Air Pollution Forecasting: Ozone Pollution Episode Report (August 2003)

Andrew Kent, **netcen**
19/8/2003

INTRODUCTION

During the first half of August, the UK rural and urban air quality monitoring networks recorded ozone levels in the Defra HIGH band (90-180 ppb, 180-360 μgm^{-3}). Between 1st and 15th August, HIGH ozone levels were reported on 10 days and MODERATE concentrations (50-90 ppb, 100-180 μgm^{-3}) were reported on all 15 days. The highest concentration of the episode was 125 ppb (250 μgm^{-3}, index 8) which occurred on 11th August at Lullington Heath. In total, 38 sites reported HIGH concentrations during the episode and 78 sites in the network reported MODERATE concentrations. Concentrations remained in the LOW band at only 2 sites in the network during the period – London Marylebone Road and Bury Roadside are both sites where high NO_x emissions are likely to 'scavenge' ozone, preventing the development of an episode.

Summer ozone episodes can be hard to neatly delimit because ozone levels are often in the MODERATE band during the summer season. This report covers the period 1st to 15th August because before and after this period the number of sites reporting MODERATE concentrations could be considered to be normal for the time of year. The purpose of this report is to detail the extent and duration of these elevated levels and to describe the weather situation and other causal factors that may have contributed to the event. The final data for the period of the event has yet to be ratified and all statistics and charts are based on provisional data as used in the actual forecasting process.

Table 1 shows the number of UK sites in MODERATE, HIGH and VERY HIGH bands for ozone on each day and lists the maximum exceedence concentration (hourly/ 8 hourly running mean, on which the ozone bandings are based). Table 2 provides details of each network site involved in the episode (those which reported MODERATE concentrations or above). The number of days on which MODERATE, HIGH and VERY HIGH concentrations were reported are presented for each site, along with the maximum exceedence concentration measured at each site. Figure 1 is a time series chart showing the changing hourly concentrations for a selection of sites that reported HIGH concentrations or above. There were too many sites reporting HIGH concentrations to meaningfully present all in a single graph. Therefore, the number of sites charted in figure 1 has been limited to those reporting the highest concentrations and which best represent each zone/ agglomeration. Figure 3 presents results from Paris monitoring networks compared with the UK's highest concentration site, Lullington Heath. Figures 4 through 14 are four day back trajectory charts showing the forecast origin of air masses affecting the UK over the period. Tables 4 and 5 present the success and accuracy rates for the UK air pollution forecasting service between 1st and 15th August.

A list of appropriate internet links has been compiled and is presented towards the back of this report. These provide web based access to news articles and press releases in the national press concerning the record temperatures and this highly publicised summer smog episode.

DEVELOPMENT OVER TIME

- The weather during the period was dominated by a persistent high pressure system which brought stable conditions to the whole of the UK. There were successive days of long hours of sunshine and high temperatures, highest in the south and east of the UK. This heatwave was forecast in advance by the Met Office and was highly publicised and temperature records were threatened. There was little change in the weather during the period of the episode. Cloudless skies over the whole of the UK were typical. Winds remained light throughout although the direction changed several times as the forecast air mass back trajectories (figures 4 through 14) show. It is important to note that these are only forecast back trajectories and are therefore just a best estimate of the real situation on each day.

- Figure 4 illustrates that Saturday 2nd August saw clean Atlantic air masses affecting the UK from the west. However, despite the lack of abundant ozone precursors from the continent, the long hours of intense sunlight and associated rising temperatures with light winds over the UK did result in ozone levels rising into the MODERATE band. MODERATE levels were recorded at 17 sites, mostly in London and the south east.
- Sunday 3rd August saw continuing light westerly winds, as shown in figure 5. Ozone levels continued to rise, particularly in the south east and ozone entered the HIGH band at 3 sites, all in London, (Hillingdon reported an hourly concentration of 95 ppb, Brent reported 97 ppb and North Kensington reported 102 ppb). MODERATE levels of ozone were reported by 53 network sites on this day.

- The following day (Monday 4th August), clean air masses affecting Scotland and Northern Ireland were originating over the Atlantic without passing over any major sources of the ozone precursors. However, air affecting the whole of England and Wales were recirculating over the UK (figure 6), resulting in elevated concentrations in Wales, south west England and northern England. A total of 60 sites reported MODERATE concentrations. There were 5 sites reporting HIGH concentrations – Bottesford recorded an hourly concentration of up to 97 ppb, London Hillingdon recorded 93 ppb, and in the north of England Ladybower reported 92 ppb and Wigan Leigh reported 98 ppb. The highest concentration of 102 ppb was reported by Harwell. The instrument at Harwell was recently discovered to be over reading by as much as 15%. However, the instrument was replaced on 17th July as part of a site upgrade. The data presented for Harwell in this report are therefore from a new analyser which should not be over-reading although the data remains provisional until final ratification is complete.

- The back trajectory for Tuesday 5th August (figure 7) shows that almost all of the UK is affected by air that has passed over significant land masses and associated pollution sources in the hours before measurement. Air originated over the UK and circulated over northern Germany and France before passing over the UK again from the south. Given the conditions and the modelled levels shown in the back trajectory, it might have been expected that this day would have seen the highest ozone levels of the episode to date. However, generally levels dipped on this Tuesday and only 3 sites (Bournemouth, Harwell and Yarner Wood) reported HIGH concentrations with 54 reporting MODERATE concentrations, a reduction from the previous day. Early week days have historically produced the fewest occurrences of HIGH ozone[1] because generated ozone levels are dependent on VOCs accumulated in the previous days, which tend to be lower over the weekends. Therefore it is not surprising that levels dipped on this Tuesday. The previous day (Monday) may also have seen more ozone than this Tuesday due to VOC contributions to the chemistry from the end of the previous week, before the weekend.

- A slight shift in the winds on Wednesday 6th August resulted in air masses passing over industrial heartland areas of Germany and France before arriving at the UK. These air masses, likely to have been abundant in hydrocarbons, were influencing southern and eastern England and Scotland. The rest of the UK was fed by cleaner air masses originating over south western France and the Bay of Biscay, as shown in figure 8. Incoming hydrocarbons from industrial Germany and France, coupled with the stable weather conditions, bright sunshine and high temperatures are likely to have combined to result in the dramatically increased ozone levels on 6th August compared with the previous day. There were 17 sites reporting concentrations in the HIGH band and 60 reporting MODERATE concentrations. All of the sites reporting HIGH concentrations were in London, the south east or midlands of England and the highest concentrations was 121 ppb, measured at London Brent.

- Over Thursday 7th and Friday 8th August, concentrations dropped again slightly. HIGH levels were measured at 4 sites (maximum hourly concentration of 105 ppb at Harwell) on 7th and 9 sites (maximum hourly concentration of 101 ppb at London Hillingdon) on Friday 8th August. Back trajectories for these days are provided in figures 9 and 10.

- The height of the episode occurred on Saturday 9th August with HIGH levels of ozone being reported across 26 sites and MODERATE levels at 69 sites. Most of the sites reporting HIGH concentrations were located in southern regions of the UK, particularly the south east, London and midlands. However, there was also a large number of sites reporting HIGH ozone in the north west of England including Glazebury, Liverpool Speke, Wigan Leigh, Blackpool and Preston. The highest concentration measured on this day was 120 ppb at Portsmouth. As shown by figure 11, air masses affecting the UK had passed over significant potential sources of VOCs from the continent prior to being measured in the UK. Saturdays typically report more HIGH ozone than early on in the week[1]. This is because the five previous days are likely to have resulted in an abundance of VOCs being accumulated

[1] Jenkin, M E, Davies, T J and Stedman, J R (2002) The origin and day-of-the week dependence of photochemical ozone episodes in the UK. Atmospheric Environment, 36, 999-1012

throughout the working week which fuel the chemical reaction that results in ozone. Furthermore, it is likely that the characteristic reduction in NO_x emissions from road traffic over the weekends compared with the working week might have further exacerbated rising ozone levels on this day, particularly noticeable in urban areas.

- From Sunday 10th August, the episode was beginning to decline and table 1 illustrates how the number of sites reporting HIGH concentrations fell to just 4 on 12th August. Trajectories shown in figures 13 and 14 show how the wind changed direction over this time to bring in clean Atlantic air into the UK from the north (figure 14). Despite this general decline in ozone concentrations, several notable points occurred during this period. Firstly, the highest ozone concentration of the episode was actually measured at this time - an hourly average of 125 ppb was recorded at Lullington Heath on 11th August (see tables 1 and 2 and figure 1). Secondly, as shown in the time series chart (figure 1) and in the more detailed chart (figure 2), there was a peak in ozone concentrations around midnight at sites in the south east. Being a photochemically derived pollutant, night time ozone peaks are normally a sign of a mechanical fault with the monitoring equipment. However, this trend was observed at several different stations which supports the argument that these levels were genuinely representative of the ambient conditions rather than the result of equipment failure. Thurrock recorded the highest concentration of 106 ppb at midnight on Sunday 10th August. Southend-on-sea and Rochester both reached their peaks at 23.00 on 10th, measuring 99 ppb and 97 ppb respectively. St. Osyth, London Brent and London Bexley each exhibited similarly unusually timed peaks although these were of a lower magnitude and occurred several hours earlier in the evening. This unusual trend is difficult to explain. The timing of these high levels in the late hours of August 10th dictates that ozone generation cannot be responsible in the absence of a photochemical mechanism. The most reasonable explanation therefore is that ozone levels recorded by these sites was generated elsewhere hours earlier and has subsequently drifted over south east England. The back trajectories (figures 12 and 13) show complex winds at this time. Wind direction changed from north easterly to due easterly for a few hours around midnight. This may have brought ozone rich air to some south easterly sites from the sea, where the night time loss mechanisms are much reduced relative to night time deposition to the land surface. Therefore, this strange night time ozone elevation is most likely the result of drifting ozone generated elsewhere during the daytime of Sunday 10th August.

- By Wednesday 13th August no sites in the network were reporting ozone HIGH ozone levels and MODERATE levels were only being recorded at 18 sites. Figure 14 shows the back trajectories for 14th August which was characteristic of the winds from this point onwards, bringing cleaner air with fewer ozone precursors to the UK.

DISCUSSION

The August 2003 episode was notable for a number of reasons, Duration, high temperatures and the highest ozone concentrations recorded in London for over a decade.

Duration

High (greater than 90 ppb, 100 $\mu g\ m^{-3}$) concentration of ozone were measured on 10 consecutive days, ozone episodes more typically last for 3-6 days. This was due to the sustained period of very hot weather. The Met Office website reports the following:

"During the summer of 1976, Heathrow had 16 consecutive days over 30 °C from 23 June to 8 July (their highest number of consecutive days above 30 °C). This year, Heathrow managed three consecutive days above 30 °C between 4 and 6 August 2003, and five consecutive days between 8 and 12 August 2003 (digital data records go back to 1949).

During the summer of 1976, Enfield had six consecutive days over 30 °C from 23 June to 28 June, and seven consecutive days between 2 July and 8 July. This year, Enfield has had ten consecutive maximum temperatures over 30 °C from 3 to 12 August 2003 (their highest number of consecutive days above 30 °C, using patchy digital records back to 1960's)."

High temperature

The highest temperature ever recorded in the UK was 38.1 C at Gravesend in Kent on 10 August 2003. Thus temperatures similar to or hotter than the summer of 1976 were recorded during 2003 but maximum hourly ozone concentrations in 2003 were approximately 50-60 % of those measured in 1976. This shows the significant reductions in emissions of ozone precursors between 1976 and 2003.

High ozone concentrations in London

The highest hourly mean ozone concentration recorded at sites in the national network in London during this episode was 121 ppb at Brent on Wednesday 6 August 2003. The highest concentration at sites in the London Air Quality Network (LAQN) was 131 ppb at Enfield Ponders End on the same day. This was the highest concentration measured in London since 1990. Table 3 lists the annual maximum of hourly average ozone concentrations in London for exceedences of 130 ppb since measurements commenced in the early 1970s. The highest concentration was 212 ppb at County Hall in 1976.

Ozone concentration in excess of 130 ppb were relatively frequent in the 1970s but rather less frequent in the 1980s ceasing after 1990. It is clearly important to understand why ozone concentrations this high were measured for the first time in 13 years in London. It is likely that this was due to a combination of changes in emissions over the years and the extreme weather during August 2003 although it is not possible to provide a definitive explanation at this stage. VOC emission reductions and changes in the mix of VOCs released have reduced peak ozone in rural and urban areas across North West Europe since the 1970s, as discussed above. Superimposed on this trend has been an increase in urban traffic NO_x emissions from the 1970's, peaking in about 1990, with a subsequent decline. It is possible that a turn over point has now been reached, where the urban titration of ozone in London has weakened to the extent that urban ozone concentrations are much more similar to rural ozone concentrations, even on weekdays.

The high ozone concentrations recorded in London during August 2003 were likely to have been due to a combination of the very hot weather and the reductions in UK traffic NO_x emissions, which are now at similar levels to the early 1970s. The relative importance of these two influences is not clear at the moment but comparisons of measured ozone concentration in urban and rural areas during future episodes should provide additional useful information.

European concentrations, Summer 2003

Elevated ozone levels in were recorded in the UK and across northern Europe over July and August of 2003. This section will briefly examine measured ozone concentrations from mainland Europe, in particular France. The UK experienced 2 distinct ozone episodes over this time; 8th-20th July and 1st-15th August. The July ozone episode is discussed in detail in a separate report[2].

Figure 3 provides a time series chart of hourly data reported by the Paris automatic monitoring network. The data was available for 26 sites, of which 8 are presented in the chart for clarity. The sites selected were representative of the highest concentrations during the episodes. The chart contains data over July and August, spanning two ozone episodes. For comparison with the UK monitored data over July, it is necessary to see the report on the July ozone episode[2]. The data was downloaded from the French AirParif website[3] and is provisional at the time of writing this report. Of the 26 automatic Parisian sites, all reported hourly concentrations in excess of 180 μgm^{-3} (90 ppb, the HIGH band in the UK) over July to August. All but one of these sites reported hourly concentrations over 200 μgm^{-3} (100 ppb) and 15 of the 26 sites reported hourly concentrations in excess of 250 μgm^{-3}. The maximum hourly concentration was 282 μgm^{-3} (141 ppb) reported by the Zone rurale Sud-Est - Forêt de Fontainebleau site on the afternoon of August 7th. This was slightly higher than the 248μgm^{-3} (124 ppb) UK maximum measured at Lullington Heath on 11th August. Between 1st and 15th August, Parisian ozone concentrations were in the Defra HIGH band on 13 days compared with 10 in the UK.

More general analysis of French ozone levels across the entire country can be found in a recent report that can be found on the internet[4]. This report analyses the medical repercussions of the August heatwave and includes a section on ozone. The report points out that not only were concentrations significantly high but the duration of the episode was also notable. The 180μgm^{-3} (90 ppb) 1 hour information threshold was exceeded on almost 50 days in Provence Alpes Côte d'Azur and on 30 days in Alsace and Ile-de-France. An hourly maximum concentration of 417μgm^{-3} was reported in the Rhone delta.

---

[2] Air Pollution Forecasting: Ozone Pollution Episode Report (July 2003) which can be found at:
can be found at: http://www.airquality.co.uk/archive/reports/reports.php?action=category&section_id=12

[3] http://www.airparif.asso.fr/english/index.php

[4] http://www.invs.sante.fr/publications/default.htm 'Impact sanitaire de la vague de chaleur en France survenue en août 2003' 29 août 2003, *Département des maladies chroniques et traumatismes et Département santé environnement*

Data for other continental sites, obtained through **netcen**'s informal 'Smogwarners' data exchange system[5], show similarly high levels being measured across many parts of Europe. Denmark, Finland and the Czech Republic exhibited the lowest daily maximum concentrations each day. Belgium, the Netherlands, Luxembourg and Austria reported higher daily maximum concentrations with sites exceeding hourly concentrations of 200 μgm^{-3} (100 ppb) on several occasions, most notably in Belgium. Levels measured at sites around Europe on 9th August (the day on which there were the greatest number of UK sites reported HIGH concentrations) were comparatively low relative to other days around that time. Only Belgium exceeded 200 μgm^{-3} (205 μgm^{-3} at Offagne) on 9th. Belgium reported the highest daily maximum concentration of 262 μgm^{-3} (131 ppb) at the Roeselare station on 11th August at 17.00. On this day levels were also well above 200 μgm^{-3} at Ukkel (Belgium), Deuselbach (Germany) and Elvange and Mt. St. Nicolas (Luxembourg).

Forecasting performance, Summer 2003

Analysis of the forecasting performance is performed for each of the 16 zones and 16 agglomerations used in the daily forecasting service. Forecasting performance is analysed for a single, general pollutant category rather than for each individual pollutant. This analysis of forecasting performance is based on provisional data before ratification as used in the daily forecasting process. The analysis treats situations where the forecast index was within ±1 of the measured index as a successful prediction as this is the accuracy forecasters hope to obtain. Because the calculations of accuracy and success rates are based on a success being ±1 of the measured index, it is possible to record rates in excess of 100% rather than 'true' percentages.

The forecasting success rates for each zone and agglomeration forecasted for are presented in tables 4 (forecasting performance in zones) and 5 (forecasting performance in agglomerations), below. These tables give:

- the number of 'HIGH' days measured
- the number of 'HIGH' days forecast
- the number of days with a correct forecast of 'HIGH' air pollution
- the number of days when 'HIGH' air pollution was forecast ('f' in the tables) but not measured ('m') on the following day
- the number of days when 'HIGH' air pollution was measured ('m') but had not been forecast ('f').

The two measures of forecasting performance used in this report are the 'success rate' and the 'forecasting accuracy'.

The forecast success rate (%) is calculated as:
- (Number of episodes successfully forecast/total number of episodes measured) x 100

The forecast accuracy (%) is calculated as:
- (Number of episodes successfully forecast/[Number of successful forecasts + number of wrong forecasts]) x 100

Tables 4 and 5 indicates the percentage success and accuracy of the UK air pollution forecasting service over July and August 2003, during 2 ozone episodes. Forecasting performance was consistently high over the period of both the July and August ozone episodes and Defra and the Devolved Administrations were informed of the probability of an episode prior to HIGH concentrations being measured by the network.

[5] http://www.aeat.co.uk/netcen/airqual/forecast/smogwarners/

SUMMARY

- A persistent high pressure system over the UK and mainland Europe was responsible for long hours of intense sunshine and low wind speeds in all areas of the UK each day during the episode, resulting in record temperatures.
- Recirculating air over the UK and south easterly/ easterly winds during the episode supplied the UK with abundant ozone precursors, providing ideal conditions for ozone generation.
- The episode built over a couple of days (3rd to 6th August) before dipping slightly (7th and 8th August) and then subsequently peaking rapidly on 9th August. From 10th to 12th August the episode declined gradually until typical summer time levels were achieved on 13th.
- An interesting and unusual minor peak in levels occurred at several sites in SE England over night on 10th August. The reasons for this are complex but may have been due to drifting ozone generated earlier in the day elsewhere in the UK or perhaps even on the continent.
- Measured ozone levels during the August episode did not exceed the population warning threshold (an hourly mean concentration in excess of 360μgm^{-3} or 180 ppb[6]) and therefore did not trigger an alert. The 3rd Daughter Directive (Directive 2002/3/EC) on ozone in ambient air, due to be implemented on 9th September 2003, establishes a stricter alert threshold of 240 μgm^{-3} (120 ppb) as an hourly average over three consecutive hours. During the August episode this alert threshold was exceeded only once, at a single site - Lullington Heath reported consecutive concentrations of 121 ppb, 125 ppb and 124 ppb between 15.00 and 17.00 on 11th August.
- The episode was not limited to the UK and elevated ozone levels were widely reported over Europe with many places experiencing higher levels than the UK.

LINKS

Below is a list of internet links to press articles, press releases and other sources of information concerning the high pollution levels associated with the August heatwave.

- An article from London's Evening Standard:

  'Heat brings smog danger'
  Victoria Fletcher, Consumer Correspondent
  Dated 7th August 2003
  http://www.thisislondon.co.uk/news/articles/6123729?source=Evening%20Standard

- An article from The Daily Telegraph:

  'Heat brings worst smog for 10 years'
  Graham Tibbetts
  Dated 8th August 2003

  http://www.telegraph.co.uk/news/main.jhtml?xml=%2Fnews%2F2003%2F08%2F08%2Fnsmog08.xml

- An article from The Times:

  'Smog clouds the picture as heatwave turns toxic'
  Patrick Barkham
  Dated 8th August 2003
  http://www.scientific-alliance.org/news_archives/climate/smogcloudsthe.htm

- A press release from Friends of the Earth:

  'Smog Smashes Health Limits in Summer Scorcher'
  Dated 12th August 2003
  http://www.foe.co.uk/resource/press_releases/smog_smashes_health_limits.html

[6] Council Directive 97/72/EEC, Annex I

Table 1 – Ozone concentrations by date and band

Date	Number of MOD sites	Number of HIGH sites	Number of V HIGH sites	Maximum exceedence (ppb)
01/08/03	1		-----	50
02/08/03	17		-----	66
03/08/03	53	3	-----	102
04/08/03	60	5	-----	101
05/08/03	54	3	-----	99
06/08/03	60	17	-----	121
07/08/03	51	4	-----	105
08/08/03	63	9	-----	101
09/08/03	69	26	-----	120
10/08/03	60	10	-----	115
11/08/03	31	13	-----	125
12/08/03	37	4	-----	114
13/08/03	18		-----	72
14/08/03	6		-----	61
15/08/03	15		-----	77

Table 2 – Ozone concentrations by band and duration

Site	Number days MODERATE	Number days HIGH	Number days VERY HIGH	Maximum hourly/ 8 hourly mean mean (ppb)
London Brent	13	7	-----	121
London Hillingdon	12	7	-----	105
Harwell	12	7	-----	119
Rochester	11	6	-----	113
Thurrock	12	5	-----	111
Southend-on-Sea	11	5	-----	108
Wigan Leigh	8	4	-----	110
Bottesford	12	3	-----	102
London Bexley	12	3	-----	103
London Teddington	12	3	-----	111
Bournemouth	12	3	-----	115
Portsmouth	12	3	-----	120
St Osyth	11	3	-----	109
London Westminster	11	3	-----	112
Lullington Heath	10	3	-----	125
Northampton	12	2	-----	113
Yarner Wood	11	2	-----	99
Southampton Centre	11	2	-----	113
Birmingham East	10	2	-----	91
Coventry Memorial Park	10	2	-----	93
London Bloomsbury	8	2	-----	90
Cwmbran	12	1	-----	95
Leicester Centre	12	1	-----	102
Wicken Fen	12	1	-----	113
Leamington Spa	11	1	-----	90
Ladybower	11	1	-----	92
Sibton	11	1	-----	93
Bolton	10	1	-----	95
Weybourne	9	1	-----	91
Liverpool Speke	8	1	-----	91
Sandwell West Bromwich	8	1	-----	93
Glazebury	8	1	-----	94
Plymouth Centre	8	1	-----	95
Blackpool	8	1	-----	106

Site	Number days MODERATE	Number days HIGH	Number days VERY HIGH	Maximum hourly/ 8 hourly mean mean (ppb)
Swansea	7	1	-----	91
Salford Eccles	5	1	-----	96
Preston	4	1	-----	94
London N. Kensington	4	1	-----	97
Somerton	11	-----	-----	77
Norwich Centre	10	-----	-----	77
Port Talbot	10	-----	-----	86
Manchester Piccadilly	9	-----	-----	77
Hull Freetown	8	-----	-----	63
High Muffles	8	-----	-----	65
Aston Hill	8	-----	-----	74
Cardiff Centre	8	-----	-----	82
Redcar	7	-----	-----	59
Middlesbrough	7	-----	-----	63
Strath Vaich	7	-----	-----	73
Exeter Roadside	7	-----	-----	75
Great Dun Fell	7	-----	-----	78
Narberth	7	-----	-----	79
Wolverhampton Centre	7	-----	-----	84
Bristol Centre	6	-----	-----	70
Manchester South	6	-----	-----	75
Leeds Centre	5	-----	-----	59
Bradford Centre	5	-----	-----	63
Nottingham Centre	5	-----	-----	63
Sheffield Centre	5	-----	-----	63
Eskdalemuir	5	-----	-----	64
Stoke-on-Trent Centre	5	-----	-----	66
Newcastle Centre	4	-----	-----	52
London Southwark	4	-----	-----	55
Barnsley Gawber	4	-----	-----	61
Bush Estate	4	-----	-----	61
Rotherham Centre	4	-----	-----	63
London Haringey	4	-----	-----	67
Belfast Centre	4	-----	-----	69
London Eltham	3	-----	-----	48
London Lewisham	3	-----	-----	53
London Hackney	3	-----	-----	54
Glasgow Centre	3	-----	-----	62
London Wandsworth	2	-----	-----	53
Wirral Tranmere	2	-----	-----	53
Lough Navar	2	-----	-----	63
Derry	2	-----	-----	71
Aberdeen	1	-----	-----	46
Birmingham Centre	1	-----	-----	64
Edinburgh Centre	1	-----	-----	50

N.B – In tables 1 and 2, in cases where levels progress through the MODERATE band and into the HIGH band over the course of a day, the occasion is counted in both the MODERATE and HIGH categories.

Table 3 Annual maximum of hourly mean ozone concentrations for exceedences of 130 ppb in London.

Year	Site	Ozone concentration (ppb)
1973	Central London	136
1974	Central London	164
1975	County Hall	171
1975	Teddington	140
1976	Central London	144
1976	County Hall	212
1976	Hainalt	175
1976	Teddington	211
1976	St Bartholomews	203
1977	London Canvey	179
1978	Central London	149
1978	Teddington	157
1978	London Canvey	147
1979	County Hall	153
1979	Kew	156
1979	London Harrow	180
1984	Chigwell	160
1985	Central London	149
1986	County Hall	130
1990	Teddington	141
2003	Enfield	131

FORECAST ANALYSIS FOR (1ST TO 15TH AUGUST 2003)

Table 4 - Forecast Analysis for UK Zones 'HIGH' band and above.

ZONES	Northern Ireland	North East Scotland	North Wales	Highland	Central Scotland	Eastern	South East	South Wales	South West	East Mids	Scottish Borders	North East	Greater London	West Mids	Yorks & Humberside	North West & Merseyside	Total
measured days	0	0	0	0	0	7	9	1	6	4	0	0	10	2	4	4	47
forecasted days	5	0	5	6	0	9	9	2	5	6	6	1	9	5	4	5	77
ok (f and m)	0	0	0	2	0	8	8	1	7	7	0	0	10	3	5	3	54
wrong (f not m)	5	0	5	4	0	1	1	1	1	0	6	1	0	2	2	2	31
wrong (m not f)	0	0	0	0	0	3	1	1	0	0	2	1	1	0	0	1	10
success %	100.00	100.00	100.00	100.00	100.00	114.29	88.89	100.00	116.67	175.00	100.00	100.00	100.00	150.00	125.00	75.00	-----
accuracy %	0.00	0.00	0.00	33.33	0.00	66.67	80.00	33.33	87.50	100.00	0.00	0.00	90.91	60.00	71.43	50.00	-----

Table 5 - Forecast Analysis for UK Agglomerations 'HIGH' band and above.

AGGLOMERATIONS	Belfast UA	Greater Manchester UA	Nottingham UA	Glasgow UA	Tyneside	Swansea UA	Cardiff UA	Bristol UA
measured days	0	1	0	1	0	1	0	0
forecasted days	0	0	1	0	0	3	1	0
ok (f and m)	0	1	0	0	0	3	1	0
wrong (f not m)	0	0	1	0	0	0	0	0
wrong (m not f)	2	0	0	1	0	0	0	0
success %	100.00	100.00	100.00	0.00	100.00	300.00	100.00	100.00
accuracy %	0.00	100.00	0.00	0.00	0.00	100.00	100.00	0.00

AGGLOMERATIONS	Portsmouth UA	Liverpool UA	Leicester UA	Edinburgh UA	West Midlands UA	Brighton/Worthing /Littlehampton	West Yorkshire UA	Sheffield UA	Total
measured days	4	1	1	0	2	0	0	0	11
forecasted days	3	0	4	0	4	0	1	0	17
ok (f and m)	3	1	3	0	2	0	1	0	15
wrong (f not m)	1	0	2	0	2	0	0	0	6
wrong (m not f)	1	0	0	0	1	0	0	0	5
success %	75.00	100.00	300.00	100.00	100.00	100.00	100.00	100.00	-----

accuracy %	60.00	100.00	60.00	0.00	40.00	0.00	100.00	0.00	-----

*** All performance statistics are based on provisional data as used in the daily forecasting process**

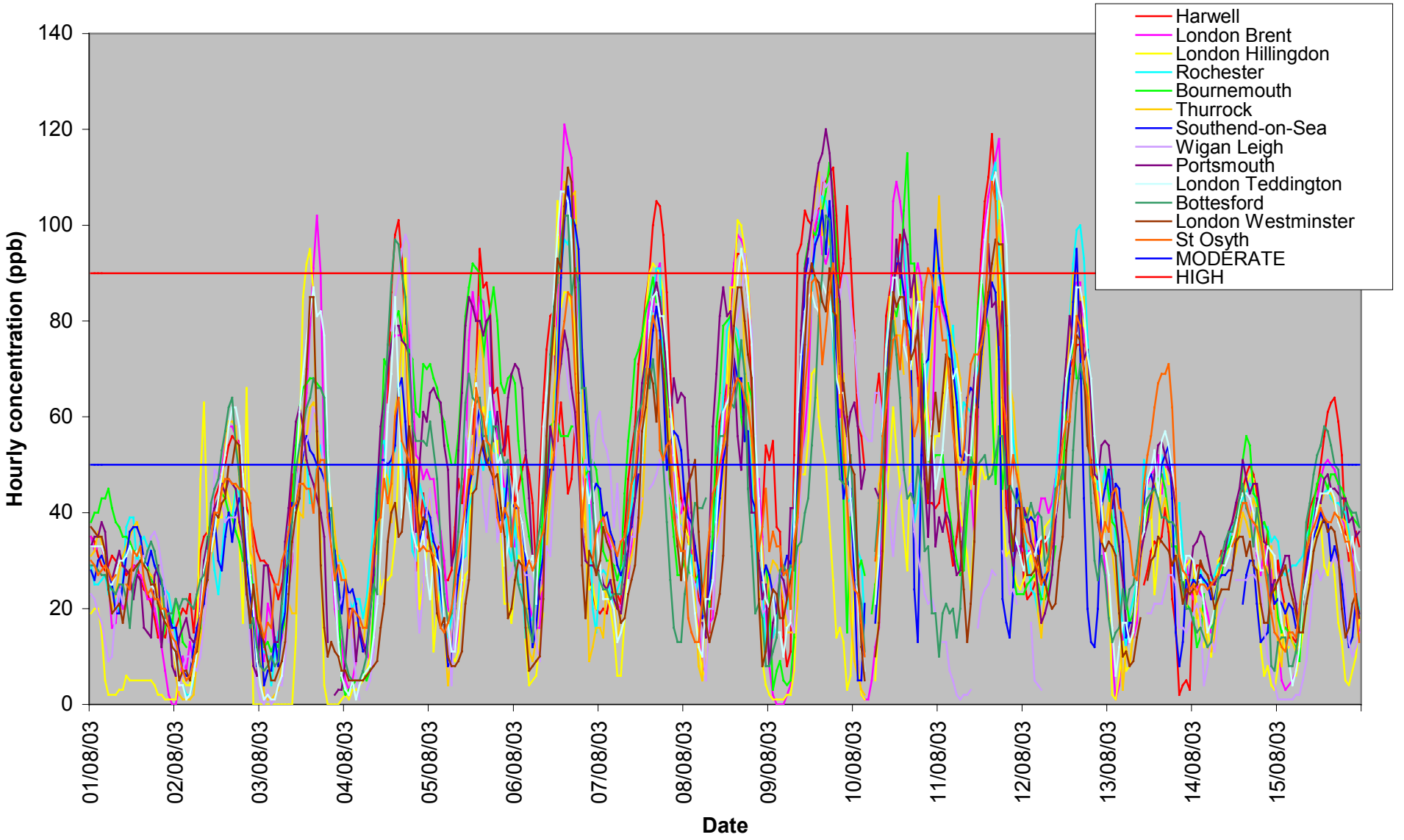

Figure 1 – Hourly ozone concentrations at a selection of sites which reported the highest concentrations over the episode

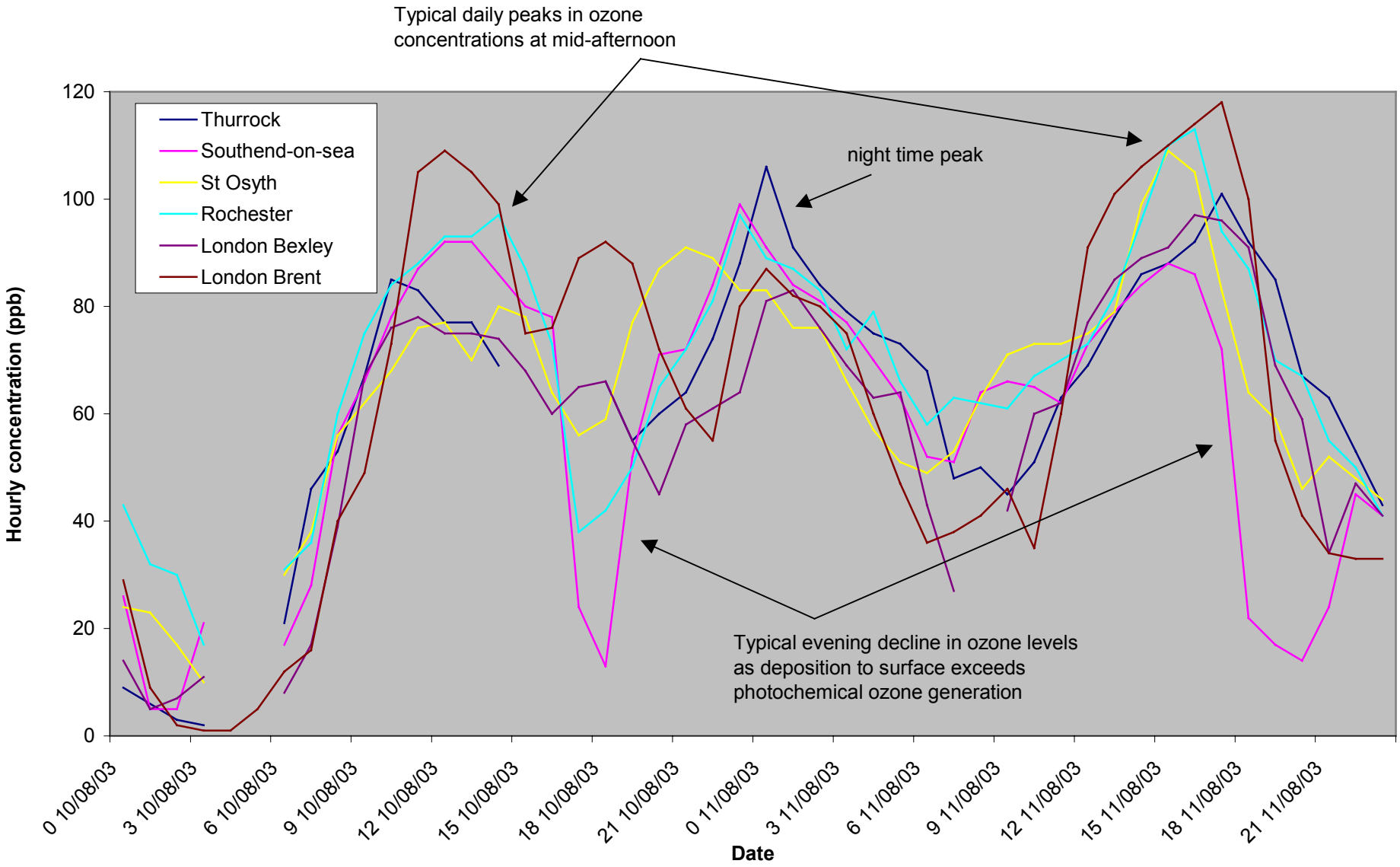

Figure 2 – Hourly concentrations at sites in SE England which recorded a night time peak between 10th and 11th August

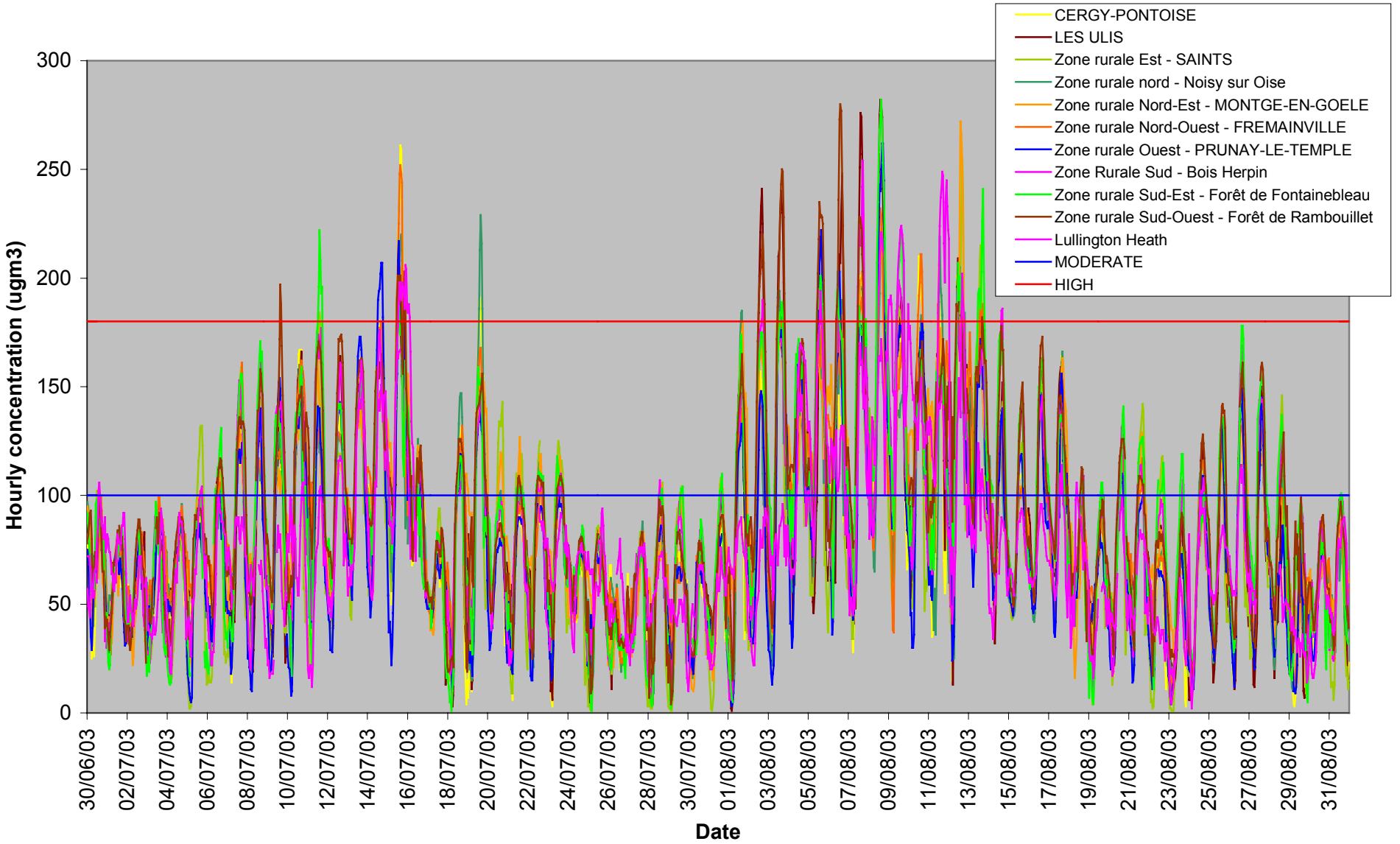

Figure 3 – Hourly concentrations at selected Parisian sites over July and August 2003 compared with Lullington Heath in the UK

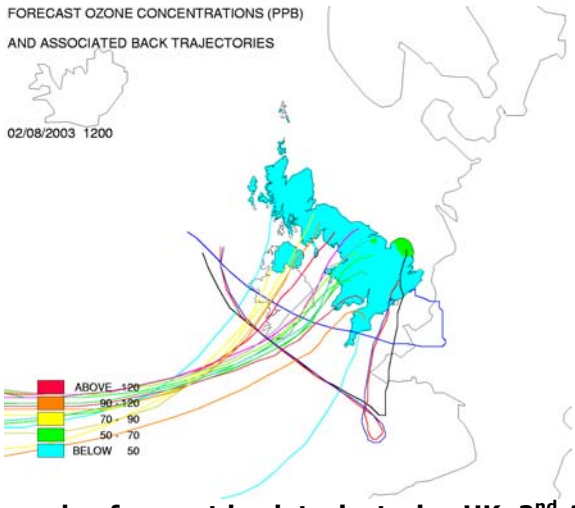

Figure 4 – Four day forecast back trajectories UK, 2nd August 2003

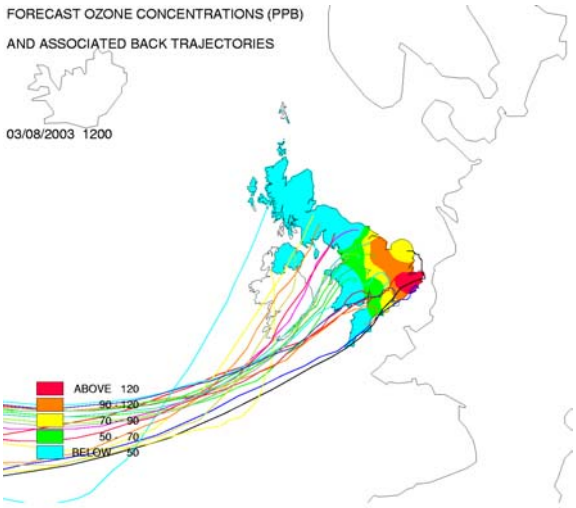

Figure 5 – Four day forecast back trajectories UK, 3rd August 2003

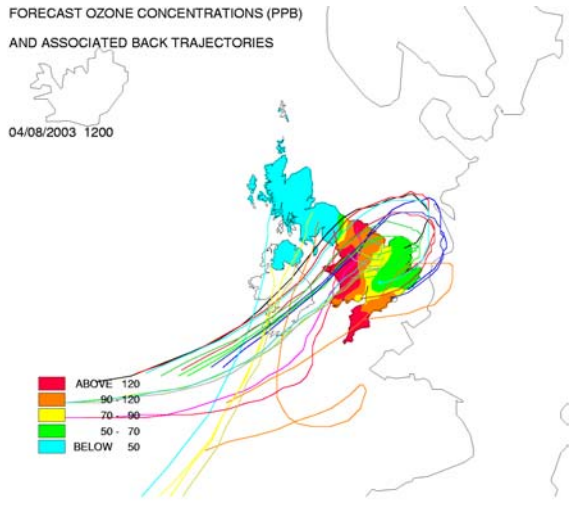

Figure 6 – Four day forecast back trajectories UK, 4th August 2003

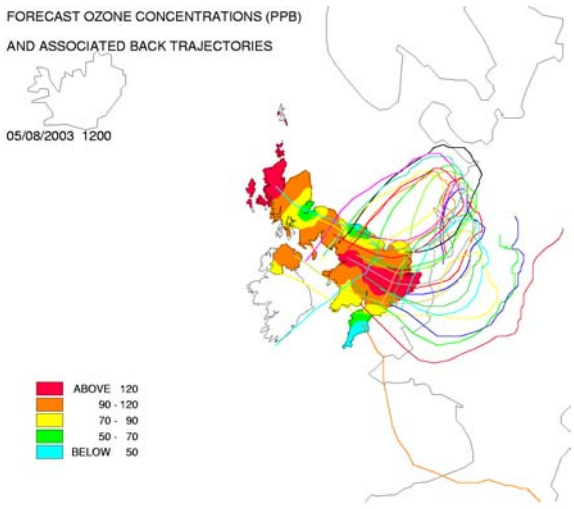

Figure 7 – Four day forecast back trajectories UK, 5th August 2003

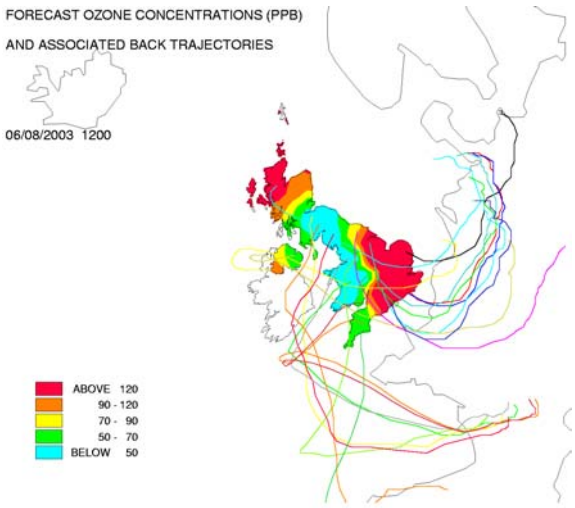

Figure 8 – Four day forecast back trajectories UK, 6th August 2003

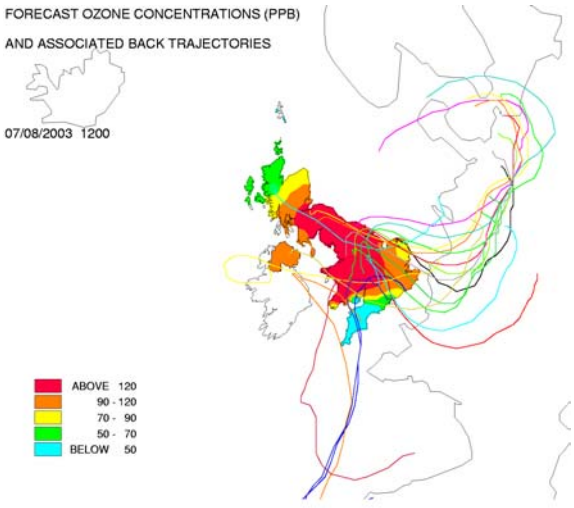

Figure 9 – Four day forecast back trajectories UK, 7th August 2003

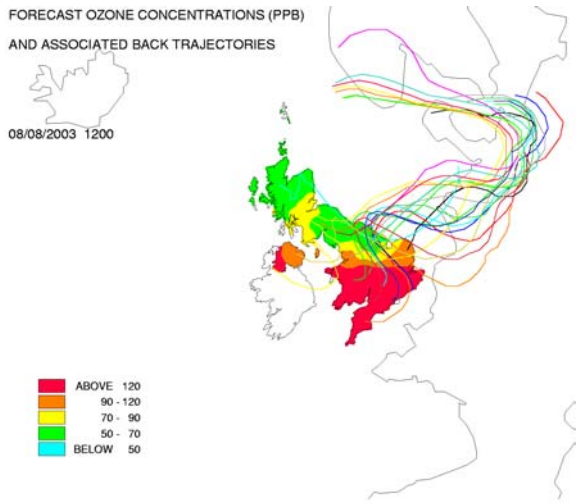

Figure 10 – Four day forecast back trajectories UK, 8th August 2003

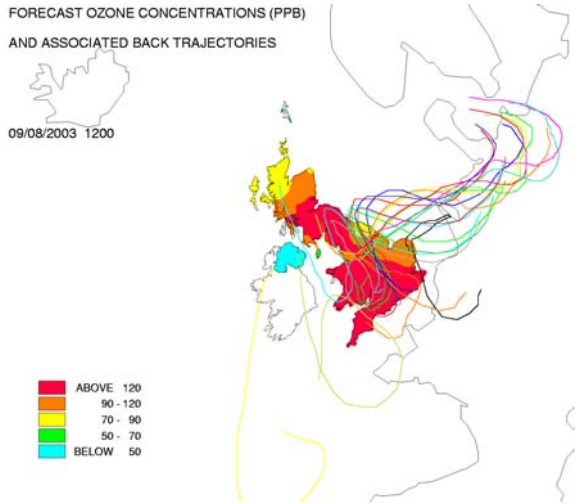

Figure 11 – Four day forecast back trajectories UK, 9th August 2003

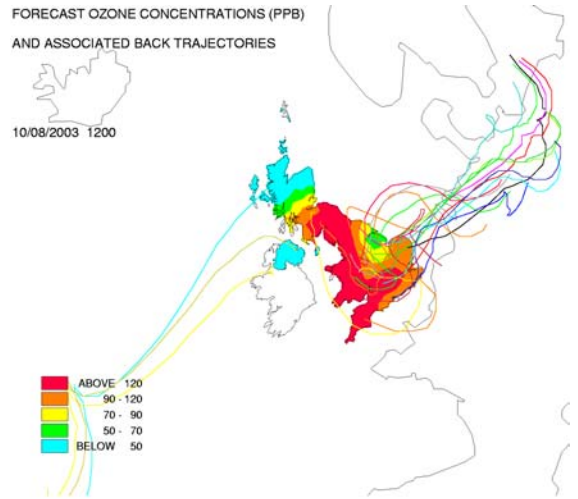

Figure 12 – Four day forecast back trajectories UK, 10th August 2003

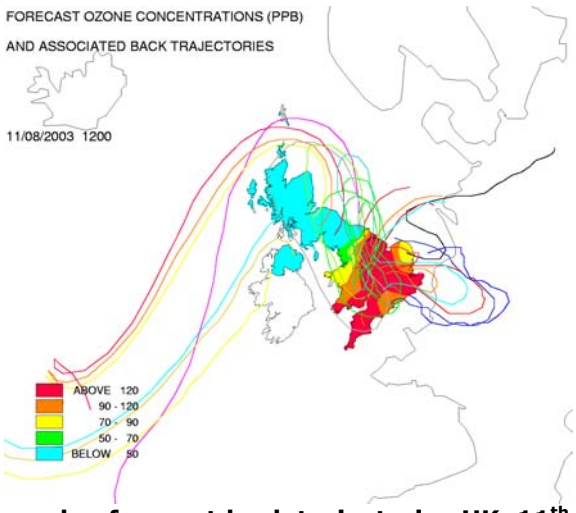

Figure 13– Four day forecast back trajectories UK, 11th August 2003

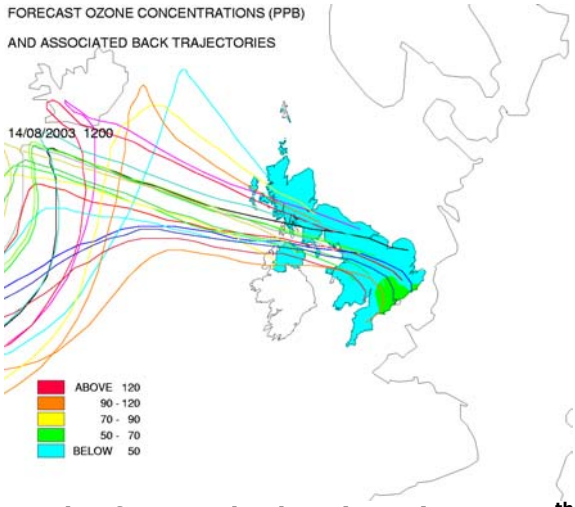

Figure 14 – Four day forecast back trajectories UK, 14th August 2003