REPORT

UK Air Quality Forecasting: Operational Report for January to March 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/2213 Issue 1
April 2006

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AEA Technology plc
Netcen
Building 551
Harwell
Didcot
Oxfordshire
OX11 0QJ
UK
+44 (0) 870 190 6441 tel.
+44 (0) 870 190 6608 fax.

Andy.cook@aeat.co.uk

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	Name	Date
Author	Andy Cook	18/04/2006
Reviewed by	Paul Willis	25/04/2006
Approved by	Jon Bower	30/04/2006

Executive Summary

This report covers the operational activities carried out by Netcen and the Met Office on the UK Air Quality Forecasting Contract from January to March 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 first quarter of 2006, there were 21 days on which HIGH air pollution was recorded. Over ninety percent of the HIGH measurements were due to PM_{10}, nine percent due to SO_2. None of these were forecast due to the unpredictable and localised nature of these (..sometimes building related) events, reflected in the poor success and accuracy of HIGH forecasts within zones and agglomerations (all 0%). Many MODERATE days were measured (mainly for PM_{10} but around 30 % on coincident days for PM_{10} and O_3 during this quarter) and were forecast with a high degree of success and 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 66 % indicates that only 34 % 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', January 1st to March 31st 2006.

Region/Area	HIGH		MODERATE	
	% success	% accuracy	% success	% accuracy
Zones	0	0	163	77
Agglomerations	0	0	108	55

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 January and March; all bulletins were delivered to the Air Quality Communications contractor on time.

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 quarter reported on. 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 EMERGENCY CONTACTS UPDATE

The Netcen "AQtoolkit" spreadsheet has been updated with five emergency contact telephone numbers for key staff at Defra and the Met office. This should prevent any recurrence of the weekend communication difficulties surrounding the Buncefield Oil Depot explosion during quarter 4, 2005.

2.2 MET OFFICE DEVELOPMENTS

During the first quarter, the Met Office Air Quality Forecast System was fully integrated into the main production processes of the Met Office. This provides greater operational resilience and will allow structured development at all levels: customer support, software, hardware and model enhancement. During this period of handover there were restrictions on operational changes so there have been no major model upgrades. Work has continued on the development system on improvements mentioned in previous reports.

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 JANUARY 1ST TO MARCH 31ST 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	1	0	0	2	0	0	0	0	0	0	0	0	2	0	0	2	7
forecasted days	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ok (f and m)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
wrong (f not m)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
wrong (m not f)	1	0	0	2	0	0	0	0	0	0	0	0	2	0	0	2	7
success %	0	100	100	0	100	100	100	100	100	100	100	100	0	100	100	0	0
accuracy %	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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	3	0	0	0
forecasted days	0	0	0	0	0	0	0	0	0
ok (f and m)	0	0	0	0	0	0	0	0	0
wrong (f not m)	0	0	0	0	0	0	0	0	0
wrong (m not f)	0	0	0	0	0	3	0	0	0
success %	100	100	100	100	100	0	100	100	100
accuracy %	0	0	0	0	0	0	0	0	0

AGGLOMERATIONS	Nottingham UA	Portsmouth UA	Sheffield UA	Swansea UA	Tyneside	West Midlands UA	West Yorkshire UA	Overall
measured days	0	0	0	0	0	0	12	15
forecasted days	0	0	0	0	0	0	1	1
ok (f and m)	0	0	0	0	0	0	0	0
wrong (f not m)	0	0	0	0	0	0	1	1
wrong (m not f)	0	0	1	0	0	0	12	15
success %	100	100	0	100	100	100	0	0
accuracy %	0	0	0	0	0	0	0	0

*** 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	5	11	14	34	8	7	6	8	6	6	0	3	5	7	8	11	139
forecasted days	5	18	17	34	11	19	6	7	9	15	4	13	14	9	17	16	214
ok (f and m)	4	14	21	40	15	16	8	10	12	13	4	12	11	14	15	17	226
wrong (f not m)	1	6	1	6	1	4	1	4	0	3	0	1	7	1	3	3	42
wrong (m not f)	4	7	2	6	0	2	1	1	0	1	0	0	1	0	0	2	27
success %	80	127	150	118	188	229	133	125	200	217	100	400	220	200	188	155	163
accuracy %	44	52	88	77	94	73	80	67	100	76	100	92	58	93	83	77	77

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	3	0	0	0	26	9	4	0
forecasted days	11	7	3	3	3	20	14	7	1
ok (f and m)	8	6	0	0	2	21	13	5	1
wrong (f not m)	6	4	3	3	1	8	3	2	0
wrong (m not f)	0	0	0	0	0	9	0	2	0
success %	200	200	100	100	100	81	144	125	100
accuracy %	57	60	0	0	67	55	81	56	100

AGGLOMERATIONS	Nottingham UA	Portsmouth UA	Sheffield UA	Swansea UA	Tyneside	West Midlands UA	West Yorkshire UA	Overall
measured days	2	1	1	4	2	4	32	92
forecasted days	5	4	4	7	1	8	21	119
ok (f and m)	3	3	3	8	3	7	16	99
wrong (f not m)	3	2	1	2	0	1	9	48
wrong (m not f)	0	0	1	0	0	0	22	34
success %	150	300	300	200	150	175	50	108
accuracy %	50	60	60	80	100	88	34	55

*** 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 January to March 2006 (Based on latest provisional data)

Pollutant	High or above days	Moderate days	Max. conc. ($\mu g/m^3$) *	Site with max. conc.	Zones or Agglomeration	Date of max conc.	Forecast success HIGH days (%) [no. incidents, zone or agglomeration days] **
Ozone	0	33	116	High Muffles (first 2 incidents) Wicken Fen	Yorks. and Humber. Zone Eastern zone	10/3/06 18/3/06 22/3/06	N/A [0]
PM_{10} gravimetric	20	51	169	Bradford Centre	West Yorkshire urban area	25/01/06	0 % [20]
NO_2	0	0	283	London Marylebone Road	Greater London	17/01/06	N/A [0]
SO_2	2	3	912	Barnsley Gawber	Yorkshire and Humberside zone	03/03/06	0 % [2]
CO	0	0	2.2	Bristol Old Market	Bristol urban area	02/01/06	N/A [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 (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 22 zone or agglomeration-day incidents of HIGH band pollution measured during this quarter, measured on 21 separate days. 91 % of these HIGH incidents were due to PM_{10} only, 9 % due to SO2, one day had both an SO_2 and PM_{10} HIGH exceedence caused by unconnected events. None of the HIGH exceedences were forecast successfully due to the inherently unpredictable and localised nature of PM_{10} and SO_2 episodes, around 64 % of which were building work related, 23 % traffic or partially traffic related and 14 % industry related over the reporting period. 68 % of the incidents occurred within agglomerations, 55 % of incidents were due to ongoing building works near to the Bradford AQM site. These HIGH episodes were not considered to broadly represent ambient levels across their associated regions so were therefore not accounted for during the forecasting process.

Fifty one MODERATE days were seen due to PM_{10} , measured at geographically diverse locations, mainly as a result of still, cold conditions near roadside and industrial locations (65 % measured at roadside locations) with further contributions from areas of coal burning used for domestic heating (further 18 % contribution).

No MODERATE days were measured for nitrogen dioxide at any site in the network, an unusual occurrence for any quarter and particularly during the winter months, this may be a result of slightly higher than average wind speeds over these 3 months compared to previous years.

Three MODERATE days were measured for SO2 at the Grangemouth AQM site during periods of easterly breezes, likely to have been the result of industrial emissions from the petro-chemical complex situated to the east.

Thirty three MODERATE days were measured for ozone during this quarter, measured at more than 2 sites on any one day from 10th March to 21st March, during a period of predominantly easterly trajectories. Over January and February virtually no MODERATE band exceedences were measured, as could be expected for the winter months.

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

Very few MODERATE days were measured during the first 2 months of this quarter, as normally expected for the winter months. Two sites or more measured MODERATE levels on the same day between 10th and 21st March, during a period of predominantly easterly trajectories. More than 20 sites measured MODERATE levels on Friday 17th March following several days of easterly air from Europe reaching the UK (6 were rural sites, sites were generally geographically widespread but 5 situated in the East Anglia area). The number of sites MODERATE or above then fell to around 7, finally falling further with the onset of south-westerly winds from the 23rd. Secondary pollution reaching the UK from Europe is often at its highest at the end of the working week, explaining the build up in the number of sites recording MODERATE ozone pollution to Friday 17th. The weather over that period comprised mostly of cool, cloudy conditions with wintry showers. Background levels of ozone are at their highest annually between mid March and mid May in the UK, also possibly contributing to the number of exceedences.

Forecasting success rates of above 100 % for the MODERATE band indicate that these ozone MODERATE periods were forecasted successfully with a fair degree of accuracy. Ozone exceedences are often easier to predict than for the primary pollutants, building up slowly over wide areas under the right meteorological conditions.

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

PM_{10}

As previously noted none of the 20 HIGH band exceedences were forecast due to their localised and unpredictable nature. Twelve intermittent HIGH or above days were measured at the Bradford AQM site throughout the first 2 months of the period as the result of ongoing building works (highest measurement was 169 ug/m^3 as a gravimetric daily maximum 24 hour running mean). Few exceedences were seen in March at the Bradford site. Other HIGH exceedences were seen at Cwmbran (continued stone cutting assumed over 2 days in early January, highest daily gravimetric mean 119 ug/m^3), Camden kerbside (2 days in early February associated with high pressure and traffic emissions, highest daily gravimetric mean 99 ug/m^3), Glasgow kerbside (2 days in late February and one in early March, likely to have been topographically and site environment related, highest daily gravimetric mean 120 ug/m^3) and one day measured at the Scunthorpe Town site during a transitional phase of incident wind direction, likely to have been the result of industrial emissions (daily gravimetric mean of 103 ug/m^3).

More than 5 sites measured MODERATE or above levels on the 24th and 25th January during a period of cold conditions, daily temperatures averaging around freezing with very cold overnight frosts, particularly in England and Wales where the clearest conditions persisted. Winds were light and generally easterly. Wind speeds increased from the 26th onwards, dispersing the build up of particulates. Of the 11 sites measuring elevated concentrations on the 25th, four were designated "roadside", five were in the north of England, four in London and one in each of the countries of Scotland and Northern Ireland. The high pressure centre was situated over Scotland up to the 25th explaining the predominance of exceedences towards the north of the UK, in the stillest conditions.

Between the 2nd and 4th February ten or more sites measured MODERATE or above concentrations on each day. High pressure had been centred over the UK from 26th January, laying stationary until the 5th February. Wind speeds were light from the 1st to 5th February, initially from the east on the 1st, becoming northerly on the 2nd and remaining northerly until the 5th. The wind speeds increased on the 5th, explaining the drop in the number of exceedences from then onwards. Conditions were just above freezing on the 1^{st} and just below freezing on the 2^{nd} with widespread formation of freezing fog. On the 1^{st} exceedences were seen at geographically widespread locations, 50 % of which were designated "roadside". On the 2^{nd}, seventeen sites exceeded: 9 in the Midlands, 5 in the north of England, 2 in Glasgow and one in London. The 3^{rd} saw many of the same sites exceed again, by the 4^{th} that number had dropped by about one-third but included sites in new areas such as Northern Ireland and Wales. The high pressure centre started moving southwards from the 5^{th}, wind speeds increasing, with Atlantic air being drawn in from the west thus dispersing the particulate build up.

Between the 15^{th} and 22^{nd} March during a cool period, with daytime temperatures hovering around a few degrees C, the UK experienced an entire week of easterly air trajectories. The greatest effect was seen on the 15^{th} with 4 sites exceeding the MODERATE band (three designated "roadside", one designated "industrial", two located in London). Glasgow kerbside exceeded daily over those days, this is thought to be related to the topography of the city combined with the monitoring environment. A south-westerly breeze picked up from the 24^{th} preventing the further build up of particulates.

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

NO_2

No MODERATE days were seen during this period as mentioned earlier in the "general" section.

SO_2

Sulphur dioxide levels reached the HIGH band on 2 days during this period. During the first case on 3^{rd} March, a maximum of 912 ug/m^3 was measured at the "urban background" designated Barnsley Gawber site, changes in the other pollutants measured at the site seemed to corroborate a pollution event occurred there. The second high measurement was made at the Grangemouth site on the 14^{th} March during a transitional phase of incident wind direction. The following day started a trend of continual easterly winds for an entire week, during which elevated SO_2 levels were measured throughout. During the transitional phase, a plume of emissions from the nearby petro-chemical plant may have been collected by the wind reaching the monitoring station. Three further MODERATE days were measured only at the Grangemouth AQM site, all three occasions related to easterly trajectories, high pressure and therefore sampling air from the direction of the petro-chemical plant.

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

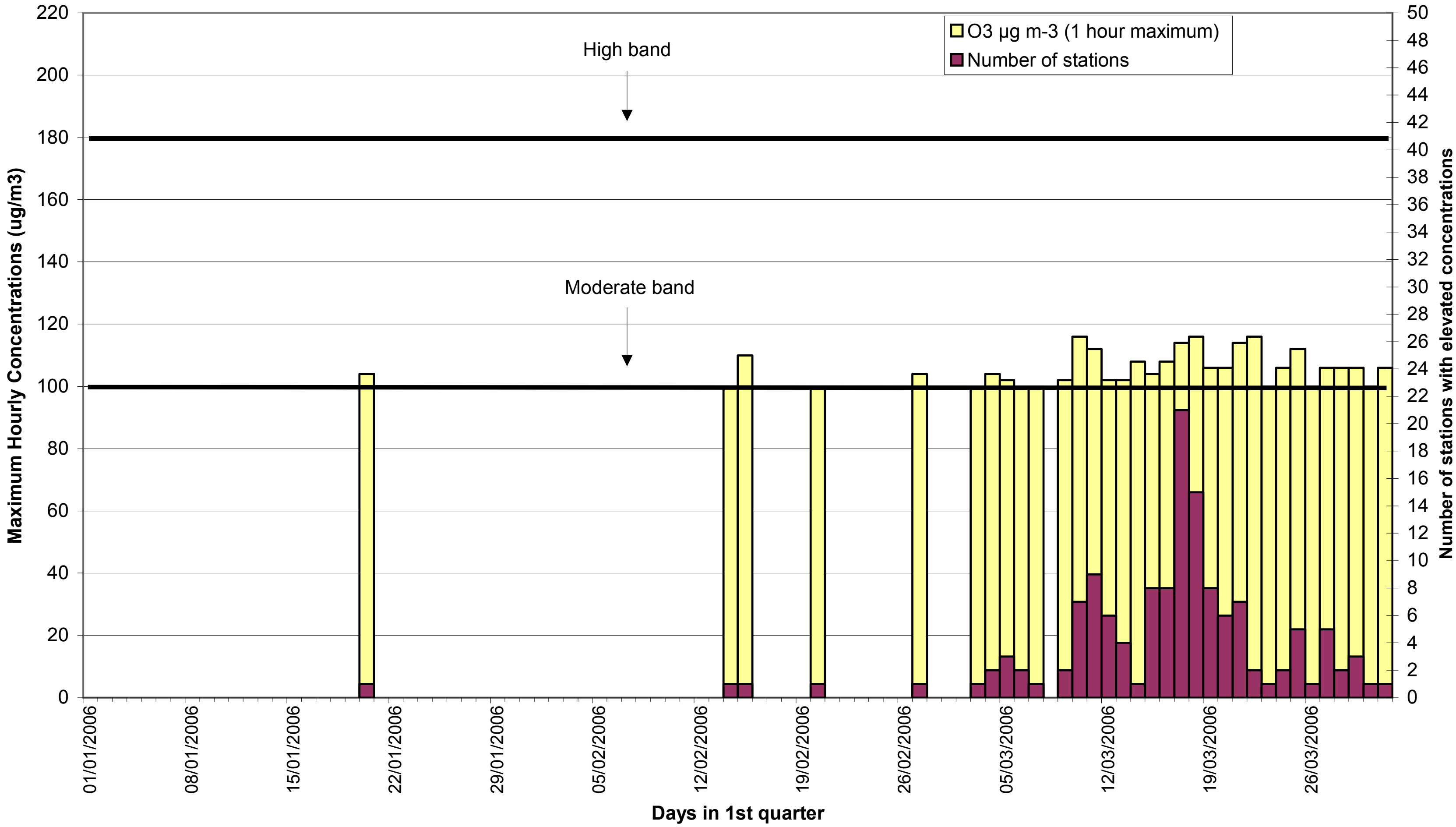


Figure 3.1 Daily maximum hourly ozone concentration across AURN Network with total number of stations measuring MODERATE or above levels of ozone over 1st quarter 2006.

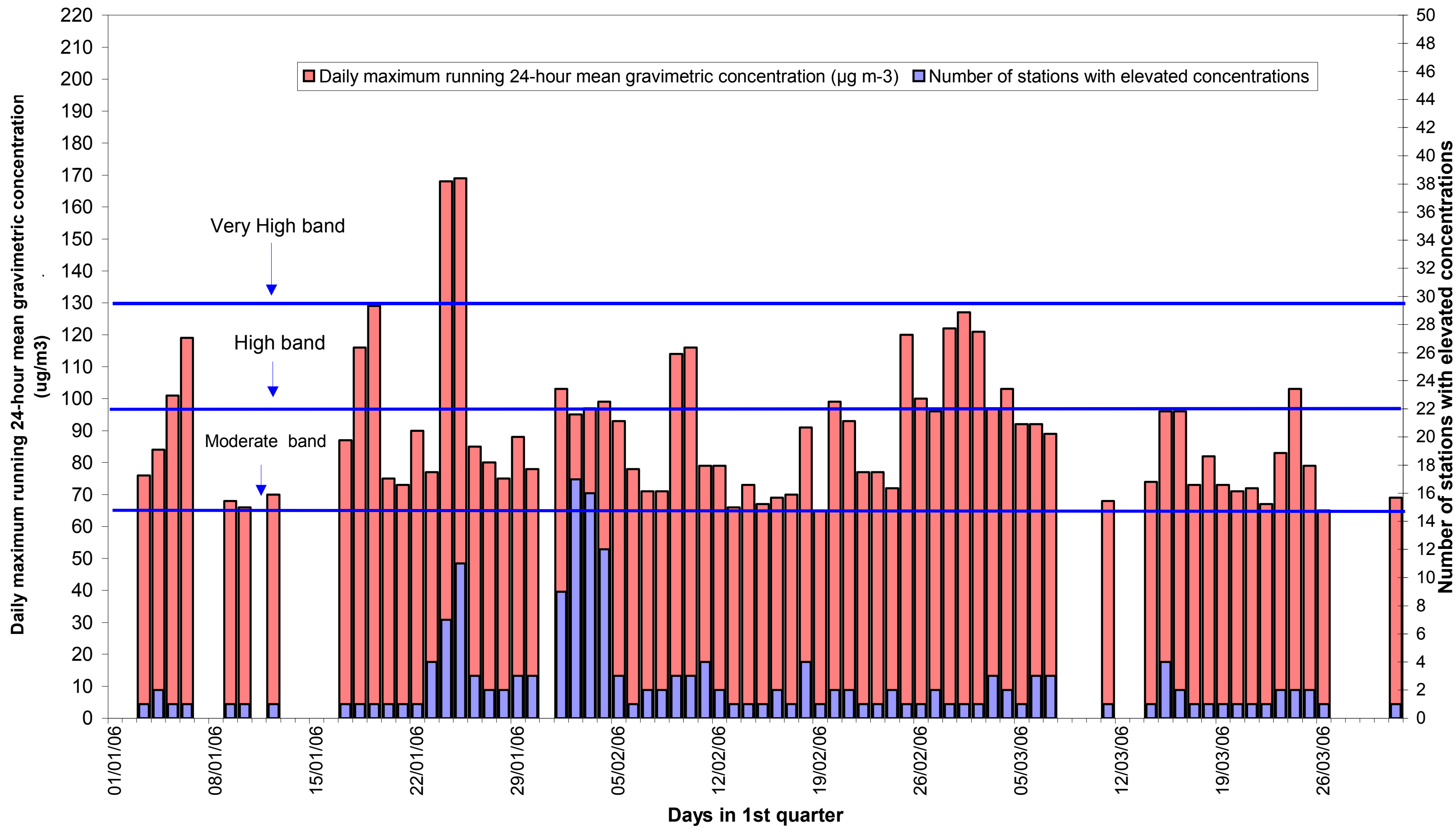


Figure 3.2 Daily maximum running 24-hour mean PM_{10} concentration across AURN Network with total number of stations measuring MODERATE or above levels over the 1st quarter 2006.

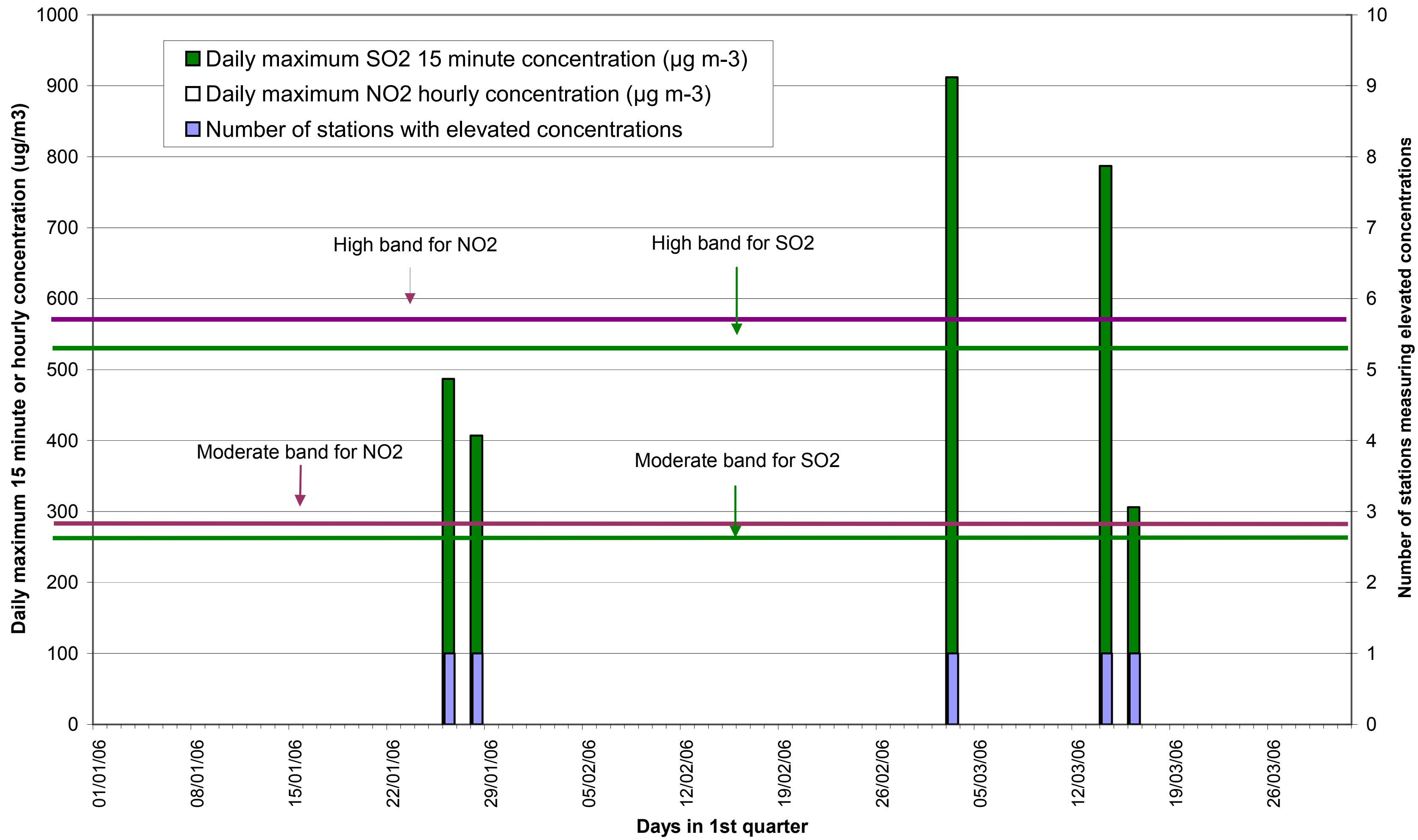


Figure 3.3 Maximum 15 minute average concentrations of SO_2 and hourly average of NO2 across AURN Network with total number of stations measuring MODERATE or above levels over the 1st quarter 2006.

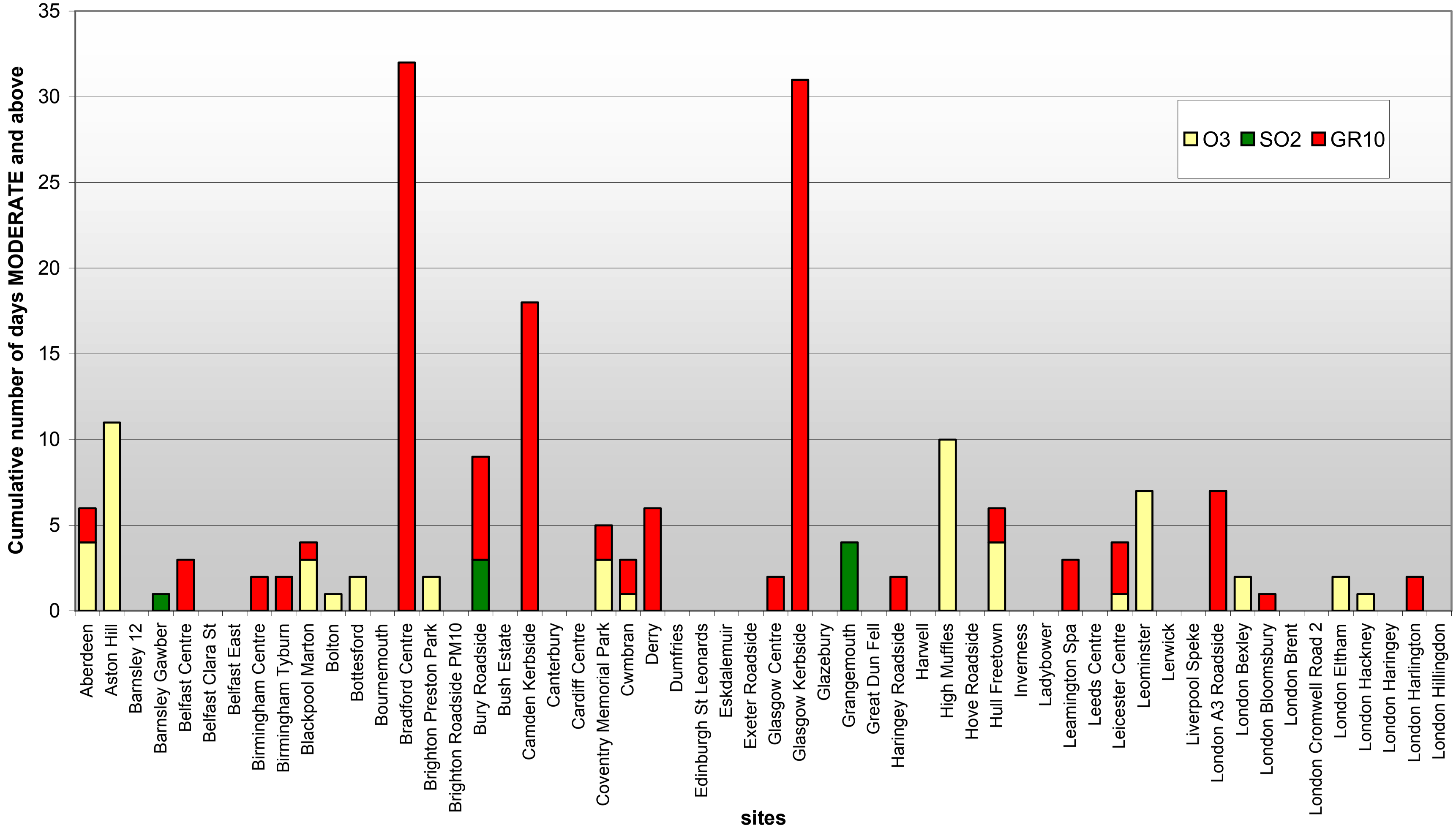


Figure 3.4a Number of days moderate and above for each AURN Network station over 1st quarter 2006 – provisional data

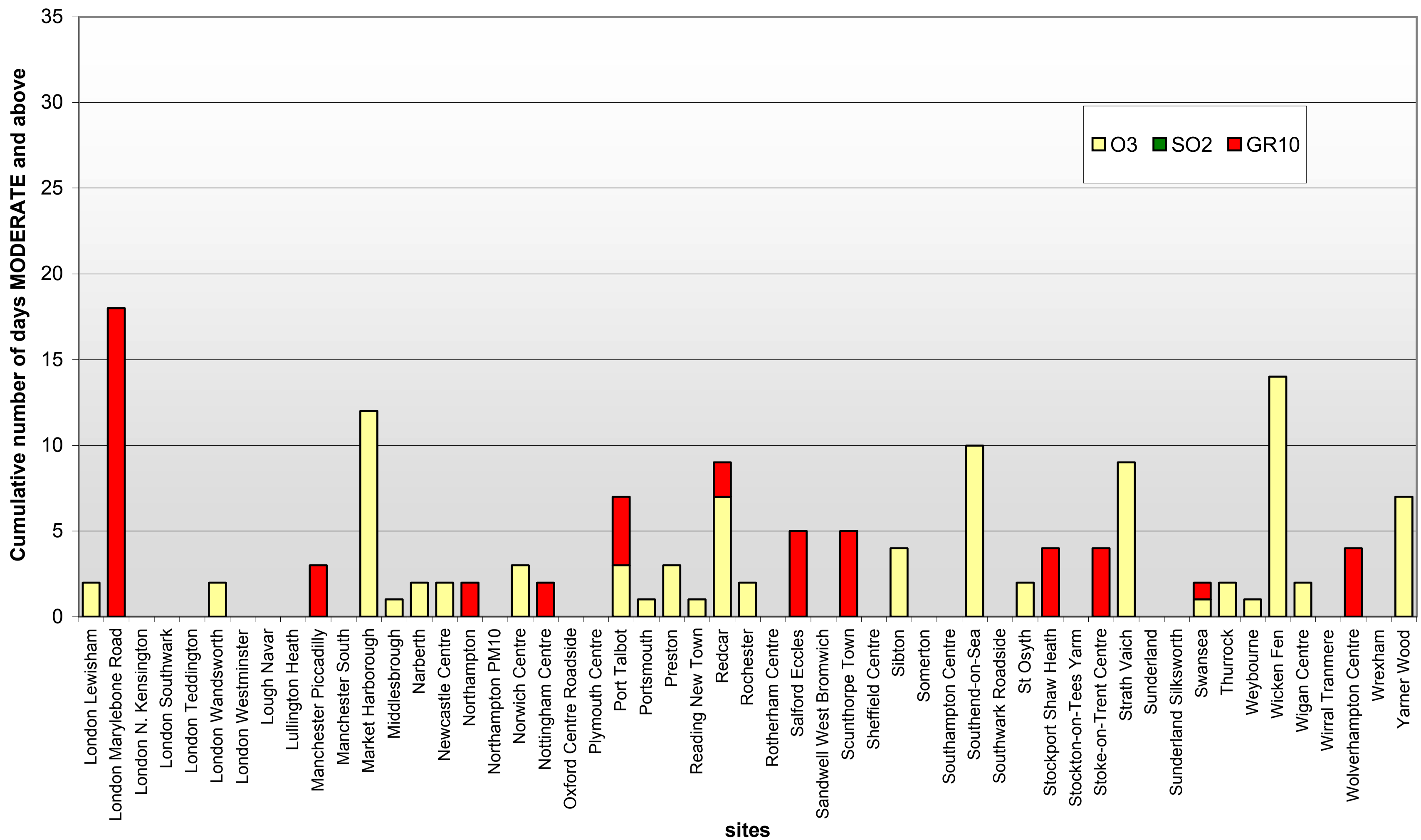


Figure 3.4b Number of days moderate and above for each AURN Network station over 1st quarter 2006 – provisional data

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 – INITIAL REVIEW

Netcen and the Met office have continued to work on this, liasing closely with Defra, EA and HPA.
A first draft report titled “Initial review of Air Quality aspects of the Buncefield Oil Depot Explosion” by Targa et al, will be shortly submitted to Defra and devolved administrations for approval to issue. In summary the report concluded that no significant increases in ground-level air pollution were measured at nearly all sites in several air quality networks in southern England during the period of the fire. Two sites in a London network measured elevated levels of particulates which could not be directly attributed to traffic emissions during the evening of the first day of the incident but the levels measured weren’t considered to be significant in terms of longer term pollution trends. However, the possibility was raised of micro-scale grounding of fractions of the plume at non- air quality monitored locations.

7 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.

8 Forward work plan for April to June 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 quarters 2, 3, 4 and annual 2005 reports on the Air Quality Archive Web Site.
- Arrange a 2006 Forecasting seminar on the Buncefield incident.

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.

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	$\geq$ 360 μgm^{-3}	$\geq$ 180 ppb	$\geq$ 764 μgm^{-3}	$\geq$ 400 ppb	$\geq$1064 μgm^{-3}	$\geq$ 400 ppb	$\geq$ 23.2 mgm^{-3}	$\geq$ 20 ppm	$\geq$ 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

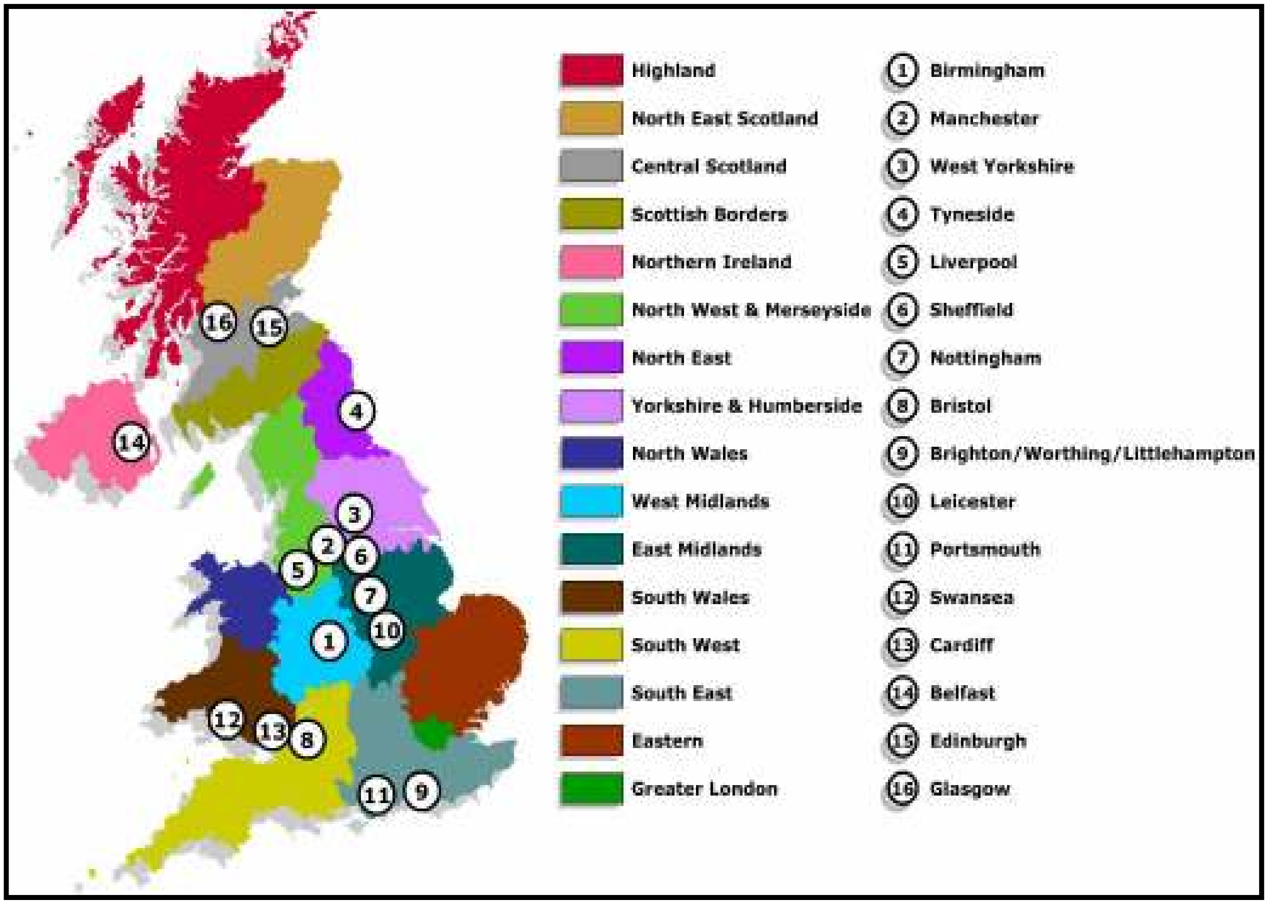
Forecasting Zones

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.