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Asperities synchronization and triggering of subduction mega-earthquakes: insights from 3d analog models

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Asperities synchronization is the key mechanism responsible for earthquakes growth to hundreds of km in length and, in turn, the genesis of devastating mega-events. Hypotheses on how asperities interact during earthquakes have been proposed. However, the asperities' behavior during subsequent seismic cycles is still not fully understood due to the limited observations. Here we tackle this argument using 3D analog models embedding two asperities (with velocity weakening friction) separated by a barrier (with velocity strengthening friction) of variable width D. Our models have the advantage of reproducing tens of seismic cycles in a simplified but physically self-consistent setting. Spontaneously nucleating ruptures propagating along the plates interface are observed. Interseismic coupling and rupture characteristics are investigated systematically as a function of D and asperities width. Experiments show that the percentage of synchronized asperities ruptures is inversely related to the barrier efficiency (i.e. the ratio between the barrier strength and the stress produced by the ruptured asperity). Under the experimental conditions, a permanent barrier is observed when D is larger than a scaled-to-nature value of about 50 km. The percentage of synchronizations increases as a function of seismic moment averaged over the experimental run. The maximum earthquake magnitude and interseismic coupling decrease as a function of D. These observations provide insights for seismic hazard assessment shedding light on the conditions that may promote the triggering of subduction mega-earthquakes.