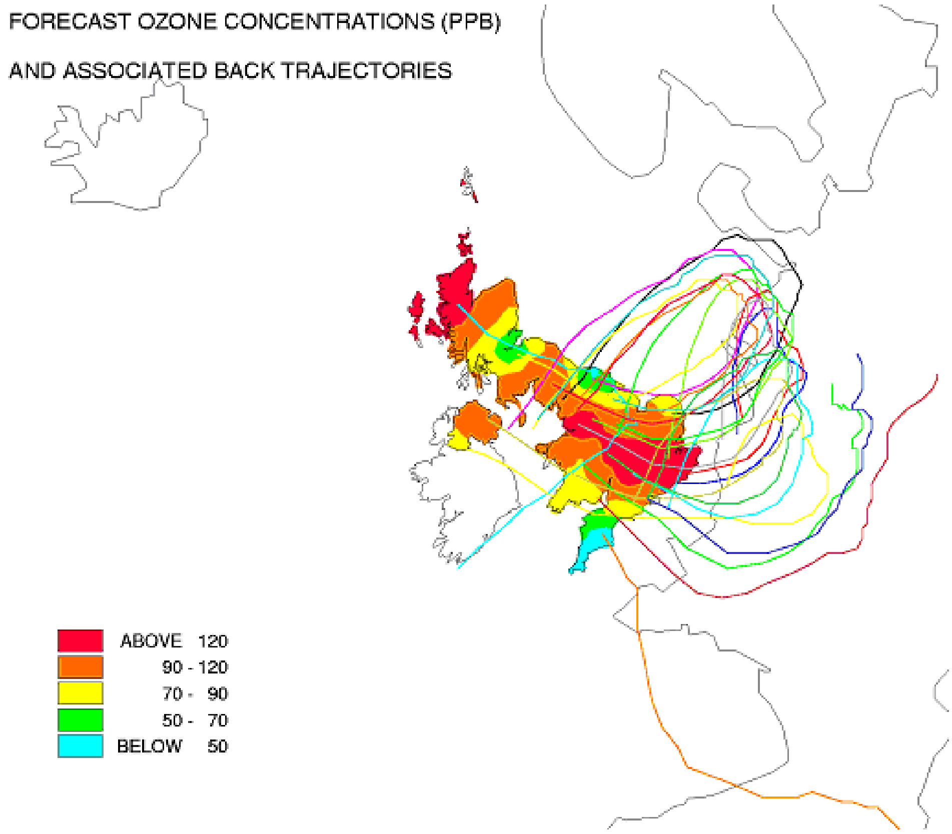
UK Air Quality Forecasting: Annual Report 2004

A report produced for the Department for Environment, Food and Rural Affairs, the Scottish Executive, the Welsh Assembly Government and the Department for the Environment in Northern Ireland



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March 2005

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Executive Summary

This report covers the operational activities carried out by Netcen and the Met Office on the UK Air Quality Forecasting Contract for the year 2004. The work is funded by the Department for Environment Food and Rural Affairs (Defra), the Scottish Executive, Welsh Assembly Government and the Department of the Environment in Northern Ireland.

During 2004, there was a total of 30 days on which HIGH air pollution was recorded across the UK. 22 of these days were due to PM10 alone, 2 were due to ozone alone and 4 solely due to SO2. One day occurred each for coincident PM10/SO2 and PM10/O3. A total of 24 regional days were recorded HIGH in zones, together with a further 16 days in agglomerations.

The forecasting success and accuracy for this year is summarised in Table 1 below. The overall forecasting performance for HIGH episodes has dropped by 25 % since 2003, mainly due to highly unpredictable localised PM10 -related episodes over this period, and the small number of (easier to forecast) ozone episodes in 2004 compared to 2003.

Table 1 – forecast success/accuracy for incidents above 'HIGH' and above 'MODERATE' in 2004

Region/Area	HIGH % success	% accuracy	MODERATE % success	% accuracy
Zones	79	36	137	81
Agglomerations	13	13	136	62

During this year, one ad-hoc report was presented to Defra and the devolved administrations. This report analysed the Ozone Pollution Episode of July – August 2004.

All episode reports can be found on the National Air Quality Archive (www.airquality.co.uk/archive/reports/list.php).

There were no reported breakdowns over the year and all bulletins were delivered to the Air Quality Communications contractor on time.

We continue to actively research ways of improving the air pollution forecasting system by:

- Investigating the use of automatic software systems to streamline the activities within the forecasting process, thereby allowing forecasters to spend their time more efficiently in maximising forecast accuracy.
- Researching the chemistry used in our models, in particular the NOx→NO2 conversion used in NAME and the chemical schemes for secondary PM10 and ozone.
- Improving the NAME model runs which can be used for ad-hoc analysis, in particular with regard to investigating the possible long-range transport of PM10.
- Improving and updating the emissions inventories used in our models.

Contents

1 Introduction

Netcen and the Met Office are contracted by The Department for Environment, Food and Rural Affairs (Defra), the Scottish Executive, the Welsh Assembly Government and the Department for the Environment in Northern Ireland to provide an hourly update on air pollution levels, together with a 24-hour air pollution forecast. These are widely disseminated through the media. The forecasts allows individuals who may be affected by episodes of high air pollutant concentrations to take appropriate preventative measures. These can include increasing medication or taking steps to reduce exposure and dose.

A forecast of the following day's air pollution is prepared every day by Netcen. The forecast consists of a prediction of the air pollution descriptor for the worst-case situation in 16 zones and 16 agglomerations over the following 24-hours. Forecasts are disseminated in a number of ways to maximise public accessibility; these including Teletext, the World Wide Web and a Freephone telephone service.

Updates can occur at any time of day, but the most important forecast of the day is the “daily media forecast”. This is prepared at 3.00 p.m. for uploading to the Internet and Air Quality Communications contractor before 4.00 p.m. each day. It is then included in subsequent air quality bulletins for the BBC, newspapers and many other interested organisations.

This report covers and analyses the media forecasts issued during the 12 months from January 1st to December 31st 2004. Results from forecasting models are available each day and are used in constructing the forecast. The forecasters issue predictions for rural, urban background and roadside environments but, for the purposes of this report, these have been combined into a single “worst-case” category.

Twice a week, on Tuesdays and Fridays, Netcen also provides a long-range pollution outlook. This takes the form of a short piece of text which is emailed to approximately sixty recipients in the Defra and other government Departments, plus the BBC weather forecasters. The outlook is compiled by examining the outputs from our pollution models, which currently extend to 3 days ahead for Defra and the DAs, and by assessing the long-term weather situation.

We continue to use a comprehensive quality control system in order to ensure that the 5-day forecasts provided by the Met Office to the BBC are consistent with the “daily media forecasts” and long-range pollution outlook provided by Netcen for Defra and the DAs. The BBC requires 5-day air pollution index forecasts for 230 UK towns and cities for use on its BBC Online service. The quality control review is carried out at 3.00 p.m. daily, with the resulting forecast updating onto the BBC Online Web site at 4.00 a.m. the following morning.

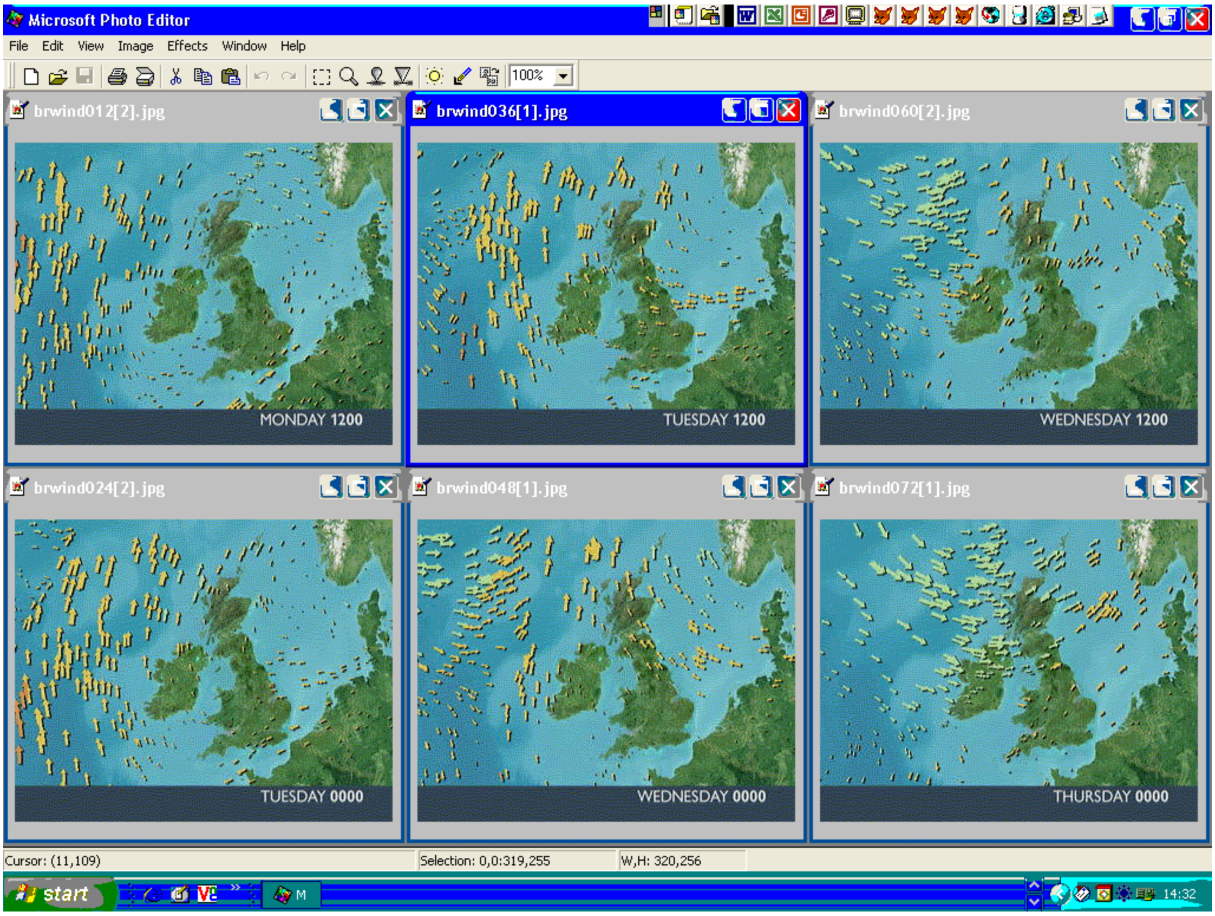
2 New developments during this year

During this year, a number of improvements have been introduced to assist with the analysis of forecasting performance and day-to-day forecasting.

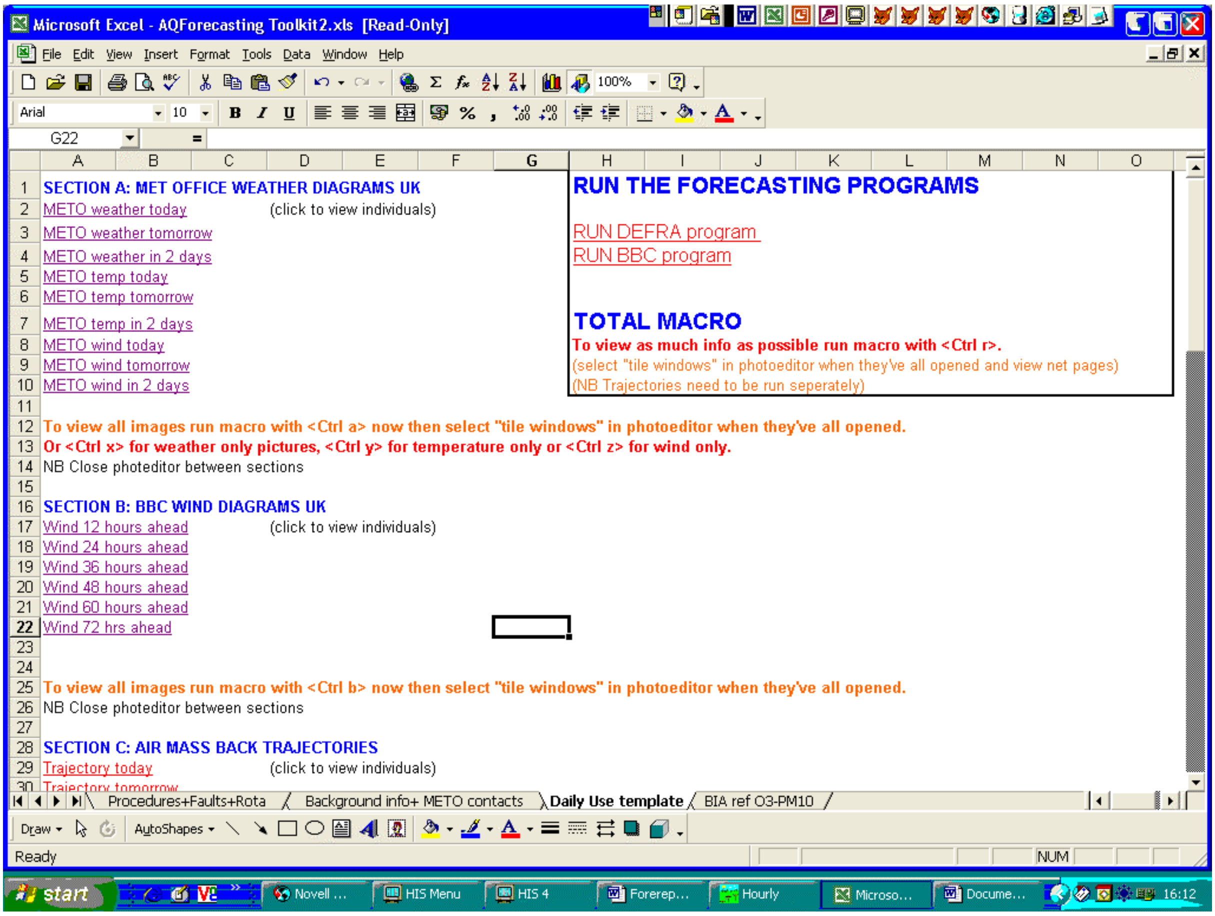
2.1 AIR QUALITY FORECASTING TOOLKIT

During 2004, a comprehensive MS Excel spreadsheet system has been developed - the “AQ Forecasting Toolkit” - which allows faster access to relevant web images and current information used during the process of daily forecasting. All relevant links to information and run models have therefore been centralised.

Below is an illustration of 3-day wind diagrams, now viewed with two key presses:



Below is an illustration of the top third of the worksheet used during daily forecasting:



This new system allows the forecaster to concentrate more on compiling the forecasts, by reducing the time spent in routine information gathering.

2.2 E-MAIL CIRCULATION LIST

The email circulation list for bi-weekly forecasts has been extended to over sixty recipients, including AURN network managers and equipment service units who expressed an interest. It is hoped that this will provide network end-users of the service with greater warning of air pollution episodes, so that calibrations and servicing can be rescheduled where necessary. This will hopefully minimize the loss of air pollution episode data.

2.3 FORECAST ANALYSIS SOFTWARE

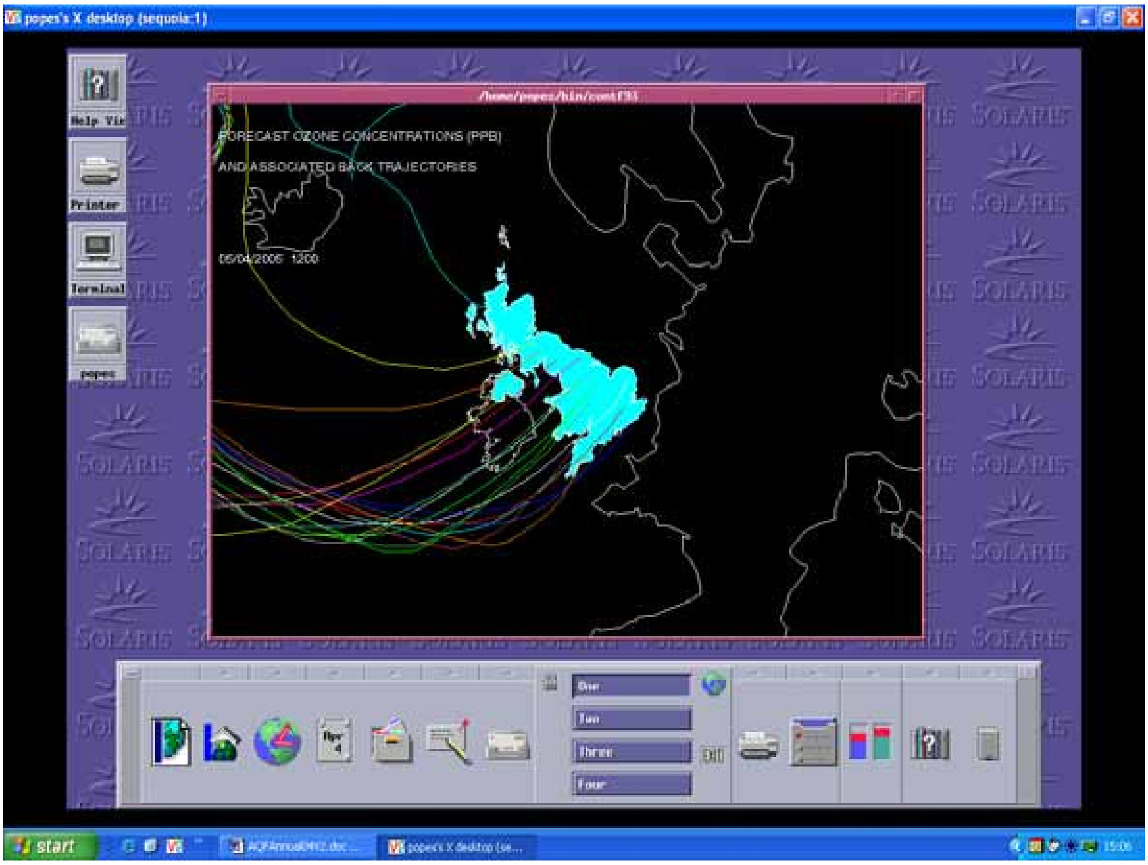
The Netcen forecasting analysis software has been updated to include analysis for forecasting success and accuracy after data have been ratified, as well as accounting for alterations after the provisional, as-collected stage. The updated software compares forecasted levels from the date/ time of day issued (normally around 3 pm) with the most up-to-date data stored on the National Air Quality Archive for the 24 hours that followed the issue of each forecast. This helps to remove or reduce the incidence of obviously faulty data often seen in the as-collected data and therefore improves the overall quality of the analysis results.

2.4 QUARTERLY REPORT FORMAT

An enhanced format for quarterly reports has been agreed with Defra and the Devolved Administrations, including features such as clearer graphical formats, updated information in the text and a clearer explanation of the analysis results.

2.5 VNC CONNECTION TO OZONE FORECASTING MODEL

In a wholly new development, the forecasters now use a VNC connection to a central server in order to run and view the ozone forecasting model. This means that the power of the UNIX server is now easily accessed from any networked WINDOWS PC in Netcen. The VNC connection environment is illustrated below:



This again helps improve speed and efficiency whilst reducing routine effort, allowing greater focus on the science.

3 Analysis of forecasting success rate

3.1 INTRODUCTION

Analysis of the forecasting performance is carried out for each of the 16 zones and 16 agglomerations used in the daily forecasting service. Further details of these zones and agglomerations are presented in Appendix 2. Forecasting performance is analysed for a single, general pollutant category rather than for each individual pollutant and has been aligned to the forecasting day (a forecasting day runs from the issue time, generally 3 pm). The analysis is based on latest data in the Air Quality Archive (www.airquality.co.uk), so any obviously faulty data should have been removed.

The analysis treats situations where the forecast index was within ±1 of the measured index as a successful prediction, as this is the target accuracy we aim to obtain in the forecast. 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. Appendix 1 provides a detailed description of the UK Air Pollution Index.

The forecasting success rates for each zone and agglomeration for October - December 2004 are presented in Tables 3.1 (forecasting performance in zones) and 3.2 (forecasting performance in agglomerations) for 'HIGH' days. Table 3.5 provides a summary for each pollutant of the number of days on which HIGH and above pollution was measured, the maximum exceedence concentration and the day and site at which it was recorded. The forecasting performance Tables 3.1 and 3.2 give:

- The number of 'HIGH' days measured in the PROVISIONAL data
- The number of 'HIGH' days forecast
- The number of days with a correct forecast of 'HIGH' air pollution, within an agreement of ±1 index value. A HIGH forecast is recorded as correct if air pollution is measured HIGH and the forecast is within ±1 index value, or it is forecast HIGH and the measurement is within ±1 index value. For example measured index 7 with forecast index 6 counts as correct, as does measured index 6 with forecast index 7.
- The number of days when 'HIGH' air pollution was forecast ('f' in the tables) but not measured ('m') on the following day to within an agreement of 1 index value.
- The number of days when 'HIGH' air pollution was measured ('m') but had not been forecast ('f') to within an agreement of 1 index value.

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

3.2 FORECAST ANALYSIS FOR 2004

Table 3.1 - Forecast Analysis for UK Zones 'HIGH' band and above *

ZONES	Central Scotland	East Mids	Eastern	Greater London	Highland	North East	North East Scotland	North Wales	North West & Merseyside	Northern Ireland	Scottish Borders	South East	South Wales	South West	West Midlands	Yorkshire & Humberside	Overall
Measured days	4	1	5	4	0	1	0	0	6	0	0	2	0	0	0	1	24
Forecasted days	0	4	6	4	0	2	0	1	1	0	0	5	1	1	4	1	30
Ok (f and m)	0	4	5	3	0	0	0	0	0	0	0	6	0	1	0	0	19
Wrong (f not m)	0	1	2	2	0	2	0	1	1	0	0	0	1	0	4	1	15
Wrong (m not f)	4	0	3	3	0	1	0	0	6	0	0	1	0	0	0	1	19
Success %	0	400	100	75	100	0	100	100	0	100	100	300	100	100	100	0	79
Accuracy %	0	80	50	38	0	0	0	0	0	0	0	86	0	100	0	0	36

Table 3.2 - Forecast Analysis for UK Agglomerations 'HIGH' band and above *

AGGLOMERATIONS	Belfast UA	Brighton/Worthing/ Littlehampton	Bristol UA	Cardiff UA	Edinburgh UA	Glasgow UA	Greater Manchester UA	Leicester UA	Liverpool UA
Measured days	0	0	0	0	0	0	1	0	6
Forecasted days	0	0	0	0	0	0	0	0	1
Ok (f and m)	0	0	0	0	0	0	0	0	1
Wrong (f not m)	0	0	0	0	0	0	0	0	0
Wrong (m not f)	0	0	0	0	0	0	1	0	5
Success %	100	100	100	100	100	100	0	100	17
Accuracy %	0	0	0	0	0	0	0	0	17

AGGLOMERATIONS	Nottingham UA	Portsmouth UA	Sheffield UA	Swansea UA	Tyneside	West Midlands UA	West Yorkshire UA	Overall
Measured days	0	1	0	7	0	1	0	16
Forecasted days	0	1	0	0	0	0	0	2
Ok (f and m)	0	1	0	0	0	0	0	2
Wrong (f not m)	0	0	0	0	0	0	0	0
Wrong (m not f)	0	0	0	7	0	1	0	14
Success %	100	100	100	0	100	0	100	13
Accuracy %	0	100	0	0	0	0	0	13

* All performance statistics are based on provisional data. Obviously incorrect data due to instrumentation faults have been removed from the analyses.

Please refer to the start of section 3 for an explanation of the derivation of the various statistics, figures >100 % may occur.

Table 3.3 - Forecast Analysis for UK Zones 'MODERATE' band and above *

ZONES	Central Scotland	East Mids	Eastern	Greater London	Highland	North East	North East Scotland	North Wales	North West & Merseyside	Northern Ireland	Scottish Borders	South East	South Wales	South West	West Midlands	Yorkshire & Humberside	Overall
Measured days	31	71	120	134	89	64	47	26	43	45	17	120	25	79	31	93	1035
Forecasted days	27	113	131	140	68	88	41	47	65	26	26	132	67	95	102	81	1249
Ok (f and m)	29	117	142	169	109	100	52	44	63	59	23	150	64	106	73	117	1417
Wrong (f not m)	11	12	16	18	18	13	13	11	13	4	10	14	13	10	33	12	221
Wrong (m not f)	14	3	11	17	4	9	9	3	10	1	3	8	1	7	5	12	117
Success %	94	165	118	126	122	156	111	169	147	131	135	125	256	134	235	126	137
Accuracy %	54	89	84	83	83	82	70	76	73	92	64	87	82	86	66	83	81

Table 3.4 - Forecast Analysis for UK Agglomerations 'MODERATE' band and above *

AGGLOMERATIONS	Belfast UA	Brighton/Worthing /Littlehampton	Bristol UA	Cardiff UA	Edinburgh UA	Glasgow UA	Greater Manchester UA	Leicester UA	Liverpool UA
Measured days	19	0	15	30	31	22	43	21	31
Forecasted days	18	47	45	41	22	38	53	52	33
Ok (f and m)	22	0	35	39	31	33	57	39	37
Wrong (f not m)	8	47	18	10	13	14	10	21	10
Wrong (m not f)	4	0	3	6	5	2	10	2	11
Success %	116	100	233	130	100	150	133	186	119
Accuracy %	65	0	63	71	63	67	74	63	64

AGGLOMERATIONS	Nottingham UA	Portsmouth UA	Sheffield UA	Swansea UA	Tyneside	West Midlands UA	West Yorkshire UA	Overall
Measured days	11	37	20	57	10	60	24	431
Forecasted days	35	71	31	59	23	64	45	677
Ok (f and m)	18	62	29	63	15	74	33	587
Wrong (f not m)	21	17	10	16	13	16	21	265
Wrong (m not f)	4	2	5	21	5	8	7	95
Success %	164	168	145	111	150	123	138	136
Accuracy %	42	77	66	63	45	76	54	62

* All performance statistics are based on provisional data. Obviously incorrect data due to instrumentation faults have been removed from the analyses.

Please refer to the start of section 3 for an explanation of the derivation of the various statistics, figures >100 % may occur.

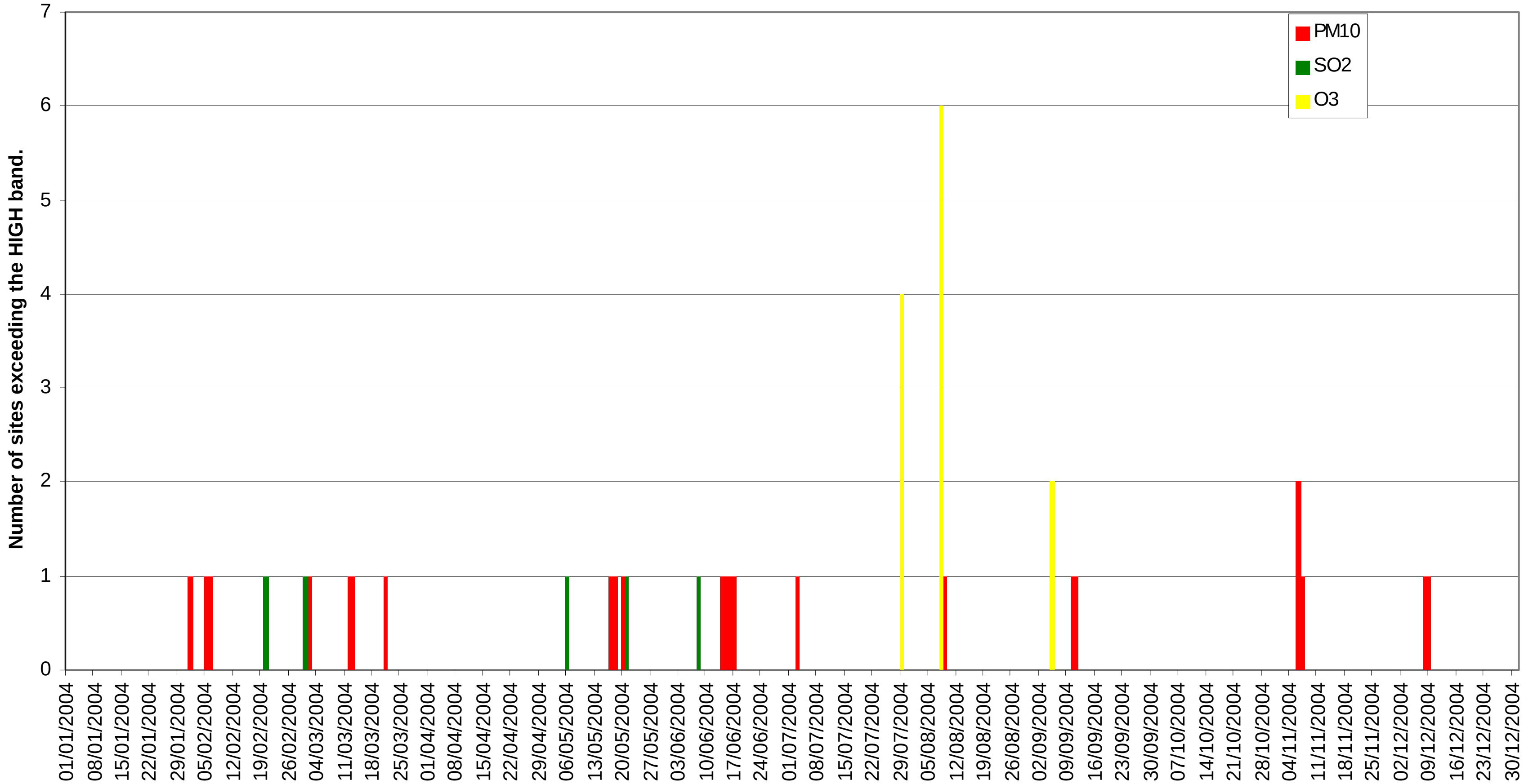


Figure 3.1 Number of stations with air pollution levels of HIGH and above for days throughout 2004.

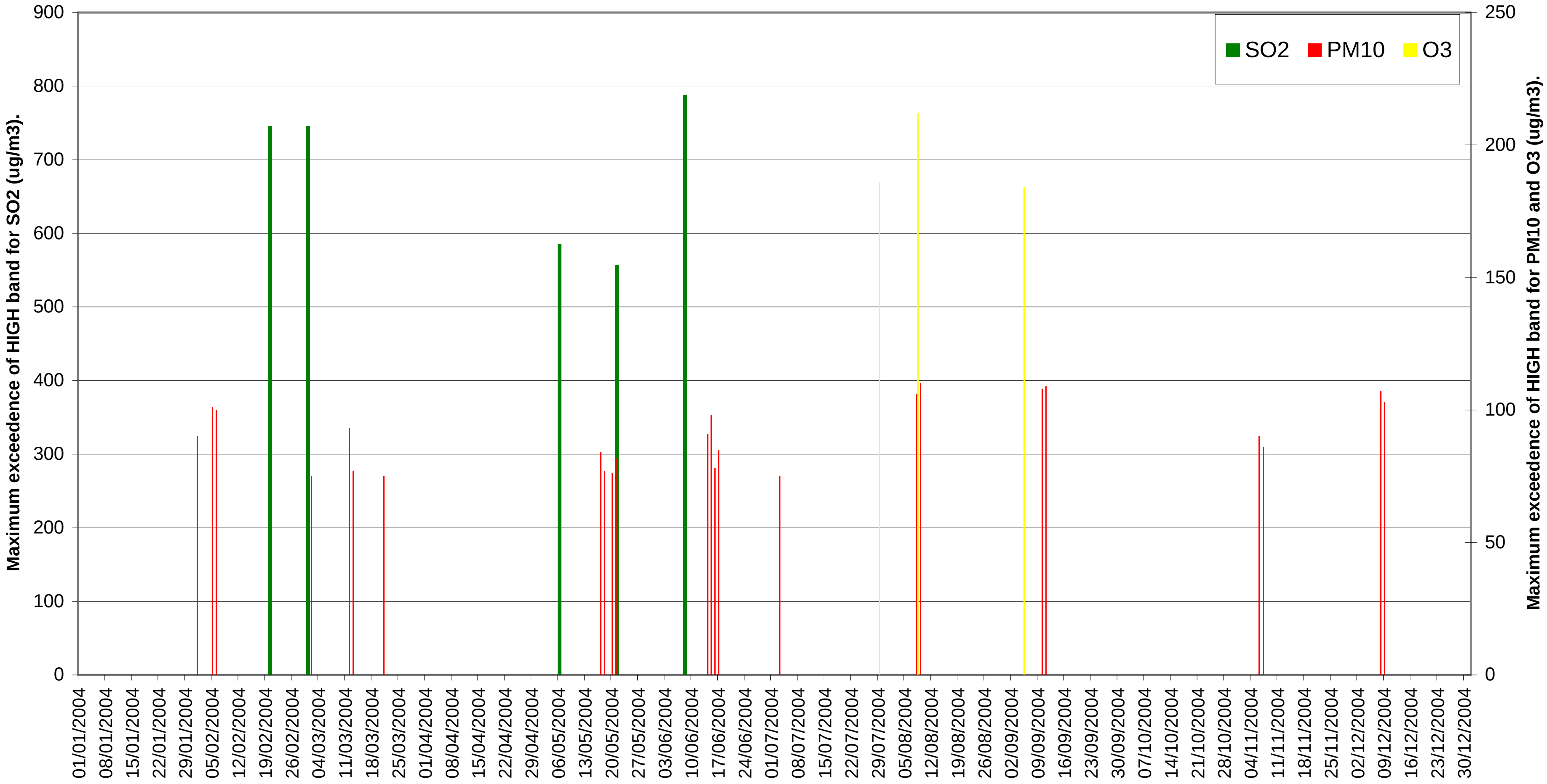


Figure 3.2 Maximum exceedence when air pollution levels were HIGH and above for days throughout 2004.

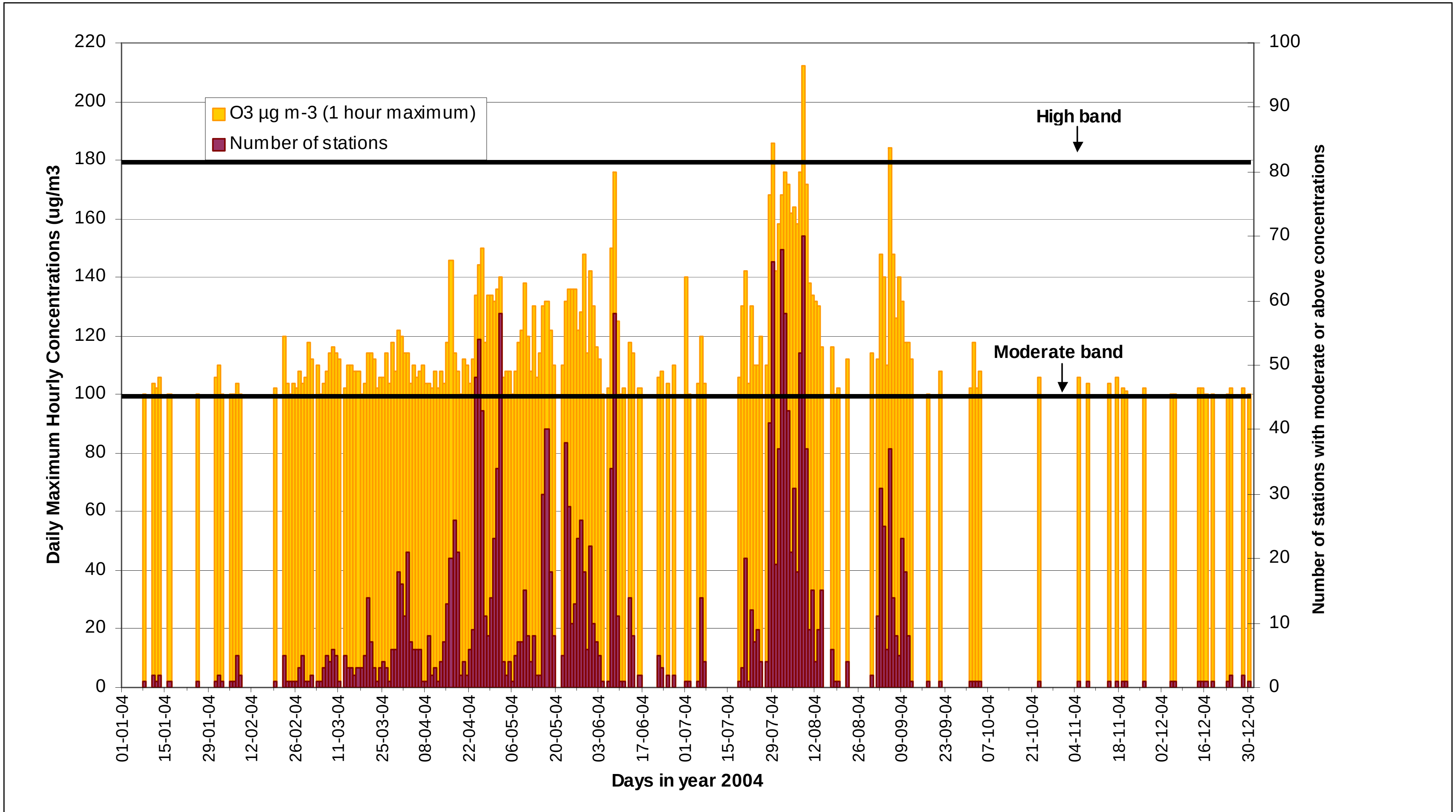


Figure 3.3 Daily maximum hourly ozone concentration across AURN Network with total number of stations measuring moderate or above levels of ozone over 2004.

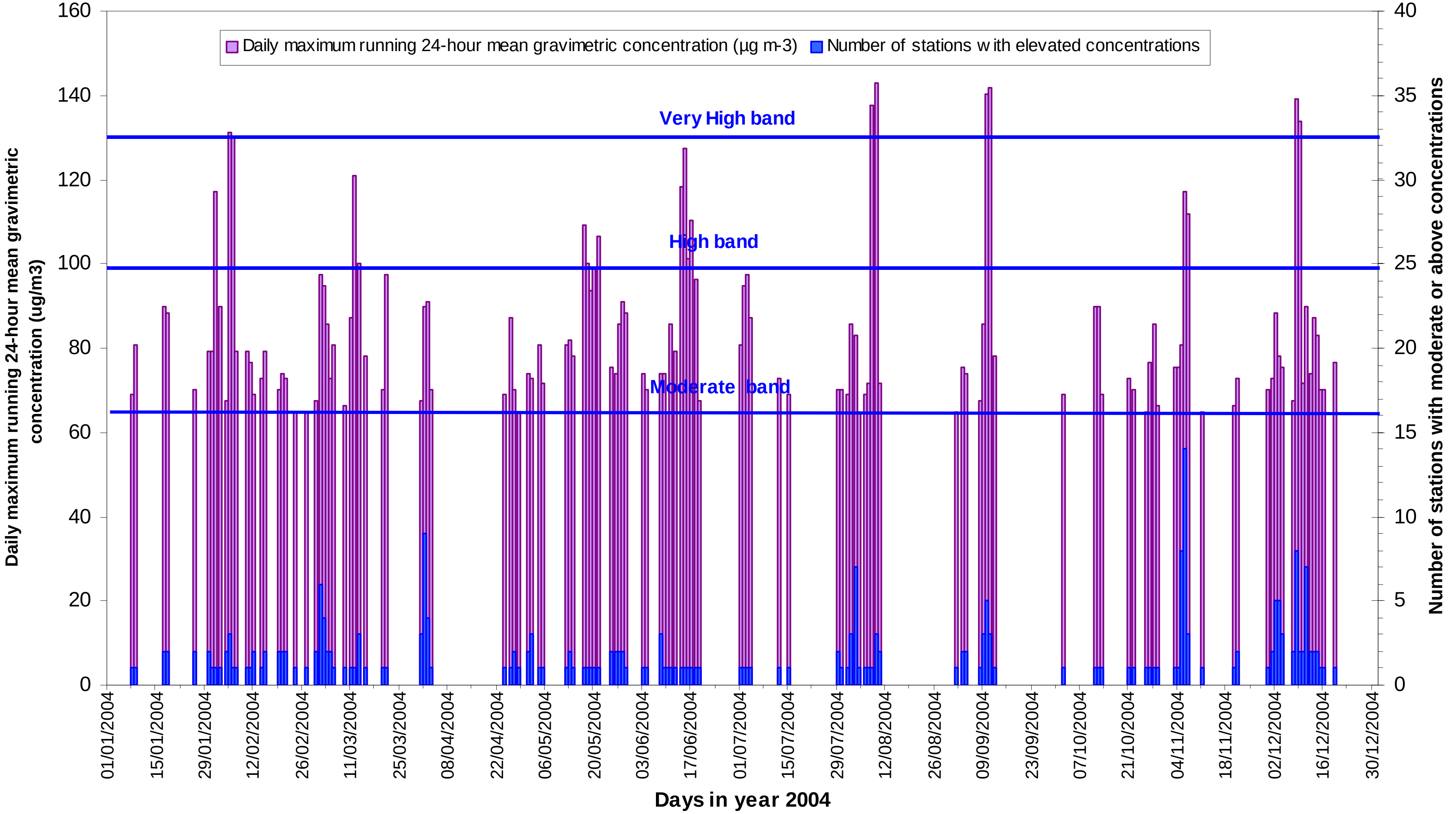


Figure 3.4 Daily maximum running 24-hour mean PM_{10} concentration across AURN Network with total number of stations measuring moderate or above levels over 2004

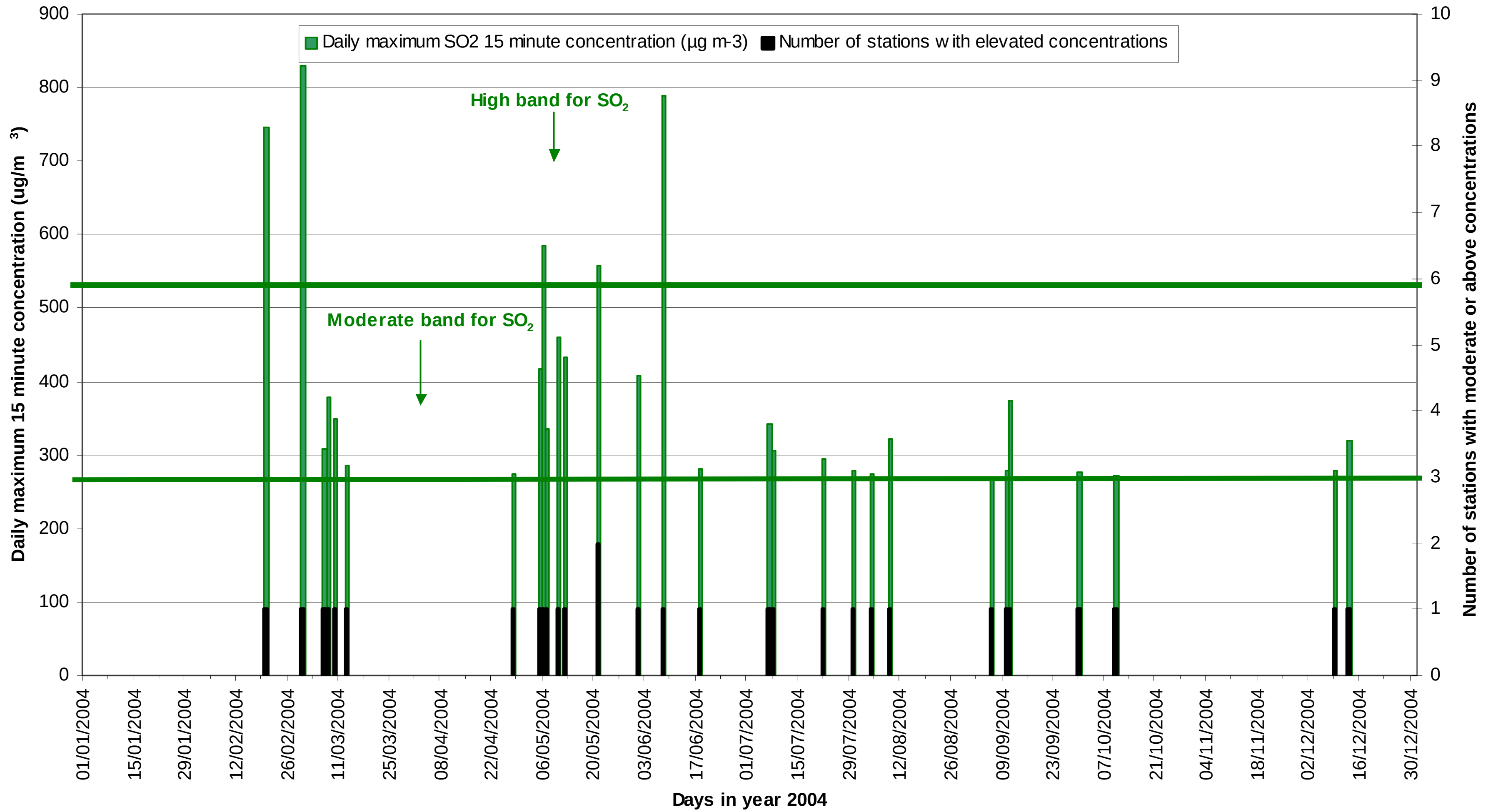


Figure 3.5 Maximum 15 minute average concentrations of SO_2 across AURN Network with total number of stations measuring moderate or above levels over 2004

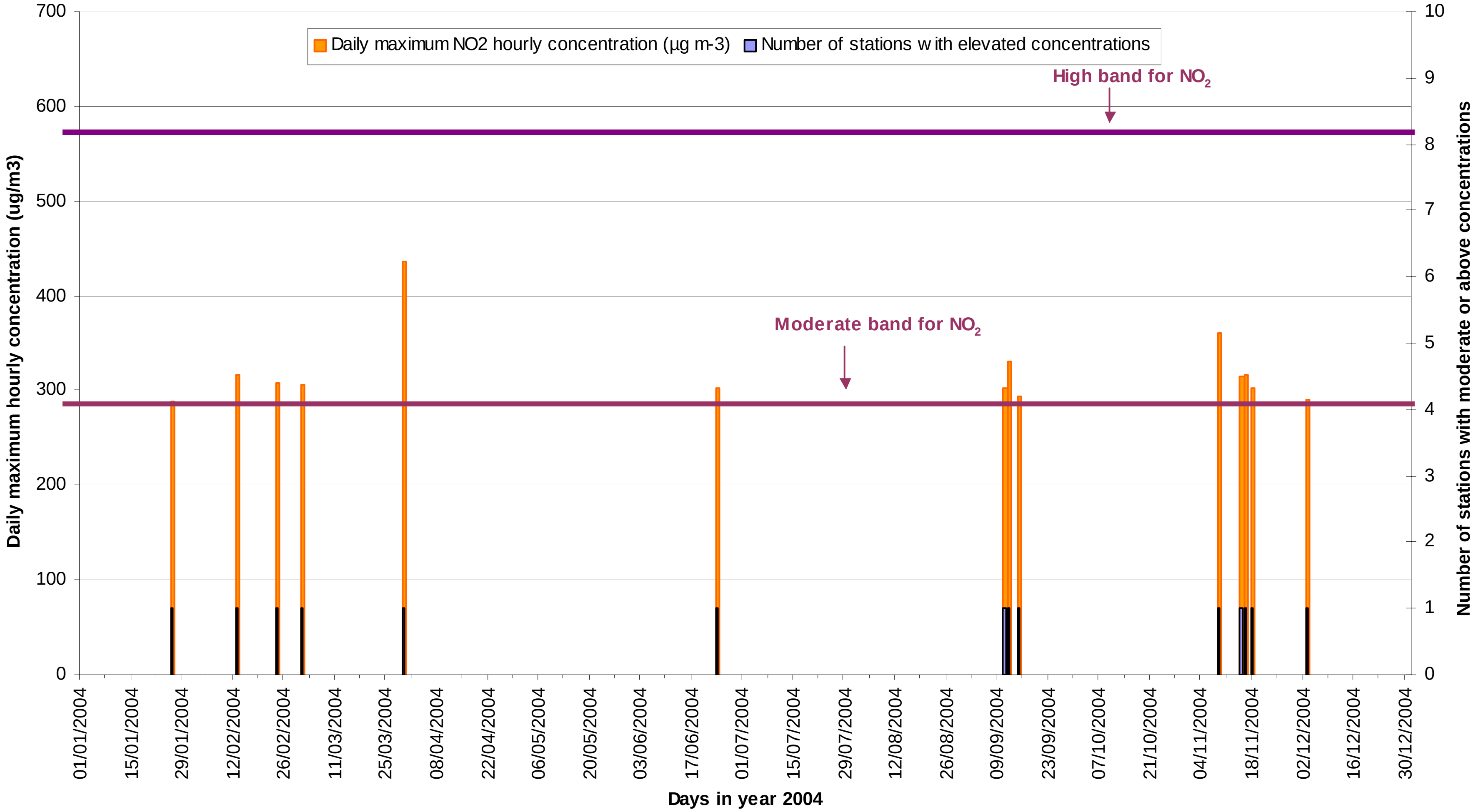


Figure 3.6 Daily Maximum hourly average of NO_2 across AURN Network with total number of stations measuring moderate or above levels over 2004

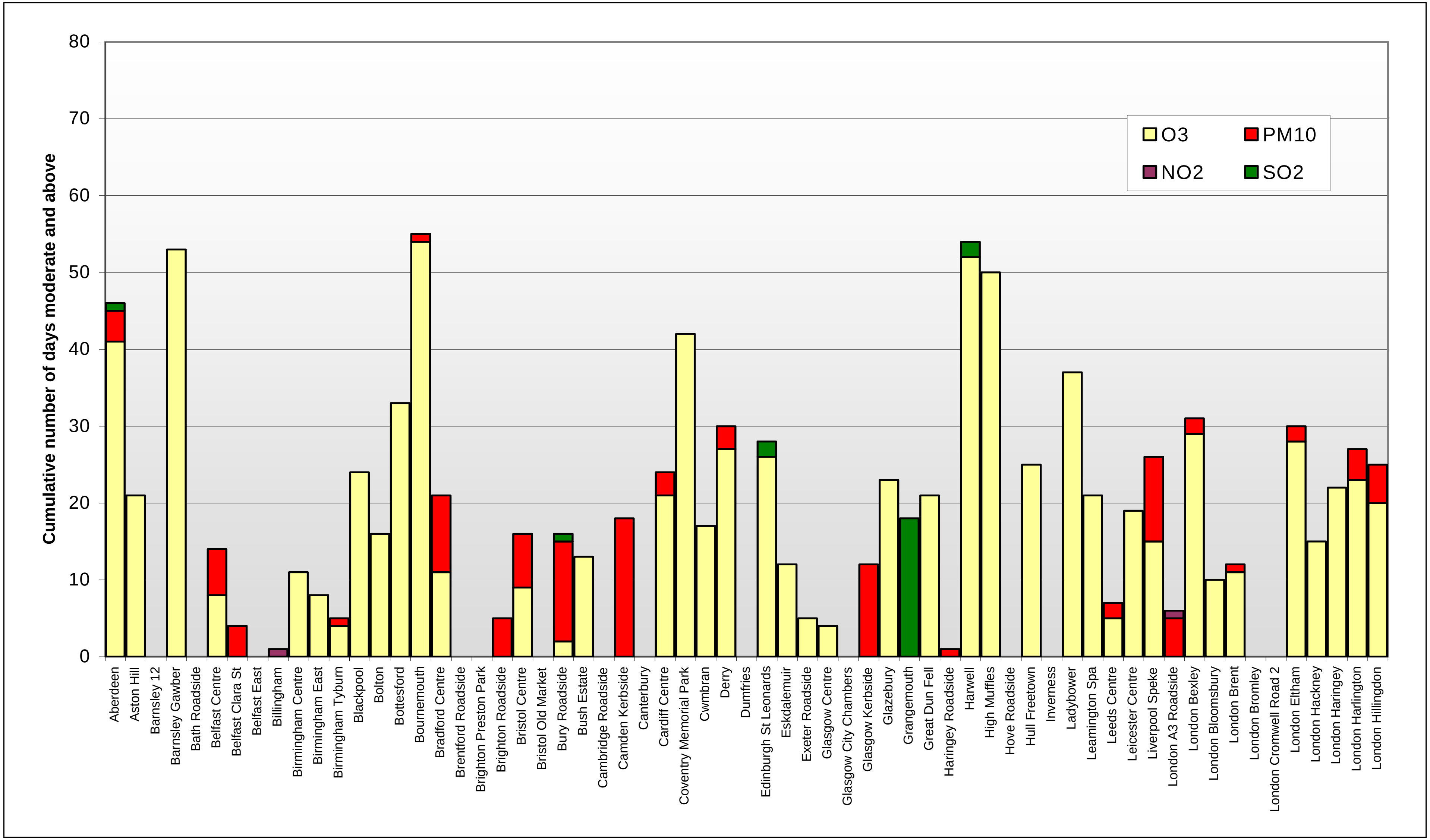


Figure 3.7a Number of days moderate and above for each AURN Network station over 2004– provisional data

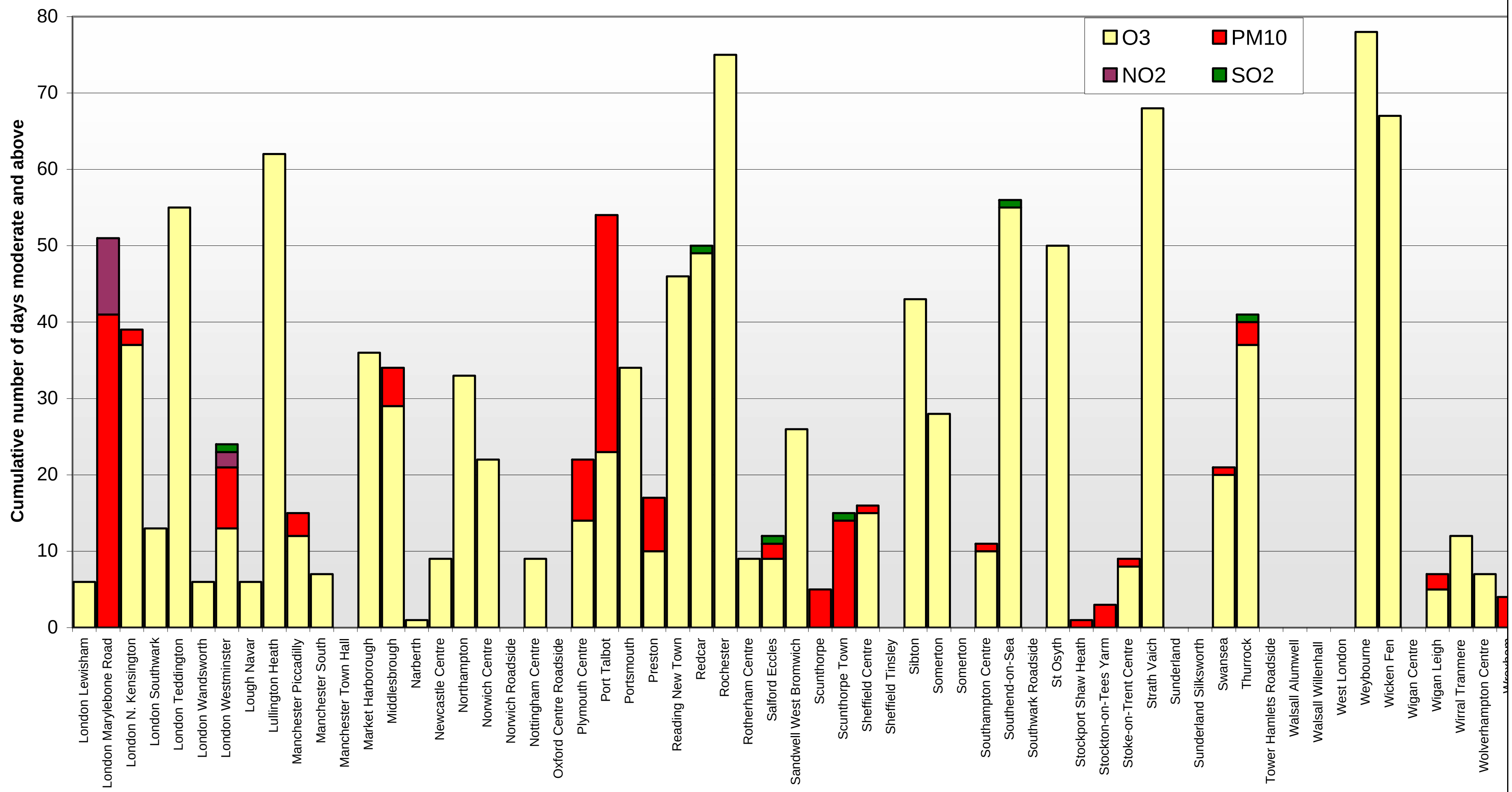


Figure 3.7b Number of days moderate and above for each AURN Network station over 2004 – provisional data

Table 3.3 – Summary of HIGH episodes year 2004

Pollutant	No. of HIGH days	No. of MODE RATE days	Maximum conc.* (Index)	Site with max concentration	Zone or Agglomeration	Date of max conc.	Forecast success HIGH days (%) [no. of instances].
Ozone	3	200	212 μgm^{-3} (index 7)	Sibton	Eastern	08/08/04	77 % [13]
PM_{10}	9	133	143 gravimetric μgm^{-3} (index 8)	Scunthorpe Town	Yorkshire and Humberside	09/08/04	8 % [24]
NO_2	0	14	436 μgm^{-3} (index 5)	London A3 Roadside	Greater London UA	30/03/04	[0]
SO_2	5	24	830 μgm^{-3} (index 8)	Salford Eccles	Greater Manchester UA	01/03/04	0 % [5]
CO	0	0	6.3 mgm^{-3} (index 2)	Manchester Picadilly	Greater Manchester UA	23/12/04	[0]

* *Maximum concentration relate to 8 hourly running mean or hourly mean for ozone, 24 hour running mean for PM_{10}, hourly mean for NO_2, 15 minute mean for SO_2 and 8 hour running mean for CO.*

Appendix 3 provides a worked example of how UK forecast success and accuracy rates are calculated.

General trends

As seen in figures 3.1 to 3.6, during some periods, levels were repeatedly in the Defra HIGH band due to PM_{10} and occasionally for ozone and sulphur dioxide. PM_{10} episodes were generally more localised events, while ozone episodes tended to be monitored at more locations (figures 3.3 and 3.4).

PM_{10} was the only pollutant measured to repeatedly exceed the Defra HIGH band during the first six months in 2004, with five excursions also for sulphur dioxide.

During July and August, ozone was experienced in the Defra HIGH band as previously reported by Targa (23/08/2004), with two excursions also for PM_{10} in localized areas. The success rate for ozone-related episodes continues to be comparatively high (77% success rate for the 13 incidences in 2004). This is because forecasters can see ozone levels progressively increasing over several days of hot, sunny weather. Unsuccessful forecasts of ozone are therefore rarely the result of measured HIGH levels that are not forecast, but more often HIGH forecast levels that are not measured when an episode ends before the forecaster expects.

In periods throughout the year during 2004, PM_{10} was measured as HIGH in localised areas. For PM_{10} related HIGH episodes, which tend to dominate in agglomerations where road traffic pollution, industry and construction are abundant, the success rate is low. Sources of PM_{10} are by their nature unpredictable. This indicates the difficulties associated with forecasting episodes of this complex multi-source pollutant. Only two of twenty four incidences of HIGH band measurements were forecasted in 2004.

Particulate matter

HIGH concentrations were measured periodically throughout 2004 at localized locations. Six exceedences were measured at the urban background site at Preston due to a series of local fires during short periods in February, September and December (maximum measured 142 ug/m3 gravimetric), five at Port Talbot due activities at the local steelworks and a favourable wind direction (maximum measured 117 ug/m3 gravimetric), periodically during the first half of the year, six at Liverpool Speke as a result of local building works (maximum 127 ug/m3 gravimetric) from May to July. A significant number of sites measured MODERATE levels on 2nd March (6 sites) during a period of settled weather, 1st April (9 sites) during cloudy weather , 3rd August (7 sites) in warm, thundery weather, 6th November (14 sites) due to bonfire night celebrations, 8th and 11th December (8 and 7 sites) during a period of foggy, cloudy weather.

It is likely that these elevated PM_{10} levels were attributable to several factors including:

1) Poor dispersion due to low wind speeds, including recirculation of air over the UK and possible formation of secondary particulates from UK emissions.
2) Easterly winds bringing secondary pollution across from Europe during warm settled weather (some days during the warm period from late July to early August).

Ozone

HIGH ozone levels were recorded on two days during a very warm period from late July to early August (29th July and 8th August). Four sites ranging from East Anglia to the Midlands measured HIGH band concentrations on 29th July (highest 186 u/m3 at Southend on Sea) then a further 6 sites ranging from East Anglia to the north east of England on 8th August (highest 212 ug/m3 at Sibton). Two sites measured HIGH on a further, unusually hot, day in September (5th September) in the south and south east of England (Lullington Heath at 184 ug/m3 and Portsmouth 182 ug/m3). The development of the ozone episode has been chronicled in detail in the ad-hoc report called “Ozone Pollution Episode Report (July – August 2004)” (Targa) which may be found on the National Air Quality Archive at:

http://www.airquality.co.uk/archive/reports/cat15/0409060809_03_episode_summer2004_final.pdf

The hot spell was in general characterised by mixed air trajectories, both westerly and easterly.

MODERATE levels of ozone were persistently measured at greater than just under 20 sites over the period 28th July to 9th August, the highest number of sites measuring MODERATE or above levels peaking at nearly 70 sites on the days 29th July, 1st August and 8th August.

A significant number of MODERATE levels were also measured from 24th April through to 2nd May, peaking at 58 sites on the last day then 16th – 31st May with a maximum of 40 sites on the 17th in accordance with warm UK temperatures.

Sulphur Dioxide

Five HIGH days were measured in 2004; all incidences were confined to the first half of the year. Harwell measured a 15-minute average of 557 ug/m3 on 21st May during an excursion in wind direction from northerly to easterly sampling, Salford Eccles measured 830 ug/m3 on 1st March, likely to have been the result of localised industrial emissions, Grangemouth reached the HIGH band on 3 occasions between Feb and June, with a maximum of 788 ug/m^3 due to activity at the refinery and a conducive wind direction. None of the incidences were successfully forecasted in 2004 due to the unpredictable nature of these emissions.

3.3 COMPARISON WITH 2003/2004

FORECASTING SUCCESS RATE

Figure 3.8 below shows the UK forecasting success rates for zones and agglomerations for 2002 - 2004. These figures are not comparable with the analyses for earlier years which were based on a different system of ten UK forecasting regions. 2002 was an incomplete year because zones and agglomerations were introduced to the system in May of that year. The graph presents the percentage of HIGH days that were correctly forecast.

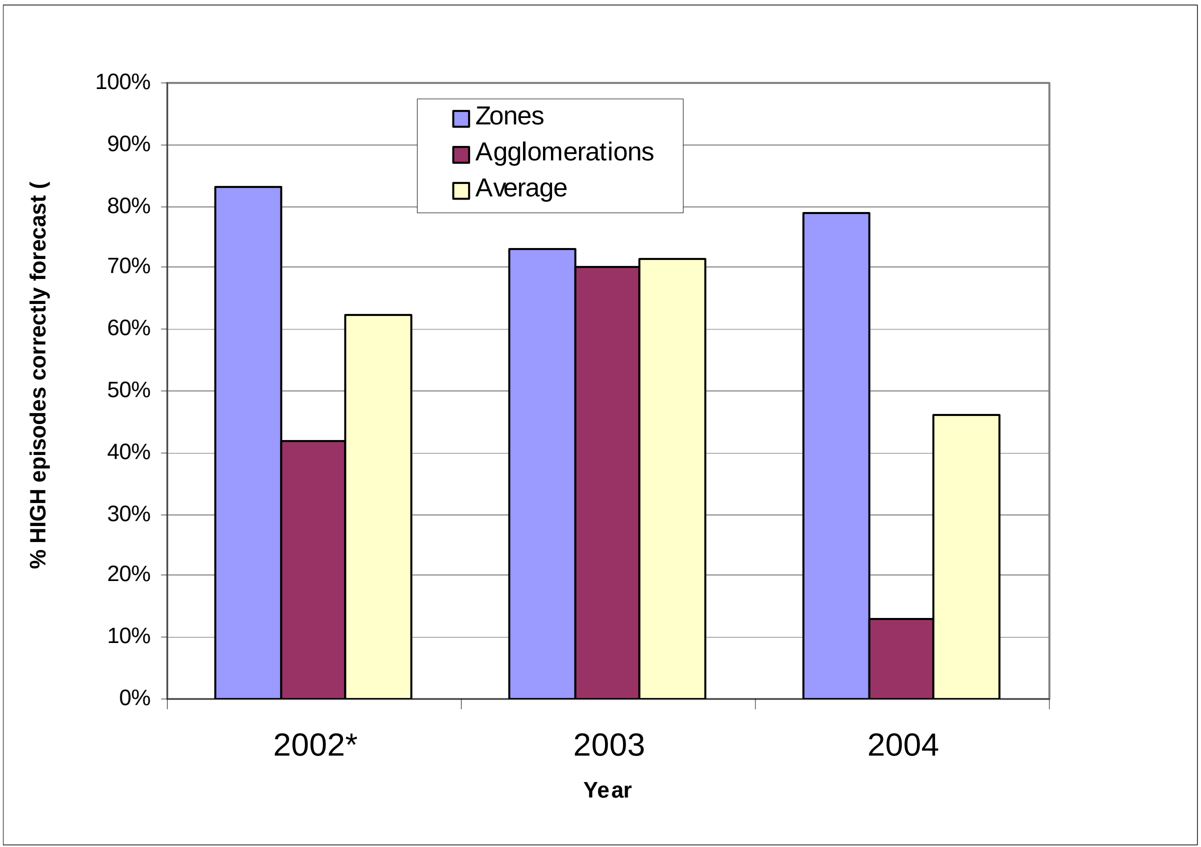


Figure 3.8 - Forecasting Success Rates for the whole of the UK, 2002-2004

The forecasting success rate for zones (mainly rural areas with towns and smaller cities) does not change significantly from one year to the next. This is because most of the high pollution episodes in zones are due to ozone, and these episodes can generally be forecast accurately using the tools which we have available in the UK. For agglomerations however, many of the high pollution episodes are due to local incidents of PM10 pollution and these are extremely difficult to forecast. 2003 was an exception in that the heat-wave summer also caused many ozone pollution episodes in agglomerations - these were successfully forecast - and this pushed the success rate up above what we would normally expect.

Of the 16 HIGH measurements experienced in agglomerations in 2004, 6 were due local building works and 5 as a result of localised industrial activity (therefore at least 70 % of the HIGHs could not have been reasonably predicted). Agglomerations, which cover urban and industrial areas rather than rural areas, tend to be characterised by unforeseeable particulate sources and higher road traffic levels which result in scavenging of ozone.

The forecasting system currently predicts ozone episodes with a greater degree of success and accuracy than PM_{10}. In 2003, the zones and agglomerations success rates were much more similar due to the exceptionally large number of ozone episodes (correctly predicted) in this heatwave year.

In terms of MODERATE forecasts, which by far represent the majority of forecasts issued, a different picture is seen, with a 137 % success rate for zones and 136 % success for agglomerations (success rates are able to exceed 100% as an agreement of within one index band is used for the analysis).

LOCALISED INFLUENCES

In addition to the problems of interpreting and forecasting the weather patterns, there are also occasional difficulties in forecasting accurately in areas where local effects on pollution are significant and unpredictable. The following are examples of such sites that reported HIGH concentrations during 2004:

- Scunthorpe is surrounded by local heavy industry, which often results in unpredictable elevated concentrations of PM10.
- Port Talbot monitoring station is located to the NE of the Corus Steelworks. As a result, emissions from the furnace are known to contribute to local PM10 concentrations when winds are south-westerly.
- Glasgow Kerbside regularly reports elevated PM10 concentrations as a result of its kerbside location. In addition, there is a taxi rank nearby and vehicles with idling engines for long periods may contribute to local levels.
- Liverpool Speke experienced a large amount of nearby building work in the early summer, over a period of several months.
- A series of local fires near the Preston monitoring station accounted for HIGH exceedences on six days.

OVERALL CONTRIBUTION FROM UK AND EUROPE IN SUMMER

A far lower contribution from European sources was seen in 2004 compared to the previous year, due in part to mixed air trajectory directions during the warmest period in the summer.

4 Breakdowns in the service

All bulletins were successfully delivered to the Air Quality Communications contractor on time and there were **no reported breakdowns** in the service over the year.

There was a **100% success rate** in uploading the forecast bulletins to the Air Quality Communications contractor and no breakdowns in the service were reported during the rest of the year.

5 Additional or enhanced forecasts

No formal enhanced forecasts can be issued until the format of the new service has been agreed with Defra and the Devolved Administrations. Nevertheless, there have been numerous informal discussions by email and telephone between the Netcen forecasters and Defra during this period. In particular, these were frequent during the ozone pollution episode at the end of July/beginning of August.

The air pollution forecast is always re-issued to Teletext, Web and Freephone services at 10.00 a.m. local time each day, but this is only updated when the pollution situation is changing.

The bi-weekly air pollution outlooks have continued to be delivered successfully to Defra and other government departments by email on Tuesdays and Fridays.

6 Ad-hoc Services

During this year, one ad-hoc report was presented to Defra and the devolved administrations. This detailed the extent and circumstances of a pollution episode and is listed below:

- Ozone pollution Episode Report (July- August)

All episode reports can be found on the National Air Quality Archive (www.airquality.co.uk/archive/reports/list.php).

In addition to these formal reports, regular contact was maintained with the Department throughout regarding possible 'HIGH' levels over the UK.

7 Ongoing Research

7.1 OPERATIONAL RESILIENCE

During 2004, a development project was initiated to improve the operational resilience of the Met Office Air Quality Forecast System. Even though the Met Office have always met our contractual requirements regarding operational service, the system was previously maintained by a limited number of specialised staff within the Development area of the Met Office. This responsibility has now passed to the Met Office Production and IT Operation teams.

This development improves the operational resilience of Air Quality Forecast System, as the responsibility of maintaining continuous operation is provided by dedicated teams responsible for maintaining all Met Office systems.

The impact of this development on our commitments under UK Air Quality Forecasting Contract will be unnoticeable externally, as we have always reacted immediately to ensure an operational service is maintained. However, from an internal perspective, a more robust and efficient service is now being provided.

7.2 STORAGE OF FORECAST AND OBSERVATION DATA

The Met Office has identified a requirement to monitor the day-to-day performance of the air quality forecasts produced by NAME. To meet this need, the Met Office intends to implement a new method of measuring NAME's performance - the air quality forecast skill index.

The air quality forecast skill index will be used to assess the forecast accuracy of NAME output. Regular comparisons between observed air concentrations recorded at a selection of monitoring stations and NAME forecasts will be undertaken to calculate a skill score.

During 2004, the first steps towards producing a skill score began. With assistance from Netcen, an automated process for routinely obtaining measured air concentrations stored in the national air quality archive (www.airquality.co.uk) was implemented. Further development was then undertaken to automatically convert the monitoring data into a suitable format for direct comparison with the NAME air quality forecast data. This work is still to be completed.

The intention of the AQ skill score is not only to measure current performance, but also to identify which aspects of the NAME model require further development, and to assess impacts on model performance from such development. In addition, the skill score will provide a quantitative measure of confidence in the overall scientific basis that underlies the NAME model.

8 Scientific Literature Review

This section reviews a selection of the scientific literature available in the public domain that is relevant to air quality forecasting. A list of reports produced by the UK Met Office during 2004 is also provided at the end of this section.

Recent literature concerned with air quality forecasting is summarised below.

8.1 CLUSTER OF EUROPEAN AIR QUALITY RESEARCH PROJECTS - FUMAPEX PROJECT

The main objectives of this project were the improvement of meteorological forecasts for urban areas, the connection of NWP (numerical weather prediction) models to UAP (urban air pollution) and exposure models, the building of improved UAQIFS (Urban Air Quality Information and Forecasting Systems), and their application in cities in various European climates.

The necessary steps will evolve in ten separate, but inter-linked Work Packages realised by 16 participants and 6 subcontractors. They represent leading NWP centres, research organisations, and organisations responsible for urban air quality, population exposure forecast and control, and local/city authorities from ten European countries.

The main impact of FUMAPEX will be improved, validated, inter-compared, and accessible UAQIFS implemented in an increasing number of European cities. Forecast and prevention of the worst air pollution episodes in large cities according to air quality directives will lead to an improved quality of human life and of the environment. Additional impacts are the potential use of improved weather and pollution forecasts for emergency management (fires, accidental emissions) and for long-term air quality management (scenario studies, emission abatement strategies, sustainable city life). Linking scientists and administrators of different specialisation will also lead to speed-up and innovation in related urban research and application addressed by FP5 (e.g. urban climate, sustainable transport, environment, health).

Further information can be found at: http://fumapex.dmi.dk/

8.2 CAMBRIDGE ENVIRONMENTAL RESEARCH CONSULTANTS

A comparison of ADMS-Urban, Netcen and ERG Air Quality Predictions for London was undertaken on behalf of Defra and devolved administrations by CERC in 2003. Findings included: all methodologies appeared to perform well based on objective criteria, empirically based methodologies (Netcen, ERG models) tended to generate less NO_2 for given NOx than the ADMS-urban model, longer term predictions generated from the three models vary for the extent of future exceedences in London, although all agree on the existence of exceedences in 2005 and 2010.

Further information can be found at: http://www.cerc.co.uk/index.htm

8.3 ANTHONY VEAL (MET OFFICE, LOCAL R AND D GROUP BRACKNELL)

Development of a Surface and Upper Air Synoptic Climatology to Assess Variations in Atmospheric Pollutant Concentrations in Birmingham.

Anthony finished writing a paper which looked at the relationship between air pollutant concentrations and weather and then looked in particular at the situation in Birmingham. He used several meteorological datasets ranging in coverage area from Europe down to just data for Birmingham and from heights ranging from the surface to 500 hPa. The research successfully related atmospheric motions at a number of different scales to local air quality in Birmingham using an automated synoptic climatological methodology. The statistical techniques used included principal components analysis, cluster analysis and discriminant analysis.

Further information can be found at: http://www.antveal.com/work.htm

8.4 ISB52

The aim of this project was to improve air quality forecasts. Air quality forecasting currently relies upon semi-empirical parameterisations within numerical models for the description of turbulent diffusion. Current schemes for parameterisation of turbulent diffusion do not adequately describe the effects of urban surfaces on the turbulence. The Salford Lidar research group based at the University of Salford is a collaborator in a project aimed at improving air quality forecasts which has been funded by the UK government's Invest to Save Budget. The other participants in this project were the Met Office, OinetiQ and the University of Essex.
Within this project two lidar systems (Salford and QinetiQ) were deployed simultaneously to measure wind turbulence in and near urban conurbations. The resulting data was be used to produce flow visualisations by the University of Essex, with the aim of improving the UK Met Office models of local air-flow and thus providing a better prediction of pollution concentration and dispersal.

Further information can be found at: http://www.ties.salford.ac.uk/people/fd/isb52b.htm

8.5 FORECASTING AIR QUALITY IN THE GREATER ATHENS AREA FOR THE YEAR 2004

Forecasts for the NO_x concentration levels in the Greater Athens area in 2004 were compared to the corresponding figures for 1990. Simulations were performed for two meteorological cases using four different dispersion models. Two different emission inventories were employed in the simulations. The first was based on the conditions for the year 1990, while the second was the reference scenario for the year 2004, taking into account all major public works under construction. In order to ensure the validity of the individual models, simulation results were compared with available measurements for the year 1990. All models showed an over prediction of the maximum NO_x concentrations, but in general the simulation results showed satisfactory agreement with the observations. Excellent agreement was found between the results of all models with regard to the distribution of the 50 maximum hourly NO_x concentrations. Reductions of the peak NO_x levels of the order of 35% were forecast by all models between 1990 and the reference scenario for 2004.

Further information can be found at this internet address:
www.inderscience.com/search/index.php?action=record&rec_id=556&prevQuery=&ps=10&m=or

Relevant reports produced by the UK Met Office during 2004 are listed below:

* Jones A.R., Thomson D.J., Hort M. and Devenish B., 'The U.K. Met Office's next-generation atmospheric dispersion model, NAME III', submitted to Proceedings of the 27th NATO/CCMS International Technical Meeting on Air Pollution Modelling and its Application, 2004

* Morrison N.L. and Webster H.N., 'An assessment of turbulent profiles in rural and urban environments using local measurements and NWP results', Boundary-Layer Meteorology; In Press

* Webster H.N. and Morrison N.L., 'An assessment of turbulence profiles in urban areas' in Ninth international conference on harmonisation within atmospheric dispersion modelling for regulatory purposes, ed. P. Suppan, vol. 2, 325-329, 2004

* Simmonds P.G., Derwent R.G., Manning A.J.and Spain G., 'Significant growth in surface ozone at Mace Head, Ireland 1987-2003', Atmospheric Environment 38, 4769-4778, 2004

* Gloster J., Champion H.J., Ryall D.B. and Brown A.R., 'The 2001 UK epidemic of foot-and-mouth disease - a meteorological review: Part 1', Weather 59, 8-11, 2004

* Gloster J., Champion H.J., Ryall D.B. and Brown A.R., 'The 2001 UK epidemic of foot-and-mouth disease - a meteorological review: Part 2', Weather 59, 43-45, 2004

Forward work plan for 2005

The two tables below summarise both the weekly and annual activity for 2005/2006 (Table 10.1 and 10.2 respectively).

Table 10.1 Weekly Activity Chart

1 Task	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Daily Forecast							
Forecast Outlook Summary							

Table 10.2 Annual Activity Chart

2 Task	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Quarterly Reports												
Quarterly Progress Meetings												
Annual reports												
Seminars												

9 Hardware and software inventory

Defra and the Devolved Administrations own the code for the ozone and secondary PM_{10} models, but not the graphical interface for these. Defra and the Devolved Administrations own the software for delivering the air pollution forecast to the Air Quality Communications system. Defra and the Devolved Administrations also own the web pages used to display the forecasts.

No computer hardware being used on this project is currently owned by Defra and the Devolved Administrations.

10 References/Internet links

http://www.antveal.com/work.htm

http://www.cerc.co.uk/index.htm

http://fumapex.dmi.dk/

http://www.ties.salford.ac.uk/people/fd/isb52b.htm

www.inderscience.com/search/index.php?action=record&rec_id=556&prevQuery=&ps=10&m=or

Appendix 1 - Air Pollution Index

CONTENTS

The UK Air Pollution Indices

Old Banding	Index	Ozone 8-hourly/ Hourly mean		Nitrogen Dioxide Hourly Mean		Sulphur Dioxide 15-Minute Mean		Carbon Monoxide 8-Hour Mean		PM_{10} 24-Hour Mean
		μgm^{-3}	ppb	μgm^{-3}	ppb	μgm^{-3}	ppb	mgm^{-3}	ppm	gravimetric μgm^{-3}
LOW										
	1	0-32	0-16	0-95	0-49	0-88	0-32	0-3.8	0.0-3.2	0–21
	2	33-66	17-32	96-190	50-99	89-176	33-66	3.9-7.6	3.3-6.6	22-42
	3	67-99	33-49	191-286	100-149	177-265	67-99	7.7-11.5	6.7-9.9	43-64
MOD										
	4	100-126	50-62	287-381	150-199	266-354	100-132	11.6-13.4	10.0-11.5	65-74
	5	127-152	63-76	382–477	200-249	355-442	133-166	13.5-15.4	11.6-13.2	75-86
	6	153-179	77-89	478-572	250-299	443-531	167-199	15.5-17.3	13.3-14.9	87-96
HIGH										
	7	180-239	90-119	573-635	300-332	532-708	200-266	17.4-19.2	15.0-16.5	97-107
	8	240-299	120-149	636-700	333-366	709-886	267-332	19.3-21.2	16.6-18.2	108-118
	9	300-359	150-179	701-763	367-399	887-1063	333-399	21.3-23.1	18.3-19.9	119-129
V. HIGH										
	10	$\geq$ 360 μgm^{-3}	$\geq$ 180 ppb	$\geq$ 764 μgm^{-3}	$\geq$ 400 ppb	$\geq$1064 μgm^{-3}	$\geq$ 400 ppb	$\geq$ 23.2mgm^{-3}	$\geq$ 20 ppm	$\geq$ 130 μgm^{-3}

Old Banding	New Index	Health Descriptor
LOW		
	1	
	2	Effects are unlikely to be noticed even by individuals who know they are sensitive to air pollutants
	3	
MODERATE		
	4	
	5	Mild effects unlikely to require action may be noticed amongst sensitive individuals
	6	
HIGH		
	7	Significant effects may be noticed by sensitive individuals and action to avoid or reduce these effects may be
	8	needed (e.g. reducing exposure by spending less time in polluted areas outdoors). Asthmatics will find that their
	9	“reliever inhaler is likely to reverse the effects on the lung.
VERY HIGH		
	10	The effects on sensitive individuals described for “HIGH” levels of pollution may worsen.

Appendix 2 - Forecasting Zones and Agglomerations

CONTENTS

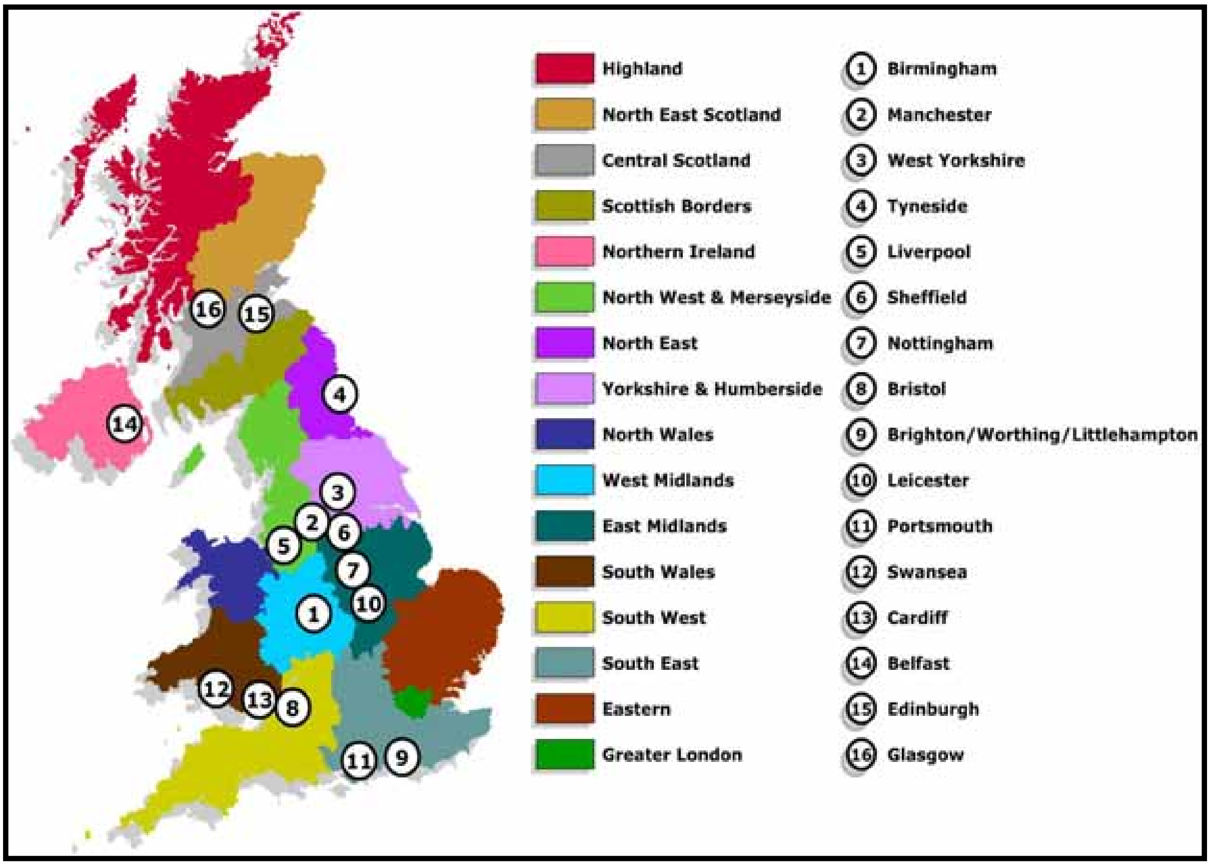
Forecasting Zones

Zone	Population
East Midlands	2923045
Eastern	4788766
Greater London	7650944
North East	1287979
North West and Merseyside	2823559
South East	3702634
South West	3728319
West Midlands	2154783
Yorkshire and Humberside	2446545
South Wales	1544120
North Wales	582488
Central Scotland	1628460
Highland	364639
North East Scotland	933485
Scottish Borders	246659
Northern Ireland	1101868

Forecasting Agglomerations

Agglomeration	Population
Brighton/Worthing/Littlehampton	437592
Bristol Urban Area	522784
Greater Manchester Urban Area	2277330
Leicester	416601
Liverpool Urban Area	837998
Nottingham Urban Area	613726
Portsmouth	409341
Sheffield Urban Area	633362
Tyneside	885981
West Midlands Urban Area	2296180
West Yorkshire Urban Area	1445981
Cardiff	306904
Swansea/Neath/Port Talbot	272456
Edinburgh Urban Area	416232
Glasgow Urban Area	1315544
Belfast	475987

Map of forecasting zones and agglomerations



Appendix 3 – Worked Example of How UK Forecasting Success and Accuracy Rates are Calculated.

CONTENTS

A worked example showing how forecasting accuracy and success rate are defined and calculated in this report

This analysis is based on an imaginary period of high pollution concentrations in South East England – which occurred during warm weather and resulted in the formation of photochemical ozone. There were 4 days on which HIGH concentrations were measured; 29th July, 30th July, 1st August and 2nd August. Over the slightly longer period from 29th July – 3rd August, there were 6 days on which HIGH levels were either measured or forecast. During the whole reporting period, there were no other observations of HIGH band measurements, either forecast or actual. 31st July was a cooler day and measurements did not reach the HIGH band, despite being forecasted. Measured air pollution and previous day forecast are shown below for each day during this period, in terms of index and descriptive bands:

Date	28/7	29/7	30/7	31/7	1/8	2/8	3/8	4/8
Measured Index value (M)	5 (MOD)	7 (HIGH)	7 (HIGH)	6 (MOD)	7 (HIGH)	7 (HIGH)	5 (MOD)	5 (MOD)
Forecast Index value (F)	5 (MOD)	6 (MOD)	7 (HIGH)	7 (HIGH)	8 (HIGH)	5 (MOD)	7 (HIGH)	6 (MOD)

Based on the figures above, the success and accuracy of predicting HIGH episodes (>= Air Pollution index 7) for the South East Zone may be analysed as shown below:

Date	28/7	29/7	30/7	31/7	1/8	2/8	3/8	4/8
Measured Index value (M)	5 (MOD)	7 (HIGH)	7 (HIGH)	6 (MOD)	7 (HIGH)	7 (HIGH)	5 (MOD)	5 (MOD)
Forecast Index value (F)	5 (MOD)	6 (MOD)	7 (HIGH)	7 (HIGH)	8 (HIGH)	6 (MOD)	7 (HIGH)	6 (MOD)
HIGH forecast or measured	No, so not used in calculations	Yes	Yes	Yes	Yes	Yes	Yes	No, not used in calcs
OK- Agreement of F and M to +/- 1 index band	N/A	Yes	Yes	Yes	Yes	Yes	No	N/A

HIGH days measured	4
HIGH days forecast	4
OK (M and F) [i.e. Agreement of F and M to +/- 1 index band	5
Wrong (F not M)	1
Wrong (M not F)	0

The forecasting **success** during this period is calculated as:

[OK (M and F) / HIGH days measured]*100 = [5/4]*100 = **125 %**

The corresponding **accuracy** is calculated as:

[OK (M and F) / {OK (M and F) + Wrong (M not F) + Wrong (F not M)}]*100

= [5 / {5+0+1}]*100 = [5/6]*100 = **83**

The analysis is then repeated for each of the 16 UK zones and 16 UK agglomerations.