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地震検知率の日変化が completeness magnitude に与える影響
The influence of the daily variation of the detection capability on the completeness magnitude

岩田 貴樹 [1*]
IWATA, Takaki[1*]

[1] 統計数理研究所
[1]The Institute of Statistical Mathematics

Evaluating the detection capability of earthquakes in an earthquake catalogue is the first step of statistical seismicity analysis. Conventionally the completeness magnitude M_c, the minimum magnitude of complete recording, is estimated for a catalogue ranging over several weeks, months or years [e.g., Wiemer and Wyss, 2000, BSSA]. It is well known, however, that the detection capability of earthquakes is lower in daytime than in nighttime because of human activity [e.g., Rydelek and Sacks, 1989, BSSA; Atef et al. 2009, BSSA];, and hence an estimated M_c for a catalogue ranging over more than one day would be smaller than Mc in daytime. Therefore, a quantitative analysis of daily variation of detection capability is necessary to discuss the completeness of an earthquake catalogue.

In this study, we used a statistical model representing a magnitude-frequency distribution of all observed earthquakes [e.g., Ringdal, 1975, BSSA; Ogata and Katsura 1993, GJI]. The distribution was assumed to be the product of the Gutenberg-Richter (GR) law and a detection rate function $q(M)$. Following the previous studies, the cumulative distribution of the normal function was used as $q(M)$. Hence, $q(M)$ has two parameters m and s. In the evaluation of the detection capability, the parameter m is fundamental, and it indicates the magnitude where the detection rate of earthquake is 50%. By combination of and m and s, we can compute the magnitude where the detection rate is equal to a particular probability.

Data used in this study was taken from the JMA catalogue from 2008 to 2010. Subareas covering whole of the inland of Japan with a size of 1 x 1 degree were considered, and sequences of shallow (depth <= 30 km) were constructed for each of the subareas. The earthquake sequences were divided into one-day increments, and divided sequences were stacked in each of the subareas. Then, a Bayesian approach with a piecewise linear function and smoothness constraint [Iwata, 2008, GJI; 2011, Research in Geophysics] was applied to these stacked data to estimate the daily variation of m in each of the subareas. The value of s and the b-value of the GR law were also estimated through the framework of the maximum likelihood method.

In this study, the value of m+3s, corresponding to the magnitude where the detection rate is approximately equal to 99.9%, was regarded as the completeness magnitude. In most of the subareas, the value of m+3s is close to 1 or less than 2, which is consistent with Nanjo et al. [2010, BSSA] investigating Mc in Japan using the 1-year JMA catalogue. In a few subareas, however, the value of m+3s exceeds 2, suggesting that, to ensure the completeness of an earthquake catalogue, it is important to consider the daily variation of the detection capability.

キーワード: completeness magnitude, 地震カタログ, ベイズ統計, 統計地震学
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