The Mantle Magnitude $M_m$ and the Slowness Parameter $\Theta$: Five Years of Real-time Use in the Context of Tsunami Warning

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We study a database of more than 115,000 measurements of the mantle magnitude $M_m$ introduced by Okal and Talandier (1989), obtained since 1999 as part of the operational procedures at the Pacific Tsunami Warning Center. The performance of this method is significantly affected by the seismic instrumentation at the recording station, with the very broad-band STS-1 and KS54000 systems offering the lowest residuals between measured values of $M_m$ and those predicted from the Harvard CMT catalog, and also by the period at which spectral amplitudes are measured, with the best results between 70 and 250 s. With such mild restrictions, estimates of seismic moments can be obtained in real time by retaining either the maximum value of $M_m$ measured on each record, or its average over the various mantle frequencies, with the resulting residuals on the order of 0.1 ± 0.2 moment magnitude units. $M_m$ deficiencies in the case of the two large earthquakes of Peru (2001) and Hokkaido (2003) are attributed to azimuthal bias from an excess of stations (principally in North America) in directions nodal for the focal mechanism and directivity patterns. We further study a group of more than 3000 measurements of the energy-tomoment ratio $\Theta$ introduced by Newman and Okal (1998), which allows the real-time identification of teleseismic sources violating scaling laws, and in particular of so-called “tsunami earthquakes”. The use of a sliding window of analysis in the computation of $\Theta$ allows the separation of “late earthquakes”, characterized by a delayed, but fast, moment release from truly slow earthquakes. A number of such events are recognized, notably on major oceanic and continental strike-slip faults.

Three-dimensional plots of the residuals $r_w$ as a function of period and seismic moment (expressed as $M_w$ published in the Harvard Catalogue). For each of the standard frequencies, values of $r_w$ are regrouped in magnitude bins of width 0.1 $M_w$-unit, and an average value computed in each bin. The resulting function is then plotted in three dimensions and color-coded. Separate plots are made for the various types of instruments.