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Rapid determination of energy magnitude from P-waves of teleseismic seismograms

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The event magnitude, as a measure of the "earthquake strength", is a parameter of fundamental importance for characterizing a seismic event. Among the non-saturating magnitude scales, the energy magnitude Me is related to a well defined physical parameter of the seismic source, that is the radiated seismic energy E_S (e.g. Bormann et al., 2002): Me = 2/3($\log_{10}$ E_S – 4.4). Me is more suitable than the moment magnitude Mw in describing an earthquake's shaking potential. Indeed, Me is related to the energy released by a seismic source around its corner frequency and hence reflects the dynamic characteristics of the rupture process, whereas Mw is related to the low-frequency asymptote of the source spectrum and describes the static (tectonic) effect of an earthquake.

The calculation of E_S requires the integration over frequency of the squared P-waves velocity spectrum corrected for the attenuation experienced by the seismic waves along the path from the source to the receivers. The correction for attenuation is one of the most challenging aspects of the $E_S$calculation. In fact, the energy decay is frequency-dependent, hence attenuation functions for different periods must be computed. For this purpose, we use numerical simulations by the reflectivity method (Wang, 1999) adopting the reference Earth model AK135Q from Kennett *et al.* (1995) and Montagner and Kennett (1996). By this approach, the attenuation functions are derived from the P-wave trains numerically simulated, and are used to backproject the observed velocity spectra to the source.

We propose a fast and robust procedure to calculate E_S and Me using P-waves of tele-

seismic broad-band recordings in the distance range 20˚-98˚. The dataset analyzed is composed of ∼60 earthquakes (Mw in the range 6.0-9.3) recorded at the broad-band stations managed by the GEOFON, IRIS/IDA, IRIS/USGS, and GEOSCOPE global networks, as well as other regional seismic networks. We show that such calculations can be performed in a robust and fast way and can be suitable for implementation in rapid response systems. In fact, the final aim of our procedure is to determine Me while data are still flowing to the data centre, calculating E_S for cumulative P-waves windows starting 4s after the first P-wave arrival until the S-wave arrival. Such a procedure will prevent the underestimation of E_S and hence of Me for large earthquakes, providing a rapid determination of Me only a few minutes after the earthquake's origin time using stations at closer distances.

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