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Physics-based Broadband Ground Motion Simulations for Probable M>7.0 earthquakes in the Marmara Sea Region (Turkey)

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The city of Istanbul is characterized by one of the highest levels of seismic risk in Europe and the Mediterranean region. The important source of the increased risk in Istanbul is the remarkable probability of the occurrence of a large earthquake, which stands at about 65% during the coming years due to the existing seismic gap and the post-1999 earthquake stress transfer at the western portion of the North Anatolian Fault Zone (NAFZ).
In this study, we have simulated hybrid broadband time histories from two selected scenario earthquakes having magnitude M>7.0 in the Marmara Sea within 10-20 km of Istanbul believed to have generated devastating 1509 event in the region. The physics-based rupture scenarios, which may be an indication of potential future events, are adopted to estimate the ground motion characteristics and its variability in the region. Two simulation techniques (a full 3D wave propagation method to generate low-frequency seismograms, $<\sim 1$ Hz and a stochastic technique to simulate high-frequency seismograms, >1Hz) are used to compute more realistic time series associated with scenario earthquakes having magnitudes Mw >7.0 in the Marmara Sea Region. A dynamic rupture is generated and computed with a boundary integral equation method and the propagation in the medium is realized through a finite difference approach (Aochi and Ulrich, 2015). The high frequency radiation is computed using stochastic finite-fault model approach based on a dynamic corner frequency (Motazedian and Atkinson, 2005; Boore, 2009). The results from the two simulation techniques are then merged by performing a weighted summation at intermediate frequencies to calculate broadband synthetic time series.
The hybrid broadband ground motions computed with the proposed approach are validated by comparing peak ground acceleration (PGA), peak ground velocity (PGV), and spectral acceleration (SA) with recently proposed ground motion prediction equations (GMPE) in the region. Our simulations reveal strong rupture directivity and super-shear rupture effects that generate a large spatial extent of extremely high near-fault motions exceeding the 250 cm/sec PGV, along the entire length of the ruptured fault under the Sea of Marmara.