Using W phase for regional tsunami warning and rapid earthquake hazard assessment

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We recently developed a source inversion technique using W-phase records to obtain a fast and robust estimation of the overall source parameters of large earthquakes (Kanamori and Rivera, 2008). W-phase is a very long period phase traveling at a high group velocity (5-9 km/s) and is suitable for fast tsunami warning purposes.

The original algorithm was targeted at large earthquakes ($M_w \geq 7.5$) and was tested with global data. We used a frequency pass-band from .001 to .005 Hz and a data time window starting at the P-arrival time and lasting for 15 Δ s/° (Δ = epicentral distance). This time window essentially determines the total process time since the execution of the algorithm itself is quasi-instantaneous. With this scheme it takes 35 min after the origin time to collect all the data up to $\Delta = 90°$.

In the present work we adapt the algorithm to regional data and extend it to events with smaller magnitudes. The data-set used comes from the Japanese broadband network F-net (with STS-1 and STS-2 seismometers). We use the vertical component data with 1hz-sampling (LHZ channel) for 22 Japanese earthquakes with magnitude $M_w > 6.7$ which occurred between 2003 and 2008. We use only the stations within 12 degrees of the epicenter so that we can provide a solution within about 6 min after the origin time.

Modifications are necessary to adapt the algorithm for the regional application in the two aspects : the frequency pass-band and the data time-windowing. In order to have a sufficiently high signal to noise ratio for smaller events, it's necessary to shift the pass-band towards higher frequencies. This is related to the well known behavior of the background noise steadily growing with period longer than 200s. On the other hand, some of the seismometers used (STS-2) start to be noisy at very long period. As an example, for events with $Mw \sim 7.0$ W-phase has a significantly better s/n ratio in the band 0.00167Hz-0.005Hz than in the original band. Concerning the time window, the '15Δ' time window leads to extremely short data segments at distances less than 10°. We adopt here a constant length window of 180s which corresponds to the window length at $\Delta = 12°$ in the original scheme. One drawback of this new scheme is the higher possibility of including clipped records within the window. To minimize this possibility, we limit the distance range to $\Delta > 5°$.

The basis of the algorithm is a linear inversion for the moment tensor components which requires the source location to be known. We use the JMA preliminary epicenter as a first approximation to the centroid and then perform a spatial grid search around it to determine an optimal centroid location. As a byproduct of this grid search we have the rms-misfit as a function of the trial centroid location. A geographic map of rms proves useful for estimating the orientation and size of the rupture.

The focal mechanisms and the M_w estimates obtained for this set of events are in good agreement with the solutions obtained with the standard techniques (e.g. surface wave inversion). We use the spatial distribution of the 1-day aftershock area as an independent measure of the rupture size. This is in general well correlated with that estimated from the map of the rms-misfit. The quality of this correlation deteriorates as the epicenter moves away from the network. In the extreme cases of very poorly covered events like, for example, the Sep. 28, 2007 earthquake near Iwo-jima, the misfit map is mainly controlled by the station coverage.