



## **Geodetic record of a complete earthquake cycle: constraints on frictional properties and earthquake hazard in the Imperial Valley, southern California**

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We analyze a suite of geodetic observations across the Imperial fault in southern California that span the complete earthquake cycle, and show that co-, post- and interseismic observations are all required to obtain a robust constraint on the frictional properties and behavior of the fault. Coseismic and postseismic slip on the fault was measured with high precision following the 1979 M6.6 Imperial Valley earthquake, and interseismic deformation is presently recorded by a combination of multiple InSAR viewing geometries and survey-mode GPS. We combine more than 100 survey-mode GPS velocities (Crowell et al., 2013) with new InSAR observations from Envisat descending tracks 84 and 356 and ascending tracks 77 and 306 (149 total acquisitions), processed using the Stanford Method for Persistent Scatterers (StaMPS) package (Hooper et al., 2007). The result is a dense map of surface velocities across the Imperial fault and surrounding areas, revealing the rate of interseismic loading and along-strike variations in surface creep. We compare the geodetic data to models of earthquake cycles with rate- and state-dependent friction and find that a complete record of the earthquake cycle is required to constrain key fault properties including the velocity-strengthening or velocity-weakening parameter ( $a-b$ ) and its variation with depth; moment accumulation rate; and recurrence interval of large events. We also investigate the possibility that a little-known extension of the San Jacinto fault through the town of El Centro may accommodate a significant portion of the slip previously attributed to the Imperial fault. Models including this additional fault are more consistent with the available observations, a scenario which has significant hazard implications.