AI & Companies Week

Academic research meets industry to solve mathematical problems.

November 22-26

Estimating accessibility to healthcare facilities by public transport

instant system

MÉTROPOLE NICE CÔTE D'AZUR

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Context

- According to World Health Organization, **685000** women died in 2020 because of breast cancer [1].
- To reduce up to **25%** the risk of dying from breast cancer [2], it is highly recommended for women aged from 50 to 74 years to do a screening mammogram every 2 years.

Why there are still women who don’t do it ?

There are several reasons for this, and one of them is the difficulty of accessing an accredited radiology center.

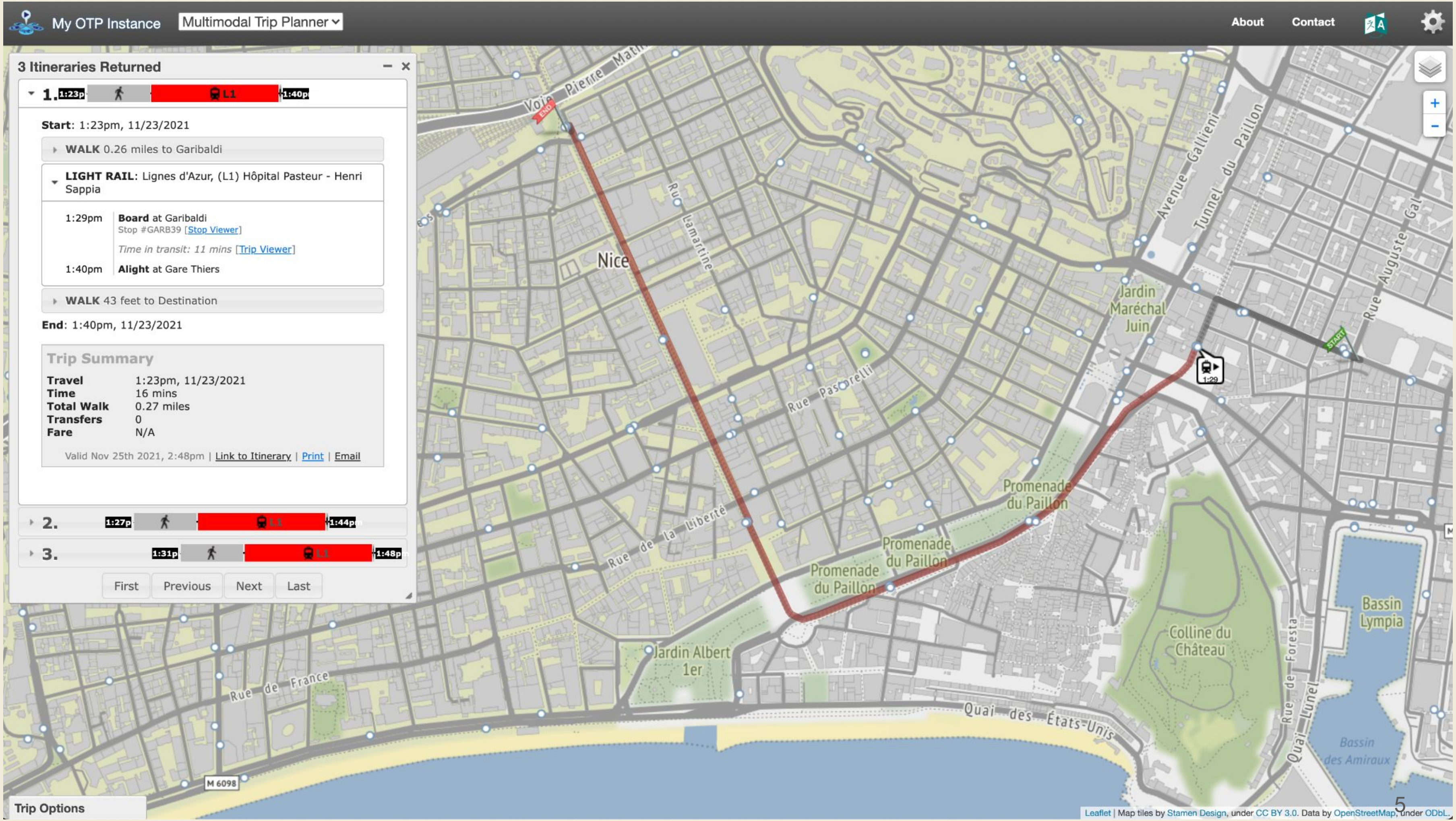
Task 1

- determine the time required to reach the closest radiological center by public transportation combining walking and using bus and tramways from Lignes d'Azur network
- 4 time points during a work day : 9h, 11h, 14h , 16h
- Extension: isochrones

Methods

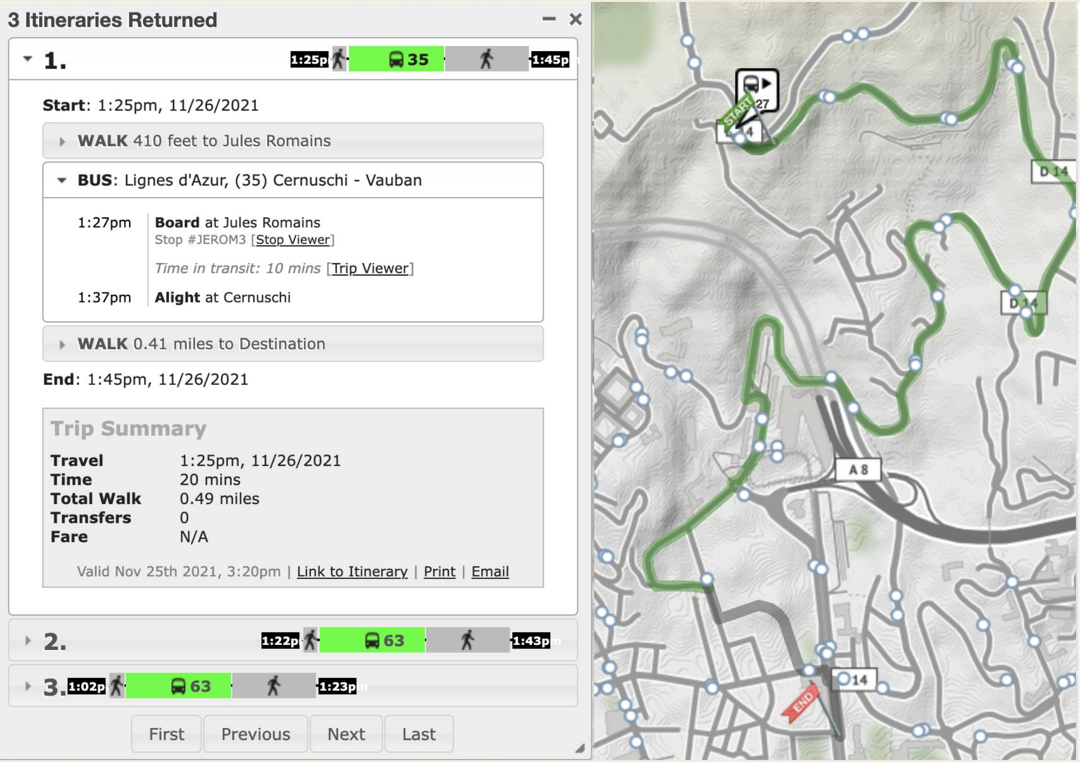
OpenTripPlanner[3]:

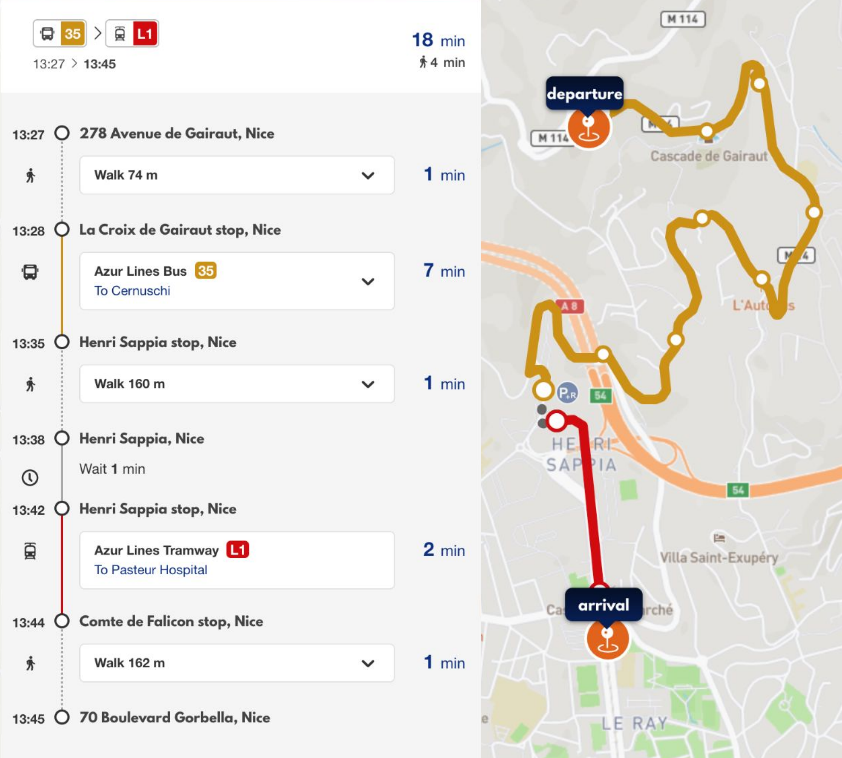
- Open Source Tool that integrates maps and GTFS (General Transit Feed Specification) files to build transit graph for buses and tram.
- Trips are planned using A-star algorithm with the Tung-Chew heuristic (i.e. a graph grown backward from the destination providing a lower bound on aggregate weight) for queue ordering.
- Allow us to compute travel times for 2 different points taking into account different parameters like:
  - minTransferTime
  - maxWalkDistance
  - waitReluctance
  - and many more
- Generate isochrone maps for a given location



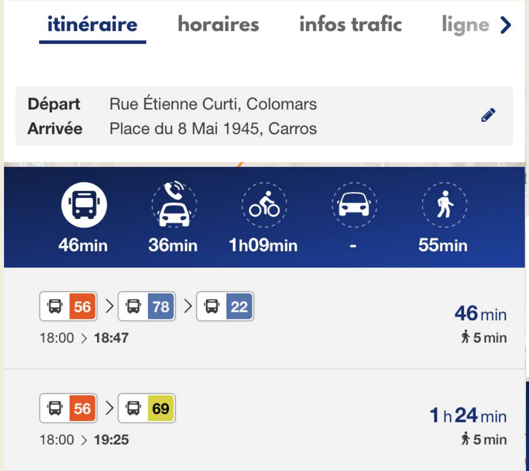
My OTP Instance
Multimodal Trip Planner
About
Contact
3 Itineraries Returned
1. 1:23p L1 1:40p
Start: 1:23pm, 11/23/2021
WALK 0.26 miles to Garibaldi
LIGHT RAIL: Lignes d'Azur, (L1) Hôpital Pasteur - Henri Sappia
1:29pm Board at Garibaldi
Stop #GARB39 [Stop Viewer]
Time in transit: 11 mins [Trip Viewer]
1:40pm Alight at Gare Thiers
WALK 43 feet to Destination
End: 1:40pm, 11/23/2021
Trip Summary
Travel Time 1:23pm, 11/23/2021 16 mins
Total Walk 0.27 miles
Transfers 0
Fare N/A
Valid Nov 25th 2021, 2:48pm | Link to Itinerary | Print | Email
2. 1:27p L1 1:44p
3. 1:31p L1 1:48p
First
Previous
Next
Last
Trip Options
Nice
Rue Lamartine
Rue Pastorelli
Rue de la Liberté
Rue de France
Promenade du Paillon
Jardin Albert 1er
Jardin Maréchal Juin
Avenue Gallieni
Tunnel du Paillon
Rue Auguste Gal
Colline du Château
Bassin Lympia
Bassin des Amiraux
Quai des États-Unis
Rue de Foresta
Quai Lunel
M 6098
START
END
Leaflet | Map tiles by Stamen Design, under CC BY 3.0. Data by OpenStreetMap, under ODbL.

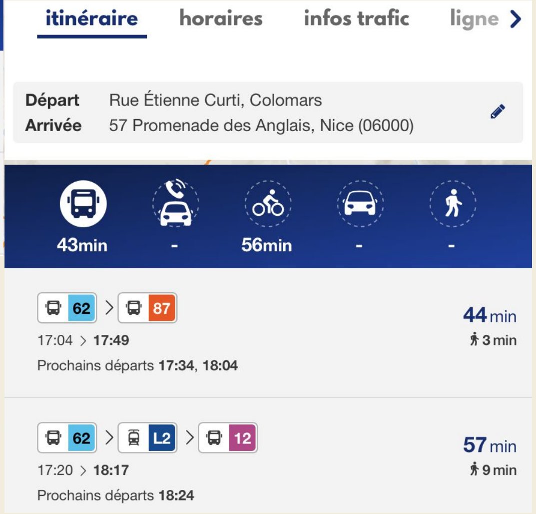
Comparison between systems

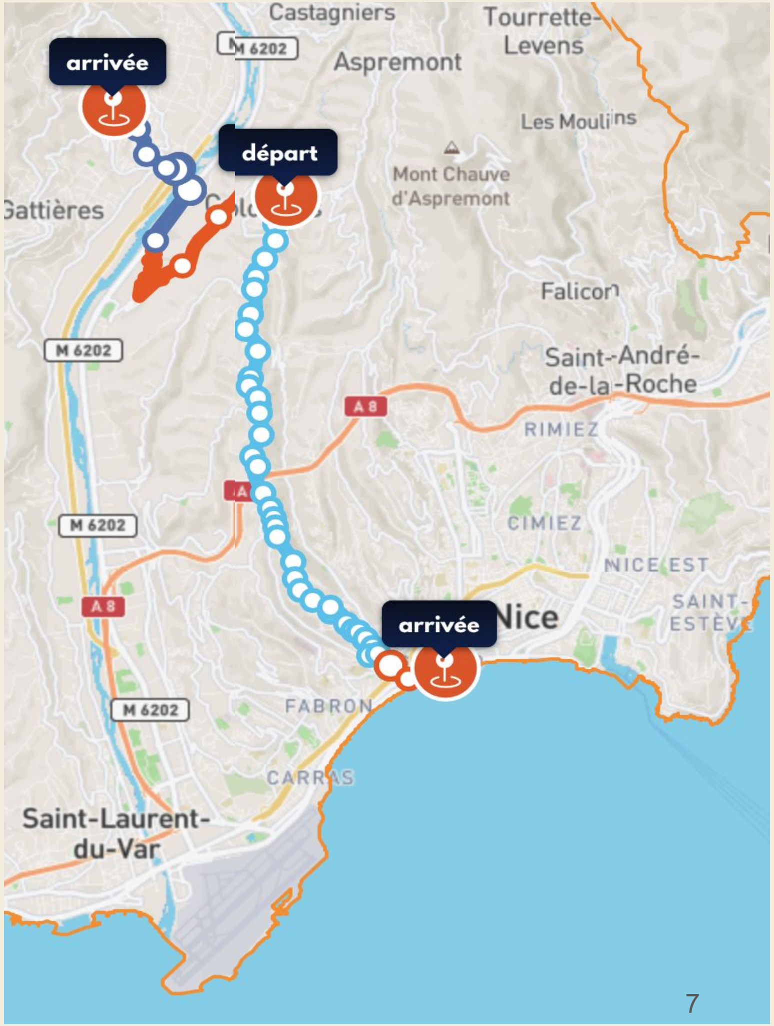




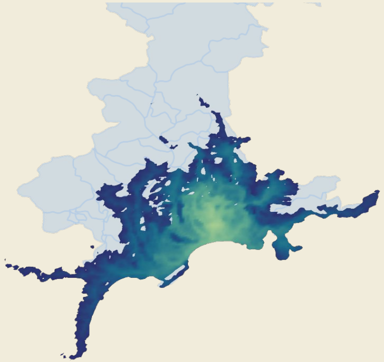
The closest center ?



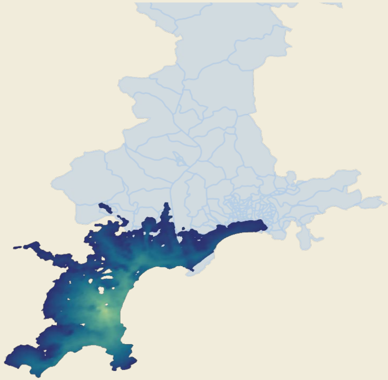




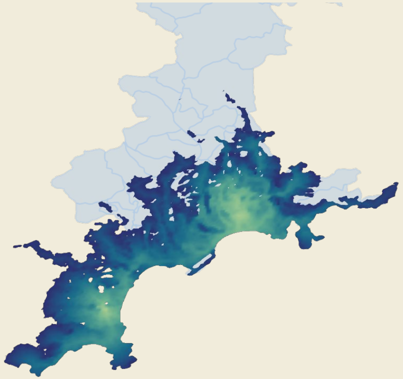
Isochrone maps



Isochrone of
clinic 1

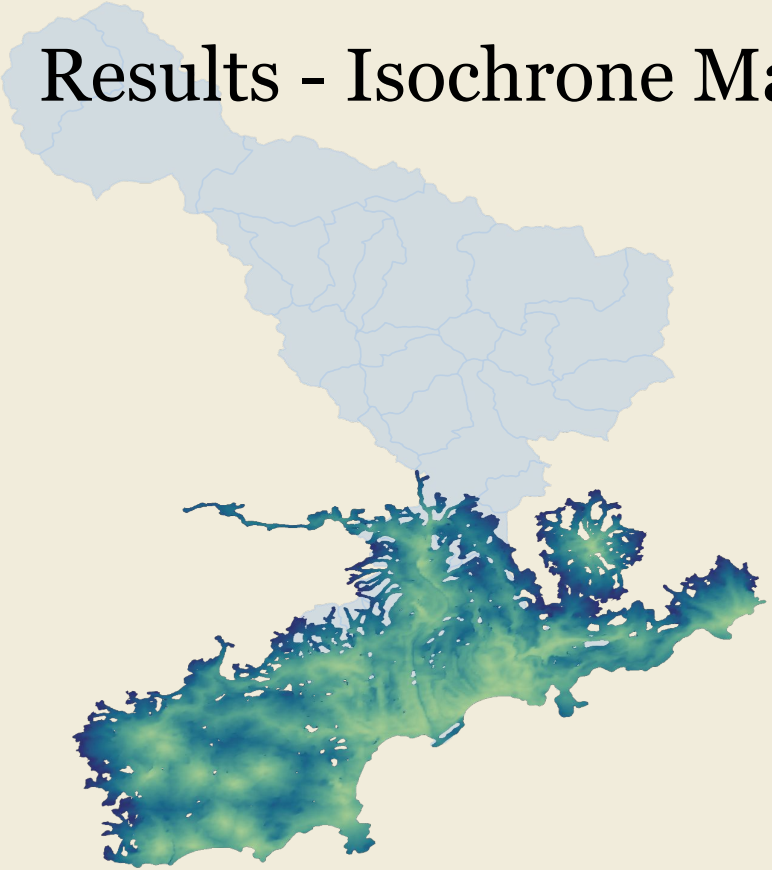


Isochrone of
clinic 2

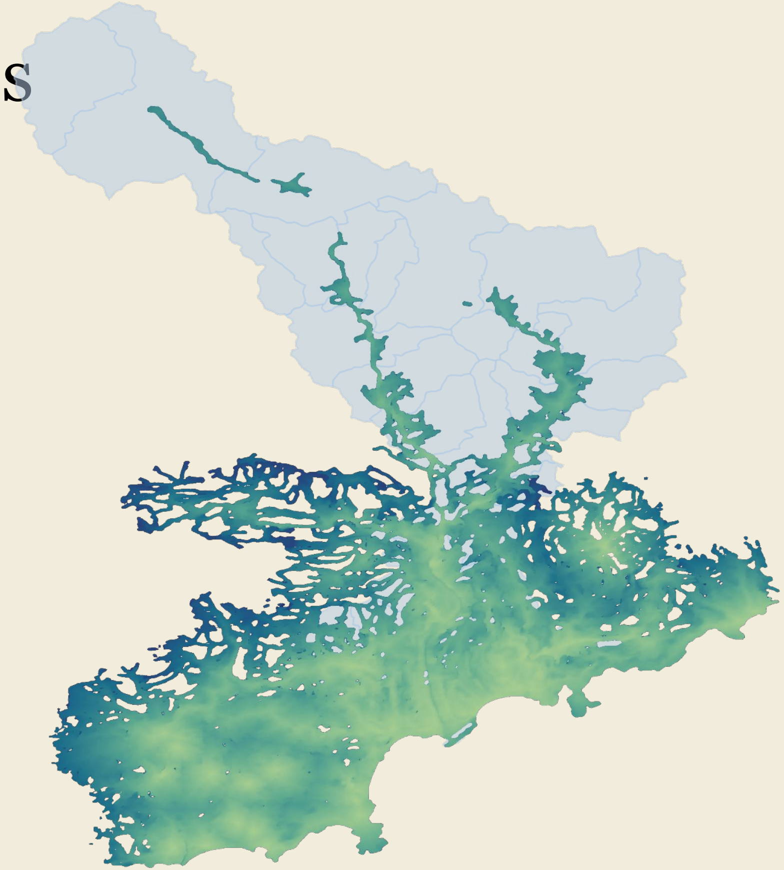


Isochrone of
both clinics

Results - Isochrone Maps

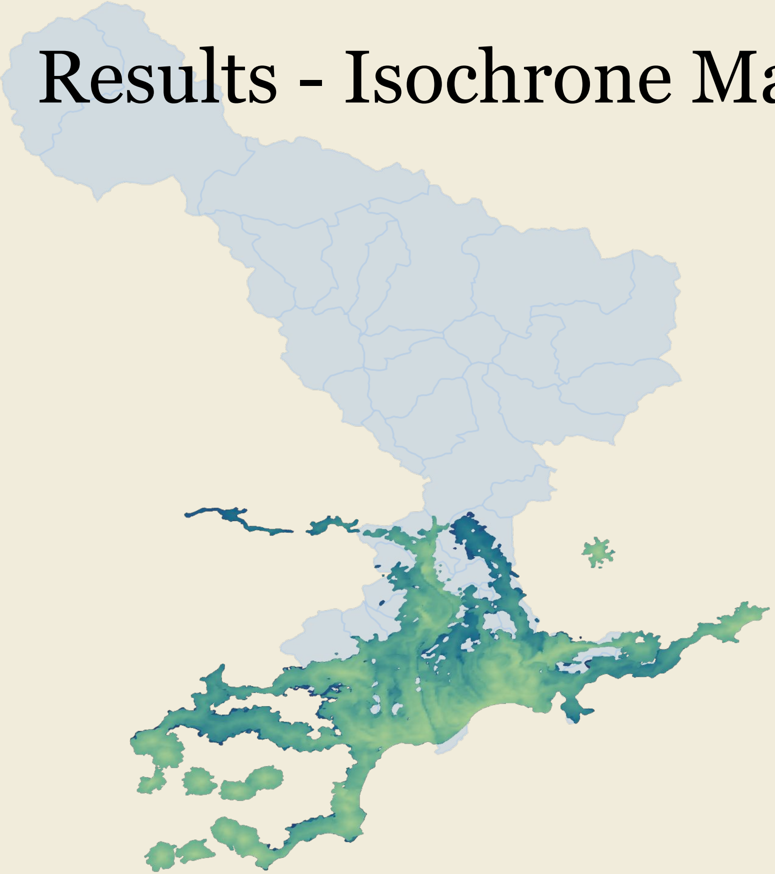


100 mins max travel time
10km max walk distance
9:00 am

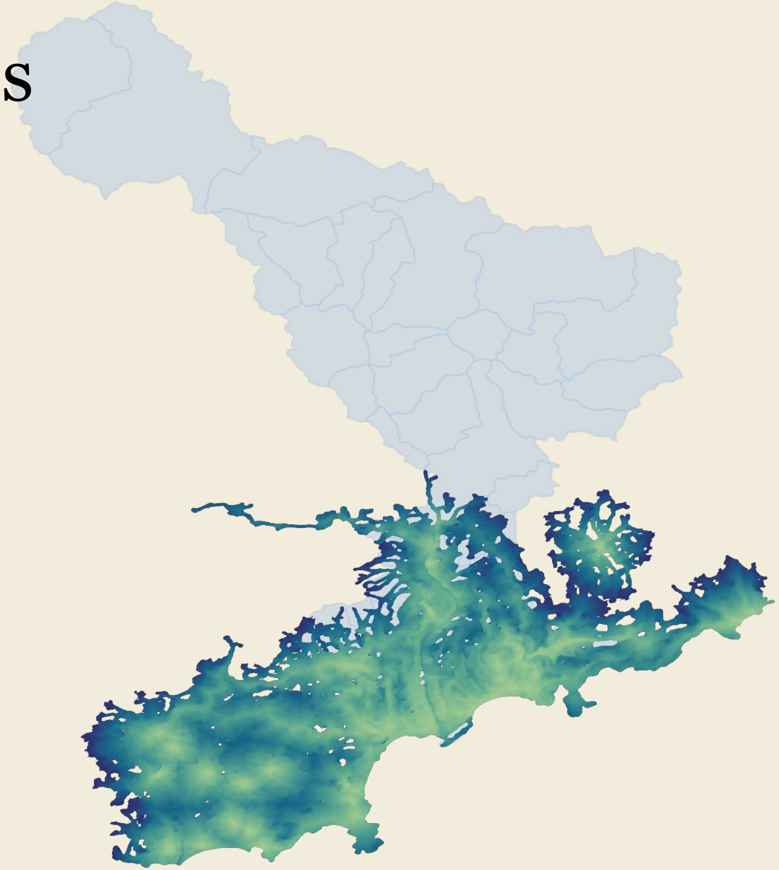


200 mins max travel time
10km max walk distance
9:00 am

Results - Isochrone Maps

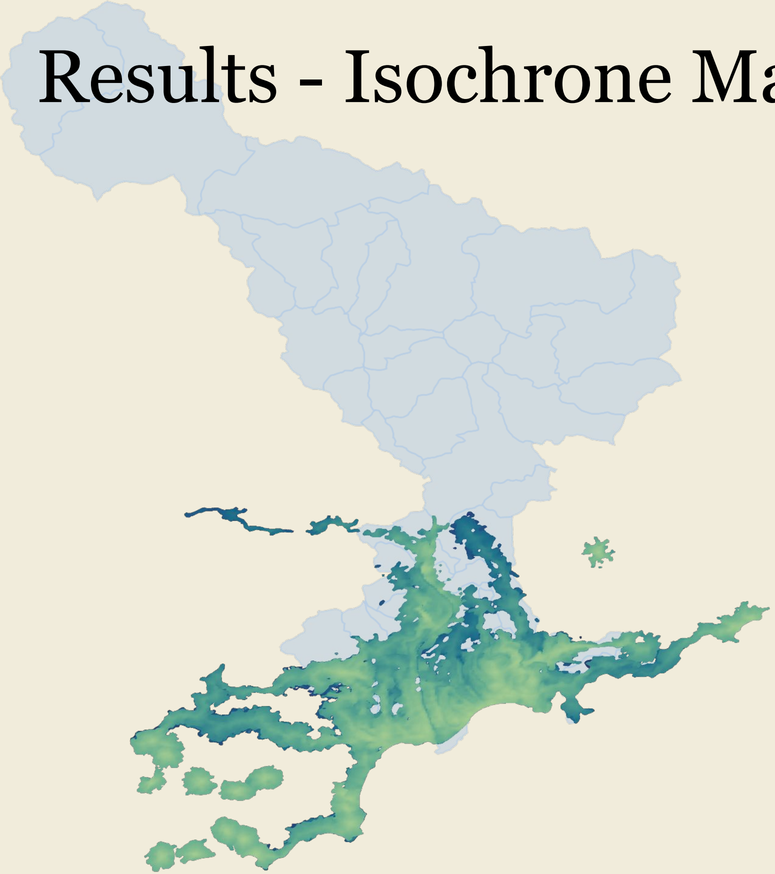


100 mins max travel time
1.5km max walk distance
9:00 am

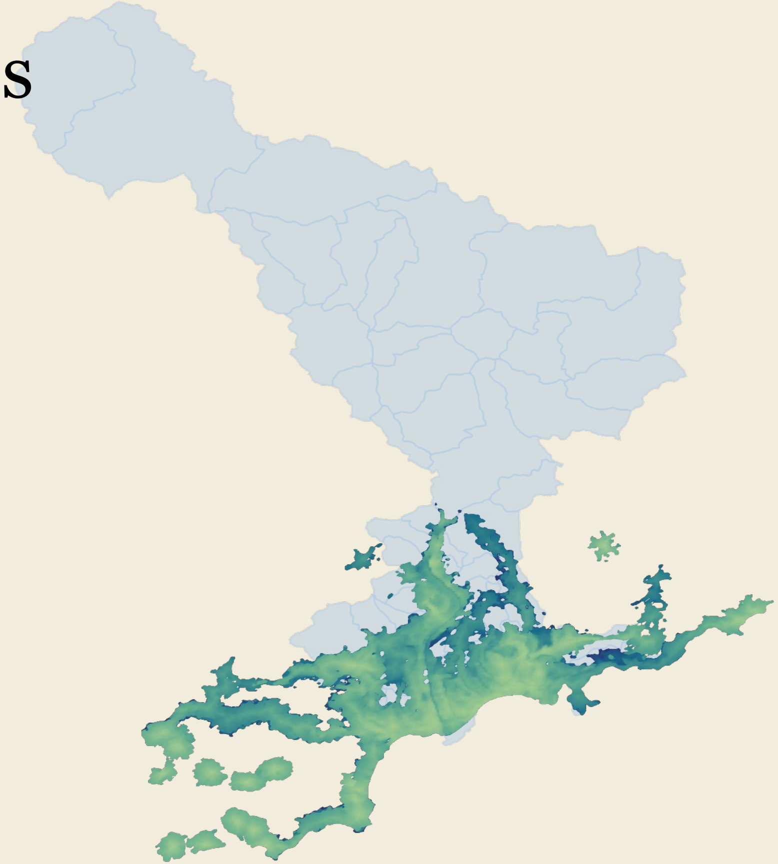


100 mins max travel time
10km max walk distance
9:00 am

Results - Isochrone Maps



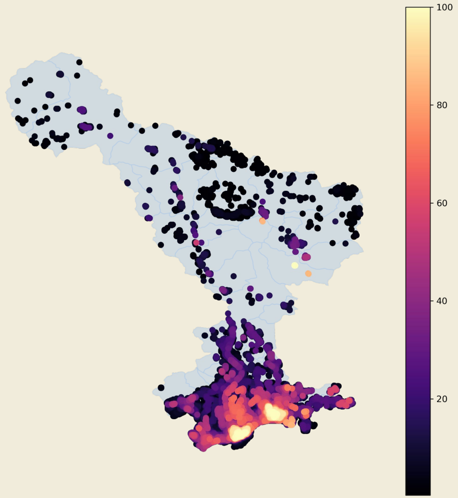
100 mins max travel time
1.5km max walk distance
9:00 am



100 mins max travel time
1.5km max walk distance
4:00 pm

Task 2

- compute the expectation of the shortest travel time by public transportation to reach the closest radiological centers for each small entity of the territory (236 IRIS in the Metropolis) at the 4 time points.
- Must take into account the population density inside each territory (IRIS)



Histograms

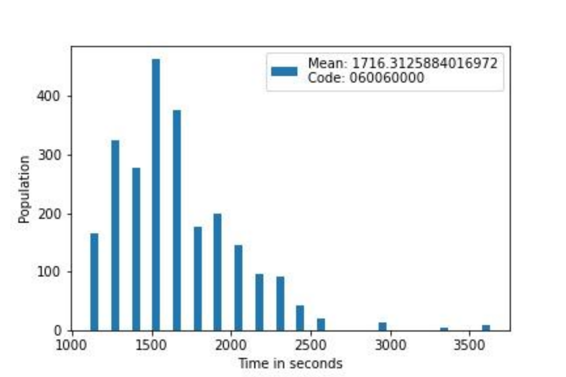
For each IRIS we calculate all the shortest connections from each county to each radiological center

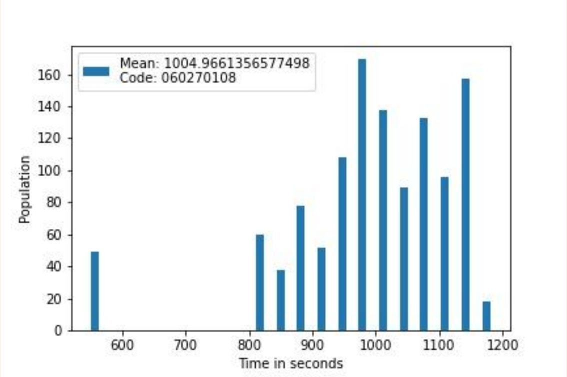
For each county we choose the shortest connection

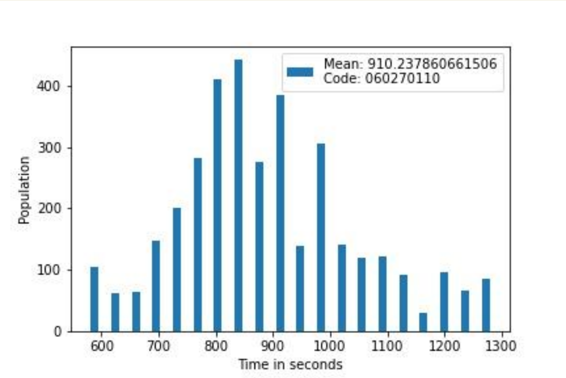
Based on the results we build a histogram for each IRIS

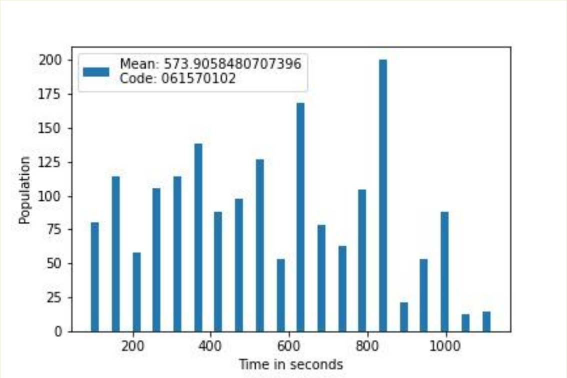
In the end we calculate the mean

Histograms


Mean: 1716.3125884016972
Code: 060060000
Population
Time in seconds
0
100
200
300
400
1000
1500
2000
2500
3000
3500

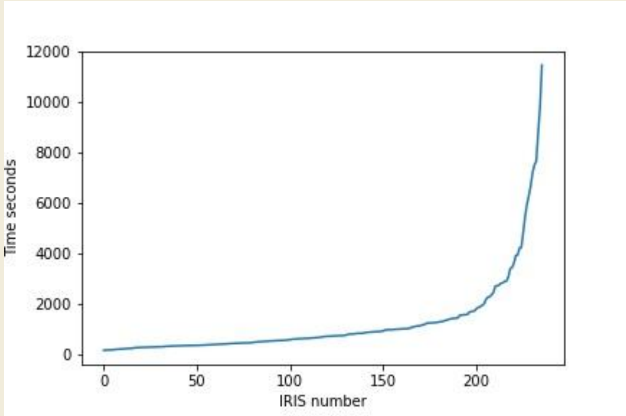

Mean: 1004.9661356577498
Code: 060270108
Population
Time in seconds
0
20
40
60
80
100
120
140
160
600
700
800
900
1000
1100
1200

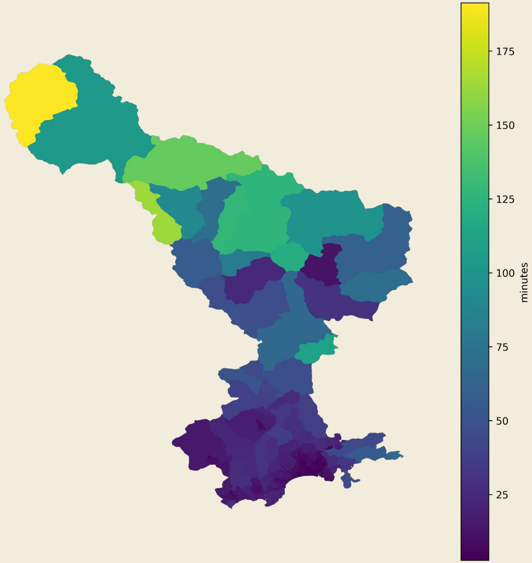

Mean: 910.237860661506
Code: 060270110
Population
Time in seconds
0
100
200
300
400
600
700
800
900
1000
1100
1200
1300

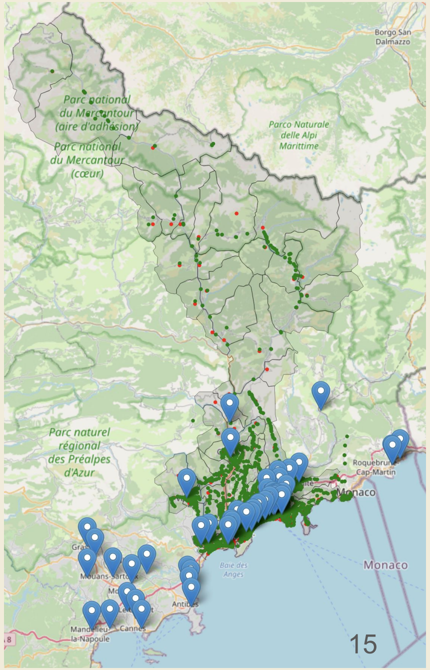

Mean: 573.9058480707396
Code: 061570102
Population
Time in seconds
0
25
50
75
100
125
150
175
200
200
400
600
800
1000

Histograms

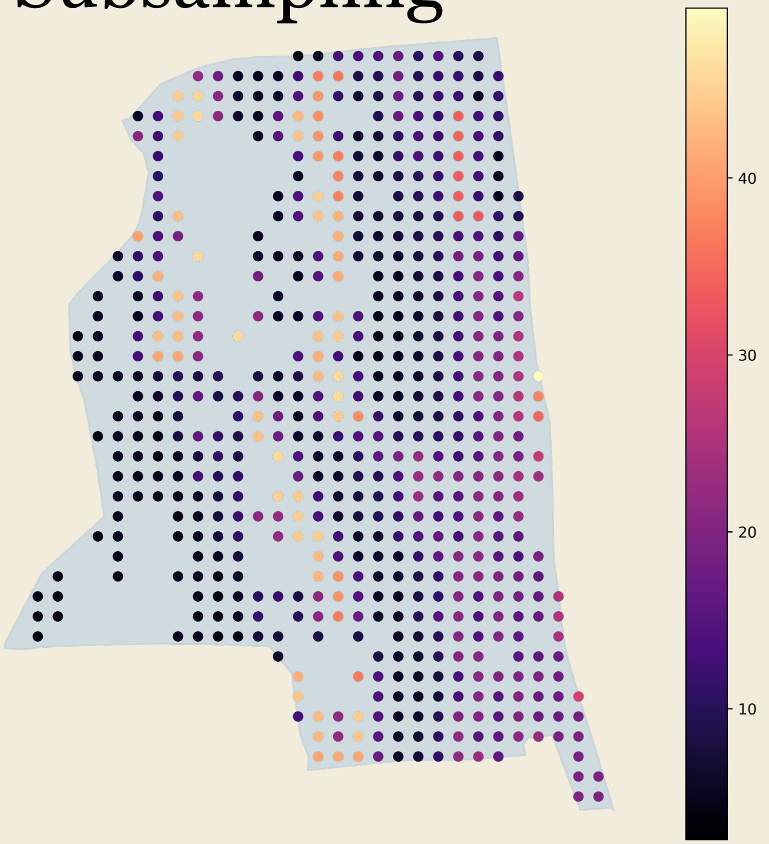
Each IRIS colored based on their time distance means form the previous histograms

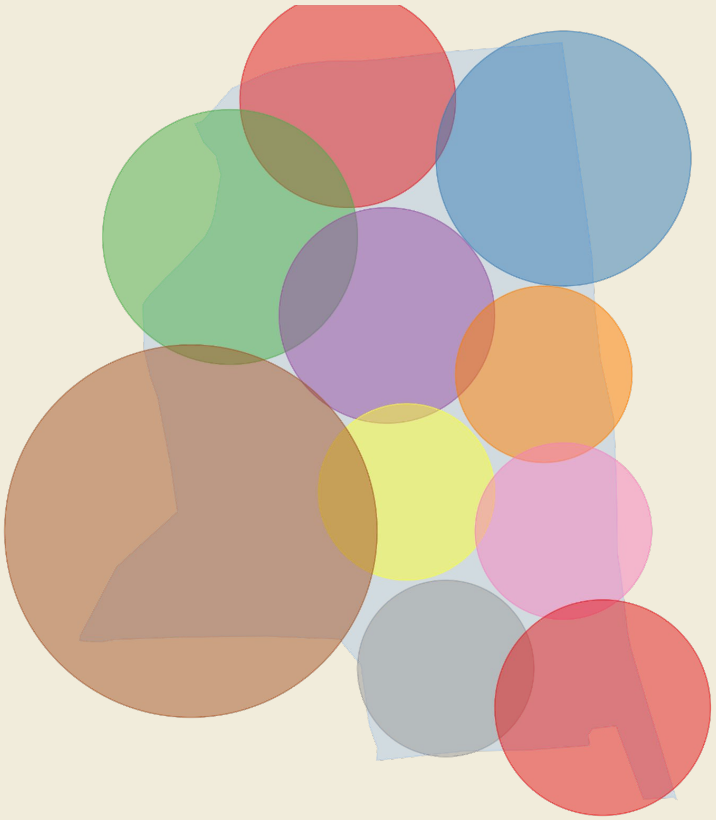




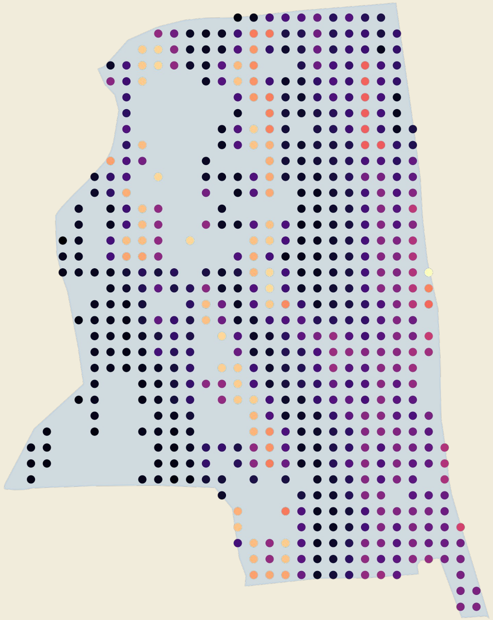


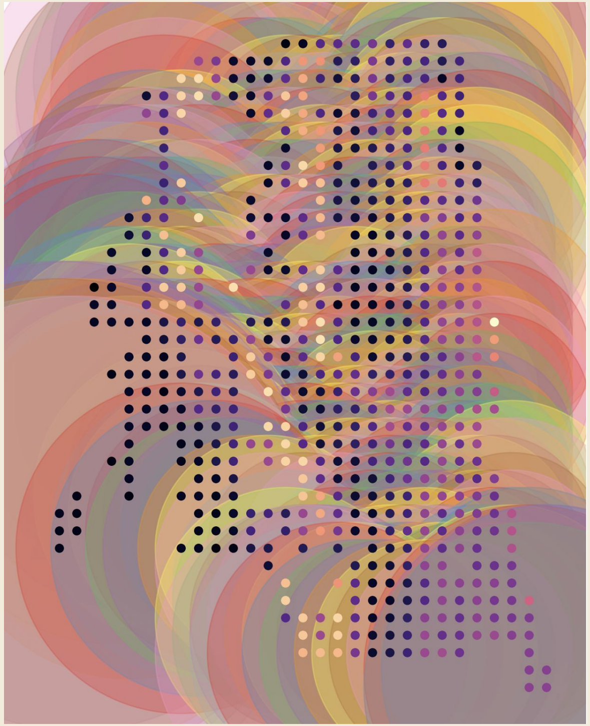
Subsampling

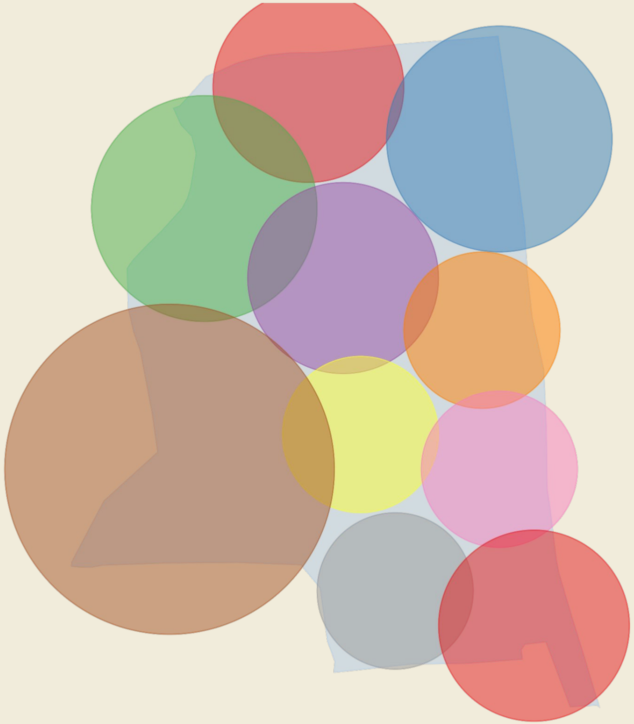


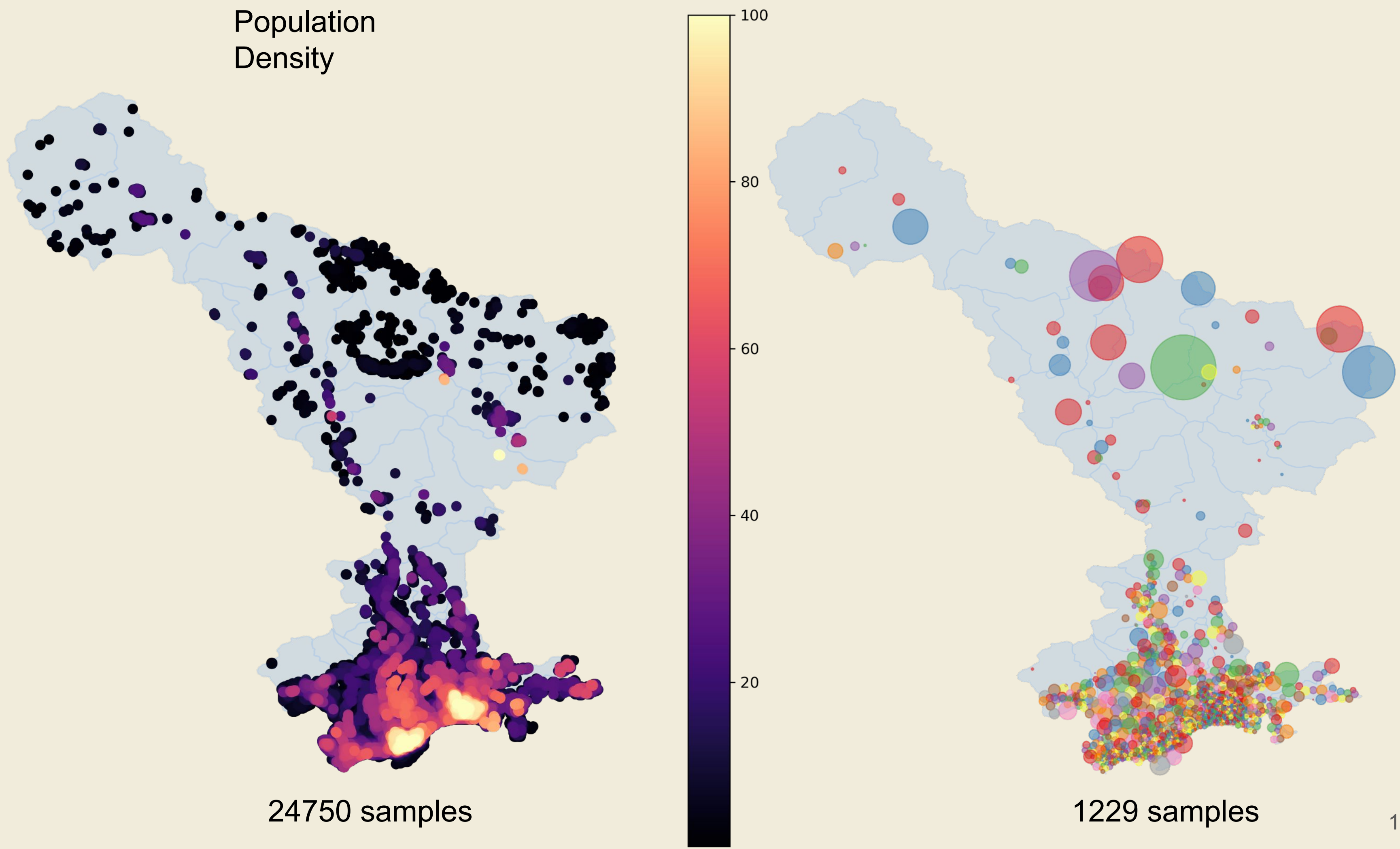


Subsampling









Population
Density
100
80
60
40
20
24750 samples
1229 samples

Future work

To have a more accurate and reliable system, we can add to it some deep learning algorithms.

This will lead to taking into account more parameters that can significantly affect the traveling time, like:

- Weather conditions
- Real time road traffic status
- Real time waiting delays in the different centers

References

[1] : https://www.who.int/news-room/fact-sheets/detail/breast-cancer

[2] : Pace LE et al. A systematic assessment of benefits and risks to guide breast cancer screening decisions. *JAMA*. 2014;311(13):1327-1335.

[3] : Malcolm Morgan, Marcus Young, Robin Lovelace, Layik Hama (2019). “OpenTripPlanner for R.” Journal of Open Source Software, 4(44), 1926. doi: 10.21105/joss.01926.

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