Determination of space–time characteristics of sources of large earthquakes from teleseismic high-frequency records

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For large earthquakes, high-frequency (HF) source size and duration can be recovered using time histories of the instant power (squared amplitudes, high frequency power signals, HFPS) of radiated HF waves, in particular teleseismic *P* waves. The technique for such an inversion was developed by A.A.Gusev and V.M.Pavlov in 1990ies. It is based on two original procedures: (1) to apply inverse filtering to observed HFPS using an aftershock records to determine empirical Green function representing HFPS propagated along a certain ray path and (2) to reconstruct, by linear inversion, power moments of the radiator and use them to deduce gross space-time properties of a source.

Recently this approach was applied to two interesting earthquakes. The first is the great Sumatra-Andaman islands earthquake of 2004 December 26 (Mw = 9.1–9.3) We processed teleseismic *P* waves at 36 BB stations, using, in sequence: (1) bandpass filtering (four bands: 0.4–1.2, 1.2–2, 2–3 and 3–4 Hz); (2) squaring wave amplitudes, producing four HFPS per trace and (3) stripping the propagation-related distortion (*P* coda, etc.) from the recorded HFPS, thus recovering radiated source HFPS. For each ray we thus obtain signals with relatively well-defined end and no coda. From these signals we extract: total duration (joint estimate for all four bands) and temporal centroid of signal power for each band. Through linear inversion, the set of duration values for a set of rays delivers estimates of the rupture stopping point and stopping time. Similarly, the set of temporal centroids can be inverted to obtain the position of the space– time centroid of HF energy radiator. For the source length and duration the following estimates were obtained: 1241±224 km, 550±10 s. The estimated stopping point position corresponds to the northern extremity of the aftershock zone. Spatial HF radiation centroids are located at distances 350–700 km from the epicentre, in a systematic way: the higher is the frequency, the farther is the centroid from the epicentre. Average rupture propagation velocity is estimated as 2.25 km/s.

Similar technique was applied to records of 2006 April 20 (Mw=7.6) Olyutorskii earthquake, a unique crustal event in Koryakia whose rupture delineated a 150-km stretch of arguable Beringia-North America plate boundary. This is a smaller-scale event, making data processing more difficult; in addition, its bilateral mode of rupturing prevented simple determination of fault size from the position of a single rupture stopping point. Still, using 57 stations and two frequency bands (0.7–1.7 and 1.5–2.5 Hz), we have determined the parameters of the HF radiator for this event. To overcome problems with bilateral rupture, we assumed the source to consist of two linked linear segments ruptured bilaterally from the hypocenter at a constant velocity. The estimates of space-time parameters are as follows: total length 128 ± 52 km, the strike of the longer arm of the rupture 225° ± 19° SW, the distance from the epicenter to the centroid 23 ± 9 km, and rupture velocity 2.5 ± 0.8 km/s. The rupture was bilateral with a moderate asymmetry. The rupture duration was 35.0 ± 1.6 s for the southwestern arm and about 23 s for the northeastern arm. Estimated spatial parameters match fault rupturing observed at the day surface by T.K.Pinegina, and agree with the geometry of the aftershock cloud.