Earthquake Early Warning for the 2016 Kumamoto earthquakes: on overview of how warnings and forecasts were issued and expected improvements that come from introducing new methods

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During the period from 14 to 30 April 2016, the Japan Meteorological Agency (JMA) issued 175 forecasts and 19 warnings of Earthquake Early Warning (EEW) whose estimated hypocenters were located around the Kyushu district. For an earthquake in the Kumamoto prefecture at 21:26 (JST) in 14 April (M6.5), JMA issued a warning about 3.8 sec. after detecting the seismic wave. For an earthquake in the Kumamoto prefecture at 01:25 (JST) in 16 April (M7.3), JMA issued two warnings about 3.8 and 8.6 sec. after the detection. Scores of seismic intensity prediction(*) in the warning for the M6.5 earthquake in 14 April and the second warning for the M7.3 earthquake in 16 April were 100.0% and 97.4% respectively. During the period, there were 18 earthquakes where the maximum observed JMA seismic intensity was 5-lower or more. JMA disseminated warnings or forecasts that predicted the maximum intensity of 4 for all of them, which means the EEW system did not miss strong motions in large earthquake events. After the M7.3 earthquake in 16 April, zones of earthquake occurrence expanded and simultaneous multiple earthquakes happened frequently with a distance of about 50 to 100 km away. Since the 2011 off the Pacific coast of Tohoku earthquake, JMA has continued to improve the process of grouping trigger data when simultaneous multiple earthquakes happen (e.g. JMA implemented a strict range limitation of stations targeted for comparing trigger data based on a station network configuration). However, in the Kumamoto earthquakes, distances of simultaneous multiple earthquakes were too short for the system to correctly discriminate each of them. There were some cases that it over-predicted seismic intensities by wrongly processing trigger data from multiple earthquakes, assuming that the data came from a single earthquake. During the period, JMA issued four incorrect warnings whose score of seismic intensity prediction was less than 10% due to simultaneous multiple earthquakes.

JMA plans to introduce new methods: Integrated Particle Filter (IPF) method, expected to be a measure for over-prediction with simultaneous multiple earthquakes, and Propagation of Local Undamped Motion (PLUM) method, for under-prediction with huge earthquakes. Simulations for the incorrect warnings mentioned above show IPF method avoids issuing incorrect warnings in three cases and reduces the number of areas affected by a warning in the remaining case. Simulations with PLUM method reveal that it makes the system issue the first warnings for the M6.5 earthquake in 14 April and the M7.3 earthquake in 16 April about 2.6-3.6 and 3.0-4.0 sec. faster than the current method, which resulted from denser observation network in PLUM method.

(*) “Score of seismic intensity prediction” is defined as a percentage of areas where an error of seismic intensity prediction is within one degree on the JMA scale among areas where observed or predicted seismic intensity is 4 or more.

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