Calibration of Hybrid Simulation Methodology

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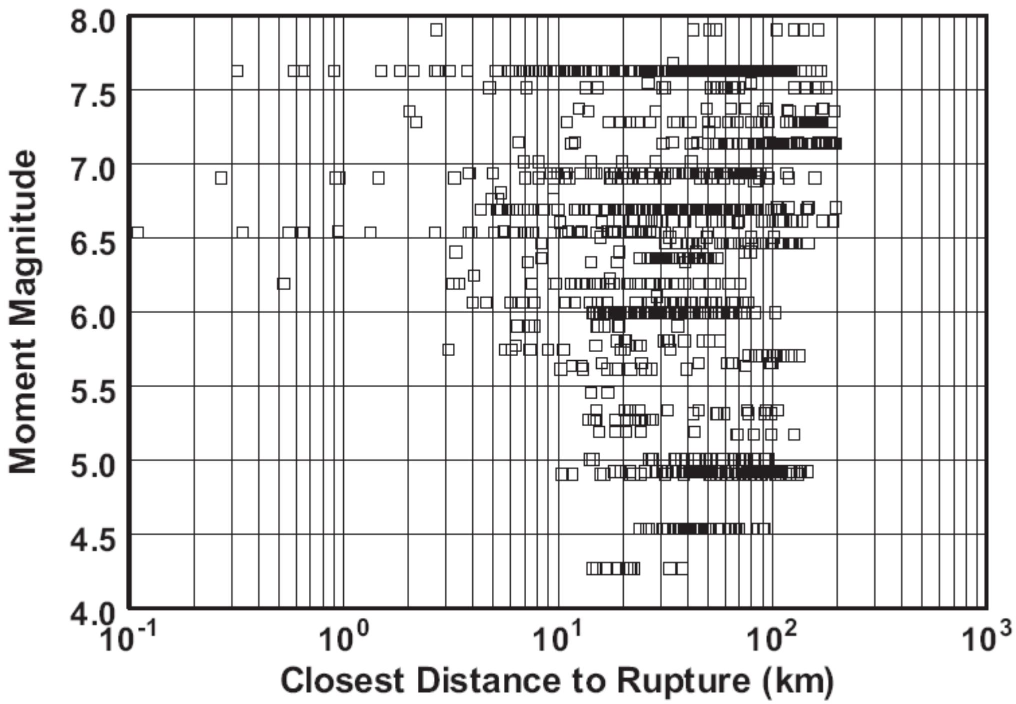
Outline

- Hybrid simulation procedure
- Problems with existing procedure
  - Distance attenuation
  - Standard deviation
- Planned scope
  - Distance attenuation calibration
  - Intra-event scatter calibration
  - Verification

Motivation

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



Motivation

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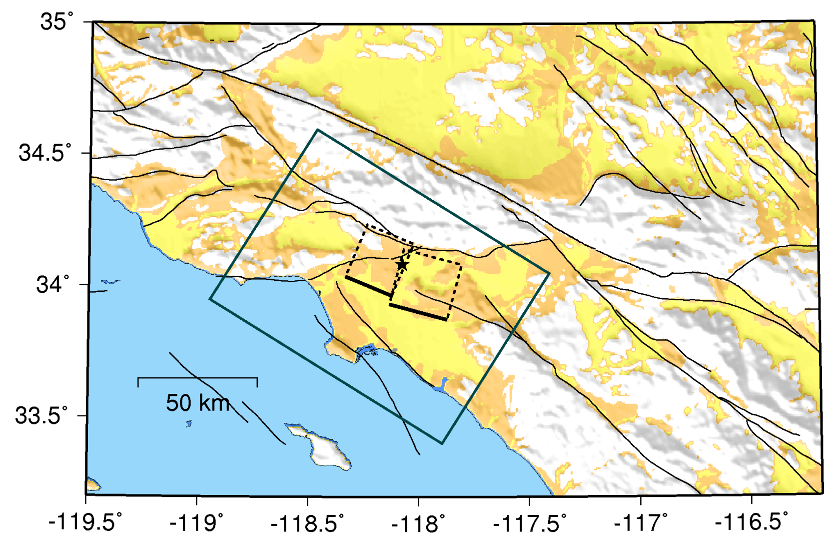


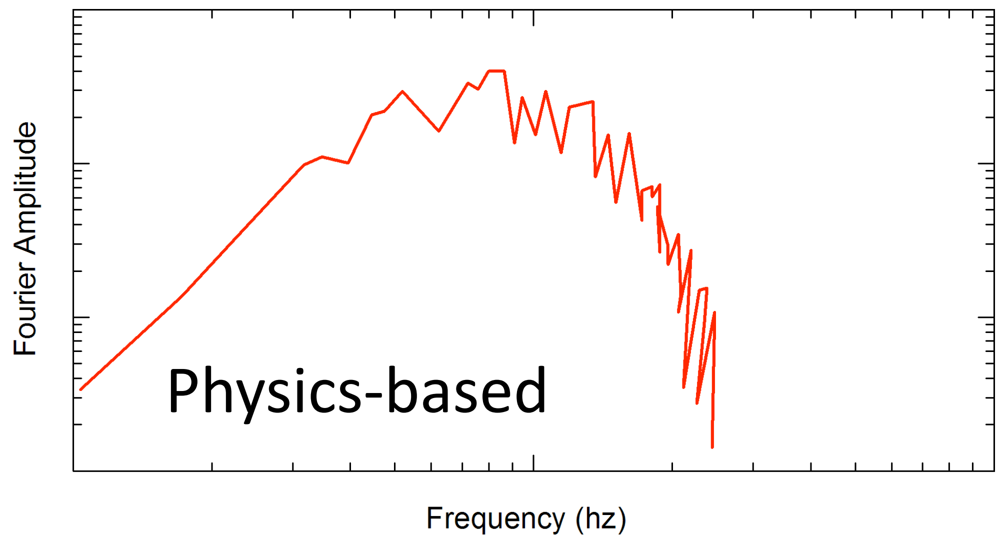
- Motions needed with

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

  – Near fault effects

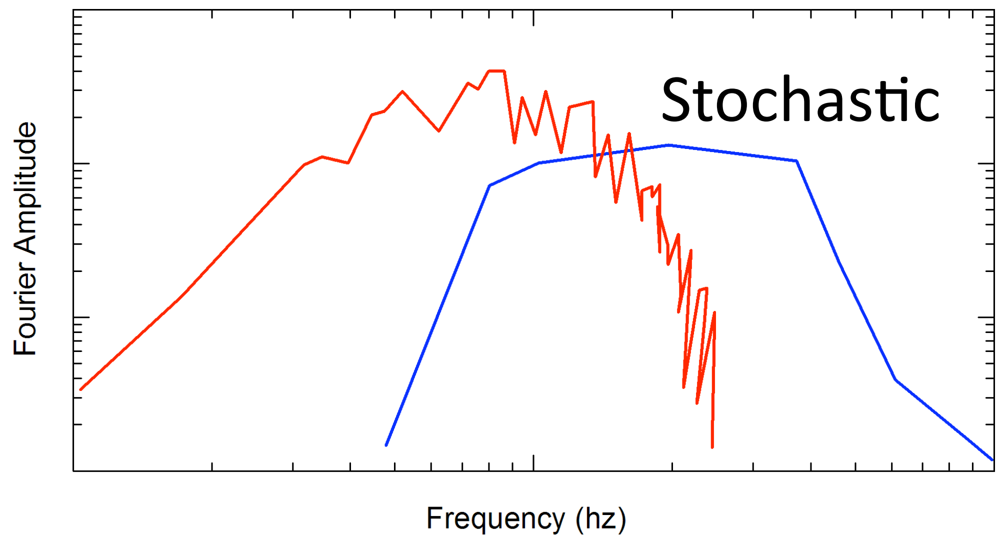
Simulation Procedure

- Hybrid procedure
  - f<1 Hz: physics based



Simulation Procedure

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



Simulation Procedure

- Hybrid procedure
  - f<1 Hz: physics based
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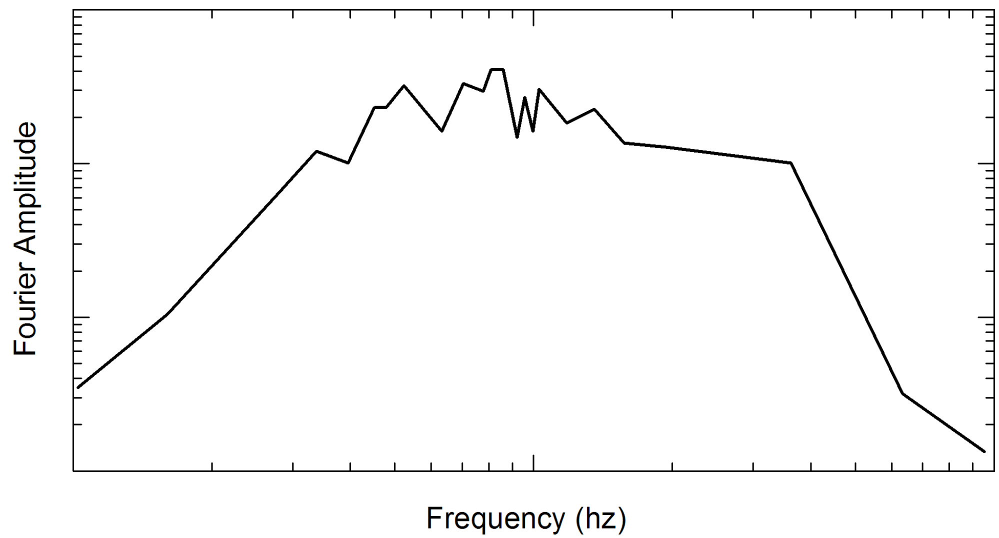
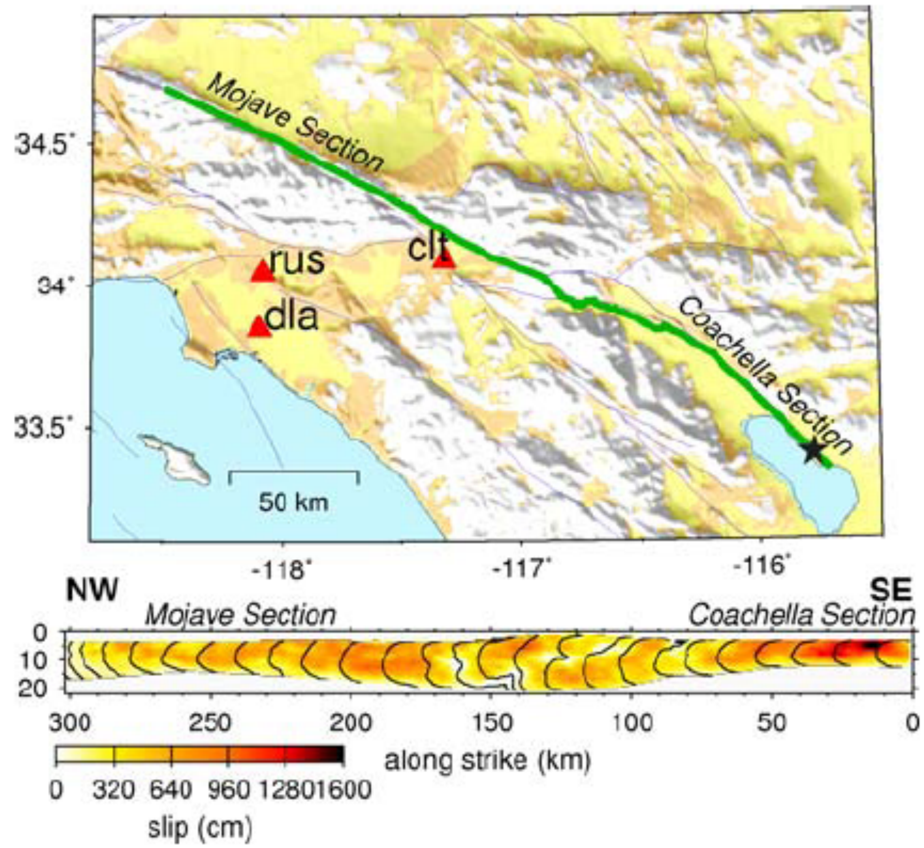


Simulation Procedure

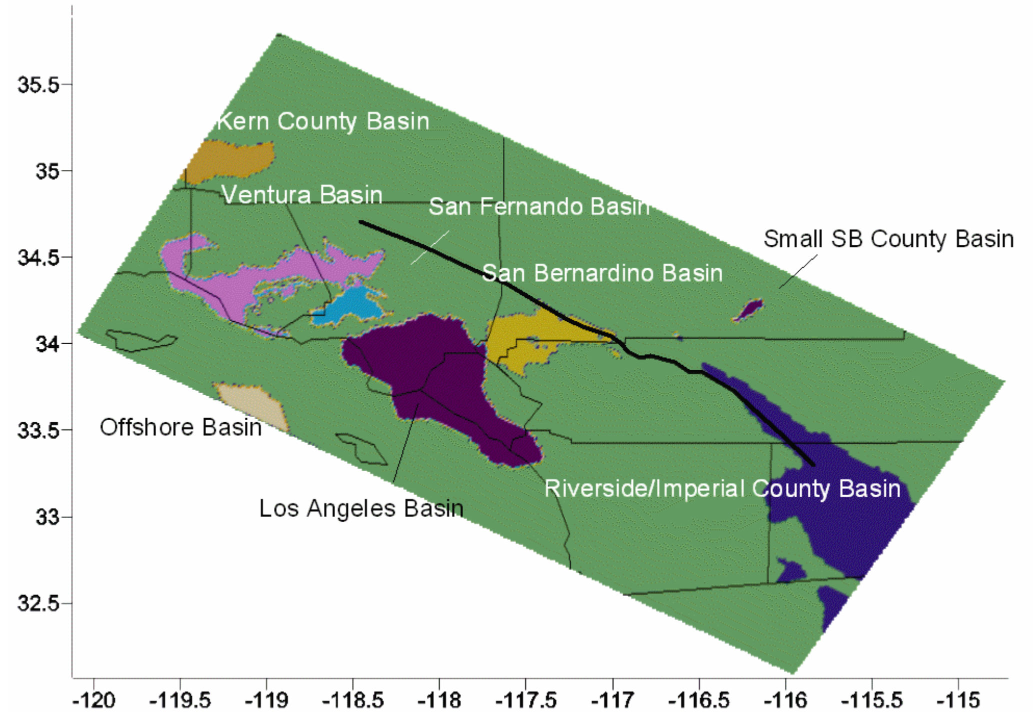
- Hybrid procedure
- Source function
  - Slip distribution
  - Rupture velocity



Shakeout, M_w 7.8

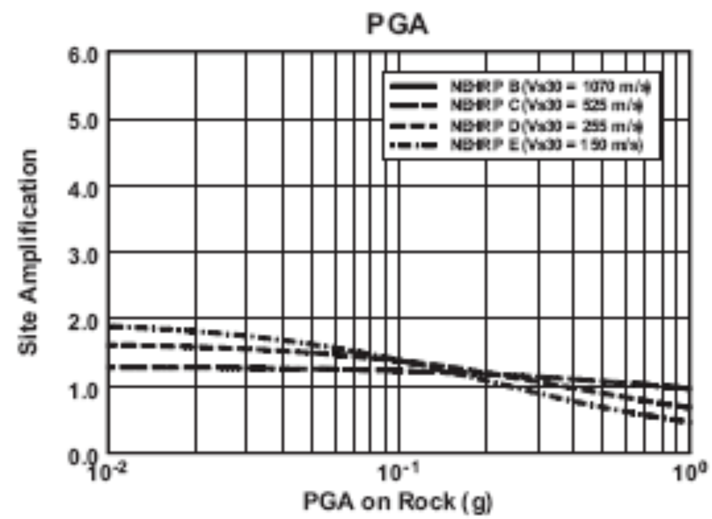
Shake Out Simulations

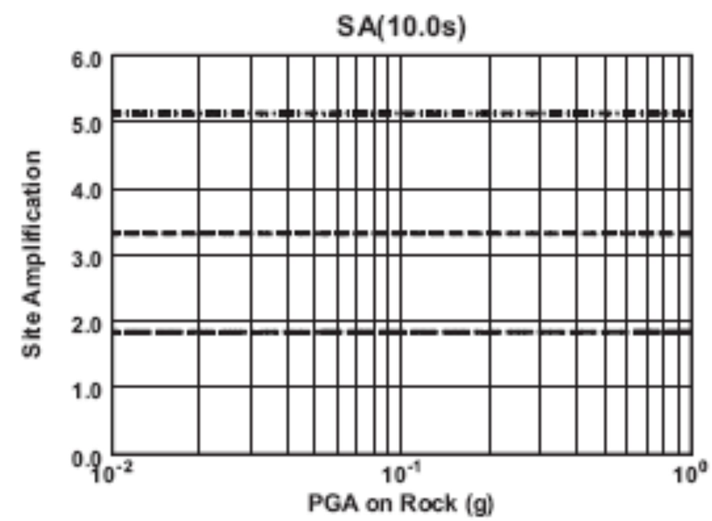
- Hybrid procedure
- Source function
- Finite difference calculation
  - SCEC 3D velocity model



Shake Out Simulations

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



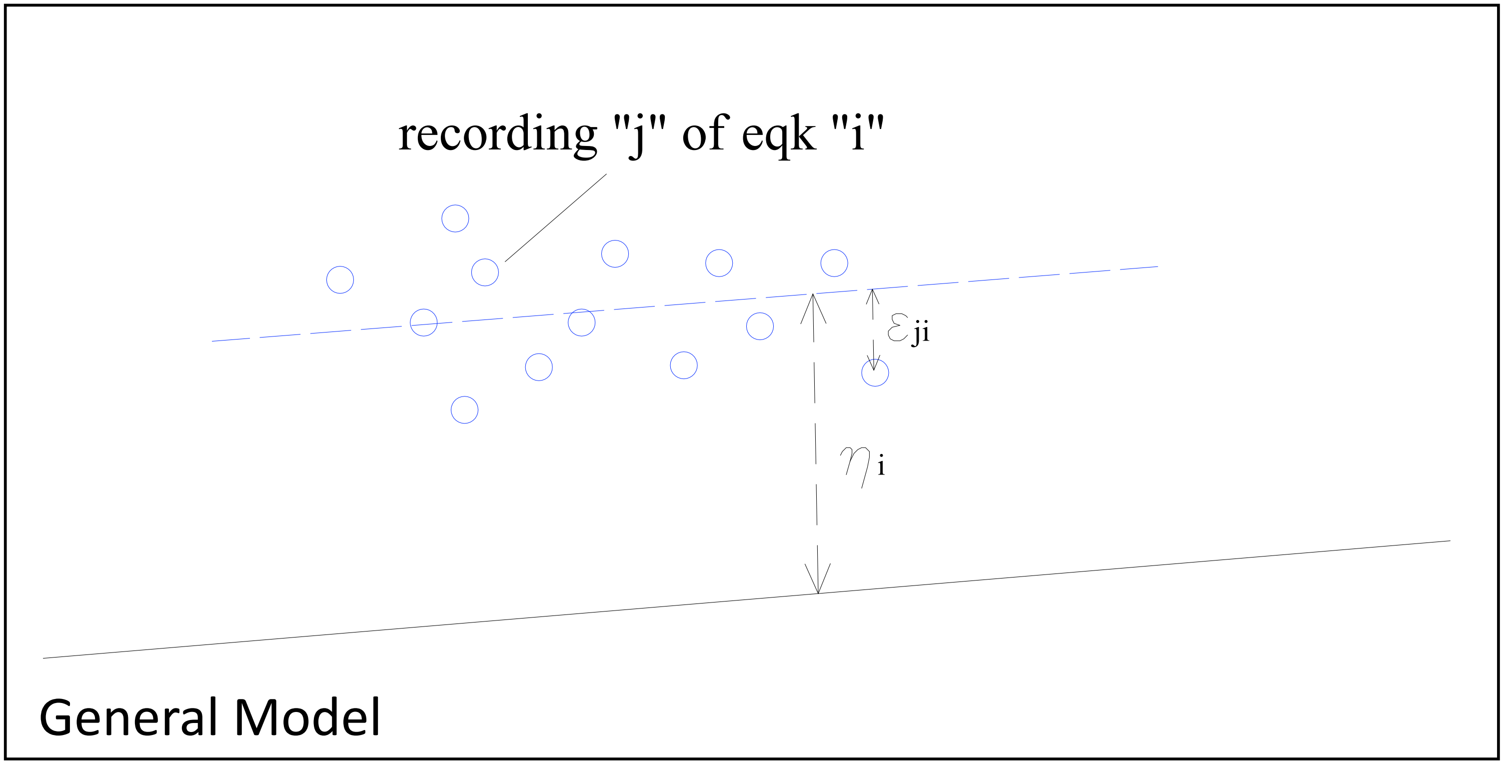


Data Analysis

Approach:

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

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



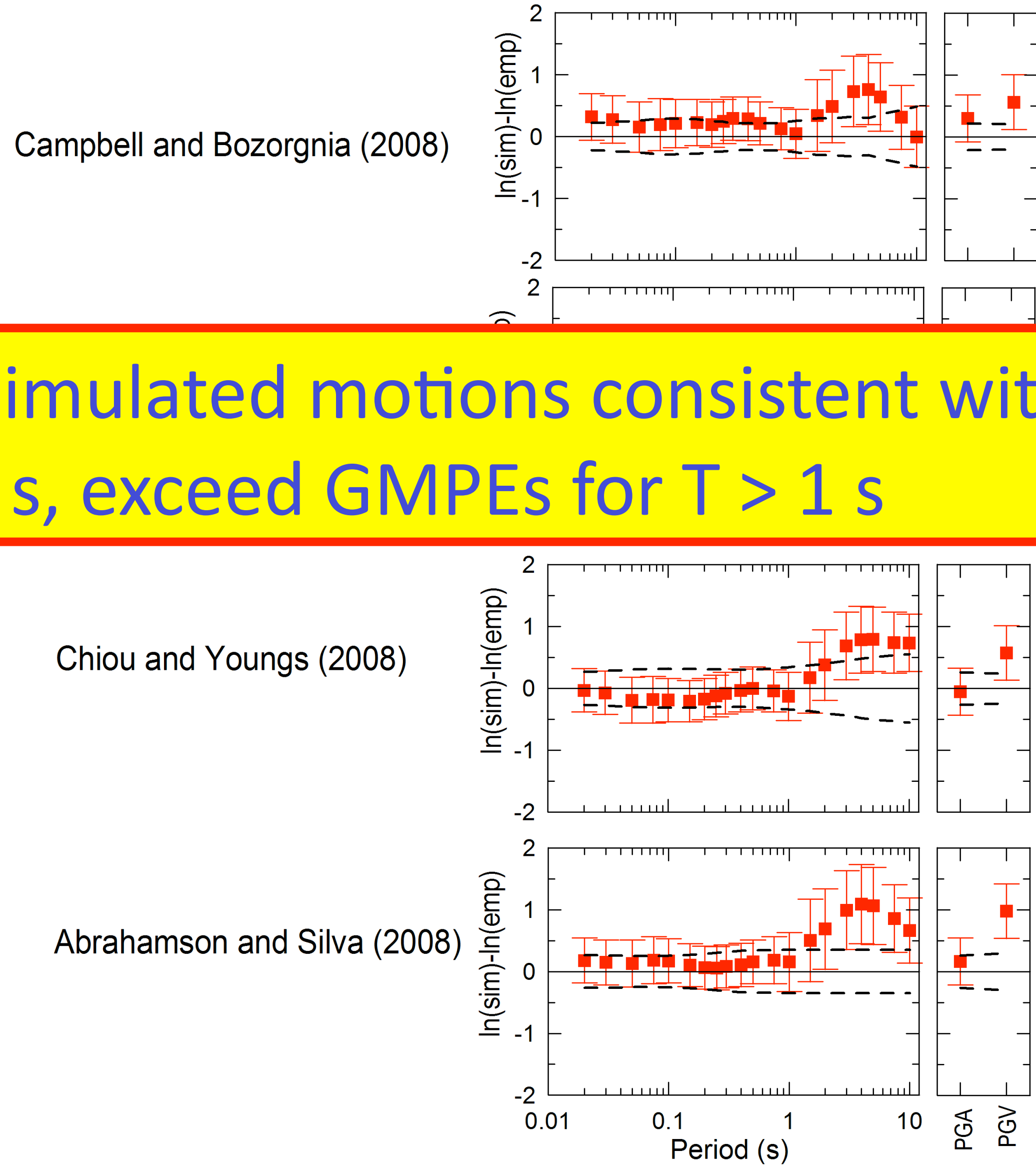
Use ε_{ij} to evaluate σ, distance attenuation, directivity, and site effects

Data Analysis

Approach:

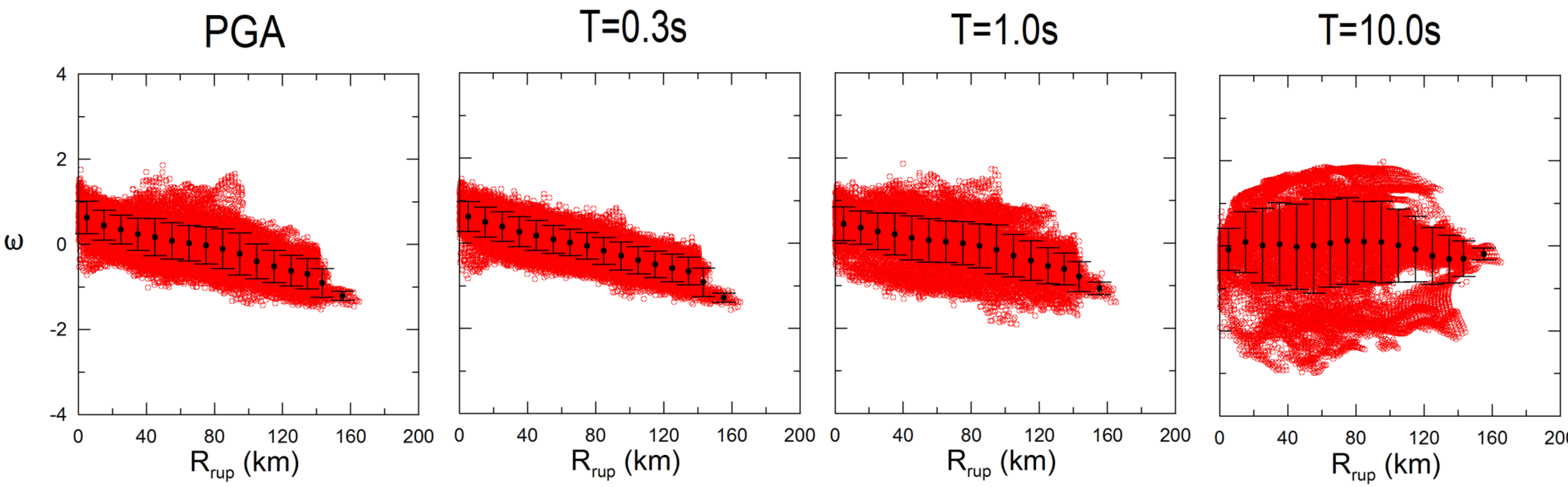
- Calculate residuals
- 4 NGA GMPEs: AS, BA, CB, CY
- Random effect analysis: Separate event term (η_i) from within-event residual ($\varepsilon_{i,j,}$)
- Gross assessment of source from η_i
- Distance-scaling evaluated from $\varepsilon_{i,j}$

Results: Event Terms



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

Results: Distance-Scaling



Result: Faster attenuation except at long periods.

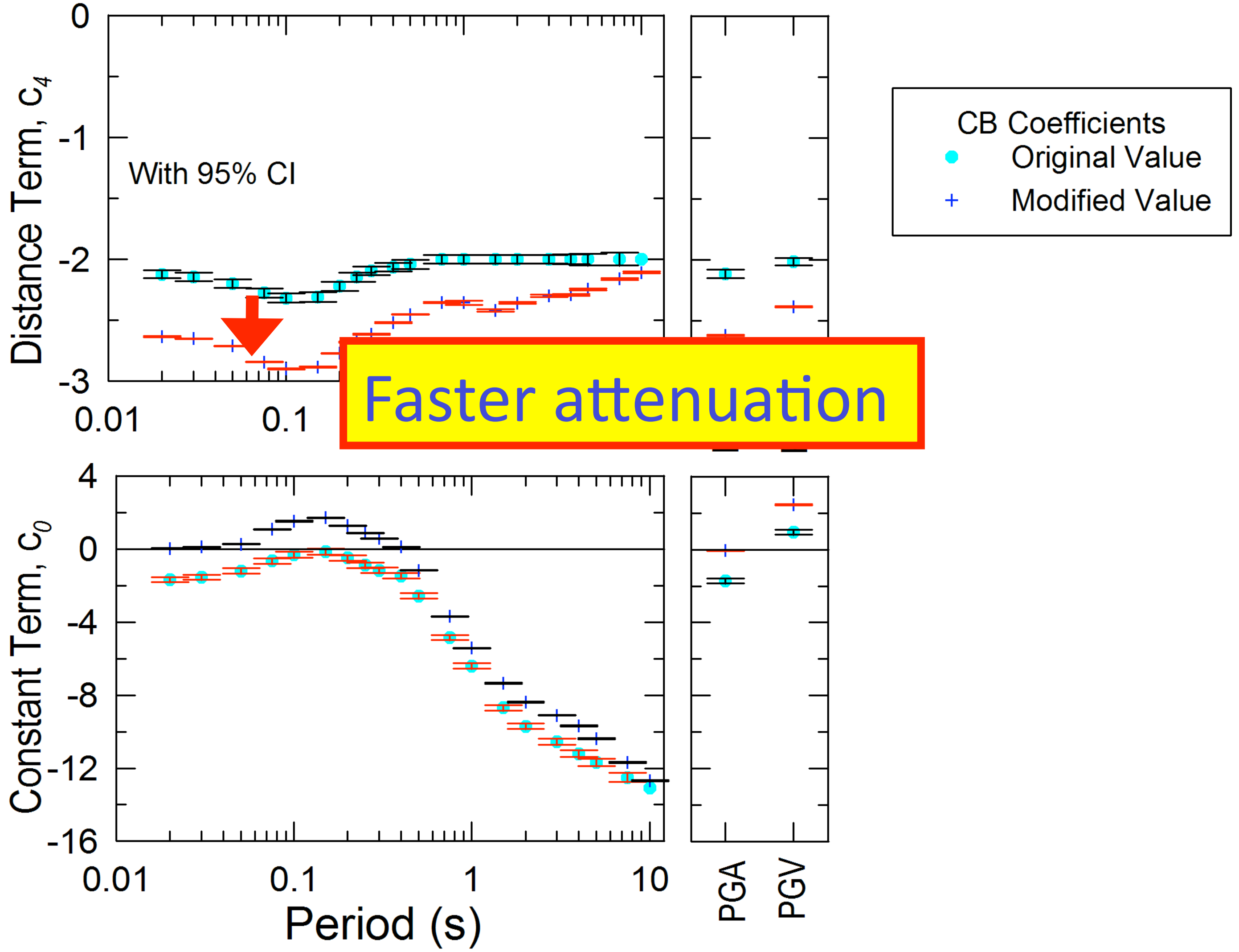
Removing R-Scaling Bias

Procedure:

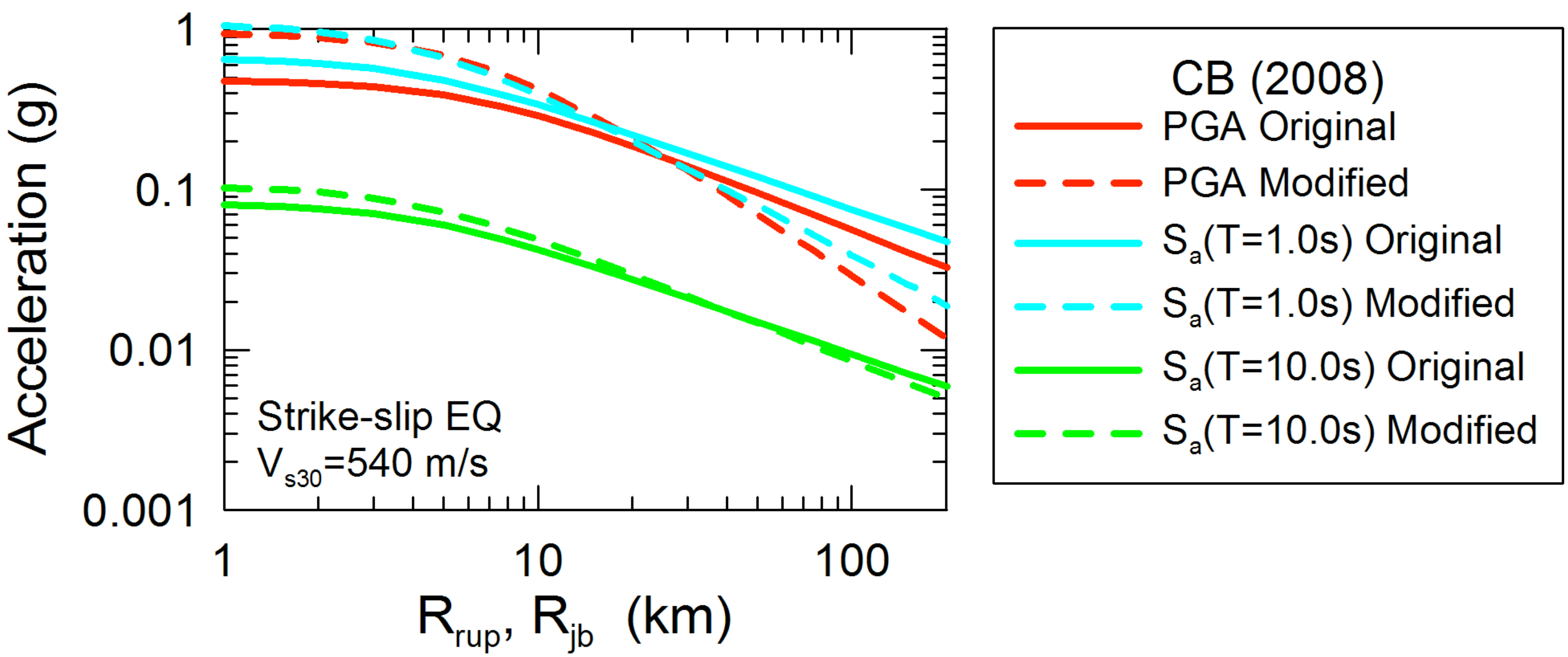
- Regress distance-scaling parameters in NGA equations
- Retain original functional form.

$$F_{DIST} = [c_4 + c_5 M] \times \ln\left(\sqrt{r_i^2 + h^2}\right)$$

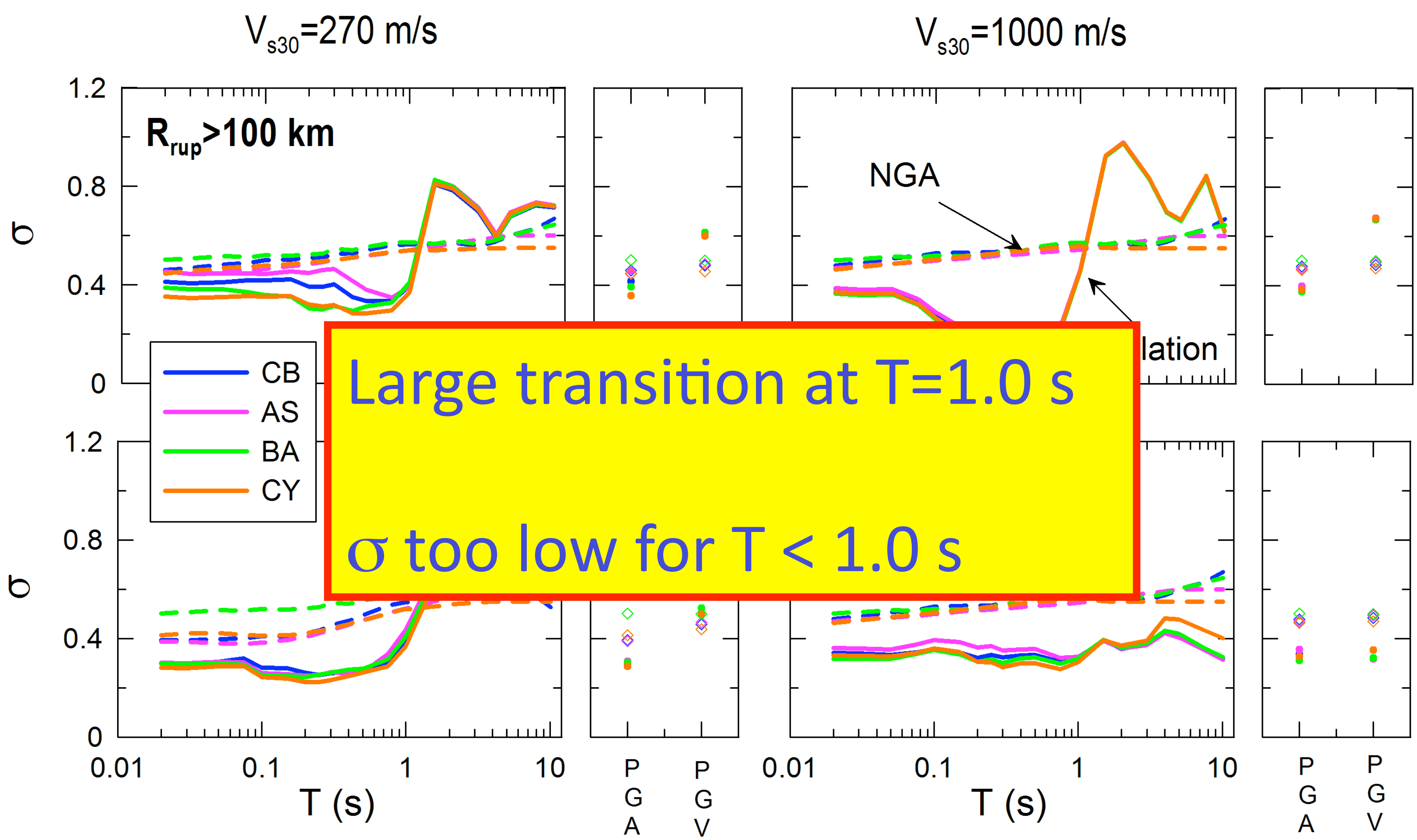
Modified Coefficients



Modified GMPEs



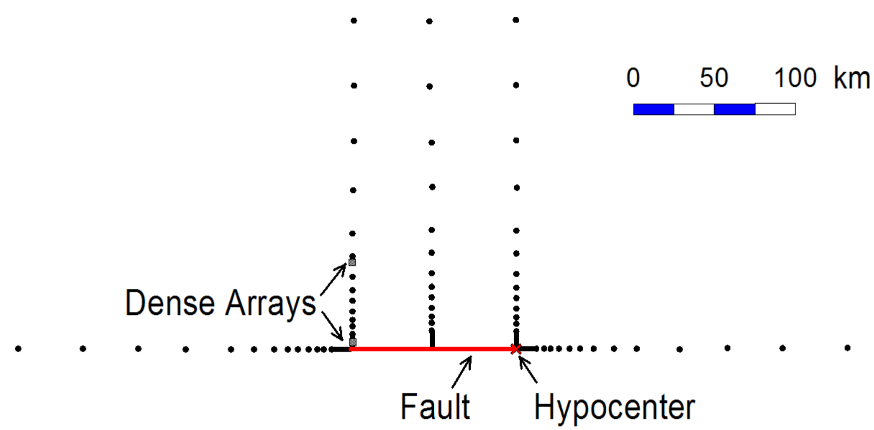
Standard Deviation



σ=stdev(ε)

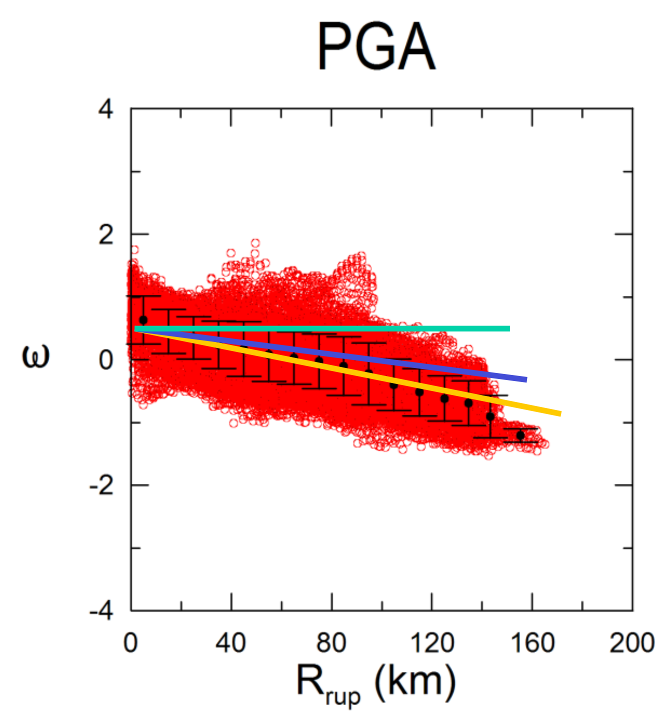
Scope

- Distance attenuation calibration
  - Strike slip fault, M 5, 6.5, 8
  - Distributed and dense arrays



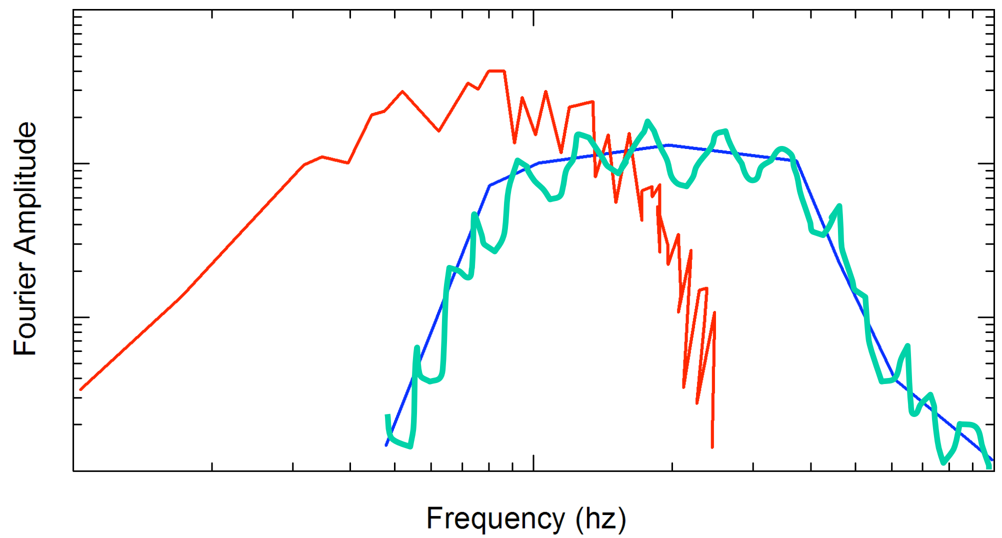
Scope

- Distance attenuation calibration
  - Strike slip fault, M 5, 6.5, 8
  - Distributed and dense arrays
  - Repeat Hybid sim. for various levels of crustal damping
  - Identify parameters that remove bias



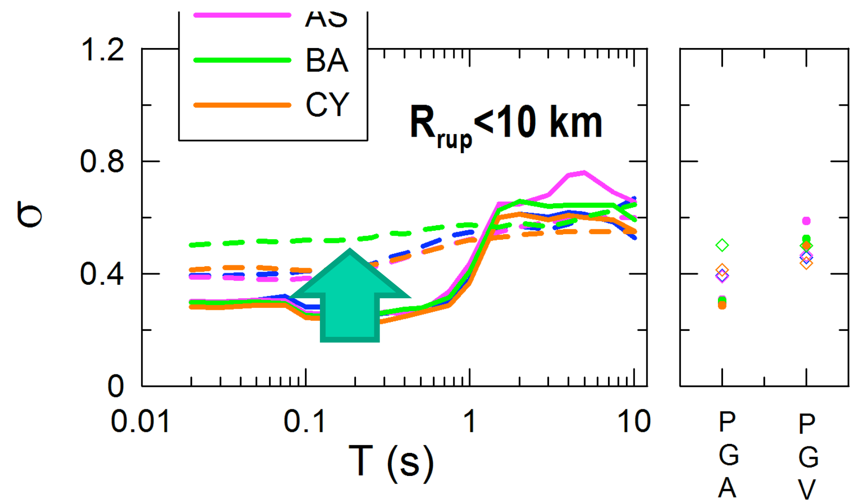
Scope

- Distance attenuation calibration
- Intra-event scatter calibration
  - Stochastic component of model
  - Fourier Amp. Randomized
  - Randomization of Q
  - Various ways of specifying phase



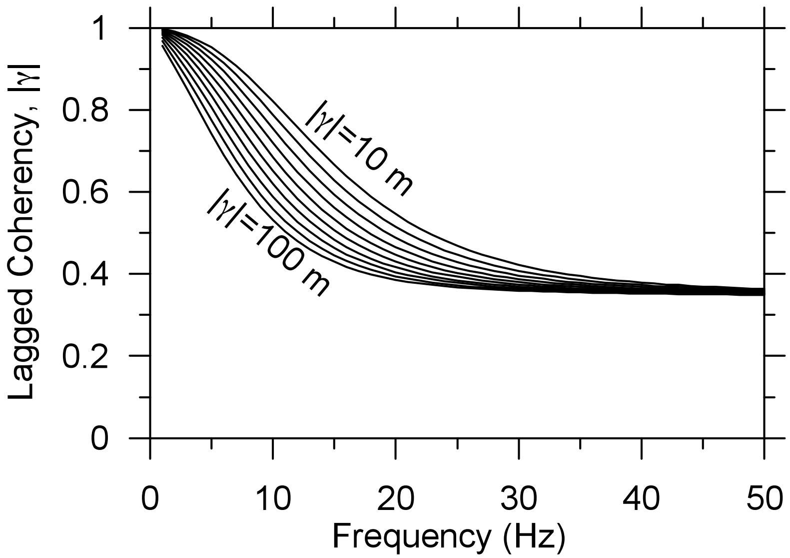
Scope

- Distance attenuation calibration
- Intra-event scatter calibration
  - Evaluate effects of modifications on
    - Sigma



Scope

- Distance attenuation calibration
- Intra-event scatter calibration
  - Evaluate effects of modifications on
    - Sigma
    - Coherency within dense array



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- Verification