Sanity checks of the seismic model

1. Introduction

We perform sanity checks of the model that describes the number and the spatial distribution of the earthquake rates by using two different types of statistical test: the N test, that checks if the total number of observed events is compatible with the one predicted by the model, and the S test, that checks if the spatial distribution of the observed events is compatible with the one predicted by the model.

We want to outline that these tests are not prospective, but retrospective; so to perform these we use the same (or very similar) dataset that we have already used to build the models. Nevertheless, the testing phase (or sanity check phase) is fundamental to control the robustness of the models and to avoid computational errors.

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3. Results

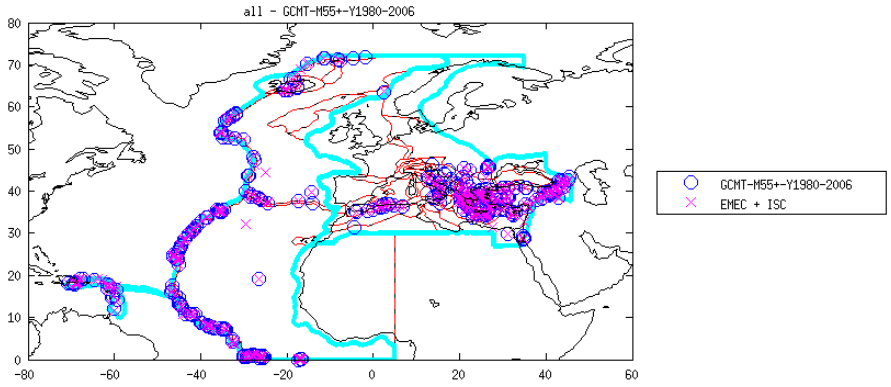
3.1. N-Test

We perform the N test by using three different catalogues: the official catalogue used to build the models (EMEC + ISC), the GCMT catalogue from 1980 to 2006 (completeness magnitude Mw 5.5) and the Pacheco and Sykes catalogue from 1900 to 2006 (completeness magnitude Mw 7.0).

From our ensemble model we compute mean, 95% and 99% confidence intervals of the distribution of the total number of earthquakes (that is a negative binomial distribution, see Marzocchi et al. 2017), and we compare these intervals with the observed number of events for each cumulative magnitude bin. We perform these tests for the whole zone, and in each of the two macro-regions (relative to EMEC or ISC catalogue), and we use all the three different catalogues, to be more confident in the final results.

As show in Figures 1 - 6, all the observed rates in the magnitude range of interest for tsunamis (Mw > 6.5) fall inside the confidence intervals so this result tells us that the total observed number of events in the time interval 1980-2006 (from Mw 5.5) and in the time interval 1900-2006 (from Mw 7.0) is compatible with the one predicted by the ensemble model.

Figure 1: TSUMAPS-NEAM source region (EMEC + ISC catalogues) and Global CMT (1980-2006).



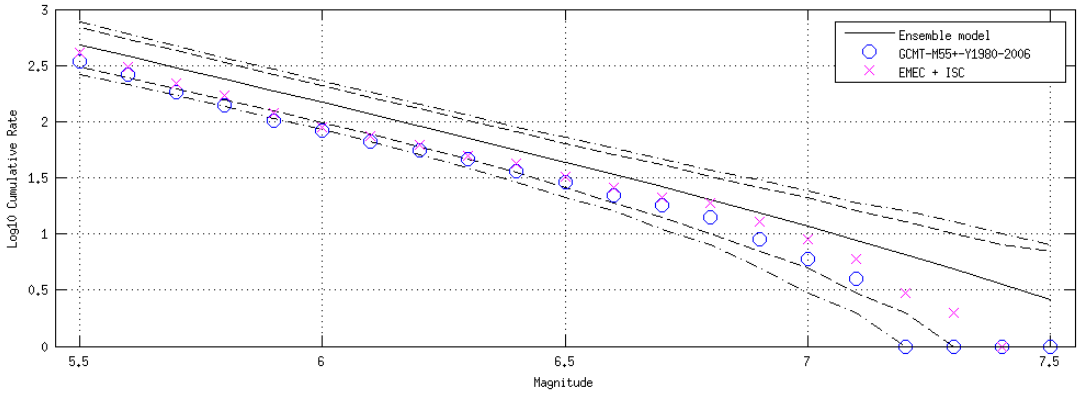
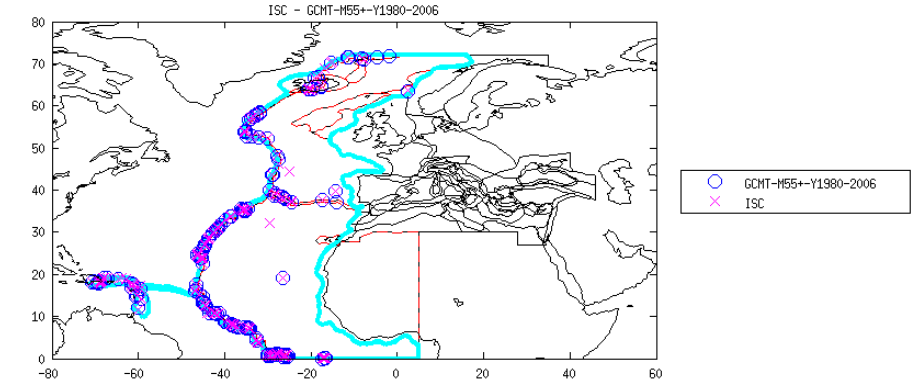


Figure 2: Atlantic region (ISC catalogue) and Global CMT (1980-2006).



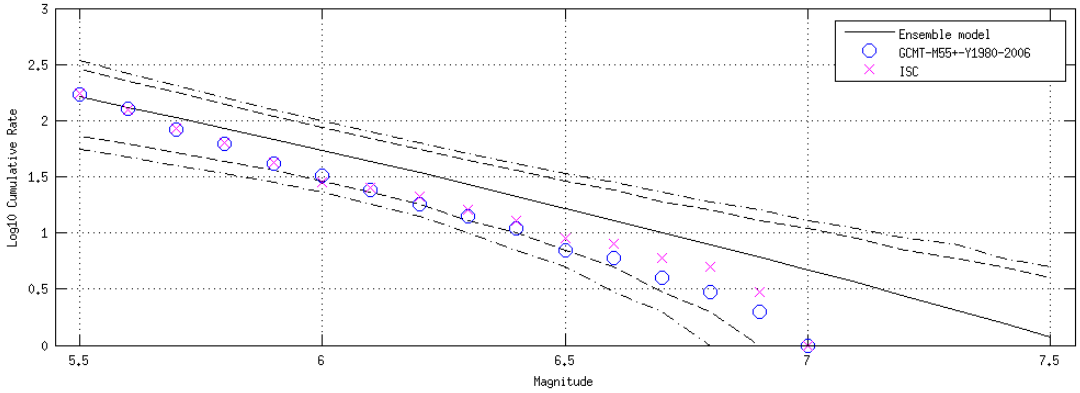
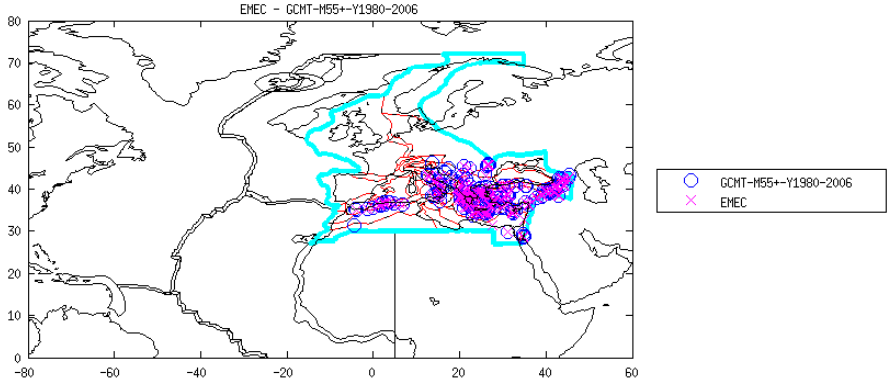


Figure 3: Mediterranean region (EMEC catalogue) and Global CMT (1980-2006).



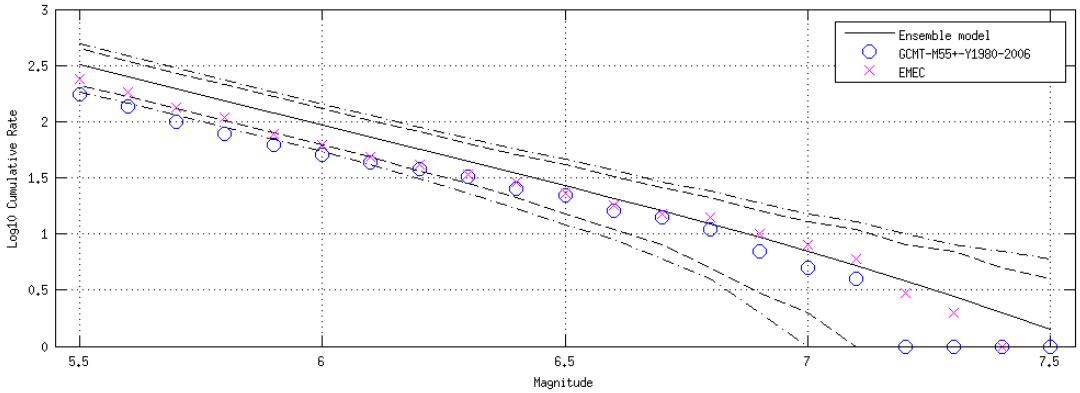
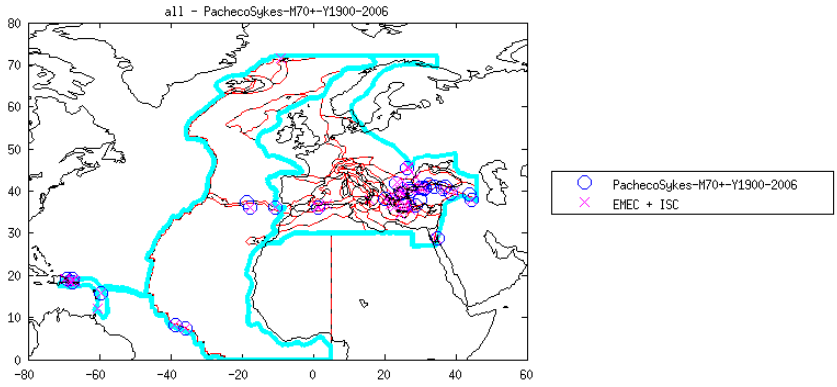


Figure 4: TSUMAPS-NEAM source region (EMEC + ISC catalogues) and Pacheco and Sykes catalogue (1900-2006).



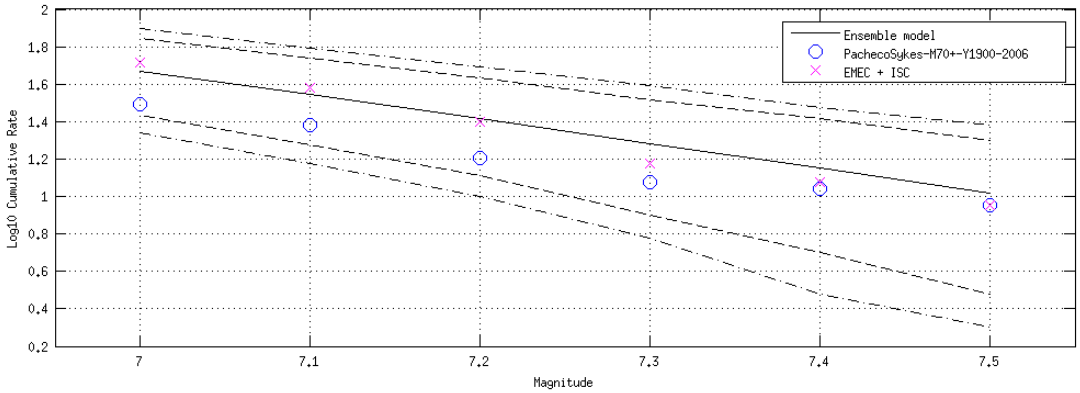
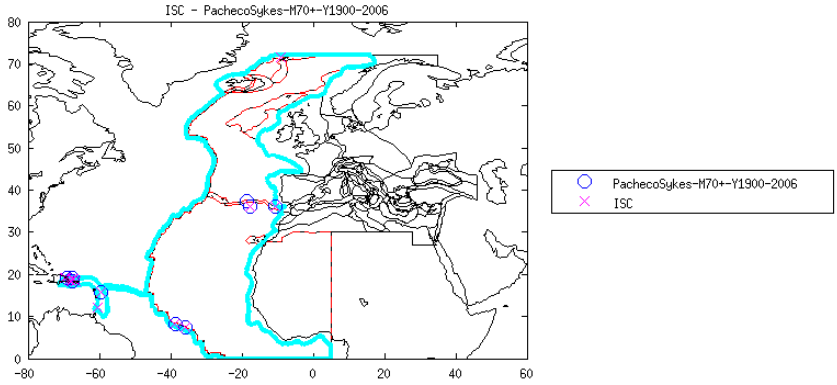


Figure 5: Atlantic region (ISC catalogue) and Pacheco and Sykes catalogue (1900-2006).



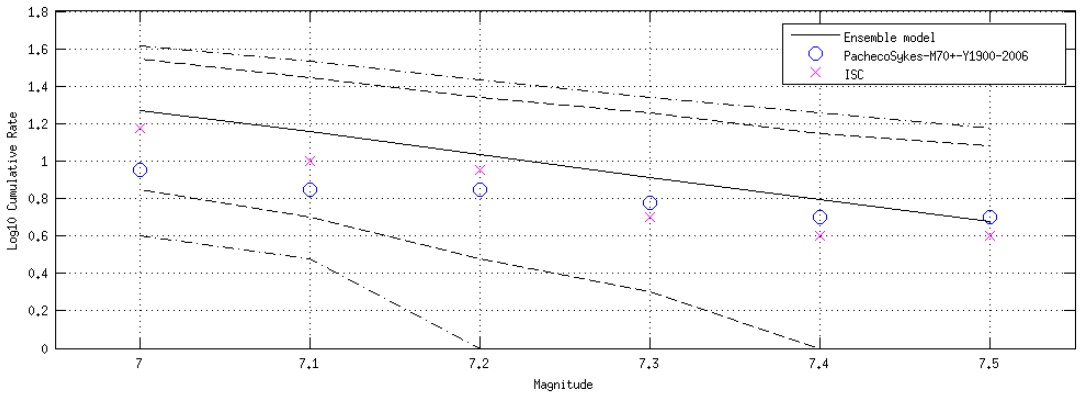
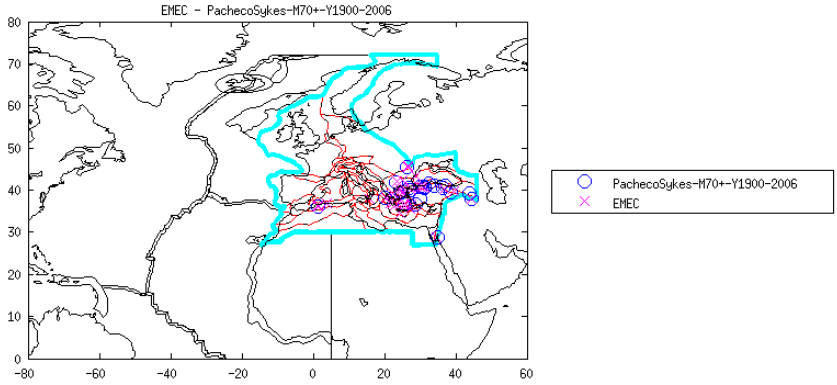
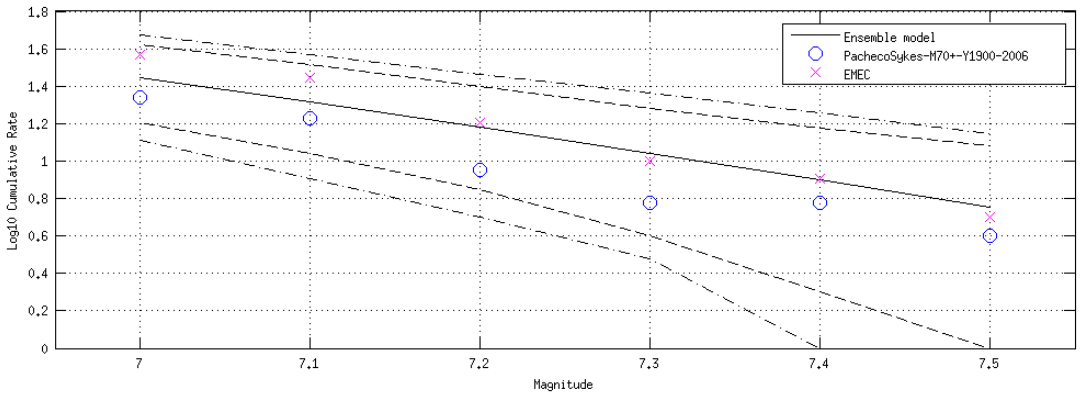


Figure 6: Mediterranean region (EMEC catalogue) and Pacheco and Sykes catalogue (1900-2006).





3.2. S-Test

Regarding spatial distribution of seismic events (more info in Zechar et al. 2010), we check the models only in the areas where Backgournd Seismicity was modelled (black polygon in Figure 7).

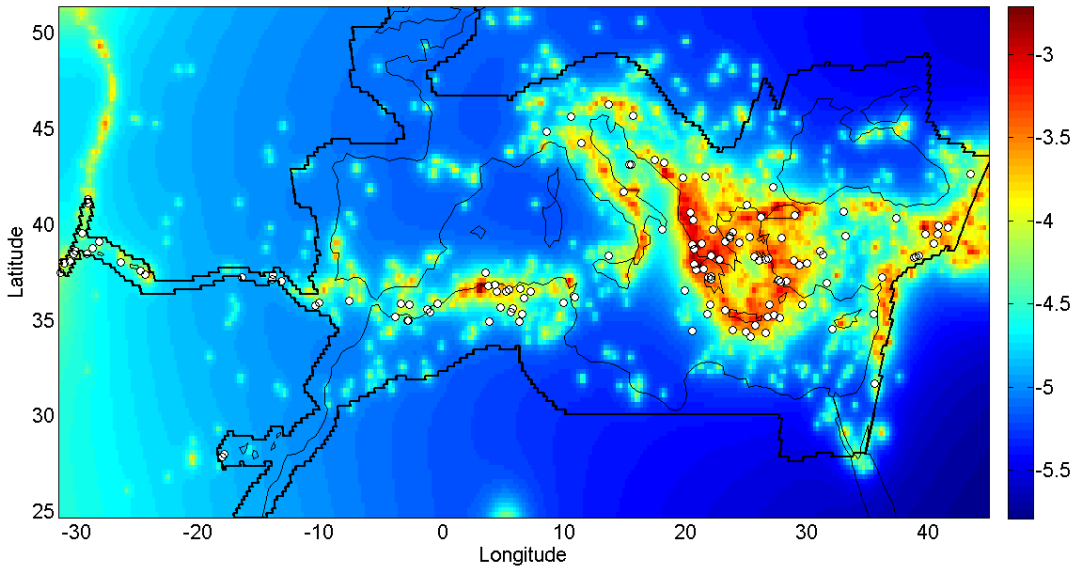
To check the reliability of the spatial model we perform a statistical test, called S test (Schorlemmer et al 2007), that is the official test used by the Collaboratory for the Study of Earthquake Predicatability (CSEP, Zechar et al 2010) to assess the performance of the earthquake forecasting models. In order to have a pseudo-prospective test, we rebuild the model using the earthquake until 1999 (EMEC + ISC catalogs) in the proper CSEP format (uniform degree area) and the we use the earthquake from 2000 to 2015 to perform the S test. Since we use independent data, the results of the tests are not only a classical sanity check, but they give a strong information on the behaviour of the model.

In Table 1 we summarize the results, showing the p-values for the tests: all values (> 0.05) tell us that the models give a reliable spatial description the seismicity, even using independent dataset to test them.

Table 1: p-values of the S test applied to the two spatial model, build with the catalogs without the events with a distance lesser than 5 and 10 Km from the bigger subduction in the Mediterranean sea, that are modelled with a different approach. We use two different minimum magnitudes for testing.

Model	p-value S test from Mw 5.0	p-value S test from Mw 6.0
Smoothing 5 km (fault distance)	0.94 (131 events)	0.79 (13 events)
Smoothing 10 Km (fault distance)	0.90 (123 events)	0.78 (13 events)

Figure 7[FR1]: in this figure we show the fist model in Table 1 (the colorbar show the log10 value of the spatial PDF of the smoothing seismicity model) and the testing catalog from magnitude 5.0 (white dots) inside the zone of interest (black poligon).



These values near 1 (Table 1) tell us that the spatial distributions of the observed events are compatible with the predicted ones (Figure 7): this high value is not surprising just because, as mentioned above, the testing catalogues are the same used to build the models.

4. Summary

To conclude, looking both at the N test and the S test, the ensemble model that describes the number and the spatial distribution of the events is compatible with the observations of the last century.

5. References

Marzocchi, W., Taroni, M., & Falcone, G. (2017). Earthquake forecasting during the complex Amatrice-Norcia seismic sequence. Science Advances, 3(9), e1701239.

Schorlemmer, D., M.C. Gerstenberger, S. Wiemer, D.D. Jackson, and D.A. Rhoades (2007). Earthquake likelihood model testing, Seism. Res. Lett. 78, 17-29.

Zechar, J. D., D. Schorlemmer, M. Liukis, J. Yu, F. Euchner, P. J. Maechling and T. H. Jordan (2010a). The Collaboratory for the Study of Earthquake Predictability perspective on computational earthquake science, Concurrency Comput. Pract. Ex. 22, 1836-1847.

Zechar, J. D., Gerstenberger, M. C., & Rhoades, D. A. (2010). Likelihood-based tests for evaluating space–rate–magnitude earthquake forecasts. Bulletin of the Seismological Society of America, 100(3), 1184-1195.