SYSTEMATIC VARIATIONS OF EARTHQUAKE COMPLEXITY FROM CLUSTERING ANALYSIS OF SOURCE TIME FUNCTIONS

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Source Time Functions (STFs) characterize temporal evolution of moment release during earthquake rupture and exhibits tremendous inter-event variations. In this study, we introduce a Dynamic Time Warping (DTW) technique to quantitatively cluster large earthquakes based on the general shape of STFs. We analyze the clustering of STFs from seismic observations, and further relate the results to the rupture dynamics via numerical simulations.

We first apply the DTW clustering to STFs of 3,395 earthquakes (Mw$>$5.5) in the SCARDEC database. The results indicate that the complex STFs correspond to the shallower focal depth and mostly strike-slip mechanism with smaller magnitude, while the simple STFs correspond to the deeper focal depth and mostly thrust mechanism with larger magnitude. We further perform simulations to explore the relation between the STF clusters and rupture dynamics. We produce stochastically self-similar pre-stress distributions and nucleate spontaneous rupture on such heterogeneous faults. This gives us a large population of statistically identical dynamic earthquakes with a wide coverage of magnitudes. We simulate three large earthquake populations with different characteristic slip parameters (Dc) of the slip weakening constitutive relation. The same DTW clustering analysis reveals a systematic pattern that larger Dc tends to produce more earthquakes with complex STFs.

Associated with dynamic simulations, the observed patterns in STF clustering can help to constrain the dynamics of large earthquakes: one possible explanation is the systematic variation of dynamic parameters, such as the depth-varying length scales in different constitutive relations.