



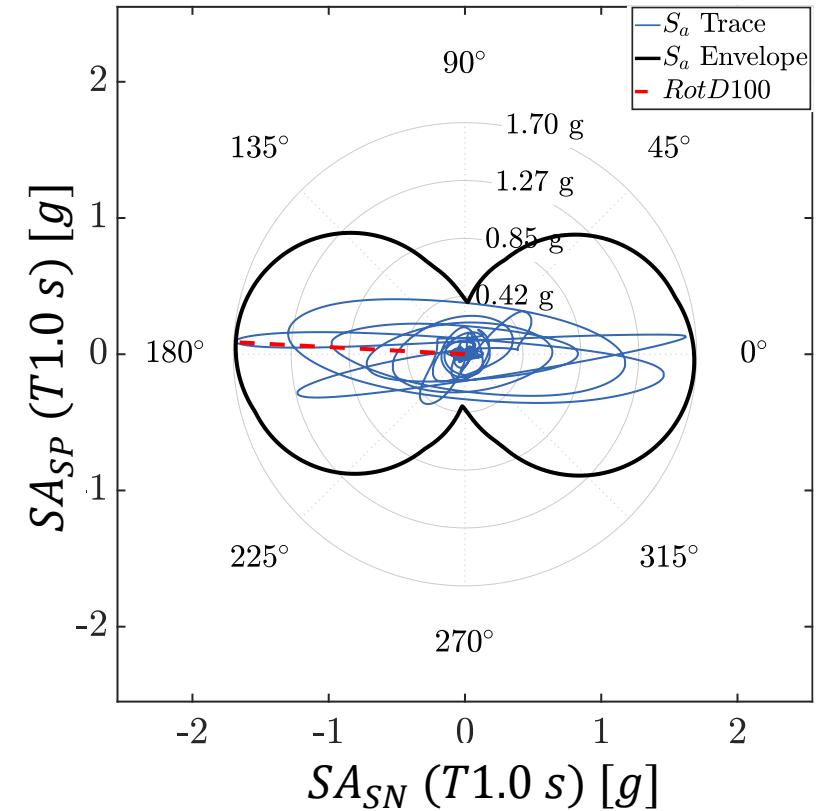
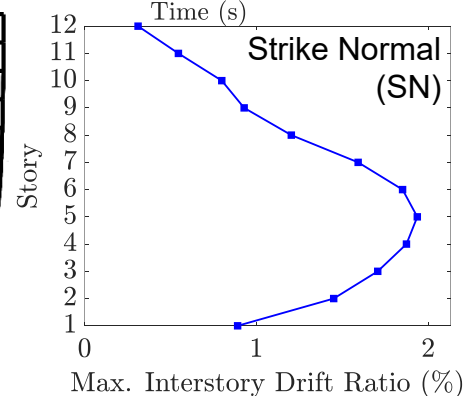
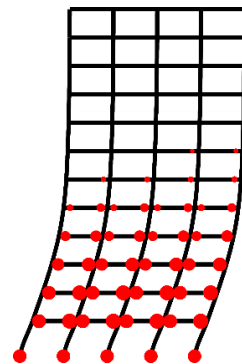
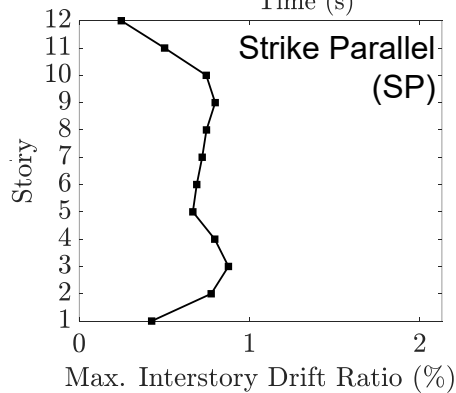
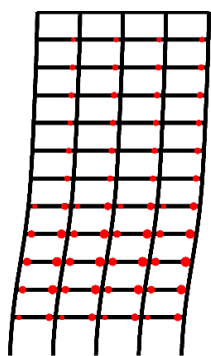
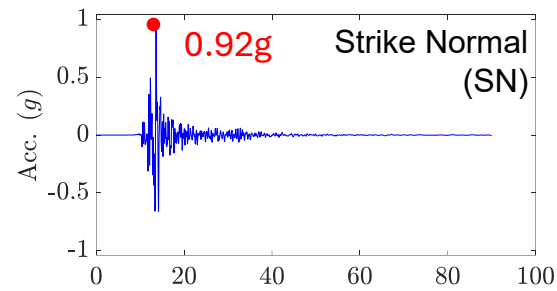
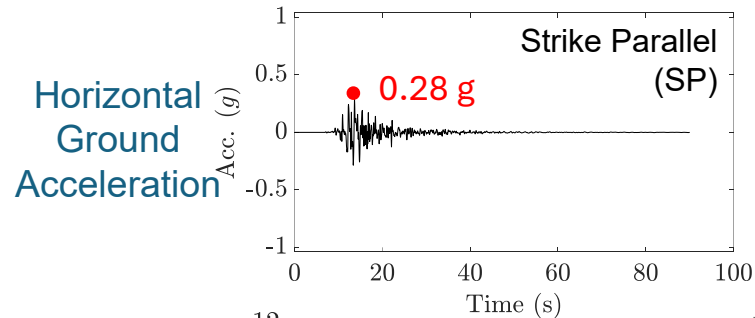
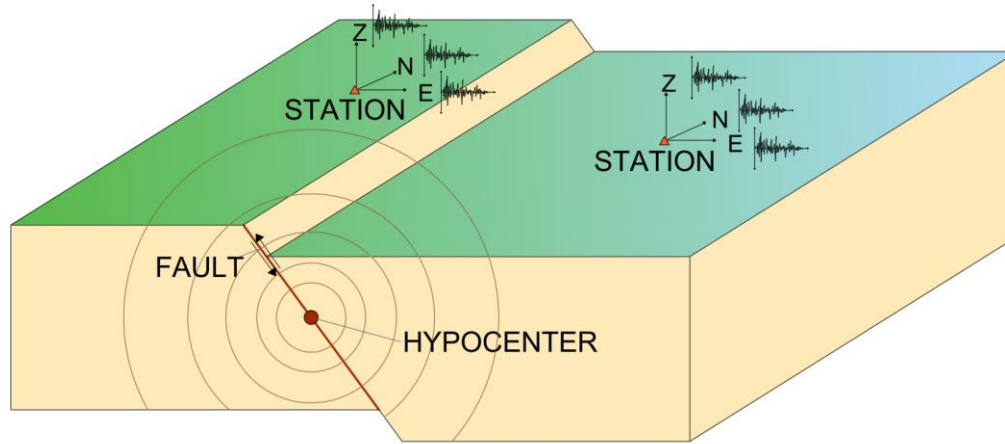
Directionality Characteristics of Near-Fault Simulated Ground Motions from Physics-Based Hayward Fault Rupture Simulations

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Maha Kenawy, PhD.
Assistant Professor

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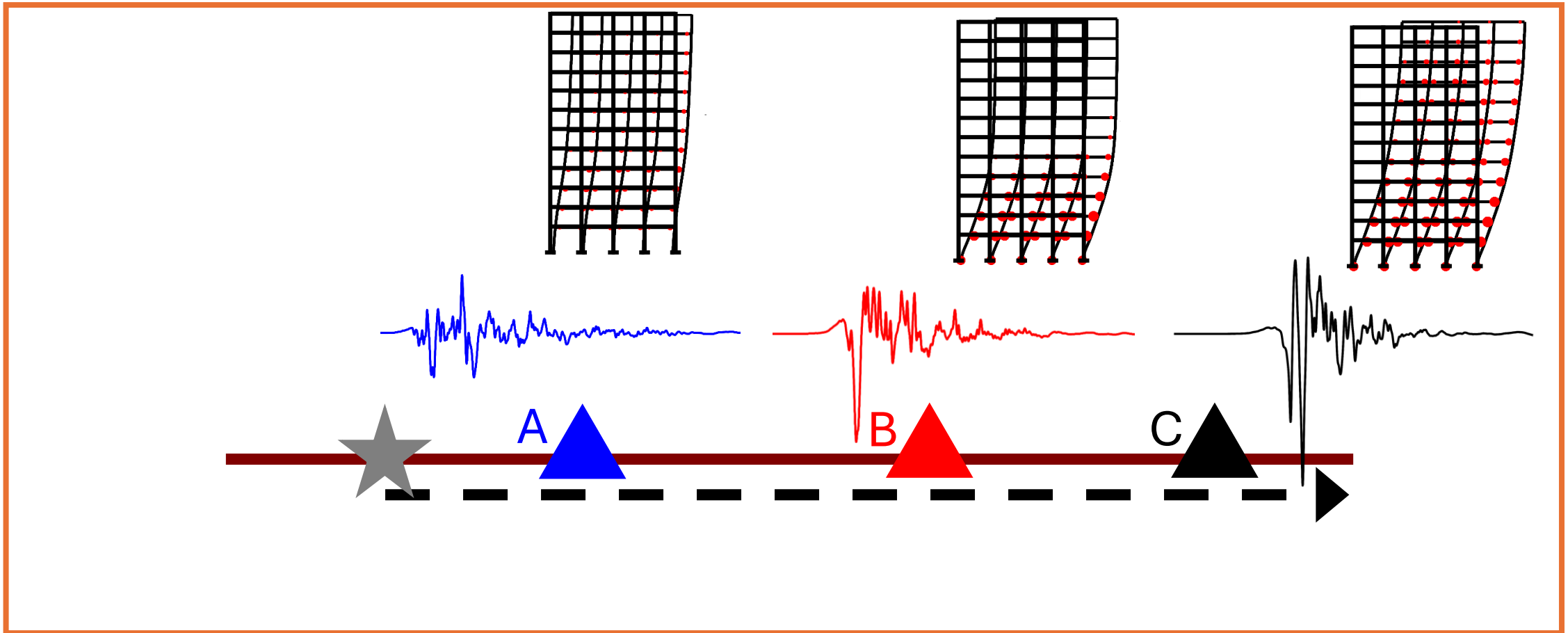
What is directionality?



Boore, D. M. (2010). "Orientation-independent, nongeometric-mean measures of seismic intensity from two horizontal components of motion." *Bulletin of the Seismological Society of America*, 100(4), 1830-1835.

Rupture directivity effects increase polarization of ground motion

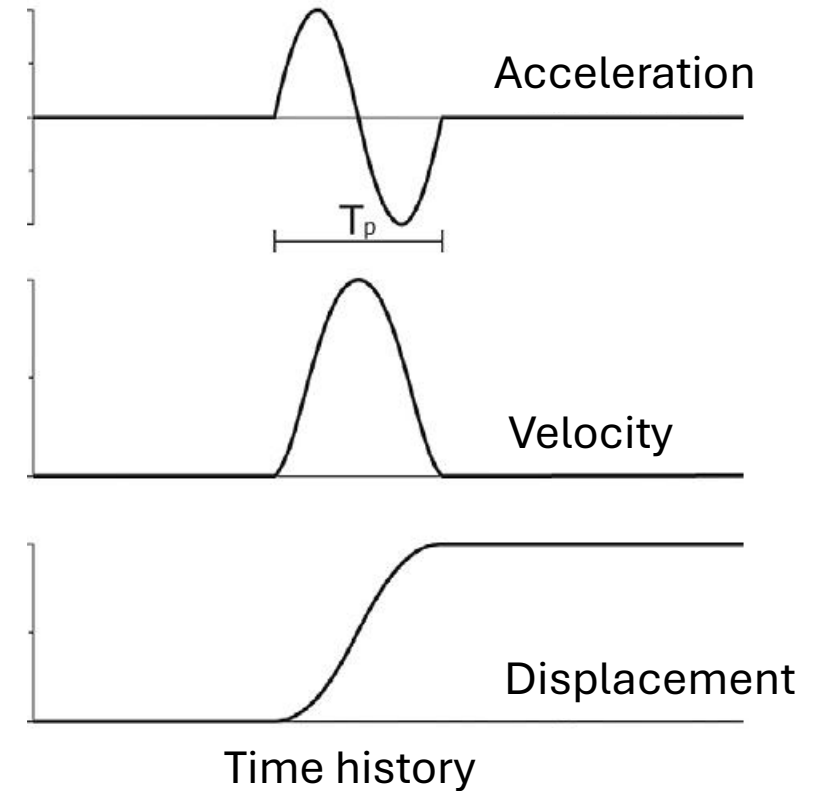
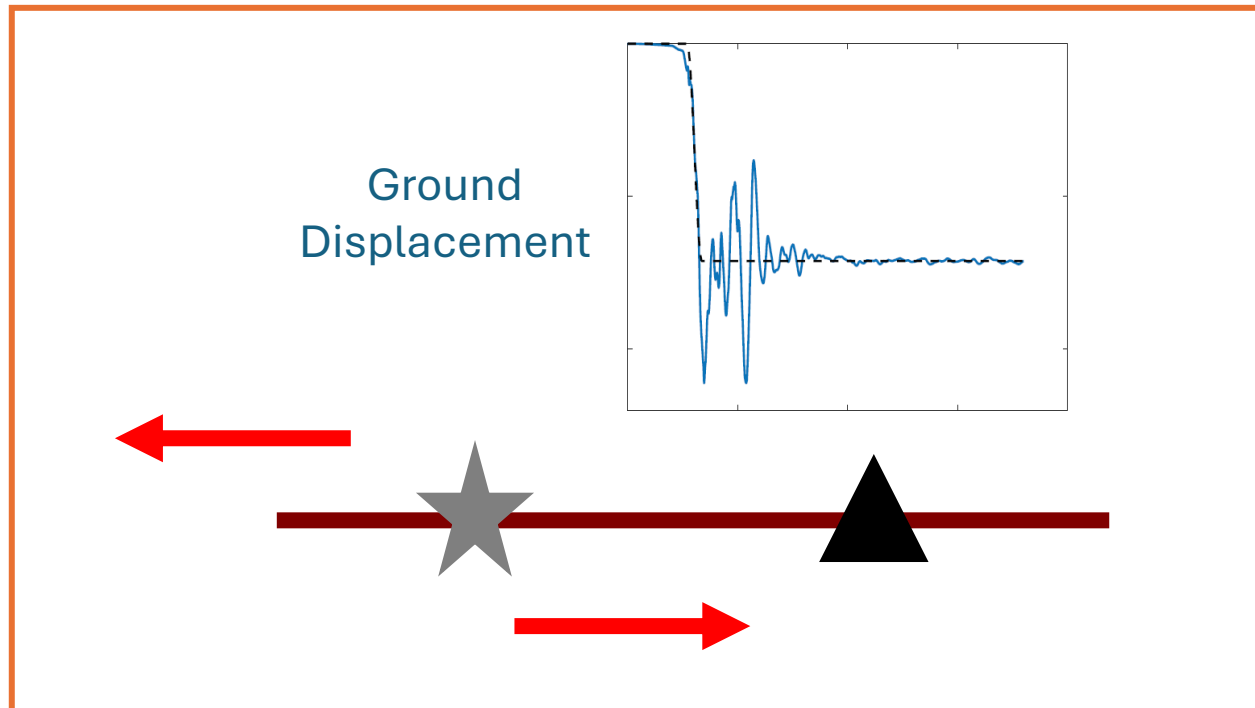
Plan view of geographical region



How does fling step influence ground motion directionality?



Plan view of the geographical region

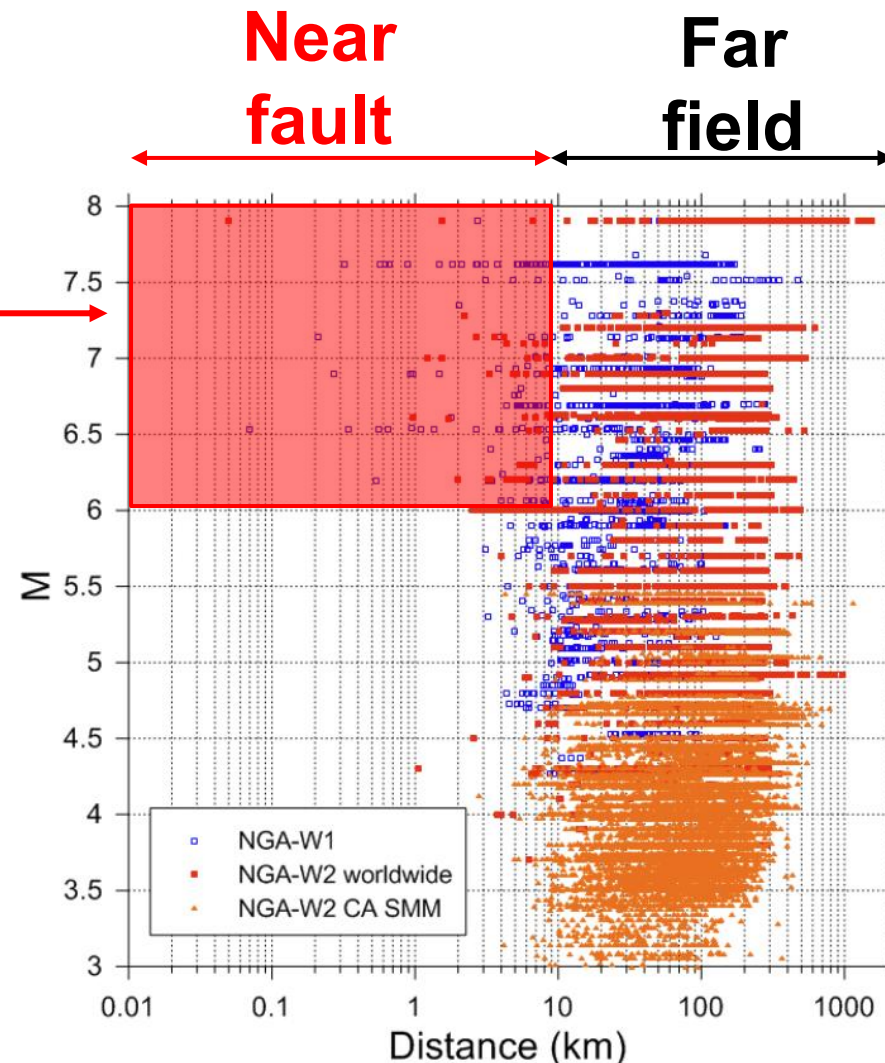


Grimaz, S., & Malisan, P. (2014). Near field domain effects and their consideration in the international and Italian seismic codes. *Bollettino di Geofisica Teorica ed Applicata*, 55(4), 773-788

Sparsity of ground motion observations in the near-fault region

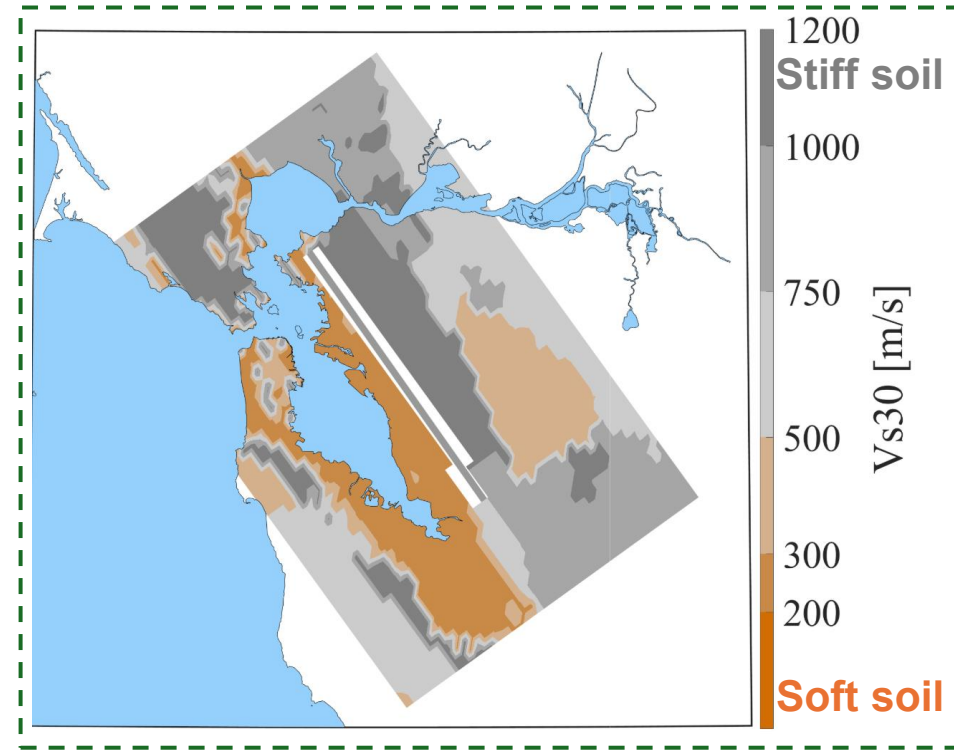
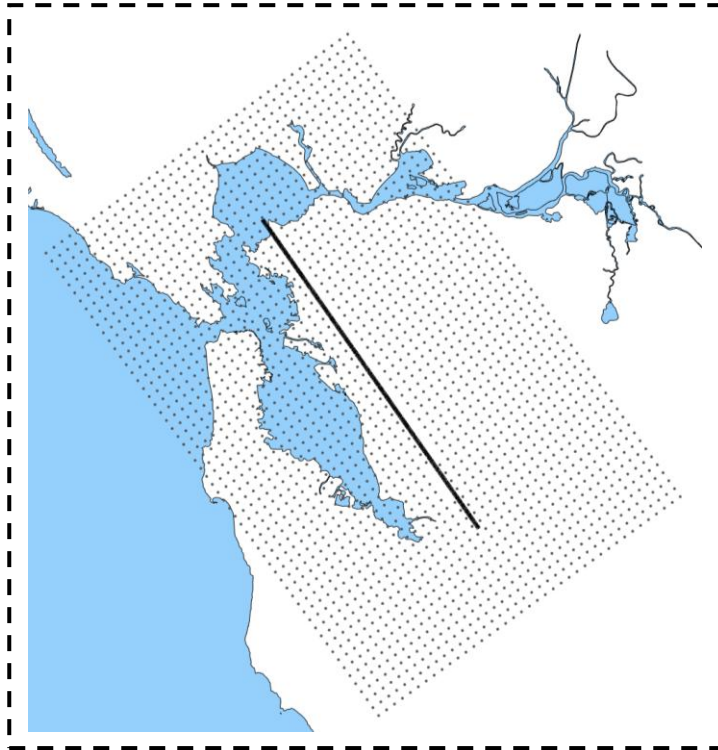


Few observations exist for large magnitude earthquakes at short distances



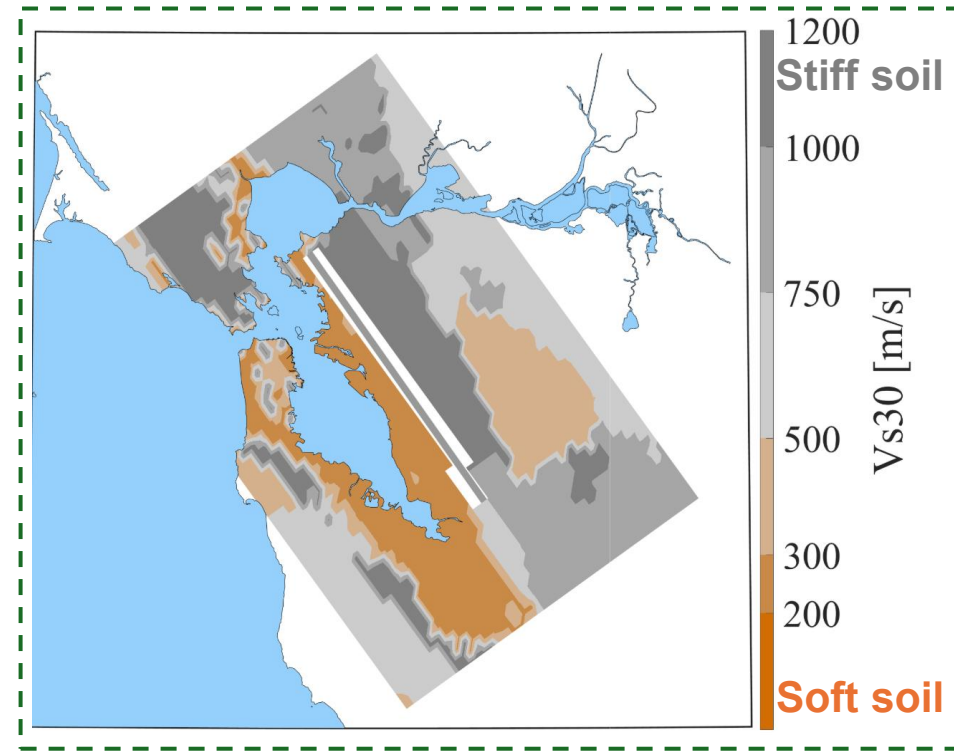
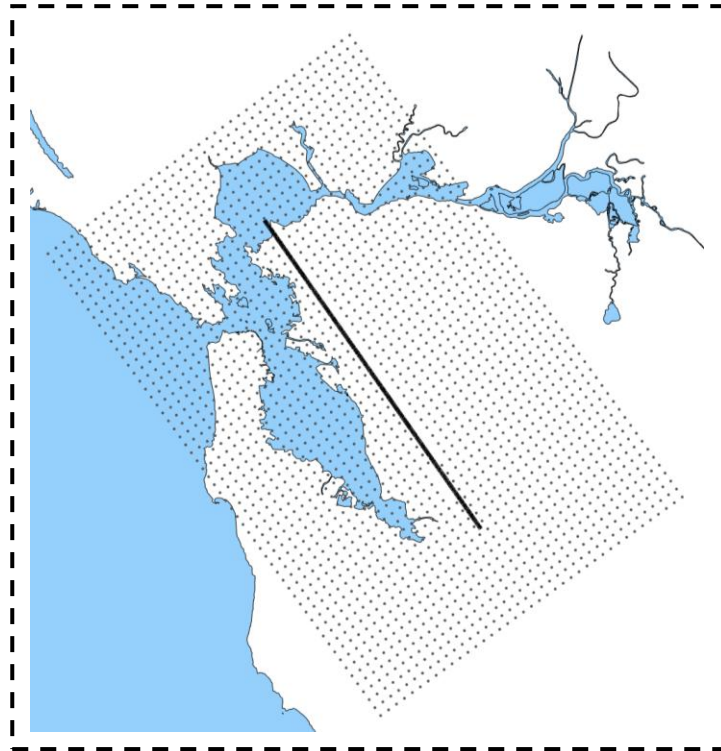
Ancheta et al. (2013). "PEER NGA-West2 Database." PEER Report 2013/03, Pacific Earthquake Engineering Research Center, University of California, Berkeley, CA

Physics-based M7 strike-slip rupture simulations on the Hayward fault

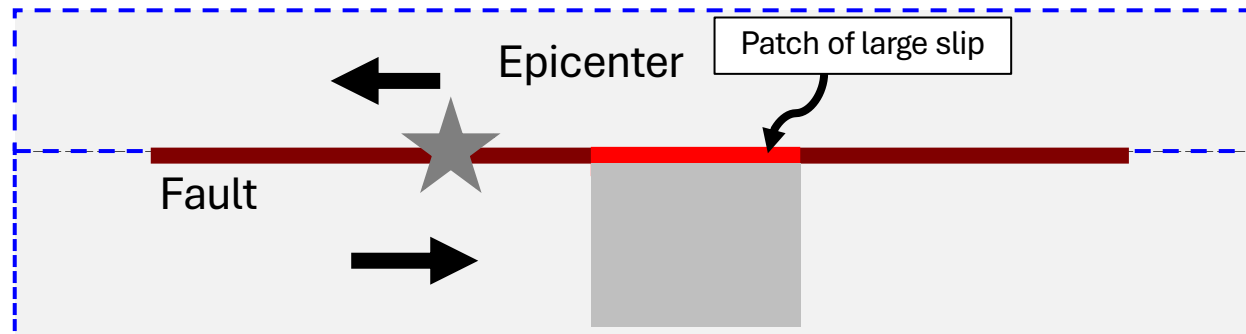


McCallen, D., et al.(2025).
An open-access simulated
earthquake ground motion
database for an M7
Hayward Fault earthquake
in the San Francisco Bay
Region. *Earthquake
Spectra*.

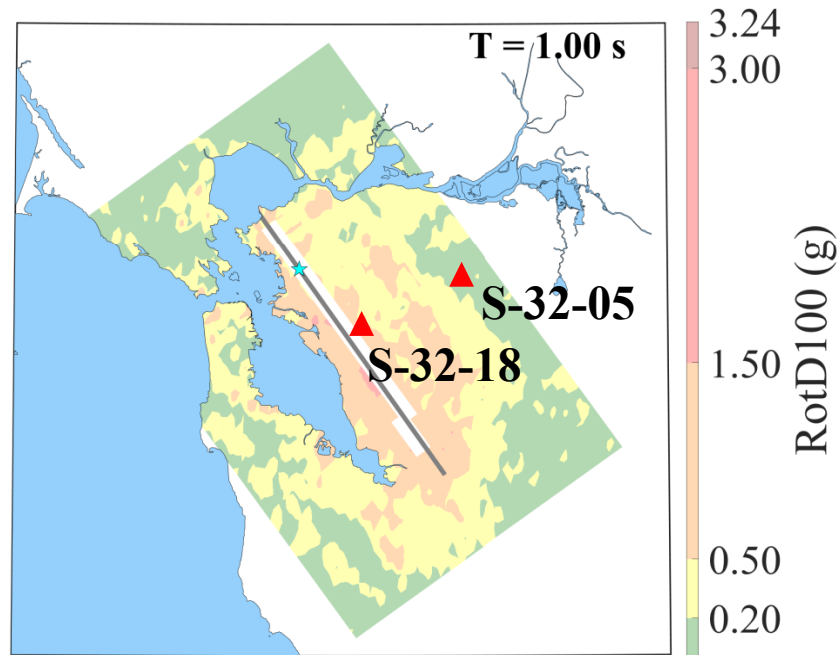
Physics-based M7 strike-slip rupture simulations on the Hayward fault



McCallen, D., et al.(2025).
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database for an M7
Hayward Fault earthquake
in the San Francisco Bay
Region. *Earthquake
Spectra*.

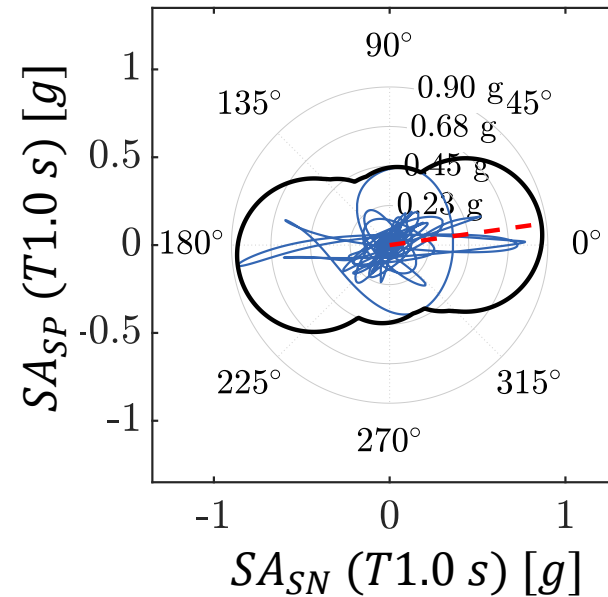


Near-fault simulated ground motions exhibit strong polarization



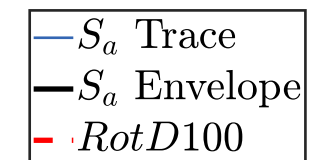
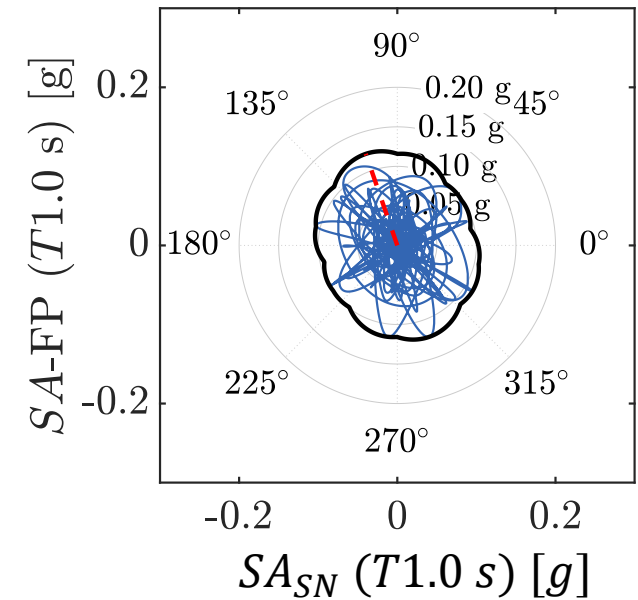
Near fault

Station: /S_32_18



Far field

Station: /S_32_05

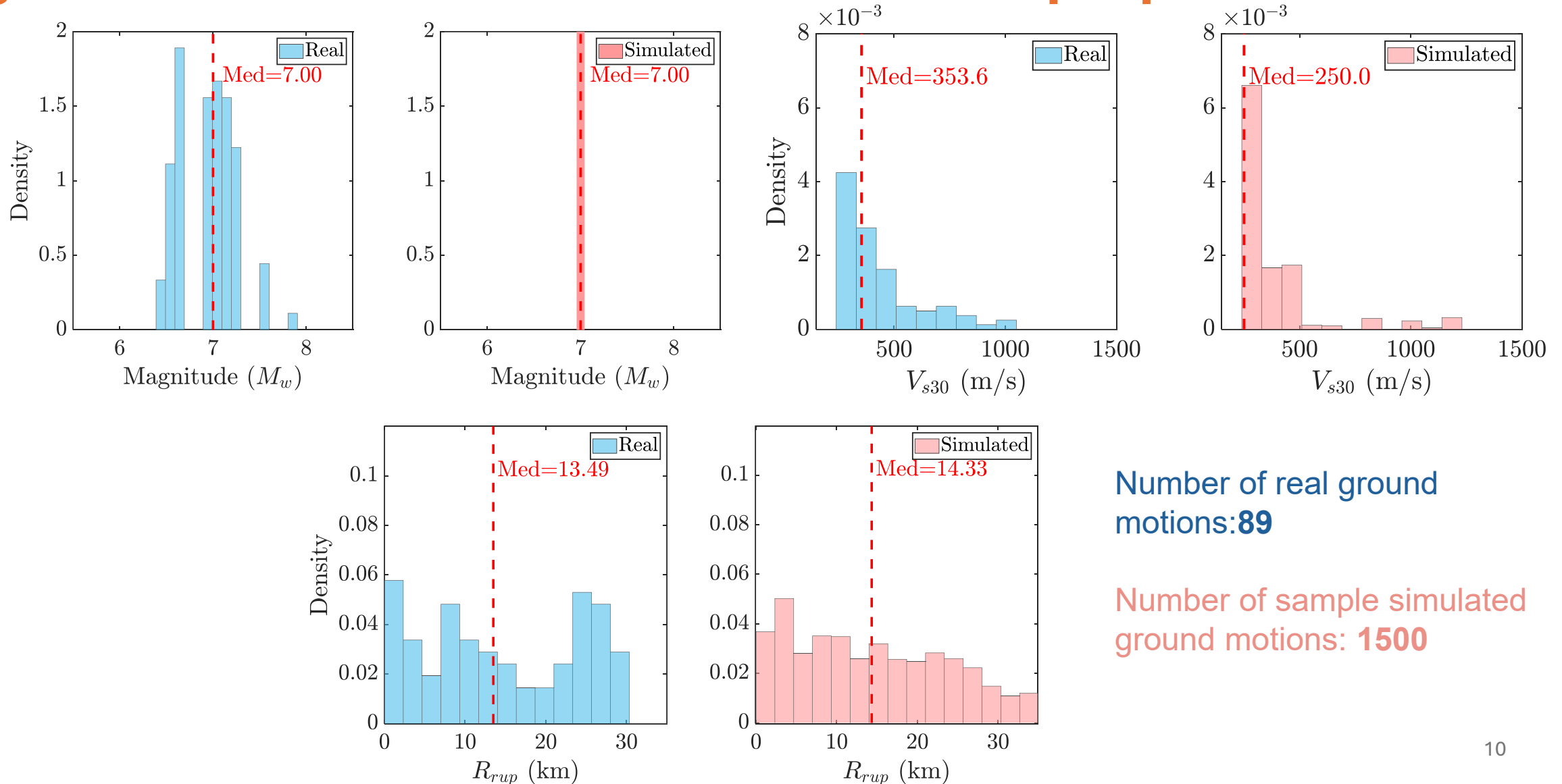


Using simulated ground motions to understand the variation of directionality features

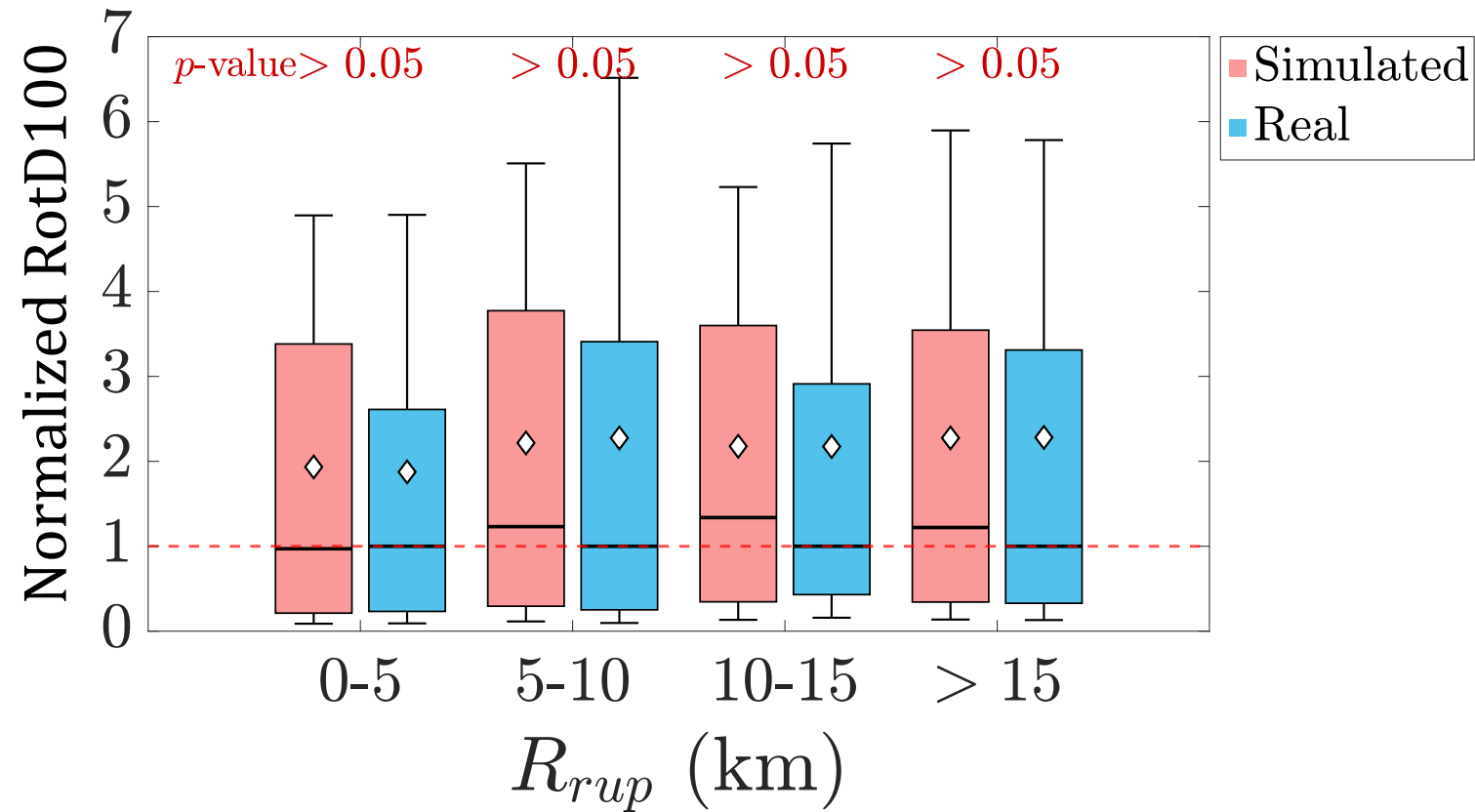


- Do the simulated and real ground motions have similar directionality features?
- How does ground motion polarization vary across distances and vibration periods?
- What is the influence of fault rupture characteristics on the directionality features?

Comparing groups of near-fault simulated and real ground motions with similar statistical properties



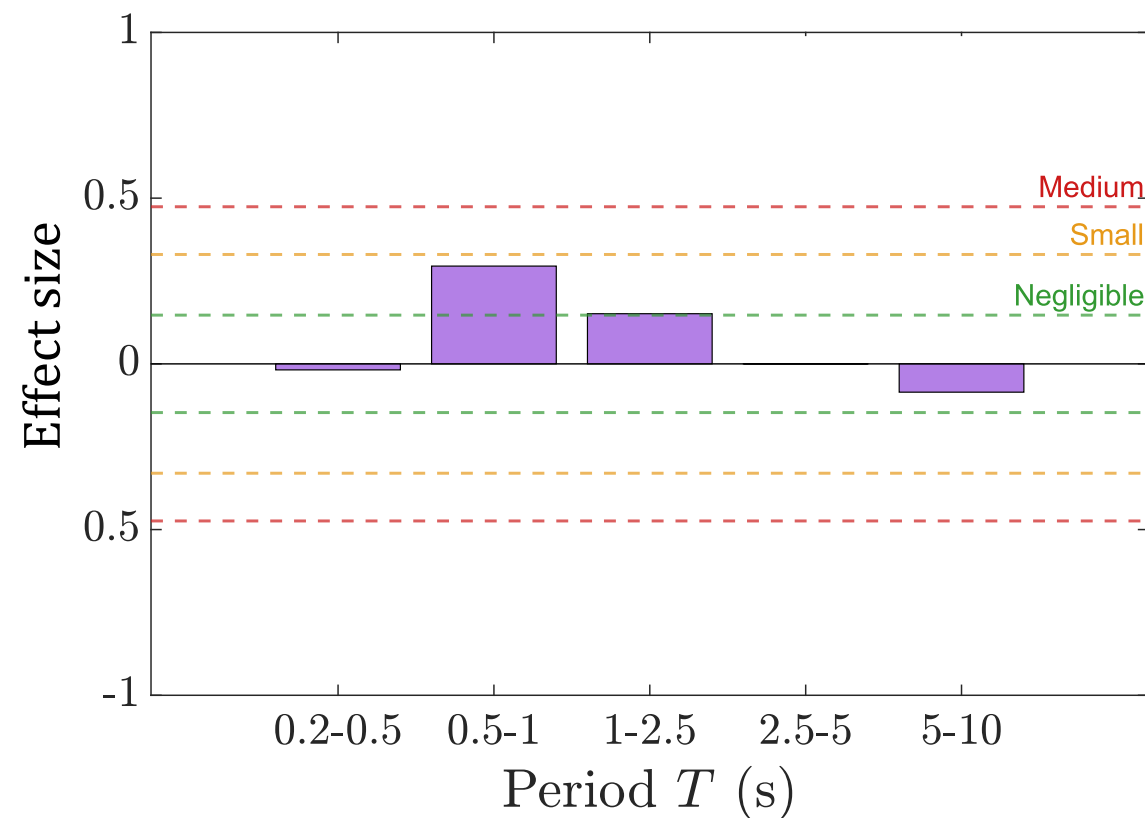
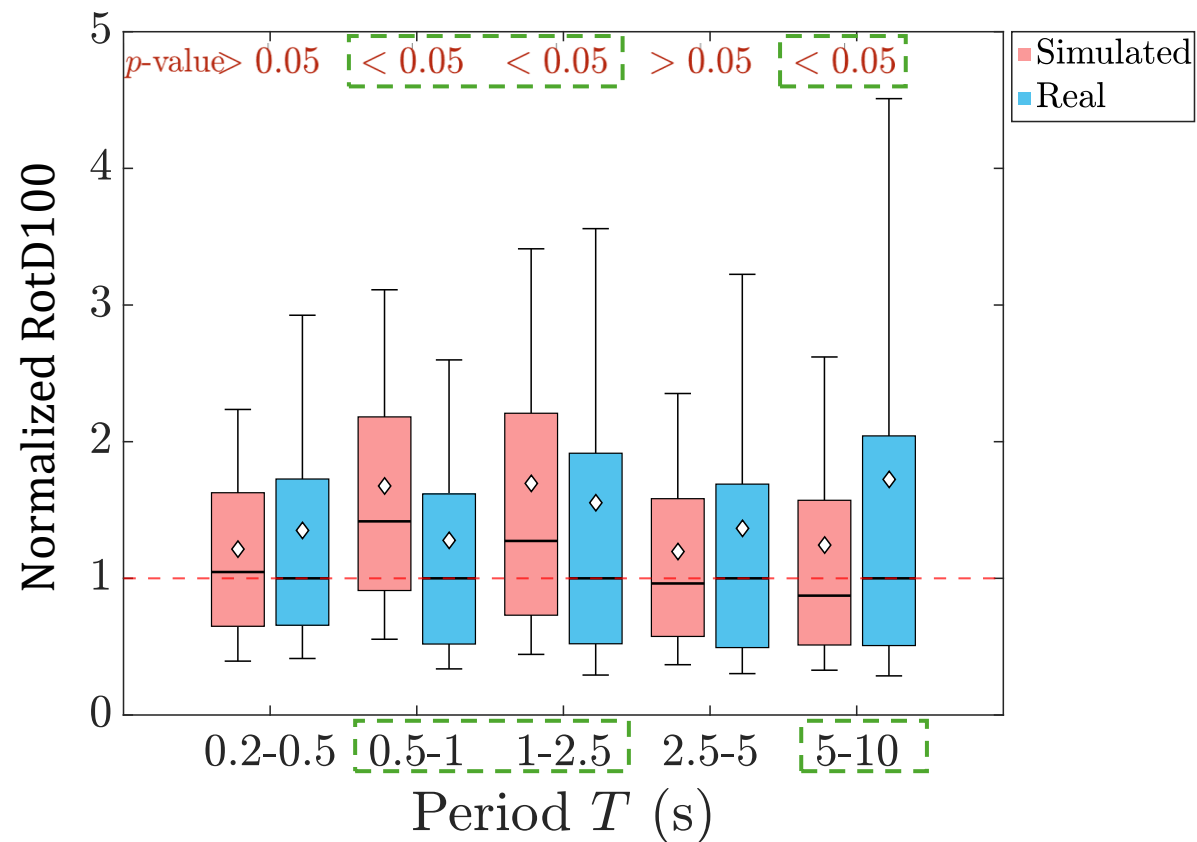
RotD100 intensities of simulated and real ground motions are similar



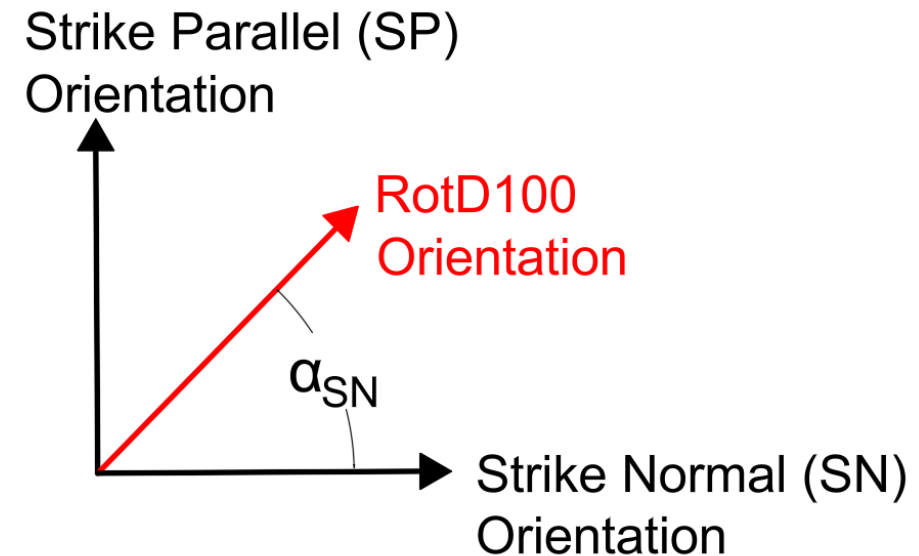
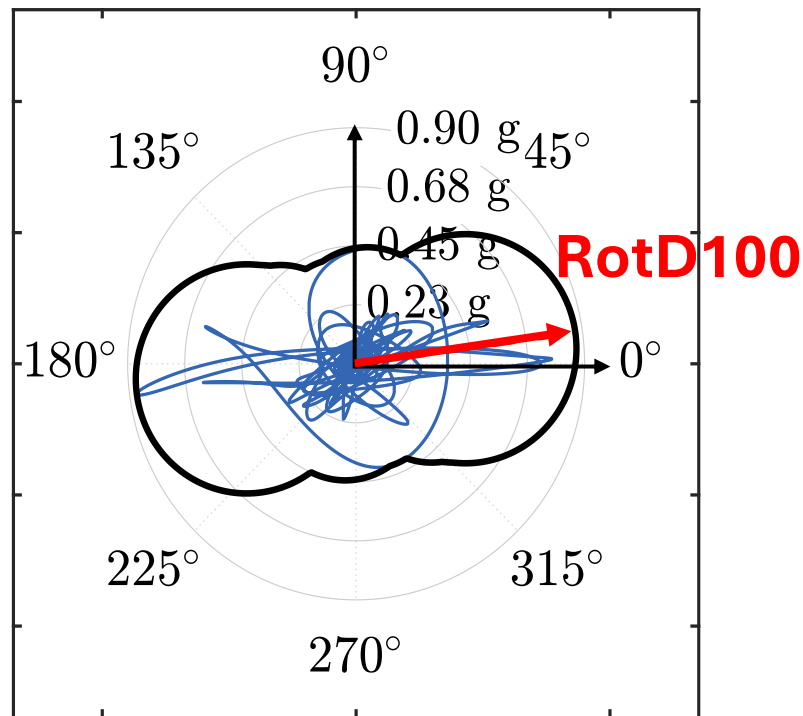
There is no statistically significant difference between simulated and real ground motions

Wilcoxon Rank-Sum Test at the 5% confidence level

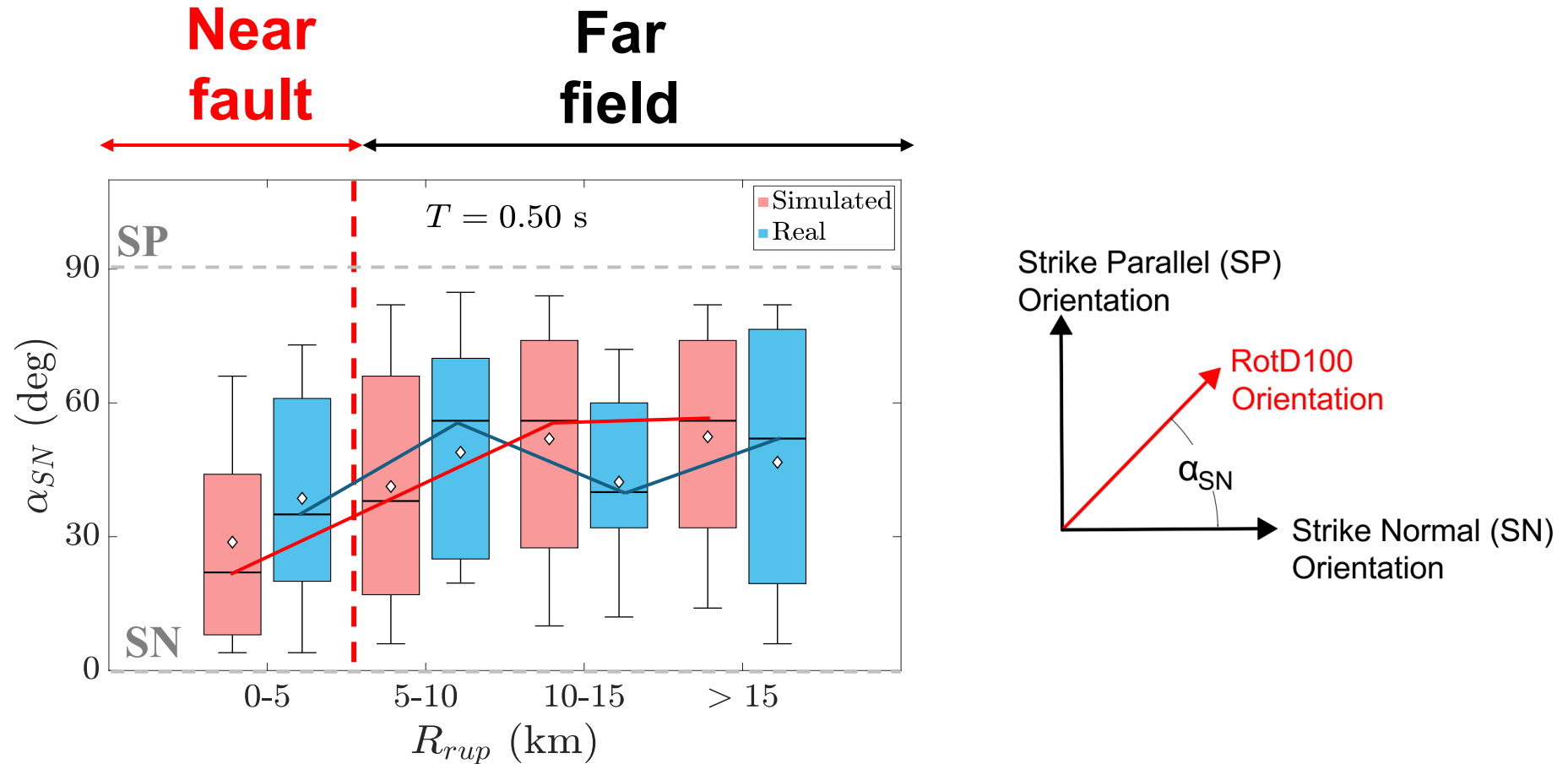
RotD100 intensities of simulated and real ground motions are similar



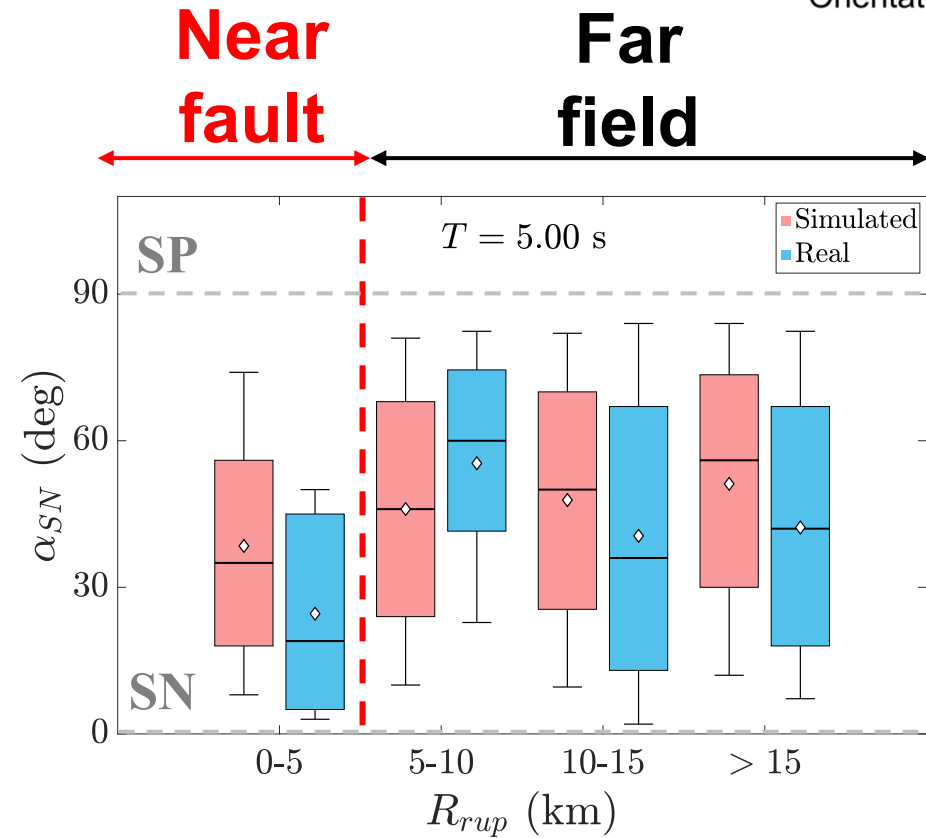
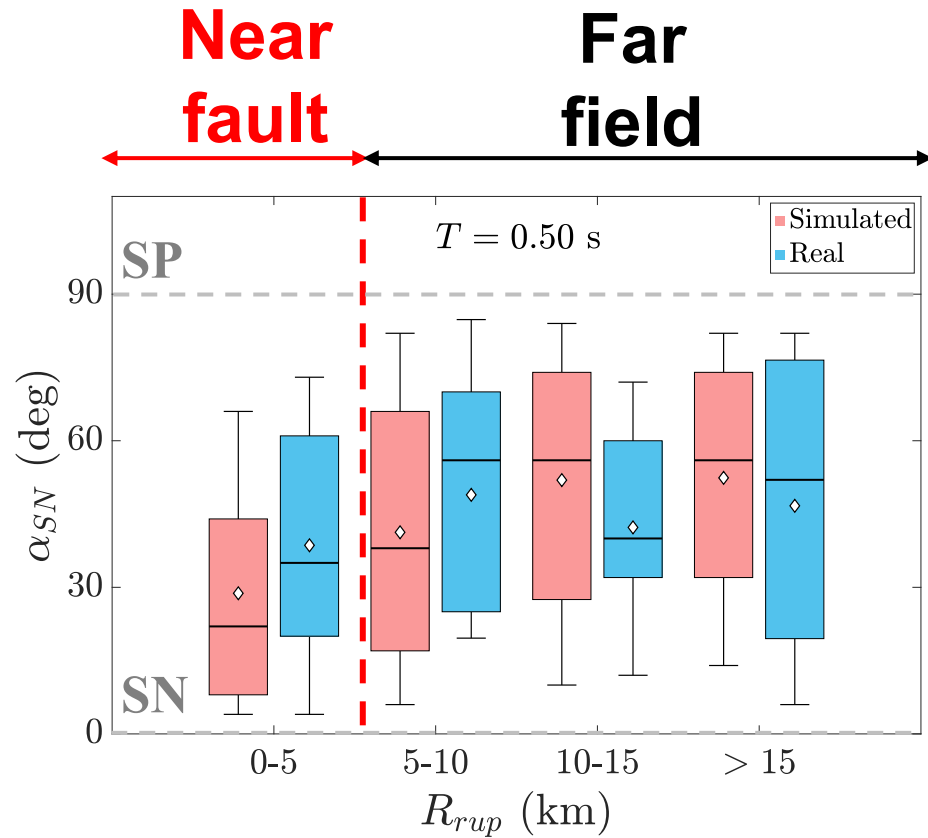
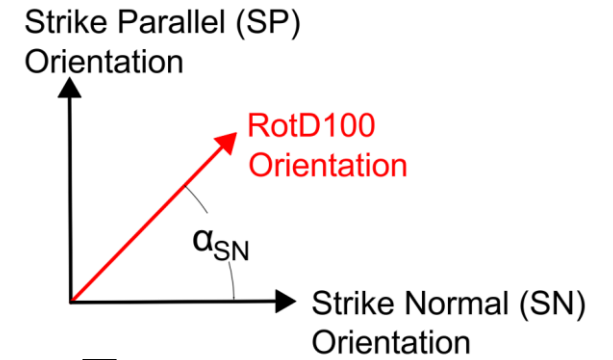
How does the orientation of maximum intensity vary across distances and vibration periods?



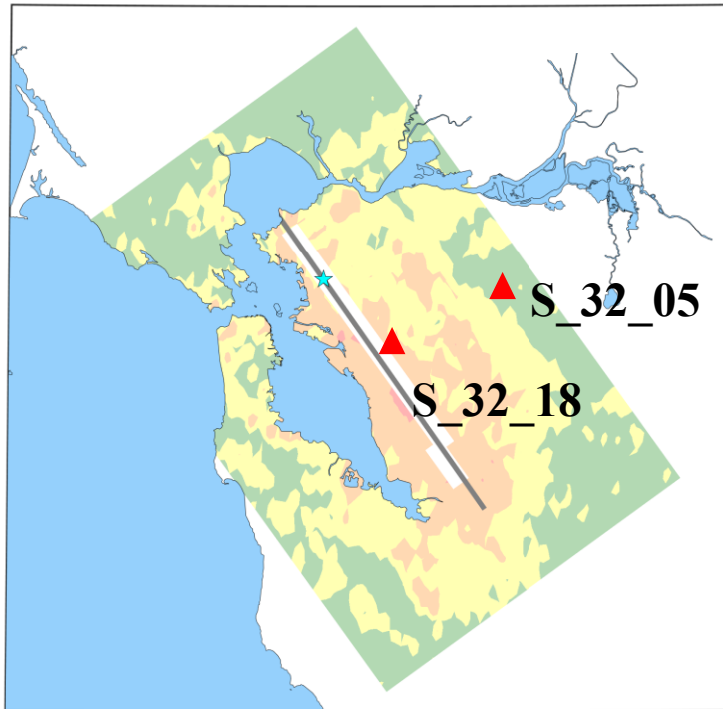
Simulated and real ground motions may be strongly polarized near the fault



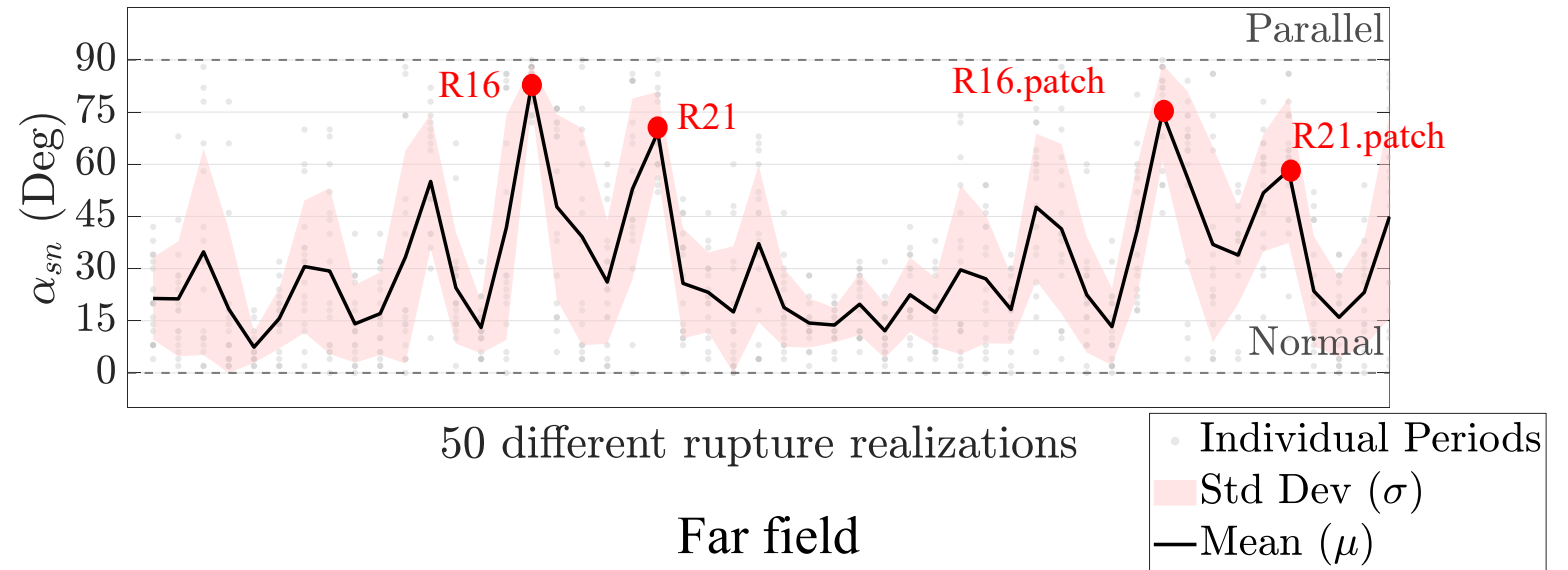
Ground motion polarization near the fault varies across periods



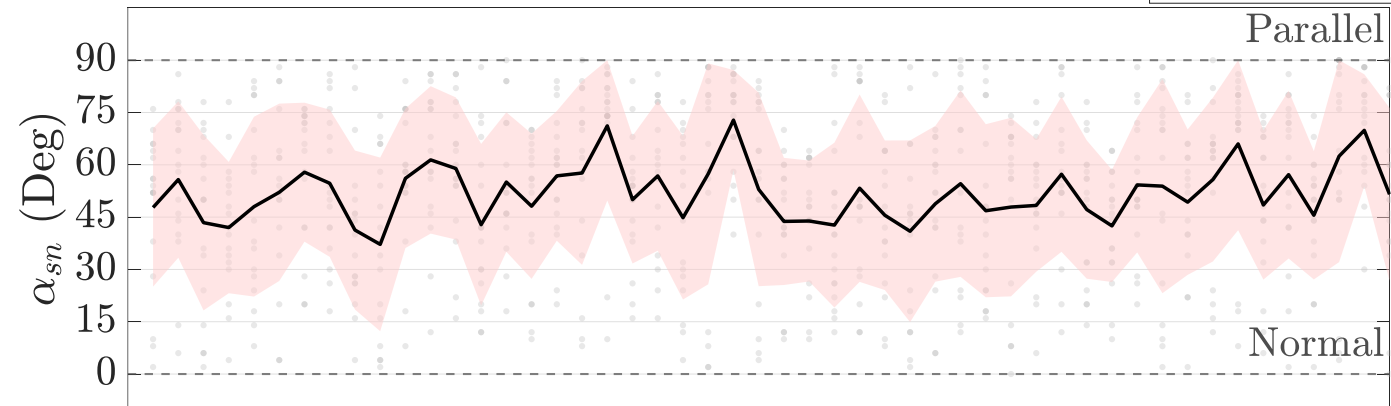
Variability of the RotD100 orientation across different rupture realizations



Near fault



Far field

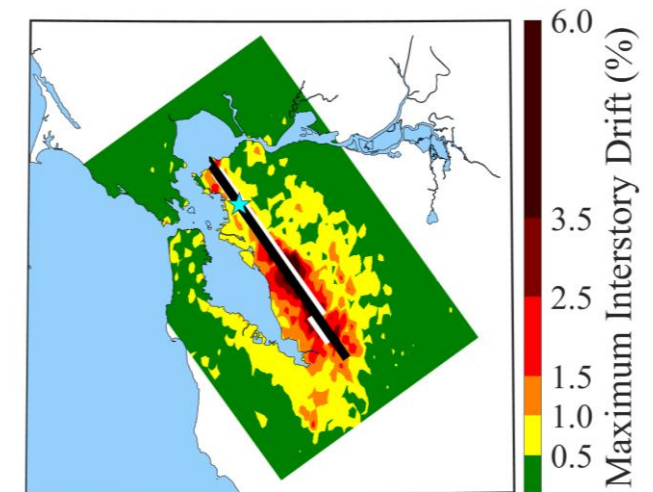
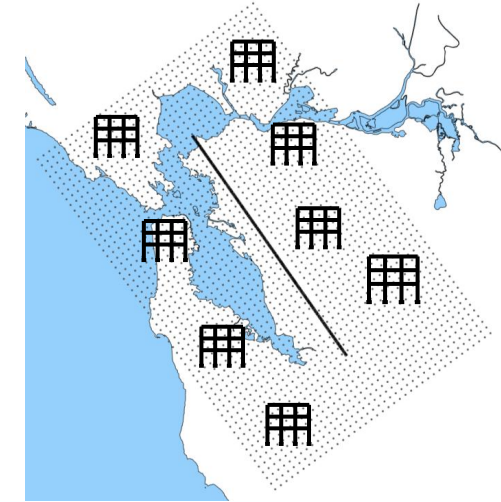
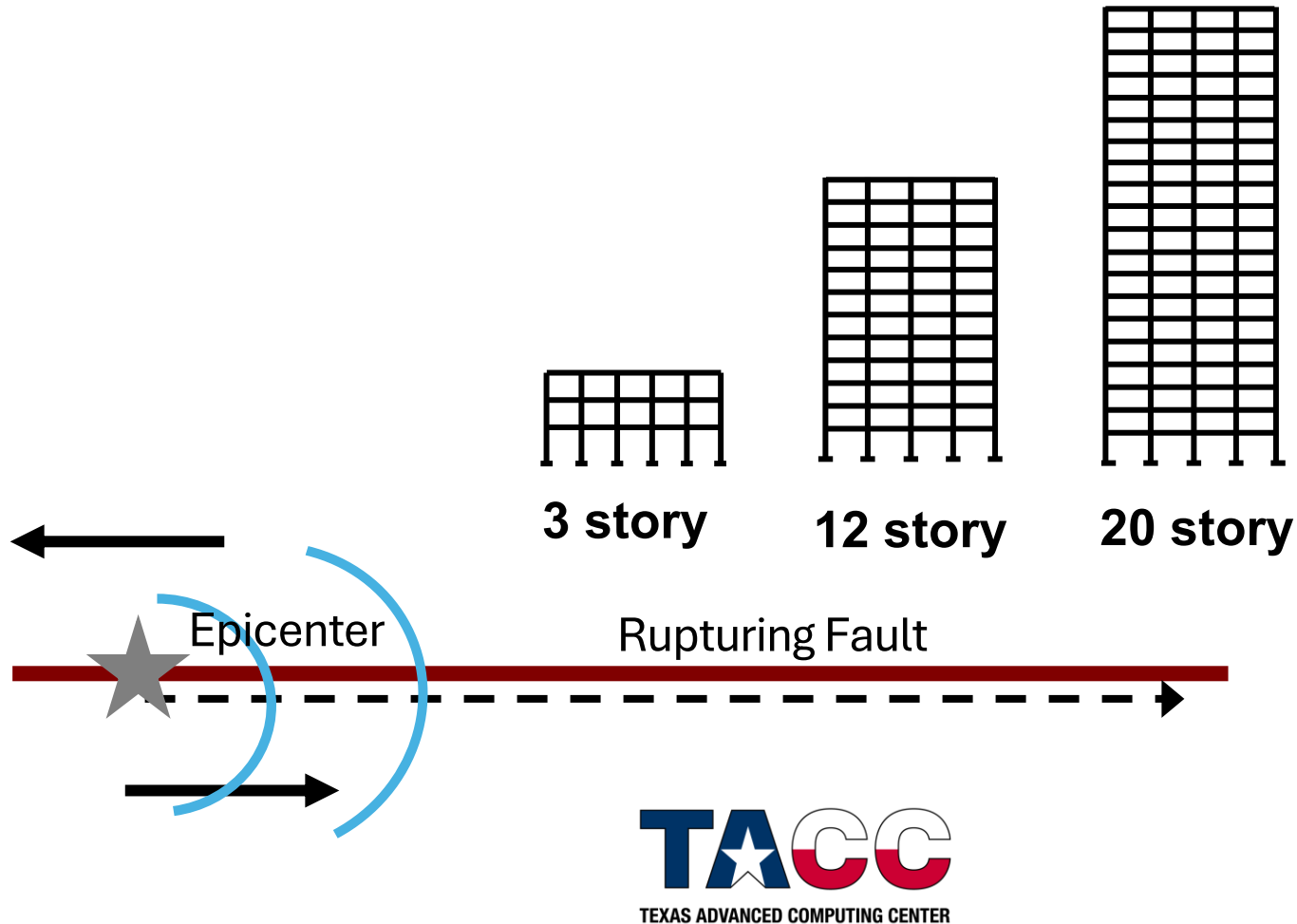


50 different rupture realizations

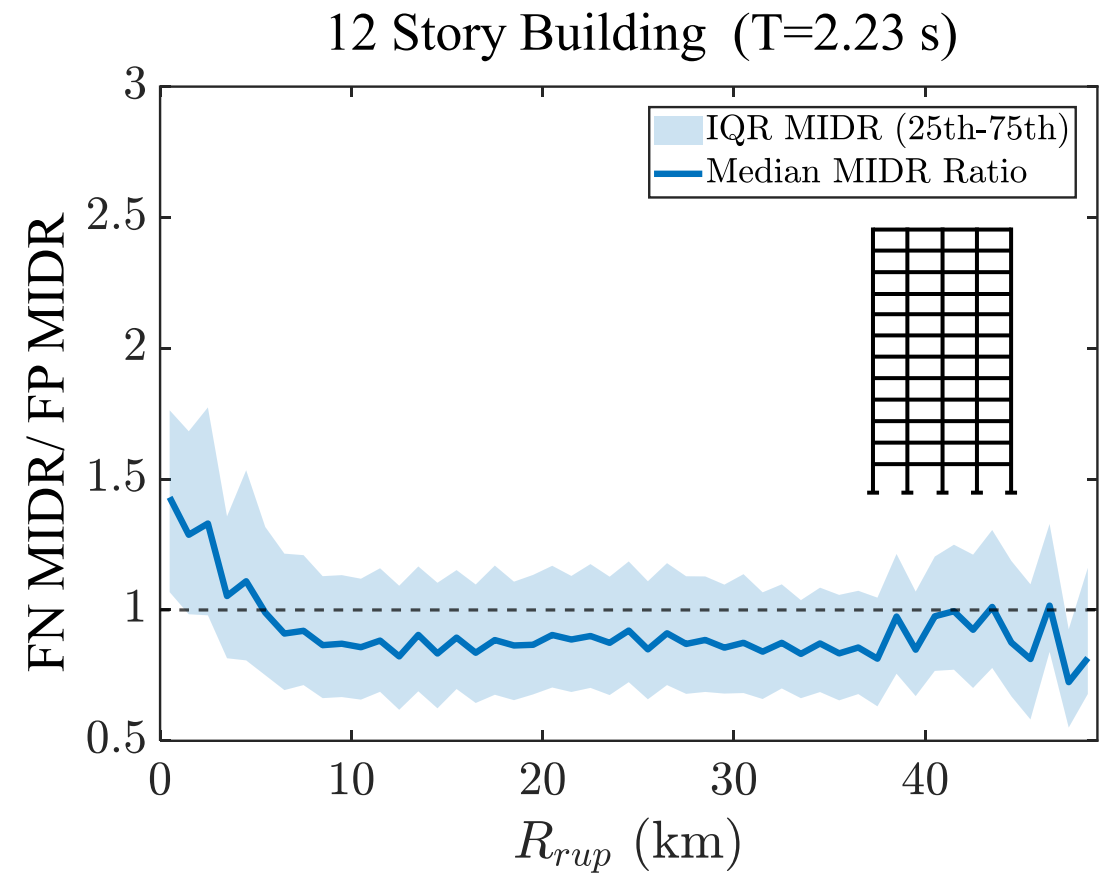
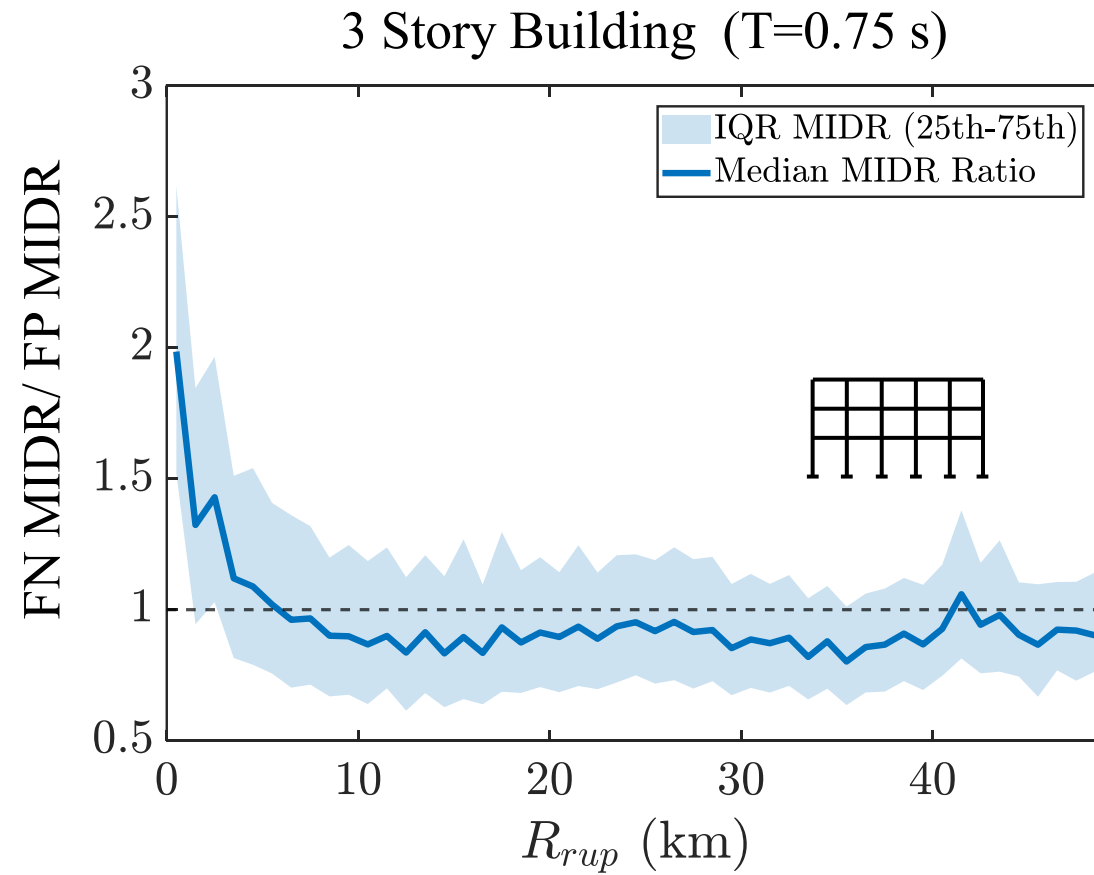


**How does ground motion
polarization affect seismic
demands on structures?**

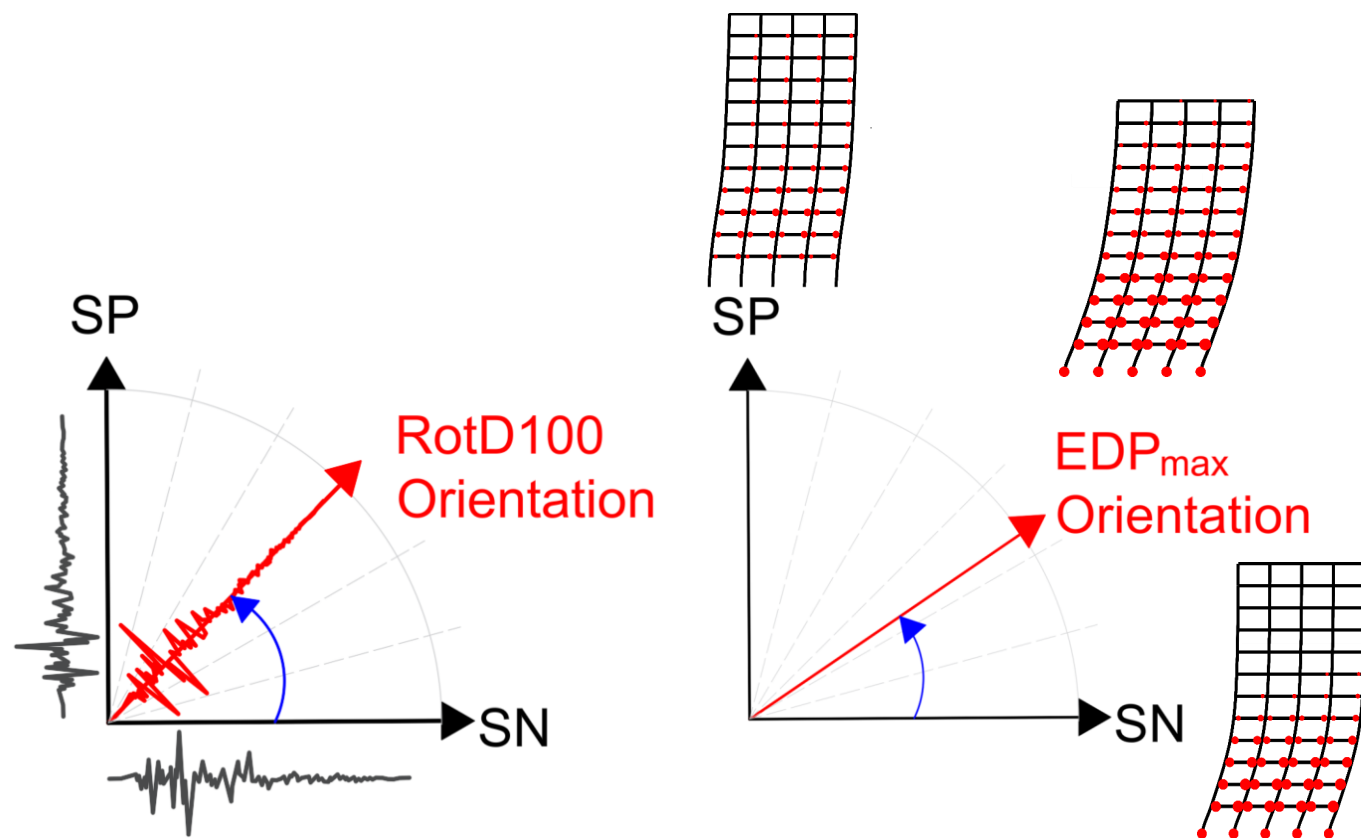
Structural analysis of buildings across the San Francisco Bay Area



Polarization of seismic demands on structures



Ongoing work



- How does the direction of the maximum structural demands vary spatially across the region?
- Does the orientation of maximum structural demand (EDP_{max}) significantly deviate from the *RotD100* orientation?
- How do directionality trends vary for structures with different dynamic characteristics?

Upcoming presentations and publications



- Herrera, M., & Kenawy, M. (2026, July 13–17). Directionality Characteristics of Near-Fault Simulated Ground Motions from Physics-Based Hayward Fault Rupture Simulations [Paper presentation]. 13th National Conference on Earthquake Engineering (13NCEE), Portland, OR, United States.
- Herrera, M., & Kenawy, M. (2026, May 28–29). Quantifying the Effects of Near-Fault Ground Motion Directionality on Regional Seismic Risk Assessment using Physics-Based Fault-Rupture Simulations [Symposium presentation]. 2026 NHERI Computational Symposium, University of California, Berkeley, CA, United States.
- Herrera, M., & Kenawy, M. (2026). *Spatial Variability of Structural Seismic Demand Directionality: Insights from Physics-Based Rupture Simulations of the Hayward Fault* [Manuscript in preparation]. Department of Civil and Environmental Engineering, Oklahoma State University

Acknowledgements



- Support from Dr. David McCallen and Dr. Arben Pitarka with access and analysis of the fault-rupture simulations
- Access to the Texas Advanced Computing Center facilities for running the regional-scale structural simulations



Thank you!

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