*air*TEXT Black Carbon Forecasts for London

Amy Stidworthy

Joaquin Coordination Group Meeting

25th June 2013

Brighton

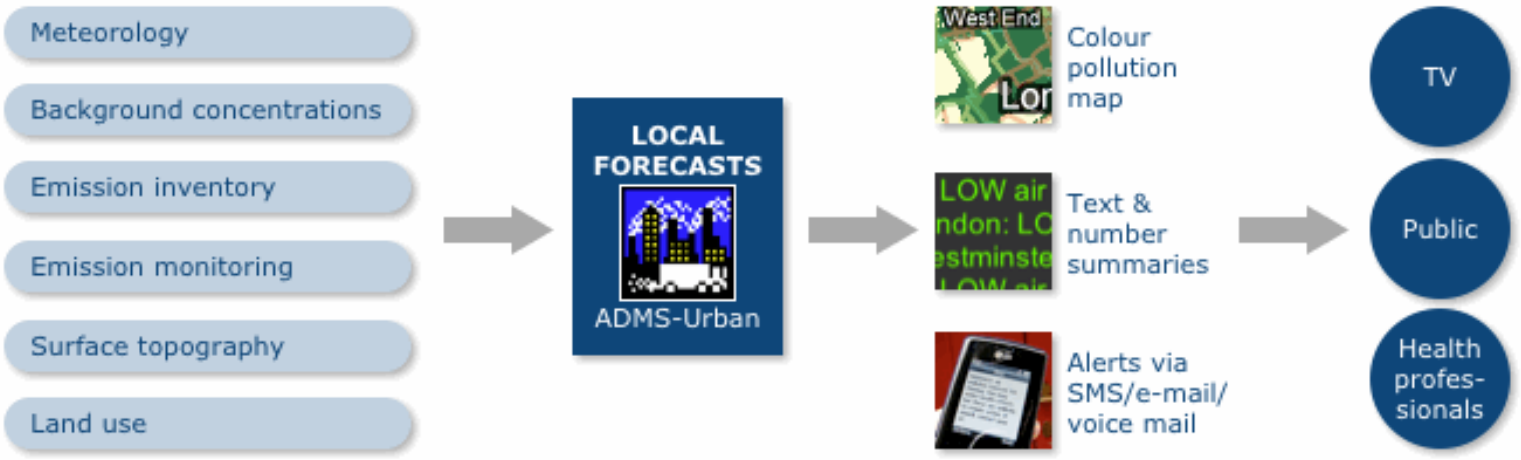
Contents

- Introduction to *air*TEXT
- Overview of the *air*TEXT black carbon project
- Monitored black carbon levels in London
- Estimates of local black carbon emissions in London
- Validation of black carbon forecasts for London
- Concluding remarks

*air*TEXT

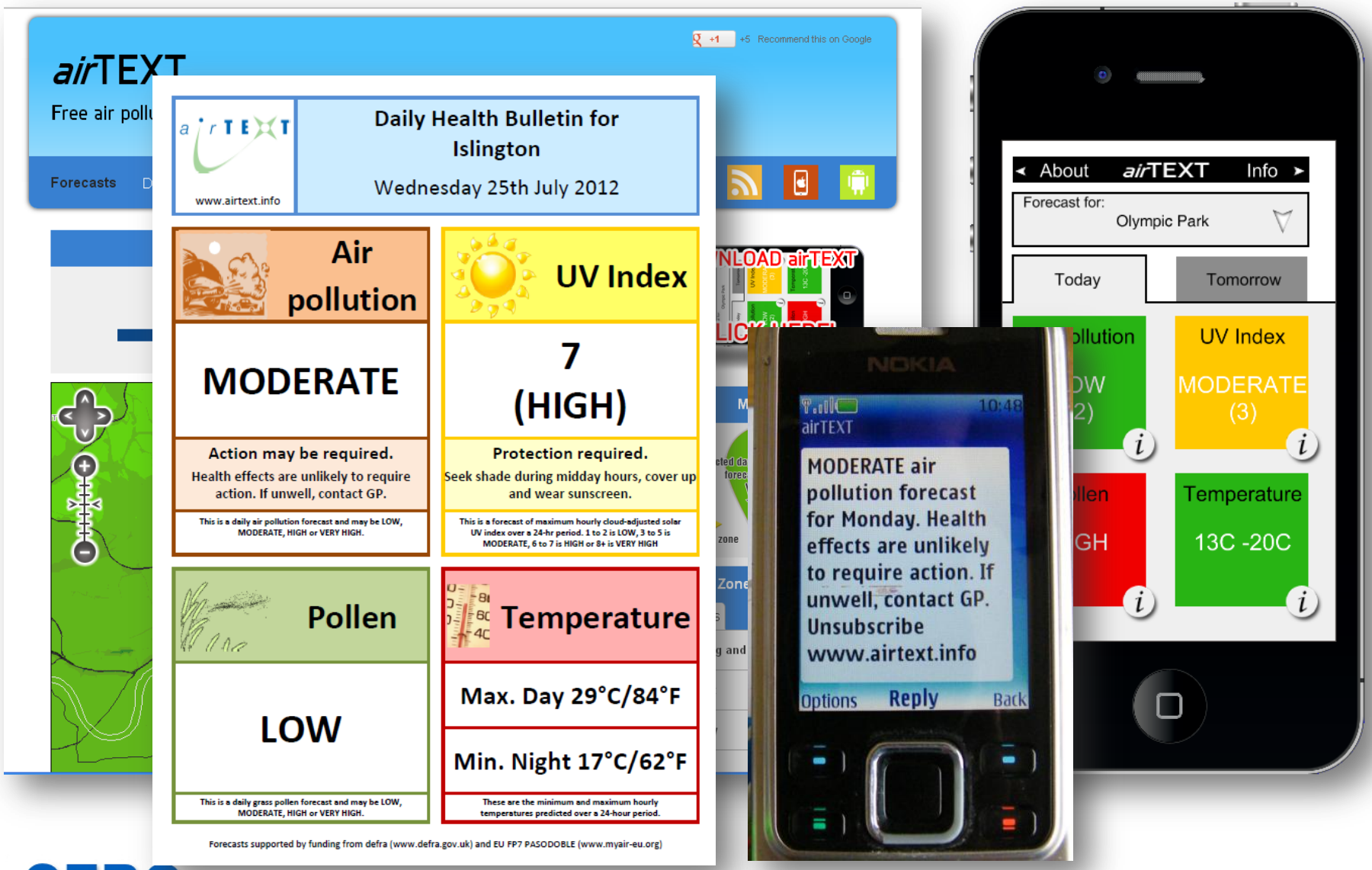
- *air*TEXT is the **air quality forecasting service for London**, operated by CERC on behalf of the *air*TEXT consortium, a group of organisations including UK Environment Agency, Health Protection Agency, Greater London Authority (GLA) and all Greater London local authorities
- *air*TEXT provides free air quality alerts direct to over 7000 subscribers
- *air*TEXT was initially developed in 2007 under ESA-funded PROMOTE, and supported by further funding from FP7 PASODOBLE, Joaquin, UK National Government (Defra), the GLA and all the Greater London Local Authorities

*air*TEXT system



- *air*TEXT system delivers street-scale air quality forecasts for a city as maps and alerts
- Key inputs are forecast meteorology, local emissions and regional pollution forecasts ("background")
- Currently provides forecasts of O_3, NO_2, PM_{10} and $PM_{2.5}$
- Forecasts provided as indices and alerts (Defra's Daily Air Quality Index – DAQI)

*air*TEXT products



*air*TEXT black carbon project

- Black carbon (BC) is a light-absorbing carbonaceous particulate produced by incomplete combustion of various fuels
- Objective is to provide a 3-month trial of a BC forecasting and alert service for Islington in London, only to GLA and Islington council initially
- Project funded by GLA with match-funding from Joaquin
- Trial scheduled for September, October and November 2013
- Key components of the project:
  - Emissions Inventory: Adding BC to the London Atmospheric Emissions Inventory (LAEI)
  - Adding BC to the *air*TEXT system
  - Validating BC forecasts against monitored data
  - *Establishing an index scale and alert criteria for BC*
  - *Produce summary report of the 3-month trial*
- First three components discussed in this presentation

UK Black Carbon Network: UK-AIR website

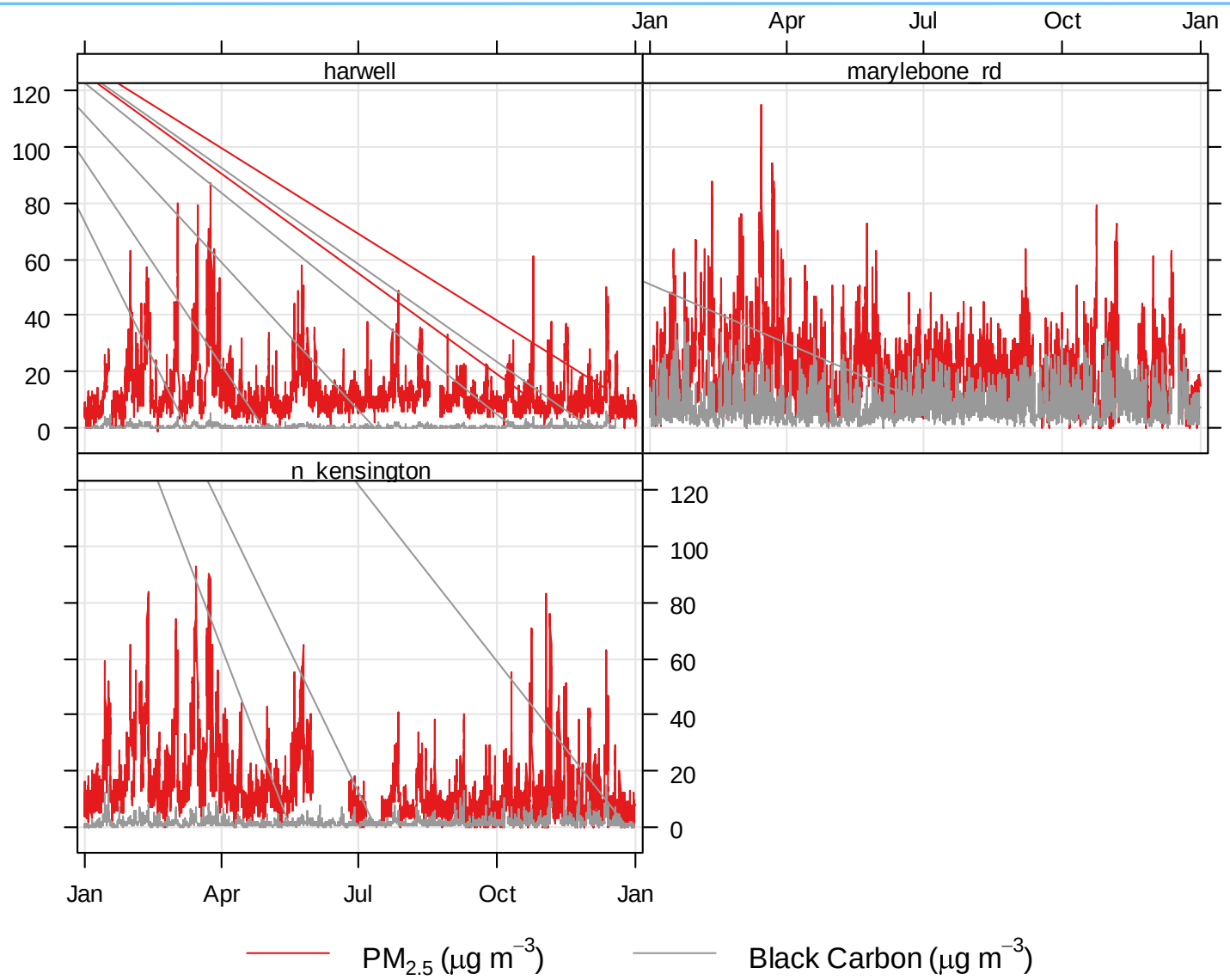
- UK Black Carbon Network has 3 BC monitors in and around London:
  - Marylebone Rd (kerbside)
  - North Kensington (urban background)
  - Harwell (rural)
- Detling (rural site south-east of London) new in 2012 but no data available yet

Analysis of 2012 $PM_{2.5}$ and BC monitoring data

Site	Type	Average (µg/m³)		Maximum (µg/m³)		Date (dd/mm) of maximum		$BC/PM_{2.5}$	
		$PM_{2.5}$	BC	$PM_{2.5}$	BC	$PM_{2.5}$	BC	Average	Maximum
Harwell	Rural	12.8	0.486	87	5.7	24/03	12/12	0.0345	0.4
North Kensington	Urban background	14.6	1.596	93	14.8	15/03	12/12	0.1519	4.4
Marylebone Road	Kerbside	21.5	8.878	115	37.9	15/03	24/01	0.4458	7.6

- Not only does the kerbside site have the highest $PM_{2.5}$ concentrations, but it has the highest proportion of BC
- Ratio of BC to $PM_{2.5}$ is greater than one in some cases: is there an issue here?

Time variation of BC compared with $PM_{2.5}$

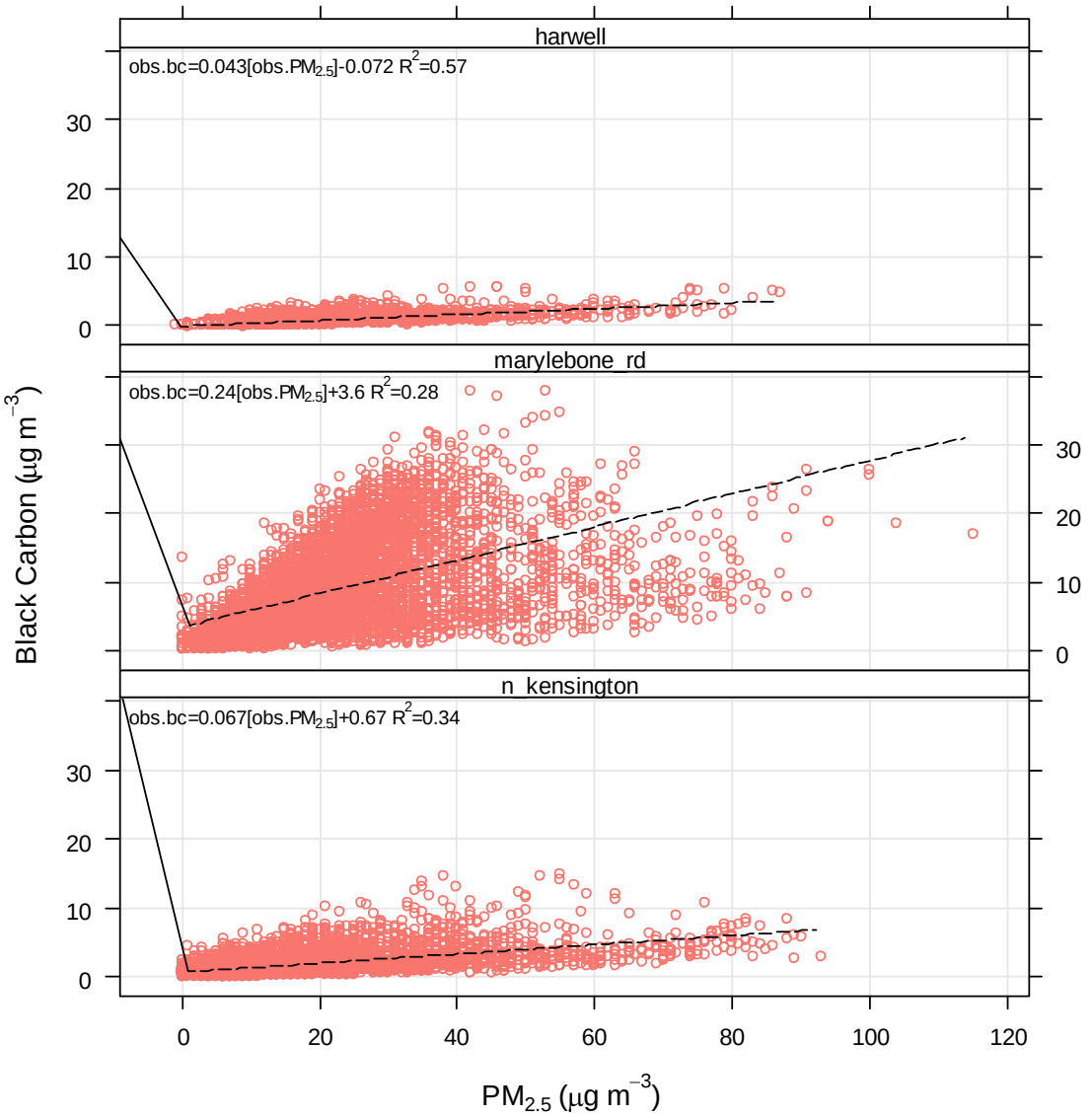


Scatter plots of BC versus $PM_{2.5}$

RURAL

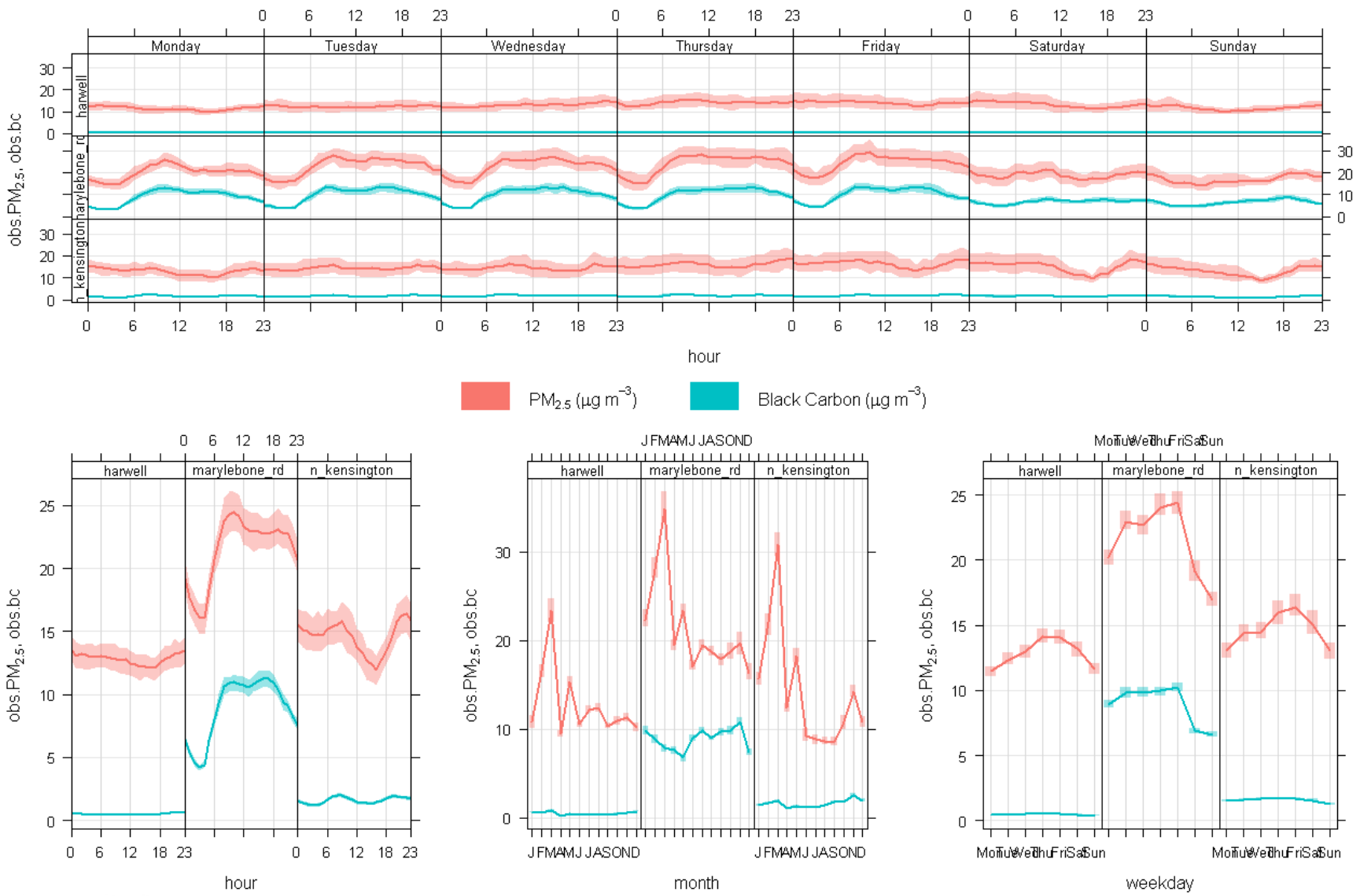
KERBSIDE

URBAN BACKGROUND



CERC

Time variation of 2012 $PM_{2.5}$ and BC



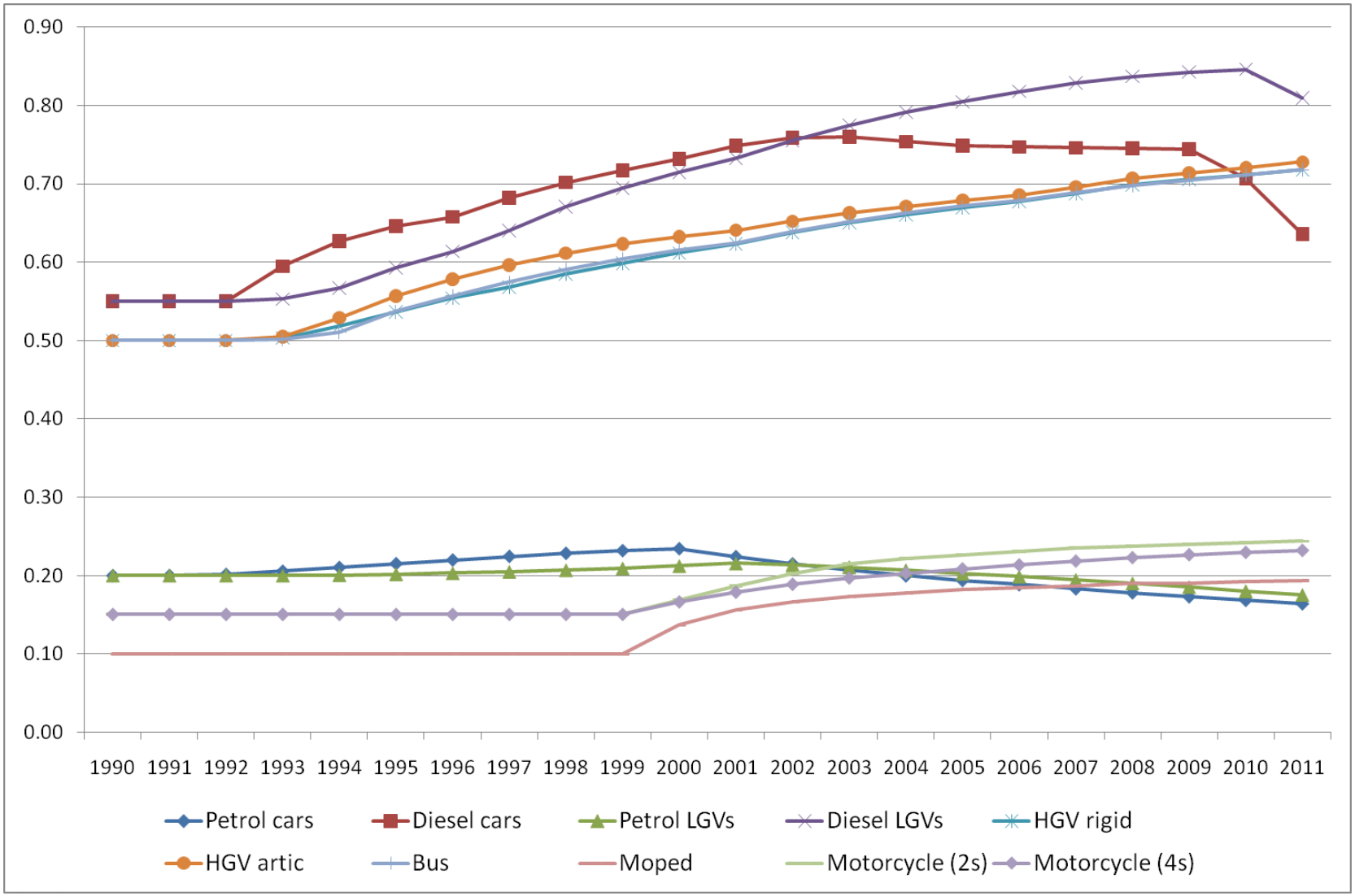
*air*TEXT particulate emissions

- All *air*TEXT local emissions are taken from the London Atmospheric Emissions Inventory (LAEI), published in 2008
- LAEI (2008) contains emissions data for the base year 2008 and two projected years: 2011 and 2015
- LAEI (2008) contains PM_{10} for all sources, $PM_{2.5}$ for road sources only and no BC
- Our approach:
  - For 2013 we interpolate between 2011 and 2015
  - For non-road sources we calculate $PM_{2.5}$ emissions from PM_{10} using emission factors consistent with Defra's National Atmospheric Emissions Inventory (NAEI)
  - We double the particulate emissions (PM_{10} and $PM_{2.5}$) from non-exhaust (brake and tyre wear, road wear, resuspension) because the emission factors used in the LAEI are known to underestimate these emissions in real conditions

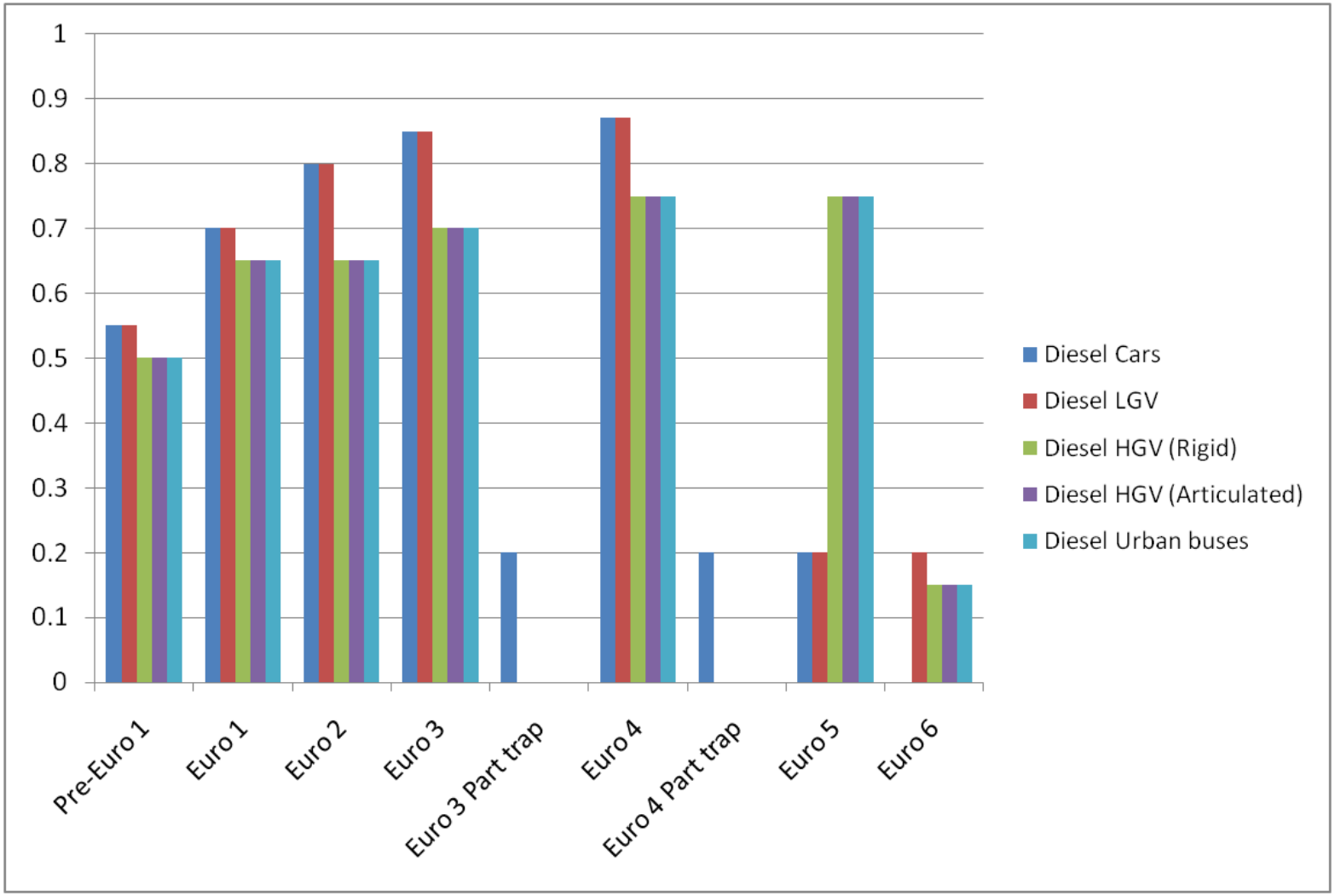
*air*TEXT BC emissions

- Methodology draws heavily on a draft report for Defra by Richard Claxton, Chris Dore and Tim Murrells from the NAEI team at Aether from March of this year
  - Describes development of a BC emissions inventory for inclusion in the NAEI
  - Approach uses the BC emission factors in the updated EMEP/EEA Air Emissions Inventory Guidebook (2012/2013)
  - BC emission factors reported there as a fraction of $PM_{2.5}$
  - Report recognises that there are substantial uncertainties associated with the resulting BC emission factors, but that they represent the best possible estimate given the data currently available
- NAEI methodology for BC has been applied to the LAEI, calculating BC by applying emission factors to $PM_{2.5}$

Fleet-weighted BC road vehicle emission factors



BC emission factors by diesel Euro category



Model validation for BC

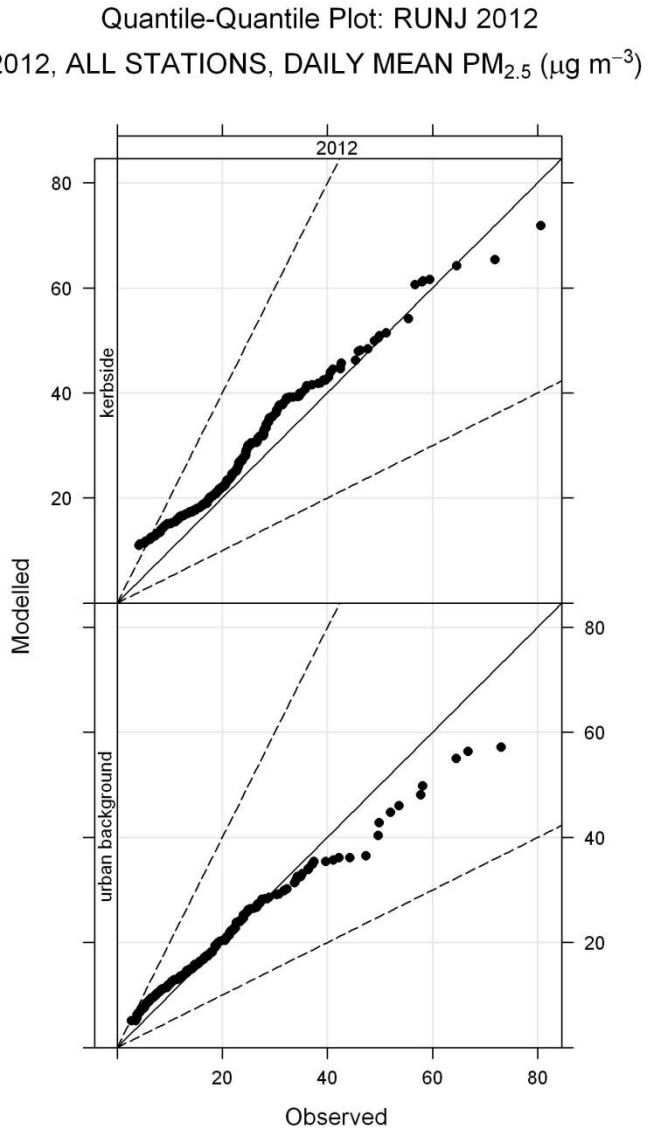
- Three stages in *air*TEXT validation for all pollutants:
  - Stage 1: Validate concentrations calculated using measured meteorology (Heathrow) and measured background concentrations (rural sites)
  - Stage 2: Validate concentrations calculated using forecast meteorology and measured background concentrations (rural sites)
  - Stage 3: Validate concentrations calculated using forecast meteorology and predicted background concentrations (from regional pollution forecast)

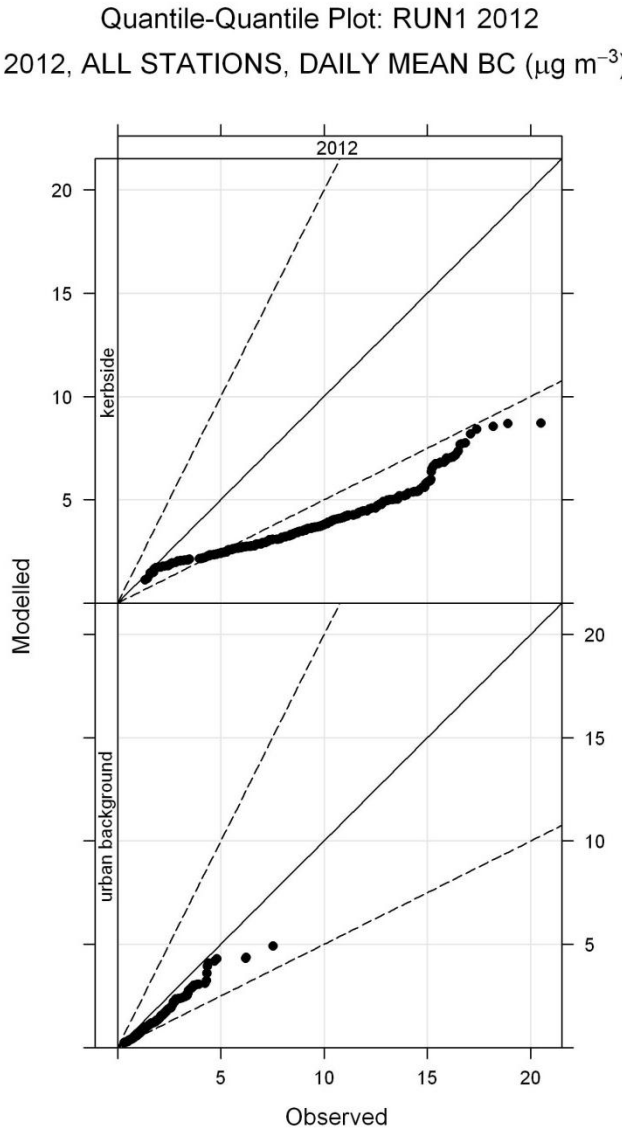
- Completed Stages 1 and 2 for BC; Stage 3 is ongoing

Validation of BC and $PM_{2.5}$ concentration results for 2012

- Validation runs at 2 sites in London for 2012:
  - Urban background (North Kensington)
  - Kerbside (Marylebone Road)
- Monitored meteorology: Heathrow
- Monitored background: Harwell
  - Only one site so will not be representative for full range of wind directions

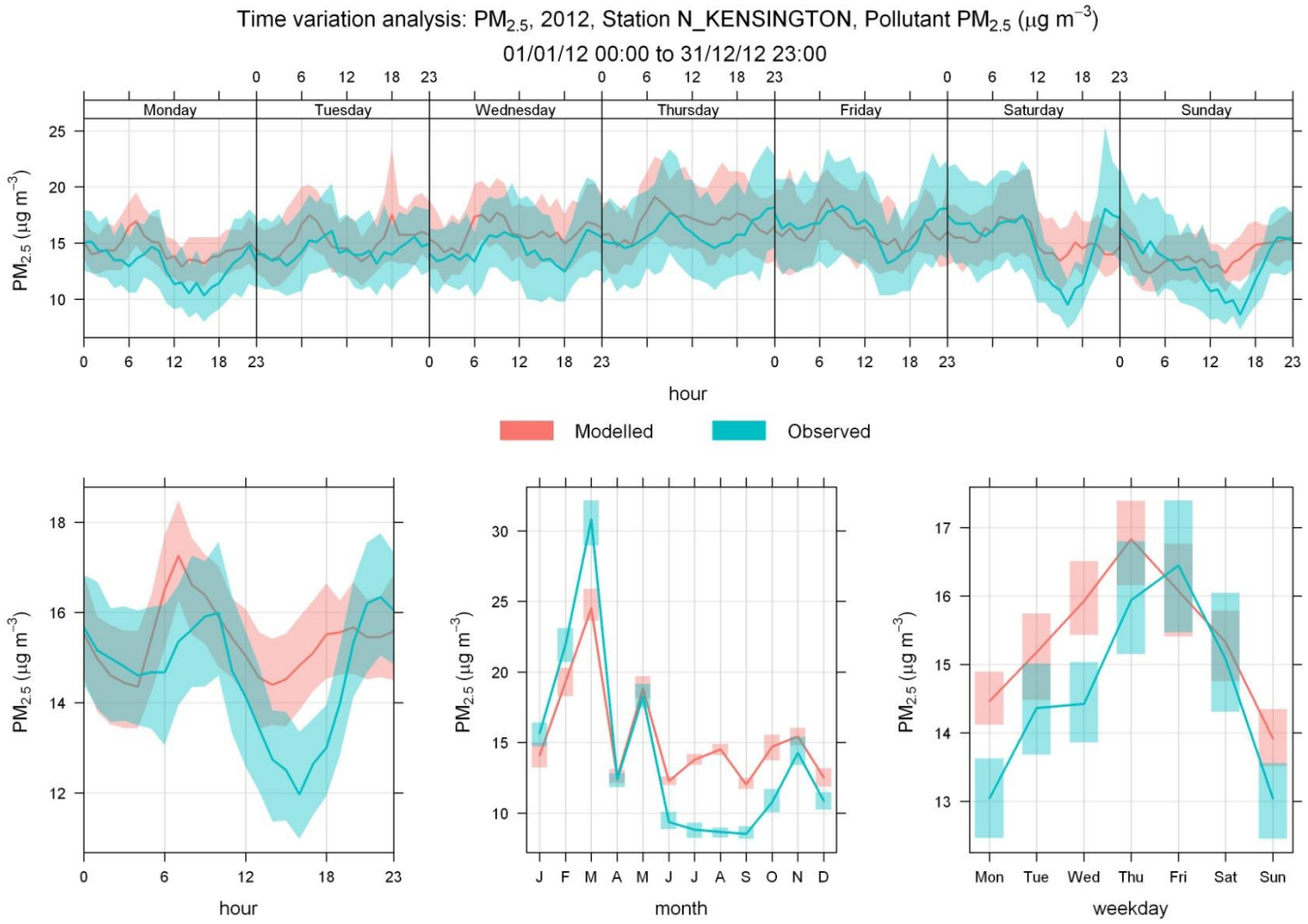
Validation of BC and $PM_{2.5}$ concentration results for 2012



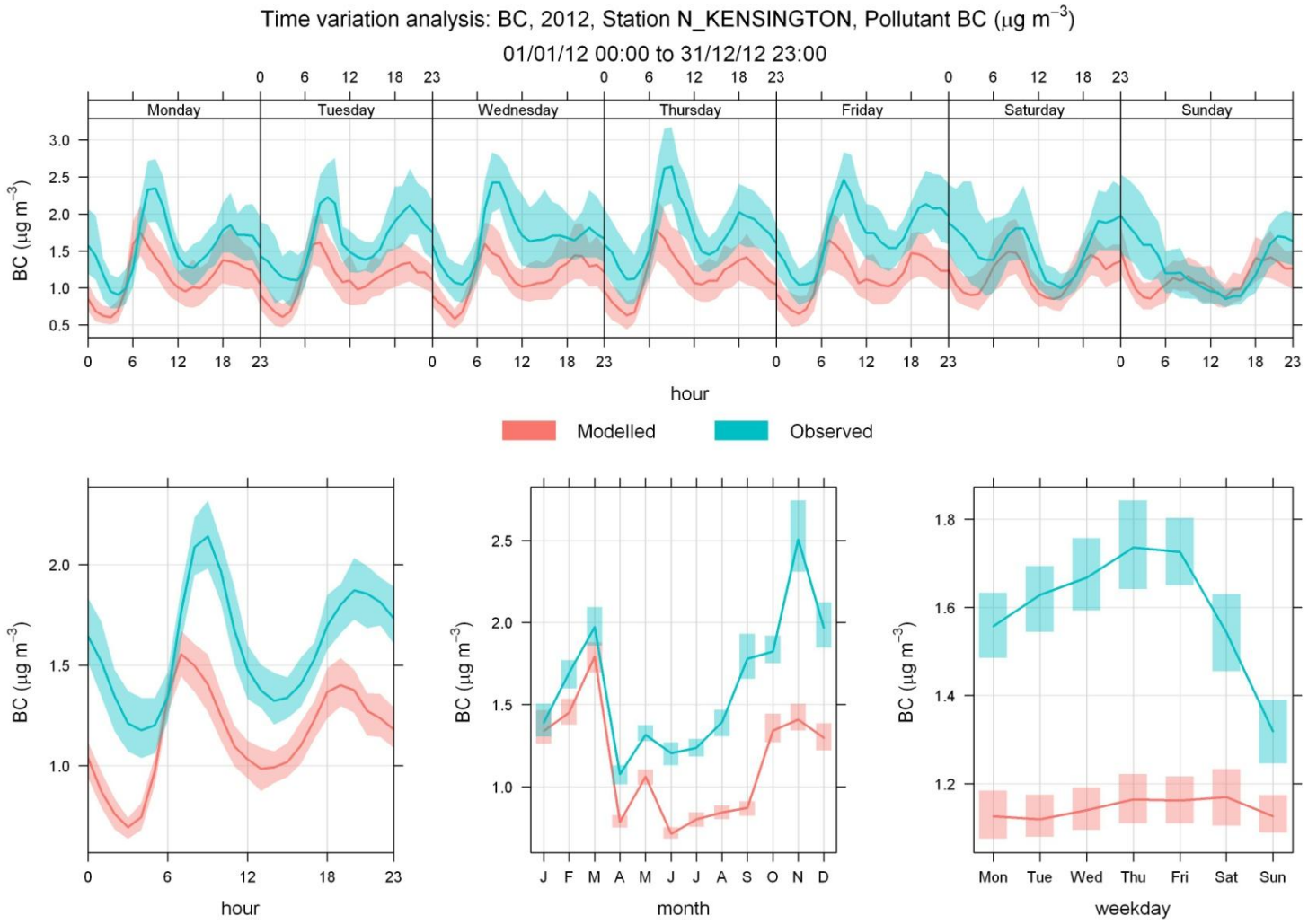


CERC

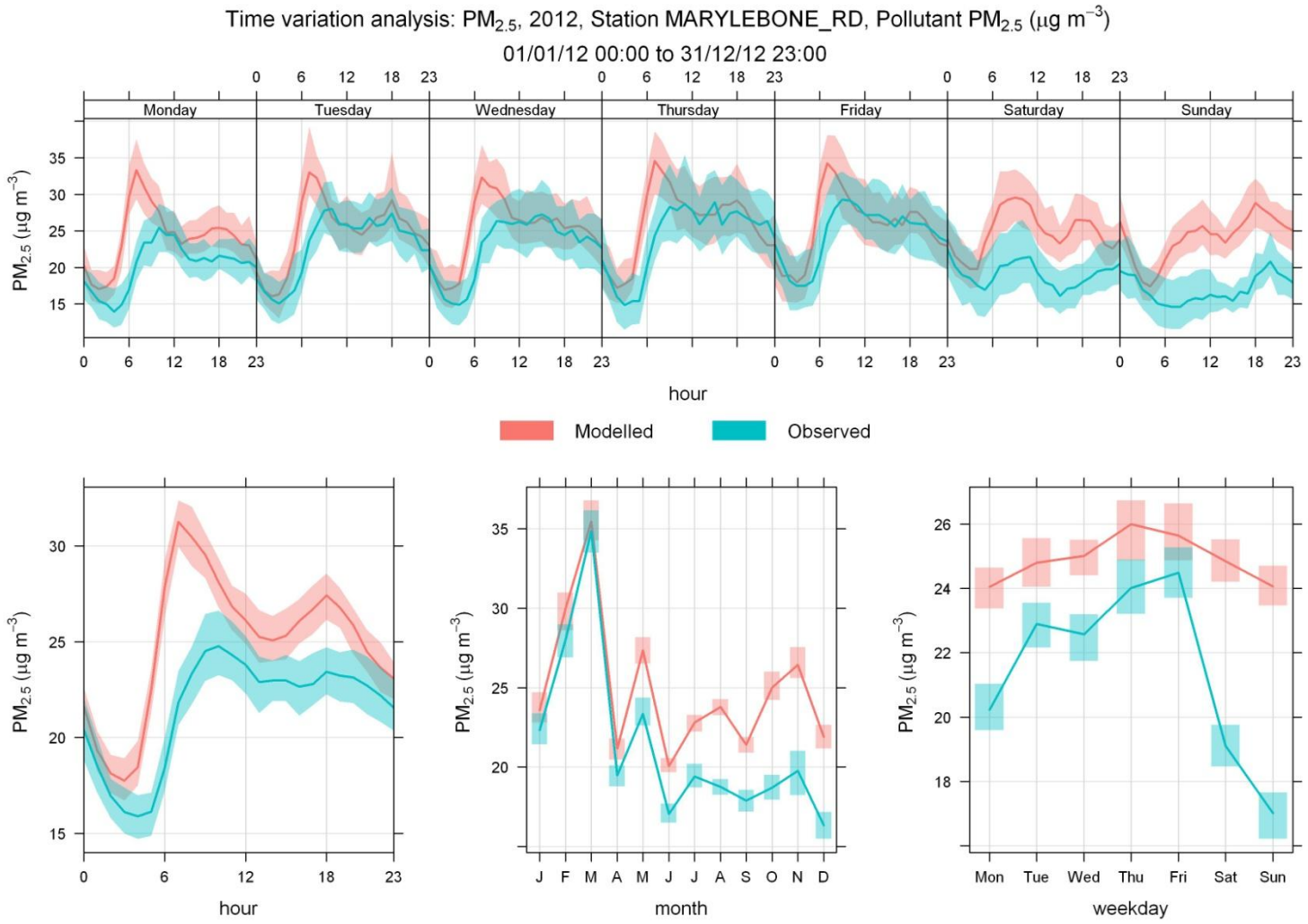
North Kensington $PM_{2.5}$



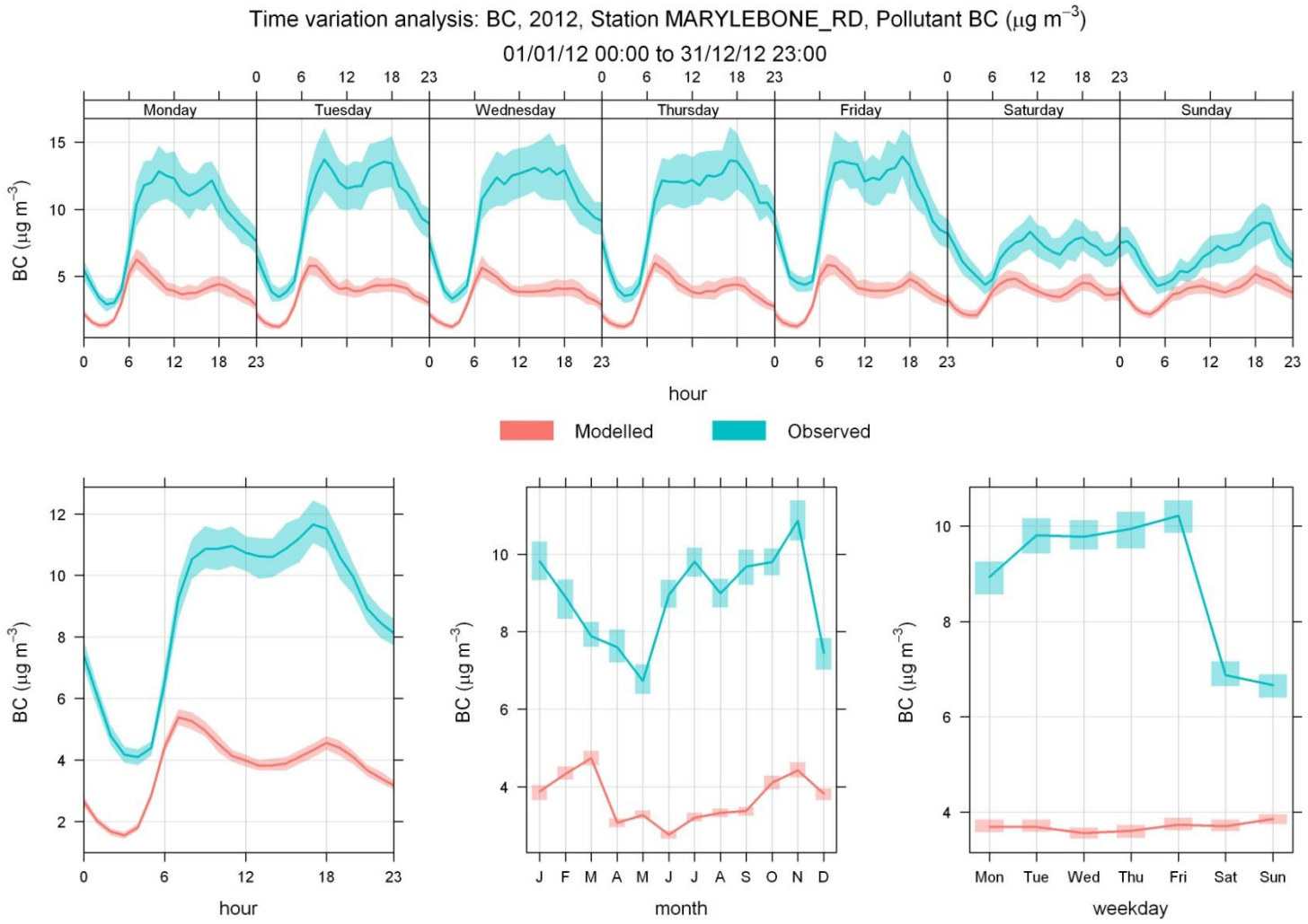
North Kensington BC



Marylebone Road $PM_{2.5}$



Marylebone Road BC



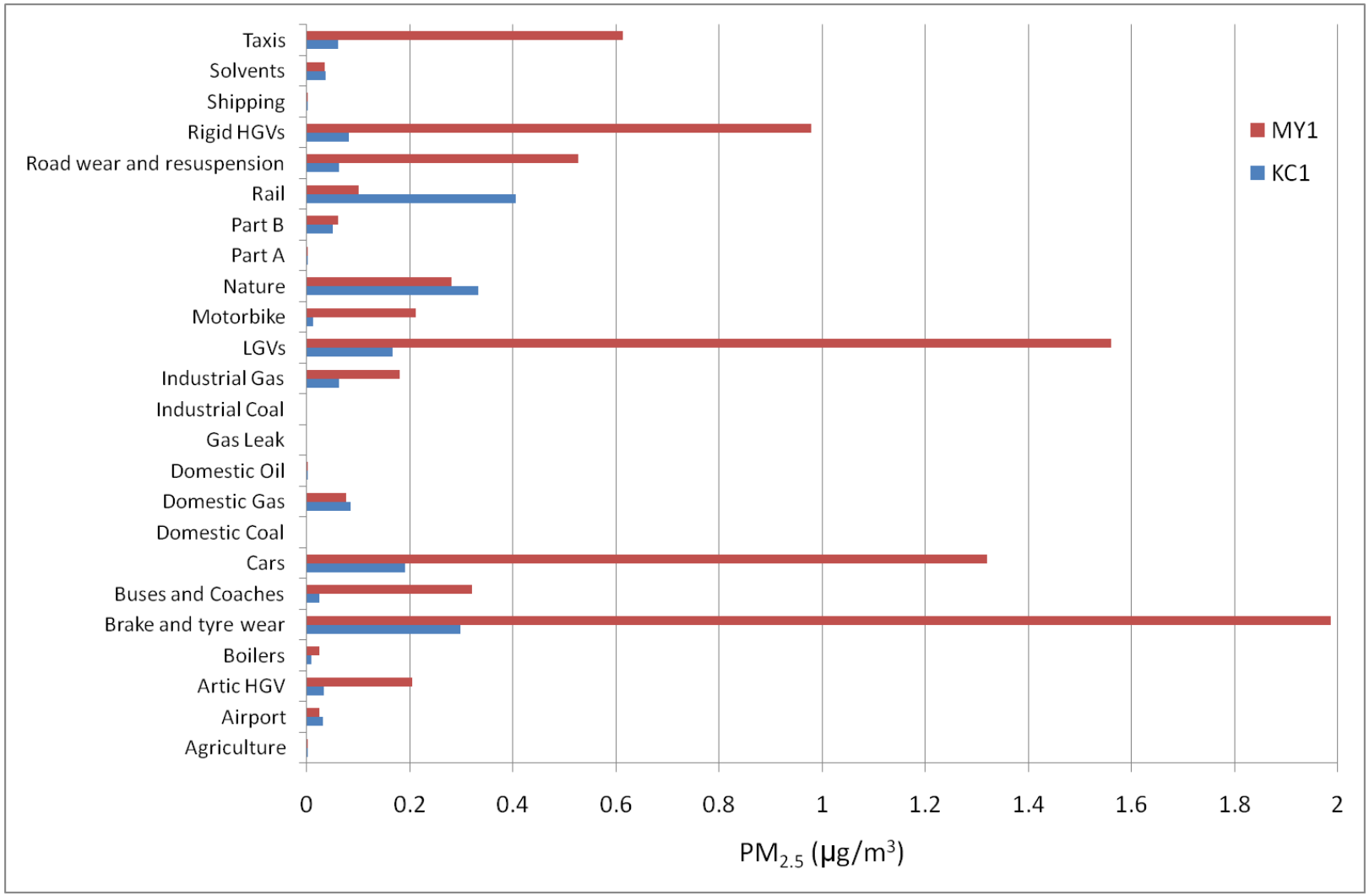
Validation of BC and $PM_{2.5}$ concentration results for 2012

Pollutant	Site type	Fractional Bias	NMSE	Correlation	Factor of 2
PM2.5	Urban background	0.07	0.12	0.9	0.91
	Kerbside	0.15	0.12	0.78	0.91
BC	Urban background	-0.33	0.34	0.79	0.74
	Kerbside	-0.83	1.41	-0.02	0.42

- General underestimate for BC, whilst $PM_{2.5}$ reasonably good
- For BC urban background site predictions much better than kerbside
- Possible reason for BC underestimate at kerbside: monitor next to bus/taxi lane, individual lanes not represented in emissions – not usually significant, but maybe significant for BC

CERC

Source apportionment of $PM_{2.5}$



Remaining work before trial

- Complete preparatory validation of BC forecasts:
  - Include regional pollution forecast data
  - Repeat validation exercise for 2011 data
- Test and refine London BC emissions on the basis of preparatory validation
  - Possible test: BC emission factor of 1 on diesel vehicles
- Determine index scale and alert thresholds for BC for *air*TEXT

Concluding remarks

- Scarcity of BC monitoring sites in London is an issue for model validation, but with increasing attention on BC from UK Government and EU, hopefully more monitors will be installed in London in the medium term
- Underestimate of BC at the kerbside site is of concern:
  - Could be due to resolution of road network in that locality
  - Could also be due to using average-speed emission factors: it's thought that BC is very dependent on driver behaviour; though this is a wider issue, it's possibly particularly relevant to BC
  - Could be due to different monitoring techniques for PM2.5 and BC
  - Cases where measured BC > $PM_{2.5}$ suggests that some BC components >2.5 microns
  - Generally much higher uncertainty in BC emission factors than emission factors for other pollutants
- We are grateful to Tim Murrells, Richard Claxton and Chris Gore at Aether for sharing their work for Defra on the NAEI at the draft stage

Thank you for your attention