

Hydro Engineering Center

TOWARD THE INTEGRATION OF 15 YEARS OF RESEARCH AND DEVELOPMENT IN A SEISMIC MAP OF THE FRENCH TERRITORY

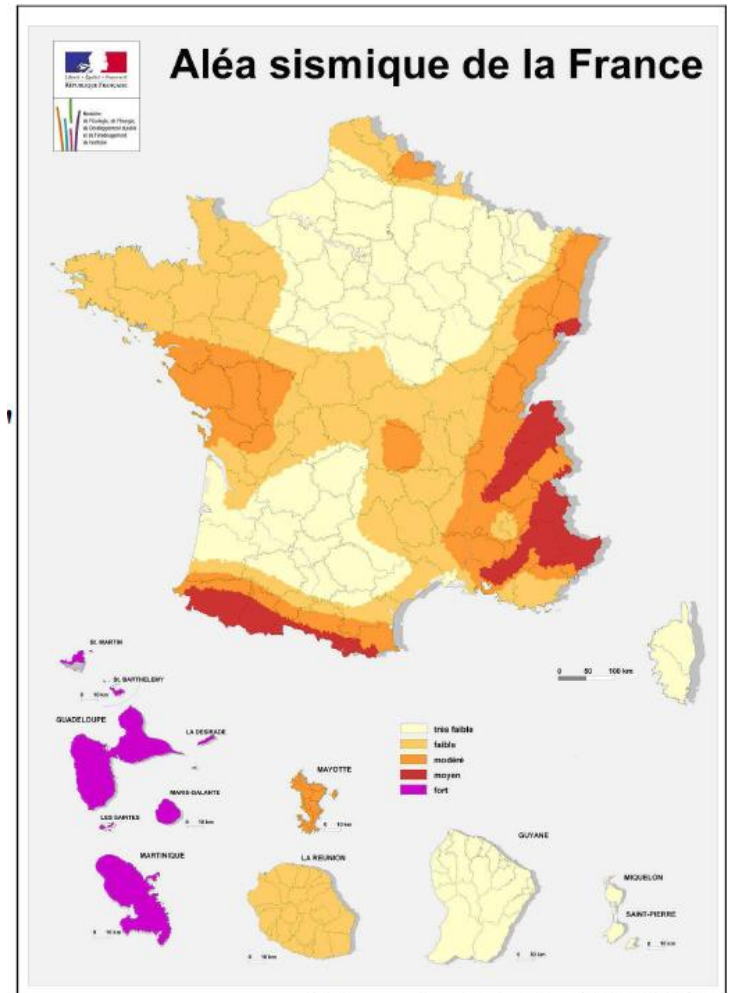
EWG Dams & Earthquakes
Tuesday 7 Feb.

Nicolas HUMBERT



CONTEXT & MOTIVATIONS

- The French seismic hazard map is based on a 2002 assessment.
 - More than 15 years old
- No update available
- Still used as a reference in regulatory context (French regulation project for dams)
- However: a lot of Research and Development programs
 - PEGASOS
 - SIGMA
 - . . .



CONTEXT & MOTIVATIONS

- Assessment of a seismic hazard map for France,
 - This map has to include the results of the last 15 years of research.
 - This map has to be published.
 - And if possible, this map has to be consistent on the borders with other countries!

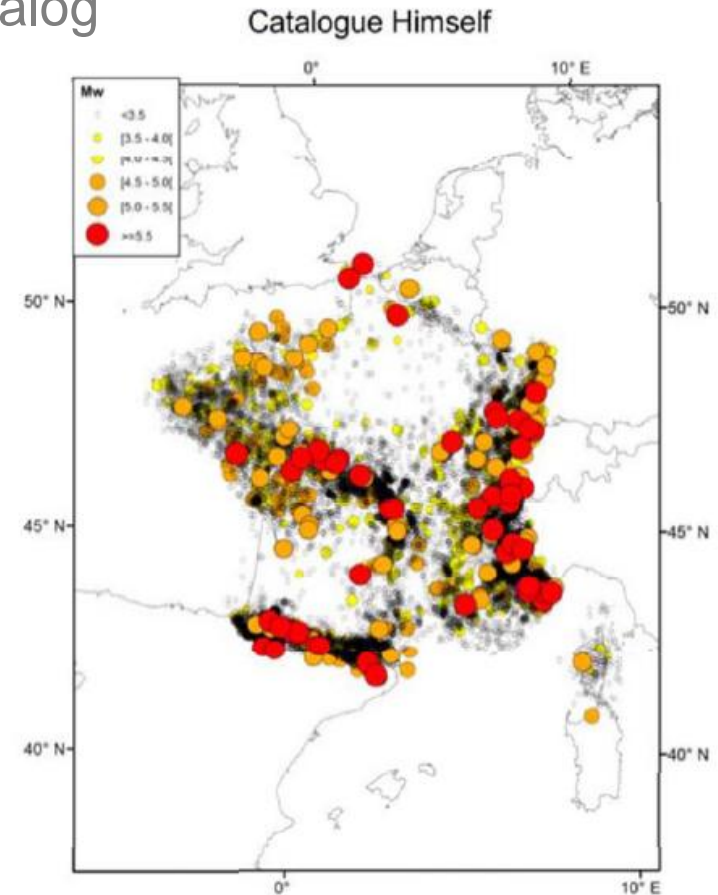
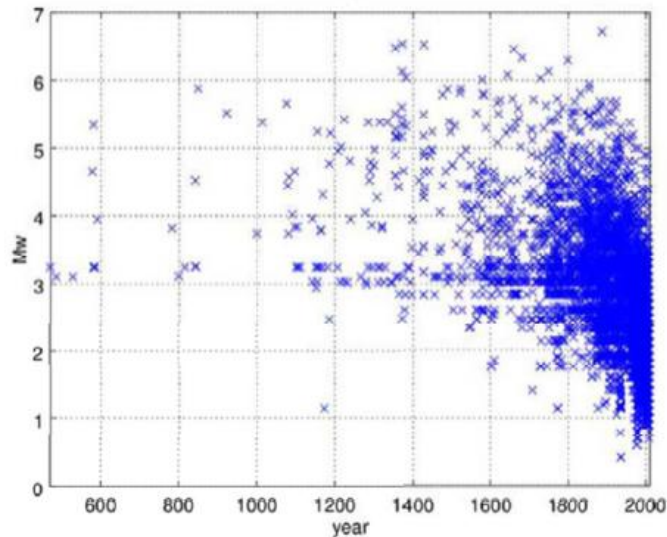
SUMMARY

- **Focus on 3 specific points**

- ISSUE N° 1: Coherency in Magnitude scale
- ISSUE N° 2: Using all available local data in hazard assessment
- ISSUE N° 3: Using the condition spectrum

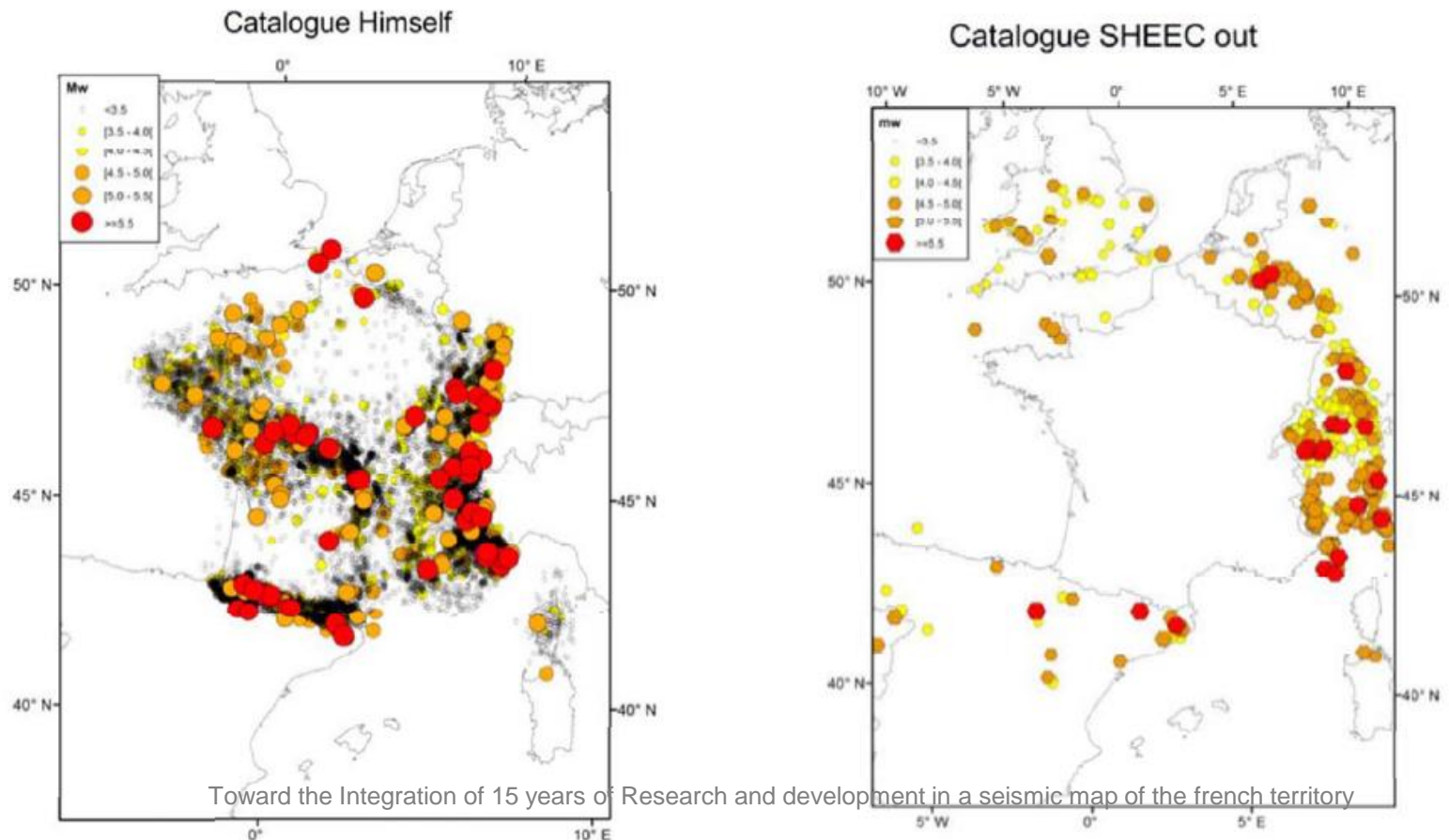
ISSUE N° 1: COHERENCY IN MAGNITUDE SCALE

- Only one type of magnitude: MOMENT MAGNITUDE (M_w)
- Huge work on instrumental M_w : Himself catalog
 - BUT: lot of work on the borders



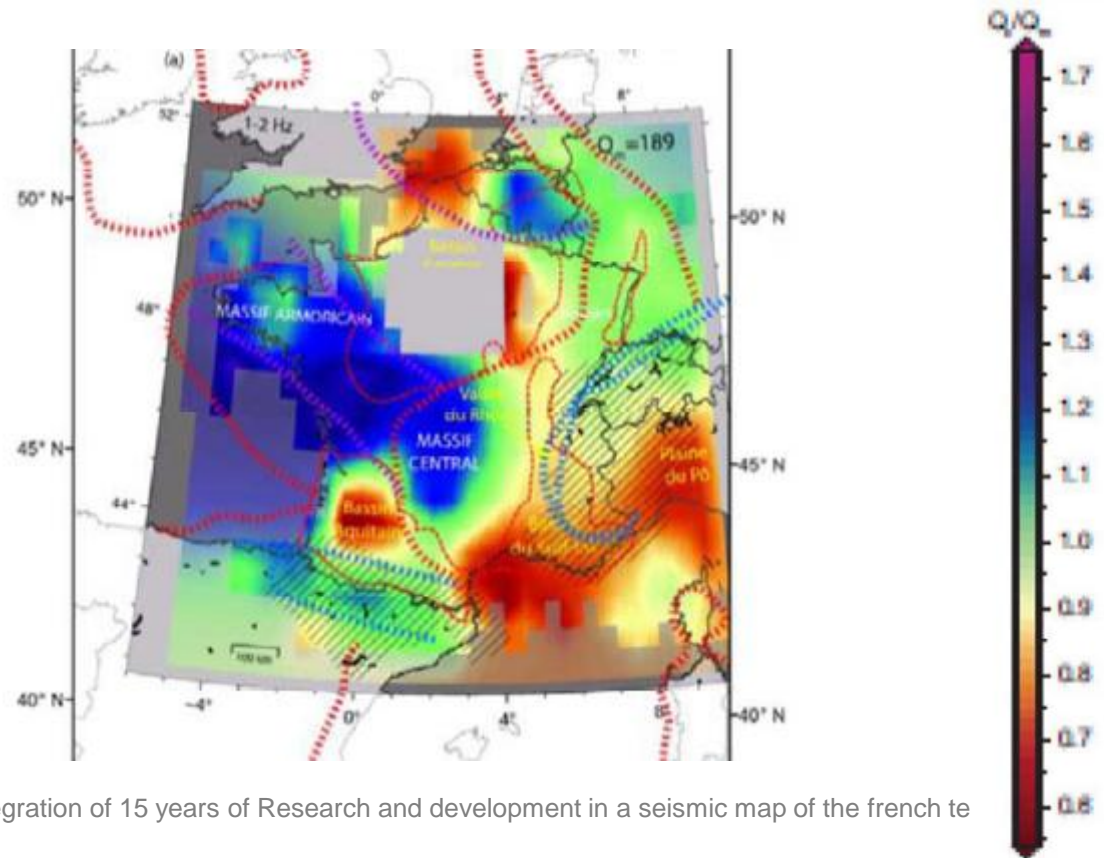
ISSUE N° 1: COHERENCY IN MAGNITUDE SCALE

- Work on the borders
 - Avoid double counting....
 - Need to work together (England – Italy – Germany – Swiss – Spain...)



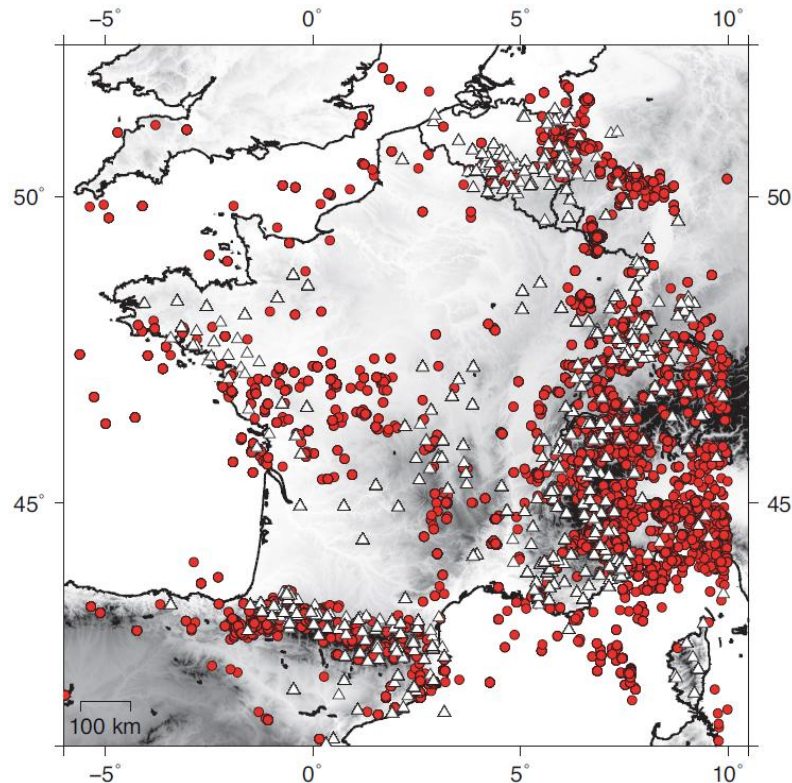
ISSUE N° 2: USING ALL AVAILABLE LOCAL DATA

- Moderate seismicity in France → attenuation model are empirical comes from other countries (mostly Greece – Turkey & Italy)
 - Expert judgment to choose the hypothesis
- But at the end, local data are not used!!!
 - Example: map of Q



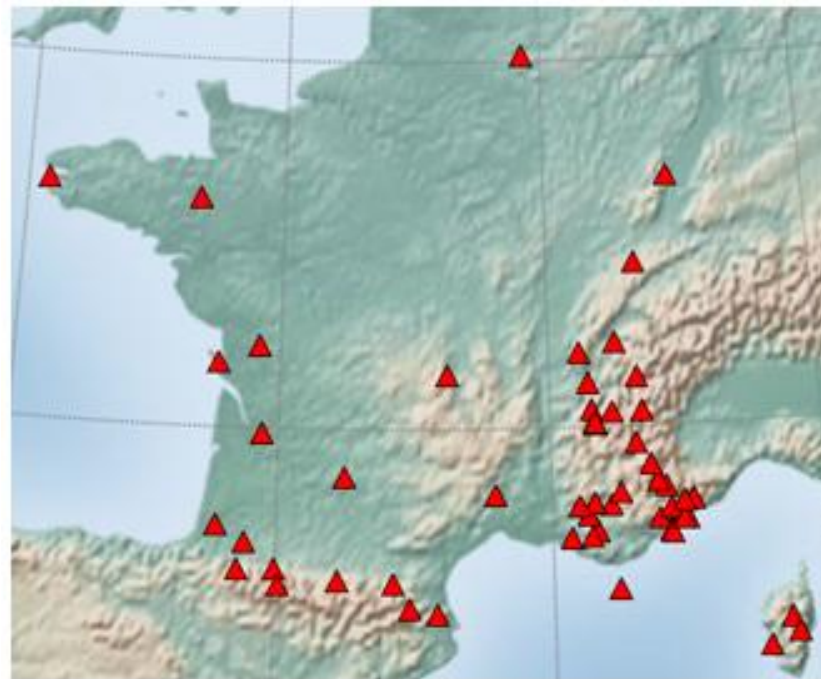
ISSUE N° 2: USING ALL AVAILABLE LOCAL DATA

- **Too complex to include it in hazard assessment:**
 - Softwares do not allow geographical dependence of attenuation!
 - How to link an empirical equation with physical properties?



FRENCH EXAMPLE: LOCAL DATA

- the French broadband and accelerometric permanent network
 - (more than 100 stations),



FRENCH EXAMPLE: LOCAL DATA

- **CEA velocimetric network**
 - (since 1950 - 40 velocimetric stations)



FRENCH EXAMPLE: LOCAL DATA

■ Industrial networks:

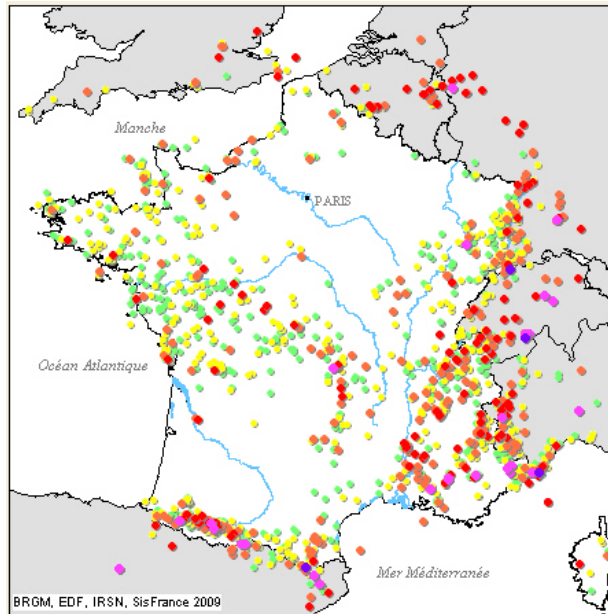
- TGV network (French high speed train - 24 stations),
- nuclear power plants accelerometric stations (18 sites)



FRENCH EXAMPLE: LOCAL DATA

■ Historical feedback:

- Sisfrance: 1300 → 2007
- 6000 earthquakes



Epicentres de séismes et intensités épicentrales (1300-2007)

- | | |
|--------------------------------------------|-----------------------------------------|
| ● Degré 4 à 4.5 (secousse modérée) | ● Degré 5 à 5.5 (secousse forte) |
| ● Degré 6 à 6.5 (dommages légers) | ● Degré 7 à 7.5 (dommages prononcés) |
| ● Degré 8 à 8.5 (destructions importantes) | ● Degré 9 à 9.5 (destructions massives) |

FRENCH EXAMPLE: LOCAL DATA

- Precarious structures:



FRENCH EXAMPLE: LOCAL DATA

- **We need of mathematical tools to use these data in hazard assessment:**
 - Vertical velocity
 - Number of exceeding
 - Accelerations
 - ...
- **The most common tool is the Bayesian inference**

ISSUE 2: BAYESIAN INFERENCE

■ Workshop of Pavie in 2015

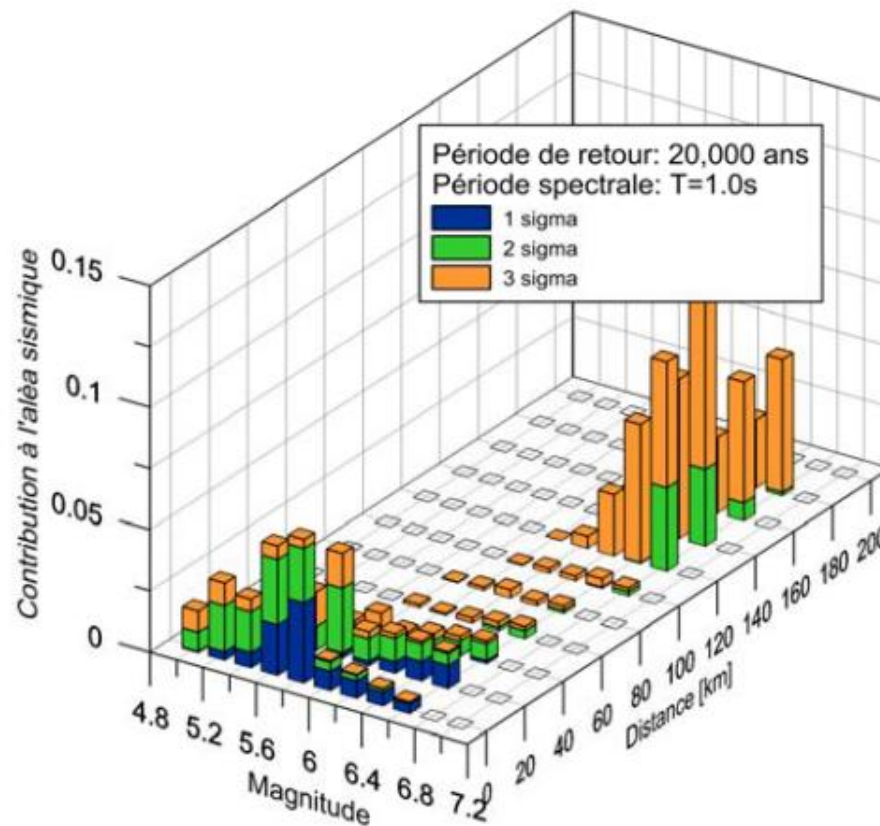


- “Statistical tests of PSHA models.” Roger Musson.
- “Non-Ergodic Seismic Hazard: Using Bayesian Updating for Site-Specific and Path-Specific Effects for Ground-Motion Models” Nicolas Kuehn, Norman Abrahamson
- “Probabilistic Seismic Hazard Assessment: Combining Cornell-Like Approaches and Data at Sites through Bayesian Inference.” Jacopo Selva
- ... (x20 papers)

ISSUE 3: MISUSE OF THE UNIFORM HAZARD SPECTRUM

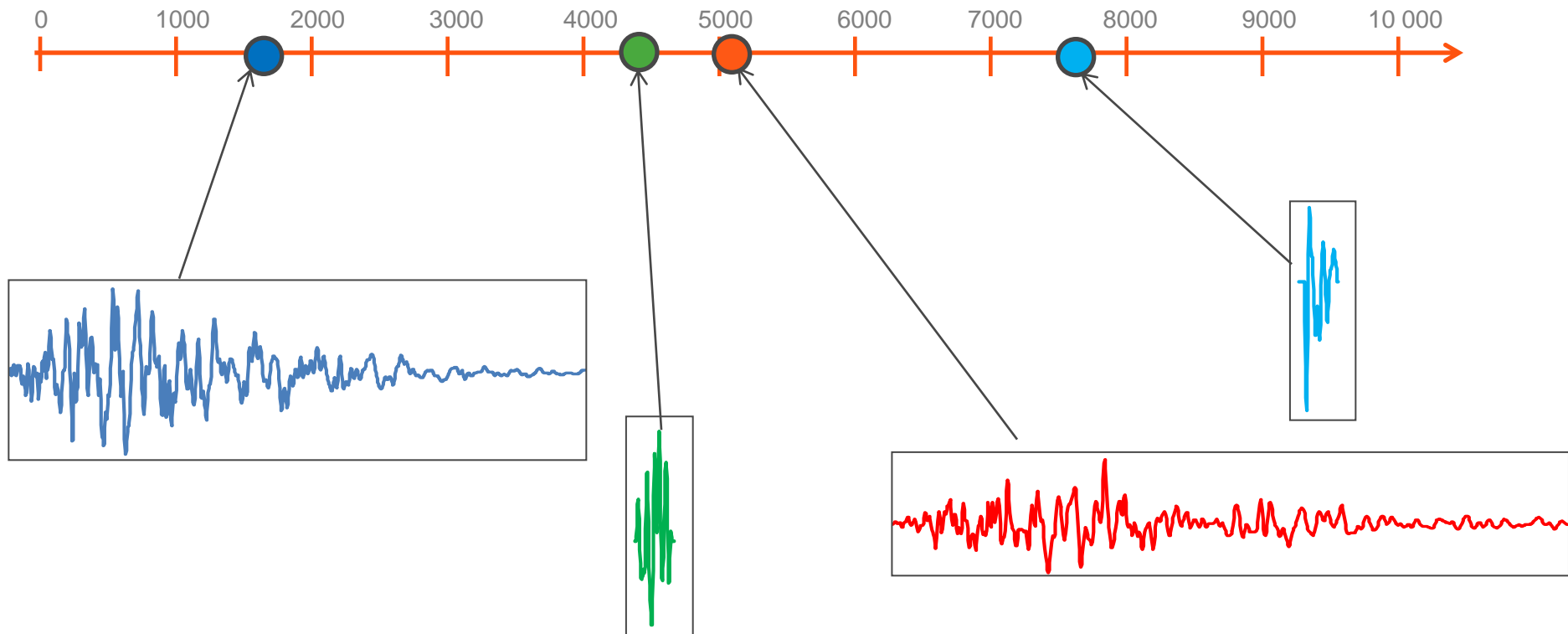
UHS is an aggregation of multiple scenarii

- Using it as an input motion in a computation is a methodological mistake



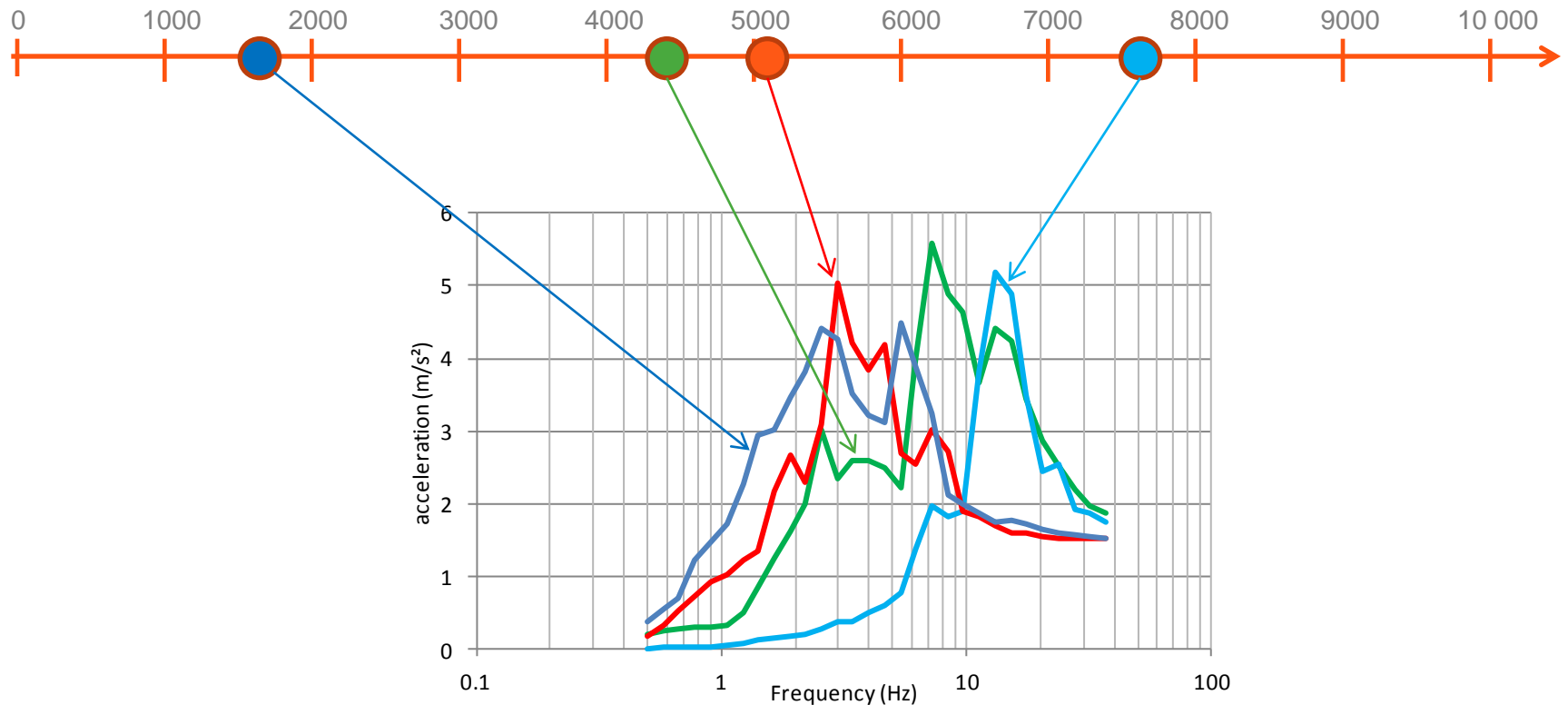
ISSUE 3: MISUSE OF THE UNIFORM HAZARD SPECTRUM

What is a UHS 10 000y ?



ISSUE 3: MISUSE OF THE UNIFORM HAZARD SPECTRUM

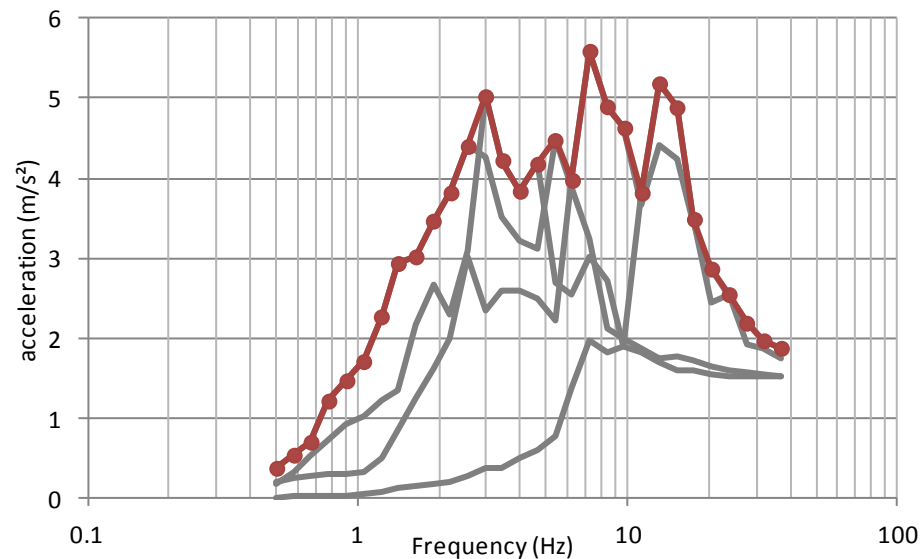
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ISSUE 3: MISUSE OF THE UNIFORM HAZARD SPECTRUM

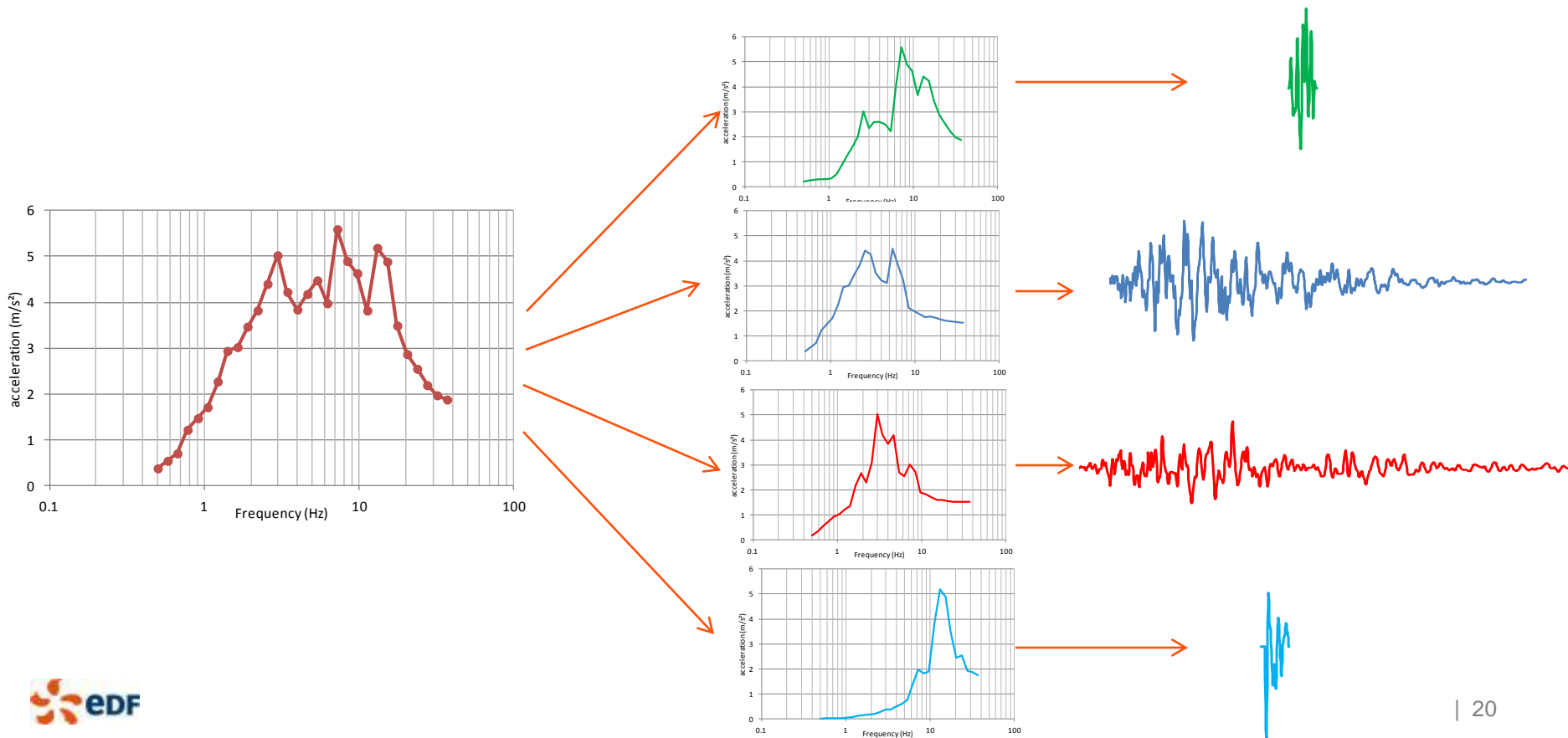
What is a UHS 10 000y ?

- Uniform hazard spectrum is not a unique event
 - Not possible to generate time histories on it
 - Spectral modal unrealistic (cumulation of modes is over-conservative!)



ISSUE 3: MISUSE OF THE UNIFORM HAZARD SPECTRUM

Need to divide again the Uniform Hazard Spectrum into physical scenariii!!



ISSUE N° 3: USING THE CONDITION SPECTRUM

- What is the expected improvement in using condition spectrum for DAMS?

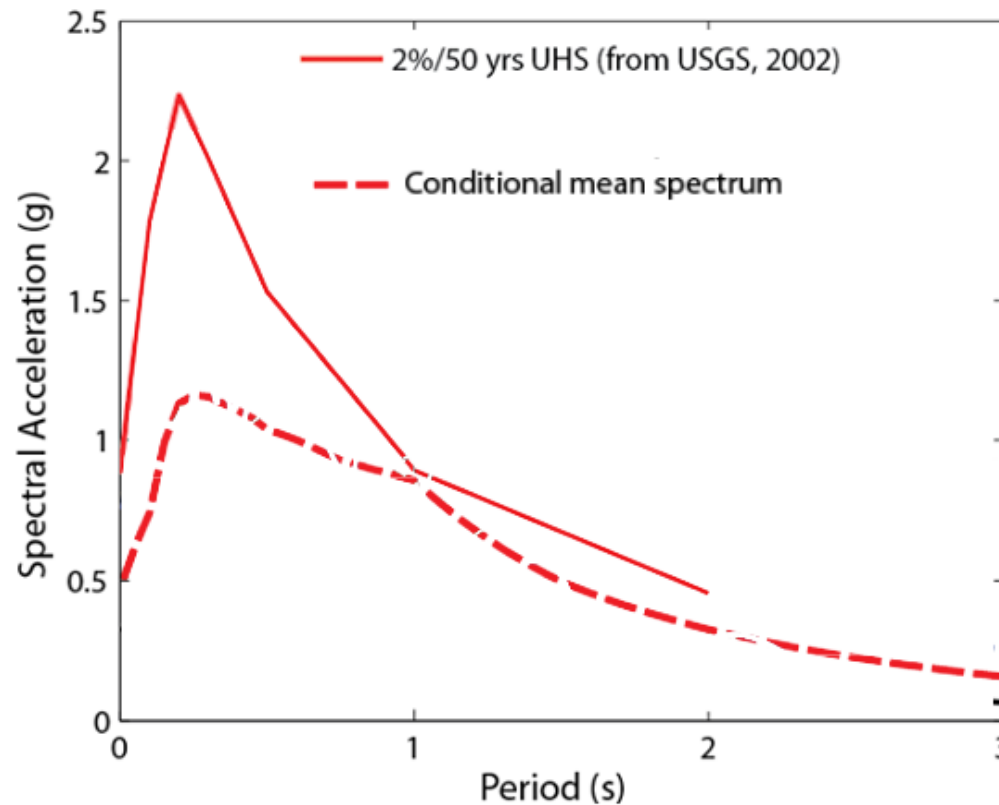
Using the Conditional Spectrum Method for Improved Fragility Assessment of Concrete Gravity Dams in Eastern Canada

Carl Bernier,^{a)} M.EERI, Ricardo Monteiro,^{b)} and Patrick Paultre,^{c)} M.EERI

The accurate estimation of fragility functions requires the proper selection of ground motion records at different intensity levels. However, most of the available fragility assessments of concrete dams use the same records at all intensity levels and often selects them with an inadequate target spectrum. In order to

ISSUE N° 3: USING THE CONDITION SPECTRUM

- What is the expected effect of using condition spectrum for DAMS?



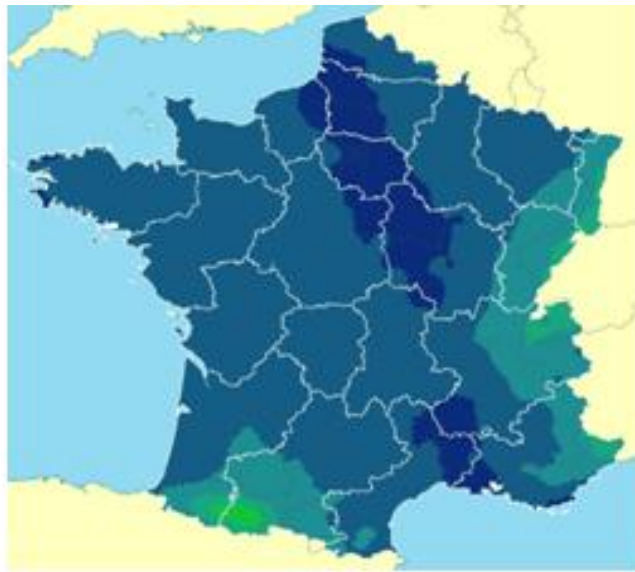
ISSUE N° 3: USING THE CONDITION SPECTRUM

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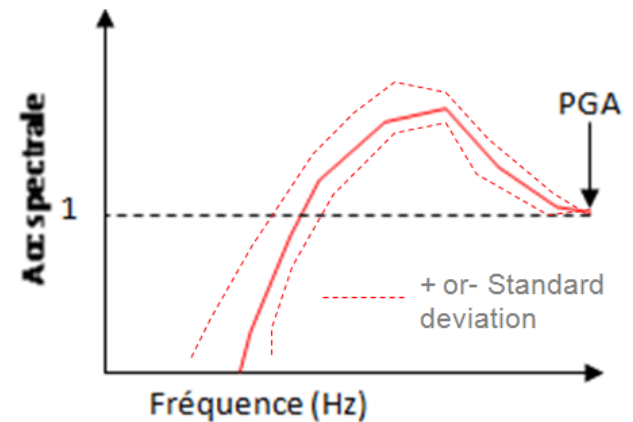
$S_a(T_1)$	Base sliding			
	Mean (mm)		Std. dev.	
	Method 1	Method 2	Method 1	Method 2
0.1 g	0.0	0.0	0.0	0.0
0.2 g	4.6	4.3	9.6	6.4
0.3 g	12.2	9.9	16.5	15.5
0.4 g	30.1	27.0	32.2	33.6
0.5 g	55.4	40.1	58.4	55.8
0.7 g	151.2	80.3	140.0	102.1
0.9 g	247.2	119.5	218.5	98.6

ISSUE N° 3: USING THE CONDITION SPECTRUM

- **Solution 1: Produce a map + a spectral shape consistent with a Condition spectrum**



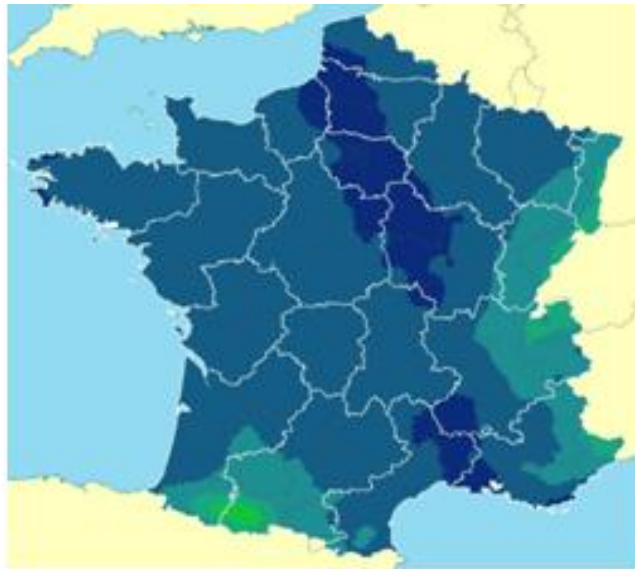
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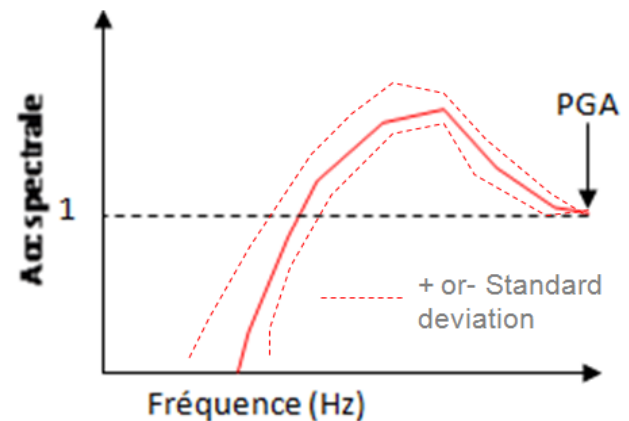
475 years motion

ISSUE N° 3: USING THE CONDITION SPECTRUM

- **Solution 2: Produce a map based on another parameter than PGA**
 - S(5Hz)
 - Housner intensity
 - JMA numerical intensity
- **A map (in PGA or else) AND a conditional spectrum**



+



CONCLUSION

- Objective: assess a new seismic hazard map for France,
- This map has to include the results of the 15 years of research,
 - Coherency of data (same magnitude scale for all data and attenuation)
 - More coherence of hypothesis with local observation: Bayesian inference
 - Provide a real 475 years input motion for computation: map + spectrum (condition spectrum)