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Rapid, energy-duration estimates of seismic moment and implications for rupture scaling and dynamics

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We describe a new, rapid and robust, *energy-duration* procedure (Lomax, Michelini and Piatanesi, 2006) to obtain earthquake moment, M_0^{ED}, and a moment magnitude, M_{ED}. Using seismograms at teleseismic distances (30º-90º), this procedure combines measures of radiated seismic energy, E, on the P to S interval of broadband signals and measures of source duration, T_0, on high-frequency, P-wave signals to estimate moment through the relation M_0^{ED}=$kE^{1/2}T_0^{3/2}$. The M_0^{ED} energy-duration moment is scaled to correspond to Harvard Centroid-Moment Tensor (CMT) moment, M_0^{CMT}, and can be calculated within about 20 minutes or less after the event origin time. The availability of a reliable size estimation for large earthquakes within this time frame is important for tsunami warning and emergency response. The measured energy and duration values also provide the energy-to-moment ratio used for identification of tsunami earthquakes and for analysis of apparent stress and other source properties.

The energy-duration moments, M_0^{ED}, for a set of $\sim$40 major and great earthquakes (M_w =6.6-9.2) match closely M_0^{CMT}, typically within a factor of 2 ($i.e.$, $M_{ED} = M_w^{CMT}\pm$0.2 or less), even for the largest, great earthquakes. This result indicates that the M_0^{ED} measure is accurate and does not saturate, and implies that seismic moment for large earthquakes scales with the square-root of far-field radiated energy, E, and with the 3/2 power of the total source duration, T_0.

We examine the implications of these results to the scaling and dynamics of the earthquake rupture process. We show that the energy-duration relation, M_0^{ED}=$kE^{1/2}T_0^{3/2}$, suggest a scaling relation between T_0 and a characteristic duration of initiation or termination of rupture of individual asperities, providing evidence that, in a given tectonic setting, longer duration events involve rupture on larger asperities. The energy-

duration results also suggest a scaling relation between increasing duration, T_0, and an increasing deficiency in observed, far-field, radiated wave energy relative to that expected from very long period moment estimates such as M_0^{CMT}, providing evidence that relatively more energy is dissipated on or near the fault for events of longer duration than for shorter duration events.

Lomax, A., A. Michelini and A. Piatanesi, (2006). An energy-duration procedure for rapid and accurate determination of earthquake magnitude and tsunamigenic potential, submitted to *Geophys. J. Int.*, (www.alomax.net/posters/energy-duration).