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Moment magnitude estimation of large earthquakes using source time function inversion in real-time

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The precise and fast evaluation of earthquake location and magnitude is necessary in earthquake early warning systems, which release alert messages quickly after a large earthquake. A source time function inversion technique is developed to estimate moment magnitude (Mw) in real time using waveforms at regional distances. Given a preliminary location estimate, the Mw is continuously estimated from the determined source-time function (STF), which is simultaneously updated while the waveform data coming in. After converting velocity waveforms to displacements by the instrument response correction and integration with respect to time, the STF inversion is carried out by deconvolving the Green's functions. A moment rate function is obtained by cumulating the updated STF in the time domain, and sequentially the Mw can be determined. A real-time simulation of Mw estimation was done with waveforms of large earthquakes, e.g., the Southern Sumatra earthquake Mw=7.6 that occurred at 10:16:09 UTC on September 30, 2009, the Haiti earthquake Mw=7.0 (21:53:10 UTC on January 12, 2010) and the Chile earthquake Mw=8.8 (06:34:14 UTC on February 27, 2010). About 20 to 30 seconds of source time function (STF) are necessary to reach Mw 7.0 – 8.8. We can estimate the size and duration of a strong earthquake within 10 to 15 minutes after the origin time depending on the epicentral distance of the considered regional stations and the source duration. We performed sensitivity tests to assess the robustness of the method, varying fault plane solutions and source depth. These tests suggest that rough estimates of the hypocenter and the source mechanism are sufficient to estimate Mw. The estimated Mw compares well with those of the GCMT solution. These results indicate that we can estimate Mw and the duration of a strong earthquake using regional real-time recordings.