Thoughts on Time History Fitting Criteria to Obtain Reliable Dynamic Results

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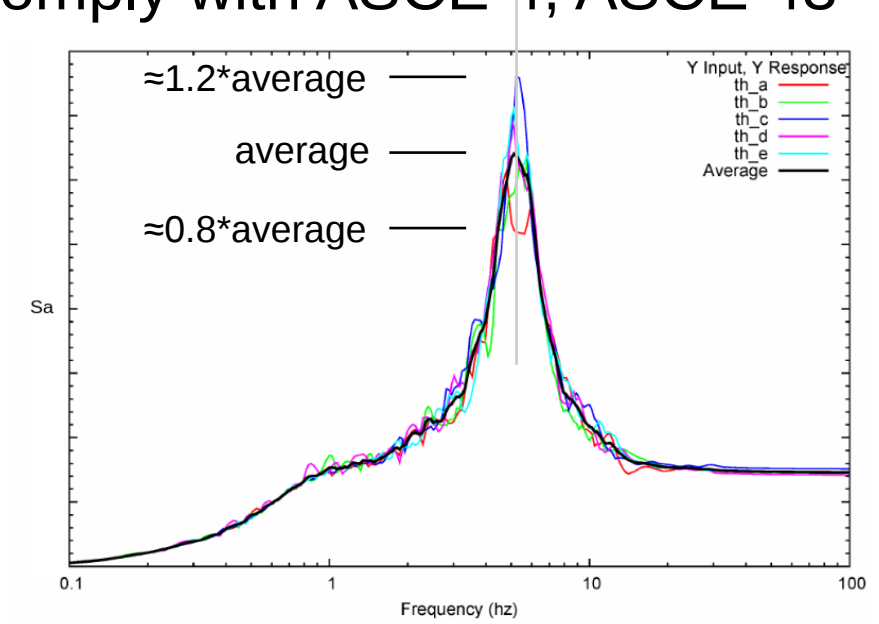
Problem Statement

- ISRS can vary significantly with different time histories
  - Lab Building Roof Spectra,
    - Individual time histories comply with ASCE 4, ASCE 43
    - ± 20% Sa
  - Caused by variations in
    - Fourier amplitude
    - Phase angle



Candidate Solutions

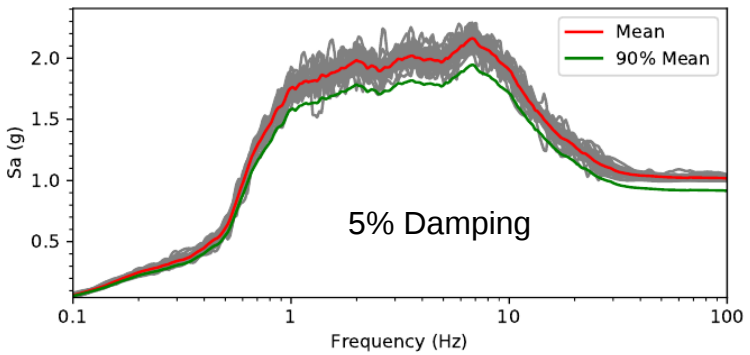
- Use RVT
  - But RVT is benchmarked by TH analysis...
- PSD Check
  - Smoothed PSD may hide variations in Fourier amplitude, ignores phase
  - Target generation is non-trivial
  - Dual criteria leads to more conservative results
- Tighten TH fitting criteria
  - Recommended by NUREG/CR-6728, implemented in ASCE 43-05
- Perform analysis with multiple TH
  - Variations in input power and phase will average out with multiple TH
  - How many TH are required to obtain reliable results?

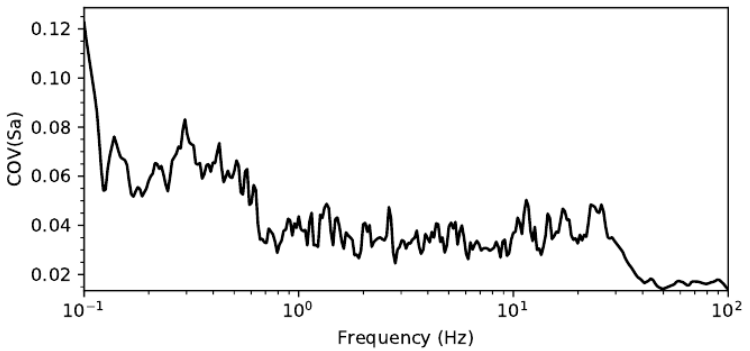
Study: # of TH to Average

- Population of many TH fit to common target spectra
  - Benchmark is the mean structural response spectra
- Randomly select 1, 3, 5, 7, 9 or 11 TH for analysis
  - Amplitude scale to ensure average input meets ASCE 43 criteria
    - Alternately include PSD check
  - Compare mean of 1, 3... structural responses to the benchmark
    - Peak Sa, ZPA
  - Repeat
    - Select 3 out of a population of 32 → ≈5k combinations
    - Select 5 out of a population of 32 → ≈200k combinations
    - Randomly sample 1001 combinations

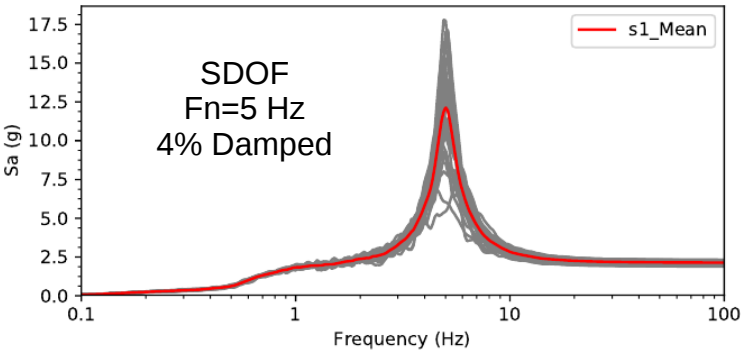
Input and Benchmark

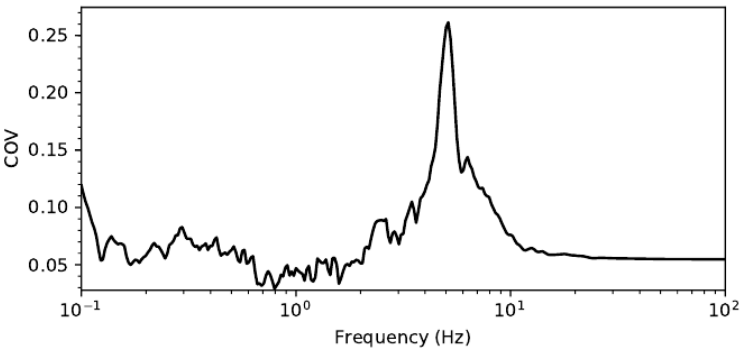
- Input – 32 TH





- Benchmark Response





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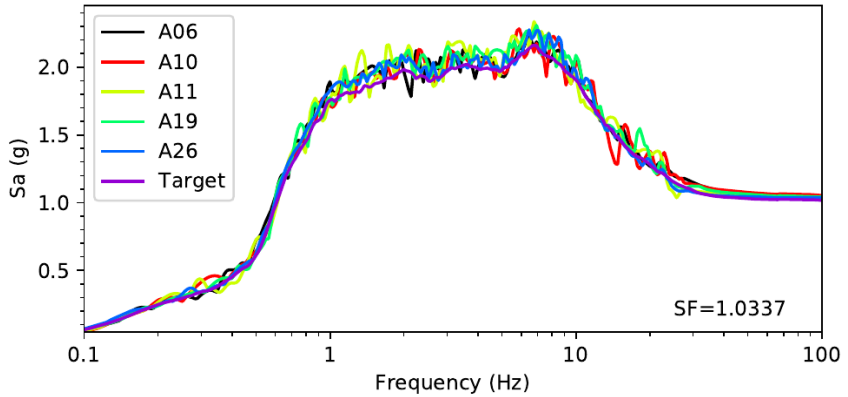
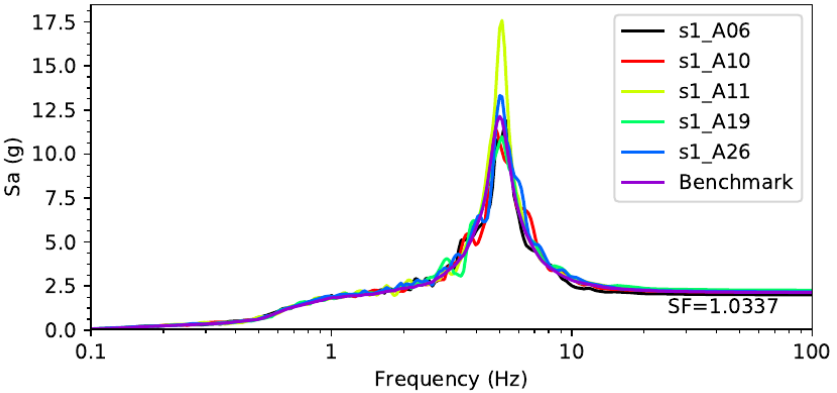
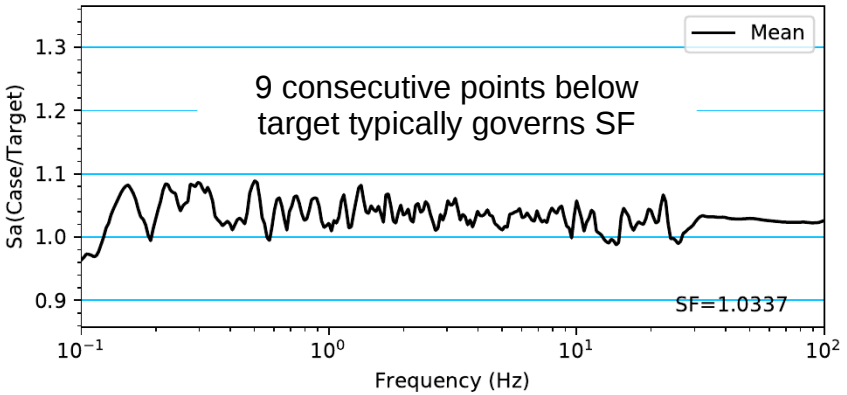
Select, Scale & Calculate Response

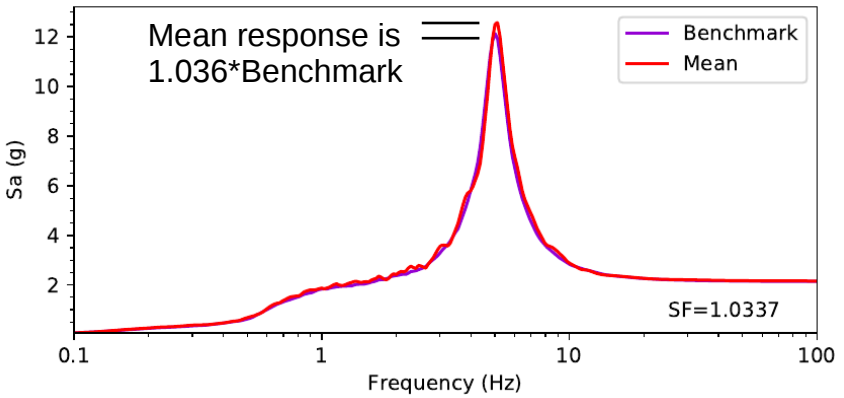
Select 5 Random TH, Input case #1



Response Structure #1







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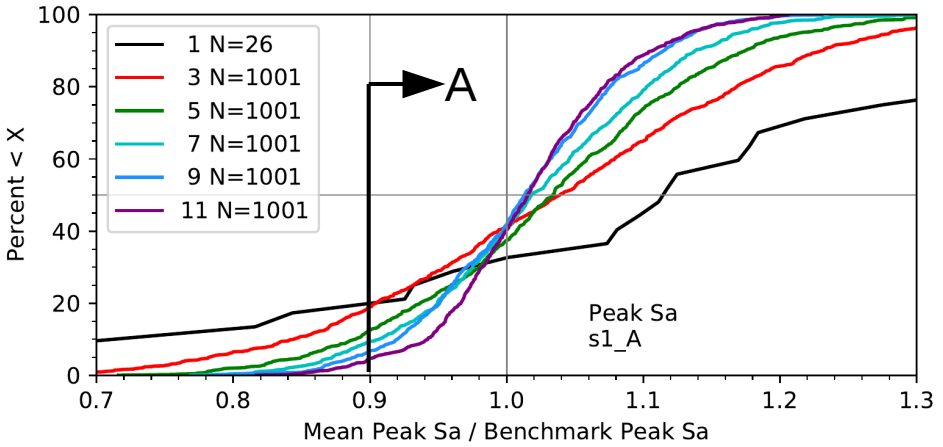
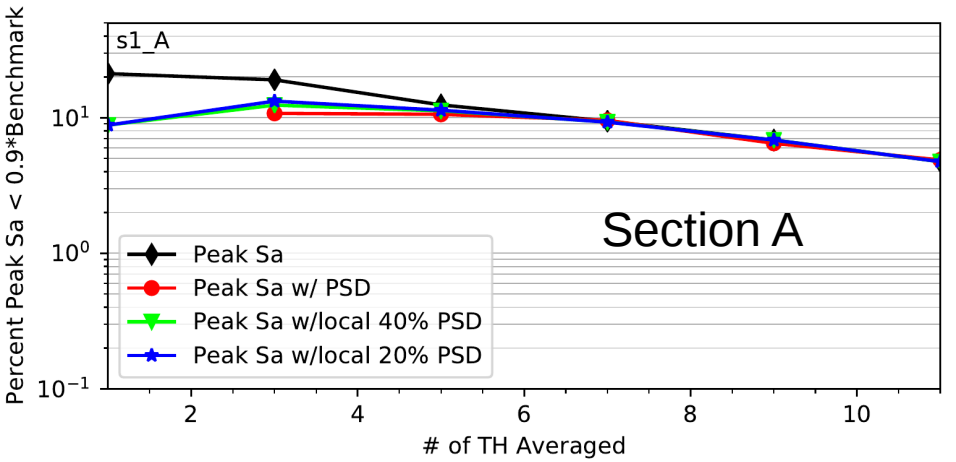
Statistics for 1001 Cases

- On the average
  - 1 TH, 12% conservative
  - 5 TH, 3.4% conservative
- At 90% of Benchmark
  - 1 TH
    - 78% exceedance
    - 91% exceedance w/PSD* ck
  - 5 TH
    - 88% exceedance
    - 89% exceedance w/PSD ck

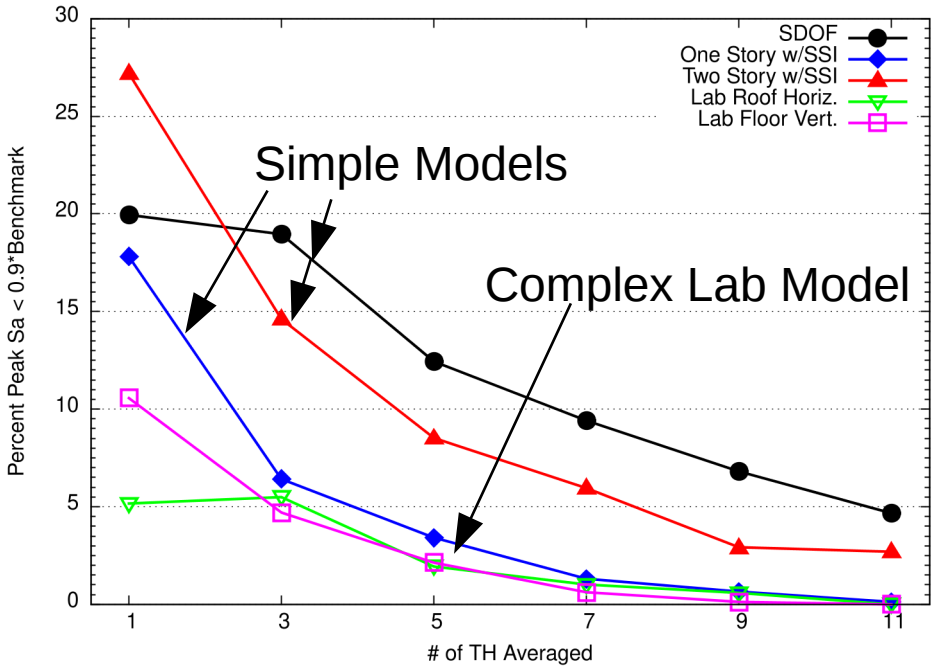




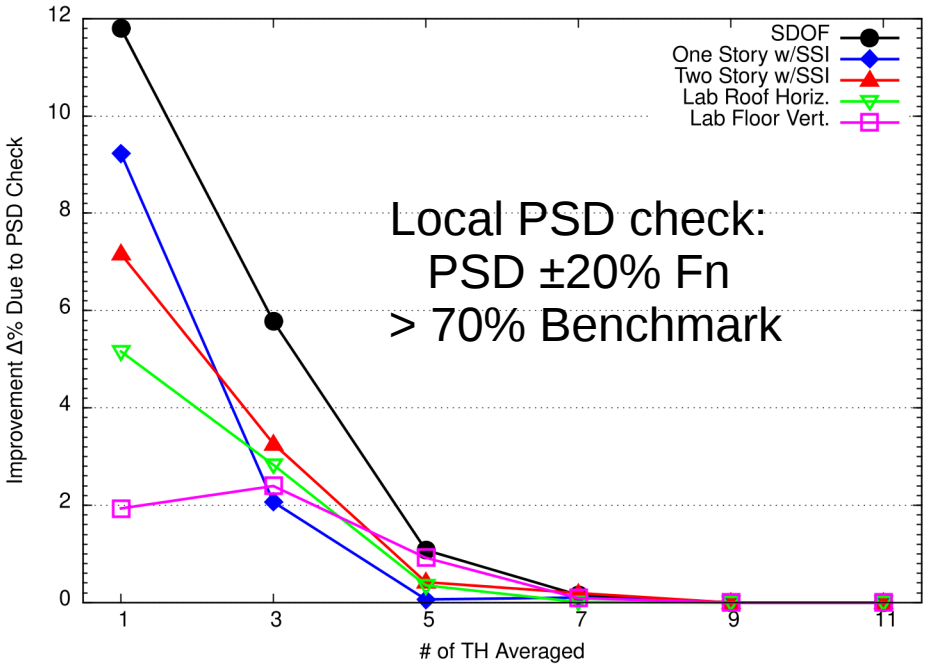
* Local PSD check ±20% from peak

Other Building Models

- Percent runs with Peak Sa < 0.9*Benchmark
  - error



- Improvement Δ% due to Local PSD check



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Response Trends

- Peak acceleration and ZPA are more accurate than peak Sa
- Accuracy increases when more TH are averaged
- Simple models (SDOF, 1 & 2 Story) generally have larger error than complex models (Lab)
- PSD check improves results <2% when 5 or more TH are averaged
  - PSD check does improve response when 1 or 3 TH are averaged
- Future Work
  - Expand building models
  - Expand TH sets
  - Evaluate alternate TH fitting criteria
    - 7, or 5 consecutive points below Target
    - Lower limit of 95% Target
    - ...