Geophysical Research Abstracts
Vol. 12, EGU2010-8878-1, 2010
EGU General Assembly 2010

Kinematic inversion of strong motion data using a Gaussian parameterization of the slip: application to the Iwate-Miyagi earthquake.

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We present a non linear technique to invert strong motion records with the aim of obtaining the final slip and the rupture velocity distributions on the fault plane. Kinematic inversion of strong motion data is an ill-conditioned inverse problem, with several solutions available also in the case of noise-free synthetic data (Blind test on earthquake source inversion,http://www.seismo.ethz.ch/staff/martin/BlindTest.html).On the other hand, complete dynamic inversion still looks impracticable, because of an unclear understanding of the physical mechanisms controlling the energy balance at the rupture tip and a strong correlation between the initial stress field and the parameters of the constitutive law. Hence a strong effort is demanded to increase the robustness of the inversion, looking at the details of the slip and rupture velocity parameterization, at the global exploration techniques, at the efficiency of the cost-function in selecting solutions, at the synthesis process in retrieving the stable features of the rupture.
In this study, the forward problem, i.e. the ground motion simulation, is solved evaluating the representation integral in the frequency domain by allowing possible rake variation along the fault plane. The Green's tractions on the fault are computed using the discrete wave-number integration technique that provides the full wave-field in a 1D layered propagation medium. The representation integral is computed through a finite elements technique on a Delaunay triangulation of the fault plane. The rupture velocity is finally defined on a coarser regular grid and rupture times are computed by integration of the eikonal equation.
For the inversion, the slip distribution is parameterized by 2D overlapping Gaussian functions, which can easily relate the spectrum of the possible solutions with the minimum resolvable wavelength, related to source-station distribution and data processing. The inverse problem is solved by a two-step procedure aimed at separating the computation of the rupture velocity from the evaluation of the slip distribution, the latter being a linear problem, when the rupture velocity is fixed. The non-linear step is solved by optimization of an L2 misfit function between synthetic and real seismograms, and solution is searched by the use of the Neighbourhood Algorithm. The conjugate gradient method is used to solve the linear step instead. The developed methodology has been applied to the M7.2, Iwate Nairiku Miyagi, Japan, earthquake that was recorded by the K-net and Kik-net accelerometric networks.