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A new prototype system for earthquake early warning in Taiwan

Nai-Chi Hsiao [a,*], Yih-Min Wu [b], Li Zhao [c], Da-Yi Chen [a], Wei-Ting Huang [b], Kuan-Hung Kuo [a], Tzay-Chyn Shin [a], Peih-Lin Leu [a]

[a] Seismological Center, No. 64, Gongyuan Rd., Central Weather Bureau, Taipei 10048, Taiwan
[b] Department of Geosciences, National Taiwan University, Taipei, Taiwan
[c] Institute of Earth Sciences, Academia Sinica, Taipei, Taiwan

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ABSTRACT

A new prototype earthquake early warning (EEW) system is being developed and tested using a real-time seismographic network currently in operation in Taiwan. This system is based on the Earthworm environment which carries out integrated analysis of real-time broadband, strong-motion and short-period signals. The peak amplitude of displacement in the three seconds after the P arrival, dubbed P_d, is used for the magnitude determination. Incoming signals are processed in real time. When a large earthquake occurs, P-wave arrival times and P_d will be estimated for location and magnitude determinations for EEW purpose. In a test of 54 felt earthquakes, this system can report earthquake information in 18.8 ± 4.1 s after the earthquake occurrence with an average difference in epicenter locations of 6.3 ± 5.7 km, and an average difference in depths of 7.9 ± 6.6 km from catalogues. The magnitudes approach a 1:1 relationship to the reported magnitudes with a standard deviation of 0.51. Therefore, this system can provide early warning before the arrival of S-wave for metropolitan areas located 70 km away from the epicenter. This new system is still under development and being improved, with the hope of replacing the current operational EEW system in the future.

1. Introduction

Earthquake early warning (EEW) system is considered as one of the most useful tools for emergency response in reducing seismic hazards [1]. When a large earthquake occurs, an EEW system provides the warning a few to tens of seconds in advance of impending disastrous ground motions, allowing for immediate mitigation actions to be taken. For instance, high-speed trains can slow down to resist strong ground shakings, critical facilities such as gas pipelines can be turned off automatically, and surgeries in hospitals can be suspended in time, etc. To be sure, the early warning time is too short for people to evacuate buildings. However, through careful planning, training, and drills, an educated general public can take necessary measures in time to avoid loss of lives from large earthquakes.

Taiwan is located on the western portion of the Circum-Pacific seismic belt with a plate convergence rate of 8 cm per year, and earthquake is one of the most serious disasters in Taiwan. Nearly 18,000 seismic events occur around the Taiwan region every year, and numerous destructive earthquakes with severe casualties and property losses have happened in the last century (Fig. 1), such as the 1906, M_L=7.1 Meishan earthquake (1258 deaths), the 1935, M_L=7.1 Hsinchu-Taichung earthquake (3276 deaths) and the 1999, M_L=7.3 Chi-Chi earthquake (2455 deaths). Therefore, it is essential for Taiwan to seek means through scientific research to reduce earthquake hazards.

EEW systems have already been developed and tested in a number of countries [2–13]. Taiwan has been one of the leading countries with more than ten years of operational experiences on EEW. For the sake of rapid reporting of felt earthquakes, a real-time strong-motion network was established in Taiwan by the Central Weather Bureau (CWB) and has been in operation since 1995 [14]. Fig. 1 shows the distribution of these strong-motion stations. The network consists of 102 stations currently. When a potentially felt earthquake occurs around the Taiwan area, the location, magnitude and shake map of seismic intensities can be automatically reported within about 1 min [15]. For large earthquakes, the magnitude [16], shake map [17] and losses [18,19] can be estimated within 2 min after the earthquake occurrence. Within 3–5 min, an official earthquake report can be disseminated to various organizations and individuals.

Meanwhile, this network has been utilized for the development of Taiwan's EEW system [4,5,13,20]. As an experiment, a quick magnitude estimation using the M_{L10} approach [20], based

* Corresponding author. Tel.: +886 2 2349 1350; fax: +886 2 2349 1179.
E-mail addresses: naigi@cwb.gov.tw, naigi@scman.cwb.gov.tw (N.-C. Hsiao).

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