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SSS28-08 Room:312 Time:May 2 12:00-12:15

Updating of Earthquake Early Warning for Long-Period Ground Motions

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Introduction: In the present EEW systems developed by the JMA, Japan, hypocenter and magnitude of an earthquake are determined quickly, after which ground shaking strengths such as seismic intensity are predicted based on a ground motion prediction equation and then earthquake warning are sent to public when the seismic intensity are beyond 5-lower. This method might underestimate ground motions for large earthquakes with wide rupture area because source extent produces error in estimating distance from source to site and the effects of rupture directivity prediction are not taken into account. Another problem is that the magnitude and source distance cannot be determined before the rupture terminate. Therefore, lead times of prediction become smaller in disastrous regions as earthquakes become larger. Long-period strong motions related to damage of skyscrapers and large oil-storage tanks are generated only from large earthquakes.such as mega-thrust earthquakes. It takes very long time before the rupture terminates. A new idea applying the Kirchhoff-Fresnel boundary integral equation proposed by Hoshiba (2013) will solve the above problem by predicting ground motions at front stations where ground motions do not arrive yet without estimating the hypocenter and magnitude of an earthquake. We attempt to examine the applicability of the front detection method to prediction of long-period strong motions.

Methodology: Ground motion u(P,t) in the wavefield at location P and time t inside a close region is approximated as Kirchhoff-Fresnel Integral.

Equation (1)

In the above equation, u(r,t) is ground motion at a reference point on S and G(P-r,t) is the Green's function between a reference point r and a target point P. The above equation is available for the case where the wave length is much smaller than the spatial fluctuation of absolute amplitude of u(r, t) and G(P, t?t, r , 0), i.e. in high-frequency motions.

When the distance to the source is much larger than |P ? r|, plane wave incidence can be assumed locally around P. Then, u(P,t) is approximated as a convolution between G(P-r,t) and u(r,t).

Equation (2)

When the target point is almost aligned along a line connecting the source to the reference point, the crosscorrelation of u(P,t) and u(r,t) is approximated as follows.

Equation (3)

T(P,r, t) is the transfer function between the reference point and the target point. S(t) is defined as the autocorrelation of the source time function s(t).

Equation (4)

We can estimate the transfer function when the ground motions from some small earthquakes are obtained at the target point and at the reference point at the same time from (3). The autocorrelation function of the source time function of the small earthquake is estimated in advance, e.g. from the waveform inversion of the source process. When large earthquakes such as mega-thrust earthquakes happen in the subduction zone, we can evaluate long-period ground motions at sites where large shakings do not arrive yet using ground motions at stations already observed closer to the source and the transfer functions calculated in advance.

Keywords: Earthquake Early Warning, Long-Period Ground Motions, the applicability of the front detection method

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$$u(\boldsymbol{P},t) = \int \frac{1}{v(\boldsymbol{r})} \cdot (\cos\theta + \cos\theta') \cdot G(\boldsymbol{P} - \boldsymbol{r}, t) * \dot{u}(\boldsymbol{r}, t) dS \quad (1)$$

$$u(\boldsymbol{P},t) = G(\boldsymbol{P},\boldsymbol{r},t) * u\left(\boldsymbol{r}, t - \frac{\boldsymbol{P}-\boldsymbol{r}}{v}\cos(\theta' - \theta)\right) \quad (2)$$

$$u(\boldsymbol{P},\boldsymbol{r_0},t) * u(\boldsymbol{r},\boldsymbol{r_0},-t) = T(\boldsymbol{P},\boldsymbol{r},t) * S(\boldsymbol{r_0},t) \quad (3)$$

$$S(\boldsymbol{r_0},t) = s(\boldsymbol{r_0},t) * s(\boldsymbol{r_0},-t) \quad (4)$$