

REPORT

UK Air Quality Forecasting: Operational Report for January to March 2004

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/1784 Issue 1
May 2004

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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 January to March 2004. The work is funded by the Department for Environment Food and Rural Affairs, the Scottish Executive, Welsh Assembly Government and the Department of the Environment in Northern Ireland.

During this period, there were a total of 6 localised events on which 'HIGH' air pollution was recorded across the network. These HIGH periods are recorded within the forecasting success calculations. The forecasting success and accuracy for this quarter for HIGH and MODERATE episodes is summarised in Table 1 below. The poor success and accuracy of these HIGH recordings are due to their PM₁₀ and SO₂ nature- which is always unpredictable- and because these were very localised events.

Table 1 – Forecast success/accuracy for incidents¹ above 'HIGH' and above 'MODERATE', January 1st to March 31st 2004

Region/Area	HIGH		MODERATE	
	% success	% accuracy	% success	% accuracy
Zones	0	0	139	82
Agglomerations	0	0	100	39

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 efficiently considering the most accurate forecasts.
2. Researching the chemistry used in our models, in particular the NO_x->NO₂ conversion used in NAME, and the chemical schemes for secondary PM₁₀ and ozone.
3. Improve the NAME model runs which can be used for ad-hoc analysis, in particular with regard to investigating the possible long-range transport of PM₁₀ 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 between January and March and all bulletins were delivered to the Air Quality Communications contractor on time.

During this period, no new ad-hoc reports were presented to Defra and the Devolved Administrations.

¹ Note that the calculations of accuracy and success rates are based on a success being ± 1 of the measured index and that it is possible to record rates in excess of 100% rather than 'true' percentages.

Contents

Executive Summary	ii
1 Introduction	4
2 New developments during this period	5
3 Analysis of forecasting success rate	5
3.1 FORECAST ANALYSIS FOR JANUARY 1 ST TO MARCH 31 ST 2004	6
4 Breakdowns in the service	13
5 Additional or enhanced forecasts	13
6 Ad-hoc services	13
7 Ongoing research	13
8 Forward work plan for April to June 2004	14
9 Hardware and software inventory	14
Appendix 1 - Air Pollution Index	15
Appendix 2 - Forecasting Zones and Agglomerations	17

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; it is then included in subsequent air quality bulletins for the BBC, newspapers and many other interested organisations.

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

Twice every week, on Tuesdays and Fridays, we also provide a long-range pollution outlook. This takes the form of a short piece of text that is emailed to around twenty recipients in Defra and other government Departments, together with the BBC weather forecasters. The outlook is compiled by examining output from our pollution models- which currently extend to 3 days ahead- and by assessing the long-term weather situation.

We continue to provide a comprehensive 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

During the first quarter in 2004, there have not been any new developments to report.

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 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. 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 January – March 2004 are presented in Tables 3.1 (forecasting performance in zones) and 3.2 (forecasting performance in agglomerations) for 'HIGH' days. Table 3.5 provides a summary for each pollutant of the number of days on which HIGH and above pollution was measured, the maximum exceedence concentration and the day and site at which it was recorded. The forecasting performance Tables 3.1 and 3.2 provide details of the number of days:

- 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:

$$\square \quad (\text{Number of episodes successfully forecast} / \text{total number of episodes measured}) \times 100$$

The **forecast accuracy** (%) is calculated as:

$$\square \quad (\text{Number of episodes successfully forecast} / [\text{Number of successful forecasts} + \text{number of wrong forecasts}]) \times 100$$

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

3.1 FORECAST ANALYSIS FOR JANUARY 1ST TO MARCH 31ST 2004

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

ZONES	Central Scotland	East Mids	Eastern	Greater London	Highland	North East	North East Scotland	North Wales	North West & Merseyside	Northern Ireland	Scottish Borders	South East	South Wales	South West	West Midlands	Yorkshire & Humberside	Overall
measured days	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	3
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	1	0	0	0	0	1	0	0	0	0	0	0	0	3
success %	0	100	100	0	100	100	100	100	0	100	100	100	100	100	100	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	0	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	0	0	0	0	0	0	0
success %	100	100	100	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	3	0	0	0	3
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	3	0	0	0	3
success %	100	100	100	0	100	100	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	4	4	12	23	21	13	13	0	3	19	0	24	1	7	3	28	175
forecasted days	1	12	18	24	15	11	8	0	4	5	0	18	12	11	13	8	160
ok (f and m)	2	11	22	32	28	16	17	0	4	21	0	31	11	12	6	30	243
wrong (f not m)	0	4	3	3	2	4	2	0	1	0	0	5	2	2	9	3	40
wrong (m not f)	3	0	1	3	0	1	0	0	2	1	0	1	0	0	0	1	13
success %	50	275	183	139	133	123	131	100	133	111	100	129	1100	171	200	107	139
accuracy %	40	73	85	84	93	76	89	0	57	95	0	84	85	86	40	88	82

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	6	0	2	2	4	5	5	1	3
forecasted days	4	3	4	4	1	5	6	7	1
ok (f and m)	8	0	0	1	4	6	5	1	4
wrong (f not m)	0	3	4	3	0	1	2	7	0
wrong (m not f)	0	0	2	2	0	0	2	0	0
success %	133	100	0	50	100	120	100	100	133
accuracy %	100	0	0	17	100	86	56	13	100

AGGLOMERATIONS	Nottingham UA	Portsmouth UA	Sheffield UA	Swansea UA	Tyneside	West Midlands UA	West Yorkshire UA	Overall
measured days	0	0	0	11	0	2	0	41
forecasted days	3	7	2	10	3	7	4	71
ok (f and m)	0	0	1	8	0	3	0	41
wrong (f not m)	3	7	1	5	3	6	4	49
wrong (m not f)	0	0	0	8	0	0	0	14
success %	100	100	100	73	100	150	100	100
accuracy %	0	0	50	38	0	33	0	39

* 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 2004

Pollutant	High days	Moderate days	Maximum concentration *	Site with max concentration	Zones or Agglomeration	Date of max conc.
Ozone	-	51	122 μgm^{-3}	Lullington Heath Wicken Fen	South east East Anglia	30/03/04
PM ₁₀ (teom)	7	28	101 μgm^{-3}	Preston	Preston UA	05/02/04
NO ₂	-	5	436 μgm^{-3}	London A3 Roadside	Greater London UA	30/03/04
SO ₂	2	4	821 μgm^{-3}	Salford Eccles	Greater Manchester UA	01/03/04
CO	-	-	-	-	-	-

* Maximum concentration relate to 8 hourly running mean or hourly mean for ozone, 24 hour running mean for PM₁₀, hourly mean for NO₂, 15 minute mean for SO₂ and 8 hour running mean for CO.

General Observations

The first quarter of 2004 has been characterised by localised events rather than regional episodes. There have been seven HIGH days due to PM₁₀ and two due to sulphur dioxide. MODERATE levels of PM₁₀ have been scattered throughout the period and MODERATE levels of ozone have been more persistent towards the second half of the quarter. Figures 3.1 – 3.3 show the trends of pollutants in graphical form. A site-by-site breakdown is given in Figure 3.4.

O₃

Ozone did not reach HIGH levels during this period. The highest recorded level of 122 μgm^{-3} was at both Lullington Heath and Wicken Fen on the 30th March. Fifty one days were characterised by levels of MODERATE pollution due to ozone. Stations measuring the highest number of MODERATE days were Straith Vaich (20), Wirral Tranmere (19), Rochester (16), Redcar (13), Aberdeen (12) and Weybourne (11). MODERATE levels of ozone were recorded more frequently during the second part of this first quarter. Figure 3.1 shows the trends in ozone levels over this period.

PM₁₀

PM₁₀ levels HIGH and above were recorded on 7 days across the UK: two each in Scunthorpe, Preston and Port Talbot and one in London Marylebone Road. A maximum peak of 101 μgm^{-3} was recorded at Preston on the 5th February. During this first quarter, 28 days were recorded with MODERATE levels. London Marylebone Road with 9 days and Port Talbot with 8 days were the stations measuring the highest number of MODERATE PM₁₀ days.

For PM₁₀ related HIGH episodes, which tend to dominate in agglomerations where road traffic pollution, industry and construction are abundant, the success rate was low. None of the seven measured PM₁₀ high levels were forecasted. This is due to the localised nature of the events at London Marylebone Road, Port Talbot, Preston and Scunthorpe. Sources of PM₁₀ are by their nature unpredictable and diverse. Figure 3.2 shows the trends in PM₁₀ levels over this period.

SO₂

Sulphur dioxide levels reached HIGH levels at two locations: Grangemouth and Salford Eccles. Due to their unpredictability, these two events were not forecasted. Figure 3.3 shows the trends in SO₂ levels over this period with NO₂ also included.

NO₂

Nitrogen dioxide remained below HIGH levels with only five MODERATE recordings.

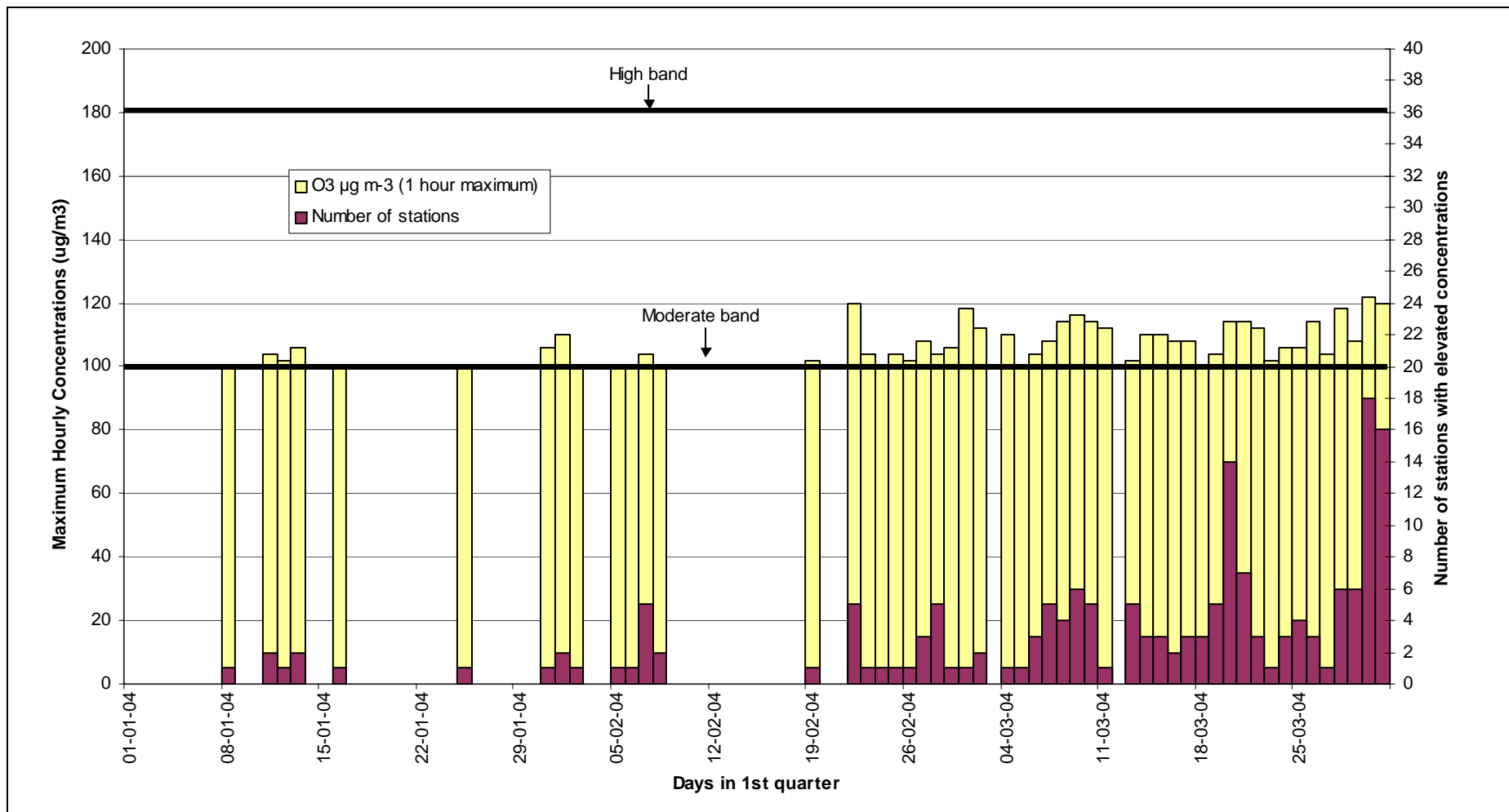


Figure 3.1 Daily maximum hourly ozone concentration across AURN Network with total number of stations measuring moderate or above levels of ozone over first quarter 2004

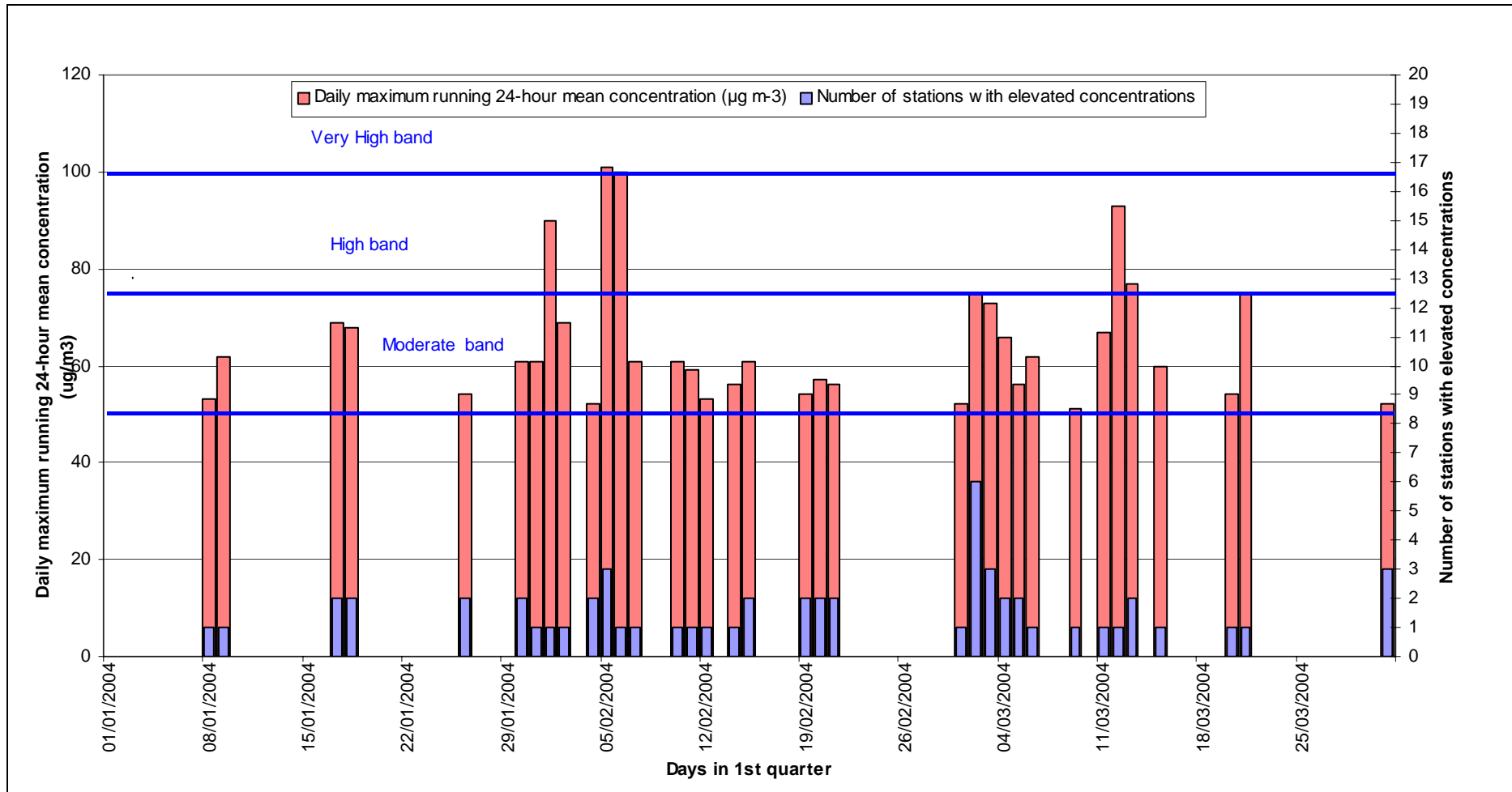


Figure 3.2 Daily maximum running 24-hour mean PM₁₀ concentration across AURN Network with total number of stations measuring moderate or above levels over the first quarter 2004.

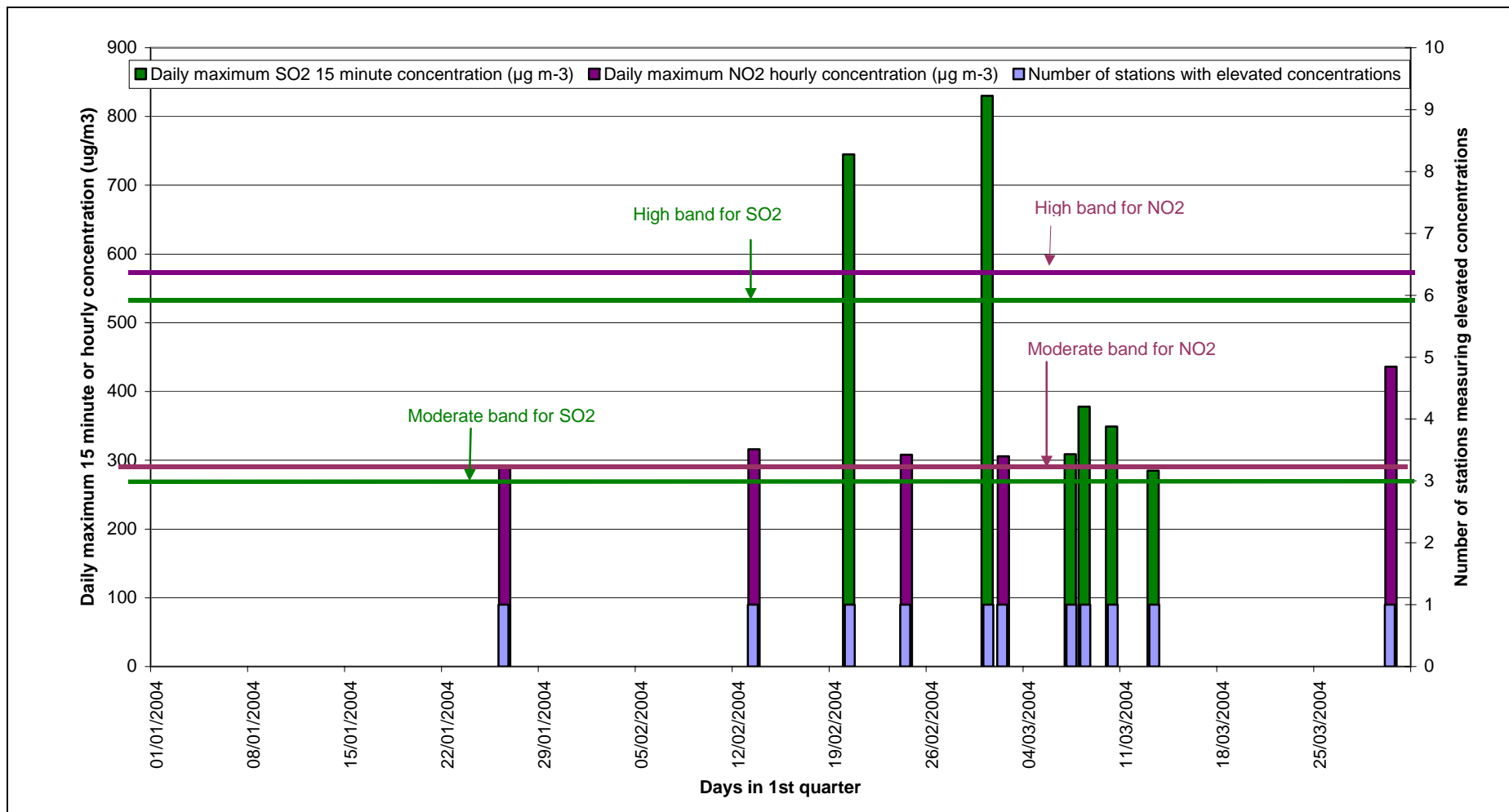


Figure 3.3 Maximum 15 minute average concentrations of SO₂ and hourly average of NO₂ across AURN Network with total number of stations measuring moderate or above levels over the first quarter 2004

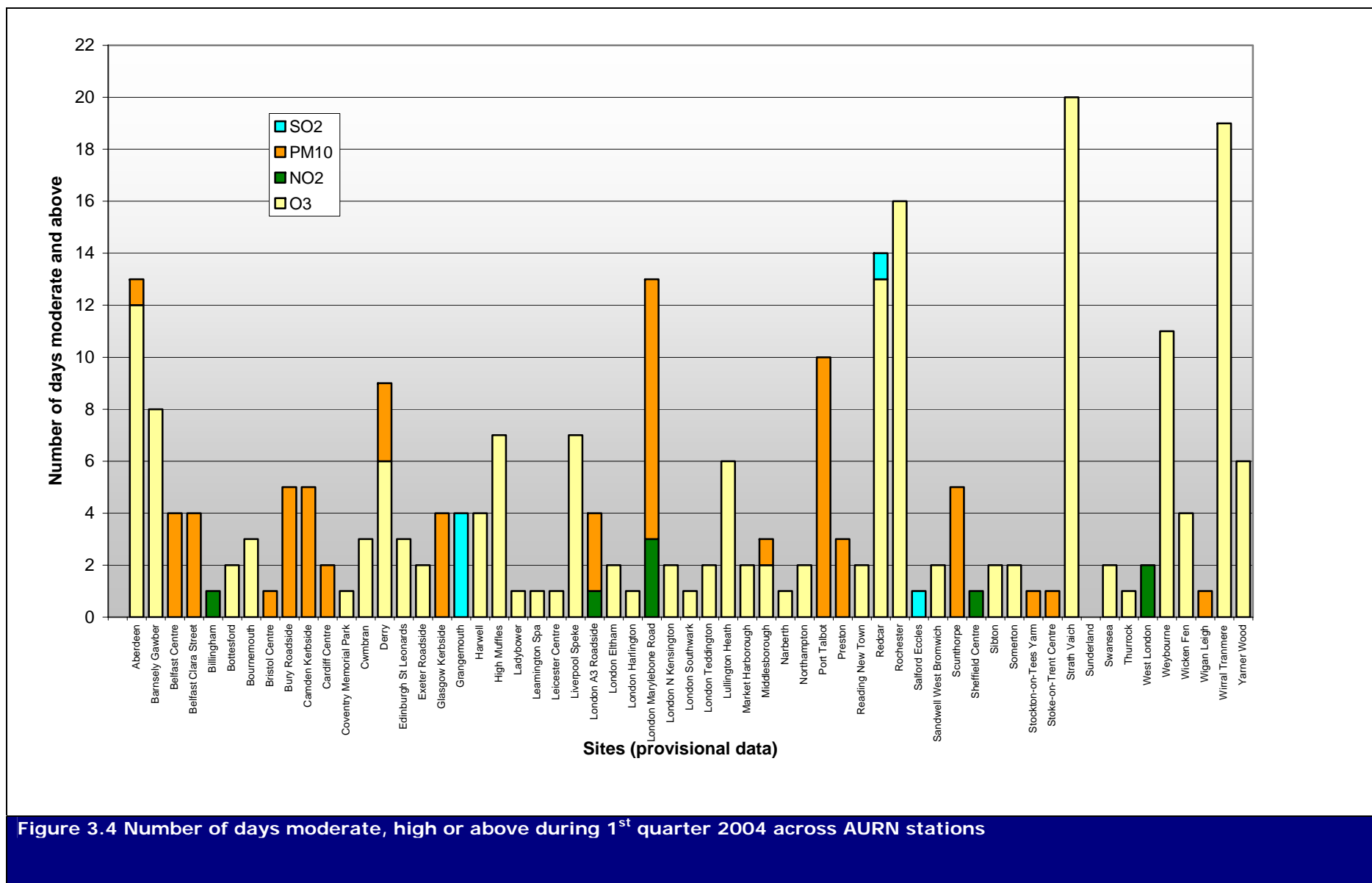


Figure 3.4 Number of days moderate, high or above during 1st quarter 2004 across AURN stations

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 a.m 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

During this period, no new ad-hoc reports were presented to Defra and the Devolved Administrations.

The July 2003 ad-hoc report relating to ozone episodes was, however, reissued following revision of monitoring data.

This and other ad-hoc reports for 2003 are published on the Air Quality Archive at <http://www.airquality.co.uk/archive/reports/list.php>.

7 Ongoing research

Netcen and the Met office will 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->NO₂ conversion used in NAME, and the chemical schemes for secondary PM₁₀ and ozone.

3. Improve the NAME model runs which can be used for ad-hoc analysis, in particular with regard to investigating the possible long-range transport of PM₁₀ 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 2004

The following activities are planned:

- Ongoing daily air pollution forecasting activities.
- Ongoing improvements to NAME model including improved modelling over steep topographical gradients, higher resolution model runs with reduced statistical noise, update of emissions inventory used in the model.
- Publication of the UK Air Quality Forecasting: Annual Report 2003 on the Air Quality Archive Web Site.
- Publication of the October to December 2003 report on the Air Quality Archive Web Site.
- Improve the accessibility of the website by use of meta-tags to improve its rating in search engines. Also refine some of the buttons so that they are easier to select.

9 Hardware and software inventory

Defra and the Devolved Administrations own the code for the ozone and secondary PM₁₀ 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
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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	µgm ⁻³
LOW										
	1	0-32	0-16	0-95	0-49	0-88	0-32	0-3.8	0.0-3.2	0-16
	2	33-66	17-32	96-190	50-99	89-176	33-66	3.9-7.6	3.3-6.6	17-32
	3	67-99	33-49	191-286	100-149	177-265	67-99	7.7-11.5	6.7-9.9	33-49
MODERATE										
	4	100-126	50-62	287-381	150-199	266-354	100-132	11.6-13.4	10.0-11.5	50-57
	5	127-152	63-76	382-477	200-249	355-442	133-166	13.5-15.4	11.6-13.2	58-66
	6	153-179	77-89	478-572	250-299	443-531	167-199	15.5-17.3	13.3-14.9	67-74
HIGH										
	7	180-239	90-119	573-635	300-332	532-708	200-266	17.4-19.2	15.0-16.5	75-82
	8	240-299	120-149	636-700	333-366	709-886	267-332	19.3-21.2	16.6-18.2	83-91
	9	300-359	150-179	701-763	367-399	887-1063	333-399	21.3-23.1	18.3-19.9	92-99
VERY HIGH										
	10	≥ 360 µgm ⁻³	≥ 180 ppb	≥ 764 µgm ⁻³	≥ 400 ppb	≥ 1064 µgm ⁻³	≥ 400 ppb	≥ 23.2 mgm ⁻³	≥ 20 ppm	≥ 100 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

- 1 Table showing the Air Pollution Forecasting Zones and Agglomerations, together with populations (based on 1991 Census).
- 2 Map of Forecasting Zones and Agglomerations.

Forecasting Zones

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

Forecasting Agglomerations

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

Map of forecasting zones and agglomerations

