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Reducing differences in earthquake activity rate estimates across borders in Europe

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Abstract

Earthquake activity rates estimated in cross-border regions can differ between countries. For example, considering the FCAT or CPTI15 catalogues in the Italian and French Alps, earthquake activity rates can differ from 20 to 80% depending on the magnitude bin. This study aims at answering the following question: how much of the difference in the annual seismicity rates in the Alps cross-border region is due to different methodologies used to compute historical earthquake magnitudes?

To answer this question, we built two new historical (pre-1980) parametric earthquake catalogues for this region considering a common post-1980 earthquake catalogue based on the CPTI15. To focus on methodological differences, it was necessary to first build a common macroseismic and instrumental magnitude dataset to calibrate the two methodologies considered, namely Boxer and QUake-MD. We then applied the two methodologies to the same macroseismic dataset to build the two new historical (pre-1980) parametric earthquake catalogues. Finally, we computed earthquake rates for the two catalogues and found them to be statistically similar. This exercise underlines that reducing existing differences in seismic activity rate estimates across border regions will necessarily require a common definition of instrumental magnitudes and a common macroseismic dataset.

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References

- Manchuel, K., P. Traversa, D. Baumont, M. Cara, E. Nayman, and C. Durouchoux (2018). The French seismic CATalogue (FCAT-17). *Bull. Earthq. Eng.* 16, no. 6, 2227–2251, doi:10.1007/s10518-017-0236-1.
- Rovida, A., M. Locati, R. Camassi, B. Lollini, and P. Gasperini (2020). The Italian earthquake catalogue CPTI15. *Bull. Earthq. Eng.* 18, no. 7, 2953–2984, doi:10.1007/s10518-020-00818-y.
- Stucchi, M., A. Rovida, A. A. Gomez Capera, P. Alexandre, T. Camelbeeck, M. B. Demircioglu, P. Gasperini, V. Kouskouna, R. M. W. Musson, M. Radulian, et al. (2013). The SHARE European Earthquake Catalogue (SHEEC) 1000–1899. *J. Seismol.* 17, no. 2, 523–544, doi:10.1007/s10950-012-9335-2.
- Gasperini, P., G. Vannucci, D. Tripone, and E. Boschi (2010). The Location and Sizing of Historical Earthquakes Using the Attenuation of Macroseismic Intensity with Distance. *Bull. Seismol. Soc. Am.* 100, no. 5A, 2035–2066, doi:10.1785/0120090330.
- Provost, L., and O. Scotti (2020). QUake-MD: Open-Source Code to Quantify Uncertainties in Magnitude–Depth Estimates of Earthquakes from Macroseismic Intensities. *Seismol. Res. Lett.* 91, no. 5, 2520–2530, doi:10.1785/0220200064.
- Albarelo, D., R. Camassi, and A. Rebez (2001). Detection of space and time heterogeneity in the completeness of a seismic catalog by a statistical approach: An Application to the Italian Area. *Bull. Seismol. Soc. Am.* 91, no. 6, 1694–1703, doi:10.1785/0120000058.
- Weichert, D., H. (1980). Estimation of the earthquake recurrence parameters for unequal observation periods for different magnitudes. *Bull. Seismol. Soc. Am.* 70, no. 4, 1337–1346.

Introduction

Computing activity rates may differ when using different catalogues, especially along border regions. This is the case at the France/Italy border, in the Alps area where three catalogues are available : FCAT [1], CPTI [2] and SHARE [3] catalogues. In this area, activity rates are mainly based on historical earthquakes.

Possible origins for differences :

- macroseismic data used
- data used to calibrate the methodologies
- Methodology used

We investigate here the influence of using different methodologies to estimate magnitude for historical earthquakes on activity rates

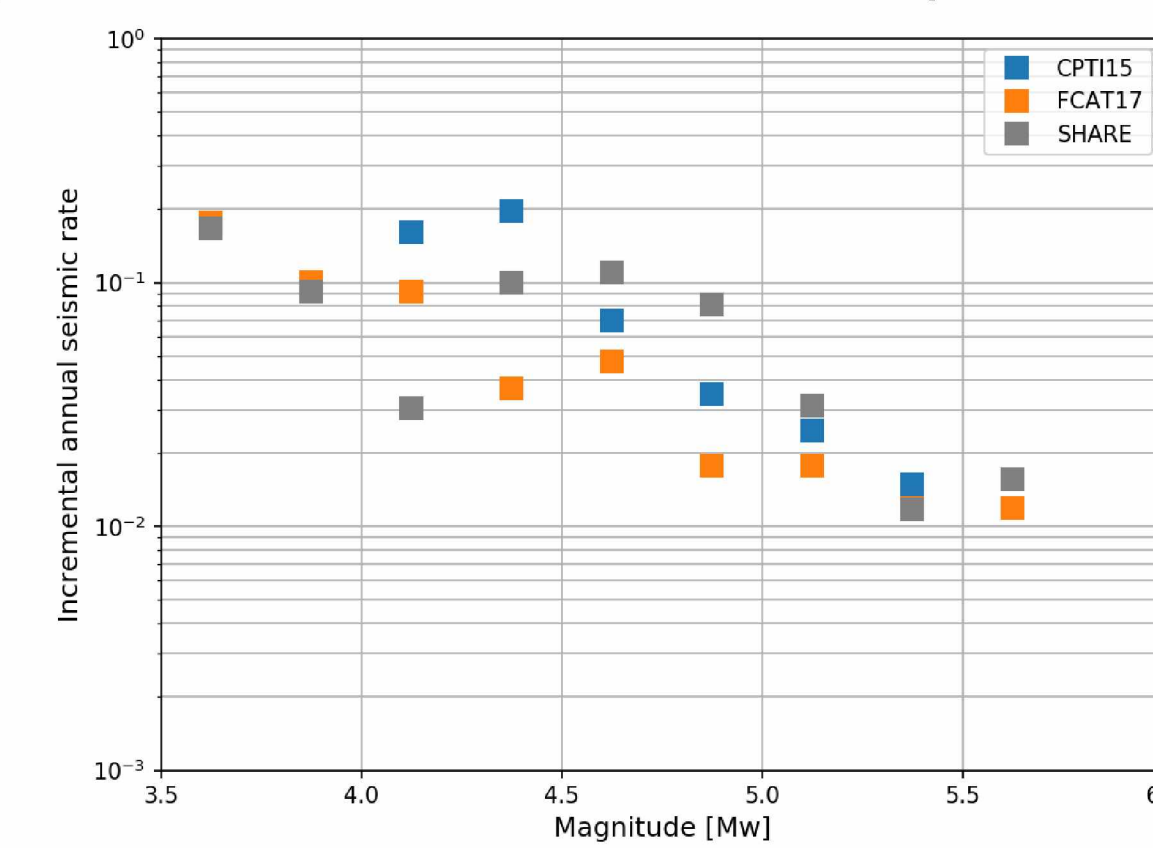


Figure 1. Activity rates for SHARE, CPTI15 and FCAT catalogues at the France/Italy border.

Methods and Materials

We calibrate Boxer [4] and QUake-MD [5] methodologies on the same data, i.e. same macroseismic intensity data points and same calibration event parameter (Magnitude/depth). Both methodologies are applied to the same macroseismic data at the France/Italy border (blue-violet polygon on Fig.2) to obtain a Boxer and a QUake-MD catalogue.

Completeness times (CT) are computed with Albarello et al 2001 algorithm [6]. The more recent CT between the two catalogues is used for each magnitude bin to compute activity rates.

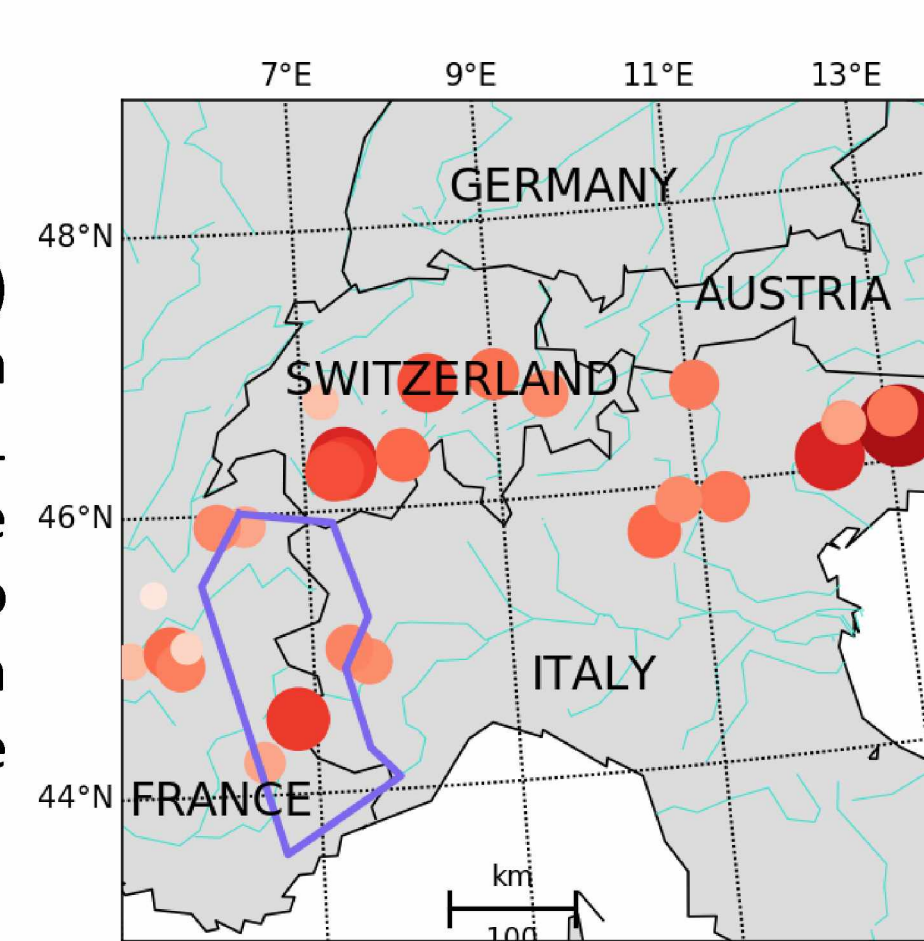


Figure 2. Calibration dataset (28 earthquakes) and area used to compute activity rates (blue-violet polygon).

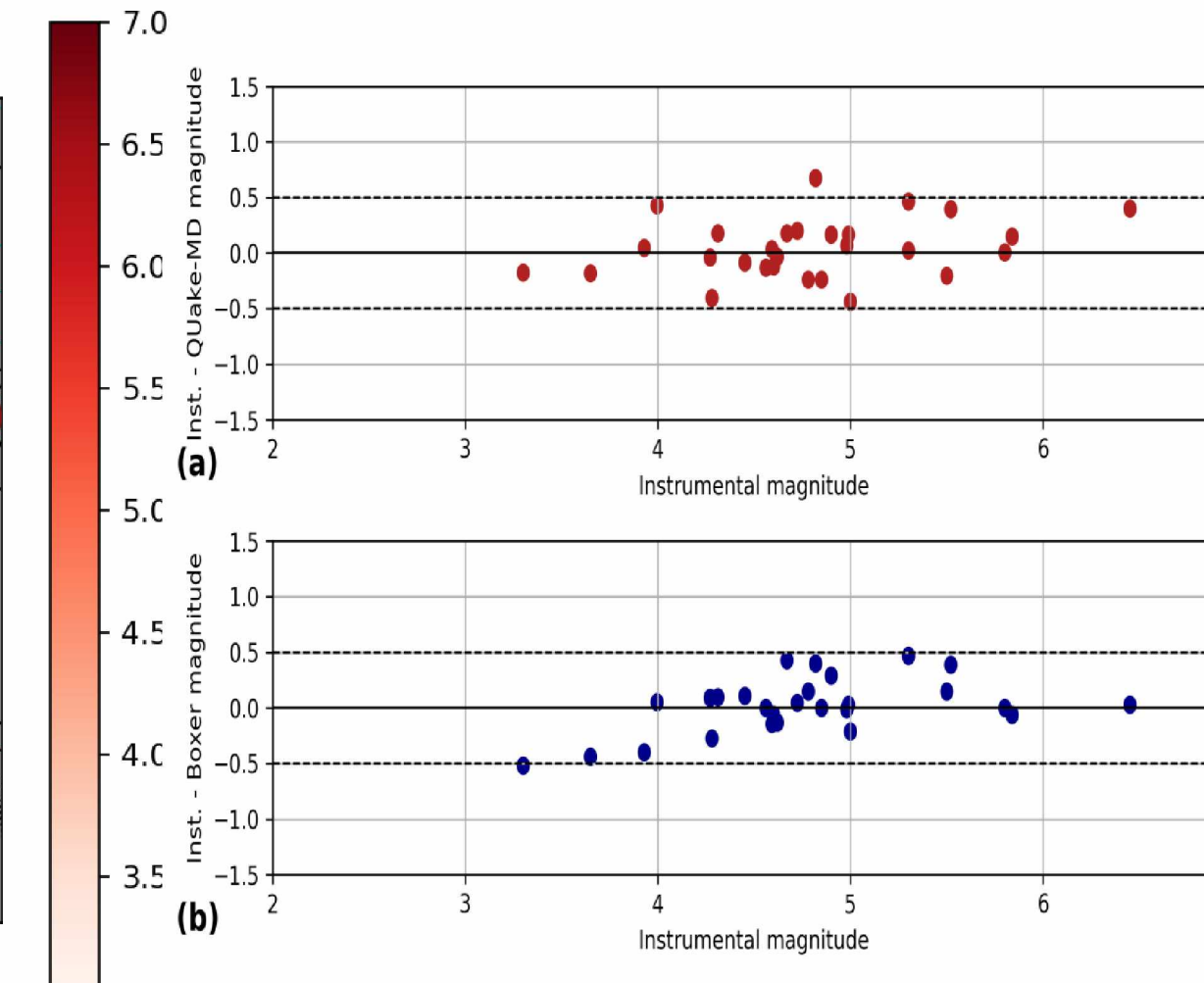


Figure 3. QUake-MD (a) and Boxer (b) magnitude residual on the calibration database.

Results

Activity rates for both Boxer and QUake-MD catalogues are similar. Some differences are observed at higher magnitudes and are within the activity rates uncertainties [7]. The differences observed between Boxer and QUake-MD catalogues are significantly smaller than the differences observed between CPTI15, FCAT and the SHARE catalogues.

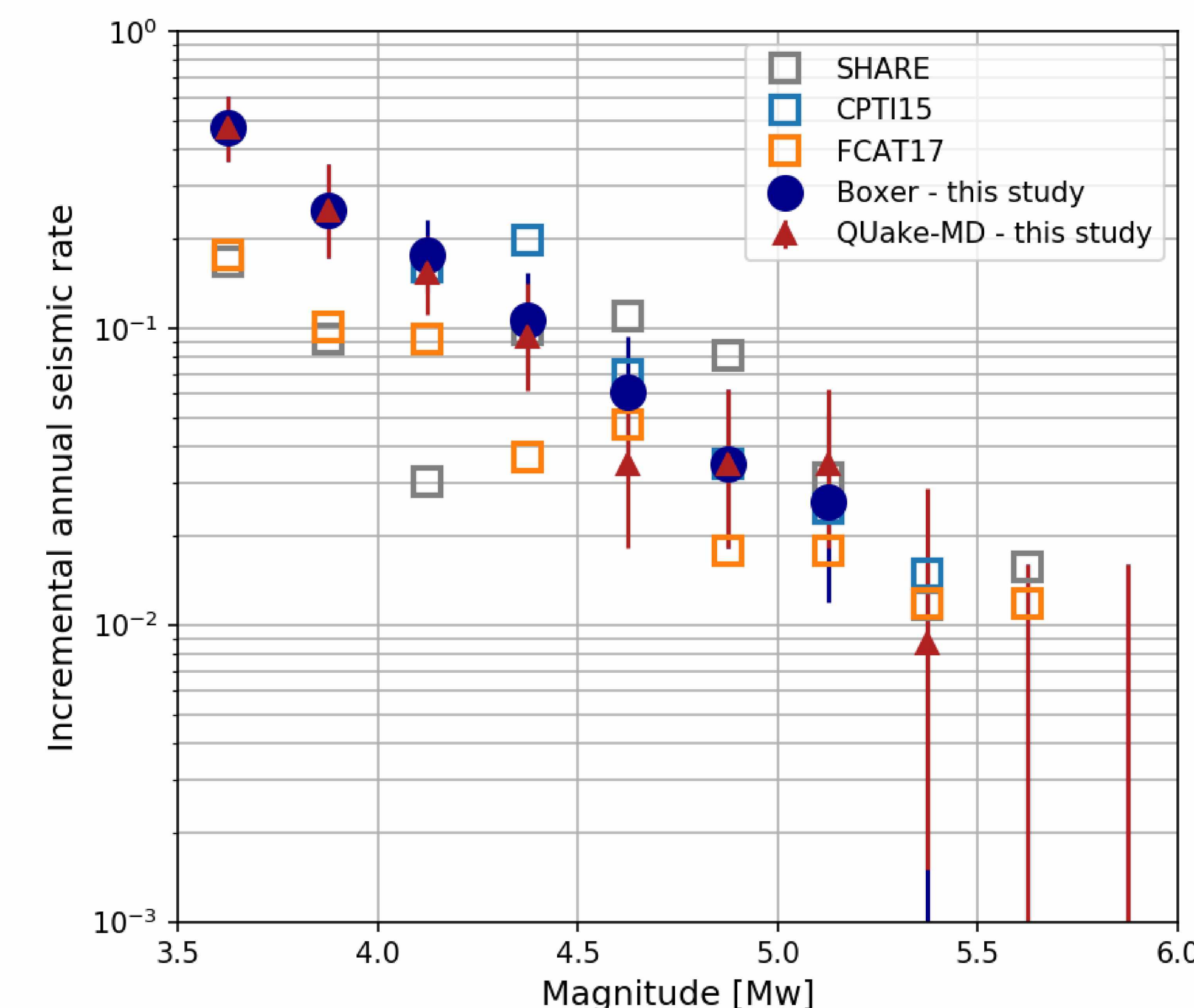


Figure 4. Activity rates for SHARE, CPTI15, FCAT catalogues and our study Alps-Boxer and QUake-MD catalogues at the France/Italy border.

Discussion

The two methodologies differ in their approach : QUake-MD estimates depth as well as magnitude whereas depth is implicitly taken into account in Boxer through the epicentral intensity. If both methodologies offer the same performance in terms of magnitude estimates, a systematic difference that correlates with the depth estimates in the QUake-MD inversion scheme is found.

The differences between Boxer and QUake-MD catalogues are expected to be low as long the study area is large enough to have a sufficient number of earthquakes in a balanced depth range to compute robust activity rates.

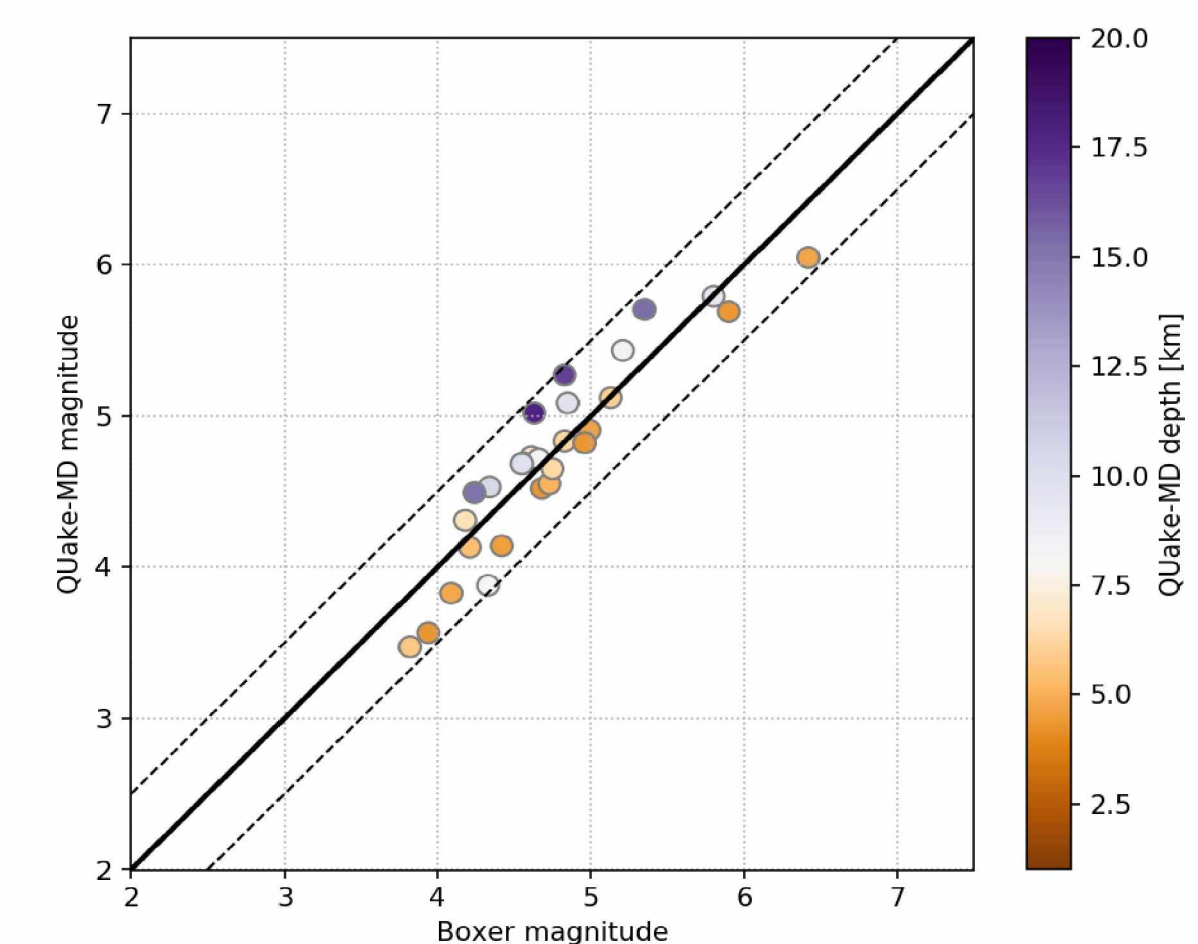


Figure 5. Boxer magnitude compared to QUake-MD magnitude for the calibration dataset. Color is linked to QUake-MD depth

Conclusions

Our results show that differences in earthquake activity rates across borders in Europe can be reduced as long as we share the same macroseismic data and the same datasets to calibrate our respective methodologies to estimate historical earthquake magnitudes. However, differences between methodologies may in some cases induce systematic differences in activity rates: using different methodologies may be a way to capture these epistemic uncertainties affecting activity rate estimates.

Acknowledgements

We would like to thanks Francesco Visini for lending us the codes to compute completeness times and activity rates. If you want to know more about his codes and earthquake activity rates uncertainties, please see his poster/presentation in the same ESC session ☺