Characteristics and possible origins of the seismicity in northwestern France

É. Beucler, M. Bonnin, C. Hourcade, B. Van Vliet-Lanoë, C. Perrin, L. Provost, A. Mocquet, J. Battaglia, L. Geoffroy, P. Steer, B. Le Gall, J.M. Douchain, D. Fligiel, P. Gernigon, B. Delouis, J. Perrot, S. Mazzotti, G. Mazet-Roux, S. Lambotte, M. Grunberg, J. Vergne, C. Clément, É. Calais, J. Deverchère, L. Longuevergne, A. Duperret, C. Roques, T. Kaci and C. Authemayou

eric.beucler@univ-nantes.fr

November 16, 2021
A polyphased geological setting

Faults & shearing zones
- observed and inferred major shear zones
- other faults
- Variscan front
- Bay of Biscay rift
- Cadomian suture zone
- Medio-European suture zone (Eo-Variscan)
- Lizard and Rheic suture zones (Variscan)

Structural and geological domains
- Mesozoic and Cenozoic sedimentary basins
- Proterozoic and Paleozoic metasedimentary and crystalline terrains
- Continental slope
- Abyssal plain
- Coastline

Field observations of faulting over the Quaternary (pre-historical)
- Mio-Pliocene faulted basins
- volcanic record
- rupture evidences
- cluster at 290-275 ka

Seismic profiles
- ARMOR 2
- ECORS
A polyphased geological setting

Beucler et al.

NW France seismicity

November 16, 2021
Historical data

565 events in SISFRANCE database (Jomard et al., 2021)
**Instrumental data**

1962-2020 dataset

- **1962-2009**: SI-Hex (Cara et al., 2015)
  - 6631 NW events vs 38028
  - \( (M_W \geq 2.5, 597/2591 \simeq 23\%) \)

- **2010-2020**: unified catalogue BCSF-\( \text{RéNaSS} + \)CEA
  - 2689 NW events vs 38048
  - \( (M_W \geq 2.5, 847/3326 \simeq 25\%) \)

Total: **9320** events in the northwestern part of France (including NW of Auvergne)

\( V_S \) model from (Gaudot et al., 2021)
Permanent seismic coverage evolution

Beucler et al.

NW France seismicity

November 16, 2021
Respective distributions of moment magnitudes for the western part (green) and for the rest of metropolitan France (orange) during two different time ranges. The green histograms are computed for a region comprised between 2° E and 6° W and 45.4° N and 50° N, using bins of 0.4.
Focal mechanisms

fmhex database (Mazzotti et al., 2021)

Beucler et al.

NW France seismicity

November 16, 2021 8
Toward a comprehensive catalog? 2-year of continuous seismic signal
Template matching + discrimination (see C. Hourcadc poster for ML implementation and details)
Discussion

Possible geodynamic factors controlling the seismicity

1. **Plate-scale stress field**
   Overall NW-SE orientation of the maximum horizontal stress and a general extensive to transtensive tectonic style with a NE-SW deviatoric tension

2. **Local and temporal stress modulations**
   Spatial variations of gravitational potential energy / isostatic adjustment to erosion and sedimentation / mechanical response to hydrological or meteorological transients / post-glacial adjustments / tides

3. **Tectonic and fault inheritance**
   Are earthquake locations compatible with known (active) faults? → back to the question about a comprehensive catalogue

Frequency: 0.4 → 1 event/day
Cara, M., Y. Cansi, A. Schlupp, P. Arroucau, N. Béthoux, É. Beucler, S. Bruno, M. Calvet, S. Chevrot, A. Deboissy, B. Delouis, M. Denieul, A. Deschamps, C. Doubre, J. Fréchet, S. Godey, O. Golle, M. Grunberg, J. Guilbert, M. Haugmard, L. Jenatton, S. Lambotte, D. Leobal, C. Maron, V. Mendel, S. Merrer, M. Macquet, A. Mignan, A. Mocquet, M. Nicolas, J. Perrot, B. Potin, O. Sanchez, J.-P. Santoire, O. Sèbe, M. Sylvander, F. Thouvenot, J. Van Der Woerd & K. Van Der Woerd (2015). “SI-Hex: a new catalogue of instrumental seismicity for metropolitan France”. Bull. Soc. Géol. France 186(1), 3–19, doi:10.2113/gssgfbull.186.1.3.

Gaudot, I., É. Beucler, A. Mocquet, M. Drilleau, M. Haugmard, M. Bonnin, G. Aertgeerts & D. Leparoux (2021). “3-D crustal VS model of western France and the surrounding regions using Monte Carlo inversion of seismic noise cross-correlation dispersion diagrams”. Geophys. J. Int. 224(3), 2173–2188, doi:10.1093/gji/ggaa552.

Jomard, H., O. Scotti, S. Auclair, P. Dominique, K. Manchuel & D. Sicilia (2021). “The SISFRANCE database of historical seismicity. State of the art and perspectives”. C. R. Geoscience, subm.

Mazzotti, S., C. Aubagnac, L. Bollinger, K. Oscanoa, B. Delouis, D. Paco, C. Doubre, M. Godano, H. Jomard, C. Larroque, A. Laurendeau, F. Masson, M. Sylvander & A. Trilla (2021). “FMHex20: An earthquake focal mechanism database for seismotectonic analyses in metropolitan France and bordering regions”. BSGF - Earth Sci. Bull. 192, 10, doi:10.1051/bsgf/2020049.