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Small and large earthquakes: evidence for a different rupture beginning

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For the real-time magnitude estimate two Early Warning (EW) parameters are usually measured within 3 seconds of P-wave signal. These are the initial peak displacement (Pd) and the average period (τc). The scaling laws between EW parameters and magnitude are robust and effective up to magnitude 6.5-7 but a well known saturation problem for both parameters is evident for larger earthquakes. The saturation is likely due to the source finiteness so that only a few seconds of the P-wave cannot capture the entire rupture process of a large event. Here we propose an evolutionary approach for the magnitude estimate, based on the progressive expansion of the P-wave time window, until the expected arrival of the S-waves. The methodology has already been applied to the 2011, Mw 9.0 Tohoku-Oki earthquake records and showed that a minimum time window of 25-30 seconds is indeed needed to get stable magnitude estimate for a magnitude M $\geq$ 8.5 earthquake. Here we extend the analysis to a larger data set of Japanese earthquakes with magnitude between 4 and 9, using a high number of records per earthquake and spanning wide distance and azimuth ranges. We analyze the relationship between the time evolution of EW parameters and the earthquake magnitude itself with the purpose to understand the evolution of these parameters during the rupture process and to investigate a possible different scaling for both small and large events. We show that the initial increase of P-wave motion is more rapid for small earthquakes that for larger ones, thus implying a longer and wider nucleation phase for large events. Our results indicate that earthquakes breaking in a region with a large critical slip displacement value have a larger probability to grow into a large size rupture than those originating in a region with a smaller critical displacement value.