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Reply on RC1

Francesco Visini et al.

Author comment on "An updated area-source seismogenic model (MA4) for seismic hazard of Italy" by Francesco Visini et al., Nat. Hazards Earth Syst. Sci. Discuss., https://doi.org/10.5194/nhess-2022-60-AC1, 2022

Dear Referee 1,

Thank you for your useful suggestions and comments. We appreciated the detailed review and we will modify the text according to your comments.

In the following we answer point by point.

REF: Organization of the text: The introduction should be shortened and some of the material and explanations that are currently there should be transferred to a proper section: all the explanations on how ZS9 was established, using ZS4 as a starting point.

ANSW: We will separate the state of the art and explanations on how ZS9 was established adding a separate paragraph. According to REV3 We will prepare a scheme to explain the link among ZS4, ZS9, ZS16 and MPS04 and MPS19.

REF: Page 1 in the last decades => decade.

ANSW: We will correct it.

REF: Page 2, ZS9 is called ZS4, and Z16 is called ZS9, there is a mix of names which need to be corrected (mix with MPS4 and MPS9?)

ANSW: We will check for typos. The new paragraph on ZS4-ZS9 should help to avoid misunderstanding.

REF: Page 2, "in ZS9 the choice of drawing area sources large enough to include all the seismicity above a certain magnitude threshold, a criterion used in […] ", this sentence is unclear

ANSW: We will modify this sentence to better explain this point in the manuscript.

REF: "the increase in the surface of area sources incorrectly reduced the hazard estimate in the central parts of the area": this sentence is not that clear, why would the largest density of events be in the central parts ?

ANSW: The drawing of zones, especially for ZS4 and ZS9, sometimes followed the pattern of seismicity, then zones may bound "clusters" of earthquakes. In case of non-homogeneous spatial distribution of seismicity, larger zones produce a lower hazard with respect to zones designed around clustered seismicity. In practice, keeping fixed the amount of earthquakes in a zone, the larger the polygon around earthquakes, the lower the density, and this returns a spreader level of hazard.

REF: Page 3, Section, introduction, It would be nice to see maps that show how you have used the geophysical data to define the areas. This part is quickly treated without much detailed explanations or maps. It is a pity. It is important to understand how area sources are delineated, the process that leads to the polygons.

ANSW: This is a good point, also raised by the other two reviewers. We are going to include georeferenced maps of the geophysical data and shapefiles we used to draw the zones in a separate appendix. We will add in the text an explanation of how polygons were drawn. We will add these details of group of zones, for example Alps, Northern Italy and so on.

REF: Page 3, section 2.1

"Earthquakes [..] that occurred in the Italian and neighboring areas"

"The parameters of the 43% of" => the parameters of 43% of

ANSW: We will correct these sentences.

REF: Section 3.1 The SZ16 seismotectonic zoning 'be consistent with the CPTI15 earthquake catalogue': what do you mean?

ANSW: We will explain that we refer to the spatial pattern of seismicity. In particular, zone borders drawn using faults should not separate groups of earthquakes attributed to the same faults.

REF: Section 3.2. This section is difficult to read and should be re-organized for the sake of clarity, e.g. by splitting the section in different paragraphs, beginning the description with the most common sources and then describing volcanic sources.

ANSW: We will change it as suggested.

REF: Why using only 1 or 2 depth values, instead of a pdf that would best represent the depth distribution per source zone?

ANSW: hypocentres were affected by errors in the order of a few kilometres, then the precise shape of the pdf may be uncertain. We retained that the modal values were the most stable representation. In future works, however, we would examine more in detail this part, to analyse correlations among depths, magnitude and kinematics. We will briefly add this explanation in the text.

REF: Prevalent : what do you mean with this term? Is it the most appropriate?

ANSW: We will change it in a more appropriate term, we were thinking of "representative"

REF: "basing on"=> based on

ANSW: We will change it as suggested

REF: Section3.4

A reference must be indicated for the Gutenberg-Richter model (for the exact equation used).

The equation would be more readable in equation format.

ANSW: We will change it as suggested

REF: Section 3.4.1

Do you use exactly the same time windows as Stucchi et al. 2011 ? This is not clear if you apply the method, or use the same windows. I assume you use those from Stucchi et al. 2011, otherwise more information should be provided on how they have been assessed.

ANSW: We will modify the Section in order to better explain that we used the same time windows as in Stucchi et al. (2011) for epicentral intensity I0 >=6 and we defined new ones for I0 < 6. These time windows were then applied to the new macorareas defined according to ZS16 and to the Mw intervals derived from the updated I0 to Mw conversion of CPTI15.

REF: "Being the approach" ?

ANSW: We were referring to the "statistical Approach", however, will change it to be more clear.

REF: "to avoid the oversampling of some Mw intervals that contain values derived from the conversion of more than one discrete epicentral intensity value" => this sentence is not clear

ANSW: We will clarify that the Mw bins of 0.23 are defined to avoid that magnitude values converted from the same epicentral intensity fall into the same bin.

REF: This is unclear why in the historical method, a 0.23 bin is used; then in the statistical method, 0.46 is used. Strange that the historical method can handle a smaller bin.

ANSW: We will detail and better explain this point, together with the previous one

REF: More would need to be said so that the reader can appreciate the estimation of periods of completeness step.

ANSW: Following also the suggestion of REV3, we will add a plot of time versus completeness magnitude in order to compare the completeness intervals resulting from the two methods. We will also add a short description of the final catalogue(s) used in the model, i.e. declustered and complete according to the two approaches.

REF: Section 3.4.2

"for the definition of the maximum magnitude, we used the estimates provided by MPS19, described in Visini et al. 2021": can something be said about these estimates ? how they have been evaluated ?

Woessner et al. 2015 does not provide the rational behind selecting 6.5 as a minimum for active crustal areas. It would be important to have one explanation for the choice of this value as threshold.

"the two values of Mwmax were also checked with the estimates of the maximum Mw of the composite seismogenic sources of DISS …" : how checked ? What happened if one fault inside the source provided an Mmax larger than the largest magnitude observed including uncertainty ?

ANSW: We will add details on how the maximum magnitude values were estimated in MPS19 (and adopted in our manuscript) and statements on the rationale behind selecting thresholds in active crustal areas. We will also discuss the comparison between catalogue-derived maximum magnitude and the one of the composite seismogenic sources of DISS.

REF: Section 3.4.3 is not that clear. Approach I should belong to one paragraph. Approaches ii to v should be grouped in one paragraph.

ANSW: We will modify the text according to the suggestion.

REF: ii) observed rates : for which magnitude ?; iii) what is the "threshold magnitude Mt"

of an area source?; iv) observed and forecasted number of earthquakes above a given magnitude ?; v) minimize the root-mean-square of observed rates => within which magnitude interval ?

ANSW: We will modify the text and more explanations will be given. In particular, the following details will appear: Observed rates and forecasted rates refer to earthquakes above the threshold magnitude of the macroarea, i.e. the minimum magnitude of completeness according to the maximum curvature approach, which determines the Mt at the highest value of the non-cumulative FMD. The interval of the FMD is between Mt and the Maximum magnitude (Mmax01 or Mmax 02 according to the branch of the logic tree).

REF: Section 4, "3 ERFs developed adhoc" : please, what do you mean ?

ANSW: In MPS19 3 ERFs were developed for i) the Etna volcanic area, ii) the sources external to Italy, and iii) the subduction zone. These three "zones" were then excluded by the 11 seismicity models adopted for MPS19. In our manuscript, we will rephrase these sentences to be more clear.

REF: "the annual rates of earthquake occurrences are given as a non-cumulative magnitude-frequency distribution" => if this detail is provided, then you could provide the name of the distribution in openquake format, otherwise this detail is not necessary

ANSW: We will delete this sentence, we agree that this detail is not necessary.

REF: "the cov is the weighted std divided by the weighted mean": why weighted ?

ANSW: because GMM were weighted, the 60 branches have not the same weights. This implied we cannot use the CoV as simply the standard deviation divided by the mean. However, to be more clear, we will rephrase this sentence. We understand that, as it is now, it can create misunderstanding on the classical formulation of the CoV.

REF: Section 5, Discussions and Conclusions

Some sentences in the third paragraph are not clear, e.g. :

"because of the lack of available data that can even produce apparent differences in seismicity distribution at the local scale"

"seismic hazard results are different if the same quantity of seismicity is assigned to sources of different size"

ANSW: We will modify the paragraphs to be more clear. In the first case, we were referring to the fact that few earthquakes in a zone can result in a biased b-value. In the second case, we were referring to the dimension of the zones in respect to the seismicity that is actually contained in. Keeping fixed the a- and b- values, which are determined by the earthquakes inside the zone, the dimensions of a zone (i.e. the area) impact the density and therefore the levels of seismic hazard. In a point close to the centre of a zone, in fact, the seismic hazard decreases with the increase of the area.

REF: I fully agree with the last sentence of section 5. We don't know if the future will reproduce observations in the past. We know that the catalogs available are still too short to be representative of what may occur. We should not discard models on the basis that they do not reproduce the past.

ANSW: Thanks for this point.

REF: Figure 1. The new zoning should be put on top of the old one. Figure 2. Legend for zoning ZS16 should be put in the graphic that displays the zoning. Figure 3. There is no need to show the y-axis below 20 km depth.

ANSW: We will modify them according to the comments.

REF: It is not clear where the 5% bar is ? how can it be at zero depth if it is the percentile 5% of the distribution?

ANSW: We rounded to the nearest integer the value, we missed to specify this, however, we will modify the text.

REF: Figure 4. Caption is very difficult to follow. Full circle: do you mean plain circles?

ANSW: yes, we mean plain coloured circles. We will modify the caption.

REF: Figure 6. To appraise the impact on the rates of a given method, it would be extremely important to superimpose models for a given source (group by source the 5 alternative results). Also, to understand the variability of the results due to the 5 different methods, it would be very important to show a source with poor data (few events).

ANSW: We agree and we will add these figures.

REF: There are too many log scales on these graphics (from 1e-8 up to 100). It produces a visual bias on the alignment of observed rates. There is no need to keep the axis below 1e-5 nor above 10, nor above magnitude 7.5. The annual rates are cumulative or non-cumulative?

ANSW: We agree and we will modify the scales. The annual rates are cumulative.

REF: Figure 9. If indicating probabilities over 50 years (horizontal lines), it would be clearer to plot probability over 50 years versus acceleration.

ANSW: We agree and we will modify it.

REF: Figure 10. Final uncertainties are rather small (considering the 16 to 84 percentiles), with respect to other PSHA studies.

ANSW: This is due to the uncertainty explored in the logic tree. However, we will remark that MA4 is only one branch of the MPS19, and that epistemic uncertainty on the ERF modelling was considered in MPS19.

REF: To read the graphics, keeping the y-axis ticks on all graphics would help.

ANSW: We will modify the graphics.

REF: Figure 12. The figure is difficult to read, and it is then difficult to follow the corresponding text page 11. One solution would be to get rid of the individual realization, in order to see the three curves corresponding to the three GMMs. The observation made by the authors that "the uncertainty due to the GMMs is of similar order of magnitude as the uncertainty related to the ERF" is not obvious on this figure.

ANSW: we will modify the figure according to this suggestion in order to render more clear the comparison of the uncertainty related to ERF and GMM

REF: Figure 13. The cov is calculated from the distribution for a given acceleration level, and this is sound. It would be more straightforward to plot the acceleration versus the cov, rather than a mean probability which has a loose meaning. In any case, mean APO should appear in the y-axis label.

ANSW: We prefer to keep the APOE in the y-axis, to keep a link with the return period and level of seismic hazard commonly used in the maps. However, according also to REV2, we will simplify the figure to be more easy to be read.

REF: "Although the scatter in the results for the different sites and PGA levels": verb is missing?

Caption : Againt =>against

ANSW: we will adjust these phrases.