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An empirical evolutionary magnitude estimation for earthquake early warning

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For earthquake early warning (EEW) system, it is a difficult mission to accurately estimate earthquake magnitude in the early nucleation stage of an earthquake occurrence because only few stations are triggered and the recorded seismic waveforms are short. One of the feasible methods to measure the size of earthquakes is to extract amplitude parameters within the initial portion of waveform after P-wave arrival. However, a large-magnitude earthquake (Mw > 7.0) may take longer time to complete the whole ruptures of the causative fault. Instead of adopting amplitude contents in fixed-length time window, that may underestimate magnitude for large-magnitude events, we suppose a fast, robust and unsaturated approach to estimate earthquake magnitudes. In this new method, the EEW system can initially give a bottom-bund magnitude in a few second time window and then update magnitude without saturation by extending the time window. Here we compared two kinds of time windows for adopting amplitudes. One is pure P-wave time widow (PTW); the other is whole-wave time window after P-wave arrival (WTW). The peak displacement amplitude in vertical component were adopted from 1- to 10-s length PTW and WTW, respectively. Linear regression analysis were implemented to find the empirical relationships between peak displacement, hypocentral distances, and magnitudes using the earthquake records from 1993 to 2012 with magnitude greater than 5.5 and focal depth less than 30 km. The result shows that using WTW to estimate magnitudes accompanies with smaller standard deviation. In addition, large uncertainties exist in the 1-second time widow. Therefore, for magnitude estimations we suggest the EEW system need to progressively adopt peak displacement amplitudes form 2- to 10-s WTW.