REPORT

UK Air Quality Forecasting: Operational Report for April to June 2006

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

AEAT/ENV/R/2274 Issue 1
August 2006

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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 from April to June 2006. 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 the second quarter of 2006, there were 9 days on which HIGH air pollution was recorded. Over 55 % of the HIGH measurements were due to PM_{10} only and 45 % due to PM_{10} and O_3 on coincident days. Around 90 % of the HIGH ozone day-incidents were forecast successfully in the various regions they occurred and around 40 % of the incidents were forecast successfully for PM_{10}. Some of the PM_{10} exceedences occurred as a result of a cloud of particulates issuing from the east during long range transport, hence these were predicted with a reasonable degree of accuracy, the rest of the incidents were due to unpredictable and localised (..sometimes building related) events, reflected in the fair accuracy of HIGH forecasts within zones and agglomerations (average around 40 %) Overall forecast success rates for the HIGH band were excellent, at above 100 % for both zones and agglomerations. Many MODERATE days were measured (mainly for ozone but a considerable contribution from the other pollutants) and were forecast with a high degree of success and a very reasonable accuracy. These MODERATE periods are recorded within the forecasting success and accuracy calculations. The forecasting success and accuracy for this quarter for HIGH and MODERATE episodes is summarised in Table 1 below.

Success figures for MODERATE forecasts issued show that a large proportion of measured polluted days were successfully forecast (percentage above 100%)[1]. An average accuracy figure of 85 % indicates that only 15 % of the forecast MODERATE levels were not measured and remained LOW. The accuracy figures tend to be lower due to the precautionary approach that Netcen takes when issuing the daily forecasts- we issue a forecast for MODERATE pollution when there is only a small chance that it will be recorded.

Table 1 – Forecast success/accuracy for incidents above 'HIGH' and above 'MODERATE', April 1st to June 30th 2006.

Region/Area	HIGH		MODERATE	
	% success	% accuracy	% success	% accuracy
Zones	107	53	144	90
Agglomerations	129	30	188	79

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

1. Investigating ways of using automatic software systems to streamline the activities within the forecasting process, thus allowing forecasters to spend their time more productively considering the most accurate forecasts.
2. Researching the chemistry used in our models, in particular the NO_x->NO_2 conversion used in NAME, and the chemical schemes for secondary PM_{10} and ozone.
3. Improving the NAME model used for ad-hoc analyses. In particular, recent improvements have assisted with investigations of the possible long-range transport of PM_{10} pollution from forest fires in Russia and the long-range transport of particles from Saharan Dust Storms.
4. Improving and updating the emissions inventories used in our models.

There were no reported breakdowns in the forecasting service between April and June; all bulletins were delivered to the Air Quality Communications contractor on time.

Several ad-hoc pollution episode reports were compiled or published this quarter. The fifth annual AQ Forecasting seminar was held at Culham on 22nd June 2006, this successful event covered the AQ impact of the Buncefield incident.

Contents

1 Introduction

A forecast of the following day's air pollution is prepared every day by Netcen in collaboration with the Met Office. 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 can be updated and disseminated through Teletext, the World Wide Web and a Freephone telephone number 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, and is then included in subsequent air quality bulletins for the BBC, newspapers and many other interested organisations.

This report covers the media forecasts issued during the second quarter. 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 every week, on Tuesdays and Fridays, we also provide a long-range pollution outlook. This takes the form of a short text message which is emailed to approximately sixty recipients in Defra and other Government Departments, together with the BBC weather forecasters. The outlook is compiled by careful assessment and review of the outputs from our pollution models, which currently run out to 3 days ahead, and by also considering the long-term weather situation.

We continue to provide a quality control system 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 on their BBC Online service. The quality control work is carried out at around 3.00 p.m. daily, with the forecast updating onto the BBC Online Web site at 4.00 a.m. the following morning.

2 New developments during this period

2.1 MET OFFICE DEVELOPMENTS

During this quarter, the Met Office collaborated with Netcen on the real-time response and consequent ad-hoc report for the May 2006 PM_{10} incident that affected the north of the UK. Considerable effort also went into the Defra report on the Buncefield incident and the subsequent air quality seminar.

Met Office system developments include the reintroduction of output of UK air quality maps to a development version of the model. Discussions with Netcen will be undertaken to determine the best format and methods for delivering this data from the operational system. Improvements to the resilience and error notification of the operational air quality system have also been made.

3 Analysis of Forecasting Success Rate

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). This analysis of forecasting performance is based on provisional data, as used in the daily forecasting process. Any obviously faulty data 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 3 shows a worked example of how accuracy and success rates are calculated. Further details of the text descriptions and index code used for the forecasting are given in Appendix 1.

The forecasting success rates for each zone and agglomeration for the quarter reported on 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

The forecasting success rates for 'MODERATE' days or above for each zone and agglomeration are presented in Tables 3.3 (zones) and 3.4 (agglomerations). Table 3.3 and 3.4 give the same information as in Tables 3.1 and 3.2, but summarised for 'MODERATE' days and above.

3.1 FORECAST ANALYSIS FOR APRIL 1ST TO JUNE 30TH 2006.

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	0	2	5	1	0	5	0	1	1	0	0	0	3	0	3	6	27
forecasted days	2	3	4	5	2	5	2	1	2	0	2	2	3	2	3	5	43
ok (f and m)	0	2	5	4	0	5	0	2	1	0	0	2	3	1	3	1	29
wrong (f not m)	2	1	0	1	2	0	2	0	1	0	2	0	1	1	1	4	18
wrong (m not f)	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	5	8
success %	100	100	100	400	100	100	100	200	100	100	100	100	100	100	100	17	107
accuracy %	0	67	71	80	0	83	0	100	50	0	0	100	75	50	75	10	53

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	2	1	2	0
forecasted days	0	2	1	1	2	2	2	3	0
ok (f and m)	0	1	0	0	0	1	1	2	0
wrong (f not m)	0	1	1	1	2	1	1	1	0
wrong (m not f)	0	0	0	0	0	1	0	0	0
success %	100	100	100	100	100	50	100	100	100
accuracy %	0	50	0	0	0	33	50	67	0

AGGLOMERATIONS	Nottingham UA	Portsmouth UA	Sheffield UA	Swansea UA	Tyneside	West Midlands UA	West Yorkshire UA	Overall
measured days	0	0	0	1	0	0	1	7
forecasted days	2	1	1	1	3	3	4	28
ok (f and m)	1	0	0	0	0	2	1	9
wrong (f not m)	1	1	1	1	3	1	3	19
wrong (m not f)	0	0	0	1	0	0	0	2
success %	100	100	100	0	100	100	100	129
accuracy %	50	0	0	0	0	67	25	30

*** 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	23	43	84	44	53	46	18	46	62	22	17	55	60	59	61	55	748
forecasted days	56	72	75	60	69	64	55	58	63	53	56	71	70	74	74	61	1031
ok (f and m)	55	71	86	63	73	65	52	68	69	53	52	77	78	73	74	65	1074
wrong (f not m)	5	4	3	4	5	4	6	2	4	5	5	2	4	4	5	8	70
wrong (m not f)	3	3	3	5	4	3	3	0	3	0	2	1	4	2	7	8	51
success %	239	165	102	143	138	141	289	148	111	241	306	140	130	124	121	118	144
accuracy %	87	91	93	88	89	90	85	97	91	91	88	96	91	92	86	80	90

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	4	39	0	13	19	14	51	29	17
forecasted days	34	58	47	43	42	36	49	56	45
ok (f and m)	27	61	2	38	44	33	61	53	44
wrong (f not m)	7	3	45	6	4	5	2	9	3
wrong (m not f)	1	4	0	1	3	4	2	5	1
success %	675	156	100	292	232	236	120	183	259
accuracy %	77	90	4	84	86	79	94	79	92

AGGLOMERATIONS	Nottingham UA	Portsmouth UA	Sheffield UA	Swansea UA	Tyneside	West Midlands UA	West Yorkshire UA	Overall
measured days	16	44	12	46	18	28	18	368
forecasted days	44	61	39	63	46	52	41	756
ok (f and m)	34	65	32	64	44	50	38	690
wrong (f not m)	15	3	11	7	9	6	6	141
wrong (m not f)	1	2	1	8	3	3	8	47
success %	213	148	267	139	244	179	211	188
accuracy %	68	93	73	81	79	85	73	79

*** 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 3.5 – Summary of episodes April to June 2006 (Based on latest provisional data)

Pollutant	High or above days	Moderate days	Max. conc. (µg /m^3) *	Site with max. conc.	Zones or Agglomeration	Date of max conc.	Forecast success HIGH days (%) [no. incidents, zone or agglomeration days] **
Ozone	4	76	220	Middlesborough	North East zone	10/6/06	88 % [17]
PM_{10} gravimetric	9	28	137	Scunthorpe Town	Yorks and Humberside zone	10/6/06	39 % [13]
NO_2	0	8	325	London Westminster	London UA	12/5/06	N/a
SO_2	0	6	386	Salford Eccles	Greater Mancs UA	12/6/06	N/a
CO	0	0	4.2	Tower Hamlets Roadside	London UA	11/6/06	N/a

* 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 (CO units are mg/m3).
** the number of incidents is the total of the number of HIGH days in all zones and agglomerations (ie a HIGH day on the same day in many zones or agglomerations is counted as many incidents, not just one)

General Observations

There were 30 zone or agglomeration-day incidents of HIGH band pollution measured during this quarter, measured on 9 separate days. 57 % of these HIGH incidents were due to HIGH ozone levels, 43 % due to HIGH particulate PM_{10} levels. All of the four HIGH days measured for ozone occurred on HIGH days for PM_{10}. 88 % of the HIGH exceedences were forecast successfully for ozone, one incident was not forecast successfully in early May for the East Anglia region (the only region to reach the HIGH band during that episode) and a second incident was again not forecast in the north-east of England when an unusual HIGH measurement was recorded at the Sunderland Silksworth AQM site on the 11th June. Five of the thirteen incidents of HIGH PM_{10} were successfully forecast during a period of easterly air trajectories in early May, during a period in which a cloud of particulates had travelled to the UK as long range transport from the east and Europe. Seven of the thirteen PM_{10} incidents were due to primarily industrial related sources and one as the result of, primarily, traffic emissions. Due to the inherently unpredictable and localised nature of PM_{10} episodes, these 8 HIGH incidents were not successfully forecast and were not considered to broadly represent ambient levels across their associated regions, so were therefore not accounted for during the forecasting process.

Seventy six MODERATE days were measured for ozone during this quarter, measured at more than 50 sites on any one day during 11 individual days, during periods of predominantly easterly trajectories.

Twenty eight MODERATE days were seen due to PM_{10} , measured at geographically diverse locations, mainly as a result of air reaching the UK from Europe combined with localised traffic or industrial sources.

Eight MODERATE days were measured for nitrogen dioxide at sites in the network, half of these incidents were measured at the London Marylebone Road kerbside site.

Six MODERATE days were measured for SO2 at a few industrial-designated and urban background AQM sites, evenly spaced throughout the reporting period, likely to have been the result of localised industrial emissions.

Figures 3.1 – 3.3 show the trends of pollutants in graphical form. A site-by-site breakdown is given in Figures 3.4a and 3.4b.

O_3

Four HIGH days were measured during the reporting period. Chronologically the first HIGH day happened on Thursday 4th May. Only one AQM site measured a HIGH band reading (Wicken Fen in East Anglia), a day on which nearly 70 sites measured MODERATE or above levels. Air trajectory plots show southerly air arriving from France on that day, with maximum daytime temperatures of up to 28 degrees C in the south east of England, for example, and up to 27 C in the Midlands. The 66 sites which had measured in the MODERATE band were geographically widespread but the most persistently elevated levels appear to have been in East Anglia, London, south east England and the Midlands. Before and after the 4th May air was sourced from a south-westerly direction, explaining the sudden change in ozone levels before and after that date.

From 6th May onwards high pressure atmospheric air was gathering over the north Atlantic and for a while much of the UK experienced air from the east, while areas such as Wales and the south west of England were sampling air from a south-westerly direction. By the 10th May all areas were experiencing easterly air sourced from northern Europe and western Russia, which continued until the 14th, after which came a change to cleaner northerly air. On the 11th May temperatures of 24 degrees C were measured in the south east of England, other areas in the low 20's C. Nearly 70 geographically diverse sites measured MODERATE levels on that day, the most persistent levels seen at rural and remote locations. Friday 12th saw a similar number of sites in the MODERATE band with temperatures of 25 C measured in the south east of England and 23 C in the Midlands. A drop in daytime temperatures from the 13th May onwards saw a decrease to minimal ozone exceedences at all network sites for approximately 2 weeks.

A second episode occurred between the 9th and 12th June, including a significant number of sites measuring in the HIGH band on two of the days. By the 8th June westerly air included a fraction of air that had circulated over France. On the 9th winds were light and the incoming air was becoming increasingly easterly in direction, a trend which was completed on the 10th. On the following two days the easterly air trajectories destabilised, becoming both southerly and westerly for a while, after which no HIGH episodes occurred for the remainder of June. Over the period 7th to the 12th June daytime temperatures gradually built up, for example in the south east of England a rise from 25 C to 30 C was seen. After the 13th temperatures dropped. On the 9th nearly 90 sites measured MODERATE or above levels. Nine sites entered the HIGH band, these sites were mainly situated in the southerly half of England. On the 10th the most persistently elevated levels of ozone were measured towards the west of the UK, for example in Wales and the north west of England, in both urban and rural environments. More than 75 AQM sites measured MODERATE levels on that day, HIGH levels were experienced at a further 15 sites, predominantly in East Anglia and the Midlands, with a fraction of sites situated in the north of England and one in South Wales. HIGH levels were again seen at 2 sites on the 11th, one in East Anglia, the other was at Sunderland in the north east of England which measured an unexpected localised increase, before falling back to the MODERATE band. The number of sites entering the MODERATE band daily fell below 65 for the remainder of June.

An ad-hoc report will be available shortly on the National Air Quality Archive website detailing the ozone episode in mid-June.

Figure 3.1 shows the trends in O_3 levels over this period.

PM_{10}

For the majority of the reporting period MODERATE or above levels were measured at less than 10 sites on any one day, except for the period 8th – 9th May. Between the 7th and 9th May easterly air trajectories combined with the position of a weather front lying over the UK caused a cloud of particulates issuing from an unknown eastern source (speculated to have been the result of fires in western Russia combined with general European sources, with the possible inclusion of a burst of both a UK localised and a European pollen outbreak) to be partially deposited in areas of Scotland, the north of England and Northern Ireland over a 2 or 3 day period. HIGH particulate levels were measured at Glasgow kerbside on Monday 8th and Tuesday 9th May, likely to have been the result of local contributions combined with the effect from the particulate cloud. HIGH band measurements of index 9 were experienced at the urban industrial site at Scunthorpe Town in the north east of England, again as the probable result of localised activities combined with effects from the particulate cloud. Similarly urban industrial-designated Middlesborough measured index 7 on both days. The Bradford Centre site measured 2 HIGH days but the cause of this was harder to verify due to the other unpredictable effect of ongoing localised building works. Between Monday 8th and Wednesday 10th a daily maximum of 18 national network AQM sites measured MODERATE or above levels of PM_{10}, twelve of which were thought to have been the direct result of the particulate cloud. The weather front lying over the UK broke up towards the end of that week and the remainder of the particulate cloud passed away westwards over the Atlantic.

More than 5 sites measured MODERATE levels of PM_{10} during two days of the warm period in mid June (9th and 10th June). Air trajectories indicate European air was incident on these days so the elevated levels are likely to have been the result of European contributions in combination with localised sources, exceedences were experienced at industrial and roadside locations exclusively. HIGH days were measured at Bradford on these warm days, likely to have been localised building work related. Another HIGH day was experienced at Scunthorpe on the following day, likely to have been related to industrial emissions and a change in wind direction.

Two HIGH days were seen at the Port Talbot AQM site in early April, again likely due to activity at the nearby steel works.

Figure 3.2 shows the trends in PM_{10} levels over this period.

NO_2

Eight MODERATE days were seen, fairly evenly spaced throughout this period, almost all the exceedences were seen at London sites and at the Marylebone Road station.

SO_2

Seven MODERATE days were seen fairly evenly spaced throughout this period, almost all the exceedences were seen at the industrial Grangemouth site. Two urban sites measured MODERATE exceedences on single days, possibly the result of power station plumes / longer range transport.

Figure 3.3 shows the trends in SO_2 levels over this period with NO_2 also included.

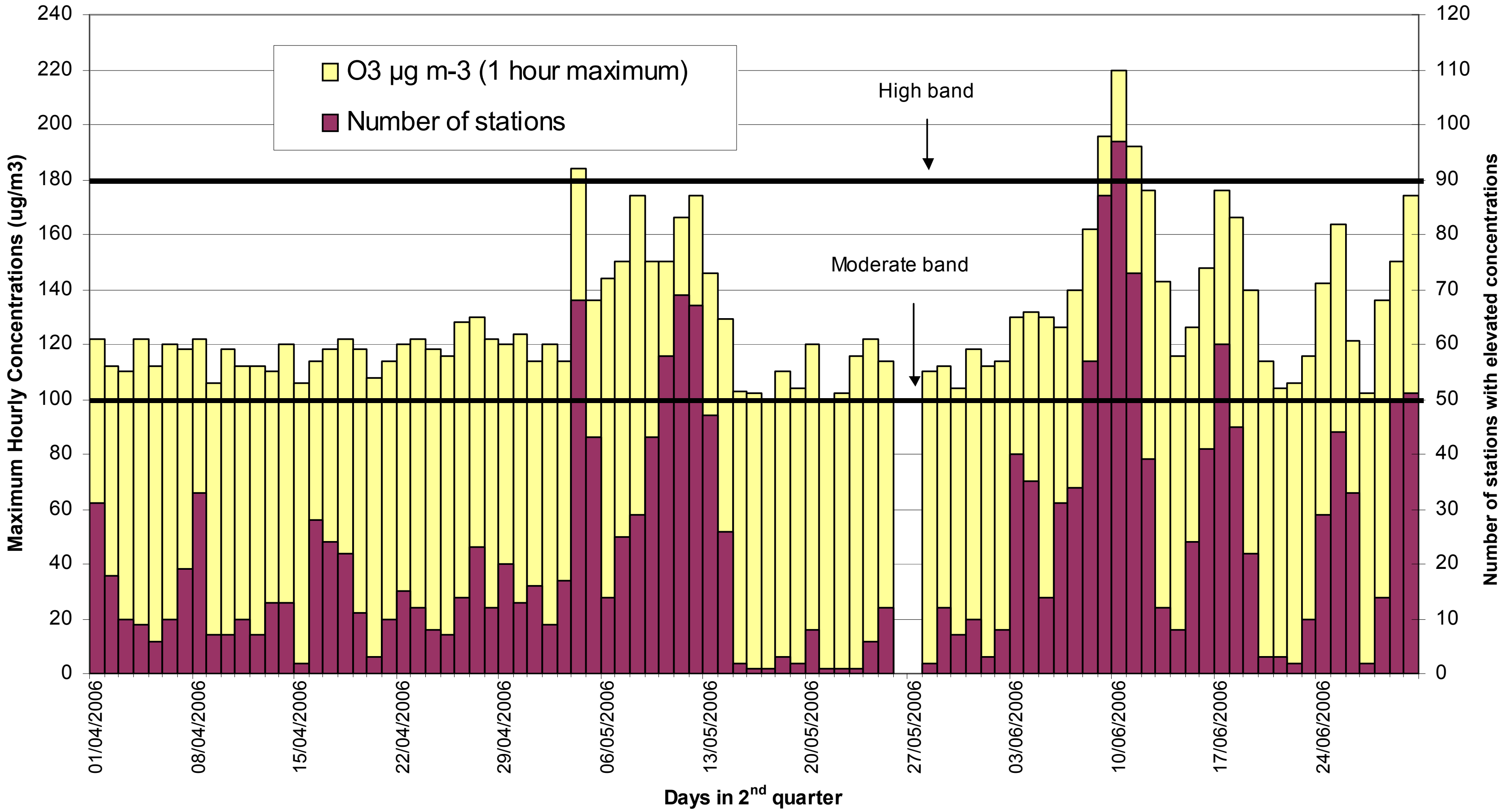


Figure 3.1 Daily maximum hourly ozone concentration across AURN Network with total number of stations measuring MODERATE or above levels of ozone over 2nd quarter 2006.

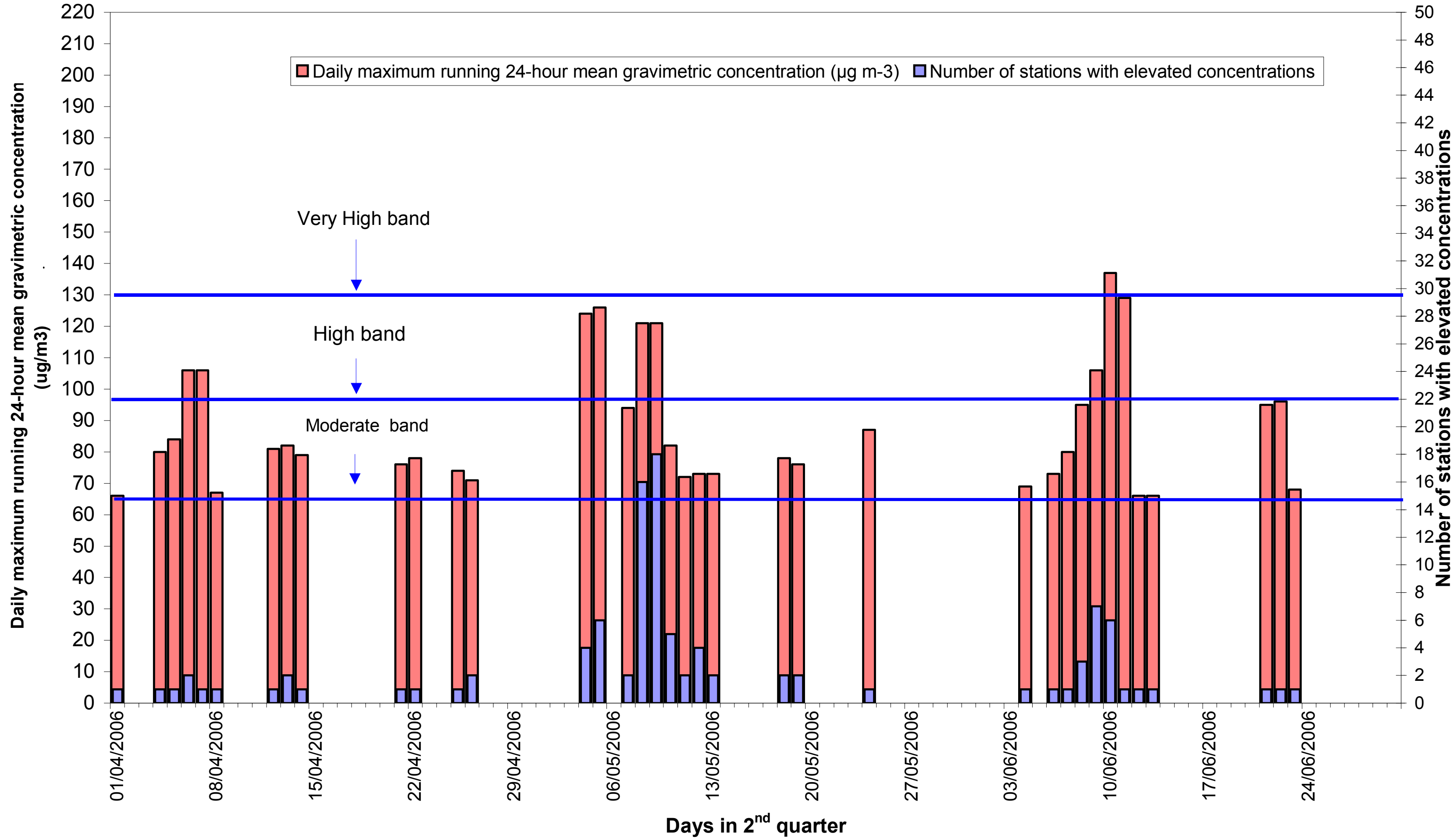


Figure 3.2 Daily maximum running 24-hour mean PM_{10} concentration across AURN Network with total number of stations measuring MODERATE or above levels over the 2nd quarter 2006.

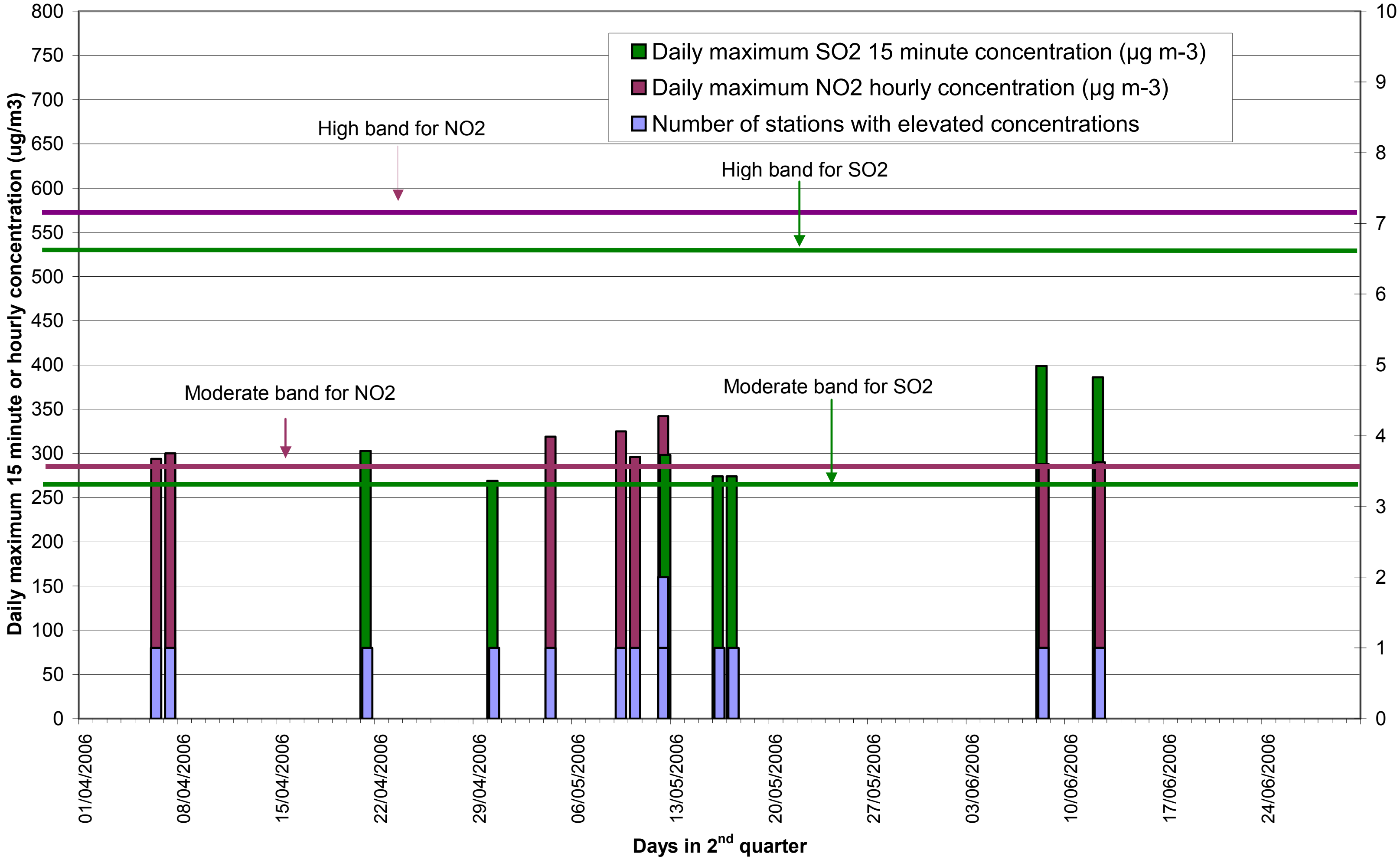


Figure 3.3 Maximum 15 minute average concentrations of SO_2 and hourly average of NO2 across AURN Network with total number of stations measuring MODERATE or above levels over the 2nd quarter 2006.

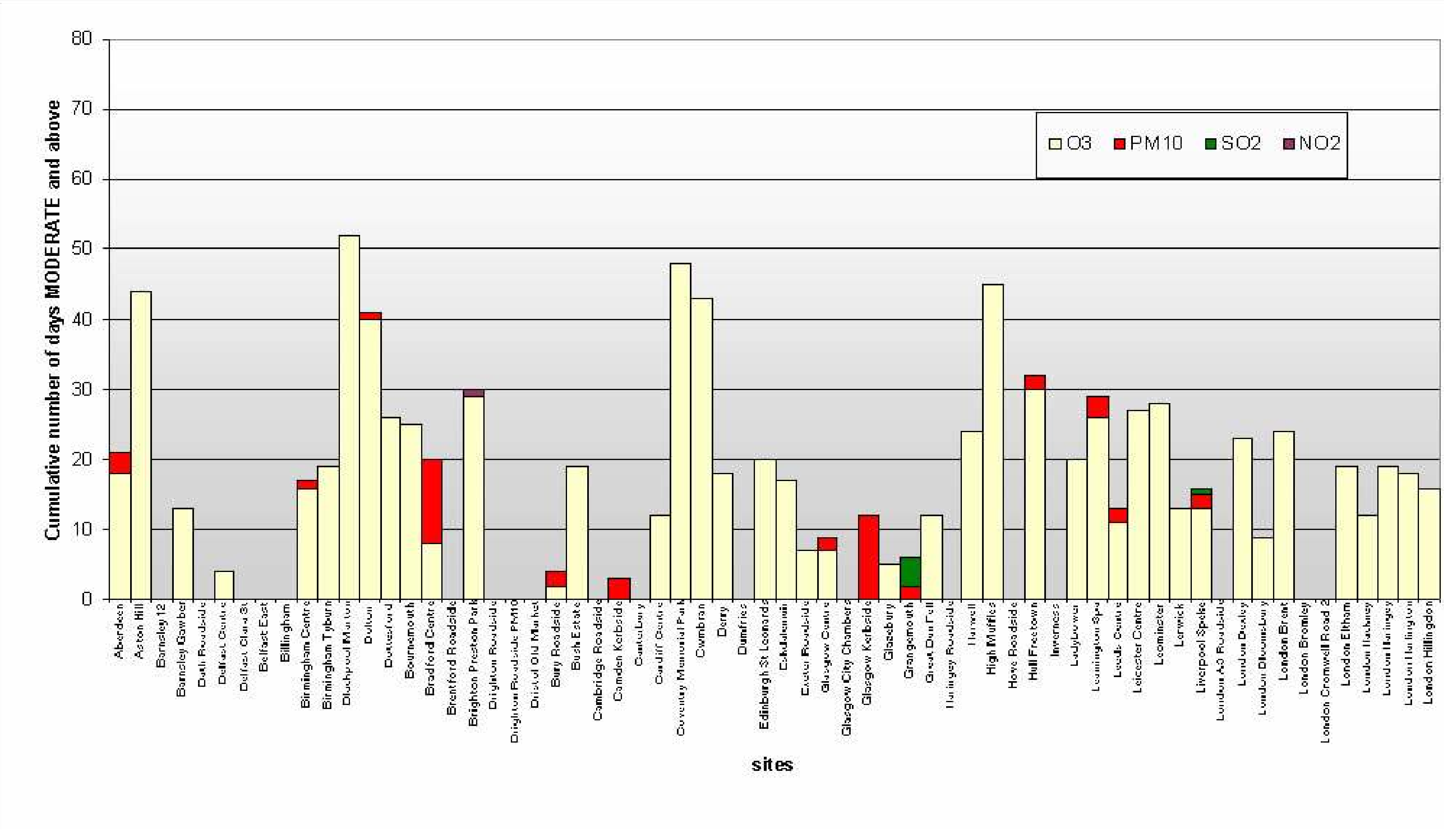


Figure 3.4a Number of days moderate and above for each AURN Network station over 2nd quarter 2006 – provisional data

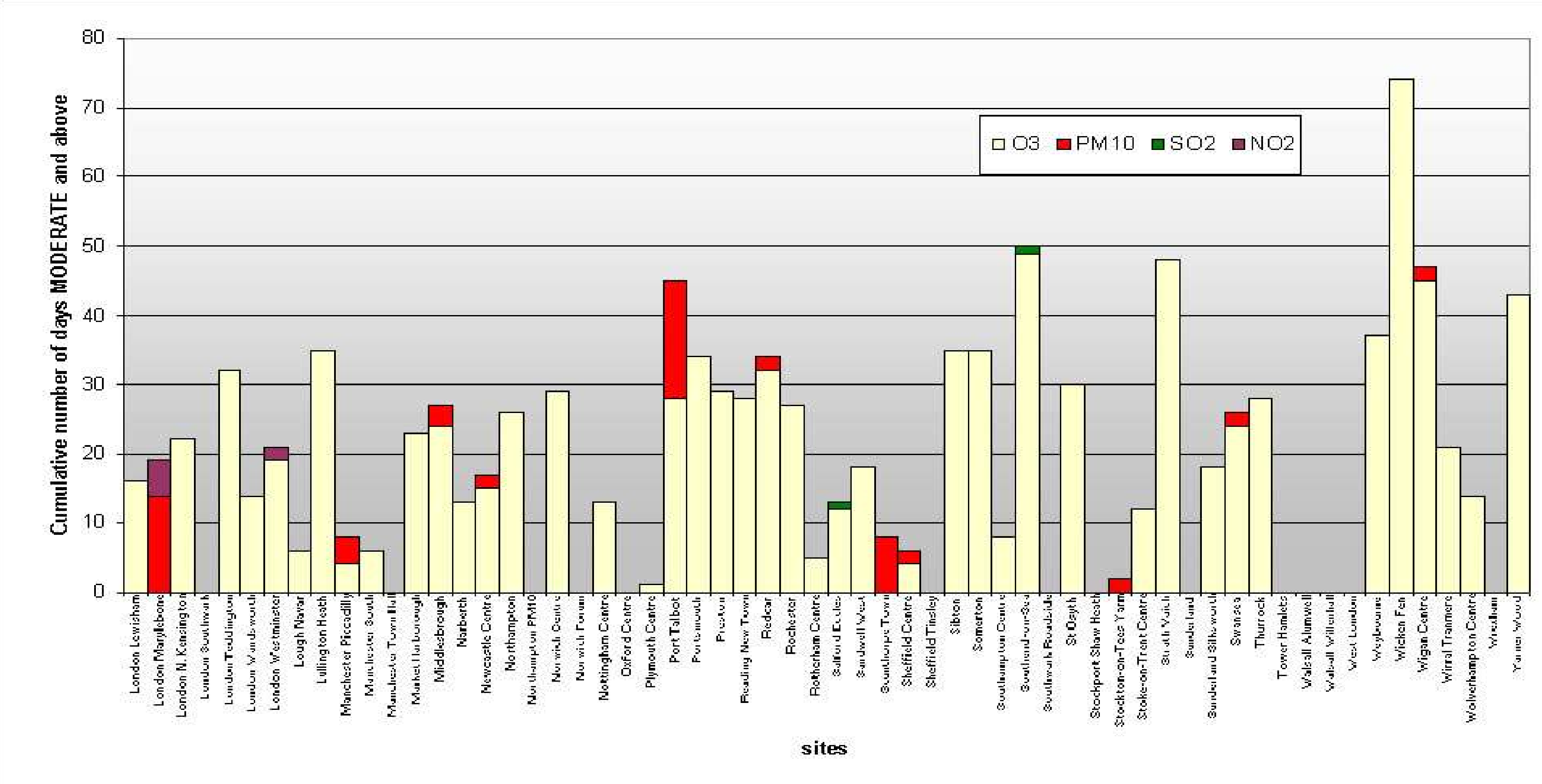


Figure 3.4b Number of days moderate and above for each AURN Network station over 2nd quarter 2006 – provisional data

4 Breakdowns in the service

All bulletins were successfully delivered to the Air Quality Communications contractor on time. There were no reported breakdowns in the service over this three-month period.

5 Additional or enhanced forecasts

No formal enhanced forecasts can be issued until the format of the enhanced service has been agreed with Defra and the Devolved Administrations.

The air pollution forecast is always re-issued to Teletext, Web and Freephone services at 10.00 local time each day, but will only be 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 and analysis

6.1 BUNCEFIELD OIL DEPOT EXPLOSION – REVIEW

An ad-hoc report has now been issued on the National Air Quality Archive detailing initial findings and conclusions from this incident. An official report on the incident can be found at: http://www.buncefieldinvestigation.gov.uk/reports/index.htm

6.2 PARTICULATE CLOUD FROM EASTERN SOURCES

An ad-hoc report has been written for submission to Defra and the devolved administrations detailing the elevated particulate measurements experienced at UK sites in early May.

6.3 SUMMER OZONE EPISODE

An ad-hoc report is being prepared for submission to Defra detailing the elevated ozone measurements experienced at UK sites in June and July 2006.

7 Air Pollution Forecasting Seminar

The Fifth Annual Air Pollution Forecasting Seminar - hosted by Netcen on behalf of Defra and the Devolved Administrations – was held on Thursday 22nd June 2006 at Culham Science Centre, near Abingdon in Oxfordshire. More than 70 delegates and speakers attended. The seminar this year provided a forum for organisations involved in the Buncefield incident to present the results of their work. These presentations provoked much useful and informative discussion.

Buncefield was the largest industrial fire in Europe for over 50 years. Estimations using the National Atmospheric Emissions Inventory have shown that the fire released 5% or more of annual UK air emissions of some pollutants – PM_{10}, $PM_{2.5}$ and benzo(a)pyrene. Emissions of other pollutants such as NO_2, CO and NMVOC were lower at < 0.1% of total annual emissions. The emergency response team of the Chemical Hazards and Poisons Division of HPA was quickly in action following the explosion, which took place at around 6 a.m. on Sunday 11th December 2005. The team worked with local and regional services and the NHS to form the Health Advisory Team (HAT) that advised multi-agency GOLD command. The team quickly received modelling input from the Met Office and the Environment Agency and requested environmental monitoring. Local, portable indicative air quality monitoring by Netcen showed high concentrations of particulate matter and unburnt hydrocarbons close to the fire. The Netcen team could see the plume rising overhead but could not detect increased concentrations downwind, where the plume appeared to be close to the ground. Concentrations of pollutants measured in nearby residential areas were low. There was much discussion of the methods used by Netcen and the difficulties in deploying emergency-response air quality monitoring equipment quickly to the scene of such an incident.

Data from UK national air monitoring networks were analysed in detail but, to-date, these show no evidence of significant ground level air quality impacts from the Buncefield plume. Likewise, similar analysis of national monitoring data from Northern France also showed no evidence of any major ground-level impacts. Additional data available from the local and regional monitoring networks co-ordinated by King's College Environmental Research Group has shown some small and short-term (15-minute) PM_{10} peaks at a few sites in Hertfordshire, North London, Surrey and Sussex. Modelling by the Met Office using the advanced NAME III system confirms that the air arriving at these sites at the times of the peaks could have come from the Buncefield area. Despite these sporadic transient events, comparison of ground-level air quality data with health-based air quality standards shows that pollution levels remained "low" or just into the "moderate" category at all national and regional monitoring locations in the southeast, for the duration of the incident. Airborne air quality measurements of the plume by the Met Office instrumented FAAM aircraft showed that the plume was mainly composed of black soot. Carbon Monoxide (CO) and Oxides of Nitrogen (NO_x) were detected but not in large quantities. Concentrations of toxic PAHs and Dioxins measured in the plume were small. The Met Office undertook detailed modelling of the plume both before and after the event. This involved large uncertainties, especially in the early stages when the composition and amount of fuel burning was not known accurately. Observations by civilian aircraft helped to fine-tune the Met Office model results. Due to the exceptional plume buoyancy and meteorological conditions, the smoke and other emissions from the fires rose high into the atmosphere before dispersing. This helps explain why ground level impacts on air quality were minimised.

The Met Office has modelled several alternative scenarios for other meteorological conditions and their conclusion was that, even under a range of other conditions to those experienced in the real case, the modelled predicted ground-level pollution concentrations would not have been significantly higher.

8 Ongoing research

Netcen and the Met office will also continue to:

1. Investigate ways of using automatic software systems to streamline the activities within the forecasting process, thus allowing forecasters to spend their time more efficiently considering the most accurate forecasts.
2. Research the chemistry used in our models, in particular the NO_x->NO_2 conversion used in NAME, and the chemical schemes for secondary PM_{10} and ozone.
3. Improve the NAME model runs that can be used for ad-hoc analyses, in particular with regard to investigating the possible long-range transport of PM_{10} pollution from forest fires in Russia and the long-range transport of particles from Saharan Dust Storms.
4. Improve and update the emissions inventories used in our models.

9 Forward work plan for July to September 2006

Major tasks include:

- Ongoing daily air pollution forecasting activities.
- Ongoing improvements to NAME model, including:
  - Increase in the horizontal model domain
  - Update of emissions inventory used in the model.
- Publication of the annual 2005 report, 2006 quarterly reports and two ad-hoc reports on the Air Quality Archive Web Site.

10 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.

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} Particles 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
MODERATE										
	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
VERY HIGH										
	10	≥ 360 μgm^{-3}	≥ 180 ppb	≥ 764 μgm^{-3}	≥ 400 ppb	≥1064 μgm^{-3}	≥ 400 ppb	≥ 23.2 mgm^{-3}	≥ 20 ppm	≥ 130 μgm^{-3}

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

Appendix 2 - Forecasting Zones and Agglomerations

CONTENTS

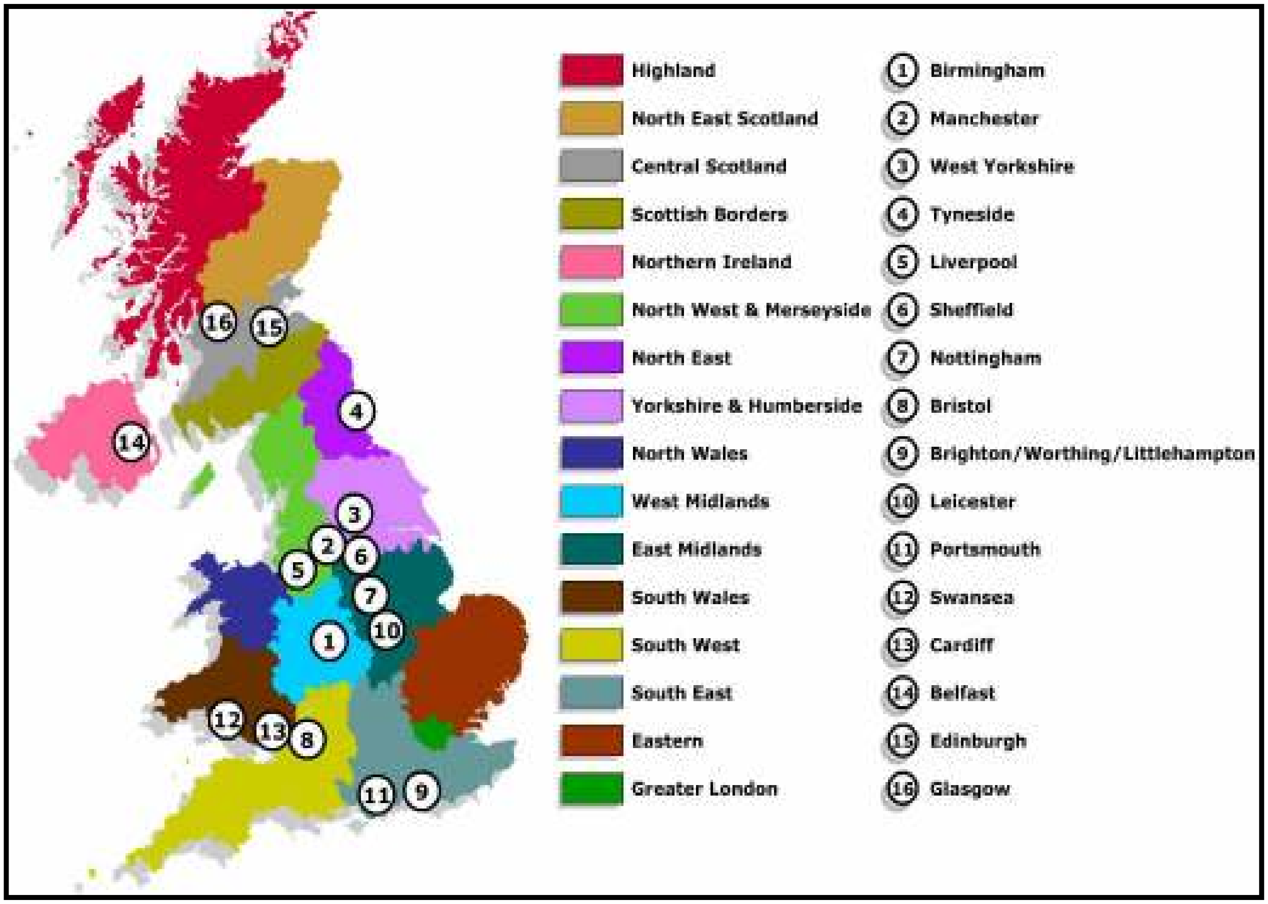
Forecasting Zones

Zone	Population
East Midlands	3084598
Eastern	5119547
Greater London	8278251
North East	1635126
North West and Merseyside	3671986
South East	6690881
South West	4364704
West Midlands	2970505
Yorkshire and Humberside	2816363
South Wales	1578773
North Wales	720022
Central Scotland	1813314
Highland	380062
North East Scotland	1001499
Scottish Borders	254690
Northern Ireland	1104991

Forecasting Agglomerations

Agglomeration	Population
Brighton/Worthing/Littlehampton	461181
Bristol Urban Area	551066
Greater Manchester Urban Area	2244931
Leicester	441213
Liverpool Urban Area	816216
Nottingham Urban Area	666358
Portsmouth	442252
Sheffield Urban Area	640720
Tyneside	879996
West Midlands Urban Area	2284093
West Yorkshire Urban Area	1499465
Cardiff	327706
Swansea/Neath/Port Talbot	270506
Edinburgh Urban Area	452194
Glasgow Urban Area	1168270
Belfast	580276

Map of UK 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.