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Increasing the Computational Efficiency of Seismic Hazard and Risk Assessment with Variance Reduction Techniques

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Probabilistic seismic hazard and risk assessment is widely used in academia and industry to model the occurrence of earthquake events and their consequences. In many applications, the Monte Carlo method is employed to solve the underlying integrals.

The error convergence order of the naive Monte Carlo method is relatively slow ($O(1/\sqrt{n})$ for sample size n). For underwriting purposes in the insurance industry, fast model runtime is a key requirement. Methods to improve the efficiency of the Monte Carlo method are referred to as variance reduction techniques. We investigate the applicability of several well-known variance reduction techniques to treat the uncertainty in seismic hazard and risk assessment. Based on three realistic loss scenarios in Indonesia, we first examine the performance of methods that explore the parameter space globally such as Latin Hypercube Sampling and Quasi Monte Carlo Simulation using low-discrepancy sequences. To this end, we compare empirical error convergence to theoretical error convergence orders. In addition, we study locally adaptive sampling techniques such as recursive stratified sampling.

The results show that variance reduction techniques can improve the convergence order of the Monte Carlo method for seismic hazard and risk assessment in many cases. We conclude with some recommendations on how to apply the results in practice.