Air pollution by ozone across Europe during summer 2009

Overview of exceedances of EC ozone threshold values for April–September 2009

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European Environment Agency

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European Environment Agency
Kongens Nytorv 6
1050 Copenhagen K
Denmark
Tel.: +45 33 36 71 00
Fax: +45 33 36 71 99
Web: eea.europa.eu
Enquiries: eea.europa.eu/enquiries

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Executive summary

Ozone levels during summer 2009 were as low as during summer 2008 and according to several indicators were among the lowest since reporting of Europe-wide data commenced in 1997 ([1]).

Average temperatures in summer 2009 were generally higher than in 2008 and close to those measured in the extremely hot summer of 2003 when the highest number of exceedances in the last decade occurred. However, ozone formation is also influenced by other meteorological conditions and the chemical composition of the atmosphere. In Europe, a general observation is that the peak ozone concentrations decrease is very likely attributable to reductions in anthropogenic ozone precursor gas emissions.

The number and spatial extent of exceedances of the information threshold (180 µg/m^3, Directive 2002/3/EC) was lower than in any of the last ten summers — lower than the number of exceedances in summers 2007 and 2008, which were the third and second lowest respectively since 1997. As in most previous years, no exceedances of the information threshold value occurred in northern Europe. The highest one-hour ozone concentration of 284 µg/m^3 was observed in France; for the first time since 1997, no concentration higher than 300 µg/m^3 was reported.

As in all previous years, the Directive's long-term objective to protect human health (maximum ozone concentration of 120 µg/m^3 over 8-hours) was exceeded in all EU Member States and other European countries. The target value for human health protection was also exceeded in a significant part of Europe. Nevertheless, both the percentage of Europe's population exposed to ozone levels above the target value and the number of occasions on which the long-term objective was exceeded were only slightly higher than in 2008 when the affected area and population were much more restricted than in the previous summers.

In contrast to previous summers, in 2009 there were no pan-European multi-day episodes. Summer 2009 was characterised by ozone episodes of two to five days followed by spells with few exceedances. A typical episode usually contained approximately 7–13 % of the total number of exceedances of the information threshold experienced during the summer.

Ozone is a 'secondary' pollutant formed in the lower part of the atmosphere, the troposphere, from complex photochemical reactions following emissions of precursor gases such as nitrogen oxide and volatile organic compounds. Ozone is a powerful oxidizing agent and one of the air pollutants of most concern in Europe.

Ozone concentrations in Europe are also influenced by emissions in other northern hemisphere countries and by poorly regulated sectors such as international shipping and aviation. Thus, ozone pollution can no longer be considered a local air quality issue — it is a global problem.

Ozone levels become particularly high in regions close to high ozone precursor emissions during summer episodes with stagnant meteorological conditions, when high insolation and temperatures persist. In 2009, levels continued to exceed both target values and the long-term objectives established in EU legislation to protect human health and prevent damage to ecosystems, agricultural crops and materials.

This report provides an evaluation of ground-level ozone pollution in Europe for April–September 2009, based on information submitted to the European Commission under Directive 2002/3/EC on ozone

([1]) Ozone levels in summer 2009 were compared with the summer ozone concentrations from 1997 to 2007 stored in the EEA air quality database AirBase, and the summer 2008 data submitted under Directive 92/72/EEC on air pollution by ozone. Data stored in AirBase are validated, whereas the 2008 and 2009 summer data are provisional and only partly validated.

in ambient air. Since Members States have not yet finally validated the submitted data, the conclusions drawn in this report should be considered as preliminary.

Directive 2002/3/EC (European Parliament and Council of the European Union, 2002) requires Member States to report exceedances of the information threshold and alert threshold values (set out in Table 1.1) to the Commission before the end of the month following an occurrence. Furthermore, by 31 October the Member States must provide additional information for the summer period. This should include data on exceedances of the long-term objective for the protection of human health (daily maximum 8-hour average concentrations of 120 µg/m^3).

In order to provide information as promptly as possible, an overview of the monthly data provided by the countries is made available by the ETC/ACC on the EEA website: http://www.eea.europa.eu/maps/ozone/compare/summer-reporting-under-directive-2002-3-ec.

In July 2006 EEA launched a pilot near real-time ozone website (http://www.eea.europa.eu/maps/ozone), which shows ground-level ozone levels across Europe. The site was developed by the EEA as a joint European project and provides up-to-date information (see Annex 3).

Overview of ozone air pollution in summer 2009

All 27 EU Member States provided information to the European Commission on observed one-hour exceedances and on long-term objective exceedances. In addition, nine other countries (Bosnia-Herzegovina, Croatia, Iceland, Liechtenstein, Norway, Serbia, Switzerland, the former Yugoslav Republic of Macedonia and Turkey) supplied information to the EEA upon request.

The occurrence of information threshold exceedances was as low as in summer 2008 and among the lowest since comprehensive reporting of Europe-wide data commenced in 1997 (Chapter 3).

Main findings

In total, 2 171 ozone monitoring sites reported data, of which 2 111 were located in EU Member States. The following preliminary conclusions can be drawn from the period April–September 2009:

Exceedance of the information threshold

- The percentage of ozone monitoring stations reporting exceedances of the information threshold (180 µg/m^3 of one-hour ozone concentration) was, — together with summer 2008, the lowest since comprehensive reporting of Europe-wide data commenced in 1997. Ozone concentrations higher than the information threshold were reported from monitoring sites in 18 EU Member States and two non-member countries. The information threshold was exceeded at approximately 20 % of all operational stations. By comparison, 33 % of stations reported exceeding the threshold in summer 2007, which at the time represented the lowest number of exceedances to date.
- Exceedances of the information threshold were observed over a much less extensive spatial range than in previous years. No exceedances occurred in northern Europe, while the highest percentage of stations with exceedances of the information threshold was observed in Belgium, Greece, Italy and Portugal.

Exceedance of the alert threshold

- Ozone concentrations higher than the alert threshold of 240 µg/m^3 were reported on 39 occasions. They occurred in only eight EU Member States (Bulgaria, France, Greece, Italy, Portugal, Romania, Spain and the United Kingdom) and in the Former Yugoslav Republic of Macedonia.
- Exceedances of the alert threshold were observed mainly in northern Italy and also at other locations where the information threshold was most often exceeded. France, Greece, Italy and Portugal reported an exceedance of the alert threshold on more than one day. Most stations (80 %) reporting an exceedance of the alert threshold did so on just one day; only 10 % of stations reported the maximum number of three days.

Maximum concentrations

- No concentrations higher than 300 µg/m^3 were reported. The highest one-hour ozone concentrations were observed in France (Rognac les Brets, 284 µg/m^3) and in Italy (Meda and Trezzo d'Adla, 279 µg/m^3).

Exceedance of the long-term objective for the protection of human health (LTO)

- As in previous years, exceedances of the long-term objective for the protection of human health, i.e. daily maximum 8-hour average concentrations higher than 120 μg/m^3, were observed in every country, in every summer month and at most stations during summer 2009. Approximately 84 % of all stations reported one or more exceedances.

- The number of exceedance days per country ranged from two (Iceland) to 175 (Spain). More than 150 exceedance days were reported by France, Greece, Italy, Romania, Spain and the Former Yugoslav Republic of Macedonia. On every single day during summer 2009 at least one of the 2 171 operational stations in Europe reported exceeding the LTO. On average, those stations observing at least one LTO exceedance reported a total of 19 days of exceedance. The maximum number of 168 exceedance days was observed at the mountain station Lazaropole in the Former Yugoslav Republic of Macedonia.

Comparison with the target value (TV) for the protection of human health

- The TV is exceeded when the LTO has been exceeded at a particular station more than 25 times per calendar year, averaged over three years. This report counts cases where the LTO limit has been exceeded more than 25 times during the summer period of 2009 for comparison with the TV, and not for checking compliance with Directive 2002/3/EC.

- During summer 2009, more than 25 LTO exceedances occurred on stations in 16 EU Member States (Austria, Bulgaria, Cyprus, the Czech Republic, France, Germany, Greece, Hungary, Italy, Luxembourg, Poland, Portugal, Romania, the Slovak Republic, Slovenia and Spain) and in three non-member countries (Serbia, Switzerland and the former Yugoslav Republic of Macedonia).

- More than 25 LTO exceedances occurred at 20 % of all monitoring stations providing reports. This corresponded to approximately 18 % of the area assessed, affecting approximately 17 % of the total population,([2]) which is only slightly more than in 2008 when the share was much lower than in the previous summers.

Main ozone episodes ([3])

- In contrast to the previous summers, in 2009 there were no pan-European multi-day episodes. Summer 2009 was characterised by short regional ozone episodes of two to five days, followed by spells with low number of exceedances. A typical episode usually contained approximately 7–13 % of the total number of exceedances of the information threshold experienced during the summer.

- One of the episodes occurred from 28 July to 1 August and accounted for approximately 13 % of the total number of exceedances of the information threshold, 21 % of the exceedances of the alert threshold and about 6 % of the exceedances of the long-term objective.

Comparison with previous years

Ozone levels during summer 2009 were among the lowest in the past decade and observed exceedances were less spatially extensive than in previous years.

Disclaimer

The preliminary overview contains summary information based on data delivered before 6 December 2009.

The information describing the situation during summer 2009 is based on non-validated monitoring data and should therefore be regarded as preliminary.

([2]) See Section 2.2 for calculation details. The figures for percentages of area and population affected are not comparable with those in summer reports for 2004, 2005 and 2006 because of different preparation of spatial distribution maps (see Section 2.3).

([3]) For a definition of the term 'ozone episode' please refer to the EEA glossary, available at http://glossary.eea.europa.eu/.

1 Introduction

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

In view of the harmful effects of photochemical pollution of the lower levels of the atmosphere, the European Council adopted Directive 92/72/EEC on air pollution by ozone. That Directive was succeeded by Directive 2002/3/EC of the European Parliament and of the Council relating to ozone in ambient air. Directive 2002/3/EC is also known as the third daughter directive to the Air Quality Framework Directive 96/62/EC. It sets long-term objectives and target values, and an alert threshold and information threshold for ozone (Table 1.1), for the purpose of avoiding, preventing or reducing the harmful effects on human health and environment. It provides common methods and criteria for assessing ozone concentrations in ambient air, and ensures that adequate information is made available to the public on the basis of this assessment. It also promotes cooperation between Member States in reducing ozone levels.

On 14 June 2008, the new Directive 2008/50/EC on ambient air quality and cleaner air for Europe ([4]) came into force. The provisions of earlier air quality directives (96/62/EC, 1999/30/EC, 2000/69/EC and 2002/3/EC) remain in force until 11 June 2010, when they will be repealed by Directive 2008/50/EC. The new Directive will not change the existing target value, long-term objective, alert threshold or information threshold.

This report gives an overview of reported ground-level ozone concentrations between April and September 2009, and provides a comparison with the years since 1997. The EEA has prepared similar overviews since 1994. Previous reports are available from the EEA website: http://www.eea.europa.eu.

The legal requirements for reporting provisional data on exceedances of the long-term objectives, targets and threshold values for ozone during the summer, which are the basis of this report, are summarised in Annex 1.

Table 1.1 Ozone threshold values, long-term objective and target value for the protection of human health, as set out in Directive 2002/3/EC

Objective	Level (µg/m^3)	Averaging time
Information threshold (IT)	180	one-hour
Alert threshold (AT)	240	one-hour
Long-term objective (LTO)	120	8-hour average, daily maximum
Target value (TV)	120 not to be exceeded more than 25 days per calendar year *	8-hour average, daily maximum

Note: * Averaged over three years and to be achieved where possible by 2010.

([4]) Directive 2008/50/EC of the European parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe. OJ L 152, 11.6.2008, p.1.

2 Ozone air pollution in summer 2009

This chapter provides detailed country-by-country, month-by-month and day-by-day tabular, graphic and geographical information on threshold exceedances during summer 2009. The largest threshold exceedance episode is also described. Details on reported data and ozone monitoring networks are provided in Annex 2.

2.1 Summary of reported hourly exceedances

Reports and information on ozone during summer 2009, as required by the EU legislation, were submitted from 27 EU Member States and 9 non-member countries. Ozone concentrations in excess of the information threshold were reported from monitoring sites in eighteen EU Member States and two non-member countries (Table 2.1).

The percentage of stations that recorded exceedances of the information threshold was, together with summer 2008, the lowest since comprehensive Europe-wide data reporting commenced in 1997. No exceedances occurred in northern Europe and the highest percentage of stations with exceedances of the information threshold was observed in Belgium, Greece, Italy and Portugal.

Table 2.2, Figure 2.1 and Figure 2.6 present the distribution of hourly exceedances during the season. The highest number of exceedances occurred during July and August, which respectively accounted for approximately 34 % and 31 % of all observed information threshold exceedances in those months and about 46 % and 23 % of alert threshold exceedances ([5]). For the summer as a whole, the occurrence of information and alert threshold exceedances was roughly as low as in summer 2008 and is among the lowest on record (Table 3.1).

Figure 2.2 presents the frequency distribution of hourly ozone concentrations that exceeded the information threshold. For each Member State that submitted data, the graph uses box plots to indicate the minimum exceedance value, the maximum, and the 25th and 75th percentile values.

In Europe as a whole, 25 % of exceedances were below 185 μg/m^3 (compared to 207 μg/m^3 in 2003, 185 μg/m^3 in 2004 and 2008, 186 μg/m^3 in 2005–2007). The 75th percentile values were all below 202 μg/m^3 which is lowest in comparison with the previous years (305 μg/m^3 in 2003, 203 μg/m^3 in 2004, 206 μg/m^3 in 2005–2008).

([5]) In this report, one-hour exceedances are counted on a daily basis, i.e. each day on which a station records ozone levels above the information or alert threshold for at least one hour is counted as one exceedance.

Table 2.1 Overview of exceedances of one-hour thresholds during the summer of 2009 on a country-by-country basis ([6])

Country	No. of stations ([a])	Stations with exceedance ([b])					Number of days with exceedance ([c])		Maximum observed one-hour concentration (μg/m³)	Occurrence of exceedances ([d])				Average duration of exceedances (hour)	
		(number)		(%)		(%)									
Austria	115	4	0	3	-	-	3	-	206	0	1	-	-	2.3	-
Belgium	40	21	0	53	-	-	5	-	202	0.8	1.4	-	-	1.8	-
Bulgaria	15	5	1	33	7	20	11	1	257	1.3	4	0.1	1	1.9	1
Cyprus	1	0	0	-	-	-	-	-	157	-	-	-	-	-	-
Czech Republic	60	2	0	3	-	-	1	-	208	0	1	-	-	3	-
Denmark	9	0	0	-	-	-	-	-	164	-	-	-	-	-	-
Estonia	7	0	0	-	-	-	-	-	155	-	-	-	-	-	-
Finland	17	0	0	-	-	-	-	-	152	-	-	-	-	-	-
France	416	121	5	29	1	4	37	4	284	0.5	1.9	0	1	2.3	1.8
Germany	273	30	0	11	-	-	8	-	226	0.2	1.4	-	-	2.2	-
Greece	24	12	4	50	17	33	41	4	264	4.3	8.5	0.2	1.3	2.5	2.4
Hungary	17	4	0	24	-	-	4	-	193	0.3	1.3	-	-	1.4	-
Ireland	11	0	0	-	-	-	-	-	141	-	-	-	-	-	-
Italy	300	142	14	47	5	10	79	10	279	3	6.4	0.1	1.5	3	2.4
Latvia	8	0	0	-	-	-	-	-	153	-	-	-	-	-	-
Lithuania	14	0	0	-	-	-	-	-	168	-	-	-	-	-	-
Luxembourg	6	1	0	17	-	-	3	-	194	0.5	3	-	-	2.3	-
Malta	4	1	0	25	-	-	1	-	194	0.3	1	-	-	2	-
Netherlands	36	5	0	14	-	-	2	-	193	0.1	1	-	-	1.8	-
Poland	75	0	0	-	-	-	-	-	180	-	-	-	-	-	-
Portugal	52	28	2	54	4	7	23	3	256	1.2	2.3	0.1	1.5	2.5	1.3
Romania	93	17	1	18	1	6	36	1	242	0.6	3.4	0	1	2.6	1
Slovak Republic	14	2	0	14	-	-	2	-	199	0.1	1	-	-	1.5	-
Slovenia	12	2	0	17	-	-	3	-	197	0.3	1.5	-	-	1.7	-
Spain	403	31	1	8	0	3	39	1	274	0.2	2.2	0	1	1.5	1
Sweden	12	0	0	-	-	-	-	-	156	-	-	-	-	-	-
United Kingdom	77	5	1	6	1	20	2	1	258	0.1	1	0	1	4	2
EU area	**2 111**	**433**	**29**	**21**	**1**	**7**	**134**	**23**	**284**	**0.7**	**3.6**	**0**	**1.3**	**2.7**	**2.1**
Bosnia-Hercegovina	2	0	0	-	-	-	-	-	156	-	-	-	-	-	-
Croatia	2	0	0	-	-	-	-	-	151	-	-	-	-	-	-
Iceland	2	0	0	-	-	-	-	-	127	-	-	-	-	-	-
Liechtenstein	1	0	0	-	-	-	-	-	159	-	-	-	-	-	-
Macedonia, FYR of	13	4	1	31	8	25	49	1	263	3.9	12.8	0.1	1	7.2	3
Norway	8	0	0	-	-	-	-	-	142	-	-	-	-	-	-
Serbia	1	0	0	-	-	-	-	-	170	-	-	-	-	-	-
Switzerland	28	6	0	21	-	-	21	-	230	1.6	7.3	-	-	2.8	-
Turkey	3	0	0	-	-	-	-	-	100	-	-	-	-	-	-
Whole area	**2 171**	**443**	**30**	**20**	**1**	**7**	**144**	**24**	**284**	**0.8**	**3.7**	**0**	**1.3**	**2.9**	**2.2**

Notes: White columns refer to exceedances of the information threshold, grey to exceedances of the alert threshold.

'-' indicates 'not applicable'.

([a]) Total number of stations measuring ozone levels.

([b]) The number and percentage of stations at which at least one threshold exceedance was observed; fifth column: percentage of stations with information threshold exceedance at which alert threshold exceedance were also observed.

([c]) The number of calendar days on which at least one exceedance of thresholds was observed.

([d]) Occurrence of exceedance is calculated as the average number of exceedances observed per station in a country.
Left column: averaged over all implemented stations (total number of stations).
Right column: averaged over all stations which reported at least one exceedance.

([6]) Unless otherwise stated, all tables and graphs have been compiled using data submitted by countries to EEA.

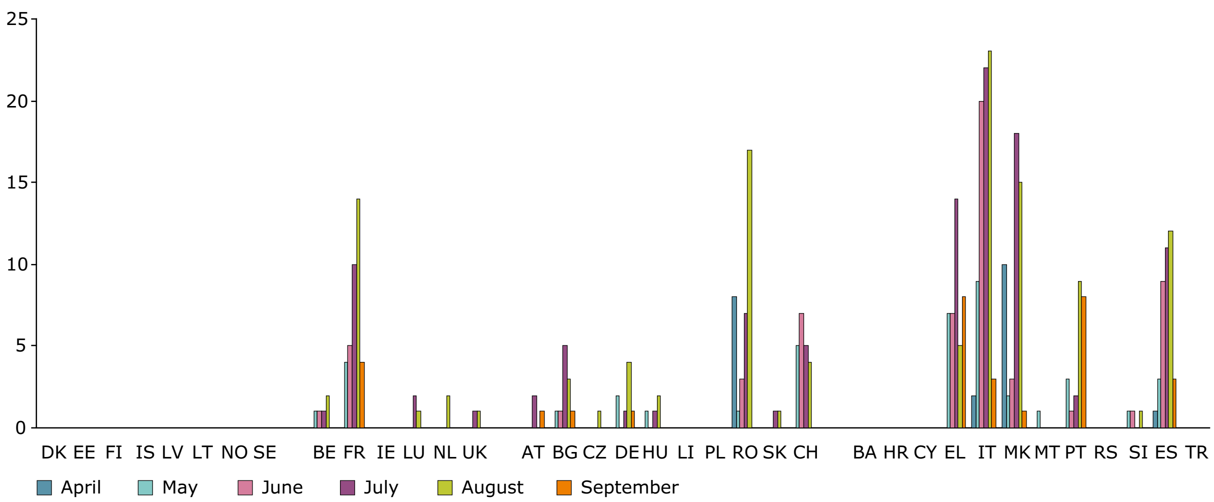
Table 2.2 Overview of exceedances of one-hour thresholds in Europe during the summer of 2009, on a month-by-month basis

Month	Stations with exceedance (ᵇ)					Number of days with exceedance (ᶜ)		Maximum observed one-hour concentration (µg/m³)	Occurrence of exceedances (ᵈ)				Average duration of exceedances (hour)	
	(number)		(%)		(%)									
April	15	1	1	0	7	18	1	242	0	0.1	0	0	4	1
May	102	1	5	0	1	18	1	243	0.1	0.5	0	0	3	1
June	120	8	6	0	7	27	6	269	0.1	0.6	0	0.3	2.8	2
July	236	17	11	1	7	30	8	279	0.3	1.2	0	0.6	3	1.9
August	257	8	12	0	3	30	7	284	0.2	1.2	0	0.3	2.7	3
September	36	1	2	0	3	21	1	253	0	0.1	0	0	1.8	2

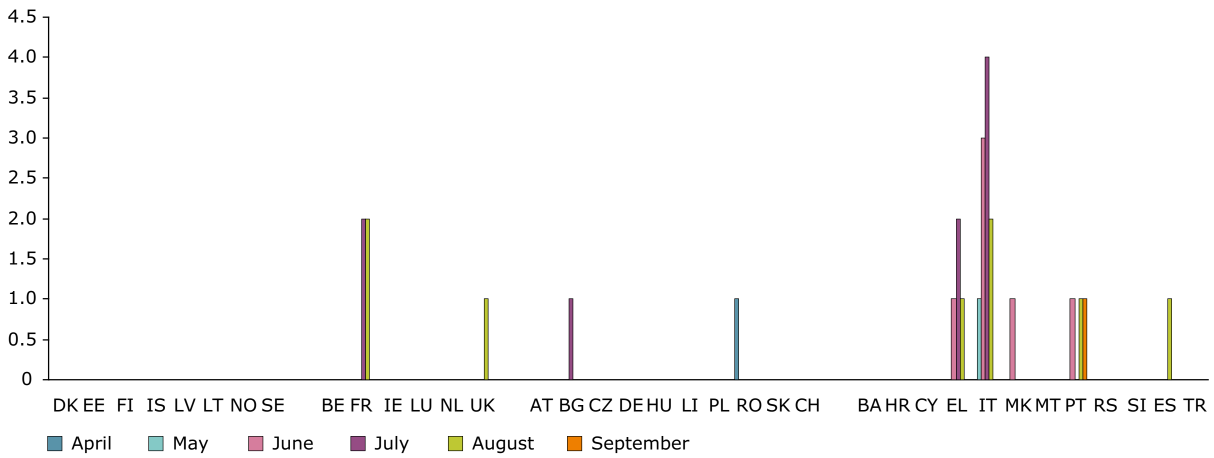
Note: (ᵇ)–(ᵈ) see notes to Table 2.1.

Figure 2.1 Number of days on which at least one exceedance of the one-hour threshold value was observed per country and per month during the summer of 2009 (only countries that submitted data are shown)

a) Information threshold exceedances

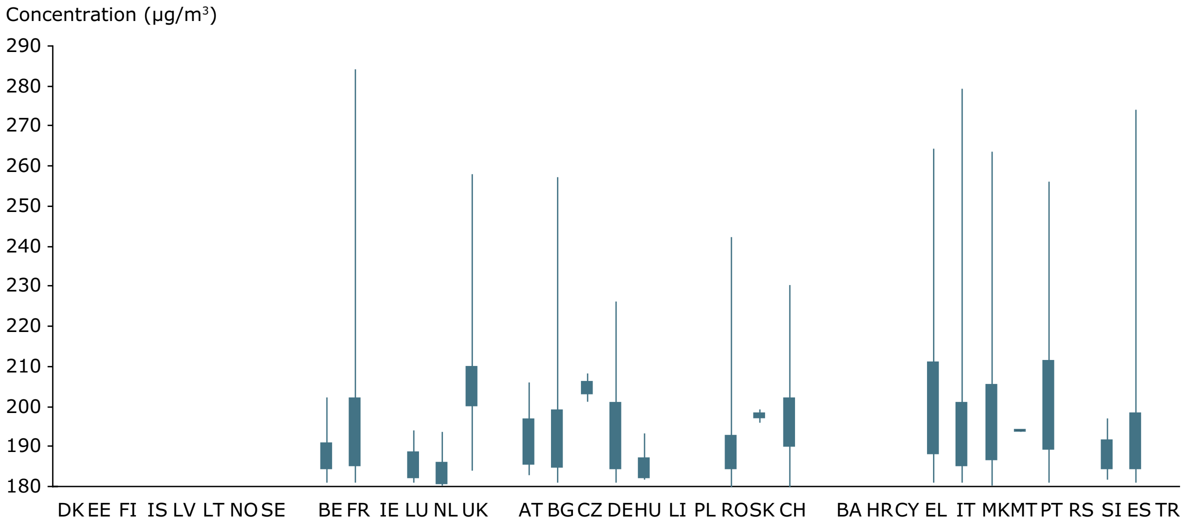


b) Alert threshold exceedances



Note: The countries were divided into four regions in the figures to show ozone levels variations due to climatic differences (see Chapter 3). This was an attempt to account for the geographical differences in terms of weather patterns over the European continent.

Figure 2.2 Frequency distribution of concentrations in excess of the one-hour information threshold during summer 2009 (only countries that delivered data are shown)



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

2.2 Overview of exceedances of the long-term objective and target value for the protection of human health

As in all previous years, during summer 2009 at least one daily maximum 8-hour average concentration of ozone over 120 µg/m³ (the long-term objective, LTO) was observed in every country except Turkey,(7) in every summer month and at most stations (see Table 2.3). The TV is exceeded when the LTO has been exceeded at a particular station more than 25 times per calendar year, averaged over three years.

Table 2.4 presents the LTO exceedances on a monthly basis and Figure 2.6 shows them on a day-by-day and country basis. Approximately 84 % of all stations reported at least one exceedance of the LTO. There was not a single day without an exceedance in Europe in summer 2009.

In total, the occurrence of LTO exceedances was roughly as low as in summer 2008 and is among the lowest since reporting of Europe-wide data commenced in 1997 (Table 2.3).

The highest number of exceedances occurred during August (27 % of all observed exceedances), the lowest in September (7 %). The occurrence of the exceedances was fairly evenly distributed during the remaining months (15–19 %). The figure of 16 % for April is exceptionally high compared with previous years (which are usually lower than 10 %, except for 24 % in 2007). Contrastingly, the figure of 15 % for June is the lowest on record. Particularly in central and eastern Europe, the high figure for April and low one for June were directly connected to the meteorological situation in summer 2009, i.e. an unusually warm, dry April and a cool, wet June (Figure 2.3).

The frequency distribution of 8-hour ozone concentrations exceeding the long-term objective level is shown in Figure 2.4. In Europe as a whole, 25 % of maximum 8-hour concentrations of all the observed exceedances were below 124 µg/m³ (125 µg/m³ in 2008, 2007, 2005 and 2004, 127 µg/m³ in 2006). Seventy five per cent were below 139 µg/m³ (143 µg/m³ in 2004, 144 µg/m³ in 2005, 148 µg/m³ in 2006 and 140 µg/m³ in 2007, 138 µg/m³ in 2008).

(7) For Turkey, the only data available for preparing this report were from three urban stations in Ankara.

Table 2.3 Overview of exceedances of the long-term objective for the protection of human health during the summer of 2009 on a country-by-country basis

Country	No. of stations ([a])	Stations with LTO exceedance ([b])		Stations with TV exceedance		Number of days with LTO exceedance ([c])	Maximum observed 8-hour concentration (μg/m³)	Occurrence of LTO exceedances ([d])	
		(number)	(%)	(number)	(%)				
Austria	115	112	97	36	31	115	170	20.7	21.3
Belgium	40	40	100	-	-	24	186	8.2	8.2
Bulgaria	15	12	80	3	20	122	183	17.5	21.9
Cyprus	1	1	100	1	100	83	142	83.0	83.0
Czech Republic	60	51	85	11	18	92	206	14.6	17.2
Denmark	9	5	56	-	-	14	155	2.2	4.0
Estonia	7	7	100	-	-	15	149	4.6	4.6
Finland	17	11	65	-	-	5	145	1.3	2.0
France	416	397	95	61	15	154	222	14.0	14.7
Germany	273	257	94	20	7	107	190	10.9	11.6
Greece	24	21	88	10	42	160	243	33.8	38.6
Hungary	17	17	100	10	59	102	167	33.7	33.7
Ireland	11	3	27	-	-	3	127	0.5	1.7
Italy	300	267	89	163	54	174	240	33.8	37.9
Latvia	8	3	38	-	-	6	147	0.9	2.3
Lithuania	14	11	79	-	-	12	157	2.8	3.5
Luxembourg	6	4	67	1	17	49	177	13.8	20.8
Malta	4	2	50	-	-	28	172	7.5	15.0
Netherlands	36	29	81	-	-	18	173	3.6	4.5
Poland	75	68	91	4	5	82	168	10.5	11.6
Portugal	52	41	79	7	13	83	214	11.6	14.7
Romania	93	57	61	17	18	168	222	12.8	20.8
Slovak Republic	14	14	100	8	57	127	164	40.8	40.8
Slovenia	12	11	92	6	50	108	166	34.4	37.5
Spain	403	308	76	66	16	175	173	12.3	16.1
Sweden	12	7	58	-	-	11	135	1.3	2.3
United Kingdom	77	24	31	-	-	23	167	0.7	2.1
EU area	**2 111**	**1 780**	**84**	**424**	**20**	**183**	**243**	**15.7**	**18.7**
Bosnia and Hercegovina	2	1	50	-	-	9	133	4.5	9.0
Croatia	2	2	100	-	-	17	135	10.5	10.5
Iceland	2	1	50	-	-	2	123	1.0	2.0
Liechtenstein	1	1	100	-	-	14	130	14.0	14.0
the former Yugoslav Republic of Macedonia	13	12	92	7	54	173	236	40.0	43.3
Norway	8	4	50	-	-	9	132	1.5	3.0
Serbia	1	1	100	1	100	46	148	46.0	46.0
Switzerland	28	28	100	9	32	103	194	23.6	23.6
Turkey	3	0	-	-	-	-	-	-	-
Whole area	**2 171**	**1 830**	**84**	**441**	**20**	**183**	**243**	**15.9**	**18.8**

Notes: '-' indicates 'not applicable'.

([a]) Total number of stations measuring ozone levels.

([b]) The number and percentage of stations at which at least one exceedance was observed.

([c]) The number of calendar days on which at least one exceedance was observed.

([d]) Left column: averaged over all implemented stations.
Right column: averaged over all stations which reported at least one exceedance.

Table 2.4 Overview of exceedances of the long-term objective for the protection of human health in Europe during the summer of 2009, on a month-by-month basis

Month	Stations with LTO exceedance (b) (number)	Stations with LTO exceedance (b) (%)	No. of days with LTO exceedance (c)	Maximum observed 8-hour concentration (µg/m³)	Occurrence of LTO exceedances (d)	
April	1 131	52	30	222	2.5	3
May	1 197	55	31	215	2.7	3.2
June	1 132	52	30	236	2.3	2.7
July	1 275	59	31	243	3	3.6
August	1 454	67	31	223	4.2	5
September	755	35	30	233	1.1	1.3

Note: (b)–(d) see notes to Table 2.3.

Figure 2.3 Number of days on which at least one exceedance of the long-term objective for the protection of human health was observed per country and per month during the summer of 2009 (only countries that delivered data are shown)

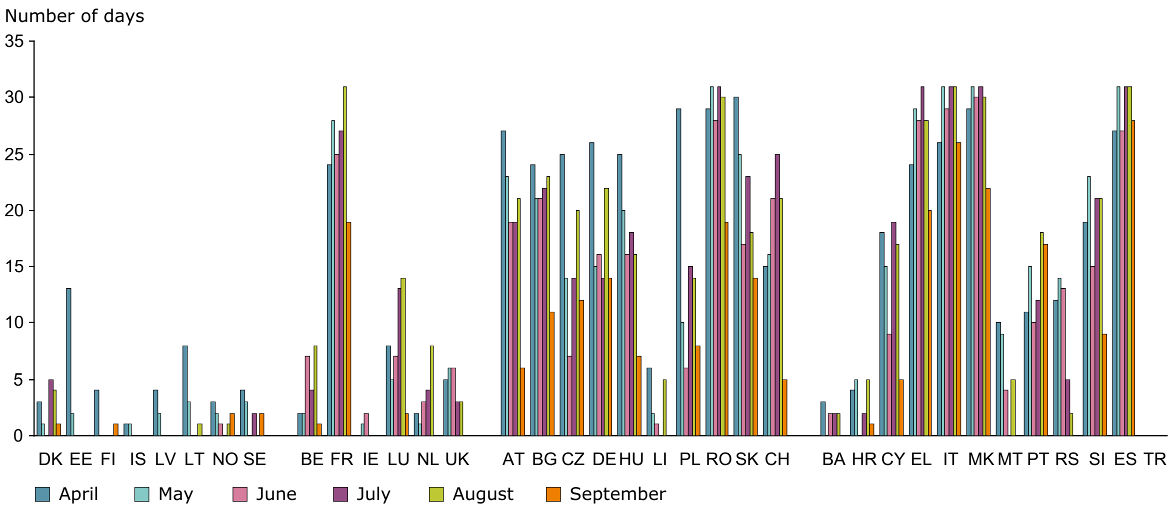
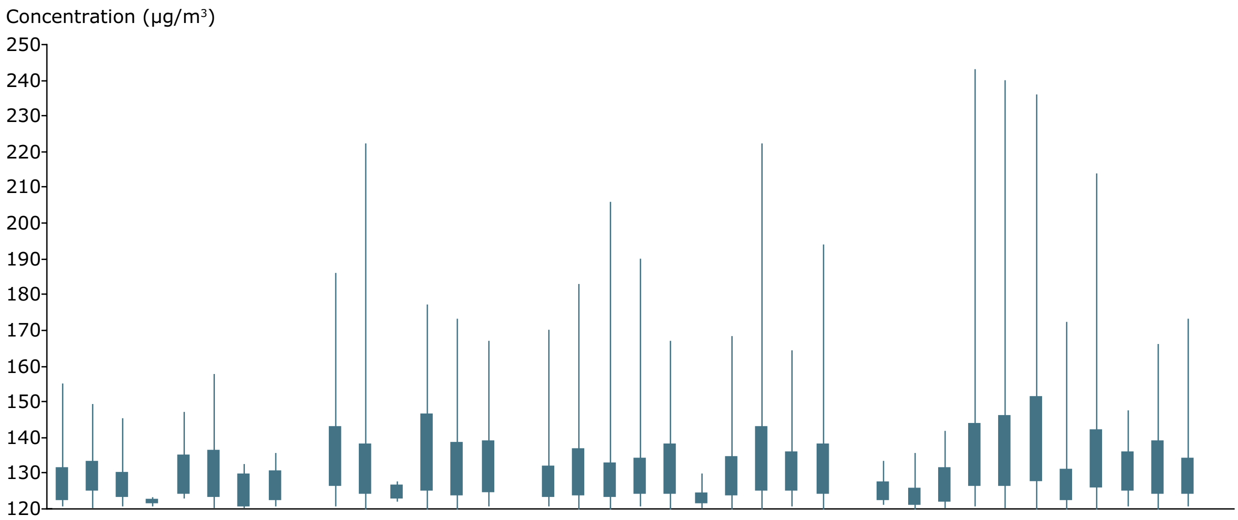


Figure 2.4 Frequency distribution of concentrations in excess of the long-term objective for the protection of human health during the summer of 2009 (only countries that delivered data are shown)



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

2.3 Geographical distribution of ozone air pollution

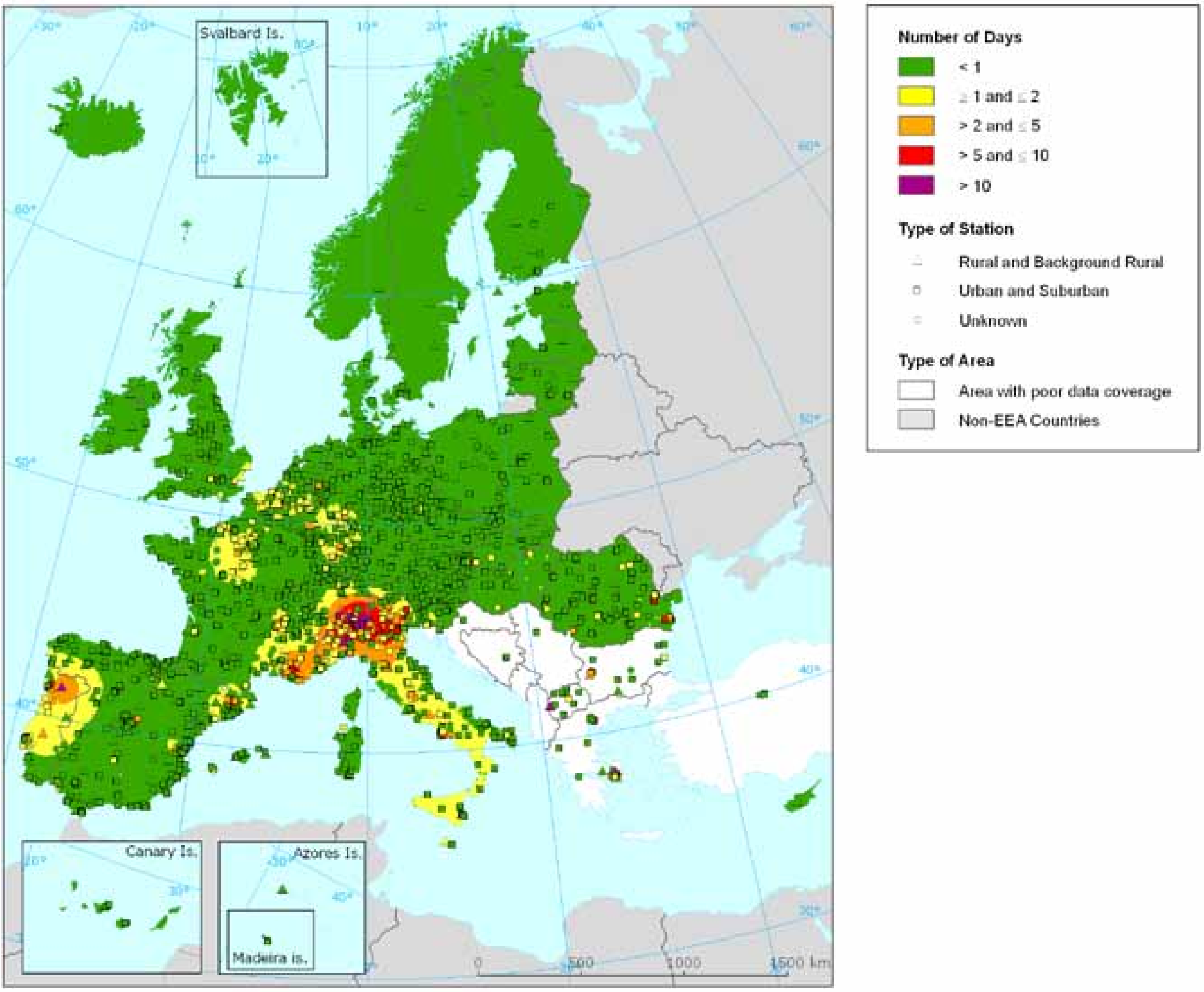
The spatial distribution of ozone exceedances throughout Europe is similar from year to year. In 2009, the highest ozone levels were found in southern and central Europe, where widespread exceedances of both the threshold and target values for the protection of human health occurred. As in previous summers, western, north-western and northern Europe were not widely affected.

The lowest ozone levels occurred in the Baltic States, Scandinavia and a large part of western Europe. No exceedances of the information threshold were reported from this area in summer 2009. This area also reported the fewest exceedances of the LTO.

Map 2.1 depicts the number of days on which the one-hour information threshold was exceeded across Europe. The spatial extent of the exceedances observed in the summer of 2009 was less than in the previous five summers.

Map 2.2 displays the number of days on which the LTO was exceeded across Europe. The areas that reported more than 25 days of LTO exceedance (relevant for determining exceedance of the TV) are similar to 2008. The target value was exceeded in approximately 18 % of the assessed area and affected approximately 17 % of the total population in the assessed territory, which is only slightly more than in 2008 and much lower than in the preceding summers. There is not significant change in the share of area and population affected for most of the individual countries in comparison

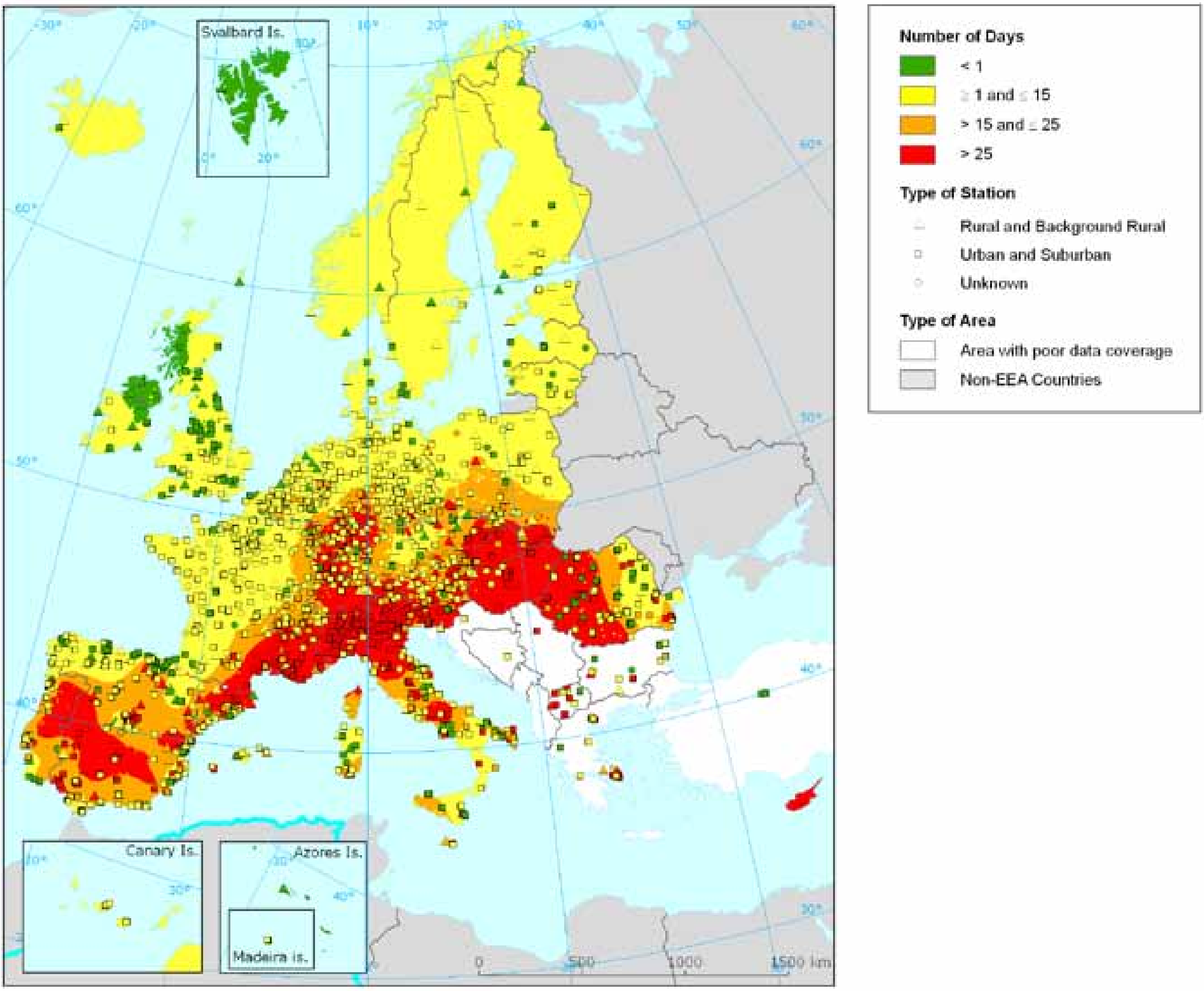
Map 2.1 Number of days on which ozone concentrations exceeded the information threshold



with summer 2008. Nevertheless, the share increased significantly in Austria, Switzerland, Hungary, Portugal, Slovenia and Slovak Republic due to the meteorological situation described above in Section 2.2 (Table 2.5) ([8]).

These maps present the number of exceedance days from the rural stations interpolated by the ordinary kriging method (Cressie, 1993) — a geostatistical method based on knowledge of the air quality field spatial structure ([9]). The colour coding is standard for station symbols as well as for interpolated maps.

Map 2.2 Number of days on which ozone concentrations exceeded the long-term objective for the protection of human health



([8]) Due to an improved methodology (see footnote 8 below) the shares of affected area and population are not exactly comparable with those in the reports for 2004, 2005 and 2006 summers. If the same methodology were applied as in previous reports, estimated percentage shares of affected area and population for the whole of Europe would be slightly lower. For more details, see: http://air-climate.eionet.europa.eu/reports.

([9]) The use of the kriging method is supported by works dealing with spatial mapping development (van de Kassteele *et al.*, 2005). Ozone exceedances are interpolated separately for rural and urban areas. The reason is the different character of urban and rural air pollution concentration fields. The final map is constructed by merging separately created rural and urban maps. In 2007, a Europe-wide population density grid was used to merge the rural map and the urban map into one combined map. Both the rural and the urban maps were created for the entire continent. The population density grid helps determine which part of the respective maps is used (Horálek *et al.*, 2007). Using a population density map to assess air quality in urban areas enables the situation there to be estimated without measurement, thereby improving overall assessment compared with the methodology used in previous reports.
The density of ozone monitoring sites is too low to provide reliable estimates of spatial distribution by interpolation for the south-eastern part of Europe and, therefore, no spatial distribution is shown in these areas. In comparison with summer 2008, spatial distribution for Romania is provided because of the increased number of monitoring stations.
The type of station was unknown for 8.5 % of stations. This fact could affect the precision of mapping in some areas.

Table 2.5 Overview of estimated percentage of area and population (10) resident in areas with ozone levels higher than the target value for the protection of human health during the summers of 2006–2009 on a country-by-country basis (only countries with spatial interpolation in Map 2.2 are shown) (11)

Country	Area with the Exceedances over Target Value (%)				Population affected by the Exceedances over Target Value (%)			
	2006	2007	2008	2009	2006	2007	2008	2009
Austria	98.9	98	12.1	52.7	93	89.1	4.2	31.5
Belgium	63.5	0	0	0	39.2	0	0	0
Switzerland	100	94	17.8	81.3	99.9	72.9	5	51.5
Czech Republic	100	96	30	17.5	99.9	73.9	20.4	16.1
Germany	84	46.3	19.4	12	83.1	26	10.5	6.8
Denmark	0	0	0	0	0	0	0	0
Estonia	0	0	0	0	0	0	0	0
Spain	82.6	42.2	33.6	23.9	42.7	20.7	15.5	11
Finland	0	0	0	0	0	0	0	0
France	47.9	24.4	10.3	17.8	36.1	18.7	6.8	14.9
United Kingdom	0	0	0	0	0	0	0	0
Hungary	97.5	99.9	69	99.5	73.6	98.5	45.8	98.1
Ireland	0	0	0	0	0	0	0	0
Iceland	0	0	0	0	0	0	0	0
Italy	87.9	74.4	46	48.3	66.7	66.3	48.6	50.6
Lithuania	0	0	0	0	0	0	0	0
Luxembourg	-	0	0	0	-	0	0	0
Latvia	0	0	0	0	0	0	0	0
Malta	13	0	0	0	2.6	0	0	0
Netherlands	11.6	0	0	0	11.2	0	0	0
Norway	0	0	0	0	0	0	0	0
Poland	75.8	25.7	2.8	1.5	58.4	25.2	2.1	2
Portugal	82.2	29.5	0	34	37.1	14.9	0	11.7
Romania	-	-	-	49.5	-	-	-	32.5
Sweden	0	0	0	0	0	0	0	0
Slovenia	99.5	99	70.8	96.4	97.4	93.5	43.4	77.8
Slovak Republic	97.1	100	69.9	98.4	88.2	100	50.5	97.8
Total	**45.2**	**28.2**	**14.2**	**18.1**	**48.3**	**28.2**	**13.1**	**17.2**

(10) The Joint Research Centre (JRC) population dataset CLC2000 has been used to estimate the affected population (available at: http://www.eea.europa.eu/data-and-maps/data/population-density-disaggregated-with-clc2000-1). The ORNL (Oak Ridge National Laboratory) Global Population Dataset, version 2002 (available at: http://www.ornl.gov/sci/landscan) has been used in areas not covered by the JRC dataset (the area related to calculations in this report covers Iceland, Norway and Switzerland). These datasets are incomparable in some respects but can be used together for the calculation of percentage of affected population because only the spatial distribution of the population is used.

(11) The data on affected area and population are indicative because the resolution of the interpolation grid is 2 kilometres.

2.4 Main ozone episode

Ozone formation in the atmosphere is a complicated, non-linear photochemical process. In the troposphere (the lower part of the atmosphere), ozone formation results from a chain of mechanisms involving photochemical reactions of nitrogen oxides, chained with oxidative decomposition of volatile organic compounds, carbon monoxide (CO) and methane, initiated by hydroxyl radicals.

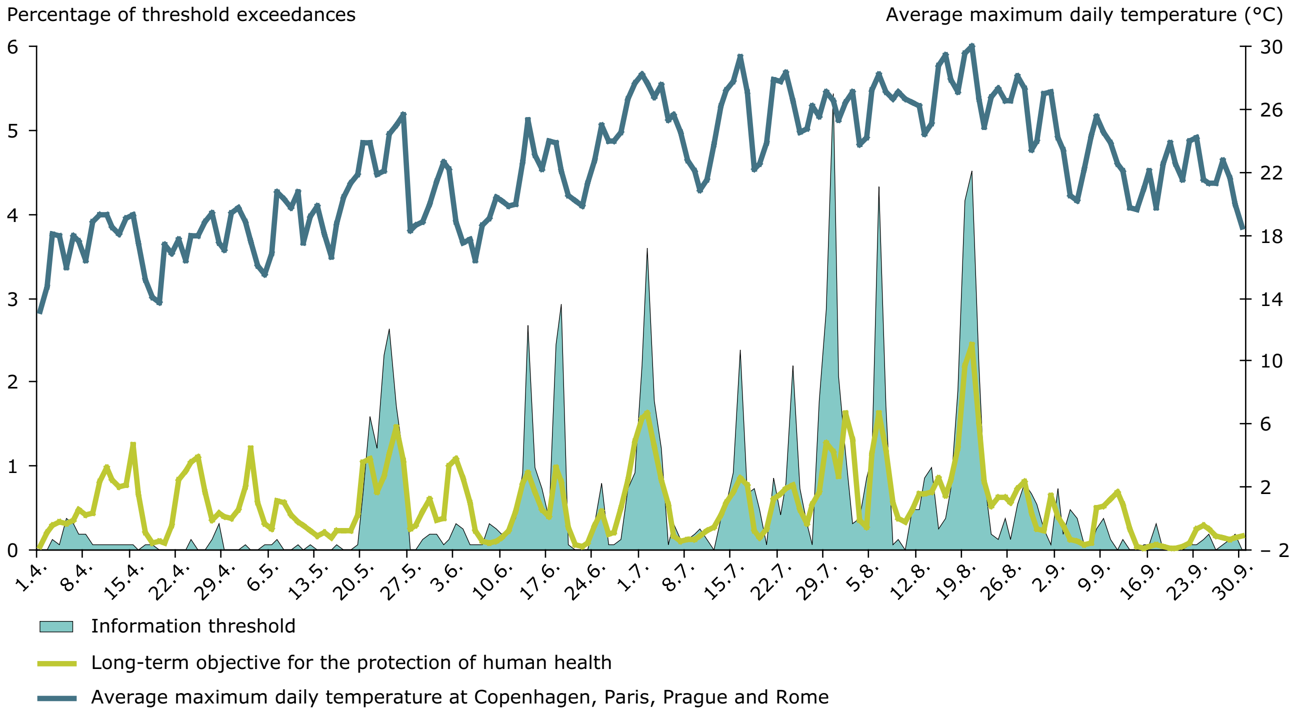
Episodes with elevated ozone levels occur during periods of warm, sunny weather. The ozone concentration depends on meteorological conditions. The largest ozone episodes with the highest ozone concentrations occur in areas of high air pressure (anticyclones). Within such areas, the prevailing stagnant conditions mean that emissions of ozone precursors are only slowly dispersed into the atmosphere and chemical reactions leading to ozone formation take place.

In contrast to previous summers, in 2009 there were no widespread multi-day episodes. Summer 2009 was characterised by short regional ozone episodes of 2–5 days followed by days with few exceedances. Typical episodes usually contained approximately 7–13 % of the total number of exceedances of the information threshold experienced during the summer.

One of the episodes occurred from 28 July to 1 August and accounted for approximately 13 % of the total number of exceedances of the information threshold, 21 % of the exceedances of the alert threshold and about 6 % of the exceedances of the long-term objective.

Figure 2.5 shows the distribution of daily exceedances for the entire continent of Europe and the maximum temperatures observed in four European capital cities (Copenhagen, Paris, Prague and Rome ([12])). The distribution of exceedances per day and per country during summer 2009 is shown in Figure 2.6. Map 2.3 clearly shows the coincidence of areas with elevated ozone concentrations and the areas with the highest temperatures.

Figure 2.5 Distribution of exceedances during the summer of 2009 on a day-by-day basis

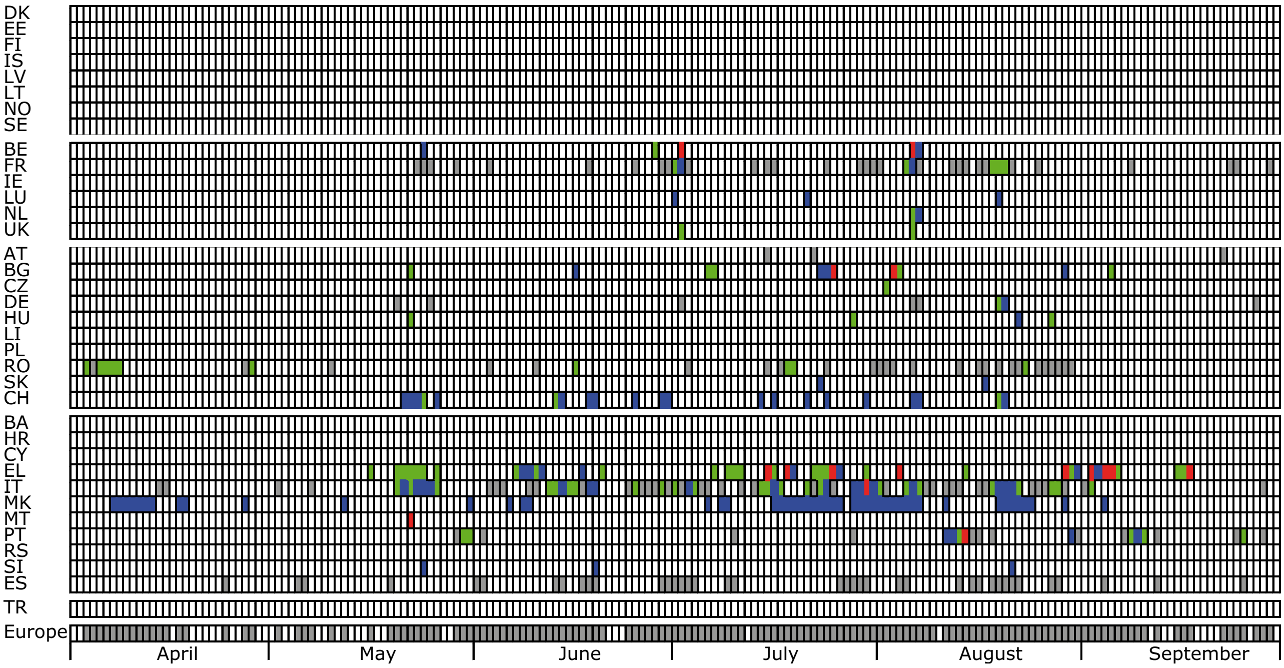


Note: The left y-axis represents the percentage of exceedances observed during a particular day. As such, the exceedances of the information threshold and the LTO depicted each total 100 % between 1 April and 30 September.
Source of maximum temperature data: http://www.wunderground.com.

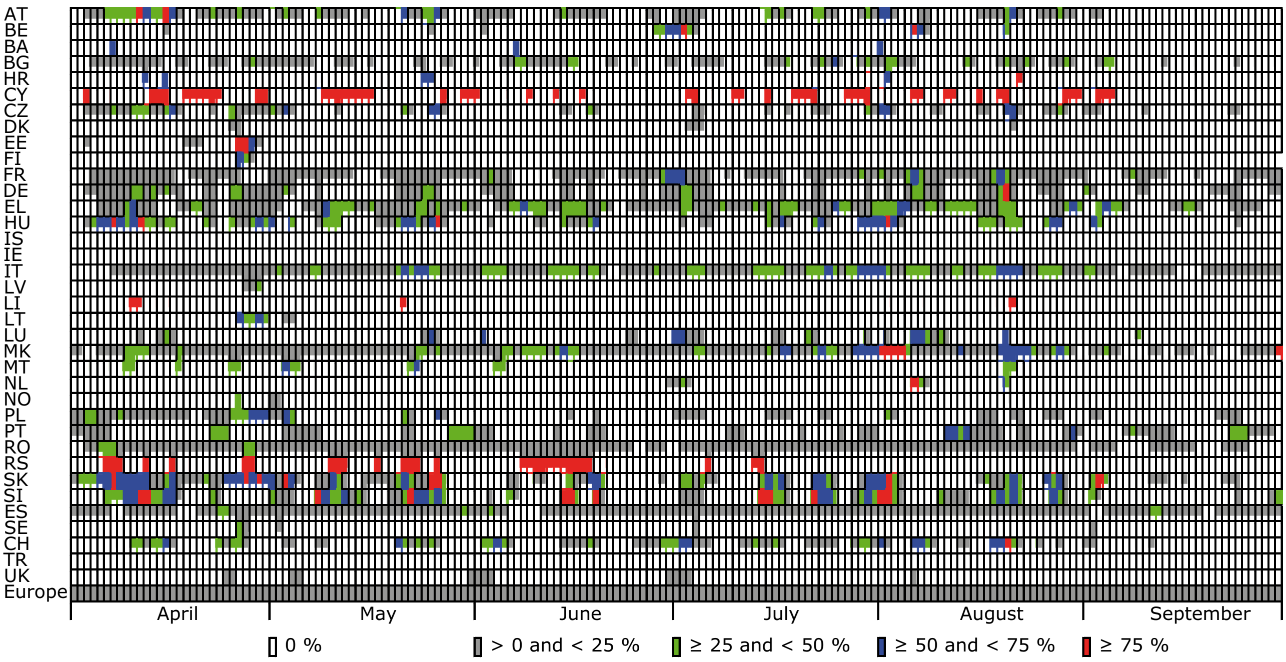
([12]) Europe was divided into four regions to analyse inter-annual variations in the trend of ozone levels due to climatic differences and four capital cities in the regions were selected to demonstrate the relation between the number of exceedances and meteorological situation (see Chapter 3).

Figure 2.6 Distribution of exceedances during the summer of 2009: percentage of stations reporting exceedances on a daily basis per country

a) Information threshold exceedances

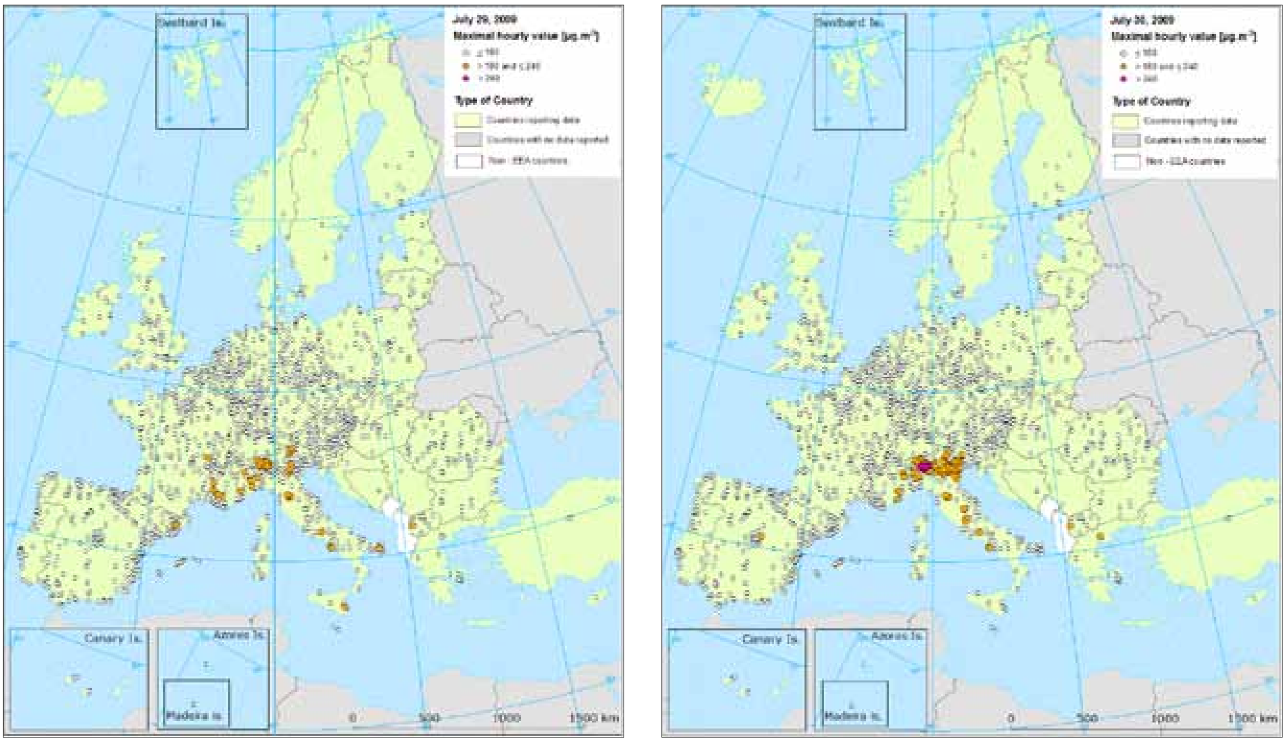


b) Long-term objective for the protection of human health exceedances



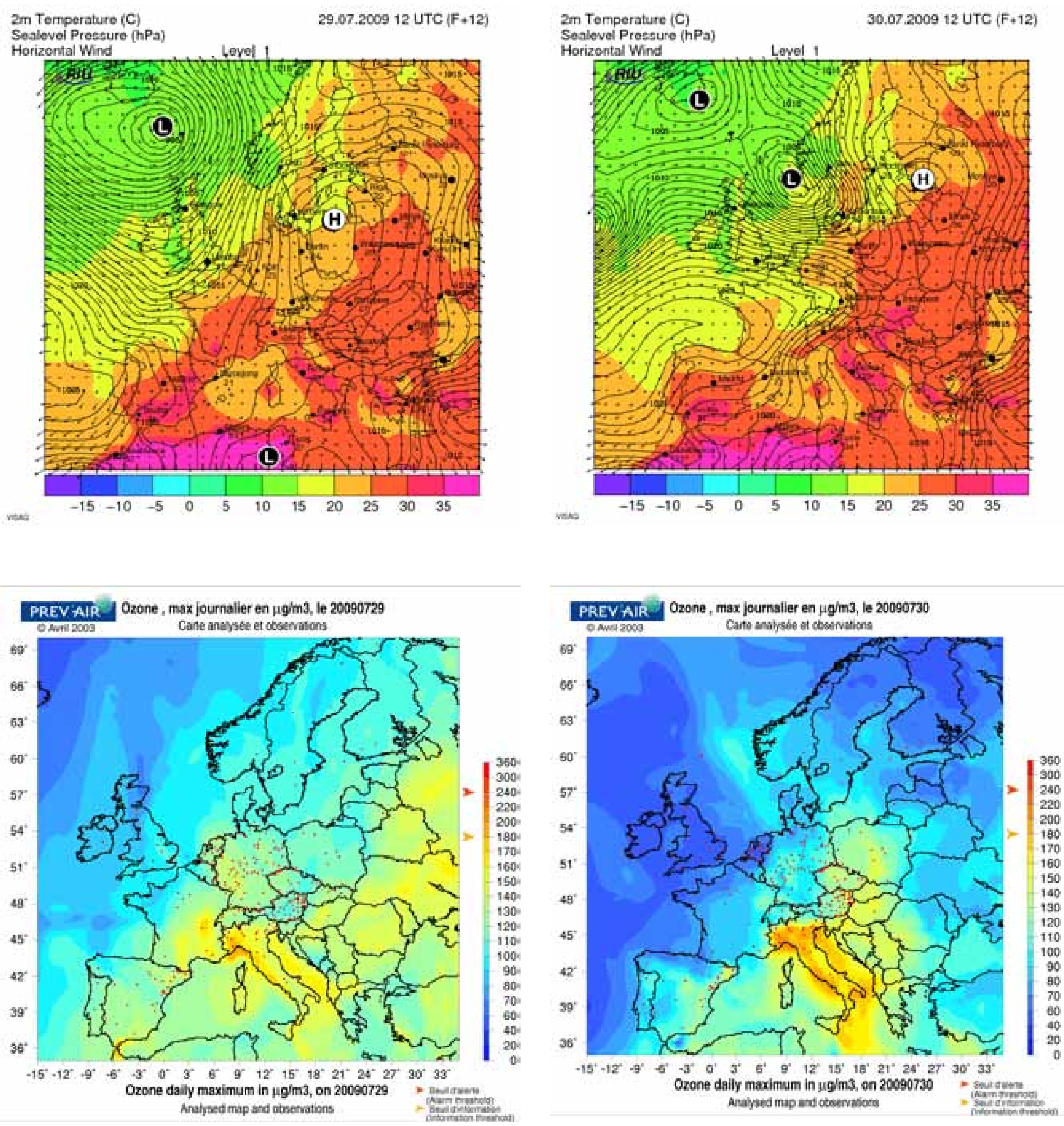
Note: The colours represent the percentage of a country's total number of stations that observe exceedances during a particular day.

Map 2.3 Selected days during one of the summer 2009 ozone episodes: observed maximum 1-hour ozone concentrations and meteorological situation



Maximal hourly value (µg.m^{-3}) 29 July 2009	Maximal hourly value (µg.m^{-3}) 30 July 2009
○ ≤ 180 µg.m^{-3}	○ ≤ 180 µg.m^{-3}
● > 180 and ≤ 240 µg.m^{-3}	● > 180 and ≤ 240 µg.m^{-3}
● > 240 µg.m^{-3}	● > 240 µg.m^{-3}
Type of country	**Type of country**
Countries reporting data	Countries reporting data
Countries with no data reported	Countries with no data reported
Non-EEA countries	Non-EEA countries

Map 2.3 Selected days during one of the summer 2009 ozone episodes: observed maximum 1-hour ozone concentrations and meteorological situation (contd)



Source: European Environment Agency; Rhenish Institute for Environmental Research (ground level pressure, temperature and horizontal wind); PREV'AIR (analysed maximum 1-hour ozone concentrations from the EEA Ozone web data).

3 Comparison with previous years

Ozone levels in summer 2009 were compared with the summer ozone concentrations from 1997 to 2007 stored in the EEA air quality database AirBase, and the summer 2008 data submitted under Directive 92/72/EEC on air pollution by ozone. Only time series that included more than 75 % of valid, measured data during the summers of 1997–2007 were selected for comparison. Data stored in AirBase are validated, whereas the 2008 and 2009 summer data are provisional and only partly validated. Before 1997, ozone data collection in Europe was not comprehensive so the data in AirBase are not comparable. Even in the period since 1997 some of the observed changes may have been caused by changes in the location of stations and the density of the monitoring networks.

As described in previous chapters, ozone concentrations over Europe vary widely due to large differences in climate over the continent. The stations were divided into four regions to analyse inter-annual variations in the trend of ozone levels due to climatic differences over Europe, based on last year's experience and this summer's data (see key for Figure 3.1).

The analysis clearly shows that exceedances occur frequently in the Mediterranean area. The number of occurrences in southern Europe was lower between 1999 and 2001 than in the extreme summer of 2003 (EEA, 2003) which saw a very large number of occurrences. This was also the case in more northern parts of Europe. While the situation during the summers of 2004 and 2005 returned to 'normal' (EEA, 2005; EEA, 2006) the summer of 2006 (EEA, 2007a) showed considerable differences in climatic conditions between northern Europe and other parts of the continent. No exceedances of the information threshold in northern Europe were significant in the hot summer of 2003, when maximum values were observed elsewhere in the continent. Ozone levels during the summer of 2007, 2008 and 2009 rank among the lowest in the past decade (see Table 3.1 for detailed annual information).

At the current level of precursor emissions, the year-to-year differences in the occurrence of ozone threshold exceedances are induced substantially by meteorological variations (Solberg and Lindskog, 2005). Hot, dry summers with long-lasting periods of high air pressure over large parts of the European continent lead to elevated ozone concentrations and more exceedances of ozone threshold values; the hotter the summer, the higher the number of exceedances. This correspondence can also be demonstrated by charting the daily maximum temperatures averaged for the period April–September of a particular year observed in four capital cities in selected regions (Copenhagen, Paris, Prague and Rome ([13])) in relation to the number of exceedances (see Figure 3.1).

Although the average temperatures measured in these cities in summer 2009 are close to the ones measured in 2003, the occurrence of threshold exceedances was roughly as low as in summer 2008 and is among the lowest since reporting of Europe-wide data commenced in 1997. The reason could be the difference in the meteorological situation. The number of summer and tropical days ([14]) was lower and there was no dominant long-lasting episode with exceptionally high temperatures in summer 2009. Contrastingly, during the first half of August 2003 the weather conditions were almost unchanged and were characterised by a long period of high air pressure above south-western Europe, accompanied by exceptionally high temperatures even at nights covering large parts of southern, western and central Europe.

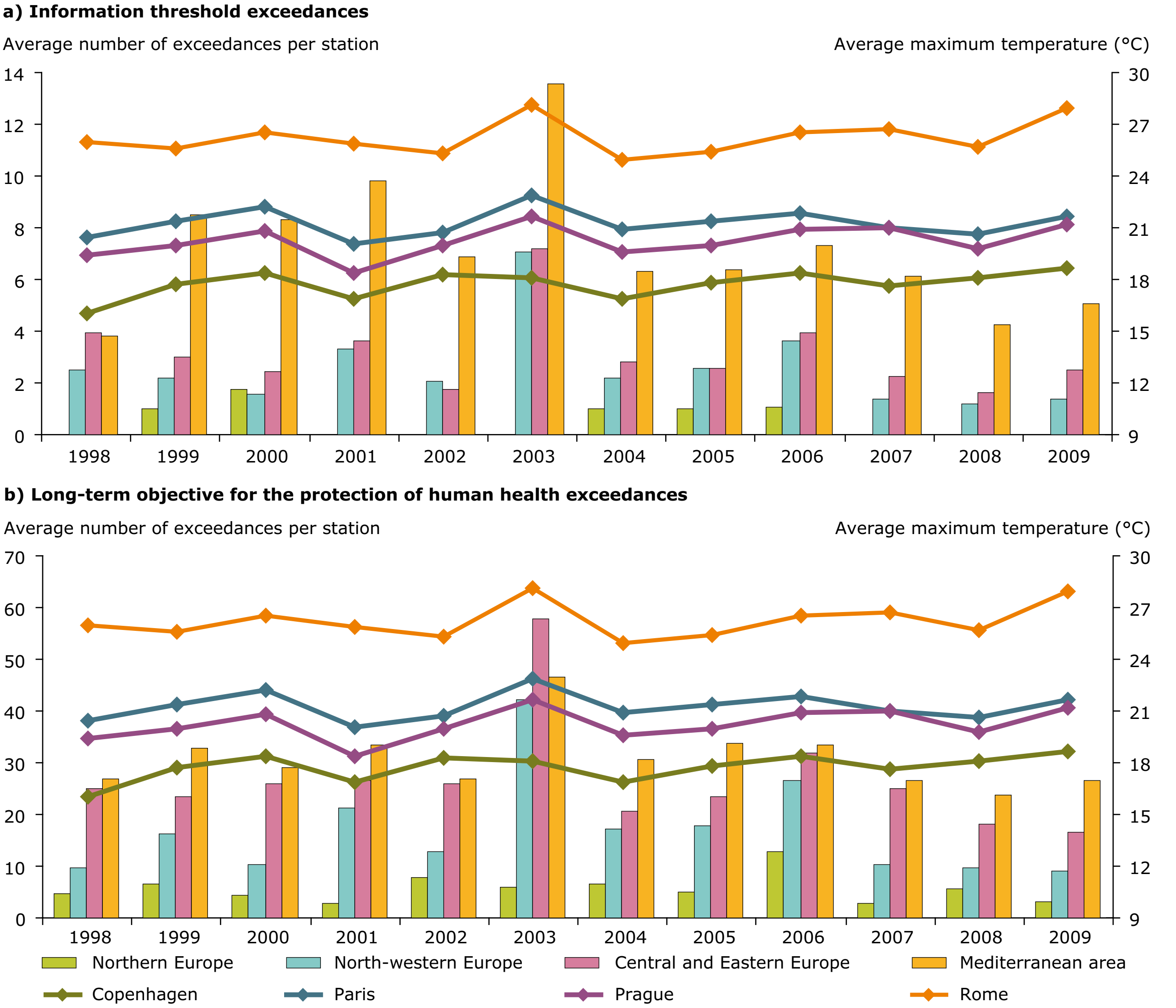
EU-27 emissions of ozone precursors, weighted according to their contribution in ozone formation (de Leeuw, 2002) fell about 40 % in the period 1990–2005. Over the periods 1996–2005 and 2001–2005 the decrease in total emissions was 25 % and 9 % respectively. Perhaps surprisingly, despite the steady decline in the release of ozone precursors, observed ground-level ozone concentrations have remained broadly stable ([15]).

([13]) These cities were selected only for demonstration of the relation between the number of exceedances and meteorological situation. The selection was not based on the statistical evaluation of the meteorological representativeness of these cities for the regions.

([14]) Summer/tropical day is the day with the maximum daily temperature higher or equal 25 °C/30 °C.

([15]) For more in-depth analysis of this issue, please refer to EEA, 2009.

Figure 3.1 Regional average number of exceedances per station during the summer for stations that reported at least one exceedance and average maximum daily temperature in selected cities



Note: Northern Europe: Denmark, Estonia, Finland, Iceland, Latvia, Lithuania, Norway, Sweden.
North-western Europe: Belgium, France (north of 45 ° latitude), Ireland, Luxembourg, the Netherlands, United Kingdom.
Central and eastern Europe: Austria, Bulgaria, Czech Republic, Germany, Hungary, Liechtenstein, Poland, Romania, Slovakia, Switzerland.
Mediterranean area: Albania, Andorra, Bosnia and Herzegovina, Croatia, Cyprus, France south of 45 ° latitude, Greece, Italy, Malta, Monaco, Montenegro, Portugal, San Marino, Serbia, Slovenia, Spain, the former Yugoslav Republic of Macedonia.

Source: EEA, http://www.wunderground.com (temperature data).

Between the late 19th century and 1980, concentrations of background ozone in the mid-latitudes of the northern hemisphere doubled to approximately 60–75 µg/m^3 and have since increased to 80 µg/m^3. The increase since 1980 is not fully understood but is thought to be due mainly to increases in emissions from poorly regulated sectors in northern hemisphere countries, such as international shipping and aviation. Increased ozone from the stratosphere may also have contributed. Ozone can no longer be considered a local air quality issue — it is a global problem, requiring a global solution (Royal Society, 2008).

Ozone pollution as a global or hemispheric problem is addressed by the Task Force on Hemispheric Air Pollution (HTAP) under the Convention on Long-range Transboundary Air Pollution (LRTAP). In their 2007 assessment report, HTAP states that a general increase in background ozone concentrations has occurred, while peak ozone levels have declined in many of the more densely populated areas of Europe and the United States. This decline is attributable to reductions in local anthropogenic emissions of nitrogen oxides and non-methane hydrocarbons (NMHCs), which are both ozone precursors (HTAP, 2007). HTAP will publish an updated assessment report by the end of 2010 (available at www.htap.org). That report will again address tropospheric ozone transport and formation in the northern hemisphere, based on latest scientific findings.

A recent analysis addresses measured ozone concentrations, particularly in the mid-troposphere (3–8 kilometres above the Earth's surface) (Cooper *et al.*, 2010). The results strongly indicate that ozone levels in the troposphere increased over western North America during April–May in the period 1995–2008. Those findings are supported by dispersion modelling results analysing the transport history of each ozone measurement. The rate of increase in the ozone mixing ratio is greatest when measurements are more heavily influenced by direct air transport from Asia, a clear indication of inter-continental transport of ozone or ozone precursors.

Setting aside the high concentrations in 2003, which were caused by extremely favourable conditions for ozone formation in that year in most of Europe, the concentrations measured at rural ground-level AirBase stations during the summer months show atmospheric ozone concentrations remaining unchanged (1997 to 2009). However, for meaningful statistical analysis of trends in ozone concentrations, long time series from stable monitoring networks are crucial, as ozone concentrations are strongly influenced by inter-annual changes in meteorology (EEA, 2009).

Data from the traffic and urban background stations suggest some increase. This can be explained by less ozone depletion due to decreasing nitrogen oxide emissions. The constant background levels are the net result of a number of possible processes:

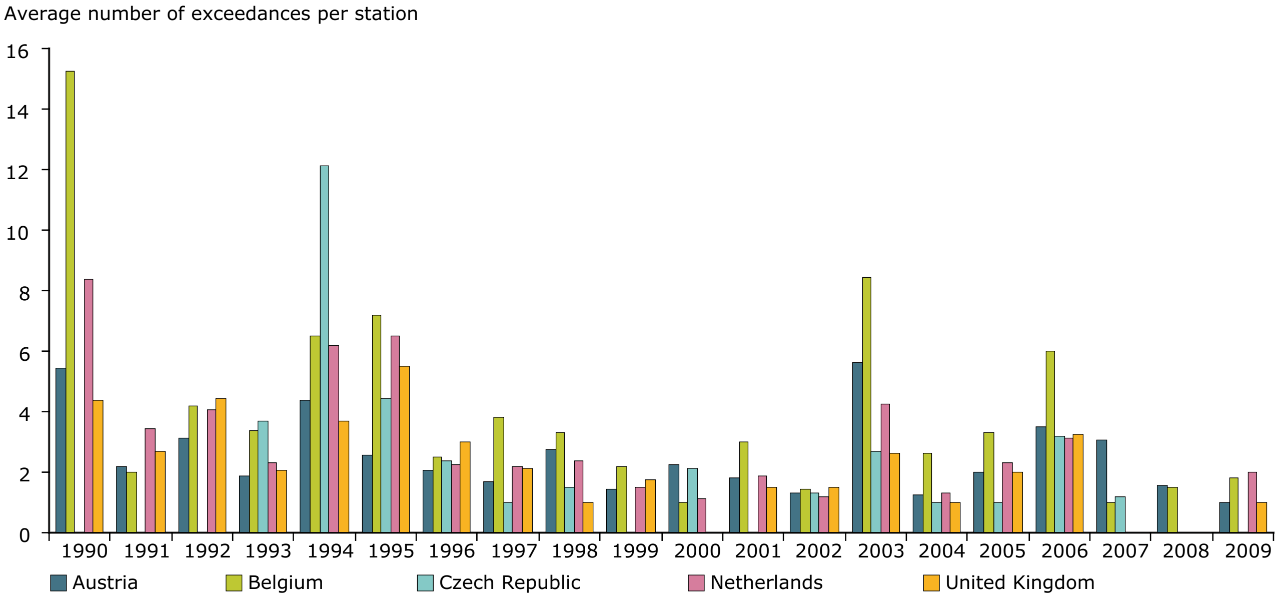
- the increase in hemispheric background concentrations;
- less ozone deposition during the (more frequent) dry periods during summer, increased ozone formation due to higher temperatures;
- less ozone formation due to emissions reduction.

Climatic changes in large-scale circulation patterns over Europe might also play a role (EEA, 2007b; Mol *et al.*, 2008).

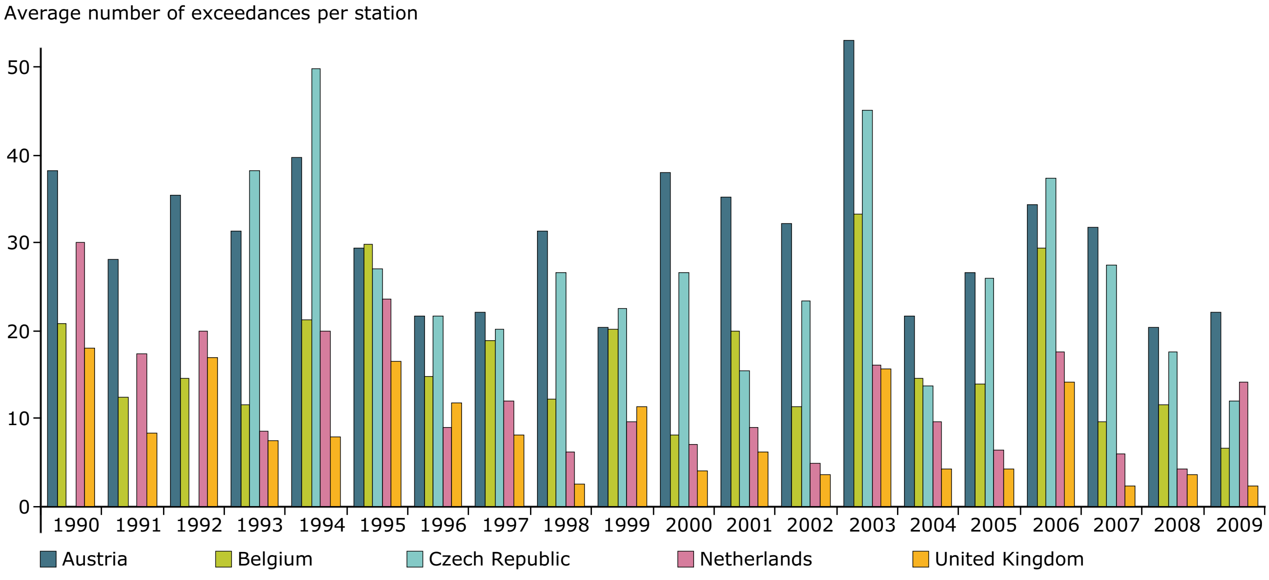
Figure 3.2 depicts the long-term trend in exceedances since 1990. The data for Figure 3.2 were provided by countries with data series of at least 15 years from several stations. The summers of 1990, 1994 and 1995 display the highest ozone levels, as well as summer 2003.

Figure 3.2 Average number of exceedances per station during the summer for stations that reported at least one exceedance ([16]) (selected countries)

a) Information threshold exceedances



b) Long-term objective for the protection of human health exceedances



([16]) Only stations with data spanning at least 15 years were included.

Table 3.1 Overview of exceedances observed during the summer season in Europe in 1997–2009 ([17])

a) Information threshold exceedances

Summer season	No. of stations ([a])	Stations with exceedance ([b]) (number)		(%)		(%)	No. of days with exceedance ([c])		Maximum observed one-hour concentration (μg/m³)	Occurrence of exceedances ([d])				Average duration of exceedances (hour)	
1997	817	344	16	42	2	5	123	18	315	1.2	2.8	0.0	1.3	2.7	1.7
1998	822	468	65	57	8	14	108	42	370	2.1	3.7	0.1	1.6	3.4	2.1
1999	1 197	405	46	34	4	11	160	95	440	1.5	4.5	0.1	3.8	3.1	3.8
2000	1 278	559	44	44	3	8	132	54	473	1.6	3.6	0.1	2.0	2.9	2.1
2001	1 444	702	89	49	6	13	147	82	470	2.6	5.4	0.2	2.6	3.1	2.0
2002	1 540	560	65	36	4	12	136	41	391	1.3	3.5	0.1	2.0	2.8	2.0
2003	1 635	1 203	318	74	19	26	171	88	418	6.6	9.0	0.5	2.4	3.9	2.2
2004	1 708	629	43	37	3	7	137	44	396	1.5	4.0	0.0	1.9	3.1	1.9
2005	1 839	851	68	46	4	8	163	61	457	1.8	4.0	0.1	2.1	3.2	2.3
2006	1 901	1 173	104	62	5	9	143	53	394	3.0	4.8	0.1	2.0	3.4	2.0
2007	1 686	561	69	33	4	12	151	44	479	1.4	4.1	0.1	1.7	3.3	1.9
2008	2 049	402	21	20	1	5	124	23	302	0.7	3.5	0.0	2.1	2.9	1.7
2009	2 171	443	30	20	1	7	144	24	284	0.8	3.7	0.0	1.3	2.9	2.2

Notes: White columns refer to exceedances of the information threshold, grey ones to exceedances of the alert threshold.

([a]) Total number of stations measuring ozone levels.

([b]) The number and percentage of stations at which at least one threshold exceedance was observed; fifth column: percentage of stations with information threshold exceedance at which alert threshold exceedance were also observed.

([c]) The number of calendar days on which at least one exceedance of thresholds was observed.

([d]) Occurrence of exceedance is calculated as the average number of exceedances observed per station in a country. Left column: averaged over all implemented stations (total number of stations), right figure: averaged over all stations which reported at least one exceedance.

b) Long-term objective for the protection of human health exceedances

Summer season	No. of stations ([a])	Stations with LTO exceedance ([b]) (number)	(%)	Stations with TV exceedance ([b]) (number)	(%)	No. of days with LTO exceedance ([c])	Maximum observed 8-hour concentration (μg/m³)	Occurrence of LTO exceedances ([d])	
1997	817	747	91	216	26	183	252	18.9	20.7
1998	822	739	90	246	30	178	330	20.0	22.2
1999	1 197	1 108	93	360	30	183	537	20.9	22.6
2000	1 278	1 155	90	368	29	181	266	19.5	21.6
2001	1 444	1 319	91	561	39	183	320	24.0	26.3
2002	1 540	1 367	89	448	29	183	310	19.9	22.5
2003	1 635	1 557	95	1 103	67	183	297	45.1	47.4
2004	1 708	1 545	90	449	26	183	364	19.9	22.0
2005	1 839	1 677	91	625	34	183	334	22.7	24.9
2006	1 901	1 791	94	988	52	183	316	28.1	29.8
2007	1 686	1 494	89	539	32	183	507	21.5	24.3
2008	2 049	1 741	85	387	19	182	245	15.2	17.9
2009	2 171	1 830	84	441	20	183	243	15.9	18.8

Notes: ([a]) Total number of stations measuring ozone levels.

([b]) The number and percentage of stations at which at least one exceedance was observed.

([c]) The number of calendar days on which at least one exceedance was observed.

([d]) Left column: averaged over all implemented stations, right figure: averaged over all stations which reported at least one exceedance.

([17]) Ozone levels in summer 2009 were compared with the summer ozone concentrations from 1997 to 2007 stored in the EEA air quality database AirBase, and the summer 2008 data submitted under Directive 92/72/EEC on air pollution by ozone. Data stored in AirBase are validated, whereas the 2008 and 2009 summer data are provisional and only partly validated.

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Annex 1 Legal requirements on data provision

Directive 2002/3/EC requires Member States to provide the following data to the European Commission and to the EEA:

Monthly data (Article 10(2)(a)(i))

For each month from April to September each year, data collected on exceedances of the information and/or the alert thresholds (one-hour ozone concentration higher than 180 µg/m^3 and 240 µg/m^3) must be reported before the end of the following month. Data submitted in the monthly reports are considered provisional and are updated, if necessary, in subsequent submissions.

Summer data (Article 10(2)(a)(ii))

Additional provisional data for the foregoing summer period (April–September), as defined in Annex III to the Directive (i.e. information on exceedances of alert and information thresholds, on exceedances of the health protection long-term objective, the daily maximum of 8-hour average ozone concentration higher than 120 µg/m^3, related NO_2 values when required and for each month one-hour maximum ozone concentrations) must be reported by 31 October.

Annual data (Article 10(2)(b))

Validated annual data for ozone and precursors (as defined in Annexes III and VI to the directive) of the previous year must be submitted by 30 September. The annual data flow is included in the questionnaire to be used for annual reporting on air quality assessment in the scheme of the Air Quality Framework Directive (96/62/EC) and its daughter directives – see Commission Decision 2004/461/EC for details (Commission of the European Communities, 2004).

Annex 2 Data reporting over summer 2009

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

Ozone monitoring stations operated throughout the whole period April–September 2009. It is possible, however, that some exceedances were not reported due to temporary maintenance work or malfunction. Nevertheless, experience with current, continuously operated ozone monitors shows that such situations occur rarely.

Countries reported information on the validity of one-hour measurements at 1 581 stations (equal to 73 % of all operational stations). Of those, 1 484 (94 %) provided valid one-hour measurements at least 75 % of the time (see Table A.1). The proportions were the same as in 2008 and similar in summer 2007 (72 % and 95 %).

An overview of monthly reported data is presented by the ETC/ACC and regularly updated on the EEA website: http://www.eea.europa.eu/maps/ozone/compare/summer-reporting-under-directive-2002-3-ec [accessed 18 December 2009].

The ozone monitoring network in 2009

Map A.1 presents the location of all ozone-monitoring stations assumed to be operational in the reporting countries during summer 2009. In total, 2 171 ozone-monitoring sites were operational in summer 2009, of which 2 111 were located in the EU.

The number of operational stations was highest on record (Table 3.1). Most countries did not significantly change the number of ozone-monitoring stations compared to the preceding year. In comparison with summer 2008, larges changes were reported by Romania (70 more stations), Italy (41 more), Spain (21 more) and France (30 fewer stations).

According to the requirements of Directive 92/72/EEC on air pollution by ozone, stations should be situated away from the influence of local emissions. When looking at the delivered station meta-information, 478 (approximately 22 %) are traffic or industrial stations (thereby not fulfilling the requirements) but were included in 2009 summer reporting to match the practice in previous years.

Most of the countries transmitted sufficient or complete information about all operational stations. To fill the gaps in station meta-information, i.e. geographical coordinates, information was extracted from AirBase. Nevertheless, for approximately 15 % of stations the type of station was not known.

Table A.1 Overview of the validity of one-hour measurements during the summer of 2009 on a country-by-country basis

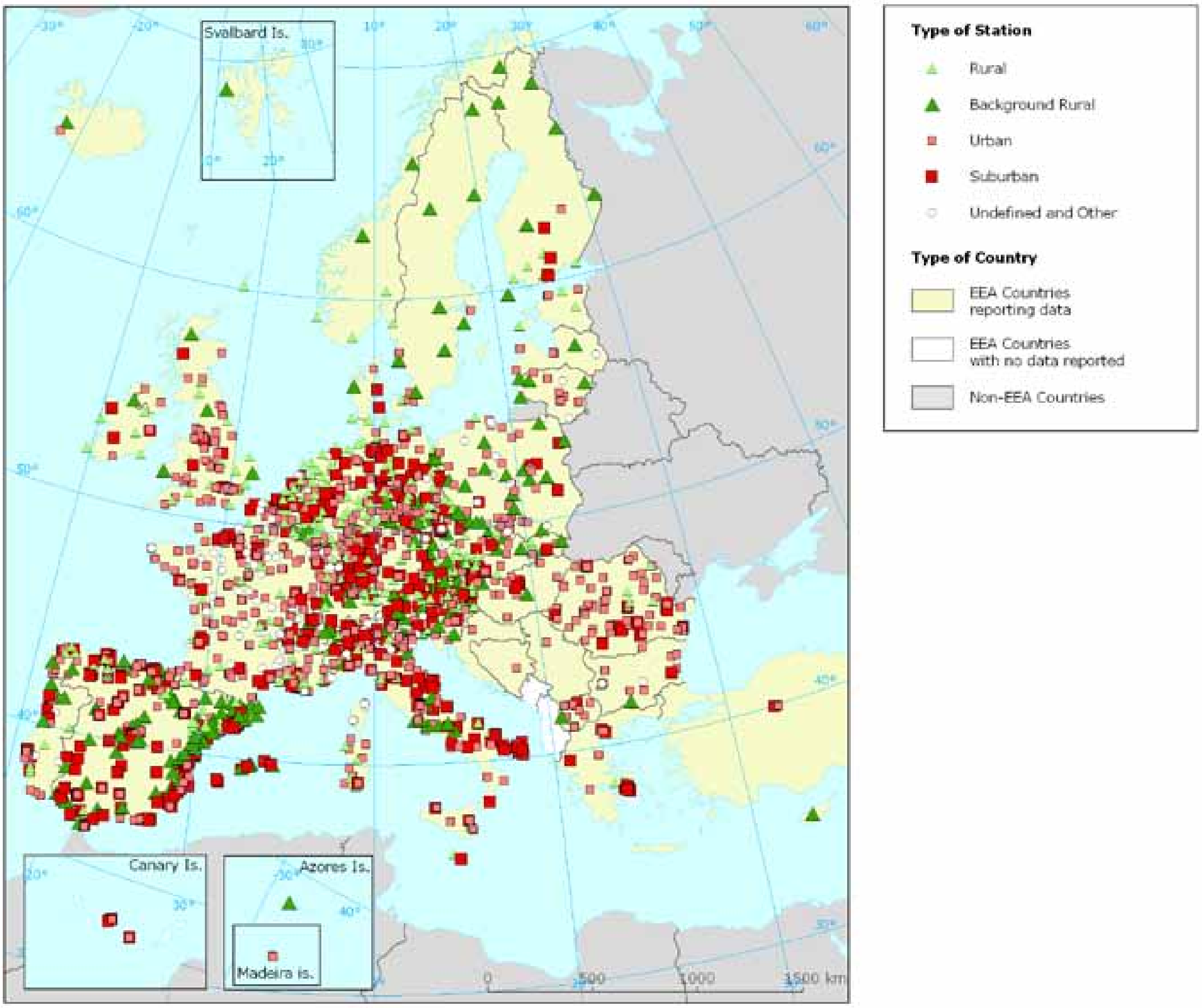
Country	Stations with available information ([a]) (%)	Stations with at least 75 % of valid one-hour data ([b]) (%)
Austria	100	97
Belgium	100	100
Bulgaria	87	100
Cyprus	100	100
Czech Republic	100	100
Denmark	100	100
Estonia	100	100
Finland	100	100
France	100	97
Germany	0	-
Greece	100	83
Hungary	100	94
Ireland	100	91
Italy	0	-
Latvia	100	75
Lithuania	100	100
Luxembourg	100	100
Malta	100	75
Netherlands	100	100
Poland	88	76
Portugal	88	100
Romania	100	76
Slovak Republic	100	100
Slovenia	100	100
Spain	100	94
Sweden	100	100
United Kingdom	100	97
Bosnia-Hercegovina	100	100
Croatia	100	100
Iceland	100	100
Liechtenstein	100	100
Macedonia, FYR of	100	54
Norway	100	88
Serbia	100	100
Switzerland	100	100
Turkey	100	33
Total	**73**	**94**

Note: '-' indicates 'not applicable'.

([a]) The percentage of stations for which the country provided information on the validity of one-hour measurements.

([b]) The percentage of stations for which the country provided information, which provided valid one-hour measurements at least 75 % of the time during summer 2009.

Map A.1 Location of ozone monitoring stations in summer 2009 as reported by Member States and other European countries



Annex 3 Near real-time ozone data exchange

The information on ozone exceedances summarised in this report is provided through monthly reporting by Member States. This practice can be streamlined and updated by adopting near real-time data exchange of ozone data (NRT).

EEA has already established Ozone Web,([18]) which is a pilot GIS-based system for collecting, providing and visualising near real-time ambient ozone levels across Europe. Developed by the EEA as a joint European project, it provides up-to-date information in the form of maps and graphs, and background information on ozone and its health impacts.

Data from stations across Europe are transmitted to the EEA in Copenhagen on an hourly basis. The information is provided by national and regional organisations on a voluntary basis and aims to serve the general public. Since the data must be as 'real-time' as possible, they are displayed as soon as possible after the end of each hour. The air quality data used in the website are preliminary and may change when validated, so are not used for legal compliance reporting. Use restrictions may apply on some data.

The ozone web page includes Snapshot and Explorer ([19]) modules which can be used for display and download of the same statistics as described in details in this report, but based on delivered near real-time data (Map A.2).

The number of stations incorporated in the NRT was approximately twice lower than officially reported during summer 2009. Nevertheless, the number of threshold exceedances recorded by NRT was often higher for the individual country and the maximum observed one-hour concentration as well because of the lack of resubmission of the validated data, i. e. incorrect values remain in the NRT database (Table A.2).

Comparisons of the threshold exceedances calculated from the real-time data and summer data were presented at the EIONET Workshops on Air Quality Management and Assessment. Those presentations are available at:

http://air-climate.eionet.europa.eu/docs/meetings/071015_12th_EIONET_AQ_WS/14_NRT_O3_and_pot_SOR_Berkhout.pdf [accessed 21 December 2009]

http://air-climate.eionet.europa.eu/docs/meetings/080929_13th_eionet_aq_ws/09_Cernikovky_SOR2008_13_EIONET_AQ_080929.pdf [accessed 21 December 2009]

http://air-climate.eionet.europa.eu/docs/meetings/091005_14th_eionet_aq_ws/08_SummerO3_2009_prelim_AQEionet09_LChernikovsky.pdf [accessed 21 December 2009]

http://air-climate.eionet.europa.eu/docs/meetings/091005_14th_eionet_aq_ws/meeting091005.html [accessed 21 December 2009]

Further details and documents on the progress of the EEA near real-time data exchange and the pilot to replace the summer ozone report are available at:

http://eea.eionet.europa.eu/Public/irc/eionet-circle/airclimate/library?l=/public/real-time_operational&vm=detailed&sb=Title [accessed 21 December 2009]

Present-day plans on data flows were discussed during the last workshop's session 6, the presentations are available at:

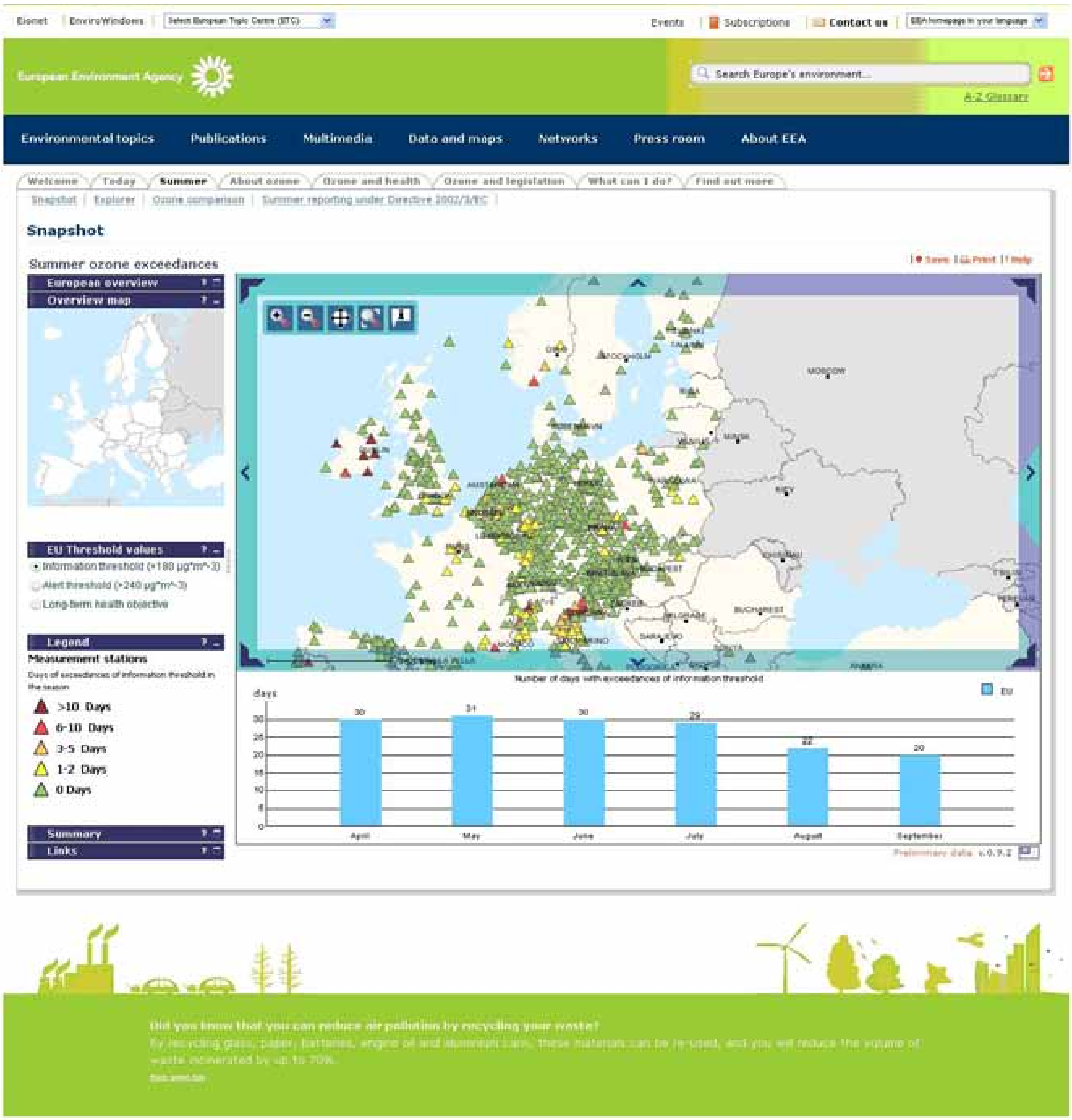
http://air-climate.eionet.europa.eu/docs/meetings/091005_14th_eionet_aq_ws/meeting091005.html [accessed 21 December 2009].

In addition to Ozone Web, EEA has expanded its 'Eye on Earth' portal to include a new application, 'AirWatch', providing air quality information to the citizens of Europe. Launched in November 2009, the site provides interactive information at all scales, from street-level to aggregated continental data. The near real-time information derives

([18]) EEA ozone web: http://www.eea.europa.eu/maps/ozone.
([19]) Summer ozone Snapshot and Explorer: http://www.eea.europa.eu/maps/ozone/compare.

from air quality measurement stations, computer modelling provided by the GMES Atmosphere Service (PROMOTE/MACC) and citizen's input. And crucially, the complex scientific data on ozone, PM_{10} and NO_2 is presented in a format that the public can easily understand: http://eyeonearth.cloudapp.net/

Map A.2 Screenshot of Ozone Web (summer tap)



Source: www.eea.europa.eu/maps/ozone/compare (from January 2010).

Table A.2 Comparison of the summer reporting (SOR) with near real-time reporting (NRT)

Country	Summer ozone reporting						Near real-time ozone reporting					
	No. of stations (a)	Stations with exceedance (b)				Maximum observed one-hour concentration (µg/m³)	No. of stations (a)	Stations with exceedance (b)				Maximum observed one-hour concentration (µg/m³)
		(number)		(%)				(number)		(%)		
Austria	115	4	0	3	0	206	113	4	0	3	0	206
Belgium	40	21	0	53	0	202	40	21	0	52	0	202
Bulgaria	15	5	1	33	7	257	2	1	0	50	0	212
Cyprus	1	0	0	0	0	< 180	2	1	1	50	50	363
Czech Republic	60	2	0	3	0	208	59	13	7	22	11	374
Denmark	9	0	0	0	0	< 180	6	1	1	16	16	348
Estonia	7	0	0	0	0	< 180	2	0	0	0	0	< 180
Finland	17	0	0	0	0	< 180	16	0	0	0	0	< 180
France	416	121	5	29	1	284	37	12	0	32	0	210
Germany	273	30	0	11	0	226	282	30	1	10	0	245
Greece	24	12	4	50	17	264	13	8	3	61	23	276
Hungary	17	4	0	24	0	193	7	2	0	28	0	236
Ireland	11	0	0	0	0	< 180	9	8	6	88	66	304
Italy	300	142	14	47	5	279	129	81	35	62	27	399
Latvia	8	0	0	0	0	< 180	1	0	0	0	0	< 180
Lithuania	14	0	0	0	0	< 180	3	0	0	0	0	< 180
Luxembourg	6	1	0	17	0	194	6	2	0	33	0	194
Malta	4	1	0	25	0	194	1	1	1	100	100	386
Netherlands	36	5	0	14	0	193	34	7	5	20	14	395
Poland	75	0	0	0	0	< 180	41	8	4	19	9	331
Portugal	52	28	2	54	4	256	14	8	2	57	14	256
Romania	93	17	1	18	1	242	0	0	0	0	0	-
Slovak Republic	14	2	0	14	0	199	13	1	0	7	0	199
Slovenia	12	2	0	17	0	197	8	0	0	0	0	< 180
Spain	403	31	1	8	0	274	165	31	14	18	8	393
Sweden	12	0	0	0	0	< 180	9	0	0	0	0	< 180
United Kingdom	77	5	1	6	1	258	74	6	1	8	1	258
EU area	2 111	433	29	21	1	284	1 086	246	81	22	7	399
Bosnia-Hercegovina	2	0	0	0	0	< 180	0	0	0	0	0	-
Croatia	2	0	0	0	0	< 180	0	0	0	0	0	-
Iceland	2	0	0	0	0	< 180	1	0	0	0	0	< 180
Liechtenstein	1	0	0	0	0	< 180	1	0	0	0	0	< 180
Macedonia, FYR of	13	4	1	31	8	263	0	0	0	0	0	-
Norway	8	0	0	0	0	< 180	10	5	2	50	20	362
Serbia	1	0	0	0	0	< 180	0	-	-	-	-	-
Switzerland	28	6	0	21	0	230	21	3	0	14	0	220
Turkey	3	0	0	0	0	< 180	3	0	0	0	0	< 180
Whole area	2 171	443	30	20	1	284	1 122	254	83	22.64	7	399

Note: White columns refer to exceedances of the information threshold, grey to exceedances of the alert threshold.

'-' indicates 'not applicable'.

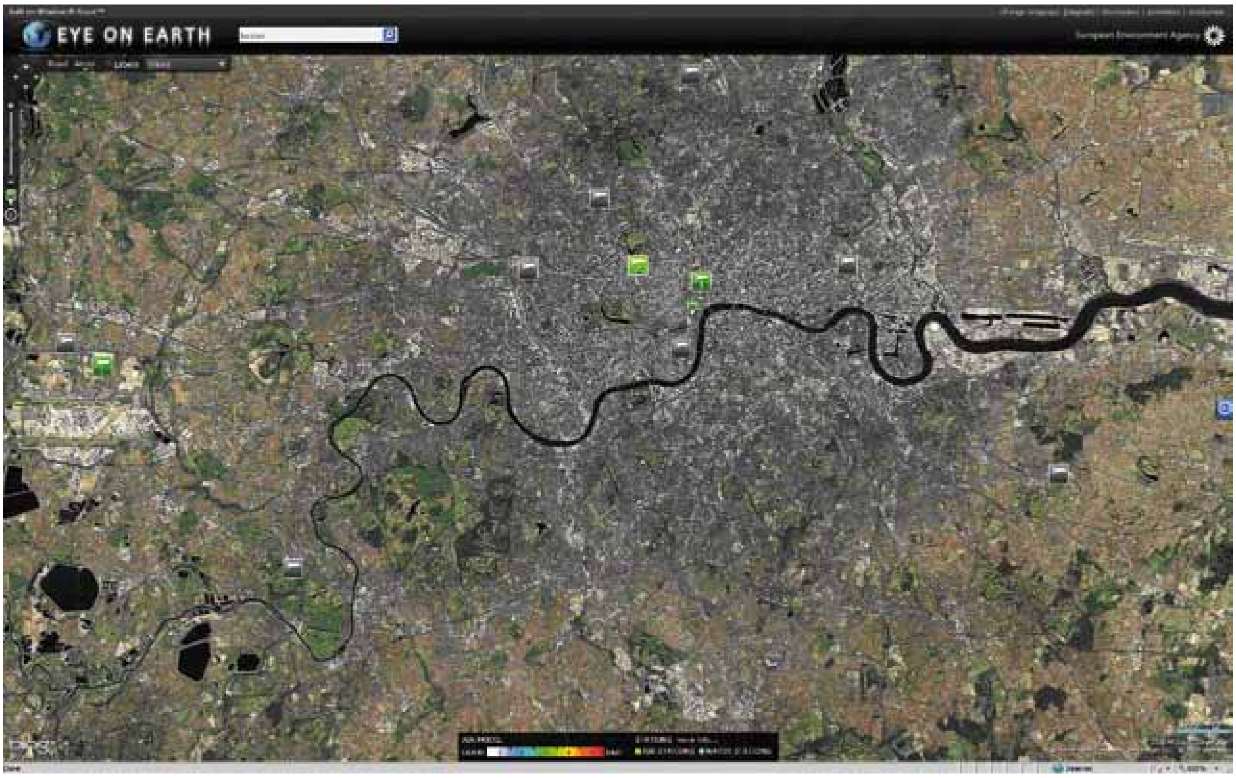
Red font refers to NRT > SOR, blue font to NRT < SOR, black one to NRT = SOR.

(a) Total number of stations measuring ozone levels.

(b) The number and percentage of stations at which at least one threshold exceedance was observed; fifth column: percentage of stations with information threshold exceedance at which alert threshold exceedance were also observed.

Map A.3 Screenshot of Eye on Earth/AirWatch showing the results of the air quality model

Map A.4 Screenshot of Eye on Earth/AirWatch showing local level air quality information



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European Environment Agency
Kongens Nytorv 6
1050 Copenhagen K
Denmark

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

Web: eea.europa.eu
Enquiries: eea.europa.eu/enquiries

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