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Real-time earthquake source imaging: An offline test for the 2011 Tohoku earthquake

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In recent decades, great efforts have been expended in real-time seismology aiming at earthquake and tsunami early warning. One of the most important issues is the real-time assessment of earthquake rupture processes using near-field seismogeodetic networks. Currently, earthquake early warning systems are mostly based on the rapid estimate of P-wave magnitude, which contains generally large uncertainties and the known saturation problem. In the case of the 2011 Mw9.0 Tohoku earthquake, JMA (Japan Meteorological Agency) released the first warning of the event with M7.2 after 25 s. The following updates of the magnitude even decreased to M6.3-6.6. Finally, the magnitude estimate stabilized at M8.1 after about two minutes. This led consequently to the underestimated tsunami heights. By using the newly developed Iterative Deconvolution and Stacking (IDS) method for automatic source imaging, we demonstrate an offline test for the real-time analysis of the strong-motion and GPS seismograms of the 2011 Tohoku earthquake. The results show that we had been theoretically able to image the complex rupture process of the 2011 Tohoku earthquake automatically soon after or even during the rupture process. In general, what had happened on the fault could be robustly imaged with a time delay of about 30 s by using either the strong-motion (KiK-net) or the GPS (GEONET) real-time data. This implies that the new real-time source imaging technique is helpful to reduce false and missing warnings, and therefore should play an important role in future tsunami early warning and earthquake rapid response systems.