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Modelling of Current and Future Concentrations of PM, NO_x and O_3 in London using ADMS-Urban

Draft Report

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

1st March 2006

C E R C

Report Information

CERC Job Number:	FM642
Job Title:	Modelling of Current and Future Concentrations of PM, NO_x and O_3 in London using ADMS-Urban
Prepared for:	DEFRA, National Assembly for Wales, The Scottish Executive, and Department of the Environment, Northern Ireland
Report Status:	Draft
Report Reference:	FM642/TR04/R1/06
Issue Date:	1st March 2006

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Reviewer(s):

Issue	Date	Comments
1	01/03/06	1st Draft

Main File(s):	TR04_R1_ModellingforLondon_01Mar06.doc

Summary

Air quality modelling of London has been carried out by Cambridge Environmental Research Consultants (CERC) for the Department of Environment, Food and Rural Affairs (DEFRA) and devolved administrations (DA) as part of the project 'Dispersion Modelling of Air Pollution in Urban Areas in the UK (Phase 2)'.

Ground level concentrations of nitrogen dioxide (NO_2), total oxides of nitrogen (NO_x), ozone (O_3) and particulate matter, both with a diameter of less than 10μm (PM_{10}) and less than 2.5μm ($PM_{2.5}$), have been predicted using ADMS-Urban (version 2.1.3) for a base year for comparison with air quality monitoring data for the city and for the years 2010 and 2020 for comparison with air quality standards and objectives.

The modelling has used traffic flow and emissions data from the 2001 London Atmospheric Emissions Inventory, together with meteorological data from Heathrow and background data from rural monitoring sites around the city. Background data have been projected forward to future years, in the case of PM_{10} taking into account the breakdown into different species. The modelling of future years has taken into account changes to traffic flows, pollutant emission rates and background concentrations.

Comparison of the concentrations generated by ADMS-Urban at locations of the AURN monitoring sites with the corresponding measured concentrations has shown good agreement for each of the pollutants considered, lending confidence to the predictions of pollutant concentrations in the rest of the city and for future years.

Concentrations of NO_2 are predicted to exceed the AQS objective value of 40μg/m³ in 2001 over 40% of the London area. In 2010 this area of exceedence is predicted to have decreased to 10% and by 2020 to 5%. The areas with the greatest concentrations are central London, the major roads in outer London and the area around Heathrow airport. Comparisons with the national model (netcen) show that this model predicts a greater rate of decrease than ADMS-Urban with lower levels in 2010 and 2020.

Exceedences of the short-term AQS objective for NO_2 are predicted to be much less widespread, being limited to the M25 and the busiest of the roads in London. By 2020, the areas of exceedence are predicted to be limited to isolated stretches of the M25.

The annual average PM_{10} concentrations are predicted to exceed the AQS objective value of 40μg/m³ along the busiest roads in central London and stretches of the M25. By 2020 these areas are predicted to disappear entirely. The national model (netcen) shows a lower rate of decrease and higher contribution from roads at background sites than ADMS-Urban.

The short-term AQS objective value for PM_{10} is predicted to be exceeded along many of the major roads in central London, sections of the busiest roads in outer London and along much of the M25. By 2010 these areas of exceedence are predicted to decrease to isolated roadside locations and by 2020 are predicted to disappear.

Annual average concentrations of $PM_{2.5}$ are predicted to exceed 20µg/m³ in 2001 over much of central London and along major roads in the rest of the city. By 2020 concentrations are predicted to be below 20µg/m³ everywhere and below 16µg/m³ over most of the city. The concentration at Bloomsbury, an urban centre site, is predicted to decrease by 1.6µg/m³ (10.5%) between 2010 and 2020.

In 2001 annual average ozone concentrations range from 40µg/m³ in the outskirts of London to less than 20µg/m³ in central London. In future years, concentrations in London are predicted to increase. By 2020 concentrations are predicted to rise to more than 52µg/m³ in the outskirts of London and are at a minimum of approximately 20µg/m³ along major roads in central London.

Contents

1. Introduction

This document describes part of the work carried out by Cambridge Environmental Research Consultants (CERC) for the Department of Environment, Food and Rural Affairs (DEFRA) and devolved administrations (DA) for the project ‘Dispersion Modelling of Air Pollution in Urban Areas in the UK (Phase 2)’.

As part of the project CERC has used ADMS-Urban to carry out modelling for the cities of London, Cardiff, Glasgow and Belfast to assess air quality in future years. This report describes the modelling carried out for London.

Ground level concentrations of nitrogen dioxide (NO_2), total oxides of nitrogen (NO_x), ozone (O_3) and particulate matter, both with a diameter of less than 10µm (PM_{10}) and less than 2.5µm ($PM_{2.5}$), have been predicted for a base year for comparison with air quality monitoring data for the city and for the years 2010 and 2020 for comparison with air quality standards and objectives.

The air quality standards and objectives against which the predicted concentrations are to be compared are listed in Section 2, and Section 3 describes the emissions data used in the modelling. Section 4 describes the model set-up for the city. The results of the model verification are given in Section 5 and maps of the predicted concentrations for the current and future situations are given in Sections 6 to 9. Section 10 gives a discussion of the results of the modelling.

2. Air quality standards

Modelling has been carried out to compare predicted concentrations with the UK Air Quality Strategy objectives for NO_2 and PM_{10}, given in Table 2.1.

Table 2.1 AQS Objectives

Substance	Limit value	Reference period and allowed exceedences	Year to be met
NO_2	200µg/m^3	hourly mean not to be exceeded more than 18 times a year (modelled as 99.79th percentile)	2005
	40µg/m^3	annual mean	2005
PM_{10}	40µg/m^3	annual mean	2004
	50µg/m^3	24-hour mean not to be exceeded more than 35 times a year (modelled as 90.41st percentile)	2004
	23µg/m^3*	annual mean	2010
	50µg/m^3*	24-hour mean not to be exceeded more than 7 times a year (modelled as 98.08th percentile)	2010

* provisional objective

For $PM_{2.5}$, under the Clean Air for Europe (Café) programme, the European Commission has proposed an annual average 'cap' of 25µg/m^3 and a reduction in concentrations of 20% between 2010 and 2020, and these have been considered in the modelling.

The following metrics for ozone have been considered:

- Mean of the daily maximum 8-hour rolling average;
- Maximum daily 8-hour rolling average;
- Mean of those daily maximum 8-hour averages > 70µg/m^3;
- Mean of those daily maximum 8-hour averages > 100µg/m^3;
- Number of days per year during which the rolling 8-hour average exceeds 100µg/m^3.

3. Emissions data

The Greater London Authority (GLA) compiles and updates emissions inventories for London, covering the area within the M25. The London Atmospheric Emissions Inventory (LAEI) includes emissions from all significant sources of Air Quality Strategy (AQS) pollutants. The 2001 LAEI, released in October 2003, has been used in this study. It includes traffic flow and emissions data for 2001 and projections for 2005.

Emissions from major roads have been calculated using traffic flows taken from the LAEI combined with fleet composition data provided by netcen and the latest set of emission factors from the UK Emissions Factor Database (UKEFD). All emissions data for other sources have been taken directly from the LAEI.

Information from the LAEI 2002 Emissions Estimation Methodology Manual[1] was used to project emissions forward to 2010. Between 2010 and 2020 traffic flow projections were made using data based on the Department for Transport (July 2004) Central Forecasts, provided by netcen. Changes to the resulting major road emissions were applied to the minor road emissions. All other sources were assumed to remain constant. Table 3.1 shows the total emissions of NO_x for the London area for 2001, 2010 and 2020. Tables 3.2 and 3.3 give the total emissions of PM_{10} and $PM_{2.5}$ for each year.

Table 3.1 Total NO_x emissions from London

	2001		2010		2020	
	t/yr	%	t/yr	%	t/yr	%
Major roads	48410	57	24090	37	17580	30
Other roads	4386	5	2252	3	1667	3
Domestic	9367	11	9729	15	9729	17
Industrial	15711	18	21606	33	21606	37
Other	7516	9	7513	12	7518	13
All sources	85390	100	65190	100	58100	100

Table 3.2 Total PM_{10} emissions from London

	2001		2010		2020	
	t/yr	%	t/yr	%	t/yr	%
Major roads	1861	42	914	28	747	24
Other roads	430	10	207	6	168	5
Domestic	629	14	653	20	653	21
Industrial	1133	26	1152	35	1152	38
Other	341	8	341	10	342	11
All sources	4395	100	3267	100	3062	100

[1] London Atmospheric Emissions Inventory 2002 – Emissions Estimation Methodology Manual, Greater London Authority, February 2005

Table 3.3 Total $PM_{2.5}$ emissions from London

	2001		**2010**		**2020**	
	t/yr	**%**	**t/yr**	**%**	**t/yr**	**%**
Major roads	1671	51	821	37	671	33
Other roads	386	12	186	8	151	7
Domestic	357	11	370	17	370	18
Industrial	642	20	653	29	653	32
Other	193	6	193	9	194	10
All sources	3250	100	2223	100	2039	100

4. Model Set-up

4.1 Modelling parameters

The modelling used the dispersion model ADMS-Urban, version 2.1.3.0. Various parameters need to be set when using ADMS-Urban to describe the modelling area and dispersion characteristics.

The surface roughness characterises the surrounding area in terms of the effect it will have on wind speed and turbulence, which are key components of the modelling.

In urban areas, the significant amount of heat emitted by buildings and traffic warms the air within and above a city or large town. This is known as the urban heat island and its effect is to prevent the atmosphere from becoming very stable. In general, the larger the area the more heat is generated and the stronger the effect becomes. In the ADMS-Urban model, the stability of the atmosphere is represented by the Monin-Obukhov parameter, which has the dimension of length. The effect of the urban heat island is that, in stable conditions the Monin-Obukhov length will never fall below some minimum value; the larger the city, the larger the minimum value.

Table 4.1 gives a summary of the parameters used in the modelling.

Table 4.1 Model set-up parameters

Parameter	**Value**
Surface roughness	1m
Surface roughness at met site	0.2m
Minimum Monin-Obhukov length	30m
Grid source height	10m
Initial mixing height of road sources	1m
Primary NO_2 percentage of modelled sources	10%
Minimum wind speed	0.5m/s
Minimum value of turbulent velocities	0.2m/s

4.2 Meteorological data

Modelling was carried out using hourly sequential meteorological data obtained from Heathrow for the year 2001. A summary of the data provided is given below in Table 4.2.

Table 4.2 Summary of meteorological data

	Heathrow 2001		
Data capture	99.9%		
Roughness length	0.2m		
Statistics	Mean	Minimum	Maximum
Temperature (°C)	11.2	-4.2	31.8
Wind speed (m/s)	3.2	0.0	11.8
Cloud cover (oktas)	5.6	0.0	8.0

The ADMS meteorological pre-processor, written by the Met Office, uses these data to calculate the parameters required by the program. Figure 5.1 shows the wind rose for the station giving the frequency of occurrence of wind from different directions for a number of wind speed ranges, for the year 2004.

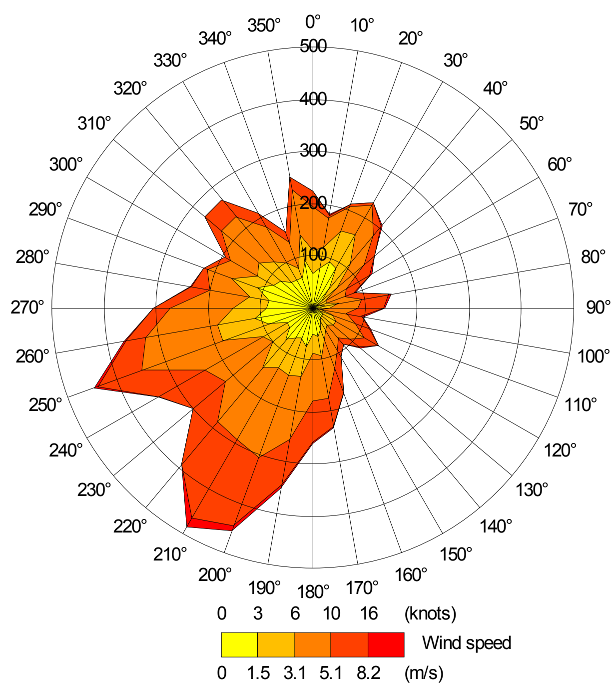

Figure 4.1 Wind rose for Heathrow, 2001

4.3 Background data

4.3.1 NO_x background

ADMS-Urban uses rural measurements of background pollutant concentrations to represent the pollutants being transported into the modelled area. In the case of NO_x, NO_2 and O_3 monitored concentrations were taken from the Harwell, Rochester, Wicken Fen and Lullington Heath monitoring sites, the measured concentration used for a particular hour depending on the wind direction during that hour. Figure 4.2a shows the background sites used for each wind direction segment.

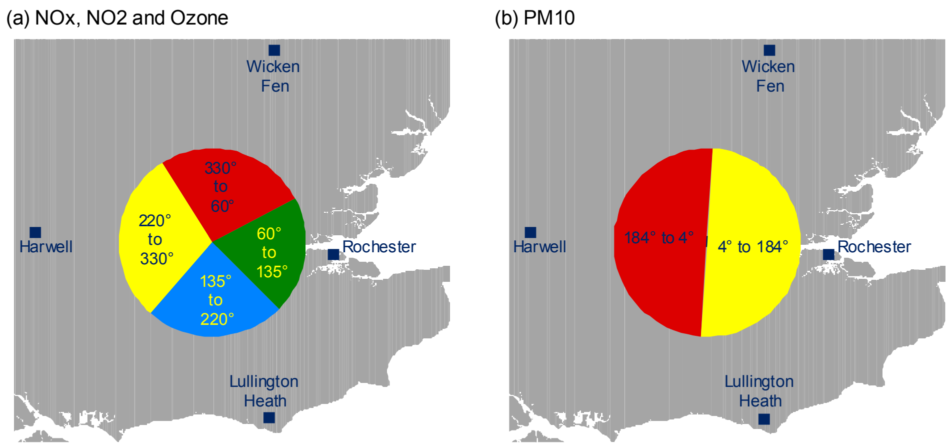

Figure 4.2 Background monitoring sites used for each wind direction segment

Table 4.3 gives a summary of the composite background data for NO_x, NO_2 and O_3 used in the modelling for 2001.

Table 4.3 2001 Background concentrations for NO_x, NO_2 and O_3

		2001
NO_x (µg/m³)	Annual Average	18.0
	Maximum hourly average	302.9
	99.8th percentile of hourly averages	185.7
NO_2 (µg/m³)	Annual Average	12.3
	Maximum hourly average	78.5
	99.8th percentile of hourly averages	74.7
O_3 (µg/m³)	Annual Average	53.4
	Maximum hourly average	198.0
	99.8th percentile of hourly averages	146.0

4.3.2 PM_{10} and $PM_{2.5}$ background

Monitored TEOM PM_{10} and $PM_{2.5}$ data from Rochester and Harwell were used. For each hour of the year either the Rochester or Harwell observations were chosen, depending upon the wind direction for that hour, as shown in Figure 6.1b. The TEOM measurements were multiplied by a factor of 1.3 to give gravimetric equivalent concentrations. Table 4.4 gives a summary of the rural background data.

Table 4.4 Summary of background PM_{10} data

		2001
PM_{10} (µg/m^3)	Annual Average	19.2
	90.4th percentile of 24-hour averages	29.3
$PM_{2.5}$ (µg/m^3)	Annual Average	13.9

4.3.3 Future NO_x and NO_2 background

Background concentrations of NO_x, NO_2 and PM_{10} are predicted to decrease in future years. Hourly background concentrations for 2010 and 2020 have been calculated by applying reductions to the 2001 data.

Background NO_x concentrations for 2010 and 2020 have been obtained by multiplying the 2001 data by factors of 0.68 and 0.53, respectively, taken from national emissions projection data supplied by netcen. To obtain concentrations of NO_2, a best-fit curve was derived to relate NO_x and NO_2 concentrations in 2001 and this was applied to the projected 2010 and 2020 NO_x concentrations. Future ozone concentrations have been calculated by assuming conservation of total oxidant (NO_2 and O_3). Table 4.5 gives a summary of the 2001, 2010 and 2020 NO_x, NO_2 and ozone concentrations.

Table 4.5 Future NO_x, NO_2 and ozone concentrations

		2001	2010	2020
NO_x (µg/m³)	Annual Average	18.0	12.3	9.6
	Maximum hourly average	302.9	206.9	160.9
	99.8th percentile of hourly averages	185.7	126.0	97.9
NO_2 (µg/m³)	Annual Average	12.3	9.5	7.7
	Maximum hourly average	78.5	51.3	51.3
	99.8th percentile of hourly averages	74.7	50.5	48.3
O_3 (µg/m³)	Annual Average	53.4	57.1	58.7
	Maximum hourly average	198.0	203.9	206.0
	99.8th percentile of hourly averages	146.0	152.6	154.8

4.3.4 Future PM_{10} background

Measurements of inorganic compounds, elemental carbon and organic compounds from rural locations have been used to determine the composition of the total annual average rural background PM_{10} concentrations for 2001. Concentrations of ammonium sulphate, ammonium nitrate and sodium nitrate have been estimated by applying the mass closure model analysis of Harrison et al, 2003, presented in AQEG's Particulate Matter in the United Kingdom report, based on sulphate, nitrate and ammonium concentrations measured at Barcombe Mills and Rothamstead. Long-term average concentrations of organic and elemental carbon measured at Harwell during 2002 and 2003 have been used to represent the background concentrations[2]. A factor of 1.4 was used to convert the mass of organic carbon to a mass of organic compound, and a factor of 1.0 was used for elemental carbon[3].

Adjustment factors for sulphates and nitrates for future years have been supplied by netcen, and these are given in Table 4.6.

Table 4.6 Sulphate and nitrate adjustment factors for future years

Year	Sulphate factor	Nitrate factor
2001	1	1
2010	0.689	0.826
2020	0.566	0.679

The measured organic carbon is assumed to decrease by the same proportion as the total inorganic PM_{10}. The measured elemental carbon concentration is assumed to decrease by the same proportion as national PM_{10} emissions, as supplied by netcen.

The total annual average concentrations for each component are given in Table 4.7. The appropriate reductions in each component were applied to the hourly measurements to obtain hourly data for 2010 and 2020. The 'other' component is the difference between the total measured concentration and the sum of the different components, and represents additional sources of PM_{10} such as salt and wind-blown dust. This component is assumed to remain constant in future years.

Table 4.7 Annual average background PM_{10} concentrations (µg/m³)

	2001	2010	2020
Organic PM_{10}	2.72	2.10	1.72
Elemental carbon	0.66	0.54	0.57
Ammonium sulphate	3.85	2.65	2.18
Ammonium nitrate	4.52	3.74	3.07
Sodium nitrate	1.19	0.98	0.81
'Other' component	6.23	6.23	6.23
Total	19.2	16.2	14.6

[2] Particulate Matter in the United Kingdom, §6.1.4.5, AQEG
[3] Particulate Matter in the United Kingdom, §6.1.5, AQEG

4.3.5 Future $PM_{2.5}$ background

Concentrations of $PM_{2.5}$ in future years have been projected using the PM_{10} data given in Table 4.7. The proportion of each component of PM_{10} assumed to be $PM_{2.5}$ has been taken from the chemical composition of urban background particles presented in *Particulate Matter in the United Kingdom*[4], and is given in Table 4.8 together with the resulting $PM_{2.5}$ concentrations. The 'other' component has been calculated as the difference between the measured $PM_{2.5}$ concentration in 2001 and the sum of the components considered for the same year. Using this method, approximately 43% of the 'other' PM_{10} component is assumed to be $PM_{2.5}$. The 'other' component is assumed to remain constant in future years.

Table 4.8 Annual average background $PM_{2.5}$ concentrations

	$PM_{2.5}$ as % of PM_{10}	Annual average (µg/m³)		
		2001	2010	2020
Organic PM_{10}	75	2.04	1.57	1.29
Elemental carbon	88	0.58	0.47	0.50
Ammonium sulphate	94	3.61	2.49	2.05
Ammonium nitrate	94	4.25	3.51	2.89
Sodium nitrate	64	0.76	0.63	0.52
'Other' component	(43)*	2.69	2.69	2.69
Total	-	13.9	11.4	9.9

* Note that this percentage has been calculated from the assumed PM_{10} and $PM_{2.5}$ concentrations and has not been used in the calculation of $PM_{2.5}$ concentrations.

[4] Particulate Matter in the United Kingdom, §6.1.6, AQEG

5. Model Verification

Modelling was carried out for 2001 and concentrations predicted at the locations of the AURN monitoring sites in London. The predicted concentrations have been compared with the measured concentrations to determine whether the emissions data and model set-up give a good representation of concentrations measured in the city.

5.1 NO_x, NO_2 and O_3 concentrations

Tables 5.1 and 5.2 give a summary of the measured and modelled concentrations of NO_x and NO_2, and O_3, respectively, at the AURN sites. Note that the statistics presented only refer to those hours for which there were both valid measured and modelled concentrations. Figures 5.1 to 5.3 show plots of measured and modelled annual average NO_x, NO_2, and O_3 concentrations.

Table 5.1 Measured and modelled NO_x and NO_2 concentrations (µg/m³)

	NO_x				NO_2			
	Annual mean		99.79^{th} percentile		Annual mean		99.79^{th} percentile	
	Meas	Mod	Meas	Mod	Meas	Mod	Meas	Mod
Bloomsbury	109	148	570	719	51	61	120	164
Marylebone Road	335	333	1219	1098	84	87	233	193
Hackney	109	104	785	632	48	50	138	163
Southwark Roadside	176	184	874	815	65	66	149	171
Tower Hamlets	228	144	990	822	69	60	182	178
Haringey	119	116	791	683	48	54	130	174
London Southwark	112	117	774	680	54	52	145	154
N Kensington	75	92	677	497	41	47	148	139
West London	95	95	690	524	52	47	141	133
Camden	203	165	916	801	66	64	162	172
Cromwell Rd	208	230	912	828	76	74	178	172
Wandsworth	135	123	891	689	53	54	157	145
Bromley	166	114	798	749	61	49	142	161
Eltham	62	77	675	720	34	38	113	161
A3	184	153	1134	893	54	56	149	166
Hounslow	148	113	992	627	54	49	139	139
Bexley	68	80	717	777	36	40	120	167
Brent	61	55	691	452	37	33	117	143
Sutton Suburban	65	64	745	558	35	33	138	134
Hillingdon	121	133	766	845	46	55	128	168
Teddington	53	58	636	565	29	30	110	124
Average	**134**	**126**	**819**	**709**	**52**	**52**	**145**	**157**

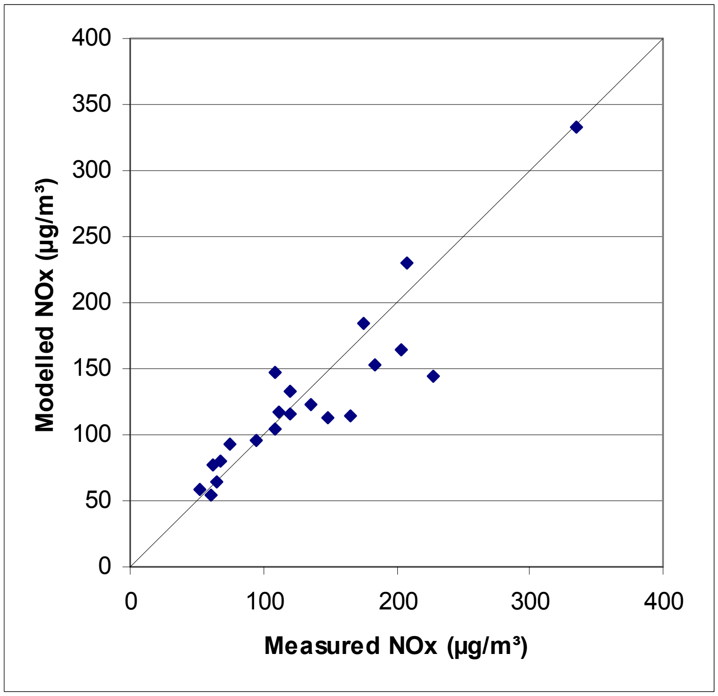

Figure 5.1. Measured and modelled annual average NO_x concentrations, 2001

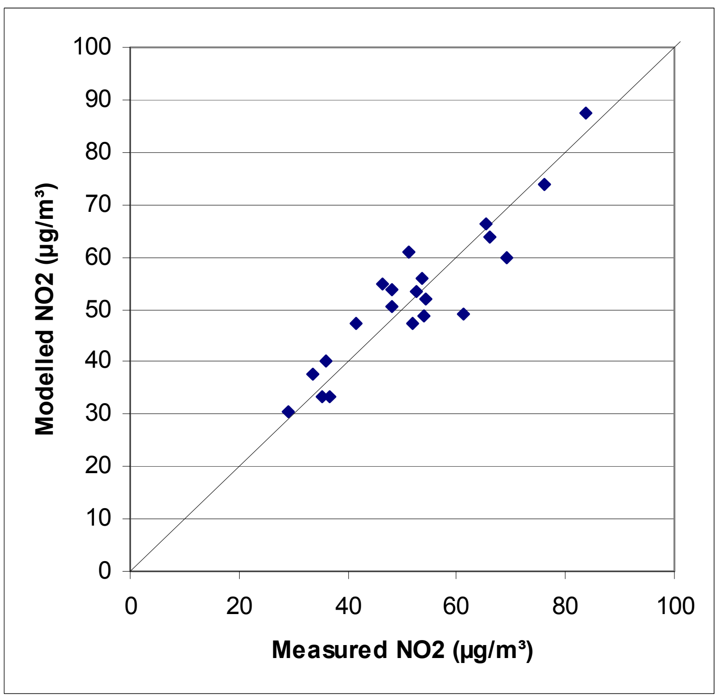

Figure 5.2. Measured and modelled annual average NO_2 concentrations, 2001

Table 5.2 Measured and modelled O_3 concentrations (µg/m³)

	Annual mean		99.79th percentile	
	Measured	**Modelled**	**Measured**	**Modelled**
Bloomsbury	23	21	116	105
Marylebone Road	14	11	80	90
Hackney	29	27	100	102
London Southwark	29	26	136	121
North Kensington	34	28	126	121
Wandsworth	27	25	132	109
Eltham	37	36	141	135
Bexley	38	34	149	130
Brent	37	37	148	130
Hillingdon	35	38	145	135
Teddington	26	24	122	104
Average	**30**	**28**	**127**	**117**

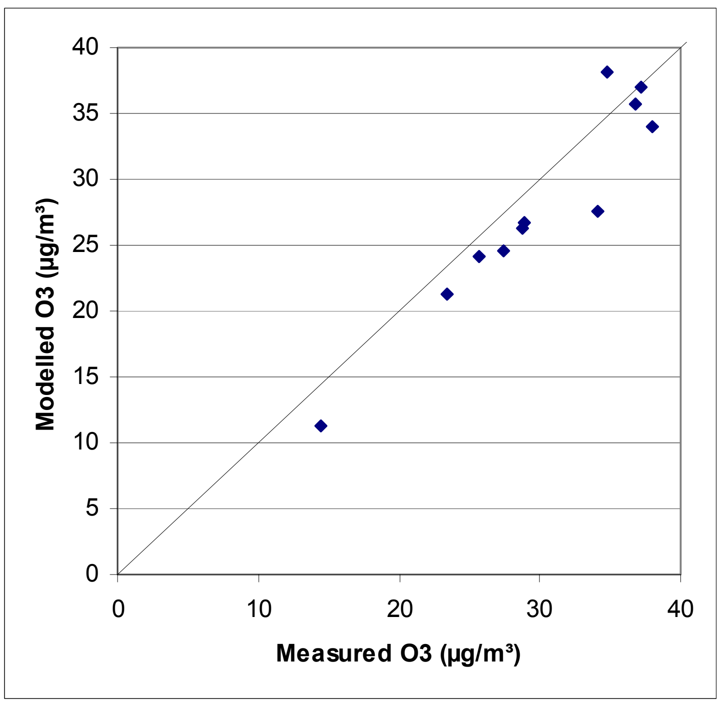

Figure 5.3. Measured and modelled annual average O_3 concentrations, 2001

5.2 PM_{10} concentrations

PM_{10} concentrations were initially modelled taking into account the dispersion of pollutants from all primary sources in London and the rural background data discussed in Section 4.3.2. Within London, additional PM_{10} may be present resulting from brake and tyre wear, road surface wear, resuspension and other sources not defined in the emissions inventory. The contribution of these additional sources in the urban area has been taken into account using two different methods.

Firstly, the initial modelled concentrations (calculated primary contribution and rural background) were compared to the measured data and the average difference at roadside and background sites derived. These differences were taken to represent the contribution of the additional sources and added to the calculated concentrations.

Secondly, for the annual average PM_{10} calculations, the additional contribution has been represented as a constant factor of the modelled primary concentrations. The difference between the initial modelled concentrations and the measured data was compared to the modelled primary concentration at each AURN site and a London-wide average ratio derived. This ratio of 0.384 was applied to the primary contribution at each receptor location. This second method has the advantage of not relying on an artificial distinction between background and roadside locations.

Both methods represent a development of the previous approach (*Modelling Air Quality for London using ADMS-Urban,* October 2003) in which a constant was added at all sites. This constant value of 5µg/m³ compares with the increments of 1.6µg/m³ and 4.3µg/m³ used for the first new method at background and roadside sites, respectively; and typical increments of 1.4µg/m³ (at the Eltham AURN site) and 7.6µg/m³ (at Marylebone Road) for the second method employing a constant factor of the primary contribution.

The resulting modelled annual average concentrations at each of the AURN sites in London are shown for each method together with the measured concentrations in Table 5.3. Figures 5.4a and b show the measured and modelled concentrations for each method.

Table 5.3 Measured and modelled annual average PM_{10} concentrations (µg/m³ - gravimetric)

	Measured	**Modelled**	
		Method 1	**Method 2**
Marylebone Road	43.6	43.3	46.5
Bloomsbury	28.9	27.4	28.5
Camden	33.2	31.7	30.4
Haringey	27.2	28.0	29.3
North Kensington	25.8	25.4	25.7
Bexley	24.3	24.4	24.2
Eltham	23.4	24.2	24.0
Brent	22.8	23.3	22.7
A3	27.3	29.2	27.0
Hillingdon	25.8	25.4	25.5
Average	28.2	28.2	28.4

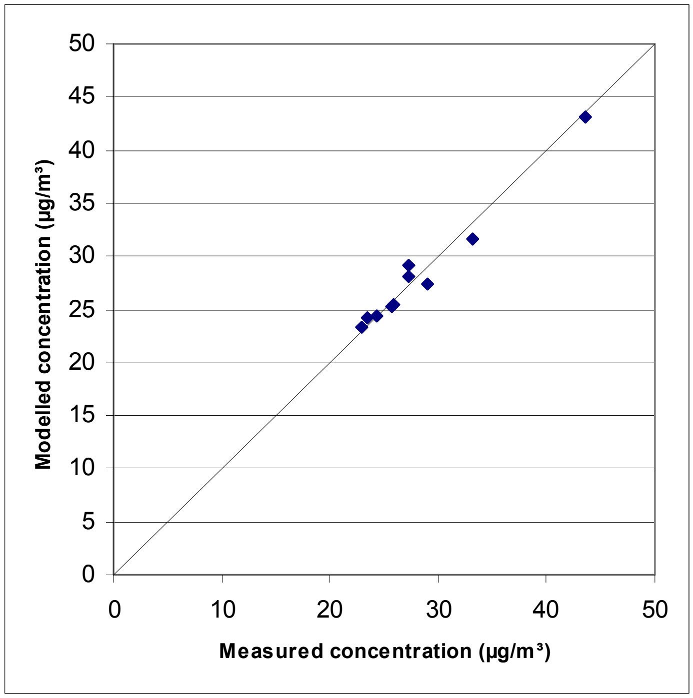

Figure 5.4a. Measured and modelled annual average PM_{10} concentrations, Method 1

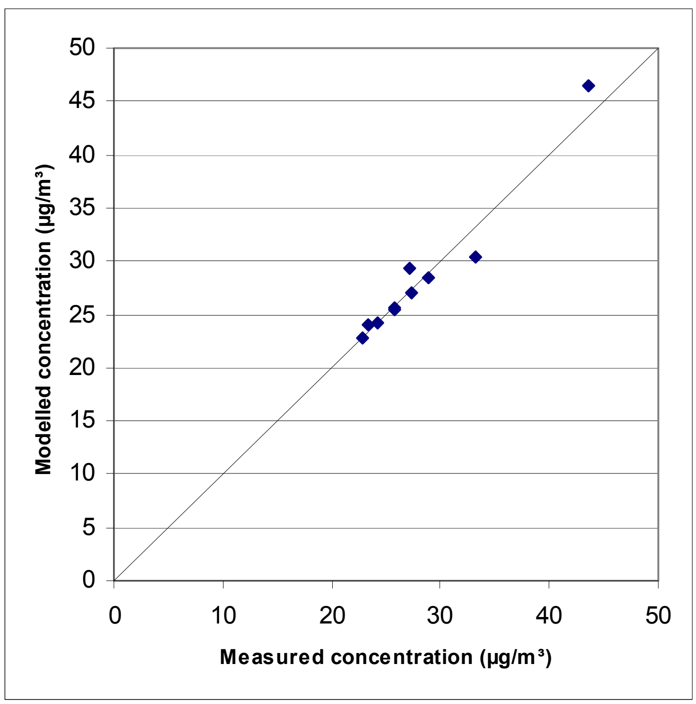

Figure 5.4b. Measured and modelled annual average PM_{10} concentrations, Method 2

A similar method has been used to calculate the additional contribution to the 90.41st percentile of 24-hour average concentrations. The combined contribution of the primary emissions and background concentrations was calculated and compared to the measured data. The annual average concentration was subtracted from the initial modelled results and the resulting 'primary component' value compared with the difference between the measured and modelled concentrations. As for the annual average concentrations, an average ratio was calculated and applied to the 'primary component' to represent the additional contribution. The results of this calculation are given in Table 5.4 and a comparison of the measured and modelled concentrations are shown in Figure 5.5. The results show good agreement between measured and modelled concentrations.

Table 5.4 Measured and modelled 90.41st percentile PM_{10} concentrations (µg/m³ - gravimetric)

	Measured	Modelled
Marylebone Road	64.1	61.8
Bloomsbury	43.9	42.6
Camden	48.4	44.8
Haringey	41.3	43.3
North Kensington	40.0	39.3
Bexley	37.9	38.0
Eltham	36.1	38.4
Brent	36.4	36.9
A3	40.6	42.7
Hillingdon	40.0	39.1
Average	42.9	42.7

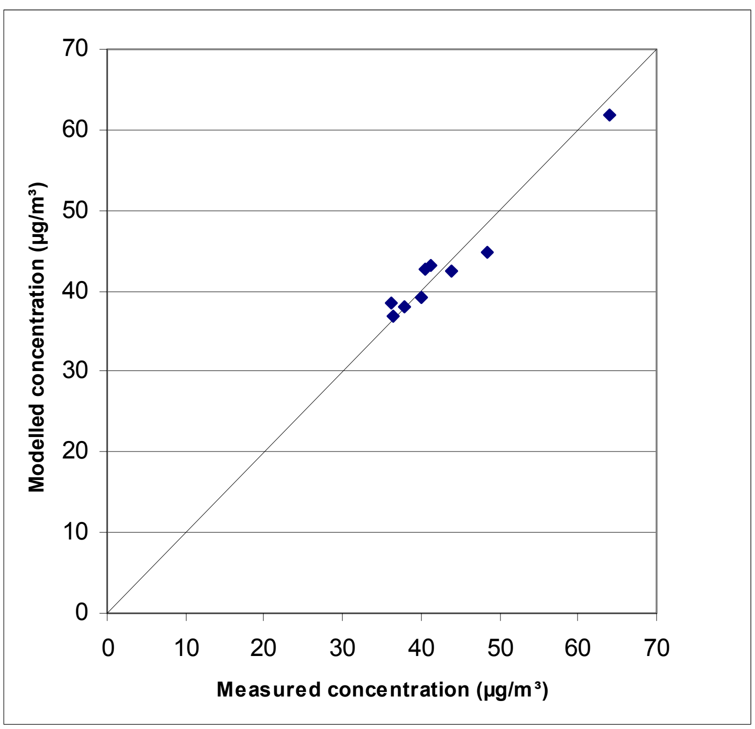

Figure 5.5. Measured and modelled 90.41st percentile PM_{10} concentrations, 2001

5.3 $PM_{2.5}$ concentrations

Concentrations of $PM_{2.5}$ have been calculated at the two AURN sites at which they are measured. Emissions data for $PM_{2.5}$ are not available for London, however emissions of $PM_{2.5}$ are related to emissions of PM_{10}. Annual average concentrations of $PM_{2.5}$ have been calculated by examining the contribution of different sources groups to total PM_{10} concentrations and applying knowledge of the typical breakdown of particulates to calculate each group's contribution to the total $PM_{2.5}$ concentration. The background concentrations are described in Section 4.3.5. The proportions of PM_{10} made up of $PM_{2.5}$ for primary emissions were taken from the AQEG report *Particulate Matter in the United Kingdom* and are given in Table 5.5. Table 5.6 shows the measured and modelled annual average $PM_{2.5}$ concentrations at the two AURN sites at which it is measured.

Table 5.5 Breakdown of primary particulate concentrations

Component	$PM_{2.5}$ as percentage of PM_{10}
Roads	90
Other	57

Table 5.6 Measured and modelled annual average $PM_{2.5}$ concentrations (µg/m³ - gravimetric)

	Measured	Modelled
Marylebone Road	32.0	32.8
Bloomsbury	17.1	19.2

6. Projections and Source Apportionment of NO_x and NO_2

Modelling was carried out with concentrations calculated over a regular grid of points, with additional points located along major roads, where the concentration gradients are steepest. Annual average and 99.79th percentile of hourly average NO_x and NO_2 concentrations have been calculated for 2001, 2010 and 2020.

Figures 6.1 to 6.3 show the modelled annual average NO_x concentrations for 2001, 2010 and 2020 respectively. Table 6.1 shows the NO_x concentrations predicted at each of the AURN monitoring sites for each of the three years modelled.

Table 6.1. NO_x concentrations at AURN sites for 2001, 2010 and 2020 (µg/m³)

	Annual average (µg/m³)			99.79th percentile (µg/m³)		
	2001	**2010**	**2020**	**2001**	**2010**	**2020**
Marylebone Road	333	215	174	1098	745	625
Bloomsbury	148	88	78	719	469	407
Tower Hamlets	144	89	73	822	559	465
London Southwark	117	78	67	680	496	423
West London	95	68	59	524	356	312
North Kensington	92	63	56	497	335	296
Cromwell Road	230	125	107	828	522	456
Wandsworth	123	75	62	689	452	387
Camden	165	104	88	801	574	481
Hackney	104	65	55	632	442	374
Haringey	116	73	61	683	482	407
Brent	55	38	32	452	324	275
Hounslow	113	68	55	627	419	338
A3	153	78	64	893	550	470
Teddington	58	37	32	565	351	305
Hillingdon	133	67	55	845	433	376
Sutton Suburban	64	45	38	558	393	342
Bromley	114	73	61	749	498	425
Bexley	80	51	43	777	522	453
Eltham	77	48	41	720	489	420
Southwark Roadside	184	122	92	815	623	472
Average	**126**	**78**	**65**	**709**	**474**	**403**

Figures 6.4 to 6.6 show the modelled annual average NO_2 concentrations for 2001, 2010 and 2020 respectively. Table 6.2 shows the annual average concentrations predicted at each of the AURN monitoring sites using ADMS-Urban together with the equivalent concentrations from netcen's national model. Note that two sets of national model results are presented: those using base years of 2003 and 2004. Table 6.3 shows the 99.79th percentile of hourly average NO_2 concentrations calculated for each of the AURN sites for 2001, 2010 and 2020.

Table 6.4 shows the area of exceedence of the AQS objective value of 40µg/m³; the population exposed to concentrations greater than the AQS objective value; and the population weighted mean NO_2 concentration. These statistics are presented for the

ADMS-Urban calculations and for the national model calculations using a base year of 2003 and 2004.

Table 6.2 Annual average NO_2 concentrations at AURN sites for 2001, 2010 and 2020 (µg/m³)

	Current			**2010**			**2020**		
	ADMS	**Netcen**		**ADMS**	**Netcen**		**ADMS**	**Netcen**	
Base Year	**2001**	**2003**	**2004**	**2001**	**2003**	**2004**	**2001**	**2003**	**2004**
Marylebone Rd	87	86	86	76	72	69	69	63	59
Bloomsbury	61	65	57	50	56	50	47	53	46
Tower Hamlets	60	61	62	50	50	49	45	43	42
London S'wark	52	45	42	45	37	36	41	33	32
West London	47	46	41	42	38	35	39	34	31
N Kensington	47	47	39	41	38	33	38	35	30
Cromwell Road	74	71	72	59	59	57	55	52	49
Wandsworth	54	39	35	44	32	30	39	29	27
Camden	64	73	72	55	59	57	50	48	45
Hackney	50	39	34	41	32	29	37	30	26
Haringey	54	59	63	45	49	47	40	42	39
Brent	33	34	28	28	28	25	25	25	22
Hounslow	49	-	-	40	-	-	35	-	-
A3	56	63	58	42	49	49	37	40	39
Teddington	30	32	26	25	26	23	23	23	21
Hillingdon	55	45	31	41	37	26	36	35	23
Sutton Suburban	33	-	-	28	-	-	25	-	-
Bromley	49	52	52	41	42	41	37	35	34
Bexley	40	31	27	32	26	23	28	22	20
Eltham	38	32	29	30	26	24	26	22	21
S'wark Roadside	66	68	69	58	56	56	50	48	47
Average	**54**	**52**	**49**	**44**	**43**	**40**	**40**	**37**	**34**

Table 6.3. 99.79th percentile NO_2 concentrations at AURN sites for 2001, 2010 and 2020 (µg/m³)

	2001	2010	2020
Marylebone Road	193	162	149
Bloomsbury	164	137	131
Tower Hamlets	178	144	136
London Southwark	154	130	122
West London	133	117	113
North Kensington	139	121	118
Cromwell Road	172	137	130
Wandsworth	145	121	115
Camden	172	144	135
Hackney	163	135	127
Haringey	174	144	134
Brent	143	122	113
Hounslow	139	116	110
A3	166	133	124
Teddington	124	107	104
Hillingdon	168	125	121
Sutton Suburban	134	118	109
Bromley	161	130	122
Bexley	167	140	129
Eltham	161	133	126
Southwark Roadside	171	147	129
Average	**157**	**131**	**123**

Table 6.4. Annual average NO_2 concentration statistics for London, 2001 base year

	% of area exceeding 40µg/m³		**% of population exceeding 40µg/m³**		**Population weighted mean (µg/m³)**	
Model	ADMS (2001)	Netcen (2003)	ADMS (2001)	Netcen (2003)	ADMS (2001)	Netcen (2003)
2001	40	-	62	-	44.0	-
2003	-	14	-	23	-	36.6
2010	10	3	18	4	35.6	29.9
2020	5	2	10	2	31.2	26.9

Exceedences of the AQS objective value of 40µg/m³ are predicted to occur for all three modelled years. For the current situation, exceedences are widespread, covering the majority of central London, the area around Heathrow airport and along major roads out to the M25. By 2020, the area of exceedence is predicted to cover a much smaller area of central London, but still extend along the major roads out to the M25 and cover Heathrow airport.

The comparison of the ADMS-Urban and national model calculations shows projected future concentrations calculated using the national model are consistently lower than those calculated using ADMS-Urban and this is reflected in the projected areas of exceedence in 2010 and 2020.

Figures 6.7 to 6.9 show the 99.79th percentile of hourly average NO_2 concentrations for 2001, 2010 and 2020 respectively. The 99.79th percentile exceeds the AQS objective value of 200µg/m³ in 2001 along the majority of the M25 and in isolated areas in central London and along other major roads. By 2020, the only exceedences are predicted to occur at isolated locations along the M25.

Tables 6.5 to 6.7 show the contribution of major roads and other modelled primary emissions to the total annual average NO_x concentration at each of the AURN monitoring sites for 2001, 2010 and 2020, respectively. Note that the total annual average concentration includes a contribution from the background data, which is the same at each site.

Table 6.5 Source apportionment of NO_x at AURN sites for 2001 (μg/m³)

	Total	Major road		Other primary		Background	
	μg/m³	**μg/m³**	**%**	**μg/m³**	**%**	**μg/m³**	**%**
Marylebone Rd	333	280	84	35	11	18	5
Bloomsbury	148	53	36	77	52	18	12
Tower Hamlets	144	91	63	35	24	18	13
London S'wark	117	52	44	47	40	18	15
West London	95	48	51	29	31	18	19
N Kensington	92	36	39	38	41	18	20
Cromwell Road	230	141	61	71	31	18	8
Wandsworth	123	71	58	34	28	18	15
Camden	165	106	64	41	25	18	11
Hackney	104	49	47	37	36	18	17
Haringey	116	65	56	33	28	18	16
Brent	55	21	38	16	29	18	33
Hounslow	113	70	62	25	22	18	16
A3	153	118	77	17	11	18	12
Teddington	58	23	40	17	29	18	31
Hillingdon	133	94	71	21	16	18	14
Sutton Suburban	64	27	42	19	30	18	28
Bromley	114	73	64	23	20	18	16
Bexley	80	34	43	28	35	18	23
Eltham	77	33	43	26	34	18	23
S'wark Roadside	184	128	70	38	21	18	10
Average	**128**	**77**	**55**	**34**	**28**	**18**	**17**

Table 6.6 Source apportionment of NO_x at AURN sites for 2010 (μg/m³)

	Total	Major road		Other primary		Background	
	μg/m³	**μg/m³**	**%**	**μg/m³**	**%**	**μg/m³**	**%**
Marylebone Rd	215	173	80	30	14	12	6
Bloomsbury	88	28	32	48	55	12	14
Tower Hamlets	89	50	56	27	30	12	14
London S'wark	78	29	37	37	47	12	16
West London	68	25	37	30	44	12	18
N Kensington	63	19	30	32	51	12	20
Cromwell Road	125	82	66	30	24	12	10
Wandsworth	75	39	52	23	31	12	16
Camden	104	59	57	33	32	12	12
Hackney	65	27	42	26	40	12	19
Haringey	73	36	49	24	33	12	17
Brent	38	11	29	15	39	12	32
Hounslow	68	34	50	21	31	12	18
A3	78	52	67	14	18	12	16
Teddington	37	12	32	13	35	12	33
Hillingdon	67	42	63	13	19	12	18
Sutton Suburban	45	14	31	19	42	12	27
Bromley	73	39	53	21	29	12	17
Bexley	51	17	33	21	41	12	24
Eltham	48	17	35	19	40	12	26
S'wark Roadside	122	72	59	38	31	12	10
Average	**80**	**42**	**47**	**25**	**35**	**12**	**18**

Table 6.7 Source apportionment of NO_x at AURN sites for 2010 (µg/m³)

	Total	Major road		Other primary		Background	
	µg/m³	**µg/m³**	**%**	**µg/m³**	**%**	**µg/m³**	**%**
Marylebone Rd	174	136	78	29	17	10	6
Bloomsbury	78	21	27	47	60	10	12
Tower Hamlets	73	37	51	27	37	10	13
London S'wark	67	21	31	36	54	10	14
West London	59	19	32	30	51	10	16
N Kensington	56	14	25	32	57	10	17
Cromwell Road	107	67	63	31	29	10	9
Wandsworth	62	29	47	24	39	10	15
Camden	88	46	52	32	36	10	11
Hackney	55	20	36	26	47	10	17
Haringey	61	27	44	24	39	10	16
Brent	32	8	25	14	44	10	30
Hounslow	55	26	47	19	35	10	17
A3	64	40	63	14	22	10	15
Teddington	32	9	28	14	44	10	30
Hillingdon	55	31	56	14	25	10	17
Sutton Suburban	38	11	29	18	47	10	25
Bromley	61	30	49	21	34	10	16
Bexley	43	12	28	21	49	10	22
Eltham	41	12	29	19	46	10	23
S'wark Roadside	92	54	59	28	30	10	10
Average	**66**	**32**	**43**	**25**	**40**	**10**	**17**

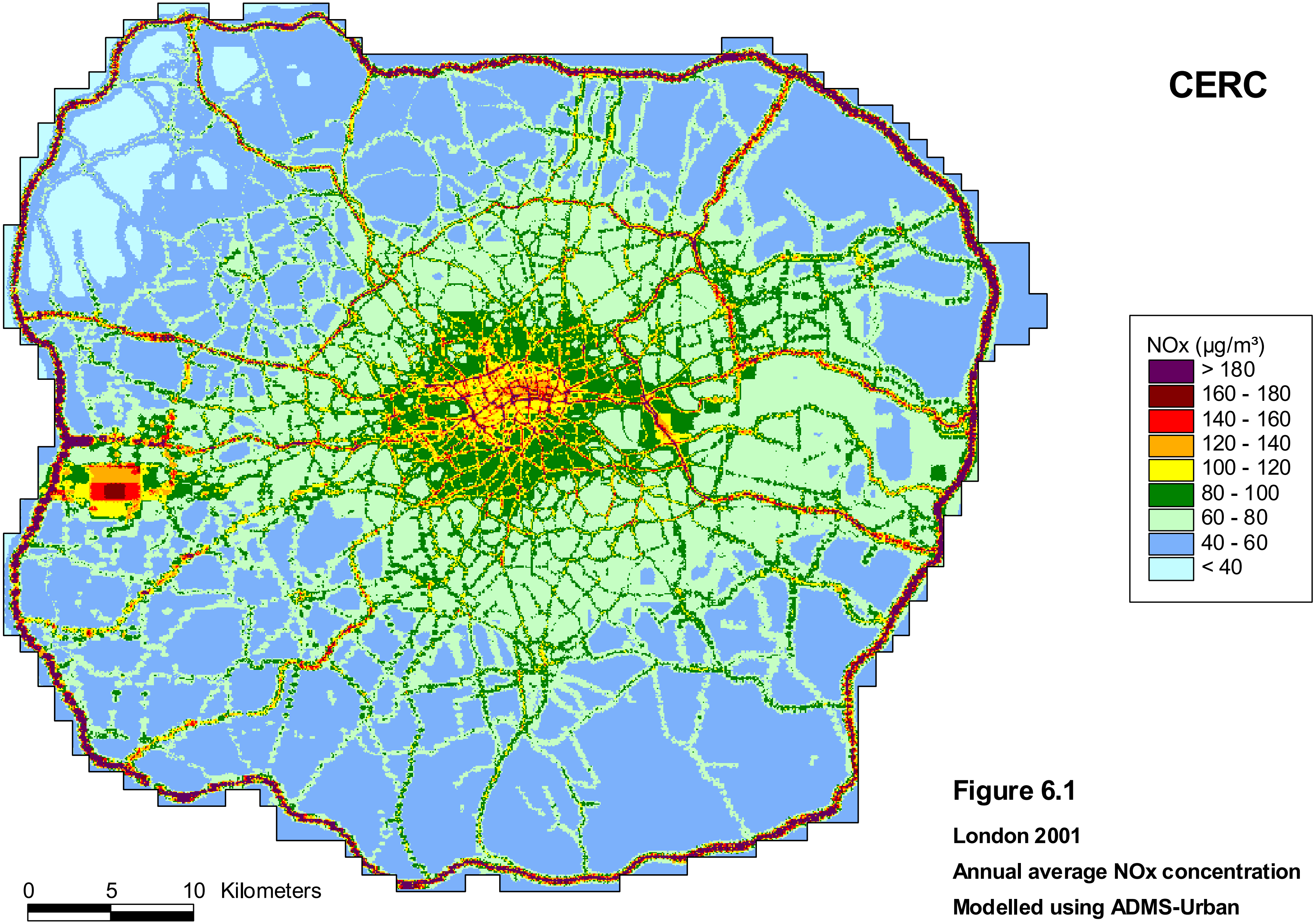

Figure 6.1

London 2001

Annual average NOx concentration

Modelled using ADMS-Urban

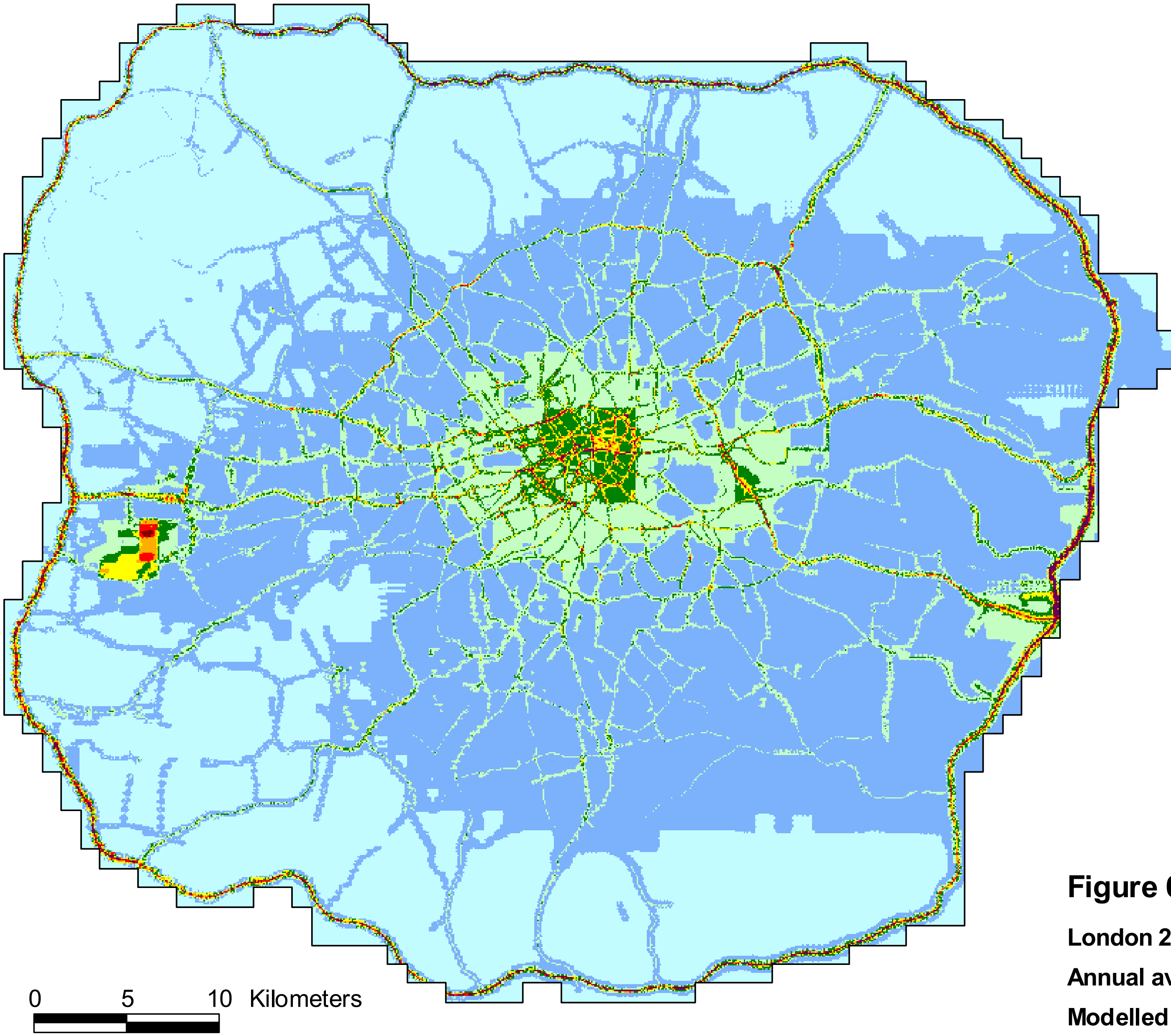

Figure 6.2

London 2010

Annual average NOx concentration

Modelled using ADMS-Urban

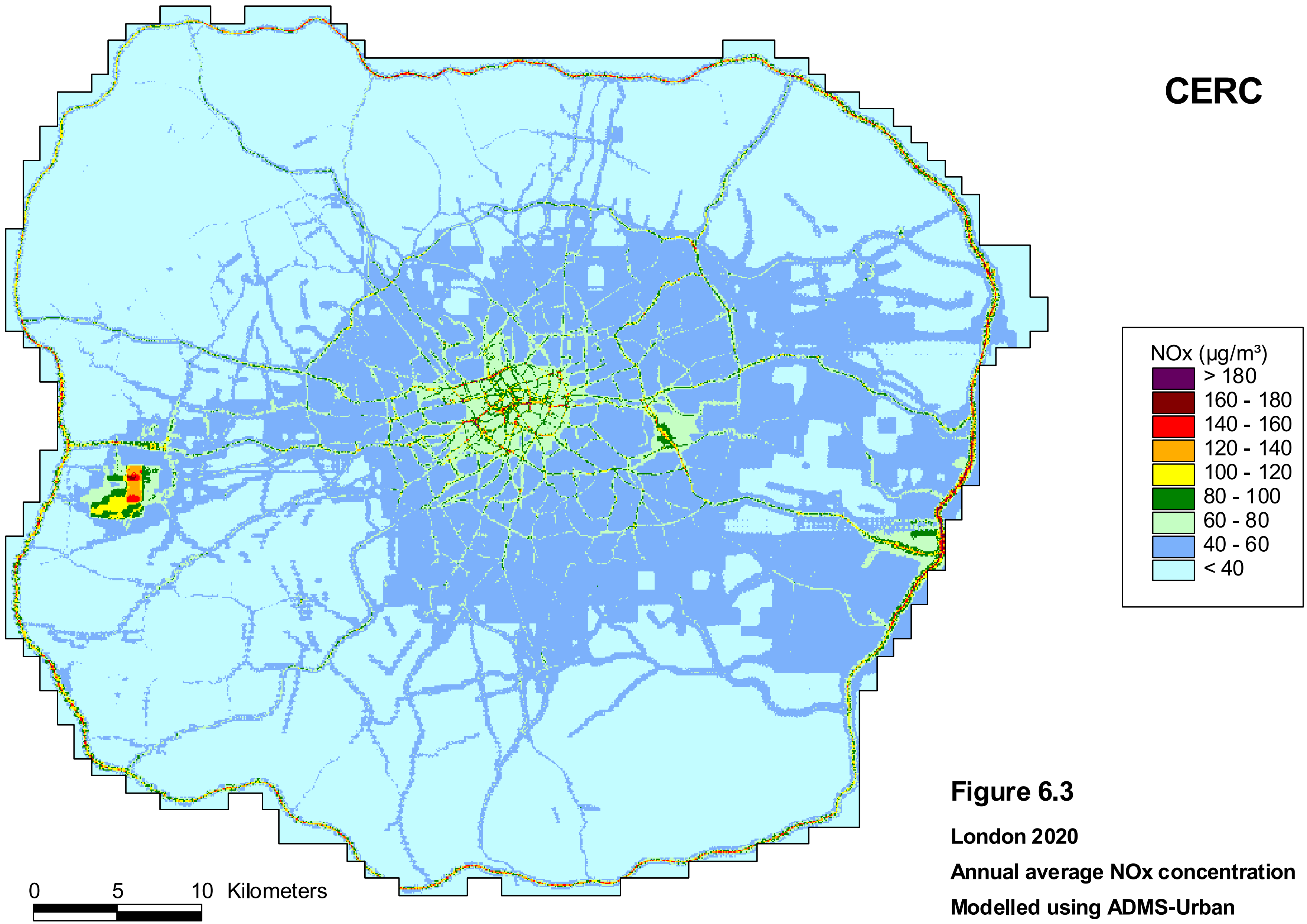

Figure 6.3

London 2020

Annual average NOx concentration

Modelled using ADMS-Urban

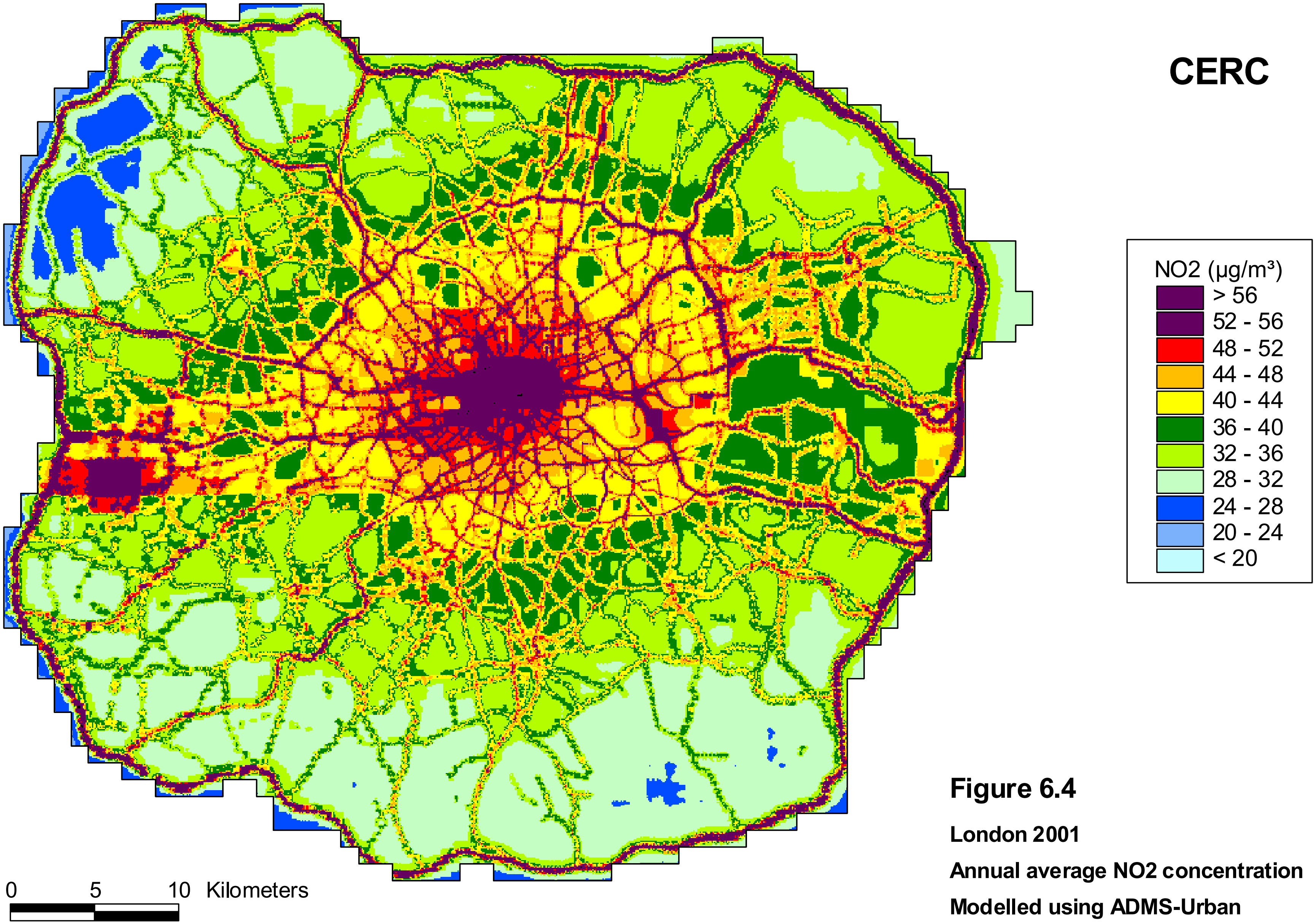

Figure 6.4

London 2001

Annual average NO2 concentration

Modelled using ADMS-Urban

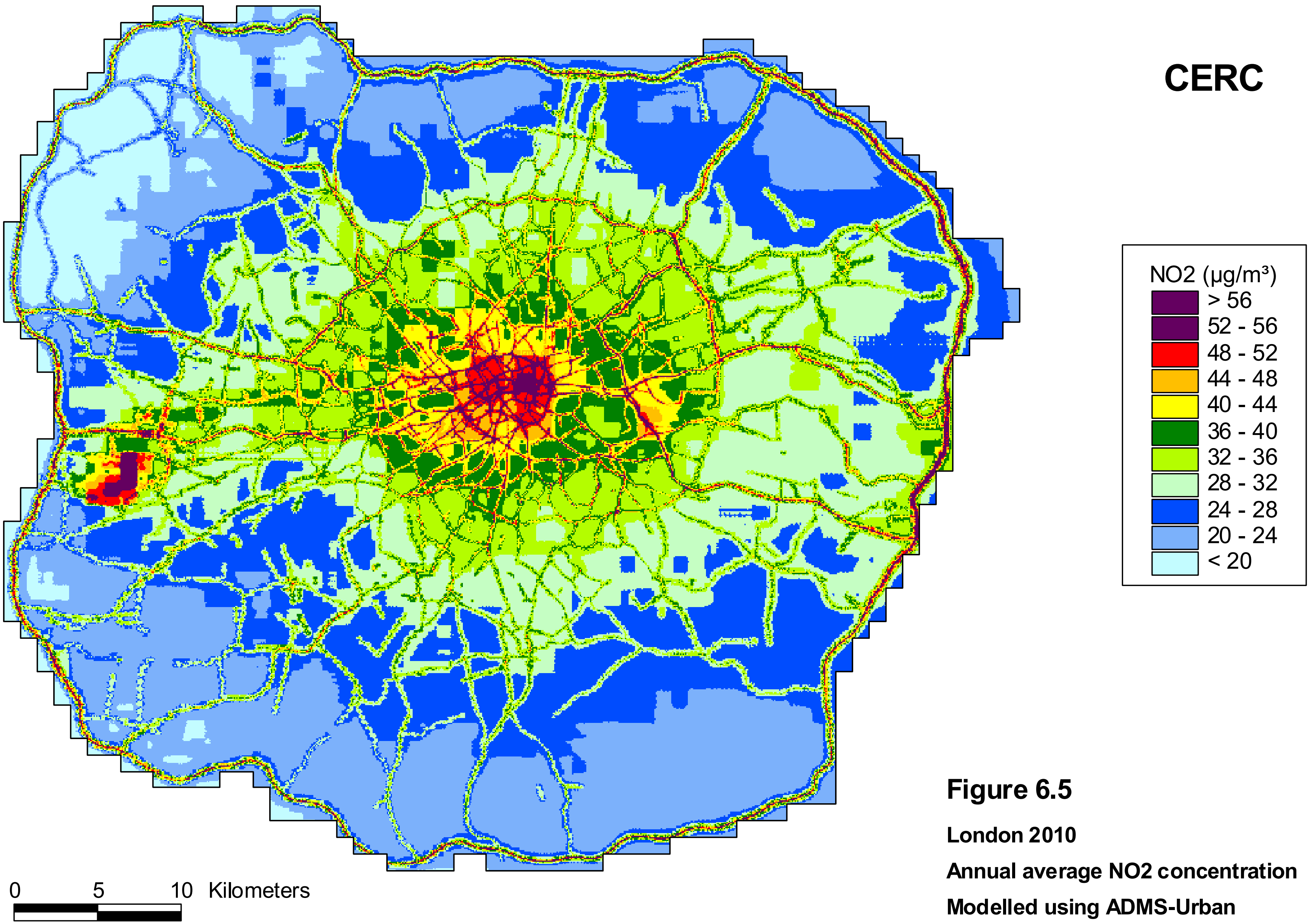

Figure 6.5

London 2010

Annual average NO2 concentration

Modelled using ADMS-Urban

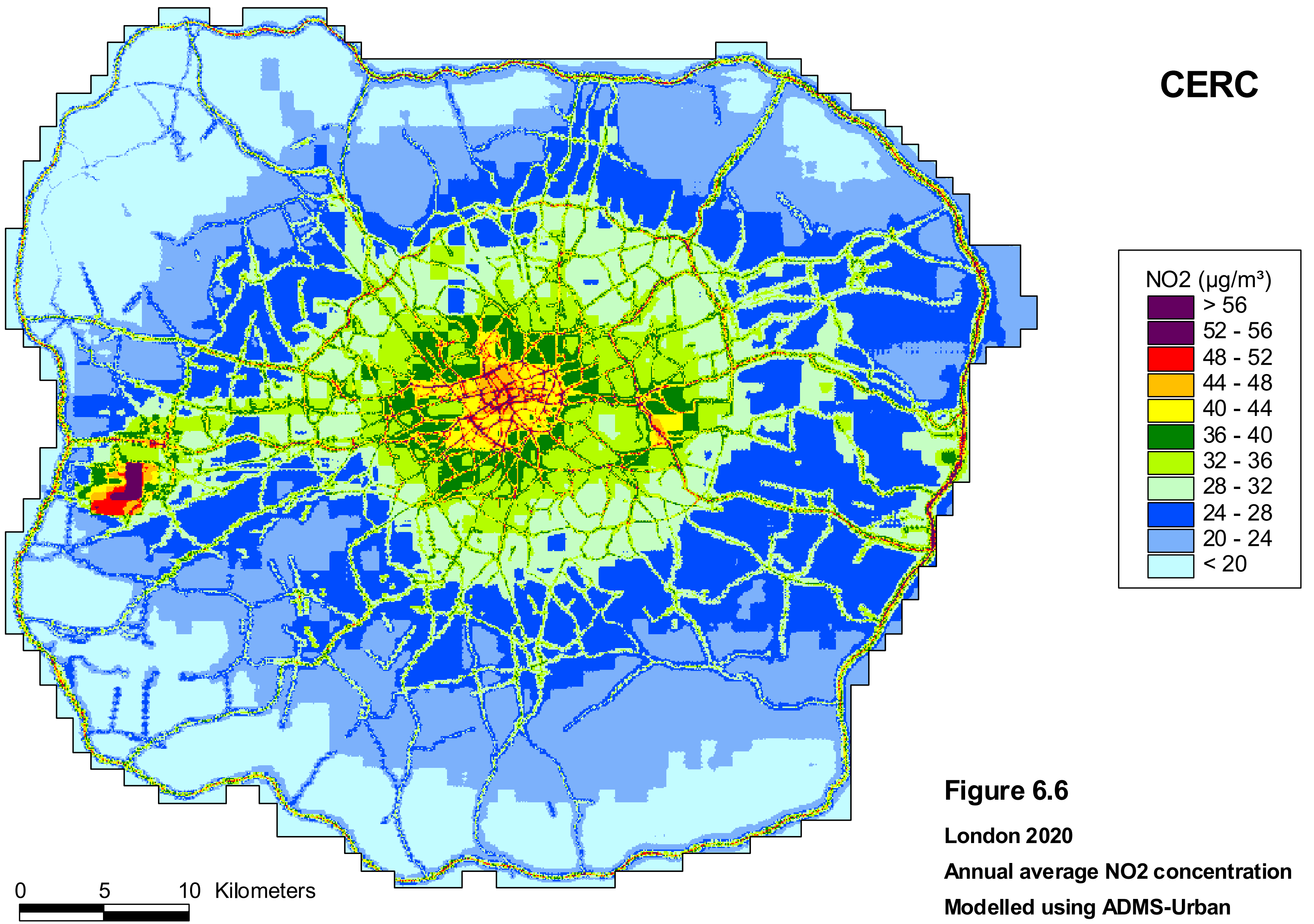

Figure 6.6

London 2020

Annual average NO2 concentration

Modelled using ADMS-Urban

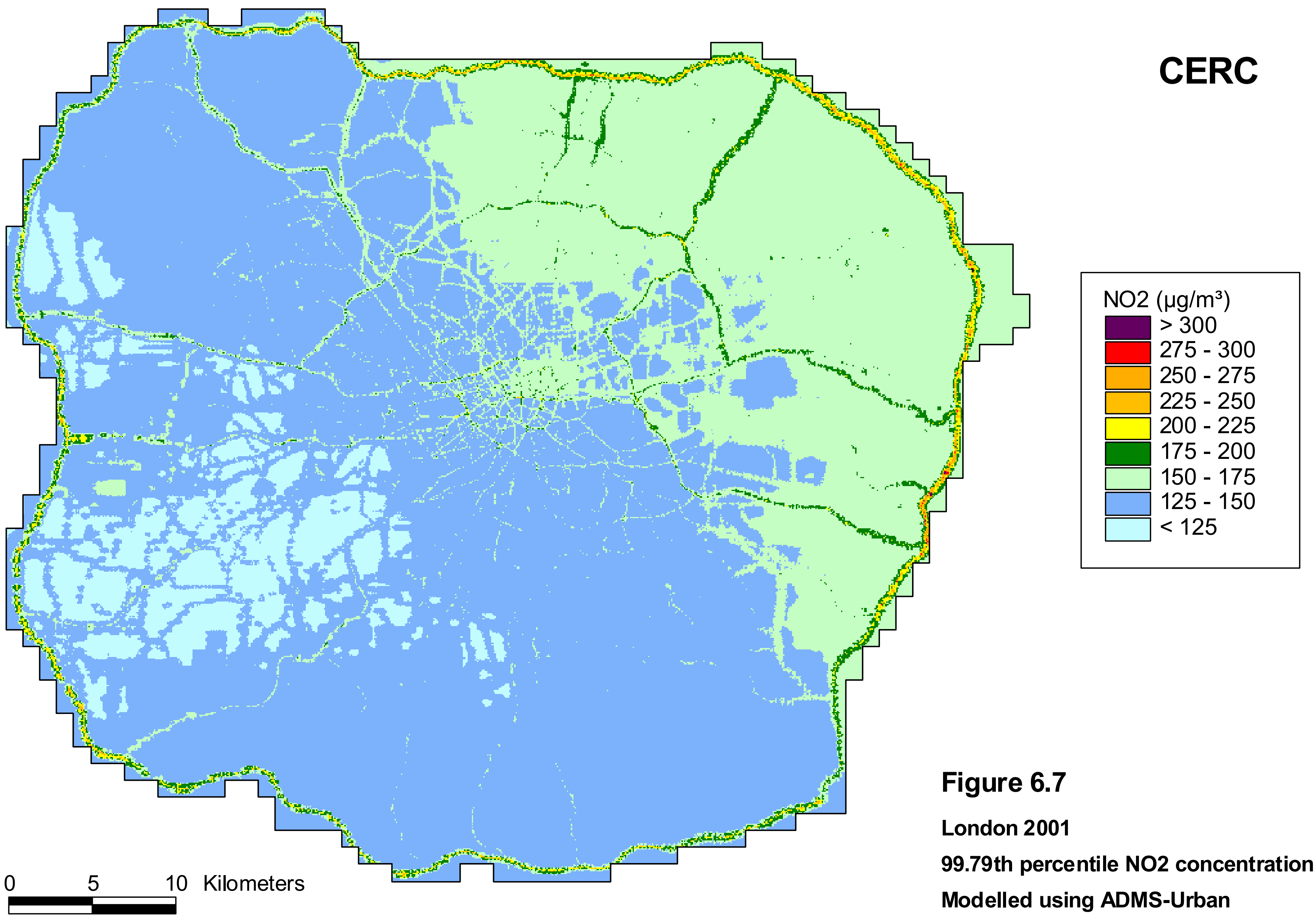

Figure 6.7

London 2001

99.79th percentile NO2 concentration

Modelled using ADMS-Urban

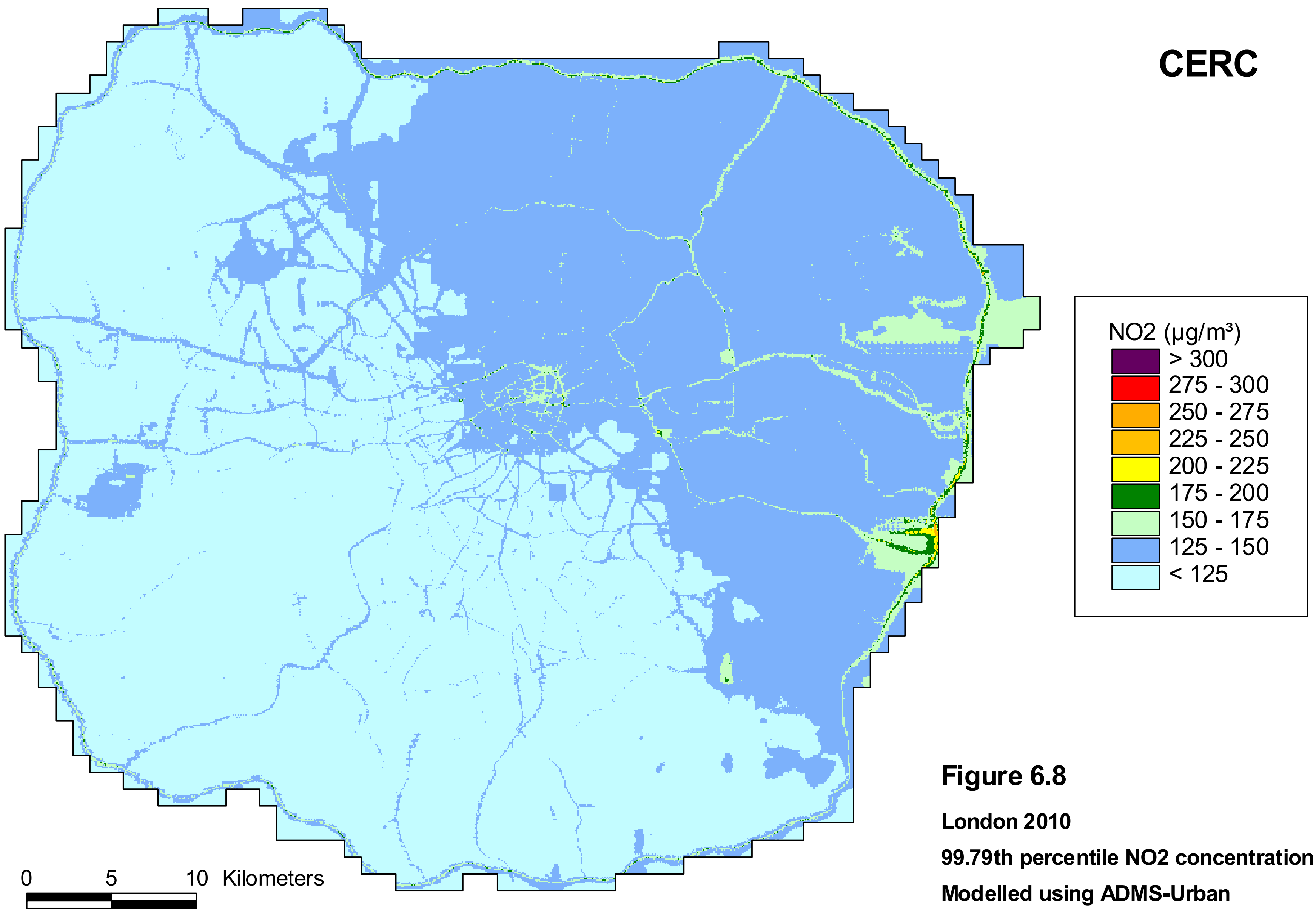

Figure 6.8

London 2010

99.79th percentile NO2 concentration

Modelled using ADMS-Urban

CERC

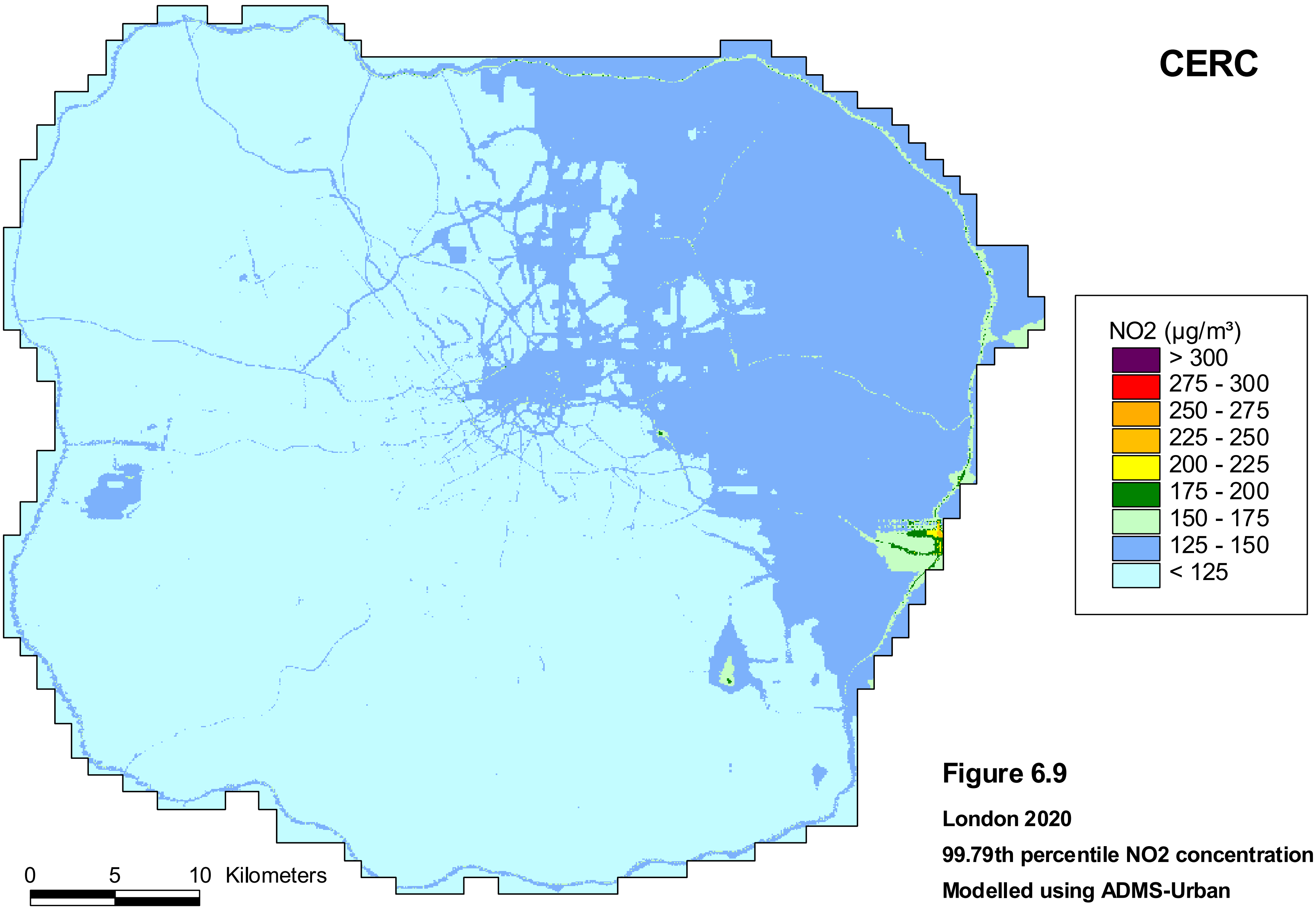

Figure 6.9

London 2020

99.79th percentile NO2 concentration

Modelled using ADMS-Urban

7. Projections and Source Apportionment of PM_{10}

Figures 7.1 to 7.3 show the modelled annual average PM_{10} concentrations for 2001, 2010 and 2020 respectively. The PM_{10} concentrations have been calculated using the second method described in Section 5.2, taking into account the additional sources of PM_{10} using a constant fraction of the primary modelled component. This additional component has been assumed to remain constant in future years.

The annual average PM_{10} concentration is predicted to exceed the AQS objective of 40µg/m³ only over a small area of central London. By 2010, there are not predicted to be any exceedences of the AQS objective value, with concentrations generally below 32µg/m³, apart from along some major roads. By 2020, concentrations in outer London are predicted to be below 20µg/m³ with concentrations in central London being below 28µg/m³ apart from along major roads.

Tables 7.1 to 7.3 show the population weighted mean PM_{10} concentration; the area of exceedence of certain threshold concentrations; and the population exposed to concentrations greater than these threshold values. Each statistic is given for the concentrations calculated using both methods described in Section 5.2 (labelled Nov 05 and Feb06), and those calculated by the national model with a 2003 base year.

Table 7.1. Population-weighted mean annual average PM_{10} concentration (µg/m³)

	ADMS Nov 05	ADMS Feb06	netcen
2001	25.8	25.2	-
2003	-	-	25.8
2010	20.3	20.9	22.7
2020	18.0	19.1	20.9

Table 7.2. Percentage of area of London which exceeds annual average PM_{10} thresholds

	% of area exceeding 40µg/m³			% of area exceeding 31.5µg/m³			% of area exceeding 23µg/m³			% of area exceeding 20µg/m³		
	ADMS Nov 05	ADMS Feb 06	netcen	ADMS Nov 05	ADMS Feb 06	netcen	ADMS Nov 05	ADMS Feb 06	netcen	ADMS Nov 05	ADMS Feb 06	netcen
2001	0	0.1	-	1	1.7	-	98	73	-	100	100	-
2003	-	-	0	-	-	0	-	-	-	-	-	100
2010	0	0	0	0	0.1	0	2	6.1	-	37	50	100
2020	0	0	0	0	0	0	0	1.9	-	3	13	80

Table 7.3. Percentage of London population exposed to annual average PM_{10} concentrations greater than thresholds

	% of area exceeding 40µg/m³			% of area exceeding 31.5µg/m³			% of area exceeding 23µg/m³			% of area exceeding 20µg/m³		
	ADMS Nov 05	ADMS Feb 06	netcen	ADMS Nov 05	ADMS Feb 06	netcen	ADMS Nov 05	ADMS Feb 06	netcen	ADMS Nov 05	ADMS Feb 06	netcen
2001	0	0	-	1	2.2	-	98	100	-	100	100	-
2003	-	-	0	-	-	0	-	-	-	-	-	100
2010	0	0	0	0	0	0	2	3	-	55	68	100
2020	0	0	0	0	0	0	0	1	-	4	20	90

Figures 7.4 to 7.6 show the 90.41st percentile of 24-hour average PM_{10} concentrations for 2001, 2010 and 2020 respectively. Concentrations are predicted to exceed the AQS objective value of 50µg/m³ along many of the major roads in central London, the busiest of the outer London roads and along the majority of the M25. By 2010 the areas of exceedence have decreased to isolated areas along some major roads and by 2020 have disappeared entirely.

Table 7.4 shows the annual average PM_{10} concentrations for the base year at each of the AURN monitoring sites for the two sets of ADMS-Urban calculations and for the national model calculations using base years of 2003 and 2004. Note that the ADMS-Urban and national model calculations are not directly comparable in this case due to the consideration of different years. Table 7.5 shows the projected annual average concentrations for 2010 and 2020 calculated using ADMS-Urban (the second method) and using the national model with base years of 2003 and 2004. Table 7.6 shows the 90.41st percentile of 24-hour average PM_{10} concentrations for 2001, 2010 and 2020 calculated using ADMS-Urban.

Table 7.4. Annual average PM_{10} concentrations at AURN sites for 2001 (µg/m³)

	2001		**2003**	**2004**
	ADMS Nov 05	**ADMS Feb 06**	**netcen**	**netcen**
Marylebone Road	43.3	46.5	47.1	41.7
Bloomsbury	27.4	28.5	31.3	28.4
Camden	31.7	30.4	36.6	33.0
Haringey	28.0	29.3	31.6	30.5
North Kensington	25.4	25.7	28.5	25.8
Bexley	24.4	24.2	25.8	23.9
Eltham	24.2	24.0	25.2	24.0
Brent	23.3	22.7	25.6	24.6
A3	29.2	27.0	34.3	31.4
Hillingdon	25.4	25.5	28.1	25.7
Average	**28.2**	**28.4**	**31.4**	**28.9**

Table 7.5. PM_{10} concentrations at AURN sites for 2010 and 2020 (µg/m³)

	2010			**2020**		
	ADMS Feb06	**netcen 2003**	**netcen 2004**	**ADMS Feb06**	**netcen 2003**	**netcen 2004**
Marylebone Rd	34.8	37.4	35.1	32.1	33.4	32.5
Bloomsbury	24.0	26.9	25.3	22.1	25.0	23.1
Camden	24.6	29.0	28.1	22.6	25.8	25.9
Haringey	24.3	26.5	25.4	22.3	24.2	23.5
N. Kensington	21.6	24.8	23.2	19.8	22.9	21.3
Bexley	20.2	22.8	21.6	18.4	21.1	19.8
Eltham	20.1	22.1	21.6	18.3	20.3	19.8
Brent	19.1	22.5	22.3	17.4	20.7	20.5
A3	22.0	29.5	27.8	20.1	26.6	25.6
Hillingdon	20.9	25.0	23.1	19.0	23.5	21.3
Average	**23.2**	**26.7**	**25.3**	**21.2**	**24.3**	**23.3**

Table 7.6. 90.41st percentile PM_{10} concentrations at AURN sites for 2001, 2010 and 2020 (µg/m³)

	2001	2010	2020
Marylebone Road	61.8	46.8	42.0
Bloomsbury	42.6	36.0	32.4
Camden	44.8	36.5	32.6
Haringey	43.3	36.0	32.2
North Kensington	39.3	33.9	29.9
Bexley	38.0	31.7	28.2
Eltham	38.4	32.4	28.7
Brent	36.9	30.3	26.8
A3	42.7	34.7	31.0
Hillingdon	39.1	32.3	29.3
Average	**42.7**	**35.1**	**31.3**

Tables 7.7 to 7.9 show the breakdown of the total annual average PM_{10} concentrations into contributions from different source groups in 2001, 2010 and 2020, respectively. The groups considered are major roads; other modelled primary emissions; the additional component calculated from the total primary contribution in 2001; and the rural background contribution.

Table 7.7. Source apportionment of PM_{10} at AURN sites for 2001 (µg/m³)

	Total	Major road		Other primary		Additional		Background	
	µg/m³	µg/m³	%	µg/m³	%	µg/m³	%	µg/m³	%
Marylebone Rd	46.5	17.1	37	2.7	6	7.6	16	19.2	41
Bloomsbury	28.5	2.7	9	4.2	15	2.7	9	19.2	67
Camden	30.4	5.0	16	3.1	10	3.1	10	19.2	63
Haringey	29.3	3.0	10	4.2	14	2.8	10	19.2	65
N. Kensington	25.7	1.6	6	3.1	12	1.8	7	19.2	75
Bexley	24.2	1.3	5	2.3	10	1.4	6	19.2	79
Eltham	24.0	1.4	6	2.2	9	1.4	6	19.2	80
Brent	22.7	0.8	4	1.7	7	1	4	19.2	84
A3	27.0	4.0	15	1.6	6	2.2	8	19.2	71
Hillingdon	25.5	3.1	12	1.4	5	1.7	7	19.2	75
Average	**28.4**	**4.0**	**12**	**2.7**	**9**	**2.6**	**8**	**19.2**	**70**

Table 7.8. Source apportionment of PM_{10} at AURN sites for 2010 (µg/m³)

	Total	Major road		Other primary		Additional		Background	
	µg/m³	µg/m³	%	µg/m³	%	µg/m³	%	µg/m³	%
Marylebone Rd	34.8	8.4	24	2.6	7	7.6	22	16.2	47
Bloomsbury	24.0	1.2	5	4	17	2.7	11	16.2	68
Camden	24.6	2.5	10	2.7	11	3.1	13	16.2	66
Haringey	24.3	1.4	6	3.9	16	2.8	12	16.2	67
N. Kensington	21.6	0.8	4	2.8	13	1.8	8	16.2	75
Bexley	20.2	0.6	3	2	10	1.4	7	16.2	80
Eltham	20.1	0.7	3	1.9	9	1.4	7	16.2	81
Brent	19.1	0.4	2	1.5	8	1	5	16.2	85
A3	22.0	2.2	10	1.5	7	2.2	10	16.2	74
Hillingdon	20.9	1.7	8	1.3	6	1.7	8	16.2	78
Average	**23.2**	**2.0**	**8**	**2.4**	**10**	**2.6**	**10**	**16.2**	**72**

Table 7.9. Source apportionment of PM_{10} at AURN sites for 2020 (µg/m³)

	Total	Major road		Other primary		Additional		Background	
	µg/m³	µg/m³	%	µg/m³	%	µg/m³	%	µg/m³	%
Marylebone Rd	32.1	7.4	23	2.5	8	7.6	24	14.6	45
Bloomsbury	22.1	1.0	5	3.9	18	2.7	12	14.6	66
Camden	22.6	2.2	10	2.6	12	3.1	14	14.6	65
Haringey	22.3	1.1	5	3.8	17	2.8	13	14.6	65
N. Kensington	19.8	0.6	3	2.7	14	1.8	9	14.6	74
Bexley	18.4	0.5	3	1.9	10	1.4	8	14.6	79
Eltham	18.3	0.6	3	1.8	10	1.4	8	14.6	80
Brent	17.4	0.4	2	1.4	8	1	6	14.6	84
A3	20.1	1.9	9	1.4	7	2.2	11	14.6	73
Hillingdon	19.0	1.5	8	1.2	6	1.7	9	14.6	77
Average	**21.2**	**1.7**	**7**	**2.3**	**11**	**2.6**	**11**	**14.6**	**71**

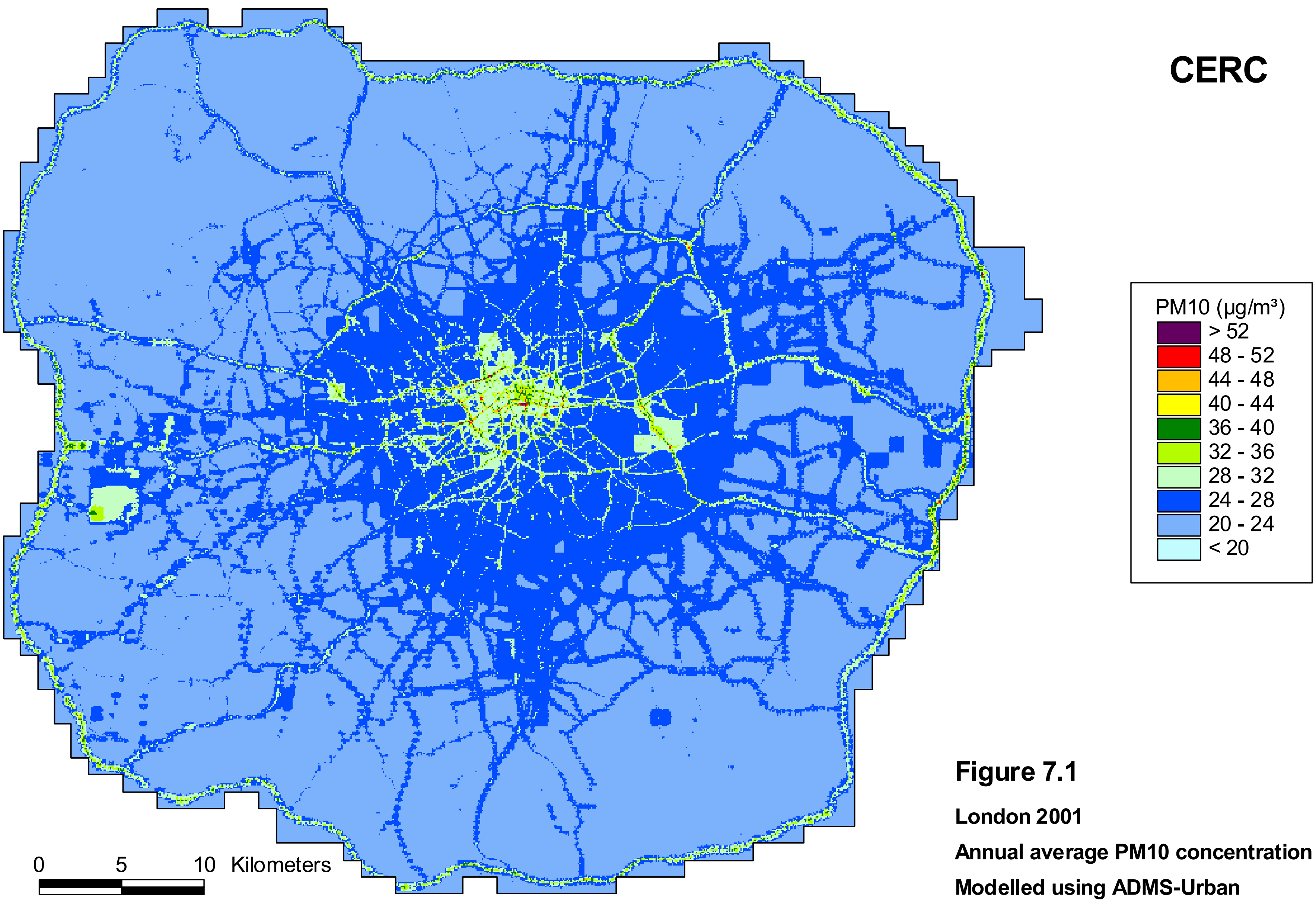

Figure 7.1

London 2001

Annual average PM10 concentration

Modelled using ADMS-Urban

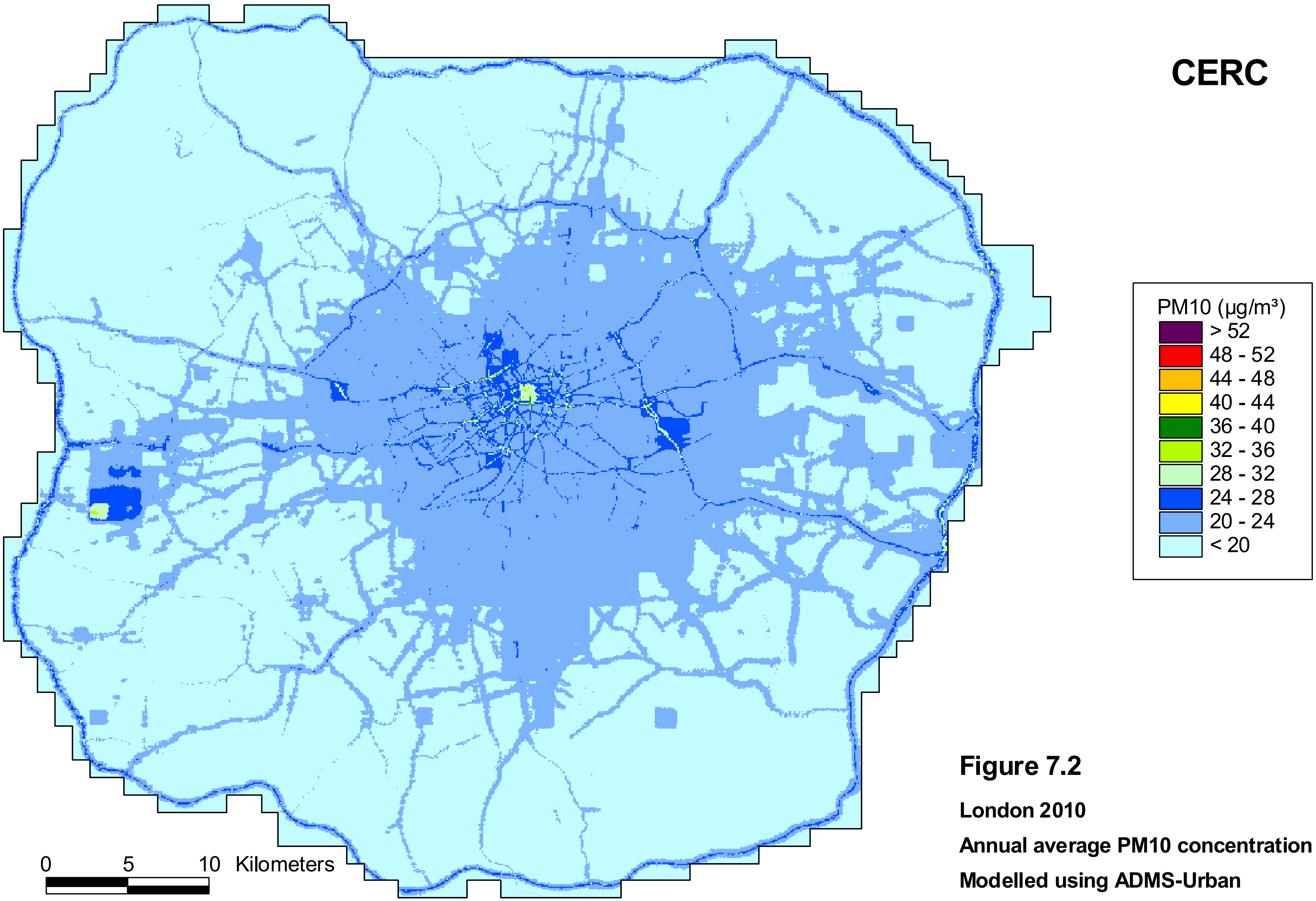

Figure 7.2

London 2010

Annual average PM10 concentration

Modelled using ADMS-Urban

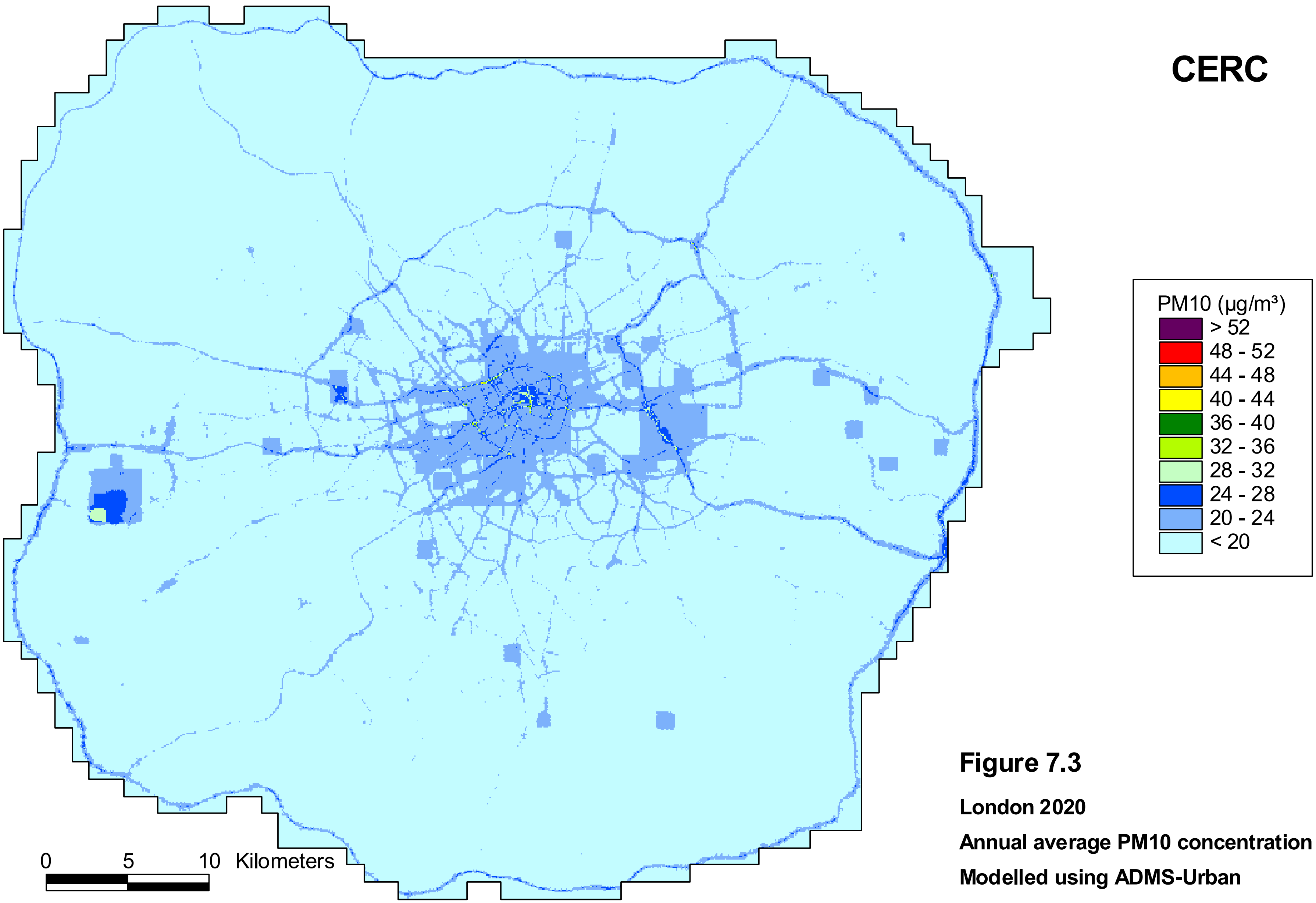

Figure 7.3

London 2020

Annual average PM10 concentration

Modelled using ADMS-Urban

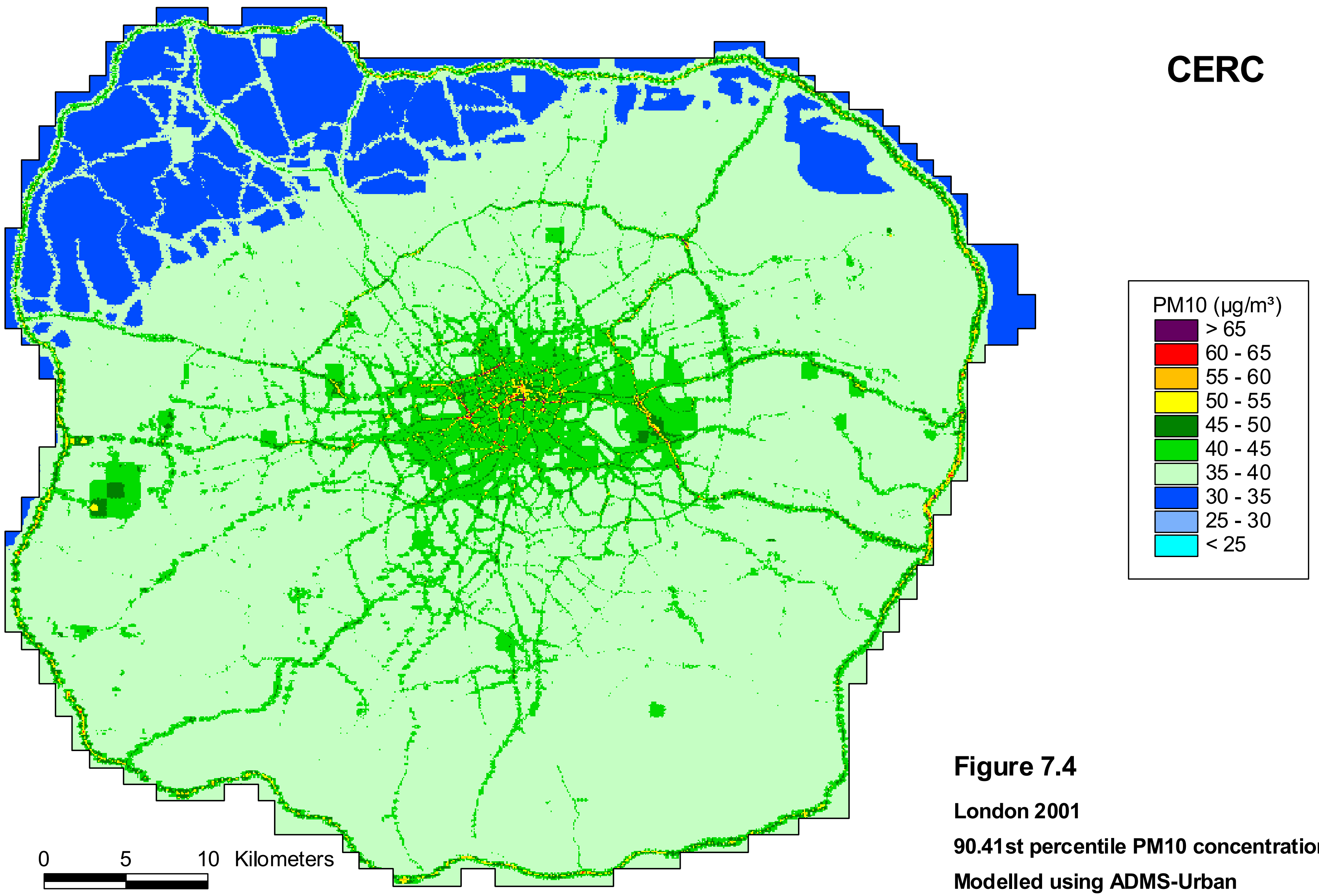

Figure 7.4

London 2001

90.41st percentile PM10 concentration

Modelled using ADMS-Urban

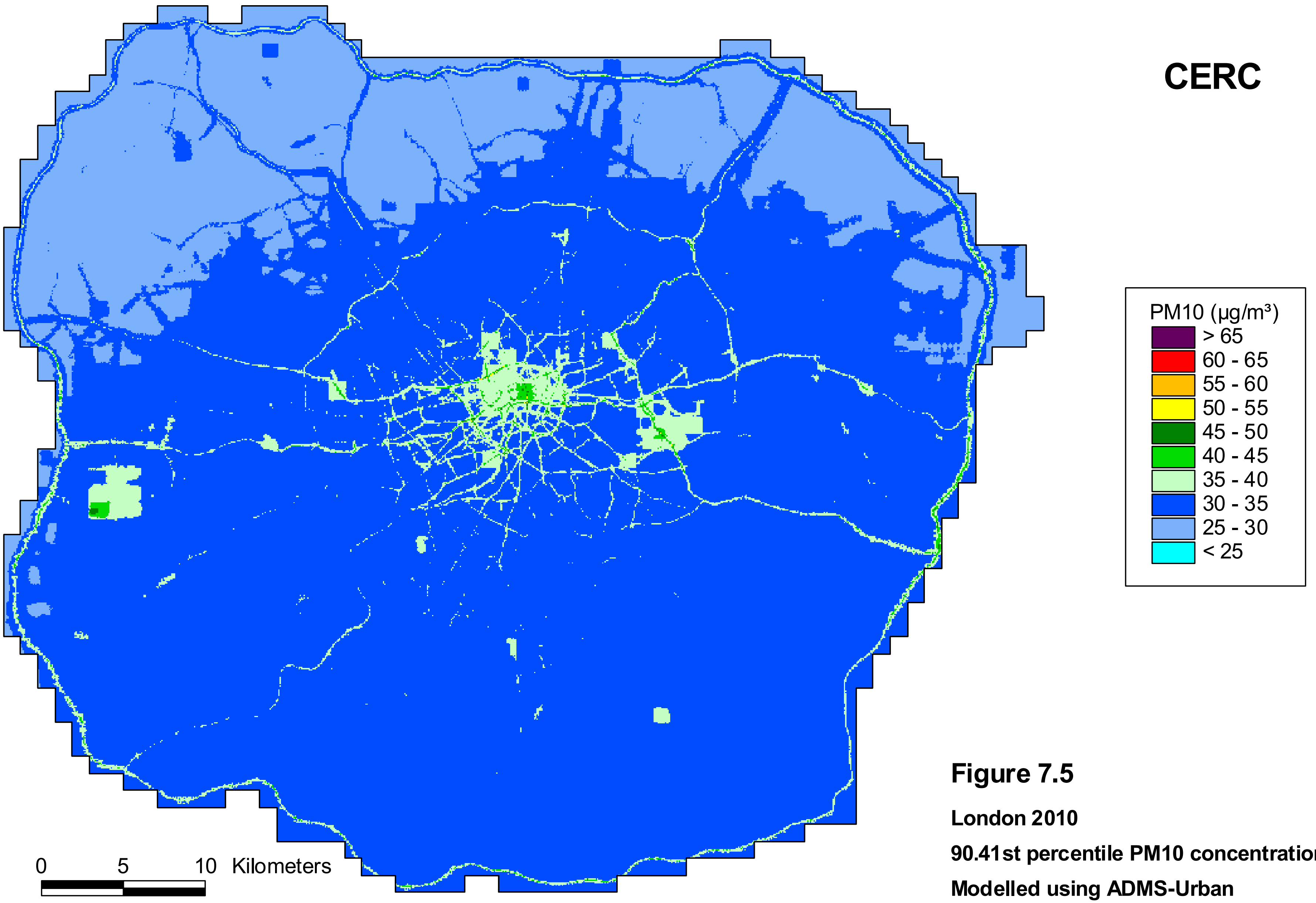

Figure 7.5

London 2010

90.41st percentile PM10 concentration

Modelled using ADMS-Urban

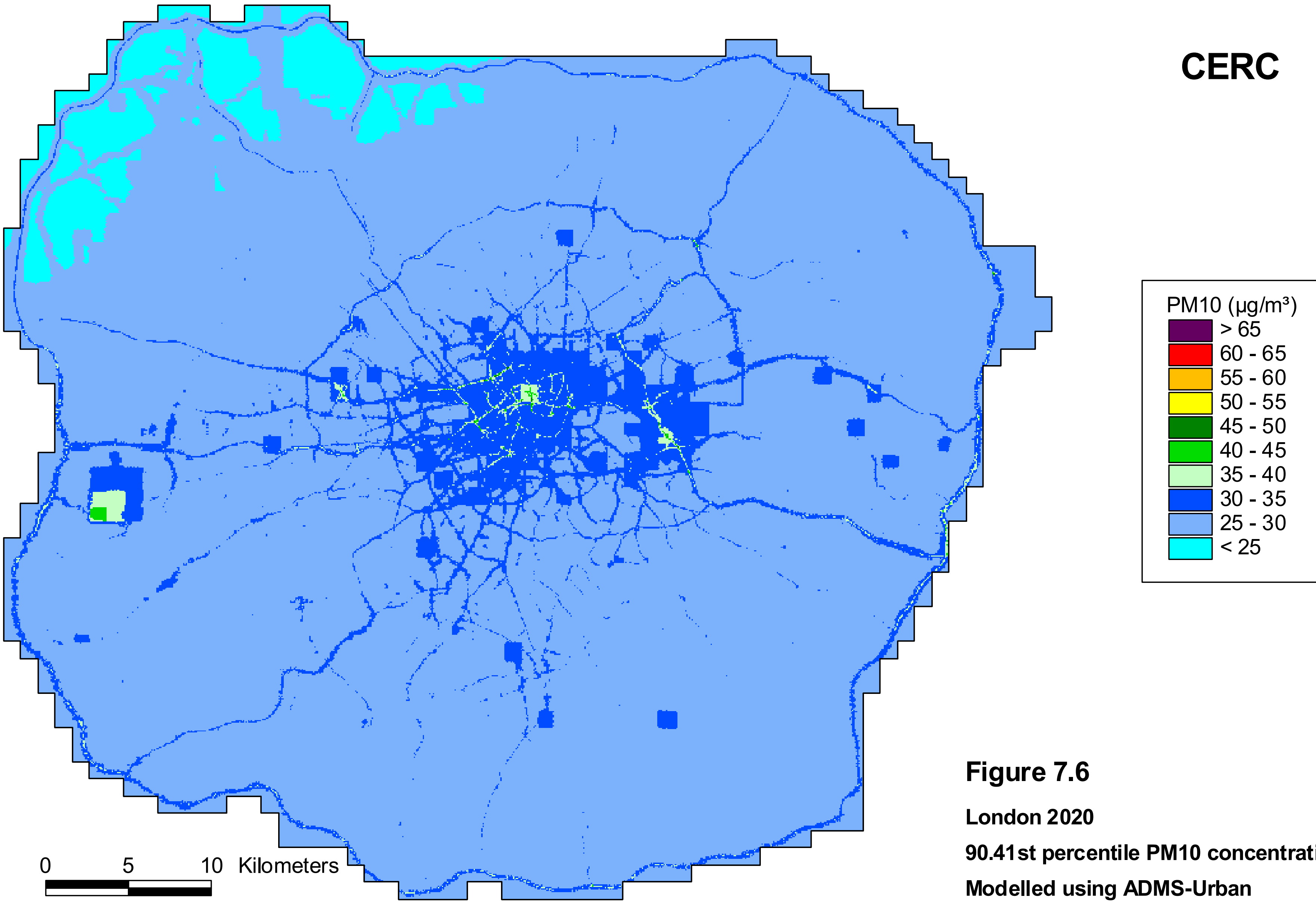

Figure 7.6

London 2020

90.41st percentile PM10 concentration

Modelled using ADMS-Urban

8. Projections of $PM_{2.5}$

Figures 8.1 to 8.3 show the modelled annual average PM_{10} concentrations for 2001, 2010 and 2020 respectively. Concentrations over the majority of London in 2001 are predicted to be between 14 and 18µg/m³, with concentrations rising to greater than 24µg/m³ on major roads in central London and along sections of the M25. By 2020, concentrations are predicted to be generally below 16µg/m³ apart from along major roads.

Table 8.1 shows the annual average $PM_{2.5}$ concentrations at the two AURN sites at which it is measured calculated using the two methods described in Section 5.2.

Table 8.1 $PM_{2.5}$ concentrations at AURN sites for 2001, 2010 and 2020 (µg/m³)

	Annual average (µg/m³)					
	2001		**2010**		**2020**	
	Nov 05	**Feb 06**	**Nov 05**	**Feb 06**	**Nov 05**	**Feb 06**
Marylebone Road	32.8	32.8	21.9	22.1	18.7	19.7
Bloomsbury	20.2	19.2	15.4	15.2	13.5	13.6

Tables 8.2 to 8.4 show the breakdown of the total annual average $PM_{2.5}$ concentrations into contributions from different source groups in 2001, 2010 and 2020, respectively. The groups considered are major roads; other modelled primary emissions; the additional component calculated from the total primary contribution in 2001; and the rural background contribution.

Table 8.2. Source apportionment of PM_{10} at AURN sites for 2001 (µg/m³)

	Total	**Major road**		**Other primary**		**Additional**		**Background**	
	µg/m³	**µg/m³**	**%**	**µg/m³**	**%**	**µg/m³**	**%**	**µg/m³**	**%**
Marylebone Rd	32.8	15.4	47	1.8	5	1.7	5	13.9	42
Bloomsbury	19.2	2.4	13	2.3	12	0.6	3	13.9	72

Table 8.3. Source apportionment of PM_{10} at AURN sites for 2010 (µg/m³)

	Total	**Major road**		**Other primary**		**Additional**		**Background**	
	µg/m³	**µg/m³**	**%**	**µg/m³**	**%**	**µg/m³**	**%**	**µg/m³**	**%**
Marylebone Rd	22.1	7.6	34	1.4	6	1.7	8	11.4	52
Bloomsbury	15.2	1.0	7	2.2	14	0.6	4	11.4	75

Table 8.4. Source apportionment of PM_{10} at AURN sites for 2020 (µg/m³)

	Total	**Major road**		**Other primary**		**Additional**		**Background**	
	µg/m³	**µg/m³**	**%**	**µg/m³**	**%**	**µg/m³**	**%**	**µg/m³**	**%**
Marylebone Rd	19.7	6.7	34	1.4	7	1.7	9	9.9	50
Bloomsbury	13.6	0.9	7	2.2	16	0.6	4	9.9	73

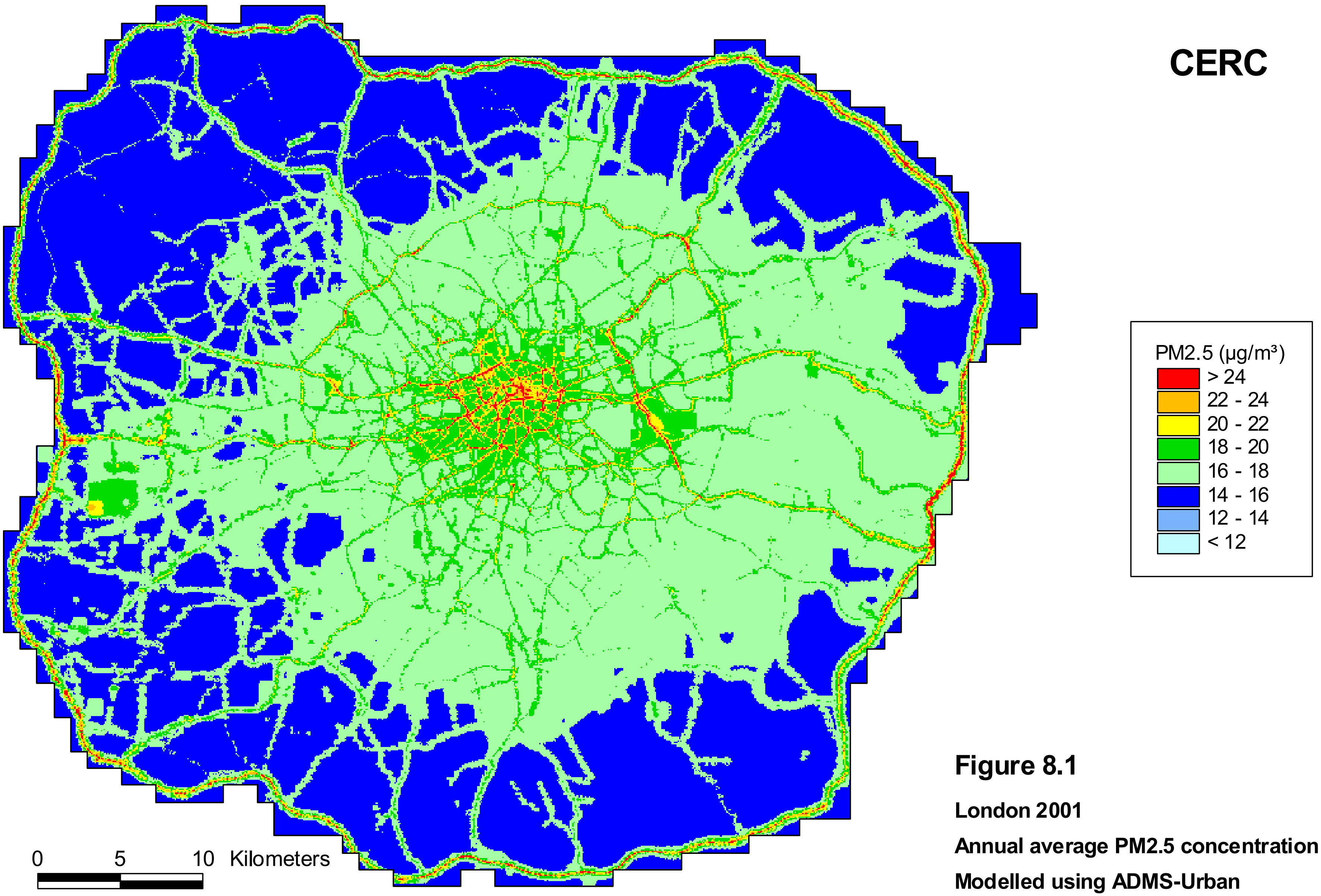

Figure 8.1

London 2001

Annual average PM2.5 concentration

Modelled using ADMS-Urban

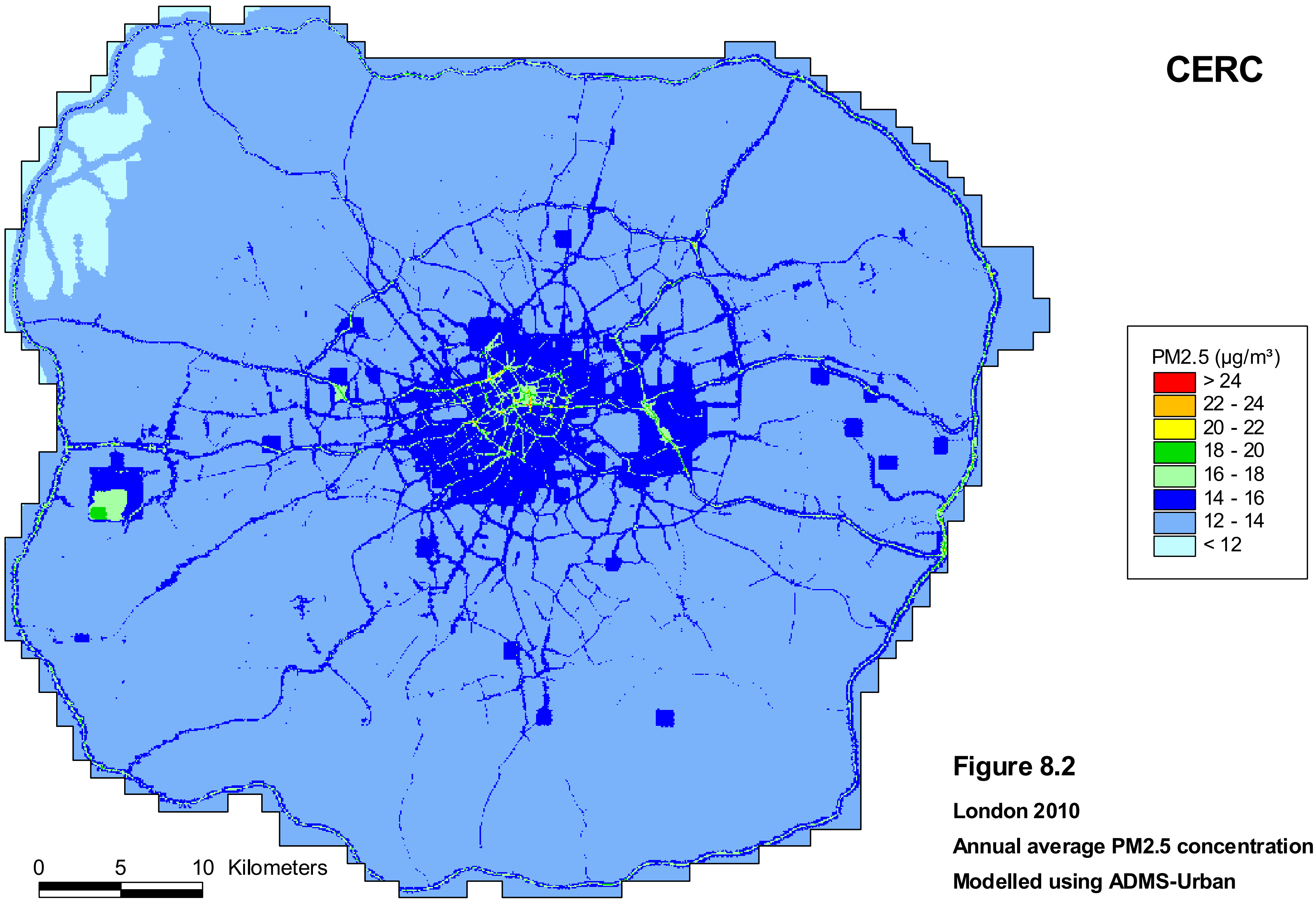

Figure 8.2

London 2010

Annual average PM2.5 concentration

Modelled using ADMS-Urban

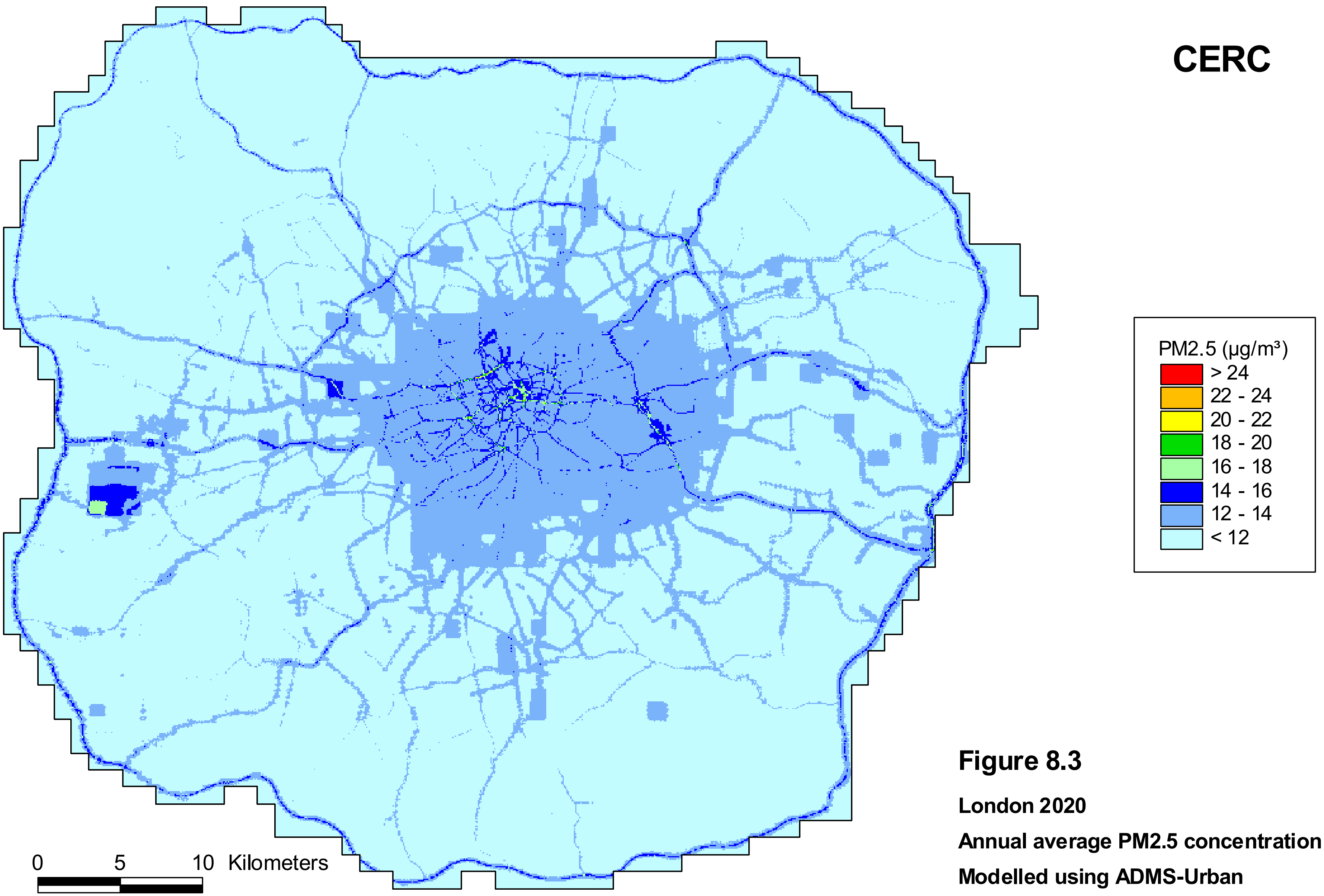

Figure 8.3

London 2020

Annual average PM2.5 concentration

Modelled using ADMS-Urban

9. Projections of Ozone

Figures 9.1 to 9.3 show the modelled annual average ozone concentrations for 2001, 2010 and 2020 respectively. Table 9.1 shows the annual average ozone concentration predicted at each of the AURN monitoring sites for 2001, 2010 and 2020. In 2001 concentrations range from 40µg/m³ in the outskirts of London to less than 20µg/m³ in central London. In future years, ozone concentrations in London are predicted to increase. By 2020 concentrations are predicted to rise to more than 52µg/m³ in the outskirts of London and are at a minimum of approximately 20µg/m³ along major roads in central London.

Table 9.2 Measured and modelled annual average O_3 concentrations (µg/m³)

	2001	**2010**	**2020**
Marylebone Road	11	12	15
Bloomsbury	21	26	28
Hackney	27	32	35
London Southwark	26	30	32
North Kensington	28	32	34
Wandsworth	25	30	34
Eltham	36	41	44
Bexley	34	39	42
Brent	37	42	45
Hillingdon	38	32	36
Teddington	24	45	47
Average	**28**	**33**	**36**

Figures 9.4 to 9.6 show the mean of the daily maximum 8-hour rolling average concentration; Figures 9.7 to 9.9 show the maximum 8-hour rolling average concentration; Figures 9.10 to 9.12 show the mean of those daily maximum 8-hour average concentrations which exceed 70µg/m³; Figures 9.13 to 9.15 show the mean of those daily maximum 8-hour average concentrations which exceed 100µg/m³; and Figures 9.16 to 9.18 show the number of days per year during which the rolling 8-hour average concentration exceeds 100µg/m³.

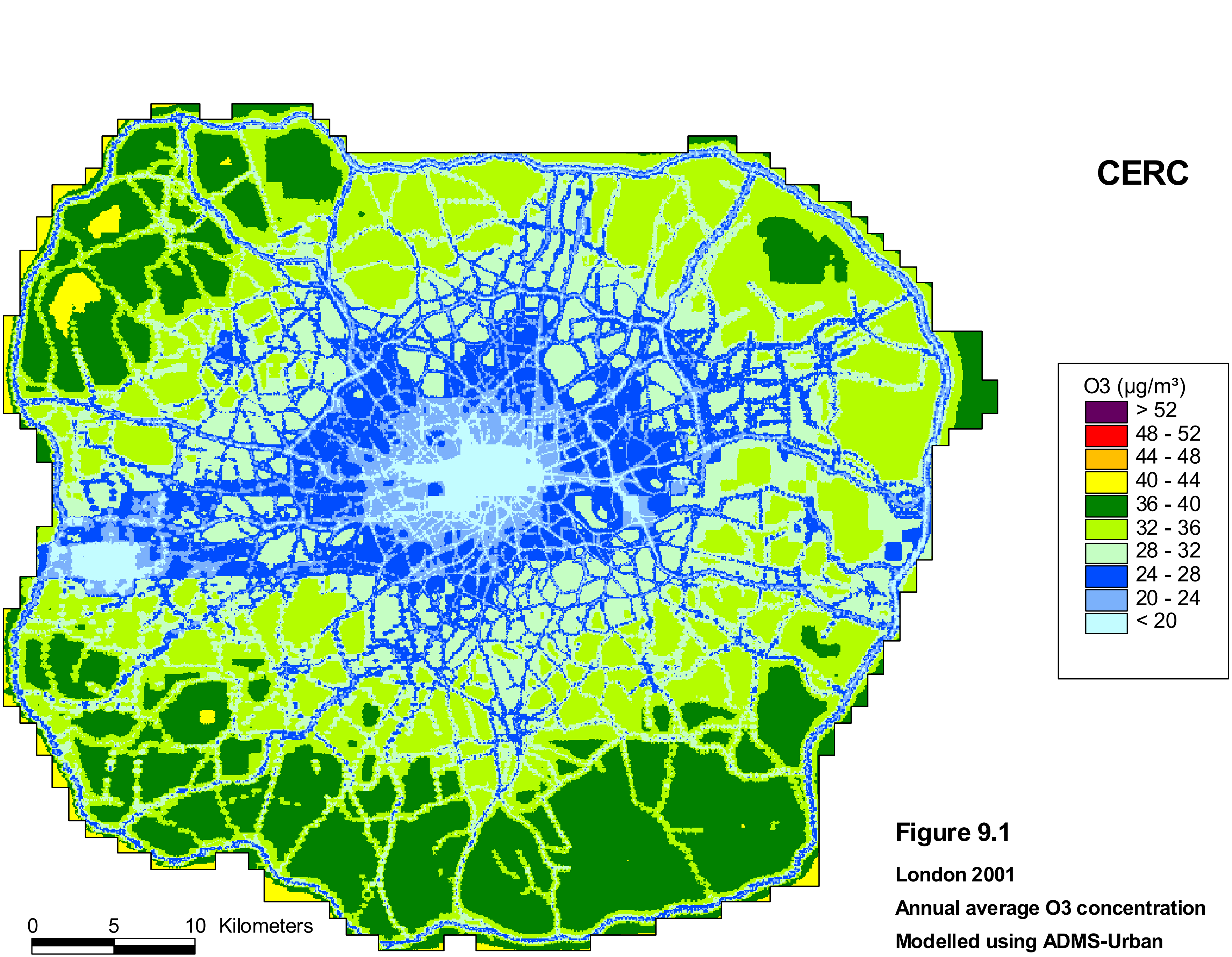

Figure 9.1

London 2001

Annual average O3 concentration

Modelled using ADMS-Urban

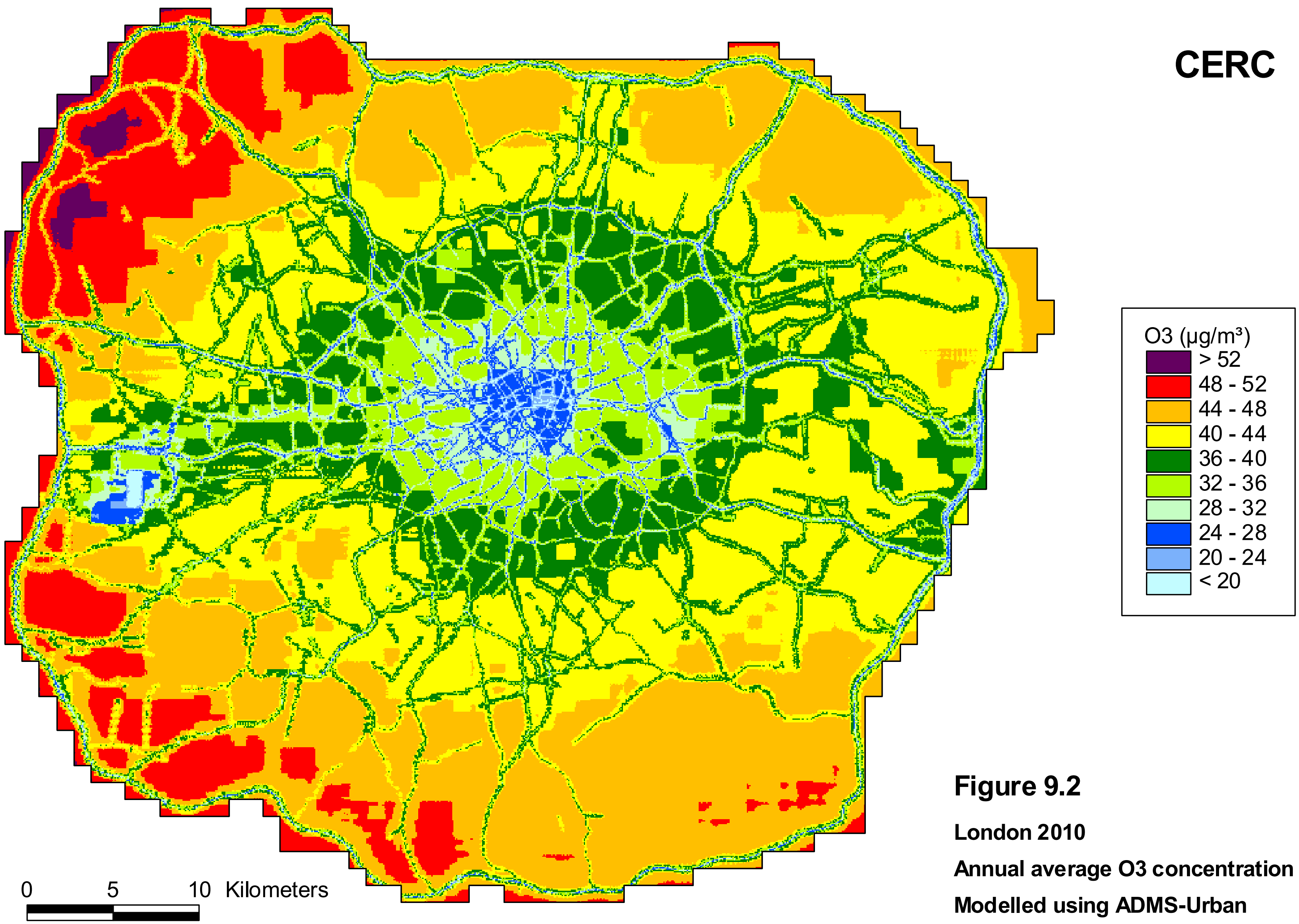

Figure 9.2

London 2010

Annual average O3 concentration

Modelled using ADMS-Urban

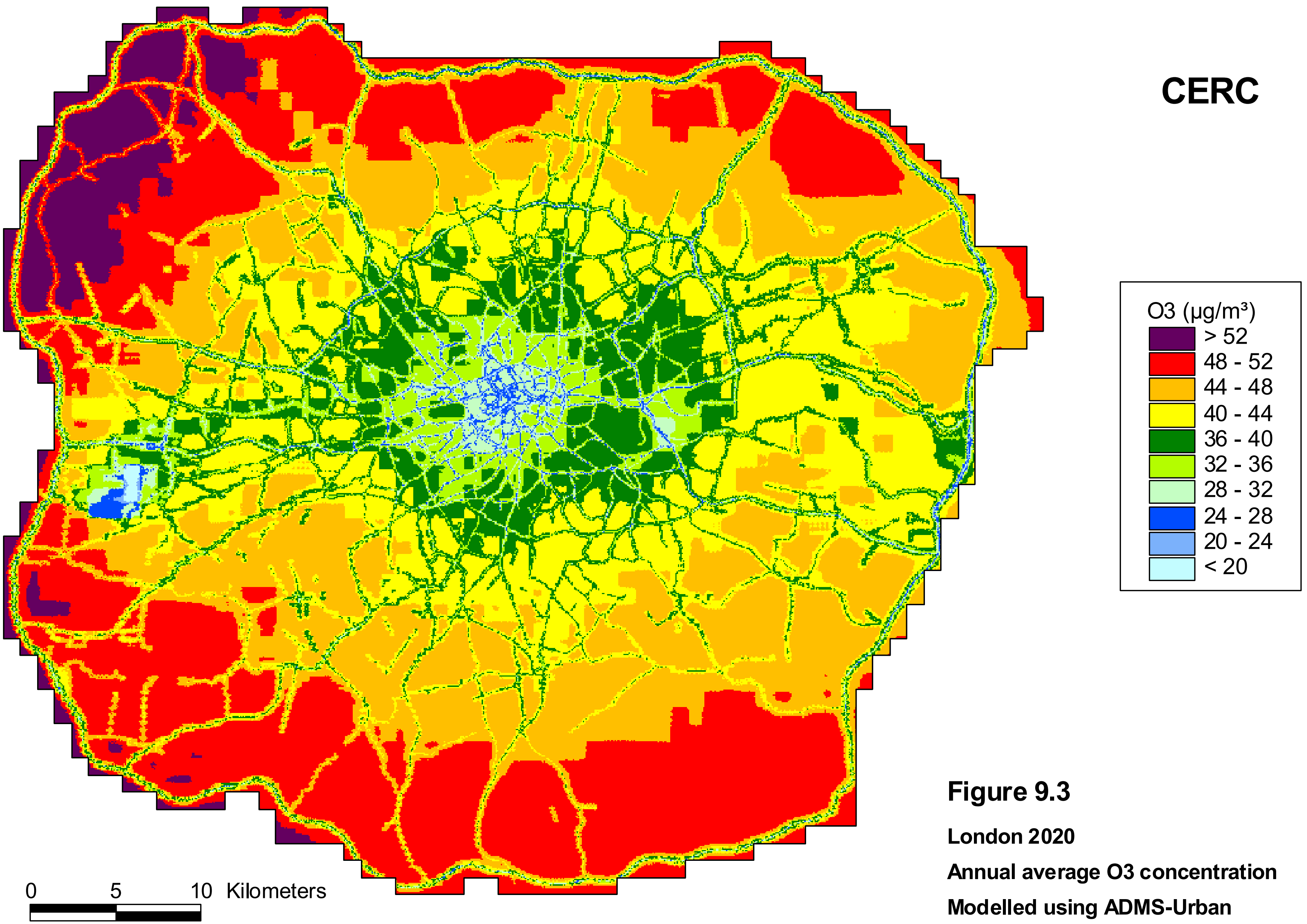

Figure 9.3

London 2020

Annual average O3 concentration

Modelled using ADMS-Urban

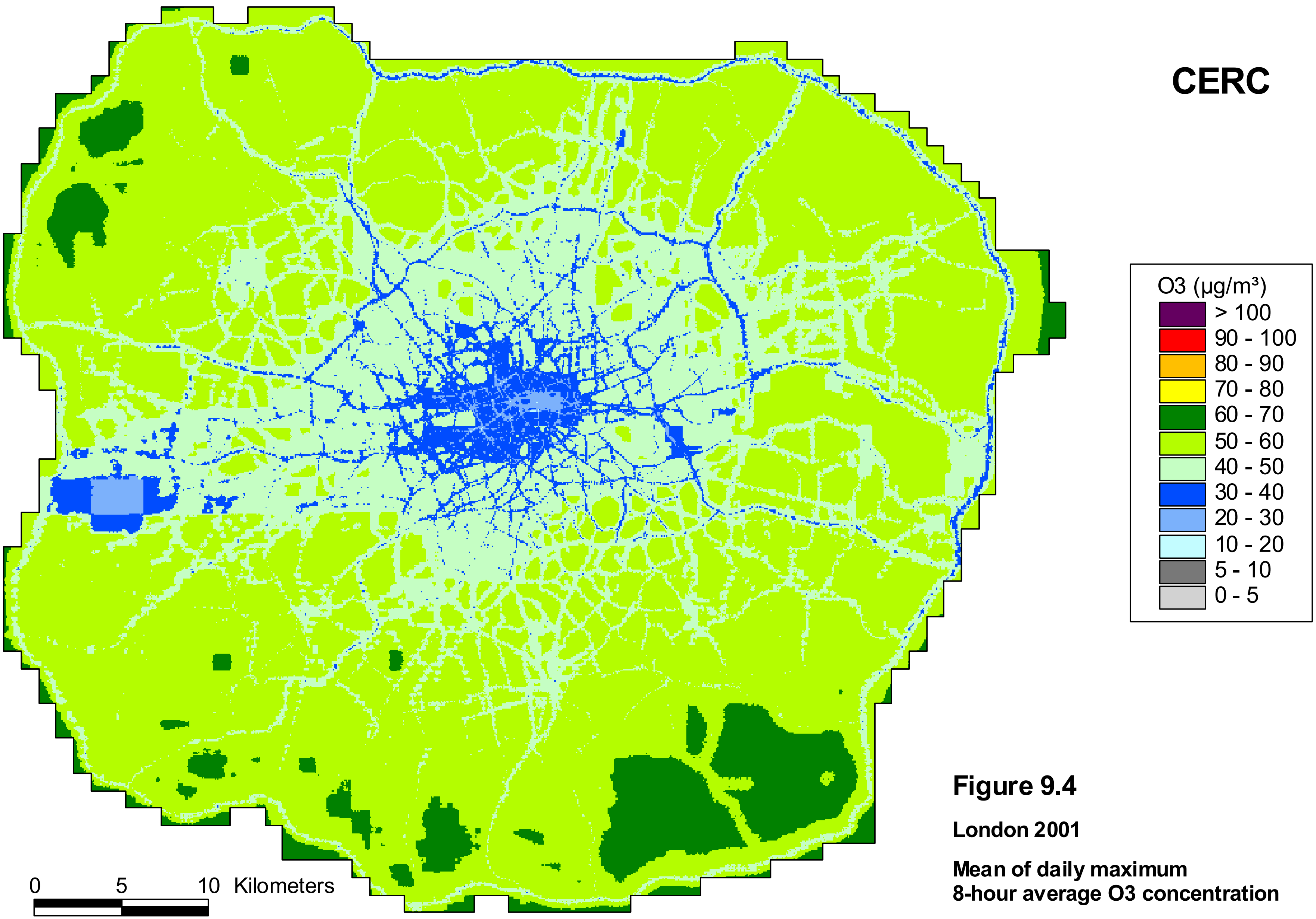

Figure 9.4

London 2001

Mean of daily maximum
8-hour average O3 concentration

Modelled using ADMS-Urban

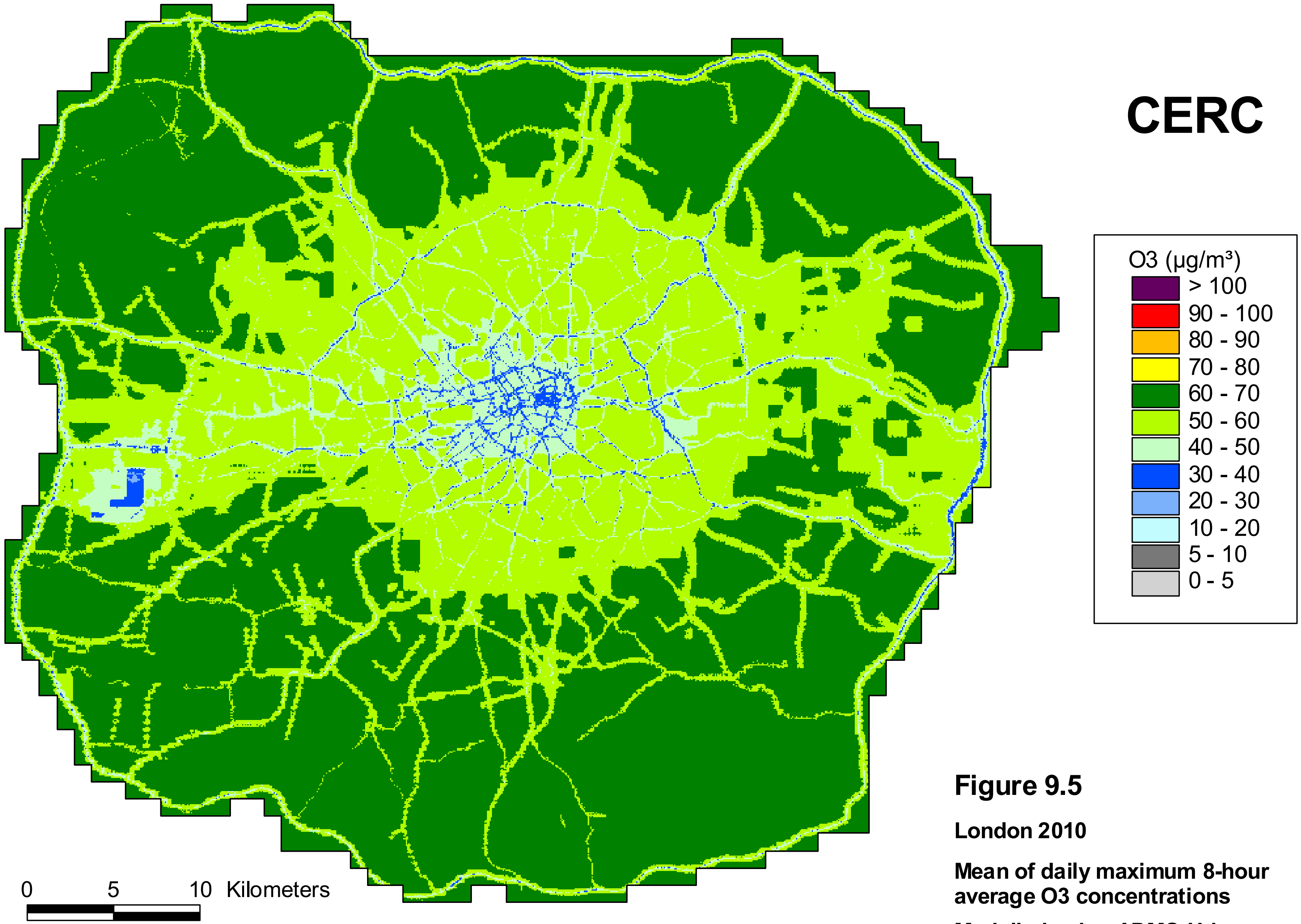

Figure 9.5

London 2010

Mean of daily maximum 8-hour average O3 concentrations

Modelled using ADMS-Urban

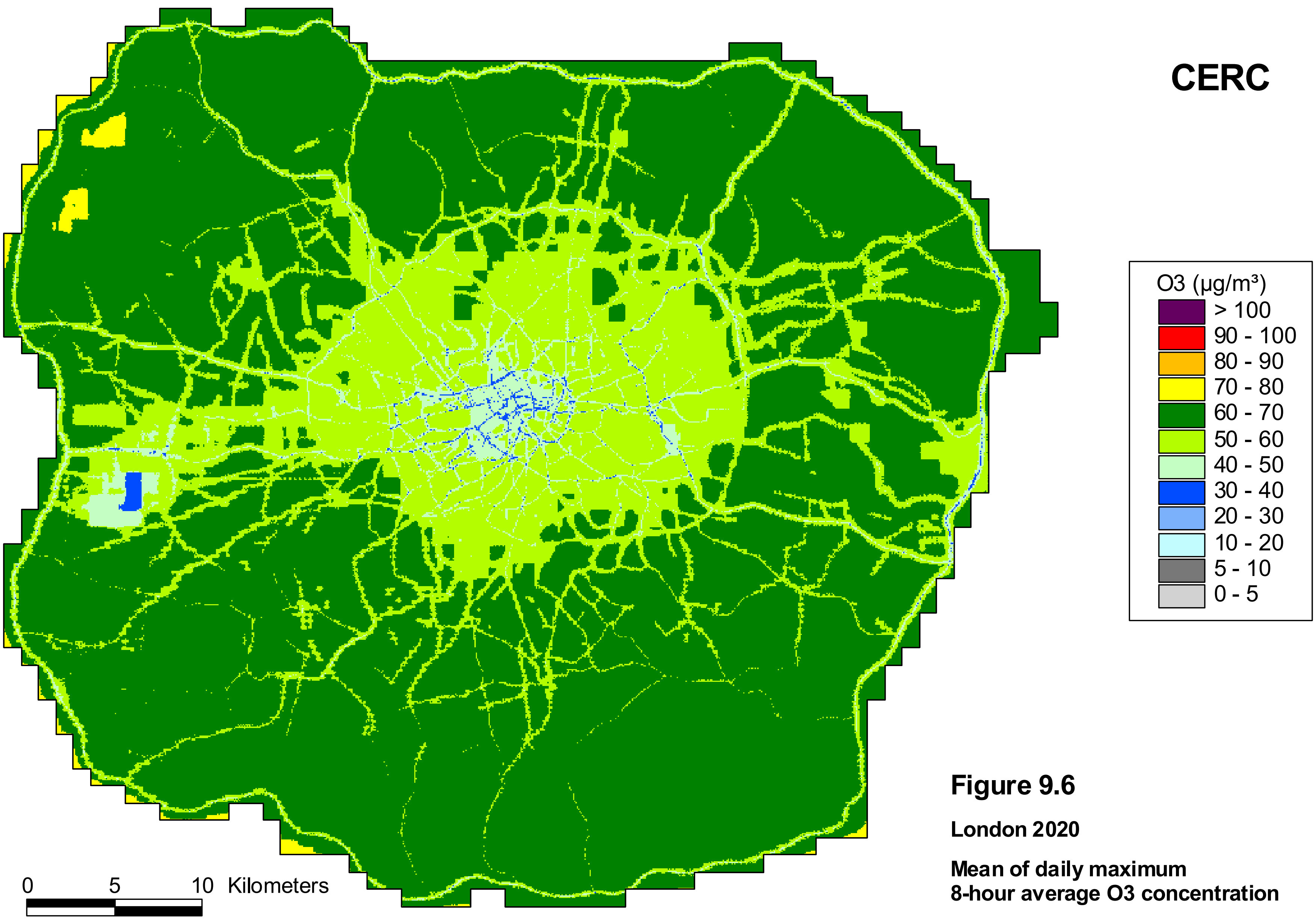

Figure 9.6

London 2020

Mean of daily maximum 8-hour average O3 concentration

Modelled using ADMS-Urban

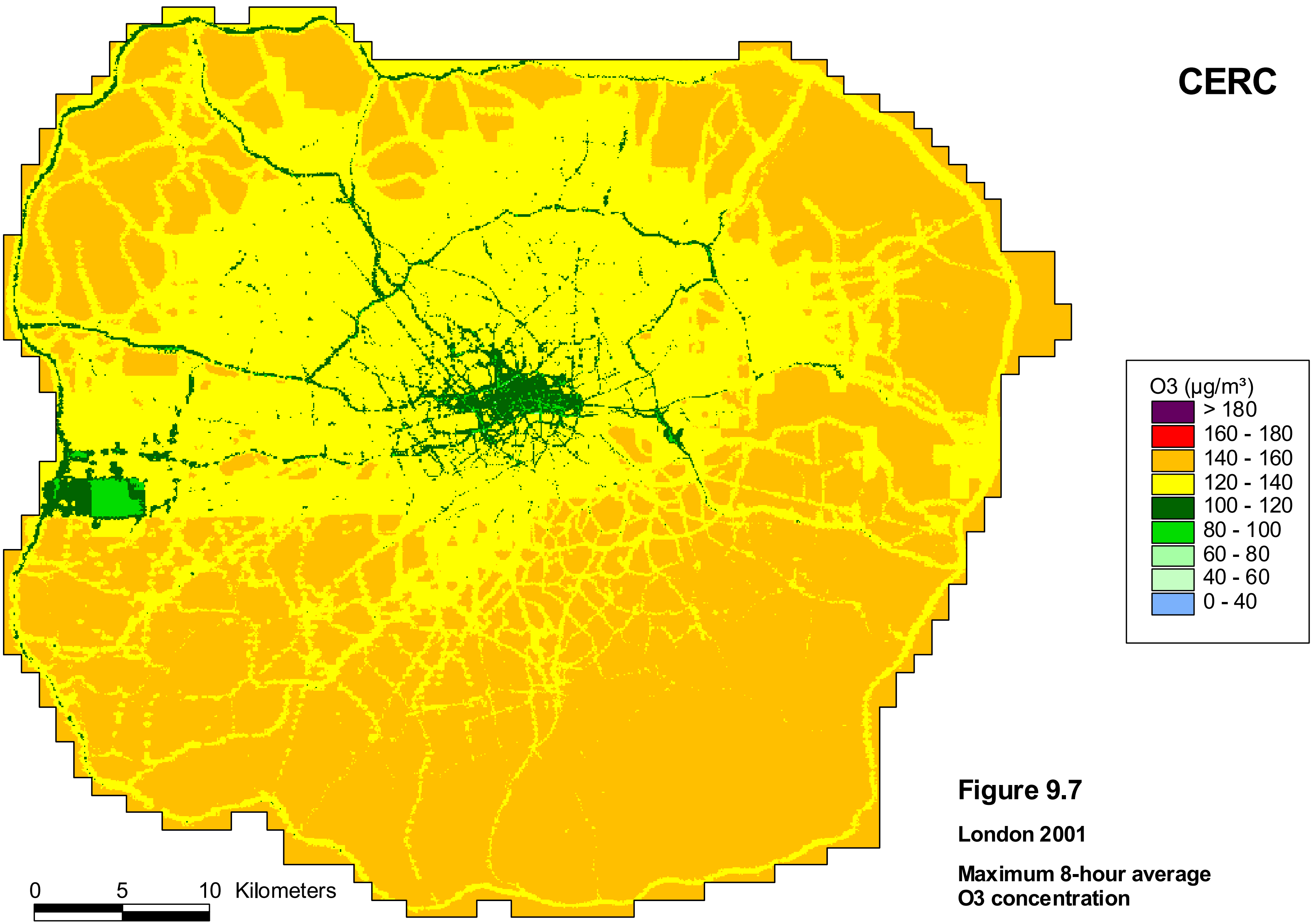

Figure 9.7

London 2001

Maximum 8-hour average O3 concentration

Modelled using ADMS-Urban

CERC

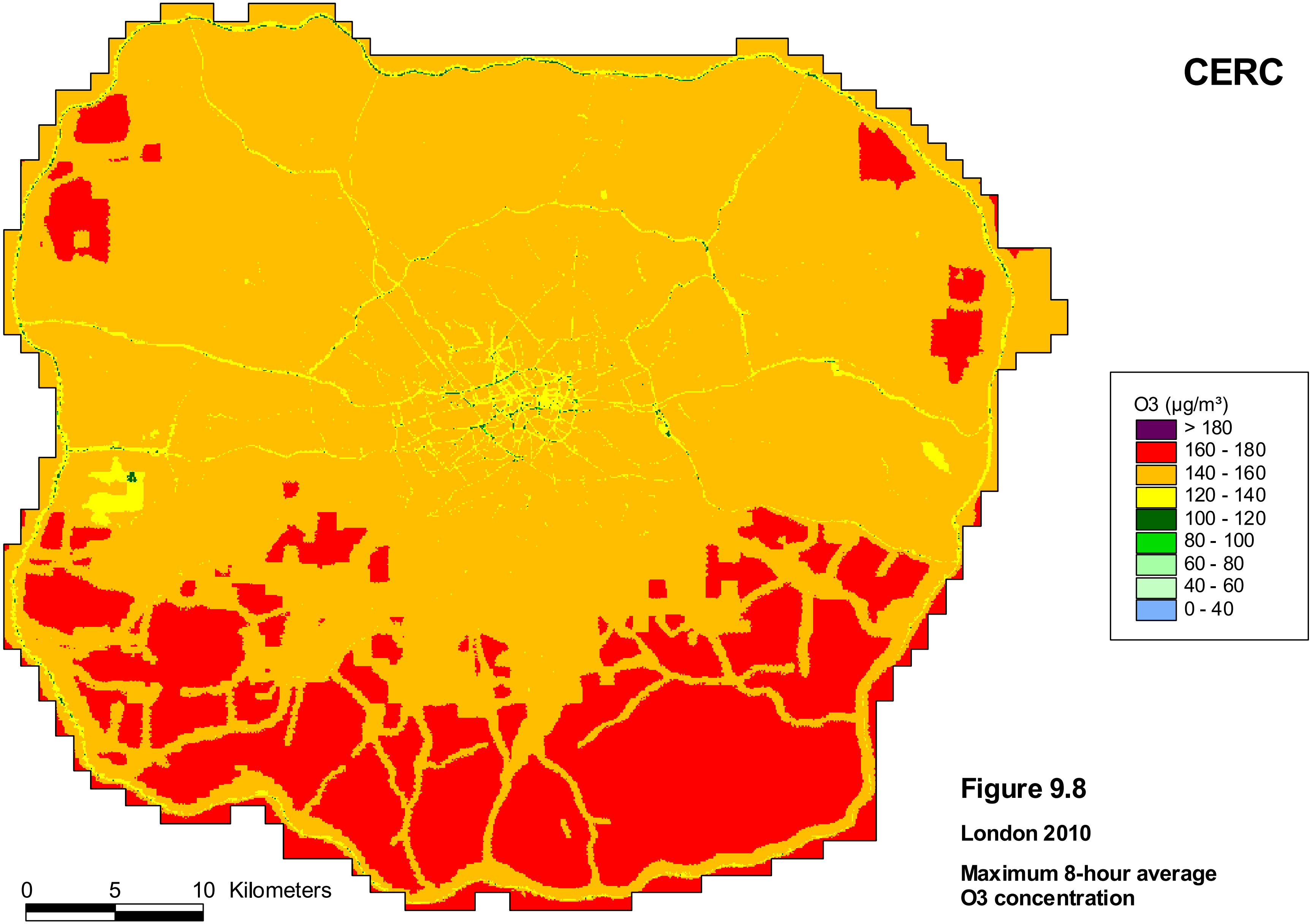

Figure 9.8

London 2010

Maximum 8-hour average O3 concentration

Modelled using ADMS-Urban

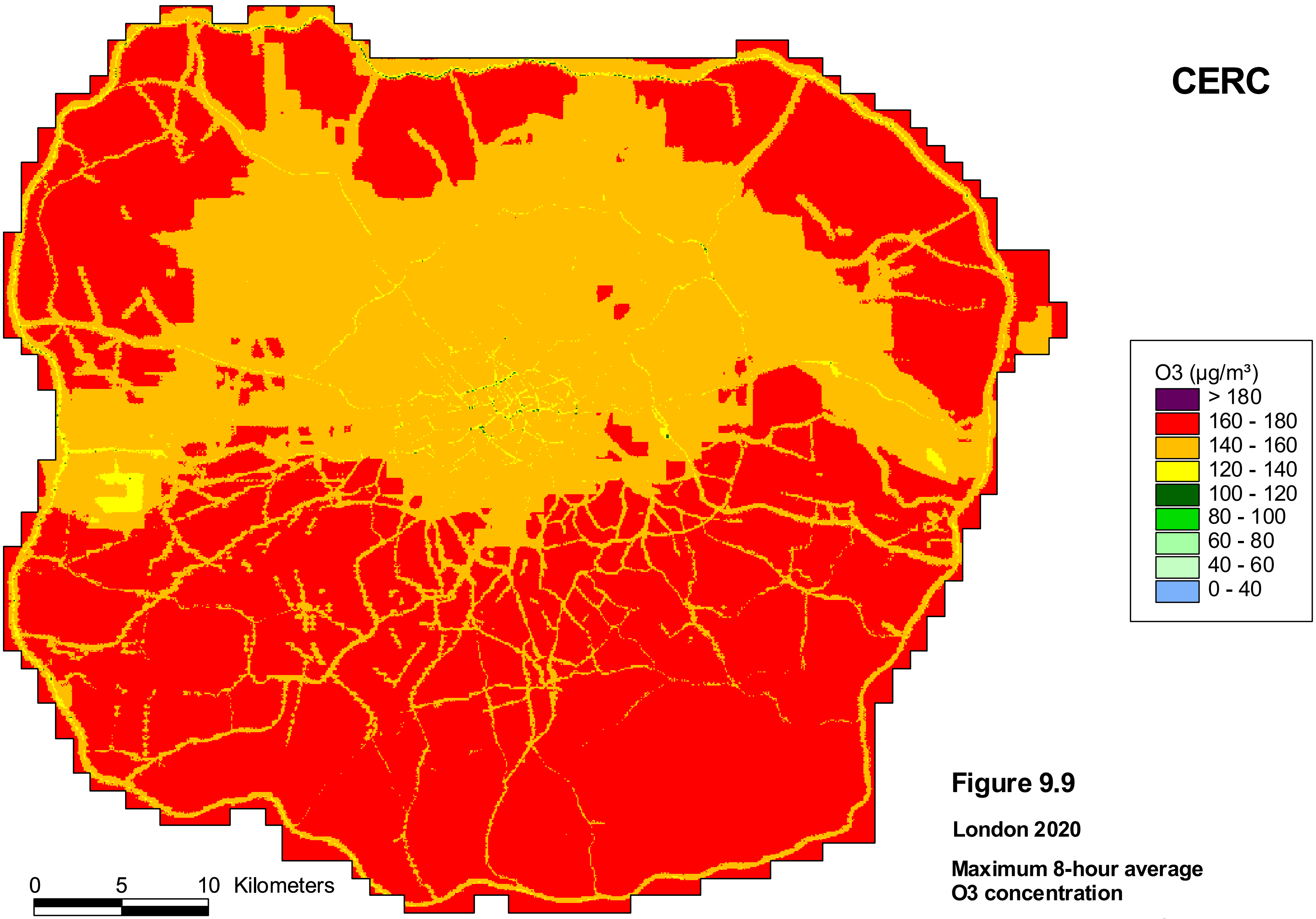

Figure 9.9

London 2020

Maximum 8-hour average O3 concentration

Modelled using ADMS-Urban

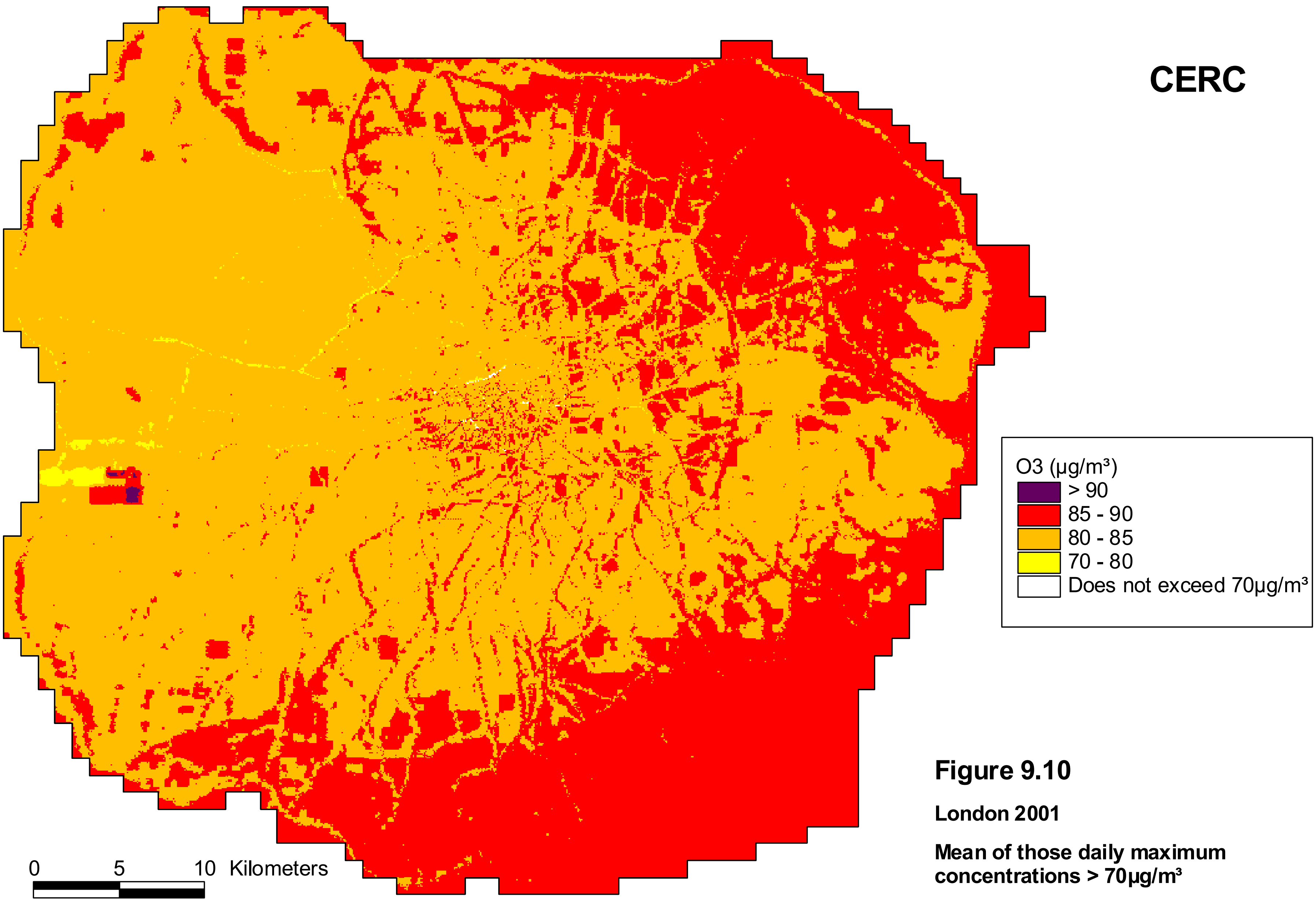

Figure 9.10

London 2001

Mean of those daily maximum concentrations > 70µg/m³

Modelled using ADMS-Urban

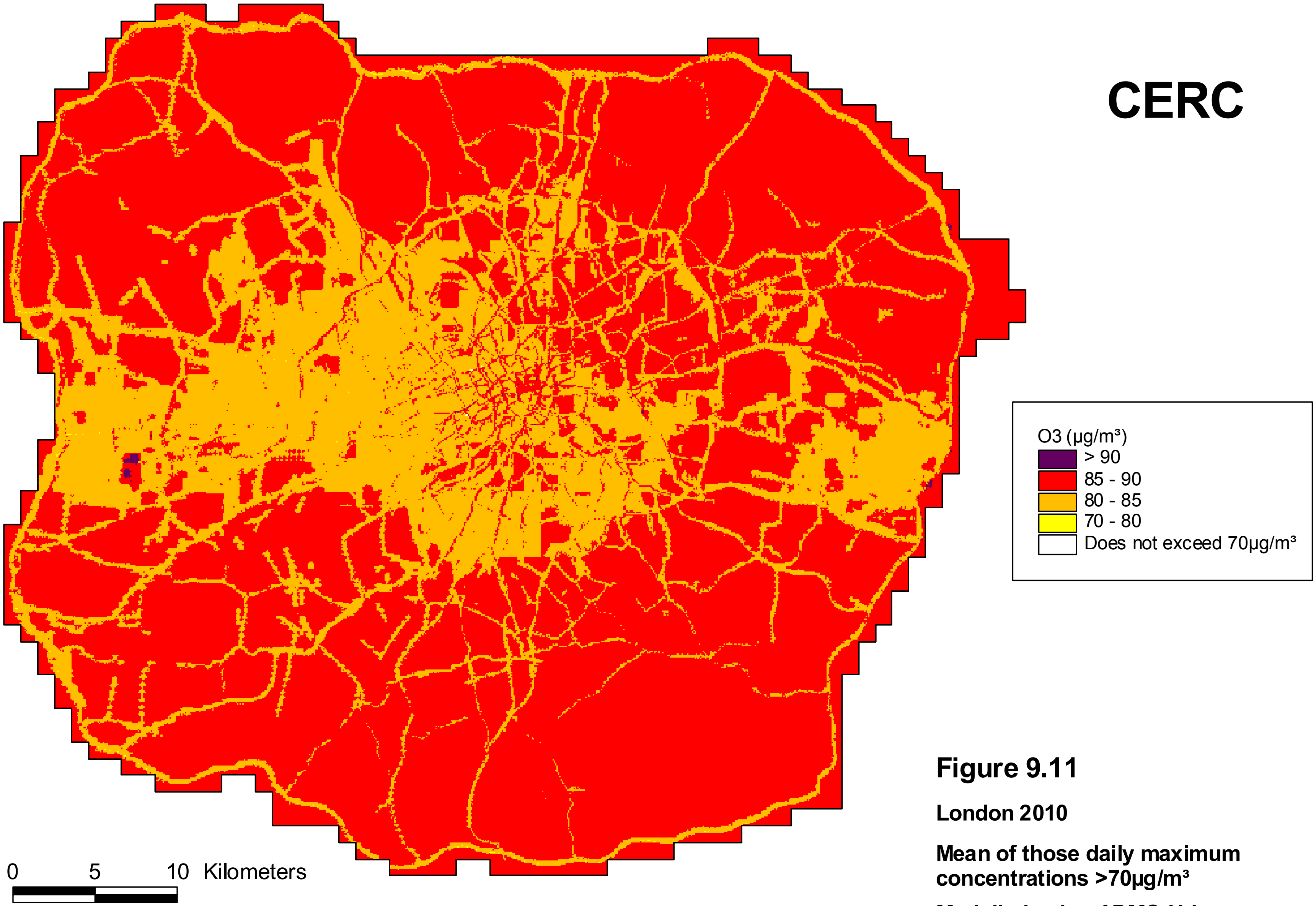

Figure 9.11

London 2010

Mean of those daily maximum concentrations >70µg/m³

Modelled using ADMS-Urban

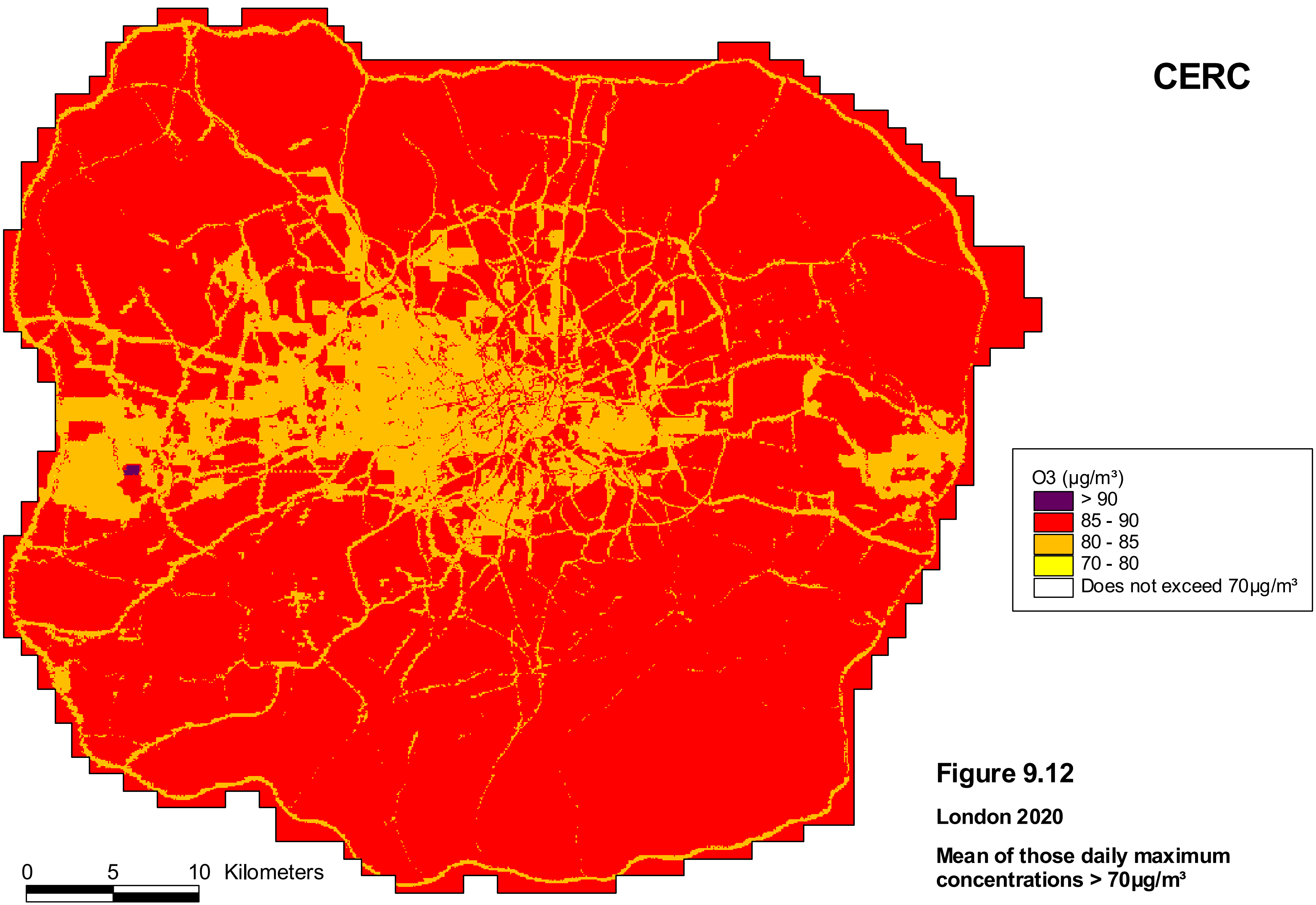

Figure 9.12

London 2020

Mean of those daily maximum concentrations > 70µg/m³

Modelled using ADMS-Urban

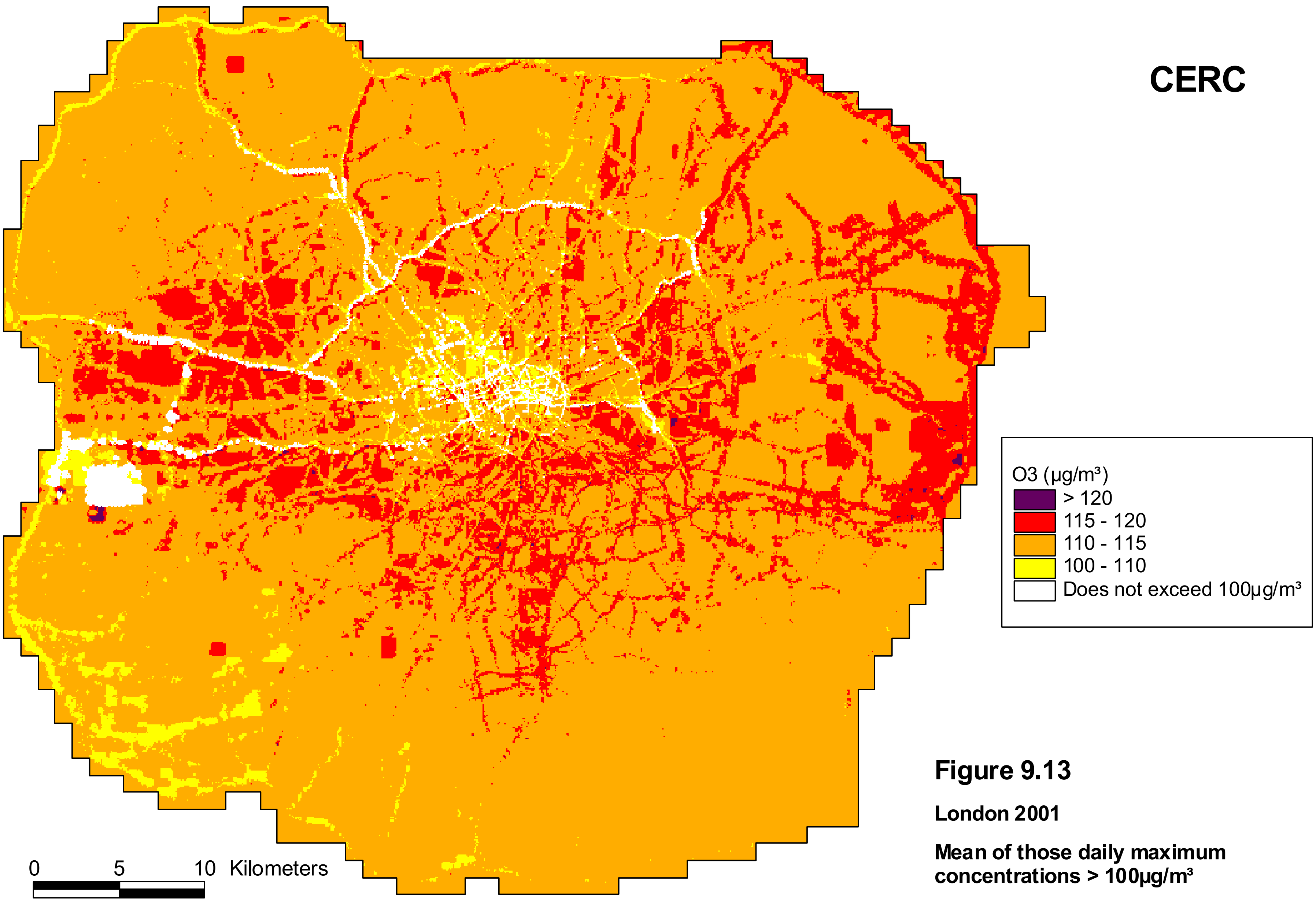

Figure 9.13

London 2001

Mean of those daily maximum concentrations > 100µg/m³

Modelled using ADMS-Urban

CERC

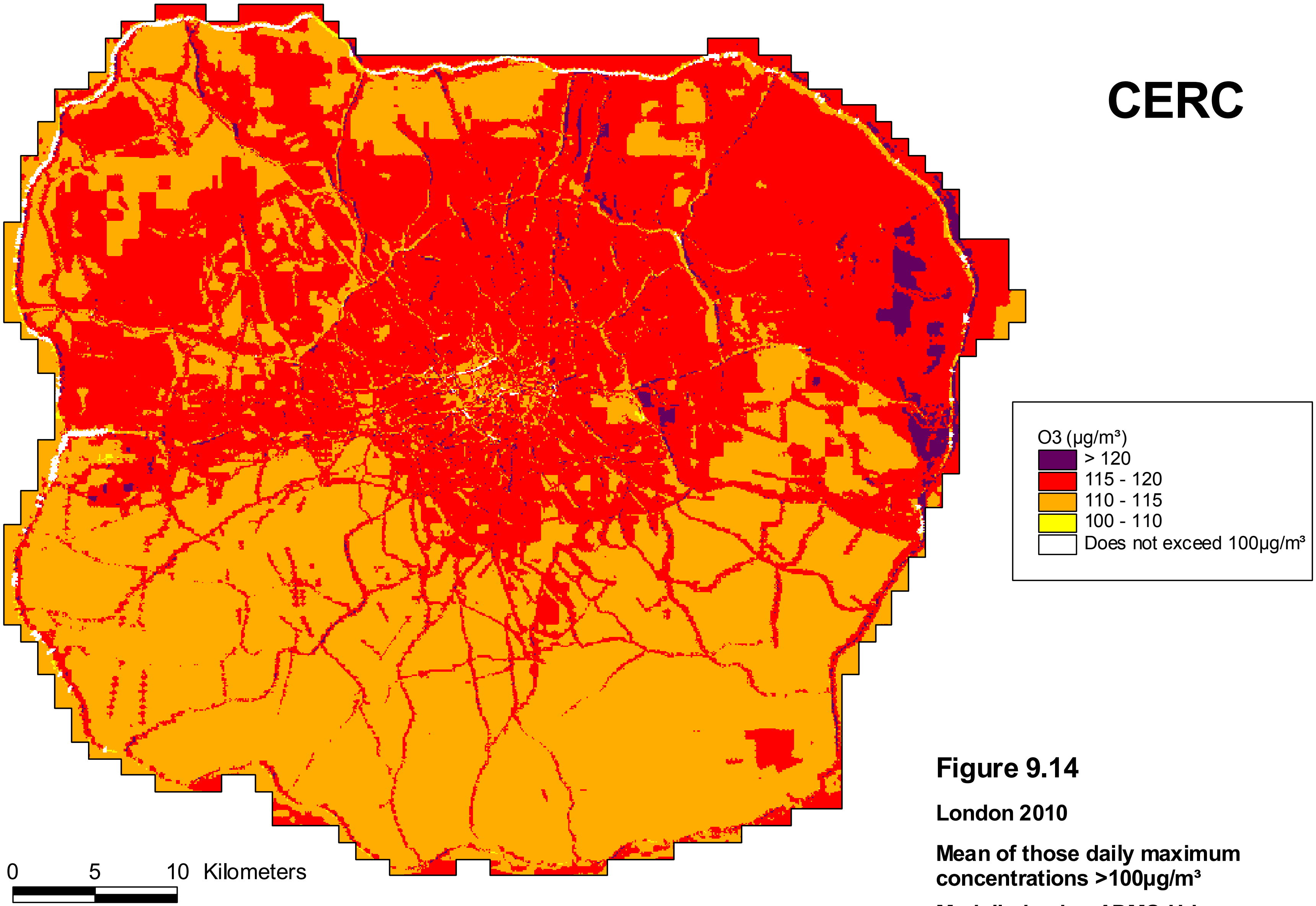

Figure 9.14

London 2010

Mean of those daily maximum concentrations >100µg/m³

Modelled using ADMS-Urban

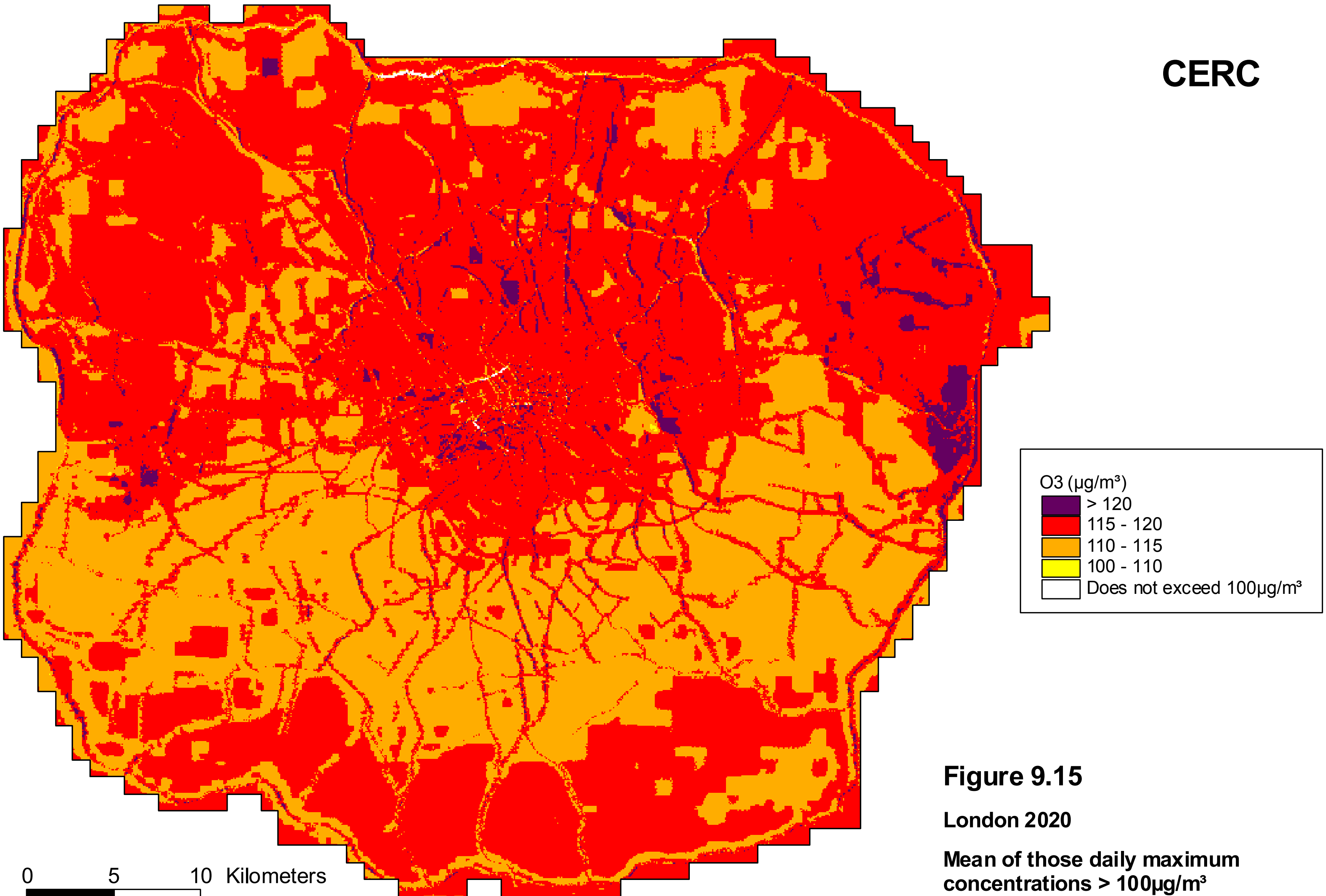

Figure 9.15

London 2020

Mean of those daily maximum concentrations > 100µg/m³

Modelled using ADMS-Urban

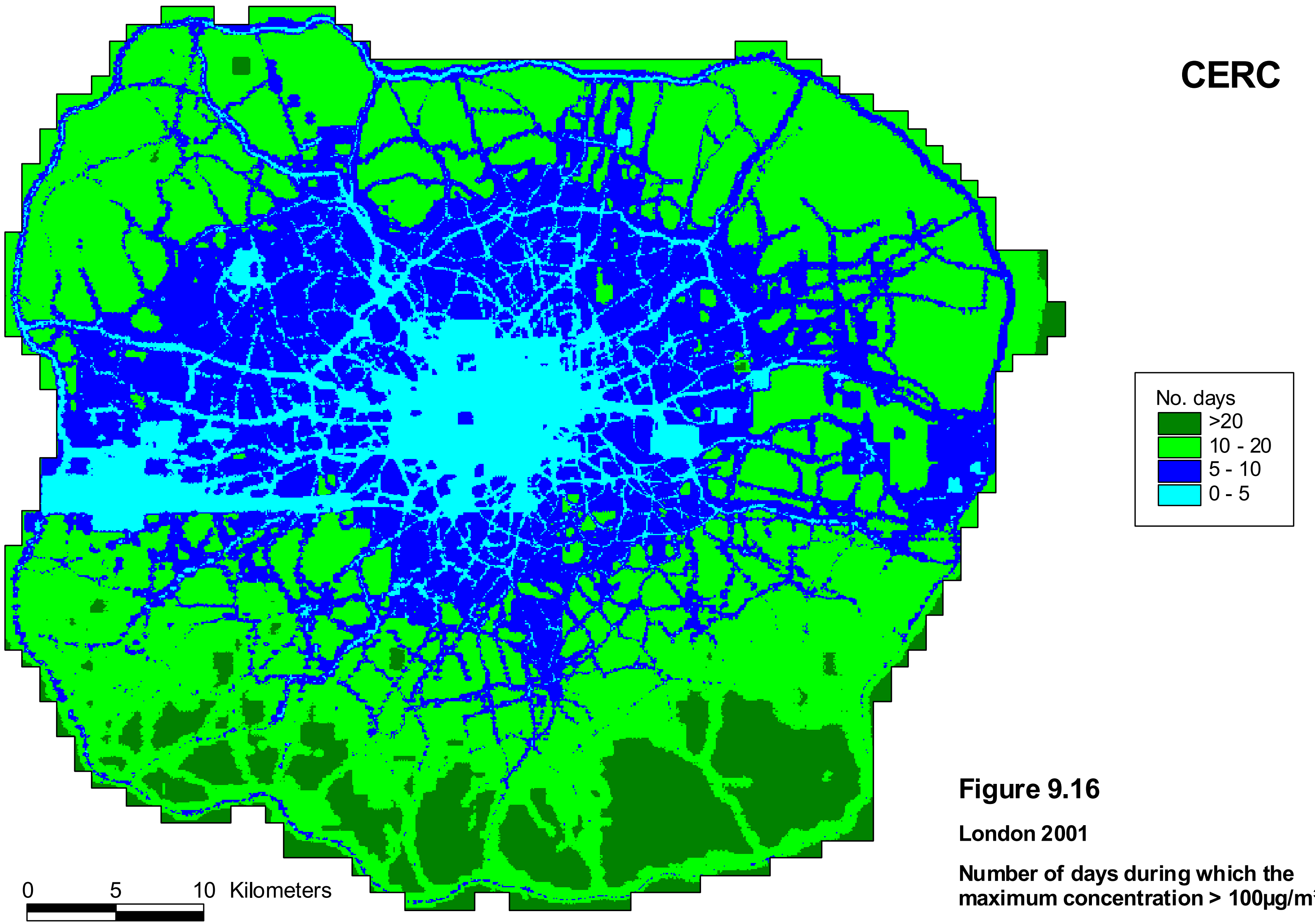

Figure 9.16

London 2001

Number of days during which the maximum concentration > 100µg/m³

Modelled using ADMS-Urban

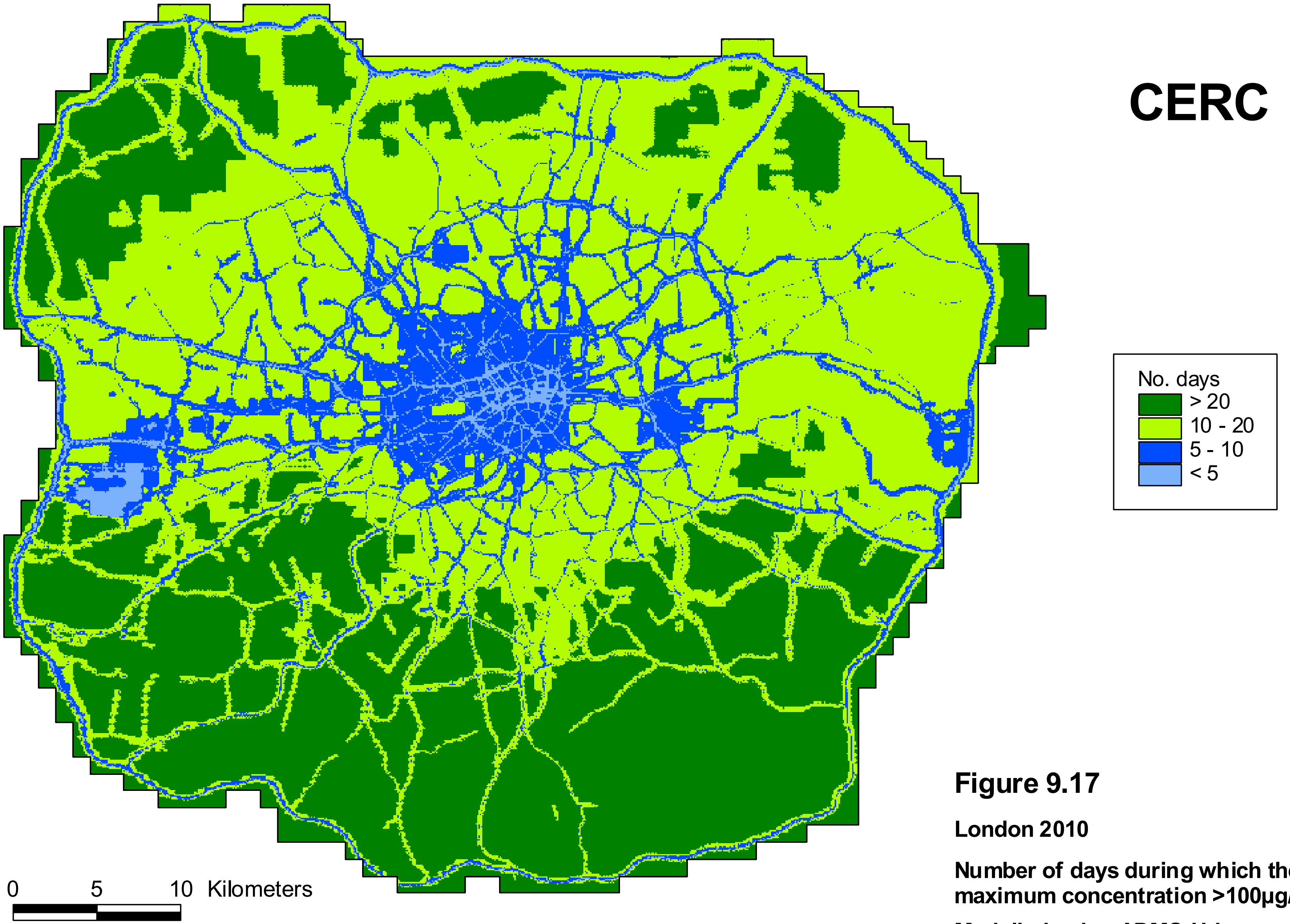

Figure 9.17

London 2010

Number of days during which the maximum concentration >100µg/m³

Modelled using ADMS-Urban

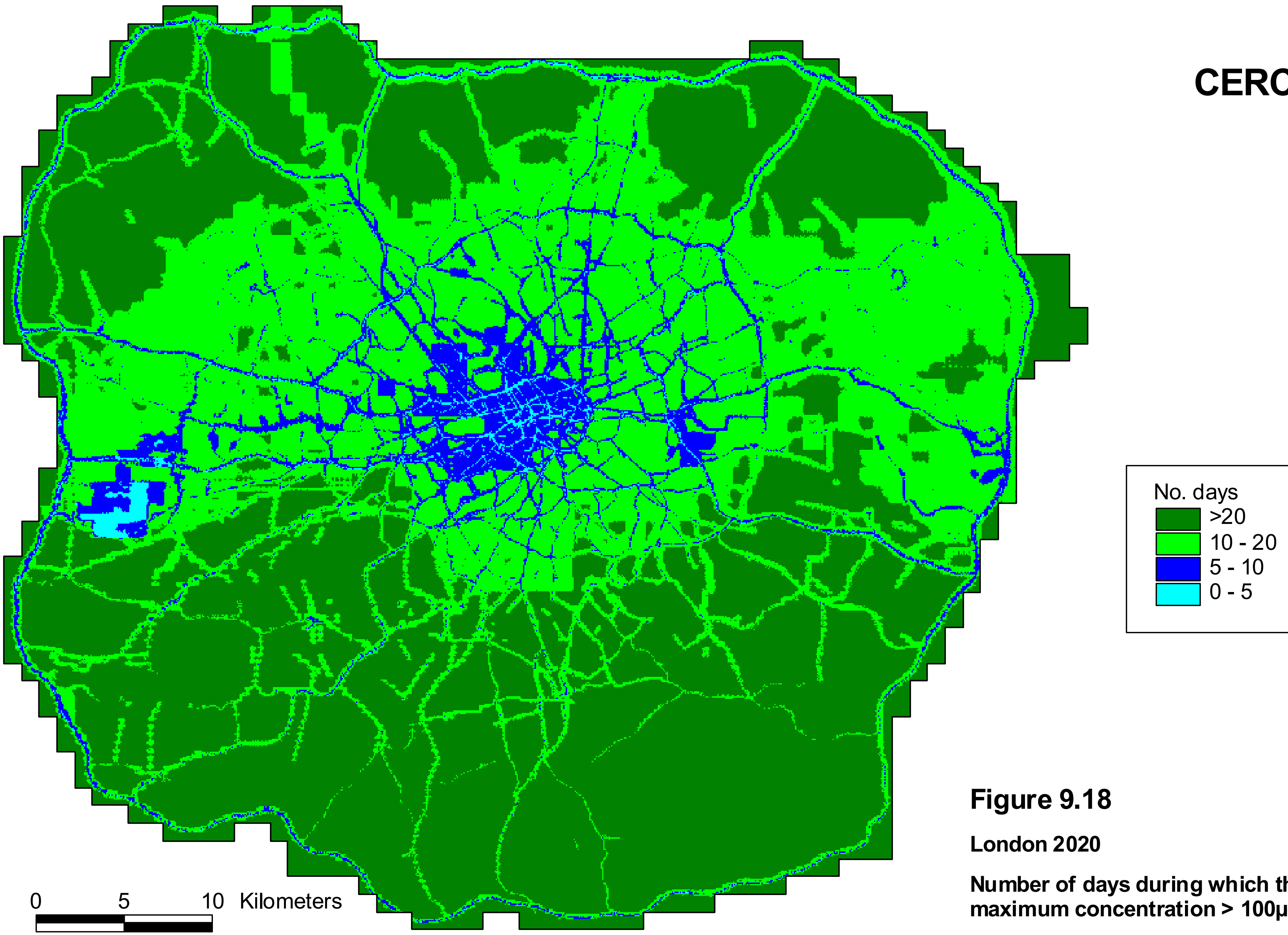

Figure 9.18

London 2020

Number of days during which the maximum concentration > 100μg/m³

Modelled using ADMS-Urban

10. Discussion

Comparison of the concentrations generated by ADMS-Urban at locations of the AURN monitoring sites with the corresponding measured concentrations has shown good agreement for each of the pollutants considered, lending confidence to the predictions of pollutant concentrations in the rest of the city and for future years.

Concentrations of NO_2 were predicted to exceed the AQS objective value of 40µg/m³ in 2001 over 40% of the London area. In 2010 this area of exceedence is predicted to have decreased to 10% and by 2020 to 5%. The areas with the greatest concentrations were central London, the major roads in outer London and the area around Heathrow airport.

Comparison of the ADMS-Urban and national model calculations shows projected future concentrations calculated using the national model are consistently lower than those calculated using ADMS-Urban and this is reflected in the projected areas of exceedence in 2010 and 2020.

Exceedences of the short-term AQS objective for NO_2 were predicted to be much less widespread, being limited to the M25 and the busiest of the roads in London. By 2020, the areas of exceedence were predicted to be limited to isolated stretches of the M25.

The annual average PM_{10} concentrations are predicted to exceed the AQS objective value of 40µg/m³ along the busiest roads in central London and stretches of the M25. By 2020 these areas are predicted to disappear entirely. Comparison of the ADMS-Urban and national model calculations shows projected future concentrations calculated using the national model are higher than those calculated using ADMS-Urban.

The short-term AQS objective value is predicted to be exceeded along many of the major roads in central London, sections of the busiest roads in outer London and along much of the M25. By 2010 these areas of exceedence are predicted to decrease to isolated roadside locations and by 2020 are predicted to disappear.

Annual average concentrations of $PM_{2.5}$ are predicted to exceed 20µg/m³ in 2001 over much of central London and along major roads in the rest of the city. By 2020 concentrations are predicted to be below 20µg/m³ everywhere and below 16µg/m³ over most of the city.

Ozone concentrations are predicted to increase in future years. In 2001, annual average concentrations range from approximately 20µg/m³ in central London to 40µg/m³ in the outskirts of the city. By 2020 concentrations are predicted to rise to more than 52µg/m³ in outer London.