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Evaluating the effect of network density and geometric distribution on kinematic source inversion models

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An essential element of understanding earthquake source processes is obtaining a reliable source model via geophysical data inversion. The most common procedure to determine the kinematic source parameters (final slip, peak slip velocity, rise time and rupture time) is to invert observed ground motions recorded at a number of different stations (typically strong motion accelerometers). Few studies have been dedicated to evaluate the effect of the number of stations and their geometrical distribution on earthquake source parameters. In this paper we investigate these effects by inverting ground motions from synthetic dynamic earthquake rupture models with heterogeneous stress distribution governed by the slip weakening friction law. Our first target model is a buried strike-slip event (Mw 6.5) in a layered half space.

The Compsyn code (Spudich and Xu, 2002) was used in the inversion procedure to generate forward synthetic waveforms, and an Evolutionary Algorithm was used to search for the source parameters: peak slip velocity (PSV), rupture time, and rise time at low frequency (up to 1Hz). The regularized Yoffe function was applied as a single window slip velocity function, which is a flexible slip velocity function defined by three independent parameters: the final slip, the slip duration and the duration of the positive slip acceleration, Tacc (Tinti, et al. 2005). The same velocity structure was used for both the foward and inversion modeling and no noise was added to the synthetic ground motions before inversion. We applied the Tikhonov regularization to smooth the final slip on fault, which is controlled by PSV and rise time.

Our preliminary results show that: First, we can capture large slip patches of the dynamic models with good ground velocity waveform fitting, using the regularized Yoffe function, which is consistent with the overall properties of dynamic rupture models. Second, the geometry of station distribution is important for finite kinematic source inversion. The number of stations affects the variation of source image, but a surprisingly small number of well-spaced stations appears sufficient to obtain a stable solution in our study. We obtained a relatively good source model even using only one station given a certain azimuthal and distance between source and station, though we note this is in the unrealistic case of perfect knowledge of ground motions (no noise, tilting), velocity structure, and fault geometry, etc.. However, even with these 'perfect' conditions, and using unrealistically large numbers of stations optimally distributed around the fault, the details of slip velocity complexities resulted from the dynamic rupture models are not well captured by the inversion procedure.