Empirical Uses of the Ground Rupture Database

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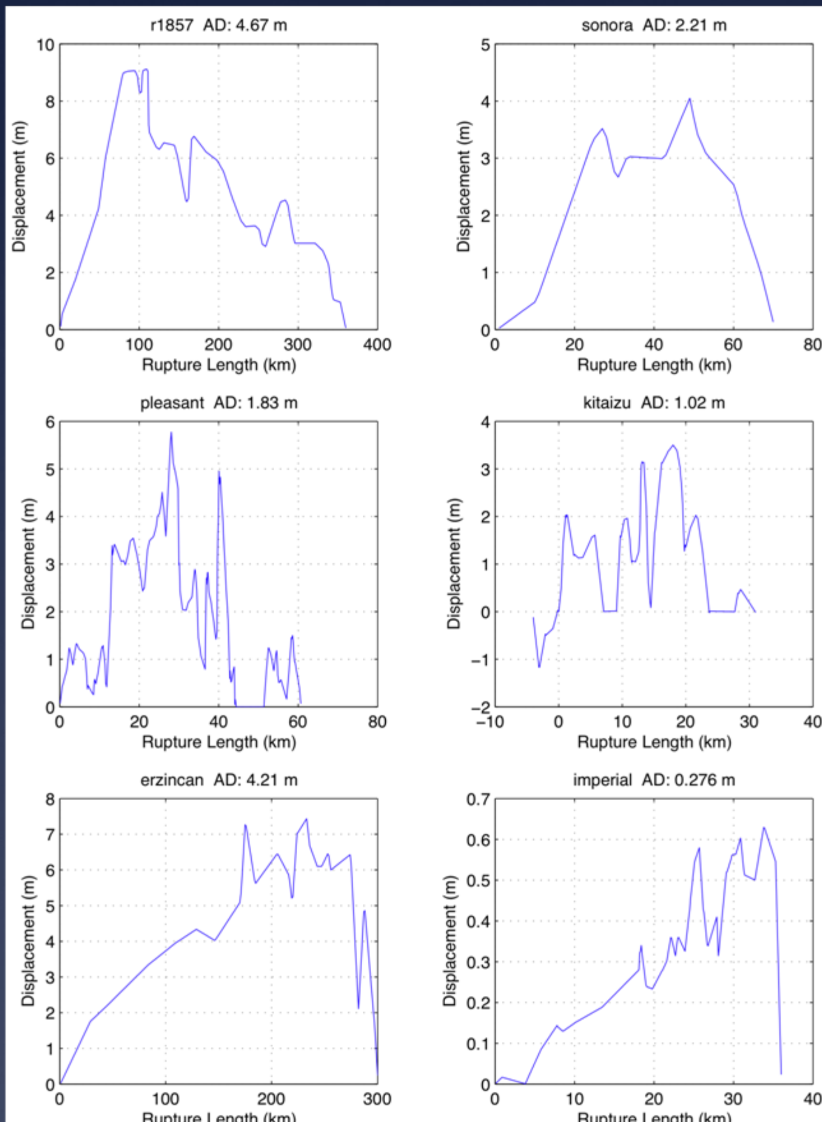
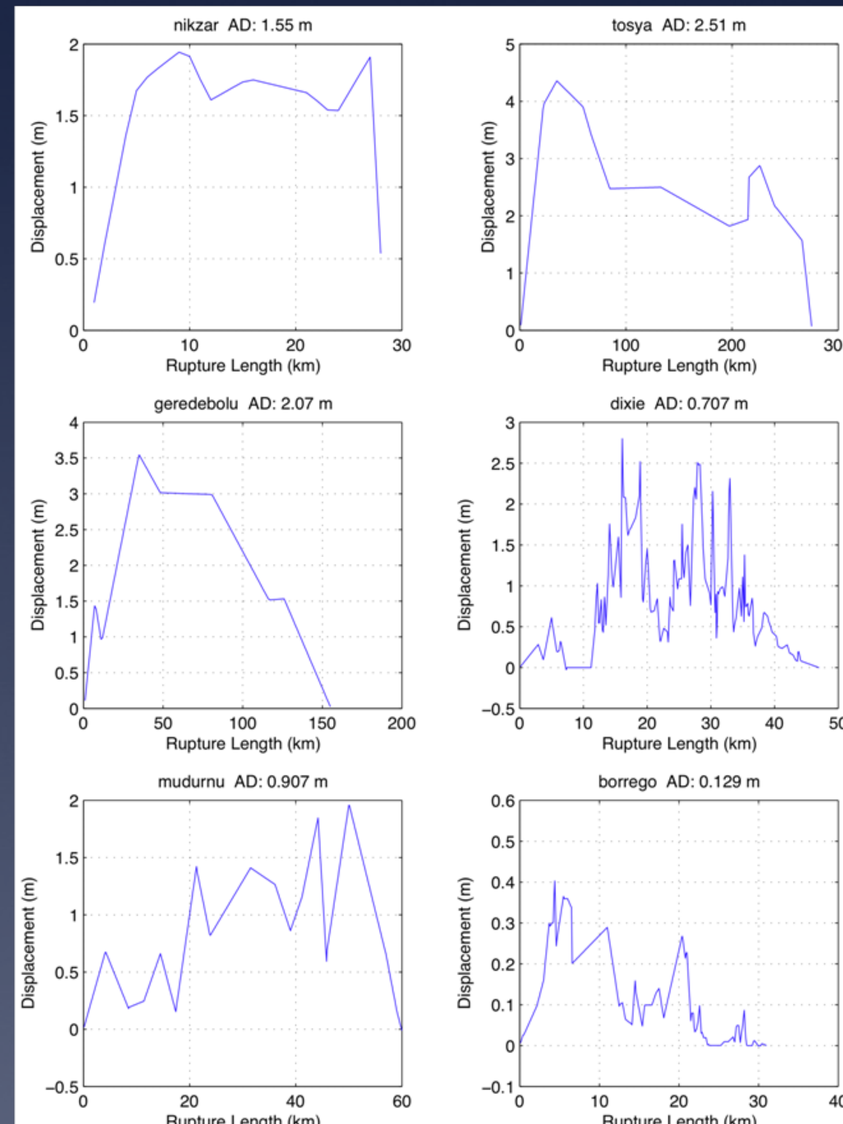
- What can we say about the average rupture shape based on available rupture profiles?
- Notes on the use of triangular shapes
- Capturing rupture variability across all published ruptures
- p(d | M) and p(M | d)

Rupture Shape for an Unknown Earthquake

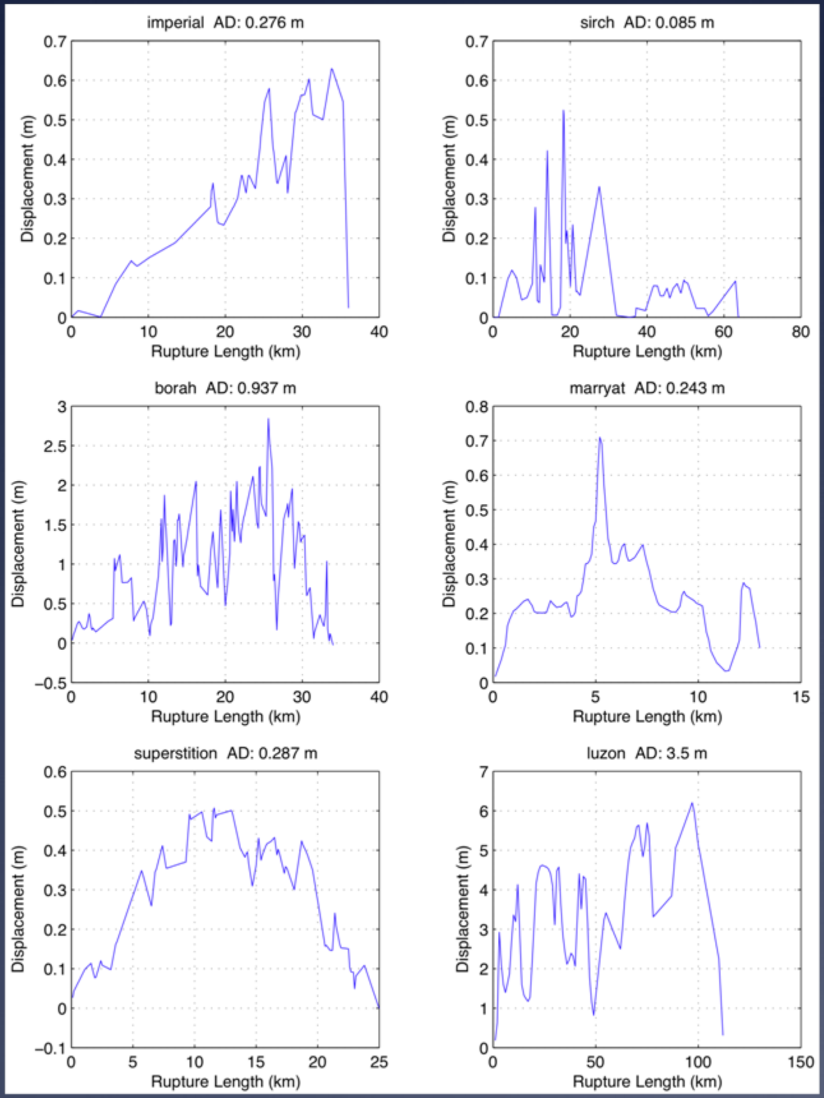
- Is there an average rupture shape?
- Does the average shape depend on rupture length?
- *Use data set of rupture profiles from Wesnousky (2008)*
- *Subset selected of 24 with length >10 km*

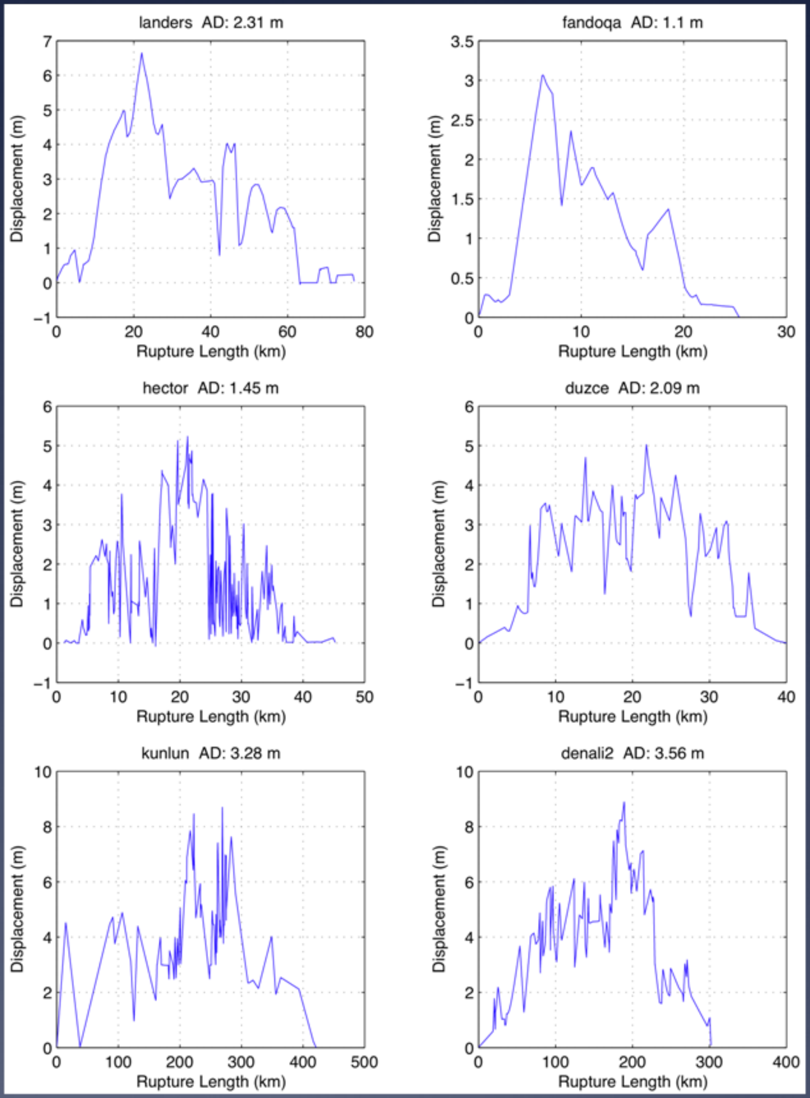
Rupture Profile Data (1)



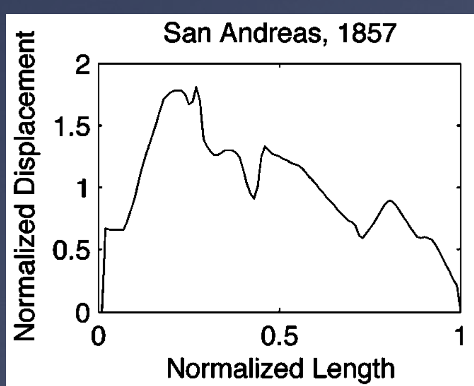


Rupture Profile Data (2)



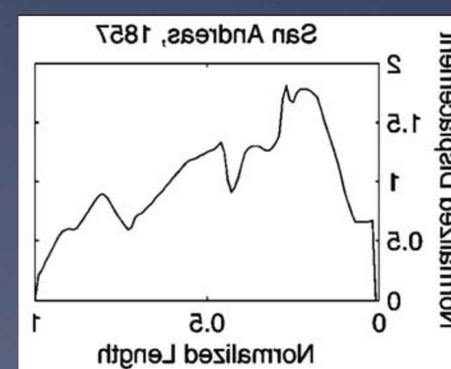


- Challenge: how to combine ruptures of different lengths and displacements.
  - Combine using the method in Hemphill-Haley and Weldon (1999) – normalize by average displacement and length
  - Assume variability of displacements around mean is similar for large and small events.
  - Compare reversed and not reversed

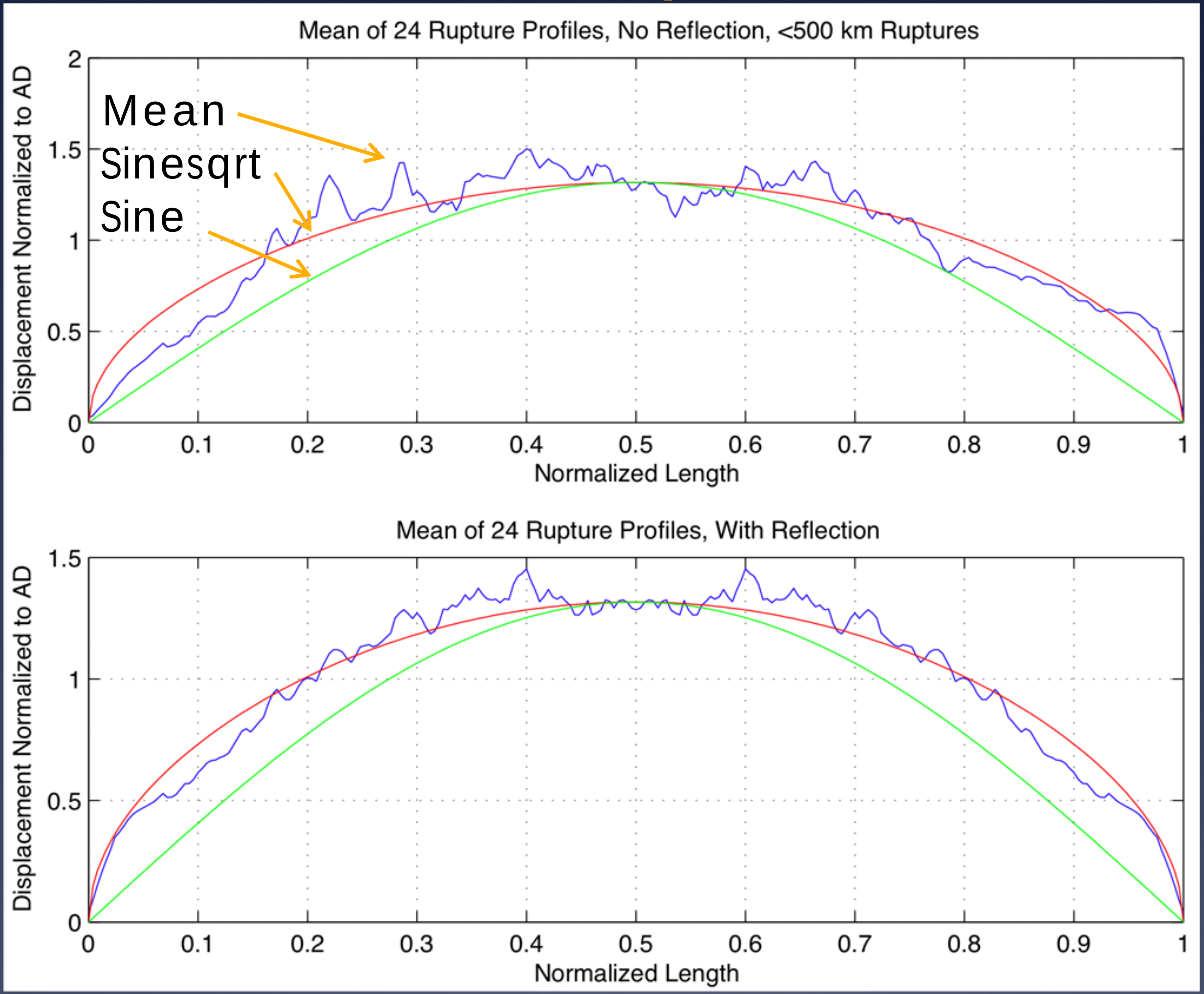


From Ventura

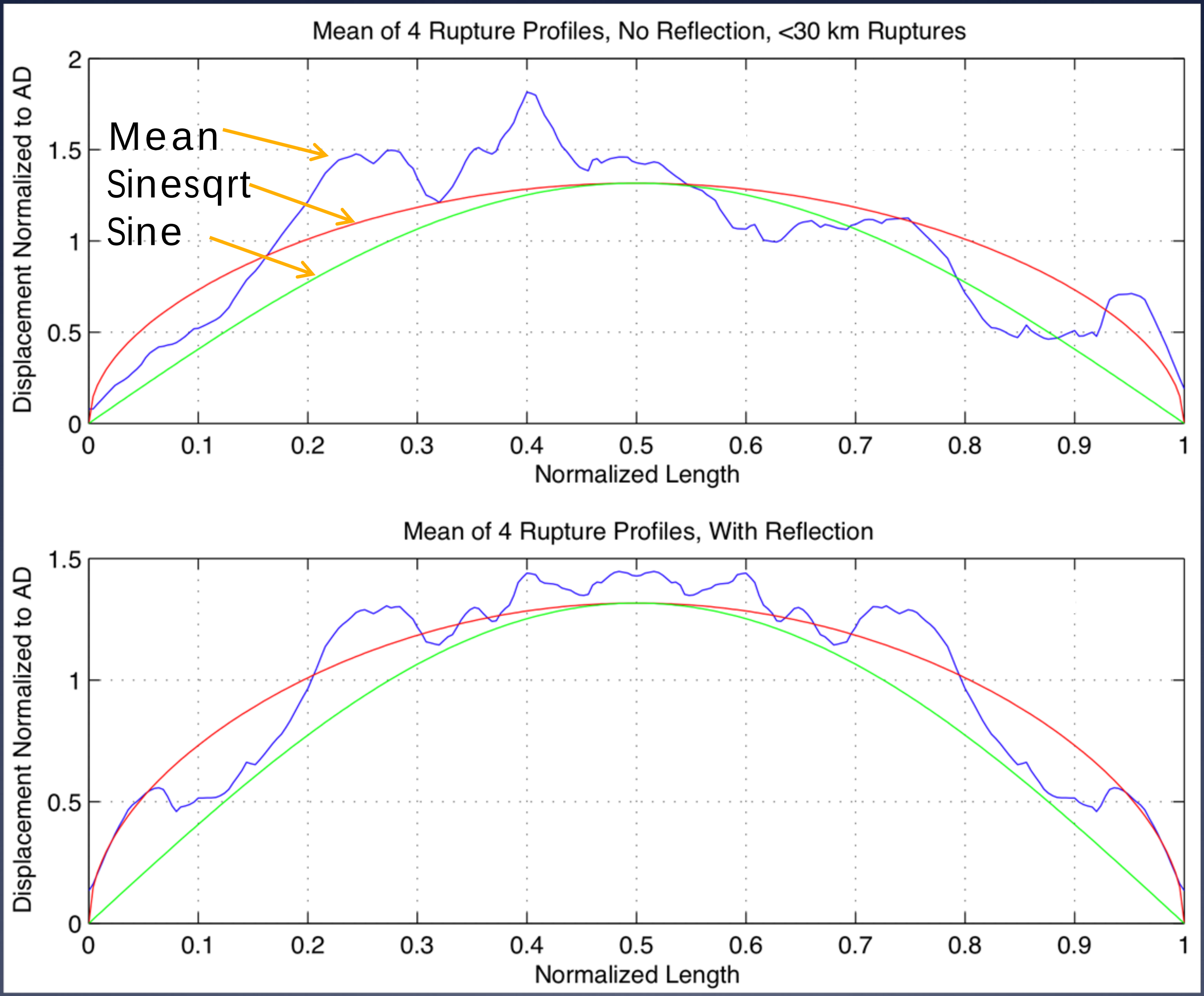
From Bakersfield



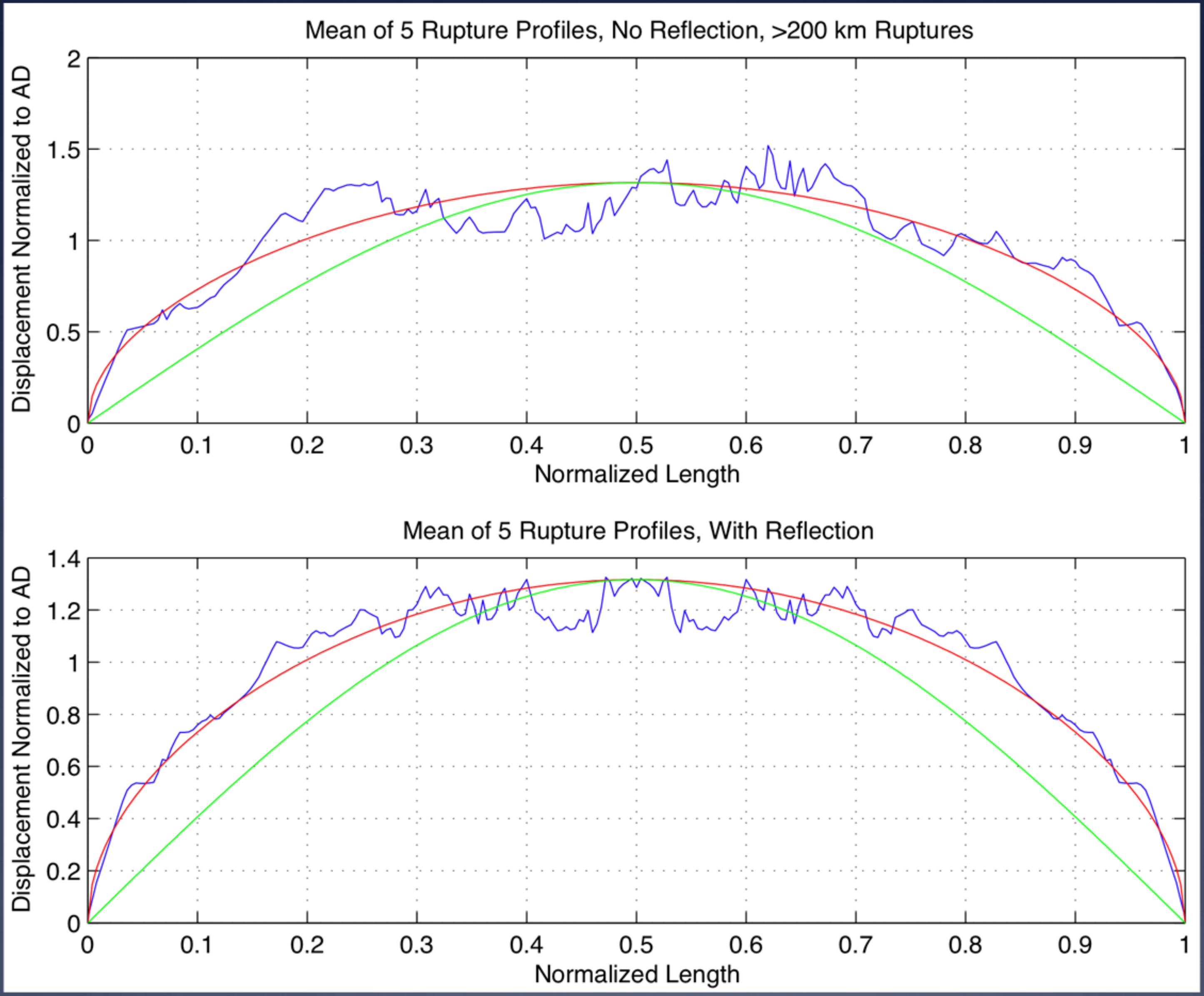
Mean, 24 Ruptures



Four ruptures <30 km



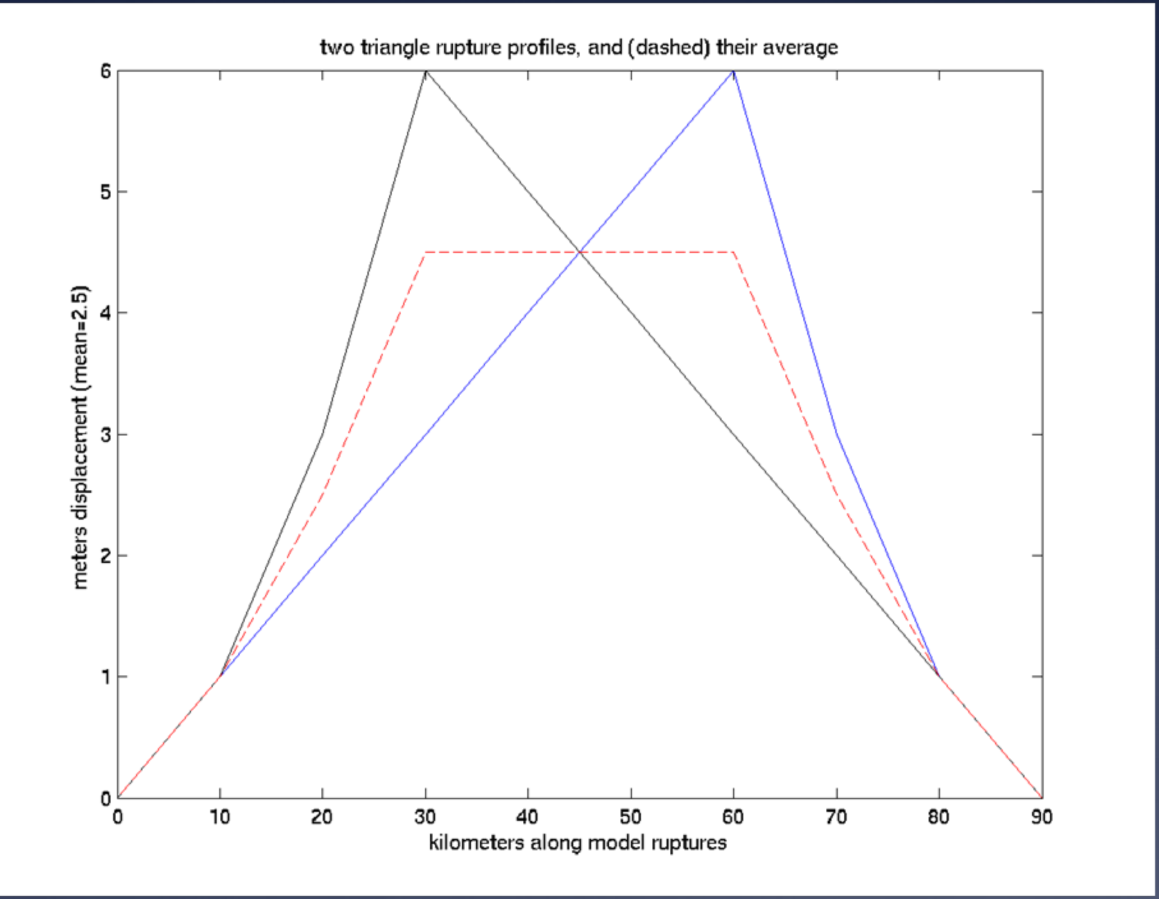
Five ruptures >200 km



Notes on the Average Rupture Shape

- Including the reflected rupture shapes in effect doubles the data set under the expectation that next events will be similar to past ones.
- Normalizing by d_{ave} removes most of the variability due to stress drop.
  - If you know the d_{ave} of the next rupture, use it.

Would I be ahead to assume a triangular rupture profile?

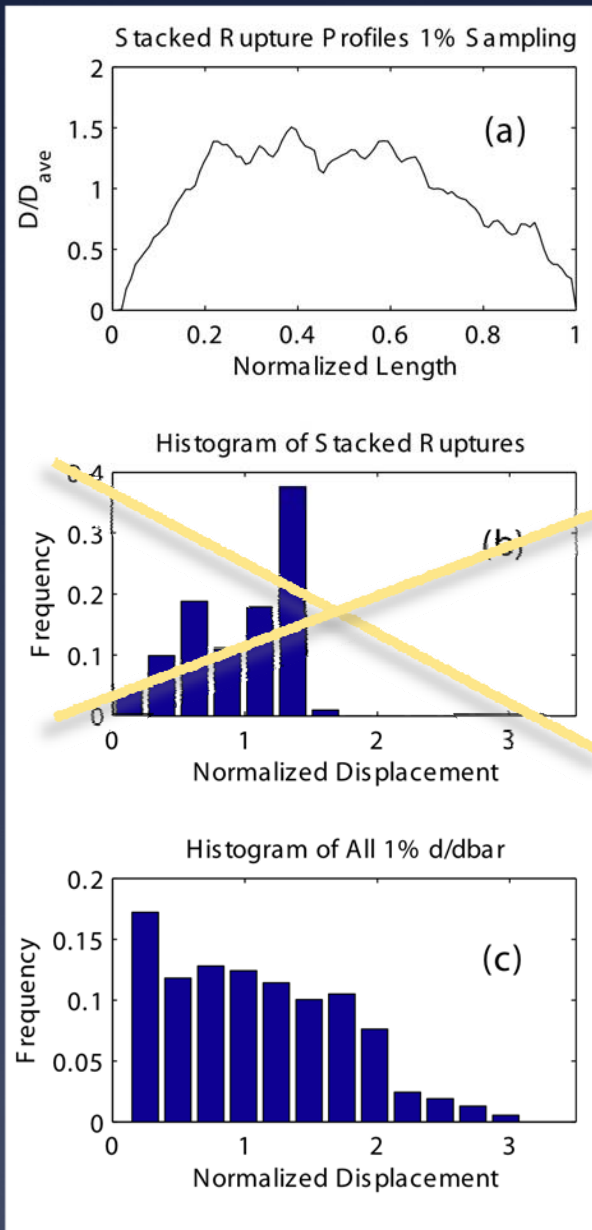


Example: 90 km rupture, d_{max}=6 m, d_{ave} = 2.5 m
Black: Left triangle
Blue: Right triangle, reflection of left triangle
Red: Average of both

Cases:
(1)Assume left triangle, next rupture is left triangle. Mean error: 0
(2) Assume left triangle, next rupture is right triangle. Mean error 1.25 m.
(3) Assume mean, get either triangle: Mean error 0.625 m (about half)
(4) Assume mean, get non-triangle: Mean error <0.625 m

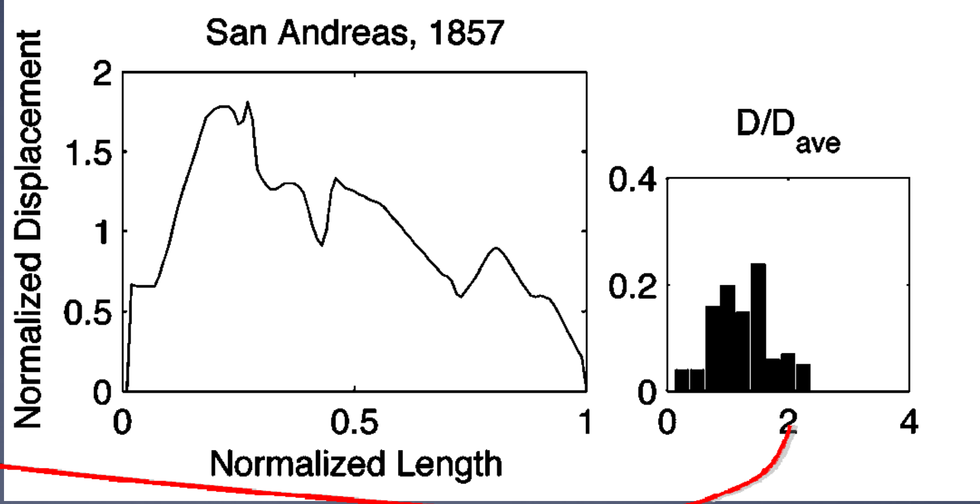
Conclusion: If you know the shape of the next rupture, use it. If not, use the mean rupture shape.

Other Uses of the Normalized Rupture Profiles

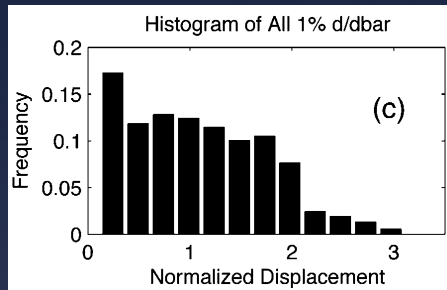


Variability averaged out

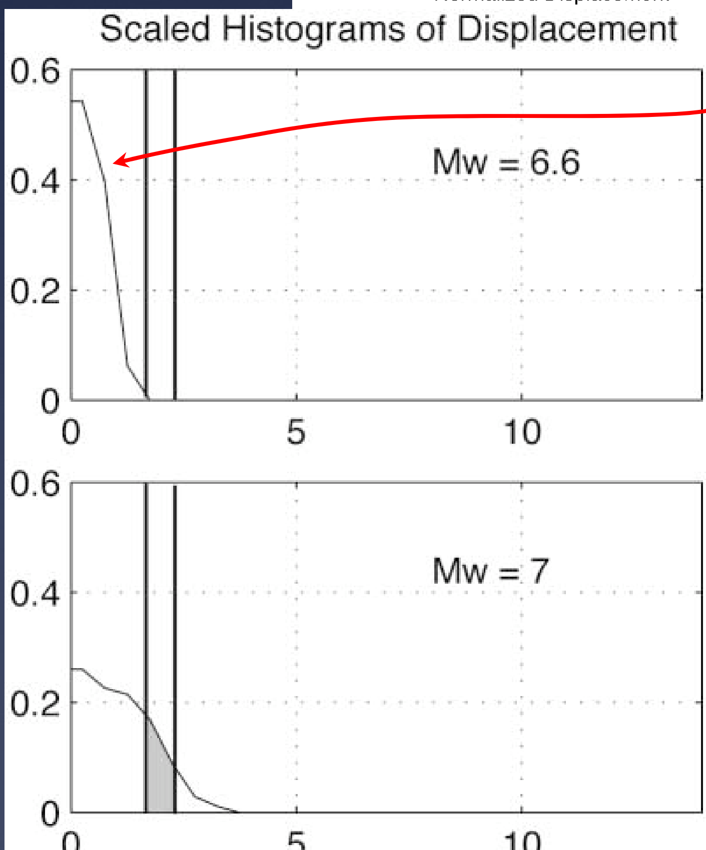
- The variability of rupture displacement can be represented by an empirical probability density function.
  - Make a histogram of d_{obs}/d_{ave} using all events -> p(d)

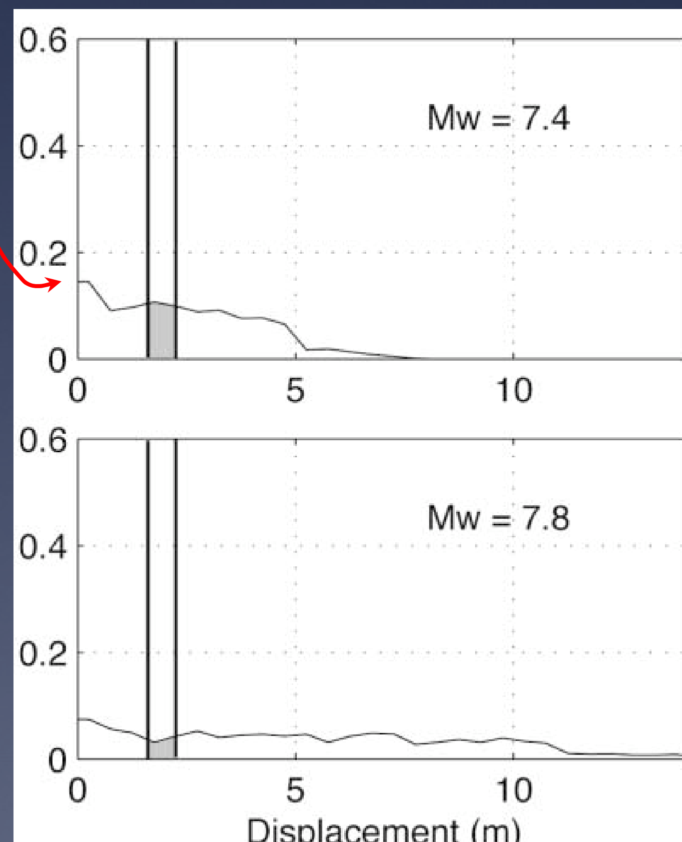


Probability of the d_{obs} as a Function of Magnitude

- Scale 

using your favorite M-> d_{ave} relationship –> $p(d_{obs} \mid M)$





Example: d_{obs}=2 m

Probability of Magnitude Given a Displacement Observation

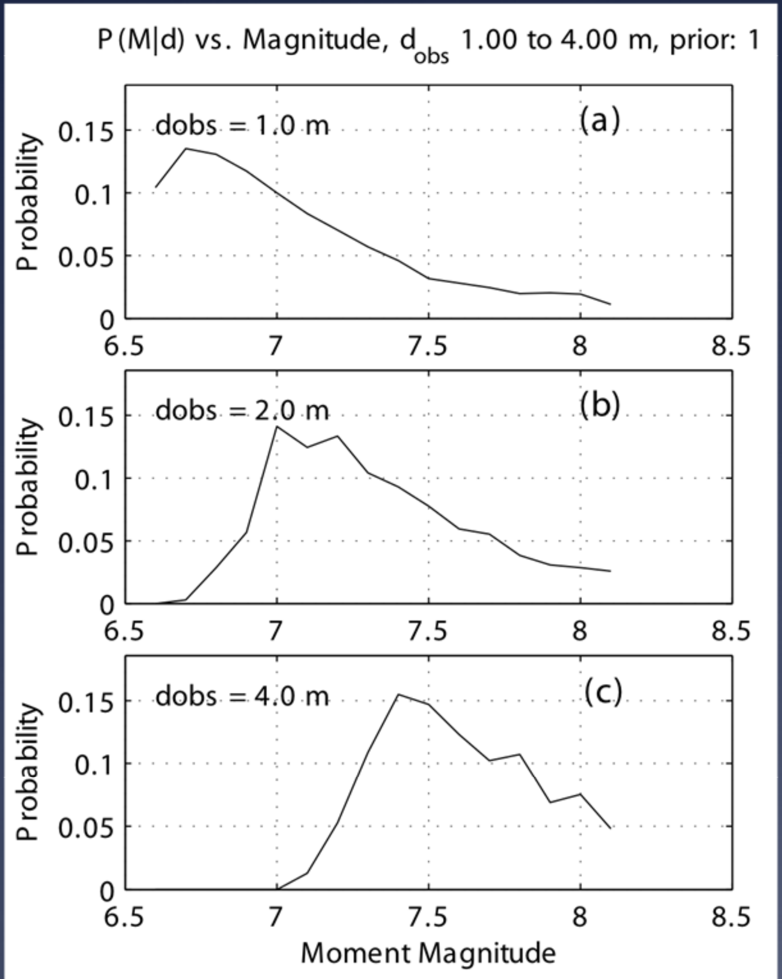


Figure 4

- Gather probabilities for all magnitudes considered and renormalize.

-Result is $p(M \mid d_{obs})$, the probability of an earthquake magnitude given one observation of displacement, d_{obs}.

-One can do better if more information is available. E.g. a prior distribution of earthquake magnitudes, an M_{max}, or a probability of ground rupture vs. magnitude.

Concluding Remarks

- The robustness of the average rupture shape suggests some constancy in mechanical behavior among faults.
  - sqrt(sin(x/2L)) works pretty well as an average rupture shape
- Normalizing by length and average displacement flattens differences in stress drop
  - M_o=mu*L*W*d_{ave}
  - If the stress drop of the next earthquake is known, it can be used to improve estimates.
- Under moderate assumptions rupture displacement variability from all documented ruptures can be encapsulated and used. E.g.,
  - $p(d_{obs} | M)$ and $p(M | d_{obs})$