Rapid Estimation of Unsaturated Earthquake Magnitude for Early Warning from the Arrival Time of the Peak Amplitude

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For the use of earthquake early warning (EEW), a simple approach is proposed to determine the magnitude (M) using the time from the onset of a body wave to the peak amplitude arrival (T_{op}). We demonstrate that this measurement is related with rupture duration and unsaturated even for extremely large earthquakes (M_w >= 8.3). As a result from analyzing seismic waveforms observed in Japan, the root mean square (RMS) residual between M_w and M_{Top} (M estimated from T_{op}) is approximately 0.5 in magnitude unit. The retrospective application of this algorithm to the 2011 Tohoku earthquake (M_w 9.0) produces a final estimate of 9.0 in magnitude unit at 120 s after the origin time. We conclude that this approach is useful for EEW even for extremely large events in order to estimate their M.