Improving the representation of apparent anelastic attenuation variability in regionalised Ground Motion Models in Europe with a focus in mainland France

Pauline Georges, Sreeram Reddy Kotha and Emmanuel Chaljub

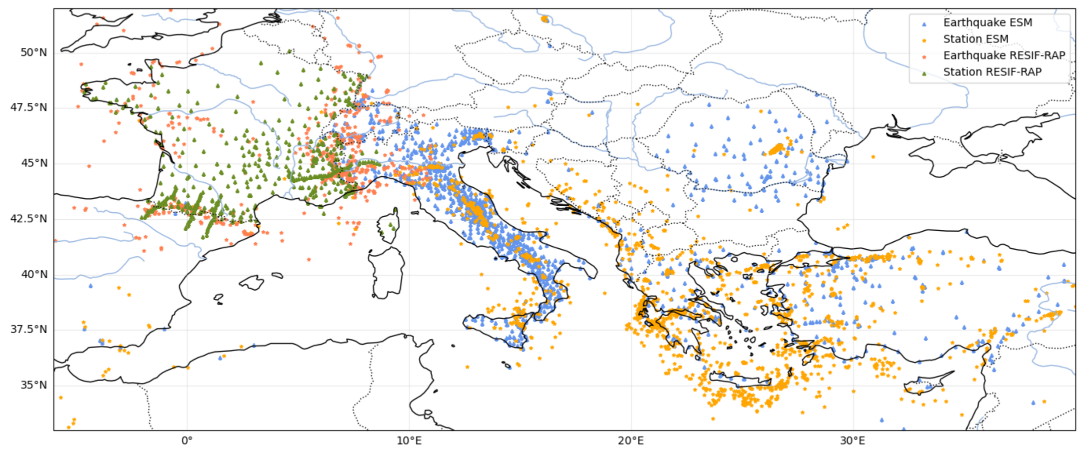
Univ. Grenoble Alpes, Univ. Savoie Mont Blanc, CNRS, IRD, Univ. Gustave Eiffel, ISTerre, 38000 Grenoble, France

Contact : pauline.georges@univ-grenoble-alpes.fr

Abstract

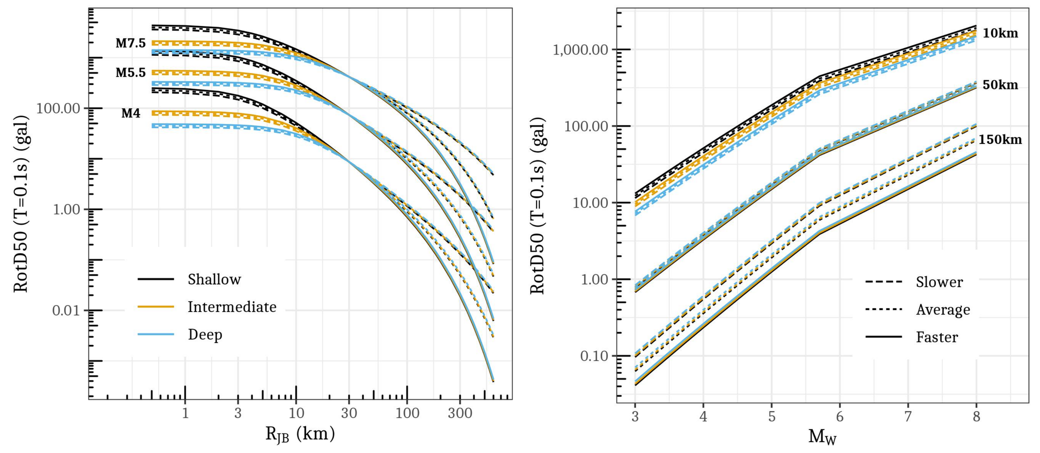
Context of the study and Methods

Ground motion records from shallow earthquakes in Europe



- Résif dataset for France
- ESM dataset for Europe
- 1459 earthquakes
- 2220 stations
- 34060 records of SA

A partially Non-Ergodic GMM for Euro-Mediterranean region



A global model with:
- Magnitude scaling
- Geometrical spreading
- Apparent anelastic attenuation

-> Fixed effect median for all Europe constrained with a linear mixed-effect regression from data

Limits of an ergodic GMM to regionalisation

- Fixed effect predictions are biased against poorly sampled region
- Large residual variabilities

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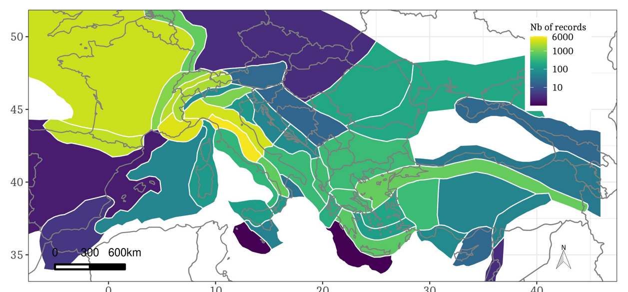
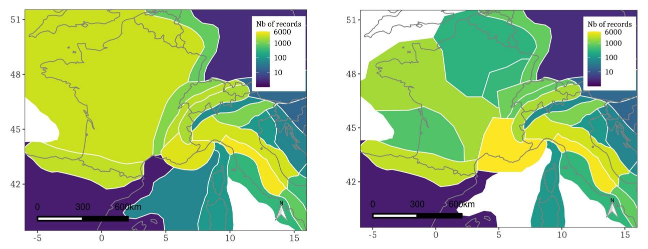
Regionalisation of GMM:
- site effect
- between event variability
- locality to locality variability
- Apparent anelastic attenuation variability

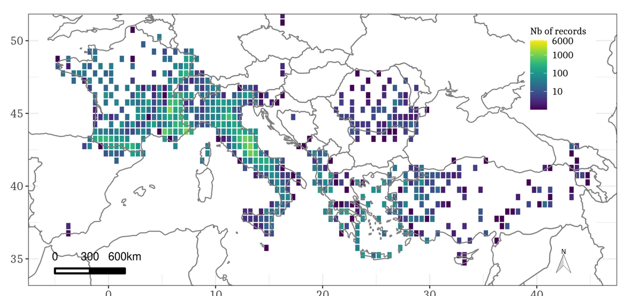
Regionalisation of apparent anelastic attenuation



Current Regionalisation used in ESHM20: model based on homogeneous tectonic processes region



Crustal properties-based regionalisation: Rayleigh wave group velocities for Metropolitan France

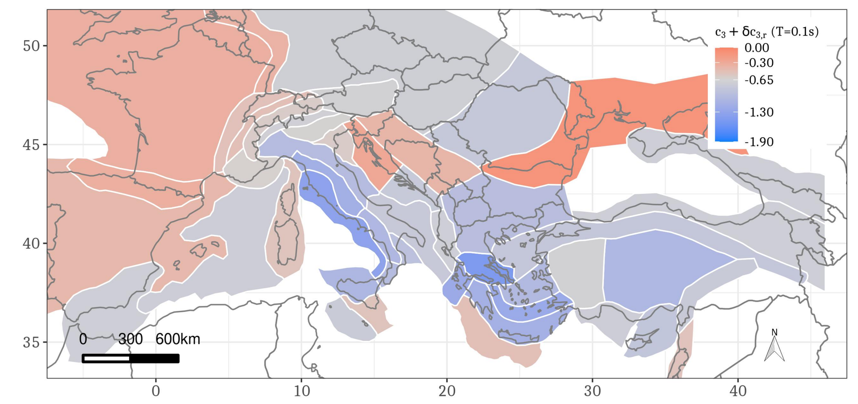


Null hypothesis based regionalisation: Regular Grid of size 0.5°*0.5°

Objectives:
- Evaluate the existing attenuation regionalisation underlying ESHM20
- Investigate the frequency/period dependence of attenuation regional variability
- Investigate the physical meaning of regional variability of attenuation in Ground-Motion Model (GMM)
- Develop an improved non-ergodic GMM for Europe

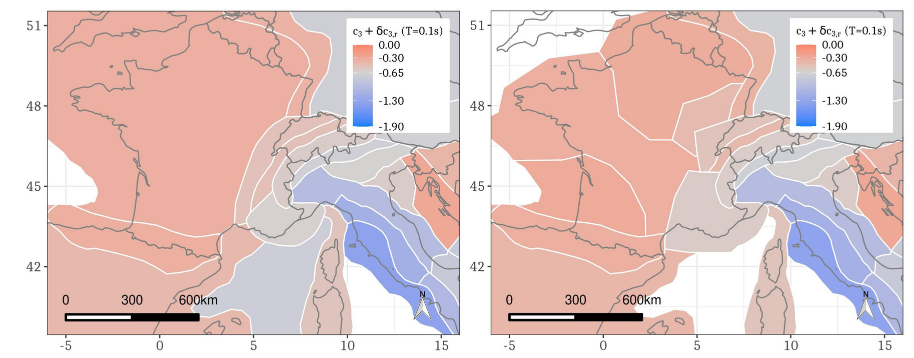
Results: Attenuation in Europe from various regionalisation

ESHM20 regionalisation



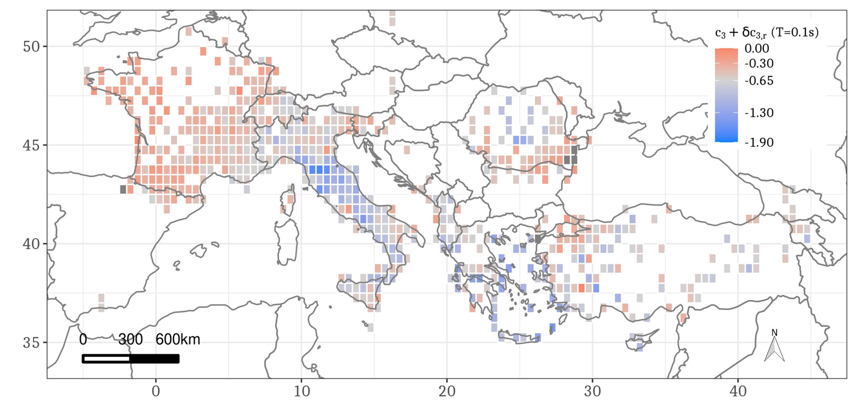
Variation of apparent anelastic attenuation in Europe
- Italy and Greece with stronger attenuation (weaker Ground-motion)
- France, Pyrenees and Alps with weaker attenuation
- AIC criteria (relative quality of statistical model): 69 247

Regionalisation from velocities



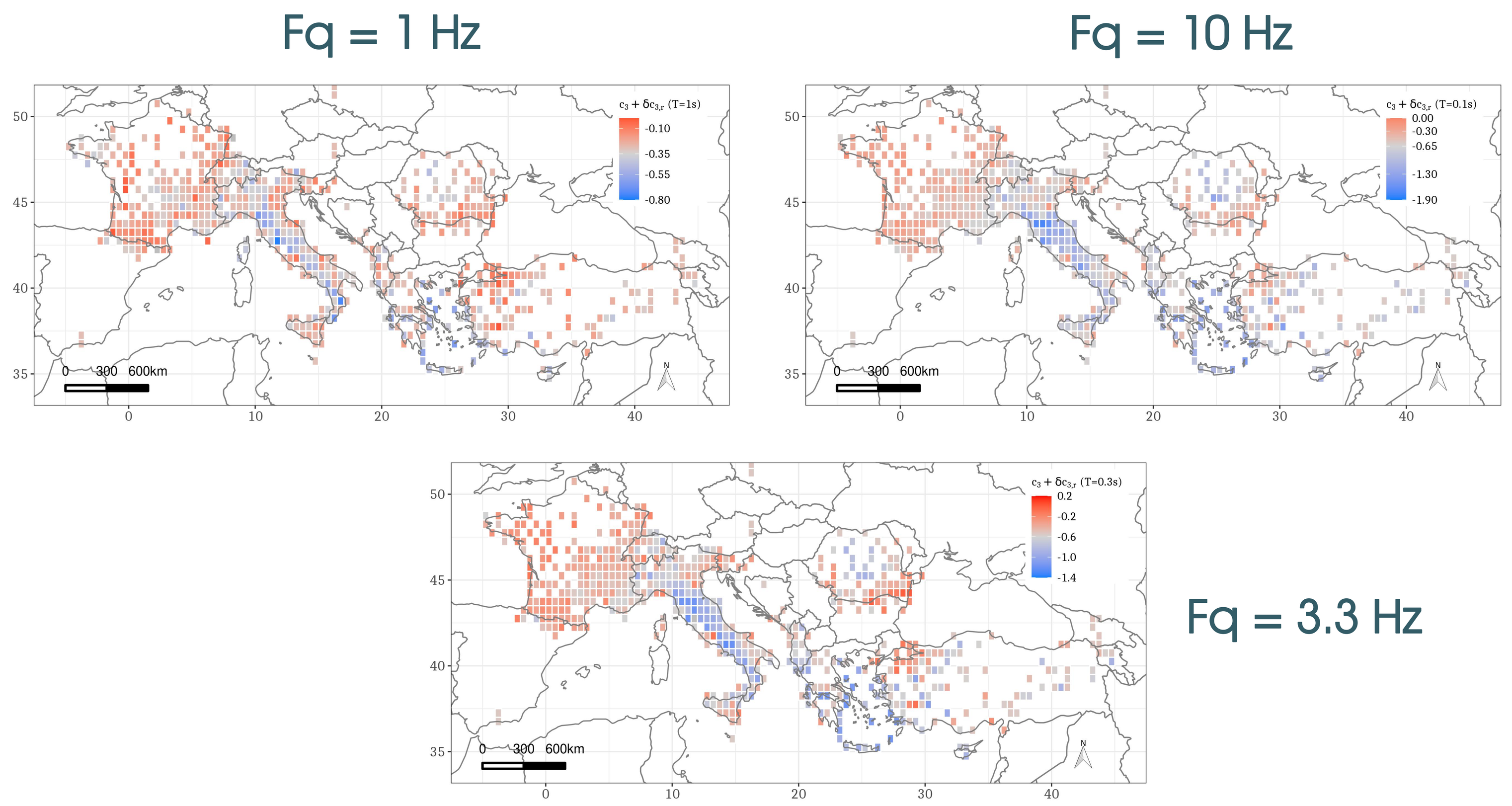
- Similar large-scale attenuation
- Highlight of intra-region variation of attenuation
- Similar average attenuation in two different regions
- AIC criteria: 69 337

Regionalisation as a Grid



- Purely data-driven - No data means no regional adjustments (e.g. Dinarides)
- More gradual variation in attenuation (e.g. Apennines)
- Greater data-driven attenuation variation (e.g. France)
- AIC criteria: 68 622

Frequency dependant variation in apparent anelastic attenuation



Frequency dependance of the attenuation:
- Stronger variation of attenuation at high frequency and stronger average attenuation at high frequencies
- Weaker attenuation in France than average value and stronger attenuation in the East part than in the West part
- Greece and Italy with stronger attenuation than the average value
- Strong small-scale variation of attenuation in the Alps

Possible correlation with the tomography of attenuation for France (Mayor et al. 2018)
Possible correlation of stronger attenuation with higher seismicity (Mitchell et al. 2008)

Take home message

Seismic hazard studies require precise and accurate (non ergodic) Ground-motion model. Due to heterogeneous geology and tectonics in Europe, regionalisation of predicted Ground-motion is necessary. In this study, we are focusing on creating homogeneous region in term of attenuation. Grid-based regionalisation presents a non a priori regionalisation with good frequency dependance, a better statistical model and smoother variations of attenuation. Those characteristics allow a good model to compare the attenuation with other crustal properties and improve the modelisation of attenuation. However, grid-based regionalisation is strongly data-driven. Without a reliable proxy parameter that explains grid-based attenuation variability, undersampled regions cannot have non-ergodic ground-motion predictions. Therefore, our next step is to evaluate the physical meaning of grid-based regionalisation.

References

Kotha, S.R., Weatherill, G., Bindi, D. et al. A regionally-adaptable ground-motion model for shallow crustal earthquakes in Europe. Bull Earthquake Eng 18, 4091–4125 (2020). https://doi.org/10.1007/s10518-020-00869-1

Mayor, J., Traversa, P., Calvet, M. et al. Tomography of crustal seismic attenuation in Metropolitan France: implications for seismicity analysis. Bull Earthquake Eng 16, 2195–2210 (2018). https://doi.org/10.1007/s10518-017-0124-8

Basili R et al. (2019) NEAMTHM18 Documentation: the making of the TSUMAPS-NEAM Tsunami 18 Hazard Model 2018

Mitchell, B. J., L. Cong, and G. Ekström (2008), A continent-wide map of 1-Hz Lg coda Q variation across Eurasia and its relation to lithospheric evolution, J. Geophys. Res., 113, B04303, doi:10.1029/2007JB005065.

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting Linear Mixed-Effects Models Using lme4. Journal of Statistical Software, 67(1), 1–48. https://doi.org/10.18637/jss.v067.i01