PART II
Information document concerning air pollution by ozone

Overview of the situation in the European Union during the 1998 summer season (April-August)

Report to the Commission by the European Environment Agency Topic Centre on Air Quality

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1. Introduction

Ozone is a strong photochemical oxidant, which may cause serious health problems and damage to materials and ecosystems. Human exposure to elevated levels of ozone concentrations can give rise to decreases in lung function and inflammatory responses. Symptoms observed are cough, chest pain, difficulty in breathing, headache and eye irritation.

Both laboratory and epidemiological data indicate large variations between individuals in response to episodic O_3 exposure, the effects seem to be more pronounced in children than in adults [WHO, 1995]. Studies indicate that exposure to ozone concentrations in the range 160-360 for a period of 1-8 hours reduces various pulmonary functions.

In view of the harmful effects of photochemical pollution, the Council adopted in 1992 Directive 92/72/EEC on air pollution by ozone. The Directive defined threshold values, established procedures for harmonised monitoring, for collecting and exchanging data and for information of the public when exceedances of threshold values occur.

More information on the current experience and knowledge concerning photochemical air pollution may be found in *Tropospheric Ozone in the European Union, The Consolidated Report* [Beck *et al.*, 1998] which has been prepared as required by Article 8 of the Directive.

The thresholds set by the Directive are presented in Table 1. As far as data reporting is concerned, two types of reporting can be distinguished according to Article 6 of the Directive:

1. Exceedances of the population information and warning thresholds (date, time, duration and maximum concentration) must be reported to the Commission within one month after occurrence (data is not necessarily validated);
2. Exceedances of all threshold values including some additional statistics (percentiles, maxima) must be provided within 6 months after the end of a calendar year (validated data).

Table 1: Threshold values for ozone concentrations set in Directive 92/72/EEC

threshold for:	concentration (in $\mu g/m^3$)	averaging period (h)
health protection	110	8
vegetation protection	200	1
	65	24
population information	180	1
population warning	360	1

According to Article 7 of the Directive, the Commission prepares a report summarising all the information transmitted by the Member States at least once a year. The report for the 1997 calendar year will become available together with this document [De Leeuw and De Paus, 1998].

In this document a first assessment is made of the 1998 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.

The report is mainly intended to provide fast feedback to the Member States on their data. It also enables the Member States to compare the levels observed in the past summer season with those observed in other Member States. Note that information presented in this document is not necessarily based on validated monitoring data and hence should be considered as preliminary.

2. Availability of data

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

In 1998, for the first time, all 15 EU Member States provided information on the observed exceedances in time (the deadline for transmitting data was set at 20 September 1998), or indicated that no exceedances were observed. It is greatly appreciated by the Commission that MS were able to transmit August exceedance data before the formal deadline as set in the Directive.

Some countries submitted files which were not formatted according to the prescribed Commission requirements [Council Directive 92/72/EEC on Air Pollution by Ozone. Information and data exchange formats. Doc.Rev. 11/243/95]. These files by exception were converted at the European Topic Centre on Air Quality (ETC-AQ) for further processing.

As was the case in 1997, Ireland, Denmark, Finland and Sweden did not record any exceedance of the 180 µg/m^3 threshold in 1998.

Table 2 presents an overview of observed exceedances per country per month.

Member States were requested to check and, if necessary, update the information made available to the Commission on ozone monitoring sites implemented in the framework of the Directive. For the interpretation of ozone data it is essential to have information on the direct surroundings of the station since ozone may be scavenged by locally emitted nitrogen oxides or by enhanced dry deposition which might occur for example under a forest canopy. Member States were requested to classify their stations as street, urban background[1], rural or industrial stations as a first description of the environment of the stations.

[1] Urban background: station located in the built-up area of the city but not directly influenced by emission sources such as traffic or industry.

Table 2: Overview of observed exceedances per month per country in 1998. p: exceedance of the population information threshold reported, -: no exceedance reported, w: exceedance of the threshold for warning of the public reported.

	April	May	June	July	August
AT	p	p	p	p	P
BE	-	p	p	-	p
DE	-	p	p	p	P
DK	-	-	-	-	-
ES	p	p	p	p	p
FI	-	-	-	-	-
FR	p	p	p	p	**w**
GB	p	p	-	p	p
GR	p	p	p	**w**	p
IE	-	-	-	-	-
IT	p	p	p	p	p
LU	-	p	p	-	p
NL	-	p	p	p	p
PT	-	-	-	-	p
SE	-	-	-	-	-

Only a few countries transmitted information on their operational stations. For other countries, the 1997 station configuration has been used throughout this report, merged with the list of stations reporting exceedances during the past summer season.

Map 1 presents the location of all ozone monitoring stations (street and urban background taken together as 'urban') assumed to be operational during the 1998 summer season.

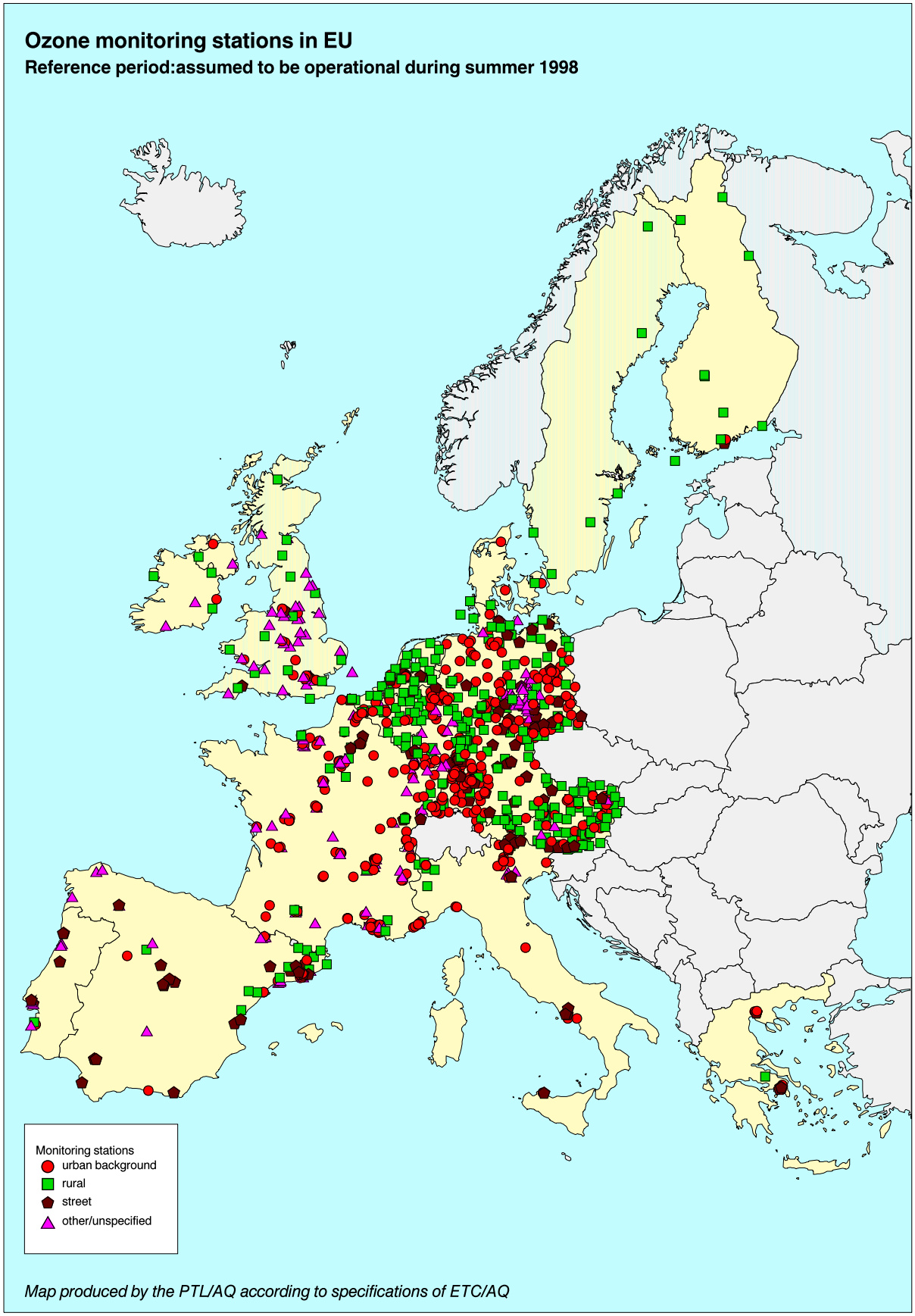
1066 ozone monitoring sites are assumed to be operational in the framework of the Directive. From these, 278 stations are situated in rural areas, 374 stations in urban background environments, 120 are street stations and 294 stations were characterised as industrial station or the monitoring environment was not specified. The number of stations is comparable to the number of stations operational in 1997.

Note that, as only exceedances of thresholds were reported, it is not clear whether stations were operational continuously during summer 1998. 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[2].

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

[2] The 1997 annual report [De Leeuw and De Paus, 1998] gives information on the percentage of time stations were operational, most stations score >90%.

Map 1: Ozone monitoring stations implemented in the framework of Directive 92/72/EEC on air pollution by ozone, operational during 1997.



3. Summary of data reported for summer 1998

The threshold for warning of the public (1h> 360 µg/m^3) was exceeded at two stations in the Athens conurbation (both on more than one day), and at one station in France (Table 3):

Table 3: Observed exceedance of the threshold for warning of the public (1h concentration > 360 µg/m^3) during summer 1998 (April-August).

Country	City	Station	Maximum observed hourly concentration (µg/m^3)	Date, time
Greece	Athens	Marousi	421	2-7-98, 13.00
Greece	Athens	Marousi	401	3-7-98, 12.00
Greece	Athens	Lykovrissi	410	2-7-98, 13.00
Greece	Athens	Lykovrissi	425	3-7-98, 12.00
Greece	Athens	Lykovrissi	367	29-7-98, 13.00
France	Le Havre	Notre Dame de Gravenchon, mairie	405	7-8-98, 11.00

During the summers of 1996 and 1997 the threshold for warning of the public was also exceeded in the Athens conurbation, although partly at different stations. The Athens episode will be described in more detail in Chapter 4. The French exceedance occurred in an isolated industrial area near Le Havre during a day when only a few other French stations reported concentrations above 180 µg/m^3.

Table 4 presents a general overview of the observed exceedances of the threshold for information of the public during April-August 1998 on a country by country basis. As the number of stations differs widely from country to country, the absolute number of exceedances is less suitable for comparison. As in the annual ozone report [De Leeuw and De Paus, 1998], the concept of 'occurrence of exceedances' is used here. Occurrence of exceedances is defined as the total number of exceedances summed over all stations divided by the number of stations.

Table 4: Summary of exceedances of the threshold for information of the public (1h concentration > 180 µg/m^3) during summer 1998 (April-August) on a country by country basis.

	No. of stations[1]	No. of stations with exceedance	No. of days with exceedance[2]	Maximum observed concentr. (µg/m^3)	Averaged maximum concentr. (µg/m^3) [3]	Occurrence of excee-dances[4]	Average duration of excee-dances (hour)
AT	113	54 (48%)	20	284	199	1.2/2.5	2.5
BE	26	21 (*81*%)	7	238	196	2.0/2.5	2.9
DE	387	273 (71%)	31	287	200	2.7/3.9	3.2
DK	5	0	-	<180	<180	-	-
ES	70	57 (*81*%)	*74*	316	200	3.3/4.0	2.1
FI	11	0	-	<180	<180	-	-
FR	234	174 (74%)	65	405	199	3.1/4.2	2.2
GB	71	15 (21%)	13	340	208	0.3/1.3	1.9
GR	14	8 (57%)	53	*425*	*234*	8.3/14.5	2.9
IE	6	0	-	<180	<180	-	-
IT	65	16 (25%)	41	290	203	1.5/5.9	2.7
LU	5	4 (80%)	8	230	195	3.4/4.3	2.8
NL	39	29 (74%)	10	262	200	1.7/2.3	2.8
PT	14	3 (21%)	8	259	206	0.9/4.3	1.5
SE	6	0	-	<180	<180	-	-
EU	1066	654 (61%)		425	201	2.4/3.9	2.7

[1] Number of stations implemented in the framework of the Ozone Directive

[2] The number of 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.

Denmark, Finland, Ireland and Sweden did not observe exceedances of the population information threshold this summer. These countries did not report any exceedances in 1997 either. In other countries, the number of days within the April-August period of 153 days on which at least one exceedance was observed ranged from 7 in Belgium to 74 in Spain. 61% of all stations reported one or more exceedance. On average 3.9 exceedances occurred in 1998 on stations which recorded at least one exceedance. The average maximum hourly concentration during an exceedance of the threshold in 1998 was 201 µg/m^3.

Table 5 summarises the exceedances on a month by month basis. The relative abundance of observed exceedances in May can be attributed mainly to an early stable period of warm summer weather in Western Europe. April, June and July were on average unfavourable for the formation of ozone in Northern and Western Europe. August had the highest number of stations reporting exceedances and the highest occurrence, due to one period (9-12 August) of favourable ozone formation conditions in Western Europe.

Table 5: Summary of exceedances of the threshold for information of the public (1h concentration > 180 µg/m^3) during summer 1998 (April-August) on a month by month basis.

	No. of stations with exceedance[1]	Maximum observed concentration (µg/m^3)	Averaged maximum concentration (µg/m^3)	Occurrence of exceedances[2]	Average duration of exceedances (hr)
April	10	340	204	0.0/2.0	2.0
May	236	290	193	0.4/1.8	2.5
June	127	341	200	0.2/1.9	2.1
July	154	425	209	0.3/2.0	2.2
August	569	405	202	1.4/2.7	3.0

(1) The theoretical maximum is 1066 stations (all stations which are assumed to be operational during summer 1998 and for which data was transmitted).

(2) Left figure: averaged over all implemented stations, right figure: averaged over all stations which reported at least one exceedance.

In Figure 1 the number of days per month is presented on which at least at one station in a country an exceedance was recorded. No obvious monthly dependence is apparent. In the Northern and Western countries Austria, Germany, Luxembourg, Belgium and the Netherlands, August was the month with the highest number of days with exceedances observed. In the Mediterranean region most days with exceedances were observed in July, except for Greece (August). In Portugal exceedances were only observed in August.

Figure 2 presents the occurrence of exceedances per country on a month by month basis. Again, there is no obvious dependence on the month.

Figure 1: Number of days on which at least one exceedance of the threshold value for information of the public (1h concentration > 180 µg/m^3) was observed per country and per month during summer 1998. Finland, Denmark, Sweden and Ireland did not report exceedances.

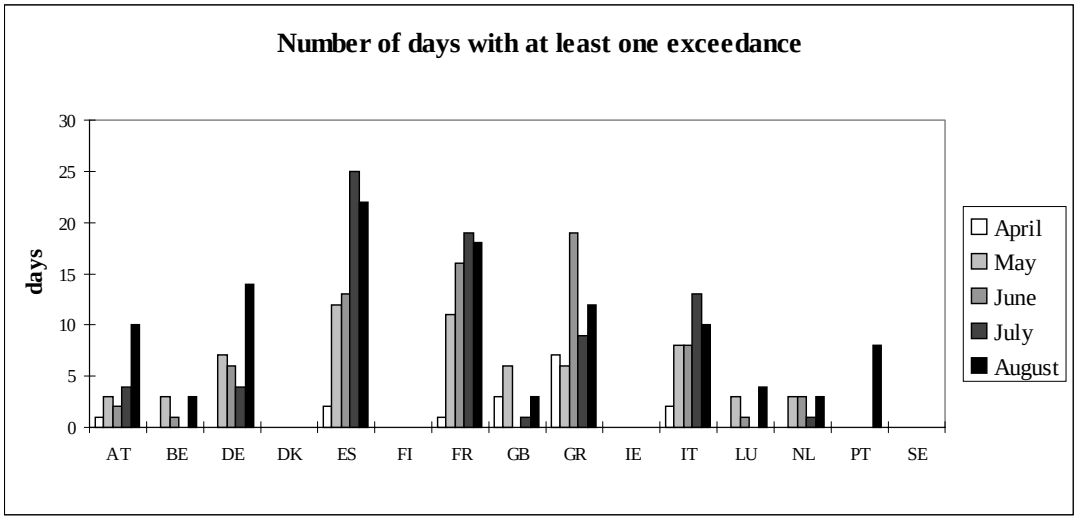
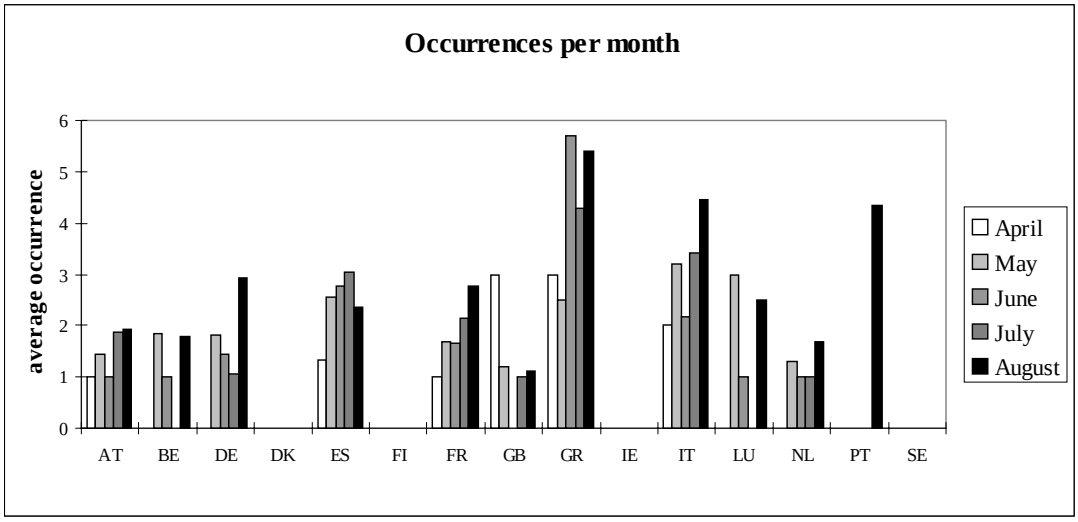


Figure 2: Occurrence of exceedances of the threshold value for information of the public (1h concentration > 180 µg/m^3) per country on a month by month basis during summer 1998. Finland, Denmark, Sweden and Ireland did not report exceedances.



The average occurrence of exceedances (in days) in each country of the threshold for information of the public by station type (rural, urban and street) is presented in Figure 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-urban-street. For some countries, this decrease is apparent. In other countries, this relation is not visible or even contradicted.

Figure 3: Average occurrence of exceedances (in days) of the threshold for information of the public (1h concentration > 180 µg/m^3) by station type (rural, urban and street) and country during summer 1998. Finland, Denmark, Sweden and Ireland did not report exceedances.

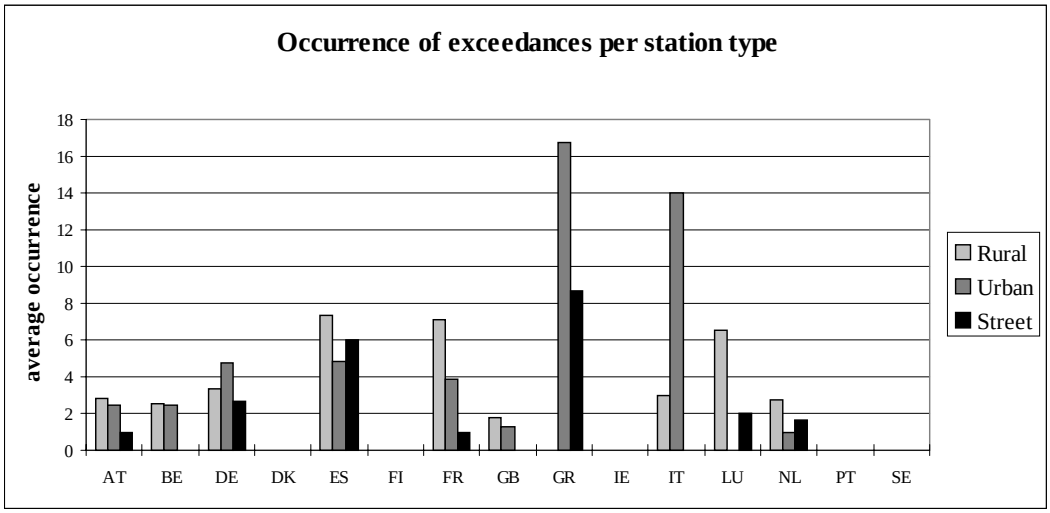
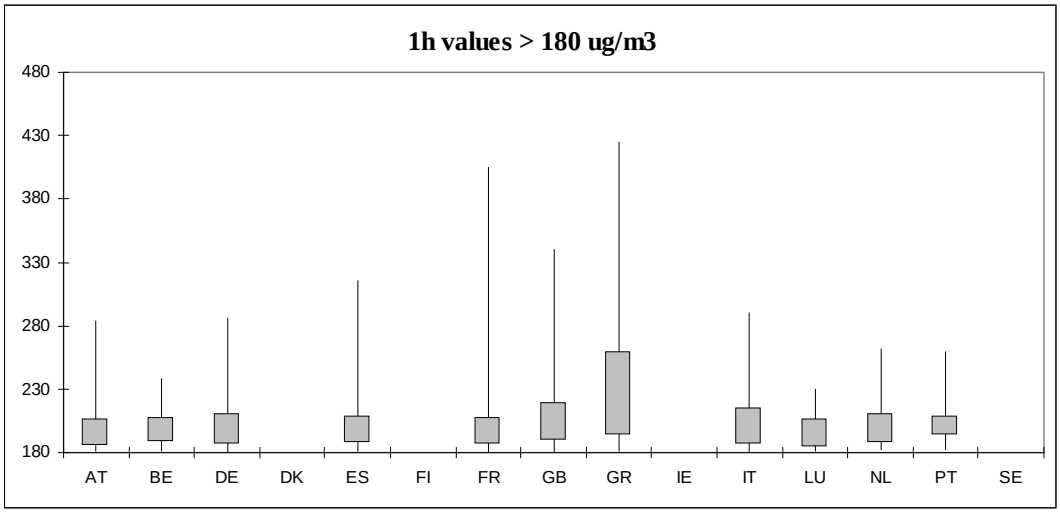


Figure 4 shows the frequency distribution of hourly ozone concentrations in excess of the threshold value using Box-Jenkins plots. For each Member State the Box-Jenkins plot indicates the minimum (here the minimum is 180 µg/m^3), the maximum, the 25 percentile and the 75 percentile value of the exceedances. The figure shows that during 25% of all observed exceedances, the maximum hourly concentration recorded was just above the 180 µg/m^3 threshold. 75% of all maximum exceedances recorded were below 214 µg/m^3.

Figure 4: Frequency distribution of ozone concentrations in excess of the 180 µg/m^3 threshold for hourly values (April-August 1998). Frequency distributions are presented as Box-Jenkins plots indicating the minimum, the 25-Percentile, the 75-Percentile and the maximum value.



	AT	BE	DE	DK	ES	FI	FR	GB	GR	IE	IT	LU	NL	PT	SE
#Ex	137	52	1052	0	229	0	732	21	116	0	95	17	68	13	0
#St	54	21	273	.	57	.	174	15	8	.	16	4	29	3	.

3.1. Geographical distribution

Maps 2 and 3 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. 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 might actually be different for the various regions in Europe.

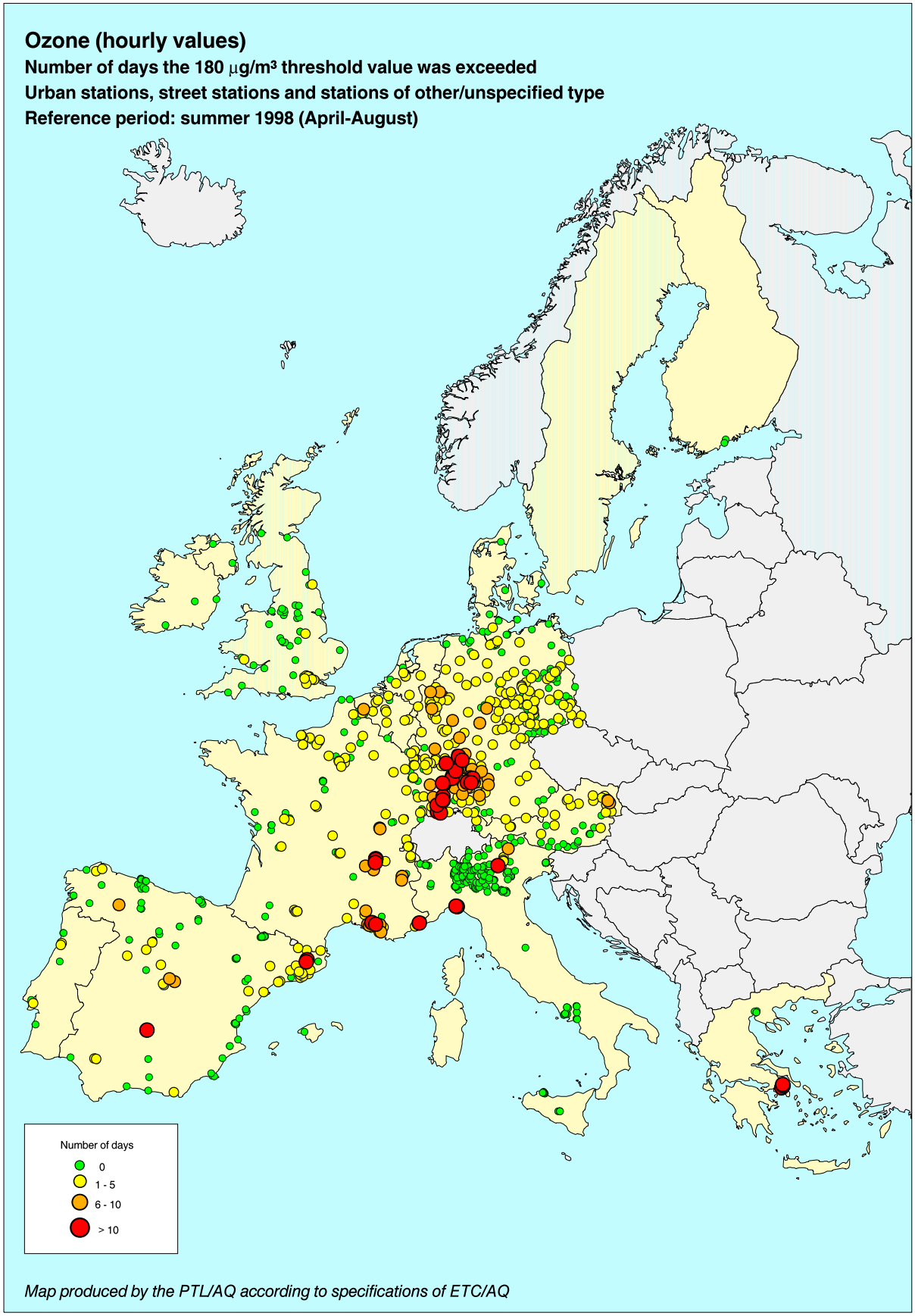
The spatial pattern of exceedances observed this summer on urban stations and on stations of unspecified type is comparable to that observed during summer 1997. The number of exceedances observed in Northern and Western Europe ranged from zero in Ireland, Denmark, Sweden and Finland to more than 10 at some stations in Southern Germany. The

[3] Exceedances reported from stations of unspecified type are also plotted in this map.

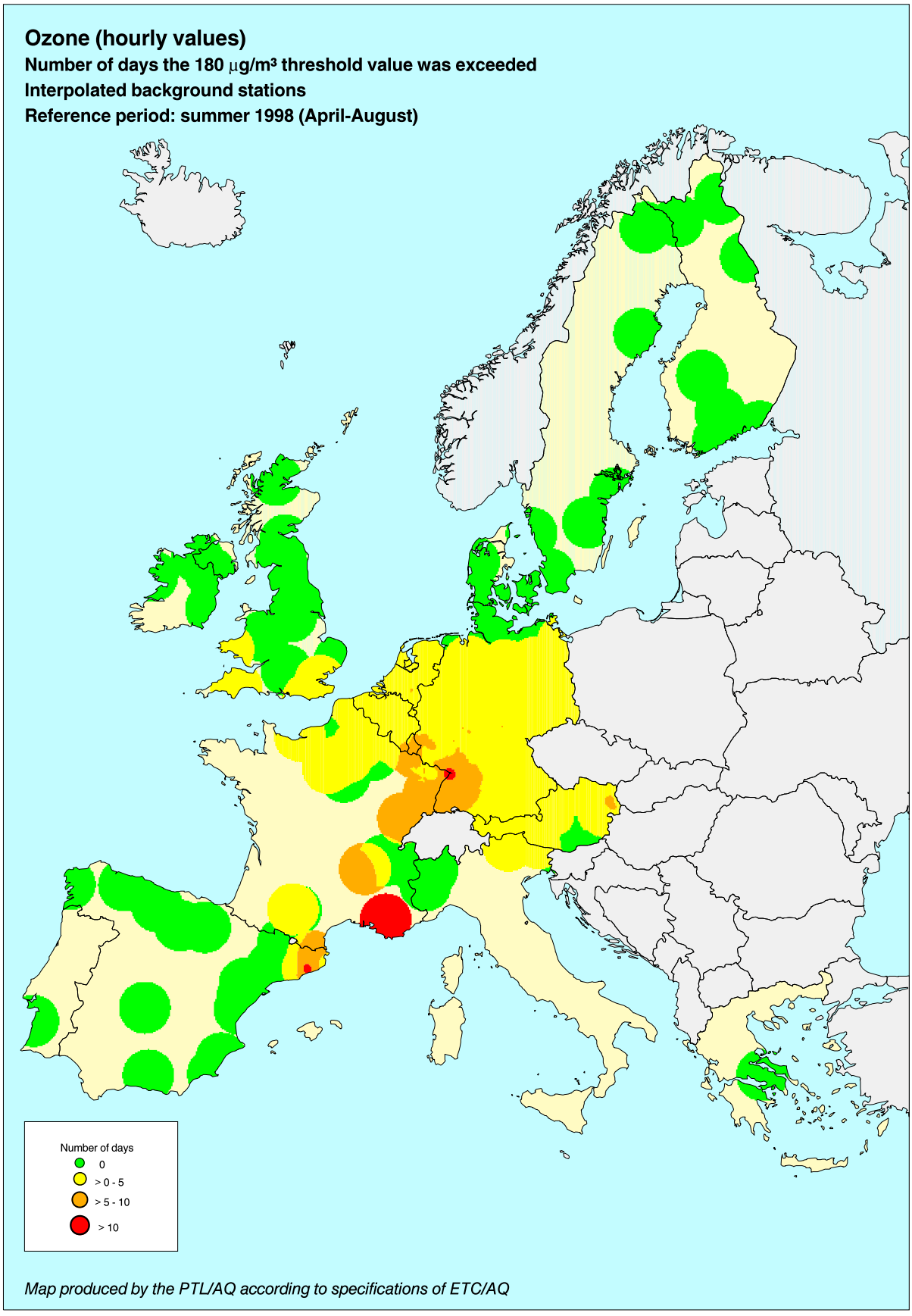
number of exceedances observed in the UK, Netherlands, Belgium and the Northern half of Germany is slightly lower than in 1997. No consistent spatial pattern is apparent in the Mediterranean region. Many stations did not report exceedances, while other stations reported more than 10 exceedances.

The spatial pattern of exceedances observed in summer 1998 at background stations (interpolated field) is similar to the field observed in the previous summers.

Map 2: Number of exceedances of the threshold value for the information of the public (1h > 180 µg/m^3) observed at urban/street stations and stations of unspecified type. Summer 1998 (April-August).



Map 3: Number of exceedances of the threshold value for the information of the public (1h > 180 µg/m^3) observed at background stations. Summer 1998 data (April-August), interpolated using inverse distance weighting, cut-off distance of 100 km.



3.2. Comparison with earlier years

Exceedances observed during the 1998 summer period were compared to exceedances observed during the same period in 1997, 1996 and 1995[4].

Figure 5.a presents the average exceedance duration[5] of the population information threshold, Figure 5.b the average occurrence and Figure 5.c presents the average maximum concentration observed during exceedances. The figures for 1997 are different from those presented in the 1997 summer report [Sluyter and van Zantvoort, 1997] because in the present report data from France and Italy could be included[6].

Figure 5.a: Average duration in hours of exceedances during the summer period (April-August, French and Italian data were not included in 1995 and 1996).

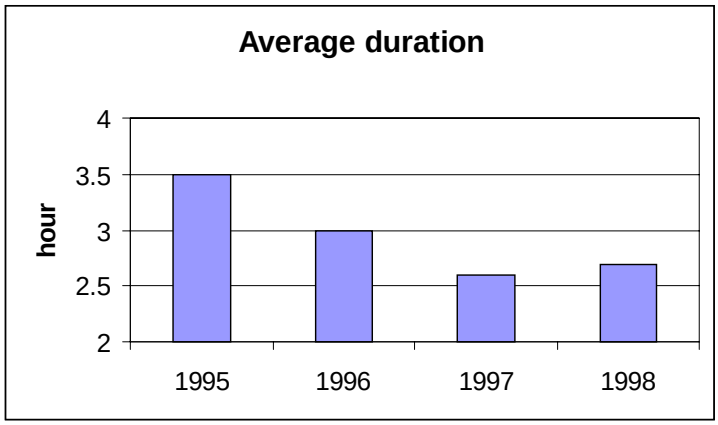
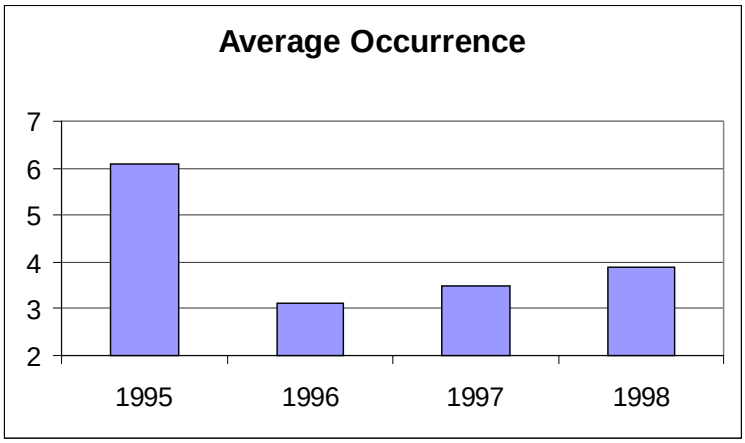


Figure 5.b: Average occurrence (number) of exceedances at stations which reported at least one exceedance during the summer period (April-August, French and Italian data were not included in 1995 and 1996).

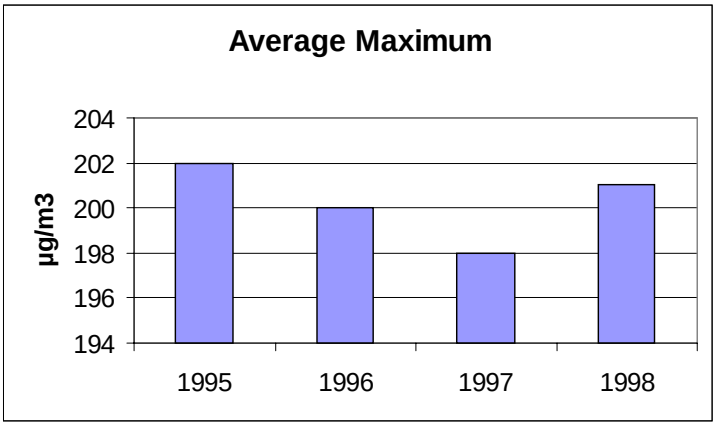


[4] 1995, 1996, 1997: Validated exceedance statistics as transmitted by Member States were used for this purpose.

[5] Averaged over all stations which reported at least one exceedance.

[6] Data from France and Italy were not included in the calculations for 1995 and 1996; data was missing, incomplete or inconsistent.

Figure 5.c: Average maximum concentration (µg/m^3) observed during exceedances during the summer period (April-August, French and Italian data were not included in 1995 and 1996).



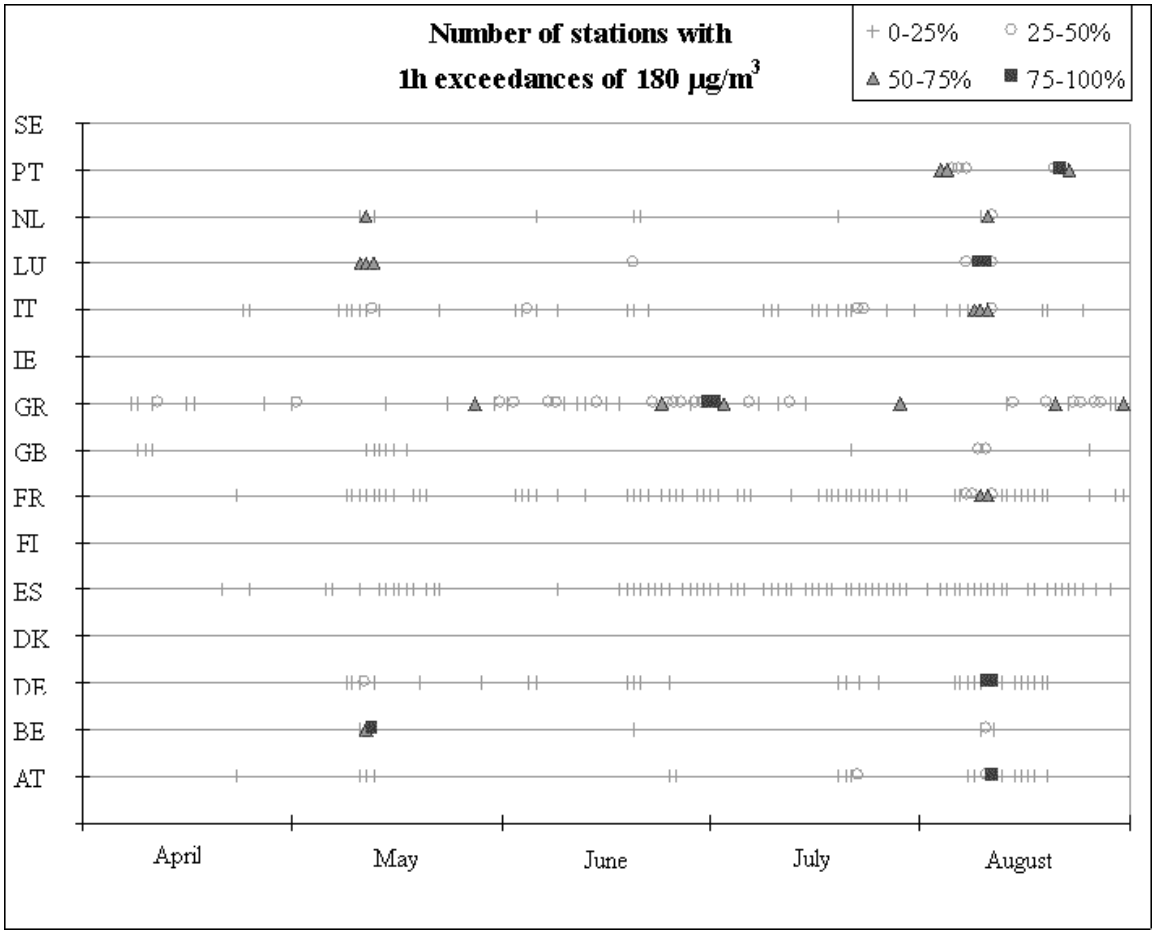
All three indicators are slightly higher in summer 1998 than in 1997 but lower than in 1995 and 1996. It is difficult to assess a possible trend in the number, duration and severity of exceedances of the threshold for information of the public which in turn could indicate a possible trend in precursor emissions, because:

- 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 four 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 about 20% during the period 1995-1997 and remained at the 1997 level in 1998. The increased territorial coverage can have implications for the number of exceedances observed. Also, a changing ratio between the number of rural and urban/street stations can have implications for the number of observed exceedances since peak ozone levels will on average be lower in urban areas then in rural areas.

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 then the rural ('background') concentrations due to chemical scavenging by local nitrogen oxide emissions (see for example Figure 3, which shows that the occurrences of exceedances are in general highest at rural stations).

Figure 6: Qualitative overview of exceedances of the 180 µg/m^3 population information threshold value (1h) during the period April-August 1998. The symbols represent the percentage of stations which observed at least one exceedance of the threshold for information of the public during a particular day.



Episodes, periods with elevated ozone levels, will mainly occur during periods of warm sunny weather. In the Mediterranean countries, having 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, highest levels are usually found downwind of cities.

Figure 6 presents a graphical representation of the percentage of stations in each Member State that reported exceedances of the threshold value for population information (180 $\mu g/m^3$ for hourly values) during the 1998 summer season. From Figure 6 it is clear that the number of episodes covering extended areas of the European territory was limited during April-August 1998. As already mentioned in Section 3, weather conditions in western and northern Europe were often unfavourable for the build-up of ozone. On many days cool and relatively clean Atlantic air masses prevailed in northern and western European countries.

More frequent exceedances were observed in May and August. The most widespread northern European episode this summer occurred between 9 and 12 August. Map 4 presents an overview of the sites where exceedances were observed on 9, 10 11 and 12 August 1998. In the text box, the conditions leading to this episode are described in more detail. In contrast to the situation in northern Europe, in southern Europe exceedances were observed throughout the reporting period.

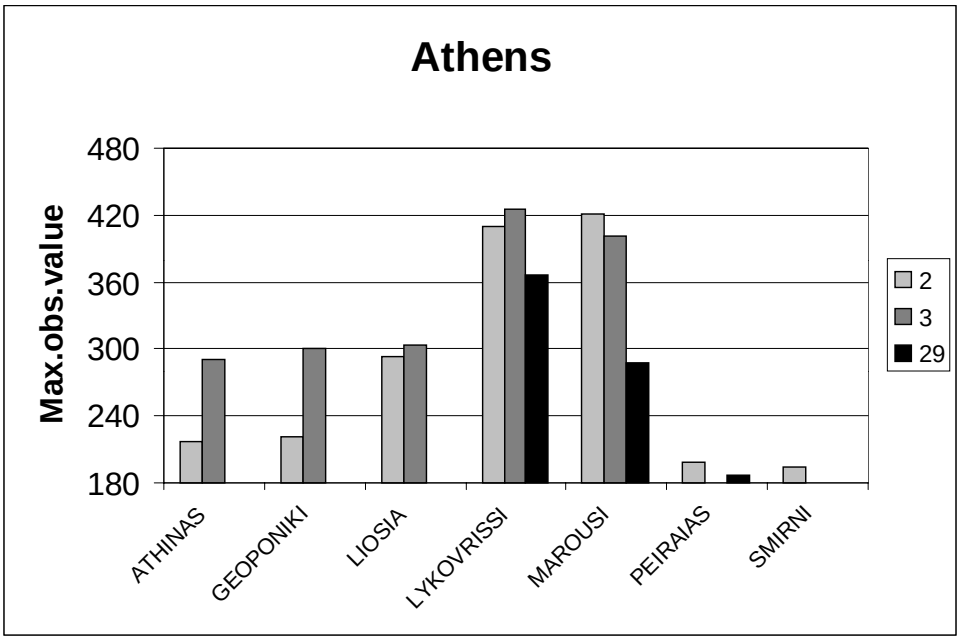
The episode of 9-12 August 1998

On 7 and 8 August, the axis of a West-East oriented high-pressure cell was located over Central Europe resulting in a light Westerly circulation. Although the weather could be characterised as warm and sunny in large parts of Europe, the air mass dominant was relatively clean and exceedances were only reported from a limited number of sites. On 9 August, the core of the high pressure cell moved to the North Sea, as a result the circulation became Easterly over large parts of Western and Central Europe. Exceedances mainly were reported from the South-western part of Germany. This synoptical situation did not change markedly on 10 and 11 August. Very hot and polluted air in the lower atmosphere became more or less stagnant over the continent. Temperatures on 11 August rose to 37.7 degrees Celsius in Paris, and 41.6 in Braunberg (Germany). On 10 August exceedances were reported from the Western part of Germany, France, South-east UK, Belgium, Luxembourg and the Southern part of Germany. On 11 August, the area where exceedances were observed increased to include large parts of Germany and parts of Austria. On 12 August, an Atlantic depression started to move in from the west over Scotland, transporting relatively clean Atlantic air masses over the UK eastwards. This ended the episode in the Western parts of France, Belgium and the Netherlands. On 13 August, the Atlantic air masses reached most of the EU territory and ended the ozone episode.

Map 4: Example of a smog episode: stations which reported an hourly ozone concentration in excess of 180 µg/m^3, 9-12 August 1998 (all station types). Error! Not a valid filename.

Figure 7 presents the maximum hourly ozone values recorded in the Athens conurbation (Greece) in July on days when the threshold for warning of the public (1h >360 µg/m^3) was exceeded, as an example of a local ozone episode in the Mediterranean region. Note that not all stations presented reported exceedances on every day during this period. More information on the specific conditions leading to these particular episodes was not available to the authors for inclusion in this report.

Figure 7: Example of local ozone episodes, Athens July 1998. Maximum observed 1h values (µg/m^3) on stations in the Athens conurbation which observed an exceedance of at least 180 µg/m^3 (1h) on 2, 3 and 29 July.



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 1998 (April-August). Information is not necessarily based on validated monitoring data and hence the conclusions drawn should be considered as preliminary.

Information on the occurrence of exceedances has been received from all EU Member States for the months April, May, June, July and August. The quality of the exceedance information supplied was good and largely according to EU specifications. Improvements can be made for a number of countries as far as characterisation of stations is concerned. Some countries did not supply meta information on stations or supplied information on observed exceedances only on paper. 1066 monitoring stations were assumed to be operational in summer 1998.

The threshold for warning of the public (1h > 360 µg/m^3) was exceeded on three days during summer 1998 in the Athens conurbation (2 and 3 July at two stations, 29 July at one station) and at one station on 7 August in France.

The threshold for information of the public (1h > 180 µg/m^3) was exceeded in all Member States except for Ireland, Denmark, Finland and Sweden. The same countries did not report any exceedances in 1997. In other countries, the number of days on which at least one exceedance was observed ranged from 7 in Belgium to 74 in Spain. 61 % of all stations reported one or more exceedance. On average 3.9 exceedances occurred this year on stations which recorded at least one exceedance with an average duration of 2.7 hours. The average maximum hourly concentration during an exceedance of the threshold this year was 201 µg/m^3.

The most widespread ozone episode occurred on 9-12 August. During the episode nine Member States recorded exceedances of the threshold value for population information.

6. References

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