Validation of Ground Motion Simulations via Response History Analysis of Complex Seismic Systems

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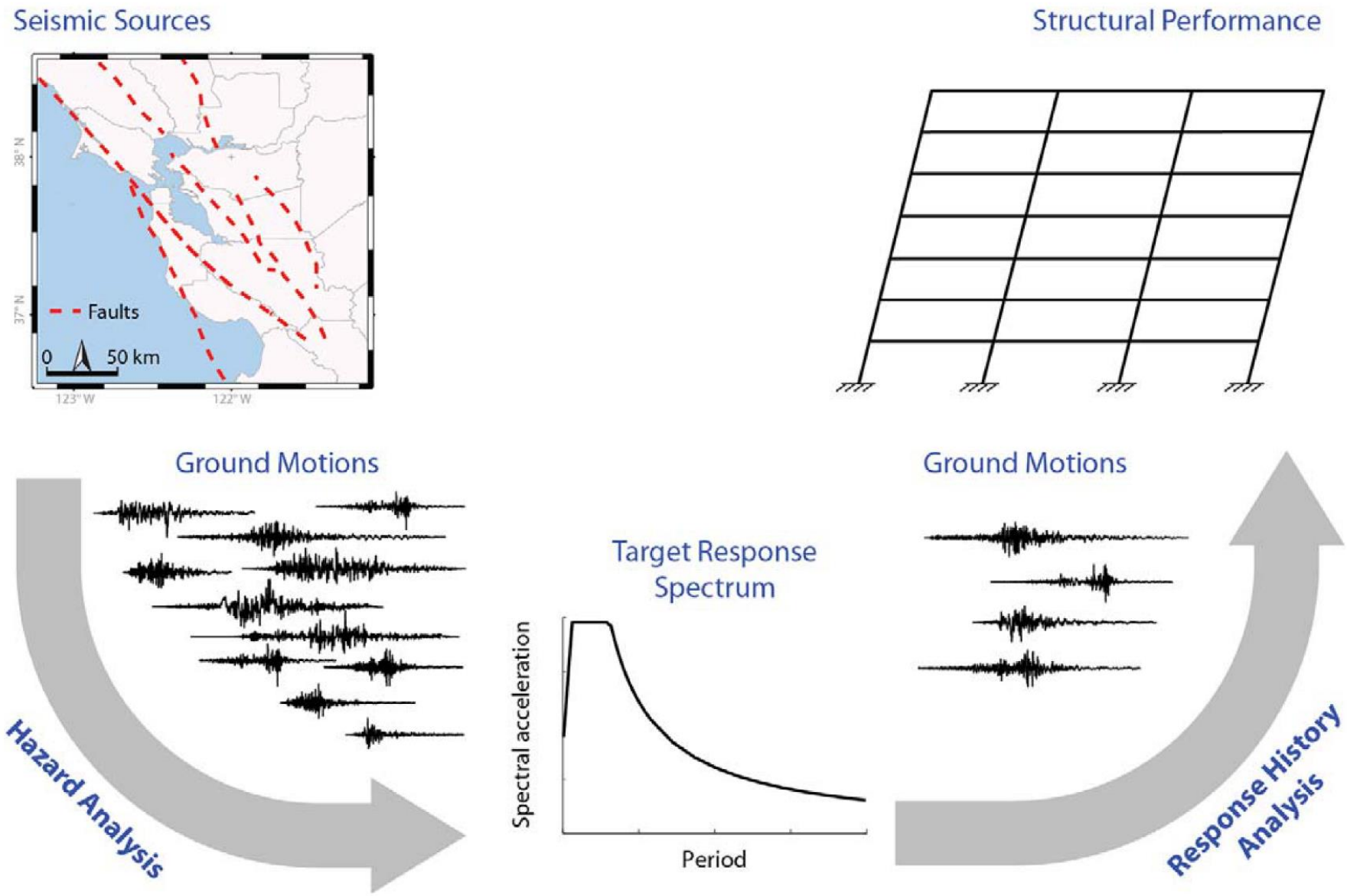
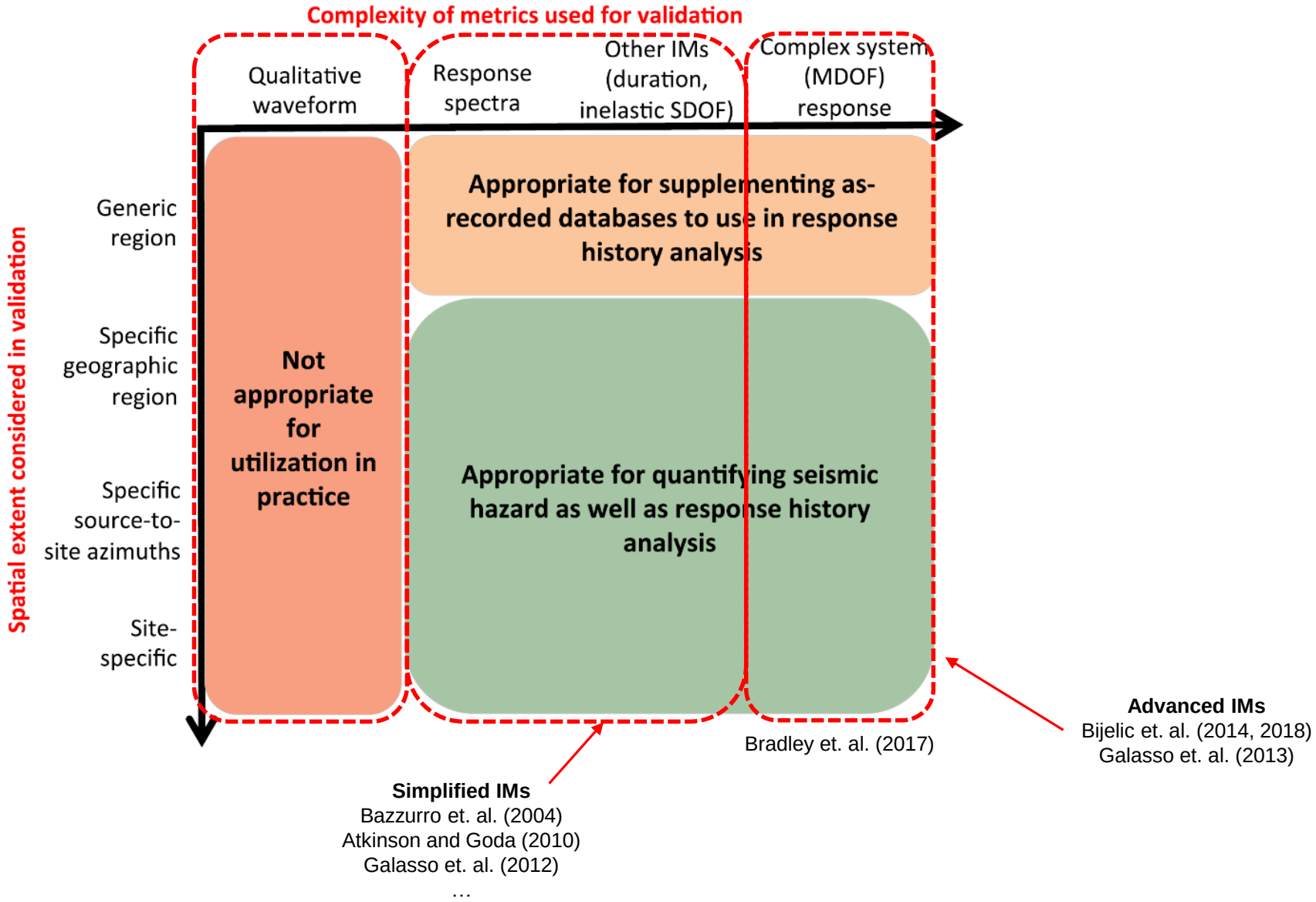
Applications Of Ground Motions



Bradley et. al. (2017)

Validation Matrix



Objective

✓ **Objective :** Validation of simulated GMs by comprehensive analysis of archetypical engineered systems

- **Different ground motion (GM) sets:** Historical earthquakes in NZ
- **Different GM simulation methods** (2010-2020)
- **Different types of Models:**

  Building structures: High-rise to low-rise buildings, 3D models…

  Different structural systems/material : MRFs, braced systems, Shear wall… Concrete, steel…

  non-building structures: bridges…

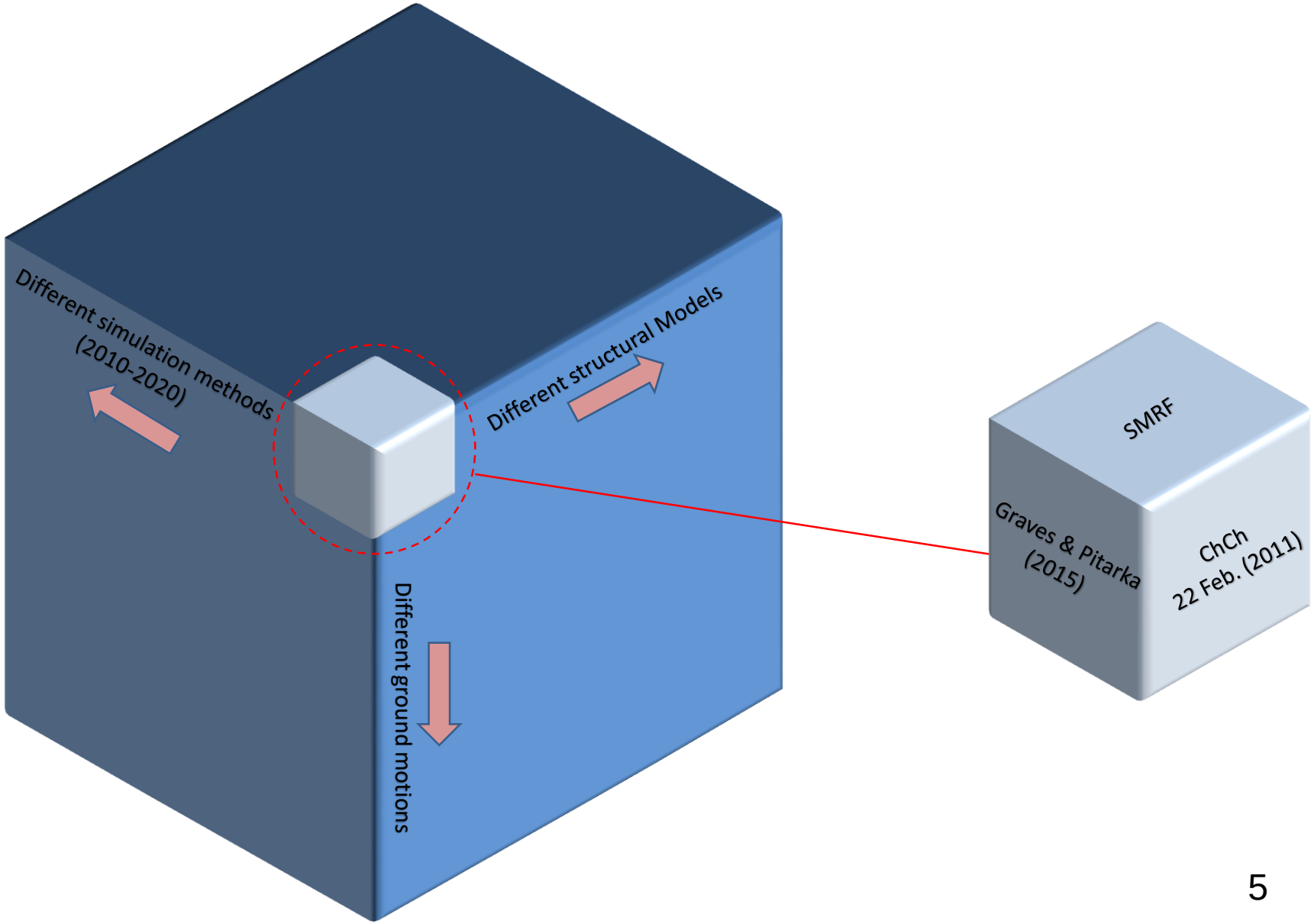
  geotechnical systems/SSI: 1D soil profile, bridge abutment model…

- **Advanced types of Intensity Measures (IMs):**
  Covering 4th columns of validation matrix (Complex Systems)

Aspects of objective

Aspects of objective:

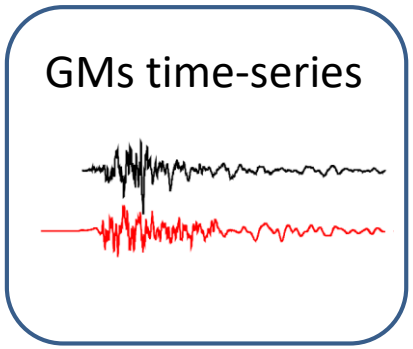
- Different ground motions
- Different structural models
- Different simulation methods



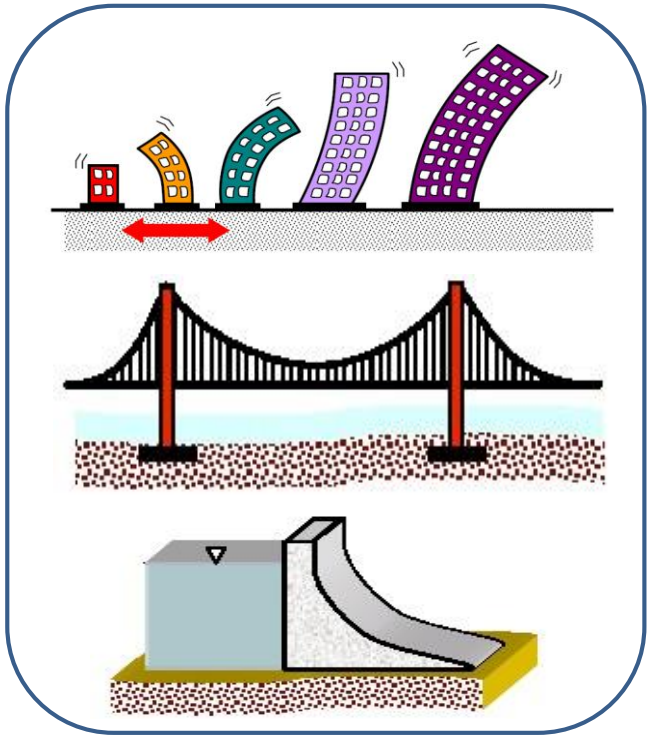
Automated Workflow

✓ **Automated workflow :**

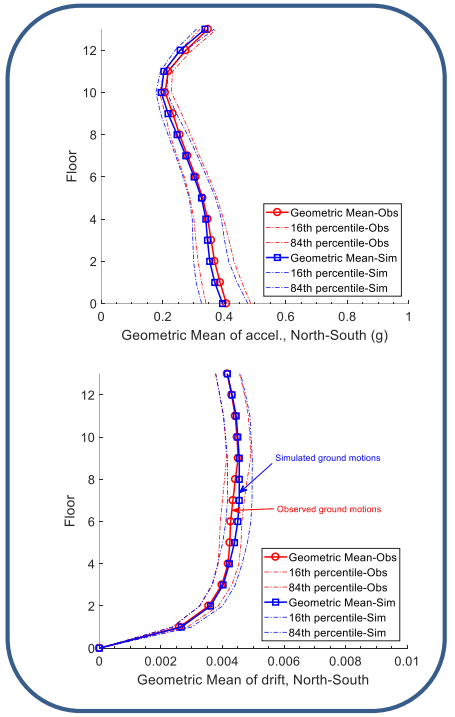
- Develop “Automated” workflow for validation advanced IMs
- Convert the validation procedure to a routine process
- Provide a platform to perform complex validation process promptly



Inputs

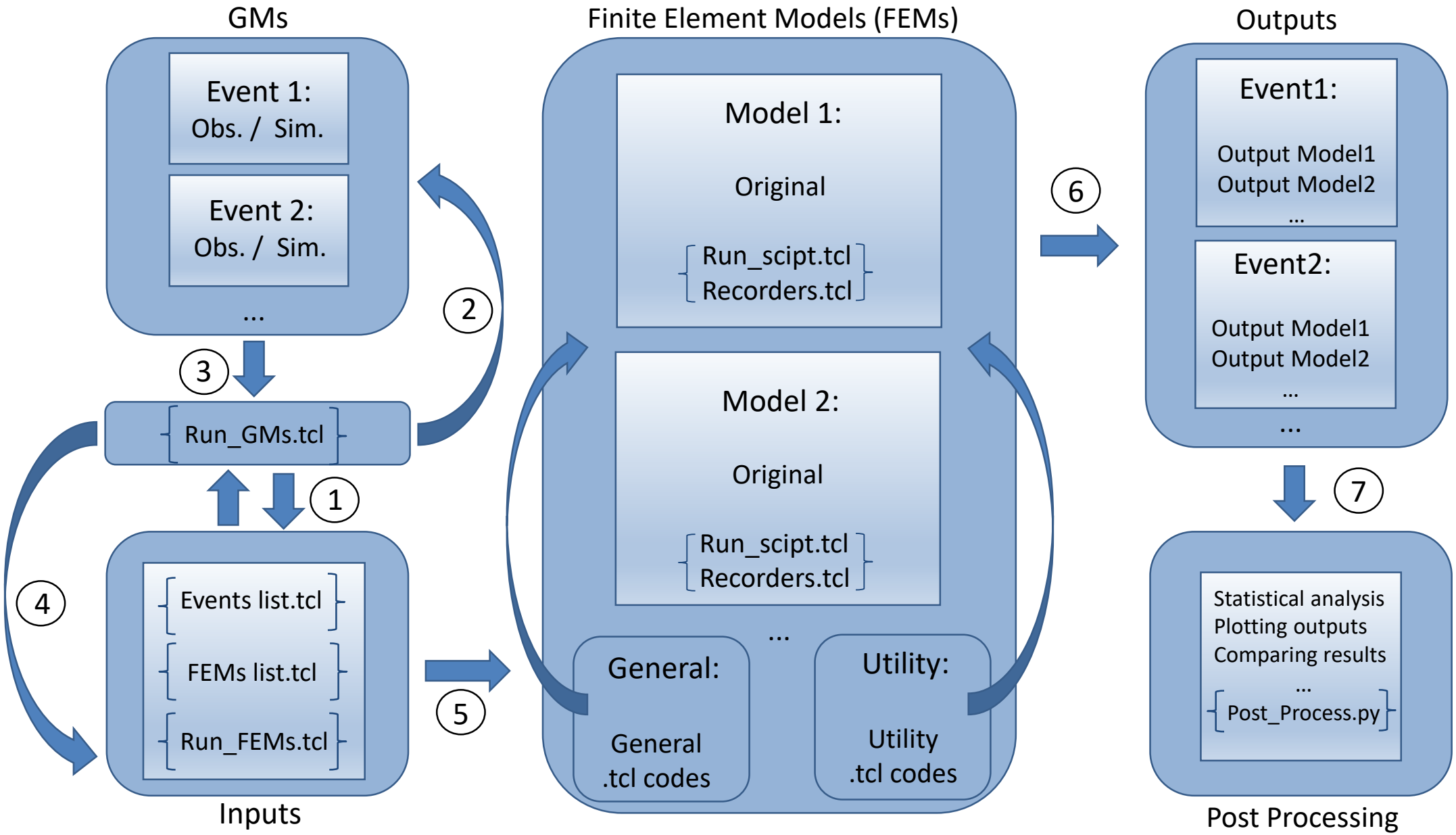


Finite Element Models (FEMs)



Outputs/Post Processing

Automated Workflow internal layout

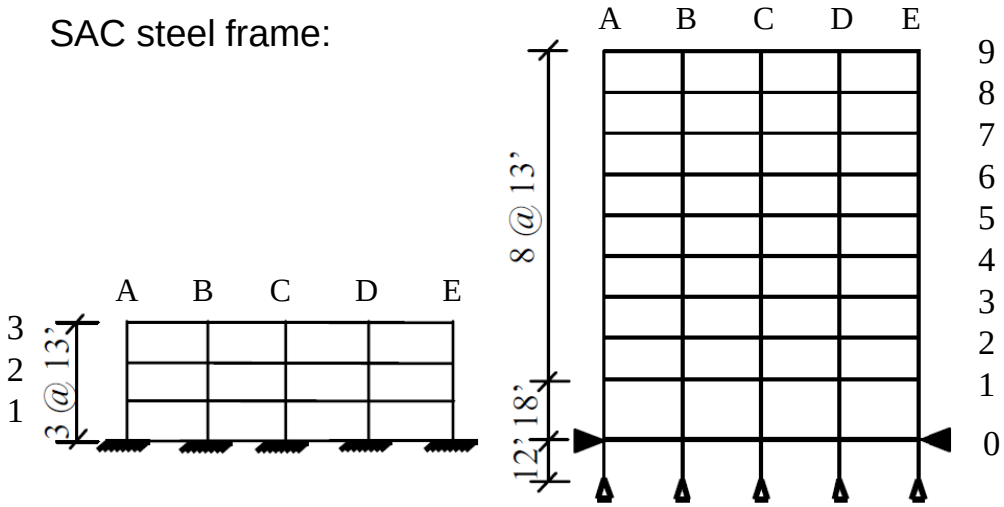


Case study: FEMs properties

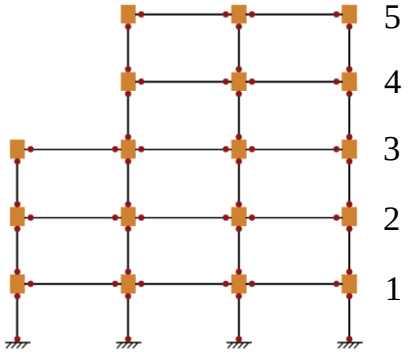
Case study:

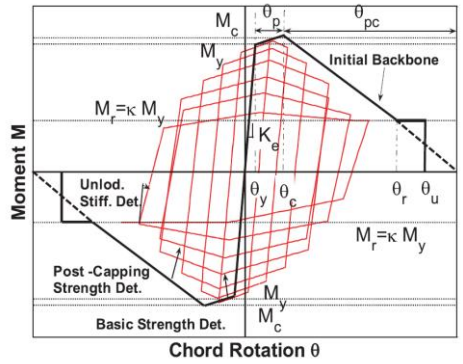
- Three SMRF archetypes
  - ✓ 3-storey, T_n= 0.98 sec, located in Seattle.
  - ✓ 9-storey, T_n= 2.95 sec, located in Seattle.
  - ✓ 5-storey, T_n= 1.64 sec, located in San Francisco.
- Nonlinear Model:
  - ✓ Elastic Elements Lumped Plastic Hinges
  - ✓ Modified Ibarra-Medina-Krawinkler hysteretic model
- Responses :
  - ✓ Inter-story drift ratio (IDR)
  - ✓ Peak floor acceleration (PFA)
- Software:
  - ✓ OpenSees 2.5.0

SAC steel frame:



a) 3-storey b) 9-storey





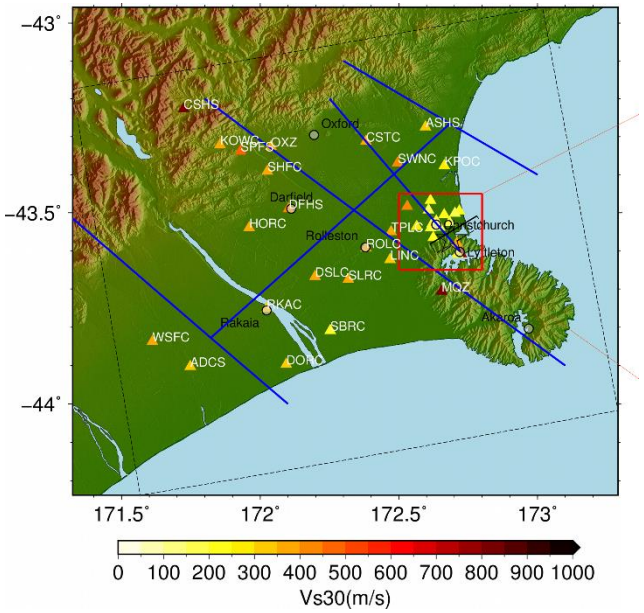
c) 5-storey d) hysteretic model

Case study: GMs properties

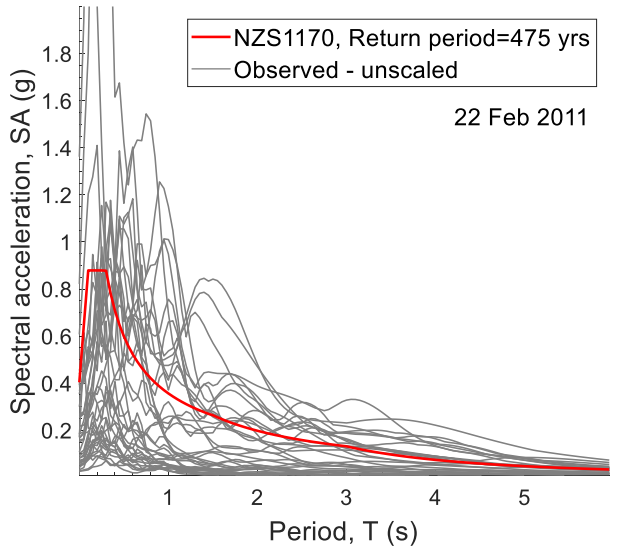
Ground Motions:

- 22 Feb. 2011 Christchurch Eq.
- 40 stations (Observed and Simulated)
- Hybrid Broadband Method for simulation
- Unscaled sets of GMs.

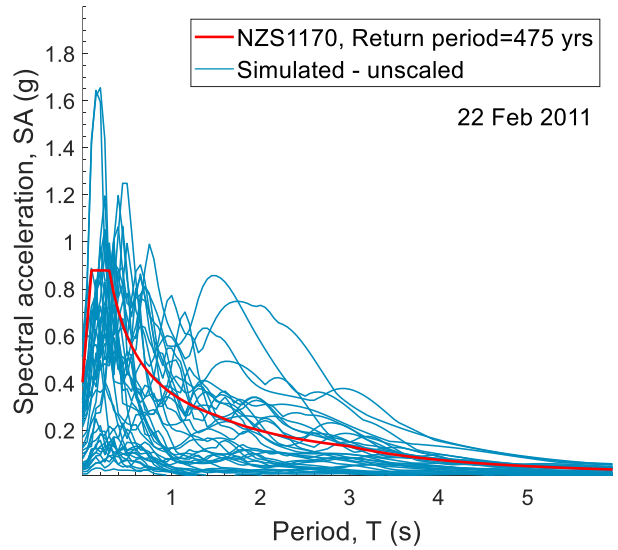
Stations-Vs30 map



Unscaled Observed



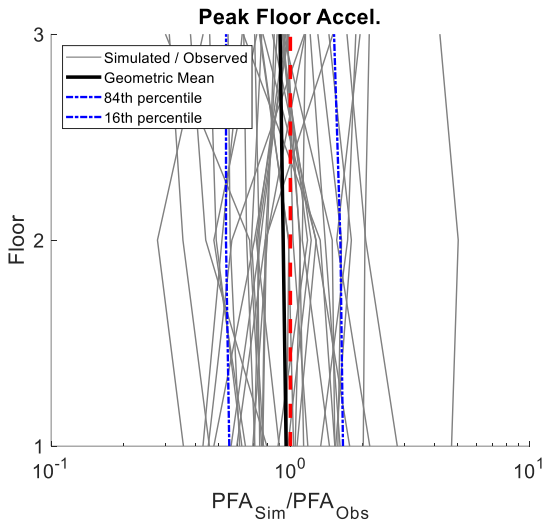
Unscaled Simulated

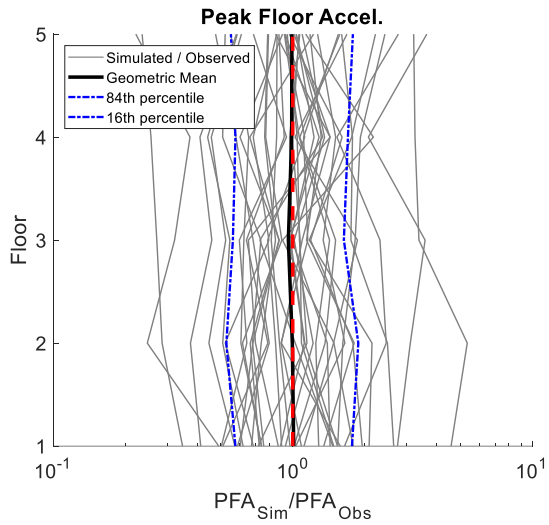


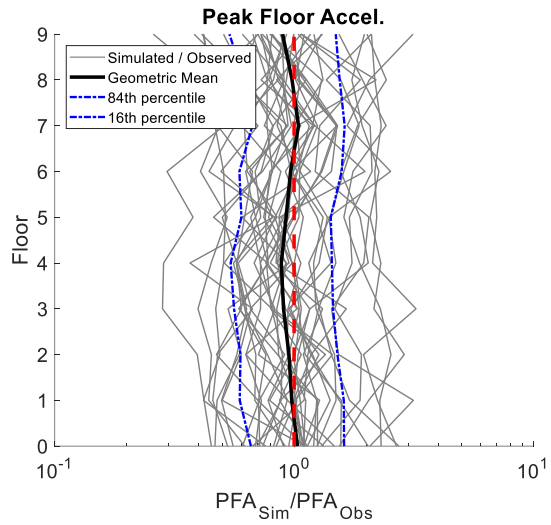
Comparison between the responses for Sim/Obs GMs

3-Storey | **5-Storey** | **9-Storey**

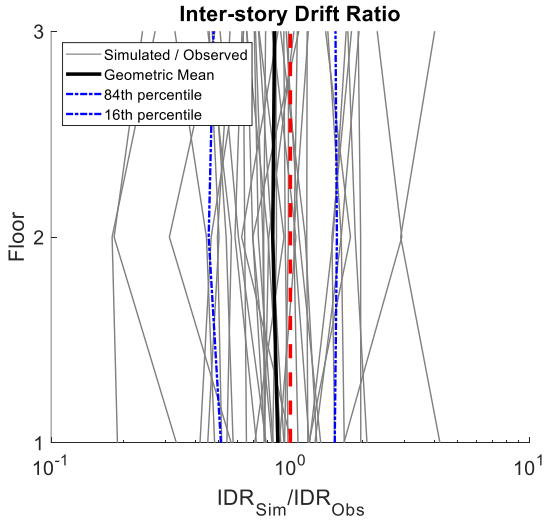
PFA :

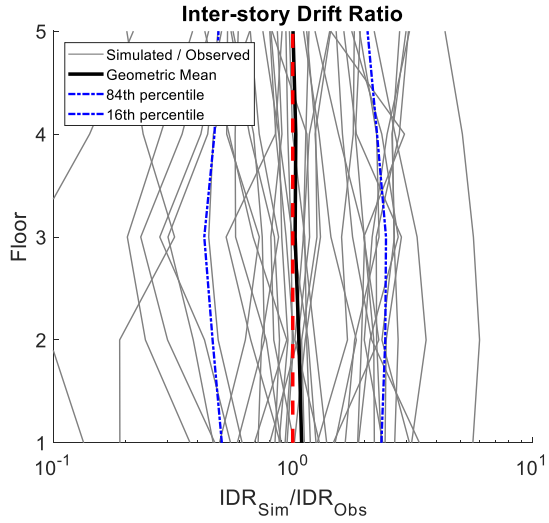


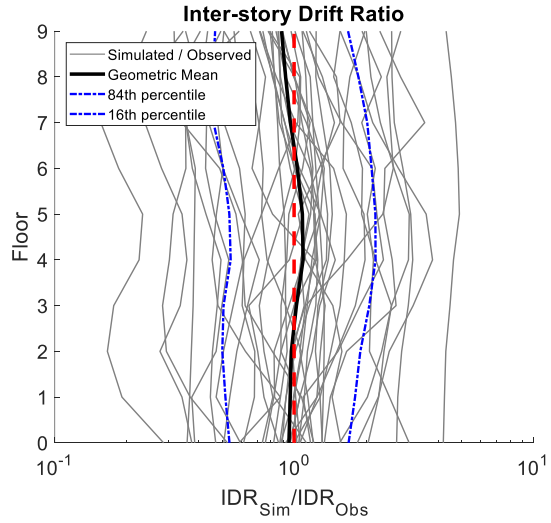




IDR :



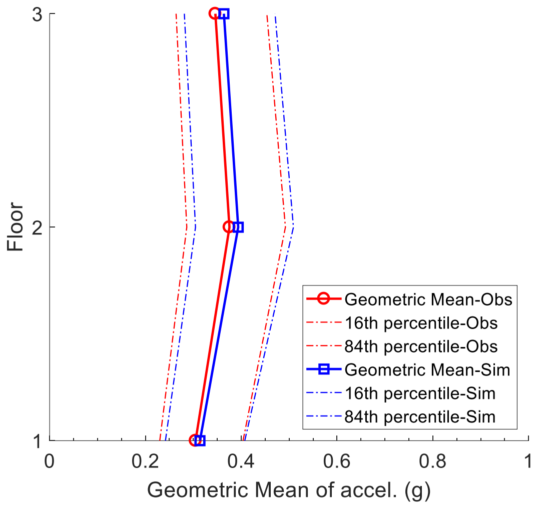


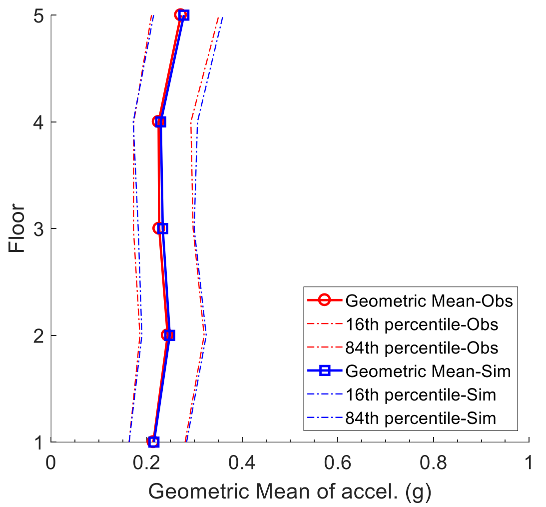


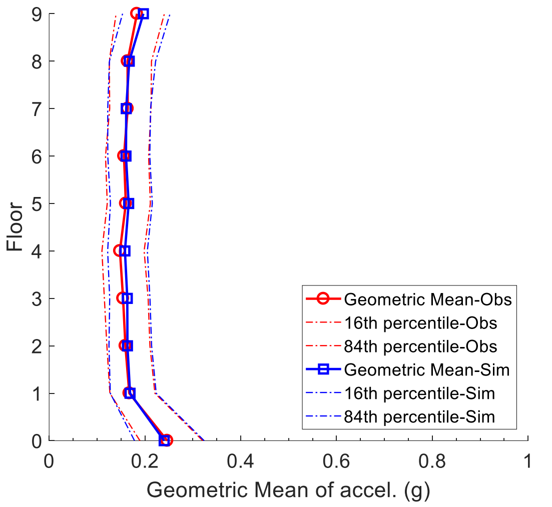
Response trends with respect to data sample size

3-Storey | **5-Storey** | **9-Storey**

PFA :







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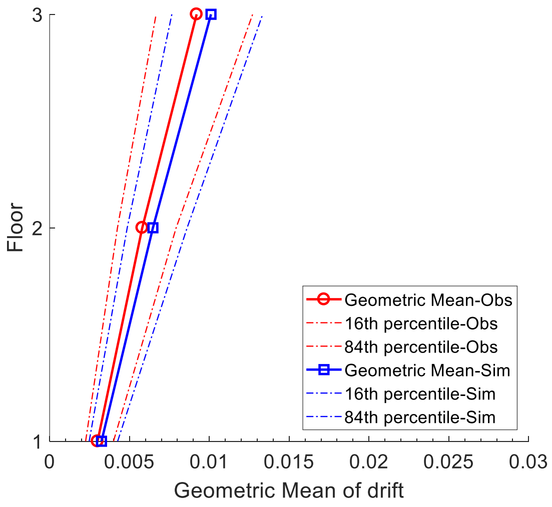

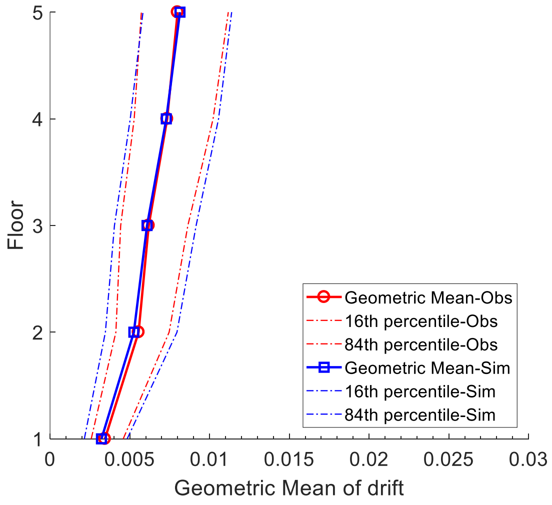

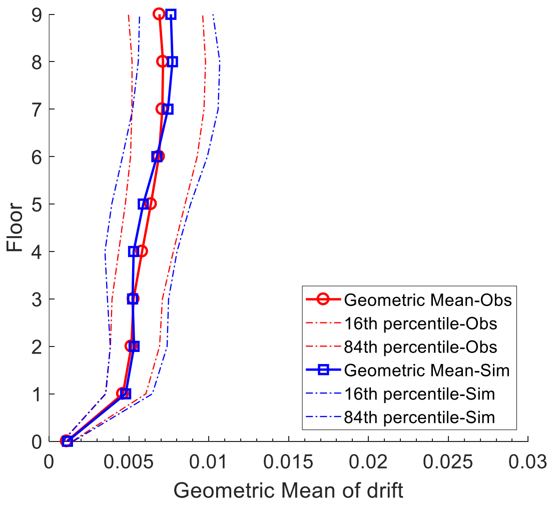

Outcomes / Future plans

Outcomes of case study:

Performing bootstrap technique and hypothesis testing:

- Comparable responses for 5-storey and 9-storey MRFs
- Comparable PFA for 3-storey MRF
- Statistically significant difference in IDR for 3-storey MRF (2^{nd} floor)

Future Works:

- Complete the automated workflow procedure
- Adding different FEMs to the workflow
- Validating different GMs sets
- Comparing different GMs simulation methods

Thank You!

Questions…?