Assessing the effects of rigidity contrasts on earthquake source inversions using PyLith

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Current methods of inverting geodetic data for coseismic fault slip generally rely on simple elastic half space or layered space models to describe the crustal response to dislocations on a given fault plane. The neglect of the 3D variations in rigidity that exist within the real Earth can bias inversion results, whether the goal is determining the optimal fault plane geometry associated with a particular event or to find the best-fitting co-seismic slip distribution. For many tectonically active areas, such as Southern California, sophisticated models of crustal elastic moduli are available. However, inversions using the full 3D elastic structure are very computationally expensive and not always necessary.

In this project, we are working towards generating quick tests that can identify cases where neglecting elastic structure is appropriate. First order goals in inversions of geodetic data may include determining the location and orientation of the fault plane and the earthquake magnitude, perhaps in near real-time for use in disaster response efforts. Other possible targets include the study of the interaction between seismicity and Coulomb stress changes or earthquake triggering through stress transfer from the lower crust. In all cases, it is essential to know how confident we can be about the conclusions we draw from the data, requiring that we assess not only the contribution from data error, but also from errors in the models we use in inversions.

To assess the effects of rigidity contrasts with various characteristics, we use *PyLith* to generate synthetic data for earthquakes within a range of realistic crustal rigidity structures such as a cross fault contrast. Inversion of these synthetic data sets for the best fitting size and orientation of dislocation within an elastic half space allows us to place bounds on the magnitude of bias introduced when using simple elastic half space models.

In regions where we have limited access to information about elastic structure, the results of this study can aid researchers in placing error bounds on their results, or in determining whether particular problems are feasible. In areas with existing velocity structure models, the target problem may require the use of sophisticated inversion schemes that ingest all the existing knowledge, instead of relying on simpler, computationally inexpensive inversions within elastic half spaces.

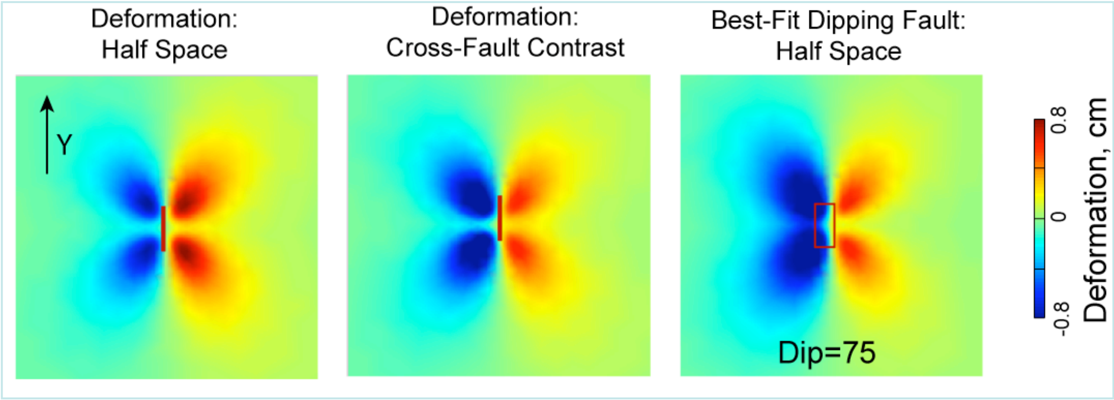

Figure 1: *Y-component of deformation expected for a vertical strike slip fault in a half space (left), and with the inclusion of a cross-fault contrast (middle, deformation field generated with* PyLith*). Right panel illustrates how the best-fit fault in a half space must* include a dip of 75 degrees in order to match the asymmetric deformation field resulting from the cross-fault contrast.

Figure 2: *Inferred dip vs. cross-fault contrast in Young's modulus, for a vertical input fault plane such as the one described in Figure 1. Lines indicate the result of inversions using the X, Y, or Z component of deformation. As expected, we retrieve the input geometry (dip=90) for all cases where the cross-fault contrast is zero.*