The correlation between the phase of the moon and the occurrences of microearthquakes in the Tamba region through point-process modeling

Takaki Iwata\(^1\) (iwata@ism.ac.jp) and Hiroshi Kato\(^2\) (kato@recep.dpr.kyoto-u.ac.jp)
\(^1\)The Institute of Statistical Mathematics; \(^2\)Disaster Prevention Research Institute, Kyoto University

Abstract

We studied the correlation between the phase of the moon and the occurrences of microearthquakes, close to the fault of the 1995 Kobe earthquake, in the Tamba region, Fukuoka, Japan, in which the existence of the correlation during the two-year period following the Kobe earthquake in a previous study in this study we investigate the statistical significance of such correlation. Using point-process modeling and AIC (Akaike Information Criterion), we confirm that the existence of the correlation is statistically significant. Second, we investigated the seasonal variation of the correlation during the fourteen-year period following the Kobe earthquake. The result of the second analysis indicates that the correlation is stronger just after the Kobe earthquake and that it becomes weaker year by year.

The objectives in this study

- To investigate the statistical significance of the correlation between the phase of the moon and the occurrence of microearthquakes in the Tamba region, Fukuoka, Japan.
- To investigate the temporal variation of the strength of the correlation.

C. Statistical significance of the correlation

With point-process modeling (e.g., Ogata, 1996), to investigate the periodicity of the seismicity, Ogata (1988a) suggested the following form as intensity function \( \lambda(t) \) (occurrence rate of earthquakes at time \( t \)):

\[
\lambda(t) = \lambda_0 \exp \left( - \frac{t}{\tau} \right) \sum_{i=1}^{N} \exp \left( - \left( \frac{t-t_i}{\tau} \right) \right)
\]

Where \( \tau \) is the period of the periodic function (in days).

We consider four cases of constraints:

- \( \tau = 0 \) no triggering effect related to the phase of the moon
- \( \tau > 0 \), an effect only related to a half-moon period
- \( \tau < 0 \), an effect only related to a full-moon period
- \( \tau = \pm \infty \), an effect related to both a half and a full-moon period

To examine which case is best, we performed the best parameters using maximum likelihood method for each case. Then we compare the goodness-of-fit of the four cases using AIC (Akaike Information Criterion). (Akaike, 1974)

Note: The order of polynomial function \( N \) representing trend is also determined using AIC.

D. Temporal variation of the correlation

When the model is determined, the parameters in the trigonometric function are assumed to have seasonal changes, which are represented by polynomial function.

\[
\lambda(t) = \mu + \sum_{i=1}^{N} \beta_i \cos(\omega_i t) + \sum_{i=1}^{M} \beta_i \sin(\omega_i t)
\]

Where \( \beta_i \) and \( \omega_i \) are parameters of the periodic function.

We consider four cases of constraints:

- \( \beta_i = 0 \) no triggering effect related to the phase of the moon
- \( \beta_i > 0 \), an effect only related to a half-moon period
- \( \beta_i < 0 \), an effect only related to a full-moon period
- \( \beta_i = \pm \infty \), an effect related to both a half and a full-moon period

To examine which case is best, we performed the best parameters using maximum likelihood method for each case. Then we compare the goodness-of-fit of the four cases using AIC (Akaike Information Criterion). (Akaike, 1974)

Note: The order of polynomial function \( N \) representing trend (N) and periodicity (\( \omega_i \) and \( \beta_i \)) are determined using AIC.

Results

1) The case \( (1) \) shows the best fit in the observed time series among the four cases (Table 1a). The intensity function is the trigonometric part which is the most suitable to the histograms. (Fig. 3)

2) The intensity function is the trigonometric part which is the most suitable to the histograms.