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Geodetic measurements and kinematic modeling of the 2014 Iquique-Pisagua earthquake

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The Northern portion of the Chilean margin is considered to be a large and longstanding seismic gap based on the magnitude and time of the last great earthquake (Mw=8.8 in 1877). The central fraction of the gap was affected by the 2014 Iquique-Pisagua earthquake (Mw=8.1), which was preceded by an unusual series of foreshocks and transient deformation. The Integrated Plate Boundary Observatory Chile (IPOC) has extensively monitored the seismic gap with various geophysical and geodetic techniques, providing an excellent temporal and spatial data coverage to analyze the kinematics of the plate interface leading up to the mainshock with unprecedented resolution. We use a viscoelastic Finite-Element Model to investigate the subduction zone mechanisms that are responsible for the observed GPS deformation field during the interseismic, coseismic and early postseismic periods. Furthermore, we separate the relative contributions of aseismic and seismic slip to the transient deformation leading up to and following the mainshock. Our analyses of the foreshocks and continuous-GPS transient signals indicate that seismic slip dominates over aseismic slip, and that slow slip was not a factor in the build up to the Mw=8.1 mainshock. Hence, the observed transient signals before the Iquique-Pisagua event can be explained by deformation due to foreshock seismicity, which was triggered after a Mw=6.7 event in a splay fault. High coseismic slip concentrated on a previously highly locked area that exhibited low amount of seismicity before the event. Foreshocks gradually occupied the center of the locked patch decreasing the mechanical strength of the plate contact. The first two months of aseismic postseismic deformation shows cumulative displacements up to 10 cm around the rupture area. The early postseismic afterslip only accounts for about 20 % of the coseismic seismic moment. We conclude that the foreshock activity may have decreased the effective friction on the locked patch resulting in a drop of locking that triggered the Iquique-Pisagua earthquake.