What Can Simulated Ground Motions Tell Us About Near-fault Seismic Hazard and Infrastructure Performance?

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Performance assessment of near-fault structures under large and rare earthquakes

Sparsity of observations for large and rare earthquakes

- Large uncertainties in empirical models
- Challenging to assess the impacts of rare earthquakes

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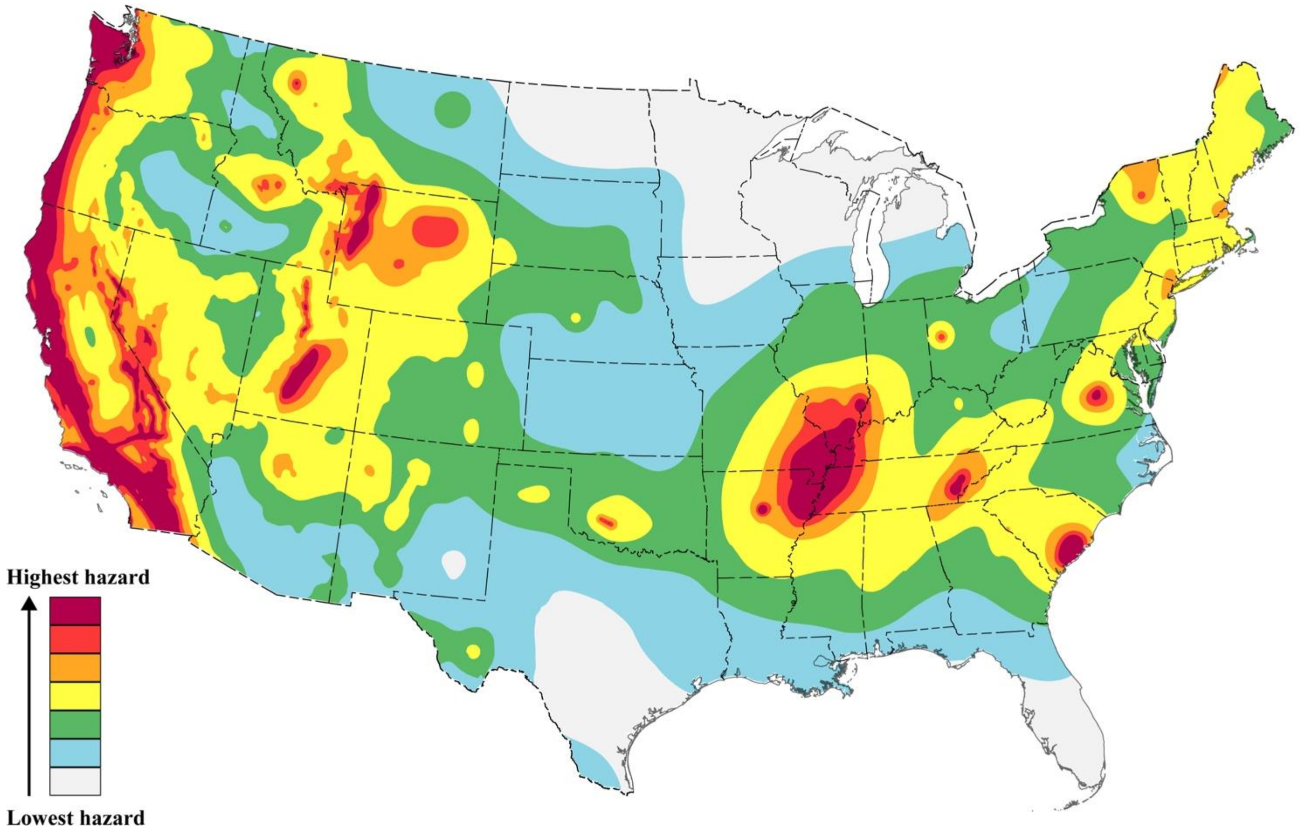
Physics-based earthquake fault rupture simulations

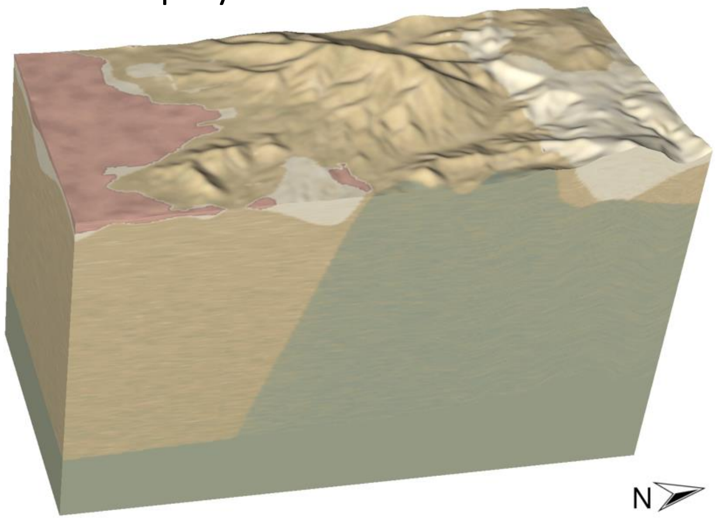


2023 National Seismic Hazard Model

Using simulated ground motions to improve the analysis of near-fault building structures

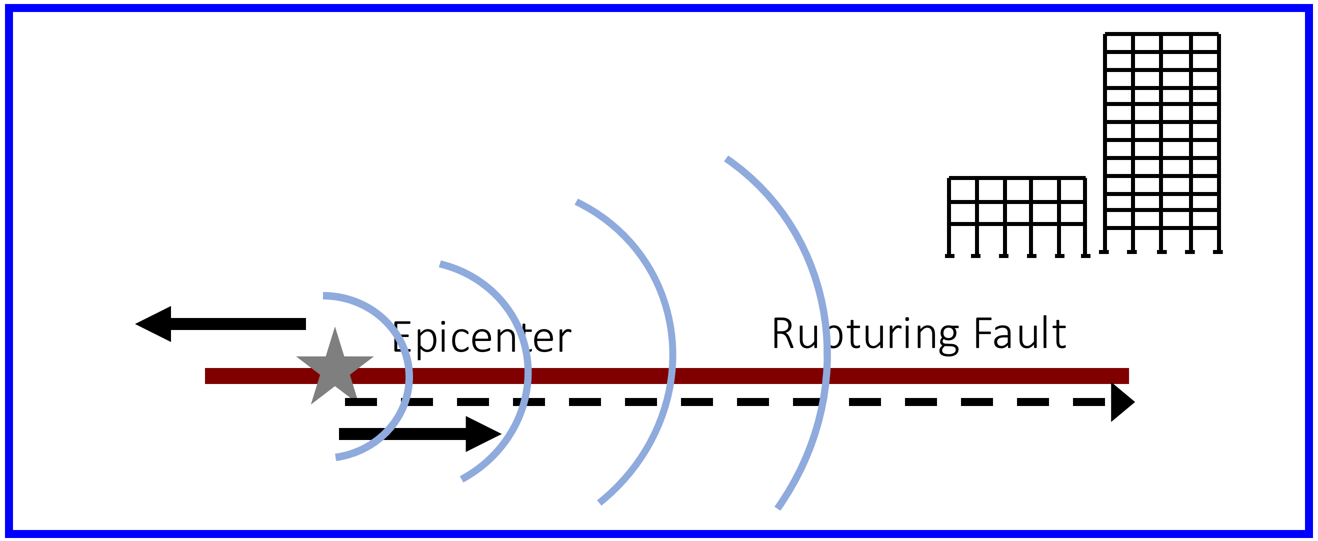
- Improve understanding and prediction of seismic hazard
- Identify effective approaches to selecting representative earthquake records for seismic risk assessment

Geophysics simulations



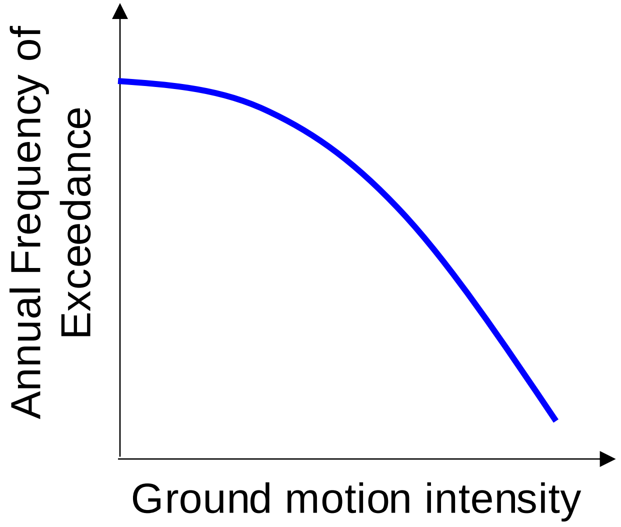
Pitarka et al. 2015

Plan view of geographical region

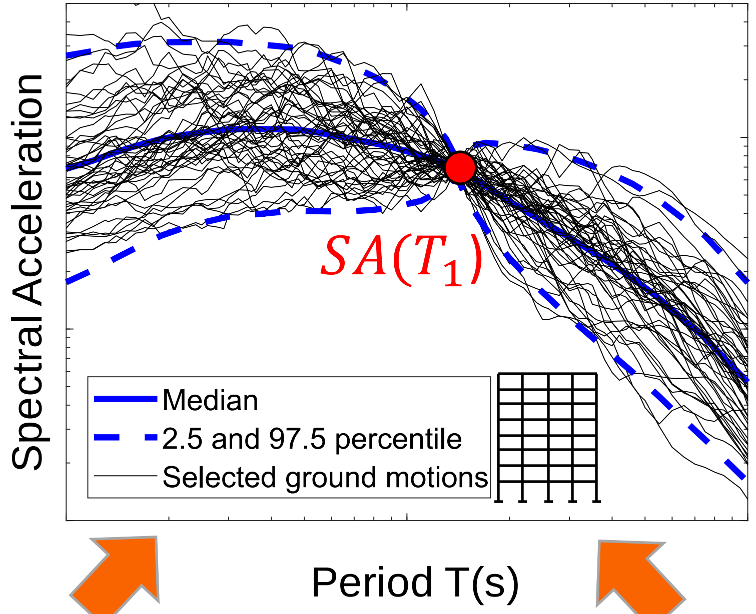


Using physics-based simulations to represent seismic hazard at near-fault locations

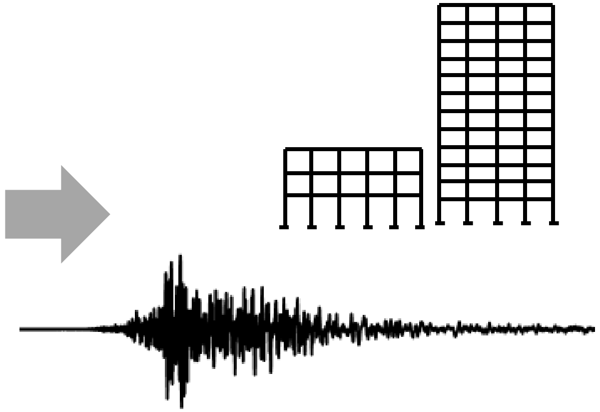
Seismic Hazard Curve



Spectra of selected ground motion records



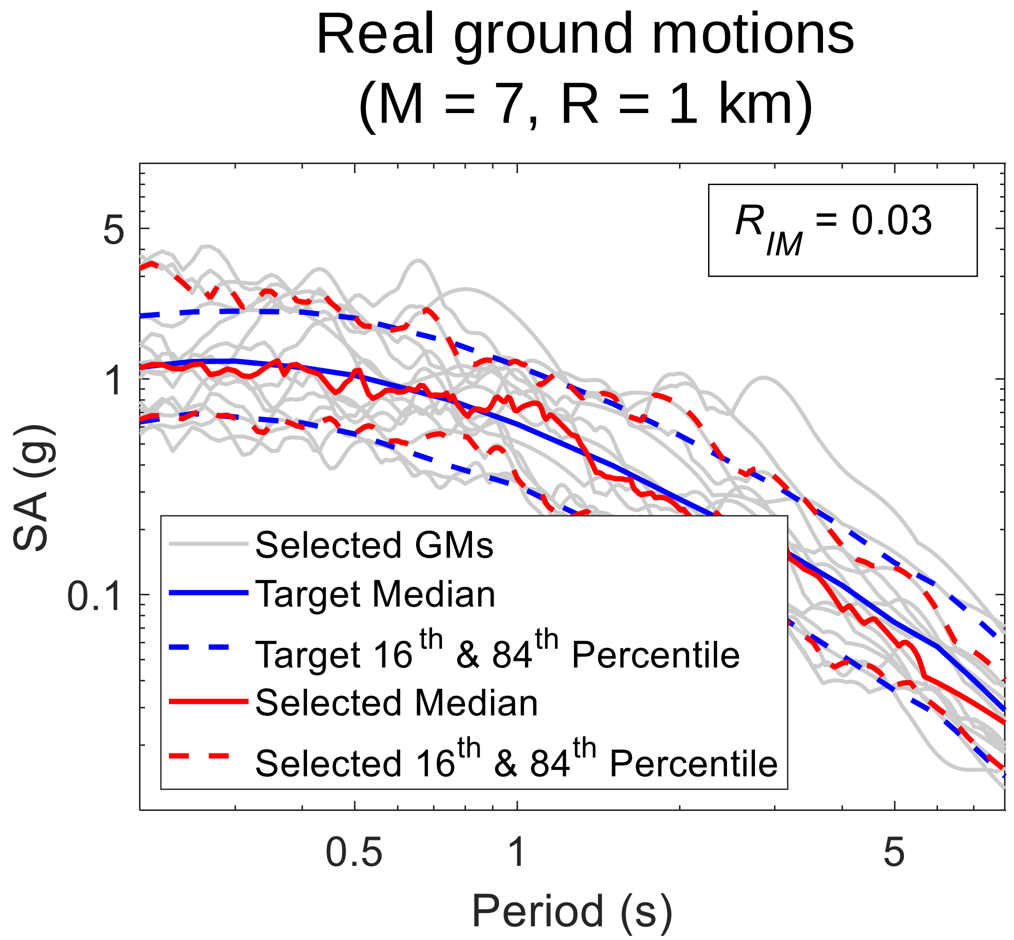
Nonlinear time-history analysis of structures

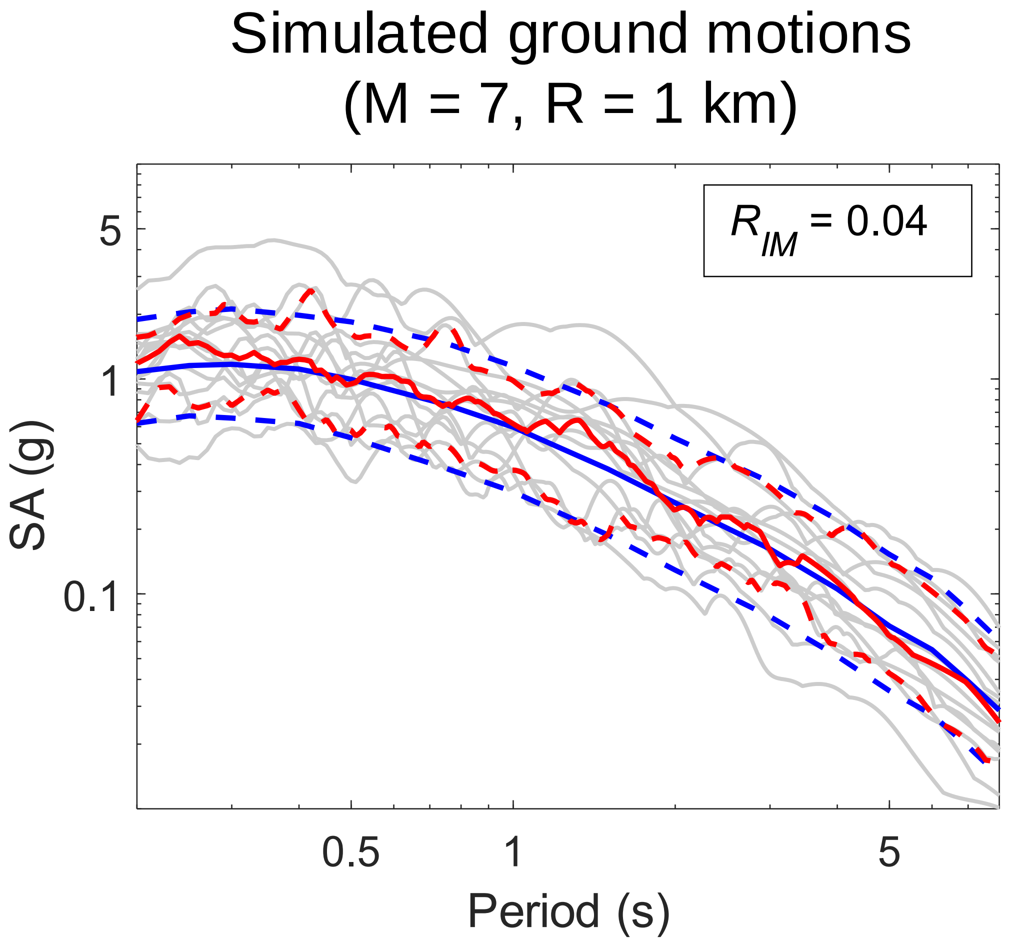


Replace/supplement recorded ground motions

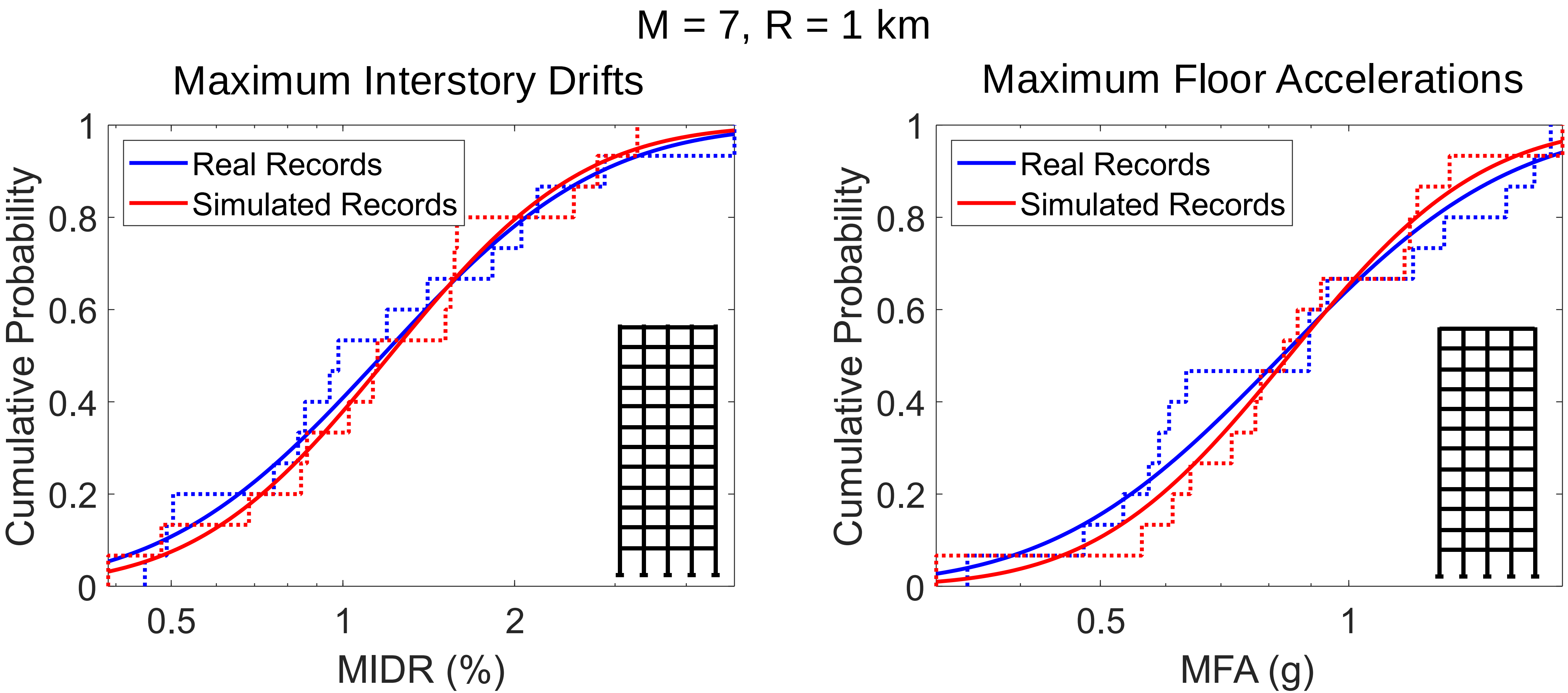
Represent seismic hazard target at a given location

Supplementing with simulated ground motions in engineering analysis

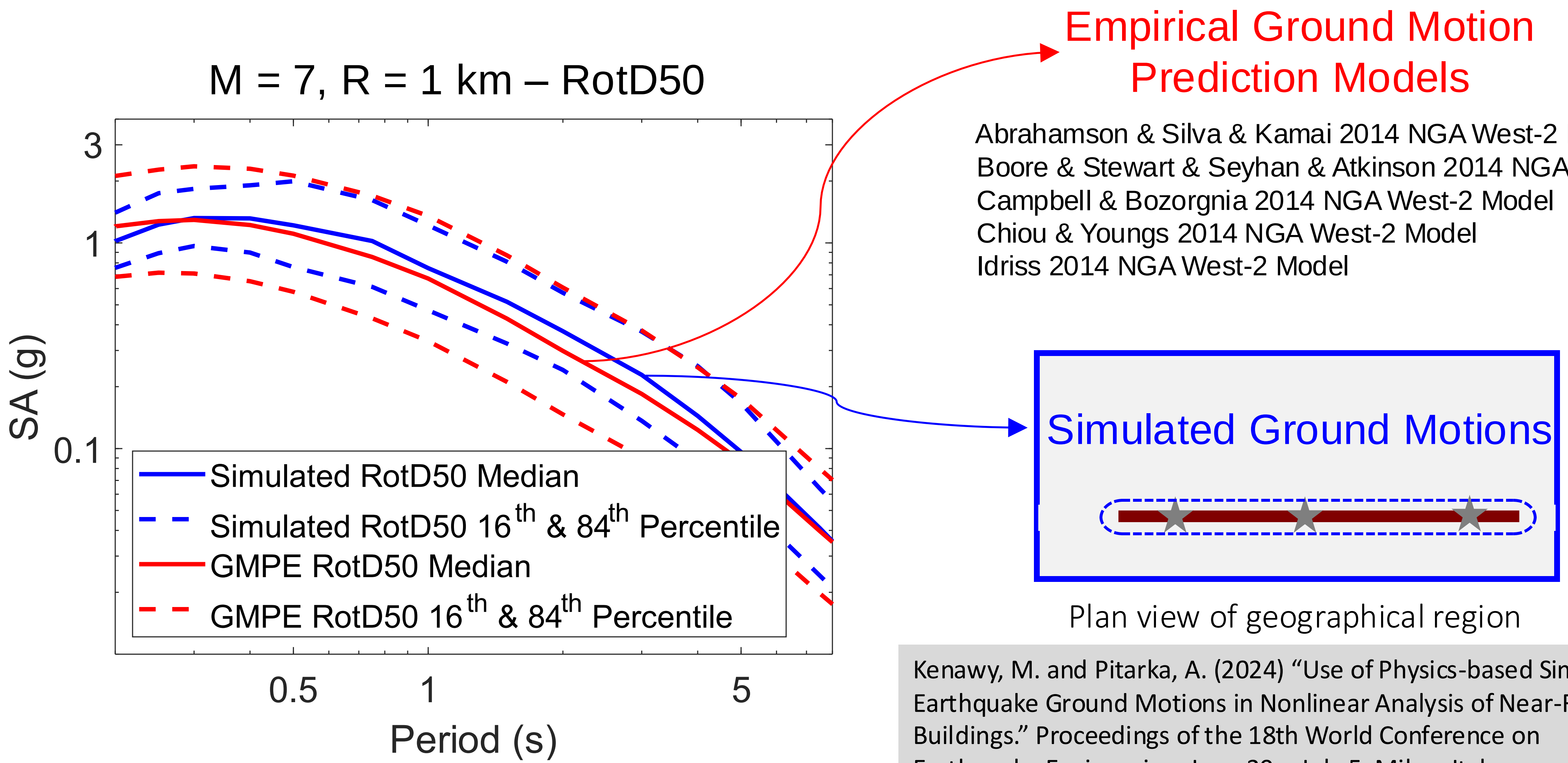




Supplementing with simulated ground motions in engineering analysis



Representing site-specific seismic hazard using earthquake simulations

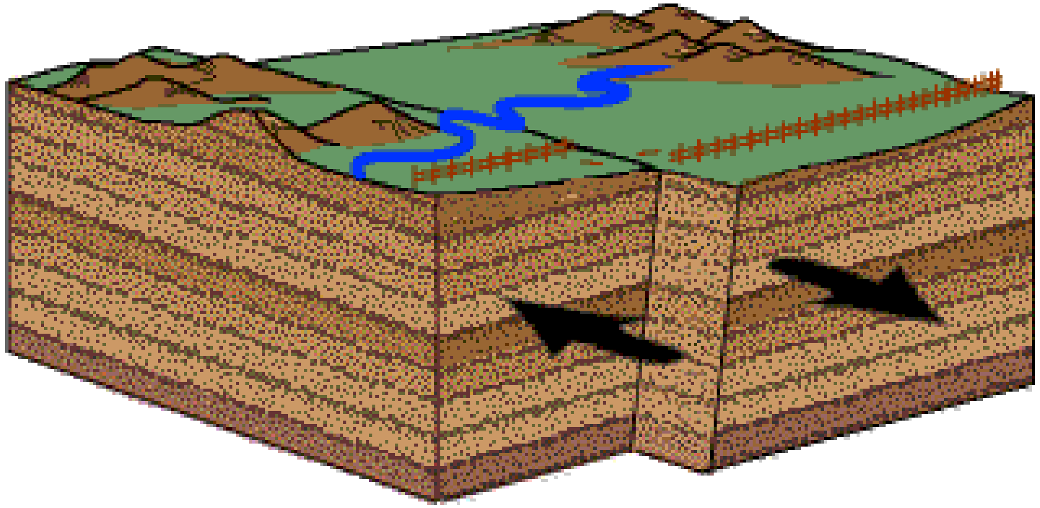


Abrahamson & Silva & Kamai 2014 NGA West-2 Model
Boore & Stewart & Seyhan & Atkinson 2014 NGA West-2 Model
Campbell & Bozorgnia 2014 NGA West-2 Model
Chiou & Youngs 2014 NGA West-2 Model
Idriss 2014 NGA West-2 Model

Plan view of geographical region

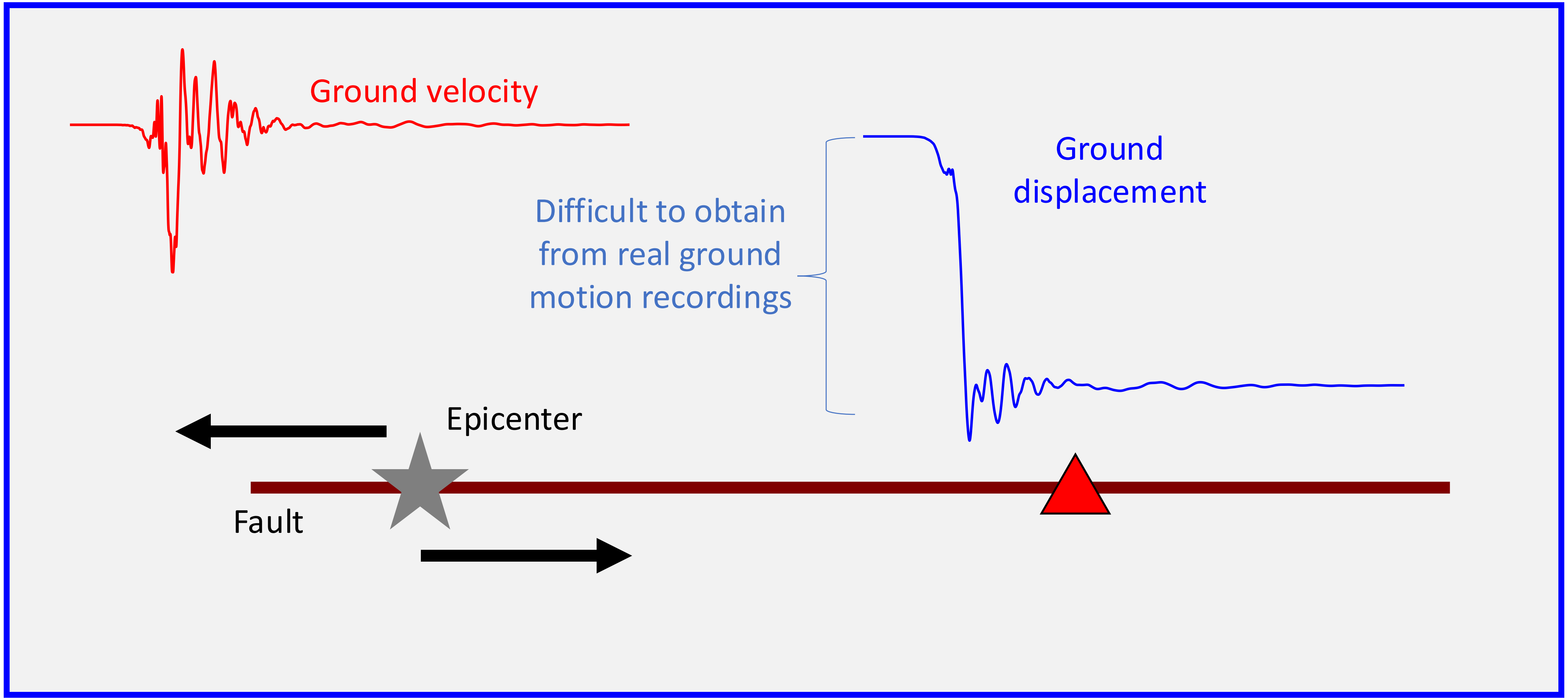
Kenawy, M. and Pitarka, A. (2024) "Use of Physics-based Simulated Earthquake Ground Motions in Nonlinear Analysis of Near-Fault Buildings." Proceedings of the 18th World Conference on Earthquake Engineering, June 30 – July 5, Milan, Italy.

Understanding co-seismic permanent displacements and associated pulses (fling step)

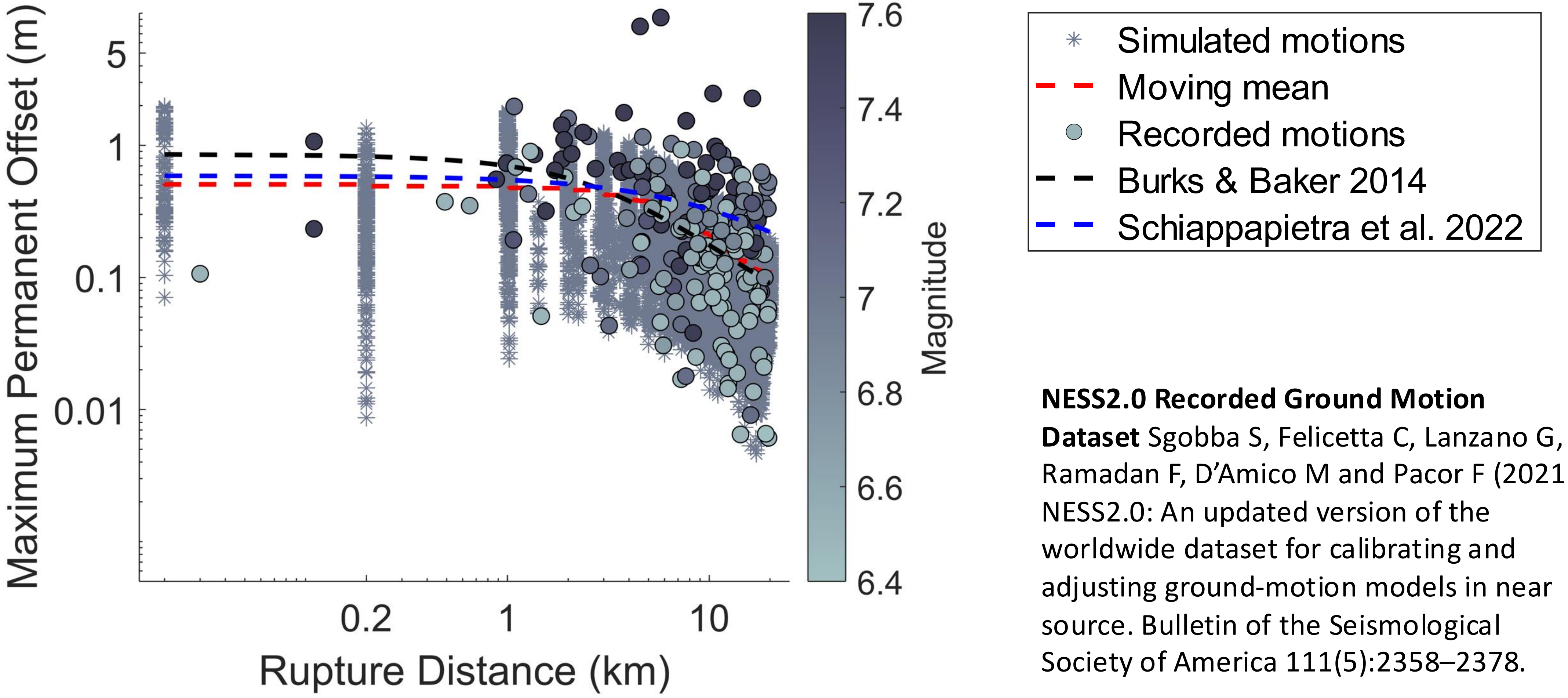


Understanding co-seismic displacements and associated pulses

Plan view of geographical region

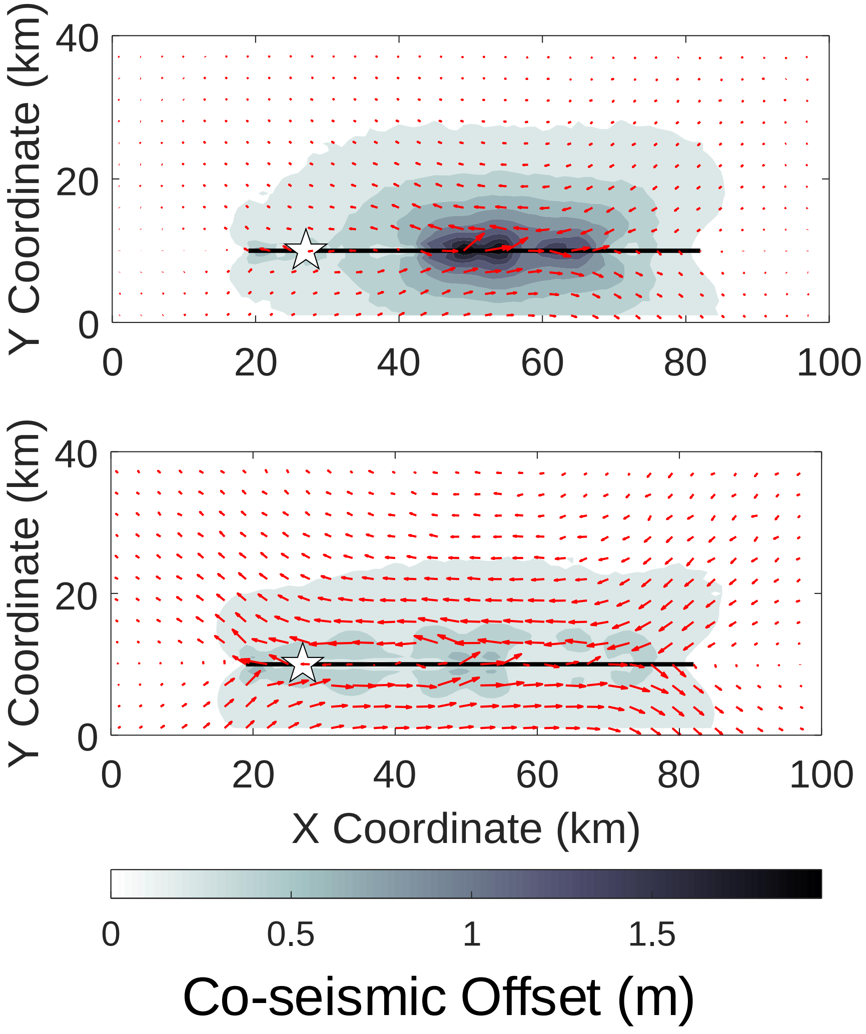


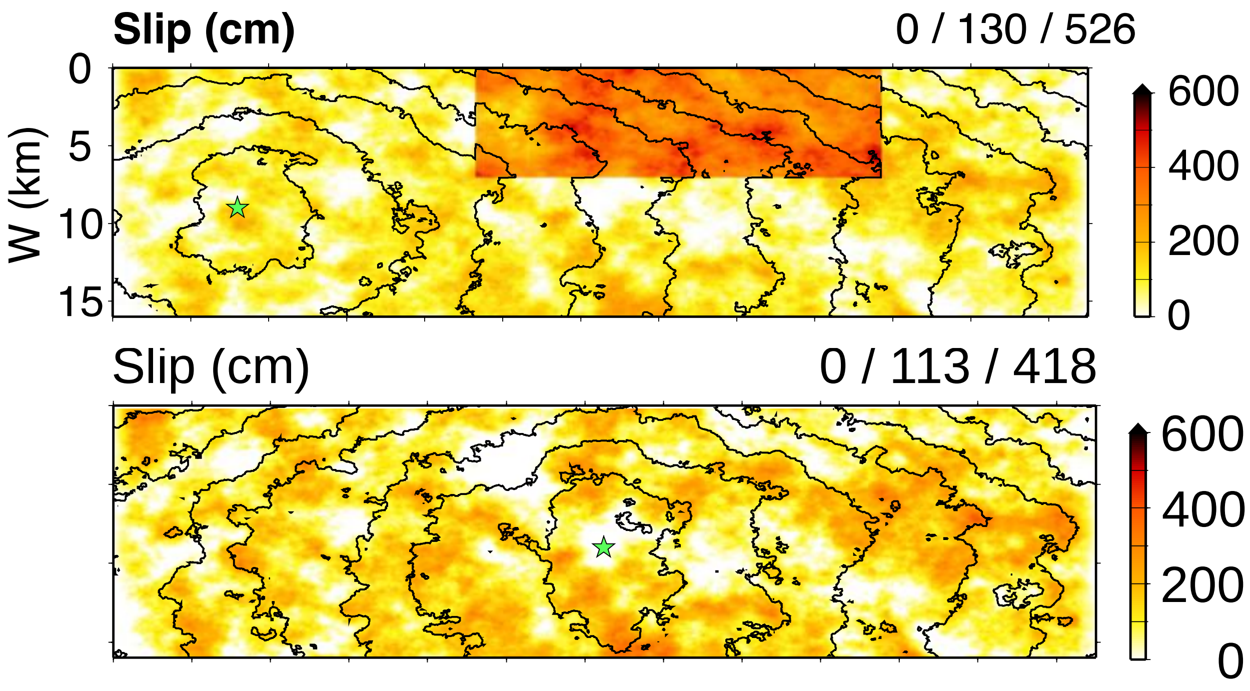
Co-seismic offset in simulated and recorded ground motions



NESS2.0 Recorded Ground Motion Dataset Sgobba S, Felicetta C, Lanzano G, Ramadan F, D'Amico M and Pacor F (2021) NESS2.0: An updated version of the worldwide dataset for calibrating and adjusting ground-motion models in near source. Bulletin of the Seismological Society of America 111(5):2358–2378.

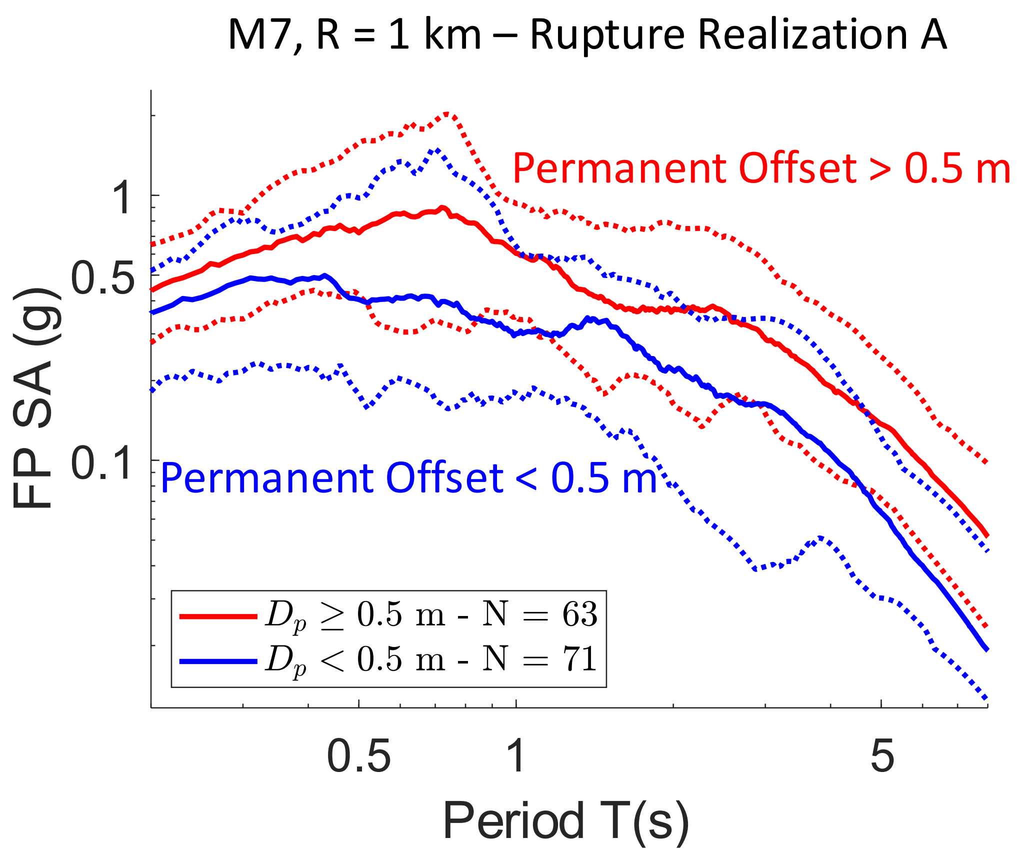
What influences the magnitude of the co-seismic offset and associated fling pulse?

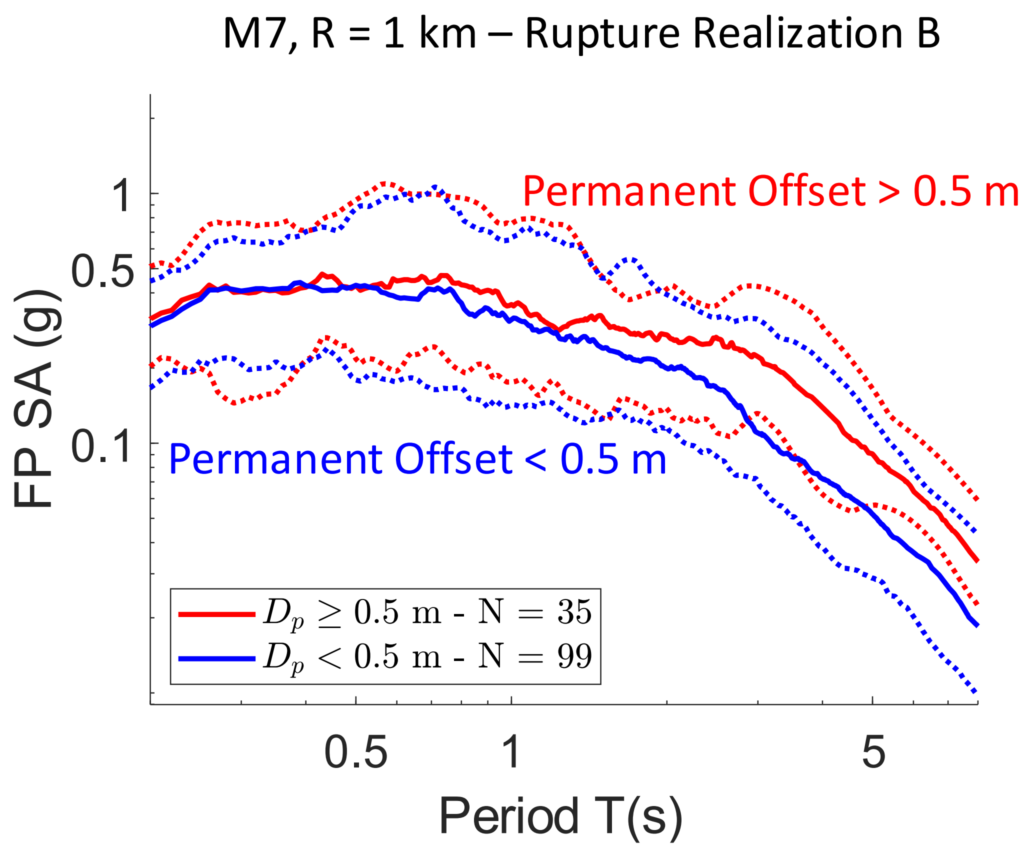




Cross section of the fault

Ground motions with strong fling pulses tend to have larger spectral accelerations

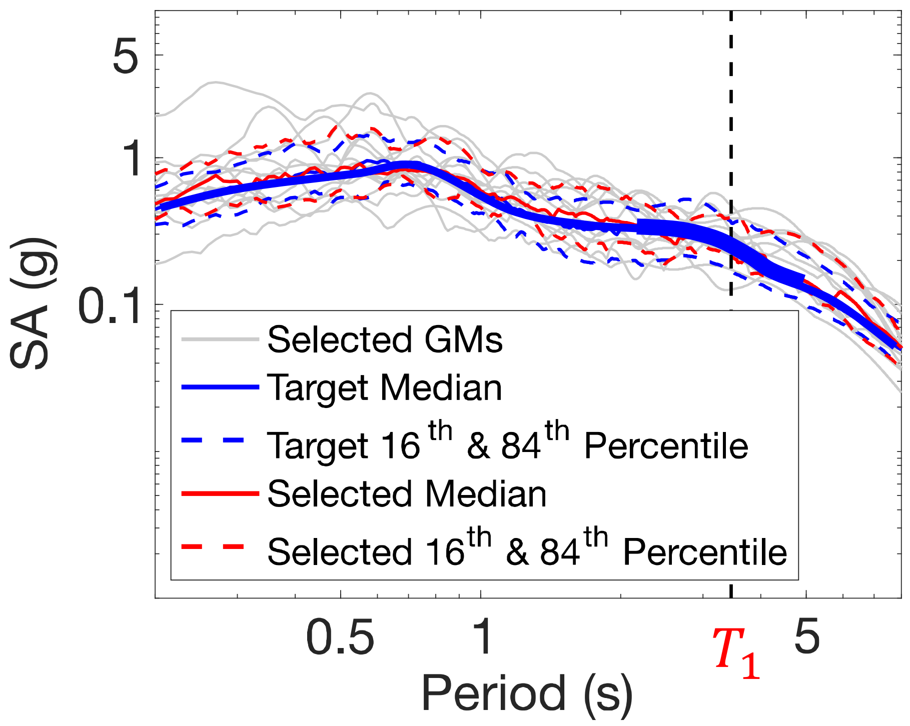


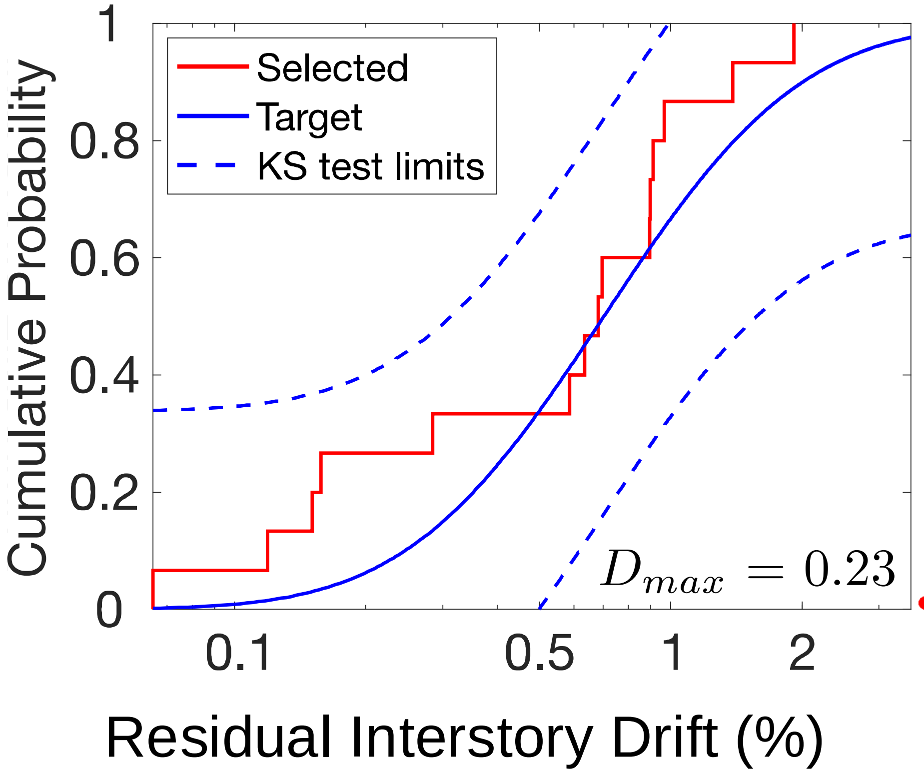


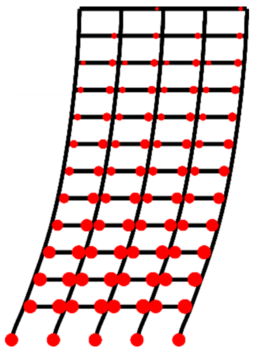
Kenawy, M. and Pitarka, A. (2024). Performance Assessment of Near-Fault Buildings Subjected to Physics-Based Earthquake Simulated Ground Motions with Fling Step. Earthquake Spectra.

Selecting representative ground motions that capture fling effects on residual drifts of tall buildings

Prioritizing long-period spectral ordinates







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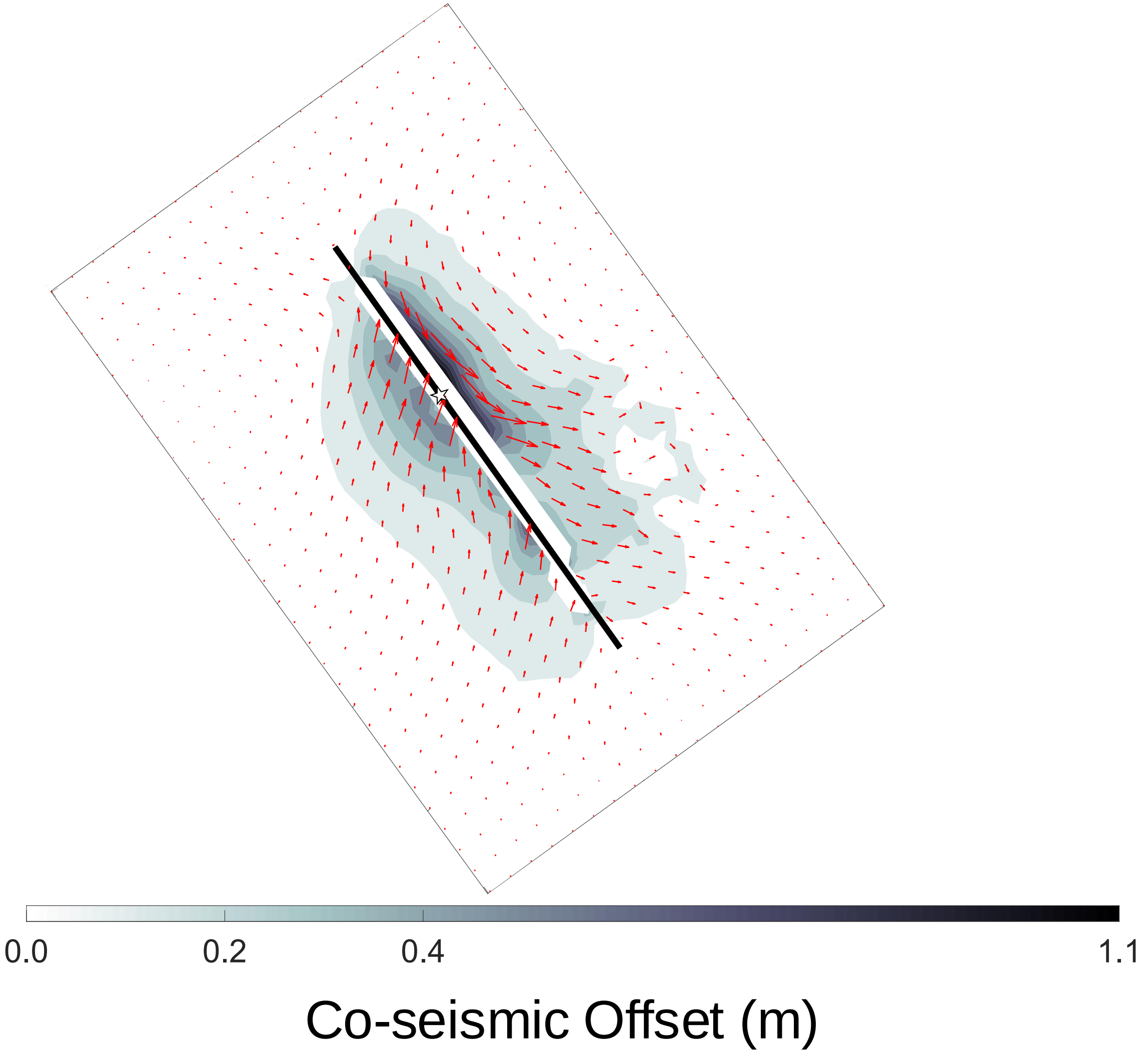
Studying the consequences of permanent co-seismic offsets to distributed infrastructure



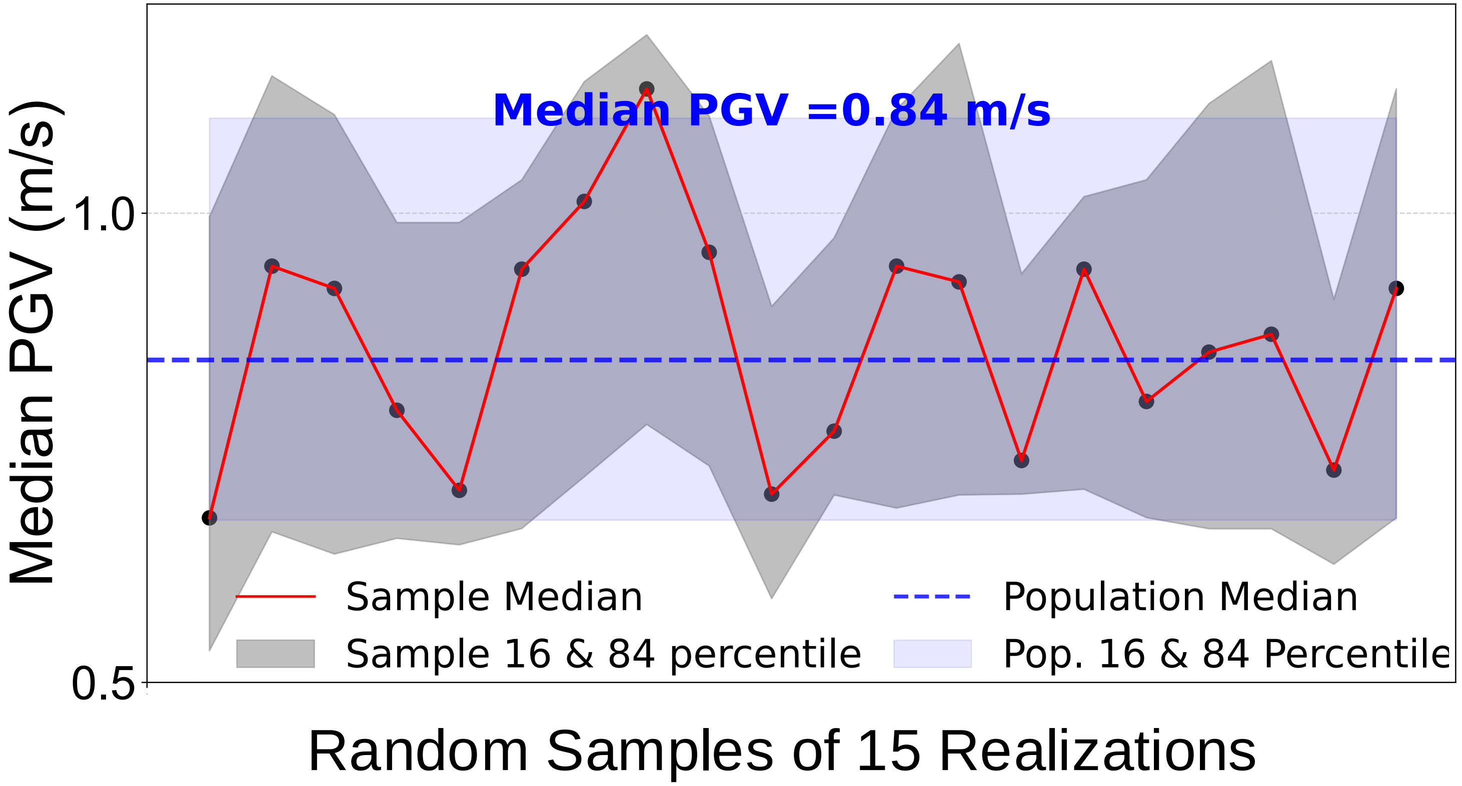
Bridge Networks in the San Francisco Bay Area

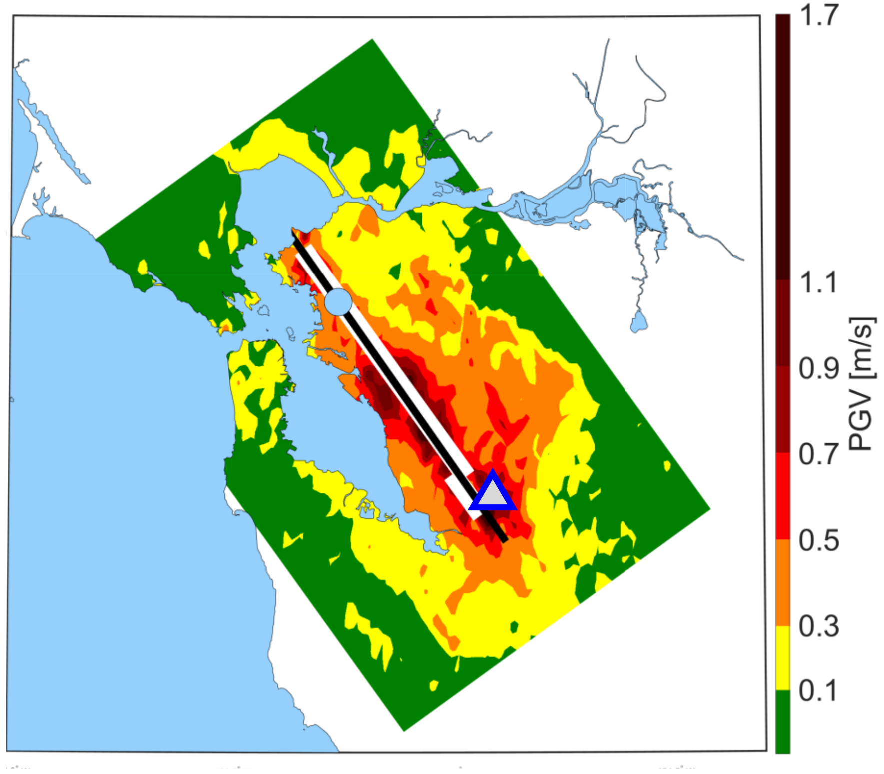
PhD Student: Melisa Herrera

How can we make the most out of a small number of ‘expensive’ simulations?

≡ *How can we reduce uncertainty at a tractable computational cost?*

How does the seismic risk vary across different M7 Hayward fault rupture realizations?

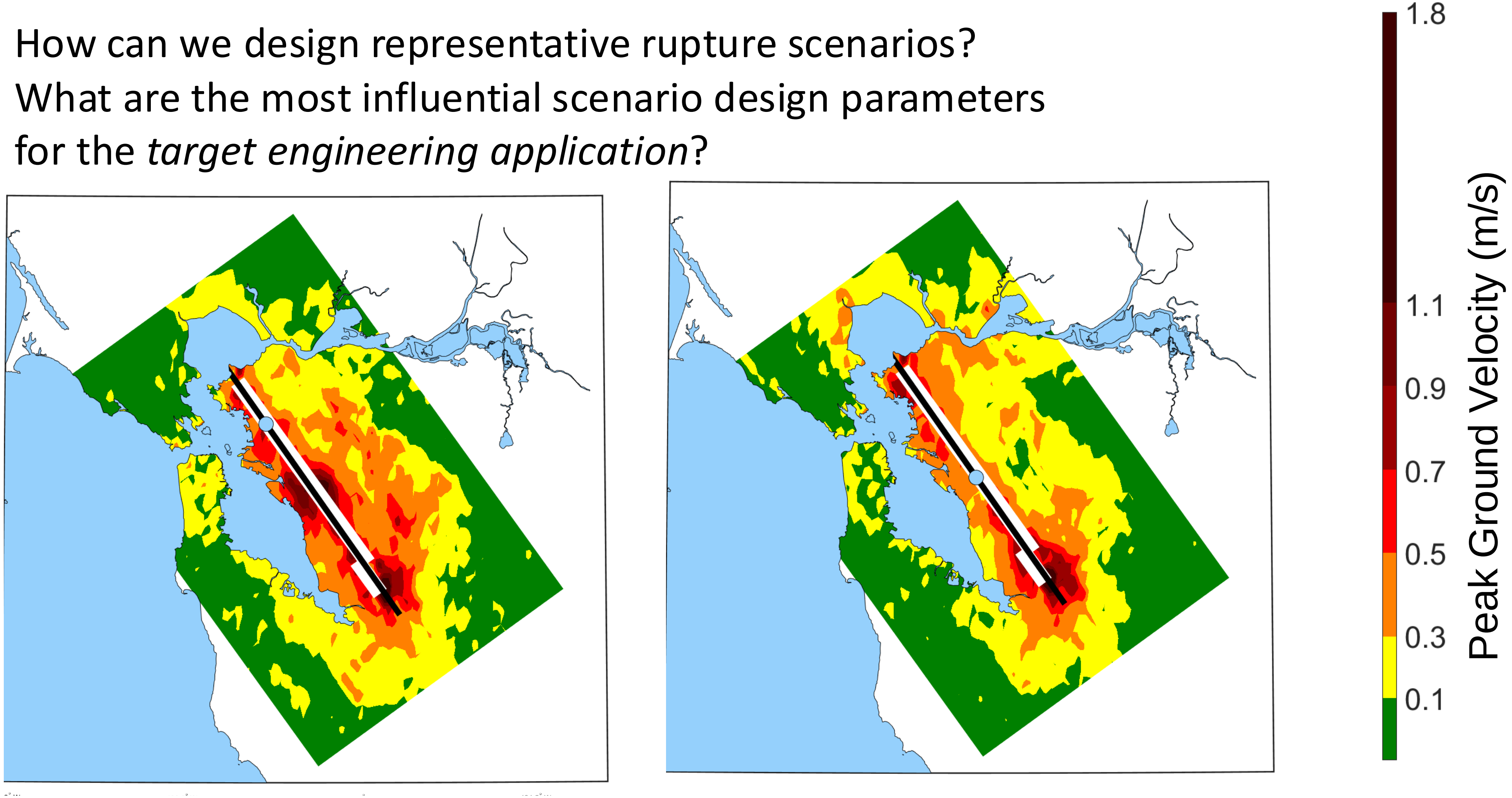




PhD Student:
Saba Yousefi

Optimizing the design of earthquake scenario simulations

How can we design representative rupture scenarios?
What are the most influential scenario design parameters for the *target engineering application*?



Funding support

Ground Motion Selection for Analysis of Near-Fault Civil Structures using Broadband Physics-Based Earthquake Simulations - Grant No. G22AP00380
Earthquake fault rupture simulations by **Arben Pitarka**, Lawrence Livermore National Laboratory
Structural simulations conducted using the Texas Advanced Computing Center

High Performance, Multidisciplinary Simulations for Regional Scale Earthquake Hazard and Risk (EQSIM)

Project PI: **David McCallen,** Lawrence Berkeley National Laboratory
Exascale Computing Project (ECP), Project Number: 17-SC-20-SC
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Earthquake fault rupture simulations by **Arben Pitarka**, Lawrence Livermore National Laboratory
Structural simulations conducted using the NERSC CORI machine

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