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Preparation phase and consequences of a large earthquake: insights from foreshocks and aftershocks of the 2014 Mw 8.1 Iquique earthquake, Chile

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The April 1, 2014, Mw 8.1 Iquique earthquake in Northern Chile, was preceded by an anomalous, extensive preparation phase. The precursor seismicity at the ruptured slab segment was observed sporadically several months before the main shock, with a significant increment in seismicity rates and observed magnitudes in the last three weeks before the main shock. The large dataset of regional recordings helped us to investigate the role of such precursor activity, comparing foreshock and aftershock seismicity to test models of rupture preparation and models of strain and stress rotation during an earthquake. We used full waveforms techniques to locate events, map the seismicity rate, derive source parameters, and assess spatiotemporal stress changes. Results indicate that the spatial distributions of foreshocks delineated the shallower part of the rupture areas of the main shock and its largest aftershock, and is well matching the spatial extension of the aftershocks. During the foreshock sequence, seismicity spatially is mainly localized in two clusters, separated by a region of high locking. The ruptures of mainshock and largest aftershock nucleate within these clusters and propagate to the locked region; the aftershocks are again localized in correspondence to the original spatial clusters, and the central region is locked again. More than 300 moment tensor inversions were performed, down to Mw 4.0, most of them corresponding to almost pure double couple thrust mechanisms, with a geometry consistent with the slab orientation. No significant differences are observed among thrust mechanisms in different areas, nor among thrust foreshocks and aftershocks. However, a new family of normal fault mechanisms appears after the main shock, likely affecting the shallow wedge structure in consequence of the increased extensional stress in this region. We infer a stress rotation after the main shock, as proposed for recent larger thrust earthquakes, which suggests that the April 1, 2014, mainshock has effectively reduced more than half of the accumulated deviatoric stress.