

# Modelling national air quality strategy scenarios with UKIAM:

Uncertainties emerging from the integration of multiple spatial scales

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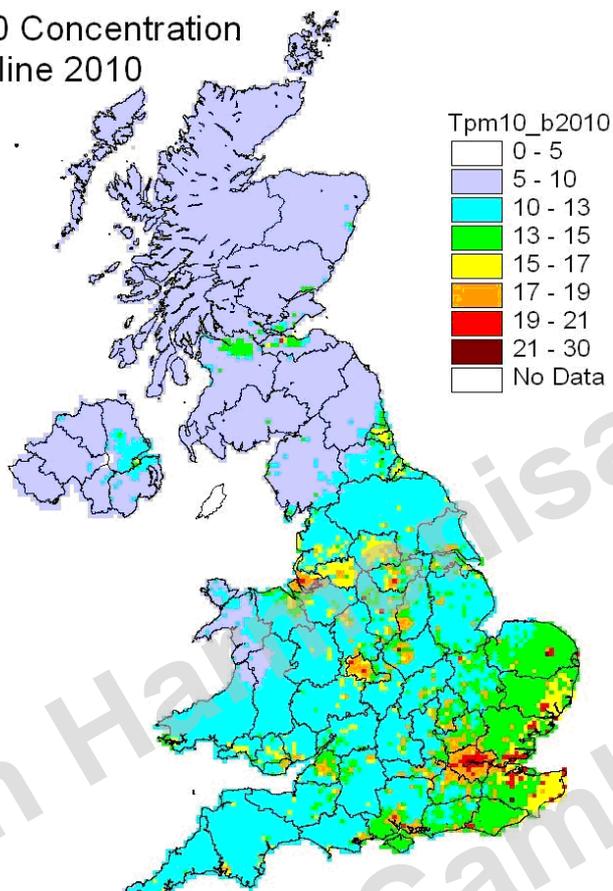
# Overview

- UK Air Quality Strategy
- UKIAM – Assess effects of national emissions changes
- ASAM – European scale effects
- Model inter-comparisons
  - EMEP Inter-comparison (transboundary)
  - DEFRA Air Quality Strategy Review (national)
- Uncertainties
  - Spatial scale of representations (50km, 5km, 1km, roads)
  - Source apportionment
    - shipping, imported contributions, Background & Initial Conditions, non-linearities etc.
  - Policy uptake
  - Multi-pollutant effects
- Linking global transboundary and local scales

# UK Air Quality Strategy

- Air Quality Limit Values
- PM<sub>10</sub>/PM<sub>2.5</sub> Concentrations
  - Local primary PM
  - Background (eg. natural, other emissions)
  - Imported primary PM
  - Long range secondary aerosols (NH<sub>4</sub>, SO<sub>4</sub> & NO<sub>3</sub>)
- NO<sub>2</sub> Concentrations
  - Secondary Ozone
  - Long-range Ozone and secondary aerosols
  - Primary NO<sub>2</sub> emissions

## PM10 Concentration Baseline 2010



Data: PM10 Concentration  
(Incl. EMEP4 SIA; +5 Rur: +9 Urb)

Units:  $\mu\text{g}/\text{m}^3$

Source: PPM - F1.78; ASAM V2.1

Emissions: Baseline 2010

Date: February 2006

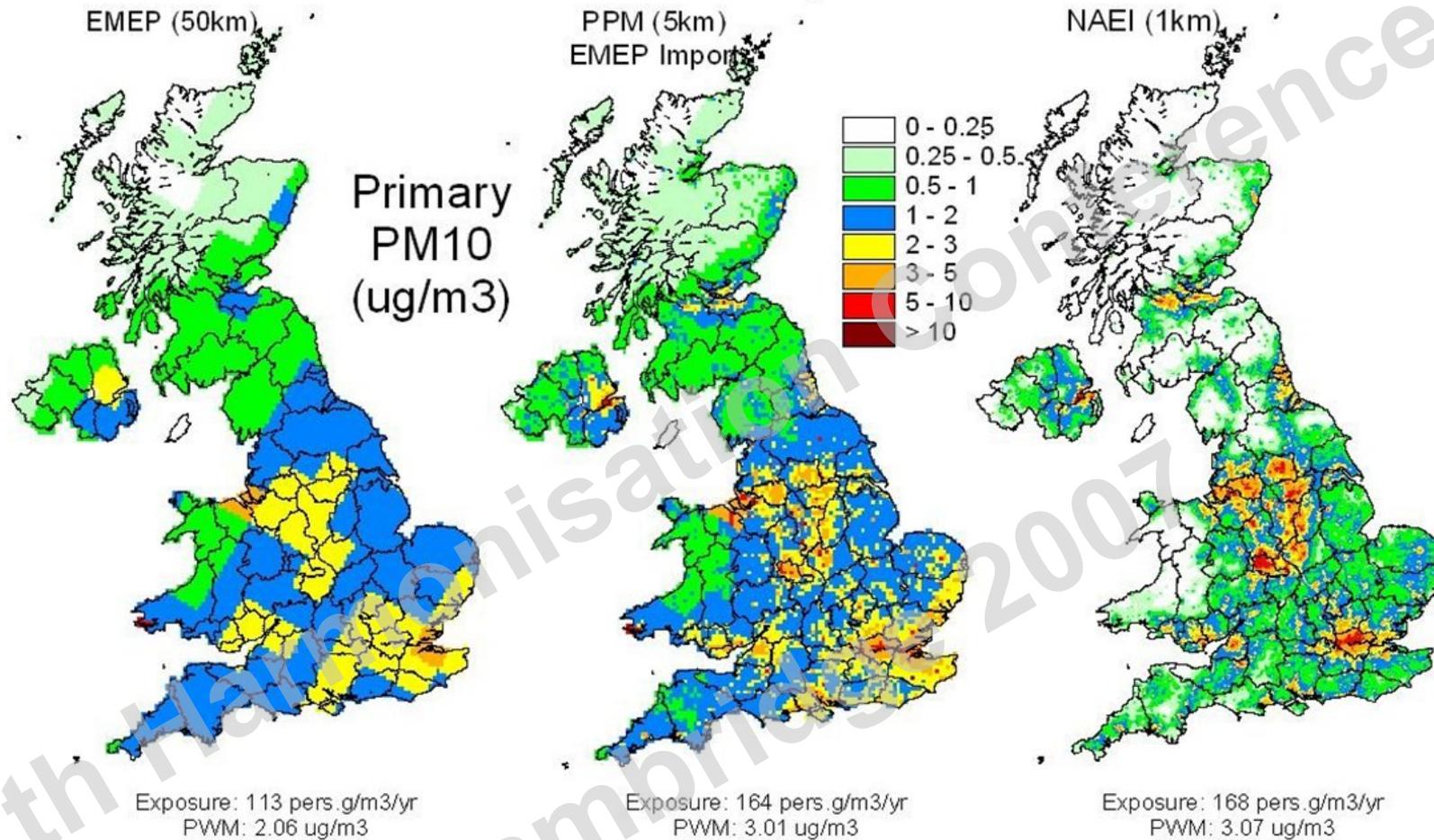
Integrated Exposure: 854 pers.g/ $\text{m}^3$

Pop. Wt Mean Conc: 15.64  $\mu\text{g}/\text{m}^3$

06 March 2006

## Total PM<sub>10</sub> Concentrations

- Similar levels of population exposure to 1km NAEI data
- Similar distribution of concentrations
- Lower localised peak concentrations
- Includes EMEP SIA
- Excludes Secondary Organic Aerosols (SOA)

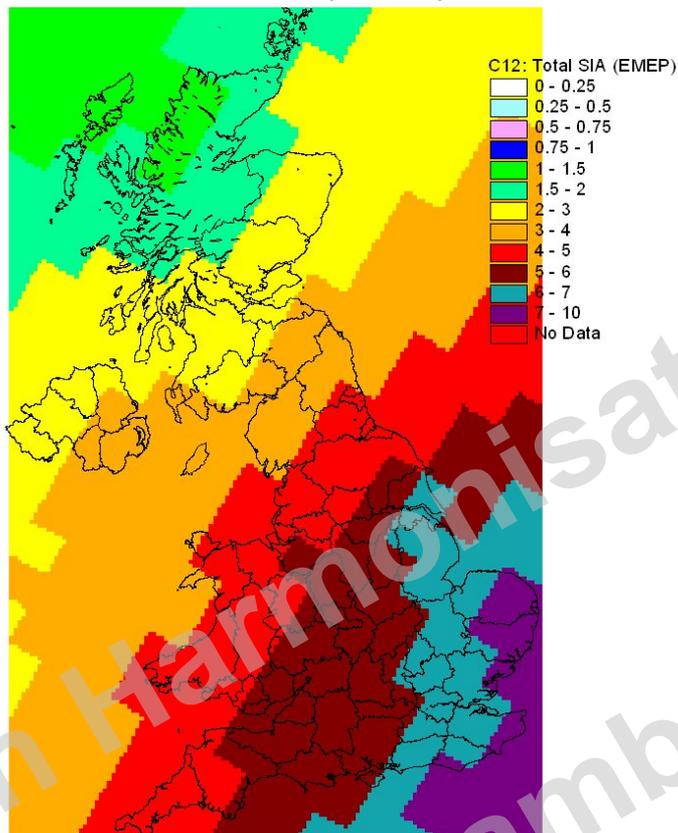


Data: Primary PM10  
Source: EMEP(3)/PPM/NAEI  
Scale: 50km/5km/1km  
Meteo: 2000/1997  
Units: ug/m3

A comparison of Primary PM10 concentrations at contrasting spatial resolutions

10 January 2006

## Total SIA Concentration (EMEP)



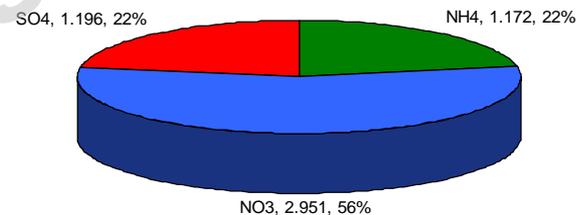
Data: Total SIA Concentration  
Units:  $\mu\text{g}/\text{m}^3$   
Year: 2010  
Source: ASAM V2.1 (EMEP)  
Scenario: BAU2010

June 2007

## Secondary Inorganic Aerosols (SIA)

- Non-linear chemistry
  - IAM based upon annual averages
- Source apportionment

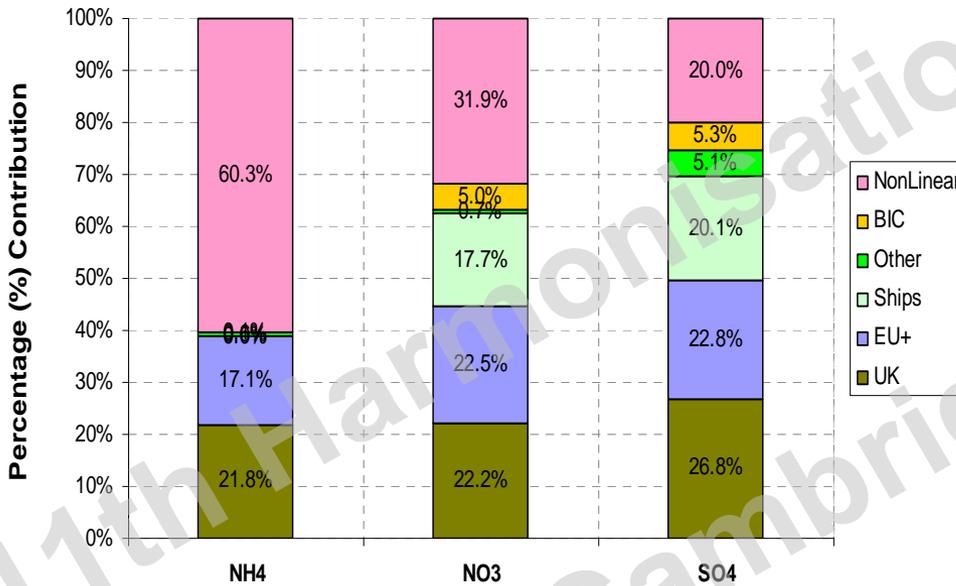
Secondary Inorganic Aerosols (PWM Conc  $\mu\text{g}/\text{m}^3$ )  
(Source: ASAM V2.1, BAU2010)



# Source Apportionment

SIA Source Apportionment (GB)

(Source: ASAM V2.1)



- Different base years may produce different non-linearities
- EMEP assume 5% of SO2 emitted as SO4
- Non-linear chemistry

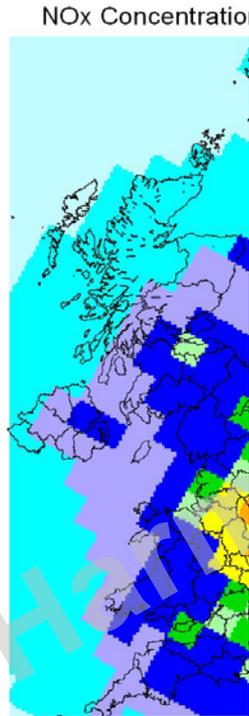
# Particulates - Uncertainties

- Assumptions about residual primary PM<sub>10</sub> (sea salt, sahara dust, resuspension etc.)
  - Secondary Inorganic Aerosols; non-linearities
- Measurements & omissions
  - TEOM measurements
  - Secondary *Organic* Aerosols
  - Water based PM<sub>10</sub>
- Implementation of policy by member states?
  - eg. EuroV, EuroVI, Congestion charging, fuel switching, LEV's etc.
  - Abatement scenarios: Will others do the same?
- Source apportionment
  - By sector: shipping, power generation, transport etc.
  - By source: EU, shipping, long-range, BIC
  - By pollutant: NH<sub>4</sub>, NO<sub>3</sub>, SO<sub>4</sub>
- Compatibility of emission inventories?
  - Sector definitions; boundaries

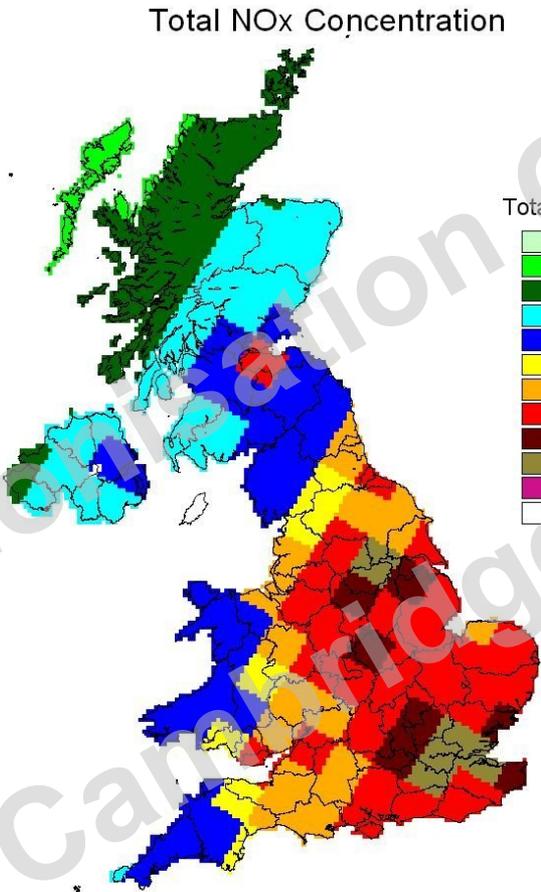
# NO<sub>x</sub> and NO<sub>2</sub> - Uncertainties

- NO<sub>x</sub> Source Apportionment
  - UKIAM assumes 50% of the background NO<sub>x</sub> comes from UK sources
  - In proportion to UK emissions changes?
    - transboundary effects
    - Shipping; EMEP 50km resolution inadequate for coastal areas
- Representation of primary NO<sub>2</sub>
  - UKIAM assumes a 5% primary NO<sub>2</sub>:NO<sub>x</sub> ratio
  - This ratio may increase to 15% [see AQEG 2006]
    - eg: effect of particle traps
- Sensitivity of secondary NO<sub>2</sub> to Ozone
  - Semi-empirical relationships
  - UKIAM: simple model of total oxidants
  - Background Ozone
  - Inter-annual variability
- Long-range transport

# NO<sub>x</sub> – Source apportionment



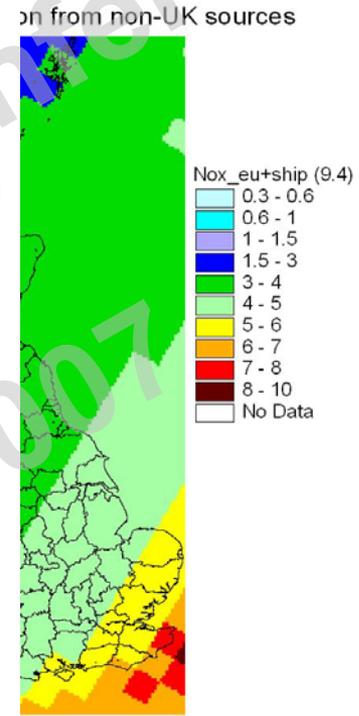
Data: NOx Concentration  
 Source: PPM(Europe)  
 Emissions: 2010 (EMEP)  
 Units: ug/m3  
 Date: October 2005



Total NOx (µg/m3)

|         |
|---------|
| 1 - 3   |
| 3 - 3.5 |
| 3.5 - 4 |
| 4 - 5   |
| 5 - 6   |
| 6 - 6.5 |
| 6.5 - 8 |
| 8 - 10  |
| 10 - 12 |
| 12 - 14 |
| 14 - 18 |
| No Data |

Data: NOx Concentration  
 Source: PPM(Europe)  
 Emissions: 2010 (EMEP)  
 Units: ug/m3



Nox\_eu+ship (9.4)

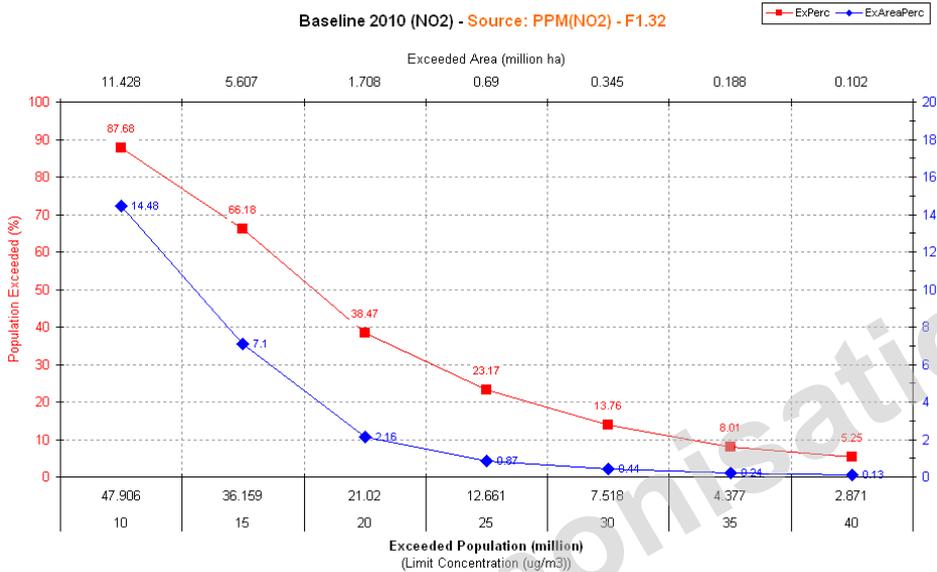
|           |
|-----------|
| 0.3 - 0.6 |
| 0.6 - 1   |
| 1 - 1.5   |
| 1.5 - 3   |
| 3 - 4     |
| 4 - 5     |
| 5 - 6     |
| 6 - 7     |
| 7 - 8     |
| 8 - 10    |
| No Data   |

20 October 2005

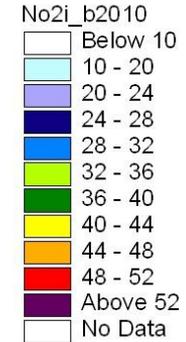
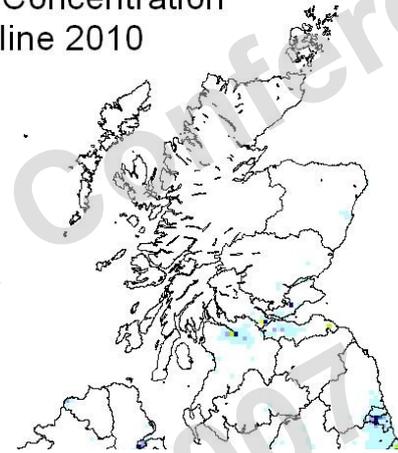
June 2007

# Representation of primary NO<sub>2</sub>

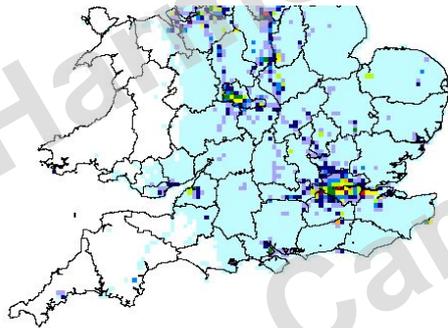
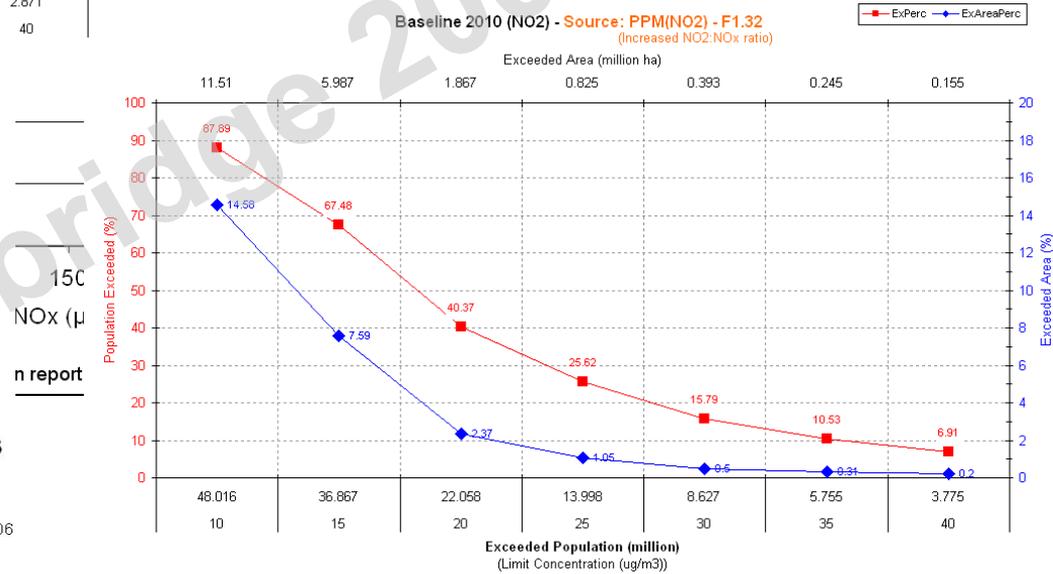
Baseline 2010 (NO<sub>2</sub>) - Source: PPM(NO<sub>2</sub>) - F1.32



NO<sub>2</sub> Concentration  
Baseline 2010



Baseline 2010 (NO<sub>2</sub>) - Source: PPM(NO<sub>2</sub>) - F1.32  
(Increased NO<sub>2</sub>:NO<sub>x</sub> ratio)



Data: NO<sub>2</sub> Concentration  
Units: ug/m<sup>3</sup>  
Source: PPM(NO<sub>2</sub>) - F33  
Emissions: Baseline 2010  
Date: February 2006

Integrated Exposure: 1079 pers.g/m<sup>3</sup>  
Pop. Wt Mean Conc: 19.75 ug/m<sup>3</sup>

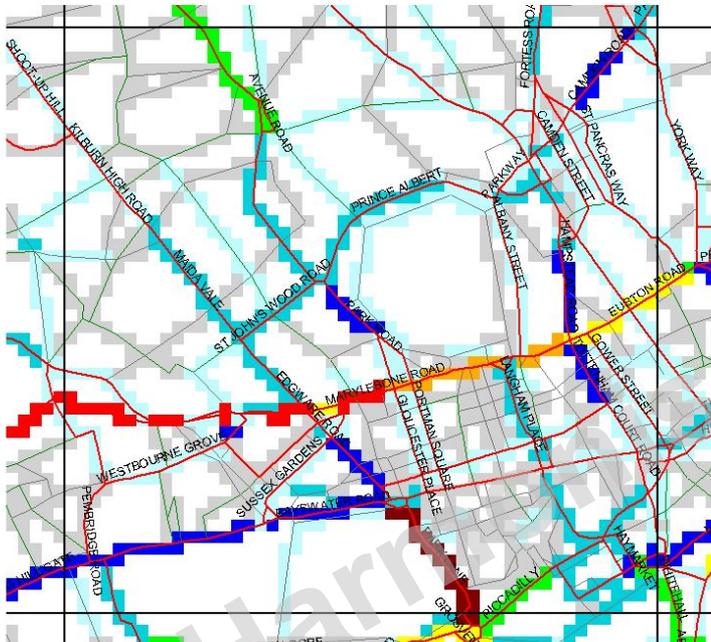
23 February 2006

# Summary

- PM<sub>10</sub> Source Apportionment
  - SIA / SOA
  - Residual PM
- Primary NO<sub>2</sub>
  - 5% or 15% primary emissions?
- Background NO<sub>x</sub>
  - How much scaling in relation to national emissions changes?
- Spatial Aggregation
  - Integration of data of different resolutions
- Temporal perspectives
  - Are annual averages adequate to assess population exposure?
- Behavioural changes as abatement measures?
  - ‘Non-Technical Measures’ (NTM)

|                               | Assumptions                          | Effect on PWM (%) |        |            |           |
|-------------------------------|--------------------------------------|-------------------|--------|------------|-----------|
|                               |                                      | 2010              |        | 2020       |           |
|                               |                                      | National          | London | National   | London    |
| Bkgd NO <sub>x</sub> scaling  | 50% scaling                          | 5.5               | 2.8    | 9.7 - 12.5 | 4.8 - 6.2 |
| Primary NO <sub>2</sub>       | 15% NO <sub>2</sub> :NO <sub>x</sub> | 4.2               | 7.9    | 3.5        | 6.5 - 7.1 |
| Resolution (NO <sub>2</sub> ) | Aggregation to 5km                   | -7.0              | -13.1  | -7.7       | -13.7     |
| Resolution (PM)               |                                      | -5.0              | -3.2   | -5.2       | -3.0      |

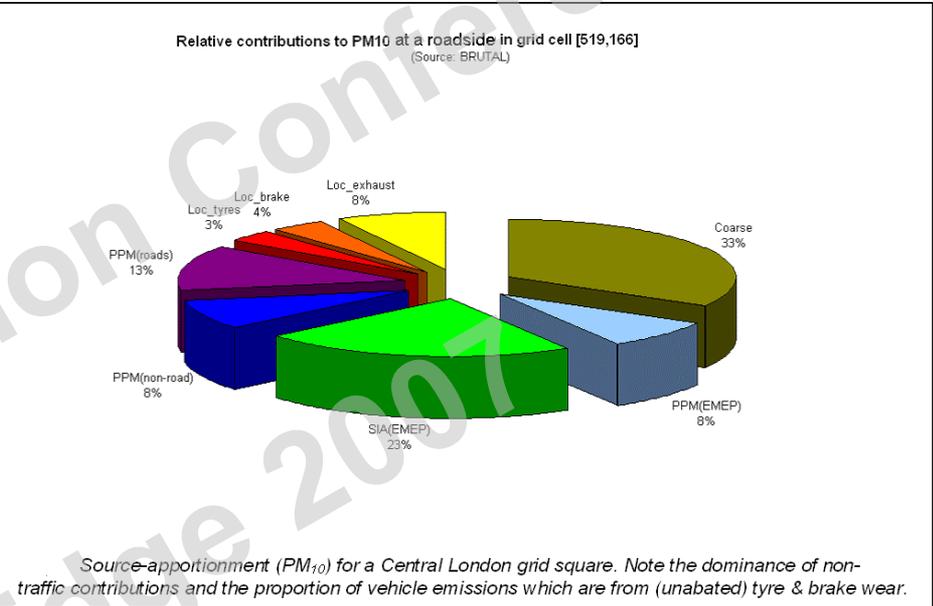
# Global, transboundary and local



Traffic Flows in the Marylebone area  
(Derived from LAEI 2001 data)

Data: AADT  
Resolution: 100m  
Source: LAEI  
Date: 2001

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e, NC

- Policy Priority
  - ce non-European sources become more important
    - Health, Emissions Ceilings, Limit Values
- Temporal effects
  - carried out under new DEFRA contracts*
    - Annual average (IAM)
    - Hours/days? (eg. CMAQ)

# Related Publications

- ApSimon *et al.*, 1994, The Abatement Strategies Assessment Model: Applications to reductions of SO<sub>2</sub> emissions in Europe, *Atmospheric Environment*, 24(4), pp649-663
- Oxley *et al.*, 2003, The UK Integrated Assessment Model, UKIAM: A national scale approach to the analysis of strategies for abatement of atmospheric pollutants under the Convention on Long-Range Transboundary Air Pollution, *Integrated Assessment*, 4(4), pp 236-249
- Oxley & ApSimon, 2007, Space, time and nesting Integrated Assessment Models, *Environmental Modelling & Software*, doi:10.1016/j.envsoft.2007.02.002
- Valiantis, 2007, Assessment of future UK transport emissions in relation to air quality, PhD Thesis, Centre for Environmental Policy, Imperial College London.

For publications related to and further developments of the BRUTAL model information will become available on the I.S.B.P project website (<http://www.tigress.ac/isbp/>)

Thank you for your attention