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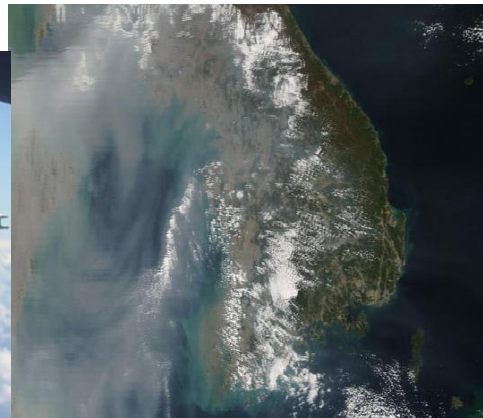
Particulate Matter from Road Traffic Contributions

Status and Implications

Ranjeet S Sokhi

Centre for Atmospheric and Instrumentation Research (CAIR)

University of Hertfordshire



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Acknowledgements

Team

- Samantha Lawrence, Home Office, UK
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- EC FP7 TRANSPHORM (www.transphorm.eu)
- Natural Environment Research Council (NERC), UK
- BOC Foundation

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Aim of presentation

Two-fold aim:

(i) To examine traffic related contributions to PM2.5 concentrations in urban areas

(ii) To estimate emissions from non-exhaust sources of PM10

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Societal impact

Global challenge of Air pollution in towns and cities:

- Air pollution is ‘world’s largest single environmental health risk’ (WHO 2014)
- 7 million premature deaths worldwide in 2012 due to air pollution exposure (one in eight of all global deaths)!
- Particulate matter is associated with a wide range of health impacts
- Regulation of traffic related particulate matter is focussed on exhaust emissions



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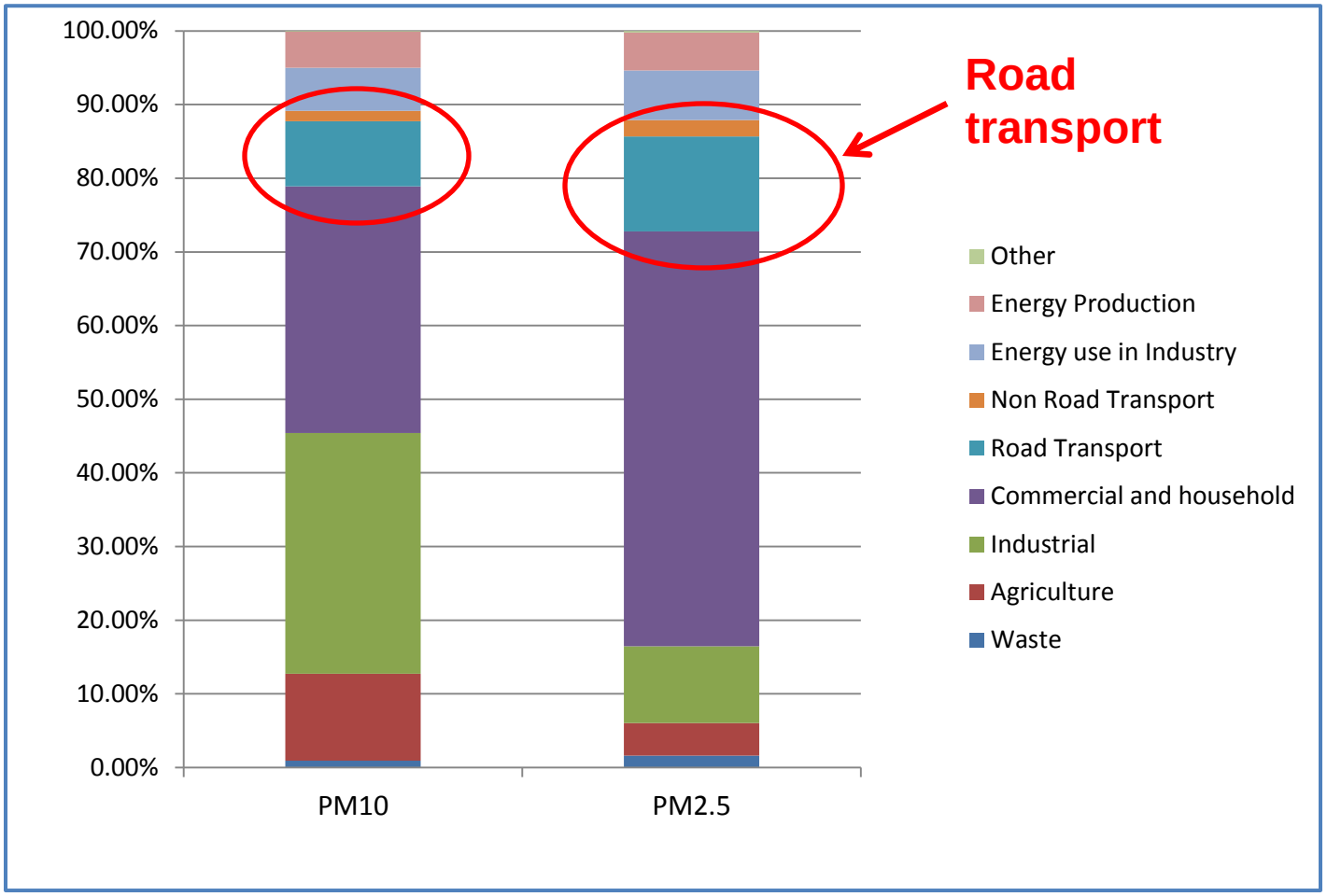
PM10 and PM2.5 emissions over Europe



Source: EEA 2014

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Emission trends of PM10

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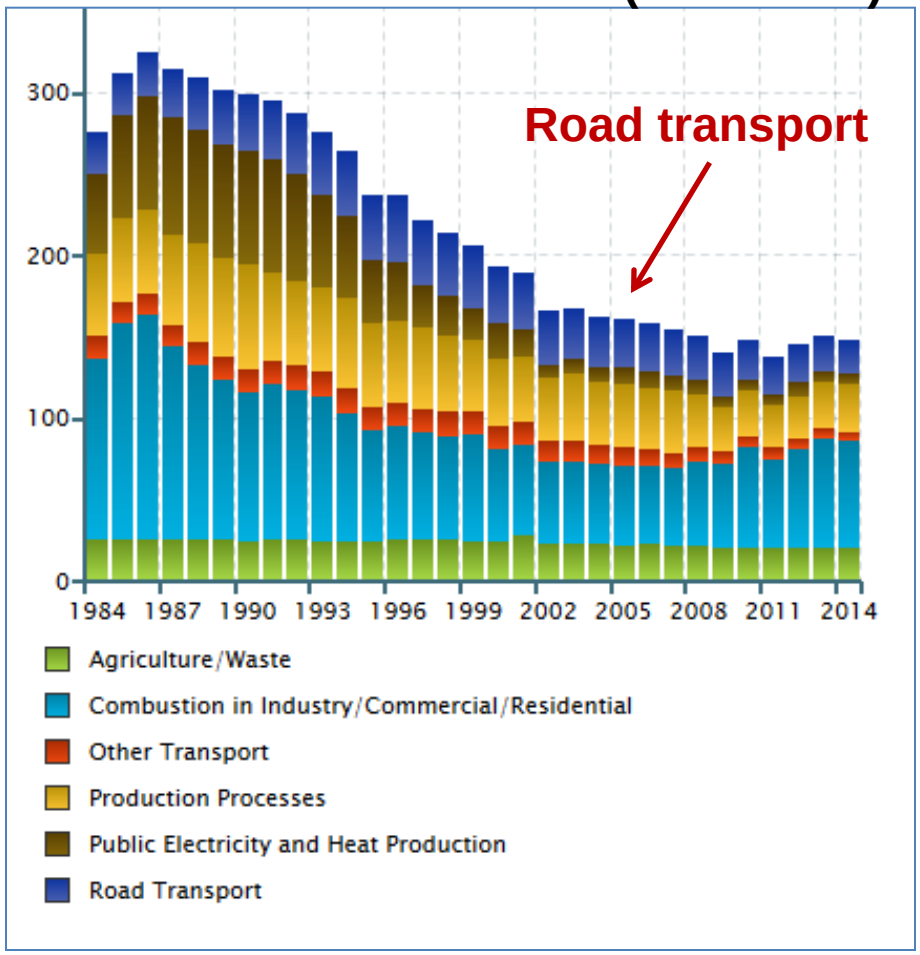
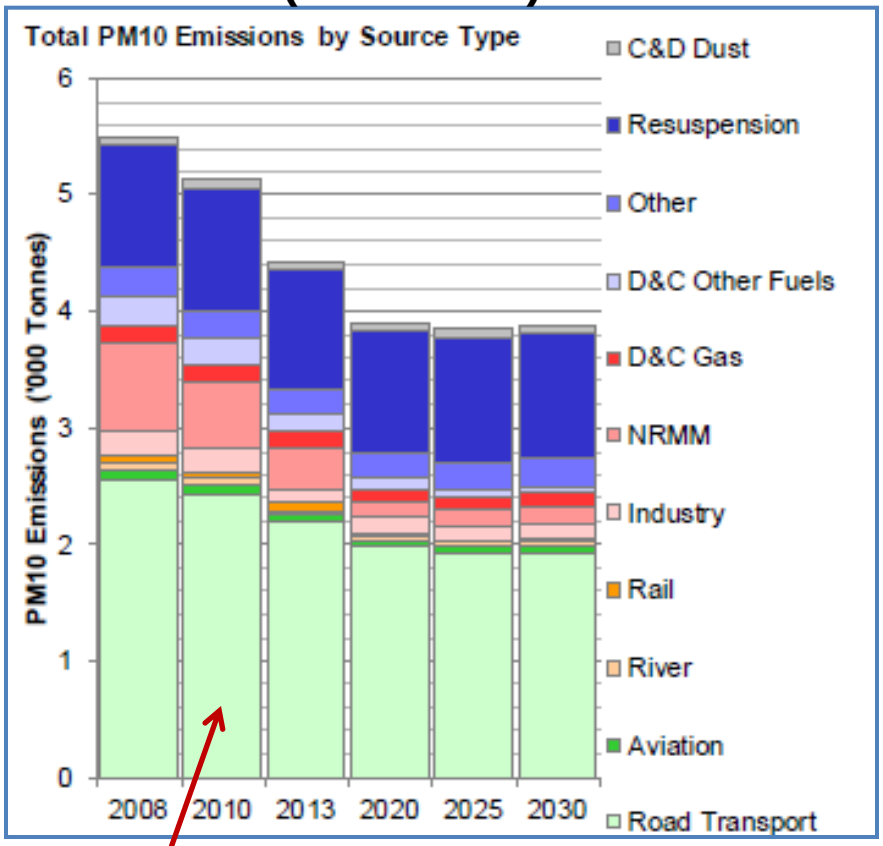
UK Emissions Ktonnes (1984-2014)



Source: National Atmospheric Emissions Inventory

Greater London Emissions Tonnes (2005-2030)



Source: Based on LAEI 2013 (Brown 2016)

Road transport

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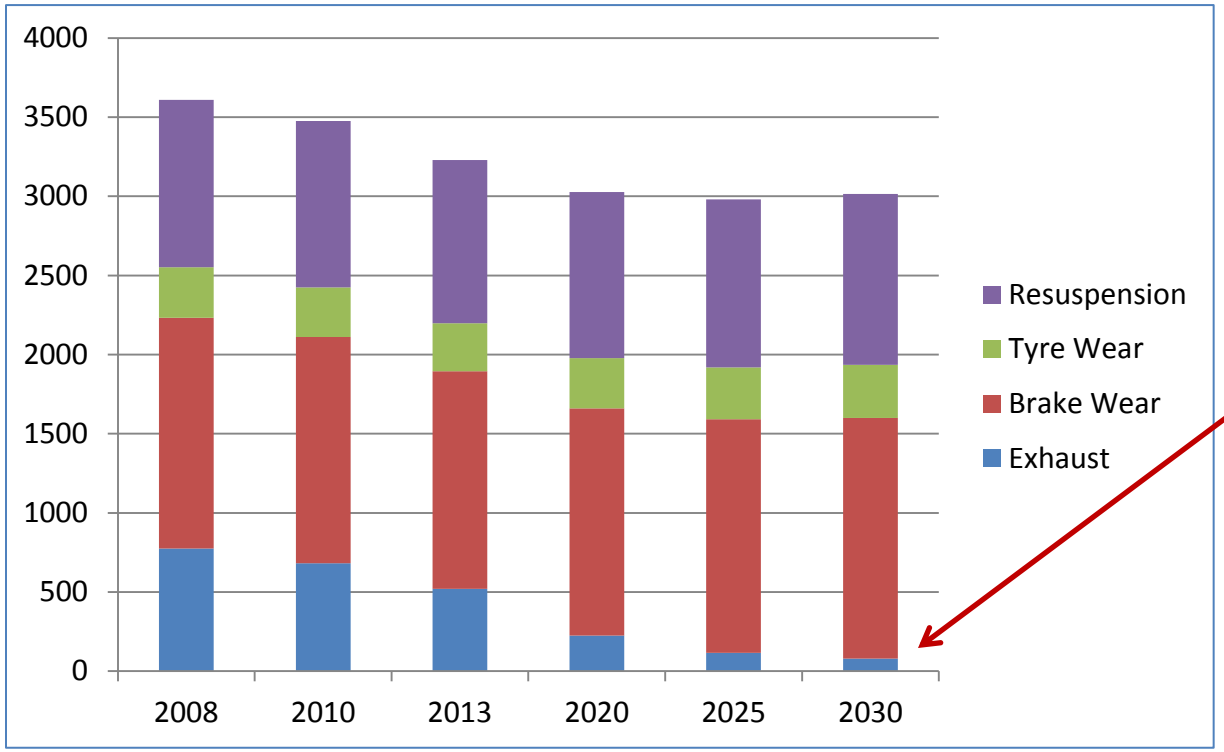
PM10 Emissions from Road Transport for London



Reductions in exhaust PM10 expected due to stricter emission controls and technological advances

Source: Based on LAEI 2013 (Brown 2016)

- Non-exhaust emissions are equal to or surpass exhaust contributions
- As exhaust emissions decrease, the unregulated emissions from non-exhaust sources will become even more important
- Large uncertainties associated with non-exhaust emission factors and wear rates

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Quantifying PM2.5 concentrations from road traffic in London

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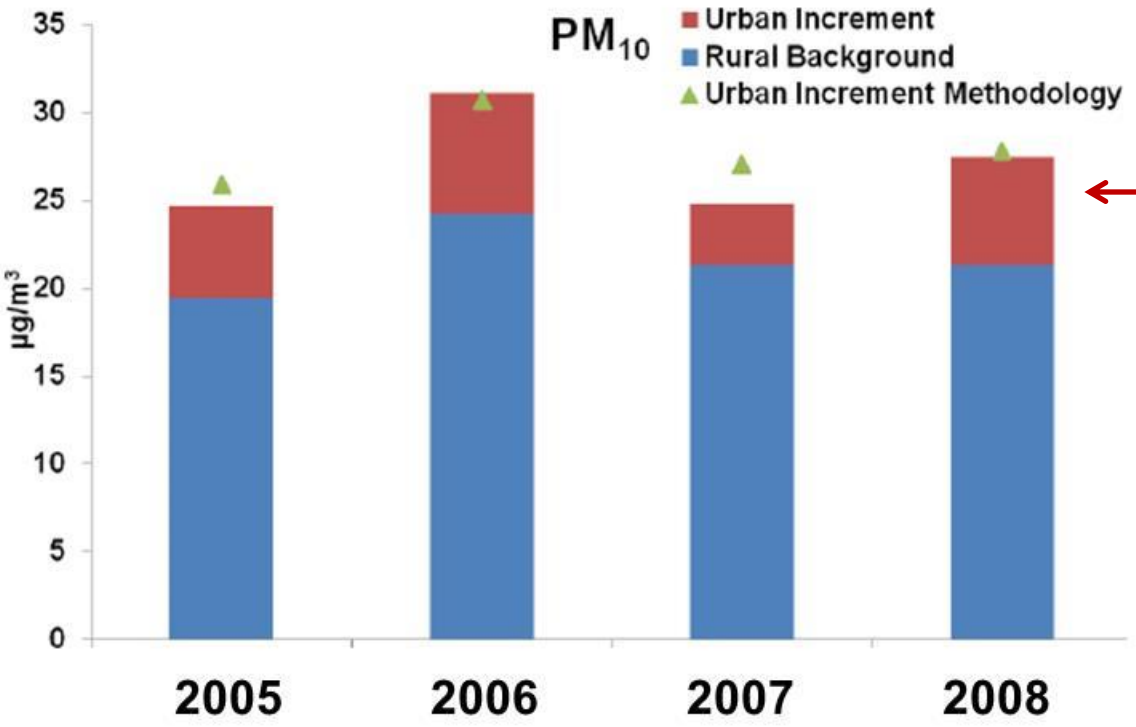
Urban and rural contributions to PM10 for London

FP7 TRANSPHORM Analysis



Urban increment

Contributions from urban sources

Figure showing measured rural and urban increment of PM10 and estimates from a simple urban increment model

Source: Douros et al., 2014 FP7 TRANSPHORM Research Report

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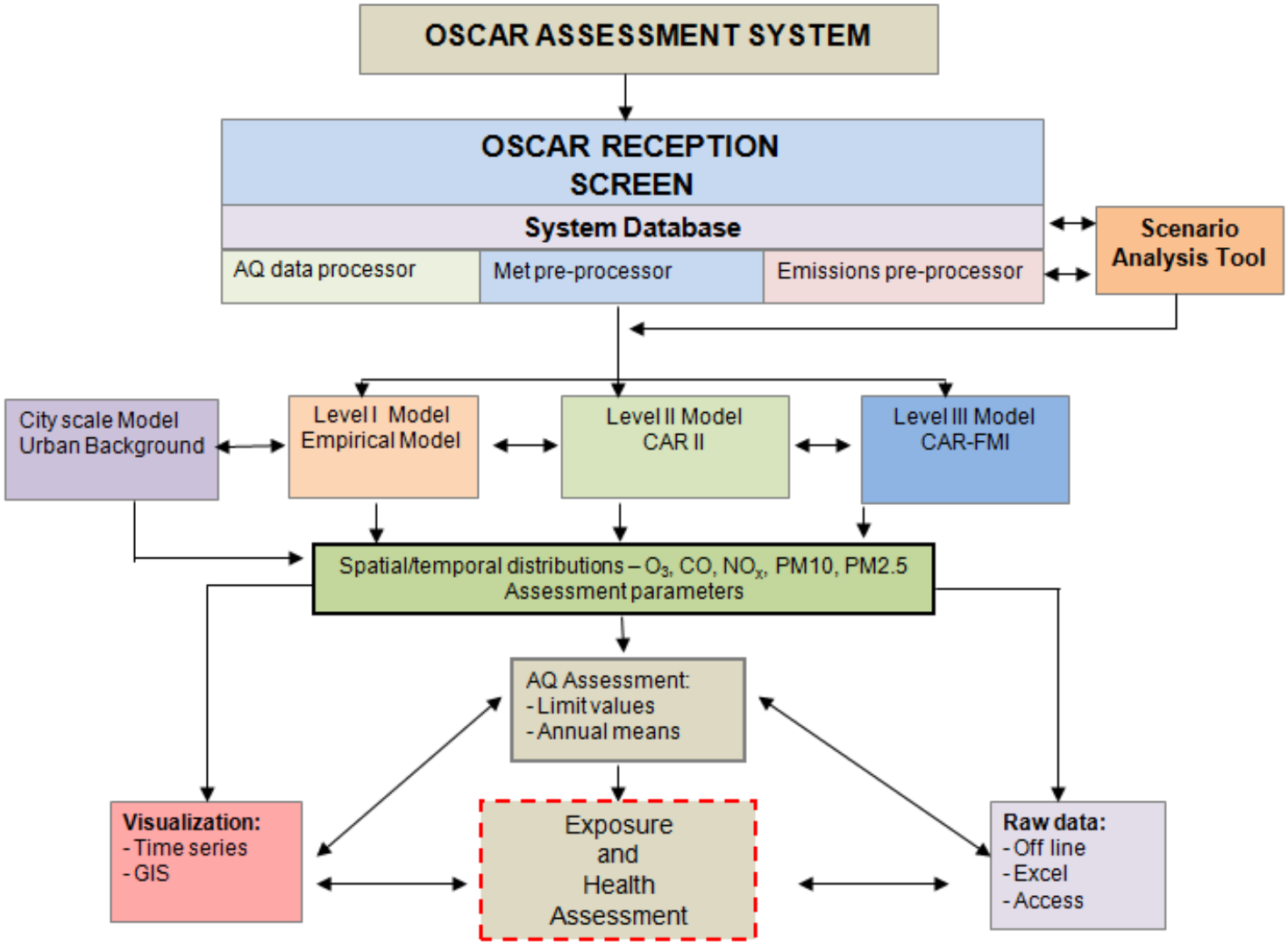
OSCAR Air Quality and Exposure Modelling System



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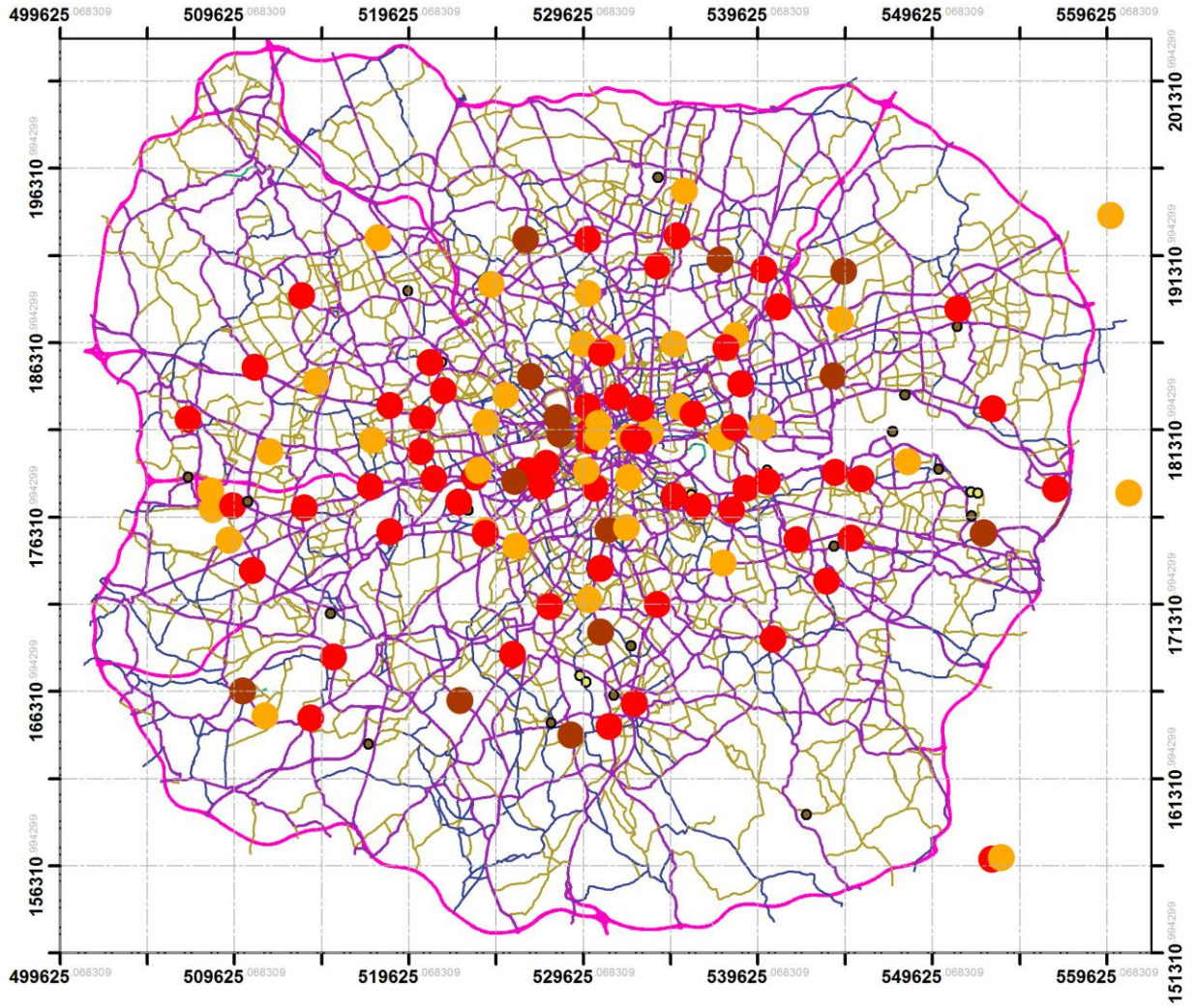
London domain and measurement stations



Domain
61km x 52km
Central and Inner London

Roadlinks
63726

Receptor points:
~200,000

OSCAR Model evaluation process for PM2.5 predictions

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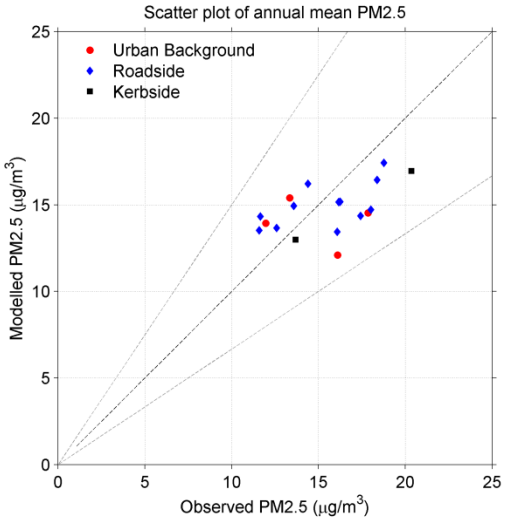
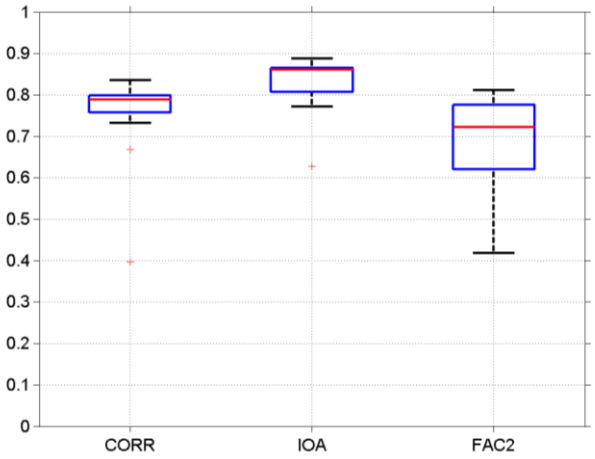
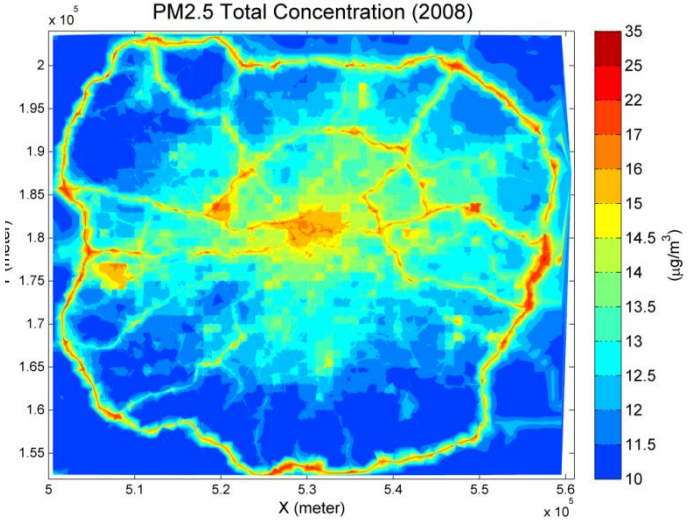
Annual means



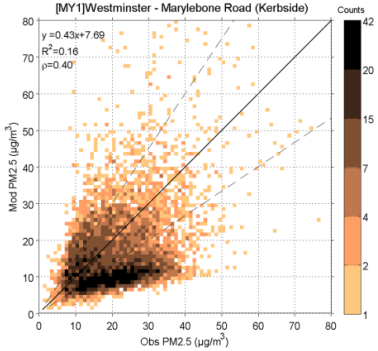
Statistical measures



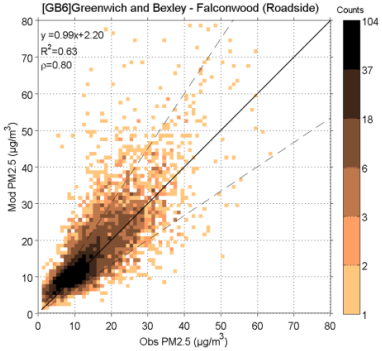
Predictions of total PM2.5



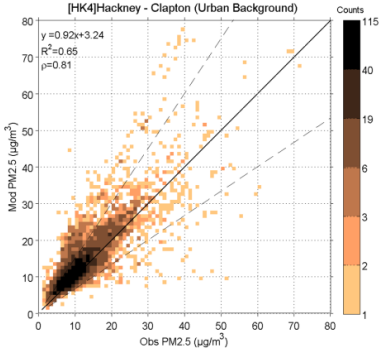
Kerbside



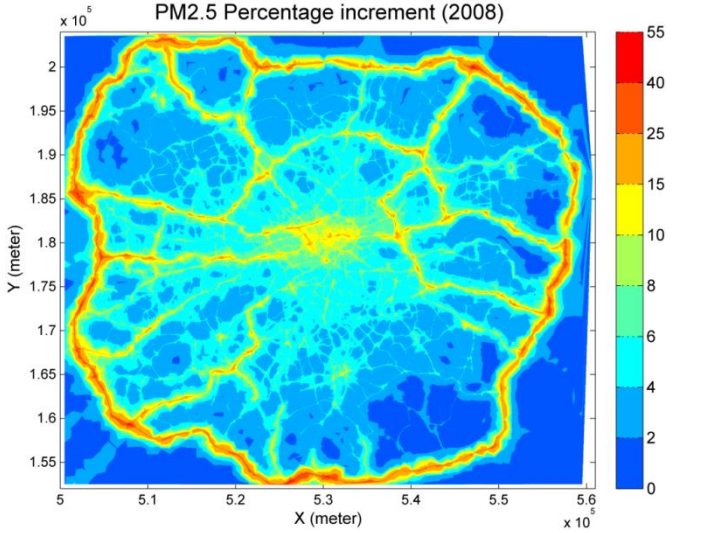
Roadside



Urban BG



PM2.5 from road traffic %



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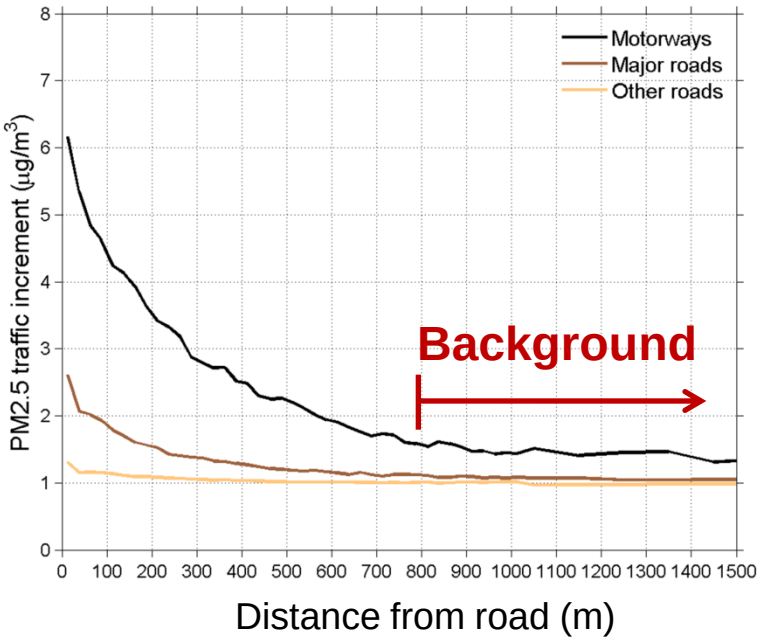
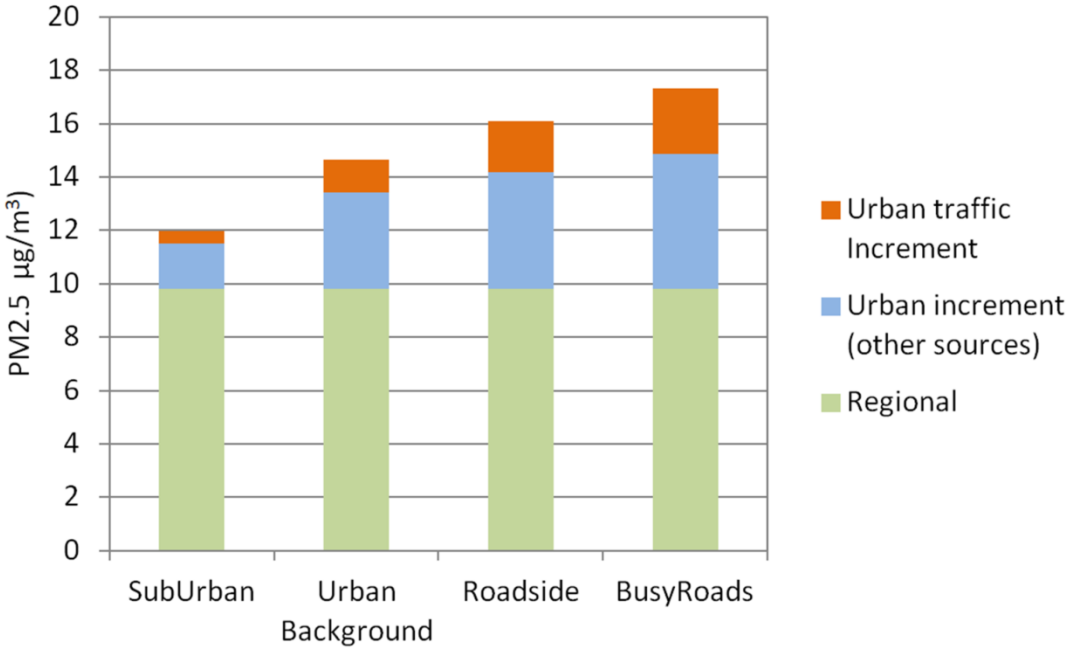
Regional and urban increments for PM2.5 for London





Analysis based on modelled annual means

Busy Roads:
Average daily traffic > 30,000 vehicles

Source: Singh, V., Sokhi, R. S., & Kukkonen, J (2013) PM2. 5 concentrations in London for 2008 - A modelling analysis of contributions from road traffic. Journal of the Air & Waste Management Association 64 (2014) 509–518

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Quantifying contributions of particulate matter from non-exhaust road traffic sources

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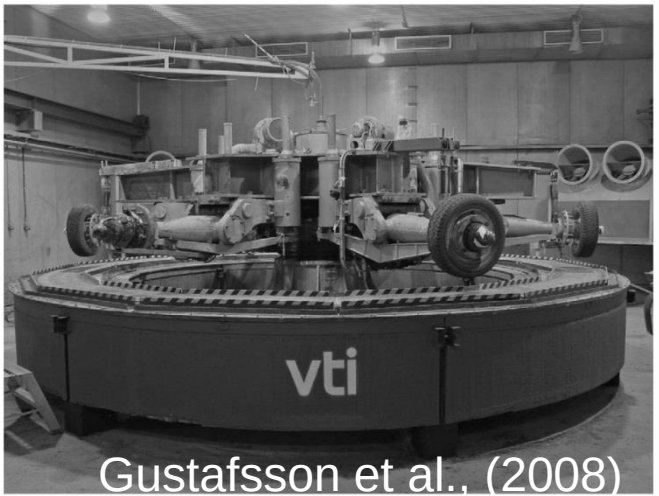
Quantifying non-exhaust emissions of particulate matter

Number of approaches to quantify non-exhaust contributions of particulate matter

- Comparison of urban sites
- Dynamometer measurements
- Road simulators
- Tunnel measurements



Gustafsson et al., (2008)

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Tunnel Laboratory North London (Hatfield)

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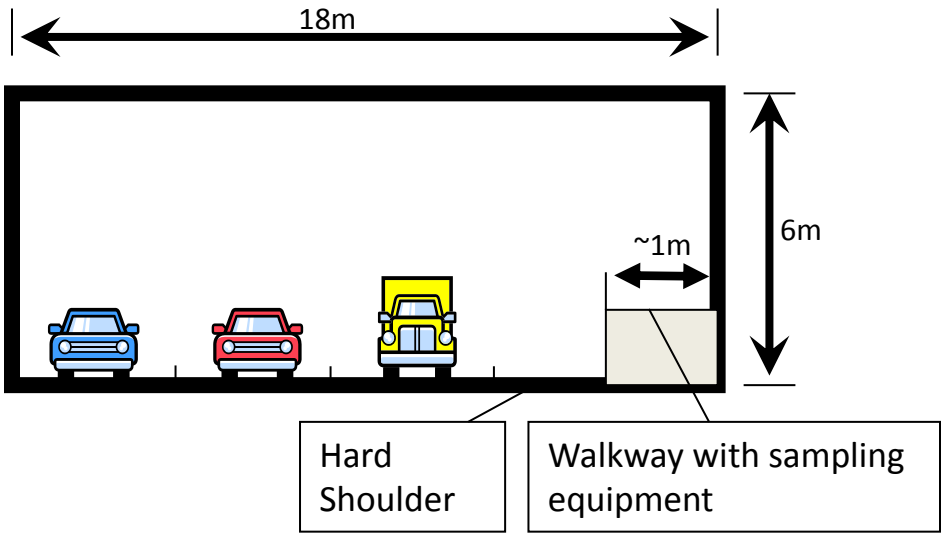

- Six week continuous campaigns
- 12 hour sampling period 7AM -7PM
- Entrance & Exit Sampling Sites
- High Volume Samplers
- Dichotomous Stacked Filter Units
- Partisol sampler
- Nomad meteorological sampler
- Golden River Marksman 660 for traffic monitoring

Source: Lawrence et al., 2013 Atmospheric Environment 77 (2013) 548-557

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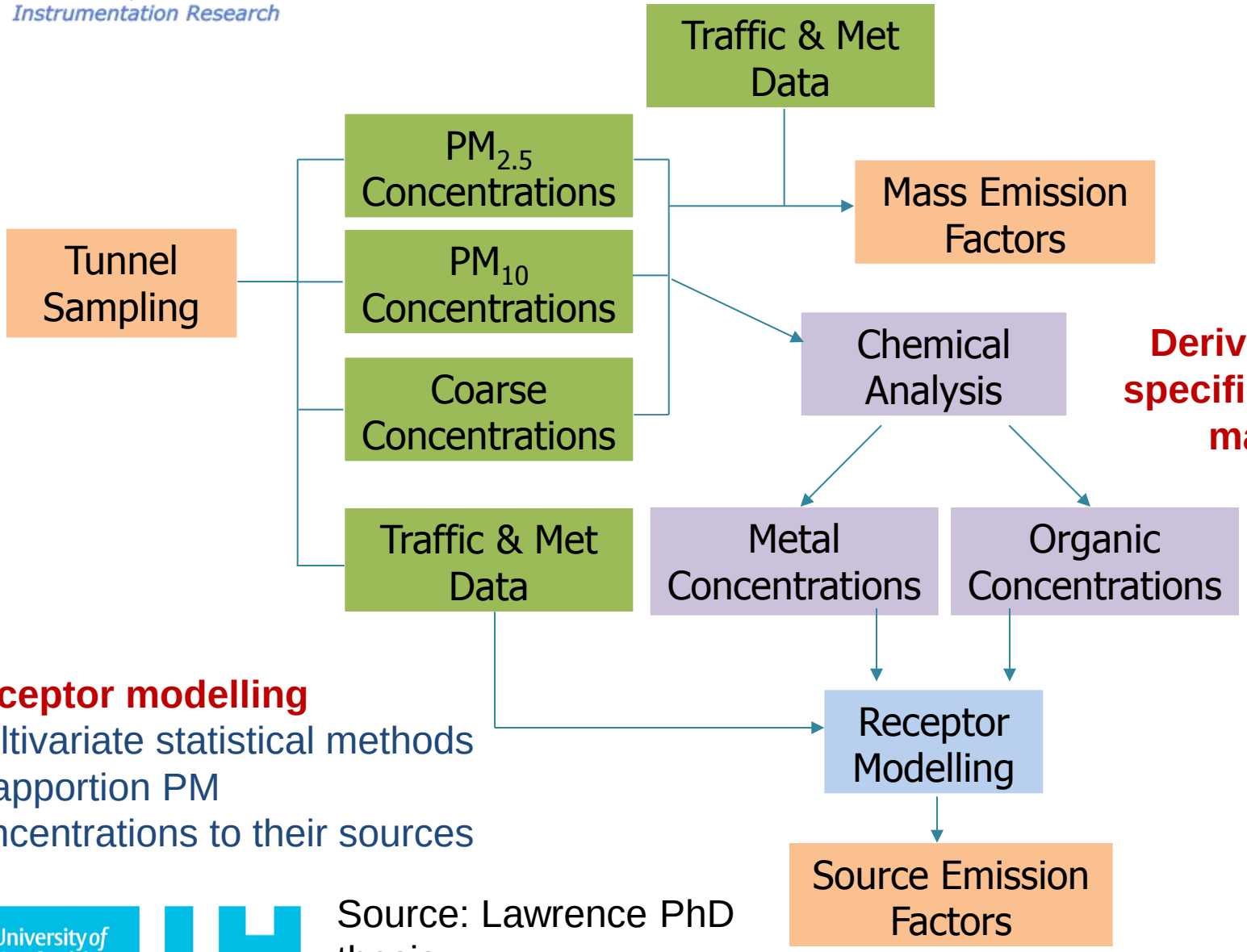
Source apportionment approach



Derive source specific chemical markers

Receptor modelling

Multivariate statistical methods to apportion PM concentrations to their sources

Source: Lawrence PhD thesis

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Chemical markers for PM sources

Emission Source	Chemical markers
Resuspension	Al, Ca, Mg
Brake Wear	Sb, Cu, Ba
Road Surface Wear	Ca, Cr, V
Tyre Wear	Zn, Benzothiazole
Petrol	benzo[a]fluorene, benzo[b]fluorene, benzo[b,k]fluoranthene, benzo[ghi]perylene, coronene, benzo[ghi]fluoranthene, benz[a]anthracene, benzo[a]pyrene, indeno(*cd*)fluoranthene and indeno(*cd*)pyrene
Diesel	phenanthrene, anthracene, fluoranthene, pyrene, methyl-phenanthrenes

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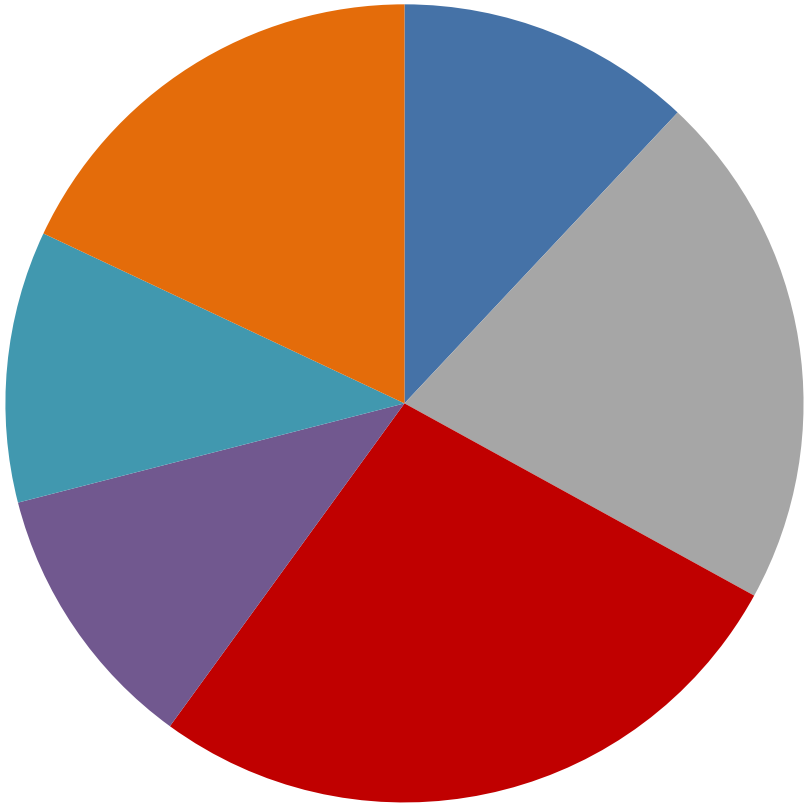
Source apportionment of PM10
North London (Hatfield) Tunnel Study



- Petrol exhaust (12%)
- Diesel exhaust (21%)

Exhaust 33%

- Resuspension (27%)
- Road surface wear (11%)
- Brake wear (11%)

Non-exhaust 49%

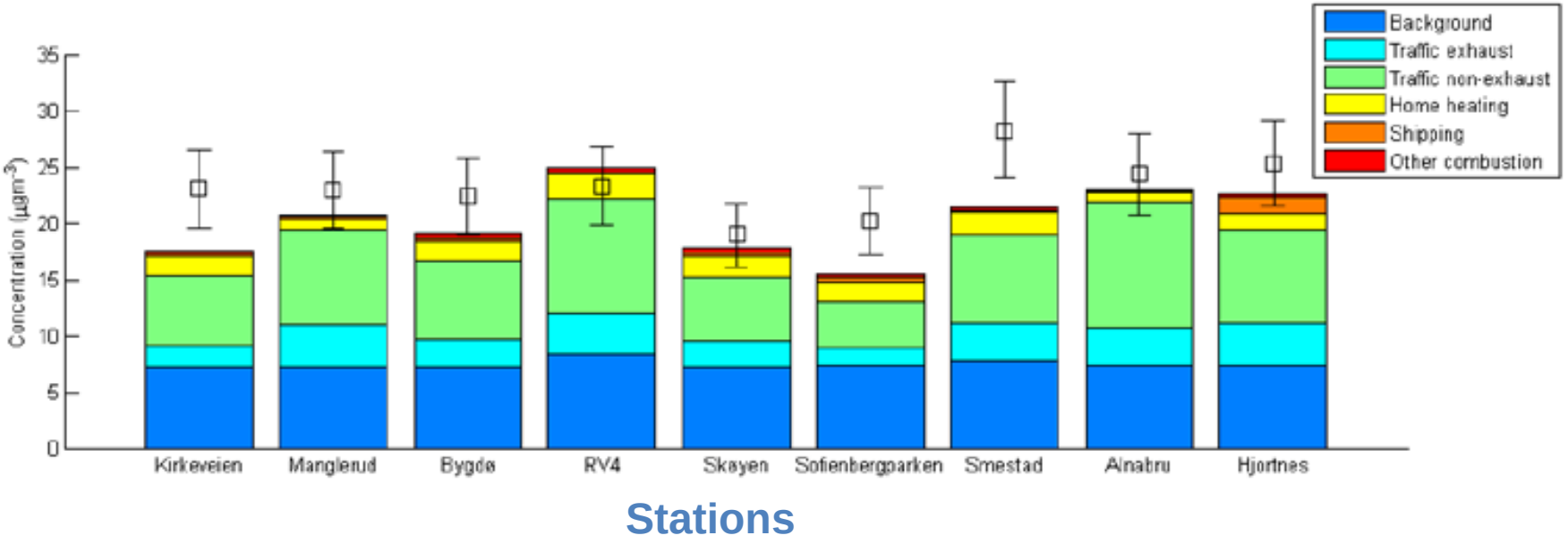
- Unexplained (18%)

Source: Lawrence et al., 2013 Atmospheric Environment 77 (2013) 548-557

Source contributions to PM10 for Oslo (2009)

Traffic non-exhaust

Traffic exhaust



Source: Denby et al., (2014) FP7 TRANSPHORM Report, D2.2.2/2.2.3

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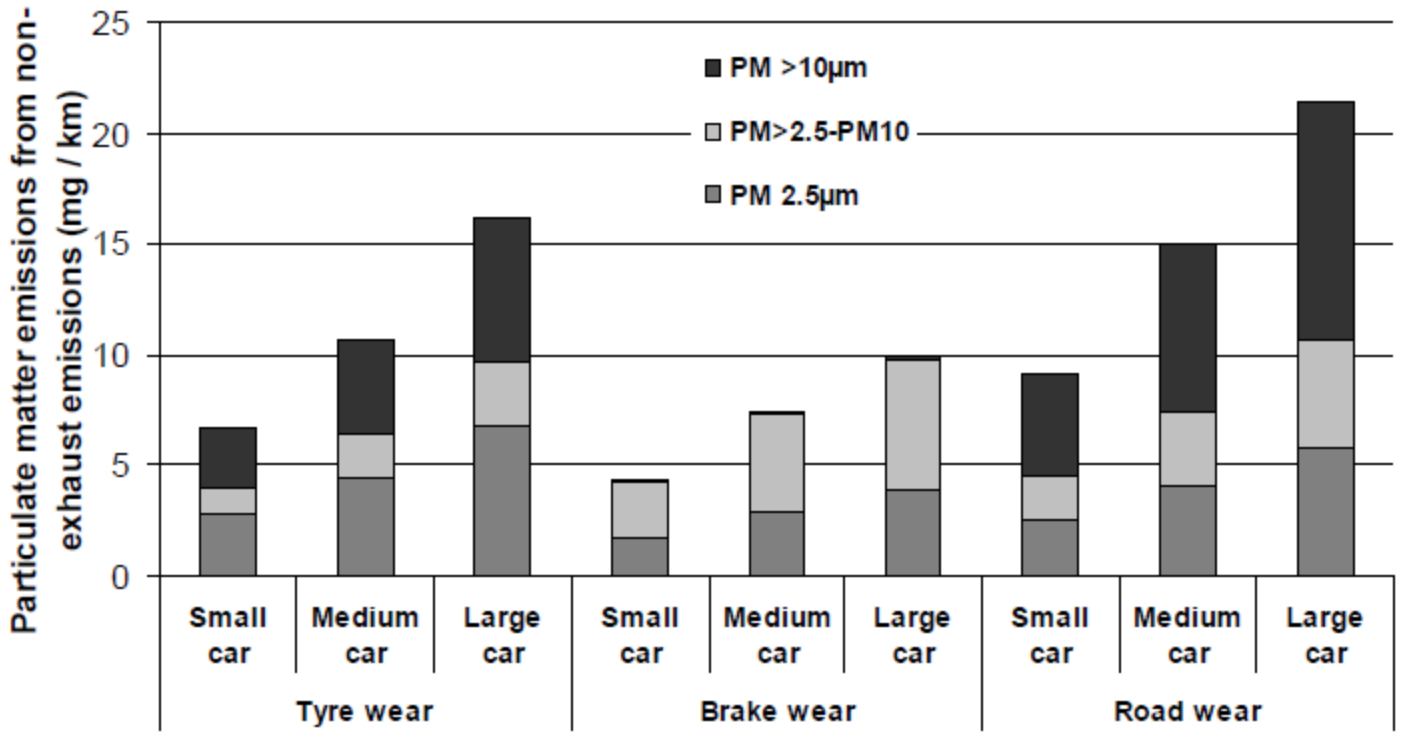
Non-exhaust particulate matter (PM) emissions from passenger cars as a function of vehicle size



Source: Ntziachristos et al., (2009) EMEP/EEA Air pollutant emissions inventory guidebook 2009: Exhaust emissions from road transport. Copenhagen, European Environment Agency

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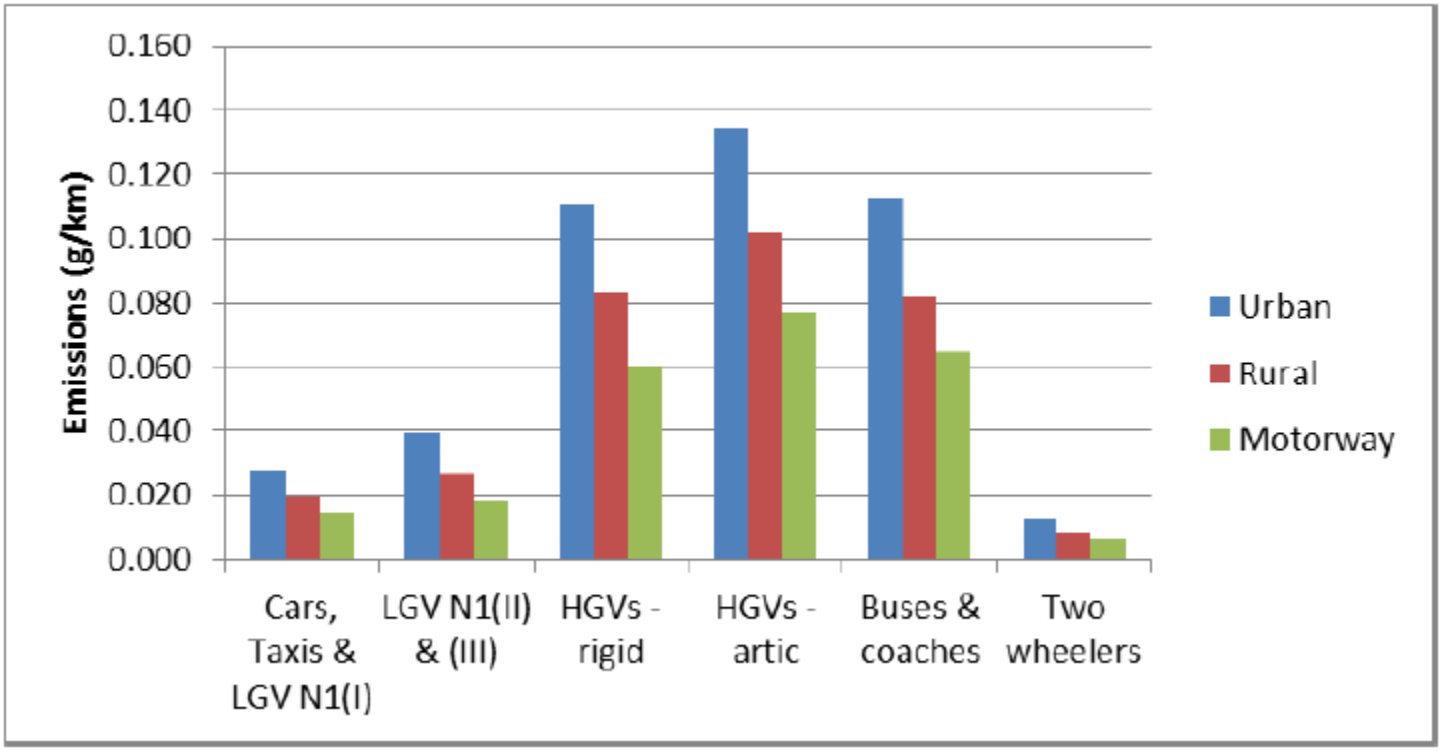
Total non-exhaust emission rates for different vehicle types under different driving conditions

Derived from the DEFRA's Emissions Tool Kit



Source: Barlow (2014) CLIENT PROJECT REPORT CPR1976
Briefing paper on non-exhaust particulate emissions from road transport

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City and regional scale predictions of PM2.5 in cities

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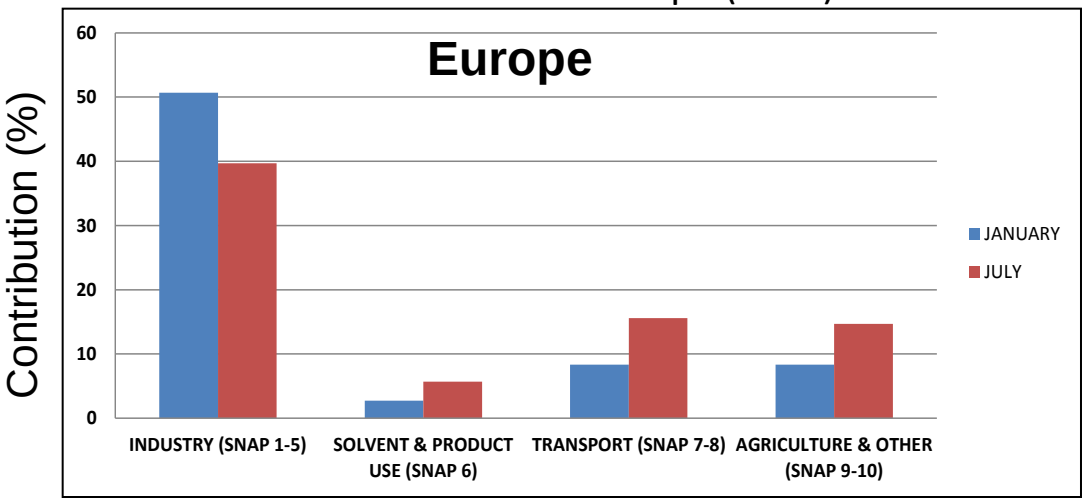
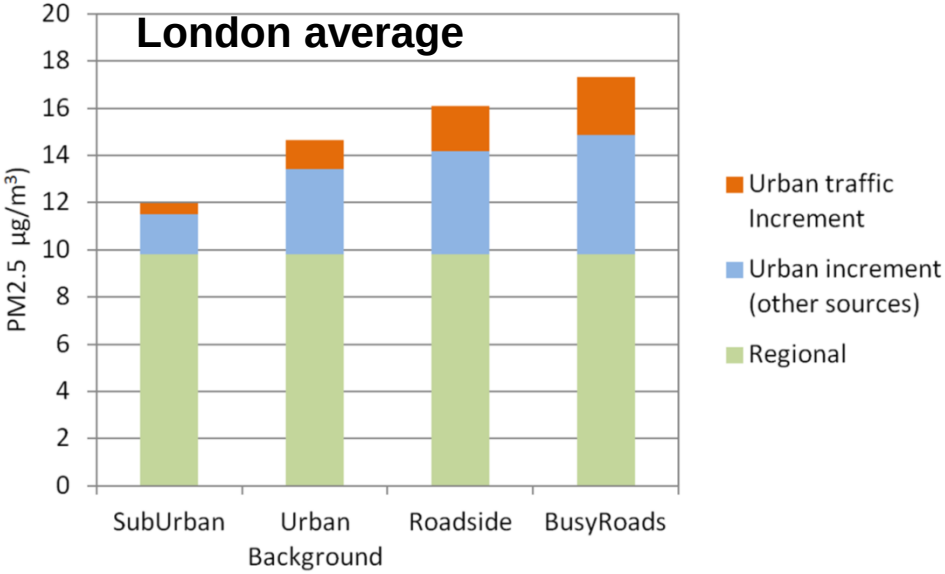
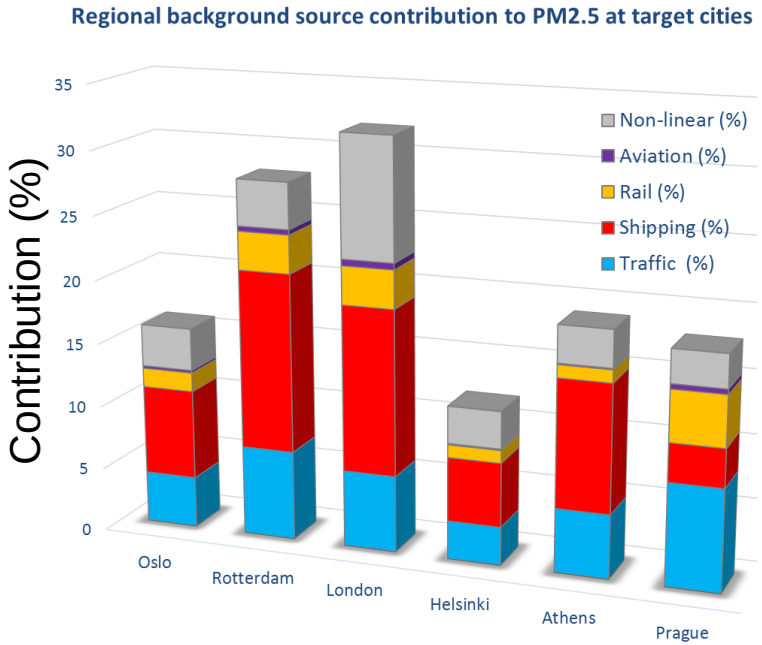
WRF/CMAQ - Contributions to regional PM2.5 from different source sectors over Europe (2005)







EMEP - Contribution of transport modes to regional PM2.5 affecting cities (2008)

OSCAR analysis for London

Comparison of traffic, urban BG and regional BG PM2.5 at London sites

Busy Roads:

Average daily traffic > 30,000 vehicles

Source contributions to Particulate Matter in Oslo (2008)

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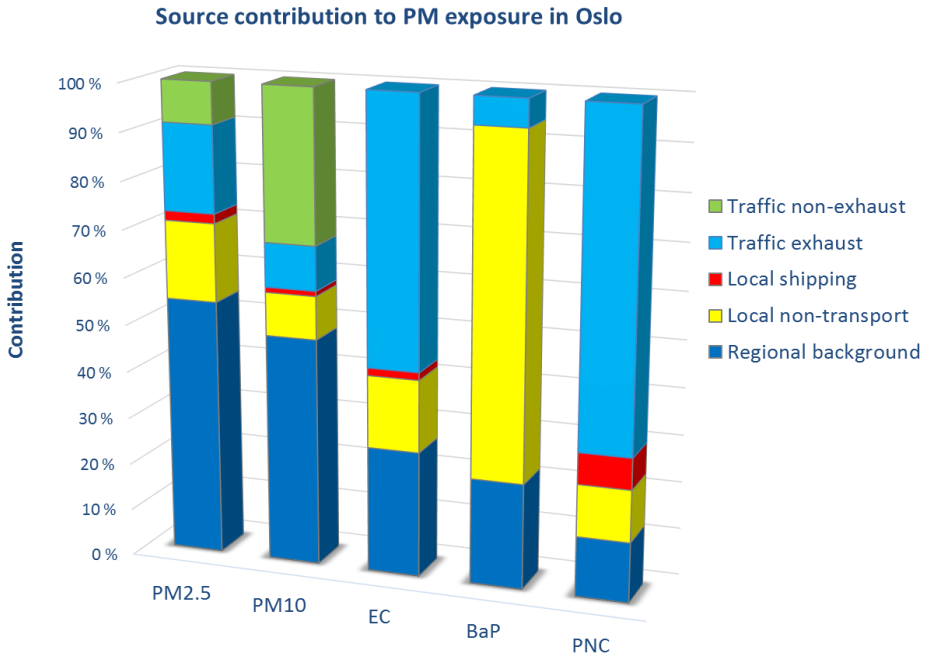
Calculations using the EPISODE model



Source: Denby et al., (2014) FP7 TRANSPHORM

Pollutant	Source orientated response
PM10	Coarse e.g. road dust
PM2.5	Regional dominant, exhaust
EC	Combustion, exhaust
BaP	Wood burning
PN	Combustion, exhaust

Controlling PM is complex and requires a multi-pollutant/component and multiscale approach

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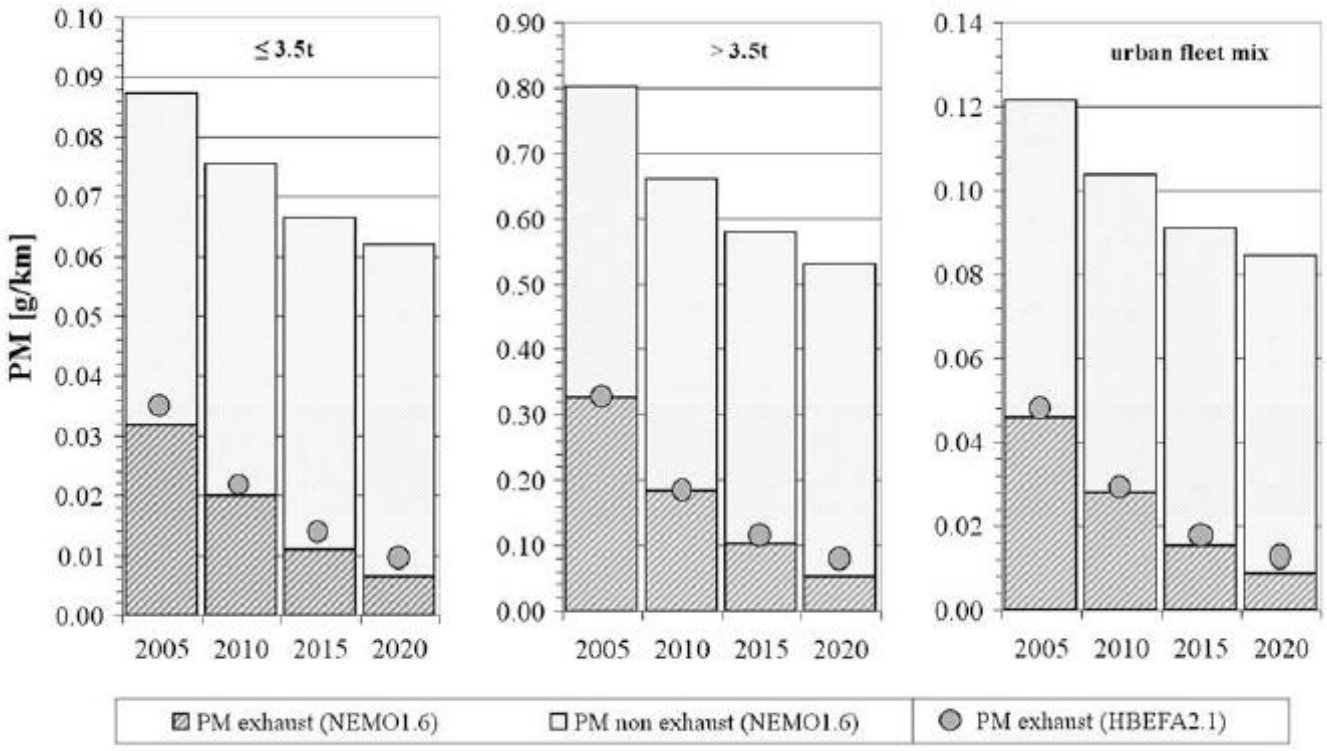
Future projections of exhaust and non-exhaust particle emissions



PM fleet emission factors for the years 2005-2020 from NEMO1.6 and HBEFA2.1 for Austrian fleet composition

Non-exhaust proportion of PM emissions expected to be dominant by 2020

Source: Rexeis and Hausberger(2009) Trend of vehicle emission levels until 2020 – Prognosis based on current vehicle measurements and future emission legislation, Atmospheric Environment 43 (2009) 4689–4698

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Implications for policy

- **Present -** Non-exhaust emissions of particulate matter are as important, if not more, as exhaust emissions
- **Future -** Non-exhaust PM will be more important than exhaust emissions
- Exhaust emission reduction technologies including electric/hybrid vehicles will not necessarily change the situation
- Reductions in PM10 and PM2.5 from road traffic in future years could be limited unless non-exhaust sources are addressed
- Regulation of non-exhaust emissions of particles from road traffic is complex due to multiple factors e.g. abrasion materials, road surface type, weight of vehicles, driving behaviour…..
- Standardised tests need to be developed to estimate non-exhaust emissions of particulate matter
- *Control of PM generally requires a multi-component and multi-scale approach*

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