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Assessing assessments

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Assessing assessments

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This lecture will discuss some of the issues that can arise when one is in the position of having to judge the adequacy of a PSHA.

In practice, coming to a conclusion on the reliability - or unreliability - of a PSHA is far from straightforward and not a task to be undertaken lightly. This is because, in any attempt to quantify hazard estimates, inevitable shortfalls in knowledge will introduce uncertainties which can only be countered by making use of expert judgement. Like all other probabilities, therefore, PSHA results depend, often in large measure, on accumulations of subjective judgements. (Some indication of the void that these judgements need to bridge in any given instance is given by a comparison between the effective time-scales required of the hazard estimate and those of the actual 'experience' data for the location in question.)

The ubiquitous presence of uncertainty, and the consequent need to employ expert judgement, explains why, for example, apparently anomalous situations can arise when successive PSHAs are carried out for the same location. Particularly in moderate seismicity environments, where significant advances in scientific understanding are likely to be few and far between, the advantages available to a new study as a result of such extra or improved information as has become available could, quite possibly, be undermined by the exercise of questionable judgement(s).

As well as cases where there is a need to explore the adequacy of just a single assessment, therefore, there are other situations where it becomes necessary to respond appropriately to the existence of several assessments. (For example, one reaction to the problem of dealing with uncertainties has been to try to reduce the reliance that is placed on judgements made by a single team of specialists by using two - or more - teams, each of which produces its own independent assessment.) There are, therefore, a number of reasons why it can become necessary to be able to judge systematically and fairly how adequate any individual hazard estimate is likely to be.

Comparisons can, of course, be made with procedural guidelines, such as those issued by the IAEA or local regulatory bodies. Beyond this, however, given the absence (blatant errors apart) of definitive “rights” or “wrongs” in decision-making, all that can sensibly be done is to either:

> (a) compare the hazard estimate itself with the evidence from other, independent, sources of information, or
>
> (b) review (and, where possible, test) the legitimacy of the individual expert judgements which have influenced that estimate.

Before all this, however, it is necessary to consider whether terms such as “adequate” are even appropriate in circumstances where there can be no objective definition of what they mean. With all the uncertainty - and, hence, subjectivity - that is involved in every PSHA, different interpretations of such terms are, more or less, bound to surface, even in cases covered by prescriptive regulatory requirements.

Terminologically, it seems to be most sensible to talk about the “robustness” of a seismic hazard assessment since this phrase - along with its converse, “fragility” - conveys the most appropriate message. A PSHA result which is not reasonably robust against the uncertainties that are present in the existing database is of little use to anyone. To be of lasting benefit, a hazard estimate also needs to be such that it is unlikely to be made fragile by the arrival of new data that are consonant with what is already known (e.g. by the occurrence of another modest earthquake).

This said, accepting the idea that robustness is the fundamental requirement of hazard estimates should not be seen as implying that the most pessimistic judgements have necessarily to be made at every turn. Robust estimates of hazard exposure just have to allow explicitly for all the uncertainties that are involved (i.e. as they are, currently, understood both the epistemic and the aleatoric uncertainties) so that they can be expected to remain stable against the arrival of all but the most extreme new data.

This is also not to say that current hazard estimates cannot be reduced. Where reliable new data or rigorous new methodologies can be used to reduce epistemic uncertainties, it is only sensible to take advantage of the results.

In assessing robustness, it would, of course, be completely to misunderstand the situation if numerical differences between the sets of results given by any two hazard assessments were simplistically seen as indicating that some absolute degree of security is vested in the higher set of values. As there is always a possibility that, for one reason or another, neither of the two is satisfactory, some detailed scrutiny is necessary.

It follows, therefore, that the primary objective in reviewing an PSHA is to come to legitimate, and fair, conclusion as to whether or not the hazard estimate given by that PSHA is likely to be robust against all the uncertainties that properly should be associated with that estimate.

Experience shows that complications conspiring to make coming to such a conclusion far from straightforward are likely to be encountered with both of the approaches identified above.

Some of these complications will be discussed and illustrated in the lecture which concentrates almost entirely on seismic hazard estimates that are expressed in terms of single variables (consideration of the other issues that can arise when characterizing the probabilistic ground motion hazard across a full range of frequencies are beyond the scope of this contribution).

The lecture will go on to describe some of the problems that were encountered and had to be overcome in a recent project where the requirement was to provide guidance on appropriate levels of offshore hazard exposure for immediate use, given three sets of independently-derived hazard maps.

There now follow a few sheets which give an indication of the type of material that will be discussed in the lecture.

Using comparisons to judge the robustness of PSHA results

Cf. with: same site: site-specific: different time
Cf. with: same site: site-specific: same time: different assessors
Cf. with: same site: site-specific: same time: different probabilistic methodology
Cf. with: same site: site-specific: same time: deterministic methodology
Cf. with: same site: macroseismic experience data
Cf. with: same site: instrumental experience data

Cf. with: nearby site: site-specific: similar time & probabilistic methodology
Cf. with: nearby site: site-specific: different probabilistic methodology

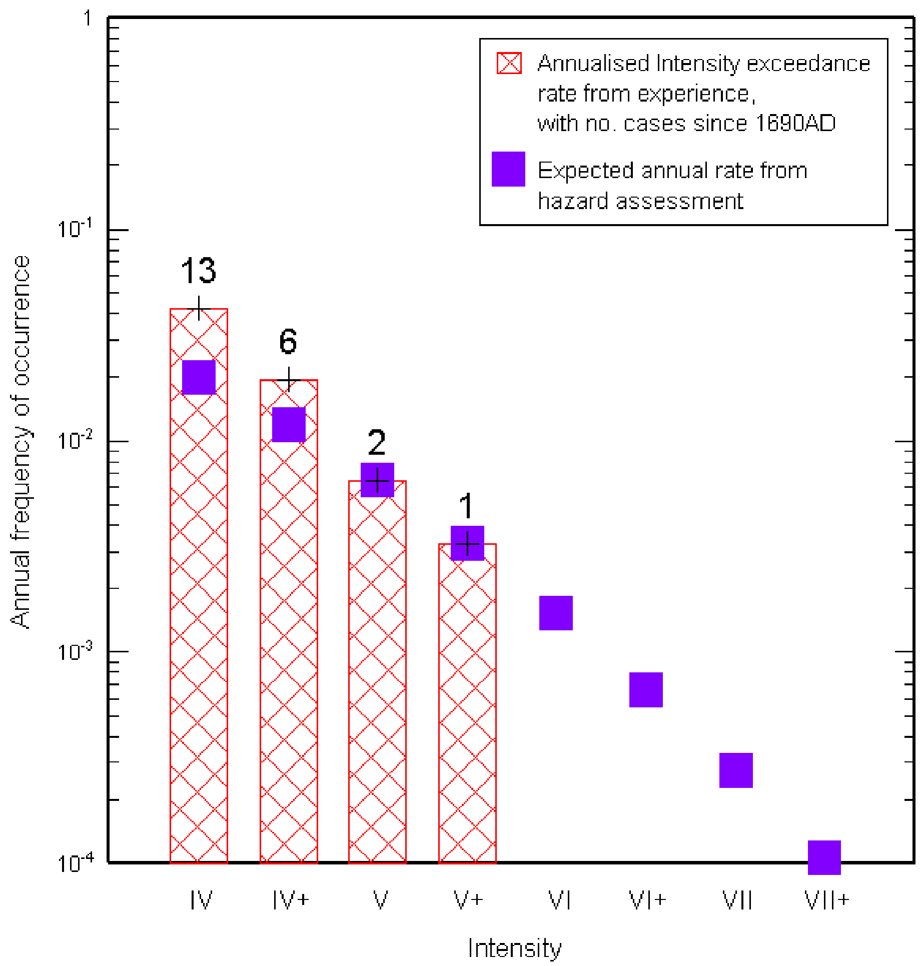
Cf. with: calculated minimal probabilistic hazard levels

Cf. with: same location: regional hazard map

Comparison of site-specific 10^{-4} p.a. probability of exceedance *pga* hazard results derived by different calculational methods

Site	Zoned Model	Zone-free Model
I	0.213g	0.200g
II	0.179g	0.15g
III	0.236g	0.203g
IV	0.257g	0.19g
VI	0.226g	0.17g
VII	0.185g	0.176g

Example of comparison between calculated site-specific macroseismic Intensity hazard curve and the `experience` data for that site



In deconstructing a PSHA to examine and assess the individual judgements on which its results are based, the process which has to be gone through is as follows:

(i) to identify all the judgements that have been made in the course of the PSHA which could have had an effect on its results;

(ii) wherever it is possible, to test the validity of each judgement that has been made and record whether, on that basis, the judgement appears to be robust or fragile;

(iii) wherever it is possible, to compare each judgement that has been made with recognised best practice in the local nuclear industry and record whether, on that basis, the judgement appears to be robust or fragile:

(iv) to categorise the judgements into:

(a) those whose effect on the hazard result is tractable, and

(b) those whose effect on the hazard result is not tractable;

(v) to arrange the list of judgements which fall into category (a) in terms of hazard sensitivity at the probability level of concern;

(vi) working through this `hierarchical` list, for each category (a) judgement, to evaluate what effect that judgement has had on the hazard results and record whether, on that basis, the judgement appears to be robust or fragile, and

(vii) to use the findings of tasks (ii), (iii) and (vi) in a coherent system which allows a conclusion to be reached on the overall robustness of the PSHA.

CASE HISTORY

In summary, the process followed was as follows:

1 replicate all maps to same scales

2. construct common grid of datum points

3. examine significance of differences between results of three studies

4. concoct robustness scoring system relevant to this problem

5. mark each assessment for robustness overall

6. using these marks, assign relative weights to each overall set of results

7. at each datum point, compute `hybrid` hazard employing this weighting system

8. plot `hybrid` hazard map

9. compare `hybrid` hazard map with site-specific hazard results for coastal sites

10. determine robust magnitude completeness thresholds for whole area

11. at each datum point, compute minimal `no earthquakes` hazard

12. plot `no earthquake` hazard map

13. at each datum point, select higher of `hybrid` hazard and `no earthquake` hazard and plot as `combination` hazard map

14. at each datum point, select higher of `combination` hazard and hazard given by top-marked study and plot as `provisionally recommended` hazard map

Other information presented in one or other of my three lectures appears in the following references:

Mallard, D.J. (1986) The investigation of historical earthquakes and their role in seismic hazard evaluation for the U.K. Paper presented at IAEA Technical Committee Meeting on "Earthquake ground motion and seismic evaluation of NPPs", Moscow, USSR. Reproduced (1989) in: IAEA-TC-472.2, Vol.1. IAEA, Vienna, 201-219.

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