SimSAEV

klima+ energie fonds

The spatial-temporal exposure to traffic-related PM emissions in Vienna

Asjad Naqvi (WIFO, WU), Stefanie Peer (WU), Johannes Müller (AIT), Markus Straub (AIT)

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WIFO AUSTRIAN INSTITUTE OF ECONOMIC RESEARCH

WU WIRTSCHAFTS UNIVERSITÄT WIEN VIENNA UNIVERSITY OF ECONOMICS AND BUSINESS

AIT AUSTRIAN INSTITUTE OF TECHNOLOGY

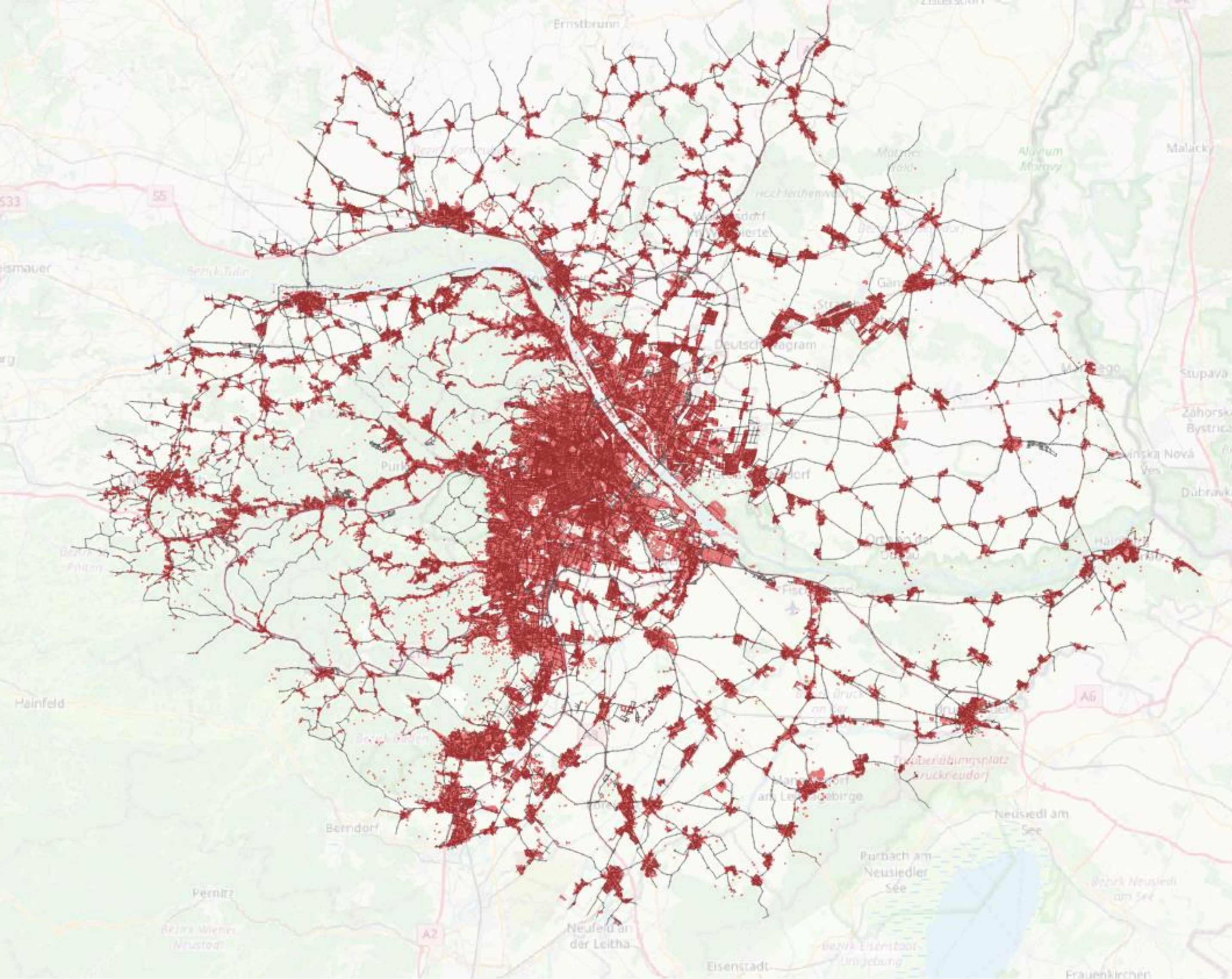
The context

- Transport and vehicles are responsible for 46% of emissions in Vienna (UBA)
  - 96% of urban population exposed to PM levels above WHO limit of 50 μg/m3.
  - Poor health outcomes, loss of life expectancy, premature deaths, loss of cognitive skills
  - Literature also discusses exposure inequality
- EU New Green Deal: 55% reduction in emissions by 2050 (esp PM)
  - Vienna also has climate targets and SDG goals, where air quality is a central focus
- Share of renewable energy in Austria is relatively high
  - 31% of energy is used by the transport sector (UBA 2022)
  - 78% of electricity in 2020: 55-67% from Hydro, 10% wind
  - High benefits from introducing e-mobility in Vienna

MATSim
Multi-Agent Transport Simulation

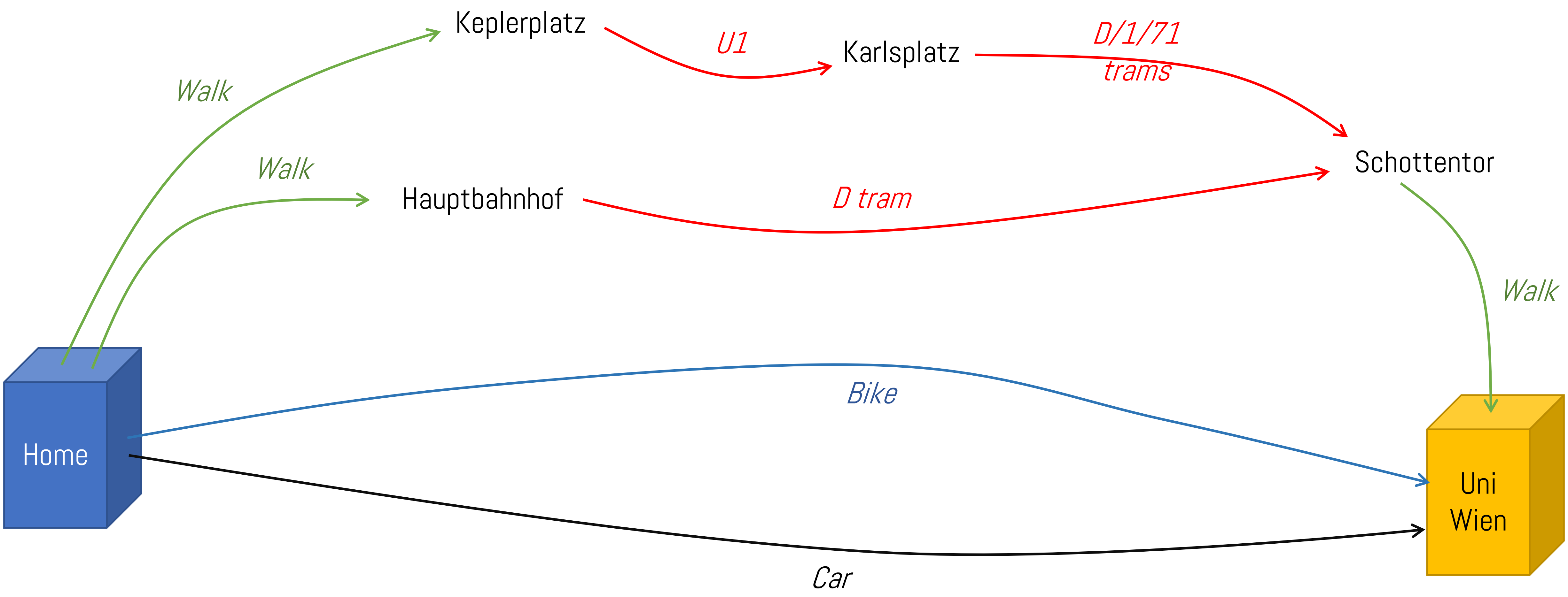
- MATSim: Multi-Agent Transport Simulation (https://www.matsim.org/)
  - Used in major cities for urban traffic and road planning (https://www.matsim.org/gallery/)
  - MATSim deals with car traffic using a queuing model and network configuration
  - Large scale microsimulation model (C++, Java, Julia)
- Integrated with AIT's routing module Ariadne that includes other modes: biking, walking, public transport
- Synthetic population, origin-destination matrices, and parametrization of the utility functions derived from Österreich Unterwegs, a representative survey of mobility expenditure and activities (Schmid et al., 2019)
- Emission module based on the Handbook Emission Factors for Road Transport (HBEFA)
  - Emissions by engine type, cold start, hot start, acceleration, speed

Simulation area



- 30km radius from the city center
  - 4100 sq kms
  - 2.3 million population (12.5% simulated)
- Road network and facility locations from **OSM**
- Population density rasters from **Eurostat/Statistik Austria**
- Employment info from **WKÖ**
- Mobility data from **Österreich Unterwegs** 2014

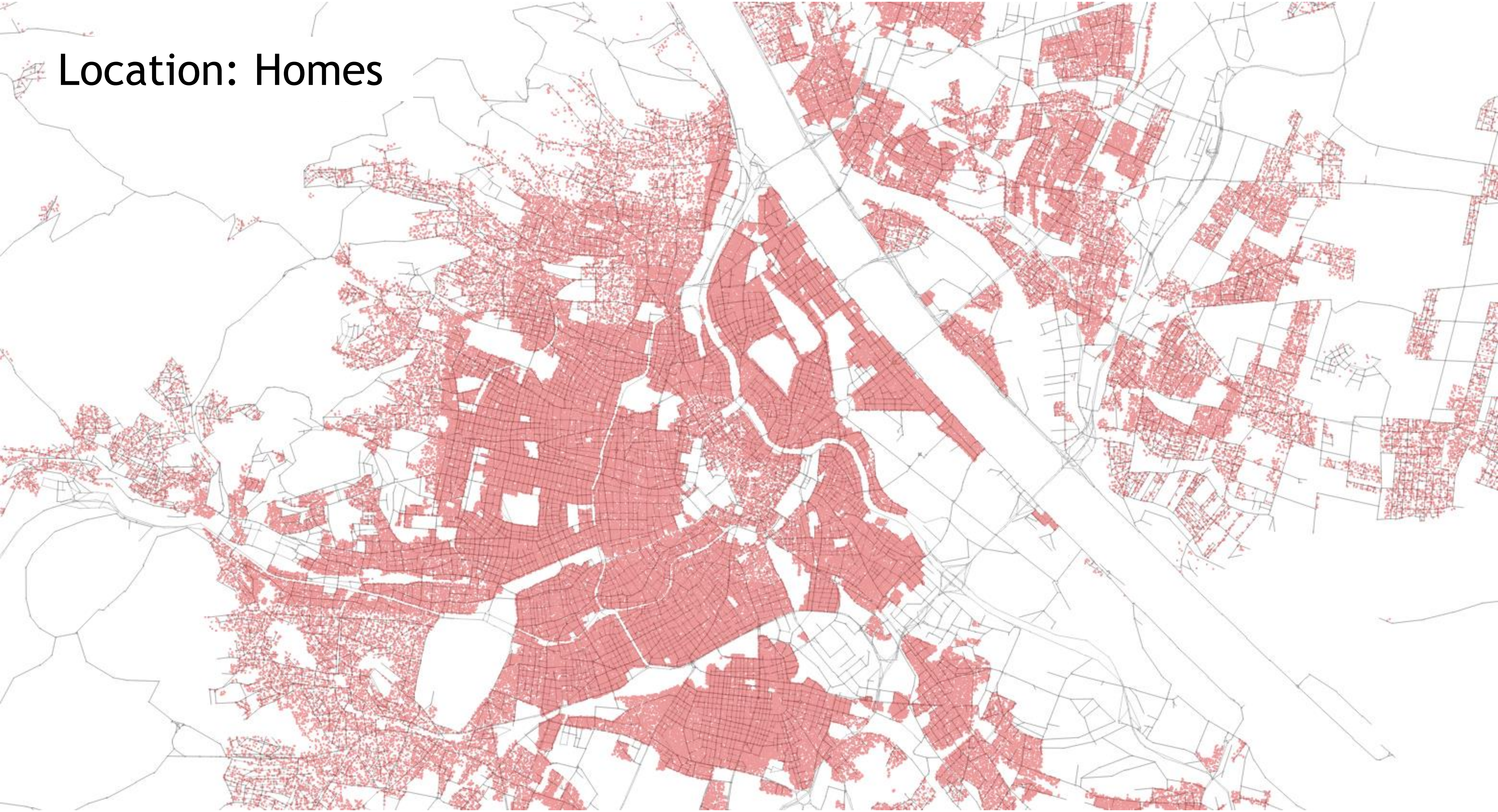
Mode choices



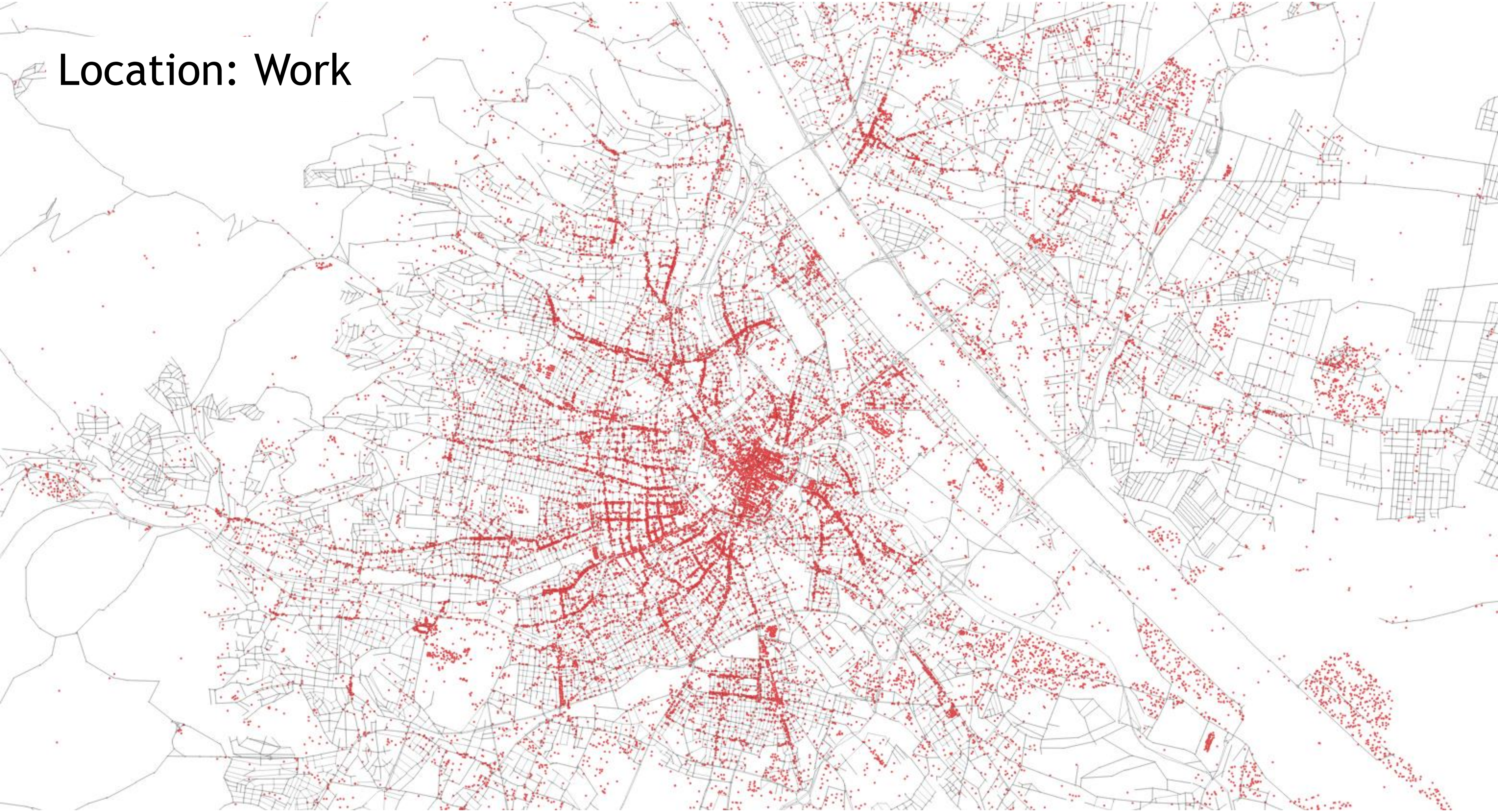
Agents

- Agents have the following properties:
  - 4 Locations: home, workplace, school, others (leisure, errand, visits)
  - 5 Travel modes: walking, biking, cars, Public Transport (PT), SAEVs
  - Socioeconomic characteristics: income, age, family, education, marital status, modes available, etc.
- Agents generate travel plans through a discrete choice model
  - Travel plans are generated over several iterations
  - Agent-level tracking at location and travel modes with timestamps
  - Car travel generates emissions

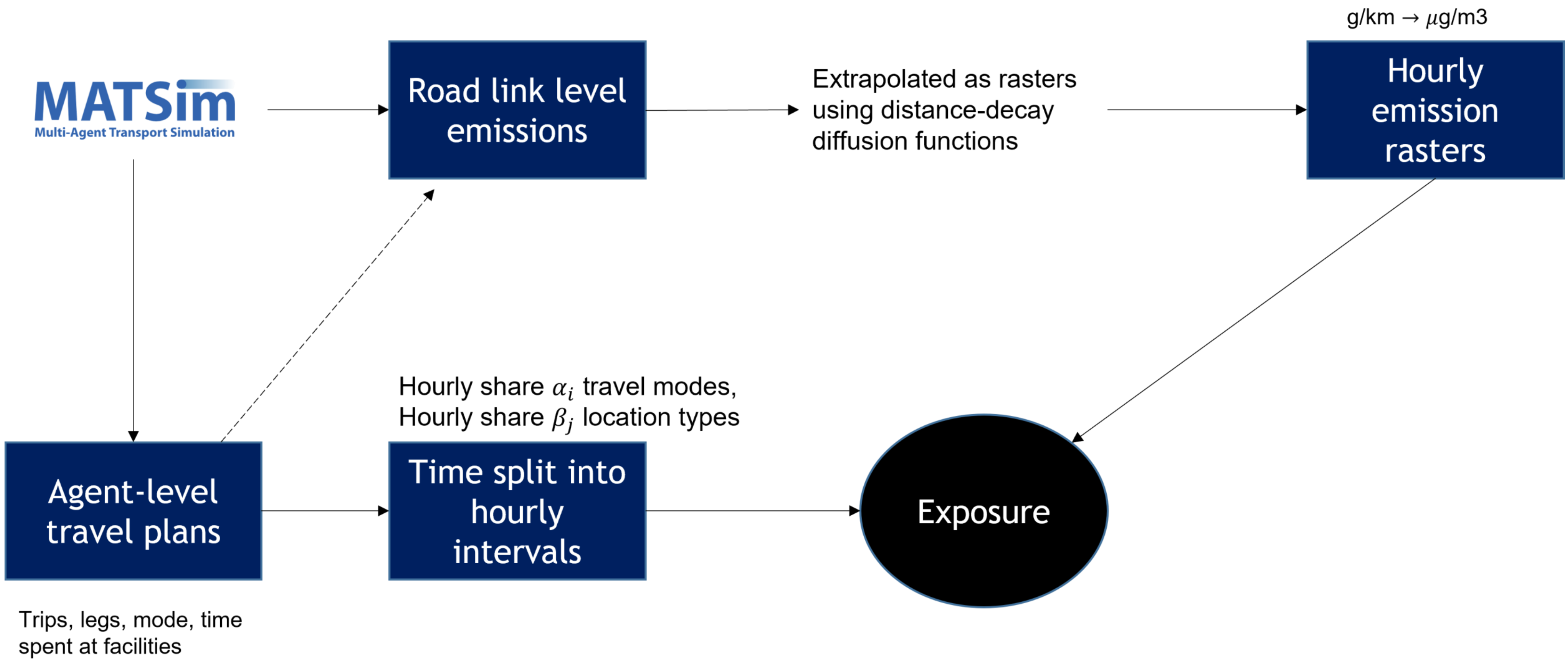
Location: Homes



Location: Work



Workflow


MATSim
Multi-Agent Transport Simulation
Road link level emissions
Extrapolated as rasters using distance-decay diffusion functions
g/km → μg/m3
Hourly emission rasters
Agent-level travel plans
Trips, legs, mode, time spent at facilities
Hourly share α_i travel modes,
Hourly share β_j location types
Time split into hourly intervals
Exposure

Exposure

- We define an Exposure as:

Exposure in transport mode

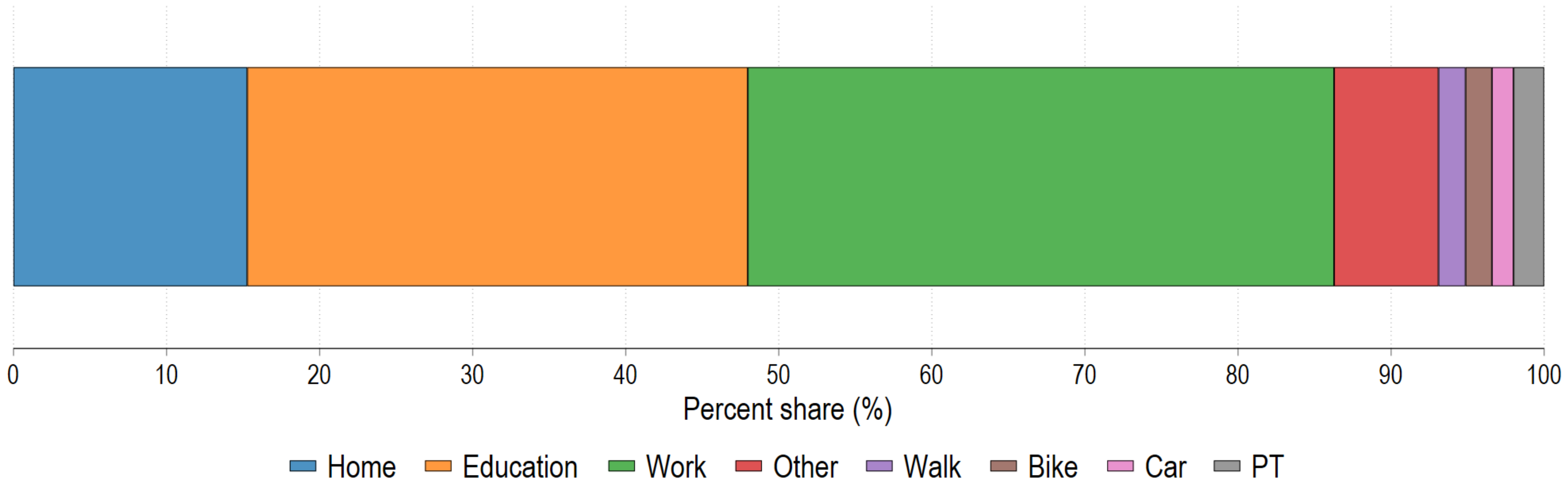
Exposure at location

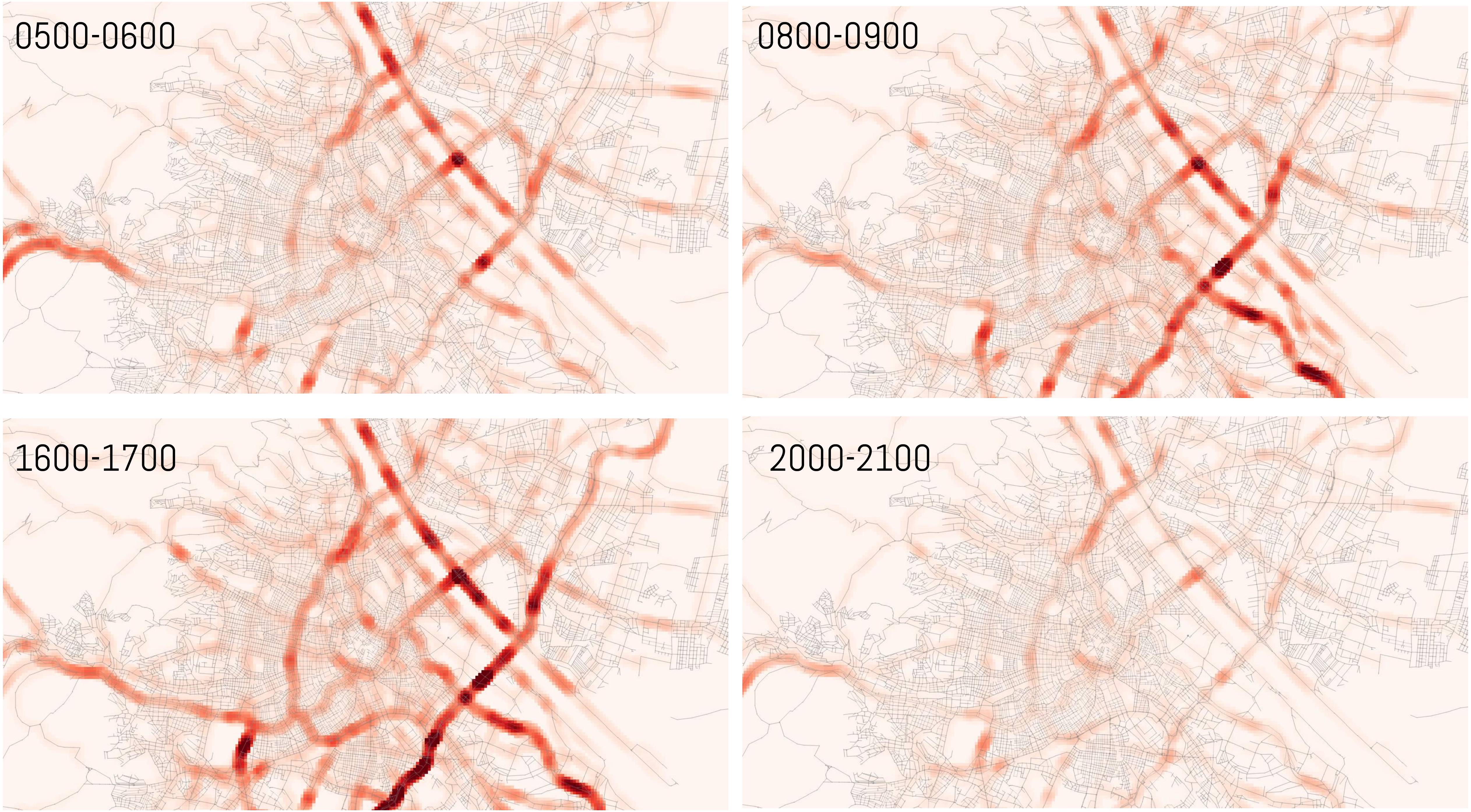
$$E_{kt} = \sum_i \alpha_i road_{it} + \sum_j \beta_j location_{jt}$$

- k = agent, t = time
- i = transport mode (cars, public transport (PT), walking, bike, SEVs)
- j = location type (home, education, work, other)
- α_i, β_j= dampening factors of mode i, location j
    - A car or bus will mitigate emissions by 50%, buildings will mitigate emissions by 50%
    - Walking and biking will result in full exposure

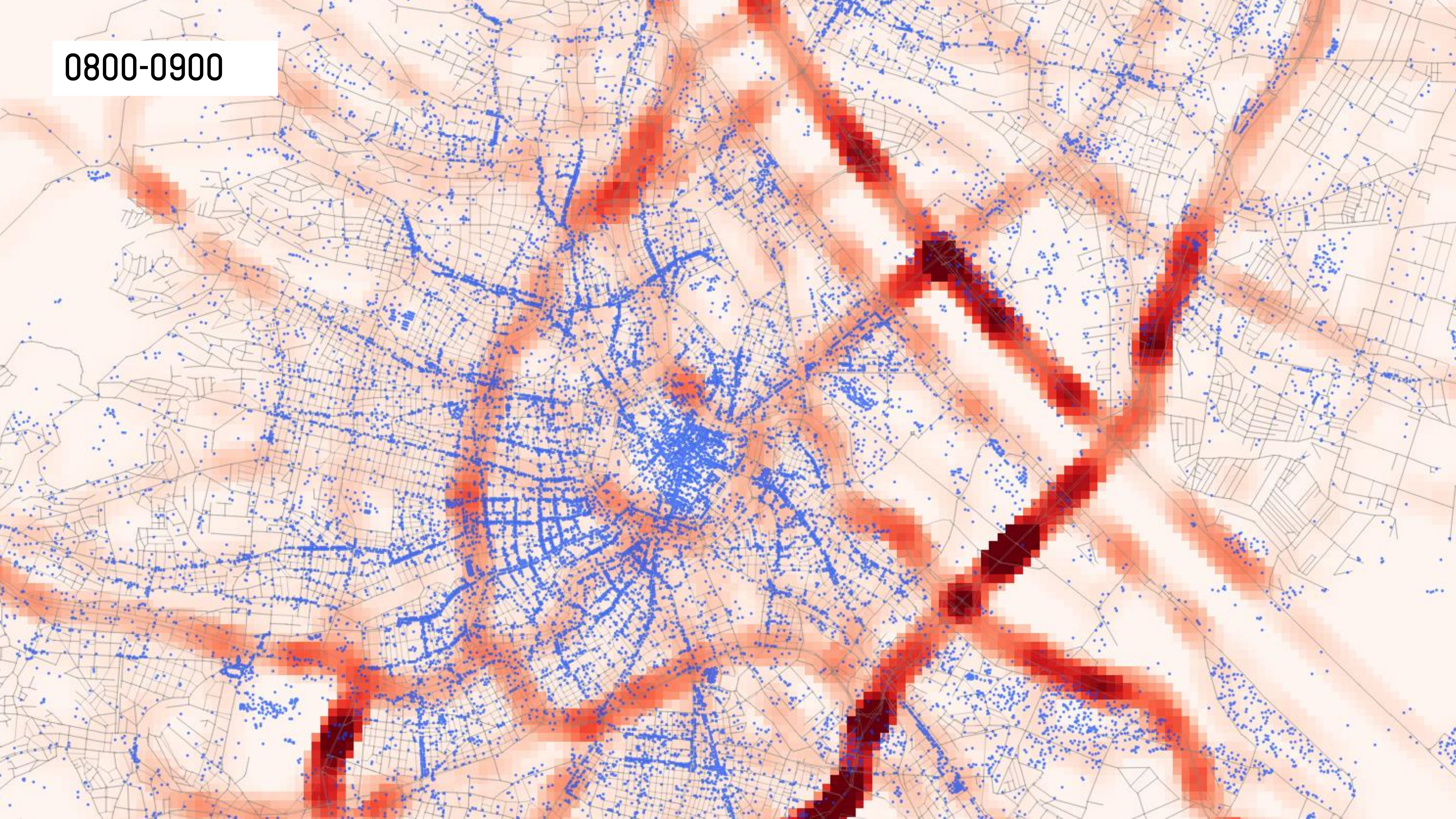
Simulations

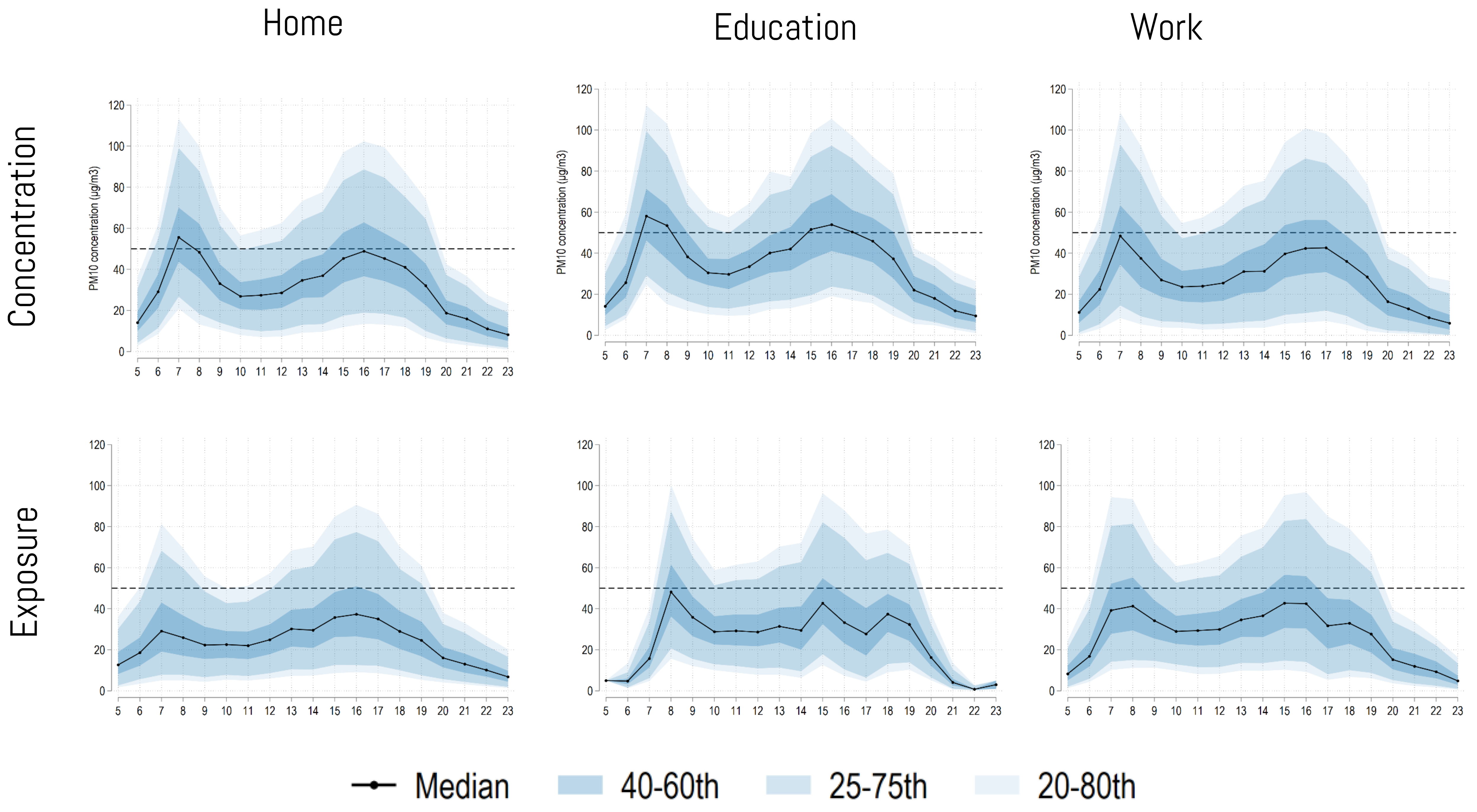
Daily activity split



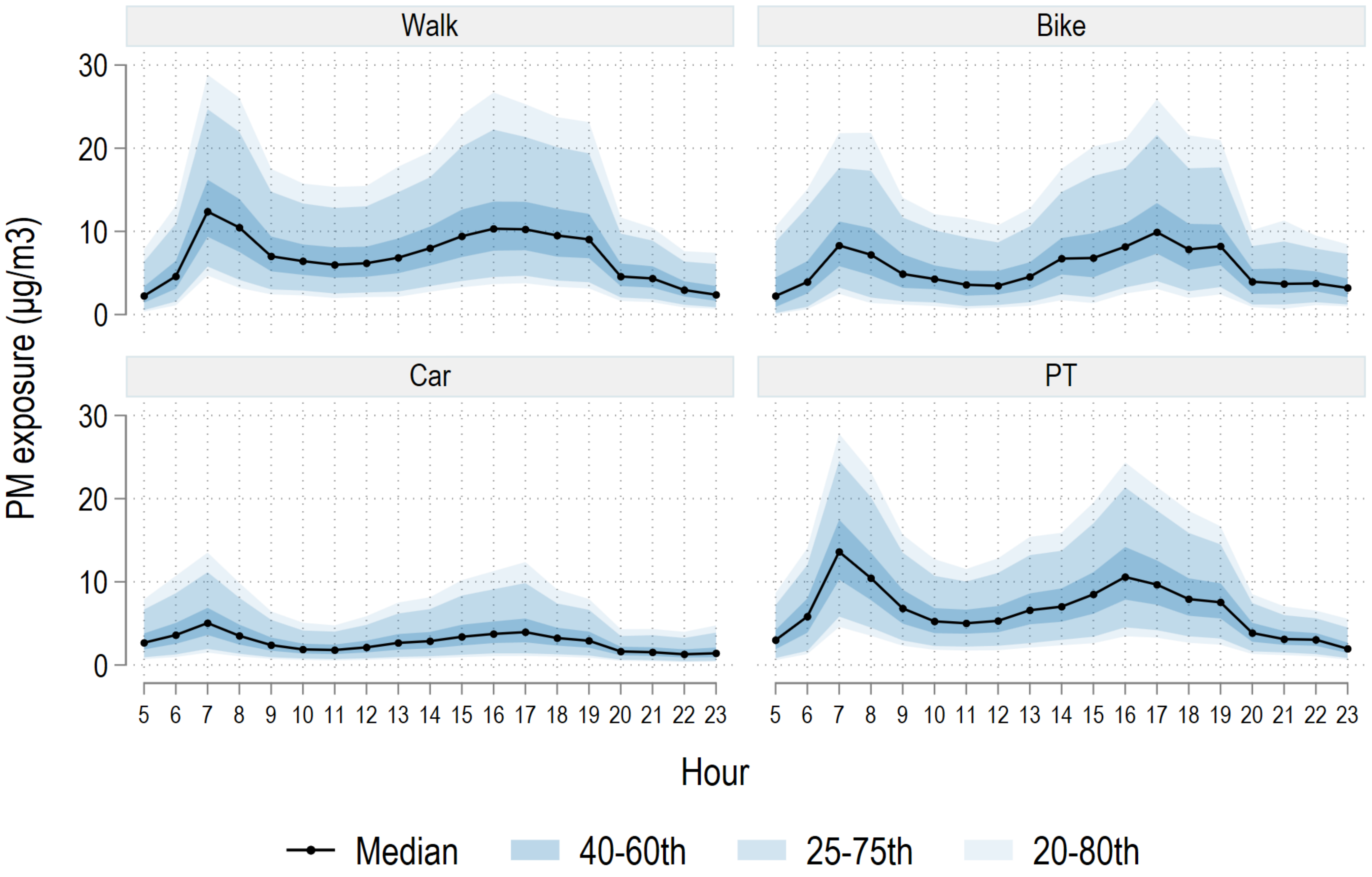

0500-0600
0800-0900
1600-1700
2000-2100

0800-0900

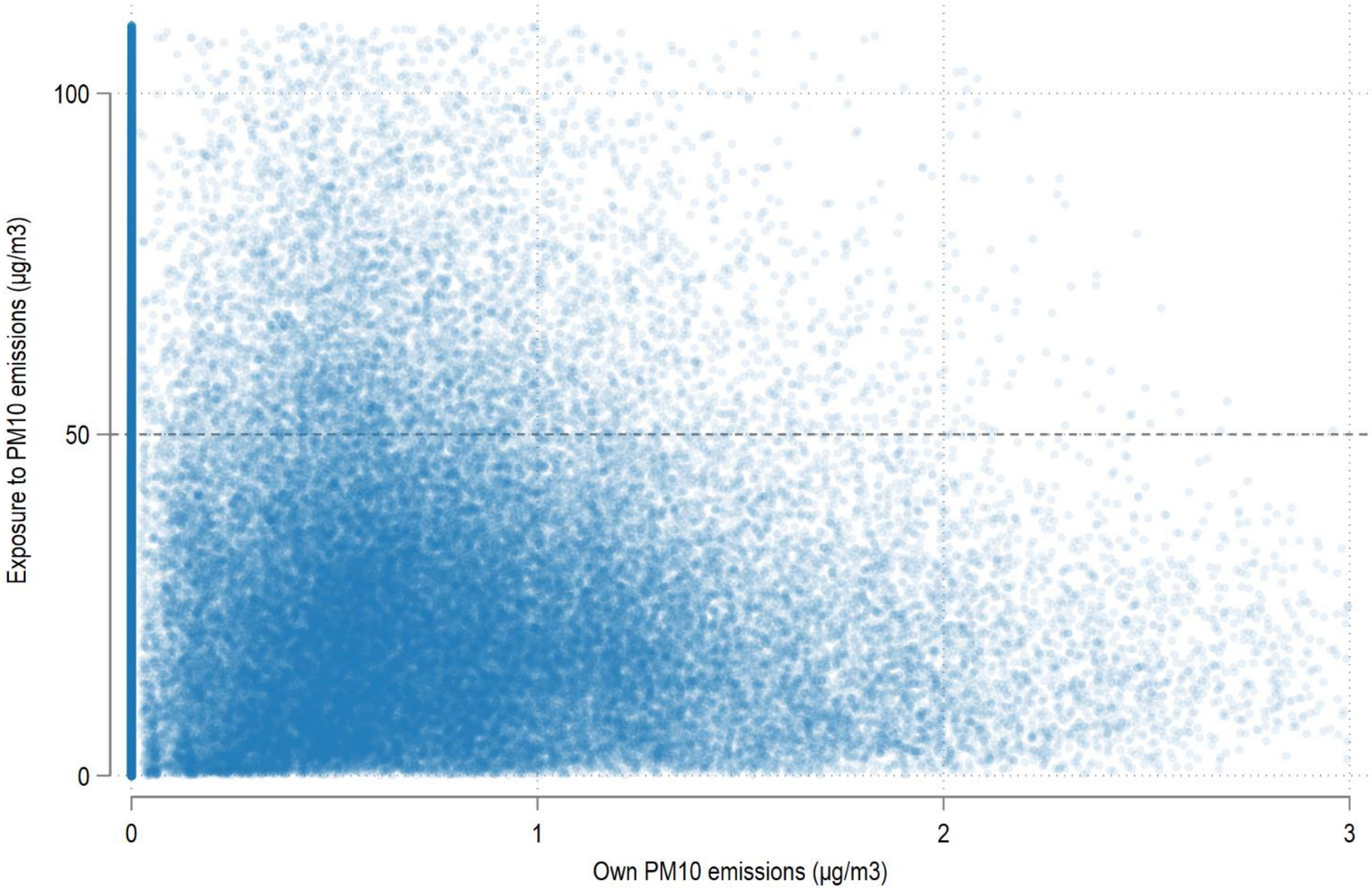




Home
Education
Work
Concentration
Exposure
PM10 concentration (µg/m3)
Median
40-60th
25-75th
20-80th



Walk
Bike
Car
PT
PM exposure (µg/m3)
0
10
20
30
5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Hour
Median
40-60th
25-75th
20-80th

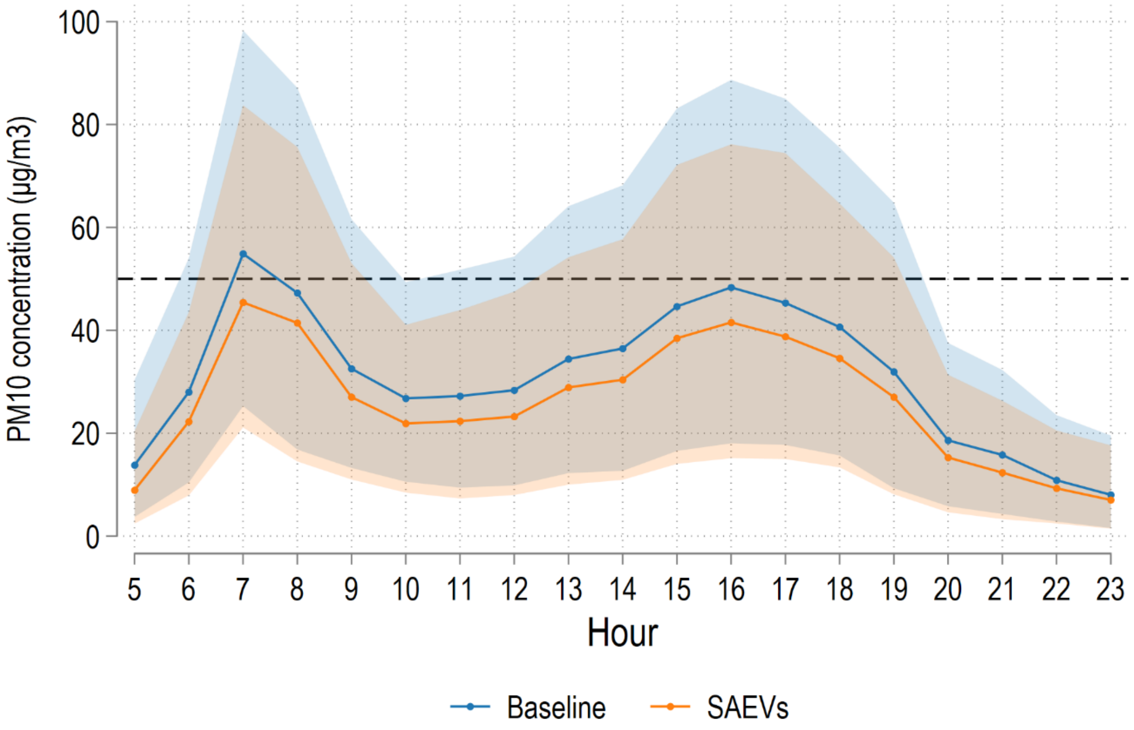


Exposure to PM10 emissions (µg/m3)
100
50
0
0
1
2
3
Own PM10 emissions (µg/m3)

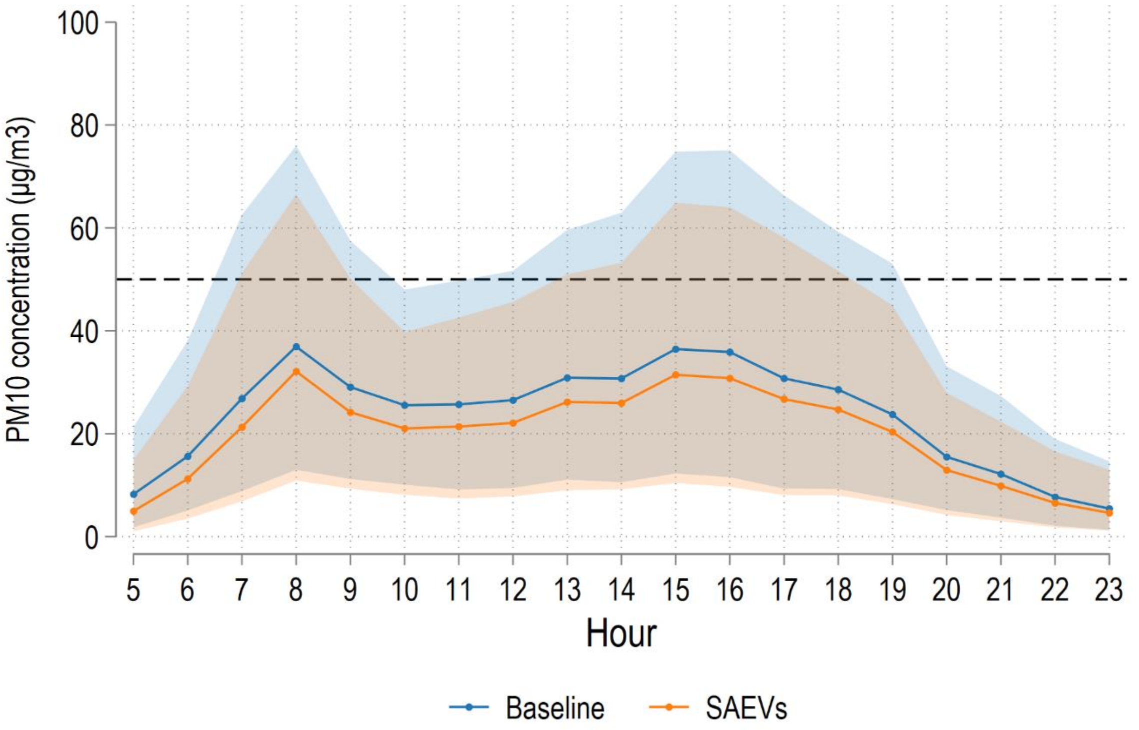
Can Shared Autonomous Electric Vehicles (SAEVs) mitigate emissions?

SAEVs reduce emissions

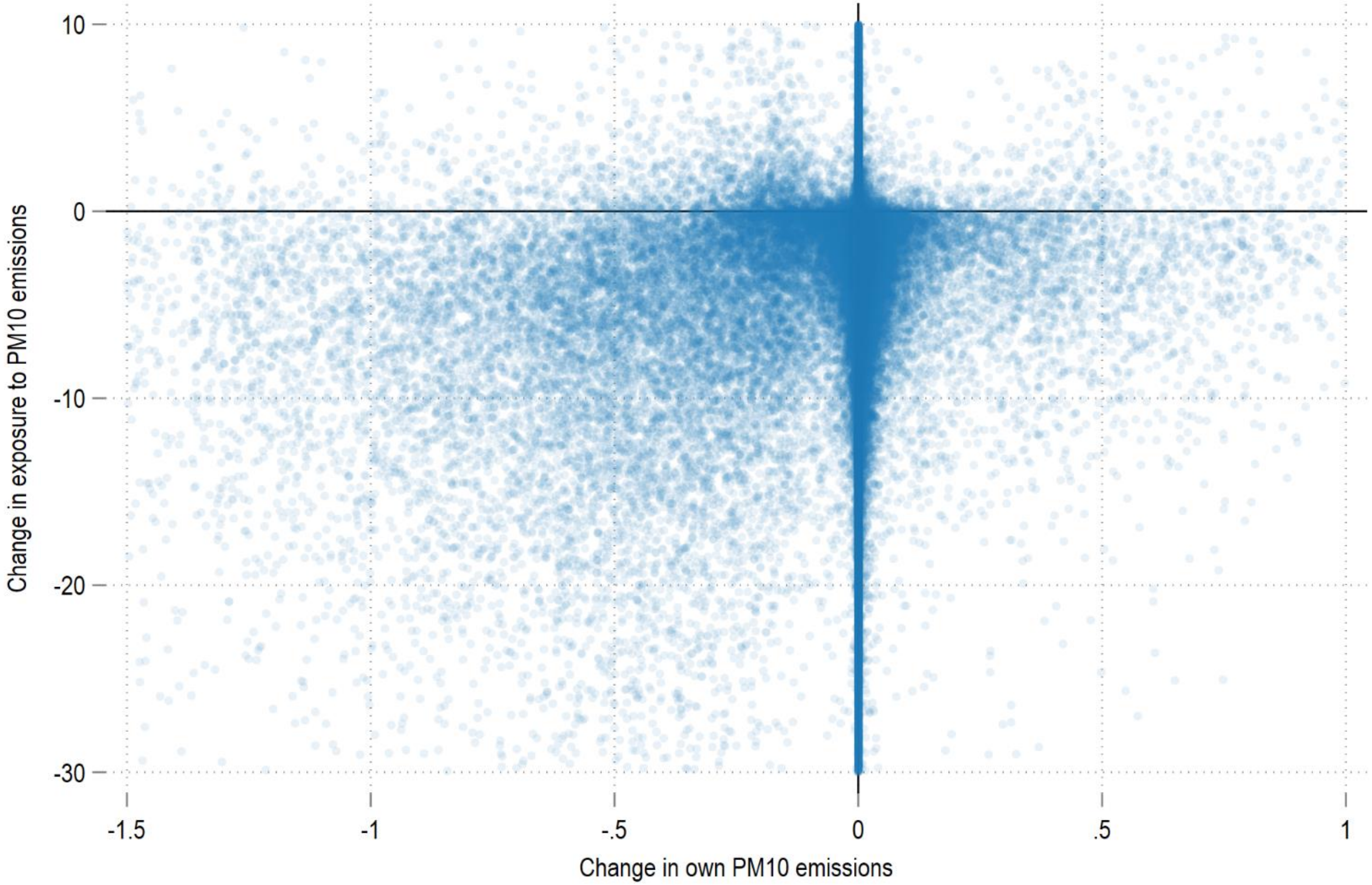
By location type

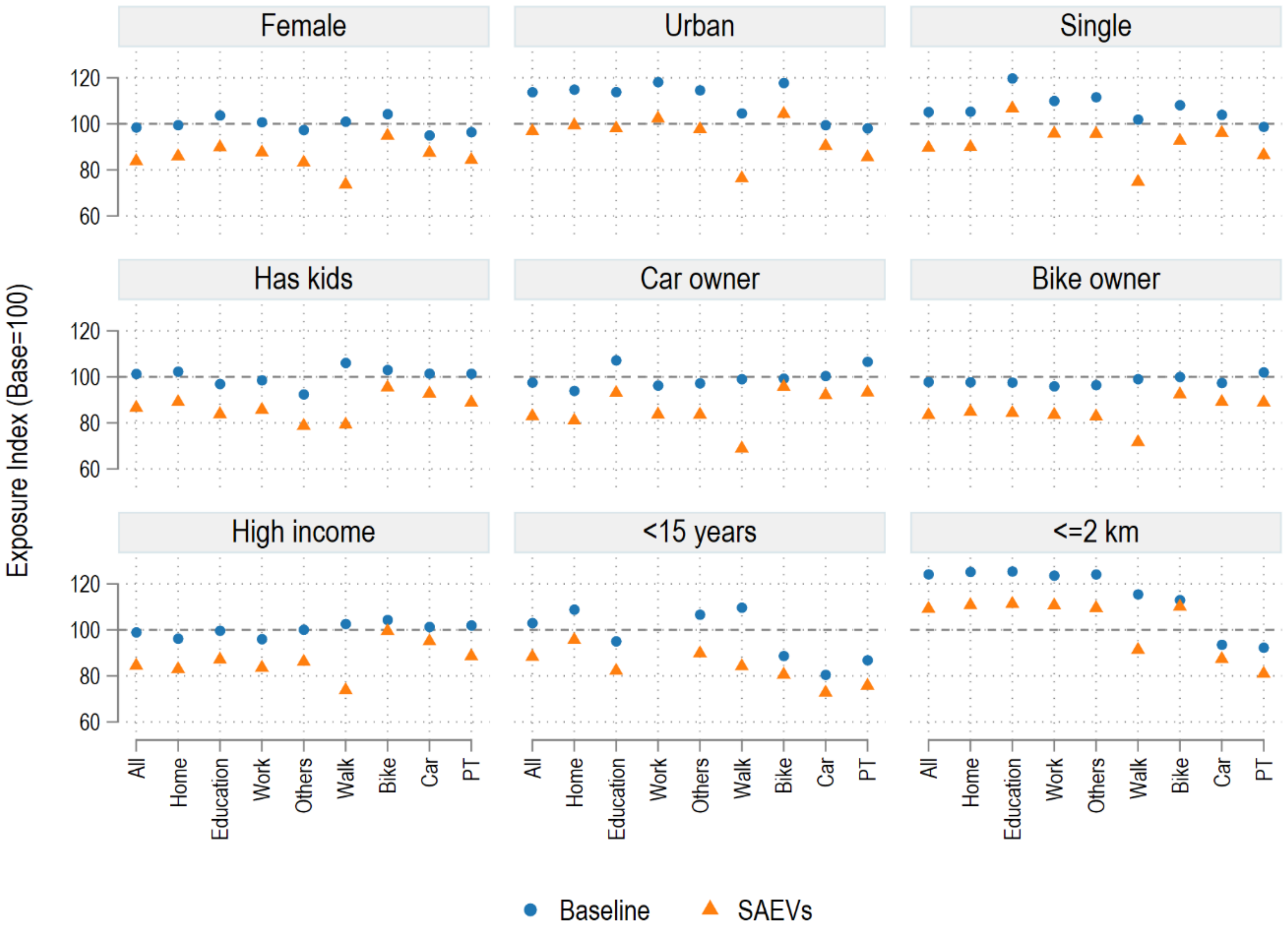


By travel mode



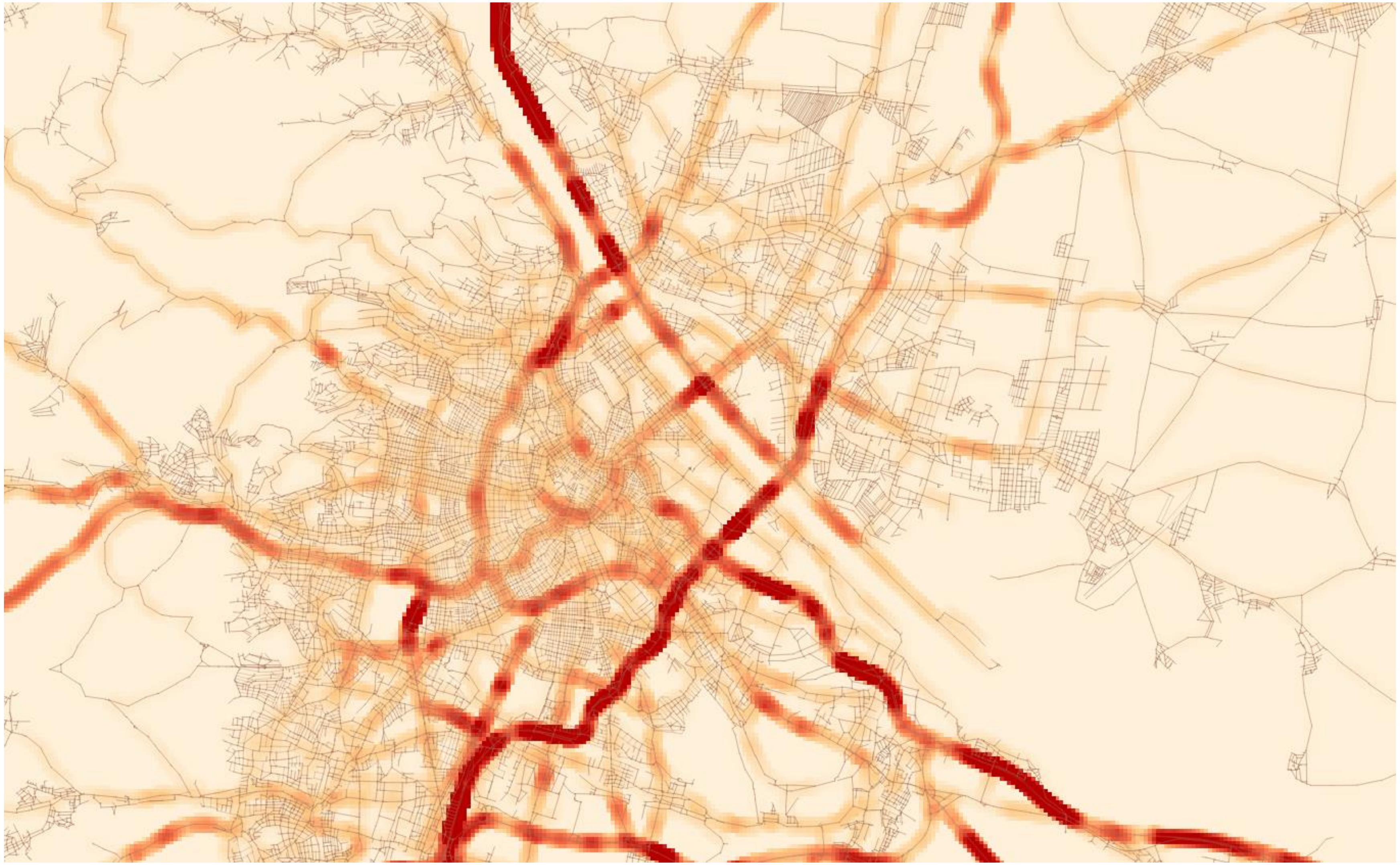
But reductions are not homogenously distributed





Female
Urban
Single
Has kids
Car owner
Bike owner
High income
<15 years
<=2 km
Exposure Index (Base=100)
120
100
80
60
All
Home
Education
Work
Others
Walk
Bike
Car
PT
Baseline
SAEVs

Thank you!



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