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Modeling the Impact of Climate Change on Insured Losses in France

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Léa Boittin, Caisse Centrale de Réassurance (CCR)

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CCR

Léa Boittin – MathWorks Finance Conference 2023

The Caisse Centrale de Réassurance (CCR)

CCR is a public reinsurer operating in France. CCR proposes, with State guarantee and according to its mission of public interest, a unlimited guarantee for the following perils:

- Natural catastrophes
- Terrorism

Accounting and financial management of public funds on behalf of the State: hereby in French

For agricultural risk, for construction, preventive measures for natural disasters etc.

- Fonds national de gestion des risques en agriculture (FNGRA)
- Fonds de compensation des risques de l'assurance de la construction (FCAC)
- Fonds de prévention des risques naturels majeurs (FPRNM)
- Fonds de garantie des risques liés à l'épandage agricole des boues d'épuration urbaines ou industrielles (FGRE)
- Fonds de garantie des dommages consécutifs à des actes de prévention, de diagnostic ou de soins dispensés par des professionnels de santé (FAPDS)

The French Nat Cat scheme

Created in **1982,** to provide **reinsurance** for perils for which the market fails to provide sufficient coverage, i.e. large natural catastrophes

Founding principles:

- **Solidarity:** unique mandatory additional premium (12%) applied to all property insurance contracts (6% for motor vehicles)
- **Responsibility:** compensation scheme with adjusting deductibles, risk prevention plans

Public-private partnership:

- Government decree declaring the state of natural disaster in a commune
- The damaged property must be covered by an insurance policy

CCR aims to offer robust and sustainable reinsurance cover, and thus to ensure the **longevity** of the natural disaster compensation scheme

The French Nat Cat scheme

List of perils falling within the scope of the 1982 Law:

- Floods (runoff, overflow, rising water table, dam failure caused by a natural phenomenon)
- Mudflows
- Earthquakes
- Land movements (including shrinkage and swelling of clays)
- Land subsidence due to underground cavities and marl pits (except mines)
- Storm surge
- Avalanches
- Cyclonic winds (up to145 km/h in average or over 10 mn or 215 km/h for wind gusts)

This list is not exhaustive

Excluded perils:

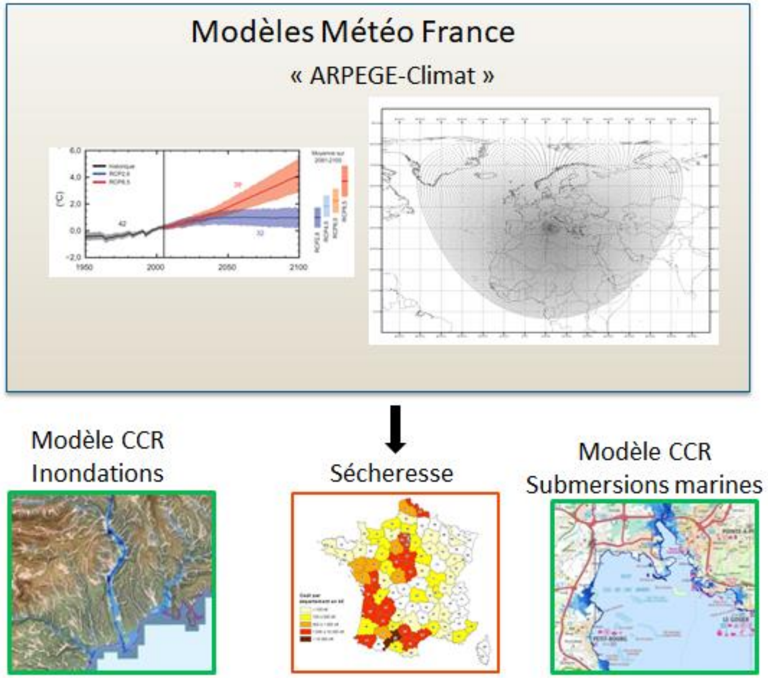
Storms (except large cyclonic winds),
hail,
snow,
frost.

They are covered by insurance, which justifies their exclusion from the legal regime of natural disasters

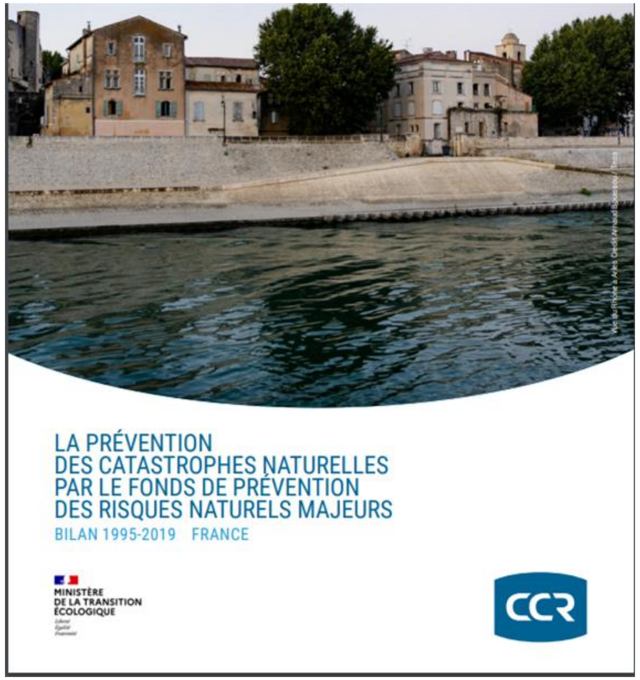
The Caisse Centrale de Réassurance (CCR)

The three CCR pillars

Reinsurance with State guarantee



Modeling activities in partnership with scientific institutions



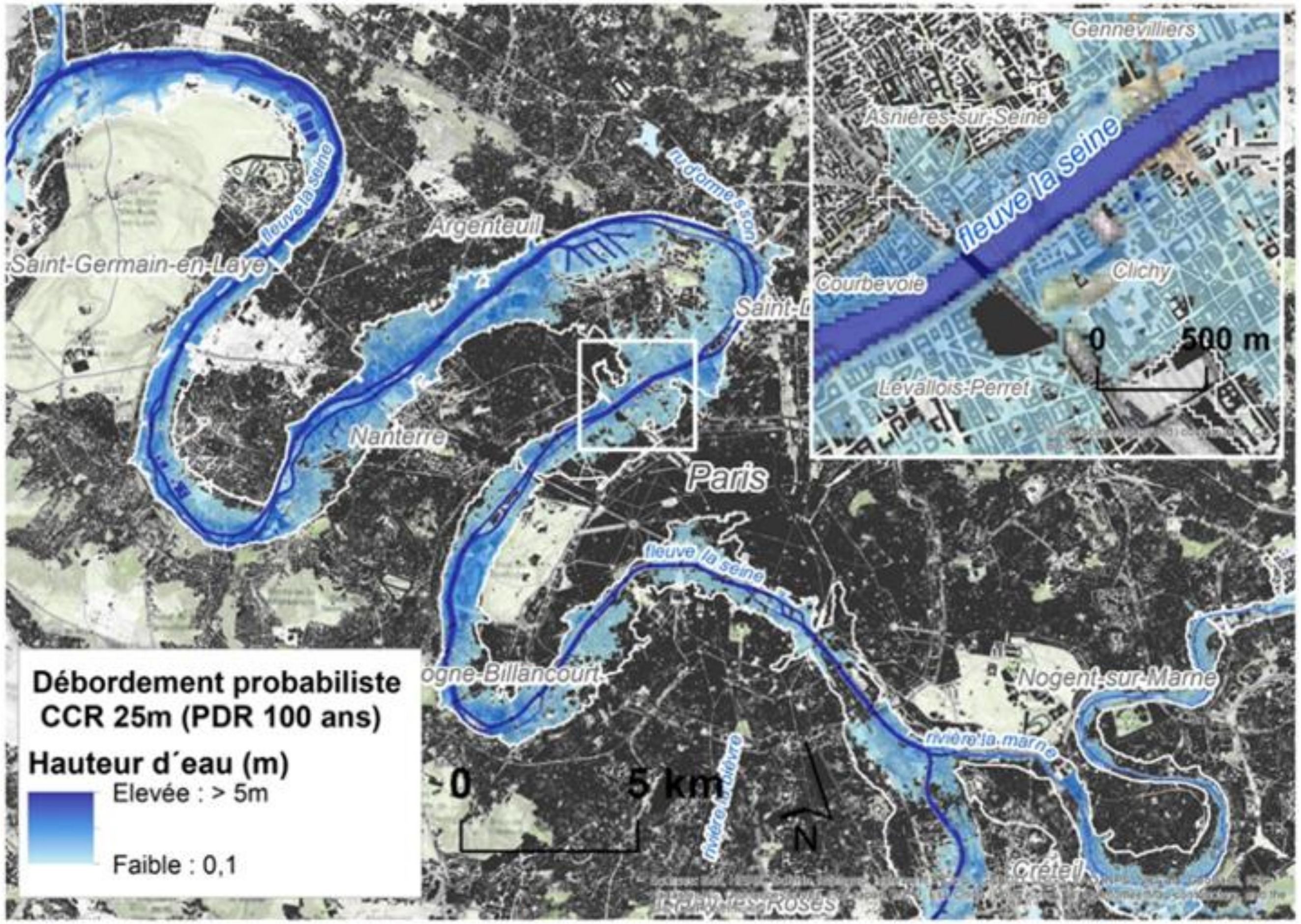
Risk prevention activities for public entities

Examples of questions tackled by the R&D department

- A hurricane made landfall yesterday in the French Antilles. What is the insured loss?

- What is the probability that the cost of floods in France this year will exceed 500 mn€?

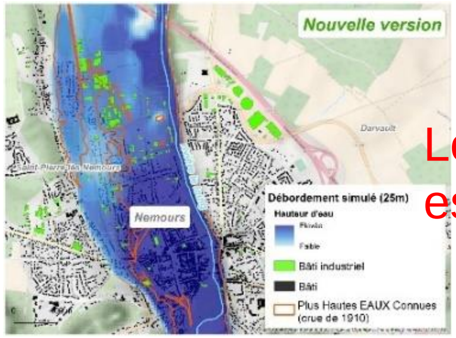
- Which areas can be flooded by a 100-year return period flood? Now, and in the future?



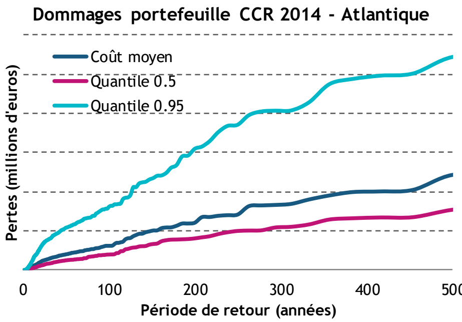
100-year return period water depth

Why do we need catastrophe models?

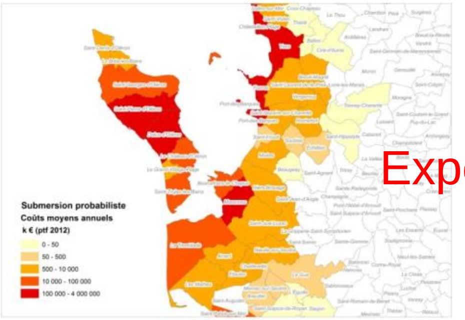
(Asap) estimation of insured losses caused by a real event
Reconstruction of historical events
Probabilistic modeling using stochastic sets of events – pricing, EP curves



Loss estimates



Pricing
Solvability
Financial balance



Exposure

Stochastic sets of events are large collections of events that are possible. They include extreme events more intense than those observed before.

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

Focus on perils covered by the Nat Cat scheme… but we keep an eye on other perils too.

Components of a catastrophe model (1)

In the (re)insurance world, a cat model is the combination of

A hazard module: where does the phenomenon occur, how intense is it?

Being able to simulate floods, storm surge, predict ground acceleration; use statistical methods to generate sets of stochastic events

An exposure and vulnerability module: which buildings are in the affected areas? Are they fragile? What is their insured value?

Work on the portfolio data provided by cedants

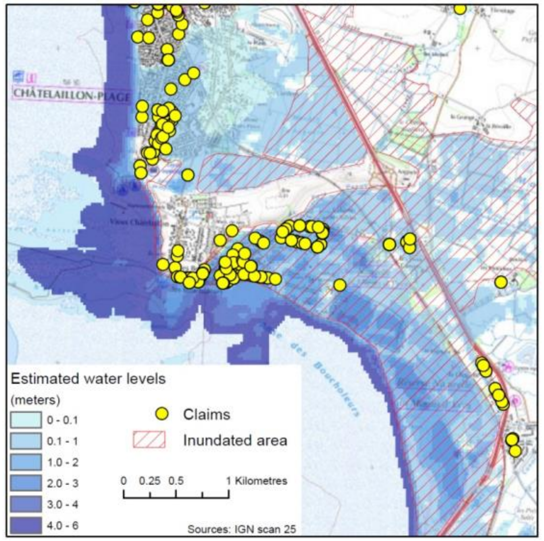
A loss module: how can we relate the intensity of the phenomenon to a damage ratio for a building?

Calibration; work on claims data; work on uncertainties

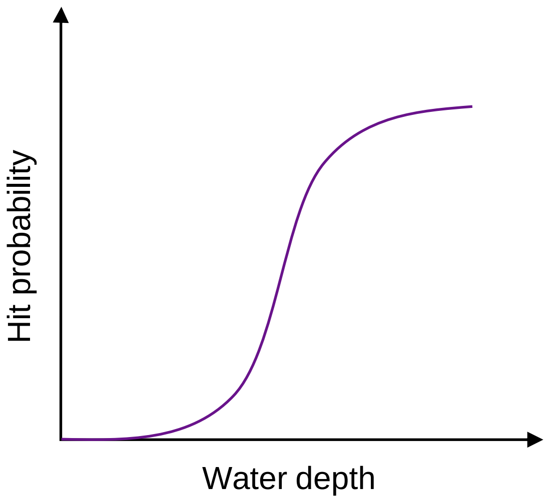
Components of a catastrophe model (2)

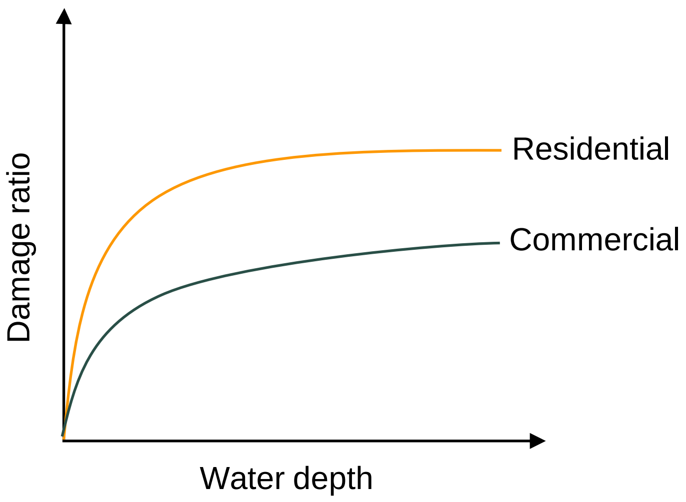
The loss module typically uses a vulnerability curve (more realistically, several vulnerability curves… or something a bit more complicated)

Loss = hit probability * damage ratio * insured value



Calibration on real events





Compute the cost of a real event… and of all the events of a stochastic set
Output at several resolutions: location, commune, department, portfolio

Software ecosystem

We use MATLAB *a lot:*

Most of our **hazard simulation models, stochastic event generators, damage models**

We also use

- ArcGIS for data preparation (topographic, hydrographic data)
- Telemac 2D for storm surge simulations far from the coastline (as input to our coastal flooding model)
- JBA for tropical cyclones in the Antilles and Reunion
- ARIA and ProSAir for terrorism, ARIA for nuclear liability

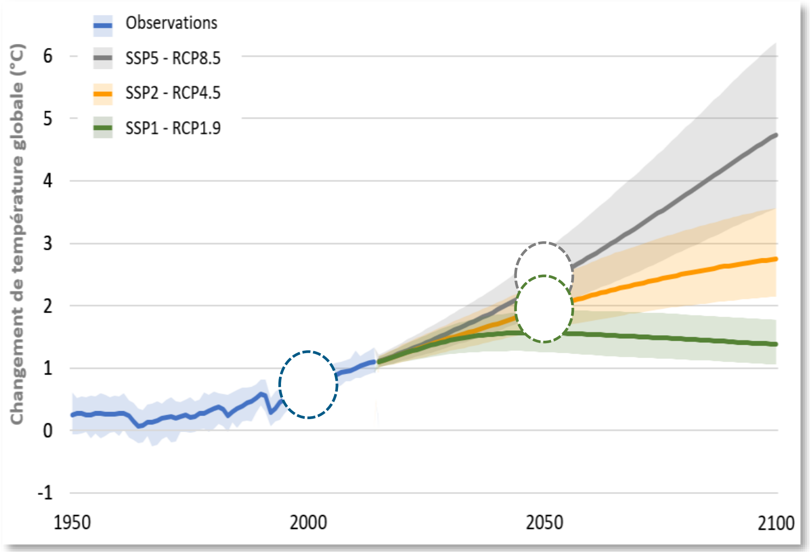
Even when we use other software/languages, **MATLAB is what we use to combine all the inputs/outputs**

Why do we want to model insured losses in the future?

The effects of climate change on losses are already **tangible**

IPCC scenarios anticipate an increase in the **frequence** and **intensity** of extreme events

- How much? Which zones will be more acutely exposed?
- What should our risk prevention strategy be?
- How should pricing evolve? Consequences for the Nat Cat scheme?



Focus on two IPCC scenarios:

- RCP 4.5: possible
- RCP 8.5: upper bound for the losses

What do we need to model insured losses in the future?

What will the hazard in the future look like?

Sets of realistic precipitation scenarios, wind speeds… obtained thanks to a partnership with Météo-France

How will the exposure evolve?

Population evolution scenarios, housing trends

… and the CCR modeling chain to compute damage

… and some computational power.

Constant-climate simulations provided by Météo-France

400 years of **constant-climate simulations**, for the current climate, RCP 4.5 and RCP 8.5

Each of the 400 years should be understood as a **possible outcome for the target year**

Advantages:

- Describe the variability of the climate for a given target year
- Allow us to compute robust statistics:
- Estimate return periods for extreme events for a given target year
- Compare the annual probability of occurrence of extreme events in a changing climate

Evolution of the exposure

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

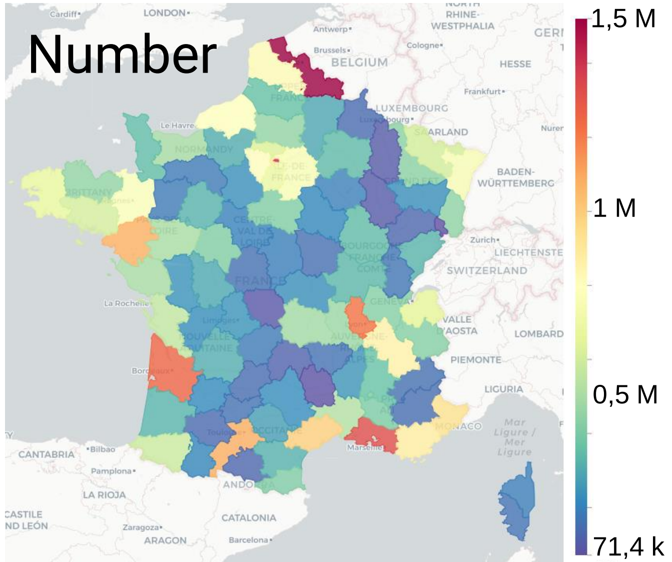
Professionals

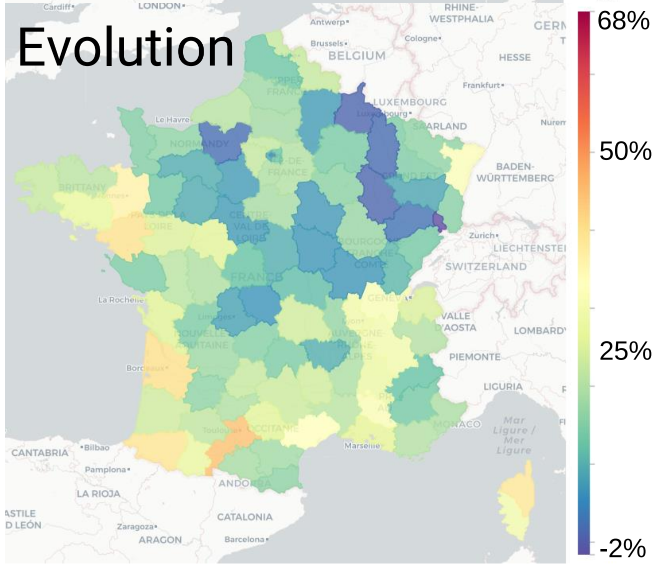
- SIRENE database (2014-2022)
- Agricultural census from the French Ministry of Agriculture and Food Sovereignty
- Report by the General Council for Food, Agriculture and Rural Areas (2020)

Projection of the estimated numbers of buildings in 2050

Residential buildings

- 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 departments

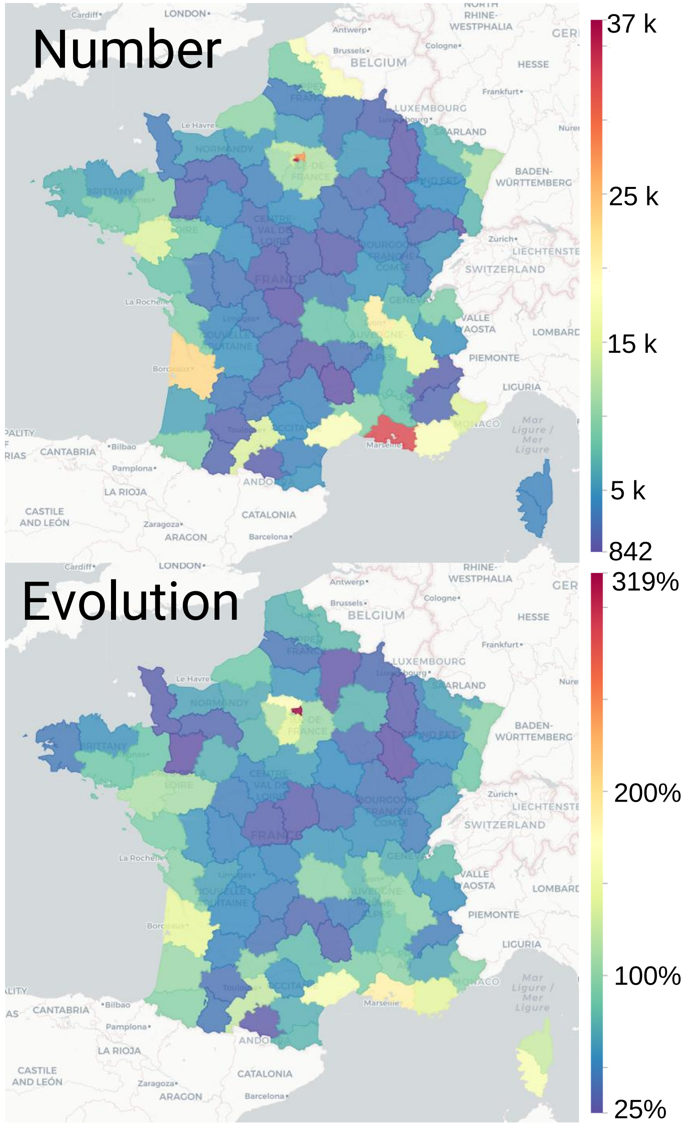




Projection of the estimated numbers of buildings in 2050

Industrial buildings

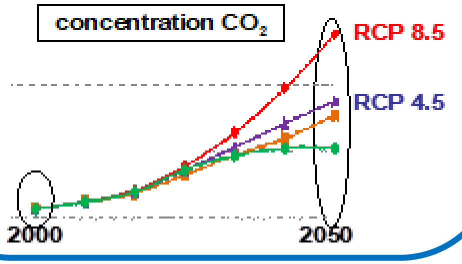
- The highest number of industrial buildings might be in the Paris area (including Seine-Saint-Denis) and in Bouches-du-Rhônes (Marseille region)
- Seine-Saint-Denis area could experience the highest evolution (+319%)
- Each of the French departments could experience a 25% increase in the number of industrial buildings



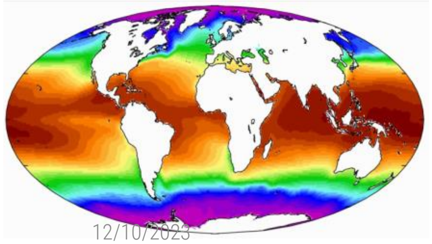
A long-term partnership with Météo-France and the constant climate modelling

3 scenarios of 400 years at constant climate

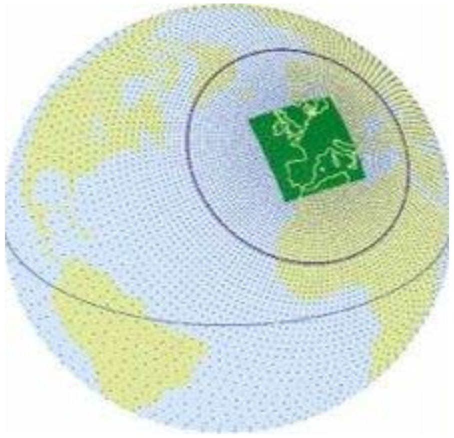
- Climate 2000
- Climate 2050 RCP4.5
- Climate 2050 RCP8.5



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

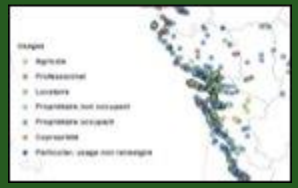
Overflow

Runoff

Storm surge model

Drought model
Shrinkage and swelling of clays

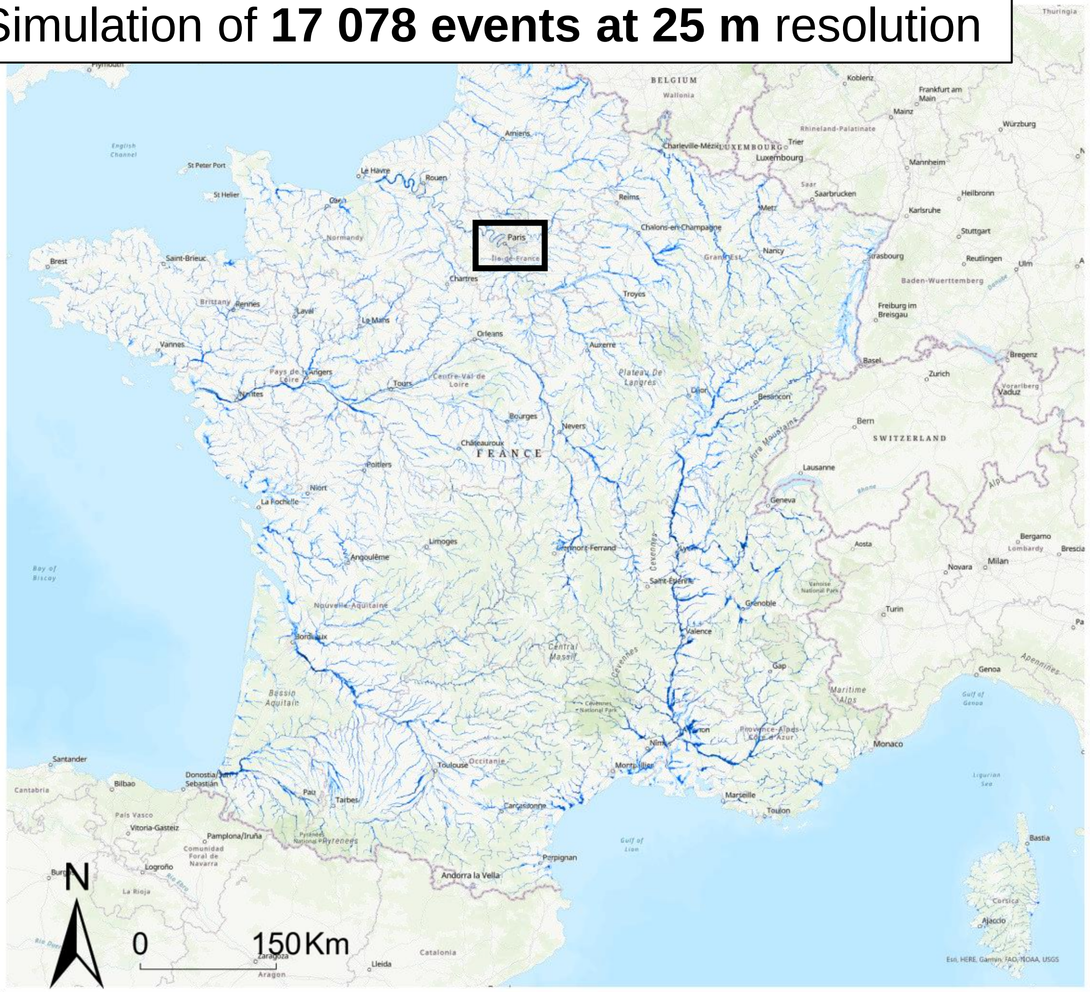
Vulnerability model Portfolio of insured assets in 2050



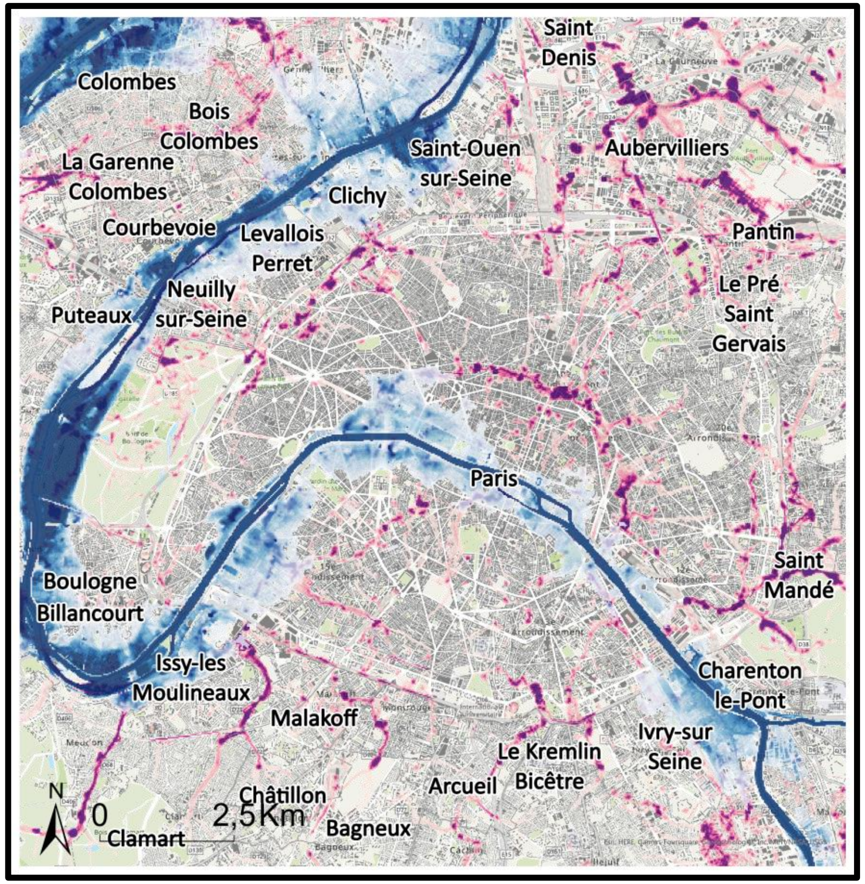
Damage model

Modelling natural hazards: flood areas

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

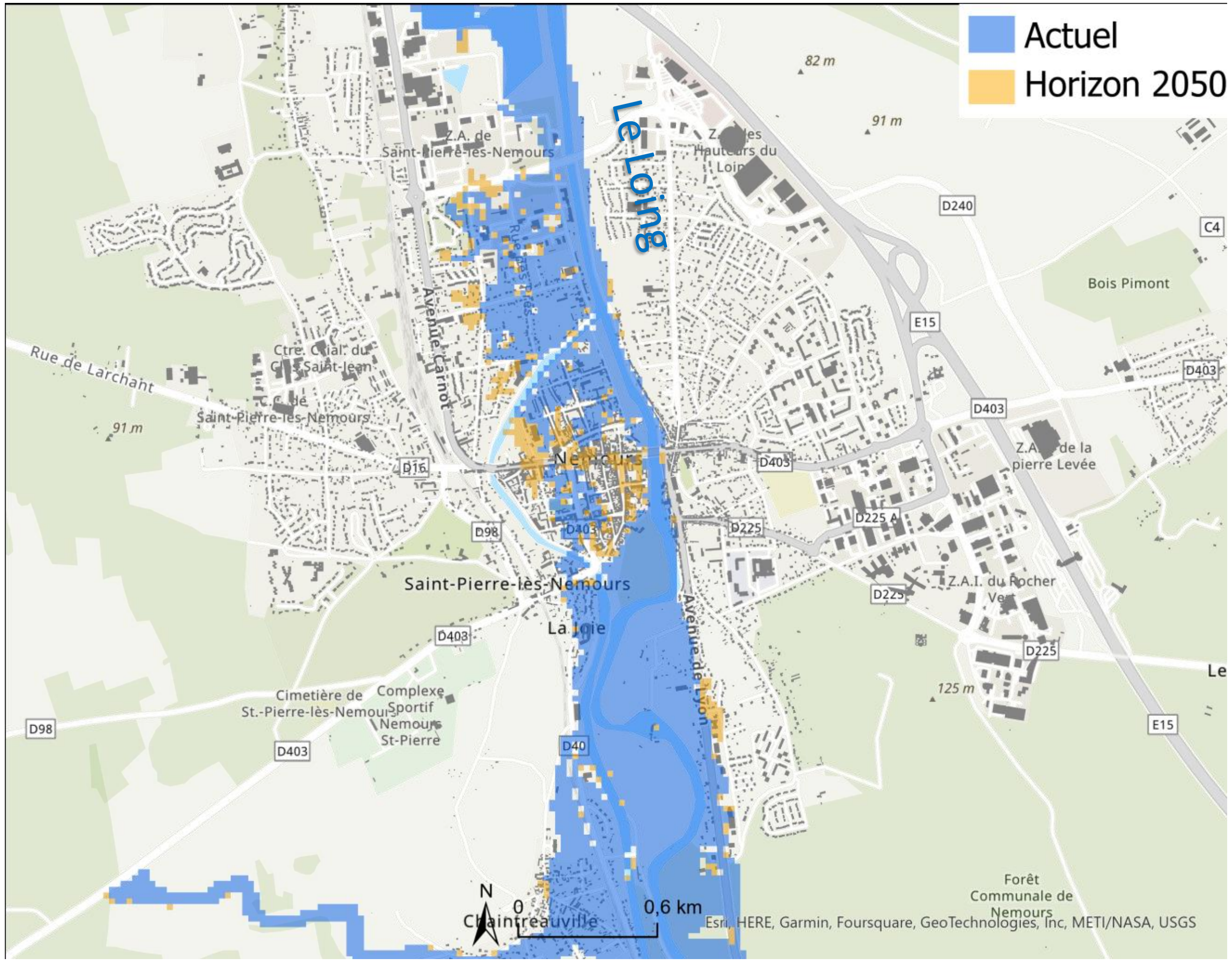


Overflow in France in 2050 (RCP 4.5) for a 200-year return period



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

Evolution of the fluvial flood frequency

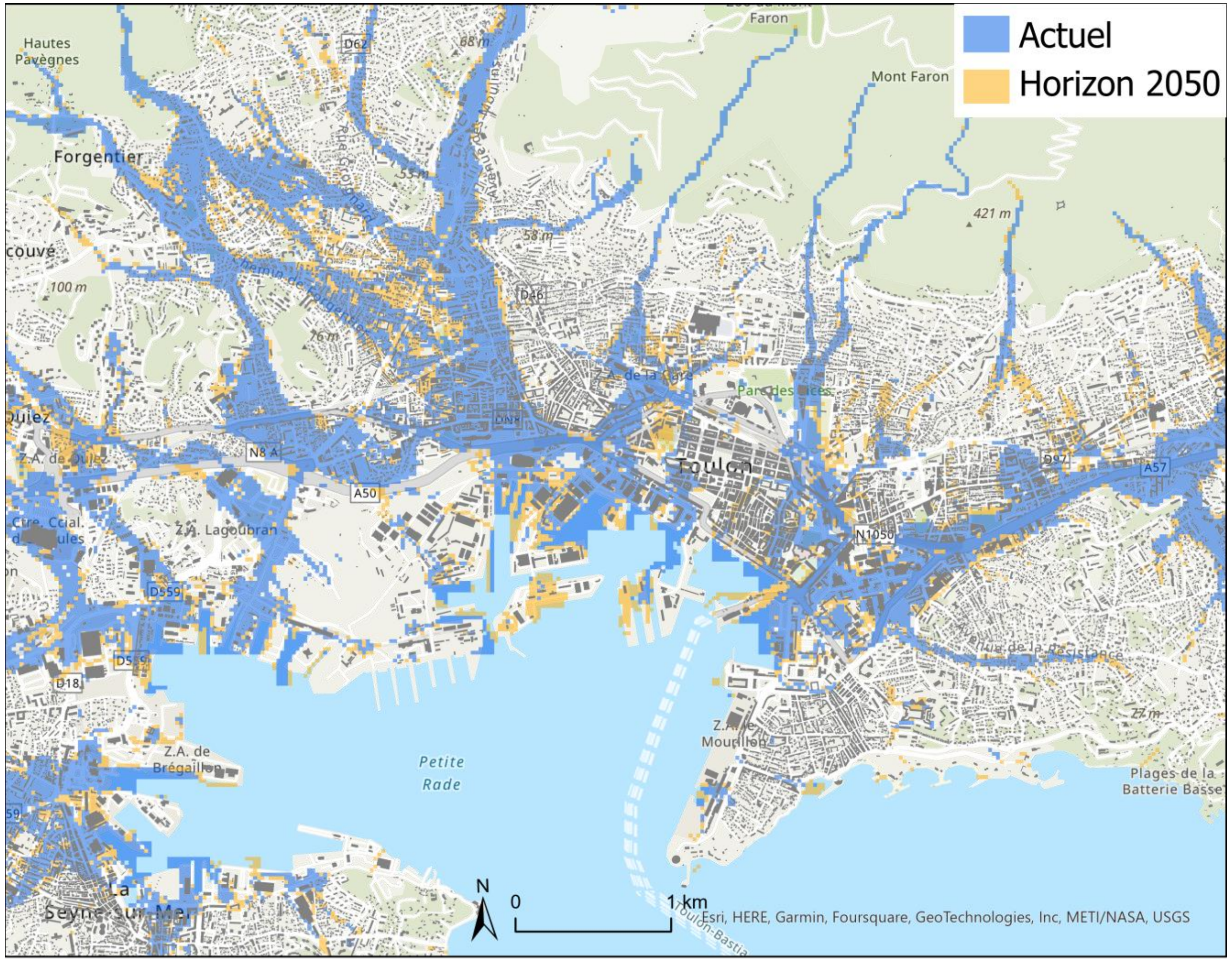


Current and future overflow in Nemours (Paris area) for a 50-year return period

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

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

Evolution of the frequency of runoff events



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

In the future, increase in the frequency and intensity of runoff events caused by short and intense precipitations

Complete results coming up soon…

In the report, we discuss:

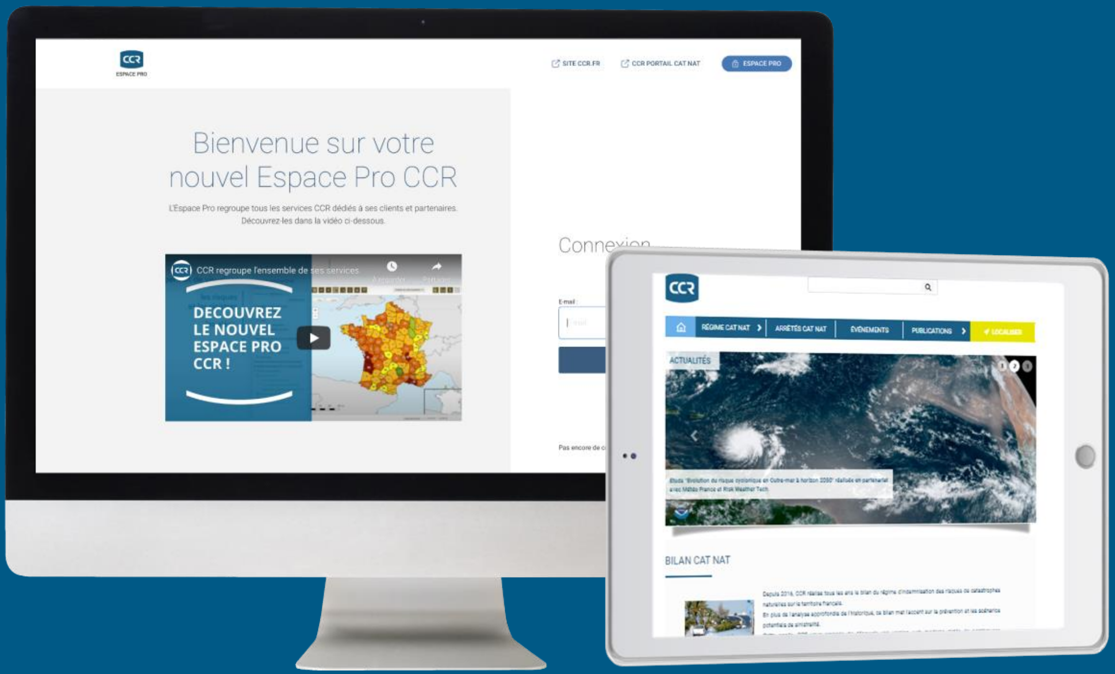
- Geographical **evolutions** of the hazard
- **Increases** in insured losses
- Due to the evolving hazard
- Due to the evolving exposure

Trends identified:

- Shrinkage and swelling of clay: highly impacted by climate change, especially under scenario RCP 8.5
- Floods: increase in the frequency of runoff events
- Storm surge: high impact of sea level rise on frequency and intensity of storm surge

Highlights the **need to invest in prevention**, especially for clay subsidence and runoff!

AVERTISSEMENT



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