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How well do onshore geodetic data resolve fault slip during the 2016 Kaikoura earthquake, New Zealand?

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The 2016 Mw 7.8 Kaikoura earthquake, New Zealand ruptured at least 21 faults, propagating from southwest to northeast for about 180 km. We use space geodetic data (InSAR and GPS) to study the subsurface fault geometry and slip distribution of this event. Based on the available onshore geodetic data, we examine three slip models: model 1 includes only the shallow crustal fault segments that were inferred from our data; model 2 involves the crustal faults, the Hikurangi subduction thrust and the Stone Jag fault; model 3 includes the crustal faults, the Point Kean fault and the Stone Jag fault. All these models show that the fault motion changes from predominantly right-lateral slip near the epicenter to transpressional slip in the northeast with a maximum coseismic surface displacement of about 10 m near the intersection between the Kekerengu and Papatea faults. We find that the linking Conway-Charwell faults aided the propagation of rupture across the stepover from the Humps fault zone to the Hope fault. We perform resolution tests to put some bounds on what is and is not resolvable from the available data. We find that the onshore geodetic data are mostly sensitive to shallow fault slip and do not have good resolution of slip on the additional deeper thrust faults we consider. Our study therefore suggests that the rupture process of the Kaikoura earthquake was complex and a multidisciplinary study of such events is warranted to better understand the rupture process.