LA-UR-19-20107
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Title: Do large and small earthquakes start alike? Rupture determinism and earthquake early warning

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Intended for: EES-16 Science Cafe Presentation

Issued: 2019-01-09

Do large and small earthquakes start alike? Rupture determinism and earthquake early warning

Do earthquakes large and small begin alike, or are there systematic differences in the nucleation or early rupture process that determine the final earthquake size? This question of rupture determinism is one of the outstanding challenges in earthquake physics, and has significant implications for earthquake early warning systems, which rely on the ability to rapidly estimate earthquake magnitudes based on small snapshots of waveform data. Here I examine the question of rupture determinism using a massive dataset of strong-motion acceleration waveforms from M4-9 earthquakes occurring near Japan over the past 20 years. We analyze the time-evolution of peak displacement from more than 130,000 strong-motion waveforms, finding no significant evidence for deterministic rupture in our dataset. We then use these observations to develop a rigorous Bayesian framework for calculating time-dependent uncertainties in earthquake early warning systems like ShakeAlert, which is currently undergoing testing for the western United States. This work forms the basis for future data-driven studies designed to improve methodology used real-time geophysical hazard assessments.