ΣIGMA2

WP1:

FAULTS AND TECTONICS

« Seismotectonic models: how better understanding tectonic processes and characterizing faults in intraplate domain?»

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First Symposium

November 28th, 2017

Motivations

- Different alternatives in building seismotectonic models for PSHA studies:

Seismotectonic models	Inputs	
Zones	Geology, Geophysics, Tectonics, and seismicity	WP1
Faults	Geometry (surface and depth), kinematic, velocity, age of last movement	WP1
Zoneless	Accurate seismicity catalogue that covers bith historical and instrumental scales	WP2

- Climatic processes tend, in intraplate regions characterized by low deformation rates, to erase potential tectonic markers ➔ **large epistemic uncertainties associated with tectonics information introduced in SHA studies**.

➔ **WP1 objectives**:

- Understanding the stress modulation on fault planes
- Improving knowledge of fault quaternary tectonic behaviour

in intraplate domains

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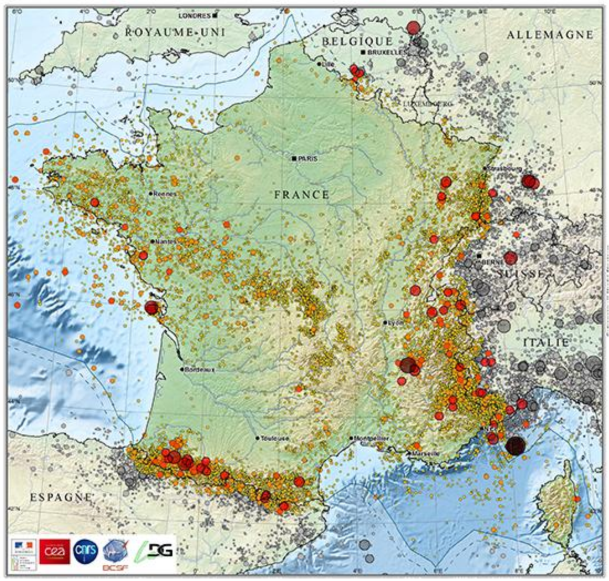
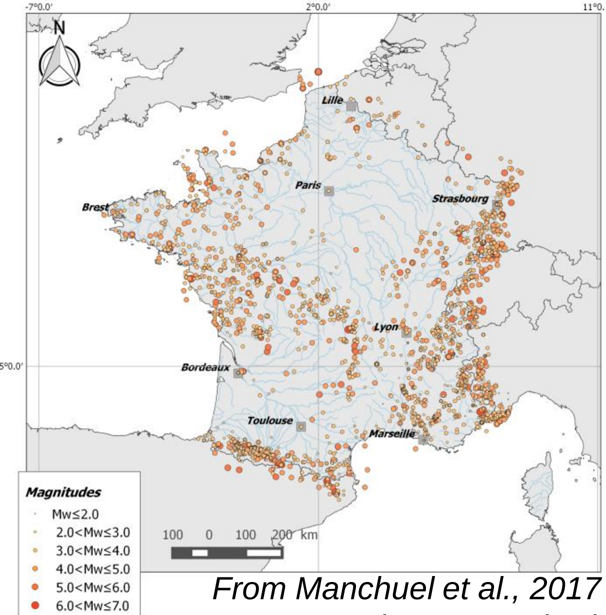
Available data and questions
(example of the French metropolitan territory)

Sismicité Instrumentale de l'Hexagone 1962-2009



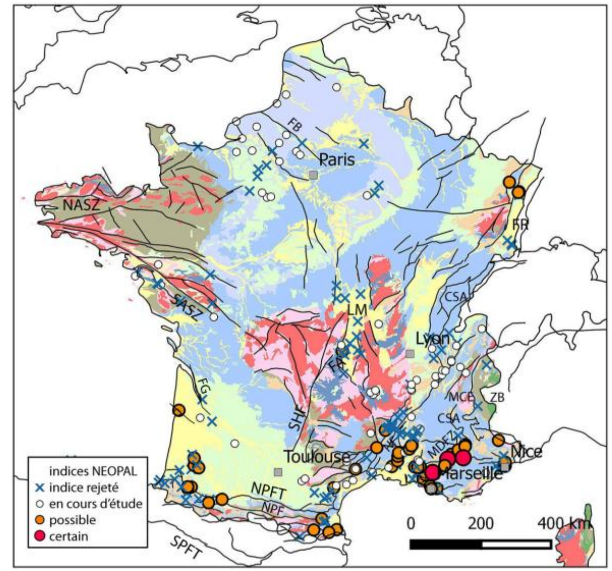
Cara et al., 2015

The French seismic CATalogue (FACT-17) [Historical part 463-1964]



From Manchuel et al., 2017 (SIGMA project)

Neotectonic indices (NEOPAL Database - BRGM)



Bertran et al., 2016 (SINAPS@ project)

- Significant spatial variability of the seismicity, stable over instrumental and historical periods

➢ Representative of stress build up? Of stress release? Consistent with location of very long term seismicity?

Available data and questions
(example of the French metropolitan territory)

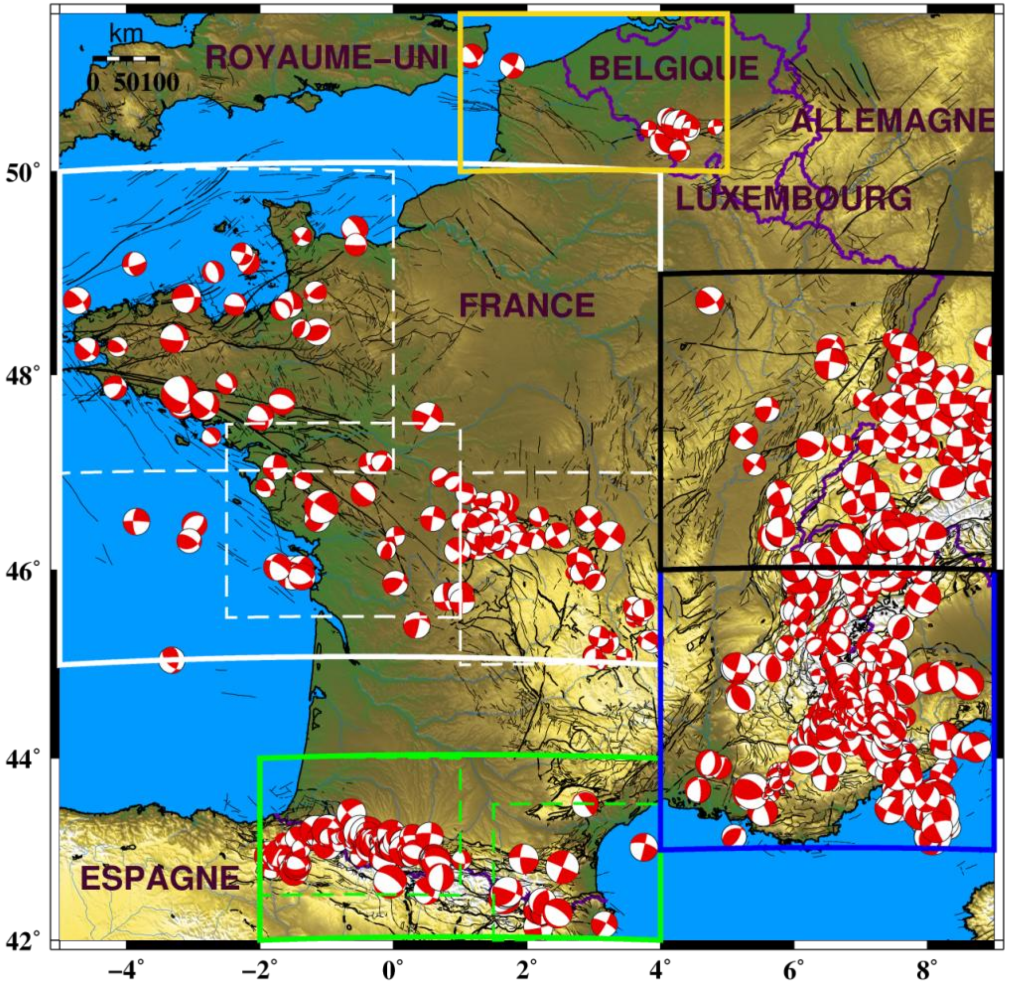
- In the meantime, **high disparities** remain associated to the instrumental seismicity:
  - in term of average depths
  - in term of focal mechanisms

➢ Is this picture traduces the structural inheritage of the crust?

➢ Can we use it as a key to understand seismicity engines:

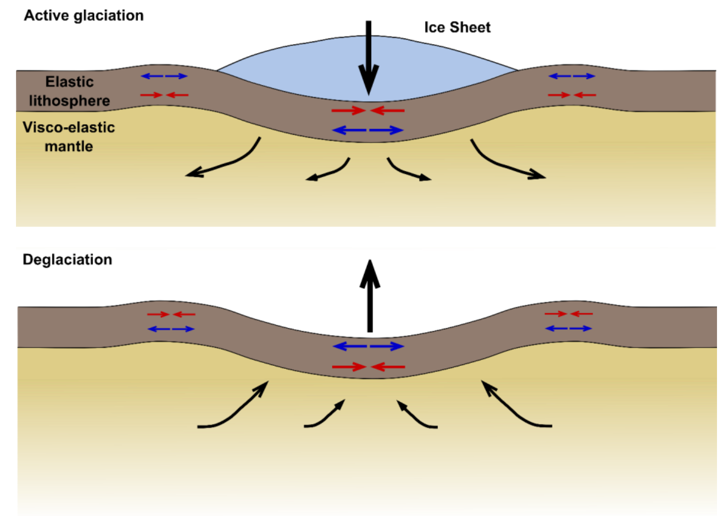
- Regional tectonics
- Fluids impacts
- Induced and triggered seismicity
- Surface loads

Focal mechanisms database



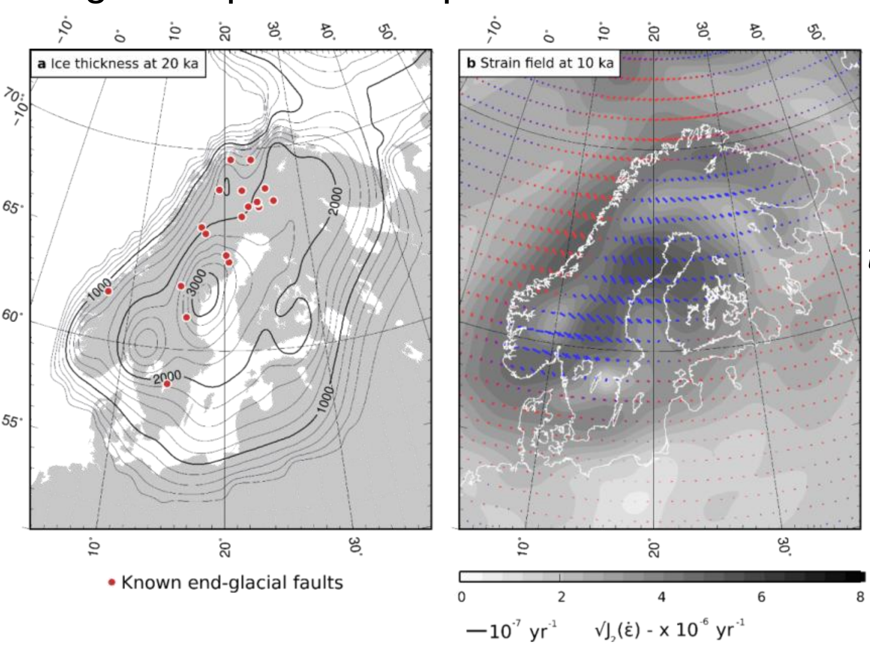
Bollinger 2017 (SINAPS@ plenary meeting)

Available data and questions



▪ Crustal stress changes induced by surface masses redistribution can load existing fault systems pushing them to the point of failure, or can change the stresses preventing failure on already loaded faults.

➔ Evidence for the release of long-term tectonic strain stored in continental interiors through large intraplate earthquakes



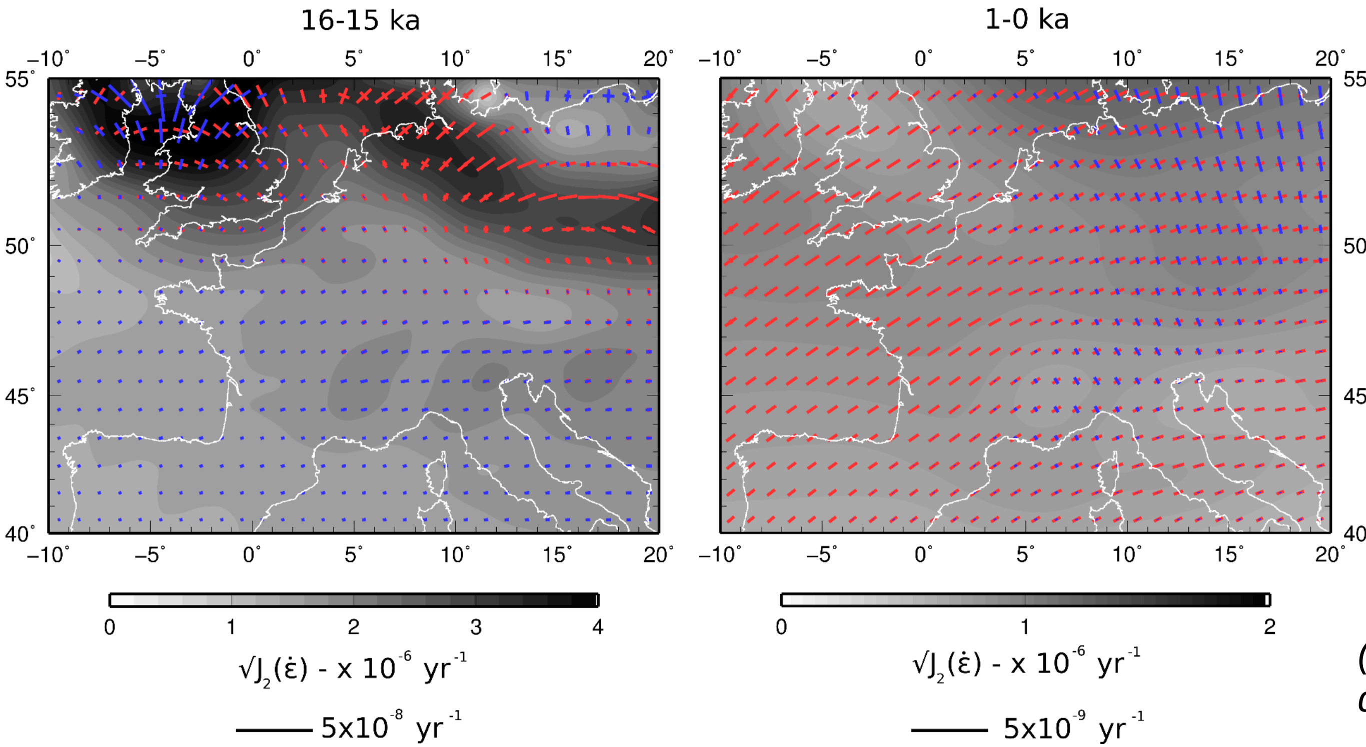
(Horizontal strain rate tensor – blue= extension; red= compression)

Stuoragurra Fault scarp (after Dehls et al., 2000)

From Craig et al., (2016) – SINAPS@ project

Available data and questions

- Despite its distance to Fennoscandia, western Europe is also affected by climatically derived strain waves during the Quaternary



(Horizontal strain rate tensor – blue= extension; red= compression)

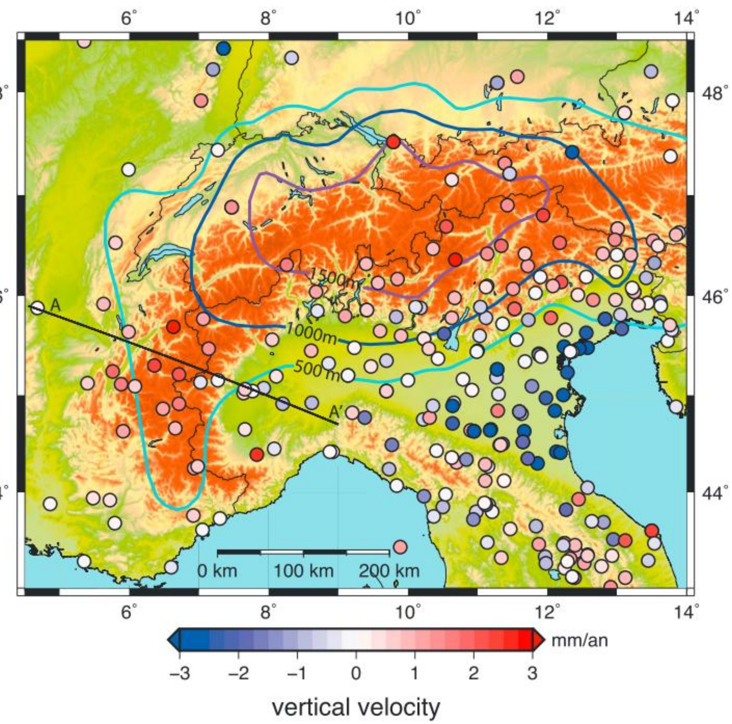
(Second invariant of the deviatoric strain rateTensor)

Craig et al., (2016) – SINAPS@ project

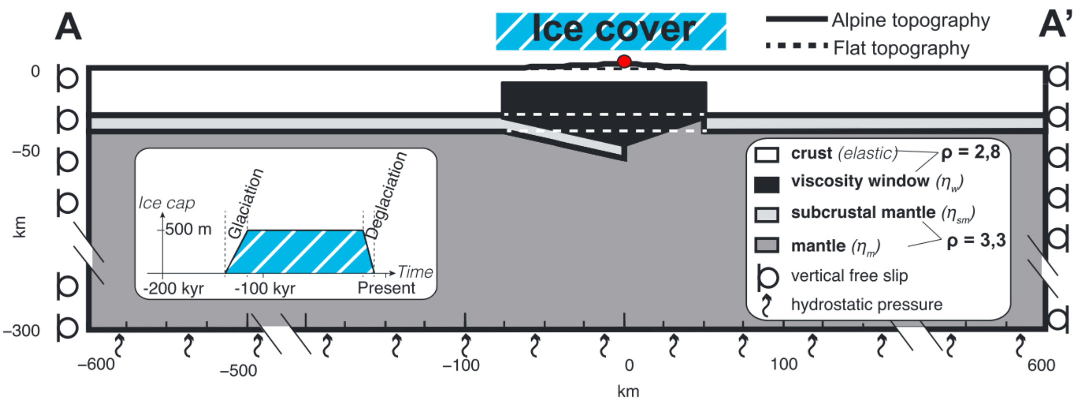
Available data and questions
(example of the French metropolitan territory)

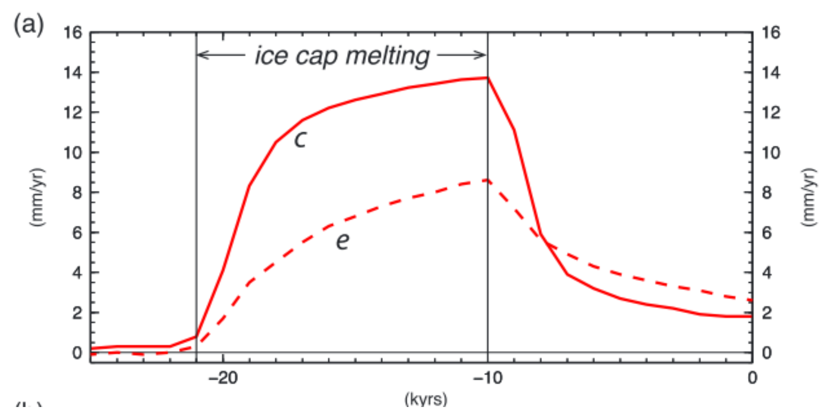
- Various hypothesis [Lyon-Caen, 1989; Gudmundsson, 1994; Champagnac, 2009] proposed to explain geodetic uplift in inner Alps [Schaer and Jeanrichard, 1974; Serpelloni et al., 2013] .

➔ Numerical modeling (Chéry et al., 2016) argue in favor of the post-glacial rebound as the main engine for the observed geodetic uplift (need for a weak mantle beneath the Alps).



Chéry et al., 2016





SIGMA2 approach

- Understanding tectonic processes in intraplate domains

  - **DEFORM_3D program (Geosciences Montpellier)**

    - Updated map of deformation rates from GPS data (France scale) + 3D numerical modeling of southern France integrating deglaciation, erosion and deep structures geometry (C. Masson, PhD);

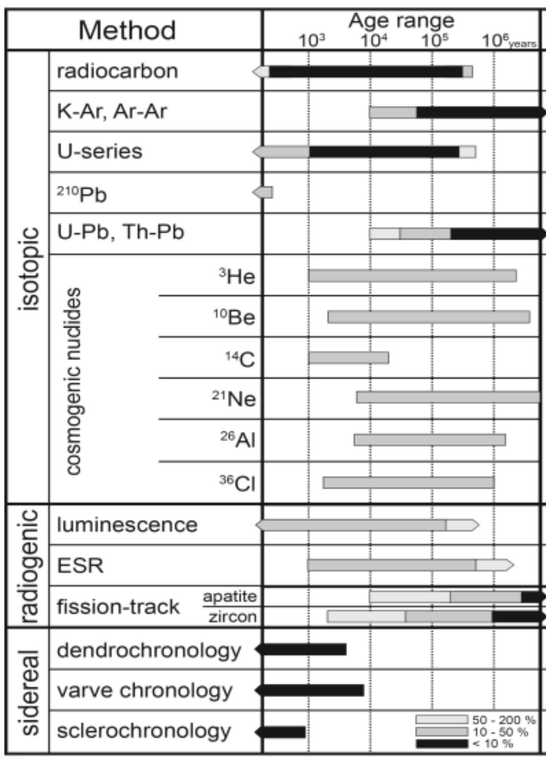
    - ***Characterization of erosion rates in Pyrenees and Cevennes regions (objective= provide constraints to erosional forcing in numerical models);***

    - Development of theoritical models integrating rheological variations traducing structural inheritance + integration in numérical models forced by regional tectonic stresses (A. Tarayoun, PhD);

    - ***3D numerical modeling of western Europe integrating main tectonics structures and large set of forcing. Confrontation with seismicity (Postdoc, 2018-2020)***

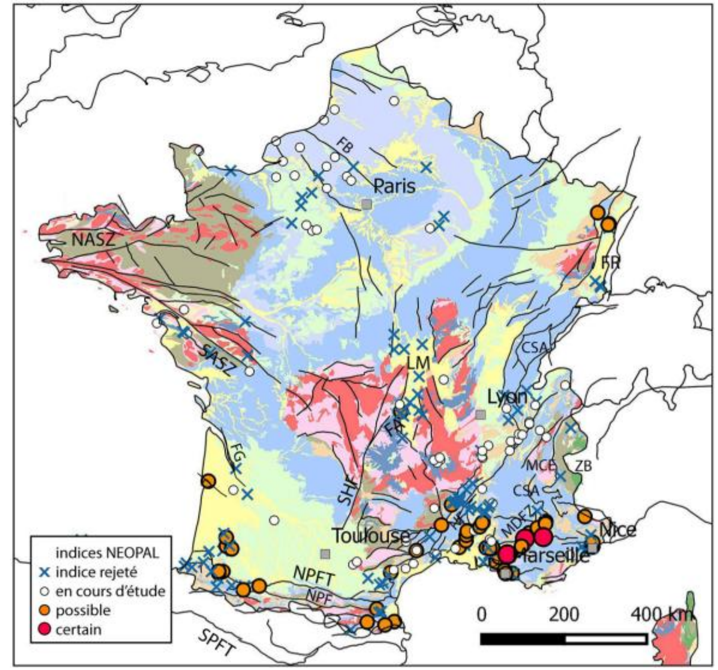
SIGMA2 approach

- Expand the temporal coverage of the neotectonic indices to make the difference between alternative models + lack of holocene markers (impact of climatic cycles)
    - ➢ Have a look on dating techniques that allow resolving the timing of the tectonic and climatic events on larger time span



IAEA-TECDOC-1767

Neotectonic indices (NEOPAL Database - BRGM)



Bertran et al., 2016 (SINAPS@ project)

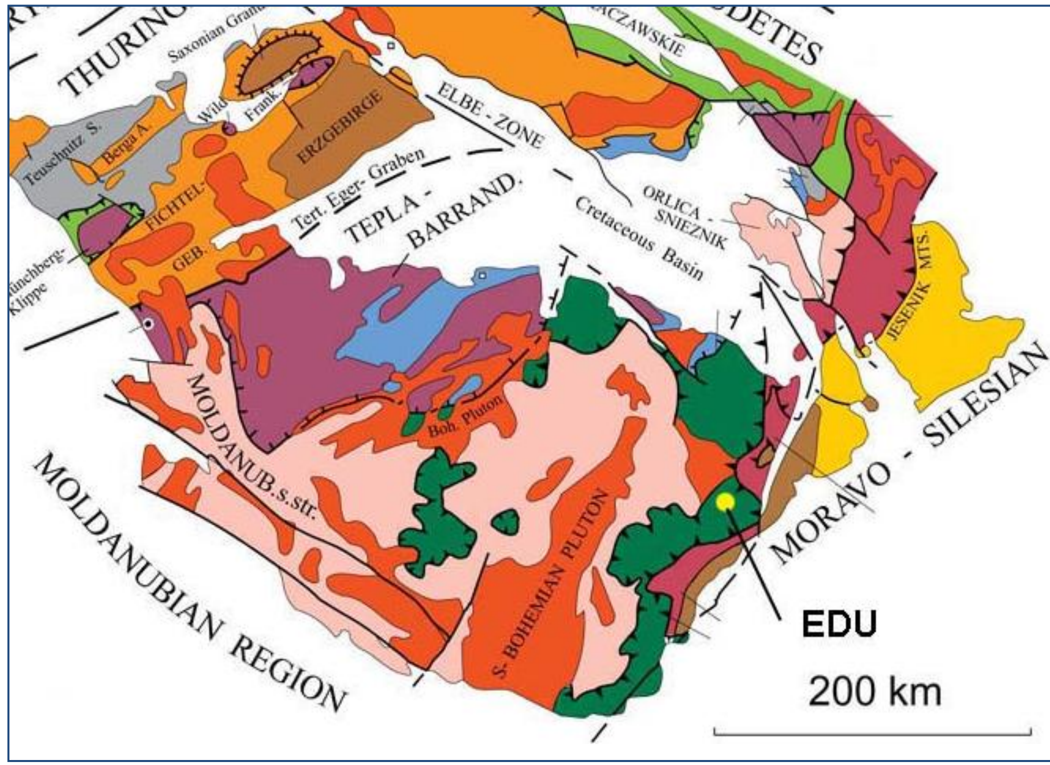
Organizing a workshop on dating techniques to estimate/constrain age of faulting

SIGMA2 approach

- Faults identification and characterization

➢ Developping procedures for faults identification and parametrization of potentially seismogenic faults in areas with low seismicity

- Development of a database of active faults for the Bohemian Massif
- Field research (reconnaissance surveys and mapping, shallow geophysics, minor trenching, fault gouge research,…)
- Development of «Guidelines » for detecting active and potentially active seismogenic faults in areas with low seismicity and characterization of zones with diffuse seismicity
- Integration of results in PSHA

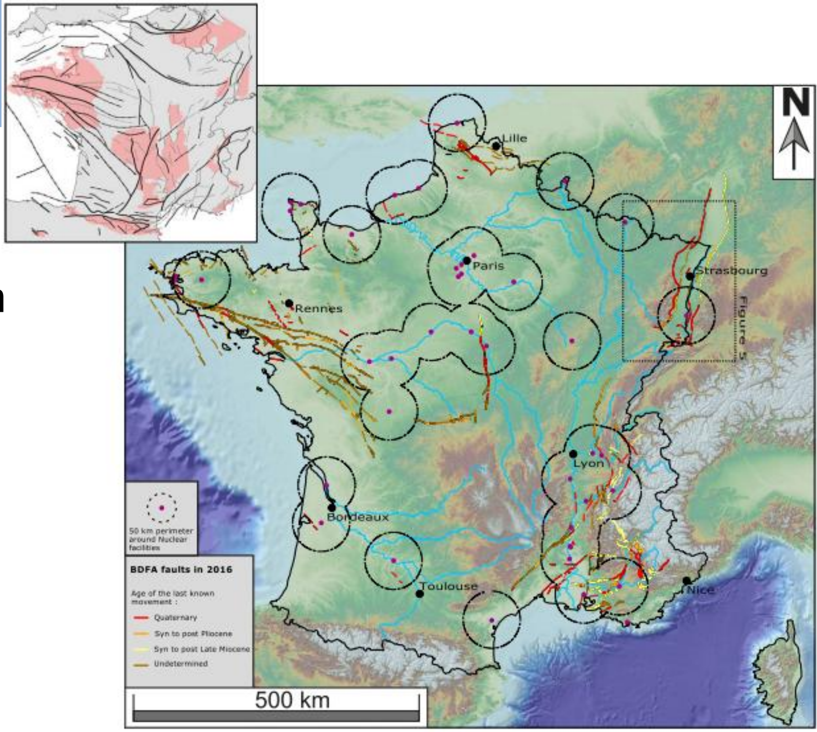


[Prachař, SIGMA2 Kick-off meeting – 06/02/2017]

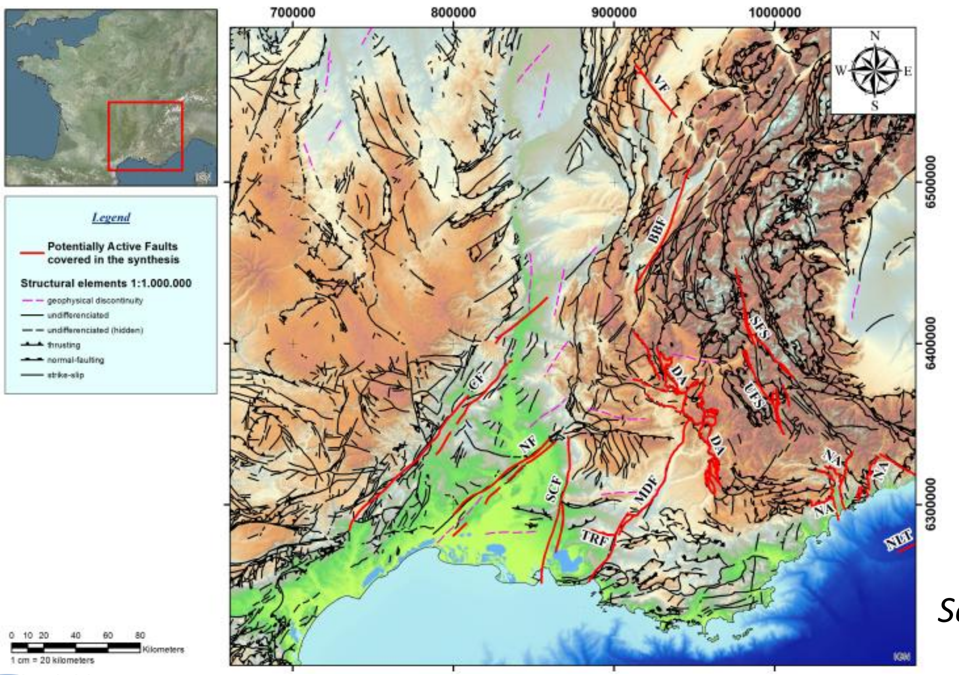
What about a french faults database ?

- Regional or localized information about faults stored in different studies/databases

➔ Lack of a unified database of potentially active faults at the scale of the whole french metropolitan territory



Jomard et al., 2017 - BDFA



Sengelen et al., 2014 – SIGMA project

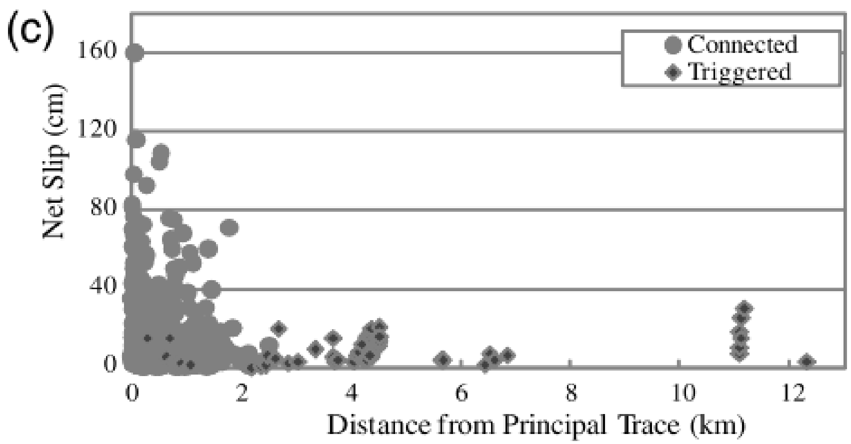
SIGMA2 approach

PFDHA (Probabilistic Fault Displacement Hazard Assessment) deals with evaluating potential surface fault displacement due to faulting events in a probabilistic manner.

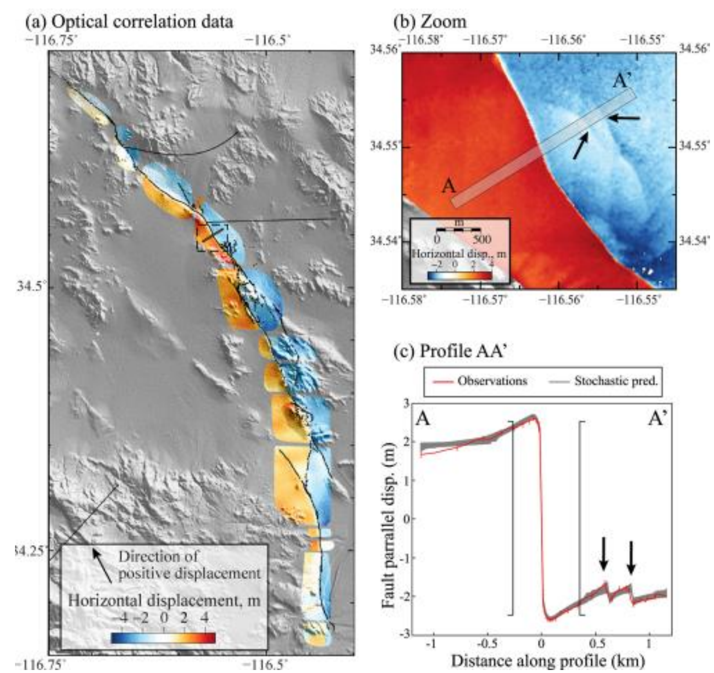
$$\nu(d) = \alpha \int_{m_0}^{m_{max}} \int_0^{\infty} f(m) f(r|m) P(D > d|m,r)\, dr\, dm$$

Slip exceedance term

- Reducing the magnitude range of application ;
- Sensitivity analysis of results according to the level of knowledge for a fault;
- Dealing accurately with secondary ruptures off main-faults



Petersen et al., 2011



Gombert et al., 2018

Conclusions

« <u>Seismotectonic models</u>: how better understanding tectonic processes and characterizing faults in intraplate domain?»

Low deformation rates + **Climatic cycles**

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Tectonic signal potentially released

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Epistemic uncertainty introduced in PSHA studies through seismotectonic models

- Understanding crustal deformation engines;
- Improving tectonic and climatic episodes dating;
- Identification and parametrization of faults at a regional scal (Bohemian Massif)
- PFDHA approach

THANK YOU

Image thèse billant
Travaille SINAPS@ périglaciaire