

Comparison of recorded and simulated strong ground motions

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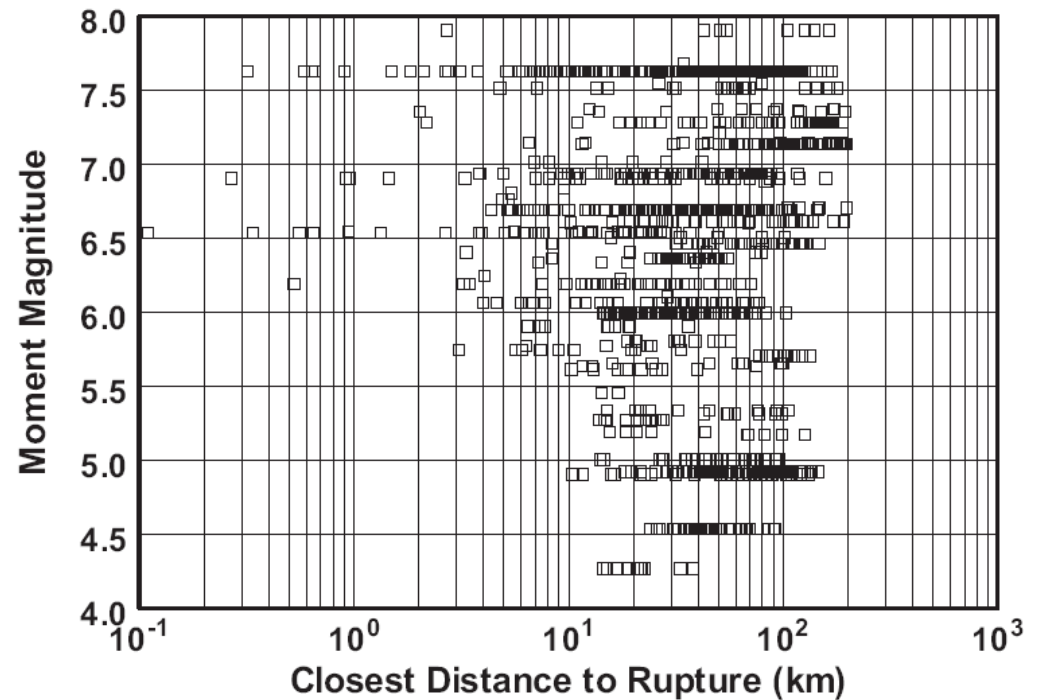


Outline

- Motivation for use of simulated motions
- Shakeout simulations
- Hybrid simulation procedure
- Data analysis
 - Event terms
 - Distance attenuation
 - Standard deviation
- Recommendations

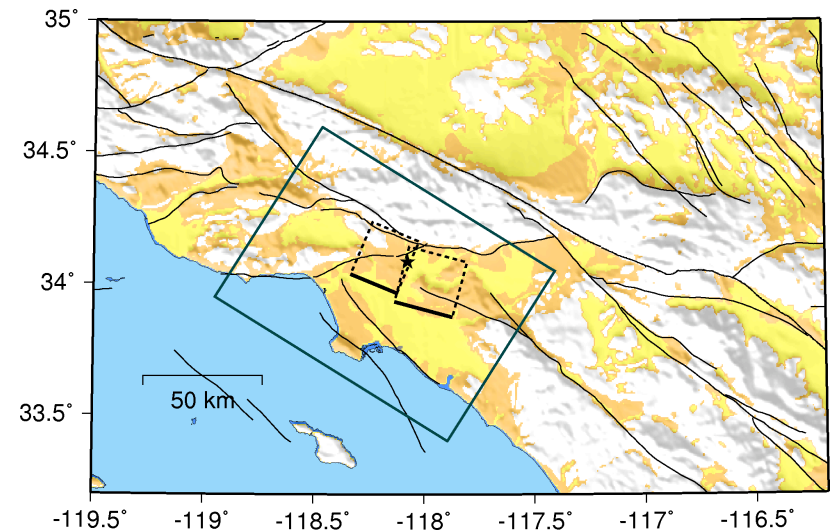
Motivation

- Broadband motions for response history analysis
- Some (M, R) ranges poorly sampled by recordings



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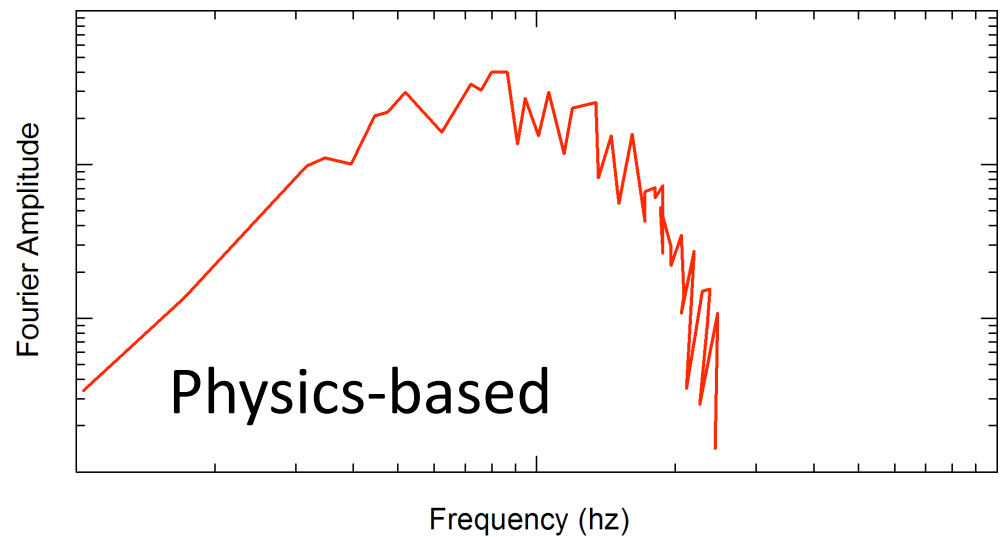
- Motions needed with

Simulations hold potential to provide useful ground motions for engineering application in these situations

- Near fault effects

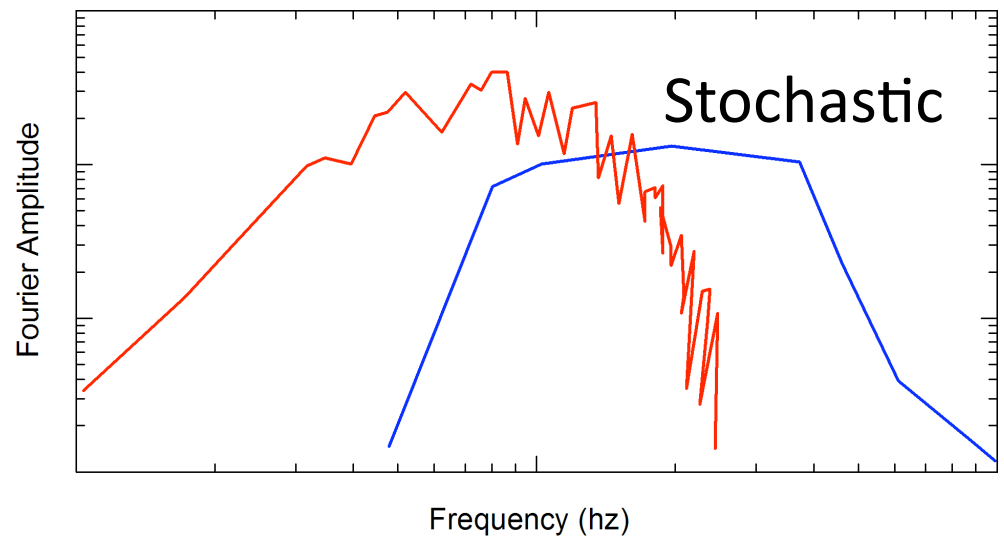
Simulation Procedure

- Hybrid procedure
 - $f < 1$ Hz: physics based
 - $f > 1$ Hz: stochastic



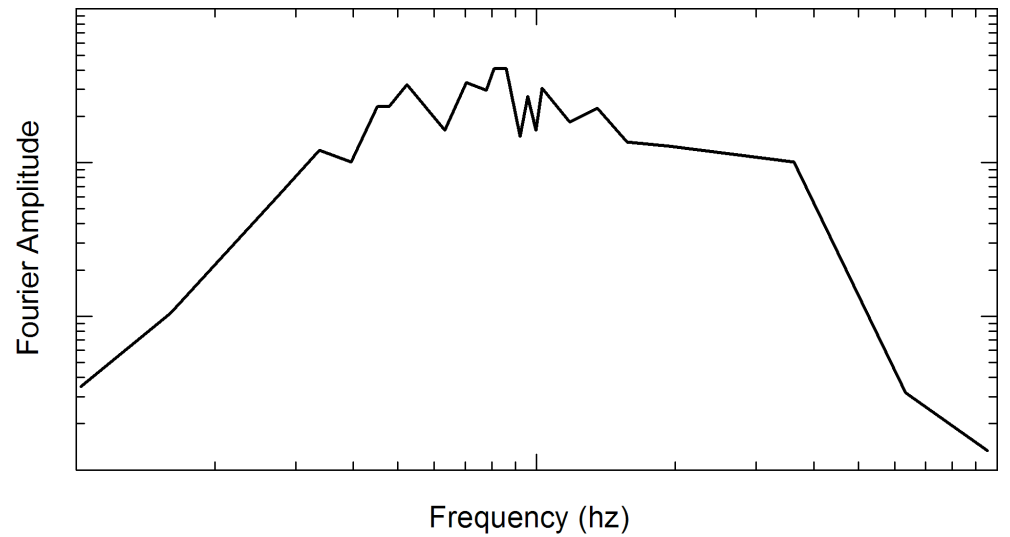
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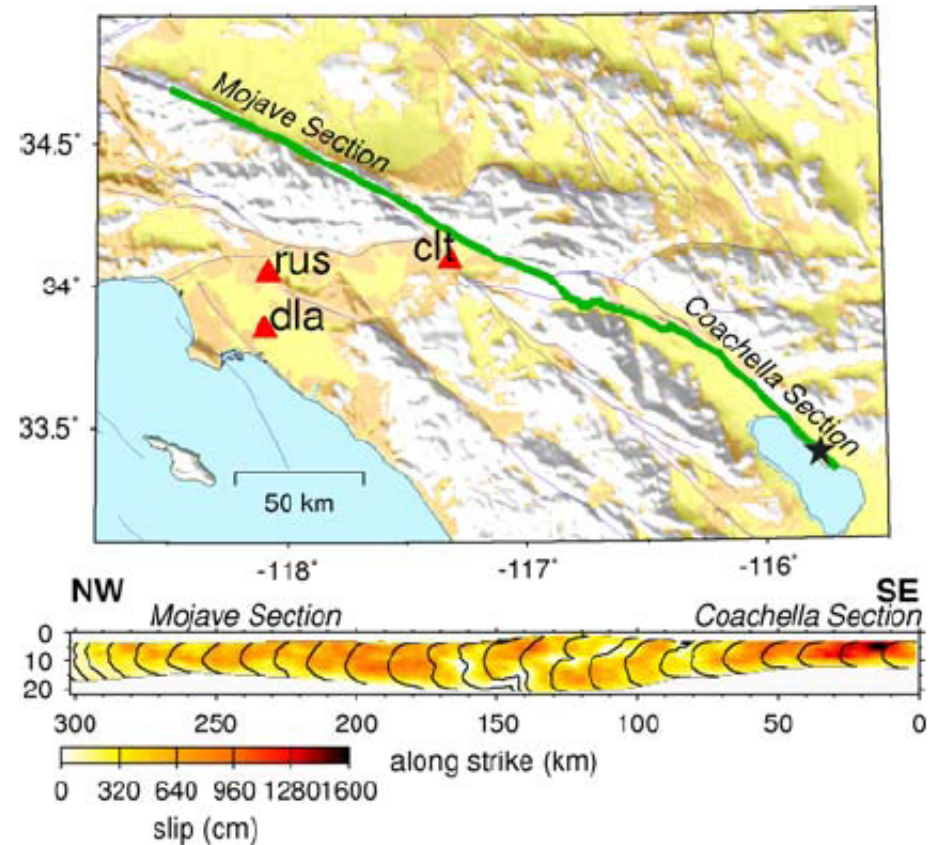
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Simulation Procedure

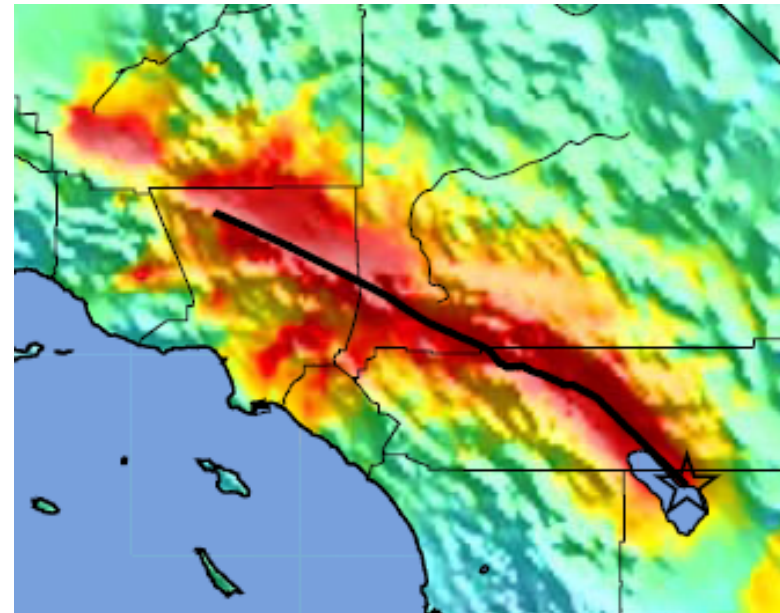
- Hybrid procedure
- Source function
 - Slip distribution
 - Rupture velocity



Shakeout, M_w 7.8

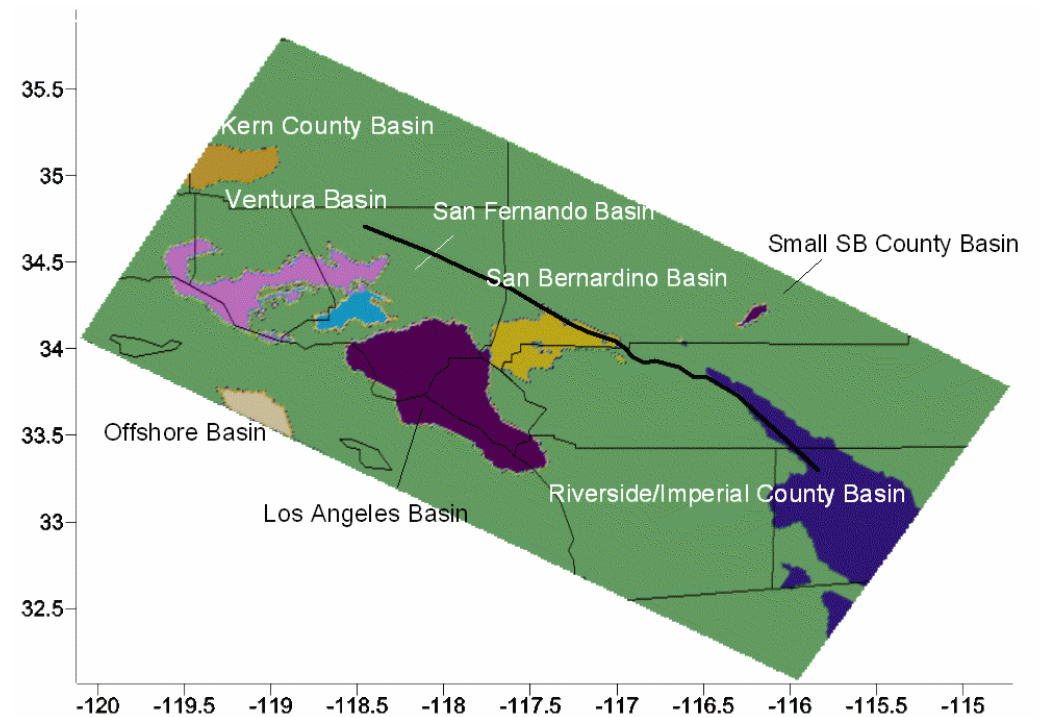
Shake-Out

- Shake-Out event
 - M_w 7.8, southern San Andreas
 - 150 yr return period (last events 1857 & 1680)



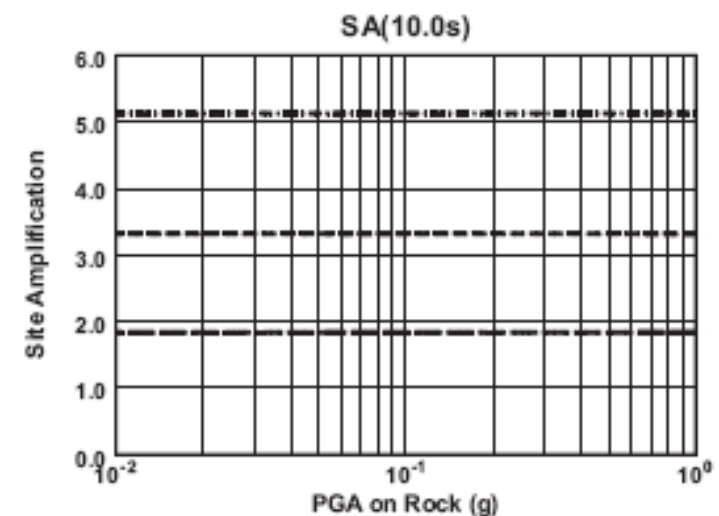
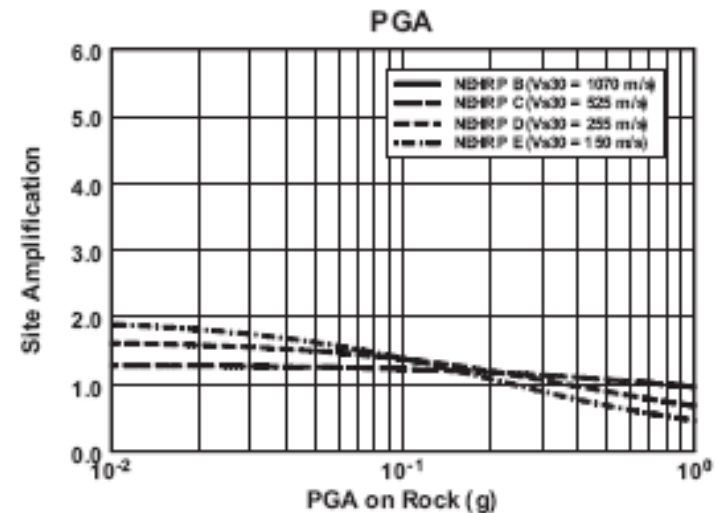
Shake Out Simulations

- Hybrid procedure
- Source function
- Finite difference calculation
 - SCEC 3D velocity model

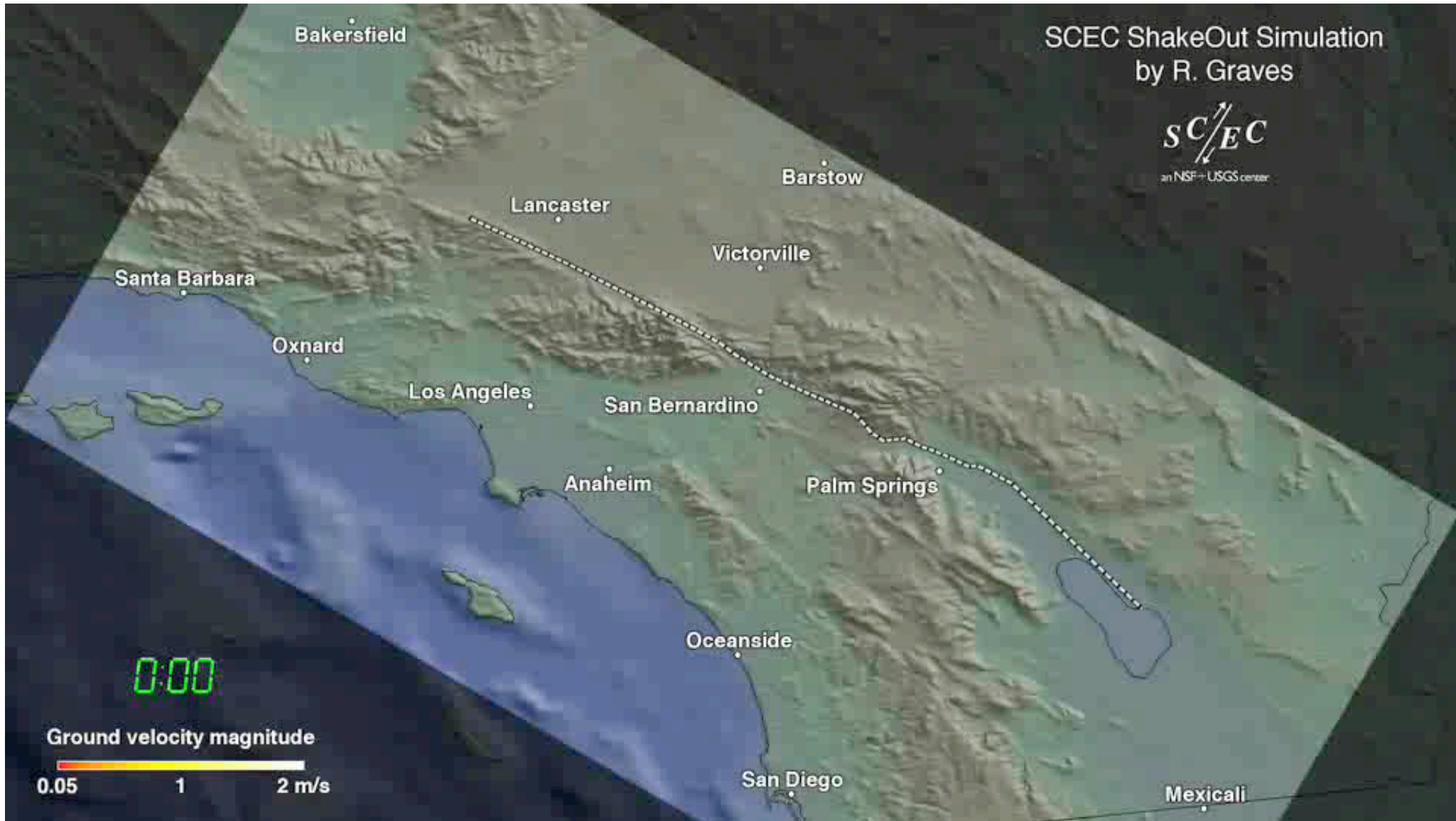


Shake Out Simulations

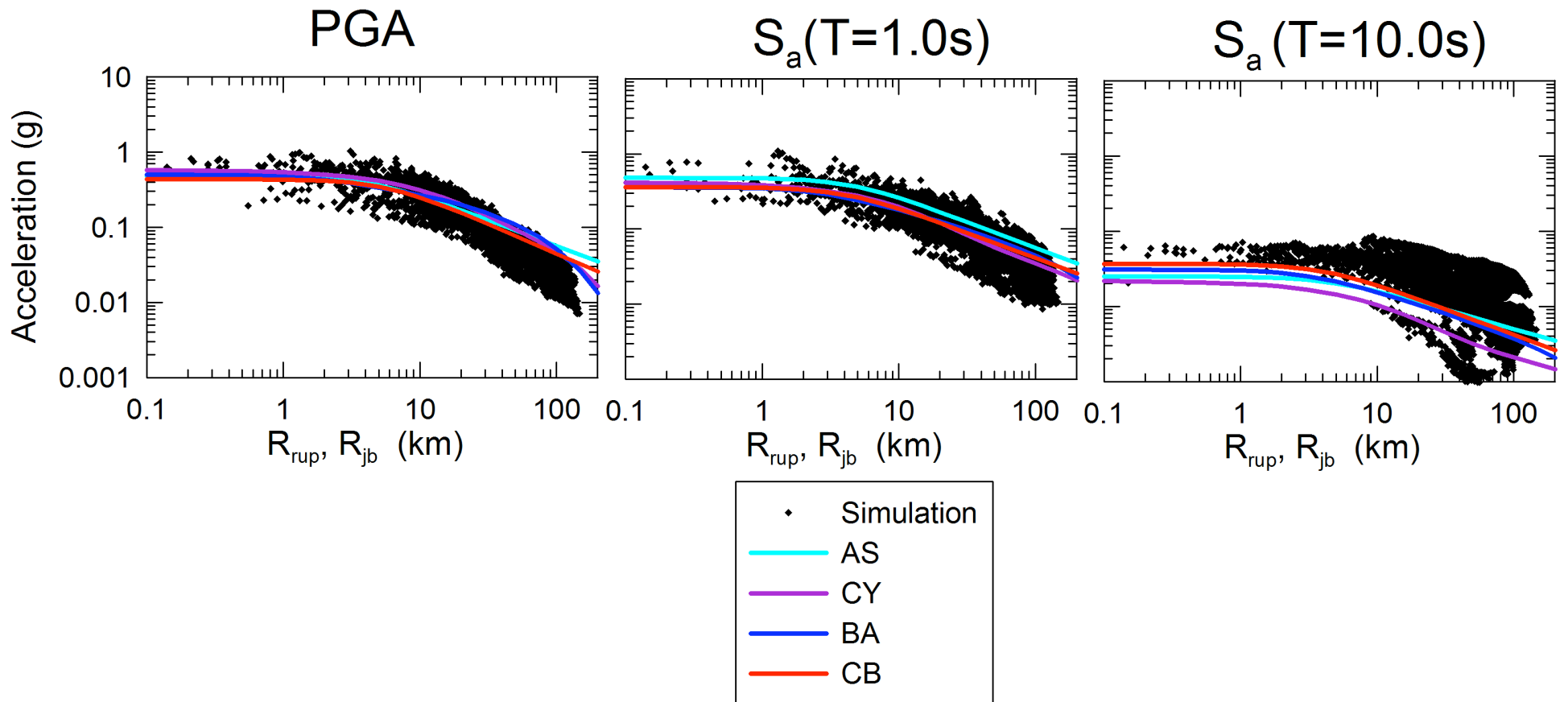
- Hybrid procedure
- Source function
- Finite difference calculation
- Semi-empirical site term (fn of V_{s30})



Shake Out Simulations



Data Analysis



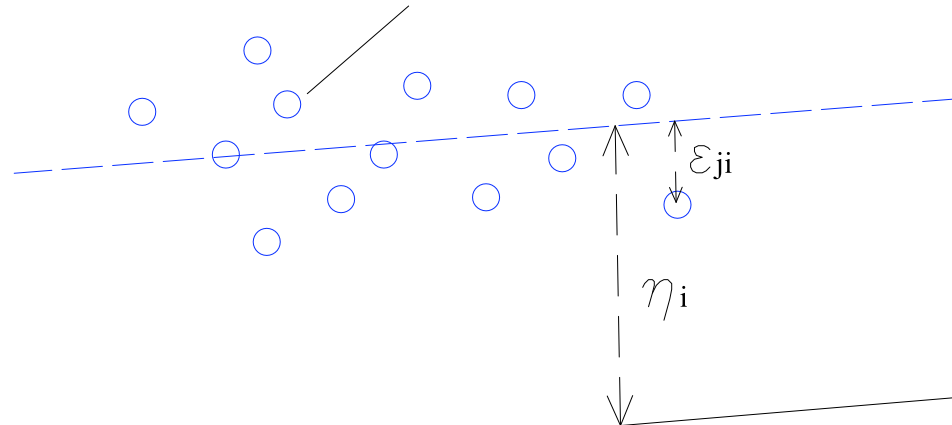
Data Analysis

Approach:

- Calculate residuals $R_i(T) = \ln(S_a(T))_{sim,i} - \ln(S_a(T))_{GMPE,i}$
- 4 NGA GMPEs: AS, BA, CB, CY
- Random effect analysis: Separate event term (η_i) from within-event residual ($\varepsilon_{i,j}$)

$$R_{i,j} = \eta_i + \varepsilon_{i,j}$$

recording "j" of eqk "i"



General Model

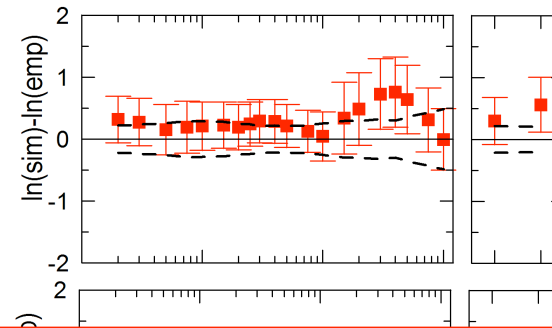
Data Analysis

Approach:

- Calculate residuals
- 4 NGA GMPEs: AS, BA, CB, CY
- Random effect analysis: Separate event term (η_i) from within-event residual ($\varepsilon_{i,j}$)
- Gross assessment of source from η_i
- Distance-scaling evaluated from $\varepsilon_{i,j}$

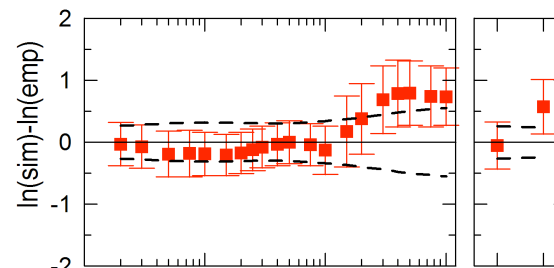
Results: Event Terms

Campbell and Bozorgnia (2008)

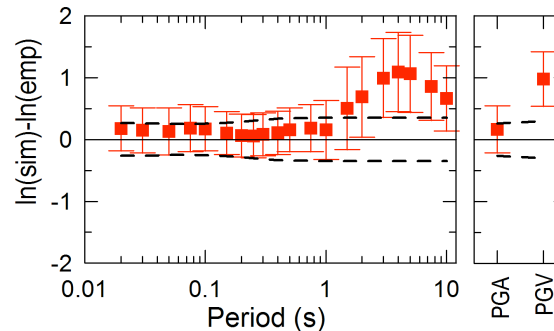


Result: Simulated motions consistent with GMPEs for $T < 1$ s, exceed GMPEs for $T > 1$ s

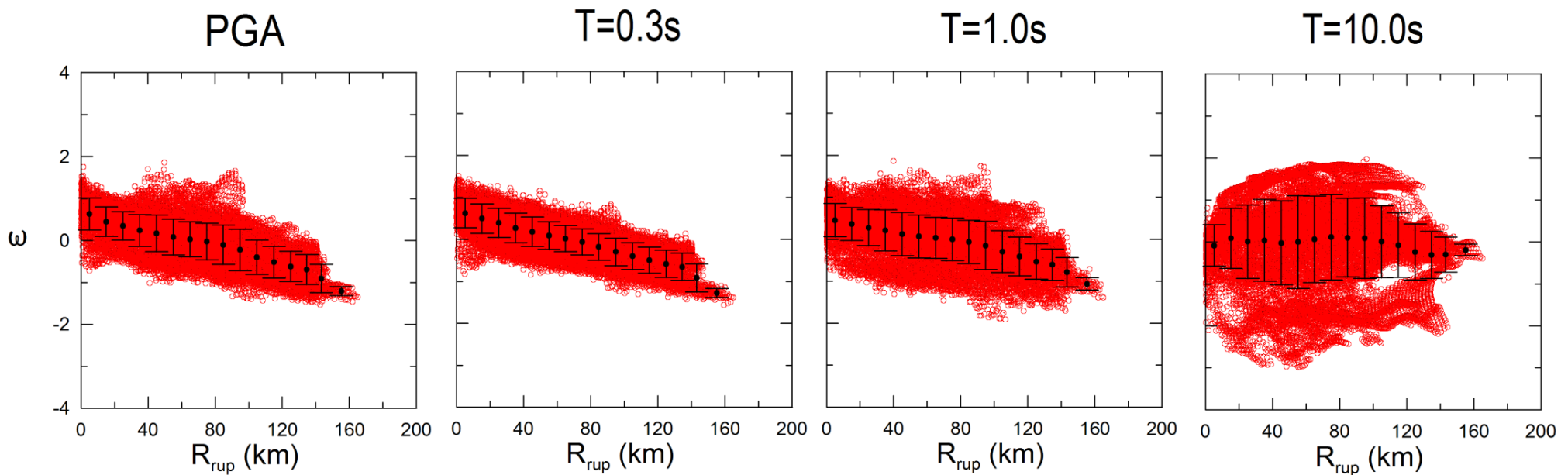
Chiou and Youngs (2008)



Abrahamson and Silva (2008)



Results: Distance-Scaling



Result: Faster attenuation except at long periods.

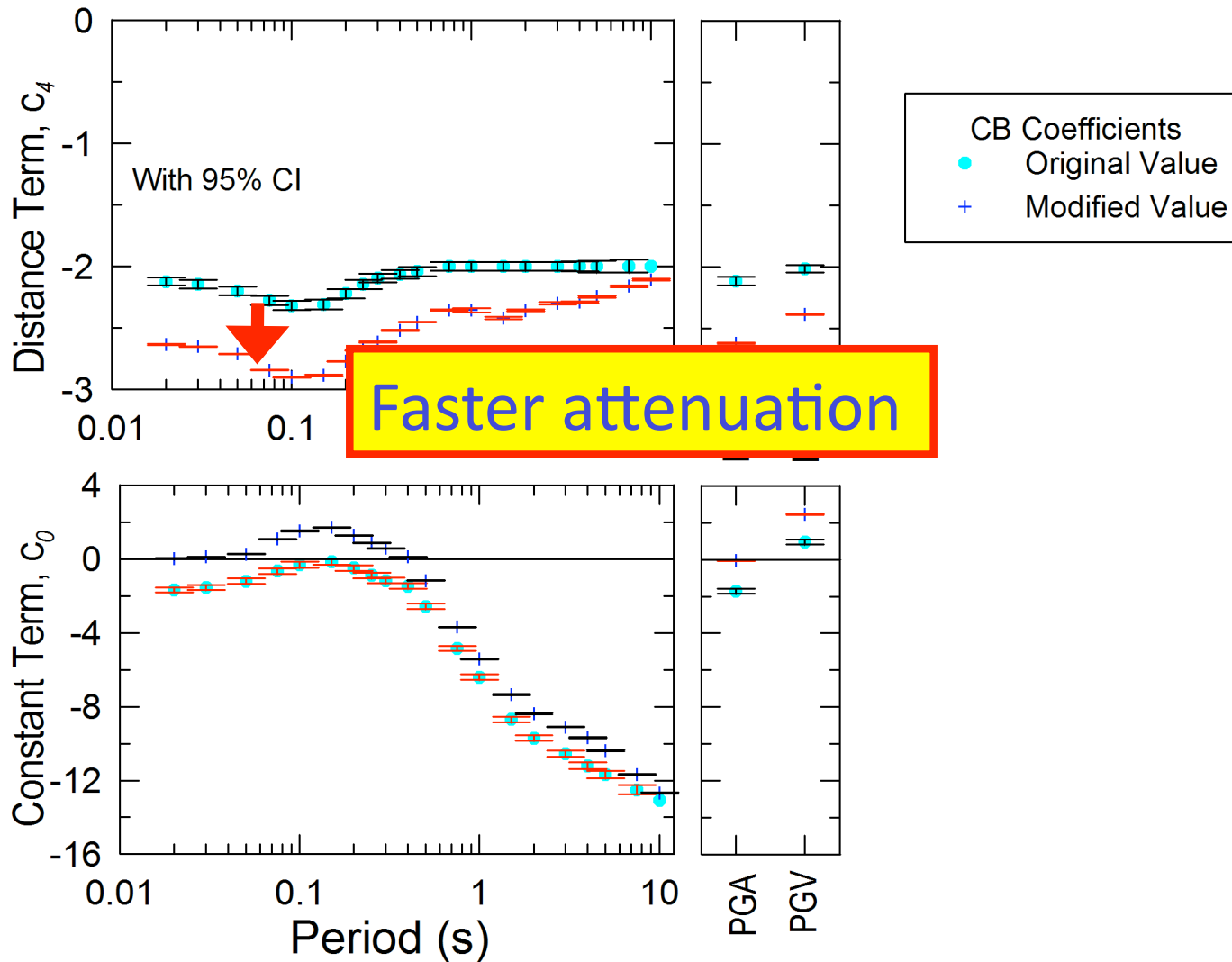
Removing R-Scaling Bias

Procedure:

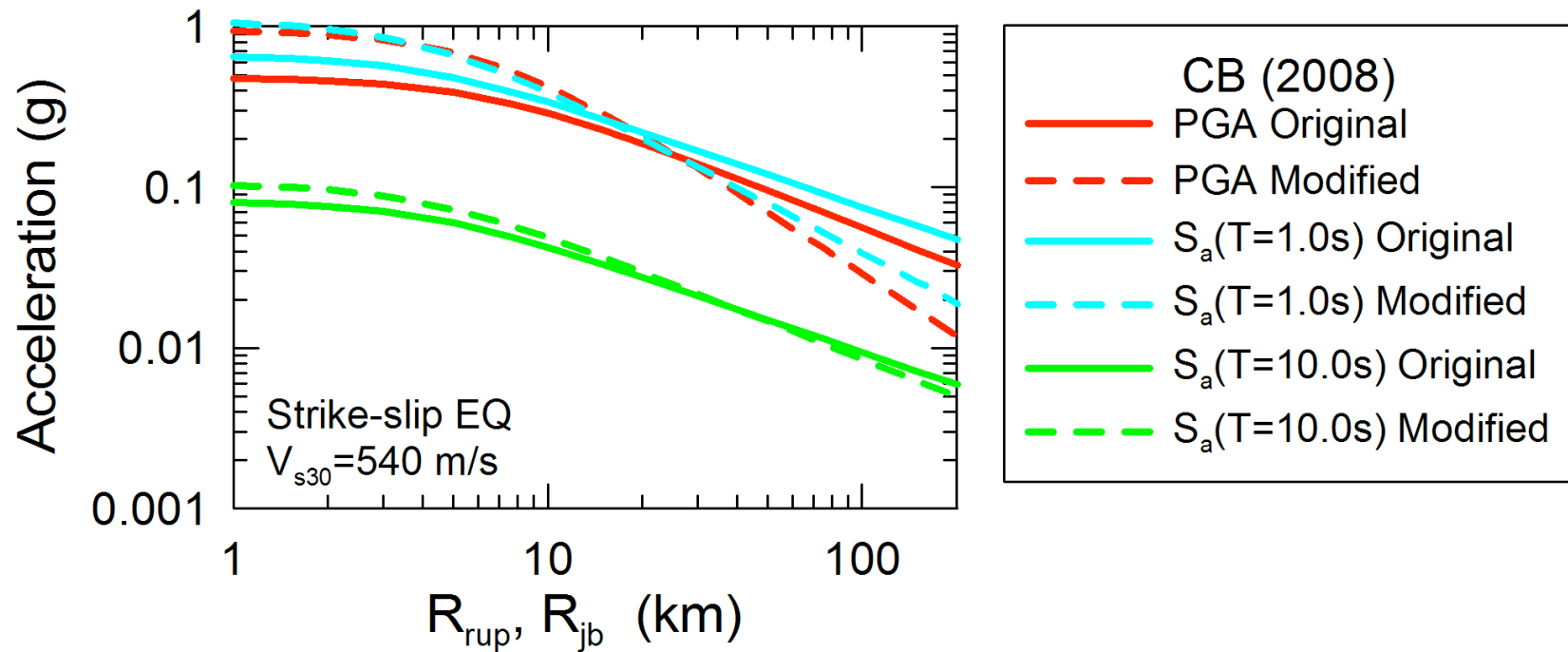
- Regress distance-scaling parameters in NGA equations
- Retain original functional form.

$$F_{DIST} = [c_4 + c_5M] \times \ln\left(\sqrt{r_i^2 + h^2}\right)$$

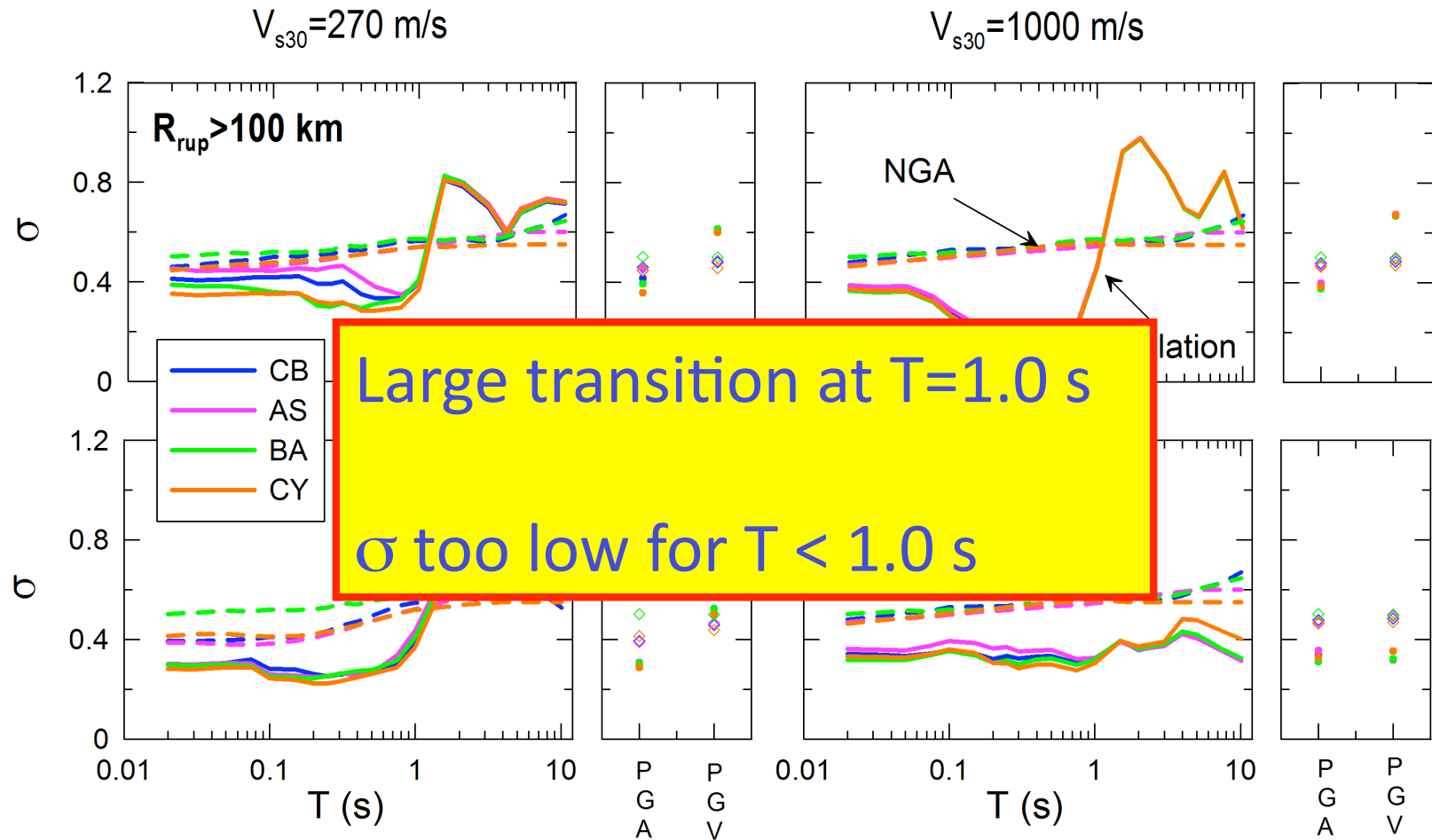
Modified Coefficients



Modified GMPEs



Standard Deviation



$$\sigma = \text{stdev}(\varepsilon)$$

Concluding Remarks

- Calibrated simulation procedures needed for engineering practice
- Hybrid simulations promising due to broadband characteristics
- Issues for engineering application
 - Distance attenuation too fast
 - Incorrect σ
 - Others
- Current work directed towards correcting the distance attenuation and σ problems