EGU21-7880, updated on 20 Jan 2022
https://doi.org/10.5194/egusphere-egu21-7880
EGU General Assembly 2021

Towards physics-based PSHA using CyberShake in the South Iceland Seismic Zone

Otilio Rojas[1], Juan Esteban Rodriguez[1], Josep de la Puente[1], Scott Callaghan[2], Claudia Abril[3], Benedikt Halldorsson[3,4], Bo Li[5], Alice Agnes Gabriel[5], and Kim Olsen[6]
[1]Barcelona Supercomputing Center (BSC-CNS), Spain
[2]Southern California Earthquake Center (SCEC), University of Southern California, USA
[3]Icelandic Meteorological Office, Reykjavik, Iceland
[4]University of Iceland, Reykjavik, Iceland
[5]Ludwig Maximilian University of Munich, Germany
[6]Department of Geological Sciences, San Diego State University, USA

Traditional Probabilistic Seismic Hazard Analysis (PSHA) estimates the level of earthquake ground shaking that is expected to be exceeded with a given recurrence time on the basis of historical earthquake catalogues and empirical and time-independent Ground Motion Prediction Equations (GMPEs). The smooth nature of GMPEs usually disregards some well known drivers of ground motion characteristics associated with fault rupture processes, in particular in the near-fault region, complex source-site propagation of seismic waves, and sedimentary basin response. Modern physics-based earthquake simulations can consider all these effects, but require a large set of input parameters for which constraints may often be scarce. However, with the aid of high-performance computing (HPC) infrastructures the parameter space may be sampled in an efficient and scalable manner allowing for a large suite of site-specific ground motion simulations that approach the center, body and range of expected ground motions.

CyberShake is a HPC platform designed to undertake physics-based PSHA from a large suite of earthquake simulations. These simulations are based on seismic reciprocity, rendering PSHA computationally tractable for hundreds of thousands potential earthquakes. For each site of interest, multiple kinematic rupture scenarios, derived by varying slip distributions and hypocenter location across the pre-defined fault system, are generated from an input Earthquake Forecast Model (EFM). Each event is simulated to determine ground motion intensities, which are synthesized into hazard results. CyberShake has been developed by the Southern California Earthquake Center, and used so far to assess seismic hazard in California. This work focuses on the CyberShake migration to the seismic region of South Iceland (63.5°- 64.5°N, 20°-22°W) where the largely sinistral East-West transform motion across the tectonic margin is taken up by a complex array of near-vertical and parallel North-South oriented dextral transform faults in the South Iceland Seismic Zone (SISZ) and the Reykjanes Peninsula Oblique Rift (RPOR). Here, we describe the main steps of migrating CyberShake to the SISZ and RPOR, starting by setting up a relational input database describing potential causative faults and rupture characteristics, and key sites of interest. To simulate our EFM, we use the open source code SHERIFS, a logic-tree method that converts the slip rates of complex fault systems to the corresponding annual seismicity rate. The fault slip rates are taken from a new 3D physics-based fault model for the SISZ-RPOR transform fault system. To validate model and simulation parameters, two validation steps using key CyberShake modeling tools have been carried out. First, we perform simulations of historical earthquakes and compare the synthetics with recorded ground motions and results from other forward simulations. Second, we adjust the rupture kinematics to make slip distributions more representative of SISZ-type earthquakes by comparing with static slip distributions of past significant earthquakes. Finally, we run CyberShake and compare key parameters of the synthetic ground motions with new GMPEs available for the study region. The successful migration and use of CyberShake in South Iceland is the first step of a full-scale physics-based PSHA in the region, and showcases the implementation of CyberShake in new regions.