Air Pollution Forecasting: Pollution Episode Report (May/June 2003)

Andrew Kent, **netcen**
10/6/2003

INTRODUCTION

From the end of May through to the beginning of June 2003, the UK rural and urban networks recorded elevated ozone levels. Between May 27th and June 3rd, there were 9 network sites that recorded HIGH concentrations and 65 that recorded MODERATE concentrations of ozone. HIGH concentrations were reported on 3 days during the period, 29th to 31st May.

The purpose of this report is to detail the extent and duration of the AQS Objective exceedences resulting from 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, 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 reporting HIGH concentrations or above. Figures 2 through 9 are back trajectory charts showing the forecast origin of air masses affecting the UK over the period.

DEVELOPMENT OVER TIME

- **27th May**

At the start of the period covered by this report, on 27th May, there were only 3 sites in the network reporting MODERATE concentrations. These were Norwich Centre, Sibton and Strath Vaich, none of which would report HIGH concentrations later in the episode. The highest hourly concentration on this day was 59 ppb (recorded at Strath Vaich). Winds at the time (see back trajectory in Figure 2) were south westerly, bringing relatively clean air to the United Kingdom. This explains the low number of sites reporting MODERATE concentrations. Those sites that did report MODERATE levels are easily explained by the wind direction. Sibton and Norwich are both in the far east of England and, despite originating over the Atlantic, air masses affecting these sites would have had opportunity to gather ozone precursors from UK sources and allowed them to form ozone. Similarly, following the back trajectory for Scotland, it is apparent that the air affecting Strath Vaich has come from the Atlantic but has travelled a considerable distance up the length of the UK before arriving in Scotland. The weather at the time was unsettled with moderate winds and showers following the passing of a low pressure area that had dominated over the previous days. Although there were some sunny intervals between showers, these were not prolonged and temperatures were typically no higher than 16°C – not enough to activate the chemical reactions necessary to generate a HIGH ozone episode.

- **28th May**

As table 1 shows, although on this day there were still no HIGH concentrations being reported, there was a significant increase in the area of the UK experiencing MODERATE ozone concentrations. The number of network sites reporting MODERATE levels rose from 3 to 25 and the maximum hourly concentration had risen to 82 ppb, well into the MODERATE band. The low pressure of the previous days had given way to a large area of high pressure situated over south east England, northern Europe and southern parts of Scandinavia. As a result, winds over the following days were to become lighter and swing round to become easterly and temperatures were expected to reach 23°C in the south east with prolonged periods of sunshine. As figure 3 (back trajectory for 28th May) shows, winds were beginning to move away from the south westerly direction and south eastern England was being affected by air that had crossed much

of southern England in the preceding hours. Northern England, Scotland and Northern Ireland was receiving clean air masses that had past over only Ireland and the sea.

- **29th May**

With high pressure firmly established over south east England there was a marked change in the wind direction on 29th May. The back trajectory (figure 4) illustrates that northern, central and southern England and Wales was affected by continental air from the east that had passed over significant sources of ozone precursors including Scandinavian oil refineries and the German industrial heartland. Even cleaner air over Scotland and Northern Ireland had passed over some parts of the UK in the preceding hours. The presence of ozone precursors with the continued fine weather and high temperatures necessary for the chemical reactions to form ozone caused the episode to develop rapidly over the day. The result was a further increase in the number of sites reporting MODERATE concentrations to 68 and 6 network sites reporting concentrations in the HIGH band. The 6 sites reporting HIGH concentrations were Bournemouth (91 ppb maximum hourly concentration), Cardiff Centre (90 ppb), Harwell (106 ppb) Port Talbot (90 ppb), Wigan Leigh (94 ppb) and Yarner Wood (92 ppb). This was the peak of the episode.

- **30th May**

The episode was beginning to subside from 30th May onward although the weather conditions remained stable and fine with persistent easterly winds. Bournemouth, Cardiff Centre, Port Talbot and Wigan Leigh reported concentrations that had dropped into the MODERATE band. Concentrations at Lullington Heath had increased to the HIGH band with a maximum hourly concentration of 90 ppb. Harwell and Yarner Wood both remained in the HIGH band with hourly concentrations of up to 106 ppb and 95 ppb respectively. This resulted in a drop from 6 to 3 sites reporting HIGH ozone concentrations and an increase to 70 sites reporting MODERATE concentrations on 30th May, as shown in table 1.

- **31st May**

The back trajectory for 31st May (figure 6) indicates that the wind direction shifted from the east. Winds were still originating from the continent and passing over France to arrive at the UK from the south west. There was a decline in the episode as the number of sites reporting HIGH concentrations dropped to 2 (Leicester Centre and Middlesbrough) and the number of sites reporting MODERATE concentrations decreased to 69. Interestingly, despite the shift in wind direction and the general decline in ozone levels across the UK, the maximum hourly concentration of ozone over the entire episode (119 ppb) was recorded on this day at Middlesbrough. This sudden peak in ozone concentrations in NE England has been seen before and may be related to emissions of VOCs or particulates from nearby petrochemical industries. Leicester Centre, the other site reporting HIGH concentrations, recorded a maximum hourly concentration of 101 ppb.

- **1st June**

The back trajectories (figure 7) show that the winds continued to originate over the continent and arrive at the UK from the south west. However, the decline in ozone levels resulting shift from the due easterly wind direction is apparent on this day. The episode decline markedly – no sites reported HIGH concentrations and the number of sites reporting MODERATE concentrations was down to 43. The maximum hourly ozone concentration was 71 ppb (reported by Strath Vaich).

- **2nd to 3rd June**

As figures 8 and 9 show, the winds over these two days had returned to the south west, bringing clean Atlantic air to the UK. These two days saw the onset of unsettled weather and a return to low pressure dominating the UK weather conditions. Correspondingly, the ozone levels dropped with only 8 network sites reporting MODERATE concentrations on 2nd June and only 5 on 3rd June. The maximum hourly concentration was 58 ppb on 2nd June and 61 ppb the following day – well below the HIGH band.

CONCLUSION

The elevated ozone between 27th May and 3rd June was a classic ozone event. The major causal factor was a persistent easterly wind direction that supplied continental air masses laden with ozone precursors. The supply of abundant ozone precursors, in the presence of rising temperatures and long, unbroken sunshine provided perfect conditions for the generation of ozone.

Table 1 – Ozone concentrations by date and band

Date	Number of MOD sites	Number of HIGH sites	Number of V HIGH sites	Maximum exceedence (µg m-3)
27/05/03	3	-----	-----	59
28/05/03	25	-----	-----	82
29/05/03	68	6	-----	106
30/05/03	70	3	-----	106
31/05/03	69	2	-----	119
01/06/03	43	-----	-----	71
02/06/03	8	-----	-----	58
03/06/03	5	-----	-----	61

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)
Harwell	6	2	-----	106
Yarner Wood	3	2	-----	95
Wigan Leigh	6	1	-----	94
Lullington Heath	5	1	-----	90
Bournemouth	4	1	-----	91
Cardiff Centre	4	1	-----	90
Leicester Centre	4	1	-----	101
Middlesbrough	4	1	-----	119
Port Talbot	4	1	-----	90
Sibton	7	-----	-----	89
Strath Vaich	7	-----	-----	85
Bottesford	6	-----	-----	82
London Teddington	6	-----	-----	82
Birmingham East	5	-----	-----	78
Bolton	5	-----	-----	89
Cwmbran	5	-----	-----	87
Hull Freetown	5	-----	-----	69
London Brent	5	-----	-----	79
London Haringey	5	-----	-----	76
London N. Kensington	5	-----	-----	81
London Westminster	5	-----	-----	72
Northampton	5	-----	-----	85
Norwich Centre	5	-----	-----	74
Redcar	5	-----	-----	76
Rochester	5	-----	-----	80
Southend-on-Sea	5	-----	-----	74
St Osyth	5	-----	-----	74
Swansea	5	-----	-----	74
Thurrock	5	-----	-----	78
Wicken Fen	5	-----	-----	77
Barnsley Gawber	4	-----	-----	71
Birmingham Centre	4	-----	-----	78
Blackpool	4	-----	-----	81
Coventry Memorial Park	4	-----	-----	83
Ladybower	4	-----	-----	81
Leamington Spa	4	-----	-----	82
Leeds Centre	4	-----	-----	67
Liverpool Speke	4	-----	-----	86
London Bexley	4	-----	-----	85
London Eltham	4	-----	-----	76
London Hackney	4	-----	-----	67

Site	Number days MODERATE	Number days HIGH	Number days VERY HIGH	Maximum hourly / 8 hourly mean mean (ppb)
London Wandsworth	4	-----	-----	69
Newcastle Centre	4	-----	-----	76
Nottingham Centre	4	-----	-----	64
Portsmouth	4	-----	-----	81
Rotherham Centre	4	-----	-----	73
Salford Eccles	4	-----	-----	77
Southampton Centre	4	-----	-----	68
Wolverhampton Centre	4	-----	-----	80
Aston Hill	3	-----	-----	78
Belfast Centre	3	-----	-----	84
Bradford Centre	3	-----	-----	66
Bristol Centre	3	-----	-----	58
Bush Estate	3	-----	-----	72
Derry	3	-----	-----	76
Glazebury	3	-----	-----	75
Great Dun Fell	3	-----	-----	74
London Lewisham	3	-----	-----	78
London Southwark	3	-----	-----	76
Manchester Piccadilly	3	-----	-----	59
Manchester South	3	-----	-----	73
Narberth	3	-----	-----	67
Preston	3	-----	-----	80
Sandwell West Bromwich	3	-----	-----	78
Sheffield Centre	3	-----	-----	71
Somerton	3	-----	-----	87
Stoke-on-Trent Centre	3	-----	-----	67
Eskdalemuir	2	-----	-----	70
Exeter Roadside	2	-----	-----	70
London Hillingdon	2	-----	-----	71
Glasgow Centre	1	-----	-----	55
Lough Navar	1	-----	-----	55
Weybourne	1	-----	-----	60
Wirral Tranmere	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.

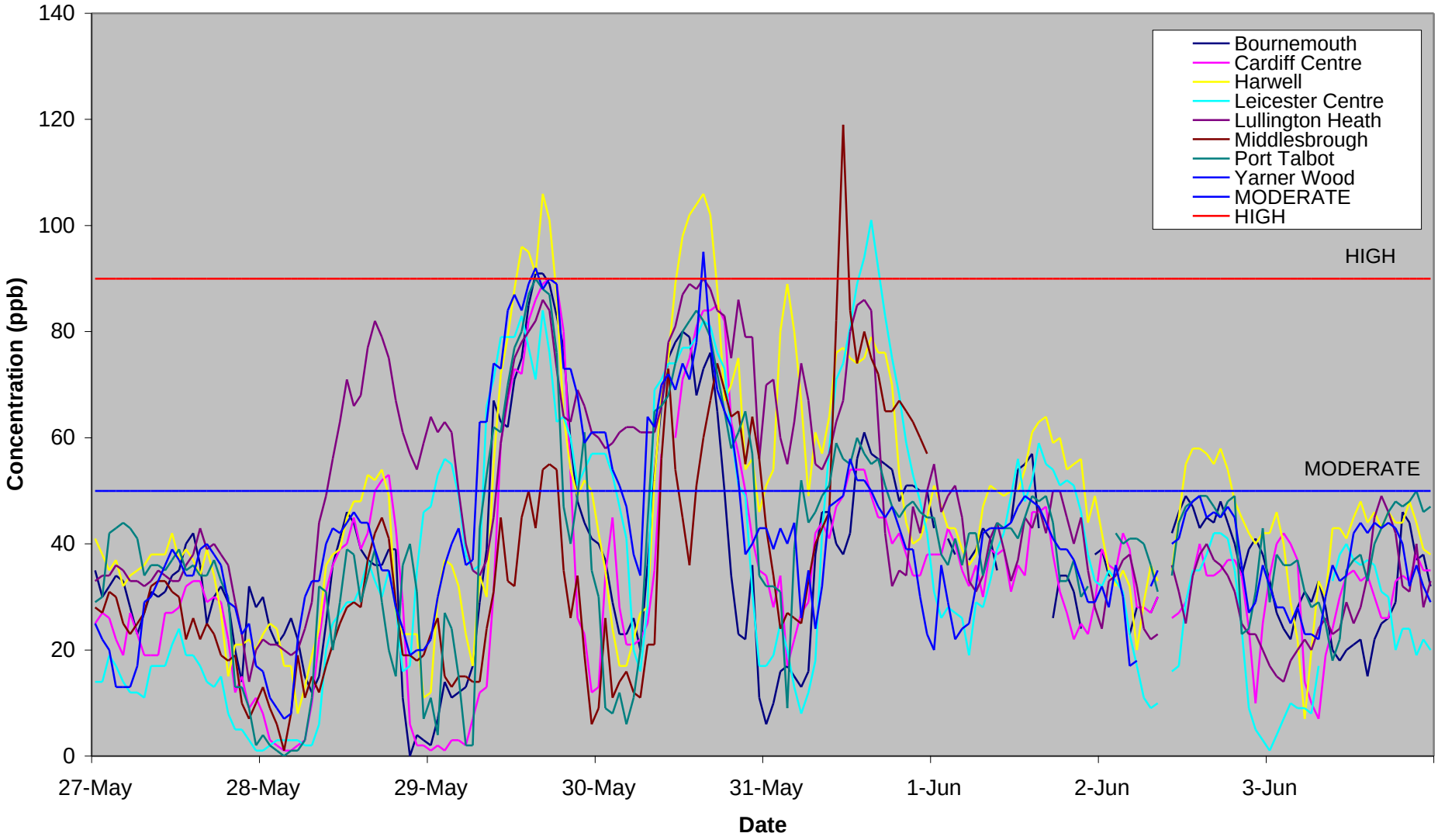

Figure 1 – Hourly ozone concentrations at sites which reported HIGH concentrations over the episode

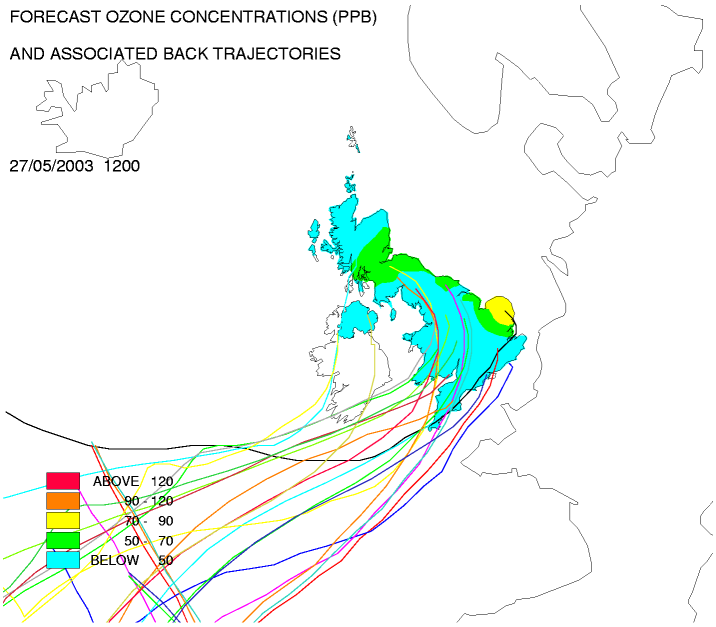

Figure 2 – Four day forecast back trajectories UK, 27th May 2003

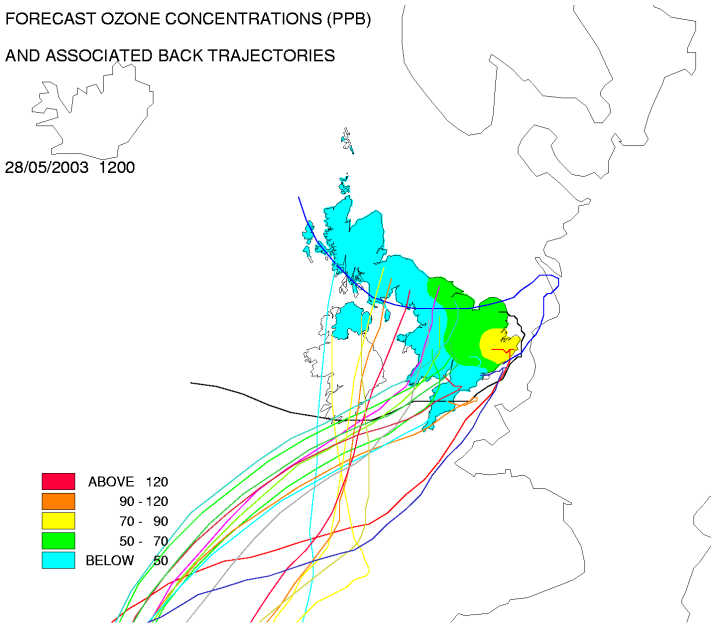

Figure 3 – Four day forecast back trajectories UK, 28th May 2003

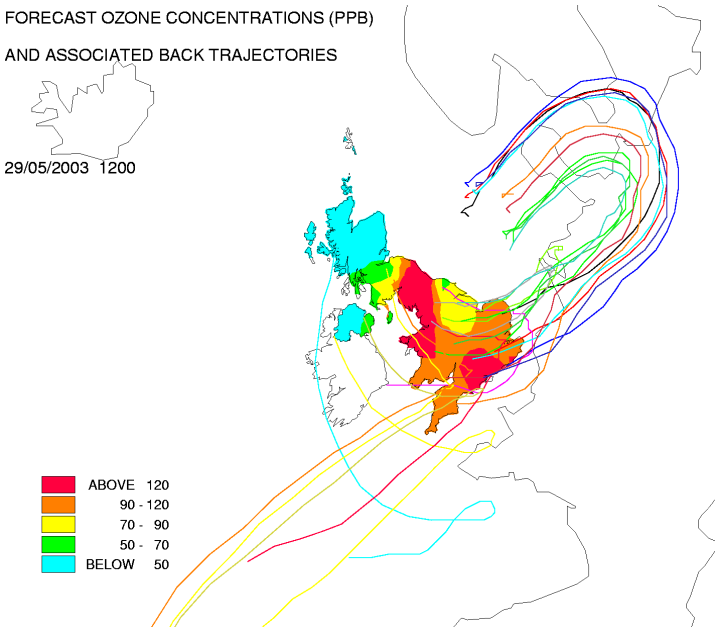

Figure 4 – Four day forecast back trajectories UK, 29th May 2003

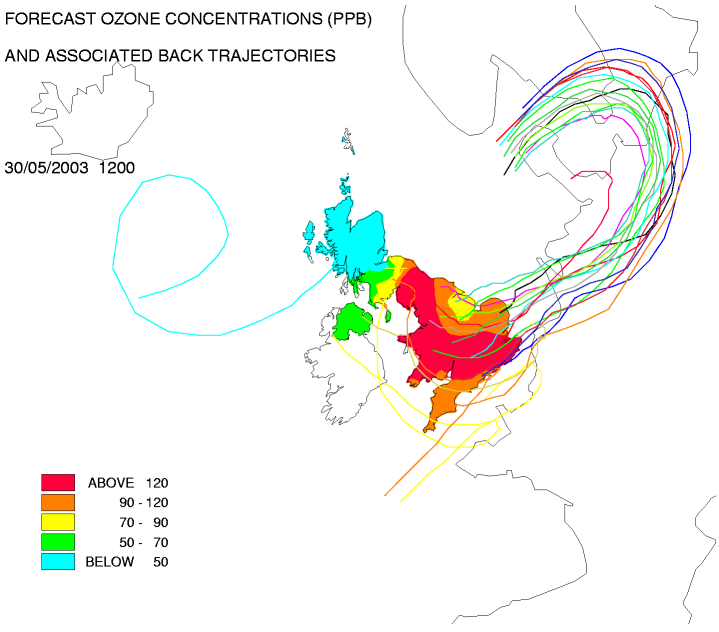

Figure 5 – Four day forecast back trajectories UK, 30th May 2003

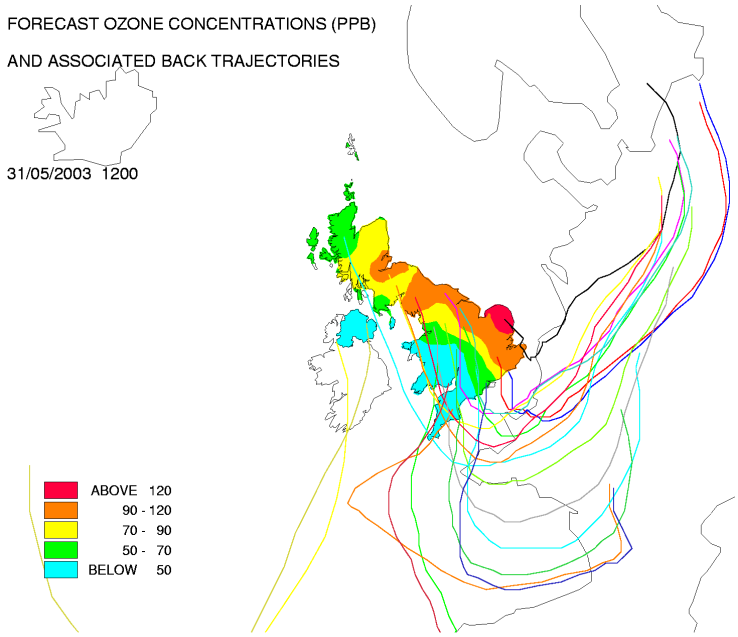

Figure 6 – Four day forecast back trajectories UK, 31st May 2003

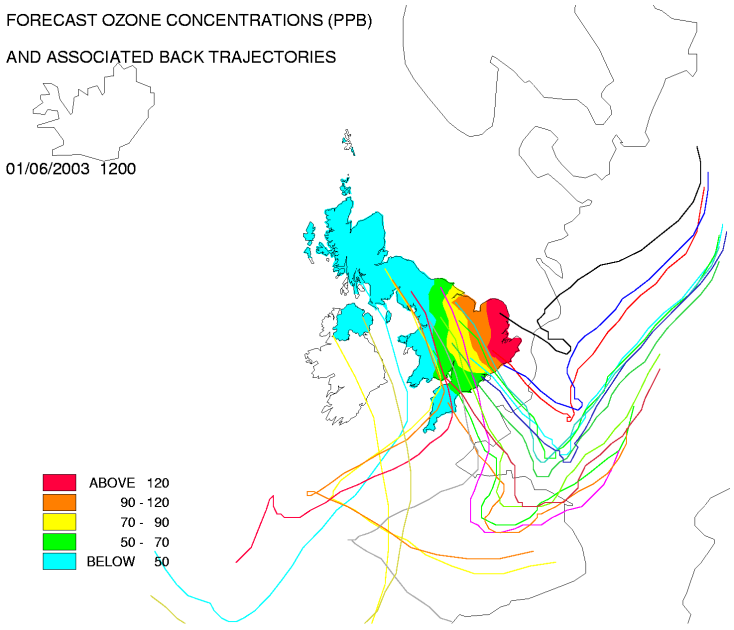

Figure 7 – Four day forecast back trajectories UK, 1st June 2003

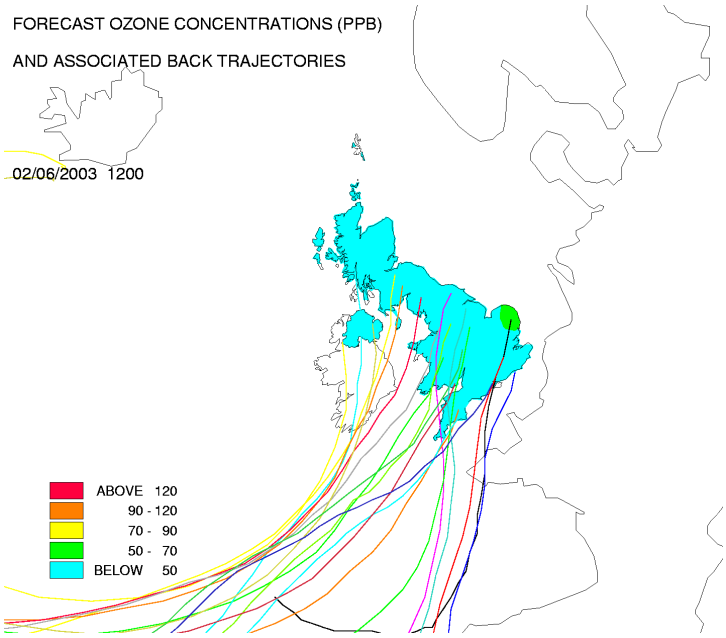

Figure 8 – Four day forecast back trajectories UK, 2nd June 2003

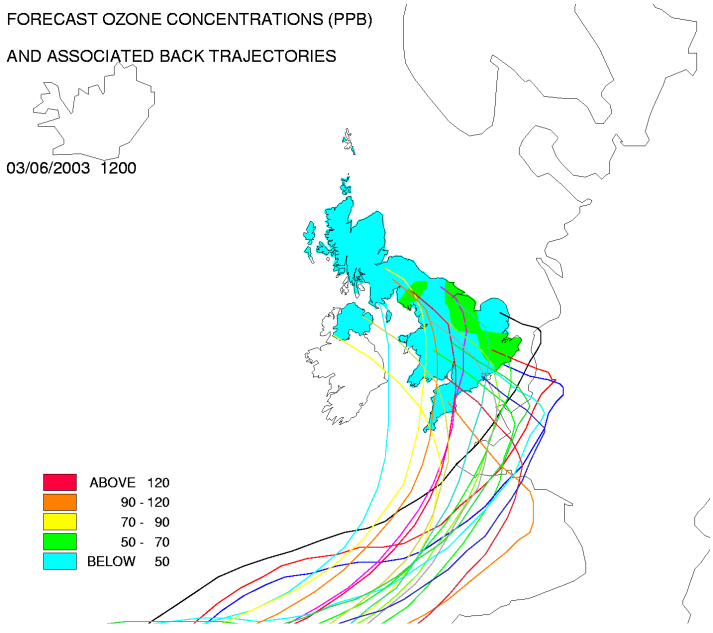

Figure 9 – Four day forecast back trajectories UK, 3rd June 2003