Cambridge
Environmental
Research
Consultants Ltd

Comparison of ADMS-Urban, NETCEN and ERG Air Quality Predictions For London

TOPIC REPORT

Prepared for
DEFRA, National Assembly for Wales, The Scottish Executive, and the Department of the Environment, Northern Ireland

17th June 2003

CERC

Report Information

CERC Job Number:	FM489
Job Title:	Comparison of ADMS-Urban, NETCEN and ERG Air Quality Predictions for London
Prepared for:	DEFRA, National Assembly for Wales, The Scottish Executive, and the Department of the Environment, Northern Ireland
Report Status:	Issued
Report Reference:	FM489/R7/03
Issue Date:	13/06/03
Author(s):	David Carruthers, Jo Blair, Kate Johnson
Reviewer(s):	

Issue	Date	Comments
1	20/04/02	1st DRAFT
2	20/06/02	2nd DRAFT
3	12/07/02	3rd DRAFT
4	02/10/02	4th DRAFT
5	22/01/03	5th DRAFT
6	16/05/03	6th DRAFT
7	17/6/03	Final Version

Main File(s): Consult_FM489_DEFRA\Topic_reports\TBR2_Comparison\Comparison(17jun03)12_TR-0232.doc

CONTENTS

EXECUTIVE SUMMARY

Three different approaches for calculating pollutant concentrations in London are compared. These are the ADMS-Urban model developed by CERC, which is essentially a transport and dispersion model, and the methodologies of the National Environmental Technology Centre (NETCEN) and the Environmental Research Group of King's College (ERG), which are both largely empirical. The NETCEN model is a national scale methodology.

All of these models are used to inform air quality policy in the UK. NETCEN's model and ADMS-Urban are used by DEFRA and the devolved administrations to inform national and policy on air quality. ADMS-Urban and the ERG model are used by the GLA and London authorities to inform their decisions and policy fir London's air quality.

The aim of this study is to compare the outputs if the models to give an indication of the sensitivity and range of results produced. This will provide additional information to policy makers when assessing future air quality and the impacts of proposed policies and actions.

In this case the London Atmospheric Emissions Inventory (LAEI) was used as input for each of the three methodologies. NETCEN normally uses the National Atmospheric Emissions Inventory (NAEI) as input because it is a national scale model. NETCEN's results using the NAEI have also been used for comparison.

The methodologies were used to predict concentrations of NO_x, NO_2 and PM_{10} for 1999, 2004 and 2005 at AURN sites, other receptor points and at each major road link. Calculate concentrations for 1999 are compared to monitoring data. The results are recorded in this report and compared, including the number of major road links exceeding various thresholds.

Care is required when interpreting road link data from NETCEN. The methodology was calibrated with the NAEI but road link data were only available for the LAEI. In addition the NETCEN methodology calculates a single 'representative' concentration for each road link. ADMS-Urban and ERG calculate spatial averages over road segments, which covers the locations on or near roads that are observed to exhibit steep concentration gradients.

Based on objective criteria the comparison suggests that each of the methodologies performs well. As would be expected there are also a number of important differences. The differences in concentration are particularly significant for future projections of the annual average NO_2 and PM_{10} concentrations. In particular, they affect the predicted area of London over which the air quality standards are exceeded and so will affect the predicted amount of benefit delivered by proposed mitigation measures.

Specific matters of note are as follows:

(i) *NO_x, NO_2 at roadside sites*

Comparisons made at monitoring sites show that the empirically based methodologies (NETCEN, ERG) tend to generate less NO_2 for given NO_x than ADMS-Urban. This reflects the difference between the ADMS-Urban Chemistry model for conversion of NO_x to NO_2 and the empirical relationships used in NETCEN and ERG. In addition, the empirically based methodologies show some tendency to predict lower NO_2 than is calculated by ADMS-Urban, especially for future projections.

(ii) *NO_x, NO_2 at background sites*

Comparisons have been conducted for AURN sites and selected additional receptor points. These suggest good performance of ADMS-Urban and both the NETCEN and ERG empirically-based methodologies. Limited ADMS-Urban calculations of a 'background' component at roadside locations were carried out by removing emissions of the local major road. They show that NETCEN (NAEI) predicts a greater background than ADMS-Urban at roadside locations.

(iii) *PM_{10}*

As the non-primary (secondary and coarse) component of PM_{10} is significantly greater than the primary component, especially for future projections, the details of local dispersion are relatively less important than for NO_x and the models might be expected to show less divergence. However, although ADMS-Urban, NETCEN and ERG show good general agreement with monitoring data, scatter plots of road contributions and percentages of road segments that exceed thresholds show significant differences between the methodologies. In particular, minimum concentrations predicted by ADMS-Urban are greater than minimum concentrations predicted by NETCEN (based on LAEI) whilst, in contrast to ADMS-Urban and NETCEN, ERG shows a large number of road segments with approximately the same lowest calculated concentration.

(iv) *Future Projections*

Future projections have been made with each of the methodologies. The results show greater differences than for 1999. ADMS-Urban predicts greater annual mean values of NO_2 (2005) and PM_{10} (2004) especially near major roads where concentrations are highest. ERG shows the greatest decline in NOx and NO_2 to 2005 at both roadside and background.

As well as the calculation methodologies, other factors such as meteorology, and accuracy of emissions affect the relative accuracy of predictions. The ADMS-Urban validation report (Carruthers et al., 2003) suggests that typical interannual variations are unlikely to affect *annual average* concentrations of NO_2 and PM_{10} by more than about five percent on average across London, although the levels at specific sites may vary by over 10%. Thus it is likely that similar conclusions about the relative performance of the three methodologies would be reached even if a different meteorological year was considered.

(v) *Areas of Exceedence of Air Quality Standards*

The percentage of road links exceeding specified pollutant concentration thresholds was calculated. For NO_2, ADMS-Urban and the ERG methodology predict a similar percentage for 1999 but ADMS-Urban predicts a significantly higher percentage for 2005. The NETCEN approach using the LAEI predicts much lower values, however this partly results from the NETCEN correlation for London having been calculated using the NAEI rather than the LAEI. NETCEN's mode is calibrated using the NAEI.

Very large differences between the methodologies are seen in the extent iof exceedences of the PM_{10} annual average standards. For example, the methodology predicting the most exceedences of the London 2010 standard (23 $\mu g/m^3$) in 2004/5 is ADMS-Urban (98%) followed by ERG (21%), with the least predicted by NETCEN (1%). This arises because small changes in predicted concentration greatly impact on levels exceeding threshold values because by 2004 concentrations of PM_{10} are relatively uniform (Carruthers et al., 2003, Blair et al., 2003).

In conclusion, all three models predict Exceedences of the annual mean NO_2 objective in 2005 and the London 2010 objective for annual average PM_{10} in 2004. There are, however, significant differences in the extent of exceedences predicted by the models due to the fundamentally different ways they operate.

1. Introduction

This comparison study is the second of a series of topic reports prepared as part of a Cambridge Environmental Research Consultant Limited (CERC) contract to model air pollutants in urban areas in the UK. The initial part of the project has focussed on using the Air Dispersion Modelling System ADMS-Urban to model several important pollutants in Greater London: Nitrogen Dioxide (NO_2); Oxides of Nitrogen (NO_x); particulates (PM_{10}); and Ozone (O_3).

The other two topic reports present a validation and sensitivity study of London pollutant concentrations predicted by ADMS-Urban (Carruthers et al., 2003); and air quality maps for London (Blair et al., 2003). The validation study demonstrated generally good agreement between ADMS-Urban calculated concentrations and measured data. The sensitivity study demonstrated that the year for which the meteorological data are recorded, the location of the meteorological site and the emissions database are the features to which the predicted concentrations show the most sensitivity. The sensitivity to reasonable variations in the ADMS-Urban model set-up parameters, namely the minimum Monin Obukhov length, height of grid sources and surface roughness, is smaller.

Other organisations predict air pollution in London with the emphasis on a mapping methodology. The techniques differ so it is important to understand how the outputs compare. The National Environmental Technology Centre (NETCEN) and the Environmental Research Group of King's College (ERG) calculate concentrations in London for the same years using the same emissions inventories as used for the ADMS-Urban work, therefore their work is of particular interest. This topic report records the comparison of the equivalent output from ADMS-Urban with NETCEN and ERG results across London.

All of these models are used to inform air quality policy in the UK. NETCEN's model and ADMS-Urban are used by DEFRA and the devolved administrations to inform national and policy on air quality. ADMS-Urban and the ERG model are used by the GLA and London authorities to inform their decisions and policy fir London's air quality.

The aim of this study is to compare the outputs if the models to give an indication of the sensitivity and range of results produced. This will provide additional information to policy makers when assessing future air quality and the impacts of proposed policies and actions.

All three models have been validated (in other studies) against measurements. It is not the intention of this study t assess which model is "correct". They have been developed for different purposes and have advantages and disadvantages compared to each other.

PM_{10} concentrations have been presented as gravimetric values whilst all NO_x concentrations are presented as "NO_x as NO_2".

The results have been compared in several different ways:

(1) Direct comparison of concentrations at specific locations, including the Automatic Monitoring Network (AURN) sites and ten other locations in Greater London;

(2) Comparison of the total road length exceeding specific concentration thresholds of NO_x, NO_2 and $PM_{10;}$ and

(3) Comparison of the predicted annual average concentrations on each of the road links.

Section 2 discusses each of the methodologies for calculating pollutant concentrations and contrasts the different approaches, Section 3 discusses the emissions inventories and Section 4 presents the comparisons; some general discussion is given in Section 5.

2. Methodology

2.1 ADMS-Urban

The ADMS-Urban air quality model (Carruthers et al., 1998) is a transport and dispersion model based on ADMS 3, the advanced Gaussian type short range dispersion model for industrial sources (Carruthers et al., 1994). Full technical details of this model are described in the technical specification (CERC, 2000). ADMS was developed by CERC in collaboration with the University of Surrey and the Met Office and has been extensively validated (e.g. Hanna et al., 1999) and continues to be developed and maintained by CERC. It is routinely used for regulatory purposes. ADMS-Urban was developed by CERC from ADMS 3 specifically for air quality calculations across urban areas and was motivated by the Air Quality Strategy. The model is able to calculate pollutant concentrations for the full range of averaging times required by the Air Quality Strategy and EU Directives (i.e. 15 minutes to 1 year).

Additional features of ADMS-Urban include:

- Modification of the line source algorithms so that they can be applied to dispersion from road sources, specifically by including traffic produced turbulence and street canyons;
- Allowance for a large array of grid sources as necessary for large urban areas; and
- A trajectory model within which the ADMS algorithms are nested and which allows the temporal variation in meteorology and emissions to impact on the chemical reaction scheme and pollutant concentrations.

The sources are treated as precisely as is possible and necessary. Thus road sources relatively close to the output domain (i.e. within 3km) are characterised by their location, width, street canyon height (where relevant) and traffic/emission characteristics, whilst more distant road sources are aggregated onto a grid without loss of accuracy. Large point sources are generally treated explicitly whilst smaller point sources and other emissions are all aggregated onto a grid.

The model is run using successive hours of meteorological data, background pollution data and emissions data as input. Thus both long term averages, shorter averaging times (as little as 15 minutes) and percentiles can be calculated. For London, meteorological data from London Heathrow, background data from surrounding rural sites and emissions data from the London Atmospheric Emissions Inventory (LAEI) are used. Local explicit sources take account only of current meteorology while other sources are affected by current meteorology as well as that prevailing over previous hours. Chemical reactions take account of the time history of a parcel of air/pollutant arriving at a particular receptor point and are characterised by the generic reaction set (Azzi et al., 1992; Ventrakan et al., 1994).

Pollution not arising from emissions included in the inventory is estimated from rural measurements (rural background). In addition, in the case of PM_{10}, the local coarse component deriving from such sources as construction dust, is also added to the

ADMS-Urban dispersion calculation. This procedure is also used in the NETCEN mapping.

ADMS-Urban has within it a number of adjustable global parameters. The most important of these are surface-roughness (z_0), minimum Monin Obukhov length L_{MO}(min) for limiting stable stratification in urban areas, and the depth of the grid sources (h_g), i.e. the depth over which the gridded emissions are mixed. In setting the model up for a particular location these parameters may be adjusted within reasonable and justifiable ranges to obtain the best overall comparison with monitoring data. It is this 'best set' of parameters which is used to calculate the modelled concentrations in this report. For instance reasonable estimates of the parameters for London might vary within the following ranges:

- $0.8 < z_0 < 2.0$m;
- 30m < L_{MO}(min) < 100m; and
- 30m < h_g < 100m.

ADMS-Urban has been subject to a large number of validation studies. These have included previous studies in London (Carruthers et al., 1999), and validation against monitoring sites and studies in Budapest and North East China. Validation of the model for 1999 concentration predictions for London has been reported in a separate topic report (Carruthers et al., 2002). It shows generally good agreement between the ADMS-Urban predicted concentrations and monitored concentrations for 1999. In particular annual mean concentration of NO_2 and PM_{10} are well predicted by the model.

ADMS-Urban is subject to strict version control procedures, and ADMS-Urban version 1.7 was used for this study.

2.2 The NETCEN Mapping Approach

The NETCEN National Empirical mapping methodology (Stedman et al., 2001) calculates annual average pollutant concentrations. It is designed to allow rapid testing of policy scenarios and their impact across the whole of the UK. Features and assumptions of the methodology include:

(a) Urban locations can be characterised as either urban *background* or *roadside*.

(b) The concentration at an urban *background* location is made up of a rural component and an urban background component.

(c) The concentration at a *roadside* location is made up of a rural component, an urban background component plus a roadside component.

(d) The urban background component is characterised by dispersion modelling of emissions from a grid of 1km × 1km squares, except for major point sources which are modelled explicitly using ADMS 3 version 3.1. The magnitude of the urban background component is determined by a correlation analysis, which uses emissions data from an emissions inventory and concentration data measured at *background* monitoring sites. The methodology is therefore calibrated for a particular emissions inventory using this correlation analysis.

(e) The correlation technique used to derive the urban background component (d) is only applied to long term averages, such as annual means.

(f) The roadside component is characterised simply by the local emissions on the road. It does not depend on road type, width, or the presence of a street canyon, except that a different coefficient is used for the M25. An empirical relationship is derived between road emissions data and concentration data measured at *roadside* and *kerbside* monitoring sites. Again, the methodology is calibrated for a particular emission inventory when using the derived empirical relationship to calculate a value for each road link. This single value is 'broadly representative' of the concentration close to the edge of the road, typically 5m from the kerb.

(g) Annual average concentrations of NO_2 are derived from NO_x concentrations using the following empirically based formulae:

- Central (non-roadside) $[NO_2]$ (ppb) = $1.750\,[NO_x]^{0.7}$
- Background $[NO_2]$ (ppb) = $2.375\,[NO_x]^{0.6}$
- Roadside $[NO_2]$ (ppb) = $1.8767\,[NO_x]^{0.6}$

The splitting of the urban contribution to the concentration into two component parts, with the road and the urban background being treated by quite distinct methods, is fundamentally different from the approach used by ADMS-Urban. The assumption (f) is a much simpler representation of a road source than that used in ADMS-Urban or in the ERG approach.

In addition to the mapping methodology described above, designed to calculate concentrations over larger areas, NETCEN also calculate site specific results for future years using a different approach. These are calculated from 1999 values, which are split into different component parts (such as road, background, coarse) and are constrained to match the measured values. Each component part is projected forward to future years to give predicted concentrations at the specific sites.

The specific version of the NETCEN methodology used in this study relates to the period January/February 2002.

2.3 The ERG Approach

The ERG approach calculates annual average pollutant concentrations based on techniques developed by ERG using a combination of commercially available models and in-house receptor modelling approaches. The methodology has been developed specifically for predicting air quality in London and makes extensive use of air quality monitoring sites from the London Air Quality Network (LAQN) and AURN sites. Features and assumptions of the methodology include:

(a) Within 500m of air pollution receptor sites in London the road network from the LAEI is split into 10 m sections, based on Ordnance Survey GIS maps, to improve the geographical accuracy of the emissions characterised close to sites, where concentration gradients are steep.

(b) Dilution from these 10m road sources is modelled using the ADMS 3 model with hourly sequential meteorological data from London Heathrow.

(c) Road sources beyond 500m from each site and non-road traffic sources are aggregated into 1 km^2 volumes and modelled separately using ADMS 3.

(d) A multiple regression is then carried out such that the concentration of NO_x at each site has three components: local road network emissions, more distant road sources and other source categories.

(e) The measurements at each site are used to explain the contribution made by each source.

(f) NO_2 is calculated by defining relationships between annual mean NO_x and NO_2 (Carslaw et al., 2001). The NO_x-NO_2 curves used to represent mixing and atmospheric chemistry effects recognise the rapid change of the ratios in the vicinity of road sources by using different curves for background and roadside locations, depending on the predicted ratio of NO_x from the local road network and more distant sources. The ratio also varies depending on the location in London.

(g) The prediction of PM_{10} includes receptor-based techniques that aim to categorise PM_{10} into broadly different components, typically primary, secondary and "other". ERG also makes use of $PM_{2.5}$ measurements to further delineate between the different components (Fuller et al., 2002). Particle fractions are identified as $PM_{2.5}$ that can be related to NO_x, $PM_{2.5}$ that is not associated with NO_x, coarse particles that are associated with NO_x and coarse particles that are not associated with NO_x.

(h) The PM_{10} fractions are defined by undertaking regression analyses of annual mean and daily concentrations of NO_x, PM_{10} and $PM_{2.5}$ at measurement sites within and around London.

(i) Daily time series of coarse and secondary PM_{10} are derived, and assumed to be invariant across London for different meteorological years. A small component of the coarse fraction that cannot be related to NO_x is also assumed to be secondary in origin since the particle size of secondary aerosol covers part of the coarse fraction (particularly nitrate aerosol).

(j) Current day estimates of the primary PM_{10} are derived from observed PM_{10}:NO_x ratios. Ambient concentrations of primary PM_{10} from road sources are derived in the same way as for NO_x, described above.

(k) Future daily mean concentrations of PM_{10} are calculated by taking account of the likely reduction in secondary aerosol and the reduction in the direct emissions of PM_{10} derived by emission inventories.

The specific set-up of the ERG methodology used in this comparison study relates to the period June/July 2002.

2.4 Expected performance of the three approaches

The above descriptions of ADMS-Urban and the NETCEN and ERG methodologies show that there are significant differences between the approaches but also common features. Before presenting the comparisons it is useful to anticipate how these differences are likely to impact on model performance and accuracy.

It should be kept in mind that all three models were developed for different end-users and each has particular characteristics designed to meet specific objectives. This section discusses some of the differences in expected performance of the models when they are compared directly.

First transport and dispersion are considered. For point and grid sources each method employs ADMS algorithms to take account of their impact: NETCEN and ERG indirectly by using ADMS 3 to link emissions to background concentrations using a correlation analysis, whilst ADMS-Urban uses the ADMS algorithms directly. The advantage of the former method is speed. This enables predictions to be made for large areas, for example, the NETCEN methodology is applicable on the national scale. It also allows alternative scenarios to be investigated rapidly, for example, ERG have examined proposed Low Emission Zone scenarios for London. However, using ADMS directly allows the calculation of hourly averages and hence percentiles; it also avoids the necessity of treating road emissions differently from other sources.

For the contribution to concentrations from adjacent roads NETCEN employs a simple formula derived from roadside and kerbside monitoring data, linking emissions from each road segment to a single concentration representative of the near road concentration. ERG uses ADMS 3 and includes the impact of road width on concentration whilst ADMS-Urban, in addition to the ADMS 3 algorithms includes traffic produced turbulence and an idealised street canyon model based on the Operational Street Pollution Model (OSPM), using building height and road widths as its input. Both the ERG and ADMS-Urban approaches calculate the concentration field at high resolution and this allows for variations in concentration over small spatial scales – an aspect which the representative NETCEN value ignores. This approach by ADMS-Urban and ERG also allows generation of high resolution concentration maps taking account of all sources.

Second, chemistry and in particular conversion of NO_x to NO_2 are considered. Both NETCEN and ERG employ empirical relationships linking annual average NO_2 to annual average NO_x; these are derived from continuous monitoring sites. NETCEN employs three relationships (background, Central London background and roadside) whilst ERG employs greater complexity with relationships depending on the calculated relative preponderance of local and more distant sources of NO_x. ADMS-Urban uses the Generic Reaction Set (GRS) which represents all the reactions for the generation of NO_2 by VOCs through one surrogate reaction. GRS results in annual average NO_2 concentrations only a few percent larger than those obtained by the coupled reactions describing generation of NO_2 by reaction of NO with O_3 and photo-dissociation of NO_2. Thus the VOC concentrations in GRS have a relatively small influence on NO_2 concentrations. Again the advantage of the empirical approach is relative speed of calculation and also the close linkage of the model with observed data. The disadvantage is that there is uncertainty as to the validity of the relationships for forward projection of NO_2 concentrations and difficulty with ensuring continuity in the spatial distribution of NO_2. GRS deals with the reactions on a more basic level and so its validity is less likely to be sensitive to the specific year being modelled.

3. The Emissions Inventories

All of the organisations have used the Greater London Authority LAEI, the final version of which was released in February 2002. London is unique in terms of its size and emissions characteristics, which is reflected by the LAEI. In particular, central London has a relatively high number of buses and taxis and low vehicle speeds. There is also a considerable amount of information concerning sources in London on which to build an inventory. Because of this, the inventory is predominately based on recorded data rather than traffic model prediction of flows, vehicle speeds and vehicle stock. Most of the current and future vehicle stock information is based on national data collected and calculated as part of the National Atmospheric Emissions Inventory (NAEI).

CERC have used both the December 2001 and the February 2002 London Atmospheric Emissions Inventory (LAEI) for the comparison work.

NETCEN used the NAEI to calibrate their mapping approach (1998 version adjusted to incorporate changes in traffic associated with the emission factors issued in Autumn 2001). They used both the NAEI and the December 2001 LAEI to predict concentrations in London. As the NAEI was used for calibration, a better fit to the measured values would be expected when using this emissions inventory. The LAEI has lower emissions than the NAEI thus lower concentrations would be expected when using this emissions inventory.

ERG used the emissions from the February 2002 LAEI mapped on to a road network that has differences from the LAEI road network. The road network in the emission inventory used to produce the maps is more geographically detailed than the road network in the LAEI. This is observed in concentration footprints due to roads in the predicted concentration maps.

4. Comparison of ADMS-Urban, NETCEN and ERG Results

4.1 Introduction

Four different types of comparisons between the different methodologies are presented to illustrate similarities and differences in model performance. Such comparisons are inherently difficult to perform since NETCEN calculates single values for road links whereas ADMS and ERG calculate concentration distribution, which may vary spatially across and along roads.

ADMS-Urban and ERG methodologies calculate concentration precisely at each receptor point and this is used as a basis for the first comparison. Each NETCEN roadside receptor point value is a single value from the nearest road link. The NETCEN background receptor point values are taken from the 1km × 1km urban background grid in which the receptor is located. Urban background values can be obtained at roadside receptor sites too; the difference between the background and the roadside values shows the magnitude of the roadside component at each receptor location.

NETCEN single road link values are again used in the road link comparisons (second and third comparisons), whereas for ADMS-Urban and ERG, spatial averages are taken along the road segment. A segment 10m wide is used for this average, but in fact the average is relatively insensitive to widths less than or approximately equal to the actual road width.

Details of the comparisons should be viewed as indicative rather than definitive. Nonetheless the comparisons provide insight into the different approaches.

The first comparisons are made at specific receptor points; these include roadside and background AURN sites (Figure 4.1) and ten additional points across London (subsequently referred to as extra sites). The extra sites are shown in Figure 4.2 and listed in Table 4.1; many of these are intermediate between roadside and background.

The second and third types of comparisons focus on predictions along roads. First, calculations of the percentage of area of road length (ADMS-Urban and ERG) and percentage of road links (NETCEN) showing exceedence of a range of pollution concentration thresholds are compared. Second, scatter plots of concentration on all road links are used to directly compare predictions of concentration at roadside locations; again ADMS-Urban and ERG values represent spatial averages and NETCEN single representative values for each road. NETCEN results produced using both NAEI and LAEI inventories were provided for the receptor point comparisons, however, only road link values produced using the LAEI were supplied for comparison of concentrations at roadside.

Finally, comparisons are made of the projected reduction in concentration between 1999 and 2004/5 (Section 4.5).

Figure 4.1 Location of Automatic Monitoring Network (AURN) Sites in Greater London

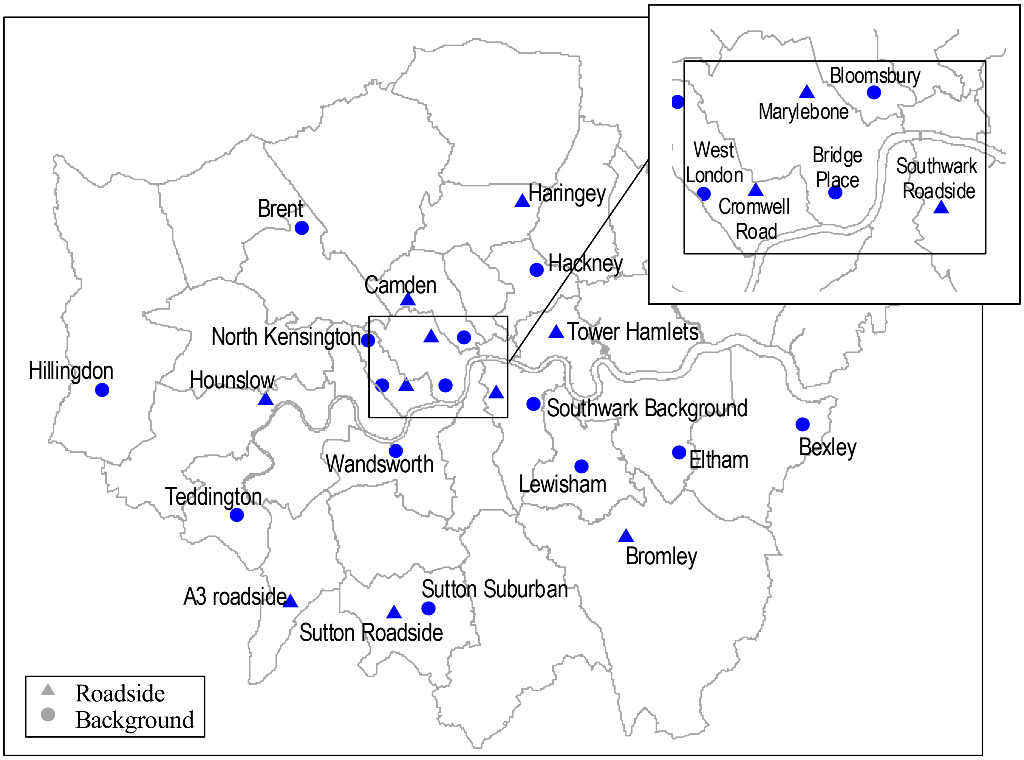


Figure 4.2 Location of Extra Comparison Sites in Greater London

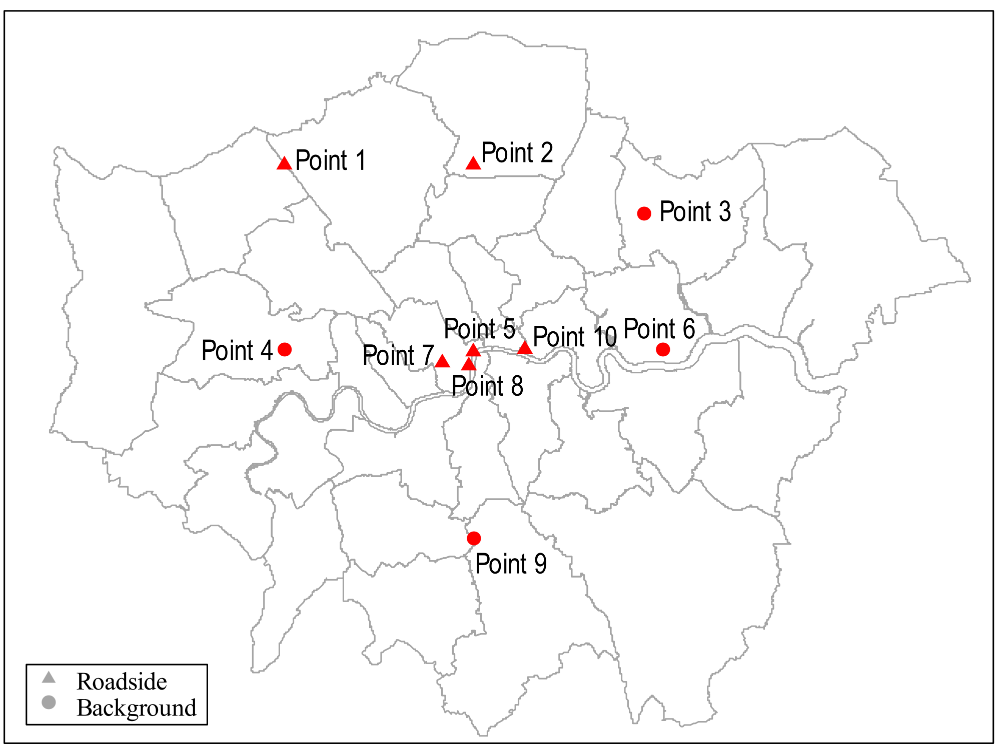


Table 4.1 Details of the Additional Receptor Points – Extra Sites

Name	Location (OS co-ordinates)	Distance from centre of nearest road to receptor (m)	Site description	Borough
Point 1	518500,192500	30	Adjacent to A5 to the north of Edgeware	Harrow
Point 2	530500,192500	30	Adjacent to road with light traffic on perimeter of Broomfield Park	Enfield
Point 3	541310,189310	100	100m from M11 on school playing field at Redbridge	Redbridge
Point 4	518500,180500	108	The middle of Ealing Common	Ealing
Point 5	530500,180500	45	Charing Cross Station	Westminster
Point 6	542500,180500	360	London City Airport	Newham
Point 7	528470,179850	30	Hyde Park Corner	Westminster
Point 8	530140,179660	37	Parliament Square	Westminster
Point 9	530500,168500	260	Residential Area	Croydon
Point 10	533720,180710	17	The Tower of London	Tower Hamlets

4.2 Receptor Points Comparison

Tables 4.2 to 4.7 present results for the annual average predicted concentrations of NO_x, NO_2 and PM_{10} for 1999 and 2004/5. The 'Measured Value' column shows the annual average monitored concentrations, the 'ADMS-Urban' column the ADMS-Urban predicted concentration at the monitoring site. The subsequent columns show the NETCEN predictions, with 'NETCEN NAEI Background' and 'NETCEN LAEI Background' showing background annual average predictions using the NAEI and LAEI, respectively, and 'NETCEN NAEI Roadside' and 'NETCEN LAEI Roadside' the roadside concentration predictions representative of the nearest major road to the monitoring site using NAEI and LAEI, respectively. The 'NETCEN Site Specific' column shows NETCEN predictions at the monitoring sites. These were not available for PM_{10}. As indicated in Section 2, NETCEN's site specific values are constrained to match monitored data for 1999 or 'current' concentrations. The final column shows the ERG predicted annual average concentrations at the receptor points.

There are rows containing relevant mean values for roadside, background, all AURN sites and extra sites. For each set of data the mean of the equivalent AURN sites has also been calculated. For example, if only three out of four PM_{10} values were available for a particular model the measured values at the same three AURN sites have been averaged to allow a relevant comparison.

The NETCEN methodology was calibrated against measured concentrations using the NAEI (Section 2.2 and 3) so mapping carried out with the NAEI should provide a better fit to measured concentrations than mapping using the LAEI. As described in the methodology section, the NETCEN results are split into background and roadside concentrations for both NAEI and LAEI. At roadside locations the appropriate comparison is between the NETCEN roadside concentration and the AURN measurement. At background sites the appropriate comparison is between the NETCEN background concentrations and the AURN values. However, for AURN sites near roads, the NETCEN background concentration might be expected to be an underestimate and the NETCEN roadside concentration an overestimate.

ADMS-Urban 'background' calculations

ADMS-Urban was used to model additional values to represent ADMS-Urban 'background' concentrations for Cromwell Road, Marylebone Road and Bloomsbury. These are calculated for comparison with the NETCEN background concentrations at roadside AURN locations. They include the rural component and urban background component by omitting emissions from the closest road to the site. For example at the Cromwell Road site, the emissions from Cromwell Road were completely omitted from the calculation. These values are given in brackets in the 'ADMS-Urban' column.

Omissions

According to NETCEN's definition, A3 and Sutton Roadside AURN locations are not considered to be roadside sites. The NAEI roadside concentrations for the remaining seven roadside sites are provided in the table. Of the roadside sites ERG have designated Hounslow (elevated road), Southwark Roadside (poor monitoring site data capture) and Sutton Roadside (poorly characterised road traffic data) AURN locations as being unsuitable for its modelling. However, ERG has also made predictions and 11 additional London Air Quality Network sites not reported here.

Concentrations at the Bromley AURN site are not thought to be representative of the true air quality at that location due to poor siting of the monitor. It may be misleading to compare predicted results against these data therefore receptor point results for this location are omitted for the comparison.

Results of Comparison at Receptor Points

Concentrations predicted by ADMS-Urban, NETCEN (both NAEI and LAEI inventories) and ERG are compared with measured concentrations for 1999. These results are also presented as scatter plots in Figure 4.3. For the extra sites future years ADMS-Urban future projections are compared with those of NETCEN and ERG.

NO_x 1999 Predictions at the AURN sites show similar patterns for each of the methodologies and generally good agreement. The NETCEN LAEI calculations exhibit significant underestimation (as anticipated because the NETCEN model is calibrated with the NAEI). At the extra sites the NETCEN NAEI background concentrations are similar to ADMS-Urban predictions suggesting that the influence in ADMS-Urban of the local roads is quite limited. ERG gives much higher concentrations than ADMS-Urban for the majority of the extra sites.

NO_x 2005 Predicted concentrations are lower in 2005. ERG exhibits the greatest reduction. This is almost proportional to the projected traffic NO_x emissions reduction. ADMS and NETCEN show smaller reductions reflecting traffic emissions reduction and the influence of background concentrations and other emissions which are not projected to reduce at the same rate as traffic.

NO_2 1999 Predicted concentrations generally agree well with measured concentrations. NETCEN (NAEI roadside and background) and ERG (roadside) may show a slight tendency to lower concentrations (~10%) than the monitoring data. Care must be taken when drawing conclusions from the comparison as the number of roadside sites compared is small. NETCEN (LAEI) produces significantly lower concentrations. At the extra sites concentrations are similar which is in marked contrast to the NO_x concentrations.

NO_2 2005 NETCEN (NAEI) and ERG predict lower concentrations (>10% difference) than ADMS-Urban with the percentage difference being greater than for 1999. At the extra sites ADMS-Urban and NETCEN are broadly similar.

PM_{10} 1999 Overall ADMS-Urban, NETCEN (NAEI) and ERG predict broadly similar concentrations which are in close agreement with monitored data.

PM_{10} 2004 The NETCEN results predicted using the LAEI are all significantly lower than the ADMS-Urban results. Neither NAEI nor ERG calculations were available for 2004.

Results of ADMS-Urban 'background' calculations

For all pollutants these ADMS-Urban calculated concentrations are lower than the NAEI background. The differences are considerable for NO_x (eg, 90 $\mu g/m^3$ as opposed to 102 $\mu g/m^3$ at Cromwell Road), less than or equal to 10 $\mu g/m^3$ for NO_2 and less than or equal to 2 $\mu g/m^3$ for PM_{10}. This suggests that the NETCEN approach may be overestimating the background component at roadside locations, a possible explanation being double accounting. These results may illustrate the difficulties of splitting the concentration into a background and roadside component in the NETCEN methodology.

Table 4.2 Annual Average NO_x Concentrations for 1999 ($\mu g/m^3$)

		Measured Value	ADMS-Urban*	NETCEN NAEI Background	NETCEN NAEI Roadside	NETCEN LAEI Background	NETCEN LAEI Roadside	NETCEN Site Specific	ERG
Roadside Monitoring Sites	A3	256	227	75	-	58	-	-	306
	Camden	210	204	92	265	78	209	208	212
	Cromwell Road	256	260 (90)	102	270	81	148	256	288
	Haringey	136	115	87	152	68	111	130	96
	Hounslow	191	132	84	211	70	82	-	-
	Marylebone Road	390	386 (109)	115	360	89	359	390	359
	Southwark Roadside	227	183	108	248	83	174	-	-
	Sutton Roadside	117	76	69	-	54	-	118	-
	Tower Hamlets	241	193	99	201	77	180	239	170
	All roadside sites mean	**225**	**197**	**-**	**-**	**-**	**-**	**-**	**-**
	NAEI/LAEI roadside sites mean	**236**	**210**	**-**	**244**	**-**	**180**	**-**	**-**
	ERG roadside sites mean	**248**	**231**	**-**	**-**	**-**	**-**	**-**	**239**
Background Monitoring Sites	Bexley	69	78	62	-	50	-	-	69
	Bloomsbury	136	120 (107)	126	-	92	-	136	141
	Brent	67	76	78	-	66	-	-	61
	Bridge Place	105	111	109	-	86	-	-	115
	Eltham	65	86	74	-	58	-	-	70
	Hackney	134	113	92	-	72	-	-	113
	Hillingdon	166	206	86	-	70	-	-	212
	Lewisham	139	117	80	-	63	-	-	-
	North Kensington	82	99	98	-	80	-	-	90
	Southwark Urban Centre	118	99	94	-	73	-	-	124
	Sutton Suburban	65	67	69	-	42	-	-	-
	Teddington	52	59	73	-	58	-	-	59
	Wandsworth	141	128	86	-	44	-	-	-
	West London	99	92	96	-	77	-	99	120
	All background sites mean	**103**	**104**	**87**	**-**	**67**	**-**	**-**	
	ERG background sites mean	**99**	**104**	**90**	**-**	**71**		**-**	**107**
Roadside and Background Monitoring Sites	**All AURN sites mean**	**151**	**140**	**89**	**-**	**69**	**-**	**-**	**-**
	Combined NAEI/LAEI background and roadside sites mean	**147**	**139**	**140**		**104**		**-**	**-**
	All ERG AURN sites mean	**152**	**149**	**-**	**-**	**-**	**-**	**-**	**153**
Non AURN Receptor Points	Point 1 (30m to road)	-	59	79	-	65	107	-	74
	Point 2 (30m to road)	-	65	80	-	64	67	-	65
	Point 3 (100m to road)	-	84	83	-	67	379	-	84
	Point 4 (108 m to road)	-	69	88	-	74	151	-	84
	Point 5 (45 m to road)	-	111	129	-	94	274	-	141
	Point 6 (360 m to road)	-	74	83	-	67	189	-	69
	Point 7 (30 m to road)	-	159	119	-	90	334	-	313
	Point 8 (37 m to road)	-	149	124	-	91	301	-	265
	Point 9 (260 m to road)	-	57	77	-	60	67	-	63
	Point 10 (17 m to road)	-	130	114	-	84	284	-	206
	Extra Sites Mean	**-**	**96**	**98**	**-**	**76**	**215**	**-**	**136**

* ADMS-Urban 'background' concentrations are given in brackets

Table 4.3 Annual Average NO_2 Concentrations for 1999 ($\mu g/m^3$)

		Measured Value	ADMS-Urban*	NETCEN NAEI Background	NETCEN NAEI Roadside	NETCEN LAEI Background	NETCEN LAEI Roadside	NETCEN Site Specific	ERG
Roadside Monitoring Sites	A3	58	67	41	-	35	-	-	61
	Camden	66	71	46	69	42	44	66	63
	Cromwell Road	93	76 (48)	54	70	46	49	92	73
	Haringey	51	55	45	49	39	41	48	50
	Hounslow	60	53	44	60	39	39	-	-
	Marylebone Road	91	88 (54)	59	83	49	83	92	80
	Southwark Roadside	75	67	51	66	44	55	-	-
	Sutton Roadside	44	42	39	-	34	-	44	-
	Tower Hamlets	70	71	48	58	42	55	67	61
	All roadsie sites mean	**68**	**66**	**-**	**-**	**-**	**-**	**-**	**-**
	NAEI/LAEI roadside sites mean	**72**	**69**	**-**	**65**	**-**	**52**	**-**	**-**
	ERG roadside sites mean	**72**	**71**	**-**	**-**	**-**	**-**	**-**	**65**
Background Monitoring Sites	Bexley	37	40	37	-	32	-	-	40
	Bloomsbury	67	57 (53)	63	-	50	-	67	65
	Brent	37	44	42	-	38	-	-	36
	Bridge Place	63	53	57	-	48	-	-	57
	Eltham	36	44	41	-	35	-	-	40
	Hackney	60	55	46	-	40	-	-	53
	Hillingdon	50	63	45	-	39	-	-	55
	Lewisham	54	55	43	-	37	-	-	-
	North Kensington	46	52	48	-	43	-	-	48
	Southwark Urban Centre	56	50	47	-	40	-	-	61
	Sutton Suburban	35	38	39	-	34	-	-	-
	Teddington	32	34	40	-	35	-	-	36
	Wandsworth	52	59	45	-	39	-	-	-
	West London	55	50	47	-	42	-	55	57
	All background sites mean	**49**	**50**	**46**	**-**	**39**	**-**	**-**	**-**
	ERG background sites mean	**49**	**49**	**47**	**-**	**40**	**-**	**-**	**50**
Roadside and Background Monitoring Sites	**All AURN sites mean**	**56**	**56**	**46**	**-**	**40**	**-**	**-**	**-**
	Combined NAEI/LAEI background and roadside sites mean	**56**	**56**	**52**		**44**		**-**	**-**
	All ERG AURN sites mean	**57**	**57**	**-**	**-**	**-**	**-**	**-**	**55**
Non AURN Receptor Points	Point 1 (30m to road)	-	40	42	-	38	40	-	40
	Point 2 (30m to road)	-	44	43	-	37	37	-	38
	Point 3 (100m to road)	-	50	44	-	38	86	-	46
	Point 4 (108 m to road)	-	44	45	-	41	49	-	44
	Point 5 (45 m to road)	-	59	62	-	51	71	-	65
	Point 6 (360 m to road)	-	46	43	-	38	57	-	40
	Point 7 (30 m to road)	-	67	62	-	50	79	-	78
	Point 8 (37 m to road)	-	65	60	-	50	75	-	74
	Point 9 (260 m to road)	-	38	42	-	36	36	-	38
	Point 10 (17 m to road)	-	59	58	-	47	72	-	67
	Extra Sites Mean	**-**	**51**	**50**	**-**	**43**	**60**	**-**	**53**

* ADMS-Urban 'background' concentrations are given in brackets

Table 4.4 Annual Average PM_{10} Concentrations (gravimetric equivalent) for 1999 ($\mu g/m^3$)

		Measured Value	ADMS-Urban*	NETCEN NAEI Background	NETCEN NAEI Roadside	NETCEN LAEI Background	NETCEN LAEI Roadside	ERG
Roadside Monitoring Sites	A3	30	31	25	-	22	-	35
	Camden	34	33	27	34	23	30	34
	Haringey	28	29	26	29	23	26	28
	Marylebone Road	44	49 (28)	29	39	25	44	43
	All roadside sites mean	**34**	**36**	**-**	**-**	**-**	**-**	**35**
	NAEI/LAEI roadside sites mean	**35**	**37**	**-**	**34**	**-**	**33**	**35**
Background Monitoring Sites	Bexley	25	26	25	-	22	-	25
	Bloomsbury	28	29 (28)	30	-	26	-	29
	Brent	23	26	25	-	23	-	24
	Eltham	23	27	25	-	23	-	25
	Hillingdon	27	29	25	-	23	-	-
	North Kensington	27	27	27	-	23	-	26
	West London	26	26	29	-	23	-	-
	All background sites mean	**26**	**27**	**27**	**-**	**23**	**-**	**-**
	ERG background sites mean	**25**	**27**	**26**	**-**	**23**	**-**	**26**
Roadside and Background Monitoring Sites	**All AURN sites mean**	**29**	**30**	**27**	**-**	**23**	**-**	**-**
	Combined NAEI/LAEI roadside and background sites mean	**29**	**30**	**29**		**26**		**-**
	All ERG AURN sites mean	**29**	**31**	**-**	**-**	**-**	**-**	**30**
Non AURN Receptor Points	Point 1 (30m to road)	-	21	25	-	23	25	-
	Point 2 (30m to road)	-	21	26	-	23	23	-
	Point 3 (100m to road)	-	22	26	-	23	38	-
	Point 4 (108 m to road)	-	21	26	-	23	27	-
	Point 5 (45 m to road)	-	24	30	-	26	38	-
	Point 6 (360 m to road)	-	21	27	-	23	29	-
	Point 7 (30 m to road)	-	29	30	-	26	39	-
	Point 8 (37 m to road)	-	28	30	-	26	39	-
	Point 9 (260 m to road)	-	20	26	-	23	23	-
	Point 10 (17 m to road)	-	26	30	-	25	38	-
	Extra Sites Mean	**-**	**23**	**28**	**-**	**24**	**32**	**-**

* ADMS-Urban ‘background’ concentrations are given in brackets

Figure 4.3 Comparison of Measured 1999 Annual Average Pollutant Concentrations (μg/m^3) with values predicted at AURN Sites by ADMS-Urban, NETCEN and ERG for (a) NO_x, (b) NO_2 and (c) PM_{10}

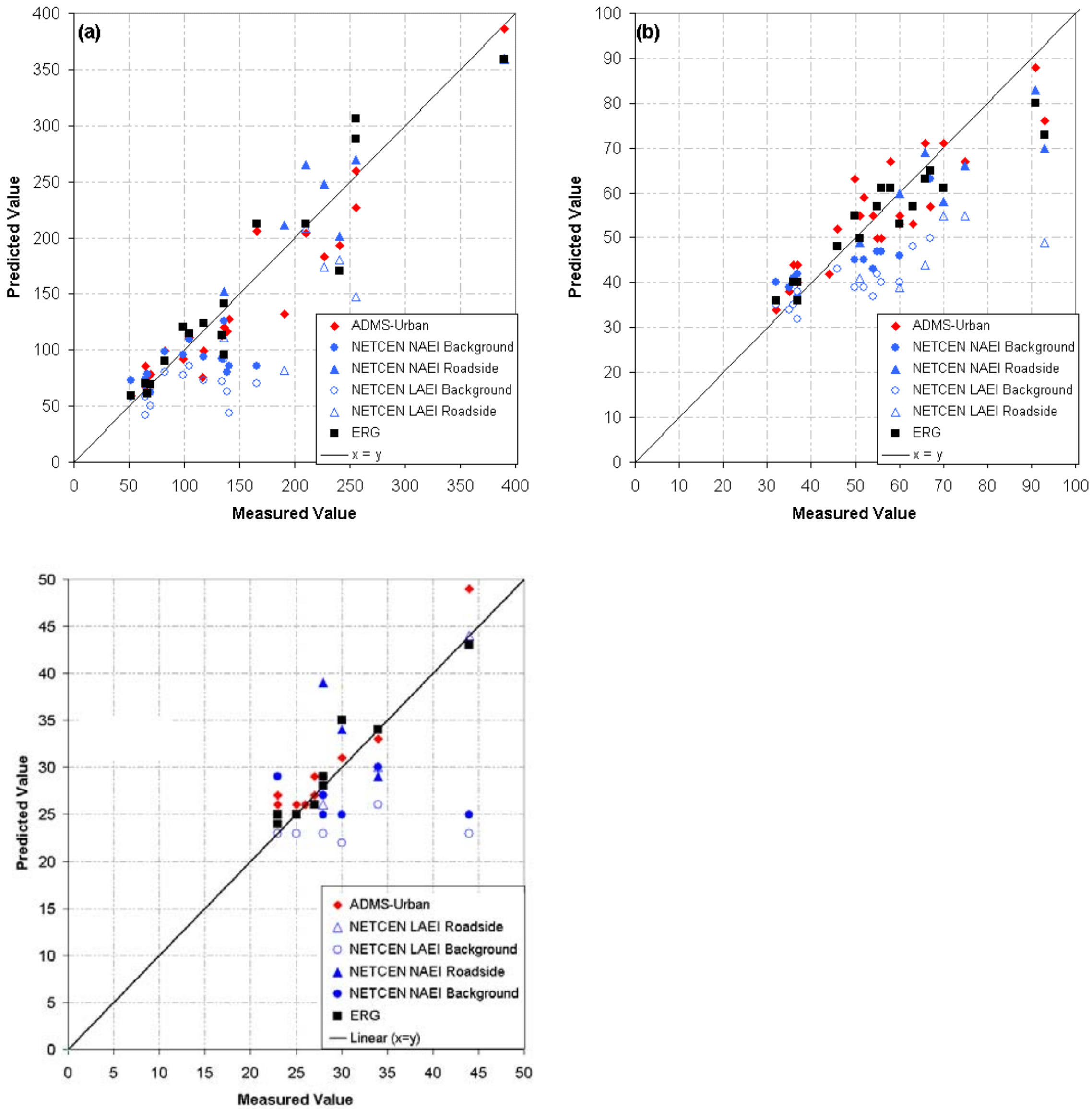


Table 4.5 Annual Average NO_x Concentrations for 2005 with 1999 meteorological data ($\mu g/m^3$)

		ADMS-Urban*	NETCEN NAEI Background	NETCEN NAEI Roadside	NETCEN LAEI Background	NETCEN LAEI Roadside	NETCEN Site Specific	ERG
Roadside Monitoring Sites	A3	138	56	-	44	-	-	172
	Camden	143	71	191	61	145	150	139
	Cromwell Road	193	79	196	64	105	188	189
	Haringey	84	66	106	54	82	92	65
	Hounslow	88	63	142	53	60	-	-
	Marylebone Road	290	90	262	70	258	284	250
	Southwark Roadside	132	84	179	65	128	-	-
	Sutton Roadside	57	52	-	41	-	80	-
	Tower Hamlets	138	76	148	60	127	173	71
	All roadside sites mean	**140**	**-**	**-**	**-**	**-**	**-**	**-**
	NAEI/LAEI roadside sites mean	**153**	**-**	**175**	**-**	**129**	**-**	**-**
	ERG roadside sites mean	**164**	**-**	**-**	**-**	**-**	**-**	**148**
Background Monitoring Sites	Bexley	61	47	-	39	-	-	48
	Bloomsbury	96	100	-	73	-	108	99
	Brent	57	58		51	-	-	42
	Bridge Place	90	87	-	67	-	-	80
	Eltham	67	56	-	45	-	-	47
	Hackney	84	71	-	57	-	-	76
	Hillingdon	132	63	-	53	-	-	124
	Lewisham	86	62	-	49	-	-	-
	North Kensington	76	76	-	63	-	-	61
	Southwark urban centre	80	73	-	57	-	-	86
	Sutton suburban	52	52	-	42	-	-	-
	Teddington	48	55	-	44	-	-	40
	Wandsworth	94	66	-	54	-	-	-
	West London	71	74	-	60	-	77	80
	All background sites mean	**78**	**67**	**-**	**54**	**-**	**-**	**-**
	ERG background sites mean	**78**	**69**	**-**	**55**	**-**	**-**	**71**
Roadside and Background Monitoring Sites	**All AURN sites mean**	**102**	**69**	**-**	**55**	**-**	**-**	**-**
	Combined NAEI/LAEI roadside and background sites mean	**103**	**-**	**103**		**79**		**-**
	All ERG AURN sites mean	**109**	**-**	**-**	**-**	**-**	**-**	**98**
Non AURN Receptor Points	Point 1 (30m to road)	46	58	-	49	73	-	-
	Point 2 (30m to road)	52	61	-	50	52	-	-
	Point 3 (100m to road)	65	62	-	52	264	-	-
	Point 4 (108 m to road)	55	66	-	57	107	-	-
	Point 5 (45 m to road)	88	98	-	74	195	-	-
	Point 6 (360 m to road)	60	63	-	52	128	-	-
	Point 7 (30 m to road)	121	98	-	71	245	-	-
	Point 8 (37 m to road)	116	93	-	72	226	-	-
	Point 9 (260 m to road)	46	59	-	47	51	-	-
	Point 10 (17 m to road)	102	89	-	67	209	-	-
	Extra Sites Mean	**75**	**75**	**-**	**59**	**155**	**-**	**-**

Table 4.6 Annual Average NO_2 Concentrations for 2005 with 1999 meteorological data ($\mu g/m^3$)

		ADMS-Urban*	NETCEN NAEI Background	NETCEN NAEI Roadside	NETCEN LAEI Background	NETCEN LAEI Roadside	NETCEN Site Specific	ERG
Roadside Monitoring Sites	A3	55	34	-	30	-	-	52
	Camden	61	40	57	29	48	49	53
	Cromwell Road	69	45	58	39	41	56	61
	Haringey	48	38	40	34	34	37	38
	Hounslow	44	37	48	33	33	-	-
	Marylebone Road	78	50	69	42	38	72	71
	Southwark Roadside	59	44	55	38	45	-	-
	Sutton Roadside	34	33	-	29	-	34	-
	Tower Hamlets	61	41	49	36	45	54	50
	All roadside sites mean	**57**	**-**	**-**	**-**	**-**	**-**	**-**
	NAEI/LAEI roadside sites mean	**60**	**-**	**54**	**-**	**41**	**-**	**-**
	ERG roadside sites mean	**62**	**-**	**-**	**-**	**-**	**-**	**54**
Background Monitoring Sites	Bexley	34	31	-	28	-	-	31
	Bloomsbury	52	53	-	43	-	56	53
	Brent	38	35	-	32	-	-	27
	Bridge Place	48	48	-	41	-	-	46
	Eltham	36	35	-	30	-	-	31
	Hackney	48	40	-	35	-	-	44
	Hillingdon	55	37	-	33	-	-	46
	Lewisham	46	36	-	32	-	-	-
	North Kensington	44	41	-	37	-	-	38
	Southwark urban centre	44	40	-	35	-	-	49
	Sutton suburban	32	33	-	29	-	-	-
	Teddington	29	34	-	30	-	-	27
	Wandsworth	50	38	-	34	-	-	-
	West London	42	41	-	36	-	42	46
	All background sites mean	**43**	**39**	**-**	**34**	**-**	**-**	**-**
	ERG background sites mean	**43**	**40**	**-**	**35**	**-**	**-**	**40**
Roadside and Background Monitoring Sites	**All AURN sites mean**	**48**	**39**	**-**	**34**	**-**	**-**	**-**
	Combined NAEI/LAEI roadside and background sites mean	**48**	**-**	**44**		**36**		**-**
	All ERG AURN sites mean	**50**	**-**	**-**	**-**	**-**	**-**	**45**
Non AURN Receptor Points	Point 1 (30m to road)	34	35	-	32	32	-	-
	Point 2 (30m to road)	37	36	-	32	32	-	-
	Point 3 (100m to road)	42	37	-	33	69	-	-
	Point 4 (108 m to road)	39	38	-	35	40	-	-
	Point 5 (45 m to road)	53	53	-	43	57	-	-
	Point 6 (360 m to road)	40	37	-	33	45	-	-
	Point 7 (30 m to road)	59	53	-	42	66	-	-
	Point 8 (37 m to road)	58	51	-	42	63	-	-
	Point 9 (260 m to road)	32	35	-	31	31	-	-
	Point 10 (17 m to road)	53	49	-	40	60	-	-
	Extra Sites Mean	**45**	**42**	**-**	**36**	**50**	**-**	**-**

Table 4.7 Annual Average PM_{10} Concentrations (gravimetric equivalent) for 2004 with 1999 meteorological data ($\mu g/m^3$)

		ADMS-Urban	NETCEN LAEI Background	NETCEN LAEI Roadside
Roadside Monitoring Sites	A3	27	21	-
	Camden	28	21	25
	Haringey	25	21	22
	Marylebone Road	37	22	33
	All roadside sites mean	**29**	**-**	**-**
	NAEI/LAEI roadside sites mean	**30**	**-**	**27**
Background Monitoring Sites	Bexley	24	21	-
	Bloomsbury	25	22	-
	Brent	24	21	-
	Eltham	24	21	-
	Hillingdon	26	22	-
	North Kensington	24	21	-
	West London	24	21	-
	All background sites mean	**24**	**21**	**-**
Roadside and Background Monitoring Sites	**All AURN sites mean**	**26**	**21**	**-**
	Combined LAEI and sites mean	**26**	**23**	
Non AURN Receptor Points	Point 1 (30m to road)	23	21	21
	Point 2 (30m to road)	23	21	21
	Point 3 (100m to road)	24	21	30
	Point 4 (108 m to road)	24	21	23
	Point 5 (45 m to road)	25	22	29
	Point 6 (360 m to road)	24	22	25
	Point 7 (30 m to road)	28	22	30
	Point 8 (37 m to road)	27	22	29
	Point 9 (260 m to road)	23	21	21
	Point 10 (17 m to road)	27	22	29
	Extra Sites Mean	**25**	**22**	**26**

4.3 Length of Road Exceeding Concentration Thresholds

Annual average concentration maps produced by ADMS-Urban, NETCEN (mapping approach using the LAEI) and ERG were analysed to determine the length of roads predicted to exceed certain threshold values. The comparison includes no monitoring data because it is not available to the required spatial detail. The predicted concentrations are compared directly with each other.

In the case of ADMS-Urban and ERG, which predict spatial variations in concentration along road segments, average concentrations were calculated along each road segment, as discussed in Section 4.1. In the case of NETCEN only a single value for each road segment is calculated at the count site. The results are presented in Table 4.8 in terms of percentage of total road length exceeding a range of threshold values, which in the case of NO_2 and PM_{10} include the 2004, 2005 and 2010 annual average air quality objectives. The total road length is 3,656 km.

For NO_x all models predict that all roads in Greater London will exceed a nominal 30 $\mu g/m^3$ for 1999 and 2005 and more than 90% of road length will also exceed 60 $\mu g/m^3$ in 1999. By 2005 there is less predicted exceedence of these thresholds. ADMS-Urban predicts most (87%) and NETCEN (LAEI) less due to its calibration with the NAEI. However, ERG predicts the lowest area of all (61%). This is surprising because they predict the same area as ADMS-Urban in 1999 and both approaches use the same NO_x emissions for 1999 and 2005, so a similar reduction in predicted road length exceedence would be expected.

For annual average NO_2 all models predict that all roads in Greater London will exceed a 20 $\mu g/m^3$ threshold (half the 2005 air quality standard) in 1999 and 2005. For 1999 they all predict that over 50% of the total road length will also exceed the 2005 air quality standard (40 $\mu g/m^3$). By 2005 there is less predicted exceedence, with NETCEN (LAEI) (19%) and ERG (36%) predicting less than ADMS-Urban (62%).

Annual average PM_{10} concentrations are below the 2004 air quality standard (40 $\mu g/m^3$) threshold for all models by 2004 and only ERG predicts any exceedence (1%) in 1999. However, both ADMS-Urban and ERG predict that all roads will exceed the UK 2010 standard (20 $\mu g/m^3$) in 1999 and 2004. They also predict that the majority of roads will exceed the London 2010 standard (23 $\mu g/m^3$) in 1999, reducing by 2004. NETCEN (LAEI), however, predicts much less exceedence length for all years and thresholds, with only a third of road length predicted to exceed the UK 2010 standard (20 $\mu g/m^3$) in 1999 and much less in 2004. Note again that NETCEN (LAEI) predicts lower concentrations than NETCEN (NAEI).

Table 4.8 Percentage road length exceeding specified annual mean values

	ADMS-Urban		NETCEN LAEI		ERG	
	1999	2004/2005	1999	2004/2005	1999	2004/2005
NO_x >30 $\mu g/m^3$	100	100	100	100	100	100
NO_x >40 $\mu g/m^3$	100	100	100	97	100	98
NO_x >50 $\mu g/m^3$	100	97	98	85	100	82
NO_x >60 $\mu g/m^3$	98	87	91	71	98	61
NO_2 >20 $\mu g/m^3$	100	100	100	100	100	100
NO_2 >30 $\mu g/m^3$	100	98	98	80	100	87
NO_2 >40 $\mu g/m^3$	**89**	**62**	**53**	**19**	**84**	**36**
NO_2 >50 $\mu g/m^3$	42	17	16	6	42	10
PM_{10}>20 $\mu g/m^3$	**100**	**100**	**31**	**5**	**100**	**100**
PM_{10}>23 $\mu g/m^3$	**100**	**98**	**8**	**1**	**100**	**21**
PM_{10}>25 $\mu g/m^3$	99	21	5	1	74	7
PM_{10}>30 $\mu g/m^3$	10	1	1	0	12	1
PM_{10}>40 $\mu g/m^3$	**0**	**0**	**0**	**0**	**1**	**0**
PM_{10}>50 $\mu g/m^3$	0	0	0	0	1	0

4.4 Comparison of Road Links

The annual average predicted values on each of the 18,201 road links have been compared by presenting the data in scatter diagrams. Again, the comparison includes no monitoring data because it is not available to the required spatial detail so the predicted concentrations are compared with each other.

Table 4.9 Receptor Point Values and Mean road link concentrations next to AURN sites Predicted by ADMS-Urban (μg/m^3)

		1999		2004/5	
		AURN site	Mean	AURN site	Mean
NO_x	Cromwell Road	260	145	193	108
	Hounslow	132	131	88	89
	Camden	204	144	143	108
	Marylebone Road	386	276	290	204
	Tower Hamlets	193	170	138	122
	Southwark Roadside	183	155	132	116
	Haringey	115	109	84	78
NO_2	Cromwell Road	76	59	69	53
	Hounslow	53	51	44	44
	Camden	71	57	61	51
	Marylebone Road	88	72	78	64
	Tower Hamlets	71	63	61	55
	Southwark Roadside	67	60	59	53
	Haringey	55	53	48	45
PM_{10}	Camden	33	30	28	26
	Marylebone Road	49	40	37	32
	Haringey	29	28	25	25

As described in Section 4.2, for the NETCEN methodology using the LAEI there is a single value predicted for each link. For ADMS-Urban and the ERG approach the values predicted along each road link have been averaged to produce a single mean value. The impact of the averaging on ADMS-Urban may be seen in Table 4.9 which compares the AURN site prediction with the in road average for the road segment adjacent to the AURN site. The ADMS-Urban average is generally lower than the calculated AURN site concentration. The scatter plots compare the 1999 and 2004/5 ADMS-Urban mean values to NETCEN values and ERG mean values for NO_x (Figure 4.4), NO_2 (Figure 4.5) and PM_{10} (Figure 4.6). The diagonal line indicates identical prediction by each method being compared.

Figure 4.4 presents the scatter plots for NO_x in 1999 and 2005, which are well distributed about the diagonal line, however the largest concentrations predicted by both NETCEN (LAEI) and ERG are significantly in excess of those predicted by ADMS-Urban. For NETCEN these values are associated with the M25 and M4 and for ERG they are associated with the M25 and A10.

The annual average NO_2 plots for the NETCEN (LAEI) methodology, Figures 4.5(a,b), show a similar pattern for both 1999 and 2005, however, the pattern is different from the NO_x plots. In this case LAEI roadside values for the links tend to be lower than the equivalent ADMS-Urban predictions, i.e. the points tend to lie below the diagonal line. As seen in the NO_x plot, there is a cluster of high LAEI roadside predictions associated with the M4 and M25.

In the ERG NO_2 scatter plots, Figures 4.5(c,d), however, the points cluster around the diagonal line. It is notable that the 1999 points mainly lie below the line and 2005 points above, that is, for road links ERG predicts higher concentrations than ADMS-Urban in 1999 and lower in 2005. Again there is a cluster of higher ERG concentrations above 95 μg/m^3 in 1999 and 70 μg/m^3 in 2005, associated with several roads including the M25.

The NETCEN (LAEI) scatter plots for PM_{10}, Figures 4.6(a,b), appear to be offset from the diagonal line by approximately 4 μg/m^3. For both 1999 and 2005 below 50 μg/m^3 the LAEI roadside concentrations tend to be lower than the equivalent ADMS-Urban mean concentrations. Again there is a cluster of points with high LAEI roadside predictions associated with the M25, A1055, A501 and A13.

ERG road link PM_{10} concentrations tend to be greater than the equivalent ADMS-Urban concentrations 1999 and less than ADMS-Urban concentrations in 2004 Figures 4.6(c,d). There is also a marked increase in scatter for concentrations greater than about 30-35 μg/m^3, with ADMS-Urban tending to give lower concentrations in this concentration range.

Figure 4.4 Comparison of Annual Average NO_x ($\mu g/m^3$) predicted on road links between ADMS-Urban and NETCEN using LAEI for (a) 1999 and (b) 2005 and ADMS-Urban and ERG for (c) 1999 and (d) 2005

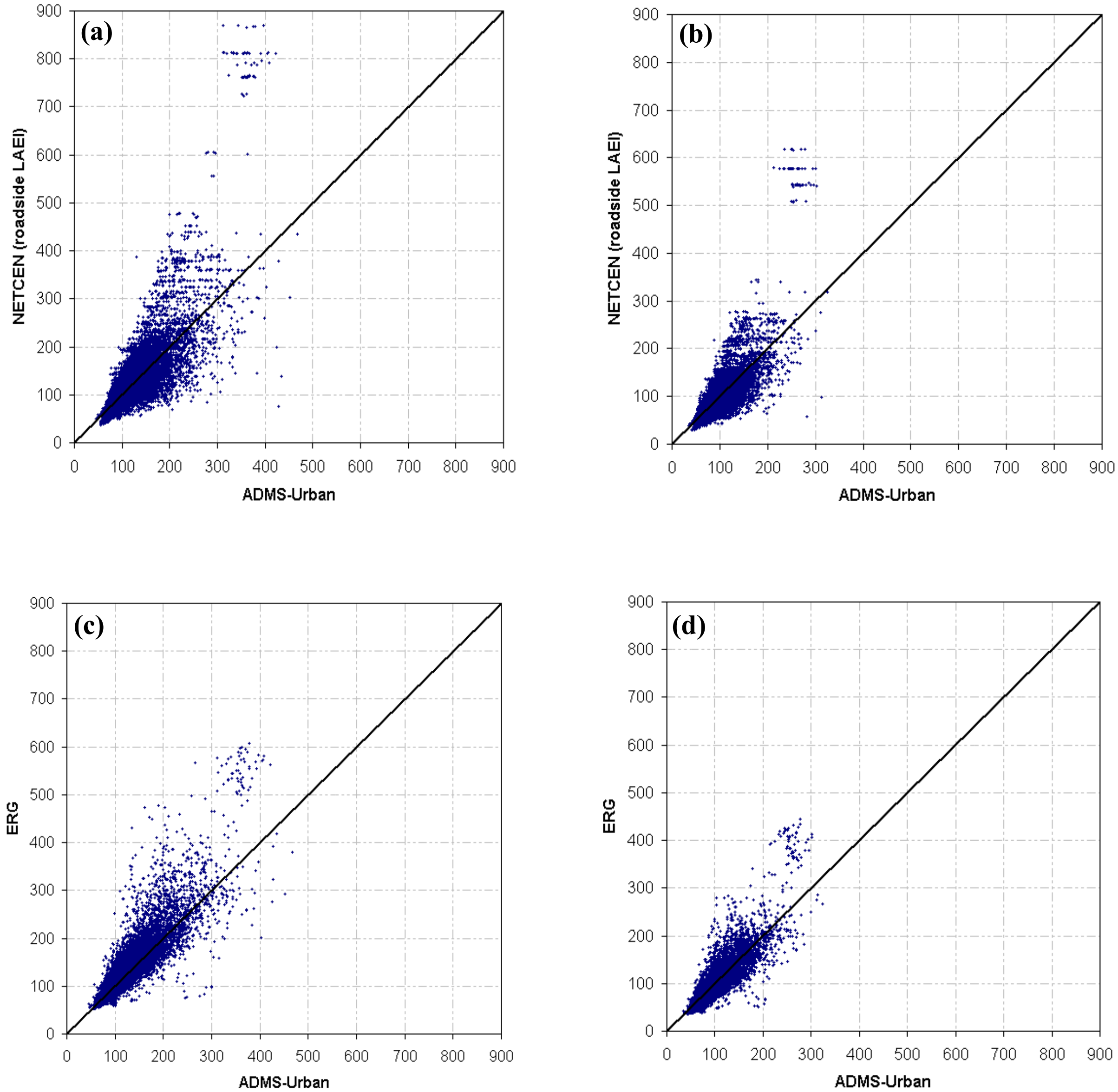


Figure 4.5 Comparison of Annual Average NO_2 (μg/m^3) predicted on road links between ADMS-Urban and NETCEN using LAEI for (a) 1999 and (b) 2005 and ADMS-Urban and ERG for (c) 1999 and (d) 2005

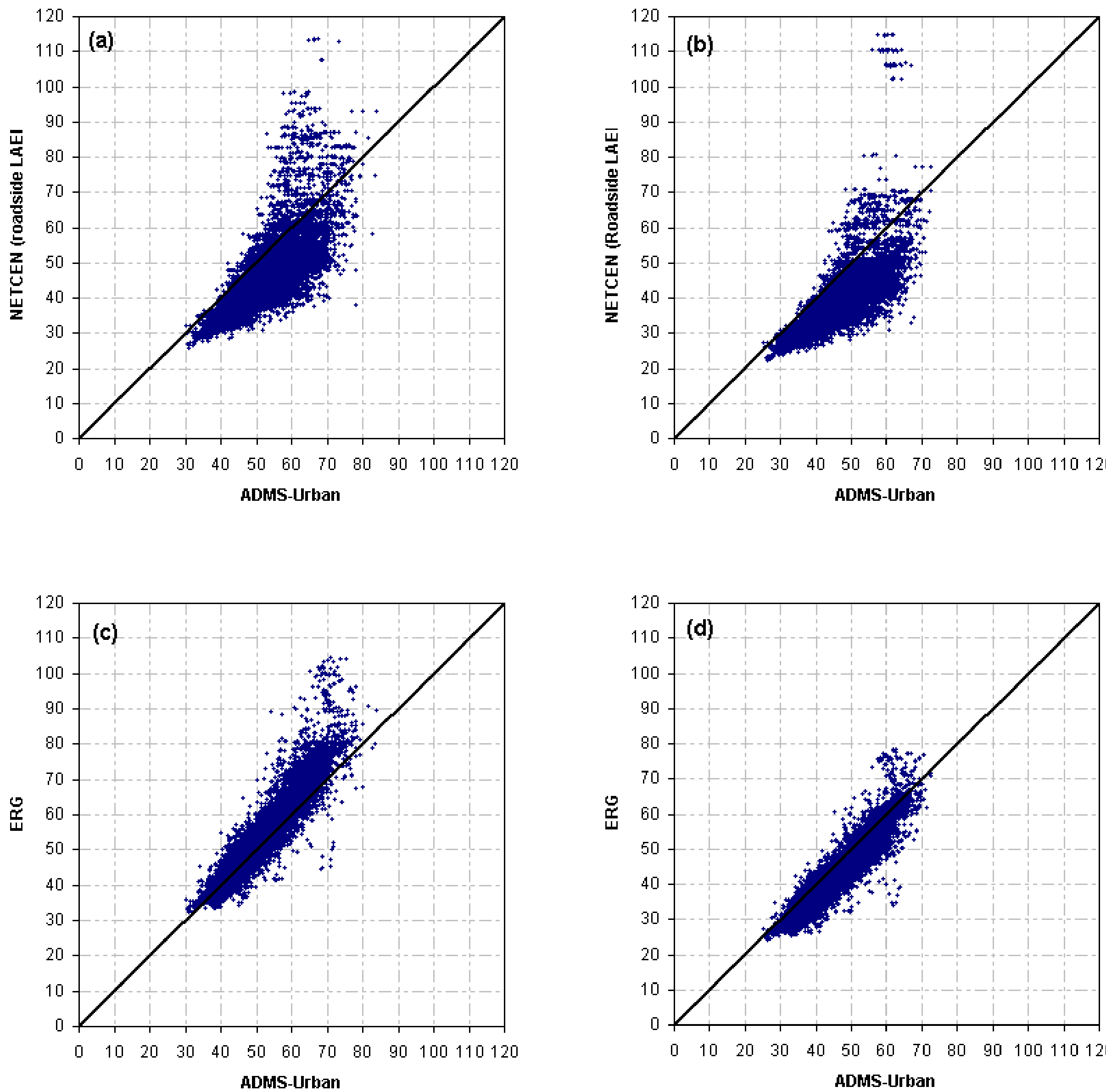
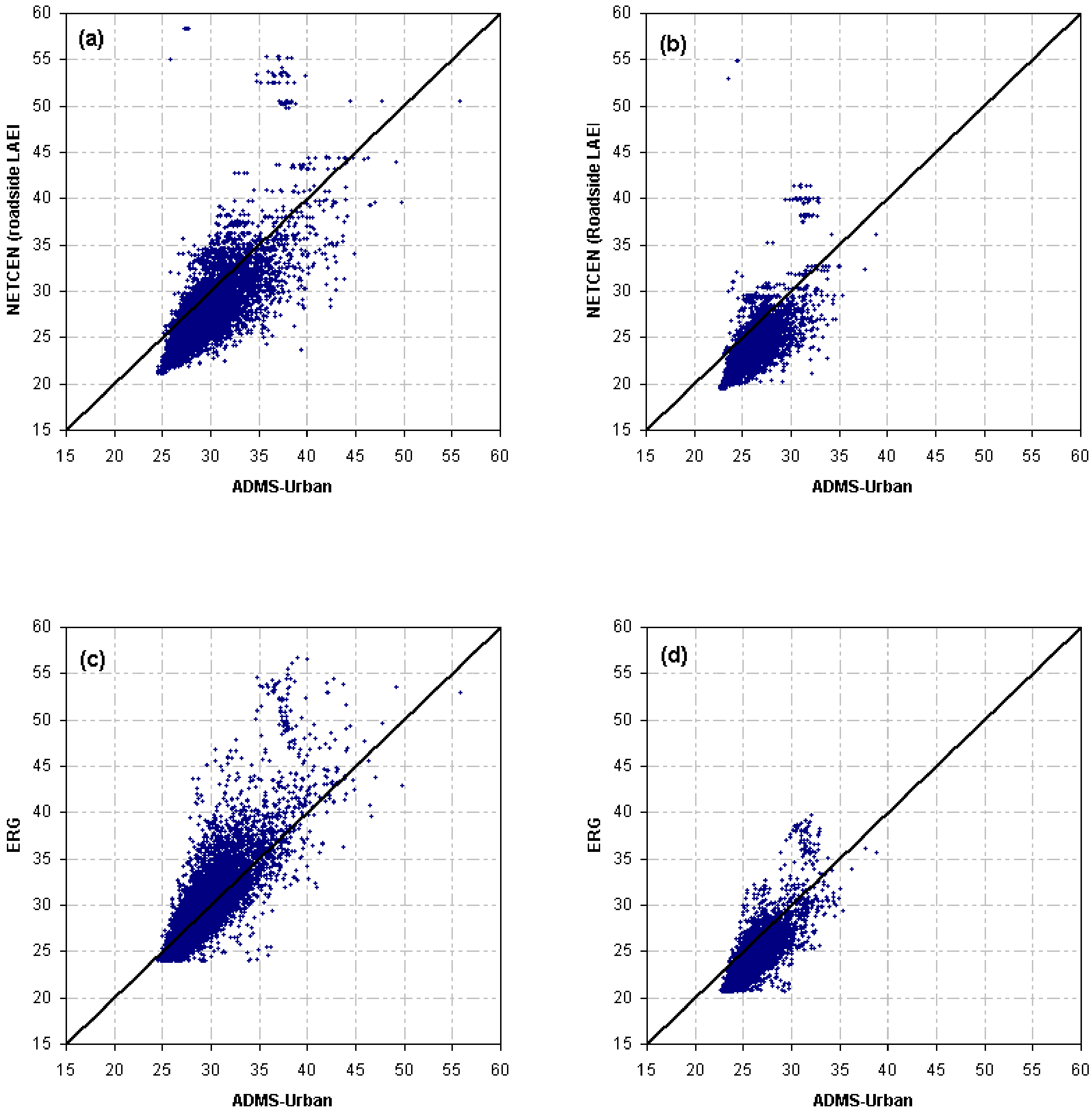


Figure 4.6 Comparison of Annual Average gravimetric PM_{10} ($\mu g/m^3$) predicted on road links between ADMS-Urban and NETCEN using LAEI for (a) 1999 and (b) 2004 and ADMS-Urban and ERG for (c) 1999 and (d) 2004



4.5 Changes in Calculated Concentrations between 1999 and 2004/5

The final method of comparing the models is a presentation of the changes in the calculated concentration between 1999 and 2004/2005. Table 4.10 shows the average concentrations first along road segments (using the data presented in Figures 4.2 to 4.6) and second at background locations, i.e. averages of calculated concentrations at background monitoring sites using data from Tables 4.2 to 4.7. These figures are also presented as percentage reductions in concentrations in Table 4.11. Table 4.12 shows the percentage reductions in emissions totals for comparison purposes. Note that a negative value indicates an increase.

Table 4.10 Average Calculated Concentrations between 1999 and 2004/5

		1999			2004/5		
		ADMS-Urban	NETCEN LAEI	ERG	ADMS-Urban	NETCEN LAEI	ERG
Roadside(1)	NO_x	122	130	128	90	93	85
	NO_2	52	45	54	45	37	42
	PM_{10}	28	26	28	25	23	23
Background(2)	NO_x	104	67	107	78	54	71
	NO_2	50	39	50	43	34	40
	PM_{10}	27	23	27	24	21	-

(1) Data from individual roadlinks calculation.
(2) Data from specific locations (Tables 4.2-4.6).

Table 4.11 Percentage Reductions between 1999 and 2004/5

		ADMS-Urban	NETCEN LAEI	ERG
Roadside(1)	NO_x	26	28	34
	NO_2	13	18	22
	PM_{10}	11	12	18
Background(2)	NO_x	25	19	34
	NO_2	14	13	20
	PM_{10}	11	9	-

Table 4.12 Percentage reduction in emission totals

	Source Type	Percentage Reduction between 1999 & 2004/05
NO_x	Road	34
	Non-road	-35
	Total	12
PM_{10}	Road	34
	Non-road	0
	Total	26

The main focus of this discussion is the change in concentrations and how this relates to the change in emissions.

Comparisons of NO_x reductions show that the ERG percentage reduction is the greatest over the time period with both roadside and background emissions decreasing on average in proportion to the road traffic emission reductions. In the ERG calculations the influence of other sources and the background of NO_x appears to be minimal. ADMS-Urban and NETCEN exhibit a lesser reduction for all sources, with ADMS-Urban showing a smaller difference between roadside and background than NETCEN. The NO_2 reductions broadly correspond to the NO_x reductions with ERG again showing much greater reduction. The NETCEN and ADMS-Urban PM_{10} reductions are similar.

5. Discussion

This report provides for the first time a detailed comparison of the ADMS-Urban, NETCEN and ERG methodologies for calculating annual average concentrations of NO_x, NO_2 and PM_{10} in London.

In conclusion, all three models predict Exceedences of the annual mean NO_2 objective in 2005 and the London 2010 objective for annual average PM_{10} in 2004. There are, however, significant differences in the extent of exceedences predicted by the models due to the fundamentally different ways they operate.

All three methodologies give fairly similar site-specific predictions which are in good agreement with measured data. In terms of magnitude of areas of exceedence of air quality objectives, or number of road segments exceeding objectives, there are some notable differences..

(i) *NO_x, NO_2 at roadside sites*

Comparisons made at monitoring sites show that the empirically based methodologies (NETCEN, ERG) tend to generate less NO_2 for given NO_x than ADMS-Urban. This reflects the difference between the ADMS-Urban Chemistry model for conversion of NO_x to NO_2 and the empirical relationships used in NETCEN and ERG. In addition, the empirically based methodologies may show a slighttendency to predict lower NO_2 than is calculated by ADMS-Urban, especially for future projections.

(ii) *NO_x, NO_2 at background sites*

Comparisons have been conducted for AURN sites and selected additional receptor points. These suggest good performance of ADMS-Urban and both the NETCEN and ERG empirically-based methodologies. Limited ADMS-Urban calculations of a 'background' component at roadside locations were carried out by removing emissions of the local major road. They show that NETCEN (NAEI) predicts a greater background than ADMS-Urban at roadside locations.

(iii) *PM_{10}*

As the non-primary (secondary and coarse) component of PM_{10} is significantly greater than the primary component, especially for future projections, the details of local dispersion are relatively less important than for NO_x and the models might be expected to show less divergence. However, although ADMS-Urban, NETCEN and ERG show good general agreement with data, scatter plots of road contributions and percentages of road segments that exceed thresholds show significant differences between the methodologies. In particular, minimum concentrations predicted by ADMS-Urban are greater than minimum concentrations predicted by NETCEN (based on the LAEI) whilst, in contrast to ADMS-Urban and NETCEN, ERG shows a large number of road segments with approximately the same lowest calculated concentration.

(iv) *Future Projections*

Future projections have been made with each of the methodologies. The results show greater differences than for 1999. ADMS-Urban predicts greater annual mean values of NO_2 (2005) and PM_{10} (2004) especially near major roads where concentrations are highest. ERG predicts much greater reductions at both roadside and background.

As well as the calculation methodologies, other factors such as meteorology, and accuracy of emissions affect the relative accuracy of predictions. The ADMS-Urban validation report (Carruthers et al, 2003) suggests that typical interannual variations are unlikely to affect *annual average* concentrations of NO_2 and PM_{10} by more than about five percent on average across London, although the levels at specific sites may vary by over 10%. Thus it is likely that similar conclusions about the relative performance of the three methodologies would be reached even if a different meteorological year was considered.

(vi) *Areas of Exceedence of Air Quality Standards*

The percentage of road links exceeding specified pollutant concentration thresholds was calculated. For NO_2, ADMS-Urban and the ERG methodology predict a similar percentage for 1999 but ADMS-Urban predicts a significantly higher percentage for 2005. The NETCEN approach using the LAEI predicts much lower values, however this partly results from the NETCEN correlation for London having been calculated using the NAEI rather than the LAEI.

Very large differences between the methodologies are seen in exceedences of the PM_{10} annual average standards. For example, the methodology predicting the most exceedences of the London 2010 standard (23 $\mu g/m^3$) is ADMS-Urban (98%) followed by ERG (21%), with the least predicted by NETCEN (1%). This arises because small changes in predicted concentration greatly impact on levels exceeding threshold values because by 2004 concentrations of PM_{10} are relatively uniform (Carruthers et al., 2003, Blair et al., 2003).

6. Acknowledgements

This report was prepared under DEFRA contract number RPG 1/3/176 for DEFRA, National Assembly for Wales, The Scottish Executive, and the Department of the Environment, Northern Ireland. Our thanks to John Stedman (NETCEN) and David Carslaw (ERG) for providing pollutant concentration data calculated using their methodologies, and also for commenting on drafts of this report.

7. References

TOPIC REPORTS

Carruthers, D.J., Blair, J.W., Johnson, K.L. (2003) Validation and Sensitivity Study of ADMS-Urban for London, Cambridge Environmental Research Consultants **TR-0191**

Blair, J.W., Johnson, K.L., Carruthers, D.J. (2003) Modelling Air Quality for London using ADMS-Urban, Cambridge Environmental Research Consultants **TR-0314**

ADMS

Validation of ADMS-Urban and ADMS-Roads Against M4 and M25 Motorway Data, http://www.cerc.co.uk/software/publications.htm

Carruthers, D.J., Edmunds, H.A., Lester, A.E., McHugh, C.A. and Singles, R.J. (1998) Use and Validation of ADMS-Urban in contrasting Urban and Industrial Locations. *Proc. 5th Int. Conf. Of Harmonisation Within Dispersion Models for Regulatory Purposes,* 429-436. Available as a special issue of the *International Journal of Environment and Pollution* (2000) **14**, Nos. 1-6

Carruthers, D.C., Holroyd, R.J., Hunt, J.C.R., Weng, W.S., Robins, A.G., Apsley, D.D., Thompson, D.J. and Smith, F.B. (1994) UK-ADMS: A new approach to modelling dispersion in the earth's atmospheric boundary layer. *Journal of Wind Engineering and Industrial Aerodynamics* **52**, 139-153. Elsevier Science B.V.

ADMS 3 Technical Specification (2000) Cambridge Environmental Research Consultants, http://www.cerc.co.uk/software/publications.htm

Hanna S.R., Egan B.A., Purdum J. and Wagler J. (1999) Evaluation of the ADMS, AERMOD and ISC3 Models with the Optex, Duke Forest, Kincaid, Indianapolis and Lovett Field Data Sets. *Proc. of Rouen Conference 11-14 October 1999*. Available as a special issue of the *International Journal of Environment and Pollution* (2001) **16**, Nos. 1-6

Azzi, M., Johnson, G. and Cope, M.E. (1992) An Introduction to the Generic Reaction Set Photochemical Smog Mechanism. In *Proceedings of the 11th International Conference of the Clean Air Society of Australia and New Zealand* (Brisbane, Australia, July 1992) (eds. P. Best, N. Bofinger, D. Cliff) **2**, 451-462

Venkatram, A., Karamchandani, P., Pai, P. and Goldstein, R. (1994) The Development and Application of a Simplified Ozone Modelling System (SOMS), *Atmospheric Environment* **28**, 3665-3678

Carruthers, D.J., Singles, R.J., Nixon, S.G., Ellis, K.L., Pendrey, M., Harwood, J. (1999) Modelling Air Quality in Central London. Cambridge Environmental Research Consultants **FM-0372**

NETCEN

Stedman, J R, Bush, T J, Murrells, T P and King, K (2001). Baseline PM10 and NOx projections for PM10 objective analysis. AEA Technology, National Environmental Technology Centre. Report AEAT/ENV/R/0726

ERG

Carslaw, D.C., Beevers, S.D., Fuller, G. (2001). An Empirical Approach for the Prediction of Annual Mean Nitrogen Dioxide Concentrations in London. *Atmospheric Environment,* Vol. 35, 1505-1515

Fuller, G.W., Carslaw, D.C., Lodge, H.W. (2002). An Empirical Approach for the Prediction of Daily Mean PM_{10} Concentrations. *Atmospheric Environment*, Vol. 36, 1431-1441