Trial Result of Long-term Occurrence Probabilities with The Moderate Repeating Earthquakes Using The Lognormal Distribution Model with Bayesian Approach

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We are investigating the moderate repeating earthquakes. And we are verifying the long-term probability forecast using the log-normal distribution model with Bayesian approach (LN-Bayes) by Okada et al. (2007). This model is that probability distribution of recurrence interval is given in the inverse gamma prior distribution. The parameters of inverse gamma use shape, ϕ=2.5 and scale, ζ=0.23. This model can be calculated from one sample. We calculated the probability of occurrence during one year from February 2016 (2016.2). Then in February 2017 (2017.2) and February 2018 (2018.2) we did the same calculation. We confirm the outcome of the forecast using evaluation index. Then compares with the result of another model.

We use three models for comparison.
(1) LN-SST: Lognormal distribution model base on the small sample theory.
(2) BPT: BPT distribution model. The coefficient of variation α use 0.24. This value is based on the Headquarters for Earthquake Research Promotion (2010).
(3) Exp: Exponential distribution model. The parameter plugged is the sample mean.

The "Mean log-likelihood (MLL)" and "Brier Score (BS)" mentioned below are used to score the forecast results.

MLL: Average of $Ev \log_e (P) + (1 - Ev) \log_e (1 - P)$

BS: Average of $(P - Ev)^2$

Here P means forecast probability for event and Ev means presence (Ev=1) or absence (Ev=0) of the event. The MLL has a negative value. The closer to 0, the better. The MLL is -0.693 when the probability is 0.5, and it is very bad if the value is smaller than that. The BS has a positive value. The closer to 0, the better. The BS is 0.25 when the probability is 0.5, and it is very bad if the value is larger than that.

In Figure 1 shows the forecast results of the MLL for the four models. With the 2016.2 trial, The LN-SST model is better than other models. With the 2017.2 and 2018.2 trials, result of the LN-Bayes model is better than the other models one. Three predictions are independent, and combining of results for three times, the result of the LN-Bayes model is superior to the other models. But results of the LN-Bayes, the LN-SST and the Exp models are gradually getting worse. The results of the LN-SST model change more than the other two models. In February 2018 results, result of the LN-SST model is inferior to result of the Exp model. The cause is unknown. The BPT model is a very bad results in all three times.

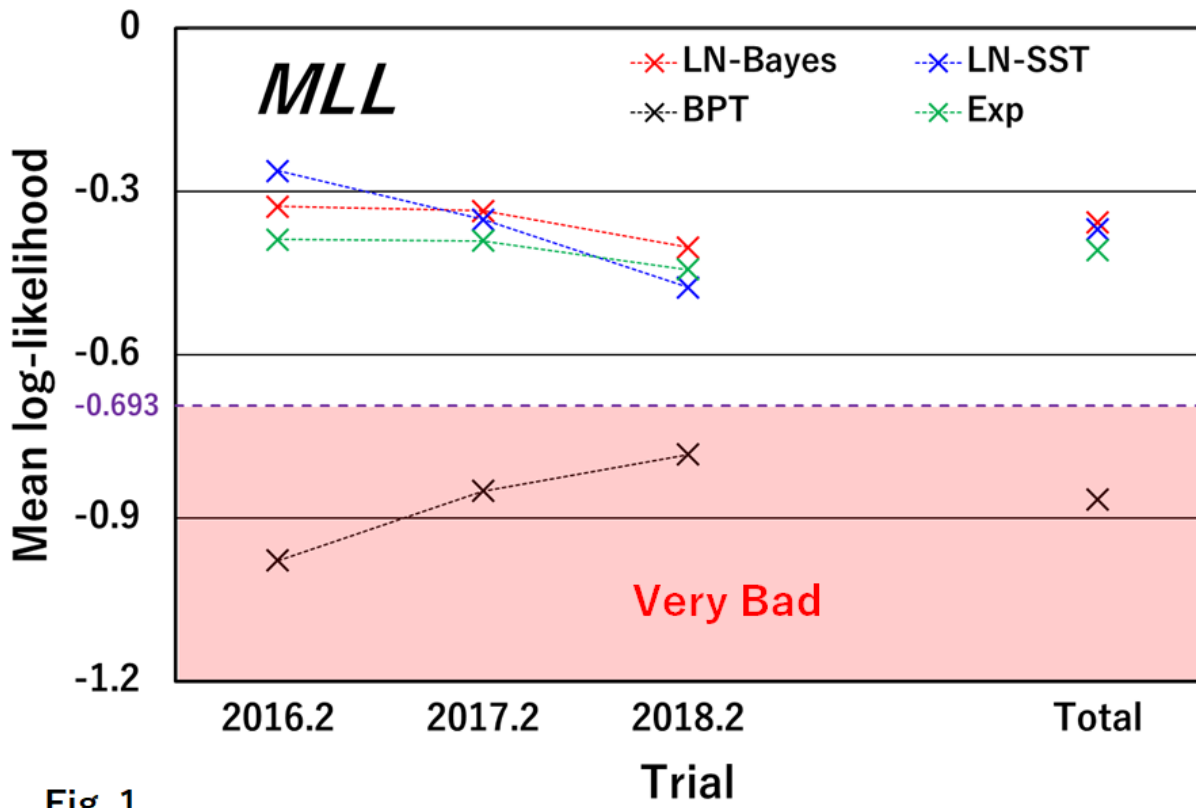Keywords: Repeating earthquakes, Forecast results, Mean log-likelihood

Fig. 1