Seismic signatures of trench rupturing megathrust earthquakes: effects of accretionary-wedge structures

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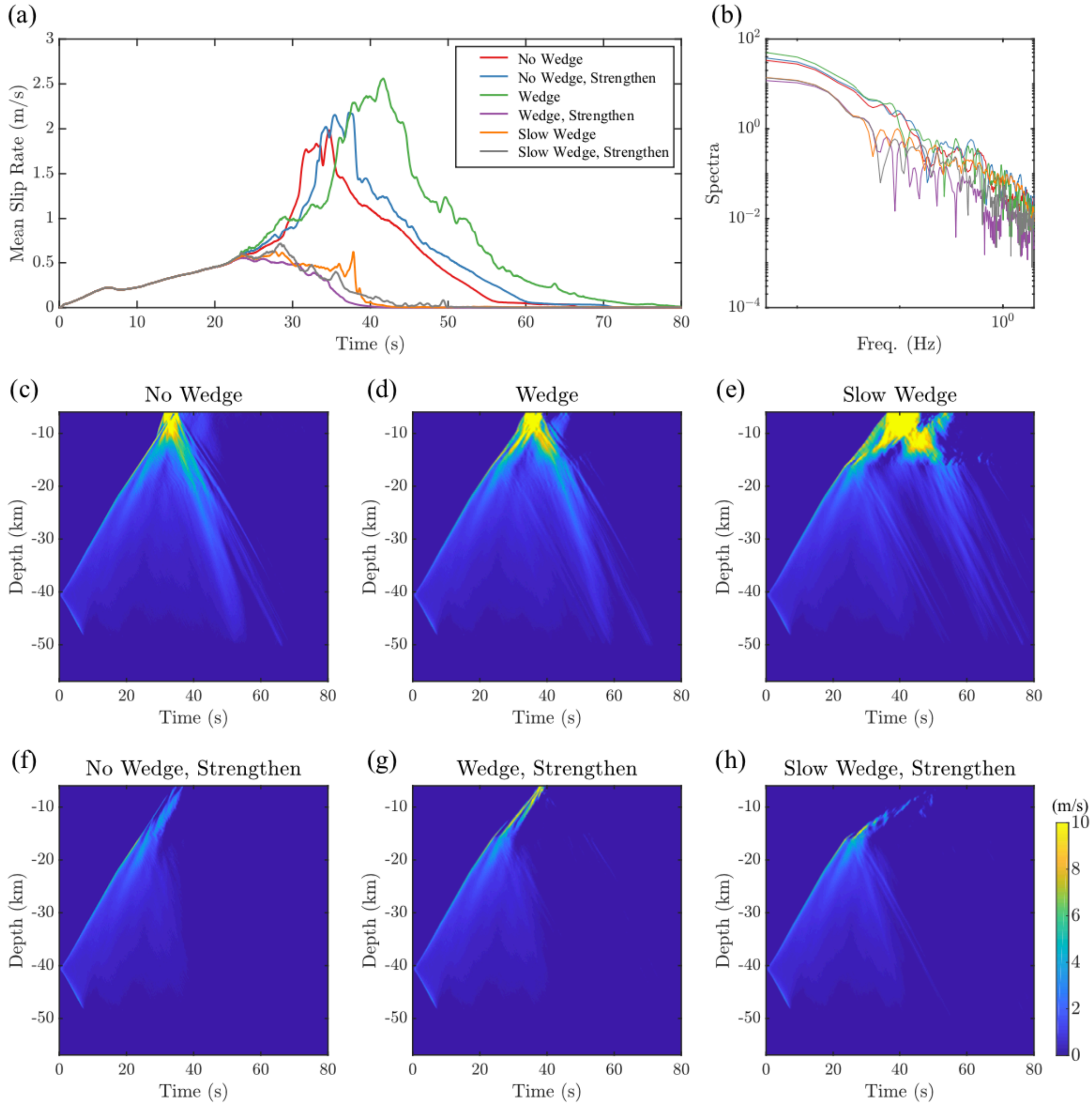
Megathrust earthquakes, especially those that rupture to the surface like the 2011 Tohoku Earthquake, pose great threats to the coastal regions. To quickly detect these shallow tsunamigenic motions, we need to better understand the seismic signature of the rupture to the trench. In particular, the shallow elastic structure is complex, with contrast in material properties, complex fault geometries, and free surface topography. In this study, we investigate these effects and model the seismic signatures expected in different shallow subduction zone velocity structures through dynamic modeling using SEM2PACK. Our set of models are built from the canonical 2D low-dip angle thrust fault model with realistic velocity structure from recent seismic tomography studies. For the same nucleation process, pre-stress distribution, and frictional properties at the dynamic source, the heterogeneous velocity structure greatly affect the near trench rupture evolution (as in Lotto et al, 2017) and the coastal ground motions. We seek their seismic signatures in the P-, S-, and Rayleigh-wave ground motions. We focus on the Rayleigh wave signatures and their frequency content for shallow slip. The low velocity sediments more effectively trap seismic waves, resulting in larger magnitude earthquake and strong reverberations in the long period ground motions. This series of systematic studies can help us to better understand and capture the seismic signatures of shallow wedge structures, thus further helping to mitigate the potential seismic and tsunami hazards in coastal regions.



Preliminary results from dynamic simulations with different wedge properties: (a) Slip histories on the fault and (b) corresponding source spectra from different models settings. Spatiotemporal evolution of dynamic rupture from: (c)-(e) slip weakening models with V_P=6km/s (effectively no wedge), V_P=3.5km/s (wedge) and V_P=2km/s (slow wedge) in the wedge, respectively. (f)-(h) models with the same wedge velocity as above but slip strengthening frictional property.