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Fast determination of earthquake source parameters from strong motion records: Mw, focal mechanism, and slip distribution

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We developed a chain of procedures allowing the fast, automated, and robust determination of source parameters relevant for seismic early warning and tsunami alert. The specificity of our approach is that it relies entirely on strong-motion data, with a unified methodology over a broad range of magnitude: from Mw $\sim$ 4 to 8, well adapted to continental earthquakes. We assume that the event has already been detected and located.

The seismic moment, and therefore the moment magnitude, is obtained from the complete displacement spectra in the near source region (dist $<$ 100 km). The method is based on the comparison of spectral levels at low frequency, between observed records and pre-computed synthetic seismograms. Finite source models scaled with moment magnitude are used to pre-compute the synthetics, allowing us to extend the method up to Mw = 8. Estimates of Mw can be computed at different elapsed time since origin time, with robust values obtained after about one minute on a single cpu.

The focal mechanism is determined by inverting the displacement waveforms using a fast converging grid search combined with simulated annealing. Depending on moment magnitude, the event is represented by a point source (for Mw $<$ 5.5) or by a linear finite source whose size is scaled with magnitude (for Mw $>$ 5.5). The focal mechanism can be obtained in less than ten minutes using various cpus.

For both moment magnitude and focal mechanism determination, a crucial point to be addressed when using strong-motion records is the appropriate filtering of the seismo-

grams. The main challenge is to remove the low frequency noise produced by baseline shifts in acceleration, while preserving as much as possible the low frequencies related to the rupture process. Here, an optimal technique of filtering has been designed, based on the shape of the acceleration spectra at low frequency.

The next step is slip inversions on two-dimensional finite fault models. We aim at performing an automated slip inversion for each nodal plane of the focal mechanism, giving way to the identification of the actual rupture plane. With the slip distribution, we target important parameters to characterize source effects, in particular rupture length and duration, rupture velocity, and directivity.

All steps, moment magnitude, focal mechanism, slip inversion, are validated on various reference earthquakes worldwide, including a few off-shore events.