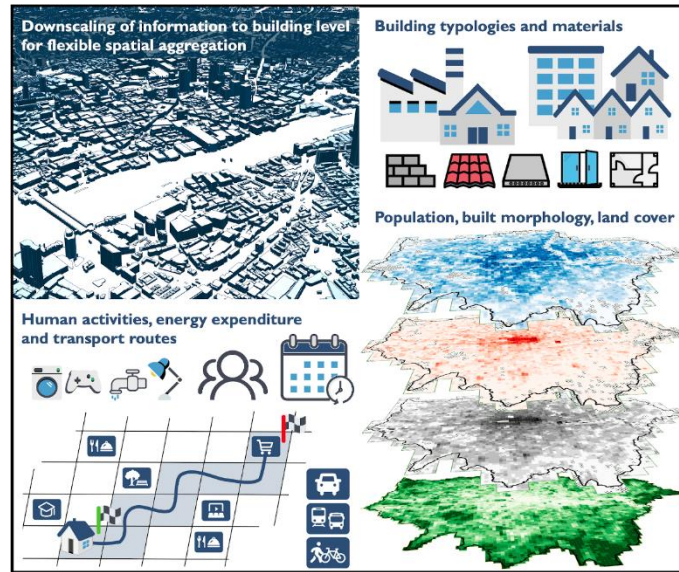


# Modelling variability of people's behaviour: time spent in different places in London

Megan McGrory, Denise Hertwig, S Grimmond, M Paskin, Tiancheng Ma, Y Liu, S Lo Piano, Stefán T Smith

Department of Meteorology & School of the Built Environment, University of Reading, UK

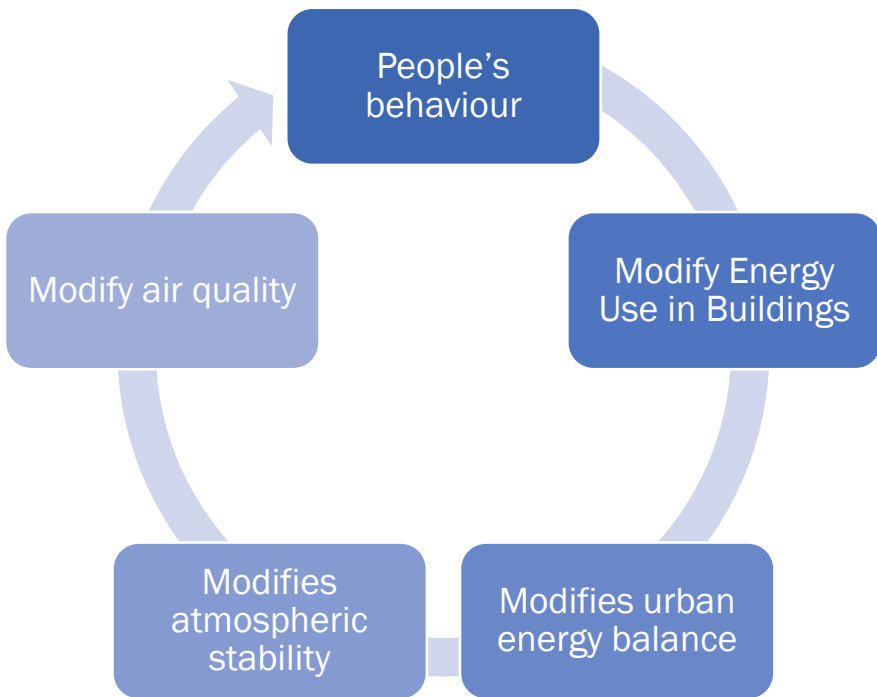


Research undertaken within NERC APEX (*Ben Barratt talk yesterday*), NERC ASSURE & ERC *urbisphere*

# Introduction

## Objective:

- to improve modelling of physical meteorological processes in urban areas by accounting for function
- to model how much time people spend doing different activities in different microenvironment (ME)



## Approach to Model

### People's behaviour:

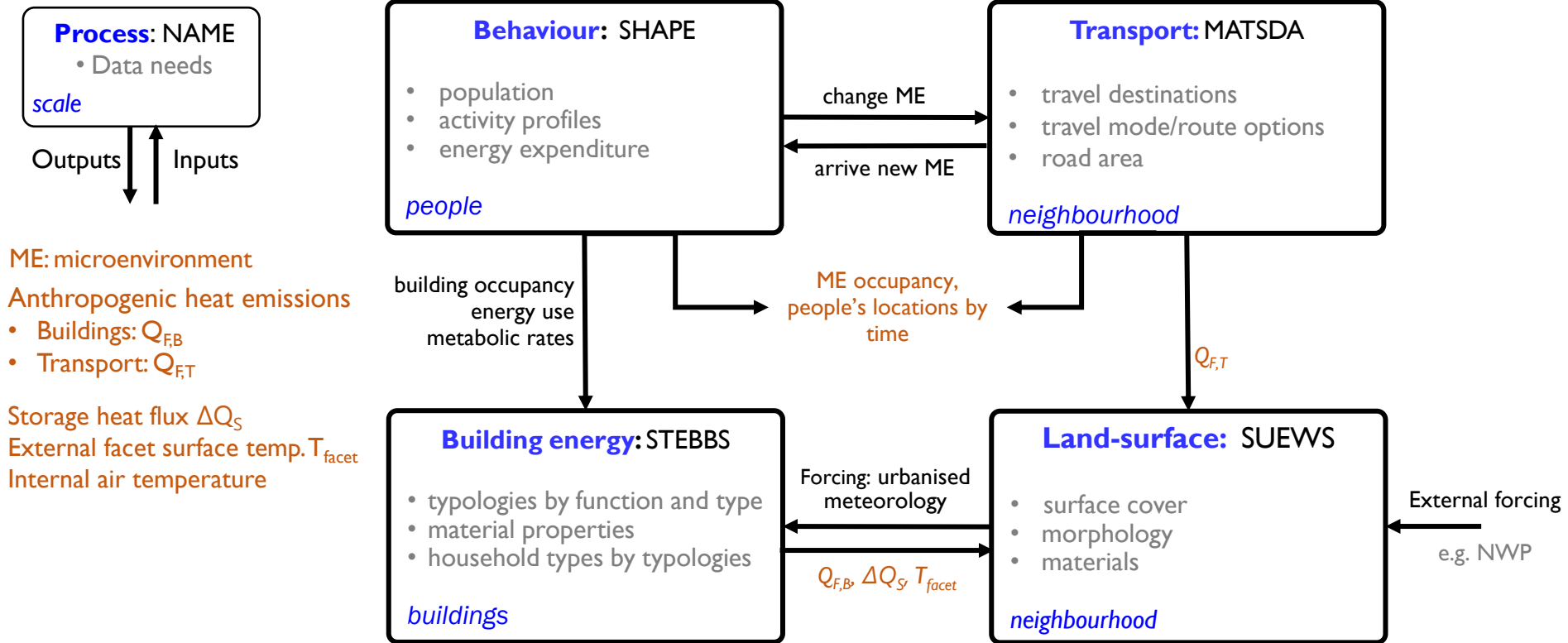
- **Activities:** cooking, exercising, working, travelling
- **Location:** outdoors, indoors, in homes, shops, offices etc.
- **Vary with:** demographics (e.g. age), time (e.g. within day, week)

### Outputs include:

- Anthropogenic heat flux (Capel-Timms et al. 2020, *GMD*): Building energy, transport, metabolism
- Time spent in locations and ME

# DAVE: Dynamic Anthropogenic activities and feedback to Emissions

## Multi-scale model system

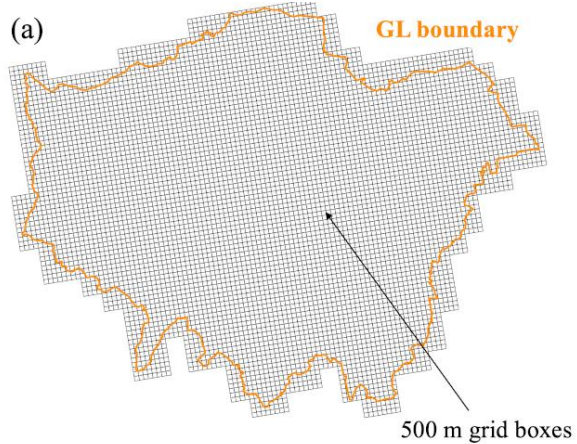


# Many aspects of city varying

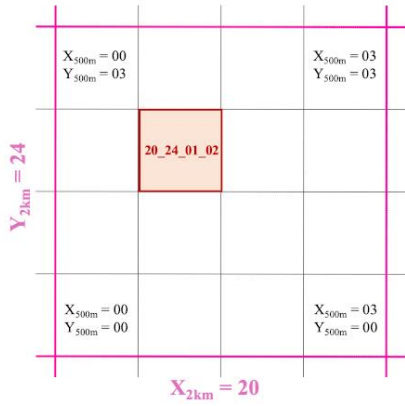
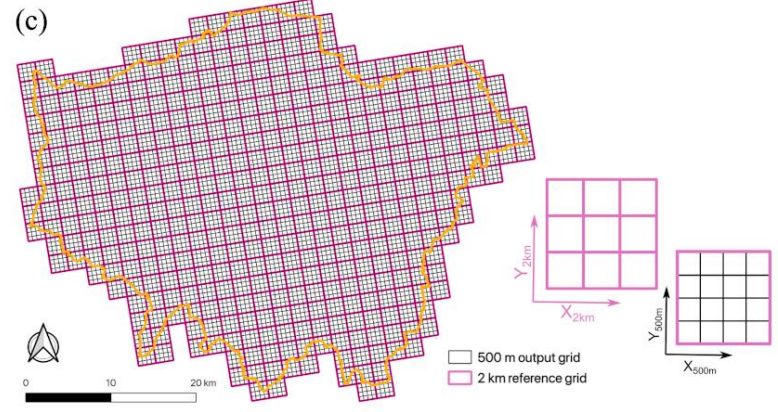
- Spaces of activity
- Land surfaces
- Building typologies
- Populations
- Activities
- Movement

a. Spaces of activity	b. Surfaces	c. Building typologies	d. Population
<p><b>Residence</b> <i>and residential sub-spaces of activity</i></p> <p> Home  OtherHome</p> <p>   Living room, kitchen, bedroom, bathroom, garage, garden <i>indoor, outdoor</i></p>	<p><b>Buildings</b></p>	<p><b>Building function</b></p> <ul style="list-style-type: none"> <li>• Residential</li> <li>• Non-residential</li> <li>• Mixed</li> <li>• Other</li> </ul>	<p><b>Residential population</b> <i>in residential &amp; mixed buildings</i></p> <p>Age cohorts:      Infants      ≤ 4                                   Children      5–11                                   Teenager      12–18                                   Adults      19–64                                   Senior      ≥ 65</p> <p>Household size:      1–8+ &amp; communal</p>
<p><b>Work, education, training</b></p> <p> <i>indoor</i></p> <p> Workplace  University</p> <p> SecondarySchool  PrimarySchool</p>	<p><b>Paved</b></p> <p><b>Pervious</b></p>	<p><b>Building type</b></p> <ul style="list-style-type: none"> <li>• Detached</li> <li>• Semi-detached</li> <li>• Terraced</li> <li>• Apartment block</li> <li>• Other</li> </ul>	<p><b>Workplace population</b> <i>in non-resident. &amp; mixed buildings</i></p>
<p><b>Leisure, necessities, temporary accommodation</b></p> <p> </p> <p> <i>indoor, outdoor</i></p> <p> Hospitality  IndoorEnt  Cultural</p> <p> LargeShop  SmallShop  Healthcare</p> <p> OutdoorEnt  Outside</p> <p> TempRes  Hotel</p>	<p><b>Building geometry</b></p> <ul style="list-style-type: none"> <li>• Height to eaves level, <math>h</math> (m)</li> <li>• Footprint area, <math>A_{foot}</math> (m<sup>2</sup>)             <ul style="list-style-type: none"> <li>• assumed equal to roof area, <math>A_{roof}</math></li> </ul> </li> <li>• External (exposed) wall area, <math>A_{wall}</math> (m<sup>2</sup>)</li> </ul>	<p><b>e. Activities</b></p> <p><b>Temporal profiles of activities</b></p> <ul style="list-style-type: none"> <li>• Diurnal sequences of peoples' activities in different <b>microenvironments</b> (10 min resolution), by             <ul style="list-style-type: none"> <li>• age cohort, household composition, type of day, work pattern, season</li> </ul> </li> </ul>	
<p><b>Transport</b></p> <p> <i>outdoor in-vehicle</i></p> <p> Walking  Cycling  Driving  Wait</p> <p> RoundTrip  Bus  Tube  Train</p>	<p><b>Building age and materials</b> <i>thermal and radiative parameters of building structure elements</i></p> <ul style="list-style-type: none"> <li>• Building envelope: external walls, roof, ground floor, windows</li> <li>• Internal mass: walls, floors, contents</li> </ul>	<p><b>Energy expenditure</b> <i>based on activity type</i></p> <ul style="list-style-type: none"> <li>• Human metabolic rates</li> <li>• Active-use electrical appliance power (<i>not incl. HVAC, hot water, standby appliances</i>)</li> <li>• Water, lighting use</li> </ul>	
<p> Microenvironment (ME)</p>	<p><b>f. Movement</b></p>	<p><b>Travel database</b></p> <ul style="list-style-type: none"> <li>• Public and private transport modes</li> <li>• Route stages and stage duration</li> <li>• Public transport capacity</li> </ul> <p><b>Spatial attractors</b></p> <ul style="list-style-type: none"> <li>• Neighbourhood attractiveness ranked by availability of <b>microenvironments</b> and distance from a point of origin</li> </ul>	

# Study area - London



- Mapping:
  - shown at 500 m x 500 m resolution
  - aligned with NAEI WRF modelling



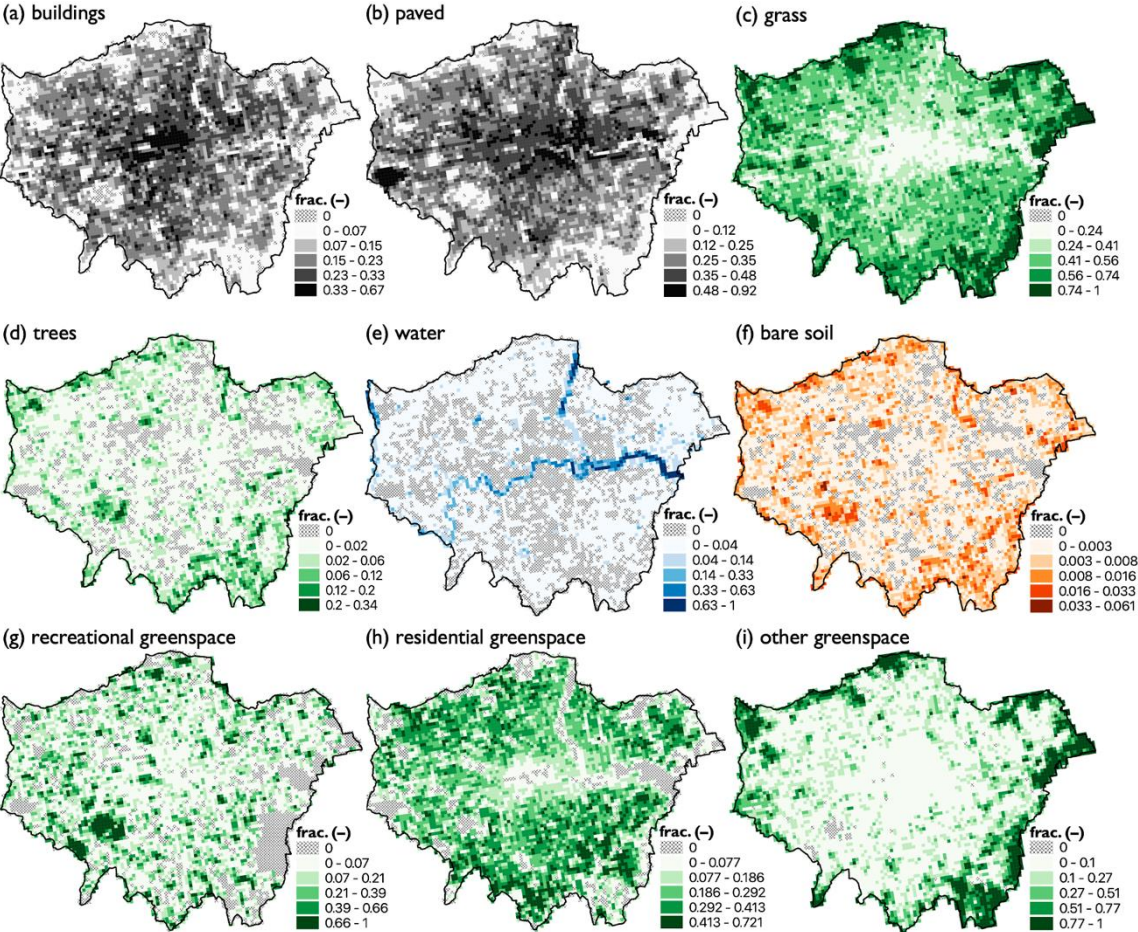


# Database development

## MAPSECC: London

Multi-scale harmonisation Across Physical and Socio-Economic Characteristics of a City region

Hertwig et al. 2024: *in review*



## Land-surface: SUEWS

- surface cover
- morphology
- materials

*neighbourhood*

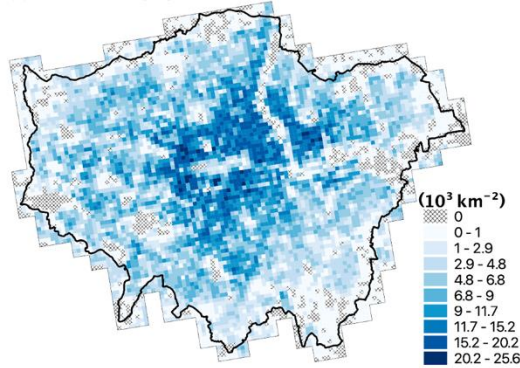
# MAPSECC: London

## Home

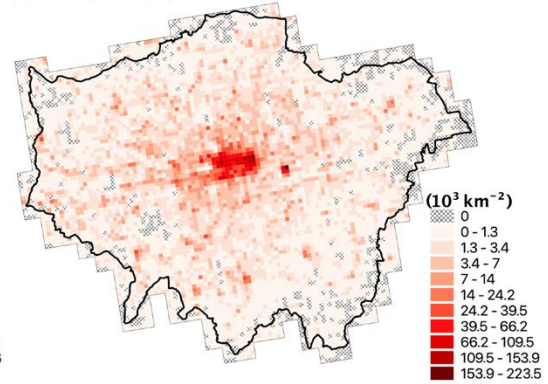
## Work

- Where people are

(a) Residential population

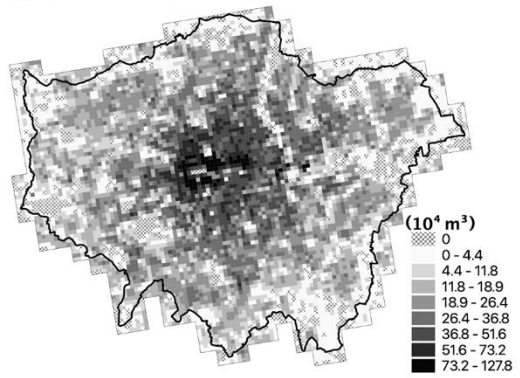


(b) Workplace population

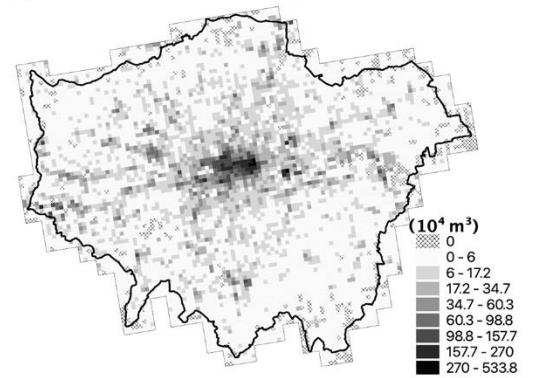


- Where different types of indoor activities occur

(c) Total residential building volume



(d) Total non-residential building volume

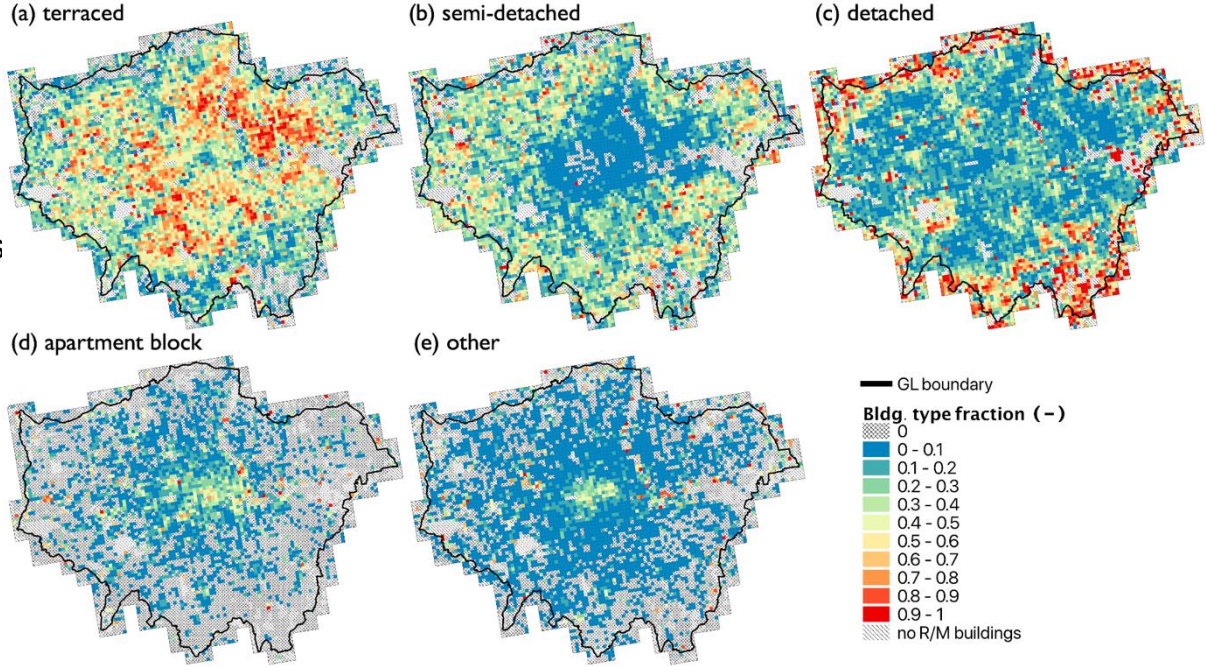


# MAPSECC: London

Residential building types differ

Simulated citizens

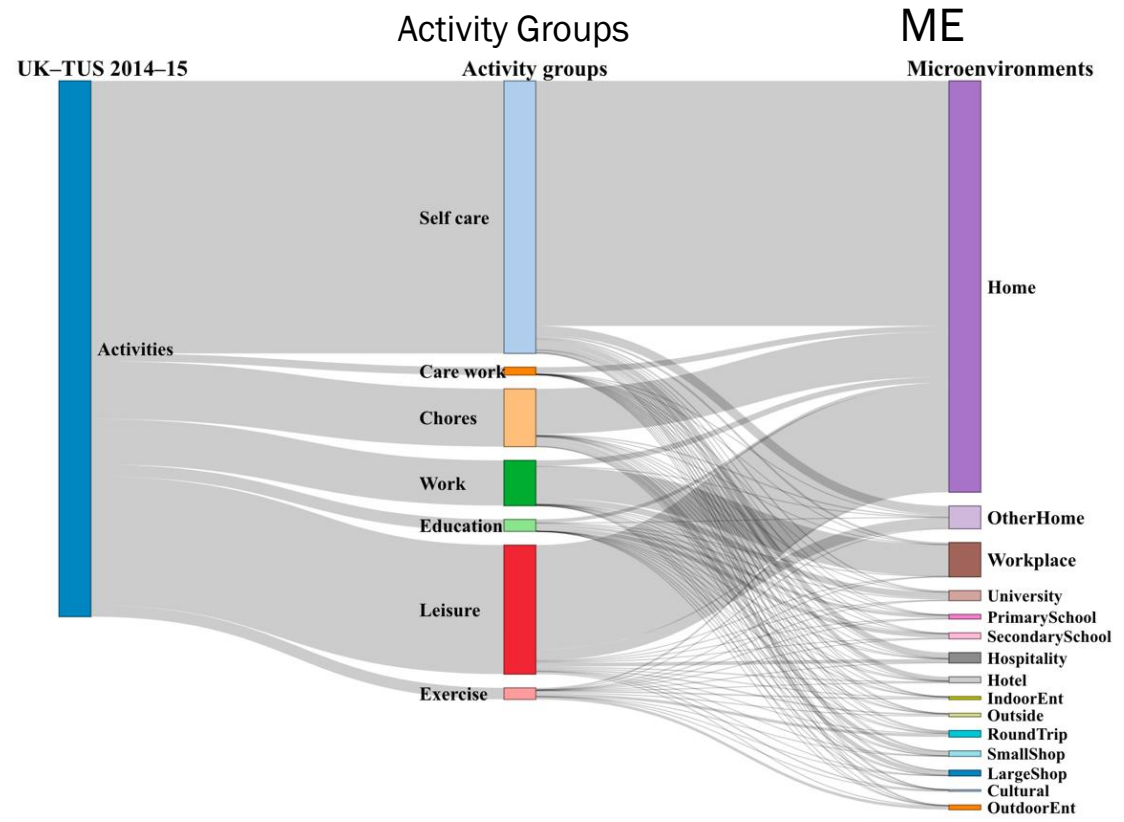
- assigned to different home building types
- constrained by census data





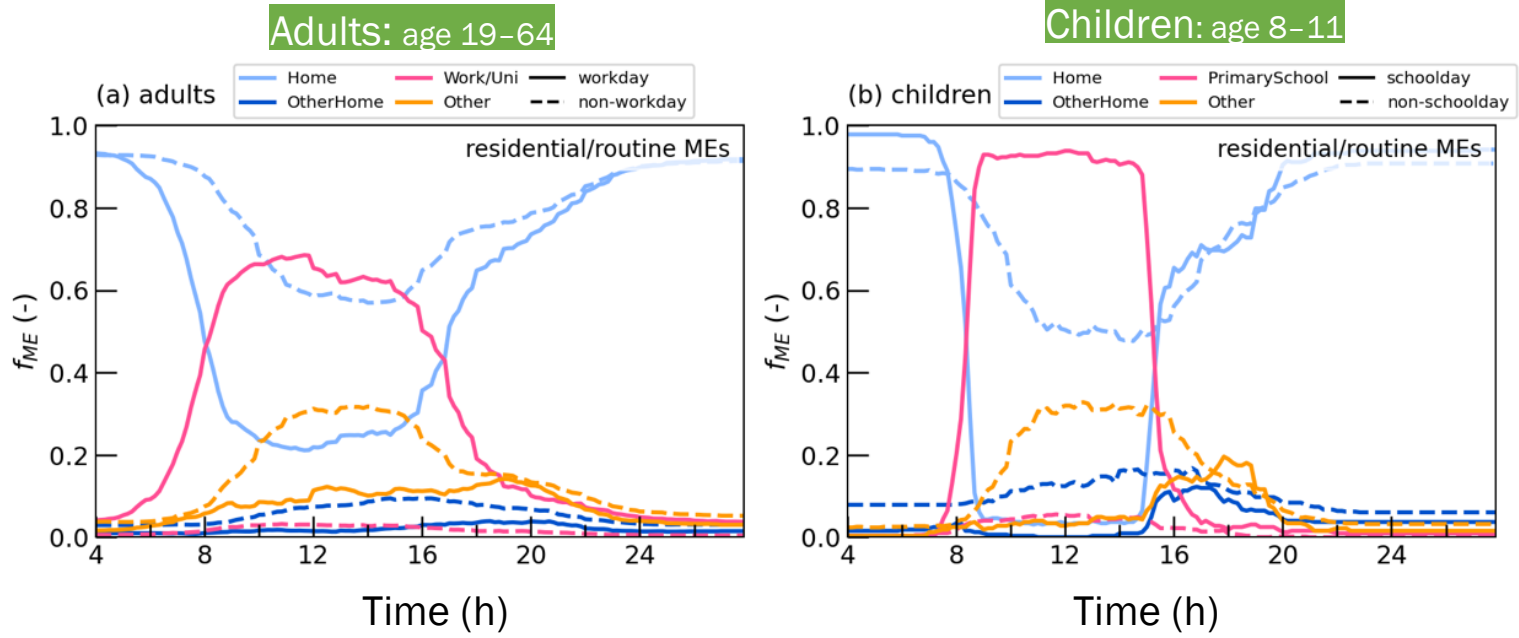
# Time Use Survey (TUS) Gershuny and Sullivan (2017)

## TUS activities mapped to



- Timestep: 10-min
- Age groups
- Household sizes
- Day types
- Seasons

# People spend their time in different locations: varies with age, day type, time of day

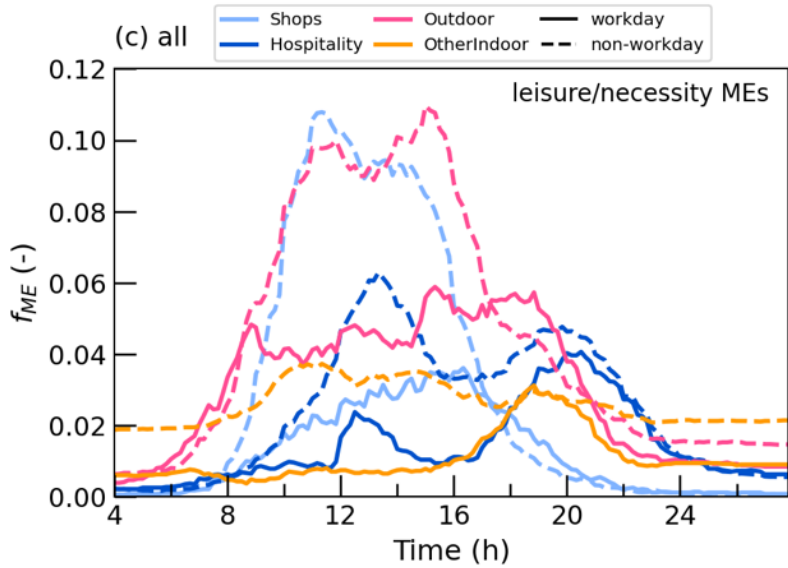


- Day type
  - Workday ———
  - Non workday - - - -

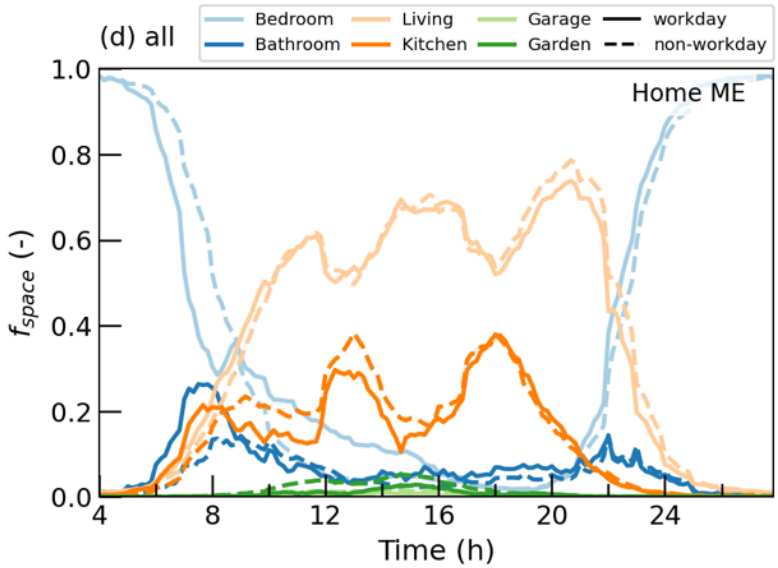
# MAPSECC: London

- Activities in different Microenvironments

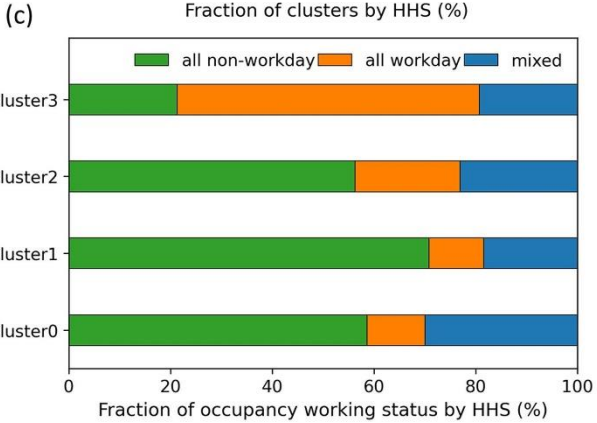
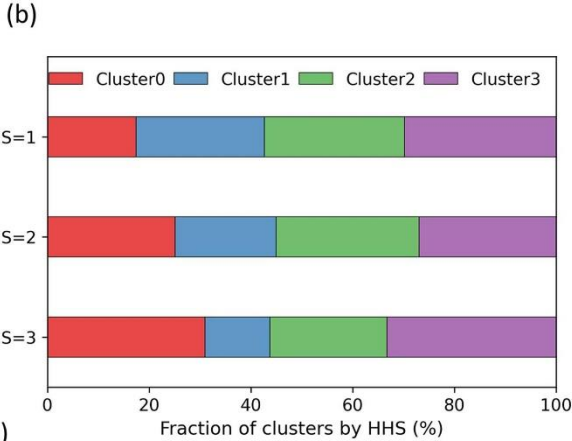
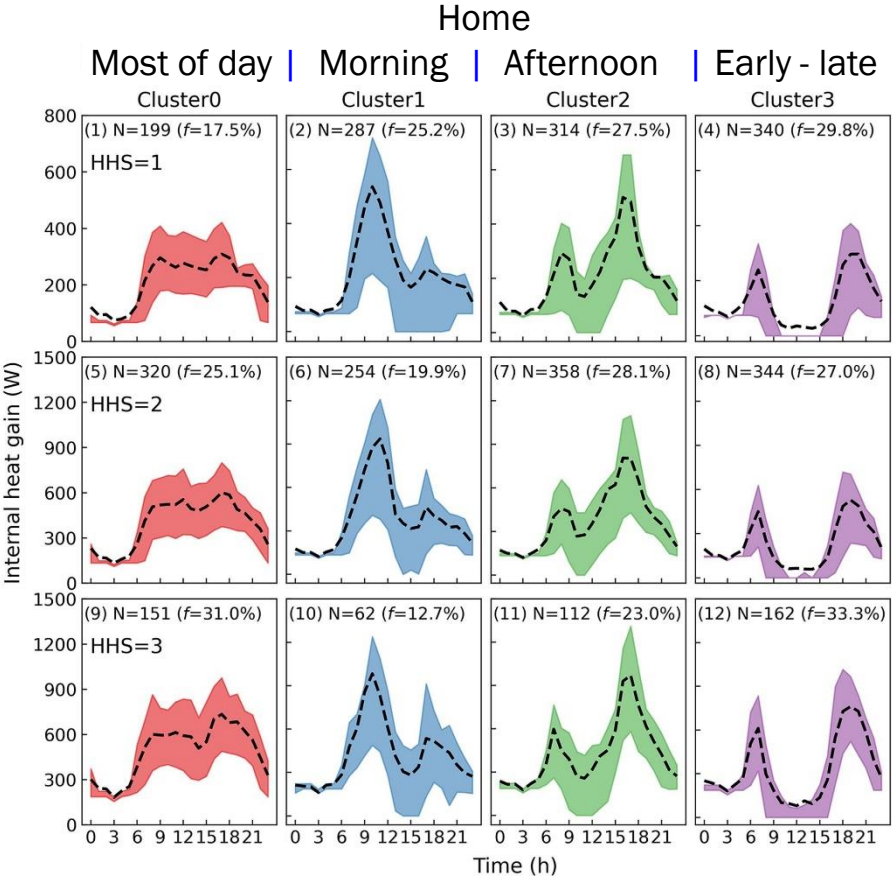
## Necessity & leisure activities



## Home ME



# Behaviour differs by household size (HHS)





# Model simulations

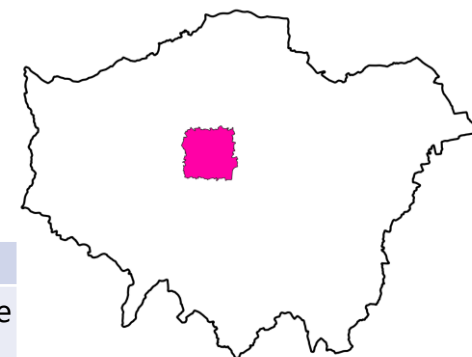
- Assess impact of travel decisions on time spent
  - by age group:
    - by mode of travel
    - at home

Group	Population (%)	Age (years)
Children	6	5-12
Teens	7	13-18
Adults	76	19-64
Seniors	11	65+
<hr/>		
Total #	332,065	

Winter workday residents of central area of London (they can leave the area)

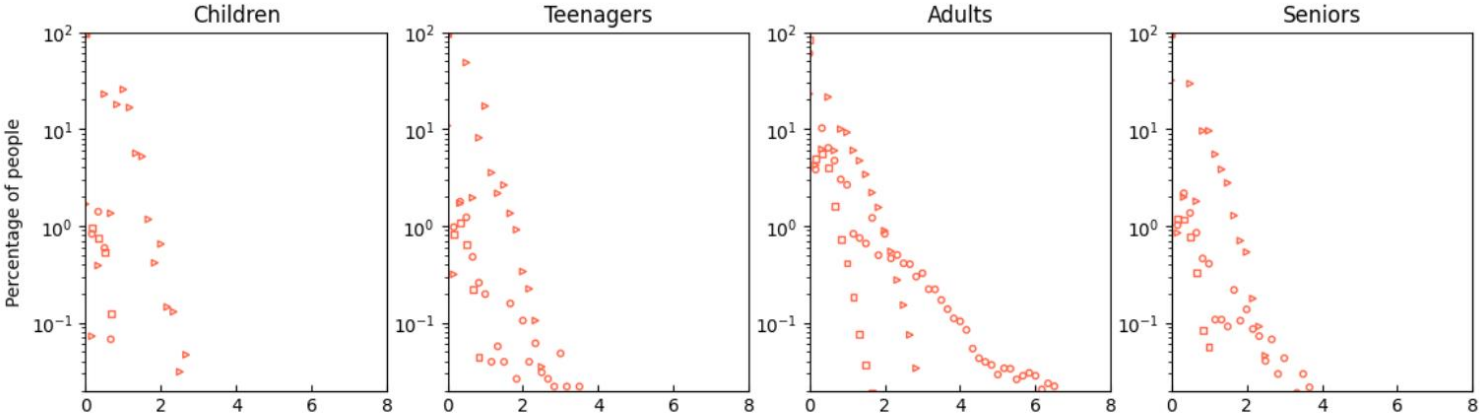
- People can use multiple modes to reach a destination
- Commute mode to/from work: same if available each day for an individual

# grids 119 0.5 km x 0.5 km



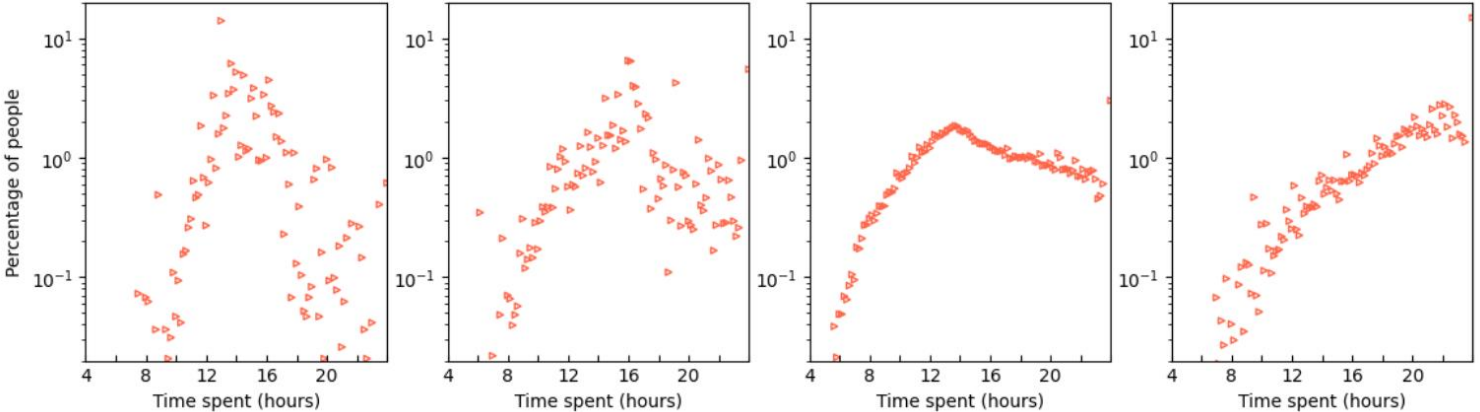
Travel mode	walking	cycling	bus	Driving	train	tube
Speed: Average	constant	constant	Δ timetable	Same all day Δ by road type Δ by location	Δ timetable	Δ timetable
Speed: Variable	constant	constant	Δ timetable	Δ w/time of day	Δ timetable	Δ timetable
Fastest	Depends on route					
Slowest	Depends on route					
Most expensive	6	5	4	1	2	3
Cheapest	1	1	2	3	2	2

# Fastest route chosen



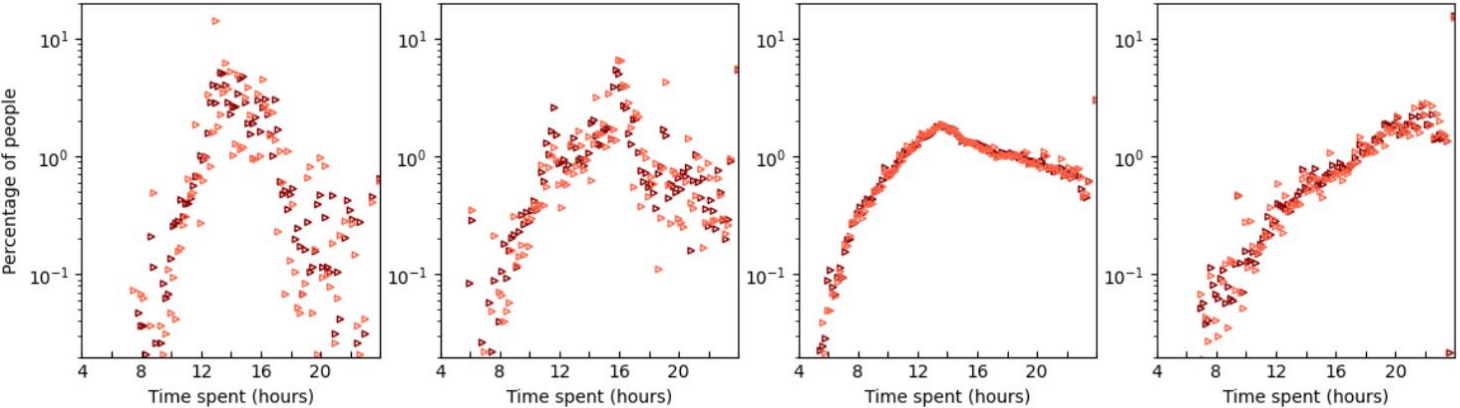
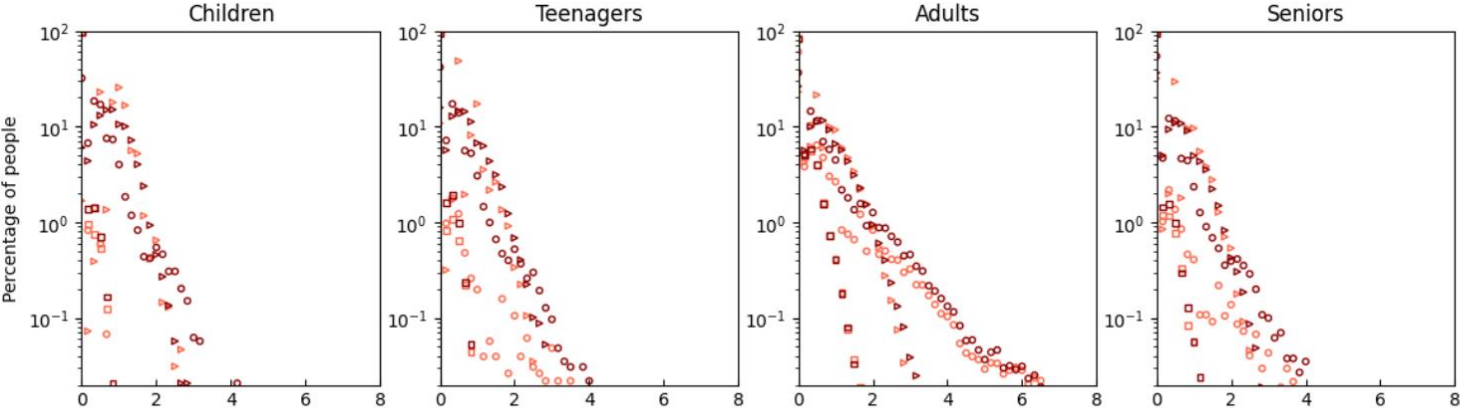
Mode

- ▷ Car/Bus
- ◻ Train/Tube
- Walk/Cycle

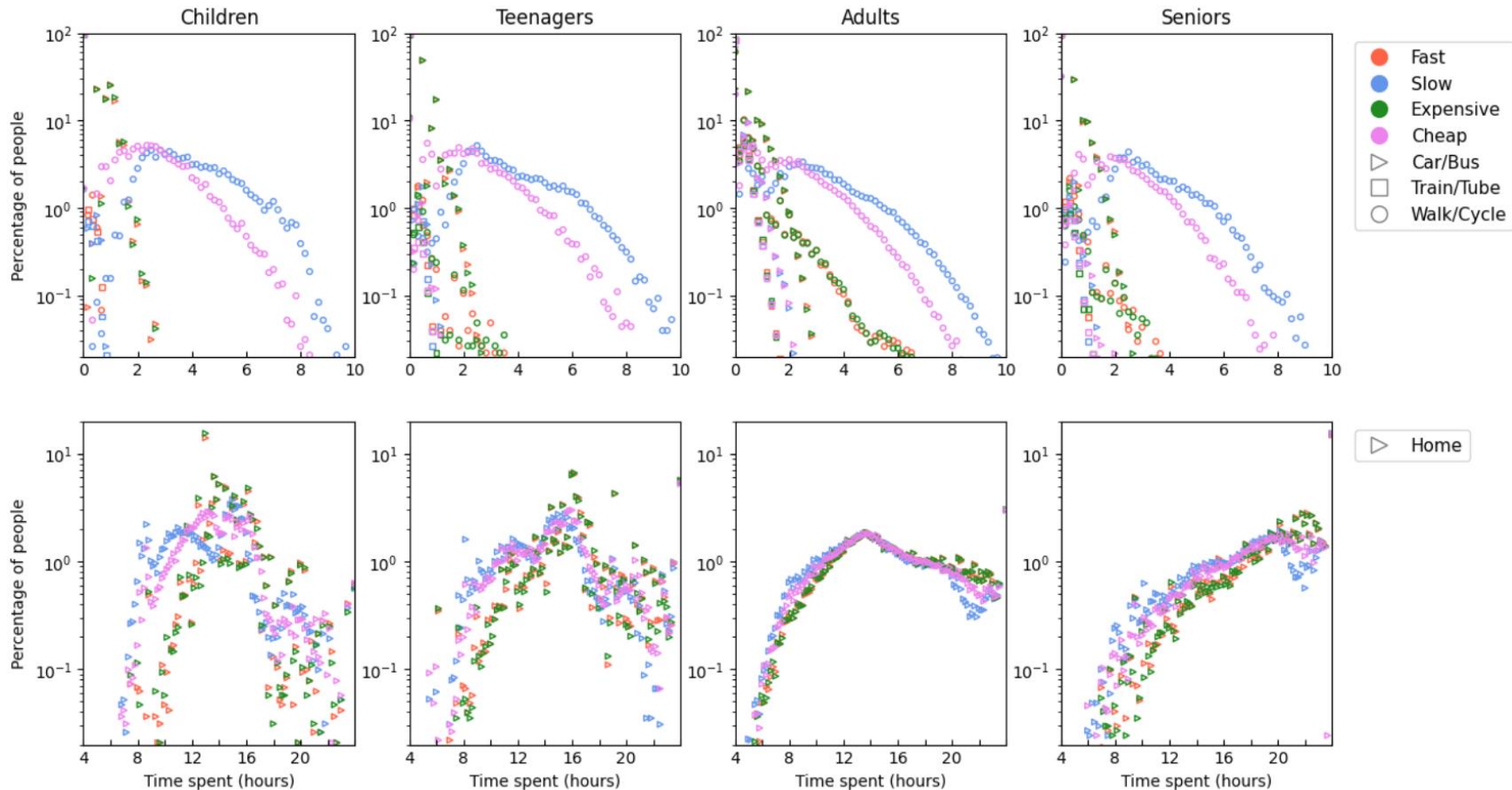


▷ Home

# Impact of variable speed on mode choices



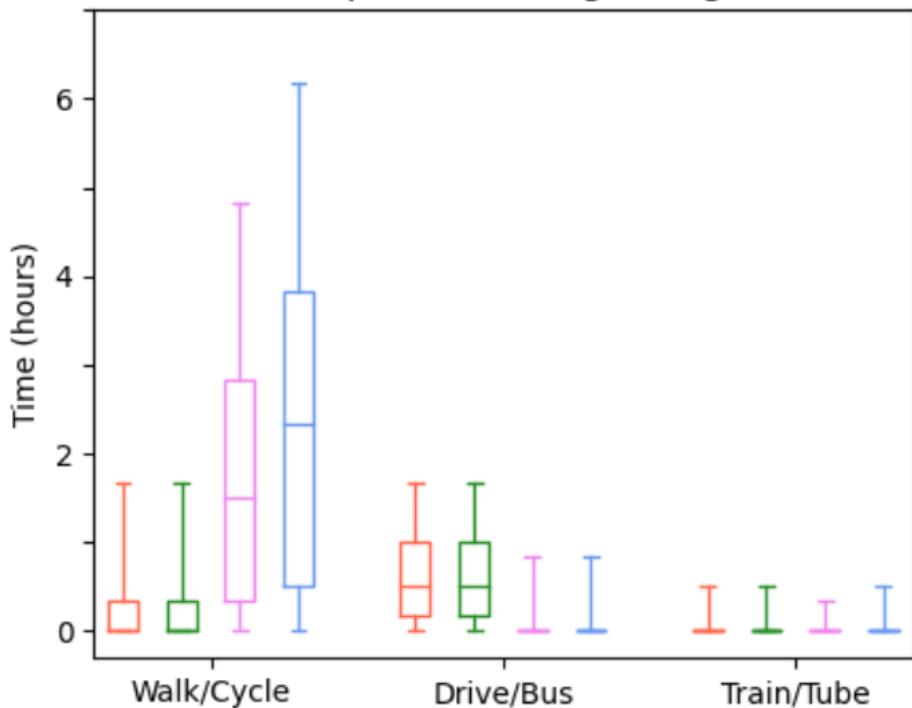
# Impact of transport choice on time spent travelling and at home



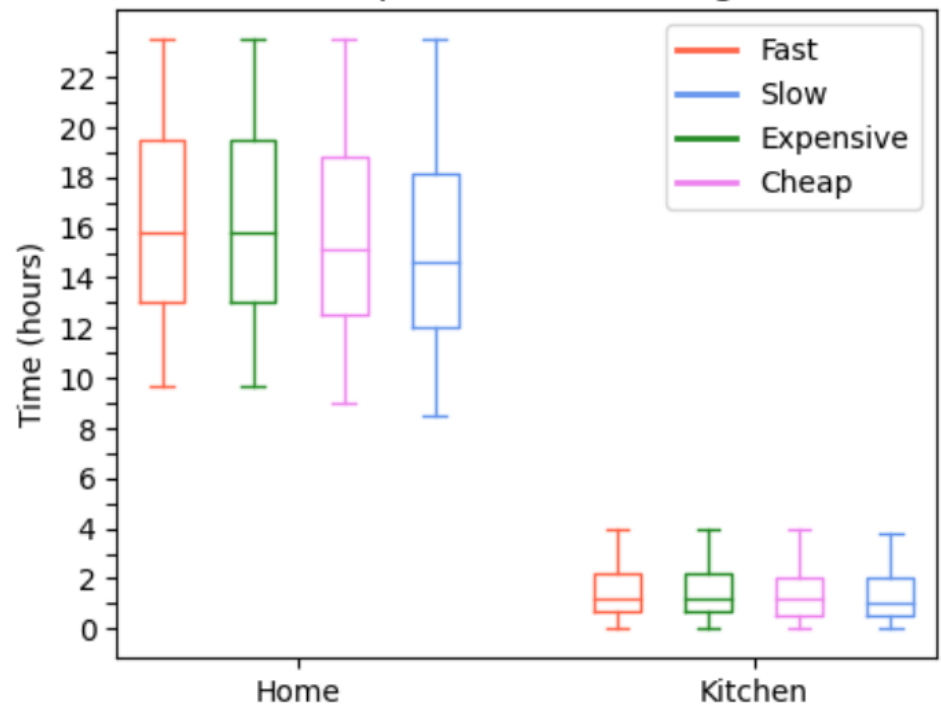


# Whole area

### Time spent travelling (all ages)



### Time spent at home (all ages)



# Final Comments

- DAVE
  - allows human activities to influence urban physical meteorology
    - inform air quality simulations
  - allows assessment of time spent in different locations and microenvironments by individuals
    - inform exposure assessments
  - allows what if experiments to be conducted

