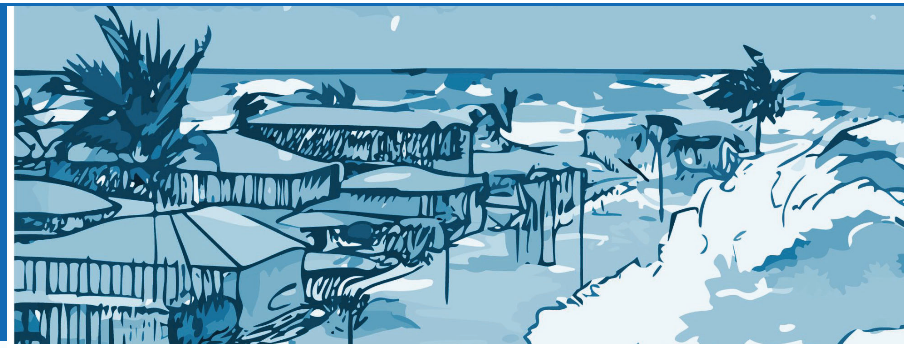
Tsunami Evacuation Mapping Workshop

30 June – 4 July 2025



CoastWAVE 2.0 Project

IOC-UNESCO (EU DG ECHO)

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Louis Monnier

Lesson #3

Tsunami evacuation routes calculation using graph-based GIS methodology

Contact : matthieu.peroche@univ-montp3.fr

unesco Intergovernmental Oceanographic Commission

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2021 2030 United Nations Decade of Ocean Science for Sustainable Development

CoastWAVE NEAMTWS

LAGAM LABORATOIRE DE GEOGRAPHIE ET D'AMENAGEMENT DE MONTPELLIER

UNIVERSITÉ PAUL VALÉRY MONTPELLIER 3

Lesson’s overview

Semi-automatic mapping of tsunami evacuation routes using graph-based GIS tools

1. Theory

- Graph’s theory
- Walking pace reference
- Others methods

2. Practice

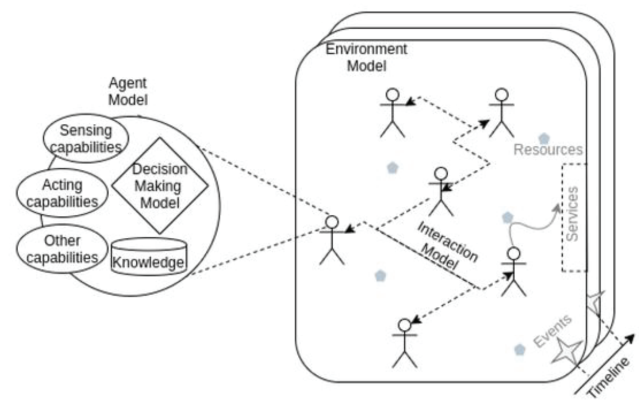
- Get the data and check topological rules
- Field work
- Specials cases
- Setting the starting points for the analysis
- Lauching the analysis

Method 3 – Agent-Based Modeling (ABM) - Simulating behavior on an individual level

- **Principle**:
  Individual-level simulation of the evacuation process. Each agent interacts with its environment and others based on predefined rules.

- **Required Data**:
  Behavioral profiles, spatial environment (raster or vector), alert scenarios, infrastructure and obstacles.

- **Configurable Parameters**:
  - Agent attributes: mobility, delay before action, knowledge of the area
  - Behavior rules: route choice, alert response, social interaction
  - Dynamic environment: congestion, blocked roads, tsunami impact



Herrera *and al*, 2020

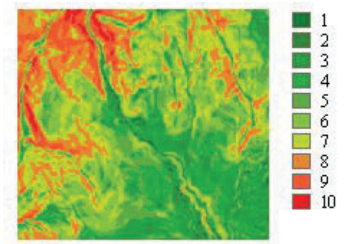
- **Expected Outputs**:
  - Individual and collective evacuation times
  - Flow maps, congestion points, critical areas
  - Success rate of evacuation under different alert and management scenarios

✅ **Advantages**: highly realistic, allows testing of planning and communication strategies

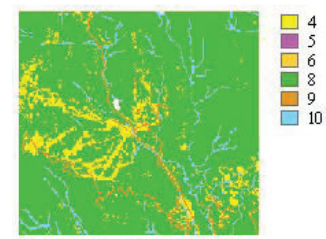
⚠️ **Limitations**: complex setup, requires behavioral data and careful calibration

Method 2 – Raster-Based GIS: Modelling evacuation with cost surfaces

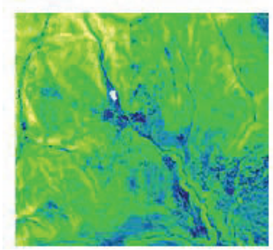
- **Principle**:
  Each raster cell is assigned a travel cost; algorithms calculate the least-cost path to a safe zone (cost distance analysis).
- **Required Data**:
  Digital Elevation Model (slope), land use, road/terrain surface types, restricted areas.
- **Configurable Parameters**:
  - Multiple parameters (slope, land use, road type) merged into a single **cost raster**
  - Reclassification of input layers to a common measurement scale
  - Weighting of each criterion based on its impact on travel speed
- **Expected Outputs**:
  - Minimum evacuation time maps
  - Identification of areas not reachable within safe time limits
  - Scenario comparisons across large and heterogeneous territories



Reclassified slope input



Reclassified land-use input


Final cost raster

https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/creating-a-cost-surface-raster.htm

✅ **Advantages**: flexible, well suited for poorly structured or natural environments
⚠️ **Limitations**: accuracy depends on raster resolution; less precise in dense urban settings

Method 1 – Graph-Based Models: Using networks for strategic planning

- **Principle**:
  The circulation network (roads, paths, stairs) is modeled as a graph composed of nodes and edges, allowing optimal route calculation to safe zones.

- **Required Data**:
  Road/path network, attributes (slope, surface type, hierarchy), location of safe areas.

- **Configurable Parameters**:
  - Edge orientation to enforce walking direction
  - Edge costs based on: slope, road hierarchy (width/importance), surface type
  - Travel speed can be weighted by segment characteristics

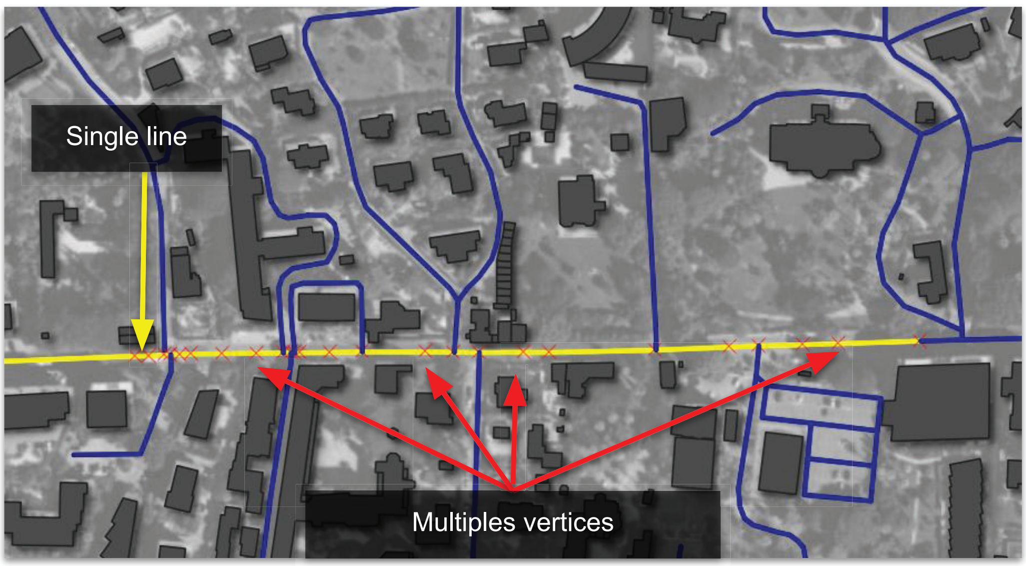
- **Expected Outputs**:
  - Shortest or safest evacuation paths
  - Evacuation isochrone maps
  - Identification of bottlenecks and critical segments

✅ **Advantages**: fast computation, easily readable, suited to urban environments
⚠️ **Limitations**: assumes optimal behavior, does not account for human interactions

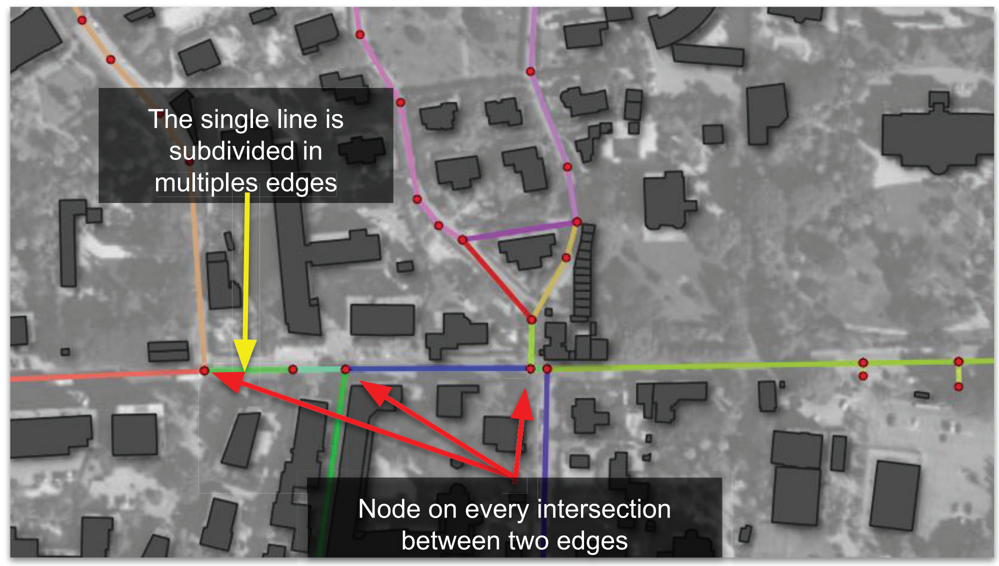
Sahal, A., F. Leone & M. Péroche.
« **Complementary Methods to Plan Pedestrian Evacuation of the French Riviera's Beaches in Case of Tsunami Threat: Graph- and Multi-Agent-Based Modelling** ».
Natural Hazards and Earth System Sciences 13, nº 7 (2013): 1735-43.
https://doi.org/10.5194/nhess-13-1735-2013.

Difference between network and graph

Network



Network in graph configuration



Depending on your national data providers, the transportation network can be already configured as a graph.

This isn't the case with OSM data

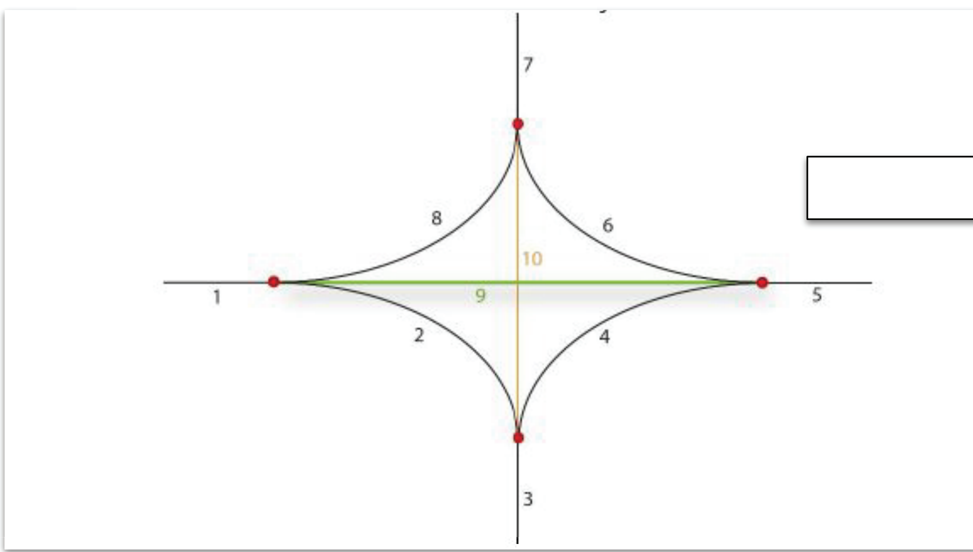
Graph topology

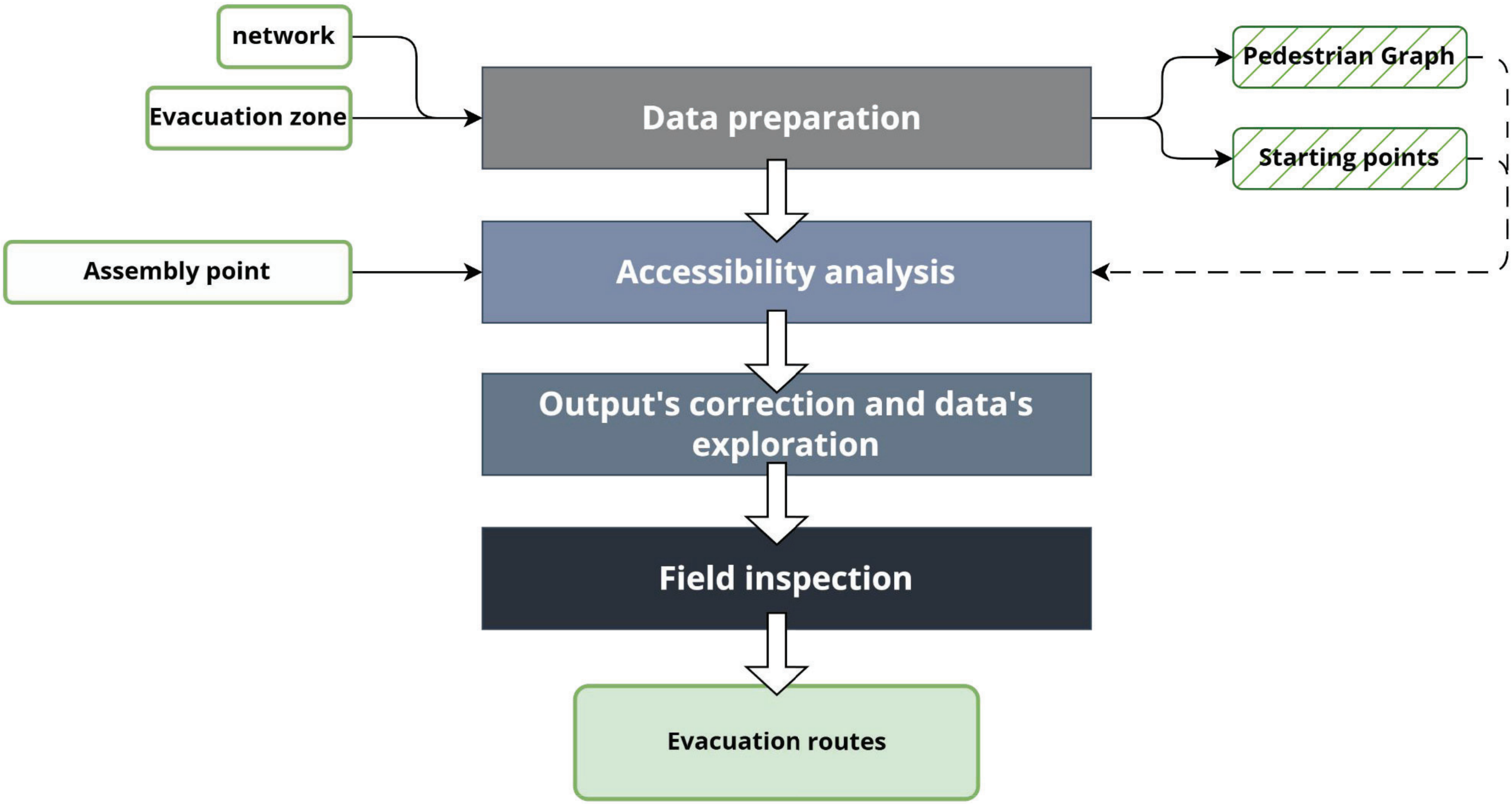
Eg. Two roads cross at different heights.

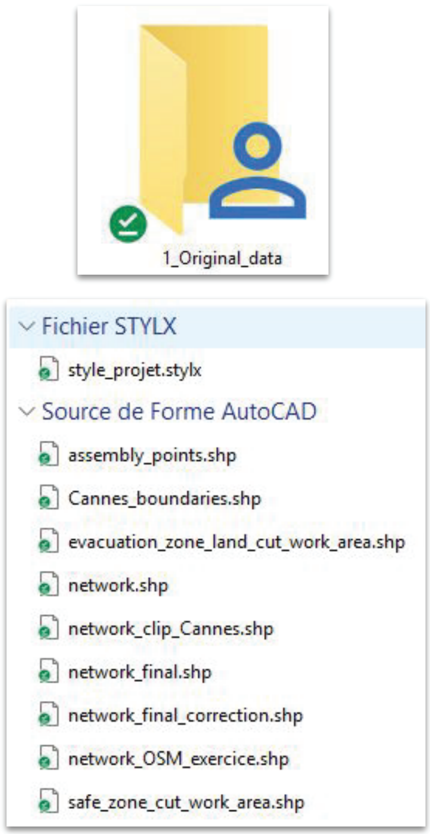
The graph topology rules allow an accurate representation of the connectivity between roads in real life

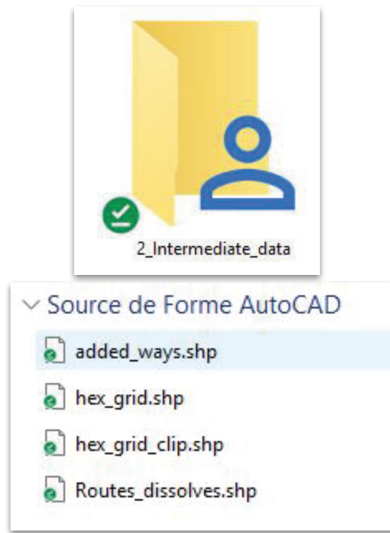
"[...] topology is the arrangement that defines how point, line, and polygon features share **coincident geometry**."

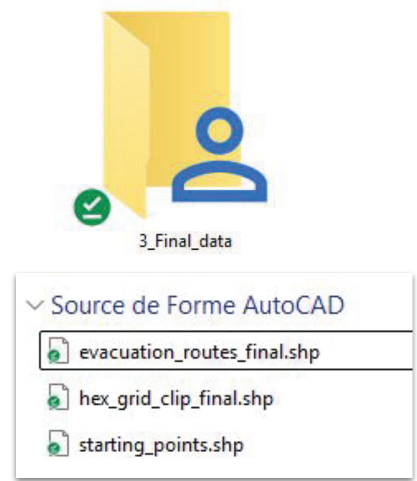
https://pro.arcgis.com/en/pro-app/latest/help/data/topologies/topology-in-arcgis.htm



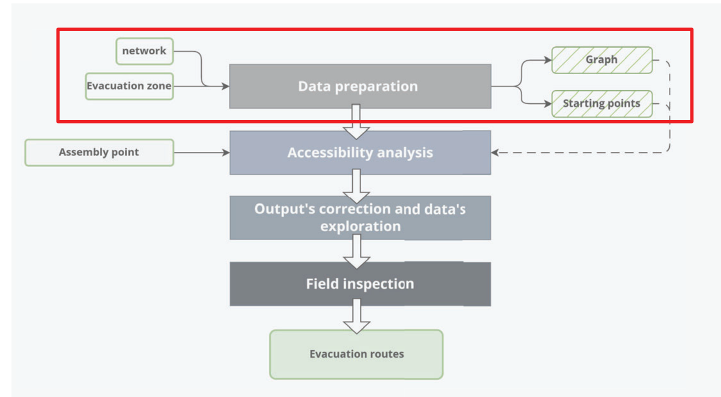

network
Evacuation zone
Data preparation
Pedestrian Graph
Starting points
Assembly point
Accessibility analysis
Output's correction and data's exploration
Field inspection
Evacuation routes

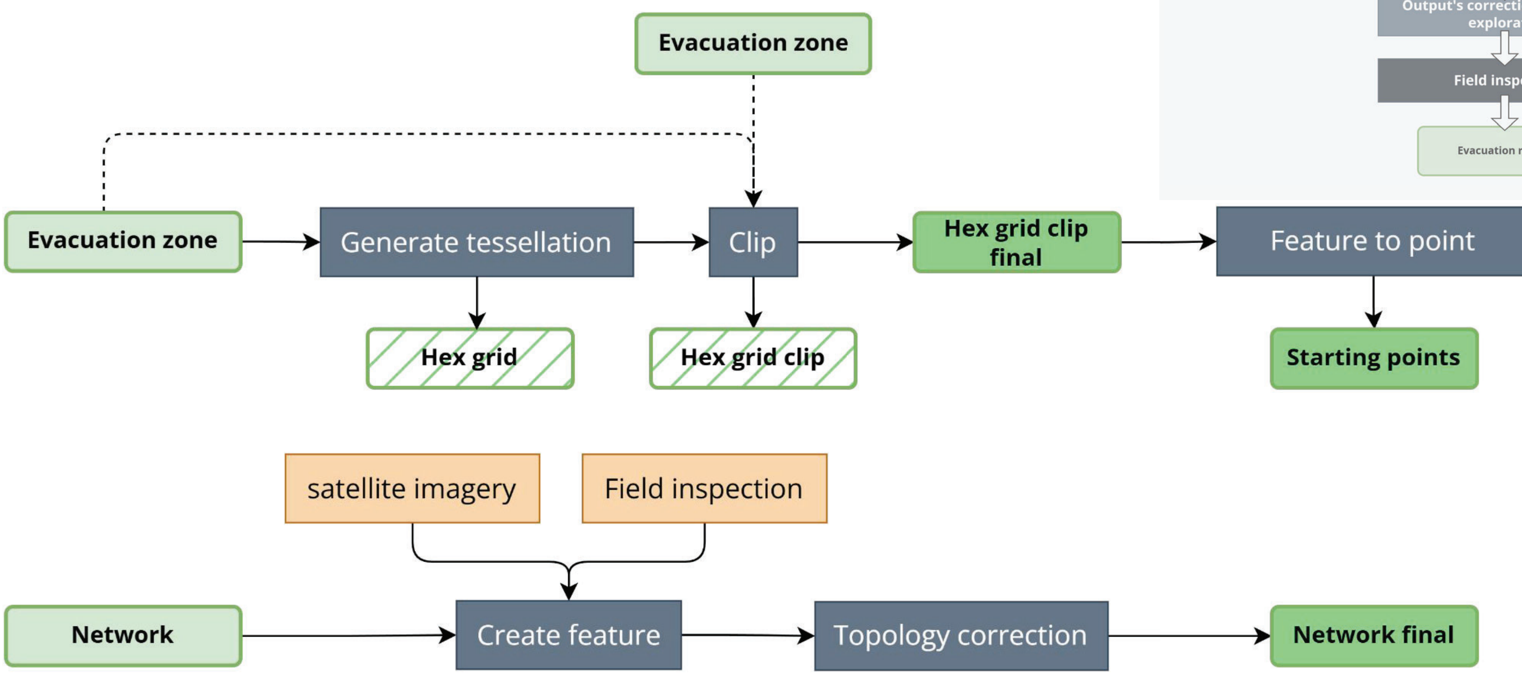

1_Original_data
Fichier STYLX
style_projet.stylx
Source de Forme AutoCAD
assembly_points.shp
Cannes_boundaries.shp
evacuation_zone_land_cut_work_area.shp
network.shp
network_clip_Cannes.shp
network_final.shp
network_final_correction.shp
network_OSM_exercice.shp
safe_zone_cut_work_area.shp


2_Intermediate_data
Source de Forme AutoCAD
added_ways.shp
hex_grid.shp
hex_grid_clip.shp
Routes_dissolves.shp


3_Final_data
Source de Forme AutoCAD
evacuation_routes_final.shp
hex_grid_clip_final.shp
starting_points.shp

Data preparation





Generate the starting points for accessibility analysis

Why use a regular grid?

- Ensures **homogeneous coverage** of the evacuation area
- Defines **departure points** for route generation
- Enables spatial analysis and comparison

What can we compute on the grid?

- **Evacuation areas**
- **Evacuation times**
- **Population and assets to evacuate**
- Other **geo-indicators** for risk and capacity assessment

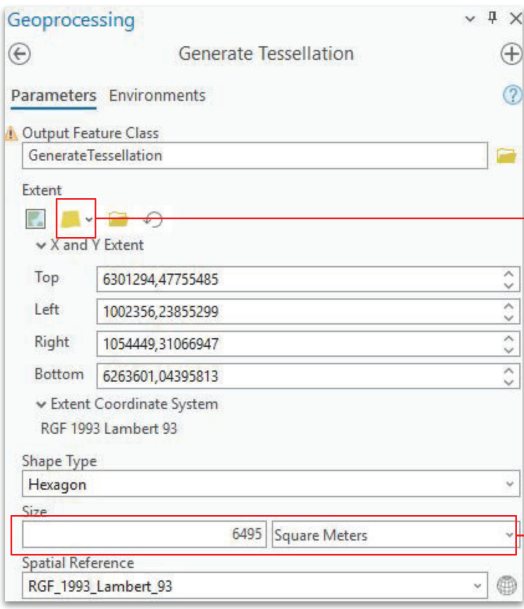
Generate the starting points for accessibility analysis

Why Use Hexagonal Grids Instead of Squares?

- Equal distance to all neighbors → **consistent spatial aggregation**
- **Avoids directional bias** from square grids
- **Matches circular influence zones** (e.g. audibility, evacuation time)
- Supports **natural aggregation of spatial indicators**
- Cleaner visual output → **smoother**, **more readable maps**
- **Uniform shape and size** across the study area
- **Better spatial aggregation** than squares
- No directional bias in spatial patterns
- **More natural for computing indicators** (density, exposure, evacuation time)
- **Visually smoother and easier to interpret**

Generate the starting points for accessibility analysis

1. Generate a hexagonal grid covering the evacuation zone using the **Generate Tessellation** tools, then **clip** it two times : with Canne's administrative boundaries and with the evacuation zone.



Select the evacuation zone layer

Area = **6495 m^2** (50m long edges)

Example of spatial data enrichment of the initial grid

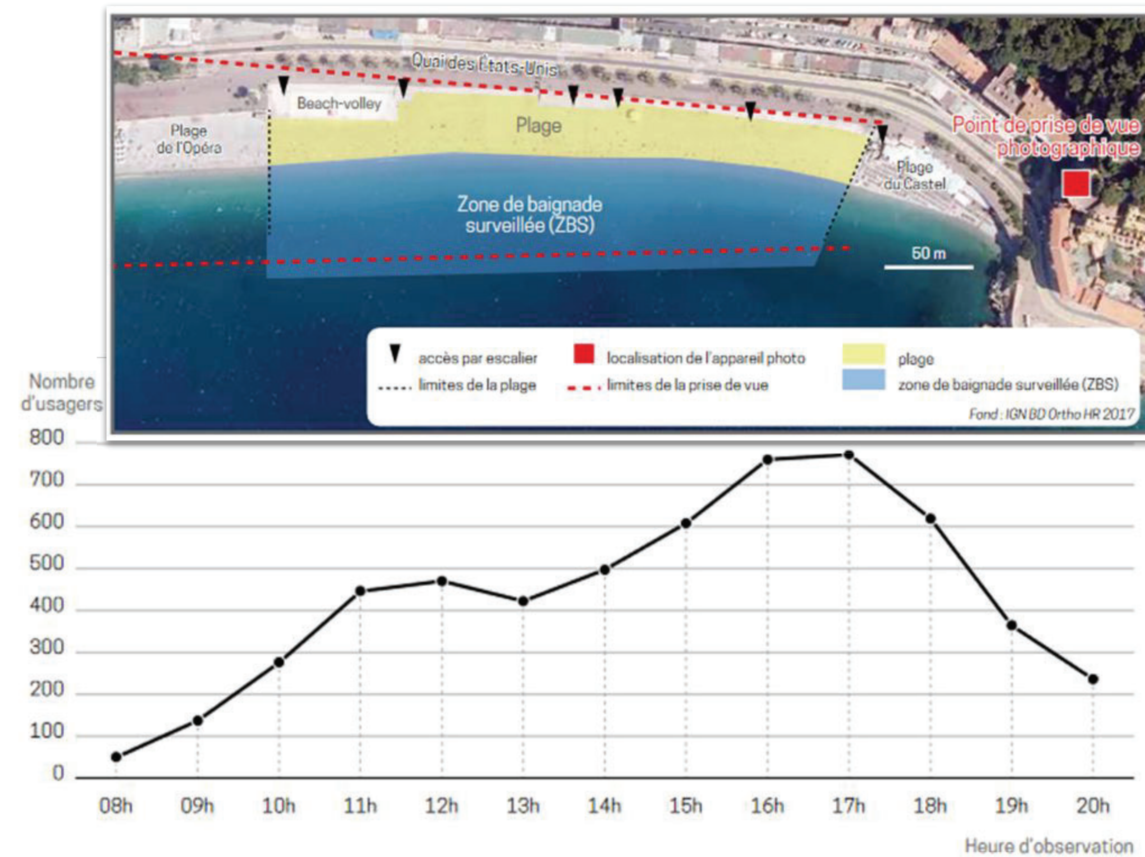
Human frequentation data is used to :

- Assess the most critical area in case of evacuation
- Adapt the assembly points capacity
- Check if the evacuation routes are sized with the traffic

Manual beach's users count method offer precise information on variation of the number of visitor on a **hourly basis**.

Limitations :

- Time consuming
- Need a high observation spot
- Limited to few beaches depending on the number of surveyor



Number of users at the Ponchettes beach, Nice, the friday 17 Jully

Example of spatial data enrichment of the initial grid

Using **high resolution imagery** (10-20 cm res.) for frequentation study allow to collect data for a larger number of beaches.

High resolution imagery was provided by **IGN** (BD Ortho, 2014) :

April 23, 2014 between 10:30 and 10:50
June 5, 2014 between 14:00 and 15:00.

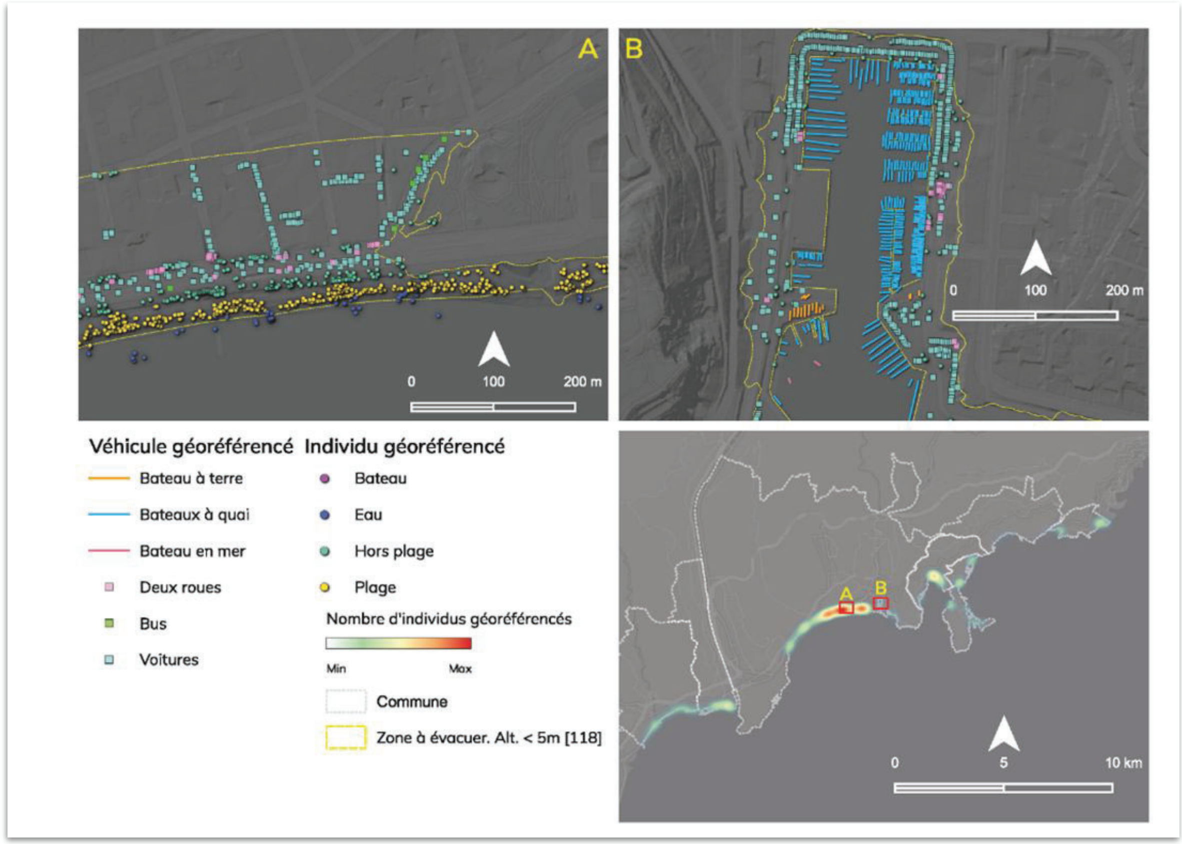
Example of spatial data enrichment of the initial grid

As part of the EVACTSU project, photo-interpretation work was used to reference **all visible individuals, vehicles and boats** in the evacuation zone of Nice's metropole.

A total of **7,659 people** were visible :
- ~ 5 000 were counted on the beach
- ~ 2 000 outside of the beach
- ~ 300 people in the sea

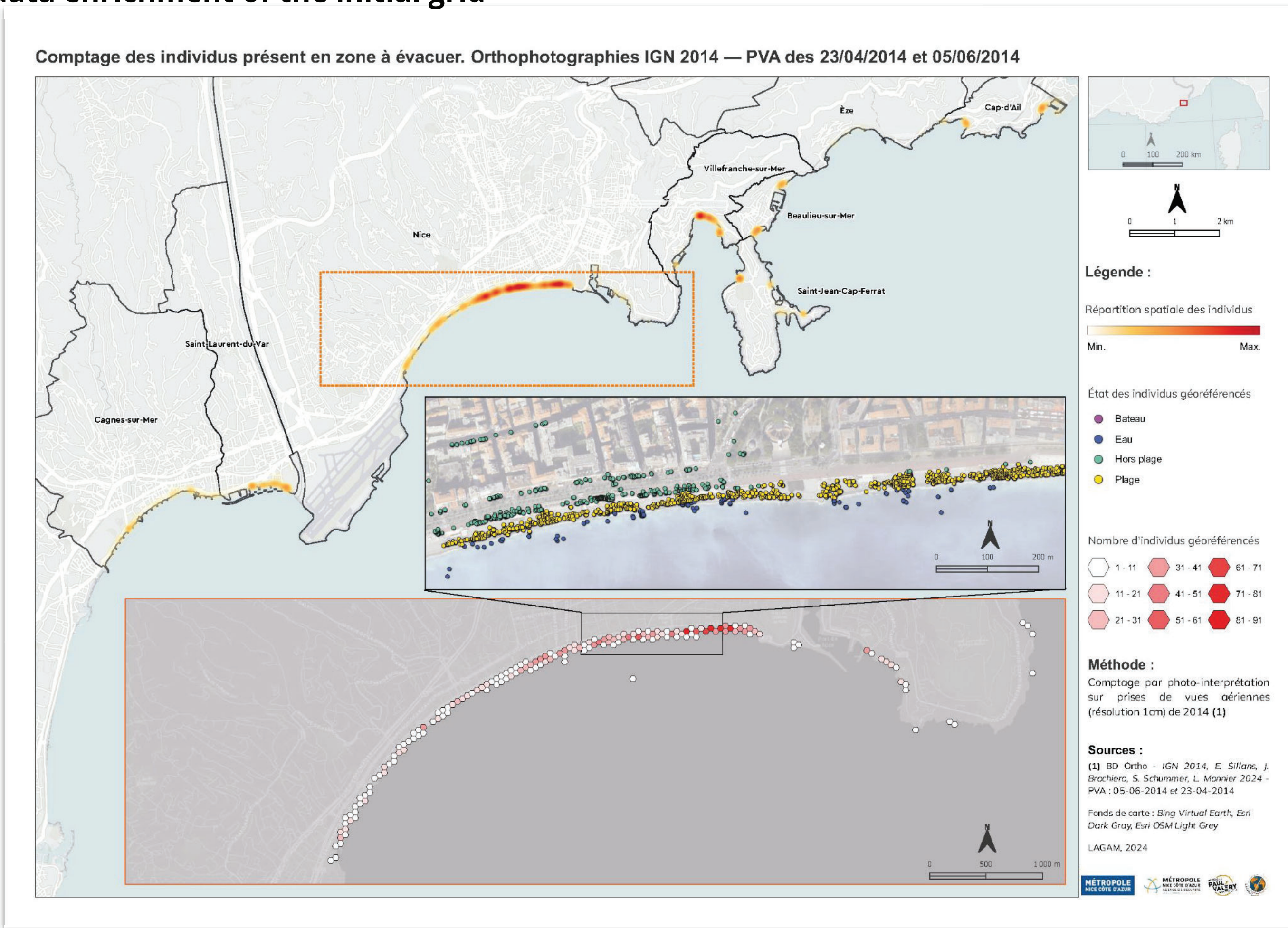
Those data were used to provide :

- A **snapshot of human frequentation** for the whole coastal area of Nice Metropole.
- The **number of people per assembly points** for this specific evacuation scenario.



Tsunami evacuation routes calculation using graph-based GIS methodology

Example of spatial data enrichment of the initial grid



Example of spatial data enrichment of the initial grid

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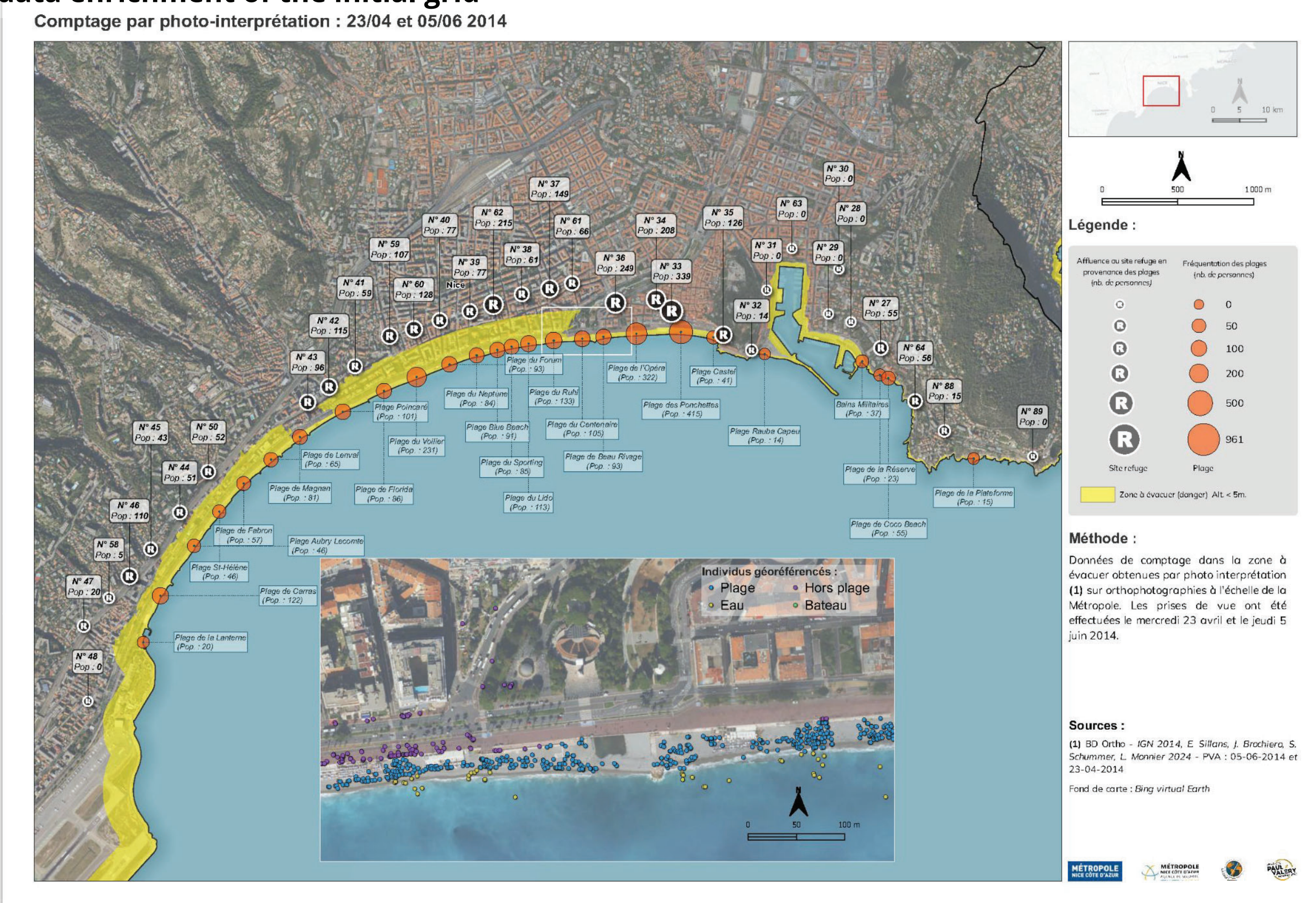
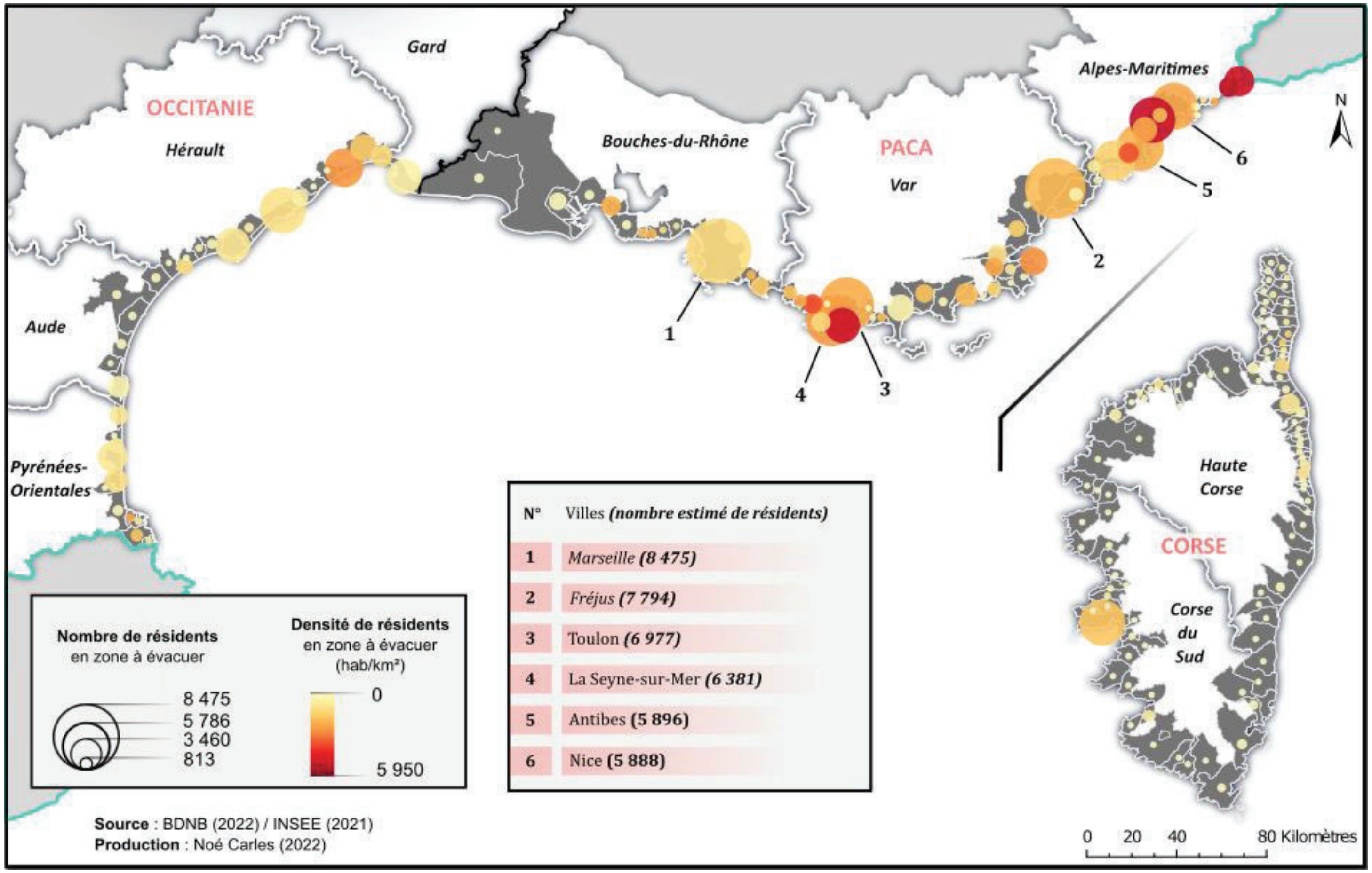


Example of spatial data enrichment of the initial grid



Estimation of the number of residents within the tsunami evacuation zone, based on land registry data and aggregated by municipality.

Noé Carles, Matthieu Péroche, Johnny Douvinet & Pierre Foulquier. « **Estimation du nombre d'individus à évacuer en cas de tsunami à l'échelle du littoral méditerranéen français** ». *Méditerranée, publication en ligne anticipée, 28 mars 2023.* https://doi.org/10.4000/mediterranee.14431.

Example of spatial data enrichment of the initial grid

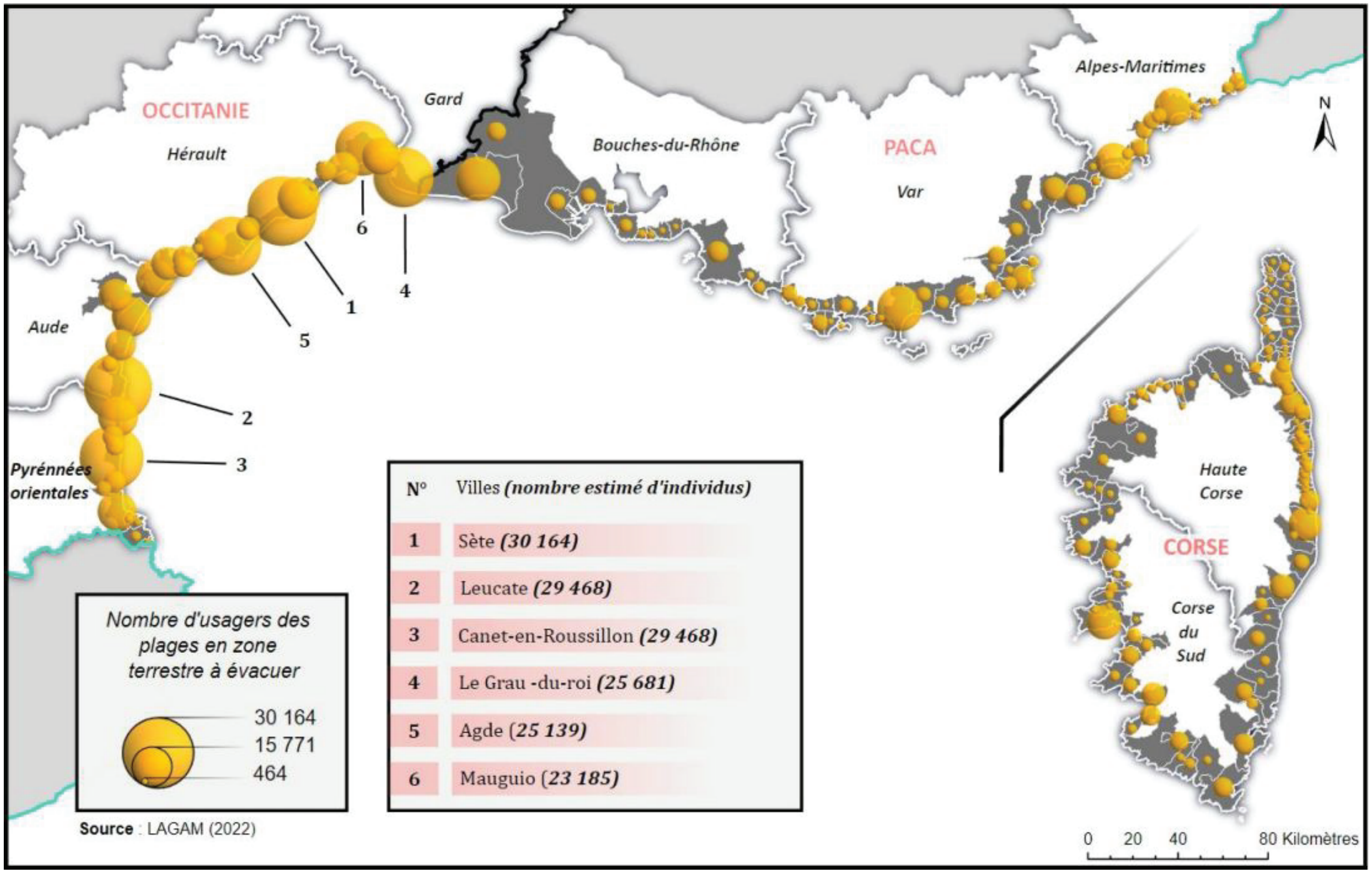
Location of photos taken during beach overflights

Photo : M. Peroche, 2021

Aerial Survey Protocol for Counting Beach Users During Peak Attendance

- **Three flights** conducted around the weekend of **August 15, 2021**
- **Aerial photographs** taken of beaches across **six departments**: Pyrénées-Orientales (66), Aude (11), Hérault (34), Gard (30), Bouches-du-Rhône (13), and Var (83)
- **1,762 geolocated images**
- **Manual counting** of people on the beach and in the bathing area across **27 beaches or beach sections**
- **Digitization of studied beaches** as polygons in a **GIS environment**
- The time of flights was set between **3:00 PM and 4:30 PM**, corresponding to the **peak beach attendance period** according to the literature

Example of spatial data enrichment of the initial grid



Number of beach users extrapolated from aerial images, and aggregated by municipality.

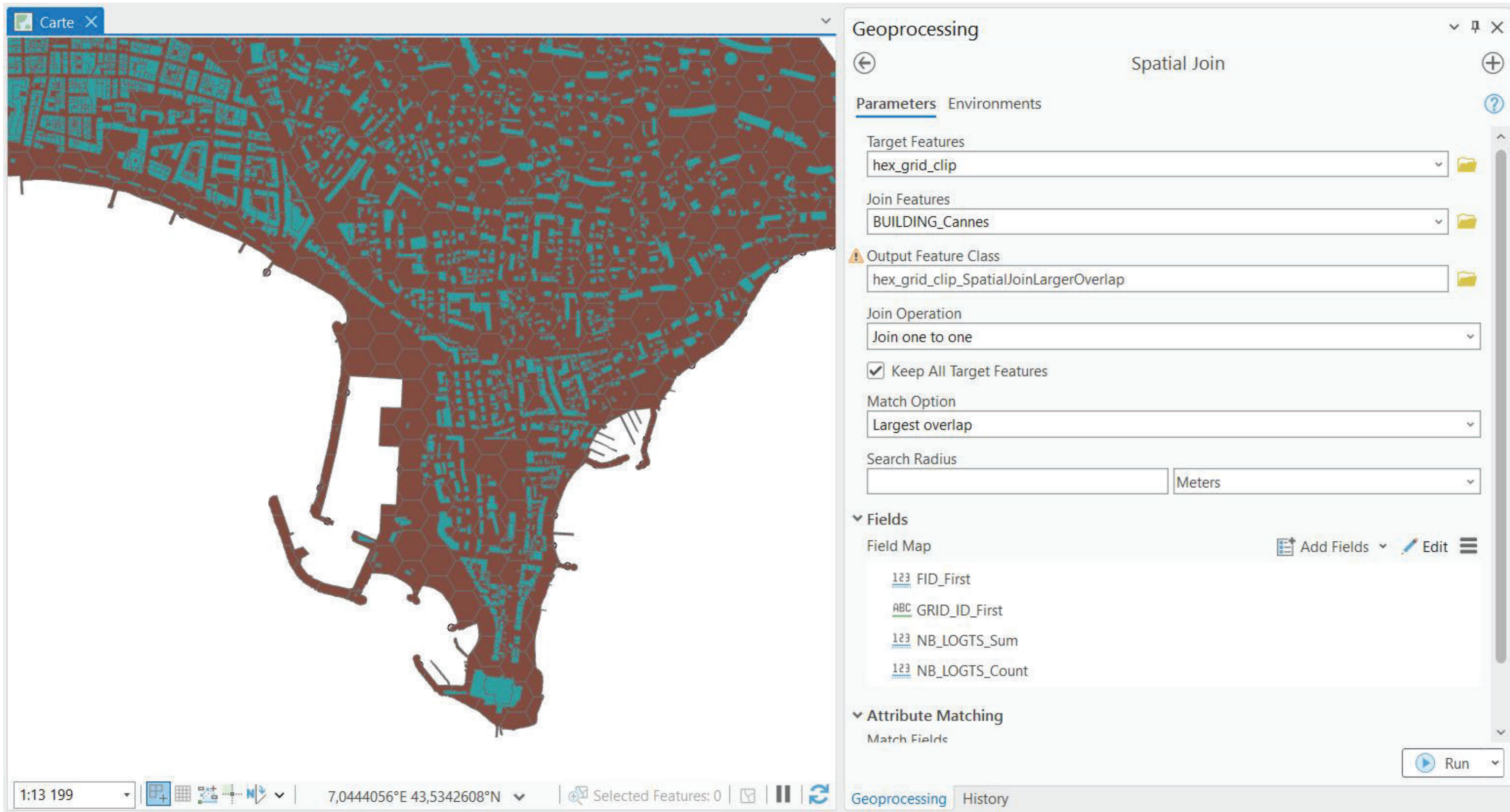
Noé Carles, Matthieu Péroche, Johnny Douvinet & Pierre Foulquier. « **Estimation du nombre d'individus à évacuer en cas de tsunami à l' échelle du littoral méditerranéen français** ». *Méditerranée, publication en ligne anticipée, 28 mars 2023.* https://doi.org/10.4000/mediterranee.14431.

Example of spatial data enrichment of the initial grid

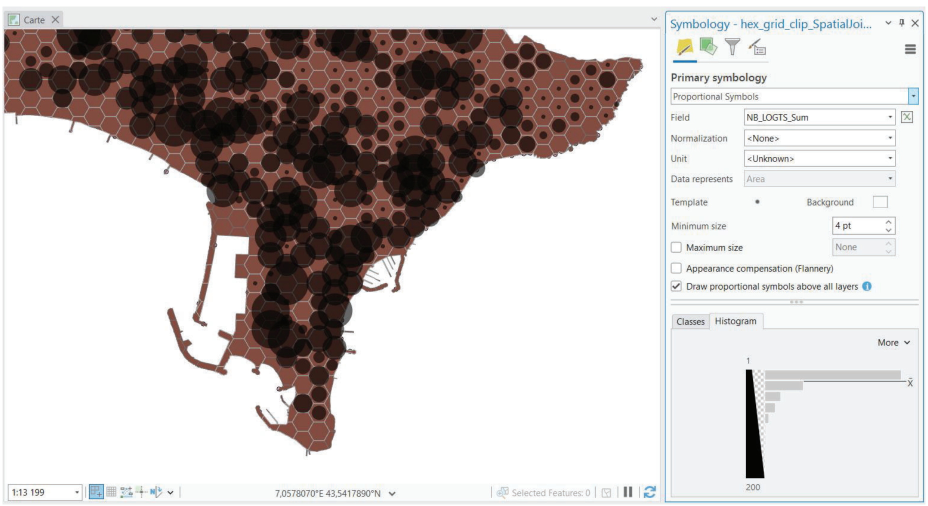
Changes in visitor numbers at the Croisette public beach (Cannes) on Saturday, July 30, 2022 between 10am (**photo A)** and 9pm (**photo B**). (Carles N., 2024)

Example of spatial data enrichment of the initial grid

Spatial join to enrich the hexagonal grid with building data (number of buildings, number of housing units). Use "Largest overlap" to avoid double counting — or convert polygons to points first.

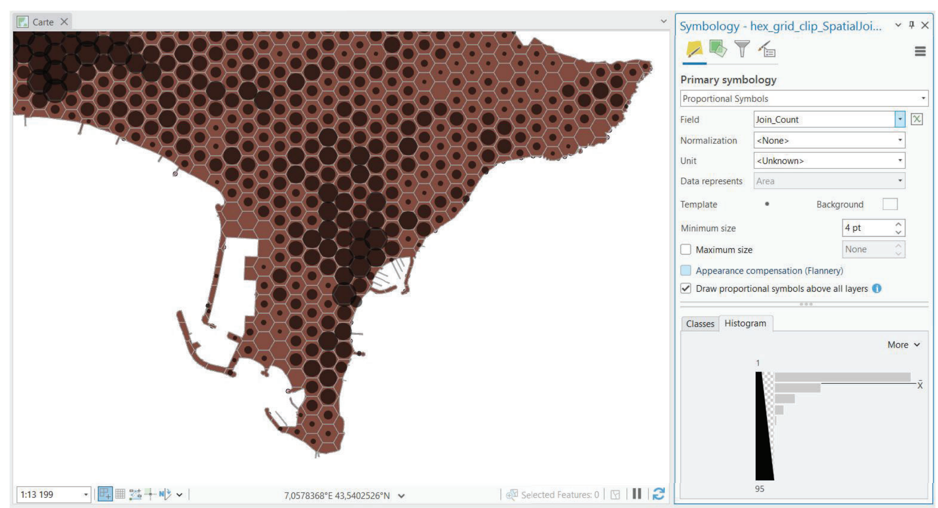


Example of spatial data enrichment of the initial grid



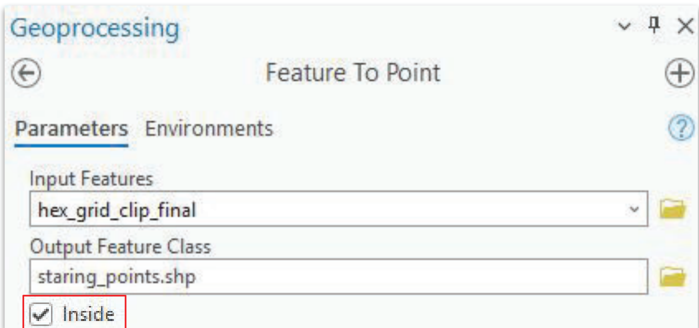
Number of housing units

Number of buildings

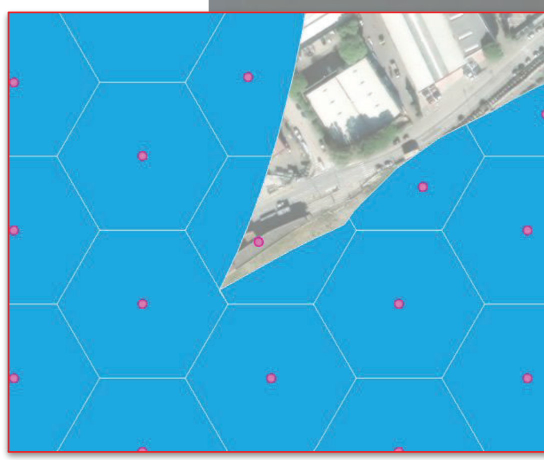


Generate the starting points for accessibility analysis

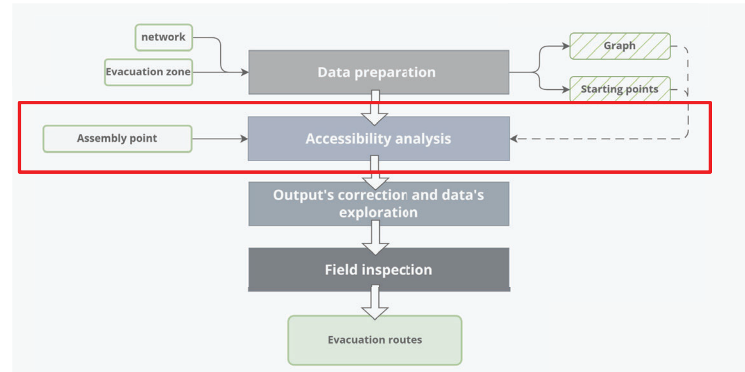
1. Generate the starting points using the **Features to point** tools.

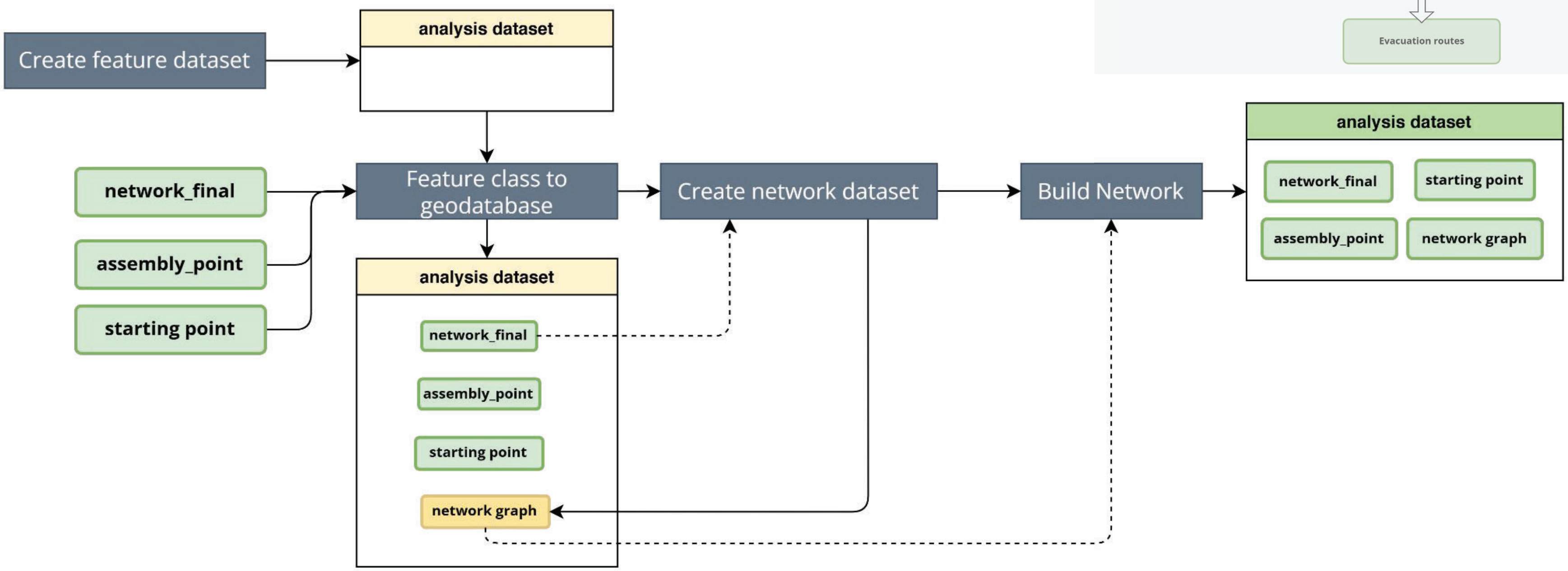


Feature to Point tools generate a point on every feature's centroid. Due to previous clipping processing, **"Inside" parameter must me activated** in order to avoid generating external points :



Accessibility analysis 1/2 : Setting the analysis database

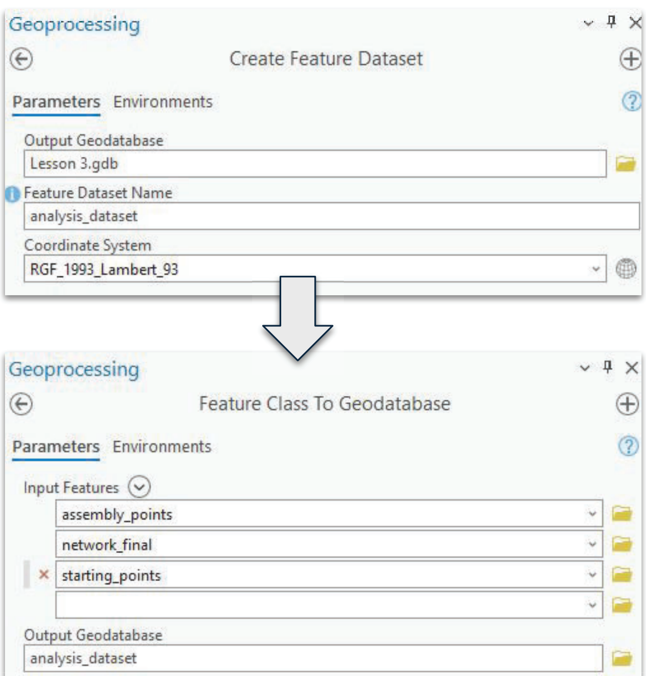




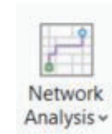
Accessibility analysis 1/2 : Setting the analysis database

In order to realize a accessibility analysis, ArcgisPro require all layers (starting point, network, and assembly point) that will be used to be gathered in a single database.

Geodatabase

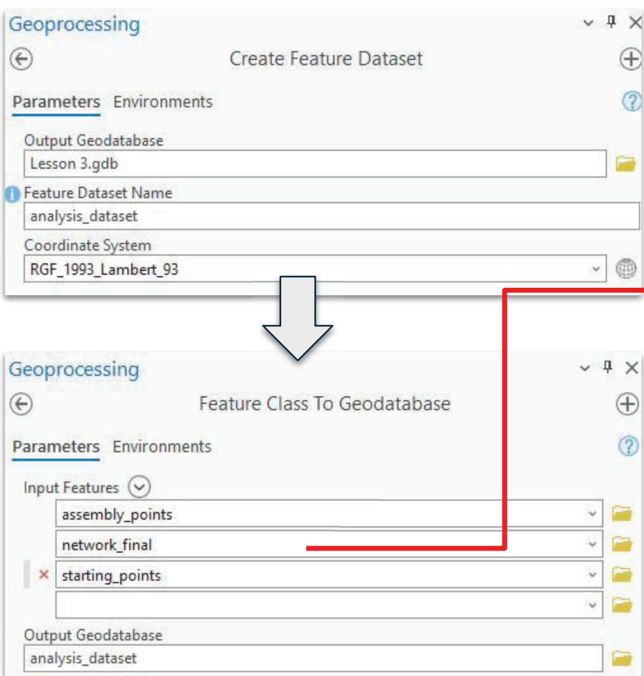


Accessibility analysis 1/2 : Setting the analysis database

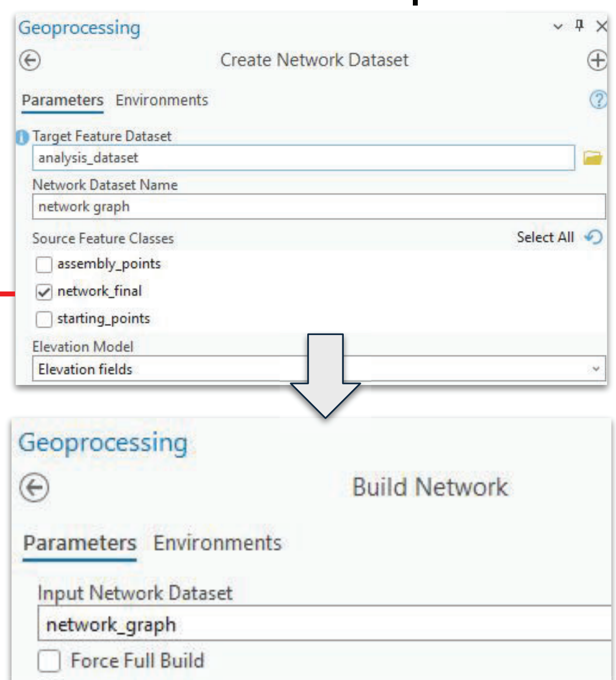


The graph must be added to the geodatabase then build

Geodatabase



Network Graph



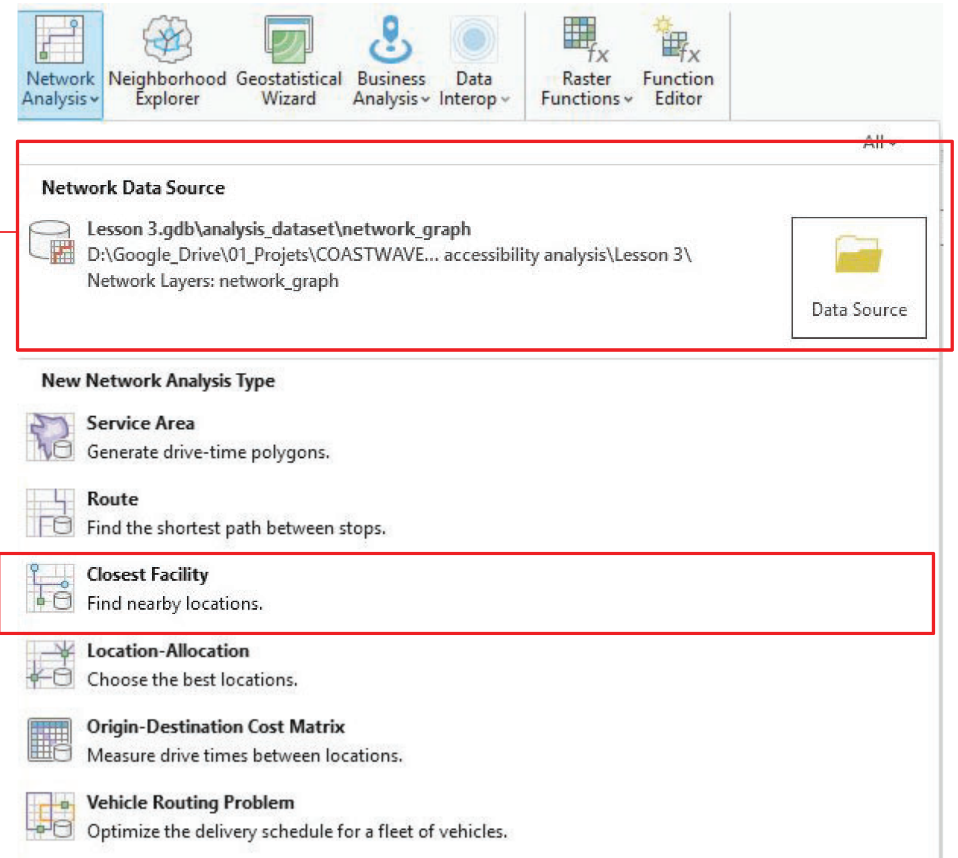
Accessibility analysis 2/2 : Launching Network Analysis

Top ribbon > Analysis > Workflow>Network Analysis

Be sure that your network graphe is set as the network Data Source

"The closest facility solver finds one or more facilities that are closest to an incident based on travel time or travel distance and outputs the best routes between the incidents and the chosen facilities."

In our case, the **facilities will be our assembly points**, and the **incidents will be the starting points.**

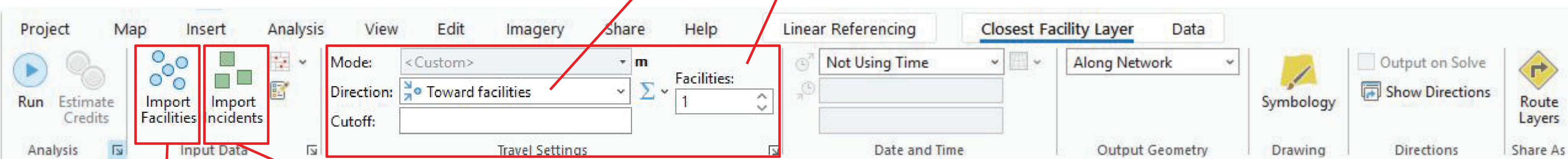


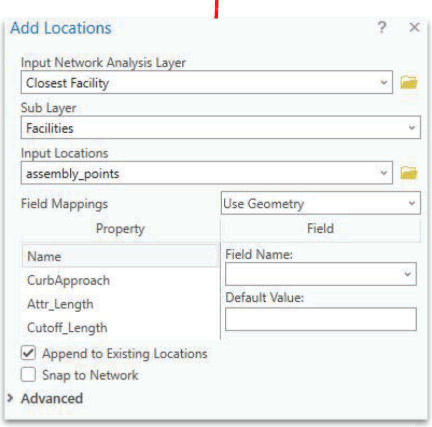
Accessibility analysis 2/2 : Launching Network Analysis

Top ribbon > Closest Facility

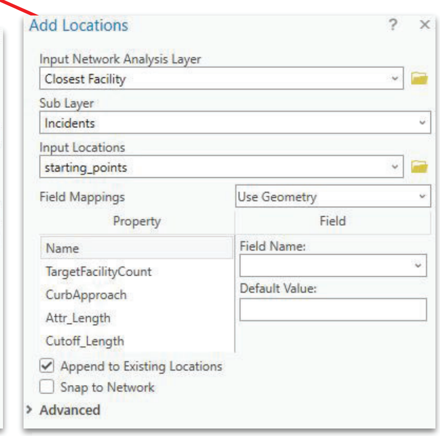
Set search direction toward assembly points

N → **1** relation





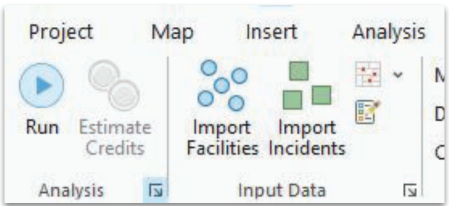
Assembly points



Starting points

Expected result :

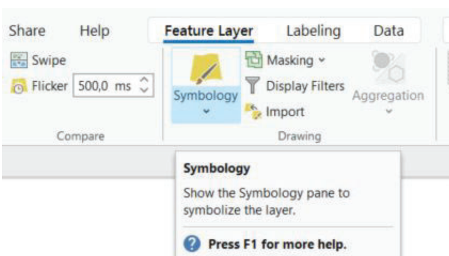
Accessibility analysis 2/2 : Launching Network Analysis

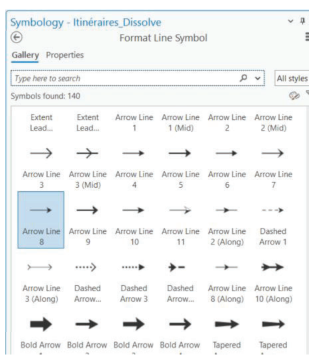


Click on **Run** to compute the shortest routes

Change the routes symbology for a better understanding of the algorithm's output :

- Feature Layer > Symbology





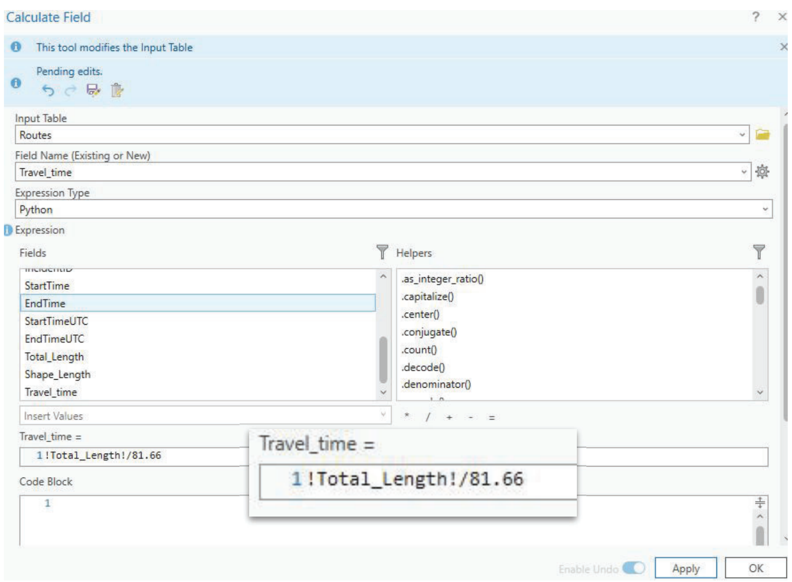
How to explore data?
What improvements can be made?

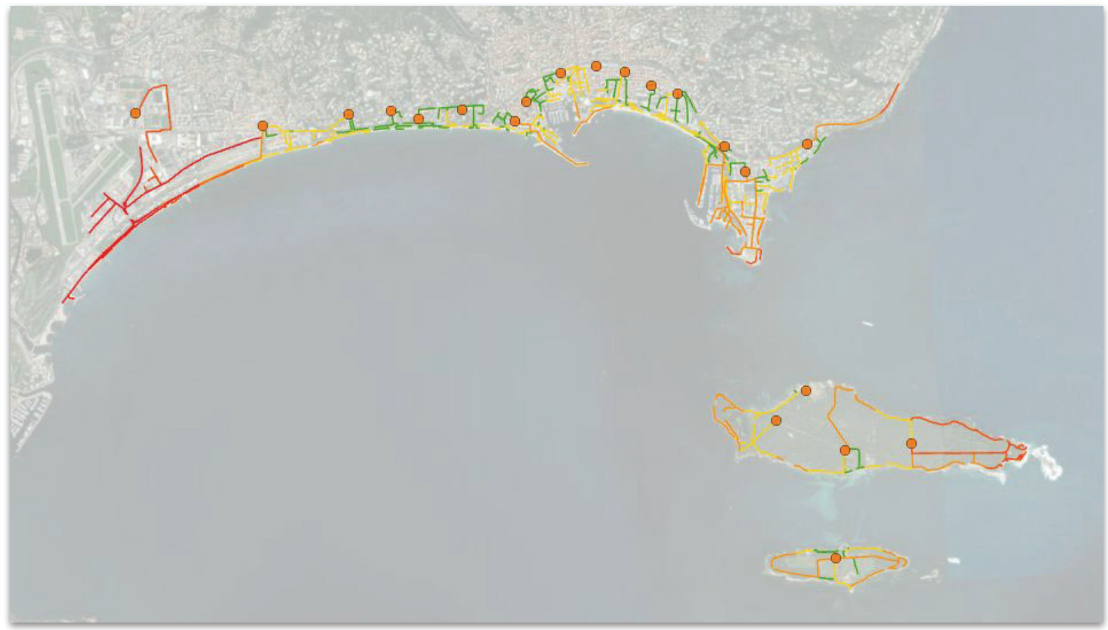
Tsunami evacuation routes calculation using graph-based GIS methodology

Output’s correction and data’s exploration

Add the field “**Travel_time”** to the routes layer. (Data Type = **Double**)

The travel speed is set at **4,9 km/h**. For this exemple, we won’t weigh the travel speed.





Other informations can be computed to enhance the discussion with to authorities during the validation process.

i.g : Assembly point mean elevation

Improving the road network to better match actual pedestrian use

Most of the networks available for download are intended for vehicular traffic, therefore, it can lack accuracy for pedestrians dedicated ways :

- Beach access
- Park's entrances / exit
- Unreferenced tracks (often the case along the coast or in wooded areas)
- Staircase
- Underground pedestrian crossing path
- Docks ...

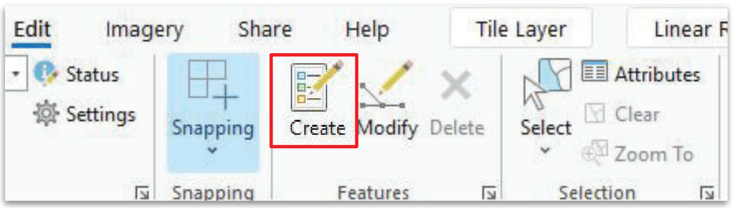
Original network

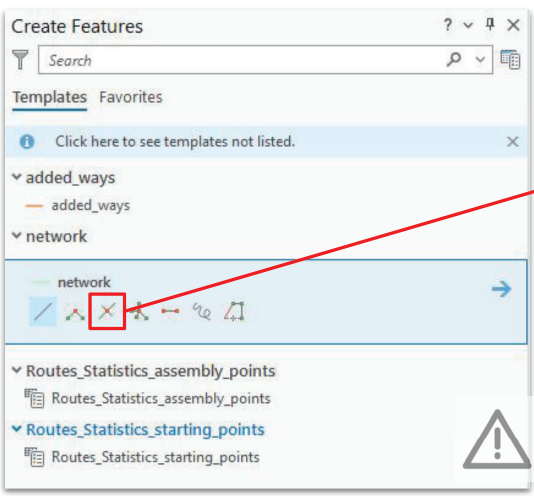
Missing pedestrian ways

Improving the road network to better match actual pedestrian use

Network must be completed manually by vectorizing all the missing pedestrian ways, **using satellite imagery and field mission**.

Once the network is complete, its topology must be checked and corrections made for sections that are not cut at intersections, **in compliance with topology rules.**





Connecting new features to the original network require to split lines where they intersect in order to be used as a graph.

Arcgis Pro provide a build-in vectorisation tools (**Split**) that automatically split lines on their intersection.

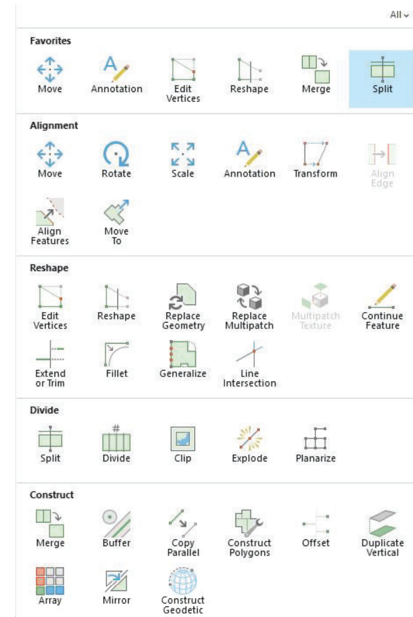
Double check is recommended for every new features created.

Exercice :

Complete the **network layer** with all the missing pedestrian ways and check for existing topology errors.

Try the following edition tools (Top ribbon > Edit > Tools) :

- Split
- Line intersection
- Explode



Why Configure the Pedestrian Network?

Graph Configuration Parameters

- **Edge orientation**: force walking direction (e.g. one-way paths, stairs)
- **Edge weighting**: define travel cost based on:
    - **Slope** (walking slower uphill)
    - **Road hierarchy** (main roads vs minor paths)
    - **Surface type** (paved, gravel, dirt, stairs)
    - **Width and condition** of each segment

Slope (%)	Travel speed (m/s)
< 3	1,3485
[3-6[	1,2644
[6-9[	1,1823
[9-12[	1,1023
[12-15[	1,0245
[15-18[	0,9491
[18-21[	0,876
[21-24[	0,8054
[24-27[	0,7373
≥ 27	0,4751

Example of travel speeds according to network gradient. (Péroche, 2016)

Why Use Graph-Based Analysis?

- Allows testing of **multiple evacuation scenarios**
- Provides **credible travel time estimates over the actual network**
  → *Without accounting for congestion effects*
- Identifies **difficult or constrained areas** in the network
- Adapts to **different walking profiles**:
  → Elderly, children, reduced mobility, responders
- Supports **comparison between evacuation options**
  → Shortest path vs fastest path, route capacity, alternative access

What simple parameters with available data?

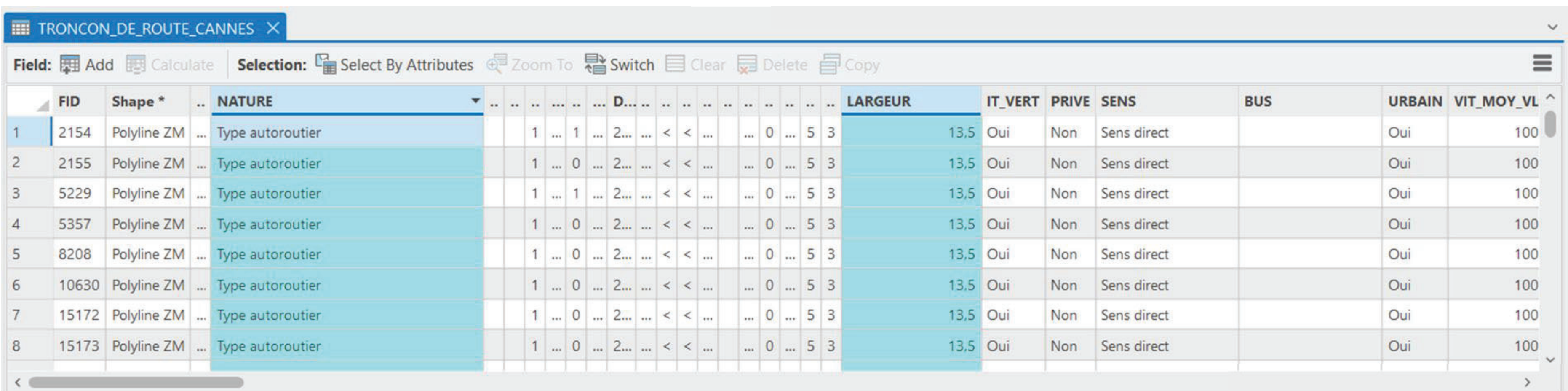
✅ What We’re Doing

- We’ll use a **limited number of walking speeds**
- Speeds will be assigned based on:
  - **Type of segment** (e.g. road, path, stairs,..)
  - **Surface material** (paved, unpaved, etc.)
  - **Width of the segment**

⚠️ What We’re Not Doing (and Why)

- **Slope will not be included** in this demonstration
  → It requires extra processing for very **minimal time differences**

  → Especially in the **Cannes**, where:
  - **Evacuation distances are short** (often < 400 m)
  - Slope has **limited impact on total evacuation time**



	FID	Shape *	..	NATURE	..	..	..	...	..	...	D...	..	..	..	..	..	..	..	..	..	..	LARGEUR	IT_VERT	PRIVE	SENS	BUS	URBAIN	VIT_MOY_VL
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4	5357	Polyline ZM	...	Type autoroutier			1	...	0	...	2...	...	<	<	...		...	0	...	5	3	13,5	Oui	Non	Sens direct		Oui	100
5	8208	Polyline ZM	...	Type autoroutier			1	...	0	...	2...	...	<	<	...		...	0	...	5	3	13,5	Oui	Non	Sens direct		Oui	100
6	10630	Polyline ZM	...	Type autoroutier			1	...	0	...	2...	...	<	<	...		...	0	...	5	3	13,5	Oui	Non	Sens direct		Oui	100
7	15172	Polyline ZM	...	Type autoroutier			1	...	0	...	2...	...	<	<	...		...	0	...	5	3	13,5	Oui	Non	Sens direct		Oui	100
8	15173	Polyline ZM	...	Type autoroutier			1	...	0	...	2...	...	<	<	...		...	0	...	5	3	13,5	Oui	Non	Sens direct		Oui	100

Assigned Walking Speeds Based on Segment Type and Width

Step 1 - define travel speed conditions

Segment Type (NATURE)	Translation (EN)	Condition (Width if needed)	Assigned Speed (km/h	Remarks
Type autoroutier / Bretelle	Motorway / Ramp	—	0.0	Not walkable (excluded)
Escalier / Sentier	Stairs / Path	—	2.0	Slow speed due to difficulty
Chemin / Route empierrée / Rond-point / Piste cyclable	Track / Unpaved road / Roundabout / Cycle path	—	3.5	Moderate walking speed
Route à 1 chaussée	Single carriageway road	Width < 5 m or unknown	3.5	Narrow or undetermined width
Route à 1 chaussée	Single carriageway road	Width ≥ 5 m	5.0	Standard road, comfortable pace
Route à 2 chaussées	Dual carriageway road	—	5.0	Large road, good walkability
Other (default)	Other (default)	—	3.0	Default speed for unclassified segments

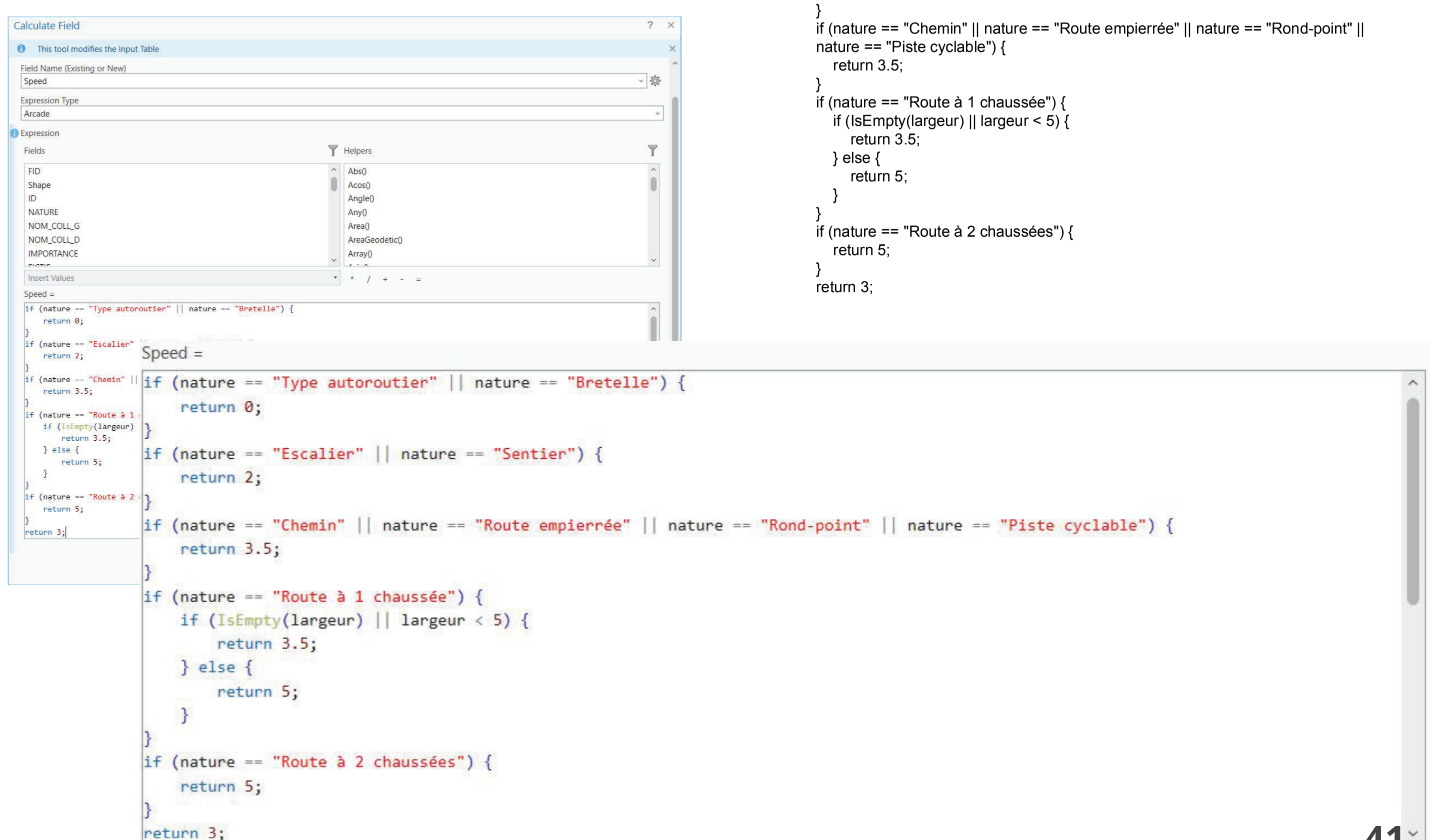
Assigned Walking Speeds Based on Segment Type and Width

Step 2 - Create a New Attribute Field and Implement Walking Speeds

1. Add a new field in the network layer to store **walking speeds (km/h)**

2. Assign values based on **segment type and width**, using IGN attributes (Sample Arcade Expression)

```
if (nature == "Type autoroutier" || nature == "Bretelle") {
   return 0;
}
if (nature == "Escalier" || nature == "Sentier") {
   return 2;
}
if (nature == "Chemin" || nature == "Route empierrée" || nature == "Rond-point" ||
nature == "Piste cyclable") {
   return 3.5;
}
if (nature == "Route à 1 chaussée") {
   if (IsEmpty(largeur) || largeur < 5) {
      return 3.5;
   } else {
      return 5;
   }
}
if (nature == "Route à 2 chaussées") {
   return 5;
}
return 3;
```



Assigned Walking Speeds Based on Segment Type and Width

Step 3 – Calculate Travel Time on Each Segment

1. Add a new field in the network layer to store **Travel Time (min)**

2. Compute **travel time in minutes** for each segment based on the segment's length and walking speed

3. Formula (Field Calculator – Python syntax)

```
0 if !Walk_Speed! == 0 else (!SHAPE_LENGTH! / 1000) / !Walk_Speed! * 60
```

Explanation

- `!SHAPE_LENGTH!` is in **meters**
- `!Walk_Speed!` is in **km/h**
- We convert meters to kilometers, then hours to minutes
- If the speed is `0`, the travel time is set to `0` (non-walkable segment)

Recalculate and compare results.

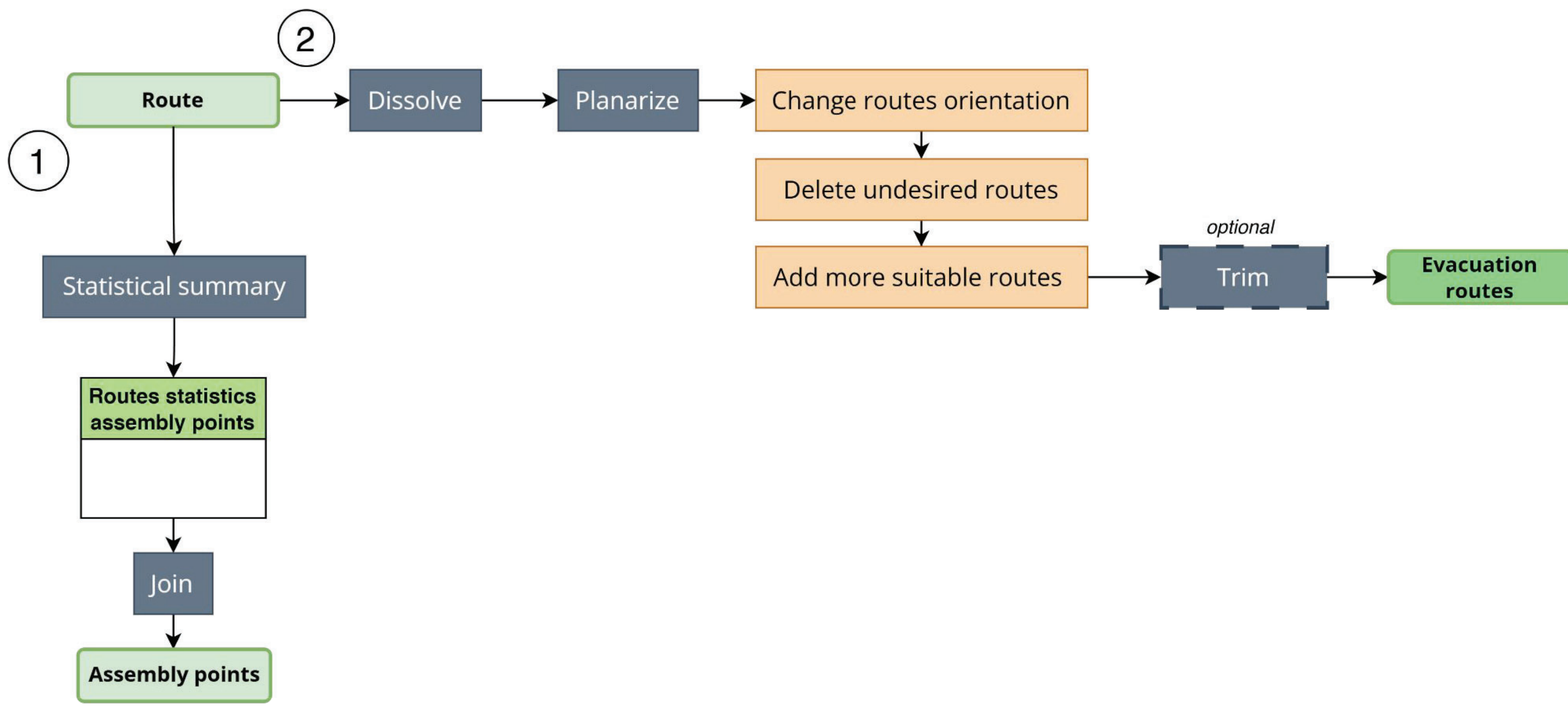
Main result used specifically for tsunami evacuation maps

- **Time-optimised evacuation routes** are identified in order to facilitate the fastest evacuation from starting points within the tsunami evacuation zone toward a designed tsunami assembly point.

- In order to obtain this result, it is necessary to set up the road network accordingly.

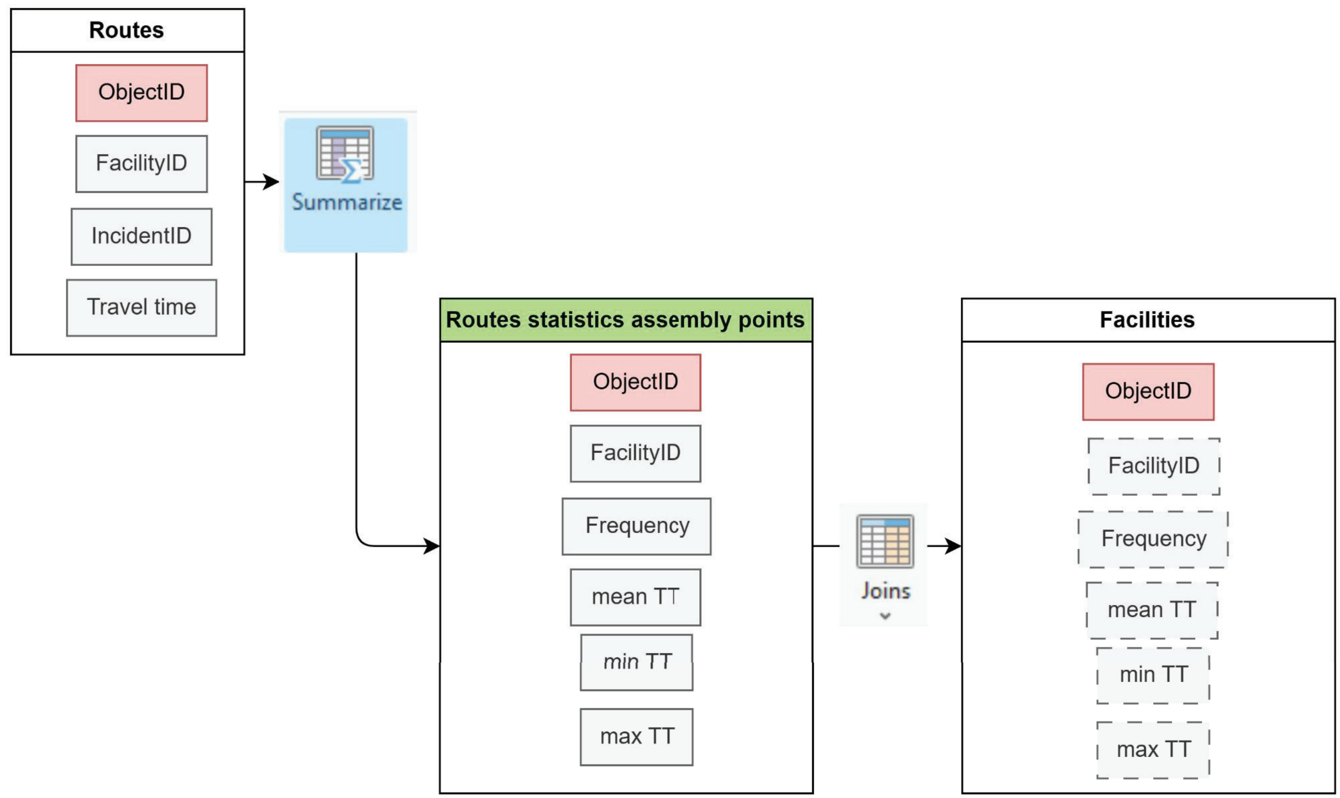
- The walking speed parameter must be set for each network's edge, in order to accurately reflect the impact of their physical characteristics (e.g. nature and width) on walking speed.

Output's correction and data's exploration



Output’s correction and data’s exploration

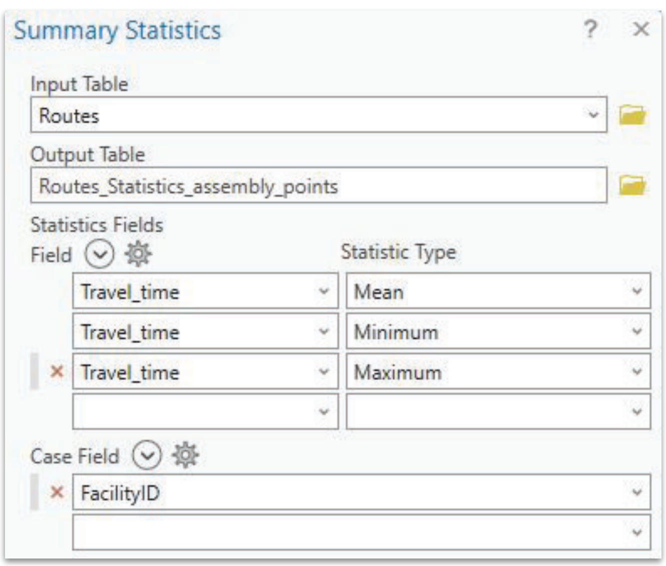
We can compute **statistical summary** (min, max and mean travel time …) from our routes layer and join the values for both assembly points and starting points.



Output's correction and data's exploration

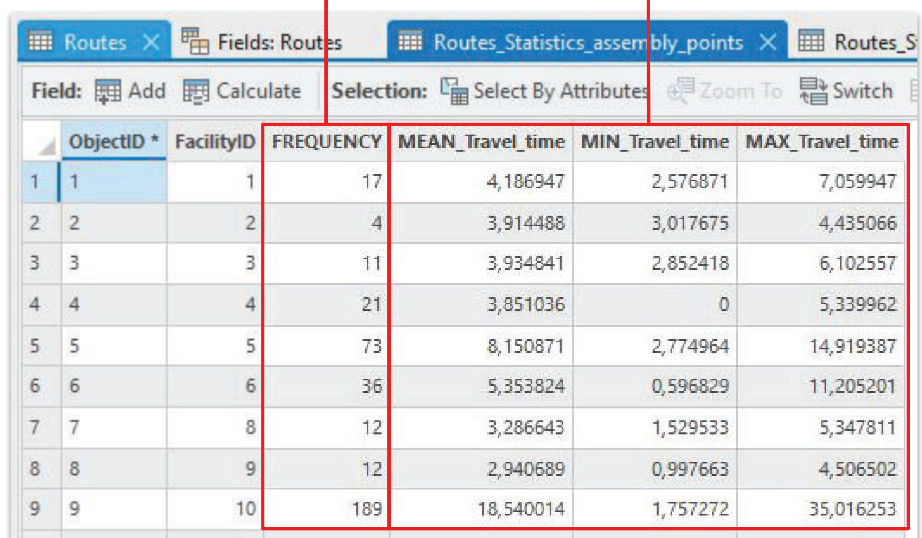
We can compute **statistical summary** (min, max and mean travel time …) from our routes layer and join the values for both assembly points and starting points.

1. Open **routes** attribute table > Top ribbon > Table
2. Launch **Summarize Statistics** two time (Using both FacilityID and IncidentsID as grouping fields)



Number of routes pointing to the assembly point

Statistical summary

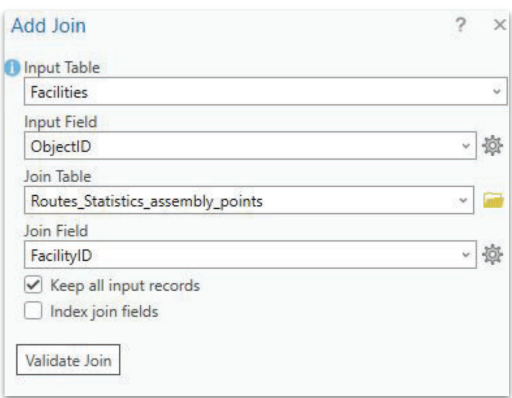


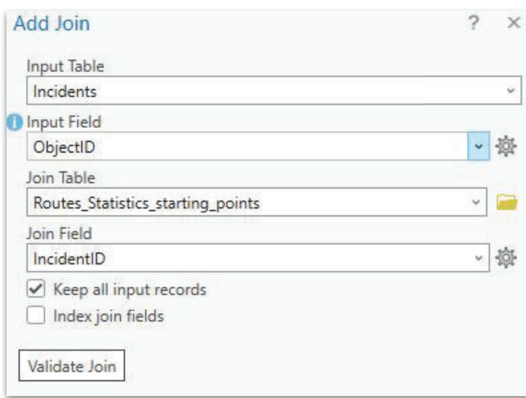
	ObjectID *	FacilityID	FREQUENCY	MEAN_Travel_time	MIN_Travel_time	MAX_Travel_time
1	1	1	17	4,186947	2,576871	7,059947
2	2	2	4	3,914488	3,017675	4,435066
3	3	3	11	3,934841	2,852418	6,102557
4	4	4	21	3,851036	0	5,339962
5	5	5	73	8,150871	2,774964	14,919387
6	6	6	36	5,353824	0,596829	11,205201
7	7	8	12	3,286643	1,529533	5,347811
8	8	9	12	2,940689	0,997663	4,506502
9	9	10	189	18,540014	1,757272	35,016253

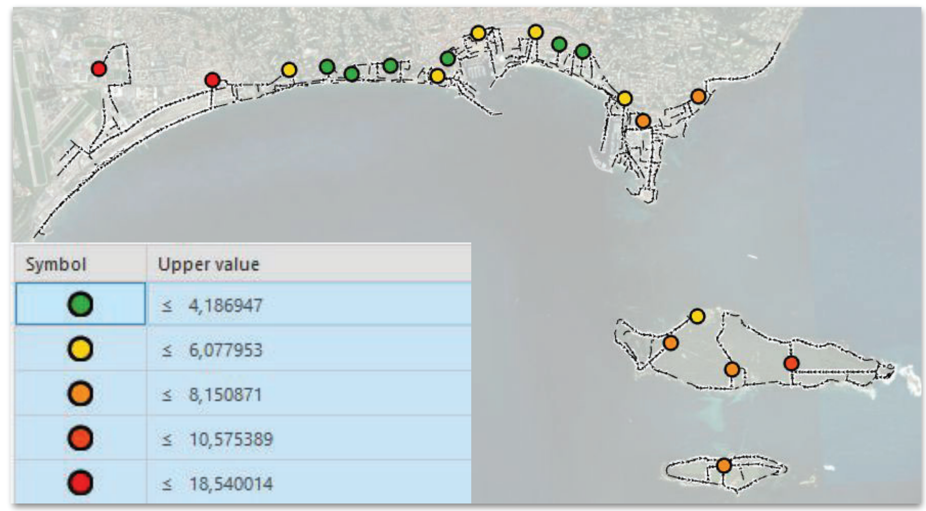
Output's correction and data's exploration

We can compute **statistical summary** (min, max and mean travel time …) from our routes layer and join the values for both assembly points and starting points.

1. Open **Facilities** attribute table > Top ribbon > Table
2. Select **Join**
3. Join the **Facilities** and the **facilities statistic table** using features Id as key values
4. Do the same for the **Incidents**





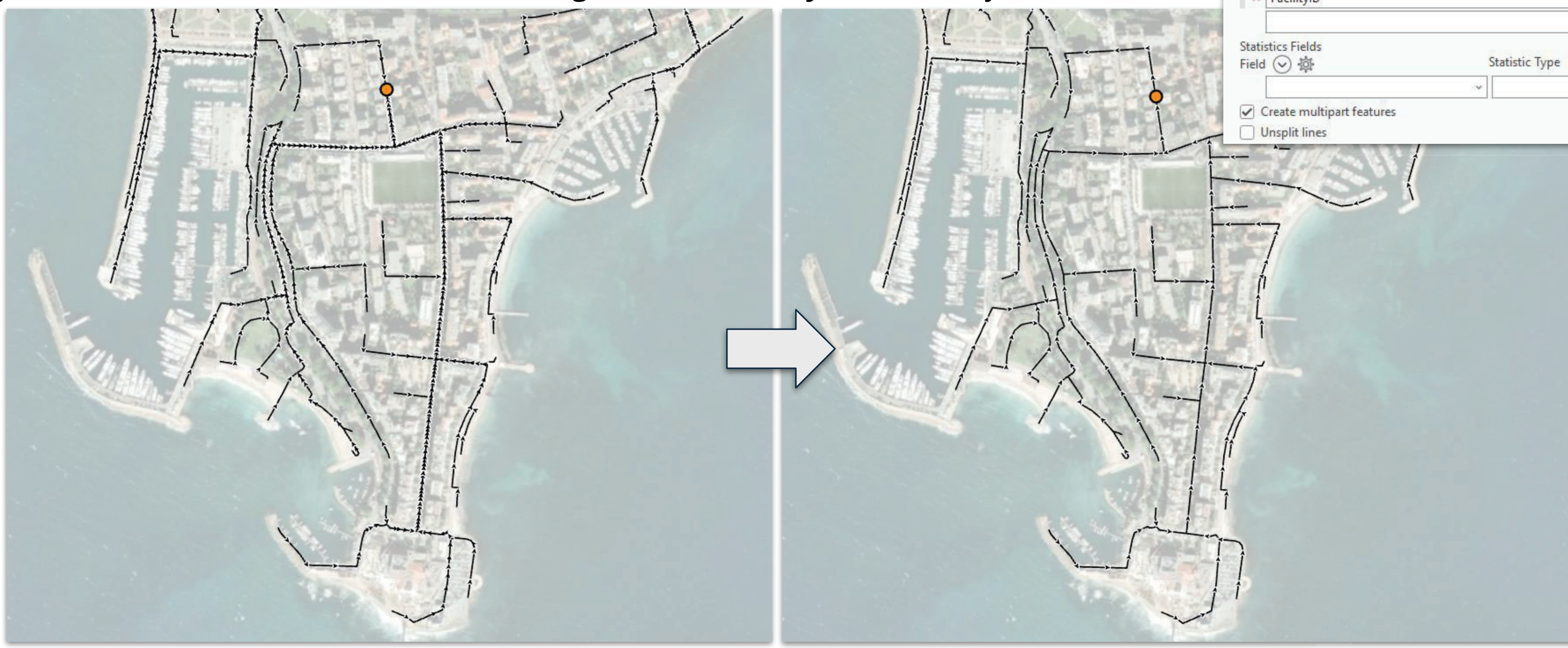


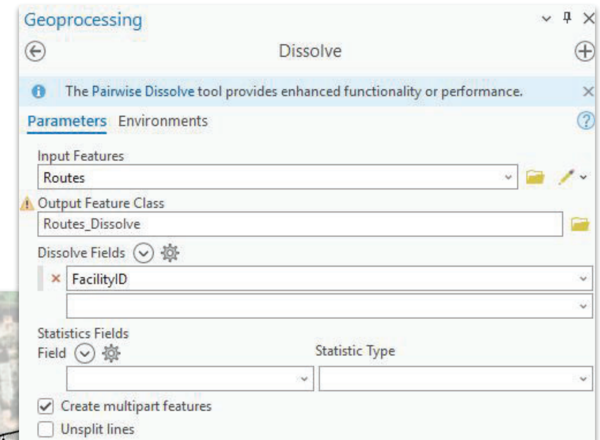
Output's correction and data's exploration

Problem :

One route is generated for each starting points, which result in a difficult to read output

They must be **dissolved** into one feature using the field **FacilityID** as the key.

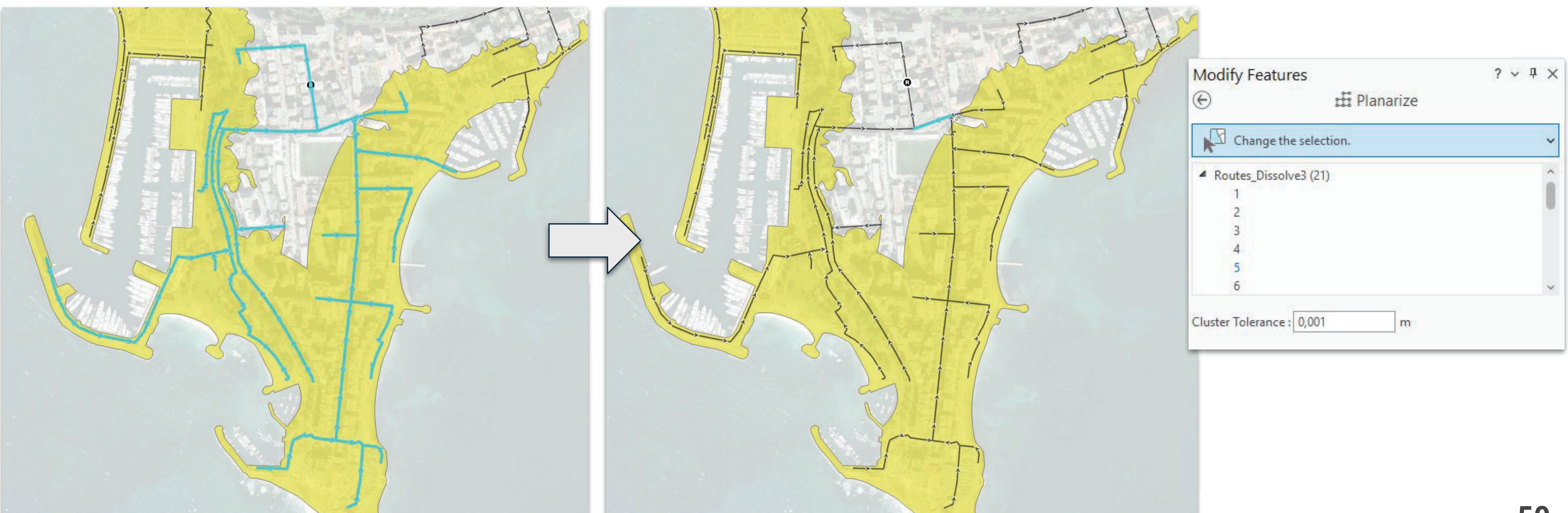




Output's correction and data's exploration

By merging feature based on a shared attributes, the **dissolve** tool can induce error in segments orientation.

In order to simplify the manual corrections easier, we need to split the dissolved routes with the **planarize tool** (Top ribbon > Edit > Tools). Less manual splitting operation will be required

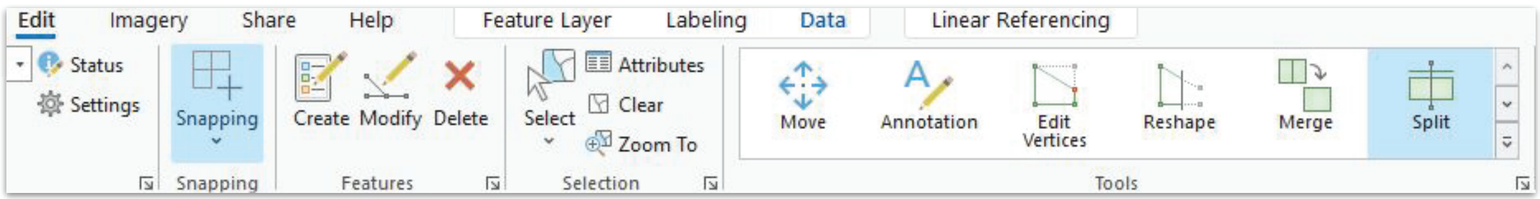


Output’s correction and data’s exploration

Changing segment’s orientation is done manually. This step is also an opportunity to control the generated routes.

Two editing tools will be needed :

- Split
- Edit vertices

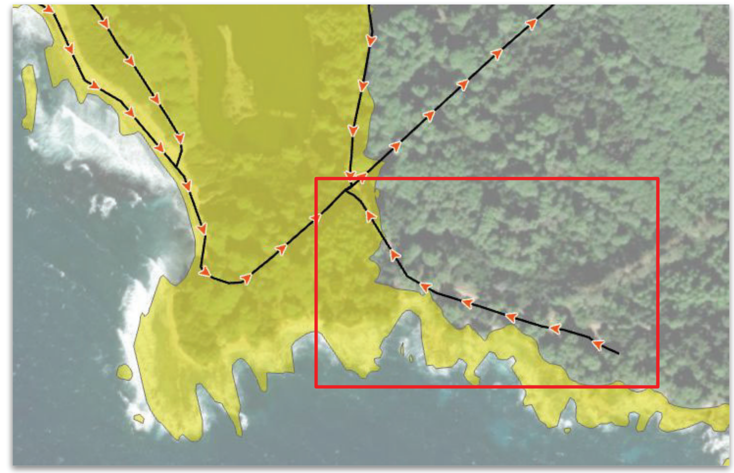


Output’s correction and data’s exploration

Removing or adding evacuation routes segment is often necessary

All routes must be inspected in order to guarantee that :

1. Once a route has left the evacuation zone, it cannot pass through it again.
2. Allow leaving the evacuation zone as quickly as possible.
3. Allow to get away from coast as quickly as possible.



Field inspection can be organized during tsunami exercices (tsunami walk), recruiting scholars, students, general public …
- + *Vérification des temps d’accès*
- + *Difficultés pratiques liées au terrain*

Other result useful for tsunami evacuation planning

- **Evacuation flow zones** for each tsunami assembly points can be identified once the network analysis has been conducted.

- The grid from which the starting points are derived allow a clear representation of the evacuation flow zone for the stakeholders.

- This grid is the basis upon which additionals geo-indicators will be built on, in order to provide meaningful insights to help the decision-making process.

Evacuation flow zone for each assembly points

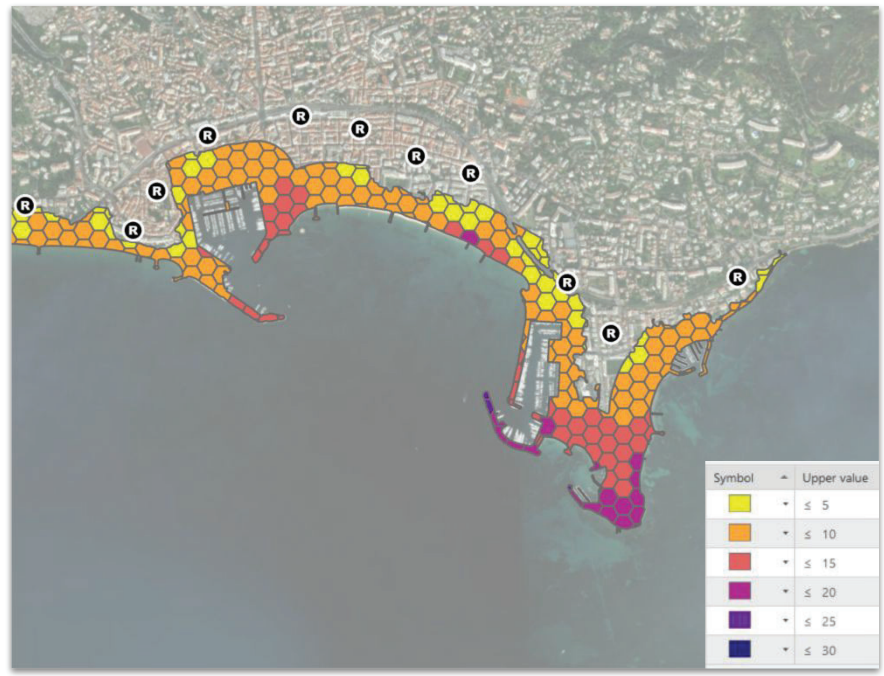
Other result useful for tsunami evacuation planning

- This cartographic result shows the **time required to reach a refuge site on foot** from each grid of the territory. It shows the areas where these times are longest, and therefore the sectors most at risk in the event of a tsunami.

- Set against the estimated time of arrival of the wave, this result reveals the **risk hotspots**. It guides planning choices: adjusting routes, increasing or relocating refuge sites.

- In the most critical areas, **targeted actions can reduce travel times**: lane openings, adapted equipment, better signage. Depending on the seismic context and topography, vertical evacuation solutions may also be considered when horizontal evacuation is not sufficient.

This is travel time, **not full evacuation time**, which also includes at least **warning** and **reaction time**.



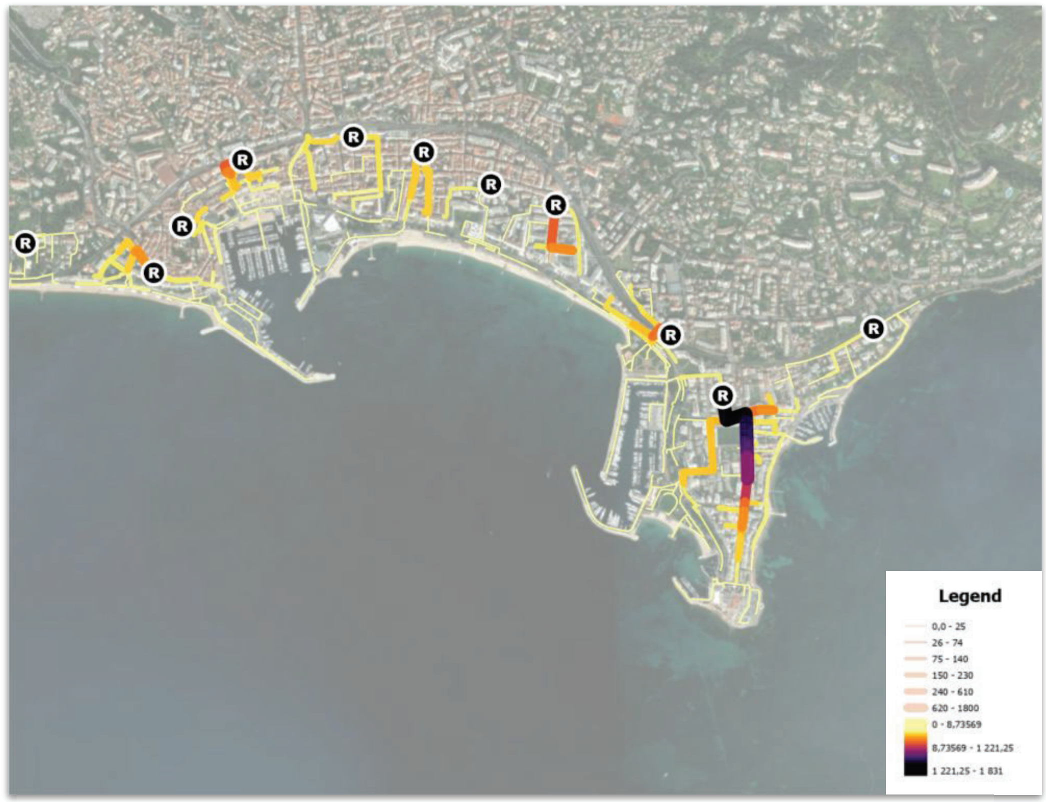
Evacuation travel time to reach tsunami assembly point *(minutes)*

Other result useful for tsunami evacuation planning

- **Data aggregation on the road network** can be conducted to visualize the spatial distribution of evacuation flow

- Therefore, in order to underpin this analysis, it is necessary to produce or obtain data regarding the spatial distribution of human population (e.g number of residents, beach's occupancy, with seasonal or daily variation).

- This cross-analysis allow for representation of theoretical number of people who are expected to use a specific evacuation route.



Example of a data aggregation on network segments. Based on the data from this exercise, it shows a number of housing.

Other result useful for tsunami evacuation planning

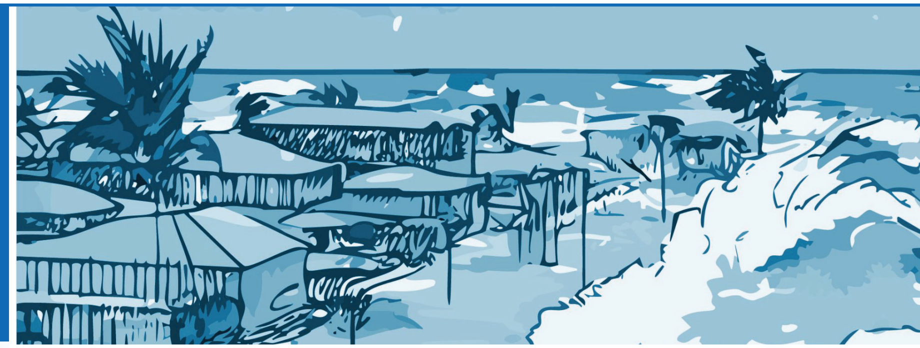
- **Theoretical number of people expected on a tsunami assembly point** is most of the time requested by the local authorities.

- The subsequent analysis provides support for the production of this geo-indicator.

- This final result can be achieved for a *worst case scenario*, or, depending on the available data, can be conducted for multiples scenarios, *e.g* :
  - Seasonal variation in the tourist population (high and low saison)
  - Day and night population variation on the most exposed area (*e.g* beaches)
  - Specific events (*e.g* festival, ceremony, sport events ...)

Theoretical number of housing expected on each assembly point

Tsunami Evacuation Mapping Workshop



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IOC-UNESCO (EU DG ECHO)

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CoastWAVE NEAMTWS

LAGAM LABORATOIRE DE GEOGRAPHIE ET D'AMENAGEMENT DE MONTPELLIER

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