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Transient evolution of plate coupling after the giant 1960 Chile earthquake at Guafo Island

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In subduction zones, elastic energy is slowly accumulated during decades to centuries and suddenly released by great earthquakes. The moment deficit–the energy available for future earthquakes–is commonly inferred by extrapolating modern plate coupling rates estimated from space geodesy back to the last great earthquake's date. However, the evolution of plate coupling between two great earthquakes integrating the moment deficit has been difficult to quantify due to limited geodetic data at decadal time scale, or longer. We infer the evolution of plate coupling below Guafo Island in the south Chilean subduction zone since the 1960 earthquake (Mw=9.5) using photographic and satellite images dating back to 1974, a campaign GPS benchmark installed in 1994, and a permanent GPS station installed in 2009. Guafo was uplifted 3.6-4.0 m in 1960 and has been subsiding since at least the late 1970s. A peaty soil that rapidly developed on the bedrock abrasion platforms that emerged in 1960 has been continuously eroding by relative sea-level rise resulting mostly from land subsidence. This process has resulted in continuous retreat of beach berms overlying bedrock platforms. We mapped such shoreline features in photographic and satellite images through time and, using the measured slope of the underlying platform, inferred relative sea-level changes between image pairs. Land-level changes were subsequently estimated by subtracting a mean absolute sea-level rise rate of 1.7 +/- 0.1 mm/yr calculated from satellite altimetry between 1992-2014. The combined time series shows a steady acceleration in the subsidence rate of Guafo Island from 6-8 mm/yr in the late 1970s to 20 mm/yr at present estimated from the permanent GPS. Using a viscoelastic numerical model and constraints for the seismogenic zone width from published thermal models we infer that interseismic plate coupling increased continuously from $\sim$30% in the late 1970s to $\sim$90% at present. Plate coupling apparently needed more than two decades to be restored after the 1960 earthquake. Changes in pore-fluid pressure, which has been suggested to be inversely related to interseismic coupling, associated with fault healing processes after damage induced by >10 m of slip in 1960 might explain restoration of full interseismic plate coupling only decades after the giant earthquake. These findings suggest a transient evolution of interseismic coupling. This has profound implications for the estimation of the moment deficit and the probability distribution for the magnitude of future earthquakes as a function of time.