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Signature of coseismic off-fault damage in intermediate- and far-field radiation

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Off-fault damage is observed around fault cores in a wide range of length scales, which is identified as an aggregation of localized fractures via geological and geodetic observations, or as low-velocity zone via seismological tomography. However, its seismological observables in earthquake traces, e.g. change in source spectra and/or radiation pattern, remains to be investigated.

Okubo et al. (2019) proposed an approach framework of physics-based dynamic earthquake rupture modeling with coseismic off-fault damage using the combined finite-discrete element method (FDEM). It shows a non-negligible contribution of coseismic damage to rupture dynamics, high-frequency radiation and overall energy budget, whereas the model domain is limited in the near-field region. This study efficiently computes intermediate- and far-field radiation propagating from earthquake sources with coseismic off-fault damage, and to identify its signature in the seismic traces.

We first conduct the dynamic earthquake rupture with coseismic damage and compute synthetic near-field radiation using FDEM-based software tool, HOSSedu, developed by Los Alamos National Laboratory. We then couple the output of HOSSedu to SPECFEM2D in order to compute intermediate- and far-field radiation. The HOSS-SPECFEM2D coupling can resolve complexities over wide range of length scales associated with earthquake sources with coseismic damage and wave propagation.

We conduct 2D dynamic earthquake rupture modeling with a finite planar fault as canonical simplest model. The comparison between the cases with and without allowing for coseismic off-fault damage shows differences in intermediate- and far-field radiation. 1) High-frequency components in ground motion are enhanced all around the fault. 2) The rupture arresting phase, which clearly appears at the stations located orthogonal to the fault for the case without off-fault damage, is damped due to the smoothed rupture arrest by coseismic damage around fault edges. 3) Radiated energy is enhanced in the direction parallel to the fault due to the substantial damage around fault edges.

These fundamental observables will help identify the existence of coseismic off-fault damage in real earthquakes. It would also contribute to resolve the mechanisms of earthquake sources and the potential distribution of aftershock locations. We also attempt to replace the planar fault to the real fault geometry, e.g. the fault system associated with the 2019 Ridgecrest earthquake sequence, and will investigate the signature of off-fault damage in the seismic traces recorded in intermediate- and far-field range.