

An integrated road traffic-emissions-CTM model chain to assess urban air quality at the street level for the Paris region

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MATSim User Meeting

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Introduction

Air quality challenge : mobility & emissions modelling

CONTEXT

- Public policies aiming to **improve air quality** focus on vehicle fleet regulation, low emission zones
- Need to assess the **effect of public transport policies** on urban air quality



Introduction

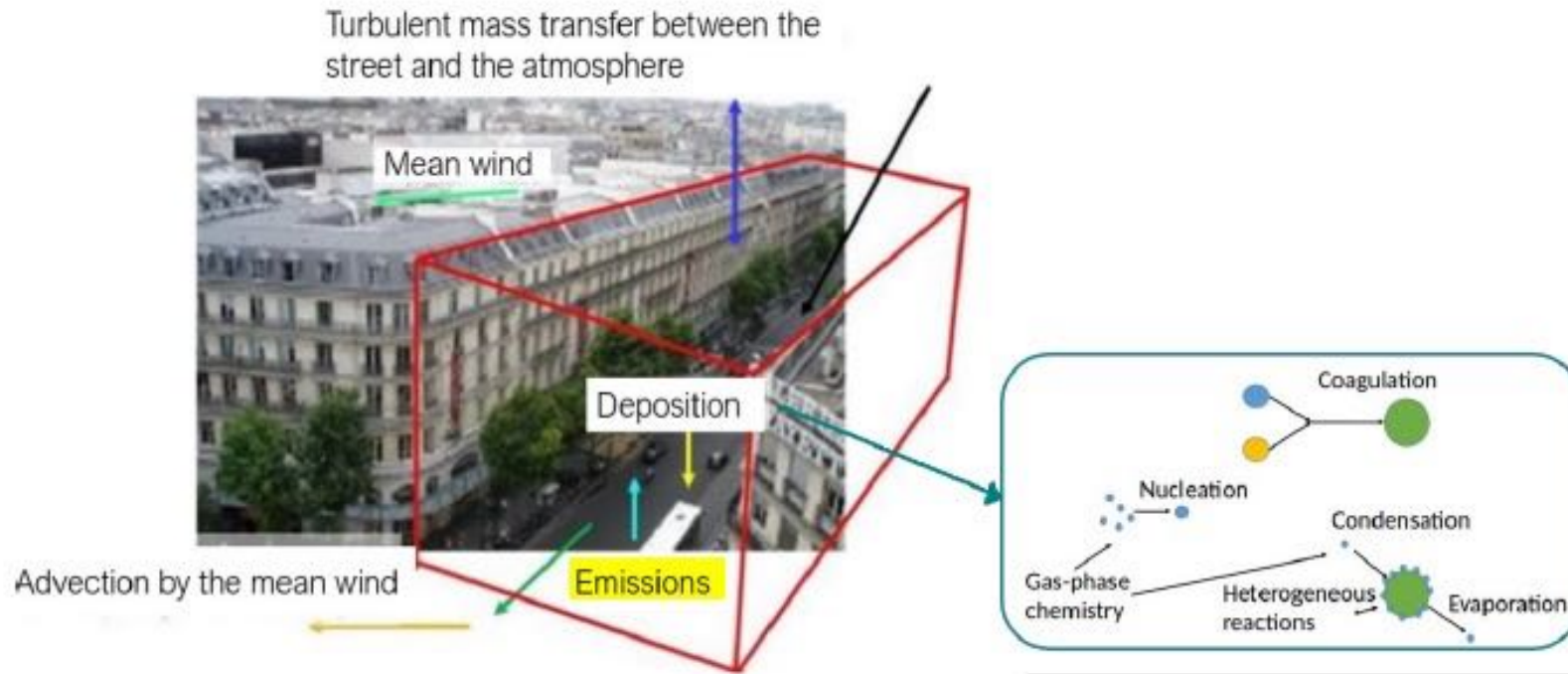
Air quality challenge : mobility & emissions modelling

CONTEXT

- Public policies aiming to **improve air quality** focus on vehicle fleet regulation, low emission zones
- Need to assess the **effect of public transport policies** on urban air quality
- Development of **modelling chain** from road traffic to chemical transport models in recent years [1] [2]
- **Uncertainties** remain little studied



Problem statement

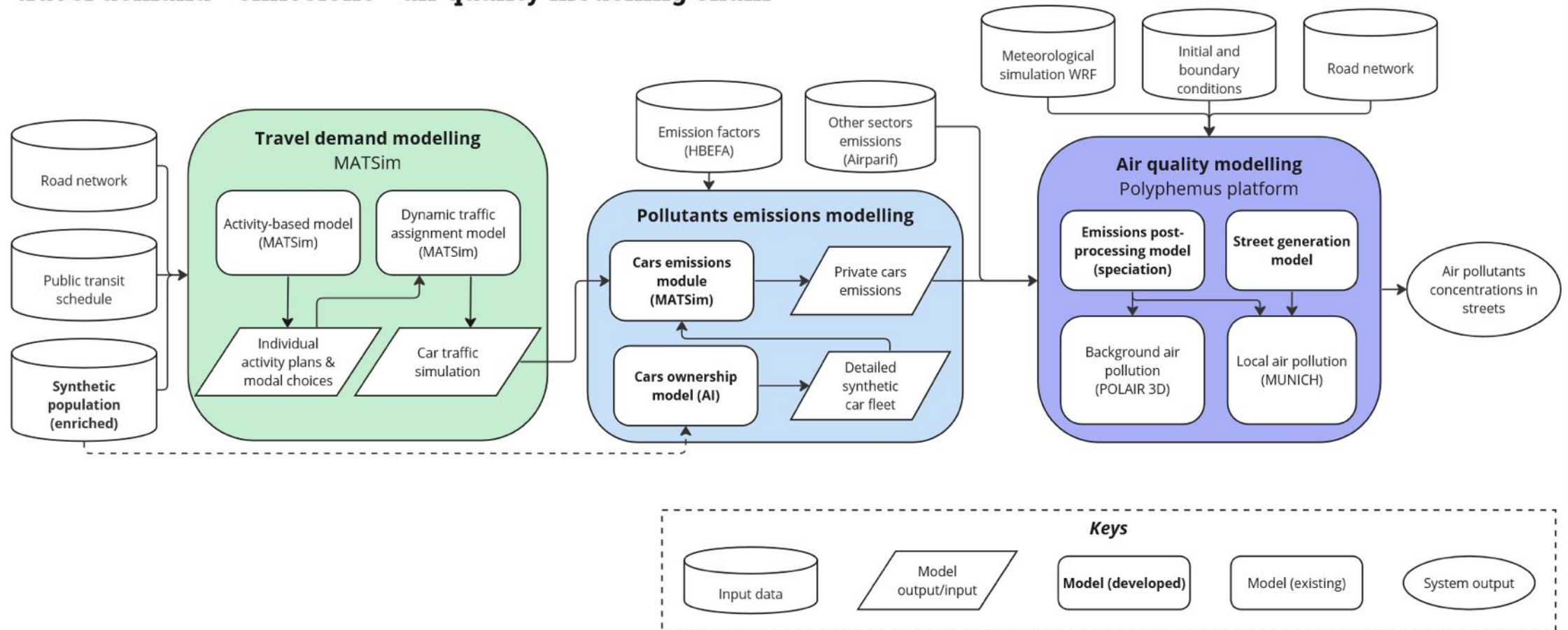


Representations of the different processes considered by MUNICH to compute concentrations in the street [3]

How to integrate high resolution traffic emissions into an air quality model based on street canyons?

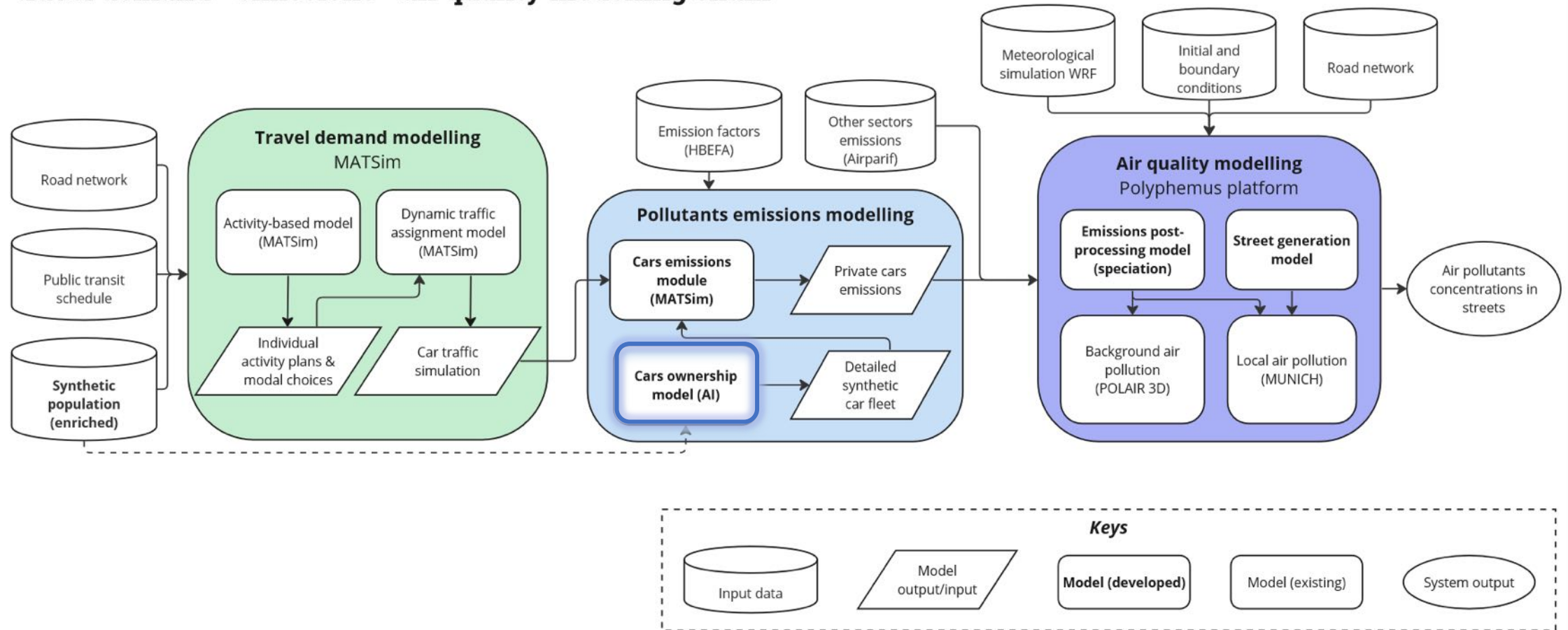
Methodology

The integrated modelling framework for air quality assessment: travel demand - emissions - air quality modelling chain



Methodology

The integrated modelling framework for air quality assessment: travel demand - emissions - air quality modelling chain



Methodology

Synthetic car fleet generation

POPULATION SYNTHESIS ENRICHMENT

- Socioeconomic variables : income, household type, housing type, max age, etc
- Built environment variables : parking at home and workplace
- Features engineering : PT shares at home & workplace

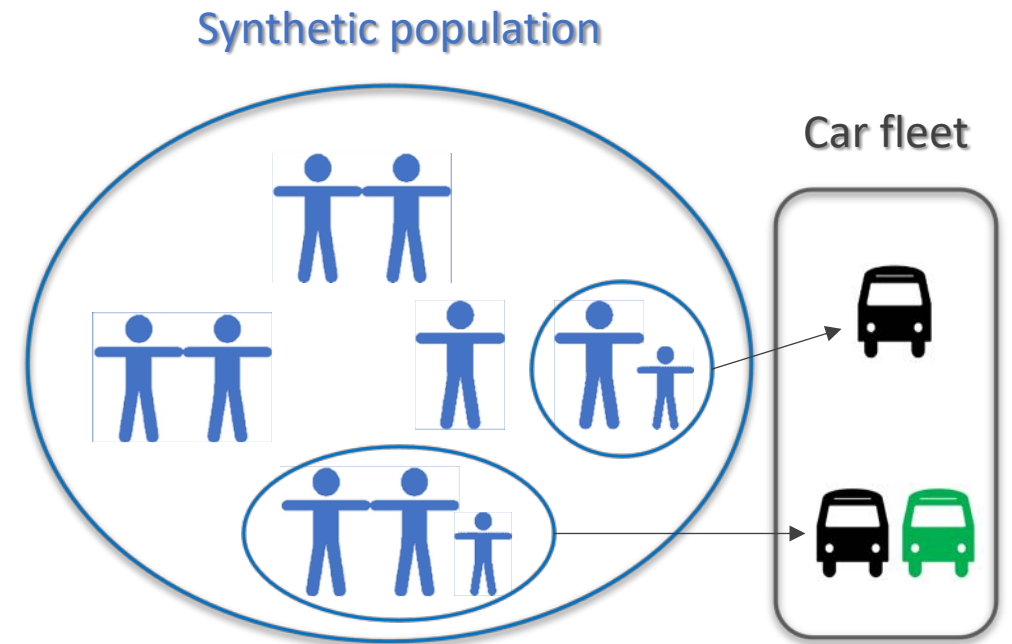
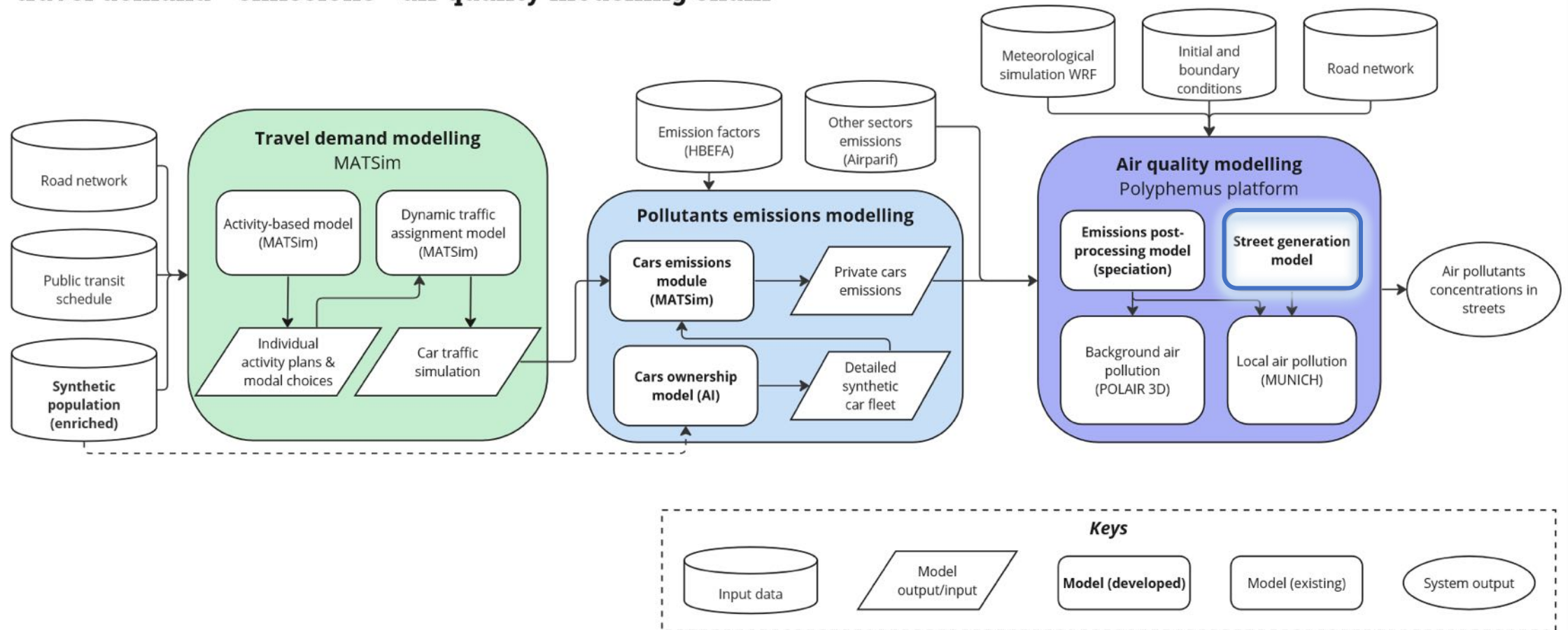


Figure: Car fleet micro-representation based on households characteristics

Methodology

**The integrated modelling framework for air quality assessment:
travel demand - emissions - air quality modelling chain**



Methodology

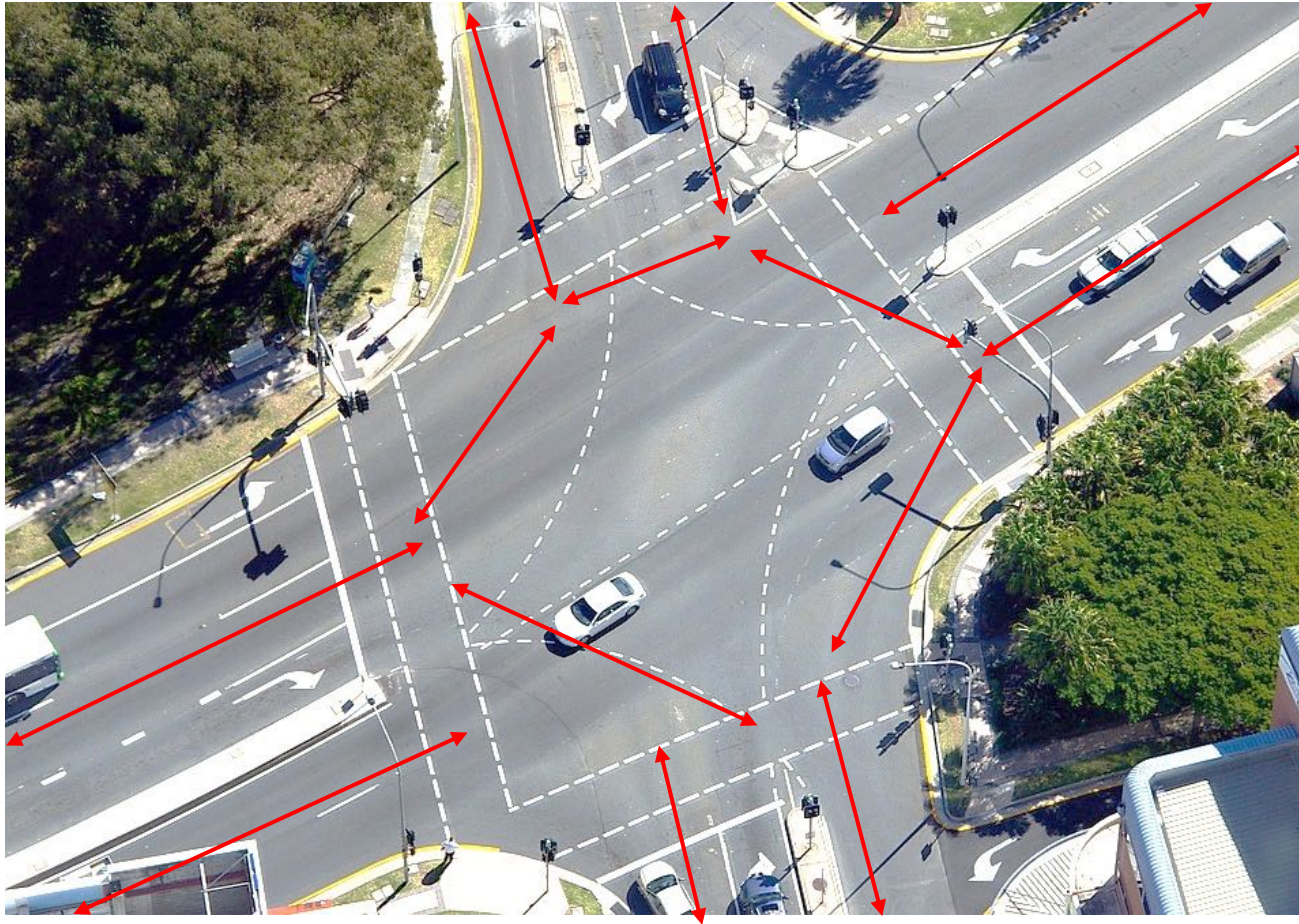
How to couple a traffic model and an air quality model?



- In transportation models, **traffic lines** and **junctions** are used as a basis for urban modeling

Methodology

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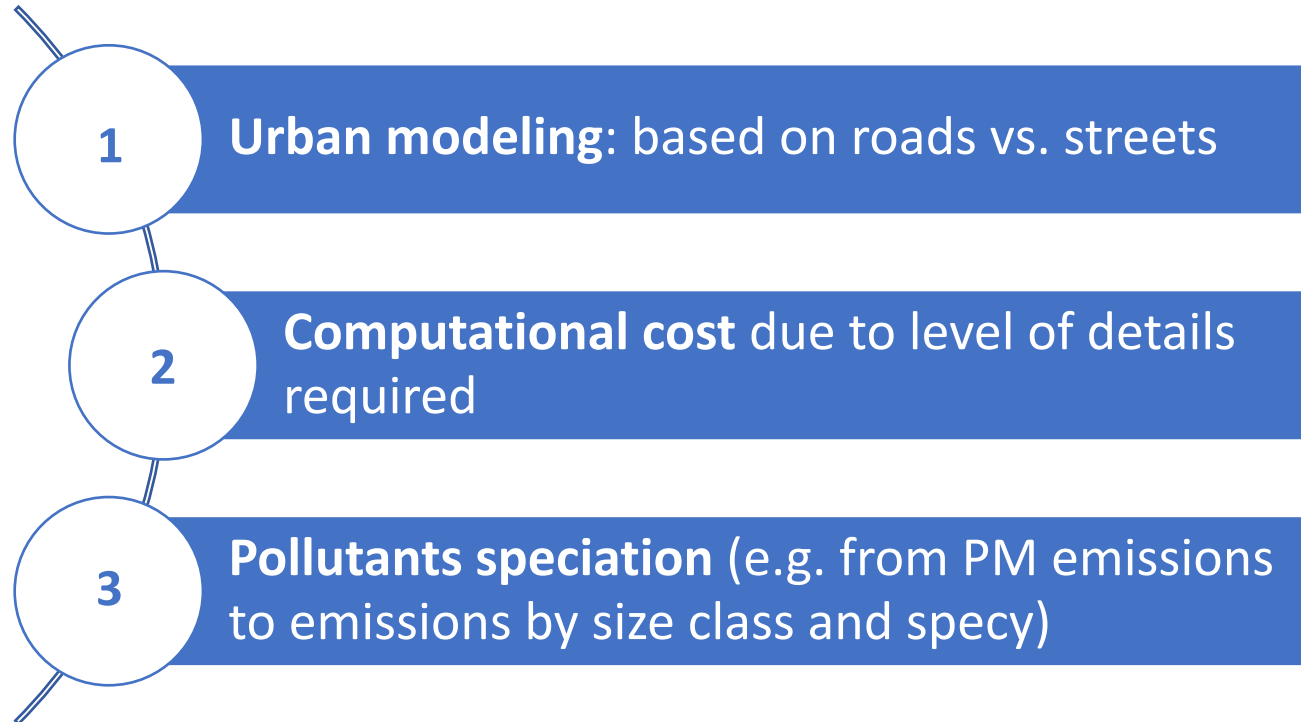


- In transportation models, **traffic lines** and **junctions** are used as a basis for urban modeling
- Air transportation models rely on a **built environment** model based on streets and intersections

Methodology

How to couple a traffic model and an air quality model?

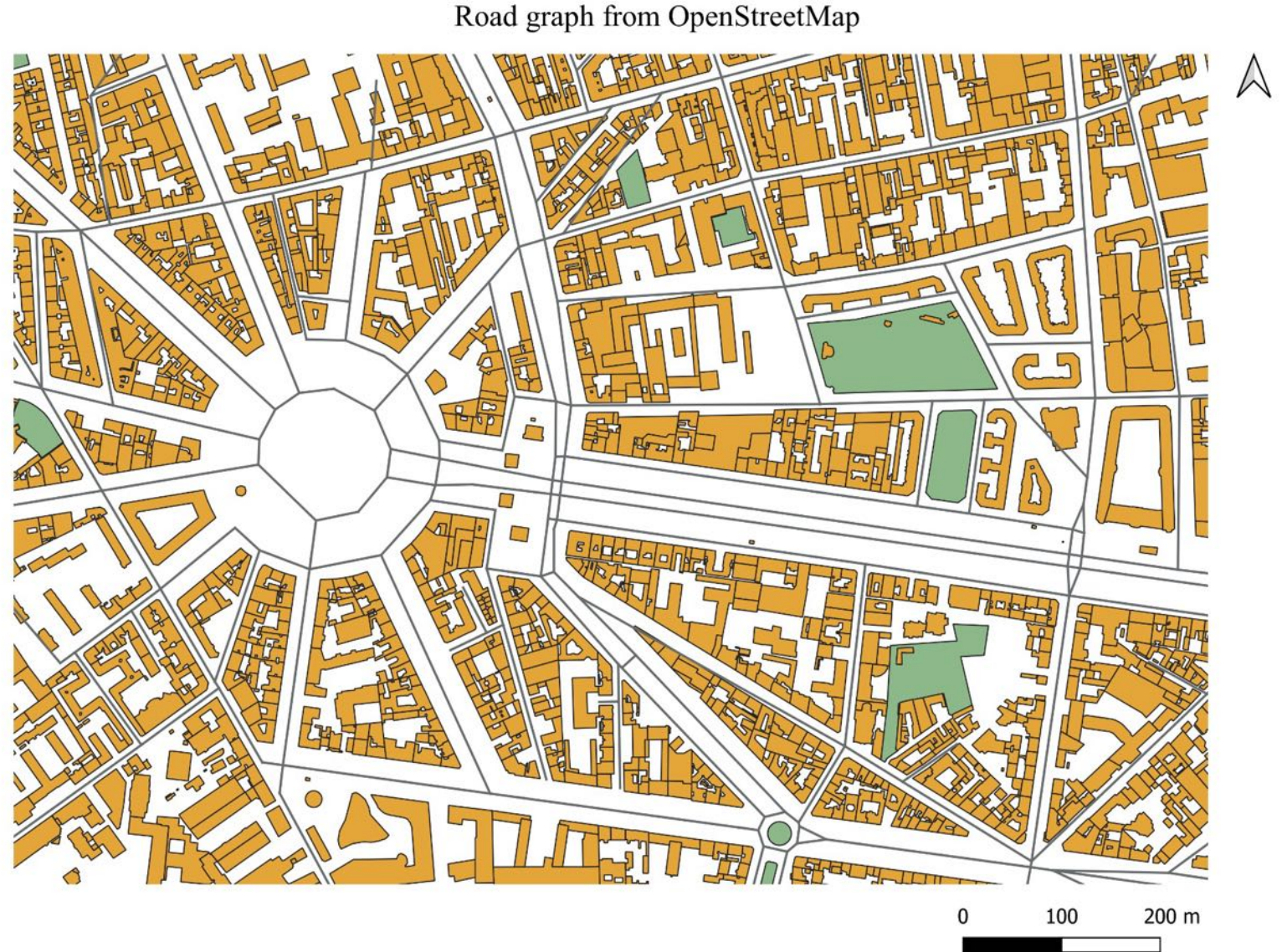
Modeling
challenges



Methodology

Street network generation

How to generate a street network for air quality modeling based on street canyons ?



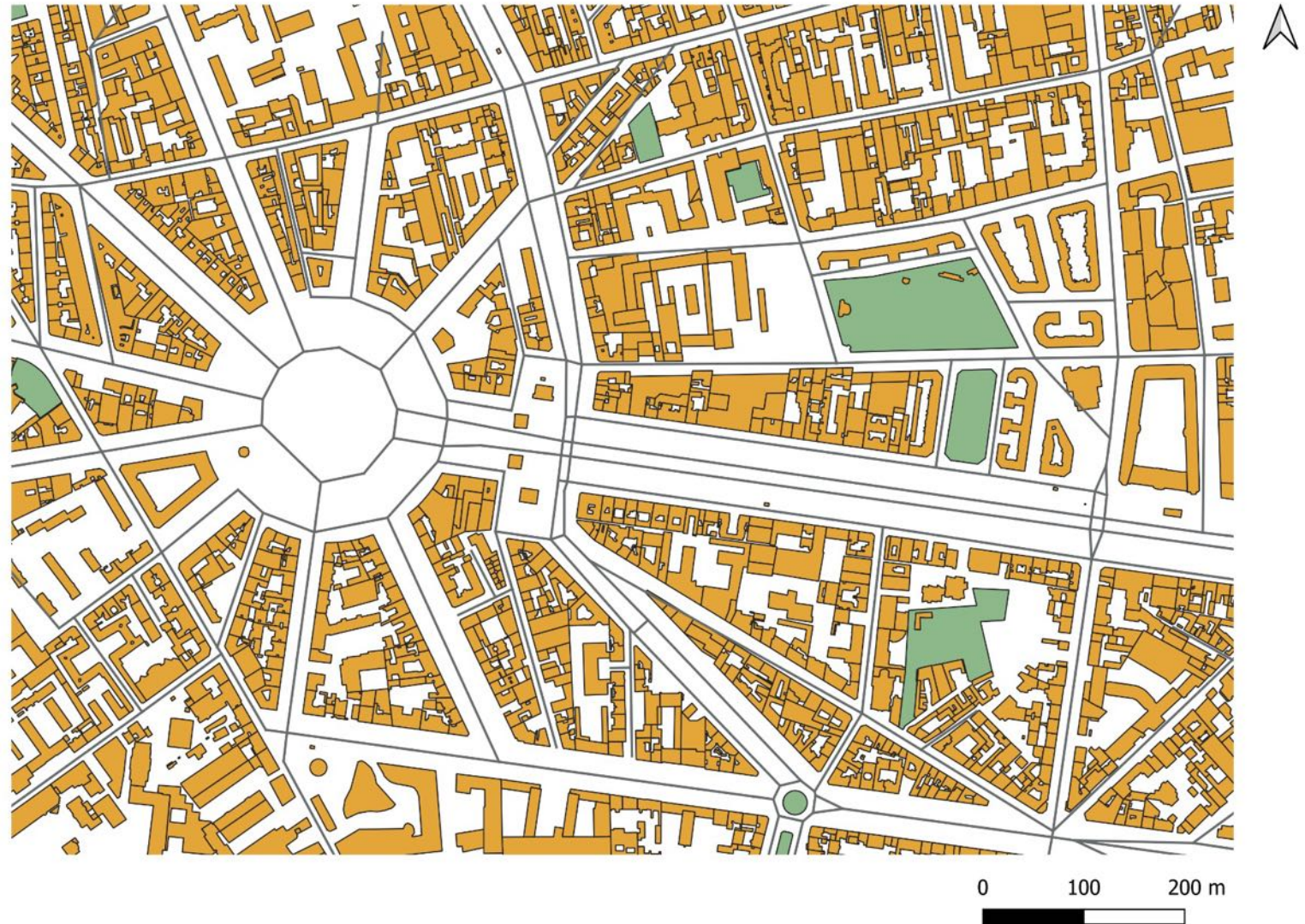
Methodology

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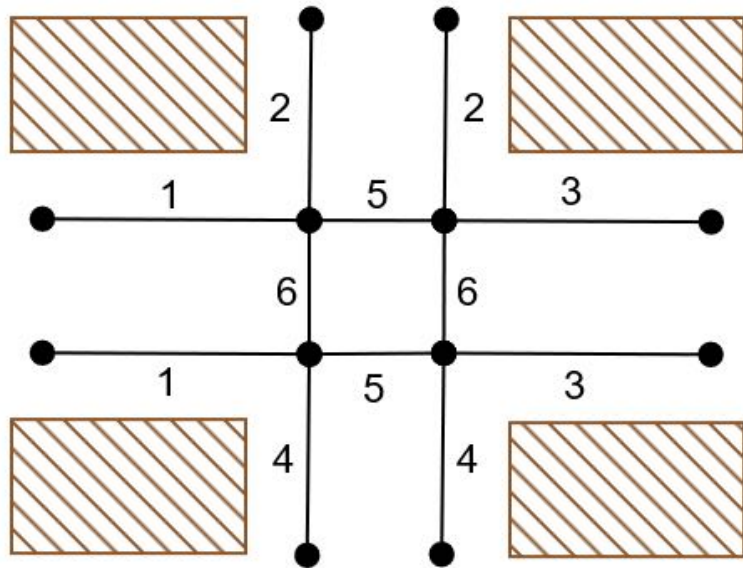
1. Identify roads to group together
2. Transform links
3. Transform nodes

Road graph from OpenStreetMap

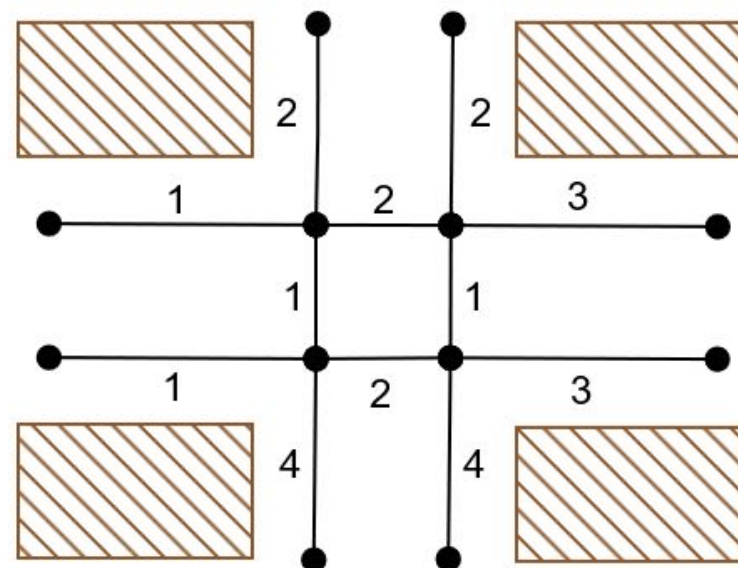


Methodology

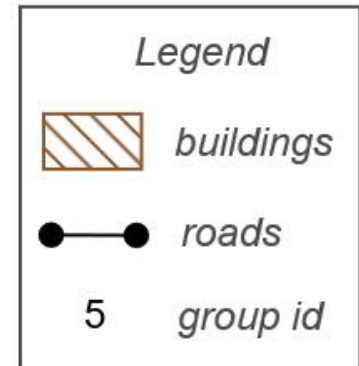
Street network generation : 1) groups identification



Step 1: parallel roads identification

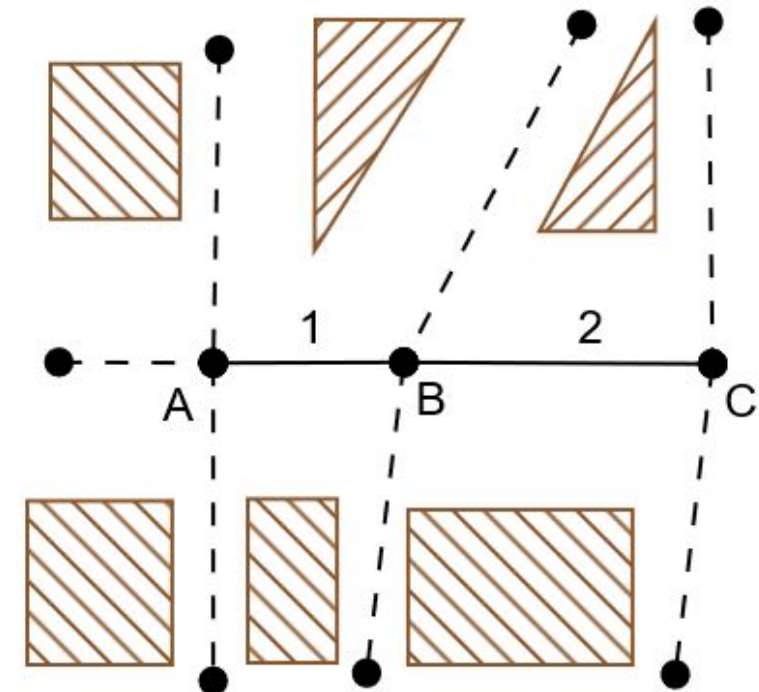
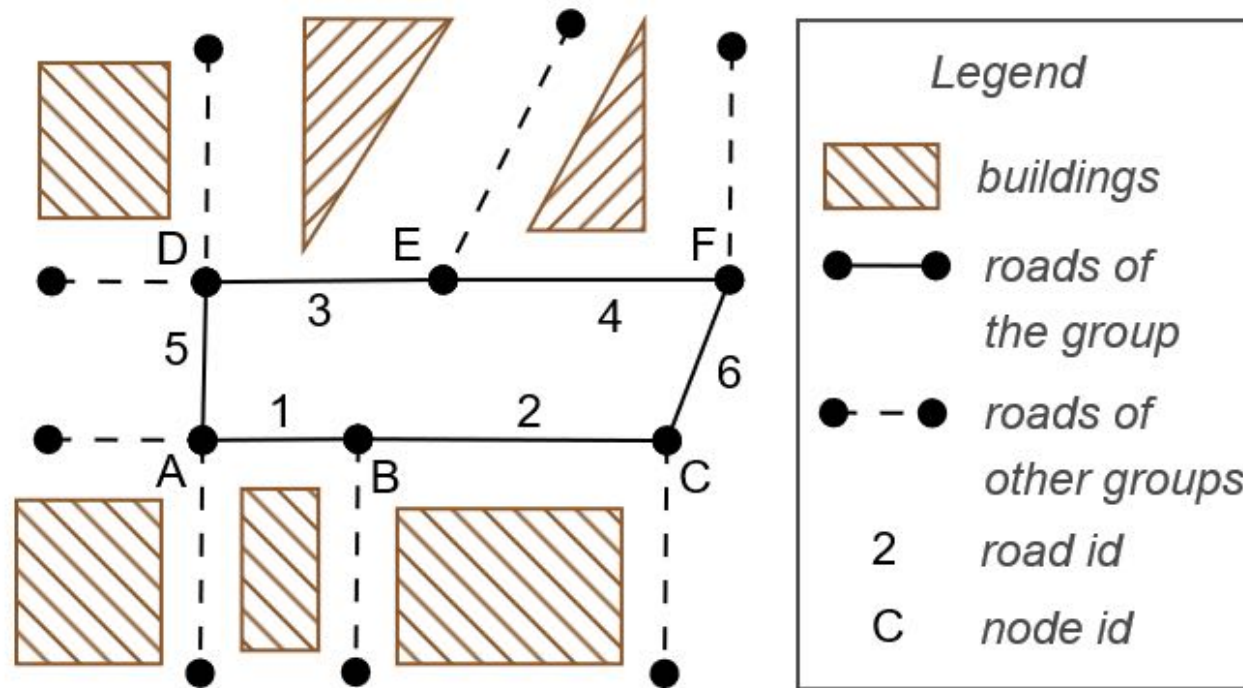


Step 2: perpendicular groups



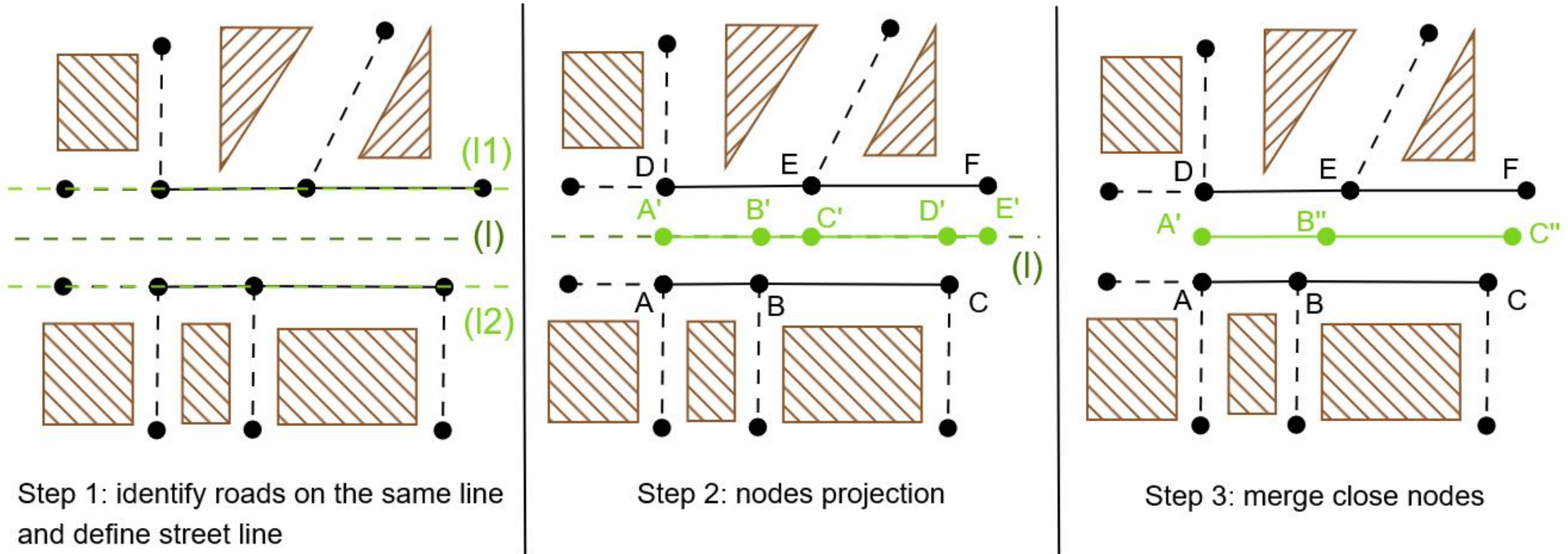
Methodology

Street network generation : 2) links transform



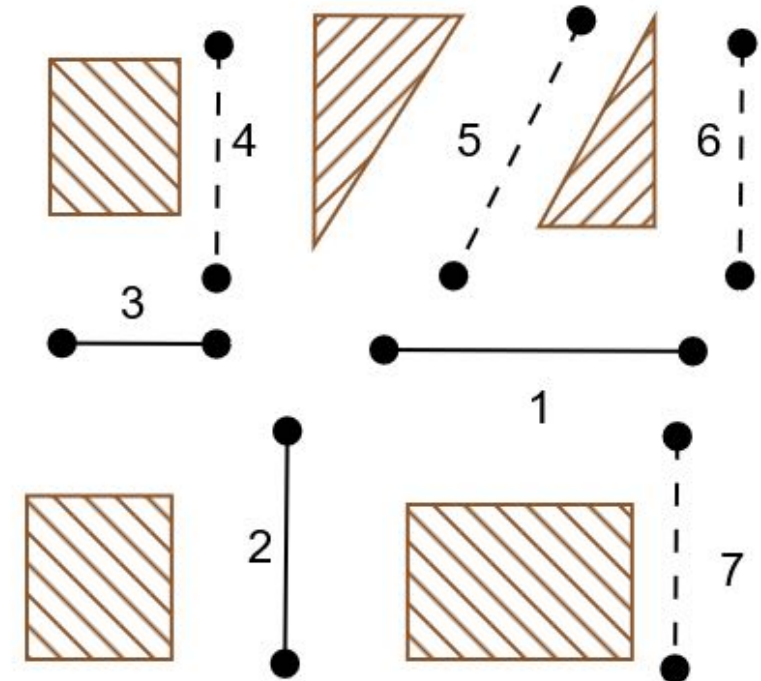
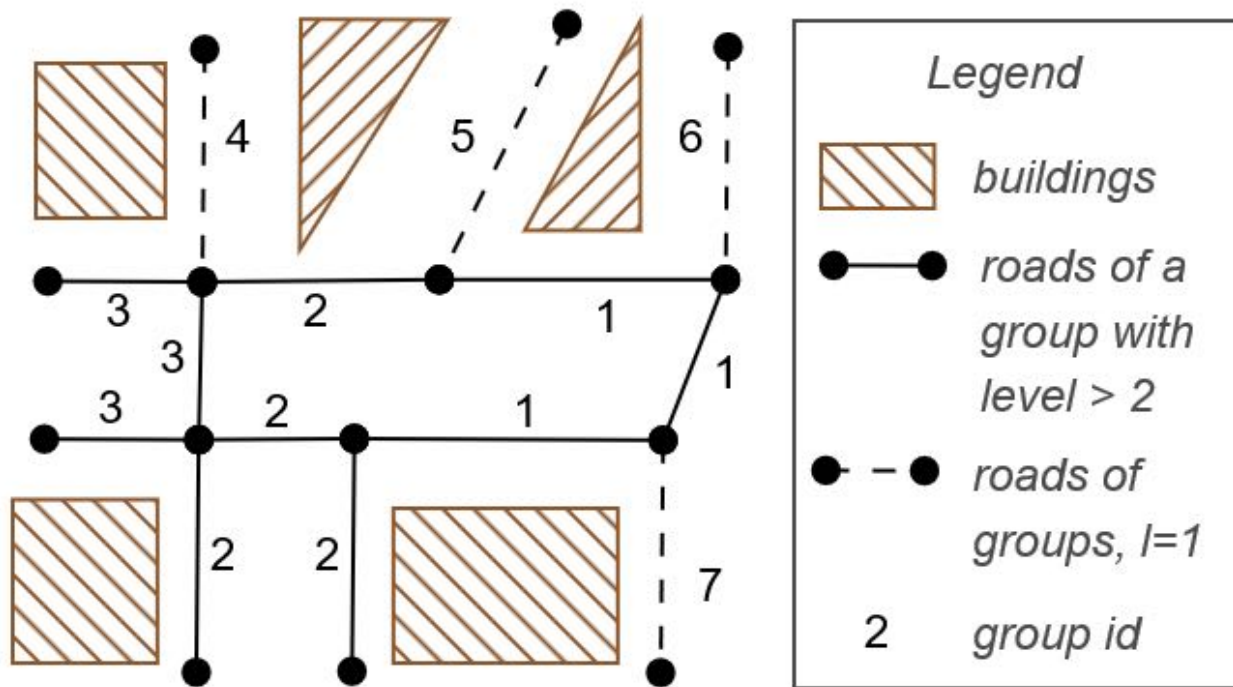
Methodology

Street network generation: 2) links transform



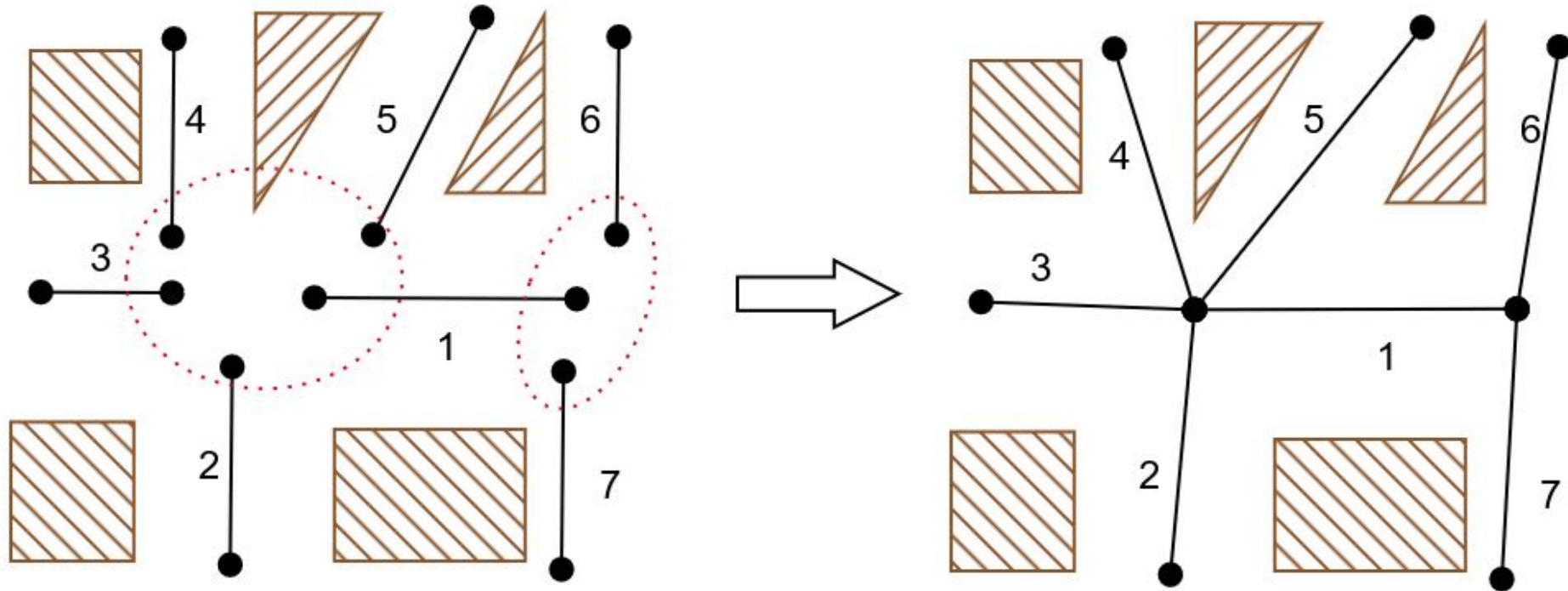
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Street network generation : 3) nodes transform



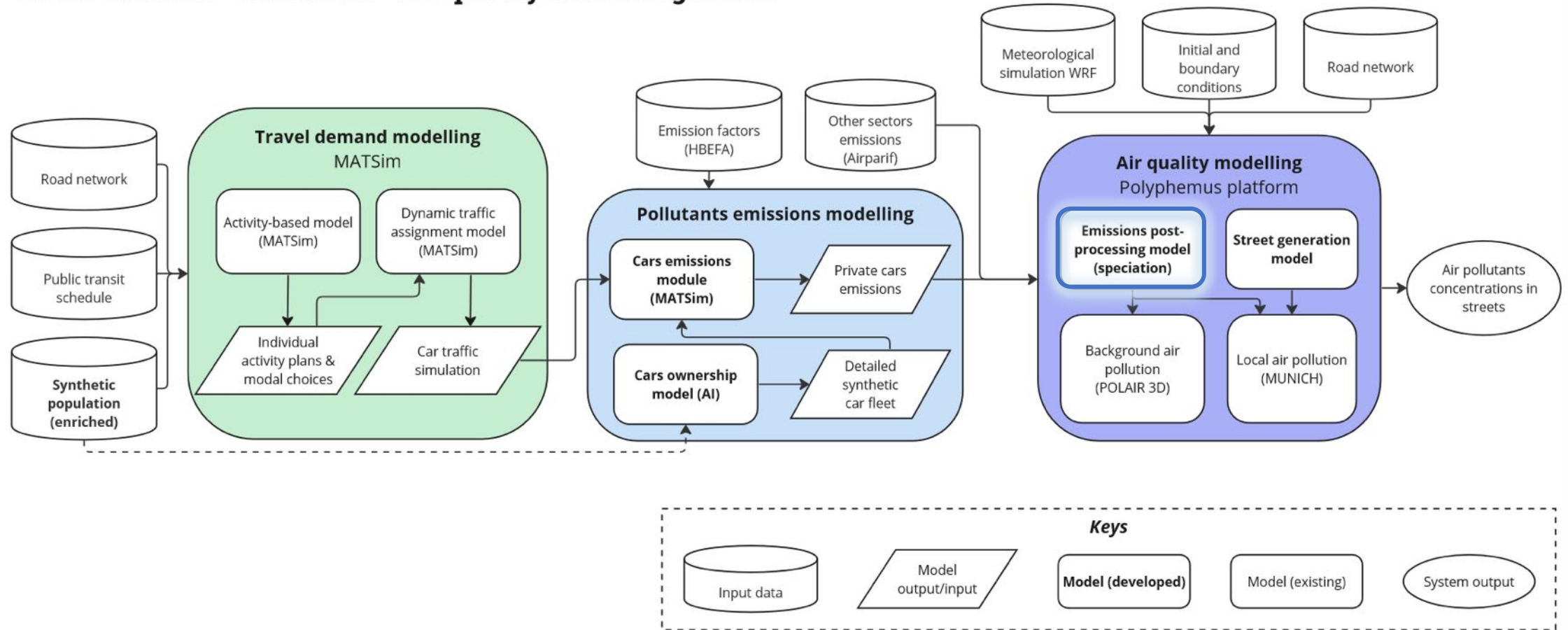
Methodology

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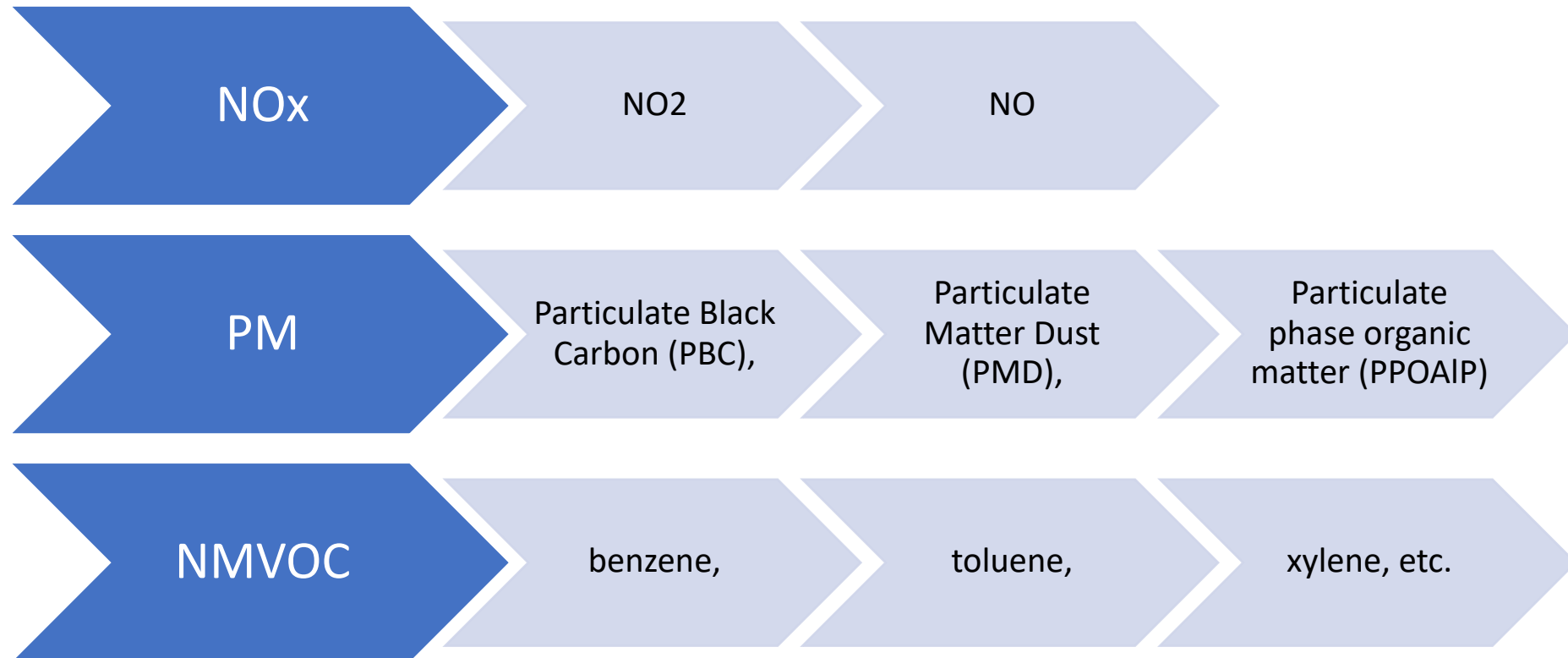
Methodology

The integrated modelling framework for air quality assessment: travel demand - emissions - air quality modelling chain



Methodology

Pollutants speciation based on COPERT



Methodology

Emissions and chemical-transport modelling

Models	Representation	Spatial resolution and urban modeling	temporal resolution	Chimical representation
HBEFA	Pollutants emissions	Road-oriented graph representation	minute	Primary emissions for aggregated species (PM, COV, etc)
POLAIR-3D	CTM for background concentrations + secondary aerosols	Grid (1 to 3 km resolution)	hour	Includes secondary chemical generation of pollution
MUNICH	CTM for canyon streets concentrations + secondary aerosols	Street-oriented graph representation	hour	idem

Case study

Île-de-France

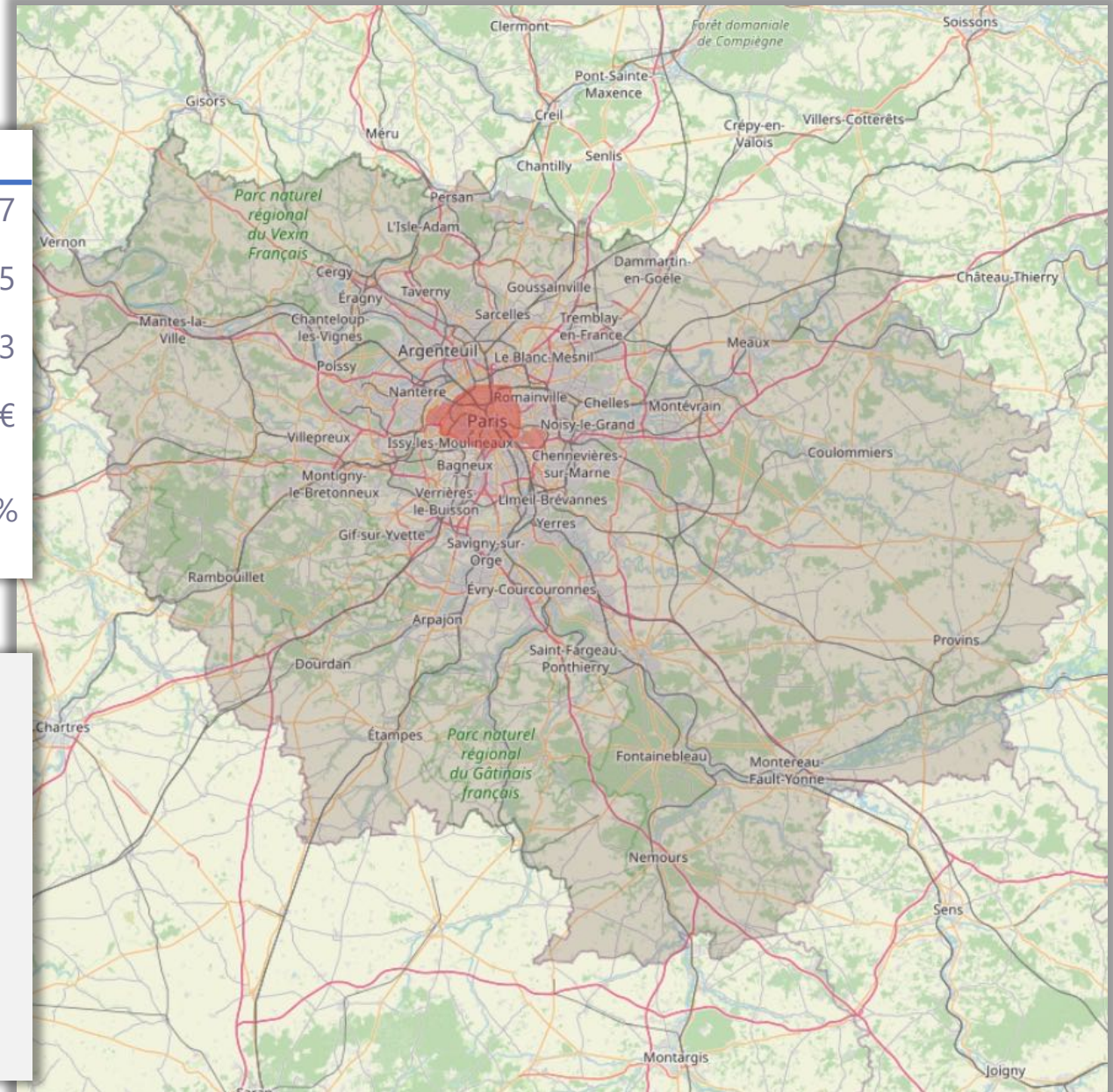
Surface	12 012.00 km ²	Dwellings	5 795 907
Population	12 174 880	Households	5 184 985
Density	1 013.5/km ²	Household size	2.3
Active population	8 010 367	Median income	23 230 €
Employment rate	66.7%	Cars: 1 / 2+	44.7%/21.1%

Source: INSEE (2017)

Île-de-France Scenario

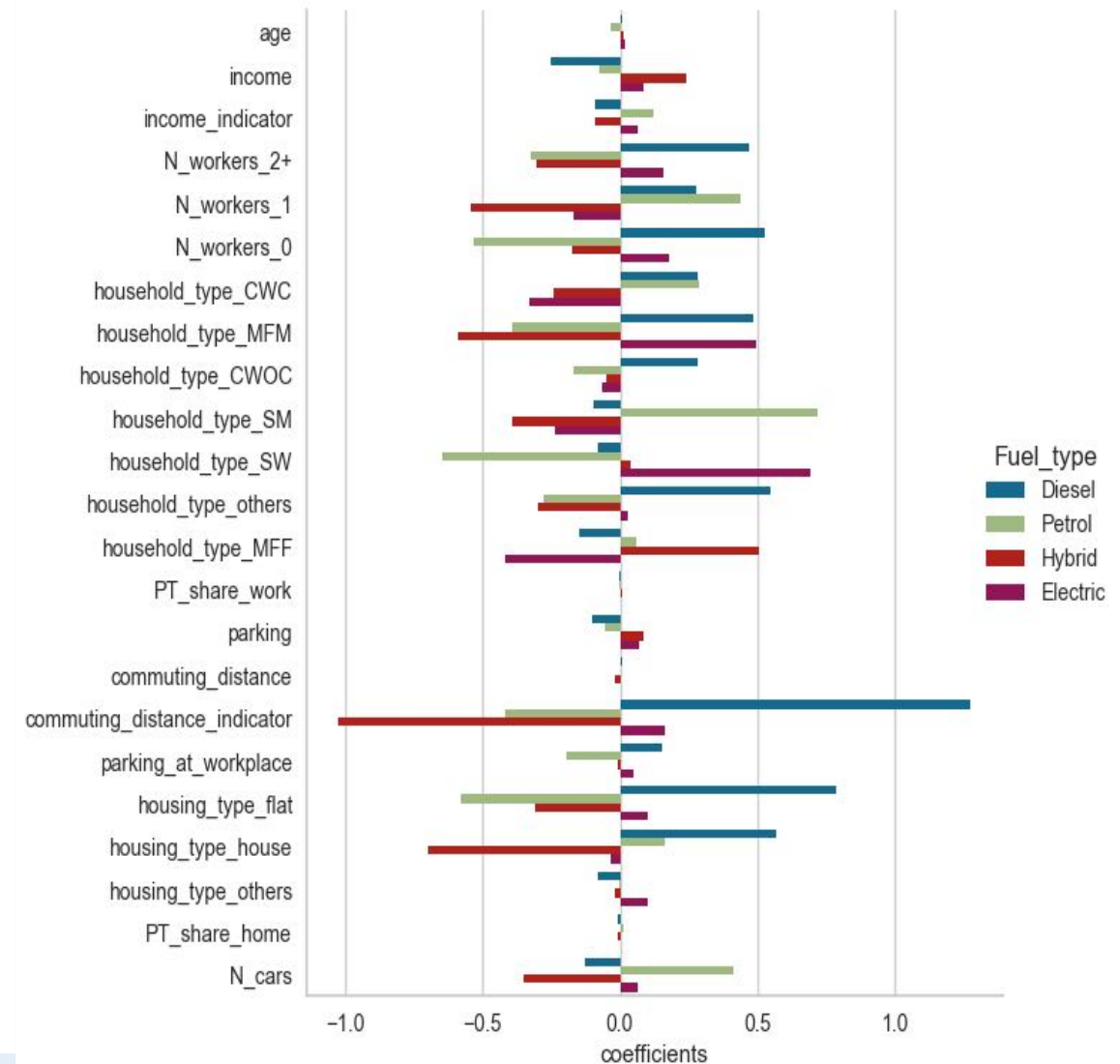
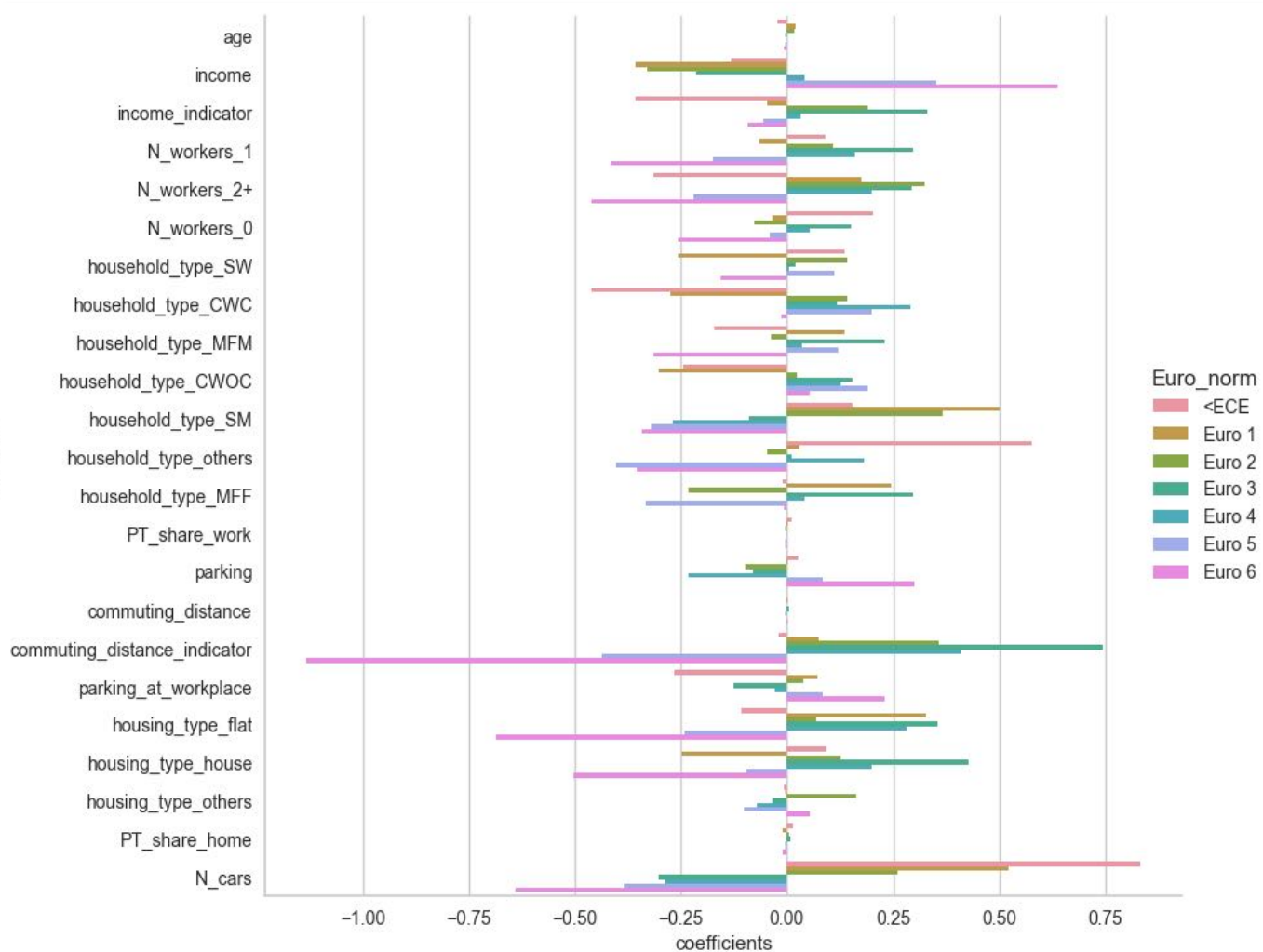
Sample size	100%
Emissions Events file	~150 GB
Total Runtime for processing and calculations (emissions by type per link)	~5h

Machine with a **64 core CPU**, Intel®Xeon®Platinum 8368 CPU @ 2.40GHz, and **768 GB** available memory.



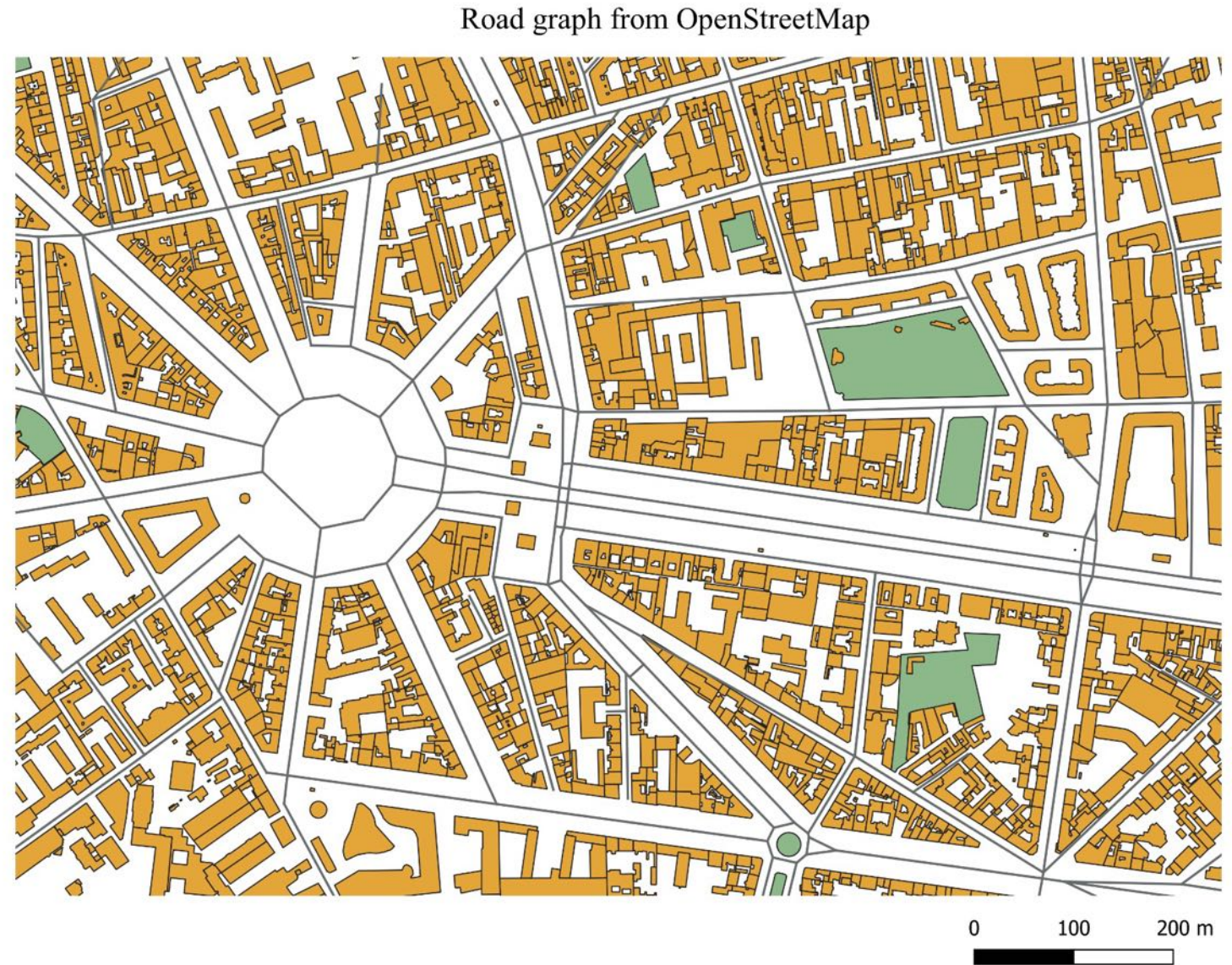
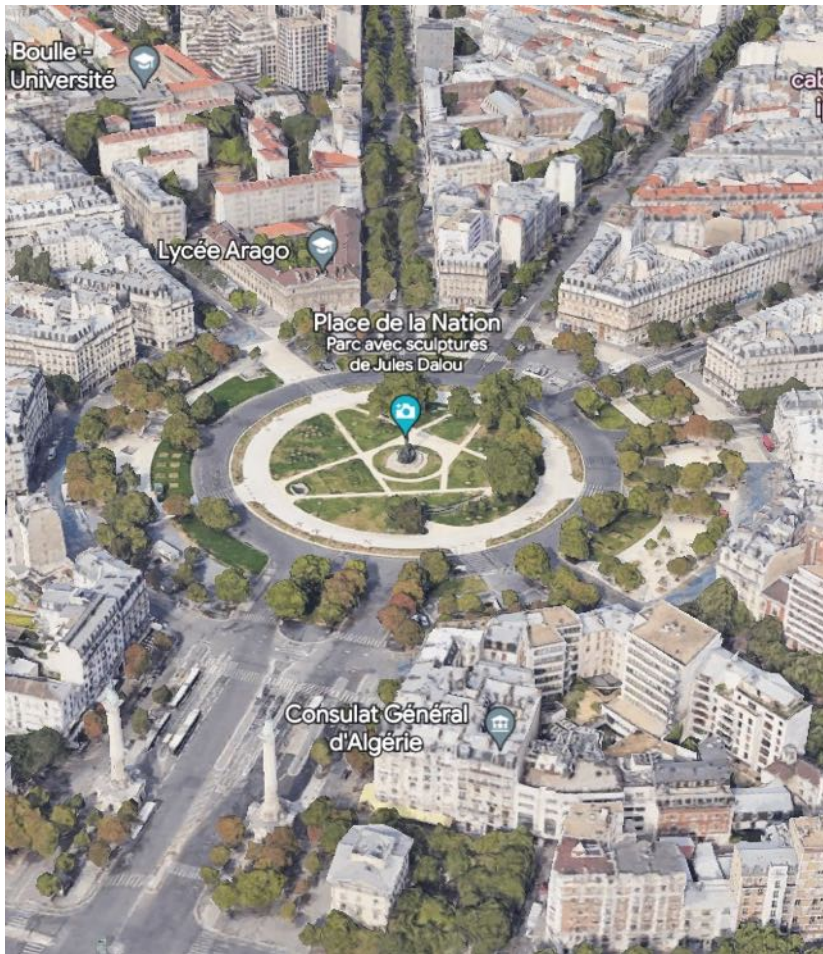
First results

Car fleet synthesis



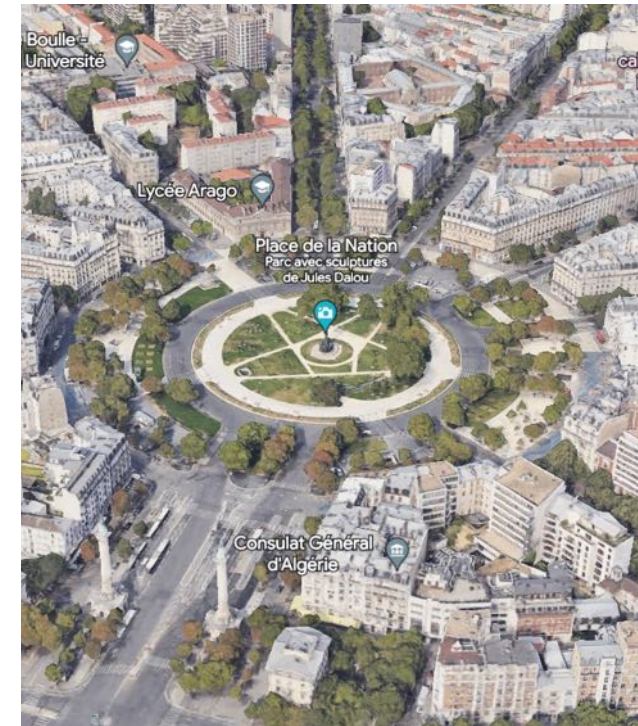
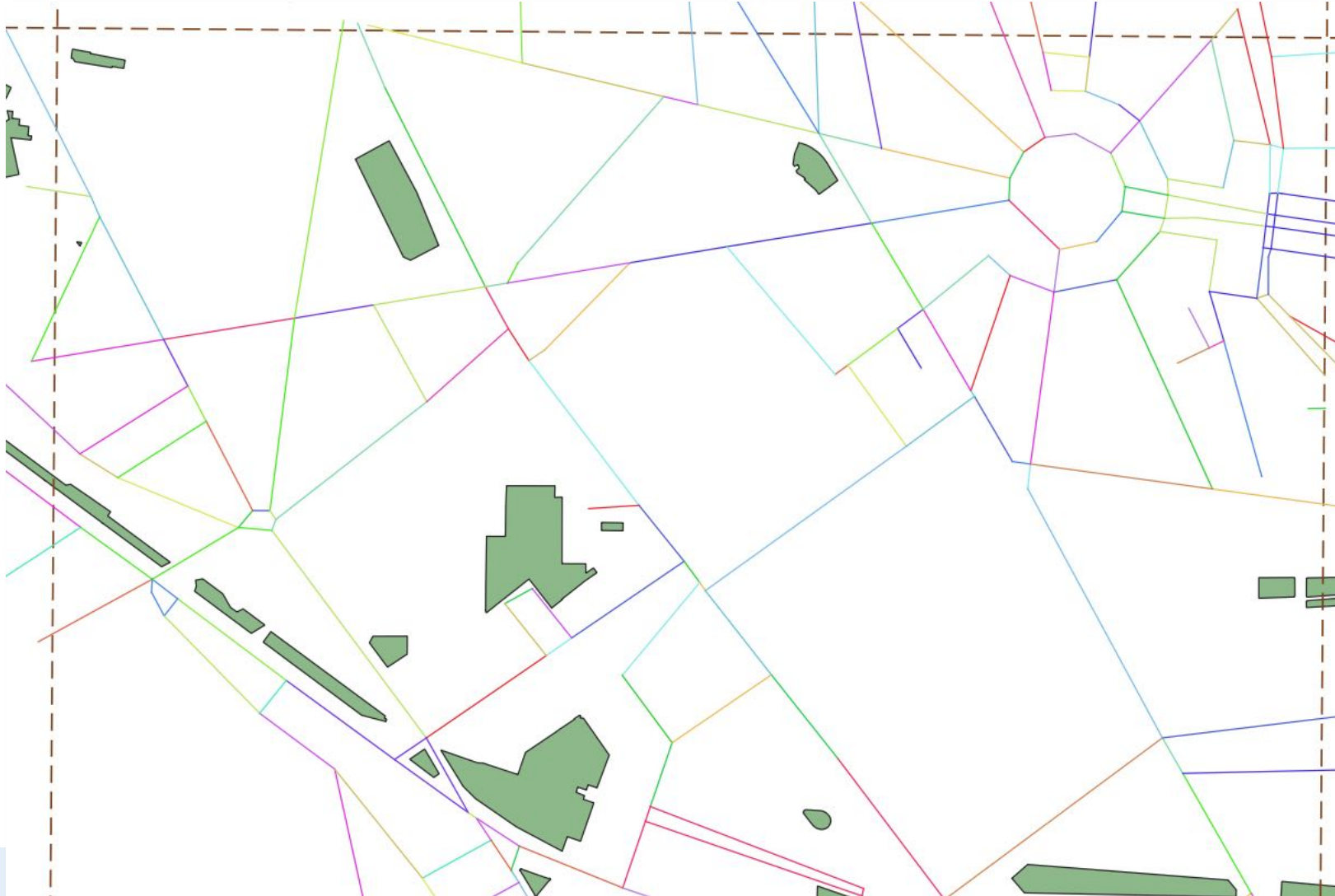
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Street network



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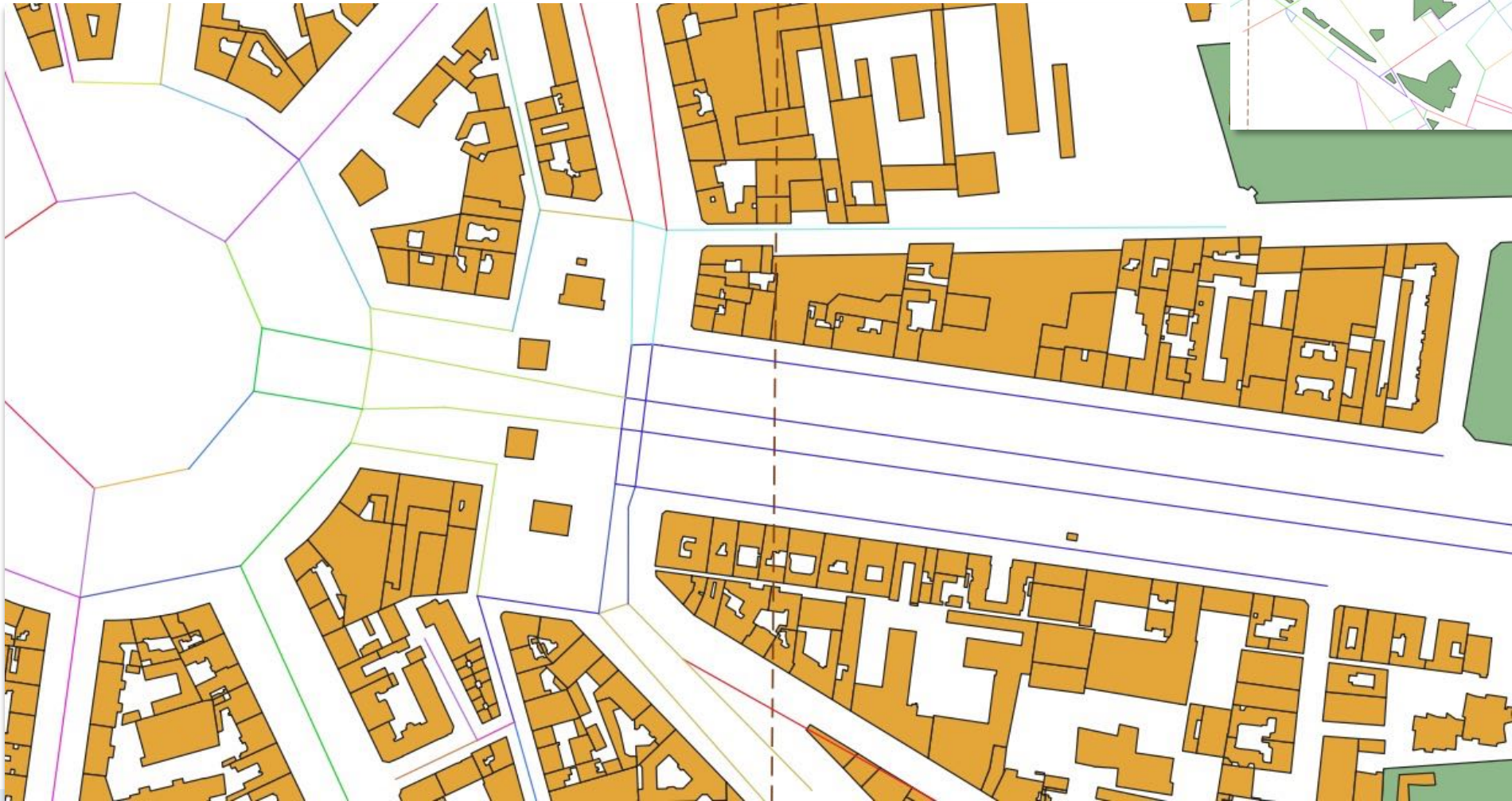
Street network



Source: Google Earth

First results

Street network



First results

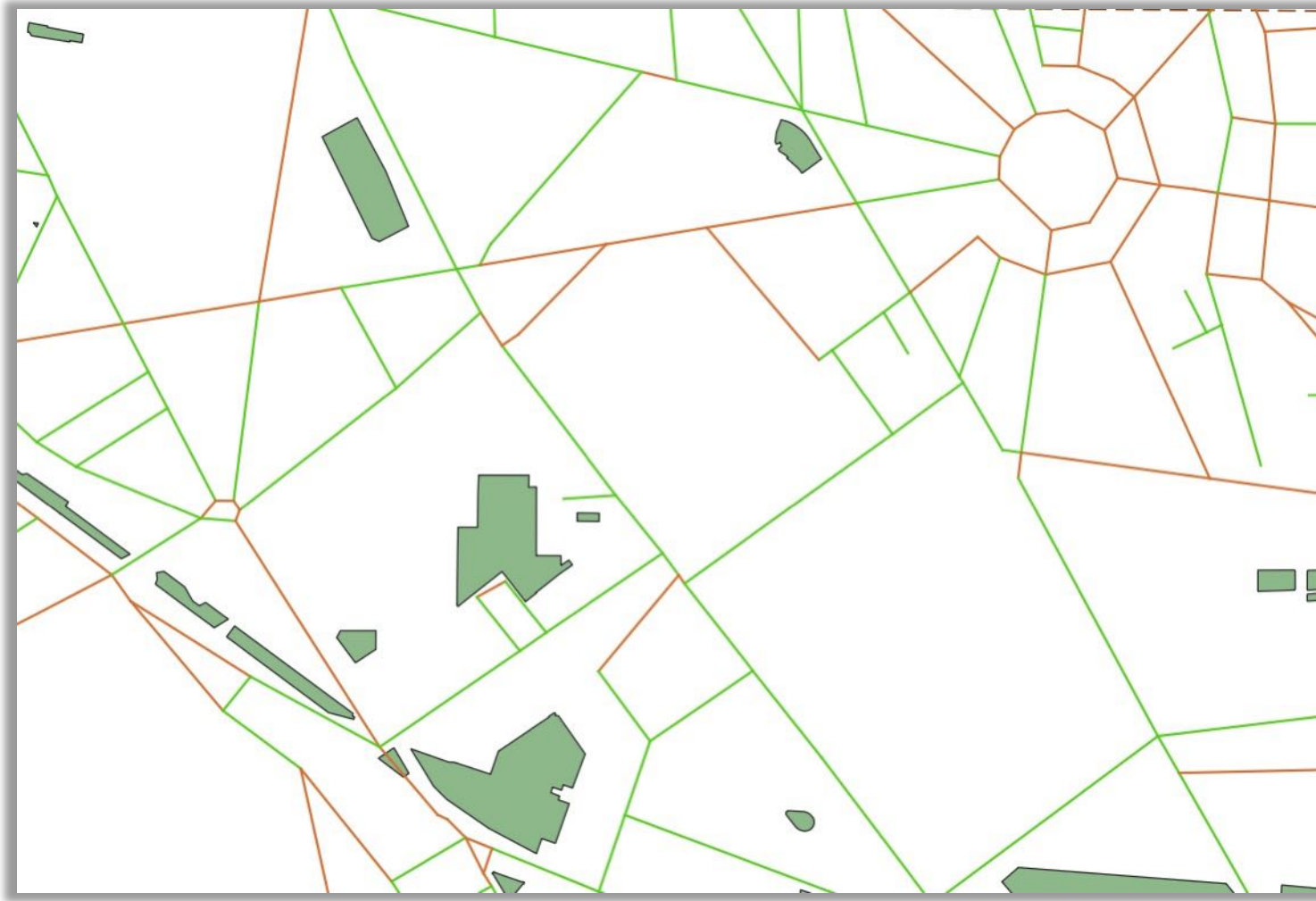
Street network



Results

Street network

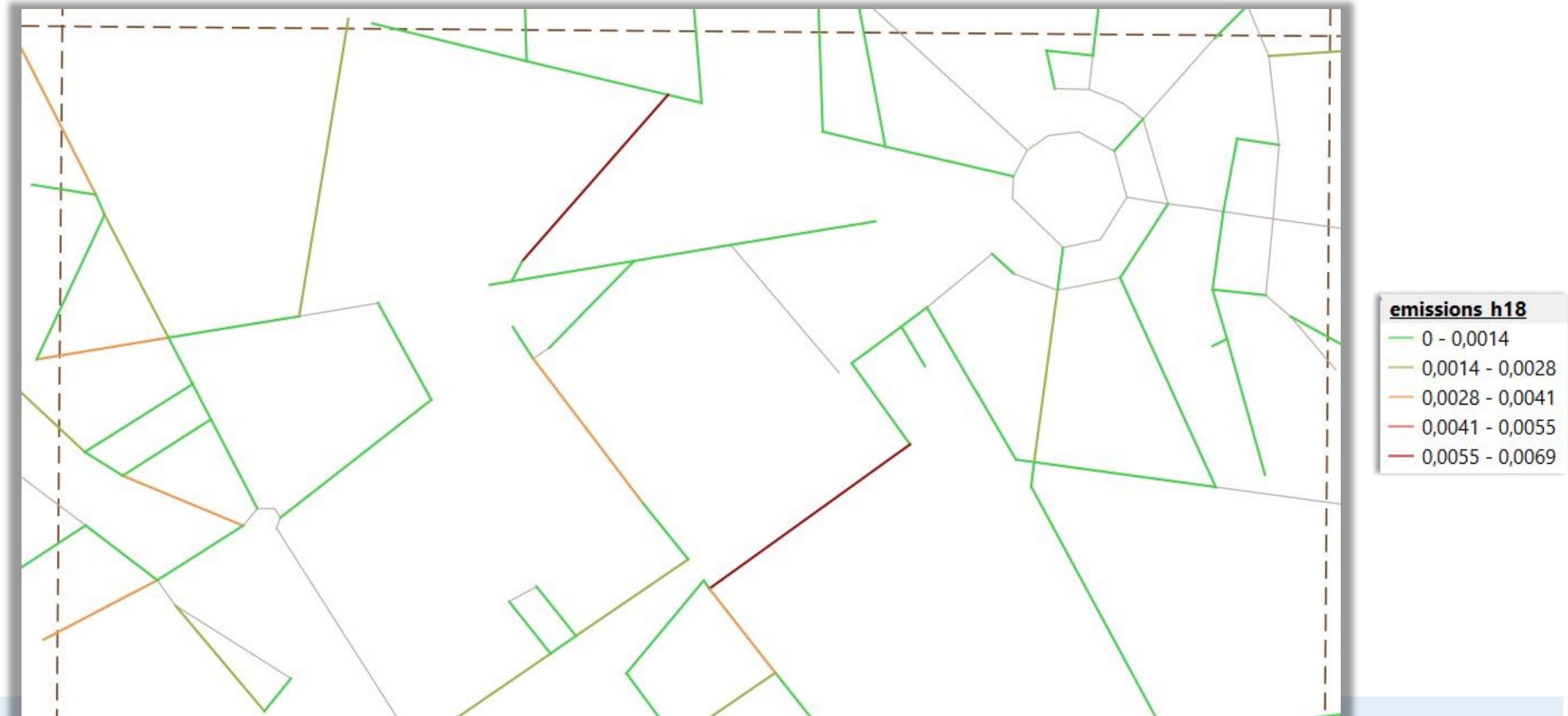
Canyon streets



$R = \text{Height} / \text{width}$
 $R_{\text{lim}} = 1/3$

Results

NO2 Emissions from 6 pm to 7 pm



Conclusions

Developments

1 – Car fleet synthesis

- Based on households characteristics
- Pollutant emissions-related typology

2 – Street network synthesis

- Based on OSM road network
- Street network adapted for air quality modelling

3 – Emissions modelling

- HBEFA module in MATSim
- Spatiotemporal aggregation (hour and link resolution)
- Pollutants speciation

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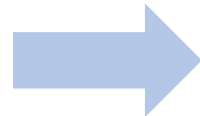
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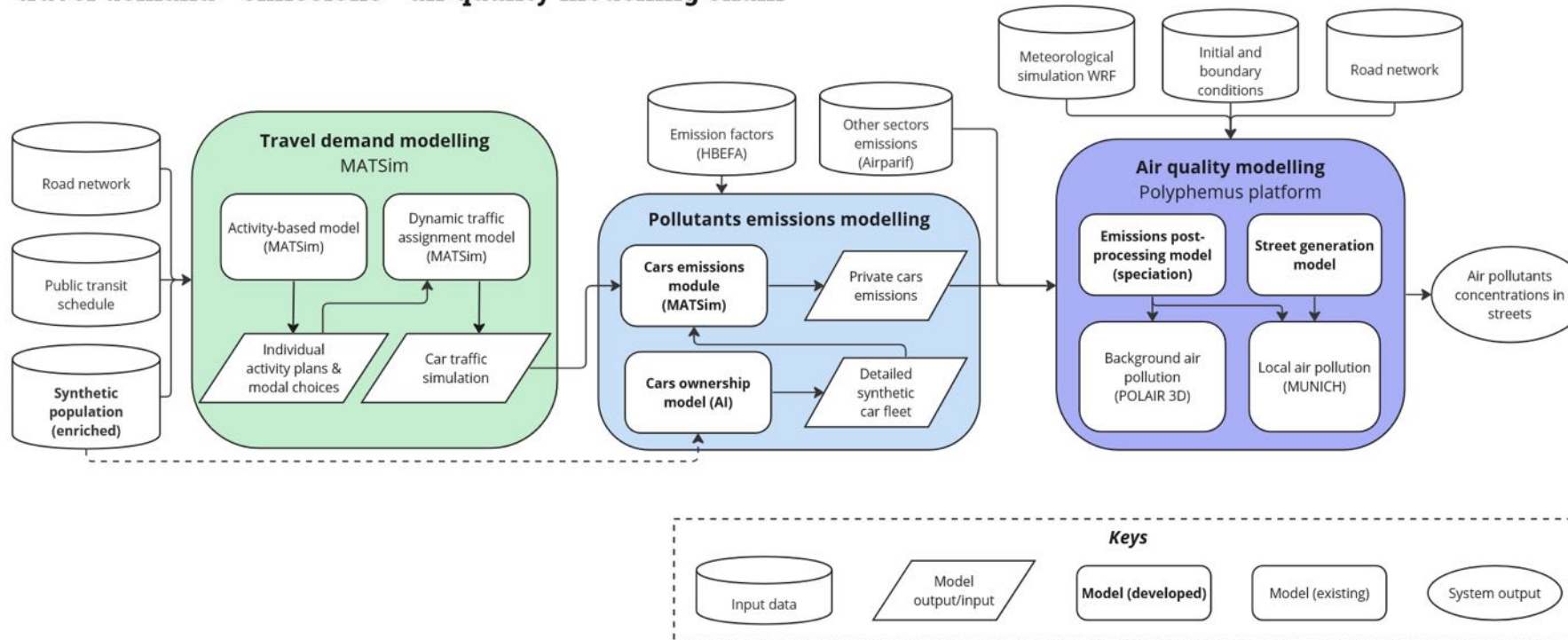


Next step : simulation of **concentrations** in the streets

Conclusions

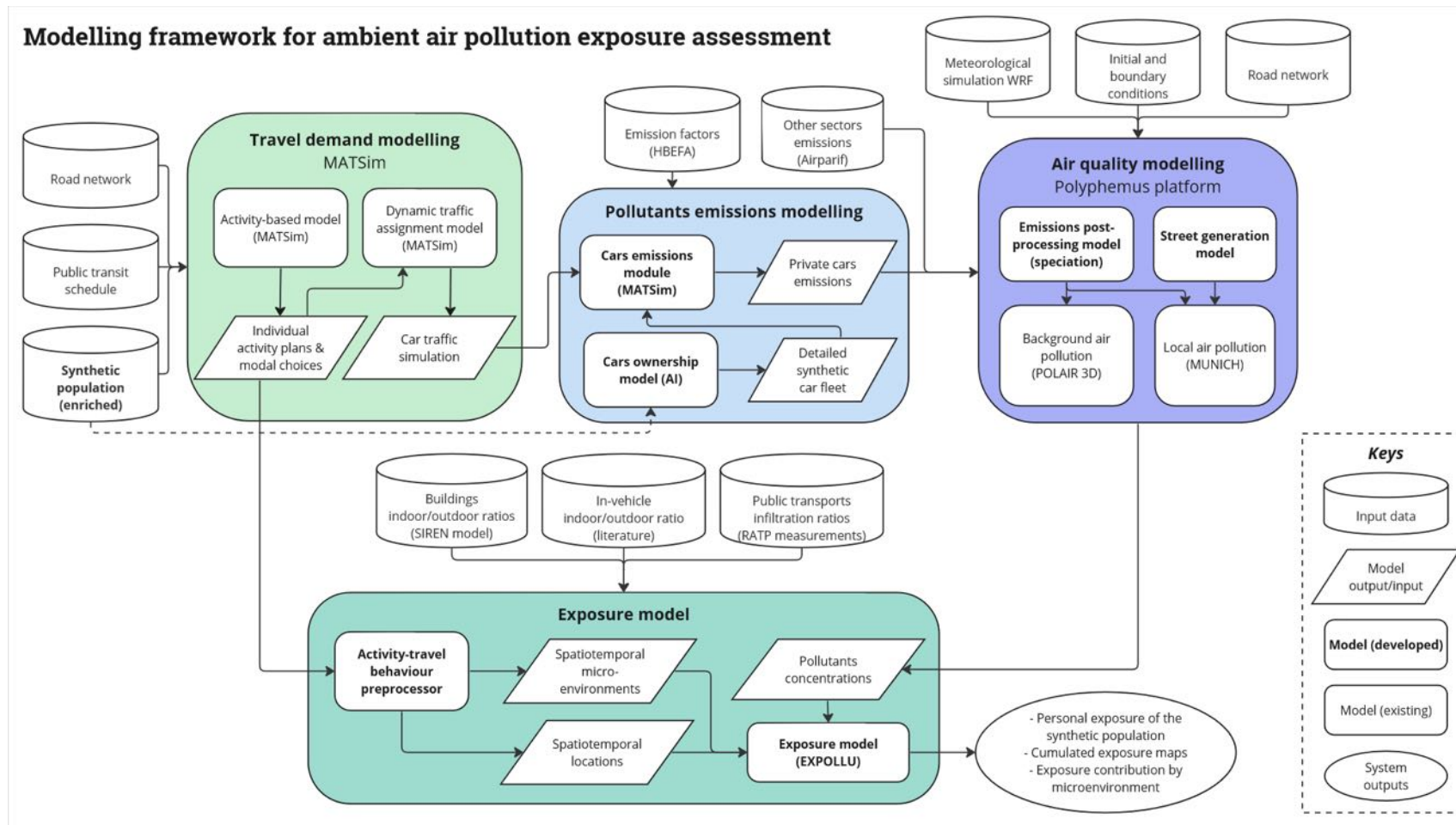
Towards exposure assessment

travel demand - emissions - air quality modelling chain



Conclusions

Towards exposure assessment



Bibliography

- [1] Gurram, Sashikanth, Amy Lynette Stuart, and Abdul Rawoof Pinjari. 2019. ‘Agent-Based Modeling to Estimate Exposures to Urban Air Pollution from Transportation: Exposure Disparities and Impacts of High-Resolution Data’. *Computers, Environment and Urban Systems* 75: 22–34.
- [2] Hörl, Sebastian, and Milos Balac. 2021. ‘Synthetic Population and Travel Demand for Paris and Île-de-France Based on Open and Publicly Available Data’. *Transportation Research Part C: Emerging Technologies* 130: 103291.
- [3] Lugon Lya, 2021. ‘Modélisation de la qualité de l’air dans les rues de Paris’.
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Thank you for your attention !

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