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A modified model for forecasting aftershocks

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Earthquake forecast models are now under testing at the Japanese test center in collaboration with Collaboratory for the Study of Earthquake Predictability. According to the present rule of the test, the expected number of earthquakes for a forecast period should be obtained based on the data before the starting time of the period. Any 1-day model, for example, must generate a forecast for the period 00:00 to 24:00, using the data before 00:00 of the day; even if a large earthquake occurs and generates aftershocks within this 1-day period, regeneration of a forecast taking these events into account is not allowed. Consequently, most models that consider aftershock clustering likely underestimate the number of observed events under the current rule, unless such a situation is considered previously. In the presentation, we give a discussion to avoid this underestimation in terms of a likelihood measure to evaluate the degree of improvement of forecast performance.

For our discussion, we first define five variables as follows. A is the expected number of aftershocks that occur in a forecast period, which are generated by parent events that have occurred before the starting time of the forecast period; Ea is the long-term average of A; Eb is the expected number of aftershocks of parent events, both occur within the forecast period; and uo and u are long-term averages for whole events with and without aftershocks, respectively. Note that uo-u=Ea+Eb. Using the parameters, the most appropriate forecast number should be u+A+Eb (i.e. uo+A-Ea). In case of the ETAS model, correction terms of higher order are omitted in these expressions. The values for Ea and Eb can be calculated using parameter values adopted in any aftershock model (e.g. p, c and K in the modified Omori formula). Alternative to the value Eb or Ea, a useful measure may be the ratio to u and/or uo. For example, the ratios Eb/(uo-u) for 1-day and 1-year testing classes seem to be around 0.2-0.5 and 0.6-0.9, respectively. However, the correction term Eb may occasionally result in a small likelihood value because of fluctuating seismic activity. If it is necessary to avoid such exceptional cases, the correction term may be slightly less than Eb.

Keywords: earthquake forecast, aftershock, modified Omori formula, ETAS, likelihood