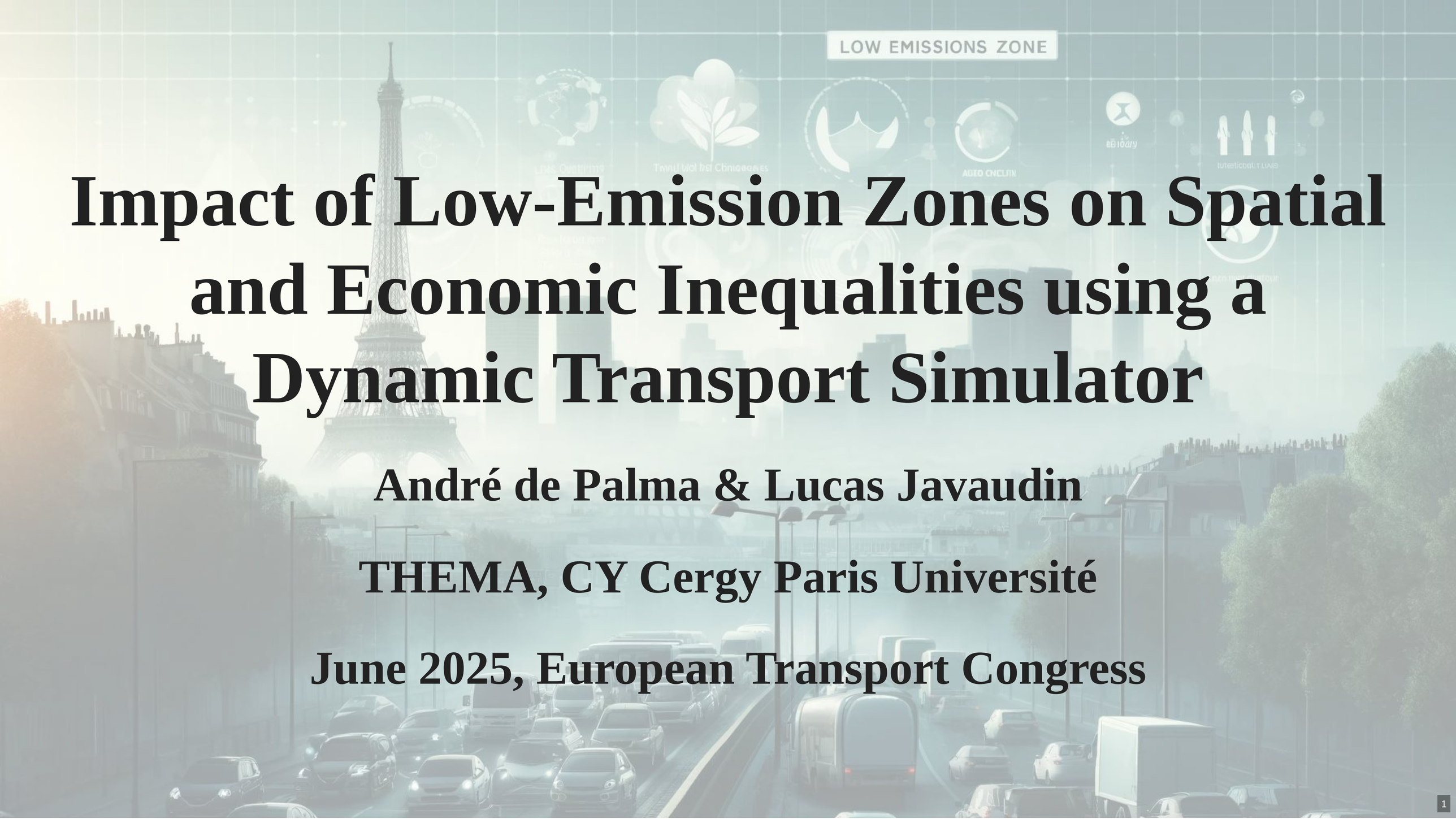

Impact of Low-Emission Zones on Spatial and Economic Inequalities using a Dynamic Transport Simulator

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June 2025, European Transport Congress

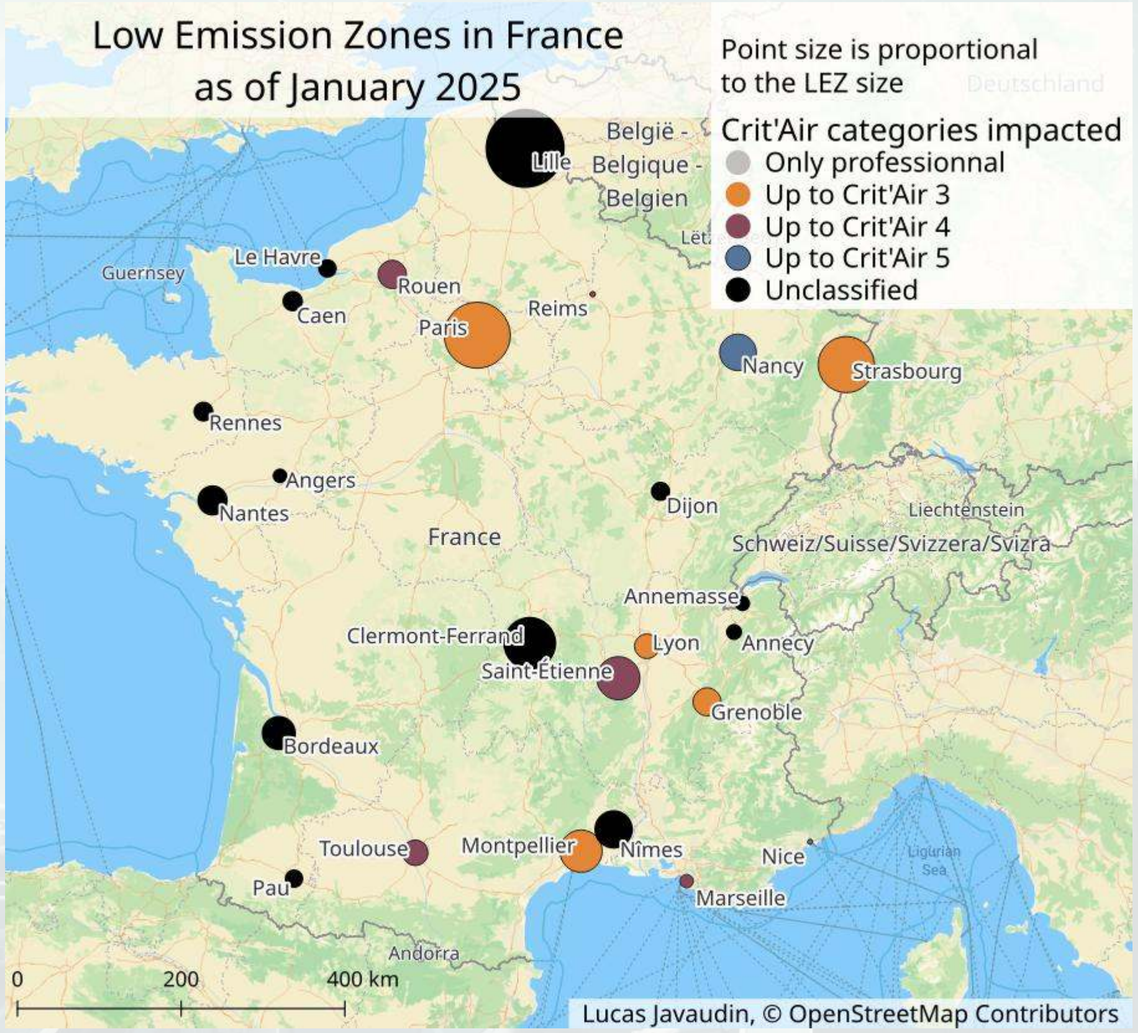
Introduction

Context

- Road transport sector is responsible for **37 % of nitrogen oxides emissions** (NO_X) in Europe (EEA, 2021)
- Nitrogen oxide pollution causes around **40,000 premature deaths** yearly in Europe (EEA, 2021)
- Air pollution causes about **7,920 premature deaths yearly** in Paris' urban area, Île-de-France (AirParif, 2022)
- Popular instrument to improve air quality: **Low Emission Zones (LEZ)**

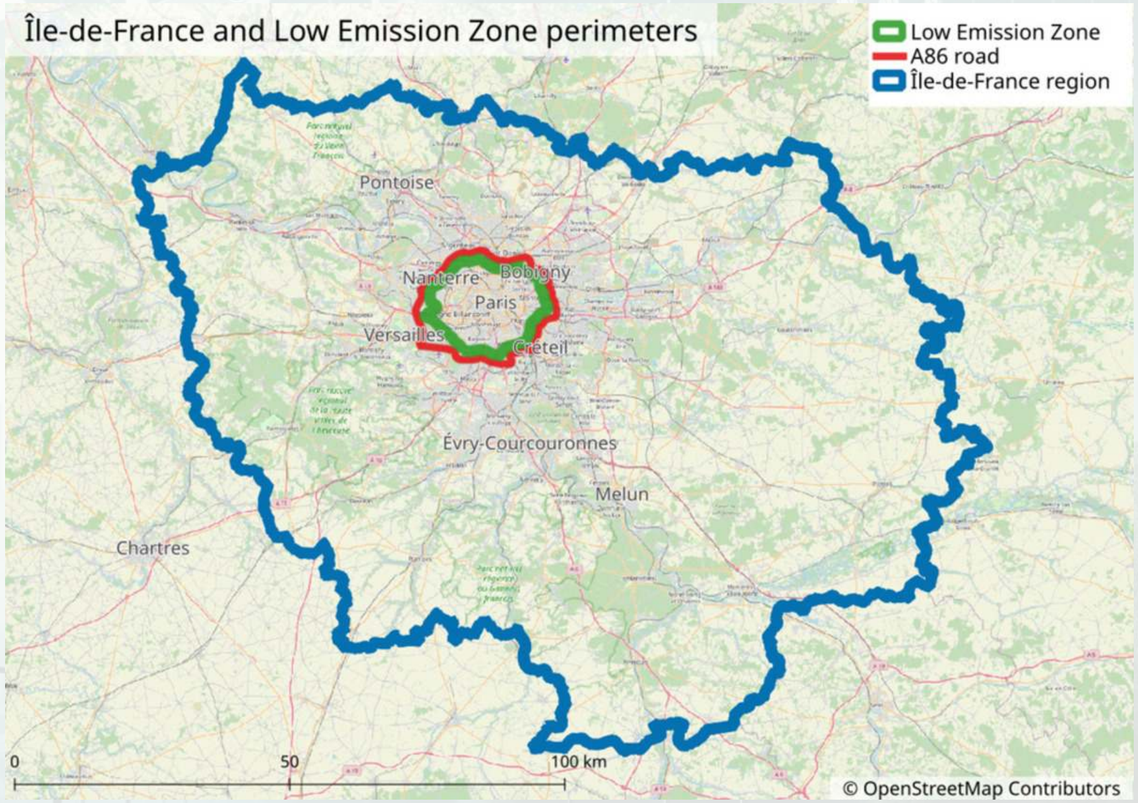
Low Emission Zones in France

- **Low Emission Zone:** area in the city center where the most polluting vehicles cannot travel
- In Europe, LEZs have been implemented in **hundreds of cities** as of today
- In France, 25 cities have implemented LEZs; cities are forced to implement a LEZ when pollution is above a threshold level
- [May 2025] Draft law in France that would prohibit LEZs across the country: "low-income households are now forced to choose between incurring significant additional costs to puchase a cleaner vehicle or giving up mobility altogether"



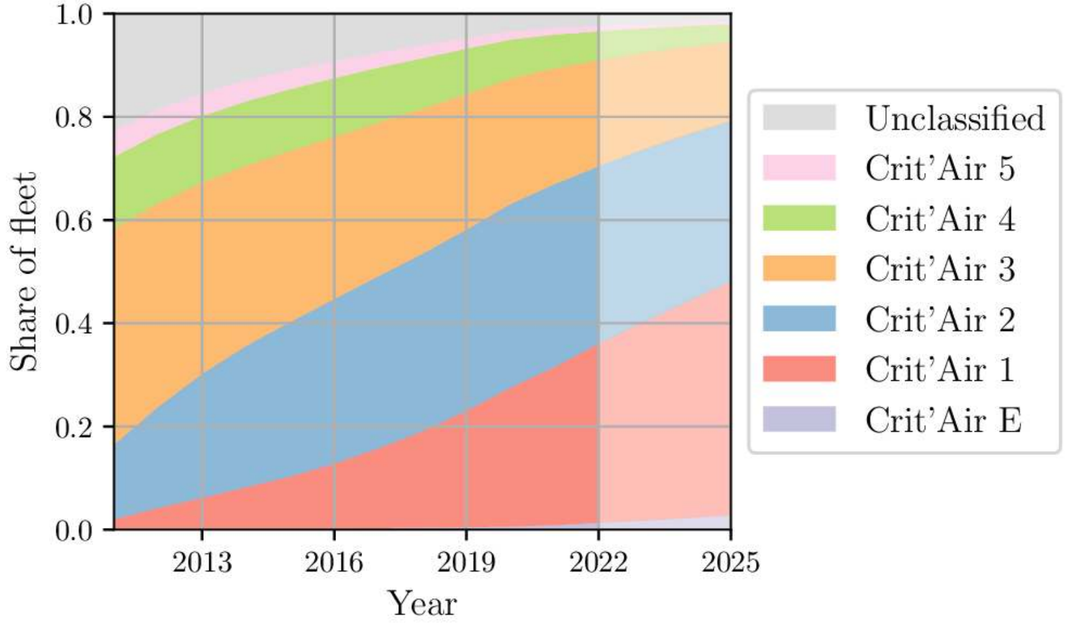
Paris' Low Emission Zone

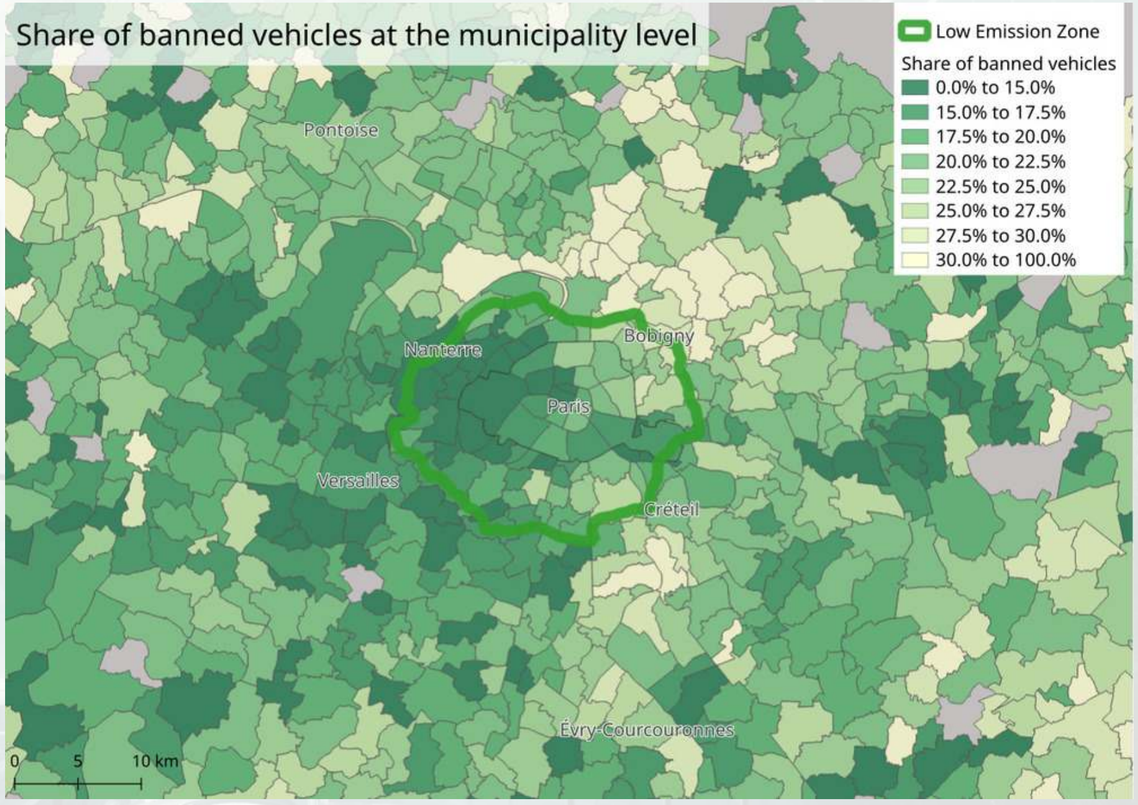
- Paris and 76 neighbor municipalities
- 367 km^2 area (3 % of Île-de-France)
- 5 M inhabitants (40 % of Île-de-France)
- A86 highway enables detours around the LEZ
- **Since January 2025:** Vehicles **Crit'Air 3 or worst** are banned
- Crit'Air categories are based on **fuel type** (diesel, petrol, electric, etc.) and **age**
- **68 € fine** for non-respect



Île-de-France Vehicle Fleet

- **Municipality-level vehicle fleet** data (with Crit'Air categories) from the Ministry of Ecology
- **Extrapolation** to predict the fleet in 2025
- In 2025, around **21 %** of vehicles in the region would be Crit'Air 3 or worst

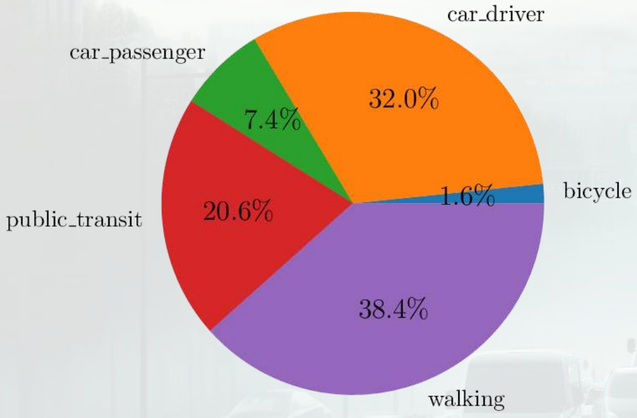


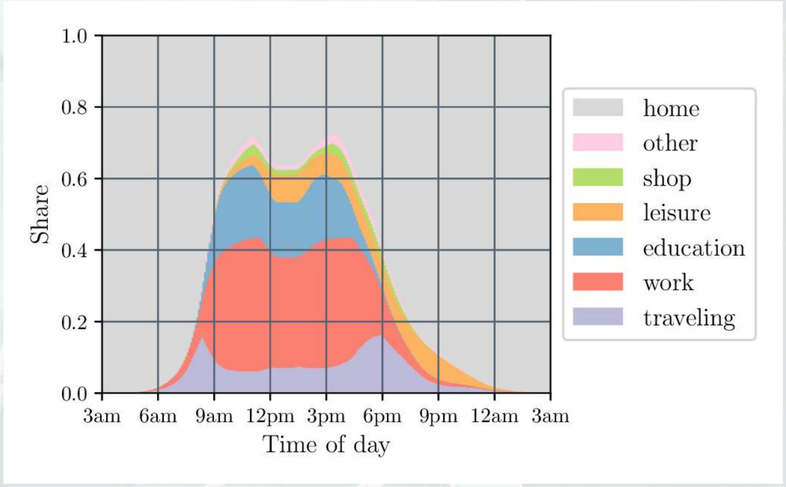


Methodology

Introduction

- We conduct **transport simulations** to evaluate ex-ante the impact of the LEZ in Paris
- **Scope:**
  - Île-de-France
  - Trips for an average working day
  - Five modes : car (driver), car (passenger), public transit, bicycle and walking
  - All trip purposes

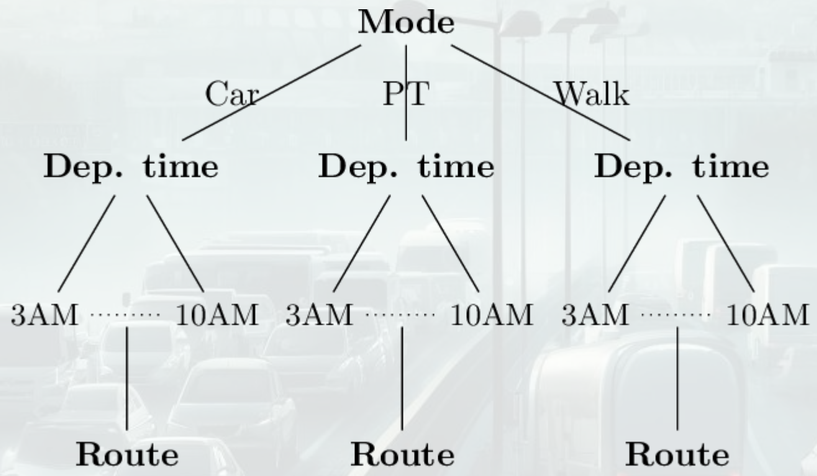




Source: Enquête Globale Transport (2010)

METROPOLIS2

- METROPOLIS2 is an **agent-based dynamic mesoscopic transport simulator**
- Simulation of **mode**, **departure time** and **route** choice, based on discrete-choice theory
- Congestion simulated from **bottlenecks** with queue propagation (spillback)
- Computation of **pollutant emissions** and **exposure of population to pollutants** with the METRO-TRACE module



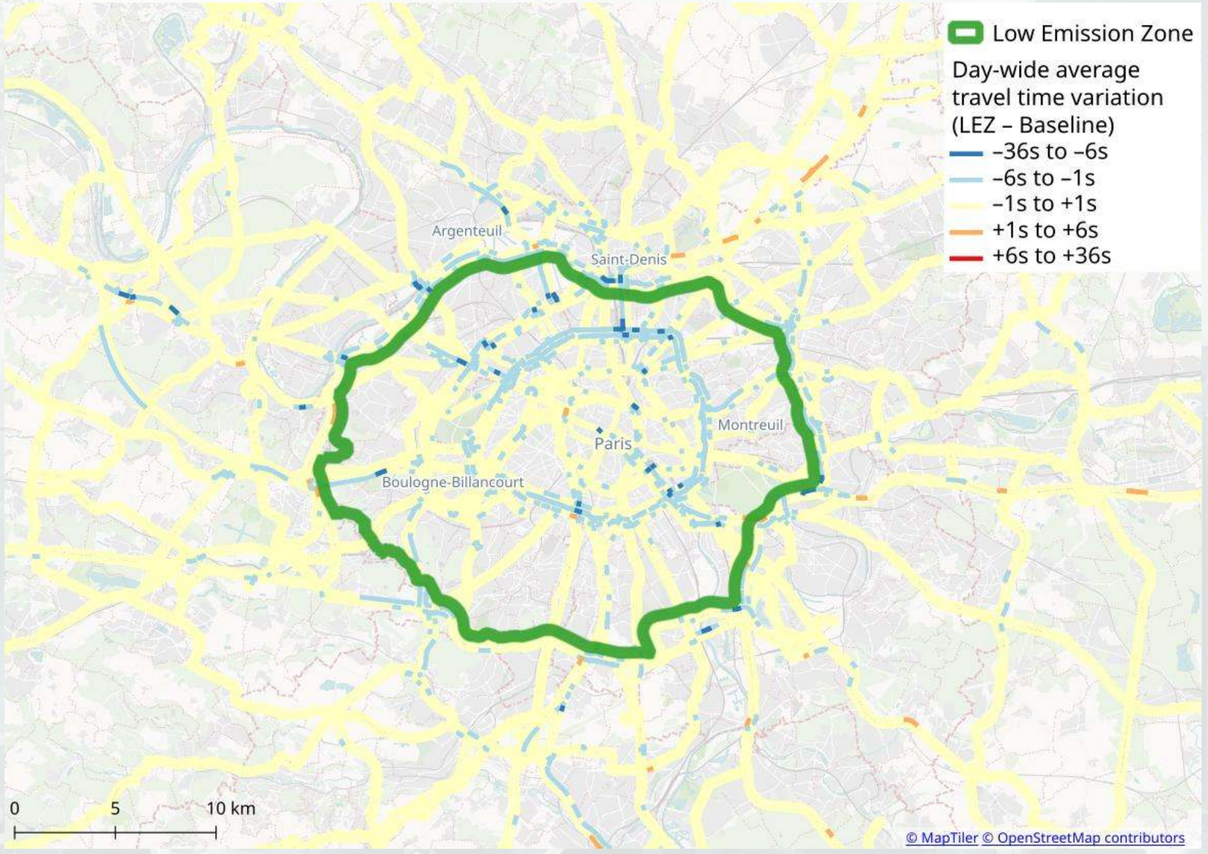
LEZ Policy Evaluation

- **Two METROPOLIS2 simulations:**
  - **Baseline** simulation (calibrated): no LEZ
  - **LEZ** simulation (counterfactual): January 2025 LEZ (Crit'Air 3 and worse)
- **Limits:**
  - Short-run analysis: no car-ownership model, no relocation (of activities or homes)
  - Temporal restrictions of the LEZ not considered
  - Exceptions and cheating not considered

Results

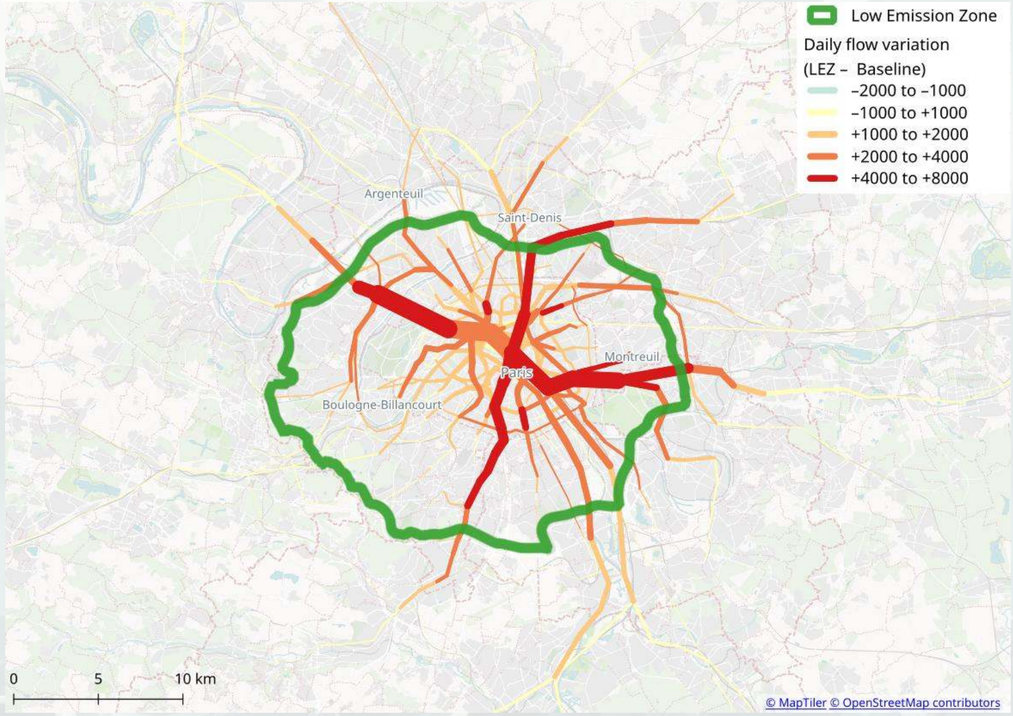
Road Congestion Impact

- Road congestion decreases on the main highways inside the LEZ (*Boulevard Périphérique* and A1 motorway)
- Little impact outside the LEZ



Public Transit Flows Impact

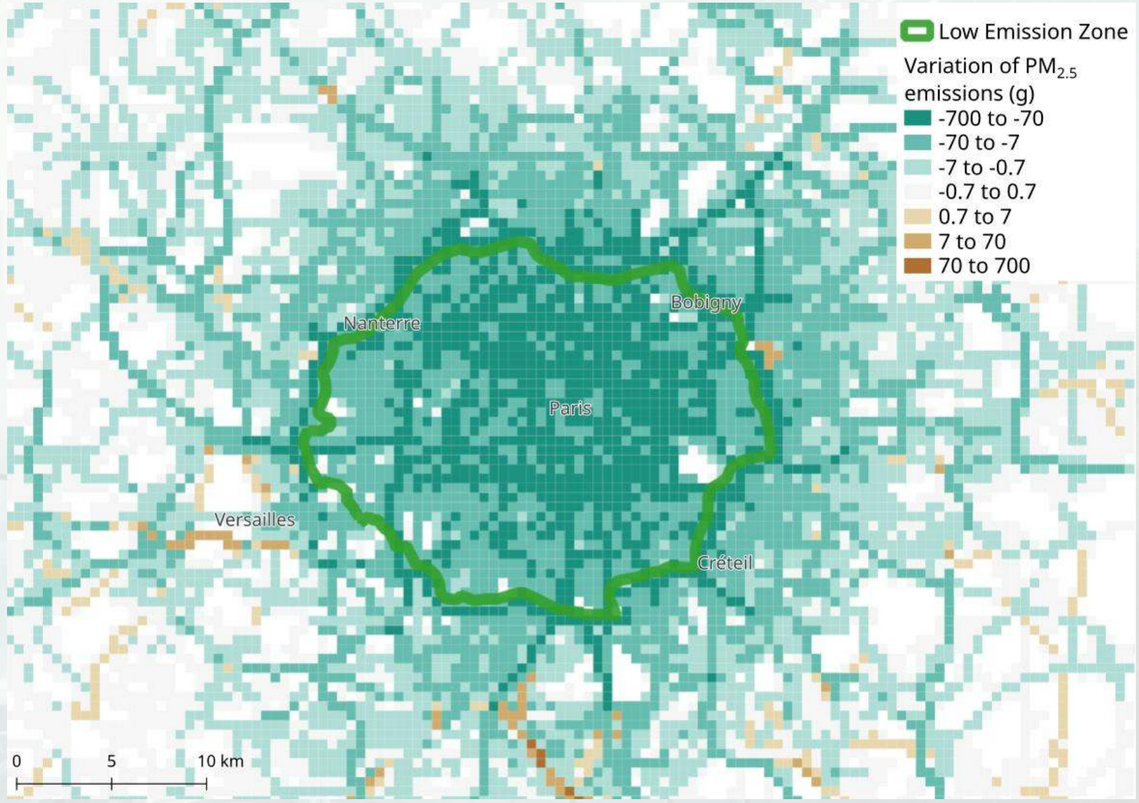
- Public transit mode share increases from 18.9% to 19.9%
- Larger flows on most legs, mainly in the surroundings of Paris (North, East and South)
- RER A: +1.2% passengers-kilometers
- RER B: +2.1% passengers-kilometers
- Tramway T7: +24.4% passengers-kilometers



Pollutant Emissions

- Emissions of **$PM_{2.5}$** and **NO_x** generated by road traffic are computed from the EMISENS model with COPERT emission factors
- Emissions depend on vehicles **fuel type** and **age** as well as **instantaneous speed** (link-level)
- Emissions decrease more inside the LEZ

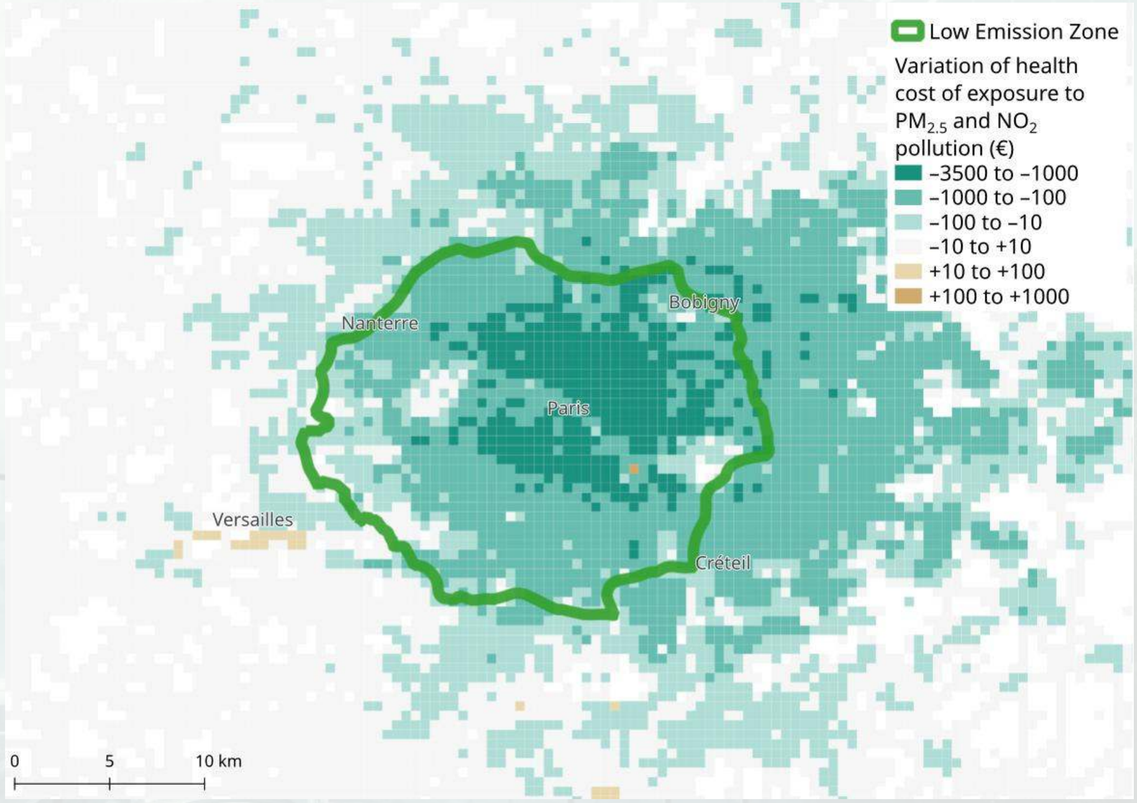
	Baseline	**LEZ**	**Variation**
$PM_{2.5}$ emissions	2.83 tons	2.66 tons	-6.0 %
NO_x emissions	33.32 tons	30.45 tons	-8.6 %
CO_2 emissions	21 730 tons	20 829 tons	-4.1 %



Population Exposure to Pollution

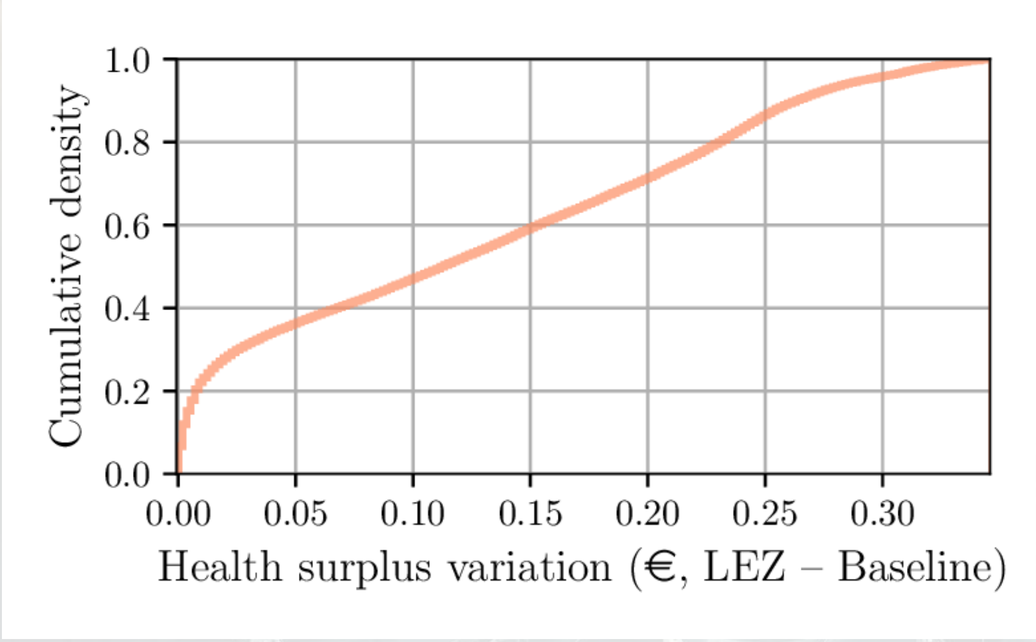
- Health impact is a function of the **increase in mortality due to exposure to pollutants**, given the concentration levels
- Exposure is computed based on the actual **location of individuals in time and space**
- Exposure decreases more near Paris (high concentration and high population density)

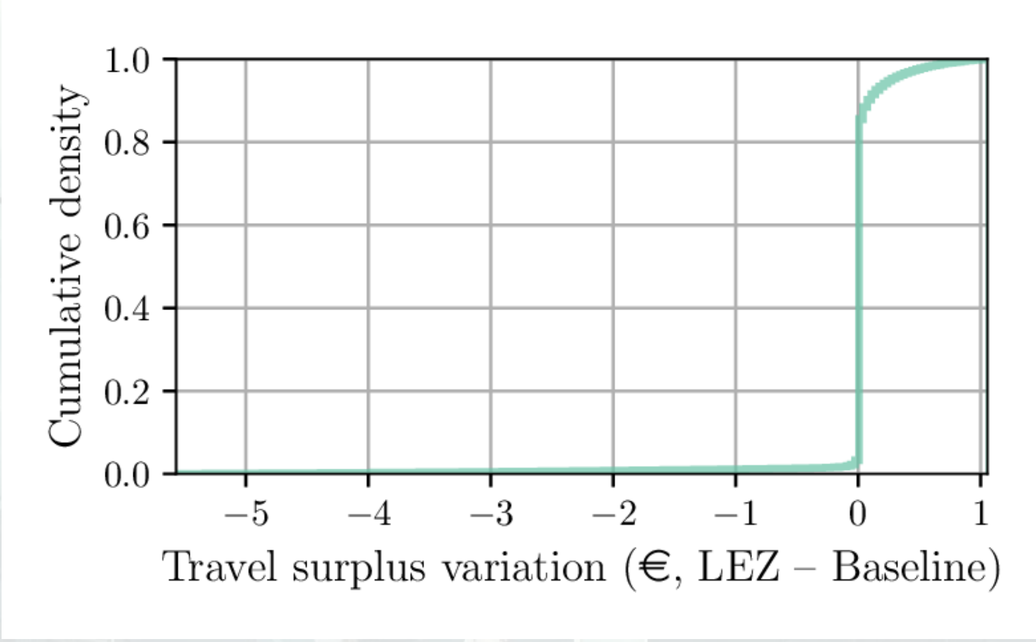
	Baseline	LEZ	Variation
$PM_{2.5}$ premature deaths	5.9	5.3	-9.4 %
NO_x premature deaths	5.4	4.9	-10.1 %
Health surplus	-12.537 M €	-11.312 M €	-9.8 %



Heterogeneous Impacts

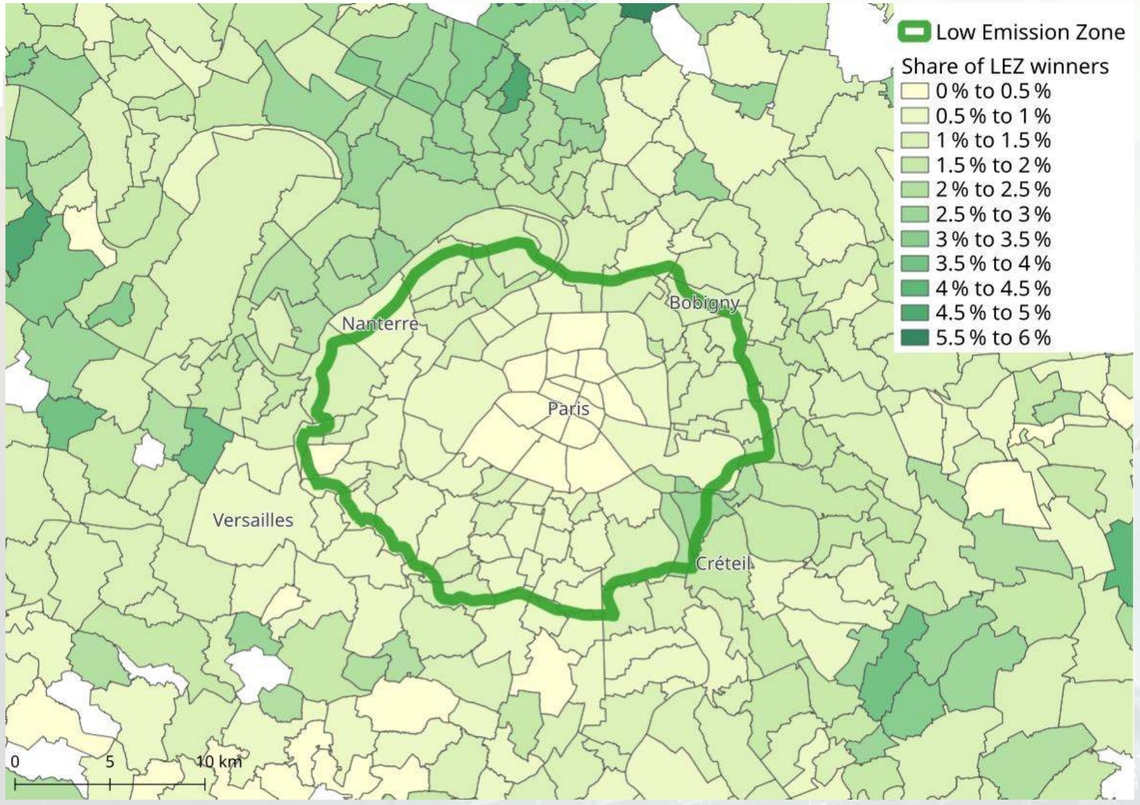
- **Health impact:** between 0 et +30 cents per day per individual
- **Travel impact:**
  - 93.2 % are not significantly impacted (variation smaller than 1 € daily)
  - 3.5 % "win" more than 1 € daily
  - 3.3 % "lose" more than 1 € daily



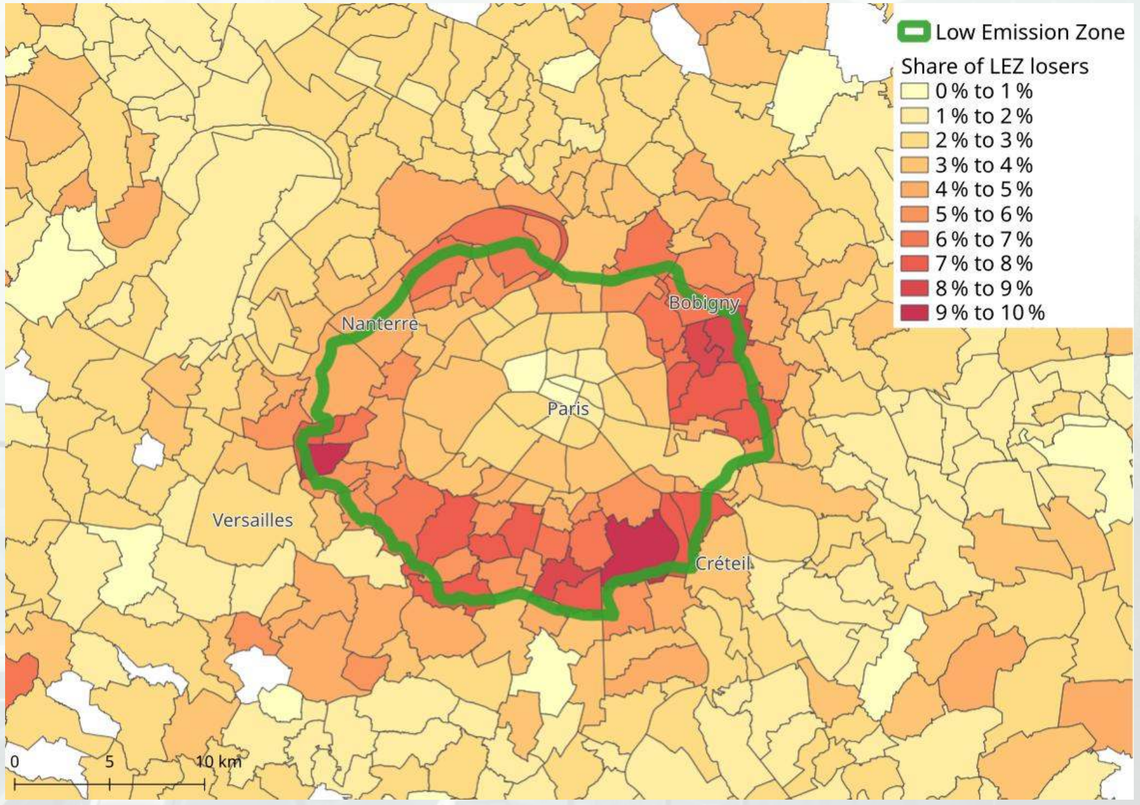


Winners and Losers Location

- "Winners" are spread over the region
- "Losers" are mainly living along the LEZ



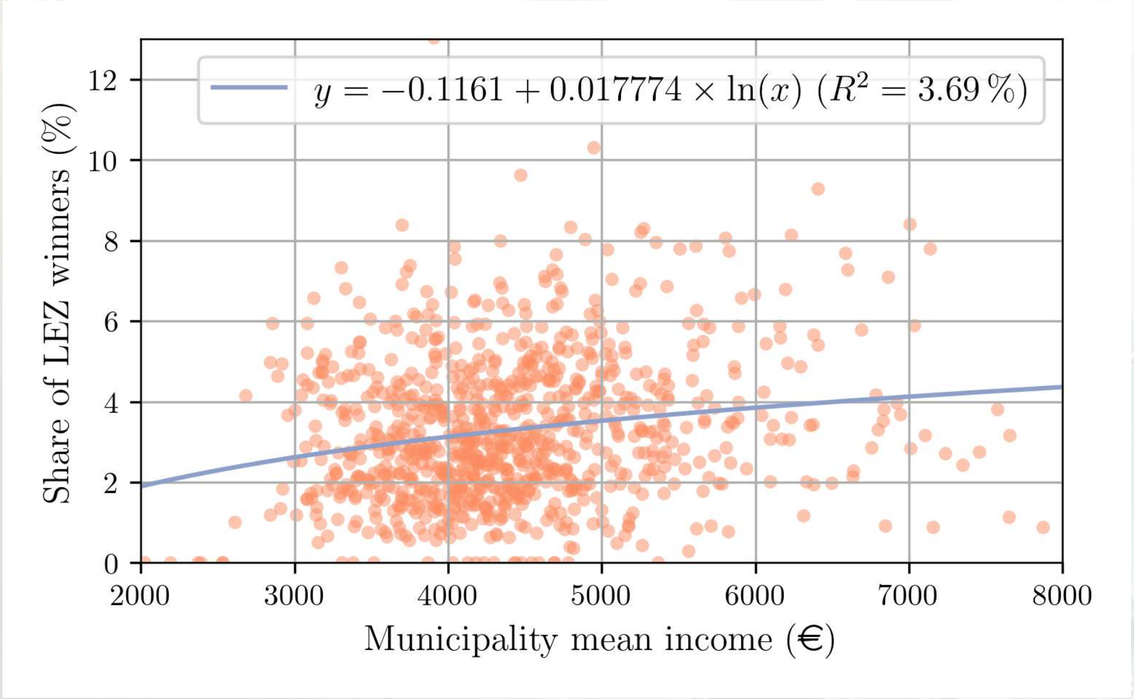
Winners



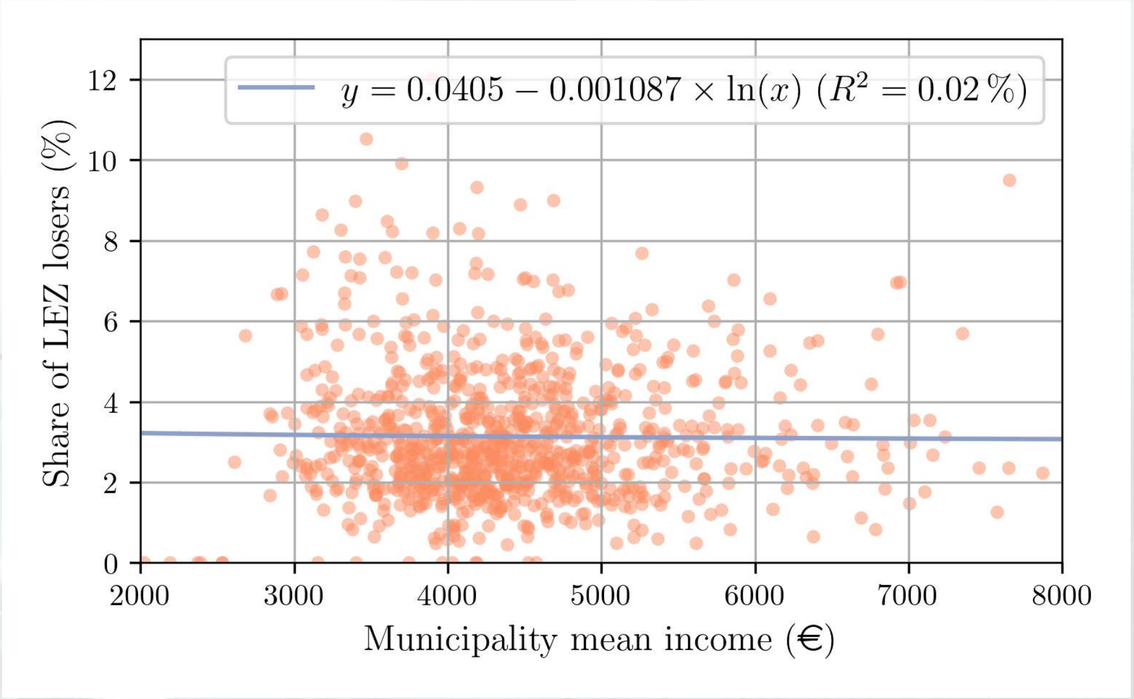
Losers

Winners and Losers Income

- Share of "winners" slightly increasing with the municipality average income
- Share of "losers" uncorrelated with the municipality average income



Winners



Losers

Conclusion

Conclusion

- Methodology for the **evaluation of public policies** with a **transport simulator**
- **Global impact:** decrease of car use, vehicle kilometers, congestion and pollution
- **Individual impact:**
  - Health impact distributed evenly across the population
  - Travel surplus impact shows great disparities
- Characteristics of the **winners** and **losers** of the policy
- **Limits:**
  - No analysis of the income effect at the individual level
  - Short-run analysis: no car-ownership model, no activity-based model, no location choice model
  - Air pollution from public transit omitted

Thank you