Wood burning PM in the UK

- a first national investigation

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MRC-PHE
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Public Health England | MRC Medical Research Council | Imperial College London | King's College London | NPL

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Wood smoke

• **Domestic wood burning in the UK** has been systematically **underestimated by a factor of three** (Walters, 2016) and over **1.2 million wood stoves have been sold in the UK in 2010 to 2016** (Milligan, STA)

•A DECC survey (Walters, 2016) estimated that **7.5 % of the population uses wood as heating**. The main wood devices were **logwood in stoves or open fires**.

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•**Wood burning** can be **10% of PM** in winter in inner London (Fuller et al., 2014)

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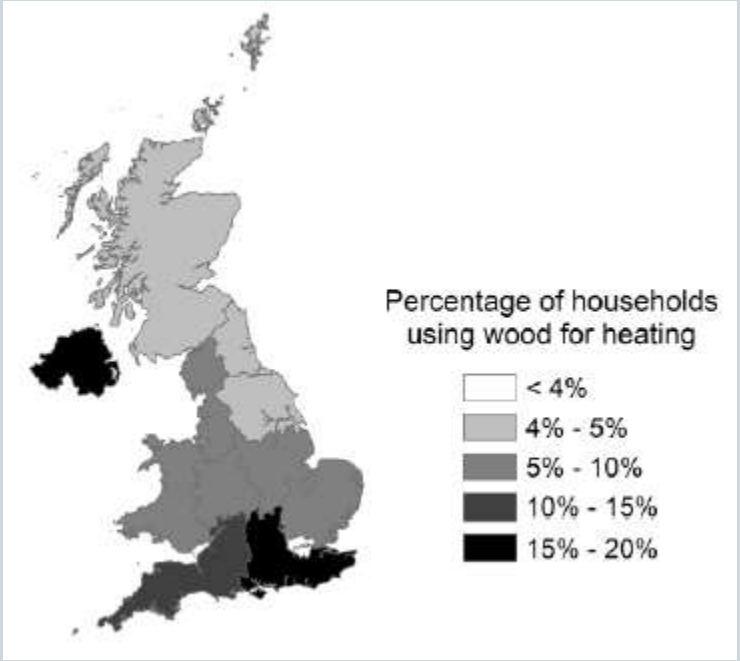


Mitchell et al 2017

Methods for wood smoke quantification

There is NO REFERENCE method

Levoglucosan measurements (chemical)

(+) Wood combustion is the only atmospheric source

(-) Low time resolution (daily); conversion ratios dependent on combustion conditions; very expensive

Fine Potassium measurements (chemical)

(-) Correction from wind-blown soil & sea salt

(-) Conversion ratios dependent on combustion conditions

Aethalometer method (physical-optical)

(+) High time resolution (hourly)

(-) Interferences when there are multiple sources of solid fuel (coal, etc.)

^{14}C measurements (physical-radioactive)

(+) Very precise for EC (-) but no quantification for OC

(-) Expensive analytical method; Conversion ratios dependent on combustion conditions

Aerosol Mass Spec-Positive Matrix Factorization (chemical-statistical)

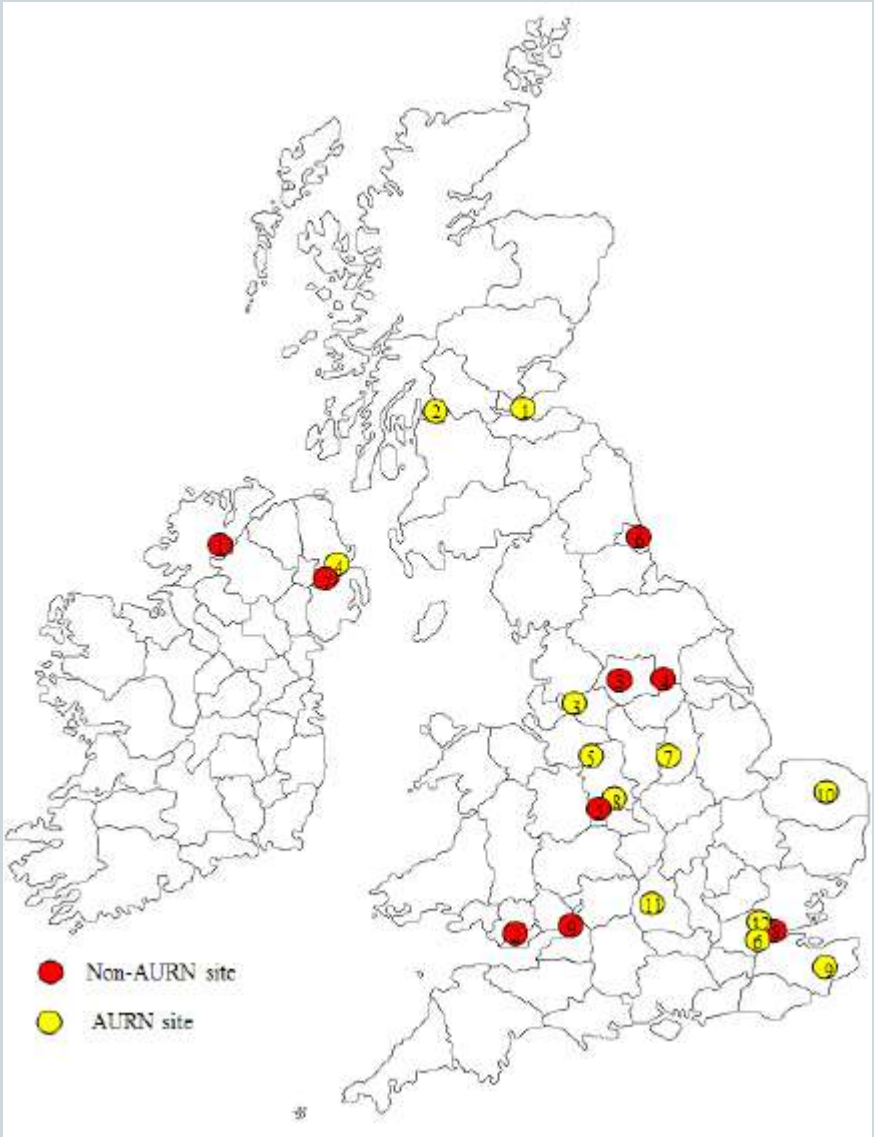
(+) High-time resolution

(-) EXPENSIVE equipment cost & possible location specific solutions to PMF

(Methods generally correlate well but differ in estimates of magnitude).

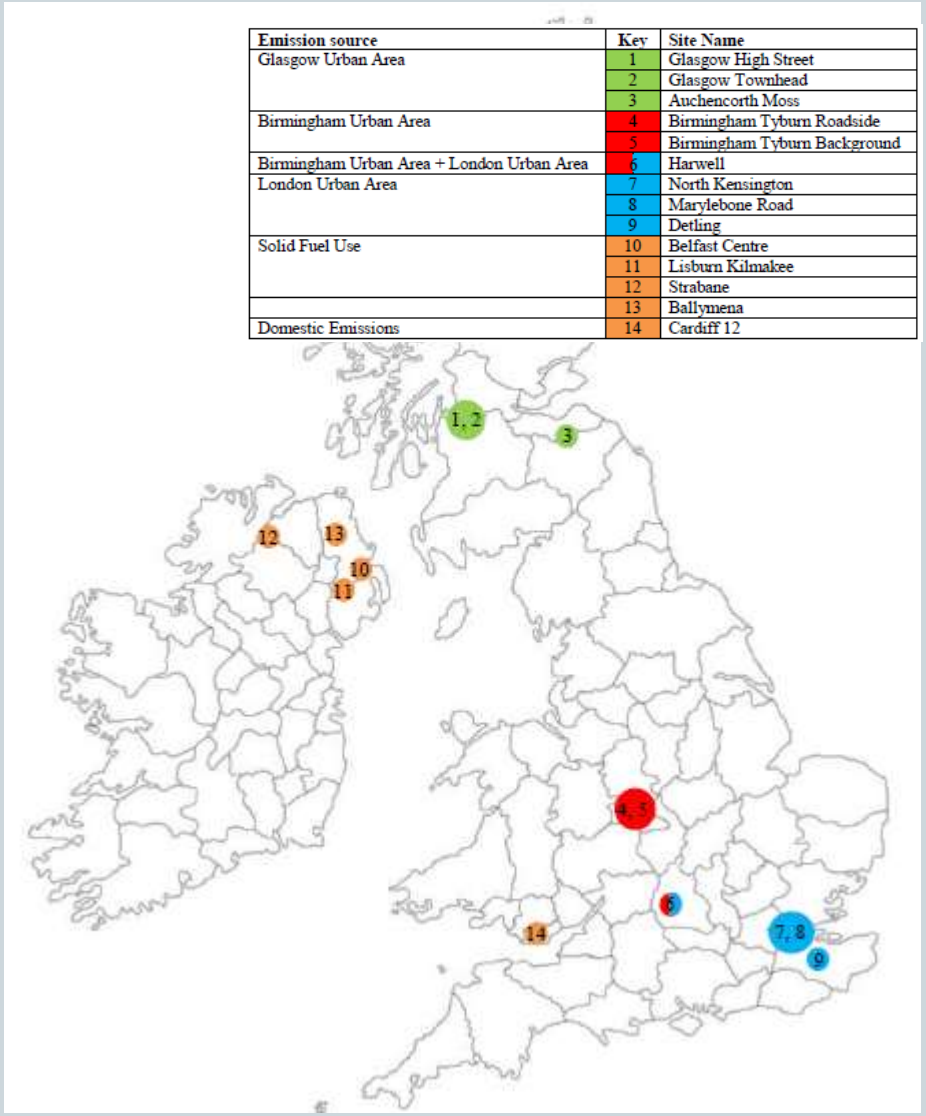
Black carbon network in the UK

The network prior to 2012



The network after 2012

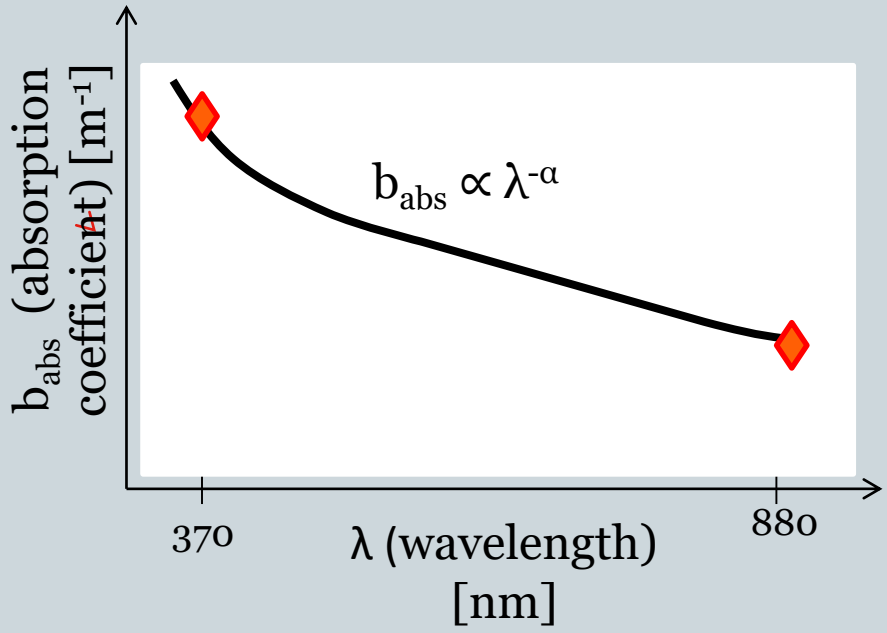
Emission source	Key	Site Name
Glasgow Urban Area	1	Glasgow High Street
	2	Glasgow Townhead
	3	Auchencorth Moss
Birmingham Urban Area	4	Birmingham Tyburn Roadside
	5	Birmingham Tyburn Background
Birmingham Urban Area + London Urban Area	6	Harwell
London Urban Area	7	North Kensington
	8	Marylebone Road
	9	Detling
Solid Fuel Use	10	Belfast Centre
	11	Lisburn Kilmakee
	12	Strabane
	13	Ballymena
Domestic Emissions	14	Cardiff 12



The aethalometer model (AeM)

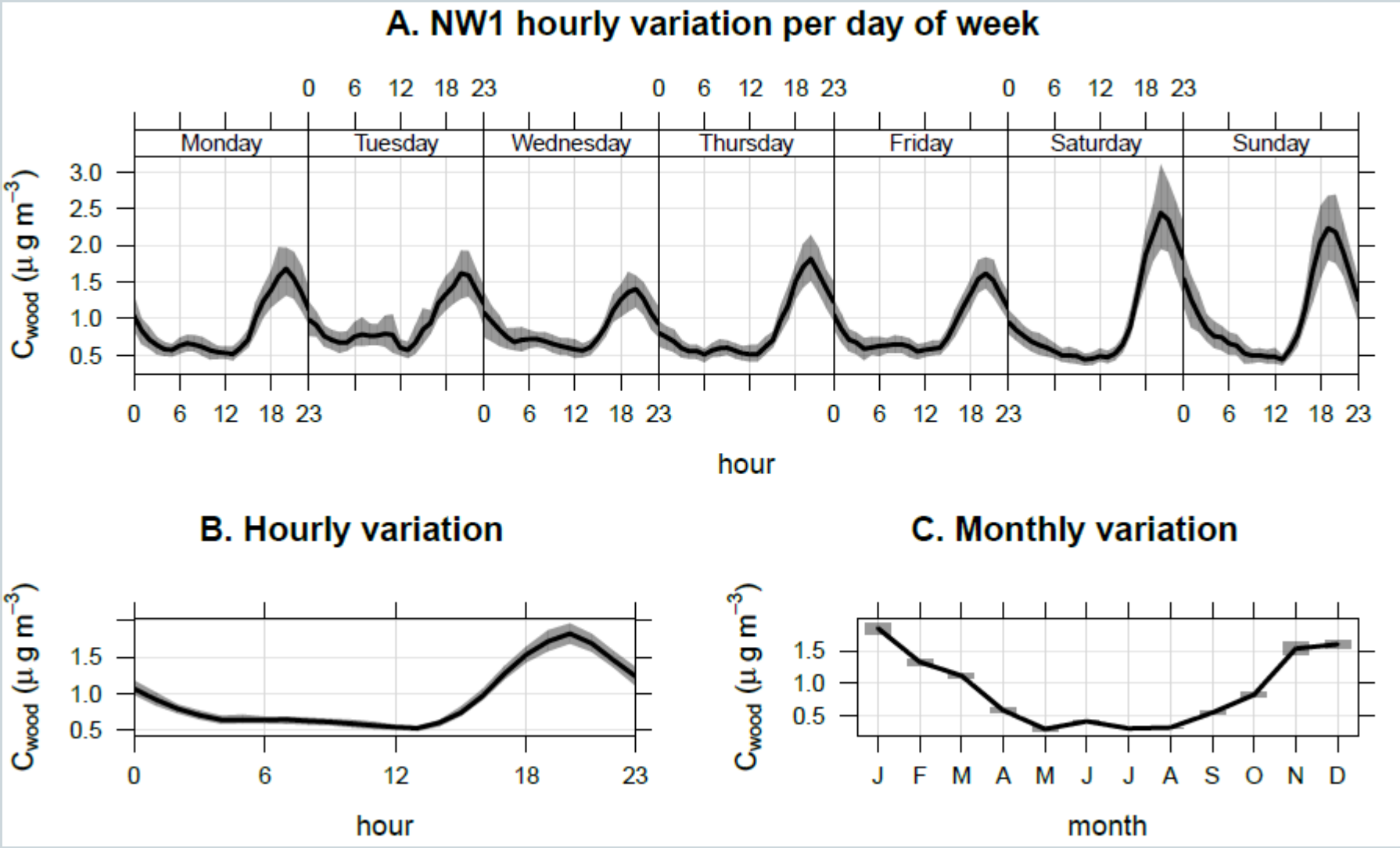
Aethalometer A22 measures the light absorbance of particles collected in the tape at two wavelengths: UV (370nm) and IR (880nm)

(Some similarities to the old black smoke method)

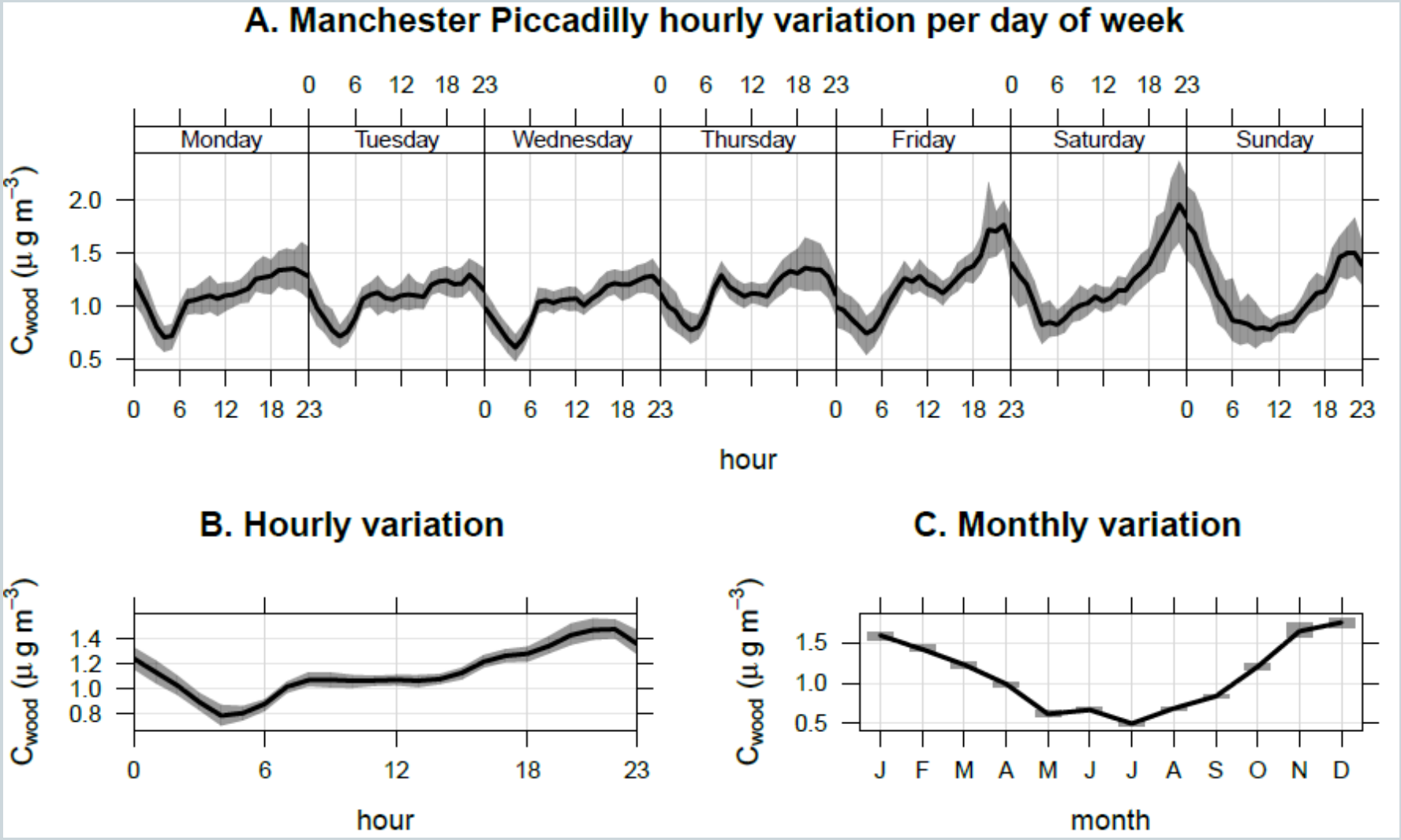


Time variation wood burning

NORWICH



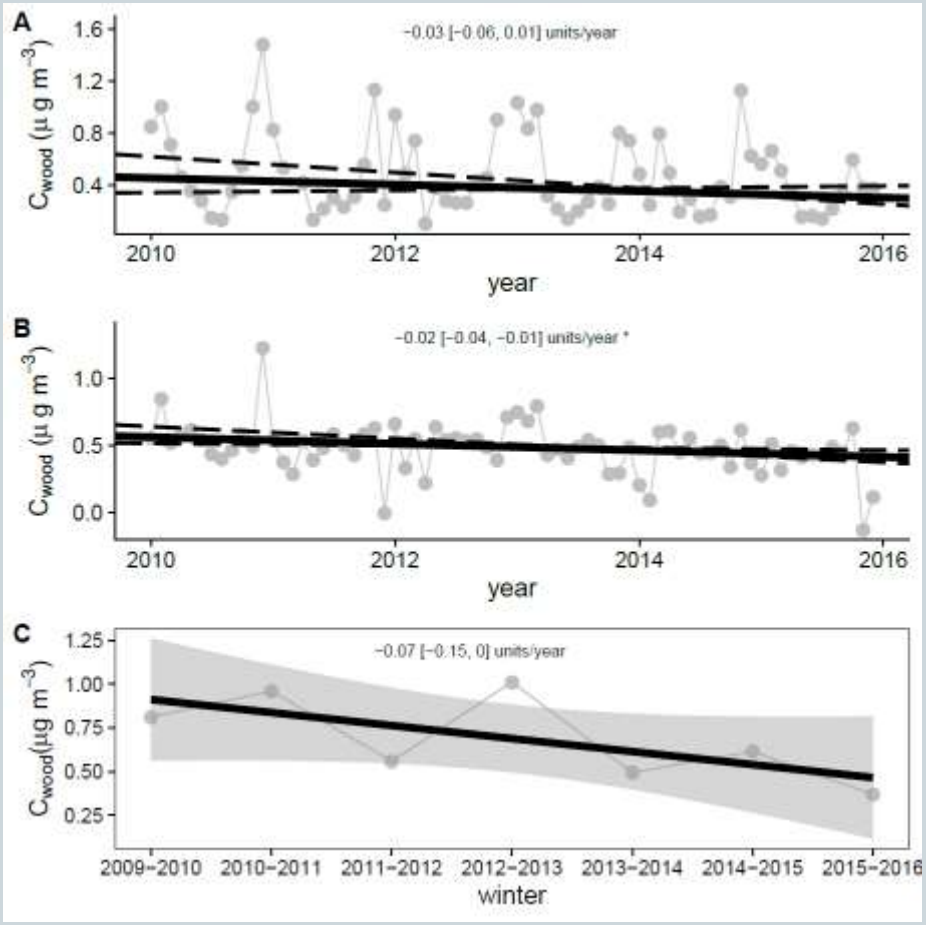
Time variation wood burning



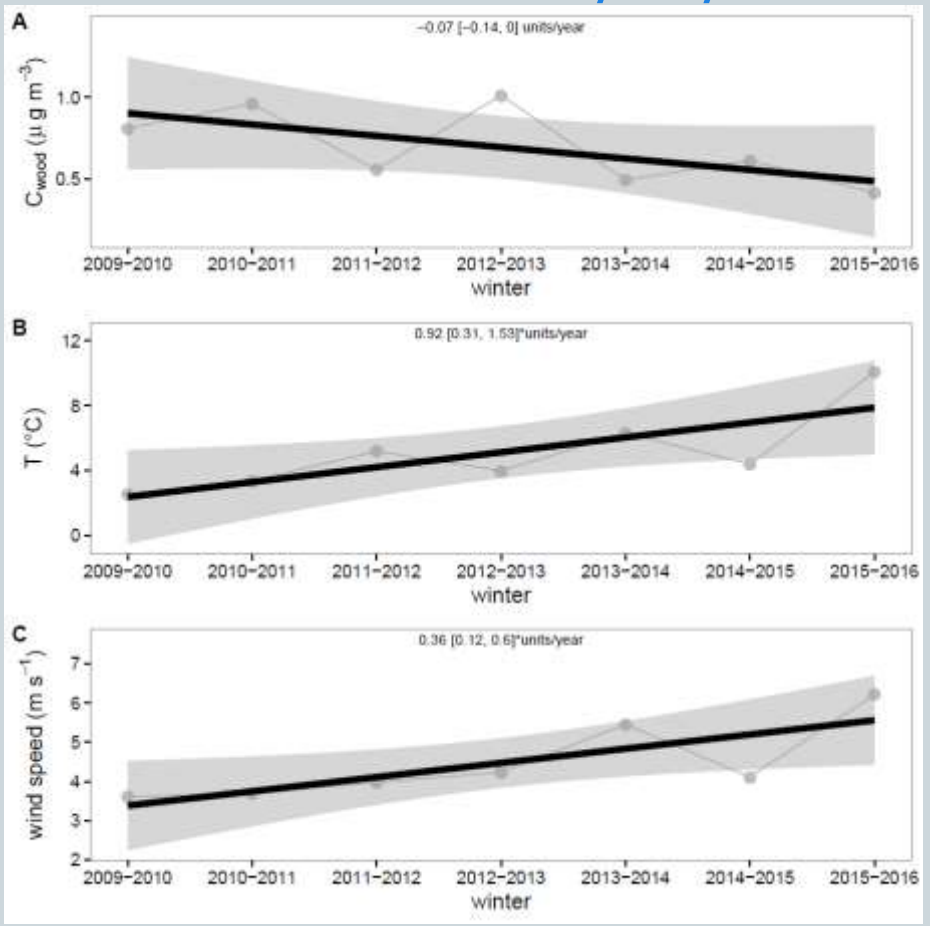
Trends in Cwood

HARWELL

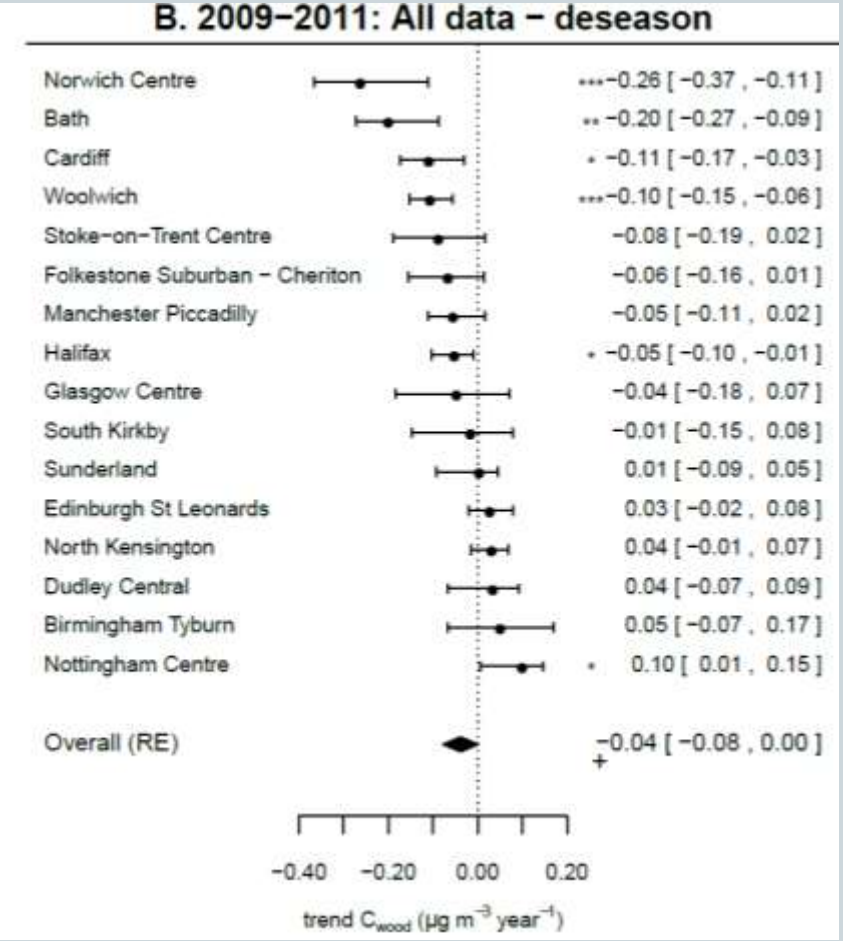
Trends in C_{wood}

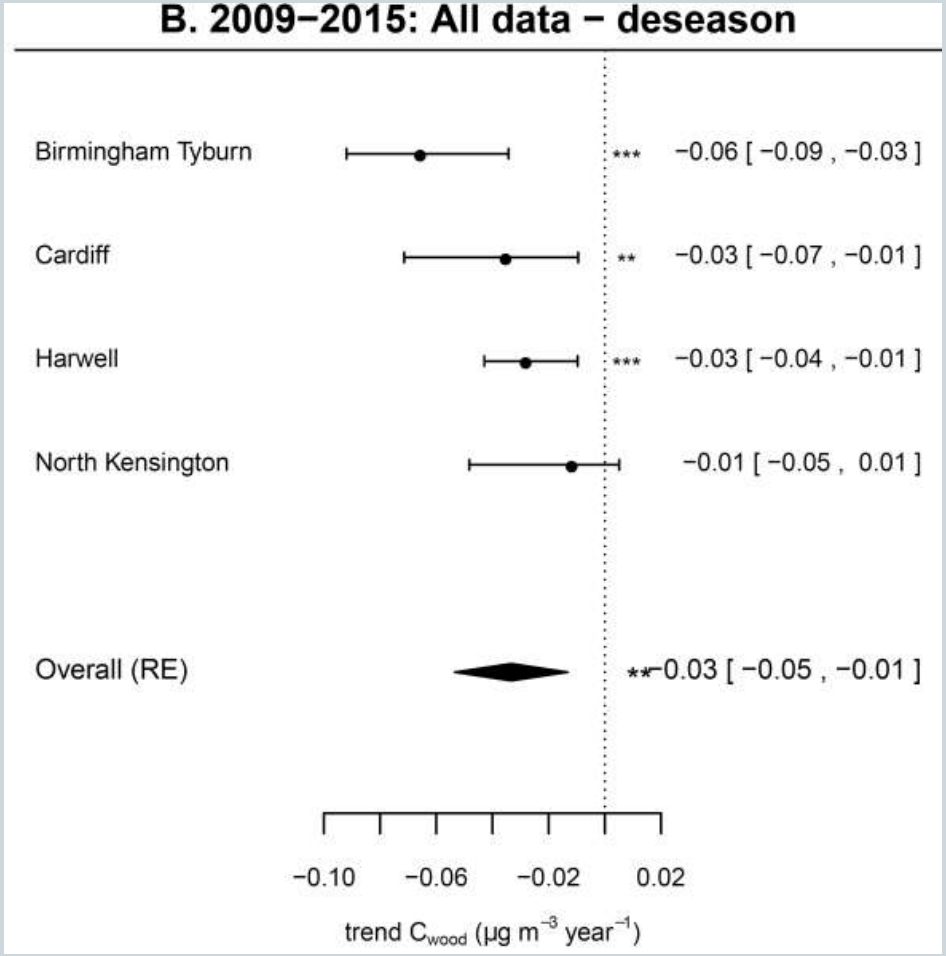


Trends in C_{wood} / T / ws



Trends in Cwood:



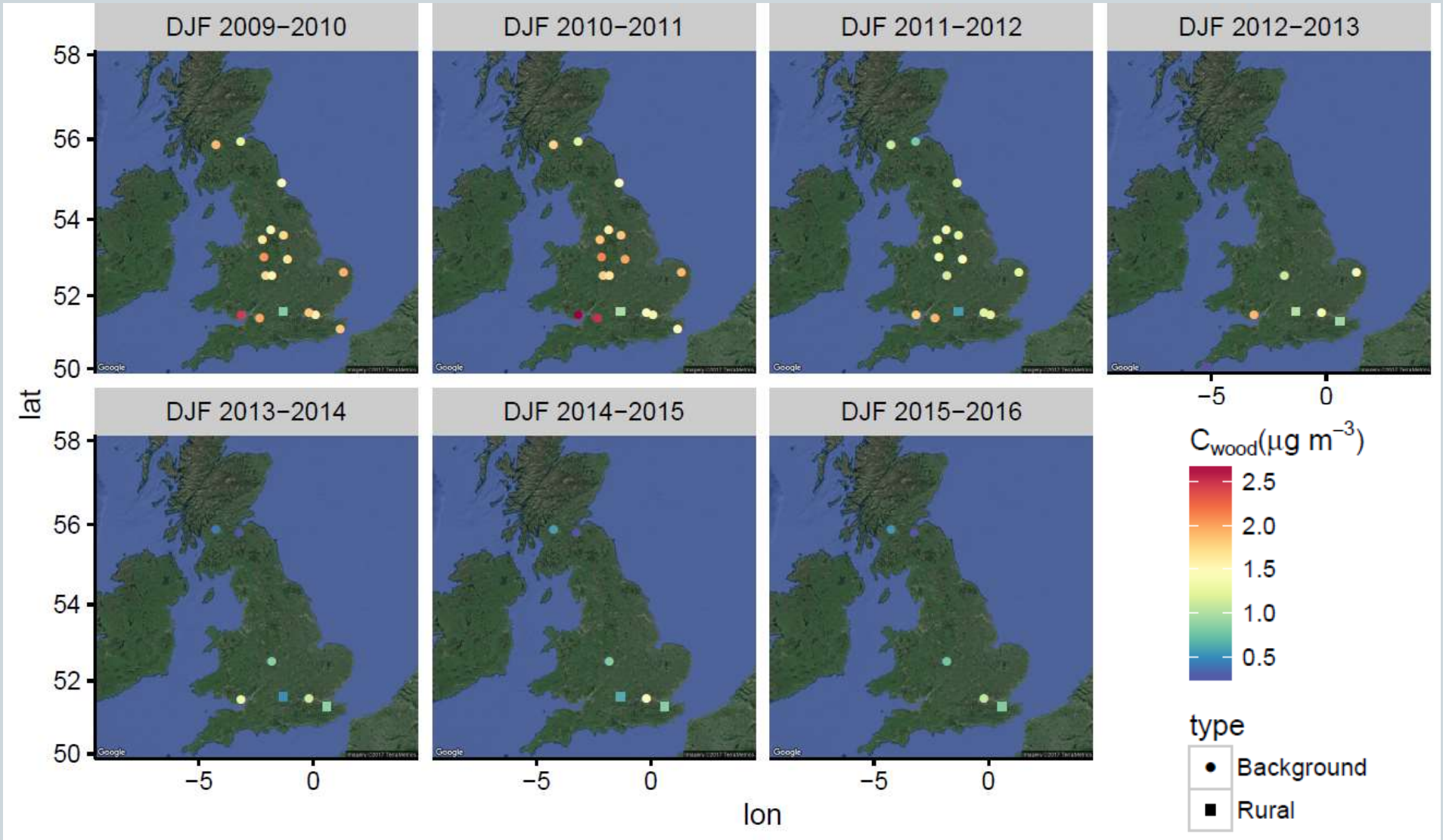


Trends in Cwood

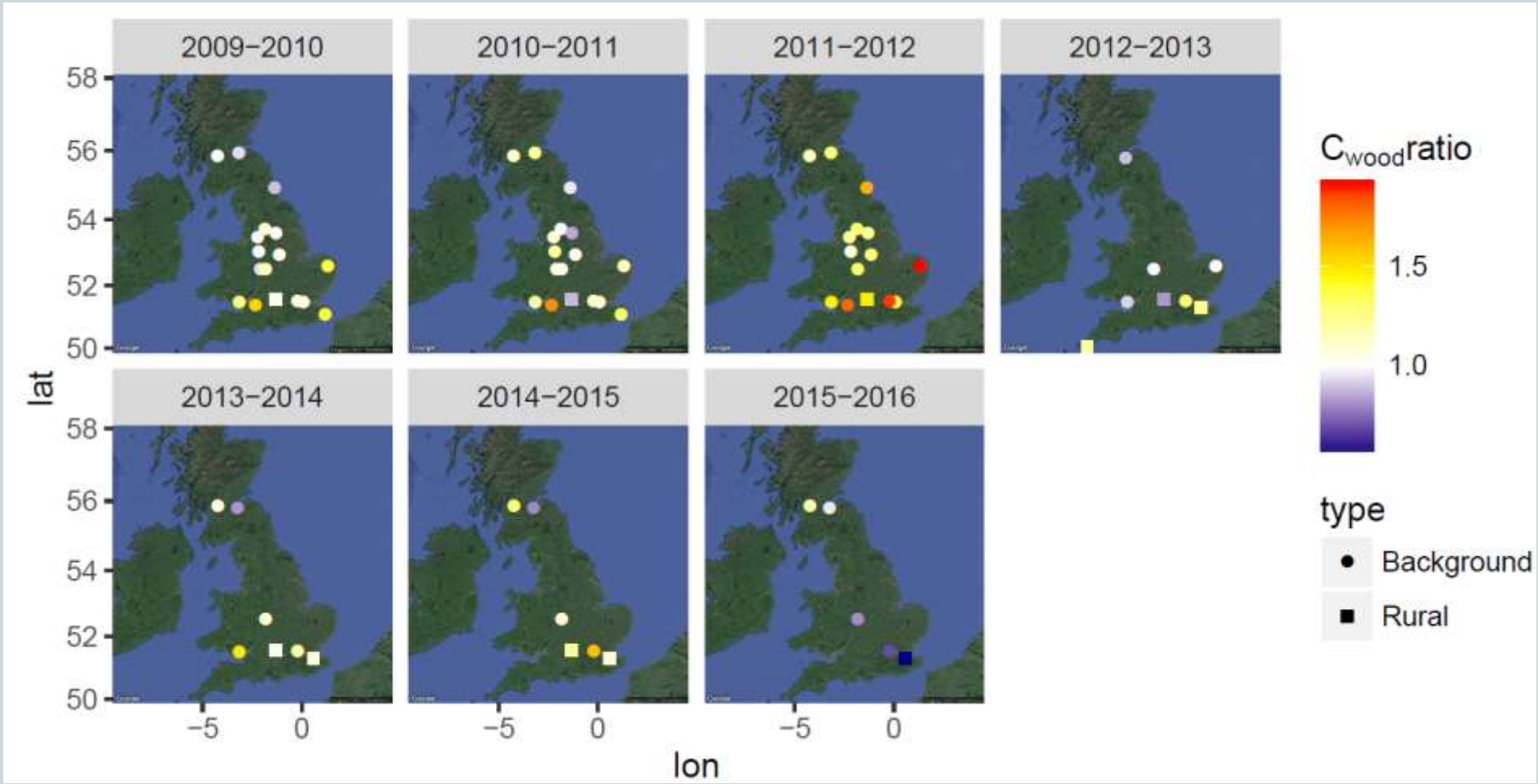
	2009 – 2011	2009 – 2015
C_{wood} all data (µg m^{-3} $year^{-1}$)	−0.07 (−0.12 , −0.02)**	−0.04 (−0.06 , −0.01)**
C_{wood} all data – deseasonalized (µg m^{-3} $year^{-1}$)	−0.04 (−0.08 , 0.00)+	−0.03 (−0.05 , −0.01)**
C_{wood} winter (µg m^{-3} $winter^{-1}$)*	−0.21 (−0.25, −0.16)***	−0.14 (−0.23, −0.05)**
C_{wood} x wind speed winter (µg m^{-3} $winter^{-1}$)*	−0.39 (−0.59, −0.19)***	−0.34 (−0.59, −0.09)**

Concentrations in DJF

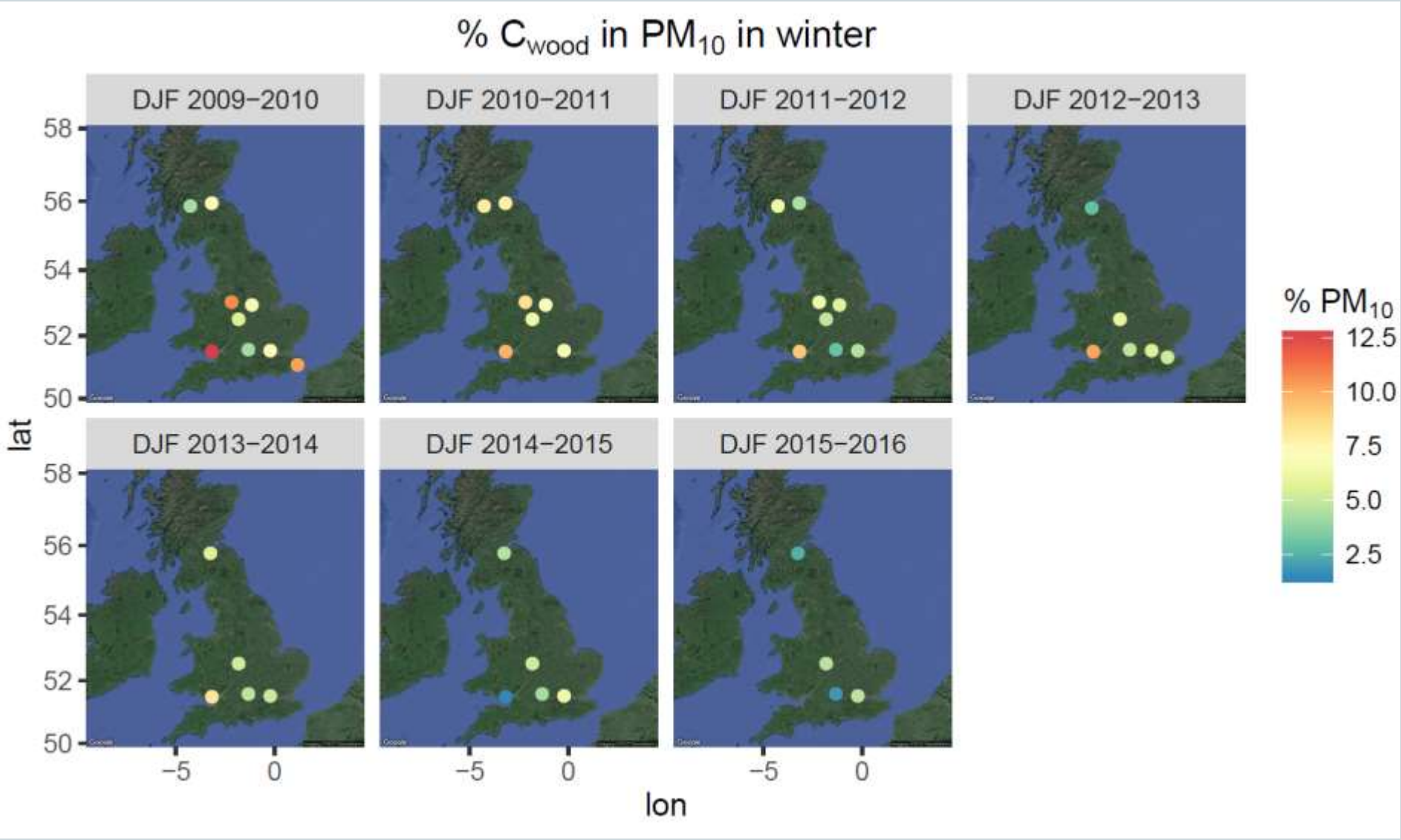
(Note: 2015-2016 based on provisional data)



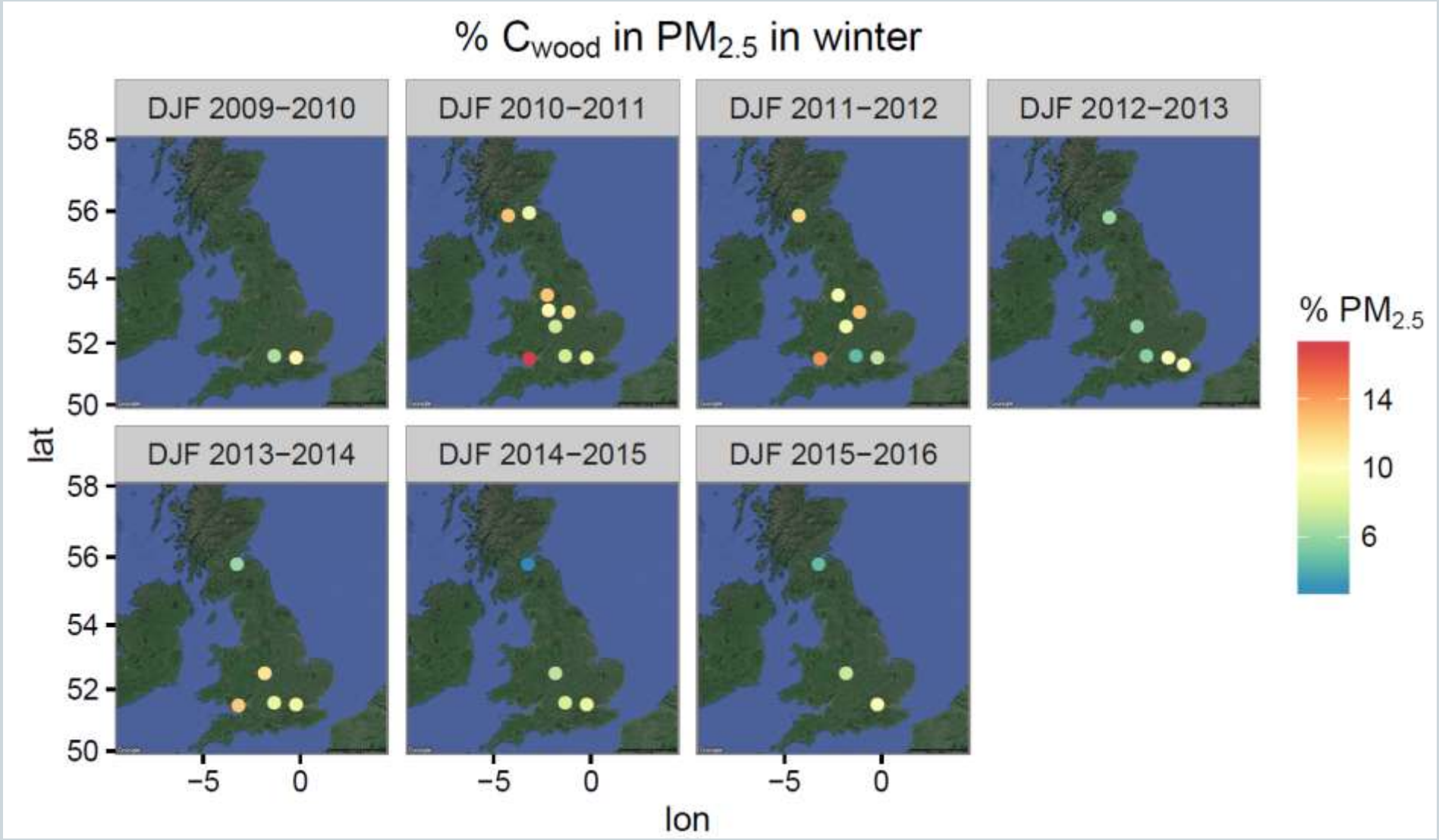
Weekend / weekday (evenings)



Cwood/PM10 winter averages

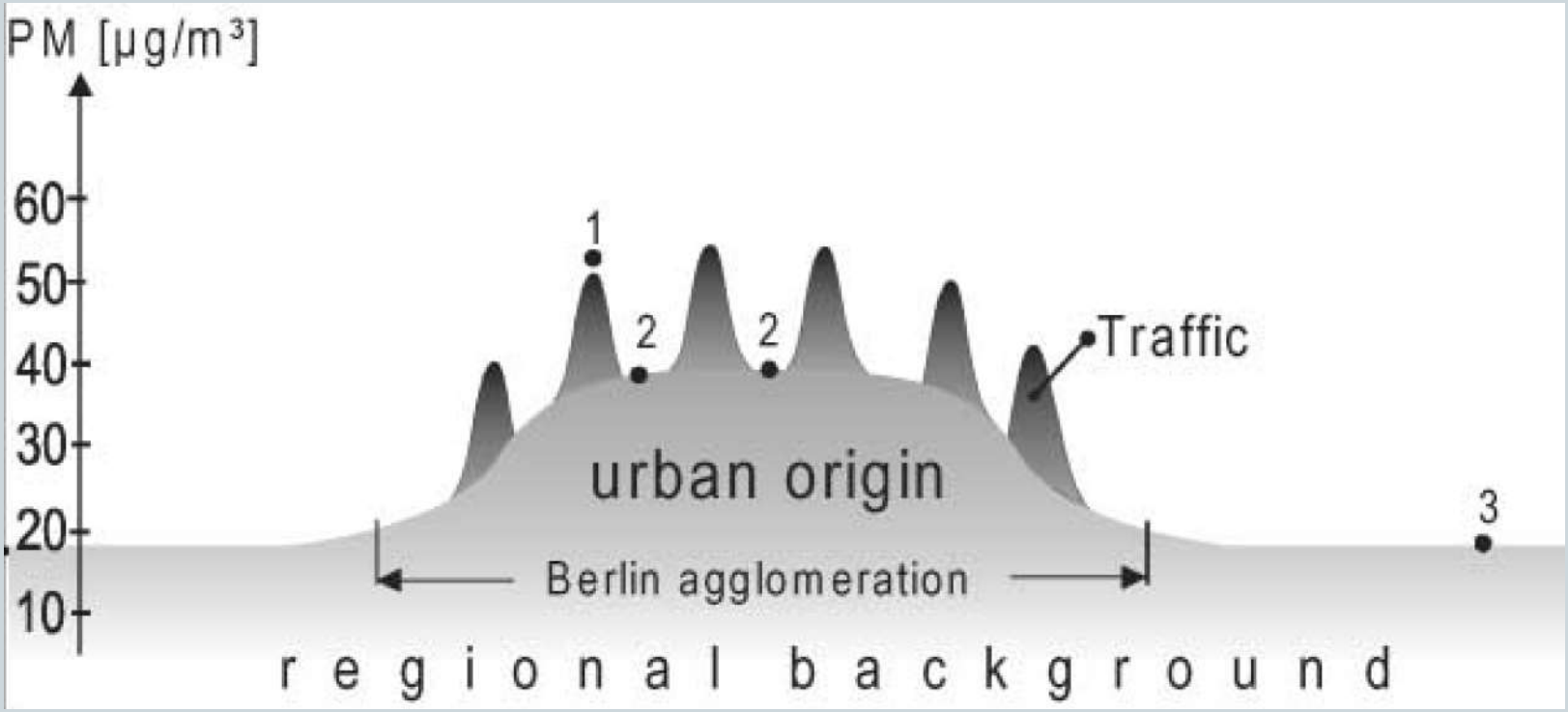


Cwood/PM2.5


% C_{wood} in $PM_{2.5}$ in winter
DJF 2009−2010
DJF 2010−2011
DJF 2011−2012
DJF 2012−2013
DJF 2013−2014
DJF 2014−2015
DJF 2015−2016
lat
58
56
54
52
50
−5
0
lon
% $PM_{2.5}$
14
10
6

Another perspective

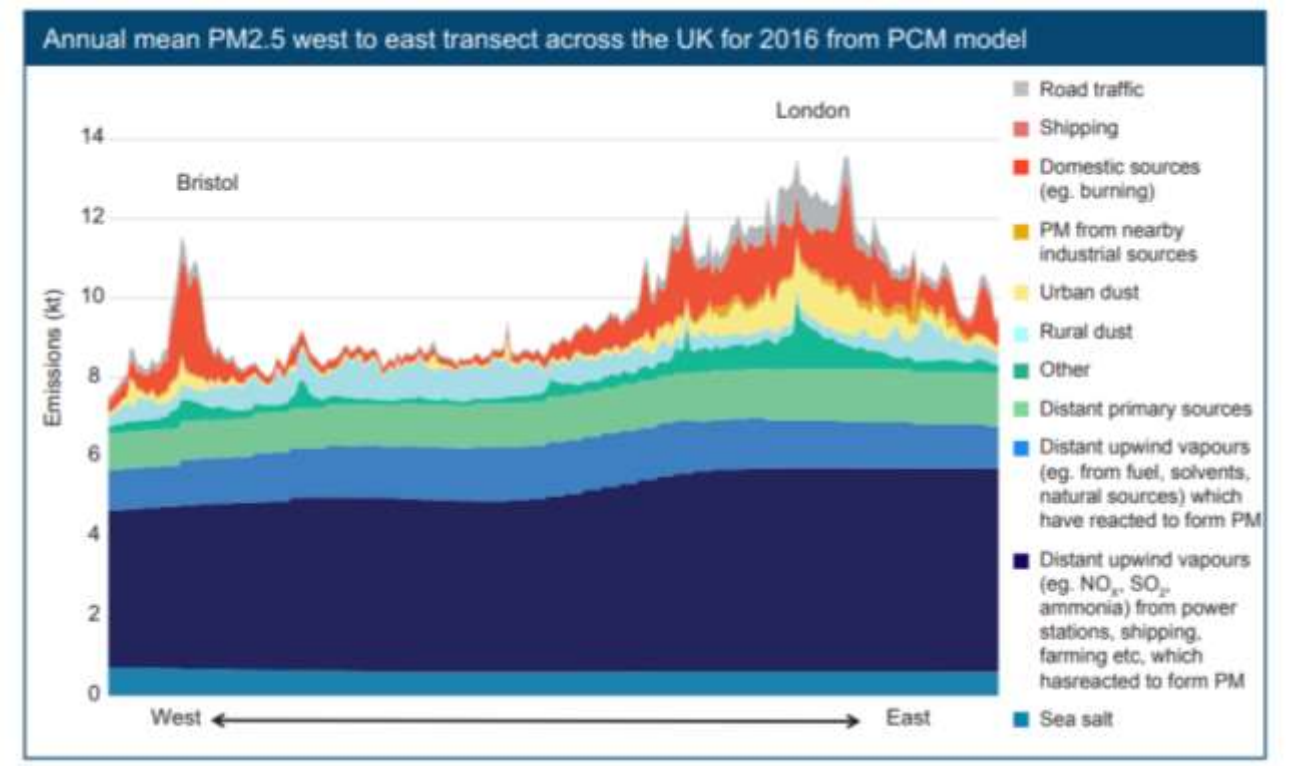
Apportion the contribution of urban Cwood using the Lenschow et al (2001) approach



Urban site	Rural site	Time period	C_{wood}/urban PM(%)	C_{wood}/urban PM(%)
London North Kensington	Harwell	Dec'09–Dec'15	23	26
London North Kensington	Detling	Jan'12–Feb'13	25	31
Birmingham Tyburn	Harwell	Jan'10–Dec'15	25	29

Another perspective

Apportion the contribution of urban Cwood using the Lenschow et al (2001) approach (ilistration - Defra, 2018)



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Conclusions

- **First estimate** of the **Cwood** contribution **nationwide**

- **Cwood** concentrations showed large seasonal variability **(higher from Nov to Feb);** and large weekly variability **(higher at evenings during the weekend)**

- **Winter Cwood** concentrations ranged from **0.24** to **2.7 µg m^{-3}**
- The **largest Cwood** concentrations were observed in the **Midlands and Wales** in winter **2010/11**

- **Cwood** represented **3 to 13%** of winter **PM_{10}** concentrations **(2-8% annually);** and **3 to 17%** for **$PM_{2.5}$ (3-12% annually).**

- **C_{wood} was 23 – 31%** of annual mean **$PM_{2.5}$ in the city increment (~urban emissions) in London and Birmingham.** This is a serious issue for urban air quality management and for legal requirements for PM2.5 exposure reduction.

Conclusions

- **Weekend/weekday** ratio ranged between 0.6 to 1.9; **mean 1.16 (median of 1.09)**.

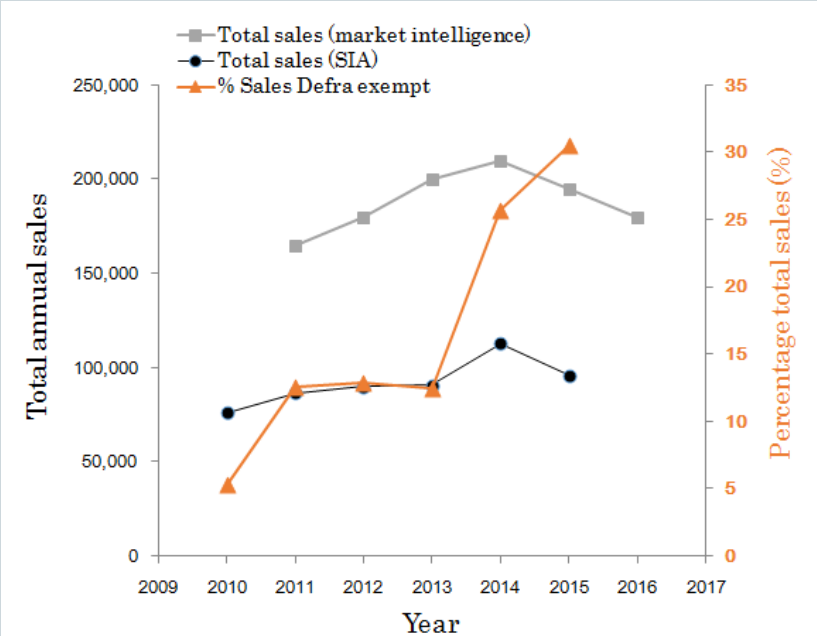
- **Cwood poor - moderately correlated with daily temperature** (R^2: 0.12 - 0.57 in winter). A max R^2 (0.76) was observed in Goonhilly (Cornwall) in winter during night hours.

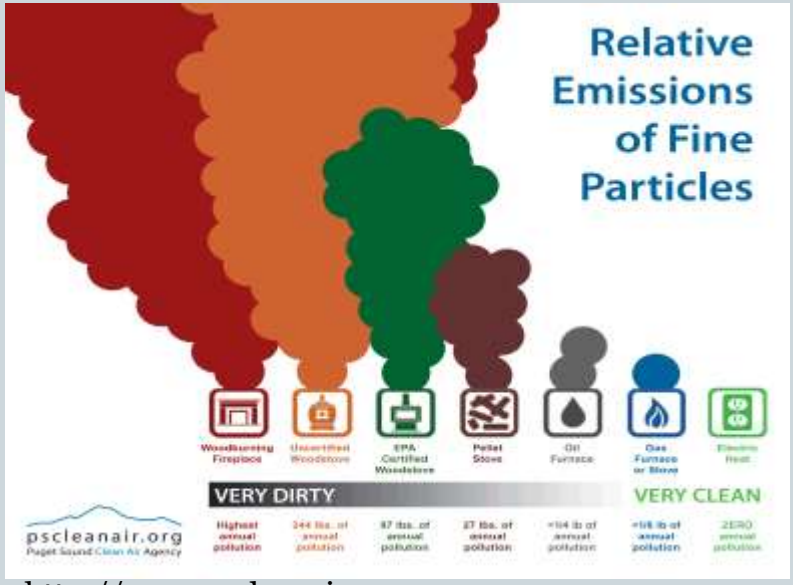
- These **might indicate recreational use** instead of main heating source

Conclusions

Trends between **2009/10 to 2015/16*** in **winter Cwood** indicate a **slightly negative** tendency.

Are more people using wood heating? But fireplaces are being replaced by stoves? Also weekend to weekday behaviour is changing

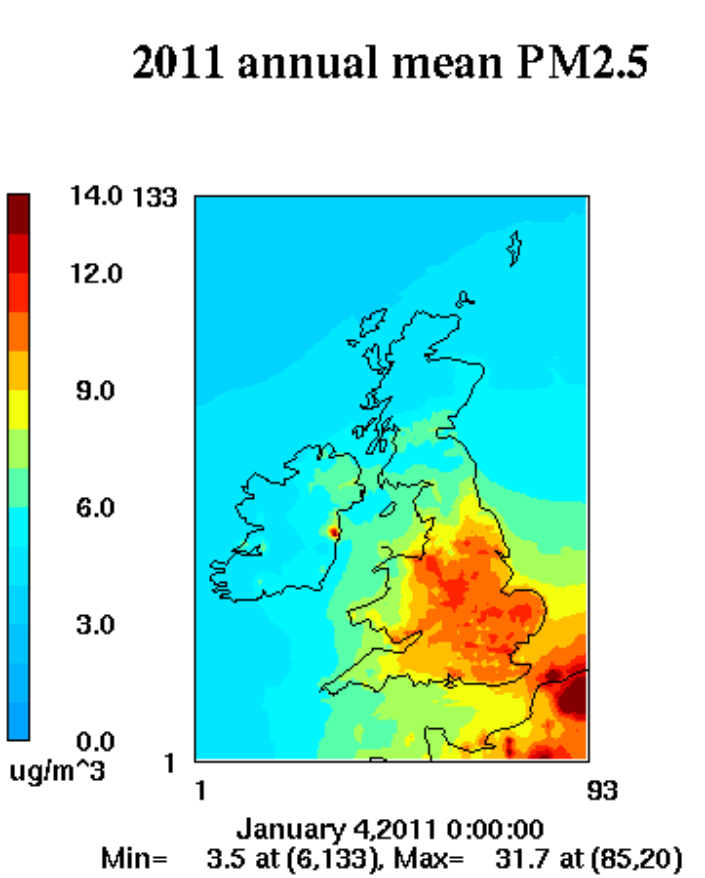


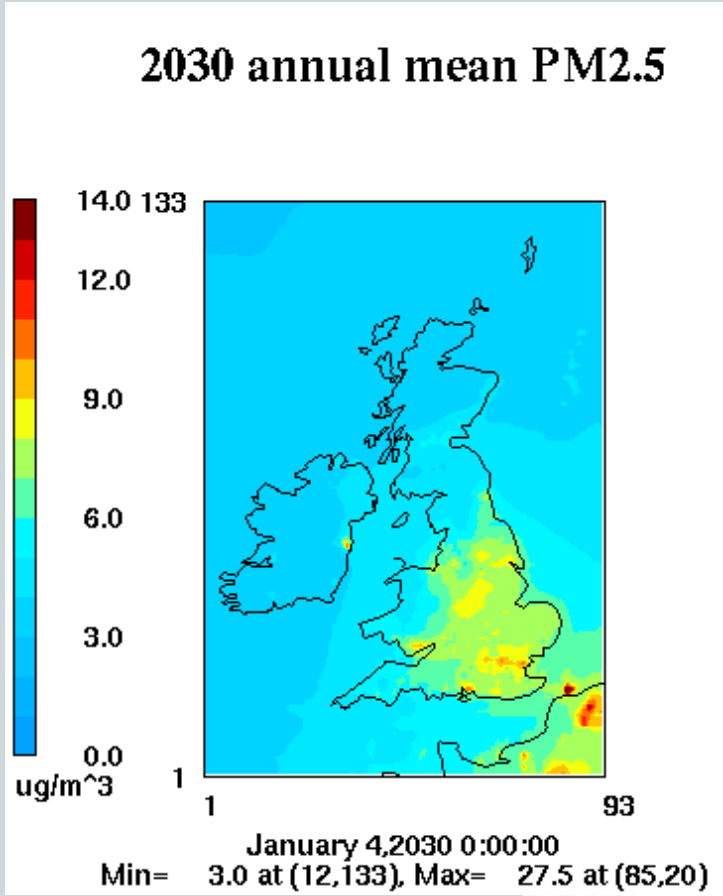


http://www.pscleanair.org

Modelling the future
Annual mean UK concentrations of $PM_{2.5}$

(Williams, Beevers, Kitwiroon 2018)





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Some behaviour insights – the beast from the east

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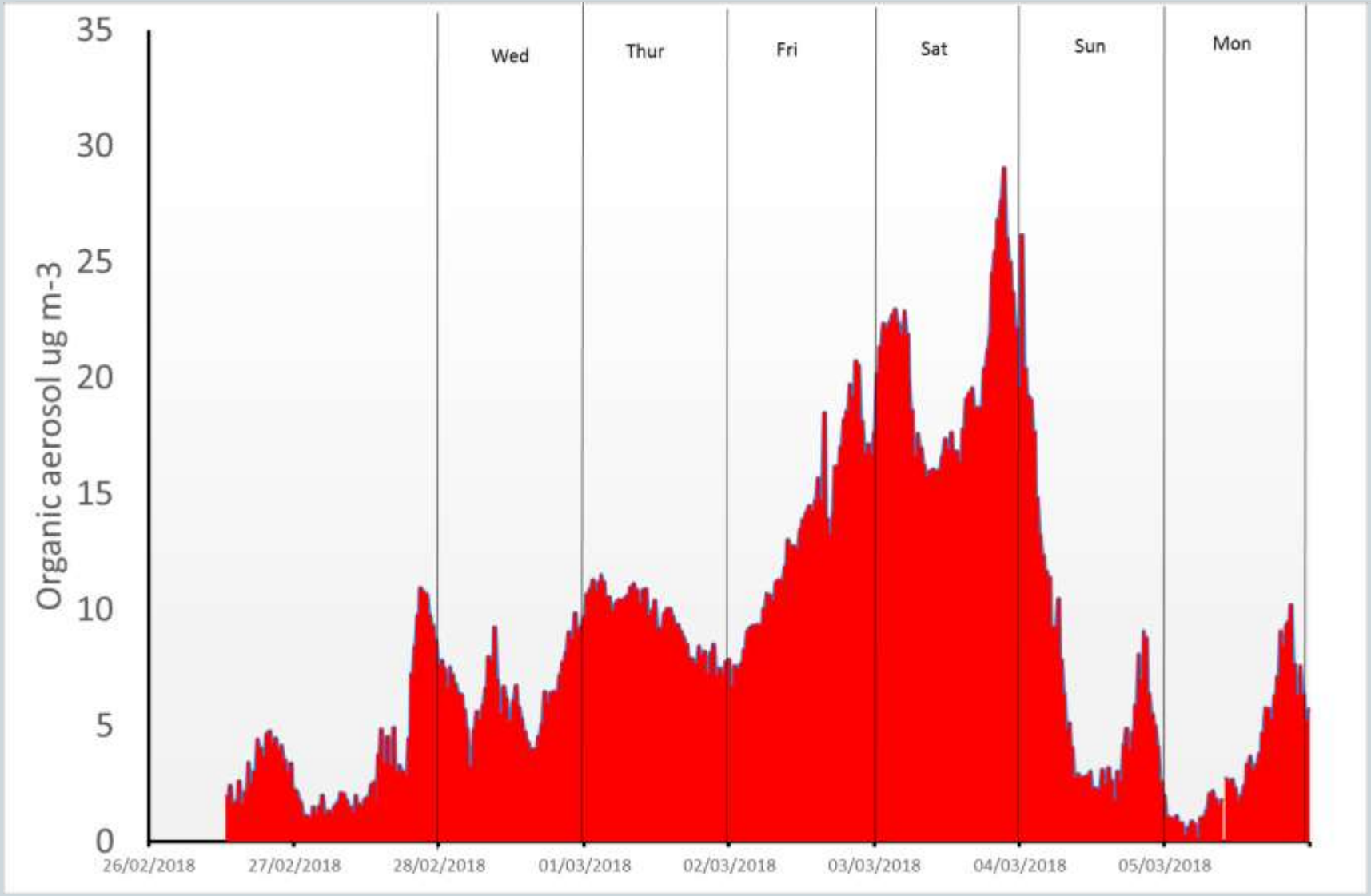
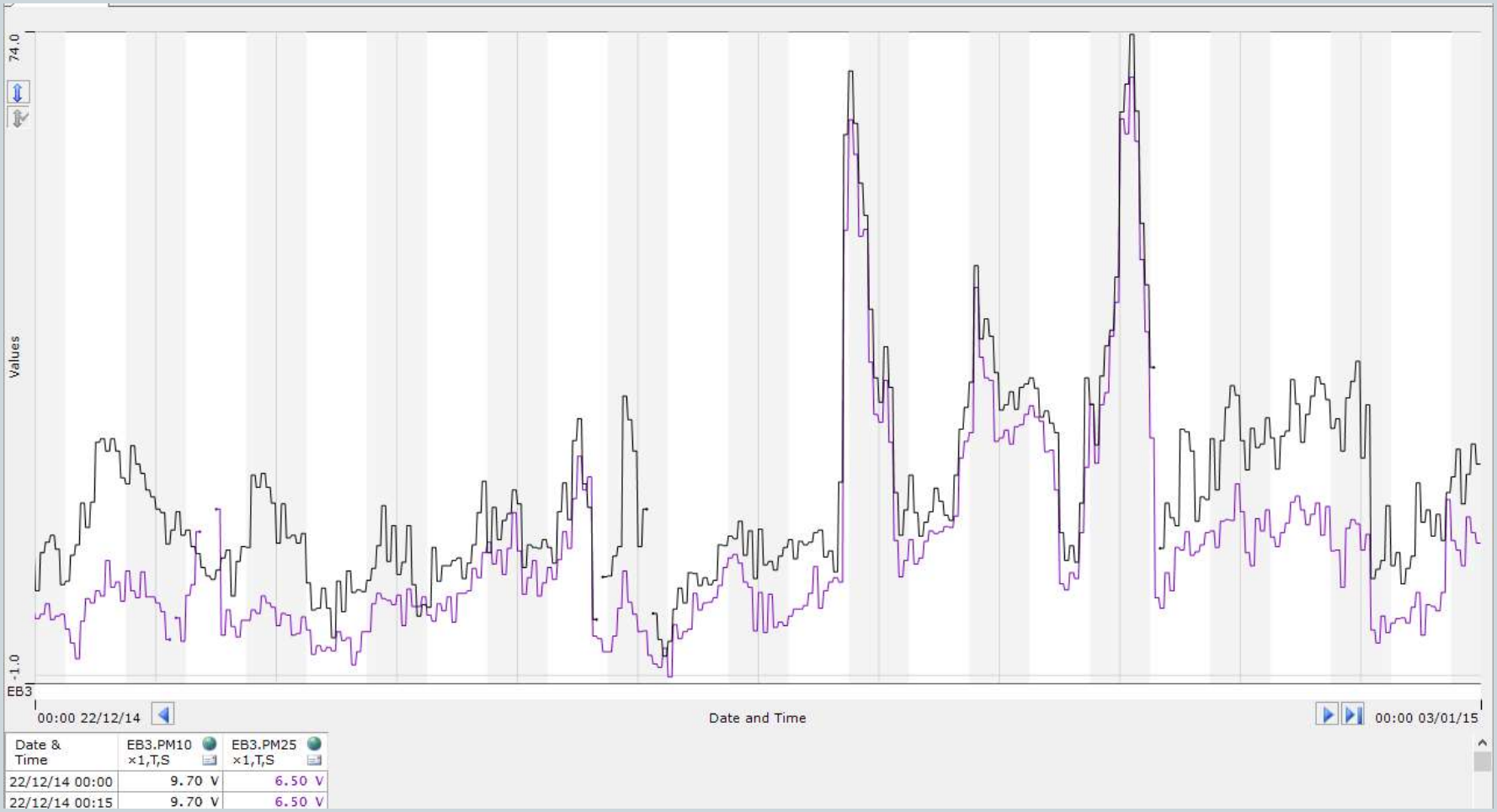
Some behaviour insights – the beast from the east



Some behaviour insights – New Year in Eastbourne



Date & Time	EB3.PM10 ×1,T,S	EB3.PM25 ×1,T,S
22/12/14 00:00	9.70 V	6.50 V
22/12/14 00:15	9.70 V	6.50 V

Thanks to Defra for funding this work, David Green and colleagues for measurements & Martin Williams for very helpful suggestions

Full report at:
https://uk-air.defra.gov.uk/assets/documents/reports/cat05/1801301017_KCL_WoodBurningReport_2017_FINAL.pdf

Contact details/for more information

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