Geophysical Research Abstracts
Vol. 18, EGU2016-10662, 2016
EGU General Assembly 2016

Uncertainty estimation in finite fault inversion

Jan Dettmer, Phil R. Cummins, and Roberto Benavente
Research School of Earth Sciences, Australian National University, Canberra, Australia (dettmer.jan@gmail.com)

This work considers uncertainty estimation for kinematic rupture models in finite fault inversion by Bayesian sampling. Since the general problem of slip estimation on an unknown fault from incomplete and noisy data is highly non-linear and currently intractable, assumptions are typically made to simplify the problem. These almost always include linearization of the time dependence of rupture by considering multiple discrete time windows, and a tessellation of the fault surface into a set of 'subfaults' whose dimensions are fixed below what is subjectively thought to be resolvable by the data. Even non-linear parameterizations are based on a fixed discretization. This results in over-parametrized models which include more parameters than resolvable by the data and require regularization criteria that stabilize the inversion. While it is increasingly common to consider slip uncertainties arising from observational error, the effects of the assumptions implicit in parameterization choices are rarely if ever considered.

Here, we show that linearization and discretization assumptions can strongly affect both slip and uncertainty estimates and that therefore the selection of parametrizations should be included in the inference process. We apply Bayesian model selection to study the effect of parametrization choice on inversion results. The Bayesian sampling method which produces inversion results is based on a trans-dimensional rupture discretization which adapts the spatial and temporal parametrization complexity based on data information and does not require regularization. Slip magnitude, direction and rupture velocity are unknowns across the fault and causal first rupture times are obtained by solving the Eikonal equation for a spatially variable rupture-velocity field. The method provides automated local adaptation of rupture complexity based on data information and does not assume globally constant resolution. This is an important quality since seismic data do not have homogeneous resolution but rather varying sensitivity to spatial and temporal length scales across the fault.

A quantitative comparison of model choices (e.g., trans-dimensional models, smoothest models) is carried out. The comparison illustrates that parameterization choice has a significant impact on both slip estimates as well as uncertainties. Therefore, it is important to carefully consider parameterization choice before results are interpreted in terms of rupture physics. We study these effects for both simulated data and for the great 2011 Tohoku earthquake with long period seismic (W-phase) and geodetic data. Our method provides simple solutions with few parameters while capturing complex rupture characteristics.