

## Development of an empirical equation for the hypocentral distance estimation using single station P wave data

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We developed an automatic system for the earthquake early warning (EEW) using Hi-net data. The system can determine reliable hypocenter location within a few seconds. However, our EEW cannot send earthquake information before the S-wave arrival in areas within 30km, while earthquake damage is most serious in the area. It is very important to develop an automatic system delivering earthquake information as soon as possible. It is required to develop a technique to determine reliable hypocentral distance using P wave of single station. JMA developed a novel method of epicentral distance determination using B-delta method (Odaka et al., 2003, et al.). However, this method has large estimation errors, as shown in the figure plotting B values versus epicentral distances. Since reliable hypocenters are obtained by using network data, the main interest of the single station method is about events closer than several ten km. Here, we present a method to determine hypocentral distance using P wave waveform data recorded at a single station for events within several ten km. Because the amplitude attenuation of the short period seismic wave is larger than that of the long period seismic wave, comparison of the both amplitudes give us information about hypocentral distance. However, this value is also the function of earthquake size and the value of site amplification. It is known that there are more than ten times of differences in values of the site amplification in high frequency range. When hypocentral distance and QP are assumed to be 50km, and 400, values of the attenuation by Q becomes about 1/3 and 1/15 at frequency of 20Hz and 50Hz, respectively. Consideration of the large change in the site amplification factor asks us to use frequency range of several ten Hz to determine hypocentral distance less than several ten km.

We used two seconds of P wave accelerogram data for about 15,000 events recorded by KiK-net, whose sampling frequency is 200Hz. We calculated the following parameters and checked correlation between these parameters and hypocentral distance.

Tp calculated from the ratios between 1) Displacement, 2) Velocity, 3) Acceleration, 4) Derivative of acceleration, 5) Double derivative of acceleration, and their derivatives. 6) Maximum velocity amplitude, 7) Spectrum amplitude ratios between 2Hz and 15Hz, and 8) between 15Hz and 30Hz, 9) Amplitude ratio between output of band pass filter with central frequency of 15Hz and 60Hz.

The obtained results are followings.

- 1) These parameters can distinguish events far off than about around 100km.
- 2) There are correlations among Tp calculated from acceleration, hypocentral distance and earthquake magnitude.
- 3) There is a large scatter in the relation between hypocentral distance and velocity amplitude even after earthquake size correction.
- 4) Although, cut off frequency of low pass filter used in Kik-net is 30 Hz, we computed band pass filters having central frequencies of 15 Hz and 60 Hz and compared amplitude ratio between the two. We found a correlation between hypocentral distances less than several 10 km and the obtained ratios. This result shows the importance of collecting high frequency seismic waves for the determination of hypocentral distance using single station.