Air pollution by ozone across Europe during summer 2010

Overview of exceedances of EC ozone threshold values for April–September 2010

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Executive summary

Despite efforts to mitigate ozone pollution, the number of exceedances of EU ground-level ozone concentration standards for protecting human health (Directive 2008/50/EC) remained at sustained levels during summer 2010 ([1]).

In 2010, the threshold of 120 µg/m³ maximum daily eight-hour mean was exceeded on more than 25 days in a significant part of Europe. This is the threshold that will be used to assess whether countries meet the target value for protecting human health ([2]). Exceedances of this threshold occurred in 17 EU Member States (Austria, Bulgaria, Cyprus, the Czech Republic, France, Germany, Greece, Hungary, Italy, Luxembourg, Malta, Poland, Portugal, Romania, the Slovak Republic, Slovenia and Spain) and four other countries (Croatia, the former Yugoslav Republic of Macedonia, Switzerland and Turkey). As in previous years, the most widespread concentrations occurred in the Mediterranean area. However, western and central Europe were affected more than in 2009.

In view of the similarity of European surface ozone levels in the last four years, it seems likely that many EU Member States will face a big challenge in meeting the target value.

As in previous years, the long-term objective to protect human health (maximum daily eight-hour mean concentration of 120 µg/m³) was exceeded in all EU Member States.

In contrast with the last three summers, in 2010 the information threshold (a one-hour average ozone concentration of 180 µg/m³) was exceeded in northern Europe, and the average number of threshold exceedances increased slightly in north-western, central and eastern Europe.

The alert threshold (a one-hour average ozone concentration of 240 µg/m³) was exceeded 44 times.

Summer 2010 was characterised by a long period with numerous exceedances during the warm meteorological conditions between 24 June and 22 July. This episode accounted for approximately 85 % of the total number of exceedances of the information threshold, 64 % of the exceedances of the alert threshold and 52 % of the exceedances of the long-term objective.

Europe-wide, the summer ozone situation in 2010 was similar to 2007, 2008 and 2009. During the past decade, the summers of 2003 and 2006 saw very large numbers of exceedances of the information and alert thresholds, the target value threshold and the long-term objective. This was principally due to very hot summer periods during those two years.

Independent of the episodic nature of ozone pollution and the strong influence of meteorological conditions, emissions of ozone precursor gases are sustaining a baseline number of exceedances of the information and alert thresholds, the target value threshold and the long-term objective. Decreased anthropogenic emissions of some ozone precursors (nitrogen oxides, carbon monoxide and some volatile organic compounds) in the past two decades did not manifest in significant reductions in the number of such exceedances. The ozone pollution problem therefore requires further mitigation efforts.

(1) Ozone levels in summer 2010 were compared with the summer ozone concentrations from 1997 to 2009. Summer ozone concentrations from 1997 to 2009 are validated and stored in the EEA air quality database AirBase. Summer ozone concentrations for 2010 are provisional. Differences between provisional and validated summer ozone data for the same year tend to be minimal.

(2) Directive 2008/50/EC on ambient air quality and cleaner air for Europe sets out the 'target value for the protection of human health'. Specifically, the maximum daily 8-hour mean concentration of ozone should not as of 2010 exceed 120 µg/m³ on more than 25 days per calendar year averaged over three years. It further specifies that the target value will first be calculated using validated data from 2010 and following years. As such, it will not be possible to assess exceedance of the target value fully until data for 2010, 2011 and 2012 have been compiled and validated.
References in this report to the 'target value threshold' pertain only to provisional ozone concentrations in 2010 (i.e. not more than 25 days with an eight-hour average exceeding 120 µg/m³), rather than the three-year validated data average used in assessing exceedance of the target value.

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 oxidising agent and one of the air pollutants of most concern in Europe.

In Europe, ozone concentrations are also influenced by emissions in other northern hemisphere countries and by poorly regulated sectors such as international shipping and aviation. Thus, ozone pollution is not only a local air quality issue but also a hemispheric and global problem.

Ozone levels become particularly high in regions where considerable ozone precursor emissions combine with stagnant meteorological conditions during the summer, when high insolation and temperatures occur. In 2010, levels continued to exceed the long-term objectives established in EU legislation to protect human health.

This report provides an evaluation of ground-level ozone pollution in Europe for April–September 2010, based on information submitted to the European Commission under Directive 2002/3/EC on ozone in ambient air (EC, 2002). Since Member States have not yet finally validated the submitted data, the conclusions drawn in this report should be considered as preliminary.

Directive 2002/3/EC 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 (a maximum daily 8-hour average concentration of 120 $\mu g/m^3$).

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/ACM on the EEA website: http://www.eea.europa.eu/maps/ozone/compare/summer-reporting-under-directive-2002-3-ec. In addition, EEA's near real-time ozone website (http://www.eea.europa.eu/maps/ozone) shows ground-level ozone levels across Europe and provides up-to-date information (see Annex 3).

Overview of ozone air pollution in summer 2010

All 27 EU Member States provided information to the European Commission on observed one-hour and long-term objective exceedances. In addition, 11 other countries (Albania, Bosnia and Herzegovina, Croatia, Iceland, Liechtenstein, Montenegro, Norway, Serbia including Kosovo under UNSC Resolution 1244/99, Switzerland, the former Yugoslav Republic of Macedonia and Turkey) supplied information to the EEA upon request.

Main findings

In total, 2 193 ozone monitoring sites reported data, of which 2 128 were located in EU Member States. The following preliminary conclusions can be drawn from the period April–September 2010:

Exceedance of the information threshold

- The percentage of ozone monitoring stations reporting exceedances of the information threshold (a one-hour ozone concentration of 180 $\mu g/m^3$) is among 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 20 EU Member States and five non-member countries. The information threshold was exceeded at approximately 34 % of all operational stations, which is more than in the summers of 2007–2009 but lower than in the summers before 2007.

- The spatial extent of the information threshold exceedances observed in the summer of 2010 was larger than in the previous three summers due to an increase in the affected area of north-western Europe. A few exceedances occurred in northern Europe and the countries with the highest percentage of stations reporting exceedances of the information threshold were Belgium, Germany, Portugal, Turkey and Switzerland.

Exceedance of the alert threshold

- Ozone concentrations higher than the alert threshold (a one-hour ozone concentration of 240 µg/m^3) were reported on 44 occasions. They occurred in nine EU Member States (Belgium, Bulgaria, France, Germany, Greece, Italy, Portugal, the Slovak Republic and Spain) and in Switzerland. Exceedances of the alert threshold were observed at 32 locations, mainly in northern Italy, northern Portugal and also at other locations where the information threshold was most often exceeded. Most stations (72 %) reporting an exceedance of the alert threshold did so on just one day; only one station (Valmadrera, Italy) reported the maximum number of four days.

Maximum concentrations

- Only one concentration higher than 300 µg/m^3 was reported (Evmolpia-AMS, Bulgaria, 332 µg/m^3, 6 August).

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

- As in previous years, exceedances of the long-term objective for the protection of human health, i.e. maximum daily 8-hour average concentrations higher than 120 µg/m^3, were observed in every EU Member State and in most of the other countries. Approximately 85 % of all stations reported one or more exceedances and most stations reported LTO exceedances during every month of summer 2010.

- The number of exceedance days per country ranged from zero to 169 (in Spain). More than 150 exceedance days were reported by Italy and Spain. On every single day during summer 2010 at least one of the 2 193 operational stations in Europe reported exceeding the LTO. On average, those stations observing at least one LTO exceedance reported a total of 22 days of exceedance. The maximum number of 127 exceedance days observed at a single station occurred in Lorca, Spain.

Exceedance of the target value (TV) for the protection of human health

- The TV is exceeded when the LTO (120 µg/m^3) has been exceeded at a particular station more than 25 times per calendar year, averaged over three years. 2010 was the first year in a rolling sequence of three years which will be used in determining whether countries are meeting the target value requirement. The report lists the cases where LTO was exceeded more than 25 times during summer 2010 alone.

- During summer 2010, more than 25 LTO exceedances occurred at stations in 17 EU Member States (Austria, Bulgaria, Cyprus, the Czech Republic, France, Germany, Greece, Hungary, Italy, Luxembourg, Malta, Poland, Portugal, Romania, the Slovak Republic, Slovenia and Spain) and in four other countries (Croatia, the former Yugoslav Republic of Macedonia, Switzerland and Turkey).

- More than 25 LTO exceedances occurred at 27 % of all monitoring stations providing reports. This corresponded to approximately 22 % of the area assessed, affecting approximately 16 % of the total population ([3]).

Main ozone episodes ([4])

- Summer 2010 was characterised by a long period with numerous exceedances during the warm and sunny meteorological conditions between 24 June and 22 July. The episode accounted for approximately 85 % of the total number of exceedances of the information threshold, 64 % of the exceedances of the alert threshold and 52 % of the exceedances of the long-term objective.

Comparison with previous years

Ozone levels during the summers of 2007, 2008 and (according to several indicators) 2009 were the lowest in the past decade. The situation in 2010 was not fundamentally different but in contrast with the

([3]) See Section 2.2 for calculation details. The figures for percentages of area and population affected are not comparable with those in previous summer reports because a different methodology for preparing the spatial distribution maps was applied (see Section 2.3).

([4]) An 'ozone episode' is defined as follows: 'A period of usually a few days up to 2–3 weeks with high ozone concentrations, characterised by daily exceedances of the thresholds set to protect human health. Ozone episodes occur under specific meteorological conditions characterised by large stagnant areas of high pressure. Since the formation of ozone requires sunlight, ozone episodes mainly occur during summer' (EEA, 2010b).

last three summers there were some exceedances of the information threshold in northern Europe and the average number of threshold exceedances increased slightly in north-western, central and eastern Europe.

The analysis clearly shows that exceedances occur frequently in the Mediterranean area. The number of occurrences in southern Europe was lower between 1999 and 2002 than in the very hot and dry summer of 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', the summer of 2006 showed considerable differences in climatic conditions between northern Europe and other parts of the continent.

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. 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.

Disclaimer

The preliminary analysis contains summary information based on data delivered before 5 December 2010.

The information describing the situation during summer 2010 is based on non-validated monitoring data.

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 vegetation such as agricultural crops and materials. The main sectors that emit ozone precursors are road transport, power and heat generation plants, households (heating), industry, and petrol storage and distribution.

In view of the harmful effects of photochemical pollution of the lower levels of the atmosphere, the European Council adopted Directive 92/72/EEC (EC, 1992) on air pollution by ozone. That Directive was succeeded by Directive 2002/3/EC (EC, 2002) 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 Directive 96/62/EC on ambient air quality assessment and management (EC, 1996). 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 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 such assessments. It also promotes cooperation between Member States in reducing ozone levels.

On 14 June 2008, the new Directive 2008/50/EC (EC, 2008) on ambient air quality and cleaner air for Europe came into force. The provisions of earlier air quality directives (96/62/EC, 1999/30/EC, 2000/69/EC (EC, 2000) and 2002/3/EC) remained in force until 11 June 2010, when they were repealed by Directive 2008/50/EC ([5]). The new Directive does not change the levels of the existing target value, long-term objective, alert threshold or information threshold for ozone.

This report gives an overview of reported ground-level ozone concentrations between April and September 2010, and provides a comparison with the years since 1997 ([6]).

The legal requirements for reporting provisional data on exceedances of the long-term objective and the target 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 and Directive 2008/50/EC

Objective	Level (µg/m³)	Averaging time
Information threshold (IT)	180	One-hour
Alert threshold (AT)	240	One-hour
Long-term objective (LTO)	120	8-hour average, maximum daily
Target value (TV)	120 (*)	8-hour average, maximum daily

Note: (*) Not to be exceeded on more than 25 days per calendar year, averaged over three years; 2010 will be the first year the data for which are used in calculating compliance over the following three years.

([5]) It should be noted, however, that the 'transmission of information and reports' Article 10 of Directive 2002/3/EC has remained into force. This Article addresses the reporting requirements concerning ambient ozone. The Article will be repealed two years after entry into force of the upcoming implementing measures of Directive 2008/50/EC.

([6]) The EEA has prepared overviews since 1997. Previous reports are available from the EEA website: http://www.eea.europa.eu/publications.

2 Ozone air pollution in summer 2010

This chapter provides detailed country-by-country, month-by-month and day-by-day tabular, graphic and geographical information on threshold exceedances during summer 2010. 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 2010, as required by the EU legislation, were submitted by all 27 EU Member States and 11 other European countries. Ozone concentrations in excess of the information threshold were reported from monitoring sites in 20 EU Member States and five other countries (Table 2.1).

The percentage of stations that recorded exceedances of the information threshold is among the lowest since comprehensive Europe-wide data reporting commenced in 1997. Only a few exceedances occurred in northern Europe, while the countries with the highest percentage of stations reporting exceedances of the information threshold were Belgium, Germany, Portugal, Turkey and Switzerland.

Table 2.2, Figure 2.1 and Figure 2.6 present the distribution of hourly exceedances during summer 2010. The highest number of exceedances occurred during July and June, which respectively accounted for approximately 73 % and 18 % of all observed information threshold exceedances and about 80 % and 9 % of alert threshold exceedances ([7]). For the summer as a whole, the occurrence of information and alert threshold exceedances was among the lowest on record. The number of days on which the information threshold was exceeded was the lowest on record, and the second lowest in terms of exceedances of the alert threshold (Table 3.1).

Figure 2.2 presents the frequency distribution of hourly ozone concentrations that exceeded the information threshold. For each country 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 $\mu g/m^3$ (compared to 207 $\mu g/m^3$ in 2003, 185 $\mu g/m^3$ in 2004, 2008 and 2009, 186 $\mu g/m^3$ in 2005–2007). The 75th percentile values were all below 203 $\mu g/m^3$ which is among the lowest levels since 2003 (305 $\mu g/m^3$ in 2003, 203 $\mu g/m^3$ in 2004, 206 $\mu g/m^3$ in 2005–2008 and 202 $\mu g/m^3$ in 2009).

([7]) 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 2010 on a country-by-country basis ([8])

Country	Number 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)	
Austria	114	34	0	30	–	–	15	–	223	0.6	1.9	–	–	1.9	–
Belgium	40	33	3	83	8	9	10	3	244	1.7	2.1	0.1	1.0	2.8	1.0
Bulgaria	17	5	3	29	18	60	16	3	332	1.2	4.0	0.2	1.0	3.2	1.3
Cyprus	2	0	0	–	–	–	–	–	157	–	–	–	–	–	–
Czech Republic	60	19	0	32	–	–	13	–	202	0.6	1.8	–	–	1.8	–
Denmark	9	1	0	11	–	–	1	–	201	0.1	1.0	–	–	5.0	–
Estonia	9	0	0	–	–	–	–	–	153	–	–	–	–	–	–
Finland	18	0	0	–	–	–	–	–	175	–	–	–	–	–	–
France	408	159	3	39	1	2	40	2	277	1.1	2.8	0.0	1.0	2.3	1.3
Germany	258	189	5	73	2	3	26	2	273	2.3	3.1	0.0	1.0	3.4	2.4
Greece	23	10	1	43	4	10	23	1	245	2.1	4.9	0.0	1.0	1.9	1.0
Hungary	17	5	0	29	–	–	3	–	190	0.3	1.0	–	–	1.2	–
Ireland	12	0	0	–	–	–	–	–	154	–	–	–	–	–	–
Italy	342	154	7	45	2	5	54	5	271	3.1	6.8	0.0	1.9	3.4	1.8
Latvia	7	0	0	–	–	–	–	–	157	–	–	–	–	–	–
Lithuania	12	0	0	–	–	–	–	–	166	–	–	–	–	–	–
Luxembourg	6	3	0	50	–	–	4	–	202	0.7	1.3	–	–	2.3	–
Malta	4	0	0	–	–	–	–	–	177	–	–	–	–	–	–
Netherlands	35	18	0	51	–	–	6	–	217	0.8	1.6	–	–	3.5	–
Poland	70	15	0	21	–	–	8	–	224	0.3	1.3	–	–	2.2	–
Portugal	41	28	6	68	15	21	34	6	288	2.7	4.0	0.2	1.5	2.3	1.6
Romania	96	3	0	3	–	–	3	–	195	0.0	1.0	–	–	4.0	–
Slovak Republic	15	2	1	13	7	50	7	2	275	0.5	3.5	0.1	2.0	5.9	6.0
Slovenia	12	3	0	25	–	–	5	–	190	0.5	2.0	–	–	1.7	–
Spain	410	49	1	12	0	2	49	3	275	0.3	2.7	0.0	3.0	2.0	1.0
Sweden	12	2	0	17	–	–	1	–	218	0.2	1.0	–	–	3.0	–
United Kingdom	79	1	0	1	–	–	1	–	194	0.0	1.0	–	–	2.0	–
EU area	**2 128**	**733**	**30**	**34**	**1**	**4**	**104**	**23**	**332**	**1.2**	**3.6**	**0.0**	**1.4**	**3.0**	**1.8**
Albania	4	0	0	–	–	–	–	–	171	–	–	–	–	–	–
Bosnia and Herzegovina	2	0	0	–	–	–	–	–	120	–	–	–	–	–	–
Croatia	2	1	0	50	–	–	1	–	188	0.5	1.0	–	–	1.0	–
Iceland	2	0	0	–	–	–	–	–	125	–	–	–	–	–	–
Liechtenstein	1	0	0	–	–	–	–	–	167	–	–	–	–	–	–
Macedonia, former Yugoslav Republic of	12	1	0	8	–	–	14	–	198	1.2	14.0	–	–	2.9	–
Montenegro	3	1	0	33	–	–	1	–	213	0.3	1.0	–	–	1.0	–
Norway	7	0	0	–	–	–	–	–	145	–	–	–	–	–	–
Serbia including Kosovo under UNSC Resolution 1244/99	1	0	0	–	–	–	–	–	157	–	–	–	–	–	–
Switzerland	28	18	2	64	7	11	27	1	257	3.9	6.0	0.1	1.0	3.3	3.0
Turkey	3	2	0	67	–	–	5	–	206	2.7	4.0	–	–	1.8	–
Whole area	**2 193**	**756**	**32**	**34**	**1**	**4**	**111**	**23**	**332**	**1.3**	**3.7**	**0.0**	**1.4**	**3.0**	**1.9**

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

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

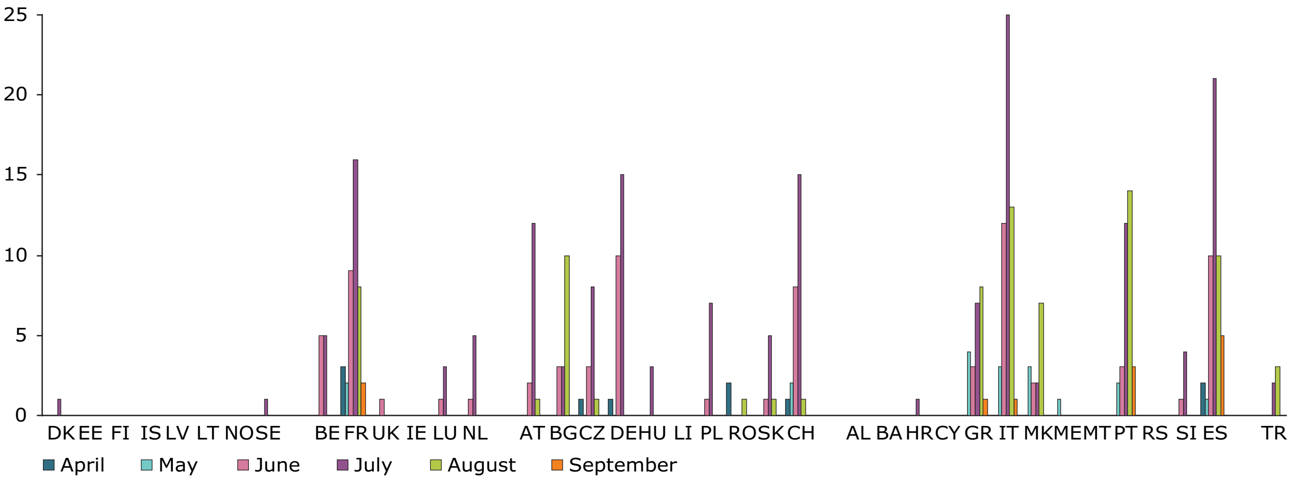
Table 2.2 Overview of exceedances of one-hour thresholds in Europe during the summer of 2010, on a month-by-month basis

Month	Stations with exceedance ([b]) (number)		(%)		(%)	Number of days with exceedance ([c])		Maximum observed one–hour concentration (µg/m³)	Occurrence of exceedances ([d])				Average duration of exceedances (hour)	
April	12	0	1	–	–	8	–	229	0	0	–	–	2.3	–
May	36	0	2	–	–	14	–	216	0	0.1	–	–	2.8	–
June	268	4	12	0	1	22	4	254	0.2	0.6	0	0.1	2.8	1
July	666	26	30	1	4	31	15	285	0.9	2.7	0	1.1	3.1	2
August	97	4	4	0	4	29	3	332	0.1	0.2	0	0.1	2	2
September	22	1	1	0	5	7	1	275	0	0	0	0	1.5	1

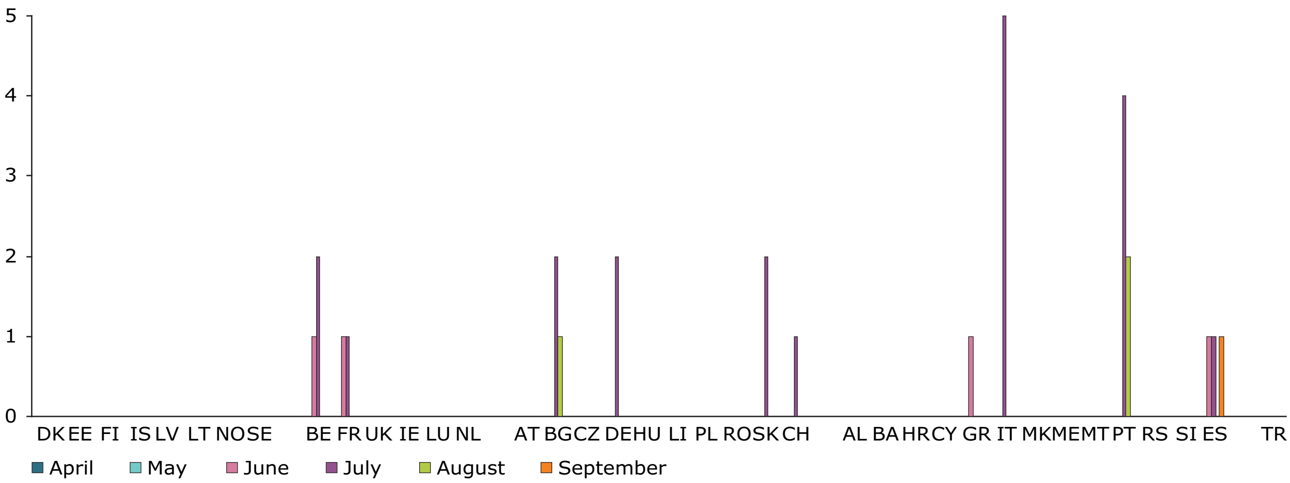
Note: ([b])–([d]) see notes to Table 2.1.

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 2010 (only countries that submitted data are shown)

a) Information threshold exceedances

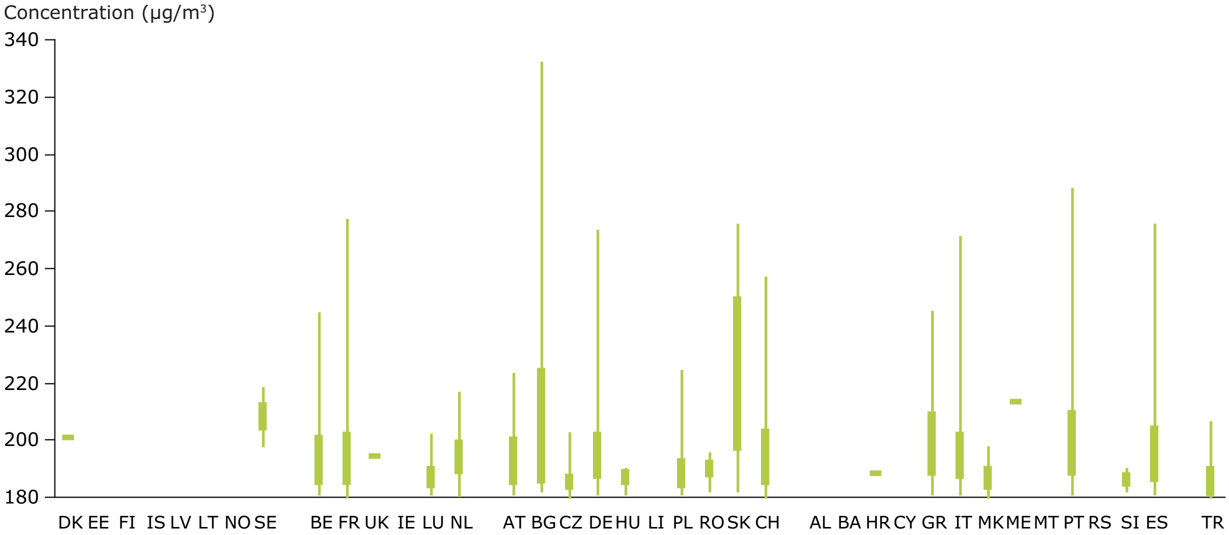


b) Alert threshold exceedances



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

Figure 2.2 Frequency distribution of concentrations in excess of the one-hour information threshold during the summer of 2010 (only countries that delivered data are shown)



Note: The box plots indicate the minimum value, 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 2010 at least one maximum daily 8-hour average concentration of ozone over 120 µg/m³ (the long term objective, LTO) was observed in every EU Member State and in most of the other countries, in every summer month and at nearly all stations (see Table 2.3). The target value 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 85 % of all stations reported at least one exceedance of the LTO. There was not a single day without a LTO exceedance in Europe in summer 2010.

The highest number of exceedances occurred during July (41 % of all observed exceedances), the lowest in September (3.6 %). The figure for July is exceptionally high compared with previous years (the values are usually between 22 and 29 %, except for 46 % in 2006). Contrastingly, the figures of 9 % for May, 10 % for August and 3.6 % for September are among the lowest on record (Table 2.4, Figure 2.3). The high number of exceedances for July was largely the result of the warm and sunny meteorological conditions (Figure 2.5).

The frequency distribution of maximum daily 8-hour mean ozone concentrations exceeding the long-term objective level is shown in Figure 2.4. In Europe as a whole, 25 % of maximum daily 8-hour mean concentrations of all the observed exceedances were below 126 µg/m³ (125 µg/m³ in 2008, 2007, 2005 and 2004, 127 µg/m³ in 2006, 124 µg/m³ in 2009). Seventy-five per cent were below 143 µg/m³ (143 µg/m³ in 2004, 144 µg/m³ in 2005, 148 µg/m³ in 2006, 140 µg/m³ in 2007, 138 µg/m³ in 2008, 139 µg/m³ in 2009).

In total, the occurrence of LTO exceedances was roughly as low as in summer 2009 and is among the lowest since reporting of Europe-wide data commenced in 1997 (Table 3.1).

2010 was the first year in a rolling sequence of three years which will be used in determining whether countries are meeting the target value of 120 µg/m³ (maximum over eight hours) not to be surpassed on more than 25 days per calendar year. This threshold was exceeded for more than 25 days in a significant part of Europe in 2010 comprising the following countries: 17 EU Member States (Austria, Bulgaria, Cyprus, the Czech Republic, France, Germany, Greece, Hungary, Italy, Luxembourg, Malta, Poland, Portugal, Romania, the Slovak Republic, Slovenia and Spain) and four other countries (Croatia, the former Yugoslav Republic of Macedonia, Switzerland and Turkey). The highest widespread concentrations occurred, as with previous years, in the Mediterranean area but also affected western and central Europe more than in 2009.

Table 2.3 Overview of exceedances of the long-term objective and target value for the protection of human health during the summer of 2010 on a country-by-country basis

Country	Number of stations (a)	Stations with LTO exceedance (b)		Stations with TV exceedance		Number of days with LTO exceedance (c)	Maximum observed 8-hour mean concentration (μg/m³)	Occurrence of LTO exceedances (d)	
		(number)	(%)	(number)	(%)				
Austria	114	113	99	39	34	92	193	23.8	24.1
Belgium	40	40	100	–	–	26	206	14.6	14.6
Bulgaria	17	16	94	4	24	98	223	17.1	18.1
Cyprus	2	1	50	1	50	31	148	15.5	31.0
Czech Republic	60	60	100	9	15	78	180	19.2	19.2
Denmark	9	6	67	–	–	10	188	2.0	3.0
Estonia	9	5	56	–	–	26	144	3.4	6.2
Finland	18	11	61	–	–	16	152	2.4	3.9
France	408	405	99	115	28	135	210	21.8	22.0
Germany	258	253	98	61	24	73	239	20.6	21.0
Greece	23	17	74	10	43	149	182	30.0	40.5
Hungary	17	17	100	4	24	72	180	18.9	18.9
Ireland	12	3	25	–	–	6	121	0.5	2.0
Italy	342	307	90	192	56	161	233	31.3	34.9
Latvia	7	3	43	–	–	4	138	0.9	2.0
Lithuania	12	10	83	–	–	15	145	3.1	3.7
Luxembourg	6	5	83	2	33	31	184	18.3	22.0
Malta	4	2	50	1	25	36	142	9.5	19.0
Netherlands	35	30	86	–	–	23	203	6.2	7.2
Poland	70	63	90	5	7	65	189	11.2	12.5
Portugal	41	34	83	8	20	98	239	16.5	19.9
Romania	96	26	27	5	5	131	189	4.0	14.6
Slovak Republic	15	15	100	2	13	62	262	17.5	17.5
Slovenia	12	11	92	5	42	88	182	29.0	31.6
Spain	410	346	84	102	25	169	197	16.7	19.8
Sweden	12	9	75	–	–	16	189	2.8	3.8
United Kingdom	79	20	25	–	–	18	160	0.6	2.2
EU area	**2 128**	**1 828**	**86**	**565**	**27**	**182**	**262**	**19.1**	**22.2**
Albania	4	0	–	–	–	–	–	–	–
Bosnia and Herzegovina	2	0	–	–	–	–	–	–	–
Croatia	2	2	100	2	100	62	162	44.0	44.0
Iceland	2	0	–	–	–	–	–	–	–
Liechtenstein	1	1	100	–	–	17	158	17.0	17.0
Macedonia, former Yugoslav Republic of	12	9	75	2	17	132	203	19.1	25.4
Montenegro	3	3	100	–	–	6	133	2.0	2.0
Norway	7	1	14	–	–	2	131	0.3	2.0
Serbia including Kosovo under UNSC Resolution 1244/99	1	1	100	–	–	2	131	2.0	2.0
Switzerland	28	28	100	18	64	80	225	32.2	32.2
Turkey	3	2	67	1	33	28	162	12.7	19.0
Whole area	**2 193**	**1 875**	**85**	**588**	**27**	**183**	**262**	**19.1**	**22.3**

Notes: '–' indicates 'not applicable'.

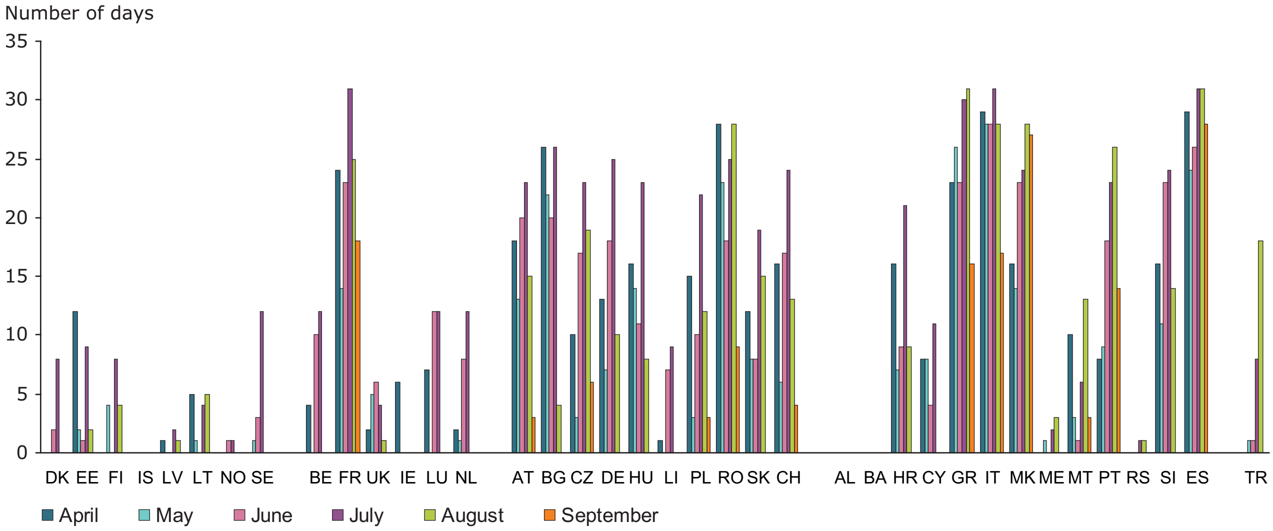
(a) Total number of stations measuring ozone levels.
(b) The number and percentage of stations at which at least one exceedance was observed.
(c) The number of calendar days on which at least one exceedance was observed. Left column: averaged over all operational stations.
(d) Right column: averaged 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 2010, on a month-by-month basis

Month	Stations with LTO exceedance ([b])		No. of days with LTO exceedance ([c])	Maximum observed 8-hour mean concentration (μg/m³)	Occurrence of LTO exceedances ([d])	
	(number)	(%)				
April	1 307	60	30	220	2.4	2.8
May	1 045	48	31	211	1.7	2
June	1 606	73	30	214	4.5	5.3
July	1 688	77	31	262	7.8	9.1
August	867	40	31	214	2	2.3
September	525	24	30	173	0.7	0.8

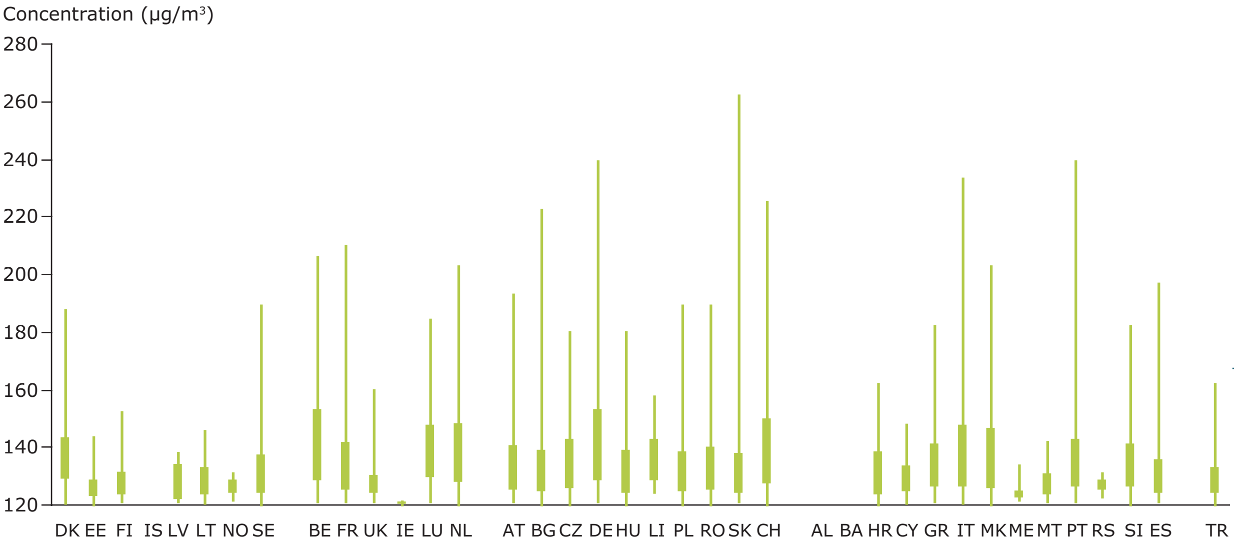
Note: ([b])–([d]) see notes to Table 2.3.

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 2010 (only countries that delivered data are shown)



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 weather patterns over the European continent.

Figure 2.4 Frequency distribution of concentrations in excess of the long-term objective for the protection of human health during the summer of 2010 (only countries that delivered data are shown)



Note: The box plots indicate the minimum value, 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 generally similar from year to year. In 2010, the highest ozone levels were found in northern Italy, southern France, central Portugal and also in several more isolated locations in Europe, where the highest number of information threshold exceedances were found.

The lowest number of exceedances occurred in the Baltic States, Scandinavia, the United Kingdom, Ireland and Iceland. A limited number of exceedances of the information threshold were reported from this area in summer 2010. Further, the fewest exceedances of the LTO across Europe were reported for this area.

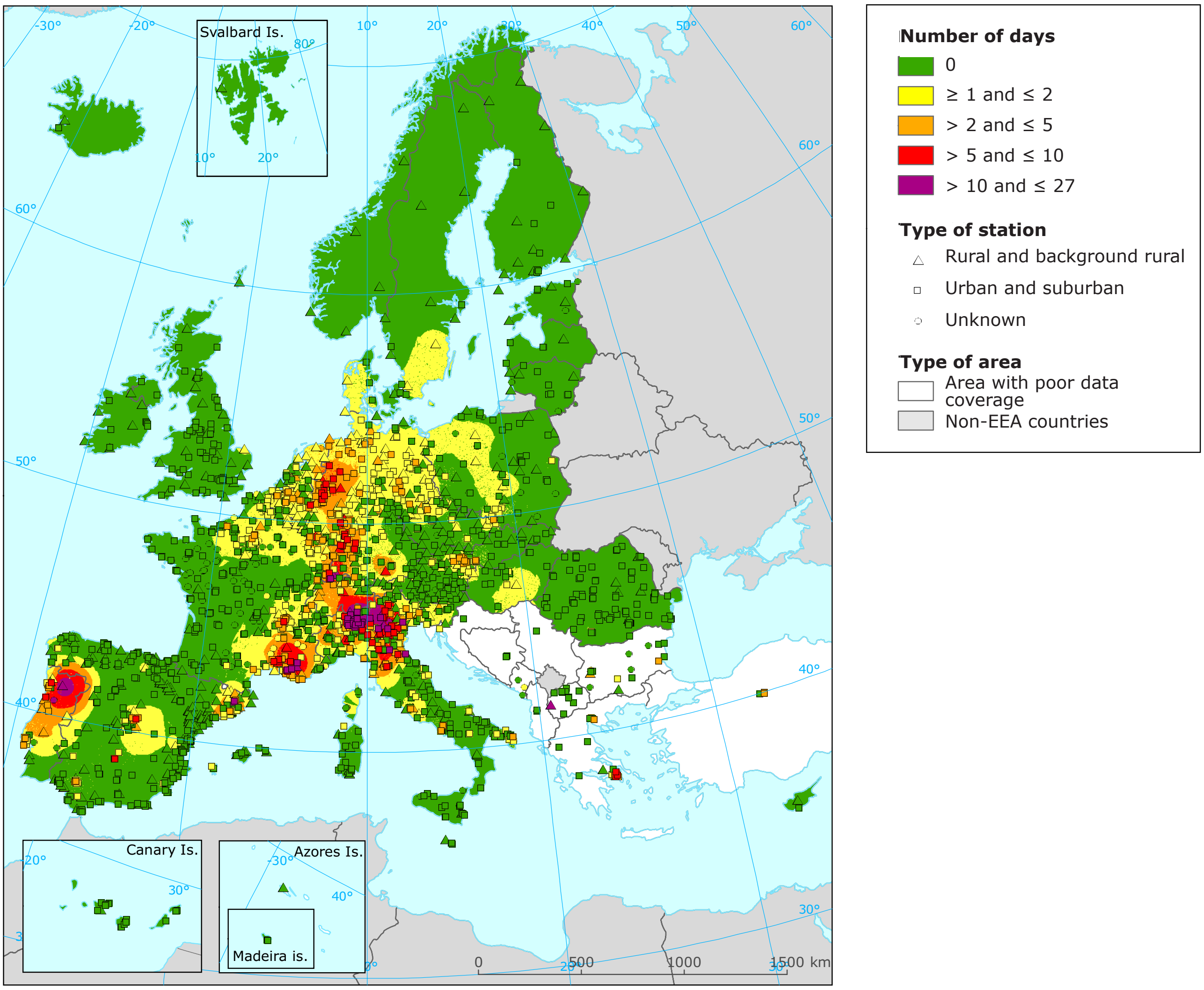
Map 2.1 depicts the number of days on which the one-hour information threshold was exceeded across Europe. The spatial extent of the exceedances observed in the summer of 2010 was larger than in the previous three summers. North-western Europe was more affected than in past years.

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) were in 2010 slightly larger than in the previous two summers but smaller than in 2007 and more than twice smaller than in 2006. More than 25 LTO exceedances were recorded in approximately 22 % of the assessed area and affected approximately 16 % of the total population in the assessed territory. Most of the countries that registered exceedances recorded significant changes in the share of area and population affected in comparison with summer 2009 (Table 2.5) [9].

[9] Due to an improved methodology (see Footnote 8) the shares of affected area and population are not exactly comparable with those published in the reports for the previous summers. For more details, see http://air-climate.eionet.europa.eu/reports.

Maps 2.1 and 2.2 present also 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 spatial structure ([10]) of the air quality field. The colour coding is equal for station symbols and the background field.

Map 2.1 Number of days on which ozone concentrations exceeded the information threshold during the summer of 2010



([10]) 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., 2006). 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 resolution of the interpolation grid has been 1 kilometre since 2010. The density of ozone monitoring sites is too low to provide reliable estimates of spatial distribution by interpolation for south-eastern Europe and, therefore, no spatial distribution is shown in these areas. Spatial distribution has been provided for Romania since 2009 because of the increased number of monitoring stations. The station type was unknown for 7.7 % of stations in summer 2010. This fact could affect the precision of mapping in some areas.

Map 2.2 Number of days on which ozone concentrations exceeded the long-term objective for the protection of human health during the summer of 2010

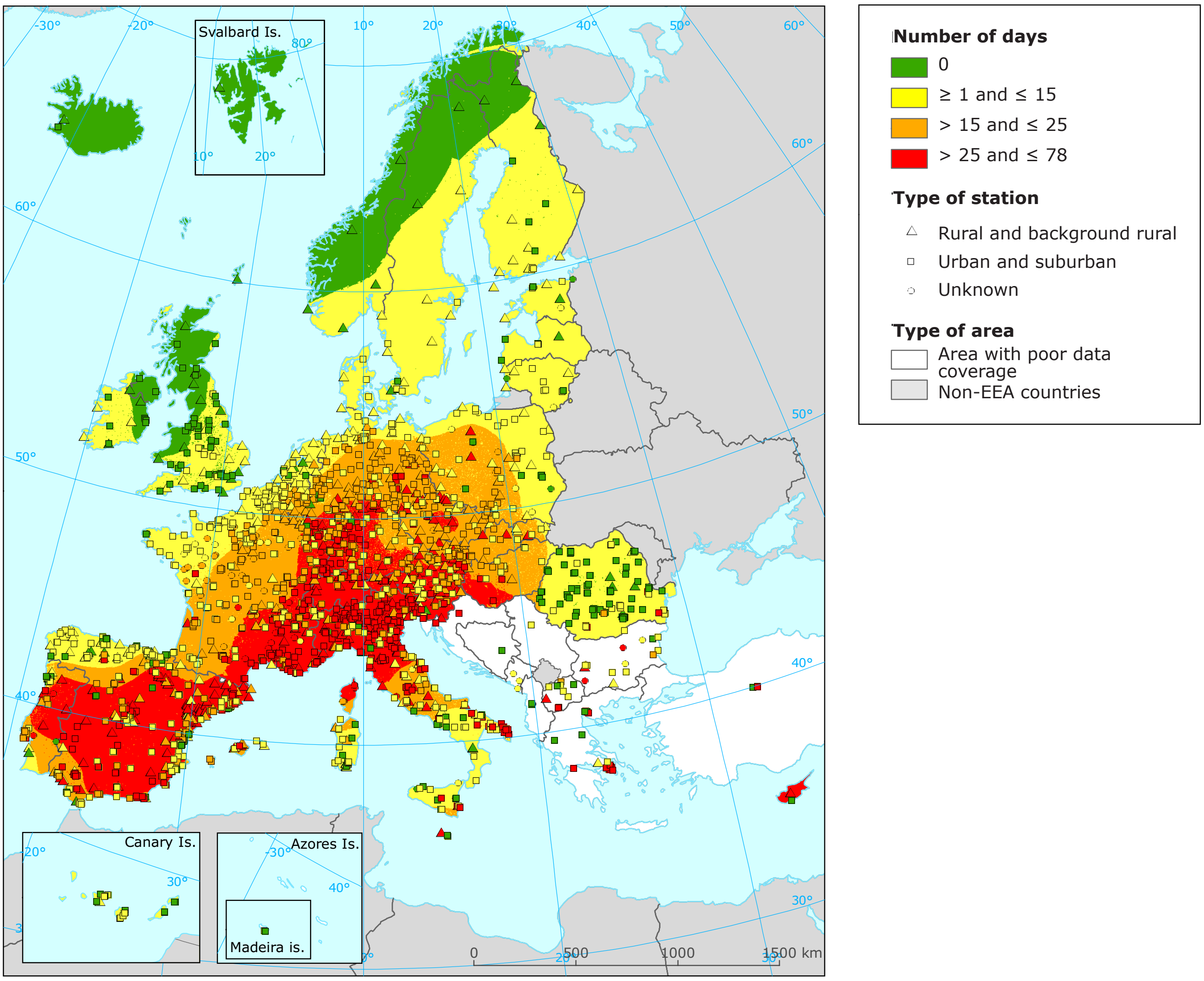


Table 2.5 Overview of estimated percentage of total area and population ([11]) resident in areas with ozone levels higher than the target value for the protection of human health during the summers of 2006–2010 on a country-by-country basis (only countries with spatial interpolation in Map 2.2 are shown) ([12])

Country	Area with exceedances of the target value (% of total area)					Population affected by exceedances of the target value (% of the total)				
	2006	2007	2008	2009	2010	2006	2007	2008	2009	2010
Austria	94.4	96.7	15	56.8	70.6	72	65.8	3.3	13.2	18.1
Belgium	69.7	0	0	0	0	41.9	0	0	0	0
Switzerland	100	92.5	10.2	81.6	99.1	100	45	3.8	19.3	90
Czech Republic	99.8	95.9	45.6	18.7	19.9	98.4	51	11.4	10.1	4.5
Germany	84.3	50.2	24.2	16.3	30.9	76.6	11.7	4.9	2.6	9.9
Denmark	0	0	0	0	0	0	0	0	0	0
Estonia	0	0	0	0	0	0	0	0	0	0
Spain	81.4	40.2	41.9	23.2	70.1	32	16.1	17.3	10.2	28.1
Finland	0	0	0	0	0	0	0	0	0	0
France	42.8	24.8	10.9	18.5	32.4	31.5	14.2	5.2	12.5	21.6
United Kingdom	0	0	0	0	0	0	0	0	0	0
Hungary	95.9	99.5	77.7	99.4	25.9	46.5	93.9	23.2	94.4	17
Ireland	0	0	0	0	0	0	0	0	0	0
Iceland	0	0	0	0	0	0	0	0	0	0
Italy	75.8	76	41.9	49	47.8	45.8	61.3	46.7	48.5	51.2
Lithuania	0	0	0	0	0	0	0	0	0	0
Luxembourg	–	0	0	0	19.9	–	0	0	0	4.3
Latvia	0	0	0	0	0	0	0	0	0	0
Malta	49.3	49	0	0	0	2	1.9	0	0	0
Netherlands	15.4	0	0	0	0	11.5	0	0	0	0
Norway	0	0	0	0	0	0	0	0	0	0
Poland	77.6	27.2	3.5	2.8	0	41.5	21.8	1.1	2.8	0
Portugal	72.4	33	0.1	31.6	50.6	21.1	10.3	0.4	8	15.1
Romania	–	–	–	25.7	0	–	–	–	12.3	0
Sweden	0	0	0	0	0	0	0	0	0	0
Slovenia	100	98.2	76.4	94.7	95.8	99.8	77.3	26.4	40.1	50.7
Slovakia	96.2	99.8	72.9	99.8	0	59.4	98.2	30.3	98.8	0
Total	**43.5**	**28.4**	**15.6**	**17.2**	**21.8**	**39.8**	**22.1**	**10.5**	**13.83**	**15.7**

([11]) The Joint Research Centre (JRC) population dataset CLC2000 was used to estimate the affected population (http://www.eea.europa.eu/data-and-maps/data/population-density-disaggregated-with-corine-land-cover-2000-2). The ORNL (Oak Ridge National Laboratory) Global Population Dataset, version 2002 (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.

([12]) The data on affected areas and populations are indicative because of the varying density of monitoring networks in different countries, the number and ratio of urban and rural stations, and the methodology used for interpolation (see Footnotes 7 and 8).

2.4 Main ozone episode

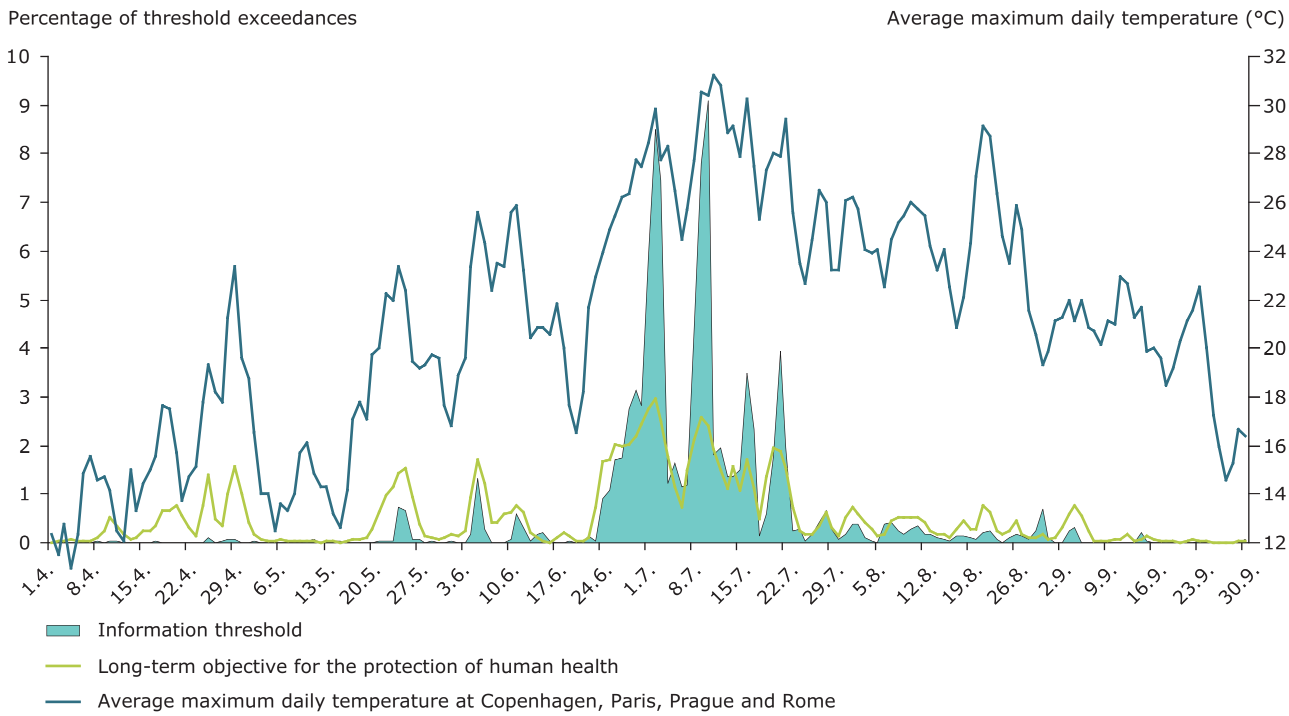
Ozone formation in the atmosphere is a complicated, non-linear photochemical process. In the troposphere (the lower part of the atmosphere), ozone formation results from a chain of mechanisms involving photochemical reactions of nitrogen oxides, chained with oxidative decomposition of volatile organic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

Episodes of elevated ozone levels occur during periods of warm, sunny weather. The ozone concentration depends not only on precursor emissions but also 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.

Summer 2010 was characterised by a long period with frequent exceedances during the warm meteorological conditions between 24 June and 22 July. The episode accounted for approximately 85 % of the total number of exceedances of the information threshold, 64 % of the exceedances of the alert threshold and about 52 % of the exceedances of the long-term objective. The other episodes were short and regional. The maximum daily occurrence of exceedances was approximately 9 % of the total for the information threshold, 18 % for the alert threshold and about 3 % for 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 ([13]). The distribution of exceedances per day and per country during summer 2010 is shown in Figure 2.6. Map 2.3 clearly shows the coincidence of areas with elevated ozone concentrations and those with the highest temperatures.

Figure 2.5 Distribution of exceedances during the summer of 2010 on a day-by-day basis

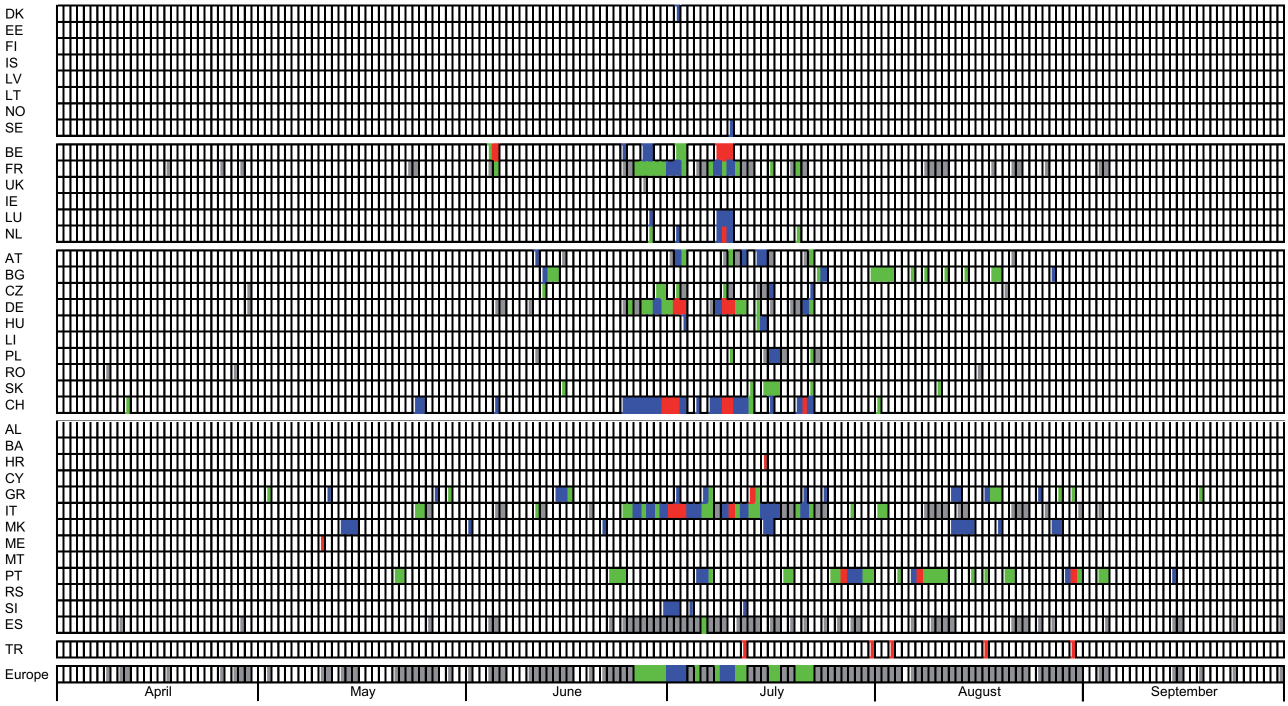


Note: The left y-axis represents the percentage of exceedances observed during a particular day. As such, the exceedances of the information threshold and the LTO depicted each total 100 % between 1 April and 30 September. Source of maximum temperature data: http://www.wunderground.com.

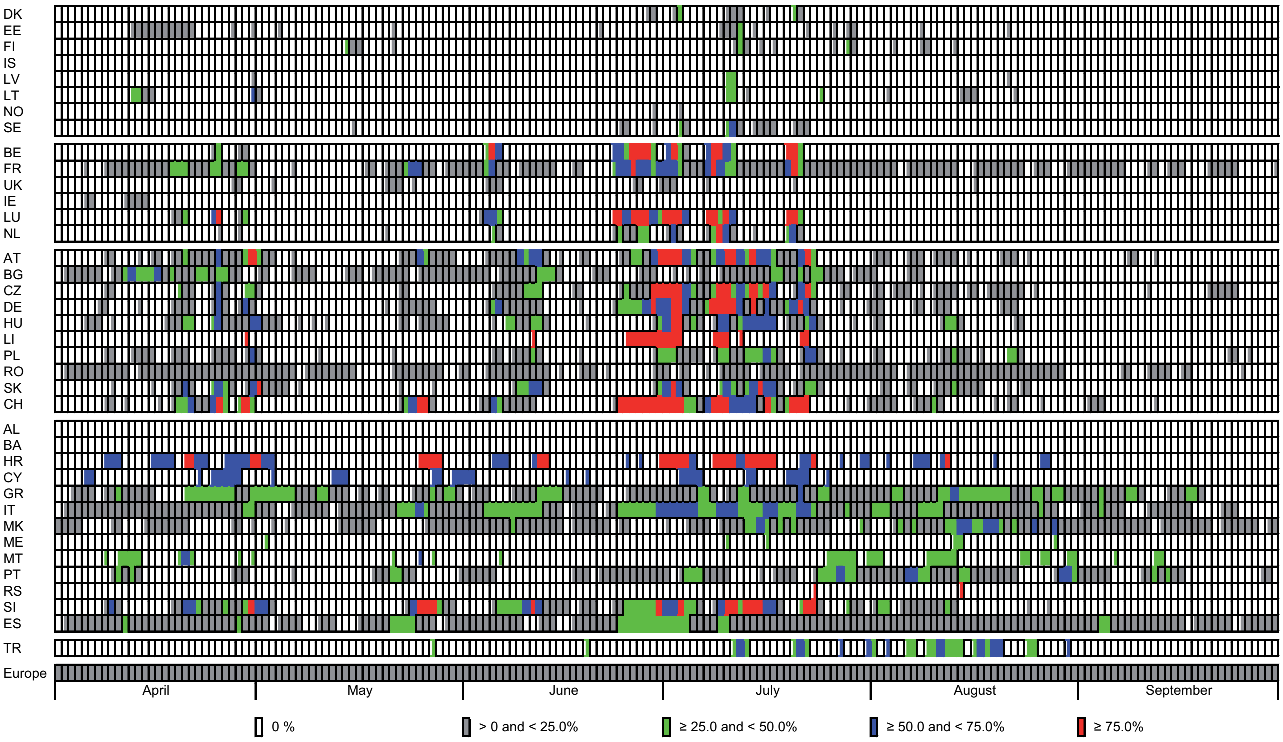
([13]) Europe was divided into four regions to analyse inter-annual variations in the trend of ozone levels due to climatic differences and four capital cities in the regions were selected to demonstrate the relation between the number of exceedances and meteorological situation (see Chapter 3).

Figure 2.6 Distribution of exceedances during the summer of 2010: percentage of stations reporting exceedances on a daily basis per country

a) Information threshold exceedances

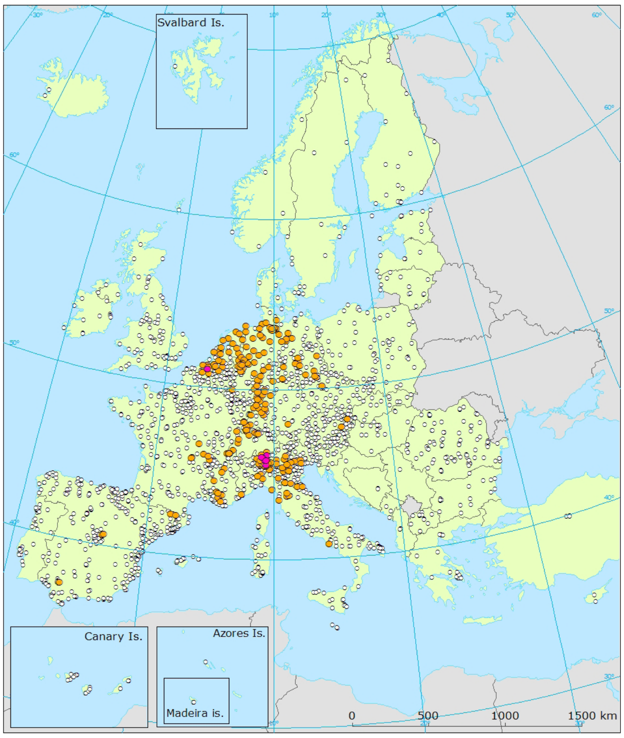


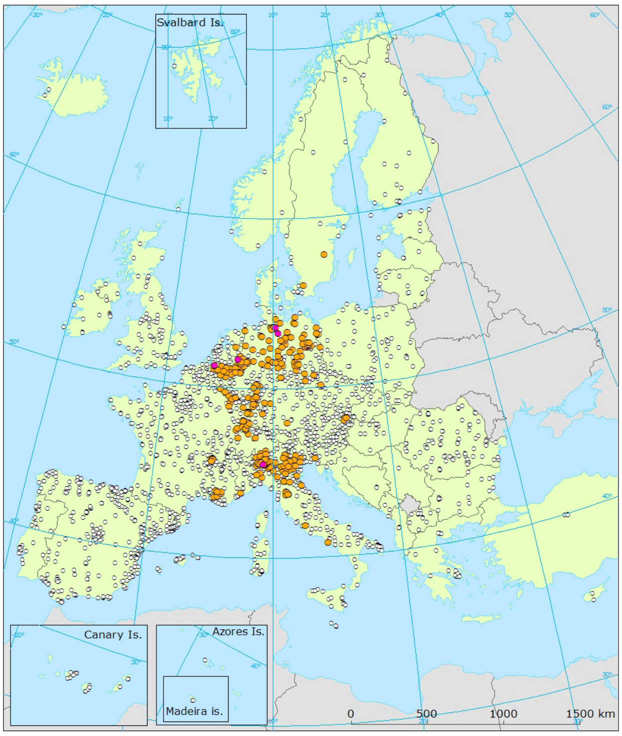
b) Long-term objective for the protection of human health exceedances



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 the summer 2010 ozone episodes: observed maximum 1-hour ozone concentrations and meteorological situation





9 July 2010

Maximal hourly value (μg.m-3)

- ≤ 180
- > 180 and ≤ 240
- > 240 and ≤ 271

Type of country

- Countries reporting data
- Non-EEA countries

10 July 2010

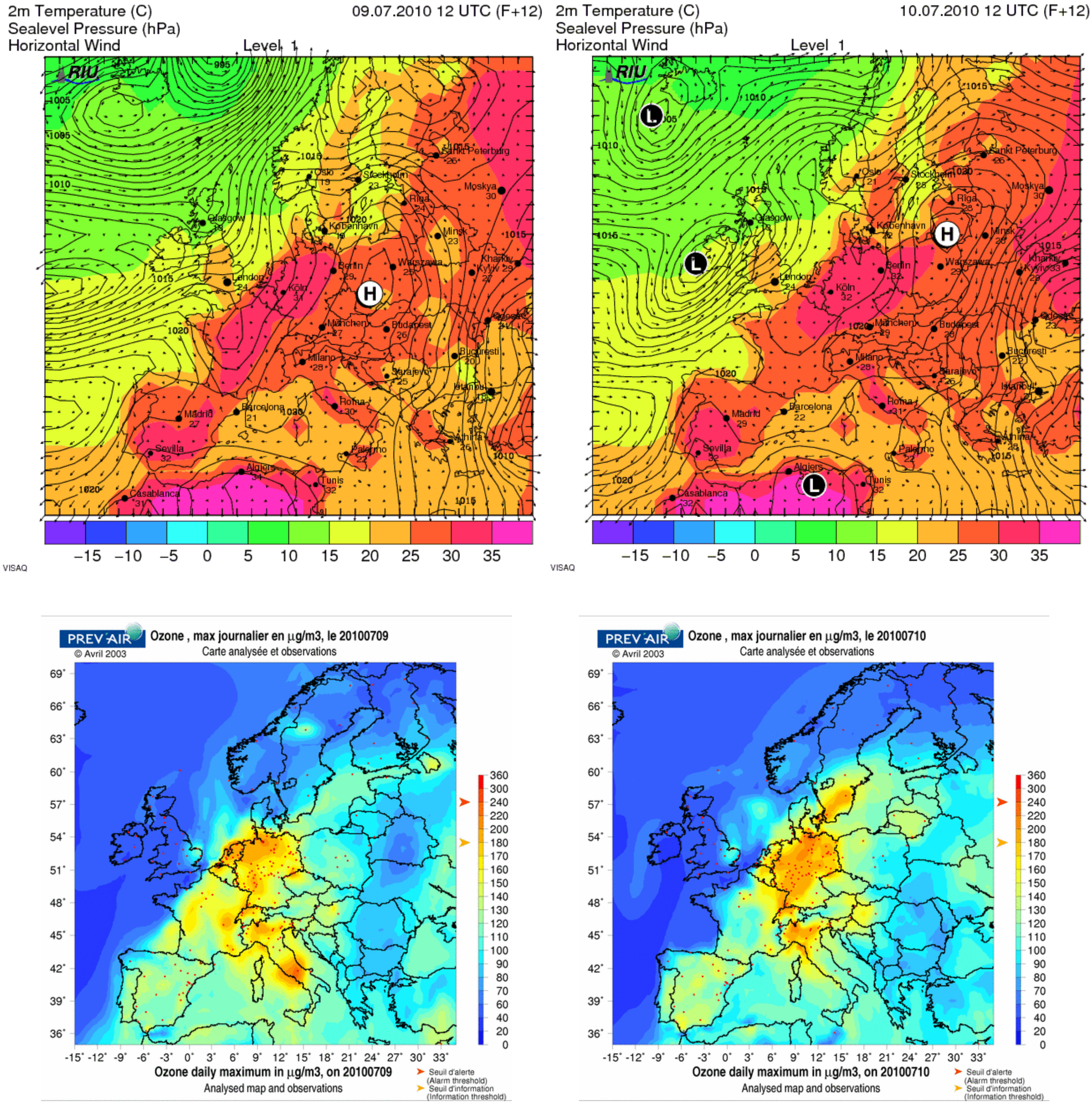
Maximal hourly value (μg.m-3)

- ≤ 180
- > 180 and ≤ 240
- > 240 and ≤ 271

Type of country

- Countries reporting data
- Non-EEA countries

Map 2.3 Selected days during the summer 2010 ozone episodes: observed maximum 1-hour ozone concentrations and meteorological situation (cont.)



Source: European Environment Agency; Rhenish Institute for Environmental Research (ground level pressure, temperature and horizontal wind); PREV'AIR (modelled ground-level ozone maximum 1-hour ozone concentrations).

3 Comparison with previous years

Ozone levels in summer 2010 were compared with the summer ozone concentrations from 1997 to 2009. Only summer time series that included more than 90 % of measured data during the summers were selected for comparison. Summer ozone concentrations from 1997 to 2009 are validated and stored in the EEA air quality database AirBase. Summer ozone concentrations for 2010 are provisional.

Before 1997, the number of ozone stations reporting to AirBase is too low to provide a representative picture for each of the four regions. 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.

Based on experience from previous years, stations were divided into four groups (regions) according to the impact of climatic conditions on ozone concentrations (see key for Figure 3.1). To illustrate climatic differences among the groups of countries and also inter-annual variations, the graphs included the average summer temperatures of selected cities representing a specific region.

The analysis clearly shows that exceedances occur frequently in the Mediterranean area (Figure 3.1). The number of occurrences in southern Europe was lower between 1999 and 2002 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.

Ozone levels during the summer of 2007, 2008 and 2009 were the lowest in the past decade. The situation in 2010 was not fundamentally different but in contrast with the last three years there were some exceedances of the information threshold in northern Europe. The average number of exceedances of both thresholds increased slightly in north-western, central and eastern Europe (see Table 3.1 for detailed annual information). Ozone is formed in the lower part of the atmosphere following emissions of precursor gases such as nitrogen oxides (NO_X) and volatile organic compounds (VOC). NO_X are emitted during fuel combustion, for example by industrial facilities and road transport. VOCs are emitted from a large number of sources including paint, road transport, dry-cleaning and other solvent uses. Biogenic VOCs are emitted by vegetation, with amounts dependent on the chemical species and on temperature. Methane (CH_4), itself a VOC and an important ozone precursor, is released from coal, oil and natural gas extraction and distribution, landfills, sewage treatment, ruminants, rice cultivation, and biomass burning. Fire plumes from wild forest and other biomass fires can also contribute to ozone formation.

Ozone pollution as a global or hemispheric problem is addressed by the Task Force on Hemispheric Air Pollution (HTAP) under the United Nations Economic Commission for Europe (UNECE) Convention on Long-Range Transboundary Air Pollution (LRTAP). The Gothenburg Protocol to the LRTAP Convention (UNECE, 1999) contains emission ceilings for the pollutants nitrogen oxides, non-methane volatile organic compounds (NMVOC), sulphur oxides (SO_X) and ammonia (NH_3) that Parties to the protocol must meet by 2010. In addition to the ceilings for individual countries, the protocol also specifies ceilings for the European Union, which itself is a Party to the protocol.

Member States report data on emissions of air pollutants annually to the European Commission (with copies to EEA) under Directive 2001/81/EC on national emission ceilings for certain pollutants (EC, 2001). The 'NEC Directive' contains national emission ceilings that, for the EU Member States, are either equal to or more ambitious than those in the Gothenburg Protocol. The ceiling applies to the EU-15 grouping of Member States that constituted the European Community at the time the Gothenburg Protocol was agreed.

The European Union's emission inventory report 1990–2009, published in 2011, reports that EU-27 emissions of the three air pollutants primarily responsible for the formation of harmful ground-level ozone in the atmosphere fell significantly in the period since 1990: CO emissions were reduced 62 %, NMVOCs by 55 % and NO_X by 44 %. Compared to 2008, the highest emission reduction was achieved for CO (11 %).The NO_X emissions remained significantly above the level of the NEC Directive ceiling. The nitrogen oxides ceiling remains the most difficult to comply with, partly because demand for road transport has grown faster than anticipated. For the remaining pollutants, emissions in 2009 were below the pollutant ceilings (EEA, 2011), although the decreased emissions did not manifest themselves in equally diminished ground-level ozone concentrations.

Differences in the distribution of ozone precursor emission sources, the chemical composition of the air, and climatic conditions along the north-south and east-west gradients in Europe result in considerable regional differences in summer ozone concentrations.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 (EMEP, 2005). Hot, dry summers with long-lasting periods of high air pressure over large parts of Europe lead to elevated ozone concentrations and many exceedances of ozone threshold values.

This correspondence can also be demonstrated by charting the maximum daily temperatures averaged for the period April–September of a particular year observed in four capital cities in selected regions (Paris, Prague, Rome and Copenhagen ([14])) in relation to the number of exceedances (see Figure 3.1). The exceptionally warm summer of 2003 also illustrated the link. In 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 covering large parts of southern, western and central Europe. Ozone concentrations were high for the entire period.

Numerous exceedances also occurred in the warm summer of 2006, especially in the Mediterranean region. However, temperature is clearly not the only predictor of ground-level ozone concentrations. Although the average summer temperatures in 2010 were lower than in the previous year, the average number of exceedances per station increased slightly.

In the years 2007–2010, the number of exceedance was fairly consistent in each of the four regions. However, as inter-annual variations in weather conditions have a significant impact on yearly ozone levels, no conclusions on a possible trend can be made. Long time series of measurement data are needed from stable networks of monitoring stations in order to discern the effect of reduced ozone precursor emissions (EEA, 2009).

Measurements in many regions show that the hemispheric background level of ozone has been increasing (by typically 2 ppb per decade since 1980) in the mid-latitude northern hemisphere over the period during which emission reductions have been achieved in Europe and North America. The increase in background O_3 is not fully understood but is thought to be due mainly to emission increases in other northern hemisphere countries and increases in emissions from poorly regulated sectors such as international shipping and aviation (Royal Society, 2008).

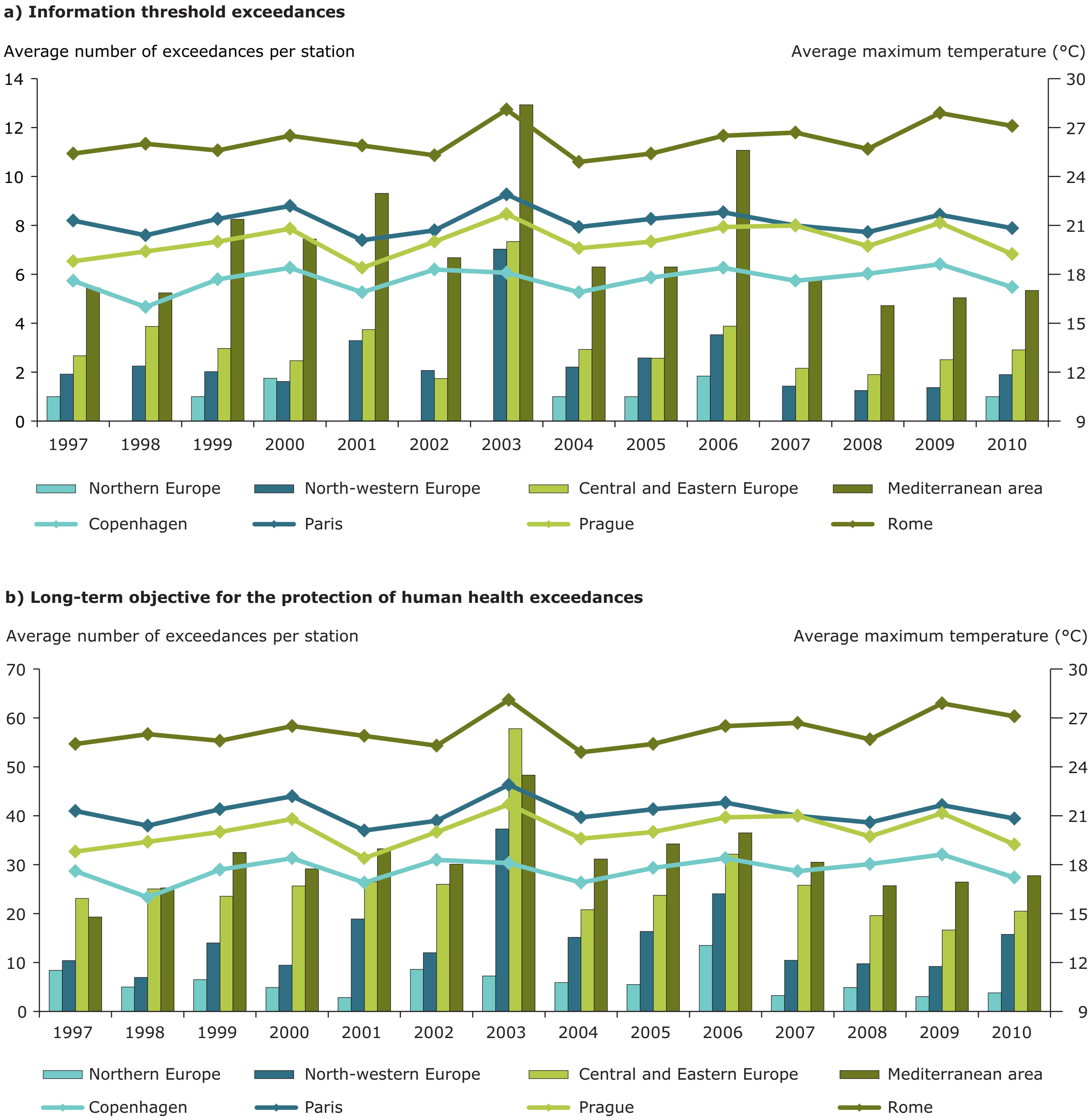
Figure 3.2 depicts five long-term trends in exceedances since 1990. The underlying data were provided by countries with data series of at least 15 years from several stations. The number of stations meeting the criteria (a long time series and data capture over 90 %) varies between countries. Nevertheless the long-term change of exceedances is evident. The summers of 1990, 1994 and 1995 display the highest ozone levels, as well as summers 2003 and 2006 ([15]). Remaining years do not display significant change in the number of exceedances.

Independent of the episodic nature of ozone pollution and the strong influence of meteorological conditions, emissions of ozone precursor gases are sustaining a baseline number of exceedances of the information and alert thresholds and the long-term objective. Decreased anthropogenic emissions of some ozone precursors (nitrogen oxides, carbon monoxide and some volatile organic compounds) in the past two decades did not manifest themselves in significant reductions in the number of such exceedances. The ozone pollution problem therefore requires further mitigation efforts.

([14]) 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.

([15]) For more in-depth analysis of this issue, please refer to the References chapter.

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, the United Kingdom.

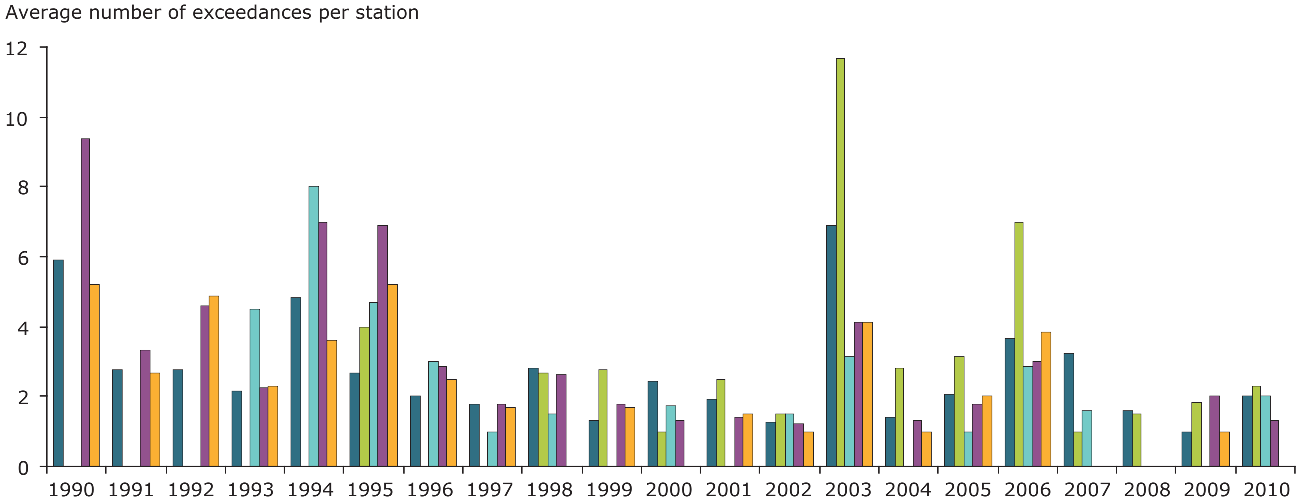
Central and eastern Europe: Austria, Bulgaria, Czech Republic, Germany, Hungary, Liechtenstein, Poland, Romania, Slovakia, Switzerland.

Mediterranean area: Albania, Andorra, Bosnia and Herzegovina, Croatia, Cyprus, the former Yugoslav Republic of Macedonia, France south of 45 ° latitude, Greece, Italy, Malta, Monaco, Montenegro, Portugal, San Marino, Serbia including Kosovo under UNSC Resolution 1244/99, Slovenia and Spain.

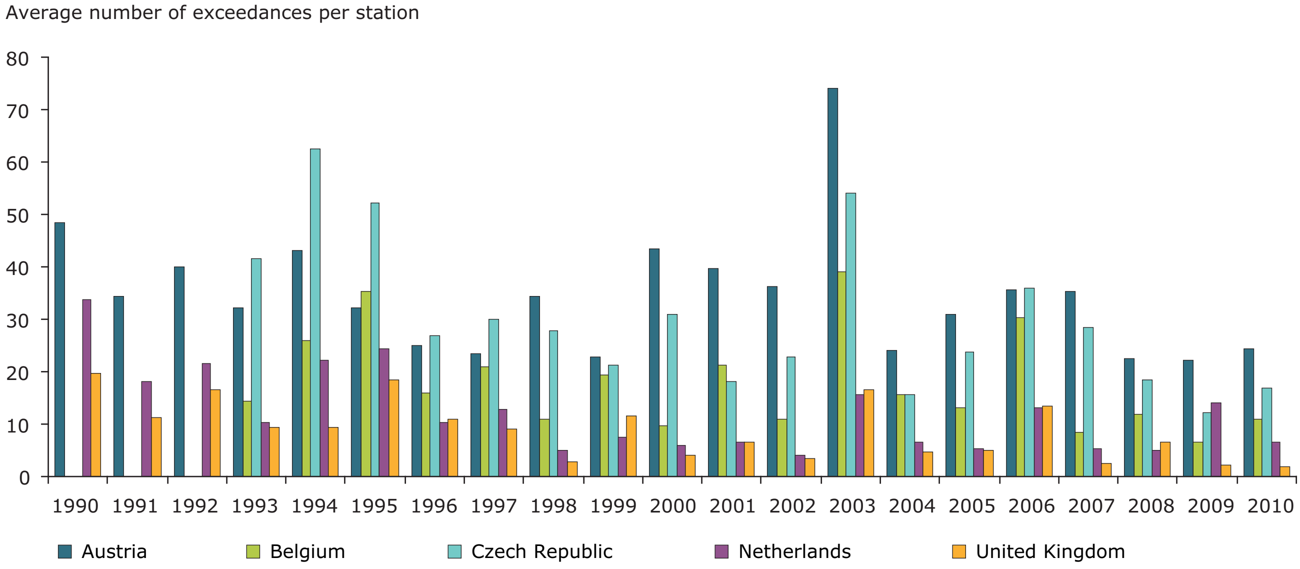
Source of temperature data: http://www.wunderground.com (temperature data).

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 1997–2010 ([17])

a) Information threshold exceedances

Summer season	Number 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)		(%)		(%)									
1997	731	312	13	43	2	4	131	21	383	1.2	2.8	0.0	1.4	2.7	1.6
1998	778	451	62	58	8	14	134	59	421	2.2	3.8	0.1	1.6	3.3	2.0
1999	1 089	360	38	33	3	11	162	100	829	1.3	4.1	0.1	3.9	3.1	4.1
2000	1 173	524	32	45	3	6	132	54	471	1.5	3.3	0.0	1.8	2.9	1.9
2001	1 347	667	73	50	5	11	147	82	470	2.5	5.1	0.1	2.5	3.0	2.0
2002	1 404	510	55	36	4	11	136	41	391	1.2	3.3	0.1	2.1	2.8	2.0
2003	1 474	1 094	279	74	19	26	171	88	417	6.5	8.7	0.5	2.4	3.9	2.1
2004	1 516	552	37	36	2	7	137	44	385	1.5	4.0	0.0	1.8	3.0	2.0
2005	1 641	770	59	47	4	8	163	61	361	1.8	3.9	0.1	2.2	3.1	2.4
2006	1 730	1 089	101	63	6	9	181	138	447	3.6	5.7	0.4	7.7	4.3	5.2
2007	1 761	514	62	29	4	12	152	46	479	1.1	3.9	0.1	1.7	3.3	2.0
2008	1 874	378	20	20	1	5	135	27	399	0.7	3.6	0.0	2.2	2.9	2.6
2009	2 171	443	30	20	1	7	144	24	284	0.8	3.7	0.0	1.3	2.9	2.2
2010	2 193	756	32	34	1	4	111	23	332	1.3	3.7	0.0	1.4	3.0	1.9

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 operational stations (total number of stations).
Right column: averaged over all stations which reported at least one exceedance.

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

Summer season	Number of stations ([a])	Stations with LTO exceedance ([b])		Stations with TV exceedance ([b])		Number of days with LTO exceedance ([c])	Maximum observed 8-hour mean concentration (µg/m³)	Occurrence of LTO exceedances ([d])	
		(number)	(%)	(number)	(%)				
1997	756	698	92	206	27	183	243	20.1	21.1
1998	811	736	91	248	31	178	263	21.1	22.3
1999	1 137	1 059	93	340	30	183	537	21.6	22.2
2000	1 206	1 108	92	352	29	181	242	20.3	21.5
2001	1 368	1 259	92	533	39	183	269	24.1	25.8
2002	1 420	1 262	89	423	30	183	310	20.4	22.7
2003	1 508	1 435	95	1 023	68	183	296	46.5	47.8
2004	1 543	1 409	91	410	27	183	256	20.5	22.0
2005	1 665	1 525	92	560	34	183	291	23.0	24.7
2006	1 762	1 672	95	939	53	183	399	29.7	30.8
2007	1 794	1 566	87	554	31	183	277	20.8	23.4
2008	1 901	1 701	89	423	22	183	399	17.3	19.1
2009	2 171	1 830	84	441	20	183	243	15.9	18.8
2010	2 193	1 875	85	588	27	183	262	19.1	22.3

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 stations.
Right column: averaged over all stations which reported at least one exceedance.

([17]) Ozone levels in summer 2010 were compared with the summer ozone concentrations from 1997 to 2009. Summer ozone concentrations from 1997 to 2009 are validated and stored in the EEA air quality database AirBase. Summer ozone concentrations for 2010 are provisional.

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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 maximum daily 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).

The countries provided the data following these requirements during the summer of 2010.

Annex 2 Data reporting over summer 2010

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 data exchange (ETC/ACC, 2004).

Ozone monitoring stations were operated throughout the whole period April–September 2010. 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 1 576 stations (equal to 72 % of all operational stations). Of those, 1 460 (93 %) provided valid one-hour measurements at least 75 % of the time (see Table A2.1). The proportions were similar as in 2007–2009.

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 30 November 2010).

The ozone monitoring network in 2010

Map A2.1 presents the location of all ozone monitoring stations assumed to be operational in the reporting countries during summer 2010. In total, 2 193 ozone-monitoring sites were operational in summer 2010, of which 2 128 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 2009, larges changes were reported by Italy (42 additional stations).

According to the requirements of Directive 2008/50/EC, stations should be situated away from the influence of local emissions ([18]). Station meta-information reveals that 456 (approximately 21 %) traffic or industrial stations are used for summer ozone assessment in the various countries. Thereby the requirements of siting the ozone stations are not fulfilled. These stations were included in 2010 summer reporting and the current analysis to match the practice in previous years. The share of the traffic and industrial stations remains similar during the past 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 8 % of stations the type of station was not known.

([18]) The same requirements were requested by Directive 92/72/EEC.

Table A2.1 Overview of the validity of one-hour measurements during the summer of 2010 on a country-by-country basis

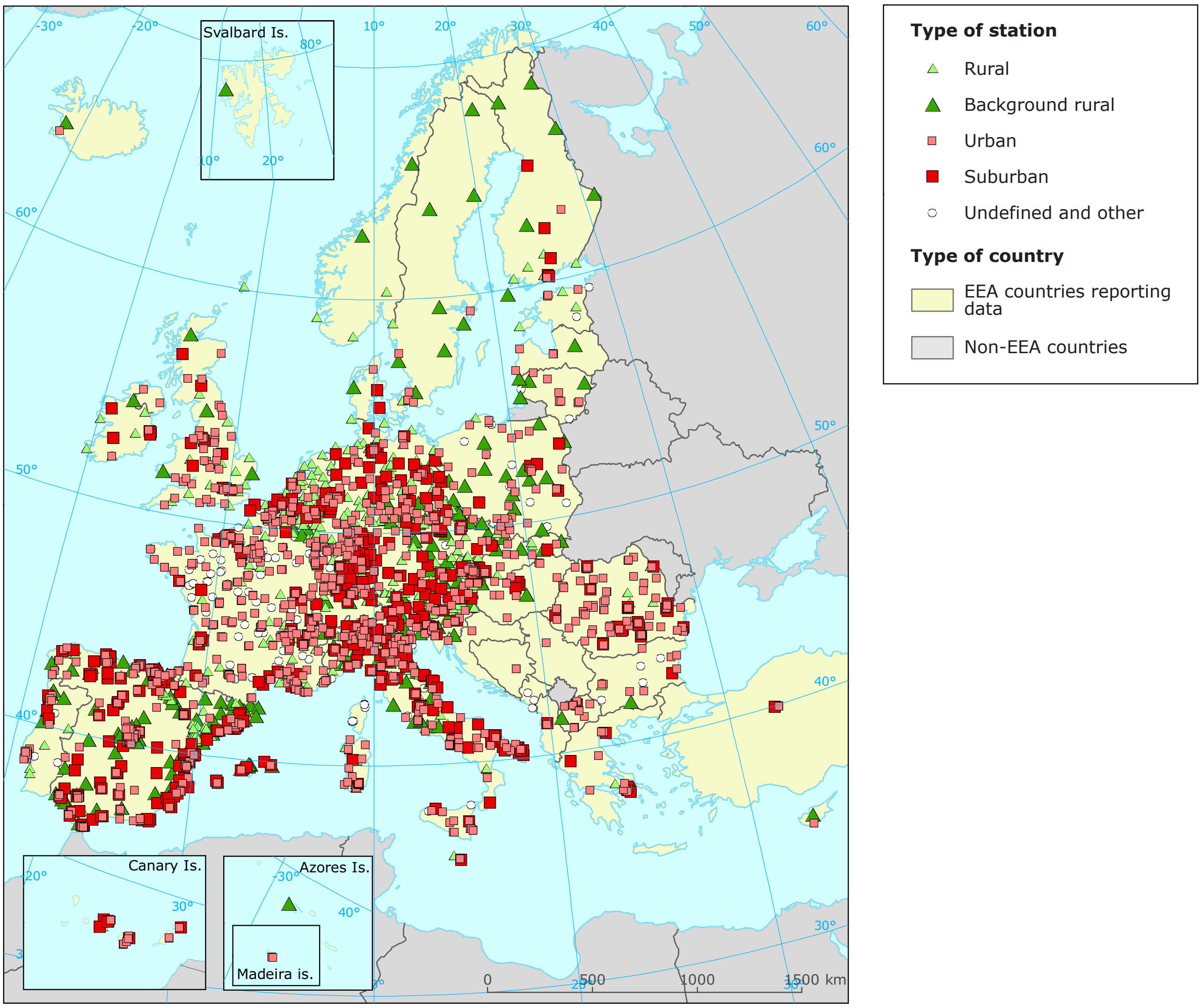
Country	Stations with available information ([a]) (%)	Stations with at least 75 % of valid one-hour data ([b]) (%)
Austria	100	99
Belgium	100	100
Bulgaria	100	100
Cyprus	100	100
Czech Republic	100	98
Denmark	100	89
Estonia	100	89
Finland	100	94
France	100	97
Germany	0	-
Greece	100	87
Hungary	100	100
Ireland	100	92
Italy	0	-
Latvia	100	86
Lithuania	100	100
Luxembourg	100	100
Malta	0	75
Netherlands	100	83
Poland	100	84
Portugal	83	100
Romania	100	69
Slovak Republic	100	100
Slovenia	100	100
Spain	100	95
Sweden	100	100
United Kingdom	100	94
Albania	0	-
Bosnia and Herzegovina	100	100
Croatia	100	100
Iceland	100	100
Liechtenstein	100	100
Macedonia, former Yugoslav Republic of	100	50
Montenegro	0	-
Norway	100	100
Serbia including Kosovo under UNSC Resolution 1244/99	100	100
Switzerland	100	100
Turkey	0	-
Total	**72**	**93**

Notes: '-' 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 A2.1 Location of ozone monitoring stations in summer 2010 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 ([19]), 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 by 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 ([20]) 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.3.1).

The number of stations incorporated in the NRT was lower than officially reported during summer 2010. 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 poor resubmission of the validated data, i.e. incorrect values persisted in the NRT database (Table A.3.1).

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 30 November 2010).
>
> http://air-climate.eionet.europa.eu/docs/meetings/080929_13th_eionet_aq_ws/09_Cernikovky_SOR2008_13_Eionet_AQ_080929.pdf (accessed 30 November 2010).
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> http://air-climate.eionet.europa.eu/docs/meetings/091005_14th_eionet_aq_ws/08_SummerO3_2009_prelim_AQEionet09_LChernikovsky.pdf (accessed 30 November 2010).
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> http://air-climate.eionet.europa.eu/docs/meetings/101014_15th_eionet_aq_ws/26_Targa_EEA_NRT.pdf (accessed 30 November 2010).

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 30 November 2010).

Management of data flows were discussed during the 14th and 15th Eionet Air Quality Management and Assessment Workshops and the relevant presentations are available at:

> http://air-climate.eionet.europa.eu/docs/meetings/091005_14th_eionet_aq_ws/23_NRT_status_AQEionet09_PGabrielsen.pps (accessed 30 November 2010).
>
> http://air-climate.eionet.europa.eu/docs/meetings/101014_15th_eionet_aq_ws/26_Targa_EEA_NRT.pdf (accessed 30 November 2010).

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

Map A3.1 Screenshot of Ozone Web

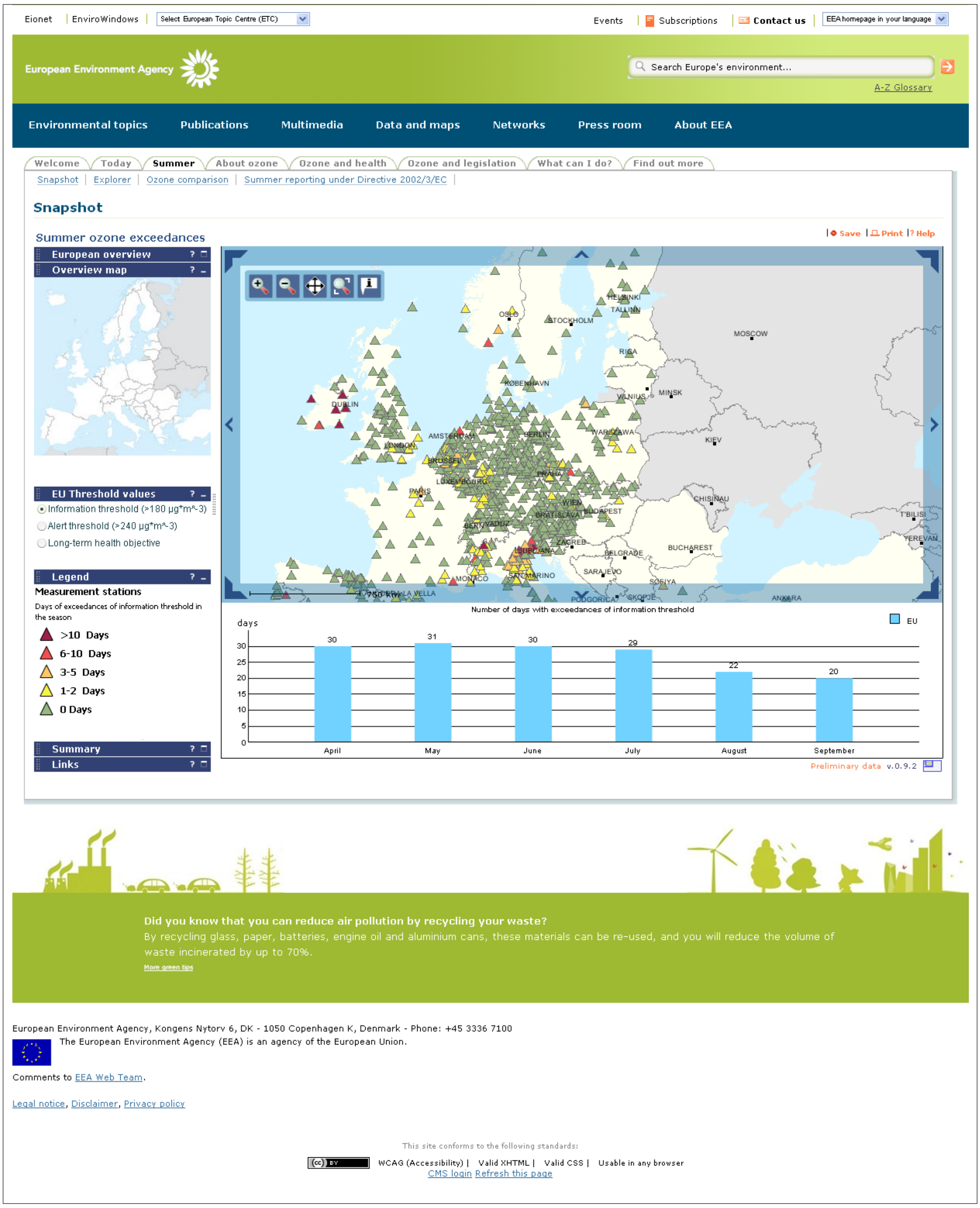


Table A3.1 Comparison of the summer 2010 reporting (SOR) with near real-time reporting (NRT)

Country	Summer ozone reporting						Near real-time ozone reporting					
	Number of stations (a)	Stations with exceedance (b)		Number of days with exceedance (c)		Maximum observed one-hour concentration (µg/m³)	Number of stations (a)	Stations with exceedance (b)		Number of days with exceedance (c)		Maximum observed one-hour concentration (µg/m³)
Austria	114	34	0	15	0	223	111	34	2	16	2	296
Belgium	40	33	3	10	3	244	40	33	3	10	3	244
Bulgaria	17	5	3	16	3	332	2	2	1	3	1	332
Cyprus	2	0	0	0	0	157	1	1	0	1	0	234
Czech Republic	60	19	0	13	0	202	59	29	7	42	21	381
Denmark	9	1	0	1	0	201	6	0	0	0	0	(d)
Estonia	9	0	0	0	0	153	2	0	0	0	0	145
Finland	18	0	0	0	0	175	17	1	0	2	0	226
France	408	159	3	40	2	277	347	19	3	24	3	388
Germany	258	189	5	26	2	273	269	198	8	29	5	294
Greece	23	10	1	23	1	245	5	0	0	0	0	(d)
Hungary	17	5	0	3	0	190	7	2	0	3	0	193
Ireland	12	0	0	0	0	154	9	1	0	2	0	208
Italy	342	154	7	54	5	271	154	91	31	89	48	399
Latvia	7	0	0	0	0	157	1	0	0	0	0	143
Lithuania	12	0	0	0	0	166	6	0	0	0	0	166
Luxembourg	6	3	0	4	0	202	6	3	0	3	0	210
Malta	3	0	0	0	0	177	1	1	1	1	1	350
Netherlands	35	18	0	6	0	217	33	17	1	7	1	337
Poland	70	15	0	8	0	224	41	11	5	11	5	339
Portugal	41	28	6	34	6	288	31	15	3	22	3	337
Romania	96	3	0	3	0	195	36	1	1	1	1	343
Slovak Republic	15	2	1	7	2	275	3	1	0	2	0	208
Slovenia	12	3	0	5	0	190	8	2	0	5	0	190
Spain	410	49	1	49	3	275	240	31	5	44	7	287
Sweden	12	2	0	1	0	218	9	2	0	1	0	218
United Kingdom	79	1	0	1	0	194	76	1	1	2	1	376
EU area	2 127	733	30	104	23	332	1 520	496	72	134	86	399
Albania	4	0	0	0	0	171	(e)	-	-	-	-	-
Bosnia and Herzegovina	2	0	0	0	0	120	(e)	-	-	-	-	-
Croatia	2	1	0	1	0	188	(e)	-	-	-	-	-
Iceland	2	0	0	0	0	125	1	0	0	0	0	125
Liechtenstein	1	0	0	0	0	167	1	0	0	0	0	167
Macedonia, former Yugoslav Republic of	12	1	0	14	0	198	(e)	-	-	-	-	-
Montenegro	3	1	0	1	0	213	(e)	-	-	-	-	-
Norway	7	0	0	0	0	145	8	0	0	0	0	163
Serbia including Kosovo under UNSC Resolution 1244/99	1	0	0	0	0	157	(e)	-	-	-	-	-
Switzerland	28	18	2	27	1	257	28	18	2	27	1	257
Turkey	3	2	0	5	0	206	3	2	0	3	0	206

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

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

(a) Total number of stations measuring ozone levels.

(b) The number of stations at which at least one threshold exceedance was observed.

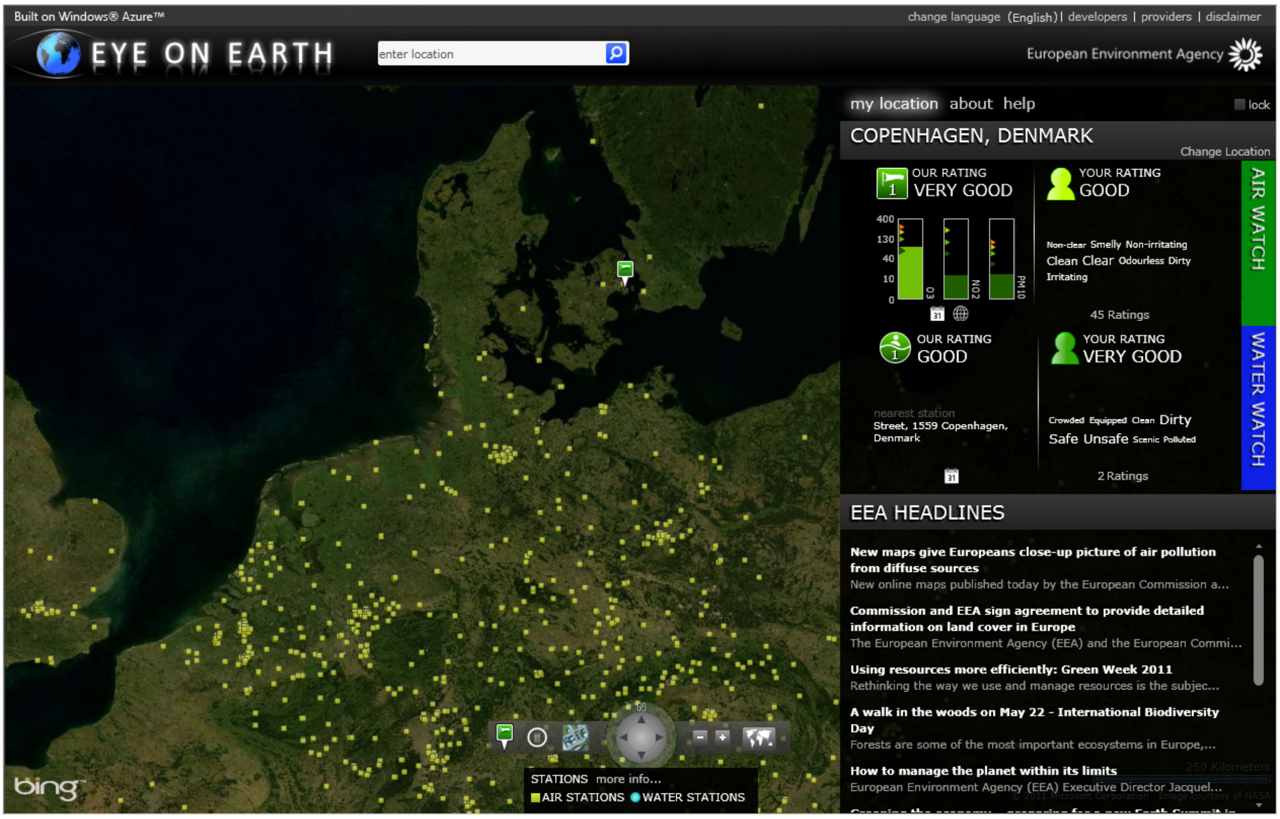
(c) The number of calendar days on which at least one exceedance of thresholds was observed.

(d) Not calculated due to poor data capture in NRT database.

(e) Not participating in NRT.

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 scales from street-level to continental. The near real-time information derives from air quality measurement stations and chemical transport modelling provided by the pre-operational GMES Atmosphere Service (project outputs from the MACC project — Monitoring Atmospheric Composition and Climate, see Map A3.2): http://www.eea.europa.eu/data-and-maps/explore-interactive-maps/eye-on-earth.

Map A3.2 Comparison of the summer 2010 reporting (SOR) with near real-time reporting (NRT)



European Environment Agency

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