Geo-INQUIRE installation: Cyber-PSHA - Probabilistic Seismic Hazard Analysis (TA2-541-9)

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Project title: A closer look at CyberShake finite fault rupture modeling for improved near-fault ground motion simulation (up to 1 Hz) of strong earthquakes in Southwest Iceland

Project acronym: CyberSISZ

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Geo-INQUIRE Virtual Access: in progress

Data/Products: in progress

Project report:

The project's objectives included adapting the CyberShake framework to accommodate the unique geological and seismological characteristics of the Southwest Iceland transform zone, and performing kinematic simulations of near-fault ground motions on the basis of an adjusted slip generator that produces slip patches that better match the inferred slip distributions responsible for observed low-frequency (up to 1 Hz) near-fault velocity pulses in strong earthquakes in Southwest Iceland. The workflow relies on realizations of slip distributions for hypothetical scenario faults using an "effective" source area relationship [1] that conforms to the high-stress drop earthquake source characteristics in the region, along with the Graves–Pitarka slip generator, consistent with the methodology used in Rojas et al. [2].

The main issue identified in the current version of CyberShake is that the physical dimensions of the simulated slip patches can be inconsistent with those predicted by

empirical and theoretical patch-dimension relationships [e.g., 1,3,4]. In practice, this appears as heavy fragmentation: slip is broken into many small, disconnected patches rather than a small number of larger and coherent asperities with realistic spatial scales. This fragmentation makes the slip field depart from scaling-law expectations that link event size and effective rupture area to the characteristic dimensions and organization of slip patches.

Minor adjustments to the rupture generator code resulted in marked improvements, as illustrated in Figure 1, that shows synthetic slip distributions (of same seed number) without (left) and with (right) the adjustment. The original rupture generator creates a highly fragmented pattern with many small slip patches, while the adjusted rupture generator shows a more coherent slip structure, with smoother and more contiguous high-slip regions that are closer to the expected patch dimensions from scaling relationships [3]. The latter fits better the inferred slip distributions of recent strong earthquakes in the region, supports increased coherence of near-fault waveforms, which conforms to the recorded near-fault data [5]. The adjustment therefore is expected to lead to more realistic near-fault wavefields with important implications for physics-based PSHA in Southwest Iceland. These results will be presented at the 18th European Conference on Earthquake Engineering (ECEE 2026), Berlin [6].

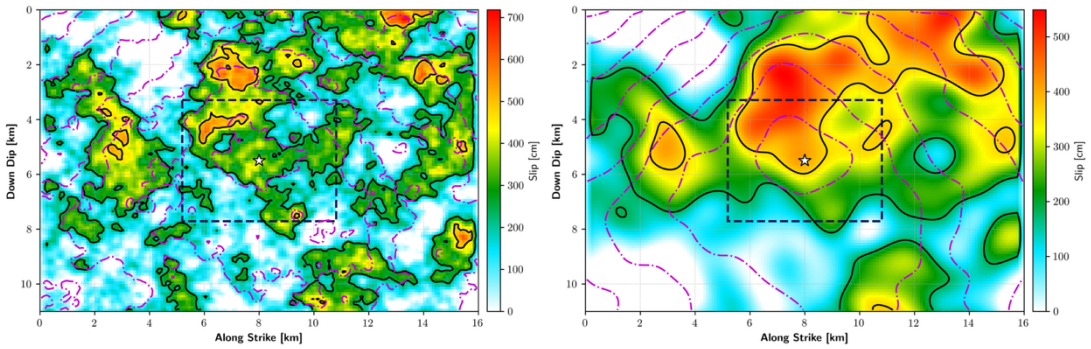

Figure 1: Comparison of slip distributions on the fault plane: (left) slip from the current CyberShake configuration, showing fragmented slip patches and less scaling-consistent patch dimensions; (right) slip from the adjusted CyberShake slip generator, showing more coherent, scaling-consistent patch structure.

References:

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[2] Rojas O, Monterrubio-Velasco M, Rodríguez JE, Callaghan S, Abril C, Halldorsson B, et al. Earthquake Fault Rupture Modeling and Ground-Motion Simulations for the Southwest Iceland Transform Zone Using CyberShake.

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[6] Halldorsson B, Davari H, Bayat F, Abril C, Kowsari M, Gabriel, Alice-Agnes AA. On the scaling of the earthquake source and near-fault wavefield in Icelandic transform zones. 18th European Conference on Earthquake Engineering (ECEE 2026), Berlin: 2026.