

Validation approach for application of simulated ground motions to duration-sensitive systems

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Outline

- Differentiation from other GMSV projects
- Applications where duration is a relevant IM
- Duration definition
- Approach and results to date
 - Update empirical duration GMPE using NGA-West 2 data
 - Compare simulated ground motions to calibrated GMPE
- Next steps

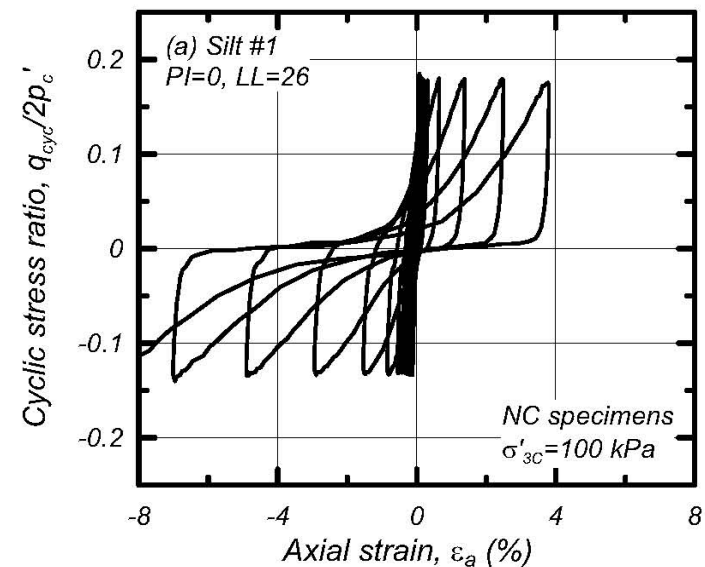
Context Relative to Other Validation Projects

- PSA: SCEC Phase 1 Broadband Platform Validation project (Dreger, Beroza, Day, Goulet, Jordan, Spudich, Stewart).
- Inelastic SDOF: GMSV-SEISM, Baker group
- MDOF systems: GMSV-SEISM, Zareian group
- Landslide analysis: Rathje group
- IMs distinct from PSA: *this project*

Why Duration?

- Weakly correlated to PSA, hence an independent IM
- Important for geotechnical applications

Liquefaction & Cyclic Softening

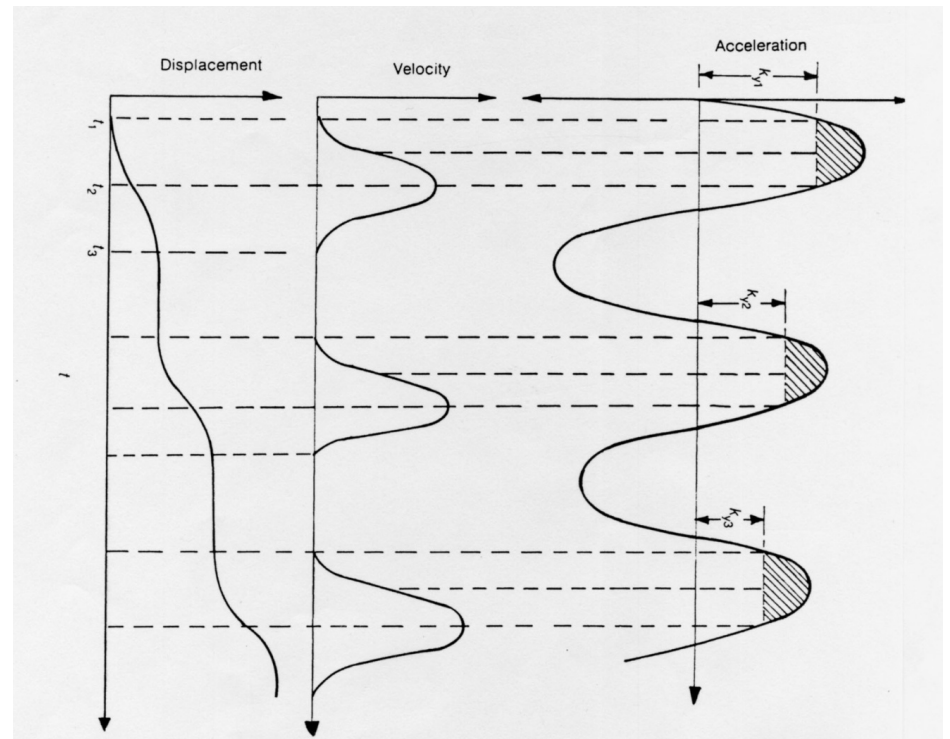


Boulanger and Idriss, 2004

Why Duration?

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- Important for geotechnical applications

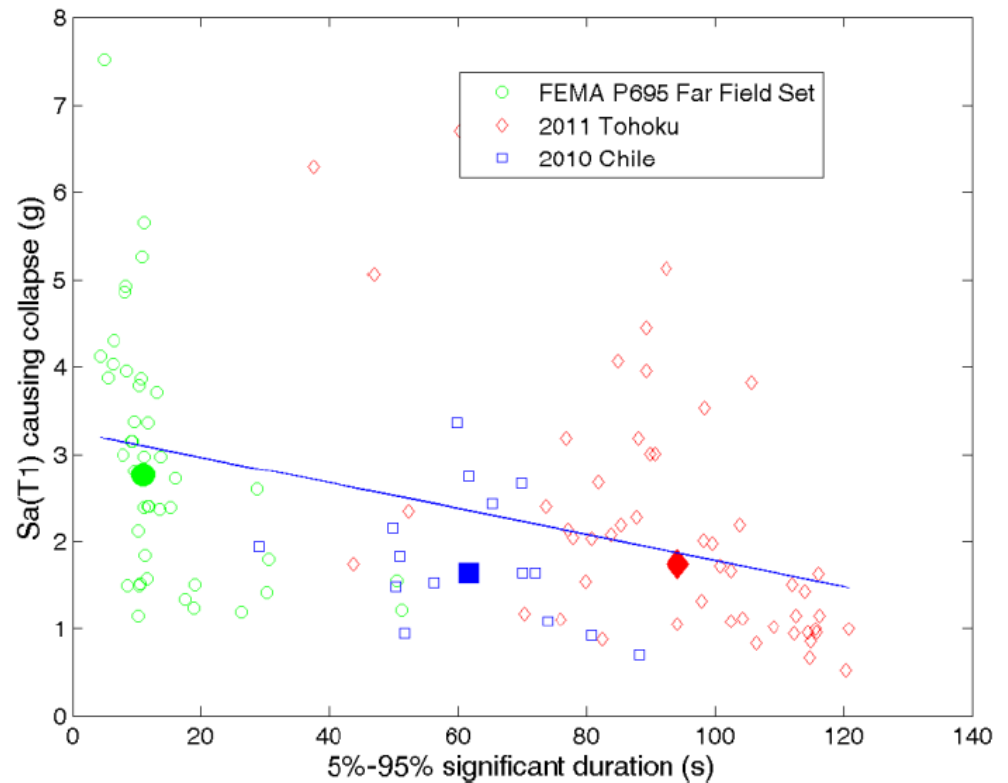
Seismic Landslides



Seed, 1979

Why Duration?

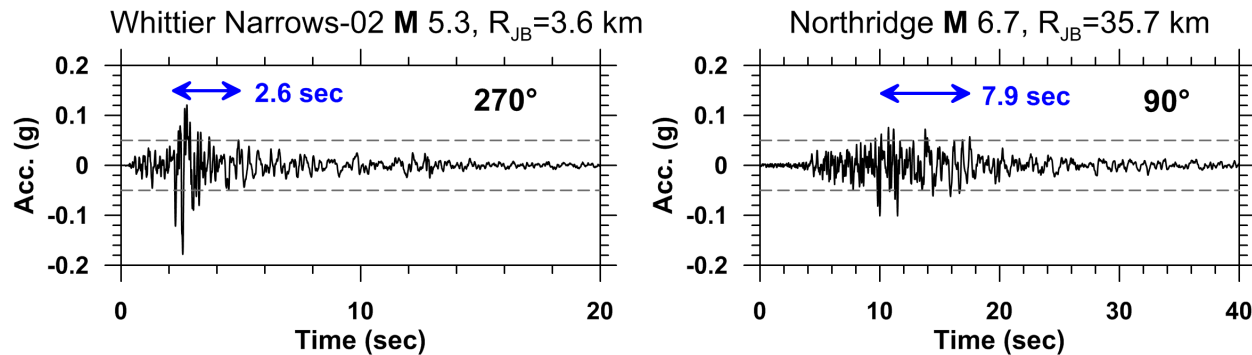
- Weakly correlated to PSA, hence an independent IM
- Important for geotechnical applications
- Structural collapse capacity is affected by duration



Foschaar et al., 2012

Duration Definition

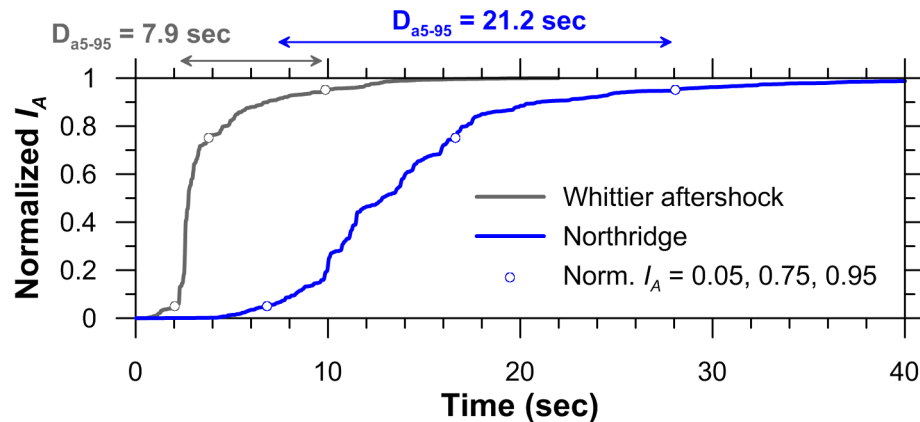
Bracketed duration (not used)



Significant duration (used)

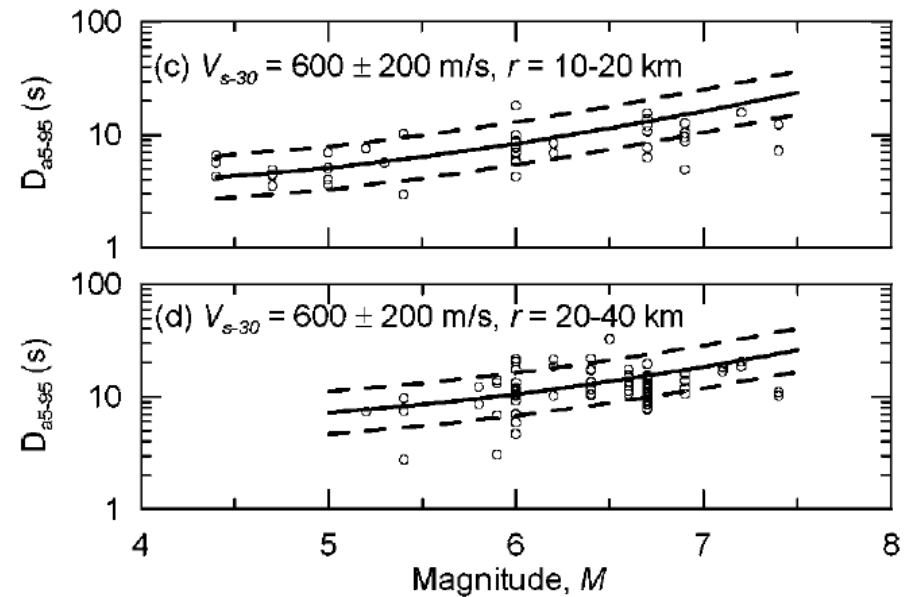
$$I_A = \frac{\pi}{2g} \int_0^{\infty} [a(t)]^2 dt$$

Normalized I_A = integral
to time t $\div$ I_A



Approach

- Select GMPE: Kempton & Stewart (2006)

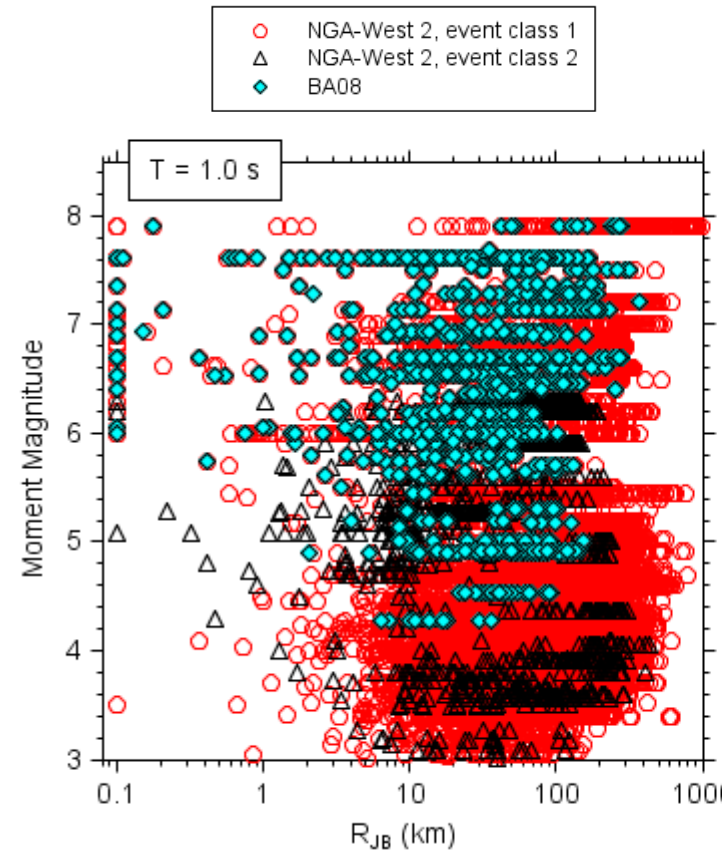


$$m_{ln} = f(M, R_{rup}, V_{s30})$$
$$s_{ln} = 0.44$$

Data set similar to NGA-West 1

Approach

- Select GMPE: Kempton & Stewart (2006)
- Adjust model using NGA-West 2 data:



Boore et al., 2013

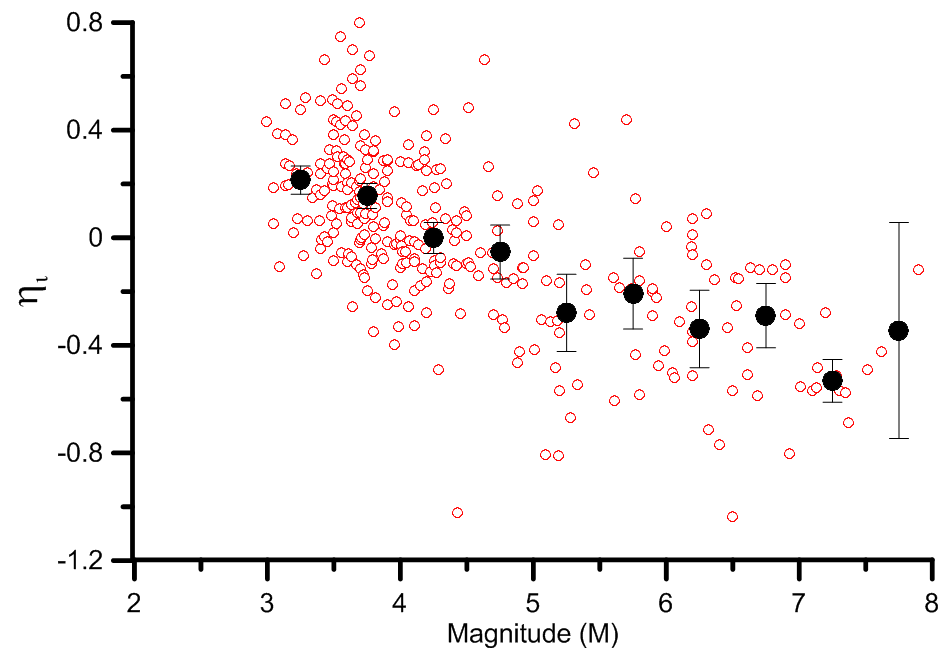
Approach

- Select GMPE: Kempton & Stewart (2006)
- Adjust model using NGA-West 2 data:
 - Mixed effects residuals analysis of current model (to check $\mathbf{M}$ -, R_{rup} , and V_{s30} -scaling)

$$R_{ij} = \ln(D_{ij}) - \ln(m_{ij})$$

Event i , recording j

$$\text{ME analysis: } R_{ij} = c_k + h_i + e_{ij}$$



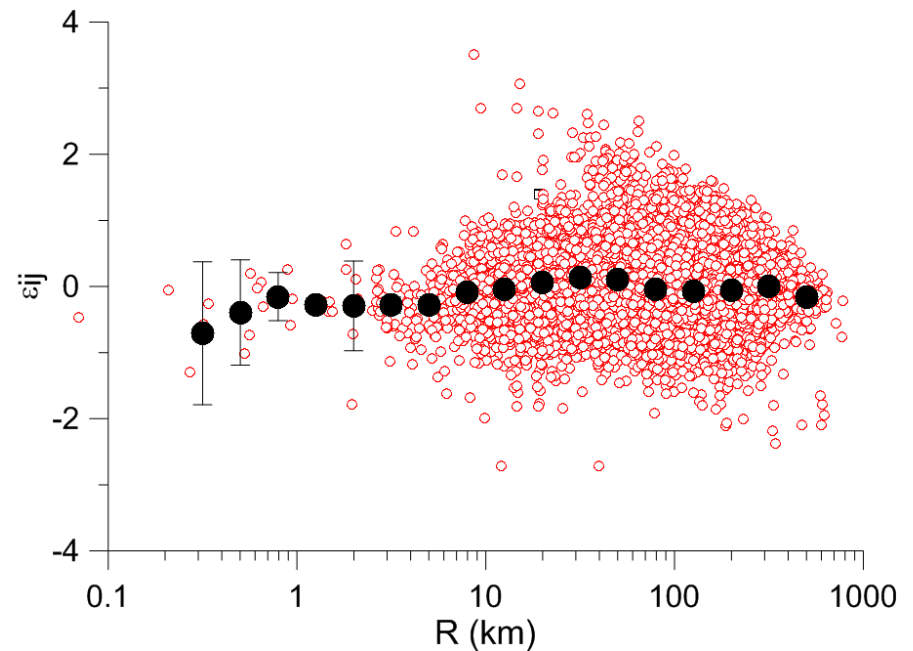
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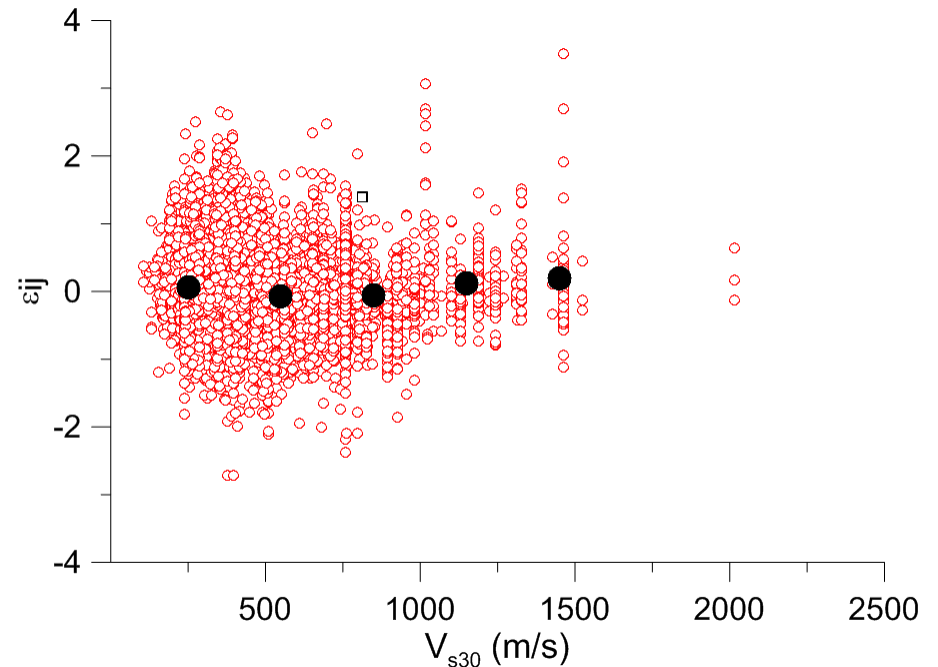
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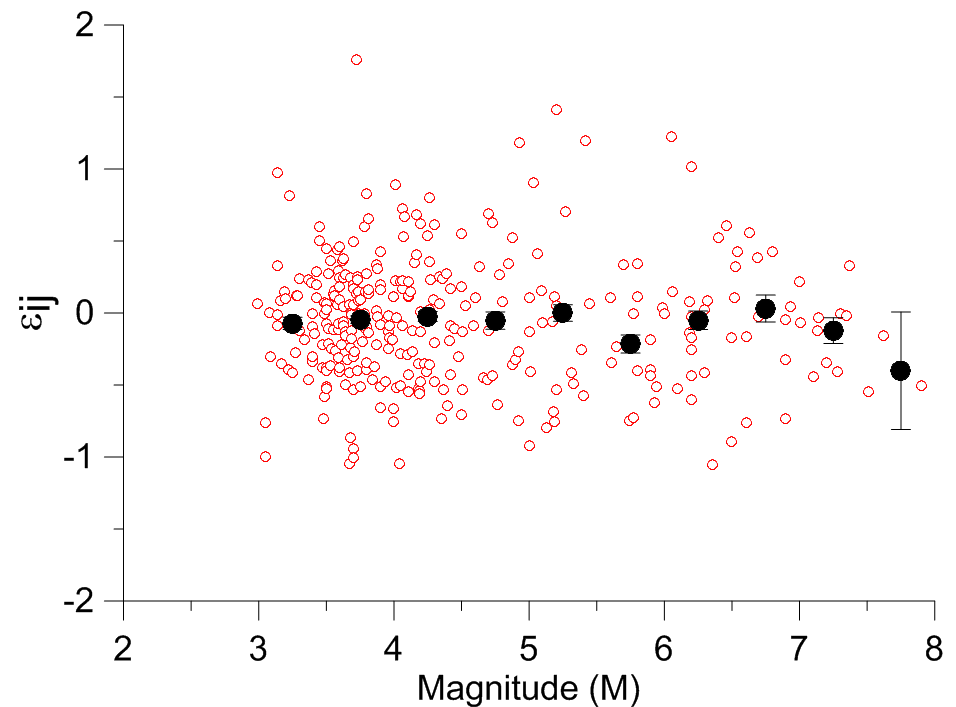
Event i , recording j

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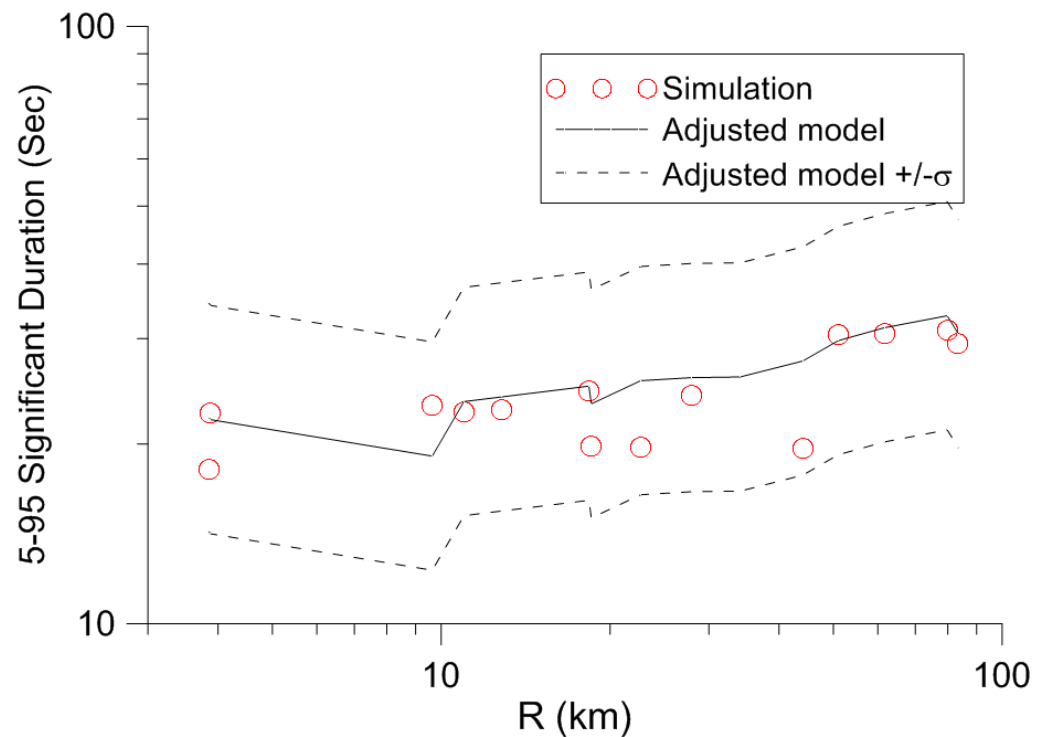
Approach

- Select GMPE: Kempton & Stewart (2006)
- Adjust model using NGA-West 2 data:
 - Mixed effects residuals analysis of current model (to check M -, R_{rup} , and V_{s30} -scaling)
 - Adjust model



Approach

- Select GMPE:
Kempton & Stewart
(2006)
- Adjust model using
NGA-West 2 data
- Compare adjusted
model to simulated data
 - Loma Prieta
Validation Event
 - Results by SDSU



Next Steps

- Formalize the adjustment to the duration GMPE
- Consider many events
- Look at the **M**-, R_{JB} -scaling from simulations as compared to GMPE.
- Test alternate simulation codes
- Time allowing, consider alternate IMs (CAV, etc.)

References

Boore, DM, JP Stewart, E Seyhan, and GM Atkinson (2013). NGA-West 2 equations for predicting response spectral accelerations for shallow crustal earthquakes, *PEER Report 2013/05*, Pacific Earthquake Engineering Research Center, Berkeley, CA.

Boulanger, RW and IM Idriss, 2004. Evaluating the potential for liquefaction or cyclic failure of silts and clays, Report No. UCD/CGM-04/01, University of California, Davis, Department of Civil & Environmental Engineering.

Foschaar, JC, JW Baker, and GG Deierlein, 2012. Preliminary assessment of ground motion duration effects on structural collapse, Proc. 15th World Conf. Eqk. Eng., Lisbon, Portugal.

Kempton, JJ and JP Stewart, 2006. Prediction equations for significant duration of earthquake ground motions considering site and near-source effects, *Earthquake Spectra*, **22**, 985-1013.

Seed, HB (1979). Considerations in the earthquake-resistant design of earth and rockfill dams, *Geotechnique*, **29**, 215-263.