AEA Energy & Environment
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Modelling $PM_{2.5}$ Concentrations for the UK and Projections to 2020

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Outline

- Introduction
- Overall method
- Recent years results
- Source apportionment results
- Projections and calculation method
- Other results

Introduction

- Pollution Climate Mapping (PCM) Model
- UK model developed within a Geographical Information System (GIS)
- PCM model used to provide maps of $PM_{2.5}$ concentration for 2005, 2006 and 2007
- Used to supply data for assessments required by EU ambient air quality directives
- Maps of future projections up to 2020 (with 2005 as a base year) used to underpin the development of UK air quality policy

Method

- Components of $PM_{2.5}$
  - Secondary inorganic aerosol
  - Secondary organic aerosol
  - Large point sources of primary particles
  - Small point sources of primary particles
  - Area sources of primary particles
  - Regional primary particles
  - Iron & calcium rich dusts
  - Sea salt

Method

- Secondary aerosol
  - Secondary inorganic aerosol
    - Interpolation & scaling of rural sulphate, nitrate & ammonium measurements
    - Scaling factors used to take into account bound water & counter ions & to apportion PM fractions
  - Secondary organic aerosol
    - Semi-volatile organic compounds
    - Estimated from results from the HARM/ELMO model

Method

- Primary particulate matter
  - Emissions estimates from the UK NAEI
  - Large point sources
    - Emissions > 500 tonnes per year
    - Modelled explicitly using ADMS
  - Small point sources
    - Emissions < 500 tonnes per year
    - Estimated using a generic model derived using ADMS
  - Area sources
    - 1km x 1km grid squares
    - Local area source contribution estimated using a dispersion kernel based model derived using ADMS
      - calibrated using monitoring data
    - Regional background estimated using TRACK
      - Emissions estimates from NAEI & EMEP

Method

- Iron and calcium rich dusts
  - Estimated from measurements made in Birmingham
  - Using surrogate variables for spatial distribution of emissions
    - Vehicle movements & population
  - Additional urban increment
- Sea salt
  - Derived by interpolation of chloride measurements at 28 rural sites
    - Scaled to take account of sodium counter ion

Method

- Calculation of fine fraction of PM

Species		**Percentage of total that is fine**
Secondary organic aerosol		75%
Secondary inorganic aerosol	Ammonium	95%
	Sulphate	95%
	Ammonium nitrate	55%
	Sodium nitrate	25%
Calcium rich dusts		25%
Iron rich dusts		25%
Sea salt		25%

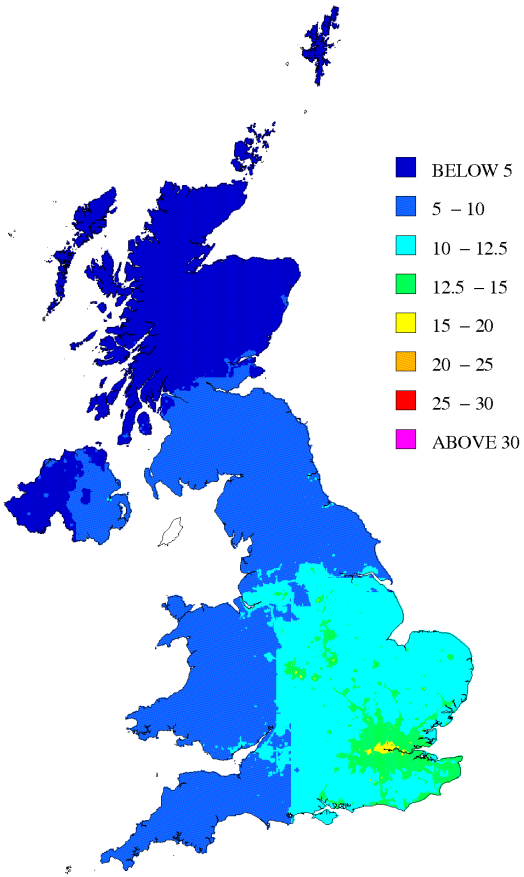
Primary $PM_{2.5}$ is calculated separately by NAEI

Method

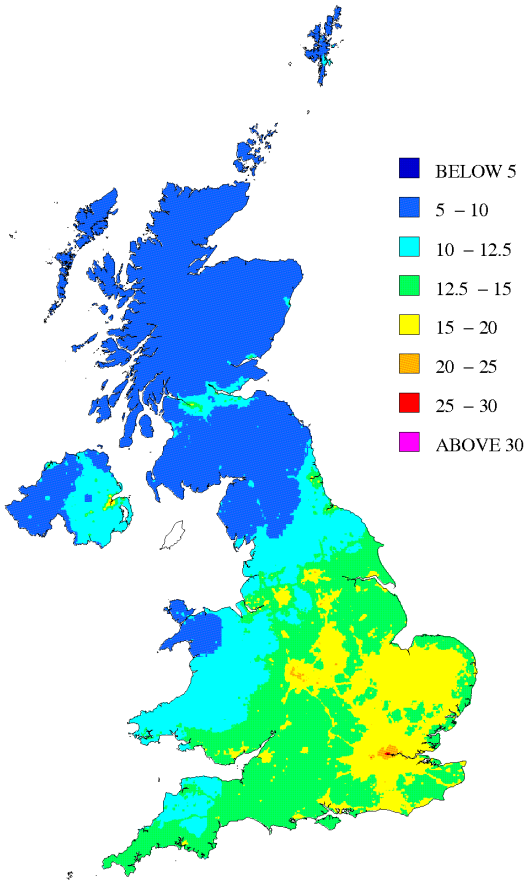
- Maps calculated on a 1 km x 1 km grid for the whole of the UK land area
- Monitoring data
  - From UK national monitoring networks
    - Few $PM_{2.5}$ sites up to 2008
    - 64 sites from 2009 onwards as required for compliance with CAFÉ Directive
- Model calibration and verification
  - Using ambient monitoring data
  - Measurements of PM_{10} and $PM_{2.5}$ from Partisol 2025 gravimetric instruments (Range of measurement methods for PM_{10} verification)
  - Corrected for field blanks

Results - Maps for 2005, 2006 and 2007

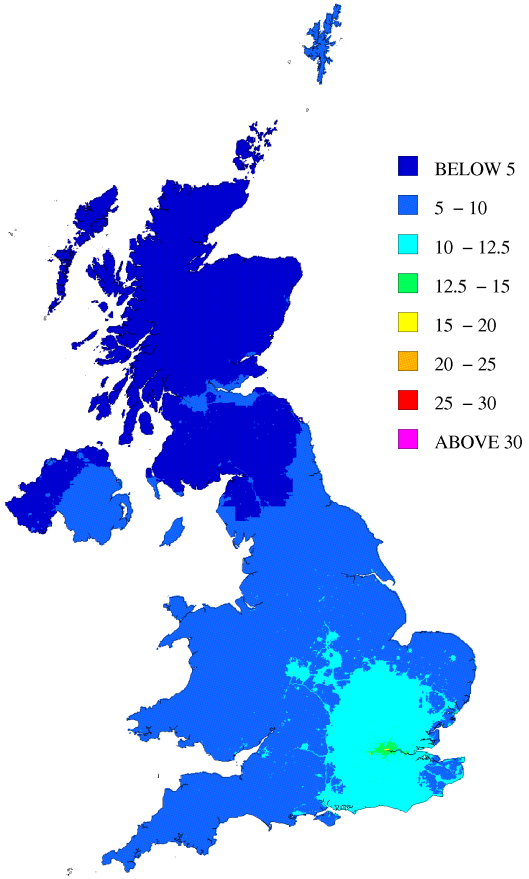
- Mapped annual mean background $PM_{2.5}$ concentrations in 2005 ($\mu g\ m^{-3}$)



- Mapped annual mean background $PM_{2.5}$ concentrations in 2006 ($\mu g\ m^{-3}$)



- Mapped annual mean background $PM_{2.5}$ concentrations in 2007 ($\mu g\ m^{-3}$)



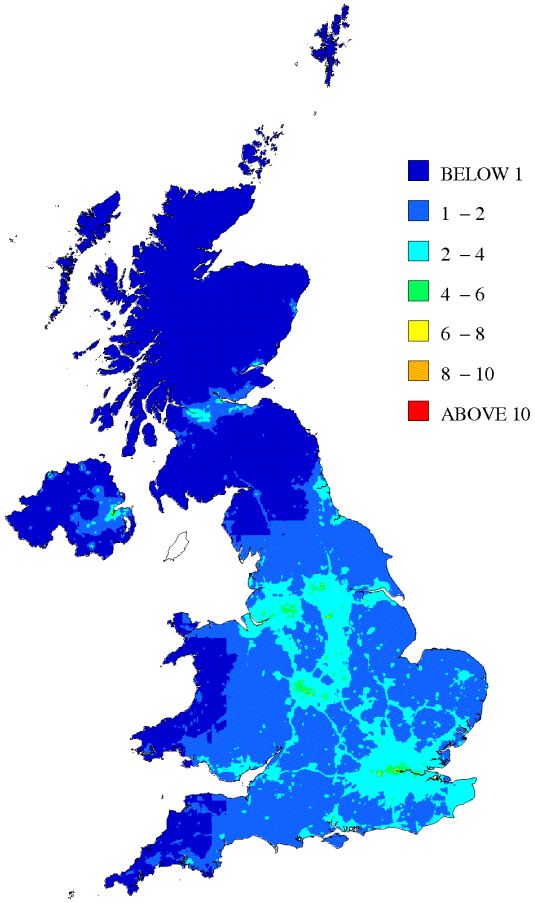
Results – Source Apportionment

- UK Population-weighted annual mean $PM_{2.5}$ concentrations in 2005 (µg m^{-3})

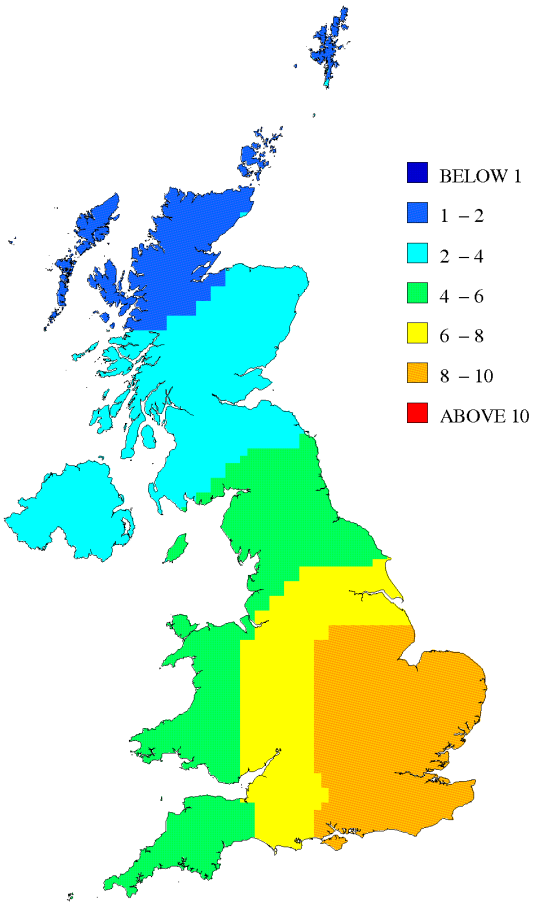
Component	Concentration
Primary PM	2.72
Secondary PM	7.10
Iron & calcium rich dusts	0.87
Sea salt	0.50
Total	11.19

Results – Source Apportionment

- Primary PM contributions to mapped annual mean background $PM_{2.5}$ concentrations in 2005 (µg m^{-3})

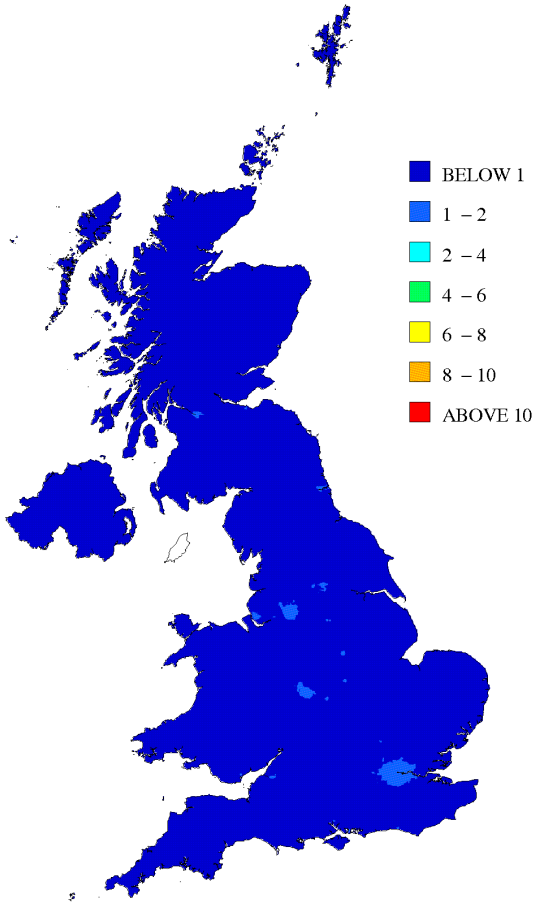


- Secondary PM contributions to mapped annual mean background $PM_{2.5}$ concentrations in 2005 (µg m^{-3})

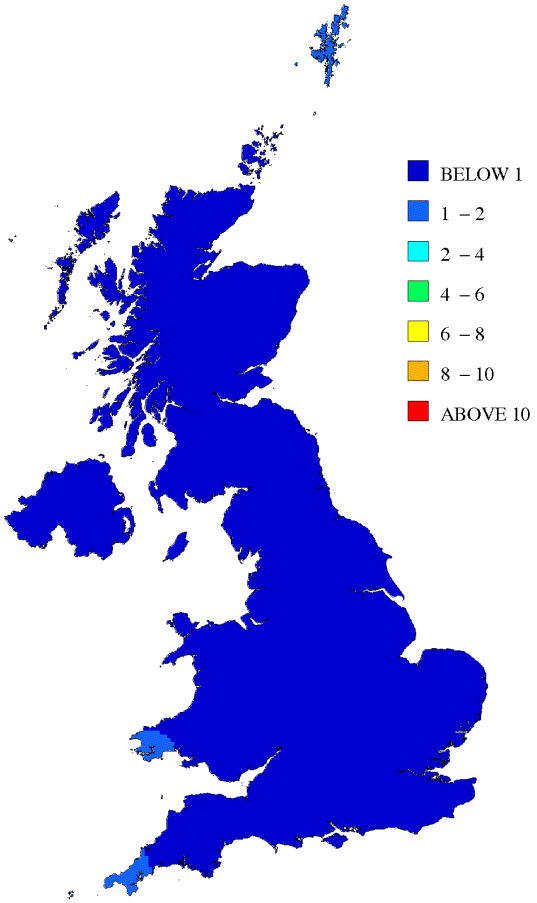


Results – Source Apportionment

- Iron & calcium rich dust contribution to mapped annual mean background $PM_{2.5}$ concentrations in 2005 (µg m^{-3})



- Sea salt contribution to mapped annual mean background $PM_{2.5}$ concentrations in 2005 (µg m^{-3})



Method - Projections

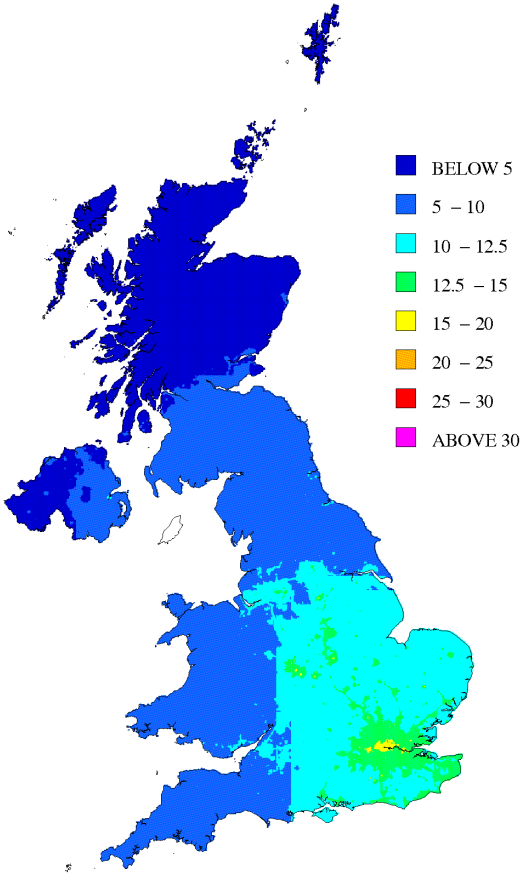
- Projections of concentration to 2020
  - Maps of $PM_{2.5}$ concentration in 2010, 2015 & 2020 have been calculated for the baseline scenario
  - Primary PM from NAEI
  - Secondary inorganic aerosol, precursor emissions from EMEP
  - Secondary organic aerosol, iron & calcium rich dusts and sea salt assumed to remain unchanged from 2005
- Future impacts of potential measures
  - Can be modelled using PCM
  - No alternative scenarios presented here

Method - Calculations

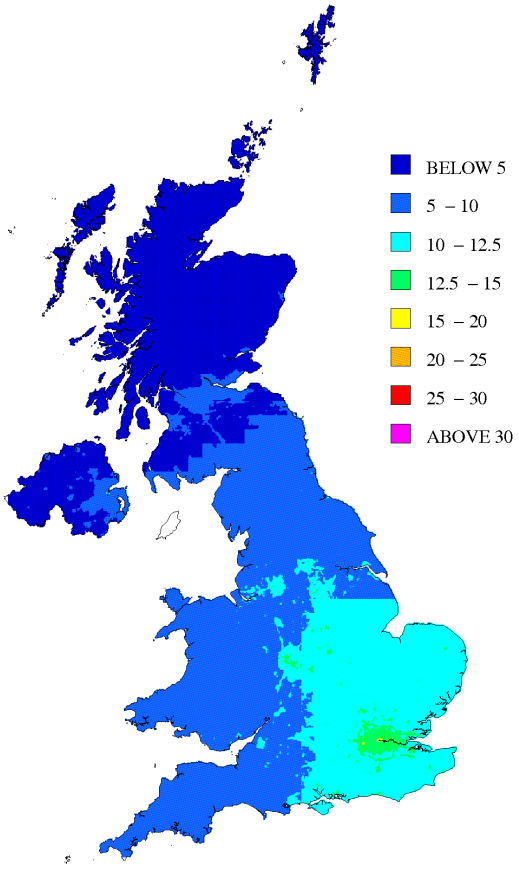
- Concentrations
  - Number of exceeding zones
- Exposure Concentration Obligations
  - Based on modelled results at urban background & urban centre sites measuring PM_{10} in 2005
- Exposure Reduction Targets
  - For agglomerations > 100,000 population
  - Population-weighted means
    - $$\frac{\sum(1\,\text{km x}\,1\,\text{km background maps})\ \text{x}\ (1\text{km x}\,1\text{km population stats})}{\text{Total population}}$$
    - Population data from 2001 census

Results – Projections to 2020

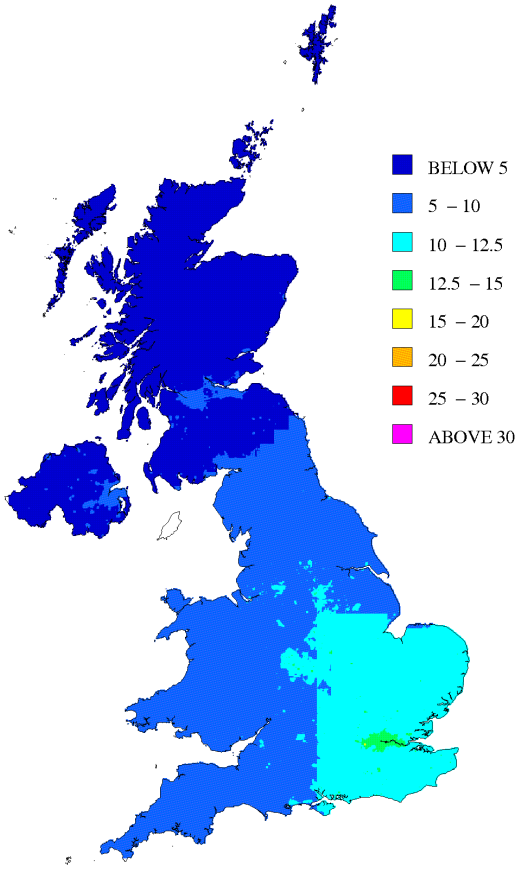
- Mapped annual mean background $PM_{2.5}$ concentrations in 2005 ($\mu g\ m^{-3}$)



- Mapped annual mean background $PM_{2.5}$ concentrations in 2010 ($\mu g\ m^{-3}$)



- Mapped annual mean background $PM_{2.5}$ concentrations in 2020 ($\mu g\ m^{-3}$)



Results

- Number of exceeding zones (out of total of 43 for UK)

		2005	2010	2015	2020
>20 ug m^{-3} (indicative L.V. 2020)	Background	0	0	0	0
	Roadside	3	1	0	0
	Total	3	1	0	0
>25 ug m^{-3} (T.V. 2010, L.V. 2015)	Background	0	0	0	0
	Roadside	0	0	0	0
	Total	0	0	0	0

Results

- Exposure Concentration Obligation (ug m^{-3})

	2005	2010	2015	2020
Annual Exposure Indicator	12.3	11.2	10.7	10.4

Results

- Exposure Reduction Target

	2005	2010	2015	2020
UK (ug m^{-3})	12.33	11.32	10.84	10.60
2010-2020 ER (Target = -10%)				-6.35%

Acknowledgements

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