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The Earthquake Rupture Should Be Deterministic

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Increasing the understanding of earthquake rupture process is essential to improve our knowledge of fault systems and earthquake hazards. Previous studies state the rupture process is to some degree deterministic by using the $\tau_p^{\max}$ method, and the vertical displacement of P-wave (Pd), refuting the correctness of the cascade model. However, the issue remains unsolved for nearly a decade due to both the $\tau_p^{\max}$ and the Pd method simply fails on devastatingly larger earthquakes (M>7), and concerns about the methodology and the statistical result evokes. Consequently, evidence of the relation between rupture initiation process and the magnitude for large earthquakes (M>7) is crucial for understanding the physics of the rupture process. Here we show the earthquake rupture should be deterministic by a method called the fundamental frequency method, a source parameter which based on nonlinear dynamics that can be used to calculate the frequency component of seismic waveform. We obtain a relation between the duration of obtaining the initial fundamental frequency, the rupture duration and the momentum magnitude, which ranges from M5 to M9 that overcomes the major flaw of previous studies. This evidence indicates the rupture duration could be estimated before the rupture process ceases, and therefore implies the earthquake rupture should be deterministic. Our results provide important implication to characterize and understand the physics of the rupture process of earthquakes. Furthermore, the fundamental frequency method, which is capable of analyzing the frequency component of the rupture process of the earthquake's source, could be applied to various geosciences discipline for developments relevant to signal processing.