A stochastic view on the strain budget of the Ecuador-Colombia subduction zone

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Abstract

The 2016 Pedernales earthquake (Mw=7.8) ruptured a portion of the Colombia-Ecuador subduction interface where several large historical earthquakes have been documented since the great 1906 earthquake (M=8.6). Considering all significant ruptures that occurred in the region, it has been suggested that the cumulative moment generated co-seismically along this part of the subduction over the last century exceeds the moment deficit accumulated inter-seismically since 1906. Such an excess challenges simple models with earthquakes resetting the elastic strain accumulated inter-seismically in locked asperities. These inferences are however associated with large uncertainties that are generally unknown. The impact of spatial smoothing constraints on co-seismic and inter-seismic models also prevents any robust assessment of the strain budget. We propose a Bayesian kinematic slip model of the 2016 Pedernales earthquake using the most comprehensive dataset to date including InSAR and GPS offsets, tsunami waveforms, and kinematic records from high-rate GPS and strong-motions. In addition, we use inter-seismic geodetic velocities to produce a probabilistic inter-seismic coupling model of the subduction interface. Our stochastic co-seismic and inter-seismic solutions include the ensemble of all plausible models consistent with our prior information and that fit the observations within uncertainties. The analysis of these model ensembles indicates that an excess of co-seismic moment during the 1906 - 2016 period is likely in Central Ecuador only if we assume that 1942 and 2016 earthquakes are colocated. If this assumption is relaxed, we show that this conclusion no longer holds given uncertainties in co- and inter-seismic processes. The comparison of 1942 and 2016 teleseismic records reveals large uncertainties in the location of the 1942 event, hampering our ability to draw strong conclusions on the unbalanced moment budget in the region. Our results also show a heterogeneous coupling of the subduction interface that coincides with two slip asperities in our co-seismic model for the 2016 Pedernales earthquake and with the location of historical

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ruptures in 1958, 1979 and 1998. The spatial variability in coupling and complexity in earthquake history suggest strong heterogeneities in frictional properties of the subduction megathrust.