# Research report for “Short-term earthquake forecasting through a smoothing Kernel and the rate-and-state friction law: Application to the Kanto region, Japan”

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During the visit of ERI, I was hosted by Prof. Hirata. Our collaboration focused on construction of earthquake forecasting models through a smoothing Kernel and the rate-and-state friction law. The following is the description of our joint research.

Earthquake forecasting approaches were employed for estimating the spatio-temporal distribution of seismicity density in the Kanto region, Japan. To evaluate long-term seismicity rate, a smoothing Kernel function based on the distribution of past earthquakes was proposed. With the use of the rate-and-state friction model, short-term rate evolution according to the fault-interaction stress disturbance was forecasted. To test feasibility of this model, it was applied using a catalog for the Kanto region. The earthquakes from 1923 to 2009 were considered for establishing the long-term forecasting model using the smoothing Kernel function. The earthquakes from 2010 to 2011 were referred for the retrospective forecast and for establishing a short-term forecasting model using the rate-and-state friction model. We first proposed a forecasting model in two-dimension, which is depth-independent (Figure 1). The forecasting rates in different magnitude bins were evaluated. It shows a higher rate for the bin with smaller magnitude. This is consistent with the Gutenberg-Richter magnitude-frequency relation. To test its forecasting ability statistically, we compared forecast model with the distribution of target earthquakes using the Molchan diagram (blue dots in Figure 2). It shows insignificant correlation between forecasting model and observations. Such result could be attributed to complex tectonic setting in the Kanto region. For further improvement of the model, a three-dimensional forecasting model, which is depth-dependent, was proposed (Figure 3). The high seismicity rate off the Pacific coast can be associated with stress increase imparted by the 2011 Tohoku sequence. This phenomenon can be forecasted according to the rate-and-state friction model. Besides, some seismic clusters inland Japan at various depths can also be forecasted. The corresponding Molchan diagram also confirms its forecasting ability (green dots in Figure 2). Furthermore, only 23% of target earthquakes were located within the study area that has a low (<50 percentile) forecast seismicity rate. The proposed approach, with verified applicability for seismicity forecasts, could be useful for seismic hazard mitigation. The application could provide a warning before the occurrence of consequent earthquakes and would be valuable for consequent studies, e.g., probabilistic seismic hazard assessment.

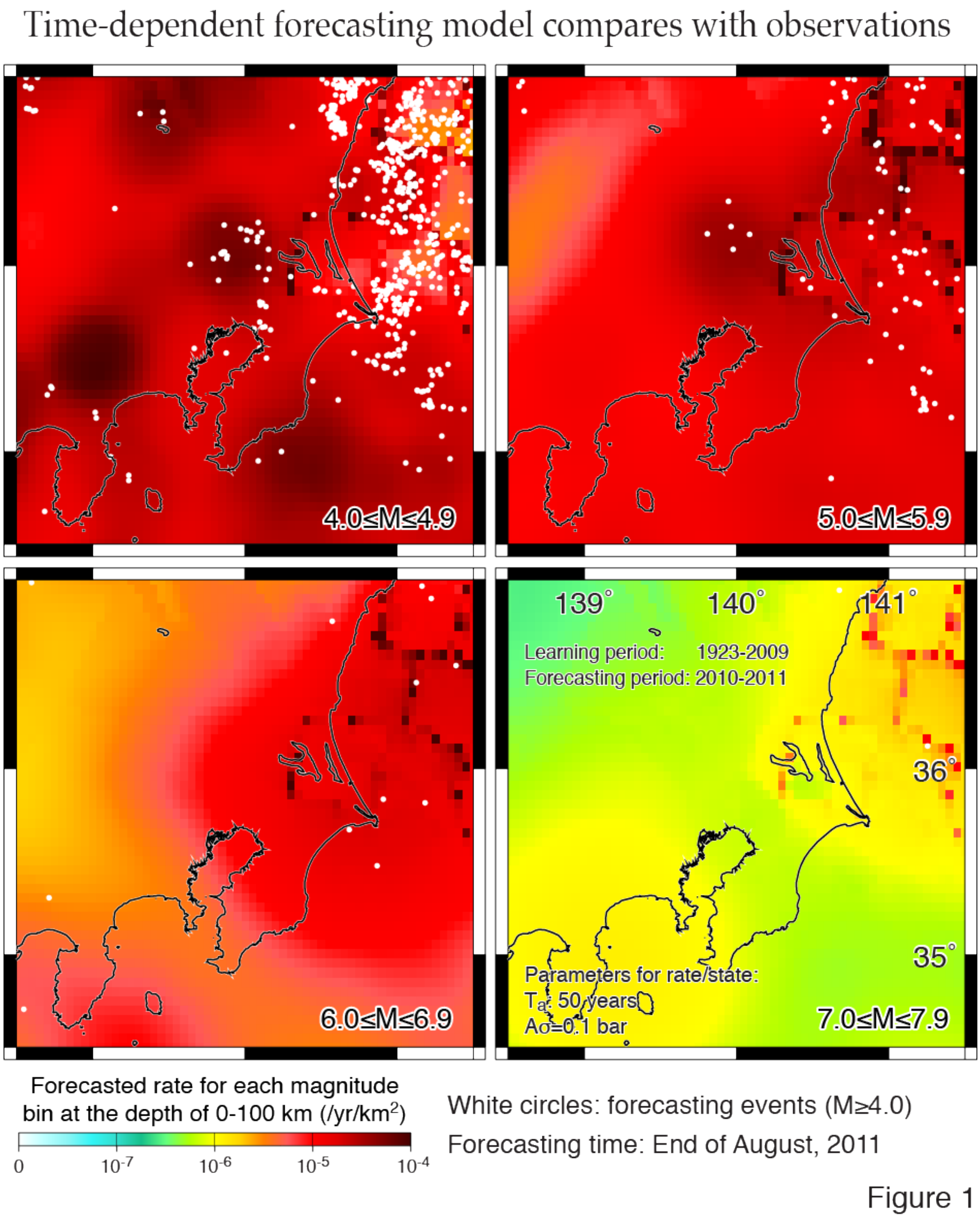


**Figure 1** The forecasting models for different magnitude ranges. Observations during forecasting period are shown as white circles.

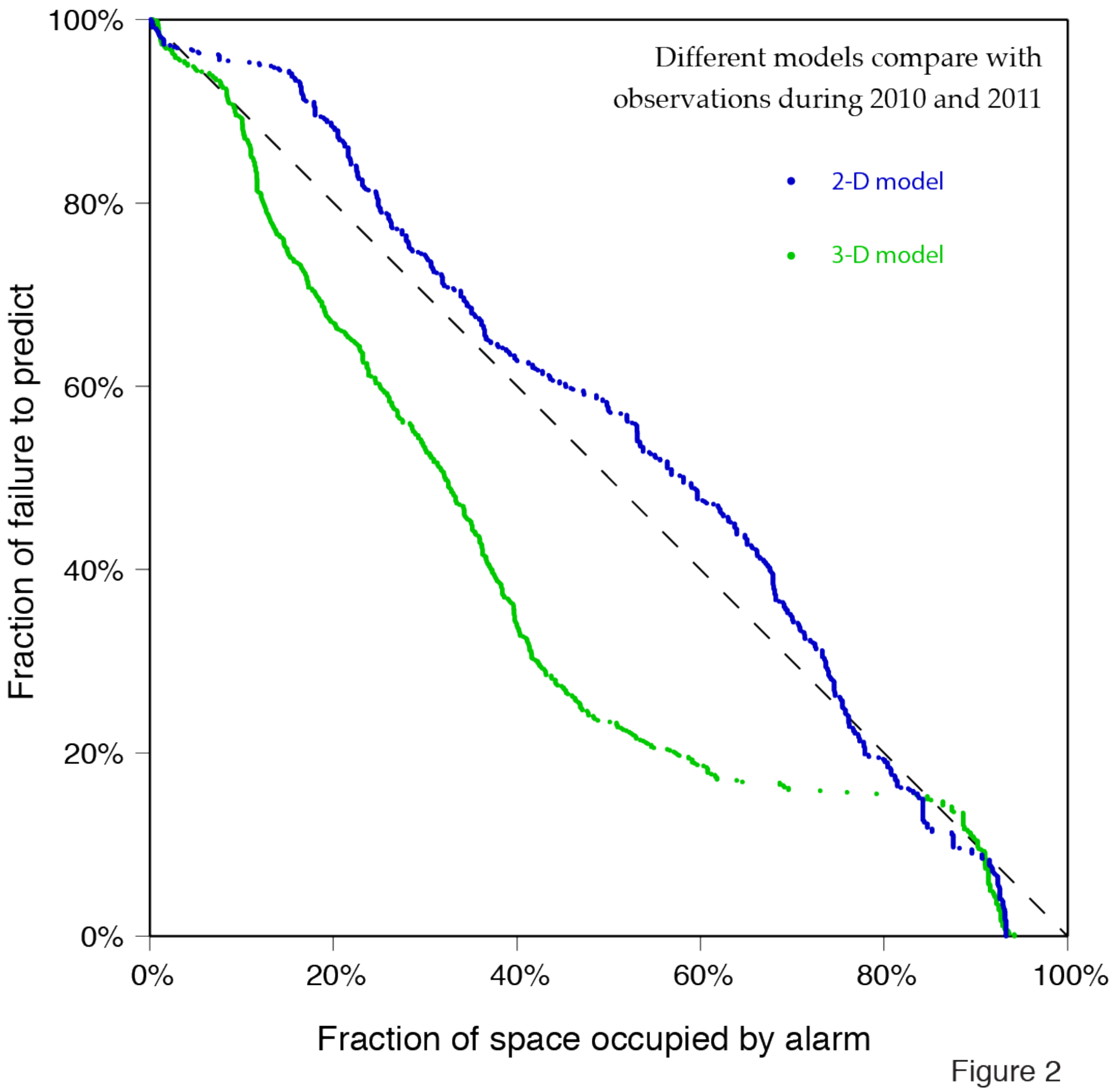


**Figure 2** The Molchan diagram for investigating the correlation between different forecasting models and observations. If the results are along the dashed diagonal line, it denotes no correlation between model and observation.

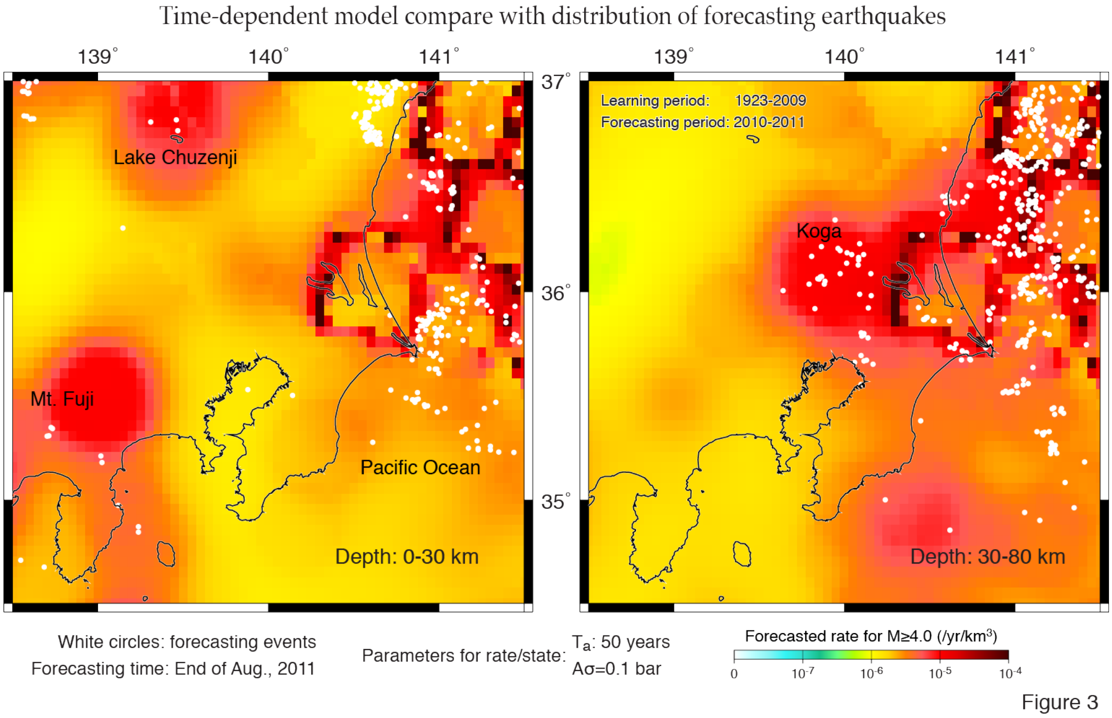


**Figure 3** The forecasting models for the depth of (a) 0-30 km and (b) 30-80 km, respectively. Observations during forecasting period are shown as white circles according to their hypocentral depths. Based on the model, higher rates are expected beneath Lake Chuzenji and Mt. Fuji at the depth of 0-30 km, and beneath Koga at the depth of 30-80 km. Besides, a significant high rate is expected off Pacific coast. Such forecasting model is consistent with observations.