Overview of PEER Research on Selection and Scaling of Time-Series for Nonlinear Analysis

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What's our objective?

- Determine the average response of a nonlinear system given a design event (or hazard)
- Provide an estimate of the response σ

Approaches to the problem..

- Select records that have similar...
  - Origin characteristics (M_w, r, V_{s30}, basin depth,...)
  - Record properties (Sa, PGV, epsilon,...)

  ...as the design event.

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- Select records using new IM's based on..
  - Record property vectors (Sa-AVG)
  - Response of simple inelastic systems (inelastic oscillators, Newmark sliding block)

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    Tothong and Cornell, Watson-Lamprey and Abrahamson, Shantz, Bozorgnia

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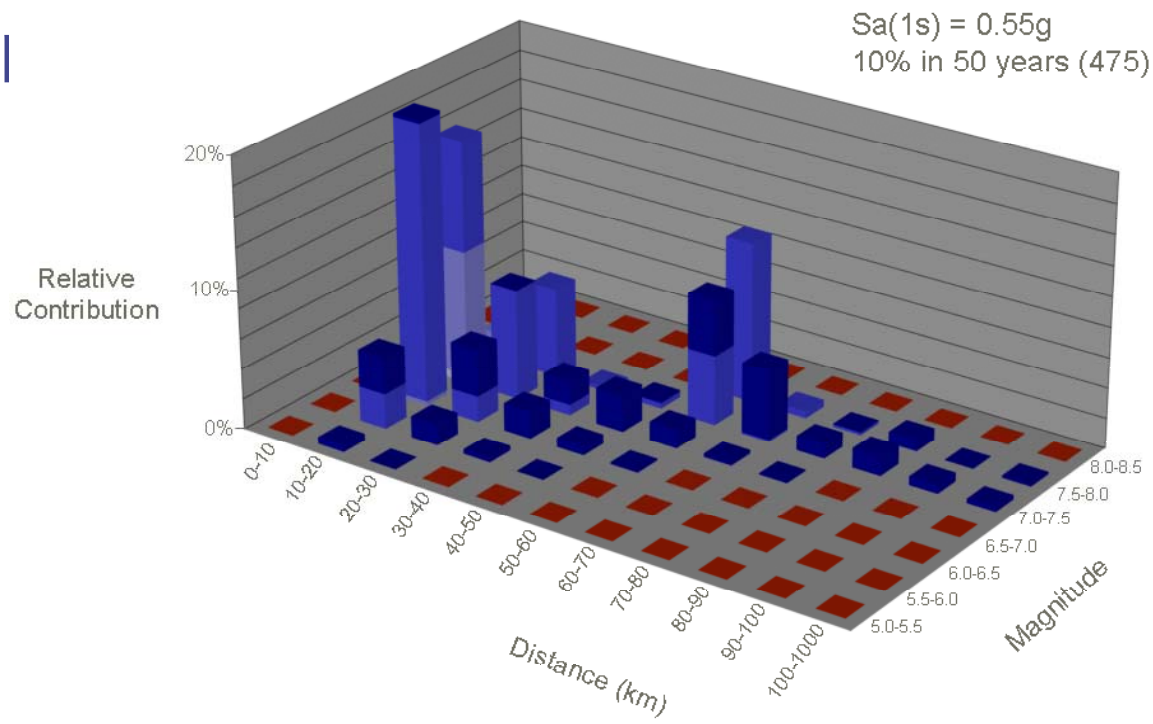
Improved Search Tools... (Goulet and Stewart)

- Hazard Disaggregation
  - Get the relative contribution of parameters controlling the hazard
- Disaggregation |
  - Magnitude
  - Distance
  - Epsilon
  - Others
    - Fault type
    - Directivity
    - Site condition



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Improved Search Tools…

The proposed selection tool will allow the user to select *any* of the parameters present in the NGA "flatfile" for record selection.

Examples:

- Ranges of magnitude, distance, latitude, Vs_{30}, basin depth, etc.
- Ranges of Sa, PGA, PGV, Epsilon (for multiple period values)
- Instrument location, soil category, rupture mechanism and directivity, etc.

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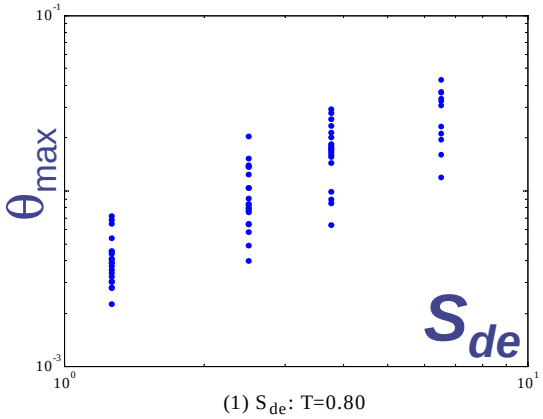
Evaluation of new IM's.. (Tothong and Cornell)

- 3 different IM's compared :
  - *Sde* (elastic spectral displacement)
  - *Sdi* (inelastic spectral displacement)
  - *Sa-AVG.* (Sa averaged over several periods)

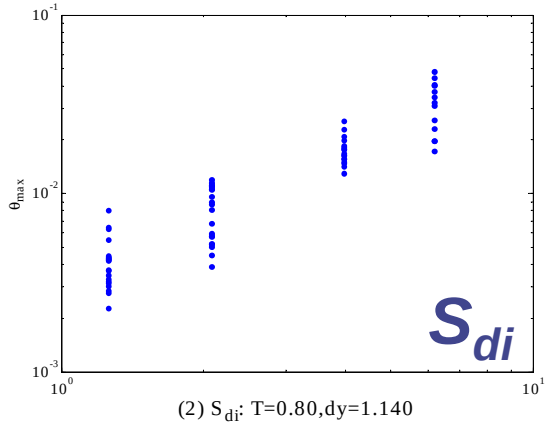
Efficiency

Efficiency: small dispersion of EDP|IM

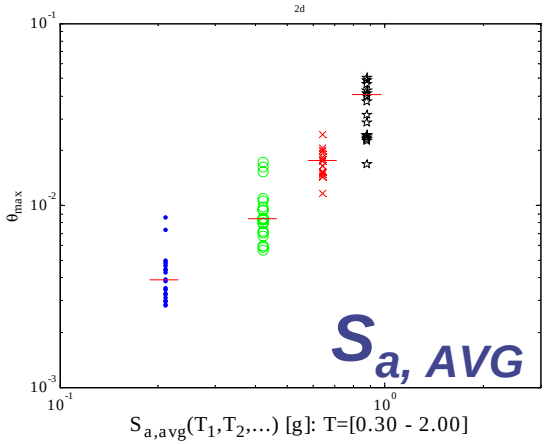
- Compare dispersion of EDP when GMs have been scaled to a specified IM level
- Plots show the EDP, (θ_{max}) of the Van Nuys test bed structure. Both *Sdi* and *Sa-AVG.* reduce the dispersion in estimating EDP|IM



σ= 0.31, 0.41, 0.41, 0.48



σ= 0.30, 0.36, 0.17, 0.34
%Reduction= 2, 12, 58, 28

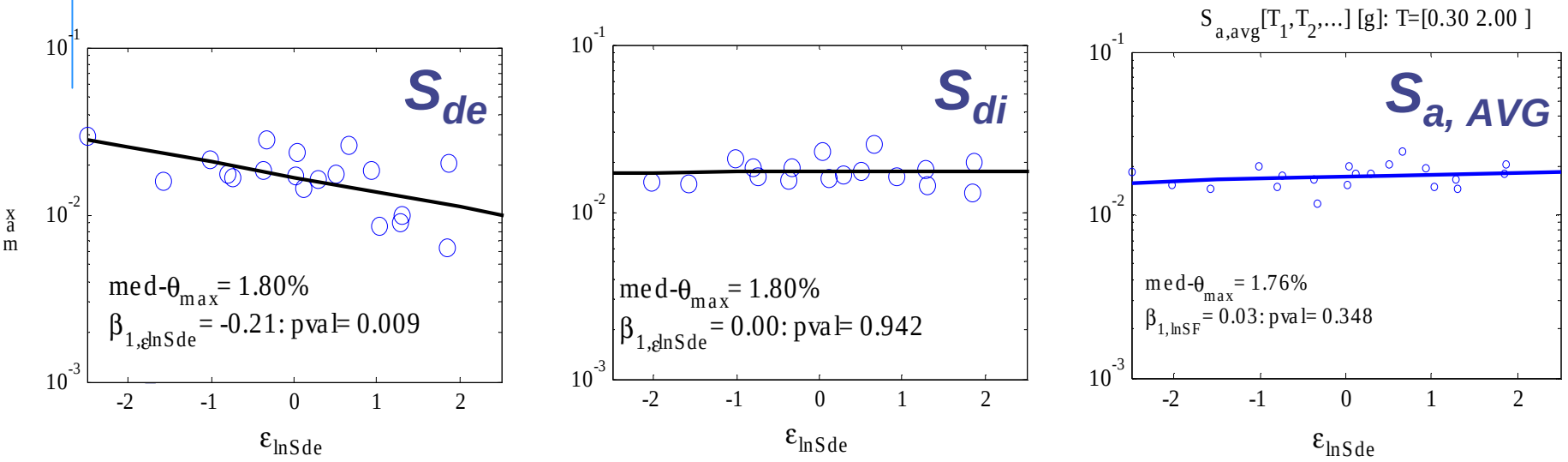


σ= 0.30, 0.32, 0.17, 0.34
%Reduction= 2, 22, 59, 28

- *Sdi* and *Sa-AVG.* tend to reduce the EDP dispersion.

Sufficiency

- Sufficiency: Defined as $f_{EDP|im}$ being independent of GM record characteristics, e.g., Mw, distance, ε.
  - Plots show the EDP|im against the variable that may improve the prediction (here ε)
  -



- ε helps improve response prediction for *Sde* case
- Scaling GMs based on *Sdi* and *Sa-AVG.* show sufficiency w.r.t. ε, i.e., no dependency on ε.

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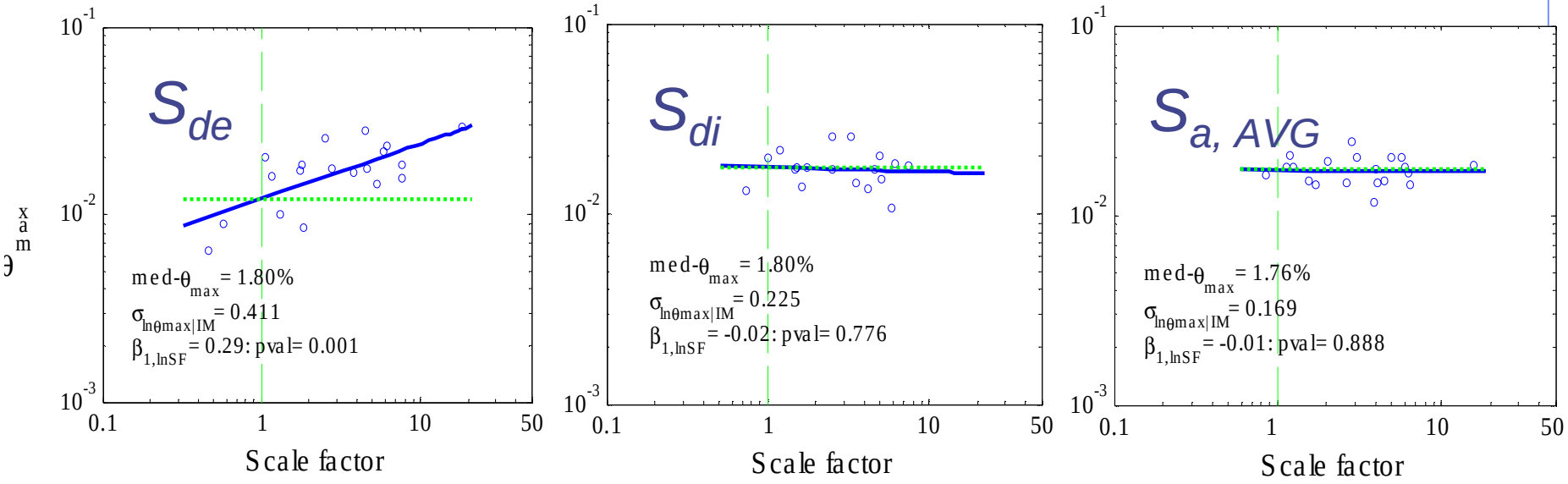
Bias-scaling

- Plots show EDP|im versus scale factor



- Scaling GMs based on *Sdi* and *Sa-AVG.* does not introduce bias in the response of a structure.

Evaluation of new IM's... (Tothong and Cornell)

- Conclusions
  - Sdi and Sa-AVG are robust IM's w.r.t. GM selection and scaling.
  - Epsilon is not an issue when using Sdi and Sa-AVG.
  - Both IM's require new attenuation relationships (feasible and available).

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Evaluation of new IM's... (Watson-Lamprey and Abrahamson)

- Approach
  - Uses a simple inelastic system as a proxy for a more complicated system (Newmark block, inelastic oscillator)
  - Seek record properties that correlate well with peak system response (PGV, A_{rms}, Dur_{ky})
  - Develop predictive model for peak system response using above parameters
  - Choose scaled records that have record properties that are expected to produce an average response

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Example: Newmark Sliding Block.. (Watson-Lamprey and Abrahamson)

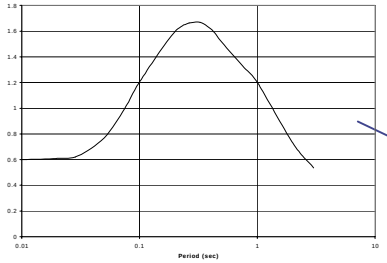
M = 7

R = 5 km

Vs_{30} = 400 m/s

PGA = 0.6g

ky = 0.1g



Calculate

A_{RMS} = 0.185g

Dur_{ky} = 2.411s

PGV = 92 cm/s

Calculate

Average Expected Design Event

Newmark Displacement = 57.3 cm

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Select Candidate Records

$6 < M < 8$

$0 < R < 50$

All Soil Classes

1233 records

Scale to Spectral Value

Scale all records to PGV = 92 cm/s

Reject Bad Fits

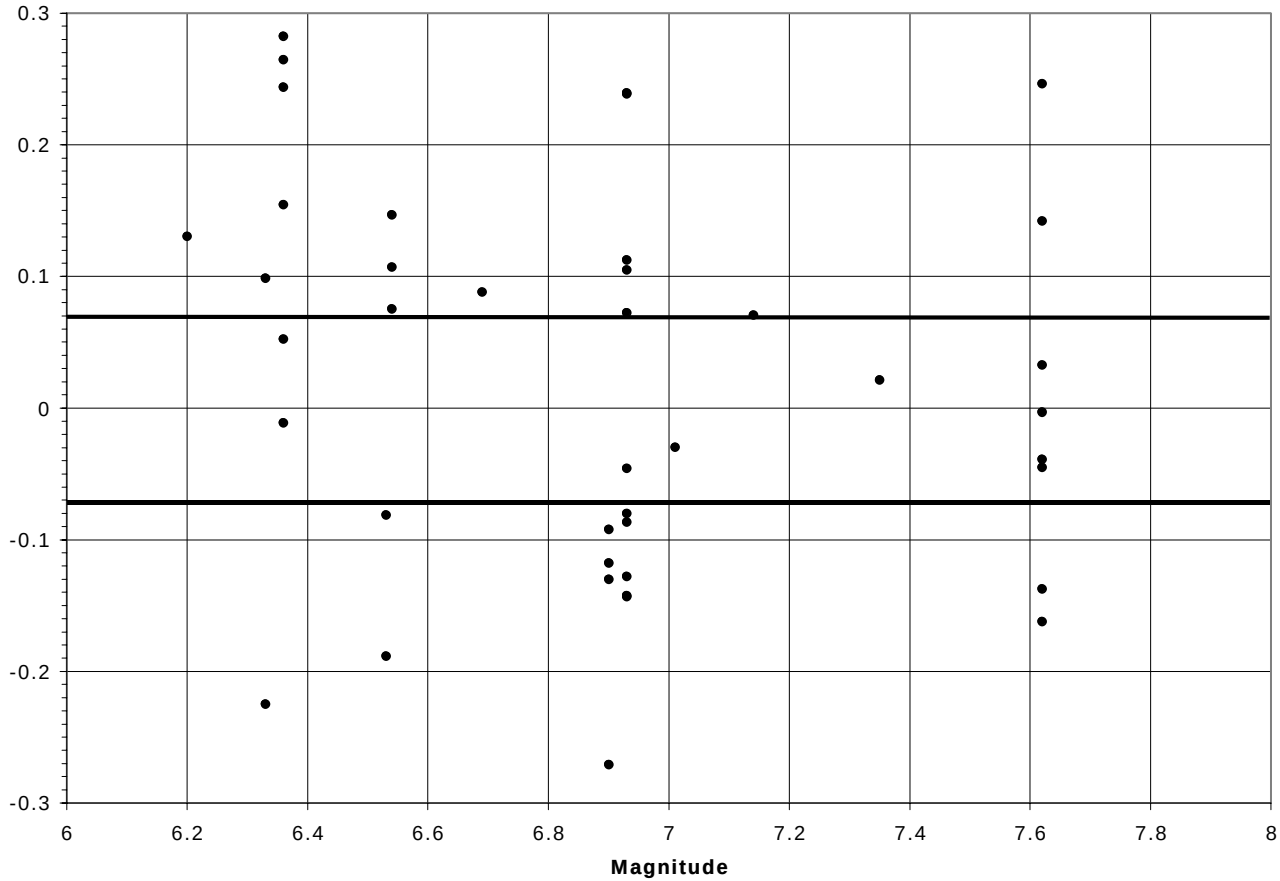
$0.167g < A_{RMS} < 0.204g$

$1.86s < Dur_{ky} < 3.13s$

41 records

Calculate the expected Newmark displacement for each scaled record

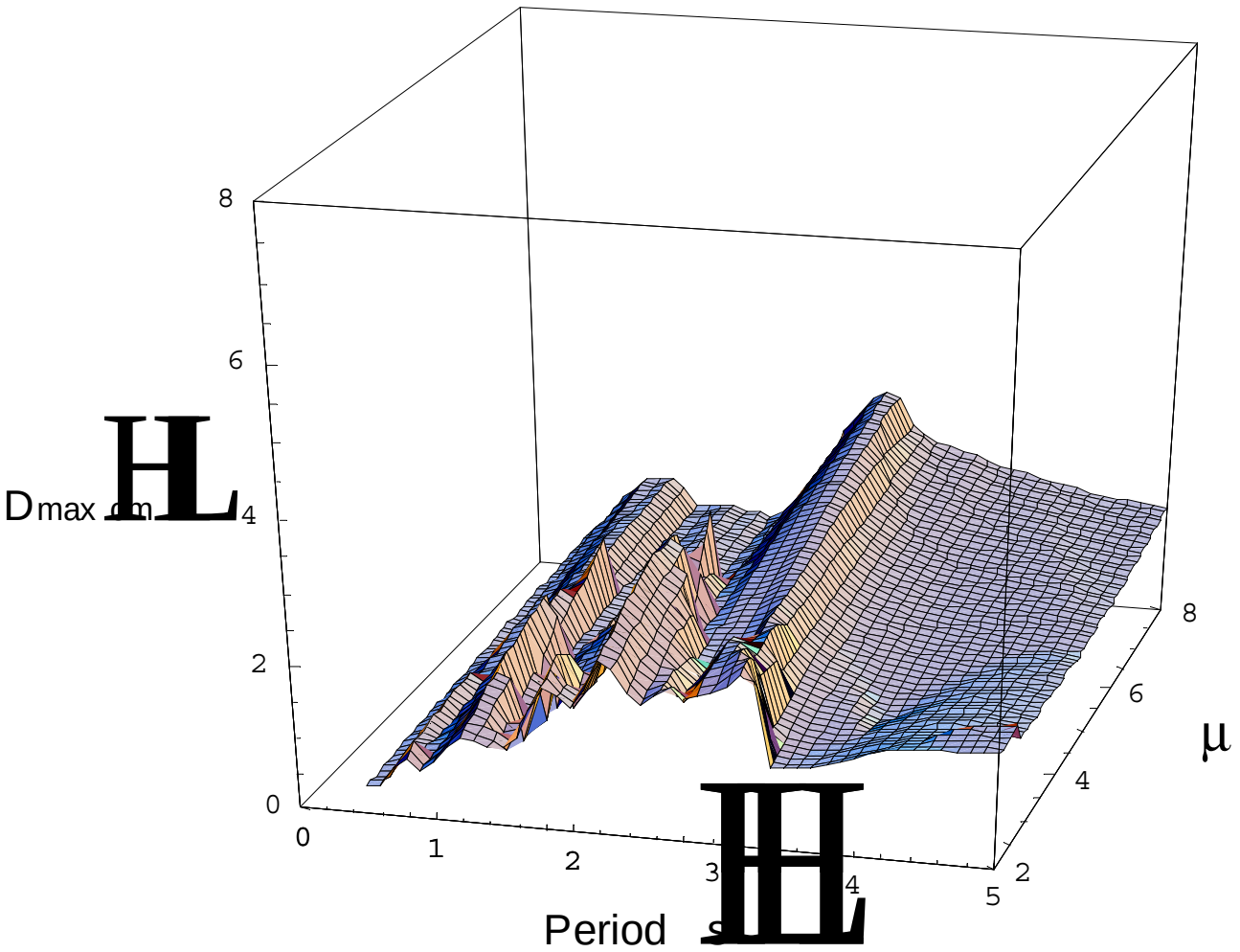
Calculate the difference between the expected displacements and the Design Event Displacement



Evaluation of new IM's... (Watson-Lamprey and Abrahamson)

- Advantages:
  - Allows for a much wider selection of records than magnitude-distance binning
  - Scale factors as large as 20 can be used without bias

Inelastic Disp. Surface Method... (Shantz)



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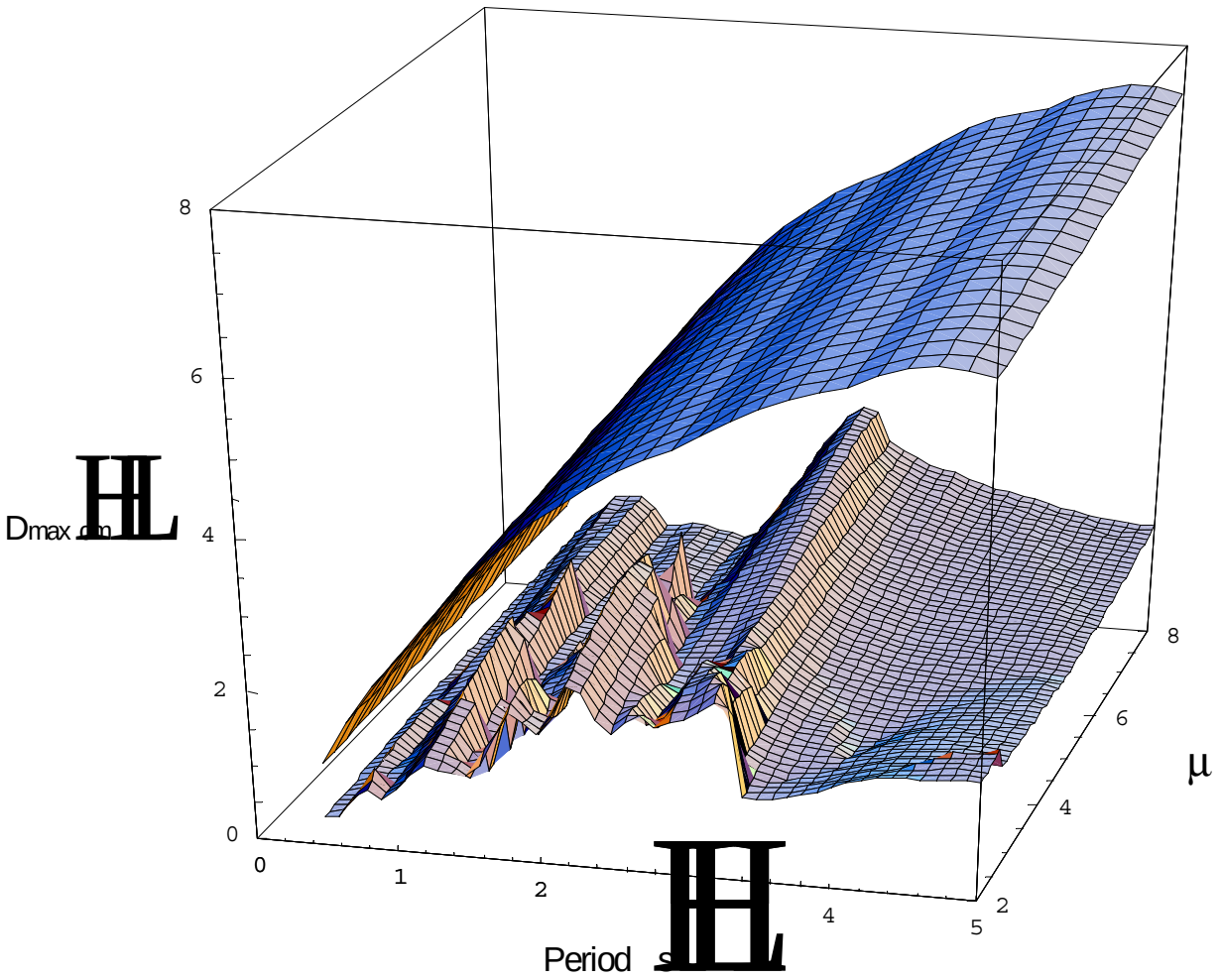

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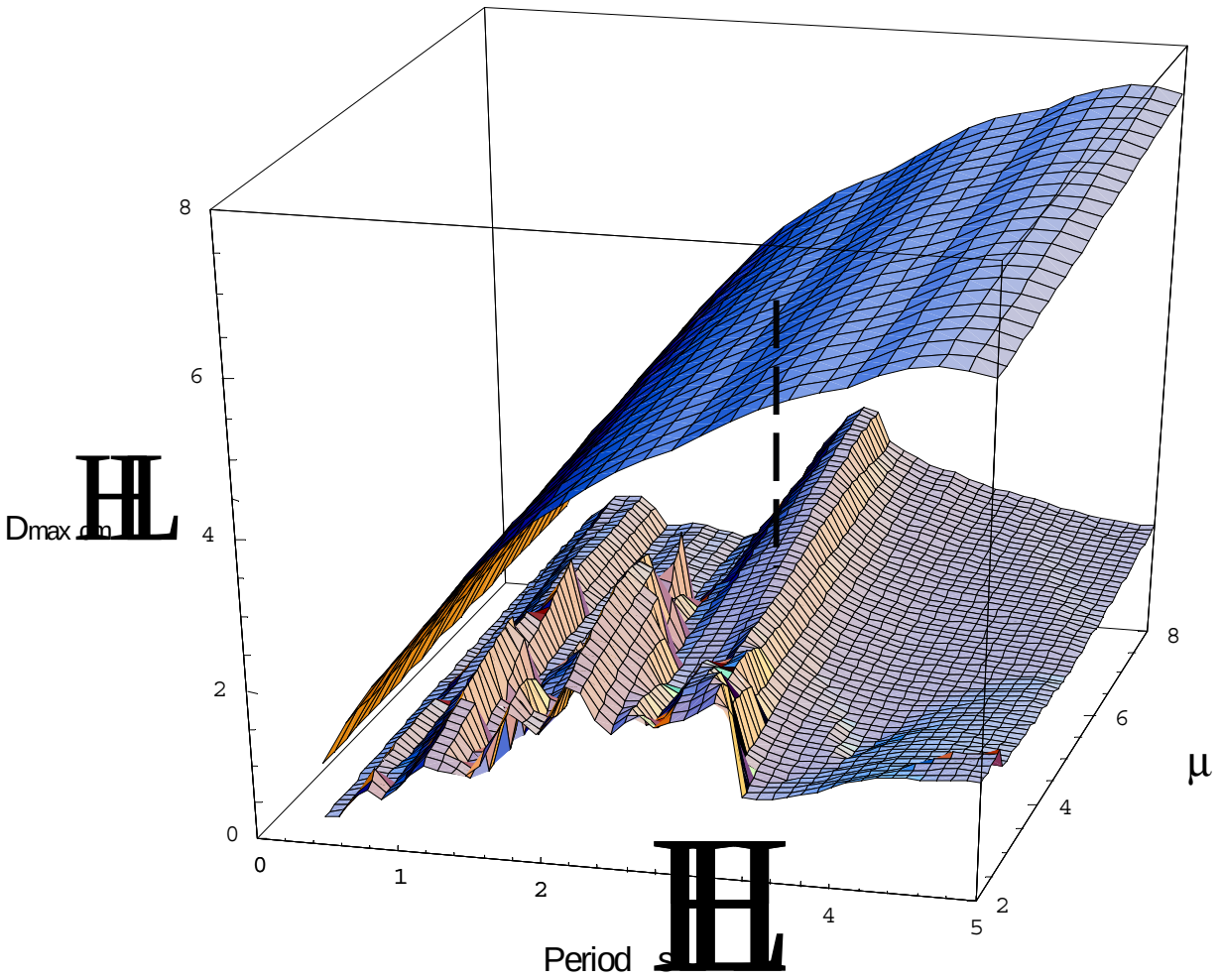

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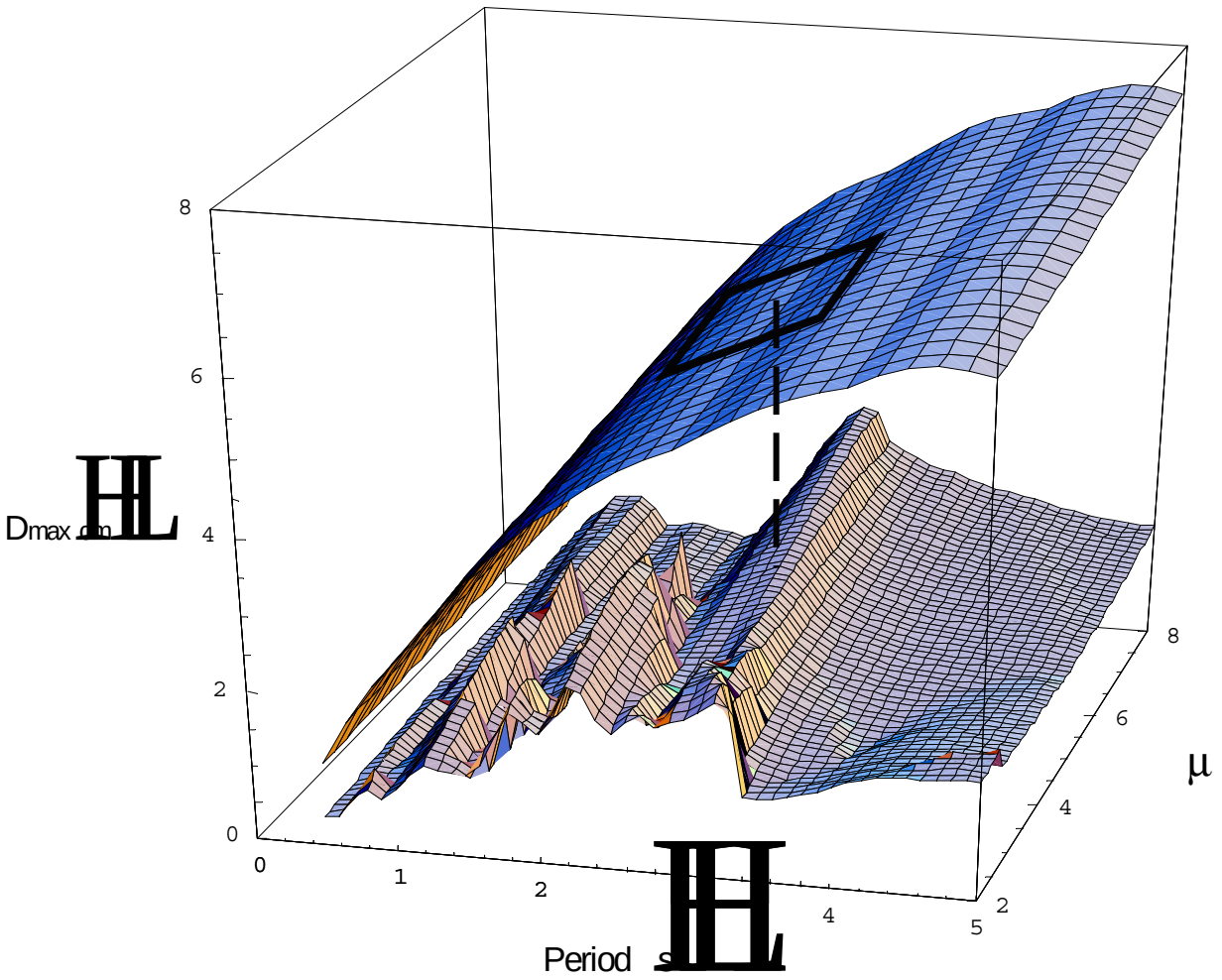

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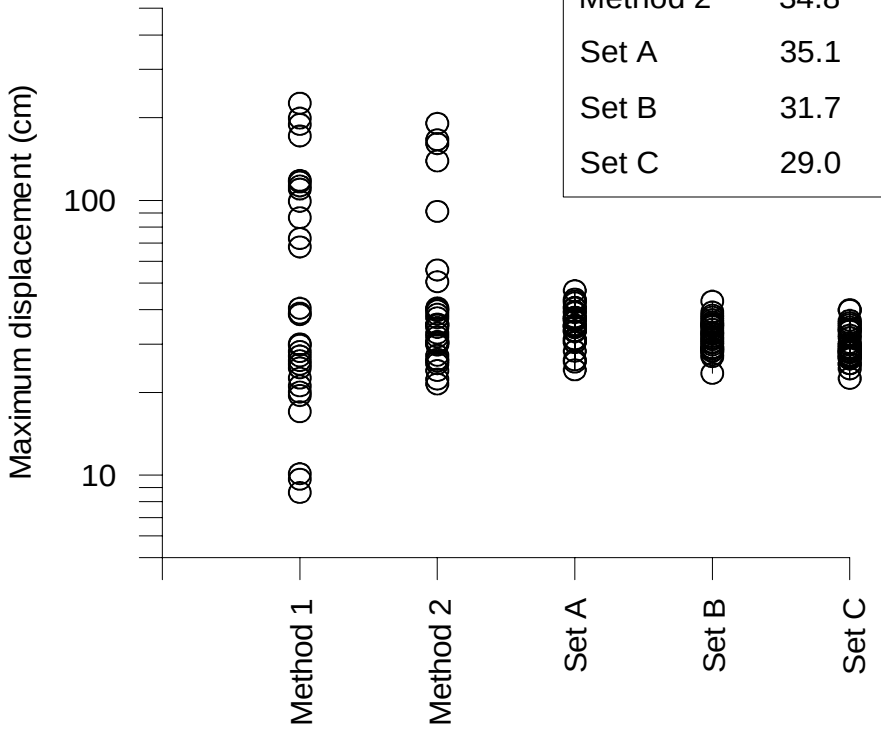

	Median	σ_{ln}
Method 1	34.2	0.95
Method 2	34.8	0.62
Set A	35.1	0.16
Set B	31.7	0.13
Set C	29.0	0.14

Attenuation of Inelastic Spectra (Bozorgnia et al.)