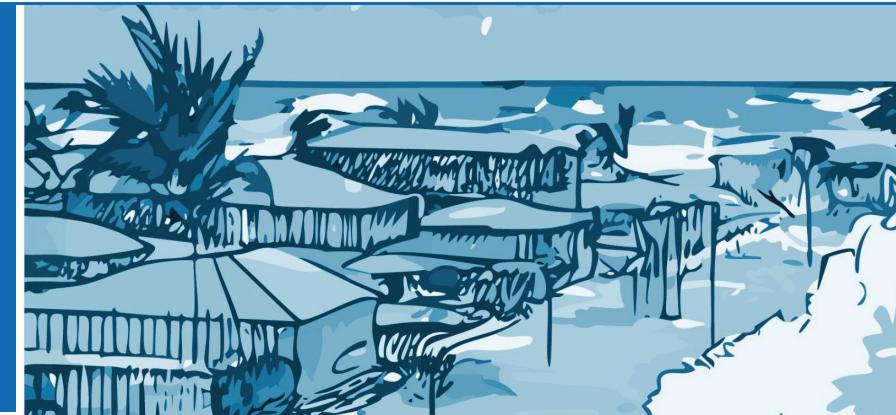


Tsunami Evacuation Mapping Workshop



Montpellier, France

30 June – 4 July 2025

Dr. Matthieu Peroche
Pr. Frédéric Leone
Lorraine Monnier
Eduardo Lagahé
Monica

CoastWAVE 2.0 Project
IOC-UNESCO (EU DG ECHO)

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Contact : matthieu.peroche@univ-montp2.fr



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LABORATOIRE
DE GÉOGRAPHIE ET D'AMÉNAGEMENT
DE MONTPELLIER



Lesson #1 Tsunami evacuation zone mapping

Lesson #2 Method for identifying tsunami assembly points

Lesson #3 Tsunami evacuation routes calculation using graph-based GIS methodology

Lesson #4 Graphical semiology and map layout

Lesson #5 Dynamic cartography - Support for evacuation map diffusion

Lesson #6 Tsunami evacuation signage

Bonus Greetings to participants and introduction to the workshop context

Coastwave 2.0 Evacuation Mapping Workshop

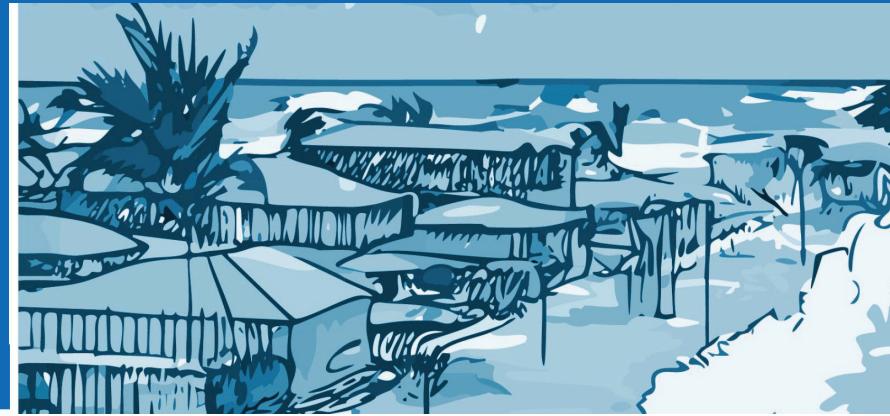


you to all the workshop participants for this week of knowledge sharing, for your commitment and your good mood despite this heatwave !



Tsunami Evacuation mapping Workshop

30 June – 4 July 2025



CoastWAVE 2.0 Project

IOC-UNESCO (EU DG ECHO)



Funded by
European Union
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of Ocean Science
for Sustainable Development



LABORATOIRE
DE GEOGRAPHIE ET D'AMENAGEMENT
DE MONTPELLIER

Dr. Matthieu
Leroi

Lesson #1

Tsunami evacuation zone
mapping

Contact : matthieu.peroche@univ-montp2.fr



Lesson's overview

Use of a DEM to map a “standardized” inland tsunami evacuation zone.

1. Theory

- Cannes area
- Presentation of the selected approach for evacuation area definition in France
- Pro and cons

2. Practice

- Extract the altitude range set from numerical modelisation using DEM and GIS
- Corrections needed for a coherent evacuation zone
- Derivate safe zone

Tsunami evacuation zone mapping



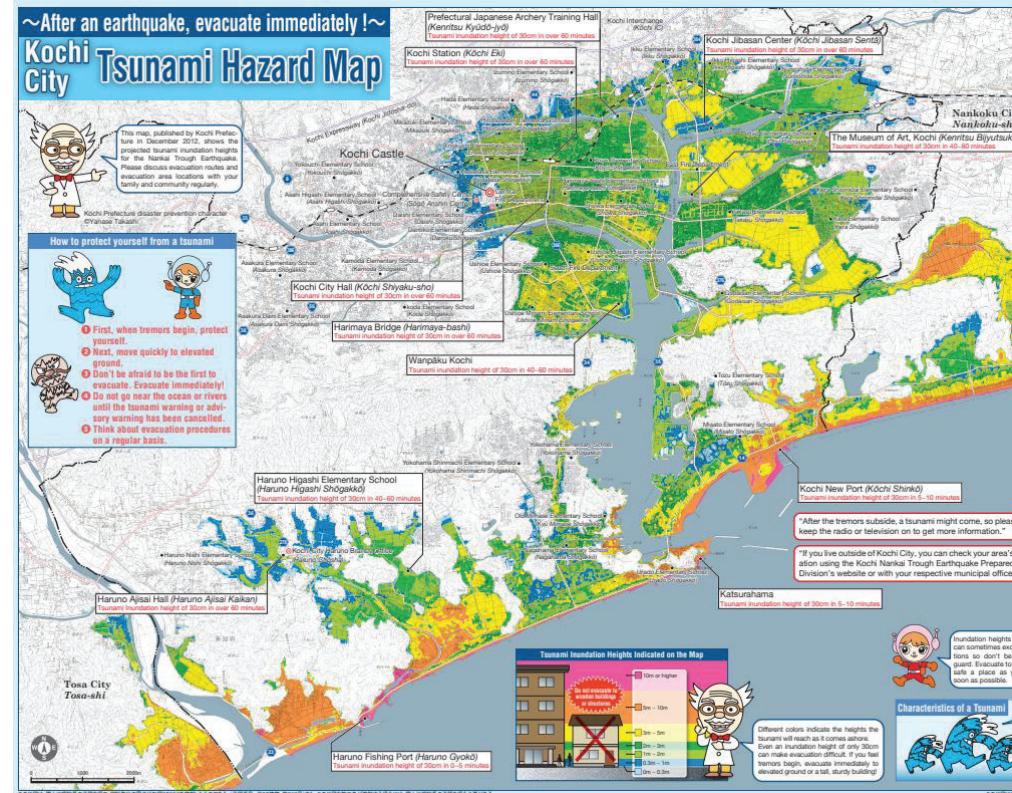
Creating Tsunami Evacuation Zones: 4 Key Methods

Different methods exist to map tsunami danger zones

The choice depends on data availability, local knowledge, and technical capacity

Methods range from advanced simulations to basic elevation-based approaches

Each method offers trade-offs in precision, effort, and accessibility





Creating Tsunami Evacuation Zones - 1. Envelope from Multiple Simulations (deterministic or probabilistic)

Definition

This method combines the results of several validated tsunami simulations to produce a single envelope representing the maximum potential inundation.

Applications

High-exposure coastal zones

Critical infrastructure (ports, airports, energy sites)

Strengths

Conservative and robust

Detailed outputs for maximums : wave arrival time, water depth, flow speed

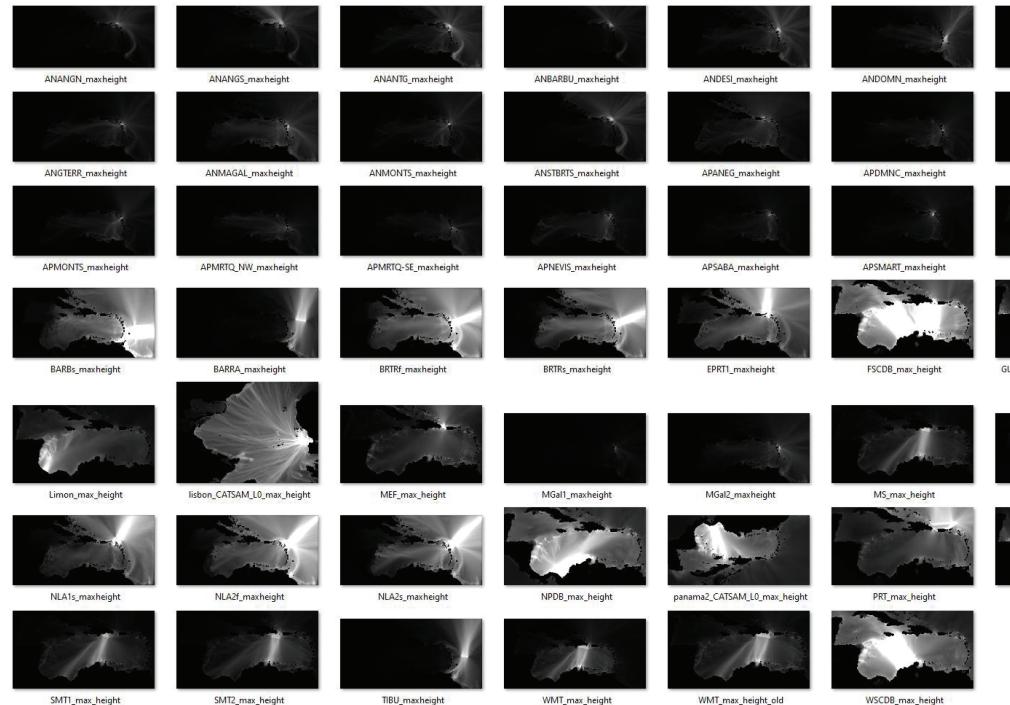
Integrates uncertainty from different scenarios
Useful for long-term planning and zoning

Limitations

Requires multiple simulations

High technical and financial cost

Not always feasible for small territories





Mapping Tsunami Evacuation Zones - 2 : Hydrodynamic Modelling (Single Scenario)

Definition

Hydrodynamic simulation of tsunami generation, propagation, and inundation for **one predefined scenario** (one-case plausible event).

Applications

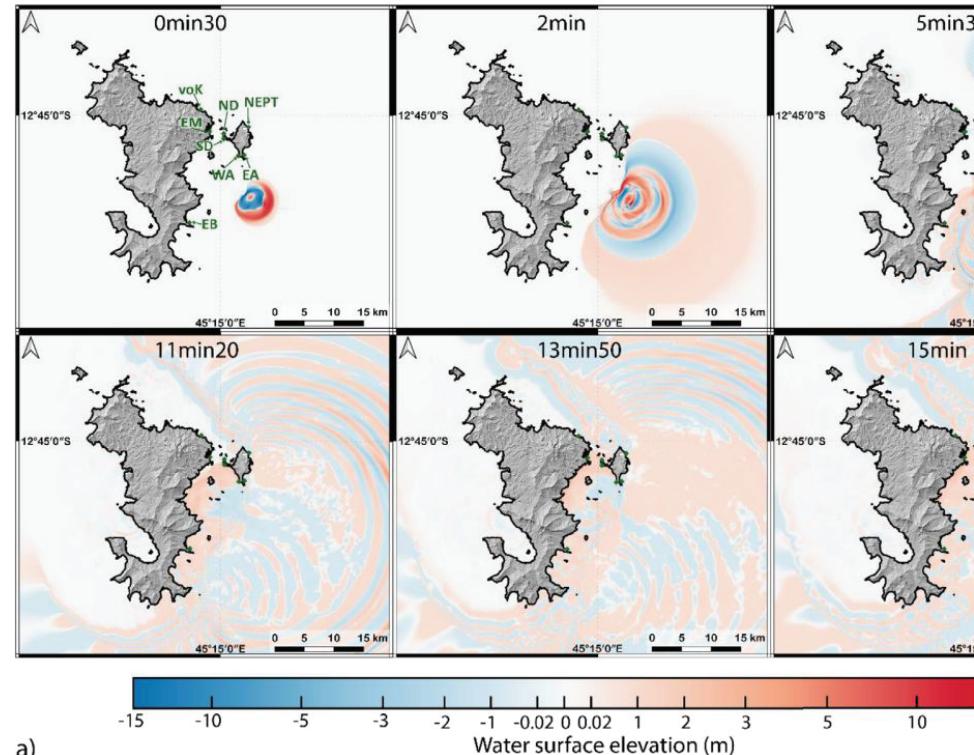
High-exposure coastal zones
Critical infrastructure (ports, airports, energy sites)

Outputs

Physically accurate and scenario-specific
Detailed outputs: wave arrival time, water depth, flow speed
Helps visualize and communicate local risk
Ideal for long-term planning and zoning

Limitations

Requires multiple simulations
Only reflects one event configuration
May miss other potential threat sources



Pablo Poulain et al, 2022



ng Tsunami Evacuation Zones - 3 : Topographic Projection from Simulated Coastal Heights

ition

Evacuation zones are derived by **projecting simulated maximum wave heights onto land**, using a Digital Elevation Model (DEM). No inland flood modelling is performed.

cations

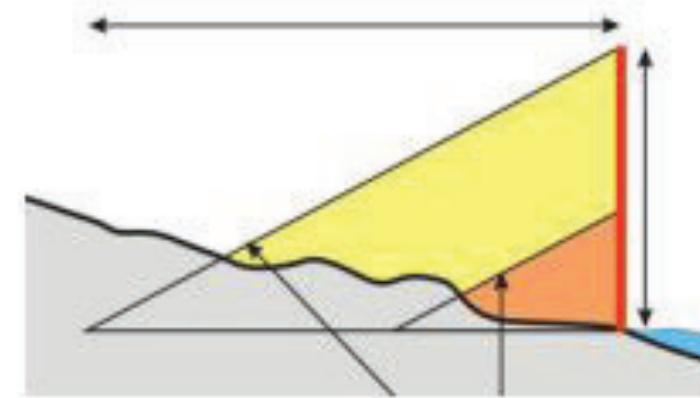
territories with access to tsunami simulations but limited modelling capacity
easier to generalize over **large coastal areas**
suitable for regional-scale evacuation planning

gths

uses outputs from actual tsunami scenarios
faster and less costly than full inundation models
requires fewer computational resources

ations

still needs accurate input data (DEM, coastal wave heights)
doesn't account for local hydrodynamics (flow, obstacles, direction)
may overestimate or underestimate extent in flat or complex terrain





ng Tsunami Evacuation Zones - 4 : Simple Elevation-Based Method ("Bathtub")

ition

Tsunami danger zones are mapped using a fixed elevation threshold (e.g. 10–15 m), without relying on simulation results. It is also recommended to set a maximum inland penetration distance, to avoid unrealistic inland extent.

ations

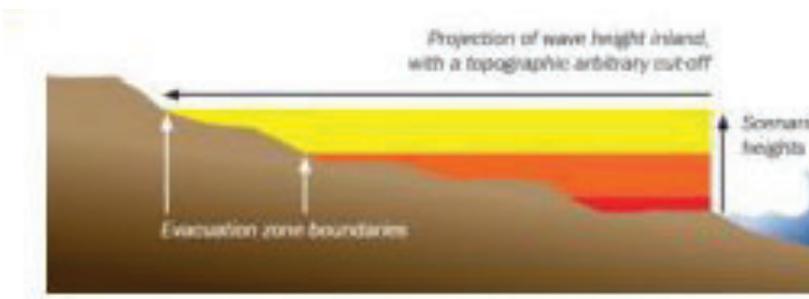
territories with no access to tsunami modelling
useful for early-stage planning and awareness
can be applied using basic topographic data (DEM)

ths

requires no simulation
easy to implement and to communicate to the public
good starting point for evacuation planning

tions

ay overestimate inland extent
o information on wave dynamics or timing
ssumptions must be validated by risk management authorities





Common Approach for French Territories

Operational Choice

Evacuation planning in France began with the **Simple Elevation-Based Method (10 m threshold)**

Selected due to the **lack of usable simulation data** and the need for **consistency across territories**

Formed by **international practices, historical runup values, and partial modelling outputs**

Massive National Deployment

Method first used in the **French Antilles (2013–2014)**

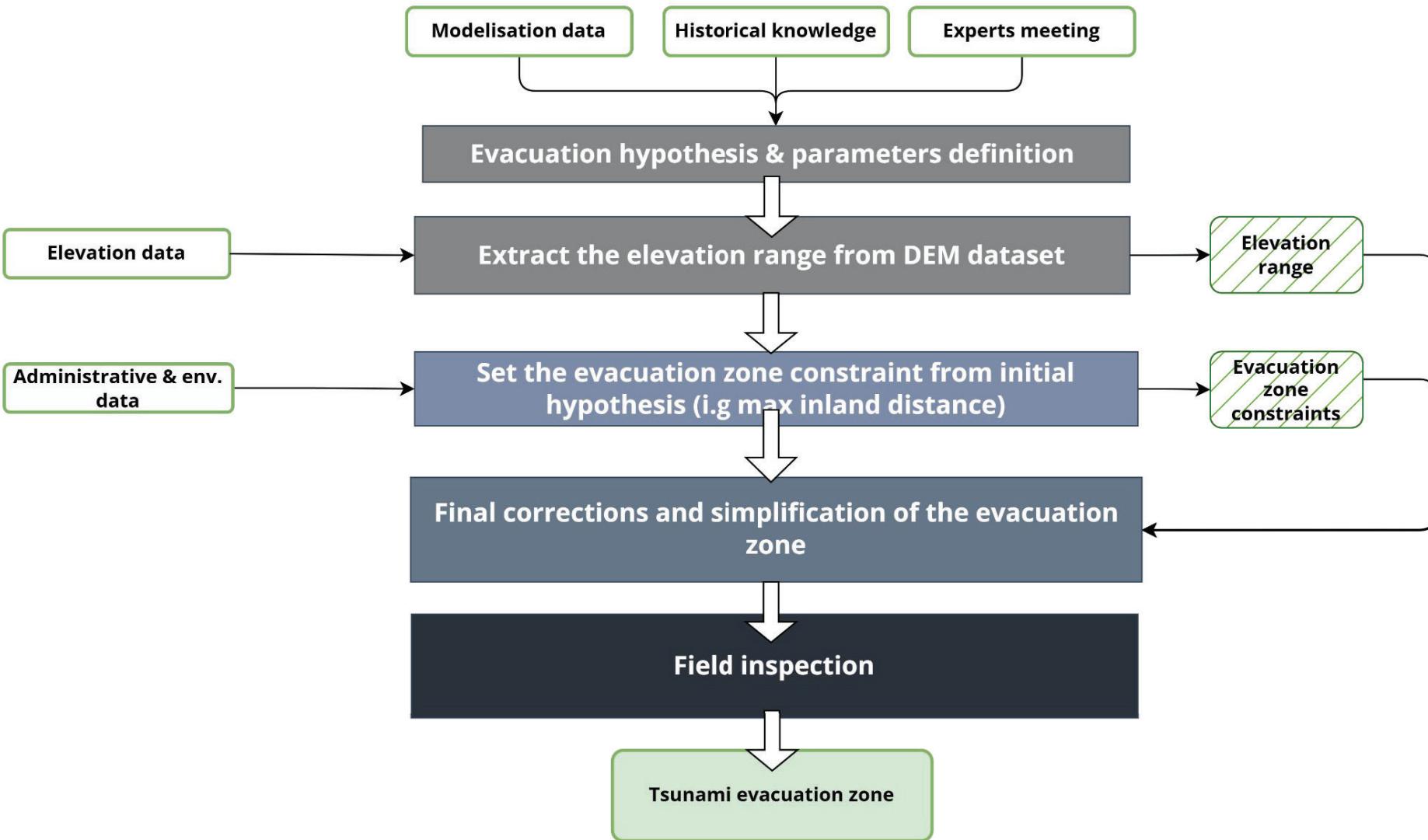
Then adapted and applied in the Mediterranean (2019) under the **TASOMA project**

Finally adopted in Mayotte (2020) as a starting point for tsunami preparedness

A simple, shared method has enabled nationwide progress in tsunami evacuation planning despite data gaps and regional diversity.



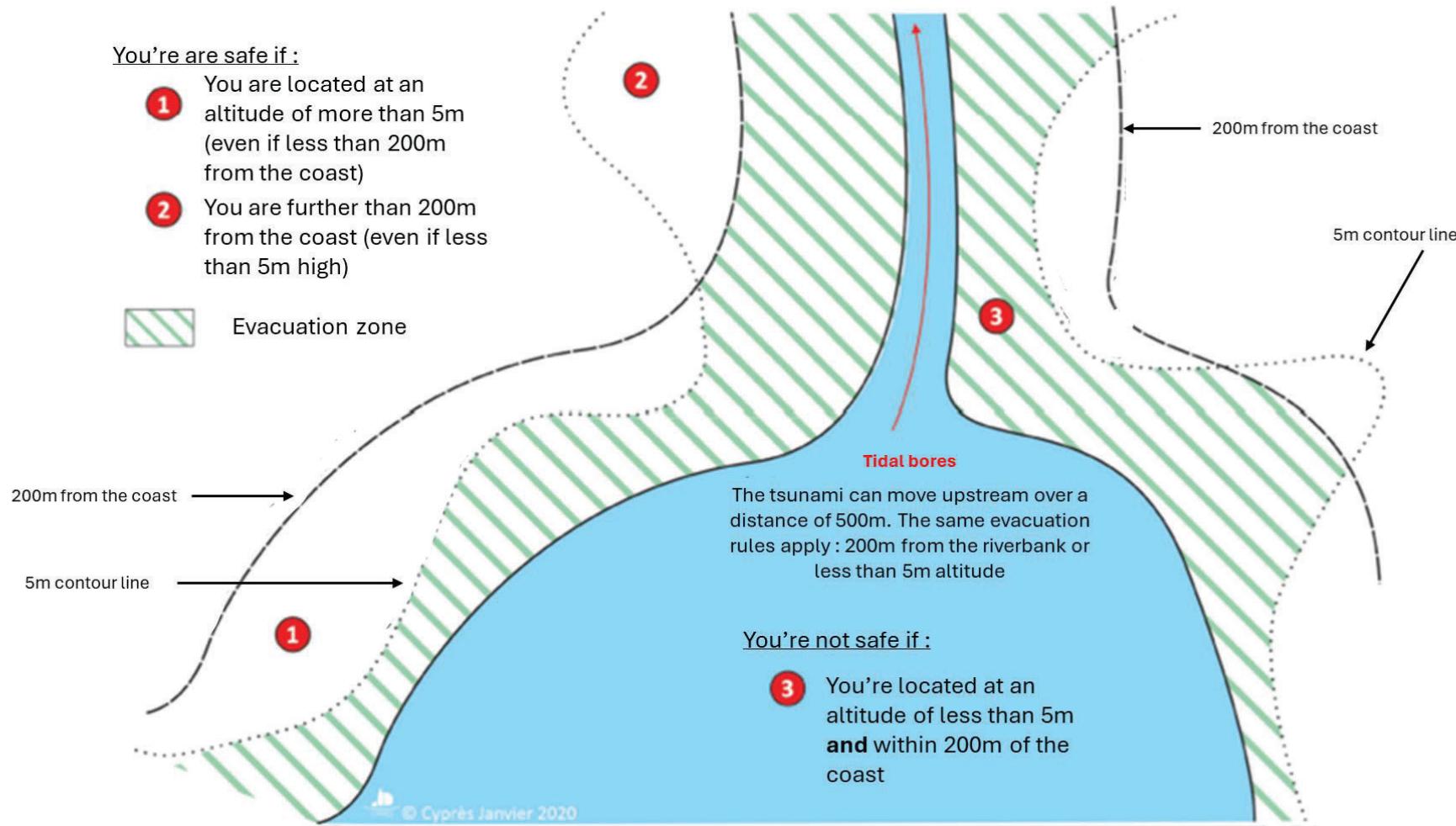
Review of the theoretical stages





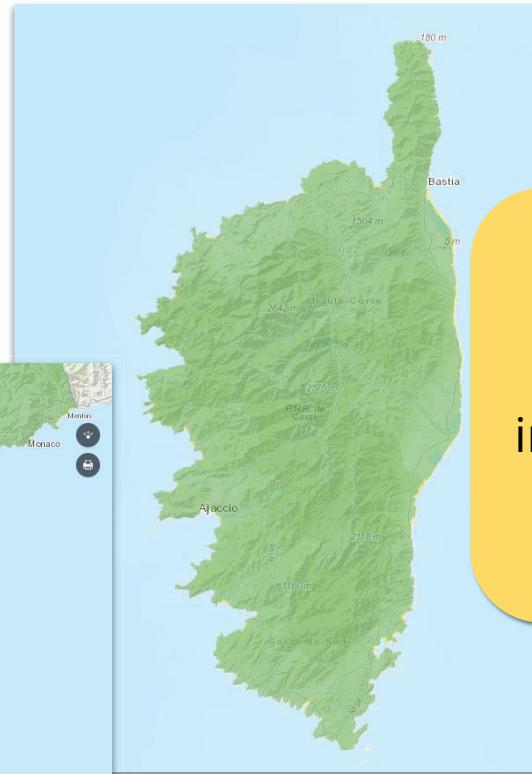
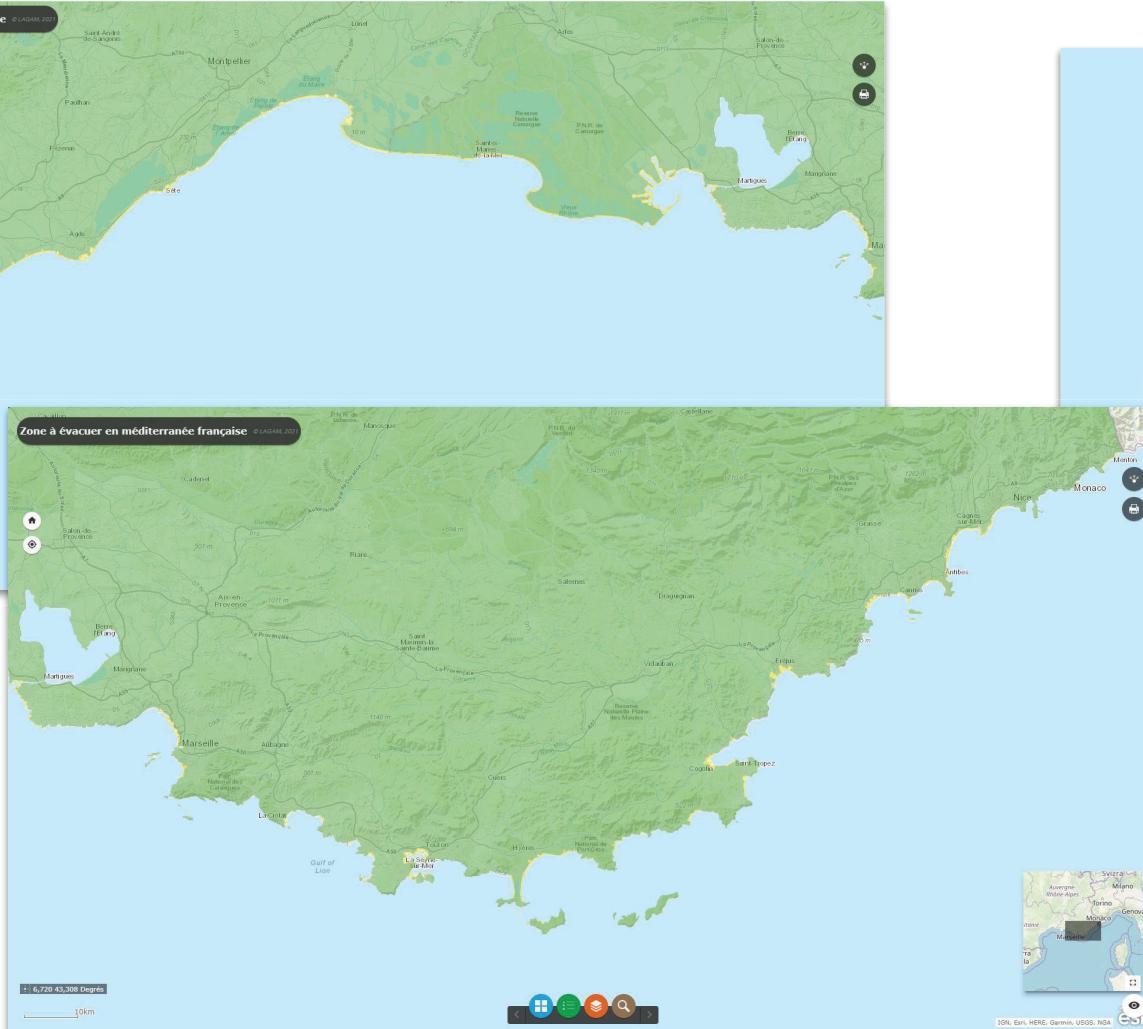
Tsunami evacuation zone definition for the french mediterranean coast

Tsunami on the mediterranean arc : Evacuation zone





Defining tsunami evacuation zone definition for the french mediterranean coast



Using this method, we were able to map the evacuation zone for the entire coast in around a month during

TASOMA Project

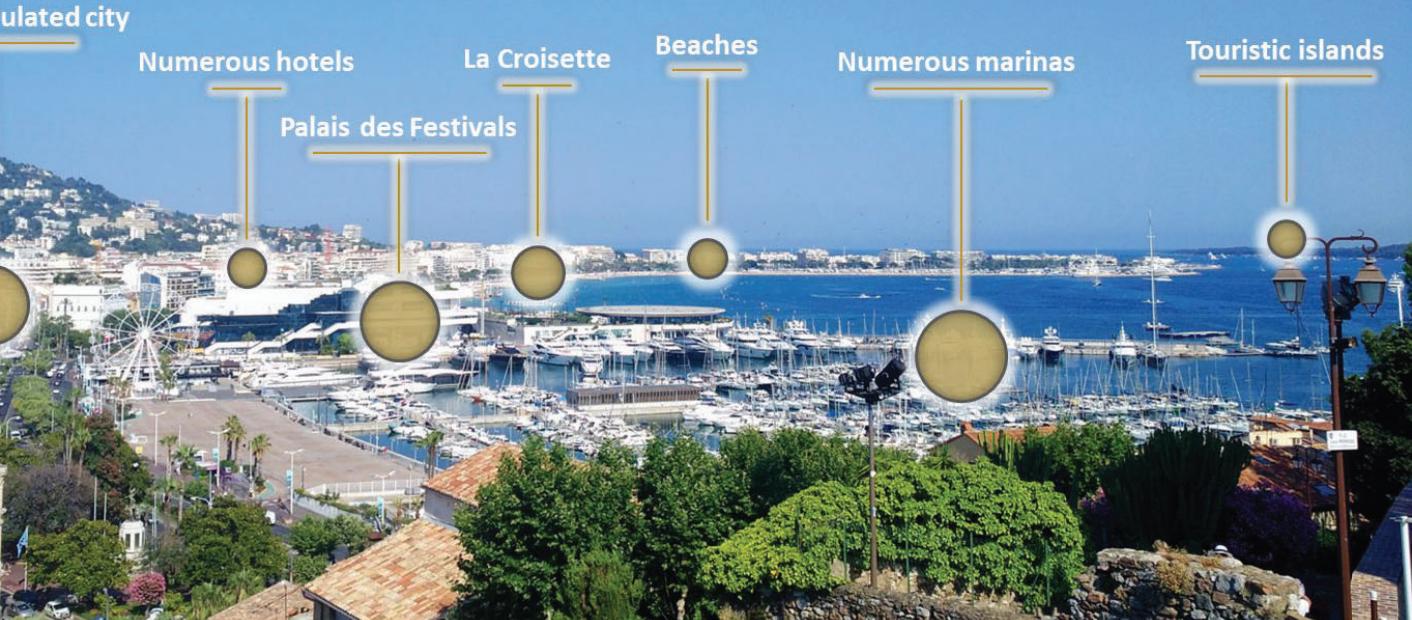
<https://arcg.is/1vfGSz>



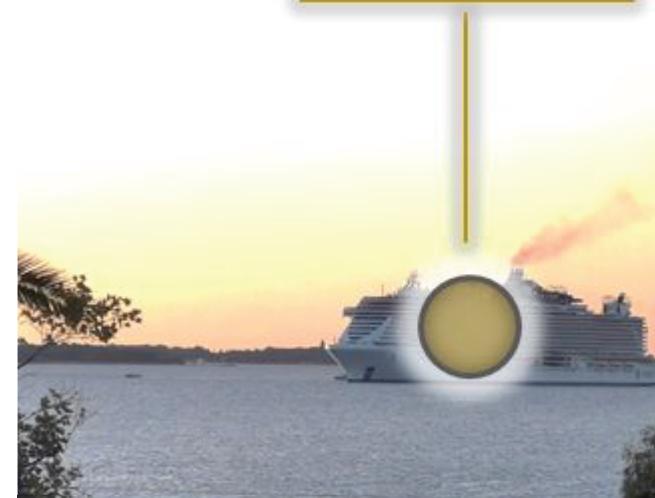
Cannes area presentation

- ✓ Population of 74,686 (INSEE, 2019)
- ✓ 3 million visitors per year
- ✓ 320 cruise passengers in 2017
- ✓ Nearly 130 hotels and 500 restaurants
- ✓ Accommodation capacity of 17,000 people

Cannes evacuation challenges in case of tsunami alert ...



Passenger ship

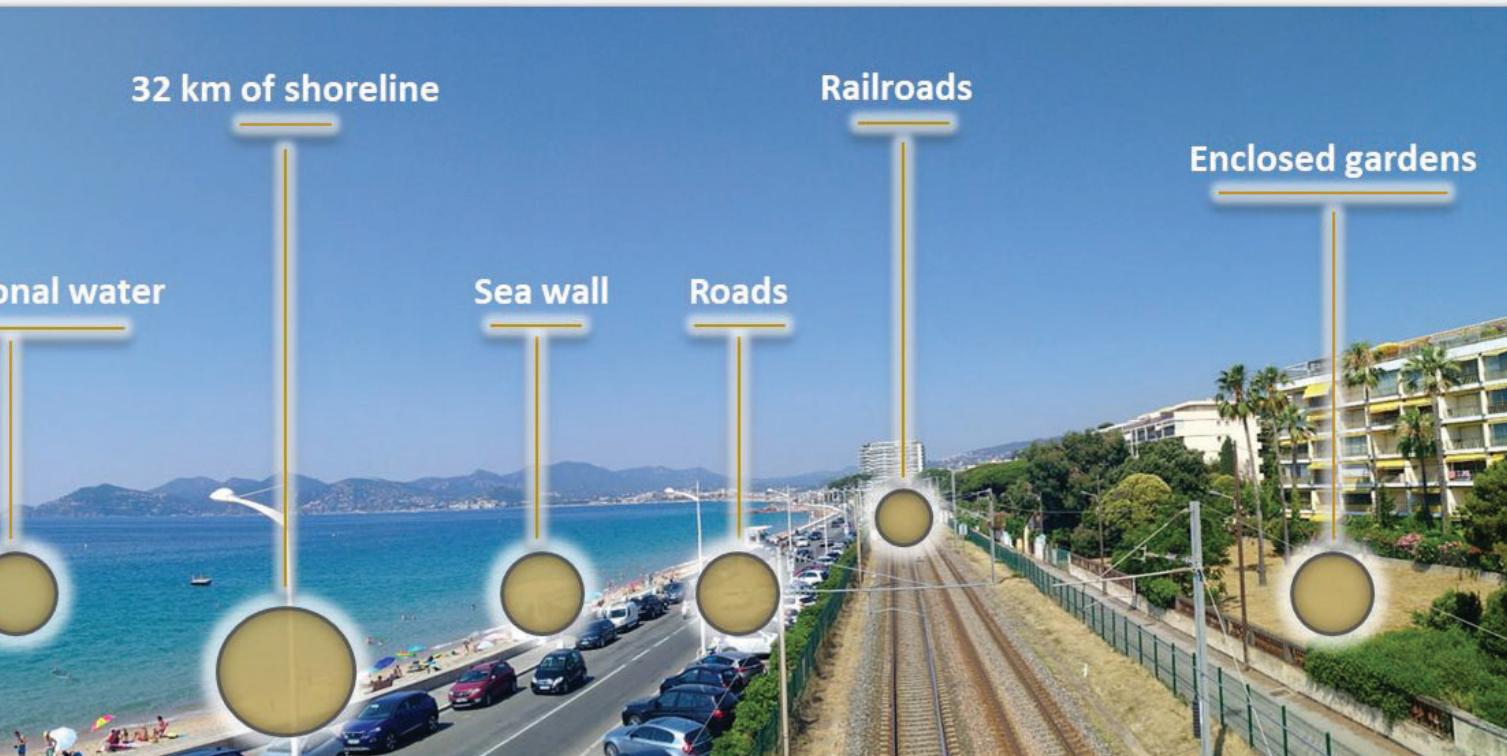




Area presentation

In the past year, awareness-raising activities (public meeting, meeting in schools) have been carried out locally, in particular in cooperation with CENALT and DGSCGC.

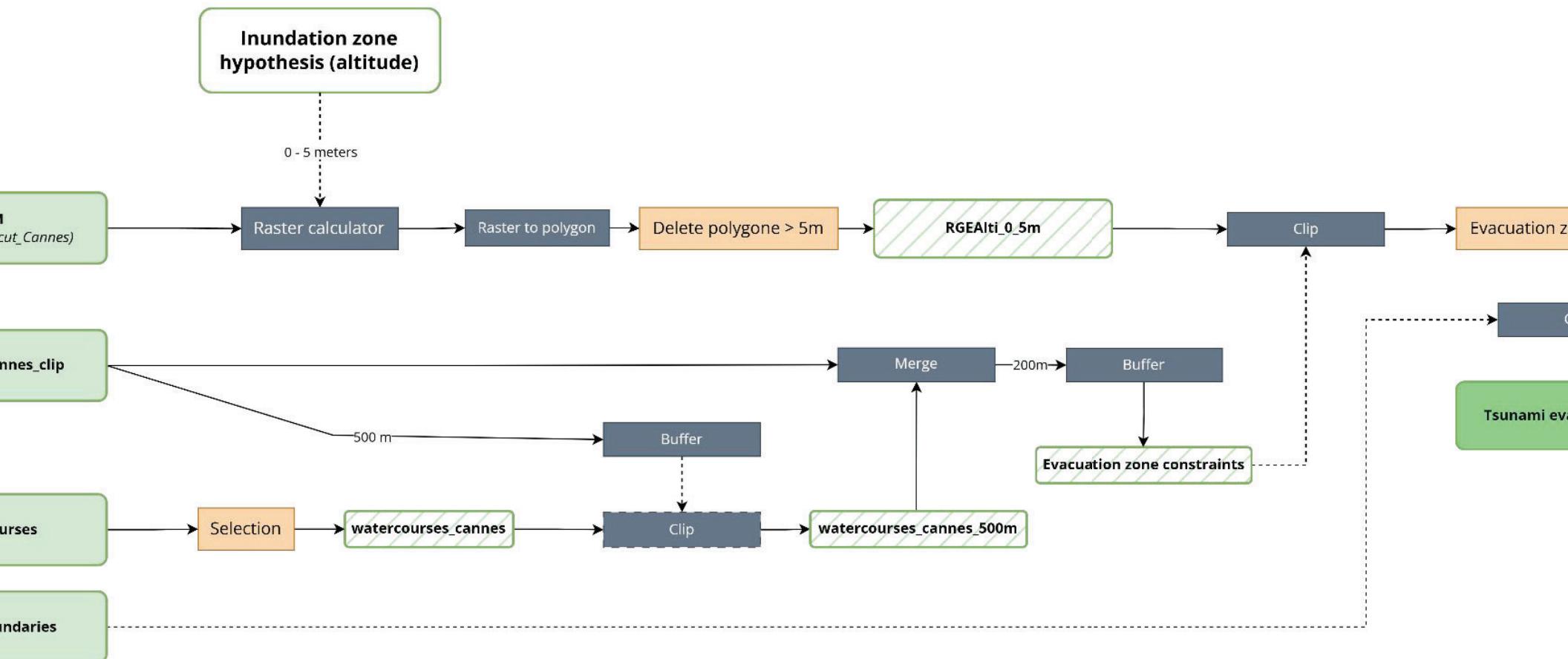
Discussions within the national Tsunami working group have led to recommendations that have been validated at the national level. This scientific partnership with the University Paul-Valéry Montpellier 3, has enabled the design of standardised evacuation plans and tsunami signage according to a method already deployed in the French West Indies (Caribbean sea)



"The taking into account of the Tsunami hazard in Cancer is part of a strong political will initiated since 2015. It is a concerted management of natural risks and a real awareness of citizens".



Detailed overview



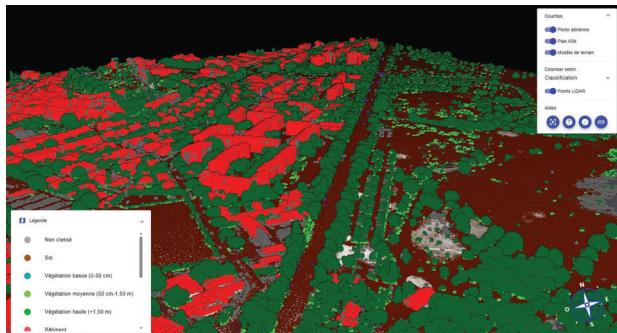
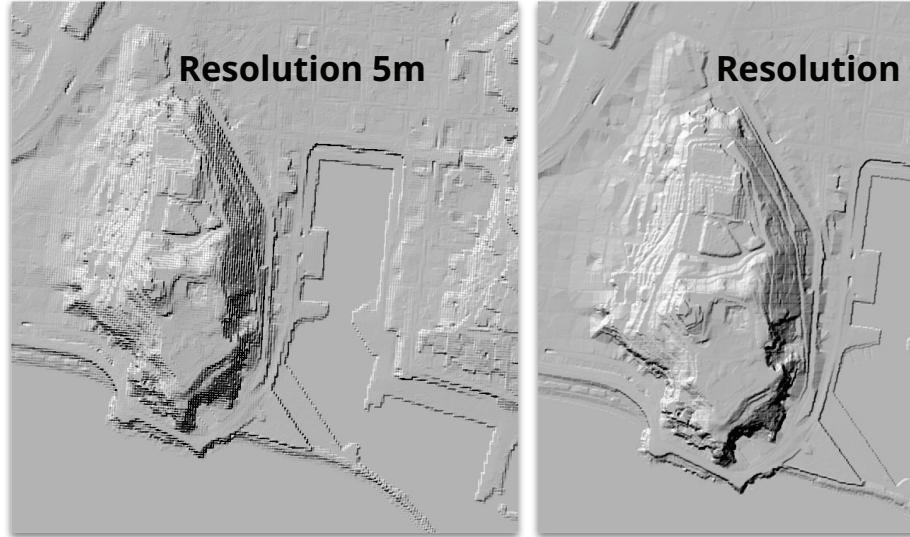


5m and 1m resolution DEM accessibility
varies between countries.

higher accuracy for terrain
with significant altitude
variation
1m resolution evacuation
zone

Cons

- Slow to process
- 1m res DEM cannot be used for a whole region on most computer.



Chimme national LiDAR HD :
geoservices.ign.fr/lidarhd



n's data

1_Ori ginal_data

- ✓ Fichier TIF
 - bathymetry_GEBCO_cut.tif
 - RGEALTI_5M_cut_Cannes.tif
- ✓ Source de Forme AutoCAD
 - administratives_boundaries.shp
 - Cannes_boundaries.shp
 - watercourses.shp
 - coastline_cannes_clip.shp

quired layers for the lesson

2_Intermediate_data

- ✓ Fichier TIF
 - RGEALti_0_5m_raster.tif
- ✓ Source de Forme AutoCAD
 - evacuation_zone_constraints.shp
 - RGEALti_0_5m.shp
 - RGEALti_0_5m_Clip_200m.shp
 - Watercourses_cannes.shp
 - Watercourses_cannes_CI_Merge.shp

Processed layers

3_Final_data

- ✓ Source de Forme AutoCAD
 - evacuation_zone_land_cut_work_area.shp
 - safe_zone_cut_work_area.shp

Results



solution DEM with a world coverage are largely available in open access.

Shuttle Radar Topography Mission (SRTM) -

<http://dwtkns.com/srtm30m/>

Copernicus DEM - Global and European Digital Elevation Model

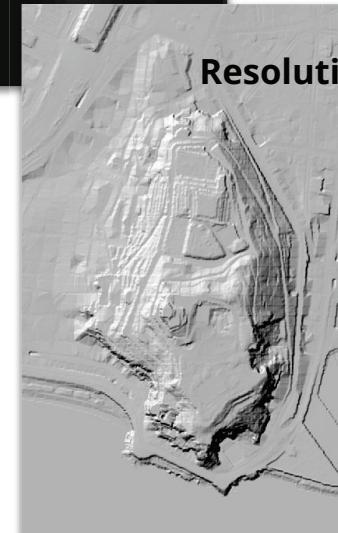
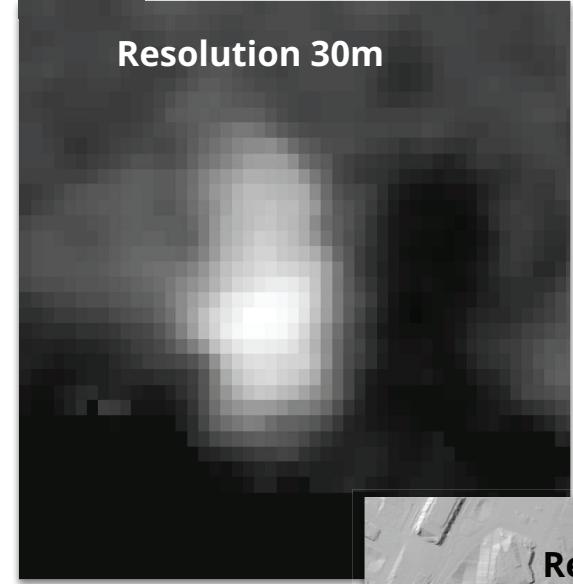
<http://dataspace.copernicus.eu/explore-data/data-collections/copernicus-dem>

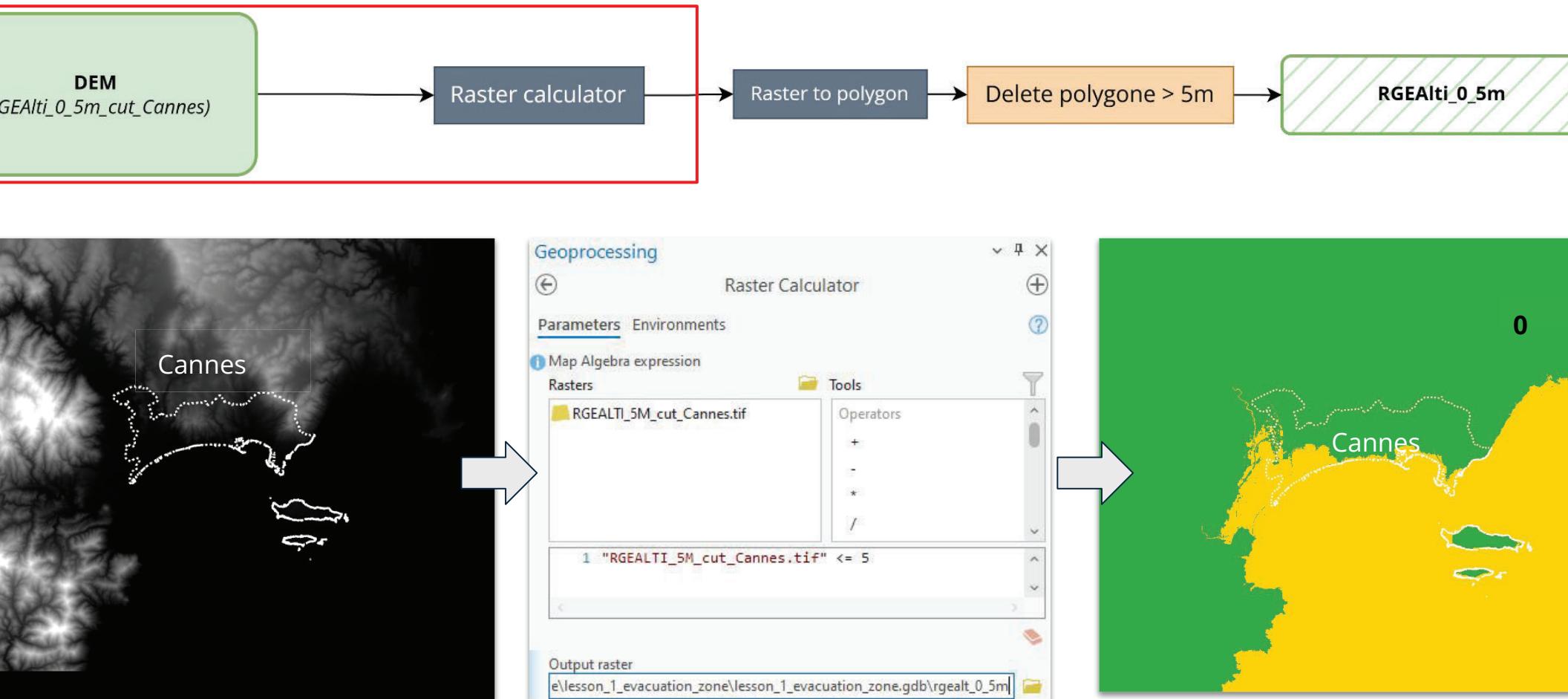
<http://contributing-missions/collections-description/COP-DEM>

Fast to process
Suitable for large studies
Area (country)
World coverage

Cons

- Low evacuation zone precision
- Not suitable on terrain with significant altitude variation

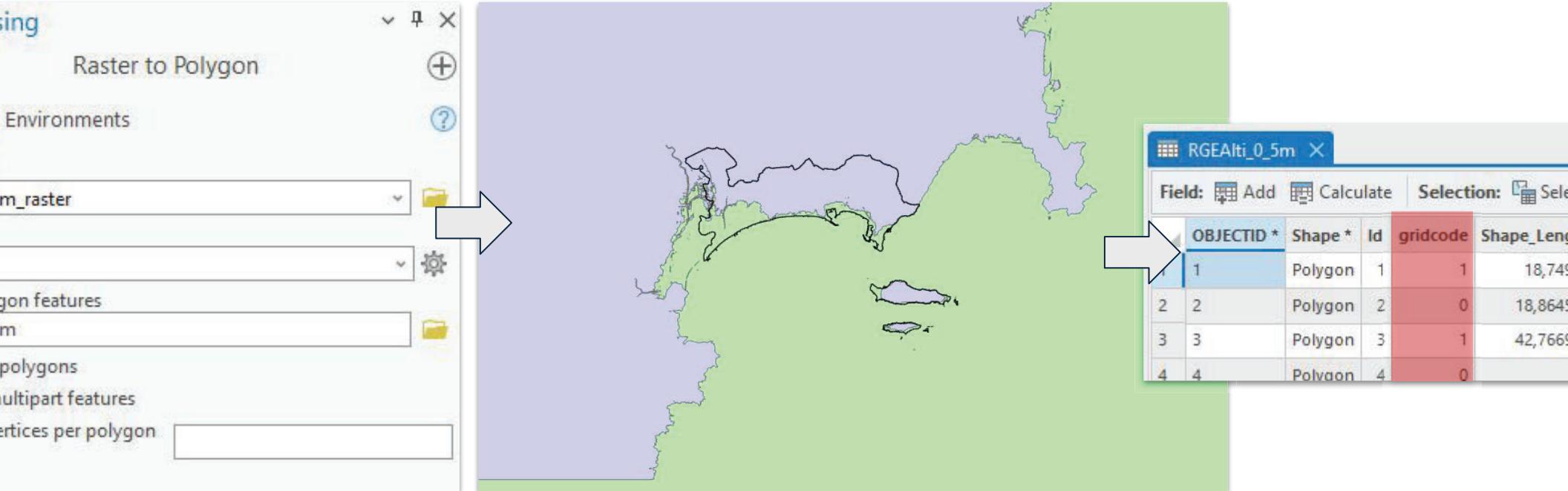
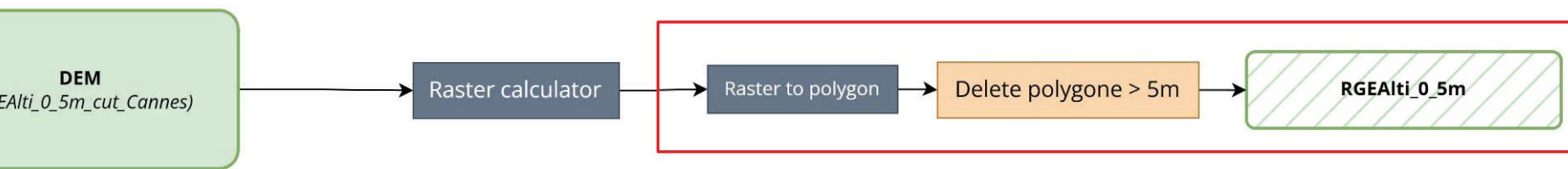




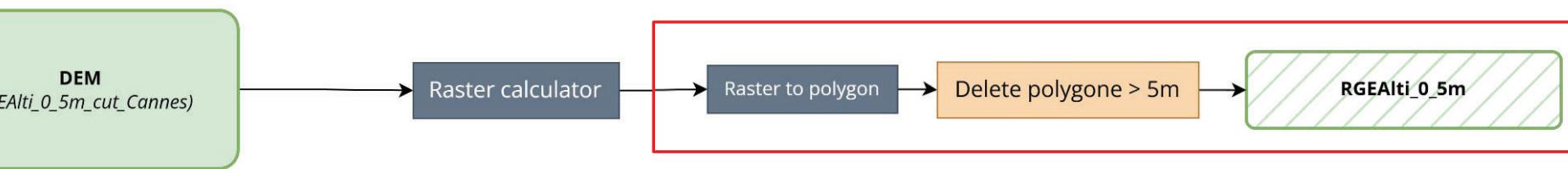
s in the image have a pixel elevation

"LAYER_NAME" <= 5

Pixel's value is now "0" or "1" depending on the pixel elevation value matching the condition or not.



The previous raster's pixel values are in the field
"gridcode".



Screenshot of a GIS application showing the selection of features based on attributes.

Selection: Select By Attributes

OBJECTID *	Shape *	Id	gridcode	Shape_Length	Shape_Area
1	Polygon	1	1	18,74914	16,009706
2	Polygon	2	0	18,864507	17,116872
3	Polygon	3	1	42,766992	82,311303
4	Polygon	4	0	50	100

Attributes

gridcode is equal to 0

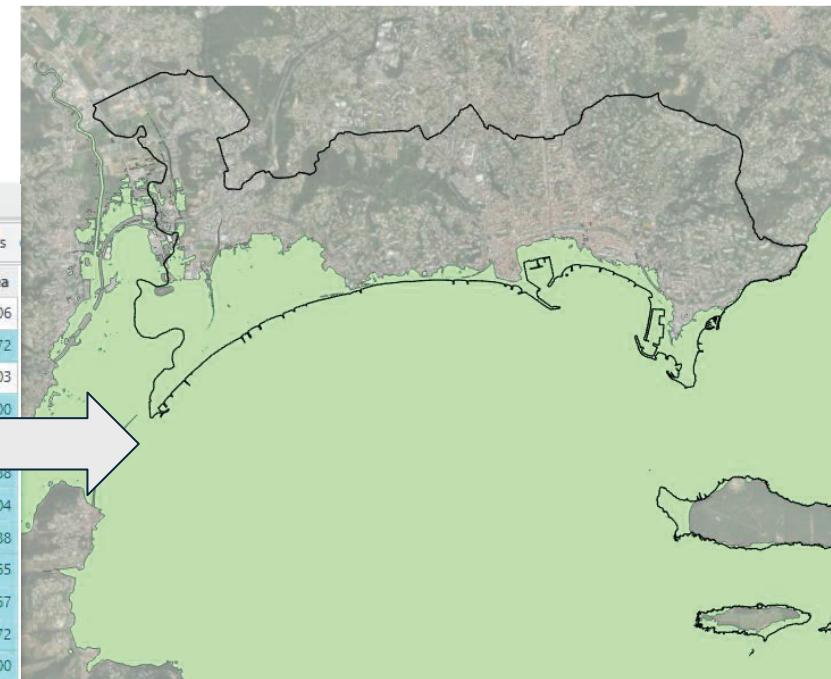
OK

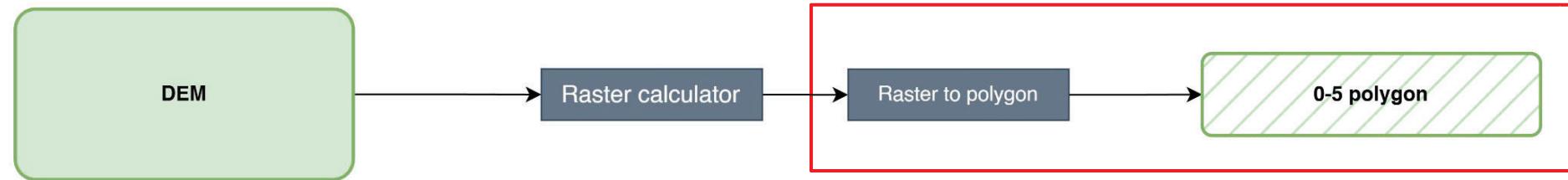
Screenshot of a GIS application showing the creation and modification of features.

Create Modify Delete

Features

OBJECTID *	Shape *	Id	gridcode	Shape_Length	Shape_Area
1	Polygon	1	1	18,74914	16,009706
2	Polygon	2	0	18,864507	17,116872
3	Polygon	3	1	42,766992	82,311303
4	Polygon	4	0	50	100
5	Polygon	5	1	50	100
6	Polygon	6	0	18,864512	17,116868
7	Polygon	7	0	28,295347	34,139504
8	Polygon	8	0	18,864512	17,11688
9	Polygon	9	0	18,864504	17,116865
10	Polygon	10	0	58,113697	85,755767
11	Polygon	11	0	335,857743	1495,293372
12	Polygon	12	0	50	100
13	Polygon	13	0	38,137204	50,11608
14	Polygon	14	0	47,866595	69,650121





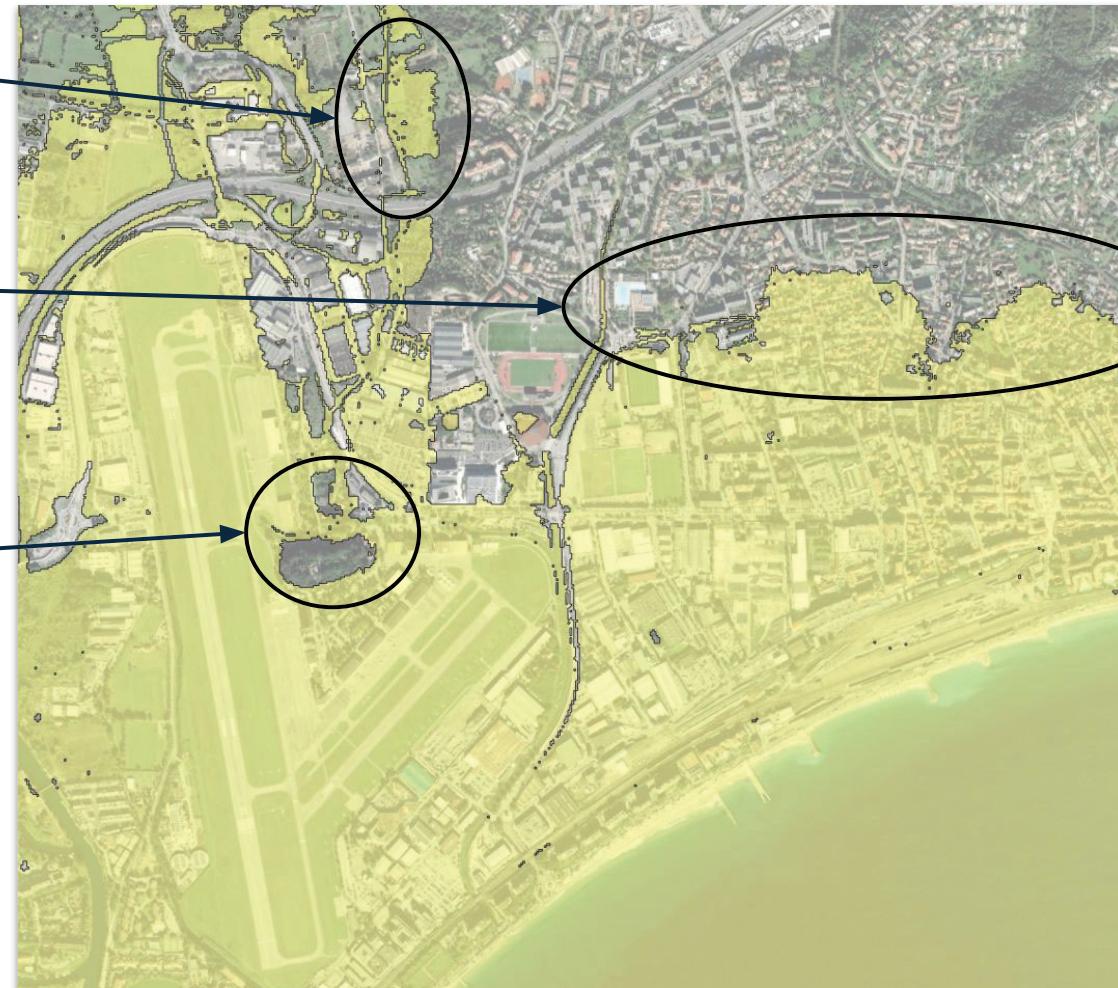
tain a polygon with a very
e level of detail that leads to
l geometries to be
lized

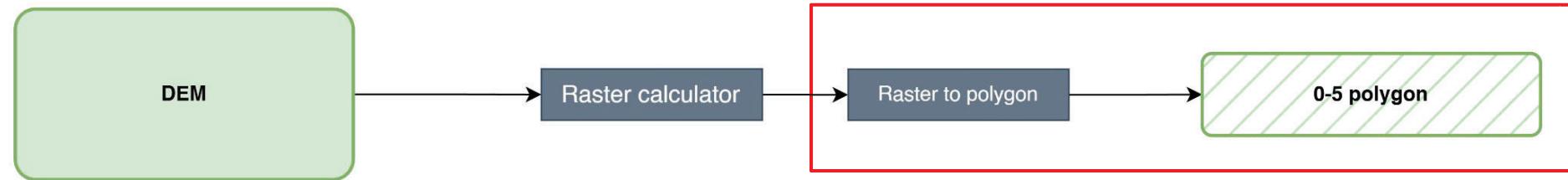
{

Isolated
polygon

Polygon's
edges need
simplification

local variations
in altitude
must be
deleted





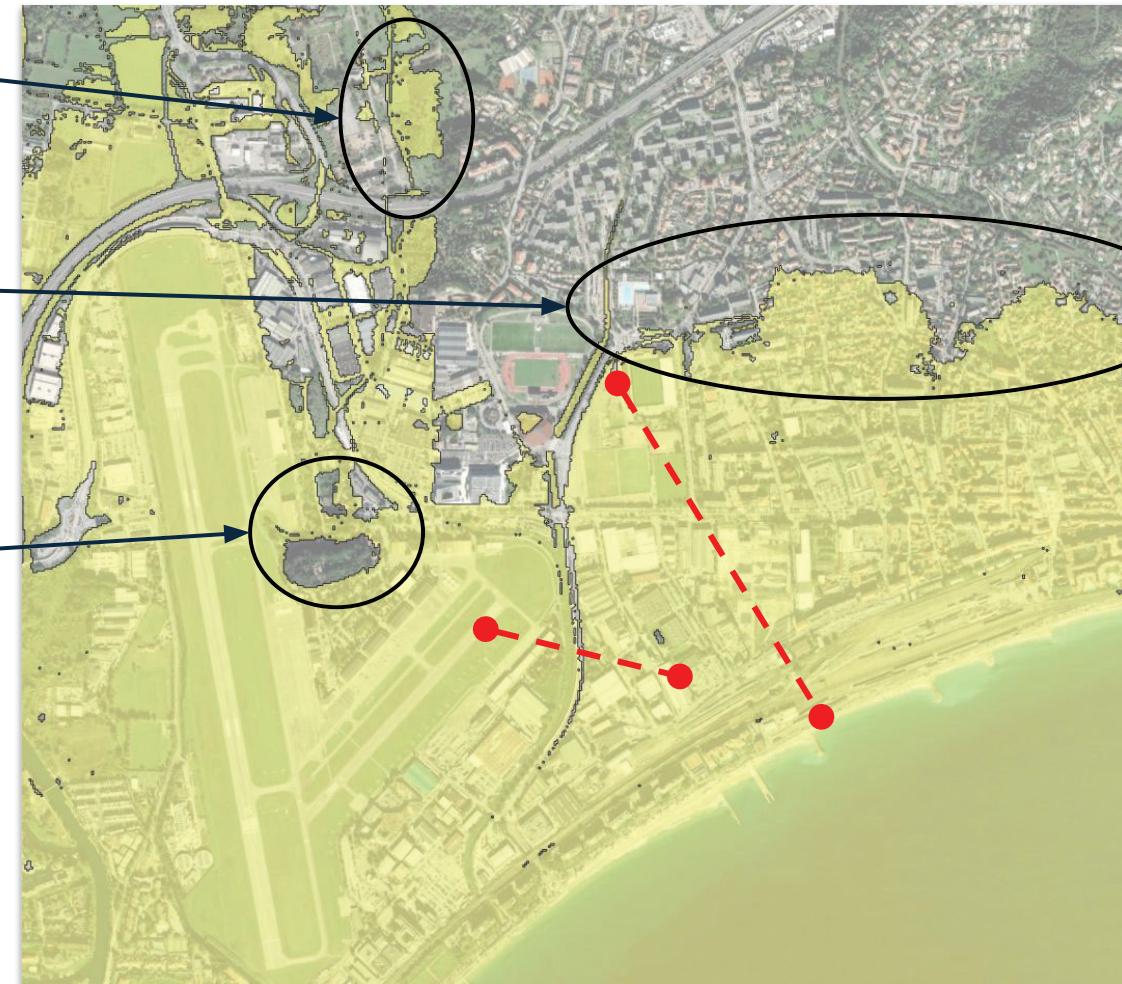
tain a polygon with a very
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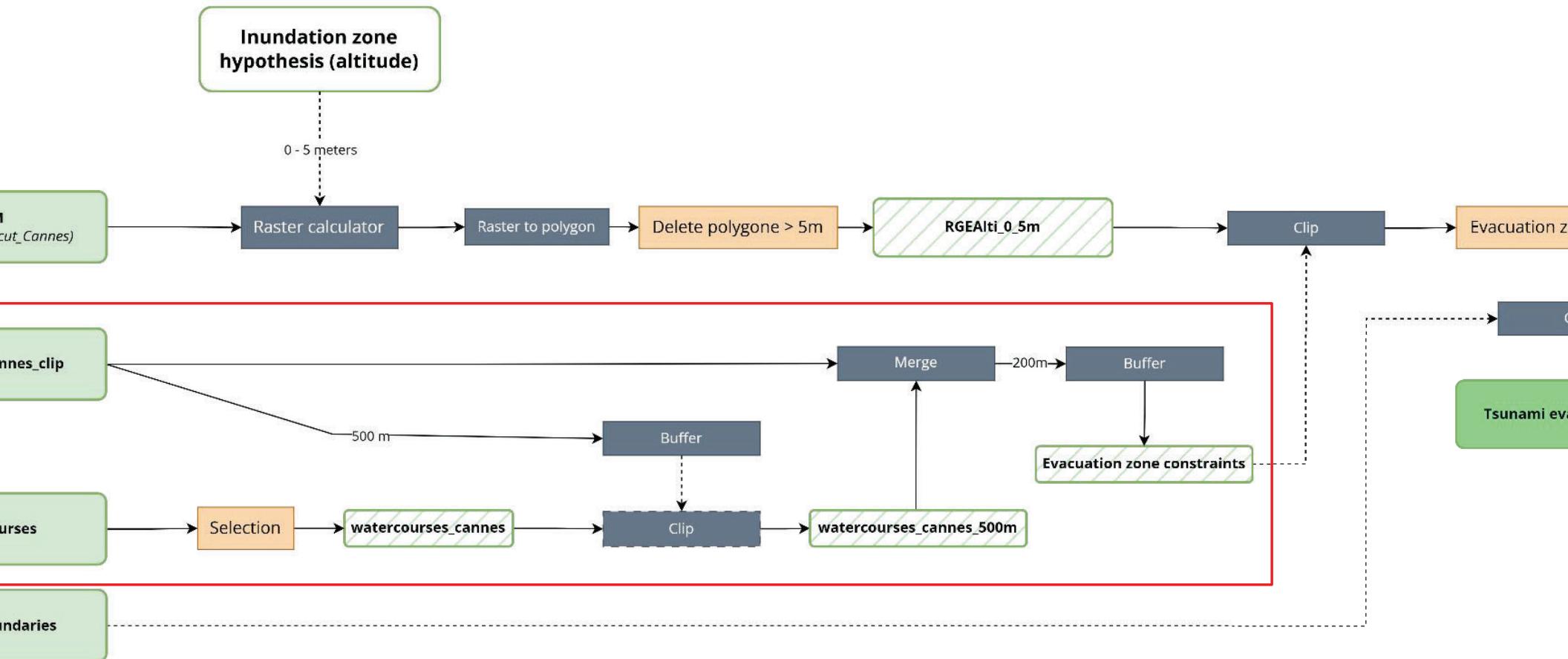
Isolated
polygon

Polygon's
edges need
simplification

local variations
in altitude
must be
deleted



this step, we need to take into account the
assumptions regarding maximum distances
and around watercourses.





Only open-air hydrographic network will be taken into account for the evacuation zone
⇒ During **field mission** or through **aerial image interpretation**



Non cased drainage



Cased drainage



Generate 500 meters buffer on clipped coastline

processing

Buffer

The Pairwise Buffer tool provides enhanced functionality or performance.

parameters Environments

Input Features: coastline_cannes_clip

Output Feature Class: coastline_cannes_clip_Buffer

Distance [value or field]: Linear Unit: Meters: 200

Coordinate System Type: WGS 1984 UTM Zone 31N

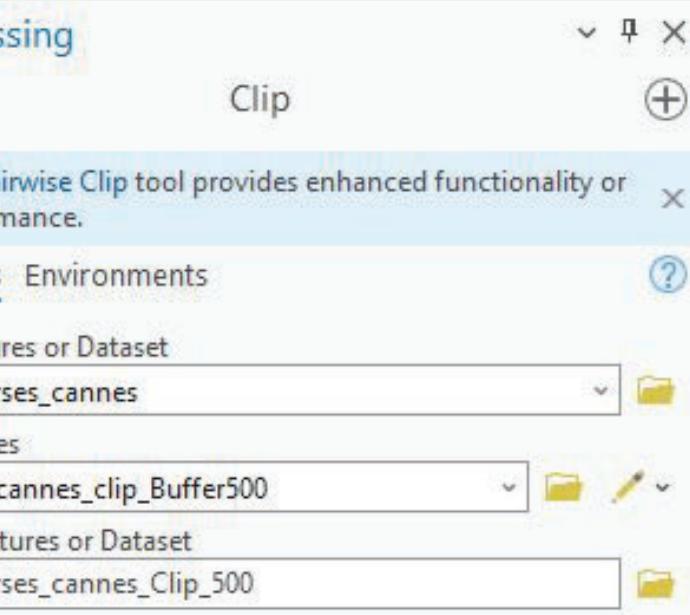
Tool Type: Geoprocessing Tools

Solve Type: Solve all output features into a single feature





course with previous buffer



n #1

Tsunami evacuation zone mapping

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both watercourse & coastline

Sing

Merge

Environments

Projects

- watercourses_cannes_Clip_500
- coastline_cannes_clip
- coastline_cannes_clipped
- coastlines_cannes_Cl_Merge

Add Fields Edit

2)

DE_HYDRO (2)

ONYME

TUT_TOP

ORTANCE

E_CREAT (2)

E_MAJ (2)

E_APP (2)

E_CONF (2)

RCE (2)

SOURCE (2)

TIT (2)

Source information to output





200 meters buffers with the merged layer and export the result as "**evacuation_zone_constraints**"

ing

Buffer

The Buffer tool provides enhanced functionality and performance.

Environments

Environment Class

ses_cannes_CI_Merge

Feature Class

ses_cannes_C_Buffer_200m

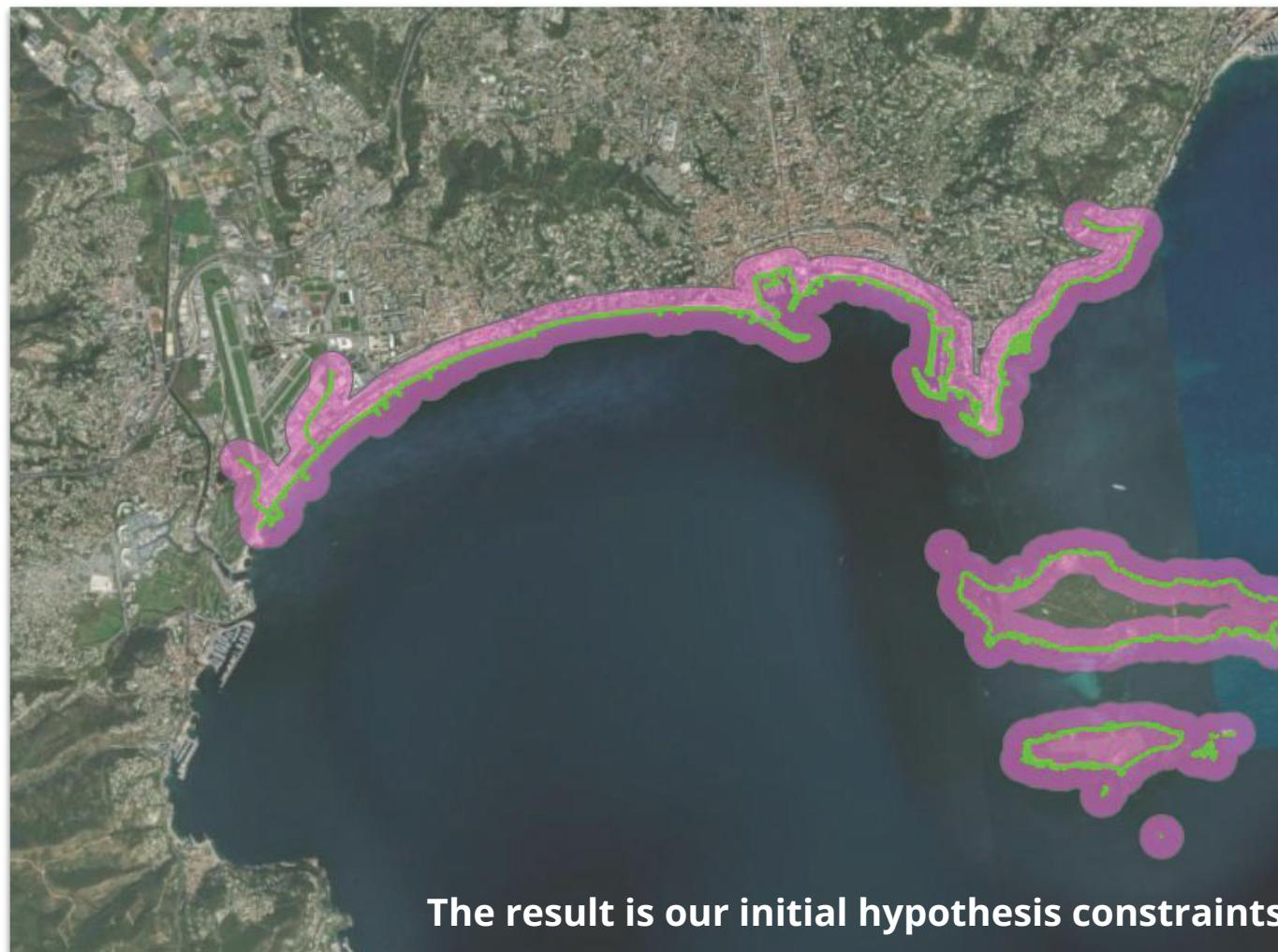
Value or field

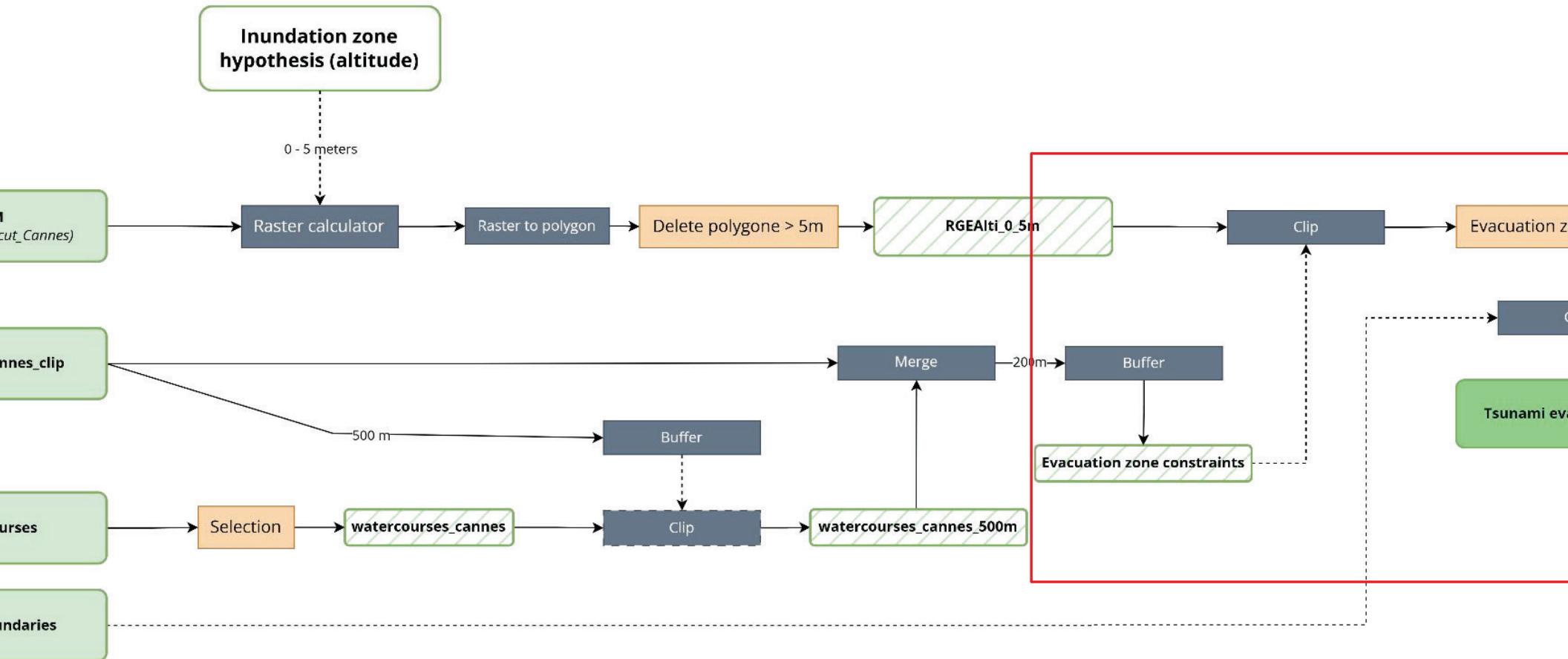
Linear Unit

200 Meters

Output

I output features into a single feature







RGEAlt_0_5m on the **evacuation_zone_constraints** layer.

essing

Clip

The pairwise Clip tool provides enhanced functionality or performance.

Environments

ures or Dataset

0_5m

res

on_zone_constraints

atures or Dataset

0_5m_Clip_200m

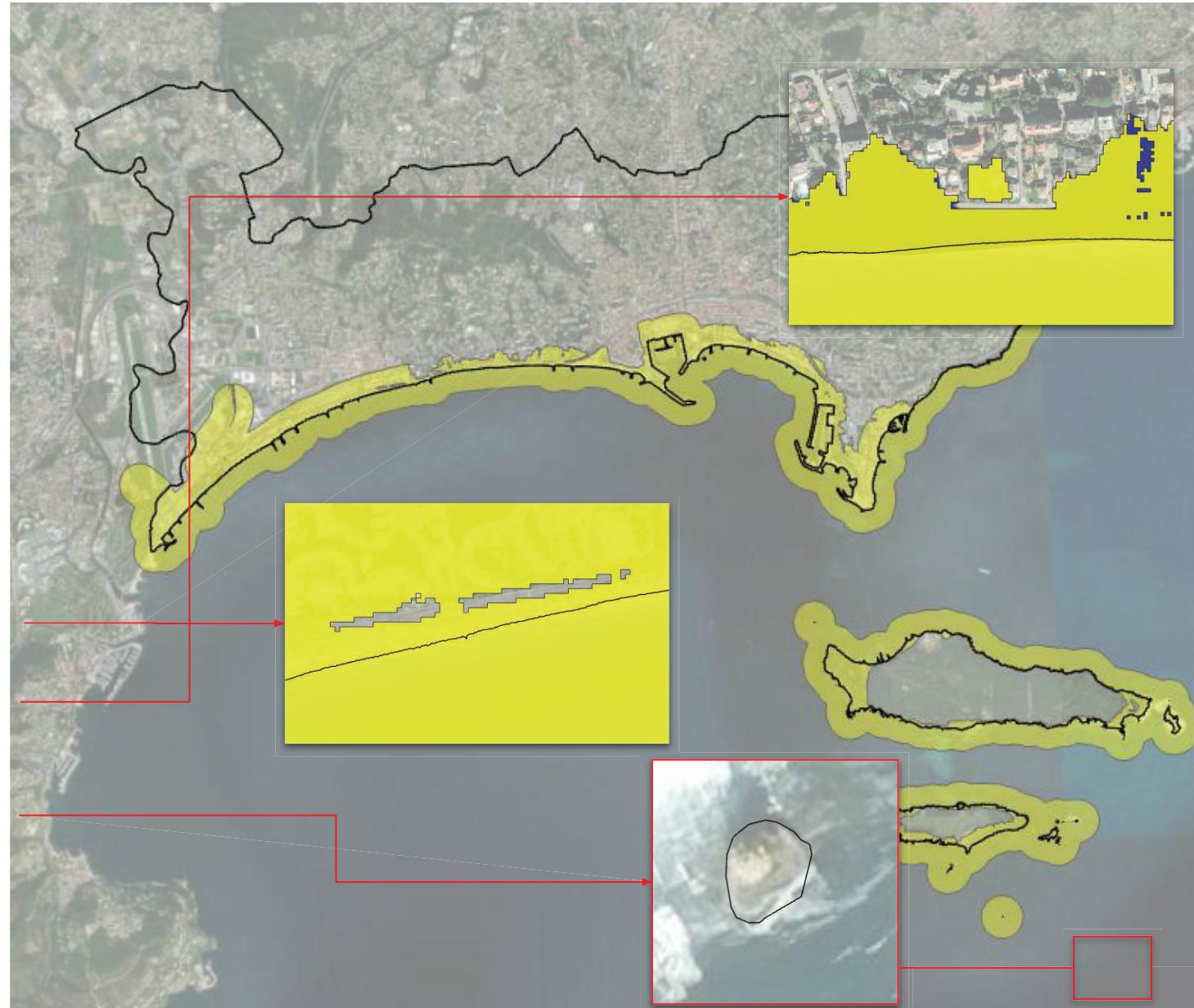




g the RGEAlt_0_5m with constraints polygon provide **raw version** of the evacuation zone which will be used to create the final tsunami evacuation zone.

Actions are needed at this stage:

- moving off-lands parts
- moving holes due to local elevation change
- moving parts not connected with the sea
- smoothing the polygon's edges
- moving small inhabited set



n #1

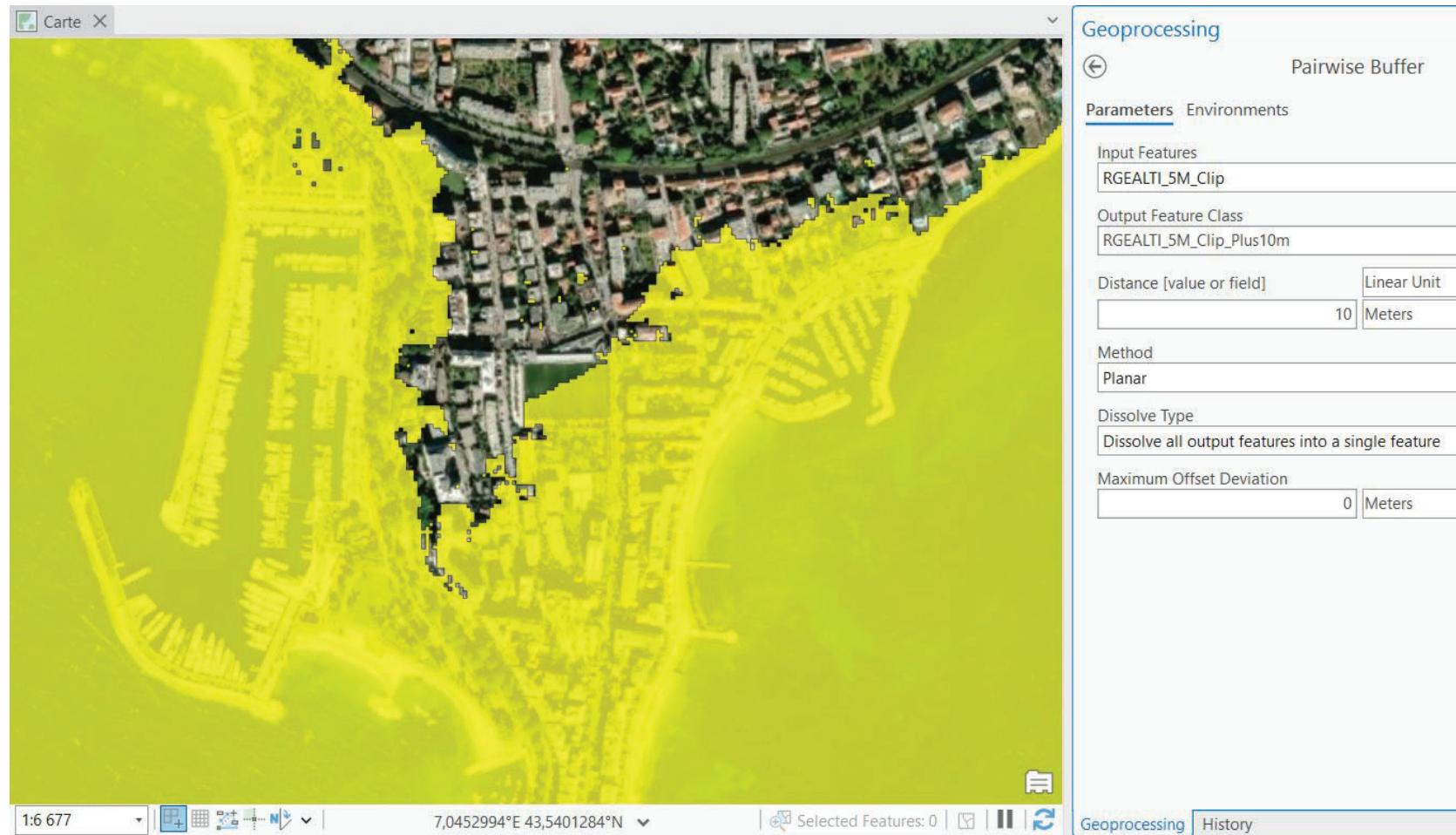
Tsunami evacuation zone mapping

Coastwave 2.0 Evacuation
Mapping Workshop



& Dilation on Vector Data

r the
evacuation_zone"
by **10 meters**
smooth and
select isolated
regions.



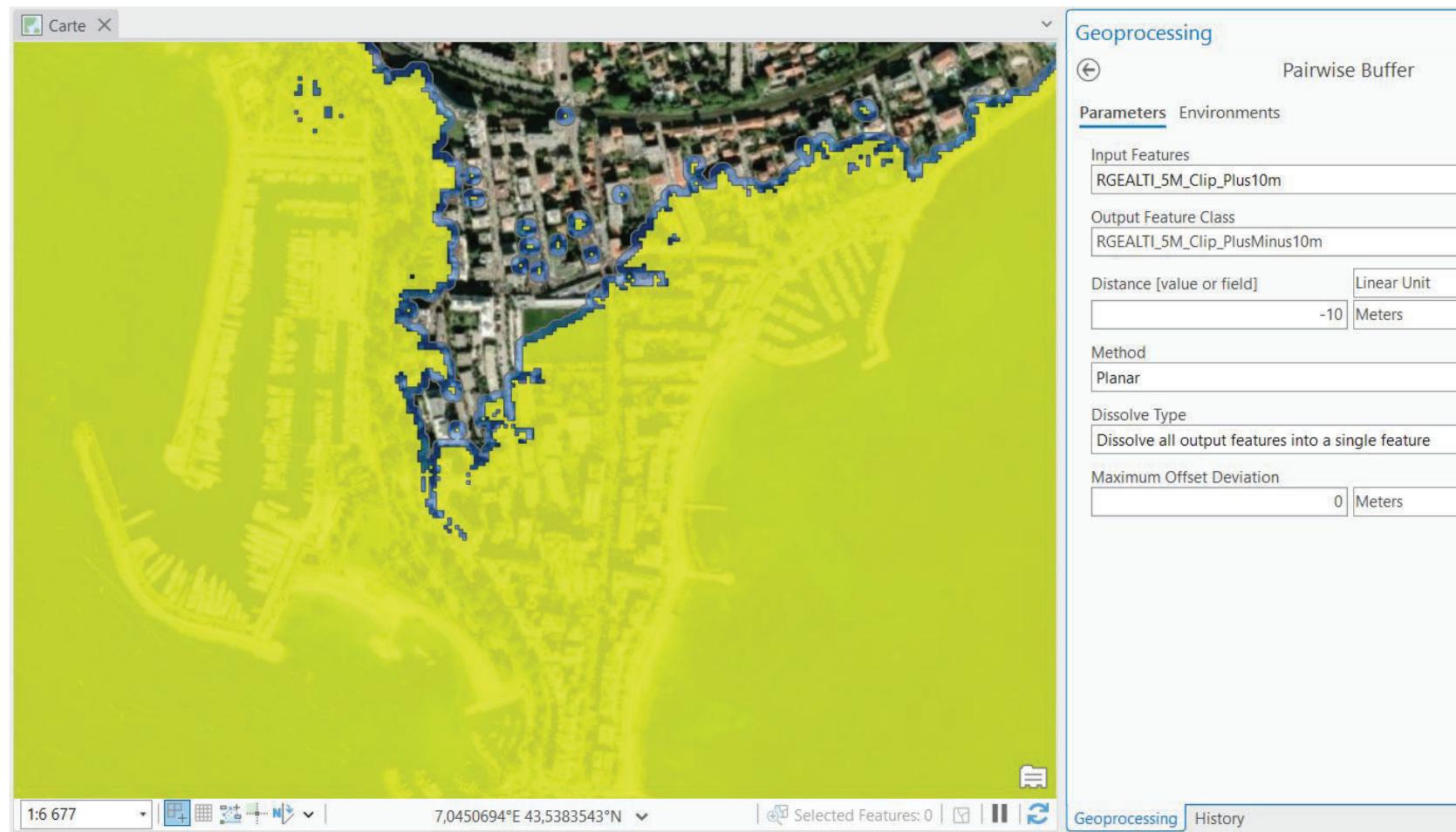
n #1

Tsunami evacuation zone mapping

Coastwave 2.0 Evacuation
Mapping Workshop



& Dilation on Vector Data



ne
ion_zone"
-10 meters
fy the
y and
e narrow
ons.

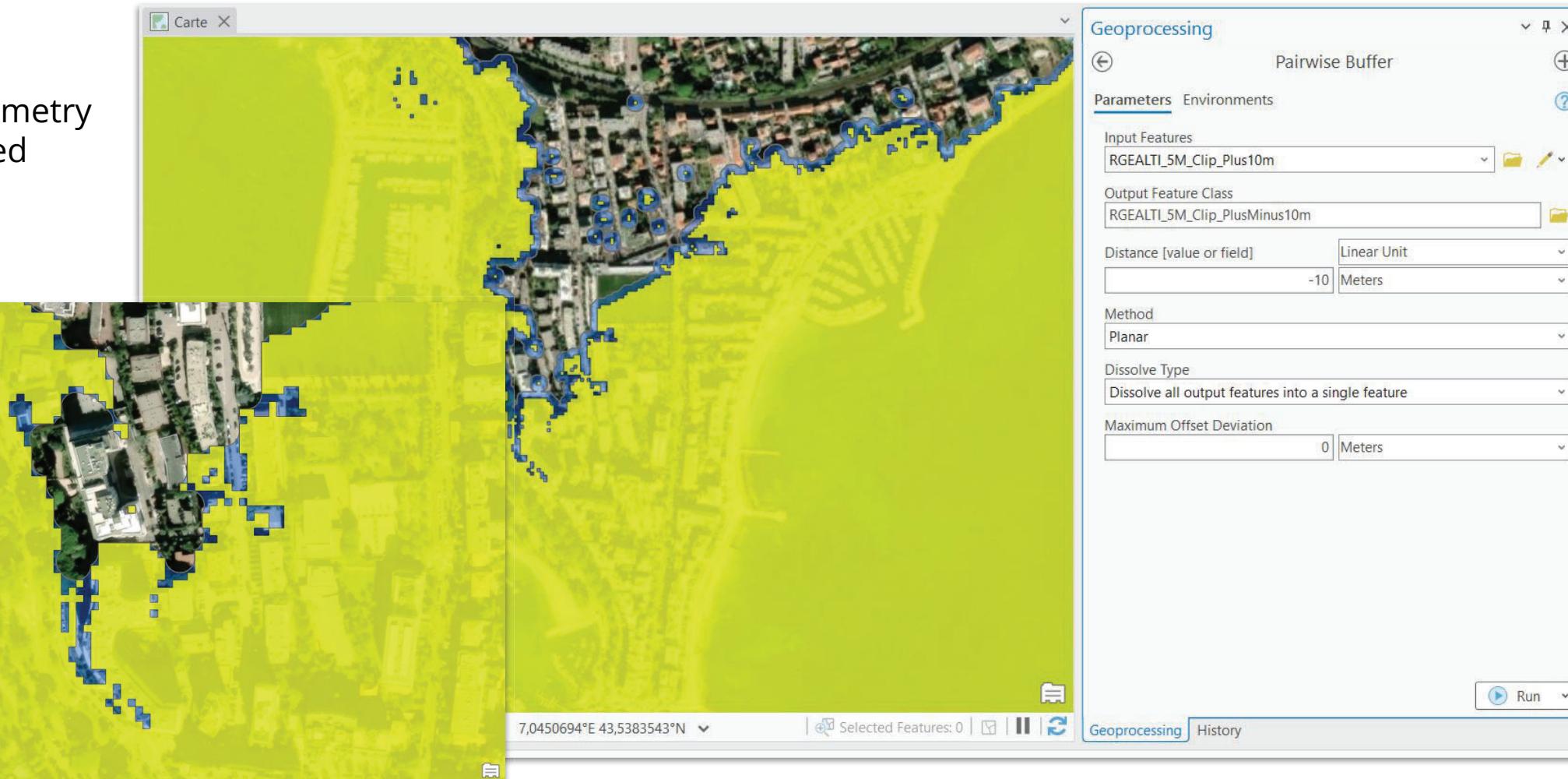
n #1

Tsunami evacuation zone mapping

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& Dilation on Vector Data





The **Eliminate Polygon Part** geoprocessing tool allows holes larger than the **minimum hole size** parameter. The result of the algorithm can vary significantly depending on the input parameters.





Create Polygon Part geoprocessing tool allows holes larger than the **minimum hole size** parameter.
Result of the algorithm can vary significantly depending on the input parameters.

Select

Geoprocessing

Multipart To Singlepart

Parameters Environments

Input Features: RGEALTI_5M_Cli_EliminatePoly

Output Feature Class: RGEALTI_5M_Cli_MultipartToSi

Run

Multipart To Singlepart completed.

View Details Open History Suggestions

Geoprocessing History

7,0434663°E 43,5438921°N

Inverse selection

Feature Layer Labeling

Fields Subtypes Domains Attribute Rules Contingent Values Add Archive Spati Archiving

Section selected rows.

Carte

Insert Analysis View Edit Imagery Share Help

No Topology Status

Save Discard Error Inspector Settings

Manage Templates Manage Edits

Snapping Create Modify Delete

Carte

Save Ed Save all Edits

Don't Save Edits

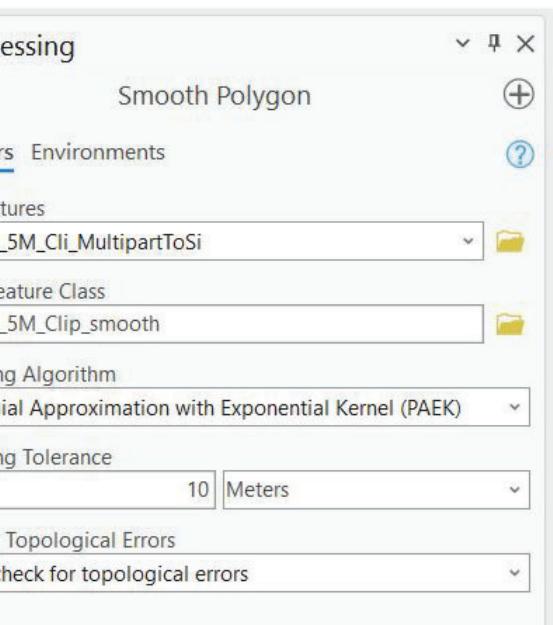
Show Edits

MultipartToSi EliminatePoly



smoothing for Clearer Boundaries

with the evacuation_zone
to reduce angular
es and improve boundary
ibility.





off-land parts by
the layer with Cannes
es polygon.

g the layer with coastline
ossible if the community's
s aren't accurate along

erate a polygon using a
ution coastline and the
our work area

ing

Clip

The Coastwave Clip tool provides enhanced functionality or
ance.

Environments

es or Dataset

n_Clip_200m

Boundaries

res or Dataset

n_Clip_200m_Clip_Cannes





Check that the result of the clipping operations is conform to our initial hypothesis (0-5m high & 200m inland or 500m for watercourses that are connected to the sea)



Tsunami evacuation zone mapping



cation is mandatory in order to detect the need for local adaptations that are assessed through imagery analysis.

00, Nice's metropole's largest mall

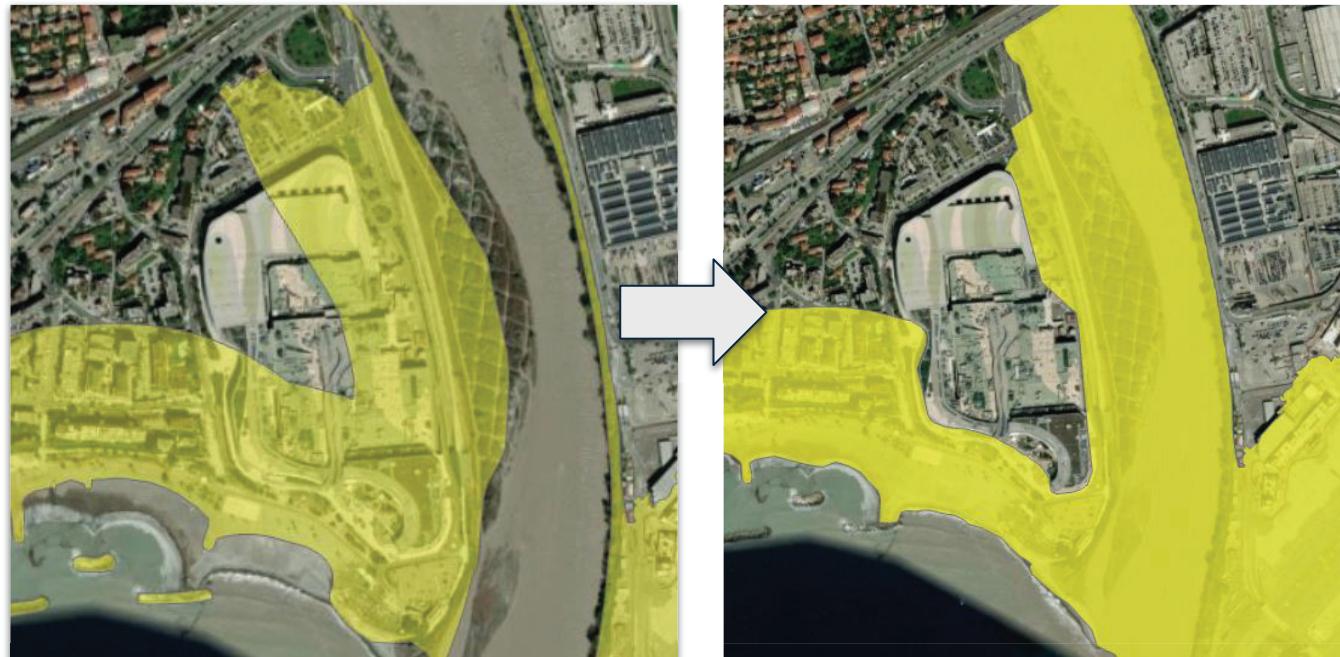
the large numbers of visitors, the decision was made to make an exception to the evacuation instructions for this center: people already in the mall will stay inside.

was allowed to take into account the constructed seafront terrace that is visible on satellite imagery at the end of the project.

The evacuation zone along the mall was based on the field verification and Lidar data



Lidar's 0-5m range extraction



Dr. Matthieu Péroche (matthieu.peroche@univ-montp3.fr) - L



Generate the tsunami safe zone !



use the **Symmetrical difference** tool between the evacuation zone and Cannes boundaries to generate the safe zone

processing

Symmetrical Difference

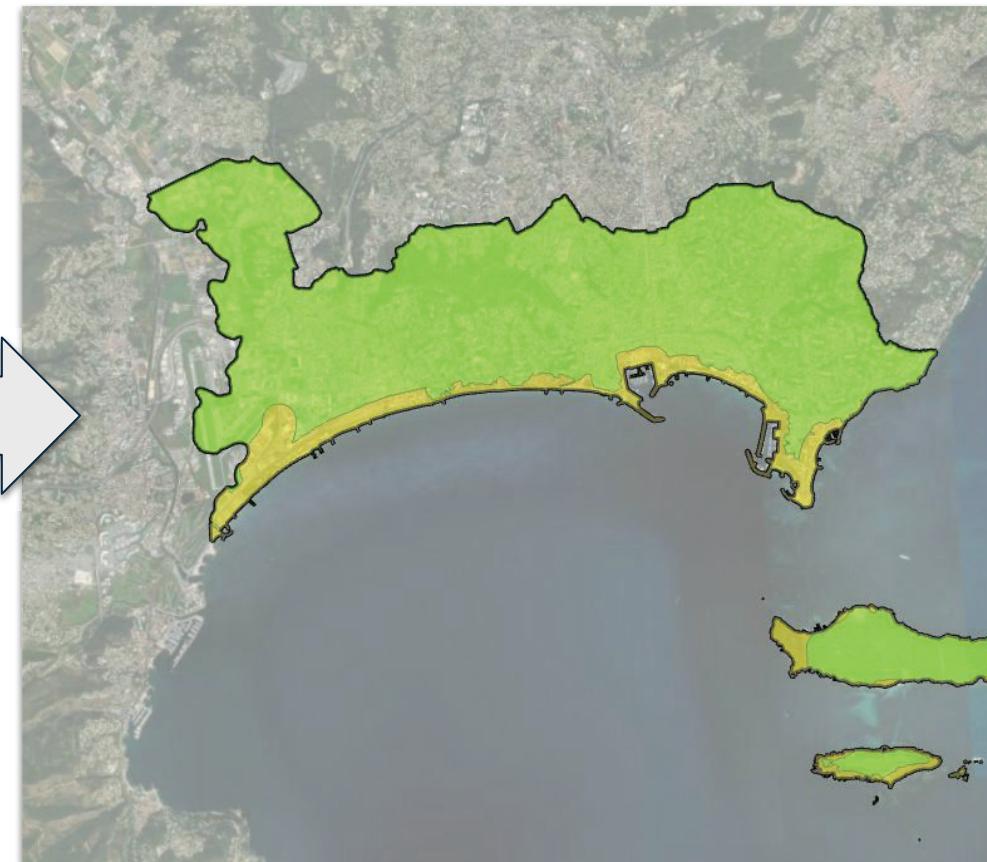
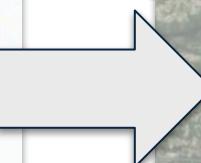
Parameters Environments

Input Features Cannes_boundaries

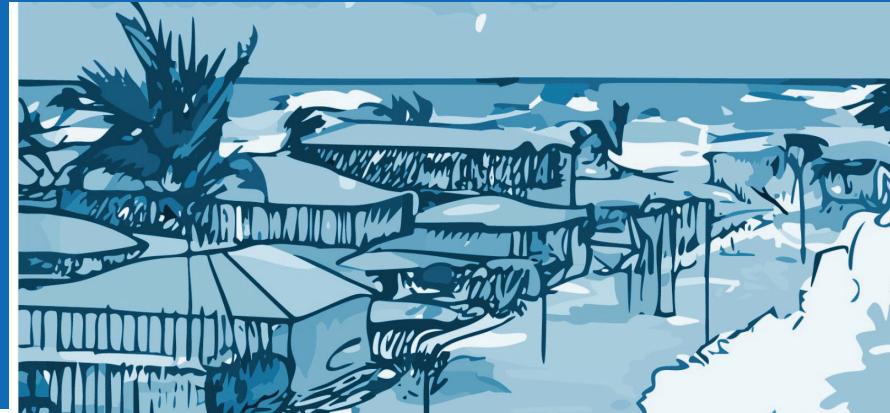
Update Features evacuation_zone_land_cut_work_area

Output Feature Class Safe_zone

Attributes to Join All attributes



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