Developments in ADMS-Airport and its Applications to Heathrow Airport

David Carruthers
Cambridge Environmental Research Consultants

IAE (Institute of Aviation and the Environment)
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Contents

- Key Factors affecting AQ at Airports
- Feature of ADMS-Airport
- Model Performance and sensitivities
- Heathrow Consultation – Mixed Mode and R3

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1) Key factors affecting
air quality at airports

Key factors affecting air quality at airports

- Emissions
- Background concentrations
- Meteorology
- Near field dispersion processes
- Chemical reactions

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2) Features of ADMS-Airport

Features of ADMS-Airport

- An extension of ADMS-Urban – Gaussian type model nested in regional trajectory model
- Includes chemical reaction scheme, meteorological preprocessor, Monin-Obukhov and mixed layer scaling for boundary layer structure
- Allowance for up to 6500 sources: road (1500, each with up to 50 vertices), point, line area and volume (1500), grid sources (3000) and up to 500 runway sources (exhaust modelled as moving jets)
- Other airport features
  - Hour by hour time varying data
  - Multi-segment line sources e.g. taxi ways
  - GIS link displays line, volume and runway sources

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Features: MODELLING EXHAUSTS AS MOVING JETS & THE IMPACT OF WAKE VORTICES

- Models engine exhausts as moving jet sources
- As the aircraft accelerates
  - buoyancy and emissions increasingly spread along the runway
  - the exhaust jet sees a faster ambient wind speed, this affects the plume rise
- The plume from the faster aircraft rises less than that from a slower aircraft
- Allows for the impact wake vortices may have on jet plume rise

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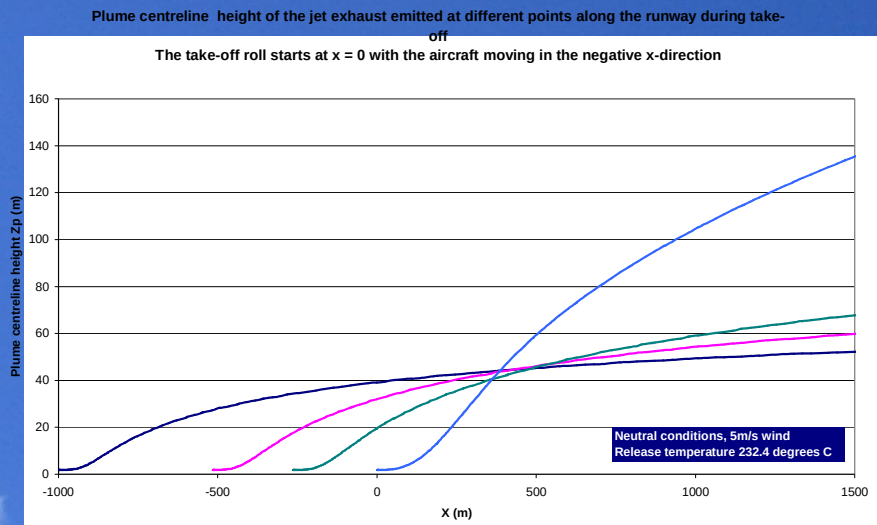
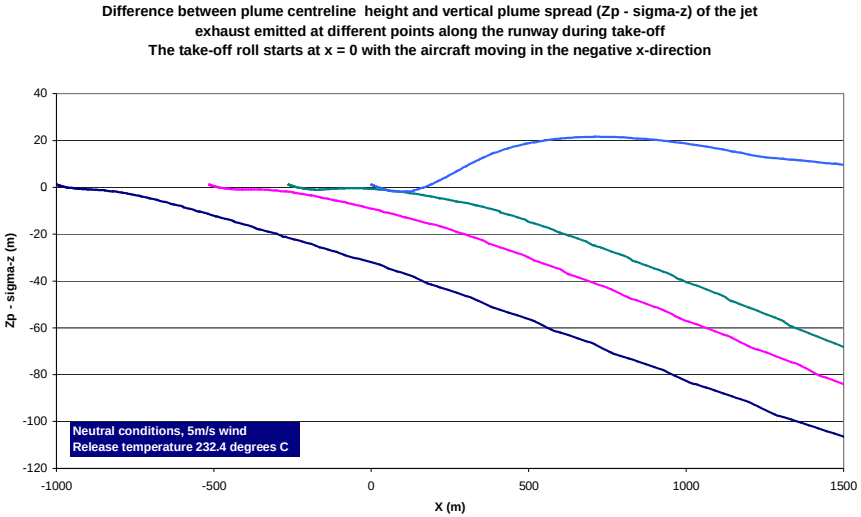
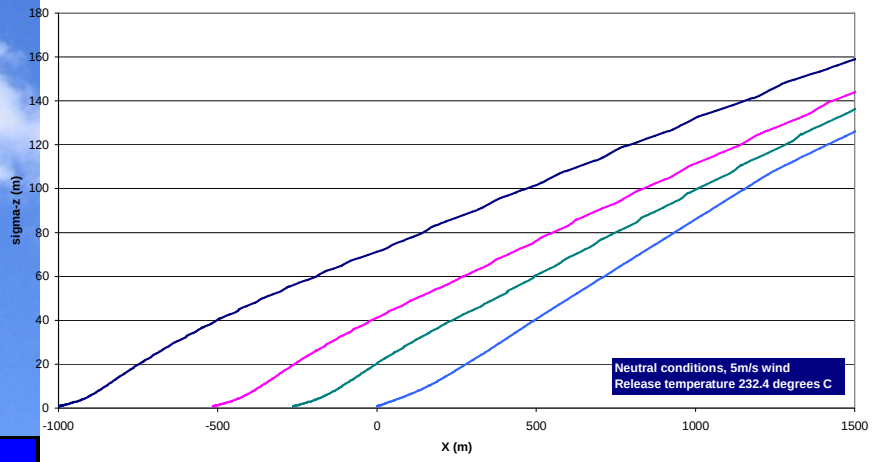
Neutral met conditions, plume trajectory (z_p) (top), vertical spread (σ_z) (middle) and z_p - σ_z (bottom)







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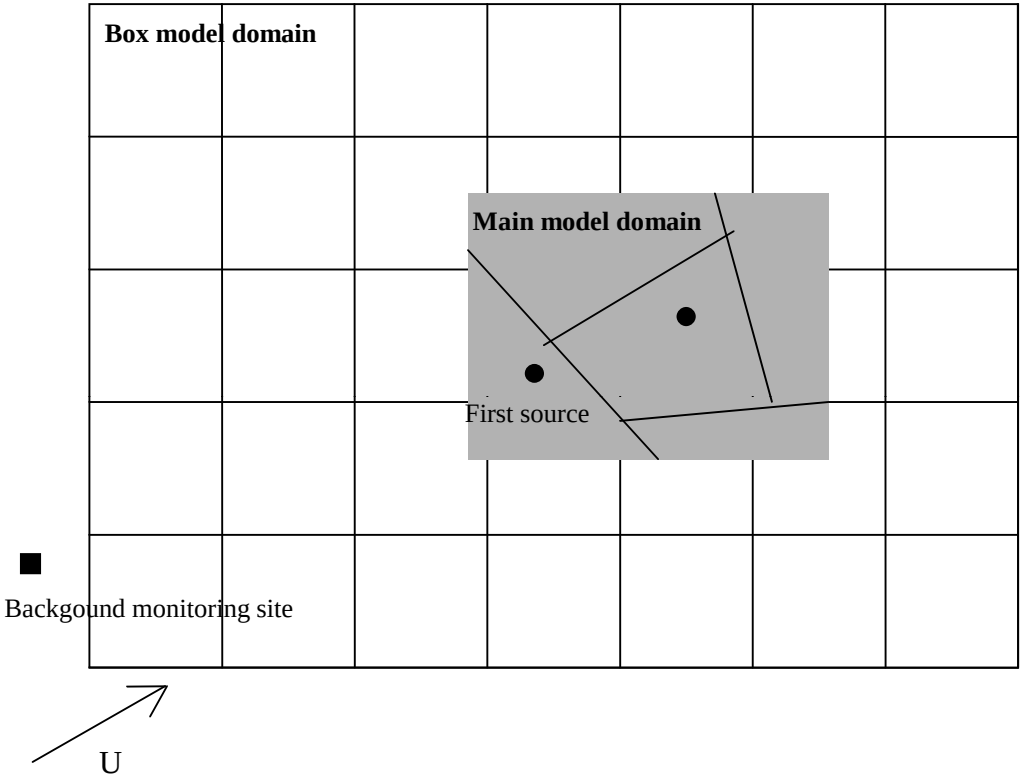
Local and Regional Scales



- Main model nested within large, area-wide trajectory model

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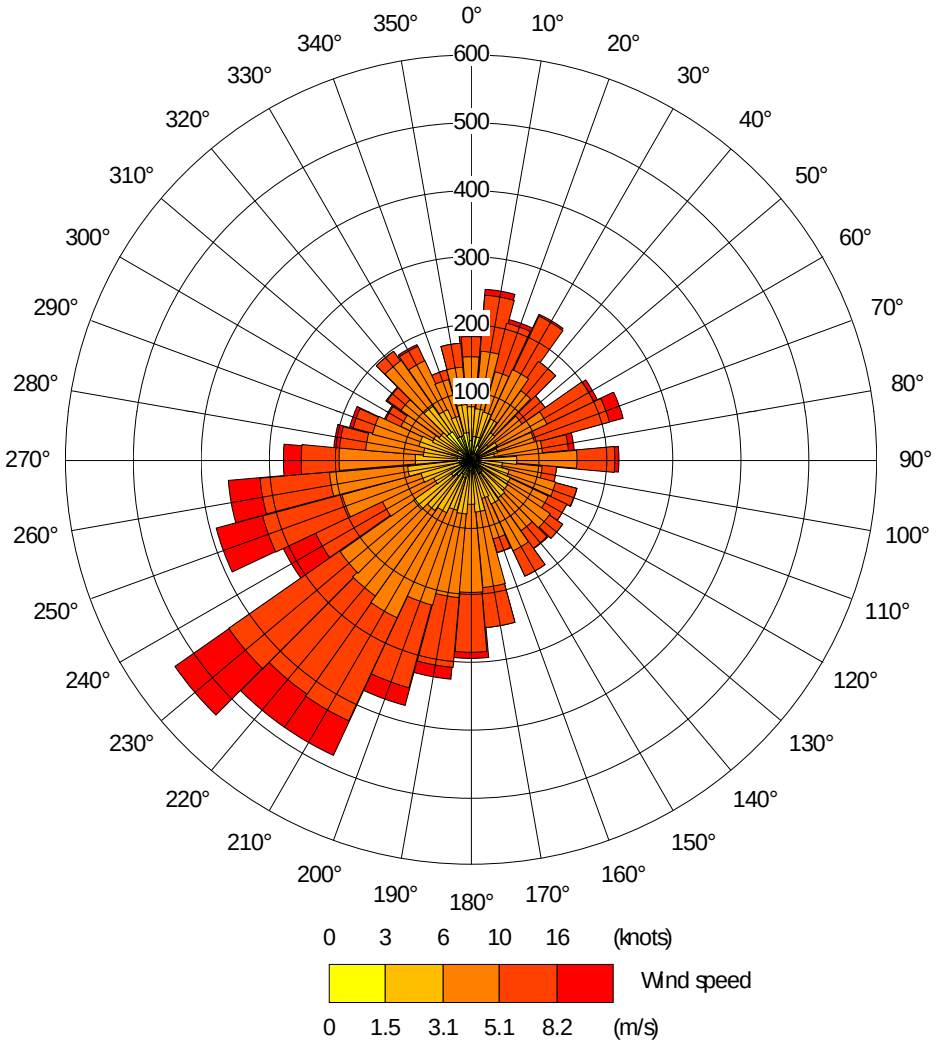
3) Model performance and sensitivities: MODEL SET UP

Heathrow: METEOROLOGICAL DATA



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Heathrow: EMISSION SOURCES

- Gridded sources for all of London
- Roads – local to Heathrow from LAEI (London Atmospheric Emissions Inventory) and the Heathrow Inventory
- LTO: taxi-in, taxi-out, landing, approach, initial climb, climb out
- Other: APU, airside vehicles, car parks, taxi ranks modelled as area or volume sources

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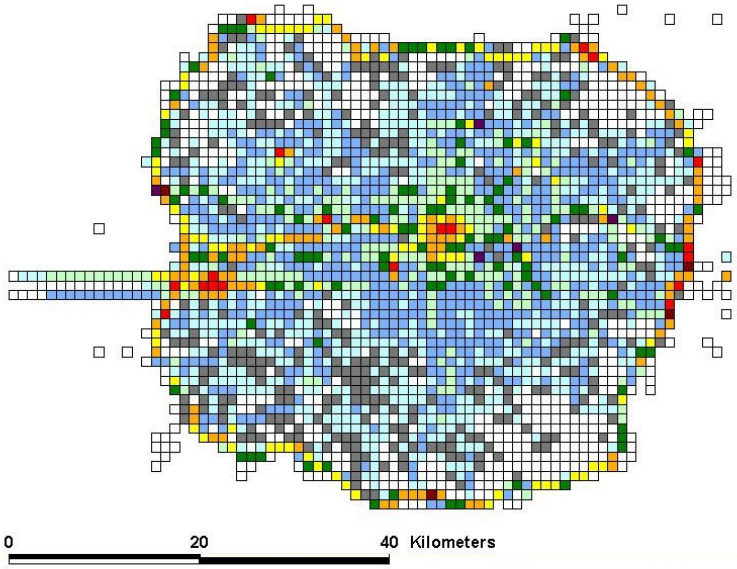
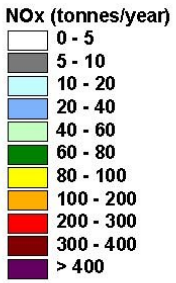
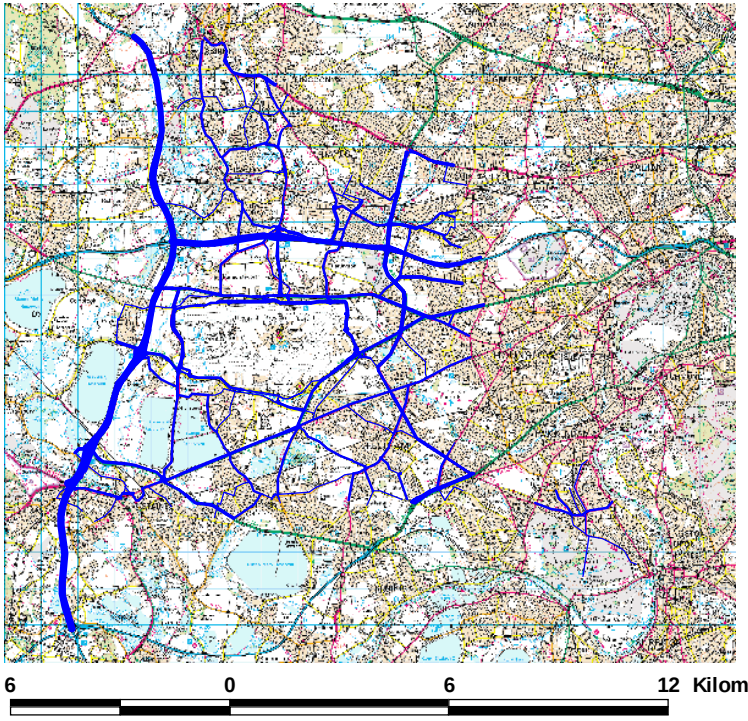
2002 NOx emission rate

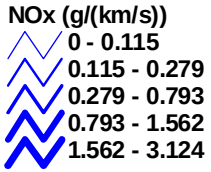




Grid sources from London Atmospheric Emissions Inventory

Explicitly modelled road sources





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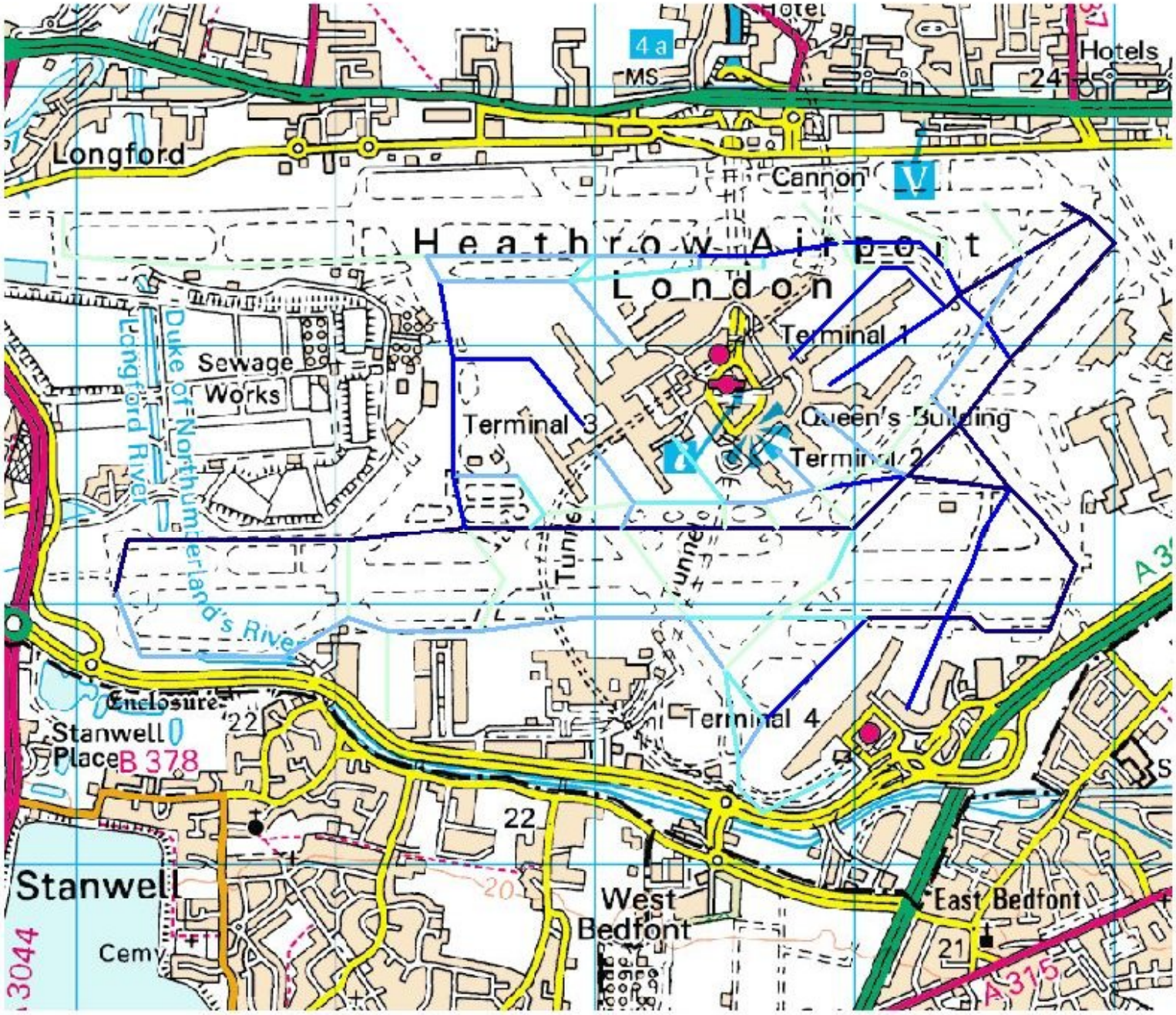
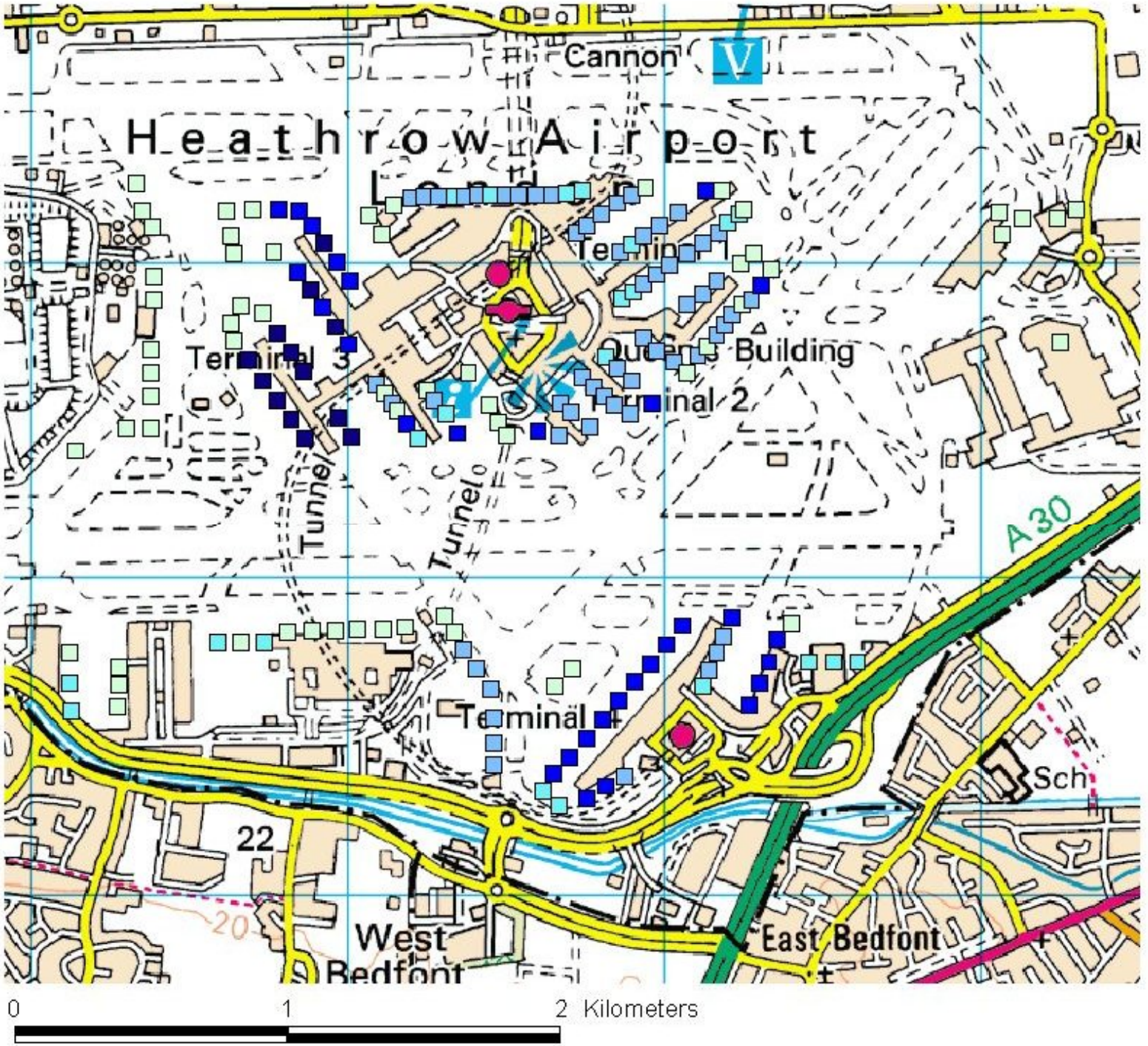
Taxi out



NOx (g/km/s)

- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 1.4

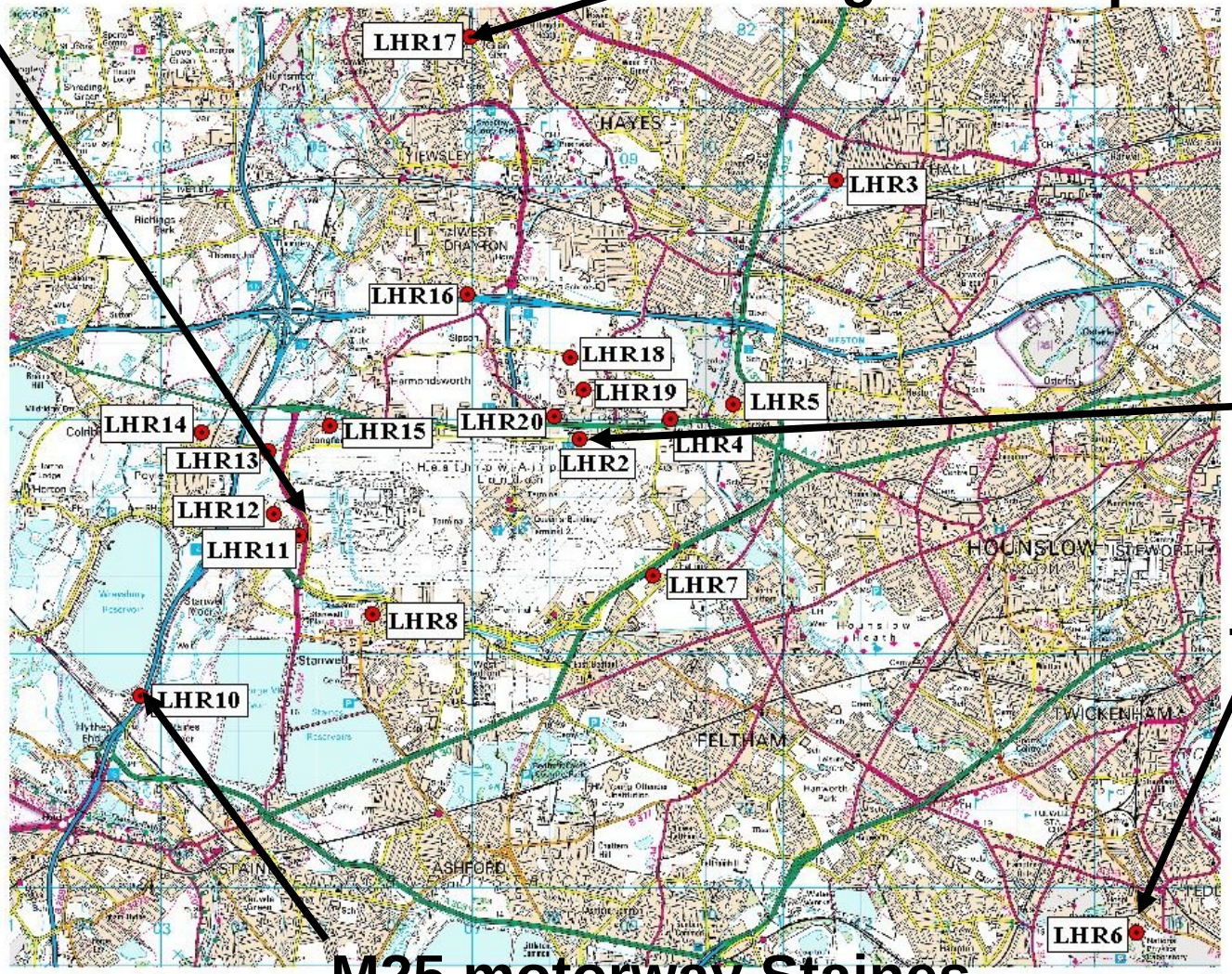

Heathrow Airport
London
Cannon
Terminal 3
Queens Building
Terminal 2
Tunnel
Tunnel
A30
Terminal 4
22
West
Bedfont
East Bedfont
Sch
0
1
2 Kilometers
NOx (g/s)
0 - 0.012
0.012 - 0.030
0.030 - 0.054
0.054 - 0.093
0.093 - 0.132

APU

Heathrow: MONITORING DATA

PM from T5 works

Hillingdon hospital



LHR2 closest monitor

Teddington

M25 motorway Staines

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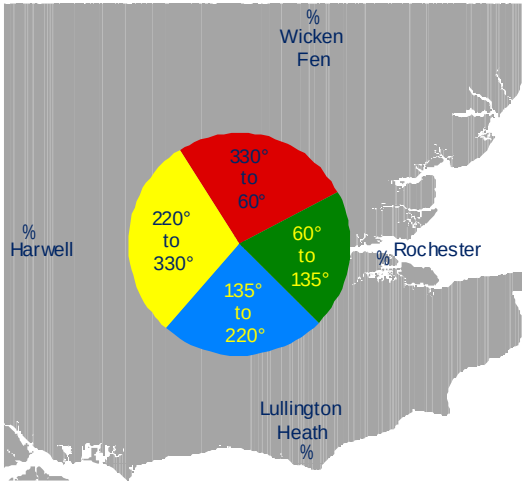
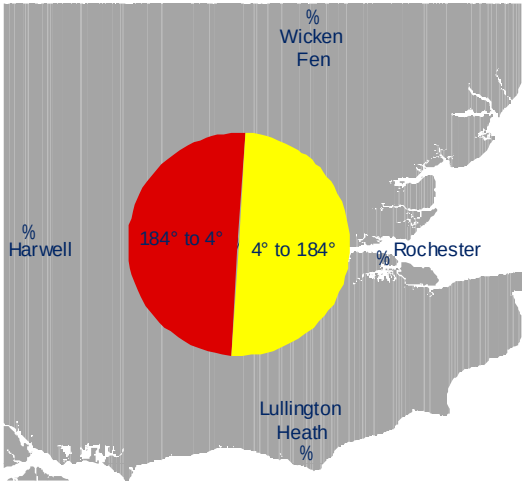
Heathrow : BACKGROUND CONCENTRATIONS

NO_X
NO_2
O_3





PM_{10}

		2002
NO_x as NO_2 ($\mu g/m^3$)	Annual average Maximum hourly average 99.79th percentile	15 215 127
NO_2 ($\mu g/m^3$)	Annual average Maximum hourly average 99.79th percentile	12 84 62
O_3 ($\mu g/m^3$)	Annual average Maximum hourly average 99.79th percentile	52 188 135
PM_{10} ($\mu g/m^3$)	Annual average Maximum hourly average 90.41st percentile of 24 hour averages 98.08th percentile of 24 hour averages	19 124 33 48

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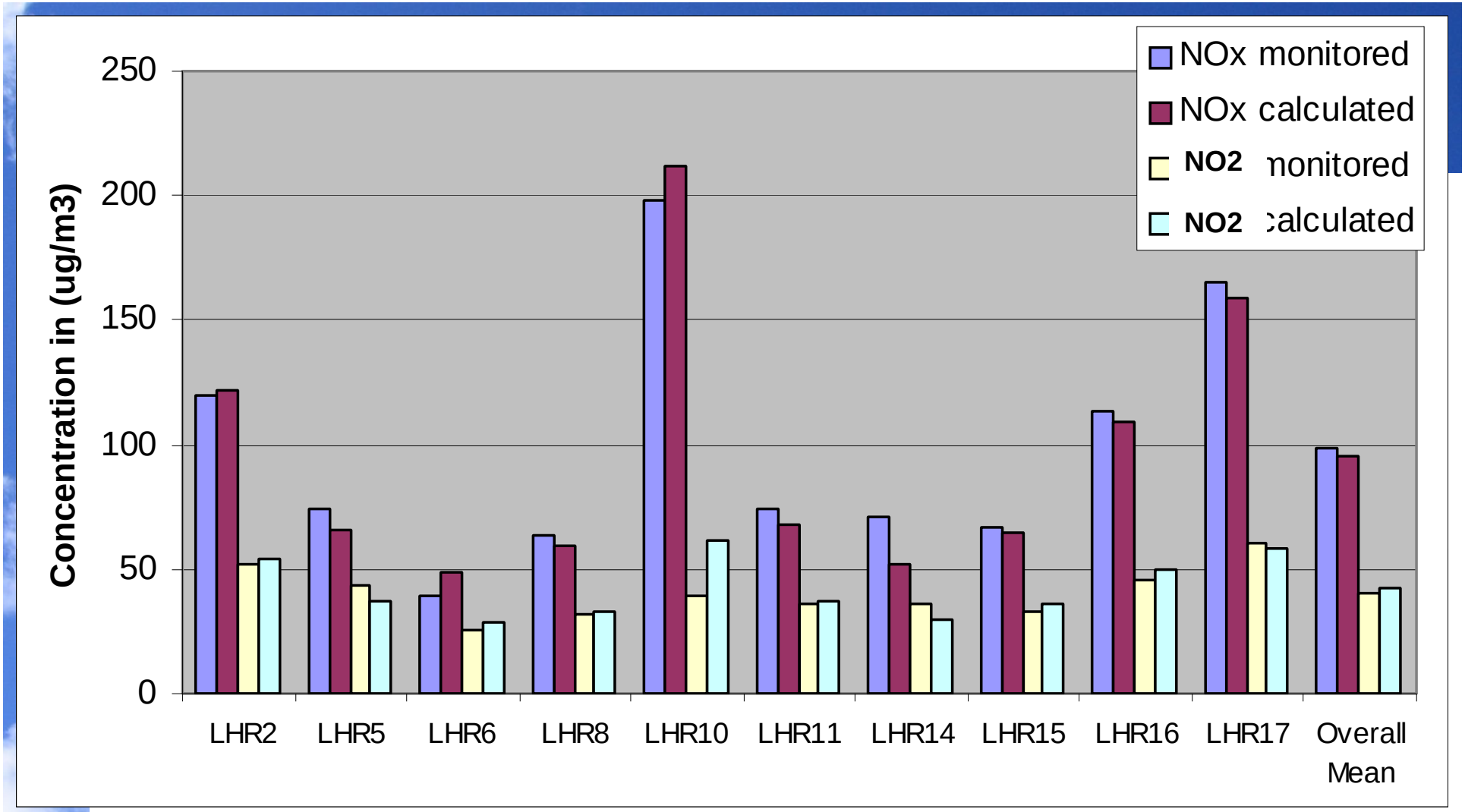
3) Model performance and sensitivities: ANALYSIS OF RESULTS



NO_X (dark blue and red) and NO_2 (yellow and light blue) monitored and calculated annual mean concentrations at the automatic monitoring sites

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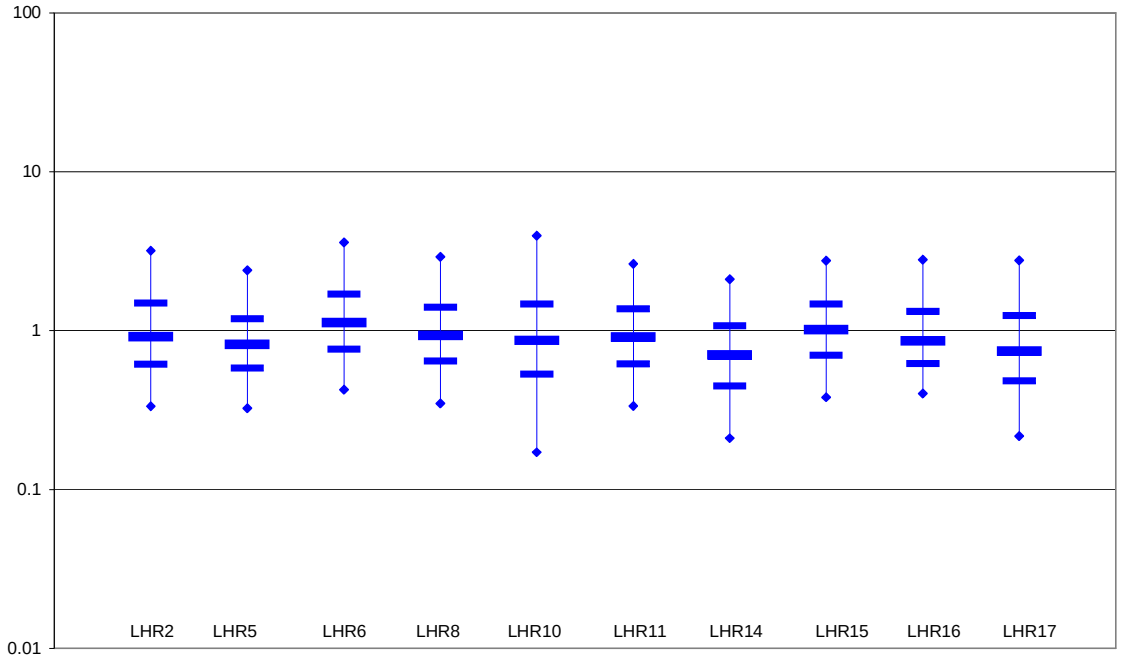
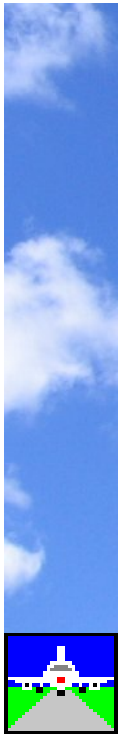
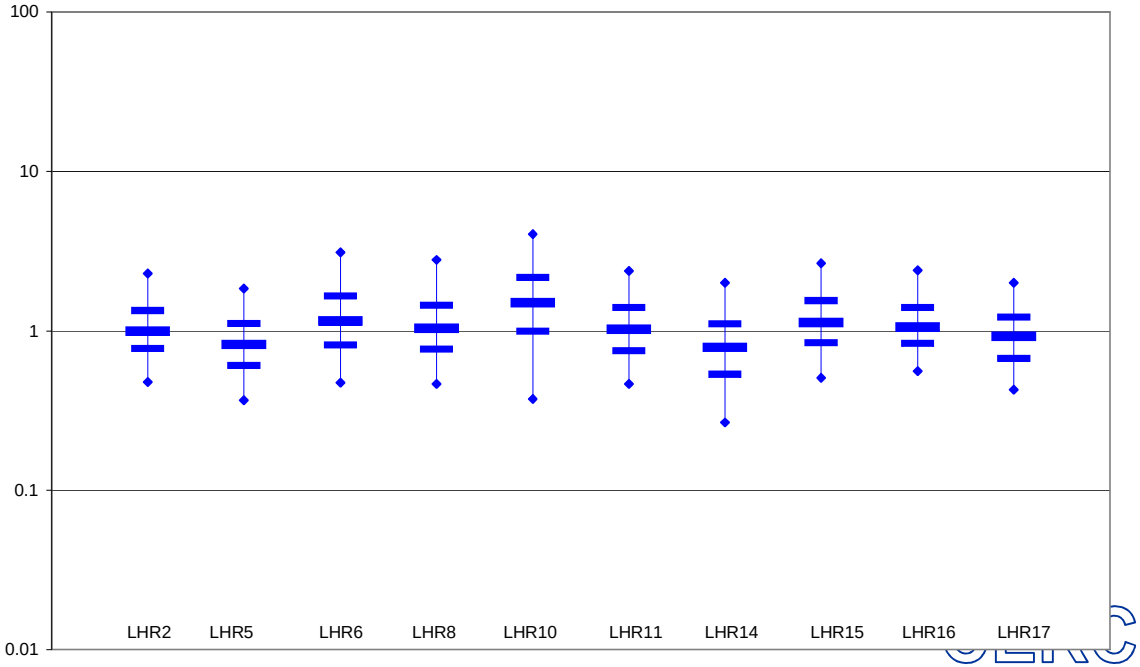


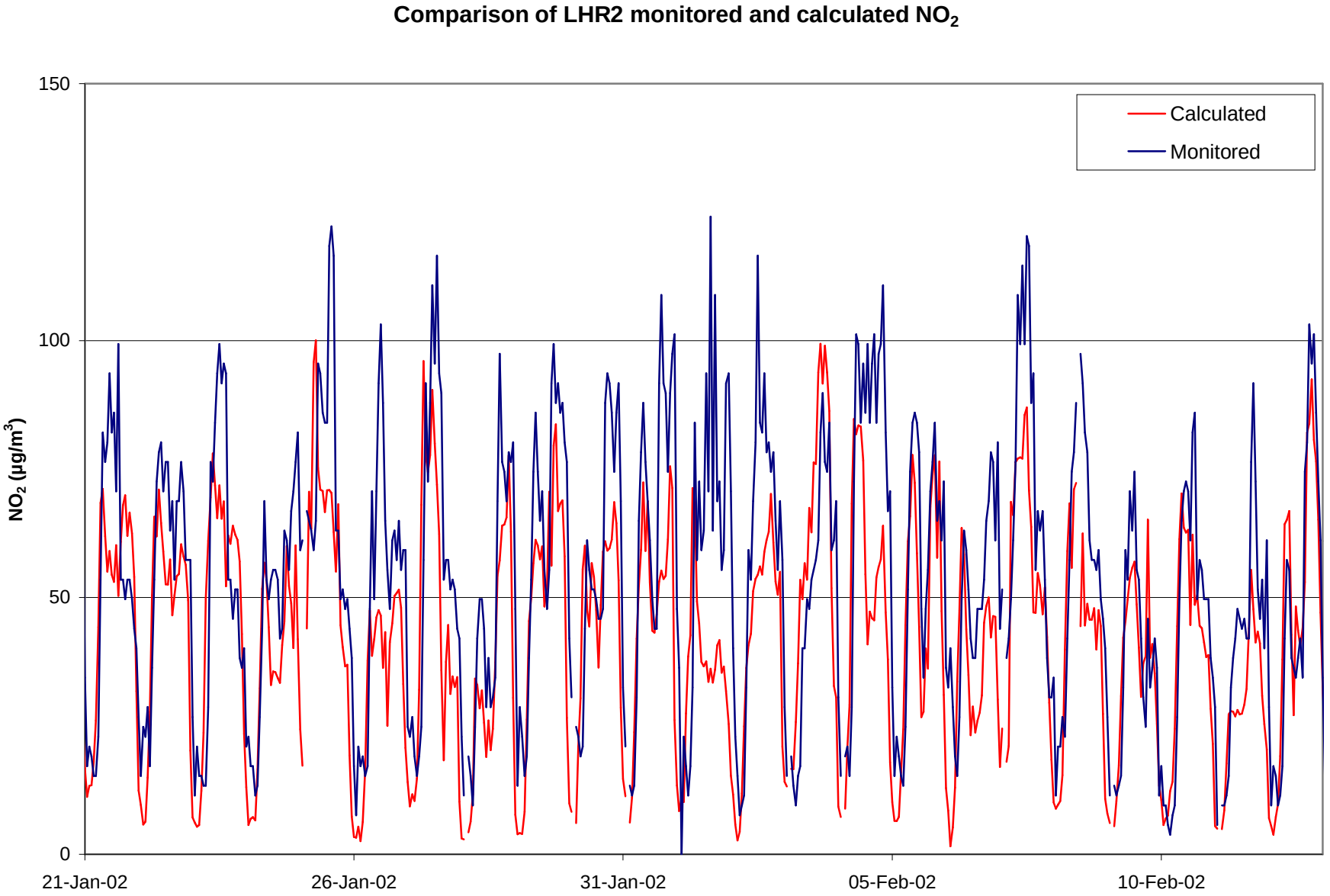
LHR2 "Box and whisker" plots for the ratio of (calculated/monitored) concentrations, NO_X (top) and NO_2 (bottom).

2002 NO_2 box and whisker plot



The lines indicate the 75th, 50th and 25th percentiles and the lines extend from the 95th to 5th percentile.





Detailed time series comparison of monitored (blue) and calculated (red) hourly concentrations at receptor LHR2. 2l Jan 2002 – mid February 2002

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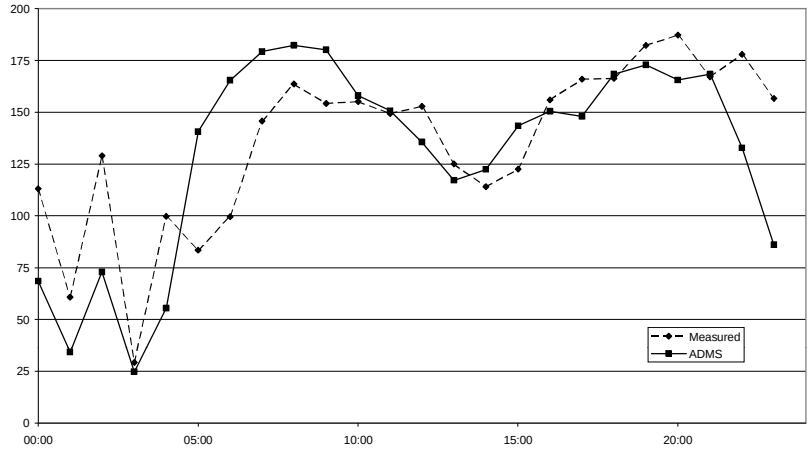
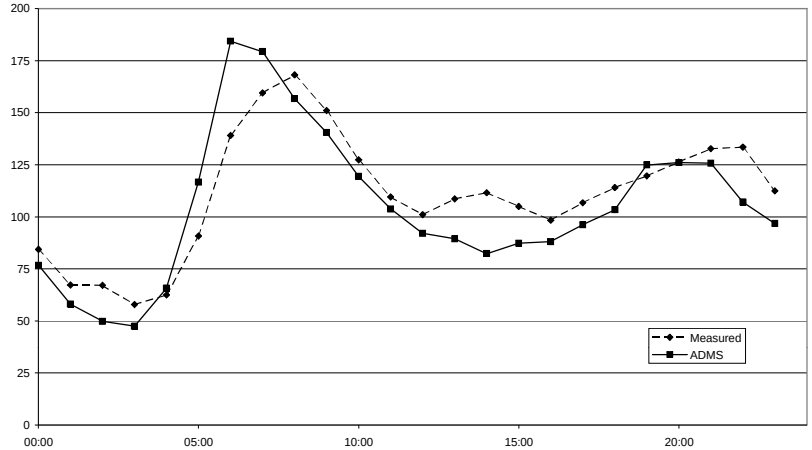
LHR2 diurnal variation ADMS-Airport (solid line) compared with measured data (dotted line), different runway use

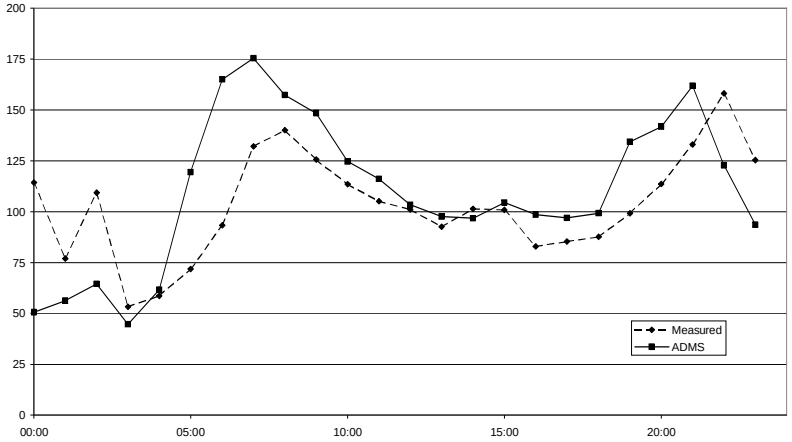
Departure on 27 R



No departure on 27 R



Arrival on 27R



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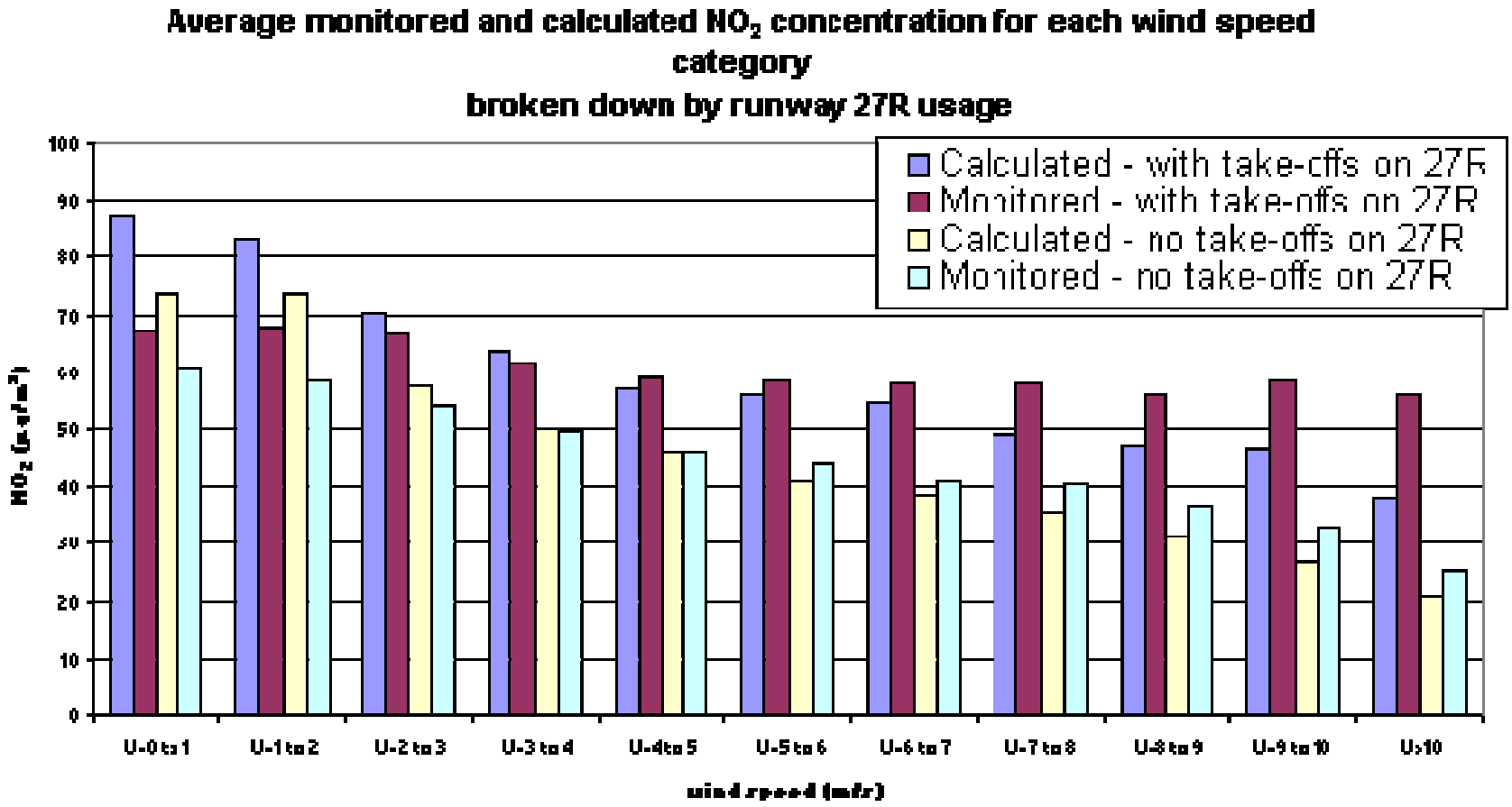
Comparison of monitored and calculated NO_2 in $\mu g/m^3$ at LHR2 as a function of wind speed for the hours when 27R is operational (blue an red) and the hours when it is not operational (cream and pale blue) separately.



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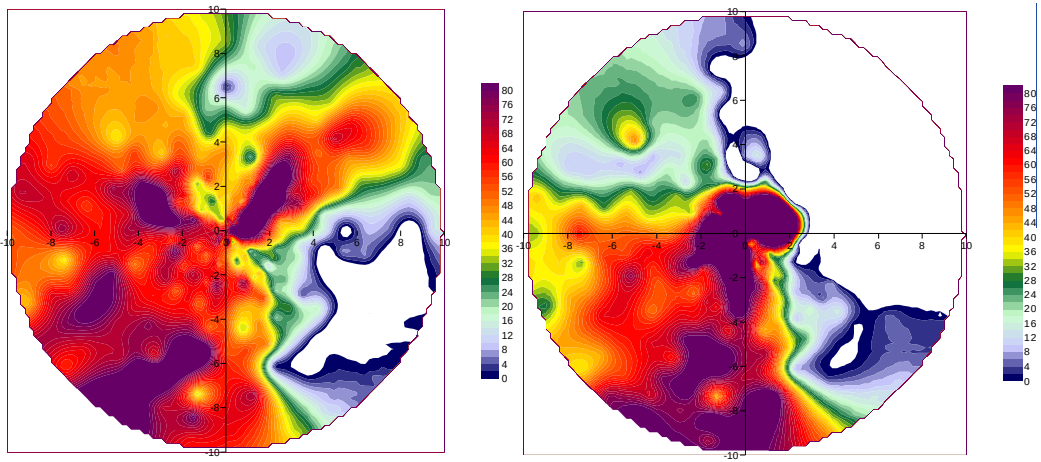
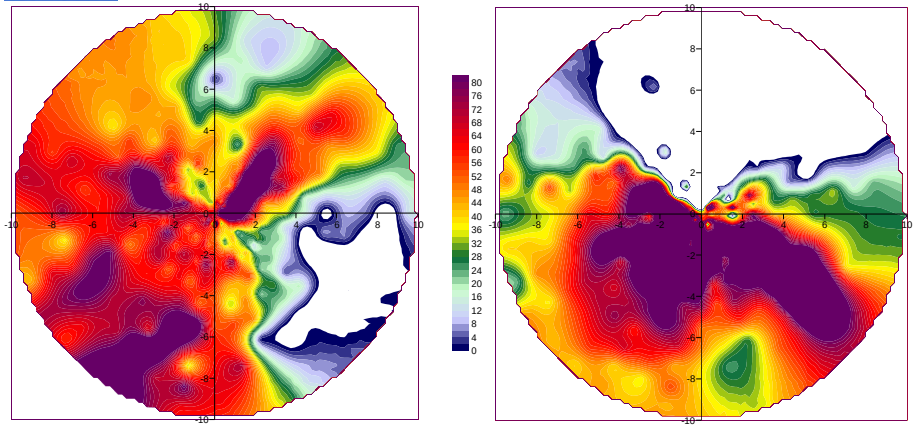
Measured v ADMS modelled



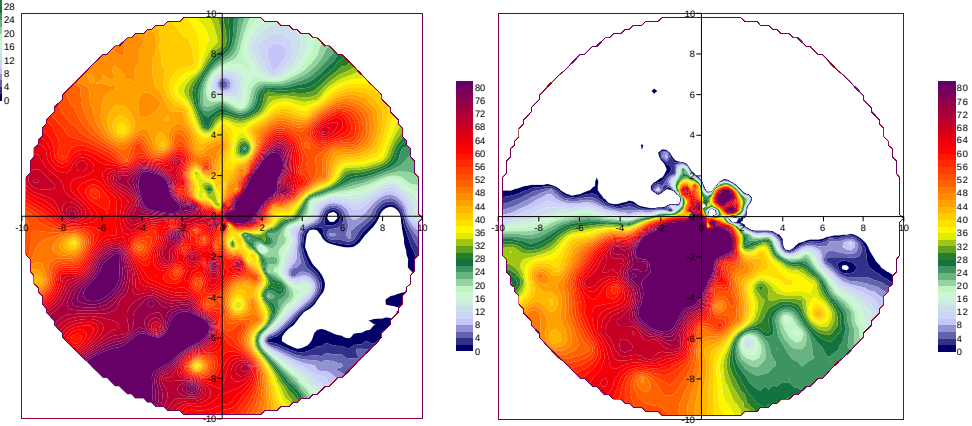
Measured LHR2

CERC predicted

Measured v Model 2



Measured v Model 3



<u>Polar plots</u> of NO_x at LHR2 with background concentrations subtracted. Radius: <u>wind speed</u> in m/s.

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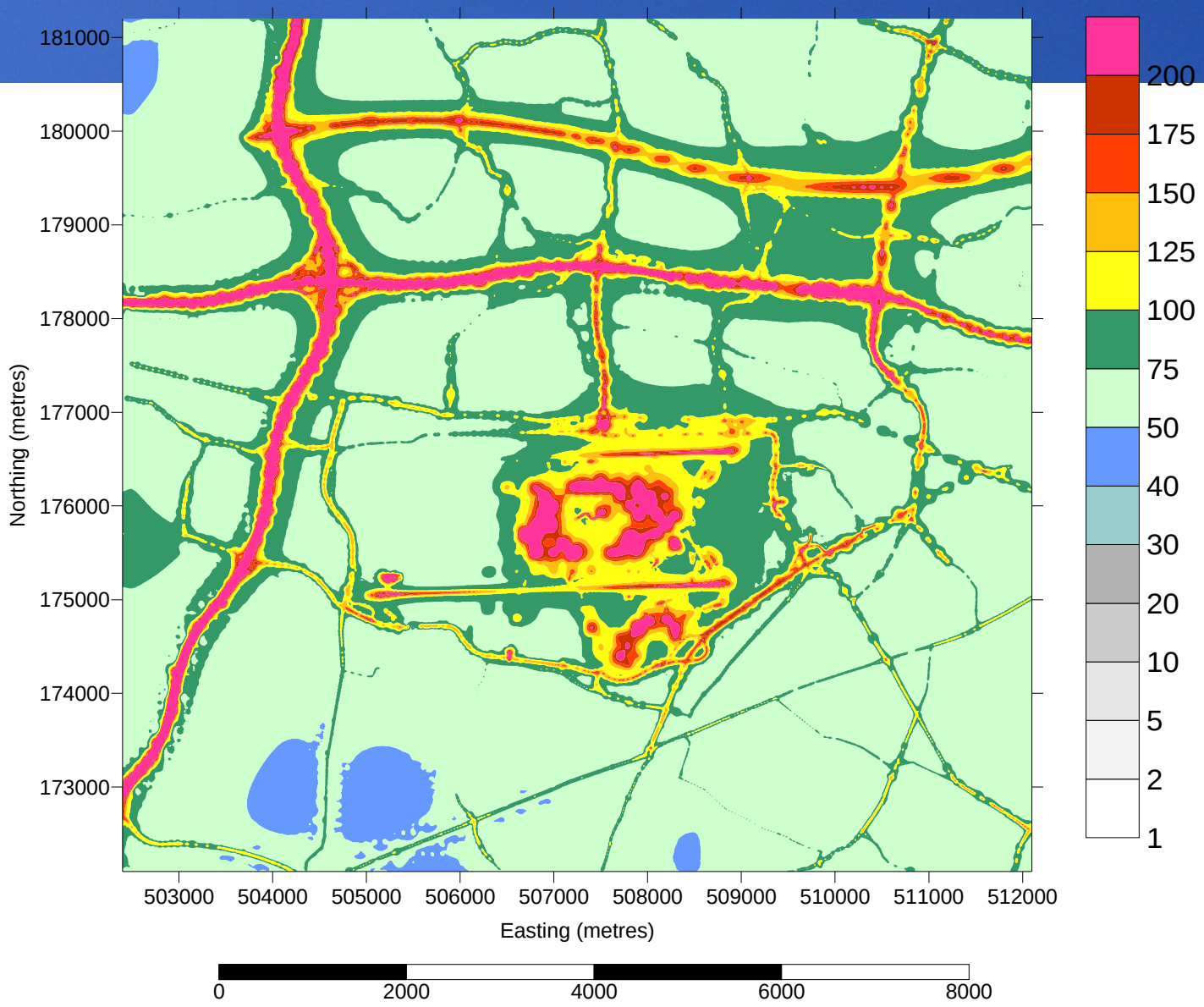
Base
Case
NOX



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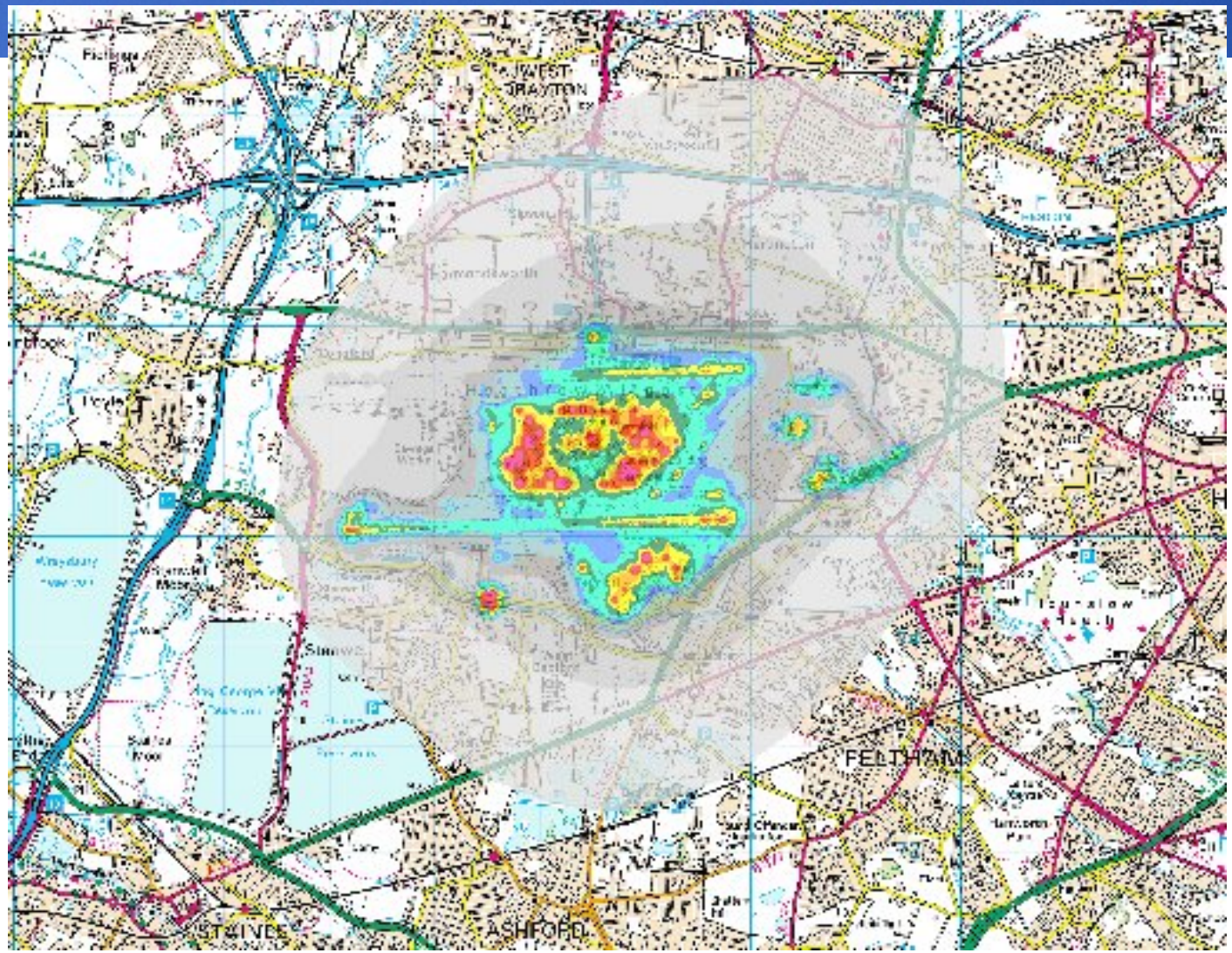
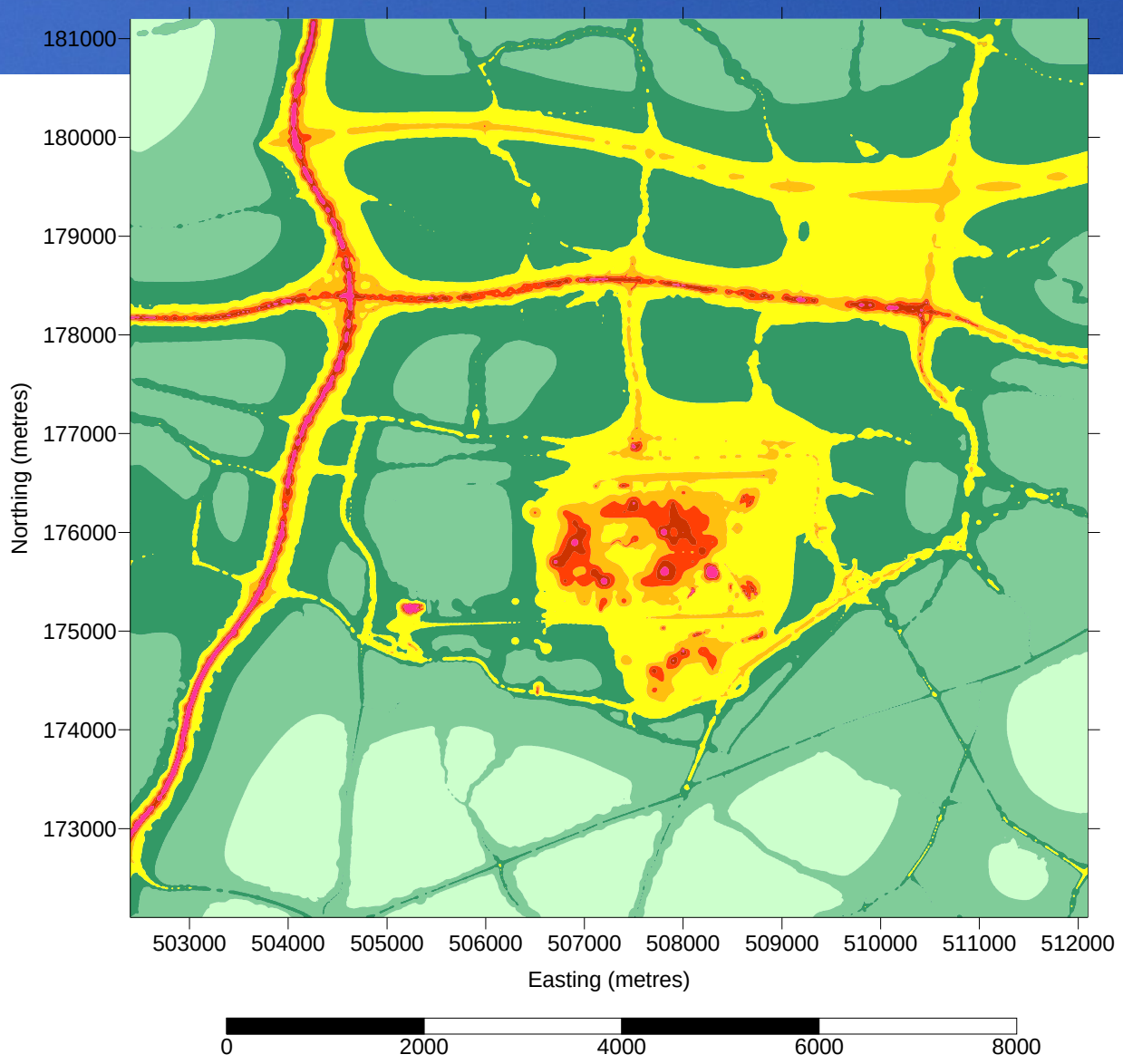


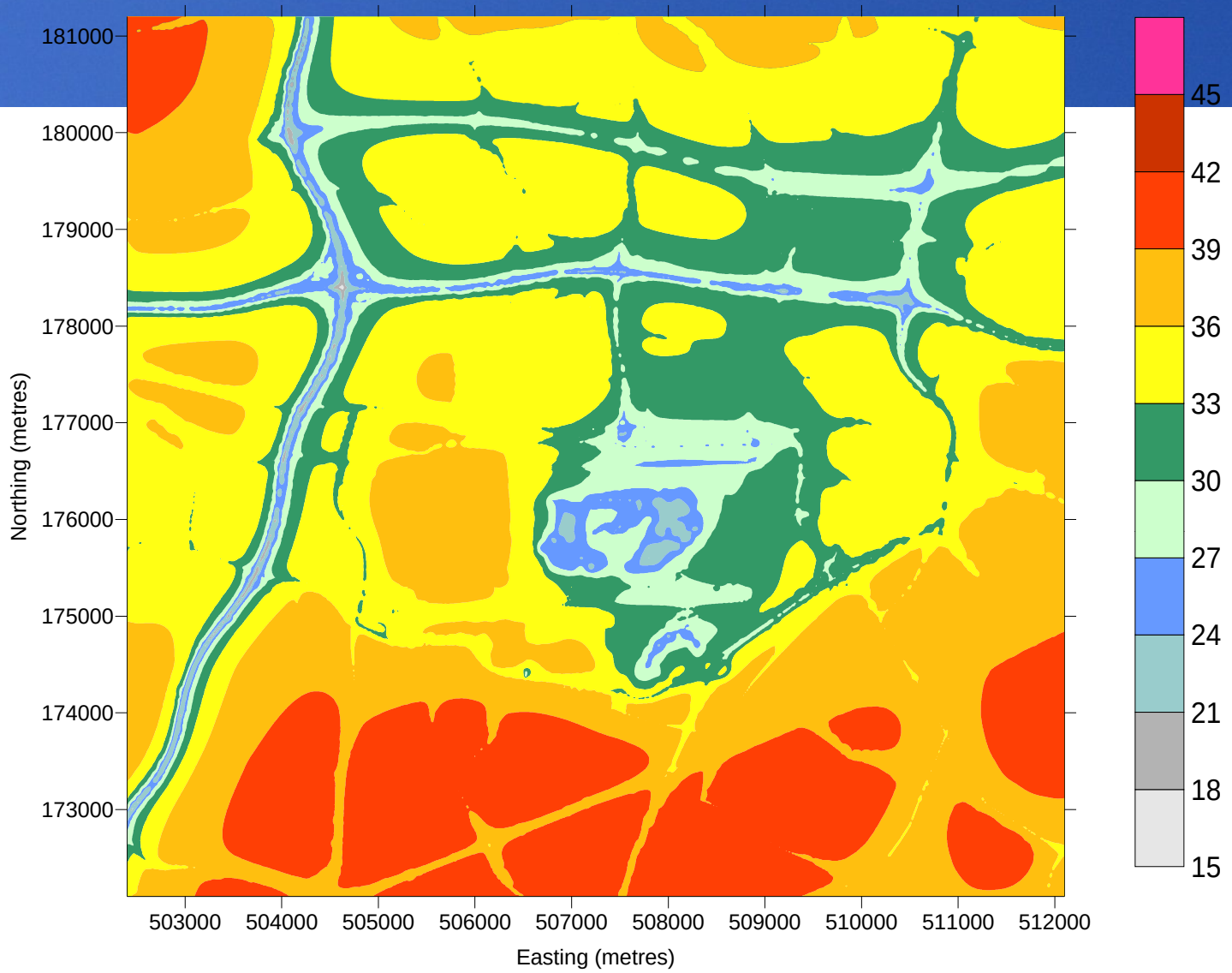
Annual NOX due to aircraft and other airport sources (10km x 10km)

Base
Case
NO2



CERC

Base Case ozone



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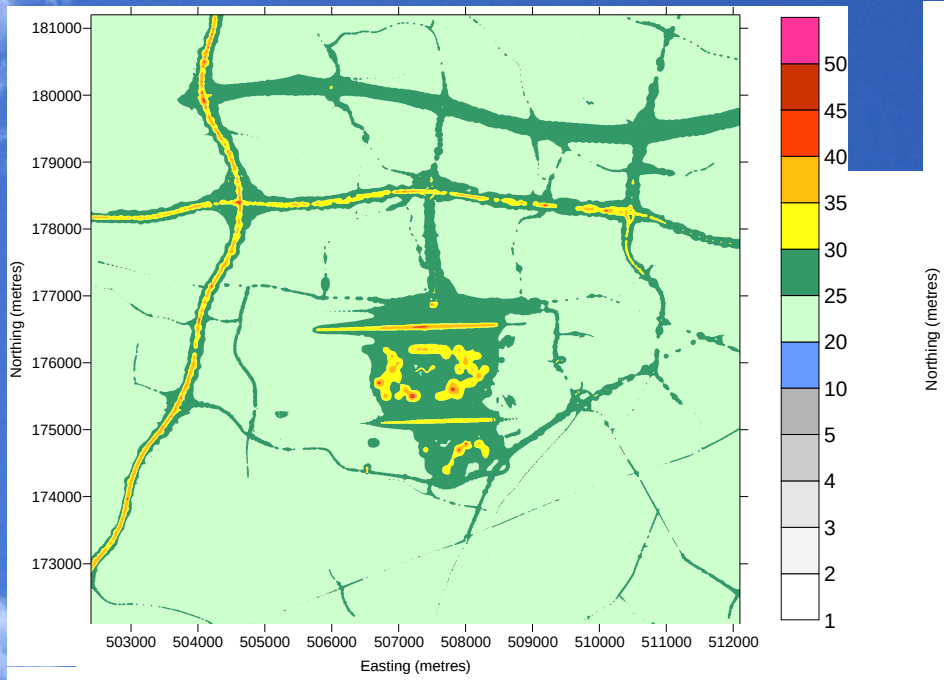

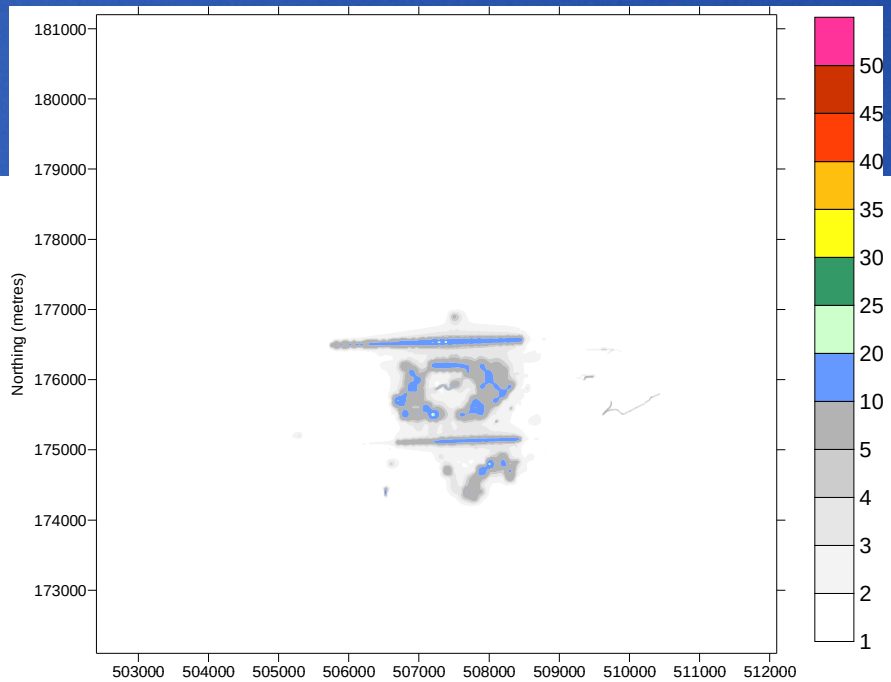

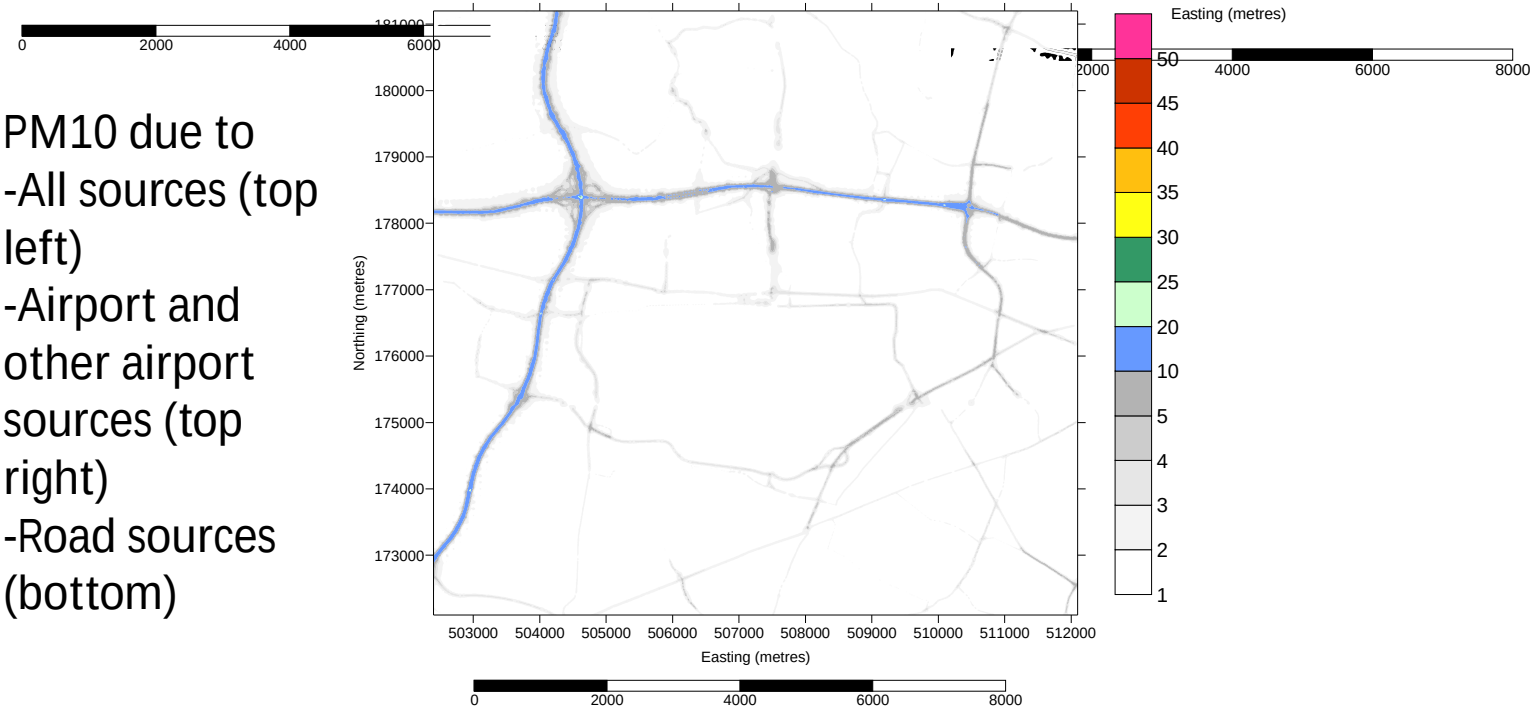

PM10 due to
-All sources (top left)
-Airport and other airport sources (top right)
-Road sources (bottom)

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3) Mixed Mode and R3
Consultation

Scenarios for Mixed Mode and R3

- 2 runways operating in “Segregated Mode”
  - 2002 Base Case
  - 2010 SM
  - 2015 SM
- 2 runways operating in “Mixed Mode”
  - 2015 MM
- 3 runways; “Segregated Mode” on existing long runways & “Mixed Mode” on proposed short runway
  - 2020 R3
  - 2030 R3

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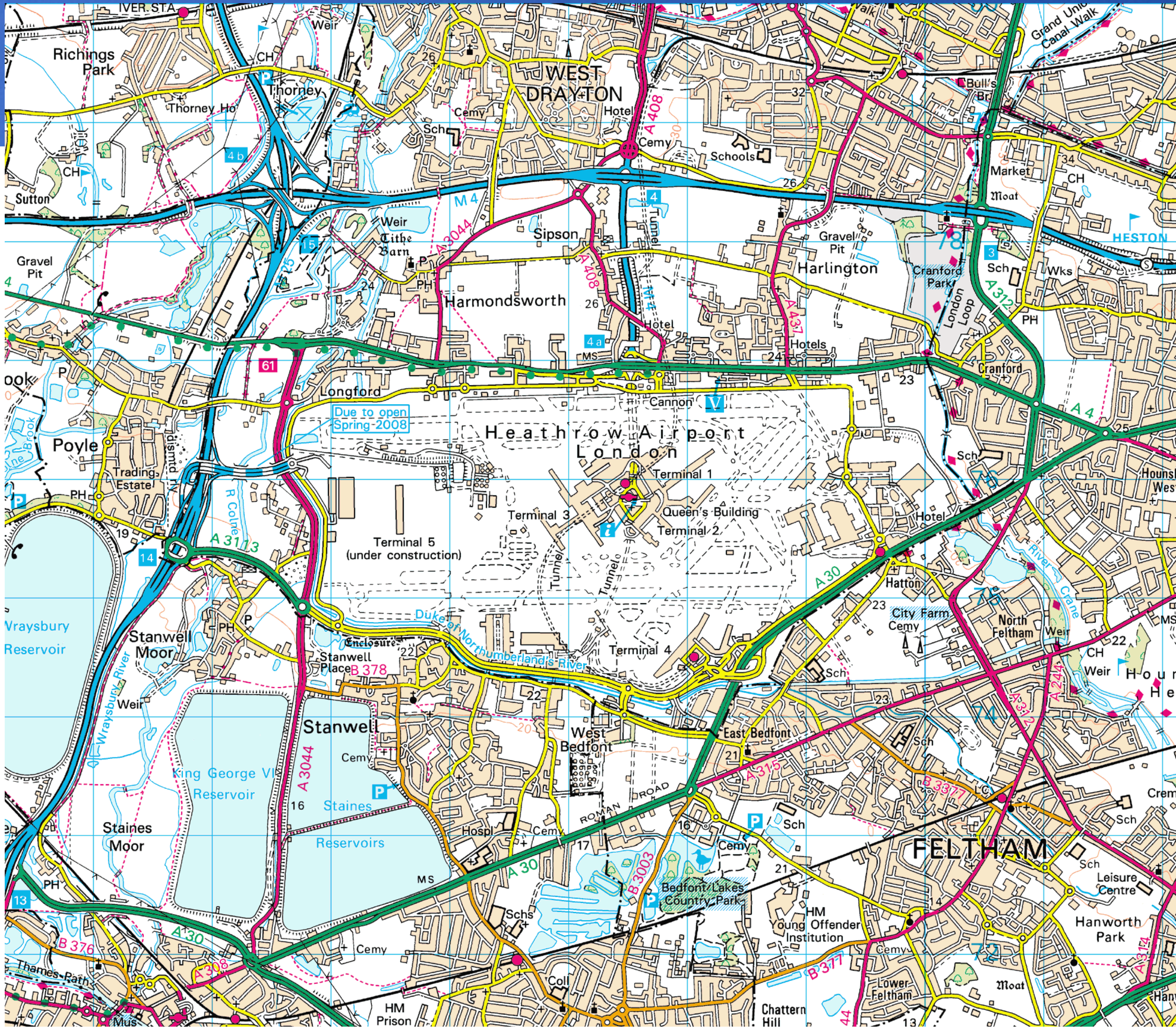
Richings Park
Thorney
Thorney Ho
WEST DRAYTON
Sipson
Harmondsworth
Harlington
Cranford
HESTON
Longford
Poyle
Heathrow Airport London
Terminal 1
Terminal 2
Terminal 3
Terminal 4
Terminal 5 (under construction)
Queen's Building
Due to open Spring 2008
Cannon
Hatton
North Feltham
City Farm
Stanwell Moor
Stanwell
Stanwell Place
West Bedfont
East Bedfont
Wraysbury Reservoir
King George VI Reservoir
Staines Reservoirs
Staines Moor
FELTHAM
Hanworth Park
Lower Feltham
Chattern Hill
Bedfont Lakes Country Park
HM Young Offender Institution
HM Prison
Duke of Northumberland's River
River Crane
Grand Union Canal Walk
M 4
M 25
A 30
A 4
A 3044
A 408
A 437
A 3113
A 315
A 312
B 378
B 3003
B 377
B 3377
B 376
A 308
A 244

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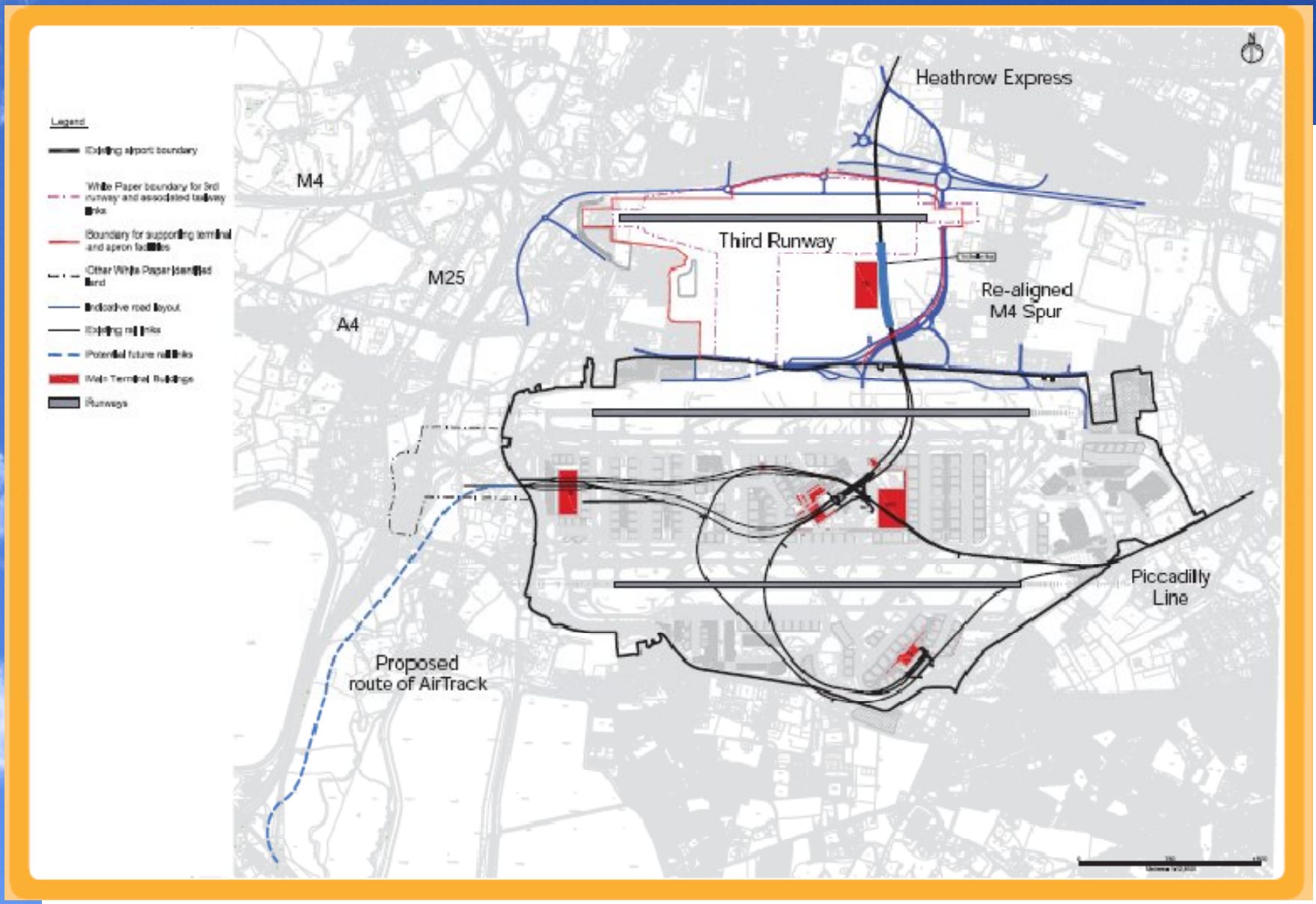

Page 41, "Adding Capacity at Heathrow Airport: Consultation Document",
Department for Transport, November 2007

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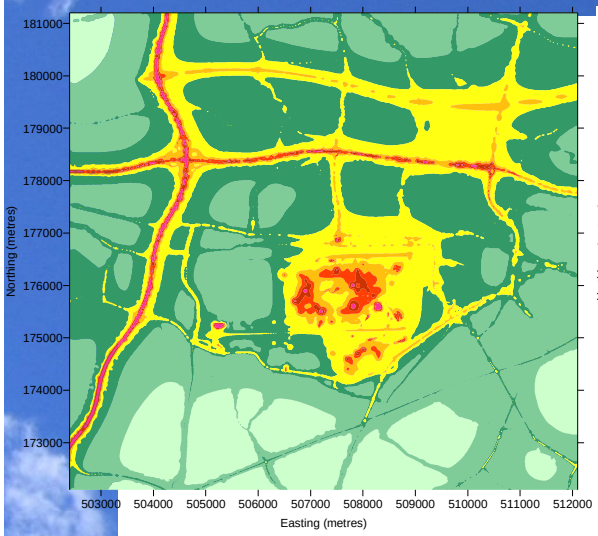
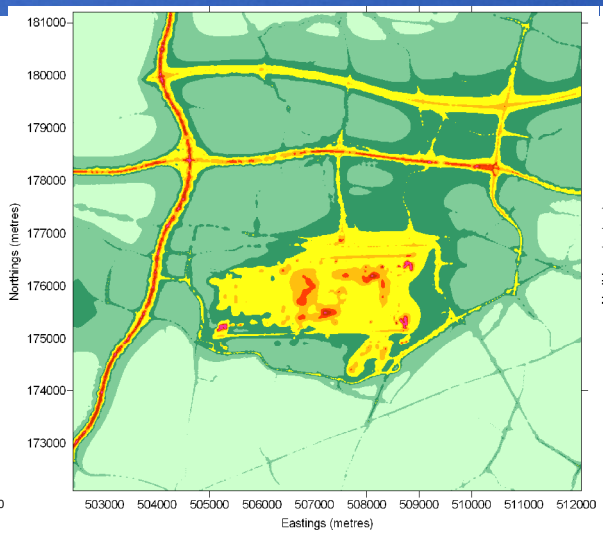
Predicted NO_2 concentrations

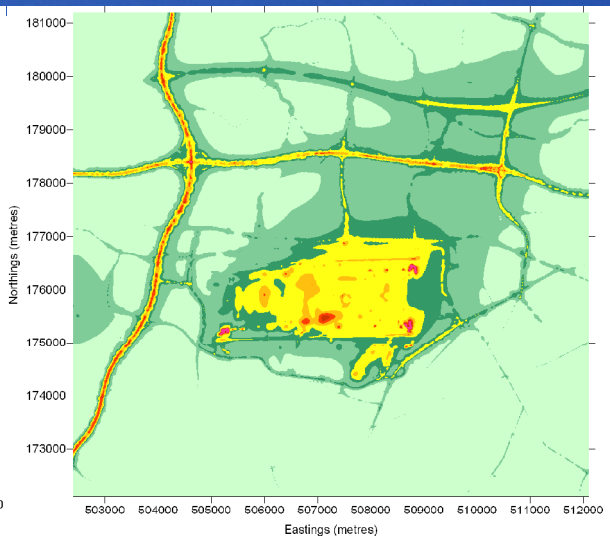
2002 Base Case



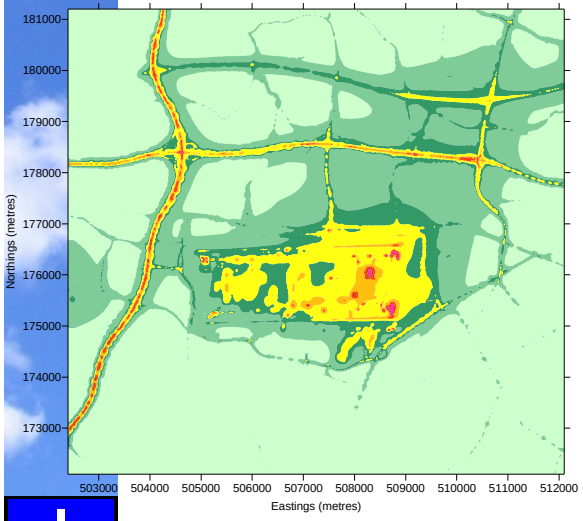
2010 SM



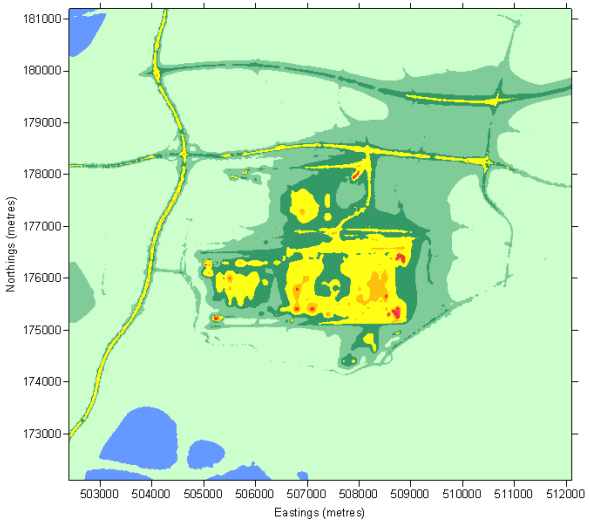
2015 SM



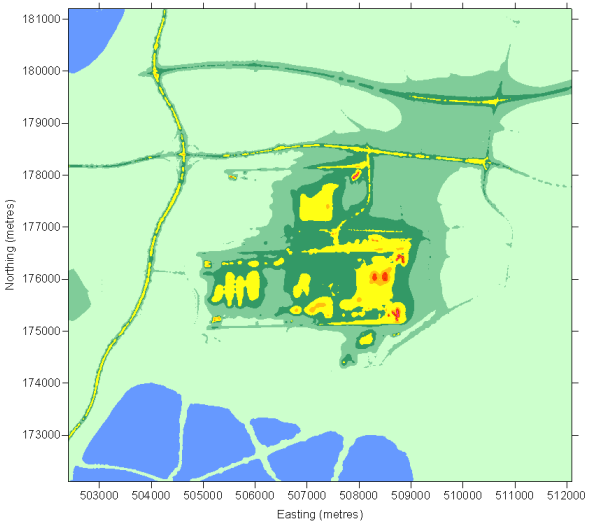
2015 MM

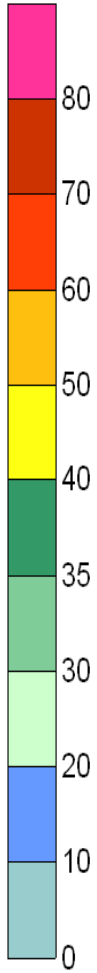


2020 R3



2030 R3





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Conclusions

Key factors affecting pollutant concentrations in the neighbourhood of airports include the following:

- Emissions including primary NO_2
- Background concentrations e.g. O_3
- Meteorology
- Near field dispersion processes, buoyancy of the aircraft exhausts
- Chemical reactions

Heathrow Mixed Mode and R3 – Consultation period over; DfT preparing response

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