Using Ground Motion Prediction Equations to Validate Large-Scale Seismic Simulations

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Large-scale ground motion simulations have attracted a lot of research lately for various applications like supplementing ground motions for probabilistic seismic hazard analysis (PSHA), identifying new fault structures and improving general understanding of seismic wave propagation. As the research community moves forward with the Risk-Informed-Performance-Based-Design philosophy, it is evident that we need ground motion simulations that correlate well with observed ground motions to improve the risk analysis of structures. The advent of superlative computational infrastructure has made it possible to perform intensive calculations to solve physics-based wave propagation equations *(Rodgers et al., 2019)*. In this research, we evaluate the validity of large-scale three-dimensional (3D) ground motions simulations carried out in SW4 for a nuclear power plant site in Japan using well-established ground motion prediction equations (GMPEs) from the Pacific Earthquake Engineering Research Center (PEER) Next Generation Attenuation-West2 project (NGA-West2).. The site of interest in Japan is the Kashiwazaki-Kariwa Nuclear Power Plant (KKNPP) where ground motions have been recorded by a dense instrumentation such as the well-studied Service Hall Array (SHA). The seismic event simulated is one of the aftershocks of the 2007 Niigata-Chuetsu earthquake which will be the basis for this presentation.

While utilization of observed ground motion remains crucial for validating waveforms, spectral parameters and site amplification, GMPEs summarize the overall performance of the attenuation model in simulations. Examination of GMPEs from NGA-West2 against ground motion simulations that are already validated against observed motions will be of value to users worldwide since these models employ very limited ground motions from outside United States for empirical model development as well as testing. There are several ground motion intensity measures that are used for the purpose of validation- PGA, PGV, and RotD50.

The large-scale simulations have been carried out at Los Alamos National Laboratory (LANL) using an advanced numerical finite difference code, SW4, developed by Lawrence Livermore National Laboratory, to simulate an M_j= 4.2 (M_w=3.5) event following a point source model. This particular aftershock event was selected for its proximity to SHA (5 km) which contains the computational model within a 13 km x 17 km area that is 10 km deep. A sophisticated material model is developed by integrating community velocity models with shallow crustal information gathered by nation-wide strong-motion seismograph networks of Japan, K-NET and Kik-net. Borehole data from Kik-net as well as SHA has been instrumental in improving simulations that compare well with observed ground motions. The heterogeneous model is of a high-resolution, with the finest mesh of size 4 m at the surface and totaling at 132 million grid points. The simulations generally compare well with the GMPEs and provide deep insight into the uncertainties involved in site-specific hazard estimates.