Long-term Predictability for Repeating Earthquake using Standard Value of Lognormal Distribution

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Event numbers of sequential recurrent large/medium earthquakes listed in seismic catalog are frequently very small, because they recur at long intervals. Then it may be useful to adopt a standard value in some parameters which is commonly applied for such sequences in calculating the probability for the coming event. We are studying the predictability by two models, LN-NORM and LN-SST-Pin, involving those parameters. The standard values of σ_0=0.581 for standard deviation in log-normal distribution are determined from the 166 small interplate repeating earthquakes along the Japan Trench, which were used for the experiment of prospective forecasts from 2006 to 2010. Event data were taken in order from the last earthquake, with 3, 4, 5 and 5 or more. In 248 of 524 forecast sequences the repeater occurred during the forecast period.

(1) LN-NORM: Lognormal distribution model. The mean and variance parameters for each sequence are the sequential mean of logarithm of interval and the standard value squared, σ_0^2, respectively.

(2) LN-SST-Pin: Lognormal distribution model based on the idea of the small sample theory. The mean and variance parameters for each sequence is the same as LN-NORM and ((n+1)/n) σ_0^2, respectively.

(3) LN-Bayes: Lognormal distribution model with Bayesian approach. The parameter of the inverse gamma distribution, which is the prior distribution of σ^2, are ϕ=0.25 in shape and ζ=0.44 in scale (2006, 2008) or ϕ = 1.5, ζ = 0.15 (2009, 2010).

(4) LN-SST: Lognormal distribution model base on the small sample theory.

(5) Exp: Exponential distribution model. The parameter plugged is the sample mean.

(6)- (8) BPT-pin: BPT distribution models. The mean parameter for each sequence is the sequential mean of interval. And the parameter of coefficient of variation is the median of the values calculated from sequences of 4 repetitions, α_0=0.367, for model (6), the mean, α_0=0.52 for model (7), and the standard value by the Headquarters for Earthquake Research Promotion in Japan, α_0=0.24 for model (8), used in the long term evaluation of the large and great earthquake, respectively.

The "Mean log-likelihood" mentioned below are used to score the forecast results.
Mean log-likelihood (MLL): Average of Ev*ln (P) + (1-Ev)* ln (1-P)
Here P means forecast probability for event and Ev means presence (Ev=1) or absence (Ev=0) of the event. If the Mean log-likelihood is larger than those of the alternative, the model is considered to be superior to the alternative one.

The ROC (Receiver Operating Characteristic curve) is a diagram showing the relationship between "False Alarm Rate" and "Hit Rate" when the threshold value changes. It can be said that the model is better as the curve swells to the upper left side of the figure.

In Figure 1 the forecasts by six models become worse surely as the number of preceding events is smaller. When the number of event interval data is 2 or less, compared with the result of LN-SST-Pin model, the decline of the LN-NORM model is remarkable. The results of the LN-NORM model and the LN-SST-Pin model are inferior to those of the LN-Bayes model and the LN-SST model. When the LN-NORM model and the LN-SST-Pin model are predicted with 1 event data, the score is poor, and it is below the results of the probability of 0.5 (MLL=-0.693) for all case.

In Figure 2 the supplementation rate of the LN-Bayes model and the LN-SST model is superior to other models. And the supplementation rate of LN-NORM model and the LN-SST-Pin model is inferior to the 3 types of BPT model.

Keywords: Repeating earthquakes, Forecast, Log-normal distribution, Standard value, Mean log-likelihood, Receiver Operating Characteristic curve

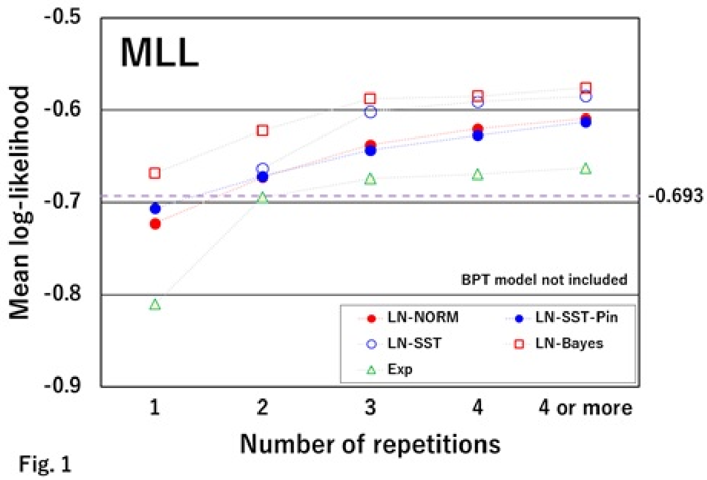

Fig. 1

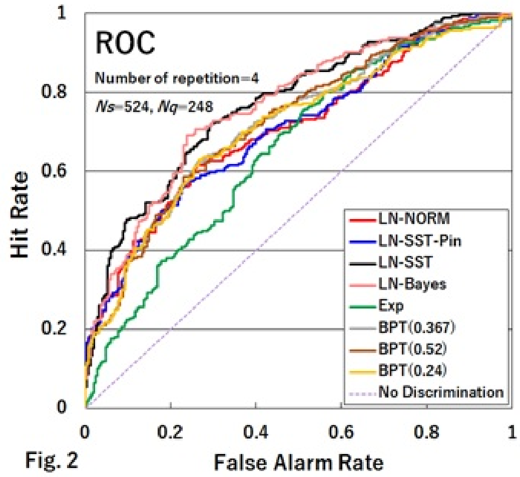

Fig. 2

