

Air Pollution Forecasting: Ozone episode report (July/August 2002)

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Introduction

Between Friday July 26th and Wednesday August 7th 2002, national networks recorded a summer ozone episode across much of the UK resulting from long periods of sunshine and high temperatures. The event was typically confined to the South, South east, East Anglia, London and the Midlands which were heavily influenced by continental air masses.

Measured levels of MODERATE ozone were widespread (at 61 sites) over the 13 days and the HIGH band was entered by 12 sites over two days. The culmination of the episode was on Monday 29th July, on which 40 sites measured MODERATE and 8 sites measured HIGH concentrations.

This report discusses the extent and duration of the episode and identifies some of the causal factors involved. As the final data for the period the event has yet to be ratified all statistics and charts are based on the provisional data used in the forecasting process.

Weather conditions

The weather during the event was dominated by stable conditions, high pressure and associated weak winds. The south east of the UK was fed by air masses from the continent (see Figure 4, page 9) bringing ozone precursors while the rest of the UK was fed by clean air originating over the Atlantic ocean.

- The weekend (27th and 28th July) weather was hot with extended sunny periods in the midlands, the south and the south east, which resulted in maximum temperatures of around 27°C. Winds at the time were westerly and clean air masses from the Atlantic dominated the UK weather (Figure 2, page 7). Winds over the weekend were extremely light.
- It was noted at this time that there was an area of high pressure moving north across the Bay of Biscay towards France. This arrived on Monday 29th July and resulted in winds moving round to the south (Figures 3 and 4, pages 8 and 9) bringing continental air masses to the South, South east, Midlands and East Anglia.
- From Monday 29th July onwards temperatures cooled although prolonged sunny periods in the south east persisted and the forecast heavy showers, thunderstorms and thickening cloud layer did not materialise.
- By Tuesday 30th July the UK was being influenced by two separate air masses. Easterly winds from the continent affected the south, south east, East Anglia, and Midlands. The rest of the UK was being fed by cleaner air from the Atlantic.
- Between Tuesday 30th July and Thursday 1st August levels dropped due to the heavier cloud and lower temperatures. The increased levels of NO_x that are typical in London during the working week were expected to reduce ozone levels in the city. On Wednesday the heavy thunder showers and lower temperatures that had been forecast finally materialised and widespread rain across the UK helped arrest the event.
- On Thursday 1st August the stagnant winds meant that the air affecting most of the UK had been lying over the UK for several days. East Anglia, the Midlands and Northern Ireland were still being fed by easterly winds from the continent.
- On Friday 2nd August and the following weekend saw levels of ozone rise again as more sun and increasing temperatures prevailed. The weekend continued to see stable high pressure conditions with weak winds. Most of the UK at this time was fed by Atlantic air but continental masses were affecting northern and eastern England. However, although MODERATE concentrations became more widespread, levels did not reach the HIGH band again.

Results

- Table 1 (below) shows the number of air quality monitoring stations recording MODERATE and HIGH concentrations on each day during the event. This illustrates how the episode developed over time. The changing trends in ozone formation and reduction were strongly related to the weather during the event, which is described above.
- There were only 3 sites measuring MODERATE concentrations on each day from Friday 26th and Saturday 27th July and the maximum hourly concentration was just into the MODERATE band.
- On Sunday 28th July the maximum hourly concentration escalated to 97 ppb (just into the HIGH band) due to increasing temperatures and bright, unbroken periods of sunshine. There were 26 sites measuring MODERATE concentrations on that day and 5 sites measuring HIGH concentrations.
- Heavy thundery showers and cooler temperatures were forecast for Monday 29th July and were expected to allow ozone levels to decline. The predicted thicker cloud cover and rain did not arise and on the Monday concentrations reached a peak with 40 sites measuring MODERATE levels of ozone and 8 sites measuring HIGH hourly levels of up to 100 ppb.
- Finally, on Tuesday and for most of the week, the forecast heavy cloud and ozone levels dropped off leaving only 18 sites with recorded levels in excess of 50 ppb and no sites measuring HIGH concentrations. Thundery rain showers forecast for earlier in the week occurred on Wednesday and Thursday. The HIGH concentrations recorded at Preston at this time are likely to have been erroneous (see below). Similarly, data from the Redcar station is likely to undergo significant re-scaling during ratification.
- By Friday 2nd August, typical high pressure conditions were reasserting themselves with increasing temperatures and prolonged sunshine. The number of sites recording MODERATE levels increased again, rising to 18 on Sunday 4th August before tailing off again. No further HIGH concentrations were recorded.
- Table 2 (page 5) lists each of the sites involved, the number of days on which they recorded MODERATE and HIGH concentrations and the maximum hourly concentration at each site.

Table 1 – changing UK ozone concentrations over time

Date	Number of sites in MODERATE band	Number of sites in HIGH band	Maximum hourly mean (ppb)
26-Jul-02	3	-----	58
27-Jul-02	3	-----	55
28-Jul-02	26	5	97
29-Jul-02	40	8	100
30-Jul-02	18	-----	78
31-Jul-02	7	-----	64
01-Aug-02	4	-----	66
02-Aug-02	5	1	94
03-Aug-02	13	-----	75
04-Aug-02	18	-----	65
05-Aug-02	16	-----	60
06-Aug-02	13	-----	61
07-Aug-02	11	-----	64

Figure 1 (page 4) is a time series graph showing the hourly concentrations of ozone at each site that entered the HIGH (90-180 ppb) band during the episode. The chart clearly shows the diurnal variation in ozone concentrations, with levels dipping markedly during the evenings. Preston is likely to have recorded spurious data possibly as a result of an analyser failure. The data from this site are not consistent with the patterns exhibited at the other sites recording HIGH concentrations during the event or consistent with other sites in the North west and Merseyside area. For example, on the 2nd and 3rd

August Preston recorded elevated levels that were not seen elsewhere. More significantly, these elevated concentrations were recorded during the night and very early in the morning when ozone levels should have been lower.

Figures 2 -4 show the forecast back trajectories for the period 27th–29th July during which levels were HIGH. These maps show the origin of air affecting the UK. Figure 2 shows south westerly clean winds which become progressively more southerly throughout the following days (Figure 3) until the south east of the UK is affected by continental air (Figure 4).

Summary

- Between Friday July 26th and Wednesday August 7th 2002, an episode of 'HIGH' ozone concentrations affected the UK.
- The areas affected were south east, central and eastern England, East Anglia and London.
- The episode culminated on Monday 29th July with 40 sites measuring MODERATE concentrations and 8 measuring HIGH concentrations.
- The episode was likely caused by a combination of high temperatures, long unbroken periods of intense sunshine driving chemical reactions in the atmosphere, and air masses from the continent containing ozone precursors.

Hourly time series of ozone concentrations (ppb) at sites entering the 'HIGH' band

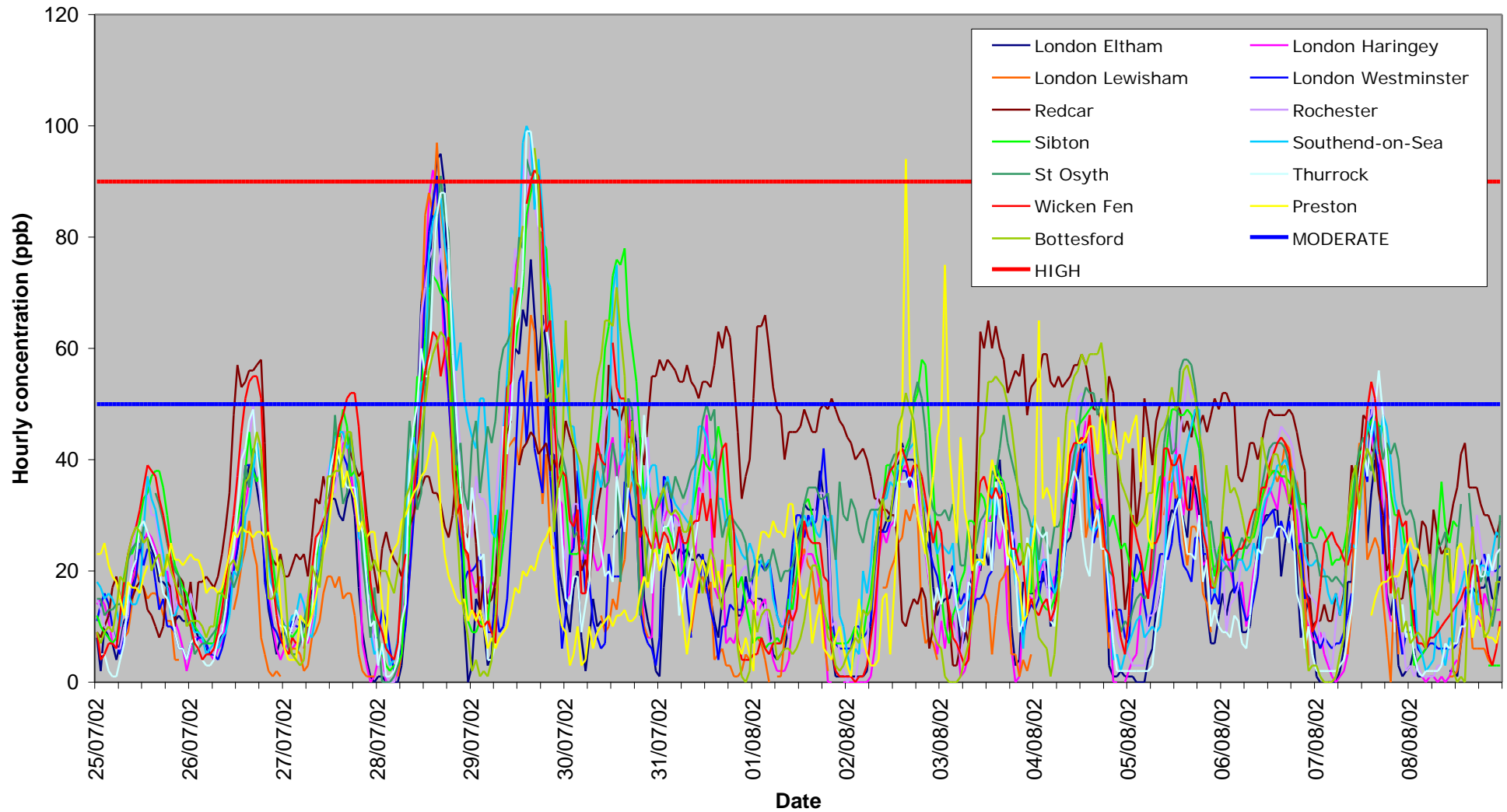


Figure 1 – time series chart of concentrations over time (ppb) at sites which entered the HIGH band

Table 2 – UK ozone concentrations at sites measuring MODERATE or HIGH levels during the event.

Site	Number of days of MODERATE pollution	Number of days of HIGH pollution	Maximum hourly mean (ppb)
London Haringey	3	2	92
St Osyth	7	2	94
Bottesford	7	1	96
London Eltham	2	1	95
London Lewisham	2	1	97
London Westminster	2	1	91
Preston	3	1	94
Rochester	7	1	97
Sibton	5	1	91
Southend-on-Sea	3	1	100
Thurrock	4	1	99
Wicken Fen	6	1	92
Redcar	8	-----	66
Weybourne	7	-----	79
High Muffles	5	-----	68
Aston Hill	4	-----	54
Coventry Memorial Park	4	-----	76
Ladybower	4	-----	59
London Teddington	4	-----	87
Lullington Heath	4	-----	89
Middlesbrough	4	-----	54
Norwich Centre	4	-----	77
Birmingham East	3	-----	66
Bolton	3	-----	54
Glazebury	3	-----	51
Harwell	3	-----	73
Leicester Centre	3	-----	73
London Brent	3	-----	87
London Hillingdon	3	-----	75
London N. Kensington	3	-----	80
Rotherham Centre	3	-----	59
Salford Eccles	3	-----	54
Yarner Wood	3	-----	58
Birmingham Centre	2	-----	67
Bristol Centre	2	-----	53
Cardiff Centre	2	-----	53
Liverpool Centre	2	-----	54
London Bexley	2	-----	72
London Bloomsbury	2	-----	80
London Hackney	2	-----	58
London Southwark	2	-----	72
London Wandsworth	2	-----	78
Nottingham Centre	2	-----	56
Reading	2	-----	85
Sheffield Centre	2	-----	67
Somerton	2	-----	61
Strath Vaich	2	-----	57
Wigan Leigh	2	-----	50
Wirral Tranmere	2	-----	60

Barnsley Gawber	1	-----	58
Blackpool	1	-----	57
Bradford Centre	1	-----	54
Derry	1	-----	57
Glasgow Centre	1	-----	52
Great Dun Fell	1	-----	53
Leamington Spa	1	-----	63
Leeds Centre	1	-----	55
Narberth	1	-----	66
Newcastle Centre	1	-----	51
Sandwell West Bromwich	1	-----	53
Southampton Centre	1	-----	64
Wolverhampton Centre	1	-----	53

FORECAST OZONE CONCENTRATIONS (PPB)
AND ASSOCIATED BACK TRAJECTORIES

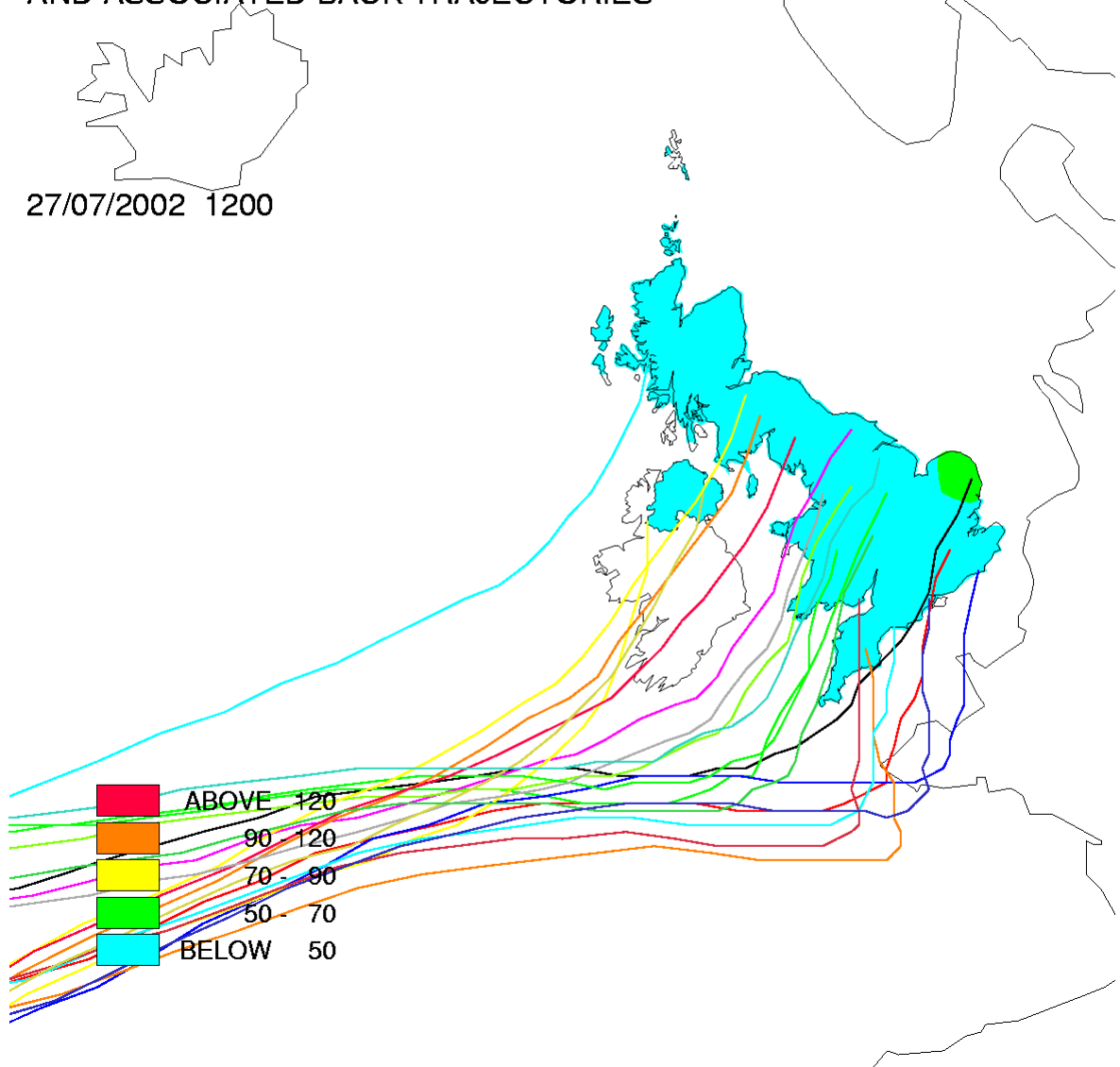


Figure 2 – forecast ozone back trajectories for the days with HIGH pollution (Sat 27th July)

FORECAST OZONE CONCENTRATIONS (PPB)
AND ASSOCIATED BACK TRAJECTORIES

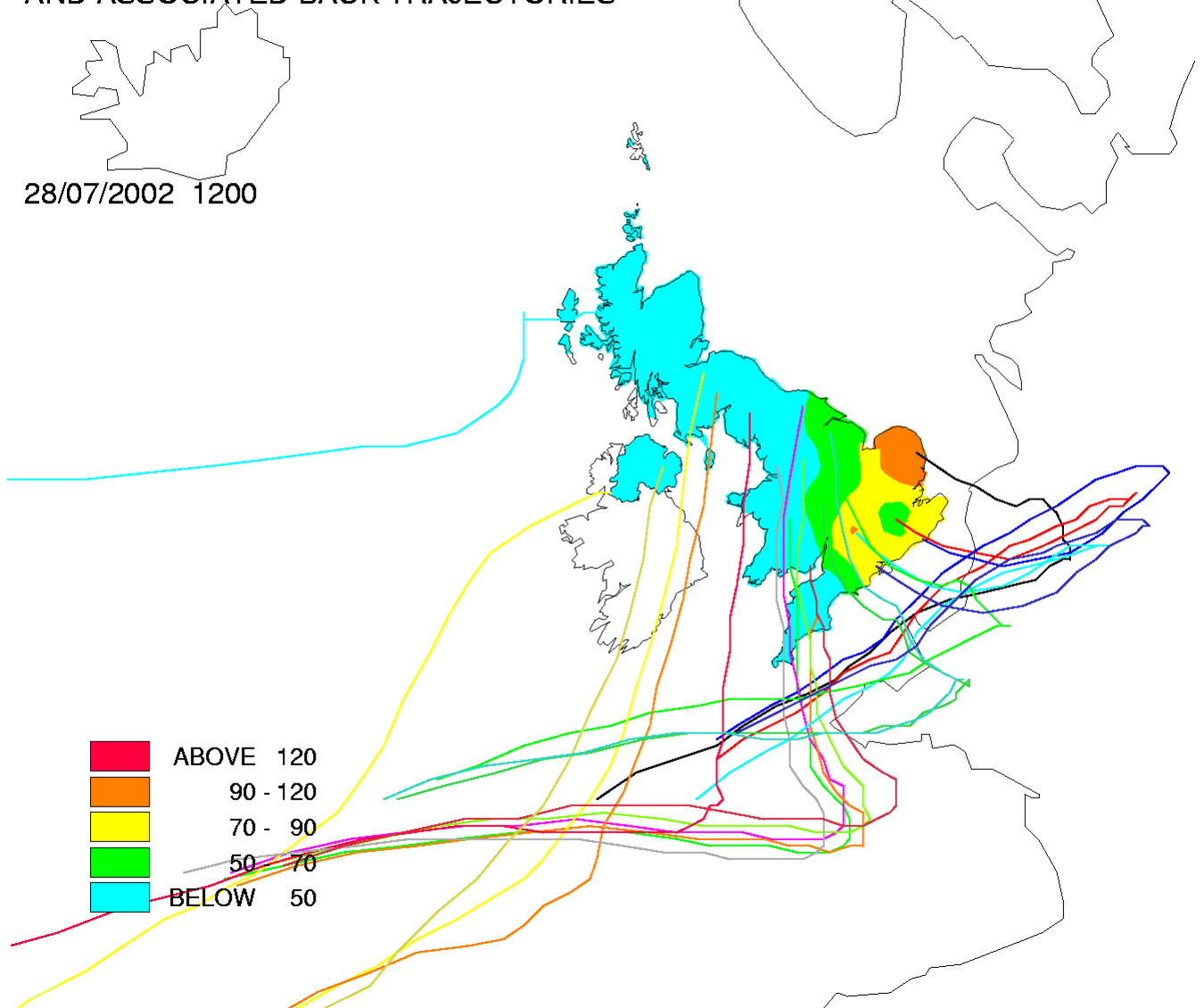


Figure 3 – forecast ozone back trajectories for the days with HIGH pollution (Sun 28th July)

FORECAST OZONE CONCENTRATIONS (PPB)
AND ASSOCIATED BACK TRAJECTORIES

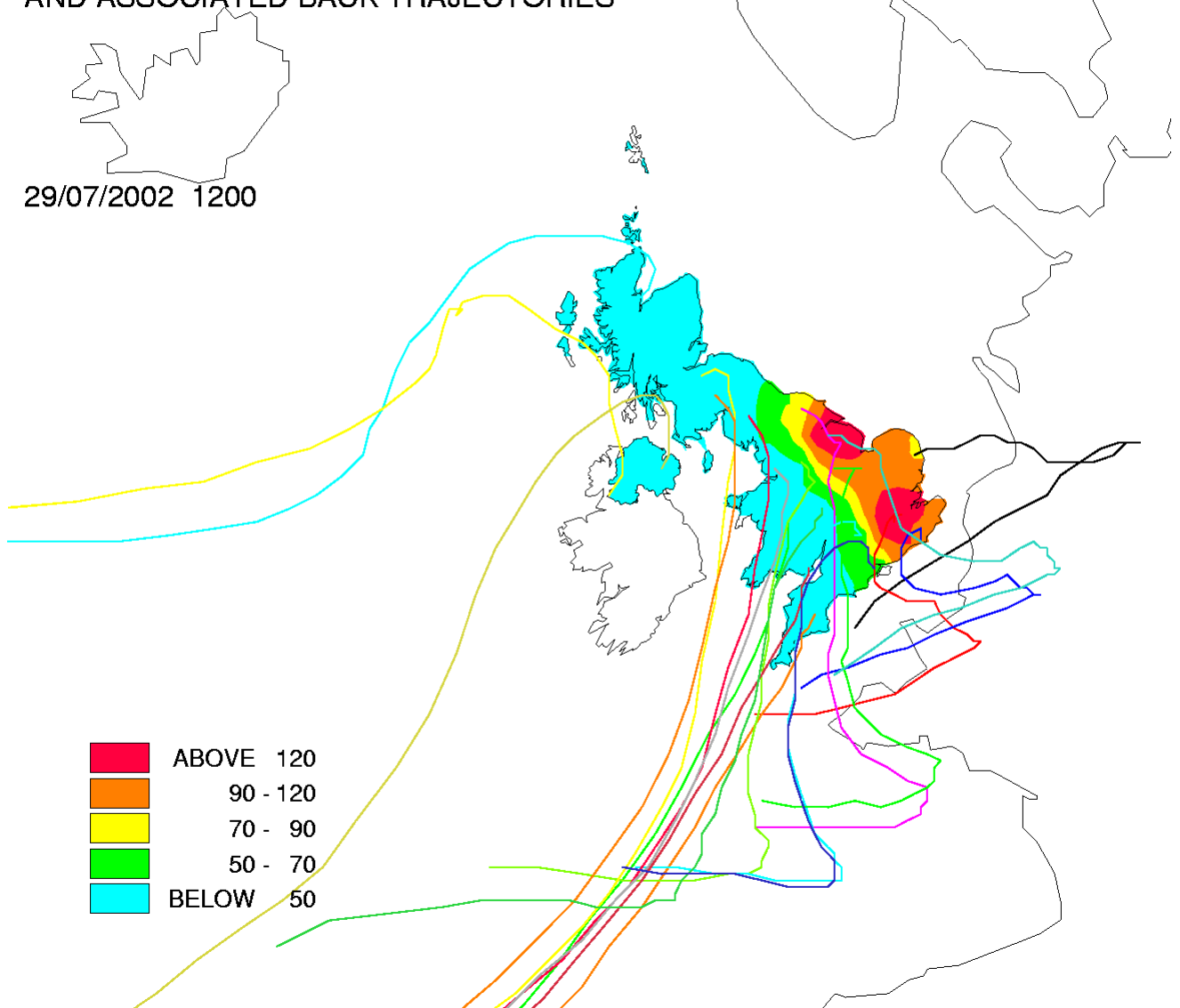


Figure 4 – forecast ozone back trajectories for the days with HIGH pollution (Mon 29th July)