Probabilistic Fault Displacement Hazard Analyses

Application to the Hayward Fault

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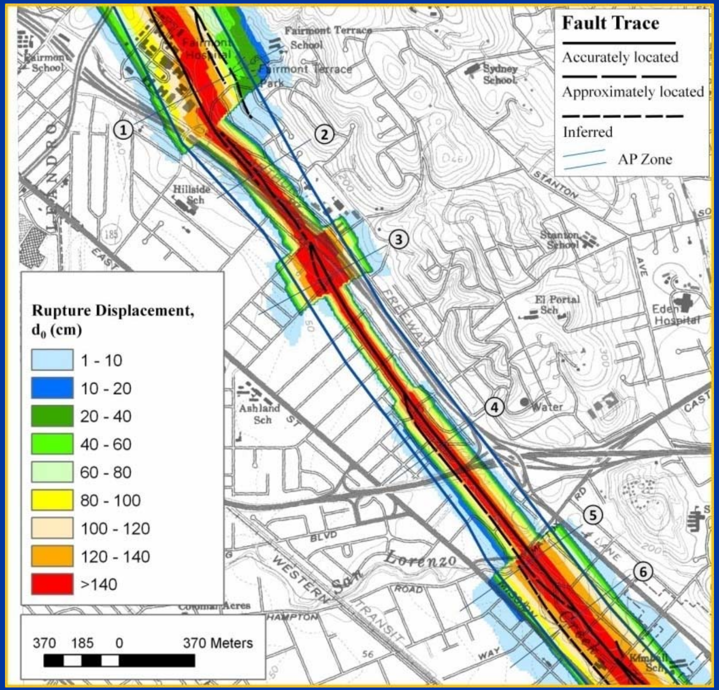
Main Objective

Develop a Probabilistic Fault Displacement Hazard Map

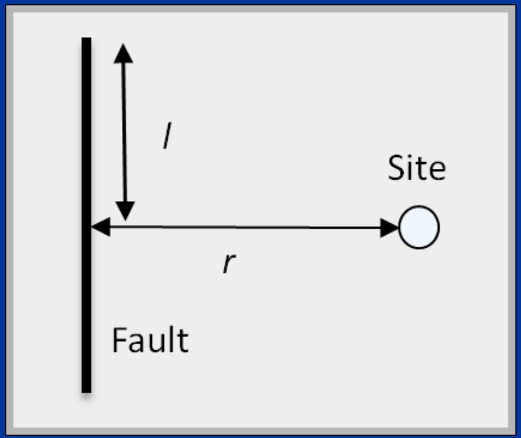
- The idea of a fault displacement hazard map (PEER Lifelines, etc.)
- PFDHA methodology and regressions (Mark Petersen et al.)
- Fault displacement data (Tim Dawson, including some of Steve Wesnousky's 2008 data)
- Fortran code for PFDHA calculation (Tianqing Cao and Mark Petersen, with modification)
- Detailed fault trace and fault branch activity (Bill Bryant)

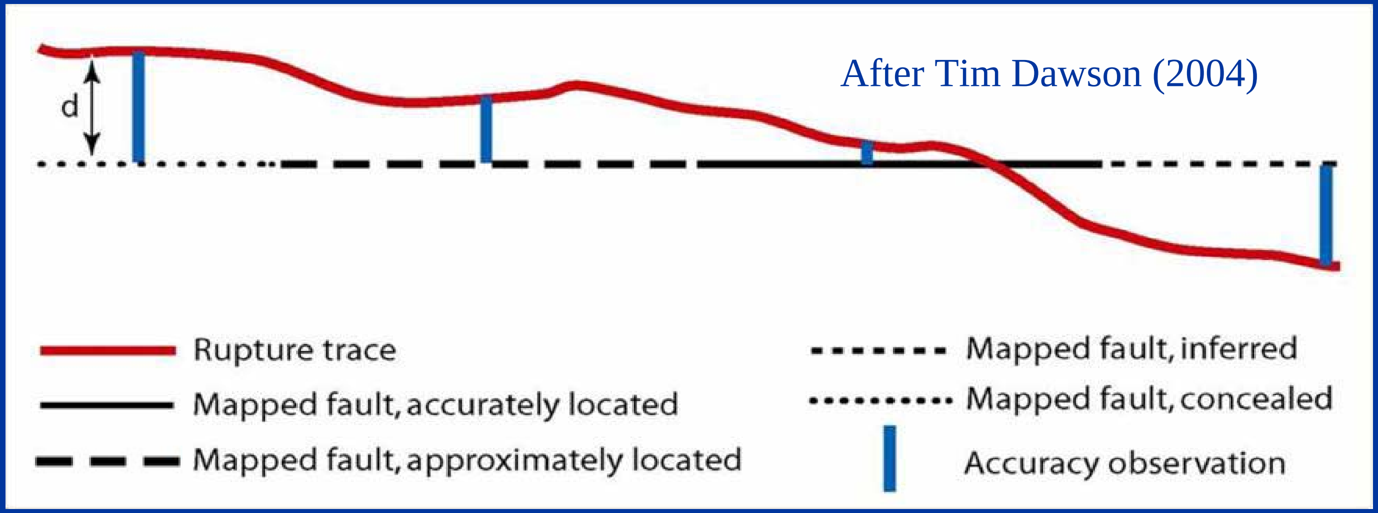


- Putting pieces together and developing the map
- Calculating hazards at Highway 580 fault crossings

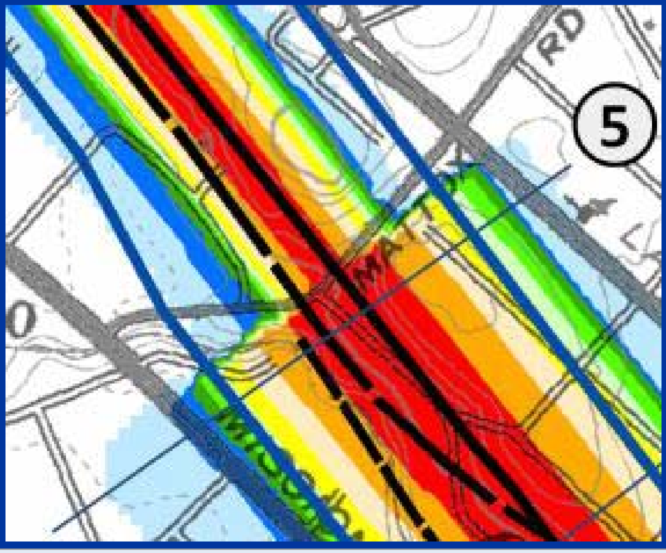
Methodology

- Mark Petersen et al. methodology (2004 – 2009). Regressions depend on:
  - Accuracy of mapped fault trace
  - Complexity of fault geometry
  - Cell size (structure footprint size)
- Fault specific application using detailed fault trace
- A large number of cross-line profiles for map generation

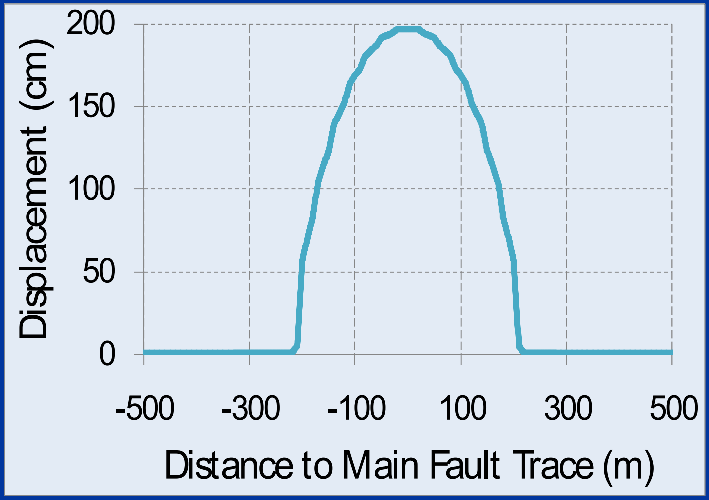




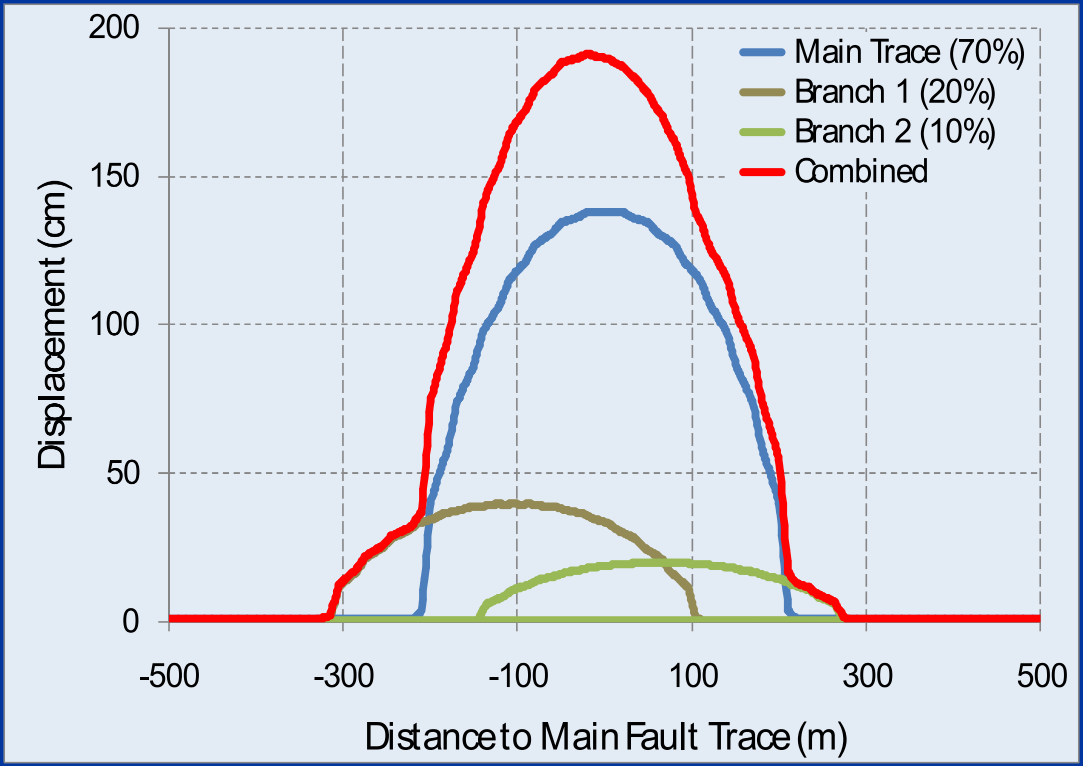
Partition of Fault Displacement



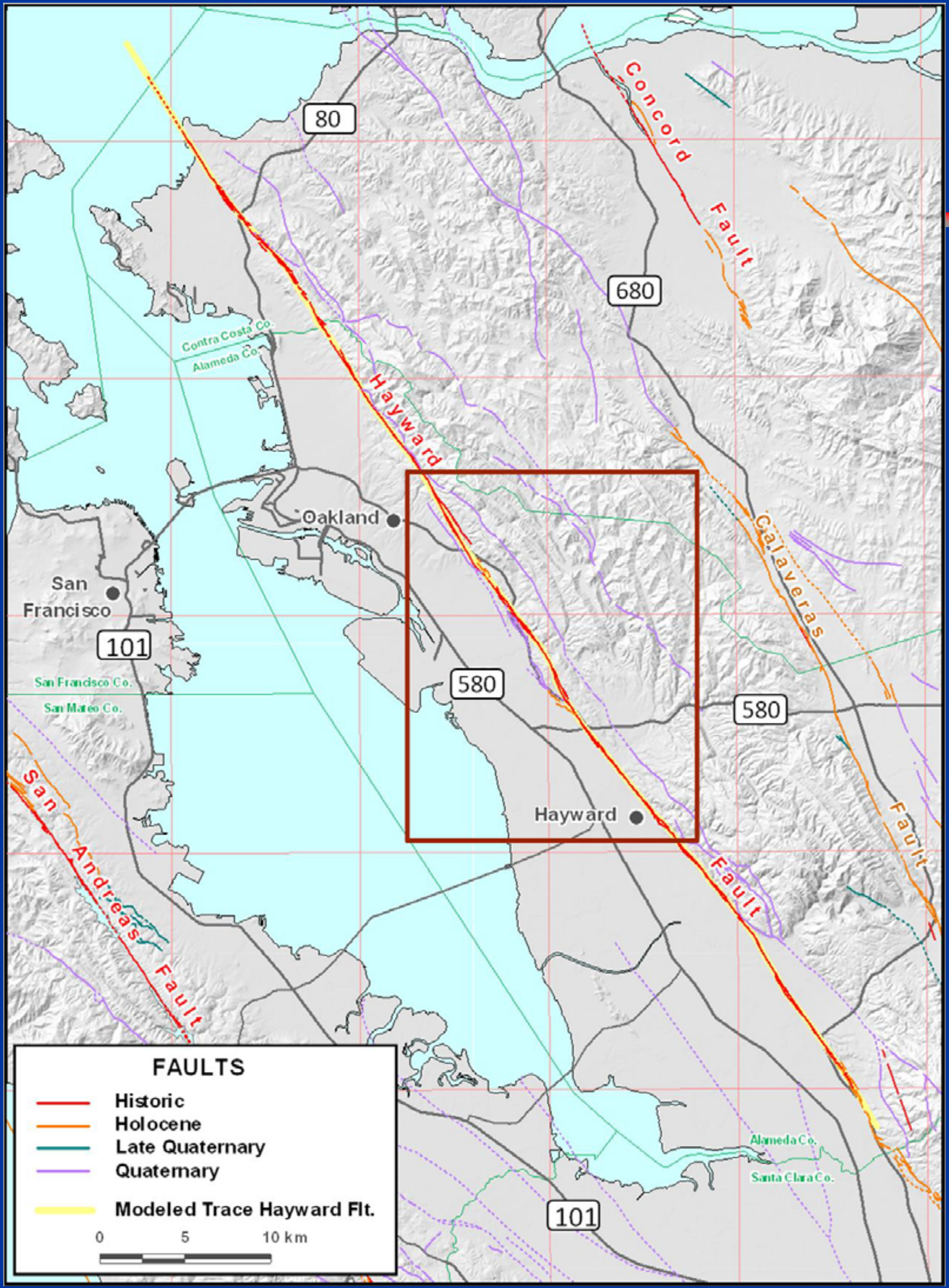
Displacement is partitioned among branches based on local geological evidence.



Without partition



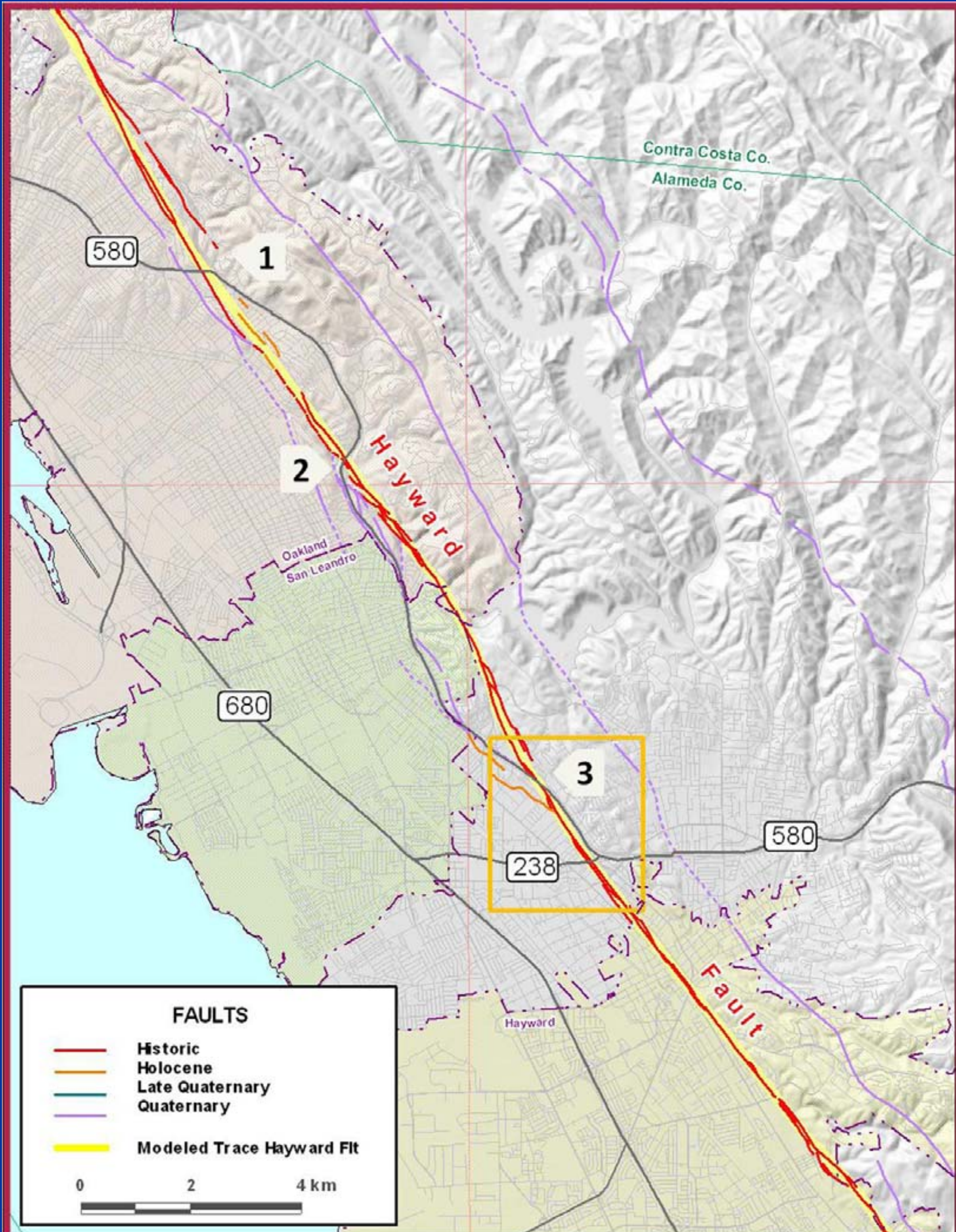
Partitioned



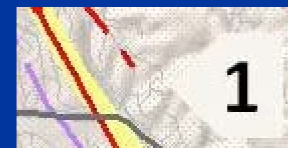
Application to the Hayward Fault

- Rupture of the Northern and Southern Hayward Fault segments
- A characteristic, M 7.0 earthquake occurring once every 140 years
- Modeled fault trace (in yellow) is defined by about 70 points selected in GIS based on:
  - Alquist-Priolo traces
  - Jim Lienkaemper traces

Fault Displacement Hazard Near Three 580 Crossings

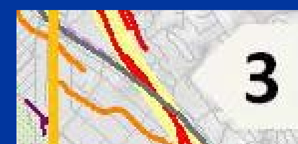


Partition
(Main Trace , Branch)

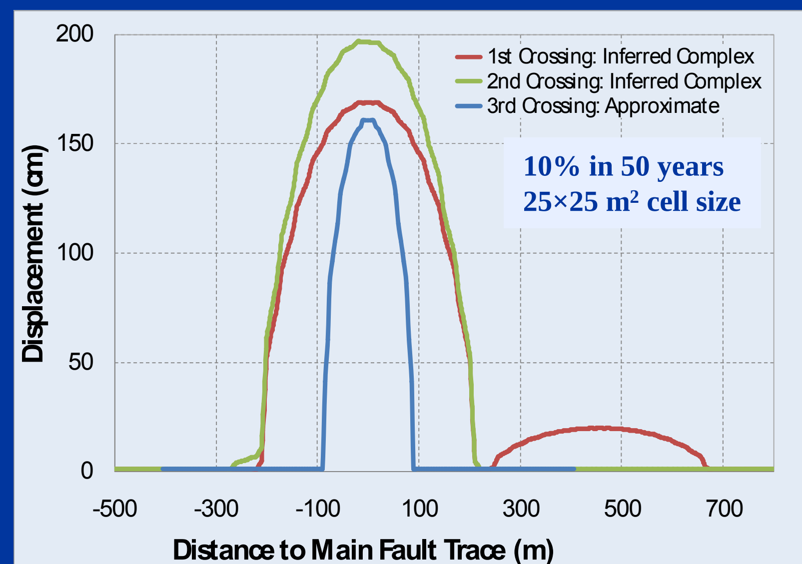


(90%, 10%)

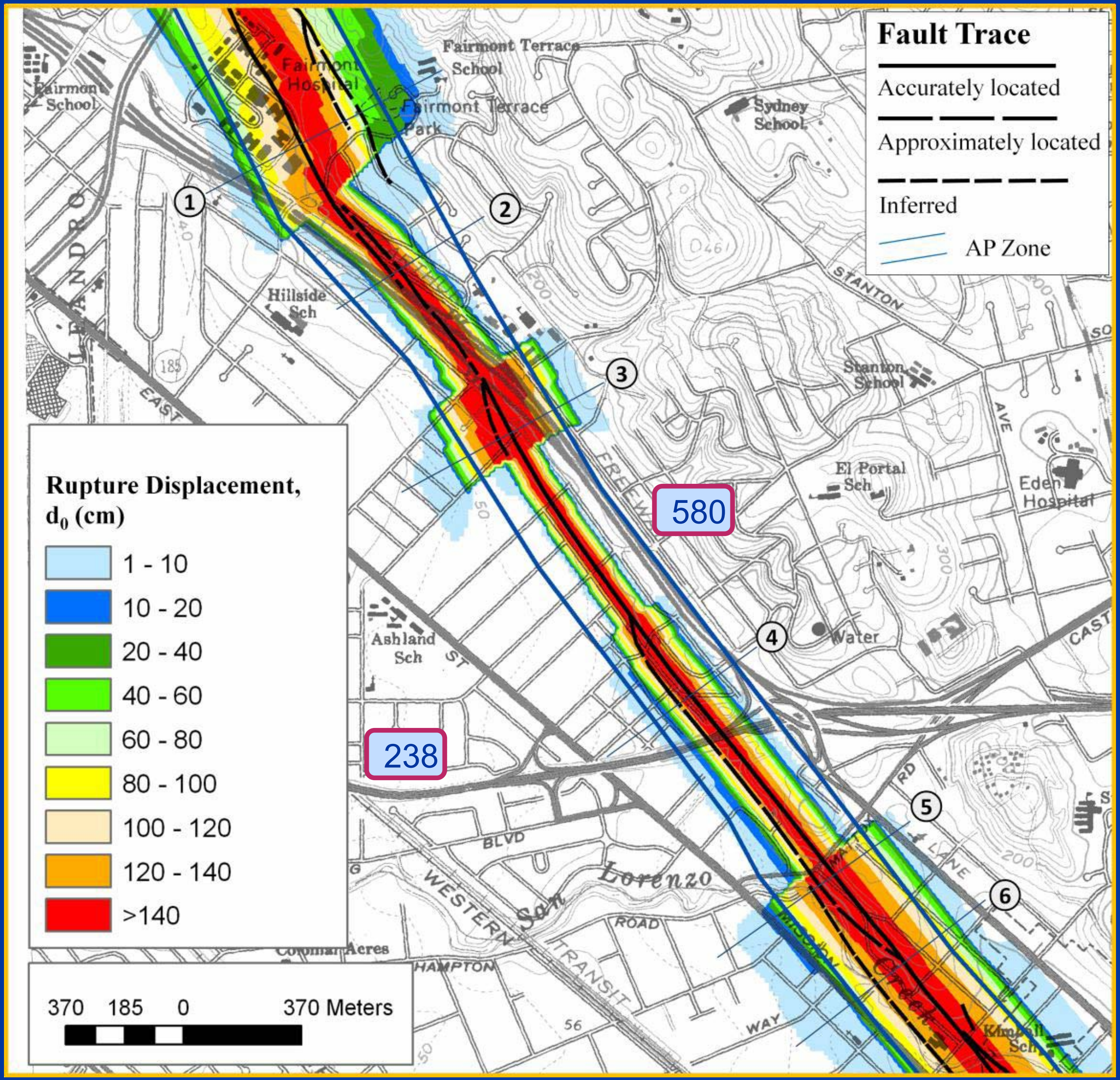
(95%, 5%)



(100%, single trace)



Fault Displacement Hazard Map Near Hayward



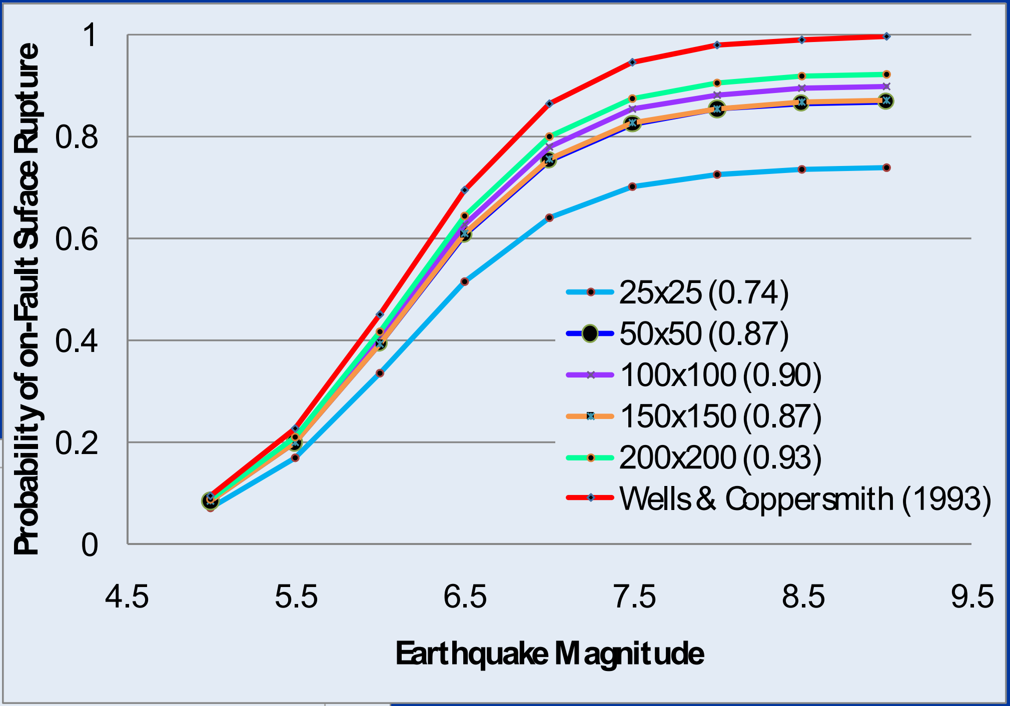
10% in 50 years
25x25 m^2 cell size

26 cross-line profiles

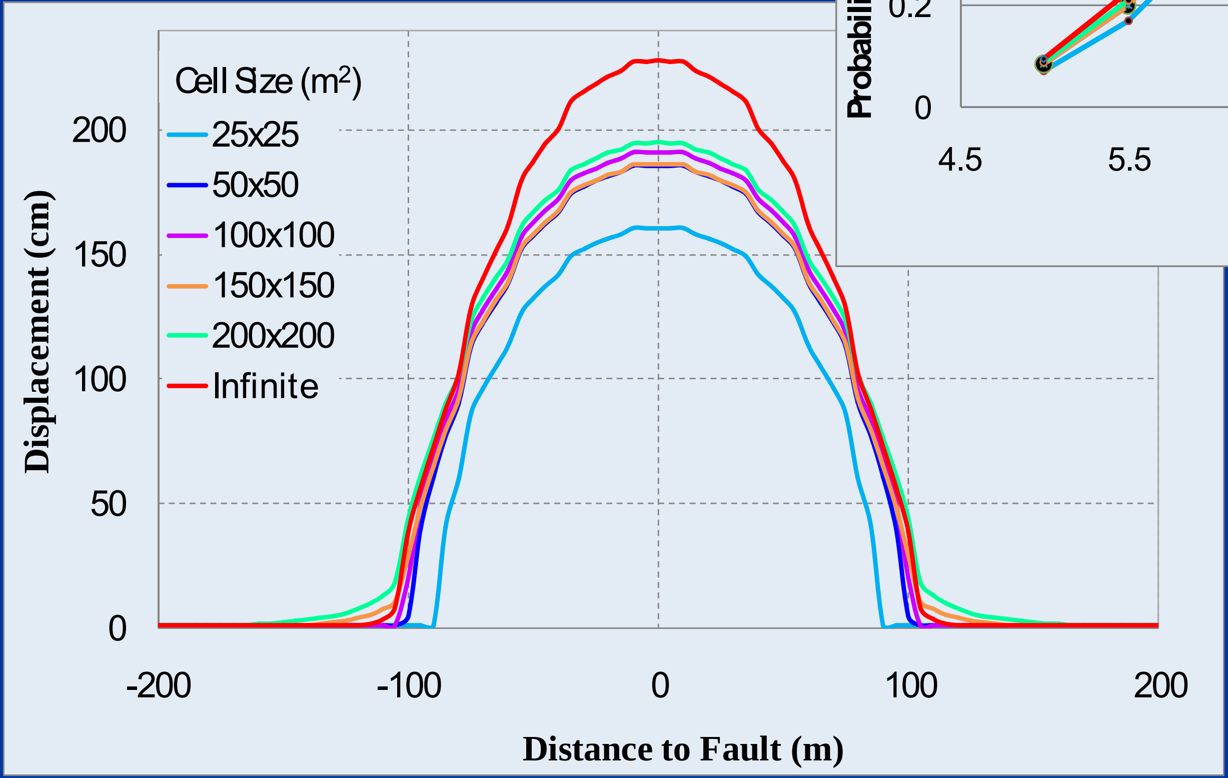
Partition of Displacement at Selected Locations

	Main Trace	Branch 1	Branch 2
1	75%	5%	20%
2	90%	10%	-
3	95%	5%	-
4	90%	10%	-
5	85%	10%	5%
6	95%	5%	-

Effect of Cell Size



3rd Highway 580 crossing
10% in 50 years



Wells and Coppersmith (1993):

$$P[sr \neq 0 \mid M] = \frac{e^{(a+bM)}}{1+e^{(a+bM)}}$$

Modification:

$$ratio = \frac{cell\ with\ rupture}{total\ number\ of\ cells}$$

Estimate of On-Fault Displacement

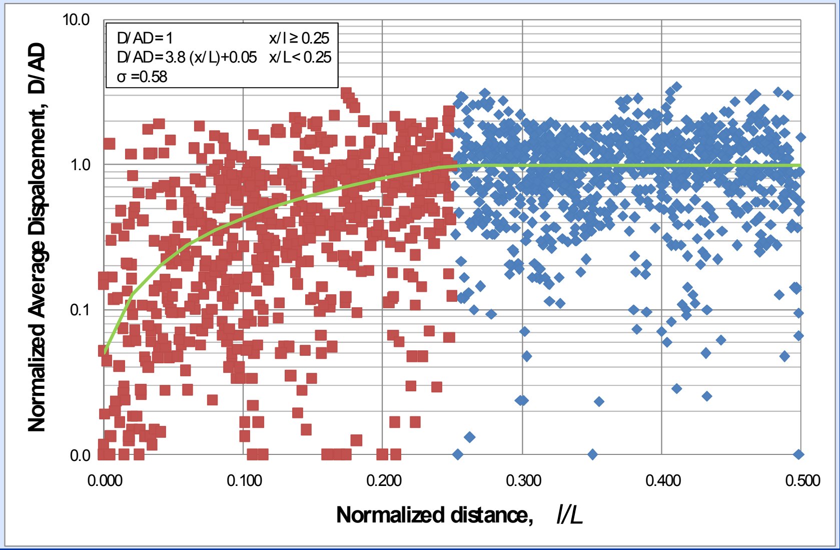
- Wells and Coppersmith (1994)

$$\log_{10}(D_{ave}) = -6.32 + 0.9M$$

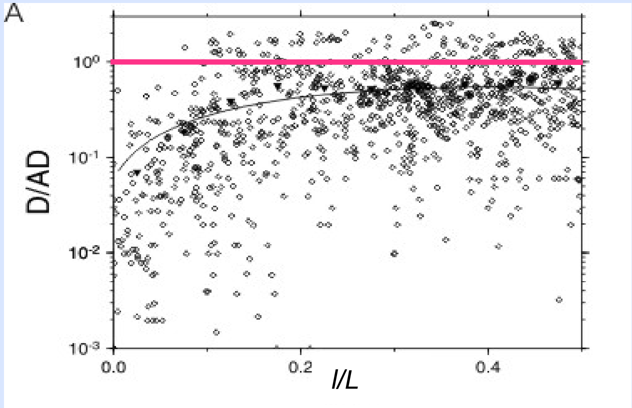
- Geological average or seismological average? What do they mean and how are they calculated?

$$D(l, D_{ave}) \;= (D/AD) \times 10^{(-6.32+0.9M)}$$

2009 revision:
(normalized to geological AD)



2004 data and regression:
(normalized to seismological AD?)



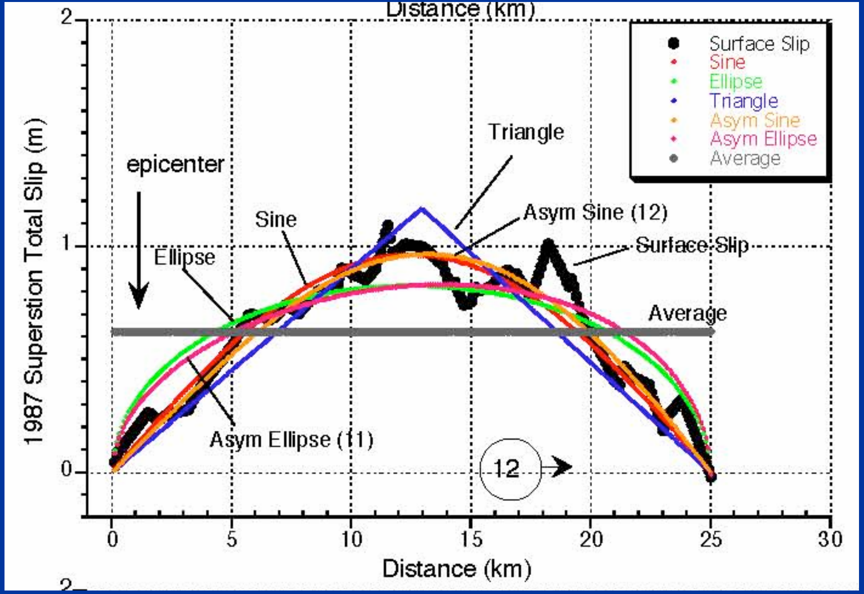
$$D/AD \;= -2.4165*(l/L)^2 + 1.9406*(l/L) + 0.0479$$

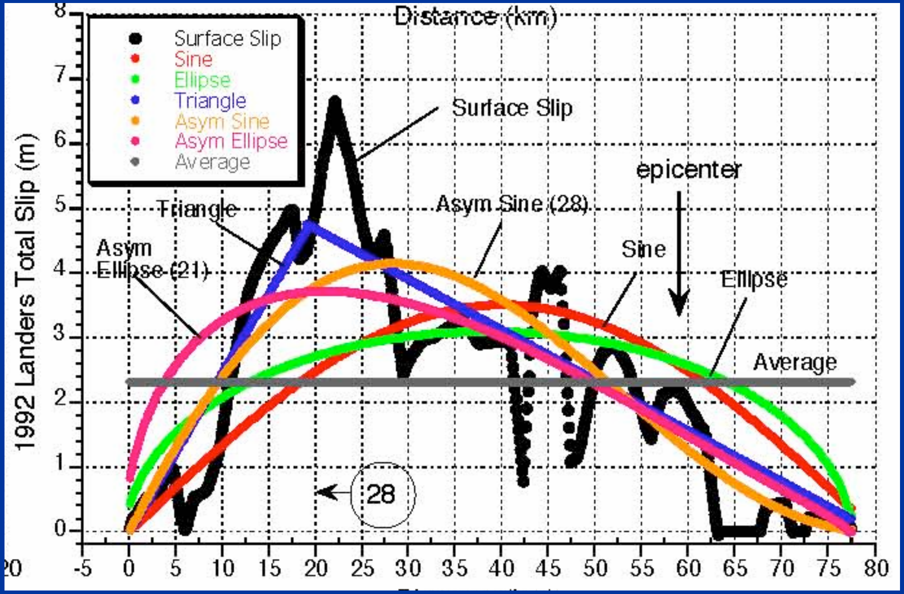
On-Fault Slip Distribution

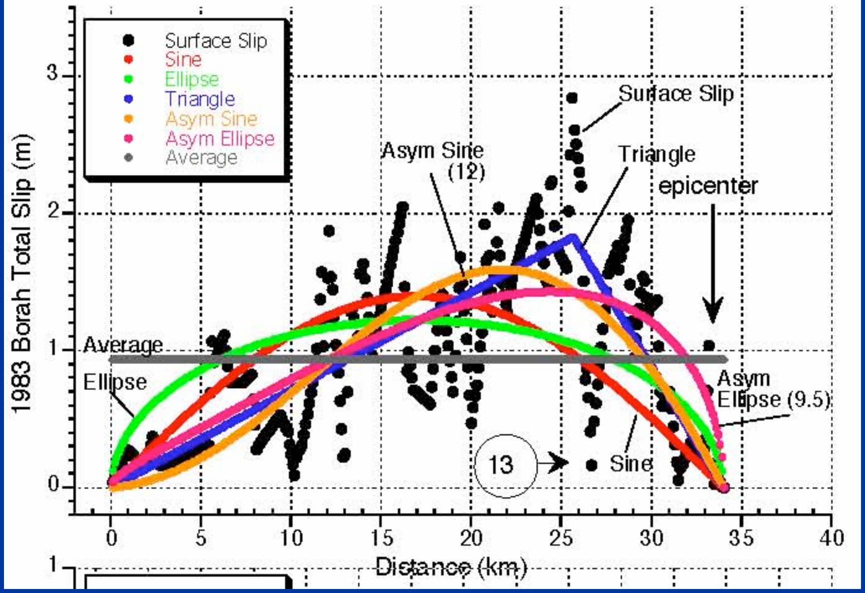
Wesnousky (2008):

- Asymmetric curves fit better than symmetric curves

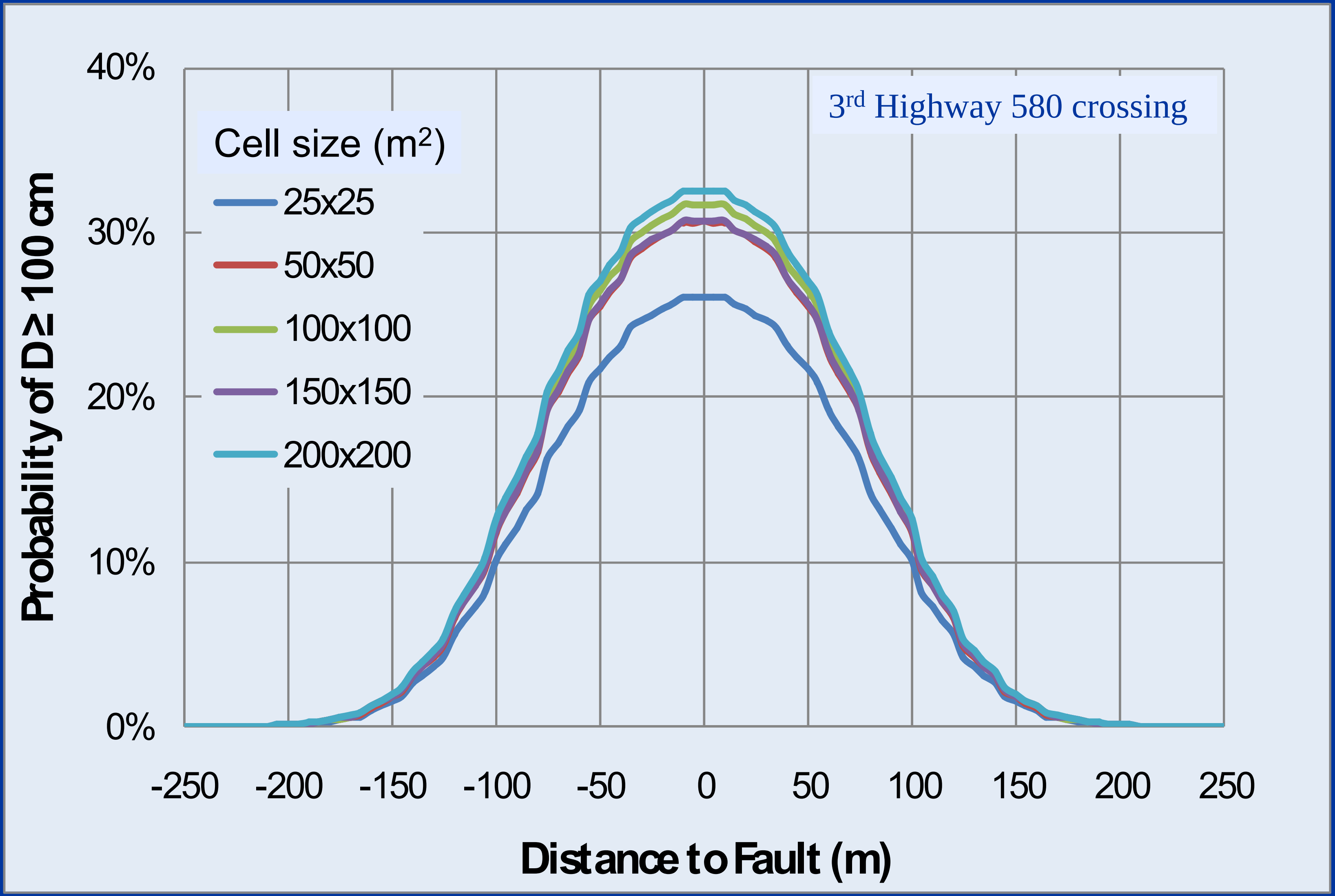
Can we incorporate variation in the degree of asymmetry in PFDHA?



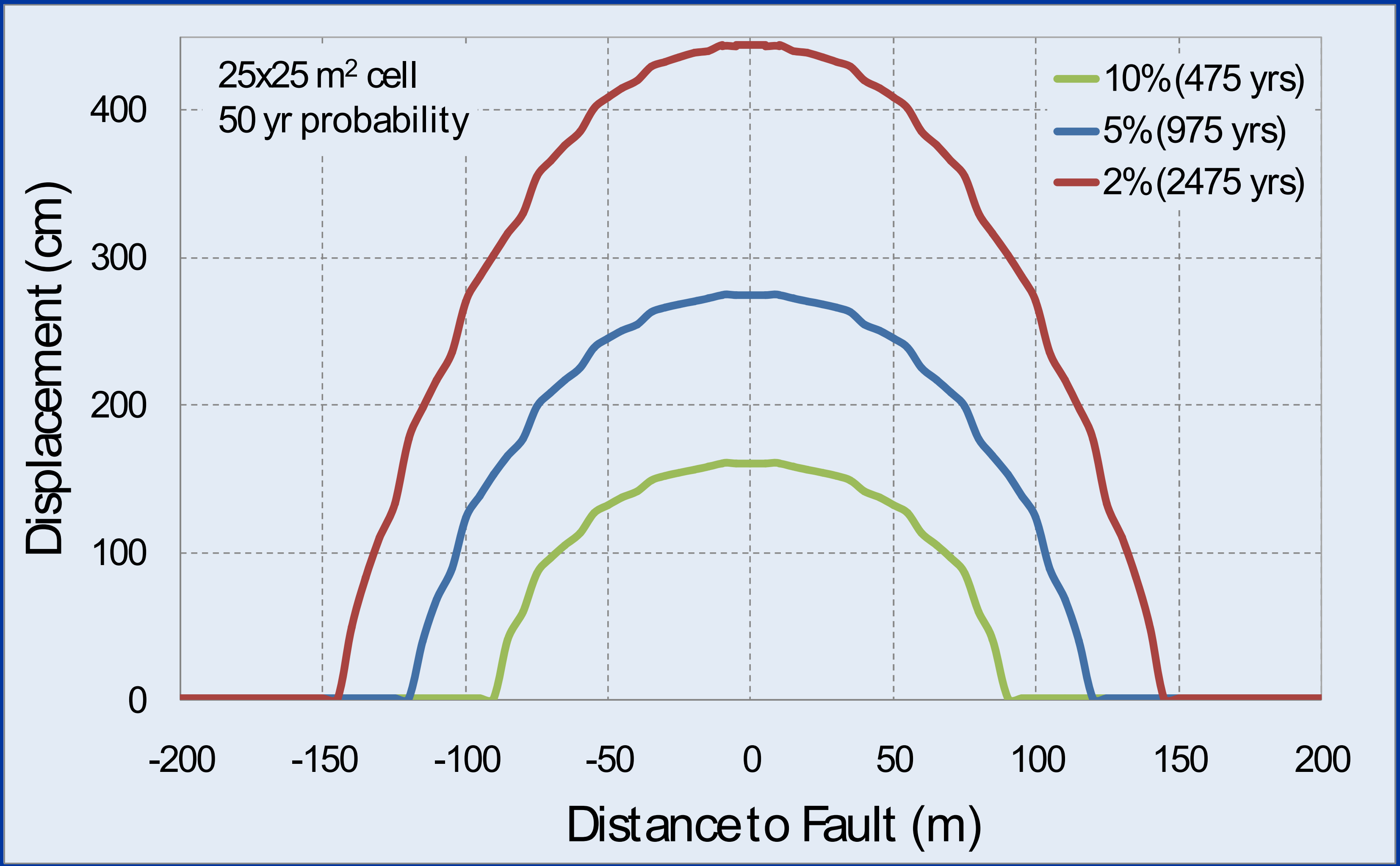




Probability Profiles



Multiple Probabilities



Summary

1. Lateral extent of estimated zone of fault displacement increases with increasing uncertainty in fault location and increasing complexity of mapped fault traces
2. Need continuous effort in augmenting fault displacement data and updating regression relations
3. PFDHA is consistent with PSHA and may be a valuable tool in design