Spectral Scaling Transfer Function Method for Scenario Ground Motion Simulation with Application to the 2019 Ridgecrest Earthquake Sequence

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A new spectral scaling transfer function-based approach is presented for simulating ground motions for scenario large-magnitude earthquakes when a smaller-magnitude earthquake from the same source region has been recorded. This method is based on Akis theory of universal similarity of earthquake radiation (Aki, 1967), in which the Fourier amplitude spectra of far-field radiated body waves can be approximated as a truncated power law with frequency, and far-field body-wave displacements scale as the moment rate function together with constants that account for radiation pattern and geometric spreading. Assuming stress drop invariance for two different magnitude earthquakes, we show how our derived scaling law can be used to estimate the corner frequencies of the two events, and then predict the spectral amplitudes of a larger event through application of a transfer function. We use observed 2019 Ridgecrest California earthquake sequence ground motions to validate the transfer function method, including data from foreshocks with M>5. This method assumes that the distance to observation is large compared to the source dimensions, which is the case here with ground motions simulated for Los Angeles basin locations at a distance of 200 km from the Ridgecrest source region. We examine geographical variations in 3-second and 6-second pseudo-spectral accelerations for the observed M7.1 Ridgecrest earthquake, and for a scenario M7.6 Ridgecrest-like earthquake. We then apply the observed M7.1 and simulated M7.6 ground motions to linear dynamic analysis with finite-element models developed and validated for an existing, instrumented 52-story high-rise and 15-story mid-rise building. The results indicate that relative to the M7.1 earthquake, the M7.6 scenario earthquake will produce peak elastic inter-story drifts that are 2 times larger for the 15-story (at around the 6th floor) and 2.7 times larger for the 52-story (at around the 30th floor). The maximum values in computed inter-story drift are mapped and interpreted as measures of building damage potential. These values indicate geographic locations that may be most vulnerable to future large-magnitude, long-period earthquake ground motions for a scenario M7.6 occurring in the same source region.

Publication:	AGU Fall Meeting 2021, held in New Orleans, LA, 13-17 December 2021, id. S15B-0239.
Pub Date:	December 2021
Bibcode:	2021AGUFM.S15B0239K

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