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Did the 2010 Chile earthquake change the locking degree at neighboring plate interface segments of the Andean subduction zone?

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A widely held view is that lateral extents and magnitudes of great earthquakes are fundamentally controlled by the stress build-up along the plate interface as inferred from the degree of locking. Therefore, inferring the distribution of locking and its along-strike variations has become an essential tool for seismic and tsunami hazard assessment. Recent studies have explored the main parameters affecting the spatial distribution of locking degree, but the time evolution of locking has not yet been clearly documented. Here we used time-series of continuous GPS at adjacent segments (> 500 km distance) to the rupture zone of the 2010 Chile (Mw=8.8) earthquake to explore the differences in locking degree before (2008-2010) and after (2010-2013) this event. Results suggest that the interseismic velocity (landward displacements) increased both in the northern (27°S-32°S) and southern (41°S-45°S) unruptured segments. The variations of displacements can be explained by an increase and homogenization of the locking degree at areas that were creeping before the 2010 earthquake. The estimated increase of locking degrees have peaks of about 20% and 100% for the northern and southern regions respectively. The b-value, which parameterizes the frequency-magnitude distribution of seismicity, decreased after the 2010 earthquake in the northern segment (in the southern segment there is not enough seismicity for estimating b-value) from 1.2 to 0.7 indicating a tendency for asperities to be brought closer to failure due to increase of shear stresses on the plate interface. By means of a 3D thermo-mechanical subduction model we are able to simulate the dynamic response of the system and study the stress variations before and after the earthquake, supporting the rearrangment of shear stresses at adjacent segments. Our results suggest that locking degree can evolve over a short timescale due to the change of the stress regime induced by great earthquakes. We propose that the seismic cycle along a margin is a self-organized system in the sense of a lateral connected evolution of build-up and release of stress at different seismotectonic segments. Importantly, the 2010 earthquake may have increased the seismic potential of the northern and southern neighboring plate interface segments, which broke last in 1922 and 1960, respectively.