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Can a pseudo-dynamic source inversion approach improve earthquake source imaging?

Youbing Zhang, Seok Goo Song, Luis Dalguer, and John Clinton
Swiss Seismological Services, ETH Zurich, Zurich, Switzerland (youbing.zhang@sed.ethz.ch)

Imaging a high resolution spatio-temporal slip distribution of an earthquake rupture is a core research goal in seismology. In general we expect to obtain a higher quality source image by improving the observational input data (e.g. using more, higher quality, near field stations). However, recent studies show that increasing the surface station density alone does not significantly improve source inversion results (Custodio et al. 2005; Zhang et al. in review). Song et al. (2009) and Song and Dalguer (2013) found interesting correlation structures between kinematic source parameters (e.g. slip, peak slip velocity and rupture velocity) obtained both from kinematic inversion and dynamic modeling. These correlation structures that effectively regularize the model space may improve source imaging more than by simply improving the observational data. In this 'pseudo-dynamic' source inversion, source images are constrained by both physical constraints derived from rupture dynamics as well all the observational data, without compromising the computational efficiency of kinematic inversion. We investigate the efficiency of the pseudo-dynamic source inversion using synthetic dynamic rupture models. Our target model is a buried vertical strike-slip event (Mw 7.3) in a homogeneous half space. In the inversion, we model low frequency (below 1Hz) waveforms using a genetic algorithm in a Bayesian framework (Moneli et al. 2008). A dynamically consistent regularized Yoffe function (Tinti, et al. 2005) was applied as a single-window slip velocity function. We have first implemented the autocorrelation of slip in the prior distribution in the Bayesian inversion - preliminary results show that estimated kinematic source models closely match the target dynamic model. The prior information describing the auto-correlation of source parameters (e.g. slip) improves the imaging of spatial distribution of source parameters. By implementing both auto- and cross-correlation of kinematic source parameters, we can regularize the model space in a more physics-based manner and improve the source imaging more significantly compared to using traditional smoothing constraints. Further investigation is needed to tune the related parameters of pseudo-dynamic source inversion and relative weighting between the prior and the likelihood function in the Bayesian inversion.