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

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INTRODUCTION

For a period of 4 days in mid-July, the UK rural and urban air quality monitoring networks recorded ozone levels in the Defra HIGH band (180-360 μgm^{-3}). 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 8th to 20th July as before and after this period, the number of sites reporting MODERATE concentrations could be considered to be normal for the time of year. In total, 25 sites reported HIGH concentrations over this period and all but 2 sites in the network (Marylebone Road and Sandwell West Bromwich) reported MODERATE concentrations.

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 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 each site to have reported HIGH concentrations or above. The number of sites charted in figure 1 has been reduced to a select number, best representing each zone/ agglomeration as there were too many sites reporting HIGH concentrations to meaningfully present in a single graph. Figures 2 through 9 are back trajectory charts showing the forecast origin of air masses affecting the UK over the period.

DEVELOPMENT OVER TIME

- Over the period Friday 11th to Monday 14th July, a high pressure system moved in from the south west to cover the UK and northern France by 13th July. This high pressure brought clear, hot weather over the whole of the UK for the period. Long, unbroken spells of sunshine resulted in temperatures which were typically between 25 and 32 °C. These ideal conditions for the formation of ozone resulted in a strong diurnal trend in concentrations with peaks reached in the late afternoon around 16.00 each day and depleted concentrations overnight through deposition to the surface. Ozone concentrations followed the classical ozone episode trend, building over several days. These diurnal characteristics are illustrated well in figure 1. Throughout the episode, back trajectories show that winds originated over the Atlantic but looped around over the UK, potentially picking up ozone precursor pollutants.

- The winds on 8th July were due westerly, bringing clean Atlantic air to the UK which resulted in all network sites reporting LOW ozone concentrations. These air masses were still originating over the Atlantic on 10th July but, as the back trajectory in figure 2 shows, the air was looping over southern England and the coastline of the continent in the preceding hours before measurement. It is likely that the air masses were passing over sources of ozone precursors during this time. This mainly affected areas of the south and east of England and figure 1 shows that sites in these areas were recording rising levels. London Teddington, Harwell, Sibton and Somerton (all of which later reported HIGH concentrations) were all reporting ozone levels in the MODERATE band at this stage. Table 1 shows that 25 sites reported MODERATE concentrations on 10th July and the maximum hourly

concentration was 168 μgm^{-3}, just below the HIGH band, which was measured at Harwell in the south east zone.

- On 11th July, winds became due westerly again (figure 3) and passed over no significant sources of ozone precursors. The number of network sites reporting MODERATE concentrations correspondingly dropped to 4, despite the continued hot, sunny weather.

- The 12th July saw an increase in concentrations again with 34 sites reporting MODERATE concentrations and maximum hourly concentrations again just below the HIGH band at 164 μgm^{-3}. The weather remained hot and sunny and the back trajectories on both 11th (figure 3) and 12th (figure 4) July were very similar. The increased levels on 12th compared with the previous day are typical of an ozone episode which tend to 'build up' over several days in the lower atmosphere. These increases may also have been exacerbated by the very slight northerly shift of winds. These would have brought air which had passed over sources of ozone precursors in Northern Ireland and industrial areas of Wales and north west England to the exceptionally hot south east England. Winds affecting the south east on 11th had passed over only rural Ireland and Wales.

- The height of the episode occurred between 13th and 16th of July when air was passing from the Atlantic and looping over the UK at northern Europe before returning to the UK (figures 5 to 7). The escalation of ozone concentrations in the UK during this time is likely due to domestic emissions of ozone precursors reacting under sunny, hot, ideal conditions. On 14th, and particularly 15th, incoming pollutants from Europe may have further compounded these domestic ozone precursors. This resulted in concentrations breaching the HIGH band for the first time on 13th - 3 sites reported HIGH concentrations and 68 sites reported MODERATE concentrations on this day. Figure 5 shows that winds affecting north of England had the greatest potential for having gathered ozone precursors because they had travelled over the greatest land area in the hours before hand. This explains why the Wigan Leigh site (North West & Merseyside) and Middlesbrough site (North East Zone) measured HIGH concentrations. The other site to record HIGH concentrations was Harwell which is regularly reports some of the highest ozone concentrations in the network, likely due to it's rural location and lack of a traffic related NO_x scavenging effect. Data from Harwell over this period may be over-reading by as much as 15% and is currently under investigation.

- The following day (14th July) saw concentrations at Harwell remain well within the HIGH band. There were 3 other sites recording HIGH concentrations on this day: Port Talbot, Cardiff Centre and Strath Vaich. This is consistent with the back trajectories in figure 6, which shows air passing over northern Europe and southern England before reaching Wales and passing over northern Europe and the length of the UK before reaching Scotland.

- The culmination of the episode occurred on 15th July with 19 network sites reporting HIGH concentrations and 71 reporting MODERATE levels. The maximum hourly concentration on this day was 282 μgm^{-3} at Harwell. This would have represented one of the highest ozone concentrations recorded in the UK since 1990 but the analyser may be over reading by 15% compared with **netcen**'s reference photometer. Re-scaling of this provisional data will result in a maximum hourly concentration of some 40 μgm^{-3} lower which is more consistent with the maximum hourly concentrations reported by other sites in the network the time. The back trajectories for this day (figure 7) indicate that ozone precursors from Europe are likely to have been compounding domestic levels and this would account for episode reaching its height on this day.

- From 16th July onwards, the path of the air masses became more scattered (figure 7) as the high pressure system broke down to be replaced by unsettled periods of low pressure. By 18th July, winds were again westerly (figure 8) and with the decline in the temperatures, increasing cloud cover and reduction in ozone precursors, levels of ozone in UK dropped back into the MODERATE and LOW bands.

SUMMARY

This was a typical ozone episode resulting from ideal, hot weather conditions and air masses passing over sources of ozone precursor pollutants. Ozone episodes in the UK usually result from hot, sunny conditions and incoming ozone precursor pollutants from European sources borne on easterly or south easterly winds. This episode was predominantly fuelled by domestic emissions of these precursors with a possible but smaller contribution from the continent at the height of the episode.

Table 1 – Ozone concentrations by date and band

Date	Number of MOD sites	Number of HIGH sites	Number of V HIGH sites	Maximum exceedence (μgm^{-3})
09/07/03	5	-----	-----	110
10/07/03	25	-----	-----	168
11/07/03	4	-----	-----	106
12/07/03	34	-----	-----	164
13/07/03	68	3	-----	202
14/07/03	61	4	-----	238
15/07/03	71	19	-----	282
16/07/03	71	5	-----	248
17/07/03	22	-----	-----	132
18/07/03	1	-----	-----	140
19/07/03	13	-----	-----	148

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 (μgm^{-3})
Harwell	8	3	-----	282
Bottesford	8	2	-----	196
Cardiff Centre	5	2	-----	192
Port Talbot	5	2	-----	192
Liverpool Speke	5	2	-----	214
Sibton	8	1	-----	212
Lullington Heath	7	1	-----	186
London Teddington	7	1	-----	190
Thurrock	7	1	-----	180
Bournemouth	6	1	-----	200
Somerton	6	1	-----	188
London Brent	6	1	-----	192
Northampton	6	1	-----	208
Wigan Leigh	6	1	-----	200
Swansea	5	1	-----	180
Leamington Spa	5	1	-----	210
Coventry Memorial Park	5	1	-----	198
Birmingham East	5	1	-----	192
Aston Hill	5	1	-----	182
Leicester Centre	5	1	-----	202
Norwich Centre	5	1	-----	248
Blackpool	5	1	-----	192
Middlesbrough	5	1	-----	180
Strath Vaich	5	1	-----	180
Wicken Fen	3	1	-----	186
Rochester	8	-----	-----	154
London Eltham	7	-----	-----	178
London Bexley	7	-----	-----	156
St Osyth	7	-----	-----	178
Weybourne	7	-----	-----	150
Yarner Wood	6	-----	-----	178
Portsmouth	6	-----	-----	168
Southampton Centre	6	-----	-----	156
Bristol Centre	6	-----	-----	148

Site	Number days MODERATE	Number days HIGH	Number days VERY HIGH	Maximum hourly/ 8 hourly mean mean (μgm^{-3})
London Southwark	6	-----	-----	154
London Hillingdon	6	-----	-----	164
London Westminster	6	-----	-----	152
London N. Kensington	6	-----	-----	170
Redcar	6	-----	-----	174
London Lewisham	5	-----	-----	164
London Bloomsbury	5	-----	-----	140
Southend-on-Sea	5	-----	-----	140
Cwmbran	5	-----	-----	172
Ladybower	5	-----	-----	158
Glazebury	5	-----	-----	178
Salford Eccles	5	-----	-----	168
Bolton	5	-----	-----	178
Preston	5	-----	-----	172
Belfast Centre	5	-----	-----	162
Great Dun Fell	5	-----	-----	154
Plymouth Centre	4	-----	-----	140
London Wandsworth	4	-----	-----	138
Narberth	4	-----	-----	160
Birmingham Centre	4	-----	-----	158
Wolverhampton Centre	4	-----	-----	156
Stoke-on-Trent Centre	4	-----	-----	158
Manchester Piccadilly	4	-----	-----	154
Bradford Centre	4	-----	-----	160
Derry	4	-----	-----	164
Eskdalemuir	4	-----	-----	138
Bush Estate	4	-----	-----	134
Exeter Roadside	3	-----	-----	148
London Hackney	3	-----	-----	142
London Haringey	3	-----	-----	142
Nottingham Centre	3	-----	-----	142
Manchester South	3	-----	-----	142
Wirral Tranmere	3	-----	-----	128
Sheffield Centre	3	-----	-----	152
Rotherham Centre	3	-----	-----	146
Barnsley Gawber	3	-----	-----	140
Hull Freetown	3	-----	-----	132
Leeds Centre	3	-----	-----	146
High Muffles	3	-----	-----	140
Newcastle Centre	3	-----	-----	158
Bury Roadside	1	-----	-----	110
Lough Navar	1	-----	-----	100
Glasgow Centre	1	-----	-----	110
Edinburgh Centre	1	-----	-----	108

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.

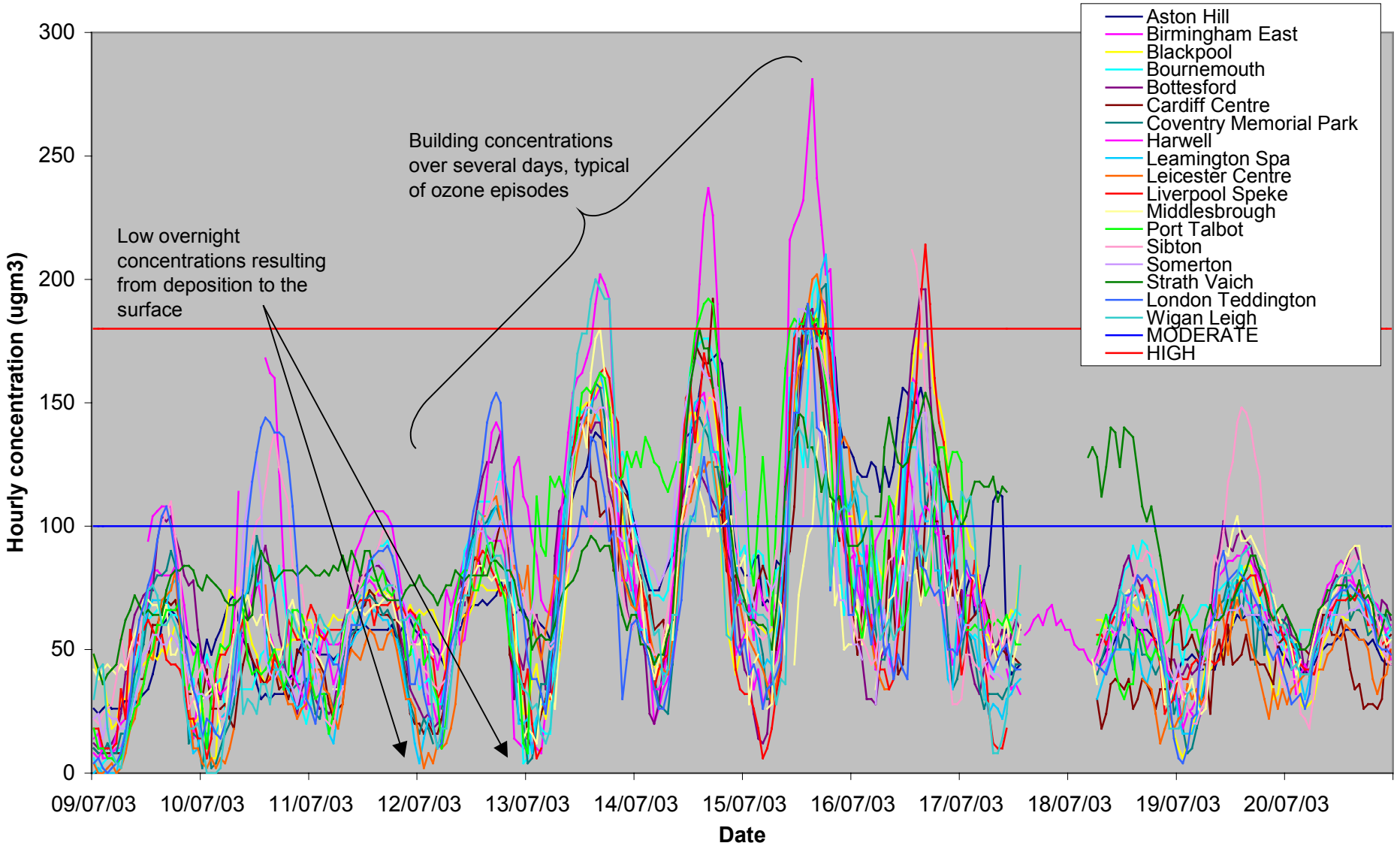

Figure 1 – Hourly ozone concentrations at sites which reported HIGH concentrations over the episode

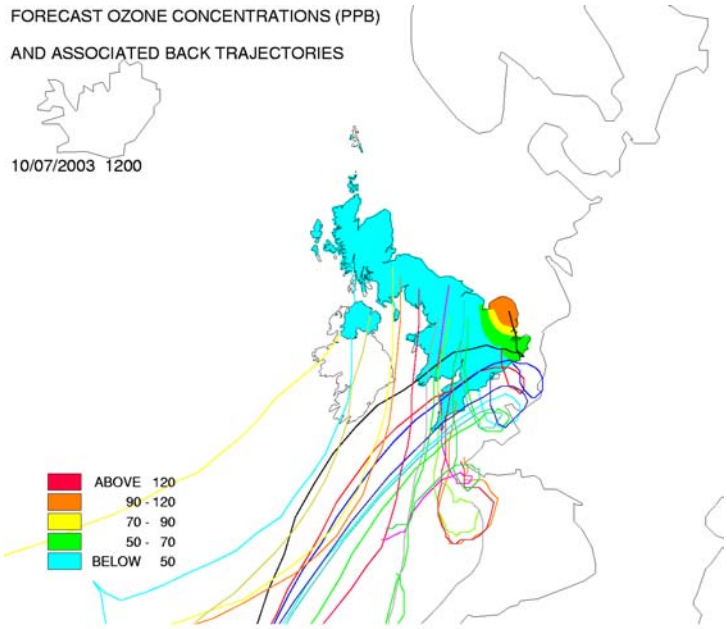

Figure 2 – Four day forecast back trajectories UK, 10th July 2003

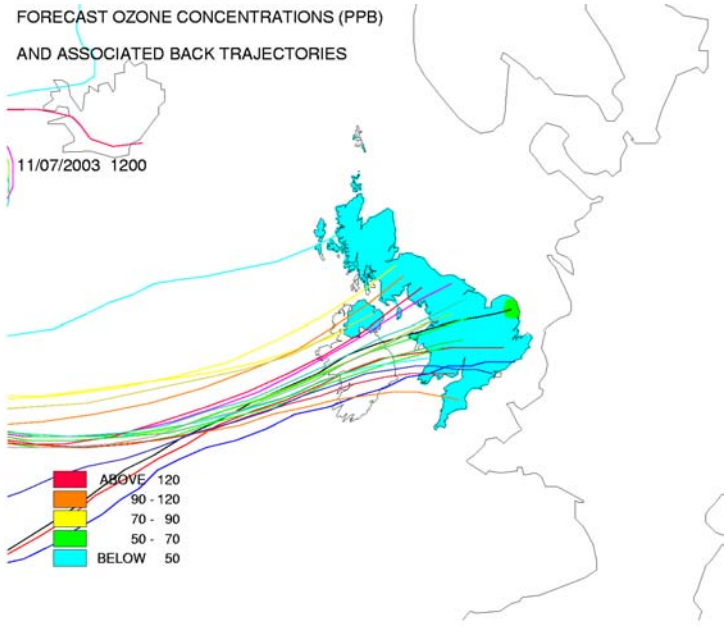

Figure 3 – Four day forecast back trajectories UK, 11th July 2003

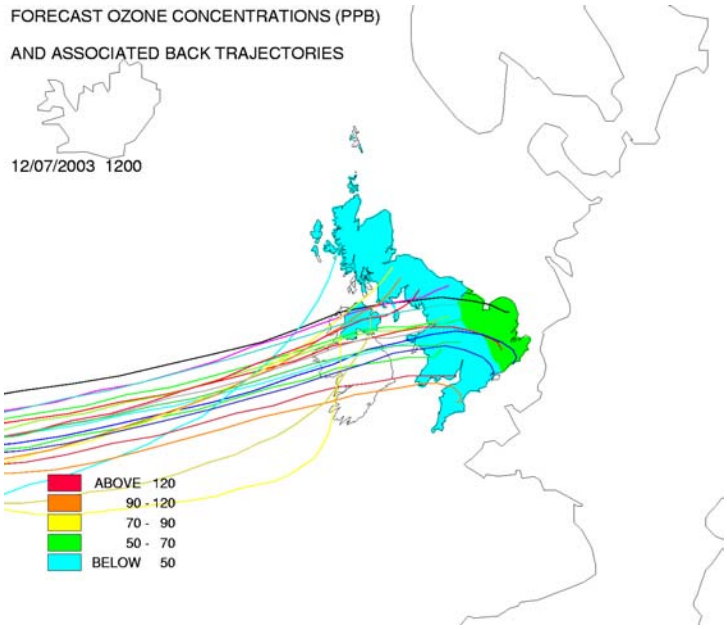

Figure 4 – Four day forecast back trajectories UK, 12th July 2003

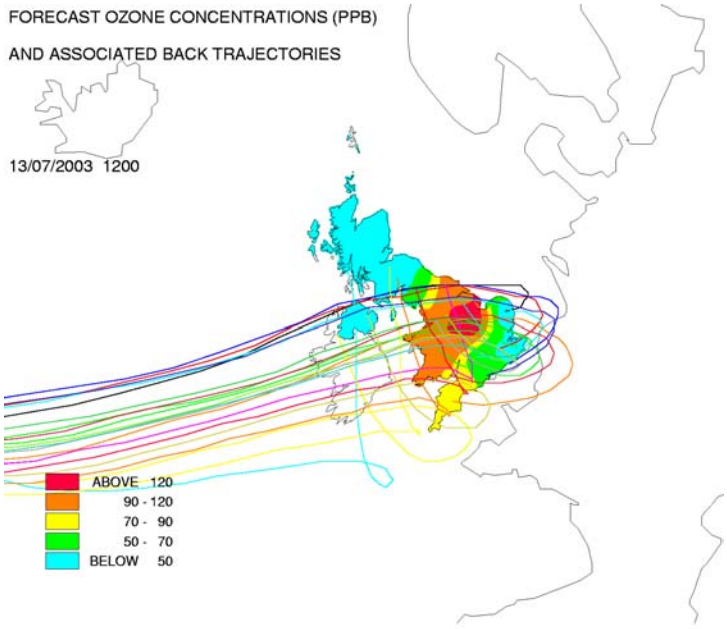

Figure 5 – Four day forecast back trajectories UK, 13th July 2003

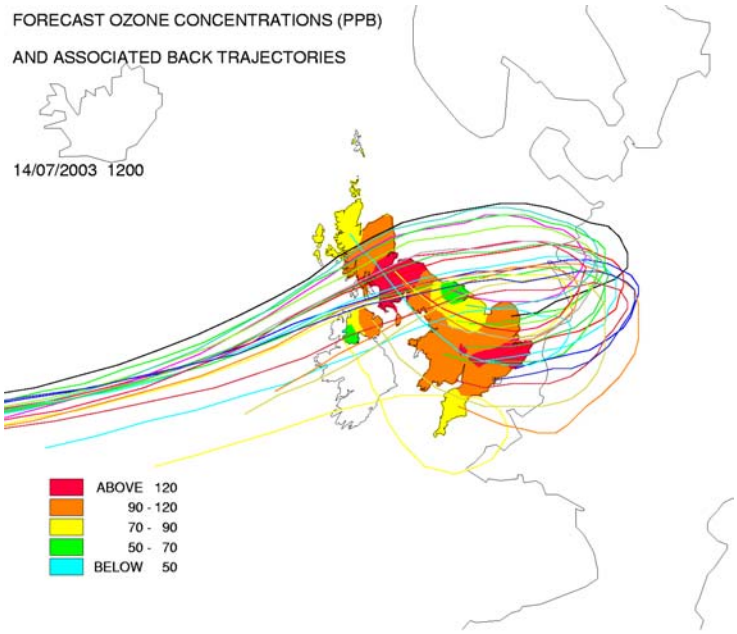

Figure 6 – Four day forecast back trajectories UK, 14th July 2003

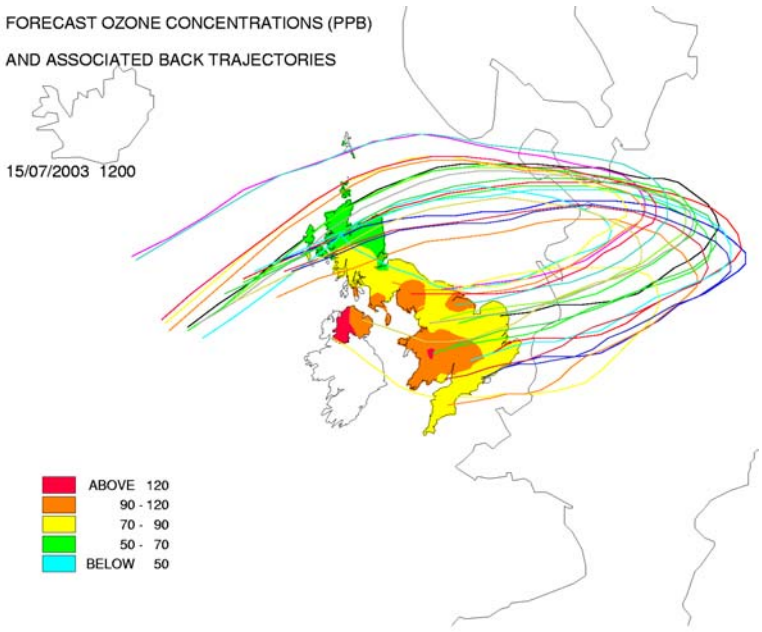

Figure 7 – Four day forecast back trajectories UK, 15th July 2003

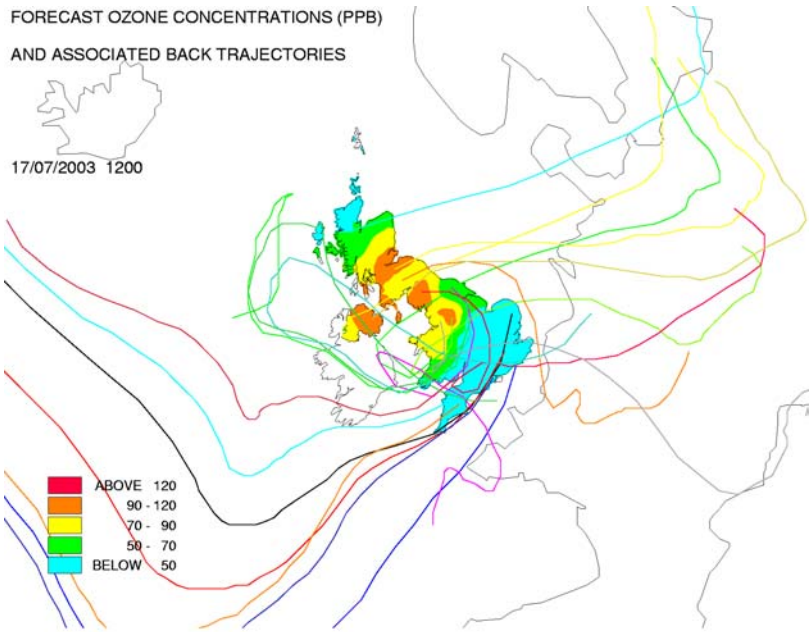

Figure 8 – Four day forecast back trajectories UK, 17th July 2003

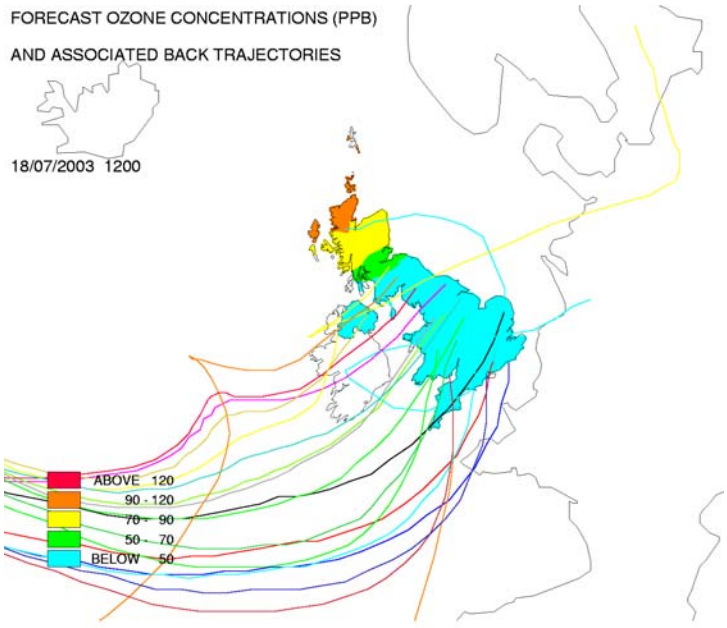

Figure 9 – Four day forecast back trajectories UK, 18th July 2003