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BIKE TRAVEL DEMAND GENERATION WITH DYNAMIC DATA: AN APPLICATION TO THE PARIS METROPOLIS

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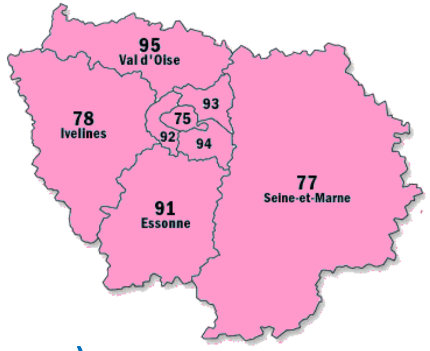
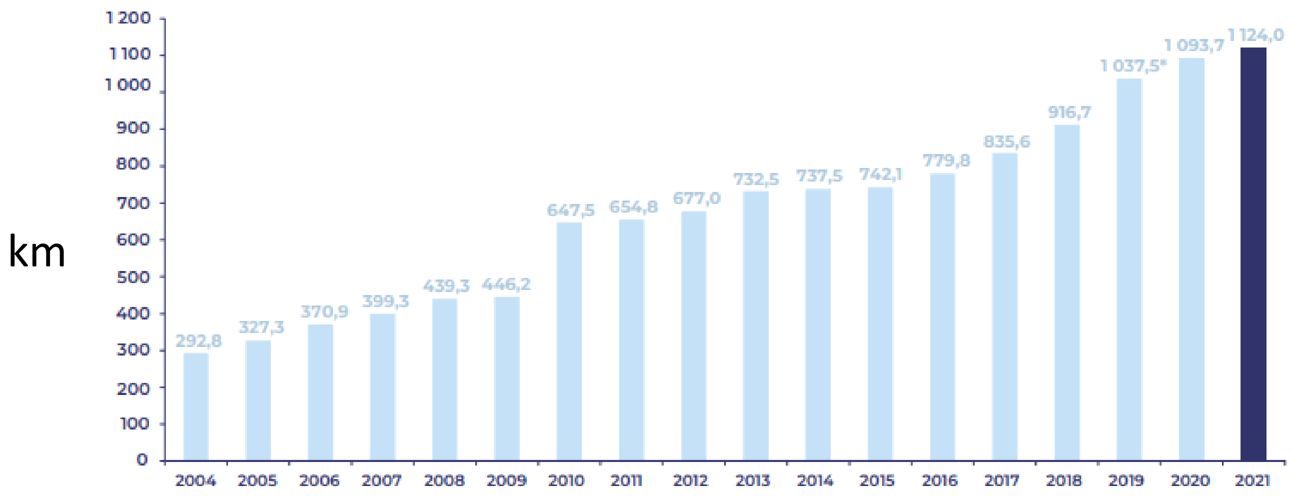
PLAN

CYCLING MOBILITY TRENDS



- Cycling mode-share in Île-de-France: 1,9% in 2018 (1,6% in 2010)
- A recent significant increase in bicycle use after the pandemic covid-19
  - Cycling counters of Paris show the growth of cyclists
  - The same tendency was observed by the data of mobile applications (GPS traces)
- Increase in cycling infrastructure and planned cycling routes:

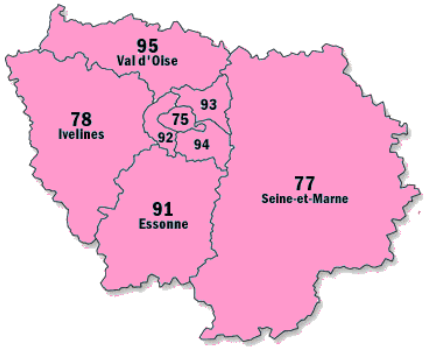


https://www.apur.org/sites/default/files/evolution_mobilites_grand_paris.pdf

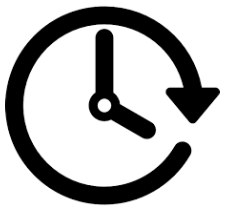
- **Objectives**: Better understand dynamic bike travel demand and evaluate the impact of new infrastructures via ABM

SIMULATION SETUP

- Eqasim
  - Discrete Mode Choice extension under MATSim framework
  - Synthetic population generation with survey data (Île-de-France)
- Bike extension
  - Conversion of cycling network from OpenStreetMap
  - Routing takes into account cycling factors:



Travel time



Distance

Cycling Infrastructure

Slope

Road quality

1. Hörl, S., Balać, M., & Axhausen, K. W. (2019). Pairing discrete mode choice models and agent-based transport simulation with MATSim. In *2019 TRB Annual Meeting Online* (pp. 19-02409). Transportation Research Board.
2. Ziemke, D., Metzler, S., & Nagel, K. (2019). Bicycle traffic and its interaction with motorized traffic in an agent-based transport simulation framework. Future Generation Computer Systems, 97, 30-40.

DISAGGREGATED CYCLING BEHAVIOURS

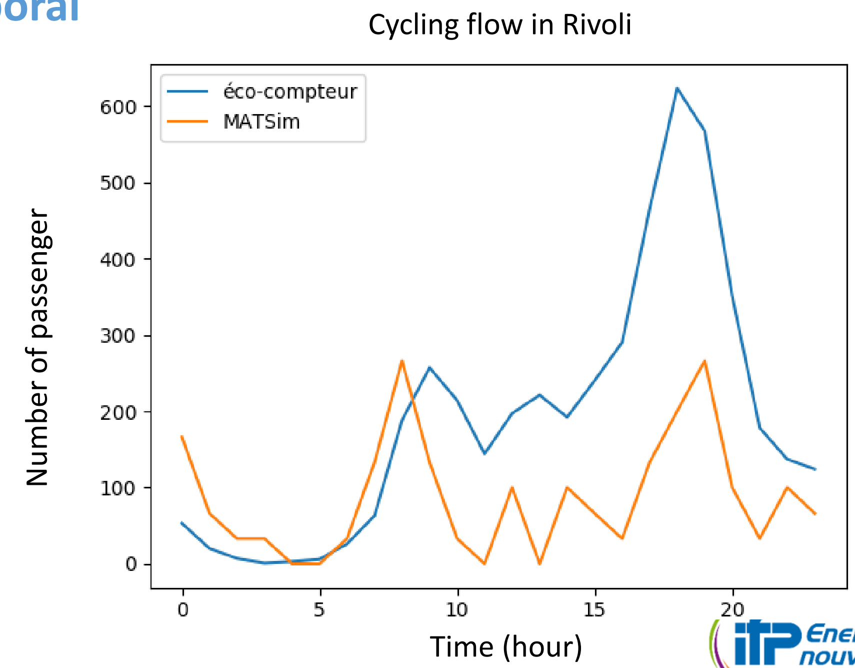
- Cycling flow :
  - **Line** (simulated flow) VS **Point** (counter flow)
    - Red: high flow
    - Bleu: low flow
  - Spatial and temporal difference

- Reproduce such behaviors observed from counters:
  - Realistic routing to generate an appropriated itinerary:

    Bicycle routing calibration from GPS track [1]
  - **Bike travel demand (OD matrix)**

Spatial

Temporal



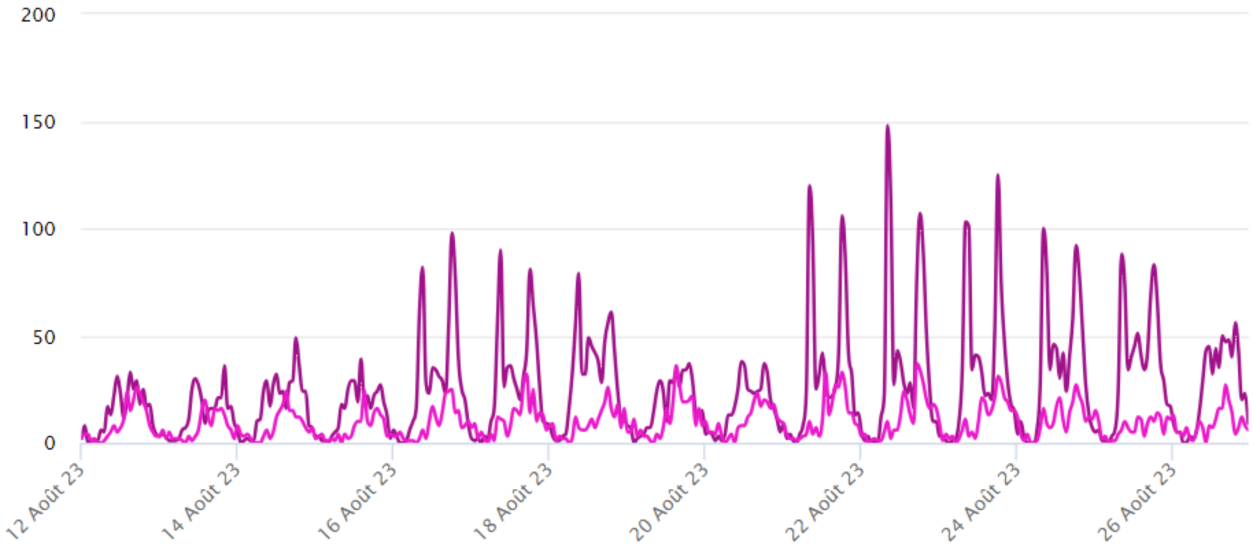
1. DUBUC D., FENG G., CHASSE A (2023) Automatic bicycle routing from GPS track, VELO-CITY 2023

PLAN

- Introduction
- Available data
- Bike travel demand (OD matrix) estimation
  - Travel pattern from GPS traces
  - Optimization formulation
  - Obtained results
- Potential application of estimated OD matrix in MATSim
  - Update bike travel demand
  - Discrete choice model calibration
- Conclusion and future works

AVAILABLE DATA

- Anonymized GPS data from mobile applications
- Bike counters
  - 90 counters in Paris
- Survey data:
  - Household travel surveys etc…



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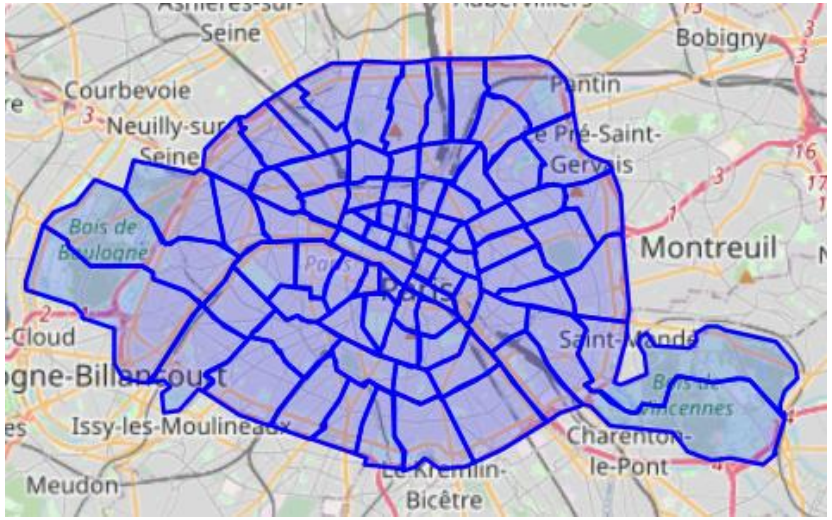
TRAVEL PATTERNS

- How cyclists move statistically for a given origin-destination

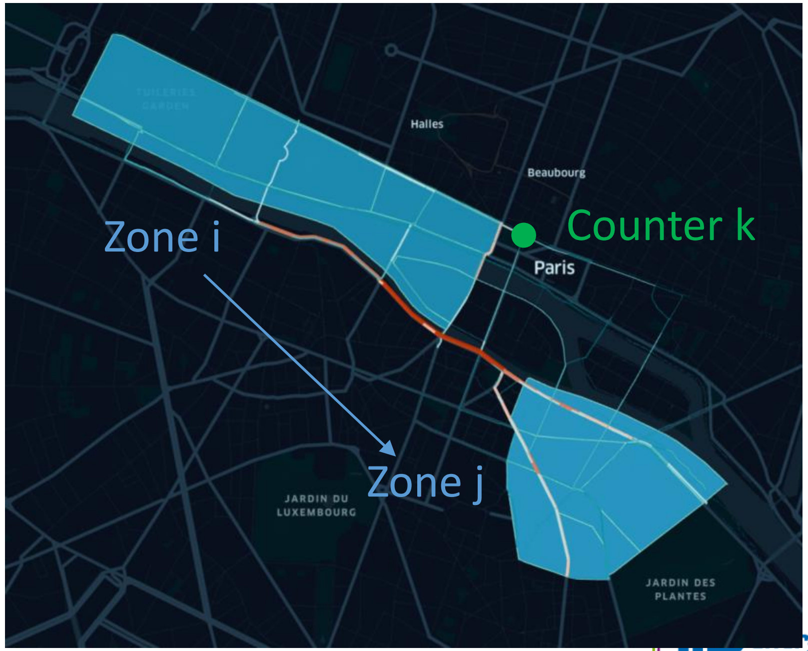


- Study case : Paris (splitted into 80 zones)
  - 6400 OD pairs

- From GPS aggregated data, we estimate the probability:

$$P_{ijk}$$

(each pair OD) where cyclists travel from a zone i to a zone j by going through a counter station k



- Assign statistically the travel demand to each counter via the probability tensor P, we obtain an estimated flow on each counter k (n=90 number of counters)

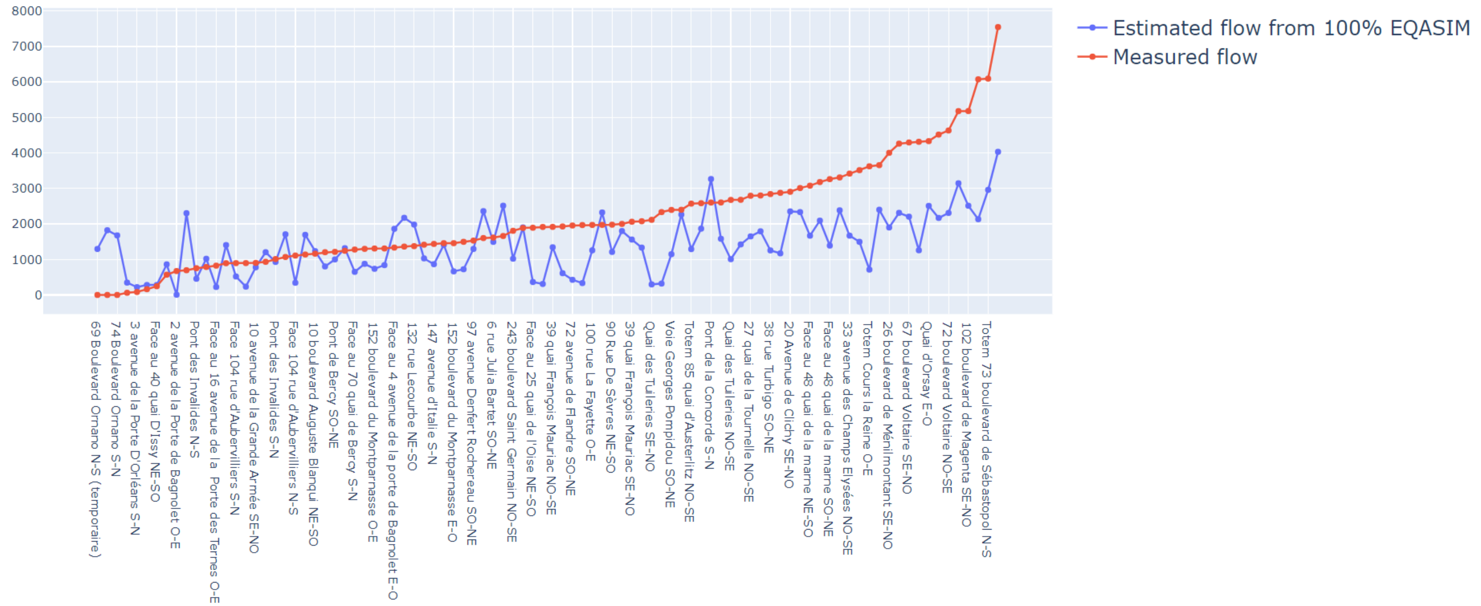
$$\hat{F}_k = \sum_{n}^{i} \sum_{n}^{j} OD_{ij} * P_{ijk}$$

TRAVEL DEMAND FROM EQASIM AND CORRECTION FACTORS

- 100% synthetic population → idea about the bike travel demand in Paris in terms of OD matrix
- Apply the obtained bike demand with $\hat{F}_k = \sum_n^i \sum_n^j OD_{ij} * P_{ijk}$:

Average counter flows of September 2021

Estimated flow



- Since the travel demand is generated from the survey and the demand could change, we propose a correction factor λ for updating the demand OD matrix:

$$\hat{F}_k = \sum_n^i \sum_n^j \lambda_{ij} * OD_{ij} * P_{ijk}$$

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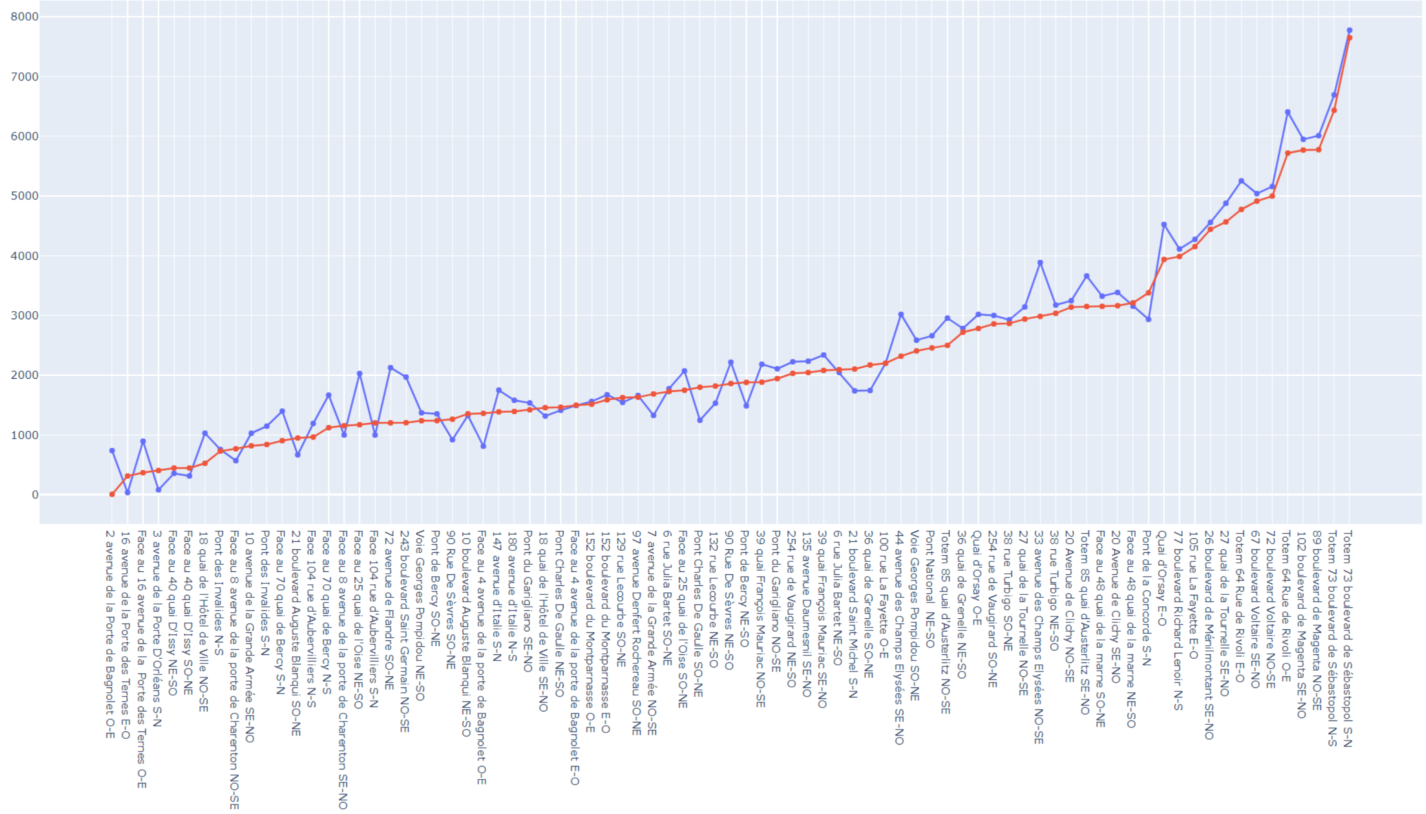
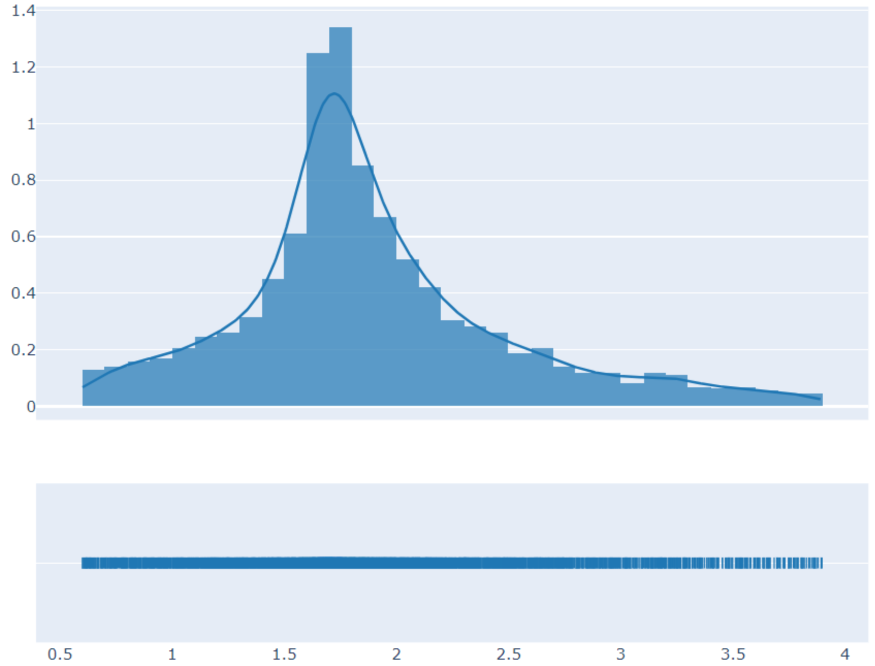
OBTAINED RESULTS

- Solving the quadratic linear optimization problem:
  - Estimated flow on counters (estimation error: 12%)
  - Correction factors distribution
  - Total estimated trips: 372,454 (specific day!)





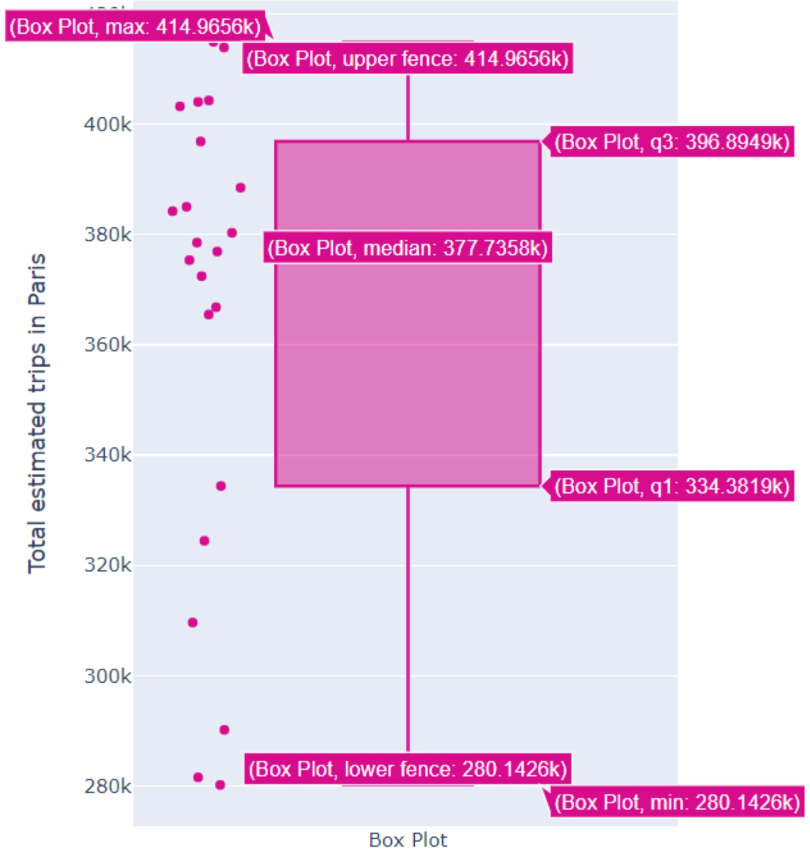
Correction factor

Counter flow of 2021-09-24

Estimated flow
Measured flow

OBTAINED RESULTS

- Estimation for the working days of September 2021
  - Total trips in Paris → validated with mobility survey EGT 2018 + 2021 (around 400 000 bike trip in Paris autumn 2021) https://omnil.fr/IMG/pdf/resultats_covid_septembre-decembre_2021-2.pdf
  - Estimated OD



Estimated demand from a given zone (green)
Red → bleu

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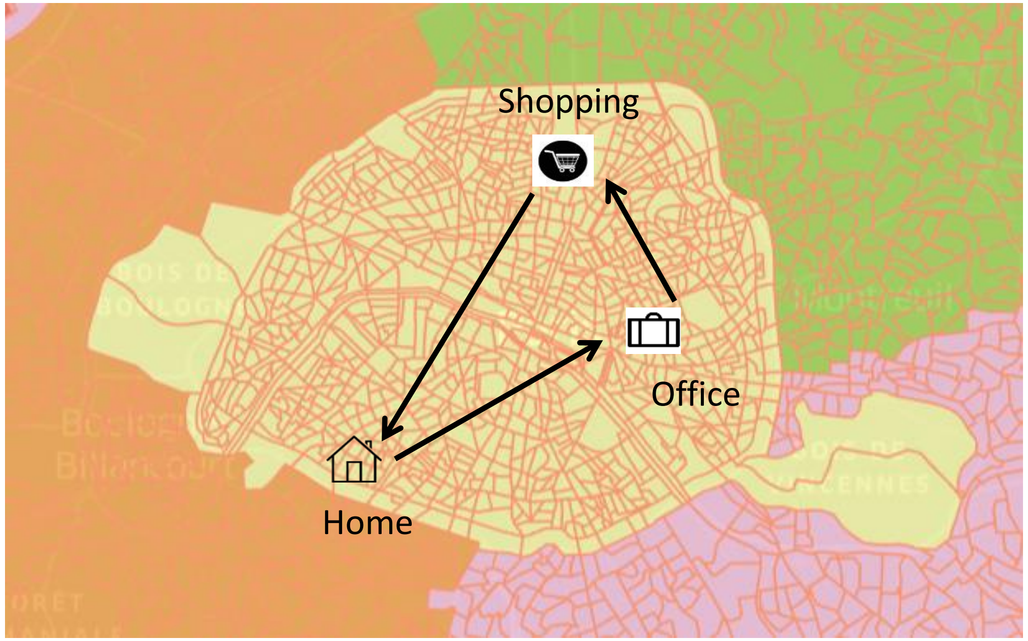
SYNTHETIC POPULATION GENERATION

- Initial demand generation considering the estimated bike OD matrix
  - Updating the survey weight → number of bike trips in Paris
    - The number of bike trips is marginal comparing to other modes
    - Multiply trip weight of survey with correction factors → to have consistent total trip in Paris
  - Attribution of primary and secondary locations:
    - Location assignment (EQASIM): certain distance distributions should be matched while assigning trips to discrete locations.
    - Spatial distribution of bike trips should be equally matched



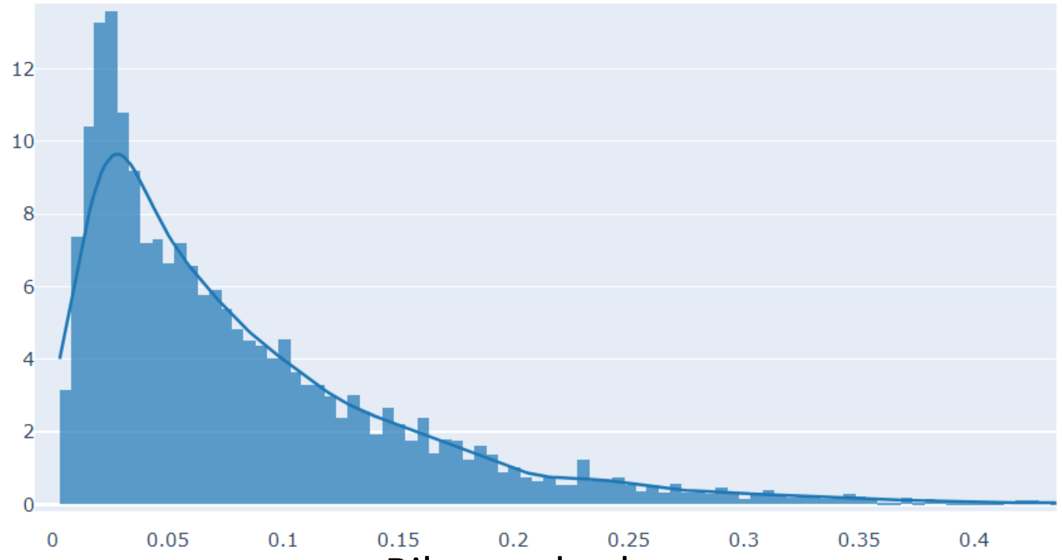
DISCRETE CHOICE MODEL CALIBRATION

- Cycling infrastructure does not impact directly the mode choice:

$$u_{\text{bike}}(\chi) = \alpha_{\text{bike}} + \beta_{\text{travelTime,bike}} \cdot \chi_{\text{travelTime,bike}} + \beta_{\text{age,bike}} \cdot \max\left(0\,,\,a_{\text{age}} - 18\right)$$

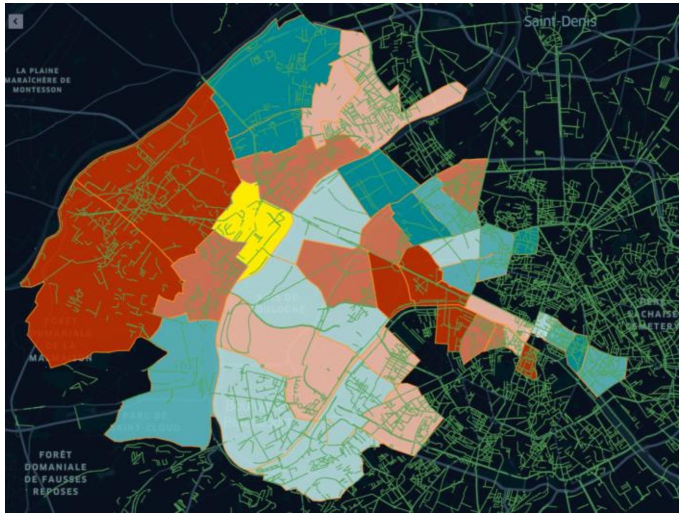
- Considerate more descriptors on the bike utility function of discrete choice model:
  - Cycling infrastructure
  - Connectivity of the bicycle lane network
- Bike mode share per OD from the estimated OD matrix
  - Bike mode share varies in function of OD from 1%→30%

Distribution



Bike mode share

Connectivity of cycling infrastructure per OD



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PERSPECTIVES

- Validate the estimated OD matrix:
  - Cross-validation with 90 counters in Paris
  - Comparison with additional data : Bike sharing data e.g. vélib

- Extend the estimation for a bigger geographic zone: Grand Paris

- Possibility to extend the proposed estimation approach to other modes
  - Public transport (ticket validation)
  - Car (floating car data FCD + counters)

CONCLUSION

- Bike travel demand estimation from different data source

- Ongoing works:
  - Apply estimated OD matrix → initial demand generation
  - Calibrate discrete choice model considering cycling infrastructure
  - Reference scenario by integrating into MATSim simulation
    1) Initial demand generation
    2) Calibrated DCM
    3) Calibrated bike routing
  - Projected scenario
    - Considering planned cycling infrastructures

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