

# New Insights into the Evaluation of Financial Impact of Earthquakes in France

*Benefits for Compensation and Prevention*

Pierre Tinard\*, J. Rey, D. Monfort-Climent, A. Imtiaz,  
R. Hoste-Colomer, C. Negulescu and P. Gehl



# General context of the BRGM/CCR partnership

## Who we are

### ► BRGM: French Geological Survey

- The BRGM is France's public reference institution for Earth Science applications for the management of surface and subsurface resources and risks. Its activities are geared to scientific research, support to public policy development and international cooperation
- Missions: **Understanding** geological phenomena and associated risks. **Developing** new methodologies and techniques. **Producing and distributing** and disseminating data to support the management of soils, subsoils and their resources. **Delivering** the necessary tools for managing soils, subsoils and their resources, preventing risks and pollution and developing climate change policies

### ► CCR: Caisse Centrale de Réassurance

- a public-sector reinsurer, **100% owned by the French State**, providing insurance companies operating in France with **coverage against natural catastrophes** and uninsurable risks
- presents the particularity of offering unlimited cover, for specific classes of business in the French market, with the **guarantee of the French State**, this applies especially to natural disasters (Nat Cat compensation scheme)

# General context of the BRGM/CCR partnership

## What we do in this partnership

### ► Global partnership since 2014:

- Enhancing the knowledge on the vulnerability of the French territories
- Evaluating the French exposure, on an economic basis, to natural disasters
- Specifically on Earthquake:
  - Assessing the hazard with both deterministic and stochastic approaches
  - Establishing vulnerability and damages curves calibrated on the French territories
  - Estimating loss for the main lines of business insured in France: dwellings (houses & apartments), commercial, agricultural and industrial properties

### ► Impact scenarios at “département” (county) level in order to evaluate the insured loss within the French Nat Cat compensation scheme for i) past events, ii) events located on the main faults or iii) with a hazard intensity based on the French regulatory Seismic Hazard map.

# Assessing insured loss related to EQ

## Why estimate insured loss related to earthquakes ?

- ▶ Since 1982: specific compensation scheme for natural disasters based on the property insurance for dwellings, commercial, agricultural and industrial facilities and vehicles
- ▶ Under defined criterion, loss related to major/unusual events are compensated within the Nat Cat compensation scheme
- ▶ CCR plays a central role in the French scheme
- ▶ Since 1982:
  - Over 36 billions € compensated / 977 millions € on yearly average, up to 3 billions € in 2003 and 2017
  - 57% for flood / 34% for terrain subsidence due to shrinking swelling clay

# Assessing insured loss related to EQ

## How to estimate insured loss related to earthquakes ?

- ▶ In a perfect world: for each building on the French territories ⇔ estimate the average annual loss and several return period loss using a stochastic earthquake dataset (10 000+ events)
- ▶ In the real world: develop a deterministic model of EQ impact and calibrate it accurately before estimating the damages and loss using and stochastic EQ generator
- ▶ Required data:
  - Stochastic EQ generator ⇔ CCR component, on-going PhD
  - Probabilistic damages to buildings ⇔ BRGM 'Armagedom' software
  - Location and insured values ⇔ CCR database on insured properties
  - Calibration of damages and loss on past events : ~5000 claims on France
- ▶ Model perimeter: French mainland and overseas territories where the Nat Cat scheme is effective
  - Dwellings : houses, apartments, condos, hotels, ...
  - Small businesses located in residential building (hair salon, bank, bakery, ...)
  - Large commercial areas and malls
  - Agricultural facilities (silos, warehouses, ...)
  - Industrial facilities
  - Direct damages + business interruption under specific conditions

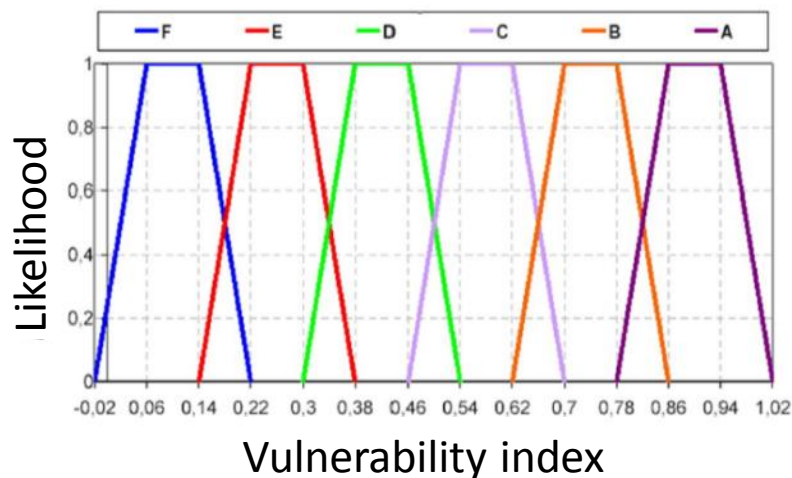
# Impact scenarios at department/county level

## Assessing building vulnerability

- INSEE-IRIS and INSEE-RIL databases ⇔ census data about number, location and properties of buildings such as elevation or mean number of apartments per residential building, ...
- EMS-98

Type of Structure	Vulnerability Class A B C D E F
MASONRY	<div>○</div>
	<div>○</div>
	<div>○</div>
	<div>○</div>
	<div>○</div>
	<div>○</div>
	<div>○</div>
WOOD REINFORCED CONCRETE (RC)	<div>○</div>
	<div>○</div>
	<div>○</div>
	<div>○</div>
	<div>○</div>
	<div>○</div>
WOOD	<div>○</div>
	<div>○</div>

○ most likely vulnerability class; — probable range;  
 .... range of less probable, exceptional cases



Type of buildings	Date of construction		
	Before 1949	1949 - 1971	...
Houses	10% A / 90 % B	100 % C	
Residential buildings	100 % B	100 % C closer to D-class	



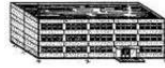







# Impact scenarios at department/county level

## Damages and loss

- ▶ Estimating damage grades 1 to 5 for each of the towns (low-populated areas) and the districts within larger cities
- ▶ Converting damages to monetary loss

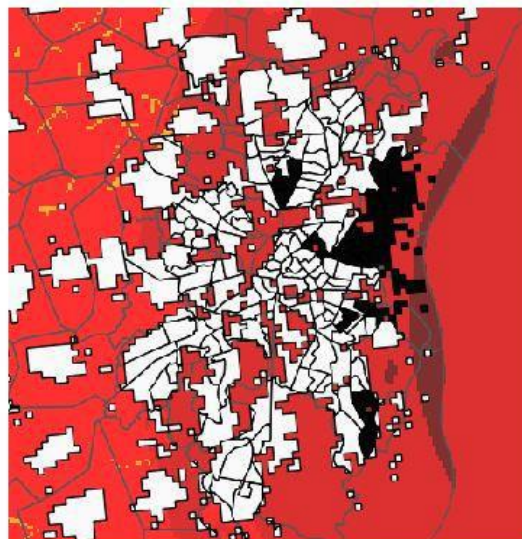
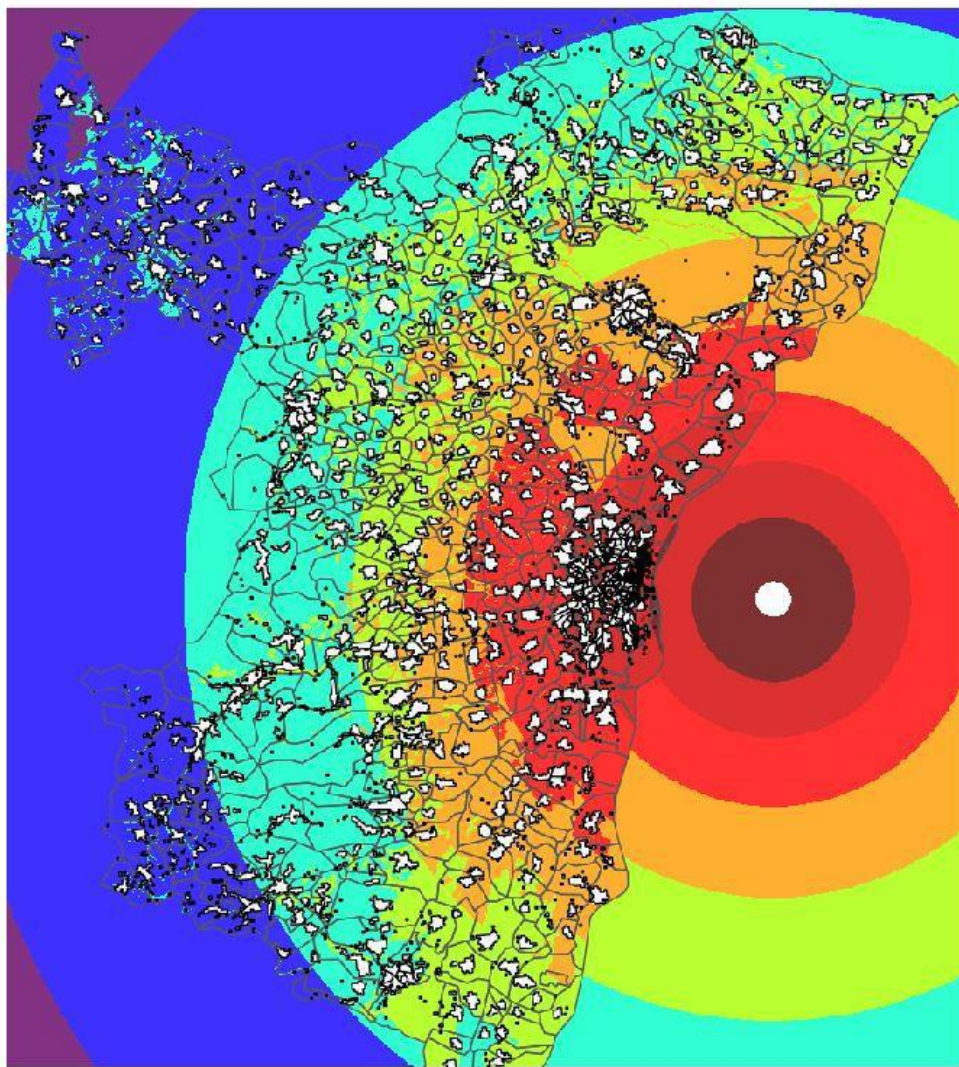
Table 15.2: Structural Repair Cost Ratios  
(in % of building replacement cost)

No.	Label	Occupancy Class	Structural Damage State			
			Slight	Moderate	Extensive	Complete
		<b>Residential</b>				
1	RES1	Single Family Dwelling	0.5	2.3	11.7	23.4
2	RES2	Mobile Home	0.4	2.4	7.3	24.4
3-8	RES3a-f	Multi Family Dwelling	0.3	1.4	6.9	13.8
9	RES4	Temporary Lodging	0.2	1.4	6.8	13.6
10	RES5	Institutional Dormitory	0.4	1.9	9.4	18.8
11	RES6	Nursing Home	0.4	1.8	9.2	18.4

Classification of damage to buildings of reinforced concrete		Classification of damage to masonry buildings	
	Grade 1		Grade 1
	Grade 2		Grade 2
	Grade 3		Grade 3
	Grade 4		Grade 4
	Grade 5		Grade 5



# Impact scenarios at department/county level



EMS-98  
intensity

0  
I  
II  
III  
IV  
V  
VI  
VII

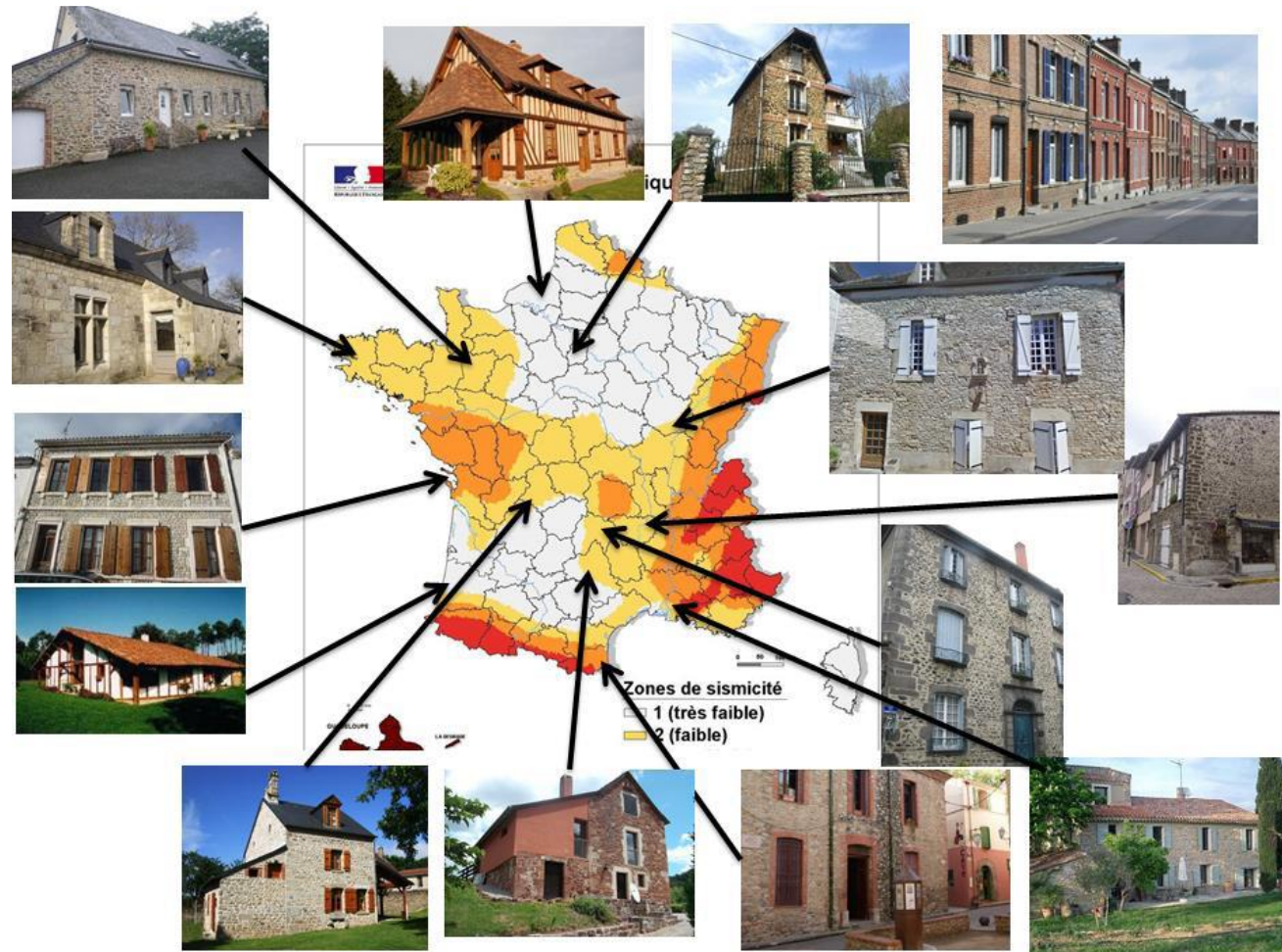
Partially or totally  
collapsed buildings

0.0% - 0.10%  
0.10% - 0.30%



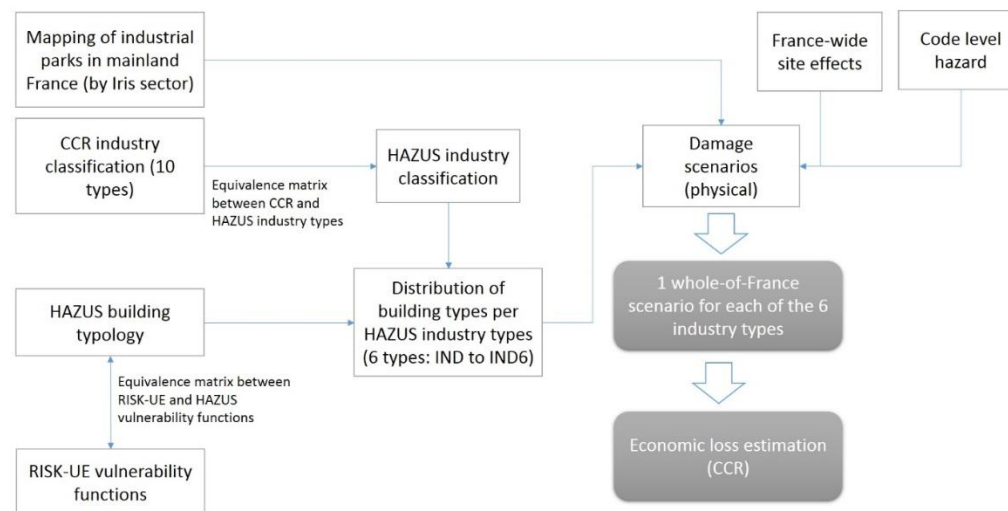
## Evaluating the vulnerability of buildings

## Residential buildings



# Evaluating the vulnerability of buildings

## Industrial facilities



Industrial facilities (HAZUS)			Industrial facilities (French repository)	
US-Code	Category	Description	Fr-Code	Description
IND1	Heavy	Factory	31 / 38	Glass, ciment, ceramics, energy including recycling units
IND2	Light	Factory	34 to 36	Textile, paper, wood industries
IND3	Food/Drugs/Chemicals	Factory	33 / 37	Chemicals, Foods, Drugs
IND4	Metals/Minerals processing	Factory	30	Metals, Minerals processing
IND5	Hight technology	Factory	32	High Technology
IND6	Construction	Office	39	Warehouses, stowage

# Assessing insured loss related to EQ

## Example of a major historical event: Bouin 1799

### ► Bouin 1779 EQ :

- Mw = 6.4
- Depth = 24 km

#### Houses

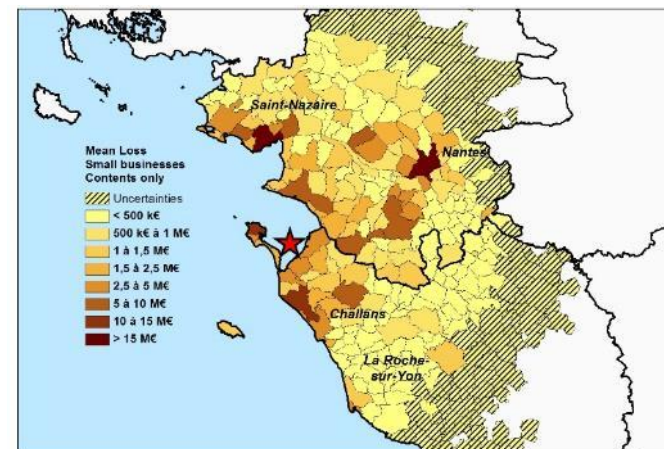
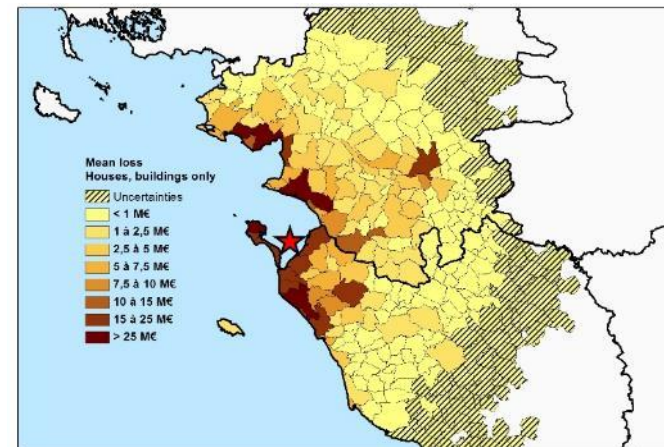
buildings	560 - 890 M€
contents	270 - 435 M€

#### Apartments

buildings	380 - 425 M€
contents	40 - 65 M€

#### Small businesses

buildings	<i>included in the res buildings</i>
contents	160 - 425 M€
business interruption	30 - 75 M€



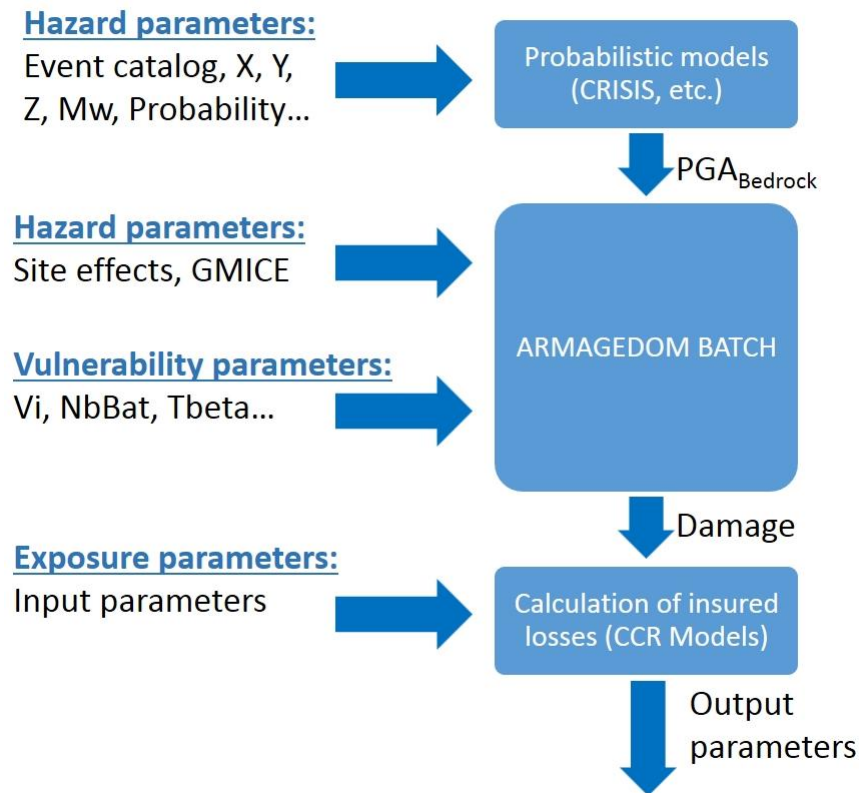
### ► Insured loss within the Nat Cat compensation scheme: 1.45 to 2.32 billions €

- Towns with an uncertainty on their Nat Cat recognition: 40 to 75 millions €

# Automated workflow

## Workflow and design of experiments

### WORKFLOW



- Stochastic dataset of 21 990 events (w/o aftershocks)
- 1 000 000 simulations planned in the design of experiments
- 42 parameters
- Uncertainties evaluated for 20 variables (soil effect, vulnerabilities, ...)
- Uncertainties on hazard implicitly taken into account with the stochastic hazard generator
- Sampling on 100 000 simulations to test the design of experiments
- 12h computing, 20 Gb output data

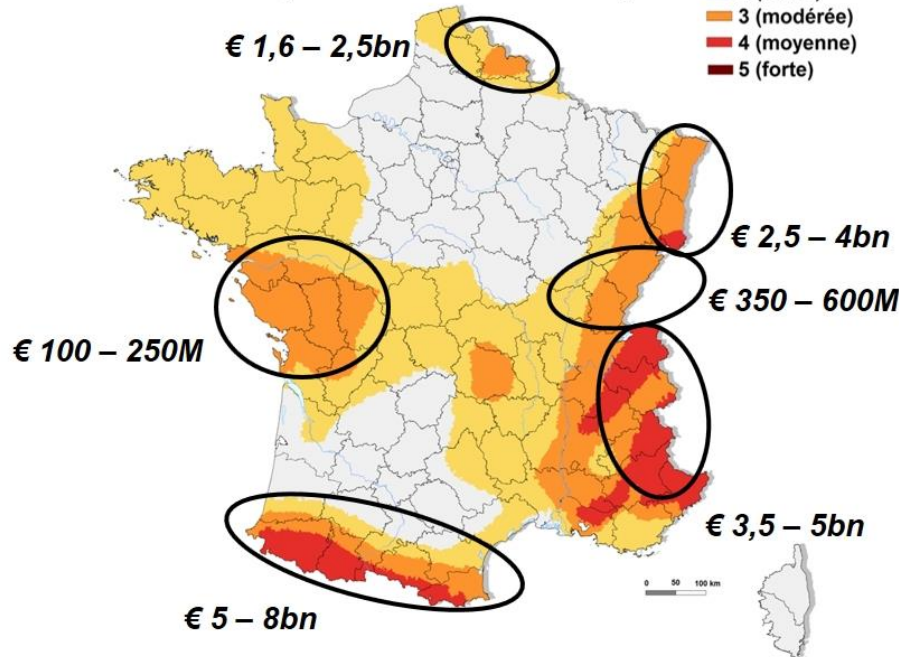


# Some results



**Zonage sismique de la France**  
en vigueur depuis le 1er mai 2011  
(art. D. 563-8-1 du code de l'environnement)

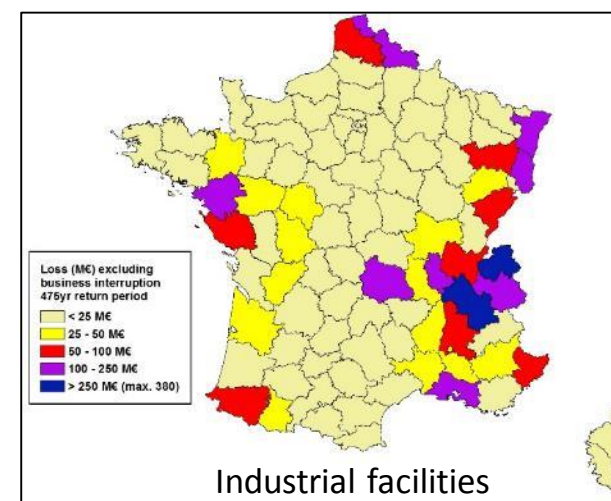
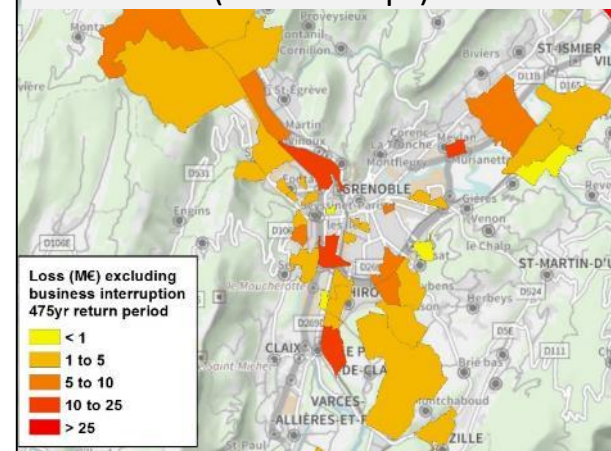
**Zones de sismicité**  
1 (très faible)  
2 (faible)  
3 (modérée)  
4 (moyenne)  
5 (forte)



€ 1,2 – 1,8bn

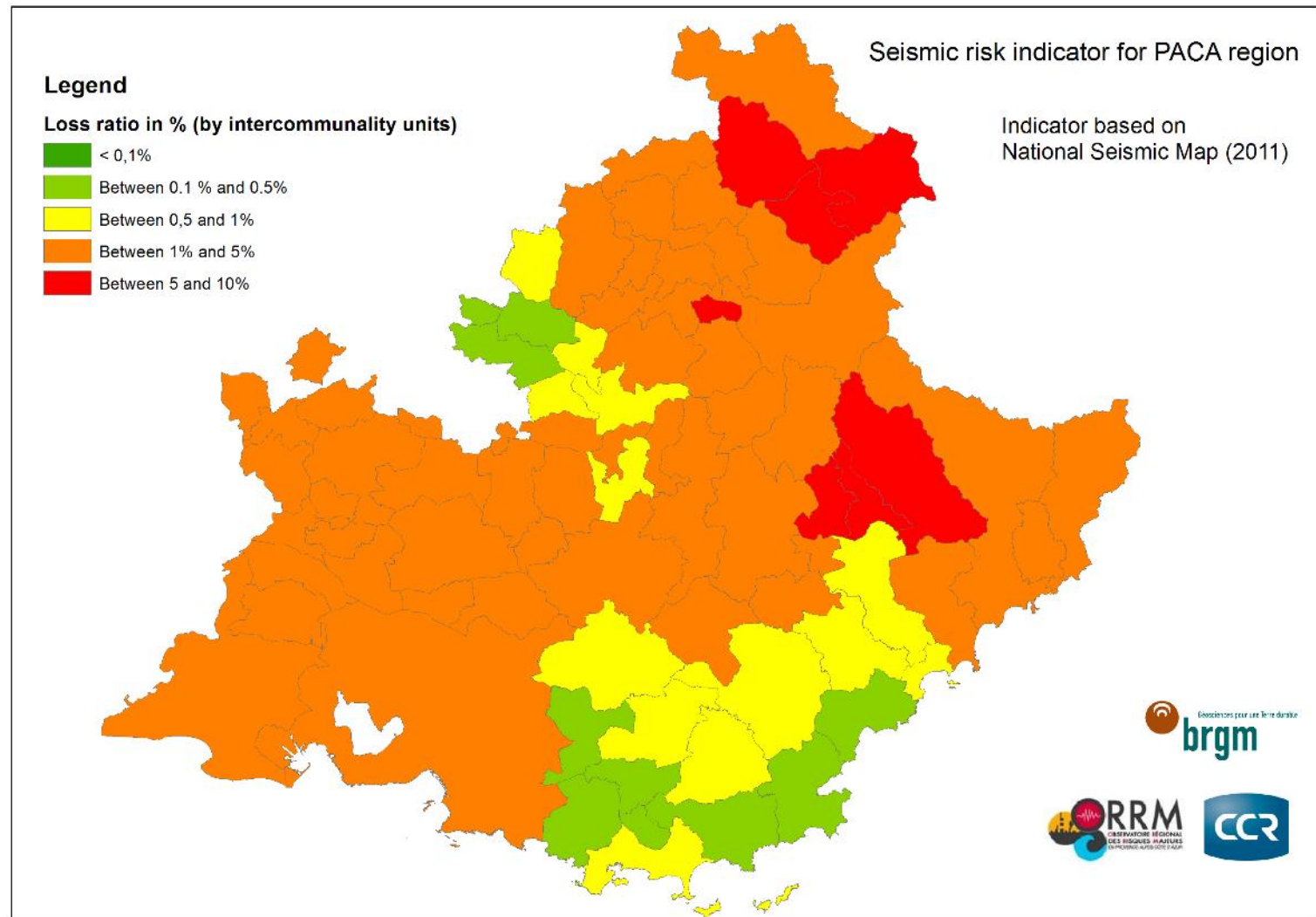


**Industrial facilities near Grenoble**  
(western Alps)



Main characteristic events by region  
**Work under progress, loss estimation could change  
in future release of our model**

# Sharing data for decision making and participative governance



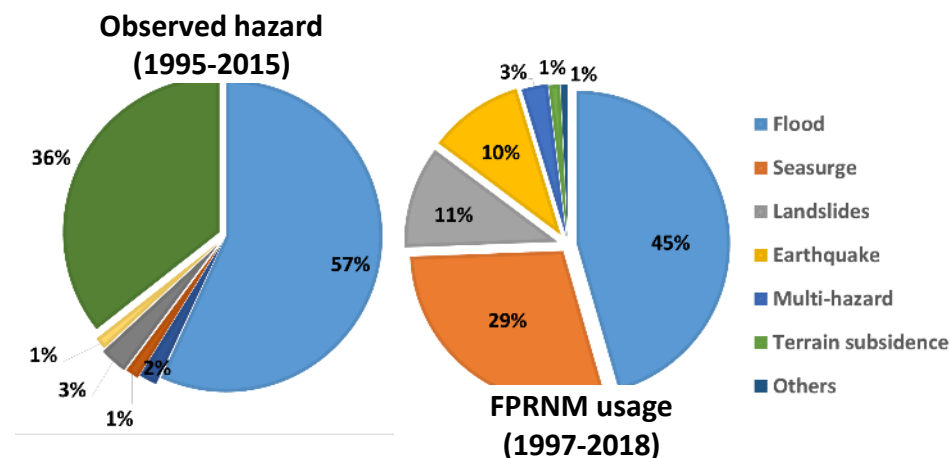
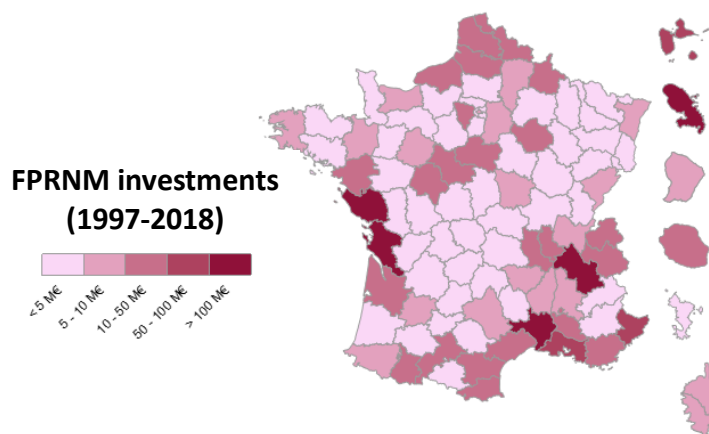


# Prevention actions within the French Public Private Partnership

- ▶ Public fund “FPNRM” created in 1995
- ▶ Mostly fed by a 12% tax on Nat Cat premium
- ▶ 2 billions € devoted to prevention 1995-2018:
  - acquisition of dwellings strongly affected by natural disasters;
  - acquisition of dwellings exposed to a potential major natural hazard threatening human lives;
  - vulnerability reduction of existing buildings;
  - studies for Risk Prevention Plans (PPR) ⇔ regulation of land use within the cities, defines adapted building codes for EQ thanks to seismic *in situ* studies on soil performance, ...



*Structural reinforcement of a school in the Lesser Antilles (most exposed area to earthquakes in France) partly financed by FPNRM.*



# Conclusions and perspectives

## ► Essential damage studies:

- support to State decision-makers and local authorities;
- more comprehensive vision during crisis exercises;
- answer to the need for rapid assessment of the impact of an event.

## ► Adding a probabilistic catalogue of EQ events is an important contribution:

- vision of probable annual losses at any point in the territory;
- aggregation of probable EQ-related losses with those of other perils under the Nat Cat scheme ⇔ Sustainability of the Nat Cat scheme over decades;
- financial reserve of loss 200-yr return period loss ⇔ European regulation Solvency 2
- knowledge for the French State of its probable commitments and encouragement to more prevention

## ► Finalization in progress for France territory (mainland and overseas)

## ► Scientific (publications, communications) and technical (dissemination of the open-source computing core?)



**Thank you for your attention**