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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "When probabilistic seismic hazard climbs volcanoes: the Mt Etna case, Italy. Part I: model components for sources parametrization" *by* Raffaele Azzaro et al.

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When probabilistic seismic hazard climbs volcanoes : the Mt Etna case, Italy. Part I : model components for sources parameterization

By R. Azzaro et al.

The paper presents a thorough work done to characterize earthquake recurrence at Mt Etna, to constrain the source model required for PSHA estimation. Earthquake recurrence is estimated using different datasets: historical seismicity, an instrumental catalog, as well as geological and geodetical deformation estimations. Mt Etna appears to be a well-studied zone, perfect for testing methods to estimate probabilistic seismic

hazard in the volcanic environment.

The manuscript is made of 3 sections: (1) historical data and estimation of mean recurrence times for earthquakes on main faults; (2) instrumental catalog and estimation of frequency-magnitude distribution for source zones enclosing faults, frequency-magnitude distributions estimated for gridded seismicity (instrumental catalog); (3) characteristic model for faults with parameters inferred from geological and geodetical slip rates.

The manuscript is well written and the content is very rich, but sometimes it lacks clarity. I am detailing below the issues that would need to be solved. There are also some technical questions that need to be addressed.

Main remarks

With a title announcing a PSHA framework, the reader expects a description of the final model used for probabilistic calculations. However, the authors do not explain how the different recurrence models will be combined to build final models, and how the source model logic tree will be built. Will the area zones and fault models constitute alternative models ? Is the gridded seismicity used as background for the fault model, and how? This information is essential to understand how the source model for PSHA is built.

Section 3, addressing earthquake recurrence from historical data, is a quick summary of a published paper (Azzaro et al. BGTA 2012). An interesting work has been done to estimate probabilities of occurrence of earthquakes on faults. However, as it is, it is not possible to fully understand the text and the results (inset figure in Fig. 2). Either this part has to be expanded, or it should be reduced and refer more strongly to the 2012 paper. Why the 1st case "events occurring everywhere inside the SZ Timpe" leads to "eight intertimes", and the second case "events occurring at the scale of individual faults" leads to "six intertimes"? The inset of Fig. 2, probabilities of occurrence of an earthquake in the next 5 years, refers to the 2nd case (+ why considering a 5 years period?)? Apparently, faults are assumed to have the same mean recurrence time, but

this is not explained. The inset is too small to correctly appreciate the curves. The time-dependent model, Brownian Passage Time model, should be introduced. The last sentence, referring to a bootstrap analysis, is difficult to understand without more explanations on the test done.

Section 4 describes the instrumental earthquake catalog, the delineation of area sources, the determination of seismogenic depths, the estimation of Gutenberg-Richter models for the area source zones, and the estimation of recurrence parameters for a gridded seismicity model. Area sources here are buffer zones around faults. Can you give more precisions on how this buffer zone is delineated (width, association of earthquakes with the fault)? Frequency-magnitude distributions based on the instrumental data is compared to the frequency distribution based on historical data. Why not combining both? E.g. at the scale of the Timpe zone, combining both would lead to a recurrence model fitting both the instrumental magnitudes (interval 2-3.5) and the historical magnitude rates (interval 3.5-5.0), instead of over-estimating slightly the historical rates? Magnitudes larger than 3.5 are contributing strongly in the probabilistic hazard estimation. Nothing is said about the presence of clustered events in the catalog (swarms, foreshocks, aftershocks?). How do the authors handle this issue, which is of importance when establishing earthquake recurrence models and calculating b-values?

Distributed seismicity : rather than arbitrarily excluding cells where “strange” b-values have been obtained, would it be possible to apply some criteria on the estimation of the b-value, e.g. increase the minimum number of events in the cell or impose a minimum magnitude range available? These criteria would ensure the reliability of the recurrence curve inside each cell. Besides, are the b-values obtained within the values expected for volcanic areas? It is hardy possible to locate the b-values mapped in Fig. 8, without any topography or country border.

The magnitude-size scaling relationship for the Taupo volcanic zone is compared to the relationship for Mt Etna, then both are used for estimating maximum magnitudes.

Is it correct to compare 2 relationships established on disjoint datasets (for Taupo, minimum length is larger than 10km, while for Etna maximum length is around 10km) ? Could you add a short discussion on extrapolating scaling relationships? The section concludes saying that “the mean recurrence times associated to Mmax values vary from 22 to 166 years, periods generally consistent with those historically observed for the individual faults”. I don’t understand the sentence, as the mean recurrence time estimated from the historical dataset is 71 years (Table 2). How is the aperiodicity factor estimated in this model (Table 2)?

Other remarks

Section 3.1 should be suppressed, as there is no Section 3.2.

Section 4, Figure 6: the time period used to estimate annual rates of historical earthquakes for SZ Timpe, FF, STF-SVF, MF-SLF, should be the same? As the completeness of historical data must be homogeneous within the rather small Timpe zone? The time period indicated in the legend, 1832-2015, corresponds to a larger time window, 184 years. Why reducing this time window to 138 or 142 years to calculate annual rates? Please make this point clear, as it is confusing.

L 248: “This overall picture is consistent with the inter-time distribution of earthquakes (Sicali et a; 2014)” : please, how do you relate b-values with inter-time distributions?

Table 2: should be cited in Section 3 dealing with mean recurrence times. Why providing the “Mmin for which is calculated the probability of occurrence” as it is not mentioned nor discussed in the text?

L184-185: “This option has a dual purpose: i) to provide a less detailed characterization mediating features inside heterogeneous, “ => there must be a word missing?

L 295: “Considering the approximations due to the use of different dimensional measurements, the comparison is fairly explanatory” => exploratory?

L 321: See tab 1 : should be Table 2?

L350 [conclusion] “Taken as a whole, the FMD of the SZ Timpe is similar to the FMDs and depth distributions of the Moscarello (MF) and S. Leonardo faults (SLF), whilst the Fiandaca Fault (FF), S. Tecla and S; Venerina faults (SVF) show, respectively lower and higher b-values and activity rates.” => sentence which is confusing and needs to be re-phrased. MF and SLF belong to the same SZ. Timpe encloses MF-SLF, FF, and STF-SVF, so the seismic rates in Timpe must be higher or equal to the sum of these 3 FMDs.

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