IMPERIAL

$PM_{2.5}$ from domestic wood & solid fuel burning - impact from lounge to London-wide.

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LONDON WOOD BURNING PROJECT

Defra Air Quality Grant Scheme

London Borough of Camden and London Borough of Islington on behalf of 13 additional London boroughs

Improve scientific understanding & increase public awareness.

- Element 1: Resident surveys
- Element 2: Air quality data collection
- Element 3: Health Impact Evaluation

What did we measure and why?

Particulate pollution - adverse health effects. (DEFRA ,2023)

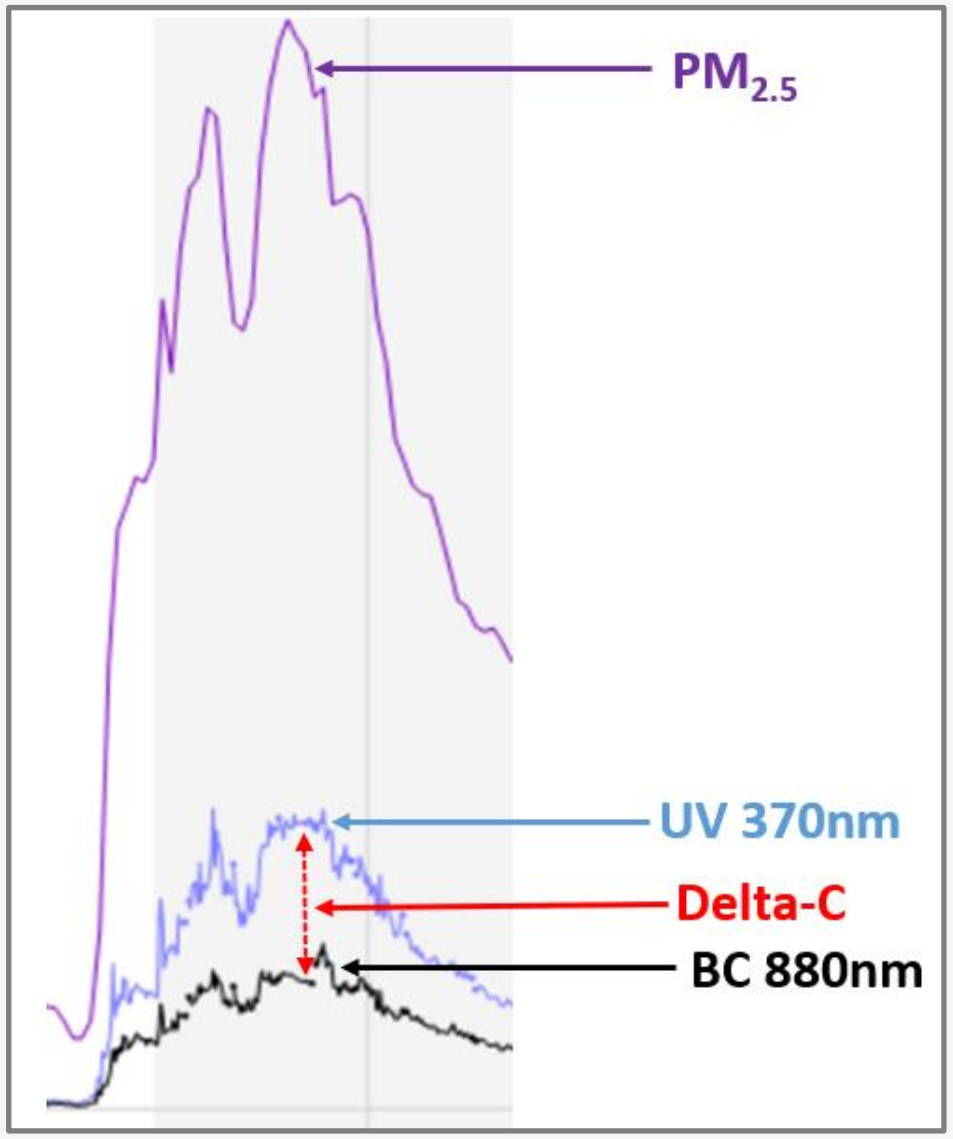
Increasing attention on health effects of $PM_{2.5}$

Cardiovascular and respiratory disease
Lung cancer
Penetrate deep into living tissue, traverses the blood-brain barrier
Diabetes and dementia
Society's most vulnerable populations, including those with chronic conditions, children and the elderly.

WHO guideline annual mean $PM_{2.5}$ concentration cut from 10 to 5 μgm^{-3} (WHO, 2021).
Increased onus on national and local government to take further action to improve air quality.

27% of UK PM2.5 emissions are from solid fuel, X2 as from vehicle exhausts, Kantar 202 survey ~ 50k homes (DEFRA, 2023)

What did we measure and how ?



$PM_{2.5}$ - reference measurement.
Woodsmoke – no reference measurement method

Aethalometer method

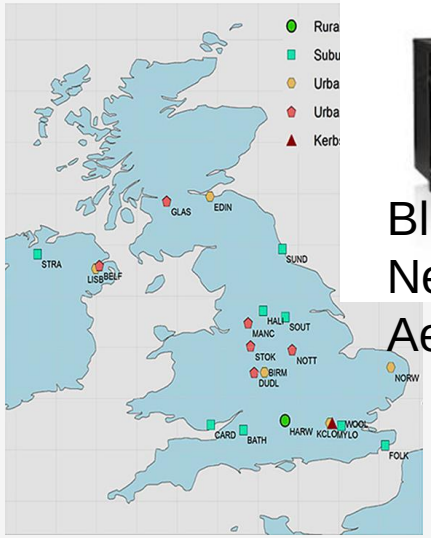
Allen et al., (2004) enhanced optical absorption at 370 relative to 880 nm (" Delta-C "). This enhanced absorption is shown to be a specific "indicator" of WS PM

Sandradewi et al., (2008) - Absorption Measurements for the Quantitative Determination of Wood Burning and Traffic Emission Contributions to Particulate Matter

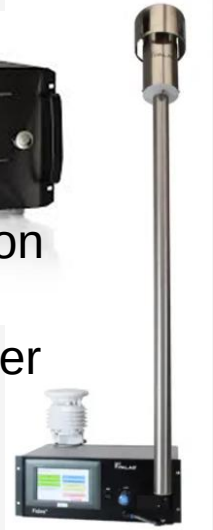
Method applied, tested and developed
Harrison et al., (2012) Fuller et al., (2014), Font et al., (2022)

Well-established method for use with full sized aethalometers but less so for use with micro-aethalometer measurements.

Portable instruments - calibration & trials



Black Carbon Network Aethalometer

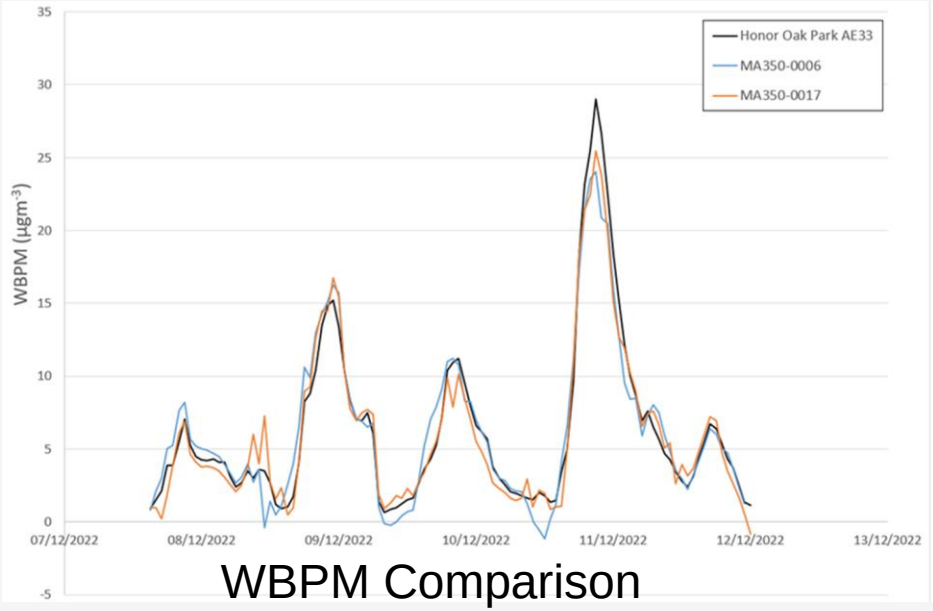


FIDAS $PM_{2.5}$

Network site co-location

$PM_{2.5}$ AM520 Sidepak

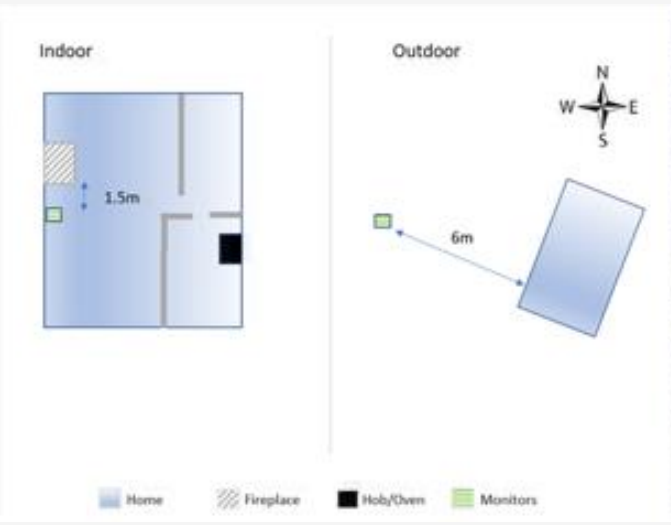
microAeth® MA300/MA350 Black Carbon monitor



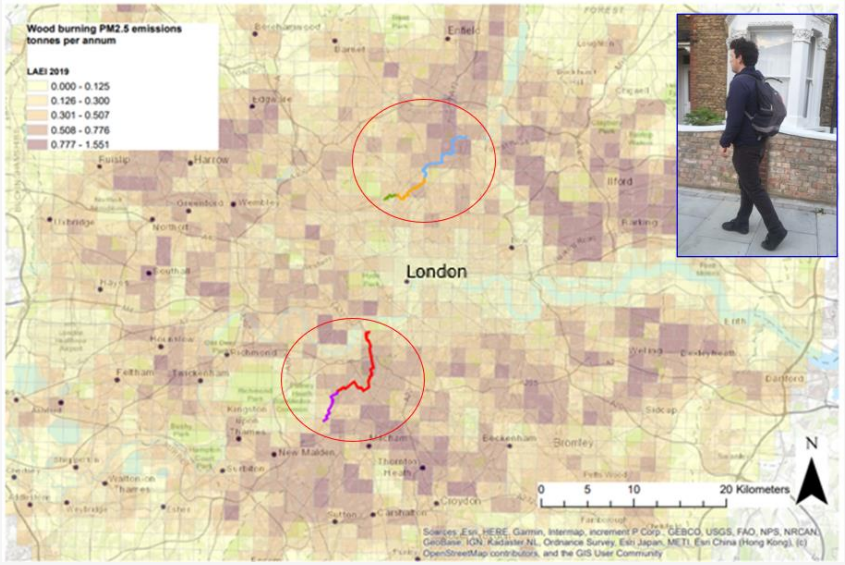
WBPM Comparison

Measurement Strategy

1. Inside & Outside Homes



2. Across Neighbourhoods & Streets – Walks



3. London wide – fixed aethalometer & Breathe London nodes (Static networks)

1
Inside & Outside Homes

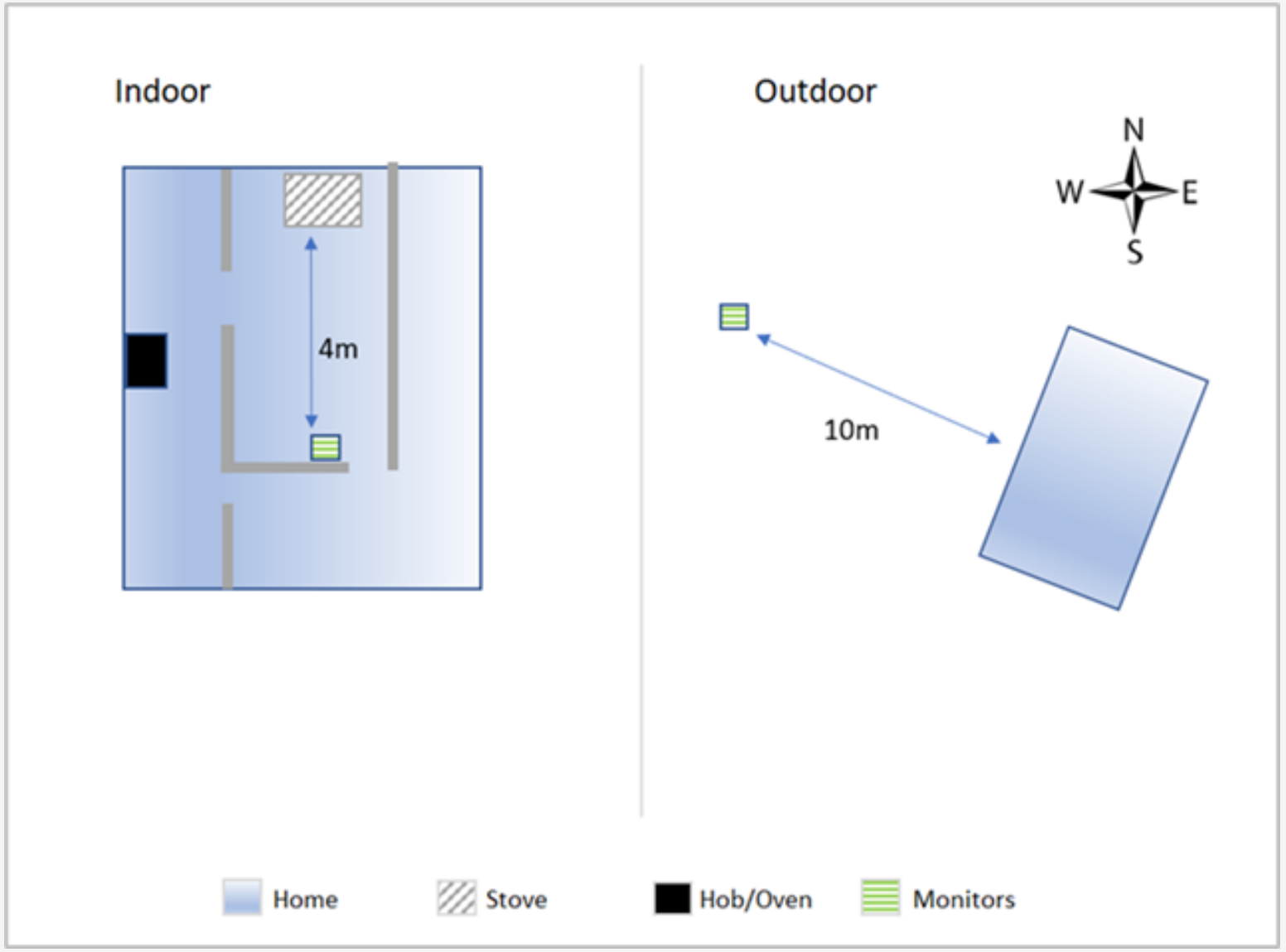
Inside & Outside Homes

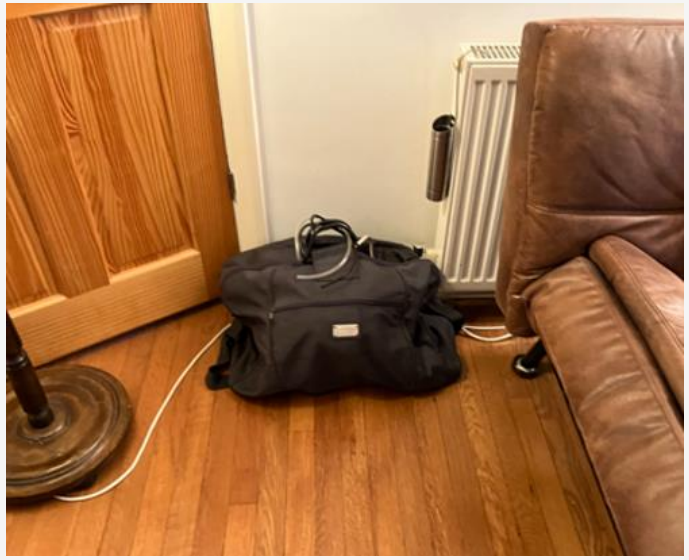
4 Appliances.
5 Fuels.
5 Days.

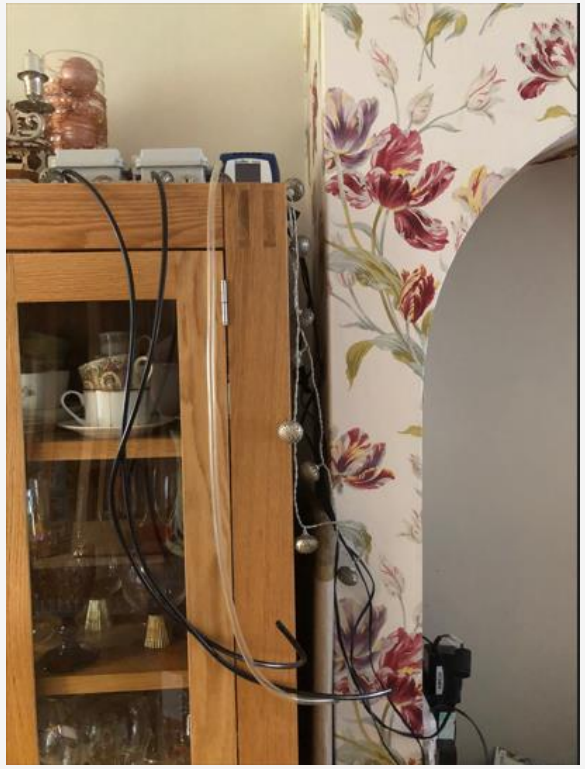
Lighting the fire involved using firelighters and kindling.

Monitoring - High Res 1 minute data
Sidepak – $PM_{2.5}$
microAehalometer – BC & UV abs
High Res 30 sec data

Participant - event log

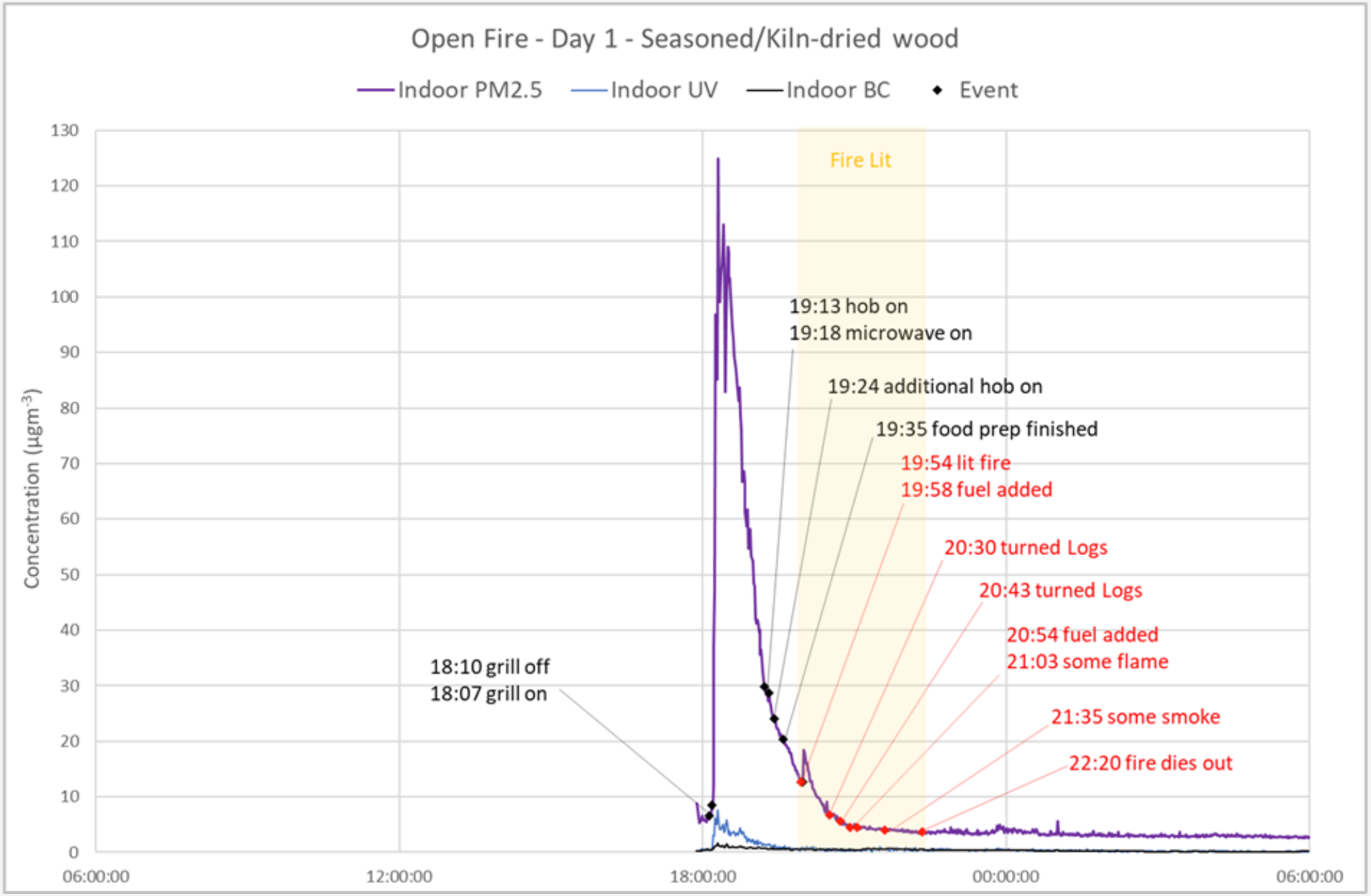






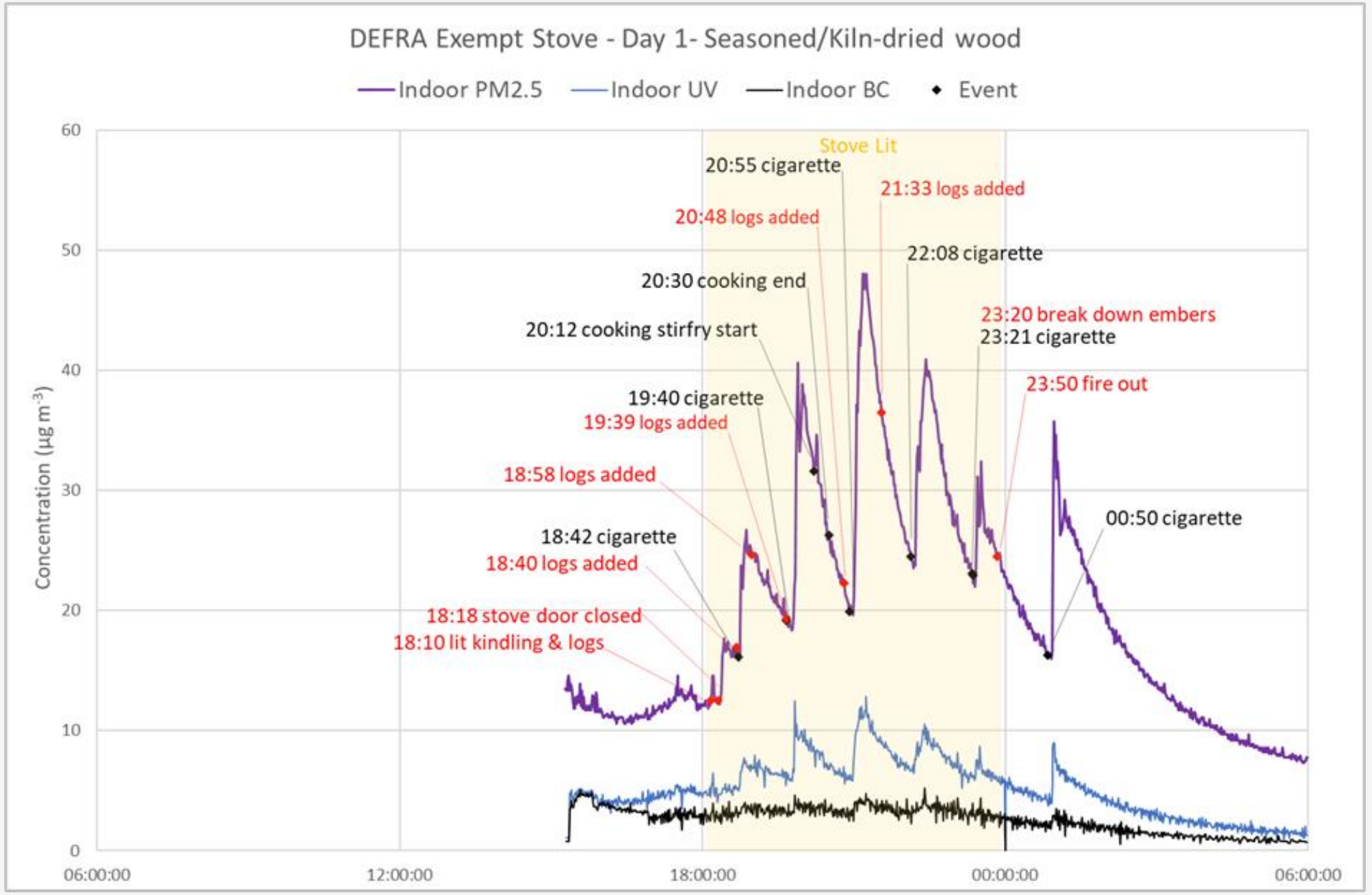
Inside Homes

Cooking, fire lighting and refuelling.



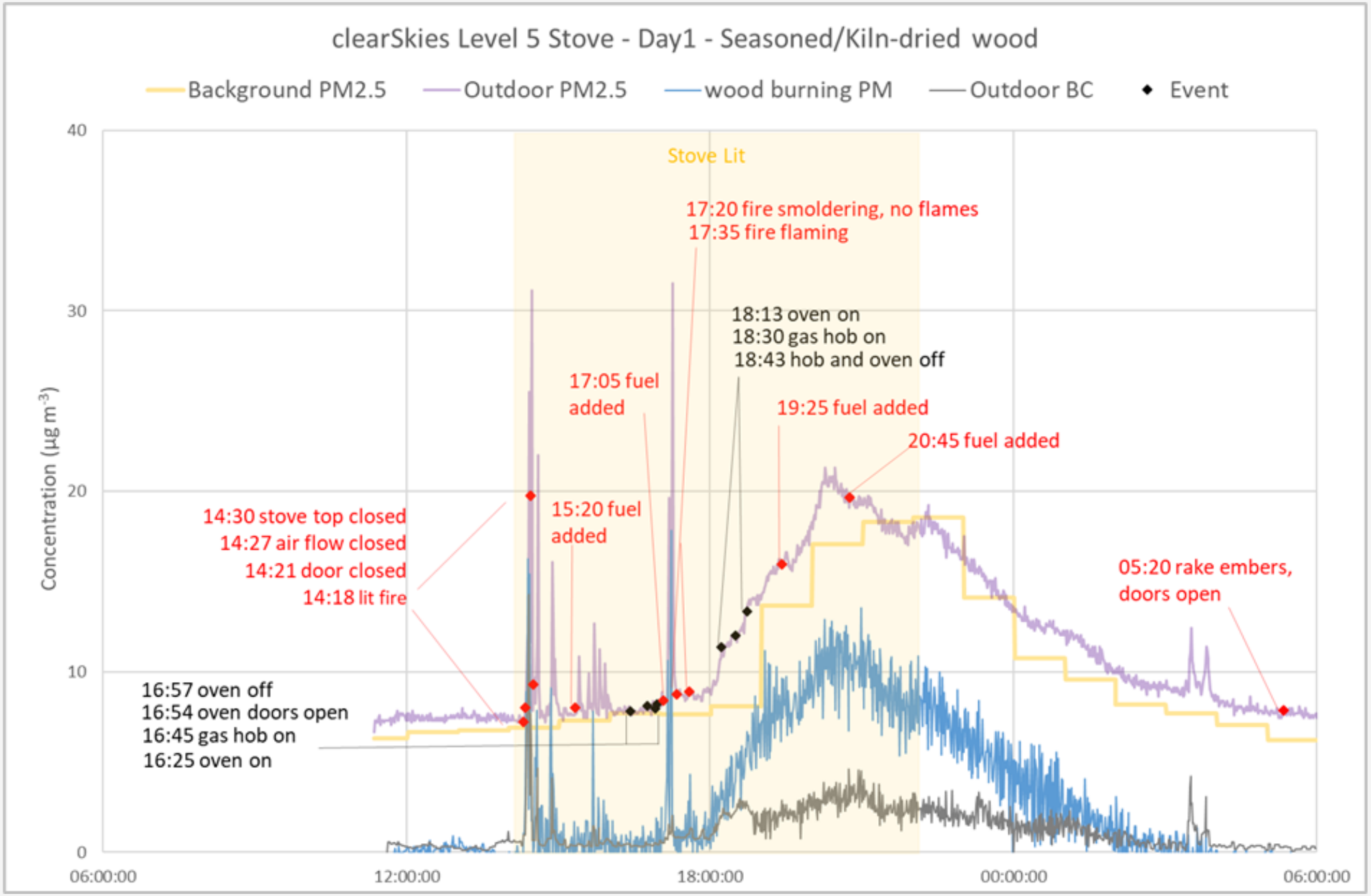
Inside Homes

Smoking.



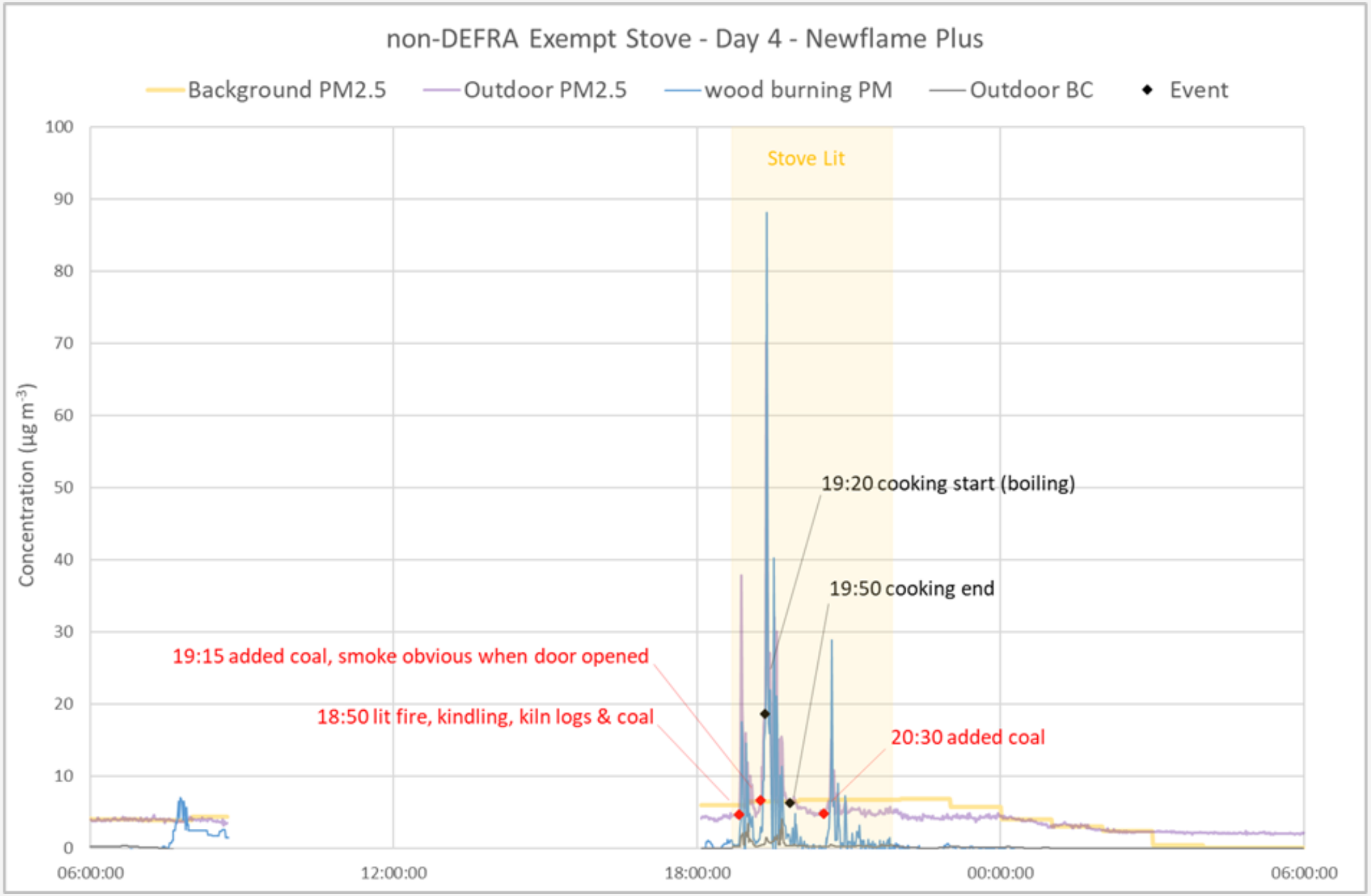
Outside Homes

Fire lighting and refuelling.



Outside Homes

Fire lighting and refuelling.



2
Across neighborhoods & streets

Walks

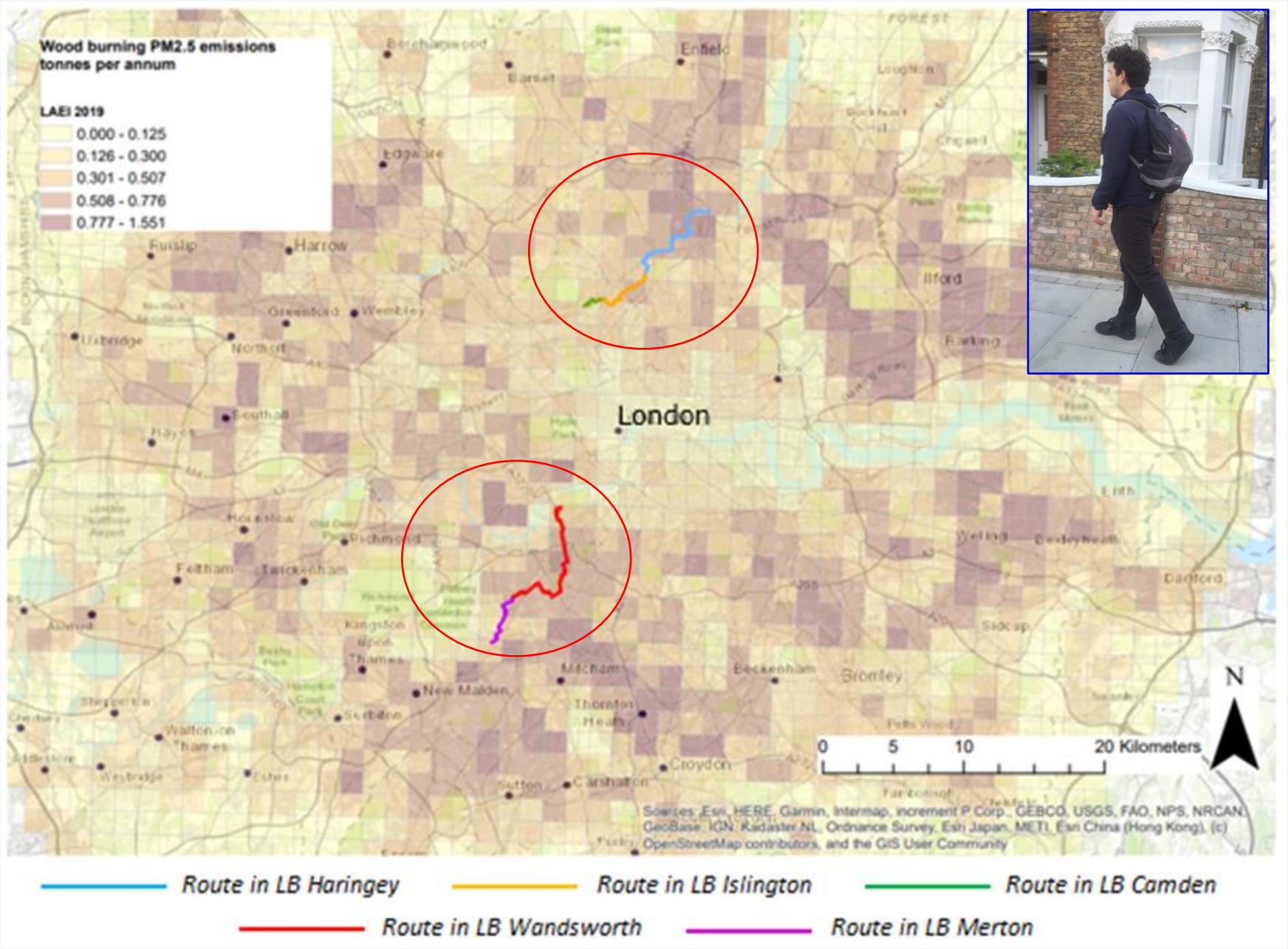
Walks

North Route
10.6 km
61 Residential streets & roads

South Route
10.6 km
53 Residential streets & roads

Monitoring backpack
Sidepak – $PM_{2.5}$
micro Aethalometer – BC & UV
High Res 30 sec data

10 walks along each route
January and February 2023
Evenings and weekends
Cold and calm evenings



Walks
Data analysis and mapping

Standardise data - so that readings on different days, obtained during different meteorological and background pollution conditions could be directly compared.

For each walk a Z-score was calculated for each individual species measurement.

The Z-score indicated the deviation between a measurement and the overall mean for all measurements on a walk, expressed in terms of the standard deviation.

$$z = (x - \mu) / \delta$$

x is a species measurement on a walk,
μ is the mean of all measurements of that species on the walk and
δ is the standard deviation of measurements of that species on a walk.

Allowed direct comparison of relative measurements across a study area over all days walked.

Sth Route Walks (10 walks combined) – Hot spot maps

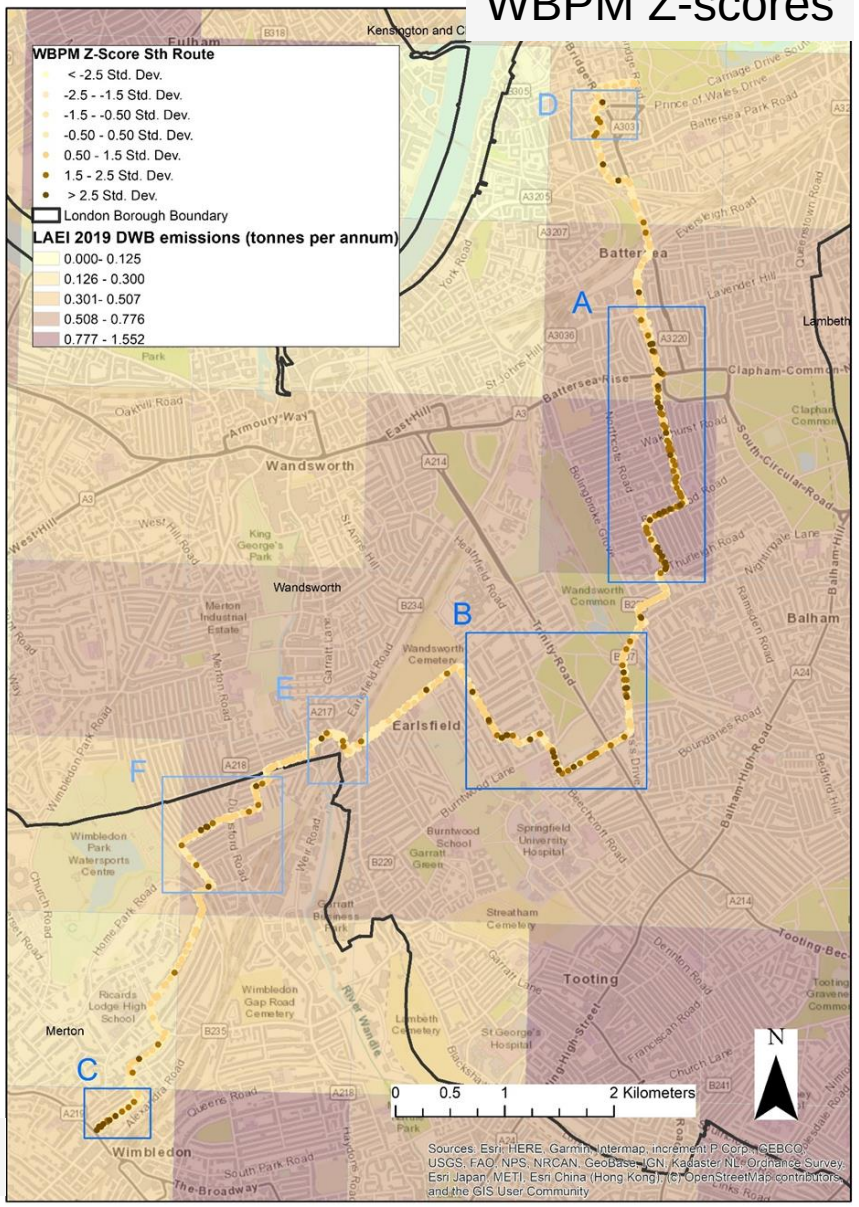
London Atmospheric Emissions Inventory – LAEI 2019 (GLA, 2021). Solid-fuel burning emissions

Model & method validation

WBPM Hot spots

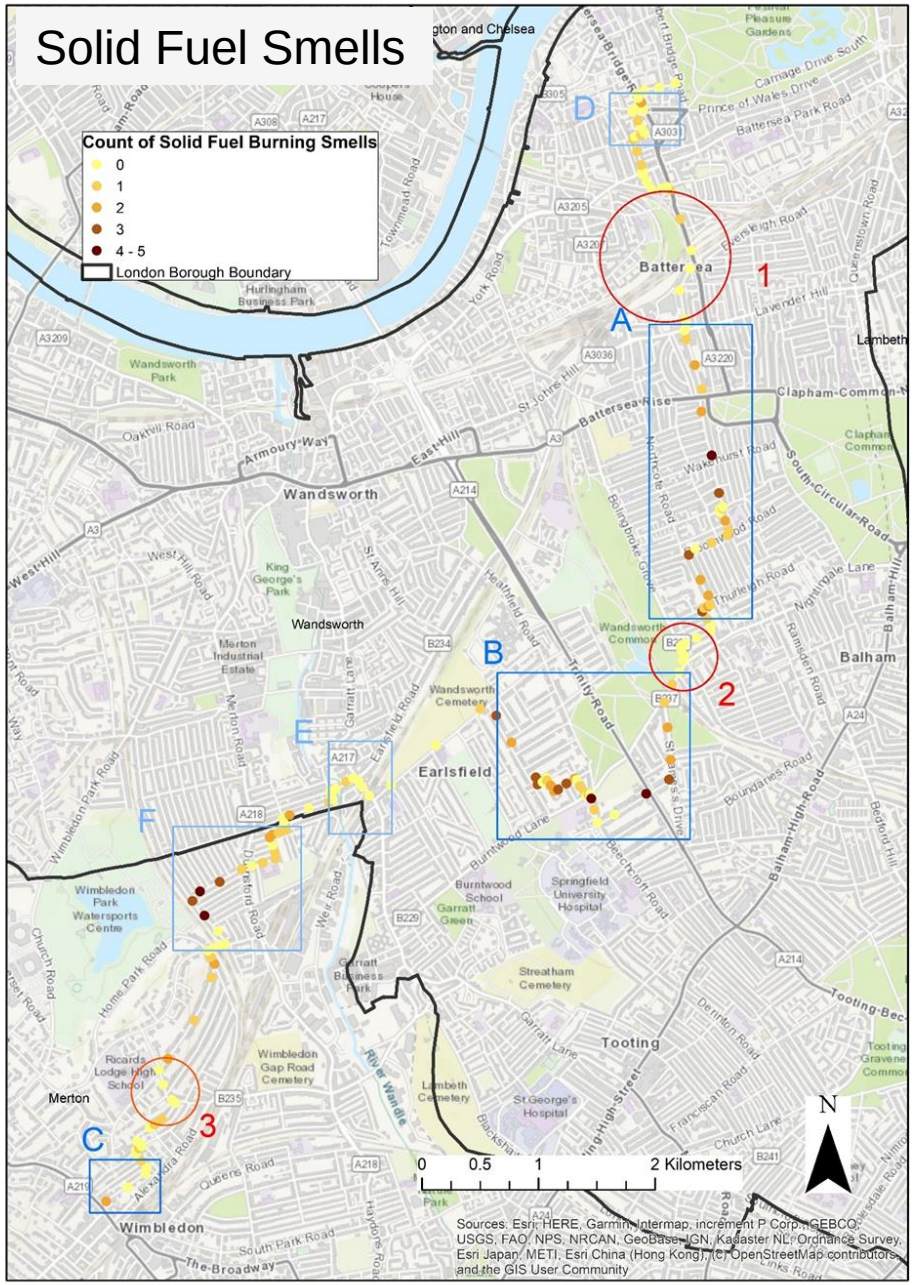
Extra BC Hot spots

WBPM Z-scores



BC Z-Scores

South Route Walks (10 walks combined) - Hot spot map



Some corelation between solid fuel hotspots and WBPM hotspots.

If you’re smelling solid fuel burning, then you are exposed to it.

WBPM method validation

WBPM Hot spots

Extra BC Hot spots

3. London wide – Fixed aethalometer & Breathe London nodes

Fixed Aethalometer Measurements

London's PM contribution from wood & solid fuel burning

Fixed aethalometers - Defra's black carbon network - adding to period covered by previous studies, Font et al., 2022

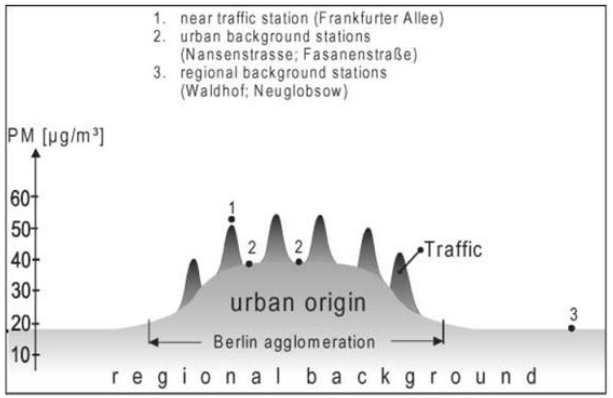
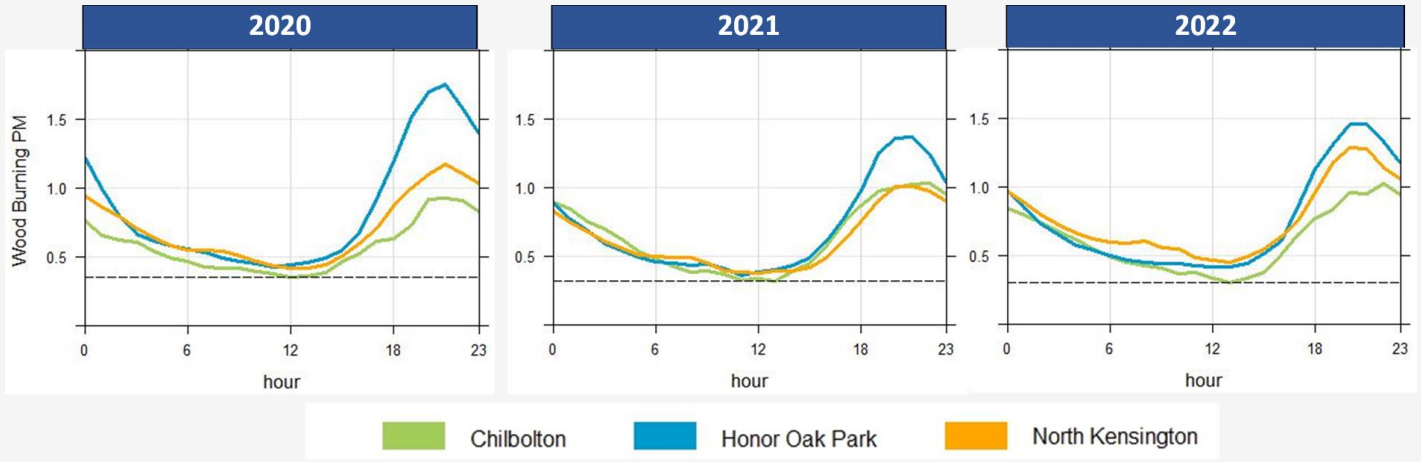


Fig. 5. Schematic horizontal profile of the ambient PM10 concentration.



Lenschow - subtract the regional background concentration

Table 5-21: Regional background concentrations of PM from wood and solid-fuel burning (µg m⁻³)

	2020	2021	2022
Regional background wood and solid-fuel burning PM	0.35	0.32	0.30

The estimated urban contribution for London for each year was calculated using the mean of the annual wood and solid-fuel burning PM concentrations at North Kensington and Honor Oak Park urban background sites and subtracting the regional background concentrations. The results are shown in Table 5-22.

Table 5-22: London urban contribution of PM from wood and solid-fuel burning (µg m⁻³)

	2020	2021	2022
London urban wood and solid-fuel burning PM	0.43	0.34	0.46

Detailed examination at HOP

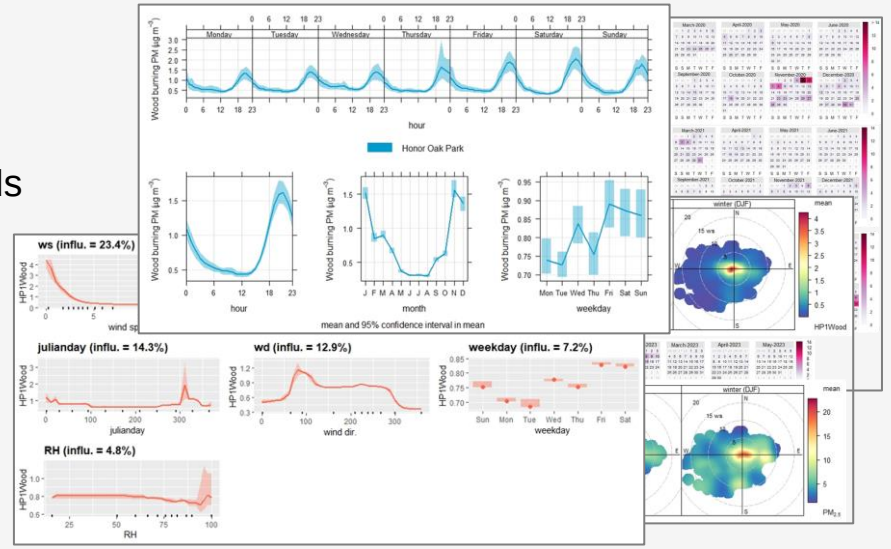
More WBPM…..

Evenings & weekends

Winter months

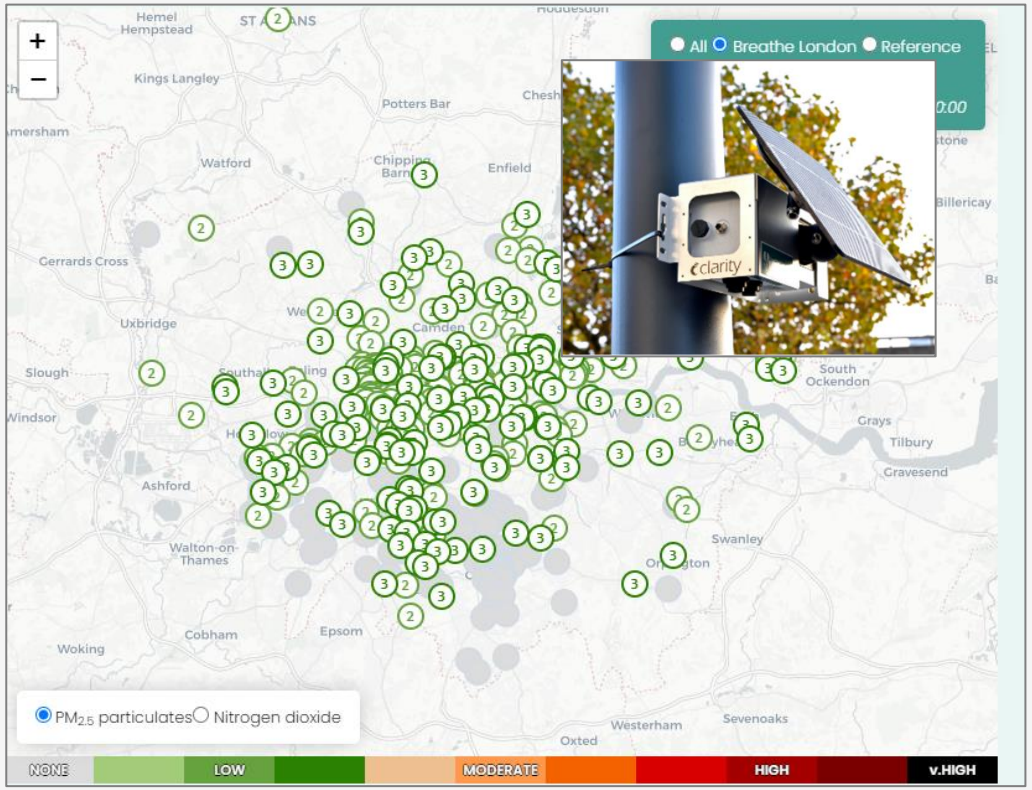
< Wind speed

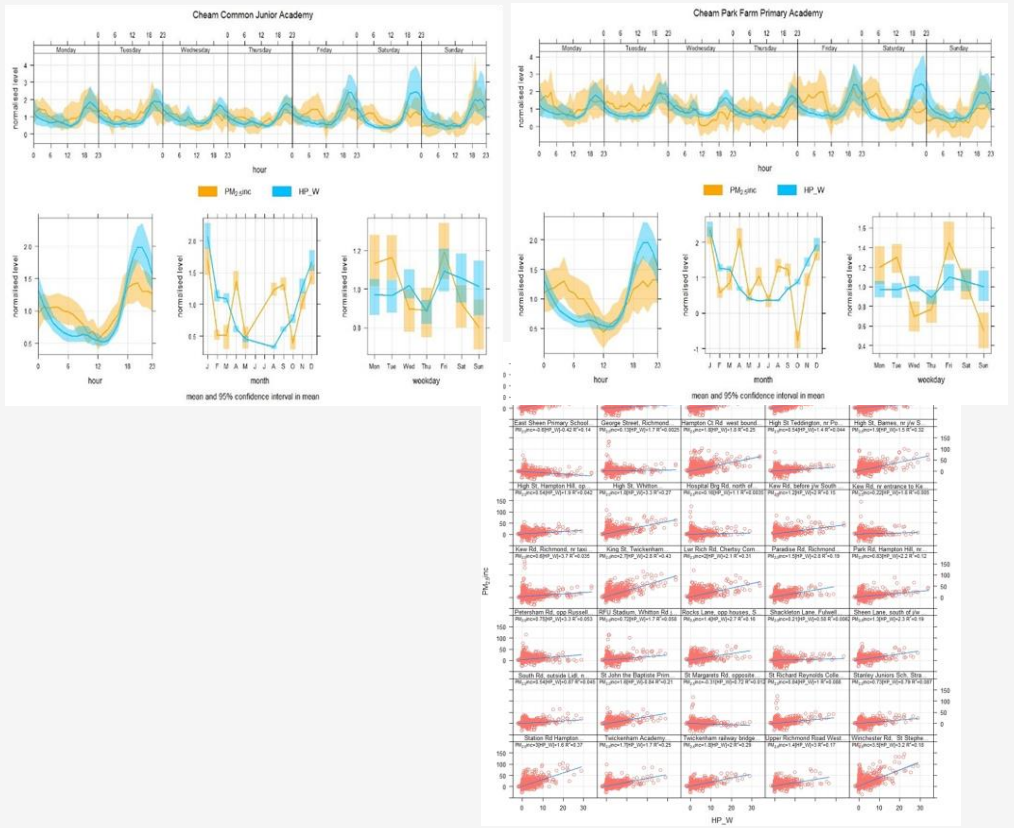
< Temperature



Breathe London $PM_{2.5}$ Measurements

Alongside evidence of wood & solid fuel burning from fixed aethalometers





Temporal pattern similarity between local $PM_{2.5}$ & WBPM from fixed aethalometer.

Identify sites where $PM_{2.5}$ concentrations more influenced by wood and solid-fuel burning emissions.

Summary

So, what did we find…..?

1. Inside & Outside Homes

- Indoors - fire lighting and refuelling $PM_{2.5}$ 1-20 µg m^{-3} but less than those from cooking and cigarette smoking.
- In gardens $PM_{2.5}$ peaks reached 50 µg m^{-3}, mainly linked to fire-lighting and refuelling and were highly dependent on wind direction.

2. Across Neighbourhoods & Streets – Walks

- Persistent hotspots of solid fuel burning.
- Differentiate between wood and solid-fuel burning and other sources of BC such as traffic.
- Coherence between solid fuel detections and LAEI emissions.
- & between solid-fuel burning smells and WBPM, encountering a solid-fuel burning smell means particulates are being inhaled.

3. London wide – Fixed Aethalometer & Breathe London nodes

- Assuming solid fuel burning is dominated by wood, the annual mean, urban background concentration of $PM_{2.5}$ from this source was 0.76 µg m^{-3} in 2022, 8-9% of the total annual mean $PM_{2.5.}$
- $PM_{2.5}$ from wood and solid-fuel burning - winter evenings and weekends - lower in summer months when indoor burning is rare and outdoor burning is more common.
- Breathe London $PM_{2.5}$ comparison to fixed aethalometer may help to identify potential hotspots.

Thank You.

https://www.imperial.ac.uk/school-public-health/environmental-research-group/research/measurement/london-wood-burning-project-air-quality-data-collection/

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