Thesis outline: Validation of ground motion simulations via response history analysis of complex seismic systems

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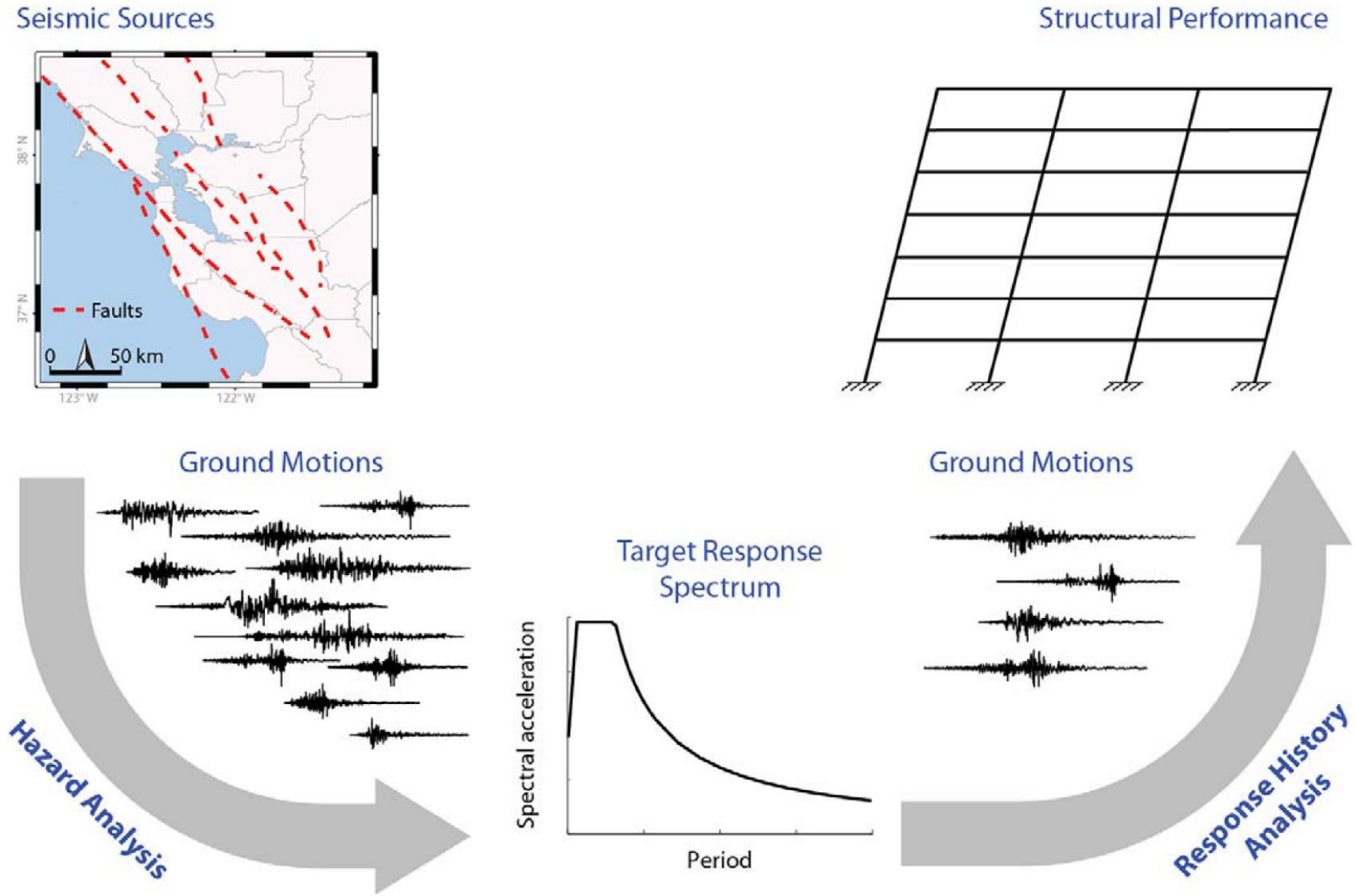
Background: Applications Of Ground Motions

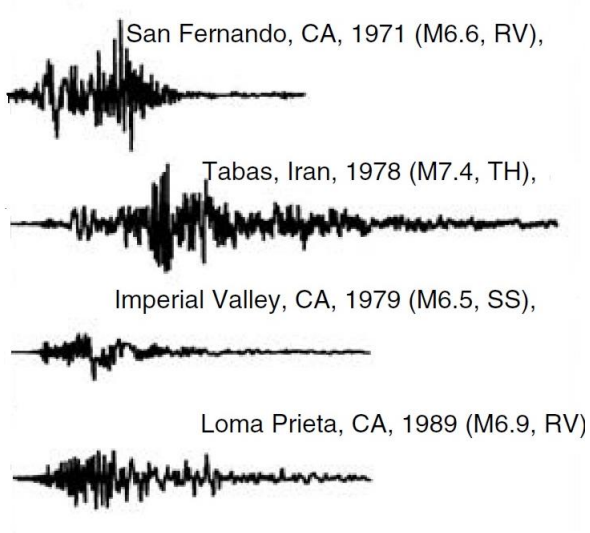


Bradley et. al. (2017)

Ground Motions in Response History Analysis

Challenges:

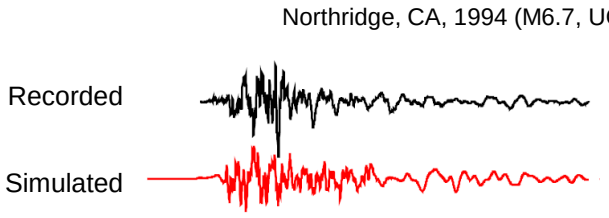
- ✓ Scarcity of ground motion representing the specific-site hazard
  - Using scaled historical ground motions?!
- ✓ Restrictions:
  - Incompatibility of selected ground motions
  - Large variability in selected ground motions from empirical databases



Bozorgnia and Bertero (2004)

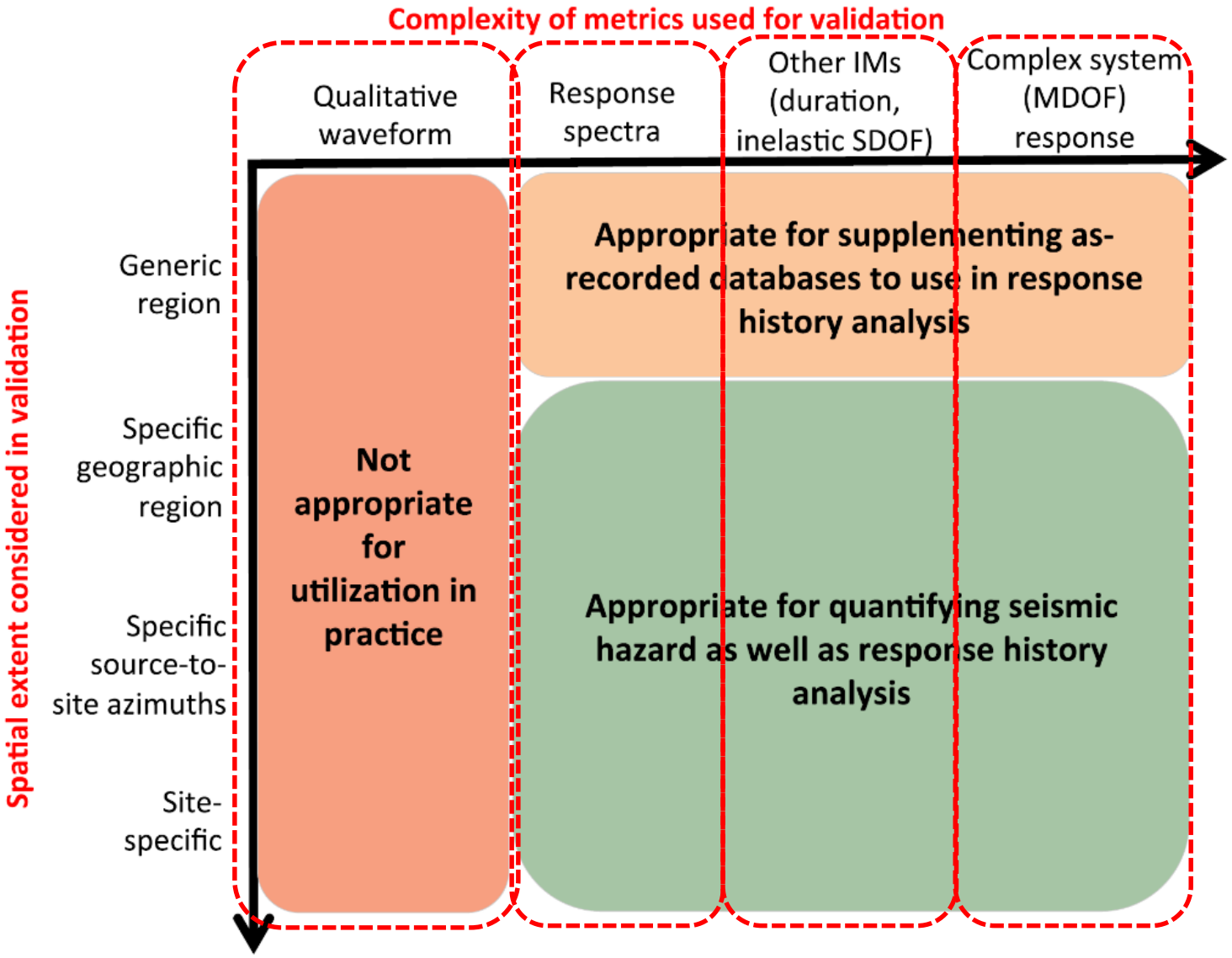
Utilizing simulated ground motions:

- Necessity of validation



Graves and Pitarka (2010)

Validation Matrix:



Bradley et. al. (2017)

Thesis Outline

Title: Validation of ground motion simulations via response history analysis of complex seismic systems

- ✓ **Objective 1:** Code-based validation of ground motion simulation
- ✓ **Objective 2:** Validation of simulated GM by comprehensive analysis of archetypical buildings
- ✓ **Objective 3:** Develop “Automated” workflow for validation using MDoF systems
- ✓ **Objective 4:** Seismic performance assessment using simulated ground motions

Thesis Outline

Title: Validation of ground motion simulations via response history analysis of complex seismic systems

✓ **Objective 1:** Code-based validation of ground motion simulation

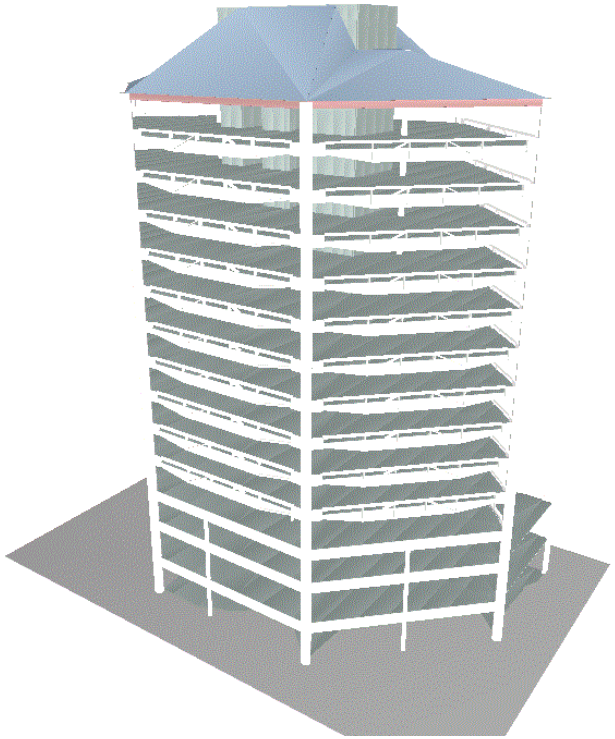
- Validation in the context of industry application
- Similar procedures in analysis and design common in practice
- NZ-1170.5 standard (structural design actions)
- Finite elements models commonly used by engineers
- Typical seismic responses by designers (e.g. Drift…)

Progress on objective 1: Code-based validation of ground motion simulation

Case Study:

- Two real buildings
- Located in Christchurch
- Building A:
  - ✓ 7-story, T_n= 0.5 sec
  - ✓ RC Frame + Shear Wall
- Building B:
  - ✓ 13-story, T_n= 2 sec
  - ✓ Steel Frame + Shear Wall
- Responses:
  - ✓ Inter-story drift ratio (IDR)
  - ✓ Peak floor acceleration (PFA)

Building A



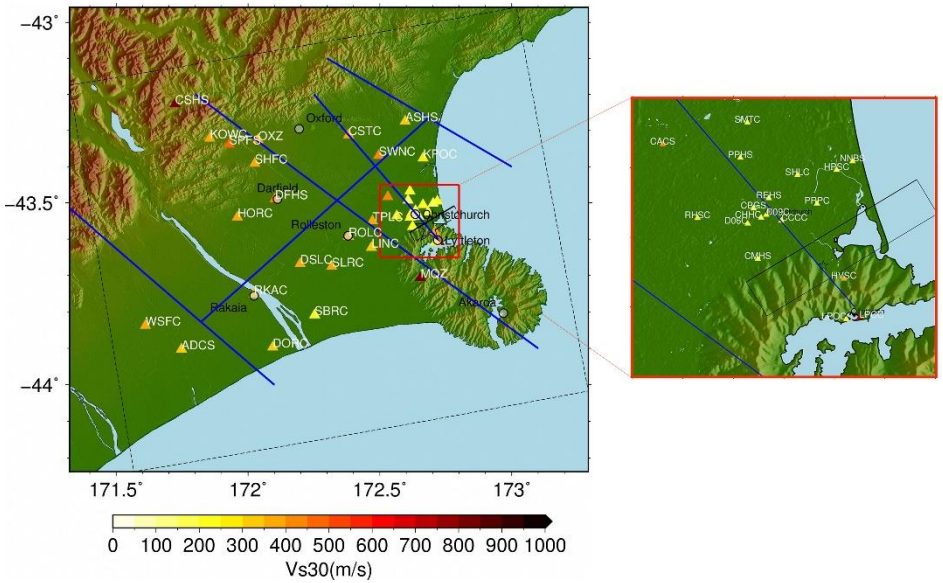
Building B

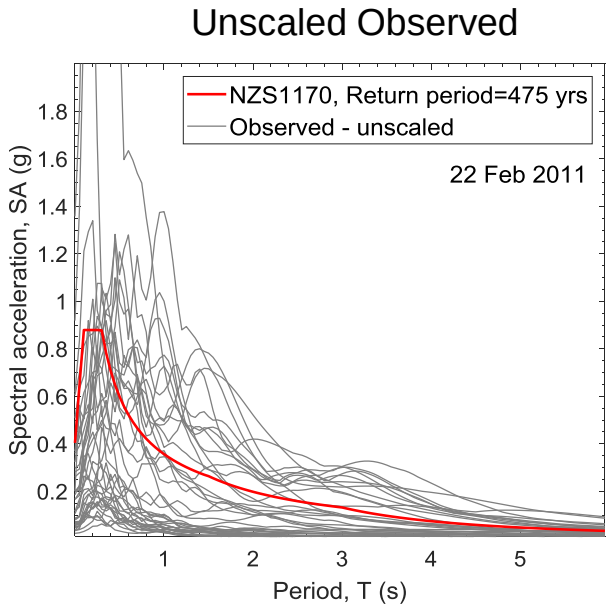
Acknowledgment: Holmes Consulting Engineering Company

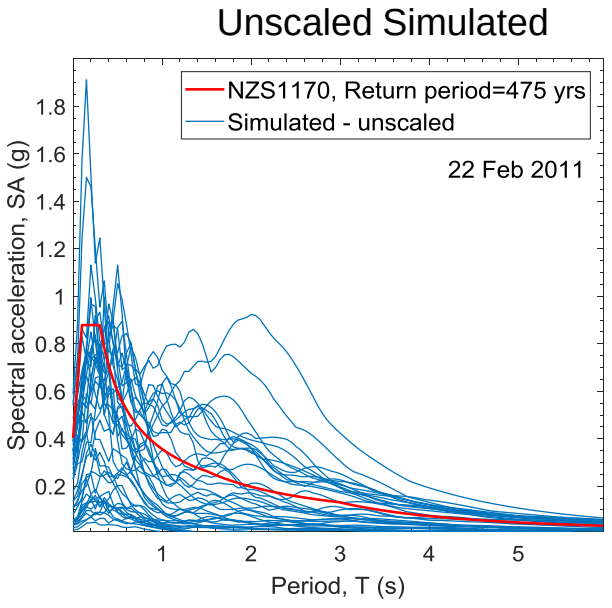
Progress on Objective 1: Code-based validation of ground motion simulation

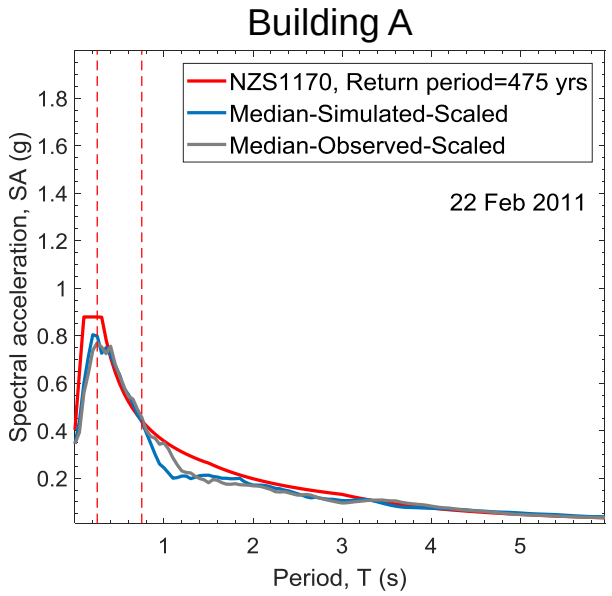
Ground Motions:

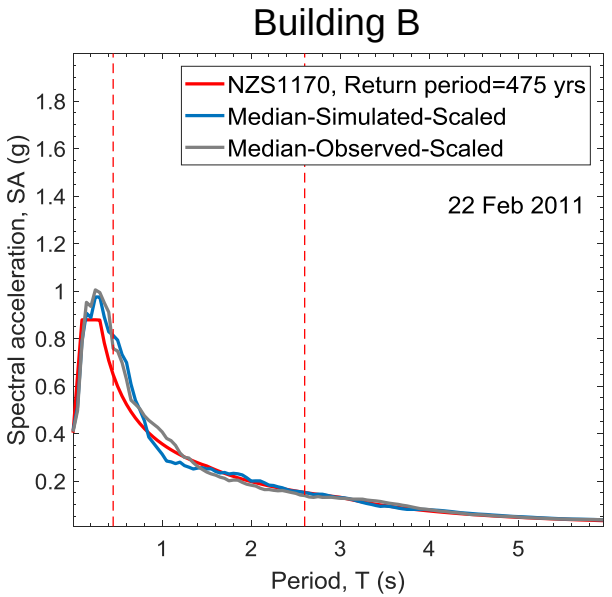
- 22 Feb. 2011 Christchurch Eq.
- 40 Stations (Observed and Simulated)
- Scaled based on NZ-1170.5





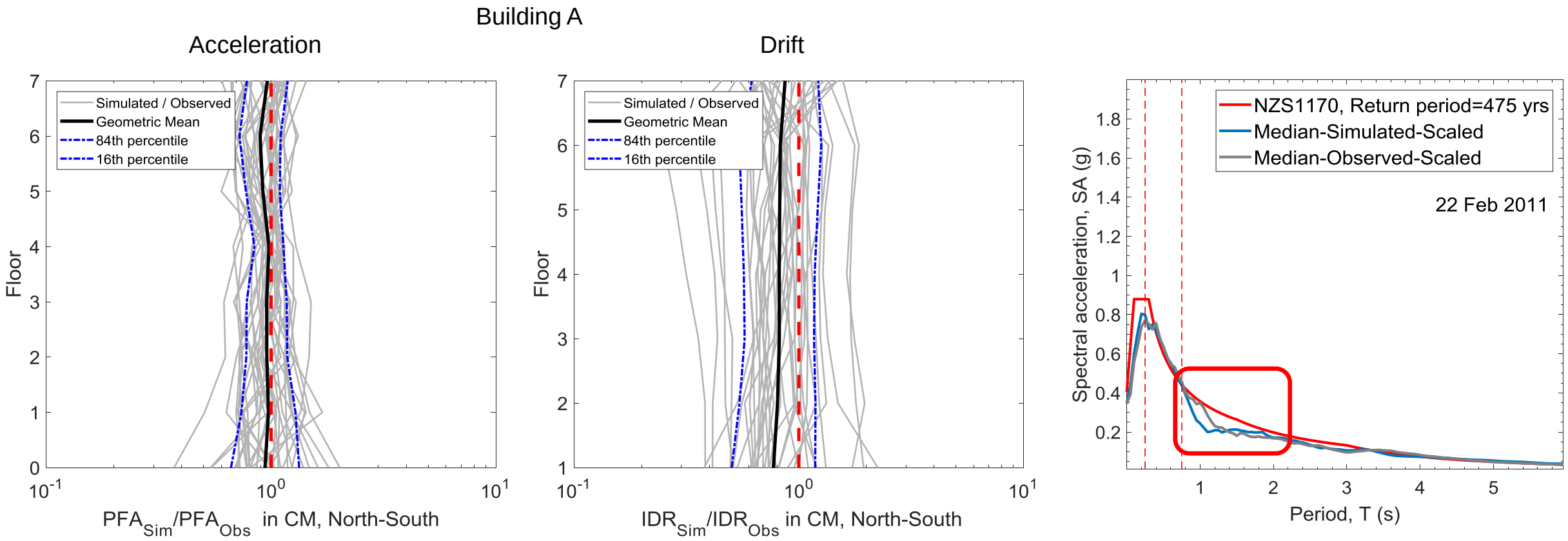






Progress on Objective 1: Code-based validation of ground motion simulation

Comparison between the EDPs for scaled Sim/Obs GMs:

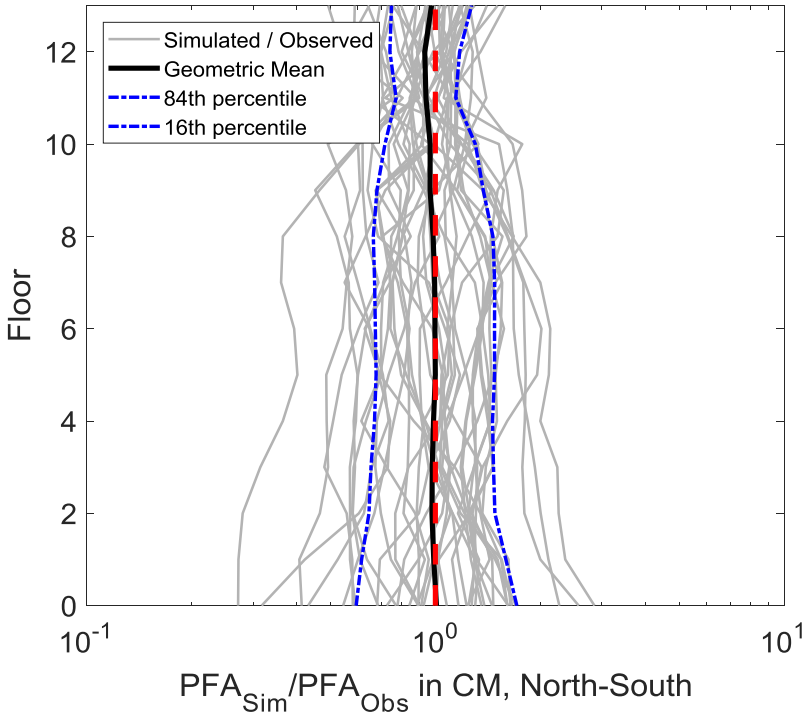


Progress on Objective 1: Code-based validation of ground motion simulation

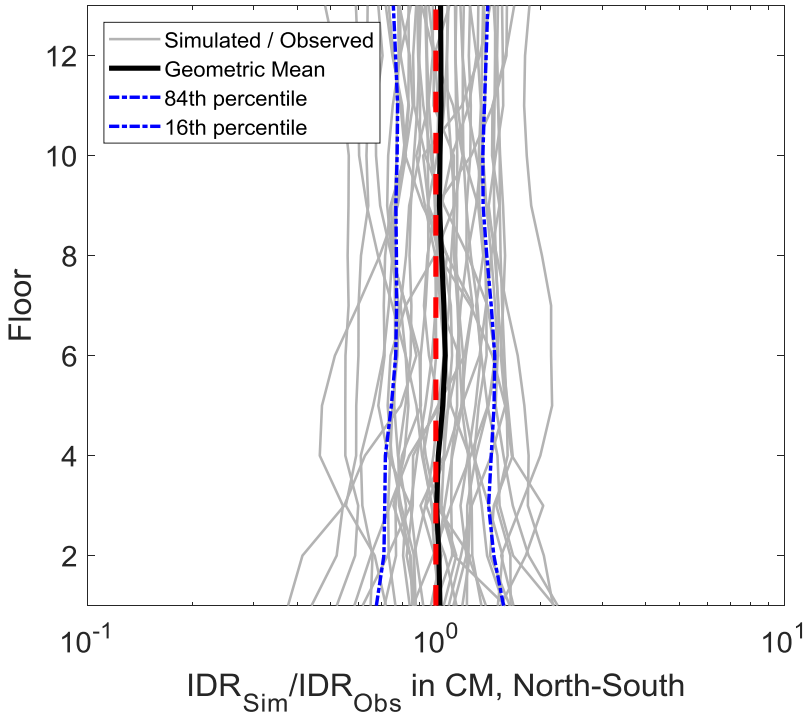
Comparison between the EDPs for scaled Sim/Obs GMs:

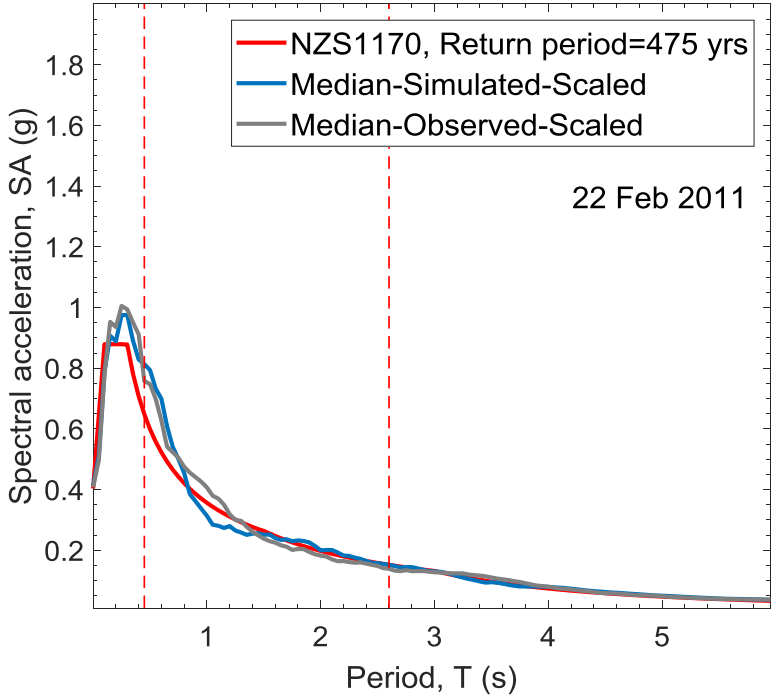
Building B

Acceleration



Drift

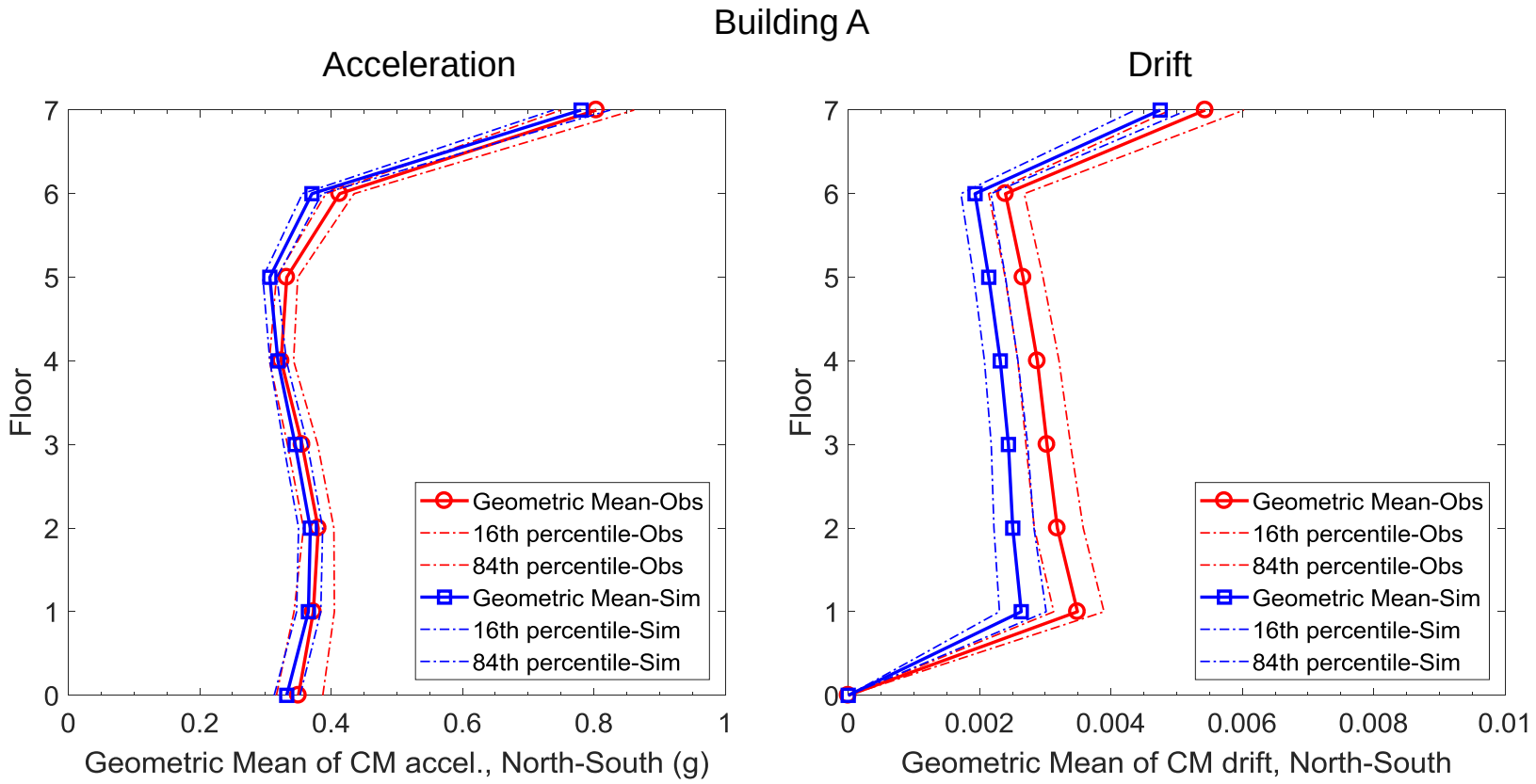




Progress on Objective 1: Code-based validation of ground motion simulation

Comparing EDPs variability due to the record-to-record variability:

- Bootstrap sampling
- T-test for comparison



Result:

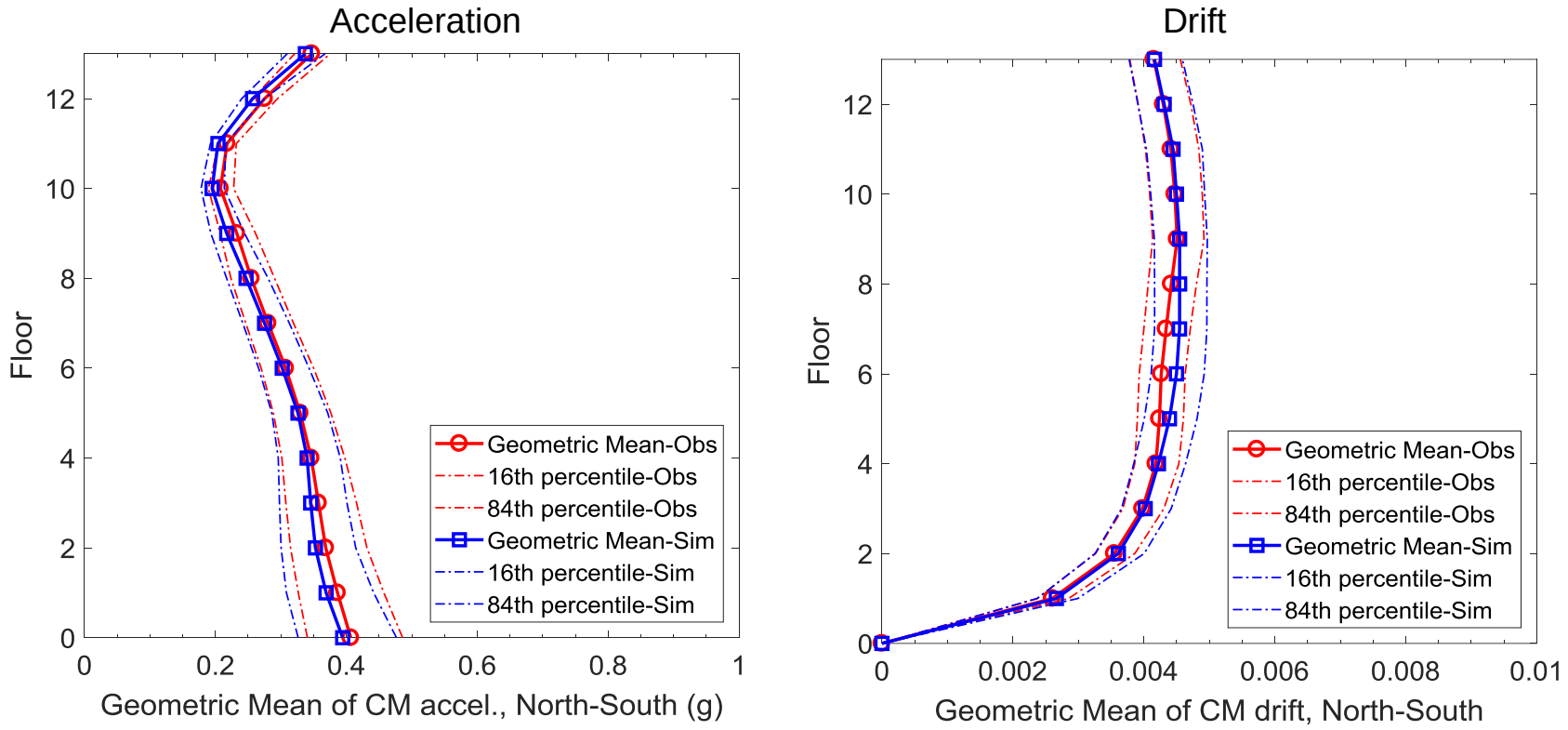
- Comparable PFA for Building A
- Statistically Significant difference in IDR Building A

Progress on Objective 1: Code-based validation of ground motion simulation

Comparing EDPs variability due to the record-to-record variability:

- Bootstrap sampling
- T-test for comparison

Building B



Result:

- Comparable responses for Building B

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✓ **Objective 2:** Validation of simulated GM by comprehensive analysis of archetypical buildings

- Different types of structures in terms of material, load carrying system
- Rigorous models (Nonlinearity, degradation…)
- Different types of Engineering Demands Parameter (EDPs)
- Different types of Intensity Measures (IMs)
- Pre-collapse and collapse levels
- Covering 4th columns of validation matrix (Complex Systems)

Thesis Outline

Title: Validation of ground motion simulations via response history analysis of complex seismic systems

- ✓ **Objective 3:** Develop “Automated” workflow for validation using MDoF systems
  - Make it a routine process
  - Comparing different methods of ground motion simulation
- ✓ **Objective 4:** Seismic performance assessment using simulated ground motions
  - Validation at different hazard levels by selecting simulated ground motions