



## **Distributed deformation field due to coseismic off-fault damage of Mw 7.8 Kaikoura earthquake**

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Recent high-resolution observations by optical image correlation techniques on the Mw 7.8 Kaikoura (New Zealand) earthquake show gradually distributed deformation field around the junction comprised of Jordan-Kekerengu-Papatea fault system. The profiles of displacement field across the faults clearly show a step-like shape far from the junction, whereas it is smoothed near the junction. We assume that an inelastic deformation by secondarily generated off-fault crack network causes the smoothed displacement field around the junction. In this study the detailed analysis of displacement field and the dynamic earthquake rupture modelling technique are cooperatively performed to investigate rupture process, activation of coseismic off-fault crack network around faults and its effect on the characteristic displacement field observed around the junction. The optical satellite images correlation techniques provided sufficiently high-resolved ( $\sim 1.8\text{m}$ ) surface displacement profiles along the faults. We also used a novel numerical modelling tool based on the combined finite-discrete element method (FDEM) to model dynamic earthquake ruptures, which accounts for the rupture propagation on the Jordan-Kekerengu-Papatea fault system with dynamically nucleating/activating off-fault crack network. The angle of maximum compressional principal stress of external loading on the Jordan-Kekerengu-Papatea fault system is well constrained by the sense of strike-slip motion; right-lateral on the Jordan thrust and Kekerengu fault, and left-lateral on the Papatea fault. The numerical simulation shows a plausible rupture process and secondarily generated off-fault crack network around the junction which is consistent with observations. The rupture might jump from Papatea fault to Kekerengu fault with nucleating off-fault crack network due to the stress concentration around the junction. Conversely, the smoothed displacement field around the junction implies the activation of coseismic off-fault crack network induced by dynamic earthquake ruptures. Our results show a mutual collaboration between high-resolution optical image correlation techniques and dynamic earthquake rupture modelling with coseismic off-fault crack network around faults to address rupture process and coseismic deformation on the fault system.