

30/01/2026

Leonardo G. LUQUEZI

# Urban noise and the assessment of environmental impacts and opportunities with agent-based transportation models



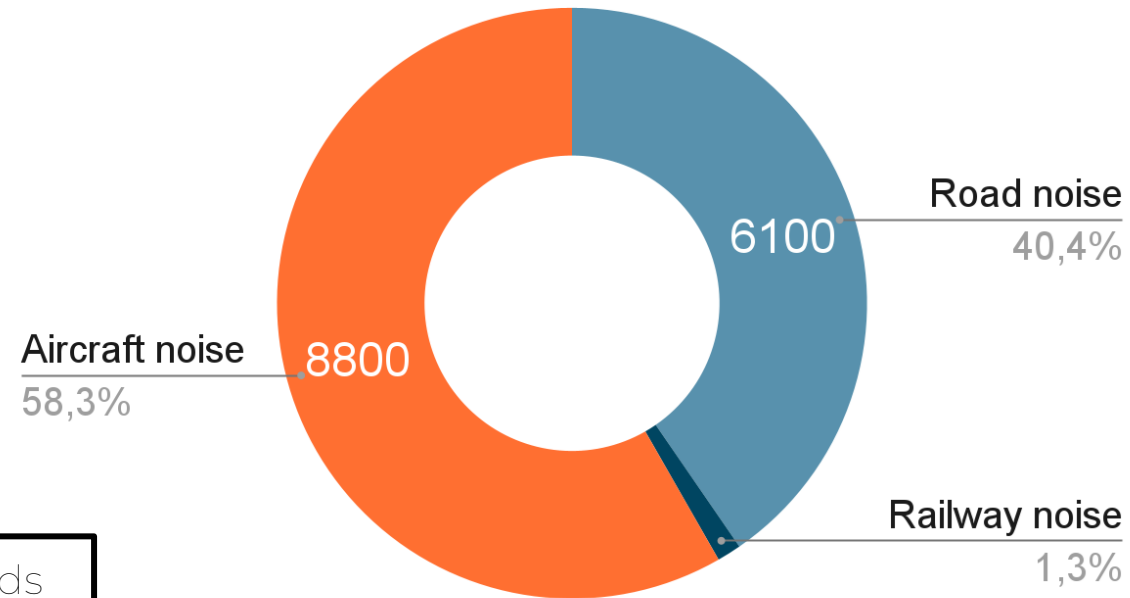
Great Nantes multi-source (road, rail, aircraft and industrial) noise map expressed by Lden.



[Nantes Métropole, 2023]

No. of individuals exposed beyond limit value by noise source.

## Lden indicator



Noise level thresholds  
[dB(A)]:

Road: 68 dB(A)  
Railway: 73 dB(A)  
Aircraft: 55 dB(A)  
Industrial: 71 dB(A)

Plan de Prévention du Bruit dans  
l'Environnement (Nantes Métropole, 2024 )

# Limits of exposure assessment in Europe

1. Static and residential exposure: it assumes people remain at home all day, without accounting for everyday mobility;
2. Averaged long-term exposure: it estimates exposure using long-term noise levels, masking short-term fluctuations;
3. Homogeneous population: the assessment of the socio-economic groups the most affected by noise is not promoted.

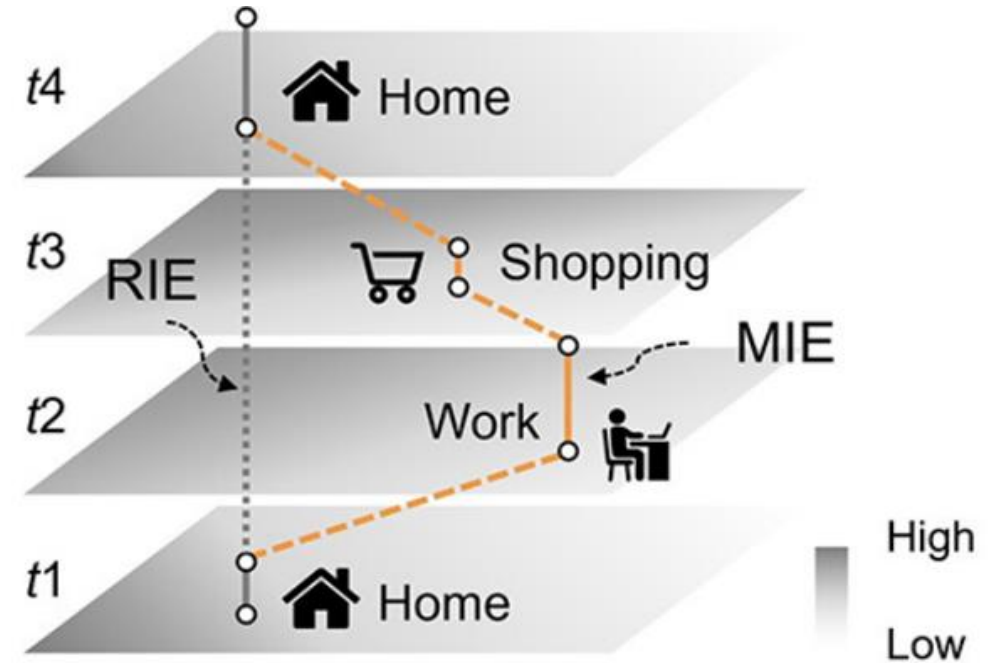
# Everyday mobility in exposure assessment:

Exposure as process:

Two spatio-temporal layers are needed:

1. The daily trajectory of individuals;
2. The daily evolution of environmental conditions.

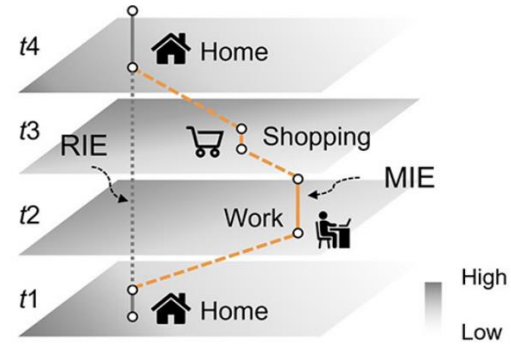
Mobility- and residential-based individual environmental exposure



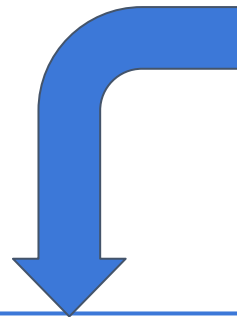
[Cai and Kwan 2024]

# Everyday mobility into exposure assessment

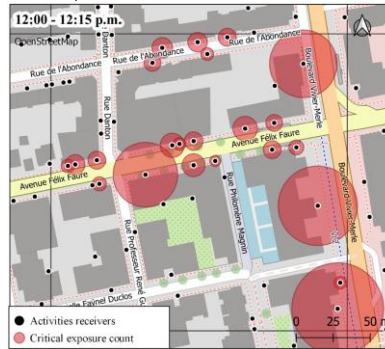
V Le Bescond, 2021  
L.G. Luquezi al. 2024



Negative effects on health

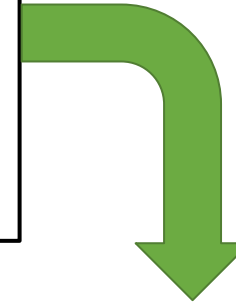


## Critical noise exposure areas

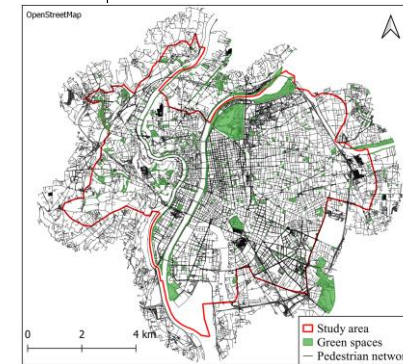


L.G. Luquezi al. 2025

Positive effects on health

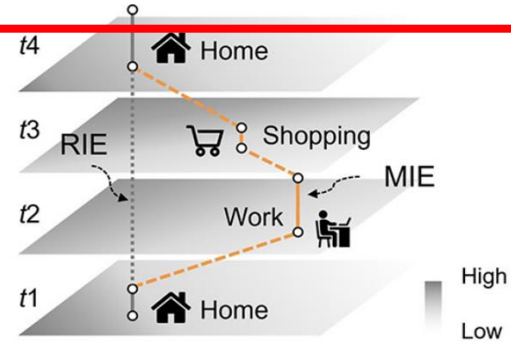


## Population access to quiet areas



L.G. Luquezi al. 2025

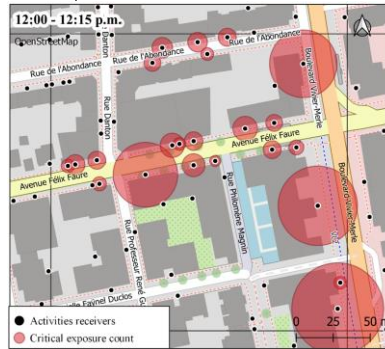
# Everyday mobility into exposure assessment



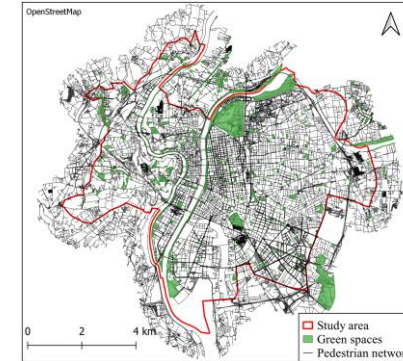
Negative effects on health

Positive effects on health

## Critical noise exposure areas



## Population access to quiet areas



# Methods

Agent-based transport models:

Individual-traveler who attempts to perform his daily activities

## Synthetic population



Households



Agents

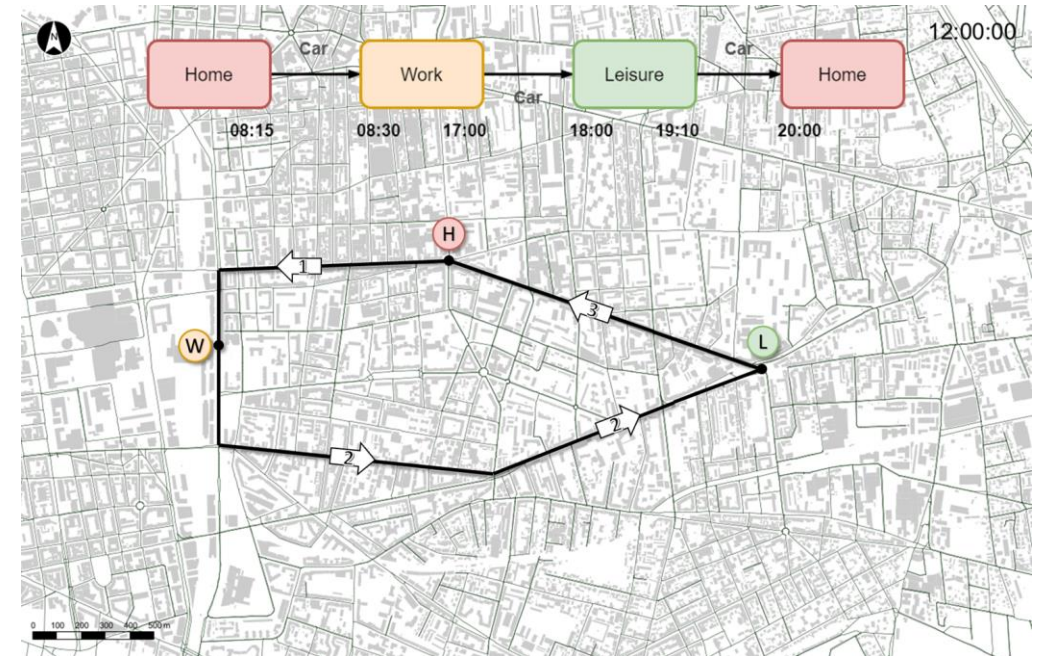


Activity plans

eqasim

[eqasim.org](http://eqasim.org)

## Activity plan

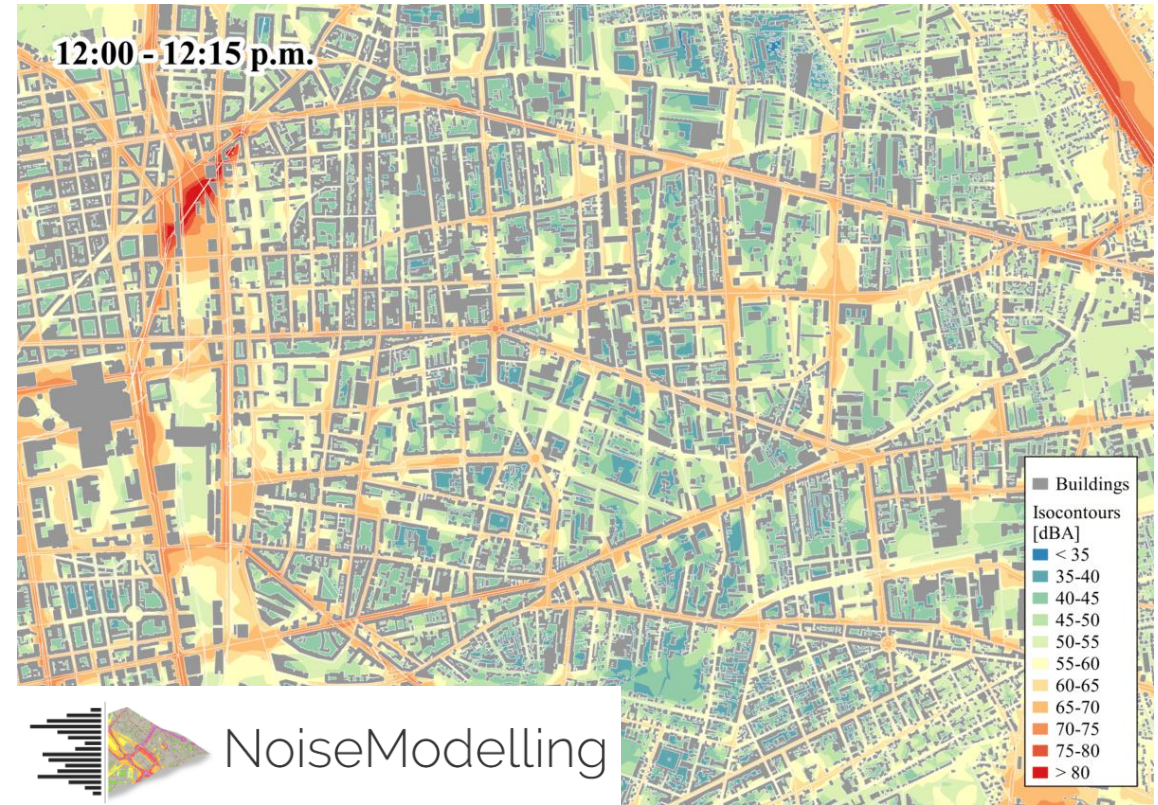


## Agent-based transport simulation



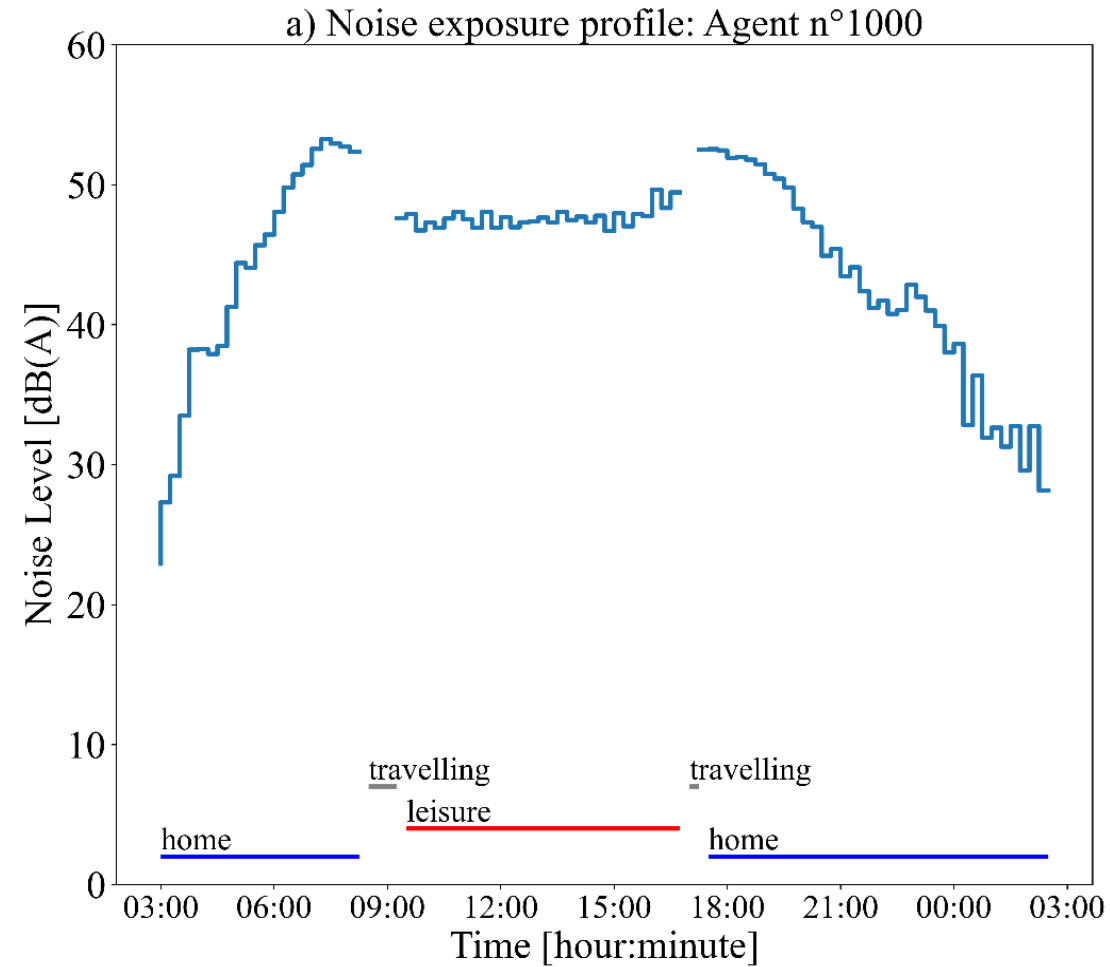
Modes: car, public transport, bike, walk  
Activities: home, work, education, shop, leisure, others.

## Dynamic noise maps

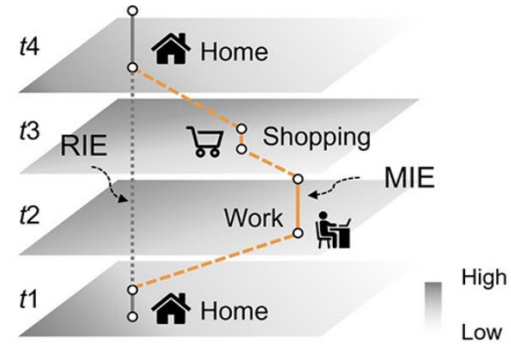


Road traffic noise: LAeq,15-min

Exposure profile to road noise for one simulated agent



# Everyday mobility into exposure assessment



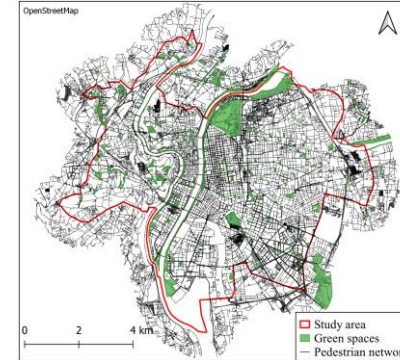
Negative effects on health

Positive effects on health

## Critical noise exposure areas



## Population access to quiet areas



# Assessing critical exposure areas

a) Definition of critical exposure:

Selected indicator:

$L_{Aeq,15 \text{ min}} \geq 65 \text{ dB(A)}$

b) Definition of critical areas:

Selected indicator:

Occurrence of critical exposure in a 15-minute interval.

Noise map and number of agents in facilities exposed to critical noise levels ( $L_{Aeq,15\text{min}} \geq 65$ ) between 12:00 and 12:15



L.G. Luquezi et al. 2025

# Lyon Metropolitan Area application

Model area:

Lyon Metropolitan Area.

Population:

1.4 million inhabitants.

Synthetic population:

100% sampling rate.

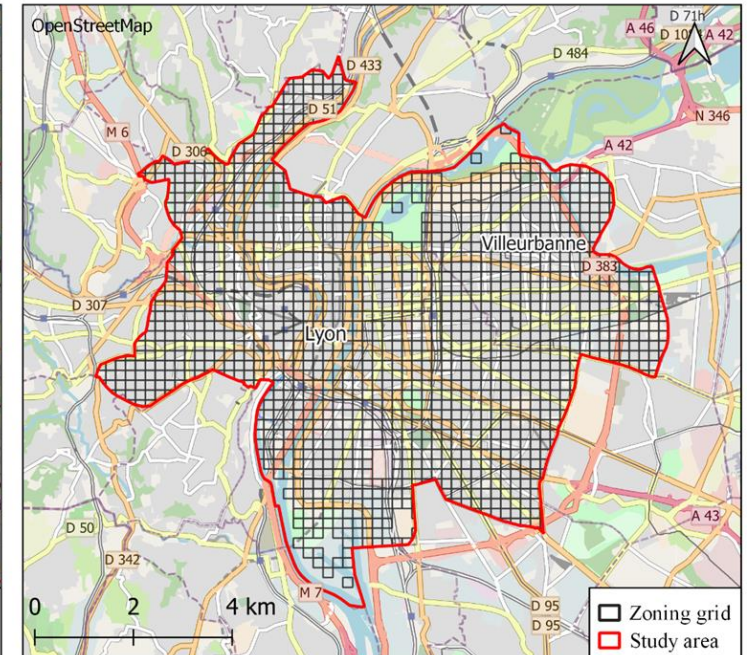
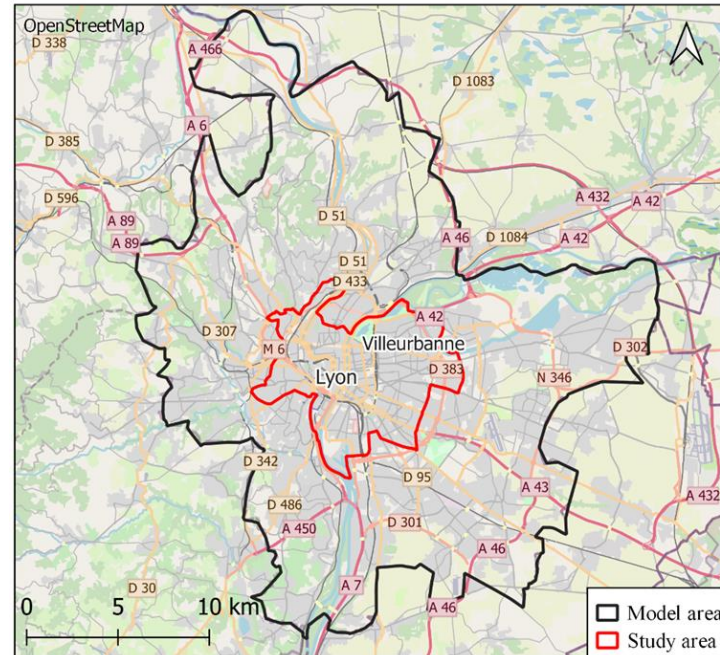
Study area:

Lyon and Villeurbanne.

Period:

06h00 to 22h00

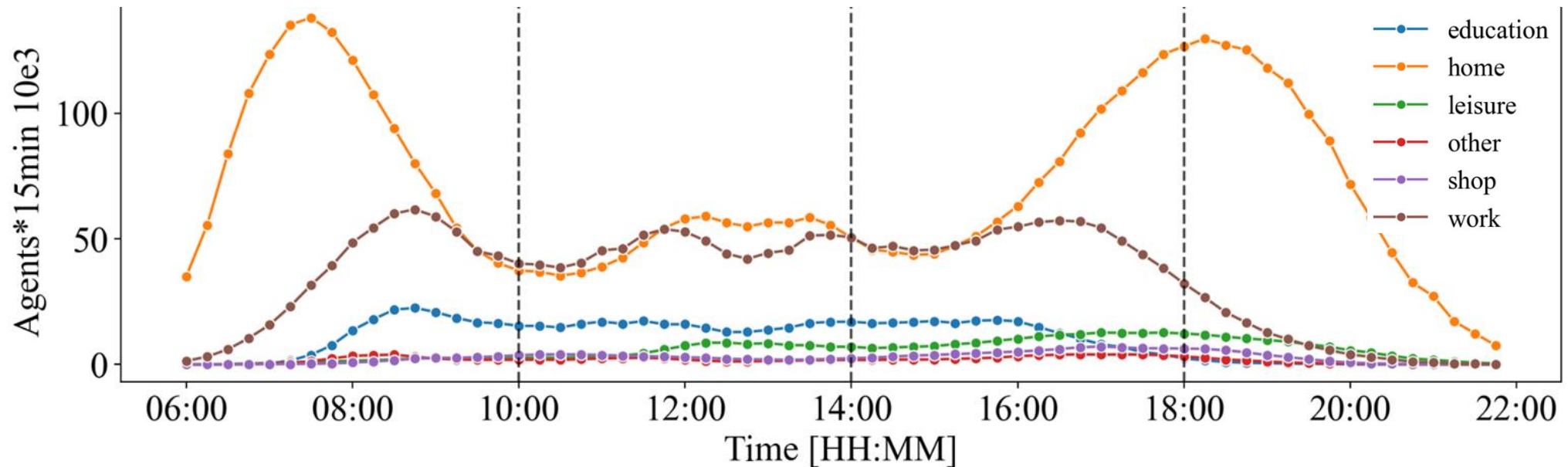
Model area, study area, and zoning grid of the agent-based framework of Lyon Metropolitan Area.



Homogeneous-grid: cell 200x200 meters

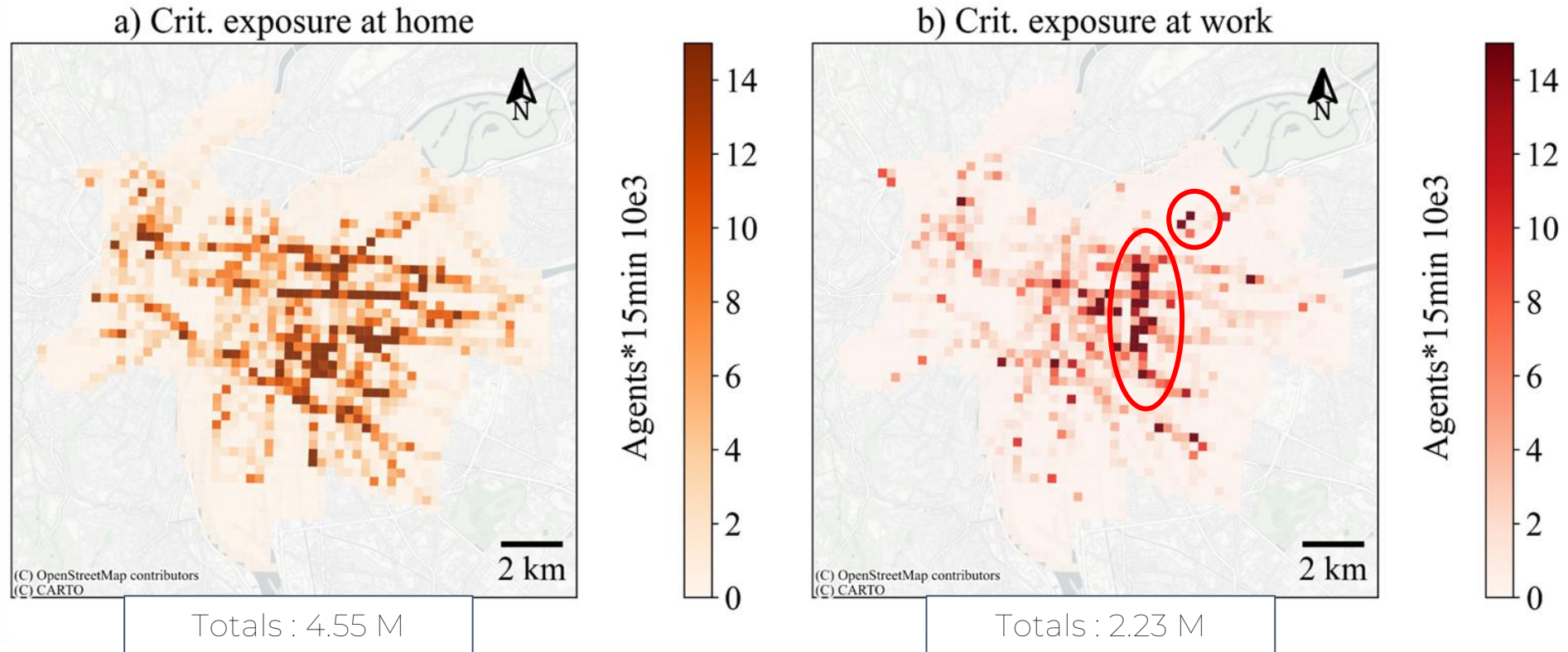
# Temporal distribution of critical exposure occurrences by activity

Number of agents critically exposed to road noise ( $L_{Aeq,15min} \geq 65dB(A)$ ) by activity in the study area



# Spatial distribution of critical exposures

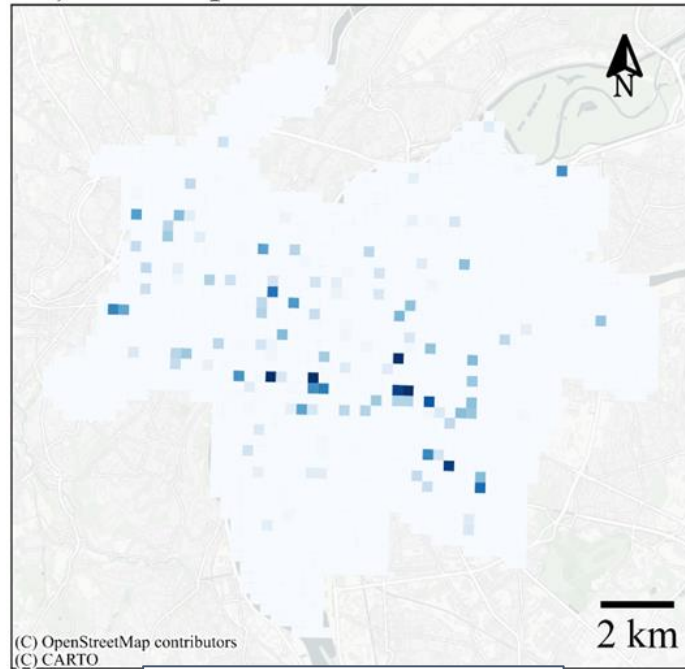
Critical exposure areas between 06:00 and 22:00 segmented by activities



# Critical exposures of young agents

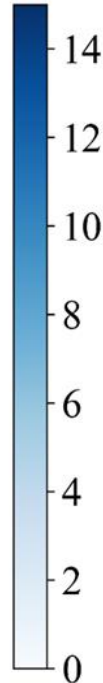
Critical exposure areas for agents with an age range of 0–15 years between 06:00 and 22:00 segmented by activity

a) Crit. exposure: 00-15 at education

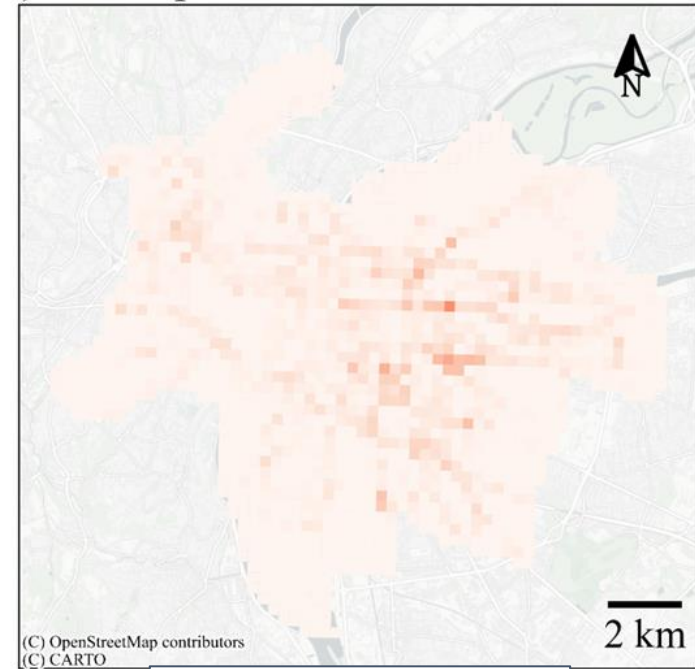


Totals : 0.52 M

Agents\*15min 10e3

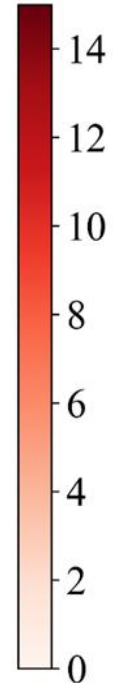


b) Crit. exposure: 00-15 at other activities

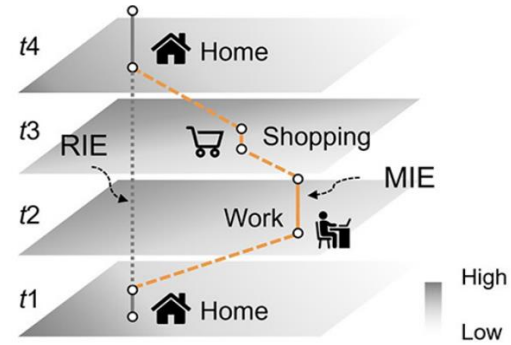


Totals : 0.61 M

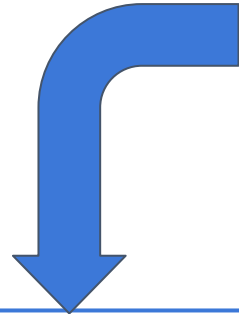
Agents\*15min 10e3



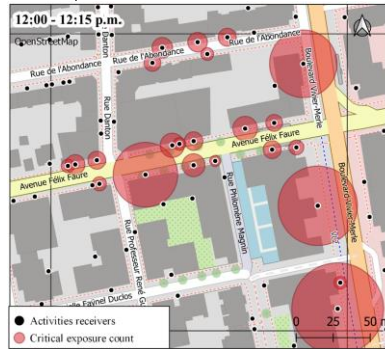
# Everyday mobility into exposure assessment



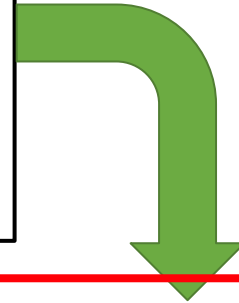
Negative effects on health



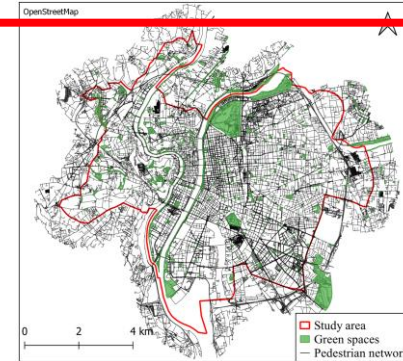
## Critical noise exposure areas



Positive effects on health



## Population access to quiet areas



## Metrics for quiet areas accessibility

a) Eligible spaces : green spaces

b) Definition of quiet area:

Selected indicator:

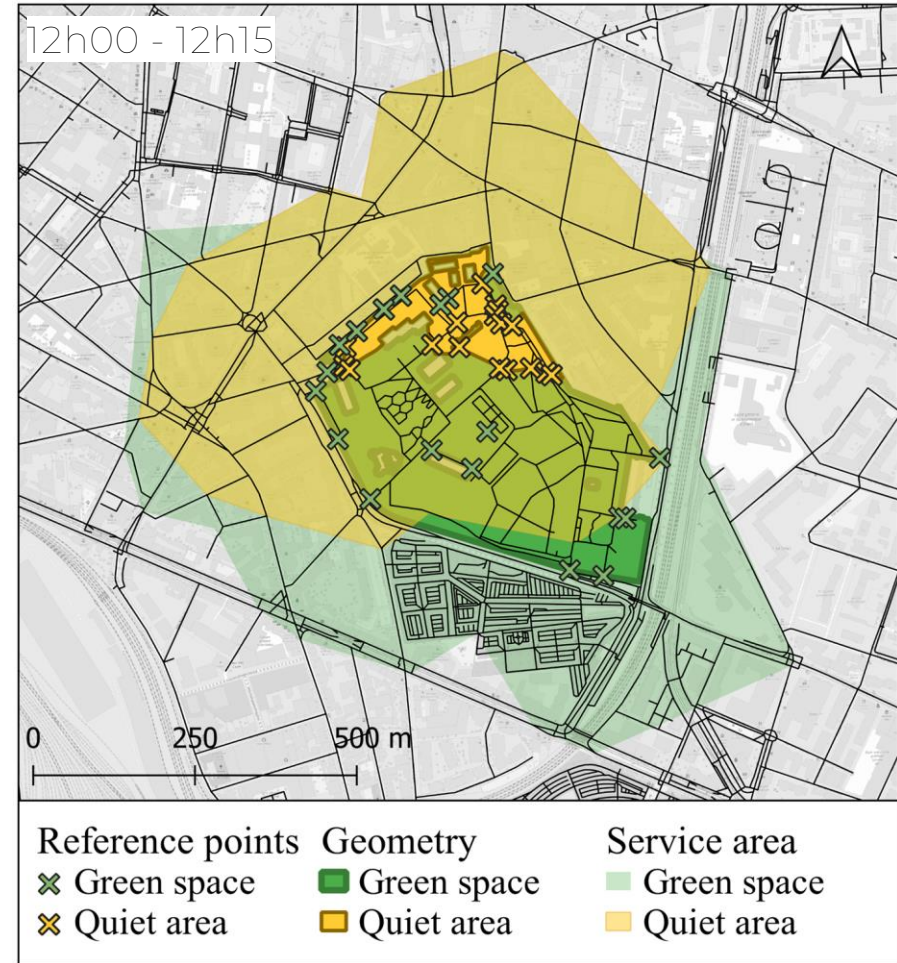
- $L_{Aeq,15-min} \leq 50 \text{ dB(A)}$
- Minimum size of  $100 \text{ m}^2$

c) Definition of accessibility:

Selected indicator:

- 'Within 5 minutes walk'

Service areas of green space and its quiet areas for a 5-minute walk at 4.5 km/h



Python OSMnx

# Lyon Metropolitan Area application

Open and green spaces and pedestrian network of the study area of Lyon

Model area:

Lyon Metropolitan Area.

Population:

1.4 million inhabitants.

Synthetic population:

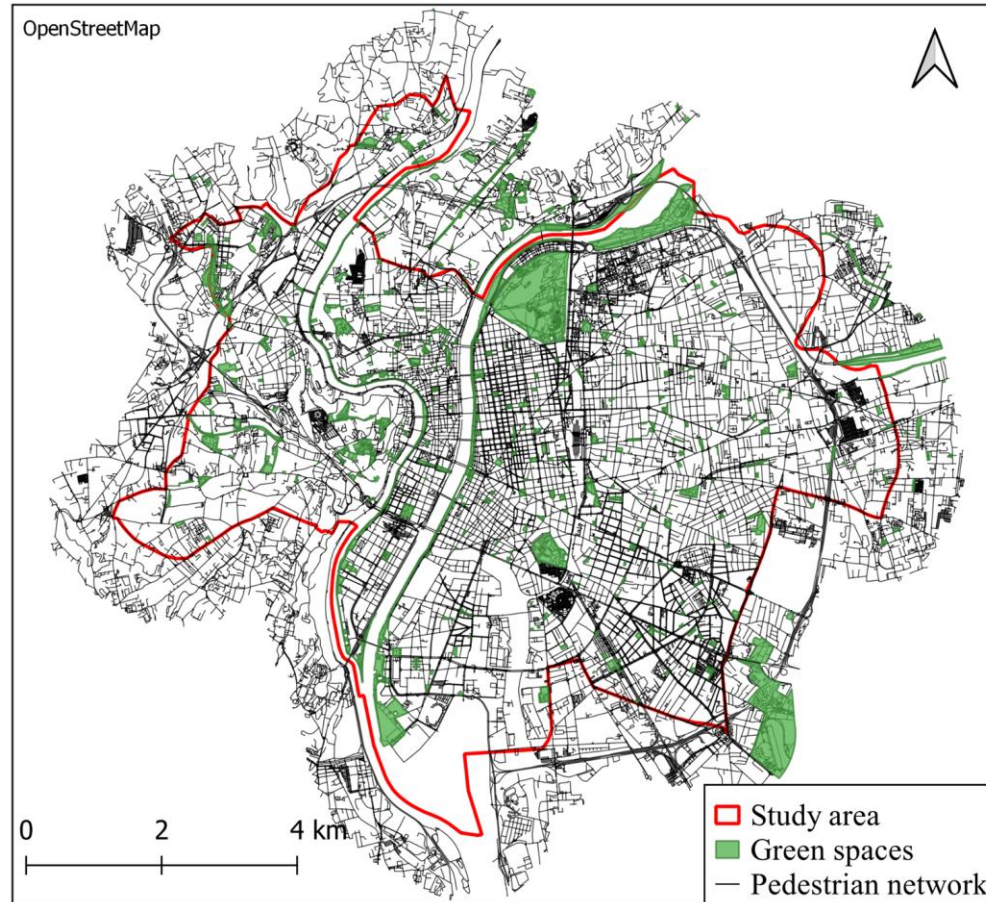
100% sampling rate.

Study area:

Lyon and Villeurbanne.

Period:

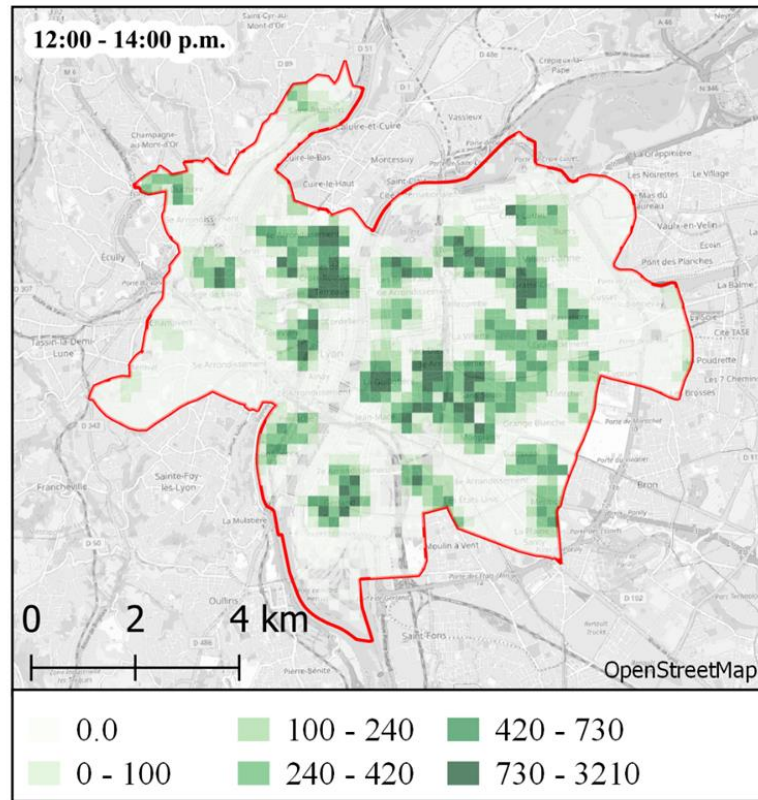
12h00 to 14h00 (lunch break)



# Spatialization of accessibility

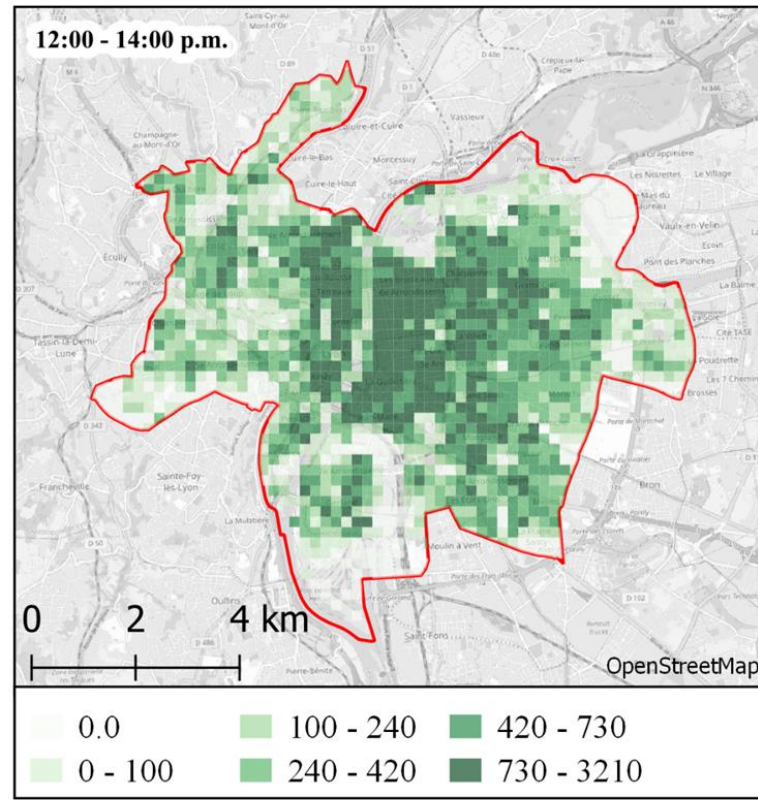
Temporal average of the no. of agents with access to a quiet area or to a green space between 12:00 - 14:00

a) Number of agents with access to a quiet area



30 % of moving agents with access

b) Number of agents with access to a green space



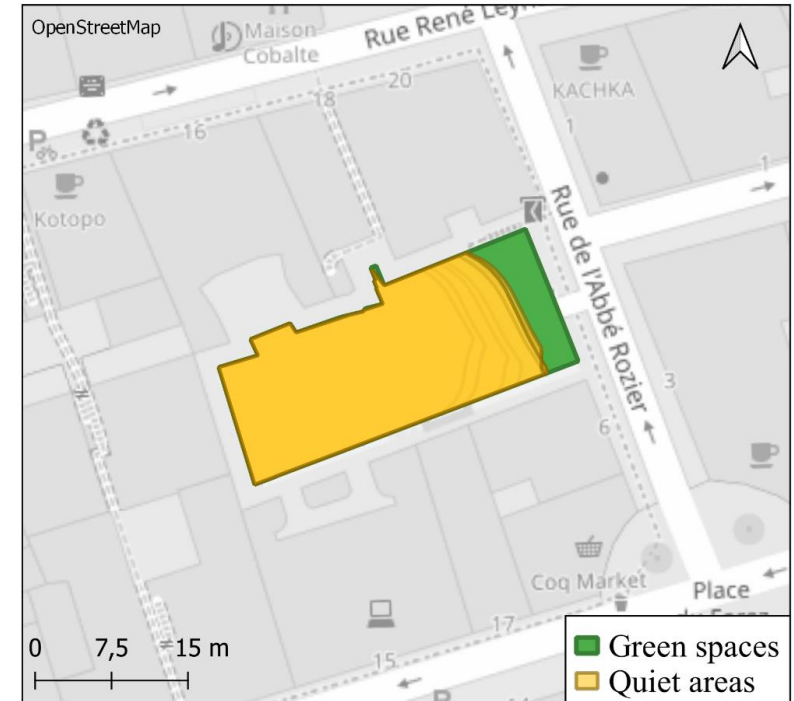
80 % of moving agents with access

## Quiet areas with high accessibility

Green spaces ordered by temporal average of the number of agents with access to their current quiet areas between 12:00 and 14:00.

Name	Category	$\bar{n}$ [No.]	$\bar{s}$ [m <sup>2</sup> ]
<b>Jardin Dalle Rozier</b>	Garden	9,177	354
Jardin Saint Michel	Garden	7,941	1,637
Jardin Clos Carret	Garden	7,786	2,920
Jardin de la Grande Côte	Garden	7,145	3,870
Jardin d'Essling	Garden	6,965	320

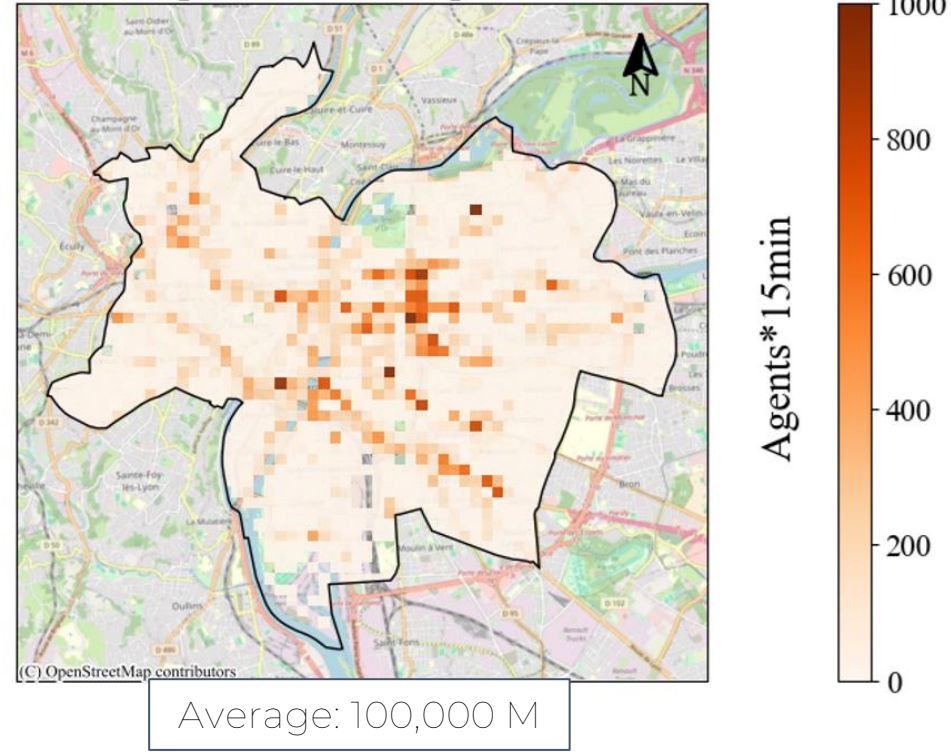
a) Jardin Dalle Rozier (Garden)



# Cross-analysis: environmental impact and opportunities.

Temporal average between 12:00 and 14:00 of the number of agents critically exposed without access to at least one quiet area

Critical exposure without quiet area access



# Overall discussion

Future improvements for agent-based exposure models

## 1 / 3) Contextual impacts assessment:

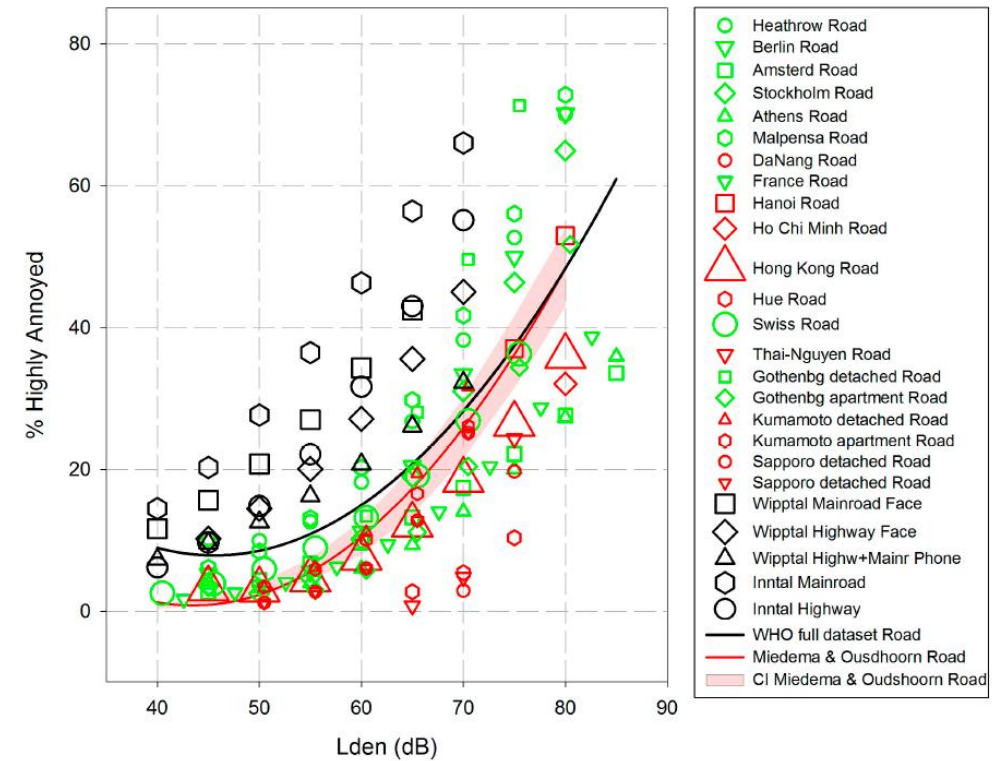
Standard exposure-response functions:

Long-exposure dose at home to annoyance.

Contextual exposure-response function:

Functions that take into account different times of the day, activity contexts, and individual characteristics (e.g. noise sensitivity).

Relation between day-evening-night noise level and percentage of individuals Highly Annoyed.



(Guski et al. 2017; Miedema and Oudshoorn 2001)

## 2 / 3) Contribution of microscopic traffic models:

Energy based indicators:

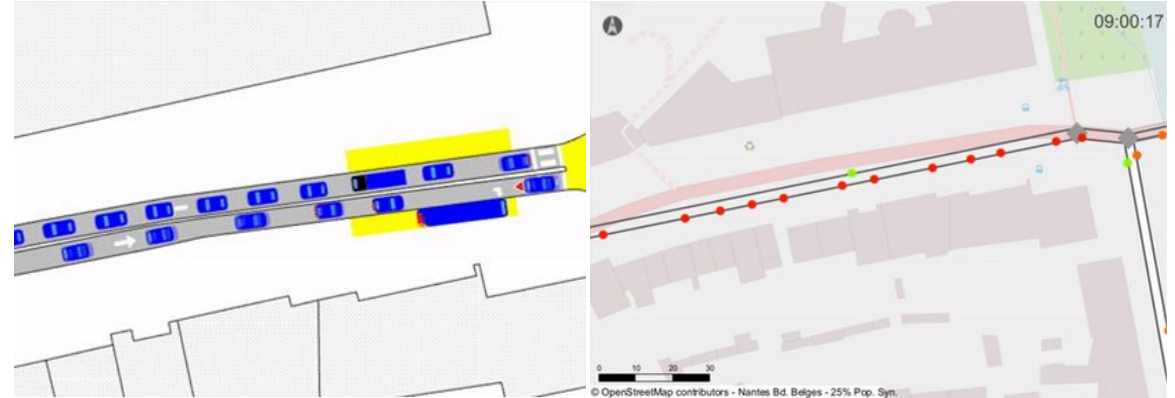
L<sub>Aeq,T</sub> : Several minutes resolution

Detailed temporal acoustic content:

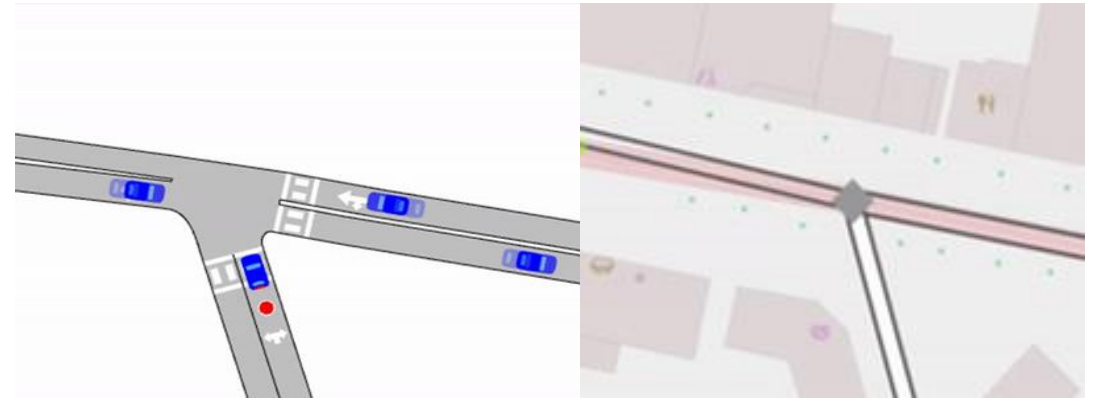
Detailed simulation of the traffic behavior, which means detailed noise dynamics:

- Number of noise peaks
- Intermittency ratio

Car-following (AIMSUN / MATSim)



Vehicle lane insertion (AIMSUN / MATSim)



## 3 / 3) Population vulnerability in noise assessment

What are the determinants of noise exposure vulnerability?

- Health attributes of the population (e.g. sensitivity to noise) ?
- Precise location of the dwelling (e.g. bedroom at quiet façade) ?
- The acoustic insulation of facilities ?

Improvement pathways to elaborate noise action plans targeting the most exposed, sensitive, and vulnerable groups.

# Conclusion

## Agent-based exposure models:

Integration of everyday mobility in noise exposure assessment:

1. Assessment of noise impacts;
2. Assessment of environmental opportunities;

Spatial, temporal and social enhancements of exposure assessment.

Challenges around modeling exposure at the individual scale.

Exposure science in progress...

# Thank you for your attention!

References :

L. G. Luquezi, P. Aumond, P. Gastineau, V. Le Bescond, and A. Can. Current limitations and opportunities for improvements of agent-based transport models for noise exposure assessment. *Journal of Environmental Management*, 2024. 368 (2024), p. 122129

L. G. Luquezi, V. Le Bescond, P. Aumond, P. Gastineau and A. Can. Assessing accessibility to quiet and green areas at the city scale using an agent-based transport model. *Journal of Landscape and Urban Planning*, 2025.

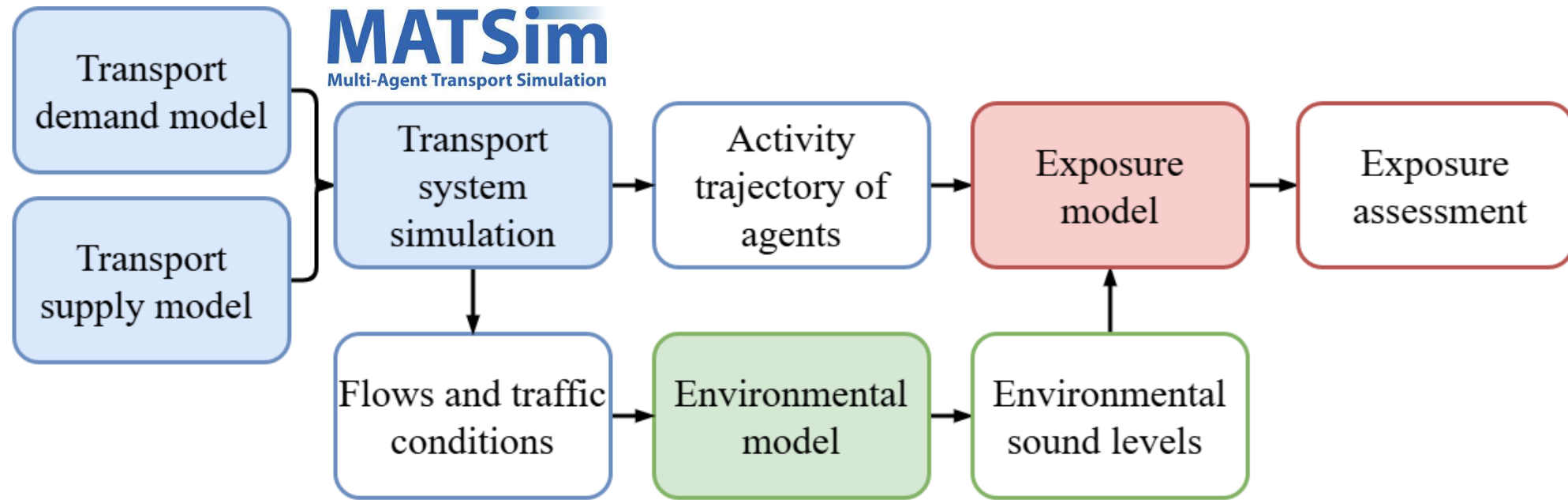
L.G. Luquezi, V. Le Bescond, P. Aumond, P. Gastineau and A. Can. Including everyday mobility with agent-based models in the assessment of urban critical areas of noise exposure. *Journal of Sustainable Cities and Society*, 2025.



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# Agent-based exposure framework

eqasim



[eqasim.org](http://eqasim.org)  
[matsim.org](http://matsim.org)  
[noisemodelling.readthedocs.io/en/latest/Matsim\\_Tutorial.html](http://noisemodelling.readthedocs.io/en/latest/Matsim_Tutorial.html)

# Transport demand modeling

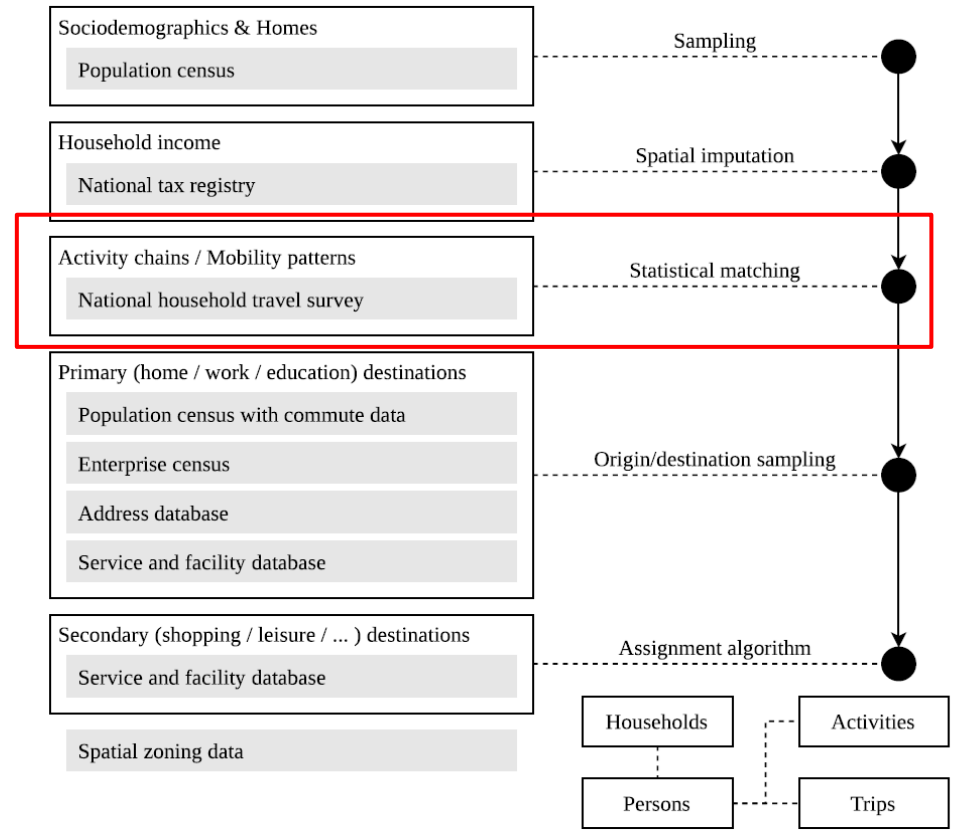
Statistical matching:

Matching between census survey and household travel survey

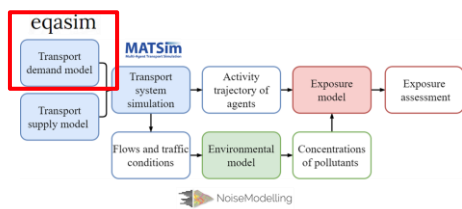
Activities:

Home, study, work, leisure, shop, others

General setup of the synthesis pipeline



(Hörl and Balac 2021b)



# Data used: Full Open data

Table: Input data of the agent-based exposure model of Lyon Metropolitan Area

Data category	Data type	Source	Date	Service
<b>Population data</b>	French population census	Recensement de la population - Fichiers détail	2015	INSEE
	French population census	Recensement de la population - Base infracommunale (IRIS)	2017	INSEE
	Households income	Revenus localisés sociaux et fiscaux	2015	INSEE
<b>Mobility behaviour data</b>	Work and education commute data	RP-MOBPRO / RP-MOBSCO	2015	INSEE
	Household travel survey	EDGT Lyon 2015	2015	CEREMA
<b>Territory and infrastructure data</b>	Transport infrastructures	OpenStreetMap	2021	OpenStreetMap
	Public transport lines	SNCF, TCL, TGV, Rhône Express, etc.	2021	SNCF, TCL, TGV, Rhône Express
	National address database	BD-TOPO	2020	IGN
	National service and facility database	Base permanente des équipements (BPE)	2020	INSEE
	National enterprise census	Système national d'identification et du répertoire des entreprises et de leurs établissements (SIRENE)	2020	INSEE
	Buildings geometries	OpenStreetMap	2021	OpenStreetMap
	Statistical zoning system	Contours IRIS	2017	IGN
	Statistical zoning system	Table d'appartenance géographique des IRIS	2017	INSEE

# Acoustic model:

Table: Parameters of the acoustic model of the Lyon Metropolitan Area framework.

Parameter	Description / Value
Method	CNOSSOS
Maximum source distance	750 m
Maximum reflection distance	50 m
Reflection order	1
Vertical diffraction	Disabled
Horizontal diffraction	Enabled
Absorption by the ground	Fully reflective
Topography	Homogeneous (flat land)
Meteorology	50% favorable occurrence (all directions)
Tunnels	Neglected
Road surface	Fine broomed concrete (NL08)
Buildings (shielding effect)	Enabled (OpenStreetMap)
Noise sources	Road traffic (car and bus)

# Summary of ABM characteristics:

Table: Attributes and features of the current state of agent-based exposure models for environmental noise assessment

Attributes / Features	Description
Transport demand	Synthetic population
Demand resolution	Everyday mobility
Agent attributes	Personal, household, neighborhood attributes
Spatial resolution	Large-scale (cities and regions)
Temporal resolution	Dynamic, several minutes
Period resolution	Typical 24-hour weekday
Traffic simulator resolution	Mesosopic
Network resolution	Network graphs (links and nodes)
Modes of transport	Car, public transport, bicycle, walking
Activity groups	Home, work, study, leisure, shop, others
Acoustic resolution	Energy-based indicators
Noise indicators	L <sub>Aeq</sub> , L <sub>den</sub> , L <sub>n</sub> , etc.
Study territories	Major global agglomerations