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About the differences between ground motion relation and regression model

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Ground motion relations (GMR) are an important element in probabilistic seismic hazard analysis. They are also called ground motion prediction equation (GMPE). The term prediction equation originates from the statistical regression analysis. Correspondingly, GMPE are understood as a regression model. I show that the concept of the regression models is not the ideal method to represent a GMR. An important difference is that regression models deal with random variables although magnitudes and local shaking intensities, e.g. the peak ground acceleration (PGA), are stochastic point processes on the line of real numbers. Additionally, the size of the set of points (sites) in the geographical space which suffer a certain or higher level of PGA can be measured for a concrete vector of event parameters by integral computation. The defined integral determines the cumulative area function. This is similar to the computation of the well-known annual exceedance frequency function of a local hazard. The concept of a regression model does not foresee such measuring function.
In this paper, I extend the concept of area functions from the expected shaking intensity to the realized shaking intensity (observations), which includes at least one random component (aleatory uncertainty). Two examples show that the difference between the GMR and the observed shaking intensity, the so called residual, must not be simply interpreted as a random component. Otherwise, the seismic hazard would be overestimated. In a GMR, the extent of over- and underestimated PGA at different sites can be in balance, while this is not possible in a regression model.