Comparison between various stochastic models that explain the paleoseismic activity data of major active fault zones in Japan

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Six active fault zones, whose paleoseismic activity data involve three or more known recurrence intervals of earthquakes, have been selected from reports on the long-term evaluation of active faults published until 2008 by the Earthquake Research Committee, Headquarters of Earthquake Research Promotion (ERC/HERP). Using a renewal process model and maximum likelihood method, we compare seven probability density functions for a renewal process model, then discuss which function is the best one to explain to paleoseismic activity data of these active fault zones.

The results by comparing likelihoods show that exponential distribution does not appropriately express the earthquake occurrence intervals than the other six statistical models (Brownian passage time (BPT) distribution, lognormal distribution, gamma distribution, Weibull distribution, double-exponential distribution, and normal distribution). This means that newly available paleoseismic activity datasets on major active faults zones in Japan confirm the validity of the provisional conclusion of the ERC/HERP, which states that the exponential distribution does not appropriately express the earthquake occurrence intervals. On the other hand, differences between the goodness of fit among six models other than the exponential distribution are small.

ERC/HERP (2001) provisionally concluded that when a renewal process model with BPT distribution is applied to the earthquake occurrence intervals from inland active fault zones in Japan, the aperiodicity parameter of the distribution should be set to 0.24 as a value common to an active fault. By applying the same method, we obtained 0.44 from six active faults examined in this paper. Although aperiodicity parameters obtained by maximum likelihood method from data in the ERC/HERP's report range between 0.17 and 0.29, those from the data used in this paper range between 0.09 and 0.66. It does not seems appropriate to represent the aperiodicity parameter of all the inland active fault zones in Japan only with the one value.

Names of active faults (segments)	Number of intervals	Parameters estimated using maximum likelihood estimator and maximum log-likelihood						
		Brownian passage time distribution	Lognormal distribution	Gamma distribution	Weibull distribution	Double exponential distribution	Normal distribution	Exponential distribution
Kita-Izu fault zone	4	$\mu = 1458$ $\alpha = 0.350$ -30.3	$m = 7.227$ $\sigma = 0.342$ -30.3	$c = 0.00603$ $\gamma = 8.79$ -30.3	$\alpha = 3.86 \times 10^{-11}$ $\beta = 3.24$ -30.4	$a = 8.06 \times 10^{-5}$ $b = 1.89 \times 10^{-3}$ -31.2	$\mu = 1458$ $\sigma = 493$ -30.5	$\mu = 1458$ -33.1
Kiso-sanmyaku-seien fault zone (northern part of the main fault zone)	3	$\mu = 7750$ $\alpha = 0.631$ -29.1	$m = 8.809$ $\sigma = 0.592$ -29.1	$c = 0.000461$ $\gamma = 3.58$ -28.9	$\alpha = 9.75 \times 10^{-11}$ $\beta = 2.54$ -28.7	$a = 1.02 \times 10^{-5}$ $b = 4.00 \times 10^{-4}$ -28.2	$\mu = 7750$ $\sigma = 3432$ -28.7	$\mu = 7750$ -29.9
Atotsugawa fault	4	$\mu = 2502$ $\alpha = 0.152$ -29.4	$m = 7.813$ $\sigma = 0.151$ -29.4	$c = 0.017$ $\gamma = 42.56$ -29.4	$\alpha = 8.97 \times 10^{-23}$ $\beta = 6.43$ -29.9	$a = 3.64 \times 10^{-6}$ $b = 2.39 \times 10^{-3}$ -30.1	$\mu = 2502$ $\sigma = 396$ -29.6	$\mu = 2502$ -35.3
Atera fault zone (southern part of the main fault zone)	5	$\mu = 1697$ $\alpha = 0.659$ -40.9	$m = 7.268$ $\sigma = 0.611$ -41.0	$c = 0.00184$ $\gamma = 3.13$ -40.9	$\alpha = 2.46 \times 10^{-7}$ $\beta = 2.01$ -40.8	$a = 1.64 \times 10^{-4}$ $b = 9.21 \times 10^{-4}$ -40.8	$\mu = 1697$ $\sigma = 898$ -41.1	$\mu = 1697$ -42.2
Nobi fault zone (northwestern part of Nukumi fault)	3	$\mu = 2314$ $\alpha = 0.089$ -20.2	$m = 7.743$ $\sigma = 0.089$ -20.2	$c = 0.0555$ $\gamma = 128.5$ -20.2	$\alpha = 3.1 \times 10^{-48}$ $\beta = 14.05$ -20.1	$a = 2.73 \times 10^{-9}$ $b = 6.06 \times 10^{-3}$ -20.1	$\mu = 2314$ $\sigma = 202$ -20.2	$\mu = 2314$ -26.2
Beppu — Hane-yama fault zone (eastern part of Beppu — Hijiu active fault zone)	4	$\mu = 1537$ $\alpha = 0.319$ -30.2	$m = 7.291$ $\sigma = 0.312$ -30.2	$c = 0.00718$ $\gamma = 11.03$ -30.1	$\alpha = 1.43 \times 10^{-13}$ $\beta = 3.98$ -30.0	$a = 3.65 \times 10^{-5}$ $b = 2.41 \times 10^{-3}$ -30.1	$\mu = 1537$ $\sigma = 442$ -30.0	$\mu = 1537$ -33.4