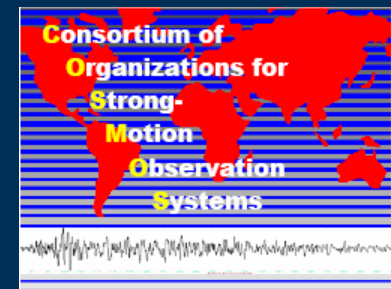


**Filling in for
“Record Selection Insights from the Study of
Epsilon and Inelastic Displacements:
Use with Deterministic Code Applications”
(C. Allin Cornell)**

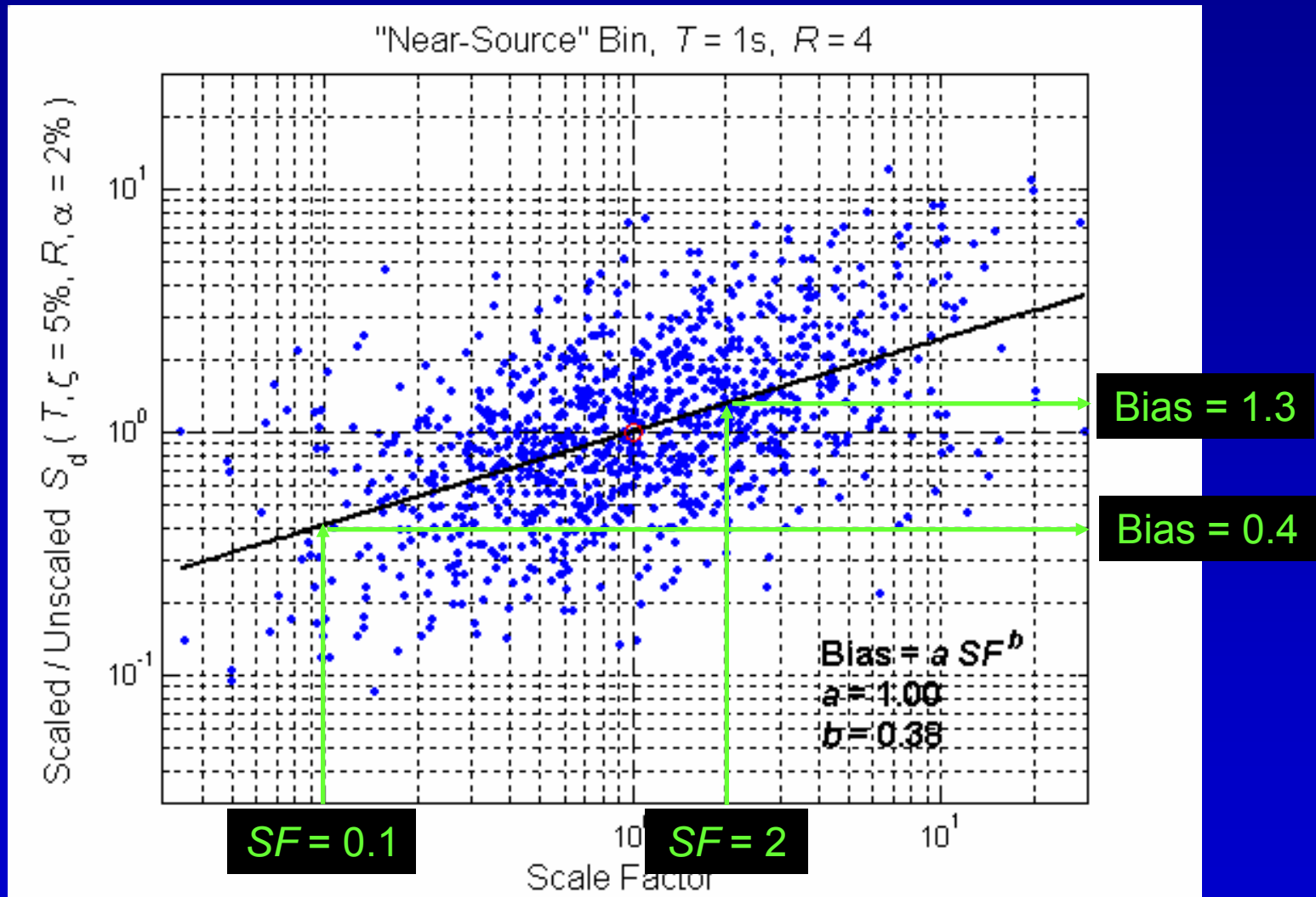
**Nicolas Luco
Research Structural Engineer
U.S. Geological Survey (Golden, CO)**

**COSMOS Technical Session
Millbrae, CA
18 November 2005**

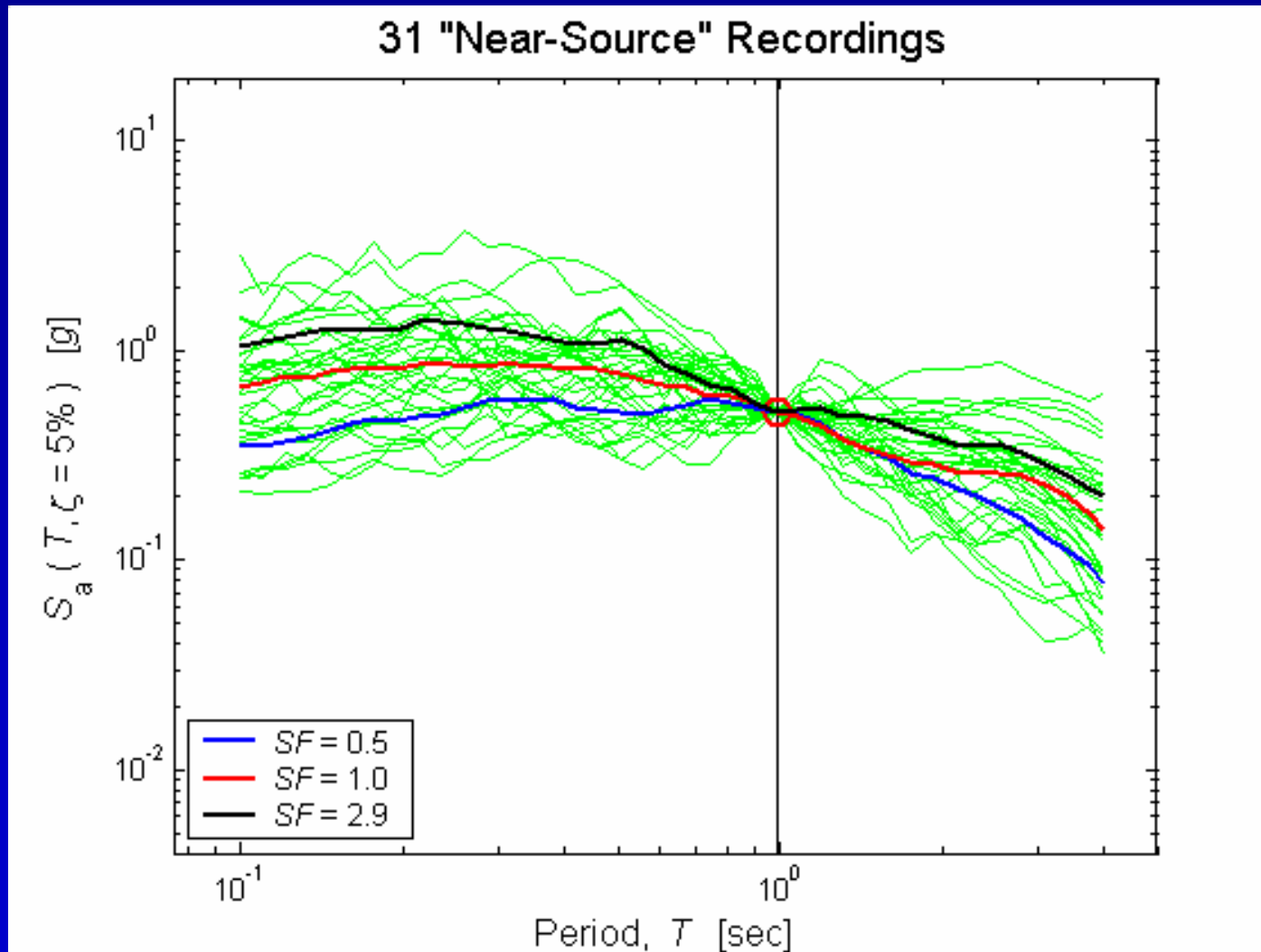


- Most appropriate definition of target?
 - 1) Building code design response spectrum (+ M, R, etc.) ?
 - 2) Uniform Hazard Response Spectrum (UHRS) ?
 - 3) $S_a(T1)$, deaggregated M, R, etc. ?
 - 4) $S_a(T1)$, deaggregated M, R, and ε , etc.?
 - 5) Inelastic Spectral Displacement ?
- Different targets can lead to different recommendations for selection/scaling, some easier to apply than others.
- Last year the focus was bias associated with scaling for Option #3, this year it's #4, next year #5?
- Same experiments need to be repeated for Option #1 (i.e., bias in nonlinear dynamic structural analysis induced by code procedures?)

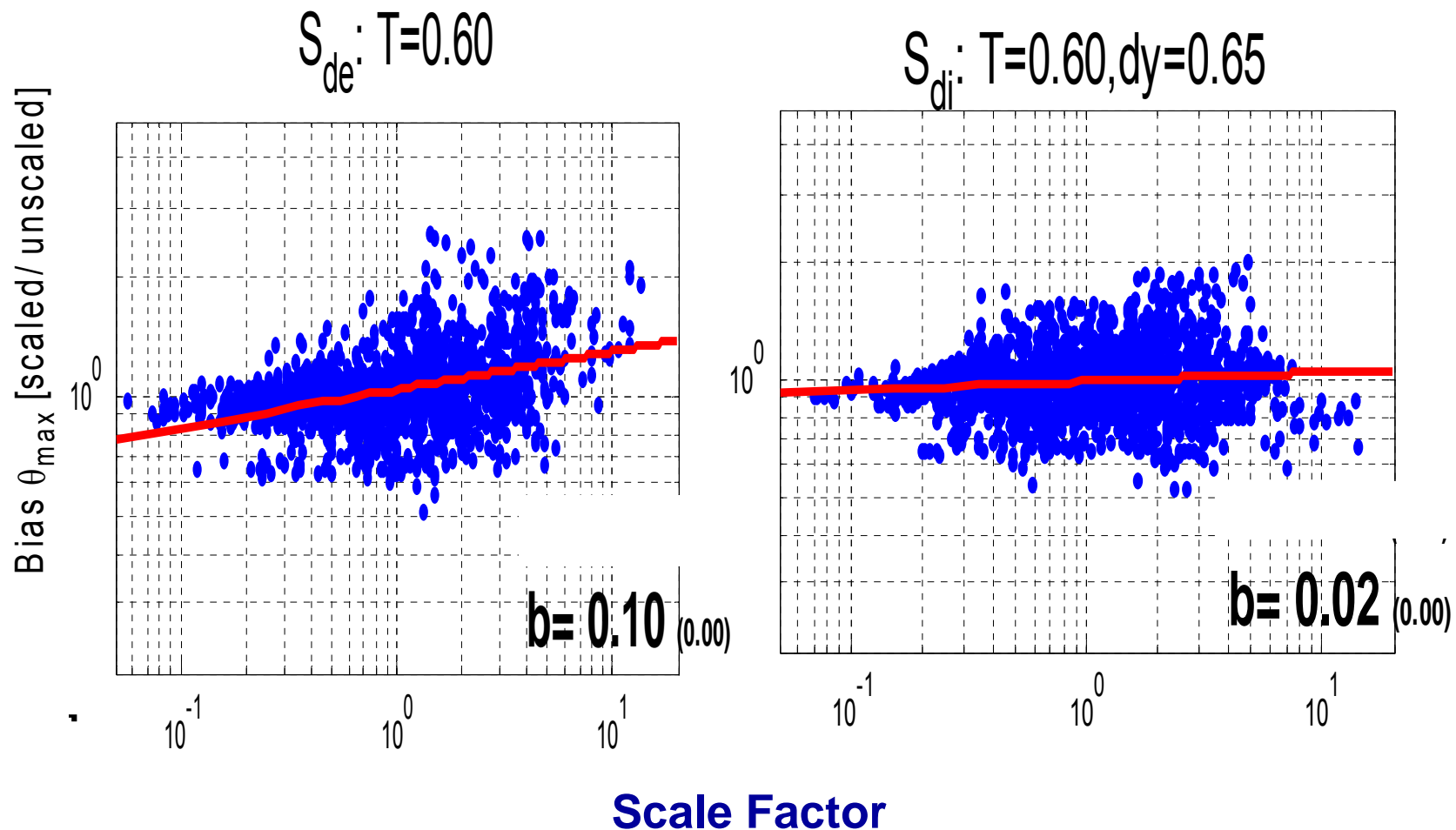
Intra-Bin Scaling for Nonlinear Oscillator



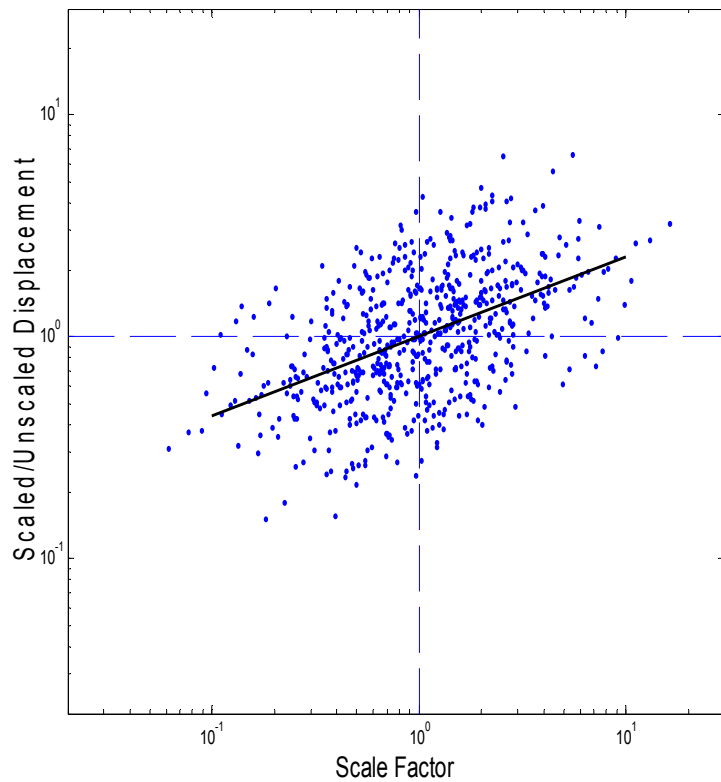
Intra-Bin Scaling for Nonlinear Oscillator



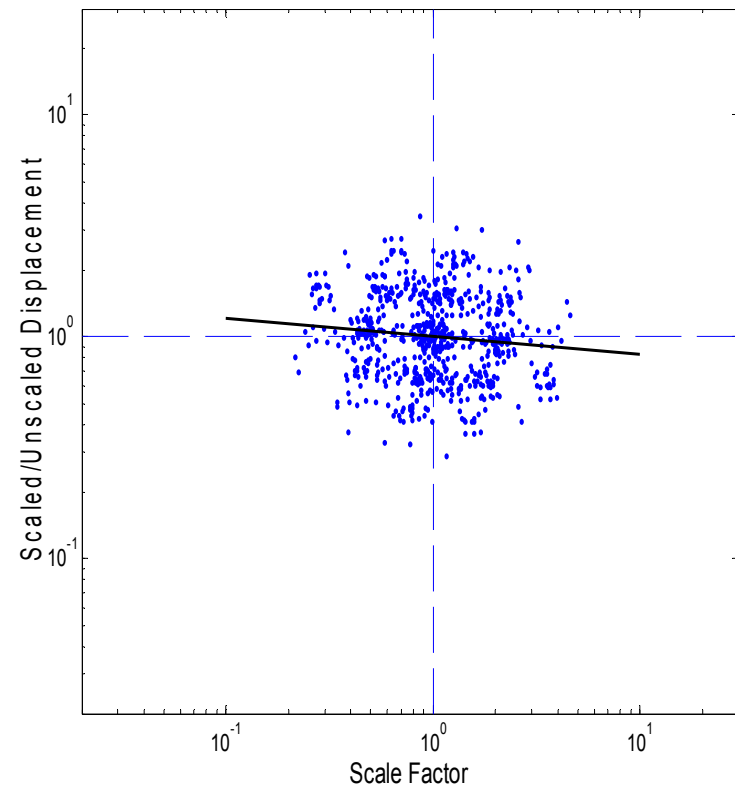
Intra-bin scaling results in term of θ_{\max} for a Three-Story Frame Model (from Tothong & Cornell)



Does Using *Only* Higher Epsilon Records Reduce Inter-bin Scaling Bias? (from Baker & Cornell)



Magnitude 7+/- Random Set



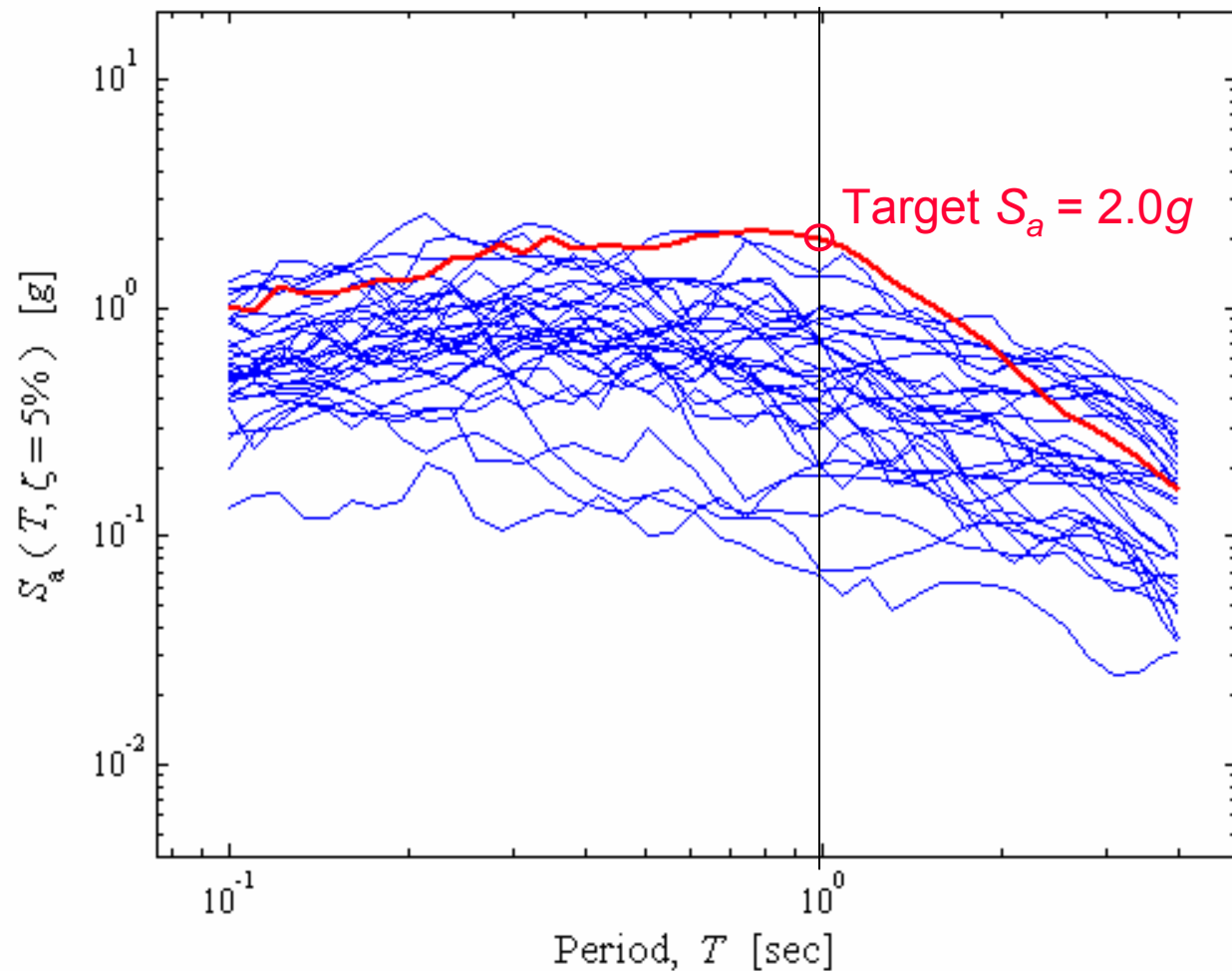
Wide M, R Range Set; Epsilon > 1.5 Only

1 Sec Bilinear Oscillator, R factor = 4

Consideration of Spectral Shape

- Considering not only the target $S_a(T_1)$ but also the “target spectral shape” ...

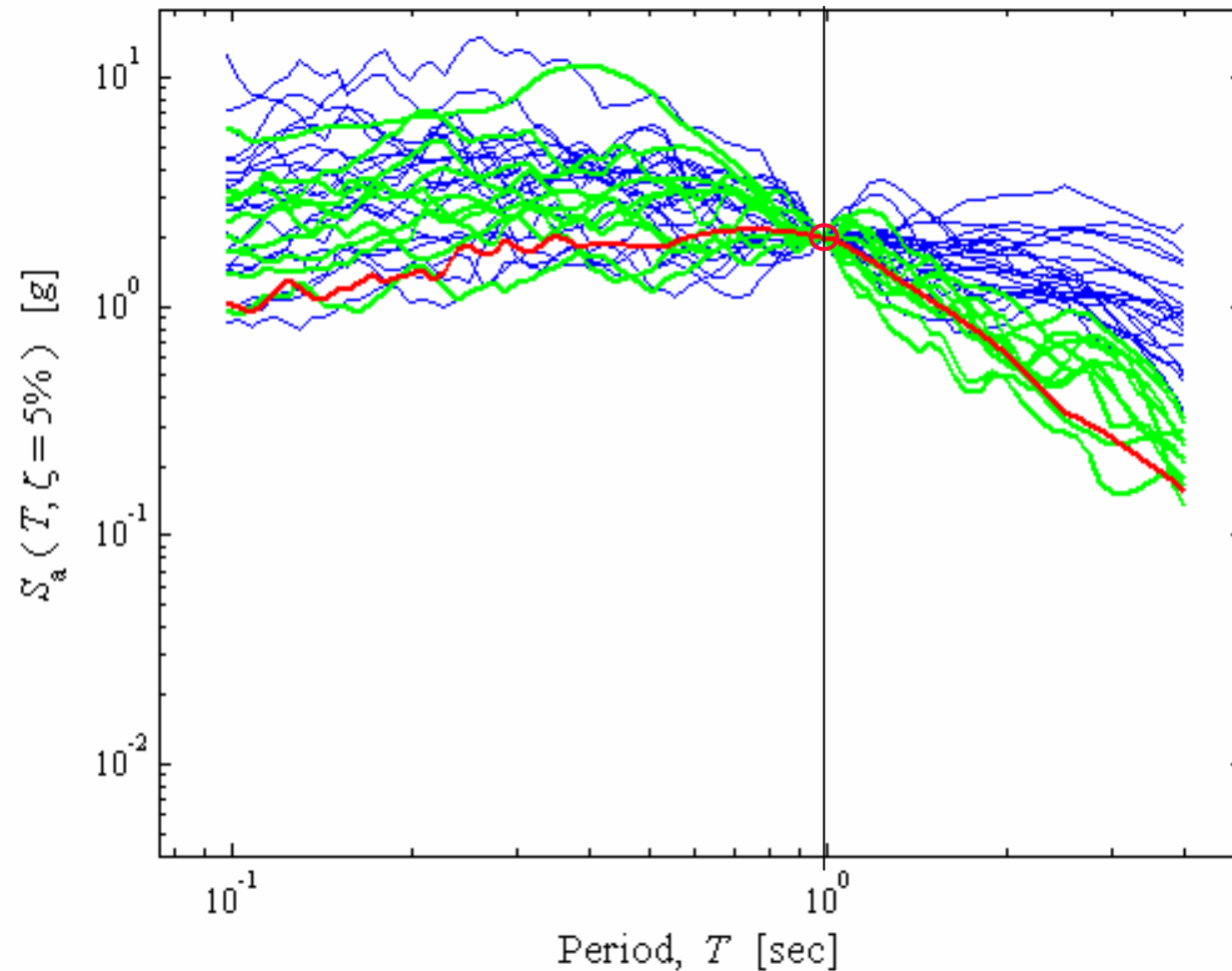
31 "Near-Source" Recordings



Consideration of Spectral Shape

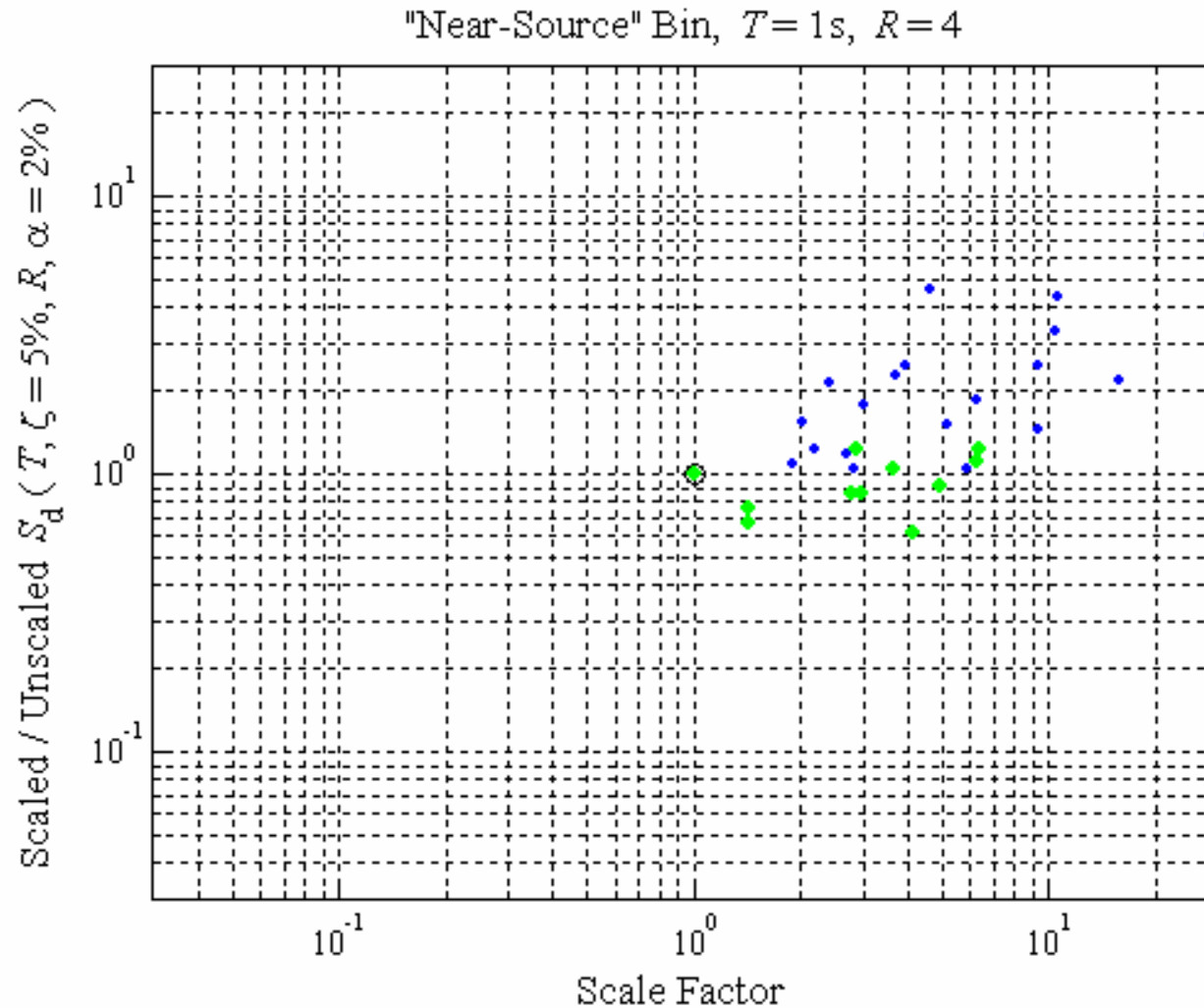
- ... and distinguishing the scaled earthquake records with spectral shapes “most similar” to the target ...

31 "Near-Source" Recordings



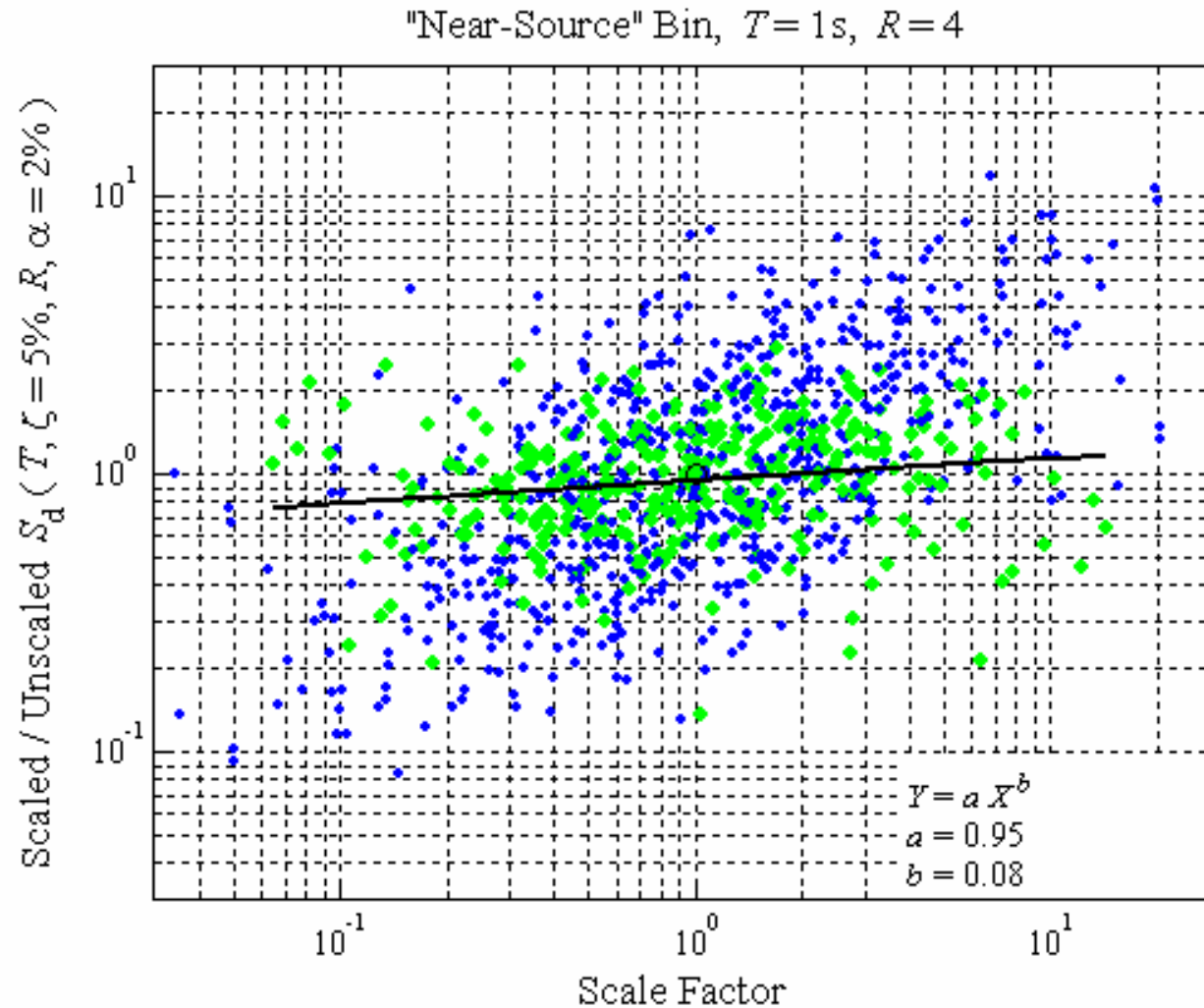
Consideration of Spectral Shape

- Little bias is induced, even at relatively large scale factors:



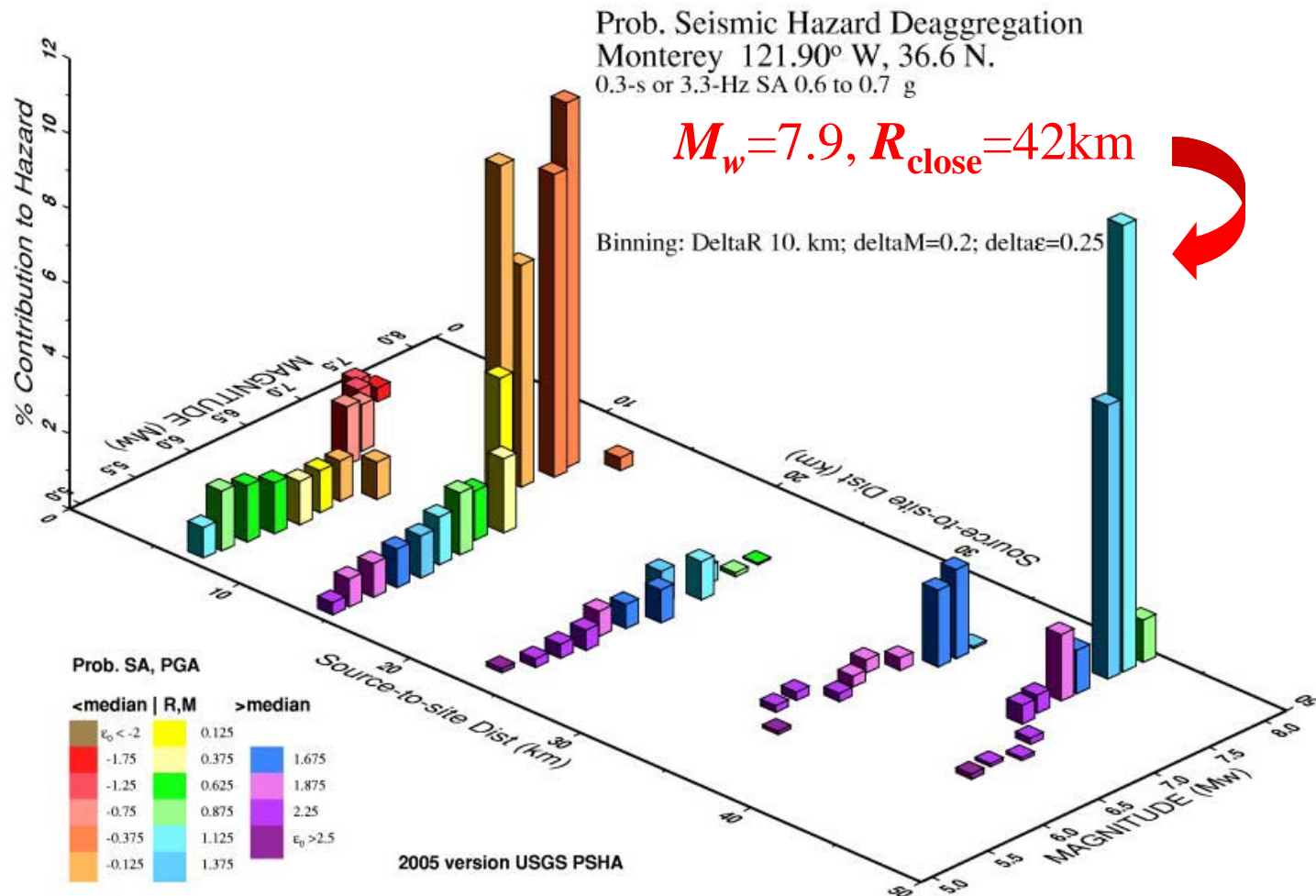
Consideration of Spectral Shape

- Little bias is induced, even at relatively large scale factors:



Setting M_w , R_{close} , $S_a(T_1)$, and Spectral Shape

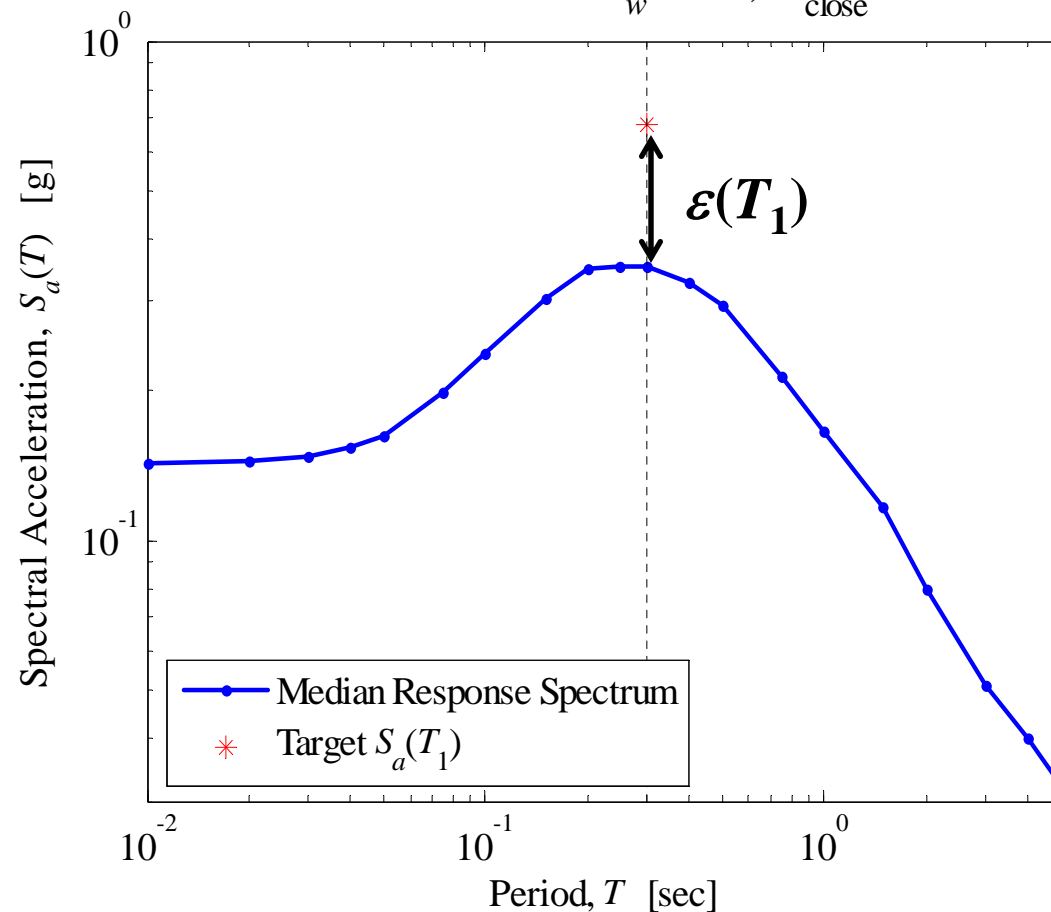
- 2) The M_w and R_{close} that contribute most to the occurrence probability of the target $S_a(T_1)$ can then be found via “banded deaggregation” (a new USGS website):



Setting M_w , R_{close} , $S_a(T_1)$, and Spectral Shape

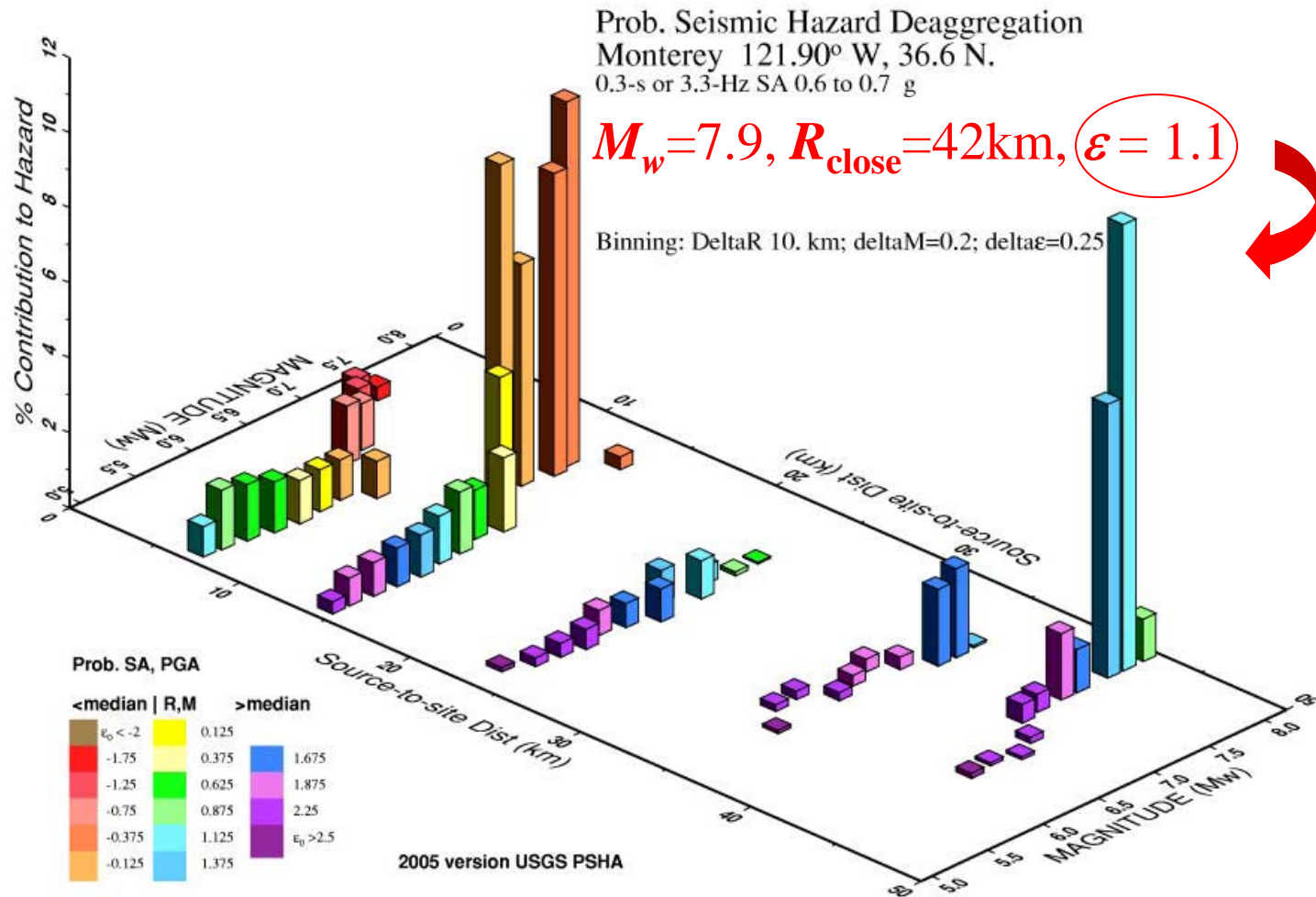
- 3) With the “target” M_w and R_{close} , the median spectral shape can be estimated via an empirical ground motion prediction equation:

San Andreas Scenario: $M_w = 7.9$, $R_{close} = 42\text{km}$



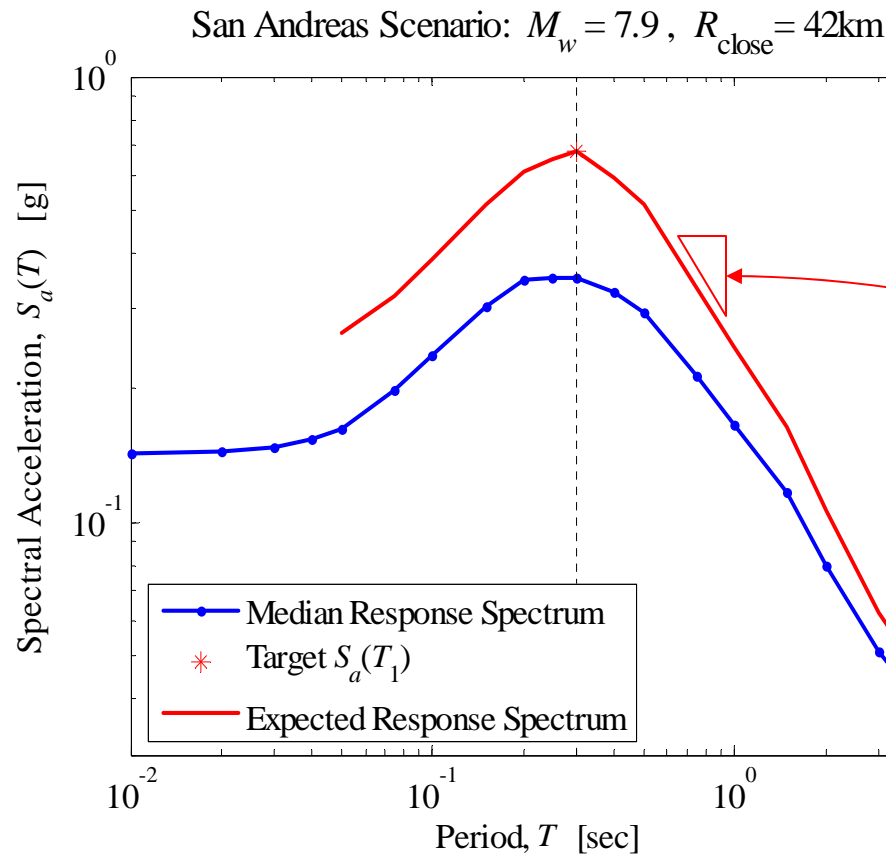
Setting M_w , R_{close} , $S_a(T_1)$, and Spectral Shape

- 2) The M_w and R_{close} that contribute most to the occurrence probability of the target $S_a(T_1)$ can then be found via “banded deaggregation” (a new USGS website):



Setting M_w , R_{close} , $S_a(T_1)$, and Spectral Shape

- 4) With M_w , R_{close} , and $\varepsilon(T_1)$, the expected spectral shape that passes through $S_a(T_1)$ can be calculated:

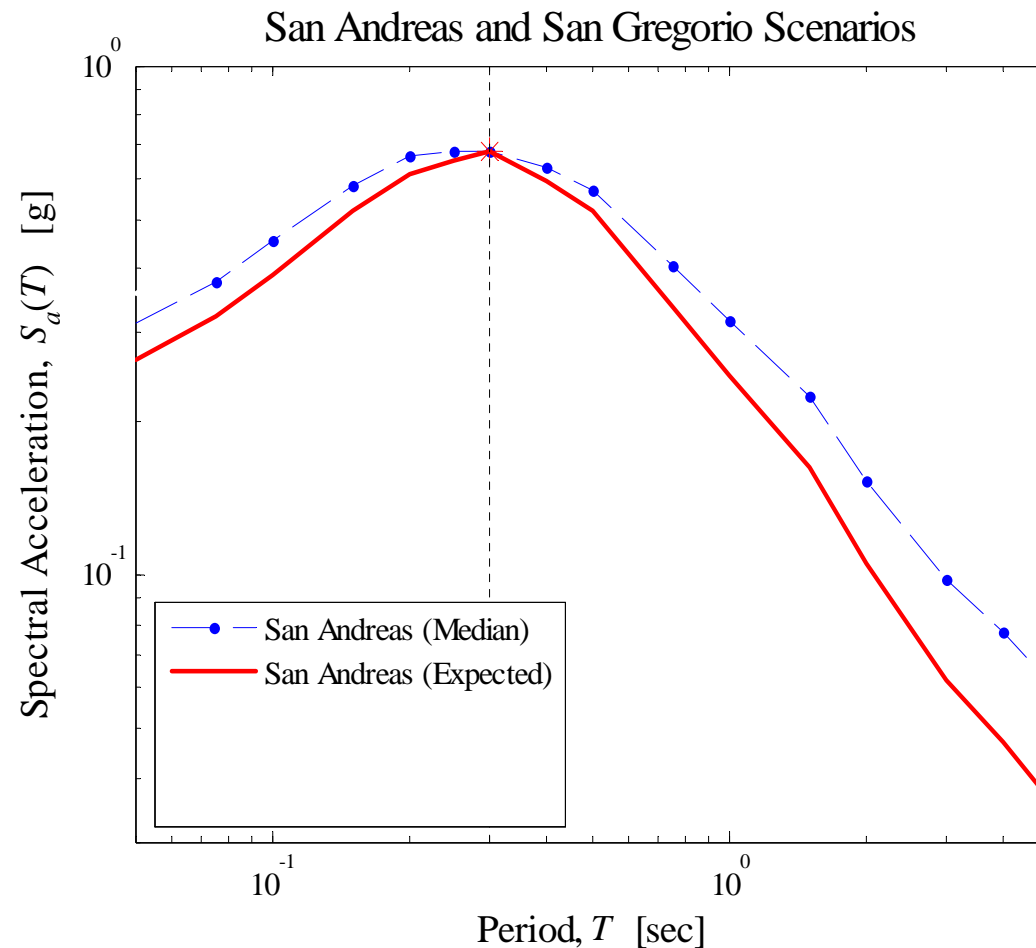


From, for example,
Baker & Cornell (2005)

Given M_w, R_{close} : $E[S_a(T) | \varepsilon(T_1)] = E[S_a(T)] + \rho[\varepsilon(T_1), \varepsilon(T)] \cdot \sigma[S_a(T)] \cdot \varepsilon(T_1)$

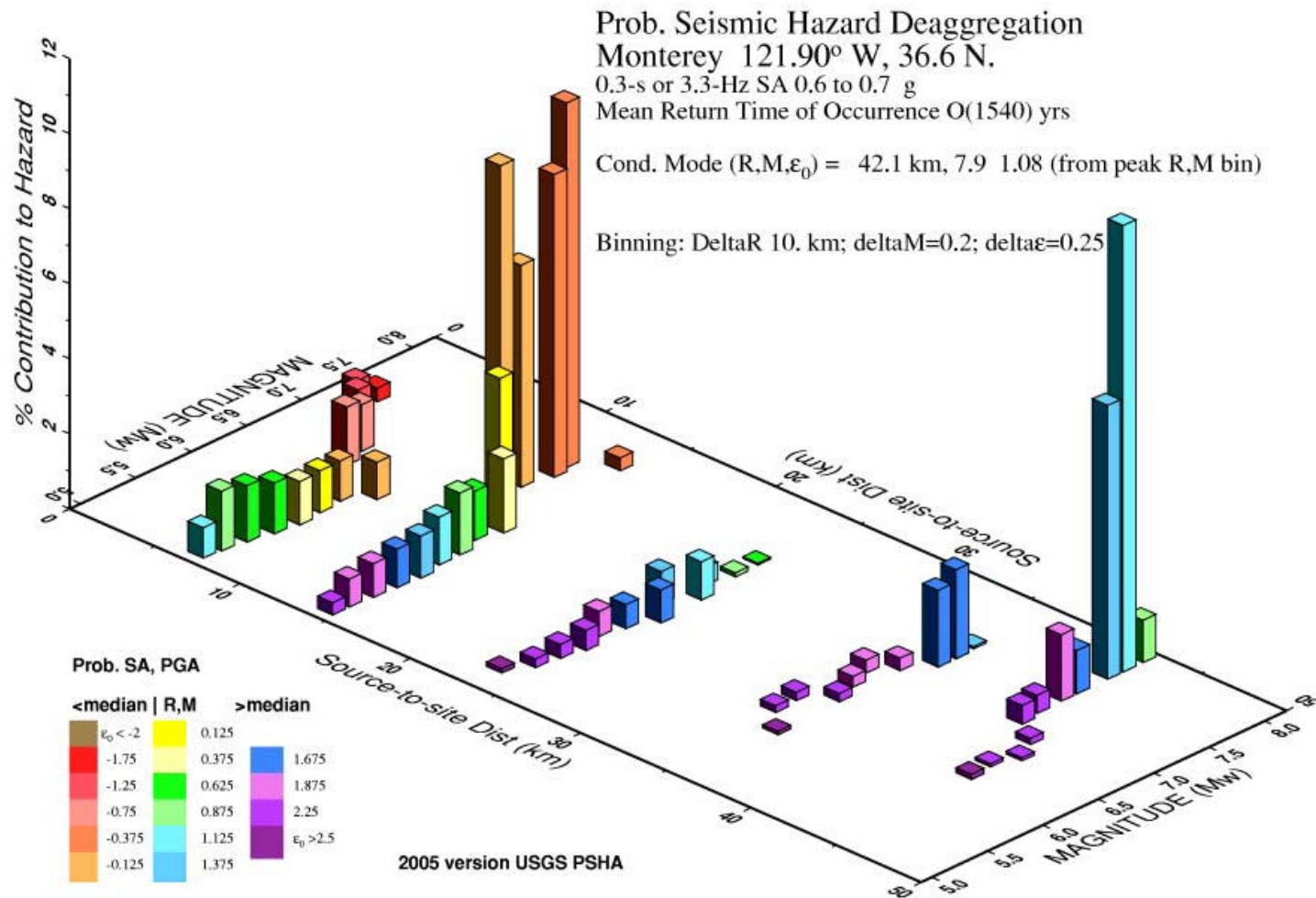
Setting M_w , R_{close} , $S_a(T_1)$, and Spectral Shape

- In short, it can be important to consider $\varepsilon(T_1)$ in addition to M_w and R_{close} in quantifying the expected (or target) spectral shape:



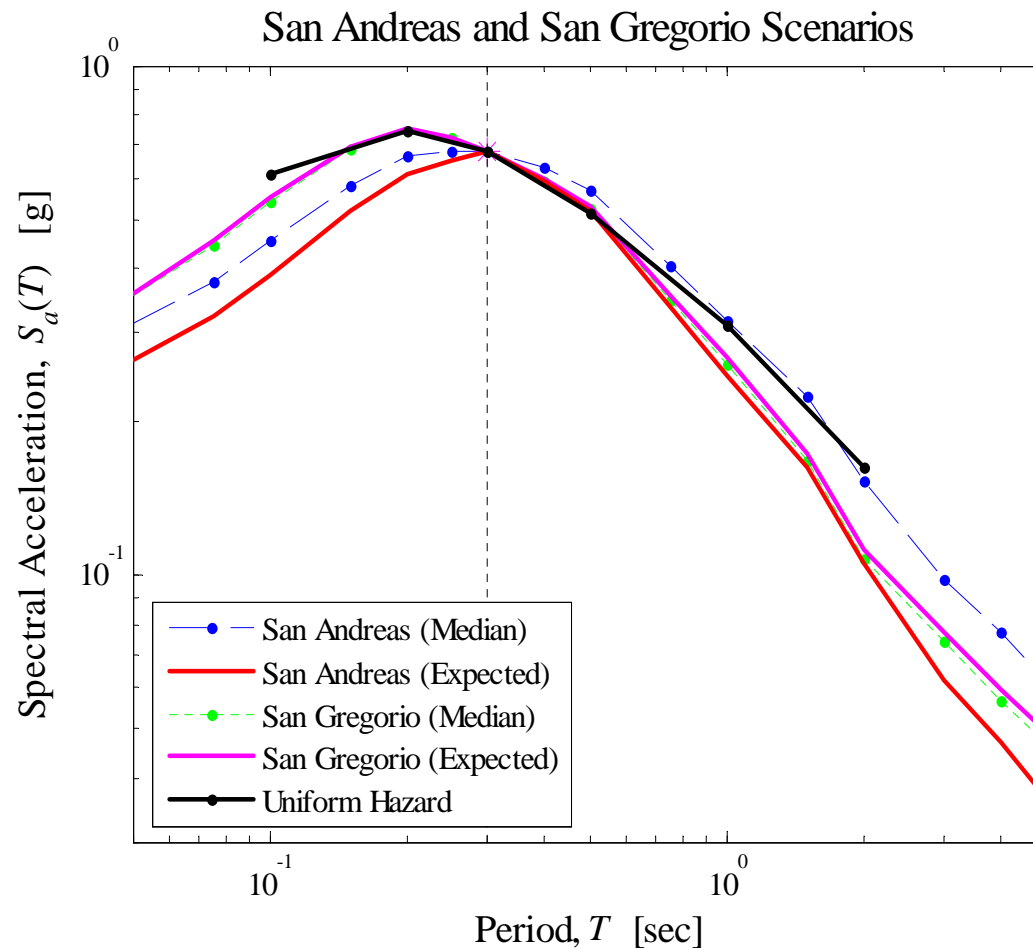
Setting M_w , R_{close} , $S_a(T_1)$, and Spectral Shape

- 2) The M_w and R_{close} that contribute most to the occurrence probability of the target $S_a(T_1)$ can then be found via “banded deaggregation” (a new USGS website):



Setting M_w , R_{close} , $S_a(T_1)$, and Spectral Shape

- In short, it can be important to consider $\varepsilon(T_1)$ in addition to M_w and R_{close} in quantifying the expected (or target) spectral shape:



More questions (without answers) ...

- What about MDOF structures, and real multi-component ground motions? ... vector hazard?
- Can we use “risk deaggregation” to defined target ground motion scenarios, even for building code applications?

Additional Slides ...

Intra-Bin Scaling for Nonlinear Oscillator

Example ...

□ Ground motion scenario

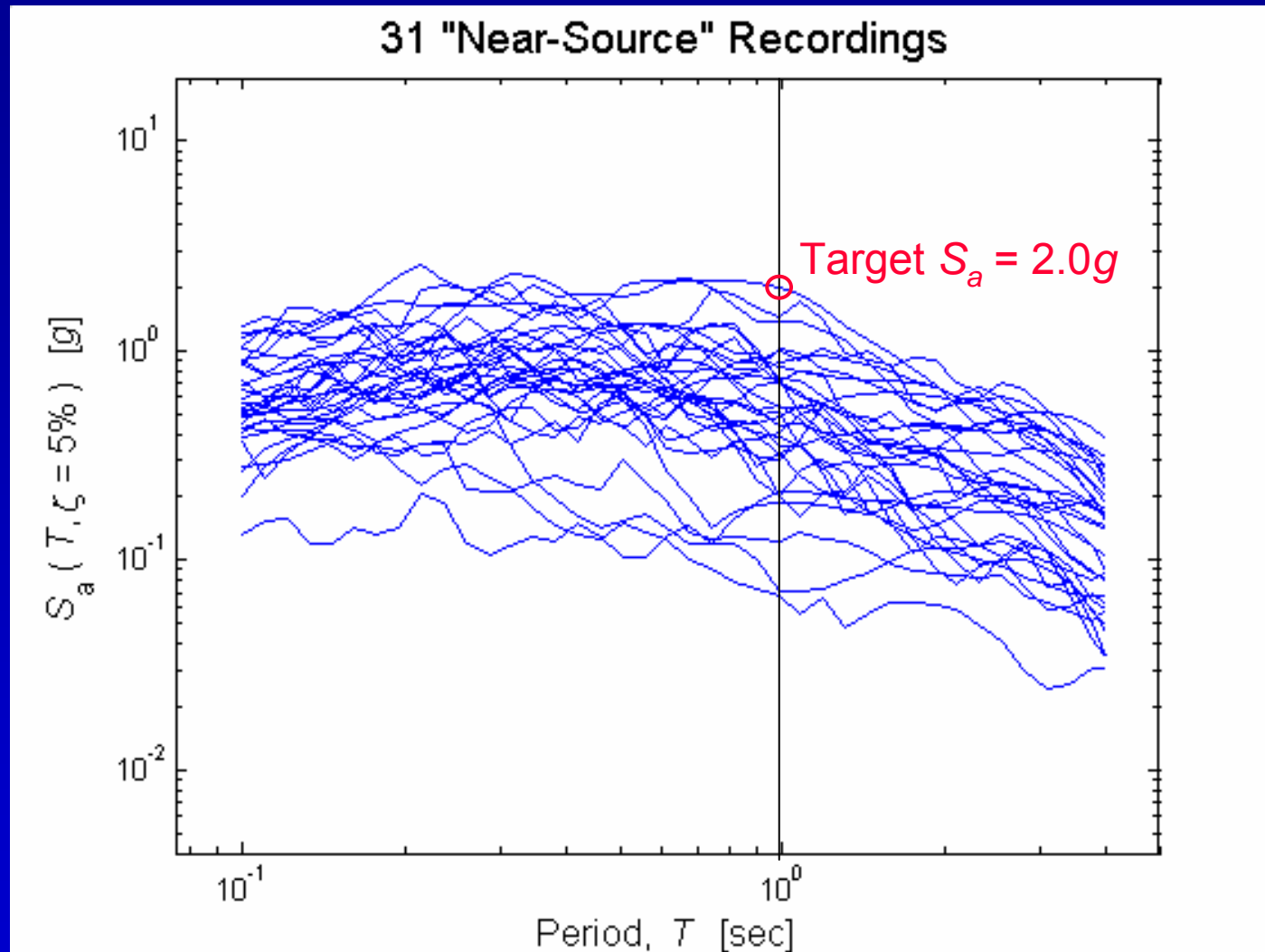
- $M_w = 6.5 - 6.9$, $R_{\text{close}} = 0 - 16$ km
- Forward-directivity conditions
- Strike-normal component
- NEHRP C or D site classification
- Shallow crustal event
- Target $S_a = 2.0g$

} "Near-Source" Scenario

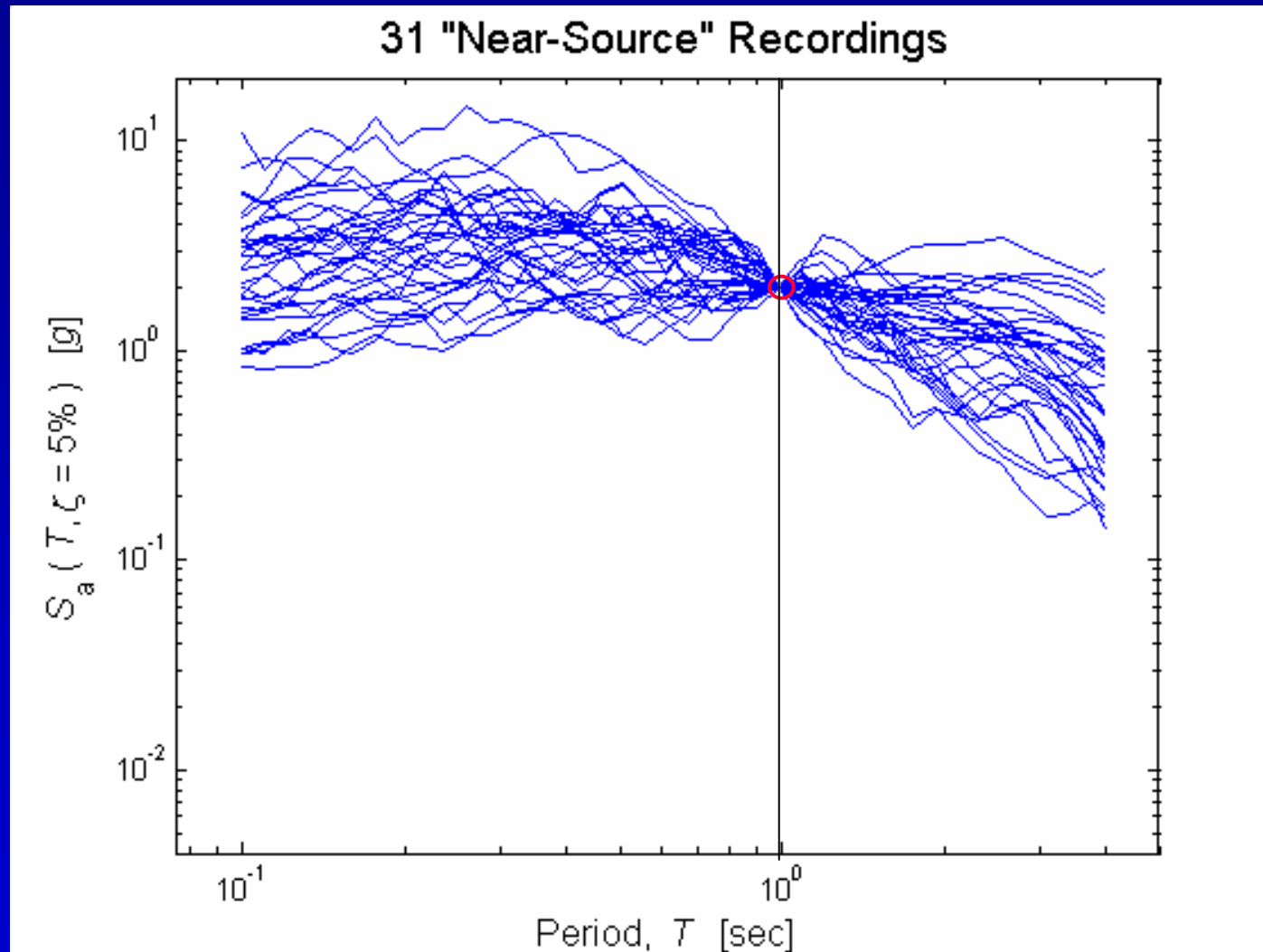
□ Structure

- SDOF oscillator (e.g., bridge bent, 1-story building)
- $T = 1$ sec, $\zeta = 5\%$
- $R = 4$ (i.e., $F_y = \text{Target } S_a * m / 4$)
- Bilinear hysteretic behavior with $\alpha = 2\%$

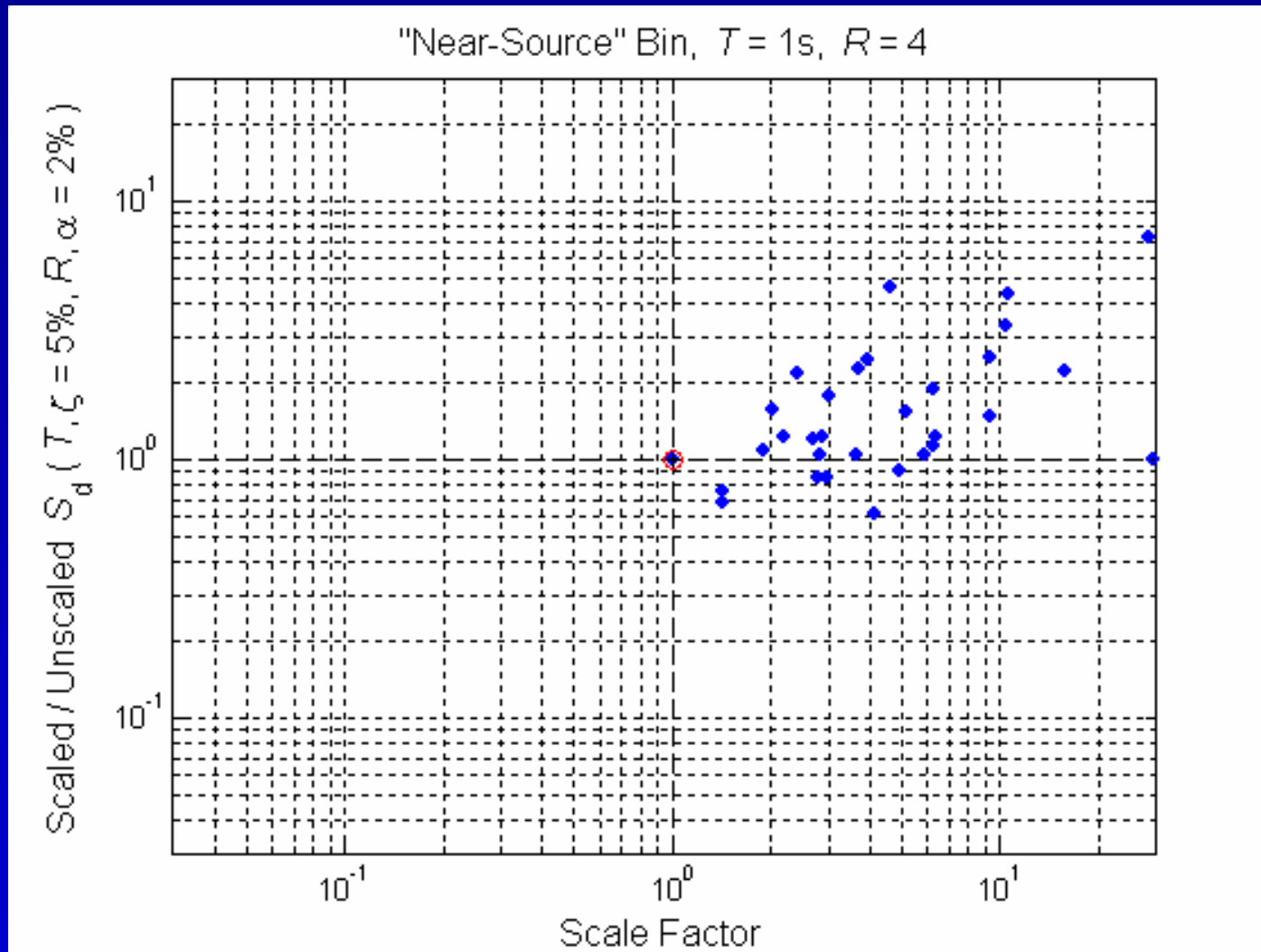
Intra-Bin Scaling for Nonlinear Oscillator



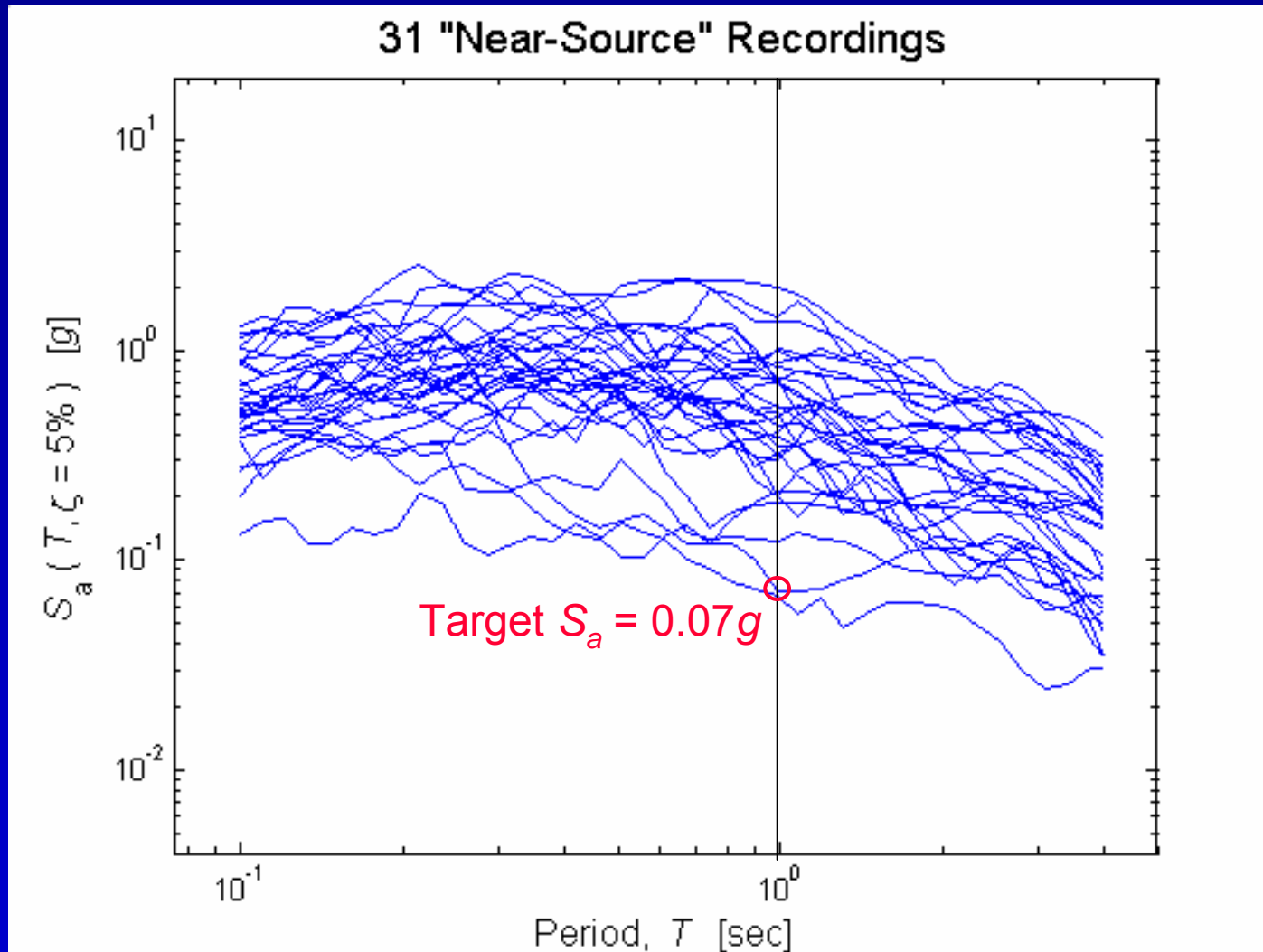
Intra-Bin Scaling for Nonlinear Oscillator



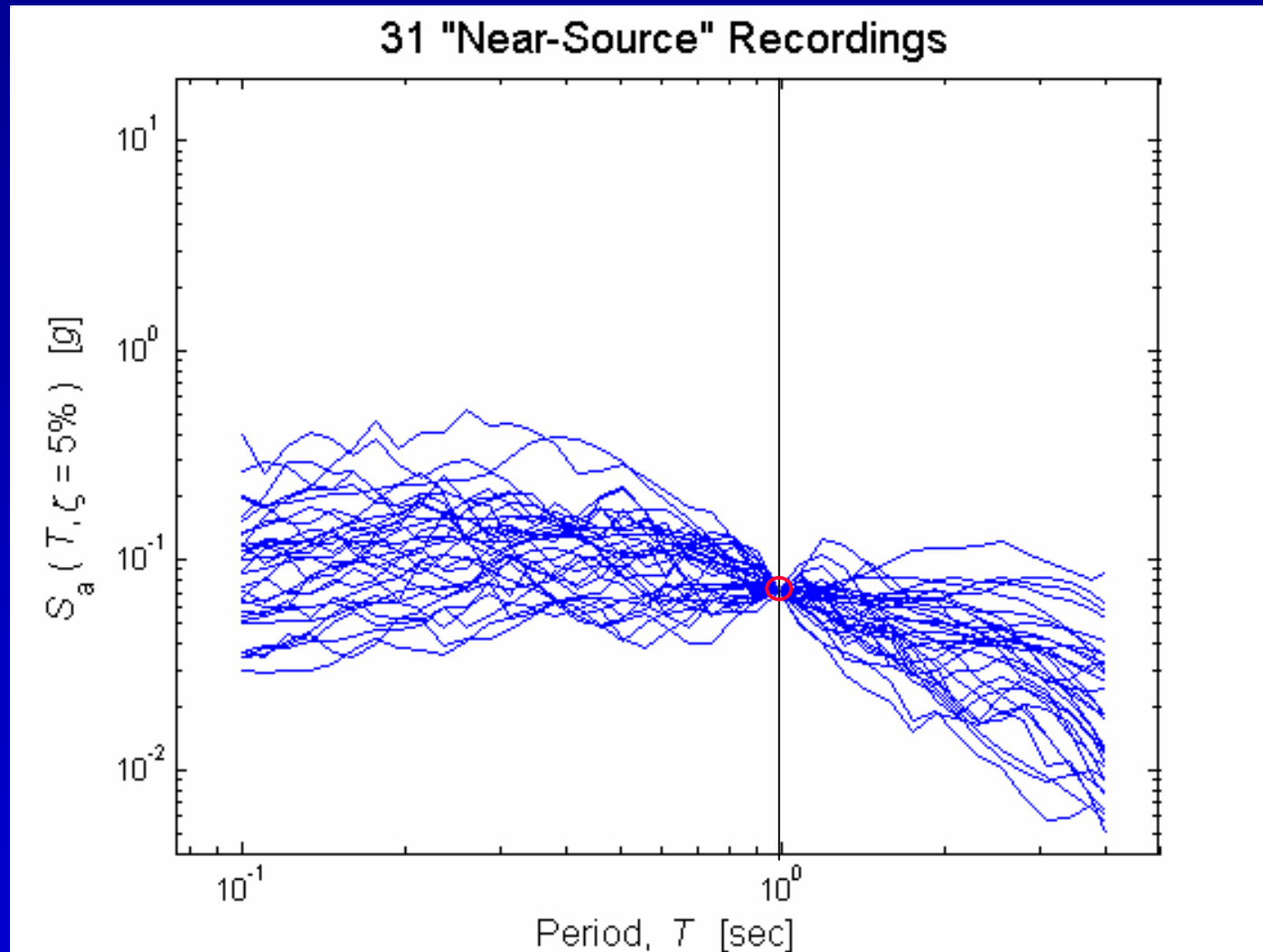
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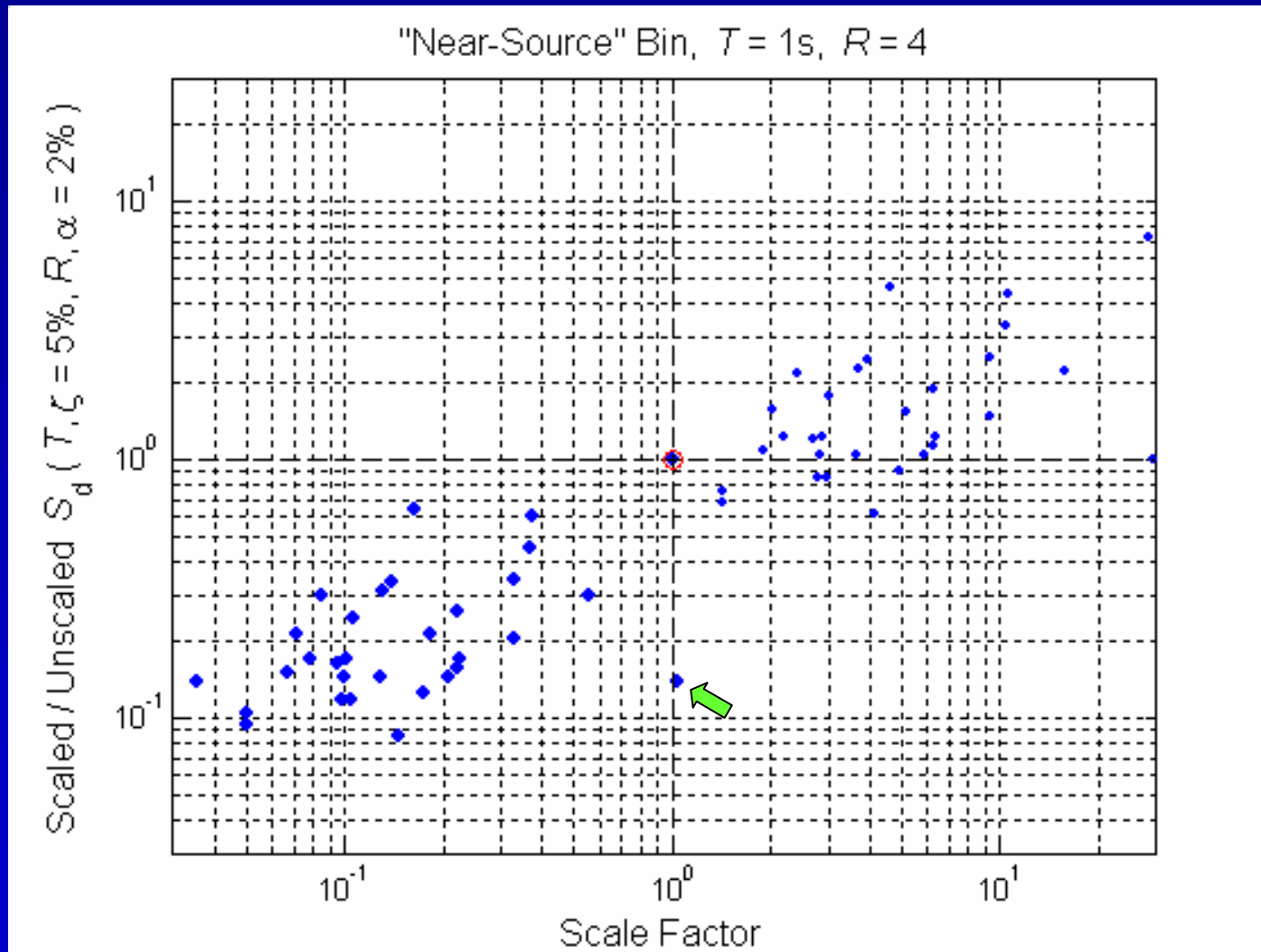
Intra-Bin Scaling for Nonlinear Oscillator



Intra-Bin Scaling for Nonlinear Oscillator



Intra-Bin Scaling for Nonlinear Oscillator



Intra-Bin Scaling for Nonlinear Oscillator

