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Multi-scenario analysis: a new hybrid approach to inform earthquake disaster risk planning

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Current earthquake risk assessments take one of two approaches: deterministic (scenario) or probabilistic, but both have notable limitations. Deterministic approaches are limited by a focus on a single scenario, as the results of the analysis are only relevant to the scenario selected, which is unlikely to represent the earthquake that occurs next, nor its impacts. Alternatively, probabilistic approaches are sensitive to the completeness of evidence of past earthquakes, which is inadequate in most seismically-active parts of the world. Consequently, earthquake risk assessments have failed to inform planning prior to major earthquakes such as the 2005 Kashmir and 2008 Wenchuan disasters.

This study presents a new hybrid approach for earthquake risk assessments that maintains the high detail of deterministic approaches but considers numerous scenarios simultaneously, similar to probabilistic approaches. The aim of such an approach is to identify impacts that recur in multiple scenarios, or impacts that occur irrespective of the given scenario. Such recurring impacts can be considered the most likely consequences to occur in the next earthquake, despite the precise details of the next earthquake remaining unknown. To demonstrate this, we apply the method to Nepal, one of the most seismically at-risk nations in the world. We model 30 different potential earthquake scenarios throughout the country with magnitude ranges 8.6 to 7.0 for three different times of day (night-time, mid-week day-time, weekend day-time) for a total of 90 different scenarios.

By combining the results from each scenario for individual districts, we are able to assess which districts are most at risk of losses in the next earthquake. By focussing on fatalities as a percentage of total population, we rank each district by its: (a) median modelled fatalities; (b) percentage of scenarios with >0 fatalities; (c) inter-quartile range of modelled fatalities; and (d) maximum modelled fatalities. Combining these measures identifies the districts with highest risk of earthquake losses. We find that the five most at risk districts are, in order of most at risk: (1) Parbat, (2) Kapilbastu, (3) Rupandehi, (4=) Kathmandu, and (4=) Syangja. Notably, with the exception of Kathmandu, these districts cluster to Western Nepal near the tourist hub of Pokhara. At a national-scale, risk is notably less in eastern districts compared to western districts. Such information may enable more robust earthquake disaster planning by allowing better informed prioritisation of mitigation efforts and a greater understanding of spatially distributed earthquake risk.