action plans (as described in Article 7) the exceedance of the threshold should be measured (or predicted) for three consecutive hours. The available information allows an evaluation of the occurrence of exceedance of the alert threshold but it is insufficient to evaluate whether ozone concentrations are above the alert threshold during three consecutive hours.

(1) The main difference between the current and the proposed directive is the time averaging. In the current directive the eight-hourly average concentrations are calculated four times a day from the eight hourly values between 0 and 8.00, 8.00 and 16.00, 16.00 and 24.00, 12.00 and 20.00. In the proposed directive the maximum daily eight-hour running average is used. In the current directive the threshold for protection of vegetation is defined as a daily averaged value; in the proposed directive, the value is calculated as AOT40, that is, the sum of the difference between hourly concentrations greater than 80 $\mu g/m^3$ ( = 40 ppb) and 80 $\mu g/m^3$over a three-month period (May–July) using only the one-hour values measured between 8 a.m. and 8 p.m.

# 2. Data reporting

## 2.1. Introduction

According to the ozone directive, EU Member States have to provide the following information for the annual reference period:

- maximum, median and 98 percentile value of one-hour and eight-hour average ozone concentrations;

- location, date and duration of periods during which threshold values as presented in Table 2.1 are exceeded and the maximum concentrations recorded during each occurrence.

In addition to this annual report based on validated data, Member States must inform the Commission on a monthly basis in case exceedances of the information and warning threshold values are observed. In this report a first assessment is made of the 2001 summer season, based only on the exceedances of the population information and warning thresholds for ozone, which were transmitted by the Member States after the end of each month. An evaluation of the data reported on an annual basis will be included in a forthcoming EEA report on air quality in Europe, which additionally covers the information collected under the EU Exchange of Information Decision (97/101/EC).

**Threshold values for ozone concentrations (in $\mu g/m^3$; ref 92/72/EEC)** Table 2.1.

| Threshold for: | Concentration | Averaging period |
|---|---|---|
| Health protection | 110 | 8 h |
| Vegetation protection | 200 | 1 h |
| Population information | 65 | 24 h |
| Population warning | 180 | 1 h |
| | 360 | 1 h |

A group of experts from the Member States has followed the practical implementation of the directive. Among other items this group discussed procedures for data reporting. The formats for information and data exchanges have been defined in document 'Council Directive 92/72/EEC on air pollution by ozone. Information and data exchange/formats', Doc.Rev. 11/243/95. In general terms, the requested information consists of two parts:

- information on stations and measurements techniques (Ozone Directive, Article 4.2, indents 1 and 2);

- information on ozone concentration: annual statistics and threshold exceedances (Ozone Directive, Article 6.1).

Based on the experiences in processing the data for the 1994 annual report, the European Topic Centre on Air Quality (ETC/AQ) provided remarks concerning data transmission and suggestions for improvement which were discussed in the expert group on photochemical pollution. Considering the increasing amount of data requiring processing, as well as the improvement in the transfer of data relating to the implementation of the directive, the Commission has prepared an update (April 1996) of the data exchange format. The major changes concern the transfer of additional information:

- type of station: definition of the location of stations as recommended in the decision on exchange of information;

- altitude of stations as recommended by the expert group;

- $NO_x$ and VOC data, according to Annex 2.3 of the ozone directive;

- file names: it is recommended to define unique names for all files in order to improve the management and transfer of the data files.

After 1996 no further modifications in data requirements and data exchange formats have been made. Non-EU countries were requested to submit their data in agreement with these data exchange formats. Information submitted using the air quality DEM (*date exchange module,* a software tool developed by ETC/AQ (see e.g. Sluyter and Schoorl, 1999) to facilitate data flows under the exchange of information decision) is accepted as well.

## 2.2. Data reported over summer 2001

According to the directive, exceedances of the population information and warning thresholds are to be transmitted to the Commission within one month following the observations.

For this report on summer 2001, the deadline for transmitting data was set at 17 September 2001. Data were timely reported by 14 of the 15 EU Member States. Information on the situation in France was received on 4 October 2001; updated information on the situation in Luxembourg and Spain was received on 11 October. As far as possible the information received after the deadline was included in this report. The data sets of two other Member States (Greece, Luxembourg) showed no information for two months. This does not necessarily imply that information on exceedances is missing. If during a month no exceedances have been observed, there is no obligation to inform the Commission on this. In such cases, however, most Member States confirm that no exceedances have been observed. In addition to the information from Member States, 10 other European countries (Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Norway, Poland, Slovakia and Switzerland) reported on the summer ozone situation. This information has been included in the report. It is greatly appreciated by the Commission and EEA that most countries were able to transmit August exceedance data before the formal deadline as set in the directive.

As in the last four years (1997–2000), Ireland and Finland confirmed no exceedance of the 180 $\mu g/m^3$ threshold in 2001. Also in Denmark, Sweden, Bulgaria, Estonia, Latvia, Lithuania and Norway no exceedances were observed. Table 2.2 presents an overview of observed exceedances per country per month. Note that the information used in this report to describe the situation during summer 2001 is partly based on non-validated monitoring data and/or on incomplete information on monitoring networks; hence the results should be regarded as preliminary.

Since only exceedances of thresholds were reported, it is not clear whether stations were operational continuously during summer 2001 (April–August 2001). It is possible that ozone concentrations exceeded a threshold at a site but this was not reported because the monitoring station was temporarily out of operation.

In this report exceedances are counted on a daily basis, that is, a day on which a threshold is exceeded during at least one hour, is counted as one exceedance.

**Table 2.2. Overview of observed exceedances per month per country in 2001**

| | April | May | June | July | August |
|---|---|---|---|---|---|
| **Austria** | – | p | p | P | p |
| **Belgium** | – | p | p | P | p |
| **Germany** | – | p | p | P | p |
| **Denmark** | – | – | – | – | – |
| **Spain** | p | p | p | P | p |
| **Finland** | – | – | – | – | – |
| **France** | – | p | p | P | p |
| **United Kingdom** | – | – | p | P | p |
| **Greece** | p | p | p | x | x |
| **Ireland** | – | – | – | – | – |
| **Italy** | – | p | p | P | p |
| **Luxembourg** | x | x | p | P | p |
| **Netherlands** | – | p | p | P | p |
| **Portugal** | – | p | p | P | – |
| **Sweden** | – | – | – | – | – |
| **Bulgaria** | – | – | – | – | – |
| **Czech Republic** | – | – | p | P | p |
| **Estonia** | – | – | – | – | – |
| **Hungary** | – | – | – | – | p |
| **Lithuania** | – | – | – | – | – |
| **Latvia** | – | – | – | – | – |
| **Norway** | – | – | – | – | – |
| **Poland** | – | – | – | P | p |
| **Slovakia** | – | – | p | P | p |
| **Switzerland** | – | p | p | P | p |

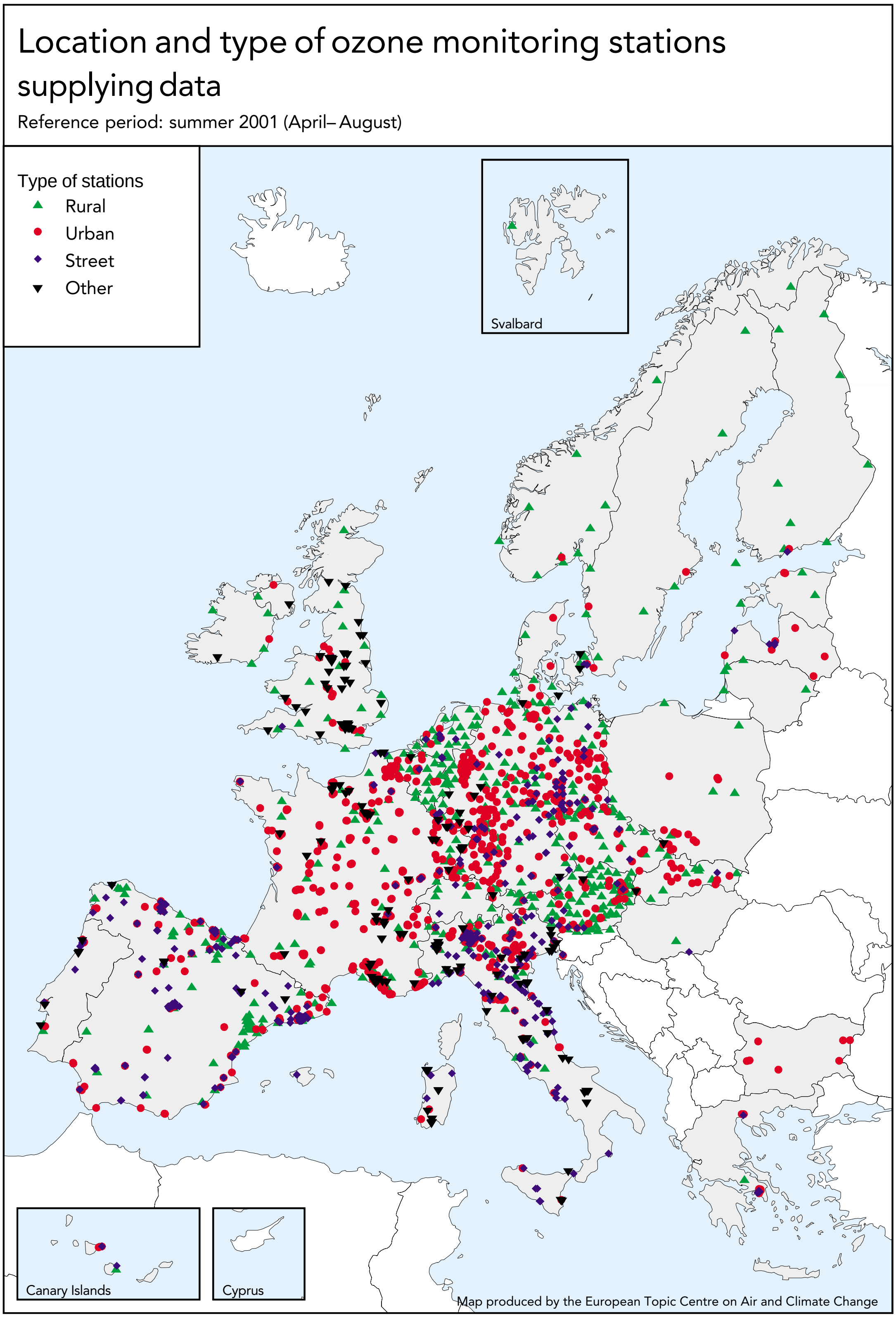
**NB:** p: exceedance of the population information threshold reported,
–: no exceedance reported;
x: no information.

## 2.3. The ozone monitoring network in 2001

About half of the countries provided information on the operational ozone-monitoring network in summer 2001 (number of monitoring stations, coordinates, station type, etc.). For the countries for which no actual information has been submitted, it has been assumed that the network configuration as found for the annual period 2000 is also in place during the summer of 2001.

Map 2.1 presents the location of all ozone monitoring stations assumed to be operational in the reporting counties during the 2001 summer season. In total 1 842 ozone monitoring sites are operational. From these stations 1 686 stations are located within the EU. A total of 444 stations are situated in rural areas, 811 stations in urban environments, 397 are classified as street stations and 190 stations were characterised as an industrial station or the monitoring environment was not specified. The number of stations is higher than in previous years, mainly because of the reporting of French stations.

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 the reference period 2001. For those countries for which no actual information on the network configuration in 2001 was received, it has been assumed that the configuration as found for 2000 was also in place during summer 2001**



# 3. Information from reported data for summer 2001

## 3.1. Summary of exceedances reported

The threshold value for warning the public (1h > 360 µg/m$^3$) was exceeded on 21 March at the French station Marignane Ville (maximum concentration 387 µg/m$^3$). Marignane is located in southern France, along the Etang de Berre not far from Marseille. On 21 March there was a local, one-day episode in the Fos-Berre region: eight other stations at distances of less than 25 km around Marignane Ville reported concentrations above 180 µg/m$^3$. During the reporting period April–August 2001 no further exceedances of the warning threshold have been reported for the European territory although the threshold value was reached, that is, highest concentration = 360 µg/m$^3$, at one station in Spain. In the annual reports for 2000, only Italy reports exceedances on three occasions at two stations of this threshold; in 1999 exceedances were observed in Spain (five stations), in Italy (one station) and in Bulgaria (two stations). Both the Spanish and Bulgarian data shows extremely high values at unexpected times so that measuring artefact and/or interference with other chemicals cannot be excluded.

Table 3.1 presents a general overview of the observed exceedances of the threshold for informing the public (1h > 180 µg/m$^3$) during the period April–August 2001 per country. Since the number of stations differs widely from country to country, the absolute number of exceedance days is not suitable for comparison of the situation in different countries. Therefore, the concept of 'occurrence of exceedance' has been introduced. Occurrence of exceedance is defined as the average number of observed exceedances per country, that is, the total number of exceedances for all stations divided by the total number of operational stations. Although this parameter is more comparable between countries, the differences in network, in particular, the ratio between street, urban and rural stations, limits a direct comparison.

With respect to EU Member States, in Denmark, Finland, Ireland and Sweden no exceedances of the 180 µg/m$^3$ threshold value were observed. Ireland and Finland have not reported any exceedance during the last five summer seasons (1997–2001). From the other countries, Bulgaria, Estonia, Lithuania, Latvia and Norway did not observe exceedance of the population information threshold.

For those countries, which reported exceedances, the number of exceedance days ranged from 2 to 80. During the April–August period of 153 days, during 101 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 4.8 exceedances were observed this summer at stations which recorded at least one exceedance. The average maximum hourly concentration during an exceedance of the threshold is 200 µg/m$^3$.

Table 3.1. **Summary of exceedances of the threshold for information of the public (1h ozone concentration > 180 μg/m³) during summer 2001 (April–August) on a country by country basis**

| | No of stations (2) | No of stations with exceedance | No of days with excee-dances (3) | Maximum observed concentr. (μg/m³) | Averaged maximum concentr. (μg/m³) (4) | Occurrence of excee-dances (5) | Average duration of exceedances (hour) |
|---|---|---|---|---|---|---|---|
| **Austria** | 121 | 46 (38 %) | 18 | 249 | 192 | 0.7/1.8 | 2.2 |
| **Belgium** | 33 | 24 (73 %) | 15 | 250 | 196 | 2.0/2.7 | 2.5 |
| **Germany** | 367 | 205 (56 %) | 33 | 299 | 196 | 2.2/3.9 | 2.9 |
| **Denmark** | 11 | 0 (0 %) | 0 | <180 | <180 | | |
| **Spain** | 293 | 64 (22 %) | 48 | 360 | 200 | 0.6/2.9 | 1.9 |
| **Finland** | 11 | 0 (0 %) | 0 | <180 | <180 | | |
| **France** | 368 | 167 (73 %) | 58 | 328 | 201 | 2.7/5.9 | 2.7 |
| **United Kingdom** | 75 | 21 (28 %) | 9 | 234 | 194 | 0.5/1.6 | 2.7 |
| **Greece (1)** | 13 | 6 (46 %) | 12 | 273 | 205 | 1.9/4.2 | 2.0 |
| **Ireland** | 6 | 0 (0 %) | 0 | <180 | <180 | | |
| **Italy** | 314 | 59 (19 %) | 80 | 353 | 203 | 2.5/13.1 | 3.5 |
| **Luxembourg (1)** | 5 | 3 (60 %) | 12 | 200 | 188 | 3.8/6.3 | 3.5 |
| **Netherlands** | 38 | 20 (53 %) | 9 | 223 | 195 | 1.2/2.3 | 2.5 |
| **Portugal** | 22 | 7 (32 %) | 10 | 358 | 215 | 0.9/2.9 | 1.0 |
| **Sweden** | 9 | 0 (0 %) | 0 | <180 | <180 | | |
| **Bulgaria** | 7 | 0 (0 %) | 0 | <180 | <180 | | |
| **Switzerland** | 13 | 9 (69 %) | 32 | 290 | 200 | 4.8/7.0 | 3.0 |
| **Czech Republic** | 56 | 12 (21 %) | 7 | 205 | 188 | 0.3/1.5 | 1.9 |
| **Estonia** | 5 | 0 (0 %) | 0 | <180 | <180 | | |
| **Hungary** | 2 | 1 (50 %) | 1 | 196 | 196 | 0.5/1.0 | 2.0 |
| **Lithuania** | 3 | 0 (0 %) | 0 | <180 | <180 | | |
| **Latvia** | 13 | 0 (0 %) | 0 | <180 | <180 | | |
| **Norway** | 14 | 0 (0 %) | 0 | <180 | <180 | | |
| **Poland** | 20 | 2 (10 %) | 2 | 182 | 182 | 0.1/1.0 | 1.0 |
| **Slovakia** | 23 | 3 (13 %) | 5 | 256 | 201 | 0.2/1.7 | 2.9 |

(1) Incomplete information received.
(2) Number of stations implemented in the framework of the ozone directive.
(3) The number of calendar days on which at least one exceedance was observed.
(4) Average of all maximum concentrations recorded during exceedances.
(5) Left figure: averaged over all implemented stations, right figure: averaged over all stations.

Table 3.2 summarises the exceedances on a monthly basis. There is a general maximum in the number of exceedances during the three months June to August; almost on every day an exceedance was observed at at least one of the reporting stations.

Table 3.2.

**Summary of exceedances of the threshold for information of the public (1h ozone concentration > 180 µg/m³) during summer 2001 (April–August) on a month by month basis**

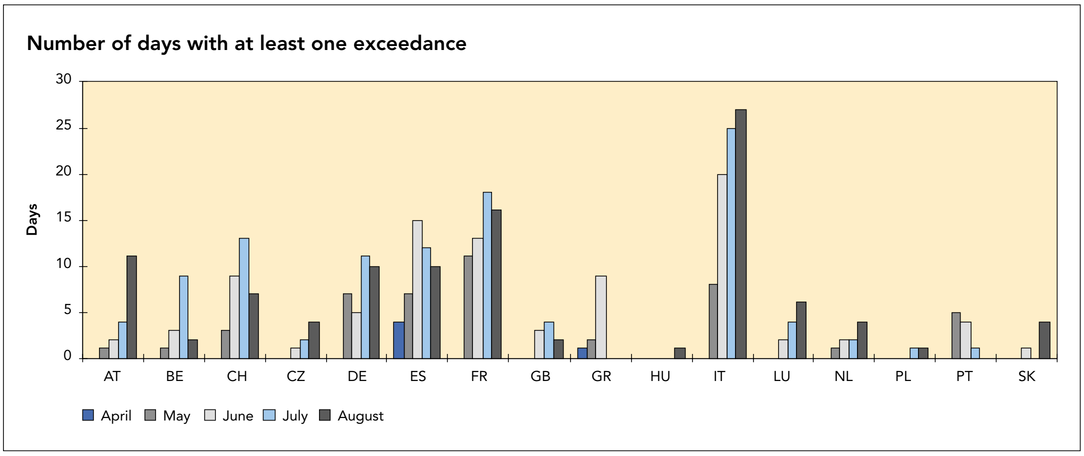
| | No of stations with exceedances (¹) | Maximum observed concentration (µg/m³) | Averaged maximum concentration (µg/m³) (²) | Occurrence of exceedances (³) | | Average duration of exceedances (hr) |
|---|---|---|---|---|---|---|
| **April** | 4 | 242 | 199 | 0.0 | 1.5 | 1.2 |
| **May** | 114 | 358 | 202 | 0.1 | 1.8 | 2.0 |
| **June** | 420 | 299 | 199 | 0.4 | 1.9 | 3.0 |
| **July** | 391 | 324 | 198 | 0.6 | 2.7 | 2.8 |
| **August** | 374 | 360 | 201 | 0.6 | 2.8 | 3.0 |

(¹) The theoretical maximum is 1 842 stations (all stations which are assumed to be operational in the reporting European countries during summer 2001); at 649 stations one or more exceedance has been observed.
(²) Average of all maximum concentrations recorded during exceedances.
(³) Left figure: averaged over all stations in operation, right figure: averaged over all stations which reported at least one exceedance.

Figure 3.1 presents the number of days per month on which at least one station in a country recorded an exceedance. The seasonal behaviour seen in Table 3.2 is, in general terms, reflected in this figure although for individual countries large temporal variations can be seen.

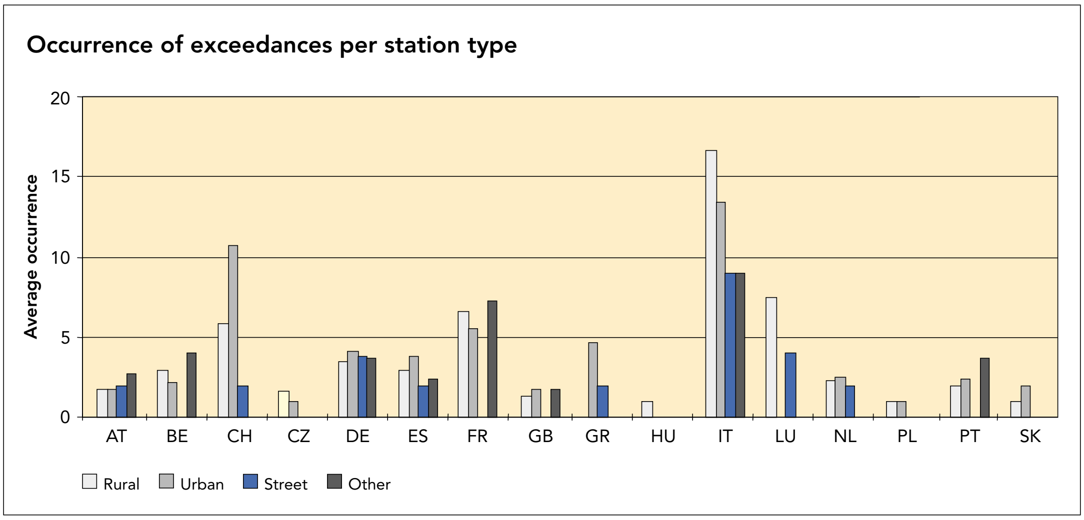
Figure 3.1.

**Number of days on which at least one exceedance of the threshold value for information of the public (1h ozone concentration > 180 µg/m³) was observed per country (²) and per month during summer 2001. Countries confirming that no exceedances were observed are not shown**




(2) In all figures the countries have been identified using the ISO 3166-1:1997 Alpha-2 code.

Figure 3.2. **Average occurrence of exceedances (in days) of the threshold for information of the public (1h ozone concentration > 180 µg/m³) by station type (rural background, urban background, street and other) and country during summer 2001. Countries confirming that no exceedances were observed are not shown**

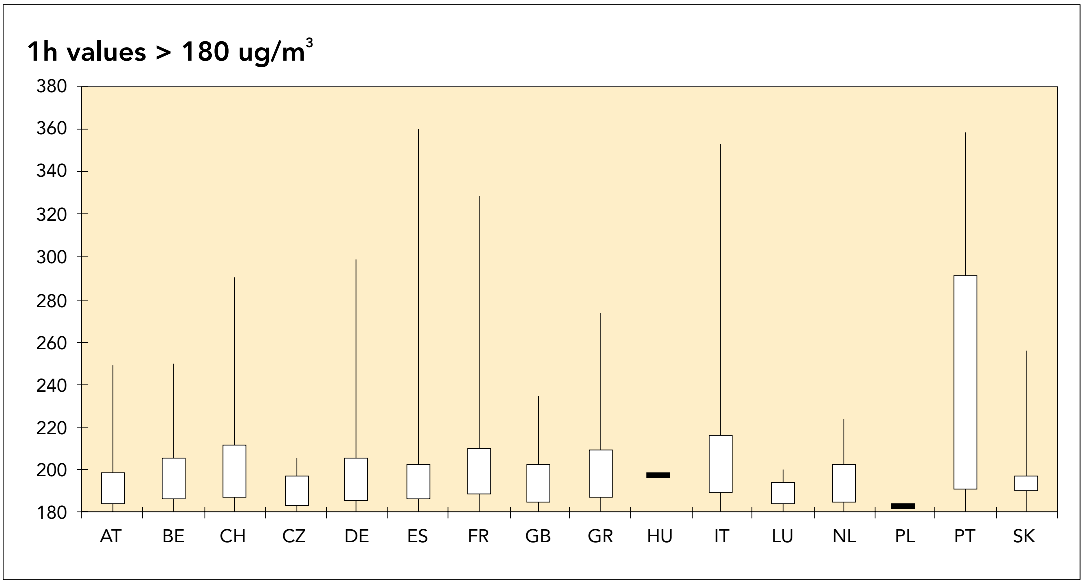



The average occurrence of exceedances (in days) in each country of the threshold for information of the public by station type (rural, urban, street and other) is presented in Figure 3.2. According to ozone phenomenology, the average occurrence rate is expected to decrease in general in the order rural background — urban background — street. For some countries, this decrease is apparent. In other countries, this relation is not visible or even contradicted.

Figure 3.3 on the next page shows the frequency distribution of hourly ozone concentrations in excess of the threshold value using Box-Jenkins plots. For each Member State the Box-Jenkins plot indicates the minimum (here the minimum is 180 µg/m³), maximum, 25 percentile and 75 percentile value of the exceedances. The figure shows that during 25 % of all observed exceedances, the maximum hourly concentration recorded was just above the180 µg/m³ threshold. 75 % of all maximum concentrations during exceedances recorded in the EU were below 208 µg/m³, which is comparable to the 75 percentile during summer 2000 (207 µg/m³).

**Top: Frequency distribution of ozone concentrations in excess of the 180 mg/m³ threshold for hourly values (April–August 2001). Frequency distributions are presented as Box-Jenkins plots indicating the minimum, the 25-percentile, the 75-percentile and the maximum value. Countries reporting no exceedances are not shown. Bottom: total number of exceedances (Ex) and number of reporting stations (St) per country (ISO 3166-1:1997 Alpha-2 code)**

Figure 3.3.




| | AT | BE | BG | CH | CZ | DE | DK | EE | ES | FI | FR | GB | GR | HU | IE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ex | 81 | 65 | 0 | 63 | 18 | 800 | 0 | 0 | 183 | 0 | 985 | 34 | 25 | 1 | 0 |
| St | 46 | 24 | | 9 | 12 | 205 | | | 64 | | 167 | 21 | 6 | 1 | |

| | IT | LT | LU | LV | NL | NO | PL | PT | SE | SK |
|---|---|---|---|---|---|---|---|---|---|---|
| Ex | 773 | 0 | 19 | 0 | 46 | 0 | 2 | 20 | 0 | 5 |
| St | 59 | | 3 | | 20 | | 2 | 7 | | 3 |

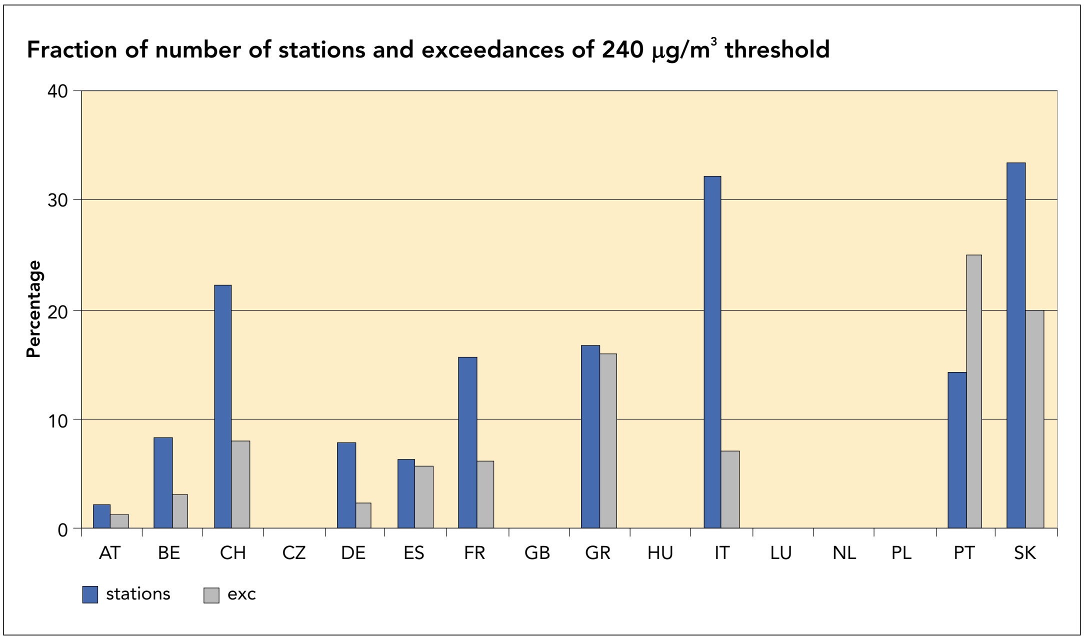
The reported information on exceedances of the information threshold is used to analyse the number of exceedances of the alert threshold (240 µg/m³) as proposed in the revision of the ozone directive. On average at 10 % of the stations, which report an exceedance of the 180 µg/m³ threshold, an exceedance of the 240 µg/m³ alert threshold is observed. In total 166 exceedances of the alert threshold are counted, that is, during about 5 % of the reported exceedances the maximum concentration reached a level above 240 µg/m³. The ratio of the number of exceedances of the 180 µg/m³ level and the number of exceedances of 240 µg/m³ thresholds varies strongly across the reporting countries, see Figure 3.4. The situation at a national level (number, location an type of stations, local meteorological conditions) will be an important factor in determining this ratio; the figure suggests a higher ratio for the more southern European countries.

## 3.2. Geographical distribution

Maps 3.1 and 3.2 show the geographical distribution of the number of days on which the threshold value for information of the public was exceeded for urban (3) and rural stations, respectively (4). Exceedance data for urban stations are presented as dots. The exceedance data for rural stations are interpolated using simple inverse distance weighting and a tentatively estimated 'radius of representativeness' of 100 km. Note that this radius actually might be different for the various regions in Europe.

(3) Exceedances reported from stations of unspecified type are also plotted in this map.
(4) Stations assumed to be operational but for which no data were transmitted are drawn in the maps with 'zero exceedances observed'. For most countries/stations this will be true, but this cannot be guaranteed because it is possible that exceedances were observed but not yet communicated. As a result, the number of stations/area with no exceedances observed could be slightly over-estimated.

Figure 3.4. **Number of stations and number of reported exceedances of the alert threshold (proposed directive, 240 mg/m³) expressed as percentage of the number of stations and number of reported exceedances of the information threshold (current directive, 180 mg/m³), respectively; summer 2001; countries reporting no exceedances of the 180 mg/m³ threshold are not shown**

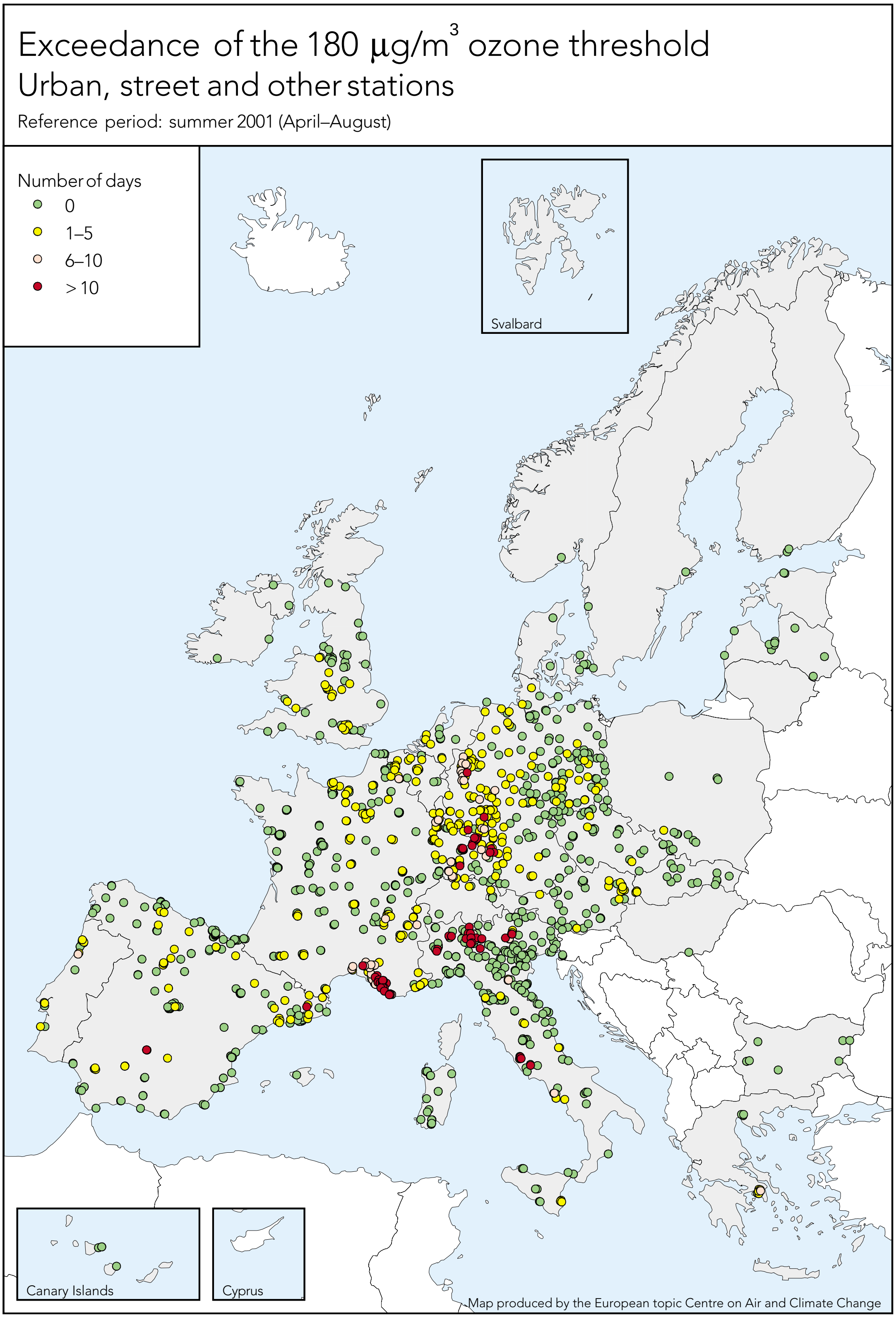



The geographical distribution of exceedances observed in summer 2001 at urban stations and stations of unspecified type in northern and western Europe follows the pattern observed in most previous summer seasons. The number of exceedances rises from zero in the Scandinavian countries, Baltic States and Ireland to a maximum in central Europe. No consistent spatial pattern is apparent in the Mediterranean region. Here, many stations did not report exceedances, while other stations reported more than 10 exceedances.

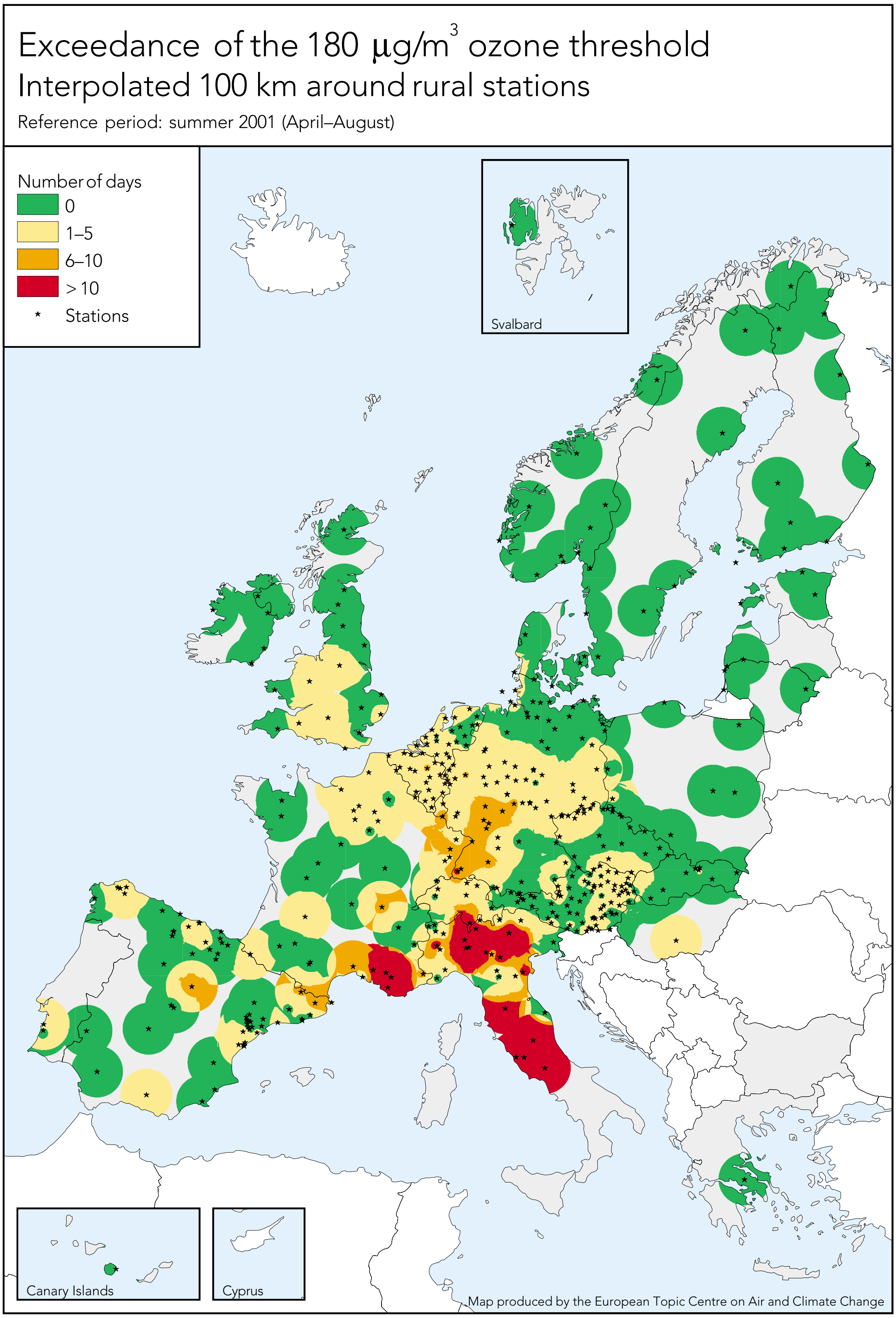
The spatial pattern of exceedances observed in summer 2001 at background stations (interpolated field), follows the pattern observed in most previous summer seasons. The highest number of exceedances is observed in southern France, the Po Valley and central Italy. However the number of background stations in a number of countries is by far not sufficient to draw any conclusions on the background ozone concentration field.

Number of exceedances of the threshold value for the information of the public (1h ozone concentration > 180 µg/m³) observed at urban/street stations and stations of unspecified type in the EU and other countries, summer 2001 (April–August)

Map 3.1.



Map 3.2. **Number of exceedances of the threshold value for the information of the public (1h ozone concentration > 180 µg/m³) observed at background station, summer 2001 data (April–August), interpolated using inverse distance weighting, cut-off distance of 100 km**



## 3.3. Main ozone episodes

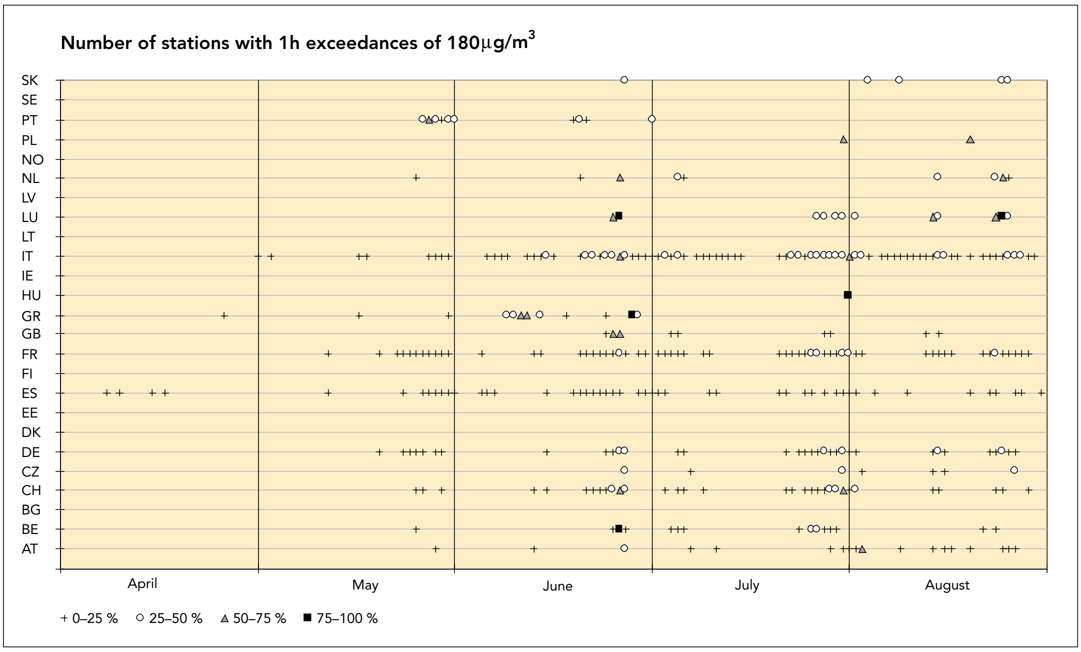
Ozone formation and destruction is dependent on emissions, concentrations and ratios of precursors (mainly VOC, $NO_X$, and CO), and on the amount and intensity of sunlight. Important in this respect is the role of nitrogen oxide emissions. In urban areas, ozone concentrations may be lower than the rural ('background') concentrations due to chemical scavenging by local nitrogen oxide.

Episodes, periods with elevated ozone levels, mainly occur during periods of warm sunny weather. In Mediterranean countries, with prolonged spells of hot and sunny weather during the summer, ozone can quickly be formed and high concentrations can occur on many days and in the vicinity of urban centres. In northern Europe the build-up of ozone is slower due to the more moderate weather conditions. Here, the highest levels are usually found downwind of cities. Figure 3.6 presents a graphical representation of the percentage of stations that reported exceedances of the threshold value for population information (180 $\mu g/m^3$ for hourly values) during the 2001 summer season ([5]).

In southern European countries exceedances are observed already in April and early May. In June, July and August exceedances are observed all over Europe except in the most northern parts. As mentioned before, weather conditions are important for the occurrence or non-occurrence of ozone episodes. An 'anti-episode' can be seen in the third week of July (16–20 July): no exceedances are observed at any of the stations. On the other hand, the geographically most extended episode occurred in the last week of June (24–27 June). An overview of the sites where exceedances were observed during this four-day period is presented in Map 3.3. In the beginning of this period a strong high-pressure cell was located over central Europe with a second cell above the North Sea. A period of warm, sunny and stable weather set in over northern and western Europe. A low-pressure area was formed on 25 June over Spain. This low-pressure system slowly travelled in a northern direction and reached Ireland on 27 June. Relatively clean Atlantic air was transported to the north-west European countries and this initiated the end of the episode.

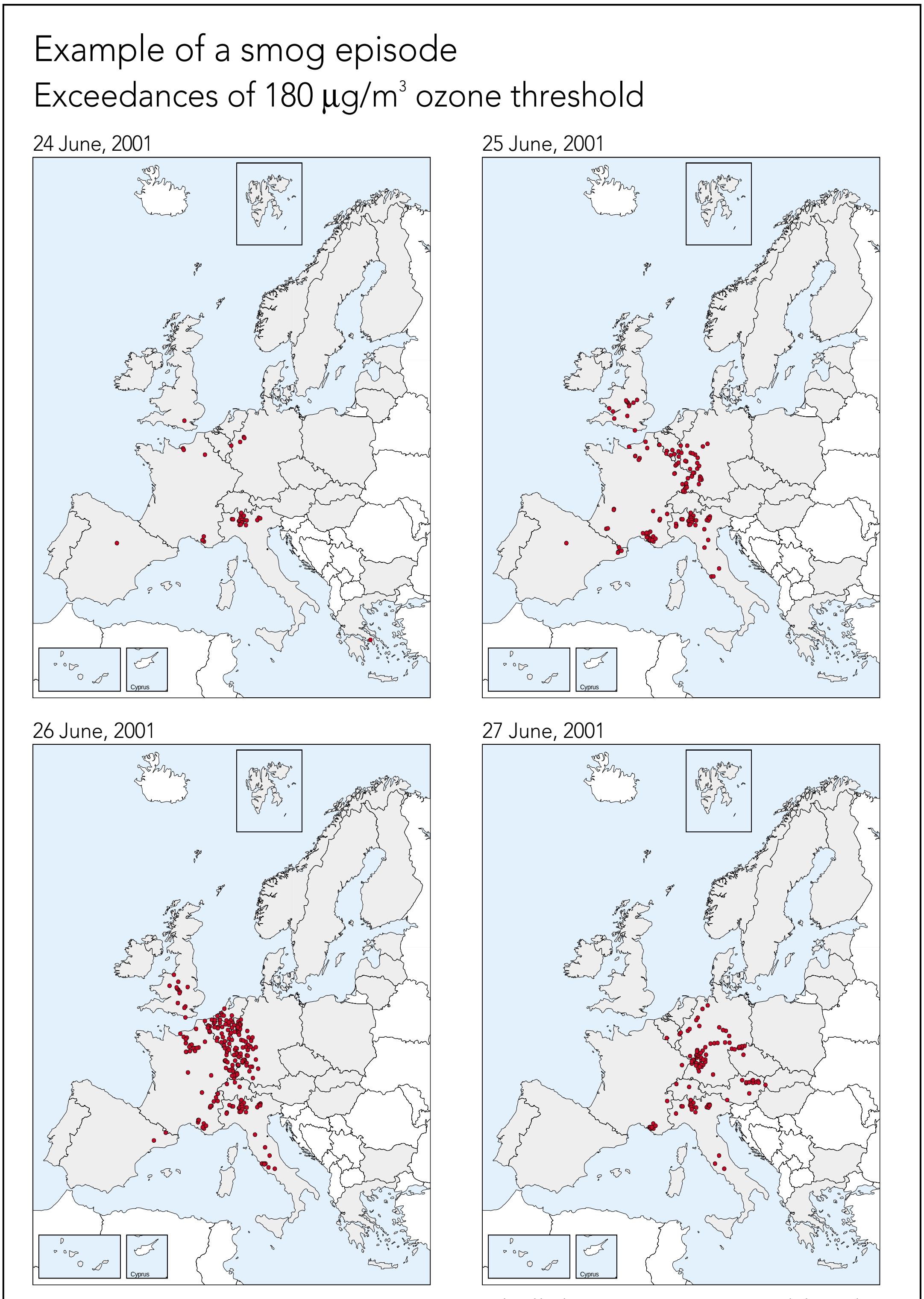
**Qualitative overview of exceedances of the 180 µg/m³ population information threshold value for ozone during the period April–August 2001. The symbols represent the percentage of stations, which observed at least one exceedance of the threshold during a particular day**

Figure 3.6.




(5) A table indicating per day and per country the number of stations where the information threshold has been exceeded is available upon request.

Map 3.3. **Example of a smog episode: stations which reported an hourly ozone concentration in excess of 180 µg/m³, 24–27 June 2001 (all station types)**




Maps produced by the European Topic Centre on Air and Climate Change

# 4. Comparison with previous years

## 4.1. Comparison with the information submitted for previous years

Exceedances observed in the EU during the 2001 summer period were compared to exceedances observed during 1995–2000. In Figure 4.1 a comparison of the average exceedance duration, the average occurrence and the average maximum concentrations during these years is presented. Note that for the period 1995–99, information is available for 12 months per year whereas for 2000–01 data is available for only five months.

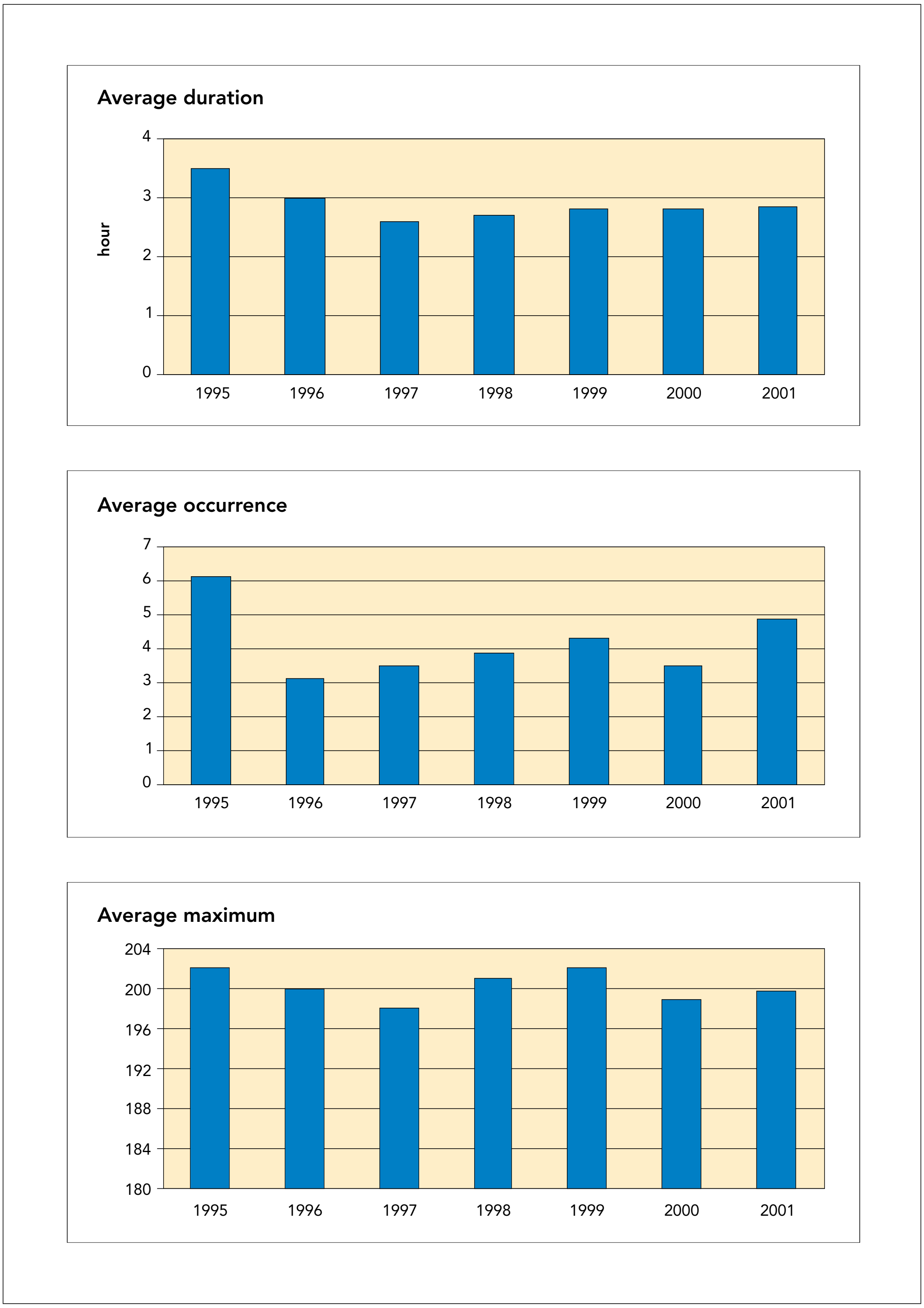
The year-to-year fluctuations reflect to a large extent the quality of the European summer, which was in 2001 in most areas better than in 2000. Compared to 2000, peak ozone concentrations tend to occur more frequently and during longer periods but the maximum concentrations are not increasing. However, it is not possible to derive from this any conclusion on a significant trend, duration and severity of exceedances. Another factor concealing a possible trend is the variability in the underlying ozone monitoring network. Over the year the number of reporting stations and hence the territorial coverage has increased strongly. This increase is not consistent over all countries and a bias might be introduced here. Moreover, the ratio between the number of stations located in urban and rural areas has changed over the year and in some years information from one or two large Member States is missing. Finally, it has been noted that within a country, the configuration of monitoring network is not constant and may show large variation in number and location of stations.

Detection of possible ozone trends calls therefore for a more in-depth analysis using the information on a station-by-station basis. Such a trend study has been performed based on the information on exceedances and on percentile concentrations submitted under the ozone directive since 1994.

## 4.2. Trends in ozone concentrations

In a recent study the data submitted under the ozone directive up to the annual period 1998 was re-analysed (de Leeuw, 2000). Applying the methodology described by De Leeuw (2000) on an extended data set covering the years 1994–99, the data have been analysed for a possible trend in statistical parameters (50- and 98-percentiles) and number and severity of exceedances of threshold values defined in the current ozone directive. Time series are rather short but the data suggests that there might be a small increasing trend in the 50 percentile values. The peak ozone concentrations, expressed as 98-percentiles or as number of exceedance days tend to decrease in the period 1994–99. However, these conclusions must be interpreted carefully since on the short time scales considered here meteorological inter-annual variations might play an important role. The decrease in peak ozone concentrations is most likely caused by the decrease in European ozone precursor emissions since 1990. Possible explanations for the increasing 50-percentile values are an increase in tropospheric ozone background values caused by a worldwide increase in $CH_4$, CO and $NO_x$ emissions and a reduced ozone titration by reduced $NO_x$ emissions at the local scale. The data submitted to date under the ozone directive is insufficient to provide firm conclusions on this point.

Figure 4.1. Average duration in hours of exceedances (top), average number of occurrences of exceedances at stations (middle) which reported at least one exceedance and average maximum ozone concentration (mµ/m³) observed during exceedances (bottom); EU-15 stations only




An overview of the 1994–99 statistical analysis is presented in Table 4.1.

The data collected under the directive does not allow the detection of different trends at different type of stations (street, urban background, rural). A more in-depth analysis using the hourly information on ozone concentrations stored in AirBase is underway and will be reported in subsequent EEA publications.

Table 4.1.

**Summary of trend evaluation of 50 and 98 percentiles of hourly average ozone concentrations and of number of exceedance days of the threshold levels of 180 µg/m³ (1h), 110 µg/m³ (8h) and 65 µg/m³ (24h); monitoring period 1994–99**

| | 50 P | 98 P | 180 µg/m³ (1h) | 110 µg/m³ (8h) | 65 µg/m³ (24h) |
|---|---|---|---|---|---|
| Number of reporting stations | 1 585 | 1 585 | 1 701 | 1 488 | 1 580 |
| Number of stations with four or five monitoring years | 685 | 685 | 713 | 647 | 650 |
| Number of stations with significant upward trend | 120 | 6 | 4 | 16 | 50 |
| Number of stations with significant downward trend | 12 | 138 | 118 | 122 | 64 |
| Number of stations in compliance with threshold during the period 1994–99 | | | 96 | 4 | 0 |

# 5. Conclusions

This report presents a first evaluation of the reported exceedances of the threshold values for information and warning of the public during summer 2001. Information is not necessarily based on validated monitoring data and hence the conclusions drawn should be considered as preliminary.

Information on air pollution by ozone has been received from all EU Member States although for two Member States information for two months is missing. In addition, information has been received from 10 non-EU countries. In total 1 842 monitoring stations were assumed to be in operation during this summer in the reporting countries.

The threshold for warning of the public (1h > 360 $\mu g/m^3$) has been exceeded on 21 March 2001 at the French station Marignane Ville (maximum concentration 387 $\mu g/m^3$); during the reporting period April–August 2001 no further exceedances have been reported. The threshold for information of the public (180 $\mu g/m^3$) was exceeded in 14 out of the 25 reporting countries. About one third of the stations (649 stations) reported one or more exceedance. In total, 3 120 exceedances (on average 1.7 exceedance per operational station or 4.8 exceedance per station where at least one exceedance is observed) have been reported. During exceedances, the average maximum hourly concentration was 200 $\mu g/m^3$.

The most widespread ozone episode occurred on 24–27 June 2001.

During summer 2001 the ozone concentrations are slightly higher in comparison to the situation in summer 2000, which reflects the more favourable meteorological conditions for ozone generation in summer 2001. A first analysis of the data submitted under the ozone directive for 1995–2001 summer periods does not reveal any significant trend, probably due to the changes in reporting networks from year to year and the high aggregated level of the submitted data. However, a more in-depth analysis of summer and winter ozone data submitted since 1994 suggests clearly a decreasing trend in peak ozone concentrations (amongst others, the number and severity of exceedances of the180 $\mu g/m^3$ threshold value) but a predominantly increasing trend in median concentrations and both upward and downward trends for the number of exceedances of the 65 $\mu g/m^3$ 24-h threshold value set for the protection of vegetation. These findings suggest that European-wide reductions of ozone precursor emissions in the same period have resulted in a reduced short-term exposure of the population and ecosystems to high ozone values but are less effective in reducing exposure to the low ozone concentrations that have adverse effects on vegetation. Further analyses of ozone trends are underway.

## 5.1. References

De Leeuw F., Sluijter R. and de Paus T., 1999. *Air pollution by ozone in Europe in 1997 and summer 1998*. EEA Topic Report 3/1999, European Environment Agency, Copenhagen.

De Leeuw F.A.A.M., 2000. 'Trends in ground level ozone concentrations in the European Union'. *Environmental Science and Policy 3,* 189–199.

EU (2001) *Common position adopted by the Council with a view to the adoption of a directive of the European Parliament and of the Council relating to ozone in ambient air.* 13114/00, 29 January 2001.

Sluyter R. and Schoorl G, 1999. *AIRBASE data exchange module (DEM), version 2.0,* European Topic Centre on Air Quality, RIVM. Bilthoven.