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Optimisation spatiale d'un réseau de sirènes d'alerte à la population en fonction de leur audibilité

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General Context- Sirens

- Sirens have long been recognized as crucial tools in disaster risk reduction and mitigation strategies.

- These audible warning systems serve as a vital component in alerting communities to imminent threats, ranging from natural disasters like tornadoes, hurricanes, and tsunamis to human-made emergencies such as chemical spills or nuclear incidents.

- Their strength lies in their ability to communicate rapidly with a large population, including those who might lack access to other communication methods like smartphones or the internet.

Problem Statement

- In the context of contemporary disaster readiness and response, sirens need to be tactically installed in areas with high risks to ensure that residents receive alerts promptly and can evacuate quickly when required.

- Hence, it becomes essential to know the maximum coverage of the sirens and their relations with the audibility.

- For strategic installation of Sirens we require a number of input parameters of the study place such as- topography, landscape, land use, and climatic conditions.

- And to find the best locations while considering these parameters we require a model to perform for providing the optimum location of siren(s) covering maximum area.

Objective

- The main objective of this study is Spatial optimisation of a siren network based on their audibility.

Secondary Objective

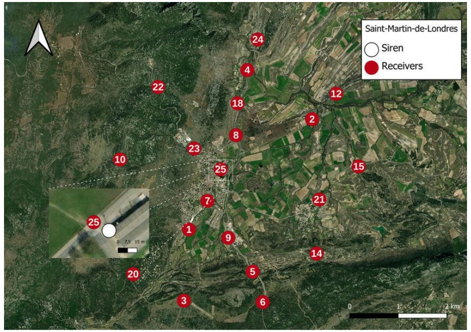
- Get a relationship between sound level of the siren and audibility

- Get a tool that perform spatial optimisation based on audibility and to find the best locations

Relationship between sound level and audibility

Earlier work

- SILIEZAR MONTOYA J, AUMOND P, CAN A, CHAPRON P, PEROCHE M. Siliézar. Case study on the audibility of siren-driven alert systems. Noise Mapping, vol. 10, no. 1, 2023, pp. 20220165. https://doi.org/10.1515/noise-2022-0165.



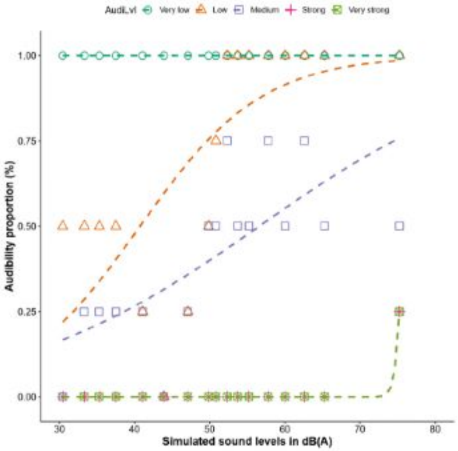


Figure 13: Audibility proportion curves (%) of the siren as a function of the sound level in decibels, for "Very low," "Low," "Medium," "Strong," and "Very strong" audibility level.

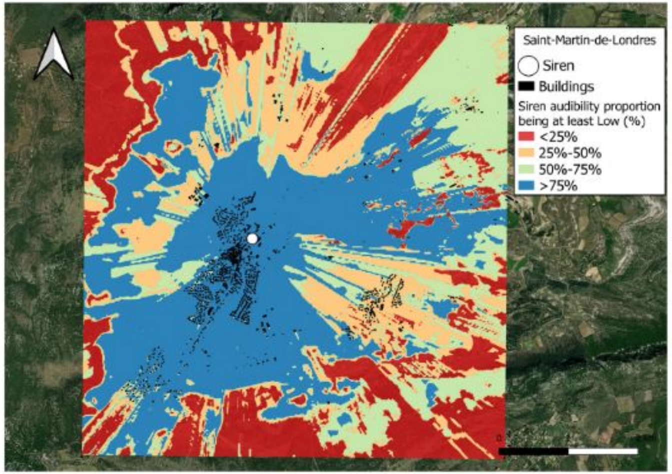


Figure 14: Audibility cartography showing the percentage of at least low audibility.

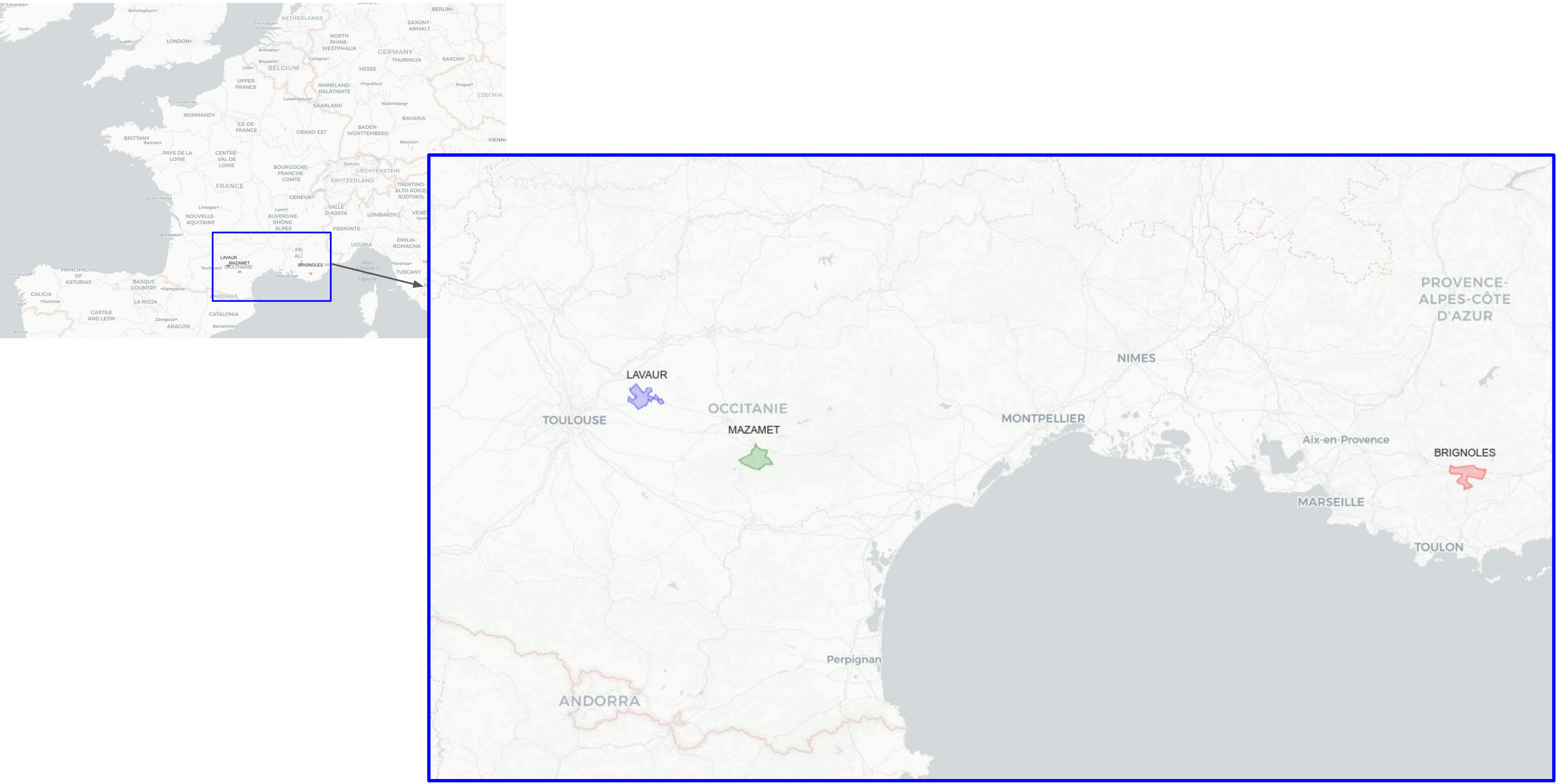
New Work (ERRATUM)

- To establish relationship between sound level and audibility this objective has been taken into account.

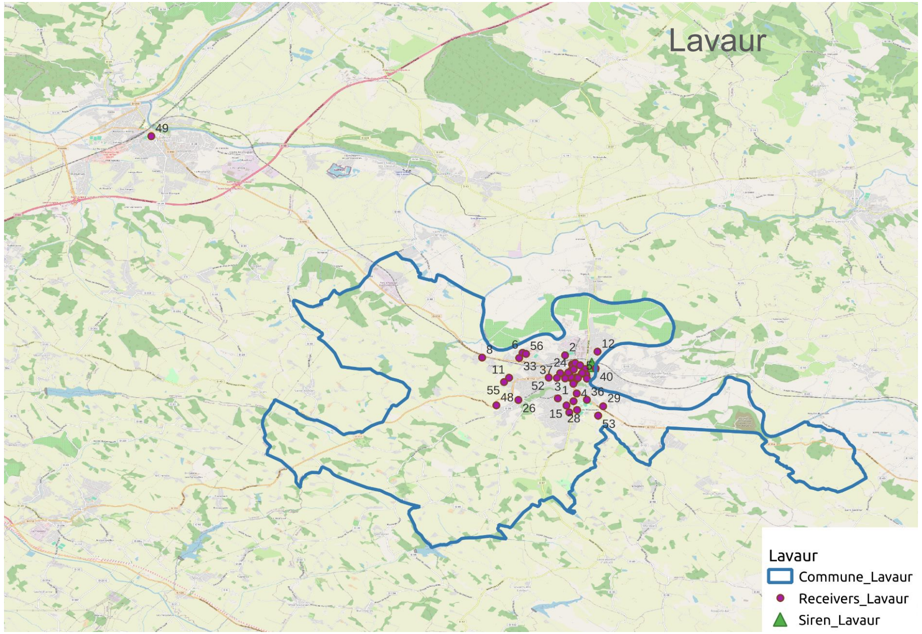
- In March 2024 through phone survey 150 people have been interviewed in 3 cities (Brignoles, Mazamet, Lavaur) to provide their experiences of audibility at home (with close & open windows) during siren test (first wednesday of the month)

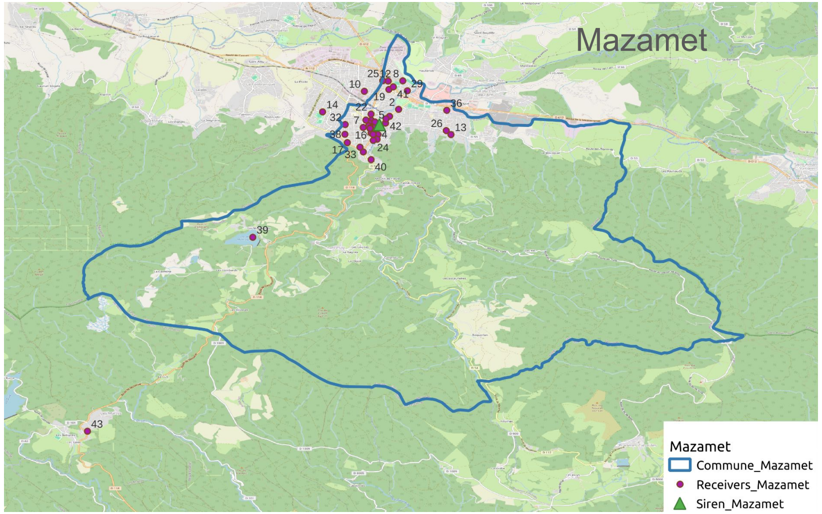
- In each city there is only one siren.

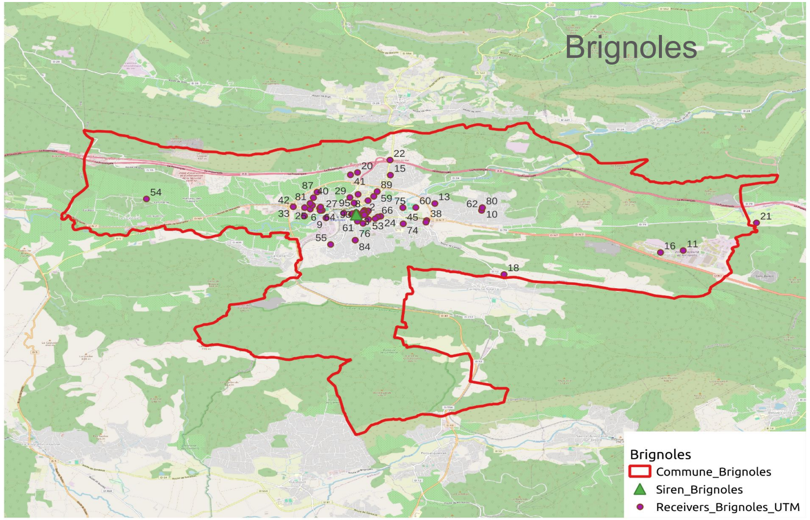
Location of 3 cities



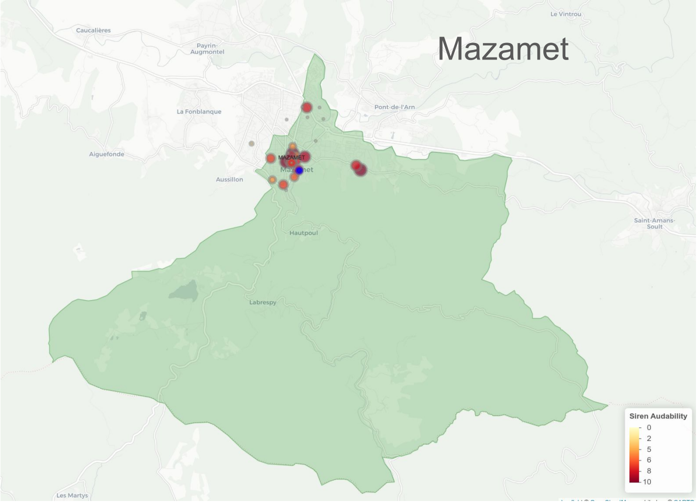
Location of Siren & Receivers (Surveyed Data)

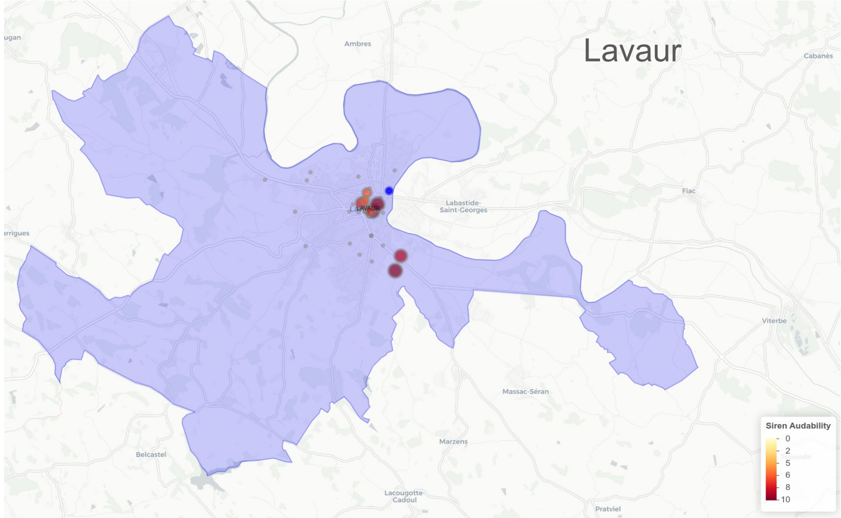


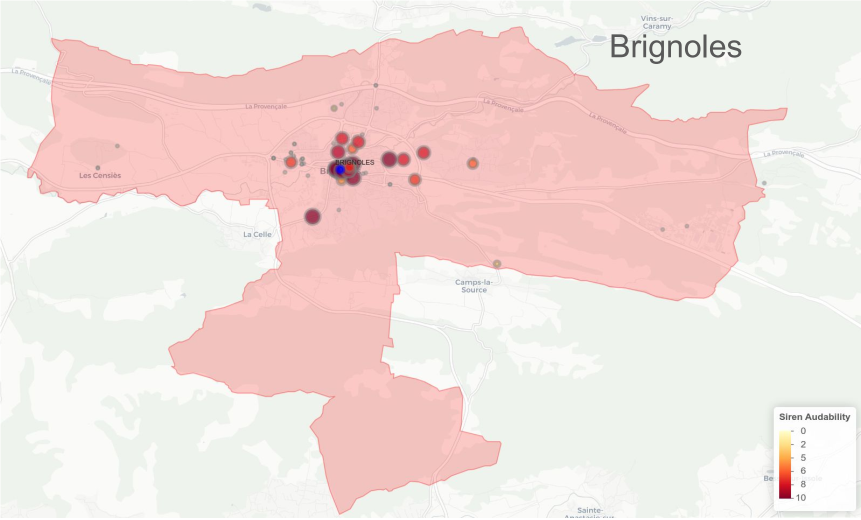




Audability (Surveyed Data)





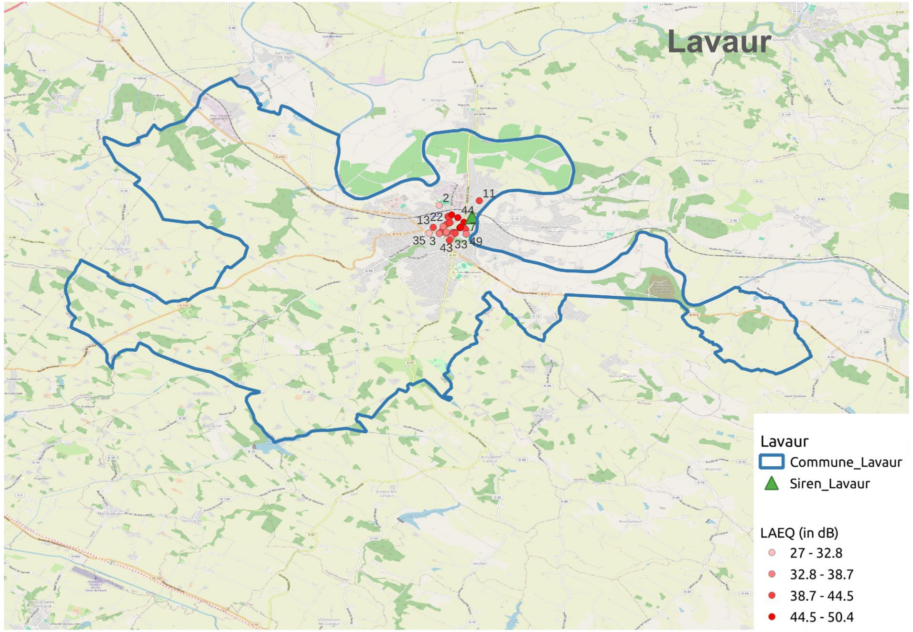


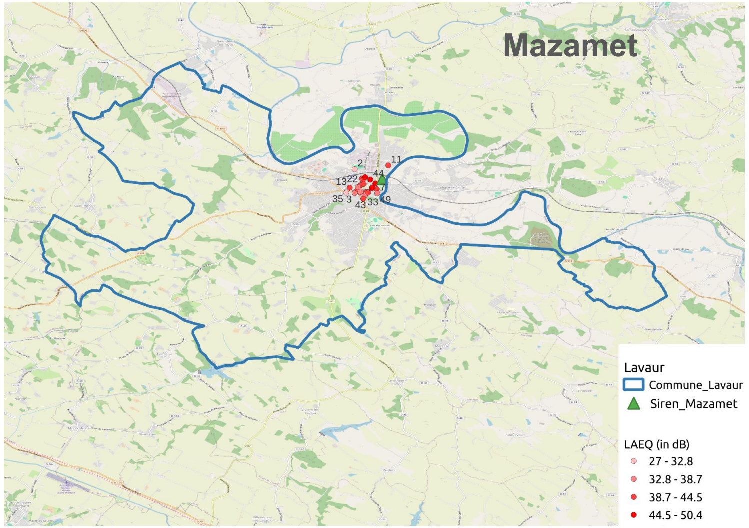
● Siren

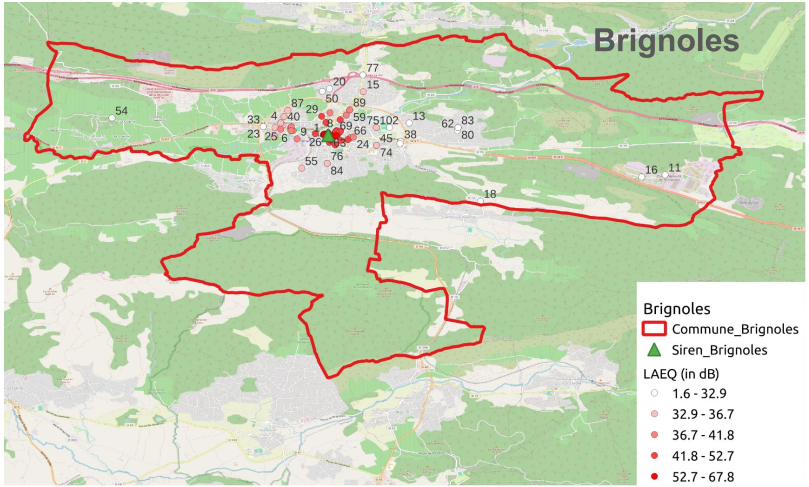
NoiseModelling- 3 cities

- Noise Mapping- maps for LAEQ (A-weighted, equivalent continuous sound level) (in dB) has been prepared for all 3 cities using NoiseModelling software.

Noise Mapping



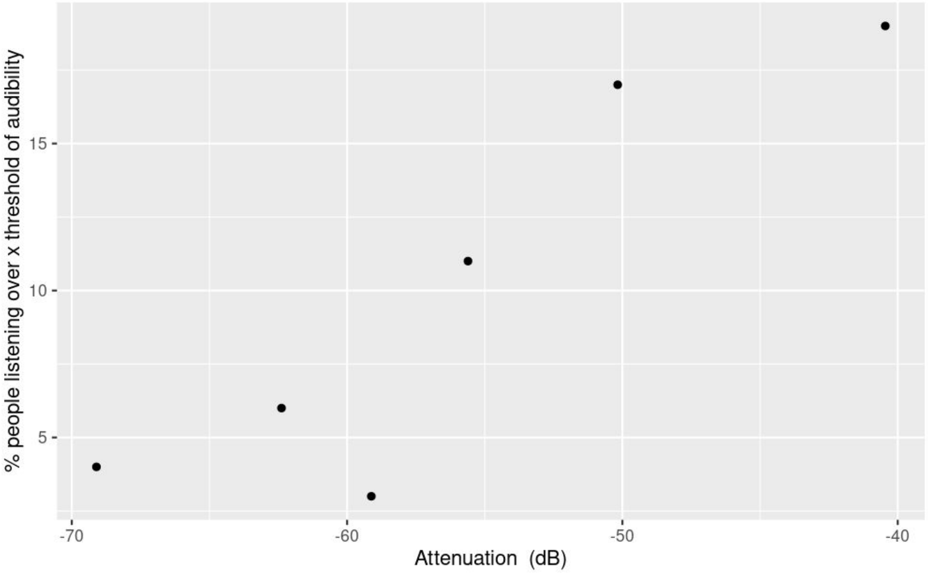




Relationship between sound level and audibility

- By calculating the distance matrix between source (siren) and receivers using audibility.

First method- No of groups = 6 with threshold = 5



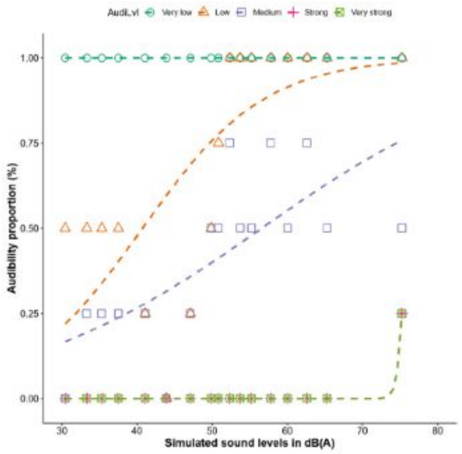
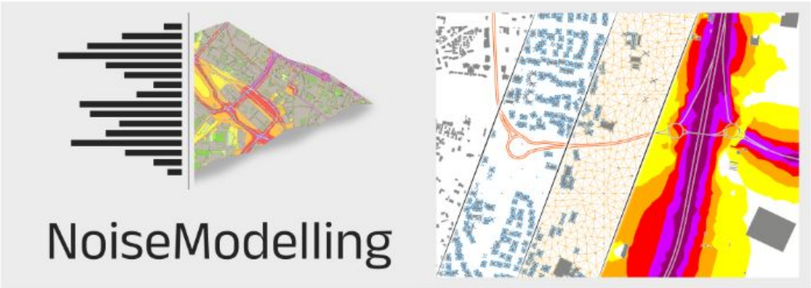


Figure 13: Audibility proportion curves (%) of the siren as a function of the sound level in decibels, for "Very low," "Low," "Medium," "Strong," and "Very strong" audibility level.

Tools for spatial optimisation based on audibility

Tools for spatial optimisation based on audibility



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OpenMOLE
the model exploration software

OpenMole

- NoiseModeling simulates the spatial coverage of a siren for a given position in an environment. But localisation of sirens having maximum coverage isn’t possible through NoiseModelling.

- For this purpose the OpenMole program, an online platform to perform model exploration in parallel computing, has been used.

- The OpenMOLE platform has been specifically designed to embed simulation models and conduct exploration experiments on Sirens. Current exploration methods includes sensitivity analysis, calibration, (multi-criteria) optimization and novelty search.

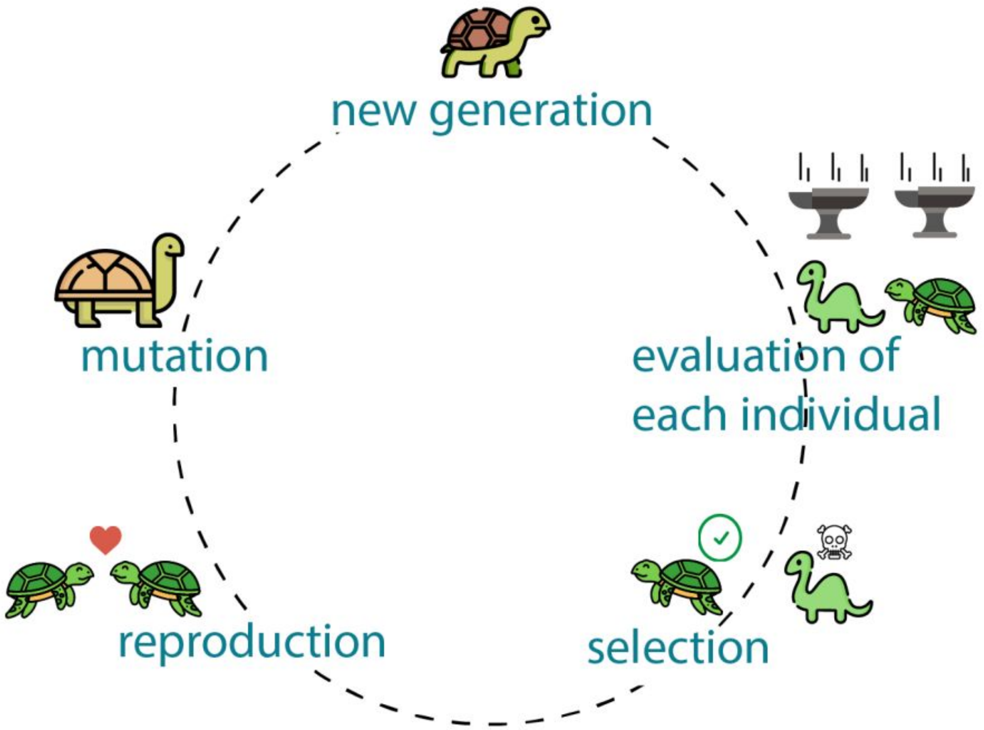
Spatial Optimization- St. Barthélemy

- Localization of 13 sirens, need to be installed, through NoiseModelling & OpenMole.

Input Data

1. Buildings- BD TOPO ©databases départementale
2. Roads & Land Use- Open Street Map
3. Digital Elevation Model (5m)- BD ALTI from IGN
4. Location of Sirens in Lat & Long- centroids of polygons created using intersection of public places and road network

NSGA-II: Non-dominated Sorting Genetic Algorithm



Model Setup

Fitness

1. maximum number of receiver with sound level => 60 dB [completed]
2. maximum number of building with at least one facade receiver > x dB
3. some points should have at least one facade receiver > x dB (i.e. schools)

Parameters

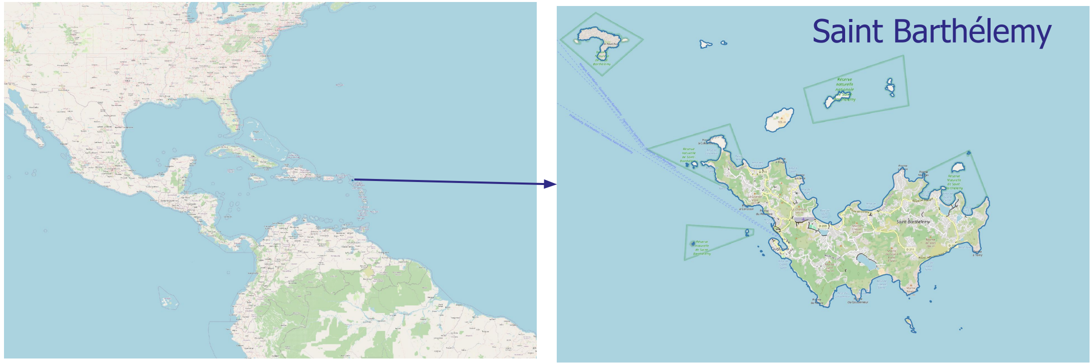
1. Localisation of the sirens (latitude, longitude)
2. Initial locations (polygons) were created by creating intersections (upto 3-5m) between the public spaces (owned by municipalities) and road networks of St. Barthélemy.

Contraints

1. Height, number of sirens, height of the sirens, meteorological conditions (‘neutral’), etc.

Case study

1. Saint Barthélemy, is an overseas collectivity of France in the Caribbean.



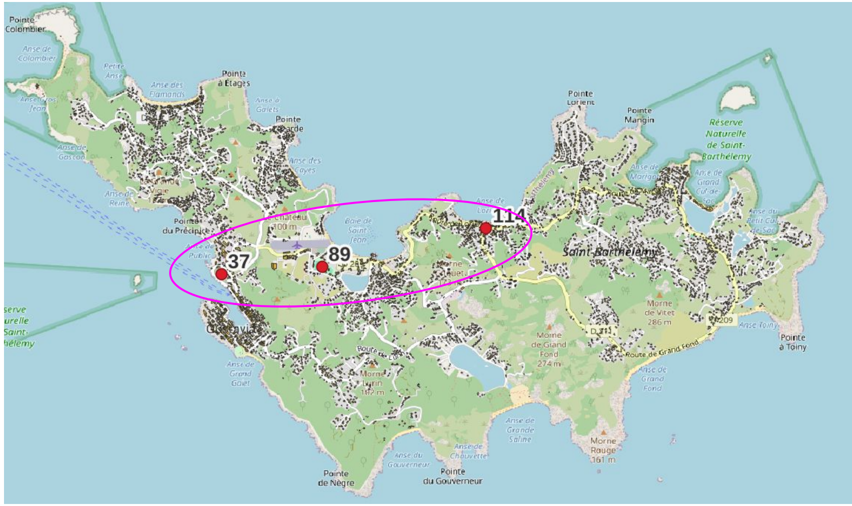
2. 13 sirens with differents sound level

Objective : compare our spatial optimisation with what will do experts on field.

Preliminary results- Best 3 locations

- Here we have used an optimization method to select, among all the parcels owned by the municipalities, the best localisation where the sirens could be set up. In primary results for first 3 best locations it resembles quite same 3 locations analysed by the experts. See below maps.

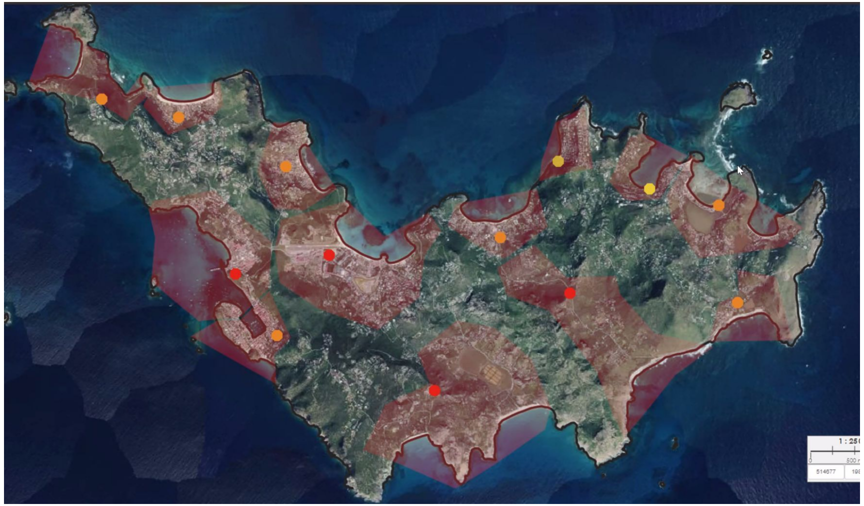
Expert positioning



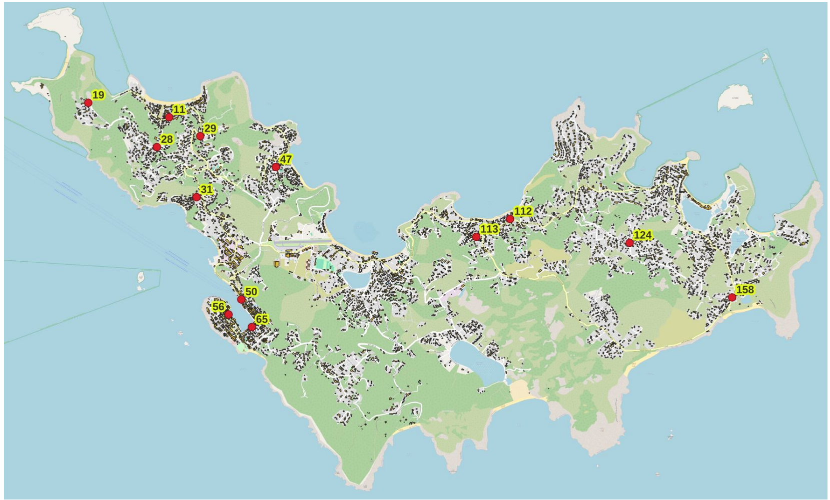
Optimisation with OM + NM

Preliminary results- All locations

- Using the similar criterion, all 13 locations have been optimized (shown in below right map). Covering 1415/8270 lodgements receiving =>60 dB.
- As per our model, for some locations it disagree with the expert based locations of sirens.



Expert positioning



Optimisation with OM + NM

Conclusion

- We have a new curve for audibility
- We have a tool that is able to do spatial optimisation
- We still have to finalise the audibility curve (sound level of sirens?)
- We still have to explore the tool and compare to expert
- Publish our results

Merci pour votre attention

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