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# UK Assessments of Air Pollution Near Roadways

Dr. David Carruthers

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US-EPA – Environment Agency Workshop on Air Quality

Chapel Hill 22-23 October 2009

- Motivation,
  - Standards, Regulations, Guidance
- Modelling Issues/Factors
- Examples
- Future

- **EU Air Quality Directives**

- **Limit values**

NO<sub>2</sub> annual mean 40µg/m<sup>3</sup> (21 ppb ~ less than typical ozone concentration)

NO<sub>2</sub> no more than 18 exceedences of 200µg/m<sup>3</sup>

PM<sub>10</sub> annual mean 40µg/m<sup>3</sup>

Daily mean must not exceed 50µg/m<sup>3</sup> more than 35 times per year

(PM<sub>2.5</sub> limit for urban background)

- **UK Air Quality Strategy**
  - **Adopts objectives for air quality similar to EU limit values, but with different timescales**
  - **Local air quality review and assessment**

Local authorities undertake modelling in some circumstances;

Air quality management areas (AQMAs) declared if objectives exceeded; most AQMAs adjacent to roads

Local Air Quality Management Technical Guidance (LAQM TG09, Feb 09) from DEFRA

- **Planning applications**
- **Health Impact Studies**
- **Traffic management**
- **Air Quality Forecasting**



# ADMS User Group

## Case Study: Antwerp Ring Study

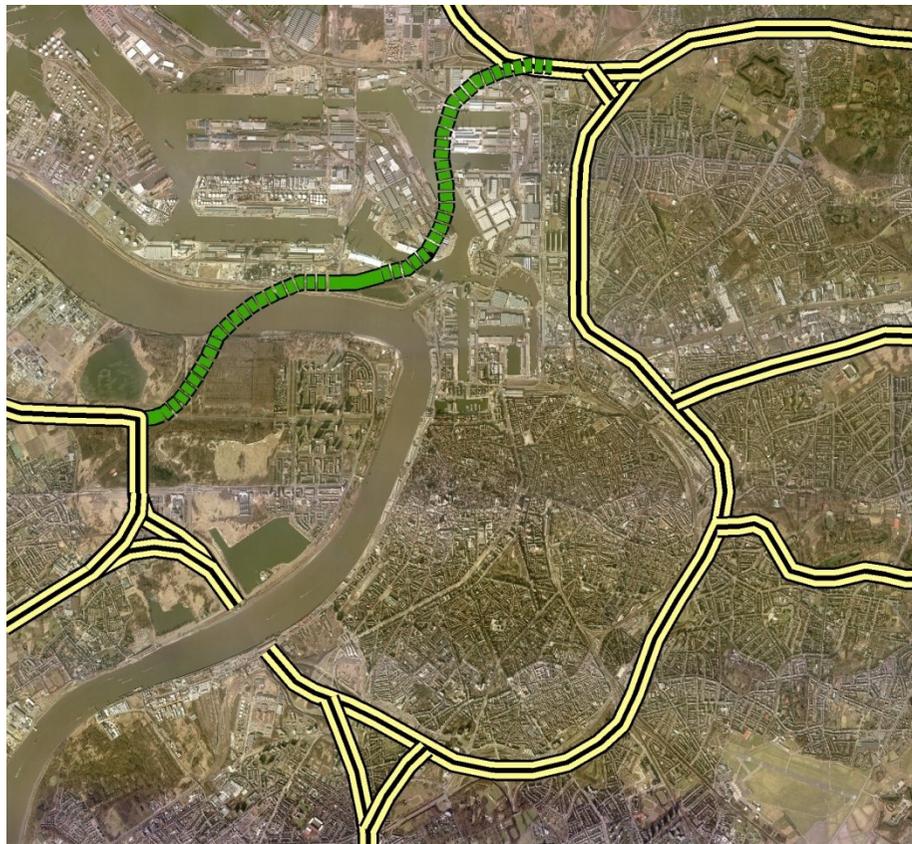
Amanda Kuffel  
Katharina Weigert

York,  
23 September 2009

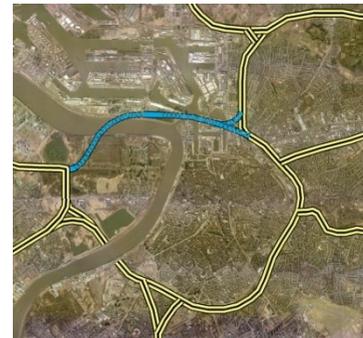
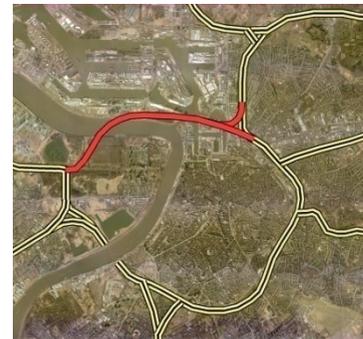
**ARUP**

# Scheme Options

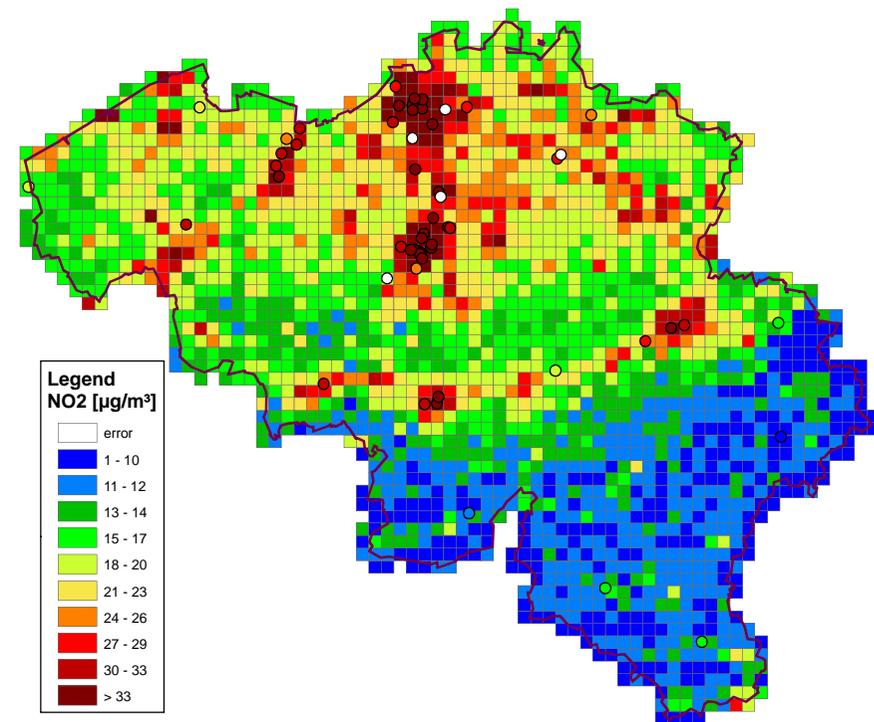
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- Main Roads
- Option 1 tunnel-bridge
- Option 2 tunnel
- Option 3 tunnel

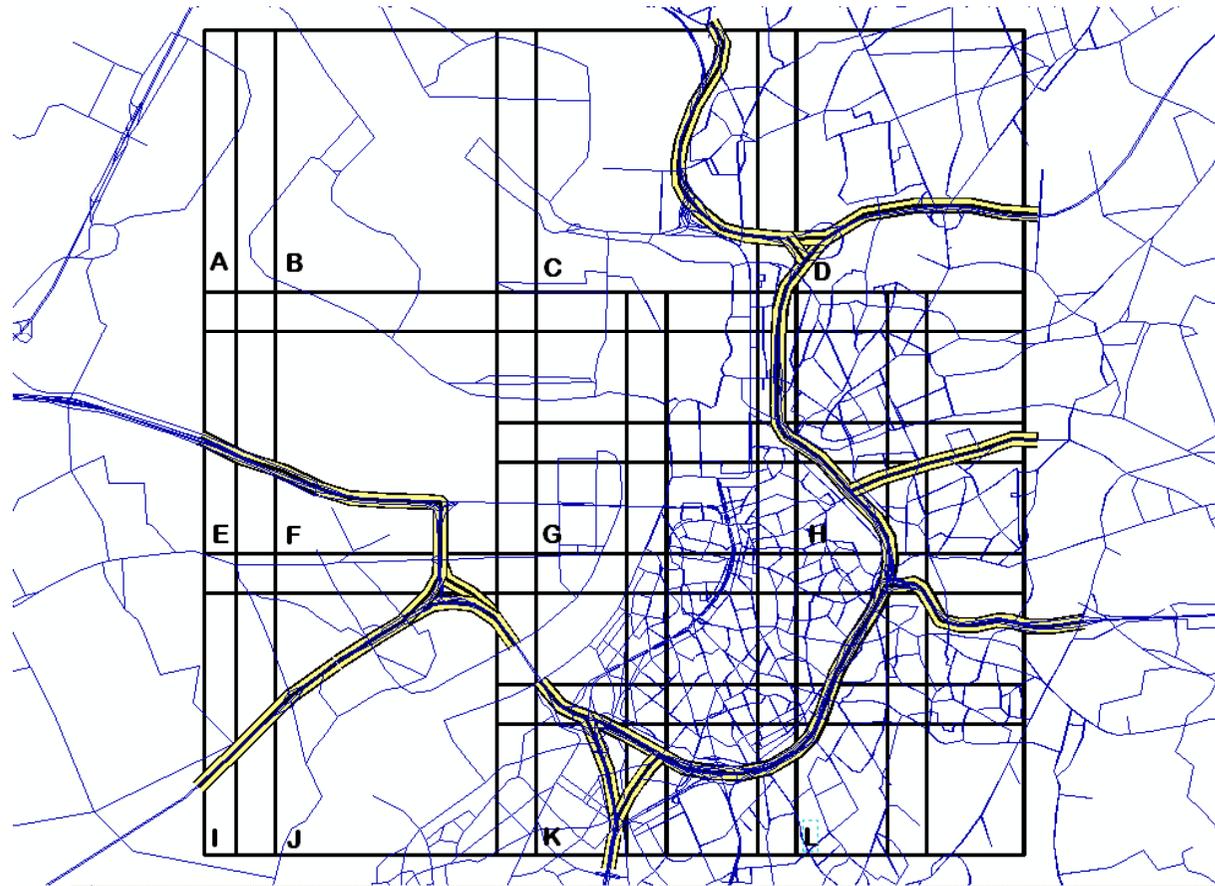


- Background concentration file generated by VITO using Rio-corine model
- Rio-corine model uses underlying land use data to interpolate air quality monitoring data
- Hourly sequential data available for 4km x 4km grid squares



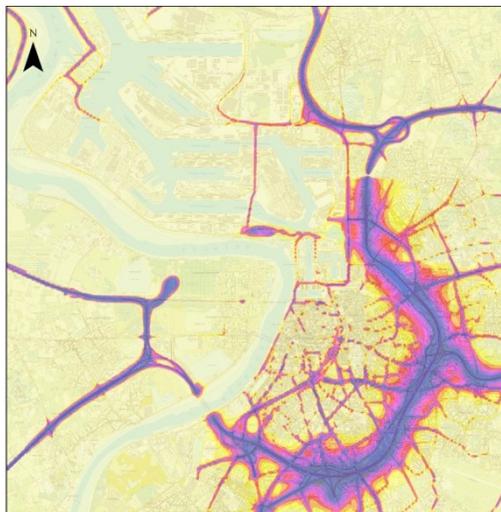
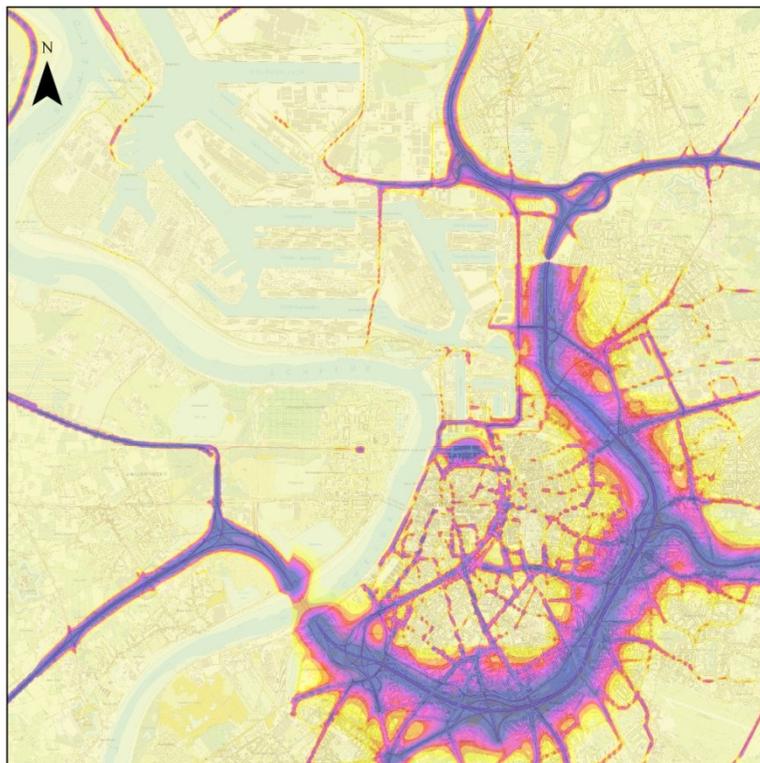
# Modelled Road Links

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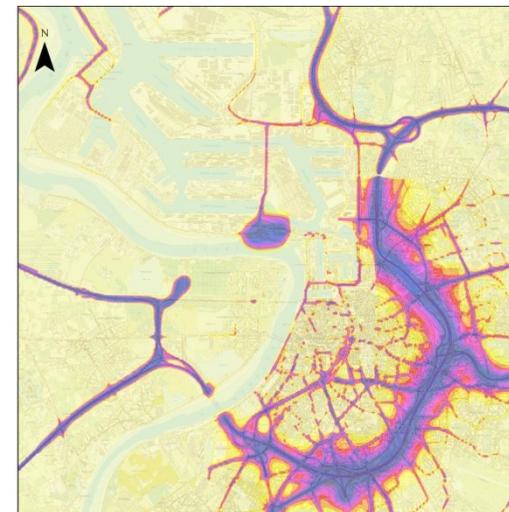


# Contour Plots – NO<sub>2</sub> Annual Mean

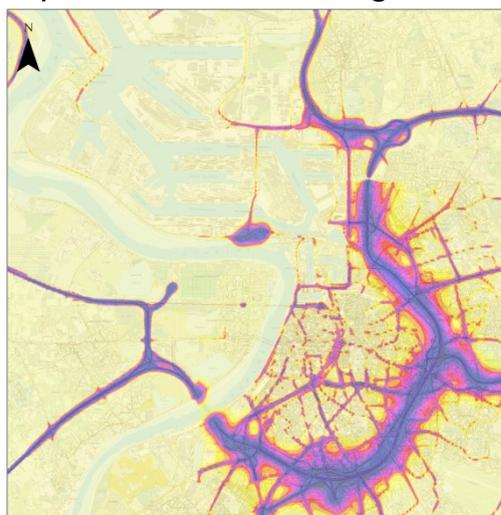
CERC



Option 1 – tunnel-bridge



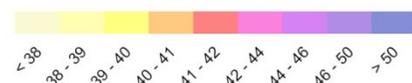
Option 2 - tunnel



Option 3 - tunnel

## Annual Mean NO<sub>2</sub>

All concentrations in microgrammes per cubic metre

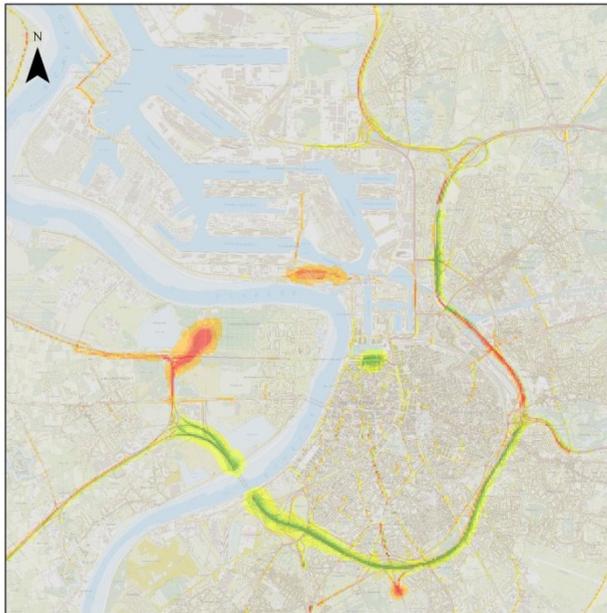


0 0.5 1 2 Km

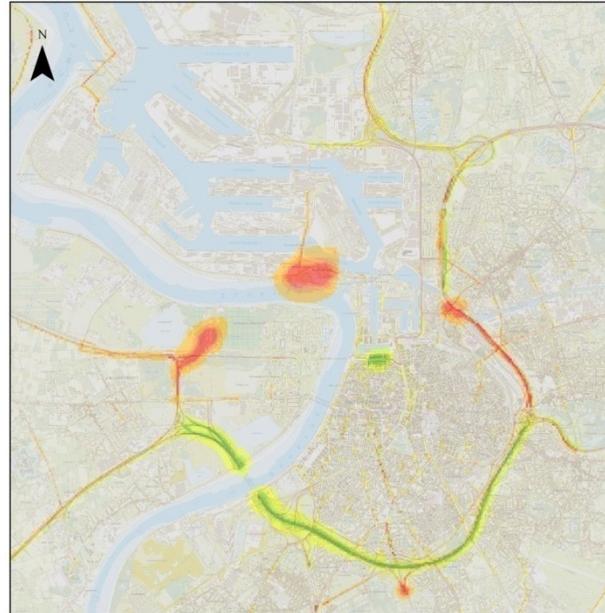


# Contour – Difference Plots

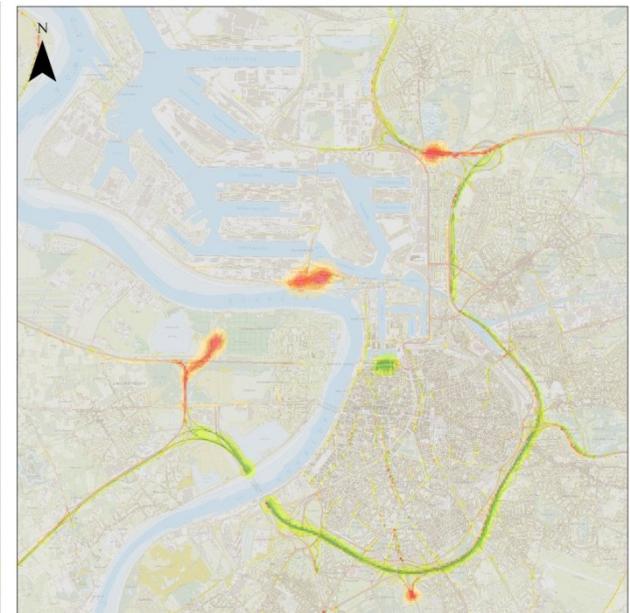
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Difference Option 1 - DM



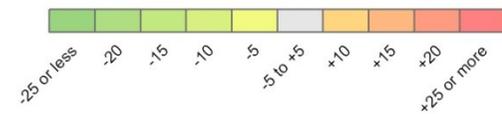
Difference Option 2 - DM



Difference Option 3 - DM

## Annual Mean NO<sub>2</sub>

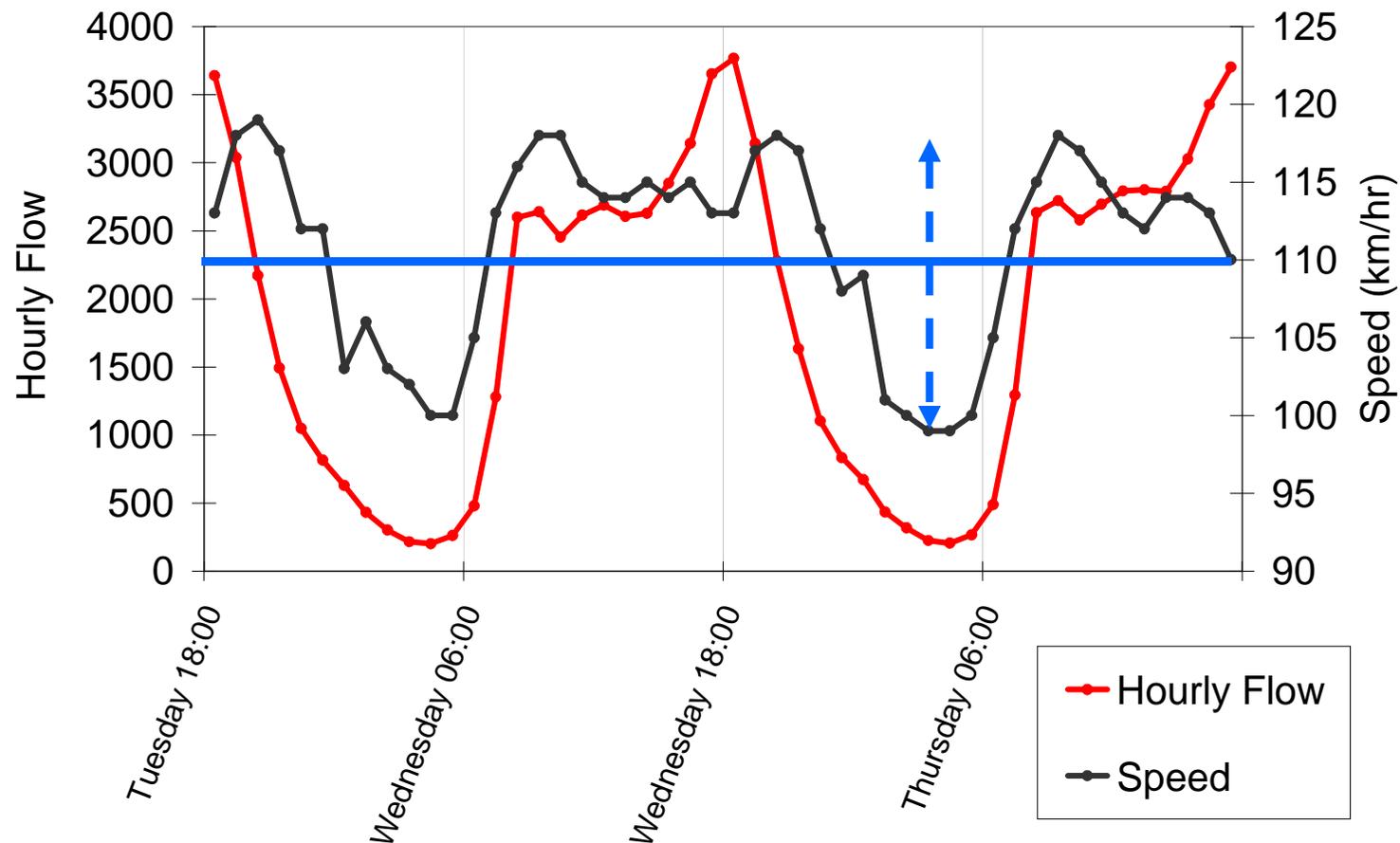
All concentrations in microgrammes per cubic metre



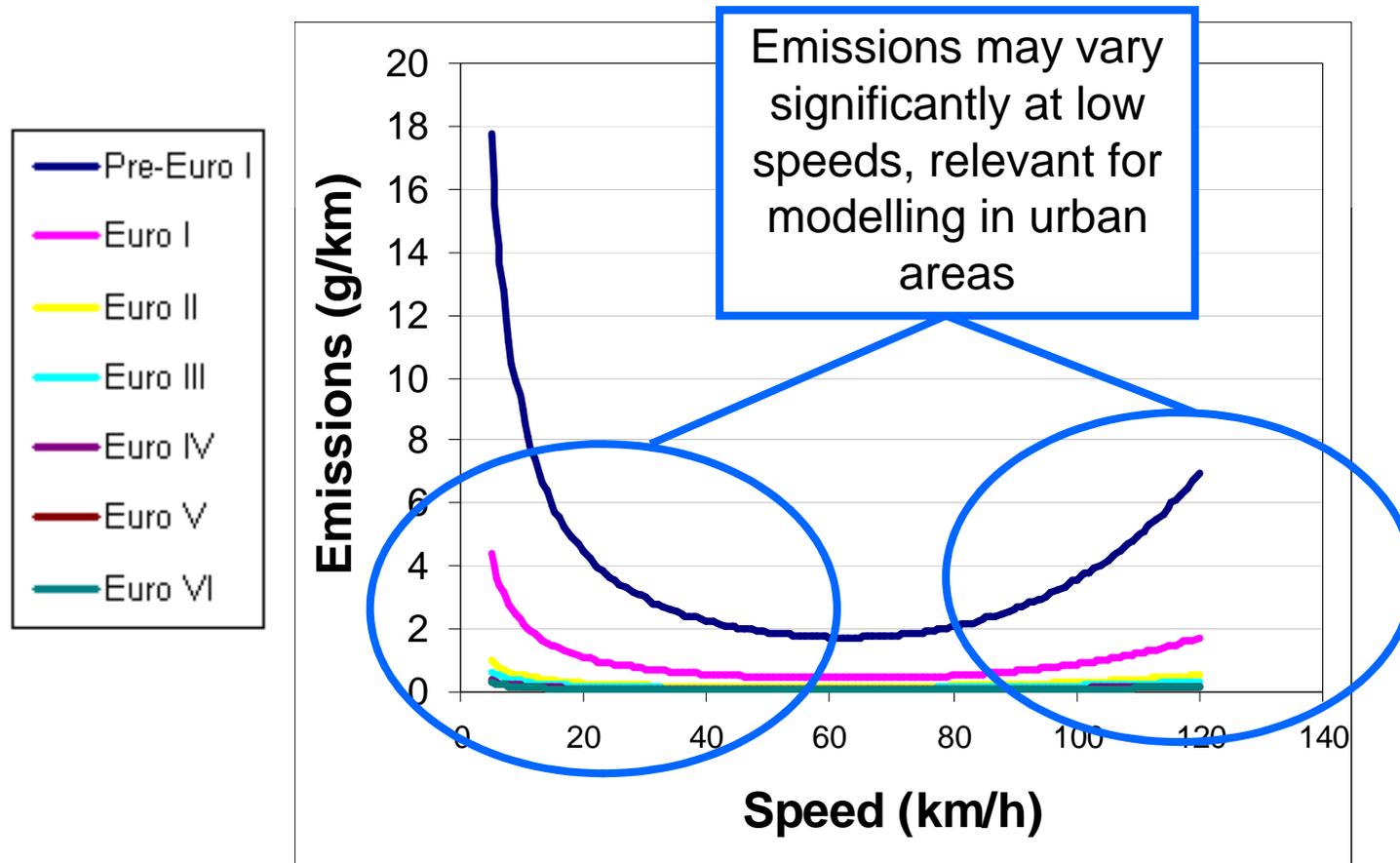
- Gaussian Type Models
  - e.g ADMS-Roads, CALINE, CAR, OSPM (Canyon), AERMOD, .....
- Lagrangian Particle Models
  - e.g. LASAT
- CFD Models
- Hybrids – Nested Gaussian
  - e.g. AirViro, ADMS-Urban
- Fine scale numerical models
  - e.g. MM5/WRF-CMAQ ....

- **Exhaust Emissions - DEFRA, DfT**
  - Emission Factors
  - Fleet mix
  - Traffic flow and speeds
- **Non Exhaust emissions – DEFRA**
  - Tyre and Brake wear
  - Road wear
  - Resuspension

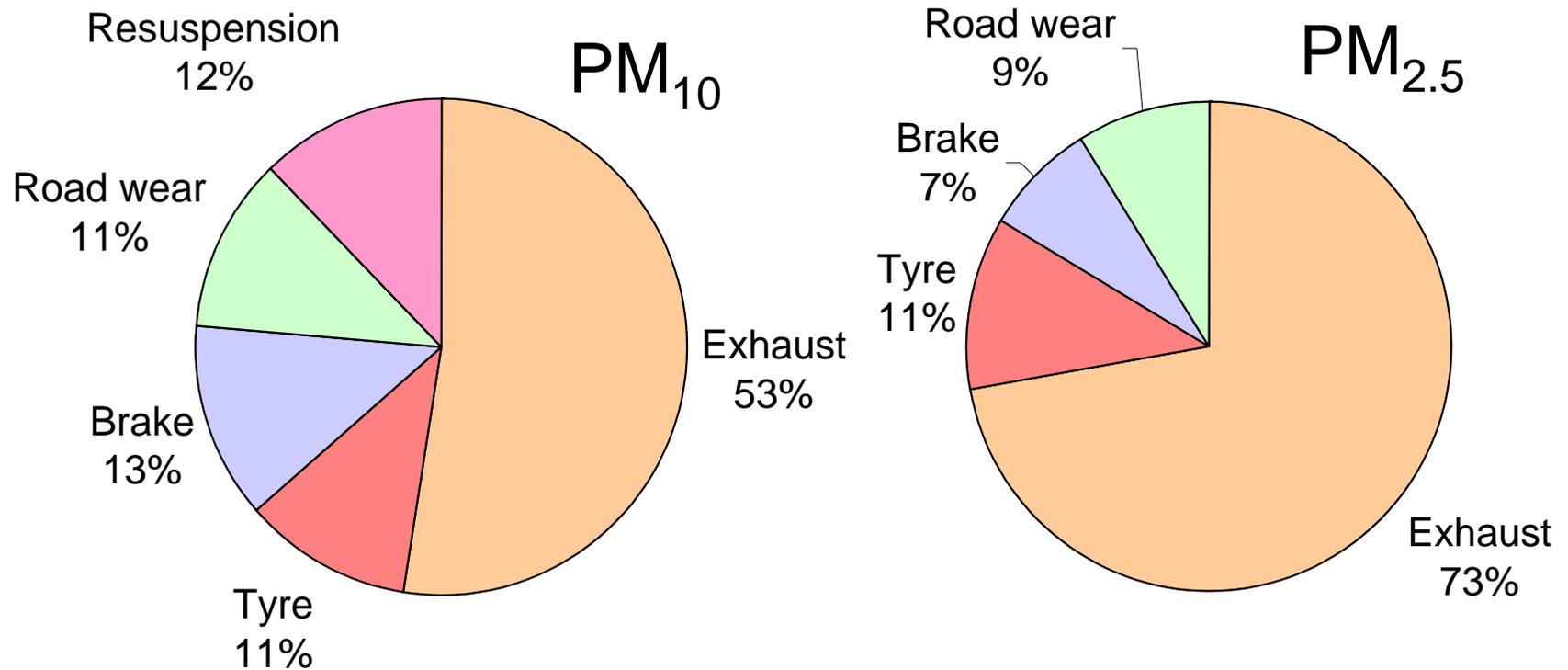
- **Account for diurnal variations in traffic speed**
  - Example traffic flow and speed data from M4



- **Account for diurnal variations in traffic speed**
  - Speed-emission curves for large petrol cars



- Non Exhaust PM emissions (London 2002)



- Current models (at most) assume initial mixing depth not dependent on traffic mix
- Study looked at impact of exhaust location and efflux parameters
- Parameterisation of effect proposed

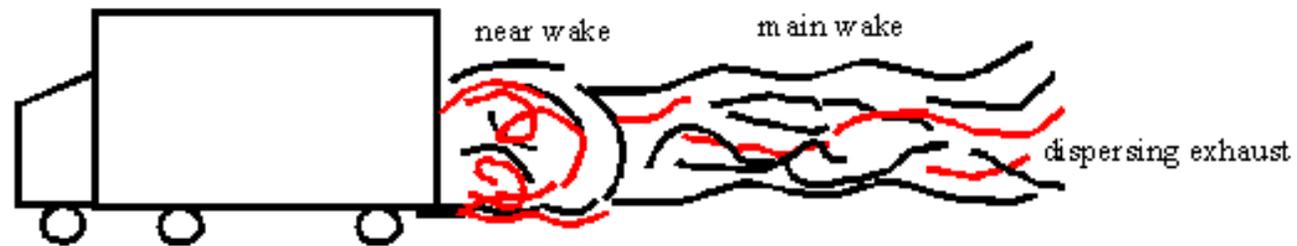


# Modelling Issues

## Dispersing vehicle exhaust

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(a) Exhaust at rear of vehicle



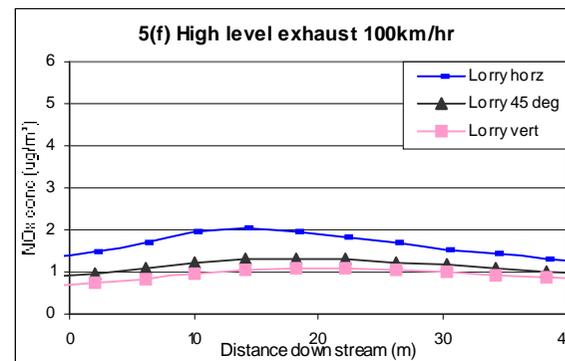
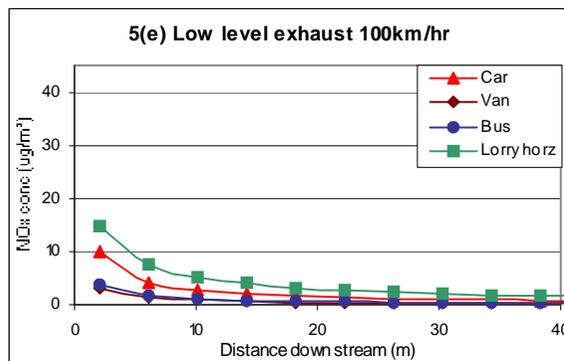
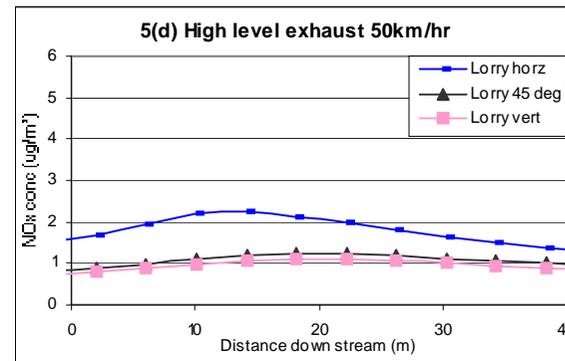
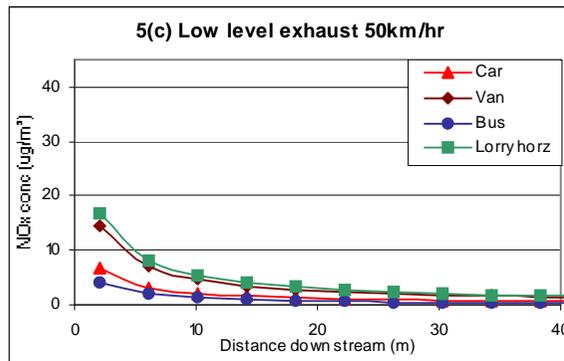
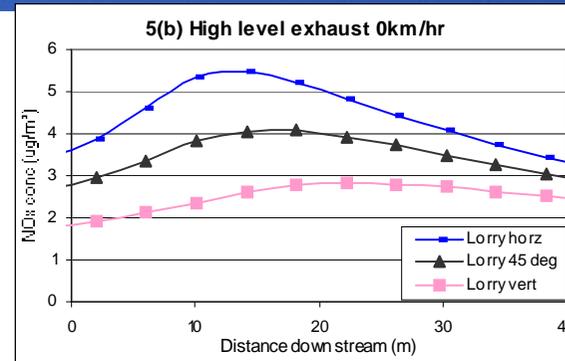
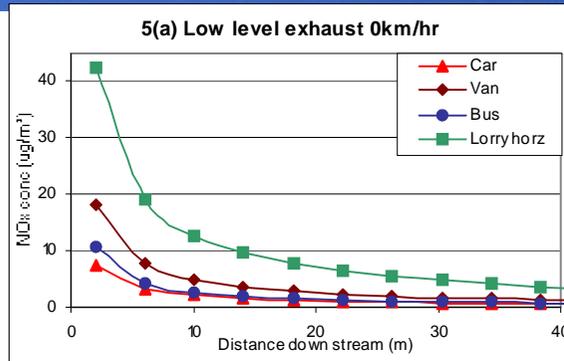
(b) Exhaust above vehicle entrained into main wake



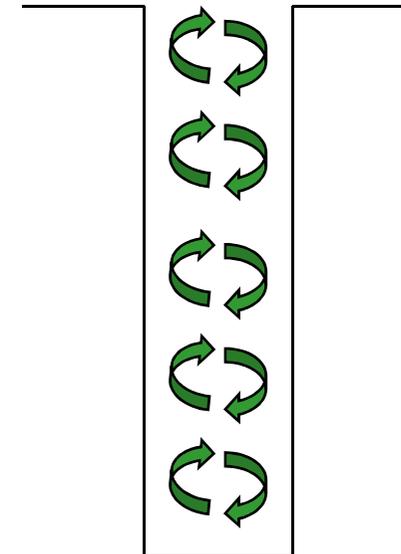
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# Annual average concentrations for each vehicle type over a range of speeds

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- **Improve street canyon modules (eg OSPM)**
- Currently:
  - 2-dimensional solution used within the canyon
  - No effect taken of canyon externally
- Possible improvements:
  - Model end effects (junctions)
  - Have some account taken of effect of street canyon externally (similar to noise barriers)
  - Model asymmetric canyons
  - Include vertical variation
  - Model multiple re-circulation regions for tall thin canyons



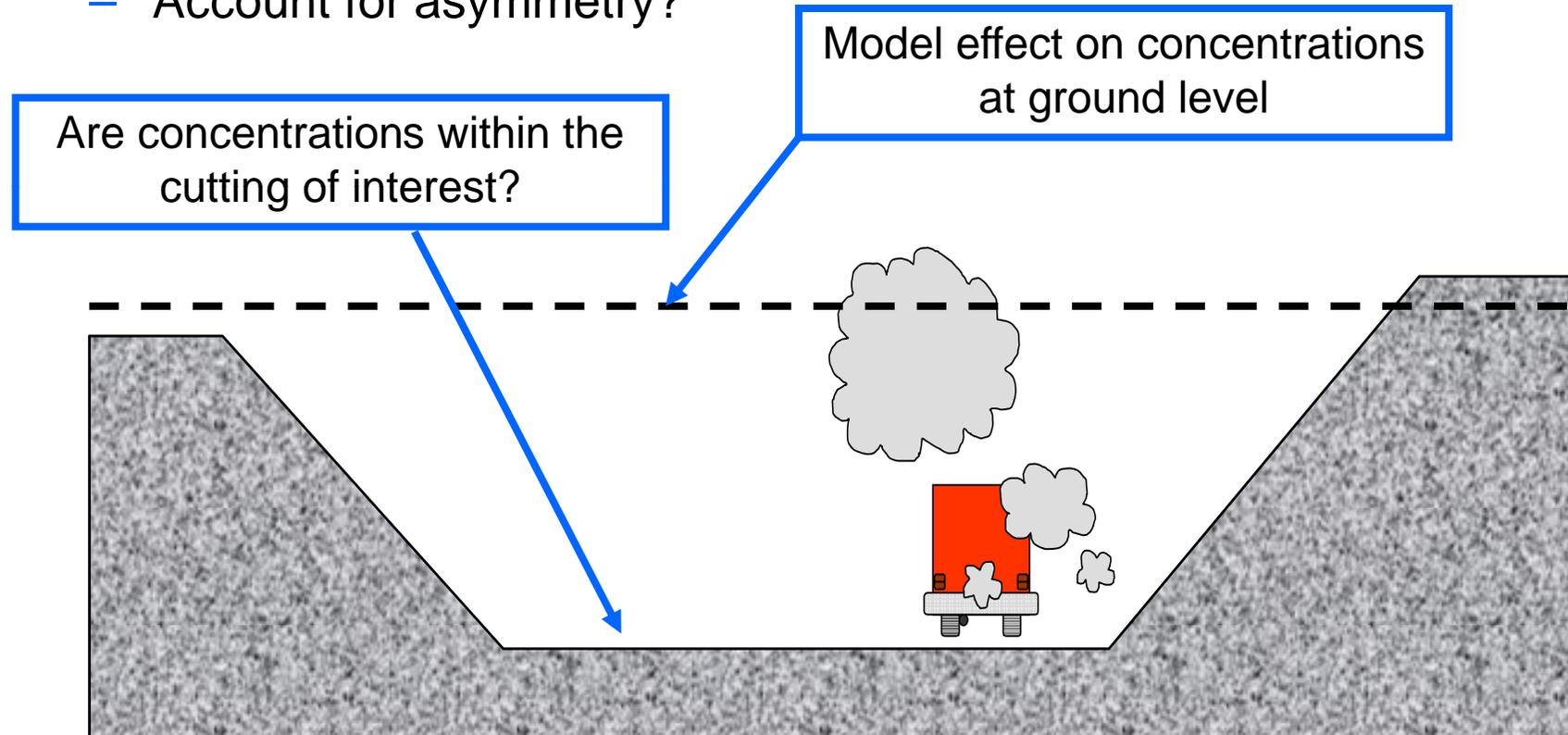
# Modelling Issues

## Road source attributes II

CERC

- **Cuttings**

- **NOT appropriate to model as complex terrain**
- Similarities to street canyon module
- Account for asymmetry?

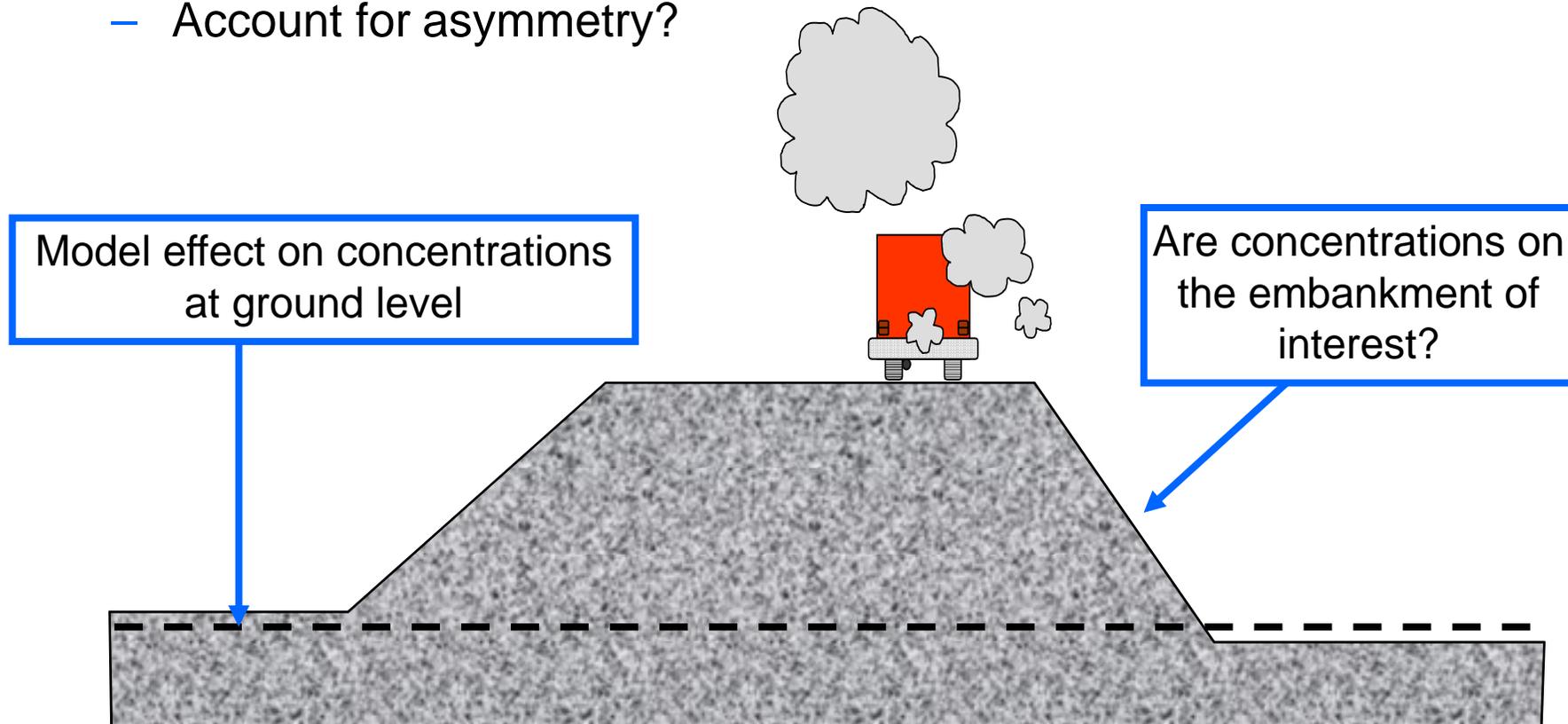


# Modelling Issues

## Road source attributes III

CERC

- **Embankments**
  - **NOT** appropriate to model as complex terrain
  - Effectively an elevated line source, shielded underneath
  - Account for asymmetry?

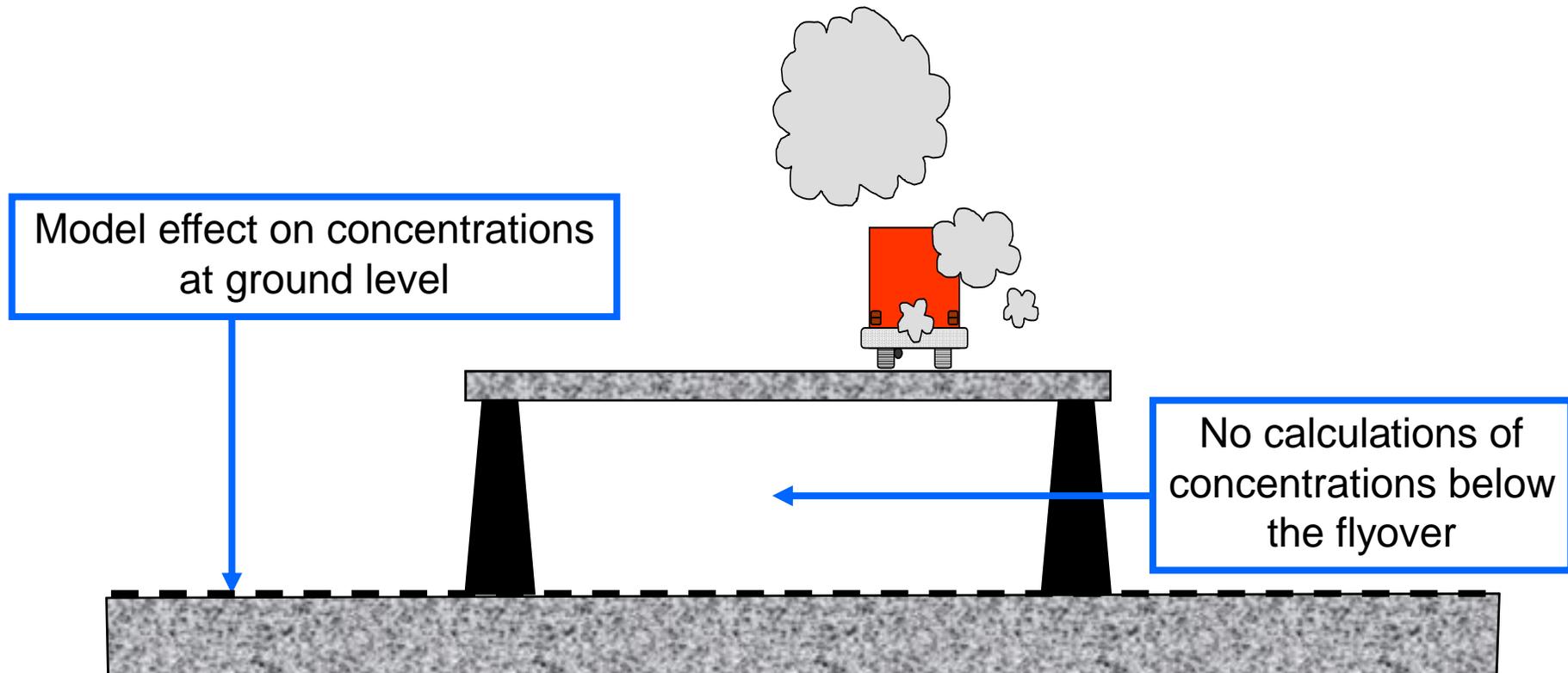


# Modelling Issues

## Road source attributes IV

CERC

- **Flyovers**
  - **NOT** appropriate to model as complex terrain
  - Effectively an elevated line source, shielded underneath

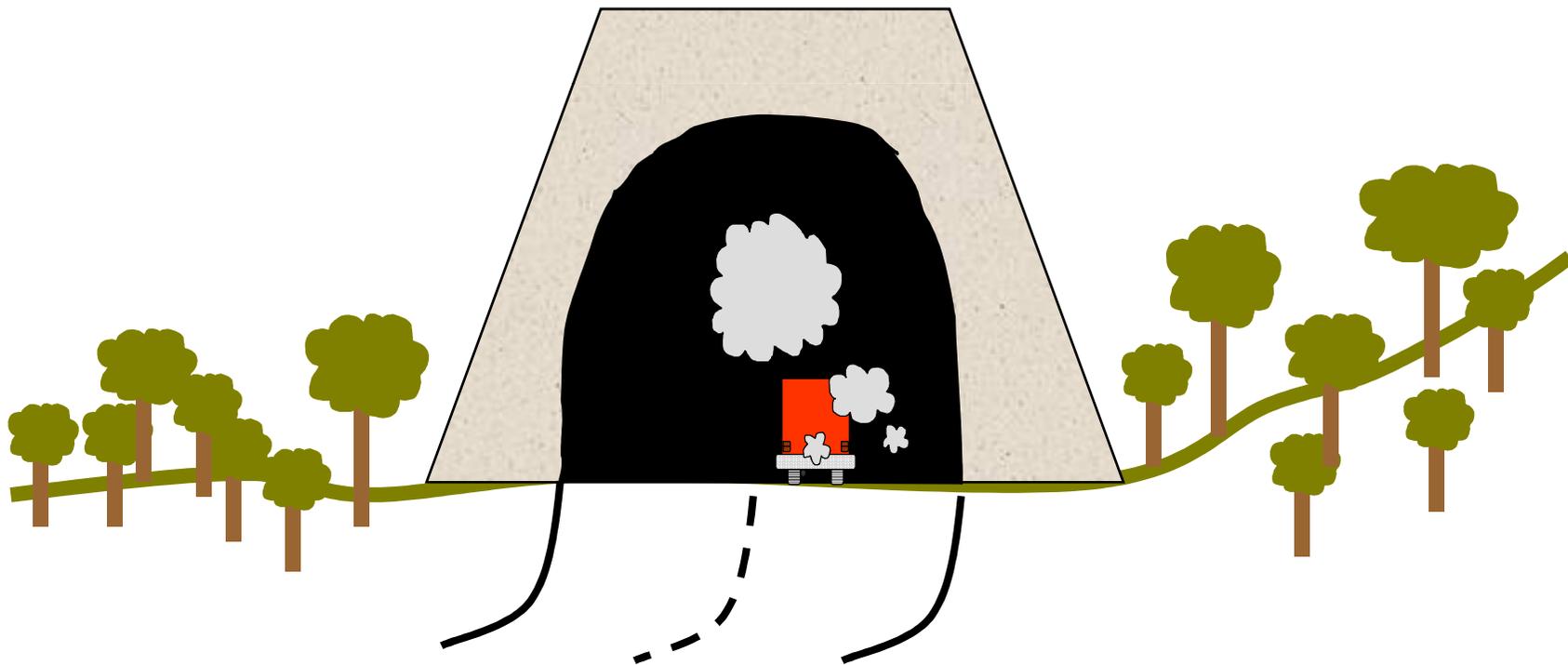


# Modelling Issues

## Road source attributes V

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- **Tunnels**
  - User enters traffic flows and speeds within the tunnel
  - Emissions modelled as volume sources at tunnel exits
  - Account taken for venting of emissions from tunnel?

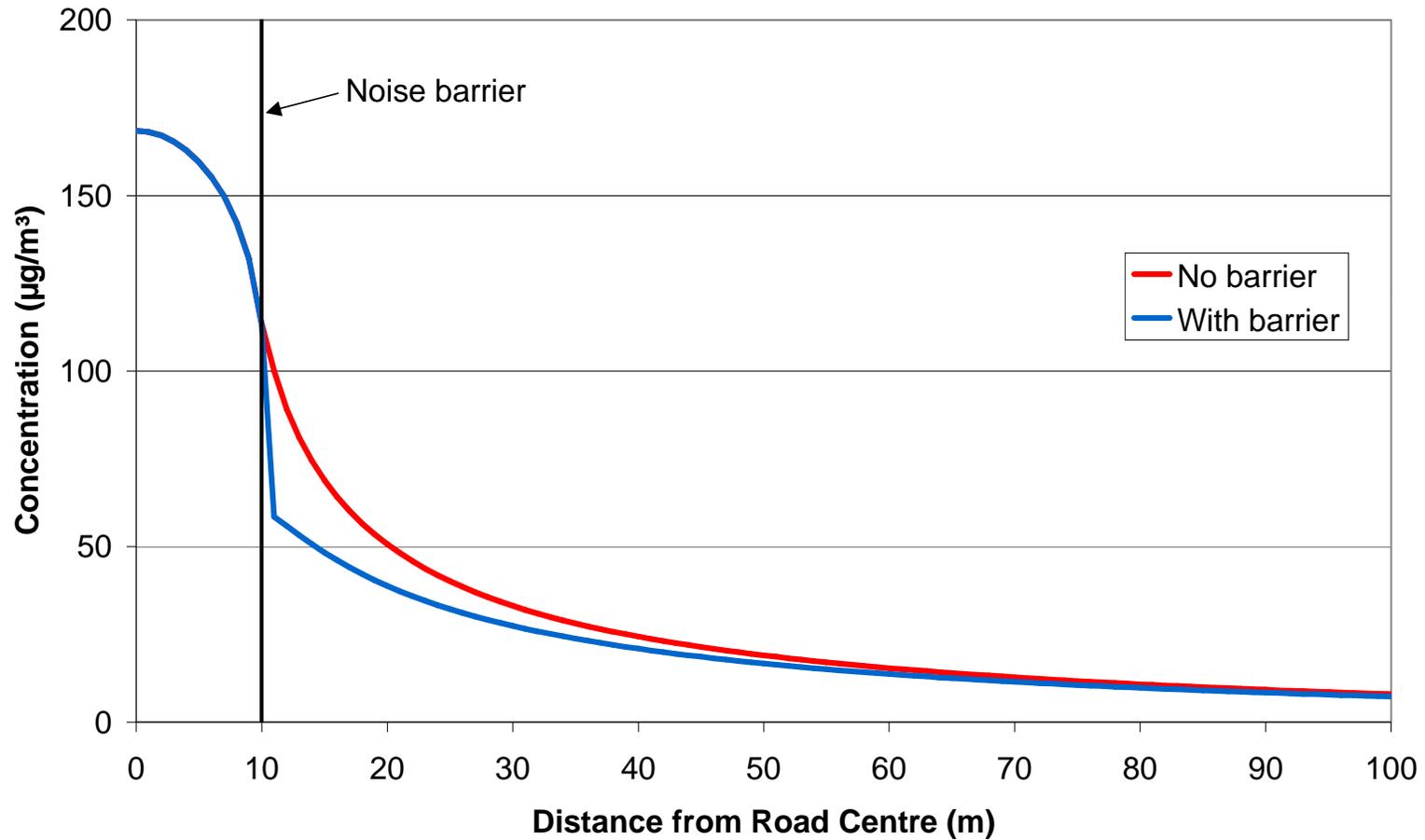


## Noise Barriers

- Noise barriers common throughout Europe

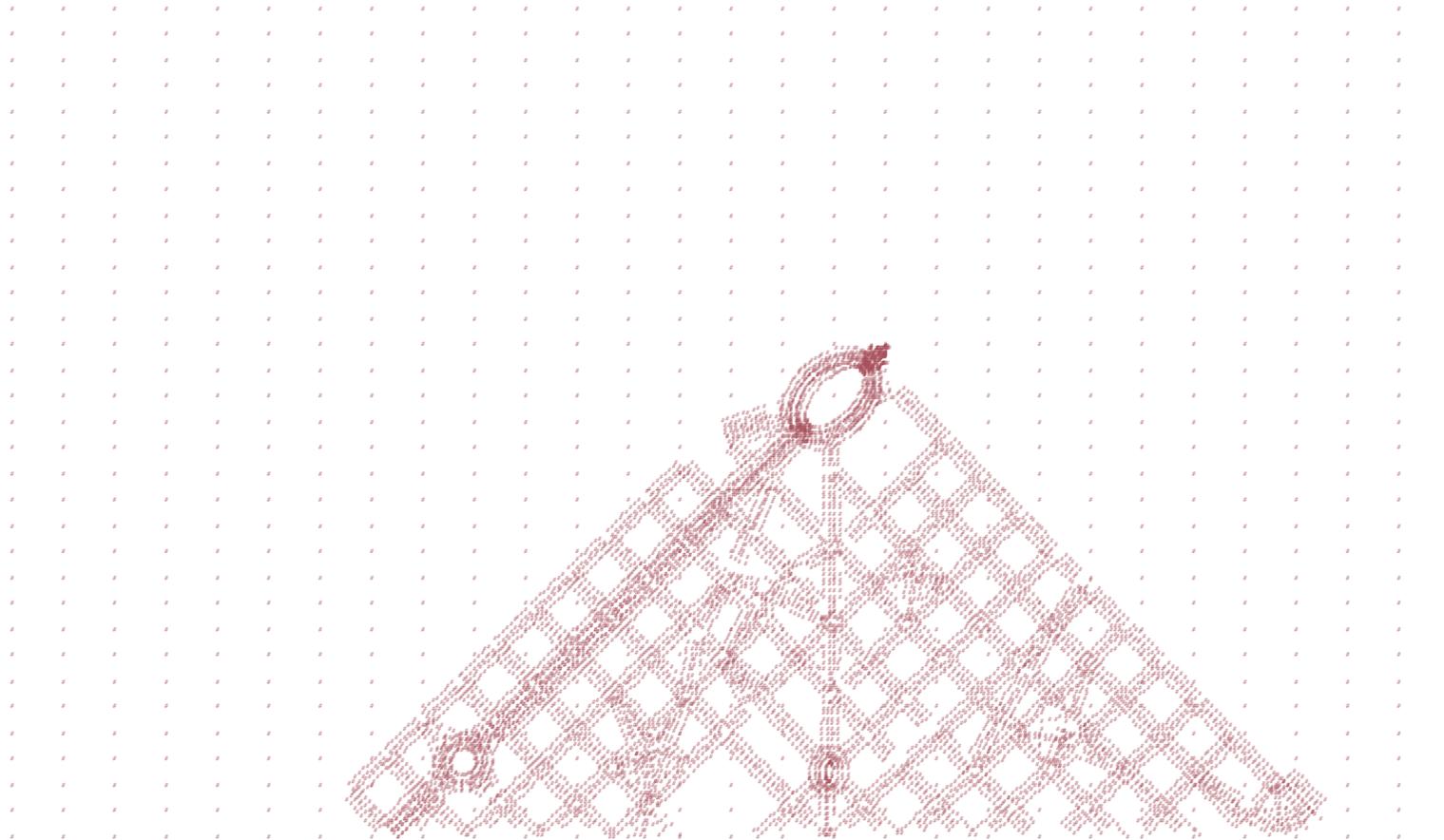


Noise Barriers – modelled using ADMS-Urban/Roads (barrier 5m)



# Model Output Points

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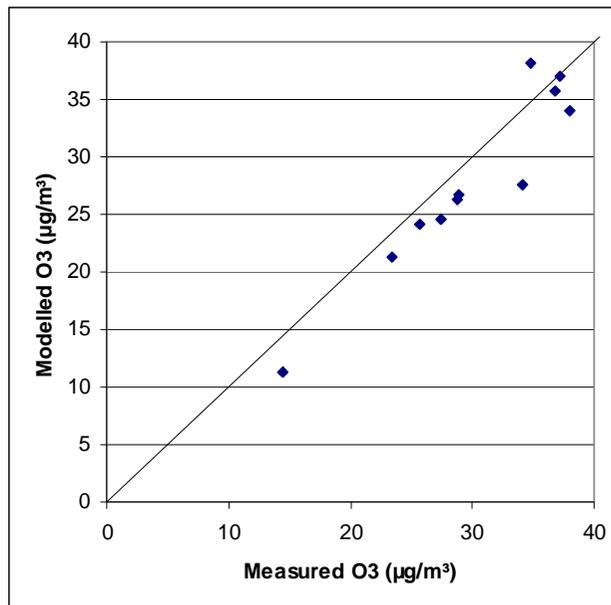
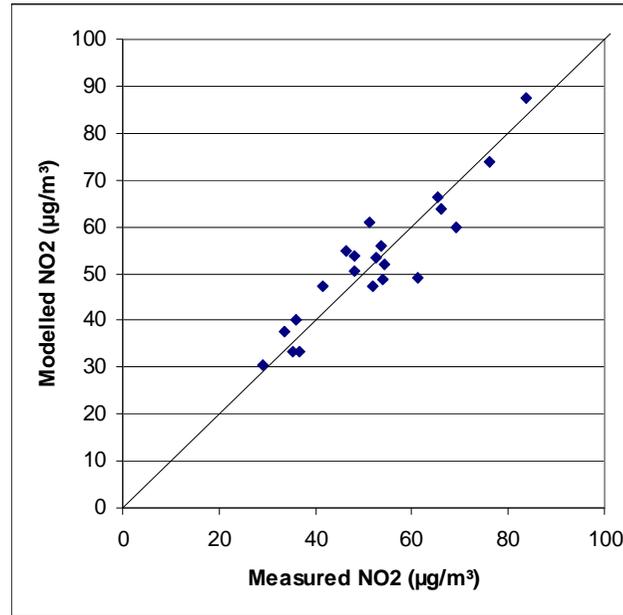
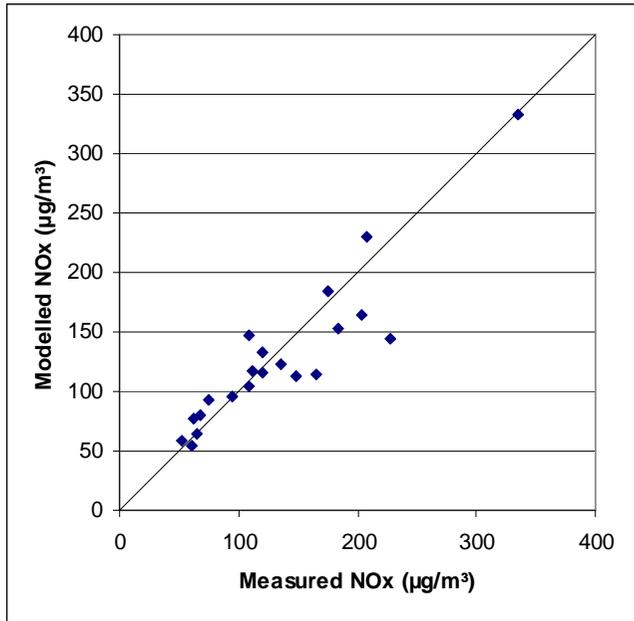
- Output points for Barcelona demo (northern section only - section 6 - to follow). Shows regular grid and enhanced resolution close to roads

- London – General (DEFRA)
- London Heathrow Airport (DfT)
- *Model Used – ADMS-Urban*
  - *Gaussian Type (road, point, area, grid sources) nested within 'trajectory' model*

# Model verification at AURN Sites

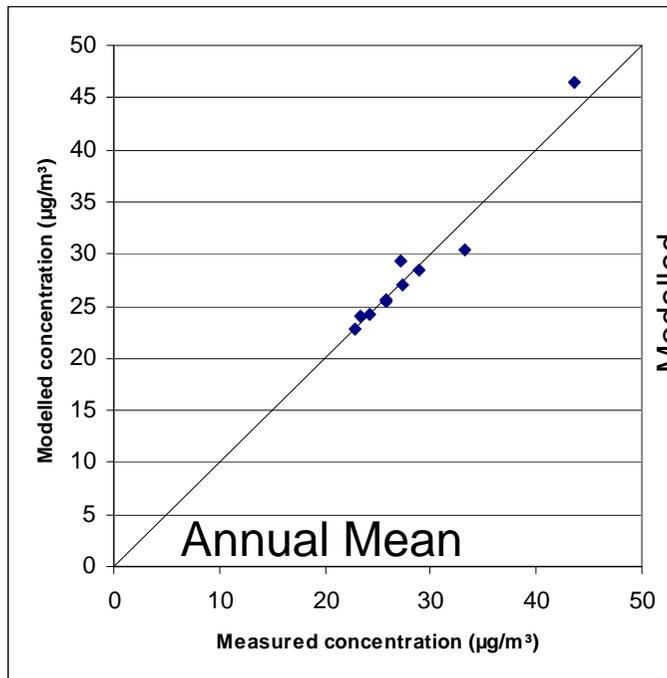
## Annual Means $\text{NO}_x$ , $\text{NO}_2$ , $\text{O}_3$

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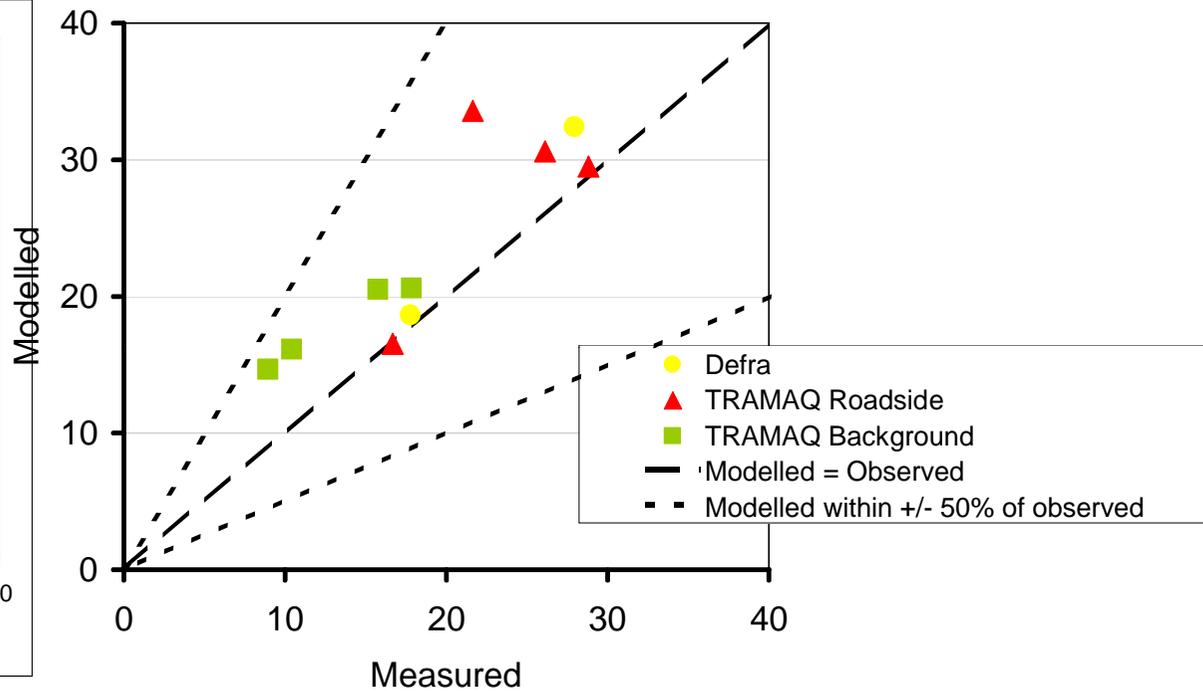


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## PM<sub>10</sub>



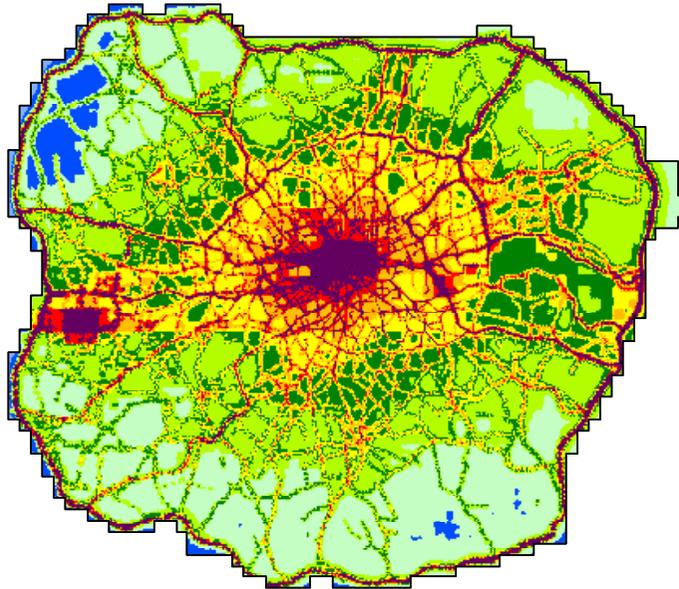
## PM<sub>2.5</sub> Annual Mean



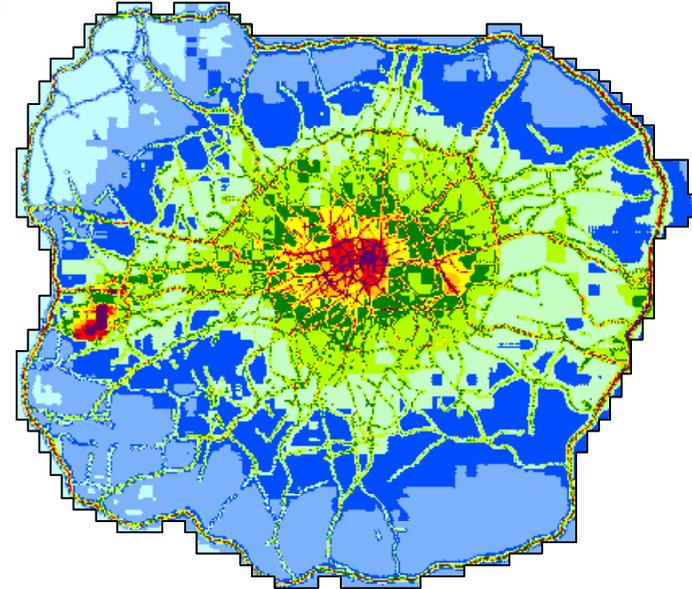
# Annual average NO<sub>2</sub> concentrations for London 2001, 2010 and 2020 – Base case

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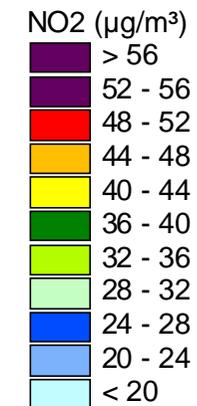
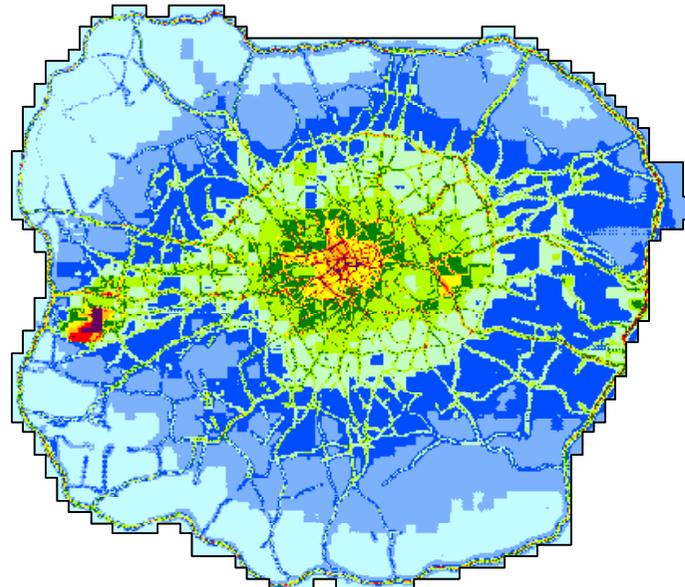
2001



2010

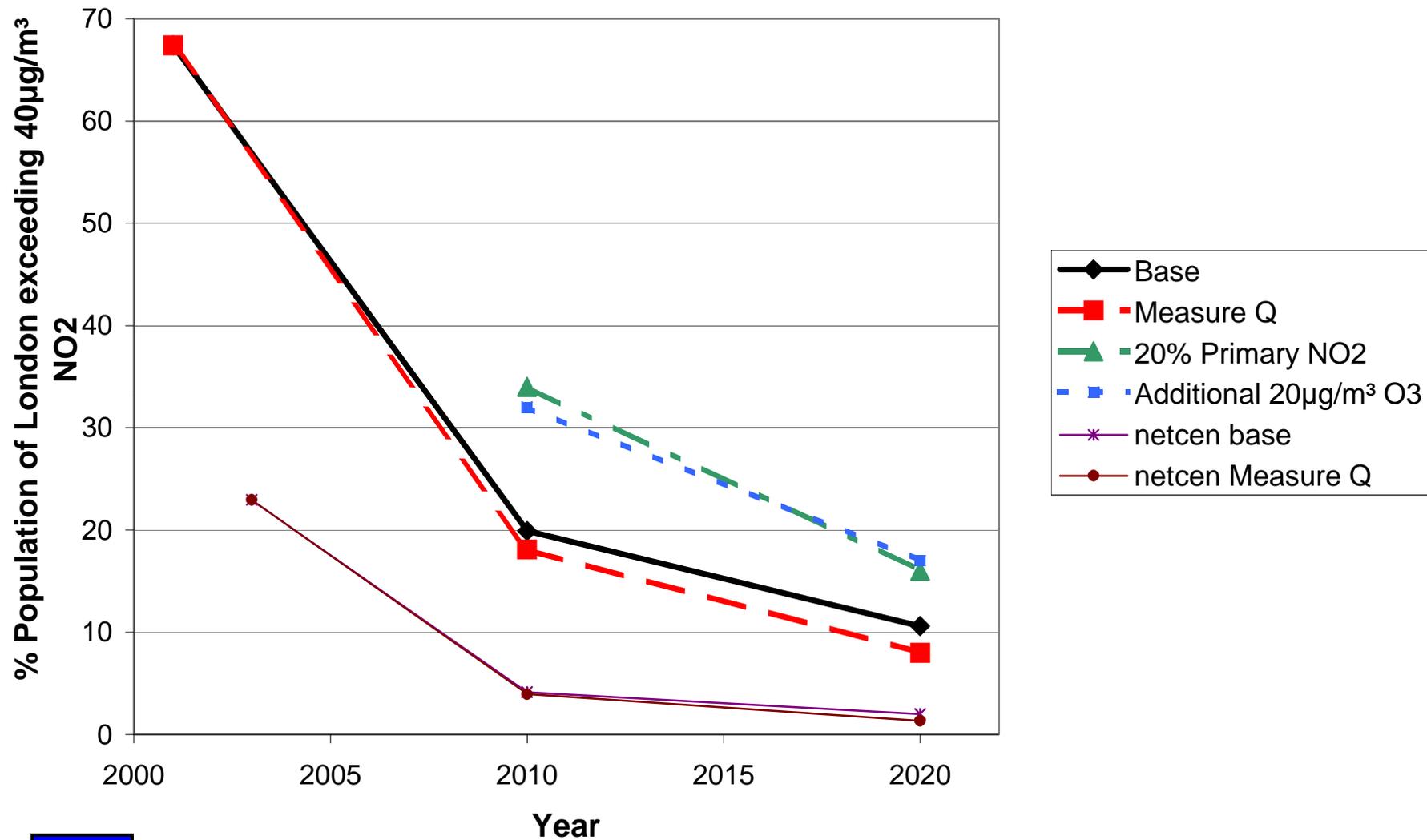


2020



# Population of London exceeding $40\mu\text{g}/\text{m}^3$ $\text{NO}_2$

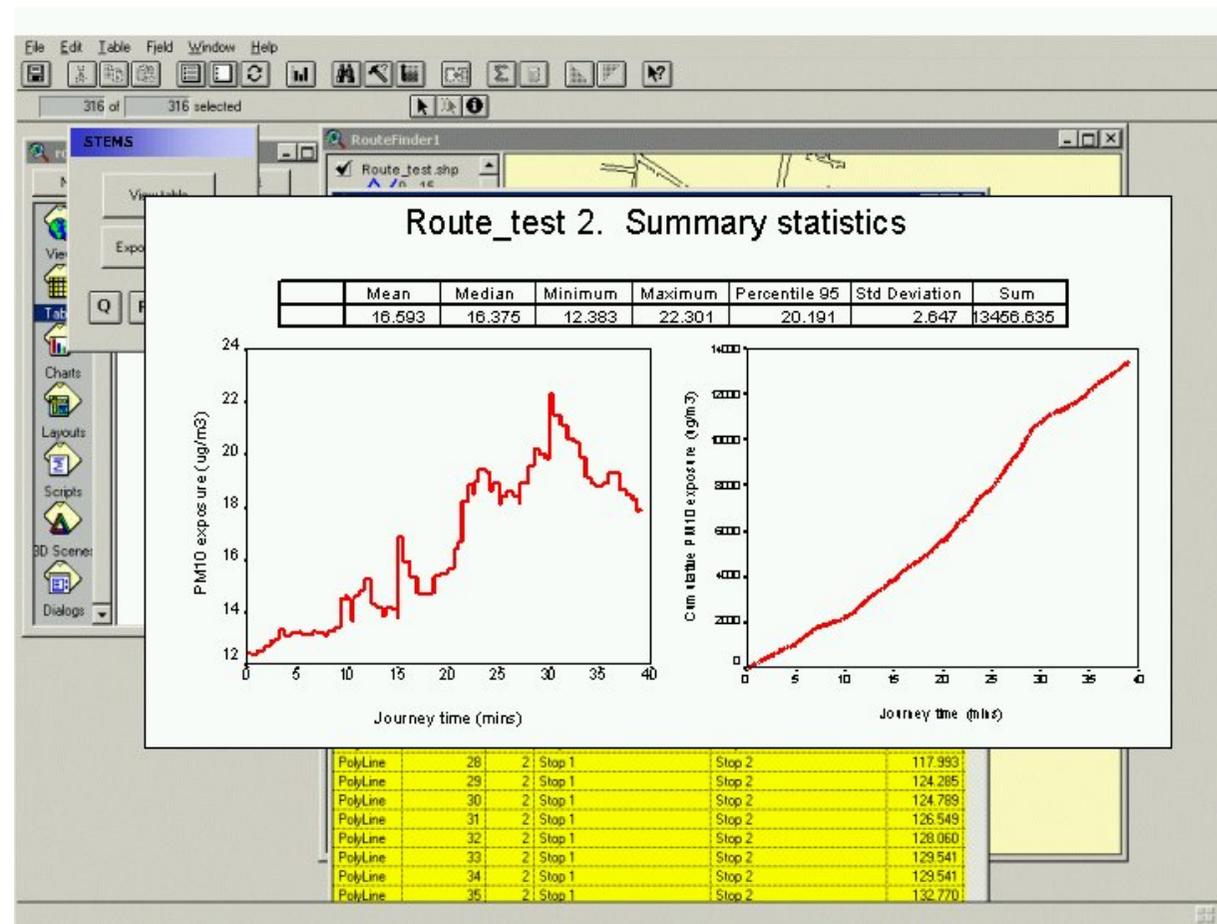
CERC



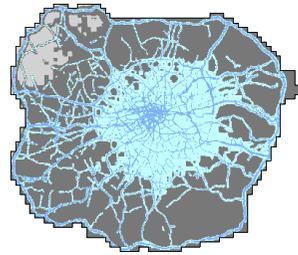
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- EU FP7 project includes calculation of exposure and health impact (morbidity and mortality),

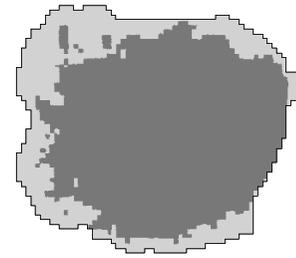
Image of UWS  
STEMS (Space-  
Time Exposure  
Modelling System),  
showing statistics for  
the route.



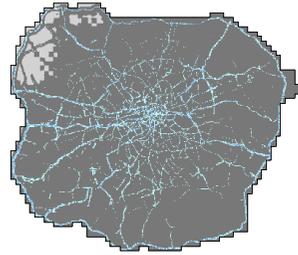
(a) Major Roads



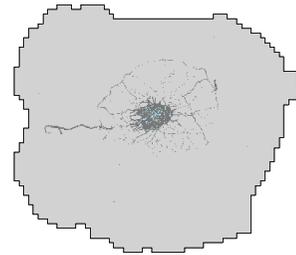
(b) Other Roads



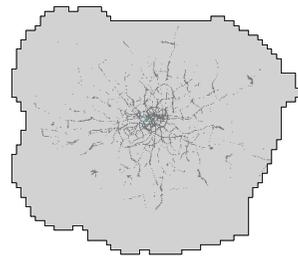
(c) Car



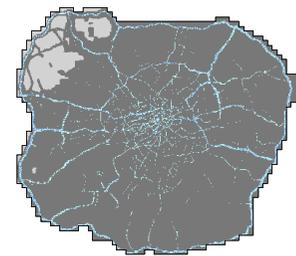
(d) Taxi



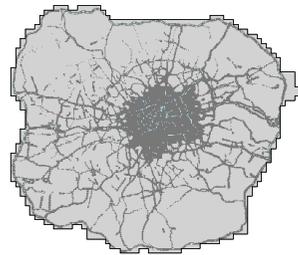
(e) Bus and Coach



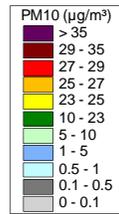
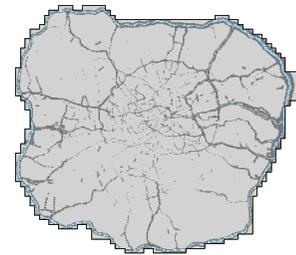
(f) LGV



(g) Rigid HGV



(h) Articulated HGV

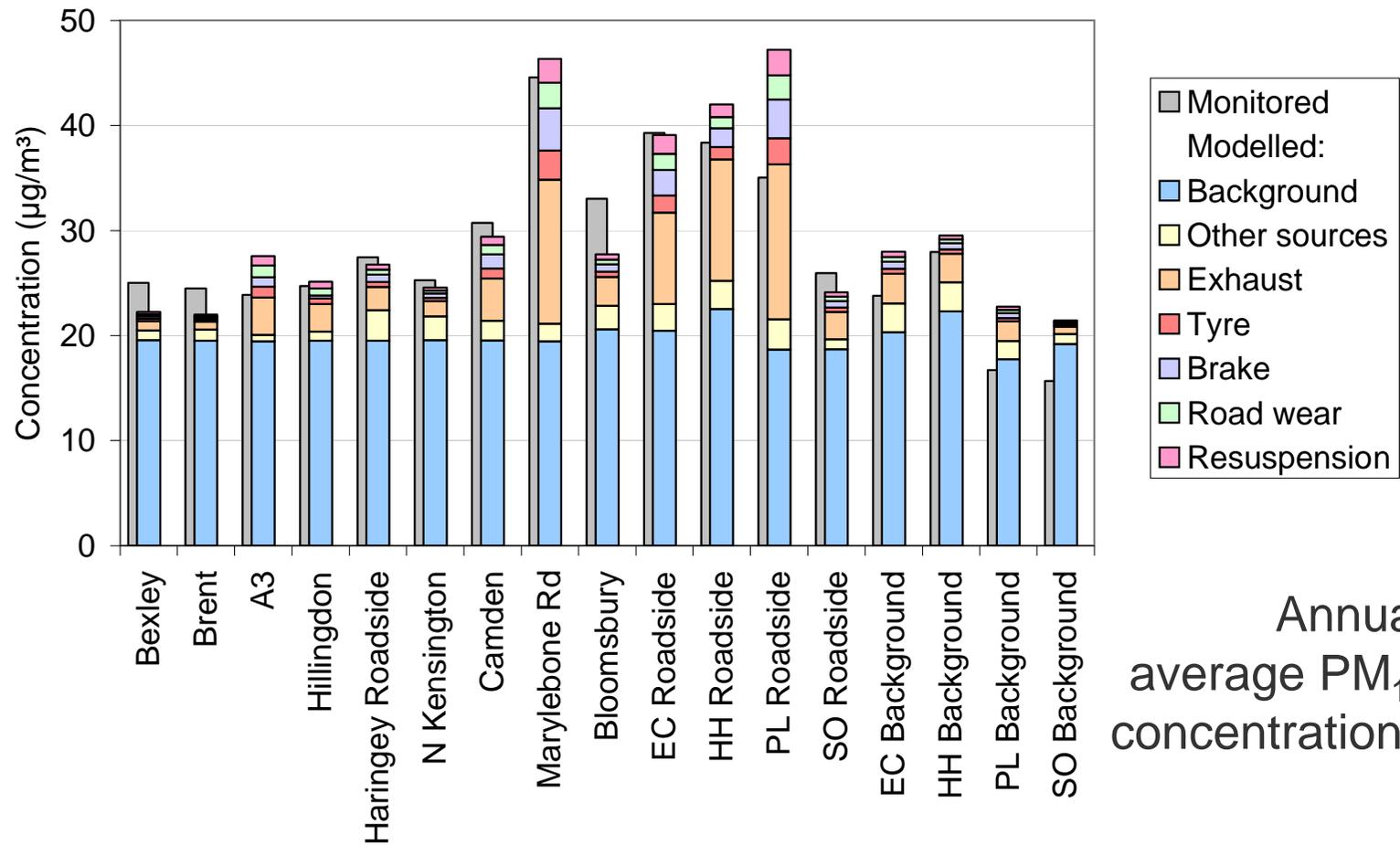


**Source apportionment of PM<sub>10</sub> from vehicle exhaust emissions 2010**



# Source apportionment

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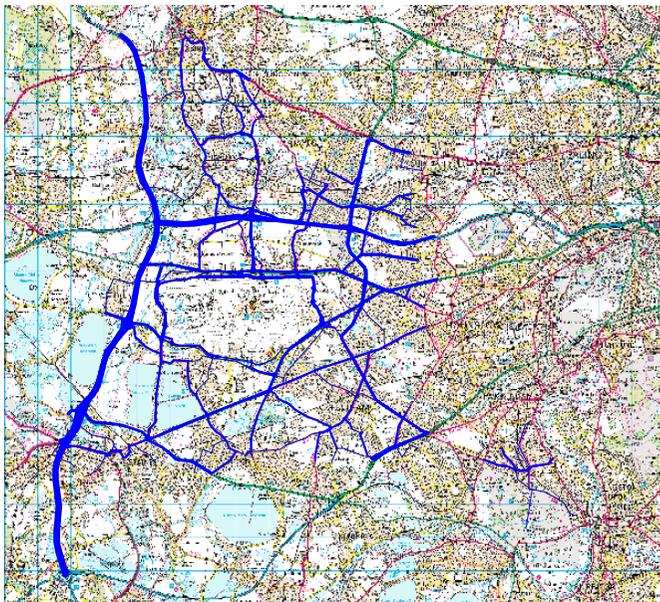


## SCENARIOS – Heathrow airport

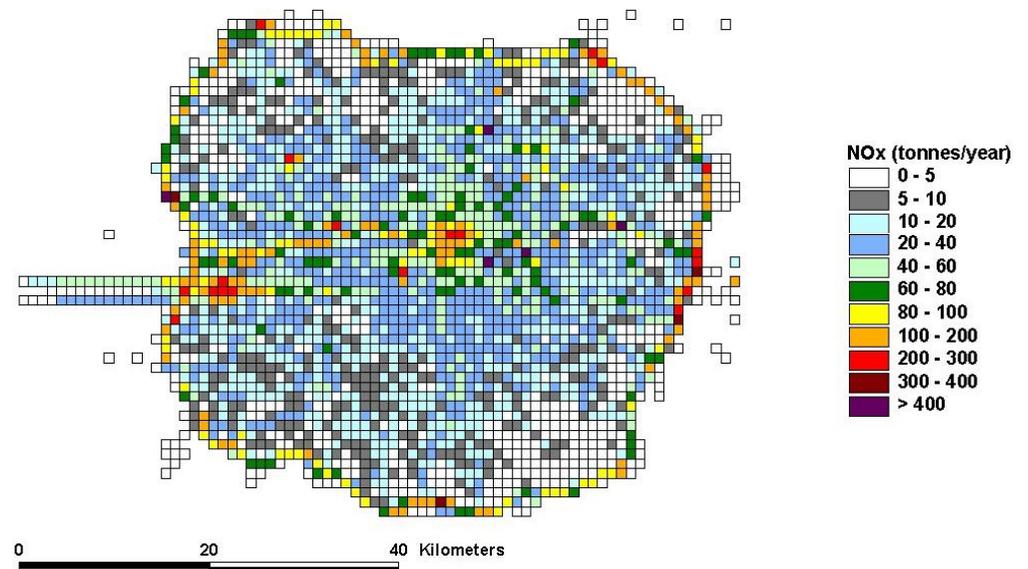
- Major study of government plans for airport expansion

2002 NO<sub>x</sub> emission rate

Explicitly modelled road sources



6 0 6 12 Kilometers

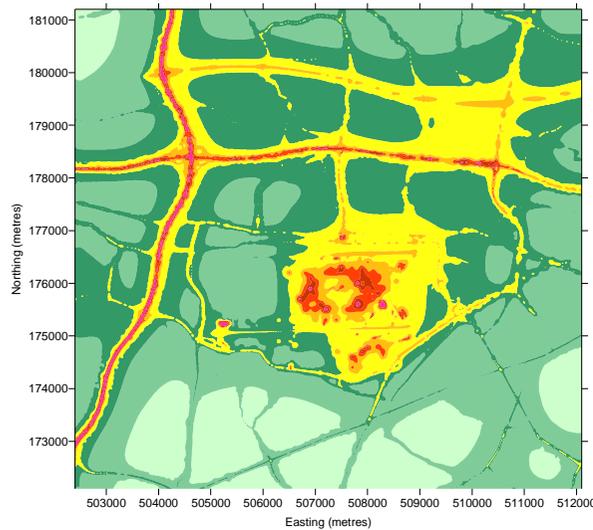


Grid sources from London Atmospheric Emissions Inventory

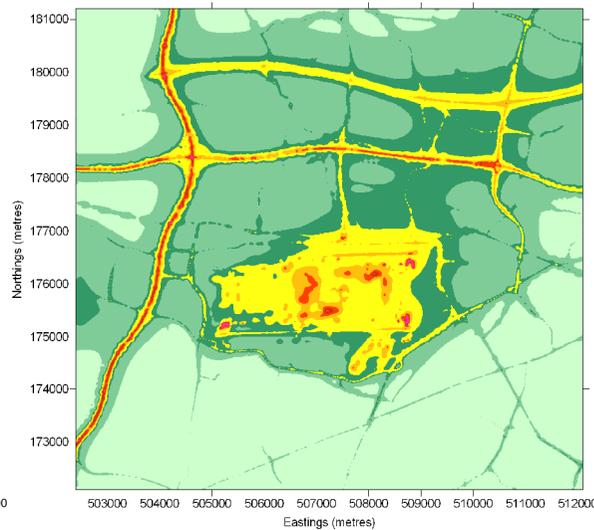
# Predicted NO<sub>2</sub> concentrations

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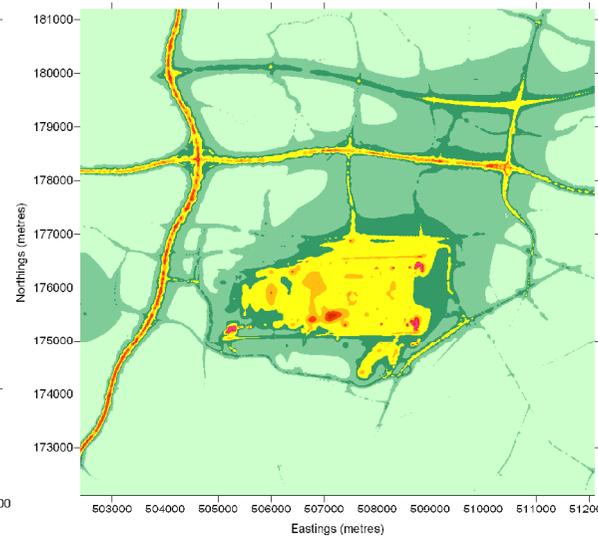
**2022 Base Case**



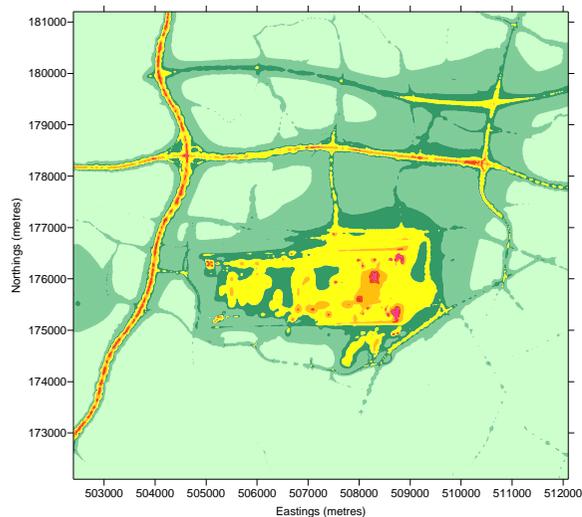
**2010 SM**



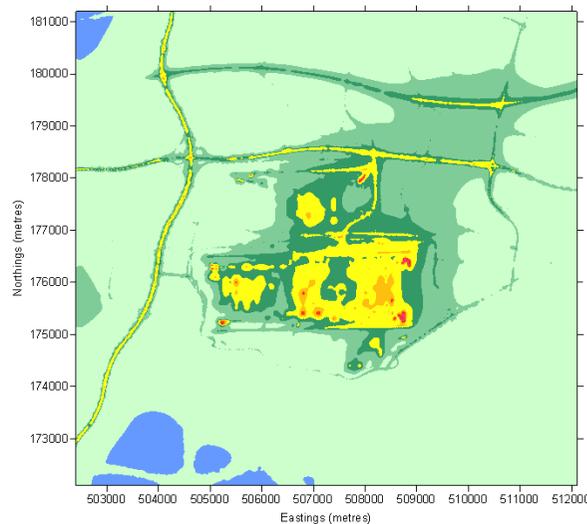
**2015 SM**



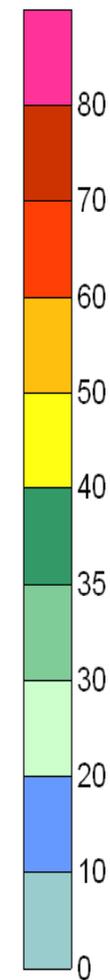
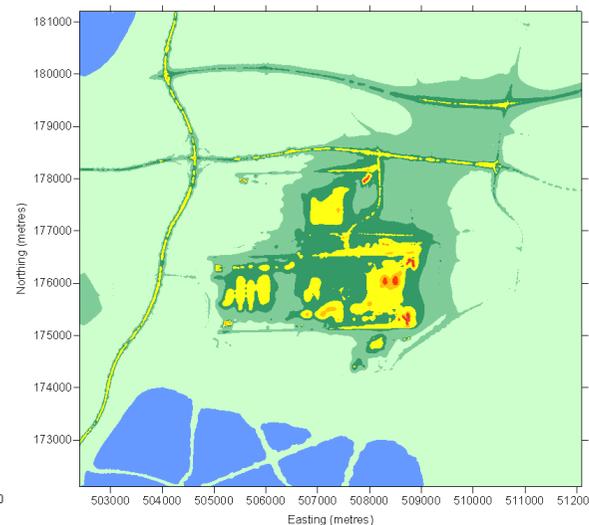
**2015 MM**



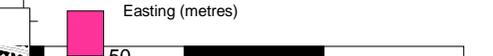
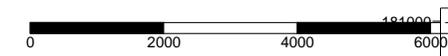
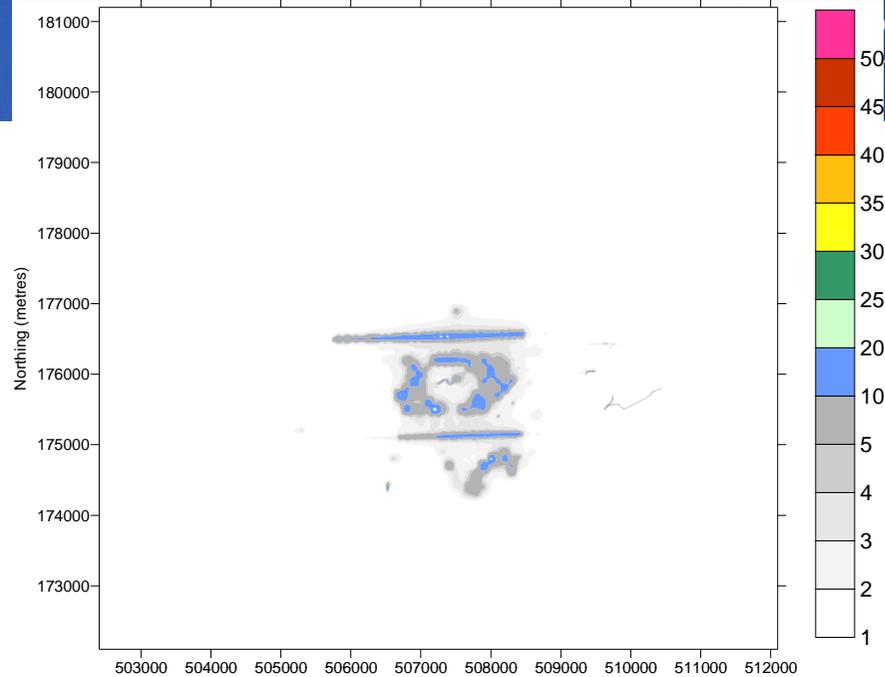
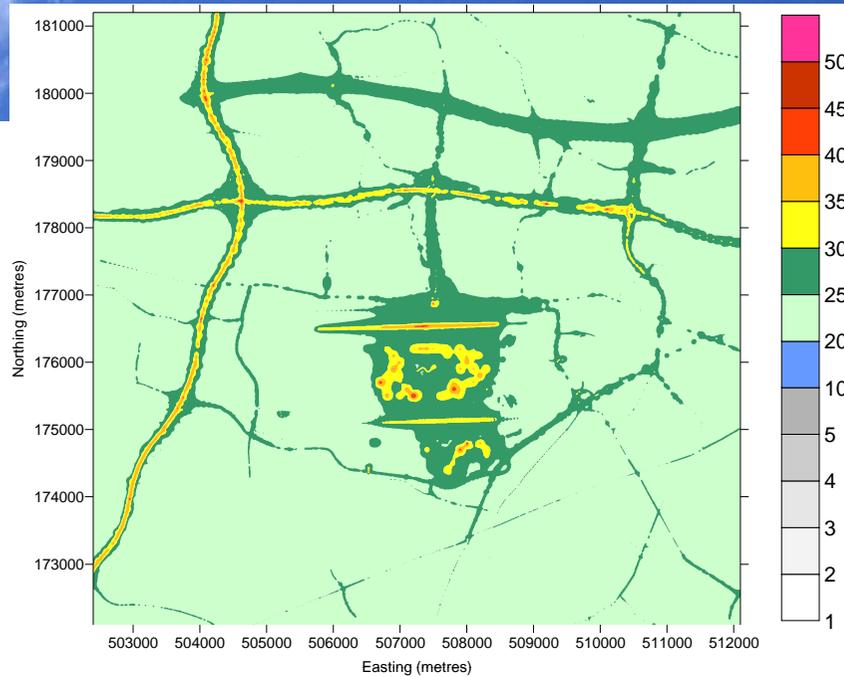
**2020 R3**



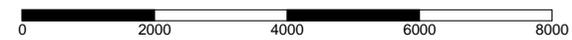
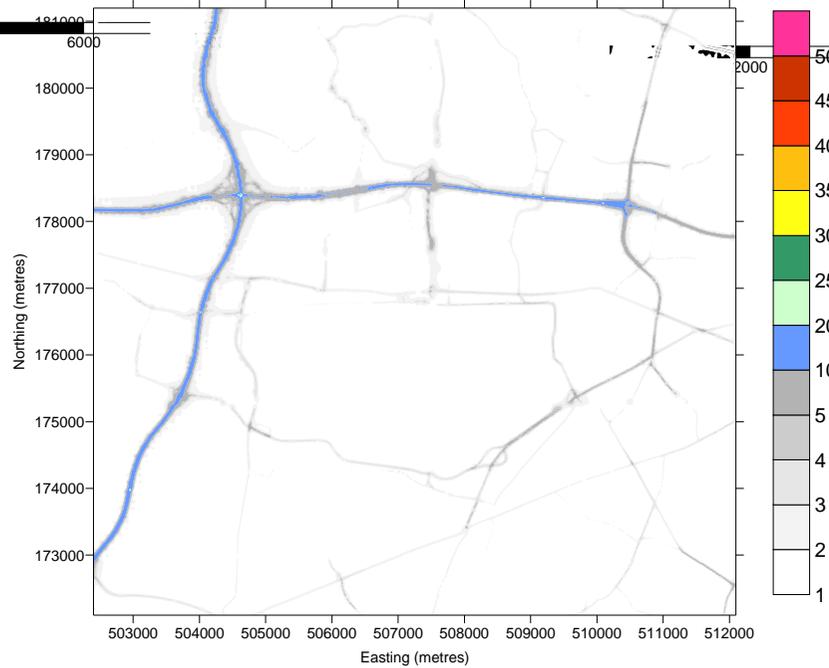
**2030 R3**



C



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



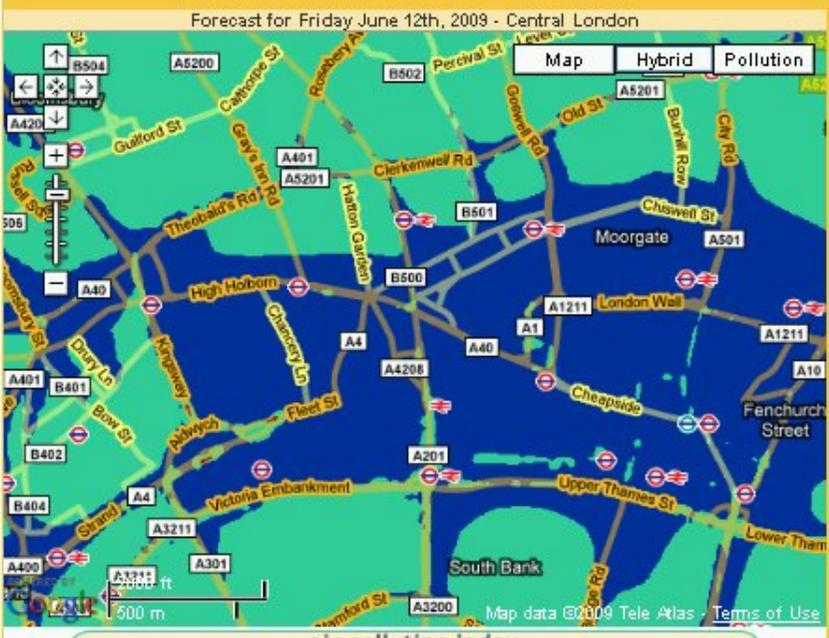
## FORECASTING – LONDON *airTEXT*

- Operational since March 2007
- Street level pollution contours posted to the web

Air pollution alerts by text, email, and voicemail

forecasts | log in | health advice | how it works | news

Forecast for Friday June 12th, 2009 - Central London



Map | Hybrid | Pollution

sign up here  
free alerts  
text - email - voice

airTEXT alerts you if elevated pollution is expected in your chosen area:

Forecast of Air Pollution Index for:  
Friday June 12th, 2009

Central London:  
LOW air pollution expected everywhere

Forecast selector:  
- Choose a Zone -  
- Choose a pollution cycle -

Calendar: archived forecasts

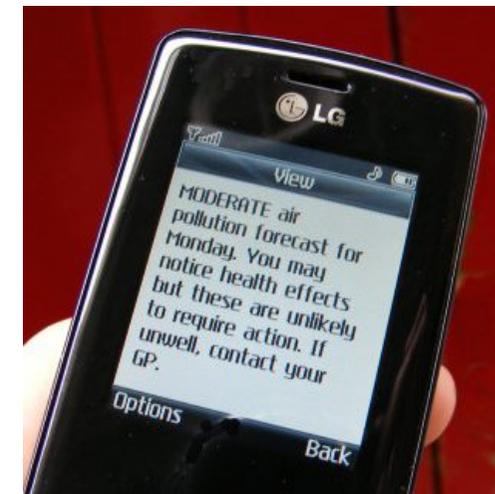
Zoom map to your post code:

good 1-3 | moderate 4-6 | high 7-9 | very high 10

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- Exhaust location & buoyancy and vehicle induced turbulence
- Road source attributes
  - canyons, tunnels, cuttings, embankments, flyovers/bridges, noise barriers
- Nesting 'local' model in 'regional' model
- Emissions
  - PM<sub>2.5</sub> factors, re-suspension
- Exposure assessment
- High resolution measurements near roads