# Long-term forecast model for crustal earthquakes using geodetic data in Japan

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We developed a regional likelihood model for crustal earthquakes using geodetic strain-rate data in Japan. First, the smoothed strain-rate distributions were estimated from continuous Global Navigation Satellite System (GNSS) measurements in three regions into which mainland Japan is divided. Second, we removed the elastic strain rate attributed to interplate coupling on the subducting plate boundary, including the observed strain rate, under the assumption that it is not attributed to permanent loading on crustal faults. We then converted the geodetic strain rates to seismic moment rates and calculated the 30-year probability for $M \geq 6$ earthquakes in $0.2 \times 0.2°$ cells, using a truncated Gutenberg–Richter law and time-independent Poisson process. Likelihood models developed using different conversion equations, seismogenic thicknesses, and rigidities were validated using the epicenters and moment distribution of historical earthquakes in southwest Japan, where the long-term catalog of historical earthquakes is available. The average seismic moment rate of crustal earthquakes recorded during 1586–2020 was only 13–20% of the seismic moment rate converted from the geodetic data, which suggests that the observed geodetic strain rate includes considerable inelastic strain. Therefore, we introduced an empirical coefficient to calibrate the moment rate converted from geodetic data with the moment rate of the earthquakes. Several statistical scores and the Molchan diagram showed our models could predict real earthquakes better than the reference model, in which earthquakes occur uniformly in space. There were no significant differences in predictive skill between uniform and variable distributions for seismogenic thickness and rigidity. Finally, we combined three regional models into a single model using the same empirical coefficient. The preferred models suggested a high (≥1 %) 30-year probability in the Niigata–Kobe Tectonic Zone, Izu Peninsula, and central Kyushu.

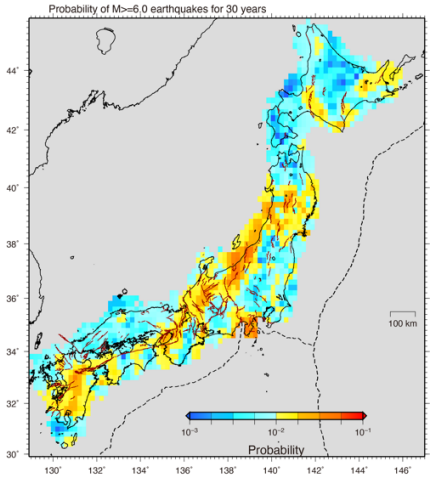


Fig. 1 30-year probability of M≥6 crustal earthquakes estimated from GNSS strain rate data in Japan. Uniform seismogenic thickness (12 km) and rigidity (30 GPa) are used.