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Reconciling geological and geodetic models of Interseismic deformation in Southern California

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In Southern California the relative motion between the North American and Pacific plates is largely absorbed by slip on mature strike-slip faults along the San Andreas Fault (SAF) system. But at places, some relative convergence is also evidenced by the presence of thrust or oblique strike-slip faults. Despite the change of azimuth of the various strands of strike-slip faults, the far-field interseismic horizontal velocity, at the surface, is relatively uniform along the SAF from Tejon Pass to the Salton Trough. At depth, the long-term average cumulative horizontal velocity vectors must be constant in time and accommodated by the interplay of both strike-slip and thrust faults. Using a combination of interferometric synthetic aperture radar, GPS, seismic and tomographic data, we identify a flower-structure kinematic model that is compatible with interseismic surface velocities and the presence of both strike-slip and thrust faults in the mid and upper crust. We investigate three different locations that represent end members of slip partitioning: the SAF transpressive big bend, the San Gorgonio Pass compressive step over and the transtensional Salton Trough. A widespread crustal decollement connecting the base of the Elsinore, San Jacinto and San Andreas Faults below their brittle-ductile transition can reconcile many geological, geodetic and geophysical observations. In this configuration, shallow thrusts and strike-slip faults merge into a deep sub-horizontal decollement in the lower crust. Slip on the intra-crustal decollement is oblique to the orientation of the strike-slip faults and accommodates both convergent and transform components of the relative plate motion. Using this geometry, we determined horizontal shortening rates of 12 mm/yr and 11 mm/yr from the San Andreas Fault (SAF) to the frontal thrusts, associated with transpression around the big bend and the 15 km-wide restraining step near San Gorgonio Pass. This shortening is distributed among the SAF, the San Gabriel Mountain and frontal blind thrusts. Across the San Gorgonio Pass, this shortening is in majority absorbed at a rate of 8 mm/yr below the San Bernardino thrust and at a rate of 3 mm/yr below the San Jacinto Fault. We find an interseismic velocities on the SAF of 25 mm/yr around the Cajon Creek segment compatible with geological estimates and a decrease of the strike-slip loading along the SAF from the north to the south inversely proportional to the degree of partitioning of slip between the San Andreas, the San Jacinto and the Elsinore faults. Across the Salton Trough, our preferred two-dimensional model indicates interseismic velocities of 15 mm/yr on the SAF, 24 mm/yr on the San Jacinto Fault and 3 mm/yr on the Elsinore Fault. Reconciling these structural features into a self-consistent kinematic fault model results in more realistic fault geometries, which is critical to building more accurate scenarios of stress evolution and better explore the potential hazards associated with thrust faults in Southern California.