Numerical Shake Prediction for earthquake early warning: prediction of distant future using Green function method

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Although many previous studies of earthquake early warning have focused on rapid estimation of hypocenter and magnitude, recently we proposed a method called “Numerical Shake Prediction” (Hoshiba and Aoki, 2015), in which ground motion is predicted directly from monitored ground motion skipping the process of estimation of hypocenter and magnitude. In the Numerical Shake Prediction, current wavefield is estimated precisely using data assimilation technique, and then future wavefield is predicted using physics of wave propagation. Hoshiba and Aoki (2015) investigated a method to predict envelope of seismic wave focusing on seismic intensity. Furumura et al.(2018) studied an application to long period ground motion. For Tsunami, Maeda et al.(2015) tried the method to tsunami early warning. The researches, estimation of current wavefield and then prediction of future wavefield skipping the process of source information, is now progressed for earthquake and tsunami early warning.

Recently Wang et al.(2017) proposed a method to use Green function method for tsunami early warning, in which Green function is used instead of simulation of wave propagation. Oba et al.(2018) investigated an application of the Green function technique to early warning of long period ground motion. Because future wavefield is estimated from iterative calculation of seismic wave propagation in Hoshiba and Aoki (2015), it requires more computation time for more distant future. Using Green function technique, the computation time is not different between near future prediction and distant future prediction. It is also possible to predict distant future, skipping the prediction of near future.

I will show application of the Green function method for prediction of envelope of seismic wave focusing on seismic intensity. For the physics of wave propagation, radiative transfer theory is applied as the same as Hoshiba and Aoki (2015). This is high-frequency approximation based on ray theoretical approach, and energy propagation is considered instead of wave propagation itself. Energy which arrives at location, (X, Y) at time T later is quantitatively calculated beforehand from unity energy which propagats at (xi, yi) into direction qn. That is, Green function; G(X,Y,T; xi, yi, qn). Energy at location (X, Y) at time T later can be predicted from spatial and directional integrals of multiplication of this Green function and current energy distribution, E(xi, yi, qn), which is evaluated from data assimilation.

Using the Green function, it is possible to predict distant future with less computational time if the target points are not so many. On the other hand, it requires more computational time for prediction of more target points. When the target points are not so many, the Green function is effective method for prediction, including distant future.

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