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Subduction megathrust earthquakes: Insights from analog models

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Subduction megathrust earthquakes occur at the interface between the subducting and overriding plates. These hazardous phenomena are only partially understood because of the absence of direct observations, the restriction of the instrumental seismic record to the past century, and the limited resolution/completeness of historical to geological archives. To overcome these restrictions, modeling has become a key-tool to study megathrust earthquakes. We present a novel analog model to investigate the seismic cycle at subduction thrusts. Here we introduce a simple scaled gelatin-on-sandpaper setup including realistic tectonic loading, spontaneous rupture nucleation, and viscoelastic response of the lithosphere. Particle Image Velocimetry allows to derive model deformation and earthquake source parameters. Analog earthquakes are characterized by 'quasi-periodic' recurrence. Consistent with elastic theory, the interseismic stage shows rearward motion, subsidence in the outer wedge and uplift of the "coastal area" as a response of locked plate interface at shallow depth. The coseismic stage exhibits order of magnitude higher velocities and reversal of the interseismic deformation pattern in the seaward direction, subsidence of the coastal area and uplift in the outer wedge. Like natural earthquakes, analog earthquakes generally nucleate in the deeper portion of the rupture area and preferentially propagate upward in a crack-like fashion. Scaled rupture width-slip proportionality and seismic moment-duration scaling verifies dynamic similarities with earthquakes. Experimental repeatability is statistically verified. Comparing analog results with natural observations, we conclude that this technique is suitable for investigating the parameter space influencing the subduction interplate seismic cycle.