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Classification of Simultaneous Multiple Earthquakes for the Earthquake Early Warning System

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The 2011 off the Pacific Coast of Tohoku Earthquake (Mw9.0) caused significant damage over a large area of northeastern Honshu. An earthquake early warning was issued to the public in the Tohoku region about 8 seconds after the first P-arrival, which is 31 seconds after the origin time. There was no blind zone, and warnings were received at all locations before S-wave arrivals, since the earthquake was fairly far offshore.

Over 70 early warnings for strong shaking were also broadcast during larger aftershocks. In general, the system worked well for these smaller events, but there were significant errors caused by event mislocations. Immediately following the earthquake, the waveforms of some large aftershocks were contaminated by long-period surface waves from the mainshock, which made it difficult to identify P-wave arrivals. Also, correctly distinguishing and locating later aftershocks was sometimes difficult, when multiple events occurred within a short period of time.

In this presentation, we propose a new approach to classify simultaneous multiple earthquakes in the current JMA system framework. We introduce a Particle Filter approach, also known as sequential Monte Carlo method, to estimate the most probable event parameter values, which include location, magnitude, and origin time. This approach provides a probabilistic solution to the problem of classifying multiple events. We formulate the likelihood function using the attenuation relationship in the current JMA system, and test the aftershock data of 2011 Tohoku earthquake. The results show that this approach can correctly classify multiple events occurred around the same time in several case studies.

Keywords: Earthquake Early Warning