REPORT

# UK Air Quality Forecasting: Operational Report for October to December 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/2378 Issue 1
January 2007

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AEA Technology plc
AEA Energy & Environment
Building 551.11
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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AEA Technology is certificated to BS EN ISO9001:(1994)

| | **Name** | **Date** |
|---|---|---|
| **Author** | Andy Cook | 05/02/2007 |
| **Reviewed by** | Paul Willis | 10/02/2007 |
| **Approved by** | Jon Bower | 15/02/2007 |

# Executive Summary

This report covers the operational activities carried out by AEA Energy & Environment and the Met Office on the UK Air Quality Forecasting Contract from October to December 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 fourth quarter of 2006, there were 5 days on which HIGH air pollution was recorded. All of the HIGH measurements were due to $PM_{10}$, three HIGH days were the result of bonfire night-weekend celebrations. None of the HIGH day-incidents were forecast successfully in terms of numerical forecasts issued, although written texts were issued leading up to the bonfire night-weekend warning that localised MODERATE or HIGH levels of $PM_{10}$ were likely to be experienced close to bonfire events. Overall forecast success and accuracy rates for the HIGH band were therefore 0 % for both zones and agglomerations during this quarter. Many MODERATE days were measured (mainly for $PM_{10}$ but a considerable contribution from $NO_2$ in particular) and were forecast with a high degree of success and a 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 56 % indicates that only 44 % of the forecast MODERATE levels were not measured and remained LOW. The accuracy figures tend to be lower due to the precautionary approach that AEA Energy & Environment 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', October 1st to December 31tst 2006.**

| Region/Area | HIGH | | MODERATE | |
|---|---|---|---|---|
| | % success | % accuracy | % success | % accuracy |
| Zones | 0 | 0 | 147 | 62 |
| Agglomerations | 0 | 0 | 161 | 50 |

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 October and December; all bulletins were delivered to the Air Quality Communications contractor on time.

# Contents

**Executive Summary** 1

**Contents** 2

**1 Introduction** 3

**2 New developments during this period** 4

2.1 MET OFFICE DEVELOPMENTS 4
2.2 AEA ENERGY & ENVIRONMENT DEVELOPMENTS 4

**3 Analysis of Forecasting Success Rate** 5

3.1 FORECAST ANALYSIS FOR OCTOBER 1ST TO DECEMBER 31ST 2006. 6

**4 Breakdowns in the service** 17

**5 Additional or enhanced forecasts** 17

**6 Ad-hoc services and analysis** 17

6.1 PARTICULATE CLOUD FROM EASTERN SOURCES IN EARLY MAY 17
6.2 SUMMER OZONE EPISODE 17
6.3 PARTICULATE CLOUD FROM EUROPEAN SOURCES IN MID SEPTEMBER 17

**7 Ongoing research** 18

**8 Forward work plan for January to March 2007** 18

**9 Hardware and software inventory** 18

**Appendix 1 - Air Pollution Index** 19

**Appendix 2 - Forecasting Zones and Agglomerations** 21

**Appendix 3 – Worked Example of How UK Forecasting Success and Accuracy Rates are Calculated.** 24

# 1 Introduction

A forecast of the following day's air pollution is prepared every day by AEA Energy & Environment 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 final quarter of 2006. 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 AEA Energy & Environment 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

The Met Office has continued its development of the chemistry of the NAME model in this quarter. A new model version has been released which includes an improved scheme for pollution modelling. Work has been started to investigate how this scheme compares to other more involved chemistry schemes. Plans mentioned in the last report to implement the upgraded model and output in this quarter have been delayed to the next quarter, but effort to reinstate the map output from NAME has continued.

## 2.2 AEA ENERGY & ENVIRONMENT DEVELOPMENTS

Two new internet (WAP) enabled mobile phones have been purchased for use in forecasting from remote locations or locations where PC access is not possible. As well as providing continuing direct access to the duty forecaster in emergency situations for important parties, the phones will also reduce the need for the duty forecaster to have access to a PC at weekends to monitor or change the numerical forecast. The use of the phones is expected to start in quarter 1 of 2007 once the testing phase has been completed.

Enhanced methods have been devised, through necessity, to analyse air quality measurements from the year 2000 onwards to help to quantify the exceptional circumstances for ozone and particulates in 2006. The new graphs and charts will be available shortly in the annual forecasting report for 2006.

# 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 OCTOBER 1ST TO DECEMBER 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 | 0 | 0 | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 9 |
| 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) | 0 | 0 | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 9 |
| success % | 100 | 100 | 0 | 0 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 0 | 100 | 100 | 0 | 100 | 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 | 3 | 0 | 0 | 0 | 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 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| success % | 100 | 100 | 0 | 100 | 100 | 100 | 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 | 1 | 0 | 4 |
| forecasted days | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ok (f and m) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| wrong (f not m) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| wrong (m not f) | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 4 |
| success % | 100 | 100 | 100 | 100 | 100 | 0 | 100 | 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 | 0 | 2 | 5 | 30 | 1 | 2 | 0 | 0 | 5 | 0 | 0 | 3 | 5 | 1 | 5 | 7 | 66 |
| forecasted days | 2 | 8 | 8 | 21 | 2 | 7 | 2 | 4 | 7 | 5 | 2 | 8 | 9 | 9 | 9 | 10 | 113 |
| ok (f and m) | 1 | 5 | 7 | 28 | 3 | 7 | 0 | 4 | 9 | 2 | 1 | 2 | 7 | 5 | 5 | 11 | 97 |
| wrong (f not m) | 1 | 4 | 2 | 4 | 0 | 2 | 2 | 0 | 0 | 3 | 1 | 6 | 6 | 5 | 5 | 1 | 42 |
| wrong (m not f) | 0 | 1 | 2 | 7 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 3 | 0 | 0 | 3 | 1 | 18 |
| success % | 100 | 250 | 140 | 93 | 300 | 350 | 100 | 100 | 180 | 100 | 100 | 67 | 140 | 500 | 100 | 157 | 147 |
| accuracy % | 50 | 50 | 64 | 72 | 100 | 78 | 0 | 100 | 90 | 40 | 50 | 18 | 54 | 50 | 38 | 85 | 62 |

**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 | 0 | 0 | 3 | 4 | 0 | 7 | 8 | 2 | 0 |
| forecasted days | 5 | 7 | 8 | 9 | 2 | 7 | 9 | 7 | 7 |
| ok (f and m) | 2 | 1 | 1 | 2 | 1 | 9 | 11 | 3 | 3 |
| wrong (f not m) | 3 | 6 | 7 | 8 | 1 | 3 | 1 | 4 | 4 |
| wrong (m not f) | 0 | 0 | 3 | 2 | 0 | 1 | 3 | 2 | 0 |
| success % | 100 | 100 | 33 | 50 | 100 | 129 | 138 | 150 | 100 |
| accuracy % | 40 | 14 | 9 | 17 | 50 | 69 | 73 | 33 | 43 |

| AGGLOMERATIONS | Nottingham UA | Portsmouth UA | Sheffield UA | Swansea UA | Tyneside | West Midlands UA | West Yorkshire UA | Overall |
|---|---|---|---|---|---|---|---|---|
| measured days | 0 | 4 | 4 | 5 | 0 | 6 | 3 | 46 |
| forecasted days | 7 | 9 | 7 | 7 | 7 | 8 | 7 | 113 |
| ok (f and m) | 3 | 6 | 6 | 6 | 3 | 8 | 9 | 74 |
| wrong (f not m) | 4 | 4 | 2 | 4 | 4 | 2 | 1 | 58 |
| wrong (m not f) | 0 | 2 | 1 | 0 | 0 | 3 | 0 | 17 |
| success % | 100 | 150 | 150 | 120 | 100 | 133 | 300 | 161 |
| accuracy % | 43 | 50 | 67 | 60 | 43 | 62 | 90 | 50 |

*** 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 October to December 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 | 0 | 2 | 102 | Narberth | South Wales | 1/12/06 | N/A |
| $PM_{10}$ gravimetric equivalent | 5 | 34 | 190 | Bristol St Paul's | Bristol UA | 5/11/06 | 0 % [13] |
| $NO_2$ | 0 | 13 | 372 | Marylebone Road | London UA | 10/11/06 | N/A |
| $SO_2$ | 0 | 0 | 210 | Port Talbot | Swansea UA | 14/11/06 | N/A |
| CO | 0 | 0 | 3.4 | Hackney | London UA | 7/11/06 | 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)

*** The success rates for the number of HIGH days in table 3.5 have been calculated using calendar days (ie midnight to midnight) and therefore may not necessarily agree with the success rates calculated within the forecast analysis tables 3.1 and 3.2, which are calculated based on media forecast days starting generally at 3 pm each day.

**General Observations**

There were 13 zone or agglomeration-day incidents of HIGH band pollution measured during this quarter, measured on 5 separate days for $PM_{10}$. Three of the $PM_{10}$ day-incidents were as a result of bonfire night and two due to possible building works near the Leamington Spa AQM site in early December. Due to the inherently unpredictable and localised nature of $PM_{10}$ episodes, all of these 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. Text based warnings were however issued leading up to the bonfire night weekend after a review of the meteorological conditions by the AEA Energy & Environment forecasting team indicated that poor dispersion conditions would be prevalent in England and Wales throughout that weekend.

Thirty four MODERATE days were seen due to $PM_{10}$, mainly due to the 28 MODERATE or above exceedences measured at the London Marylebone site.

Two MODERATE days were measured for ozone during this quarter in early December, measured at 2 or more sites on both days, during periods of predominantly westerly trajectories.

Thirteen MODERATE days were measured for nitrogen dioxide. Eight of these days were exceeded at the London Marylebone Road kerbside site.

No MODERATE days were measured for SO2 at network sites, slightly unusual when taking into consideration that two "cold spells" occurred during this quarter.

No MODERATE or above days were measured for CO during the reporting period. The highest 8-hour running mean calculated was 3.4 mg/$m^3$ at the London Hackney site on Tuesday 7th November, towards the end of a "cold spell".

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.

**$O_3$**

During this quarter very few, if any, exceedences are normally expected due to winter weather conditions; which are unfavourable for ozone formation at elevated levels.

Two MODERATE days were measured during this period, unusually in early December. On the 1st December two sites briefly just entered the MODERATE band – rural Narberth in Wales and Blackpool Marton in the north west of England. On the 3rd four sites briefly just entered the MODERATE band – all the sites were located in England or Wales, geographically spread and mainly designated urban sites. Simple air mass back-trajectory plots show that air reaching parts of England was briefly sourced from over Spain and the near continent during the generally wet weekend of the 2nd – 3rd December, which may have been a contributing factor to the exceedences which are currently based on provisional data.

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

**$PM_{10}$**

Five HIGH or above days were measured during this quarter. Three of these days were as the result of bonfire night celebrations during a period of cold and still weather conditions. Measurements entered the VERY HIGH band on three days from Saturday 4th to Monday 6th November. Bristol St Pauls, London Hillingon and London Bexley all measured two VERY HIGH days over that weekend and Swansea Roadside measured one. The 5th November was on a Sunday this year therefore celebrations were distributed from Friday (often private firework events) and Saturday / Sunday (municipal displays were most likely to have occurred on the Saturday). High pressure air travelling over the UK from the south west to the south east over that weekend and freezing overnight conditions leading up to those days caused poor dispersion conditions in England and Wales.

Eight sites reached the MODERATE band on Friday 3rd. Five of these were considered to have been the result of a general build up of particulates due to meteorological conditions and traffic emissions, which included 4 sites in the north west of England and one in the Midlands. Two sites in London and one in the Midlands may have measured MODERATE levels as the result of the first evening of bonfire celebrations or private fireworks. The highest hourly measurement on this day was 714 ug/$m^3$ in gravimetric units at Haringey Roadside.

Of the sites exceeding the MODERATE band on Saturday 4th, thirteen were located in London and the south east, five in the north west of England, one in the north east, two in the Midlands and one in the south west. Six of the sites were designated "roadside", four of these situated in London. All other sites were designated "urban". Six sites exceeded the HIGH band on the 4th, four of which were located in the London urban area, Birmingham Tyburn and Bristol St Paul's. The highest hourly measurement on this day was 888 ug/$m^3$ in gravimetric units at London Hillingdon.

The MODERATE band was exceeded by twenty two sites on Sunday 5th. Some of these may have been the result of celebrations on the previous evening being captured by the ongoing 24-hour running mean into the Sunday, in accordance with the procedure employed for the banding system for $PM_{10}$. The geographical distribution of sites measuring in the MODERATE band for Sunday was similar to the previous day with 2 more sites exceeding in London and the south east, five less sites in the north of England and 2 additional sites in Wales. Eighteen of the MODERATE band sites were designated "urban" and four "roadside". Three sites entered the VERY HIGH band on the 5th; London Bexley and Hillingdon, and Bristol St Paul's. The HIGH band was entered by a further 8

sites: five in the London Urban Area, Southampton, Southend on Sea and Swansea Roadside. The highest hourly measurement on this day was 487 ug/$m^3$ in gravimetric units at Swansea Roadside.

All the 19 sites which entered the MODERATE band on Monday 6th November were considered to have been the result of celebrations on Sunday 5th. The geographical distribution of MODERATE band sites had changed on Monday; five less than the previous day in London and the south east, three more in the north west and one less in the midlands. The site distribution change was possibly the result of movement of the high pressure centre across the UK. Four of the MODERATE sites were again designated "roadside". Three sites reached the HIGH band on the 6th: Bristol St Paul's, London Marylebone Road and Swansea Roadside and were all the result of celebrations on the previous Sunday evening. Both Bristol St Paul's and Swansea Roadside entered the VERY HIGH band. The highest hourly measurement on this day was 273 ug/$m^3$ in gravimetric units at Bristol St Paul's during the early hours of the morning of Monday 6th.

Seven sites went MODERATE on Tuesday 7th November, all of them considered to have been caused by a general build up of traffic related emissions before westerly air and favourable dispersion conditions reached the UK on Wednesday 8th. Half of these sites were located in London and 70 % were designated "roadside".

London Marylebone Road exceeded the MODERATE band twenty eight times during this period, five more exceedences compared to the same quarter in 2005.

On Monday 16th October twelve sites entered the MODERATE band. Seven of these were located in London of which four were non-roadside designated sites. Glasgow Kerbside also exceeded as well as Cardiff centre and further urban sites in the midlands and the south east. The highest daily running average was 92 ug/$m^3$ in gravimetric units at London Marylebone Road. The following day 8 sites exceeded, including two roadside sites in London and two urban sites in the north east of England. Air trajectories over this period were westerly or south westerly throughout with mild conditions and a light breeze experienced. Particulate levels gradually built up from the 14th to the 16th then fell away from midday on the 16th over most of the UK, including sites in Scotland to some extent. Satellite imagery showed that a haze had built up over the North Sea on the 13th and had passed over to areas of the UK from the 14th to the 16th. On the 16th the haze had been over all areas and mixed with cloud, Scotland appeared to have cleared of haze during the daytime. By the 18th the haze had completely cleared.

Over the 7th and 8th December approximately four sites entered the MODERATE band. One of these was due to possible building works near the Leamington Spa site. Marylebone Road and Swansea Roadside sites exceeded as well as the Port Talbot site, located near a steel works. This was a cool period just before a cold spell and is likely to have been caused by, predominantly, traffic emissions before a weekend, and a localised effect at the Port Talbot site.

A further cold spell occurred leading up to the Christmas break. Conditions were foggy, freezing and with very low or no wind speeds, particularly in the north east of England, the Midlands and the south east. From Tuesday 19th December to Friday 22nd December around 5 sites exceeded the MODERATE band on a daily basis. All the sites were located in the north of England and were split between "roadside" and "urban" designations. Examples include Bury Roadside, Sheffield Centre and Wigan. These are likely to have been the result of industrial emissions combined with traffic emissions in very poor dispersion conditions. After Friday 22nd traffic flows would have been far lower therefore no more exceedences were observed over the Christmas period.

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

**$NO_2$**

Exceedences of the MODERATE band were measured at the London Marylebone Road site on 8 days during this quarter. These were fairly evenly distributed throughout this period although no exceedences were measured during the pre-Christmas cold spell, possibly due to a fall in the number of employees at workplaces in the build up to the holiday. One day exceedences were also

observed at urban-industrial designated Billingham site in early October during a period of south westerly air trajectories, the nearby busy road and housing estates are likely to have contributed to this event and Stockton-On-Tees Yarm Roadside in late October. The airport designated site at London Harlington measured two consecutive days of MODERATE exceedences in mid November, possibly the result of local traffic build up during the morning of the first day and on the evening of the second.

**$SO_2$**

No MODERATE exceedences were measured during this quarter. The highest 15 minute averaged measurement during the quarter was 210 ug/$m^3$ at the Port Talbot site in mid November, during a mild spell with south westerly air trajectories. A steel works is located located to the south west of the site and is therefore likely to have been the cause.

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

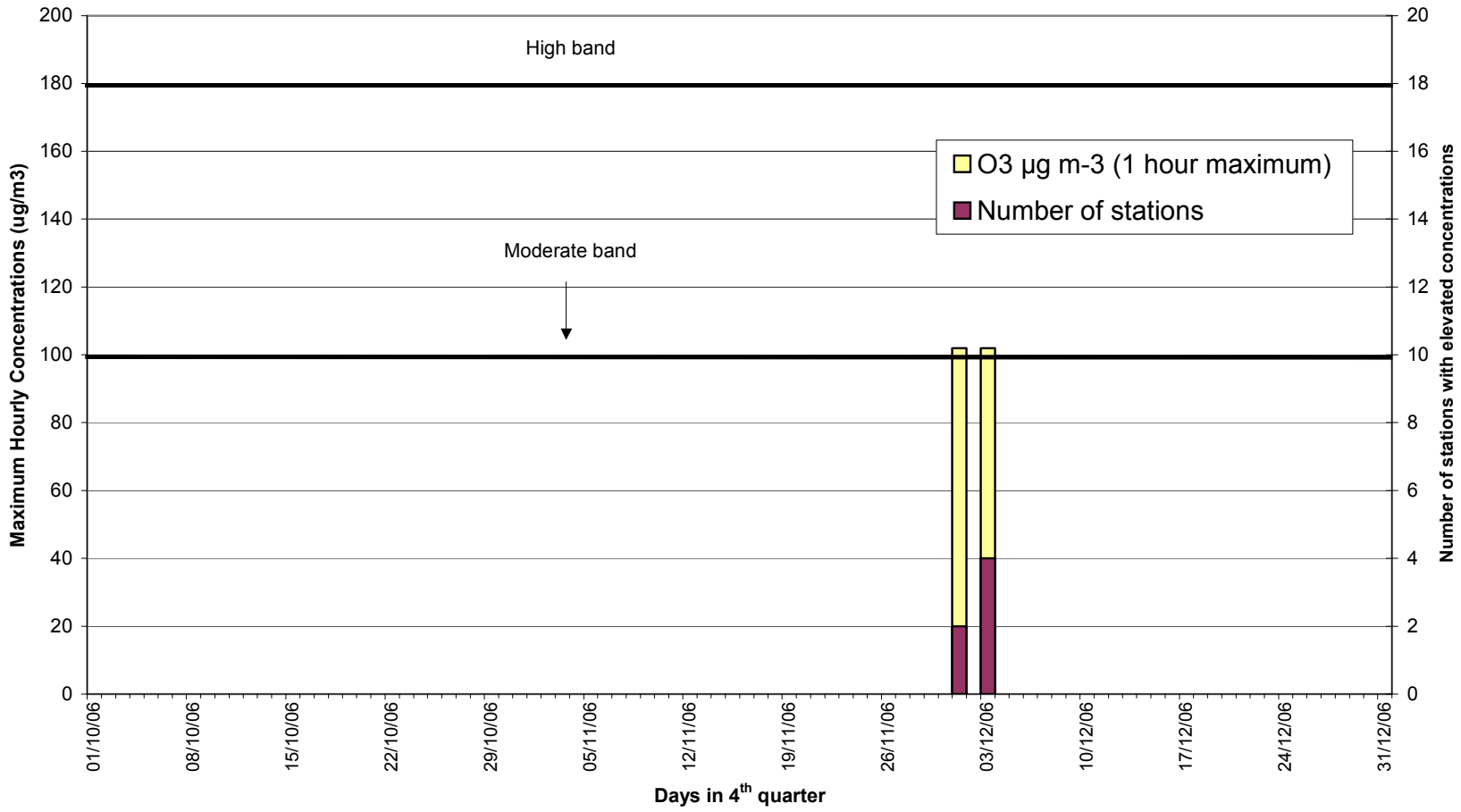



**Figure 3.1 Daily maximum hourly ozone concentration across AURN Network with total number of stations measuring MODERATE or above levels of ozone over 4th quarter 2006.**

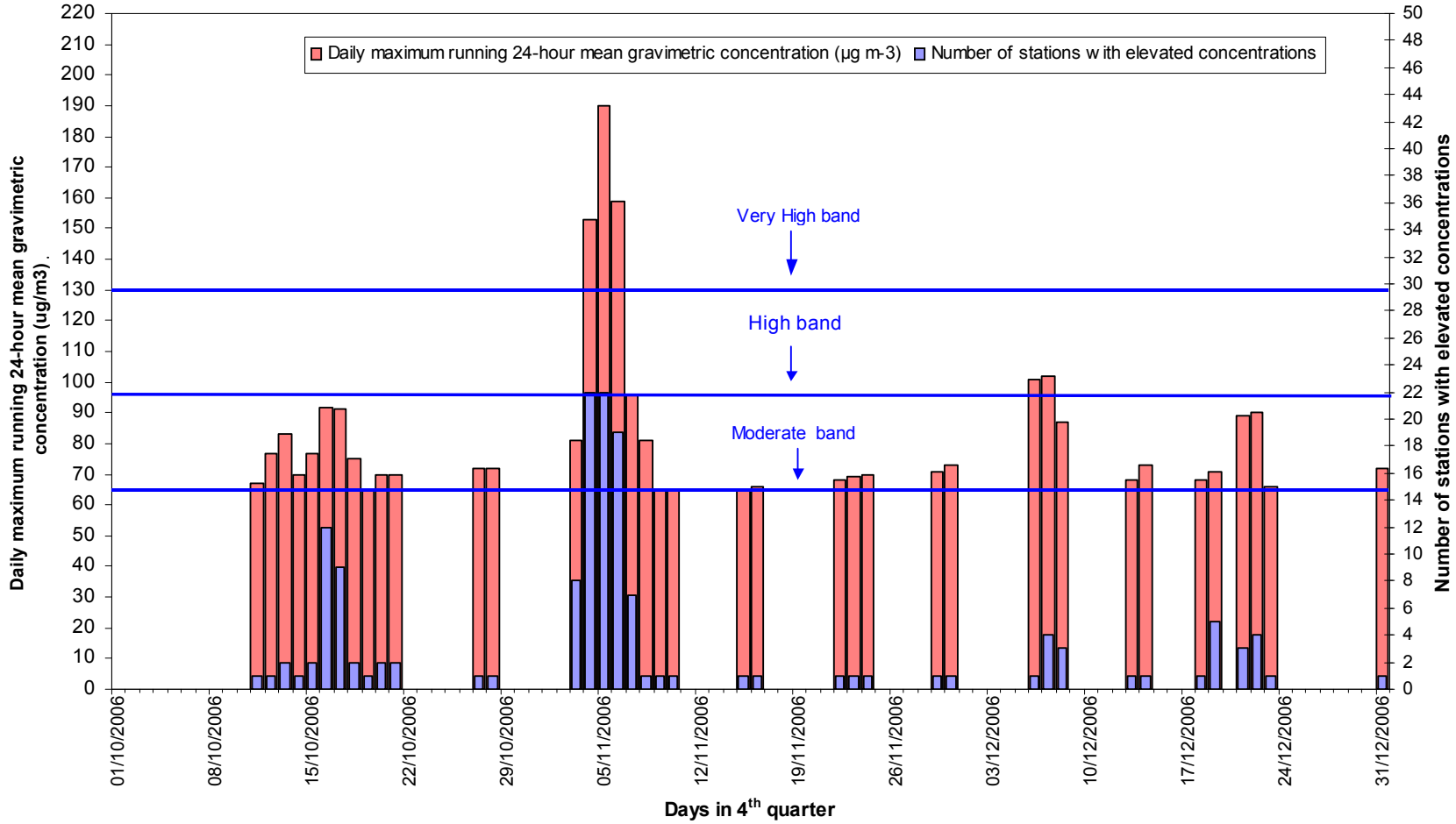



**Figure 3.2 Daily maximum running 24-hour mean $PM_{10}$ concentration across AURN Network with total number of stations measuring MODERATE or above levels over the 4th quarter 2006.**

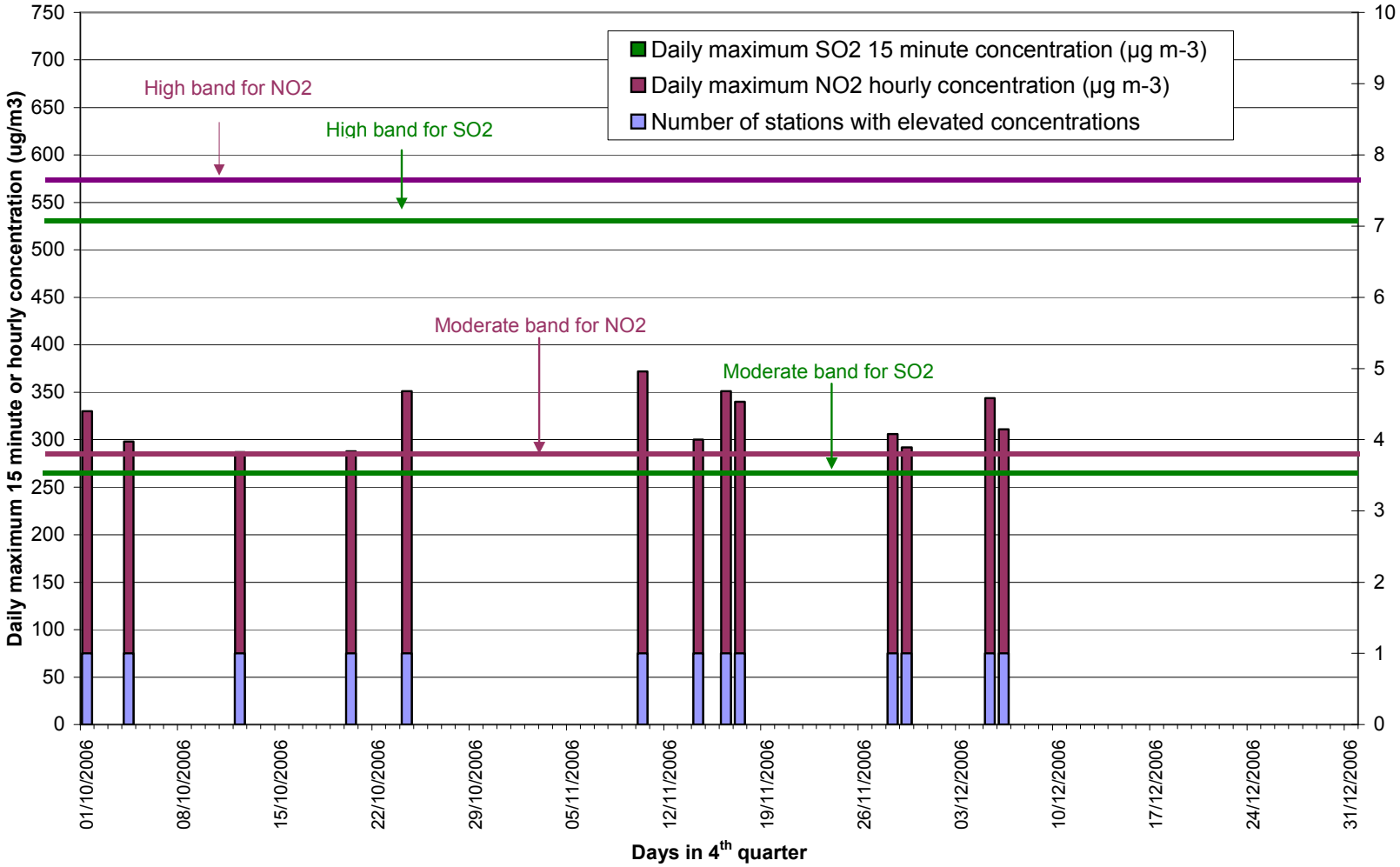



**Figure 3.3 Maximum 15 minute average concentrations of $SO_2$ and hourly average of $NO_2$ across AURN Network with total number of stations measuring MODERATE or above levels over the 4th quarter 2006.**

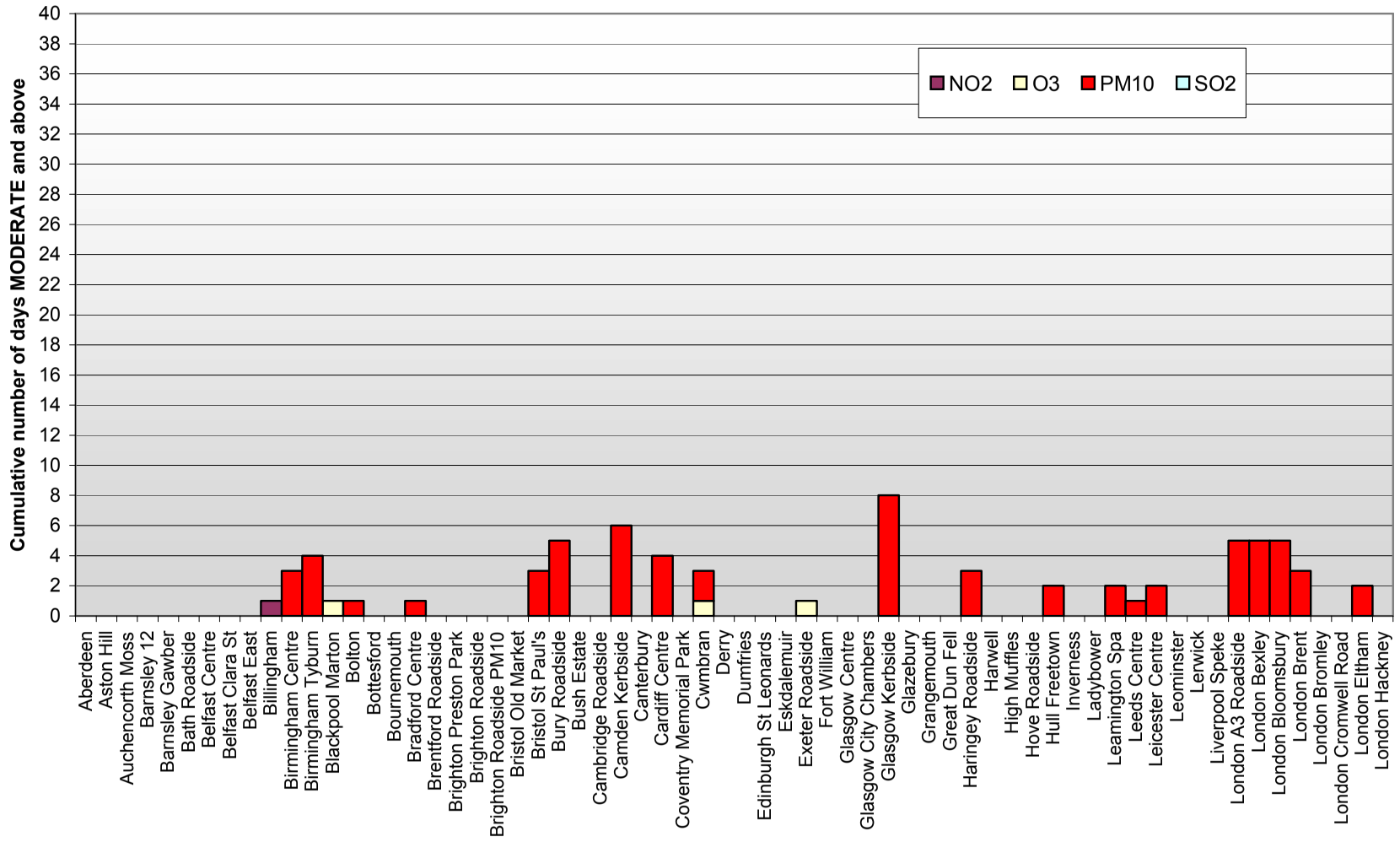



**Figure 3.4a Number of days moderate and above for each AURN Network station over 4th quarter 2006 – provisional data**

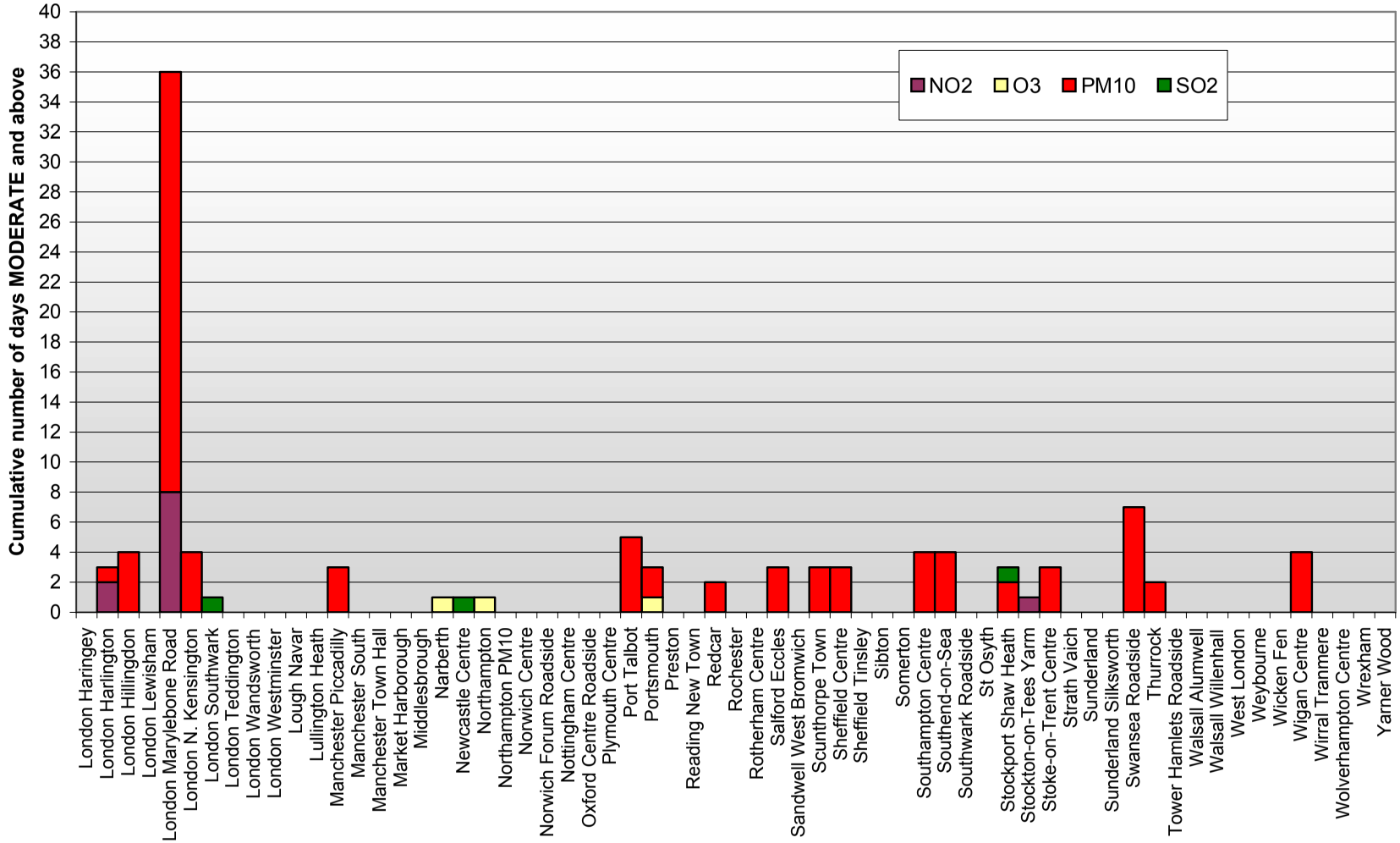



**Figure 3.4b Number of days moderate and above for each AURN Network station over 4th quarter 2006 – provisional data**

# 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 PARTICULATE CLOUD FROM EASTERN SOURCES IN EARLY MAY

An ad-hoc report will be shortly available on the National Air Quality Archive detailing the elevated particulate measurements experienced at UK sites in early May. Optical and chemical analysis of particulate samples collected over that period have now been performed and have indicated that the particulates measured over that period were combustion related, with very low contributions from pollen species.

## 6.2 SUMMER OZONE EPISODE

An ad-hoc report entitled "Air Pollution Forecasting: OZONE POLLUTION EPISODE REPORT (JUNE-JULY 2006)" by Jaume Targa has been published on the National Air Quality Archive detailing the elevated ozone measurements experienced at UK sites during the summer.

## 6.3 PARTICULATE CLOUD FROM EUROPEAN SOURCES IN MID SEPTEMBER

An ad-hoc report will be shortly available on the National Air Quality Archive detailing the elevated particulate measurements experienced at UK sites in mid September.

# 7 Ongoing research

AEA Energy & Environment 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 European sources 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 January to March 2007

Major tasks include:

- Ongoing daily air pollution forecasting activities.
- Ongoing improvements to NAME model, including:
  - Increase in the horizontal model domain
  - An upgrade providing enhanced chemistry modelling for ozone, nitrates and sulphates.
  - 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.
- The Met Office to plan the 2006 seminar.
- A project review meeting with Defra will be held at AEA Energy & Environment's Harwell location on March 7th.

# 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

1 Table showing the Air Pollution index

## 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 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | $\mu gm^{-3}$ | ppb | $\mu gm^{-3}$ | ppb | $\mu gm^{-3}$ | ppb | $mgm^{-3}$ | ppm | gravimetric $\mu gm^{-3}$ |
| **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 $\mu gm^{-3}$ | ≥ 180 ppb | ≥ 764 $\mu gm^{-3}$ | ≥ 400 ppb | ≥1064 $\mu gm^{-3}$ | ≥ 400 ppb | ≥ 23.2 $mgm^{-3}$ | ≥ 20 ppm | ≥ 130 $\mu gm^{-3}$ |

| 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


| | |
|---|---|
| 1 | Table showing the Air Pollution Forecasting Zones and Agglomerations, together with populations (based on 2001 Census). |
| 2 | Map of Forecasting Zones and Agglomerations. |

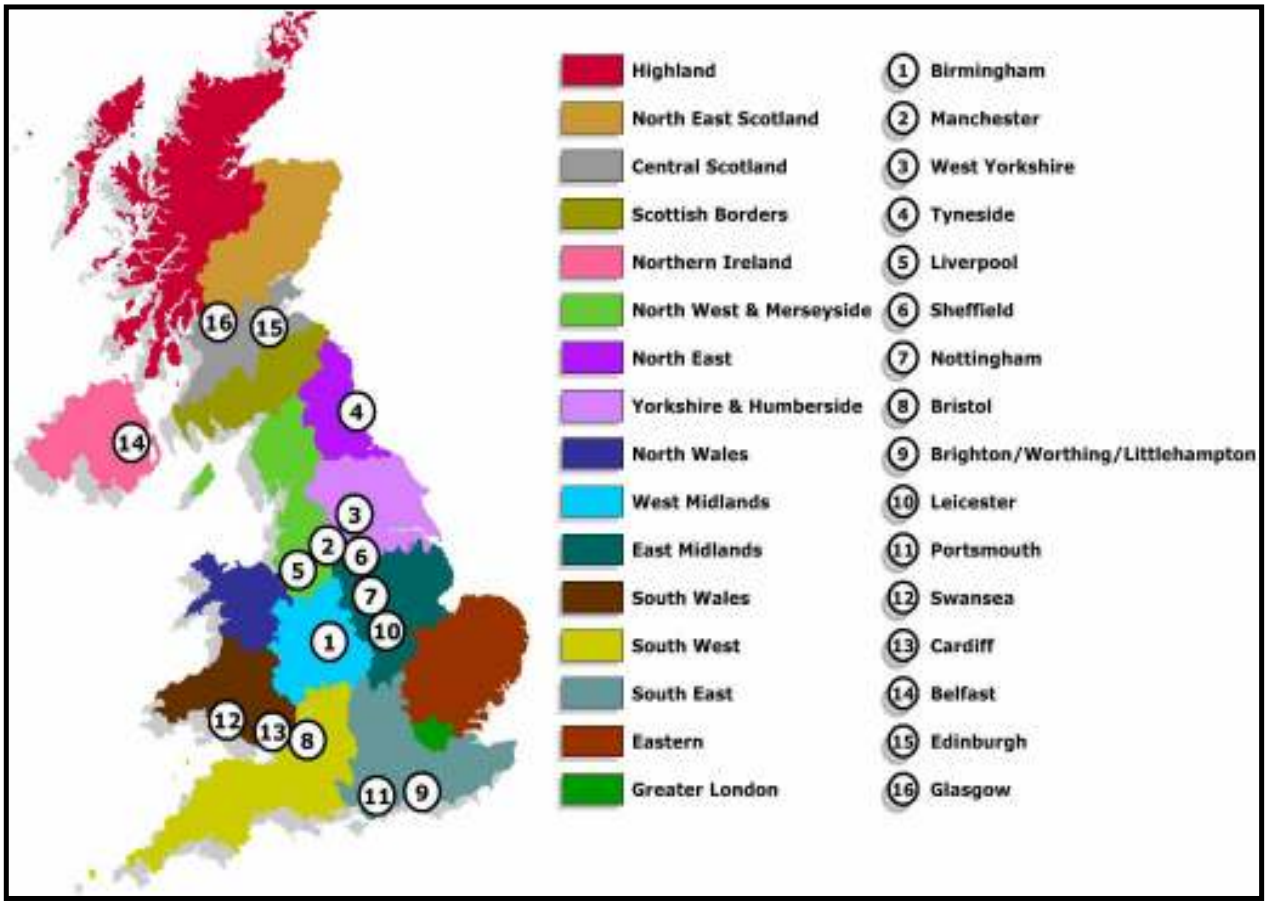
**Forecasting Zones**

| 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

1 Worked Example

## *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.