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Earthquake early warning: current status and future prospect

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Real-time prediction of strong ground motion is a strong tool for prevention/mitigation of earthquake disaster, and it has been applied for earthquake early warning (EEW). In early 1990s, Mexico started their EEW system for Mexico City, and railway companies in Japan also began their systems. The Japan Meteorological Agency (JMA) has been operated nationwide in Japan for general public since 2007, and possible use of such systems has been investigated in many countries. In this presentation, we will explain EEW methods, performance of its actual operation of JMA EEW since 2007, especially for the 2011 Tohoku Earthquake (M9.0) and its aftershocks, and future prospects based on lessons learned from the Tohoku Earthquake.

EEW methods are classified into three categories: (1) prediction of propagation, (2) prediction of S wave from P wave, (3) prediction of earthquake rupture. Regarding (3), many researchers have described their controversial opinions. At current JMA system, methods of (1) and (2) are adopted, but that of (3) is not used.

From Oct., 2007 to Feb., 2011 just before the Tohoku Earthquake, JMA had issued warning messages for 17 events, including one false alarm due to software bug. For the first 41 months, JMA and other organizations had made efforts to let people get aware ”what is EEW?”

During the Tohoku Earthquake, more than 15 s before the strong ground motion hit the cities, JMA issued EEW to the general public of the Tohoku district. The M 9.0 earthquake, however, revealed two important technical issues with the method: it under-predicted ground motion at large distances because of the large extent of the fault rupture, and it sometimes over-predicted because the system was confused by multiple aftershocks that occurred simultaneously. After the earthquakes, despite of the two issues, EEW has been recognized among people as an important tool for mitigation of earthquake disaster.

Since then, addressing the above two issues: large extent of rupture and multiple simultaneous events, has been an important research project for improving EEW system. While many researchers investigated methods for quickly determination of extent of fault rupture and for discrimination of multiple events, a new technique was proposed in which the process of determination of hypocenter and magnitude is skipped. In the method, current wavefield is estimated as precise as possible, and then future wavefield is predicted based on physics of wave propagation, which is the similar idea of ”numerical weather prediction” in meteorology. The new approach is expected to enable us to predict ground shaking even for large extent of fault rupture and multiple simultaneous events.

In JMA system which will be replaced in fisical year of 2015, the preliminary version of the new approach, which is called PLUM method, will be tested for examining its performance.

Keywords: Earthquake Early Warning, Real-time prediction of earthquake ground motion, The 2011 Tohoku earthquake, Future prospect