The INGENIOUS Study: Understanding air pollution in homes

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The Scottish Government
Riaghaltas na h-Alba

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The INGENIOUS study: understanding air pollution in homes

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Scottish Air Quality Seminar, 2025

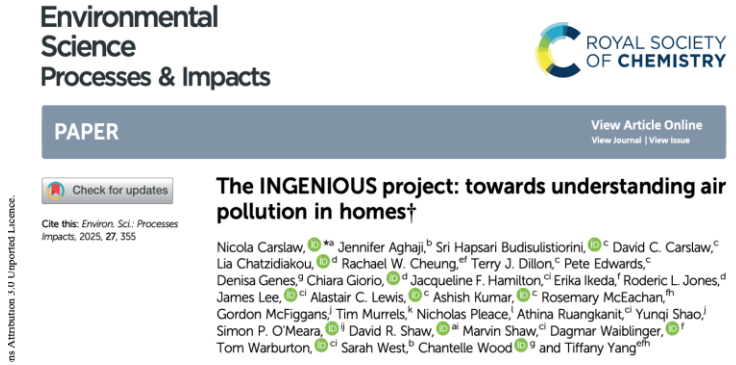
UnderstandING the sourcEs, traNsformations and fates of IndOor air pollUtantS: INGENIOUS

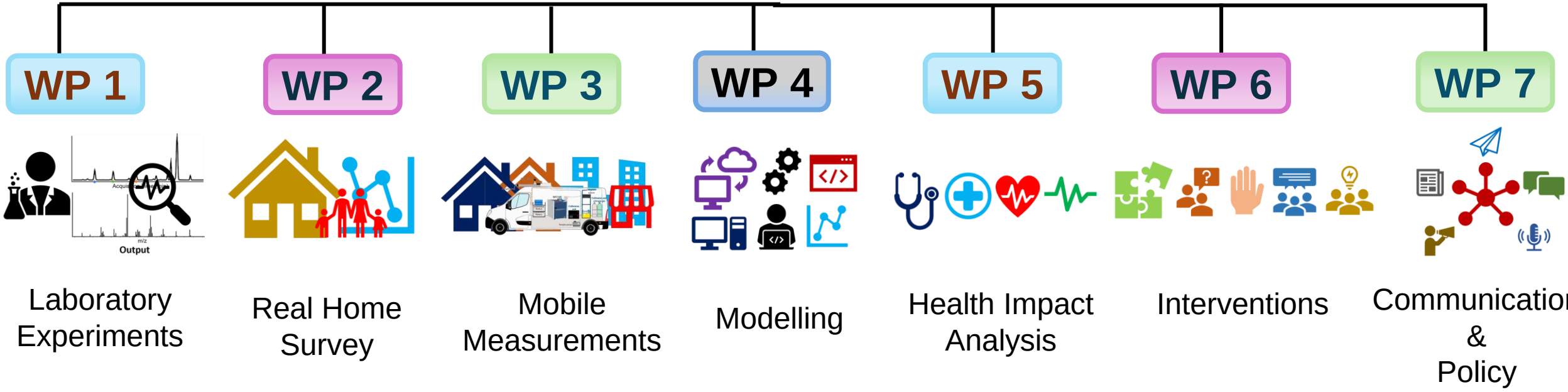
The overarching aims are to:

- Undertake the **first** comprehensive mapping exercise of the main sources, transformations and fate of air pollutants in typical UK residences
- Identify inequalities in exposure and the consequent impacts on health amongst diverse population
- Identify the physical, social and behavioural factors that control pollutant distribution
- Co-design novel, scalable interventions to improve air quality and health.

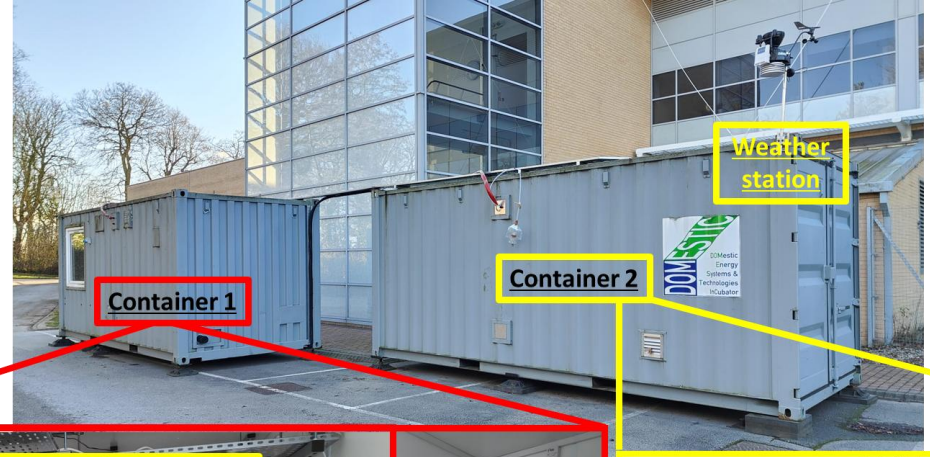
- Longitudinal birth cohort, exploring why some families stay healthy and others fall ill
- 12,500 Mums recruited between 2007-2011: oldest children now 18
- Works with decision makers to translate evidence into practice: improve lives of families in Bradford and beyond
- People powered: coproduction with communities and stakeholder underpins all activities.

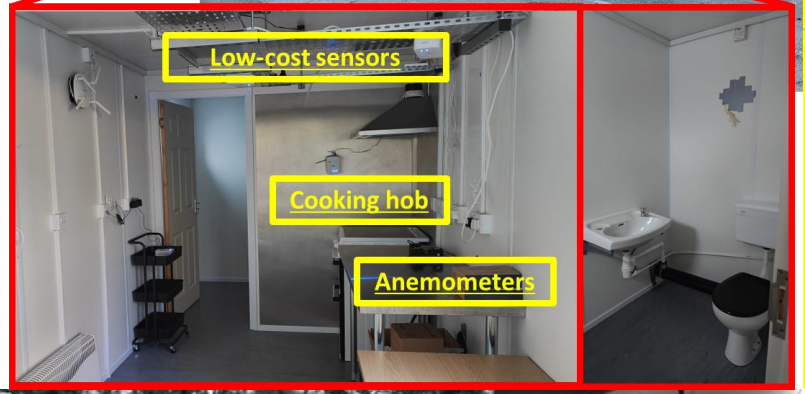
INGENIOUS Workpackages

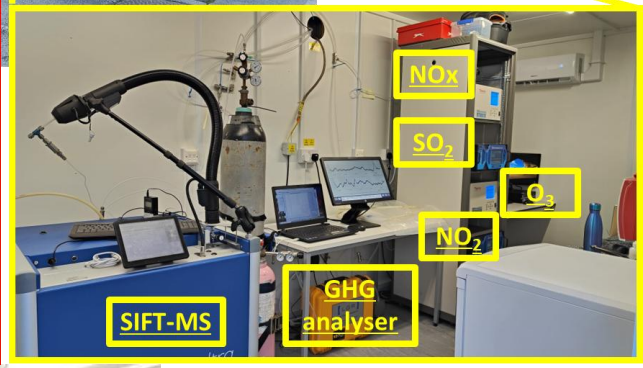




Testing facilities at York







Products tested

Table 2 A detailed breakdown of the emissions measurements carried out as part of WP1 and classified into cooking, cleaning or home scented product use

Cooking		Cleaning		Home scented products	
Frying in oils	***Number of experiments***	***Product class***[a]	***Number of experiments***	***Product class***	***Number of experiments***
Rapeseed oil	1	Surface cleaners	10	Electrical plug-in diffusers	8
Sunflower oil	1	Bathroom cleaners	5	Essential oil mist diffusers	7
Olive oil	1	Floor cleaners	3	Reed diffuser	1
Groundnut oil	1	Bleach	7	Bathroom freshener (gel)	1
Coconut oil	1	Window cleaner	1	Bathroom freshener (liquid)	1
Ghee	1	**Total**	**26**	Room spray (aerosol)	4
Total	**6**			Wax melts	8
				Scented candle	1
Full recipes	***Number of experiments***			Bakhoor	3
Beef chilli	6			Frankincense	2
Non-meat chilli	7			Incense stick	3
Chicken stir-fry	6			**Total**	**39**
Tofu stir-fry	7				
Chicken curry	7				
Paneer curry	6				
Total	**39**				

[a] All the cleaning products tested in this study were considered to be fragrant based on the manufacturer's label information indicating the presence of “parfume/perfume” in the formulation.

Cooking experiments

Stir-fry

Tofu stir-fry

Chicken stir-fry

Curry

Chicken curry

Paneer curry

Chilli

Non-meat Chilli

Beef Chilli

- Standardised 6 recipes
- Used same pan and same induction hob
- Heat setting varied according to the recipe
- Same set of ingredients used in each cook (from same shop)
- Cooking time 12-26 min.

- Continuous VOC measurement using SIFT-MS
- 1 whole air canister per recipe for GC-MS analysis
- Periodic Indoor and outdoor air measurements of VOC, CO_2, CH_4 NO, NO_x, SO_2 and O_3.

Chicken stir-fry emissions

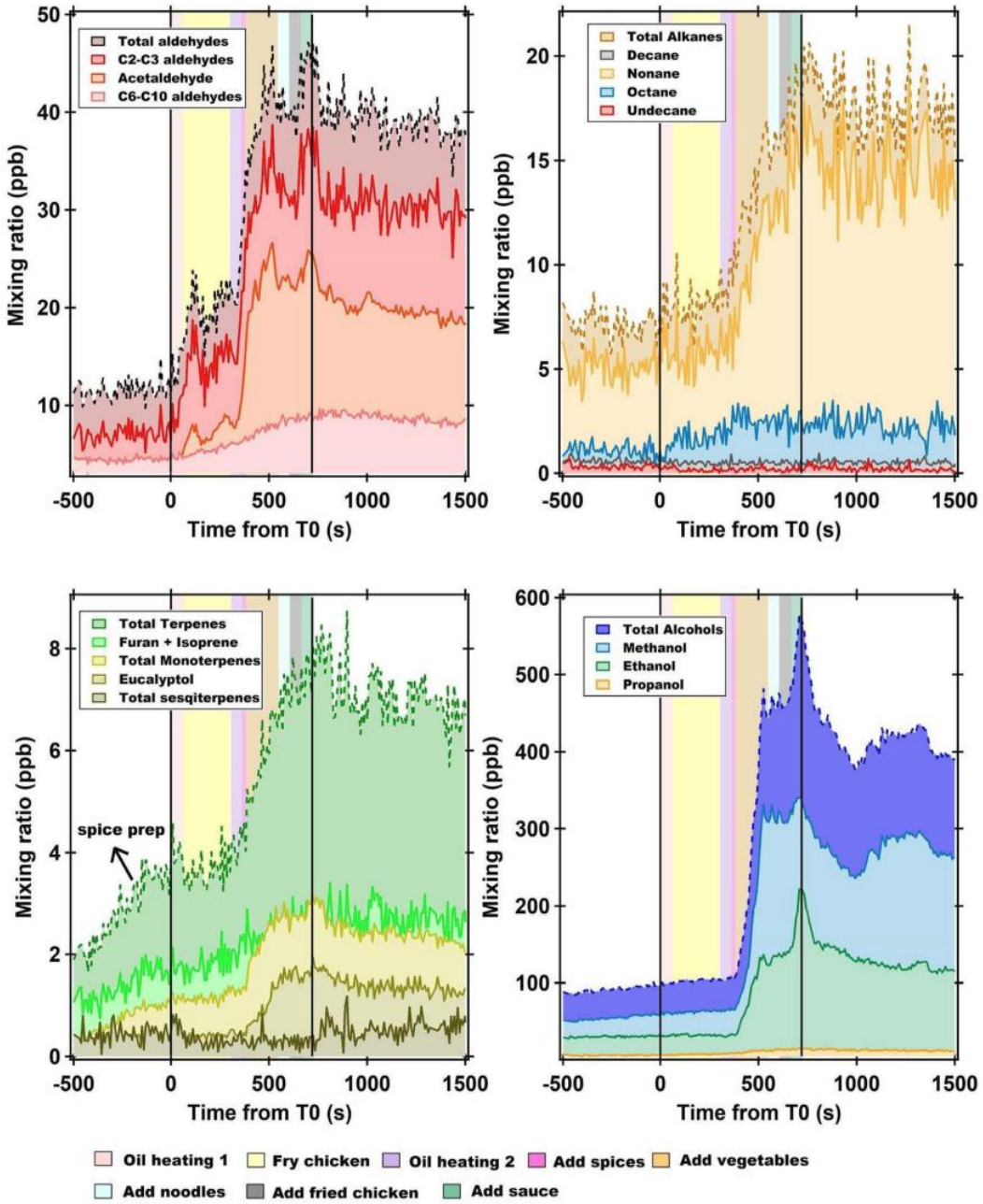
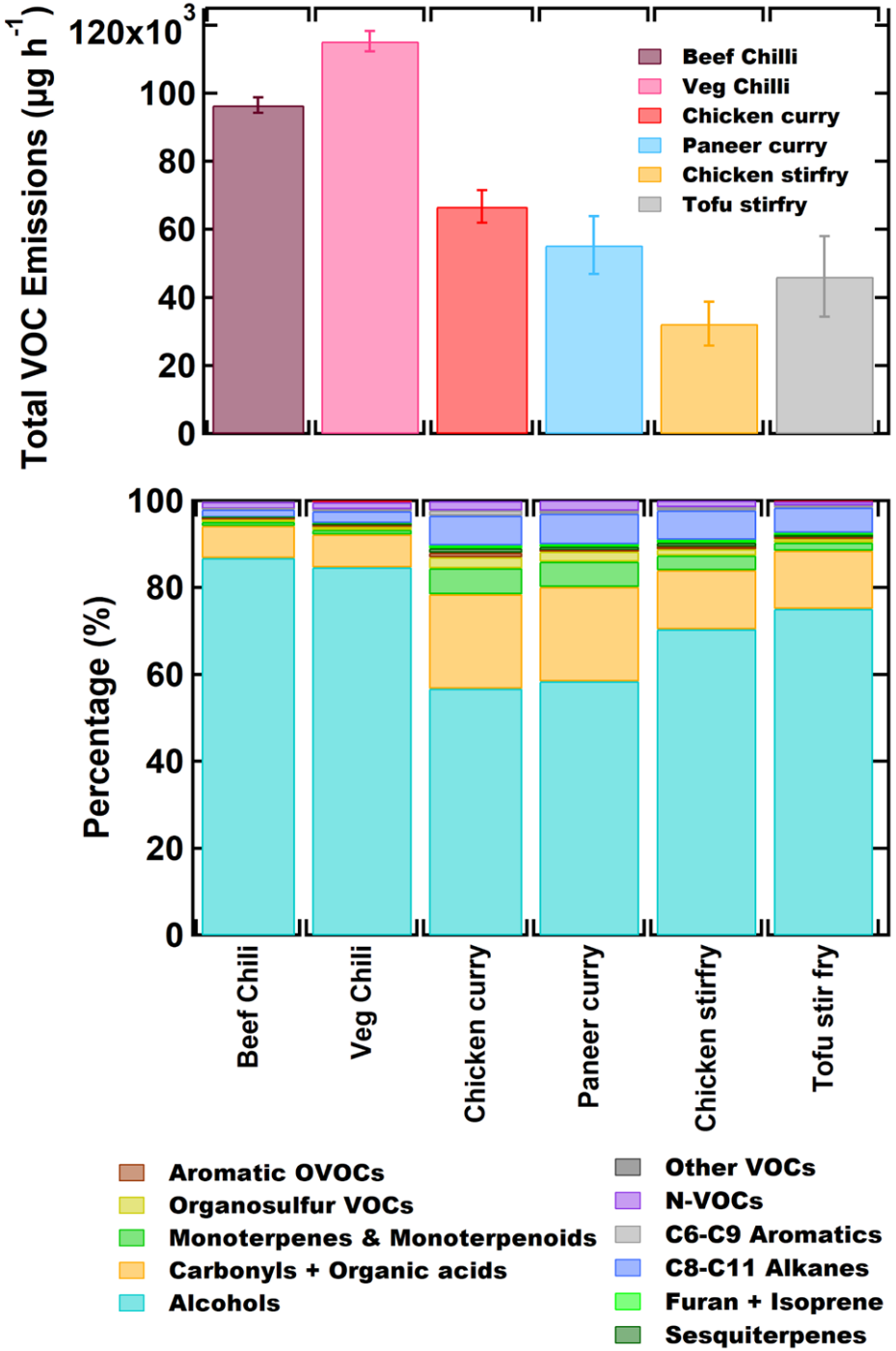


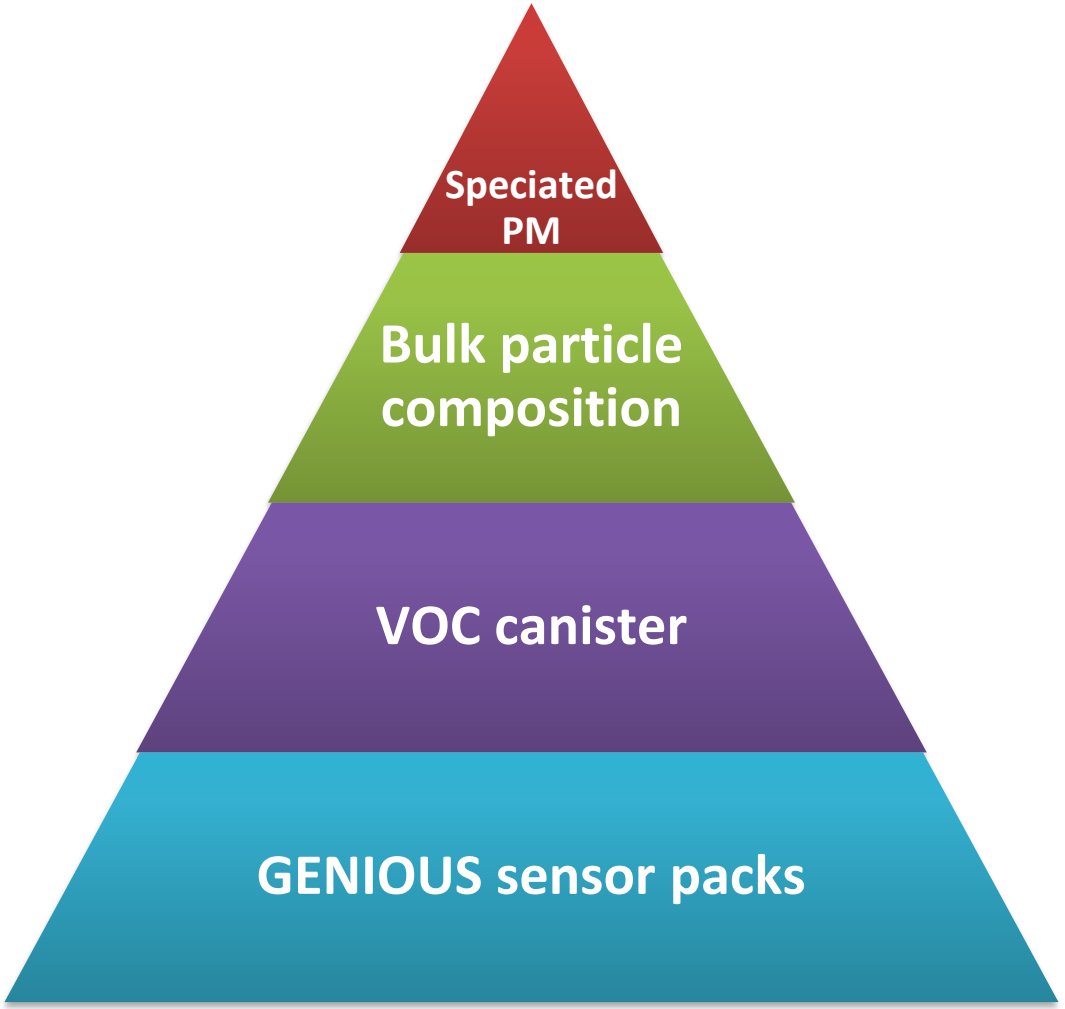
Fig. 4 Mixing ratios of aldehydes (top left panel), alkanes (top right panel), terpenes (bottom left panel), and alcohols (bottom right panel) measured using the SIFT-MS during the cooking of chicken stir-fry. The grey-shaded region shows the cooking duration and time T_0 represents the start of the cooking (when the oil is first added to the heated pan). The data shown is the averaged data of six cooking experiments.



VOC emissions from different recipes

- Alcohols dominated emissions
- Curries produced more carbonyls, monoterpenes and organic acids than other meals
- How do we represent these emissions in NAEI?

WP2: Measurements in residences



50

100

150

300

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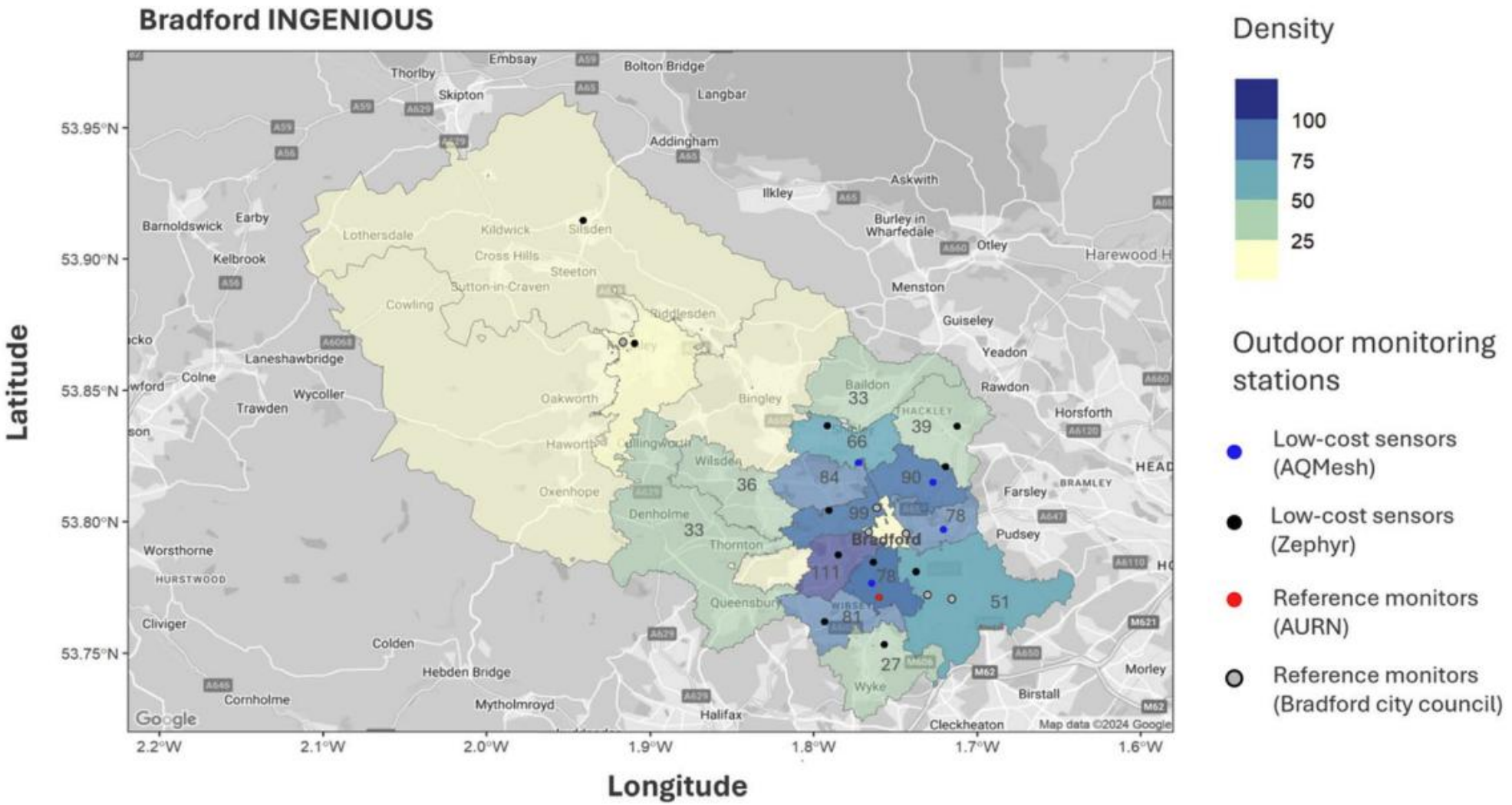
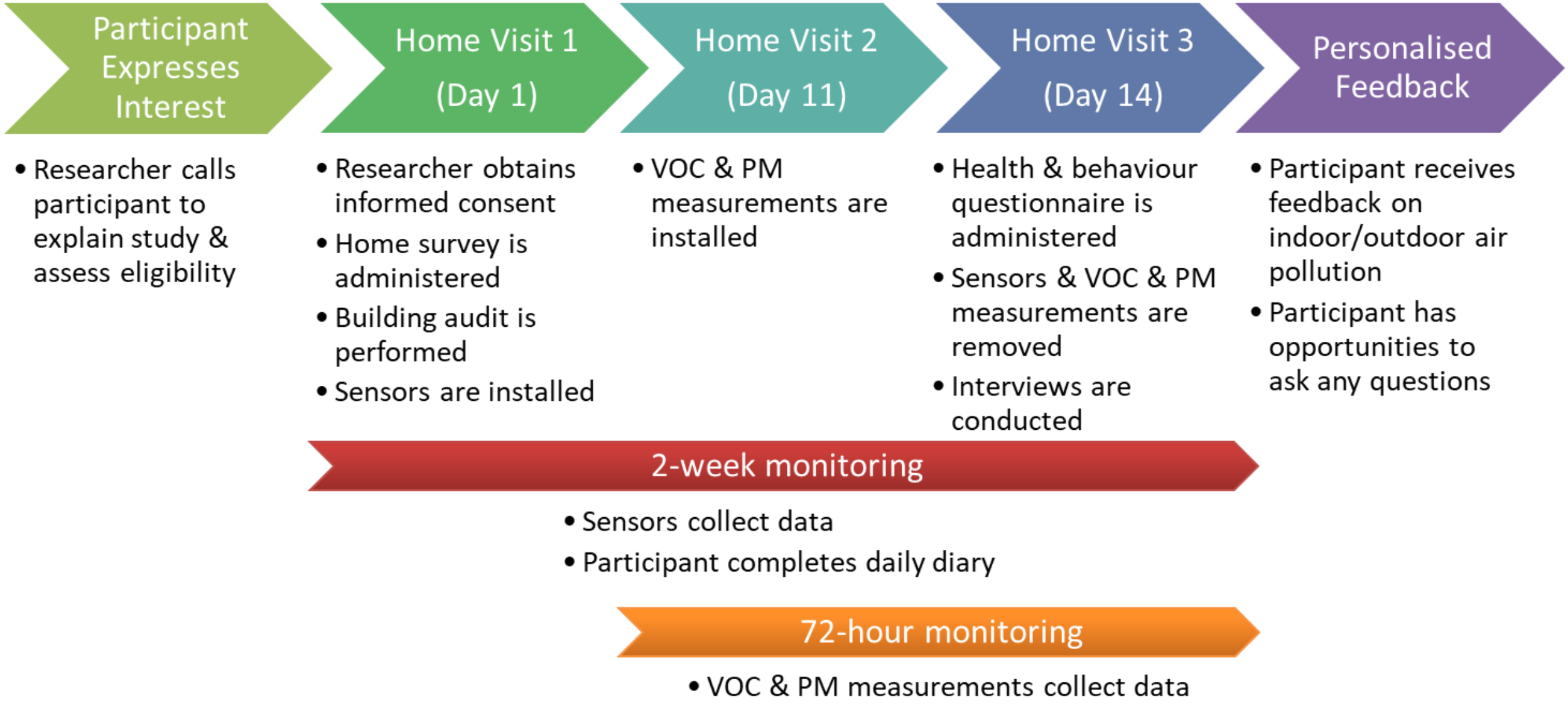
Sampling locations



Spatial distribution of INGENIOUS households by postcode district and locations of the outdoor monitoring stations of the outdoor sensor network

Recruitment & Procedure

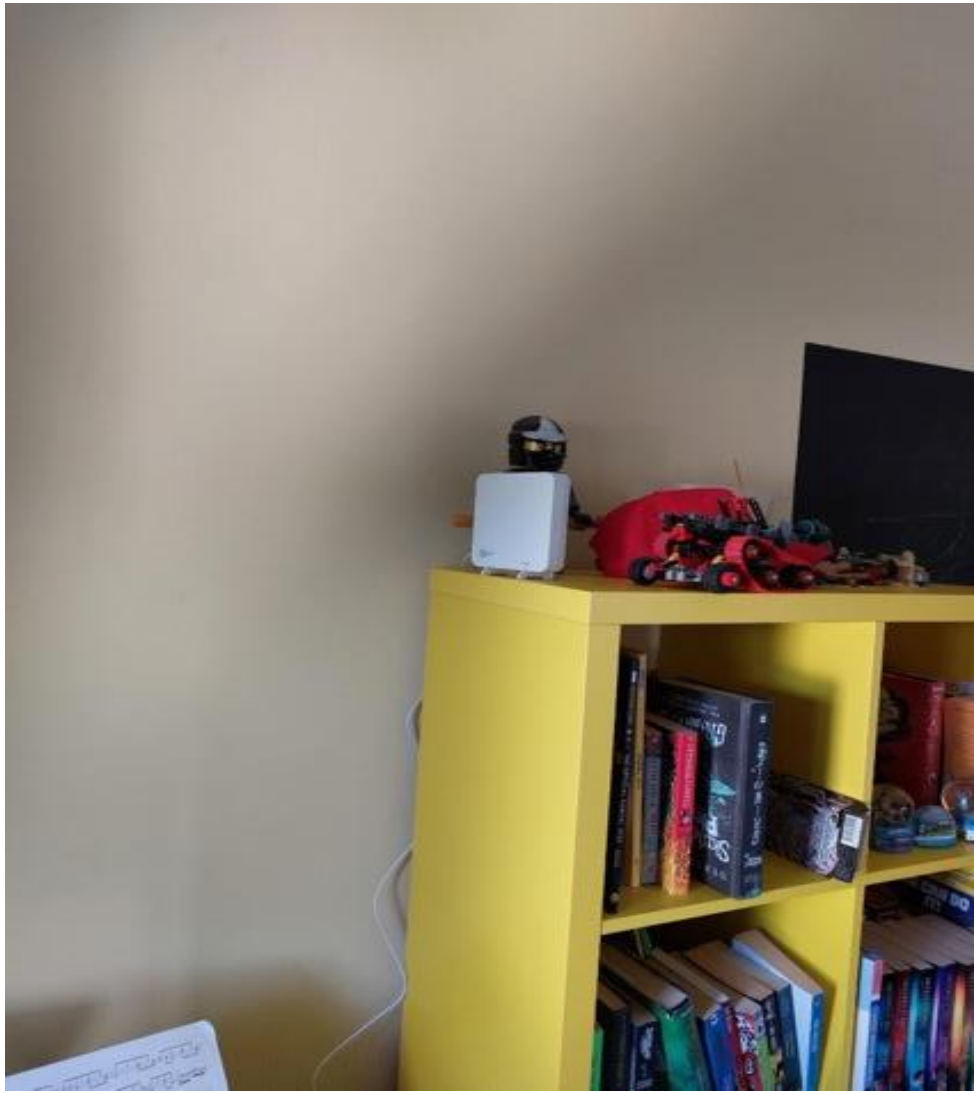


WP2: Participants

- 321 households have been recruited via BiB Growing Up cohort

		Ethnicity		
		South Asian (47%)	**White (British)** (40%)	**Other** (11%)
Housing tenure	**Private/mortgaged property** (70%)	N=95 (asthma: N=48; non-asthma: N=47)	N=95 (asthma: N=48; non-asthma: N=47)	N=21 (asthma: N=10; non-asthma: N=11)
	Rented property (30%)	N=40 (asthma: N=20; non-asthma: N=20)	N=40 (asthma: N=20; non-asthma: N=20)	N=9 (asthma: N=5; non-asthma: N=4)

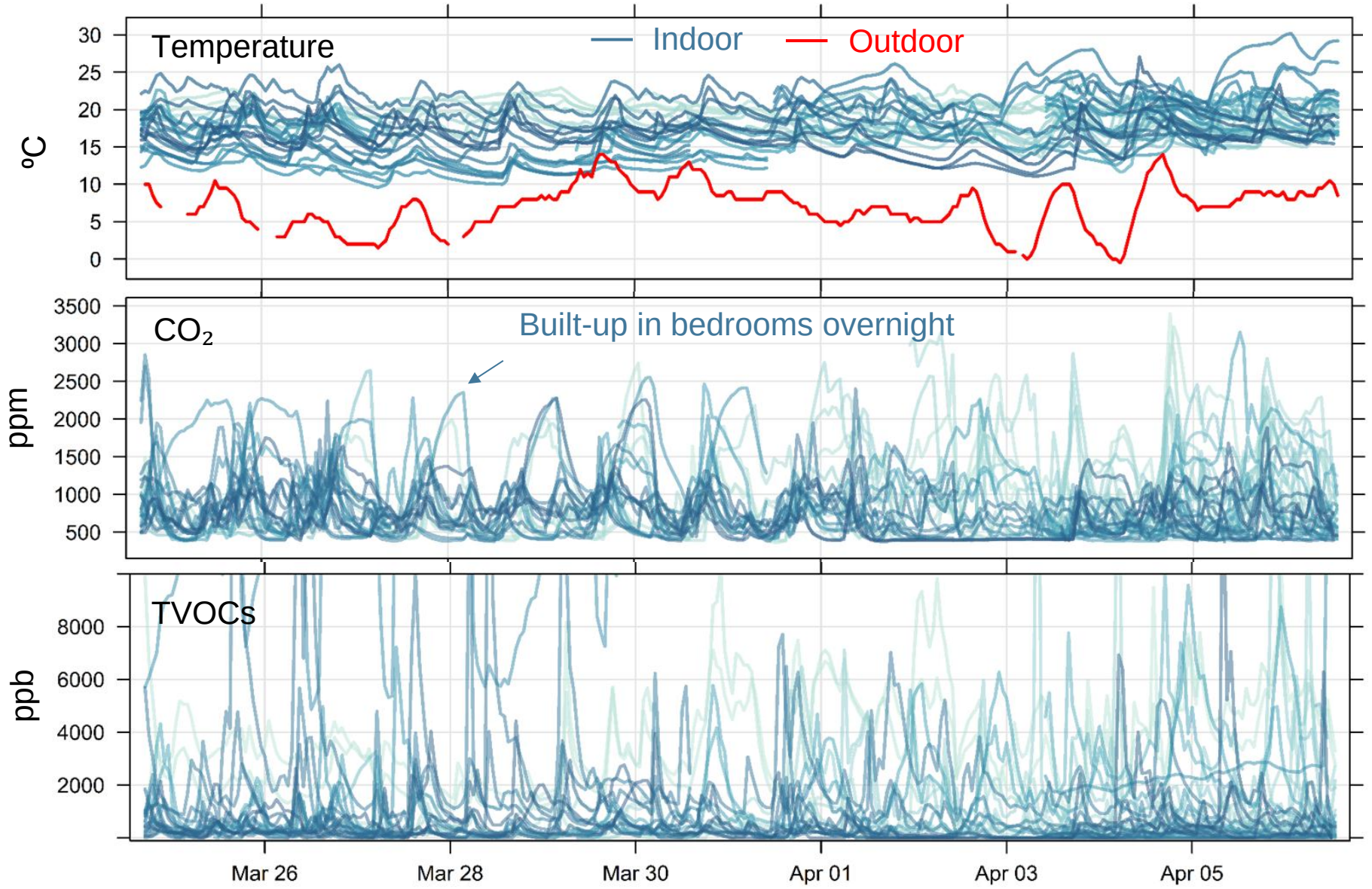
Sampling equipment in situ



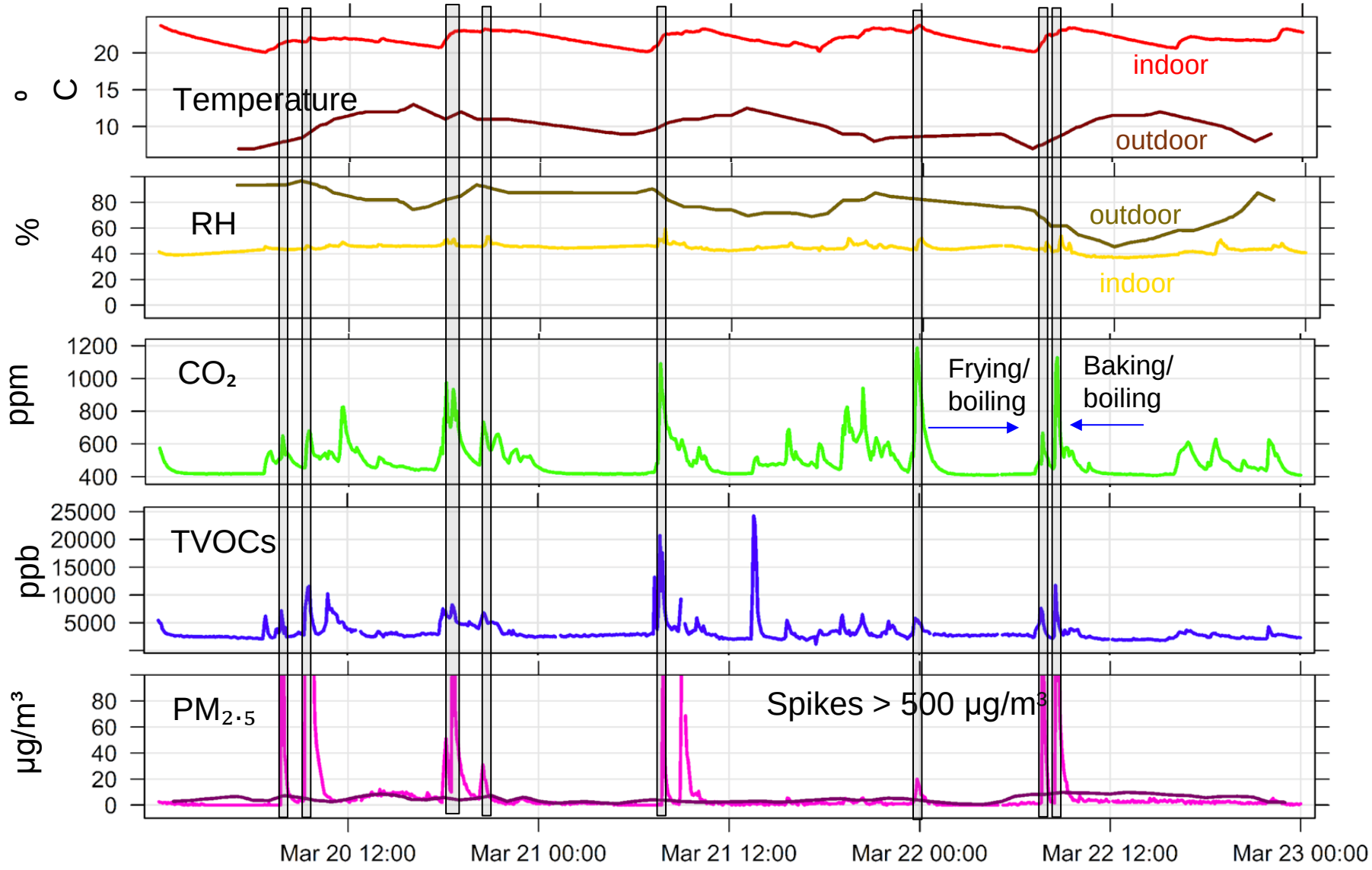
Example of 2-week collection period, March-April 2023

Fuel poverty???

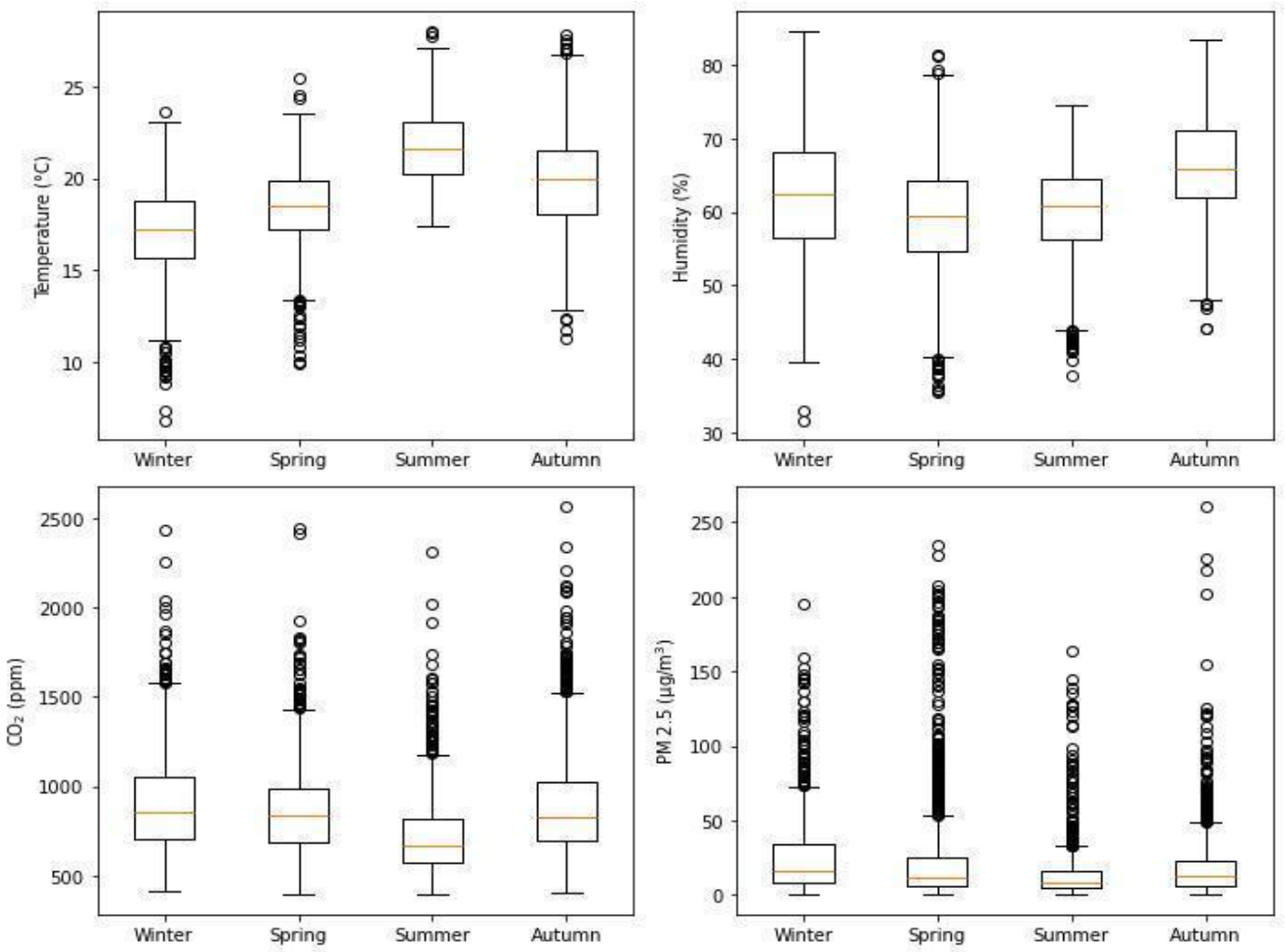
Large variability between households



Diary information

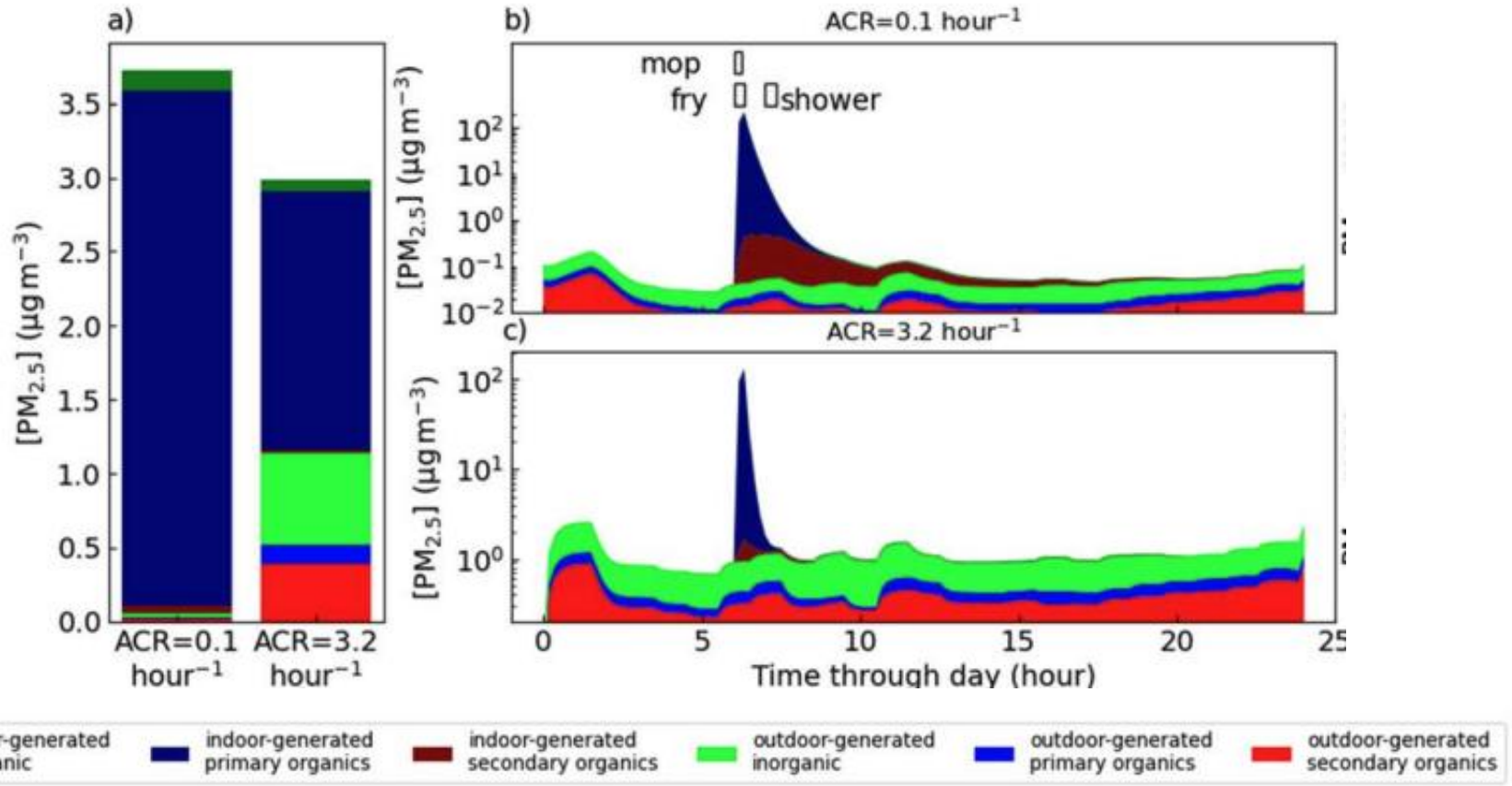


Summary of LCS data in 310 homes in Bradford



- Variability between houses > seasonal differences
- Very low internal T for significant minority
- More variability in pollutant concentrations than environmental parameters
- Human behaviour largely drives IAQ

Simulations of PM



Summary

- Wide variability in indoor measurements: behaviour is key
- Outdoor AQ only influenced IAQ in absence of activities
- Very high $PM_{2.5}$ concentrations (cf. WHO) in kitchens and high CO_2 in bedrooms
  - differential toxicity (HIPTOX)?
  - long term exposure to lower concentrations vs short-term exposure to higher concentrations?
- Low internal temperatures
  - fuel poverty
  - damp
- Implications for Net Zero policies??