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エンベロープのテンプレートを用いた本震直後の余震の検知
Detection of immediate aftershocks using seismogram envelopes as templates

小菅 正裕 [1*], 千葉 正尭 [1]
Masahiro Kosuga[1*], Masaaki Chiba[1]

[1] 弘前大学理工学研究科
[1]Graduate School of Sci. and Tech., Hirosaki Univ.

Hypoceneter location and its temporal variation of aftershocks are the source of information of mainshock rupture and stress perturbation around the fault. Since the number of aftershocks decays exponentially, study of immediate aftershocks is important to get the above information. However, the location of immediate aftershocks is difficult due to coda wave of mainshock and successive occurrence of afterrshocks.

Here we propose a new method of hypocenter location using seismogram envelopes as templates. There has been proposed some location methods using aftershock seismograms as templates. Our method employs envelope that are the logarithm of root-mean-squared (RMS) amplitude of band-pass filtered seismogram. The envelope is smoother and more stable than seismogram, and it changes absolute value with the earthquake magnitude but keeps its shape, which is the advantage of the use of envelope.

The proposed method composes of two processes. The first process is the calculation of cross-correlation coefficients between a continuous (target) envelope and template envelopes. Assuming an origin time, we set time windows in the target and templates to calculate the cross-correlation by referring to the arrival times of P-wave of template events. We define the average cross-correlation among the stations and three components as the cross-correlation for each template. We repeat this process by shifting the origin time to obtain a set of cross-correlation values for pairs of (origin time, template).

The second process is the event detection and location. First, we search for the maximum cross-correlation among all pairs of (origin time, template), which gives the origin time of the first event and corresponding template. At present, we simply regard template location as the location of the detected event. Magnitude of event is calculated by the amplitude ratio of target and template envelope. To avoid duplicate detection around this event, we set a dead time of detection around the origin time of the first event. Then we search for the second highest cross correlation value in a time window excluding the dead time. We repeat this procedure until the highest cross-correlation value falls below a threshold.

We applied this method to a data set of the 2004 Mid-Niigata Prefecture (Niigata-Chuetsu) Earthquake (M = 6.8) in central Japan. Aftershock activity of this earthquake is extensive with a number of aftershocks with magnitude greater than 6.0, and with a complex fault system that consists of two parallel westward-dipping faults and a conjugate fault plane. We tested the method by using target envelopes of two stations, 34 templates with a length of 8 s, both in a center frequency of 4 Hz. During a period of one-hour from the mainshock, we could detect 71 events, which are comparable to the number of the catalog events. The location of events are generally near the catalog location, however, the event magnitude is systematically larger than the catalog value. Of course the result depends on the above parameters and we should develop a method of suitable selection of parameters. In addition, we should improve the method of magnitude estimates and, most importantly, relative location of events against templates. Though we have much job to do, we conclude that the employment of envelopes as template works adequately even just after the mainshock of large inland earthquake.

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