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The University of Manchester

A Data Integration Approach to Estimating Personal Exposures to Air Pollution

Dr. Matthew Thomas

Session 1b – Exposures to Air Pollution

Department of Earth and Environmental Sciences
University of Manchester
Email: matthew.l.thomas@manchester.ac.uk

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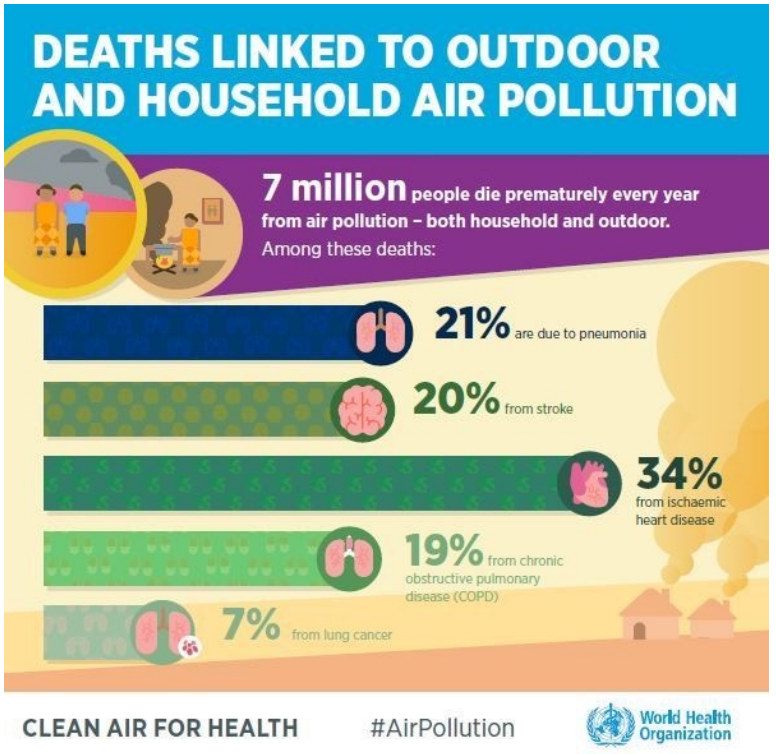
Introduction

- Globally, air pollution is the largest environmental risk to health
- Majority of research related to the health effects of air pollution has been at a population level
  - Measured or modelled concentrations of ambient pollution
  - Matched to residential address
- This does not necessarily reflect individual's exposures to different levels of air pollution throughout the day
- People move through a series of *micro-environments* with different levels of pollution
  - Work, home, school, outdoor, car, etc…

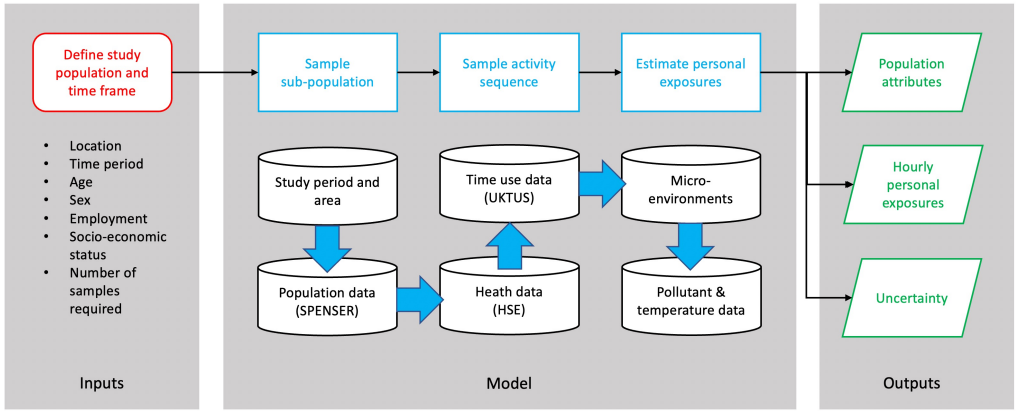


Data Integration Model for Exposures (DIMEX)

- The aim here is to estimate personal exposures to air pollution
- Framework for integrating data on air pollution concentrations with population demographics, activities, locations and other factors affecting individuals exposures
- Simulate the daily exposure of different population groups using agent based modelling
- Differences between personal exposures and concentrations
- Run ‘virtual’ scenarios

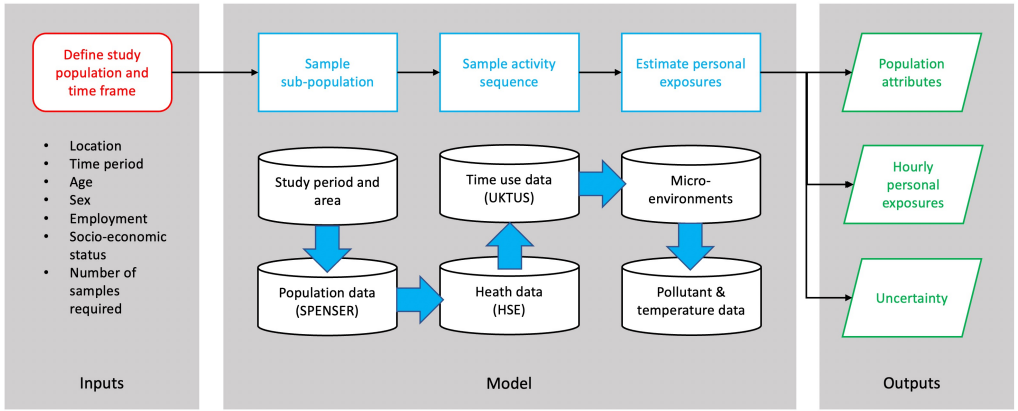
Framework for Exposures Estimation

- Consider all information relating to individual's exposure to pollutant in question
  - I: individual factors, e.g. age and sex
  - E: external factors, e.g. ambient pollution, temperature
  - B: human behaviour
- DIMEX consists of structural linkages between the model elements
- Uncertainty about model elements
  - Prediction error
  - Estimating model parameters



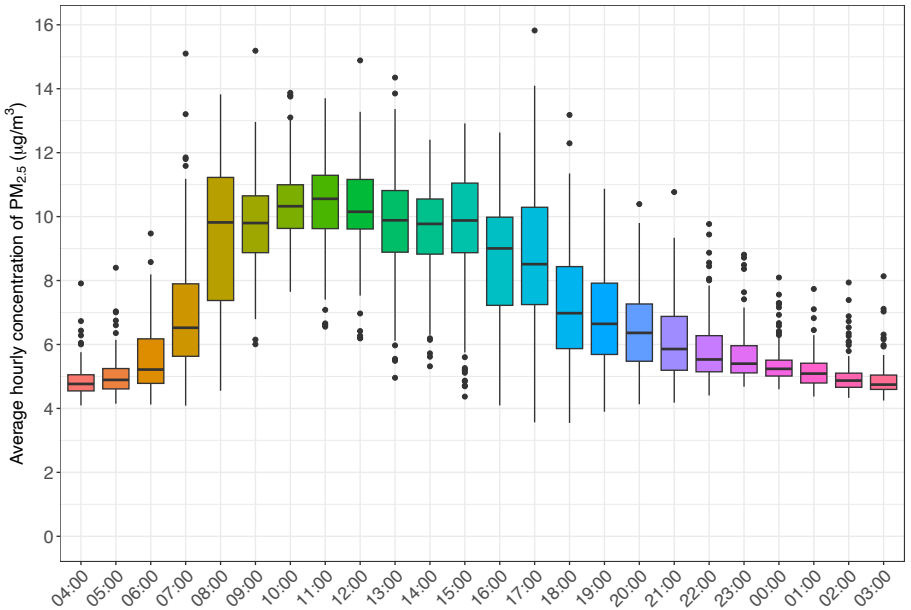
Framework for Exposures Estimation

- Builds upon previous work developing exposure simulators , including pCNEM, SHEDS, APEX
- Incorporates new modelling techniques and increasing availability of data
  - Demographic information
  - Activity patterns
  - Micro-environments
- Generates a sequence of pollutant concentrations to which a randomly selected individual is exposed over time



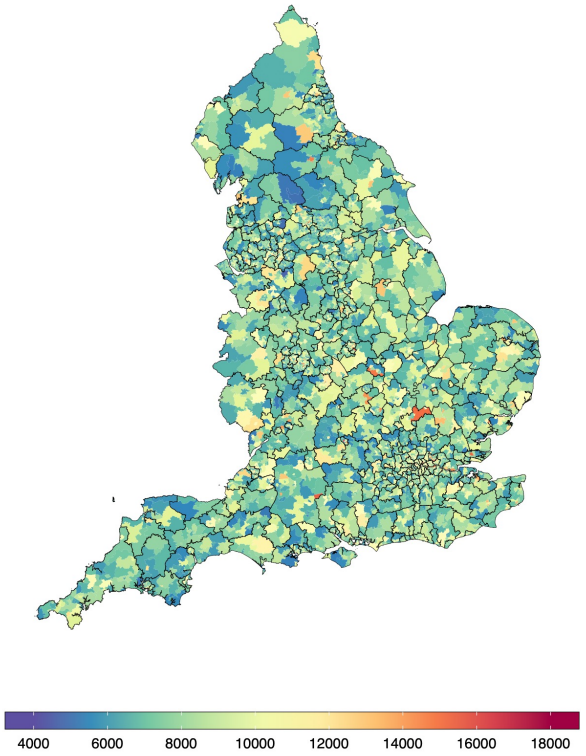
Outputs

- Estimates of personal exposures aggregated to populations
  - Measures of uncertainty
  - Individual's personal trajectory maps
  - Map differences between personal exposures and concentrations
- Can be used as inputs for health impact analyses and epidemiological risk models



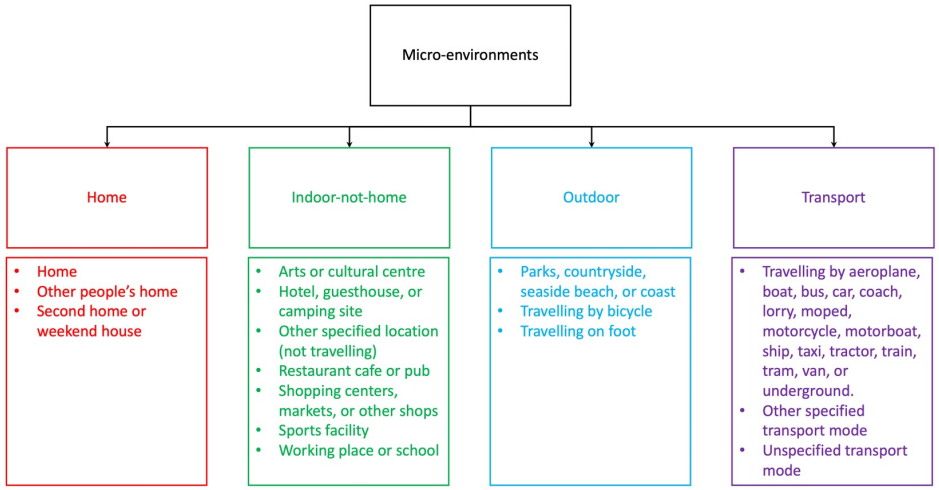
DIMEX: Underlying population

- Individuals are sampled from an underlying synthetic population from the area of interest
- SPENSER combines census data with small scale surveys and datasets to create a geo-referenced synthetic population forecast at a high resolution
- Supplemented with include data from the United Kingdom Time Use Survey and the Health Survey of England based on demographic information
- Each individual are assigned to a Middle Layer Super Output Area (MSOA)

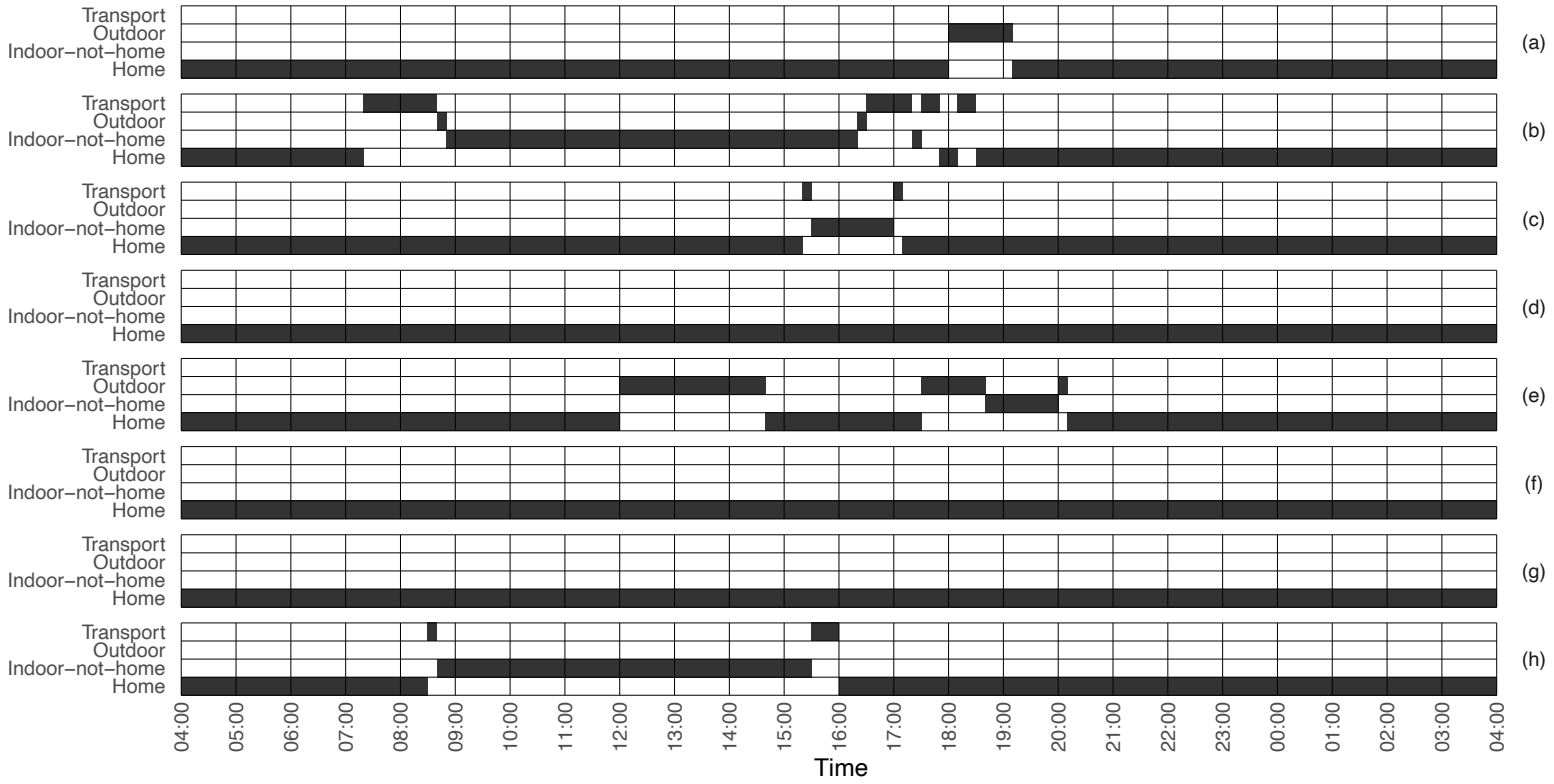


DIMEX: Activity sampler

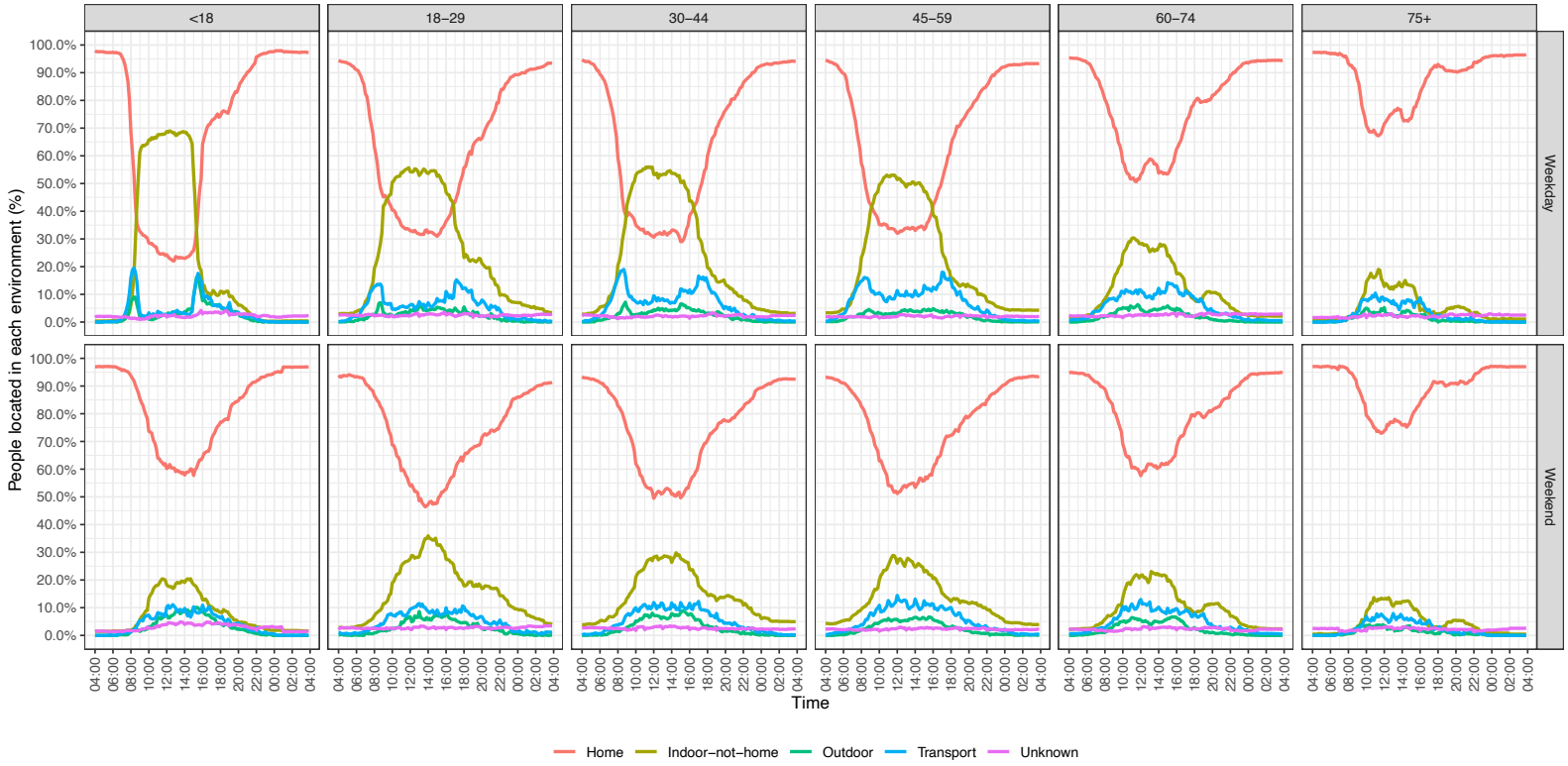
- UK Time Use Survey (UKTUS) is a nationally-representative survey that provides information on how people aged eight years and over in the UK spend their time
- Contains diaries consisting of sequences of activities and the locations that they take place between 4am to 4am in 10-minute intervals
- Locations of each activity from the activity diaries were grouped into four micro-environments: Home, Indoor-not-home, Outdoor and Transport



DIMEX: Activity sampler

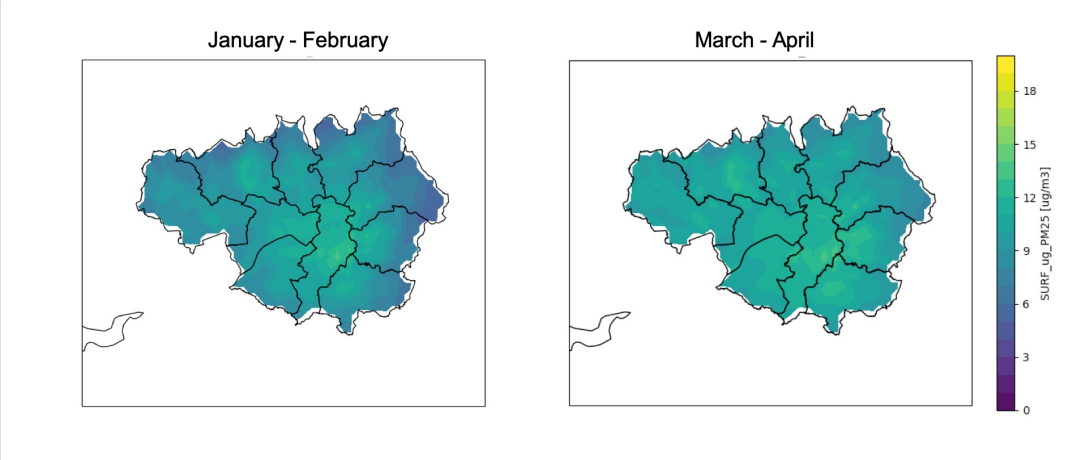


DIMEX: Activity Sampler



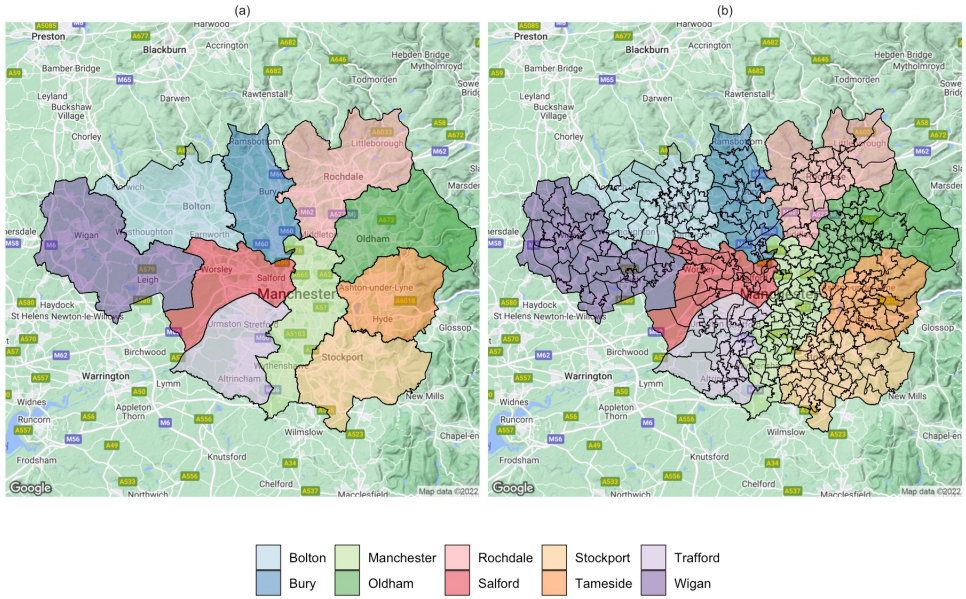
DIMEX: Exposure Estimation

- Each of the individuals activity sequence needs to be matched to the corresponding concentrations of air pollutions they are exposed to in each micro-environment
- Concentrations of PM2.5 in the home are modelled as a function of the the ambient outdoor concentrations and non-ambient sources of air pollution
- Ambient air pollution concentrations come from ground measurements and the European Monitoring and Evaluation Programme for Transboundary Long-Range Transported Air Pollutants (EMEP) model



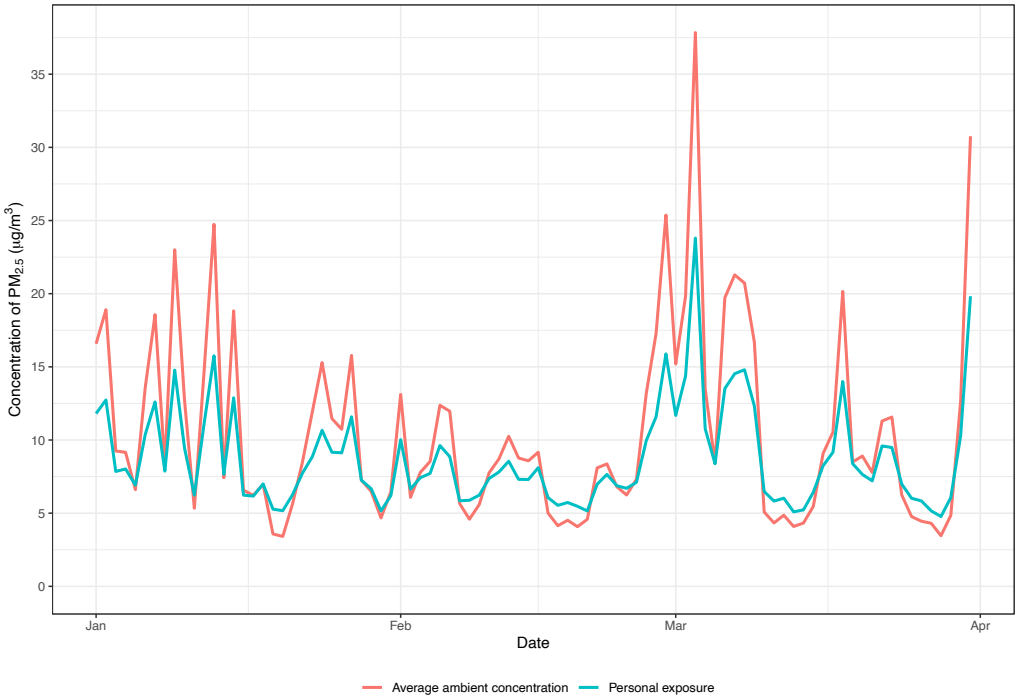
Case Study: Greater Manchester

- DIMEX was used to estimate personal exposures for simulated individuals in Greater Manchester, UK
  - 2.8 million inhabitants
  - 10 metropolitan boroughs
  - 364 MSOAs
- Used modelled concentrations from EMEP for January – March 2021
- Sampled 100 individuals from the synthetic populations for each MSOA



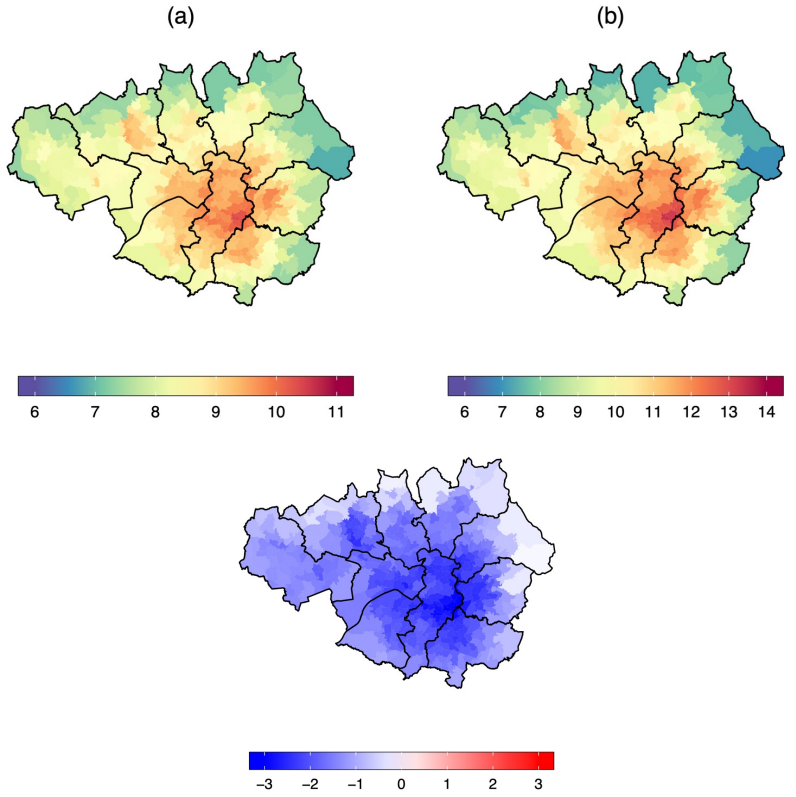
Case Study: Temporal Differences

- DIMEX outputs hourly estimates of personal exposures that can be aggregated over **time**
- Compare personal exposures and ambient concentrations **temporally**
- Personal exposures are generally lower
- Differences of up to 15 μg/m3 for days with high concentrations



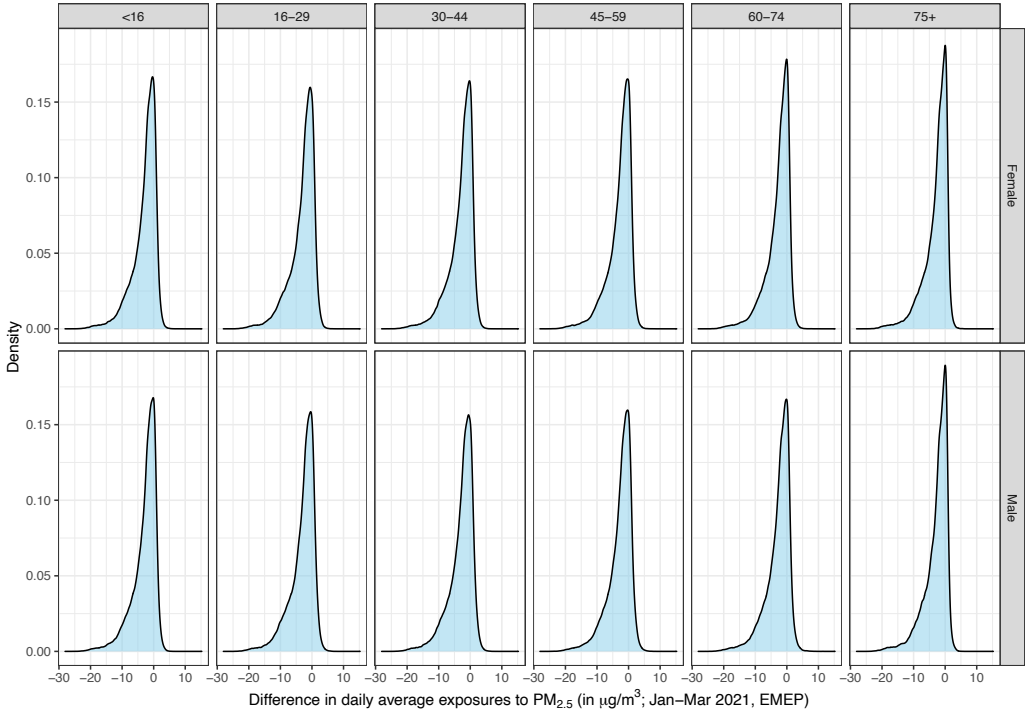
Case Study: Spatial Differences

- DIMEX outputs hourly estimates of personal exposures that can be aggregated over **space**
- Compare personal exposures and ambient concentrations **spatially**
- Personal exposures to PM2.5 are generally lower
- Largest differences between the personal exposures and the ambient concentrations in urban areas



Case Study: Impacts of Air Quality Strategies

- Able to examine the effects of proposed air quality strategies and interventions
- DIMEX was run with ambient concentrations reduced to the recently announced WHO air quality guidelines (5 μg/m3)
- Variability in exposures across different population groups
- Uncertainty estimates
- This results in a estimated reduction in personal exposures between 2.7 and 3.1 μg/m3 (mean) or 1.8 and 2.0 μg/m3 (median)



Summary

- Developed a framework that integrates data from multiple sources to estimate personal exposures to air pollution
  - Variable-resolution outputs, over time and space
  - Measures of uncertainty
- Human activity and the location of these activities plays an important role in their exposures to different levels of air pollution, with substantial variation observed across different demographic groups
- Concentrations of air pollution vary considerably across different (micro-) environments, e.g. home, outdoor and transport. As the majority of people spend the majority of their time indoors (average of 90%), this demonstrates the importance of indoor, specifically residential, air quality as an important exposure route for public health policy