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Opinion paper

Epistematic and aleatory uncertainty: a new shtick for probabilistic seismic hazard analysis

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"There is less here than meets the eye."— Tallulah Bankhead, 1922

1. Foreword

The United States has been plagued by a series of controlled workshops and review committees whose only purpose is to tell everyone they must use Probabilistic Seismic Hazard Analysis. The workings of several such groups were described by Krinitzsky (1993a, 1995), and there have been others. They are created by advocates of seismic probability and are dominated by them. Their conclusion is that seismic probability is the only method. Now, another such pedagogic crammer is taking shape for 2002. The sponsors obtained for the occasion are the National Science Foundation and the Pacific Earthquake Engineering Research Center Lifelines Program. Their announcement states they will examine "state-of-the-art ground motion predictions..., *with major emphasis on quantifying their associated aleatory and epistematic uncertainties*" (my italics).

Uncertainty is a buzz word adapted by seismic probabilists to mean seismic probability must be used (see Krinitzsky, in press). They claim everything is uncertain, therefore, only a probability can express it. The drawback is that the process of seismic probability itself constitutes the greatest uncertainty. We note that this uncertainty has blossomed into the dual aspects of epistematic and aleatory contributions. We need to ask if this is a wonderful breakthrough that we should absorb because it is apposite and instructive, or could it be as underwhelming as the rest of their thoughts.

We need to look at this.

2. Epistematic and aleatory uncertainty

SEISMIC PROBABILIST: Epistematic knowledge (of earthquakes) is uncertain because data are incomplete.

REALITY: Epistematic knowledge is interpreted knowledge. It may or may not be uncertain. Interpreted knowledge has been certain enough in the past

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to constitute a highly rational basis for the development and growth of engineering, or there would be no engineering or much of anything else on a creative level.

SEISMIC PROBABILIST: Aleatory knowledge of future earthquakes is uncertain because of the unpredictability of earthquakes.

REALITY: Aleatory knowledge is predicted knowledge. It is satisfactory or unsatisfactory, depending on the nature of the prediction and the use that is made of it.

Both the deterministic and probabilistic methods predict earthquakes. The deterministic method predicts future earthquakes for engineering purposes. This is done by selecting one or more maximum credible earthquakes as representative of the seismogenic capability of the surrounding region. The probabilist predicts them from a *b*-line projection. Unfortunately, the probabilists travel the *b*-line without disclosing any of the enormous errors unavoidable in the *b*-line conception (see Krinitzsky, 1993b). Those are gigantic uncertainties and are never disclosed. The deterministic method allows full disclosure. Determinism, therefore, is more transparent and more sensible and can always be accompanied by full disclosure of the rationale applied in each step of the computation (see Krinitzsky, 1998, in press).

The seismic probabilists wish to use epistematic and aleatory categories to constrain and thereby reduce the scatter in the data. By controlling the range in the data, they believe they will control this uncertainty. It is the only so-called uncertainty that they attempt to address and it is the least of their uncertainties.

The reality is that the probabilists cannot intelligently manipulate the scatter in the data, nor should they. The scatter is from records that are real and is there for an infinity of geologic and seismogenic causes. There is no point in focusing on individual causes, such as directivity, and consider them useful for artificially reducing the scatter. The causes are numberless and the multiplicity of causes is included in the data set from which motions are obtained. The solution is to place within brackets the range in the data by using a mean plus one standard deviation (Krinitzsky, in press), which is employed by the determinists as a conservative, one-time incorporation of the so-called uncertainty. Yet, the seismic probabilists use mean values. Thus, they lose the ability to account for this variance because they refuse a bracketing that can include the observed motions. Also, they try to make their mean values incorporate their idea of uncertainty (the range in the data) by squeezing the data. Just as well, all their numbers are mysterious.

Probabilistic values are mysterious because the seismic probabilists ignore an incredible host of errors which make *b*-line projections practically worthless (Hofmann, 1996; Mualchin, 1996; Krinitzsky, 1993b). An enormous amount of information shows that earthquake occurrences are not uniform through space and time (Krinitzsky, 1993b). Yet, the seismic probabilists assume the opposite and ask you to believe that earthquakes occur in an orderly, uniform, or predictable manner for any span of time. They ignore the impossibility of correlating the sizes of ground motion amplitudes as a linear progression through time. They take numbers for points on a *b*-line, convert them to ground motions, and absurdly claim that those are accurate for design. The enormous error bands, those really great uncertainties that accompany their values, are never disclosed because they would expose the numbers as worthless. Furthermore, we have not mentioned the way earthquakes are smeared together in the probability calculation, so that an earthquake picked for design out of the amalgam has no resemblance to any that takes place in nature (Krinitzsky, 1998). Yet, all of those utterly ridiculous flaws in Probabilistic Seismic Hazard Analysis are ignored and we are told to tinker with their notion of epistematic and aleatory uncertainty.

That is chutzpah.

Also, epistematic and aleatory are words that are offensive in their own right because they are esoteric and portentous. These are words that are meant to impress, to imply deep thinking and meaningful insight. Yet, the insight they offer is brummagem and paltry.

3. Conclusions

Many fundamental and deadly flaws in Probabilistic Seismic Hazard Analysis cry for attention. Those are ignored. Instead, the National Science Foundation and the Pacific Earthquake Engineering Research Center Lifelines Project were persuaded to embark on a workshop to examine the benefits to Probabilistic Seismic Hazard Analysis of epistematic and aleatory uncertainty. This is useless because uncertainty is accounted for more logically, more simply, and more accurately by the deterministic method, which seismic probabilists choose to ignore.

Almost as bad, epistematic and aleatory, grandiose words for miasmatic ideas, are a misuse of language.

When I was a lad, one of my joys was to go to the carnival, not to see the bearded lady but to hear the barkers. One got on a box and showed us a fountain pen, worth 10 cents. "Tonight, I have the extraordinary good fortune to be able to bring you a miraculous breakthrough in the art of metallurgy," he intoned as he unscrewed the cap and showed us the pen point. "The point of this pen is a new wonder metal called Ironium. My friends, Ironium is indestructible. You can write with it forever. And, this Ironium pen point writes with such smoothness that your words will flow effortlessly onto the paper. This extraordinary pen point will never again be sold for the bargain price I am about to offer you. One dollar! I will give you this Ironium pen point for only one dollar, and I'll tell you what I'm gonna do. Buy this genuine Ironium pen point, for only one dollar, and I will give you the pen to go with it, for free!"

When I see epistematic and aleatory, I remember Ironium.

You should too.

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