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Initiation of A Community Effort to Coordinate Seismic Site Characterization and Site Response Modeling Efforts in the Cascadia & Alaska SZs

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Overview

The U.S. Geological Survey (USGS) has initiated the Subduction Zone Science (SZS) Community of Practice. In the scope of quantification of earthquake hazards related to SZs, we summarize past efforts aimed at assessing seismic site characterization and site response towards development of empirical ground-motion models (GMMs), with a focus on Cascadia region and Alaska, with an eye towards coordination of future efforts. NGA-Subduction, a large recently completed GMM development project for SZ earthquakes worldwide, incorporated a major effort to compile and summarize site characterization data in the Pacific Northwest, including Oregon, Washington, and British Columbia, and across AK. Empirical site response models were developed by GMM developer teams using these new compilations. A 2019 workshop co-hosted by the Geological Survey of Canada and Western University "*Site Characterization in the Cascadia Region*" gathered researchers working in this domain to present site response approaches including and beyond classical V_{S30}-based generic amplification models, to become more region- and site-specific. The working group's efforts were left unfinished due to the COVID-19 pandemic.

With the commencement of the USGS SZS, we hope to follow on the work of these communities to convene a working group that:

1. Compiles state of knowledge of site characteristic data, including V_{S30}, V_S profiles, fundamental/dominant frequency (f_0 / f_d) and amplitude (A_0) of horizontal-to-vertical spectral ratio (HVSR) peaks, and so-called basin depth parameters, such as the depth to specific shear-wave velocity iso-surfaces (Z_X) as used in GMMs;
2. Reviews existing site response model parameterization as used in GMMs, and prioritize improvement of existing models via updated databases. This includes V_{S30}-Z_X correlations that were developed in NGA-Subduction;
3. Promotes integration of ergodic modeling with novel procedures, including site-specific and nonergodic methods, and those leveraging parameters beyond V_{S30}, like full V_S profiles or HVSR metrics, and those look towards interfacing with simulated GM data, such as the M9 project.

Summary of relevant work within and adjacent to NGA-Subduction

NGA-Subduction (Bozorgnia et al. 2021, *EQS*) was a large multi-institution international collaborative effort to develop empirical GMMs for subduction zones. The project assembled a database of over 71,000 uniformly processed ground motion recordings and a site database with 6500+ stations (Ahdi et al. 2022, *EQS*). We assigned station metadata related to site response (V_{S30} scaling) and deep sediment/basin response (using Z_X), developing a novel V_{S30} model for the Pacific Northwest (PNW) and AK based on the proxies of surficial geology and topographic slope (Ahdi et al. 2017, *BSSA*) and assigned $Z_{2.5}$ values from the 3D velocity model of Stephenson et al. (2017). Parker & Stewart (2022, *EQS*) developed a new ergodic site response model for subduction regions as part of their GMM. Seven basins were considered in NGA-Sub (Figure 1a) with outlines traced from existing studies (rather than following specific geologic unit boundaries or depth-to-Z_X criteria) and used for site response modeling (Parker & Stewart 2022). Stations were flagged within/outside of these basins, but these basin outline definitions differed from the criteria used in the 2018 NSHM update (Fig 1b, Petersen et al. 2019, *EQS*), which has less utility for the NSHM.

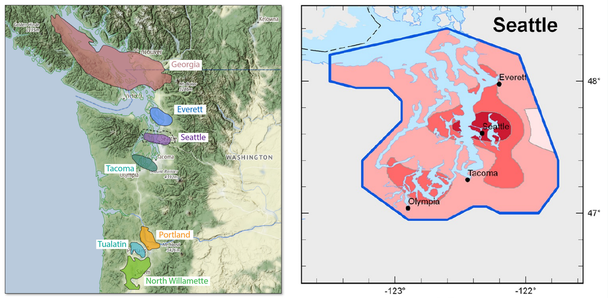

Fig. 1: An example of discrepancies between related efforts: (a) PNW sub-basins defined in NGA-Subduction (Ahdi et al. 2022, left), compared to (b) the basin outline used in the 2018 NSHM update (Petersen et al. 2019, right).

Summary of Recent Work: Site Characterization

- Stephenson et al. 2019: Seattle/Tacoma fieldwork
- Stephenson et al. 2021: Everett Basin fieldwork
- Stephenson et al. 2021: Alaska fieldwork
- Rasanen Maurer grant Wirth: updated V_{S30} map of PNW
- BC Hydro: V_S profiles on rock at ~10 dam sites

Summary of Recent Work: Site Response & GMs

- Frankel & Grant 2022, *BSSA*: Site Response, Basin Amplification, and Earthquake Stress Drops in Portland, OR
- Frankel et al. 2018; Wirth et al. 2018, *BSSA*: Broadband synthetic seismograms for magnitude 9 earthquakes on the Cascadia megathrust based on 3D simulations and stochastic synthetics, Part 1: Methodology and overall results; Part 2: Rupture parameters and variability
- Marafi et al. 2021 *SDEE*: A generic soil vel. model accounting for near-surface conditions and deeper geologic structure
- Moschetti et al 2020: Ground-Motion Amplification in Cook Inlet Region, Alaska
- Rekoske et al 2021, *BSSA*: Basin and Site Effects in the PNW
- Rezaeian et al. 202x: 2023 NSHMP update: Assessment and Implementation of NGA-Sub GMMs
- Smith et al. 202x: 2023 NSHMP update: An Evaluation of Cascadia GMMs with Consideration for M9 Basin Effects
- Stone Wirth Frankel 2021, *BSSA*: Structure and Q_P–Q_S Relations in the Seattle and Tualatin Basins
- Stone Wirth Frankel 2022, *BSSA*: Topographic Response to Simulated Mw 6.5–7.0 Earthquakes on the Seattle Fault
- Sung & Abrahamson 2022, *BSSA*: A Partially Nonergodic GMM for Cascadia Interface Earthquakes

Table 1: Summary of station information in Washington, Oregon, and Alaska in USGS's online database of V_{S30} Measurements at U.S. Strong Motion Accelerometer Sites with CESMD Data Information (Huddleston et al. 2022).

Region	WA	OR	AK
No. Stations	502	250	233
No. V_{S30} measured	130	17	5
Measured V_{S30} [m/s]	138–1416	193–1522	238–514
Proxy V_{S30} [m/s]	202–670	98–697	180–900

Desired Outcomes

- Convene a SCEC-like community for staying up-to-date on SZ-relevant site characterization and site response research.
- Promote use of hierarchy (like that developed for NGA projects) for uniform assignment of V_{S30} to stations across different seismic networks (in line with USGS NSMP).
- Promote best practices for site characterization field work and data processing using flexible, multi-method approaches.
- Improved characterization of basin depth terms (Z_X) from 3D velocity models and their incorporation in ergodic GMMs.
- Move away from California-centric thinking of V_{S30} scaling and correlation between V_{S30} and Z_X by investigating other proxies for site response that are widely available.
- Develop standardized definitions of basin extents/boundaries for use in NSHMs, GMM development exercises, and to present to building code committees.
- Facilitate coordination with researchers to update USGS V_{S30} global map server and USGS National Crustal Model with best-available models and facilitate development of new map-based models as more field data are collected.
- Coordinate activities of USGS and other stakeholders who maintain databases of V_S/V_{S30}, HVSR, and other site characterization data. Provide framework for data collectors to easily disseminate results on such databases.

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