Climate change modelling and impacts on the power system in France

David Moncoulon

ICEM – Towards climate-resilient energy systems

28 June 2023

CCR identity and R&D projects

CCR: French Reinsurance Company, in between the challenge of natural disasters and climate change

CCR at the heart of natural risk coverage, modelling and prevention:

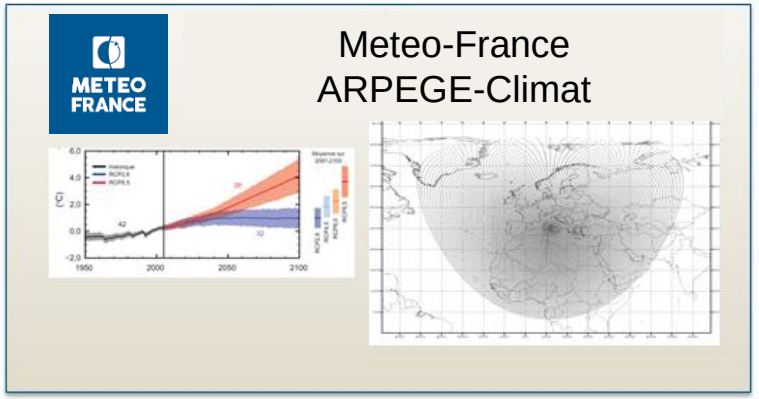
- ✓ Public reinsurer, keystone of the “Nat Cat" mutual solidarity scheme
- ✓ Leading-edge expertise in risk modelling and data collection at address-level
- ✓ Growing contribution to risk prevention by insurers and public authorities
- ✓ A look at the global situation through international cooperation and competitive activities

CCR involved in the ongoing battle to adapt to climate change:

- ✓ Evaluation of the cost of climate change for insurance companies, in conjunction with Météo-France
- ✓ Sponsorship of several scientific and technological initiatives providing a response
- ✓ Funding PhD Theses on the topics of natural disasters

The three pillars of CCR

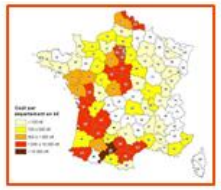
Reinsurance with State guarantee



CCR's models

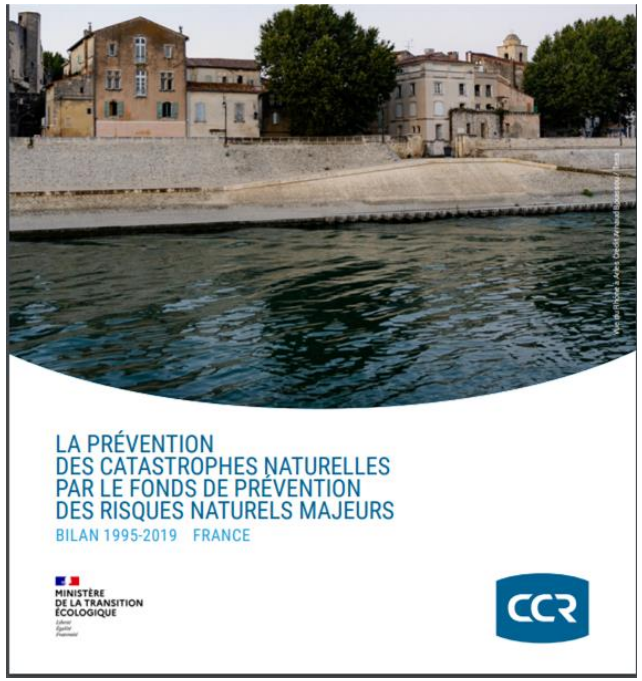
Overflow

Geotechnical drought



Marine submersion

Modelling activities in partnership with scientific institutions



Risk prevention activities for public entities

The CCR's R&D department

In order to continuously improve its risk knowledge, CCR has developed a modelling chain for different natural disasters and man-made perils in partnership with the scientific world

Man-made perils
Terrorism
CR nuclear

Dams

Water-related hazards
Floods
Marine submersions

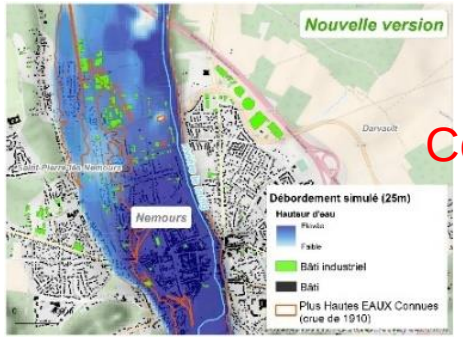
Tsunamis

Geological hazards
Earthquakes

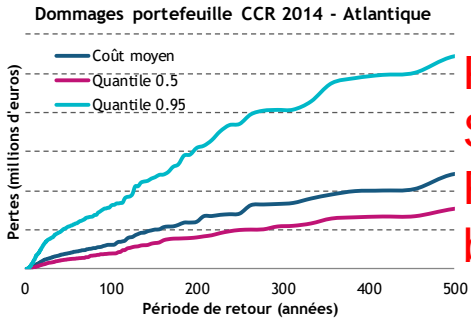
Droughts

Meteorological hazards
Cyclones
Storms
Crop insurance

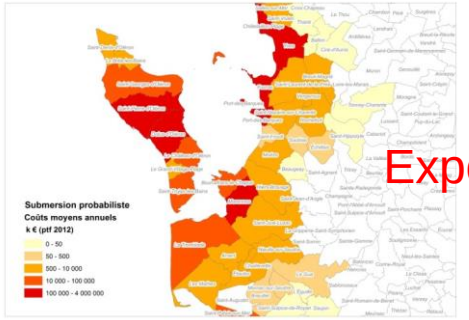
Modelling post-event losses
Reconstruction of historical events
Probabilistic modelling from stochastic portfolio



Costing



Pricing
Solvability
Financial balance



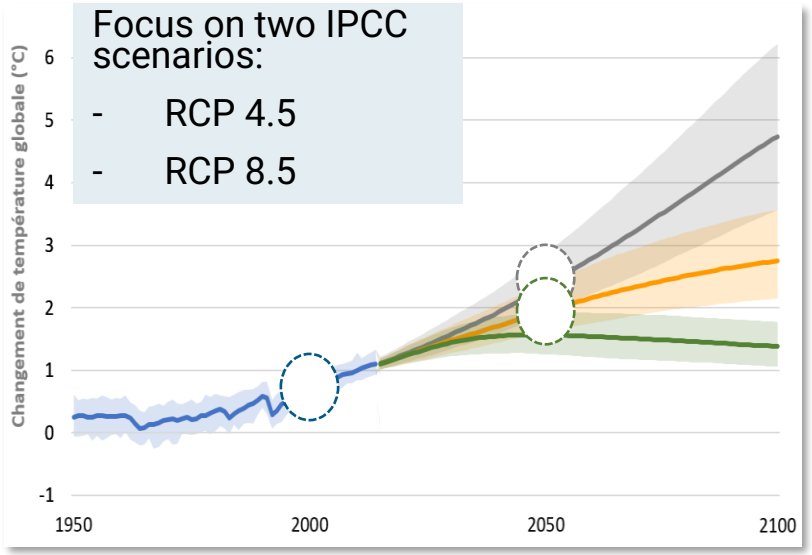
Exposure

Analysing the consequences of climate change on hazards and insured losses

Understanding the consequences of climate change

Increasing **frequency** and **intensity** of natural disasters due to climate change:

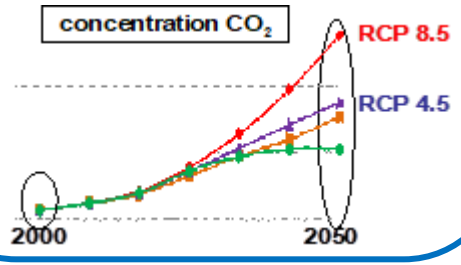
- Agricultural droughts and shrinkage and swelling of clays
- Floods (overflows of main watercourses, runoff and marine submersions)
- Cyclones
- Wildfires



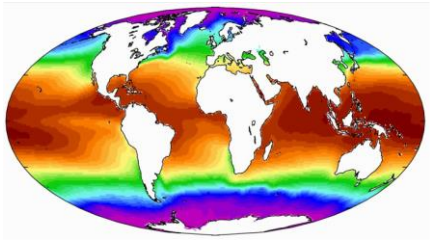
A long-term partnership with Météo-France and the constant climate modelling

3 scenarios of 400 years at constant climate

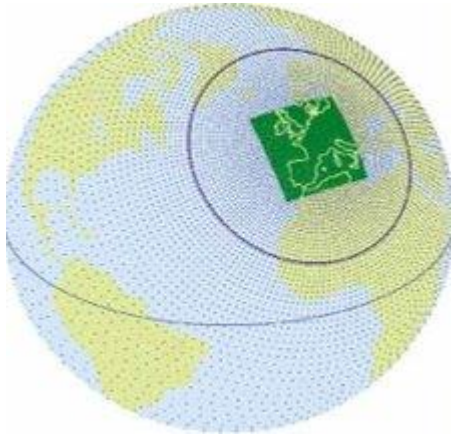
- Climate 2000
- Climate 2050 hypothesis RCP 4.5
- Climate 2050 hypothesis RCP 8.5



Range of 400 years of sea surface temperatures in a constant climate



ARPEGE-Climat 50 km



Downscaling to 8 km resolution

CCR hazard models

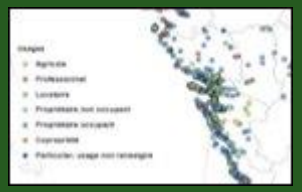
Flood models

Overflow

Runoff

Drought model
Shrinkage and swelling of clays

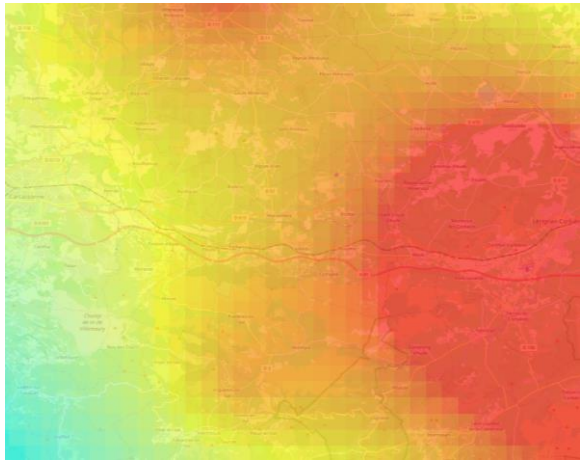
Vulnerability model Portfolio of insured assets in 2050



Damage model

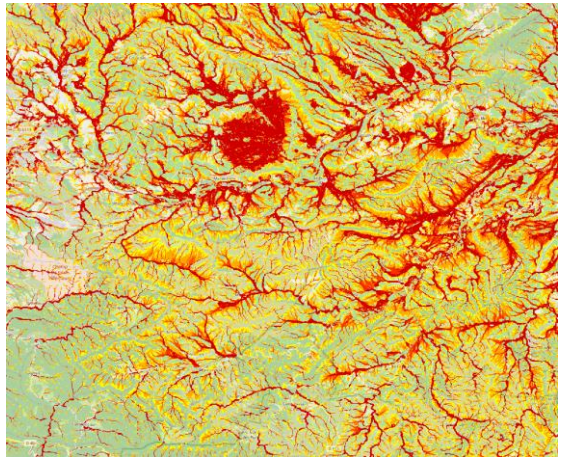
Flood model global scheme

Rainfall



Aude 2018

Pluvial floods 25m



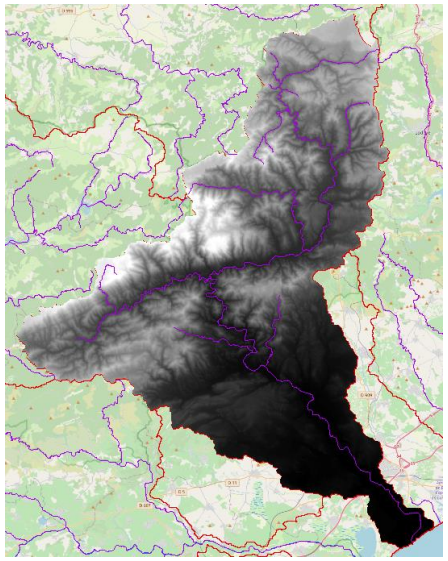
River floods 100m

Overflow 25m

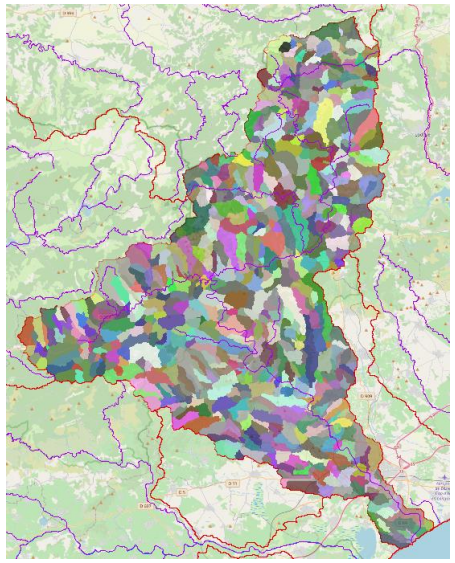
Rainfall runoff simulations

Data preprocessing

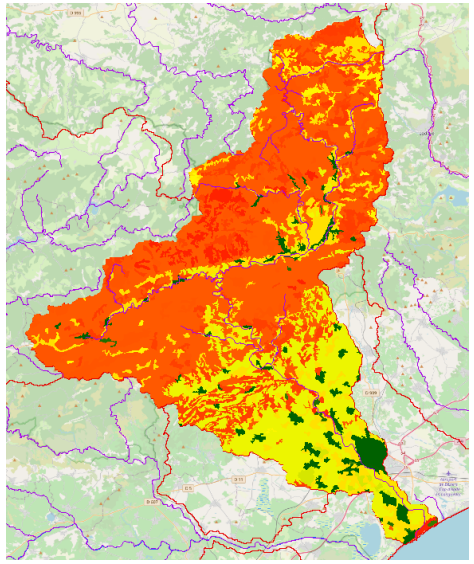
388 watersheds

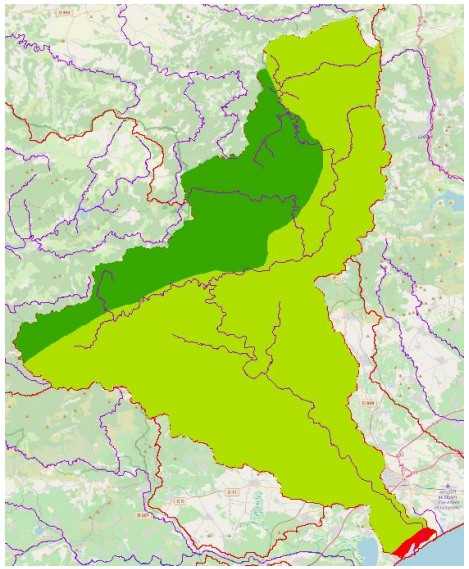


100m DTM



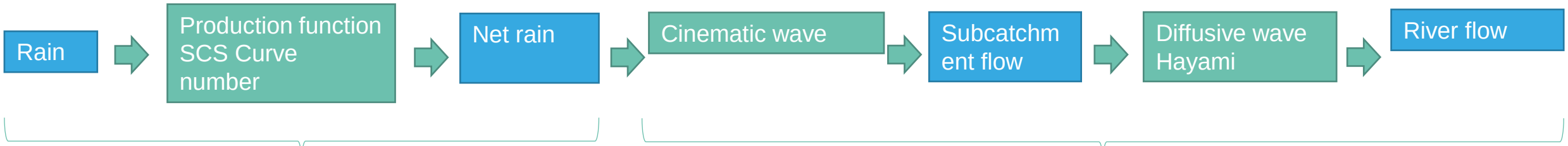
Sub catchments

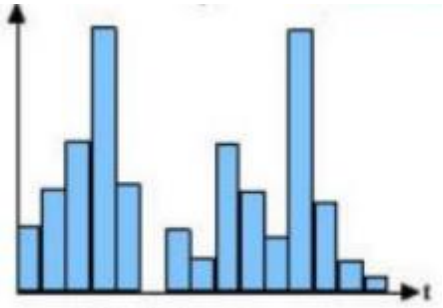


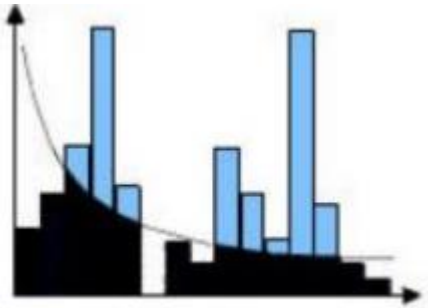


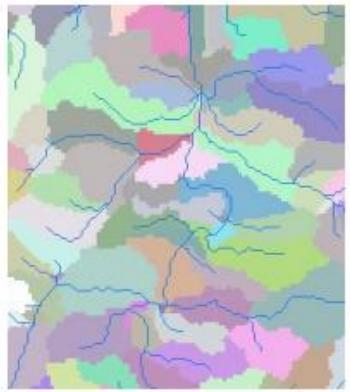
Land use cover and soil types for infitration

River flow simulations

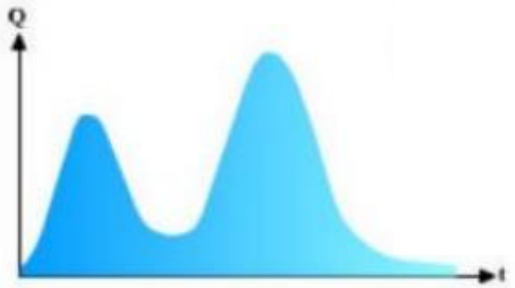






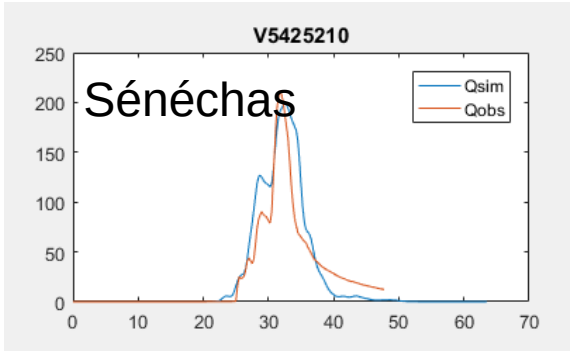


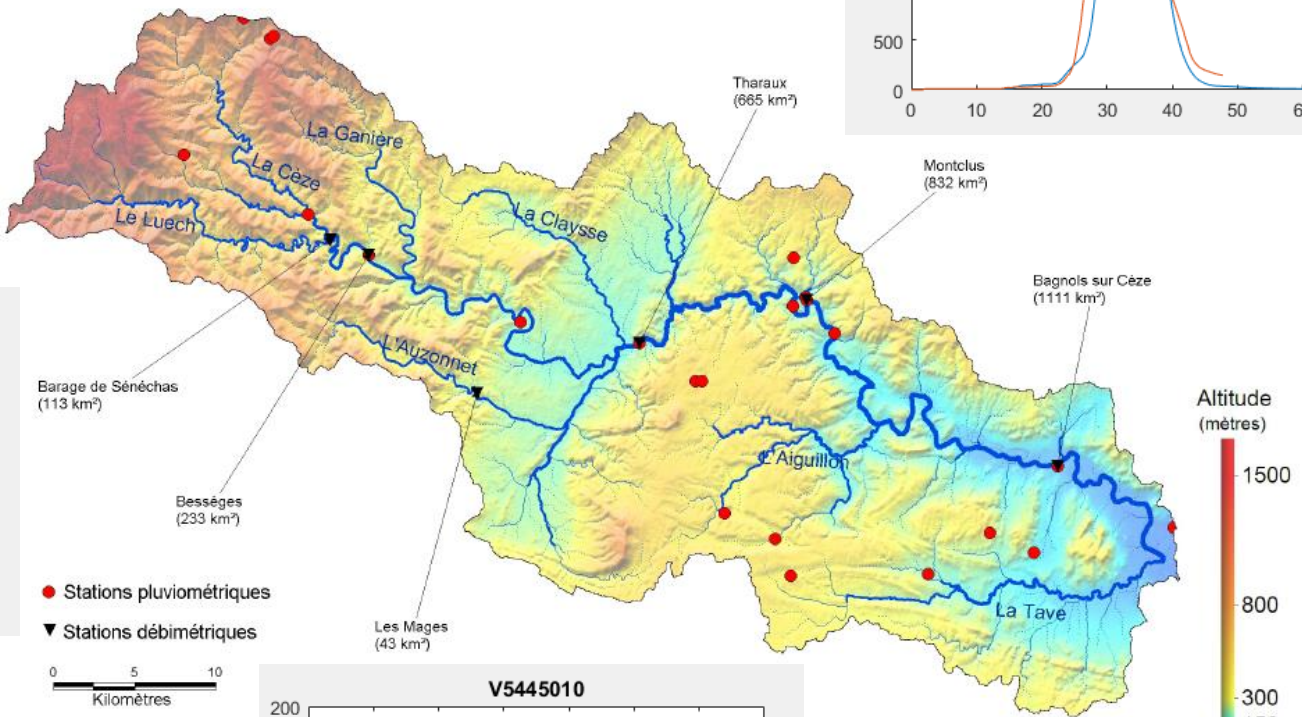
Sub catchment

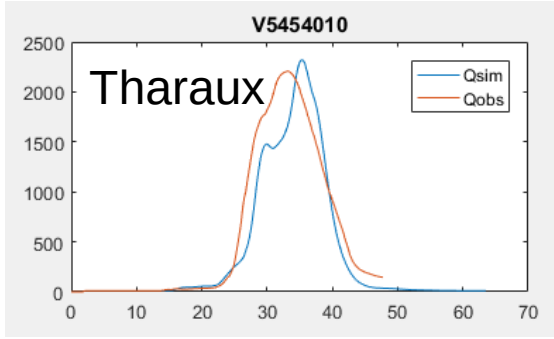


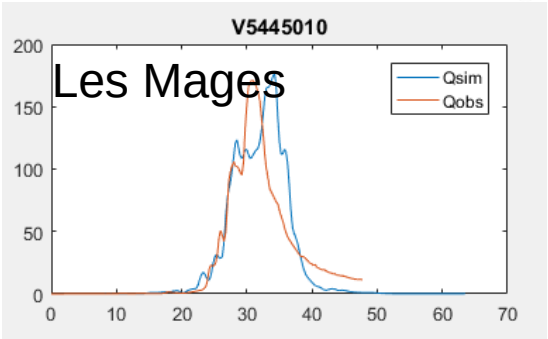
Flood Hydrograph

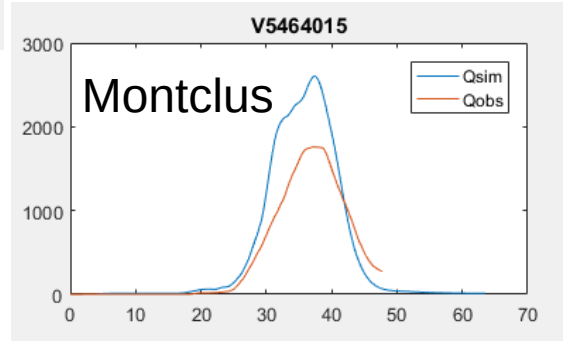
Validation of the flood model on historical event hydrographs

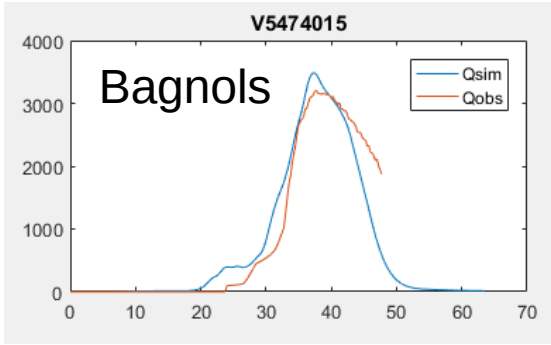






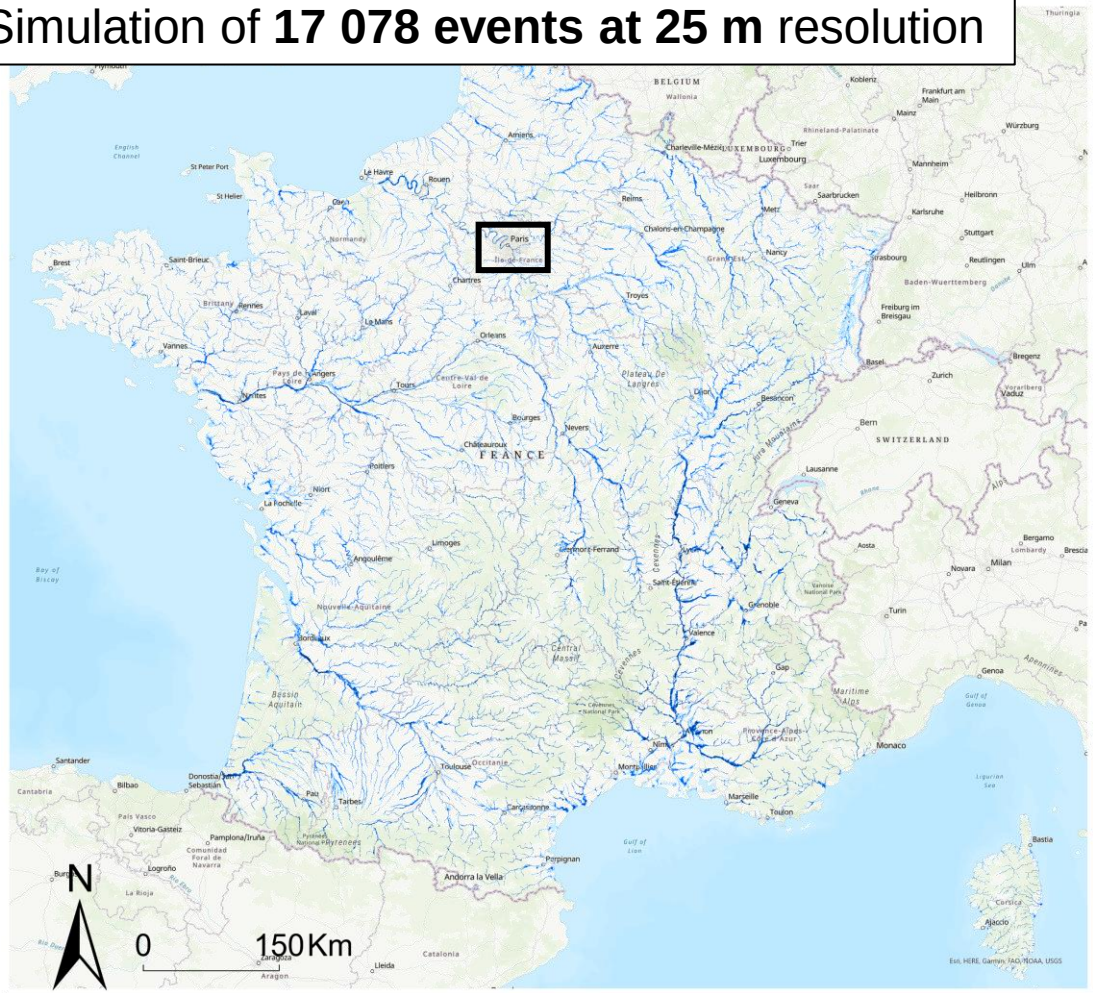




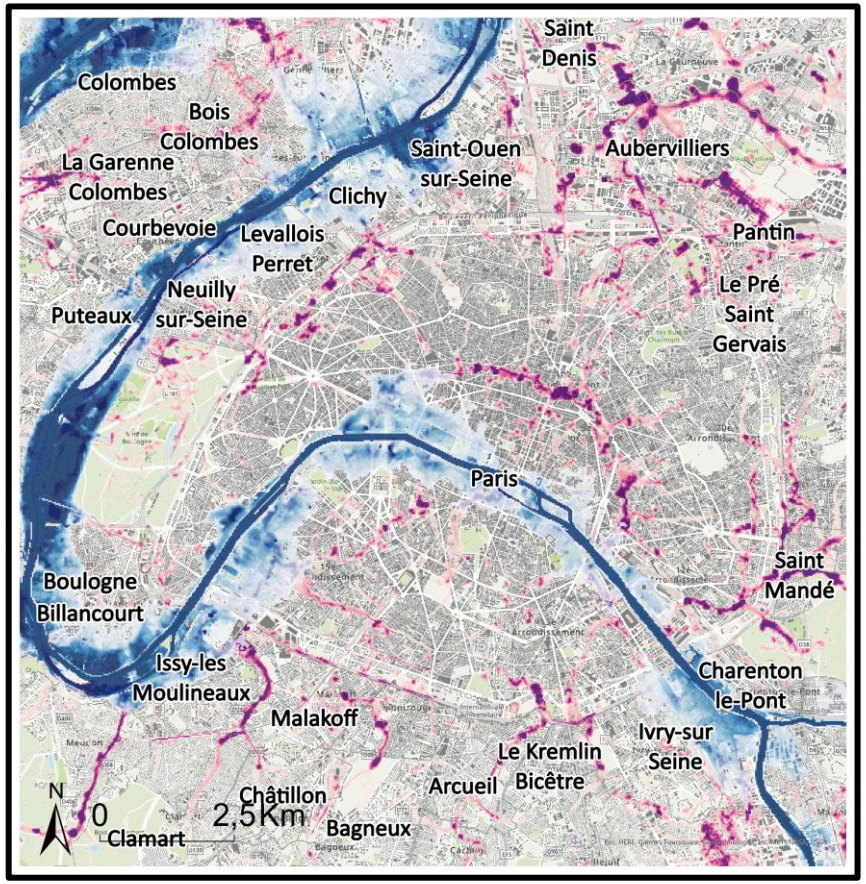


Modelling natural hazards: flood areas

Simulation of **17 078 events at 25 m** resolution

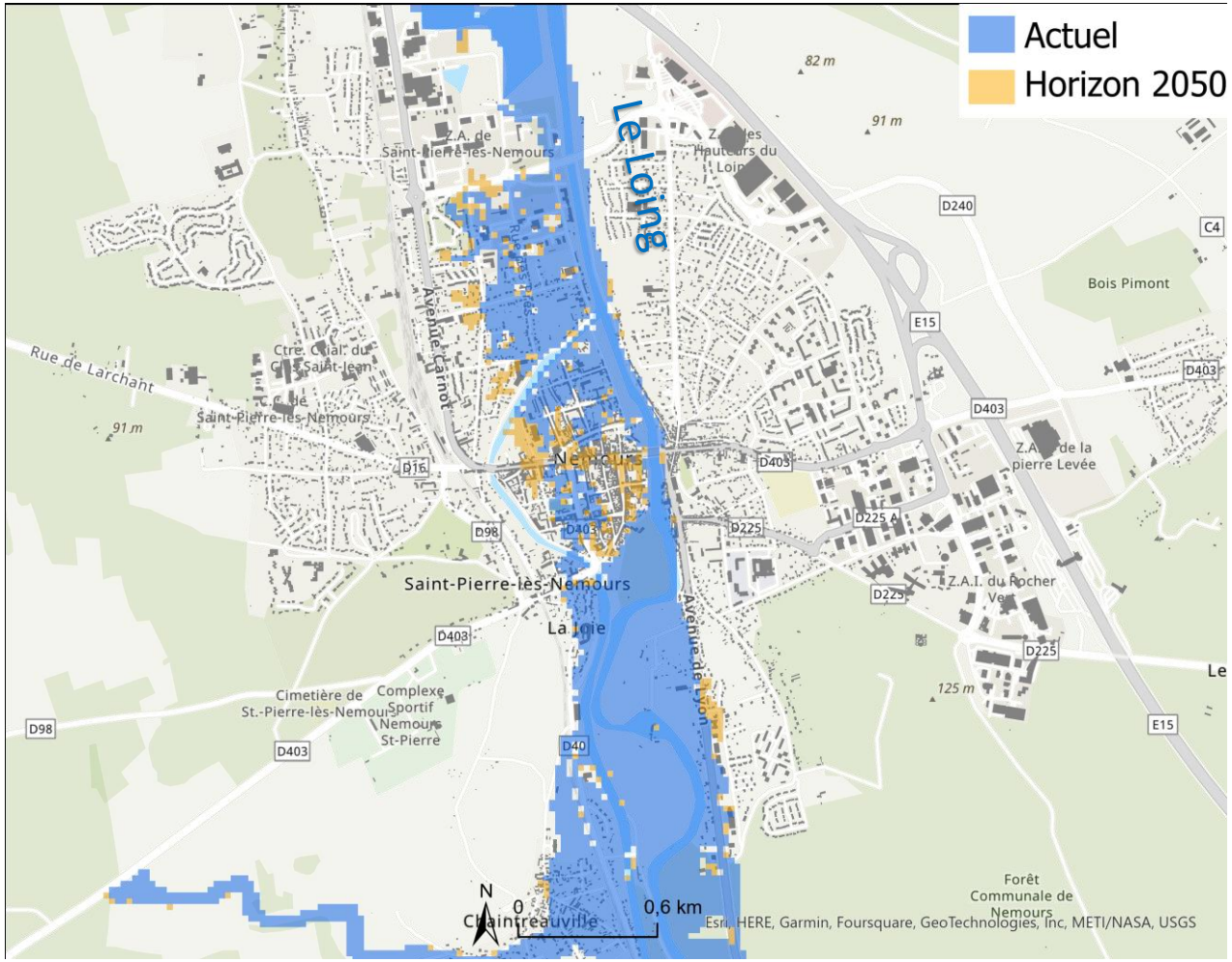


Overflow in France in 2050 (RCP 4.5) for a 200-year return period



Overflow and runoff in Paris area in 2050 (RCP 4.5) for a 200-year return period

Evolution of the flood frequency

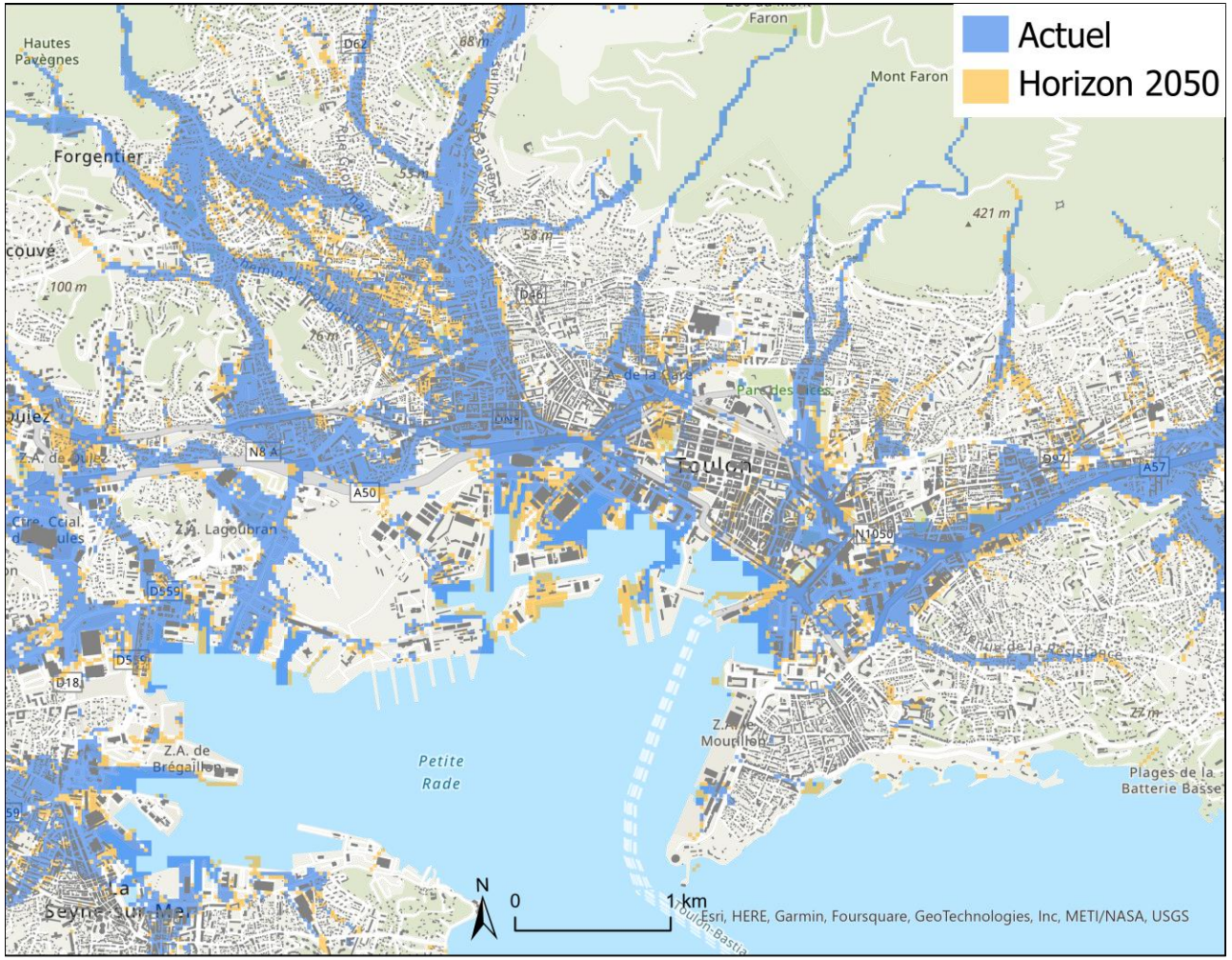


Current and future overflow in Nemours (Paris area) for a 50-year return period

Current and future overflow in Nantes (Atlantic coastline) for a 50-year return period

For slow floods, the trends vary. Precipitation patterns, diminishing water reserves and snow cover seem to be limiting the risk of major flooding on certain rivers (the Loire at Nantes). On the other hand, rivers such as the Loing, are seeing an increase in the intensity of events.

Evolution of the runoff frequency



Current and future overflow at Toulon (Mediterranean area) for a 50-year return period

- The average annual cost of flooding could increase by 60% between 2024 and 2050 for the RCP 4.5 scenario, and by 50% for the RCP 8.5 scenario.
- This increase is mainly due to runoff and flash floods across the entire territory.
- These phenomena account for 75% of the increase.

Modelling damage for the different scenarios

Input data

Individuals

- INSEE Population trends since 1876 by commune (municipality/town)
- Omphale model prediction (life expectancy, migration, fertility)
- Housing trends from 2006 to 2019 + some earlier data from 1968 onwards
- Ratio of CCR portfolio to market portfolio

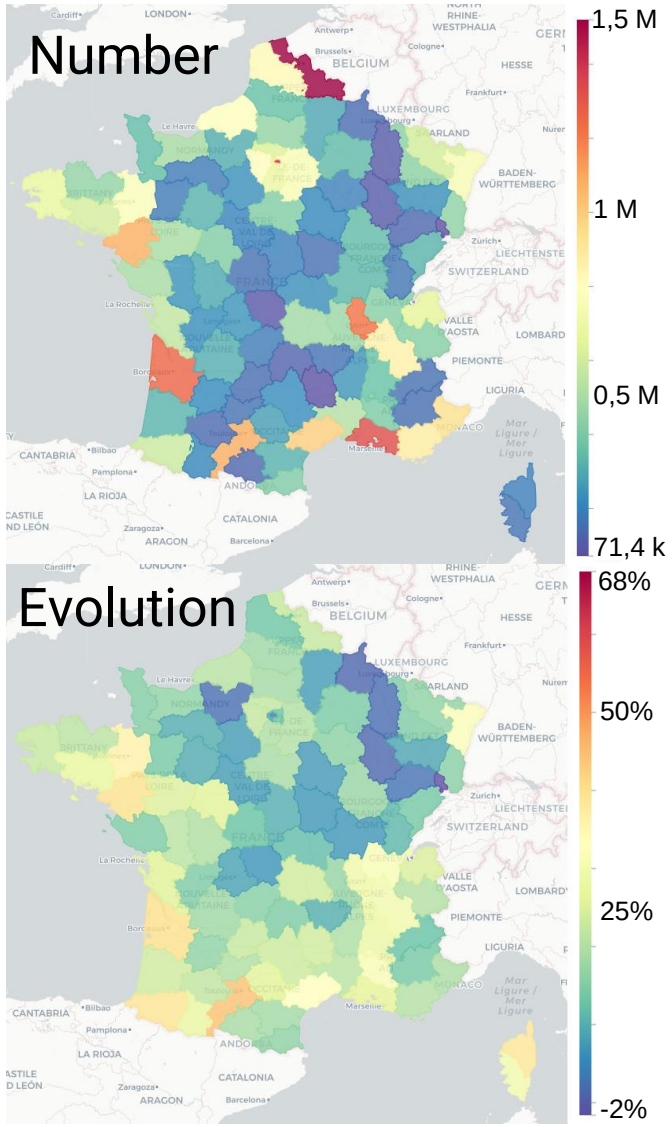
Professionals

- SIRENE database (2014-2022)
- Agricultural census from the French Ministry of Agriculture and Food Sovereignty
- Report by the General Council for Food, Agriculture and Rural Areas (2020)

Projection of the estimated numbers of buildings in 2050

Residential building

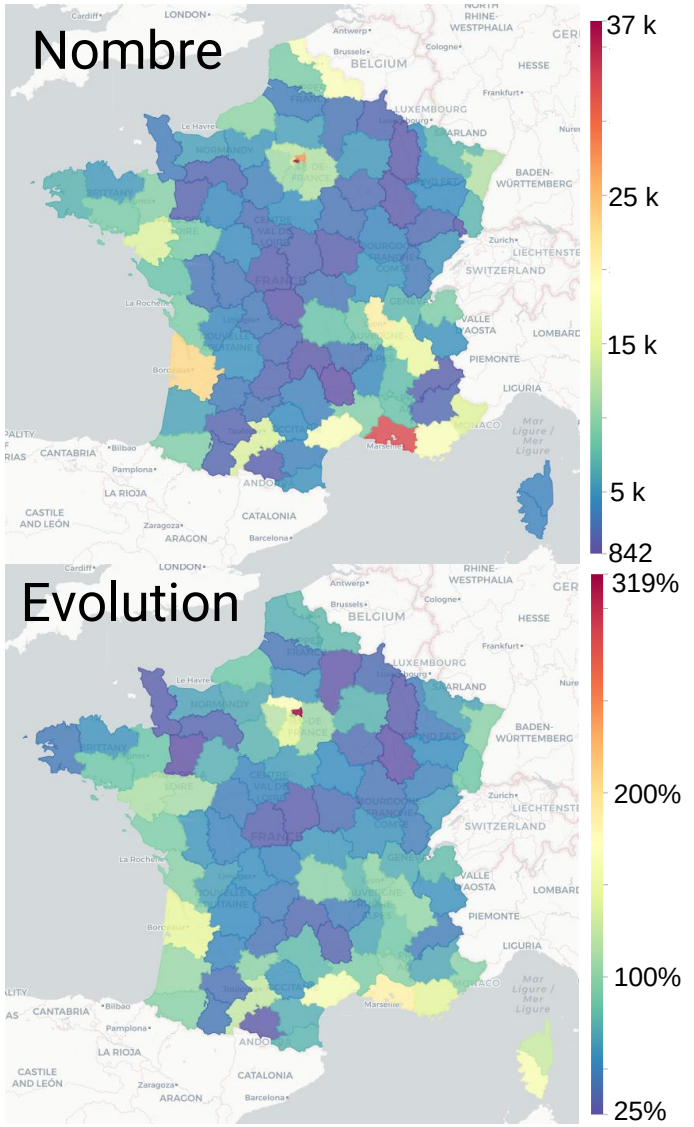
- The Nord department (north of France, in red) might be the department with the highest number of buildings (1,5 M) in 2050
- The Haute-Garonne (south-west of France, Toulouse) might have the highest increase of building number by 2050
- Attractivity of the Atlantic coastline, with large evolution for some of the departments



Projection of the estimated numbers of buildings in 2050

Industrial building

- Paris area (including Seine-Saint-Denis), Bouches-du-Rhône (Marseille region) might gather the greatest number of industrial buildings in 2050
- Seine-Saint-Denis area could experience the highest evolution (+319%)
- Each of the French departments could experience an increase of the industrial building by 25%



Projection of the insured value at 2050 horizon

Type of buildings	Portfolio	Number	Evolution of the average insured value
Residentials	*2022*	*43,8 M*	8,7%
	2050	[43,3 M – 47,8 M – 52,7 M]	
Industrials	*2022*	*348 k*	43%
	2050	[623 k – 681 k – 744 k]	
Other professionnals	*2022*	*4,1 M*	10,7%
	2050	[9,4 M – 10,1 M – 10,9 M]	
Total	***2022***	***48,9 M***	**12,5%**
	2050	**[53,9 M – 59,3 M – 65,1 M]**	

[low estimate – mean – high estimate]

Analysing the consequences of climate change on the power systems in France

Assessing the resiliency of energy infrastructure to water-related hazards in the context of climate change

Evaluation of the energy infrastructure (power station and tower) exposure to flood risks

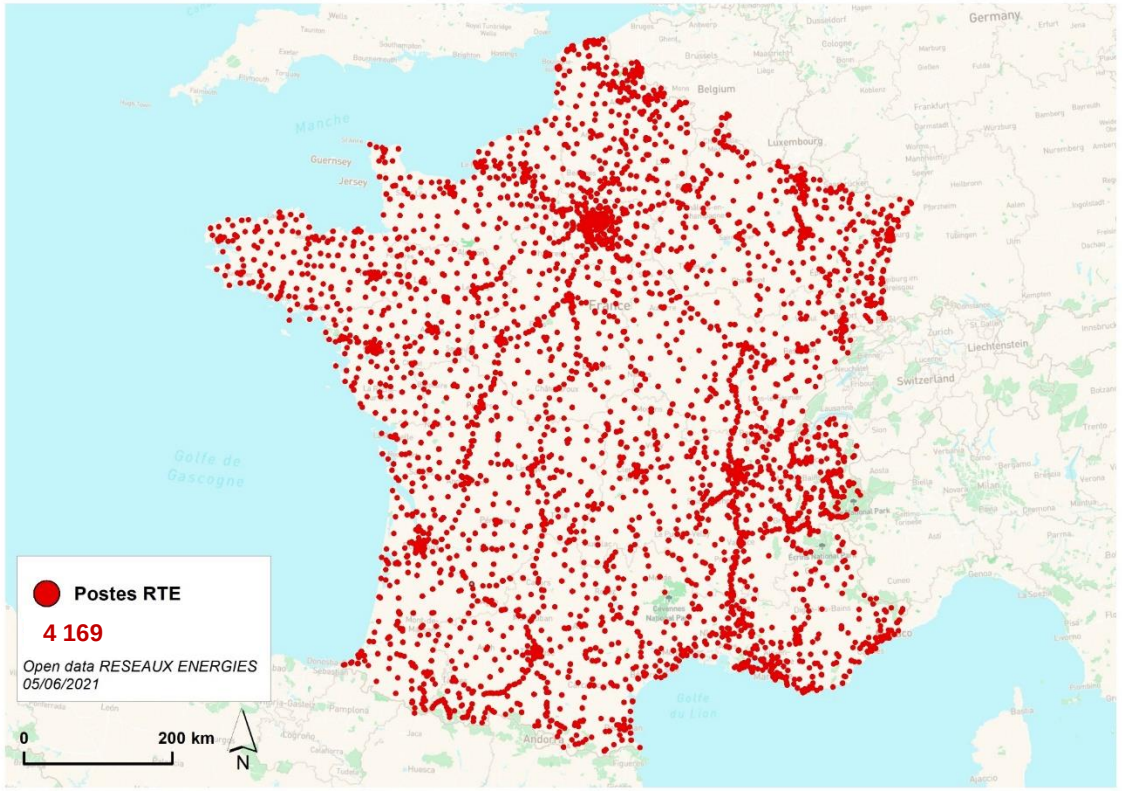
		Water heigh (m)		Flow (m3/s)		Flooded areas (m^2)		Soil erosivity	
Overflow		✓	✓	✓	✓	-	✓	✓	-
Pluvial runoff		-	-	✓	✓	-	✓	✓	-
Marine submersion		✓	✓	-	-	-	✓	✓	-

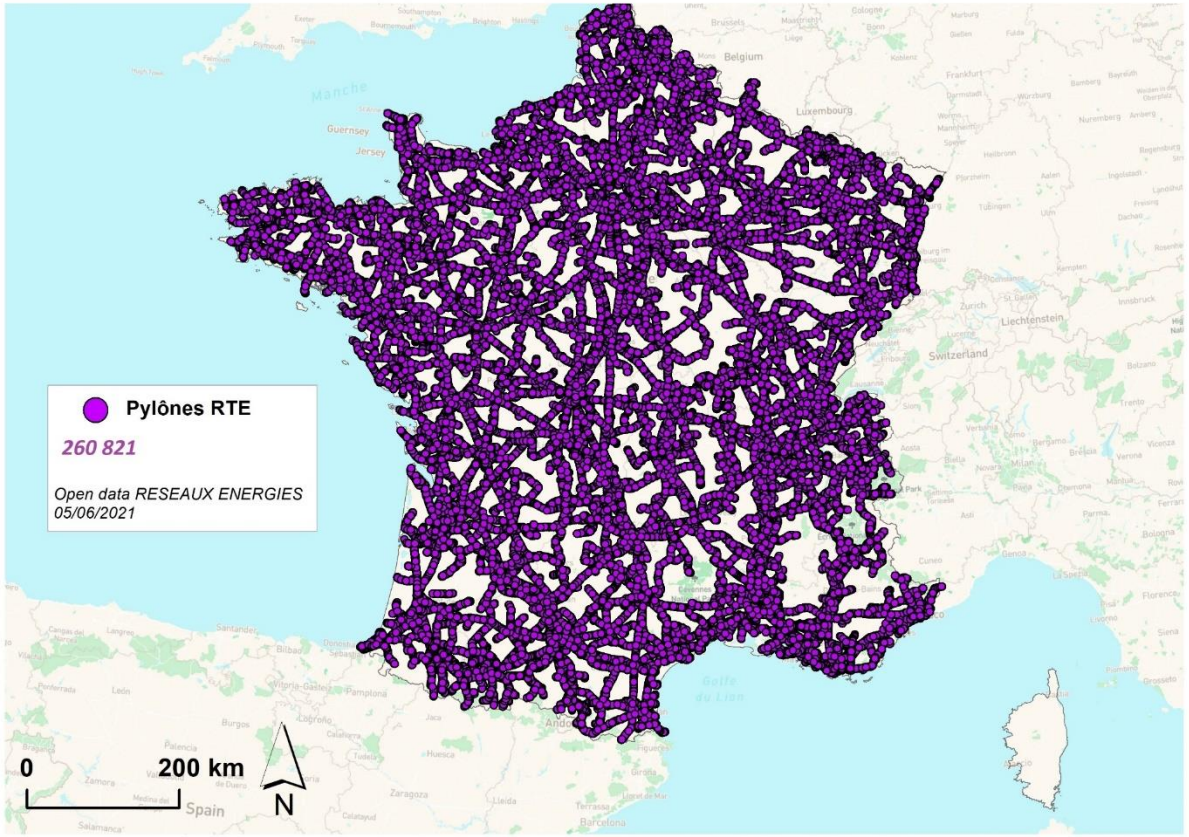
- 3 climate scenarios: current climate, RCP4.5 and RCP8.5
- 3 hazards and multiperil assessment
- 4 return periods: 20, 50, 100, and 200 years
- Range of 7 intensity per hazard, the same from one climate scenario to another, from "no exposure" to "major exposure"
- 25m resolution
- Validation of the outputs based on RTE's historical claims and NatCat recognition

Intensity
No exposure
Very low
Low
Moderate
High
Very high
Major

Covering the French territory: the portfolio of infrastructure

RTE power stations : 4 169

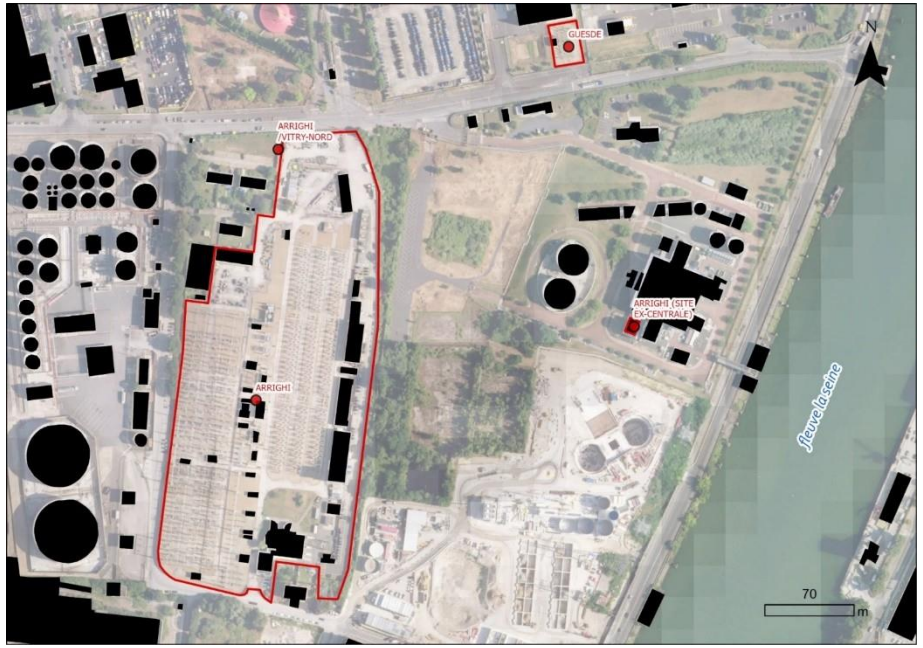




RTE towers : 260 821

Electrical structures located with high precision

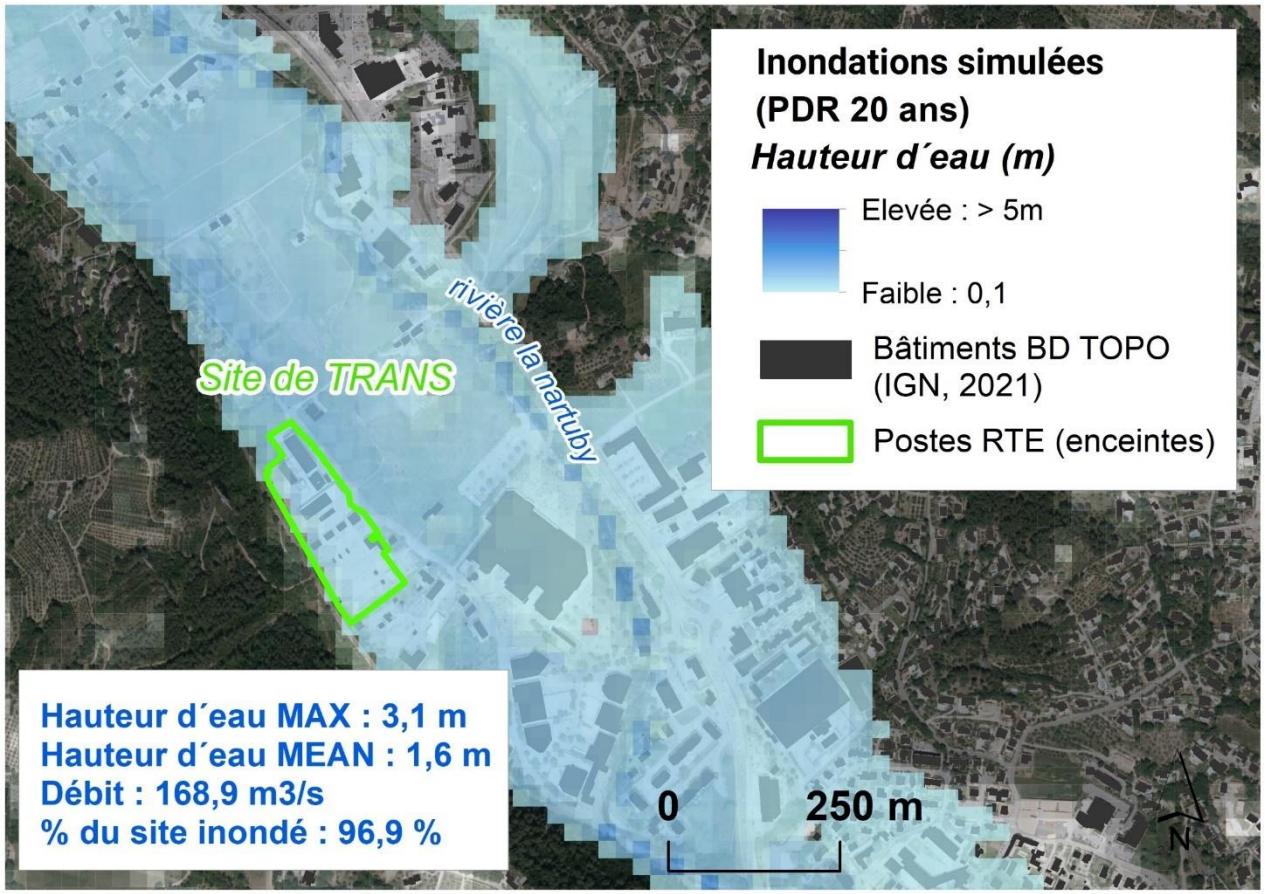
Electric stations near Seine



For each structure, an exposure indicator has been computed

Specific sites

Trans-en-Provence



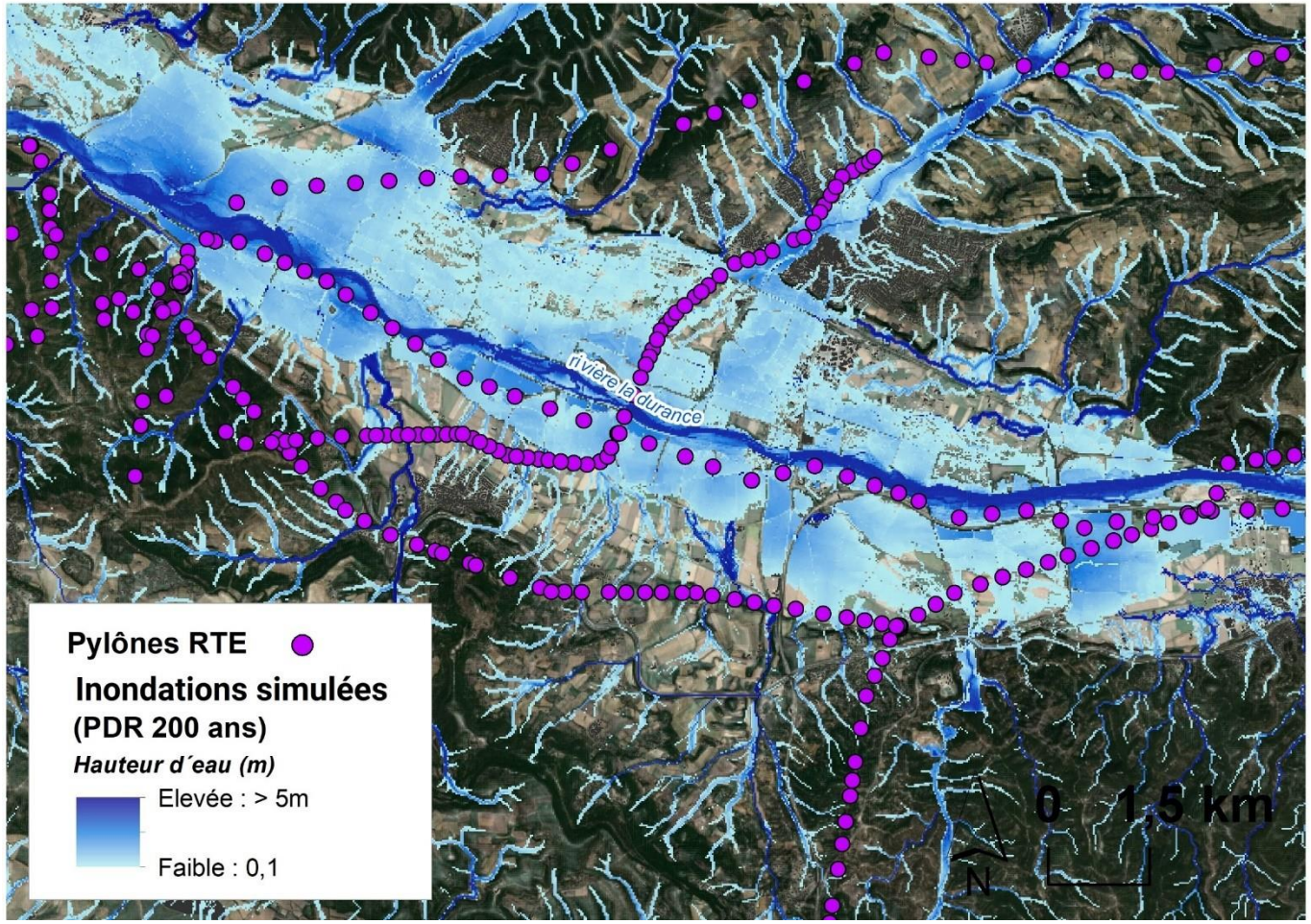
- Very high exposure at current climate for pluvial floods and flash floods
- On this site :

Current and future climate (RCP 4.5) : + 13 %

Current and future climate (RCP 8.5) : - 3 %

Specific towers

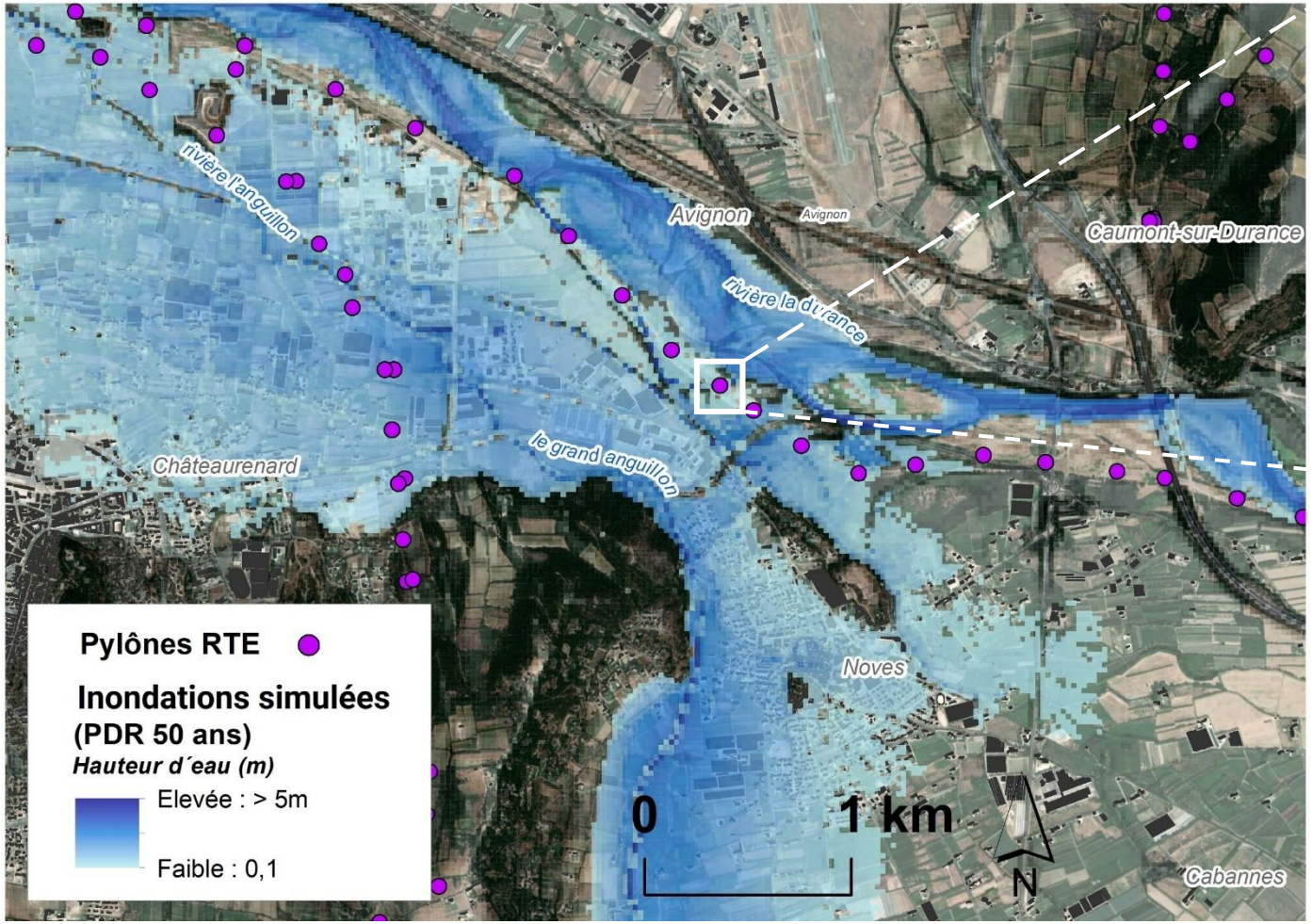
Towers near Durance river



- Exposure to pluvial floods and Durance floods
- On Durance river, the climatic study does not show significant trends for future climate with both scenarios

Example on a specific tower

Tower of the connection Plan d'Orgon Tavel (400 kV)



- Exposed to frequent floods

Return periods	Water height
20 years	1,8 m
50 years	2,2 m
100 years	2,3 m
200 years	2,7 m

Safety works on the stations

Example for an existing station and a new station

Anti-flood in the Javel Station (Seine river)


Cofferdams for Seine floods


Cofferdams)

Watertights doors

Trans (Provence)



Compact 400 kV on Stilts


2010 floods : structures on stilts were not impacted

Safety works on towers

Example

Connection 400 kV Plan d'Orgon – Tavel, sur la Durance

November 2018

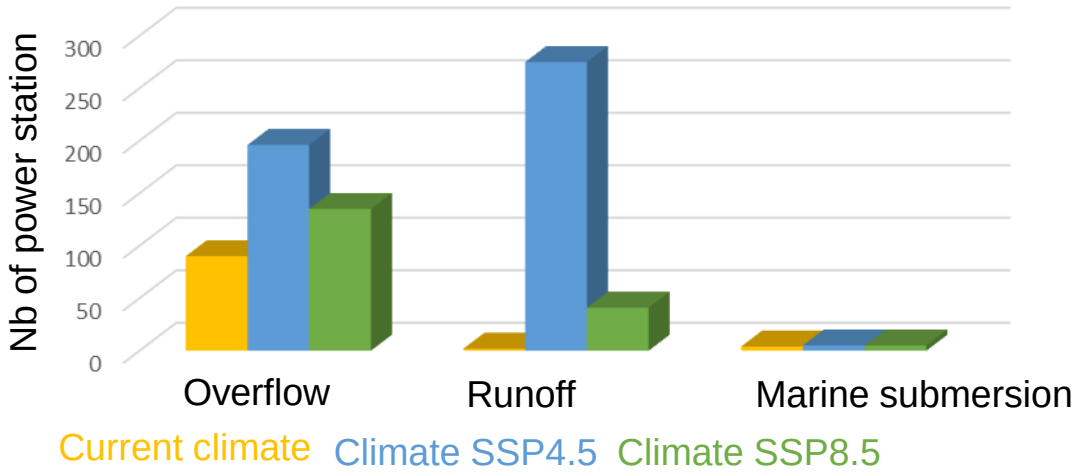
January 2019 : banks retreating

Special foundations

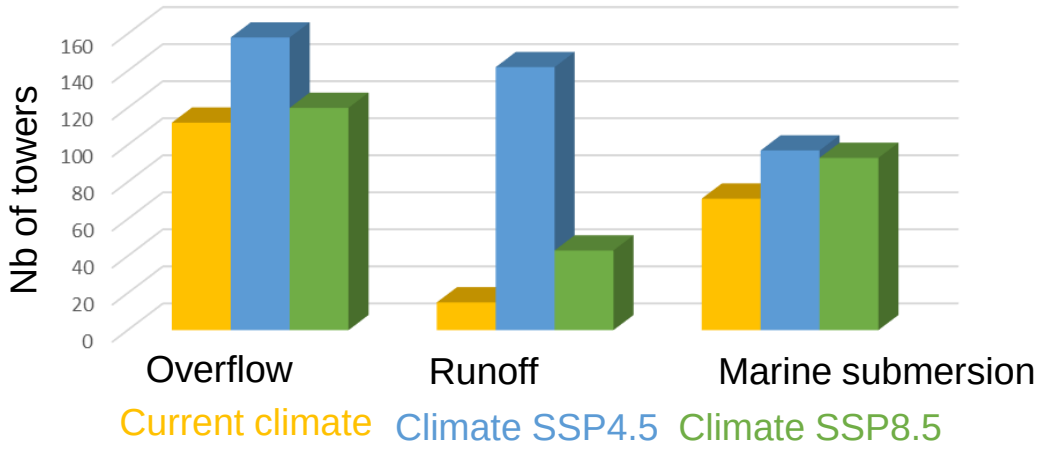
Rockfill

Key outputs of the research project

Power stations with major exposure
(based on a total of 2700 power stations)



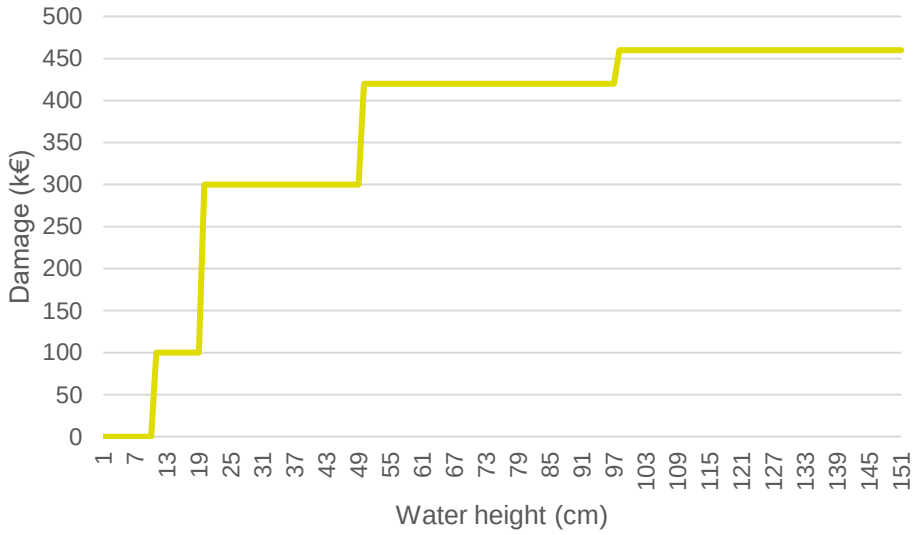
Towers with major exposure
(based on more than 260 000 pylons)



An exposed infrastructure is not necessarily damageable regarding the current preventive measures implemented

Key outputs of the research project

Development of damage curves for power station



Damage curves to evaluate the direct and indirect losses of lifelines shutdown

X

Hazard modelling

Mapping prevention scenarios of lifelines infrastructures in the context of the Ten-Year Network Development Plan

Conclusion: in a nutshell

This collaboration between RTE and CCR was a R&D Project with a duration 15 months.

It ended in March 2023 and the full detailled data were provided to RTE.

The next phase is the selection of the main exposed towers and stations to build a global adaptation project. For more informations on this project, please take contact with RTE.

In CCR we will improve our flood model and will work with Meteo-France on a multi-model approach.

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