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Inverting Source Time Functions to determine the fault kinematic characteristics

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In seismology, the analisys of source kinematic parameters (slip-rate and rupture velocity ecc.) is a fundamental way to study the time-history of the rupture process that occurs during a seismic event. To this end various method to reconstruct source kinematics models from the inversion of seismogram have been proposed during the time. In this work we present an alternative methodology to infer source models.

We aim, indeed, at obtaining the slip and rupture velocity distribution on the fault plane inverting the apparent Source Time Functions (STFs). This kind of analysis, rather than a classical inversion based on a direct study of seismograms recorded at various stations, may have several advantages. A major advantage is related to the possibility to overcome in the forward modeling any problem related to the computation of the Green's function, as the choice of the correct and reliable propagation model.

To retrieve reliable STF, we apply the stabilized deconvolution technique proposed by Vallée [2004]. Based on Empirical Green's Functions (EGF) approach, this technique integrates in the deconvolution process four physical constraints on the STFs, that are causality, positivity, limited duration, and equal area. In any case the EGF approach suffers from certain limitations related to the selection of valuable Empirical Green Function, especially for small events.

The approach used to invert the STFs is based on the technique of Emolo and Zollo [2005] to invert strong-motion data. In particular, the slip and the rupture velocity values are specified only at a set of control-points on the fault plane and their distributions on the whole fault are then obtained by a bicubic interpolation. The final slip and rupture velocity values at the fault-grid nodes are then determined by searching for the maximum of a fitness function (based of comparison between real and synthetic STFs) by using the Genetic Algorithm. The number of control-points is progressively increased to move from a high- to low-wavelength description of kinematic parameters on the fault. The optimal model parameter set is chosen according to Akaike Information Criterion [1974].

We present results for some synthetic tests and an application to a seismic events occurred during the 2009 L'Aquila (Central Italy) seismic sequence. In particular, we analyzed a small aftershock occurred on 2009 April 9, at 04:43:09 (UTC) characterized by a seismic moment of 1.07e+15 Nm (Mw 4). We found: a slip distribution, with an average value of 0.8 cm, characterized by a main slip patch located NW of the hypocenter and a rupture velocity distribution (mean value of 2.3 km/s) with a strong acceleration in the same direction.