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Detecting air pollution changes from fleet changes

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CVTF workshop

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Contents

Why do we need to measure?

A bit about NO_X and NO_2

Measurement methods

Ideas and pointers on

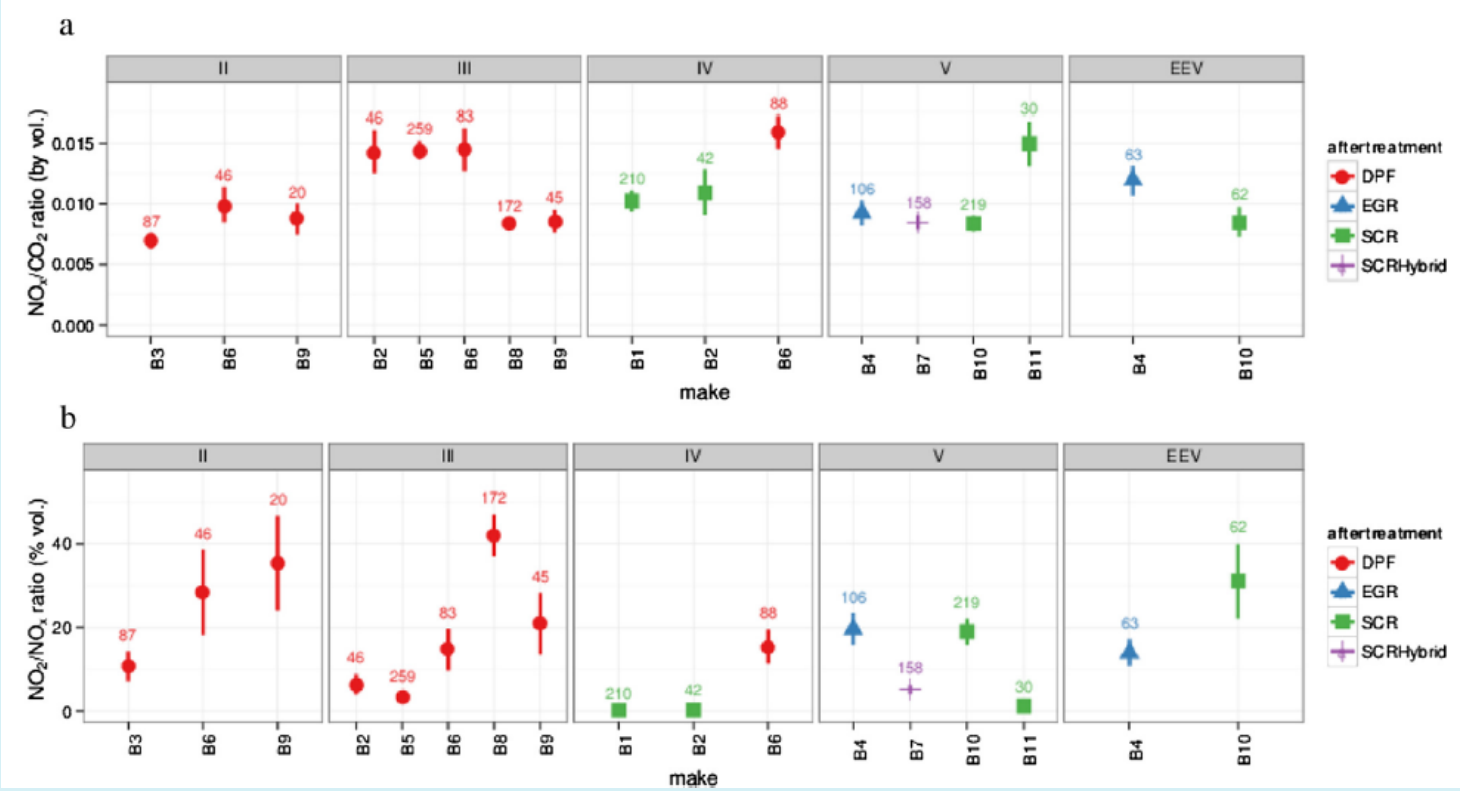
- possible study designs
- data analysis

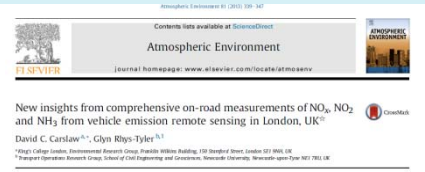
Why measure -does it work?

Carslaw and Tyler 2013 measured emissions from passing vehicles.

Do OEM buses show decreases in NO_X emissions?

Effects of retrofits need to be assessed urgently.




Contents lists available at ScienceDirect

Atmospheric Environment

journal homepage: www.elsevier.com/locate/atmosenv

New insights from comprehensive on-road measurements of NO_x, NO_2 and NH_3 from vehicle emission remote sensing in London, UK

David C. Carslaw, Glyn Rhys-Tyler

A bit about NO_X and NO_2

$NO_X = NO + NO_2$

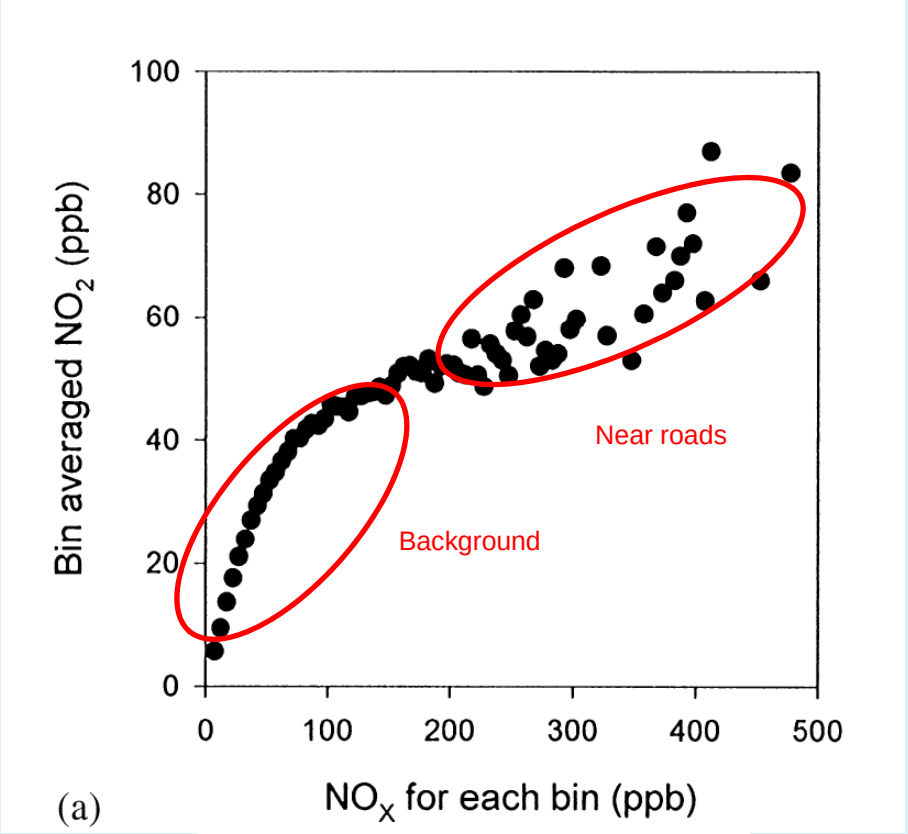
•NO_X emissions from exhaust are mostly NO with a small* amount of NO_2

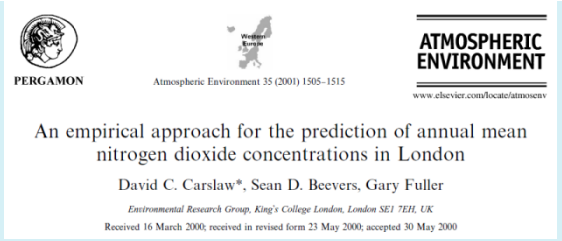
•Over time and with dilution NO is oxidised to NO_2

•From emissions perspective it is easier to deal with NO_X but health effects are linked with NO_2

(*) Important but would be a presentation in itself!

•Figure data from 1999 from Carslaw et al 2001




PERGAMON

Atmospheric Environment 35 (2001) 1505–1515

ATMOSPHERIC ENVIRONMENT

www.elsevier.com/locate/atmosenv

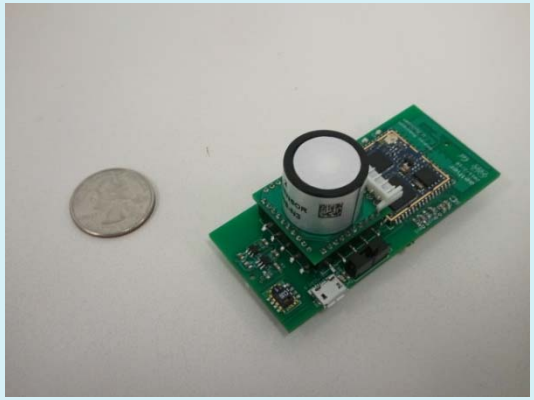
An empirical approach for the prediction of annual mean nitrogen dioxide concentrations in London

David C. Carslaw*, Sean D. Beevers, Gary Fuller

Environmental Research Group, King's College London, London SE1 7EH, UK

Received 16 March 2000; received in revised form 23 May 2000; accepted 30 May 2000

Measurement methods



Measurement methods

Method	Pros	cons
Diffusion tube	Cheap Wide availability Measure at many locations / routes	Only NO_2 Poor time resolution +/- 30%?
Electro-chemical sensors	Medium price Good time resolution	Poor long term stability, inferences and calibration
Chemi-luminesent reference methods	Standard (CEN, AURN) methods Good time resolution Good calibration can give long term uncertainty ~5%	Requires specialist tech and science support. Requires housing and utilities
Ambient exhaust e.g. remote sensing	Direct emissions measurement	Research equipment. Only NO_2 device is owned by Uni Denver. Not ambient

Cost

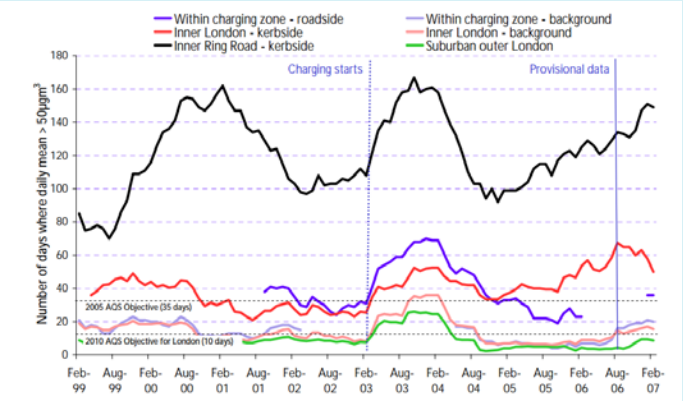
Study designs

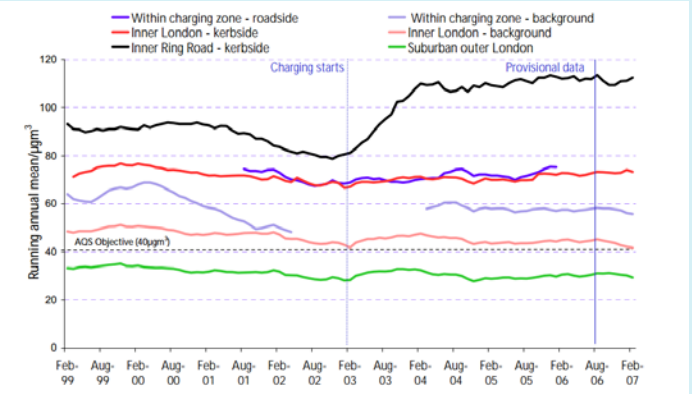
Retrofitting/ your change won't be the only change happening!

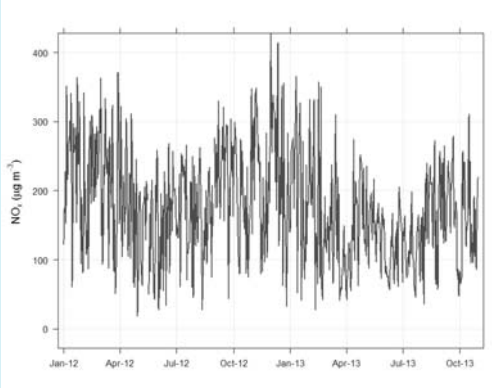
Two examples from London's congestion charging.

Barratt et al in TfL (2007)

And things change with the seasons too !







Study designs

Need to control for..

- Changes in background concentrations
- Other changes in vehicle fleet emissions
- Changes in traffic flows daily and longer term
- Weather

- Need measurements in place before the change!!!
  - At least months in advance (3?)

Study designs – Lenschow

Lenschow et al 2001

PERGAMON

Atmospheric Environment 35 Supplement No. 1 (2001) S23–S33

ATMOSPHERIC ENVIRONMENT

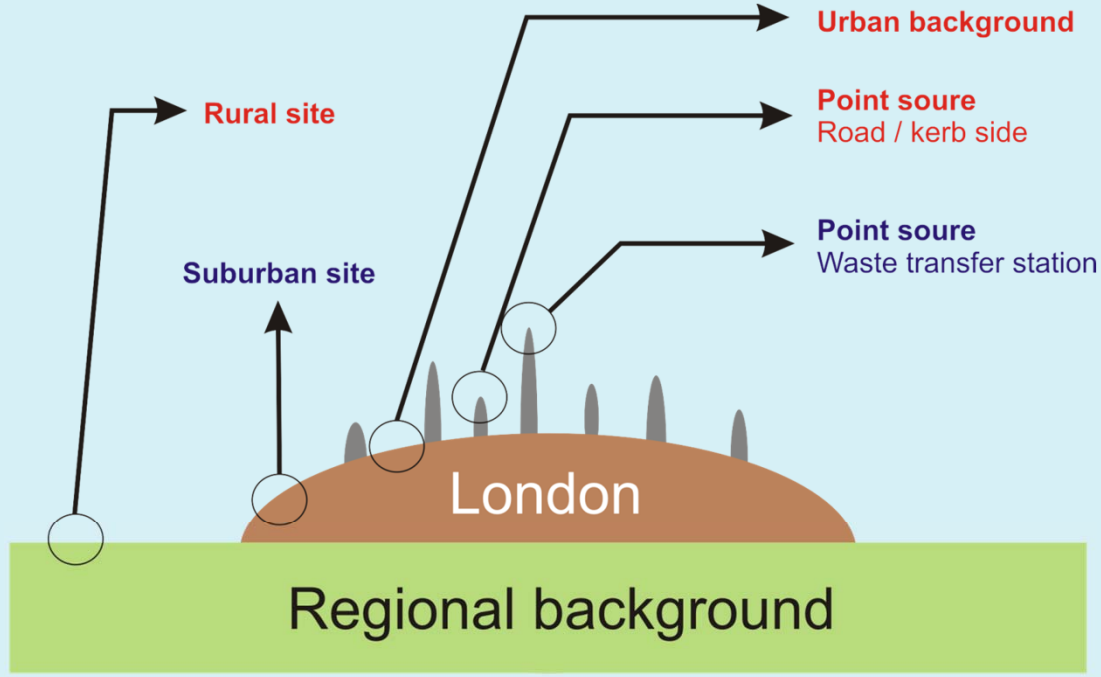
www.elsevier.com/locate/atmosenv

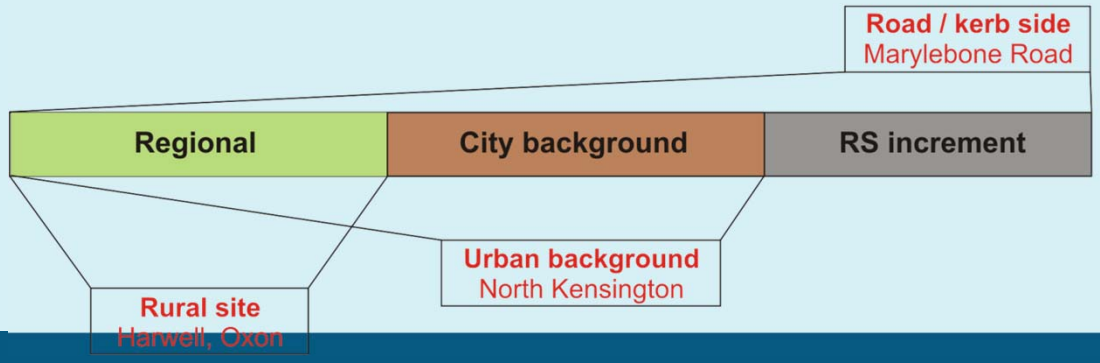
Some ideas about the sources of PM10

P. Lenschow, H.-J. Abraham, K. Kutzner, M. Lutz*, J.-D. Preuß, W. Reichenbächer

Department of Urban Development, Berlin, Germany

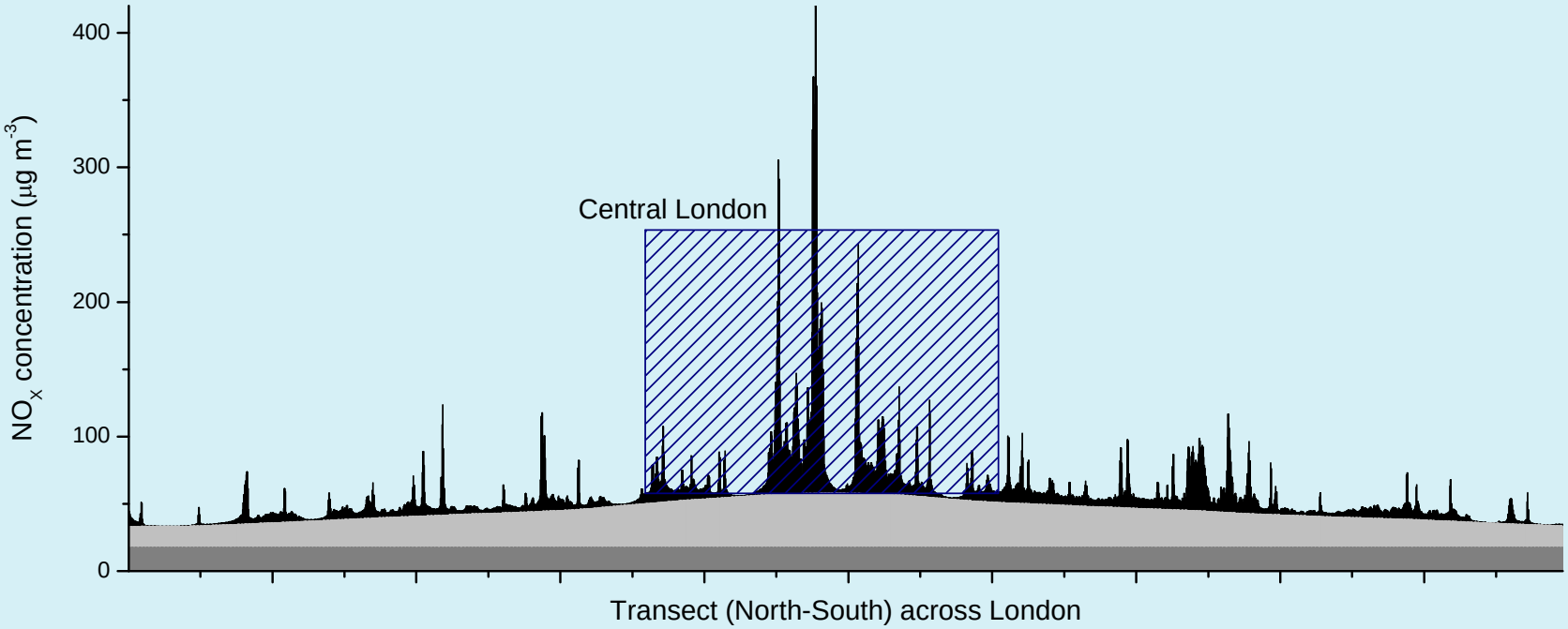
Received 3 May 2000; received in revised form 18 January 2001; accepted 24 January 2001





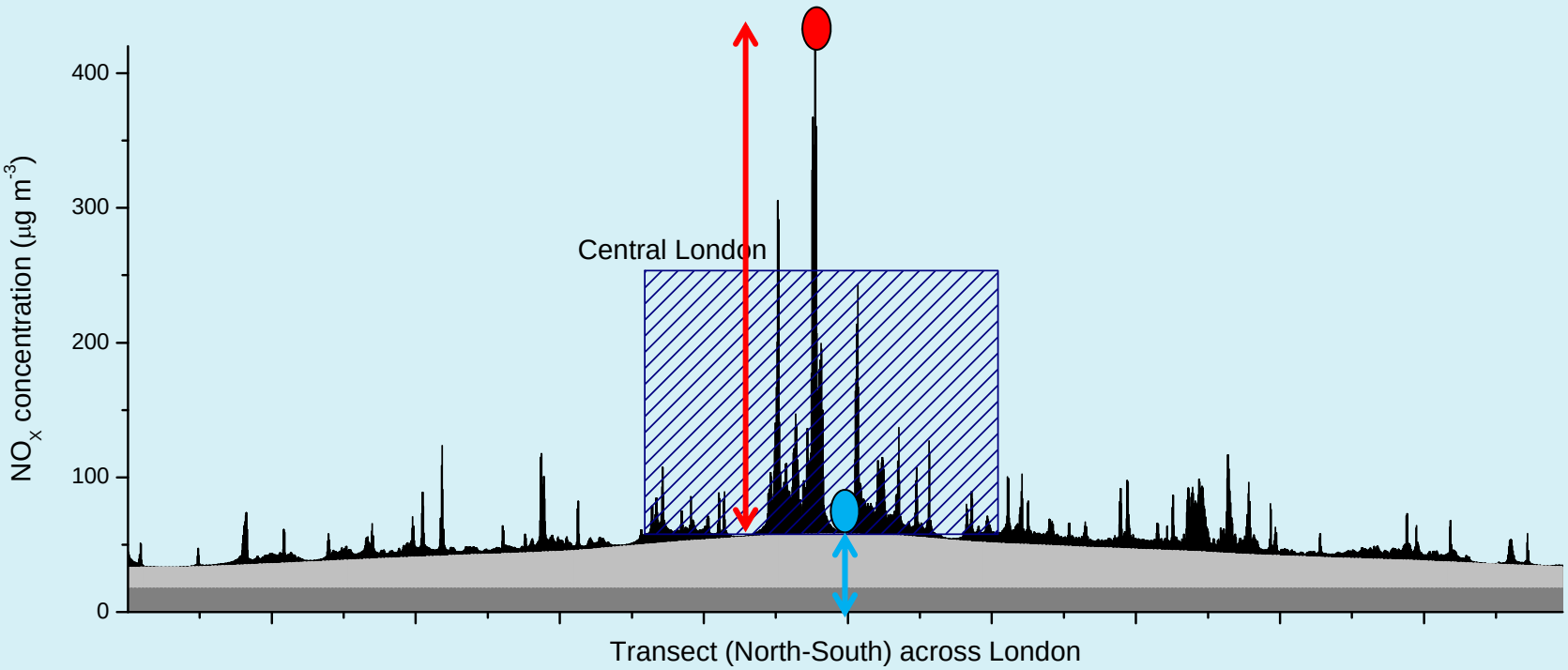
Study designs – Lenschow

Modelled NOX cross-section from Sean Beevers, King's College London



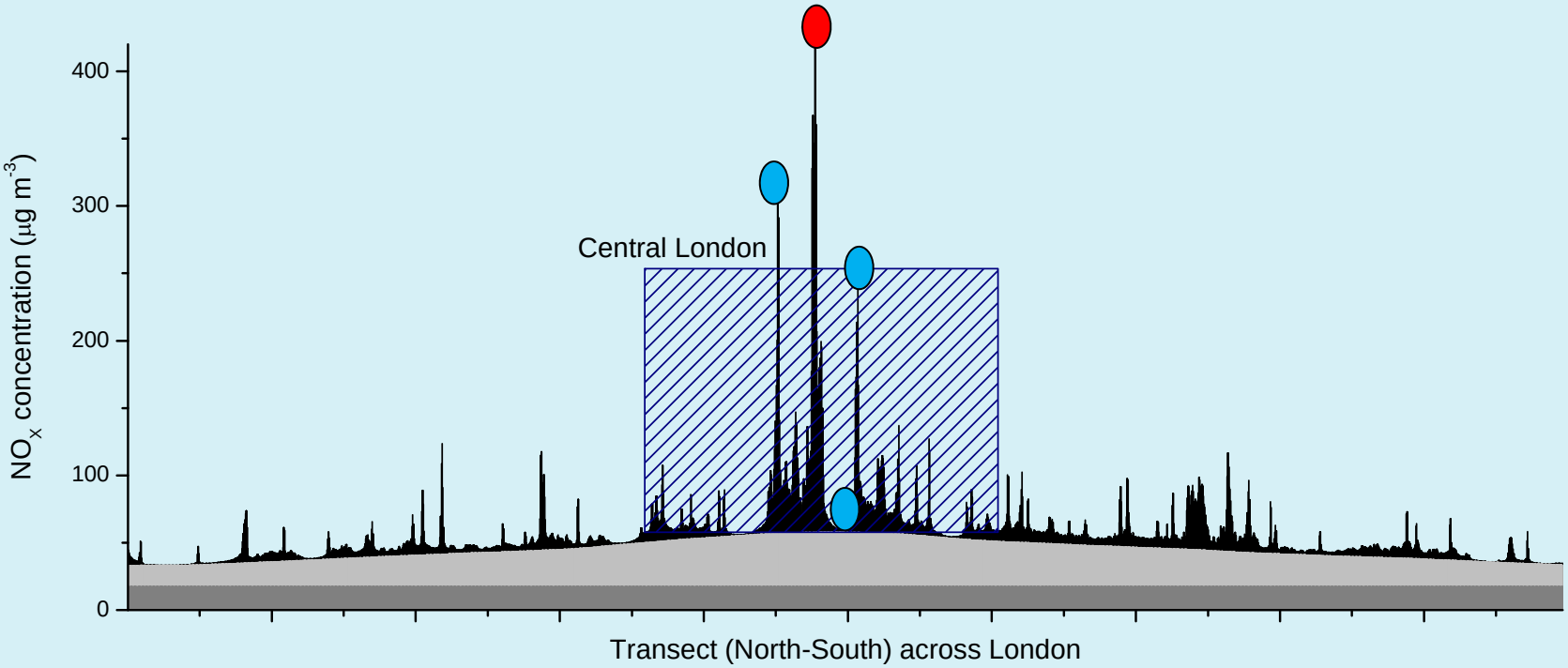
Study designs – Lenschow

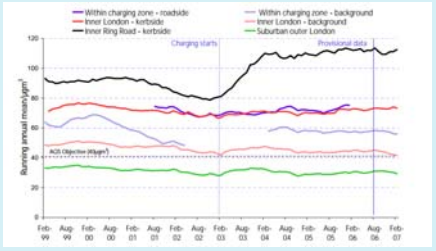
Roadside increment controlling for background changes



Study designs – Lenschow

…and controlling for other traffic changes too





Data analysis – data conditioning

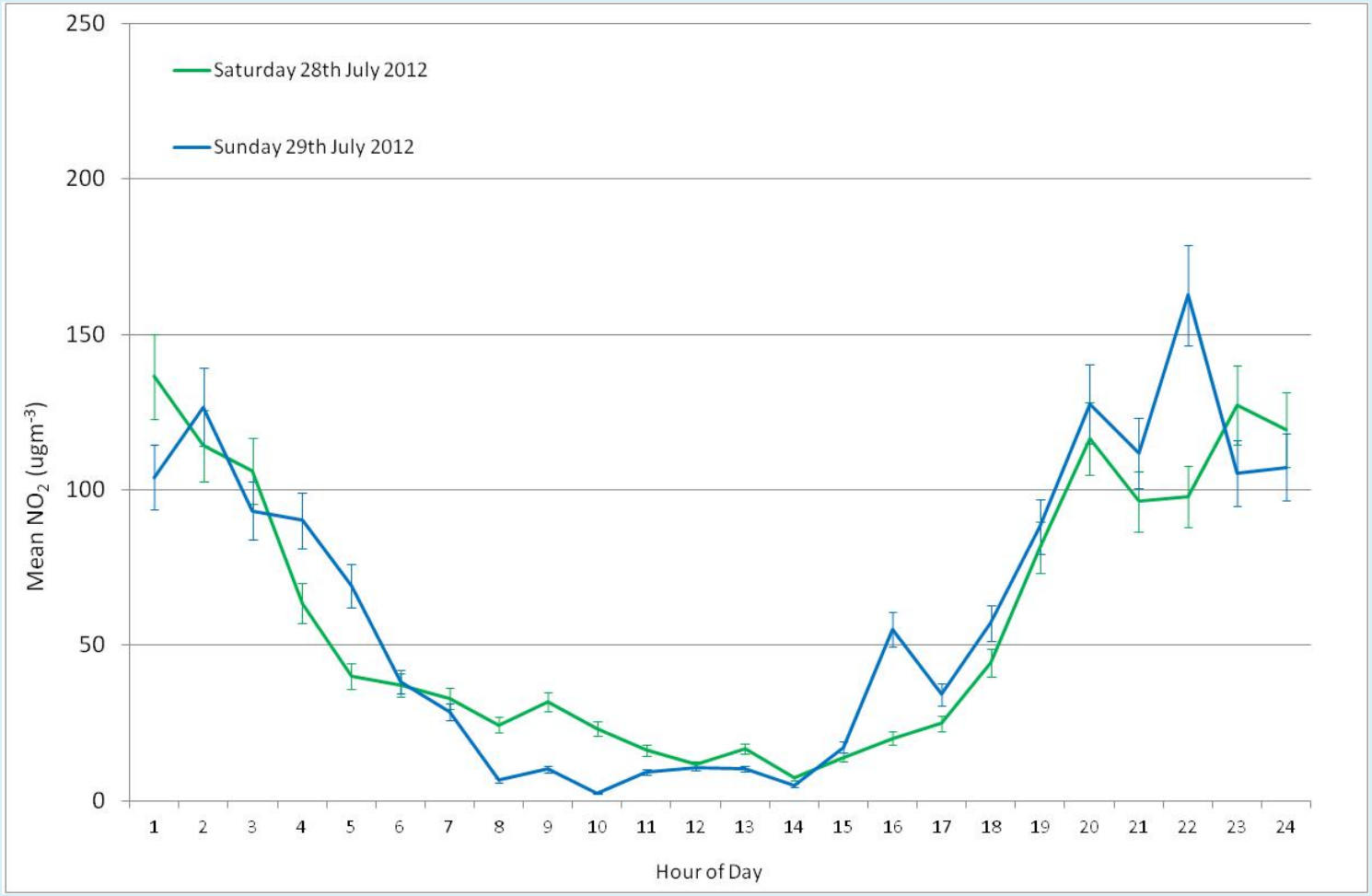
Methods of processing measurements to:

•Select measurements to focus on the pollution from the affected road.

•Deduce changes in pollution patterns without “noise” from emissions variations and weather.

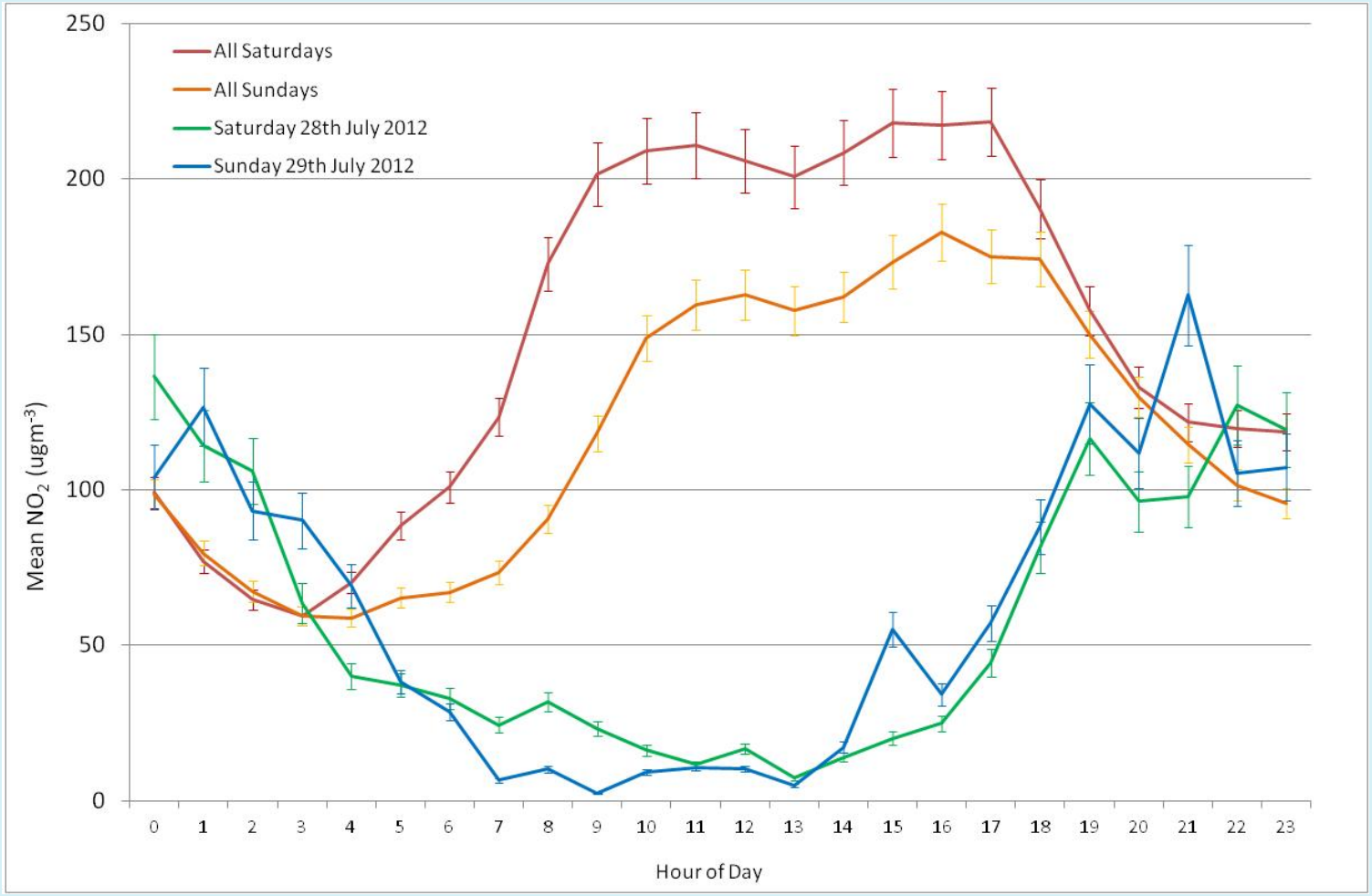
Data analysis – diurnal analysis

Changes to the norm can help quantify what comes from surroundings ?
Olympic road closures – Putney High Street



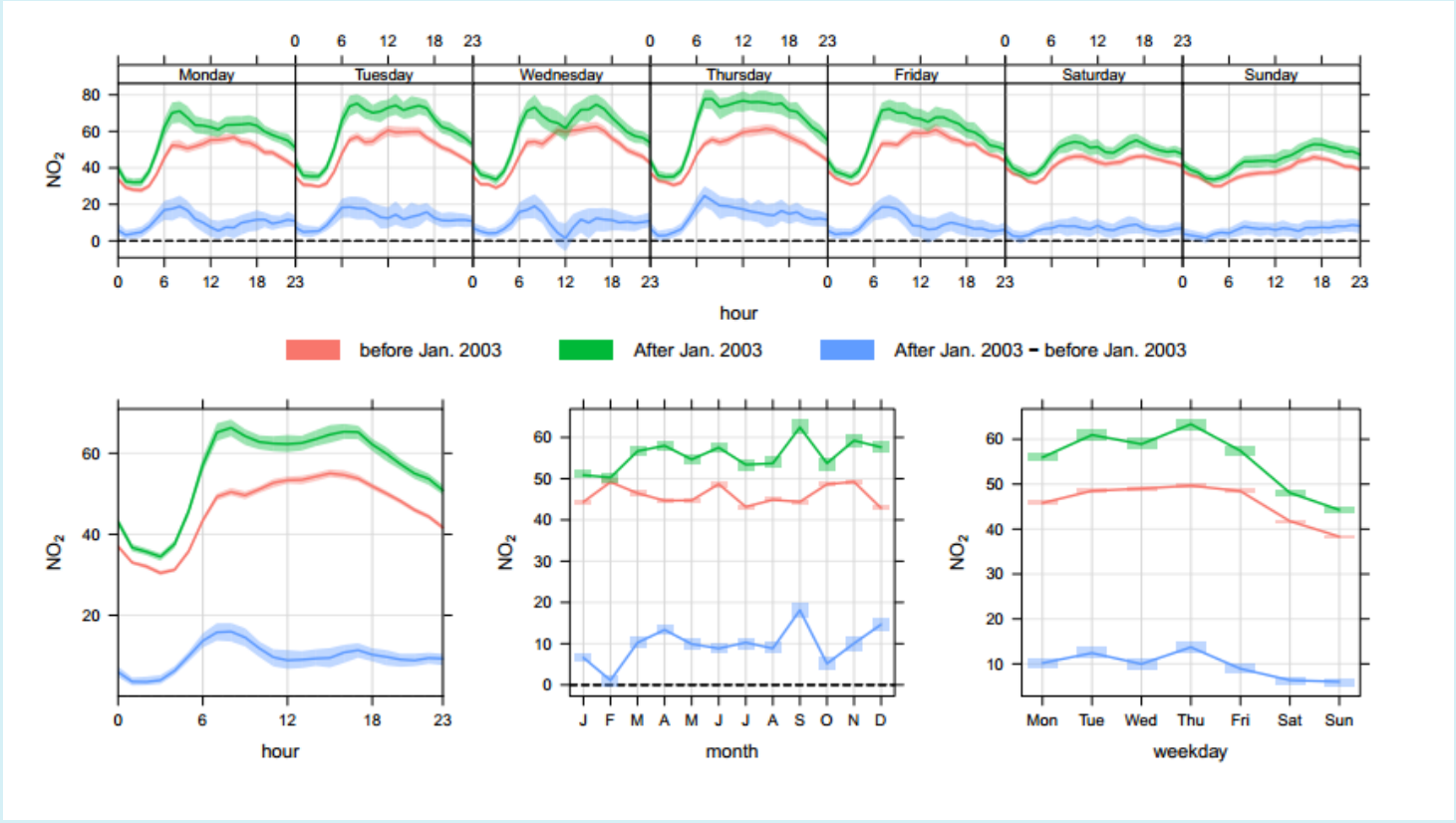
Data analysis – diurnal analysis

Olympic road closures



Data analysis – diurnal analysis

Marylebone Road in 2003



The **openair** manual

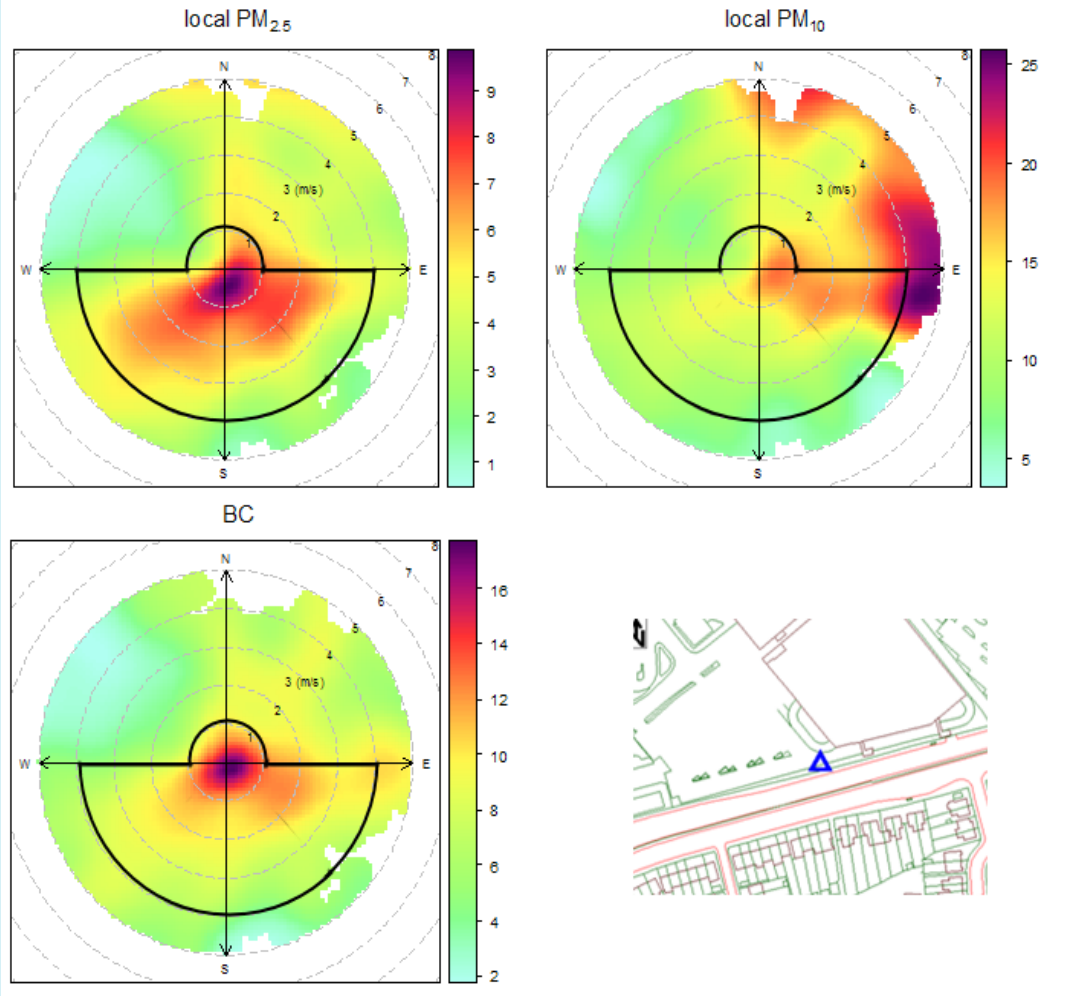
open-source tools for analysing air pollution data

King's College London

David Carslaw

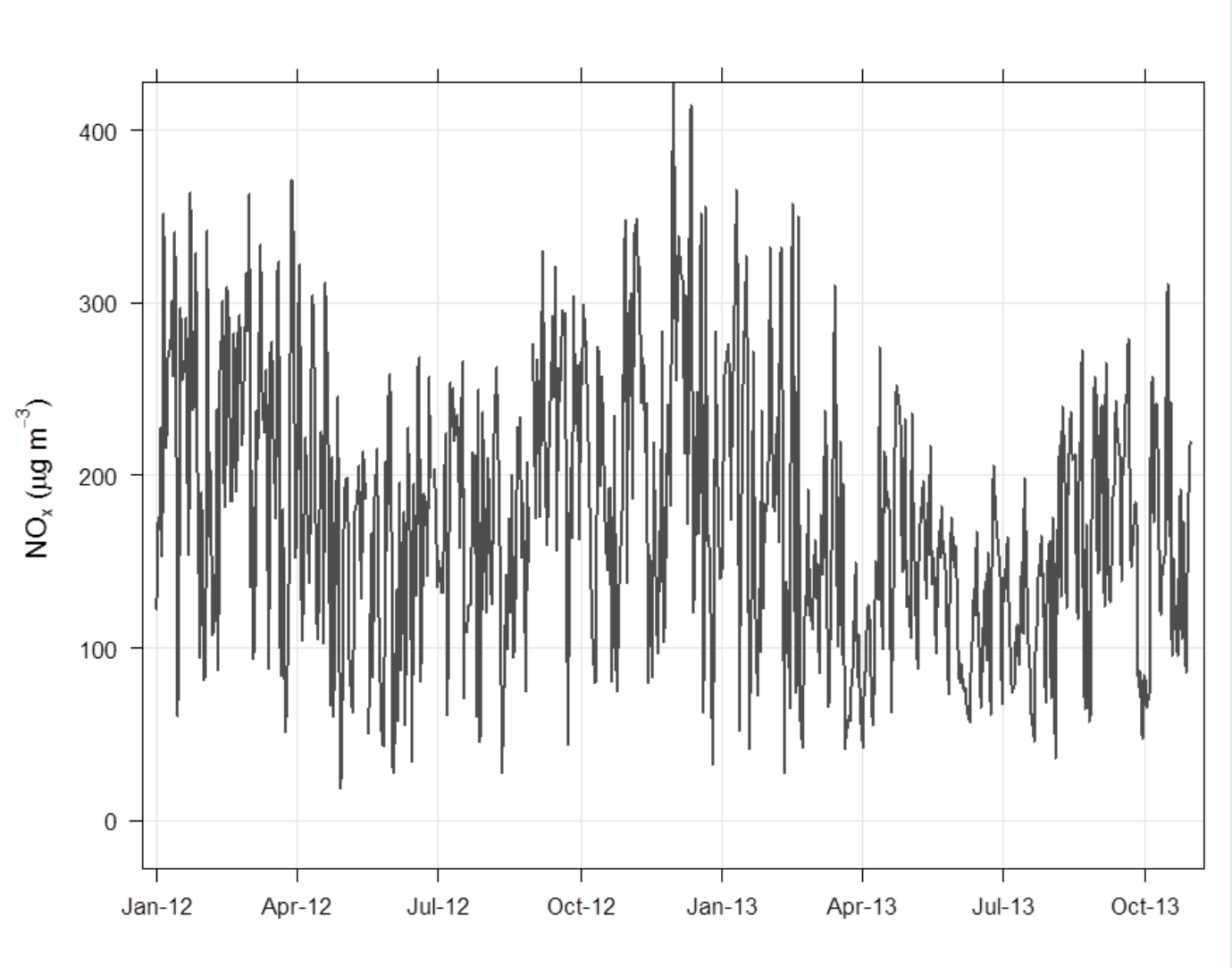
version: 14th February 2013

Data analysis – filtering to maximise air pollution from source



Data analysis – meteorological normalisation

Using statistical models to calculate air pollution on a standardised day – Carslaw et al 2012
Removing seasonal and short-term variations from weather.

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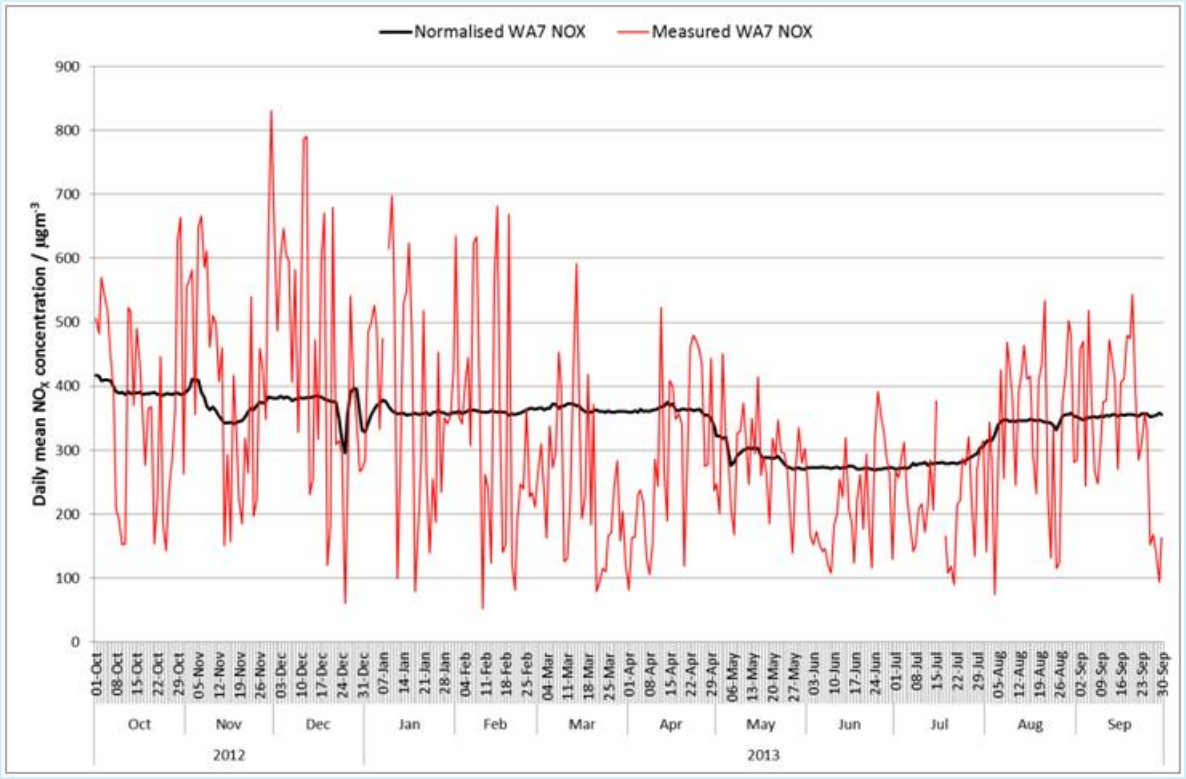
A short-term intervention study — Impact of airport closure due to the eruption of Eyjafjallajökull on near-field air quality

David C. Carslaw*, Martin L. Williams, Ben Barratt

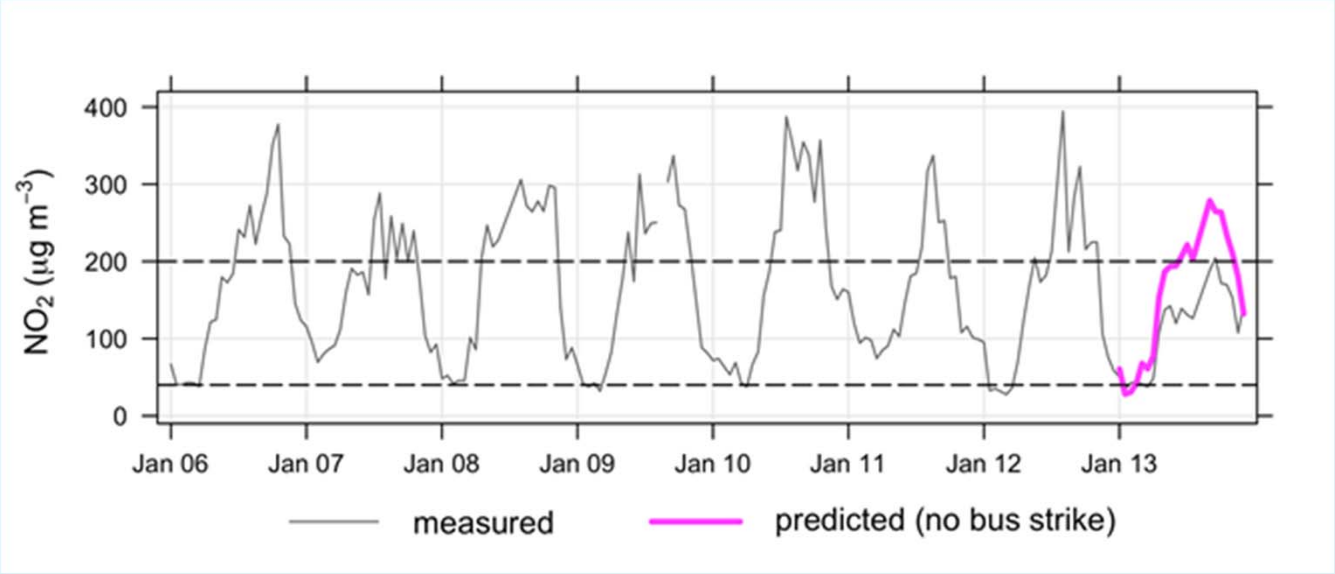
Data analysis – meteorological normalisation



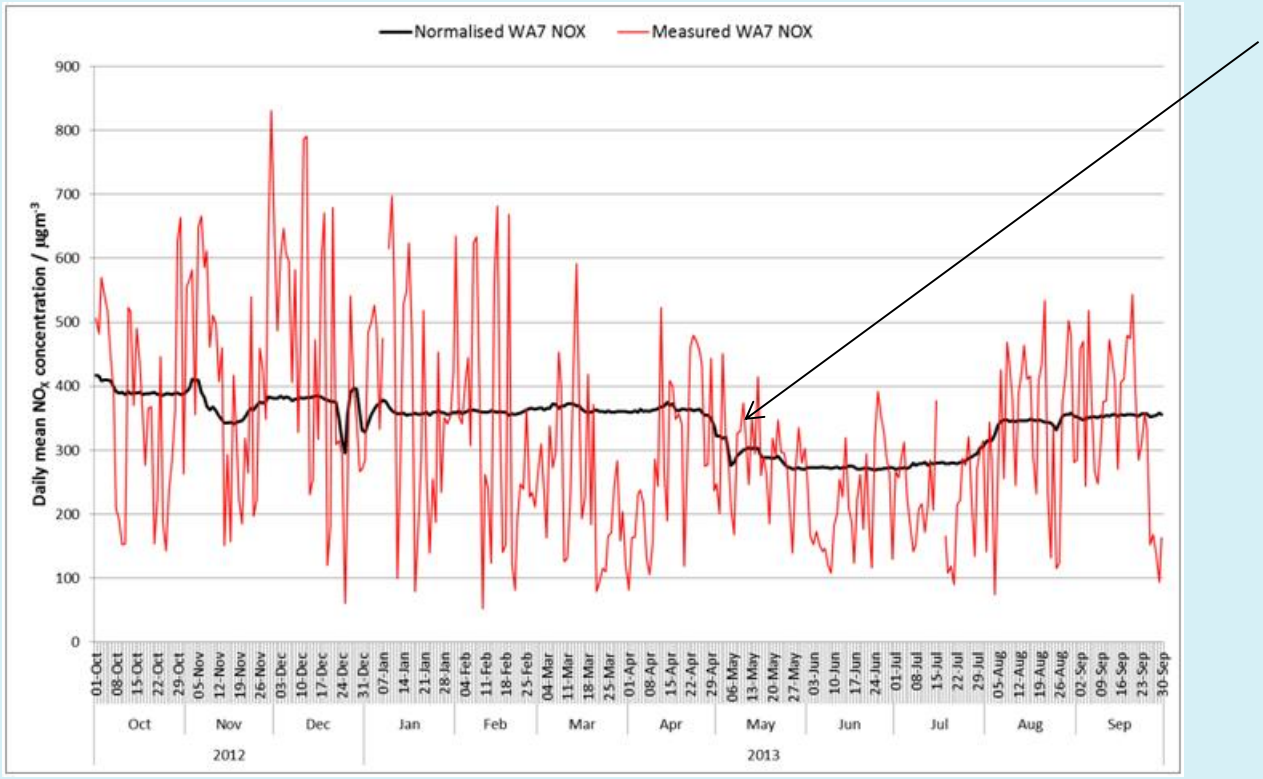
Data analysis – meteorological normalisation

Because weather always plays a part.

1. The predictions are based on statistical models described in Carslaw and Taylor (2009) and Carslaw et al (2012). These models effectively remove the variation that are due to the weather - or in this case allow us to predict what would happen under the weather conditions of the 13th Jan. 2015 with 'business as usual' (no bus strike). Without accounting for the variation in weather (very important) it cannot be known whether a reduction in concentration was due to some intervention or the weather.
2. We don't know what the bus flow actually was on Oxford Street on the 13th. The data suggests there were still buses using Oxford Street. On Christmas Day for example there were no bus services and NO2 concentrations were much lower than days either side.
3. The data have uncertainty because they have not been ratified. More robust predictions would be possible at a later date. Also, access to better meteorological data at a later date would likely improve the reliability of the predictions.

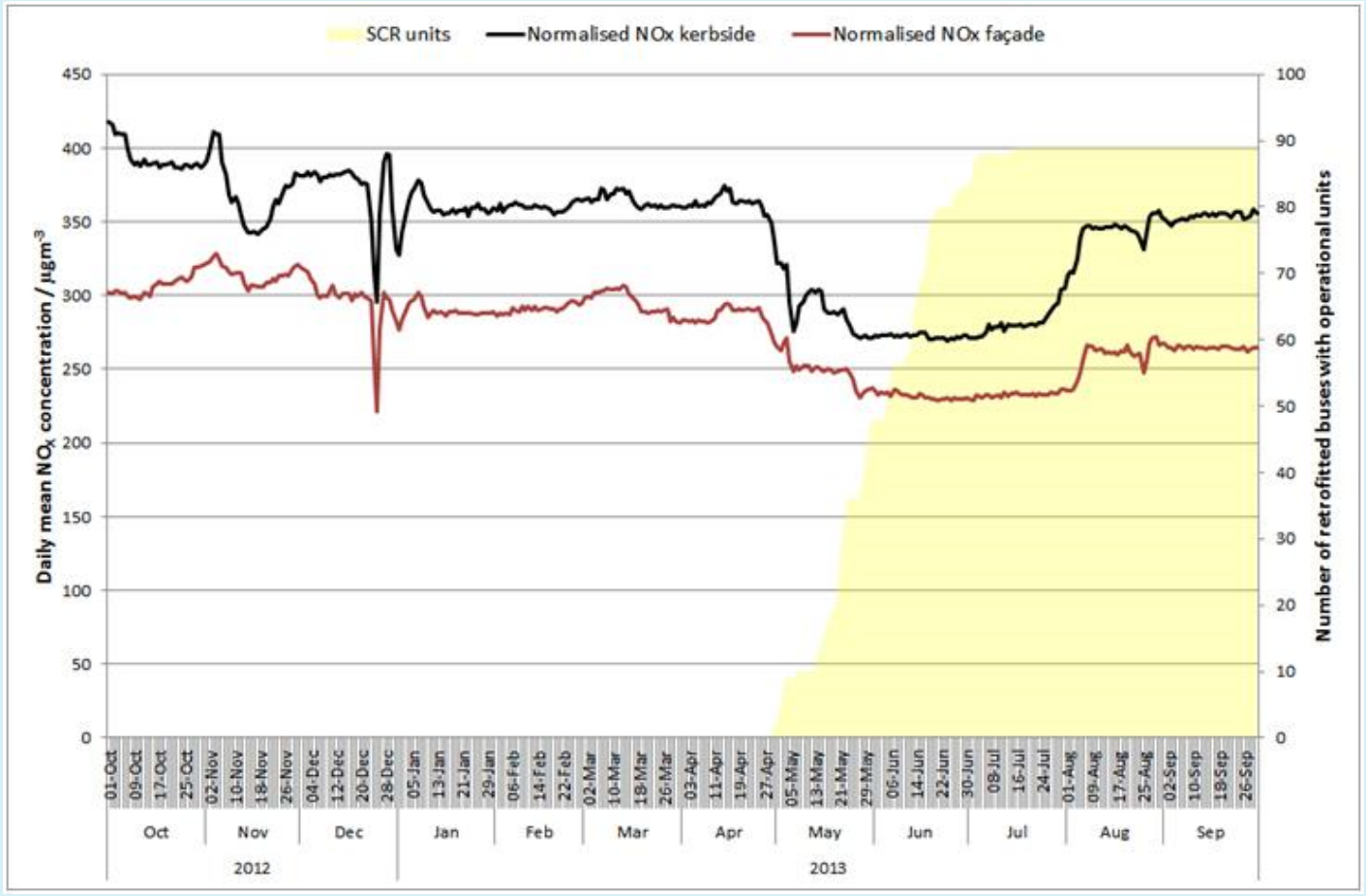


Data analysis – meteorological normalisation



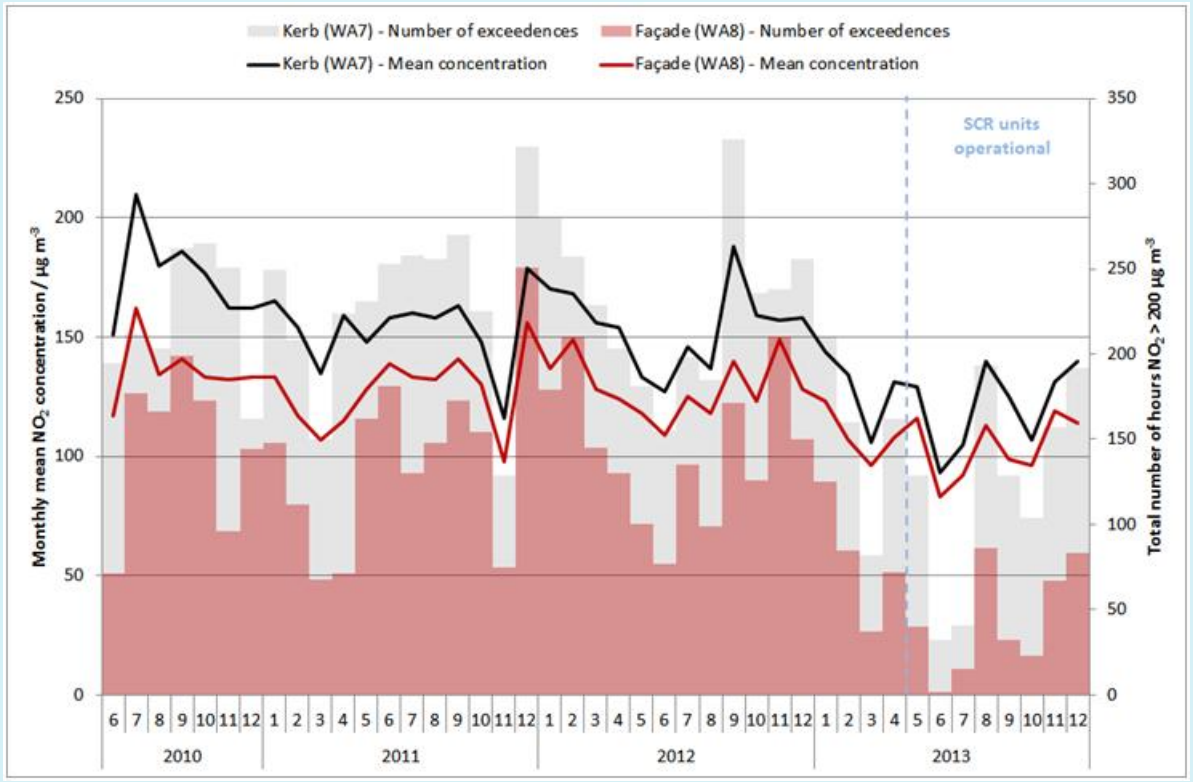
An expected change, and not.

Normalised NO_X concentrations at the kerb and facade of PHS, with the introduction of retrofitted buses overlaid in yellow.



Data analysis – peak or average ?

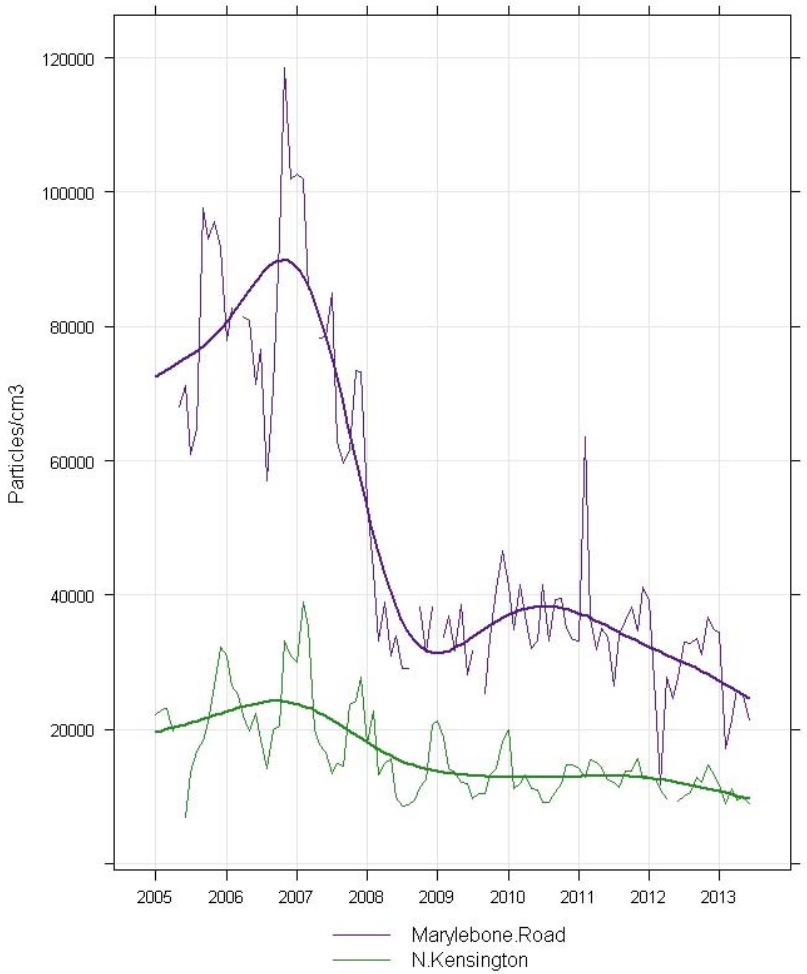
Trends in mean NO_2 concentrations and exceedences of the EU short term limit value per month recorded by both sites on PHS.



Data analysis – When did change happen?

Cumulative sum (CUSUM)

First developed for process control. Applied to detect timing air pollution changes in several studies e.g Jones et al 2012, Barratt et al 2007



Atmospheric Environment 50 (2012) 129–138

Contents lists available at SciVerse ScienceDirect

Atmospheric Environment

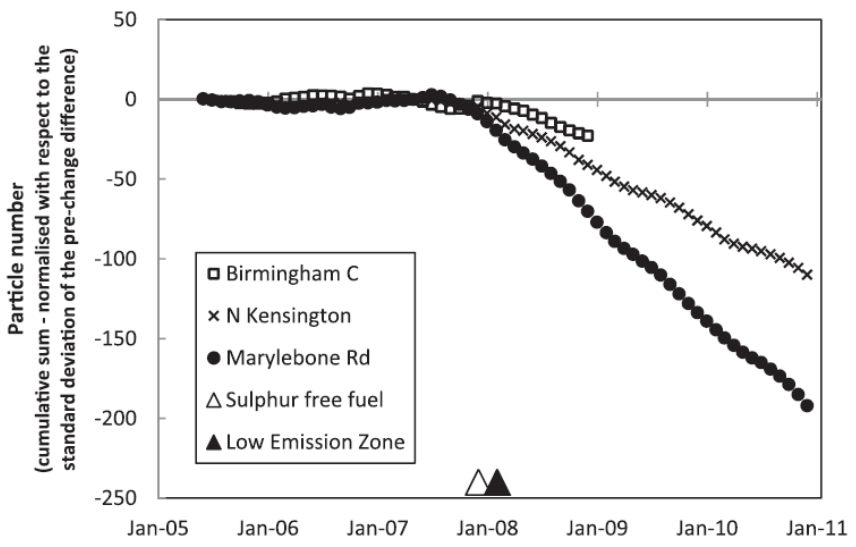
journal homepage: www.elsevier.com/locate/atmosenv

A large reduction in airborne particle number concentrations at the time of the introduction of "sulphur free" diesel and the London Low Emission Zone

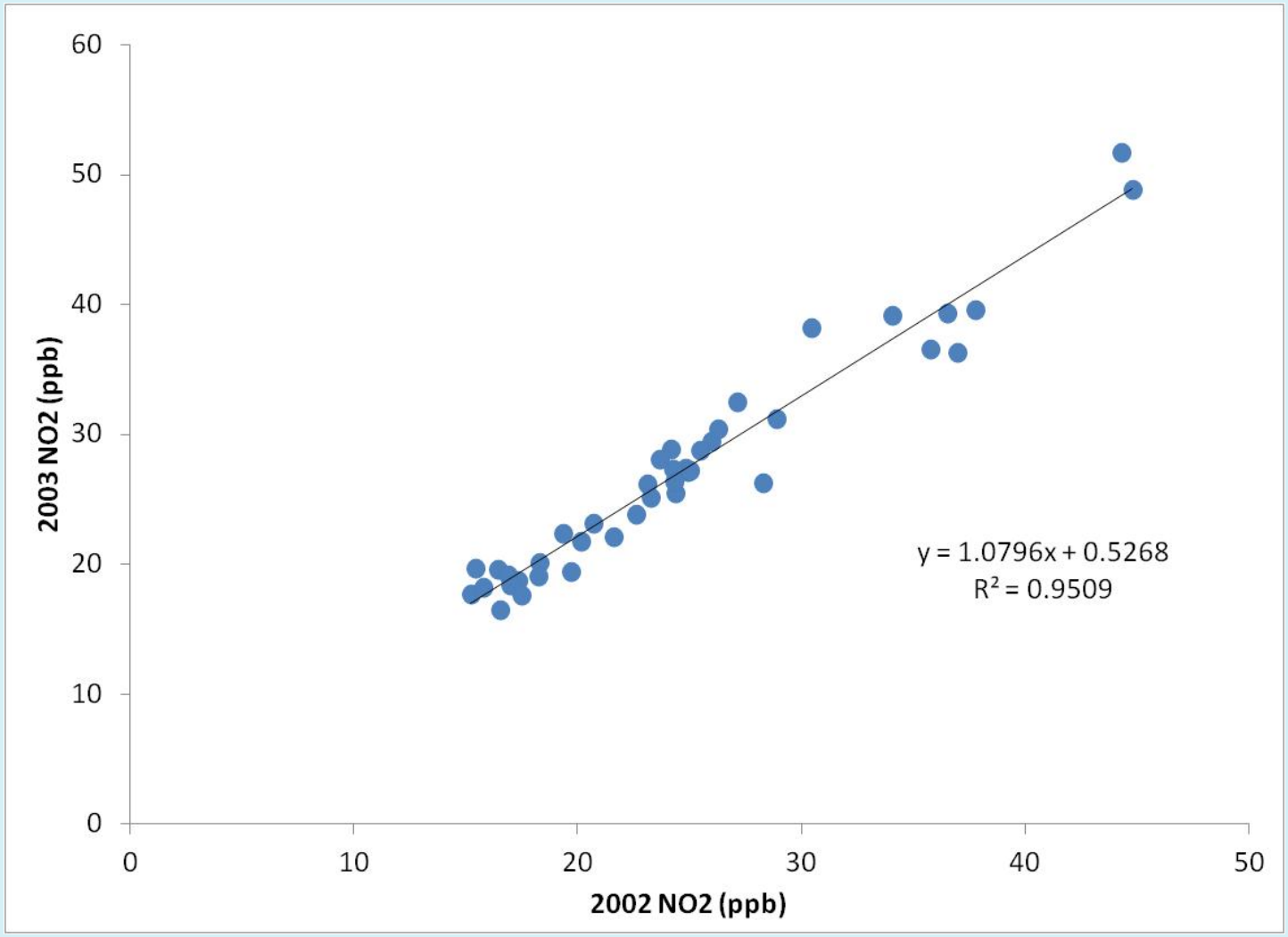
Alan M. Jones [a], Roy M. Harrison [a,*,1], Benjamin Barratt [b], Gary Fuller [b]

[a] Division of Environment Health & Risk Management, School of Geography, Earth & Environmental Sciences, University of Birmingham, Edgbaston, Birmingham B15 2TT, United Kingdom

[b] Gary Fuller and Benjamin Barratt, Environmental Research Group, Kings College, 150 Stamford Street, London SE1 9NH, United Kingdom



Data analysis – When did change happen?
Lastly a technique for annual NO_2 from diffusion tubes



Data analysis – When did change happen?
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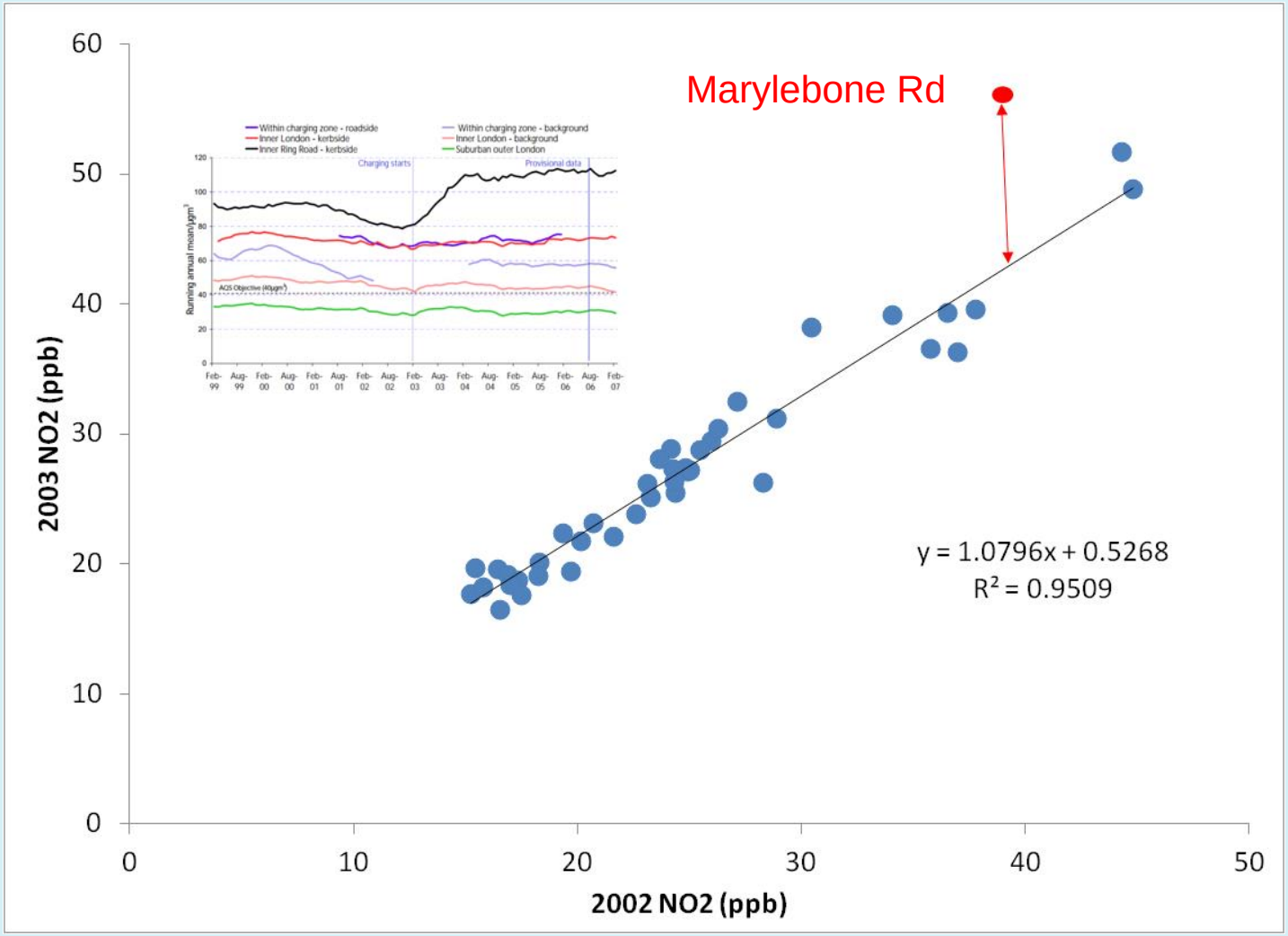

Conclusions

The effectiveness of NO_X abatement is likely to depend on technology employed and needs to be assessed.

NO_X dominates NO_2 near roads.

Continuous chemi-luminesence measurements provide rich datasets for analysis.

Study designs need to allow for control for changes in background, traffic fleet changes and seasonal and weather effects.

Different data analysis methods can tease out the change you are looking for.

Thanks

Thank you all the London boroughs, GLA, Defra and TfL who support the London Air Quality Network enabling this unique London-wide perspective.

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www.londonair.org.uk