Topic report No 1/2001

Air pollution by ozone in Europe in 1999 and the summer of 2000

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Preface

This report is based upon data submitted to the European Commission under Directive 92/72/EEC on air pollution by ozone. The Commission had asked the European Environment Agency (EEA) to assist in this reporting. The voluntary submission to the EEA of information on ozone levels by other European countries has made it possible to present an ozone assessment on a wider European scale. The data collection in Phare countries was greatly facilitated by the Phare topic link on air quality. This report was prepared by the European Topic Centre on Air Quality under contract to the EEA and a draft version was presented by the Commission to Member States at the meeting of the Environment Council in October 2000 and at the meeting of the EC Air Quality Steering Group in November 2000.

A major asset of this report is the timeliness of its initial delivery as a draft report to the Commission to present to the countries each autumn. The assessment of ozone episodes in the summer of 2000 was based upon data made available by the end of September 2000, a delay of one to six months, while the normal production time from field measurements to validated assessment reports is rarely less than 18 months. This timely reporting has only been possible with the support of the individual contact points within each Member State and the efficient communication established.

The harmful effects of tropospheric ozone on human health and well-being as well as damage to ecosystems is now recognised as a major concern throughout the European Union. The European Community has taken steps to address the problem through Directive 92/72/EEC on ambient ozone, Directive 96/62/EEC on ambient air quality assessment and management (the air quality framework directive), and development of an 'ozone daughter directive', as well as the decision to develop a Community strategy for the reduction of ozone pollution.

The measures necessary to abate pollution remain however a responsibility of each Member State and require political decisions with cost implications and consequences for the development of activities in the society. In this political process, objective and reliable information on the extent and severity of the issue is essential.

It is the intention of the EEA to continue yearly reporting and assessment of ground level ozone in Europe in close cooperation with the European Commission, EU Member States and other countries.

Gordon McInnes
Programme manager

Summary

This report summarises the annual information on ozone monitoring stations and exceedances of ozone threshold values during 1999 and gives a first evaluation of the observed exceedances of the thresholds during the summer of 2000 (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 informing and warning the population, as set in the directive, must be reported to the Commission within one month after occurrence.

The analysis for the year 1999 presented in this report is based on information made available not later than 18 August 2000. By then, information for the calendar year 1999 had been received from all Member States and, on a voluntary basis, from 12 other European countries (Bulgaria, Czech Republic, Estonia, FYROM, Hungary, Latvia, Lithuania, Norway, Poland, Slovakia, Slovenia and Switzerland).

For the summer of 2000, the deadline for transmitting data was set at 18 September 2000. All 15 EU Member States provided information on observed exceedances in time, or indicated that no exceedances were observed. In addition to the information from Member States, 11 other European countries (Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Norway, Poland, Slovakia, Slovenia and Switzerland) reported on the summer ozone situation. This information has now been included in this report.

From an evaluation of the exceedances and annual statistics, the following conclusions are drawn.

- In 1999 the threshold value set for the protection of human health (110 μg/m^3 for 8h average concentrations) was exceeded substantially in all reporting countries ([1]). On average, this threshold was exceeded on more than 24 days per year at each station.
- In 1999 the threshold value of daily average concentrations set for the protection of vegetation (65 μg/m^3) was exceeded substantially (by up to a factor 3), widely (in all reporting countries) and frequently; at 103 stations (about 8 % of the reporting stations) located in 14 different countries exceedances were reported during 200 or more days.
  The threshold value of hourly average concentrations set for the protection of vegetation
  (200 μg/m^3) was exceeded largely and widely (reported by 11 EU Member States and in 5 other European countries) on a limited number of days. On average, 0.6 exceedance days per station were reported for monitoring stations in EU Member States.
- In 1999 the threshold value for providing information to the population (180 μg/m^3 for hourly values) was exceeded during a limited number of days in 19 countries, of which 12 are EU Member States. During the summer of 2000, the number of days on which at least one exceedance was observed in the EU ranged from 3 in Luxembourg and the United Kingdom to 87 in Italy. 29 % of

(1) Two countries did not provide information on exceedances of this threshold. However, based on information on exceedances of hourly thresholds, exceedance of the 8h threshold is most likely.

all stations reported one or more exceedance. On average 3.5 exceedances occurred in the summer of 2000 at stations which recorded at least one exceedance. The average maximum hourly concentration during an exceedance of the threshold in 2000 was 199 µg/m^3.

- In 1999 exceedance of the threshold value for warning the population (360 µg/m^3 for hourly values) was reported from eight stations of which six stations are located in two Member States. At five Spanish stations, of which four are located in the Canary Islands and one in the southern part of Spain, extremely high concentrations were measured, partly during night-time hours. It might be that these high values were caused by possible interference or malfunctioning of the monitoring system. On 20 and 23 June the ozone concentrations at the Italian station Gherardi (about 70 km SSW from Venezia) reached values just above 360 µg/m^3. It appears to be a rather local effect since concentrations at neighbouring stations are much lower. In Bulgaria, two stations (AMS Rakovsky in Dimitrovgrad and AMS Rail Station in Vratza) reported exceedances; some reservation must be made here since peak values were reached during night-time or early morning hours. No exceedance of the warning threshold was reported in the summer of 2000.
- Information on annual statistics (percentile values) and on exceedances of ozone for the year 1999 was received from a total of 1 304 stations within the EU and from 147 stations in other countries. During the summer of 2000 a comparable number of stations was operational.
- Spatial coverage and documentation on monitoring data quality has improved compared to previous reporting periods but still needs further improvement as specified in earlier reports. Depending on the local situation, the ozone monitoring stations are characterised as rural background, urban, street or other (e.g. industrial). Assuming that rural background stations are representative of an area within 50 to 100 km around the station, the present subset of rural background stations covers 35 to 65 % of the EU land area. The geographical coverage of the rural background stations is reasonably adequate in north-west and central Europe but in other regions gaps are noted.

Disclaimer
The information describing the situation during the summer of 2000, presented in this report, is partly based on non-validated monitoring data and hence should be regarded as preliminary.

1. Introduction

Ozone, O_3, is a strong photochemical oxidant. Ozone in ambient air causes serious health problems and damage to materials and ecosystems (EC, 1999). Human exposure to elevated levels of 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. Both laboratory and epidemiological data indicates large variations between individuals in response to episodic ozone exposure, and the effects seem to be more pronounced in children than in adults. Studies indicate that exposure to ozone concentrations in the range 160–360 $\mu g/m^3$ for a period of 1–8 hours — concentrations often observed in ambient air over Europe — reduces various pulmonary functions.

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 averaged exposure rather than an episodic exposure is of concern. Adverse effects on vegetation can be noted at relatively low ozone levels. Within the framework of the UN–ECE Convention on Long-Range Transboundary Air Pollution the critical level ([2]) for ozone is expressed as the accumulated ozone exposure above a threshold of 40 ppb (corresponding with 80 $\mu g/m^3$). Guideline values of this accumulated ozone exposure of 3 000 ppb.h and 10 000 ppb.h are given for crops and forest, respectively. The World Health Organisation Regional Office for Europe (WHO) came forward with similar guidelines (WHO, 1996).

It is known that ozone affects materials such as natural and synthetic rubbers, coatings and textiles. However, there are still today serious gaps in knowledge on the mechanisms of damage, the attribution of ozone to damage in comparison to other factors and the economic evaluation of such damage. As far as it is understood there is no 'no-effect level' of ozone for material corrosion; it is assumed that dose-response relations for materials are linear or nearly linear under ambient conditions. Synergistic effects of ozone in combination with the acidifying components SO_2 and NO_2 have been reported to lead to increased corrosion on building materials like steel, zinc, copper, aluminium and bronze.

In the process of preparing the new 'ozone daughter directive', a comprehensive review of almost all aspects concerning ozone pollution has been carried out by an expert group established by the European Commission. This so-called *Position paper on ozone* was published in autumn 1999 (EC, 1999).

In view of the harmful effects of photochemical pollution in the lower levels of the atmosphere, the 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, for exchange of information, for 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(2)) and warning threshold (Article

(2) Critical levels are defined as concentrations of pollutants in the atmosphere above which direct adverse effects on receptors, such as plants, ecosystems or materials may occur according to present knowledge (Bull, 1991).

6(3)) for the ozone concentration 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(1)). Article 7 of the directive stipulates that the Commission shall evaluate the data collected under the directive at least once a year. The present report gives an overview of ozone monitoring results of 1999 and on the situation during the summer of 2000. Similar overviews for the period 1994–98 have been prepared by the European Topic Centre on Air Quality (previous reports are available from the Internet site of the EEA: http://www.eea.eu.int/).

Harmful ozone concentrations are observed over the whole of Europe. Formation of ozone takes place at various space 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. For improving the insight in current ambient ozone levels 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 in the framework of the directive.

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 1h and 8h average ozone concentrations;
- the number, 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 informing and warning threshold values are observed. In this report, data reported for 1999 on an annual basis will be presented and a first assessment is made of the 2000 summer season, based only on the exceedances of ozone thresholds for informing and warning the population, which were transmitted by the Member States after the end of each month.

Table 2.1: Threshold values for ozone concentrations (µg/m3)

Threshold for:	Concentration	Averaging period
health protection	110	8h
vegetation protection	200	1h
	65	24h
informing the population	180	1h
warning the population	360	1h

A group of experts from the Member States have 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 the 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), first and second indents);
- 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 of 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 Decision 97/101/EC on the exchange of information;

- altitude of stations as recommended by the Expert Group;
- NO_x and VOC data, according to Annex II(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.

For submission of the 1999 data, 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 date exchange module (DEM, a software tool developed by ETC/AQ (Sluyter and Schoorl, 1999) to facilitate data flows under Decision 97/101/EC on the exchange of information) is accepted as well.

2.2. Data reported over the summer of 2000

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

All 15 EU Member States provided information on the observed exceedances in time (the deadline for transmitting data for this report was 18 September 2000), or indicated that no exceedances were observed. In addition, 11 other European countries (Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Norway, Poland, Slovak Republic, Slovenia and Switzerland) provided information on observed exceedances.

As was the case in 1997, 1998 and 1999, Ireland and Finland recorded no exceedance of the 180 $\mu g/m^3$ threshold in 2000. Also in Estonia, Hungary, Latvia and Norway no exceedances were observed. Table 2.2 presents an overview of observed exceedances per country per month.

Since only exceedances of thresholds were reported, it is not clear whether stations were operational continuously during the summer of 2000 (April–August 2000). 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.

Table 2.2: Overview of observed exceedances per month per country in 2000 p: exceedance of the population information threshold reported, -: no exceedance reported.

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

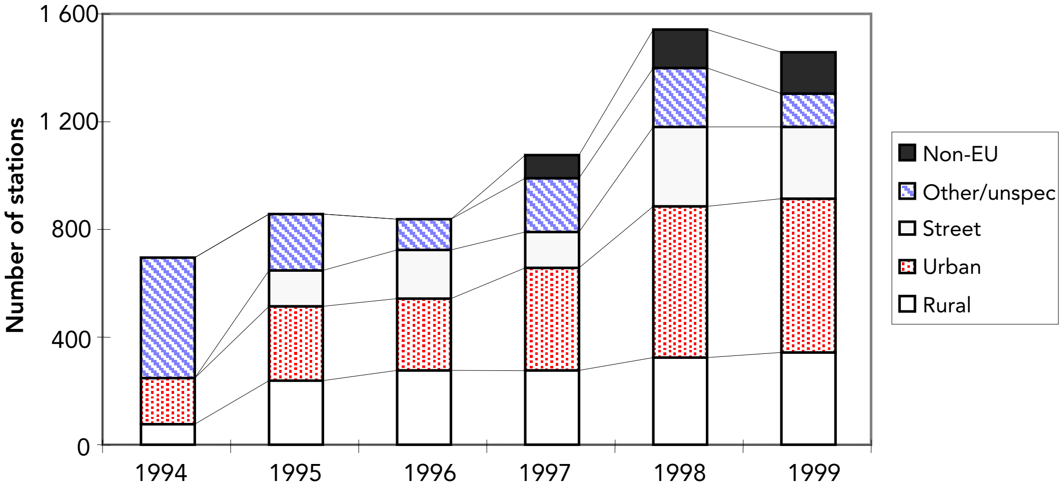
NB: p: exceedance of the threshold for informing the population reported;
—: no exceedance reported.

2.3. Data reported for 1999

According to the ozone directive the requested information for 1999 should have been forwarded to the Commission before 1 July 2000. All data forwarded by the Commission and received at the European Topic Centre on Air Quality (ETC/AQ) not later than 18 August 2000 has been processed is this report. Information on the ozone monitoring network, on statistical parameters and on exceedances has been received from all Member States. In this report the definition of the data formats as described in the document Doc.Rev. 11/243/95 and its April 1996 amendment is used as a reference. If necessary, files were converted at ETC/AQ for further processing.

Non-EU Member States were contacted by the European Environment Agency, through the Phare topic link on air quality or, in the case of Switzerland, directly and requested to voluntarily submit data following the standard formats on data exchange. Information on ozone exceedances was received from Bulgaria, Czech Republic, Estonia, FYROM, Hungary, Latvia, Lithuania, Norway, Poland and Slovakia and Switzerland. All countries except Bulgaria and FYROM provided also statistical information on ozone concentrations.

Figure 2.1: Number of stations reporting ozone data within the framework of the ozone directive



NB: For stations in non-EU countries a station classification is known but not resolved in this figure for clarity

A number of countries did not submit a measurement techniques file; in these cases, the information used for the 1998 annual report was assumed to be valid for 1999.

Voluntary data on precursor concentrations (NO_x, NO_2 and/or VOC) were received from eight Member States and four additional countries.

For 1999, information on ozone concentrations (annual statistics and/or exceedance information) was received for 1 451 monitoring stations of which 1 304 were located in EU Member States.

Figure 2.1 shows the number of stations since the first reporting year 1994. Compared to 1998, the number of EU stations is slightly lower, mainly due to a decrease in the number of stations in Italy.

While processing the data it was noted that for a limited number of stations conflicting information was submitted. For the stations listed in Table 2.3, no exceedances of the 180 and/or 200 $\mu g/m^3$ level were reported while the maximum hourly concentration is in excess of 180 and 200 $\mu g/m^3$ respectively. Errors were also found for a relatively large number of French stations; this will have some impact on the exceedance statistics reported here for France. Due to time constraints, the data suppliers have not been contacted at the time of writing this report.

Table 2.3: Stations not reporting exceedances but with a maximum hourly concentration in excess of the threshold levels for informing the population (180 µg/m³) and for protection of vegetation (200 µg/m³)

Country	Station name	Station code	City	180 µg/m3 threshold	200 µg/m3 threshold	1h max. (µg/m3)
Austria	Graz Schloßberg	018(06)	Schlossberg	error	error	285
France	Dunkerque Centre-Ville	10002	Dunkerque	error	error	218
France	Calais Centre-Ville	10023	Calais	error	0	189
France	ORAMIP	12001	Colomiers	error	error	214
France	Berthelot	12030	Toulouse	error	0	188
France	Charavines	15001	Charavines	error	0	194
France	Le Versoud	15007	Versoud	error	0	194
France	Champ sur Drac	15013	Champ-Sur-Drac	error	error	212
France	Saint Martin d'Hères	15038	Saint-Martin-D'Heres	error	0	188
France	Noyon	18025	Amiens	error	0	184
France	Crecy	18026	Crecy-En-Ponthieu	error	error	201
France	Desbordes	18032	Compiegne	error	error	205
France	Salouel	18035	Salouel	error	0	184
France	Beaumont	18036	Beauvais	error	0	185
France	Lyon Gerland	20017	Lyon	error	error	239
France	Point Du Jour	20018		error	error	226
France	Villeurbanne Croix Luizet	20020	Villeurbanne	error	0	192
France	Feyzin Mairie	20030		error	error	228
France	Saint Priest	20036	Saint-Priest	error	error	218
France	Ternay	20037	Ternay	error	error	219
France	Les Orlets	20039		error	error	218
France	Genas	20045	Genas	error	error	214
France	Dieme	20049	Dieme	error	error	256
France	Site Mobile	20901		error	0	182
France	Caen tour Leroy	21007	Caen	2	error	204
France		22010	Porcelette	1	error	213
France	VICTLM	23092	Mans	error	0	182
France	BAIRLM	23093	Mans	error	0	186
France	Coubertin	29421	Saint-Etienne	error	error	252
France	Roanne	29423	Roanne	error	error	203
France	Saint Etienne Sud	29424	Saint-Etienne	error	error	247
France	Firminy	29425	Firminy	error	0	186
France	Saint Chamond	29426	Saint-Chamond	error	error	203
France	Plan de Cuques	3035	Plan-De-Cuques	error	error	208
France	La Penne / Huveaune	3037	Penne-Sur-Huveaune	2	error	201
France	Thiers	3047	Marseille	error	0	183
France	La Valette du Var	3064	Viens	error	0	184
France	Hilaire de chardonnet	32003	Chalon-Sur-Saone	error	0	181
France	Montceau-les-Mines	32005		error	error	208
France	Annemasse	33211	Annemasse	error	0	196
France	Annemasse	33212	Gaillard	error	0	193
France	Dalton	35004	Brive-La-Gaillarde	error	0	181
France	8F78	4132		error	0	190
France	Tour Eiffel 3e etage	4299		error	error	204
Ireland	Killkitt	O3-01		error	0	188
Italy	L.Go Magna Grecia	1205810	Roma	4	error	268
Italy	Erba	301307	Erba	error	error	266
Italy	Limbiate	301523	Limbiate	error	error	266
Italy	Vimercate	301543	Vimercate	error	error	296
Italy	Gambara	301705	Gambara	error	error	243
Portugal	Avanca	202	Avanca	error	0	188

2.4. The ozone monitoring network in 1999 and 2000

All countries provided meta-information (coordinates, station type, etc.) for the majority of their monitoring stations. It has been assumed that the network configuration as found for 1999, is also in place during the summer of 2000.

There are 1 304 ozone monitoring sites assumed to be operational in the EU in the framework of the directive. From these, 346 stations are situated in rural areas, 563 stations in urban background environments, 266 are street stations and 129 stations are characterised as industrial stations or having an unspecified monitoring environment. In addition, 147 ozone monitoring sites are assumed to be operational in other European countries (61 rural background, 53 urban, 9 street, 24 industrial or unspecified).

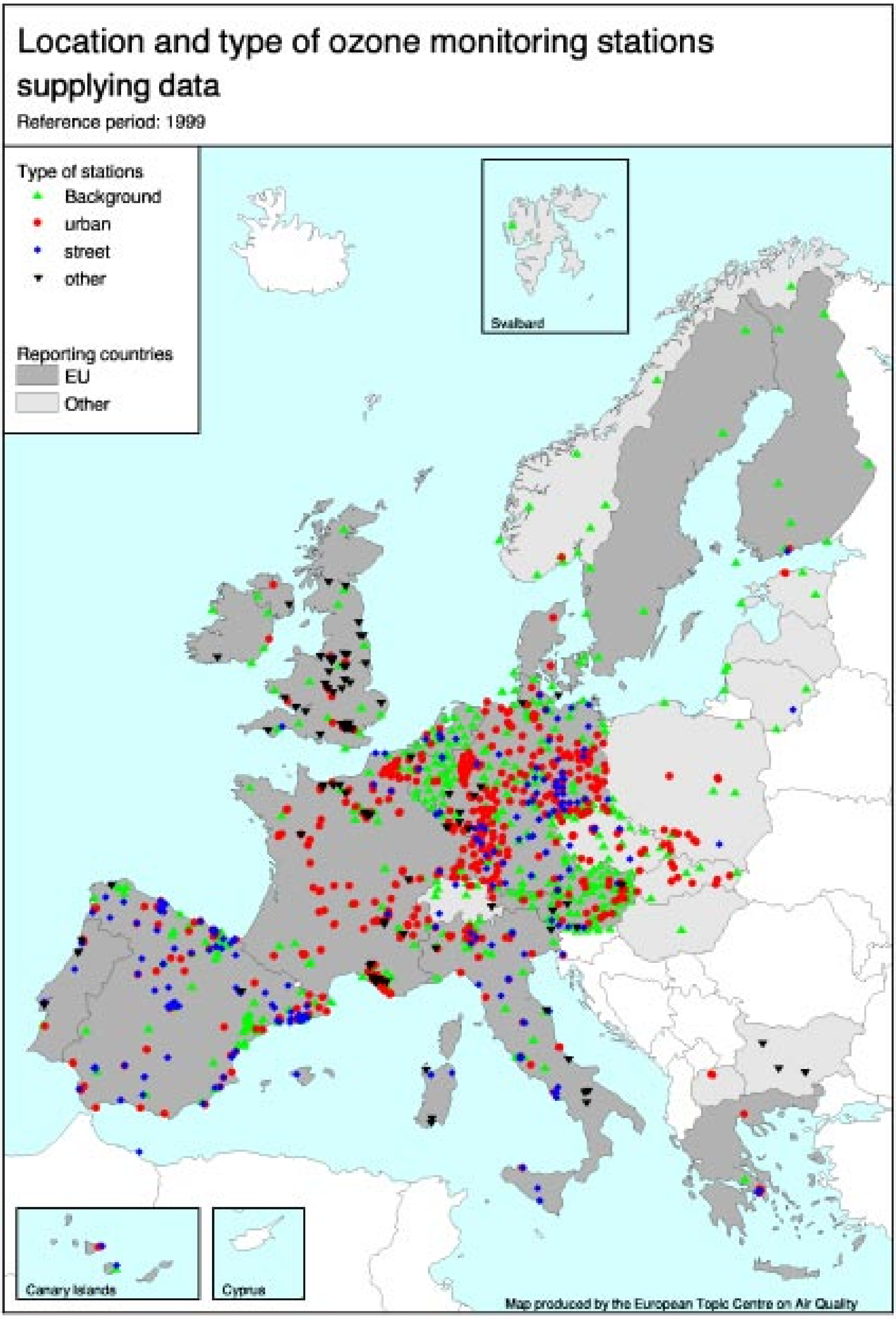
The location of monitoring stations in EU Member States which were used for the implementation of the ozone directive and which were reporting during 1999 is presented in Map 2.1. Stations located in other European countries, which have reported ozone data on a voluntary basis, are shown as well. As far as information on the analytical methods was provided, all reporting countries use the reference method (UV absorption) as prescribed in Annex V of the ozone directive. However, at a limited number of German stations chemiluminescence is used. For nearly all of the reporting stations geographical coordinates are available.

For the interpretation of ozone data it is essential to have an indication of the immediate surroundings of the station since the ozone concentration may be strongly influenced by local conditions. For example, ozone may be scavenged by locally emitted nitrogen oxides or by enhanced dry deposition as might be the case under a forest canopy. For the majority of stations information on immediate surroundings has been made available.

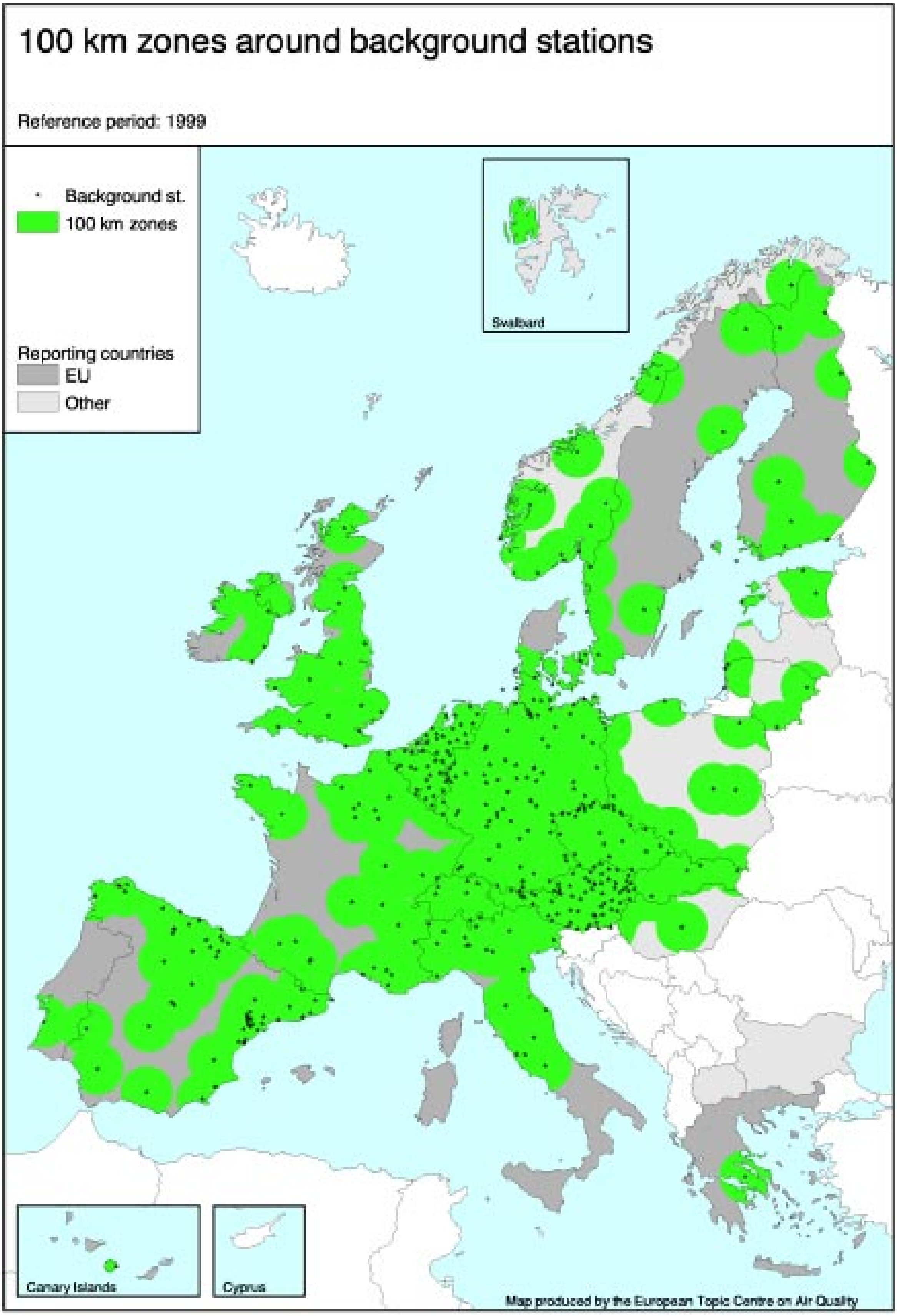
Map 2.2 shows the location of rural background monitoring stations. Tentatively, the area for which the measurements at these stations are assumed to be representative is indicated with a circle using a radius of 100 km. This 'radius of representativeness' might be different for the various regions in Europe — it might even depend on the wind direction — and should be based on more detailed analysis of the ozone phenomenology at the stations. Although the identification of the rural background stations is far from complete and the radius of representativeness may differ from the assumed 100 km, Map 2.2 suggests that the present set of stations covers large parts of the land area in the reporting countries. As is shown in Map 2.2 the geographical coverage of rural background stations is rather adequate in north-west and central Europe but in southern and most northern regions gaps are noted. In Scandinavia, the coverage by rural background stations appears to be inadequate but the small gradients in ozone concentrations over this region suggest a larger radius of representativeness than the assumed 100 km might be appropriate.

For EU-15 as a whole, the rural background stations cover 65 % of the total land area. Referring to relevant land cover classes, the coverage is 74 % for agricultural area and 59 % for forested area. When a representative radius of 50 km is assumed, these percentages are reduced to 35, 41 and 29 %, respectively. In the non-EU countries the coverage is less; 54 % of total land area assuming a 100 km radius and 25 % for a 50 km radius. This is caused partly by the absence of rural background stations in Bulgaria and FYROM.

To compare the monitoring results in the various countries it is important that in the national or regional networks similar criteria are used to classify the stations. Further work on harmonisation of station classification schemes is undertaken by ETC/AQ in cooperation with the Environment DG (Larssen et al., 1998). A second requirement for obtaining Europe-wide comparable results is the harmonisation of air quality measurements. This work is conducted on behalf of the Commission by the European Reference Laboratory of Air Pollution (ERLAP) at the Joint Research Centre in Ispra (De Saeger et al., 1997).



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 1999



Map 2.2: Location of rural background ozone monitoring stations. Tentatively the area for which the ozone measurements might be representative is indicated with a circle with a radius of 100 km; reporting period 1999

3. Information from reported data for the summer of 2000

3.1. Summary of exceedances reported

The threshold for warning the public (1h> 360 µg/m^3) was not exceeded in the European territory during the summer of 2000 (3). In 1999, this threshold was also not exceeded; the last recorded exceedances were observed during the summer of 1998.

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 2000 on a country-by-country basis. As the number of monitoring stations differs widely from country to country, the absolute number of exceedances is less suitable for comparison. Therefore, the concept of 'occurrence of exceedances' is introduced here. Occurrence of exceedances is defined as the average number of observed exceedances per country, that is, the total number of exceedances for all the stations of a country divided by the total number of reporting stations.

With regard to EU Member States, Ireland and Finland did not observe exceedances of the population information threshold this summer. These countries did also not report any exceedance during the 1997, 1998 and 1999 summer seasons. From the other countries, Estonia, Latvia and Norway did not observe exceedances of the population information threshold.

In other EU countries, the number of days within the April–August period of 153 days on which at least one exceedance was observed ranged from 3 in Luxembourg and the United Kingdom to 87 in Italy. 29 % of all stations reported one or more exceedance. On average 3.5 exceedances occurred this year on stations which recorded at least 1 exceedance. The average maximum hourly concentration during an exceedance of the threshold in 2000 was 199 µg/m^3.

Table 3.2 summarises the exceedances on a month-by-month basis. June had the highest number of stations reporting exceedances, mainly due to one period with favourable ozone formation conditions (this episode is described in detail in Section 3.4).

In Figure 3.1, the number of days per month is presented on which at least one station in a country recorded an exceedance. Figure 3.2 presents the occurrence of exceedances per country on a month-by-month basis. Average occurrence of exceedances shows no obvious dependence on the month of observation. In a number of west European countries, no exceedances were observed in July, most likely due to the wet and cloudy weather prevailing during this month.

(3) Spain reported exceedances of the threshold for warning the public but indicated that most probably these exceedances were caused by interaction with (a) yet unknown chemical compound(s). Subsequently the exceedances were flagged by Spain and they were not processed for the purpose of this report. A summary however is given in Annex I. In addition, Bulgarian data (exceedances transmitted observed on one station) were not processed because exceedances are unrealistically high. A summary of Bulgarian data is given in Annex I.

Table 3.1: Summary of exceedances of the threshold for informing the public (1h ozone concentration > 180 µg/m3) during the summer of 2000 (April–August) on a country-by-country basis

	No of stations (1)	No of stations with exceedance	No of days with exceed-ance (2)	Maximum observed concentr. (µg/m3)	Average maximum concentr. (µg/m3) (3)	Occurrence of exceed-ances (4)	Average duration of exceedances (hour)
Belgium	31	13 (42 %)	6	229	196	0.5/1.2	2.6
Denmark	12	3 (25 %)	2	212	193	0.4/1.7	2.0
Germany	396	233 (59 %)	24	253	194	1.3/2.2	2.6
Greece	15	5 (33 %)	33	334	221	3.7/11.0	2.9
Spain	286	39 (14 %)	38	309	201	0.3/2.2	1.9
Finland	12	0 (0 %)	0	<180	<180	-	-
France	335	37 (11 %)	31	277	201	0.4/3.6	1.7
Ireland	7	0 (0 %)	0	<180	<180	-	-
Italy	298	50 (17 %)	87	319	202	2.2/12.9	3.3
Luxembourg	6	3 (50 %)	3	197	190	0.8/1.7	1.7
Netherlands	39	15 (39 %)	8	221	194	0.6/1.5	1.7
Austria	114	59 (52 %)	27	231	191	1.2/2.4	2.6
Portugal	18	11 (61 %)	6	261	199	1.0/1.6	1.8
Sweden	7	2 (29 %)	2	219	204	0.6/2.0	4.8
United Kingdom	72	4 (6 %)	3	216	196	0.1/1.0	2.0
EU	1 648	474 (29 %)		334	199	1.0/3.5	2.8
Switzerland	14	6	35	243	198	4.4/10.3	3.1
Czech Republic	52	32	18	259	194	1.9/3.1	2.9
Estonia	7	0 (0 %)	0	<180	<180	-	-
Lithuania	6	1 (17 %)	1	191	191	0.2/1.0	5.0
Latvia	1	0 (0 %)	0	<180	<180	-	-
Norway	15	0 (0 %)	0	<180	<180	-	-
Poland	19	11 (58 %)	11	258	200	1.4/2.4	3.6
Slovenia	5	4 (80 %)	na	na	na	na	na
Slovakia	15	11 (73 %)	24	219	193	2.4/3.3	2.9

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

Table 3.2: Summary of exceedances of the threshold for informing the public (1h ozone concentration > 180 µg/m3) during the summer of 2000 (April–August) on a month-by-month basis in the European Union

	No of stations with exceedance I	Maximum observed concentration (µg/m3)	Average maximum concentration (µg/m3) II	Occurrence of exceedances III	Average duration of exceedances (h)
April	6 (7)	212 (212)	193 (190)	0.0/1.0 (0.0/1.3)	1.0 (1.3)
May	84 (92)	266 (266)	194 (194)	0.1/1.4 (0.1/1.5)	2.1 (2.2)
June	382 (435)	319 (319)	198 (198)	0.1/0.3 (0.5/2.2)	2.9 (3.0)
July	98 (100)	334 (334)	206 (206)	0.1/1.2 (0.1/2.6)	2.7 (2.7)
August	184 (213)	306 (306)	199 (198)	0.1/0.6 (0.3/2.4)	2.7 (2.7)

NB: Figures between brackets include non-EU countries.
(1) The theoretical maximum is 1 649 stations (EU stations only) and 1 778 stations (including non-EU countries) (all stations which are assumed to be operational); during the summer of 2000 and for which data were transmitted).
(2) Average of all maximum concentrations recorded during exceedances.
(3) Left figure: 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 threshold value for informing the public (1h ozone concentration > 180 µg/m3) was observed per country (4) and per month during the summer of 2000. Finland and Ireland did not report exceedances (non-EU countries reporting no exceedances are not shown).

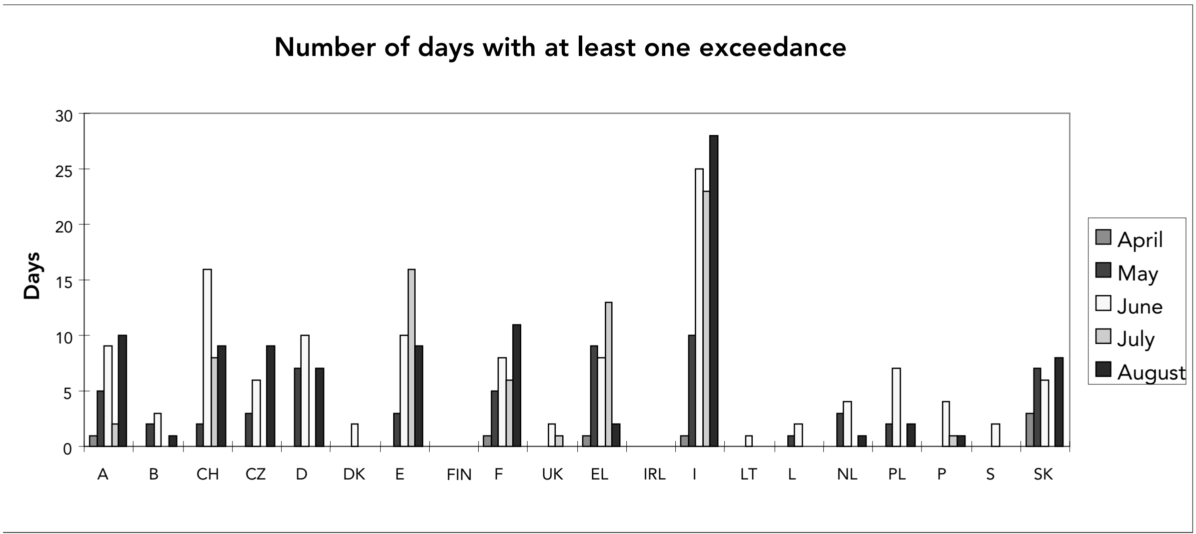
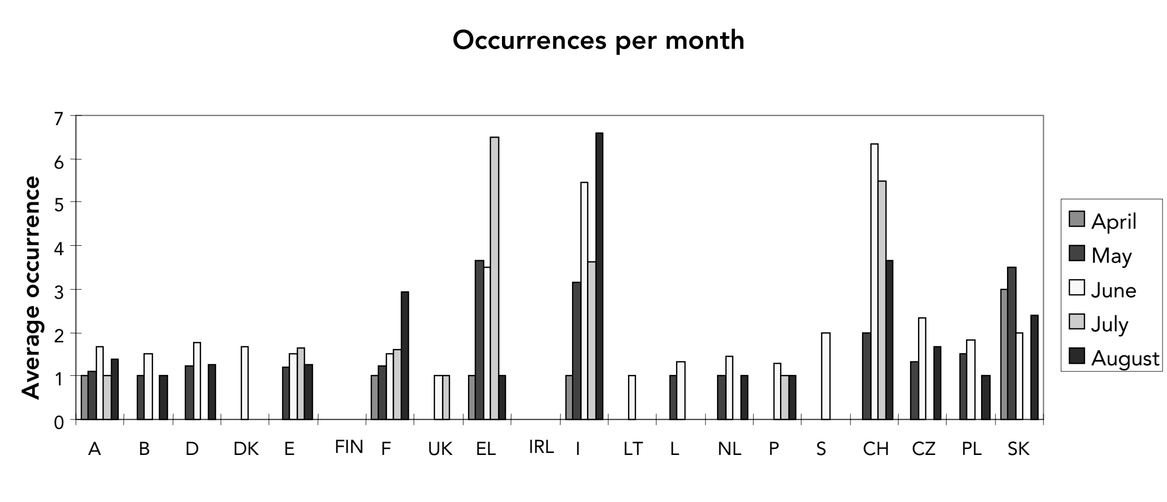


Figure 3.2: Occurrence of exceedances of the threshold value for informing the public (1h ozone concentration > 180 µg/m[3]) per country on a month-by-month basis during the summer of 2000.

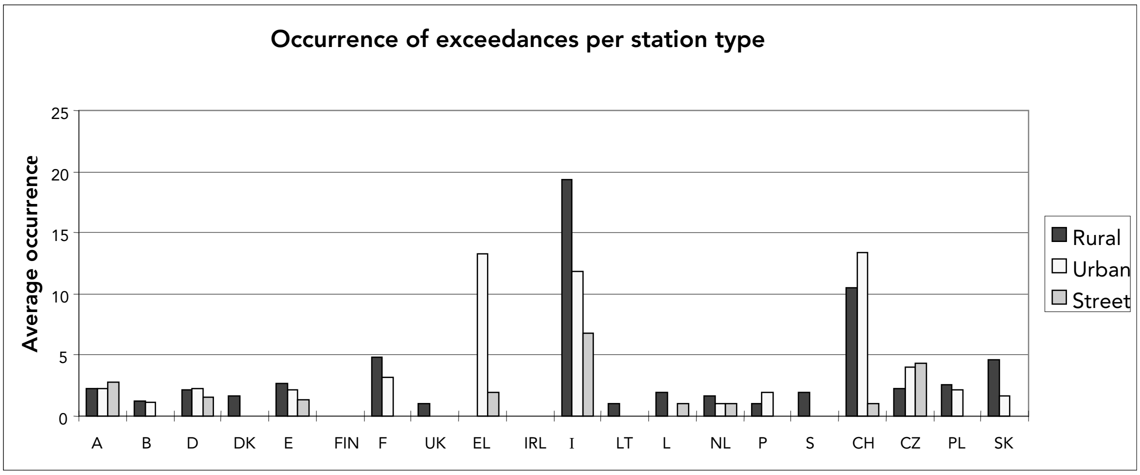


NB: Finland, and Ireland did not report exceedances (non-EU countries reporting no exceedances are not shown).

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

The average occurrence of exceedances (in days) in each country of the threshold for informing the public by station type (rural background, urban and street) is presented in Figure 3.3. Stations for which the type was not specified are not presented in this figure. The average occurrence rate is expected, according to ozone phenomenology, to decrease in general in the order; rural background, urban, street. For some countries, this decrease is apparent. In other countries, this relation is not visible or even contradicted.

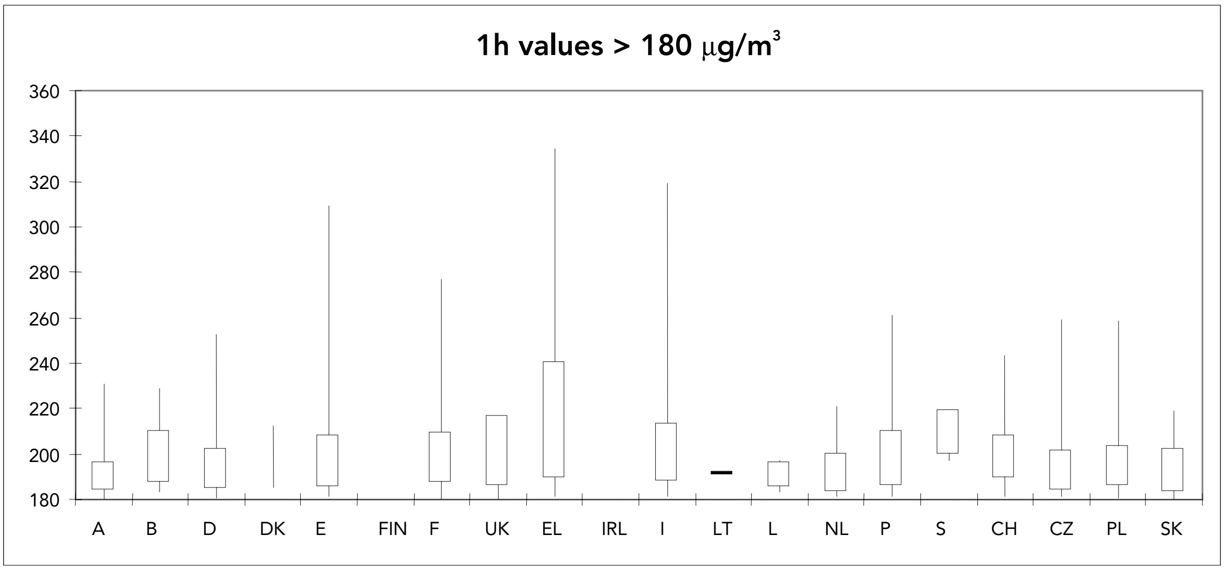
Figure 3.3: Average occurrence of exceedances (in days) of the threshold for informing the public (1h ozone concentration > 180 µg/m³) by station type (rural background, urban and street) and country during the summer of 2000.



NB: Finland and Ireland did not report exceedances (non-EU countries reporting no exceedances are not shown).

Figure 3.4 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 the 180 µg/m³ threshold. 75 % of all maximum exceedances recorded in the EU were below 207 µg/m³, which is comparable to the 75-percentile during summer 1999 (205 µg/m³).

Figure 3.4: Top: Frequency distribution of ozone concentrations in excess of the 180 µg/m³ threshold for hourly values (April–August 2000). Frequency distributions are presented as Box–Jenkins plots indicating the minimum, the 25-percentile, the 75-percentile and the maximum value. (Non-EU 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)



	B	DK	D	EL	E	F	IRL	I	L	NL	A	P	FIN	S	UK
#Ex	15	5	512	55	85	134	0	645	5	22	139	18	0	4	4
#St	13	3	233	5	39	37	.	50	3	15	59	11	.	2	4

	CH	CZ	LT	PL	SK
#Ex	62	99	1	26	36
#St	6	32	1	11	11

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 informing the public was exceeded for urban (5) and rural background stations, respectively (6). Exceedance data for urban stations are presented as dots. The exceedance data for rural background 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.

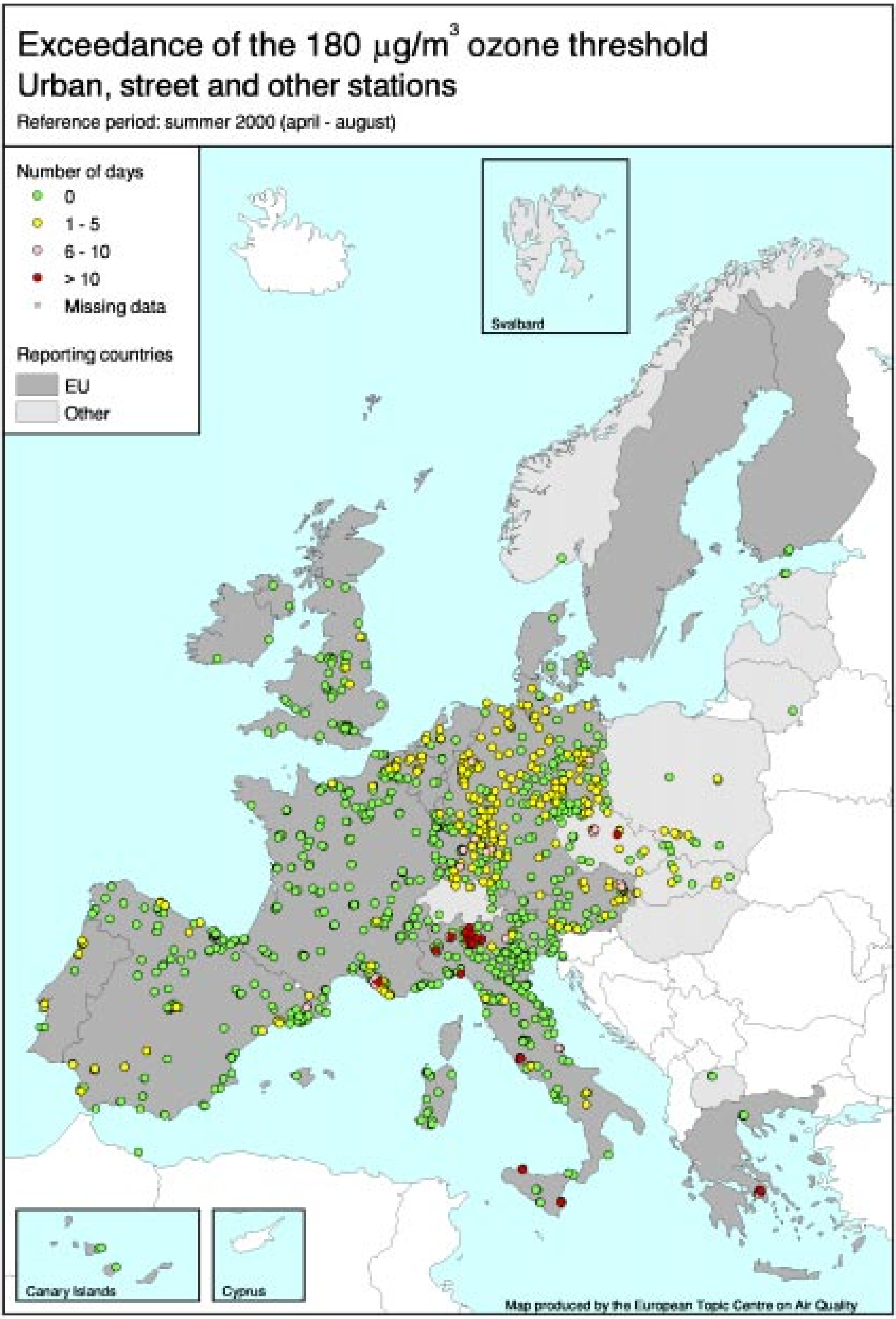
The geographical distribution of exceedances observed this summer at urban stations and stations of unspecified type in northern and western Europe follows the pattern as observed in most previous summer seasons. The number of exceedances rise from zero in the Scandinavian countries, Baltic States and

(5) Exceedances reported from stations of unspecified type are also plotted in this map.

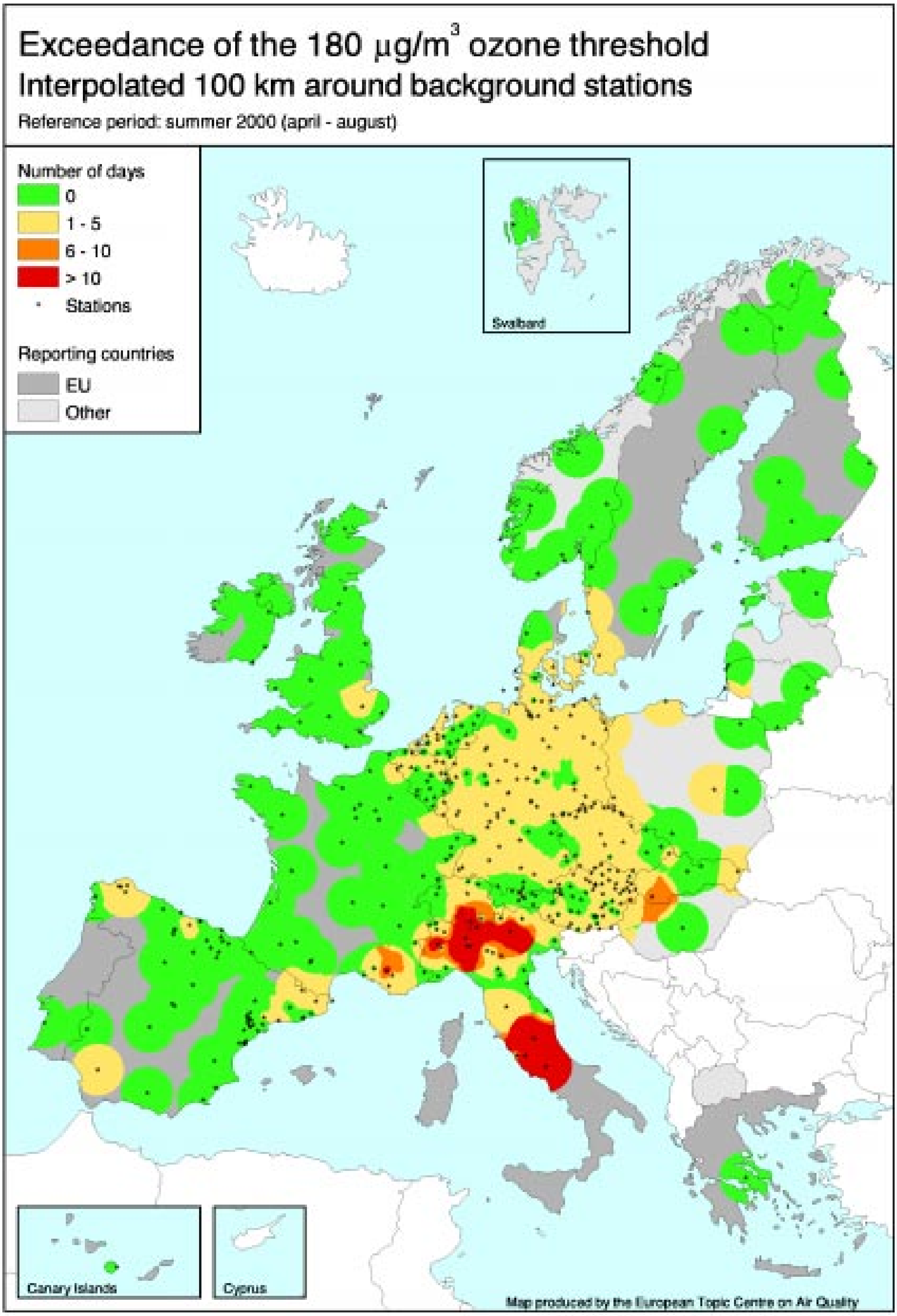
(6) Stations assumed to be operational but for which no data were transmitted are drawn in the maps with 'zero exceedances observed'. For most countries/stations this will be true, but this cannot be guaranteed because it is possible that exceedances were observed but not yet communicated. As a result, the number of stations/area with no exceedances observed could be slightly overestimated.

Ireland to a maximum in central Europe. No consistent spatial pattern is apparent in the Mediterranean region. Many stations did not report exceedances, while other stations reported more than 10 exceedances.

The spatial pattern of exceedances observed in the summer of 2000 at background stations (interpolated field), follows the pattern observed in most previous summer seasons. 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.



Map 3.1: Number of exceedances of the threshold value for informing 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 of 2000 (April–August)

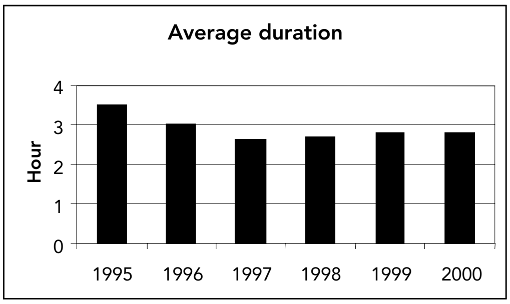


Map 3.2: Number of exceedances of the threshold value for informing the public (1h ozone concentration > 180 µg/m³) observed at background station, summer of 2000 data (April–August), interpolated using inverse distance weighting, cut-off distance of 100 km

3.4. Comparison with earlier years

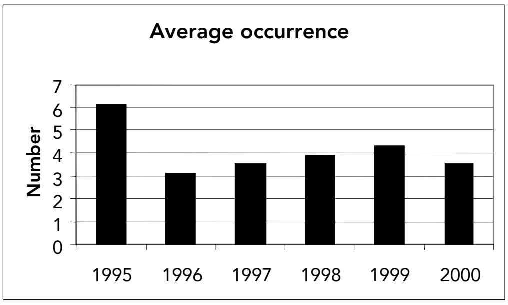
Exceedances observed in the EU during the 2000 summer period were compared to exceedances observed during the same period in earlier years (1995–99 ([7])). Figure 3.5a presents the average exceedance duration ([8]) of the population information threshold, Figure 3.5b the average occurrence and Figure 3.5.c presents the average maximum concentration observed during exceedances.

Figure 3.5a: Average duration in hours of exceedances during the summer period (April–August)



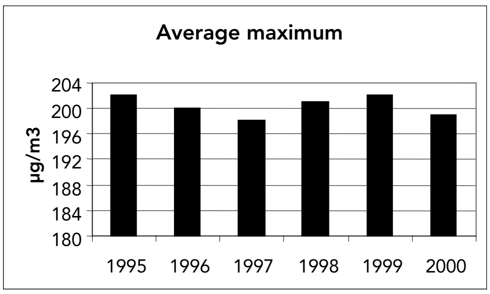
NB: French and Italian data were not included in 1995 and 1996.

Figure 3.5b: Average occurrence (number) of exceedances at stations which reported at least one exceedance during the summer period (April–August)



NB: French and Italian data were not included in 1995 and 1996.

Figure 3.5c: Average maximum ozone concentration (µg/m3) observed during exceedances during the summer period (April–August)



NB: French and Italian data were not included in 1995 and 1996.

(7) 1995, 1996, 1997, 1998: validated exceedance statistics as transmitted by Member States were used for this purpose.
(8) Averaged over all stations, which reported at least one exceedance.

It is not possible to conclude on a significant trend in the number, duration and severity of exceedances of the threshold for informing the public for the following reasons.

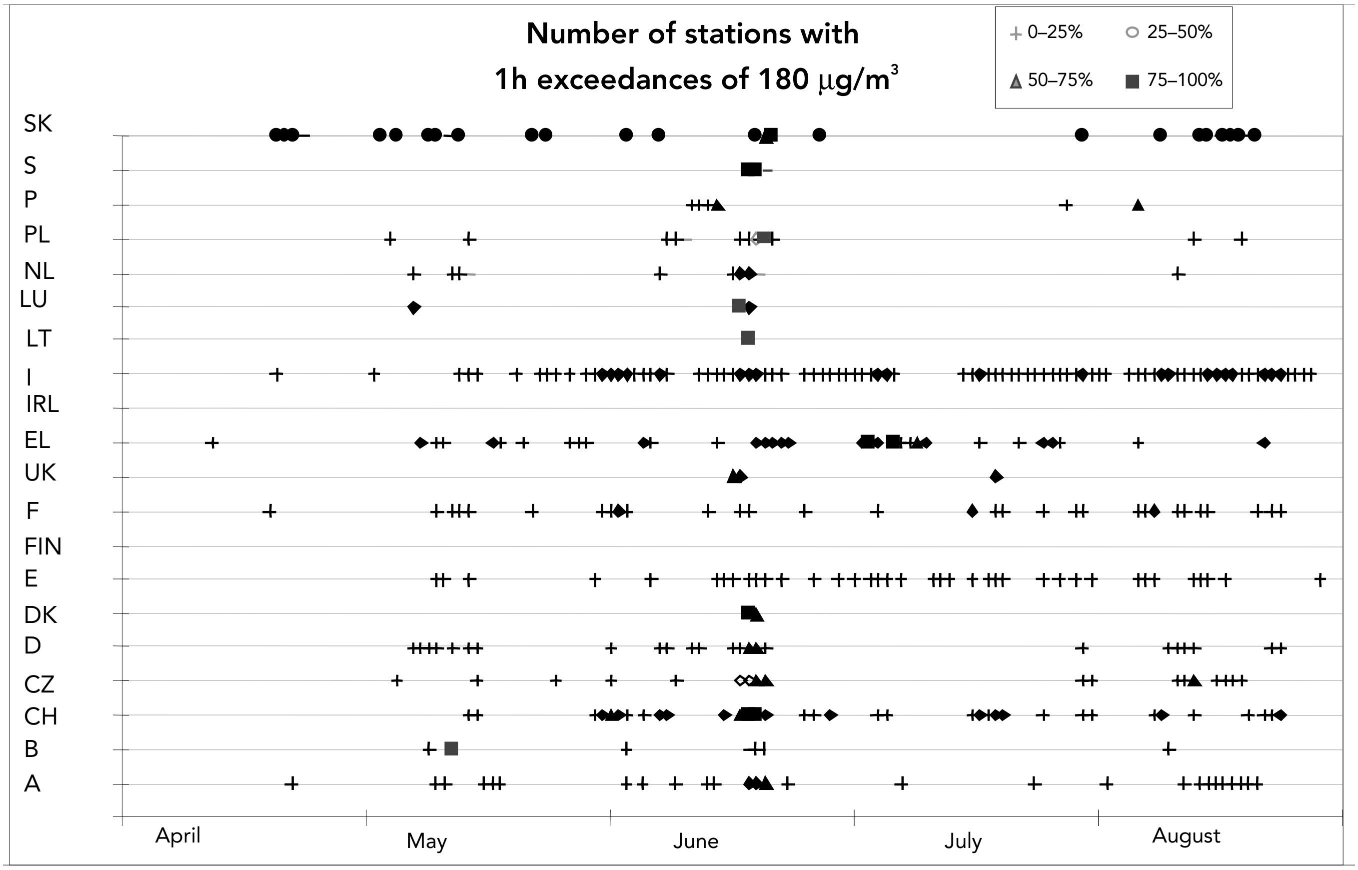
- As indicated, French and Italian data were not included in the 1995 and 1996 data analysis. From a comparison for 1997 with the indicators calculated with and without the French data, it is expected that the average duration, occurrence and maximum would increase for 1995 and 1996 if Italian and French data were included.
- High ozone levels (in this case exceedances of the population information threshold) are mainly observed during periods with warm and sunny weather. Especially in western and northern Europe, the year-to-year variations in meteorological conditions favourable for high ozone levels are large. The resulting variations in exceedance statistics can obscure a possible trend due to changes in pre-cursor emissions. It is at the moment not possible to correct for this variability on a country-by-country basis nor for the complete EU territory.
- Exceedances statistics are available for only five years which is a very short time period for the assessment of statistically significant trends.
- The number of stations implemented in the framework of the ozone directive increased by more than 50 % during the period 1995–2000. The increased territorial coverage can have implications for the number of exceedances observed, especially since the increase is not the same for all countries reporting. Also, a changing ratio between the number of rural background and urban/street stations can have implications for the number of observed exceedances since peak ozone levels will be different in urban areas and in rural areas.
- The information presented in this section is based only on reported exceedances of the threshold for informing the public and does not provide complete information on ozone levels observed in the European Union.

3.4. 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 in every country that reported exceedances of the threshold value for informing the population (180 $\mu g/m^3$ for hourly values) during the 2000 summer season.

Figure 3.6: Qualitative overview of exceedances of the 180 μg/m³ population information threshold value (1h) for ozone during the period April–August 2000



NB: The symbols represent the percentage of stations, which observed at least one exceedance of the threshold for informing the public during a particular day (non-EU countries reporting no exceedances are not shown).

From Figure 3.6 it is clear that the number of episodes covering extended areas of the European territory was limited during the period April–August 2000. As already mentioned, weather conditions in western and northern Europe, especially in July, were often unfavourable for the build-up of ozone.

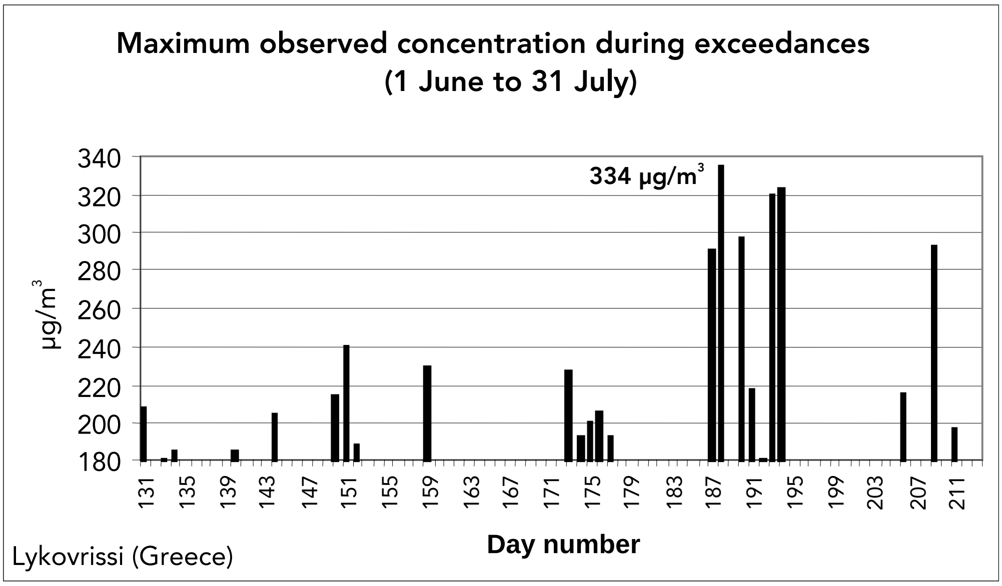
The most geographically extended northern European episode this summer occurred between 19 June and 22 June. Map 3.3 presents an overview of the sites where exceedances were observed on 19, 20, 21 and 22 June 2000. In the text box, the conditions leading to this episode are described in more detail. In contrast, in southern Europe exceedances were observed frequently throughout the reporting period.

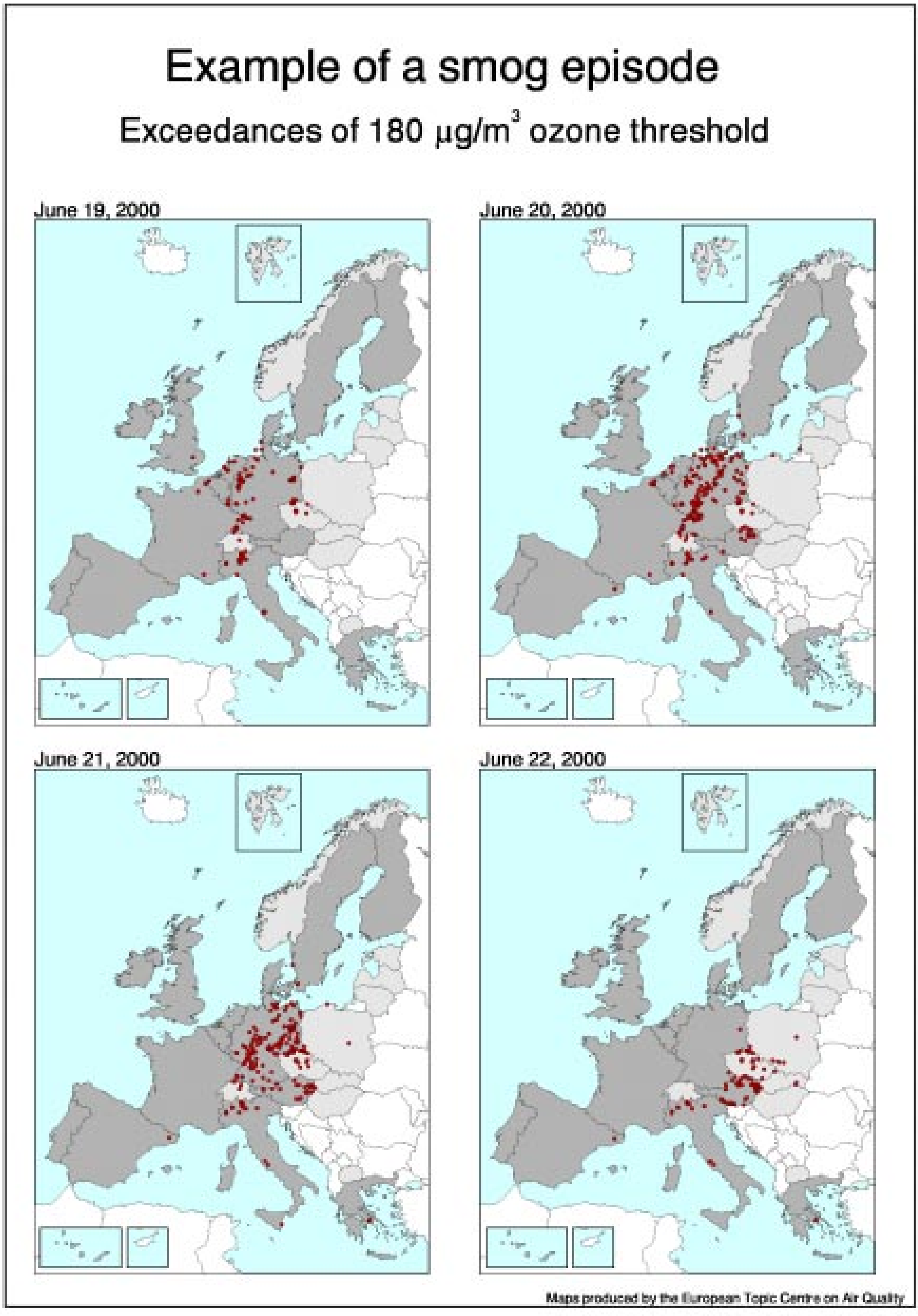
The episode of 19–22 June 2000

On the days preceding the episode, a strong high pressure cell formed above the North Sea. Relatively clean air masses were transported with a northern flow to northern and western Europe. On 18 June, the high pressure cell was located over central Europe; as a result the circulation became southerly over large parts of northern and western Europe. A period of warm, sunny and stable weather set in over northern and western Europe. The gradual build-up of precursor pollutants, in combination with the warm and sunny weather conditions resulted in ozone concentrations exceeding the 180 µg/m^3 threshold on 19 June in Benelux, south eastern United Kingdom, northern France, parts of Germany and the Czech Republic. On 20 June, a depression west of Ireland started to transport relatively clean Atlantic air over the UK and France. This ended this episode in these countries. In other parts of western and eastern Europe, exceedances were widespread. On 21 June, the Atlantic air had reached Benelux and the western part of Germany, ending the episode. On 22 June, only Austria, the Czech and Slovak Republics and Poland reported exceedances. On 23 June, the Atlantic air reached eastern Europe, no widespread exceedances were reported anymore and the episode ended.

Figure 3.7 presents the maximum hourly ozone values recorded at the Lykovrissi monitoring station (Greece), from 1 June to 31 July 2000 on days when the threshold for informing the public (1h ozone concentration >180 µg/m^3) was exceeded, as an example of frequent exceedances on a local scale in the Mediterranean region. The highest hourly ozone concentration during the summer of 2000 was observed at this station (334 µg/m^3).

Figure 3.7: Example of frequent exceedances of the threshold value for informing public. Maximum observed 1h values (µg/m3) on the Lykovrissi monitoring station (Greece, 1 June to 31 July 2000) on days when the concentration rose to at least 180 µg/m3 (1h)





Map 3.3: Example of a smog episode: stations which reported an hourly ozone concentration in excess of 180 µg/m³, 19 June to 22 June 2000 (all station types)

4. Information from reported data for 1999

4.1. Annual statistics, 1999

The geographical distribution of 98-percentile concentrations calculated on the basis of hourly concentrations is presented in Map 4.1 for rural background stations and in Map 4.2 for urban, street and other stations.

Similar to the observations in previous years (de Leeuw et al., 1999; 2000) the 98-percentiles at rural background stations generally show low values in the northern European countries, and an increase from north-west to central Europe. Similar patterns have been estimated from measurements made within the framework of EMEP (see e.g. Hjellbrekke, 2000). In particular for the stations in Austria and Switzerland, the elevated location of the monitoring stations, associated with higher concentrations, may play a role. For urban and street stations the altitude does not appear to be an important factor since other factors dominate at these types of stations.

For urban and 'other' stations (see Map 4.2) high 98-percentile concentrations of 130 $\mu g/m^3$ or more are frequently observed south of the 50 degree latitude. The local conditions appear to be more important than Europe-wide smog episodes: at stations downwind of the urban area relatively high ozone values might be observed whereas at stations with NO_x sources such as traffic in their immediate surroundings relatively low ozone levels will be measured.

The 98-percentile concentrations based on moving 8h average concentrations show a strong correlation with the hourly 98-percentile concentrations: on average, 8h 98-percentiles are about 7 % lower than the corresponding 1h value. The exact relation between the two statistics depends on the type of the stations and also has a meteorological dependence. The geographical distribution of the 8h 98-percentile values is very similar to the distribution of the 1h-percentiles.

For each of the countries the lowest and highest 50-, 98- and 99.9-percentiles observed at individual stations are presented in Table 4.1 for hourly values and Table 4.2 for 8h values. In this table information on the maximum values is also included. Note that the maximum 8h concentration, as reported in Table 4.2, is based on a moving average and may therefore differ from the values reported during an exceedance of threshold values, which are based on fixed 8h periods. From Bulgaria and FYROM no statistical information has been received. Estonia, France, Germany and Latvia have not submitted percentile values for moving 8h concentrations.

For a large number of countries additional statistical information on NO_x, NO_2 and VOC concentrations was received. This information is primarily used here for the classification of stations. Being precursors of ozone, information on ambient levels of NO_x and VOC is essential to evaluate the effectiveness of ozone abatement strategy. The information voluntarily submitted in the framework of the ozone directive is, however, not sufficient for such an evaluation. The inhomogeneity in data over the last years, the limited time series and generally lack of information on the local environment of the stations, hamper an analysis of a possible trend in precursor NO_x and VOC emissions. Since the reported NO_2

and O_3 concentrations are not measured simultaneously, it is not possible to improve the insight in spatial variability of ozone concentration based on mapping of oxidant (sum of NO_2 and ozone) concentrations. Oxidant concentrations are representative for a larger area since oxidant is less dependent on local condition and meteorological conditions than either ozone or NO_2 alone.

Table 4.1: Range in reported 50-, 98- and 99.9-percentile ozone concentrations and maximum observed concentrations (based on hourly average concentrations, period: 1999) observed at individual monitoring stations in reporting countries (µg/m3)

	1h min	P50 max.	1h min	P98 max.	1h min	P99.9 max.	1h min	Max. max.
Belgium	25	63	99	137	149	189	159	230
Denmark	48	65	98	127	129	166	142	188
Germany	14	92	72	150	102	186	121	219
Greece	19	73	57	171	81	250	101	345
Spain (1)	10	101	34	154	55	774	31	1 270
France	24	90	77	159	106	207	61	277
Ireland	49	79	78	111	na	na	139	188
Italy	8	88	24	186	29	268	41	365
Luxembourg	22	68	74	144	111	177	130	204
Netherlands	21	53	76	121	121	183	138	251
Austria	16	99	97	140	121	178	126	285
Portugal	18	63	73	126	99	184	77	242
Finland	39	75	87	123	105	146	115	175
Sweden	57	67	101	114	118	143	131	165
United Kingdom	8	74	56	126	86	224	104	248
Bulgaria	na	na	na	na	na	na	na	na
Switzerland	23	85	116	168	137	223	145	253
Czech Republic	19	81	58	143	77	173	61	193
Estonia	67	85	126	140	152	158	100	175
Hungary	65	65	136	136	158	158	183	183
Lithuania	24	62	79	116	101	135	120	151
Latvia	52	52	97	97	124	124	133	133
Norway	51	75	93	113	110	137	112	154
Poland	27	82	93	165	131	207	145	214
Slovakia	29	60	87	140	103	192	85	206

NB: na = range in percentile values not available; Latvia submitted information for one station only. The 99.9 percentiles are additional information submitted on a voluntary basis. Data from FYROM is not available.

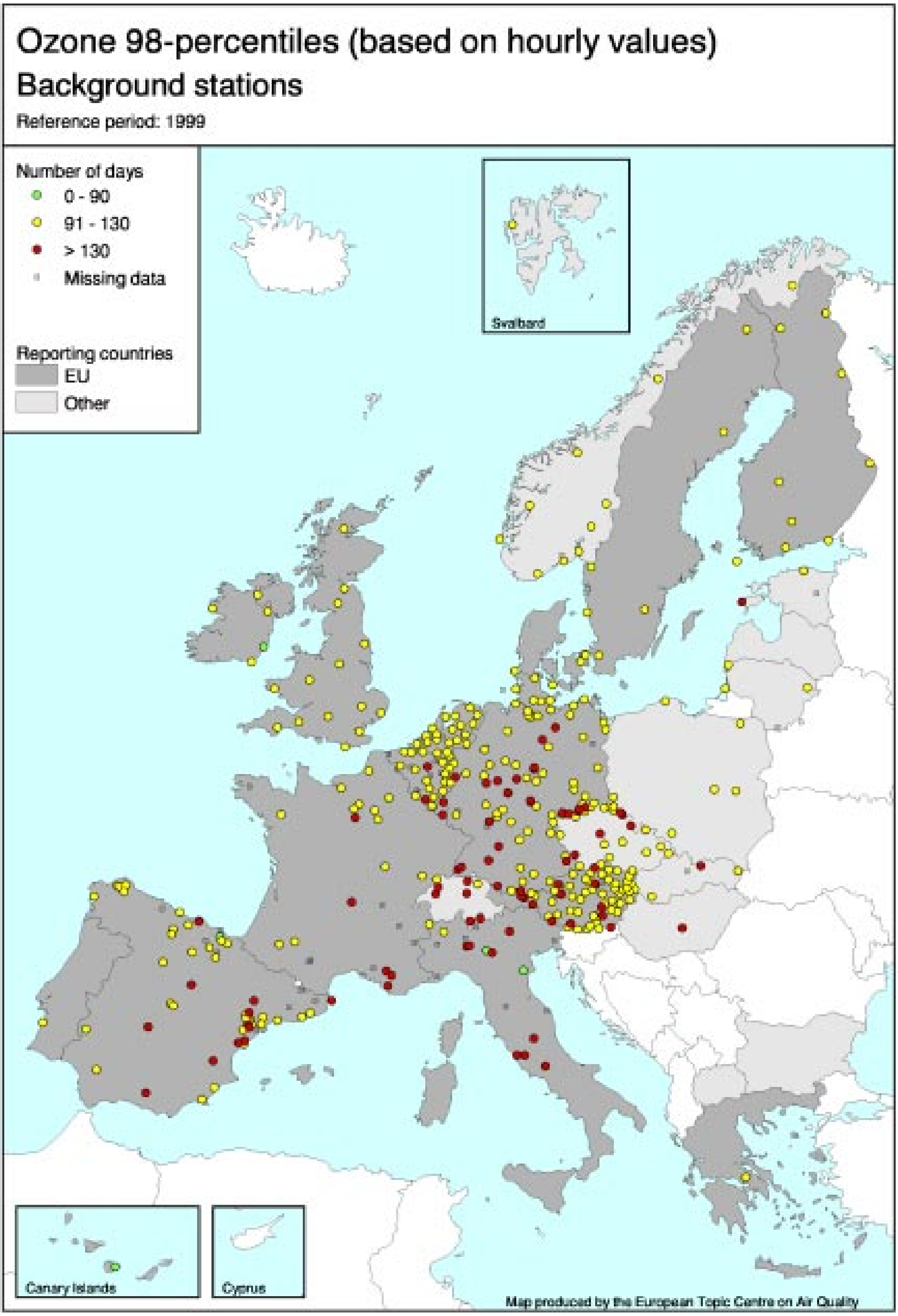
(1) At five Spanish stations extremely high concentrations have been measured for a limited number of hours. These monitoring results have been marked by the data supplier as 'Provisional data. Possible interference. Study on course not yet finished'. It cannot be excluded that these results are artefacts.

Table 4.2: Range in reported 50-, 98- and 99.9-percentile ozone concentrations and maximum observed concentrations (based on moving 8h average concentrations) and maximum daily concentrations measured during an exceedance of the 65 μg/m³ threshold value (period: 1999) observed at individual monitoring stations in reporting countries (μg/m³)

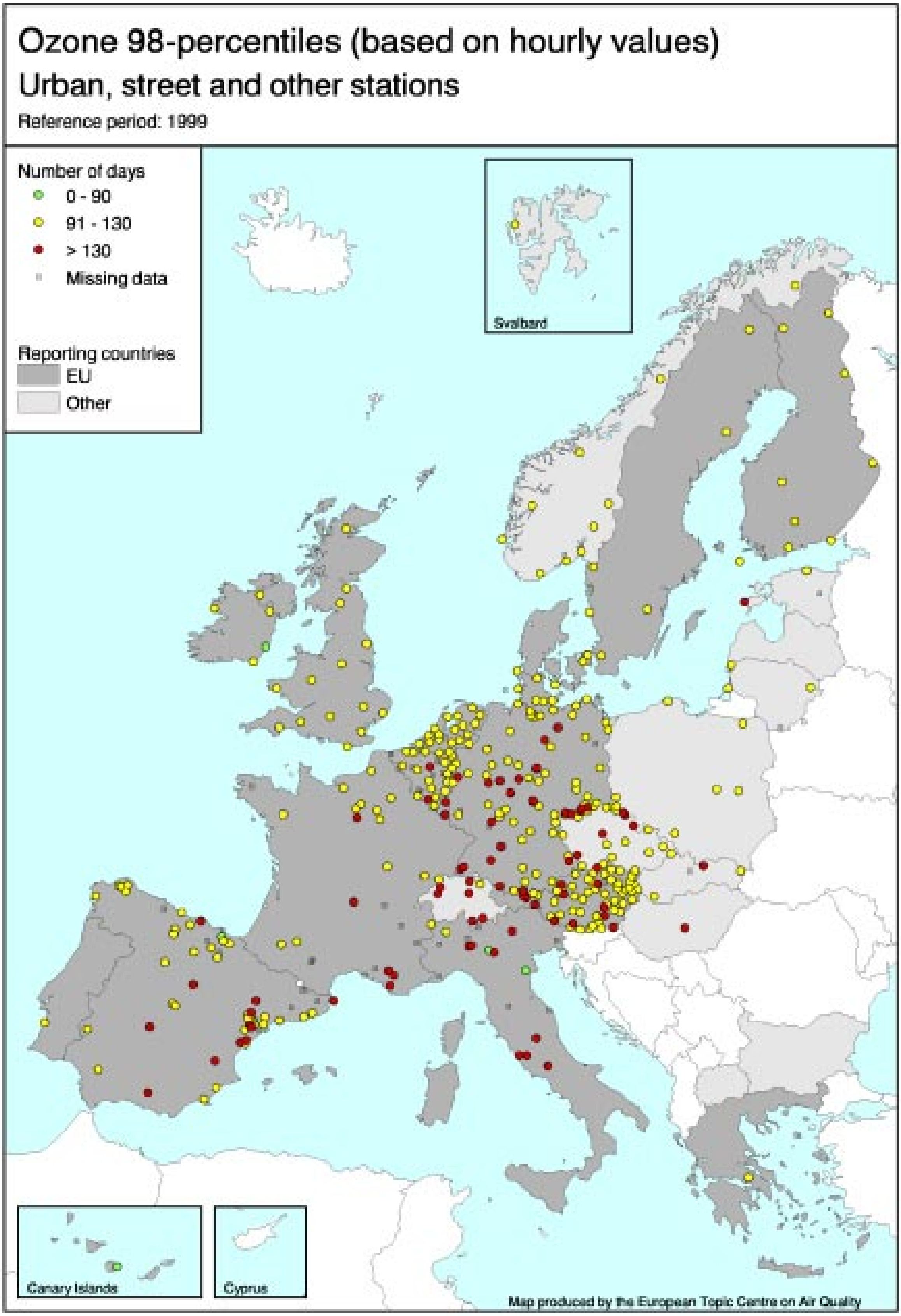
	8h min	P50 max.	8h min	P98 max.	8h min	P99.9 max.	8h min	Max. max.	Max. 65 (24)
Belgium	26	63	89	127	131	171	148	208	148
Denmark	48	66	94	121	123	154	126	176	124
Germany	na	na	na	na	na	na	na	na	162
Greece	20	73	49	152	63	205	65	233	151
Spain (1)	12	101	33	145	50	502	25	659	427
France	na	na	na	na	na	na	53	232	183
Ireland	48	79	75	109	na	na	124	172	143
Italy	9	87	22	207	na	na	29	273	177
Luxembourg	24	68	67	139	91	166	116	181	148
Netherlands	22	53	70	110	106	164	127	195	132
Austria	21	99	89	138	114	158	121	188	147
Portugal	18	63	67	120	87	144	62	189	126
Finland	39	75	82	120	97	146	103	163	127
Sweden	57	67	99	111	113	138	123	153	123
United Kingdom	8	74	48	118	74	196	90	220	162
Bulgaria	na	na	na	na	na	na	na	na	na
Switzerland	26	85	104	154	125	199	132	221	149
Czech Republic	20	81	54	139	74	163	46	174	148
Estonia	na	na	na	na	na	na	na	na	174
Hungary	66	66	128	128	147	147	155	155	na
Lithuania	24	24	74	74	92	92	100	135	107
Latvia	na	na	na	na	na	na	na	na	91
Norway	50	75	89	110	103	131	108	140	154
Poland	28	82	84	151	115	188	128	200	137
Slovakia	34	61	80	138	97	184	73	194	160

NB: na = range in percentile values not available; Latvia submitted information for one station only. The 99.9-percentiles are additional information submitted on a voluntary basis. Data from FYROM is not available.

([1]) See note Table 4.1.



Map 4.1: 98-percentiles (based on hourly concentrations; µg/m3) measured at rural background stations, period 1 January to 31 December 1999



Map 4.2: 98-percentiles (based on hourly concentrations; µg/m3) measured at urban, street and other stations, period 1 January to 31 December 1999

4.2. Exceedances of thresholds in 1999

4.2.1. Introduction

In the preliminary overview of air pollution by ozone during summer 1999 (de Leeuw et al., 2000) no exceedances of the threshold value for warning the public (360 µg/m^3 for hourly values) were reported. In the current annual report, Spain (five stations) and Italy (one station) report exceedances of this level during the summer months. The Spanish data shows extremely high values and interference cannot be excluded. A more in-depth study of the exceedances has been undertaken by Spain but not yet reported. In addition, ozone levels above 360 µg/m^3 were reported by Bulgaria for two stations. In view of the date (February) and time (between 19.00 and 7.00) of the exceedances measuring artefacts can not be excluded in this case. An overview of the exceedances of the 360 µg/m^3 threshold is presented in Table 4.3.

The exceedances in Italy appear to have a local character. On 20 June, the Gherardi station was the only Italian station for which ozone levels of 180 µg/m^3 or higher have been reported. On 23 June, 5 other stations reported exceedances but concentrations were not higher than 217 µg/m^3

A summary of occurrence of exceedances is presented in Table 4.4. However, Table 4.4. has to be interpreted carefully, as there are, in addition to differences in station density, additional aspects which affects the comparability between data from different countries. Firstly, the local environment (in particular NO_x sources) influences ozone levels; the differences between countries partly result from the differences in the fraction of street, urban and rural background stations. Secondly, about 10 % of the reporting stations show a data capture of less than 75 % (or data capture is not known); this might result in an underestimation of the number of exceedances. Also the differences in definition of an exceedance (some countries count an exceedance when the concentration is greater than the threshold value, other countries count it when the concentrations is equal to or greater than the threshold) may introduce difference in occurrence of exceedances.

Adverse effects of ozone on human health and vegetation not only depend on the frequency by which a threshold is exceeded but also on the severity of the exceedance. The severity of an exceedance can be expressed by the average concentrations during an exceedance period, see Table 4.4. The data suggests that in southern countries (Greece, Spain, Italy and Portugal) the concentrations are generally much higher during an exceedance than in the northern countries. Relatively high concentrations are also found in Austria, probably largely due to the high altitude of the stations.

Table 4.3: Reported exceedances of the threshold for warning the public (1h ozone concentration exceeding 360 μg/m3); reference period 1 January to 31 December 1999

Country	Station name and city	Date	Time and duration	Max. conc. (μg/m3)
Spain	Barrio 630, Puertollano	21.6.1999	10.00, 1h	440
Spain	Nestoralamo, Las Palmas de Gran Canaria	27.8.1999	14.00, 1h	1 270
		29.8.1999	17.00, 2h	506
Spain	Iguesta de Candelaria	28.8.1999	19.00, 1h	733
		(1)	23.00, 1h	1 194
		29.8.1999	1.00, 1h	784
		(1)	3.00, 1h	829
			5.00, 3h	394
			12.00, 4h	1 162
			17.00, 1h	464
			19.00, 1h	722
			21.00, 1h	774
		30.8.1999	1.00, 1h	1 073
Spain	Polideportivo Municipal, Santa Cruz de Tenerife	27.8.1999	15.00, 1h	389
		28.8.1999	1.00, 1h	421
		(1)	11.00, 1h	413
			13.00, 1h	386
		29.8.1999	2.00, 1h	564
		(1)	4.00, 1h	378
			8.00, 1h	424
			10.00, 1h	425
			16.00, 2h	614
			23.00, 1h	389
		12.9.1999	12.00, 1h	496
		14.9.1999	16.00, 1h	575
		16.9.1999	15.00, 4h	538
		18.9.1999	13.00, 1h	373
		19.9.1999	12.00, 5h	829
		(1)	22.00, 2h	531
		20.9.1999	1.00, 4h	435
		(1)	6.00, 2h	396
			10.00, 8h	752
Spain	Los Gladiolos, Santa Cruz de Tenerife	27.8.1999	11.00, 1h	371
		(1)	13.00, 1h	430
		28.8.1999	12.00, 2h	667
		29.8.1999	4.00, 1h	368
		(1)	7.00, 1h	387
			10.00, 5h	761
Italy	Gherardi, Jolanda di Savoia	20.6.1999	14.00, 1h	365
		23.6.1999	14.00, 1h	361
Bulgaria	AMS Rakovsky, Dimitrovgrad	19.2.1999	14.00; 1h	362
		24.2.1999	16.00, 1h	427
		17.5.1999	23.00, 2h	429
		18.5.1999	1.00, 1h	409
		(1)	3.00, 6h	434
		21.5.1999	3.00, 1h	384
Bulgaria	AMS Rakovsky, Dimitrovgrad	22.5.1999	9.00, 1h	418
		23.5.1999	17.00, 1h	371
		26.5.1999	22.00, 2h	542
		27.5.1999	1.00, 2h	517
		28.5.1999	20.00, 1h	440
		29.5.1999	7.00, 1h	365
		30.5.1999	5.00, 1h	376
		(1)	7.00, 2h	389
		31.5.1999	6.00, 2h	366
		1.6.1999	3.00, 5h	505
		(1)	21.00, 1h	400
			23.00, 2h	532
		2.6.1999	3.00, 5h	479
			20.00, 3h	465
		4.6.1999	19.00, 1h	384
		5.6.1999	19.00, 4h	582
Bulgaria	AMS Rail. Station, Vratza	14.7.1999	3.00, 5h	410

(1) As exceedances are counted on a daily basis, these non-continuous periods form only one exceedance.

Table 4.4: Occurrence of exceedances (OoE; in days) and average ozone concentration during exceedance (C-aver in µg/m3) reference period 1 January to 31 December 1999

	Number of stations (2)	Threshold value (µg/m3) 180-1h OoE	C-aver	110-8h (1) OoE	C-aver	65-24h OoE	C-aver
Belgium	31	1.7	190.2	24.5	130.7	62.4	79.0
Denmark	5	0.2	186.0	16.2	123.8	103.0	80.1
Germany	359	0.6	188.0	27.3	124.9	73.6	80.2
Greece	11	13.5	209.1	65.5	131.1	77.9	83.4
Spain	285	0.6	284.8	17.8	123.9	73.6	82.4
France	216	1.1	194.5	12.9	128.2	79.7	80.7
Ireland	5	0.0	-	3.0	123.4	118.0	78.6
Italy	78	9.7	202.7	48.3	135.2	88.1	85.2
Luxembourg	5	1.0	190.1	35.4	129.8	116.3	84.7
Netherlands	38	1.0	192.4	13.1	130.0	42.8	74.4
Austria	108	0.3	196.3	31.4	120.9	124.4	84.6
Portugal	16	1.5	196.7	5.8	130.6	30.7	76.9
Finland	11	0.0	-	12.3	119.4	144.5	82.3
Sweden	5	0.0	-	8.4	119.5	159.8	79.6
United Kingdom	70	1.1	193.0	9.9	130.4	56.1	76.3
Bulgaria	3	24.7	255.6	na	na	na	na
Switzerland	13	3.8	196.9	58.5	128.6	149.5	85.3
Czech Republic	55	0.1	186.5	29.8	121.7	123.3	83.1
Estonia	5	0.0	-	30.6	130.9	75.0	108.5
Hungary	1	1.0	181.9	65.0	123.5	na	na
Lithuania	5	0.0	-	8.0	119.1	87.8	76.5
Latvia	1	0.0	-	2.0	119.5	51.0	72.9
FYROM	2	2.0	193.7	na	na	na	na
Norway	14	0.0	-	5.6	124.6	145.5	92.7
Poland	19	1.4	190.8	33.8	125.1	114.0	82.3
Slovakia	14	0.6	188.1	29.0	123.3	87.7	83.3

NB: na = no data available.

(1) Based on the eight hourly value between 12.00 and 20.00.

(2) Note that differences in the number of stations reporting for each of the threshold levels may occur.

4.2.2. Exceedances of the threshold value for protection of human health

The threshold value for protection of human health (110 µg/m^3) is based on 8h ozone concentrations. According to the ozone directive, four 8h periods have to be considered: 0.00–8.00; 8.00–16.00, 16.00–24.00 and 12.00–20.00. Based on the average diurnal profile of ozone, the highest 8h values are generally expected for the 12.00–20.00 period and only exceedances of the threshold values for this period have been considered here.

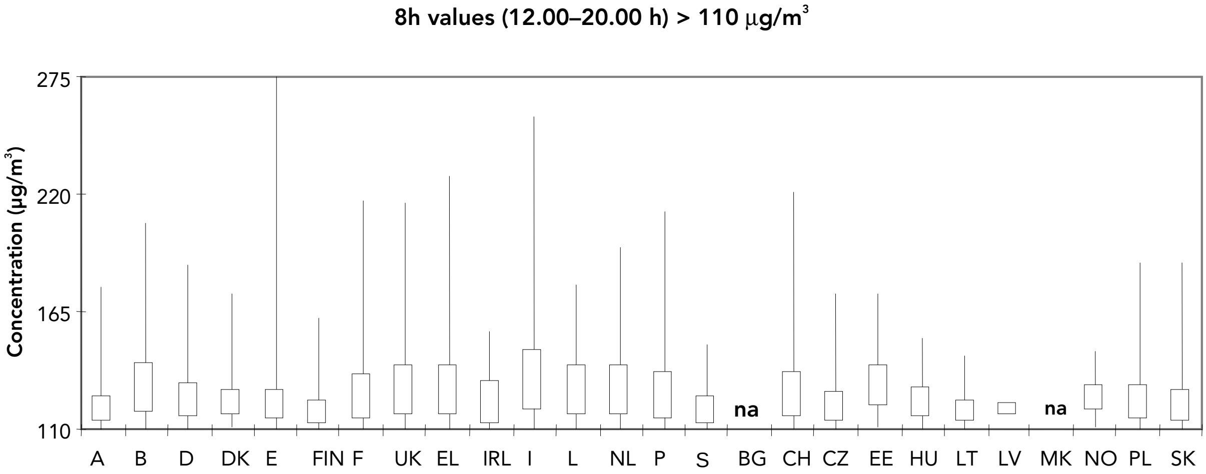
In 1999 exceedances of this threshold value were reported by 24 countries. Bulgaria and FYROM provided only information on exceedances of the hourly thresholds. A quick survey of the data shows that the 110 µg/m^3 8h threshold is more frequently exceeded than the 180 µg/m^3 1h threshold. It is therefore expected that also in Bulgaria and FYROM exceedance has occurred.

Figure 4.1 shows the frequency distribution of 8h ozone concentrations in excess of the 110 µg/m^3 threshold value using Box–Jenkins plots. For each country the Box–Jenkins plot indicates the minimum (here the minimum is of course 110 µg/m³), maximum, 25-percentile and 75-percentile concentrations during exceedance. Although peaks of more than 220 µg/m³ are observed in five reporting countries, Figure 4.1 shows that, in nearly all countries, in 75 % of all exceedance situations, the concentrations are below 165 µg/m³ (that is, below 150 % of the threshold value). Exceedances most frequently occur in the summer months.

Based on the information collected for rural background stations and assuming a representative radius of 100 km for these stations, it is estimated that 42 % of the population in EU-15 is exposed to concentrations above 110 µg/m³ during 1–25 days; 12 % experiences such an exposure during 50 days or more. For 22 % of the EU-15 population no information is available.

Figure 4.1: Frequency distribution of ozone concentrations (8h values; period 12.00–20.00; 1 January to 31 December 1999) in excess of the 110 µg/m3 threshold for 8h values.

NB: Frequency distributions are presented as Box–Jenkins plots indicating the minimum, the



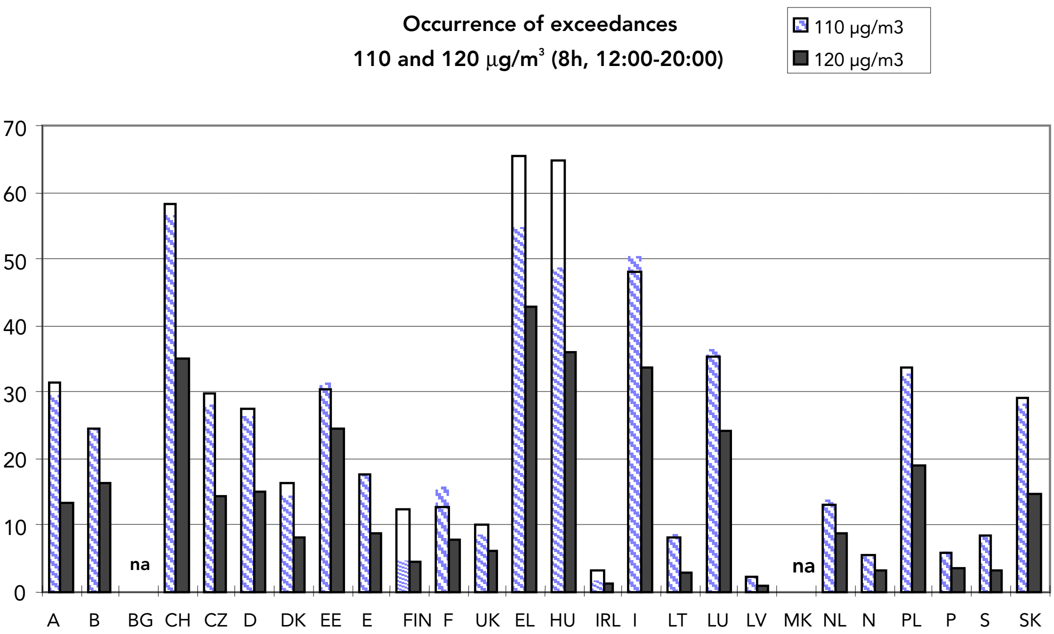
25-percentile, the 75-percentile and the maximum value (µg/m³). The maximum concentrations measured in Spain (659 µg/m³) is possibly a measuring artefact.

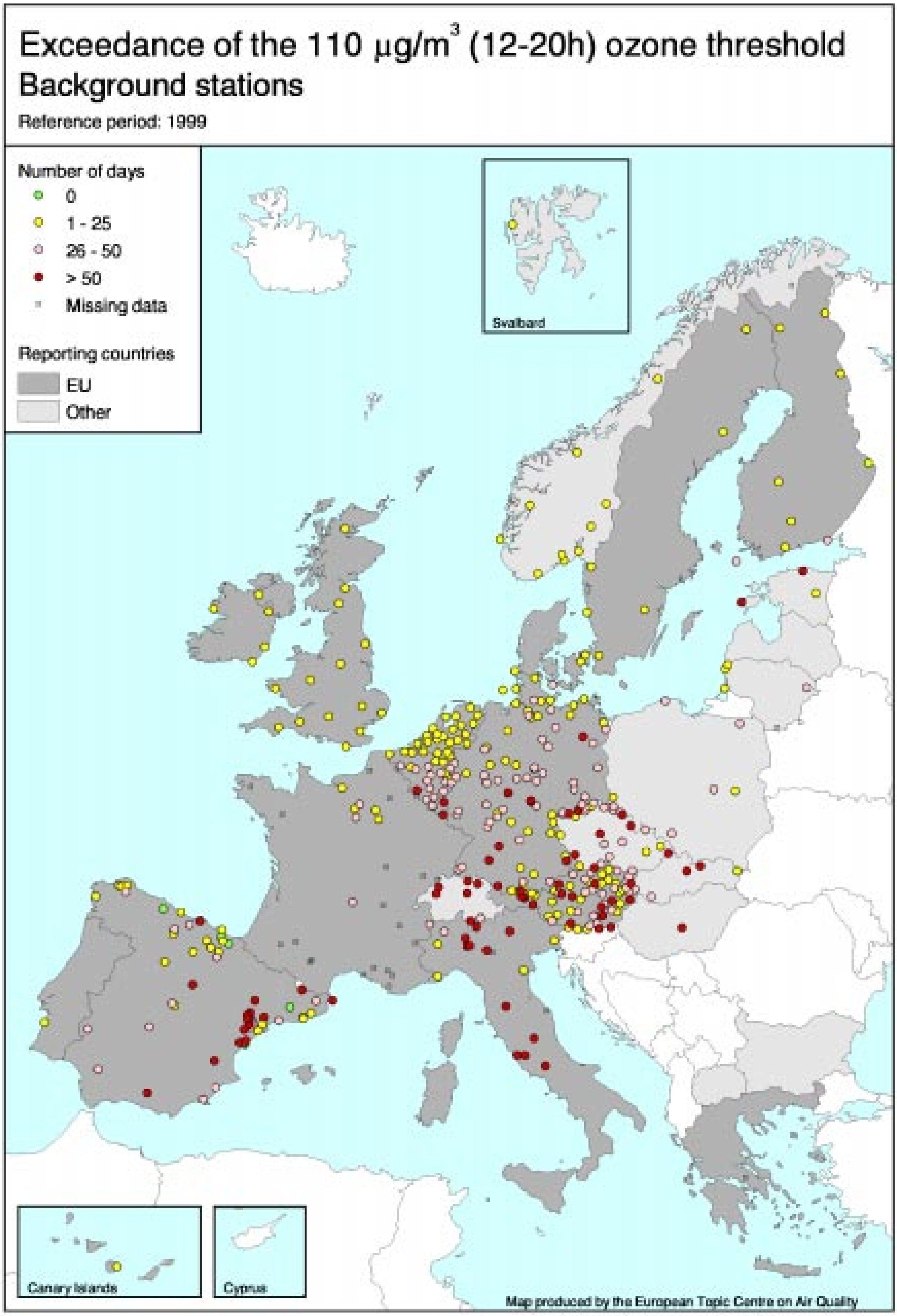
The geographical distribution of the number of days the threshold value of 110 µg/m³ was exceeded is shown in Map 4.3 for rural background stations and in Map 4.4 for urban, street and other stations. A comparison of Map 4.3 and Map 4.4 shows that exceedances are generally more frequently observed at rural background stations.

In the 1997 annual report an attempt was made to evaluate the ozone data submitted under the current directive against the proposed target values of the new ozone directive (de Leeuw et al., 1999). Following the proposed ozone directive 120 µg/m³ threshold value might not be exceeded on more than 20 days per year. The analysis showed that, due to the differences in the definitions of the threshold values, the information collected under the current ozone directive is not adequate to assess exceedances of proposed threshold values or the revised WHO ozone guidelines.

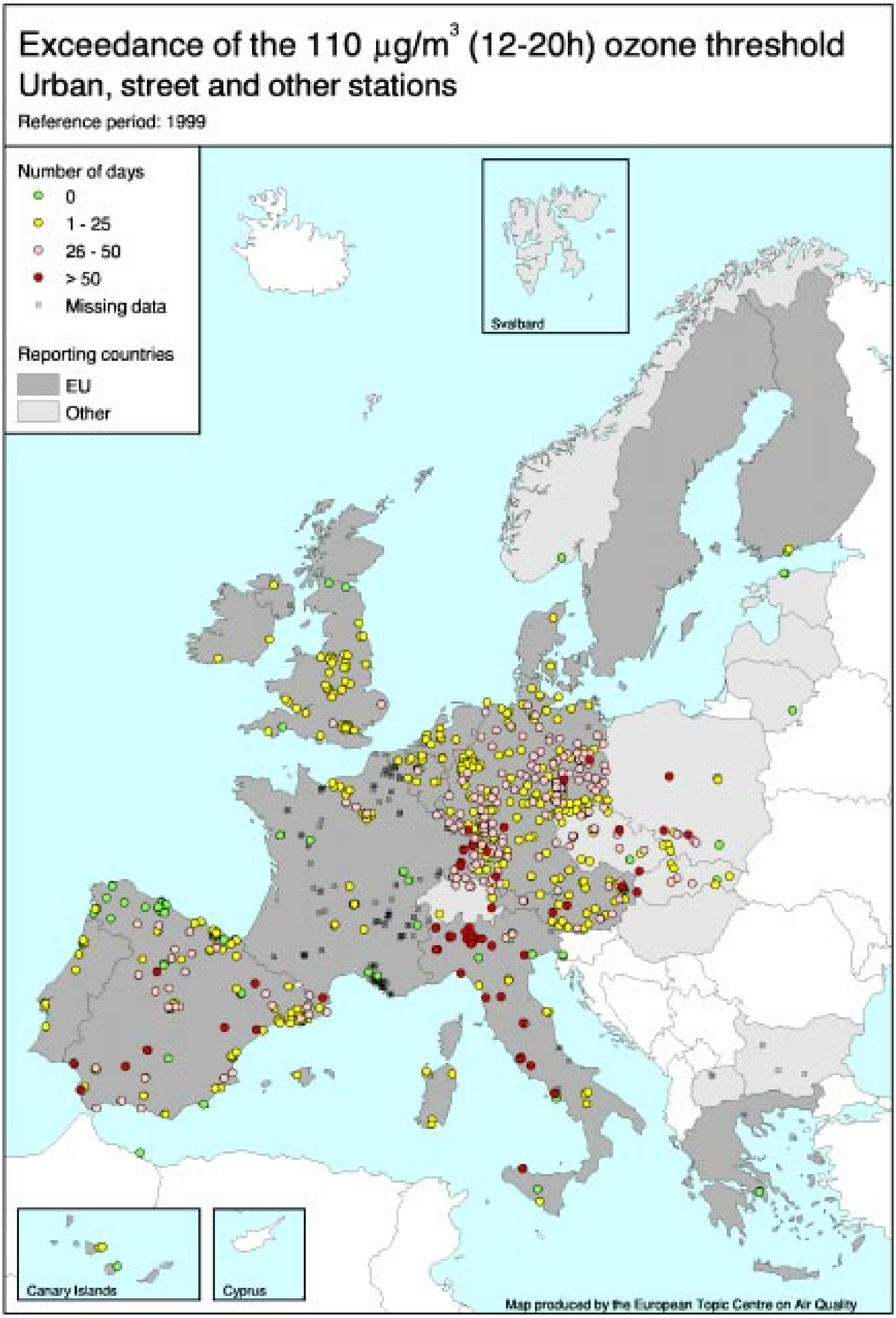
Nevertheless, in order to give the best possible approximation of exceedances of the threshold value for the protection of human health (120 µg/m³ for moving 8h values) the exceedances reported for the 8h period between 12.00 and 20.00 were used. In this way, information on exceedances of the 120 µg/m³ threshold level is available for 1 214 stations. At about 20 % of these stations the 8h average concentration between 12.00 and 20.00 is in excess of 120 µg/m³ on more than 20 days. Since ozone concentrations generally reach their maximum in the late afternoon, the average concentration over the period 12.00–20.00 is expected to be a good approximation of the highest daily 8h values calculated from a moving average. Figure 4.2 shows a European wide exceedance of this threshold value. However, evaluation of hourly data has shown that when comparing the number of exceedance days calculated from moving 8h means with such based on the fixed 12–20 h period, the latter is about 15 % lower, in urban areas 25 % lower. Figure 4.2 might therefore provide an underestimation of the exceedances of the proposed threshold value.

Figure 4.2: Comparison between the occurrence of exceedances of the current ozone threshold value for protection of human health (110 µg/m3, averaged between 12.00 and 20.00) and the proposed threshold value (120 µg/m3 for moving 8h values; calculations are, however, based ozone levels reported for the fixed time period 12.00–20.00h, see text), averaged over all stations; period 1 January to 31 December 1999





Map 4.3: Number of exceedances of the threshold value for protection of human health (110 $\mu g/m^3$ for 8h values) observed at rural background stations; 1 January to 31 December 1999, 8h average values for the period 12.00–20.00



Map 4.4: Number of exceedances of the threshold value for protection of human health (110 µg/m^3 for 8h values) observed at urban, street and other stations; 1 January to 31 December 1999; 8h average values for the period 12.00–20.00

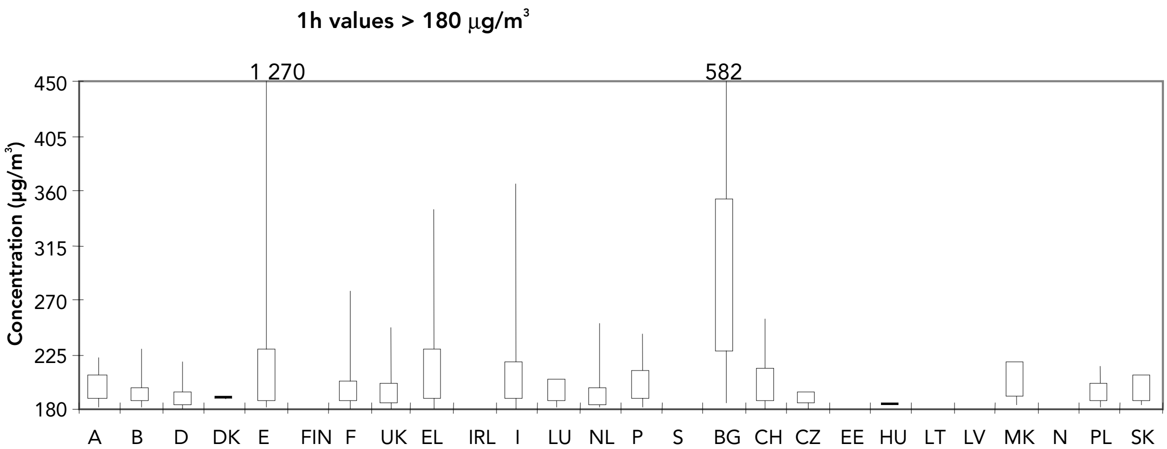
4.2.3. Exceedances of the threshold values for informing and warning the population

The threshold value for warning the population (360 µg/m^3, hourly value) was exceeded in 1999 at eight stations, see Section 4.2.1.

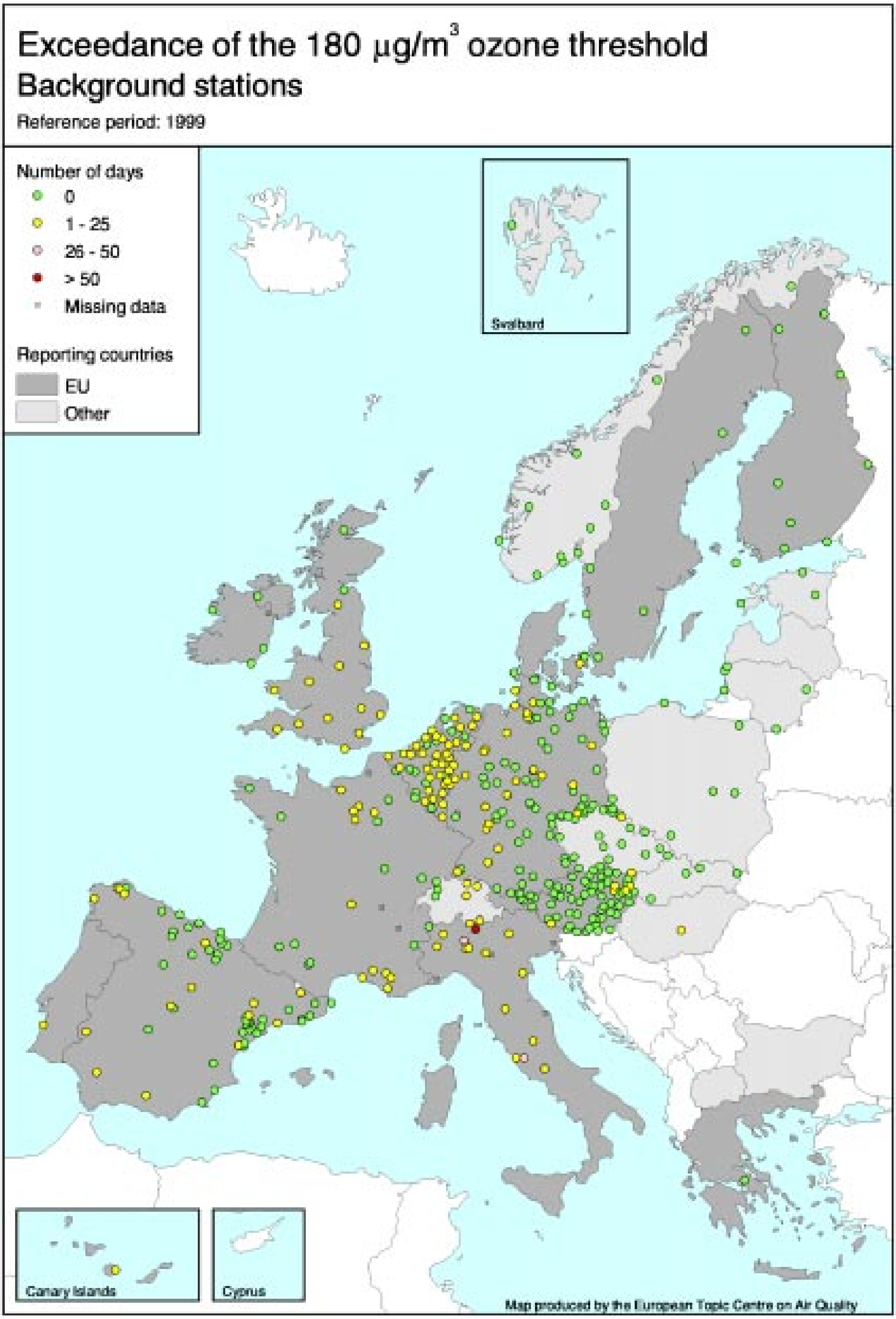
The geographical distribution of the number of exceedances of the threshold value for informing the public (180 µg/m^3, hourly value) is presented in Map 4.5 for rural background stations and in Map 4.6 for urban, street and other stations. Exceedances were reported for 19 countries (12 Member States). The remaining countries did not explicitly report exceedances but, based on the additional information provided, it can be concluded that exceedances indeed did not occur.

Figure 4.3 shows the frequency distribution of concentrations in excess of the threshold value for informing the public. Although the threshold value is exceeded by up to more than a factor of two, in almost all of the cases the exceedances were less extreme: Figure 4.3 shows that on 75 % of the days on which the threshold value was exceeded, the level of 225 µg/m^3 (that is 25 % above the threshold value) has generally not been reached.

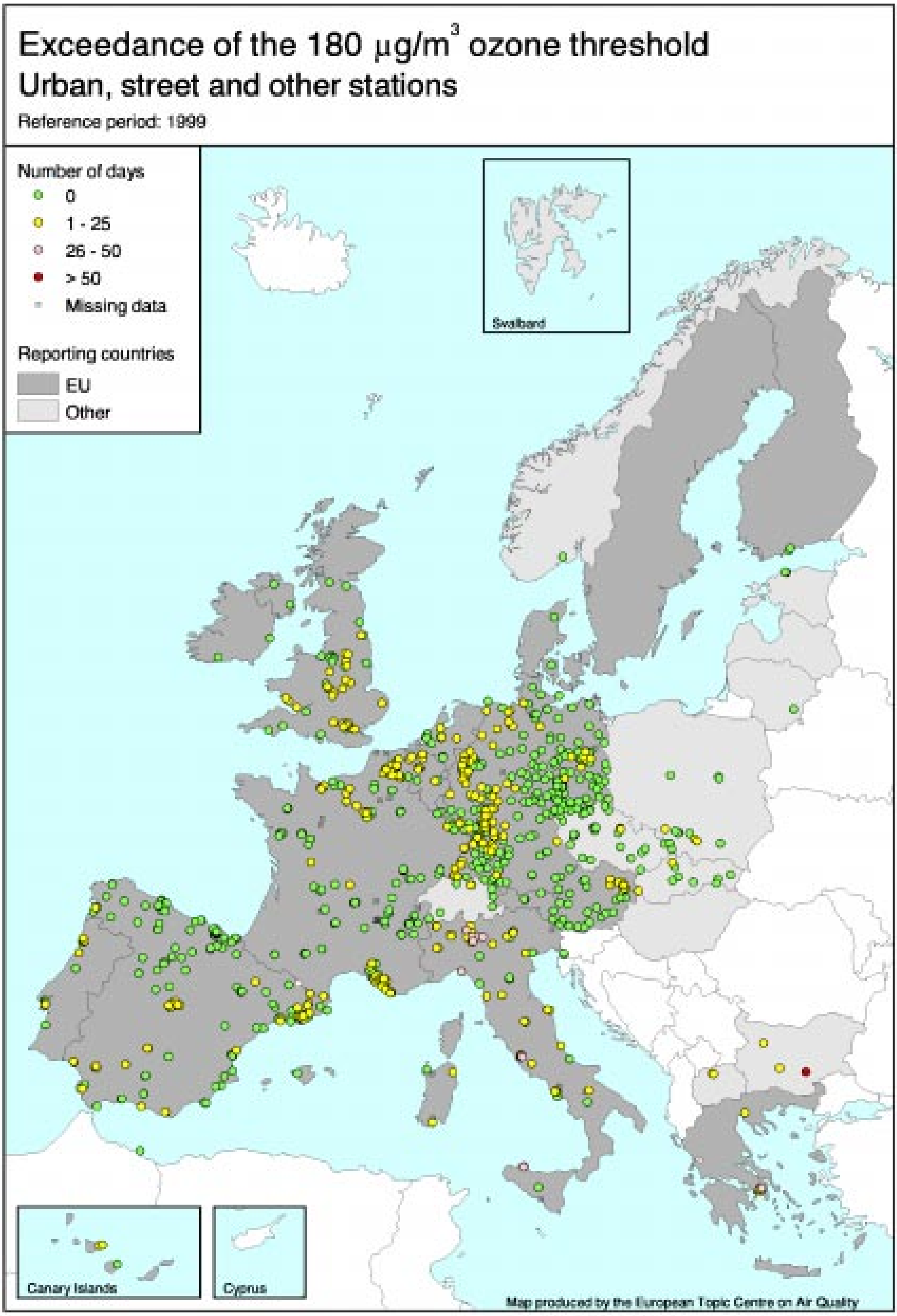
Figure 4.3: Frequency distribution of ozone concentrations (hourly values, 1 January to 31 December 1999) in excess of the 180 µg/m^3 threshold for hourly values. Frequency distributions are presented as Box–Jenkins plots indicating the minimum, the 25-percentile, the 75-percentile and the maximum value (µg/m^3)



NB: The maximum concentrations measured in Spain (1 270 µg/m^3) is possibly a measuring artefact. In Estonia, Finland, Ireland, Latvia, Lithuania, Norway and Sweden no exceedances of this threshold have been reported.



Map 4.5: Number of exceedances of the threshold value for informing the population (180 $\mu g/m^3$ for hourly values) observed at rural background stations; 1 January to 31 December 1999



Map 4.6: **Number of exceedances of the threshold value for informing the population (180 µg/m³ for hourly values) observed at urban, street and other stations; 1 January to 31 December 1999**

4.2.4. Exceedances of the threshold values for protection of vegetation

As Table 4.4 shows, exceedances of the daily threshold of 65 $\mu g/m^3$ for protection of vegetation were frequently observed in all reporting countries; the average daily concentrations during exceedance were frequently above 80 $\mu g/m^3$.

The geographical distribution of the number of exceedances of the daily threshold value is presented in Map 4.7 for the rural background stations. In Map 4.7 an attempt has been made to quantify the area where exceedances are observed. For the rural background stations a representative radius of 100 km has been assumed, see also Map 2.2. When the 'representative areas' of two or more stations overlap, the number of exceedances in this location is estimated by a distance-weighted interpolation. With the exception of a small area in Spain, no part of the forest area or the arable land for which information is available is protected against exceedances of this threshold.

The exposure of forest and arable land in relation to the assumed radius of representativeness for the rural background stations is shown in Fig 4.4. For 30–70 % of the total relevant area in EU-15 no information is available. Relative to the total area of forest or arable land, about 25 to 50 % of the area is exposed to concentrations above the daily threshold of 65 $\mu g/m^3$ during 76 days or more. Relative to the area for which data is available, these percentages increase to 70–90 %.

For exceedances of a daily average threshold value, the differences between rural background and urban stations are more pronounced than is the case for hourly threshold values. In urban areas the low concentrations during the night (caused by interaction with NO_x emissions) reduce the daily average concentrations; in rural areas the decrease in ozone concentrations during the night is generally less strong. In north-west Europe, however, the high NO_x emission density might also cause some quenching of ozone at rural sites which explains the relatively low number of exceedances in this region compared both to northern and southern Europe. The different behaviour of ozone concentrations at different types of stations is further illustrated in Figure 4.5 where the occurrence of exceedance is given per station type.

Figure 4.4: Frequency distribution of exposure classes for forest area and arable land in relation to the representativeness radius for rural background stations, 1999

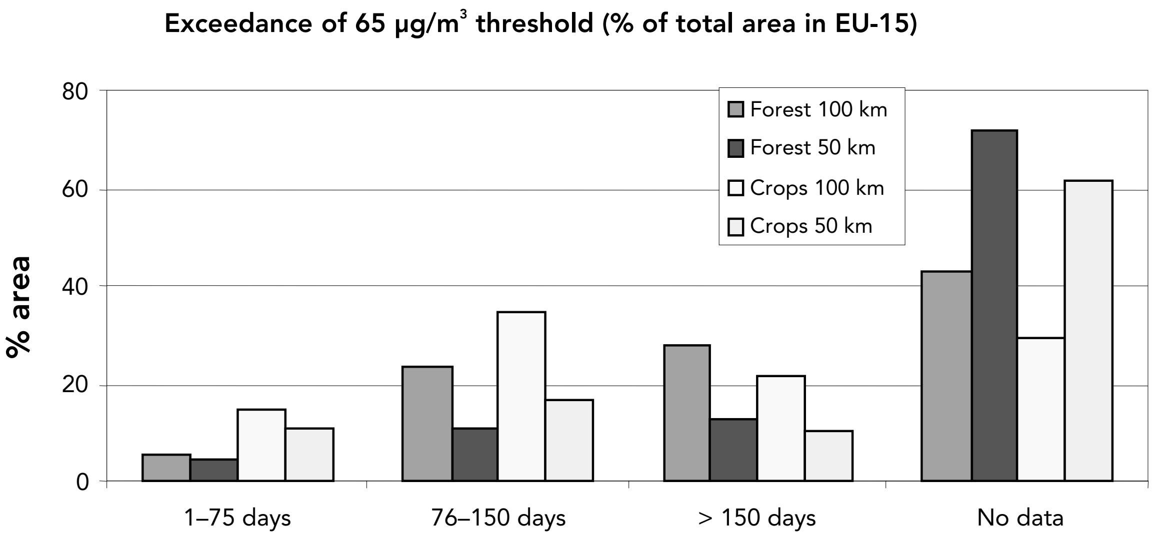
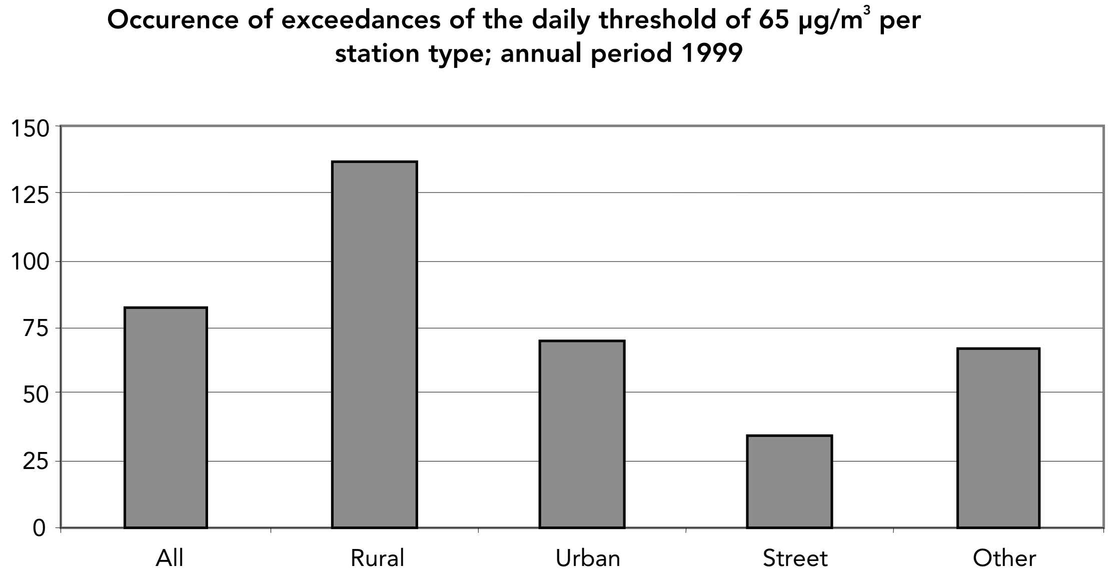


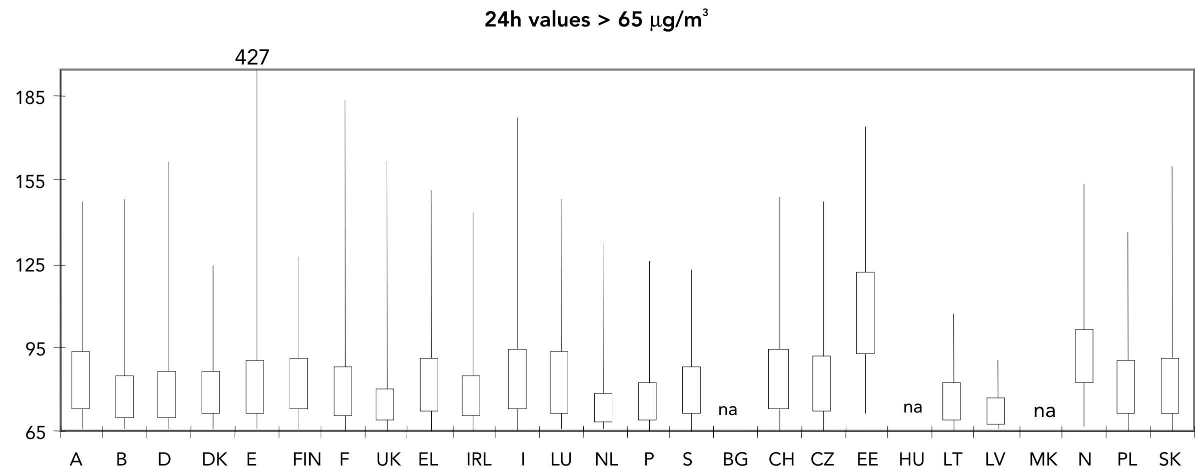
Figure 4.5: Occurrence of exceedance of the ozone daily threshold of 65 µg/m³ as function of station type, averaged over all reporting countries; period 1 January to 31 December 1999



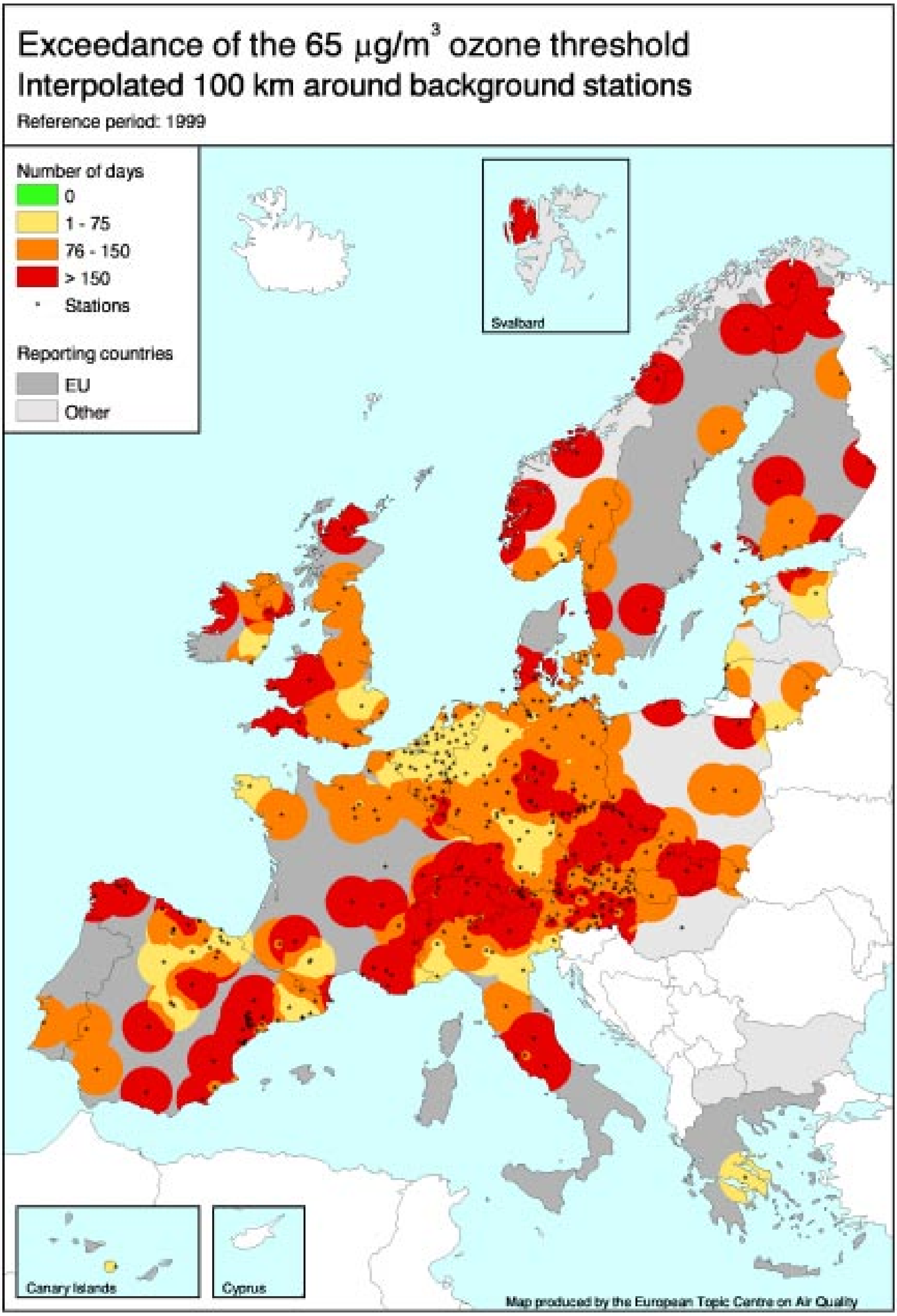
The number of exceedances at rural background, urban and street stations are roughly in the proportion of 4 to 2 to 1.

Figure 4.6 shows the frequency distribution of daily values in excess of 65 µg/m³. Although high values of more than 160 µg/m³ were observed, in all countries except Estonia and Norway for 75 % of the exceedances the daily average concentration falls between 65 and 98 µg/m³ (that is, below 1.5 times the threshold value).

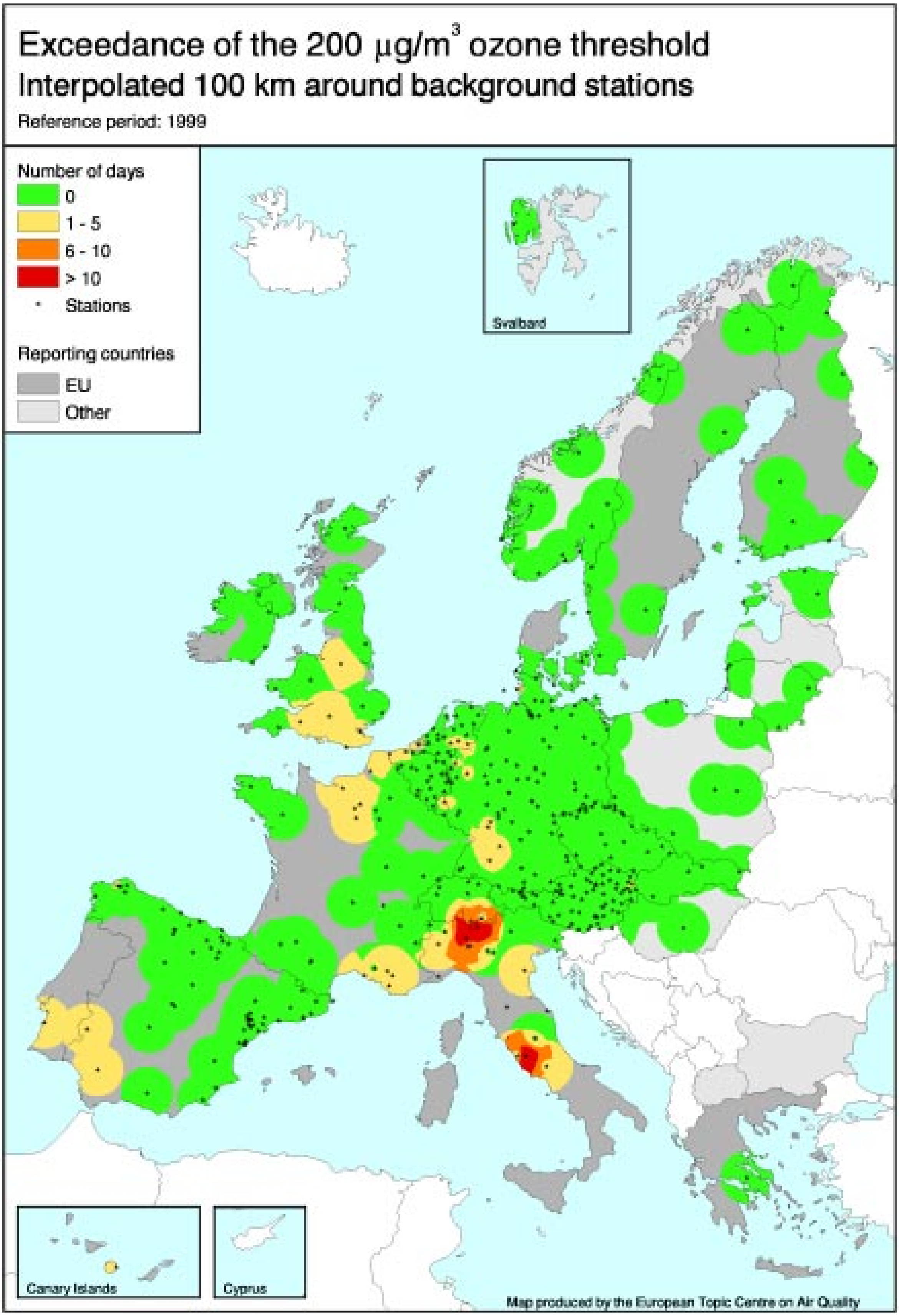
Figure 4.6: Frequency distribution of ozone concentrations (24h values; 1 January to 31 December 1999) in excess of the 65 µg/m³ threshold for daily values



NB: Frequency distributions are presented as Box–Jenkins plots indicating minimum, 25-percentile, 75-percentile and maximum values.



Map 4.7: Number of exceedances of the threshold value for vegetation (65 µg/m³ for daily values) observed at rural background stations, 1999. Data is interpolated using inverse distance weighting and a cut-off distance of 100 km



Map 4.8: Number of exceedances of the threshold value for vegetation (200 µg/m³ for hourly values) observed at rural background stations 1999. Data is interpolated using inverse distance weighting and a cut-off distance of 100 km

Exceedances of the hourly threshold value for protection of vegetation (200 µg/m^3) were reported by 16 countries (11 Member States). No exceedances were observed in Czech Republic, Denmark, Estonia, Finland, Hungary, Ireland, Lithuania, Latvia, Norway, and Sweden, see Table 4.4. The geographical distribution of the number of days on which this hourly threshold value was exceeded is presented in Map 4.8 for rural background stations. The map shows that above approximately 55° N this threshold value was not exceeded.

4.3. Comparison with previous years

In a recent study the data submitted under the ozone directive up to the annual period 1998 was re-analysed (de Leeuw, 2000). Using the available information covering the period of five years (1994–98), the data has been analysed for a possible trend in statistical parameters (50- and 98-percentiles) and number and severity of exceedances. Time series are relatively short but the data suggest 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 1994–98. However, these conclusions must be interpreted carefully since on the short time scales considered here meteorological inter-annual variations may play an important role. The decrease in peak values is most likely caused by the decrease in European ozone precursor emissions since 1990; insufficient data is available to explain the increasing 50-percentile values. Possible explanations are an increase in tropospheric ozone background values caused by a worldwide increase in CH_4, CO and NO_x emissions or a reduced ozone titration by reduced NO_x emissions on the local scale. The data submitted to date under the ozone directive is insufficient to provide firm conclusions on this point.

An overview of the 1994–98 statistical analysis is presented in Table 4.5. Extending the time series with the data from the annual 1999 report will be undertaken.

Table 4.5. 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/m^3 (1h), 110 µg/m^3 (8h) and 65 µg/m^3 (24h); monitoring period 1994–98 (de Leeuw, 2000)

	50 P	98 P	180 µg/m^3 (1h)	110 µg/m^3 (8h)	65 µg/m^3 (24h)
Number of reporting stations	1 269	1 269	1 382	1 207	1 250
Number of stations with 4 or 5 monitoring years	575	575	609	559	562
Number of stations with significant upward trend	50	6	2	7	28
Number of stations with significant downward trend	8	110	32	107	69
Number of stations in compliance with threshold during the period 1994–98	-	-	63	1	0

5. Conclusions

Summer 2000

This report presents a first evaluation of the reported exceedances of the threshold values for informing and warning the public during the summer of 2000 (April–August). Information is based on monitoring data which is not completely validated and hence the conclusions drawn should be considered as preliminary.

Information on the occurrence of exceedances has been received from all EU Member States and from 11 other countries (Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Norway, Poland, Slovak Republic, Slovenia and Switzerland) for the months April, May, June, July and August. The quality of the exceedance information supplied was good and according to EU specifications. Improvements can be made by a number of countries as far as characterisation of stations is concerned. In the summer of 2000, 1 778 monitoring stations were assumed to be operational.

The threshold for warning the public (1h > 360 $\mu g/m^3$) was not exceeded in the European territory during the 2000 summer season.

The threshold for informing the public (1h > 180 $\mu g/m^3$) was exceeded in all EU Member States with the exception of Ireland and Finland. The same countries did not report any exceedance during the 1997, 1998 and 1999 summer season. In addition, no exceedances were observed in Estonia, Hungary, Latvia and Norway.

In other EU countries, the number of days on which at least one exceedance was observed in the summer of 2000 ranged from 3 in Luxembourg and the United Kingdom to 87 in Italy. 29 % of all stations reported one or more exceedance. On average 3.5 exceedances occurred in 2000 at stations which recorded at least one exceedance. The average maximum hourly concentration during an exceedance of the threshold in 2000 was 199 $\mu g/m^3$.

Annual period 1999

In the annual reporting of 1999 data on ozone concentrations and exceedances were received by the European Commission from all Member States. In addition, information from 11 other European countries was received. The 15 EU Member States provided information on ozone concentrations measured at 1 304 monitoring stations. Bulgaria, Switzerland, the Czech Republic, Estonia, Hungary, Lithuania, Latvia, FYROM, Norway, Poland, and Slovakia provided information on ozone concentrations measured at 147 stations.

The threshold value set for the protection of human health (110 $\mu g/m^3$, 8h average) was exceeded substantially in all reporting countries. The threshold was exceeded on average on 25 days at each reporting station and during an exceedance the average concentration was about 126 $\mu g/m^3$.

The threshold values set for the protection of vegetation were exceeded substantially and in almost all EU Member States. The threshold value of 65 $\mu g/m^3$ (24h average) was reported to be exceeded substantially (by up to a factor 3), widely (in all reporting countries) and frequently (nearly all countries report exceedances during more than 100 days at one or more of their stations). The threshold value of 200 µg/m^3 (hourly average) was exceeded largely and widely (in total 16 countries, 11 EU Member States) on a limited number of days.

In 1999 exceedance of the threshold value for warning the population (360 µg/m^3 for hourly values) was reported from eight stations of which six stations are located in two Member States. At five Spanish stations, of which four are located on the Canary Islands and one in the southern part of Spain, extremely high concentrations have been measured, partly during night-time hours. It might be that high values are caused by possible interference or malfunctioning of the monitoring system. On 20 and 23 June the ozone concentrations at the Italian station Gherardi (about 70 km SSW from Venezia) reached values just above 360 µg/m^3. It seems to be a rather local effect as concentrations on neighbouring stations are much lower. In Bulgaria two stations (AMS Rakovsky in Dimitrovgrad and AMS Rail Station in Vratza) reported exceedances; some reservation must be made here as peak values were reached during night-time or early morning hours. Exceedance of the information threshold value of 180 µg/m^3 (1h average) was reported for stations in 19 countries of which were 12 EU Member States.

6. References

Bull, K. R. (1991), The critical load/level approach to gaseous pollutant emission control. *Environ. Pollut.,* Vol. 69, pp. 105–123.

De Leeuw, F., Sluyter, 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., Sluyter, R. and Camu, A. (2000), Air pollution by ozone in Europe in 1998 and summer 1999, *EEA Topic Report,* European Environment Agency, Copenhagen, in preparation.

De Leeuw, F. A. A. M. (2000), 'Trends in ground level ozone concentrations in the European Union', *Environmental Science & Policy,* accepted.

De Saeger, E., Noriega Guerra, A., Gerboles, M., Rau, H., Amantini, L. and Perez Ballesta, P. (1997), 'Harmonisation of Directive 92/72/EEC on air pollution by ozone; inter-comparisons of calibration procedures for ozone measurements', Report EUR 17662, European Commission, Brussels.

EC 1999. 'Ozone position paper', Office for Official Publication of the European Communities, Luxembourg, ISBN 92-828-7865-1.

Hjellbrekke, A. G. (2000), 'Ozone measurements 1998', *EMEP/CCC Report,* 5/2000, NILU, Kjeller, Norway.

Larssen S., Sluyter, R. and Helmis, C. (1998), Criteria for Euroairnet, the EEA air quality monitoring and information network. in preparation, ETC/AQ, NILU, Kjeller, Norway.

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

WHO (1996a), 'Update and revision of the WHO air quality guidelines for Europe. Classical air pollutants: ozone and other photochemical oxidants', WHO European Centre for Environment and Health, Bilthoven, Netherlands.

WHO (1996b) 'Update and revision of the WHO air quality guidelines for Europe. Ecotoxic effects: ozone effects on vegetation' European Centre for Environment and Health, Bilthoven, Netherlands.

Annex I: Summer 2000 exceedances transmitted by Spain and Bulgaria which were not processed

Spain

	Station name	Month	Day	h	Dur	Max.	Reason
ES	CALLE ANCHA	7	20	7	2	401	Prov.data, possible interference with hydrocarbons
ES	CAMPO DE FUTBOL	7	20	7	2	301	Prov.data, possible interference with hydrocarbons
ES	INSTITUTO N° 3	7	20	8	1	354	Prov.data, possible interference with hydrocarbons
ES	ALCORCON	4	29	4	1	479	Prov.data, WG conc.: interf. with unknown substance
ES	ALCORCON	4	29	8	1	278	Prov.data, WG conc.: interf. with unknown substance
ES	COSLADA	4	29	0	2	421	Prov.data, WG conc.: interf. with unknown substance
ES	FUENLABRADA	4	29	7	1	364	Prov.data, WG conc.: interf. with unknown substance
ES	GETAFE	4	29	2	1	311	Prov.data, WG conc.: interf. with unknown substance
ES	GETAFE	4	29	5	1	494	Prov.data, WG conc.: interf. with unknown substance
ES	GETAFE	4	29	7	1	227	Prov.data, WG conc.: interf. with unknown substance
ES	LEGANES	4	29	3	2	627	Prov.data, WG conc.: interf. with unknown substance
ES	LEGANES	4	29	7	2	291	Prov.data, WG conc.: interf. with unknown substance
ES	ESCUELAS AGUIRRE	4	29	3	1	183	Prov.data, WG conc.: interf. with unknown substance
ES	LUCA DE TENA	4	29	2	1	246	Prov.data, WG conc.: interf. with unknown substance
ES	PLAZA DE FERNANDEZ LADREDA	4	29	5	1	270	Prov.data, WG conc.: interf. with unknown substance
ES	VILLAVERDE	4	29	1	1	184	Prov.data, WG conc.: interf. with unknown substance
ES	MARQUES DE VADILLO	4	29	5	1	247	Prov.data, WG conc.: interf. with unknown substance
ES	CASA DE CAMPO	4	29	4	2	471	Prov.data, WG conc.: interf. with unknown substance
ES	CASA DE CAMPO	4	29	8	1	268	Prov.data, WG conc.: interf. with unknown substance
ES	PASEO DE EXTREMADURA	4	29	4	1	250	Prov.data, WG conc.: interf. with unknown substance
ES	MORATALAZ	4	29	1	2	240	Prov.data, WG conc.: interf. with unknown substance
ES	BARRIO DEL PILAR	4	29	5	1	183	Prov.data, WG conc.: interf. with unknown substance
ES	MOSTOLES	4	29	8	1	218	Prov.data, WG conc.: interf. with unknown substance

Bulgaria

	Station name	Month	Day	h	Dur.	Max.	Reason
BG	AMS Rakovsky	5	26	2	14	357	Unknown reason
BG	AMS Rakovsky	5	26	16	3	414	Unknown reason
BG	AMS Rakovsky	5	27	4	13	369	Unknown reason
BG	AMS Rakovsky	5	27	17	8	415	Unknown reason
BG	AMS Rakovsky	5	28	2	17	347	Unknown reason
BG	AMS Rakovsky	5	28	19	6	364	Unknown reason
BG	AMS Rakovsky	5	29	2	17	312	Unknown reason
BG	AMS Rakovsky	5	29	19	6	382	Unknown reason
BG	AMS Rakovsky	5	30	2	23	307	Unknown reason
BG	AMS Rakovsky	5	31	2	23	324	Unknown reason
BG	AMS Rakovsky	6	5	2	7	217	Unknown reason
BG	AMS Rakovsky	6	5	16	1	183	Unknown reason
BG	AMS Rakovsky	6	5	18	7	308	Unknown reason
BG	AMS Rakovsky	6	6	2	8	214	Unknown reason
BG	AMS Rakovsky	6	6	14	11	286	Unknown reason
BG	AMS Rakovsky	6	7	2	8	230	Unknown reason
BG	AMS Rakovsky	6	7	21	2	430	Unknown reason
BG	AMS Rakovsky	6	7	24	1	486	Unknown reason
BG	AMS Rakovsky	6	8	2	11	482	Unknown reason
BG	AMS Rakovsky	6	9	14	5	302	Unknown reason
BG	AMS Rakovsky	6	9	21	2	452	Unknown reason
BG	AMS Rakovsky	6	9	24	1	478	Unknown reason
BG	AMS Rakovsky	6	10	2	23	427	Unknown reason
BG	AMS Rakovsky	6	11	2	23	325	Unknown reason
BG	AMS Rakovsky	6	15	2	10	474	Unknown reason
BG	AMS Rakovsky	6	16	17	2	356	Unknown reason
BG	AMS Rakovsky	6	16	20	2	404	Unknown reason
BG	AMS Rakovsky	6	17	14	11	463	Unknown reason
BG	AMS Rakovsky	6	18	2	23	337	Unknown reason
BG	AMS Rakovsky	6	19	2	13	282	Unknown reason
BG	AMS Rakovsky	6	22	24	1	196	Unknown reason
BG	AMS Rakovsky	6	23	2	6	312	Unknown reason
BG	AMS Rakovsky	6	24	4	5	311	Unknown reason
BG	AMS Rakovsky	6	25	6	2	276	Unknown reason
BG	AMS Rakovsky	6	26	4	3	295	Unknown reason
BG	AMS Rakovsky	6	26	21	4	334	Unknown reason
BG	AMS Rakovsky	6	27	2	9	308	Unknown reason
BG	AMS Rakovsky	6	27	21	4	320	Unknown reason
BG	AMS Rakovsky	6	28	2	8	306	Unknown reason
BG	AMS Rakovsky	6	28	22	3	298	Unknown reason