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Scaling of Earthquake Rupture Growth in Parkfield Area

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Abstract:

I will present the scaling of cumulative moment functions as a new framework for the scaling of earthquake rupture growth.

The similarities of final source parameters, such as fault dimensions, displacement, stress drop, and source duration, have been studied very well [e.g., Kanamori and Anderson, 1975]. However it is not clear whether the self-similarity is held during one earthquake rupture growth. Now we examine the self-similarity of earthquake rupture growth by comparing the cumulative moment and moment rate functions of M_w 1.7 - 6.0 events in Parkfield area by slip inversion analyses using the seismic data of USGS GEOS and BSL HRSN.

We discuss on scaled moment rate functions, where time and moment rate are normalized by $T_o = 2.7 \times 10^{-6} M_o^{1/3}$ (SI units, N, m, s), and M_o/T_o, respectively. Those of all events except the event of M_w 6.0 (the 2004 Parkfield earthquake) are similar symmetric bell-shaped. However the M_w 6.0 event has ~ 3 times longer source duration and much smaller moment rate than those of the others.

The cumulative moment functions increase along the common growth curve, $M_o(t) = 2 \times 10^{17} t^3$ (SI units), decelerate, and stop. The moment function of M_w 6.0 event also follows this line until 1 s after the onset, however it bends around 1 s. That is probably because the thickness of the seismogenic layer limits the width of earthquakes and changes the slope of growth curve. The seismicity around the hypocenter of M_w 6.0 event implies ~ 5 km of the thickness of the seismogenic layer. Then, 1 s is comparable to the time that the rupture front from the middle of the seimogenic layer would reach at the top and bottom of the seismogenic layer.

We conclude that each earthquake grows self-similarly, along the common growth curve independent on its final magnitude. The growth curve can be suppressed by the thickness of a seismogenic layer. The earthquake rupture growth decelerates by some chance, its moment function runs off the common growth curve, and the rupture terminates.