The impacts of policies to meet the UK Climate Change Act target on air quality – an explicit modelling study

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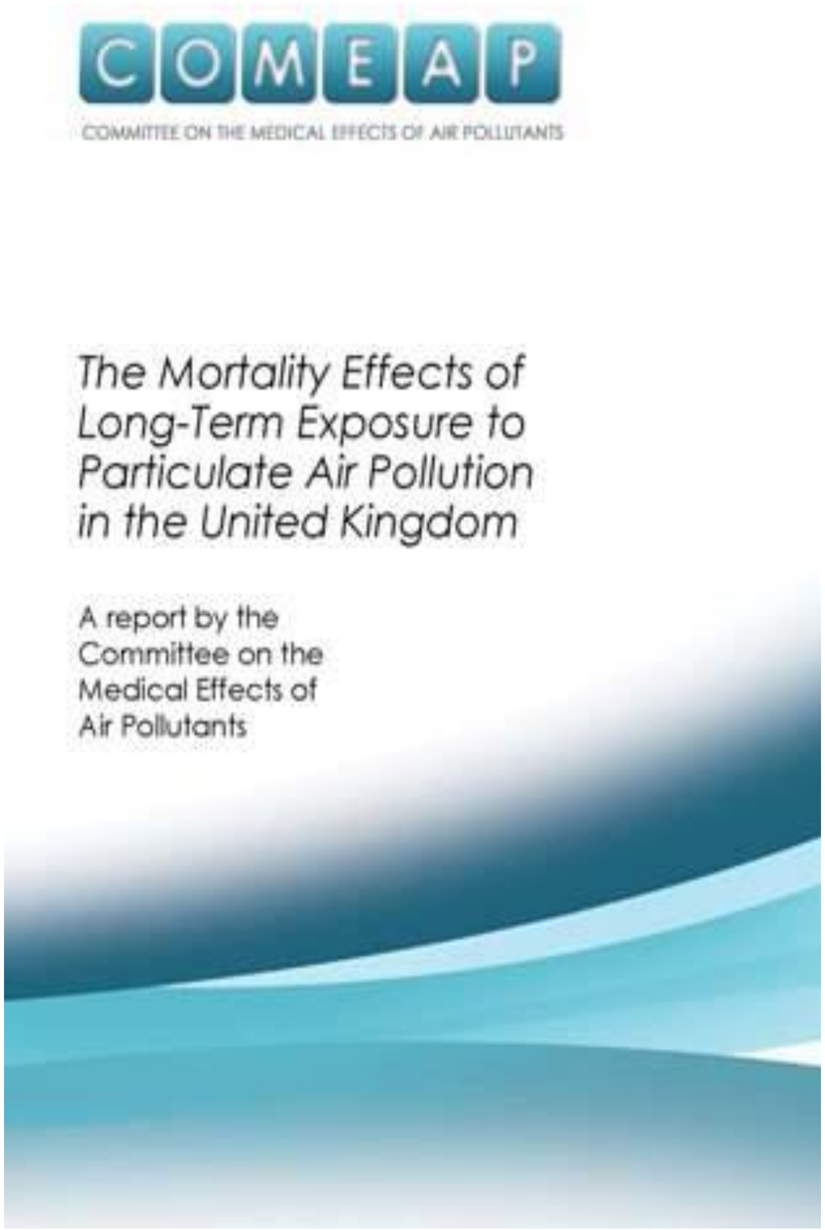
Air pollution is a major public health issue

- Mainly due to fine particles – the effects of $PM_{2.5}$ on premature mortality
- But there is increasing evidence of the independent effects of NO_2



Across the UK poor air quality......

- equivalent of 29,000 premature deaths due to breathing tiny particles released into the air (in 2008 data)

- the average loss of life was 6 months, (although the actual amount varies between individuals, from a few days to many years)

- '...air pollution may have made some contribution to the earlier deaths of up to 200,000 people in 2008, with an average loss of life of about 2 years per death affected...'

- Economic cost of the order of £8-20 billion per year (from IGCB)

Published December 2010

But estimates of the impact of air pollution on health are increasing as evidence on NO_2 strengthens

World Health Organization

REGIONAL OFFICE FOR Europe

Health risks of air pollution in Europe – HRAPIE project

COMEAP

COMMITTEE ON THE MEDICAL EFFECTS OF AIR POLLUTANTS

COMMITTEE ON THE MEDICAL EFFECTS OF AIR POLLUTANTS

INTERIM STATEMENT ON QUANTIFYING THE ASSOCIATION OF LONG-TERM AVERAGE CONCENTRATIONS OF NITROGEN DIOXIDE AND MORTALITY

RCP estimate ~ 40,000 deaths

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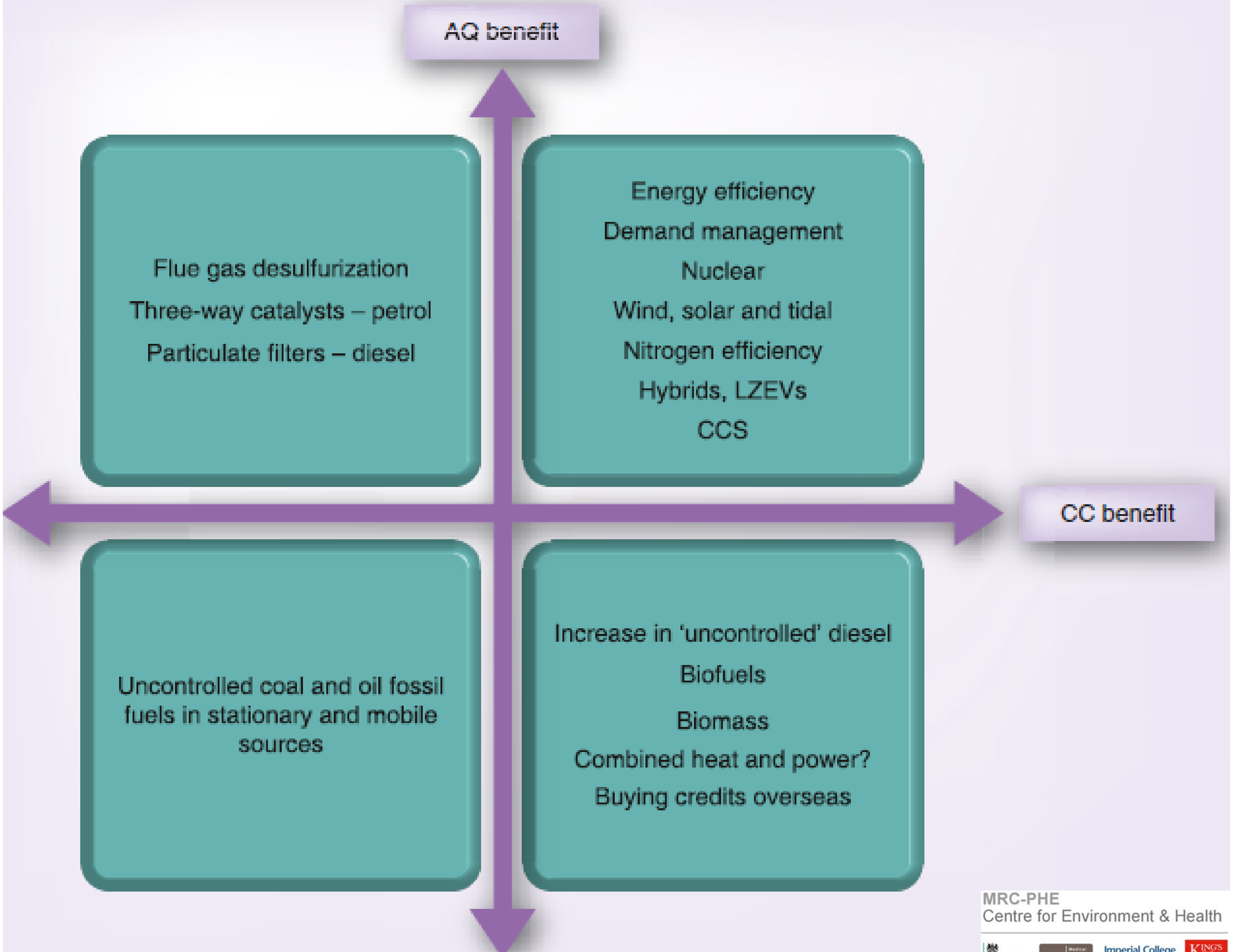
UK Climate Change Act 2008

- The UK has set a target of ***80% reduction in CO_2 equivalents by 2050*** (on a 1990 base)
- Making the right choices to achieve the Climate Change Act target offers potentially the biggest air quality & public health improvements since the Clean Air Act of 1956
- BUT – the policies need to be ***carefully chosen*** to avoid unnecessary adverse public health impacts – e.g. minimise diesel, biomass, CHP use in urban centres



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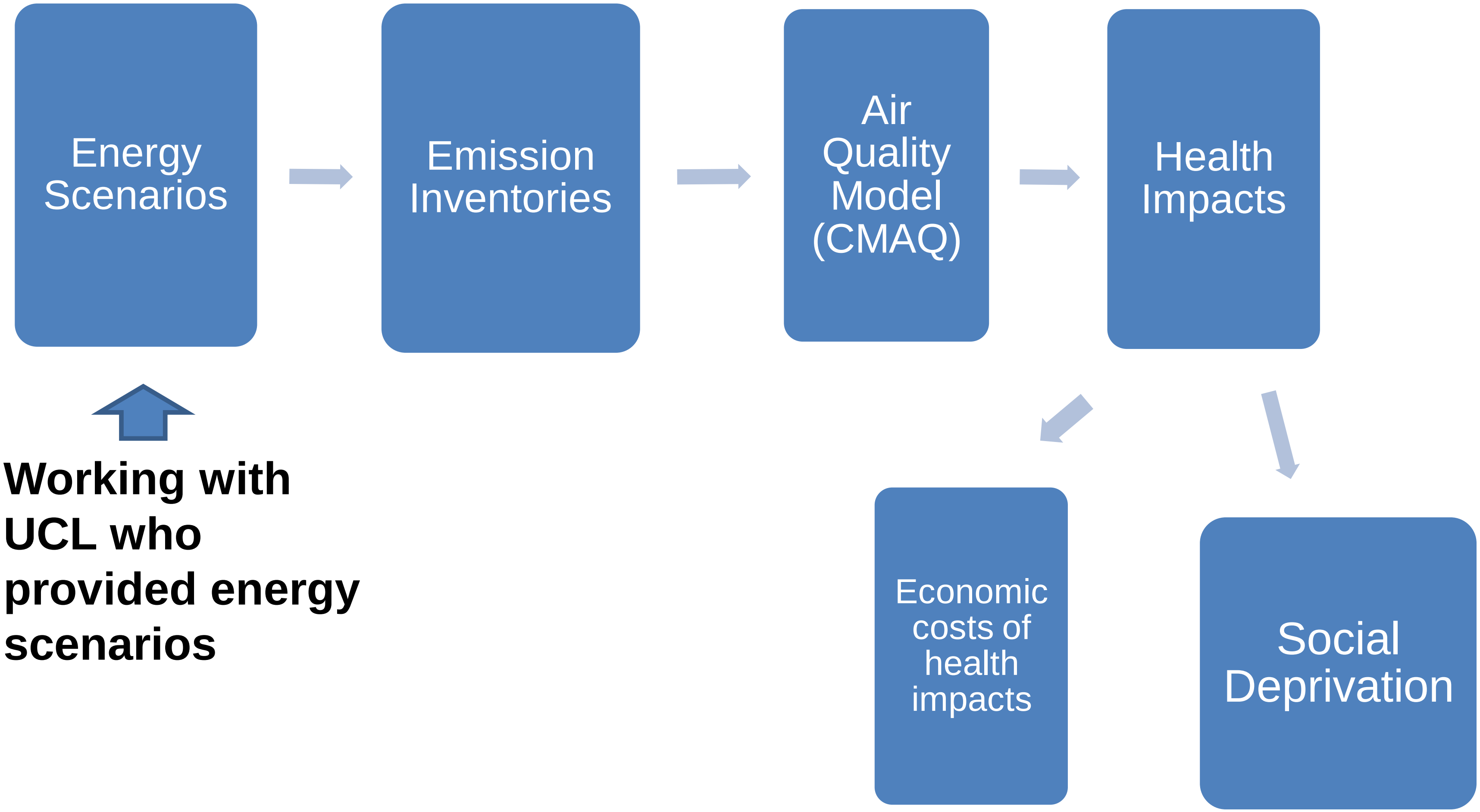
NIHR funded project



Working with UCL who provided energy scenarios

NIHR project
Linking UK Times outputs to UK and European Emissions

We have ‘soft linked’ the UK Times energy systems model (outputs provided by UCL, Mellissa Lott) which outputs energy use (PJ) - use this to ‘scale’ the 2011 NAEI 1km emissions to 2050.

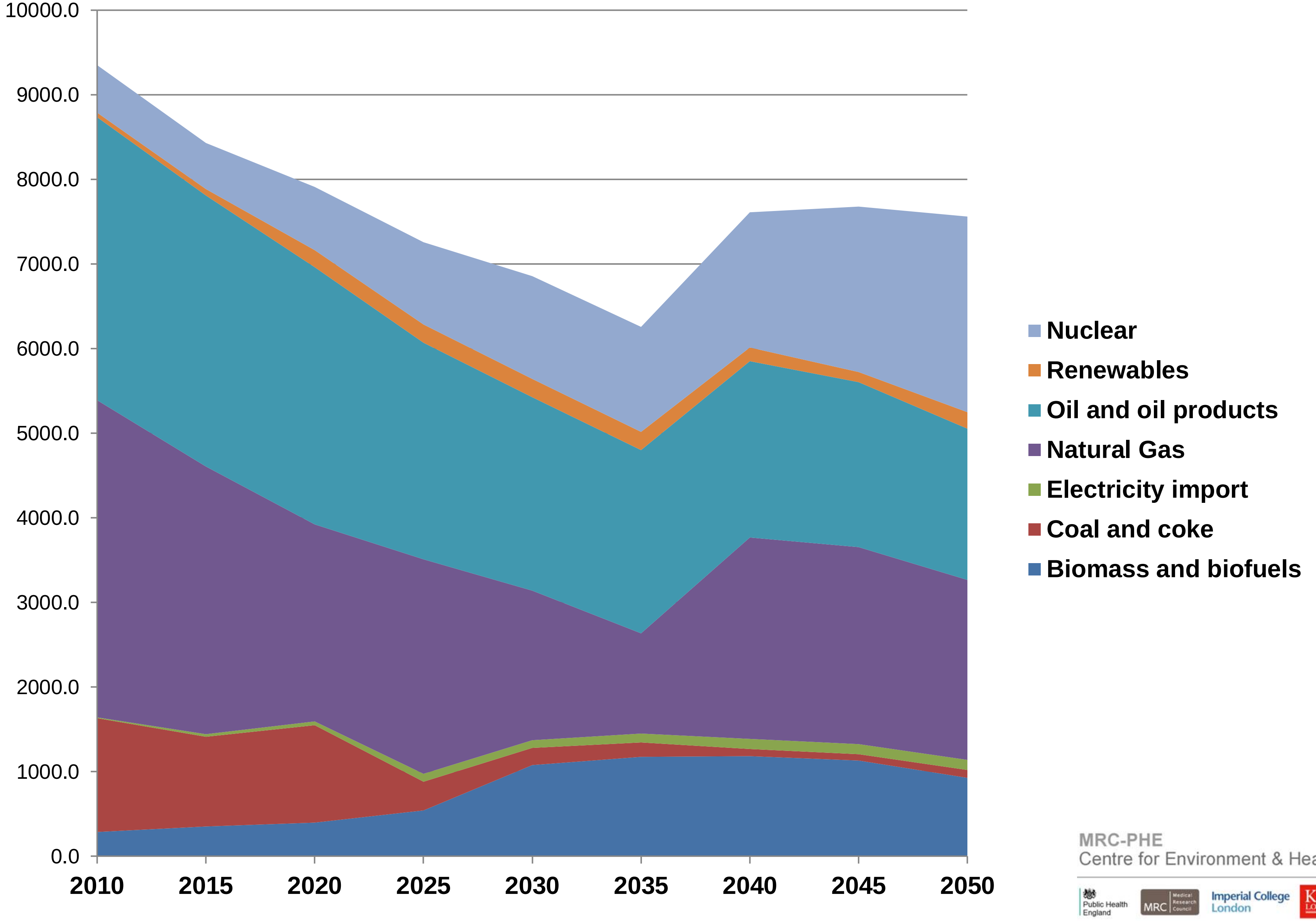
Emission factor changes are made using NAEI assumptions up to 2030 and maintained between 2030 and 2050

For road transport we are currently running King’s ‘bottom up’ emissions calculation between now and 2050 using detailed vehicle counts, speed and stock.

Scenarios

Scenario	Description	
DECC Baseline	DECC Baseline (no further carbon mitigation)	Nuclear phasing out
Reference	Same as Base + 30 GBP/tonne carbon price - increasing linearly from 0-30 GBP over the period of 2010-2030 (0-30 GBP) and then plateaued at 30 from 2030 onward; no constraints on nuclear	Nuclear expansion
Low GHG	80% reduction by 2050 + interim carbon budgets (through the 4th budget); no damage costs included for non-GHG air pollutants	In addition to 2010 and 2050, will look at an interim year (2030/5) to show the impact of the mid-term increase in residential biomass use for CHP
Nuclear – replacement only	LowGHG scenario + constraint on nuclear so that it can only maintain its current capacity levels.	Nuclear capacity capped at 10 GW (i.e. current levels)
Modal shift – active transport	In UKTM, this is the same as the lowGHG scenario, but we will replace enough car demand with active transport to maintain 2020 PM levels	To show benefits of a cultural shifts to reduce road transport/car use in London. EVs will not be enough.

Low GHG Scenario
Primary energy consumption (PJ)



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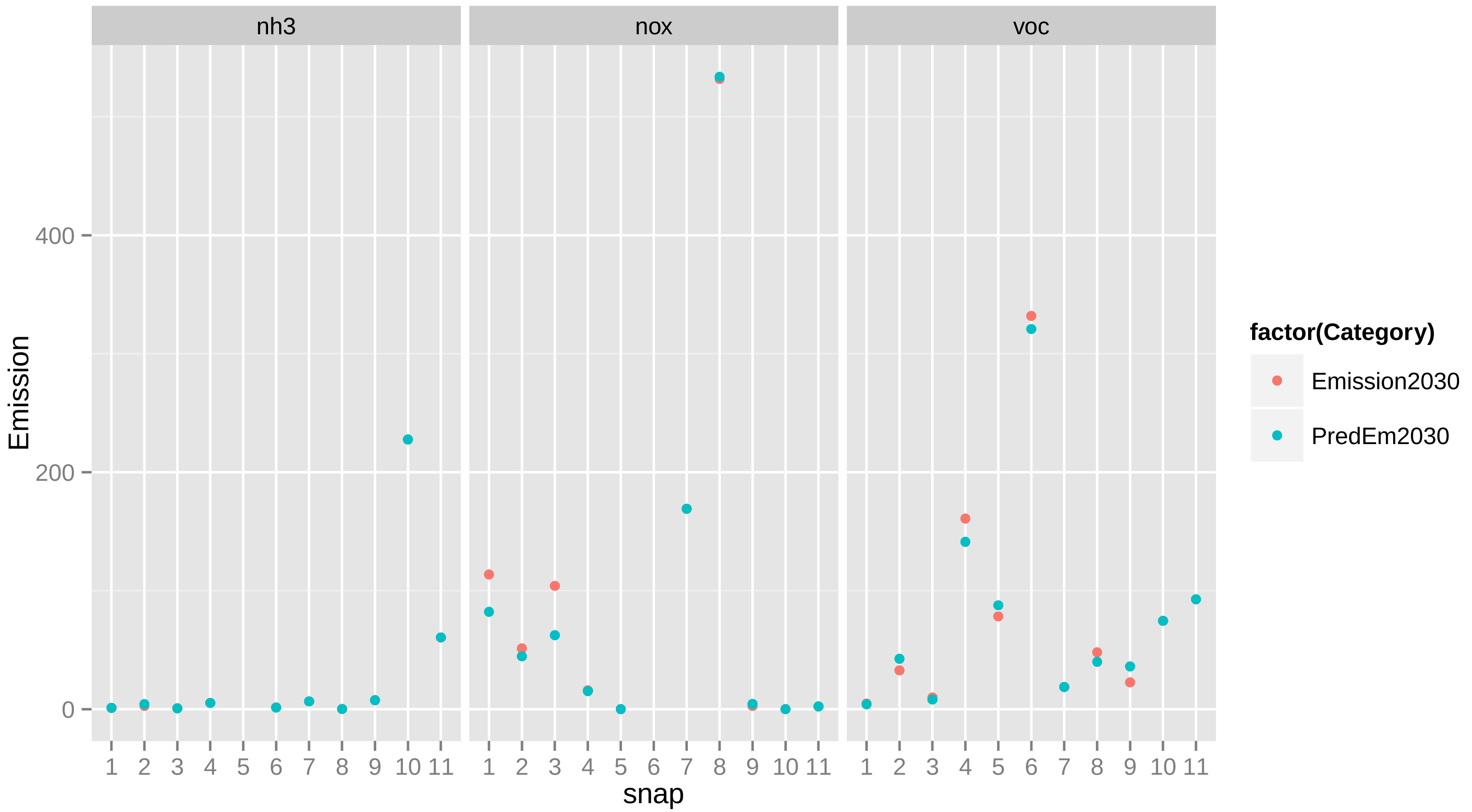
Non-combustion sources of air pollution are important

- Agriculture – emissions of ***ammonia*** from livestock and fertiliser use
- Solvent emissions of organics
- Particles from brake and tyre wear
- VOC and NH3 are taken from Eclipse 5a

Comparison with NAEI 2030 (Low GHG)



Snap 1 – Energy comb
Snap2 – Non-Ind comb
Snap 3 –Manufac comb
Snap 4 – Prod processes
Snap 5 – Extract/Distribution
Snap 6 – Solvent use
Snap 7 – Roads
Snap 8 – Other mobile
Snap 9 – Waste
Snap 10 – Agriculture
Snap 11 - Other

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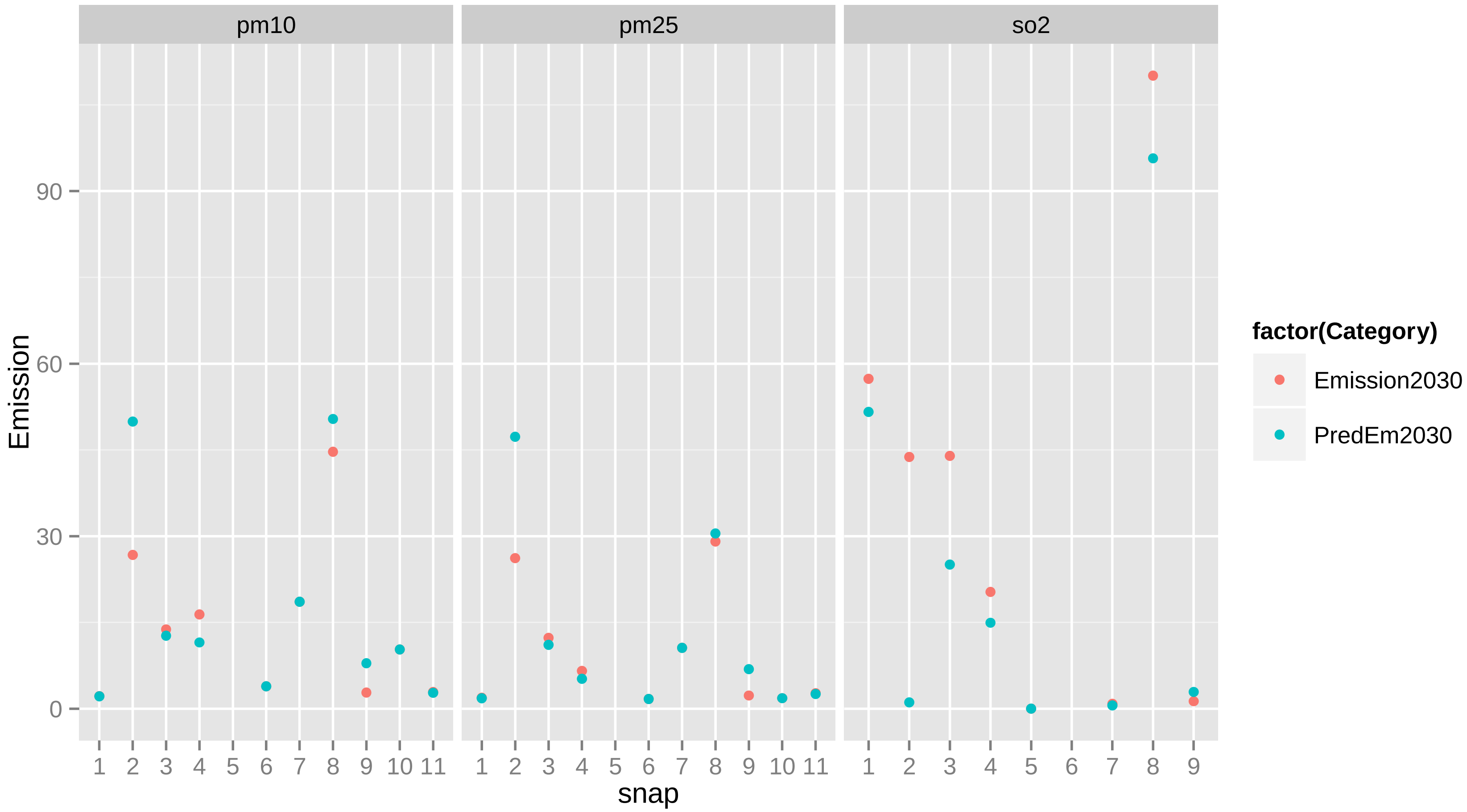
Comparison with NAEI 2030 (Low GHG)



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Bvehkm- Modal shift Active Travel (MS_AT) - Roads (snap 7)

UKTimesSector	FuelType	2010	2050
Bus	Diesel CFV	5.3	0.0
Bus	EV	0.0	1.3
Bus	HEV	0.0	0.0
Bus	Hydrogen	0.0	0.4
Bus	CNG	0.0	2.9
Bus	**Total**	**5.3**	**4.6**
Car	Diesel CFV	158.3	0.0
Car	EV	0.0	19.2
Car	Petrol	251.9	0.0
Car	HEV	1.6	473.1
Car	Hydrogen	0.0	123.1
Car	LPG	1.6	0.0
Car	CNG	0.0	0.0
Car	**Total**	**413.4**	**615.3**
HGV	Diesel CFV	27.3	0.0
HGV	HEV	0.0	0.0
HGV	Hydrogen	0.0	28.7
HGV	CNG	0.0	7.2
HGV	**Total**	**27.3**	**35.9**

UKTimesSector	FuelType	2010	2050
Van	Diesel CFV	63.7	0.0
Van	E85	0.0	0.0
Van	EV	0.0	84.7
Van	Petrol	4.4	0.0
Van	HEV	0.0	28.2
Van	Hydrogen	0.0	28.2
Van	LPG	0.0	0.0
Van	CNG	0.0	0.0
Van	**Total**	**68.1**	**141.2**

Emissions - snap 2 - includes Domestic Biomass

Pollutant	Scenario	2011 NAEI (domestic wood burning)	2030 NAEI*	Pred 2030** (domestic wood burning)	Pred 2050**
PM_{10}	LGHG	23.7 (10)	26.7	49.9 (35)	25.2 (14)
$PM_{2.5}$	LGHG	22.7 (9)	26.2	47.3 (33)	24.1 (13)

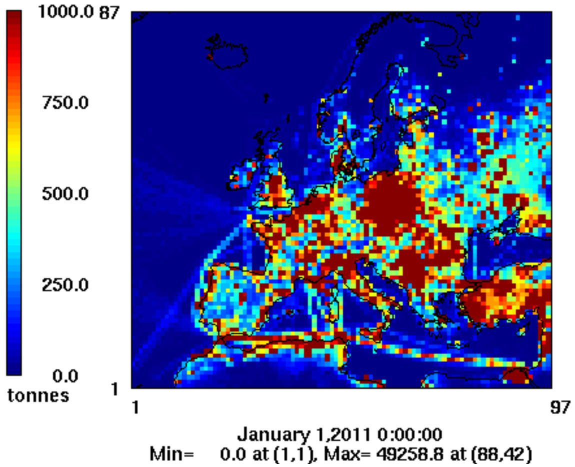
* UEP48 DECC energy forecast and NAEI 2012
** Low GHG

UK Emissions reductions 2011 to 2050 (%) - Low GHG

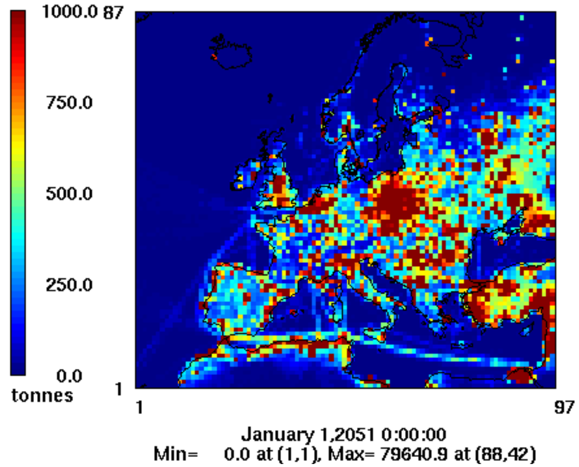
Pollutant	%
co	-42
nh3	6
nox	-64
pm10	8
pm25	-9
so2	-62
voc	11

$PM_{2.5}$ and NO_x emissions

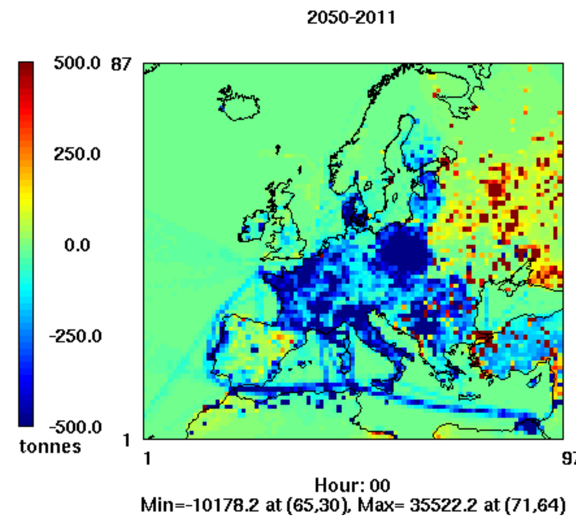
2011 Surface PM2.5 Emissions



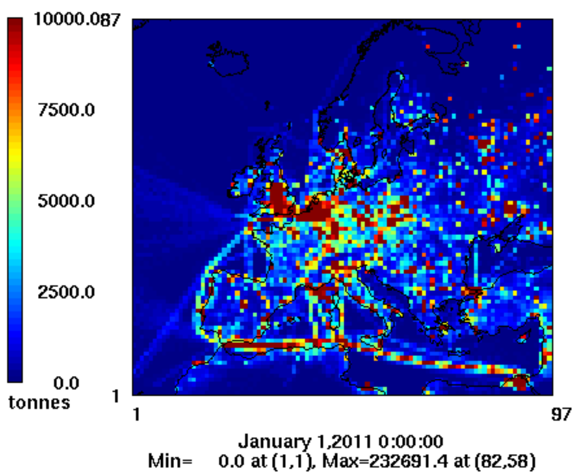
2050 Surface PM2.5 Emissions



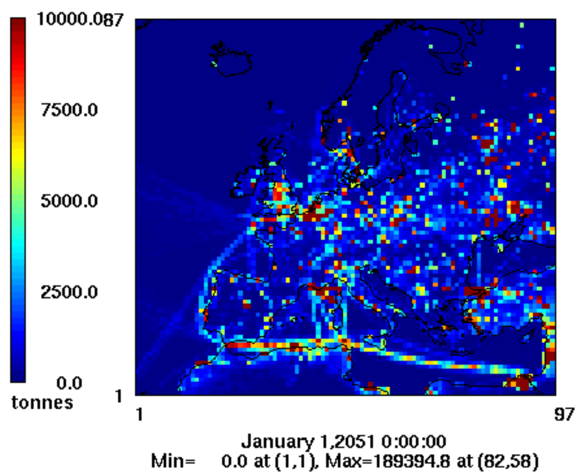
Delta surface PM2.5 emissions



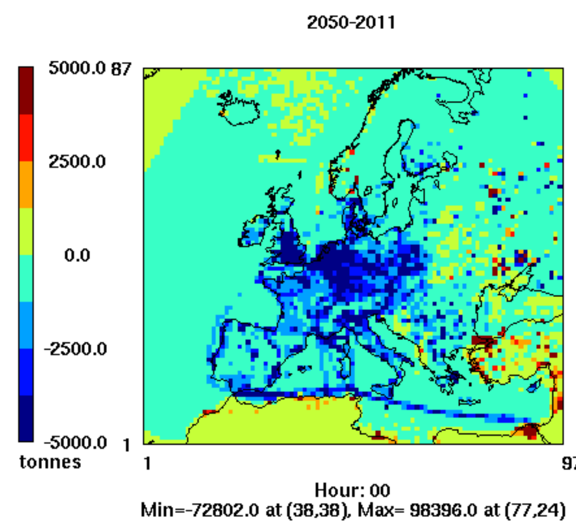
2011 Surface NOx Emissions



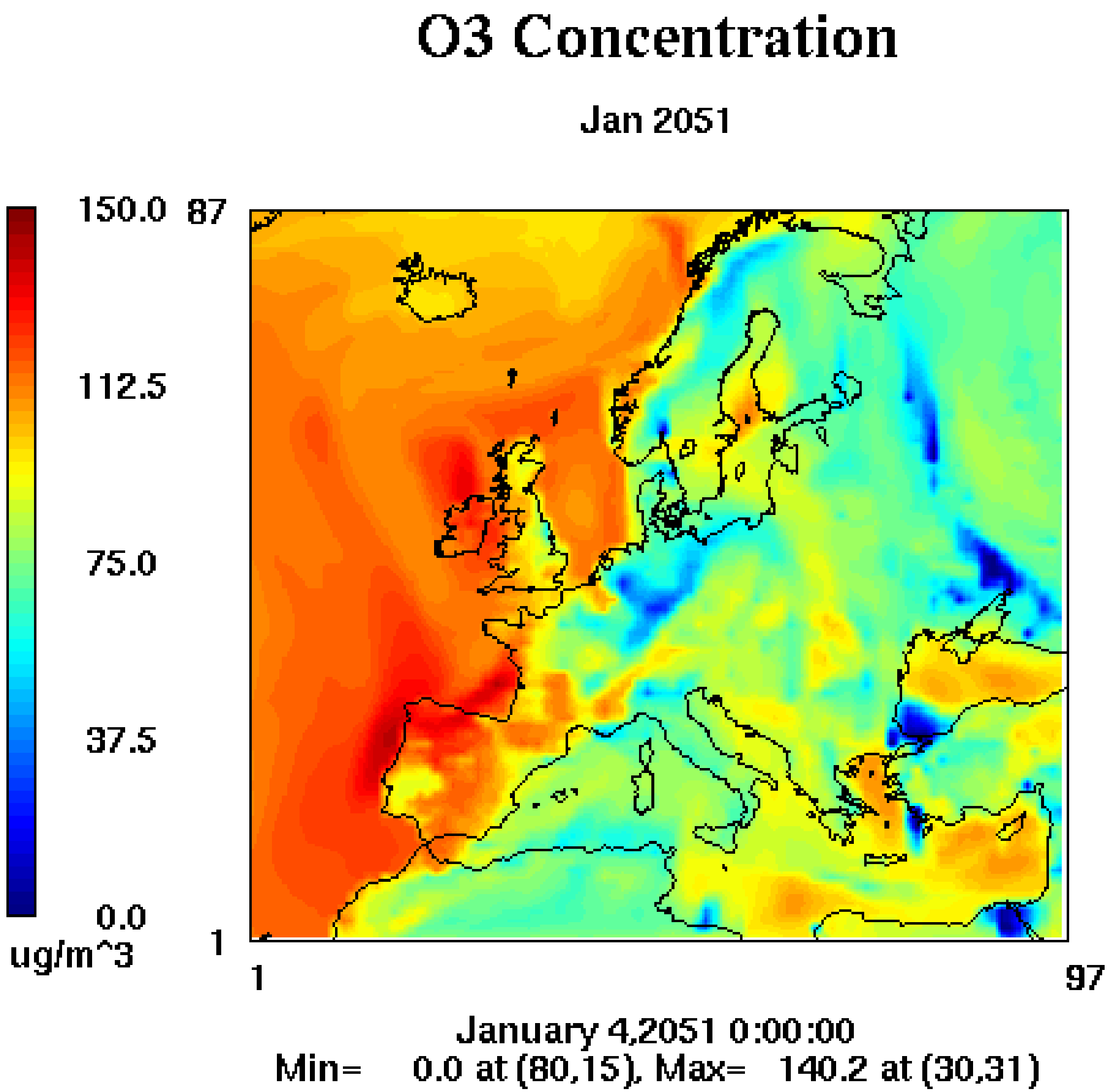
2050 Surface NOx Emissions



Delta Surface NOx Emissions



O_3 in 2050-simulations performed for every hour over the year



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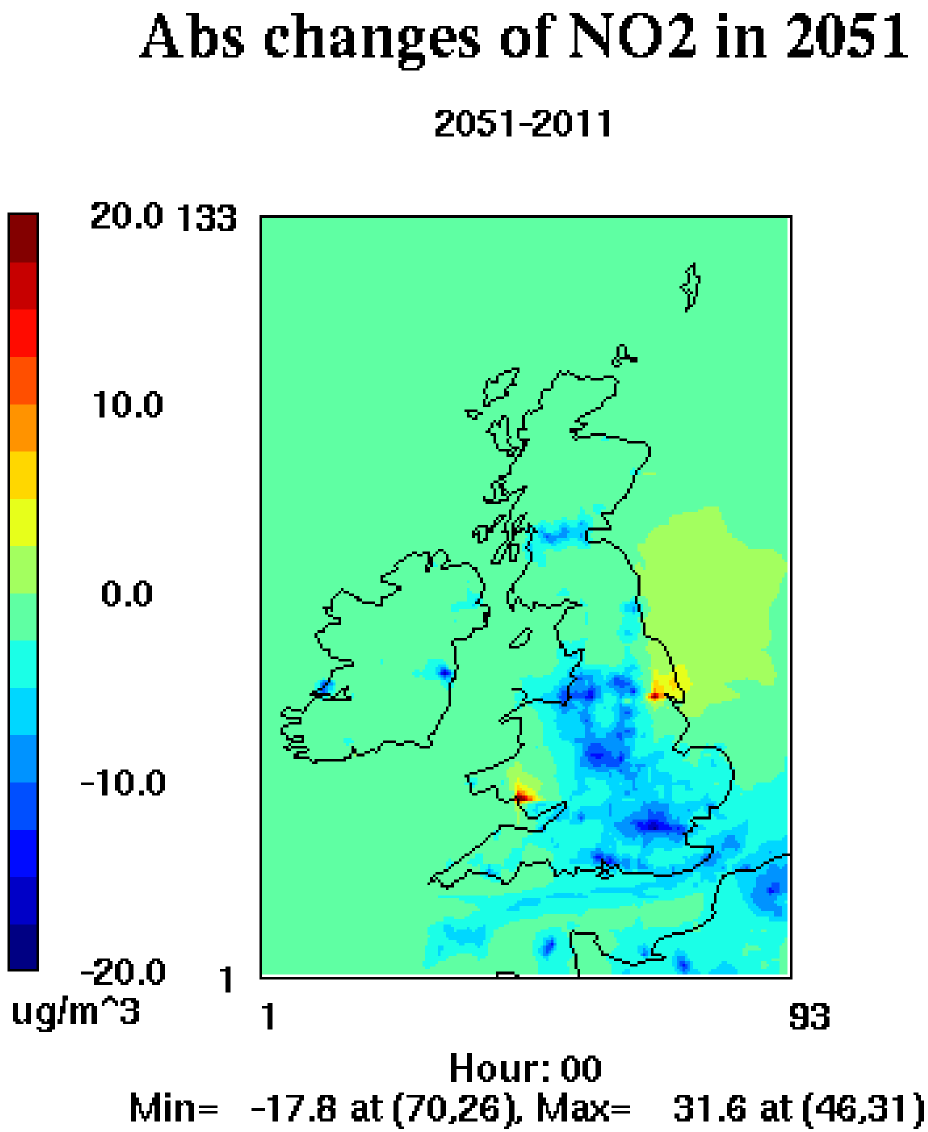
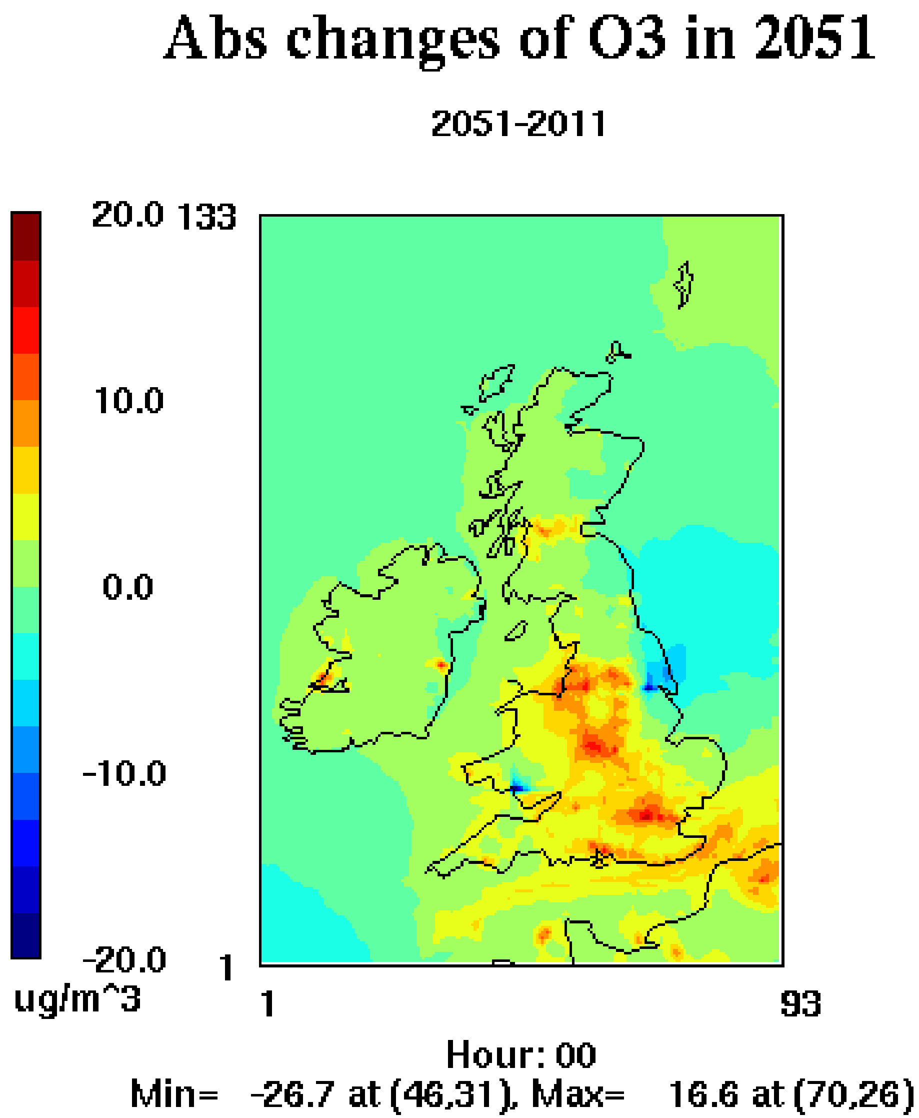
The change in annual mean UK concentration of NO_2 and O_3



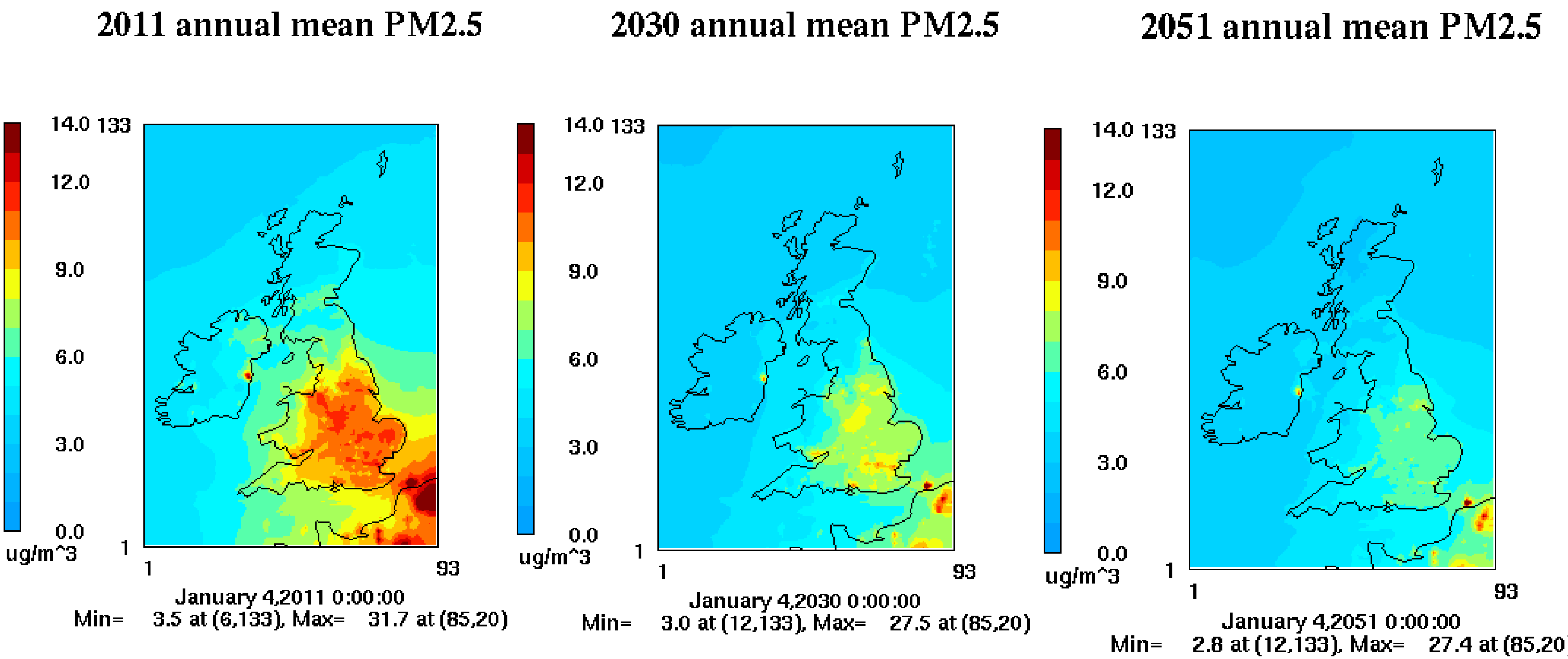


Changes in PM?

NO_X reducing strongly, as is SO_2, NH_3 not reducing and local PM sources changing, e.g. currently PM from wood burning ~ 1 $\mu g\ m^{-3}$

Secondary aerosols – ammonium sulphate and ammonium nitrate, organic aerosol – these have LONG lifetimes and can travel 100s of kilometres

Annual mean UK concentrations of $PM_{2.5}$



- Biomass inventory
- Other sources
  - Cooking
  - Diesel IVOC (C_{10}+) – VBS pm model

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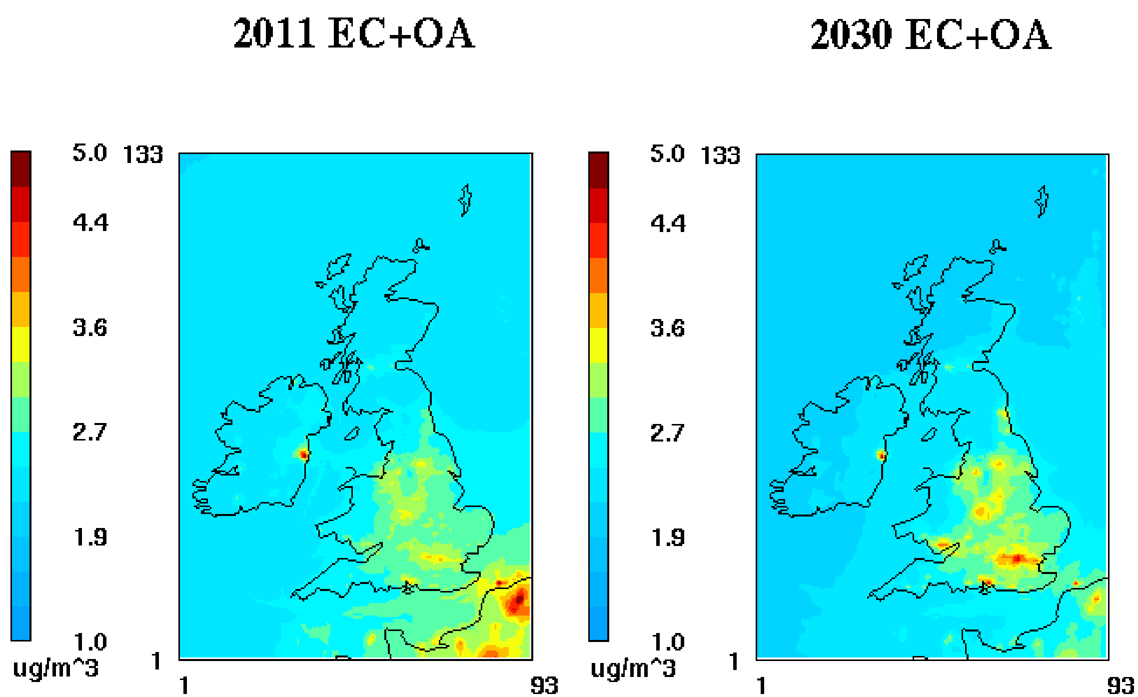
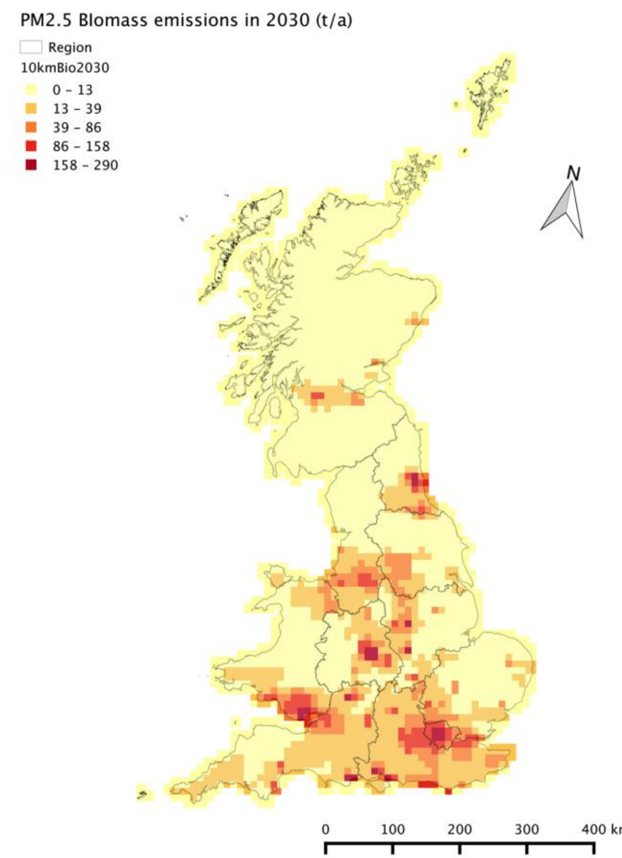
Increase in biomass use peaks in 2030-2035





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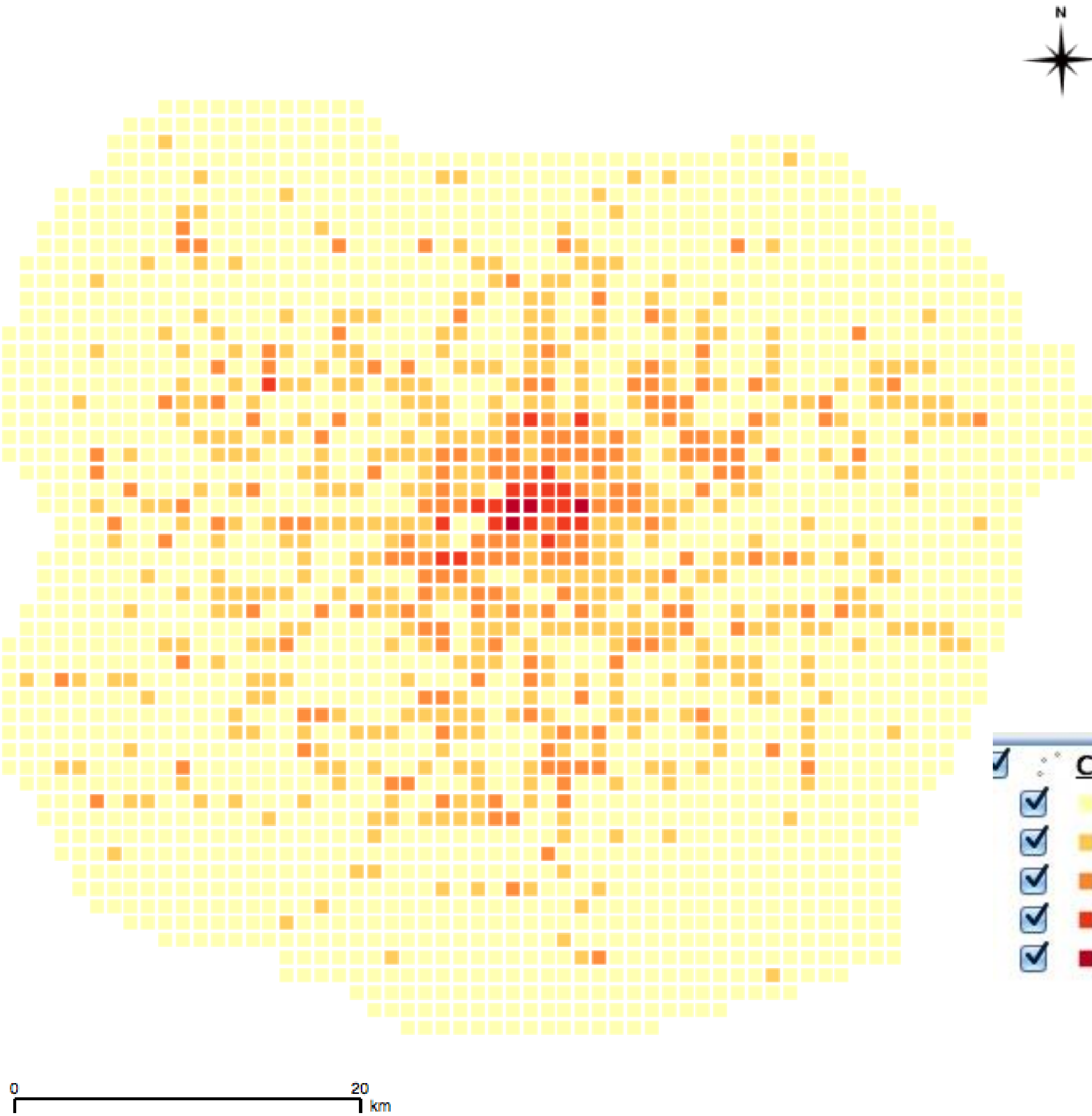
Cooking emissions in London



pm ~ 0.5 $\mu g\ m^{-3}$

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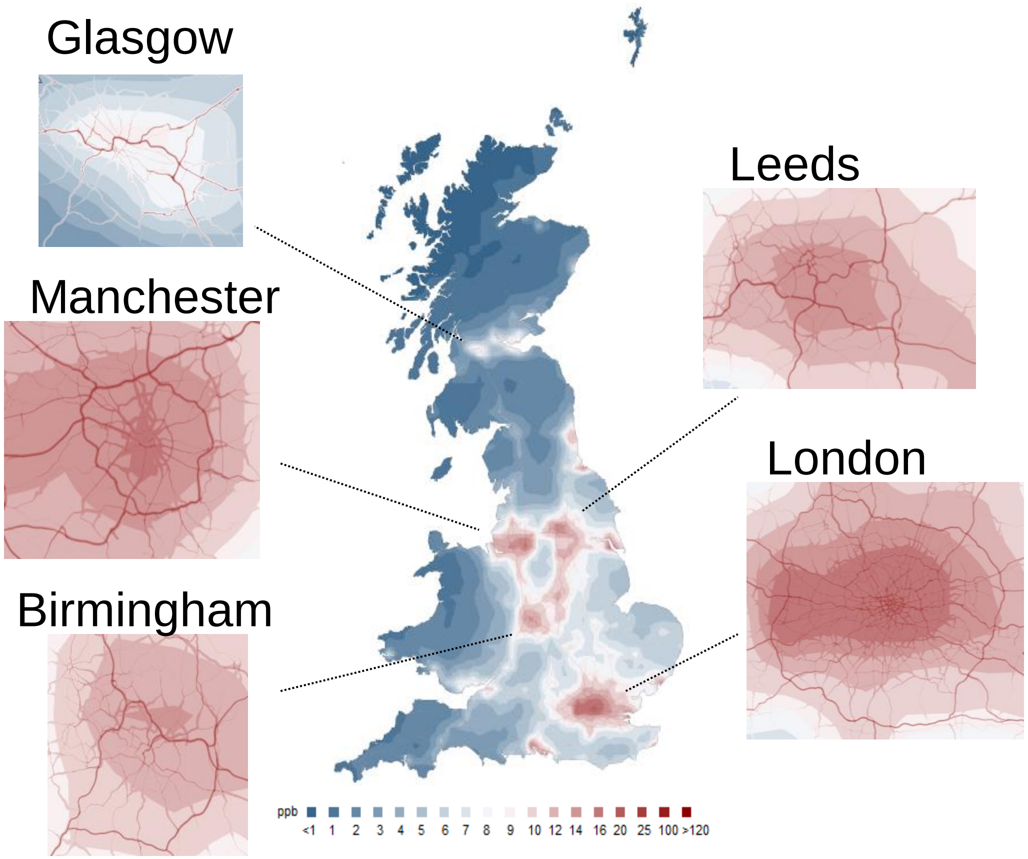
Finer resolution modelling will follow (CMAQ-urban*)



Weather Research and Forecasting (WRF) meteorological model, the USEPA's CMAQ model and ADMS-roads
Six road categories are included in the calculation

Model outputs: Hourly/Daily/Annual – nitrogen oxides (NO_X), nitrogen dioxide (NO_2), ozone (O_3), particle matter (PM) components by source type ($PM_{10/2.5}$)

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 5a - IIASA

Boundary conditions: Met. and air quality

CMAQ-urban ref - 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

*CMAQ-urban is the Community Multi-scale Air Quality (CMAQ) + Atmospheric Dispersion Modelling System (ADMS) roads model

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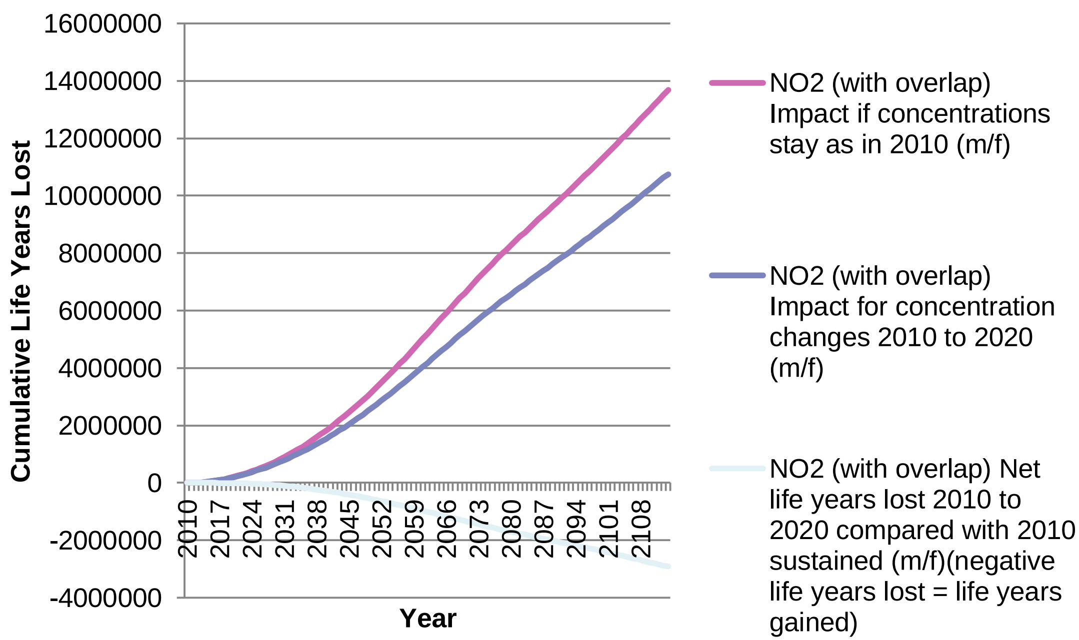
Health Impact Assessment method for long term exposure to $PM_{2.5}$ and NO_2

Full Impact methodology

- Uses life tables of pop. and death in 2010 by single year age group
- Follow life tables through for a lifetime 105 years to 2114, with new birth cohorts
- Use EPA lag 30% effect first year, 12.5% years 2-5, 20% years 5-20
- Results can be summarised as total Life Years and loss of Life Expectancy from birth
- Impact of future reduction scenarios on Life Years and life-expectancy

Recent example of scenario testing in London for NO_2



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Messages from the Low GHG (nuclear replacement only) scenario

- Urban levels of NO_2 and $PM_{2.5}$ should decrease significantly with corresponding improvements for public health
- ***BUT*** the incentivisation of biomass will lead to an increase in exposure to primary PM combustion products, including potentially to carcinogens peaking in 2030-2035
- Close to roads PM_{10} may increase (non-exhaust pm)
- Long-term ozone exposure will increase – health effect evidence is needed

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Thank you!

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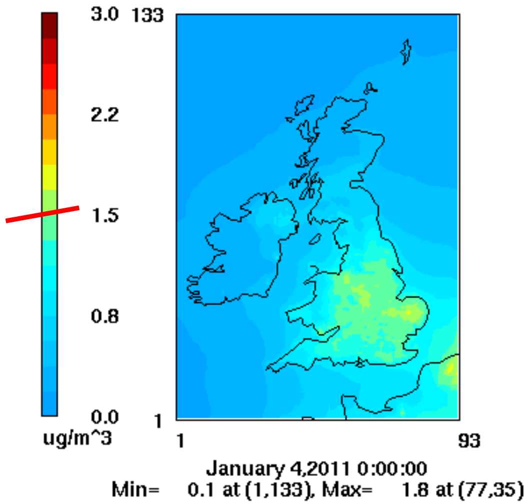
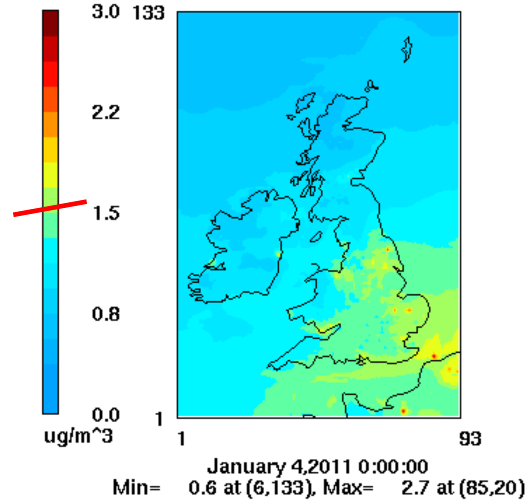
Comparison of CMAQ and EMEP4UK SIA composition

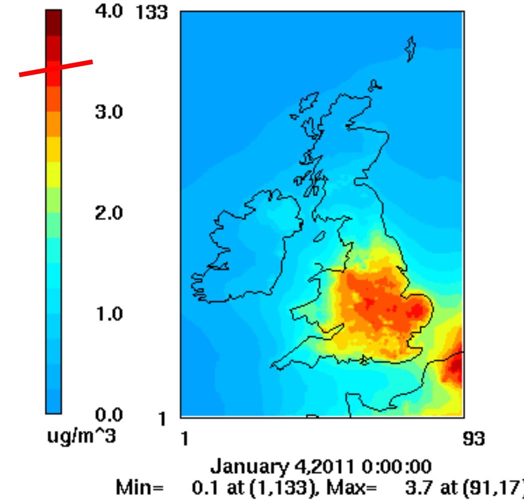
2011 PM2.5 ammonium

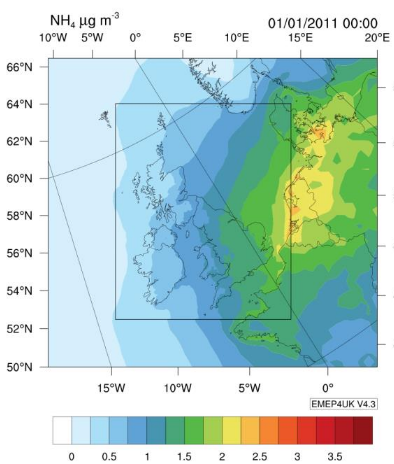


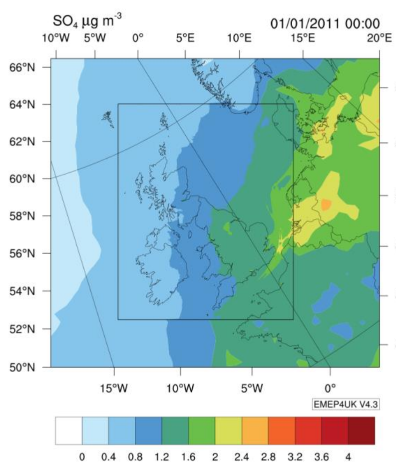
2011 PM2.5 sulphate

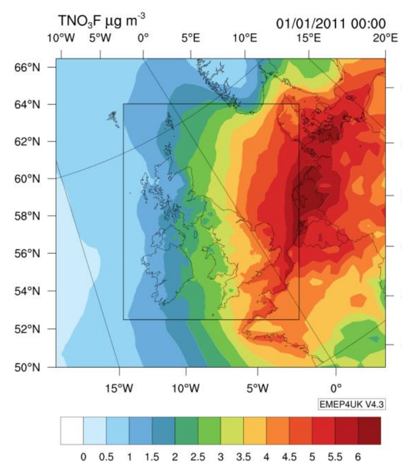


2011 PM2.5 nitrate









NH_4^+ ↑ SO_4^{2-} ↑ NO_3^- ↑

Average range of concentrations over south east of UK

http://www.emep4uk.ceh.ac.uk/2011