大地震予測の評価のための相場確率

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A reference framework for evaluating significance of earthquake predictions

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The R-score, Molchan's error diagram and the likelihood ratio are usually used for evaluating the performance of earthquake predictions. As pointed by Zhuang (2010), these methods give too much weight to small events, i.e., predictions or models that focus on small earthquakes can easily gain a higher score than those that focus on big earthquakes. To solve this problem, Zhuang (2010) proposed a "high-risk, high-return" gambling scoring method. The method regards each predictor as a gambler: each time he makes a prediction, he is considered to bet 1 point of his professional reputation on what he predicts. If his prediction fails, he looses the 1 point of reputation that he bet; if he succeeds, he is rewarded fairly. Here we need a reference model to determine how much the predictor should be rewarded. Suppose that, according to the reference model, the probability that the prediction is successful is p_0. Then the number of reputation points to reward the predictor for each point bet in this successful prediction should be $G = (1-p_0)/p_0$. This return ratio is designed in such a way that, if the reference model is true, the expected return of each prediction is zero.

For "Yes"-only predictions, this score is a partial score. That is, it only counts the advantages in the prediction, but does not count the advanced points which are in the reference model but not in the prediction. The predictor need not build a systematic prediction scheme, while in other scoring procedures, this is almost a prerequisite. He need only bet at the time when he is more confident than the reference model. If his predictions have some advantages than the reference model, his overall performance will be shown by a positive return.

In this study, we construct a framework of a reference model for a fast test of predictions of large earthquakes. We divided the whole Japan region into $1^\circ \times 1^\circ \times$ 10-day grids. After evaluating the probabilities that at least 1 earthquake of $M_J \geq 5.0$ occurs in each grid, we give the return ratios for predictions of $M_J \geq 5.0$ earthquake on each grid. Once a predictor makes a prediction, he can bet his reputation points on the grids in his prediction. He will loses the points bet on the grids that the expected earthquake does not occur, but once an expected earthquake occurs, he will be rewarded of a number of reputation points determined by the return ratio on the corresponding grid. According to the gambling scoring rules, if he bets on a big earthquake in an area of low seismicity, he will get much more return than betting in an active region. But on the other hand, such higher-return betting is more likely to fail.

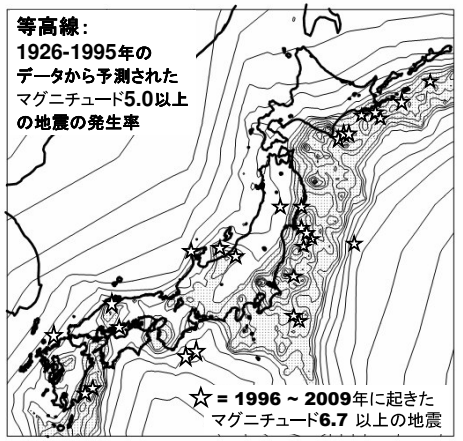

Figure 1: Seismicity rates of $M_J \geq 5.0$ earthquake in $1^\circ \times 1^\circ$ grids. The contour lines are drawn in logarithm scales. The stars represent the locations of $M_J \geq 6.7$ earthquakes during last 15 years.

References

Zhuang J. (2010) Gambling scores for earthquake predictions and forecasts. *Geophysical Journal International.* 181: 382-390.