

Air Pollution Forecasting Ad-hoc report: PM₁₀ episode (September 2002)

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Introduction

During a period covering the 12th and 13th September the UK automatic urban and rural air quality monitoring networks recorded elevated PM₁₀ concentrations across much of the United Kingdom. The episode was recorded at many sites in northern England, some in Scotland and Northern Ireland. The northern areas of the UK were most affected, however, there were sites in the south (Plymouth and London) that recorded elevated concentrations. A full list of sites is included in the tables below. Table 2 shows the number of days each site measured levels in the MODERATE or HIGH bands. Table 3 shows the number of days for each site on which the daily AQS Objective value (50 $\mu\text{g m}^{-3}$) was exceeded.

Although this PM₁₀ episode was not predicted by the netcen forecasting team, and would have been almost impossible to forecast, the Russian fires were quickly identified as a possible source. This is indicated in the forecasting correspondence provided at the end of this report.

Possible causes

Long range back trajectories provided by the Met Office (see figure 7) show that air masses affecting Scunthorpe and Sheffield during the episode had originated from the eastern end of the Baltic sea and the western regions of Russia. Satellite imagery and news reports indicated widespread forest and peat bog fires in the region at the time which may have accounted for the elevations in PM₁₀. However, there were no corresponding increases in CO or NO_x pollutants that are also emitted by combustion sources. It was suggested that the lack of corresponding increases in NO_x were attributable to the low nitrogen deposition area in which the fires were burning, resulting in fires that would not produce significant NO_x. Also suggested was that instruments weren't sensitive enough to measure increases in CO. However, even if the combustion source was low in nitrogen it is still likely that significant amounts of NO would be emitted during the combustion process. It is likely that the emitted NO_x and CO were removed during the ten day period from emission to passing over the UK as displayed in the Met Office back trajectory. NO reacts quickly with ozone to create NO₂. NO₂ will react with ozone to become NO₃ and O₂, finally becoming N₂O₅ which is readily converted to HNO₃. The HNO₃ is then readily removed by both dry and wet deposition. The conversion of NO₂ and subsequent deposition could well account for the loss of the NO_x signal over a time period of ten days. It is likely also that CO would be removed in significant amounts from the air before reaching the UK from Russia. CO reacts with OH radicals to create CO₂ and hydrogen. So it seems possible that the forest and bog fires of western Russia could account for the increased PM₁₀ levels despite the lack of corresponding rises in NO_x and CO.

Concentrations over time

As table 1 shows, the episode was limited to two days – the 12th and 13th September. Prior and subsequent to these days there was only a single site recording MODERATE levels each day. On the 9th and 10th September the site recording MODERATE levels was Scunthorpe and on the 11th September it was Glasgow Kerbside. On 14th September, only Scunthorpe again was recording MODERATE levels. On 13th September there were 18 sites measuring MODERATE levels and 2 sites measuring HIGH levels. The complete list of these sites is in table 3. Scunthorpe measured MODERATE levels on 5 days and HIGH levels on 2 days. However it should be noted that the 5 MODERATE days listed in table 3 includes the 2 HIGH days since these MODERATEs were included as concentrations rose through the MODERATE band and into the HIGH band. The running 24 hour mean concentrations of PM₁₀, on which the bands are based are shown in figure 1 for all sites recording MODERATE and HIGH concentrations during the episode. The Belfast Clara Street site also measured a maximum 24 hour running mean concentration of 94 $\mu\text{g m}^{-3}$ (the equivalent of index 9 in the HIGH band). However, this site uses a BAM (Beta Attenuation Monitor) and the DEFRA

Air Quality Index only applies to TEOM (Tapered Element Oscillating Microbalance) instruments. For this reason, Belfast Clara Street is not included in this report apart from featuring in table 2 in which exceedences of the daily AQS objective (for which it is valid) are listed.

Table 1 – Number of sites recording MODERATE and HIGH concentrations over time

Day	Number of sites recording MODERATE levels	Number of sites recording HIGH levels
09/09/02	1	-----
10/09/02	1	-----
11/09/02	1	-----
12/09/02	20	1
13/09/02	15	1
14/09/02	1	-----

Table 2 - Exceedences of the daily AQS Objective of 50 $\mu\text{g m}^{-3}$ (gravimetric equivalent) by site

Site	Number of days	Maximum exceedence ($\mu\text{g m}^{-3}$)
Scunthorpe	4	99
Glasgow Kerbside	2	88
Thurrock	2	58
Wolverhampton Centre	2	62
Belfast Centre	1	76
Belfast Clara St	1	94
Birmingham Centre	1	53
Blackpool	1	63
Bolton	1	73
Bury Roadside	1	80
Coventry Memorial Park	1	53
Derry	1	80
Edinburgh Centre	1	71
Glasgow Centre	1	61
Leeds Centre	1	56
Liverpool Centre	1	74
London Bloomsbury	1	51
London Marylebone Road	1	58
Lough Navar	1	58
Manchester Piccadilly	1	84
Middlesbrough	1	63
Nottingham Centre	1	58
Plymouth Centre	1	55
Preston	1	67
Salford Eccles	1	64
Sheffield Centre	1	67
Stockton-on-Tees Yarm	1	71
Stoke-on-Trent Centre	1	56
Wigan Leigh	1	68
Wirral Tranmere	1	61

Table 3 - Number of days each site recorded levels in MODERATE and HIGH bands

Site	Number of MODERATE days	Number of HIGH days	Maximum exceedence ($\mu\text{g m}^{-3}$)
Scunthorpe	5	2	85
Glasgow Kerbside	3	-----	71
Manchester Piccadilly	2	-----	72
Bury Roadside	2	-----	69
Stockton-on-Tees Yarm	2	-----	60
Derry	2	-----	64
Liverpool Centre	2	-----	59
Belfast Centre	2	-----	59
Bolton	2	-----	61
Edinburgh Centre	2	-----	56
Sheffield Centre	2	-----	58
Wigan Leigh	2	-----	58
Preston	2	-----	56
Nottingham Centre	1	-----	56
Middlesbrough	1	-----	57
Salford Eccles	1	-----	54
Wolverhampton Centre	1	-----	52
Stoke-on-Trent Centre	1	-----	52
Blackpool	1	-----	51
Lough Navar	1	-----	50

Prior to 12th September winds were south westerly, originating over the Atlantic Ocean as shown in Figure 1. By 12th September, winds had become strong north easterly, originating over the sea but passing over Scandinavia and fringing the area of the Russian forest fires before travelling towards the UK. On 13th September, these winds were originating from directly over the Russian fire area, being almost due easterly and still strong.

Summary

The PM₁₀ episode recorded in northern areas of the UK on 12th and 13th September resulted in a maximum 24 hour running mean concentration of 85 $\mu\text{g m}^{-3}$ (HIGH band, index 8) at Scunthorpe. This site measured HIGH concentrations on both days of the episode. MODERATE concentrations were recorded at 20 sites on 12th September and at 15 sites the following day.

Given the wind strength and the north easterly/ easterly direction over these two days, it is possible that the elevated concentrations of PM₁₀ were the result of widespread forest and peat bog fires in western Russia. The lack of associated NO_x and CO increases recorded in the UK may be due to chemical removal of these pollutants over the ten day transport time from the source.

Web links

<http://www.helsinki-hs.net/news.asp?id=200209061E6> - discusses the significant effect of the western Russian fires on Finland

<http://english.pravda.ru/region/2002/09/10/36241.html> - also discusses air pollution caused by Russian peat bog fires although it concentrates on the fires surrounding Moscow over the summer/ autumn of 2002.

Figure 1 - PM₁₀ 24-hr running mean concentrations during the episode at sites measuring MODERATE or HIGH levels

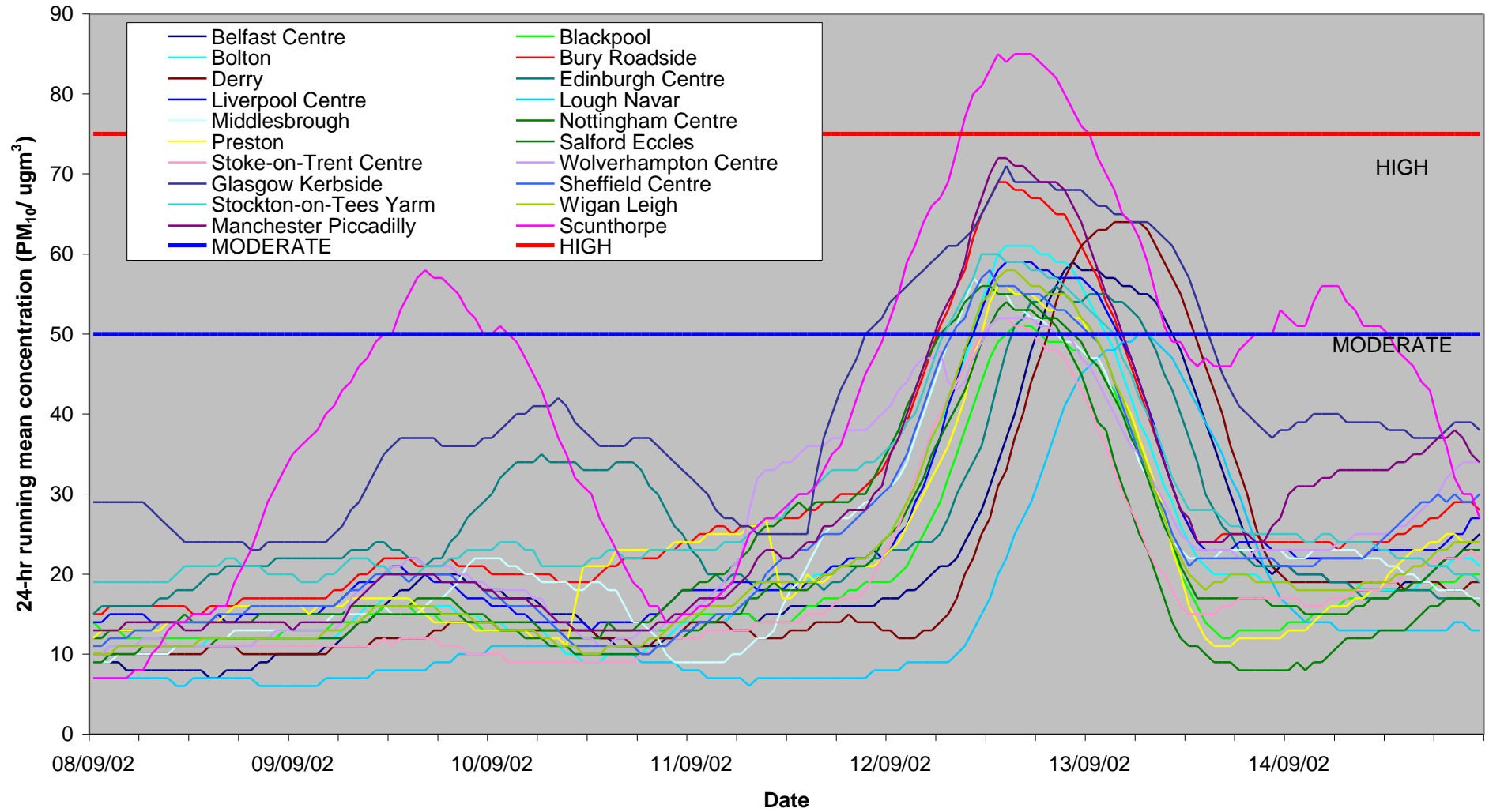


Figure 2 – Four day forecast back trajectories UK, 11th September 2022

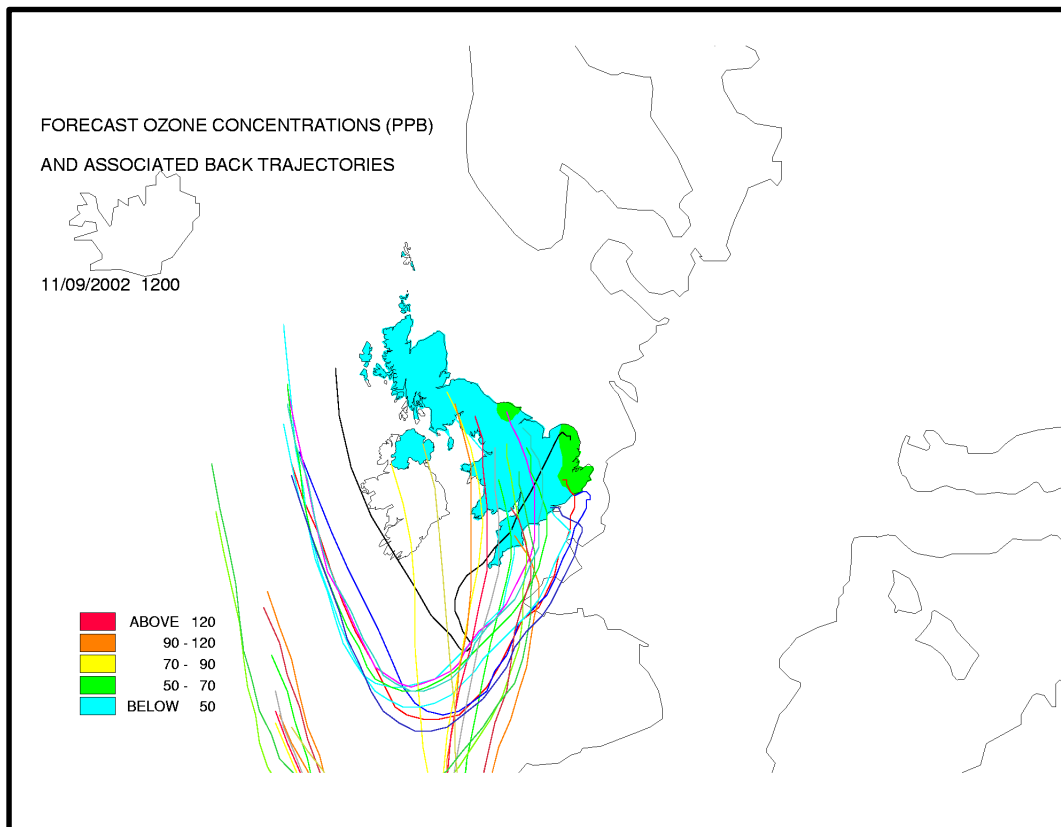


Figure 3 – Four day forecast back trajectories UK, 12th September 2022

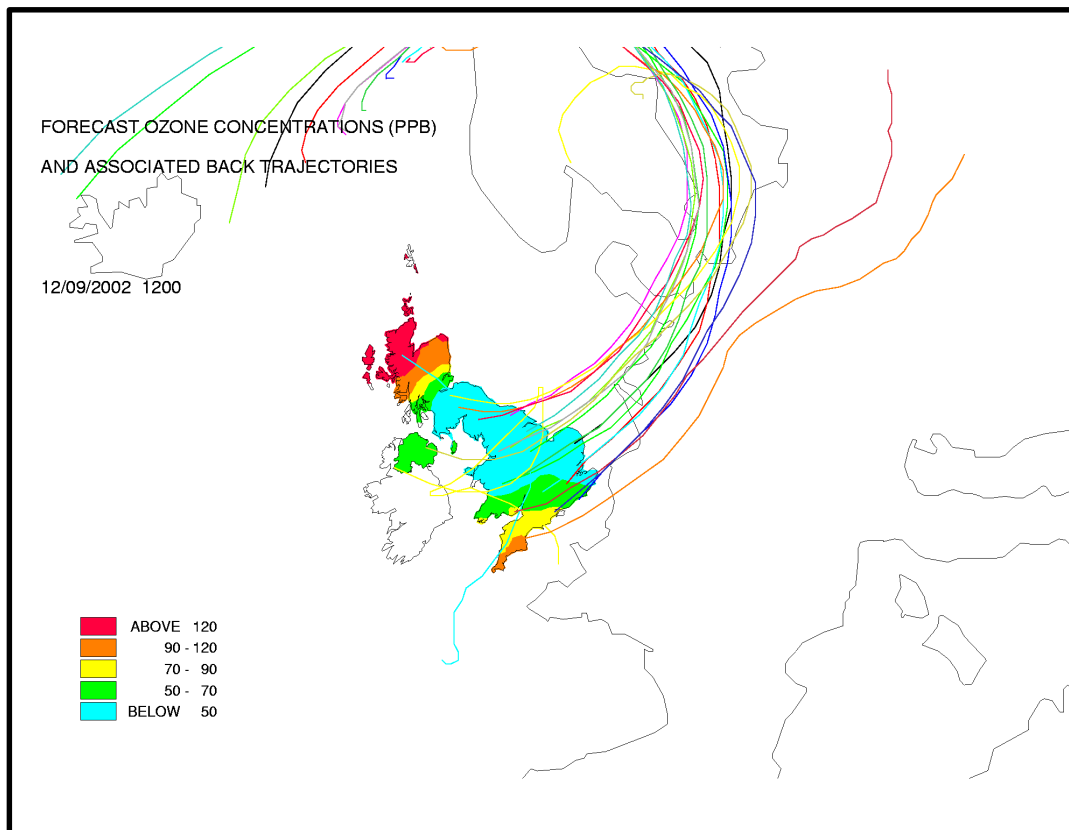


Figure 4 – Four day forecast back trajectories UK, 13th September 2002

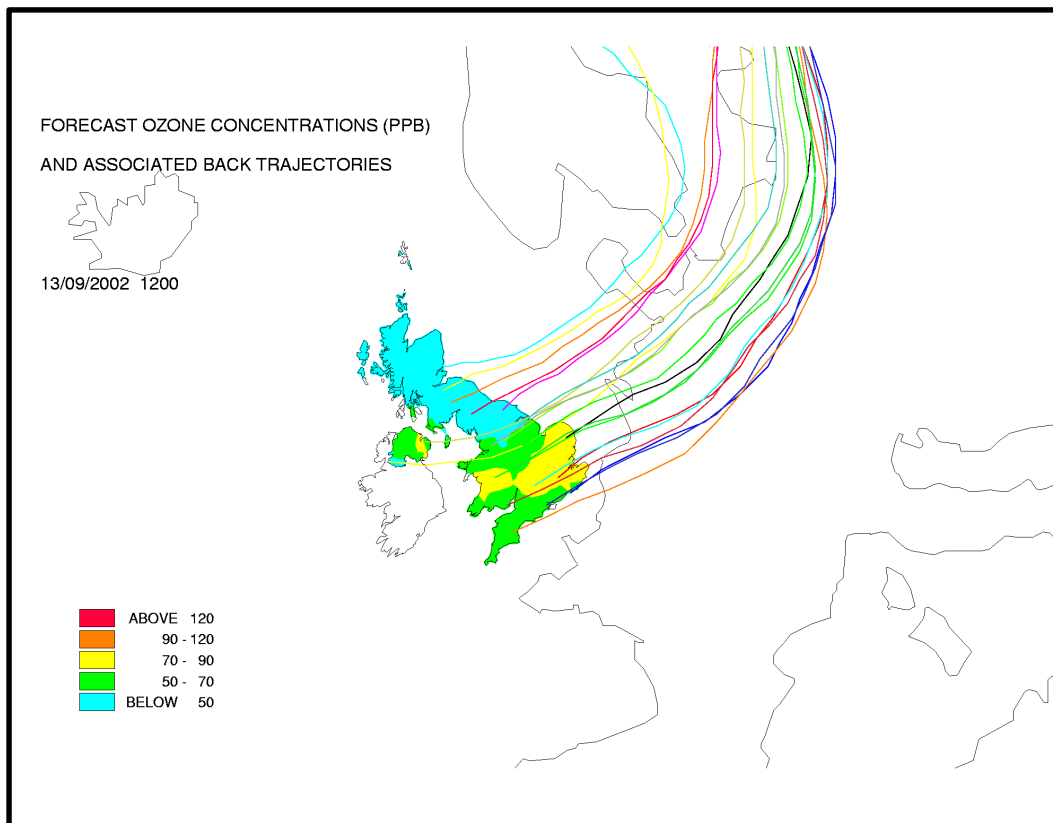


Figure 5 – Four day forecast back trajectories UK, 14th September 2002

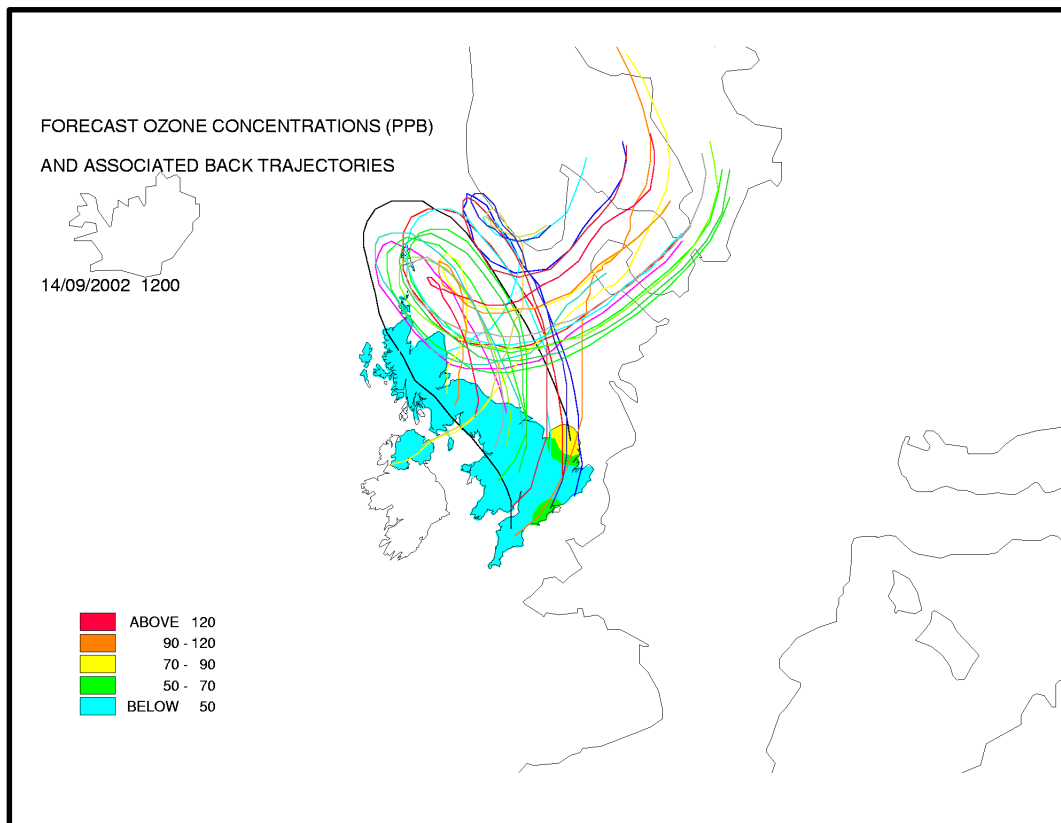


Figure 6 – Four day forecast back trajectories UK, 15th September 2002

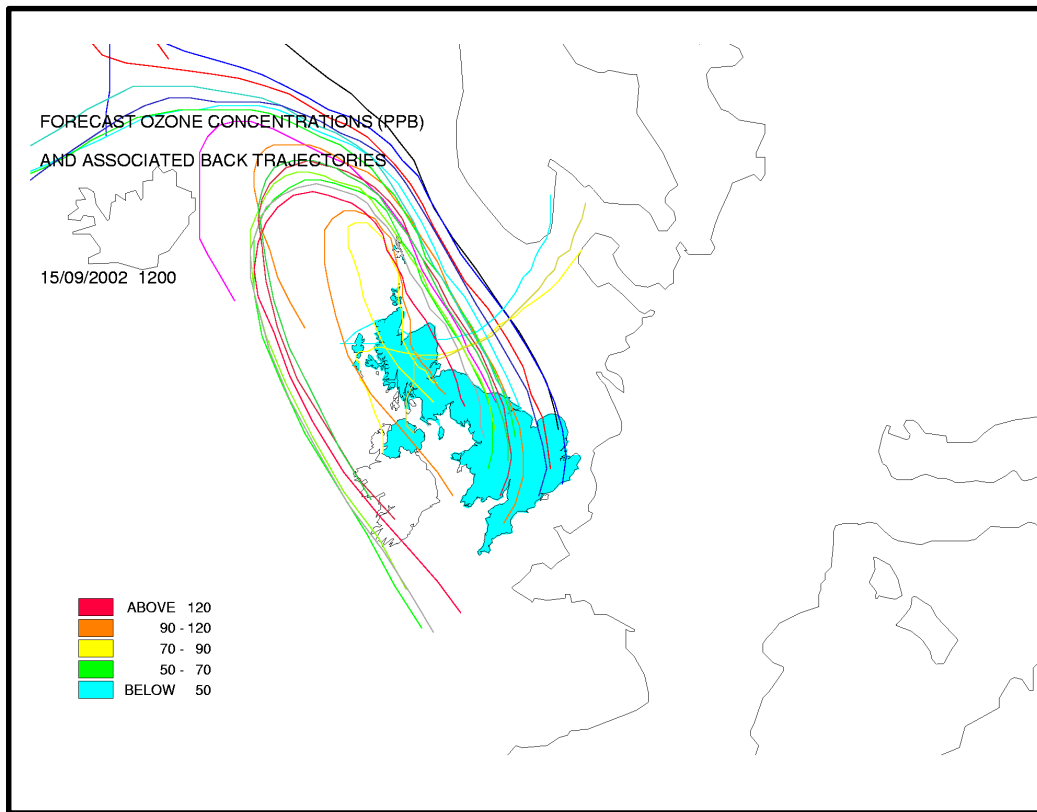
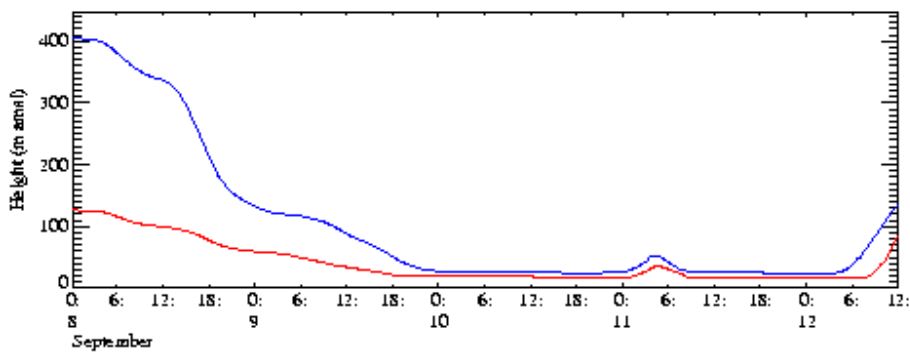
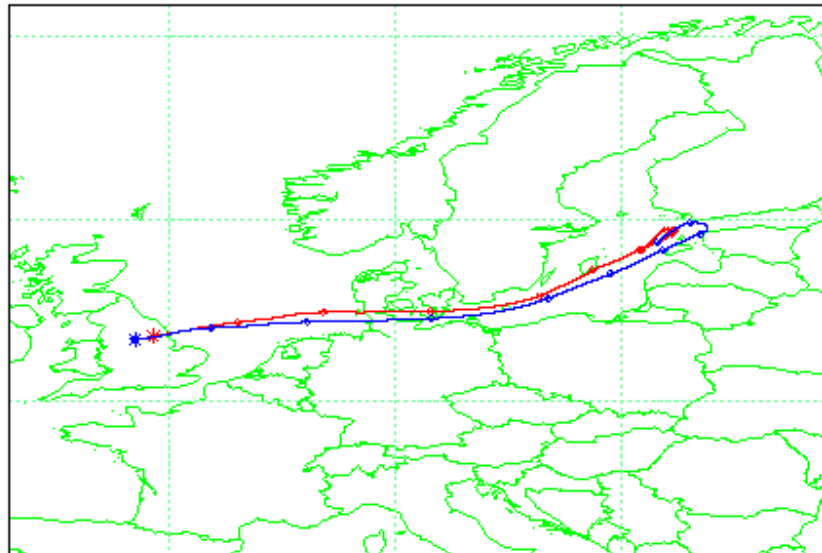


Figure 7 – Long range back trajectories over 10 days, provided by UKMO

Trajectory Model (V7.03)
TEST



Simulation Description

Run time: 09.05.01 20020913
Met data: Global
Three dimensional
Back trajectories
Start of Release: 1200UTC 12/09/2002

Met Office, Borekull (GMR)

Forecasting correspondence during the episode

Below is a series of email communications from Brian Jones (the duty forecaster during the episode) over 12th to 13th September.

12th September

PM10 Index HIGH - Hourly Concentrations of PM10 of 100 ug/m3 or greater at a no of monitoring sites

Dear Colleagues,

At present the highest rolling 24 hour mean is index 8 (High) at the Scunthorpe site. The concentrations have dropped slightly over the last 3 hours so the 24 hour mean is likely to become more stable. It is possible that the Index may reach 9 (High) depending on how rapidly the concentrations decrease over the next few hours. At present it appears unlikely that the index will reach 10 (Very High) unless hourly concentrations increase to over 100 ug/m3 for a number of hours.

The reported hourly concentrations of PM10 has reached a value of 100ug/m3 or greater at 13 sites. Concentrations at most of the sites have started to decrease. The sites include Sheffield through to Edinburgh, the most northerly monitoring location for PM10. It appears that the observed episode is affecting the more northerly regions of the UK. More Southerly regions do not appear to be affected to any significant extent. The index for PM10 at many of the sites in the south is 3 (Low)

Brian Jones

12th September

RE: PM10 Index HIGH - Hourly Concentrations of PM10 of 100 ug/m3 or greater at a no of monitoring sites

Janet,

Geoff Dollard had mentioned he had seen a report of extensive forest fires in Russia, possibly around Moscow. However, as none of the other pollutants appear to be correlated with the PM10 e.g. NOx, the source is likely to be non-combustion related. Lack of ozone also suggests that the higher concentrations are not due to 'secondary' PM10.

I can think of no obvious explanation at the present time. I'll will investigate further and should I find any relevant information I will pass it on.

Brian.

RE: PM10 Index HIGH - Hourly Concentrations of PM10 of 100 ug/m3 or greater at a no of monitoring sites

Brian,

Is there any reason why the northern half of the UK should be seeing these elevated levels of PM10? There doesn't appear to be any NOx or Ozone associated with these concentrations.

Janet

Janet Dixon

13th September

PM10 Episode on 12 September 2002

The observed episode appears to be over even though back trajectories appear to be very similar to the back trajectories for yesterday. The measured concentrations of PM10 dropped to below 30 ug/m³ at all sites for a number of hours overnight.

The timing of the maximum hourly concentrations became later for the sites that were furthest west and north. The highest concentrations at the Manchester, Bury and Scunthorpe sites occurred between 07:00 and 10:00 GMT. For Northern Ireland and Scotland the maxima occurred between 14:00 and 20:00 GMT. The episode covered a large area of the UK so was regional in scale although it did not appear to impact on any of the southern regions.

24-hour mean concentrations of PM10

The highest 24-hour mean reported by a TEOM instrument was 85 ug/m³ (Index 8, HIGH) at the Scunthorpe site. One 24-hour mean of 75.6 ug/m³ (Index 7, HIGH) was recorded at Glasgow, Hope Street. The reported concentrations for Belfast, Clara Street, reached a reported maximum of 89.7 ug/m³, however, this is a beta attenuation monitor (BAM), the TEOM equivalent is 69 ug/m³ (Index 6, MODERATE) assuming a scaling factor of 1.3.

Source of the observed PM10

To date, I have found no clear indication of the likely source of the observed PM10.

Brian Jones