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

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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 $\mu g/m^3$.
  - 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 (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

- Home to Keplerplatz: Walk
- Home to Hauptbahnhof: Walk
- Hauptbahnhof to Karlsplatz: D tram
- Karlsplatz to Schottentor: D/1/71 trams
- Home to Karlsplatz: U1 tram
- Schottentor to Uni Wien: Walk
- Home to Uni Wien: Car

Options:
- Bike
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
Workflow

Agent-level travel plans
- Trips, legs, mode, time spent at facilities

Time split into hourly intervals
- Hourly share $\alpha_i$ travel modes, Hourly share $\beta_j$ location types

Road link level emissions

Extrapolated as rasters using distance-decay diffusion functions

Hourly emission rasters
- $\text{g/km} \rightarrow \mu\text{g/m}^3$

Exposure
Exposure

• We define an Exposure as:

\[ E_{kt} = \sum_{i} \alpha_i \text{road}_{it} + \sum_{j} \beta_j \text{location}_{jt} \]

• \( k = \) agent, \( t = \) time
• \( i = \) transport mode (cars, public transport (PT), walking, bike, SEVs)
• \( j = \) location type (home, education, work, other)
• \( \alpha_i, \beta_j = \) 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

- Home
- Education
- Work
- Other
- Walk
- Bike
- Car
- PT
Can Shared Autonomous Electric Vehicles (SAEVs) mitigate emissions?
SAEVs reduce emissions

By location type

By travel mode
But reductions are not homogenously distributed.
Thank you!