Modeling Plate Boundary Stress Changes with InSAR and CGPS

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The San Andreas Fault System has long been recognized as a natural laboratory for investigating the many facets of plate boundary deformation. The growing archive of space geodetic data now culminating in the Plate Boundary Observatory is providing a detailed synoptic picture of the accumulation of stress and strain along this zone. At best, these measurements can provide a detailed snapshot of the present-day stress accumulation rate. However, an improved understanding of plate boundary physics and seismic hazard will require estimates of absolute stress and accumulated seismic moment that can only be established through model simulations. These simulations must include interseismic, coseismic and postseismic slip history on complex three-dimensional fault systems for the past several earthquake cycles (~1000 years) and also account for viscoelastic relaxation of the asthenosphere and the restoring force of gravity due to vertical loads. We have developed a three-dimensional viscoelastic body force algorithm capable of highly efficient modeling of large-scale plate boundary deformation data by making computations in the spectral domain. Initial model simulations provide a plausible description of large-scale plate boundary deformation and stress for many earthquake cycles and also explore changes in stress due to lake and ocean loading. More importantly, they provide a quantitative prediction of the present-day crustal Coulomb stress field. Model simulations, constrained by improved measurements, can be used to address the following scientific questions: What is the present level of stress on the San Andreas Fault Zone and how has it evolved since the availability (circa 1992) of InSAR and continuous GPS? What processes influence the spatial and temporal pattern of earthquake occurrence? Is the earthquake cycle modulated by lake and ocean loads on 100-10,000 year timescales? How is strain relieved during the interseismic period at shallow depths on mature faults? Another outcome of this study is a robust crustal deformation model for addressing the epoch-date surveying problem for the California Spatial Reference Center (CSRC).

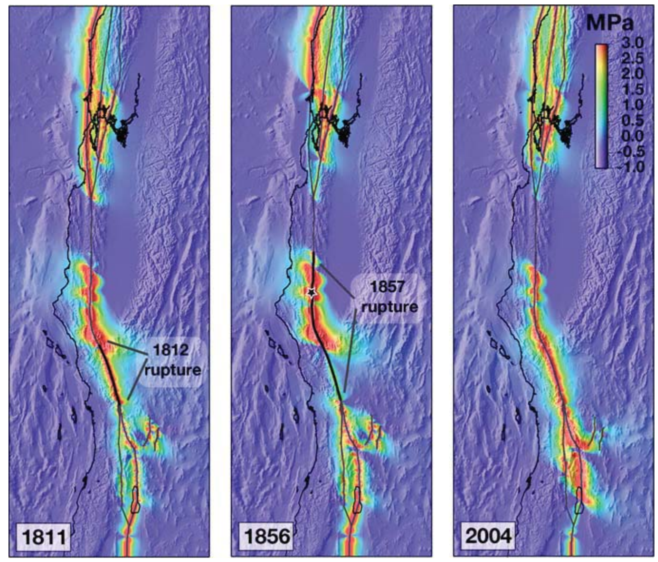

Figure 1. Coulomb stress in MPa for the San Andreas Fault System for three snapshots in time. (left) 1811 calendar year model, representing the stress field prior to the 1812 M~7 Wrightwood earthquakes. (center) 1856 calendar year model, representing the stress field prior to the M7.9 1857 Great Fort Tejon earthquake. (right) 2004 calendar year model, representing stress of ~ present day [Smith and Sandwell, 2006].

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