



**CRESCENT Spring Virtual Session**  
**April 21, 2026**

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# ***NONLINEAR DYNAMIC ANALYSES OF 2001 NISQUALLY GROUND FAILURES TO VALIDATE GROUND MOTION SIMULATIONS***

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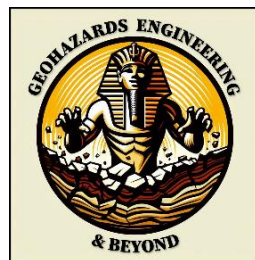
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**USC**



## **Acknowledgements**

*This work was supported by the CRESCENT Seed Grant Program (2025–2026) as Reference #2017Y0 under NSF award 2225286. Thank you to Dr. Erin Wirth Moriarty (USGS Seattle) for providing simulated ground motion data.*

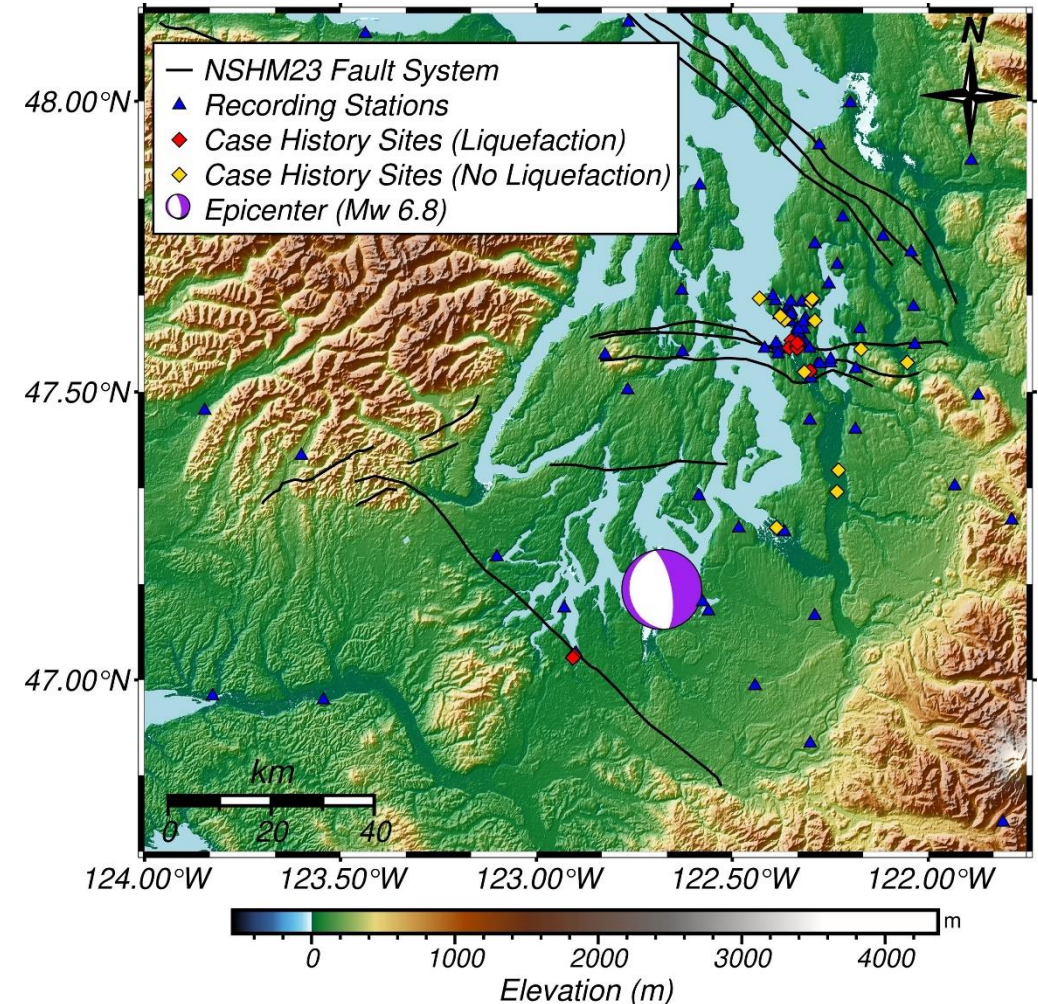
# Background and Motivation

## Background: 2001 Nisqually Earthquake (Mw 6.8)

- Affected the Seattle metropolitan region
- Well-documented liquefaction-induced ground failures (e.g., Bray et al., 2001)
- Extensive geotechnical and strong-motion data available (e.g., WADNR database, Rasanen et al. 2023)
- Community Velocity Model (CVM) v1.7
  - Improved representation of shallow soils and site effects ( $V_{s_{min}} \sim 40$  m/s) (Wirth et al., 2025)

## Motivation

- Demonstrate applicability of simulated ground motions for modeling ground failures.
- Validate simulated ground motions for soft soil sites over several case studies.

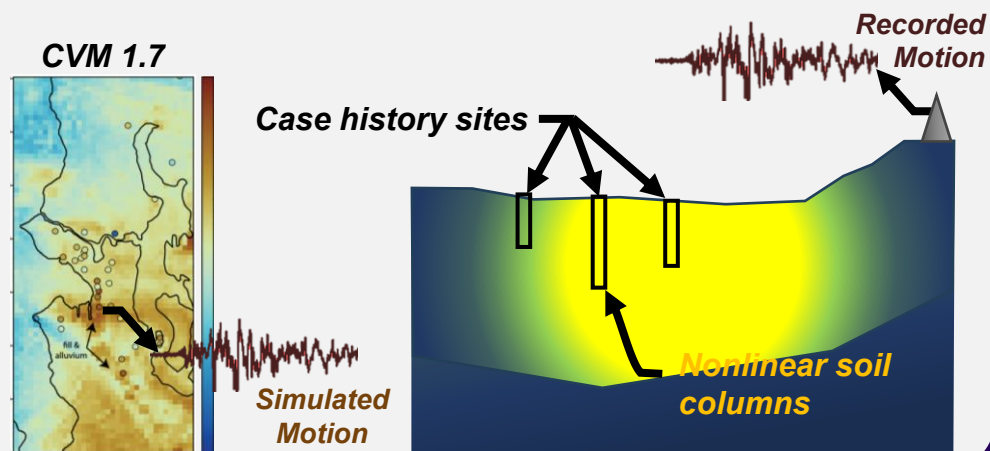


# Methodology

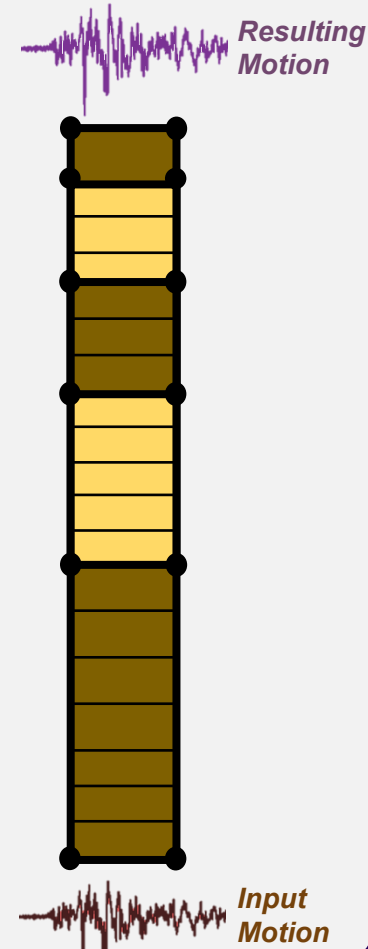
**Task 1:** Classify liquefaction occurrence and severity of 2001 Nisqually study sites (Rasanen et al. 2023).



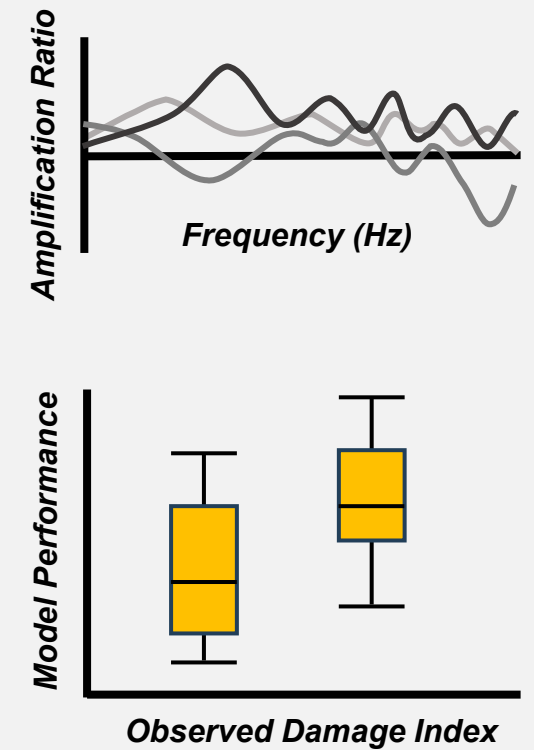
**Task 2:** Obtain recorded and simulated ground motions for input in nonlinear soil columns.



**Task 3:** Perform nonlinear dynamic analyses at study sites.



**Task 4:** Develop insights from model results relative to observations.



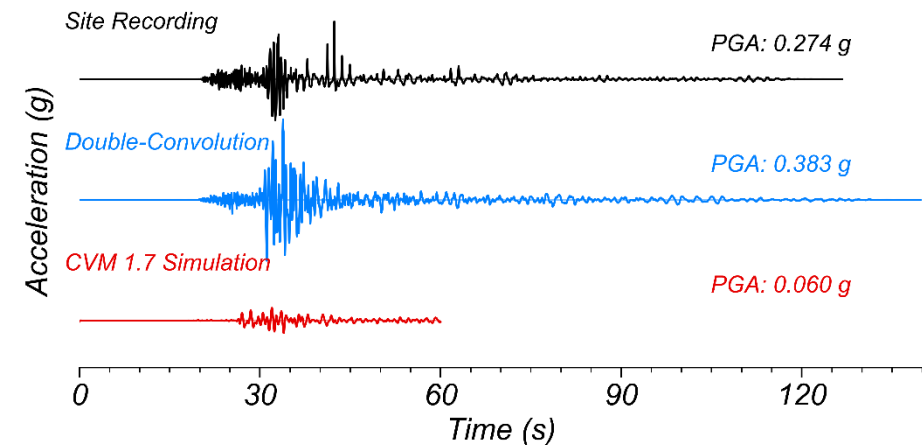
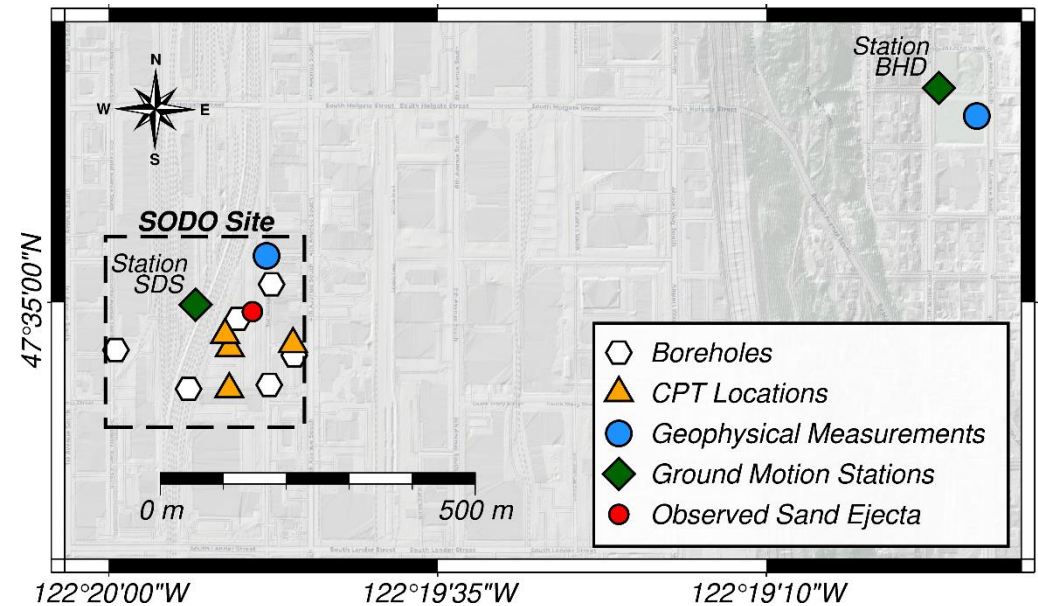
# Case Study Site

## ➤ Site: SODO-01 (South of Downtown Seattle)

- Free-field lot near Amtrak train tracks
- Moderate sand ejecta observed
- Nearby cone penetration tests (CPTs), borings, and geophysical tests
- Adjacent to recording station SDS
- ~58 m of soft soils ( $V_s < 250$  m/s)

## ➤ Input Ground Motions

- Double-convolution of BHD station records ( $V_{s30} \approx 680$  m/s, ~1.2 km away) (Pretell et al., 2025)
- Deconvolution of CVM v1.7 simulated motions



E-W trending input ground motions used in the study

# Nonlinear Dynamic Analysis: SODO-01

## ➤ Soil Profile

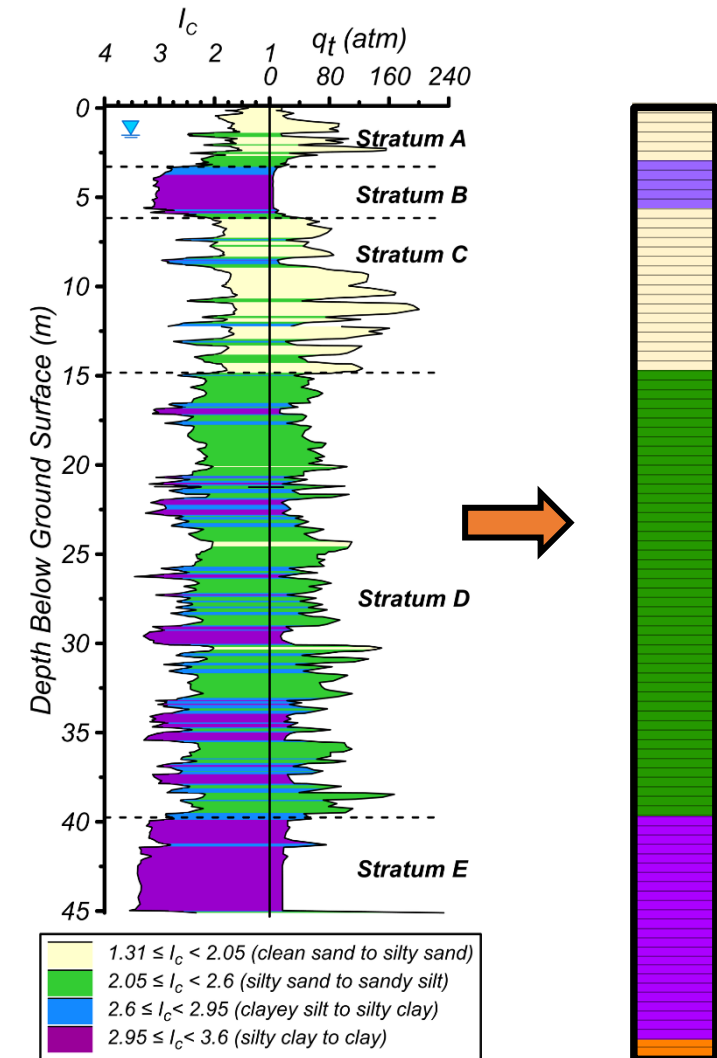
- CPTs and borings indicate 5 distinct strata
- Soft soils extend 58 m deep in nearby boring
- Representative median properties assumed from multiple CPTs

## ➤ Constitutive Soil Modeling

- PM4Sand for strata A, C, & D
- PM4Silt for strata B & E
- Captures cyclic response and pore pressure generation (Boulanger & Ziotopoulou, 2023a,b)

## ➤ NDA in Finite Difference Software FLAC2D

- 0.5 m thick elements
- 58 m soil column over elastic half-space ( $V_s=360$  m/s)
- Monitor ground motion response and porewater pressure development and dissipation



# Preliminary Results and Ongoing Work

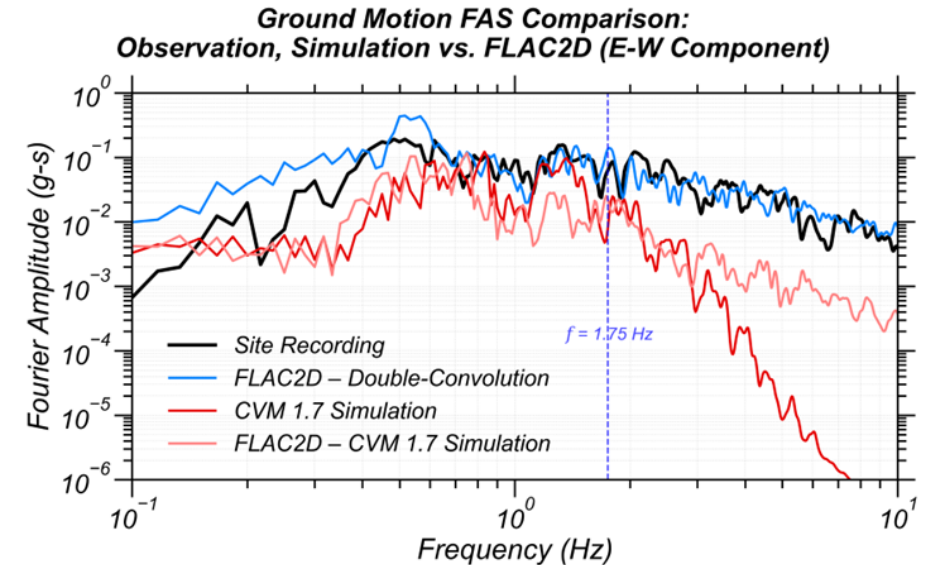
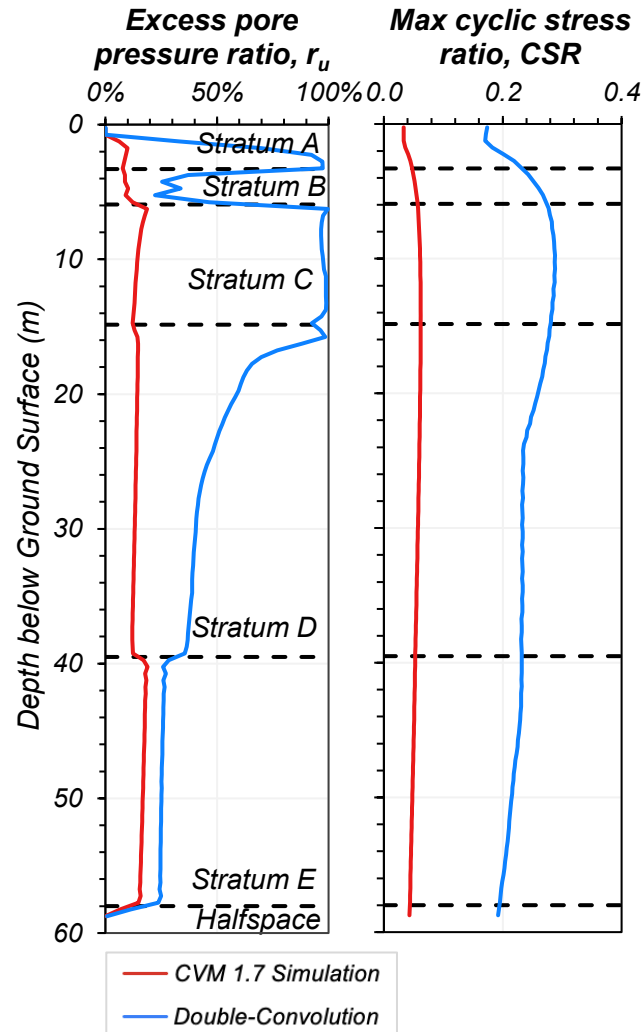
## ➤ Double-convolved motion

- Causes liquefaction ( $r_u \approx 100\%$ ) in strata A & C
- Matches site recording above  $\sim 0.55$  Hz

## ➤ CVM v1.7 motion

- Does not generate sufficient cyclic demand to trigger liquefaction
- NDA did not significantly improve FAS match with site recording

- Ongoing work is applying workflow to evaluate ground response and liquefaction potential at >20 sites



# References

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