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Observing earthquakes complexity in their source function

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Strong ground motions during earthquakes come either from a complex source time function or a complex wave propagation. Focusing on the source term, we take advantage of global databases of source time functions (STFs) to explore the observations of source complexity and support our findings with simple 2D dynamic modeling of ruptures. First, we explore the shape of the STFs, their derived radiated energy functions (seismic power), and a time-dependent scaled energy function to measure productivity in seismic radiation. We find that the onset of earthquakes is systematically more productive in radiating seismic waves than the arrest. This observation suggests that the earthquake development is fast and requires an acceleration of rupture front or growth of stress drop with time. Second, we decompose the STF into subevents through a sum of Gaussian functions. We find that the number, the size, and the duration of sub-events grow with the main earthquake magnitude, making large earthquakes more complex than small ones. The moment of the subevent is almost proportional to the main event moment. Therefore, a magnitude estimate of earthquakes can be done with a good precision as early as a few seconds from onset of rupture. Finally, we cluster the shape of the STFs using a dynamic time warping approach and explore the physical properties (magnitude, stress drop, focal mechanisms, depth) of earthquakes within the clusters.