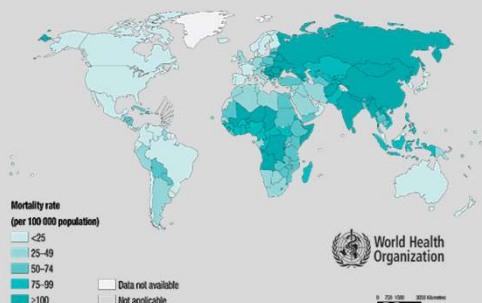**Understanding indoor air quality
for healthy buildings in a net zero world**

**Developing a novel methodological
framework for estimating exposure in health
and modelling studies (and other stories)**

Lia Chatzidiakou ec571@cam.ac.uk
Yusuf Hamied Department of Chemistry
University of Cambridge
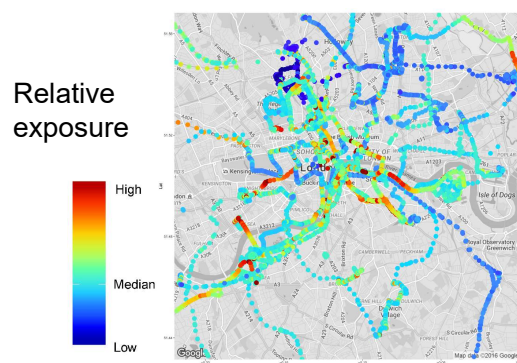
*28th September 2022
Imperial College London, London*

1

Air pollution and health

Estimated 8M premature deaths annually globally
But….

Mortality rate attributed to household and ambient air pollution, by WHO region, 2012*

Mortality rate
(per 100 000 population)
- <25
- 25–49
- 50–74
- 75–99
- ≥100
- Data not available
- Not applicable

World Health Organization

Activity patterns affect personal exposure and dose

Relative exposure

High

Median

Low

Most time spent _indoors_ - exposure to indoor air pollution major component

Transit: 6%
Other: 10%
Home: 84%
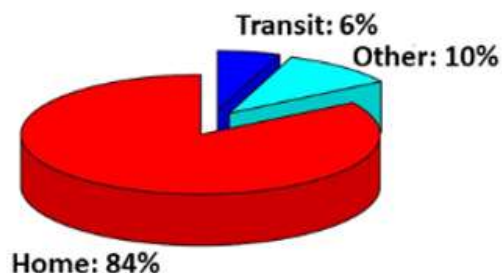
Indoor air quality (indoor sources, vs outdoor air) very different from ambient pollution

Indoor

Outdoor

CO [ppm]

Dec 08   Dec 09   Dec 10   Dec 11   Dec 12   Dec 13
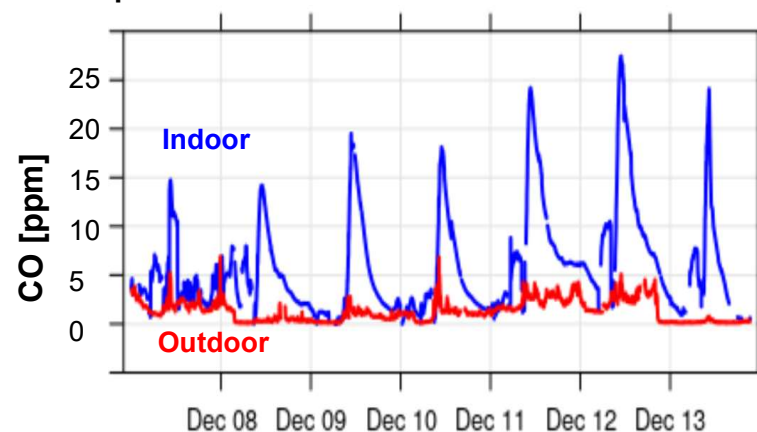
⇒ **Linking activity to dose and to health**

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(a) NN

(b) Hulls

(c) Isopleths (density)

Iso Level
0.1
0.25
0.5
0.75
0.95

(d) Isopleths (geometry)

Iso Level
0.1
0.25
0.5
0.75
0.95

● GPS coordinates

(e) Hull geometry metrics

(f) Movement classification based on hull geometry

● Directional movement
● Static locations
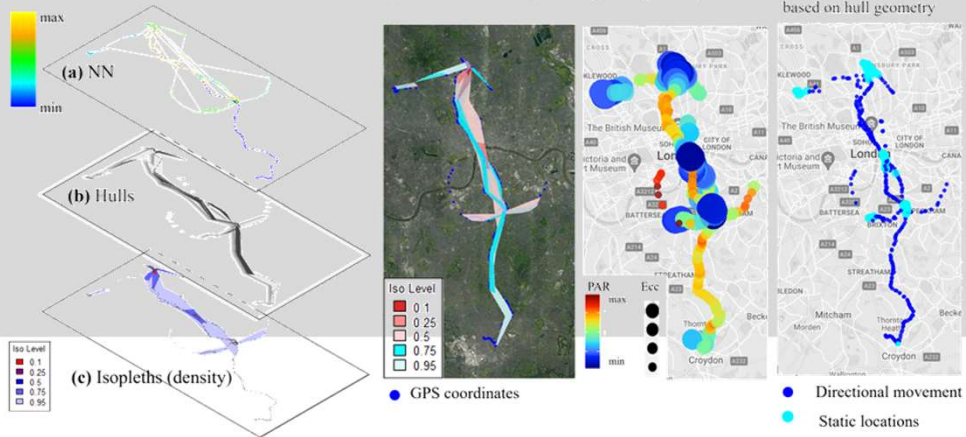
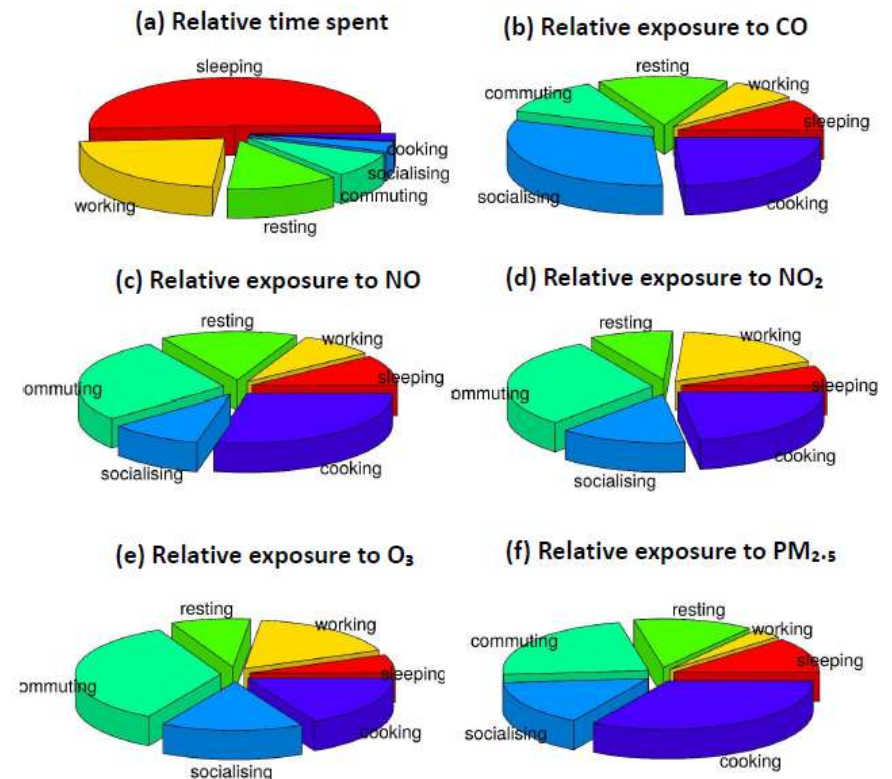# Smart AI/GIS time activity model for exposure-related activities

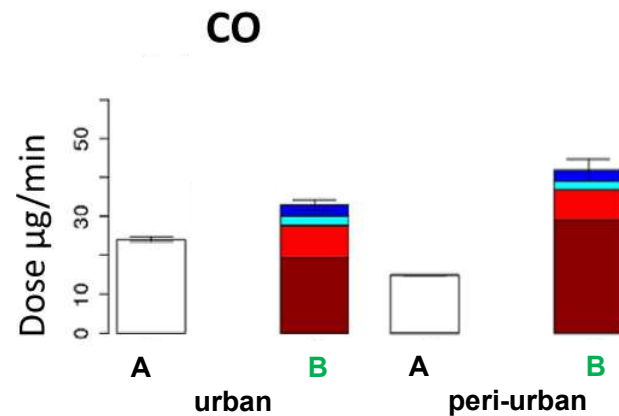$\Rightarrow$ **Personal activity affects exposure**

Smart AI/GIS time activity model for exposure-related activities: examples

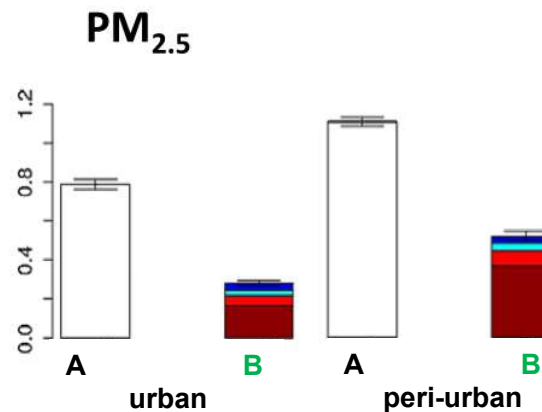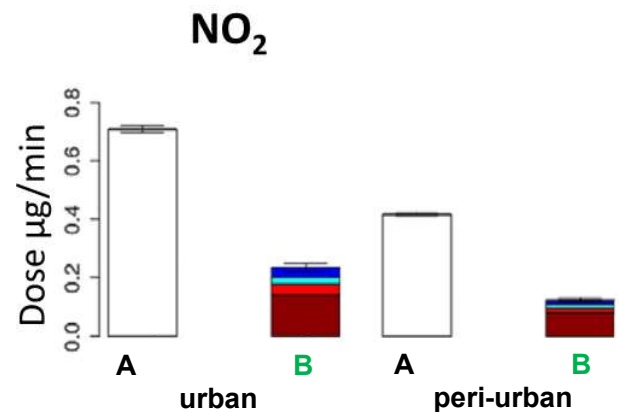⇒ **Personal activity affects exposure**

4
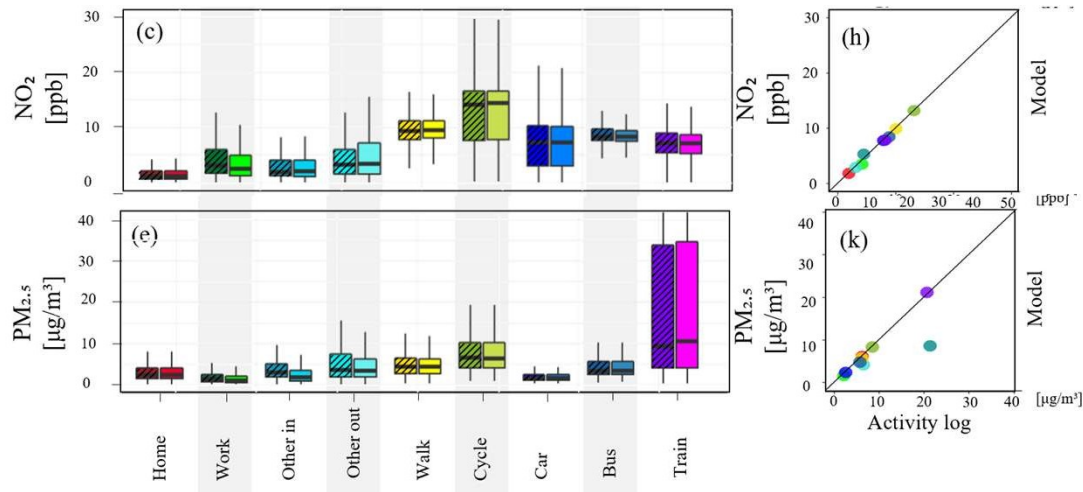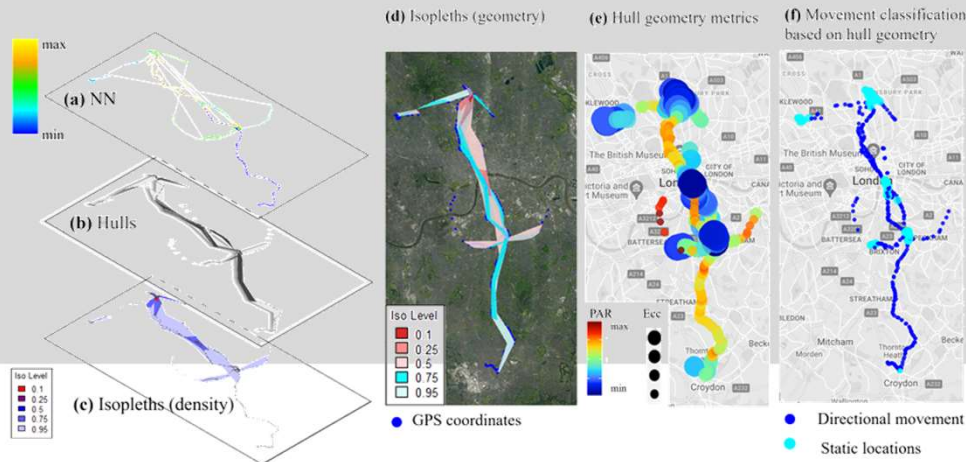
Personal exposure vs ambient monitors…

A: ambient measurements + generic inhalation

B: personal monitoring + activity

Big differences between personal vs outdoor air quality…..

5

Health outcomes (Linear Mixed Models)

Ambient
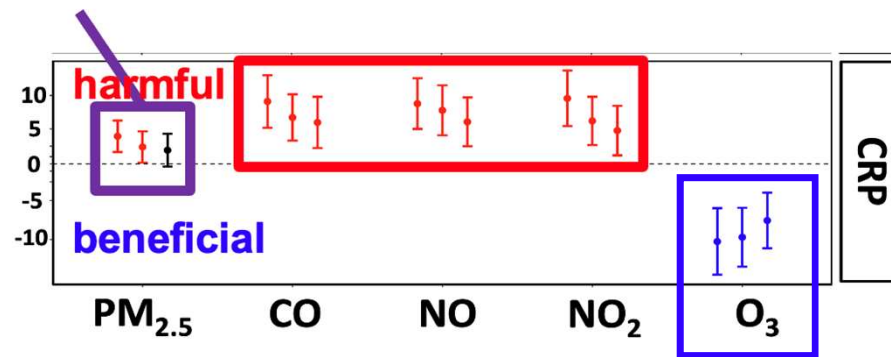
CO, NO, NO_2 all show the same (harmful) effect - why?

O_3 can have a *protective* effect? ...O_3 often *anti-correlated* with other pollutants

$PM_{2.5}$ harmful...

Personal

NO_2 no longer statistically significant......

Analysis and graph by Yiqun Han

Relative (health) risks of different pollutants
Lags of 1,2,3 days

Ambient

Health outcomes (Linear Mixed Models)

Ambient
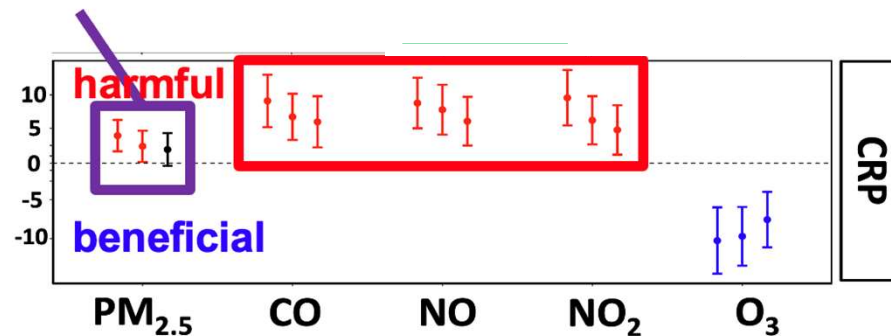CO, NO, NO$_2$ all show the same (harmful) effect - why?

O$_3$ can have a *protective* effect? ...O$_3$ often *anti-correlated* with other pollutants
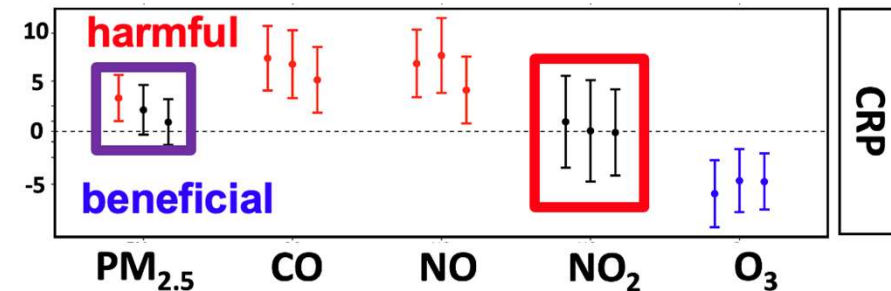
PM$_{2.5}$ harmful...

Personal
NO$_2$ no longer statistically significant......

Analysis and graph by Yiqun Han

Relative (health) risks of different pollutants
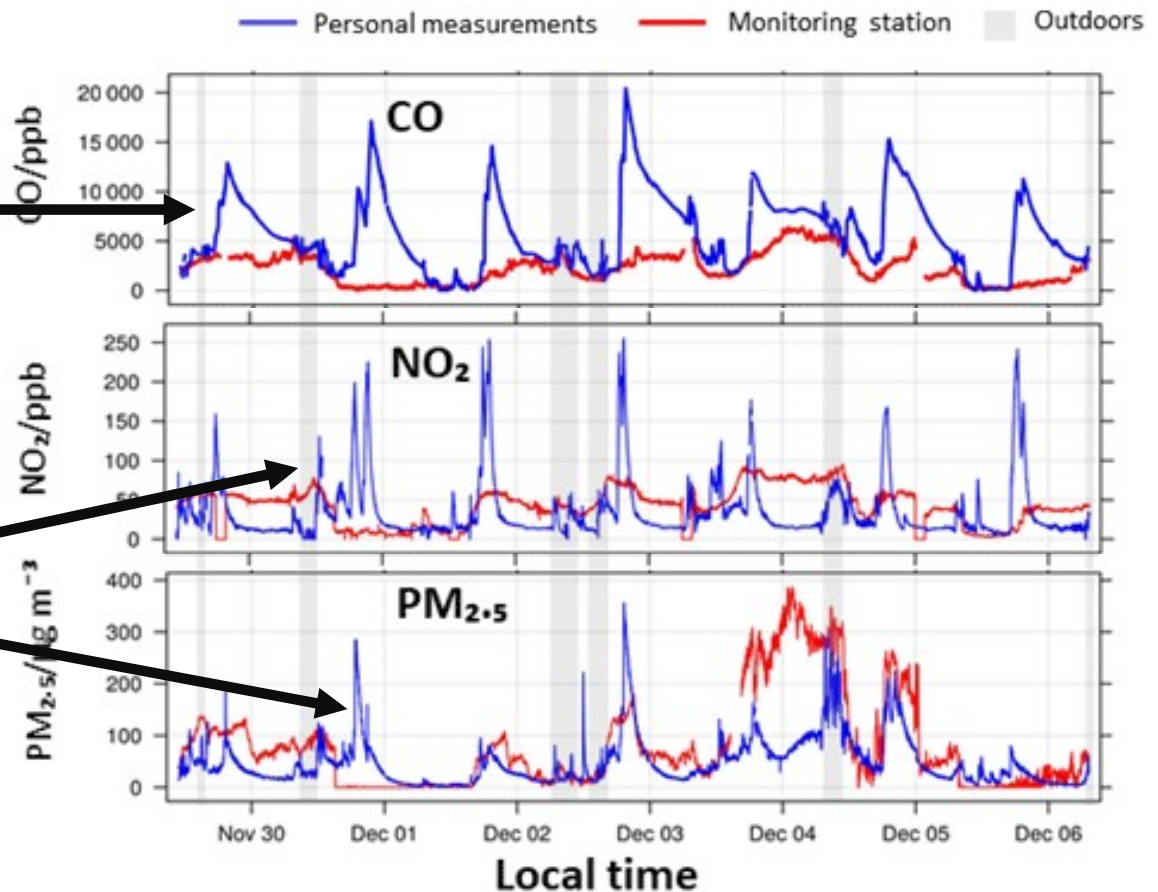Lags of 1,2,3 days

Ambient

Personal
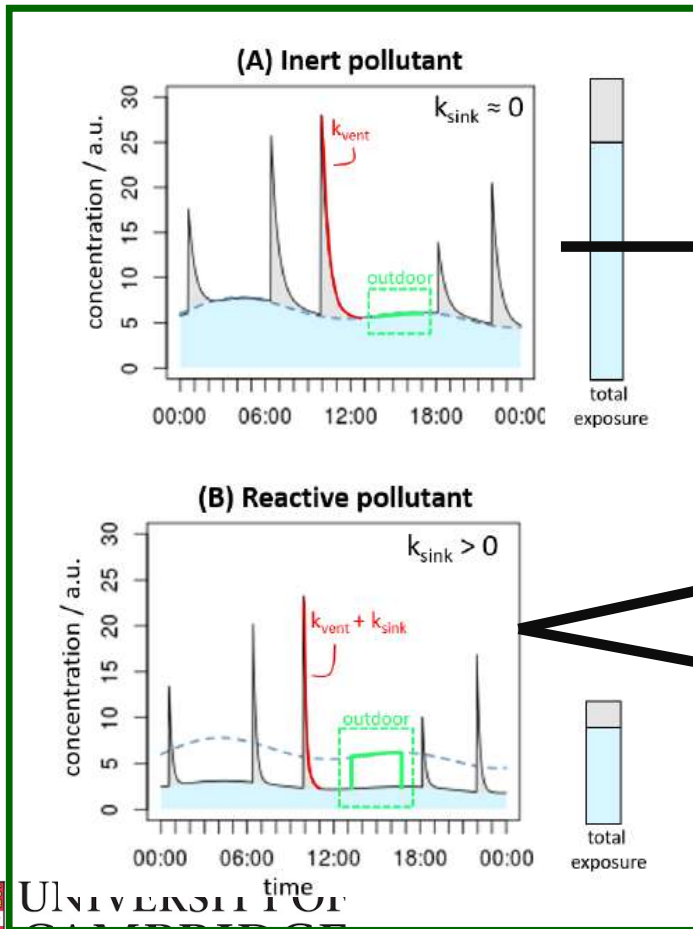
Published in: Faraday Discussions, 2020

⇒ *Ambient measurements cannot reliably distinguish causal links*

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Indoor/outdoor interface – importance of air exchange, chemistry and proxies……

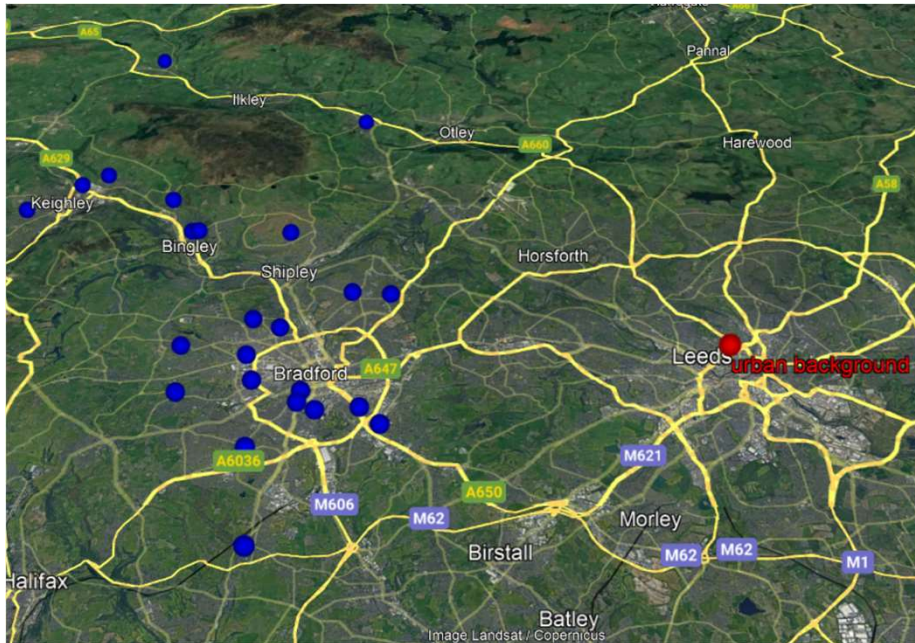**Personal source apportionment and proxy pollutants**

School-based exposure (CLASS-ACT)

30 schools in Bradford from CLASS-ACT study.
Outdoor PM measurements from the closest urban background monitoring station in Leeds (ref) @openair

School-based exposure (CLASS-ACT)
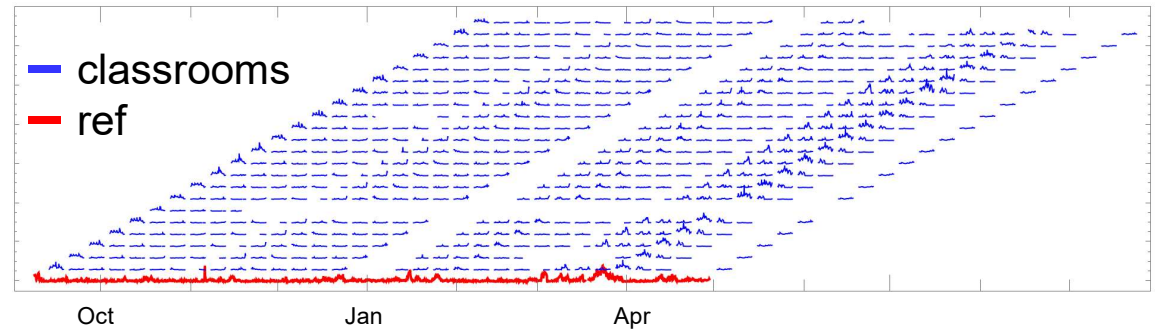
3D plot School C03 PM$_{2.5}$

30 schools in Bradford from CLASS-ACT study.
Outdoor PM measurements from the closest urban background monitoring station in Leeds (ref) @openair

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$\Rightarrow$ **Classrooms similar PM levels**
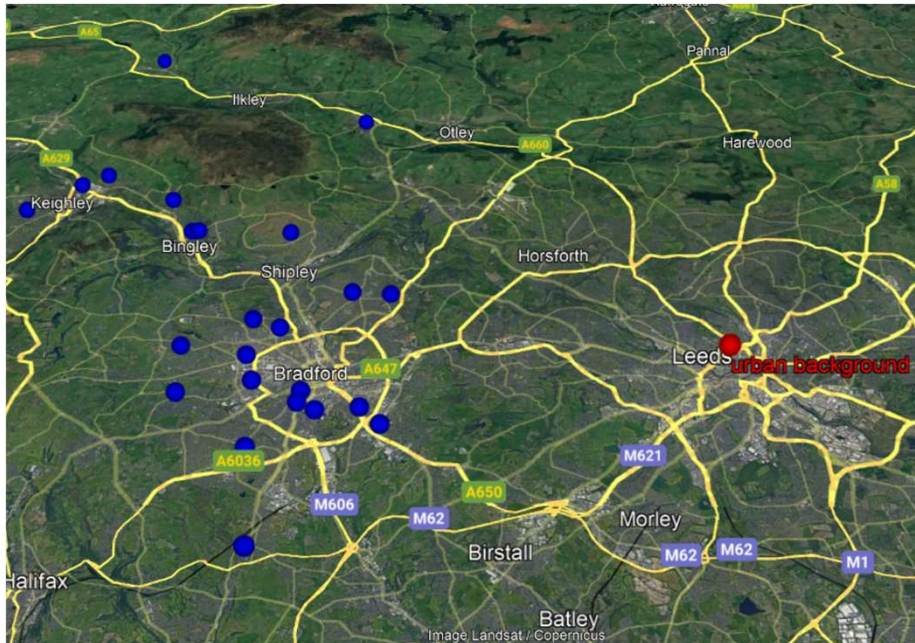
10

School-based exposure (CLASS-ACT)

30 schools in Bradford from CLASS-ACT study.
Outdoor PM measurements from the closest urban background monitoring station in Leeds (ref) @openair

3D plot School C03 PM2.5

classrooms
ref

Oct   Jan   Apr

3D plot School C05 PM2.5

classrooms
ref

Oct   Jan   Apr

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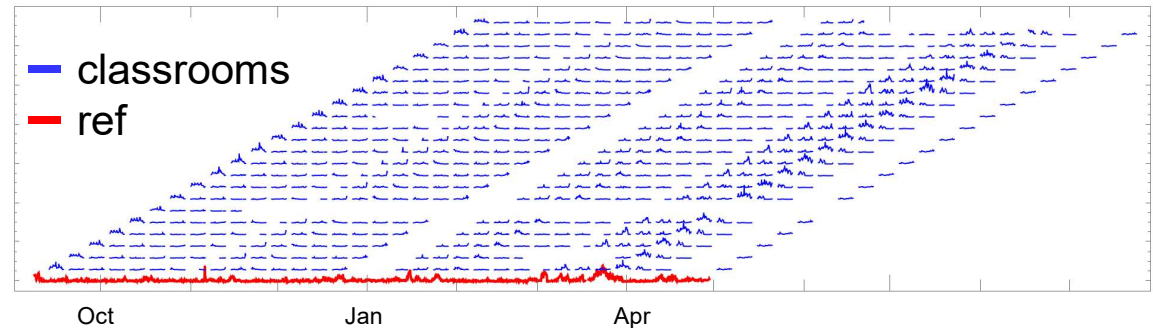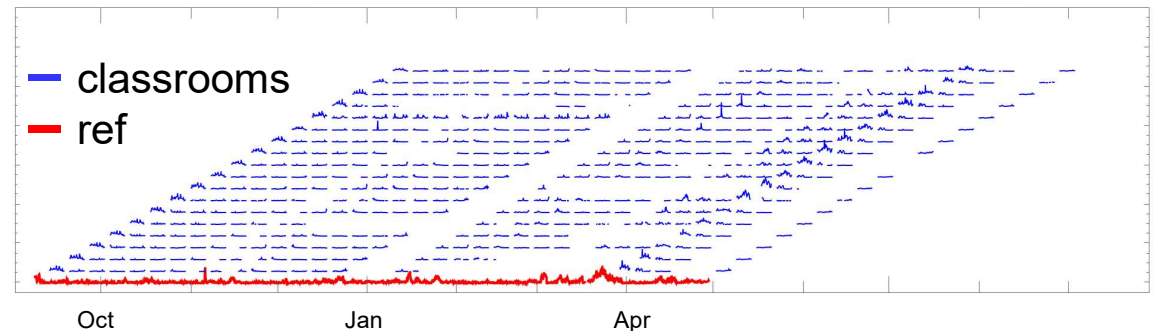⇒ **Schools similar PM levels!!!**

School-based exposure (CLASS-ACT)

30 schools in Bradford from CLASS-ACT study.
Outdoor PM measurements from the closest urban background monitoring station in Leeds (ref) @openair
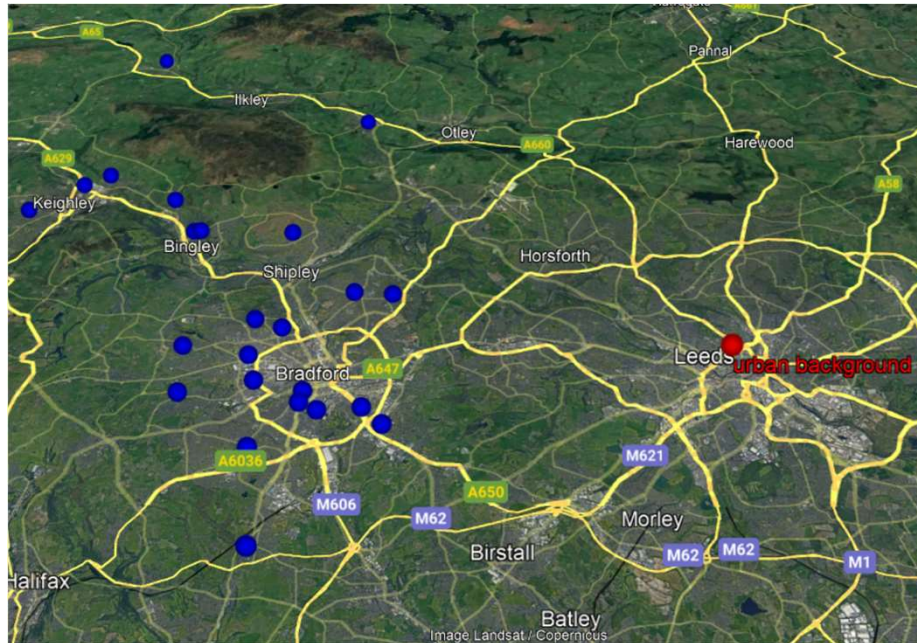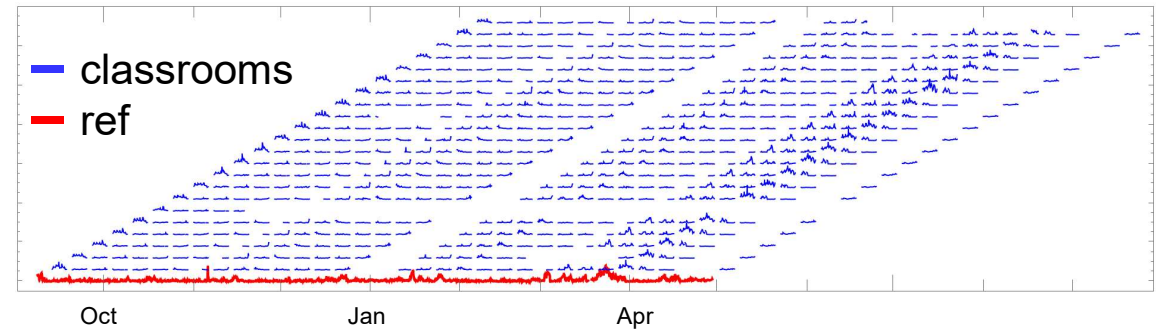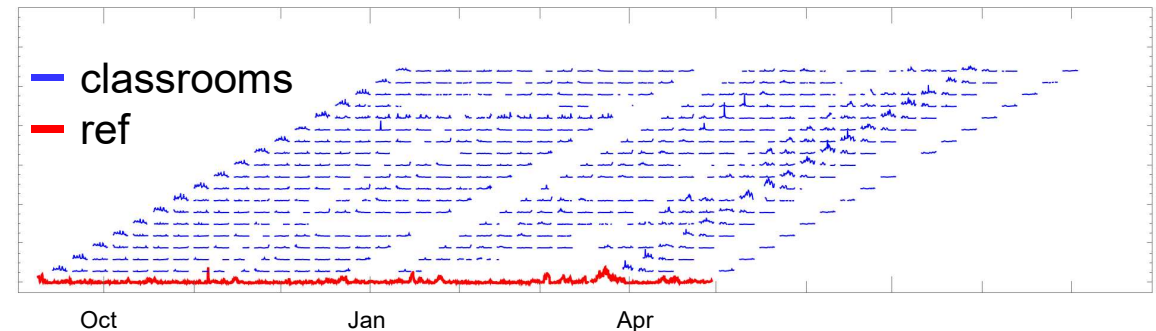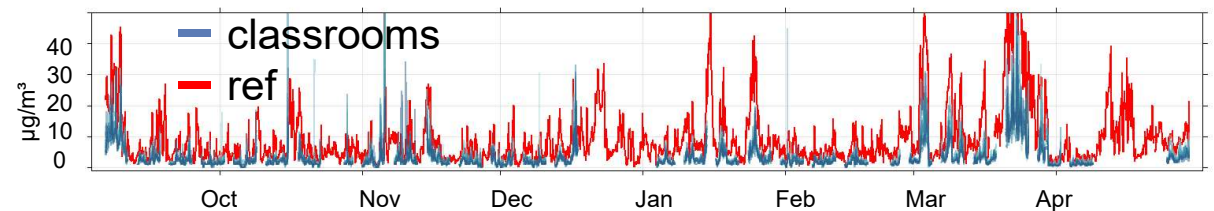
3D plot School C03 PM2.5

— classrooms
— ref

3D plot School C05 PM2.5

— classrooms
— ref

Frontal view School C04 PM2.5

— classrooms
— ref

⇒ **Outdoor-generated PM important component**

What does this tell us….

Time-activity patterns important for personal exposure

$\Rightarrow$ **Created reliable models for activity classification using ubiquitous data (i.e. smartphones, sensors ….)**

Buildings significant modifiers of personal exposure

$\Rightarrow$ **Modelling studies to identify factors affecting indoor exposure and develop novel exposure metrics (i.e. indoor- and outdoor-generated pollutants, proxies of non-targeted compounds …)**

Exposure error ("misclassification") introduces error and bias in health models

$\Rightarrow$ **Improved exposure metrics and analytical methods**

Amazing insights from CLASS-ACT data

$\Rightarrow$ **Evidence of regional-scale PM indoors!**

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Selected references

1. Chatzidiakou L. et al., (2019) Characterising low-cost sensors in highly portable platforms to quantify personal exposure in diverse environments, AMT, https://doi.org/10.5194/amt-12-4643-2019

2. Chatzidiakou L. et al., (2022) Automated classification of time-activity-location patterns for improved estimation of personal exposure to air pollution, Environmental Health, *accepted*

3. Chatzidiakou L. et al., (2020) Using low-cost sensor technologies and advanced computational methods to improve dose estimations in health panel studies: results of the AIRLESS project, JESEE, https://doi.org/10.1038/s41370-020-0259-6

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