Probability forecasts of a large earthquake by combination of statistical characteristics and anomalies of seismic activity

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The unconditional probability of a major earthquake in a region is very small. Nevertheless, conditional probability enhances in presence of suitable empirical information or anomalous phenomena as potential precursors. In addition, if mutually independent abnormal phenomena of plural types are observed, it further increases the probability. For this quantification, we can refer to the multiple elements prediction formula of Utsu (1977) and Aki (1981). There were several retrospective examples of large earthquakes to which the formula had applied (Utsu, 1979; Cao and Aki, 1983).

Despite its importance, the multi-elements prediction formula has not been applied so far since then. One of such reasons is the scarcity of clearly recognizable anomalies preceding large earthquakes. Although various measurements have been monitoring large amounts of data, we have not yet well explored anomalous phenomena as possible precursors. In fact, such anomalies should include delicate ones that can be only revealed after diagnostic analysis of standard statistical models for various relevant datasets. By these we can raise 'alarm rate' in the sense of Utsu (1977), so that we can assess stable probability gains of large earthquakes.

This talk considers seismicity anomalies such as relative quiescence in aftershock activity and statistical discrimination of foreshocks from other types of earthquake clusters, as well as the evaluation of active fault ruptures. We can obtain such anomalies and probability gains using statistical models of earthquake occurrence data and their diagnostic analysis. As an illustrative application, I retrospectively forecast an $M \geq 7$ earthquake during the period preceding the 2016 M 7.3 Kumamoto earthquake in Kyushu, Japan. Furthermore, I discuss a possible outlook on relevant studies in seismic activity and other monitoring fields. For the detail, refer to Ogata (2017).

References

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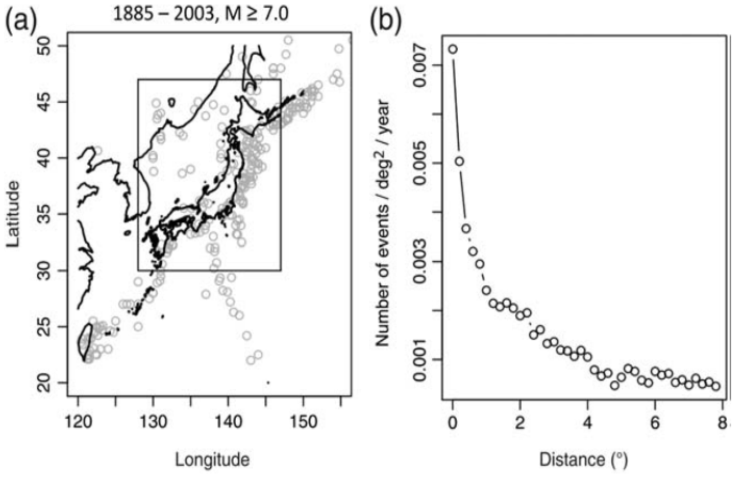
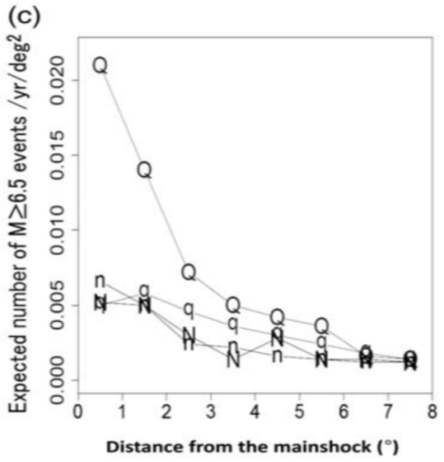
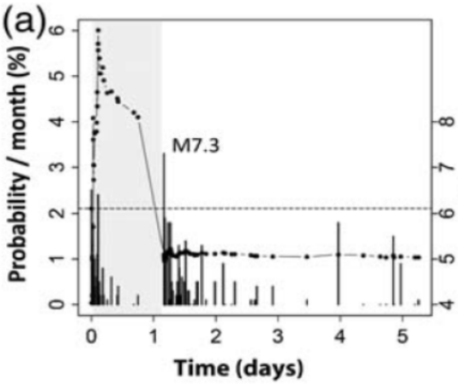


Triggering effects.
(a) Epicenter locations of $M \geq 7$ earthquakes in and around Japan between 1885 and 2003, obtained using the Utsu and JMA catalogs.
(b) Histogram of distances between $M \geq 7$ earthquakes in the inner rectangular region and those that occurred later in the entire region.



(c) Average numbers of subsequent large earthquakes ($M \geq 6.5$) per unit area (1 square degree) against distance in degrees from the M ≥ 6:5 main shock of the investigated aftershock sequence. The broken lines with upper case **Q** and **N** represent the case during the period of first 6 yrs where aftershock activity became quiet and where aftershock activity was normal relative to the ETAS model, respectively. The lines with lowercase **q** and **n** represent the case during the period from 7 to 20 yrs where aftershock activity became quiet or where activity was normal relative to the ETAS model, respectively.



Foreshock probabilities plotted against time and (b) sequential order at each time of $M \geq 4$ earthquakes before and after the M7.3 earthquake