



QUAKE WAVE VIBRATION REPORT: A THRESHOLD BASED EARTHQUAKE EARLY WARNING SYSTEM

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Earthquake Early Warning Systems (EEWS) are helping thousands of people around the world. In 2011, the magnitude 9.0 Tohoku earthquake demonstrated the effectiveness of the nascent Japanese EEWS. In California, the CISM ShakeAlert EEWS is currently under development to issue public warnings via the USGS. In the near future, engineering applications found in Japan such as stopping trains, stabilizing nuclear power plants, *etc.* will be a reality in California. However, before a fully-fledged public system can be rolled out, there are three major issues that need to be resolved: a) the false alarm rate, which is difficult to reduce to 0%, b) uncertainty in forecasting the intensity at the location, and c) the existence of a blind zone. We have developed a system, Quake Wave Vibration Report (QwVR) that addresses these concerns. In this study, we have introduced its concepts and its application specifically to rail transportation. We have tested QwVR by simulating offline, real-time data from California and the Tohoku Earthquake demonstrating that it is possible to automatically stop a train 60 seconds before peak ground acceleration arrives.

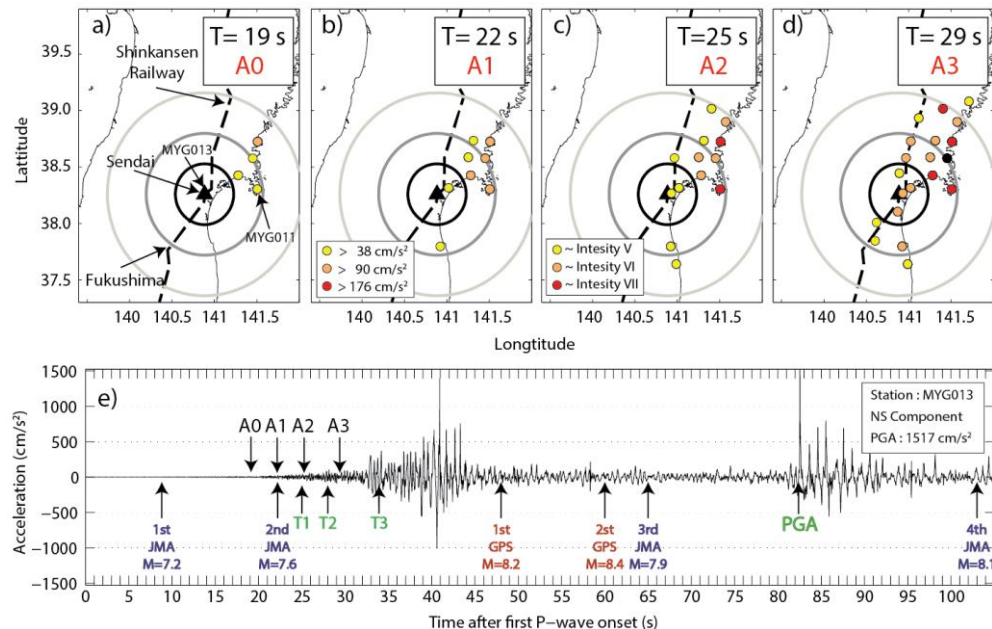


Figure 1. Example of QwVR event processing for the 2011, Tohoku Earthquake, M=9.0, (a-d) Progressive Alarms as stations trigger and the event is analyzed in real-time. Maps themselves were produced after the event but the data used to create them was available at the time indicated on the map. K-net stations are depicted as small circles with yellow, orange and red fills indicating the exceeding threshold of stations. QwVR send first alarm signal 77 seconds before PGA arrives. (e) Distribution of triggered stations when PGA arrived to

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MYG013 station. (f) Warning timeline for the Tohoku Earthquake showing when the QwVR information is available with respect to the time at which the JMA warnings and GPS information available at MYG013 station. QwVR confirms earthquake about 3 seconds before JMA's first warnings. A3 issued 10 seconds before moderate ground motion (10cm/s^2) arrives to the location. Times are since first P-wave detection in seconds.