Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)


STT13-13 Room:102A Time:May 28 12:30-12:45

# Effect of local heterogeneous conditions on growth curves of P-wave

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In the Earthquake Early Waning (EEW) system, magnitude and epicentral location of an earthquake are estimated within several seconds after P-wave arrival. According to the Odaka (2003), the equation Bt∗exp(-At) is fitted to the early portion of P-waves. In the equation, A and B are constants and t represented time. From the B value, epicentral distances are estimated using an empirical relationship. The B value decreases as the epicentral distance increases due to the geometrical spreading of seismic waves. As the amplitude of P-waves decrease by travelling through the medium, the gradient of the early portion of P-waves also decrease. So that, the B value of a given epicentral distance marks the specific value and the epicentral distance can be obtained from the B value. However in practice, the B values of different earthquakes having the same epicentral distance show quiet different values. The gap in the B values is sometimes by several hundred times. One of the causes giving major effect on the B value is seismic attenuation due to heterogeneities in subsurface. Seismic waves propagating in heterogeneous medium attenuate due to seismic scattering and absorption. Tsukada et al. (2004) conducted a theoretical calculation on broadening of scalar wave envelopes based on three-dimensional von Karman type random medium. They found that the gap in the B values of different earthquakes having the same epicentral distance is accountable by difference in the scattering condition.

In this study, we theoretically calculate P waves in heterogeneous medium considering the conversion waves between P and S waves, which were ignored in the preceding studies while they give major effect on P-wave envelopes. We show that variation in condition of heterogeneities (in concrete correlation distance) changes the B value. In other word, regional conditions of heterogeneities make the different B values of a given epicentral distance. Then we compare the theoretically calculated B value with one calculated from earthquakes in 1996 - 2011 observed by the K-, KiK-net in Japan. We calculate a regional parameter of heterogeneities (correlation distance) in Japan which can account the fluctuation in the observed B values. As a result, it is found that the spatial distribution of the correlation distance (Figure 1) shows similar tendency with that of a parameter reflecting local heterogeneities, like coda-Q.

In this study we hypothesize that variation in the condition of heterogeneities makes the B value fluctuate significantly and verify it. If we treat the fluctuation in the B values by considering the local condition of heterogeneities, estimation on epicentral distances becomes more accurate. It will improve accuracy of the EEW. Furthermore, B values, that is, initial curve of P-waves can be an exploration tool for local heterogeneities. The early portion of P-wave has a strong advantage that the Born approximation can be used. Complex heterogeneities can be treated by the simple equation.

Keywords: heterogeneities, Born approximation, EEW, scattering, growth curve of P-wave, B-delta method