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Bayesian forecast with uncertain occurrence data in a BPT renewal process

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On forecasting recurrent earthquakes in active faults, we often confront with the problem with their occurrence data; one is its scarcity and another is its uncertainty. These problems cause a large error in forecasts, so we should forecast large earthquakes by taking all the possible cases into acount. Thus, we propose a Bayesian renewal process to consider these possibility in the forecast. It gives us probability distributions for model parameters and uncertain data.

For the first problem, the error of parameter estimates, we incorporate a Bayesian procedure into a renewal process to forecast the next earthquake. This model utilizes information on other earthquake series to provide the intrinsic prior distributions of the model parameters. From various prior models, we select the common prior distribution that has the smallest value of the Akaike's Bayesian Information Criterion (ABIC) (Akaike, 1980). We also use geological information, such as single earthquake displacements (U) and deformation rate (V) to calculate mean recurrence time as T = U/V in addition to recurrence intervals obtained directly from historical records and paleoseismic investigations (Rhoades et al., 1994).

For the second problem, we discuss the inference about the uncertainty of the occurrence data and long-term evaluation with this uncertainty about some fault. Since paleoseismic investigation specifies the trace of seismic activities in stratum and infers its occurrence date from radiocarbon age of the surrounding deposits, only the upper and lower limits are specified for the occurrence date. When the estimated ranges for occurrence date are so wide, they affect probability forecast critically. Additionally, it is often the case that it is hard to judge whether earthquake occurred or not in a layer accumulated in some period of age. Even if we could specify the trace of earthquakes, there is a case that it is hard to specify how many earthquakes had occurred. In these cases, the dataset have uncertainty of occurrence itself as well as occurrence date and we have to consider them to analyze the data. To use all information from historical accounts and paleoseismic investigations, these uncertainties should be incorporated into stochastic model. Thus, we consider a likelihood function of data sets with various kinds of uncertainties for previous Bayesian model and forecast next earthquakes by the Bayesian predictive distribution.

We show the results of the analysis in some active faults in this presentation. We can see some of our probabilistic forecasts are rather different from that of the Earthquake Research Commitee of Japan, which also considers the uncertainty of parameters and occurrence data. These results are caused by the probability weight for each possible parameter and data estimated from its likelihood of our model.

Keywords: long-term forecast, recurrent earthquakes, uncertainty of data, Bayesian forecast, BPT distribution, renewal process

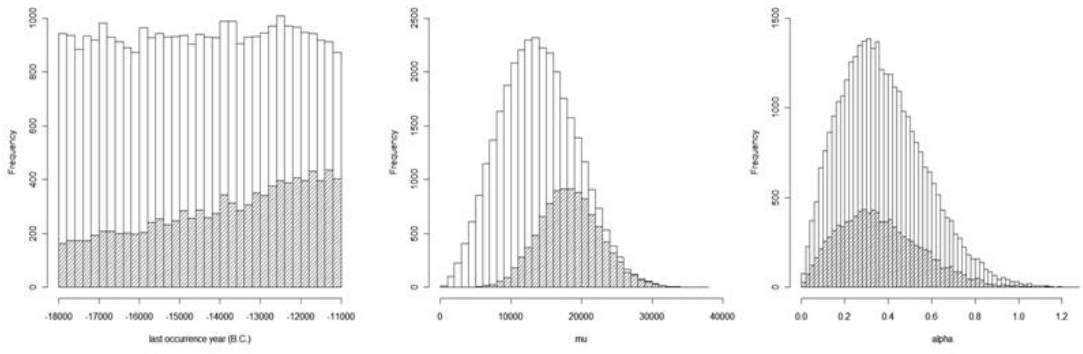

Figure: Samples from prior and posterior distribution for the last occurrence time, the mean inter-event time μ and the aperiodicity of inter-event time α in Tachikawa fault.