High-throughput Hazards Modeling and Databases

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(E) – Solving the BIG Research Questions: Then and Now

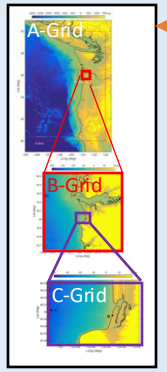
Friday, November 8, 2024 – Gaithersburg Marriott
Washingtonian Center- Salon F&G

1. Challenge: Consistent seismic and tsunami hazard modeling

- **Multiple interdependent hazards**: Earthquakes produce ground shaking, ground permanent deformation, lateral spreading, landslides, and can also produce tsunamis. These are seldom analyzed holistically.
- **Infrequent Events**: Earthquakes are relatively rare and can vary widely in their magnitude and impact, which complicates establishing reliable historical databases. Similarly, tsunamis, while often catastrophic, occur infrequently, making validation and trend analysis difficult.
- **Geological Complexity**: The geological processes that trigger tsunamis can be difficult to study comprehensively, leading to gaps in knowledge that can skew hazard assessments.
- **Insufficient data**: hinders accurate hazard assessments.

2. Current strategies to address challenges

1. USER DEFINITIONS

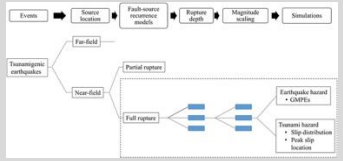


Topo-bathymetry/grids

Computational resources

Hazard Metrics

2. SEISMIC AND TSUNAMI MODELS

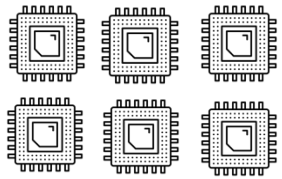


Source discretization
GMPEs
Slip distributions
Scenario probabilities

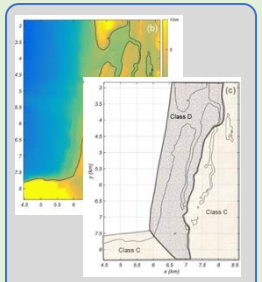
3. NUMERICAL SIMULATIONS

HPC

Eqke / Tsunami SIMULATIONS

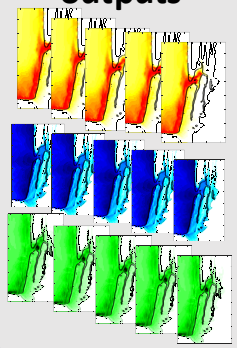


Check results

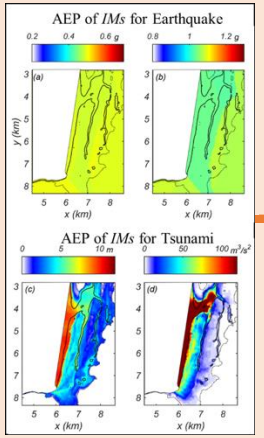


Refined sources and updated probabilities

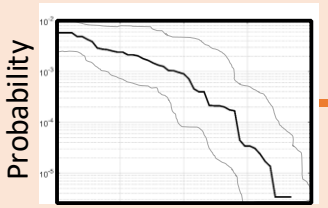
Simulation outputs



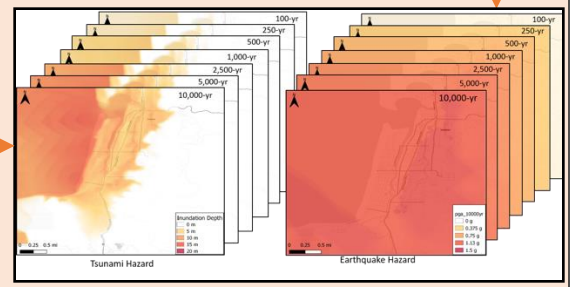
4. POST-PROCESSING



Hazard Visualizations



Tsunami Intensity
Hazard Aggregations



Probabilistic Seismic and Tsunami Hazard Maps

DESIGNSAFE

2023 Data Set Awardee

Park, H., Cox, D. T., Alam, M. S., & **Barbosa, A. R.** (2017). Probabilistic seismic and tsunami hazard analysis conditioned on a megathrust rupture of the Cascadia subduction zone. *Frontiers in built environment*, *3*, 32.

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NIST CENTER FOR RISK-BASED COMMUNITY RESILIENCE PLANNING

Resilience

Seaside Testbed Published Data Set

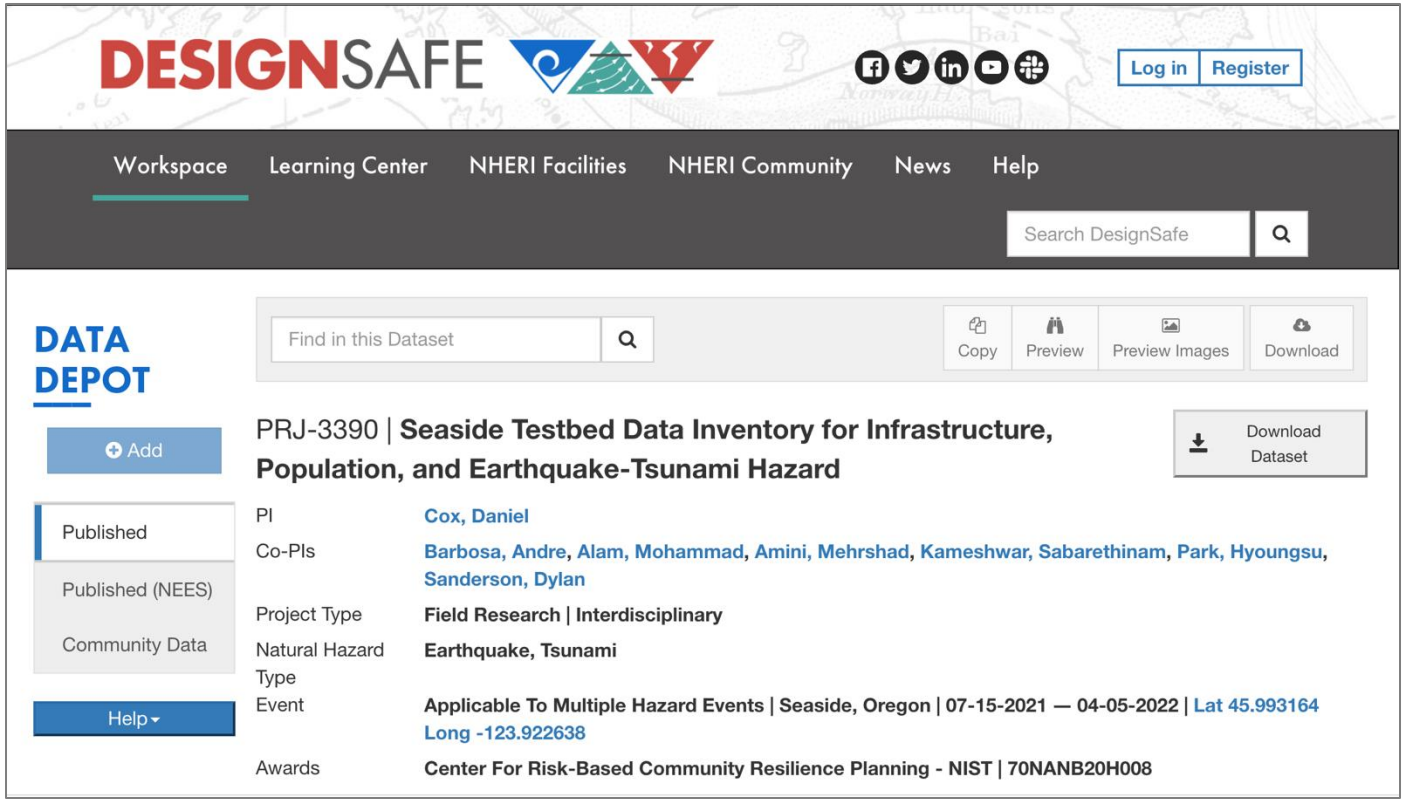
Background/Motivation:

- Provide archived data of built, natural, and human systems
- Open data for disaster & resilience modeling
- Useful for multi-hazard, risk-informed damage and loss modeling

Data Set:

- Parcel-level description
- Built Environment: buildings, transportation, water, electric power network
- **Hazard: seismic and tsunami intensity for 100 year to 10,000-year mean return interval.**
- Socio-Economic: population demographics, dollar value

DESIGNSAFE 2023 Data Set Awardee



Cox, D., A. Barbosa, M. Alam, M. Amini, S. Kameshwar, H. Park, D. Sanderson (2022). "Report", in Seaside Testbed Data Inventory for Infrastructure, Population, and Earthquake-Tsunami Hazard. DesignSafe-CI. https://doi.org/10.17603/ds2-sp99-xv89

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Seaside Example Notebook 1: Multi-Hazard Building Damage

This notebook uses the pyIncore modeling framework to compute multi-hazard damages to buildings in Seaside, Oregon. pyIncore's **BuildingDamage** and **MonteCarloFailureProbability** modules are implemented to compute damages resulting from both an earthquake and tsunami. pyIncore's **cumulativebuildingdamage** module is used to compute cumulative damages.

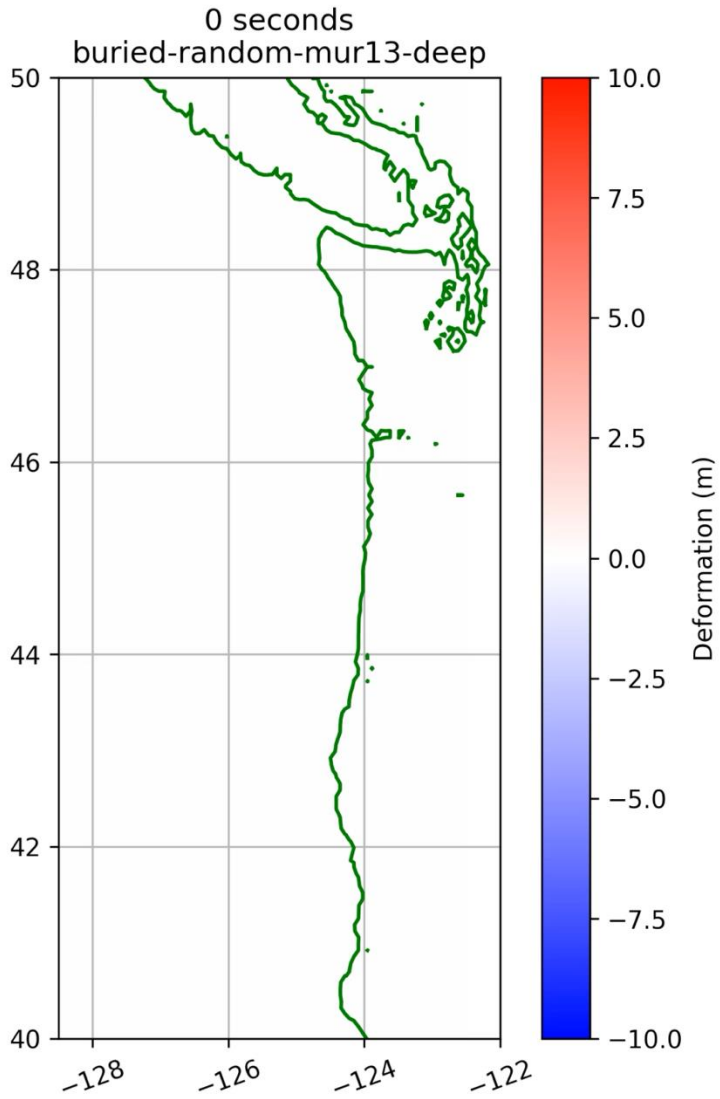
*Notebook created by Dylan R. Sanderson (OSU - sanderdy@oregonstate.edu) and Gowtham Naraharisetty (NCSA)

1. Background

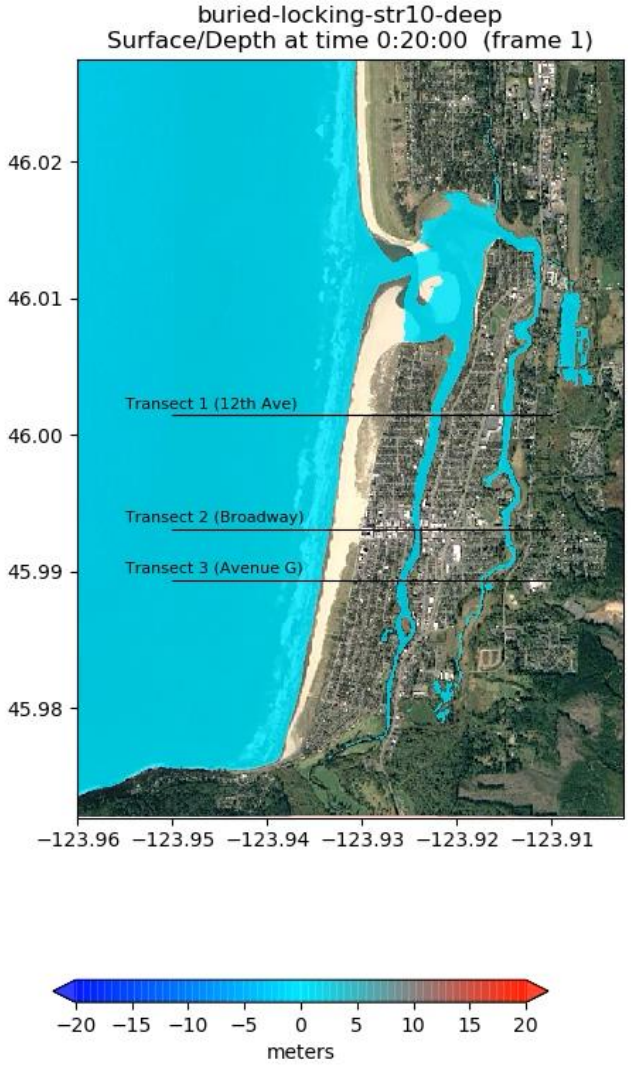
Communities around the world are subject to multiple natural hazards that often occur near simultaneously. For example, hurricanes often result in high wind speeds, as well as flooding from both rainfall and storm surge. Similarly, seismic events can result in earthquakes, tsunamis, and landslides. When considering multi-hazards, there is a consensus that the total expected damages are not the sum of the underlying single hazards. For example, in the case of seismic-tsunami events, a building completely destroyed by an earthquake cannot sustain any more damage from the tsunami. Subsequently, it is essential to consider this when performing a multi-hazard damage analysis.

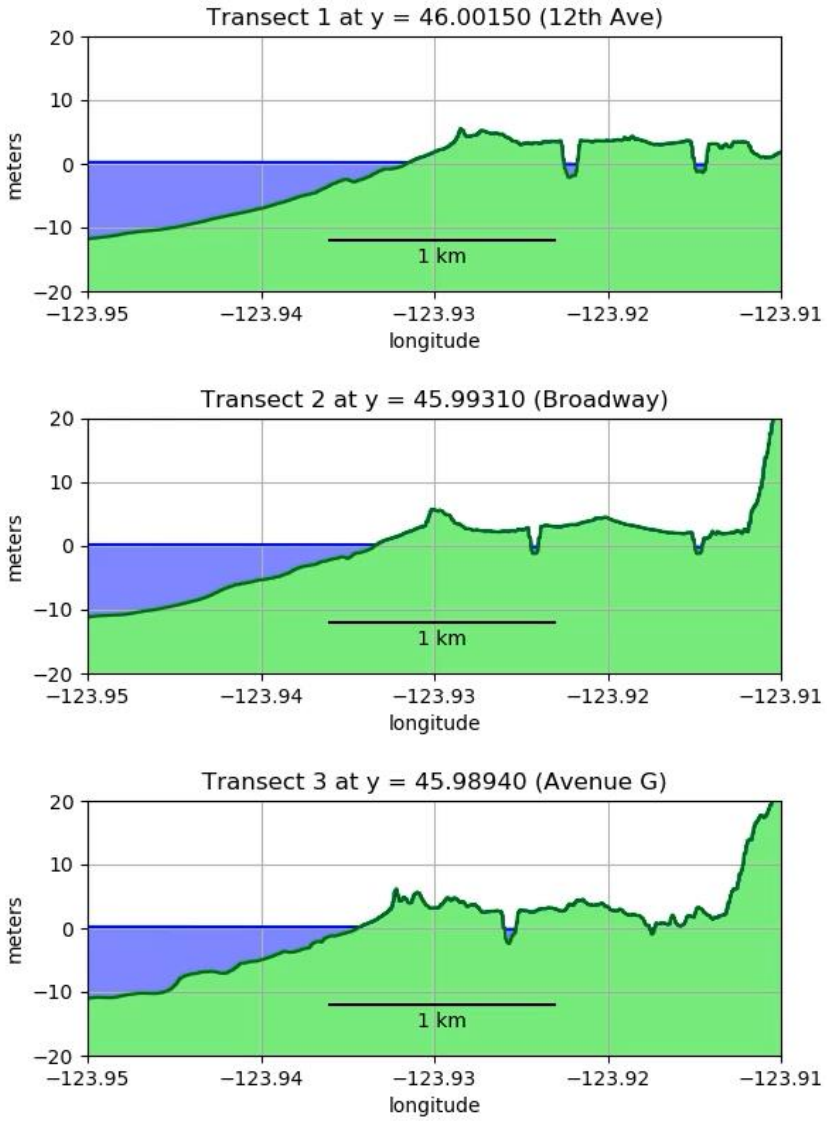
3. Opportunities moving forward

- Better understanding of faults is required for better probability distributions:
  - Studies of recent earthquakes on similar faults
  - Paleo studies (e.g. tsunami deposits, turbidites) coupled with tsunami modeling
  - Seismic studies of fault structures
  - Return times / annual probabilities
- Understanding behavior of infrastructure systems (bridges, ports, critical facilities) to cascading earthquake ground shaking and tsunamis
- Benchmarking simulations (V&V):
  - **Verification**: Comparison to analytical solutions (when the same equations are used)
  - **Validation**: Comparison to observations from real events or wave tank experiments.



Courtesy Audrey Dunham, USGS/UW





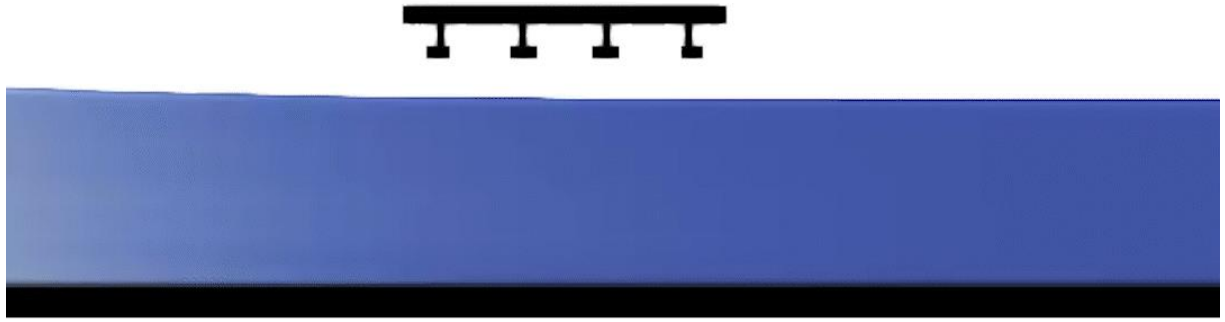
Courtesy of Randall LeVeque, UW

Infrastructure Modeling (Bridges)

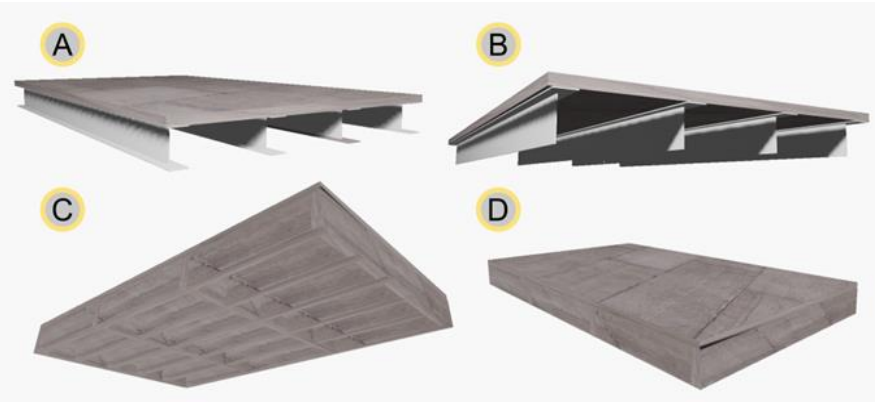
- Validated solutions with existing experimental results
- Finishing simulation of prototype Oregon and Washington bridge geometries with varying hydraulic flow conditions

Fabian Lucero, Andre Barbosa, Claudia Reis

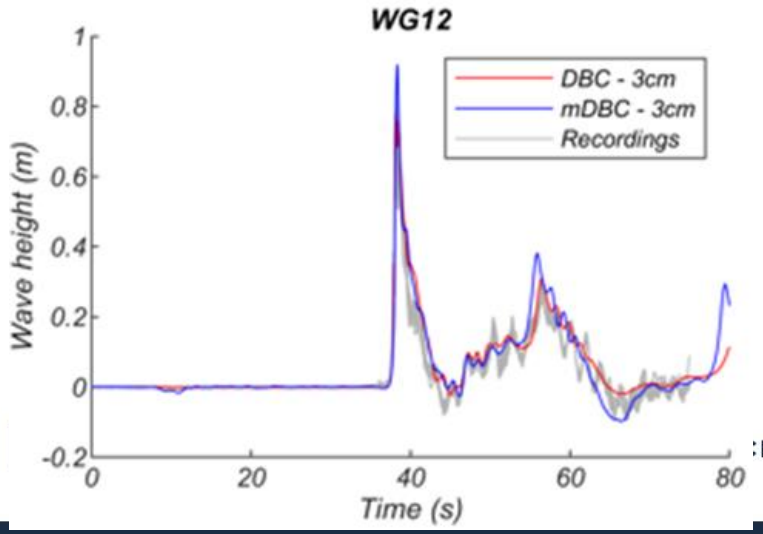
SPH Bridge Model Validation with Experimental Results



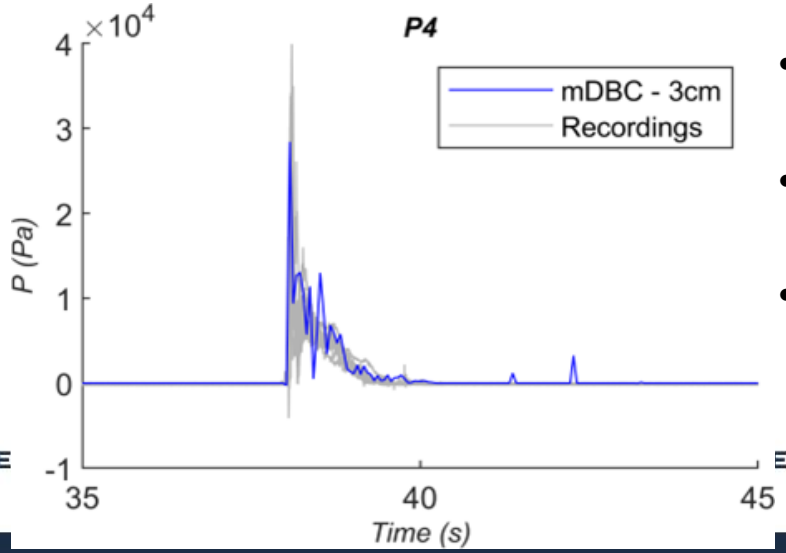
Modeling prototype Oregon and Washington bridge geometries



Free Surface Elevation



Pressure



Upcoming Activities:

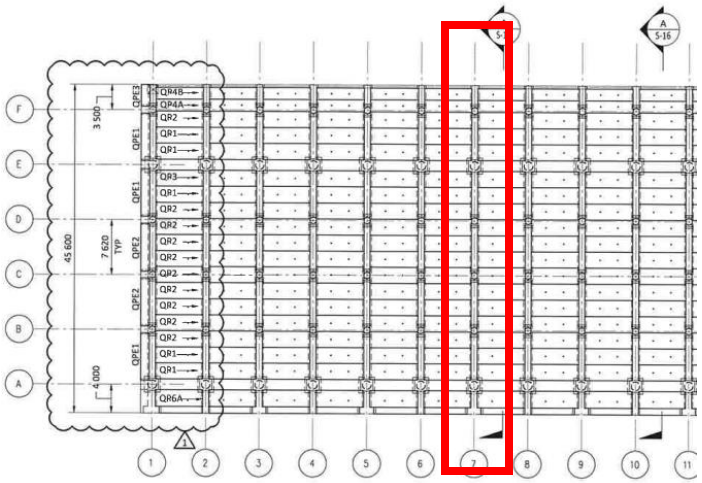
- Integration earthquake and tsunami results
- Validation of (ET) multi-hazard (Seaside)
- Continue ET multi-hazard for Astoria, Newport and Coos Bay

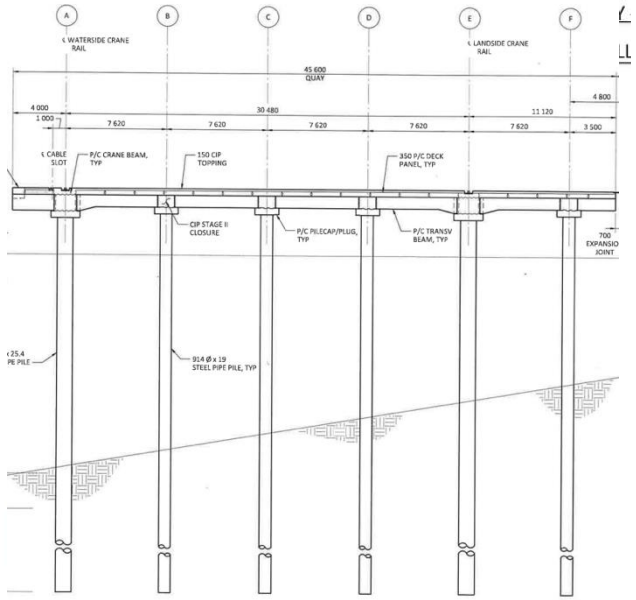
Infrastructure Modeling (Ports)

Jorge Romero, Andre Barbosa, Claudia Reis

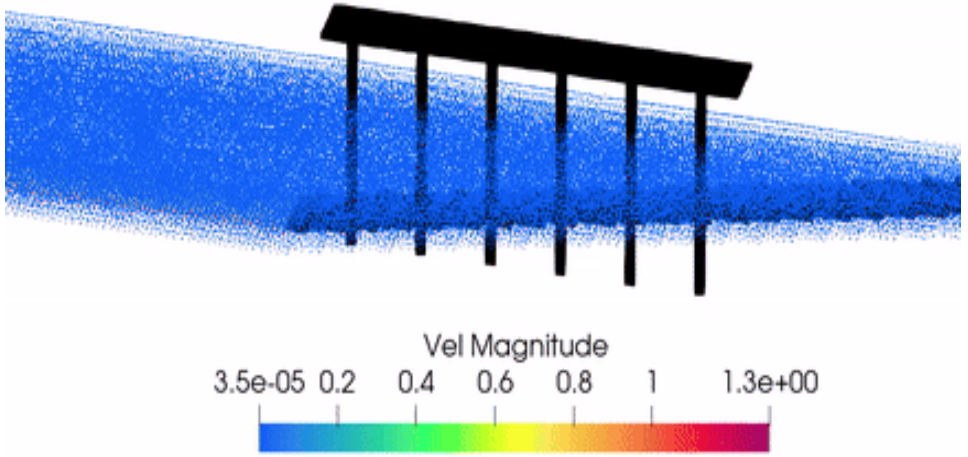
Cascadia CoPes Hub
THE CASCADIA COASTLINES AND PEOPLES HAZARDS RESEARCH HUB

- Stakeholder driven simulations

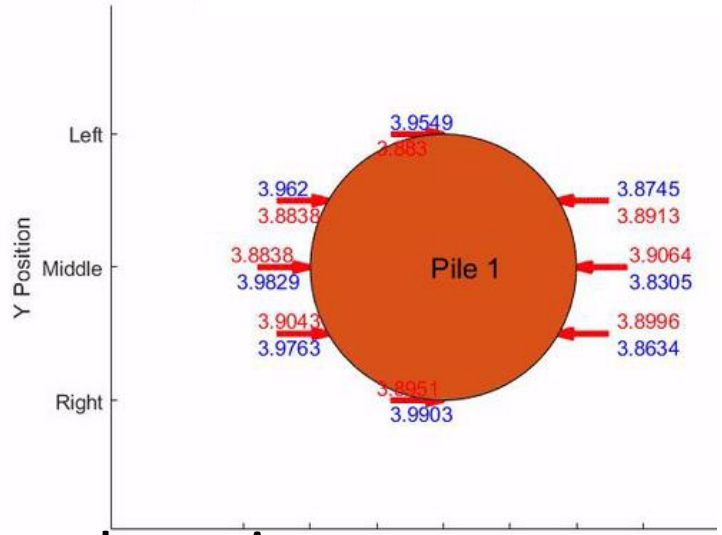




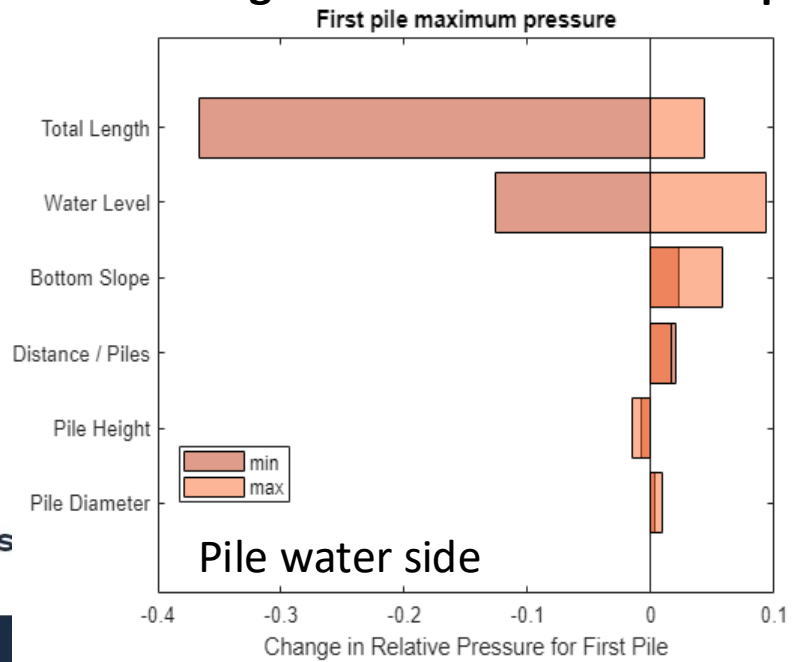
Pseudo-3D SPH Model

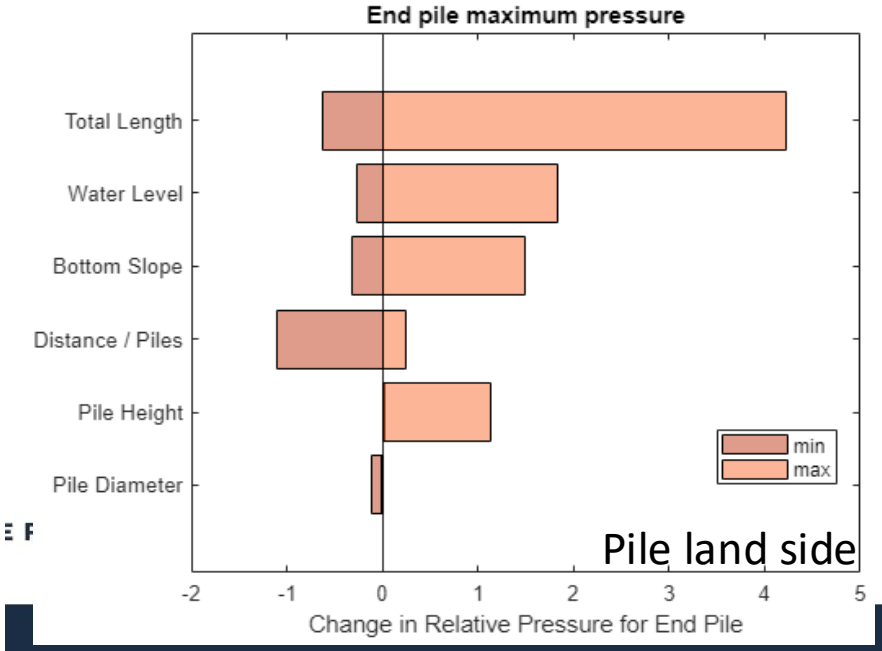


Pressure Time Series



Characterizing the influence of various parameters on changes in pressure





Thank you!