

## Earthquake Early Warning and Observed Seismic Intensity

Mitsuyuki Hoshiba<sup>1</sup>, Kazuhiro Iwakiri<sup>1\*</sup>, Yasuyuki Yamada<sup>2</sup>, Naoki Hayashimoto<sup>1</sup>, Toshihiro Shimoyama<sup>2</sup>

<sup>1</sup>Meteorological Research Institute, <sup>2</sup>Japan Meteorological Agency

The strong ground motions were recorded at wide area of north eastern Japan. Just before the strong ground motion hit cities around Tohoku district, Japan Meteorological Agency (JMA) issued the Earthquake Early Warning (EEW) to general public at the district. Eventually seismic intensity of 7 (JMA scale) was observed, which is the 2nd experience since JMA had introduced instrumental measurement for the intensity observation in 1996. Seismic intensities of 6-upper and 6-lower were also widely observed at Tohoku and Kanto districts. In this paper, we will report the outline of EEW, and its observation focusing on the seismic intensity for the Mw9.0 earthquake.

The JMA EEWs are divided into two grades; that is "forecast" and "warning". "Forecast" is issued to advanced users when estimating M3.5 or larger, or expecting seismic intensity equals to 3 or greater. In the "forecast", the regions are particularly specified where intensity 4 or larger is expected. When intensity is expected to be 5-lower or greater at any observation stations of the intensity networks, "warning" is issued to general public at the regions where intensity 4 or larger is expected. The "warning" is broadcasted through various methods such as TV, radios and cellular phone mails. JMA EEWs are updated as available data increases with elapsed time. Accordingly EEWs are issued repeatedly with improving the accuracy.

JMA EEW system was triggered for the Mw9.0 earthquake when station OURI detected the initial P wave at 14:46:40.2, March 11. The first "forecast" was issued 5.4s after the P wave detection. At the 4th "forecast", 8.6s after the first trigger, the magnitude was estimated to be 7.2, and seismic intensity was expected to be 5-lower for central Miyagi Prefecture (around Sendai city), then the 4th "forecast" was issued as "warning". The "warning" was issued to general public at Tohoku district, and then automatically broadcasted using TV, radios and cellular phone mails. It was earlier than the S wave arrival (observed intensity was at most 2), and also 15s earlier than the strong ground motion (intensity 5-lower) hit the closest station to the epicenter. The "forecast" was updated up to the 15th issue, 116.8s after the first trigger, in which magnitude was estimated to be 8.1. The estimated magnitude is almost the upper limit of JMA magnitude because of the saturation of JMA magnitude vs. Mw for events of M>8. Note that the magnitude derived from maximum amplitude is 8.4 in the unified hypocentral catalog of JMA.

The area of 6-upper and 6-lower is widely distributed from Tohoku to Kanto district, approximately in the area of 400 km x 100 km. The long duration is also another characteristic of the event. At OURI, two peaks are apparent in the acceleration envelope, which is probably due to the complicated source process. At IYASAT, strong ground motion were apparent at later phase, which is much later than direct S phase, and it took 80s to increase from intensity 1 to 5-lower.

EEW system expected intensity to be 4 in the 12th to 15th (final) issues for Tokyo region, which was underestimation as compared with actual observation (5-upper; larger than the criterion of "warning"). The underestimation is probably due to the large extent of fault rupture.

After the mainshock, the operation of EEW did not work well. For several days, because some earthquakes occur simultaneously at the wide source region, the system confused, and did not always determine the location and magnitude appropriately. After the mainshock to March, 29, 2011 (19 days), JMA appropriately issued "warning" for 15 out of the 22 events for which seismic intensity 5-lower or greater was actually observed. On the other hand, for the period of 19 days, 45 "warnings" were issued expecting intensity 5-lower or greater, but actual observed intensity was not larger than 2 at any observation stations for 11 out of the 45 events.

Acknowledgement: We used waveform of K-NET, and KiK-net of NIED.

Keywords: The 2011 off the Pacific coast Tohoku earthquake, Earthquake Early Warning, Seismic Intensity