Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

HDS030-05 Room:101 Time:May 26 17:30-17:45

Estimation of epicentral distance taking account of the effect of viscous attenuation for single station method of EEW

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1. Introduction

A single station method (an on-site method), which can estimate earthquake parameters (epicenter locations and magnitude) by using single station data, is now in use for the present Earthquake Early Warning system of JMA and Shinkansen. Although the method has higher rapidness, lower accuracy to estimate earthquake parameters is pointed out compared to multi station methods (network methods).

The B-Delta method (Odaka et al., 2003) is used as one of components of the single station method to estimate epicentral distance. In the method, a function Bt*exp(-At) is fitted to the initial phase of P-wave in order to estimate epicentral distance (Delta), which negatively correlates with the coefficient B. The coefficient B represents increasing ratio of amplitude of the initial phase. On the other hand, Yamamoto et al. (2010) proposed a new method using a simple function Ct for fitting, called the C-Delta method. The coefficient C also represents the increasing ratio of initial phase.

In the conventional B-Delta method, relationship between B and Delta is expressed as LogB=a*Log(Delta)+b taking account of only geometrical attenuation. Since the coefficient B or C have high correlation with amplitude, it is natural to take viscous attenuation into account. Therefore, we propose the following equation to express the relationship between B (or C) and Delta, LogB=c*Log(Delta)+d*(Delta)+e (B can be replaced by C). The first and second term of right side of the equation indicate geometric and viscous attenuation, respectively. In general, the farther the epicentral distance is, the greater the effect of viscous attenuation relatively is. In this study, we investigate effect of the viscous attenuation term on estimation accuracy.

2. Analysis and Result

First, B and C are calculated from K-NET acceleration records for M>5.0 earthquakes. The functions Bt*exp(-At) and Ct are fitted to the initial phase of P-wave which is filtered by 10-20 Hz band-pass. 2-second and 0.5-second data from P-wave arrival are fitted by Bt*exp(-At) and Ct, respectively.

Second, regression analysis is carried out by fitting equations, a*Log(Delta)+b and c*Log(Delta)+d*(Delta)+e, to B or C. In this analysis, data are selected according to Fukushima and Tanaka(1990) to avoid the problem due to S/N ratio.

We calculate errors (RMS) between true Delta and Delta estimated from the relationship obtained above. As results, in case that epicentral distance is less than 100km, errors taking account of viscous attenuation are almost same to ones without viscous attenuation. However, in case that epicentral distance exceeds 100km, errors taking account of viscous attenuation are decreased by 25% compared to ones without viscous attenuation. We have the same results for both the case of B and the case of C.

Those results demonstrate that the equation c*Log(Delta)+d*(Delta)+e which includes viscous attenuation is more appropriate to estimate epicentral distance accurately for the B-Delta and the C-Delta methods.

Keywords: Earthquake Early Warning, single station method, on site method, B-Delta method