A real-time warning system for a large earthquake using a probability of an earthquake growing

Takaki Iwata[1]; Masajiro Imoto[1]; Shigeki Horiuchi[1]

[1] NIED

In a real-time warning system, it is important to estimate the focal parameters of an earthquake quickly. Therefore, it is ideal if we can estimate the parameters using the first few seconds of wave data. However, estimation of the magnitude (M) is problematic. A large earthquake has a source duration of several tens of seconds, so the magnitude would be underestimated before the rupture terminated if we used only the first few seconds of wave data. That is to say, the estimated magnitude would be smaller than the final magnitude (i.e., the estimated magnitude after rupture termination). Therefore, when a small earthquake is detected in a region where a large one is expected, we need to determine whether or not the earthquake will become a large one. To do this, we suggest a method of examining the probability of an earthquake growing.

First, we determine an arbitrary Mth, the lower threshold of a large earthquake. Next, we estimate p(M), a probability density function of M using the magnitude-frequency distribution of previous earthquakes. Integrating p(M), we can obtain P(M ¥geq x), the probability that M is x or larger. Using these parameters, when the value of M obtained from a real-time warning system is Mobs, the probability that the final magnitude is Mth or larger is given by P(M ¥geq Mth)/P(M ¥geq Mobs).

We applied this method to the Tonankai-Nankai region. To examine the probability, we needed to estimate the probability density function of M for this region. To do so, we used the earthquakes in this region that are listed in historical earthquake catalogues by Usami [1987] and Utsu [1982, 1985]. We assumed two models for the probability density function: one following the Gutenberg-Richter law (Model A) and the other following the characteristic earthquake model (Model B). The parameters of the two models were determined using the maximum likelihood method. We set Mth=7.5 and examined the probability. For example, for the case Mobs=6.5, the probabilities are 25% and 45% for Models A and B, respectively.

In the real-time warning system operated by NIED, it took approximately 10 and 15 seconds for the magnitude to reach about 7.5 from about 6.5, for 2003 Tokachi-oki and 2004 Tokaido-oki earthquakes, respectively. The suggested method would allow us to give an alarm 10 or 15 seconds earlier.

References

-- Usami, T., 1987, Materials for comprehensive list of destructive earthquakes in Japan, Revised edition, Univ. of Tokyo Press, Tokyo.

-- Utsu, T., 1982, Catalog of large earthquakes in the regions of Japan from 1885 through 1980, Bull. Earthq. Res. Inst., Univ. of Tokyo, 57, 401-463.

-- Utsu, T., 1985, Catalog of large earthquakes in the regions of Japan from 1885 through 1980 (Correction and supplement), Bull. Earthq. Res. Inst., Univ. of Tokyo, 60, 639-642.