

Interactive comment on “Earthquakes on the surface: earthquake location and area based on more than 14500 ShakeMaps” by Stephanie Lackner

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Reply to RC1

I would like to thank the reviewer for the thorough review and the many helpful comments and suggestions made to improve the present work. Please find below the reviewer's comments and author's replies to these comments.

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General comments

RC1: *The submitted paper presents a new approach to the topic of characterization of earthquake shaking trying to find new ways to its use in social sciences, insurances, etc. Earthquake hazard, cited many times on the text, mainly deals with the shaking of earthquakes “to come”. Instead, this paper deals with the “past” shaking, giving some cues on how to analyze and use such data for further research. It relies in the massive analysis of the information contained in the ShakeMaps acquired for more than 40 years by the USGS. It describes the used analysis methodology, introduces some new definitions with the aim of improving the analysis and presents some conclusions about the distribution of earthquake shaking around the world.*

New, fresh approaches to problems are always welcome and as it the submitted research is really welcome. But, from another side, I think more in-depth knowledge of the topic of seismic hazard and risk, how it is assessed, communicated and managed is needed to draw proper conclusions. The common seismological terminology used and other existing approaches are not well presented and used.

Reply: I have now included many of the suggestions made by the reviewer below. In particular more details and references on the technical aspects of earthquakes have been added and the resulting limitations of the ShakeMap data are discussed.

RC1: *Seismic hazard is a topic where, from the field of seismology, large efforts have been devoted. Specifically, and dealing with global approaches, on the 90's, during the UN/IDNDR, the GSHAP Global Seismic Hazard Map project was implemented. A large amount of information about it can be found in Giardini (1999) and in the (frozen) project website <http://www.seismo.ethz.ch/static/GSHAP/index.html>. One of the main outputs is a map depicting the global earthquake hazard as the 90% chance of non-exceedance in 50 years of plotted PGA values. As 50 years is the approximate period*

covered at present by the ShakeMaps it can be really instructive comparing the “true data” presented in this research with the much more classical probabilistic calculations obtained in the GSHAP. Nevertheless, it should be kept in mind that results plotted on the ShakeMaps are a mix of observed data and assumptions/calculations about how energy/shaking propagates. Thus, the overall results are not just observed quantitative data. Anyway, I think such an exercise can show some of the possibilities the submitted research opens and it is adding value to the presented results.

Reply: A short discussion of the GSHAP project has now been added as well as a comparison of the GSHAP data with the here constructed data set of shaking exposure (please see appendix of the paper).

RC1: *At present many efforts in this topic (always from the fields of seismology and earthquake engineering) are directed through the GEM project. How communicate seismic hazard and risk is an important issue on the project development. Much more information is available at the website <https://www.globalquakemodel.org/>.*

Reply: The GEM project is obviously an important international effort on many aspects of seismic hazard and risk communication. I have now added a reference to the project.

RC1: *Coming back to the submitted research, I think the final results about the shaking suffered around the globe, presented in a $2.5^\circ \times 2.5^\circ$ world partitioning, are not so useful as such size is larger than usual administrative departments, districts, etc., and even of many not so big states. Even in case of many damaging earthquakes, such area exceeds the whole affected area (at least that where damage occurs) and just in the case of the largest events can it be considered. Certainly, I think this is not a big deal as, if I understand properly, reducing the size of the area (e. g. $1.5^\circ \times 1.5^\circ$) just takes more computer memory and calculation time.*

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Reply: The 2.5 x 2.5 resolution was chosen to ensure a higher number of events within each gridcell for the calculation of the averages. The choice of the resolution makes a decision on how to balance spatial granularity vs. sample size and there is no obvious optimal choice. It is certainly possible to reduce the resolution, and I have now included the same figures for a resolution of 1.25 x 1.25 instead of 2.5 x 2.5.

RC1: *As a résumé, I think the submitted paper presents new results, it is properly written and organized, with relevant bibliography. Thus I think the article should be accepted for publication but it needs revisions of some importance.*

Reply: I want to thank the reviewer for their résumé and have included suggested revisions.

Specific items

RC1: *Page 1. Line 5. . . . Earthquake communication outside of seismology. . . An (old) review about how this problem is seen by seismologist can be found at O'Brien and Mileti (2003).*

Reply: My intention was to point out that any discussions/ conversations/ communication about earthquakes outside of seismology are often centered around concepts (e.g. magnitude and epicenter) that are not of direct concern for those cases (unlike surface shaking /strong ground motion). I was not trying to talk about earthquake communication as a part of disaster management in particular. I have rephrased this sentence to make this clearer. The referenced paper provides a great discussion of the social dimensions of earthquake disaster management (mitigation, preparedness, response, and recovery). However, it provides little discussion on the aspect and importance of earthquake shaking for these social dimensions and is thus in my opinion not a relevant

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citation here.

RC1: *Page 1. Line 7. . . .constructed and applied TO THE DETERMINATION OF GROUND SHAKING WORLDWIDE.*

Reply: Added.

RC1: *Page 1. Line 19. Practice. . . practical*

Reply: Corrected.

RC1: *Page 2. Line 17. (e. g. Shedlock et al., 2000)*

Reply: Corrected. (I assume the comment was about line 1 and not 17.)

RC1: *Page 3. Line 2. Strong ground motion CAN BE EXPRESSED with different parameters, but...*

Reply: Changed sentence accordingly.

RC1: *Page 3. Line 5. But such data are not as. . .*

Reply: Corrected.

RC1: *Page 3. Line 16. I know it is really easy to find the USGS ShakeMaps, but it will be good to give an explicit link to the webpage.*

Reply: The link to the website is in the “Code and data availability” section.

RC1: *Page 3. Line 27. As a result, the dataset.*

Reply: Changed sentence accordingly.

RC1: *Page 4. Line 8. Earthquake shaking history is, to me, a good term; but it is not the first time such an approach is used. See the Italian macroseismic database where it is possible to search the felt earthquakes at a town (https://emidius.mi.ingv.it/CPT115-DBMI15/query_place/)*

Reply: As far as I can tell, the Italian macroseismic database provides an earthquake history at a town level, but does not provide a visualization on a pixel level that overlaps ShakeMaps (or comparable products) over time.

RC1: *Page 4. Line 15. Second? There is not a “first”. I understand the discussion in the previous paragraph is the “first” point. It is just a matter of some rewriting.*

Reply: The “first” was on line 3 of page 4. In the new version on line 11.

RC1: *Page 5. Figure 3. Abscissa axis. The last number on the right does not fit.*

Reply: Fixed both axes. Thank you for spotting this mistake!

RC1: *Page 5. Line 4. . . .points to characterize earthquake LOCATION.*

Reply: Changed sentence accordingly.

RC1: *Page 5. Line 7. ...is AT SEA.*

Page 6. Line 6. (when it falls offshore)

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Page 6. Line 13. *When the epicenter lies offshore.*

[...]

Page 8. Line 8. . . .*when the epicenter lies offshore.*

Reply: I have intentionally avoided to use “offshore” or “at sea” since the epicenter could also fall into a lake. I am aware that this is a scenario of very low relevance, but I didn’t want to exclude the theoretic possibility.

RC1: *Page 7. Line 3. “This distance increases to 53 km when the epicenter is offshore”. But this value is, for me, meaningless. It gives just a mean value of how distant from the coast are epicenters of earthquakes for which a ShakeMap is available. This value arises just because at the epicenter location there is no ground to shake. In fact, ShakeMap gives “calculated” PGA’s in sea areas. Thus, it is possible to extent shaking centroid calculation at sea.*

Reply: This is true, but the epicenter is used as a spatial reference for earthquakes no matter if the epicenter is offshore or not. When it is offshore it is a worse spatial reference for where shaking on land (which is what most people care about) is happening. This number helps to describe how much worse on average it is as a spatial reference.

ShakeMaps do provide calculated PGA’s in sea areas, but they are not intended to be used since they are not based on models with the same level of quality as the estimates on land.

RC1: *Page 8. Figure 6. I think this figure will improve if the color scale of scatter is added somewhere.*

Reply: Color scales have now been added for the individual subplots of the figure. Since the color is just used to illustrate the density of the scatters using a shared color

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scale would reduce the usefulness of using color in the first place.

RC1: *Pages 9 – 11. I suggest, for future research, to use the ISC catalogue instead of the ComCat. It has the advantage that it is accepted as “authoritative” catalogue for the world seismicity and that event duplications are almost totally filtered. Instead, it has the problem it is published with 2-3 years of delay from present.*

Reply: Thank you for the suggestion on improving future research.

RC1: *Page 10. Lines 16 and 25. I think a rounding accuracy of one degree in latitude is too wide. Much likely reducing the interval to .5 (or .25) may solve some of the possible duplicities.*

Reply: The rounding of the listed variables is only done to identify each event uniquely in the ComCat list, after 39 events were excluded from the dataset because they were identified as very likely duplicates through manual comparison. The stated rounding rules do explicitly result in uniquely identifiable events (no duplicates identifiable). However, I explain in Appendix C that I nevertheless believe that there are still duplicate events in the database (even though these rounding rules make it appear as if there shouldn't be any).

The matching of the events between the three data sets is only based on the rounded values in the first step when a unique match can be achieved. In the later matching steps the values as reported in ComCast are used. Changing the rounding accuracy, can therefore only change at what step events might be matched and not how or if they would be matched.

RC1: *Page 11. Line 10. . . .each event FROM the significant EARTHQUAKE list*

Reply: Corrected.

RC1: *Page 11. Line 17. . . .some events in the significant earthquake list seem to have typos.*

Reply: Changed sentence accordingly.

RC1: *Page 16. Line 8. For those events a “RANDOM” candidate. . . I suggest, instead of a “random” candidate, to select the shaking center nearest to the epicenter. Such a criterion has the advantage of “repeatability”.*

Reply: The suggestion has been slightly adjusted and included. The algorithm selects now the shaking center nearest to the shaking centroid. This solves all the not-unique cases in the data. In case that this would not be sufficient, the smallest distance to the epicenter can be considered. However, this does not solve that theoretically it is still possible to not have a unique shaking center.

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., <https://doi.org/10.5194/nhess-2017-422>, 2018.

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