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Slow slip events, the earthquake cycle, and rheological effects in Nicoya, Costa Rica

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In February of 2014 a Mw=7.0 slow slip event (SSE) took place beneath the Nicoya Peninsula, Costa Rica. This event occurred 17 months after the 5 September 2012, Mw=7.6, earthquake and along the same subduction zone segment, during a period when significant postseismic deformation was ongoing. A second SSE occurred in the middle of 2015, 21 months after the 2014 SSE. SSEs prior to the earthquake were also well-recorded, allowing analysis of SSE behavior during both the late and early stages of the earthquake cycle. The recurrence interval for Nicoya SSEs was unchanged by the earthquake. However, the spatial distribution of slip for the 2014 event differed significantly from previous events, only having deep (∼40 km) slip. Previous events showed both deep and shallow slip. The 2015 SSE marked a return to earlier pattern. However, slip magnitude in 2015 was nearly twice as large (Mw=7.2) as pre-earthquake SSEs. The large amount of shallow slip in the 2015 SSE maybe a result of slip missed during the 2014 SSE. These observations highlight the variability of aseismic strain release throughout the earthquake cycle generating considerable uncertainty when considering long term strain accumulation rates.

The deep slip patch in Nicoya is located near the mantle wedge. Serpentinization of the wedge is thought to be one source of fluids, commonly thought to promote SSEs and and seismic tremor. However, the presence of fluids provokes drastic changes in rheology, usually ignored when calculating simple elastic dislocation models of SSEs. Here we explore how simple models using viscoelastic rheology may change the inferred deformation field, leading to mis-estimation of the magnitude of slip, and mis-estimation of long term strain accumulation rates.