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# On the complexity of earthquake source dynamics and fault slip: Insights from the 2016 Kaikoura (New Zealand) earthquake

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The 2016 M7.8 Kaikoura earthquake was characterized by unusual fault-slip behaviors including the ruptures of a complex network of crustal faults, large (>10 m) surface offsets, slow average rupture velocity despite high stress drop, and the triggering of widespread slow slip events on a subduction plate interface. In this study, we use both kinematic and dynamic rupture simulations to uncover underlying physical processes associated with these unusual observations. First, we examine the rupture evolution using kinematic modeling techniques based on analysis of local strong-motion and high-rate GPS data. Our kinematic models capture a complex pattern of slowly (rupture velocity of <2 km/s) propagating rupture from the south to north, with over half of the moment release occurring in the northern source region, mostly on the Kekerengu fault, 60 seconds after the origin time. Our results indicate rupture re-activation on the Kekerengu fault with the time separation of ~11 seconds between the start of the original failure and start of the subsequent one. The slow rupture velocities despite large coseismic slip (up to ~20 m) may be associated with rupturing of multiple immature faults and extensive on- and off-fault inelastic deformation that led to a large amount of energy dissipation, as hinted from the analysis of near-fault seismic waveforms. Second, using dynamic rupture simulations, we quantitatively reproduce the change of fault striation directions along the Kekerengu fault documented by field surveys. Lastly the modeling of stress changes due to the Kaikoura earthquake indicates that the dynamic triggering of shallow (<15 km depth) slow slip in the Hikurangi subduction zone was likely promoted by the presence of low-velocity, sedimentary wedge.