Modelling human exposure: present and future

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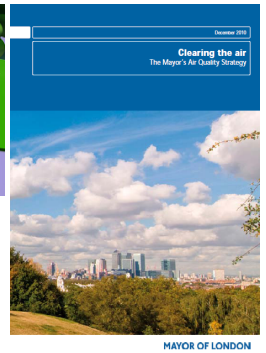
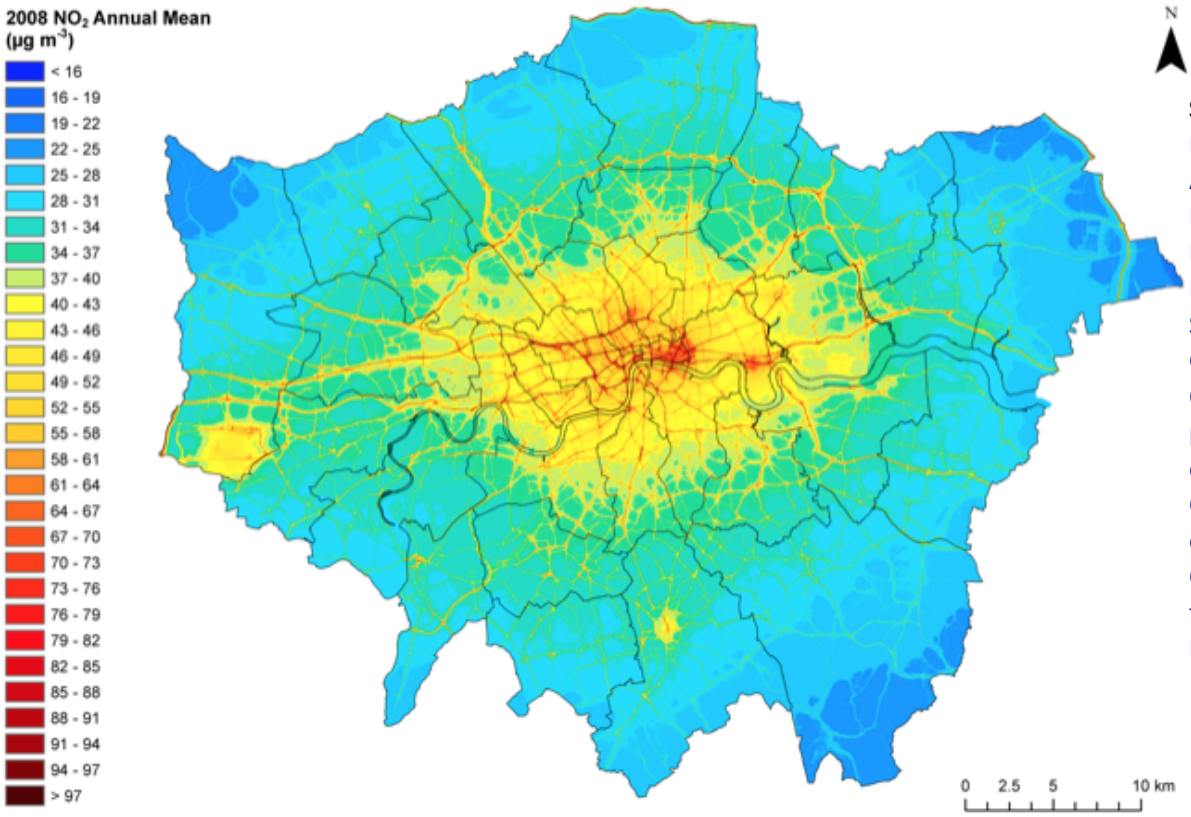
Local scale modelling





Sources

Road transport
Aviation sources
Passenger and commercial shipping
Passenger and freight rail
Large regulated industrial processes (Part A)
Small regulated industrial processes (Part B)
Gas heating (domestic and industrial-commercial)
Oil combustion sources (domestic and large boiler plant), Coal combustion sources (domestic and commercial)
Construction source (NRMM, construction/demolition)
Others (agricultural, landfill, waste transfer, accidental fires and household sources)
Biomass burning

London air quality model results - http://data.london.gov.uk/laei-2008

Uses:

Congestion charging, Low Emissions Zones, Mayor's Air Quality Strategy (http://www.london.gov.uk/sites/default/files/Air%20Quality%20Strategy%20v3.pdf)

Epidemiological research and Health Impact assessments

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Present: Static approach to exposure assessment

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Future: Hybrid approach to exposure assessment

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Static and Hybrid approaches to exposure assessment

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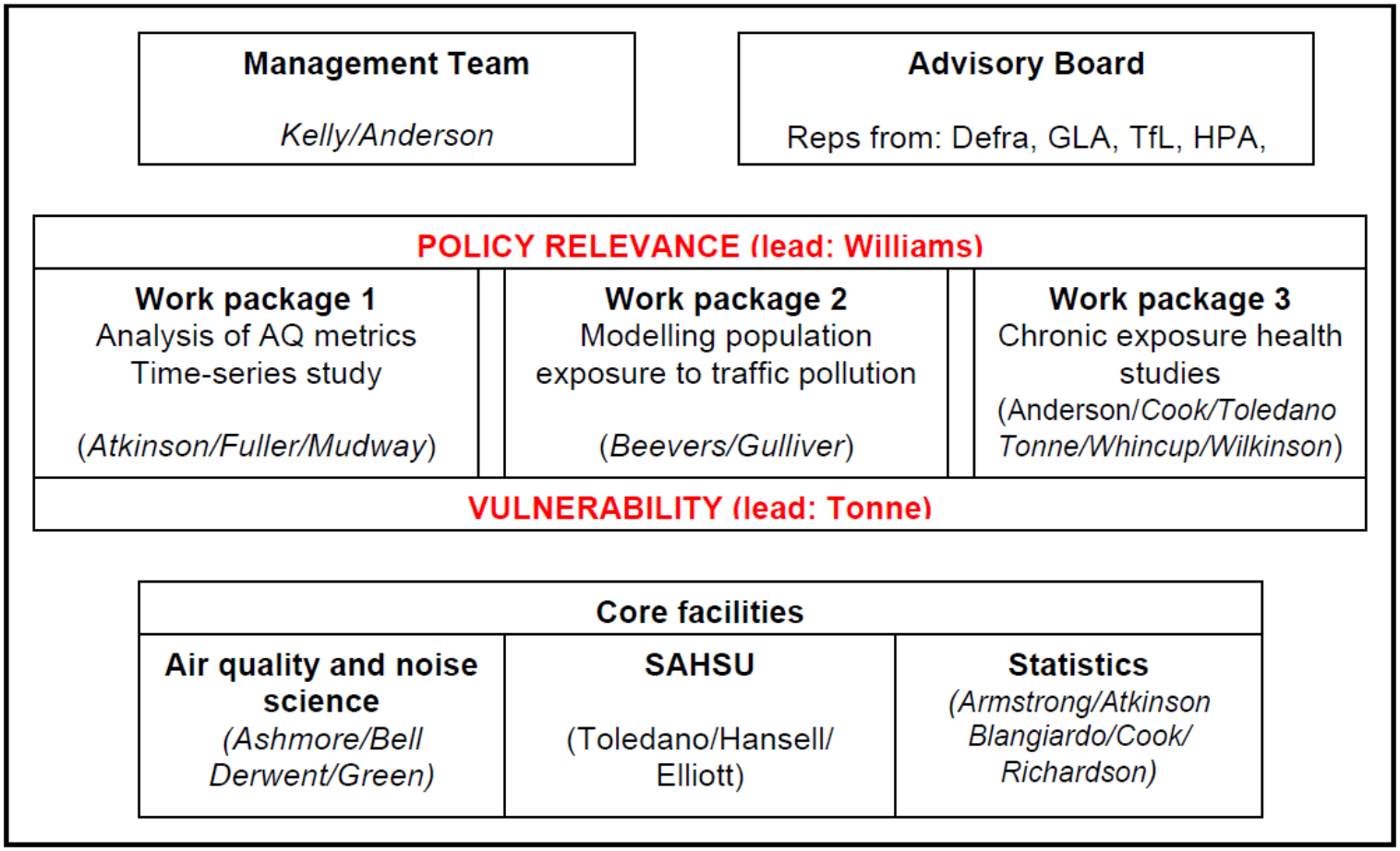
Traffic Pollution and Health in London project



http://www.erg.kcl.ac.uk/ResearchProjects/Traffic/Default.aspx?DeptID=ResearchProjects&CategoryID=ResearchProjectsTraffic

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Static modelling for “Traffic”

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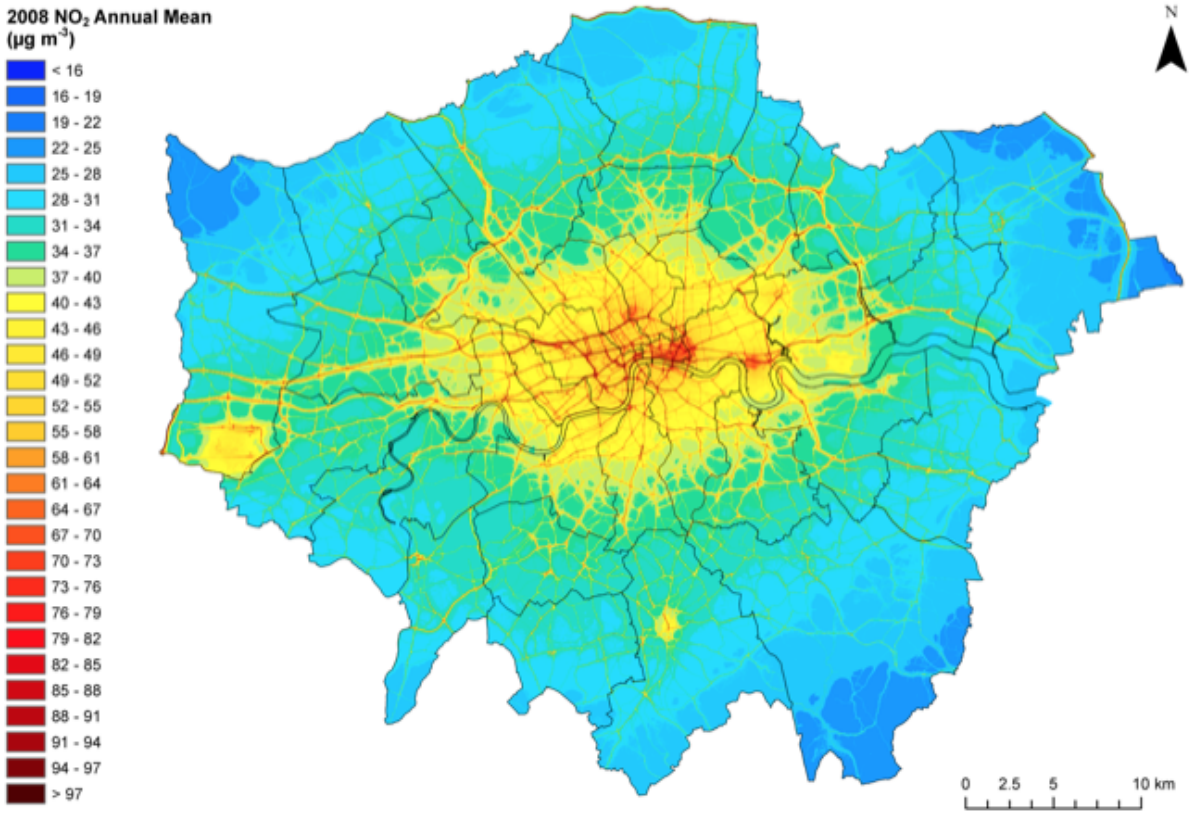
Local scale modelling



Epidemiology:

As part of the "Traffic" air quality modelling predictions (2003 – 2010) being used to investigate spatio-temporally a range of health outcomes including:

Child lung function and cardiovascular risk markers,
primary care consultations,
adverse reproductive outcomes,
hospital admissions,
acute coronary syndrome and mortality.

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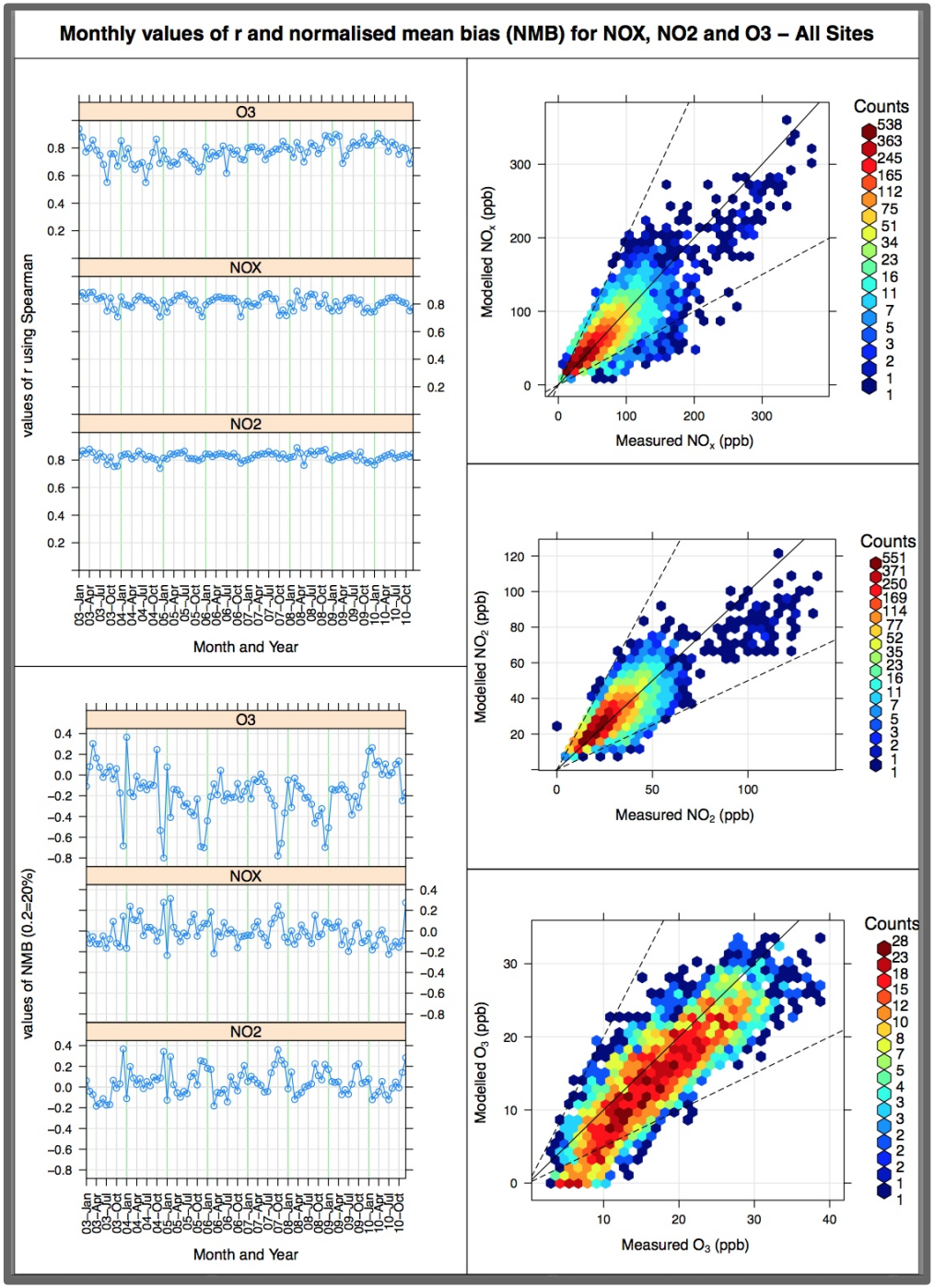

Monthly Model Evaluation

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Hybrid modelling for “Traffic”

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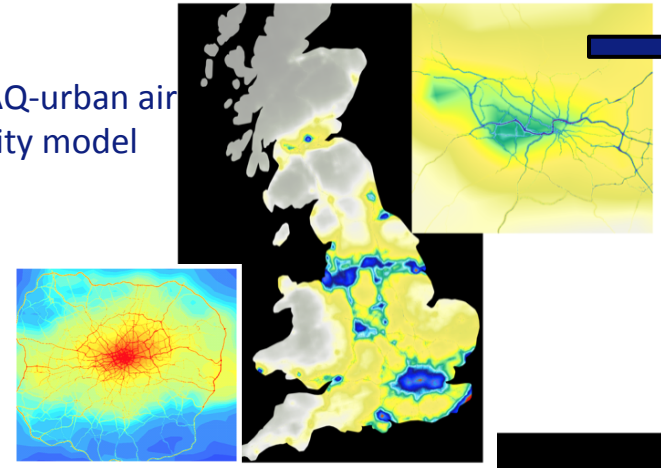
Hybrid exposure model

CMAQ-urban air quality model

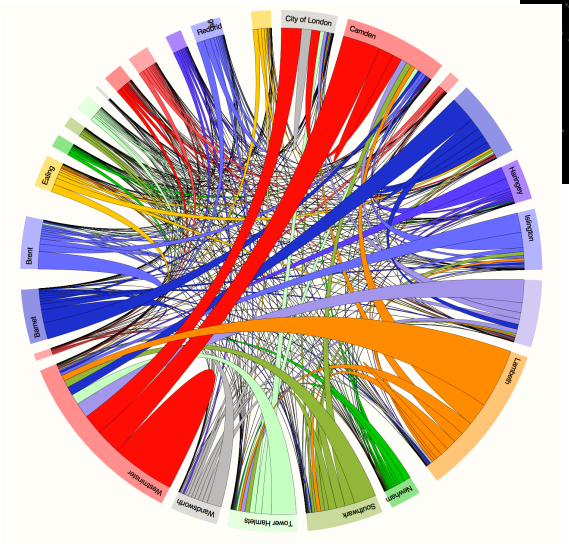


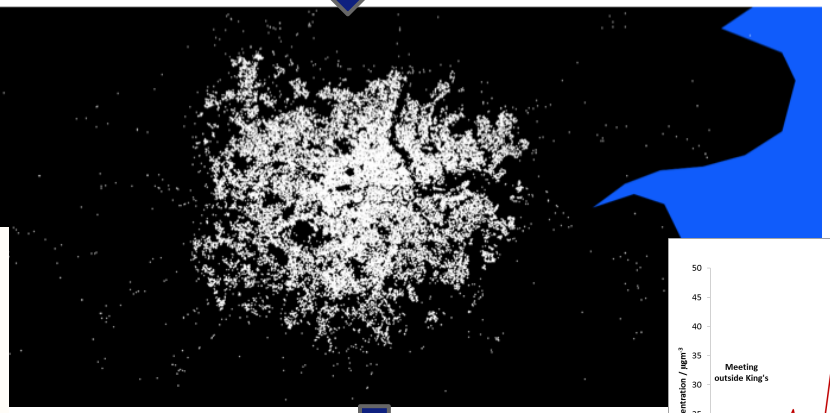
Micro-environmental modelling: in-vehicle (bus, car, train, tube), cycle, walk, indoors (I/O exchange)

$$\frac{dC_{in}}{dt} = \lambda_{win}(C_{out} - C_{in}) - n\lambda_{HVAC}C_{in} - V_g\left(\frac{A}{V}\right)C_{in} + \frac{Q}{V}$$

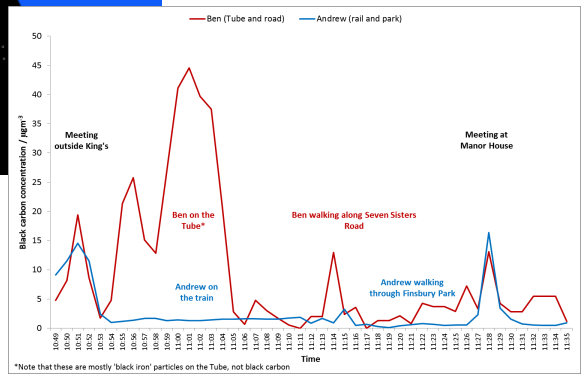
London Travel Demand Survey: Trips by transport mode: Sex, age, gender and socio-economic status

Oyster card data





Detailed human exposure



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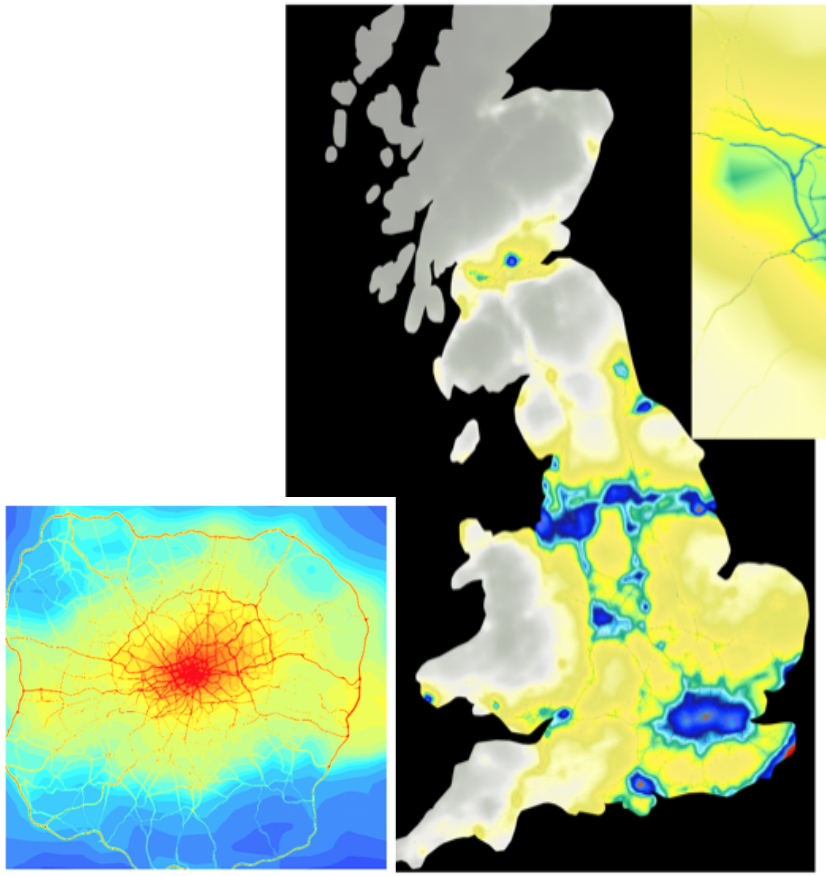
Coupled local/regional scale modelling (CMAQ-urban)



Beevers SD , Kitwiroon N, Williams ML, Carslaw DC. 2012. One way coupling of CMAQ and a road source dispersion model for fine scale air pollution predictions. Atmospheric Environment 59, pp 47-58

Model outputs: NO_X, NO_2, O_3, PM components

Computing facilities…..you can't have enough

Emissions inventories

UK National Atmospheric Emissions Inventory (NAEI)
King's Great Britain road traffic emissions
European Monitoring and Evaluation Programme (EMEP, http://www.ceip.at/)
European Pollutant Release and Transfer Register (EPRTR)
Biogenic Emission Inventory System (BEIS v3.14) VOC and soil NO
Eclipse - IIASA

Boundary conditions

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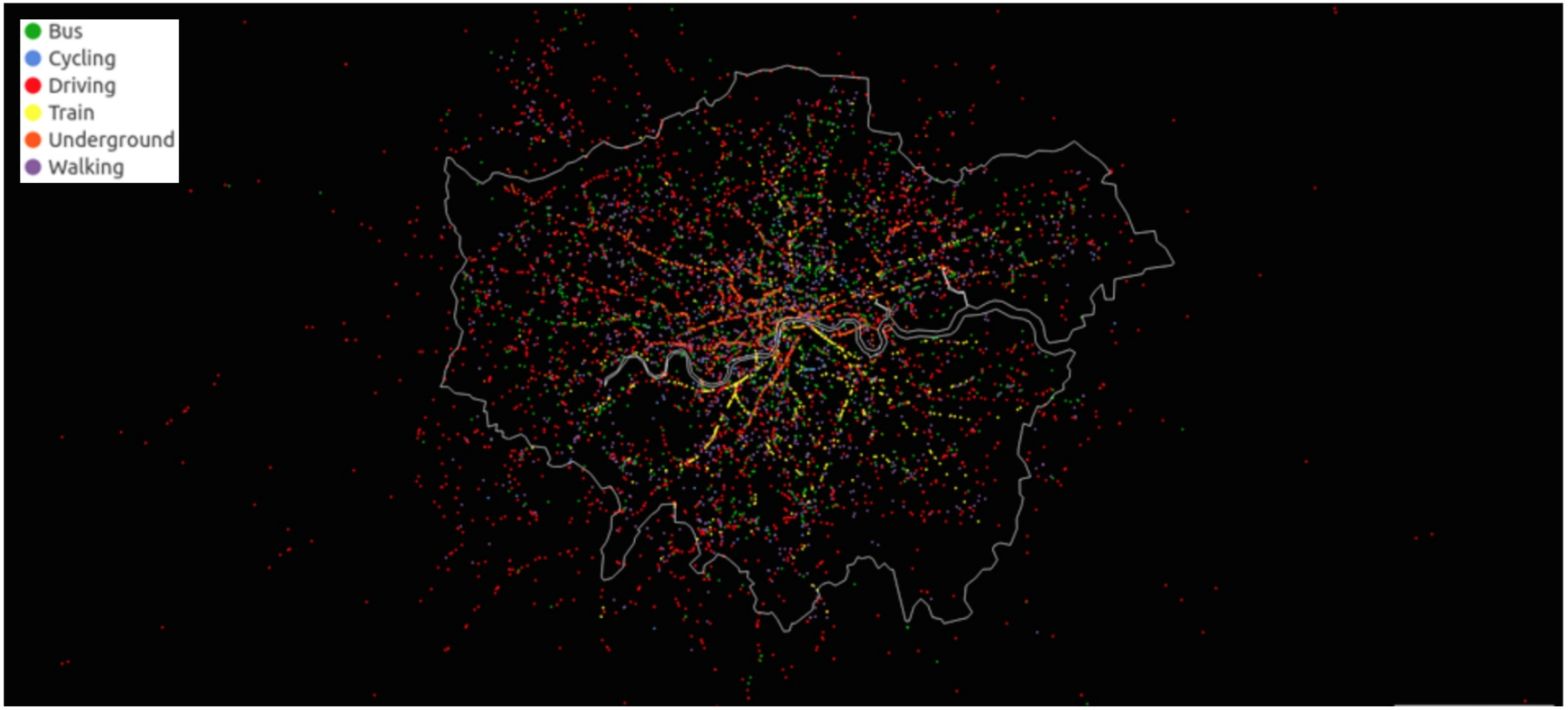
The London Travel Demand Survey (LTDS) from TfL – it's anonymised

Using the LTDS however, we have data on 85,000 people journeys for 24 hours

2005/2006	5008 households, 11583 people, 29,797 trips, 61,542 stages
2006/2007	8005 households, 18241 people, 47,029 trips, 95,930 stages
2007/2008	7873 households, 17926 people, 44,828 trips, 91,967 stages
2008/2009	8134 households, 18975 people, 43,076 trips, 89,701 stages
2009/2010	8290 households, 19187 people, 43,475 trips, 92,121 stages
2010/2011	Will get data soon
2011/2012	Will get data soon

Lots of data (!)

London journeys



Location of Londoners on a typical day as at **0816**

7am 8am 9am 10am 11am 12am 1pm 2pm 3pm 4pm 5pm 6pm 7pm 8pm

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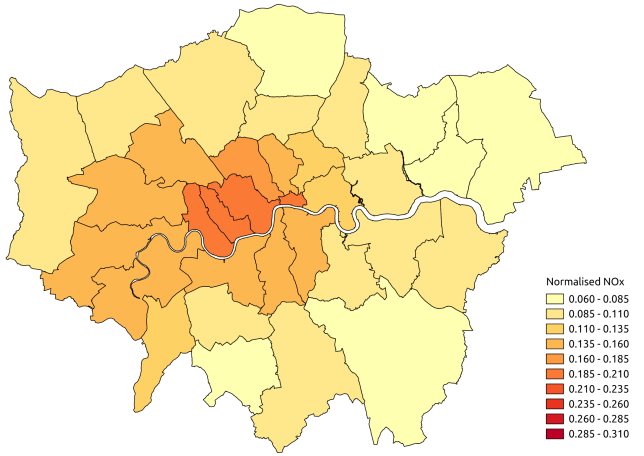
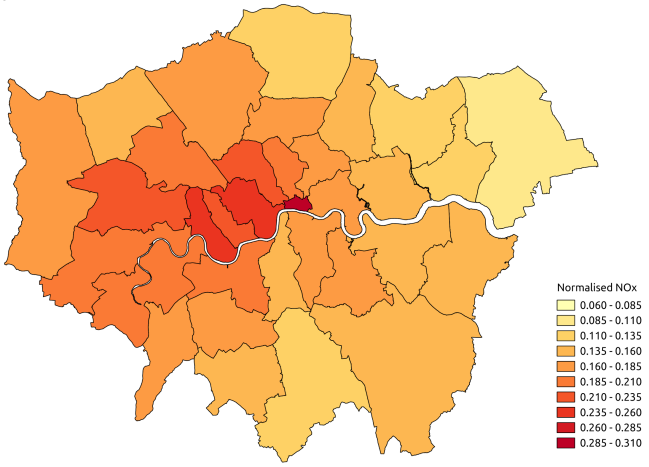
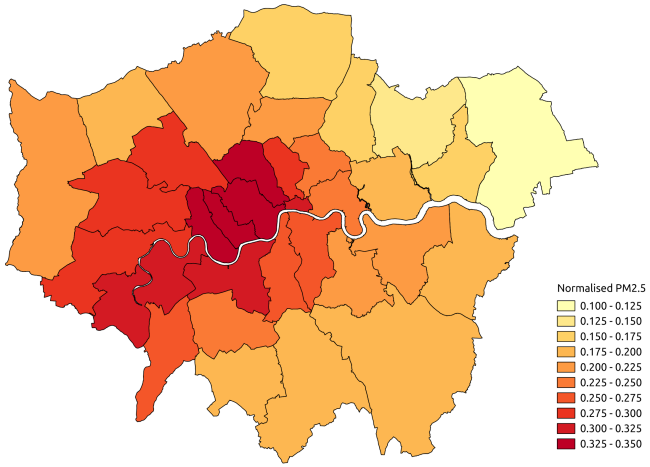
Geographic exposure to NO_X (top) and $PM_{2.5}$ (bottom)

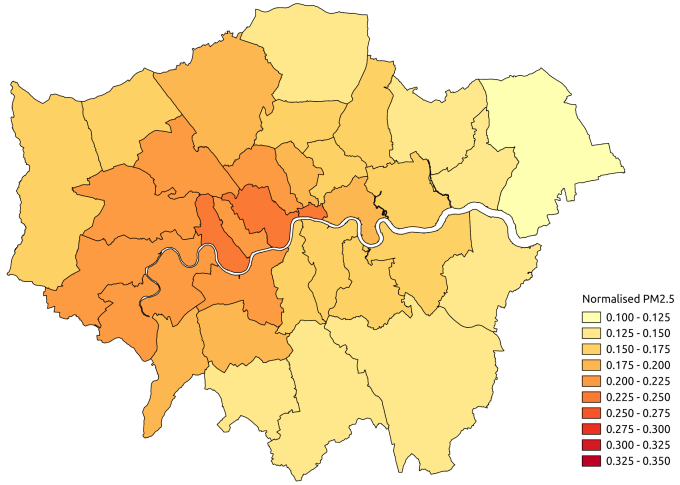
Static model



Hybrid model







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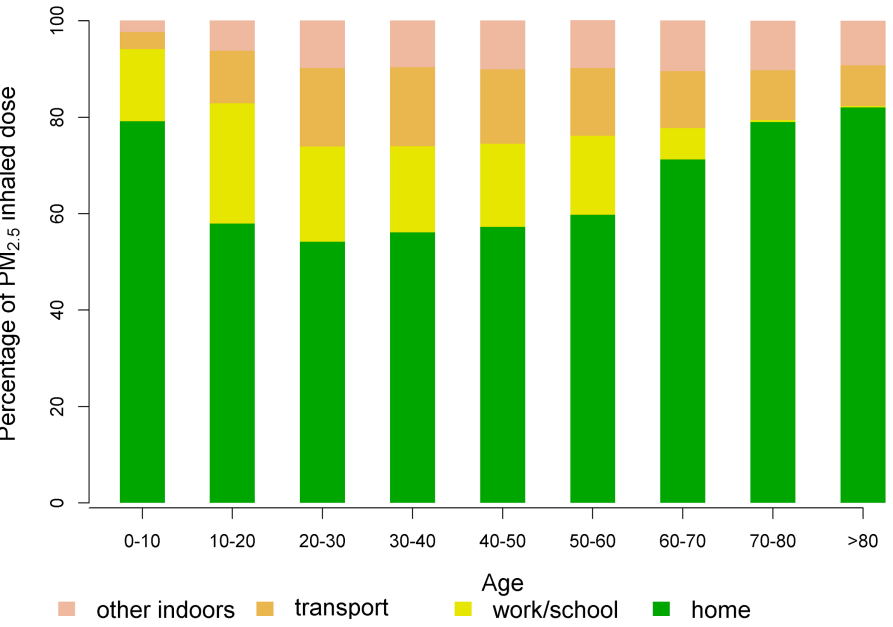
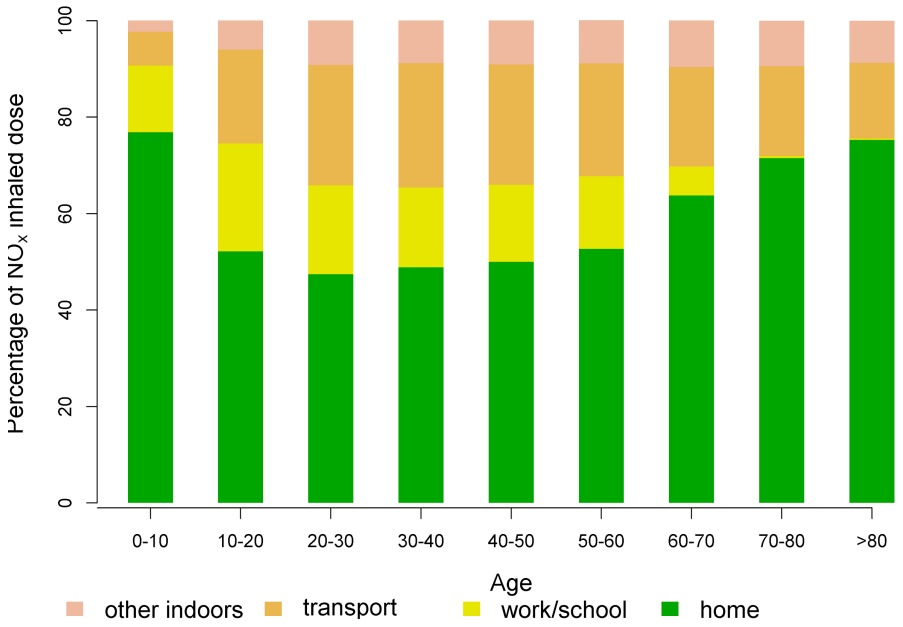
NO_X and $PM_{2.5}$ Dose by age group





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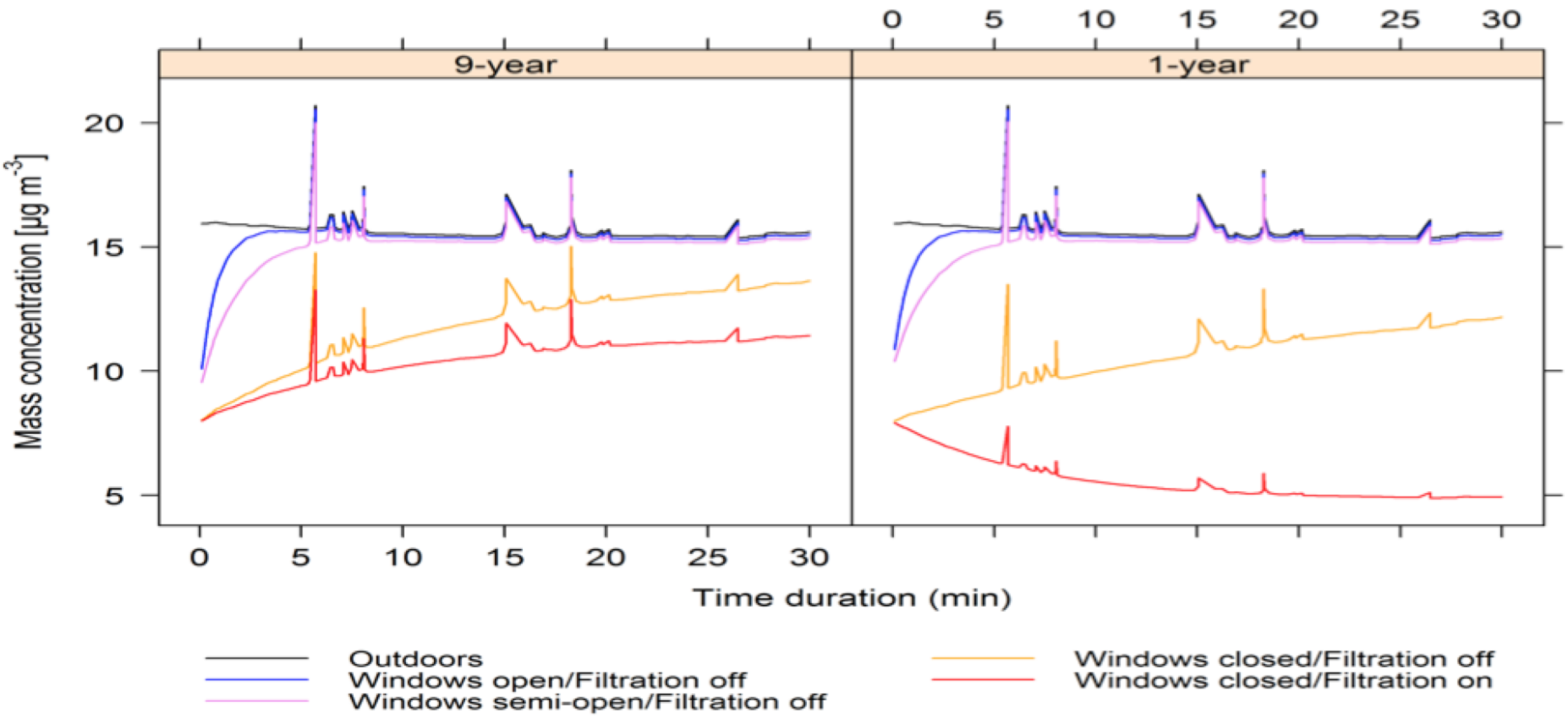
In-car $PM_{2.5}$ results



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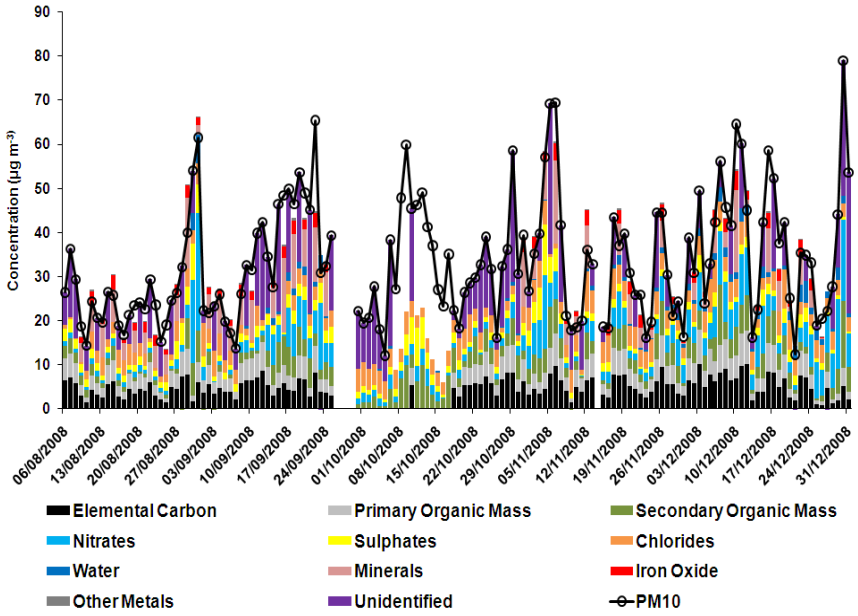
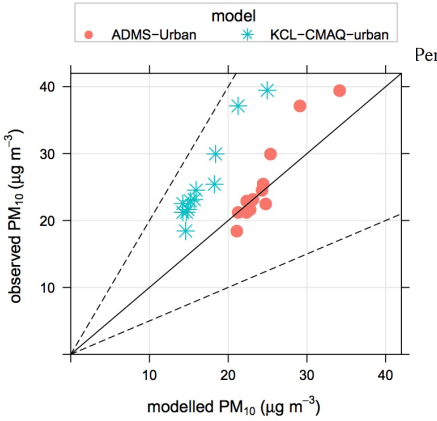
CMAQ-urban Model evaluation

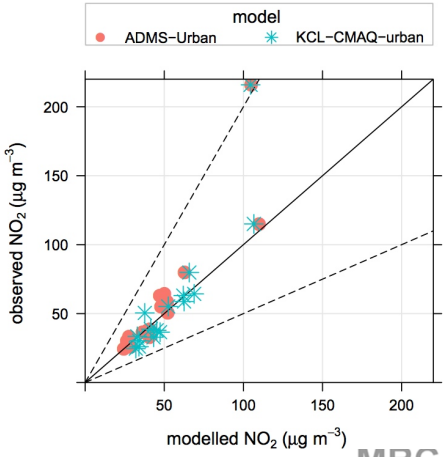


PM_{10} (top) and NO_2 (bottom)



Performance of ADMS-Urban and KCL CMAQ-Urban for PM_{10}

variable	ADMS-Urban	KCL-CMAQ-urban
n	91735.00	95973.00
FAC2	0.88	0.64
MB	-0.48	-8.68
MGE	8.35	11.09
NMB	-0.02	-0.34
NMGE	0.33	0.43
RMSE	13.12	15.91
r	0.63	0.62
COE	0.30	0.10



Performance of ADMS-Urban and KCL CMAQ-Urban for NO_2

variable	ADMS-Urban	KCL-CMAQ-urban
n	127477.00	133115.00
FAC2	0.81	0.81
MB	-9.84	-5.36
MGE	23.41	23.53
NMB	-0.17	-0.09
NMGE	0.39	0.39
RMSE	43.45	43.68
r	0.71	0.69
COE	0.38	0.38

PM components (nitrate, sulphate, organic aerosol etc)

Underestimates PM

NO_X- NO_2- O_3 reasonably well predicted

http://uk-air.defra.gov.uk/assets/documents/reports/cat20/1312021020_131031urbanPhase2.pdf

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Exposure measurements

http://www.londonair.org.uk/london/asp/news.asp?NewsId=CityAirpressrelease

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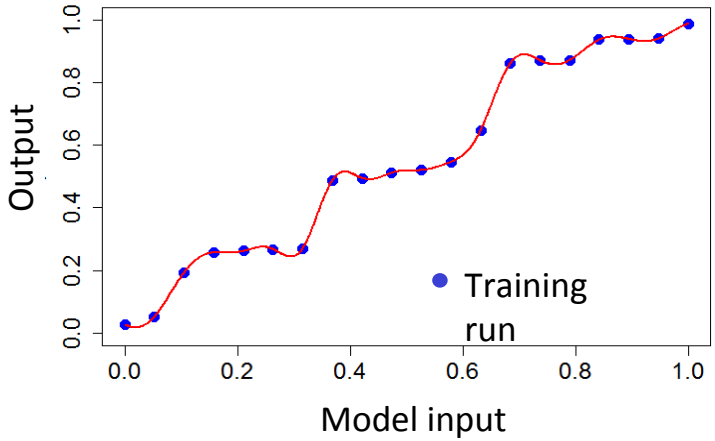
Uncertainty Analysis in Atmospheric modelling

Quantifying model uncertainty becomes prohibitive for models with long run times.

Reduce the number of parameters through sensitivity analysis (214 to 31)

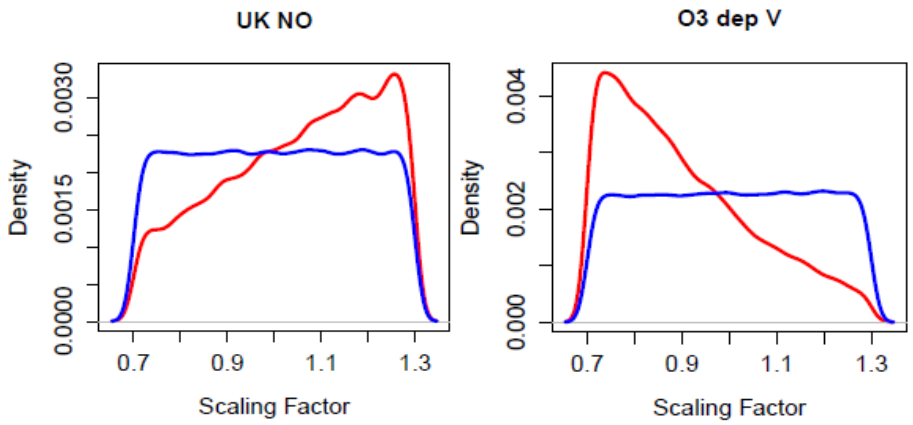
Our solution is to build an 'emulator'



Bayesian Calibration

Each Monte Carlo run is weighted according to its probability of corresponding to observational data

This shifts the mean of the uncertainty distribution towards the observed value and reduces its standard deviation



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National Institute for Health Research (NIHR)

Public health air pollution impacts of different pathways to meet the UK Climate Change Act commitment to 80% reduction of CO2 and other greenhouse gas emissions by 2050

- Based on NAEI and DECC carbon budget forecasts (2030)
- Predict to 2050
- Use CMAQ-urban and met. office HadGem future met. predictions
- Look at human exposure and health costs of future scenarios (using hybrid model)

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The future….

Indoor model - important addition to the current hybrid model

Model evaluation - MRC funded project, Characterising COPD Exacerbations using Environmental Exposure Modelling (COPE) project

Uncertainty of the hybrid approach

Develop **sources** within the model that are currently poorly understood - non-exhaust emissions, biomass burning, cooking etc

Thanks for your attention…

Thanks to colleagues ERG modelling:
Nutthida Kitwiroon, David Dajnak, Andrew Beddows, Christina Mitsakou, James Smith and Gregor Stewart

London Boroughs, Transport for London, DEFRA and the Greater London Authority

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