New Event Coordinate System

SCEC Workshop
on Probabilistic Fault Displacement

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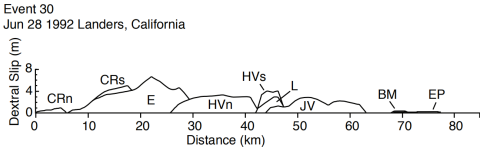
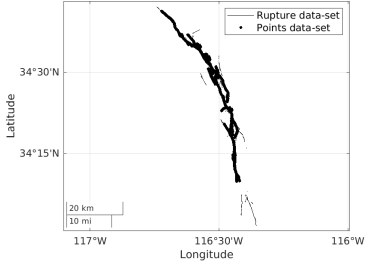
New versus existing Data-sets

- 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 $D(x)$

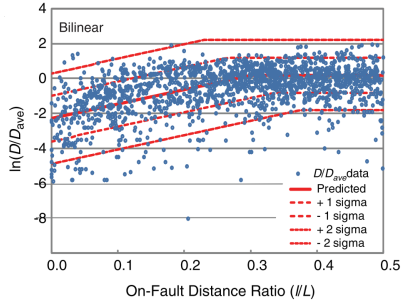


Figure: Bi-linear D/D_{avg} relationship, [PDC+11]

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.

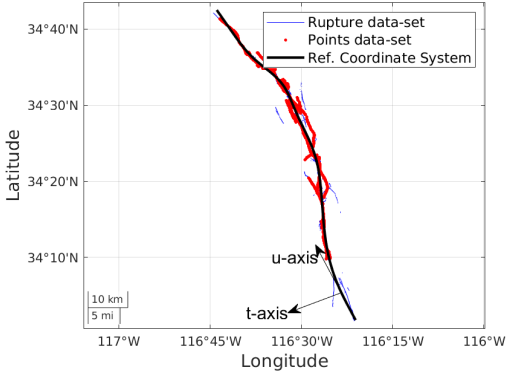


Figure: Reference Coordinate System: 1992, Landers CA earthquake

Local fault coordinate system:

$$f_{ref}(u) = \begin{cases} x_r(u) \\ y_r(u) \end{cases}$$

Objective function:

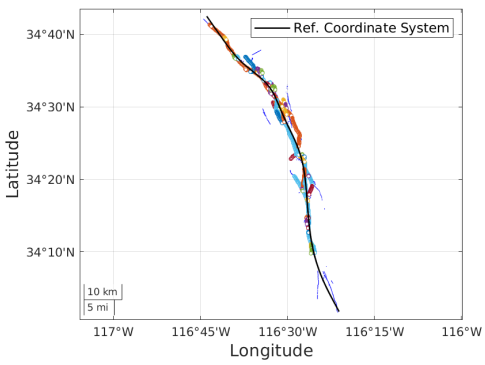
$$g = \sum_{i=1}^{n} wt_i \left[(x_{pt,i} - x_r(u))^2 + (y_{pt'i} - y_r(u))^2 \right] + \lambda \int_{u=0}^{L} \frac{\partial^2 x_r}{\partial u^2} + \frac{\partial^2 y_{nr}}{\partial u^2} du$$

ECS - NGAWest2 equivalencies:

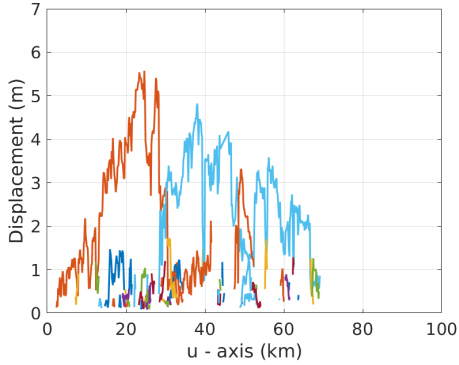
u axis - R_y, t axis - R_x

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.

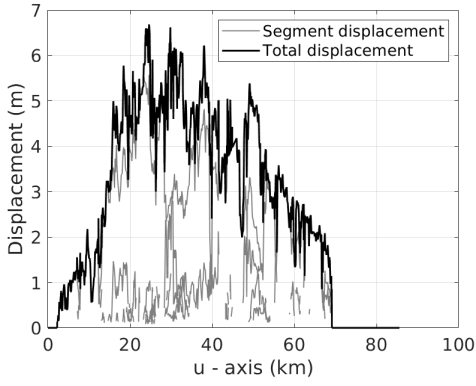


Figure: Total displacement profile: 1992, Landers CA earthquake

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:

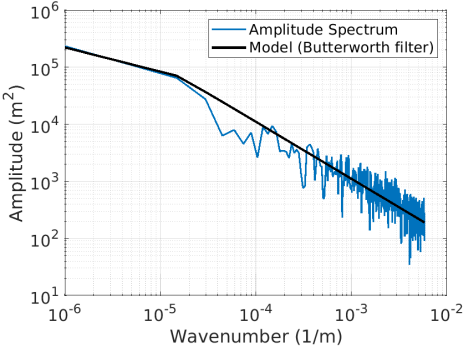
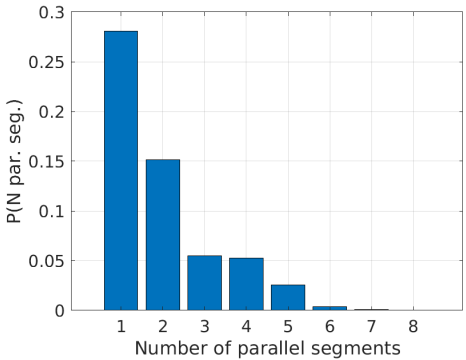


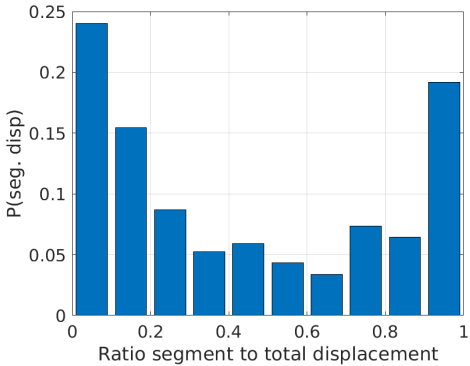
Figure: Amplitude Spectrum: 1992, Landers CA earthquake

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

Bibliography I

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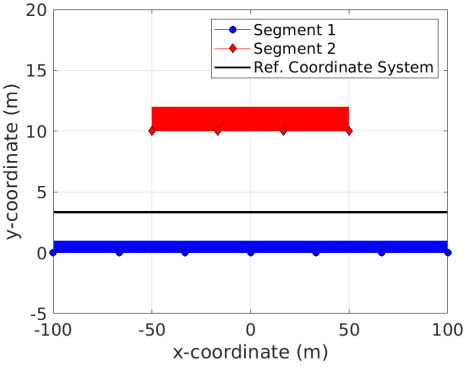
- A. Sarmiento, N.A. Abrahamson, S. Baize, Y. Bozorgnia, R. Chen, K. Coppersmith, T. Dawson, J. Donahue, V. Jacob, M. Ketabdar, A. Kottke, N. Kuehn, G. Lavrentiadis, C. Madugo, S Mazzoni, C. Milliner, A. Shamsaabadi, T. Shantz, A. Shen, S. Thompson, and B. Youngs, *A new model database for next-generation fault displacement hazard analysis*, 4 2019.
- Steven G. Wesnousky, *Displacement and geometrical characteristics of earthquake surface ruptures: Issues and implications for seismic-hazard analysis and the process of earthquake rupture*, Bulletin of the Seismological Society of America **98** (2008), no. 4, 1609–1632.

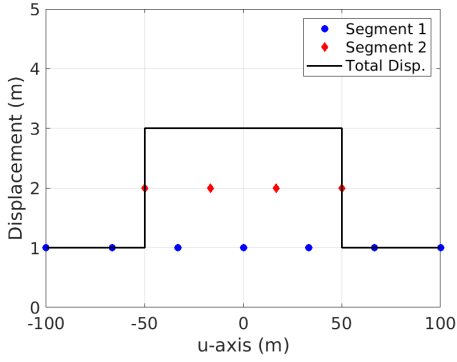
Thank You!

Any Questions?

Example Interpolation



(a) Fault segments



(b) Total displacement

Figure: Interpolation Example