SimHydro 2019

5TH INTERNATIONAL CONFERENCE
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SOPHIA ANTIPOLIS - FRANCE

A framework to design a municipal decision support tool for cyclone-induced marine flooding emergency management at Reunion Island

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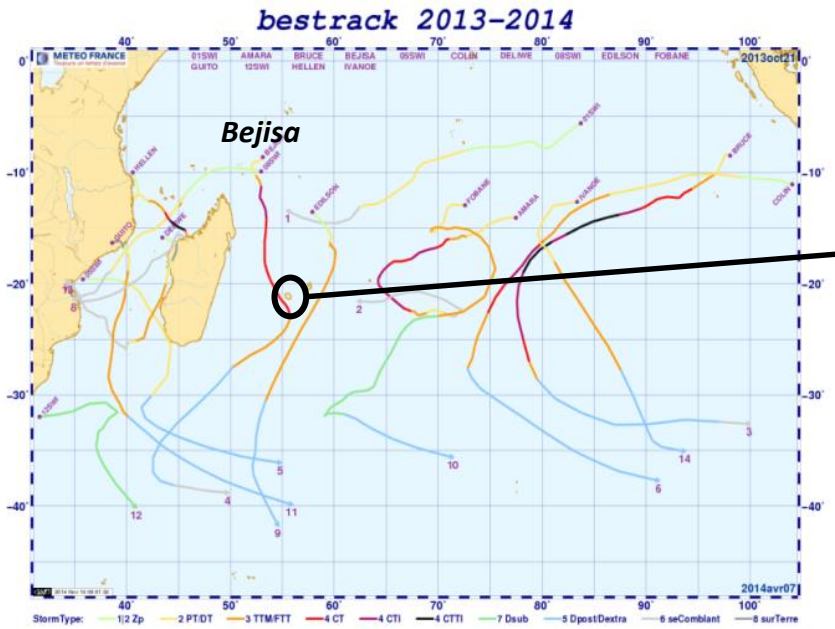
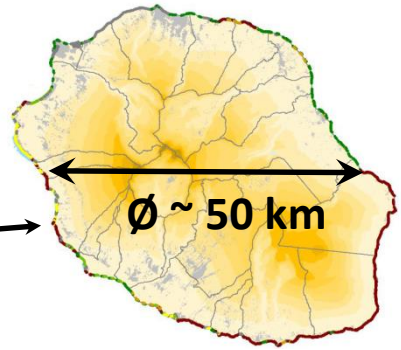
CONTEXT : REUNION ISLAND

- The most exposed among the French Overseas Territories
- 23 cyclones passed within 200km of the island over the last 30 years

… but no marine flooding forecast system so far





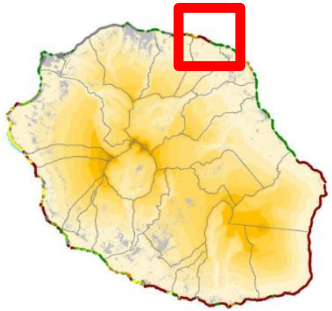
High uncertainties due to the track forecast errors !

Cyclone Bejisa (2014)

CONTEXT : SAINTE-SUZANNE CITY

> Situated on the Northern coast of the island (the most exposed)

> Marine flooding due to wave overtopping only (no overflowing)



- The municipal services don't know how to interpret marine forecasts into flooding impact
- They can't anticipate and organize their operational response

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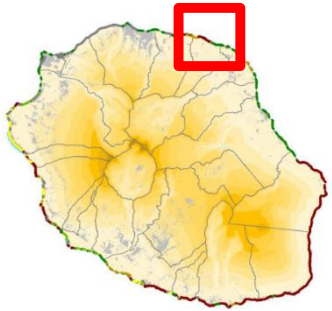

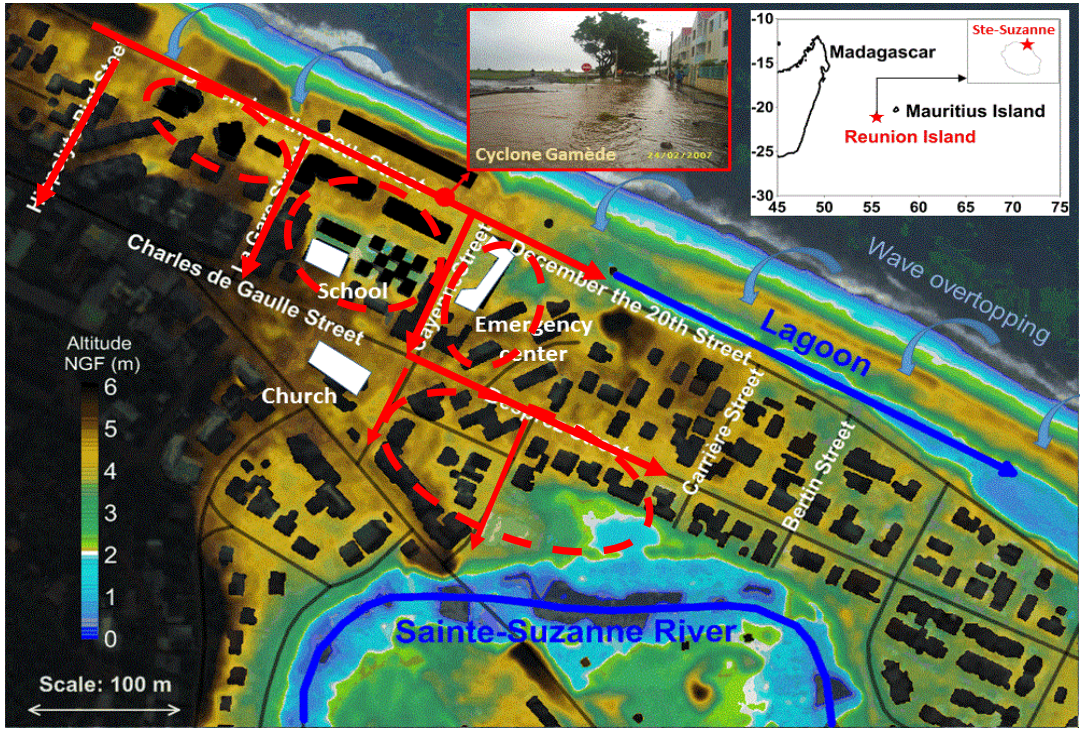

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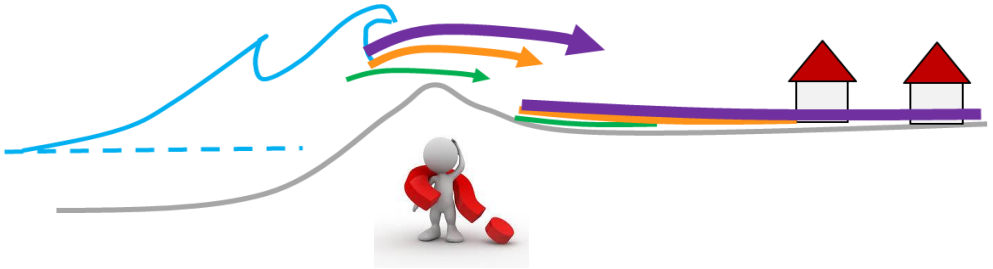
OBJECTIVE AND CONSTRAINTS



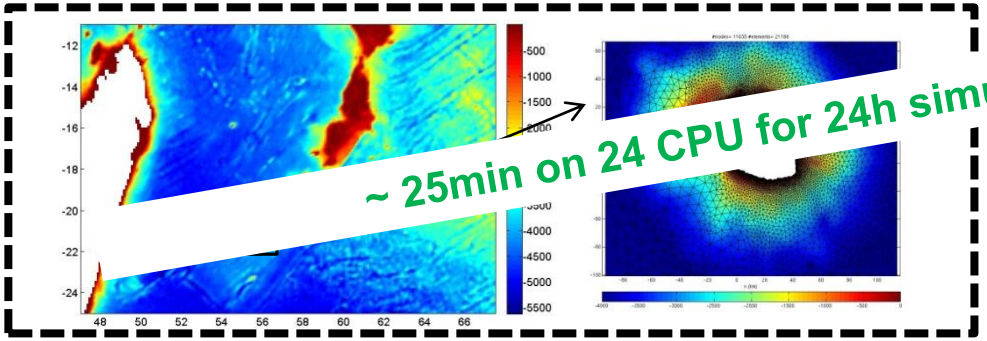
Produce a pragmatic tool linking the weather and marine forecasts with potential impacts on land and appropriate operational responses.

But …..

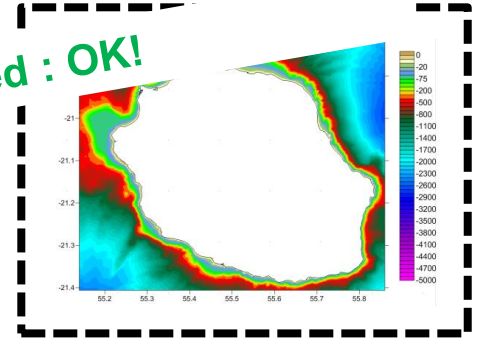
- Need to have a "**easy to use**" tool for non-experts users
- Scarcity of **historical events** (in recent years)
- The **high computation time** to simulate marine flooding by overtopping hampers the implementation of operational forecast systems

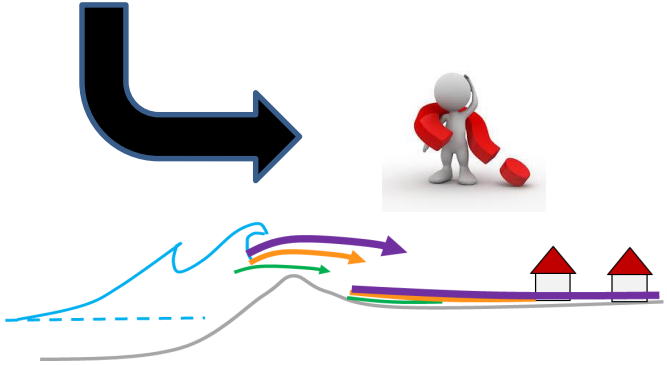
CHAIN OF MODELS USED BY BRGM

WAVES : Wavewatch 3 (10km => 300m)

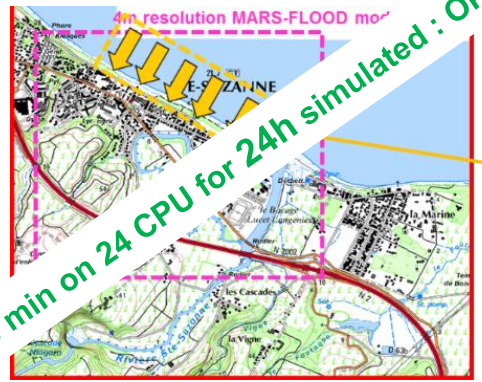


WATER LEVEL : MARS (100m)

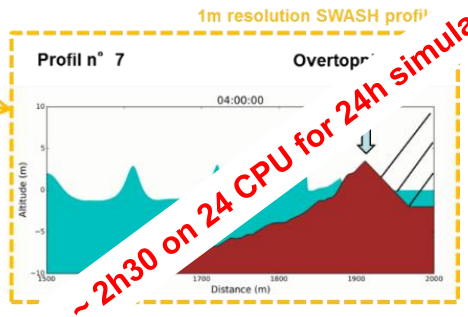




INUNDATION : MARS FLOOD (4m resolution)



VERTOPPING : SWASH profiles (1m resolution Non-hydrostatic model)



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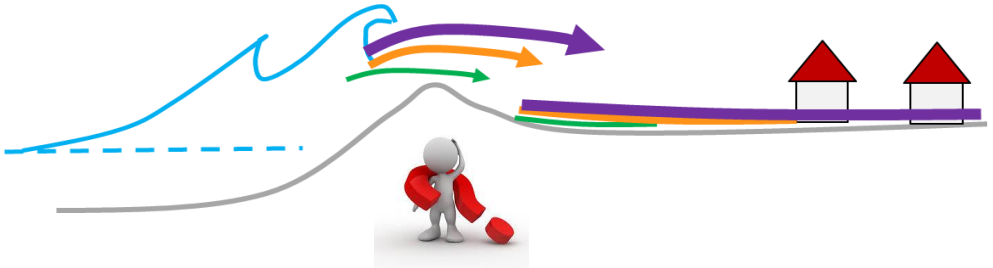


Produce a pragmatic tool linking the weather and marine forecasts with potential impacts on land and appropriate operational responses.

Solution proposed here …..

- Construct **Graduated Intervention Plans (GIP)** = series of maps representing the extent of potentially impacted areas, structured in gravity levels regarding the marine conditions
- Based on **feedback** analysis, **field** observations and state-of-the-art hydrodynamic **modelling**
- Use of the complete chain of models to build a **pre-calculated synthetic but realistic marine flooding database**

THE DATABASE

BDD Cyclones [#500]

WW3

MARS

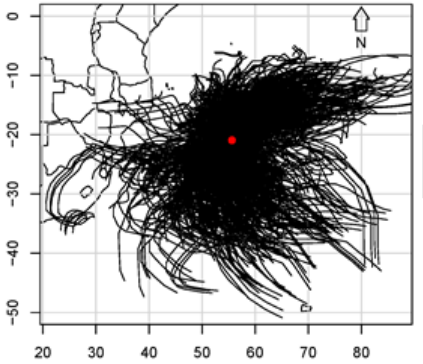
BDD Waves + Water level

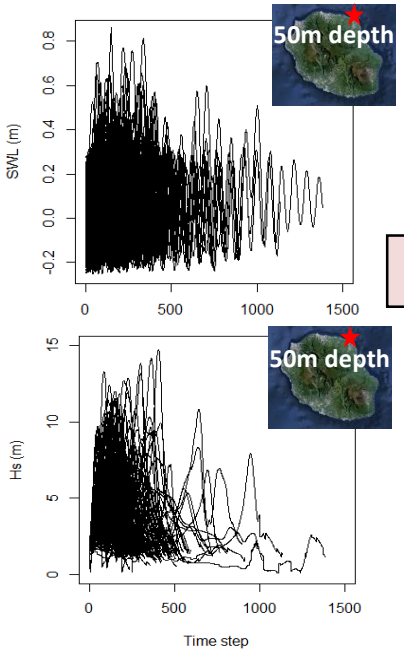
SWASH

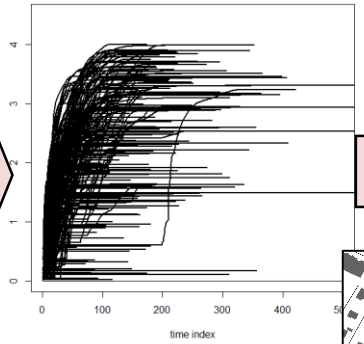
BDD *Discharge volumes*

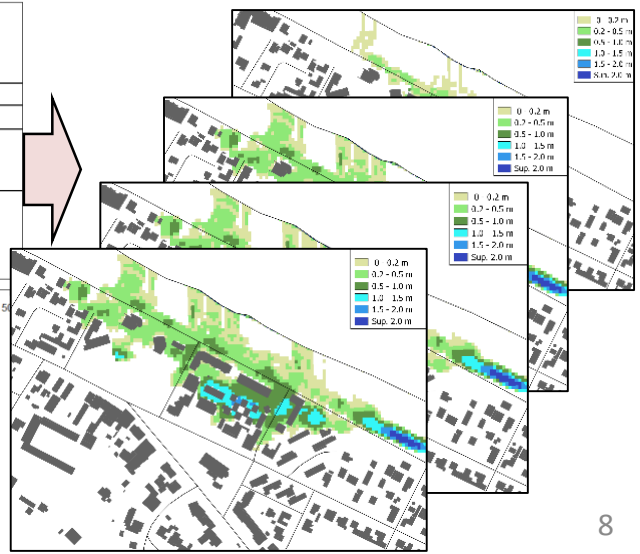
MARS *FLOOD*

BDD Marine flooding

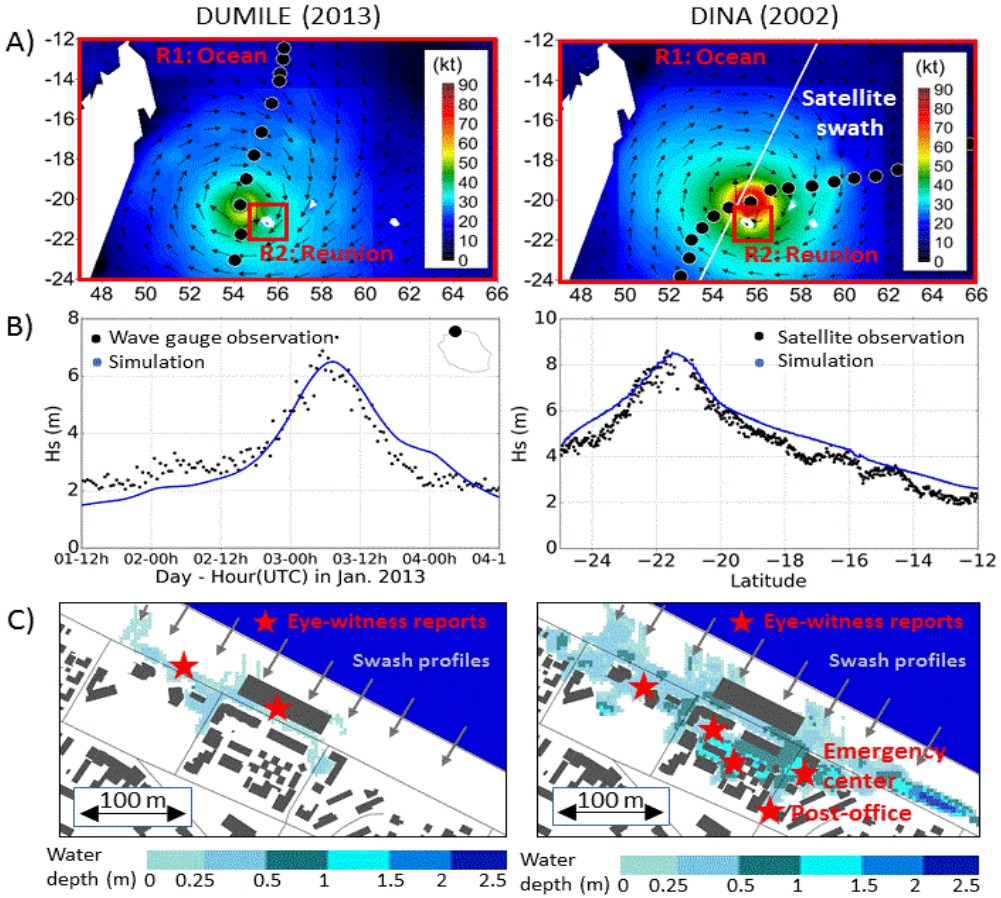






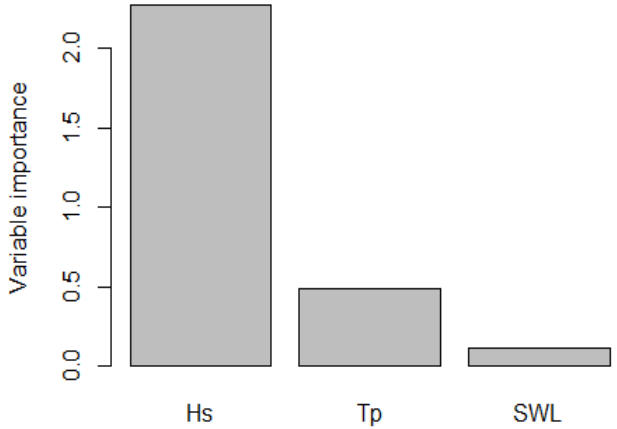


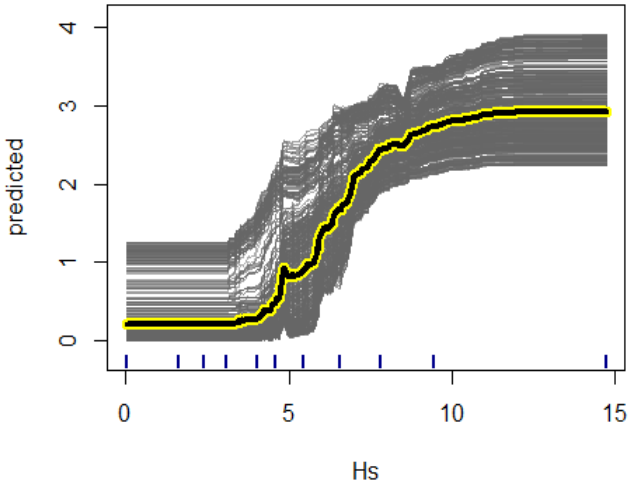
VALIDATION WITH HISTORICAL CASES



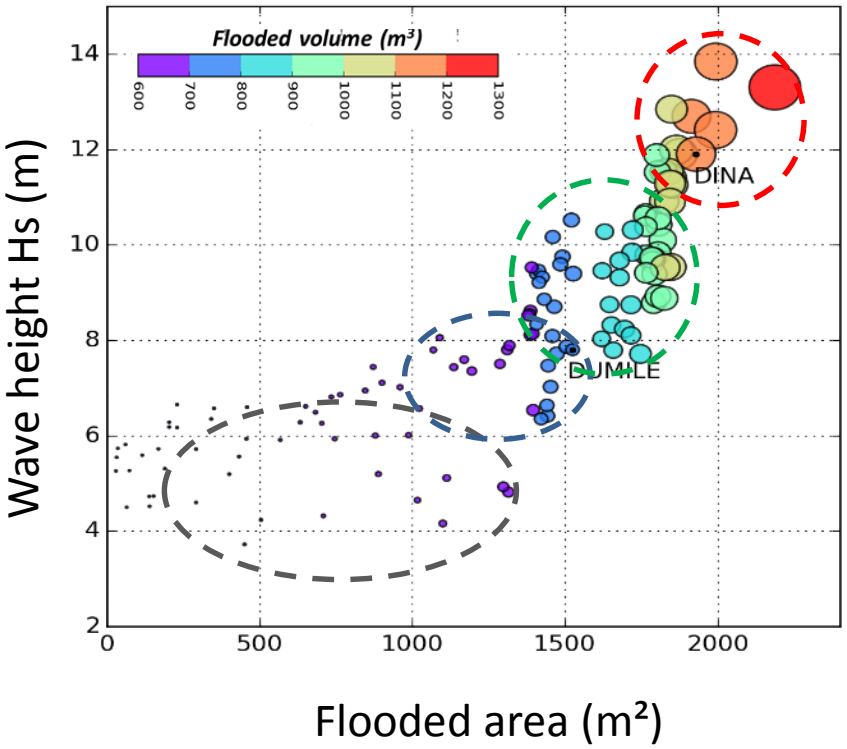
SENSITIVITY ANALYSIS

- Marine flooding is governed by **multiple parameters** (waves, tide and storm surge)
- Analysis of the relative importance of waves and water levels with the respect to the overtopping volume (Classification Random Forest – see this afternoon presentation ;-))
- The wave height (Hs) = **main parameter controlling the discharge volume**





ANALYSIS OF THE DATABASE



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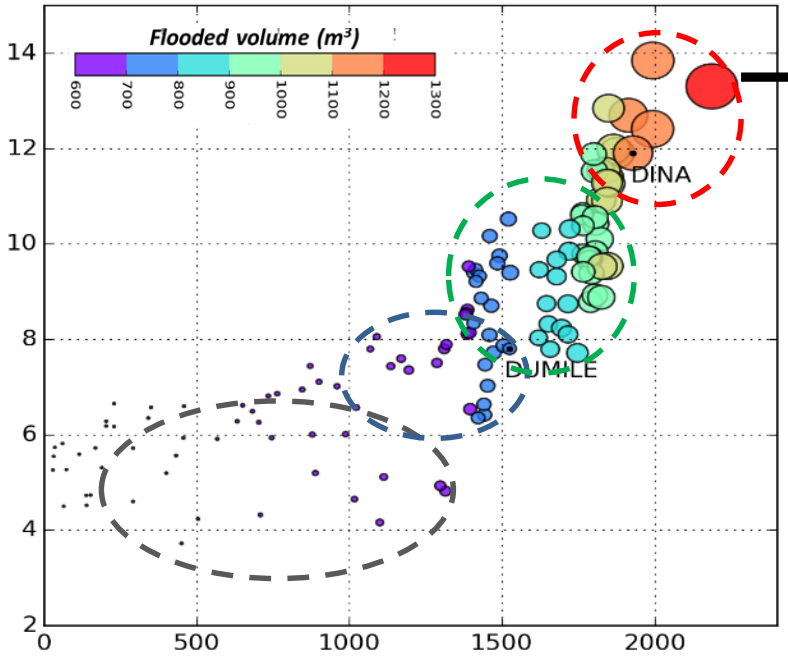

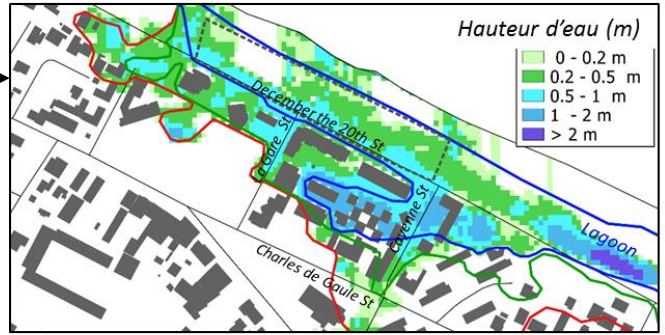

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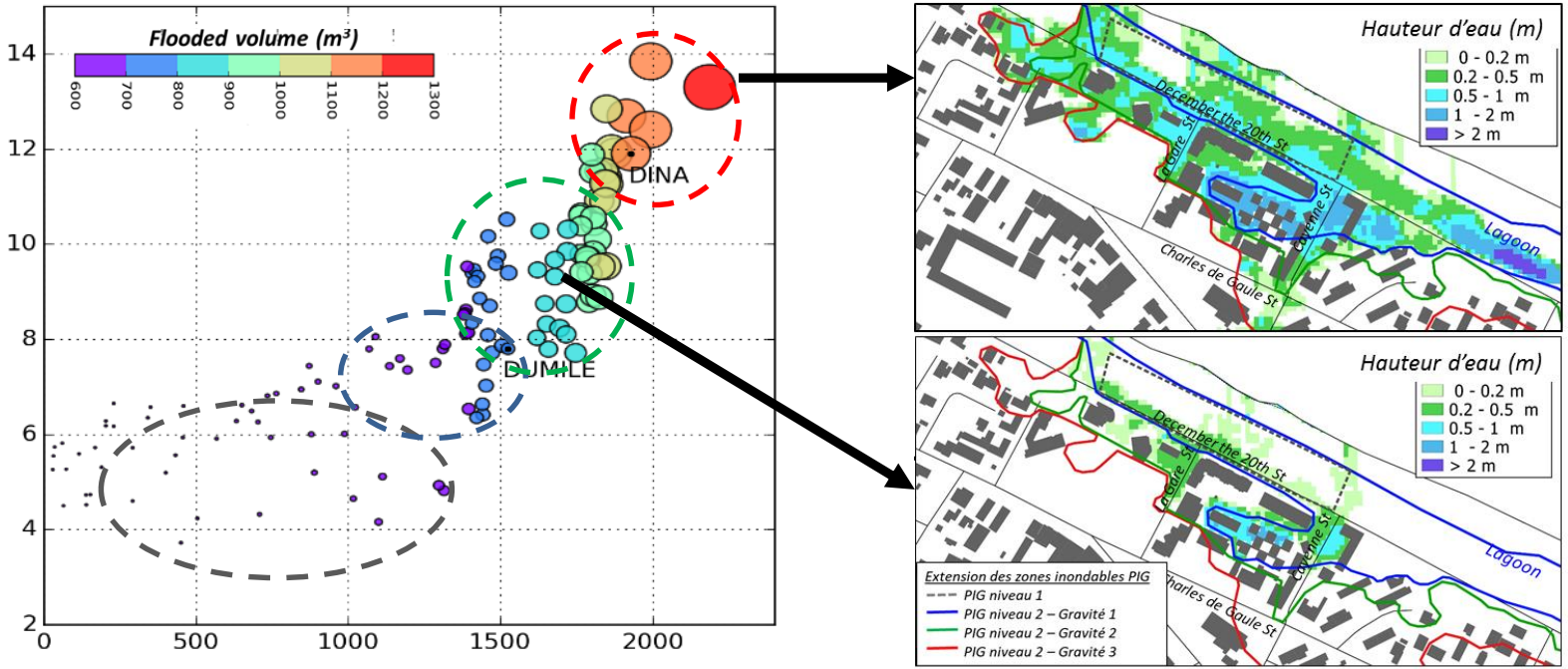

DETERMINATION OF OPERATIONAL RESPONSE

> **Collaboration with the municipal services** to transpose the flooding maps into a Graduated Intervention Plan (GIP) :

- Determination of the **number of levels** to consider
- Adaptation of the **boundaries of the maps** to fit with the particularities of the territory
- Determination of **specific actions** to conduct for each level: monitoring points, road closure points, circuit of the sound car (mobile warning system), etc.

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> The **transition conditions** between the different levels rely on :

1) Direct observations of the consequences on the field (**current practice**)
2) **Thresholds of wave heights** that can be inferred from the operational forecasts distributed by Météo-France
3) Historical benchmarks of **past major events**

=> **Possibility to use the GIP with different levels of anticipation**

DETERMINATION OF OPERATIONAL RESPONSE

Level 1 : First overtopping of the seafront

Level 2 : Flooding of the buildings

Graduated Intervention Plan (GIP)		Field observations	Wave height (m) range	
Coastal flooding plan - Level 1		*First wave overtopping and pebbles (or stones) projections on the waterfront (city center's parking)*	> 4 m	→ Felleng
Coastal flooding plan - Level 2	Severity 1	*First buildings to be flooded in the city center : School, Emergency center, town hall*	6 m - 8 m	→ Bejisa, Dumile
	Severity 2	*Bertin street behind the lagoon, first buildings along 20 december street and the Desprez neighborhood are affected by flood*	8 m - 10 m	→ Gamède
	Severity 3	*Flood reaches buildings of Desprez neighborhood, inundation and flow path throught Cayenne street exceeds General de Gaule street.*	> 10 m	→ Dina

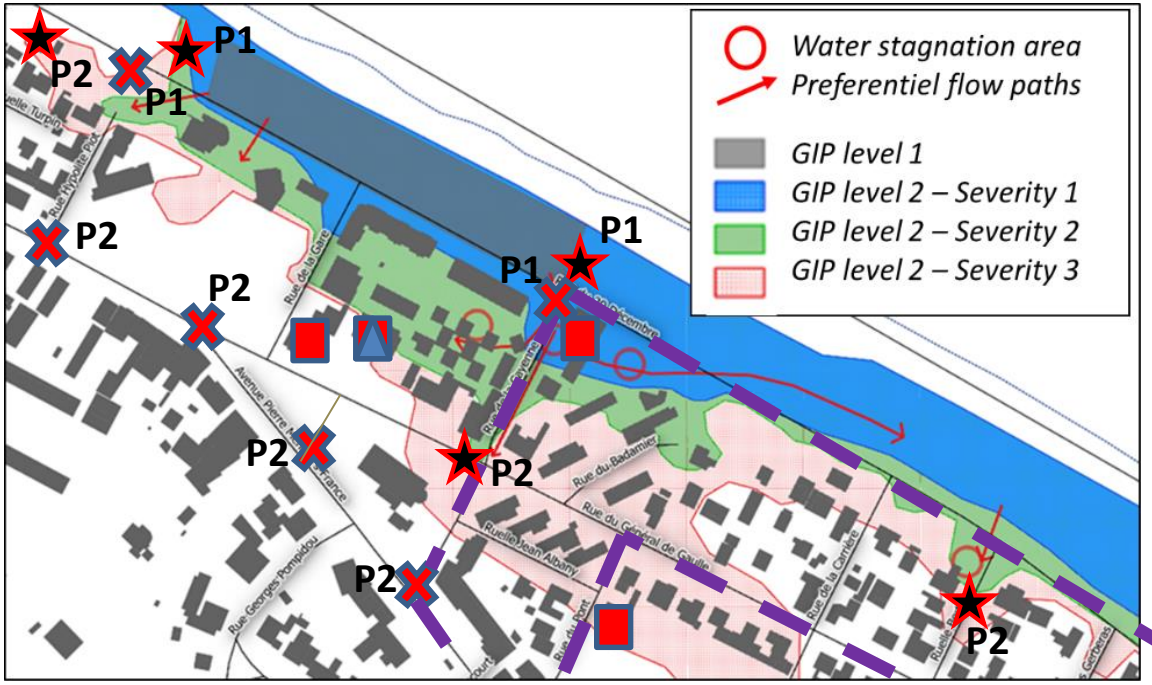
Field observations

Wave thresholds
(to compare with operational forecasts)

Historical events

Actions Plan 1 (P1) et Plan 2 (P2) : Observation pts

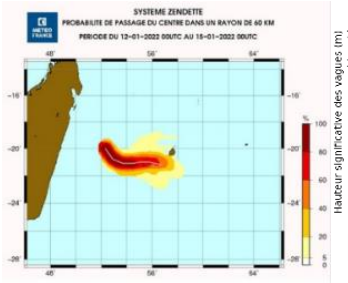
Road closure

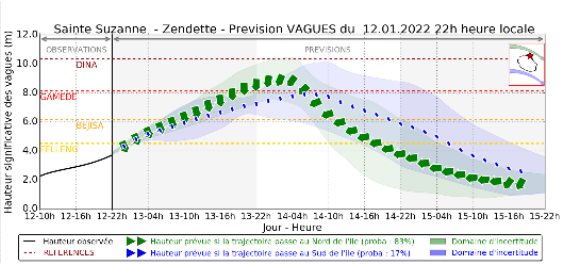


Assets (PCS) Shelter centers Monitoring pathway

TESTING THE GIP DURING A CRISIS EXERCISE

> **Crisis exercise** organised in october 2017 :
- Enabled to facilitate the appropriation of the GIP
- Enabled to **adjust the pre-determined actions**





Animation room

Crisis room

CONCLUSIONS

- A method that can **easily be adapted to other territories**, scales and any marine flooding processes (overflowing and overtopping)

- The **collaboration with the end-users** is essential

- The constitution of a **synthetic database** enables :
  1. To conduct a robust analysis of the governing parameters
  2. To take into account the uncertainties (event duration, water levels, …)

- See paper 93 on the statistical analysis of the simulation database!

THANK YOU FOR YOUR ATTENTION!

SPICy web site : http://spicy.brgm.fr http://spicy.brgm.fr/fr/page/video