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How detailed should earthquake hazard maps be: comparing the performance of Japan's maps to uniform, randomized, and smoothed maps

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Earthquake hazard maps forecast future shaking via assumptions about where, when, and how large future earthquakes will be. These assumptions involve the known earthquake history, models of fault geometry and motion, and geodetic data. Maps are made more detailed as additional data and more complicated models become available. However, the extent to which this process produces better forecasts of shaking is unknown. We explore this issue by comparing how well a 510-year-long record of earthquake shaking in Japan is described by the Japanese national hazard (JNH) maps, uniform maps, and randomized maps. Surprisingly, as measured by the metric implicit in the JNH maps, i.e. that during the chosen time interval the predicted shaking should be exceeded only at a specific fraction of the sites, both uniform and randomized maps do better than the actual maps. However, using as a metric the squared misfit between maximum observed shaking and that predicted, the JNH maps do better than uniform or randomized maps. Similarly, by the squared misfit metric, map performance improves up to a ∼75-150 km smoothing window, and then decreases with further smoothing. Because the maps were made by using other data and models to try to predict future earthquake shaking, rather than by fitting past shaking data, these results are probably not an artifact of hindcasting rather than forecasting. They suggest that hazard models and the resulting maps can be over-parameterized, in that including too high a level of detail to describe past earthquakes may lower the maps' ability to forecast what will occur in the future. For example in Nepal, where GPS data show no significant variation in coupling between areas that have had recent large earthquakes and those that have not, past earthquakes likely do not show which parts are more at risk, and the entire area can be regarded as equally hazardous.