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Robust real-time fault tracking for the 2011 Mw 9.0 Tohoku earthquake based on the phased-array-interference principle

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Based on the principle of the phased array interference, we have developed an Iterative Deconvolution Stacking (IDS) method for real-time kinematic source inversion using near-field strong-motion and GPS networks. In this method, the seismic and GPS stations work like an array radar. The whole potential fault area is scanned patch by patch by stacking the apparent source time functions, which are obtained through deconvolution between the recorded seismograms and synthetic Green's functions. Once some significant source signals are detected any when and where, their signatures are removed from the observed seismograms. The procedure is repeated until the accumulative seismic moment being found converges and the residual seismograms are reduced below the noise level. The new approach does not need any artificial constraint used in the source parameterization such as, for example, fixing the hypocentre, restricting the rupture velocity and rise time, etc. Thus, it can be used for automatic real-time source inversion. In the application to the 2011 Tohoku earthquake, the IDS method is proved to be robust and reliable on the fast estimation of moment magnitude, fault area, rupture direction, and maximum slip, etc. About at 100 s after the rupture initiation, we can get the information that the rupture mainly propagates along the up-dip direction and causes a maximum slip of 17 m, which is enough to release a tsunami early warning. About two minutes after the earthquake occurrence, the maximum slip is found to be 31 m, and the moment magnitude reaches Mw8.9 which is very close to the final moment magnitude (Mw9.0) of this earthquake.