Nat. Hazards Earth Syst. Sci. Discuss., 3, C1692–C1695, 2015
www.nat-hazards-earth-syst-sci-discuss.net/3/C1692/2015/

Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Probabilistic tsunami hazard assessment for the Makran region with focus on maximum magnitude assumption" *by* A. Hoechner et al.

Anonymous Referee #1

Received and published: 15 September 2015

This paper shows a PTHA application to the Makran tsunami source region and gives hazard assessment for Iran, Pakistan and Oman.

The method is based on 1) the creation of a synthetic, 300 Kyr long, earthquake catalogue with hypocenters in the Makran subduction zone, 2) the computation of all the corresponding tsunamis via a linear model up to nearshore coastal points (about 50 m sea depth), 3) extending the peak wave height to the coast obtaining Peak Coastal Tsunami Amplification (PCTA) at points of interest (POI) by means of the Green's law, 4) computing statistics. The synthetic tsunamis at point 2 above are computed by summing up the contributions of elementary tsunamis from sub-faults with unitary dip-

slip dislocation. Variants of the basic synthetic earthquake catalogue (called Seismic Reference Catalogue) are created by changing the frequency-magnitude relation. For each variant all the above procedure from point 2 to point 4 is repeated.

I have a number of comments to this paper that I write here below.

The Makran subduction slab geometry is scarcely known. But knowing it is essential for this study since all earthquakes are supposed to occur at the slab. The subduction surface is unfortunately built by a single profile taken from the literature (Smit et al., 2013) and applied to the whole region. The authors should provide a figure of this profile and comment on the value of their assumption.

Seismicity in the region is used to estimate the parameters of the Gutenberg-Richter-Bayes (GRB) frequency-magnitude relation. The catalogue spans a time period from 1919 to our days, which is too short to make estimates on the largest magnitudes, that cannot be constrained. The empirical data differ very much from the theoretical GRB curve estimated through the Kijko and Smit code, as can be seen from Figure 1 (right). It is hard to make estimates on magnitudes with annual rate around 1/1000 or less with only a 100 yr database. Indeed with the available data, rates in that range are determined nearly exclusively by the maximum possible magnitude. This consideration undermines the relevance of the proposed SRC analysis. Practically varying the parameters of the GRB laws is not only a sensitivity analysis, but it is a need since these parameters are not well determined, and the maximum magnitude is the one determined in the worst way.

Hypocenter coordinates of the synthetic catalog are random variables uniformly distributed on the slab surface, and the earthquake occurrence is considered a Poisson process with magnitudes obeying the GRB law. This assumption may be considered reasonable when seismicity is distributed over very many faults and fault systems loosely interacting with each other like in the entire Mediterranean region, which is the area where the method was applied by Sørensen et al., 2012, quoted in the manuscript.

But it is not justified when all earthquakes occur in the same subduction zone, since the occurrence of big earthquakes influences the occurrences of others, and the events cannot be considered independent. Having said that, since the hypocenter distribution is uniform over the subduction surface, it is expected that even the hypocenters of the largest earthquakes will cover all the surface, if one considers a time period sufficiently long. This is not the case for the 5000 hypocenters shown in Figure 2 (left). Consider that 5000 earthquakes cover a period of about 75 Kyrs. The largest earthquakes (magnitude 8.5 and over) are too few especially the ones offshore. But taking a time period much longer, they will cover all the area as well. This has a consequence on the tsunami generation and hazard, since hazard is dominated by the largest earthquakes. Practically, the 300 Kyrs could be not representative enough in this model, and a wise alternative model could be the one where the hypocenters of the largest earthquakes (the only one that matters for the largest waves) are let to float over the subduction surface. This is a technique considered in many PTHA papers. Please discuss.

The earthquake fault parameters are computed by specifying the randomly chosen hypocenter, the width and length according to the Blaser et al. (2010) scaling laws, and the slip distributed according to the arbitrary Geist and Dmowska (1999) assumptions. The authors do not specify if the hypocenter is the barycenter of the earthquake fault, or how they select the fault position, given the hypocenter position. It is known that the slip distribution and the fault position (close to or far from the earth surface) is an important factor for the sea bottom co-seismic displacements. The set of elementary sources actually activated by each hypocenter depend on these choices. Please discuss.

Linearly combining the elementary tsunami to compute the waveform at 50 m depth offshore is reasonable. But taking the peak of the record and amplifying it following the Green's law is less justified, since waveforms change in approaching the coast, even on simple linear bathymetric profiles. It should be proven with some numerical examples that Green's law provides a good estimate of the amplification of the peak values. The authors should also specify the depth (10 m, 1m, ?) at which they compute

the PCTA.

The authors provide a clear definition of the probabilistic tsunami height (PTH). But more details are needed. It is unclear to me, for example, how they compute the 5000 yr PTH. Do they split the 300 Kyr catalogue into 60 sub-catalogue of 5000 yr length, and take a distribution of the corresponding PTH? And from this, do they compute the 15- and 85-percentiles? and what do they take as PTH? The 50-percentile of this distribution. Details should be added.

The discussion of section 4 especially at P5198 is too schematic, and in a sense seems to be a telegram text.

At P5198 bottom paragraph, the authors compare their results with Heidarzadeh and Kijko's findings (2010). Comparing results obtained by a sophisticated method that considers hundreds of elementary tsunamis and thousands of composite faults scenarios with results obtained with only three scenarios and finding some basic similarities is a great value for the simplified method. Some considerations should be added on this.

Varying the GRB law leads to substantial changes of the PTH and exceedance probabilities, and the authors stress that the maximum possible magnitude has the largest role. The study seems more a sensitivity study. Indeed, another consideration can be drawn. If all the considered GRB variants are equiprobable (in the sense that all are comparable with the empirical seismicity data and none has to be preferred over the others), the result is that for the largest values of the tsunami height at the coast, the uncertainties are so large that they are not constrained. The probability of exceedance of 8m in 500 yr and of 15m in 500 yr in Iran and Pakistan (Figure 5 right) goes from 0 to 80% and from 0 to 100% (from impossible to certain)respectively. And this big uncertainty is lethal for decision makers.

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., 3, 5191, 2015.