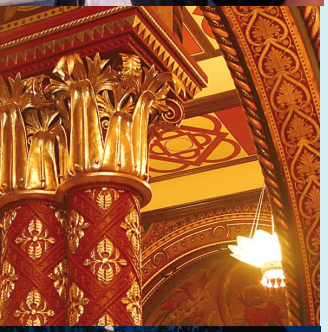

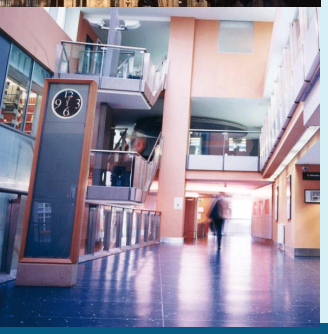

PM_{10} from wood burning in London ahead of the RHI

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David Butterfield - NPL

Contents

Why are we concerned about biomass PM in London?

Background

PM from wood burning is getting greater recognition as an issue:

- 25% PM10 wintertime emissions in Oslo (Yttri et al. 2005).
- 34% PM10 emissions in Seattle (Maykut, 2003).
- ~ 90% of winter PM10 in Christchurch and linked to hospital admissions (McGowan, 2002).
- 10 – 30% of PM2.5 in Paris during wintertime study (Favez et al., 2009).
- Concern in alpine regions too.

Background

In London (and rest of UK) 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 (mainly wood burning)

Driven by planning guidance on on-site renewable energy (Merton Rule)

Renewal heat incentive is likely to be a big driver post 2011 (700,000 new biomass burners 2010 to 2020 (Klevnäs and Barker 2009).

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

Background - objectives

- To be able to quantify the PM from wood burning in London.
- To provide a base line against which future studies can be done

Method 1
Levoglucosan

Levoglucosan

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

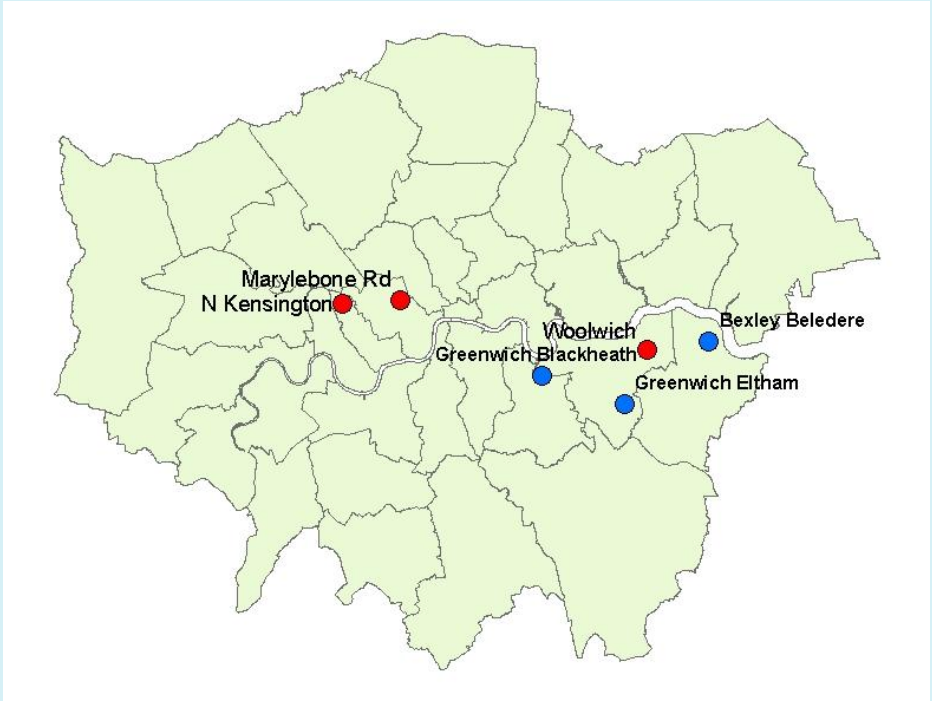
- PM from cellulose (wood and paper) combustion is associated with emissions of levoglucosan (a sugar).
- Emitted in high concentrations and not present in vapour. Can therefore be considered a good tracer for wood combustion PM. (New evidence of OH^- degradation in summer but less so in winter Hennigan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

Levoglucosan -partisol sampling

~6 weeks in middle of heating season

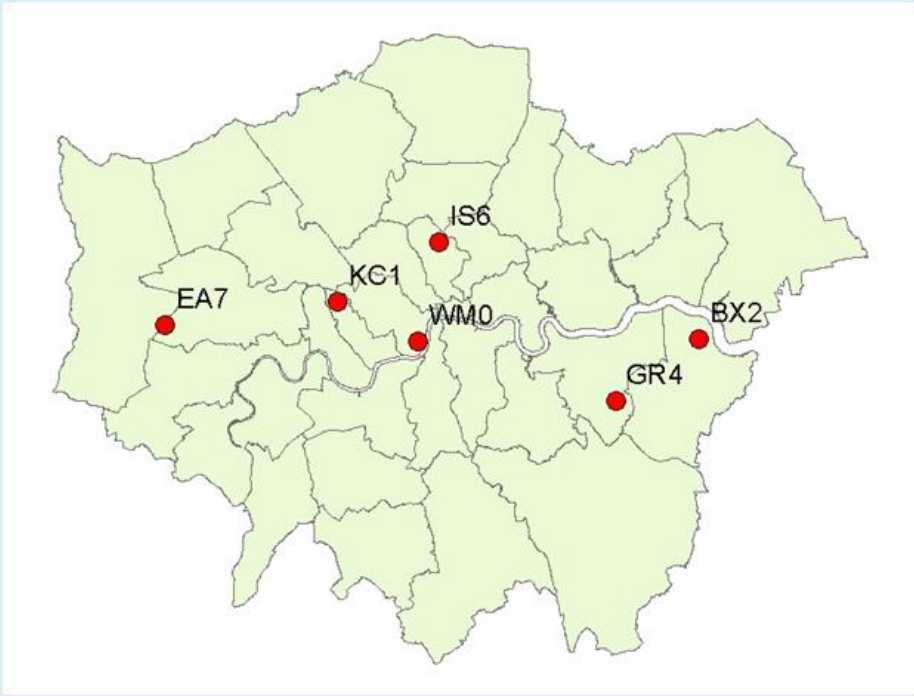
2009

R= aethalometer, B = levo



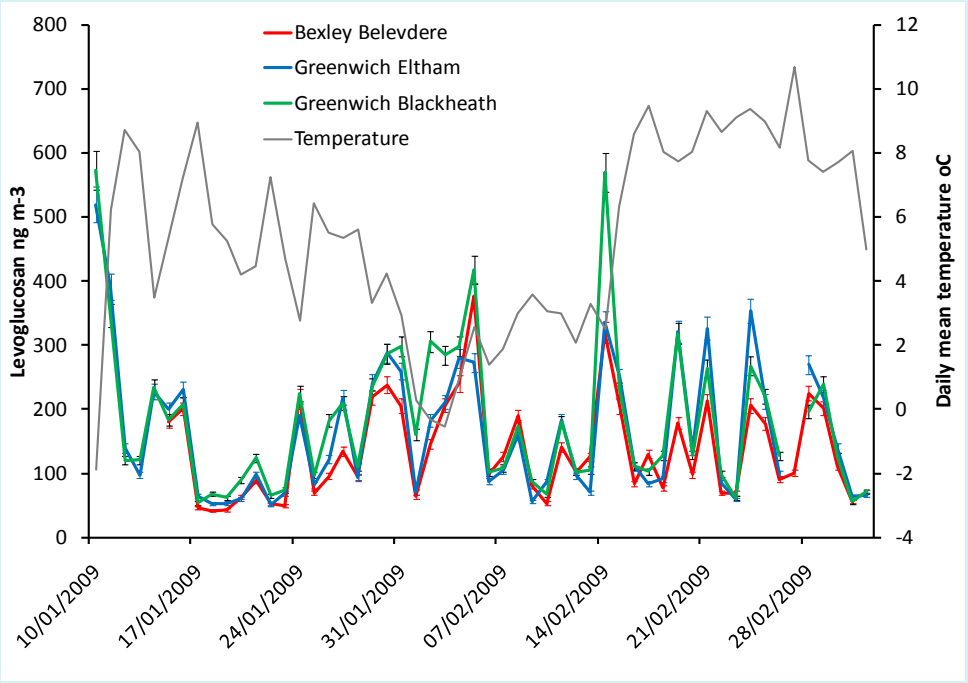
2010

R = levo, aethalometers as 2009

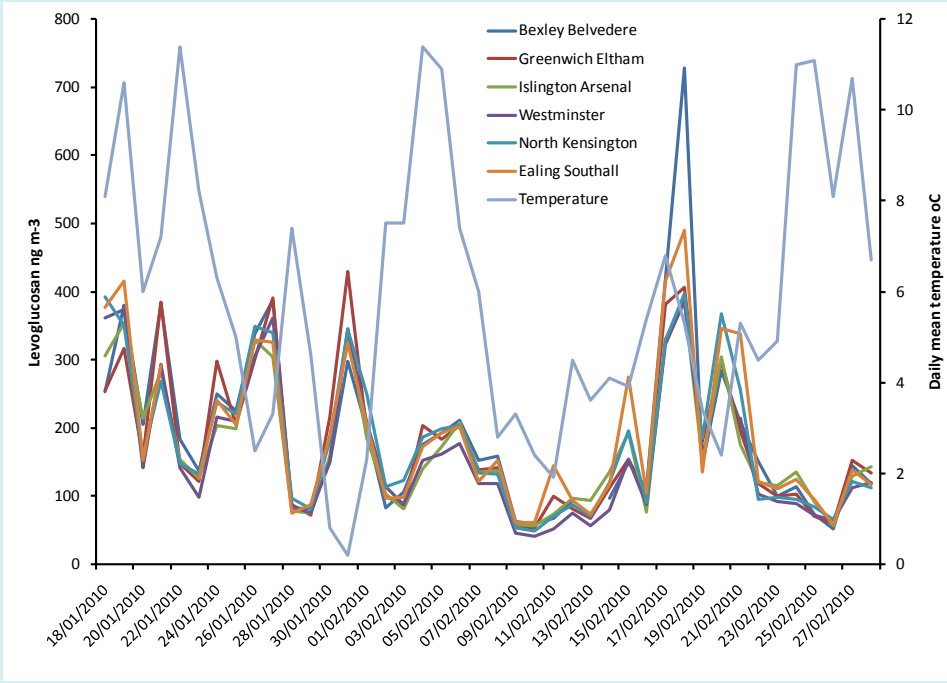


Levoglucosan – Daily mean time series

2009



2010



Mean levoglucosan concentration (ng m^{-3})

	2009	2010
Bexley Belvedere	138	200
Greenwich Eltham	167	183
Greenwich Blackhealth	183	-
Islington Arsenal		176
Westminster – Horse Ferry Rd		165
North Kensington		189
Ealing Southall		189

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

Levoglucosan - Mean PM10 concentration

Levoglucosan : PM OC emission rates depend on wood type.

Using emissions factors from other studies eg Puxbaum et al., (2007), Fine et al., (2002….), Yttri et al., (2009)

During mid **winter time** study period ……..

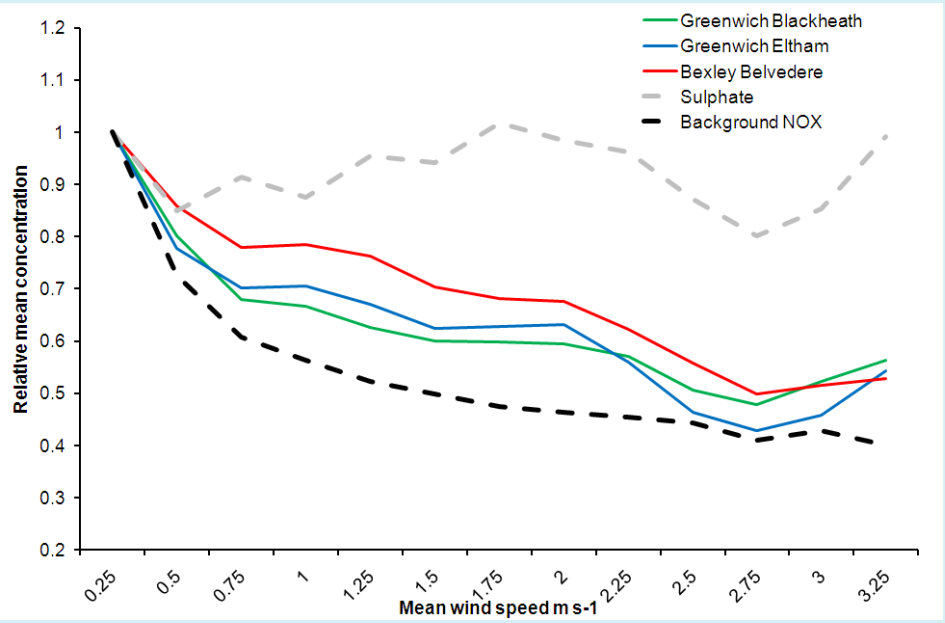
Suggests PM10 from wood smoke	~ 3 µg m^{-3}
Mean PM10 (background)	20 - 26 µg m^{-3}
PM10 from wood	~ 15%

But these are short sampling periods

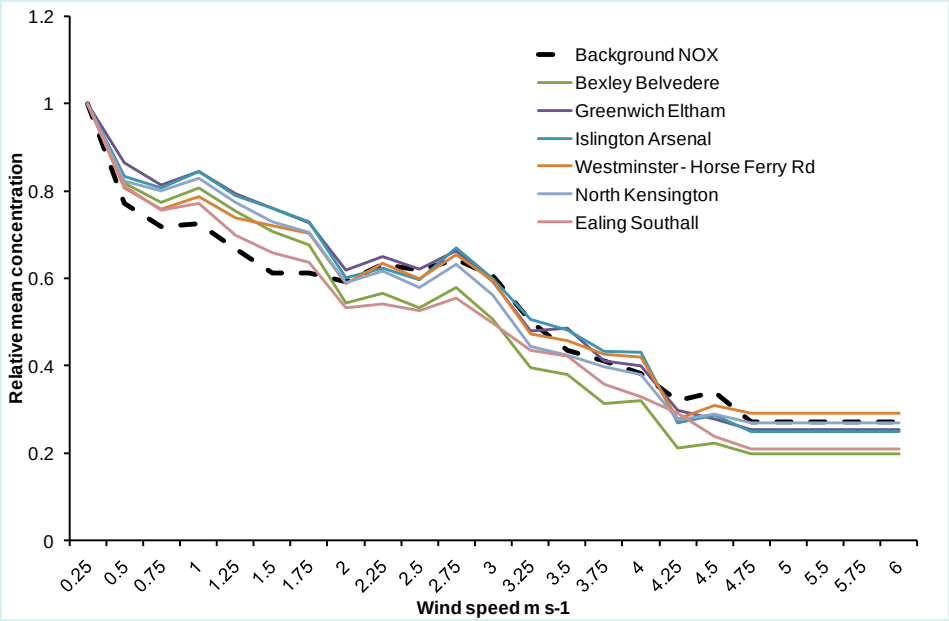
Levoglucosan

Where's it coming from? Wind speed analysis

2009



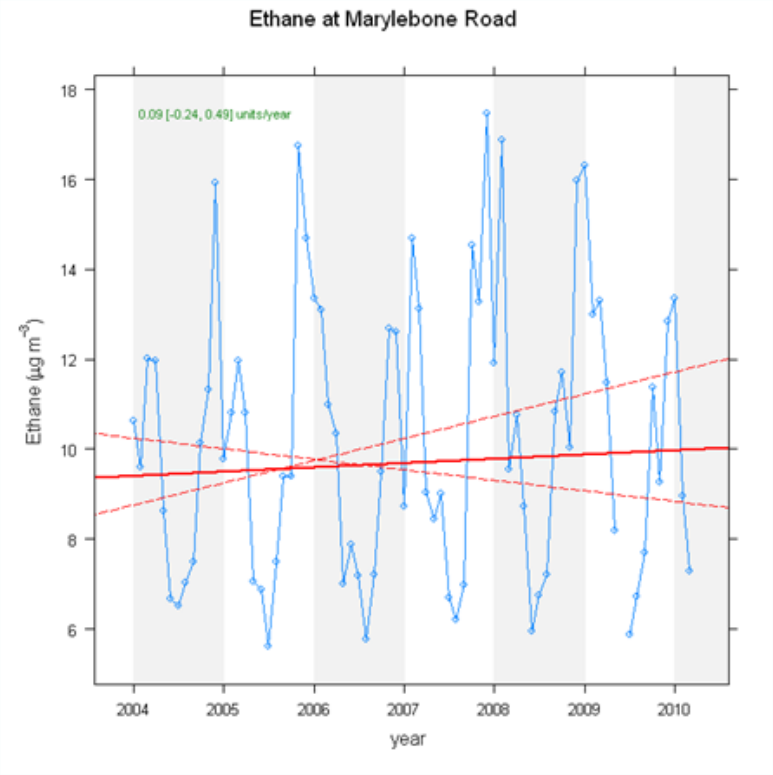
2010

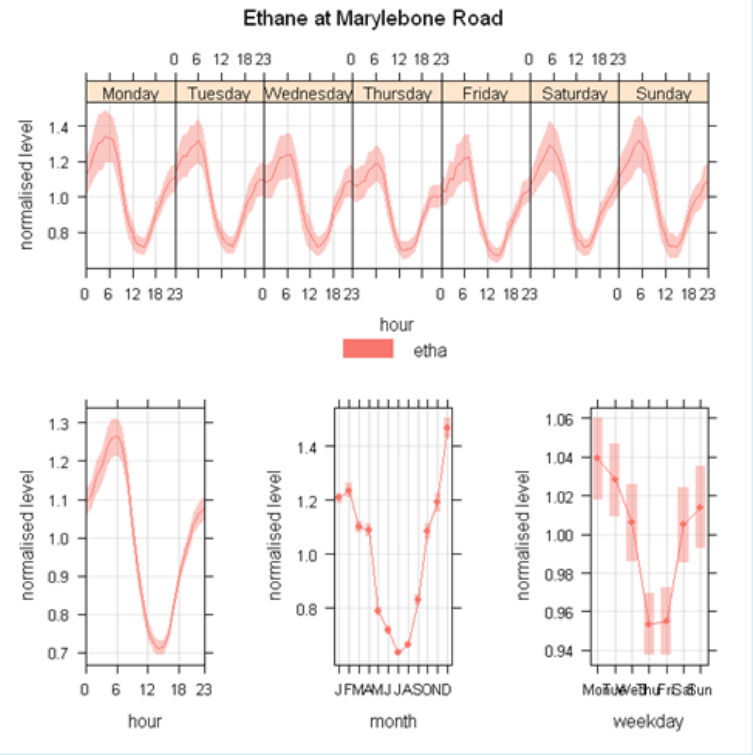


Levoglucosan

Where's it coming from? Simple ethane model

Ethane comes from natural gas leakage which is assumed to have a constant emission rate.



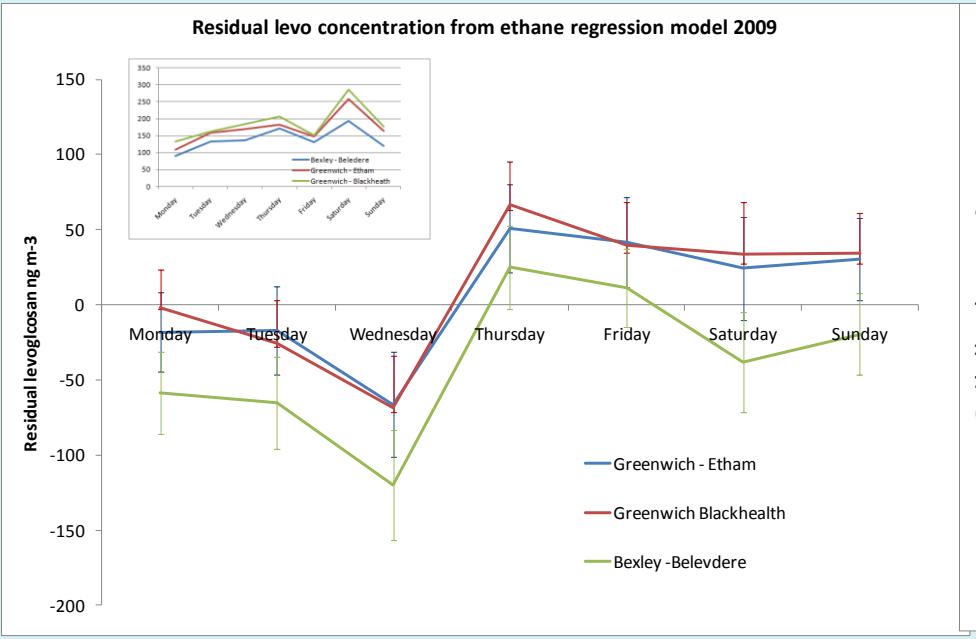


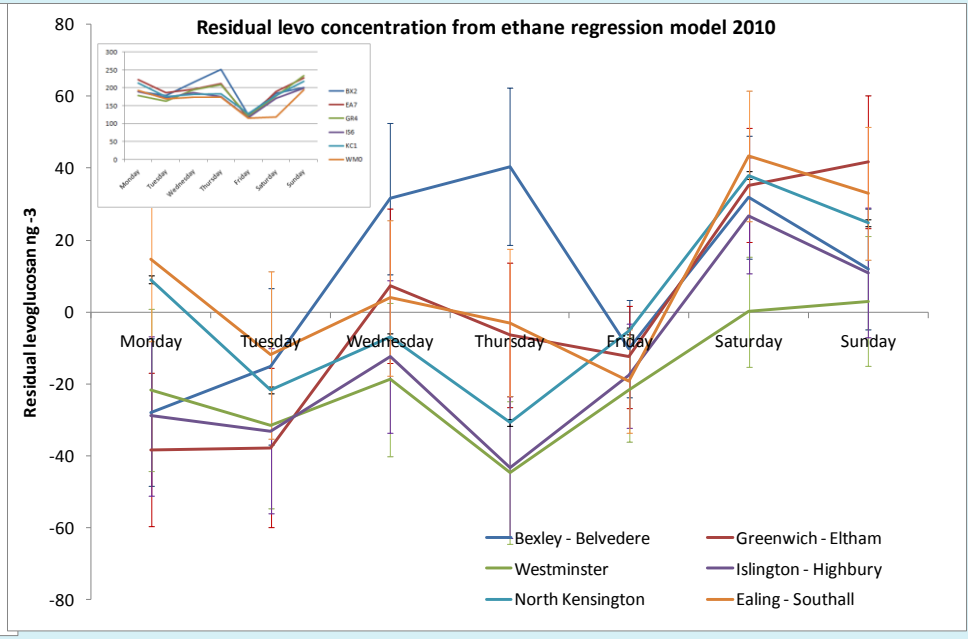
Levoglucosan

Where's it coming from? Simple ethane model

Residuals from predicted levo concentration assuming a constant emissions rate

Separate model for each site using the other ones



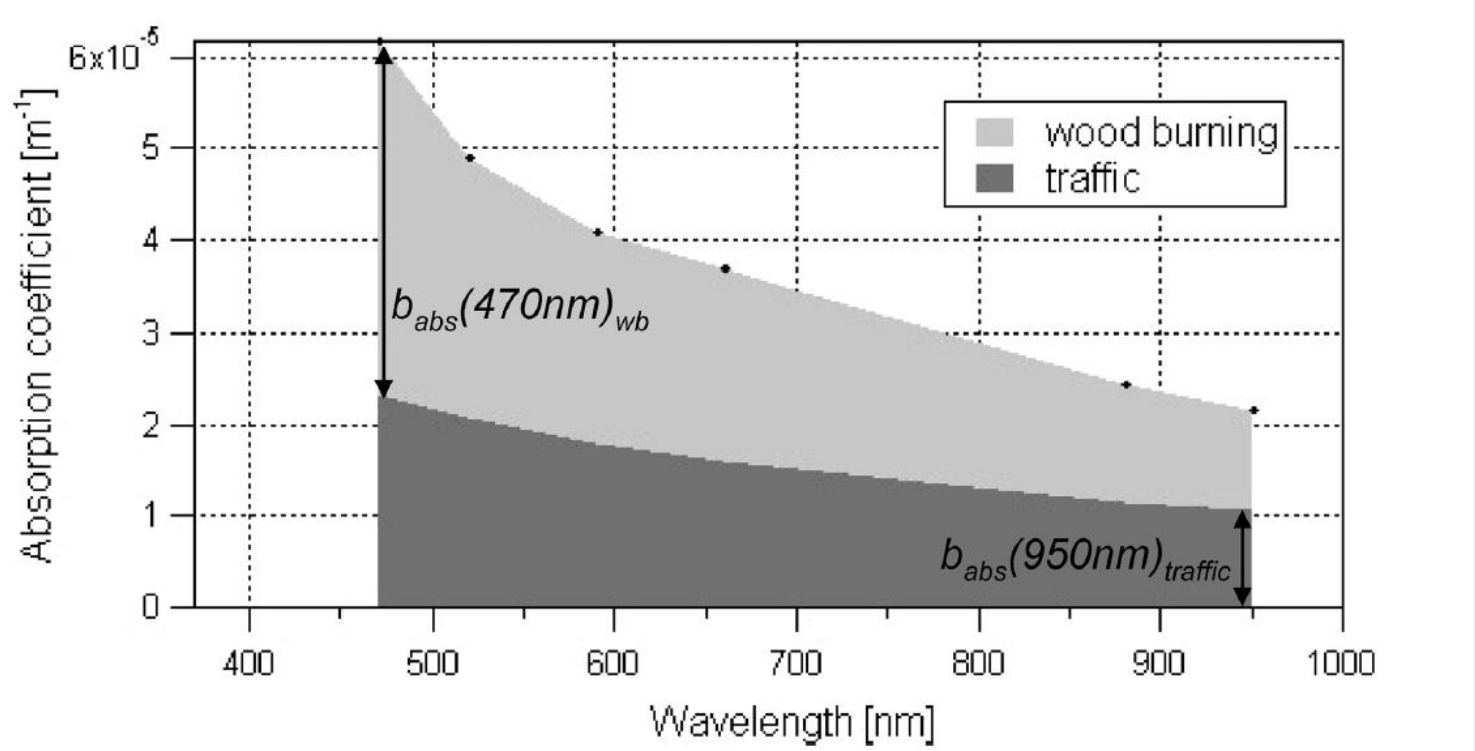


Method 2
Athelometer
Angstrom coefficient

Aethalometer

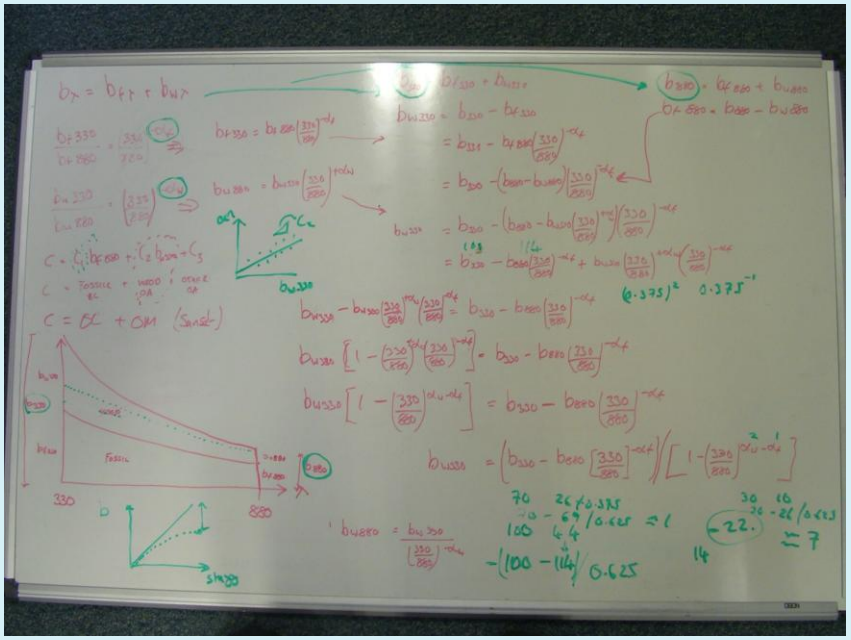
- Aethalometers installed in London as part of Defra black smoke network with UV 370nm and IR 880nm wavelengths

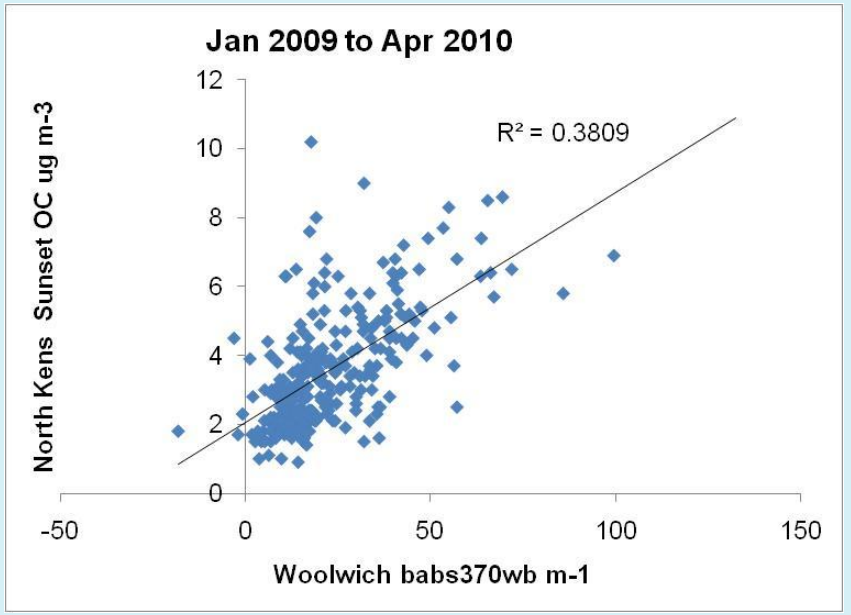
- Can be used to detect PM from wood smoke (Favez et al., 2009, 2010, Sandradewi et al., 2008a, 2008b, Sciare et al 2011 and others)

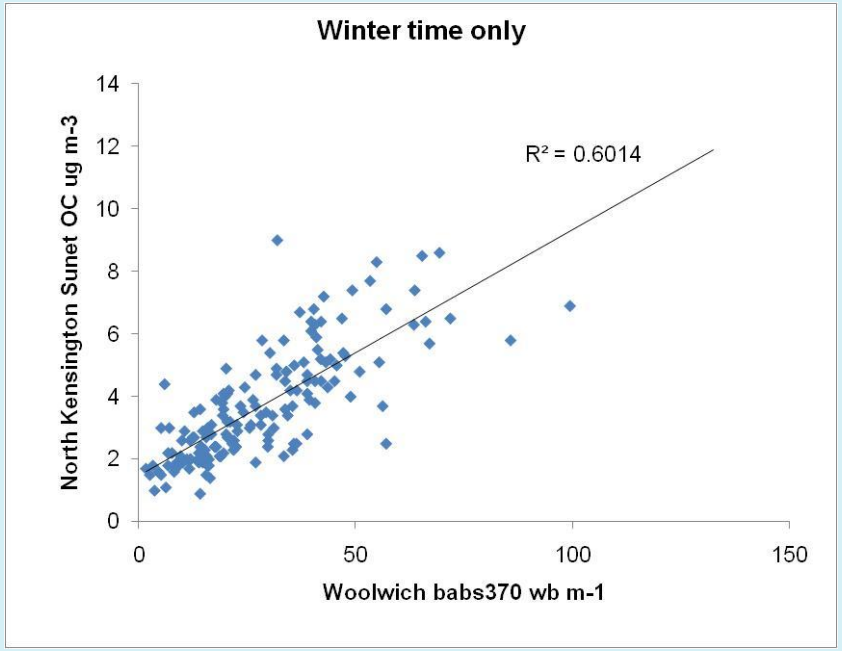


Aethalometer

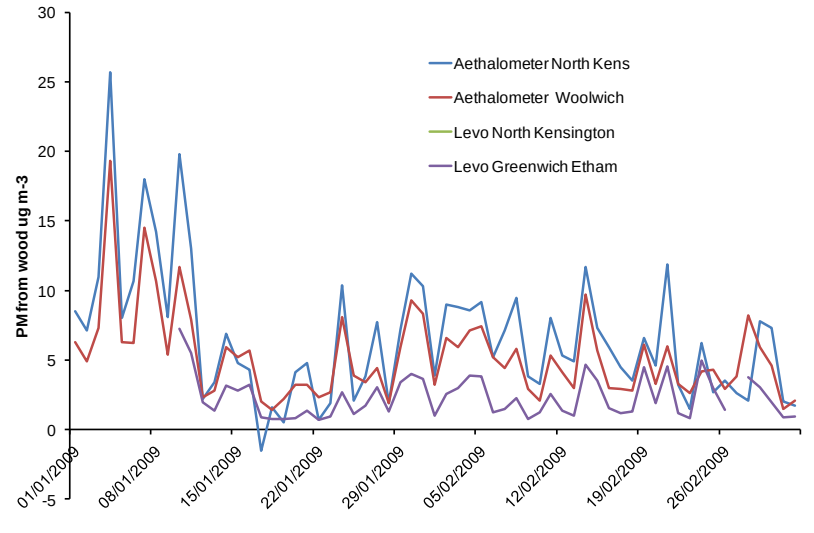
- A bit of maths later.....
- $B_{abs(370)wb}$ needs to be "calibrated" against ambient OC

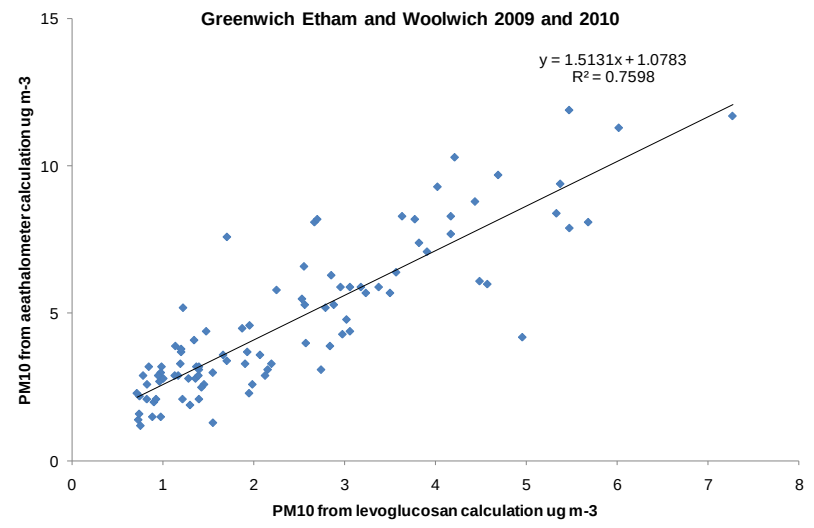


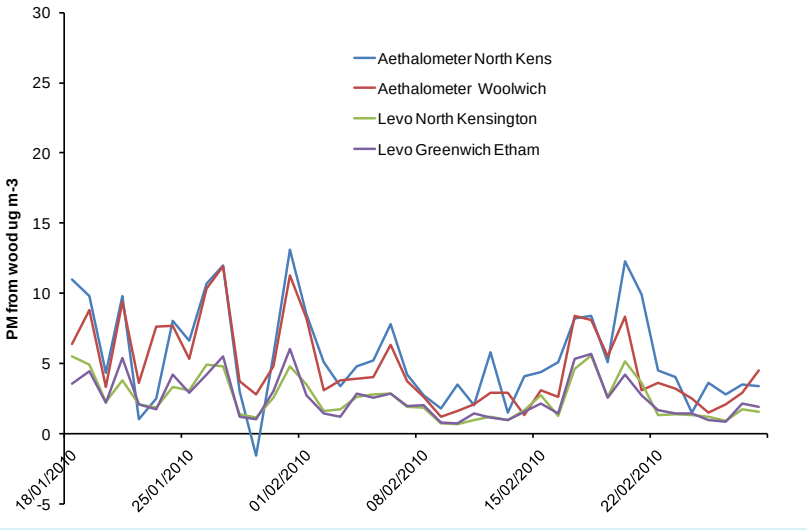


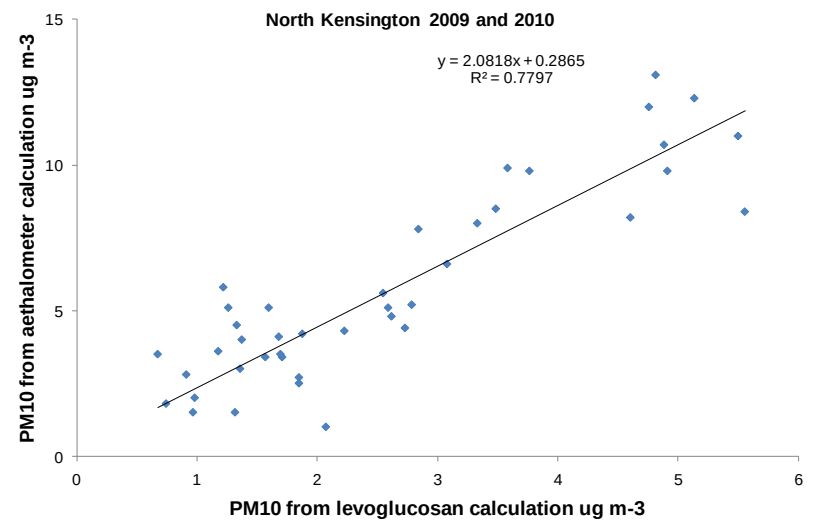


Aethalometer

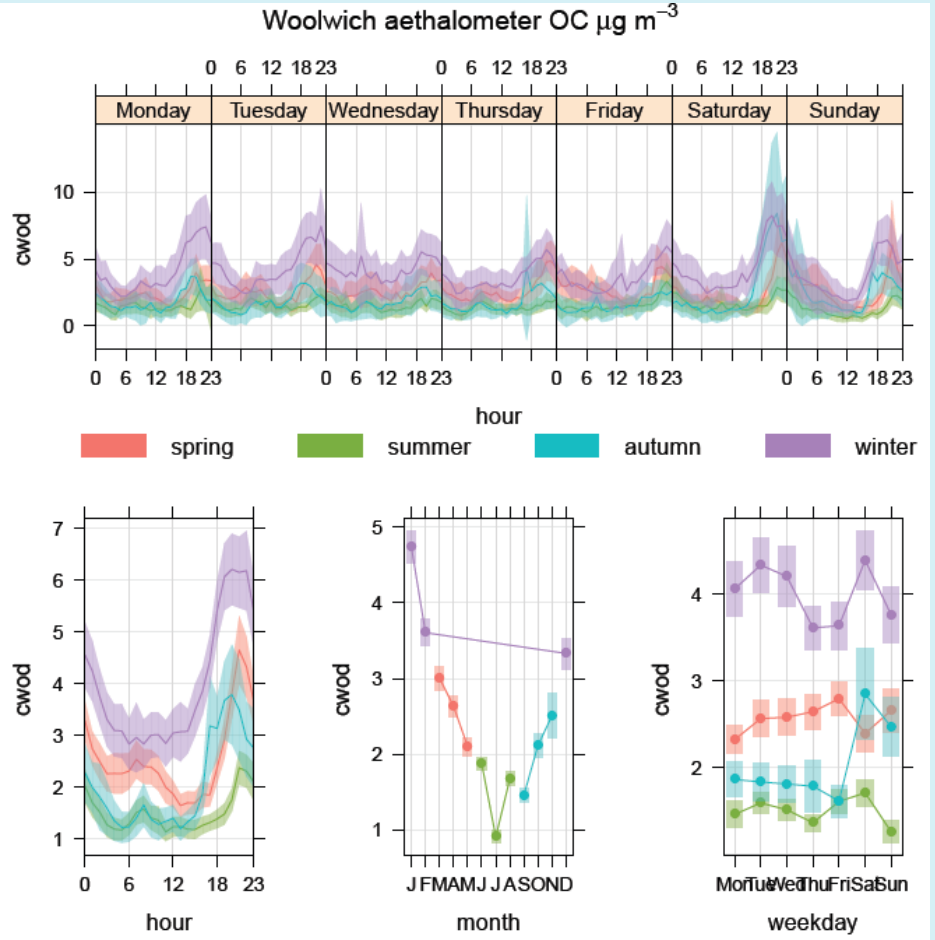


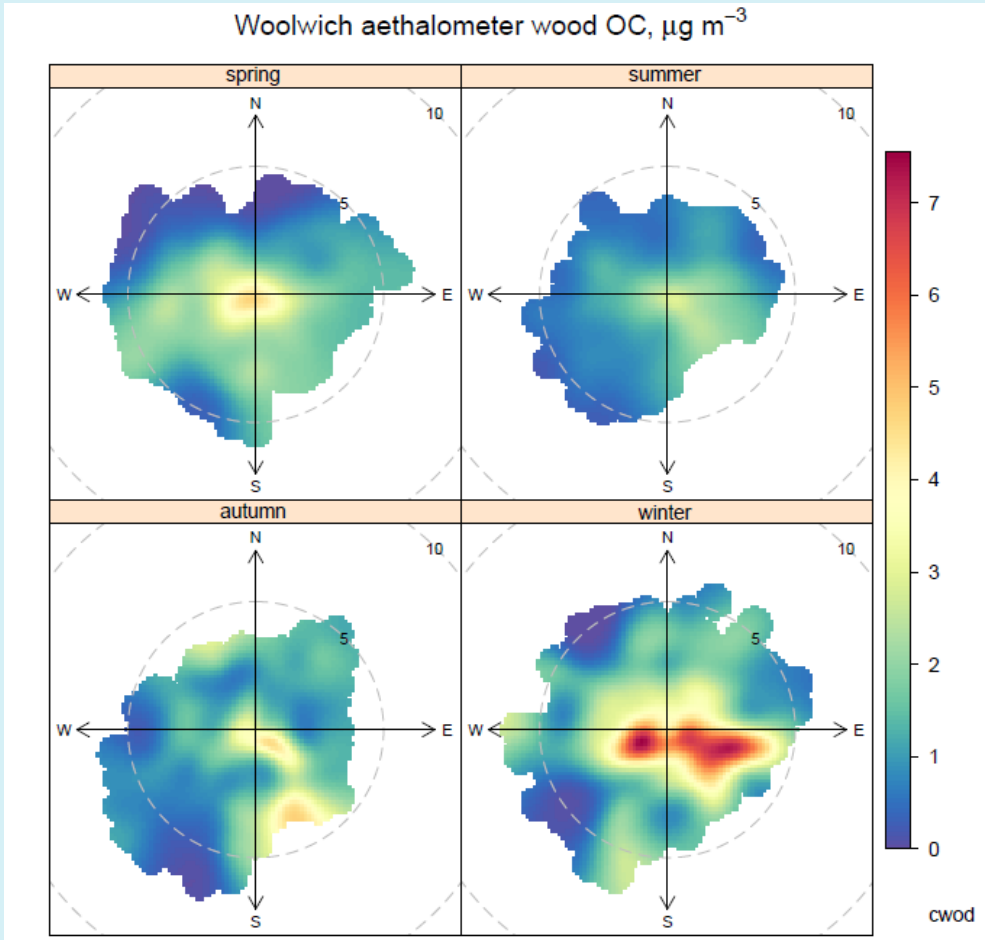






Aethalometer - Woolwich





Aethalometer

- Can be also be used to calculate BC/EC wood burning emissions.
- Annual mean PM wood (aethalometer) ~ 3 ug m-3
- But aethalometer OC from wood smoke > levoglucosan method
  - by ~1.5x at woolwich and ~2x at North Kensington
  - Probably due to other primary emissions of OC which have some correlation with PM from wood.
  - Correlations between PM wood (aethalometer) and OC are better in winter than summer but slopes are nearly the same.

Conclusions

Conclusions

Two different techniques provide evidence for PM from wood burning in London.

Two methods correlate well but aethalometer > levoglucosan (by a factor of 1.5 to 2), maybe due to confounding by other primary OC sources in London.

Conclusions

Levoglucosan measurements can be used as a baseline for future work.

Levoglucosan suggest PM10 from wood burning ~ 3 µg m^{-3} during wintertime study vs mean PM10 of ~ 25 µg m^{-3}.

Aethalometer measurements can provided highly time resolved measurements for source identification. These suggest this is mainly **winter** source.

PM wood sources are greatest at **weekends and in the evenings** suggesting that wood burning is a secondary domestic heating source

Diffusion relationships with wind speed suggest that PM10 from wood burning appears to be a **diffuse London source**.

PM from wood burning is mainly from domestic wood burning in existing fire places (NB: no incremental levo at Islington Arsenal next to modern burning)

Smoke control legislation in London isn't working

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

Conclusions – next steps?

2009 and 2010 levoglucosan study design is very expensive but may be worth repeating on a smaller scale.

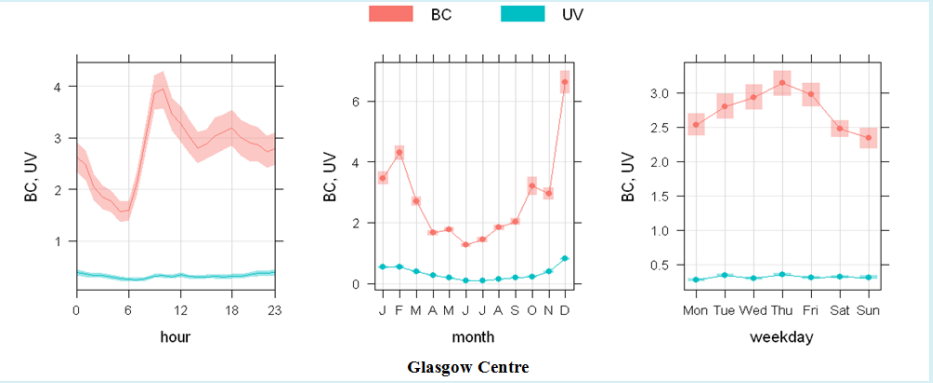
Other researchers have had good success using potassium in $PM_{2.5}$ as a tracer for PM from wood burning.

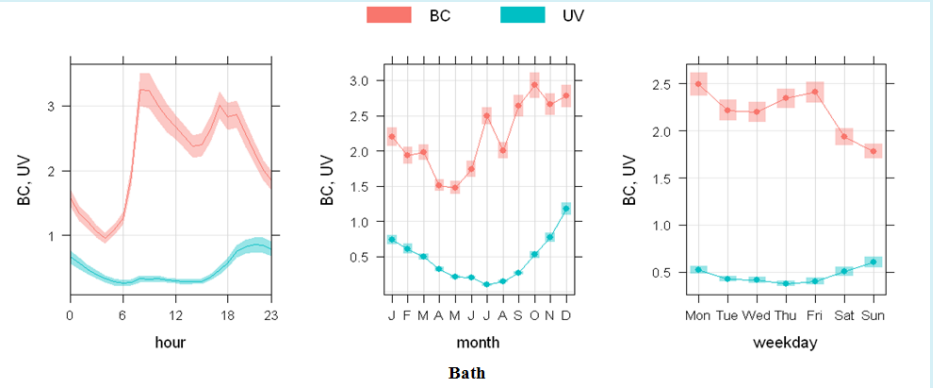
Aethalometer method should be **proportionate** even if it doesn't give good absolute concentrations.

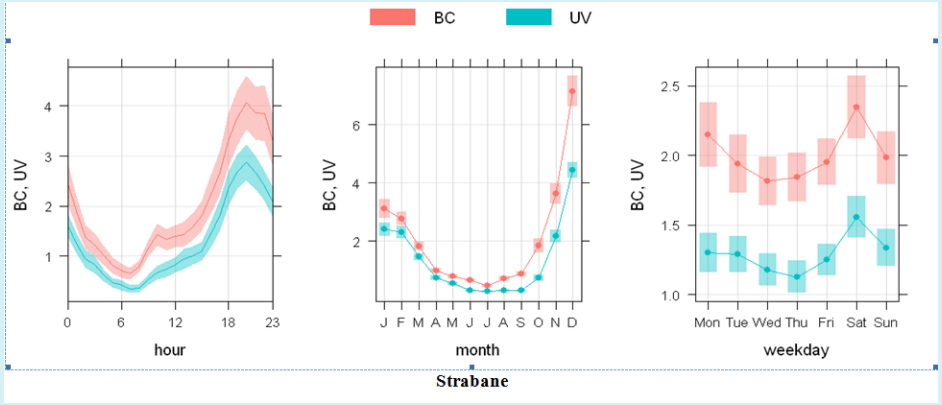
Could be applied to the national black smoke network (if we assume London wood smoke sources are representative of other urban areas of the UK.

Looking around the UK

Simple BC and UV – IR diurnals 2010 not direct assessment of wood smoke but indicative of relative concentrations of UV absorbing PM (NPL Butterfield et al 2011)







Thanks…

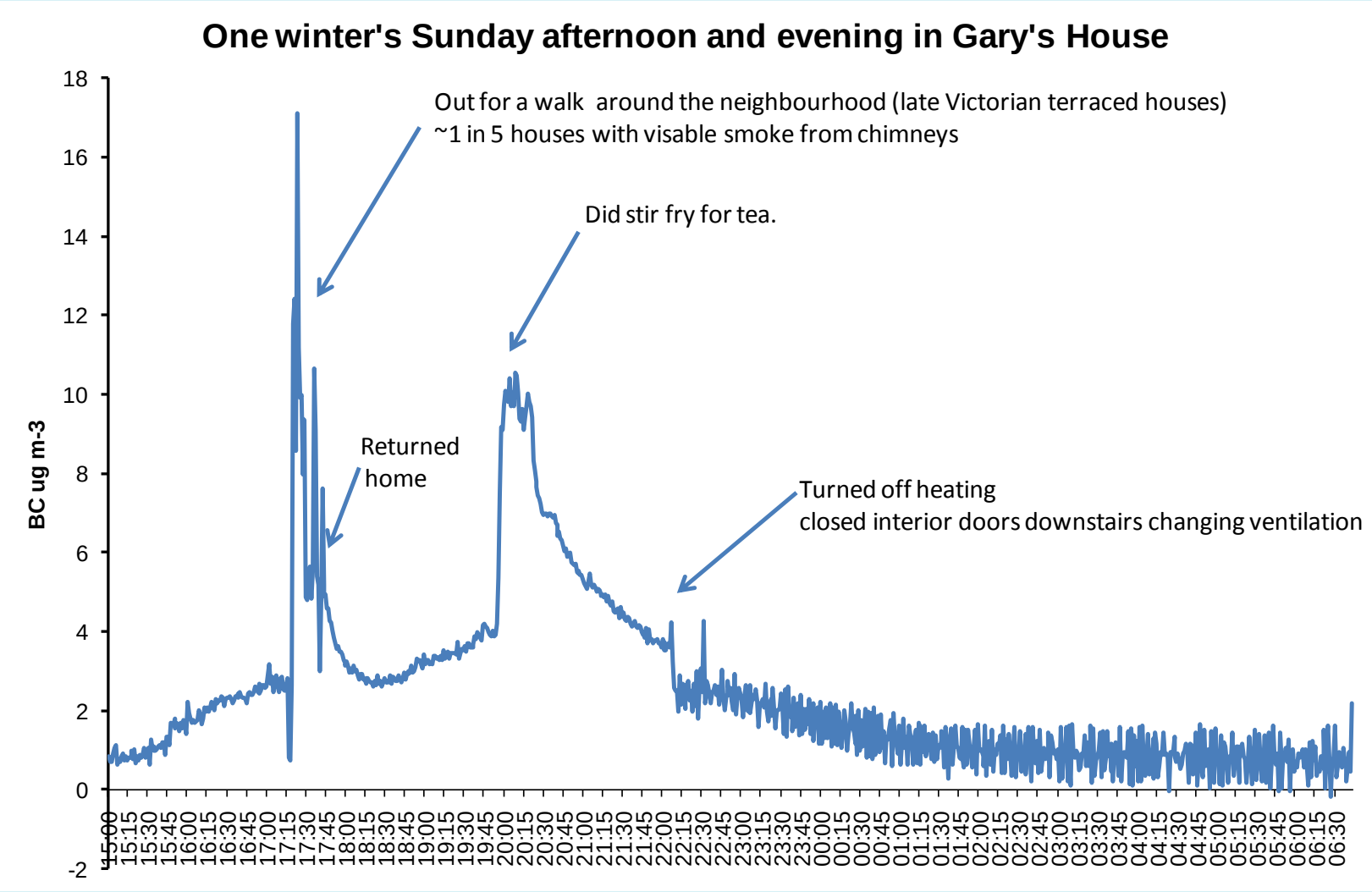
London boroughs of Greenwich, Bexley, Central London cluster group and defra for having the foresight to fund the Levoglucosan measurements and Ealing fro hosting 2010 sampling.

Jean Sciare, Laboratoire des Sciences du Climat et de l'Environnement for an excellent presentation on PM in Paris at the AirParif scientific advisory meetings.

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

Karl Espen Yittri for analysis and comments on the project.

Footnote


One winter's Sunday afternoon and evening in Gary's House
BC ug m-3
Out for a walk around the neighbourhood (late Victorian terraced houses)
~1 in 5 houses with visable smoke from chimneys
Did stir fry for tea.
Returned home
Turned off heating
closed interior doors downstairs changing ventilation