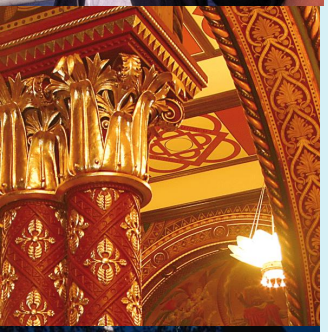

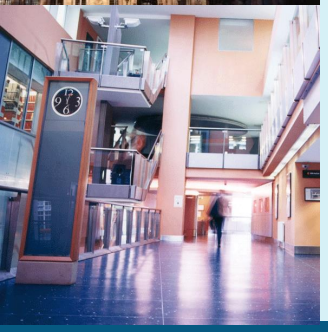

KING'S College LONDON

MRC-PHE Centre For Environment &Health
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Air quality impacts of domestic wood burning

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Karl Espen Yttri – NILU

David Butterfield - NPL

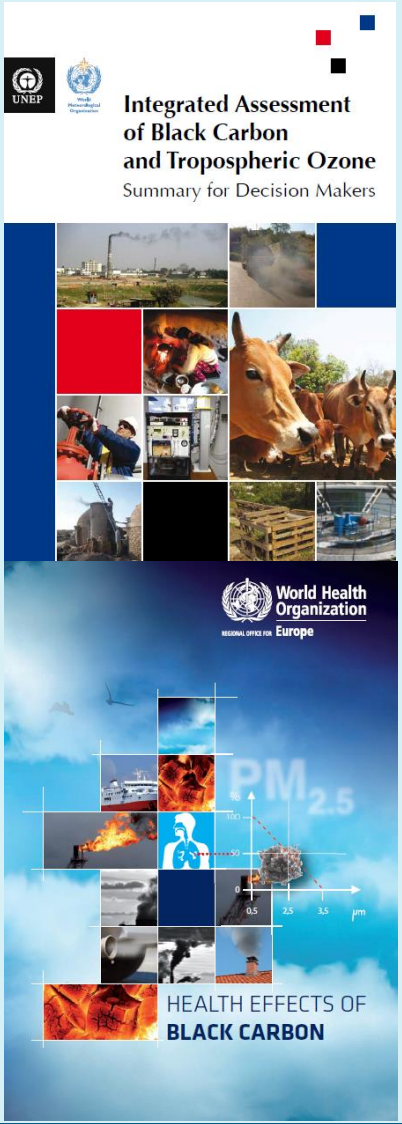
Contents

Why are we concerned about black carbon and PM from wood burning?

Background – black carbon

Black carbon is a short-term climate forcer as highlighted by recent UNEP assessment (UNEP, 2011; Shindell et al 2012; Shine et al 2007).

Black carbon has been shown to be a better predictor of short-term air pollution health effects than PM mass metrics (Janssen et al 2011; 2012 - for WHO)



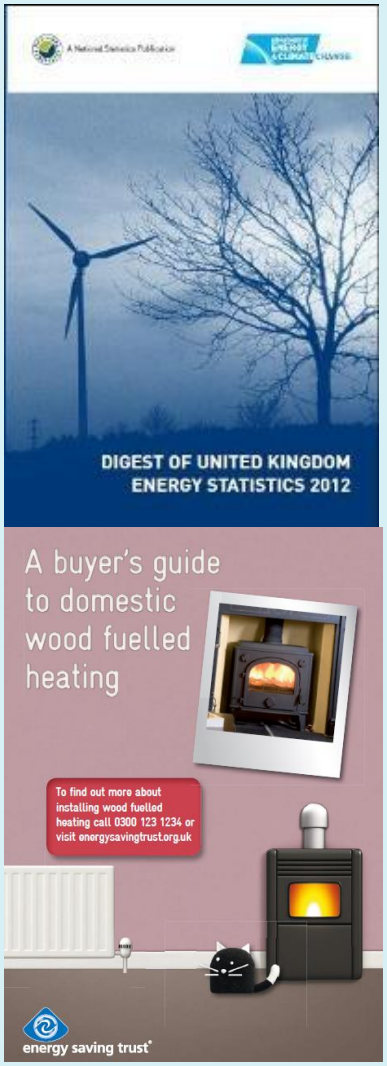
Background – wood burning

European energy projections also point to 50 - > 100% increase in biomass energy from 2010 to 2020 (IIASA, 2010)

Current UK wood heating is thought to be small but there has been recent concern over increasing amounts of wood being burnt in existing fire places and future widespread installation and use of biomass boilers.

Assessments in Berlin, Paris and London have shown wood burning to account for 0.8 and 2.3 µg m^{-3} to annual mean PM_{10} and up to 13 µg m^{-3} daily (Fuller et al 2013).

UK Renewable Heat Incentive is likely to be a big driver (700,000 new biomass burners 2010 to 2020 (Klevnäs and Barker 2009) in addition to UK planning guidance for 10% on-site renewable energy in new non-residental buildings (Merton, 2012).



Method 1
Levoglucosan

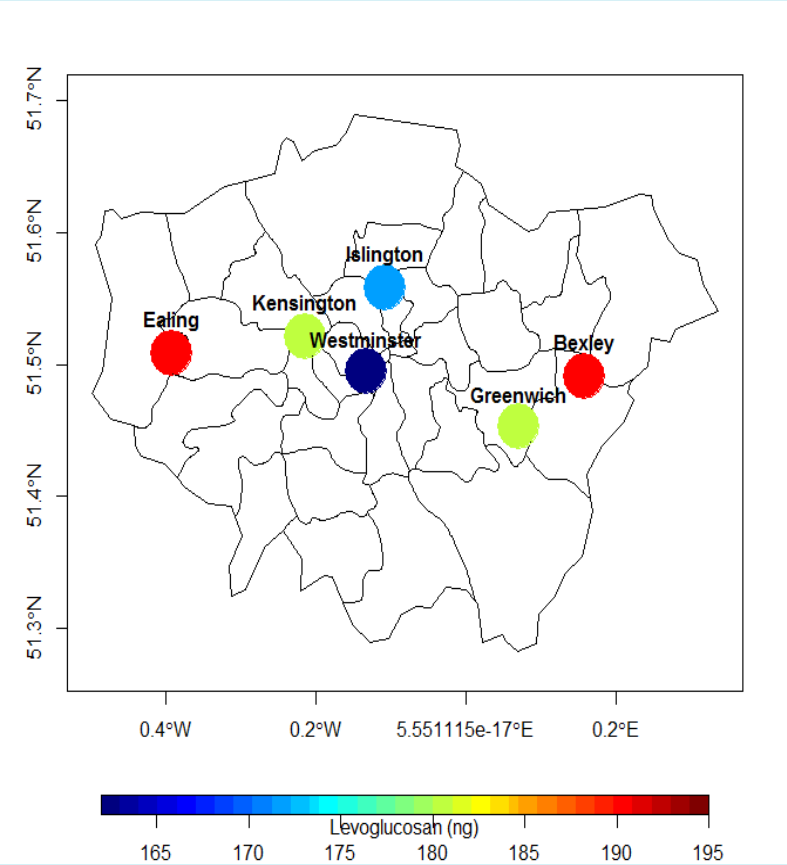
Levoglucosan

Yttri et al. (2005); Simoneit et al., (1999); Fine et al., (2004) and others.

- PM from cellulose (wood and paper) combustion is associated with emissions of levoglucosan (a sugar).
- Emitted in high concentrations and not present in vapour. Can therefore be considered a good tracer for wood combustion PM. (New evidence of OH^- degradation in summer but less so in winter Hennigan et al 2010)
- Emission rates depend on type of wood.

Levoglucosan -partisol sampling

~6 weeks in middle of heating season 2010, 38 km transect



Mean = 176 ng m^{-3} *cf* 15 European studies 60 - 900 ng m^{-3} (Szidat et al 2009)

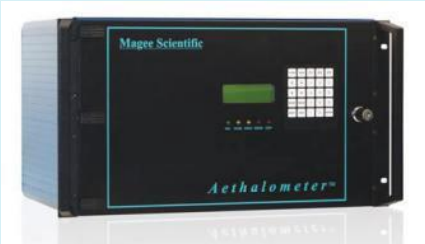
Suburbs minus central = 30±26 ng m^{-3} (k=2, ~2σ) or 19±16% of the inner London concentration.

Similar gradients between suburbs and central city were found in Berlin by Wagener et al 2012.

Method 2
Aethalometer

Aethalometer method

- Wood smoke and black carbon from fossil eg traffic sources are different colours, wood smoke tends to be brown.



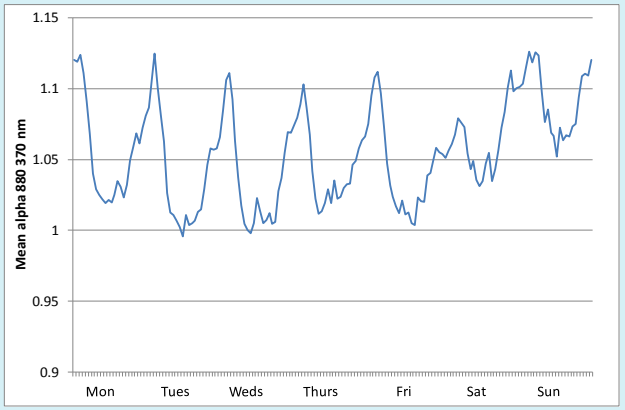
- Aethalometers used in UK (two in London, 18 across UK) as part of Defra black carbon network - UV 370nm and IR 880nm wavelengths.

- Can be used to detect PM from wood smoke (Favez et al., 2009, 2010, Sandradewi et al., 2008a, 2008b, Sciare et al 2011 and others).

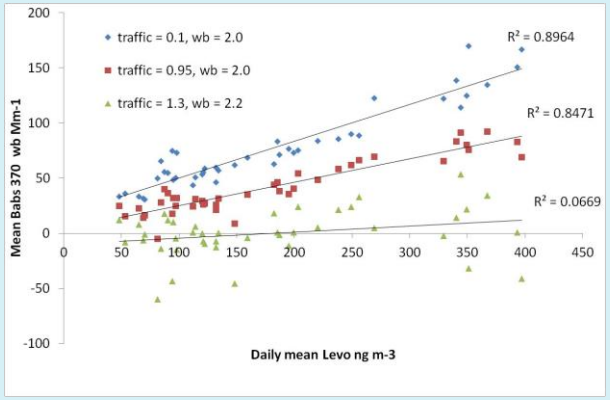
- Depends on the assumed wavelength dependent light absorption α for fossil (traffic) and wood burning.

Determining $\alpha_{traffic}$ and α_{wb}

- $\alpha_{traffic}$ ~ 1 is used in climate change models assuming it to be similar to black carbon eg Bond and Bergstrom (2006) Aerosol Sci and Tech 40:27–67



- Experimentally at the very busy traffic / roadside canyon site eg Marylebone Road $\alpha_{traffic}$ ~ 1 – 1.1



- But only one unique value ($\alpha_{traffic}$ = 0.95) allows the aethalometer and levoglosan methods to detect zero at the same time in our data.

Determining $\alpha_{traffic}$ and α_{wb}

- α_{wb} can only be determined experimentally.

- Varies by individual fire and burning conditions but in ambient air α_{wb} of 2.0 suggested from literature (Favez et al., 2009, 2010, Sandradewi et al., 2008a, 2008b, Sciare et al 2011, Kirchstetter et al 2004 and others).

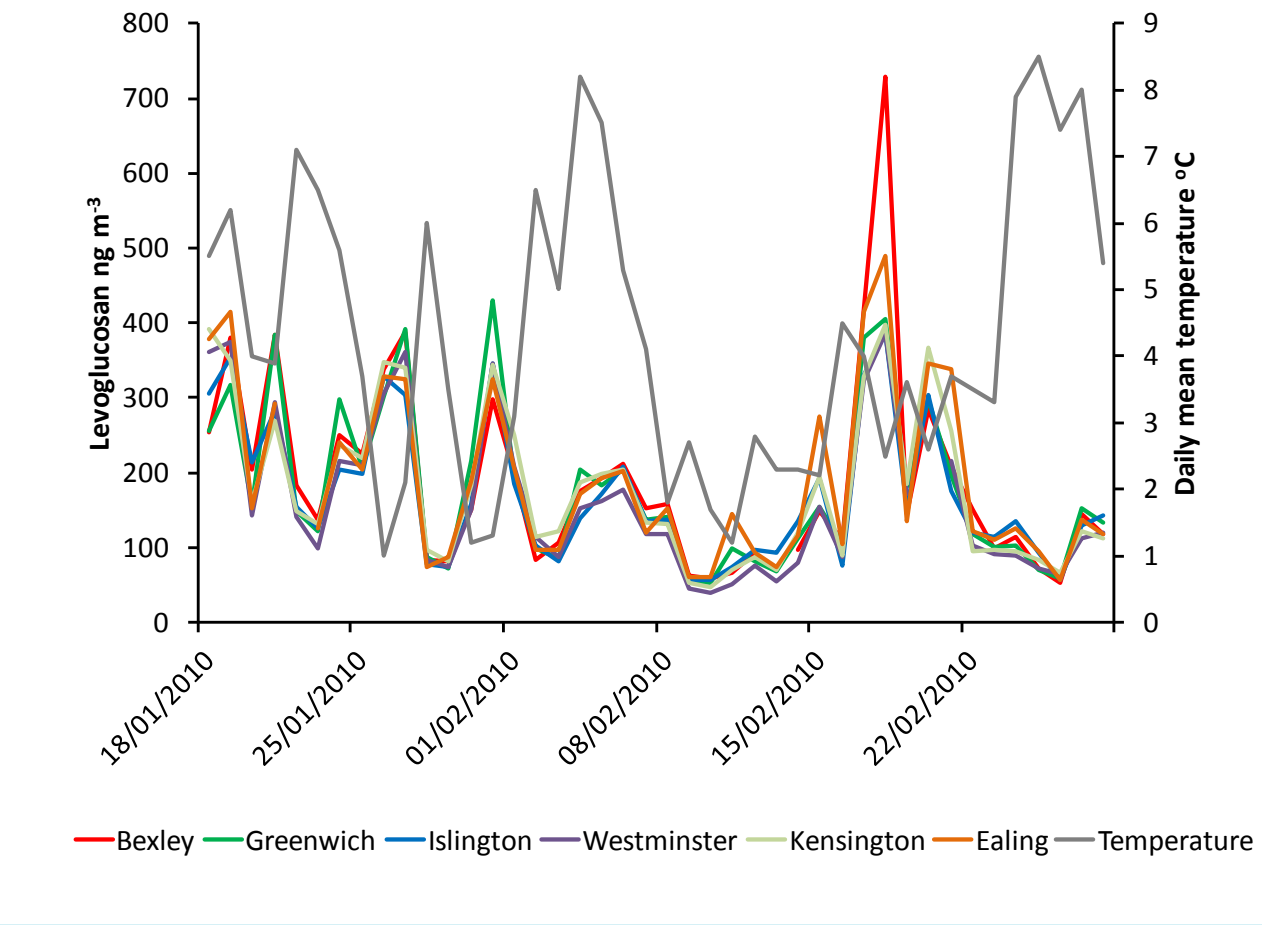
- Is this sensible? – UK α almost never bigger than 2.1 except for a couple of spikes.

- With $\alpha_{traffic}$ = 0.96 changing α_{wb} by A ±10 % change in α(wb) varied the estimates of wood burning PM by -10% and +16%.

Results

Where's it coming from? Levoglucosan

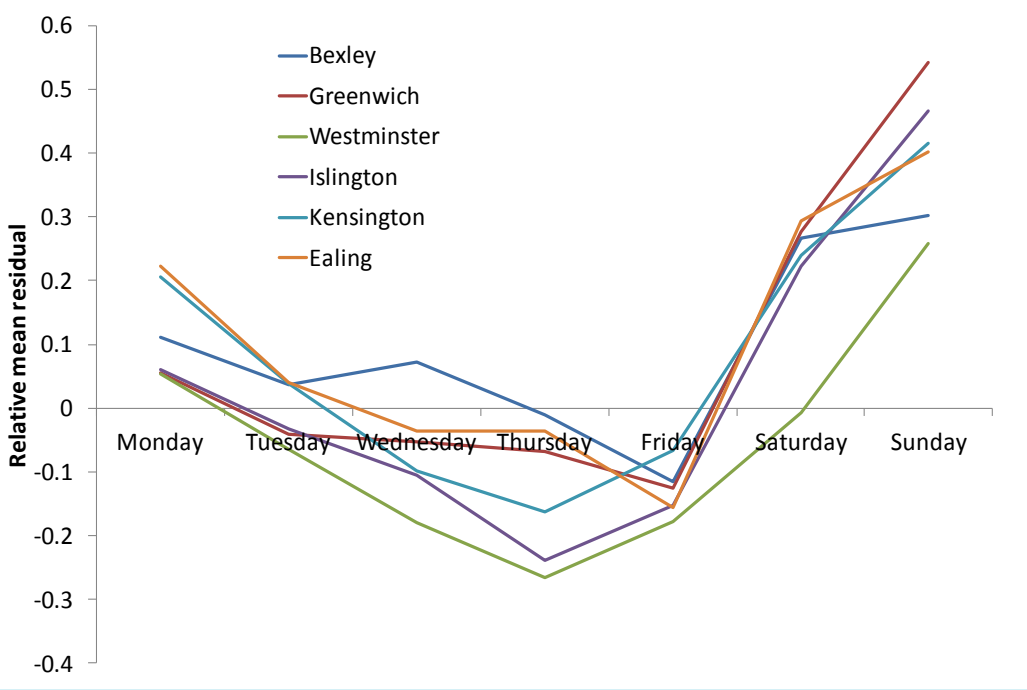
Temperature and levoglucosan badly correlated, R^2 ranging between -0.15 and -0.22



Where's it coming from?

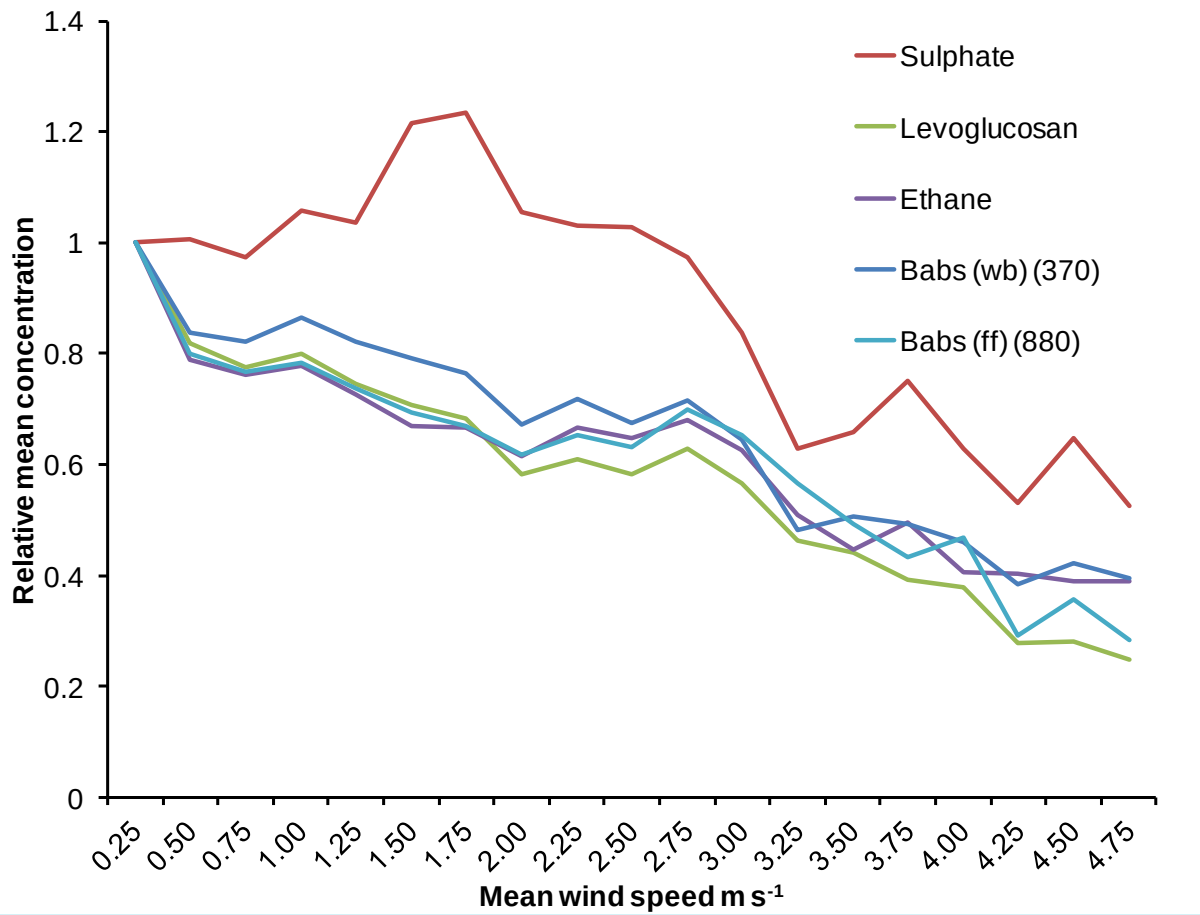
Levoglucosan

Can we say something about day of week variation?
Residuals from simple regression model with ethane
(ethane has a fixed emission rate from natural gas leakage)



Where's it coming from?

Variation with wind speed along with tracers for urban and long-range sources



Estimating PM concentrations from wood burning

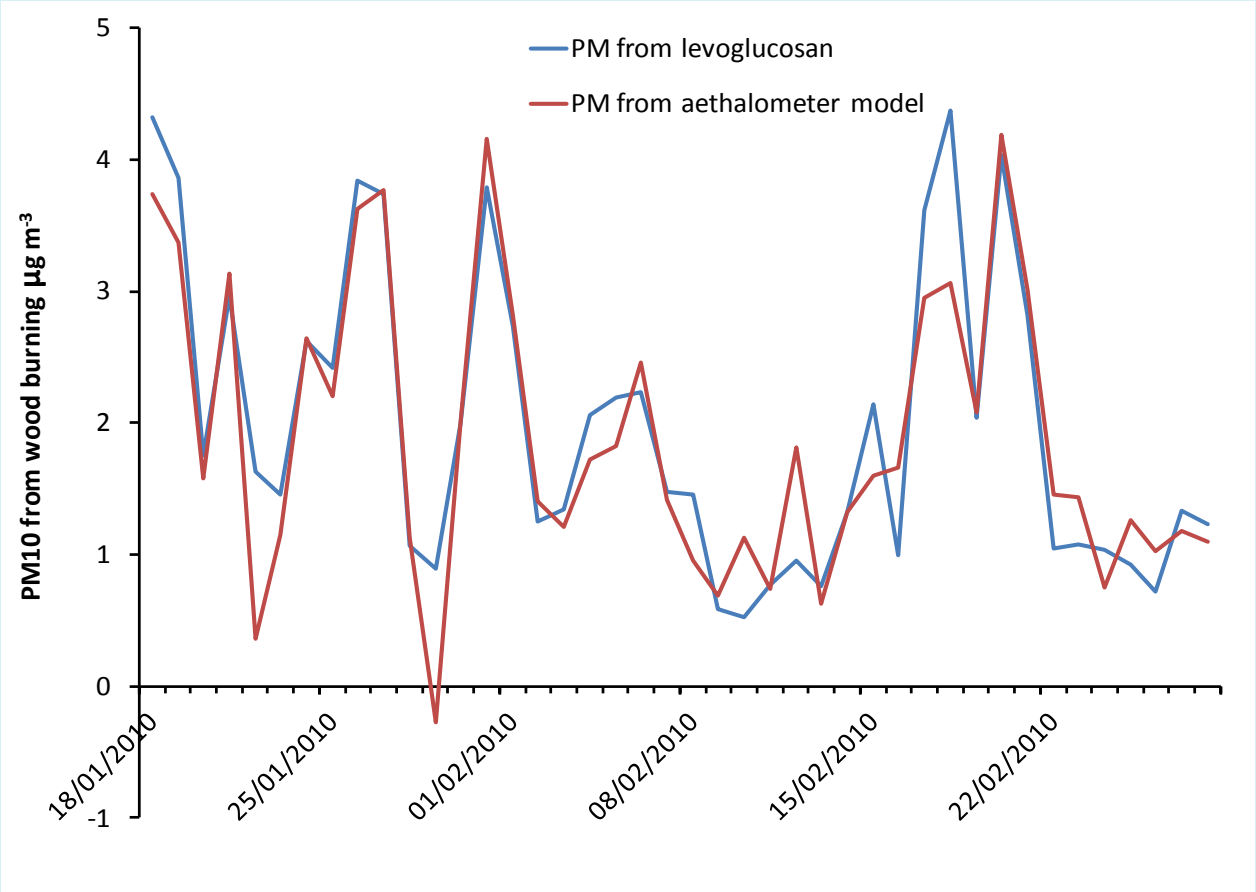
Levoglucosan PM: PM emission rates depend on wood type.

- Puxbaum et al., (2007) suggested 7.35 and an OC to OM factor 1.4 and levoglucosan to EC of 0.9. Implies Levoglucosan to PM ratio of 10.
- Within the range suggested by Szidat et al., (2009) of 5.5 to 14

Aethalometer PM: Literature factors from multiple linear regressions with EC and OM. Favez et al., (2009, 2010), Sandrewi (2008), Sciare et al., (2011), Harrison et al., (2012).

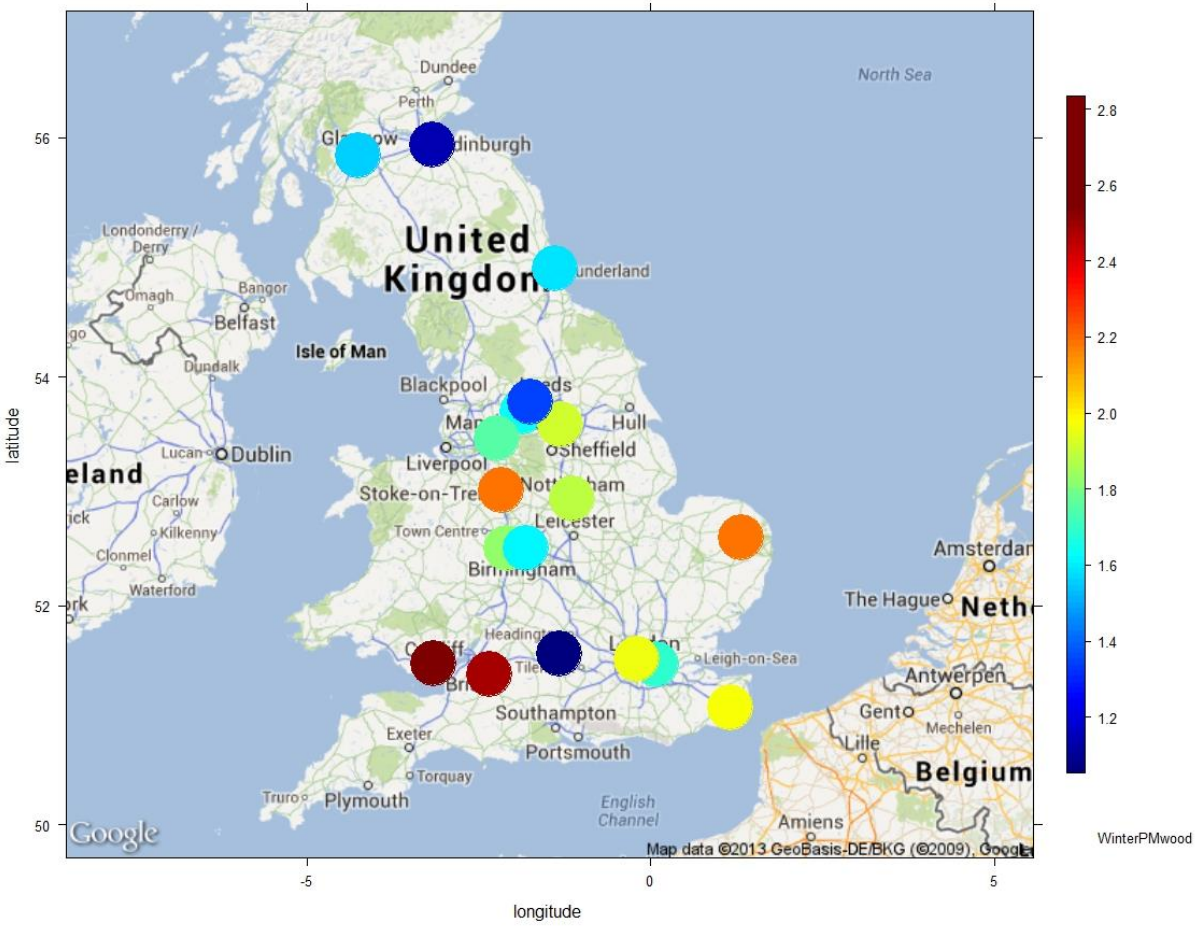
Estimating concentrations

[PM wood Aethalometer] = (0.95 ± 0.0) [PM wood levo] + (0.06 ± 0.14), r = 0.92 n= 42



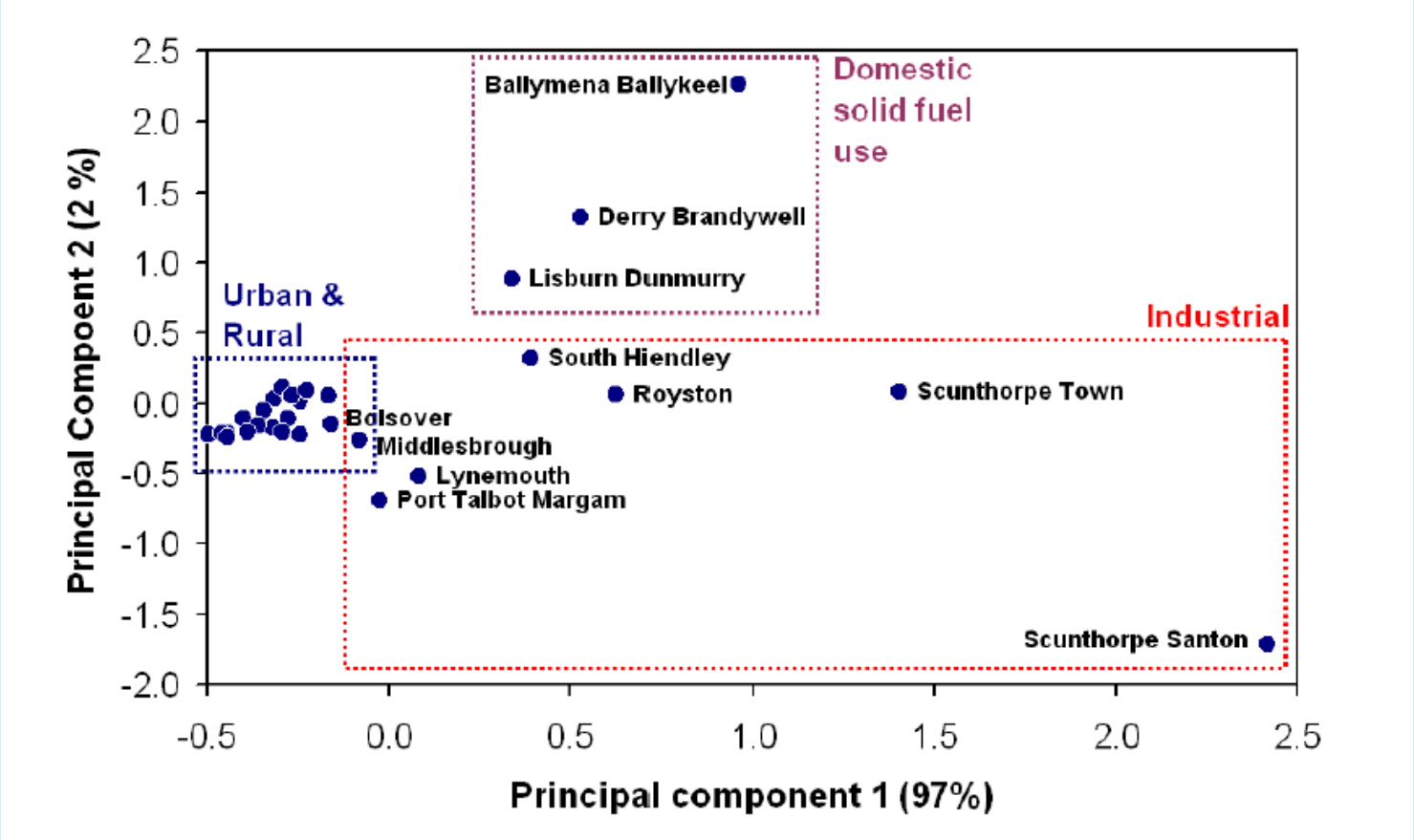
UK mainland (aethalometer)

winter time PM from wood burning (µg m-3)



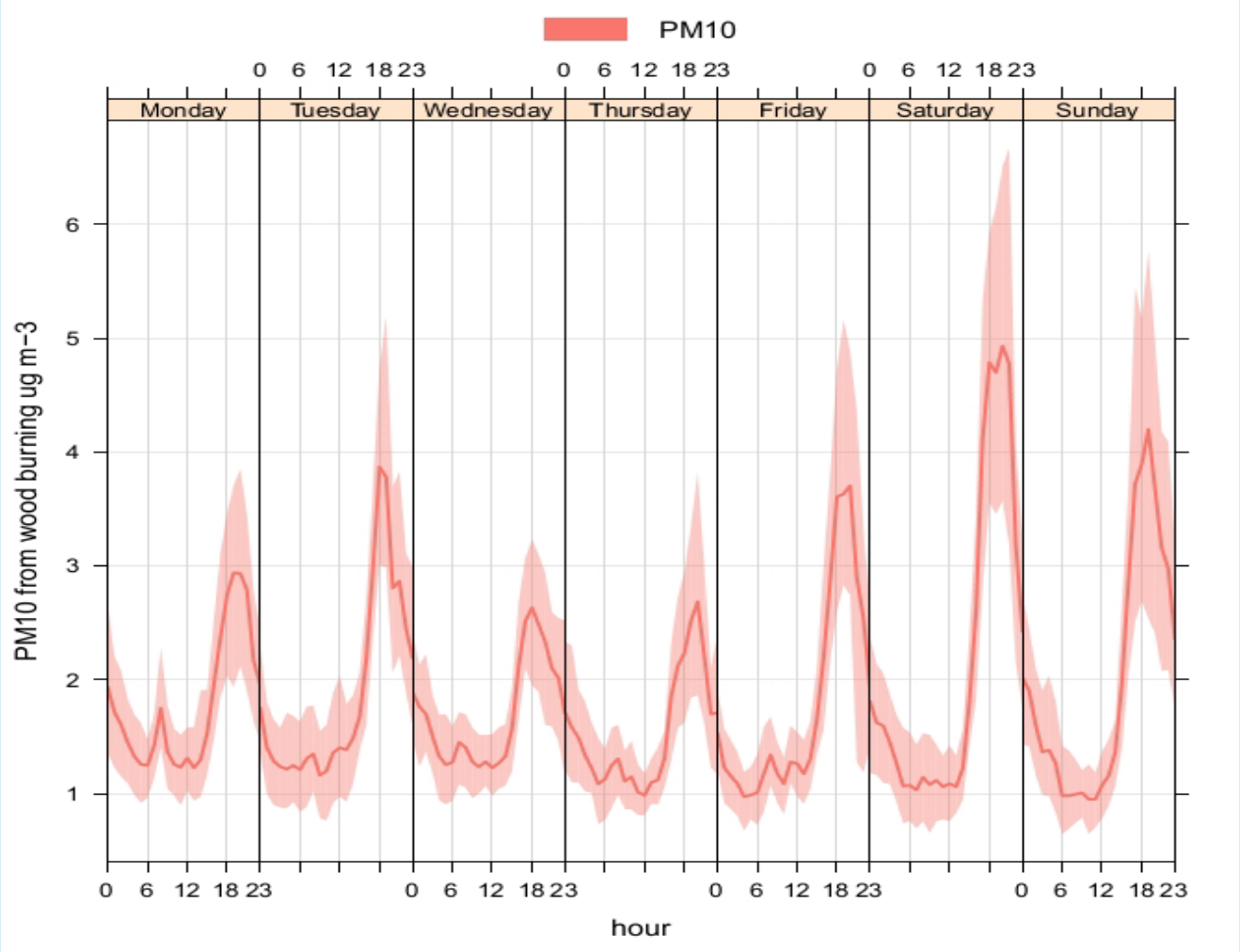
Northern Ireland

Coal is burnt widely across Northern Ireland but appears to be used little elsewhere (see PAH analysis from Butterfield and Brown, 2011 – NPL)



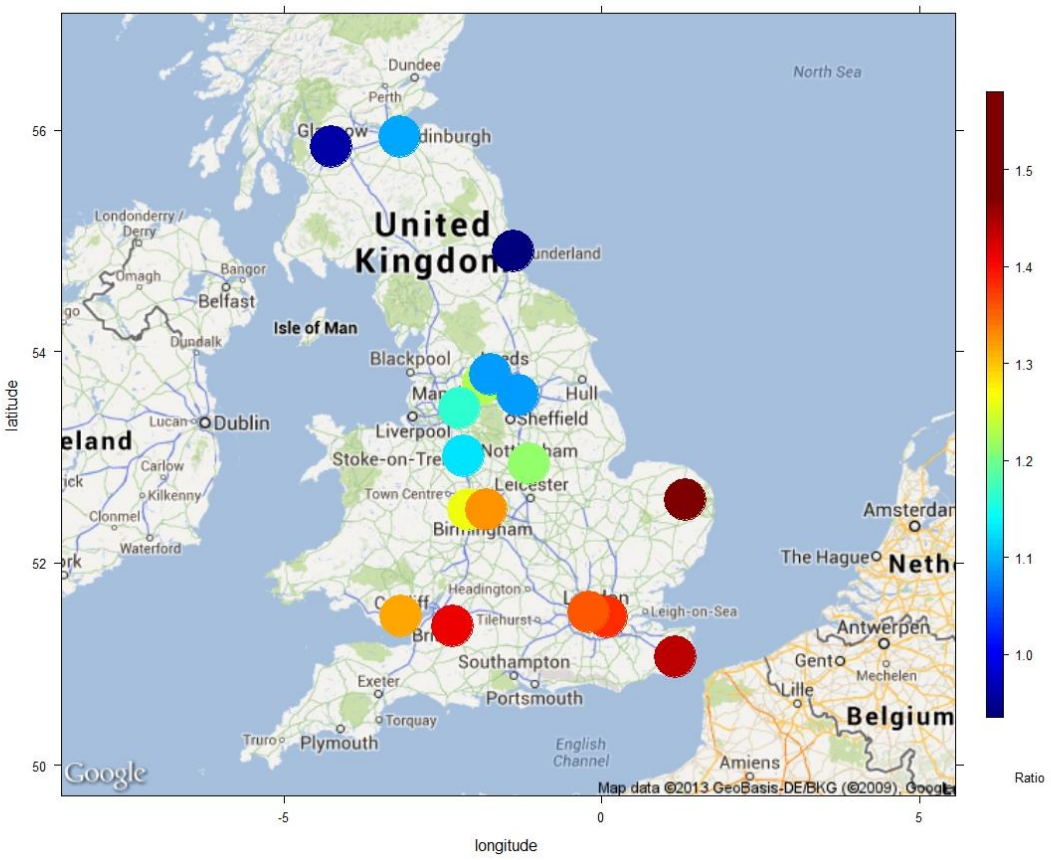
UK mainland (aethalometer)

Winter time PM from wood burning (µg m-3) in Norwich



UK mainland (aethalometer)

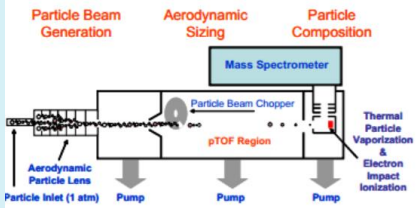
Winter evenings weekend / weekday



Evidence from aerosol mass specs

AMS
AEROSOL MASS SPECTROMETER SYSTEMS

Measure real-time, non-refractory, size-resolved particulate chemical composition and mass.



Atmos. Chem. Phys., 10, 647–668, 2010
www.atmos-chem-phys.net/10/647/2010/

Atmospheric Chemistry and Physics

Contributions from transport, solid fuel burning and cooking to primary organic aerosols in two UK cities

J. D. Allan[1], P. I. Williams[1], W. T. Morgan[2], C. L. Martin[2], M. J. Flynn[2], J. Lee[3], E. Nemitz[4], G. J. Phillips[4], M. W. Gallagher[2], and H. Coe[2]

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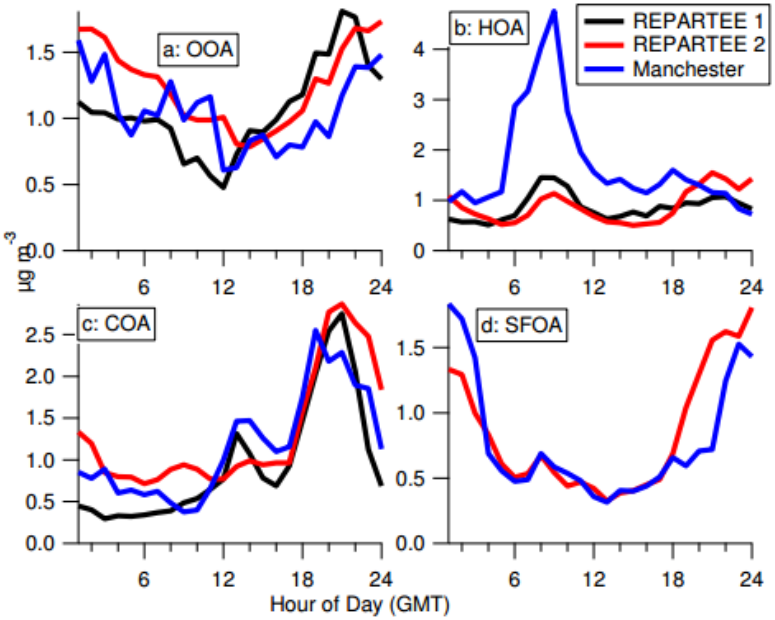
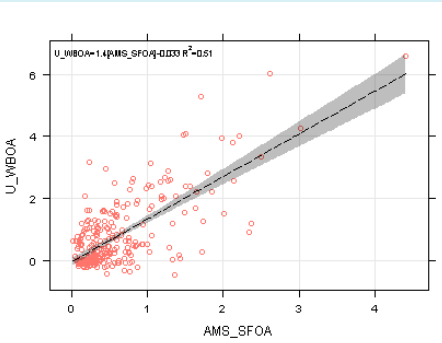
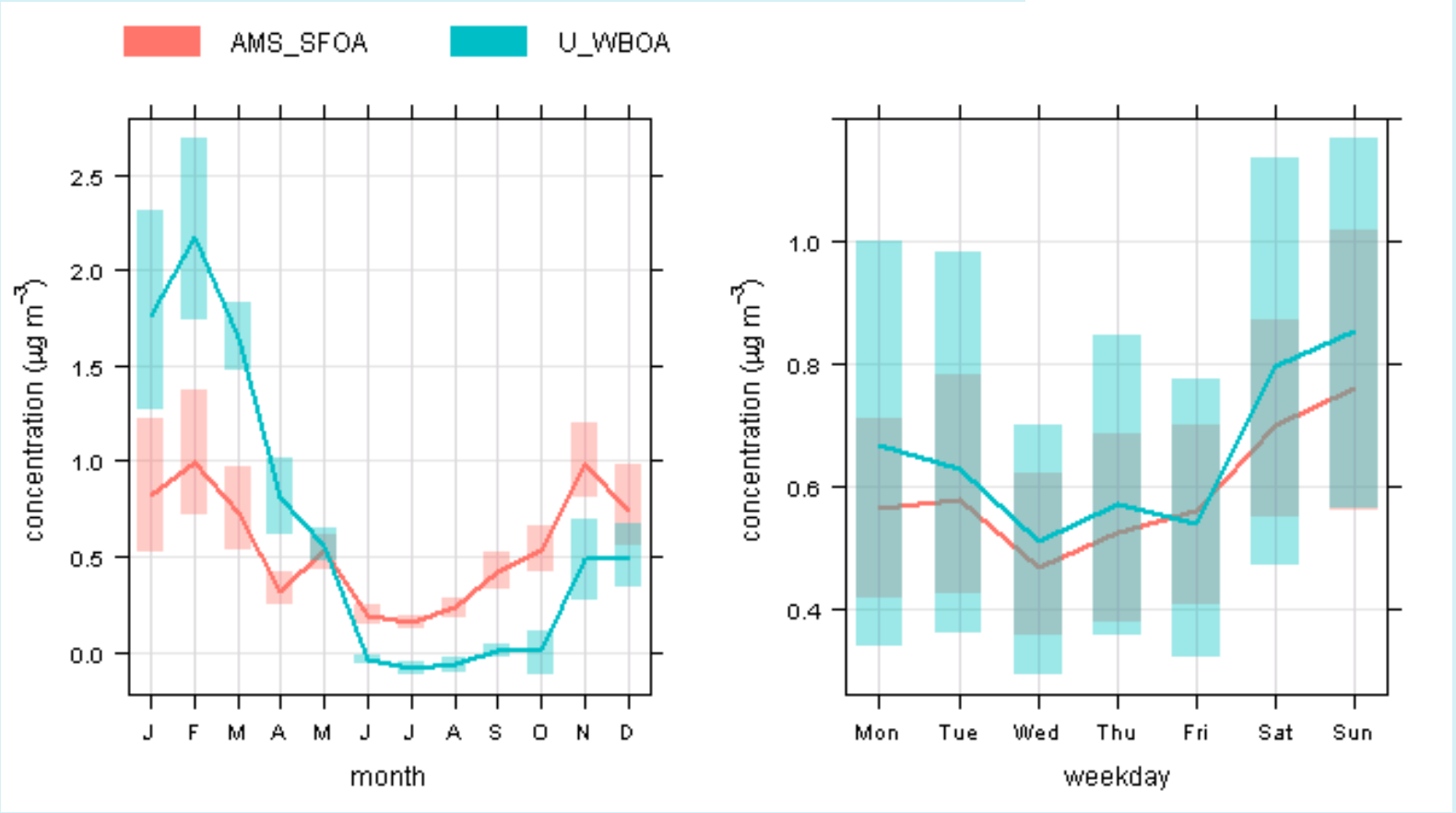
Received: 1 September 2009 – Published in Atmos. Chem. Phys. Discuss.: 15 September 2009
Revised: 11 December 2009 – Accepted: 8 January 2010 – Published: 22 January 2010



AMS SFOA vs Aeth WoodBurning





Conclusions

Conclusions

Good agreement between levoglucosan and aethalometer methods (and seems to agree well with AMS wood burning factor). Using levoglcosan to constrain aethalometer model a **α(ff) = 0.96 was found** consistent with literature values and validating the methods. A **±10 %** change in **α(wb)** varied the estimates of wood burning PM by **-10% and+16%.**

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.**

PM wood in London comes from **within the city** and is greatest at **weekends and in the evenings** suggesting that wood burning is a **secondary domestic heating** source. Similar patterns across the **southern half of England**.

Likely that PM from wood burning is mainly from **domestic wood burning in existing fire places** (NB: no incremental levo at Islington Arsenal next to modern wood burner but little wind from the right direction!)

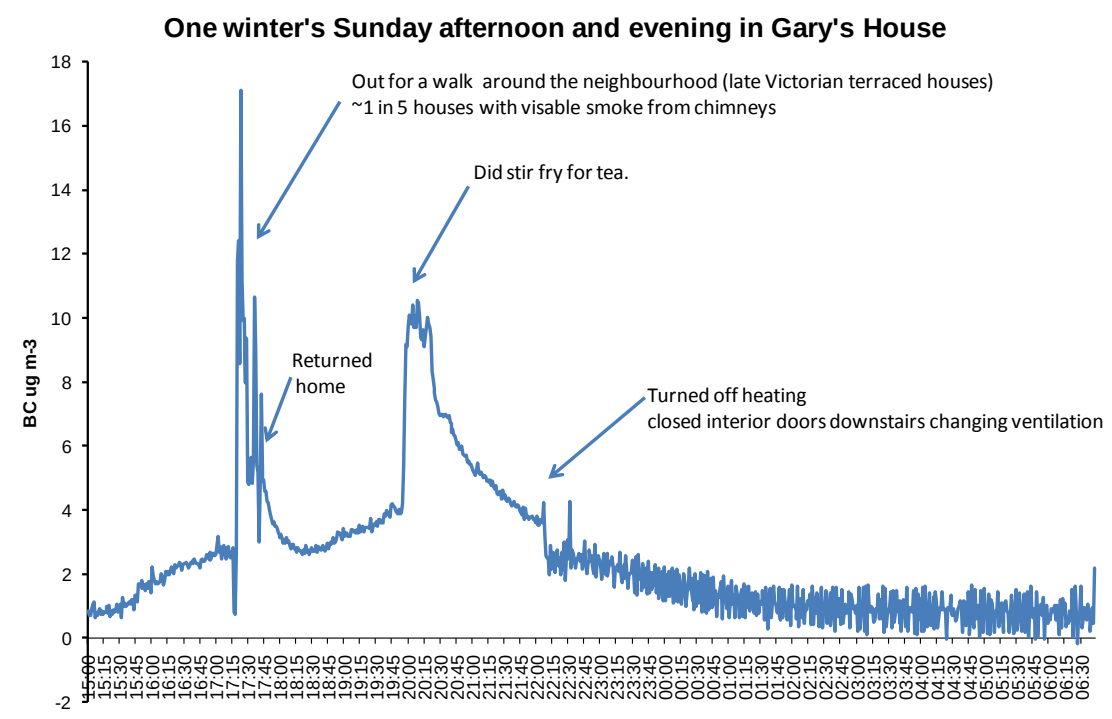
Smoke control legislation in London and other cities (like Bath) isn't working

Year on year changes hard to determine from three years (!) but more likely to be an increase than decrease (wood smoke will be almost all PM2.5 – exposure reduction)

Footnote 1 - exposure

Wood burning takes place in the areas that people live, at the times that their neighbours are at home.

With poor night-time dispersion Reiss et al 2009 suggest that even modest wood burning in a densely populated area could lead to greater population exposure than urban traffic



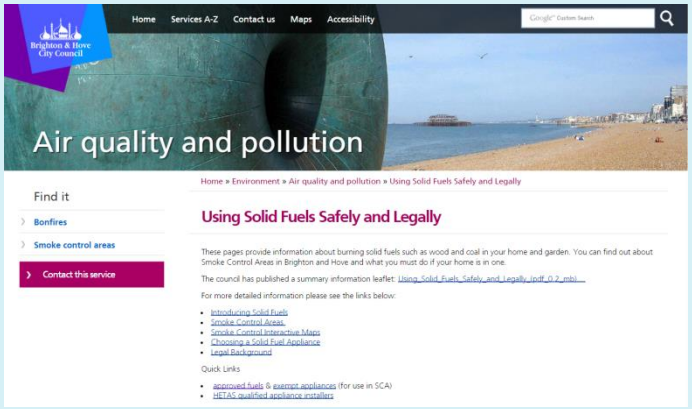
Footnote 2 – control

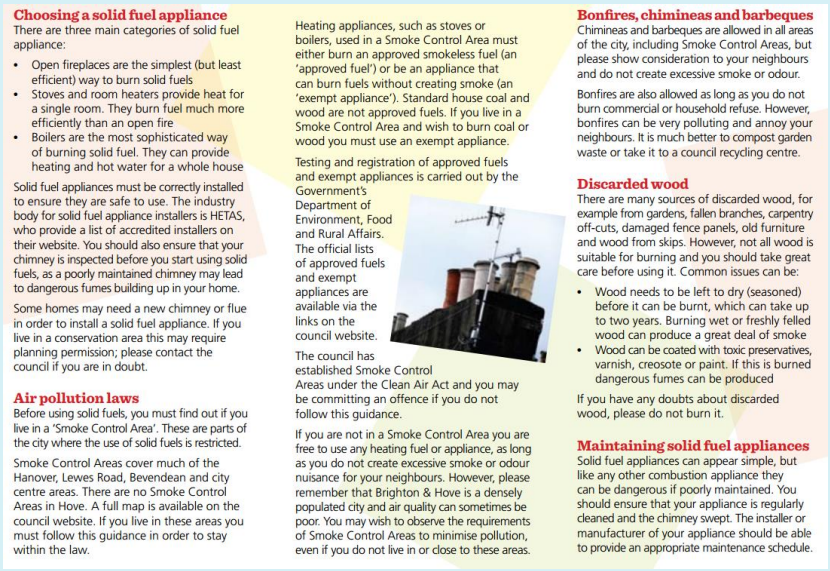
In order to de-carbonise heating we might have to increase urban wood burning in new appliances; efficient whole house wood chip heating etc.

What do we do about wood burning in existing fireplaces, stoves etc?

Paris will ban wood burning in open fires from Jan 2015.

Need to constrain the growing popularity or at the very least help people to burn wood well





Choosing a solid fuel appliance

There are three main categories of solid fuel appliance:

- Open fireplaces are the simplest (but least efficient) way to burn solid fuels
- Stoves and room heaters provide heat for a single room. They burn fuel much more efficiently than an open fire
- Boilers are the most sophisticated way of burning solid fuel. They can provide heating and hot water for a whole house

Solid fuel appliances must be correctly installed to ensure they are safe to use. The industry body for solid fuel appliance installers is HETAS, who provide a list of accredited installers on their website. You should also ensure that your chimney is inspected before you start using solid fuels, as a poorly maintained chimney may lead to dangerous fumes building up in your home.

Some homes may need a new chimney or flue in order to install a solid fuel appliance. If you live in a conservation area this may require planning permission; please contact the council if you are in doubt.

Air pollution laws

Before using solid fuels, you must find out if you live in a 'Smoke Control Area'. These are parts of the city where the use of solid fuels is restricted.

Smoke Control Areas cover much of the Hanover, Lewes Road, Bevendean and city centre areas. There are no Smoke Control Areas in Hove. A full map is available on the council website. If you live in these areas you must follow this guidance in order to stay within the law.

Heating appliances, such as stoves or boilers, used in a Smoke Control Area must either burn an approved smokeless fuel (an 'approved fuel') or be an appliance that can burn fuels without creating smoke (an 'exempt appliance'). Standard house coal and wood are not approved fuels. If you live in a Smoke Control Area and wish to burn coal or wood you must use an exempt appliance.

Testing and registration of approved fuels and exempt appliances is carried out by the Government's Department of Environment, Food and Rural Affairs. The official lists of approved fuels and exempt appliances are available via the links on the council website.

The council has established Smoke Control Areas under the Clean Air Act and you may be committing an offence if you do not follow this guidance.

If you are not in a Smoke Control Area you are free to use any heating fuel or appliance, as long as you do not create excessive smoke or odour nuisance for your neighbours. However, please remember that Brighton & Hove is a densely populated city and air quality can sometimes be poor. You may wish to observe the requirements of Smoke Control Areas to minimise pollution, even if you do not live in or close to these areas.

Bonfires, chimineas and barbeques

Chimineas and barbeques are allowed in all areas of the city, including Smoke Control Areas, but please show consideration to your neighbours and do not create excessive smoke or odour.

Bonfires are also allowed as long as you do not burn commercial or household refuse. However, bonfires can be very polluting and annoy your neighbours. It is much better to compost garden waste or take it to a council recycling centre.

Discarded wood

There are many sources of discarded wood, for example from gardens, fallen branches, carpentry off-cuts, damaged fence panels, old furniture and wood from skips. However, not all wood is suitable for burning and you should take great care before using it. Common issues can be:

- Wood needs to be left to dry (seasoned) before it can be burnt, which can take up to two years. Burning wet or freshly felled wood can produce a great deal of smoke
- Wood can be coated with toxic preservatives, varnish, creosote or paint. If this is burned dangerous fumes can be produced

If you have any doubts about discarded wood, please do not burn it.

Maintaining solid fuel appliances

Solid fuel appliances can appear simple, but like any other combustion appliance they can be dangerous if poorly maintained. You should ensure that your appliance is regularly cleaned and the chimney swept. The installer or manufacturer of your appliance should be able to provide an appropriate maintenance schedule.

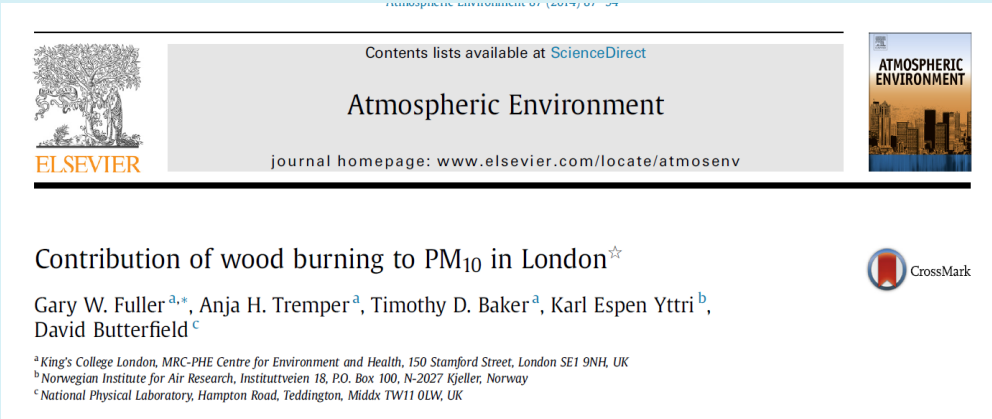
Thanks…

London boroughs of Greenwich, Bexley, Central London cluster group and defra for having the foresight to fund the Levoglucosan measurements and Ealing for hosting 2010 sampling.

Jean Sciare,Oliver Favez, Phil Hopke, Grisa Mocnik and Tony Hansen for enjoyable and helpful discussions.

Defra and our NPL partners (especially David Butterfield) in the black smoke network for the absorption measurements.

Karl Espen Yittri for levoglucosan analysis and comments on the project.



Contents lists available at ScienceDirect

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

Contribution of wood burning to PM_{10} in London☆

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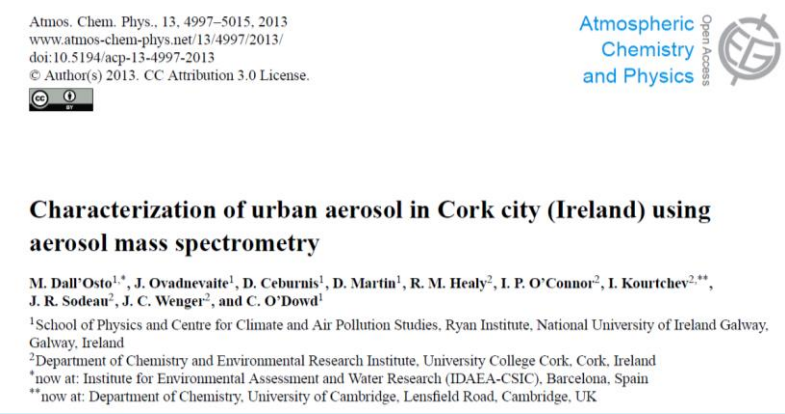
Possible coal burning interferences

Coal burning also produces PM which is strongly absorbing in the UV.

- For small towns in Northern Ireland we measure max α ~ 2 – 2.2 in areas of coal and oil burning.
- Coal and wood burning are likely to happen at the same time. Sometimes people burn both.
- Can the higher black carbon content of coal burning be used as a diagnostic?
- PM from different solid fuels is being investigated by University College Cork as part of an Irish EPA funded project.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doi:10.5194/acp-13-4997-2013

Atmospheric Chemistry and Physics
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Characterization of urban aerosol in Cork city (Ireland) using aerosol mass spectrometry

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