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Examination of a simple method to estimate earthquake magnitude by using the timing of maximum amplitude

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1. Introduction

Earthquake magnitude (M) is significant information, because it is a fundamental parameter for an earthquake early warning, a tsunami warning, a rapid estimation of the disaster damages, and so on. In general, M is determined by short-period amplitude (e.g. Mj). However, it is well-known that M determined by its way is saturated particularly in case of the extremely large events. Mw is often used to determine the large magnitude accurately, however, the long-period records (several tens or hundreds seconds) are necessary for the estimation of Mw. Therefore, it is difficult to determine Mw quickly and easily.

In order to solve this problem, Noda et al. (2011, SSJ fall meeting) proposed a new method which used the lengths of time from the arrival of initial motion (direct P or S) to the timing of the maximum amplitude. They indicated that the estimation accuracy was relatively high in case of using the high frequency (several Hz or more) acceleration data observed at K-NET stations. However, the examination of the method was not enough, because the data of extremely large events were insufficient. On the other hand, it is conceivable from Hara (2007) and Lomax & Michelini (2009) that the data for the near part of direct P-wave of which teleseismic velocity record is filtered for high frequency band (around 1Hz or more) is almost equivalent to the time series of the energy directly radiated from the source. In this study, we conduct the additional examination of the method suggested by Noda et al. (2011) by using the teleseismic data of large earthquakes.

2. Data and Method

We retrieved BHZ channel waveform data recorded by 13 events (Mw7.6 - 9.3) from IRIS DMC. The range of epicentral distance is between 30 and 85 degrees. The events are chosen so as to have no bias in the occurrence region and the type of earthquake.

At first, we manually picked the arrival times of the direct P-wave. Mean of number of the picked data for every event is approximately 42. Next, by following Hara (2007), the retrieved teleseismic velocity data were band-passed for 2-4 Hz. We calculated the lengths of time (T_{maxA}) from the P-arrivals to the timings when the absolute values of the amplitude grow to the maximum. We set the upper limit of the calculation 1.1*log(*tau*). Where, *tau* represents rupture duration indicated by Kanamori & Brodsky (2004).

3. Result and Discussion

At first, we investigate the dependency of T_{maxA} on epicentral distance. As a result, it is found that T_{maxA} is almost independent on distance. This result corresponds to the one shown in Hara (2007). Therefore, the correction by distance is not carried out in the analysis described below.

Next, we calculate the logarithmic mean of T_{maxA} every event, and then compare its mean with the result indicated by Noda et al. (2011). Consequently, it is found out that the result in this study almost corresponds with the one by Noda et al. Thus, it is confirmed that the method proposed by Noda et al. is possible to estimate Mw appropriately even in the case of extremely large earthquakes.

It is concluded that the proposed method is practical enough to determine Mw quickly and simply by using the filter whose high frequency characteristics, regardless of seismogram type (regional or teleseismic; velocity or acceleration). However, it is preferred to use many records which have a proper azimuthal coverage, because T_{maxA} have a certain amount of variance depending on the influence of crustal structure, directivity, relationship of the locations between hypocenter and asperity, and so on. Furthermore, it may be required that the combination of T_{maxA} and intensity of amplitude is used to estimate M (Hara, 2007) especially in middle or small event, because the influence of error of the arrival time is relatively large.

4. Acknowledgement

We would like to thank IRIS DMC for using the waveform records.

Keywords: earthquake early warning, tsunami warning, real-time seismology, magnitude, moment magnitude