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Natural Hazards and Earth System Sciences
Discussions

# *Interactive comment on* "Earthquakes on the surface: earthquake location and area based on more than 14500 ShakeMaps" *by* Stephanie Lackner

**Anonymous Referee #2**

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This paper aims to provide a discussion of earthquake shaking for an interdisciplinary audience and with applications in earthquake impact research, particularly in the social sciences in mind. The author is not a seismologist but has a strong background in mathematics, natural disasters, their socio-economic impacts, and sustainable development. In other words, the main purpose of this paper seems to be an earthquake communication about global seismic hazard based on past events (of limited duration) in the social science literature.

A dataset of relevant global earthquake ground shaking from 1960 to 2016 based on USGS ShakeMap data has been constructed and applied in this paper, where it is



claimed to be the first global quantitative analysis on the size of the area that is on average exposed to strong ground motion (PGA), while introducing two new definitions of earthquake location (the shaking center and the shaking centroid) based on ground motion parameters.

The idea is great. However, the paper appears to be lacking in-depth knowledge of complexities in the earthquake rupture, seismic hazard and risk. References to local/site/geologic conditions and/or quality/seismic performance of buildings/structures have been kept to a minimum if none, and there are no discussions on the rupture heterogeneity and directivity and their relations to seismic hazard. Statements on earthquake rupture physics are generally very simplistic, such as "waves radiate out from every point of the rupture area", where there is no single reference to asperities and frequency content of the waves radiated and how these are connected to seismic hazard studies. The discussion on any relevant uncertainties seems to be kept to a minimum. The argument of "the literature commonly uses magnitude or other suboptimal measures to quantify the natural hazard of earthquakes for impact research" could be true for social sciences, but definitely not acceptable for a seismologist, and this paper does not appear to be improving this deficiency. It is not the "parameter" that is misleading in earthquake hazard communication, it is "how we communicate or not communicate" the parameters to the outside community. In that respect, the paper, despite its good intentions, does not necessarily serve the purpose set by the author.

The dataset is clearly biased, as also acknowledged by the author. While a magnitude threshold has been introduced by the author to remove the effect of geographical bias as much as possible, at least in Northern America, several geographical regions hosting seismotectonic settings resulting in catastrophic earthquakes with long recurrence intervals, such as Dead Sea Fault or Hellenic Arc, for example, are simply shown with low percentages of average annual maximum PGA (%g) exceeded as a result of no-big-earthquake record for the time interval considered in this paper. In addition to the issues related to the temporal analysis, the resolution of 2.5 x 2.5 degree grid cell is most likely introducing spatial problems due to its large size, which may explain the geographical bias introduced in various regions as a result of large earthquakes during the study interval. The discussion on such uncertainties in the data set need to be clearly improved, since the figures of this paper, if communicated to non-seismology experts, may lead to convey misleading messages on the global seismic hazard and risk.

The author states that other factors (e.g. geology and water bodies) introduce significant noise in the relationship of magnitude and the area exposed to a particular shaking threshold as a result of this magnitude. This "noise", in reality, is the "data" for seismic hazard and risk studies, and impact assessment. The case of 7.4 1999 Izmit earthquake, for example, is a good example where extensive damage has occurred to high residential buildings in AvcÄślar-Istanbul, 120 km away from the epicenter, which is attributed to both the long distance effects of the high period waves of the earthquake and soil amplification.

It is questionable whether introducing two new definitions of earthquake location, namely the shaking center and the shaking centroid, respectively, will provide any additional benefit, both in terms of seismic hazard studies and earthquake communication. Earthquakes, even on the same fault with same/similar size, do not behave identically, and the well-established term "intensity" in seismology, as a measure of the strength of shaking produced by the earthquake at a certain location, is still not "digested" by many communities around the globe. In that respect, for example USGS' Pager is a considerable approach to link Modified Mercalli Scale with strong ground motion parameters, such as PGA and PGV, population exposed and potential damage.

In conclusion, the paper is an attempt with good intentions, where a publication is welcomed after enriching the paper by addressing (at least some of the) improvements implied in the comments given above. It may be very well that the author might have intentionally kept the technical/scientific details to a minimum, especially with relevance to the uncertainties in the physics of the phenomena and in the methodology, since the



target audience is particularly in the social sciences. However, the communication of such uncertainties specifically to these audiences is crucial in terms of global earthquake preparedness.

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