New Event Coordinate System

SCEC Workshop
on Probabilistic Fault Displacement

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New versus existing Data-sets

- Existing data-sets provide the on and off-fault displacements as a function of along-strike distance (1D Space)
- New data-set provides displacements as a function of latitude, longitude coordinates (2D Space)

(a) On-fault slip distribution [Wes08]  
(b) Point and Rup dataset [SAB^+19]

Figure: Slip distribution: 1992, Landers CA earthquake
Current PFDHA Methodology

Typical Model steps

▶ Estimation of the average ($AD$) or maximum ($MD$) surface displacement
▶ Estimation of the on-fault displacements along strike ($D(x)$), conditioned on $AD$ or $MD$
▶ Estimation of the off-fault displacements ($d(x)$), conditioned on $D(x)$

It is not straight forward how to apply this approach with the new data-set
New Event Coordinate System (ECS)

Goal: Define a local coordinate system to project the new data-points similarly to the existing ones.

Figure: Reference Coordinate System: 1992, Landers CA earthquake

Local fault coordinate system:

\[ f_{\text{ref}}(u) = \begin{cases} x_r(u) \\ y_r(u) \end{cases} \]

Objective function:

\[ g = \sum_{i=1}^{n} w_{ti} \left[ (x_{pt,i} - x_r(u))^2 + (y_{pt,i} - y_r(u))^2 \right] \]

\[ + \lambda \int_{u=0}^{L} \frac{\partial^2 x_r}{\partial u^2} + \frac{\partial^2 y_{nr}}{\partial u^2} \, du \]

ECS - NGAWest2 equivalencies:

\( u \) axis - \( R_y \), \( t \) axis - \( R_x \)
New Event Coordinate System

The new coordinate system can be used to project the displacements on a single line (u-axis).

(a) Fault segments
(b) Segment displacements

Figure: Displacement Profile: 1992, Landers CA earthquake [SAB+19]
New Fault Coordinate System

The segment displacements can then be interpolated and summed to compute the total displacements.

**Figure:** Total displacement profile: 1992, Landers CA earthquake
Proposed Model

Proposed model components:

▶ Model of total slip along the \( u \)-axis
▶ Model for the number and location of parallel segments.
▶ Distribution for partitioning the slip in parallel segments along the \( t \)-axis

Total displacement model:

Figure: Amplitude Spectrum: 1992, Landers CA earthquake
Proposed model

Distribution of total distribution along the $t$-axis

(a) Distribution of number of parallel traces
(b) Distribution of ratio of segment disp.

Figure: Segment displacement distribution
Discussion

Data-base Gaps:

▶ How are the displacement points connected?
▶ Are the data complete at the ends of the ruptures?

Summary

▶ The event coordinate system will be needed for any model developed in the existing framework


Thank You!
Any Questions?
Example Interpolation

(a) Fault segments
(b) Total displacement

Figure: Interpolation Example