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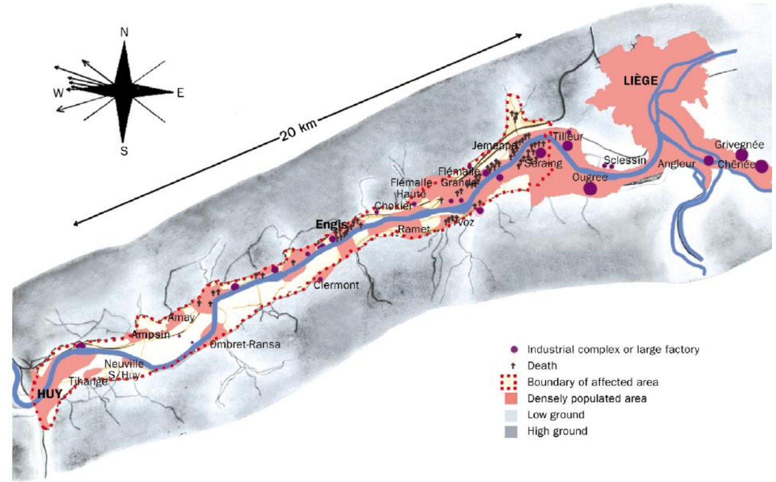
Sixty years of air pollution measurements in London – evolving techniques and advancing understanding

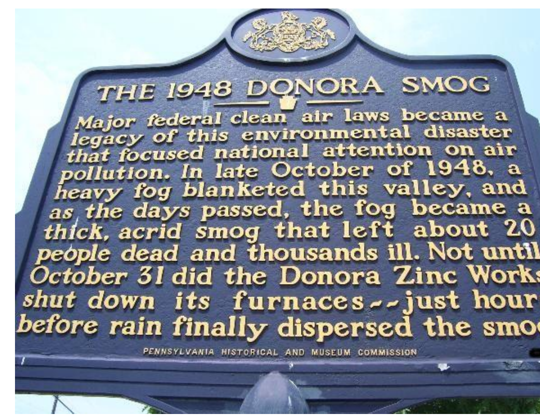
23rd June 2014
LAQN 21 years

Gary Fuller

1952

- **We should have seen the warning signs**
  - **Near Liege, the Meuse Valley smog of 1930 killed 60 people in 3 days (Nemory et al 2001)**
  - **Denora, Pensyviana, 1948 killed 20 out of 15,000 inhabitants and left 6,000 ill.**
  - **But they didn't have measurements**





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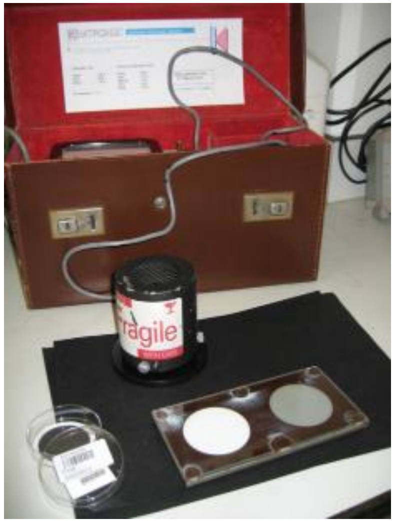
Measurements in 1952



1952

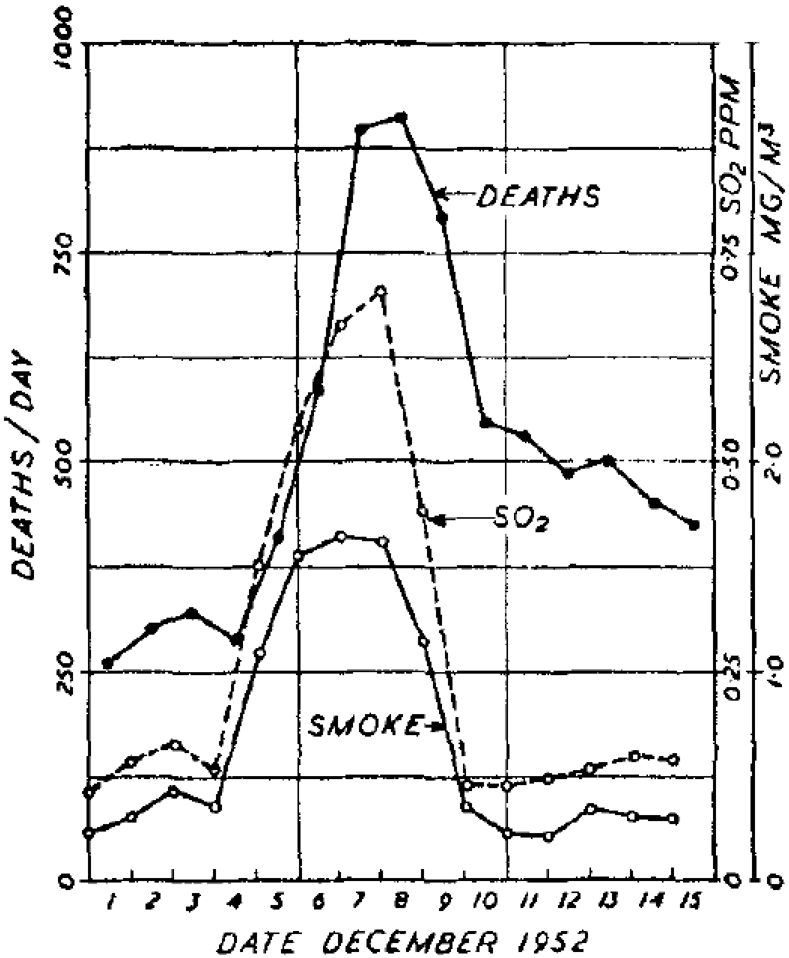


Figure 1. Daily air pollution and deaths.

Air pollution aspects of the London fog of December 1952

By E. T. WILKINS
D.S.I.R., Fuel Research Station, Greenwich

1952

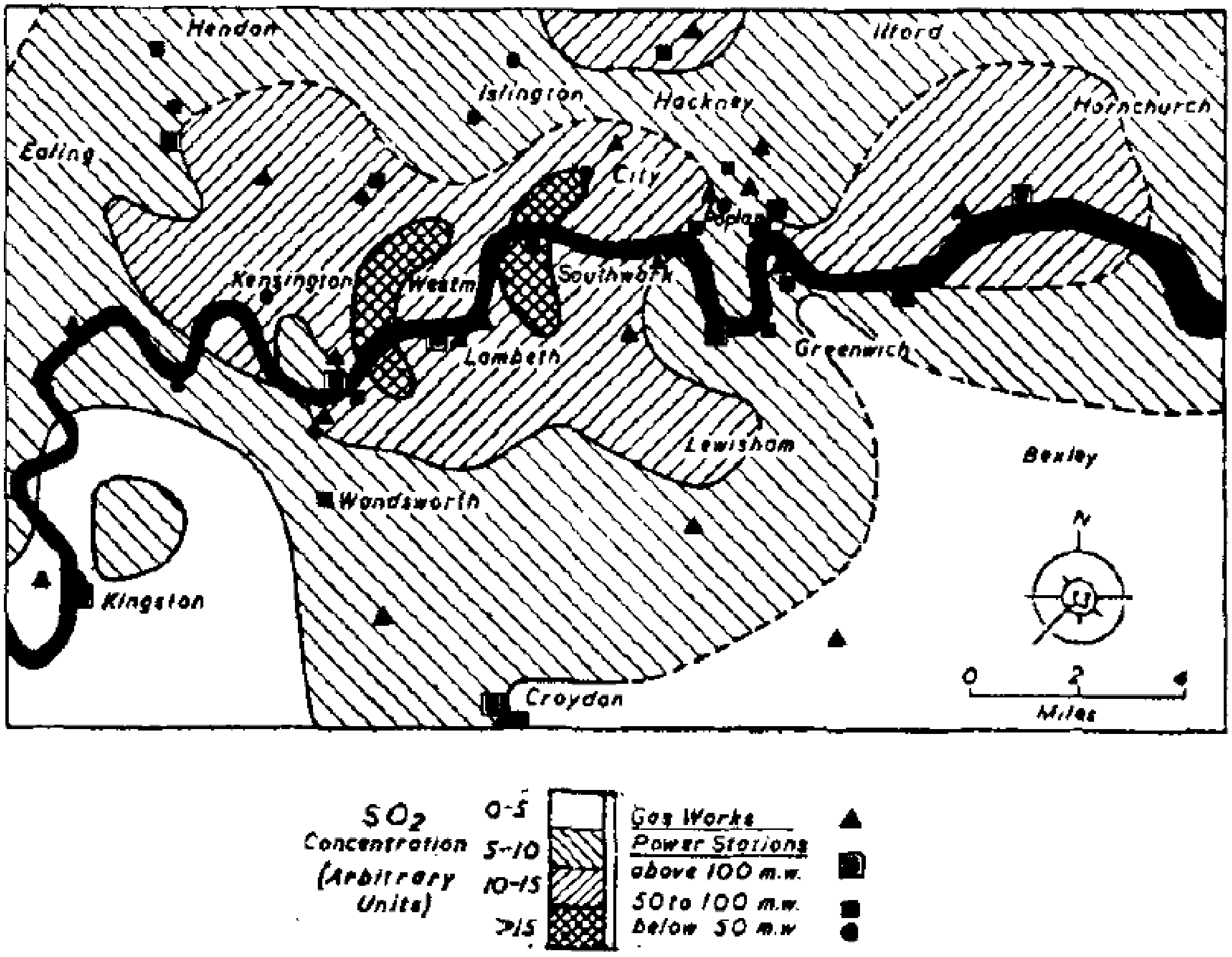
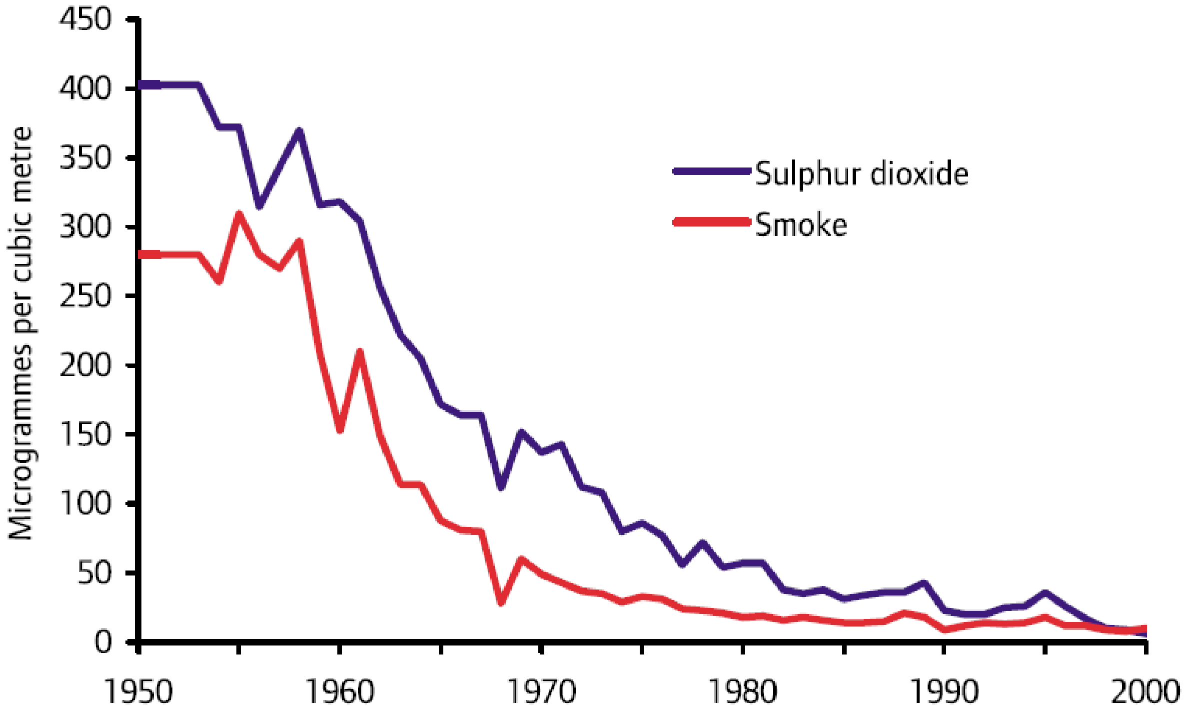


Figure 2. Approximate pattern of pollution by sulphur dioxide, 5 to 9 Dec. 1952.

1970s

- **Clean Air Acts and the wide-spread availability of natural gas meant that London smogs were becoming a thing of the past**



- **GLA, 2002**

1970s – new insights

- **While London was immersed in smoke in LA they were dealing with something different.**
  - **Eye irritation**
  - **Aerosol formation**
  - **Cracking rubber**
  - **Crop damage**

Chemistry and Physiology of Los Angeles Smog

A. J. HAAGEN-SMIT

California Institute of Technology, Pasadena, Calif., and Los Angeles County Air Pollution Control District, Los Angeles, Calif.

June 1952 INDUSTRIAL AND ENGINEERING CHEMISTRY 1343

- **actually O_3 was the subject of the world's first long-term air pollution measurement programme in Paris started 1876 and ran for 34 years – Voltz and Kley, 1983)**

1970

- **Royal College of Physician's Report – Air Pollution and Heath**
  - **"…customary lack of continued bright sunshine…saves Britain from the photo chemistry that causes Los Angeles type smog."**

Measurements in 1973

118 *Nature Vol. 255 May 8 1975*

Long-range transport of photochemical ozone in north-western Europe

R. A. Cox & A. E. J. Eggleton
Environmental and Medical Sciences Division, AERE, Harwell, Oxfordshire, UK

R. G. Derwent*
Air Pollution Division, Warren Spring Laboratory, Stevenage, Hertfordshire, UK

J. E. Lovelock
Department of Applied Physical Sciences, University of Reading, Reading, Berkshire, UK

D. H. Pack
US Department of Commerce—National Oceanic and Atmospheric Administration, Air Resources Laboratory, Silver Spring, Maryland, 20910

- **O3 over levels that would reach ‘high’ on the DAQI over much of the UK in August 1973.**

- **Goes to show that you should never trust air quality scientist who don’t have supporting measurements**

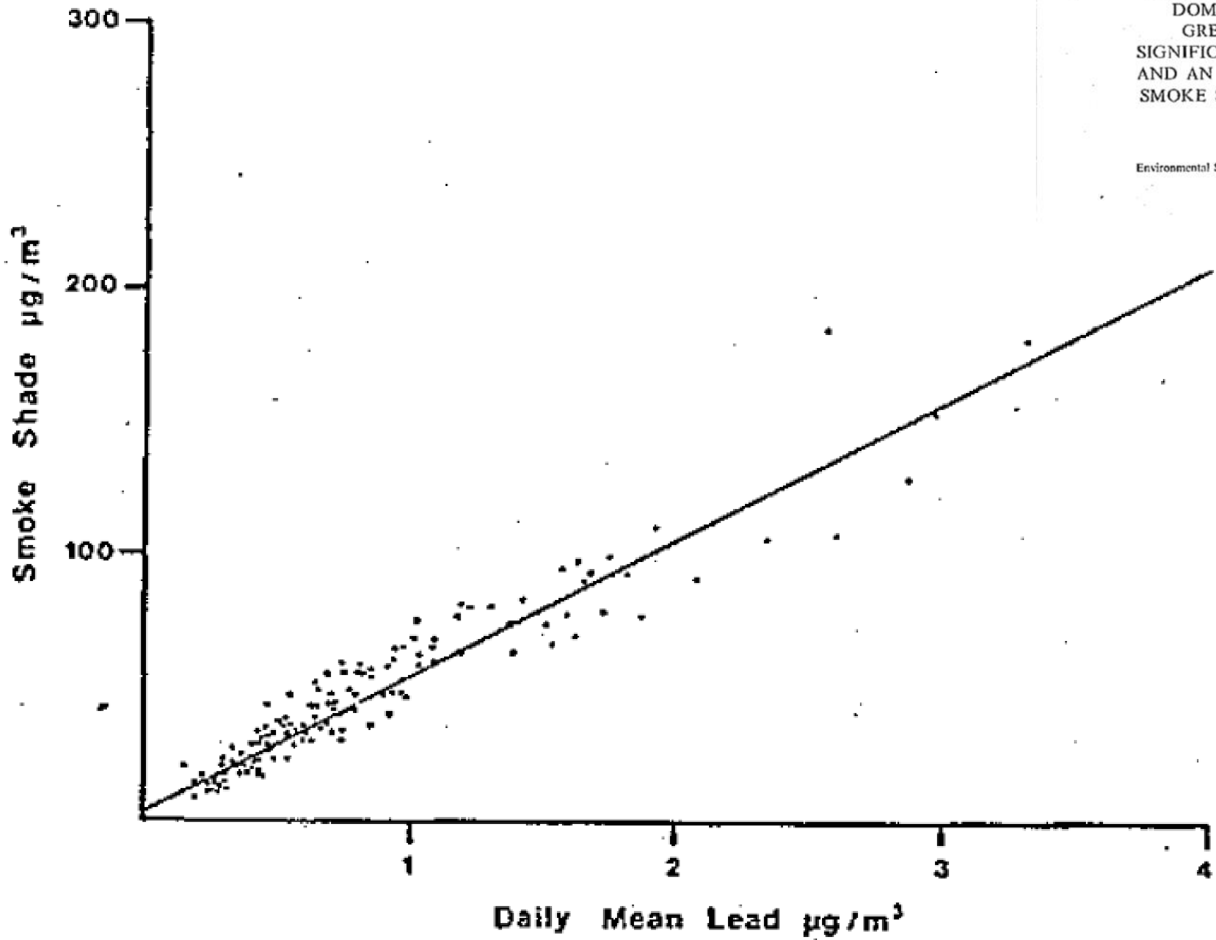
1977 – with London's air cleared

Atmospheric Environment Vol. 11, pp. 1065-1073. Pergamon Press 1977. Printed in Great Britain.

THE RELATIVE IMPORTANCE OF VEHICULAR AND DOMESTIC EMISSIONS OF DARK SMOKE IN GREATER LONDON IN THE MID-1970s, THE SIGNIFICANCE OF SMOKE SHADE MEASUREMENTS, AND AN EXPLANATION OF THE RELATIONSHIP OF SMOKE SHADE TO GRAVIMETRIC MEASUREMENTS OF PARTICULATE

D. J. BALL and R. HUME
Environmental Sciences Group, Scientific Branch, Greater London Council, The County Hall, London SE1 7PB, England

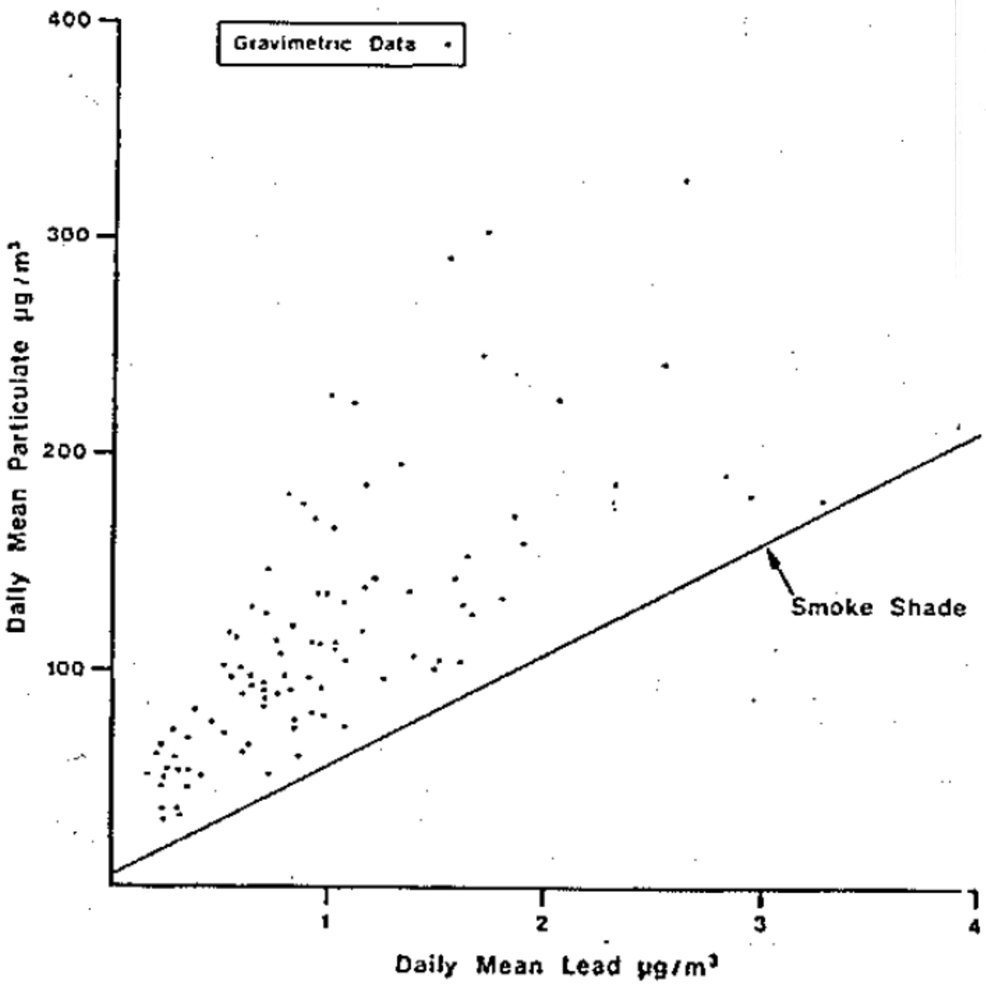
(*Received* 17 *January* 1977)



Scatter diagram of daily apparent smoke concentrations determined by the smoke shade technique vs daily airborne lead concentrations as measured at the County Hall.

1977 – with London's air cleared

Something not black was there in the PM mass concentration



Scatter diagram of daily gravimetrically determined particulate concentrations vs daily airborne lead concentrations for the County Hall site.

Atmospheric Environment Vol. 11, pp. 1065-1073. Pergamon Press 1977. Printed in Great Britain.

THE RELATIVE IMPORTANCE OF VEHICULAR AND DOMESTIC EMISSIONS OF DARK SMOKE IN GREATER LONDON IN THE MID-1970s, THE SIGNIFICANCE OF SMOKE SHADE MEASUREMENTS, AND AN EXPLANATION OF THE RELATIONSHIP OF SMOKE SHADE TO GRAVIMETRIC MEASUREMENTS OF PARTICULATE

D. J. Ball and R. Hume

Environmental Sciences Group, Scientific Branch, Greater London Council, The County Hall, London SE1 7PB, England

(*Received* 17 *January* 1977)

1993 The advent of the LAQN

London’s air pollution measurement infrastructure and expertise had been largely dismantled

Questions were being asked about the possible public health implications of new industry being proposed for the east Thames corridor.

No London-wide perspective

Some government & local authority measurements but not collected centrally and no consistent QA/QC

1993 The advent of the LAQN

South East Institute of Public Heath (then part of the NHS)

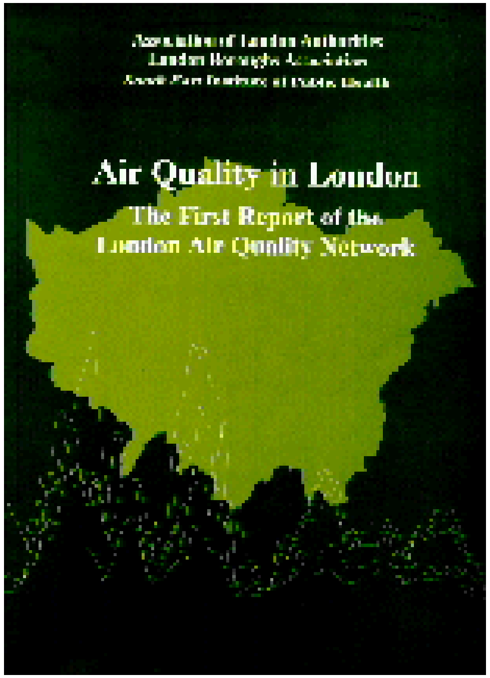
Collaborative agreement with the NHS and the two (!) bodies representing London boroughs

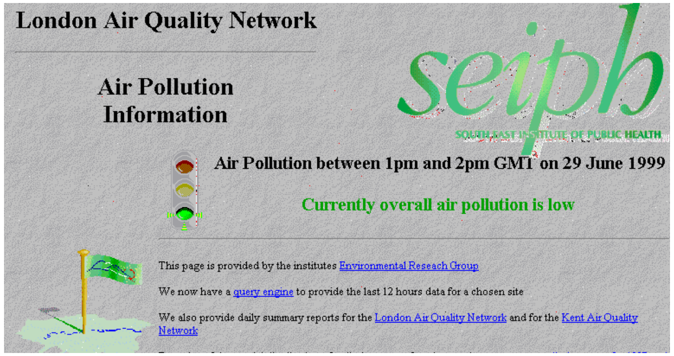
Local authority monitoring sites in

- Bexley, Bromley, City, Greenwich, Islington, Hounslow

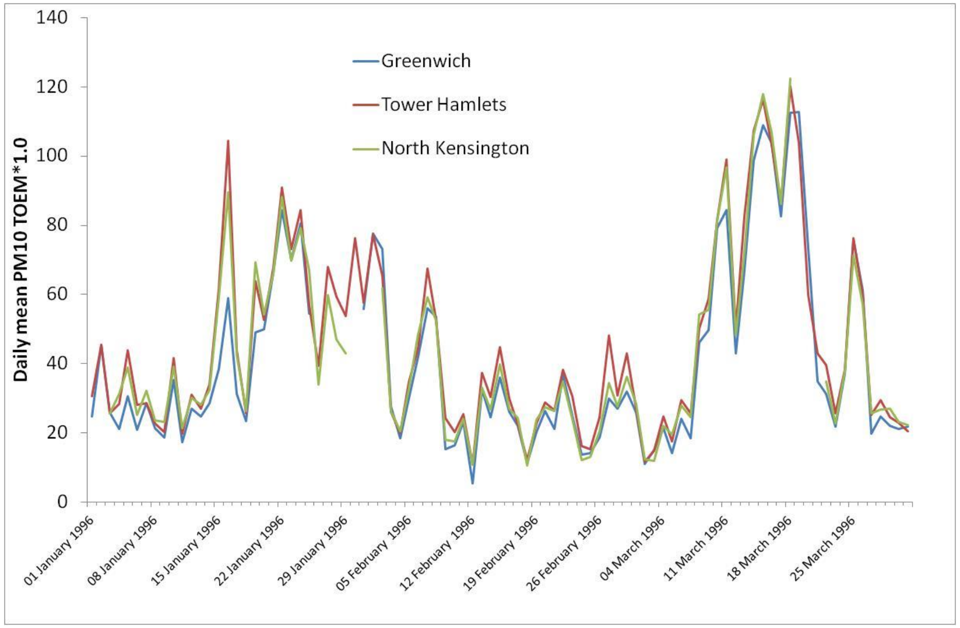
- DoE sites in central London

SEIPH provided technical / scientific support, QA/QC, central data collection and public information.



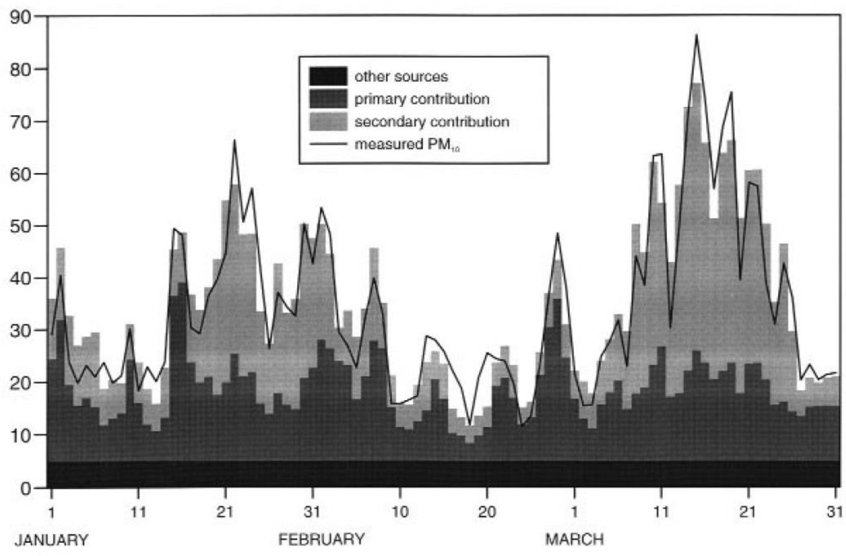


The 1996 PM10 episode



".. Since PM10 measurements only commenced in the UK in 1992 it is not clear how often we can expect this type of episode again"

Stedman (1996).



Source Apportionment of Airborne Particulate Matter in the United Kingdom

Prepared on behalf of the
Department of the Environment, Transport and the Regions, the Welsh Office, the Scottish Office and the Department of the Environment (Northern Ireland)

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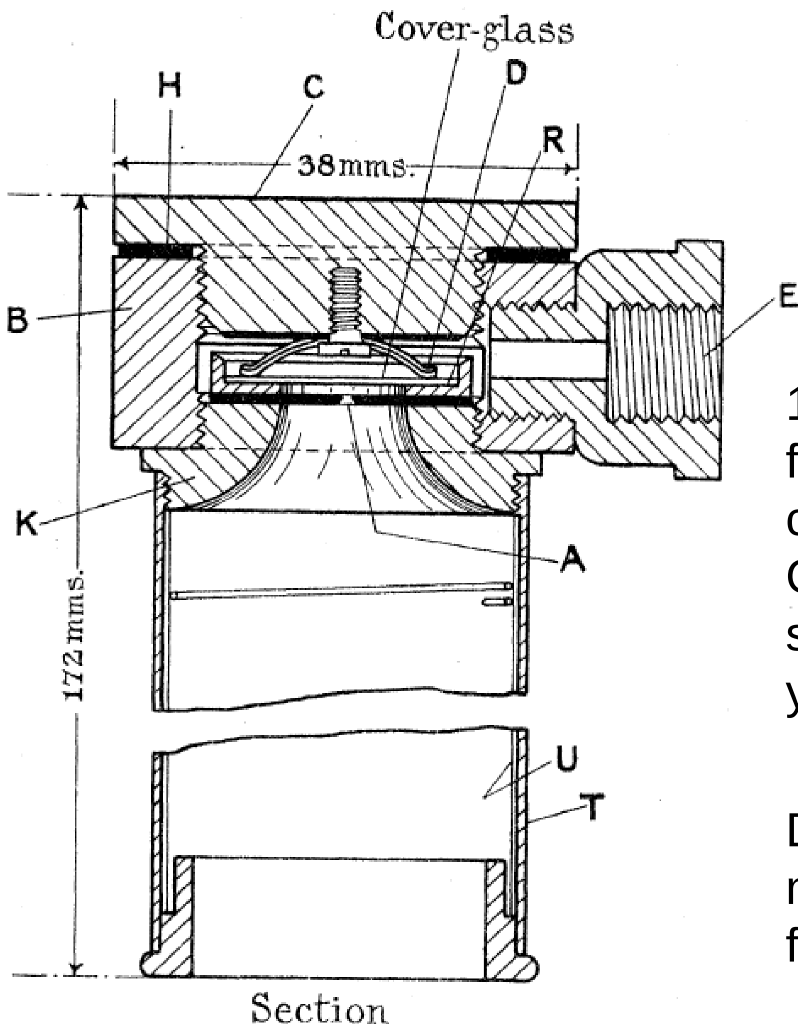
MRC Medical Research Council
Imperial College London
King's College London

Did secondary PM start in 1996 or 1977?



Suspended Impurity in the Air

J. S. Owens

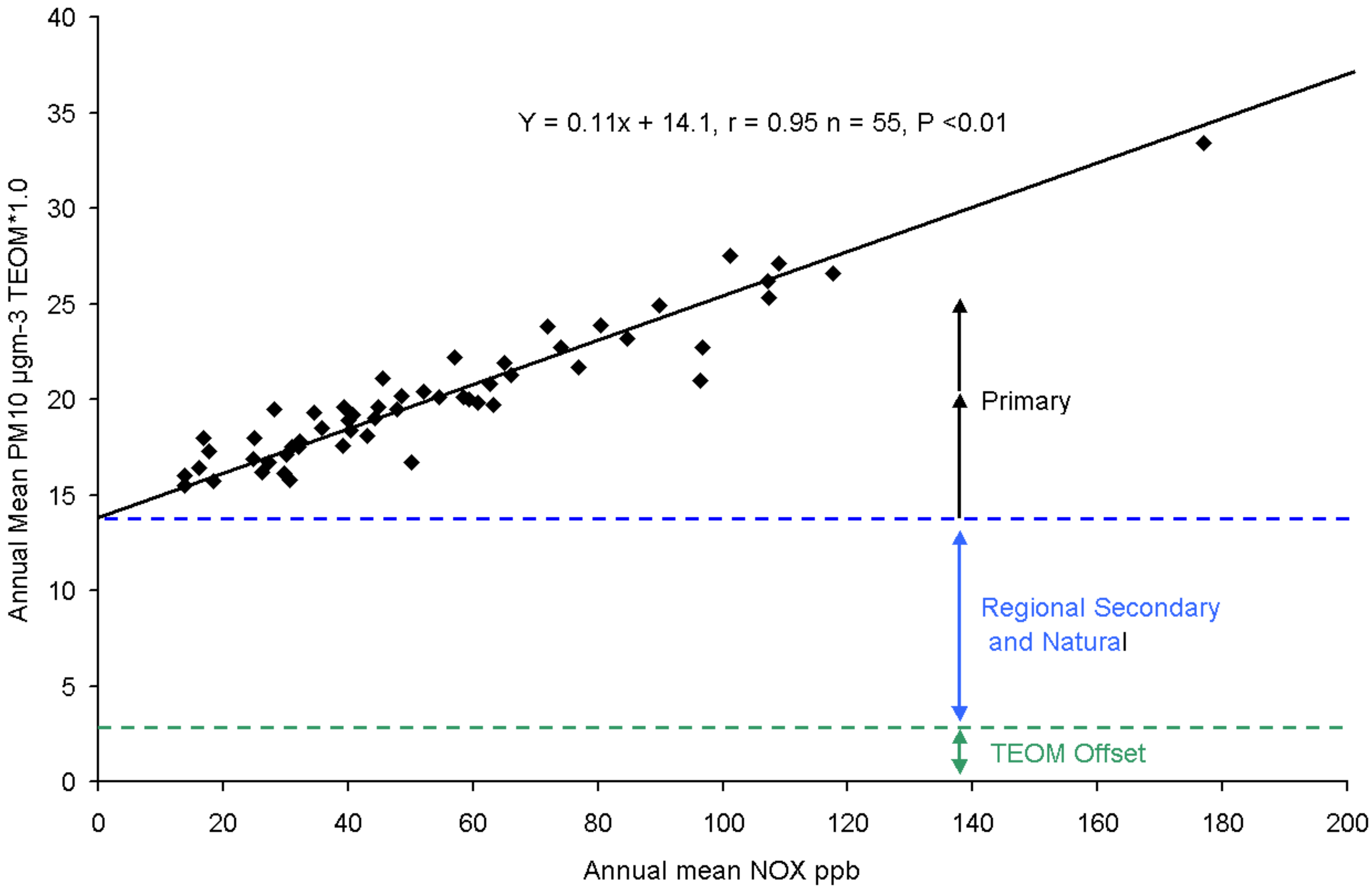
Proc. R. Soc. Lond. A 1922 **101**, doi: 10.1098/rspa.1922.0023, published 1 April 1922

1922 - while on holiday in Norfolk, Owens found particulate on winds from the continent and thought this to be due to German industrialization - measured wind speeds by chasing thistle seeds over 50 yards of beach.

Did we miss the secondary PM episodes for most of the 20th century since we were focused on measuring black smoke?

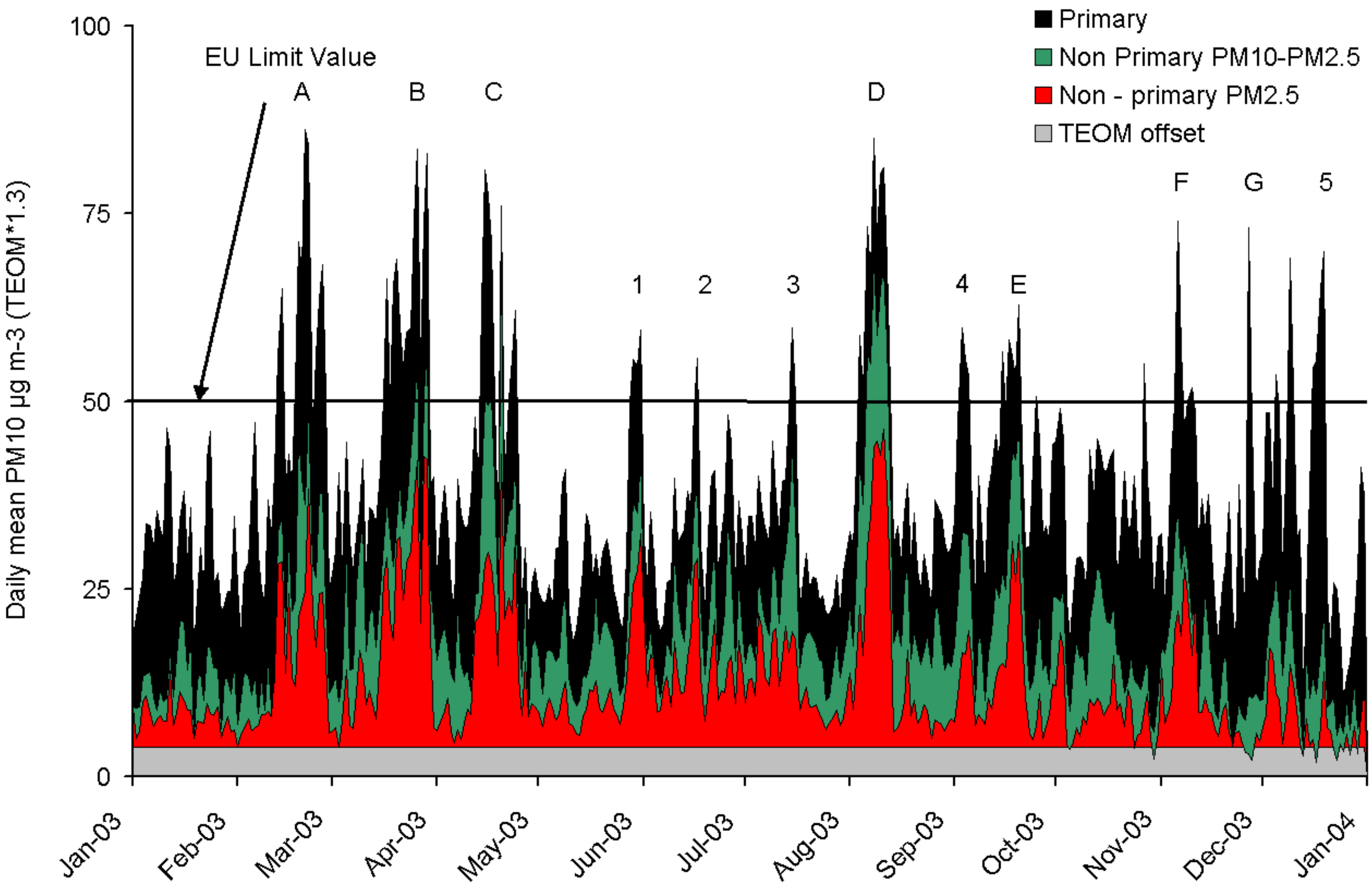
PM10 source apportionment using the whole LAQN

Fuller et al 2002, 2006



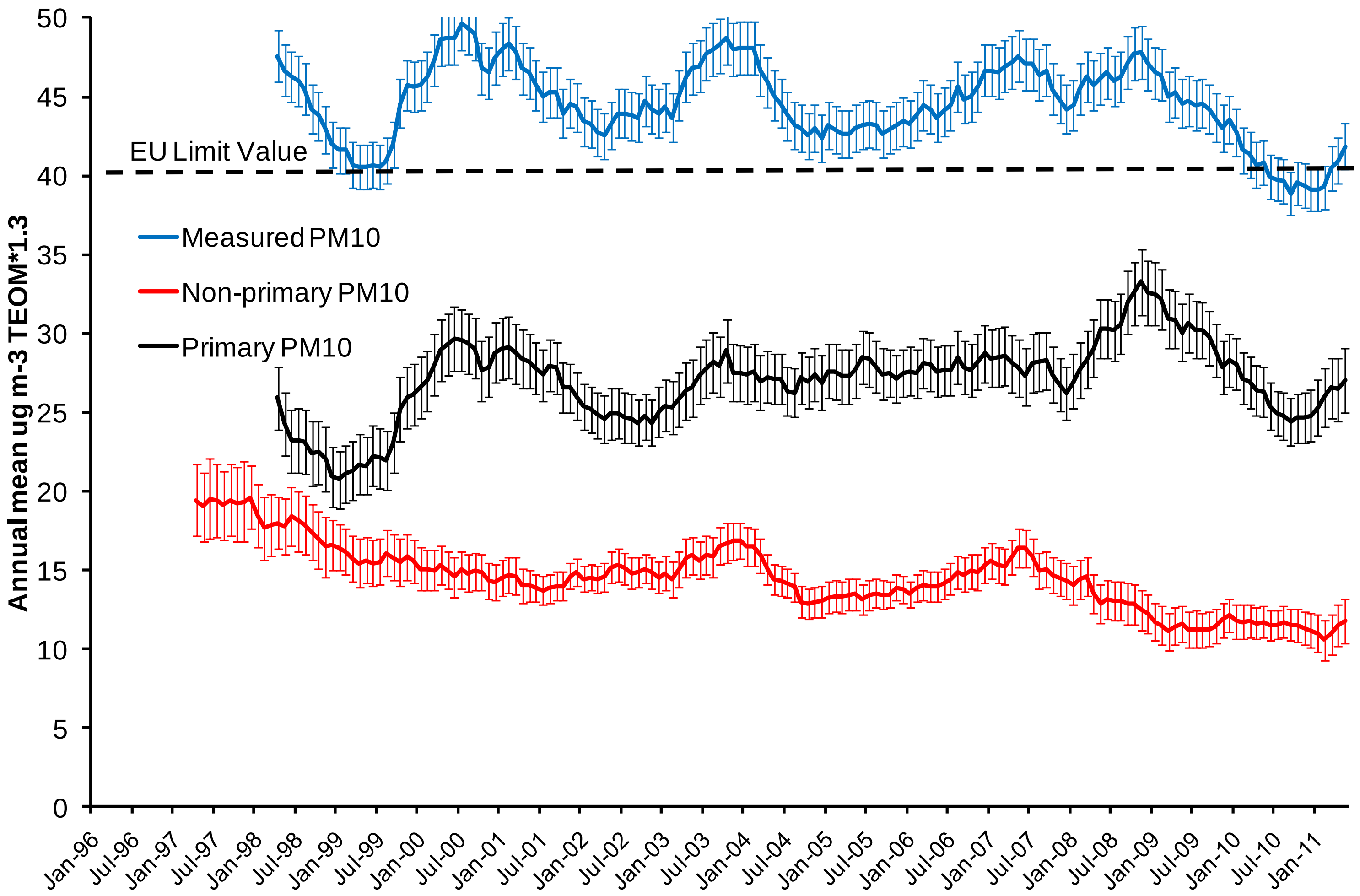
PM10 source apportionment using the whole LAQN

Fuller and Green 2006

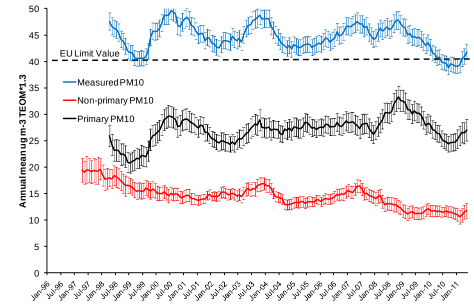


PM10 source apportionment using the whole LAQN

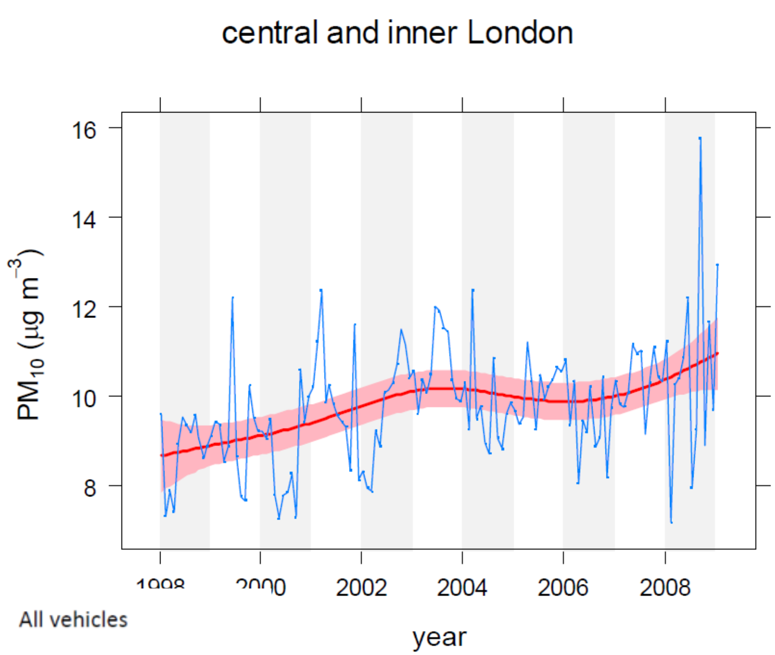
PM10 at Marylebone Road methods from Fuller and Green 2006



But shouldn't PM10 concentrations be going down?



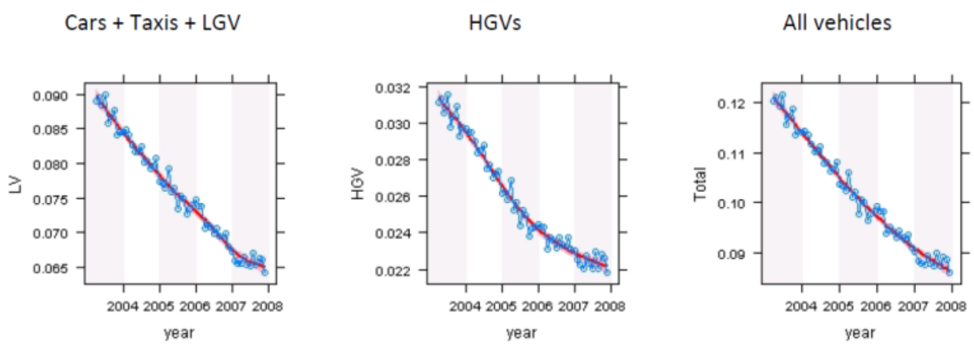
- PM10 source apportionment showed increasing roadside concentrations
- "De-weathering" local PM10 also showed increases
- But emissions all tend down



Beevers et al 2010,

PM10 apportionment as per Fuller and Green 2006

PM_{10}
Central sites



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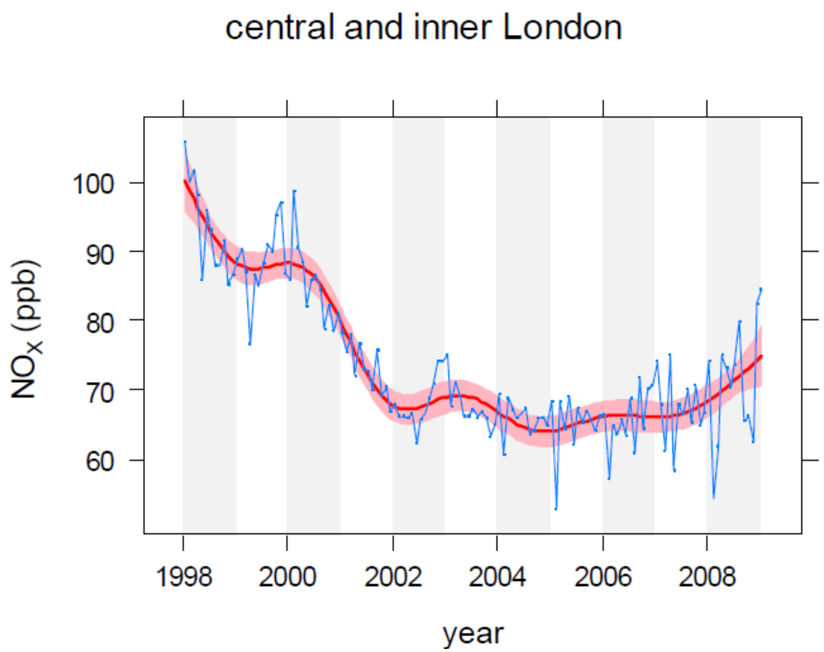
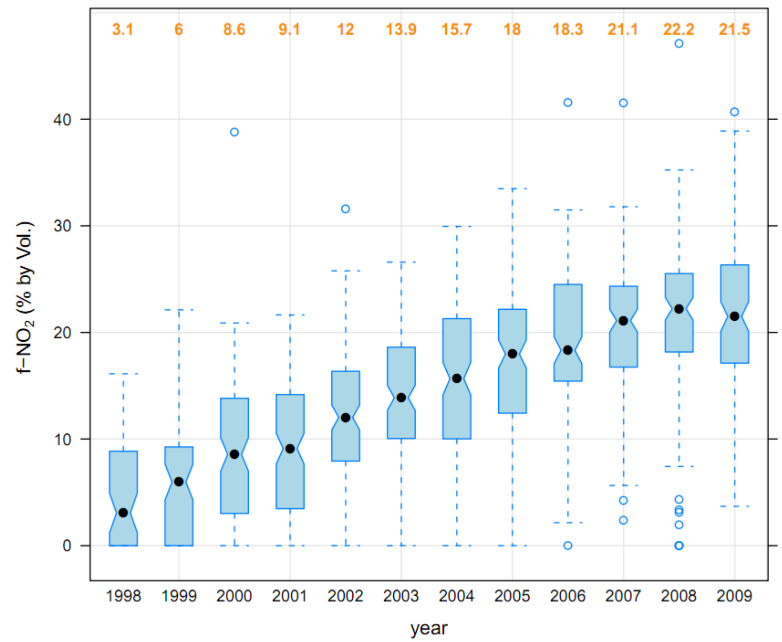
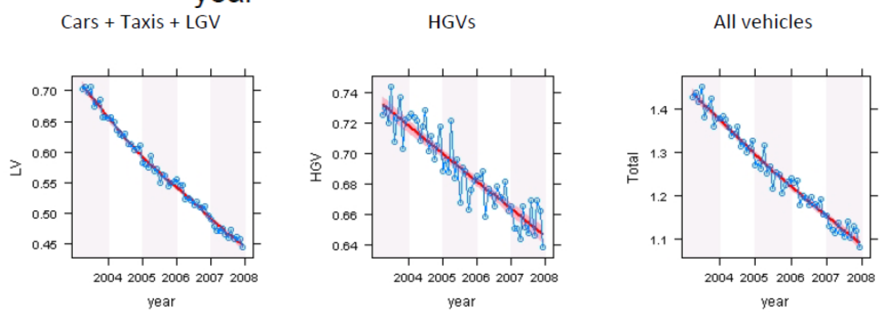
The network perspective also showed problems with NOX and NO2 fourteen years ago

Beevers et al 2010, Carslaw et al 2001 but also see Clapp and Jenkins 2001 and Carslaw et al 2001





NO_X emissions
Central sites



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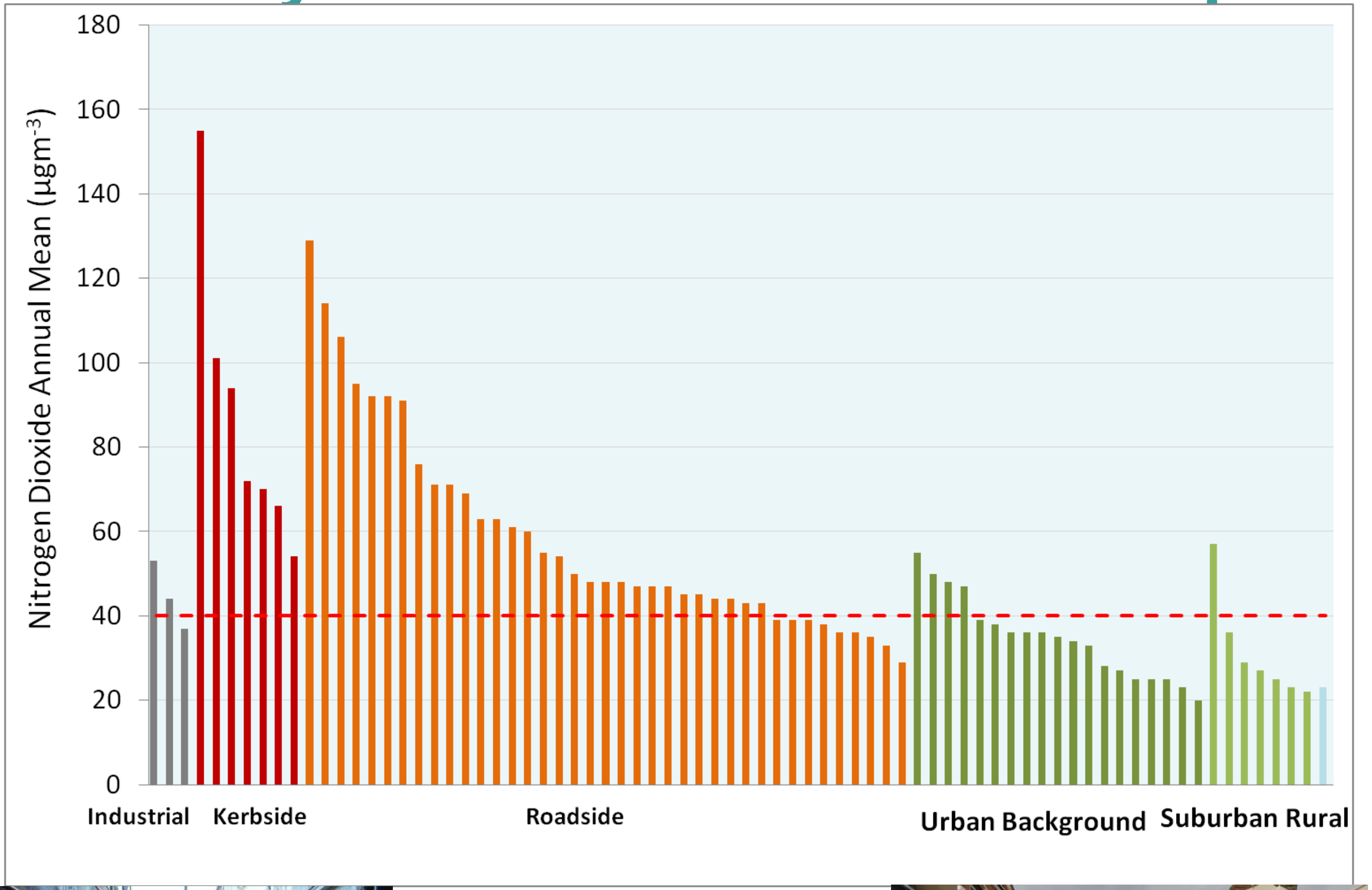
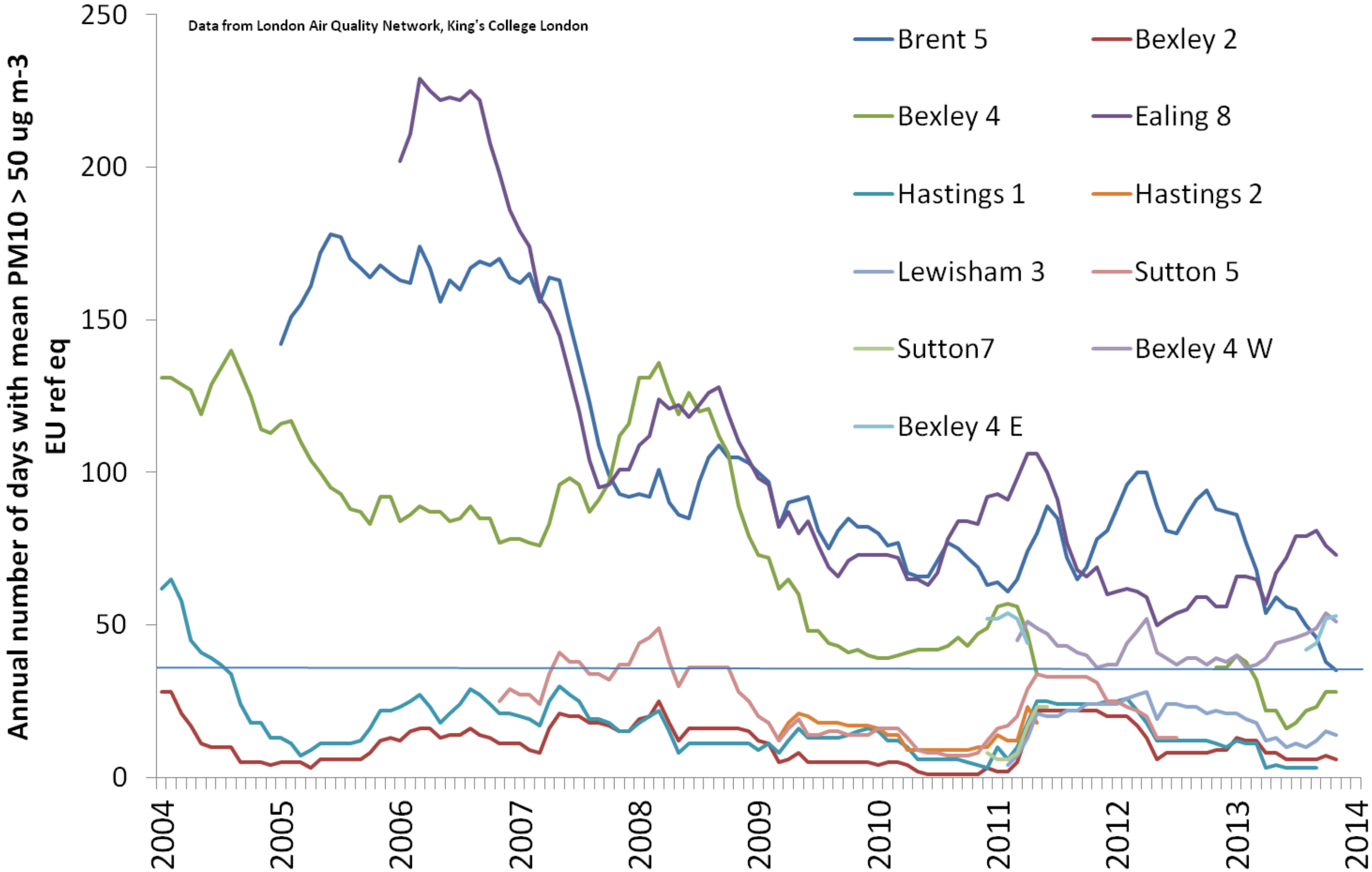
Measurements in new locations showed extraordinary NO2 where is was not expected.



Unexpected PM10 too – waste sites

Extensive studies since 2000



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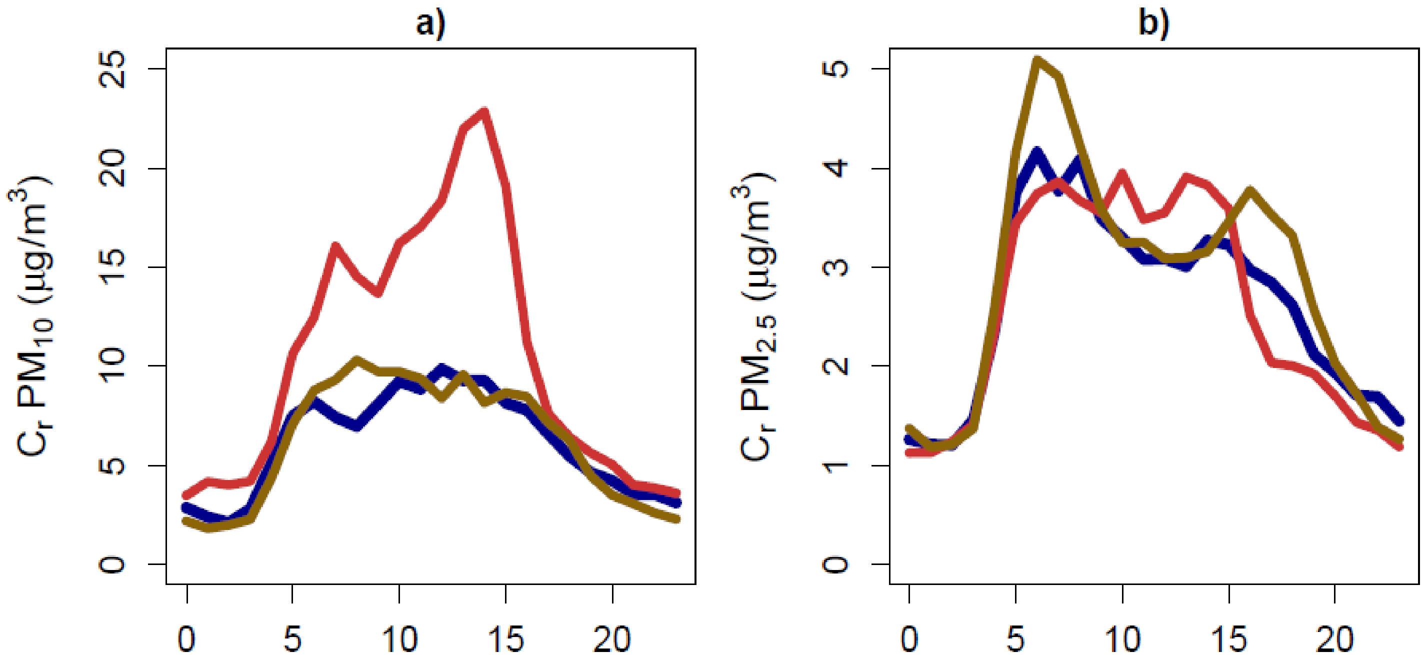
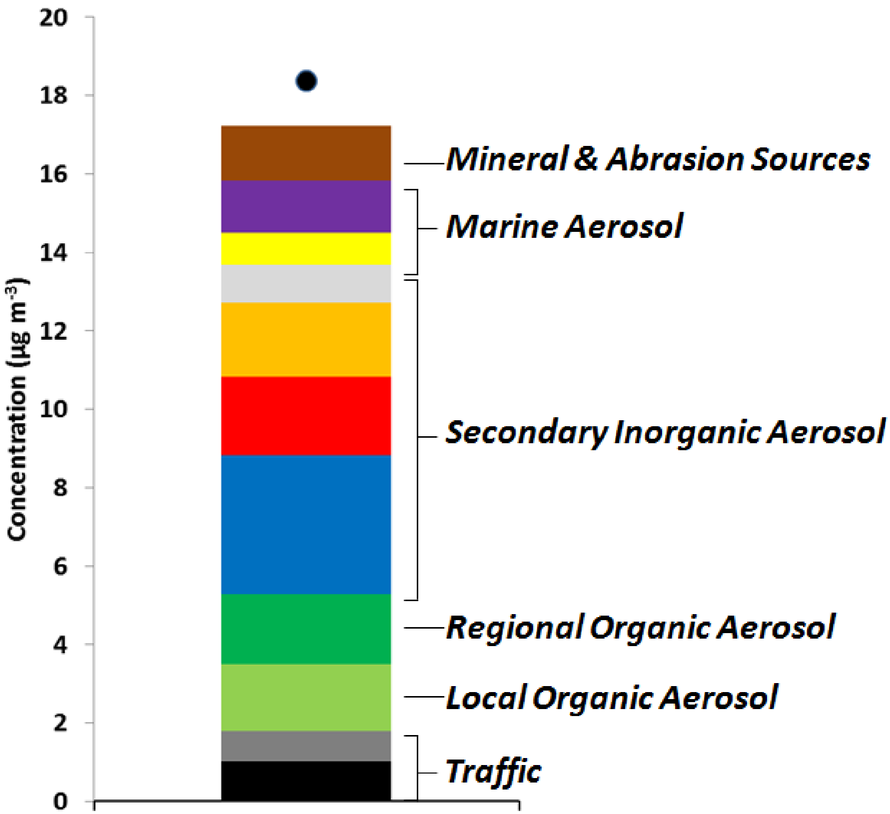
Unexpected PM10 too – construction sites

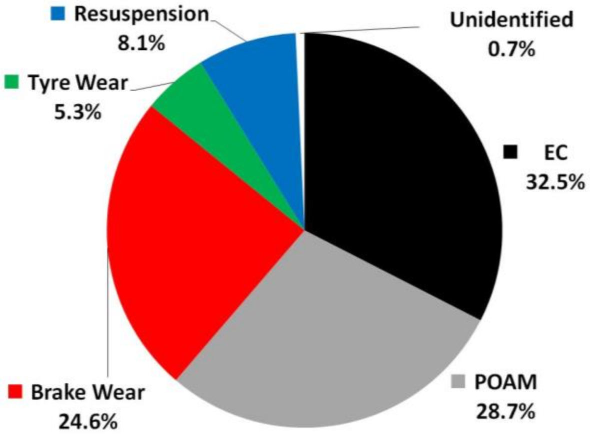
First explored in Fuller et al 2004.

Font et al 2014 (in revision) Blue = before, Red = during, Brown = after



PM10 chemical composition





Analysis from David Green, KCL

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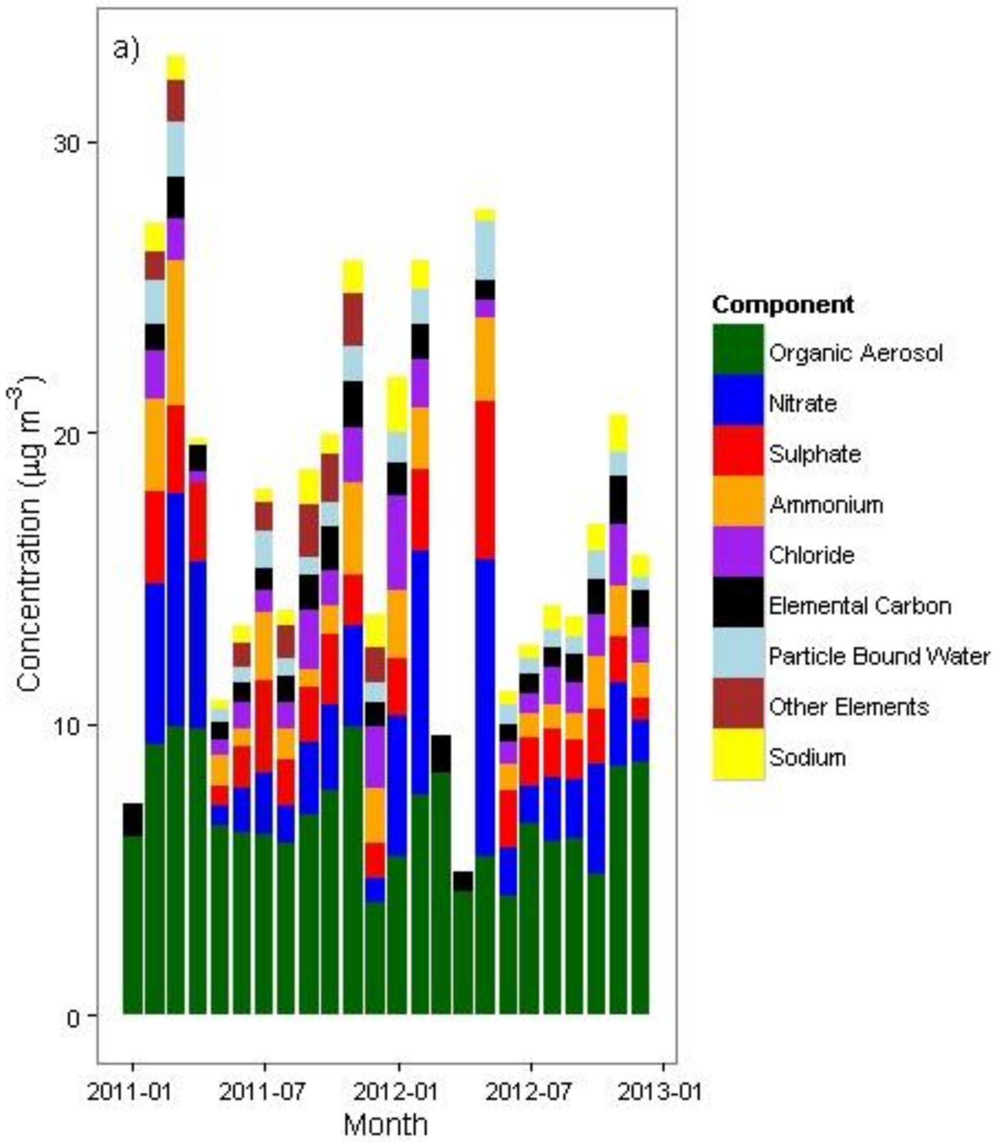
PM10 chemical composition



Analysis from David Green, KCL

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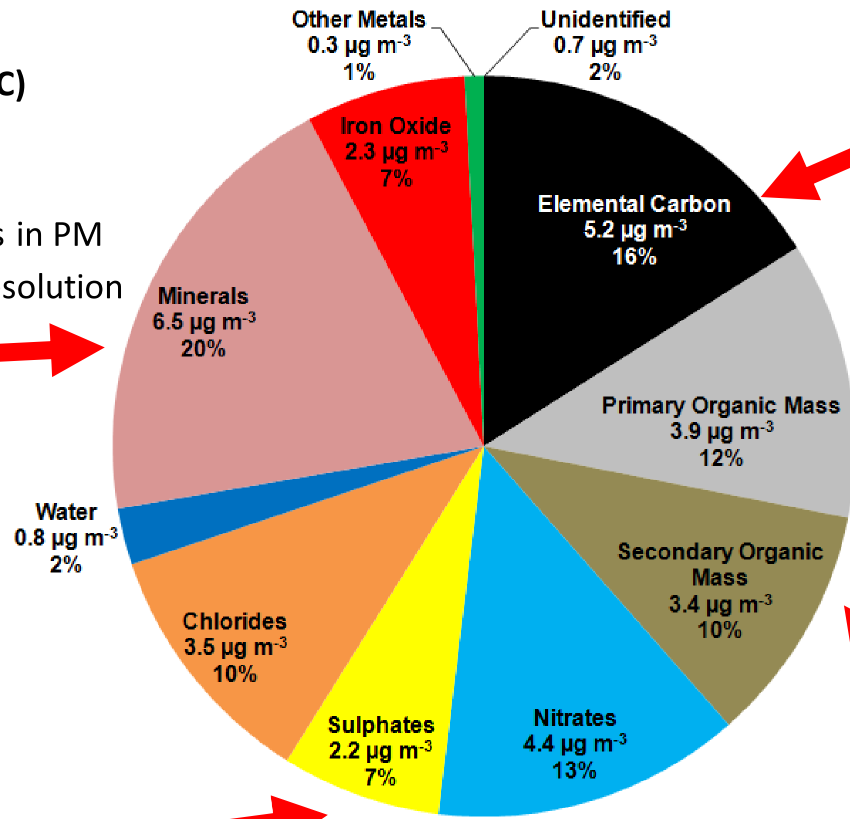
Future - time resolved PM10 composition

- Daily measurements of chemical composition provide limited opportunities to match concentrations to sources

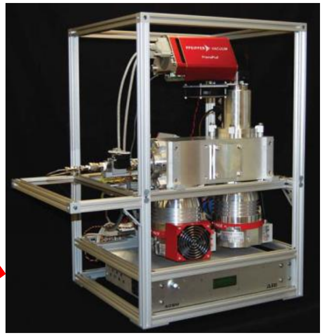
- Time resolved measurements will offer new ways of source attribution

Time resolved PM10 chemical composition

XACT 625 (NERC)
- Real time XRF
- Elemental concentrations in PM
- Hourly time resolution



Aethalometer (DEFRA)
- Real time black carbon
- 5 min time resolution

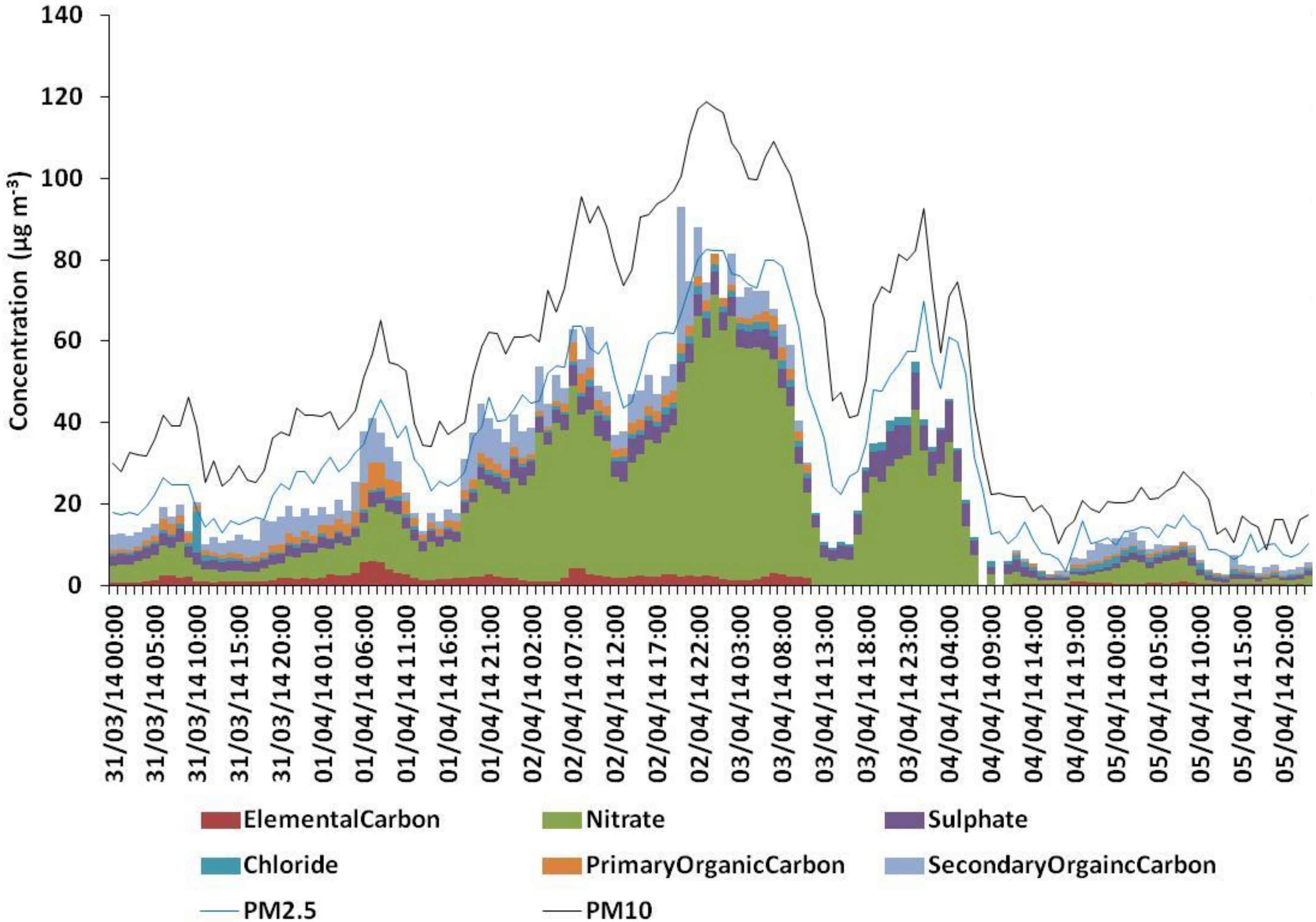


URG 9000 (DEFRA)
- Real time IC
- Anion and cation concentrations in PM
- Hourly time resolution

Aerosol Chemical Speciation Monitor
- Real time non-refractory aerosol
- Sulphate, nitrate, ammonium, organics
- 15 minute time resolution
- Organic source apportionment (vehicle / biogenic etc) using PMF
- Started with ClearfLo

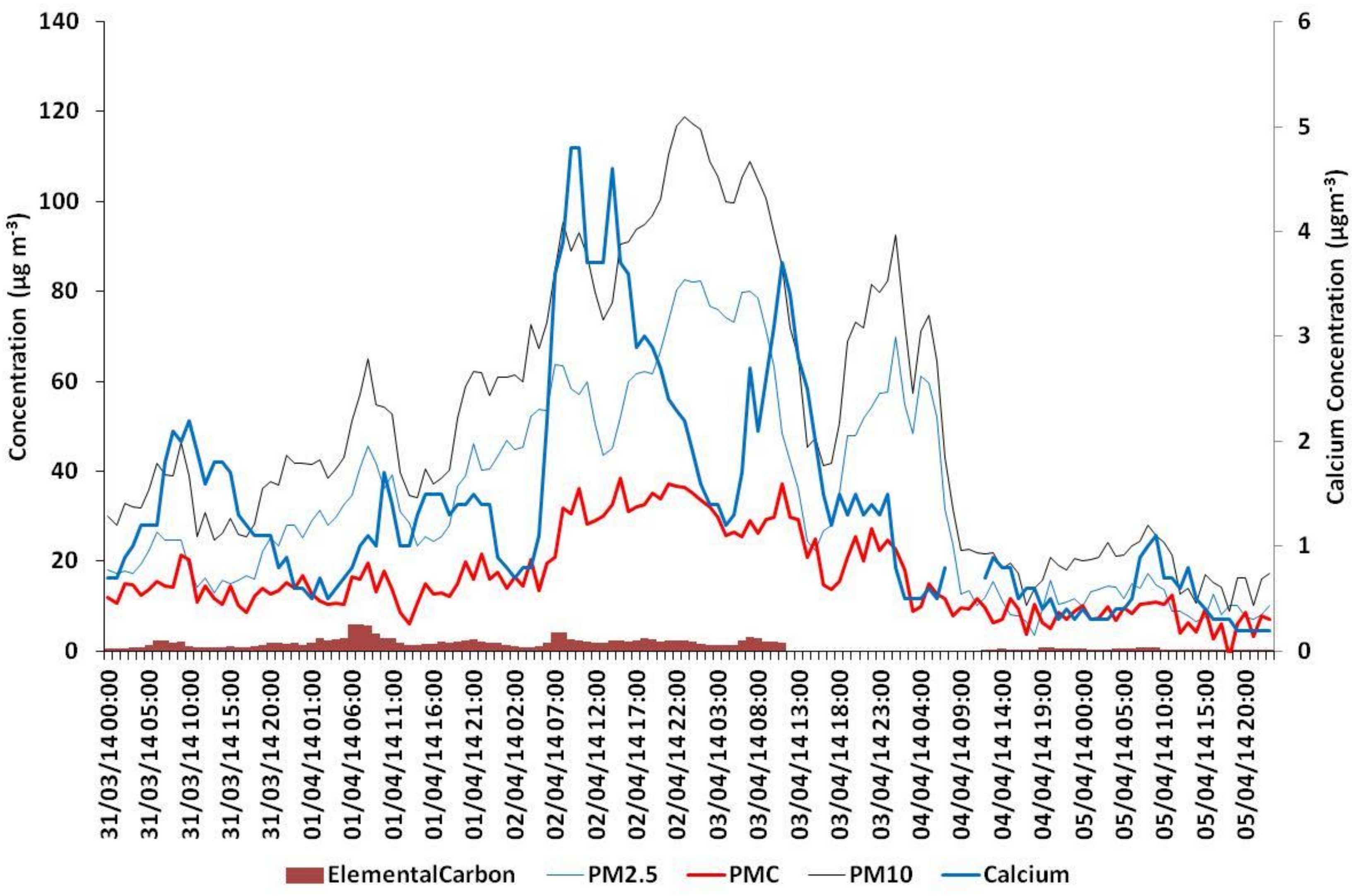
Analysis from David Green, KCL

“Airmageddon” the so called Saharan sand episode



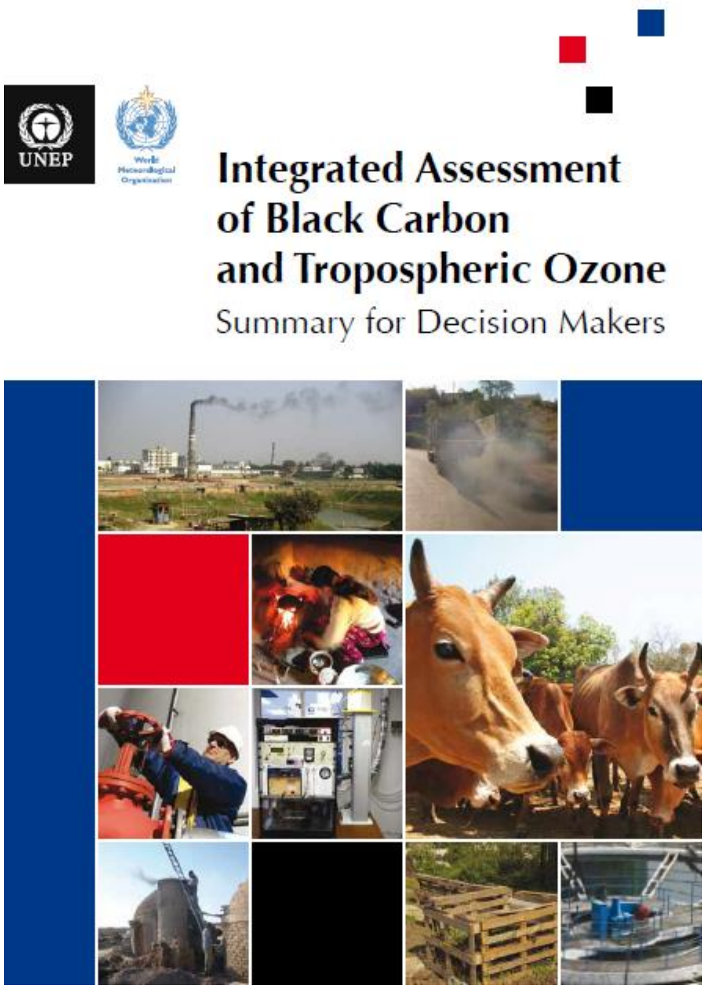
Analysis from David Green, KCL

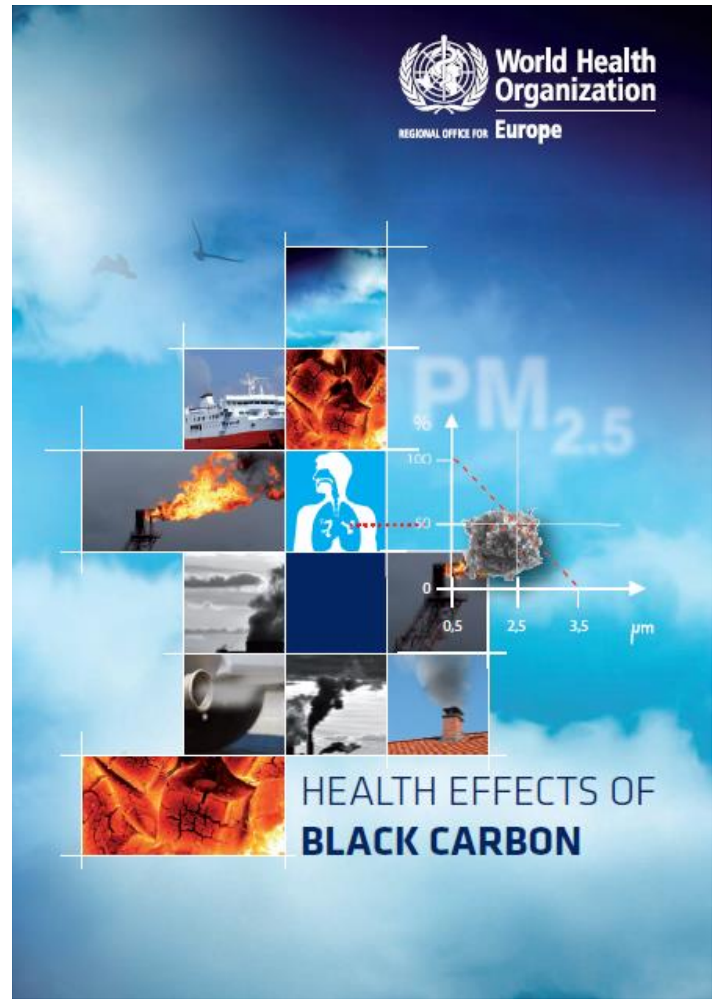
“Airmageddon” the so called Saharan sand episode



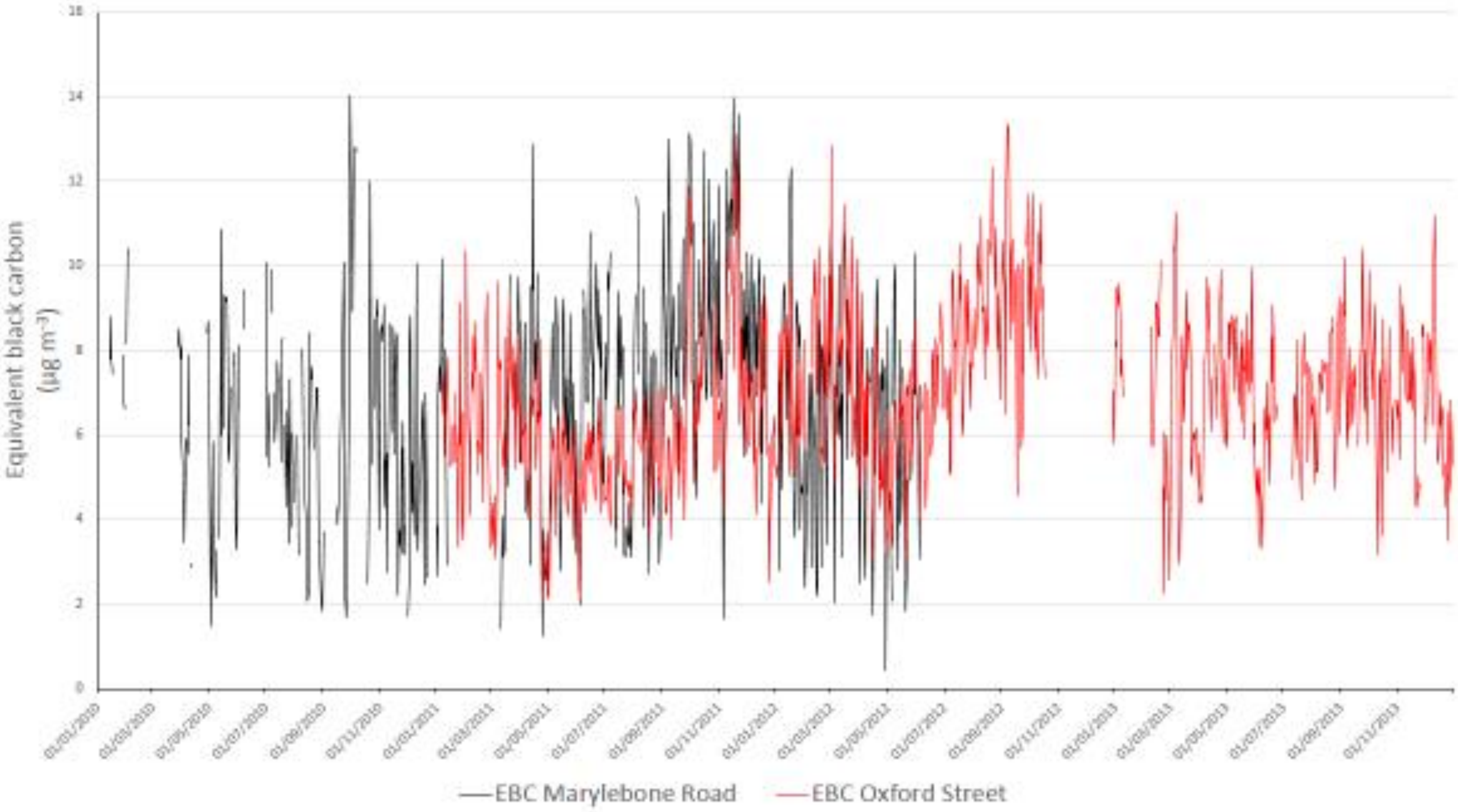
Analysis from David Green, KCL

And finally back to black stuff in air again





Optical measurements of black carbon on filters

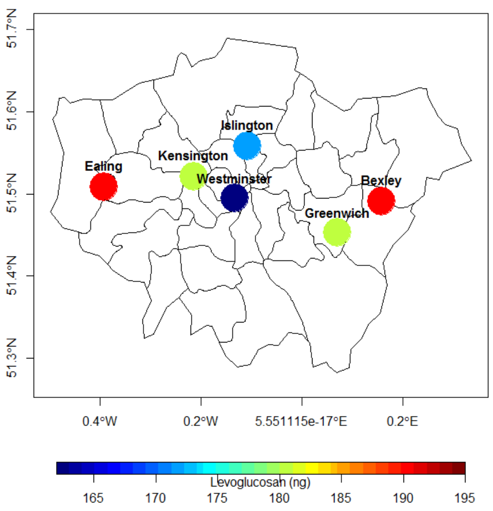


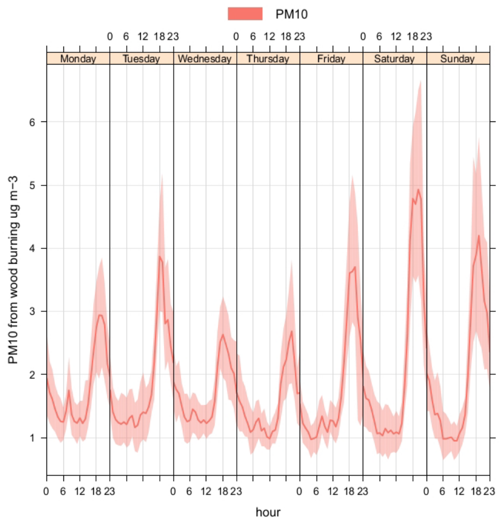
Pam Davy, PhD thesis

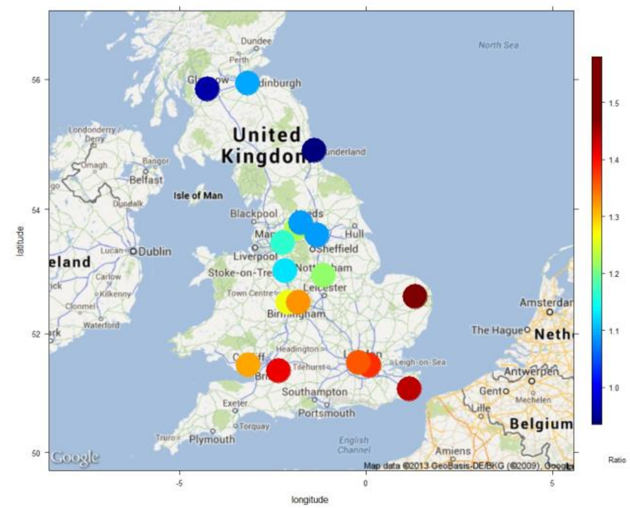
Wood burning – solid fuel is back in fashion

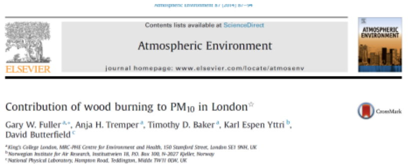
When designing the study we feared that our sample size would be too small to detect anything..

Wood burning is mainly **winter** source. Mean **wintertime PM** from wood between **1.1 and 2.5 µg m-3**. Across ten UK cities **wood burning** comprised **~2 - 7 %** of **annual mean PM10 and 3 - 13% in wintertime**





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ATMOSPHERIC ENVIRONMENT

Contribution of wood burning to PM_{10} in London

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[b] Norwegian Institute for Air Research, Instituttveien 18, P.O. Box 100, N-2027 Kjeller, Norway
[c] National Physical Laboratory, Hampton Road, Teddington, Middx TW11 0LW, UK

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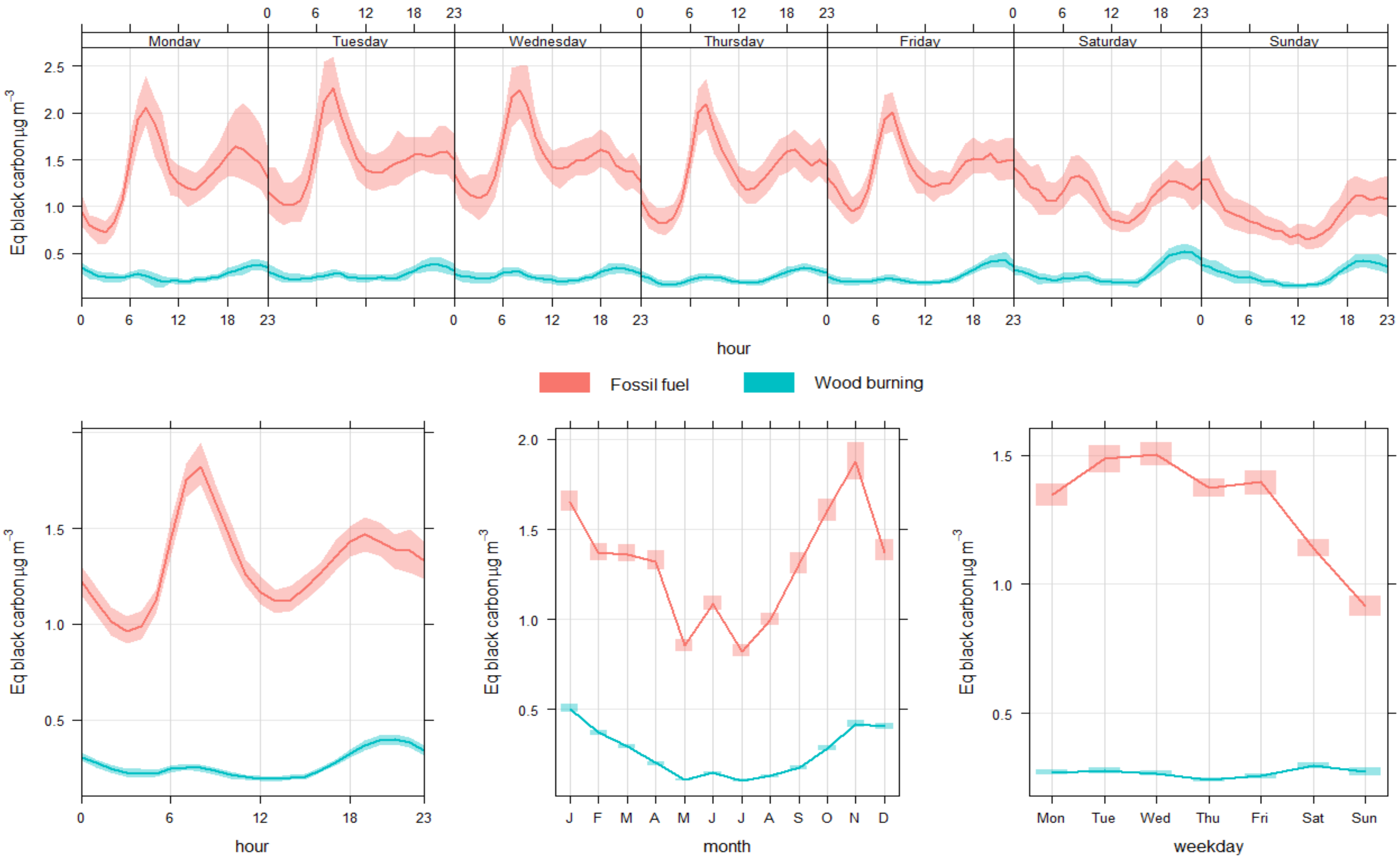
Wood burning – solid fuel is back in fashion



Fuller et al 2014.

Conclusions

- Air pollution measurements have provided understanding of London’s air. Our 21 years are part of a longer story of new insights.

- The London Air Quality Network is unique:

    - Largest and most advanced air pollution network in Europe.

    - Innovation in measurement techniques and public information.

    - With a university at its centre the network perspective takes us beyond compliance assessment to explain the effects of sources and ultimately their links to health

    - Essential for optimised policy and to determine if air pollution management working

Photo: CleanAir London

Public information has come a long way too