

Supplementary material

to: “Interseismic strain accumulation and the earthquake potential on the southern San Andreas fault system” by Yuri Fialko

Methods

The San Bernardino-Coachella Valley segment of the southern San Andreas fault has been extensively imaged by the ERS-1 and 2 satellites of the European Space Agency. Figure S3 shows a catalog of radar acquisitions from the descending satellite track 356. I use all available acquisitions (denoted by dots and orbit numbers in Figure S3) to form 59 interferometric pairs having baselines less than 200 meters. Radar interferograms used in this study are denoted by sub-horizontal lines in Figure S3. Several radar acquisitions not used in this study have either missing data, unfavorable baselines, or problems with decorrelation or unwrapping of the radar phase. To reduce the atmospheric noise, I calculate the ground velocity along the satellite line of sight (LOS) by averaging the unwrapped radar phase from properly selected sets of interferograms (see ref. 2 for details). Because I am interested in a long-wavelength signal associated with the interseismic strain accumulation, I use 200 km long strips of radar data, and do not “flatten” interferograms at the processing stage (flattening is usually performed to correct for possible errors in the satellite orbits). Although an area to the south of the SAF is decorrelated due to agricultural activities around the Salton Sea (see Figure 1 of the main text), I point out that every individual interferogram included in the stack has been confidently unwrapped across the SAF through the relatively stable Palm Springs area in the NW corner of the interferogram. Therefore there is no phase ambiguity between the northern and southern parts of the stacked interferogram. The apparent lack of phase continuity in the Palm Springs area is due to the fact that the decorrelated area in a stack is a union of all decorrelated areas in individual interferograms.

To ensure that the signal seen in Figure 1 indeed represents a secular tectonic deformation, as well as to estimate the noise level I calculate average LOS velocities using clusters of radar interferograms spanning different time intervals within the period of observations

². Figure S4 shows the average LOS velocities from three different stacks of interferograms corresponding to time intervals 1992-1996, 1993-1998, and 1996-2000. The LOS velocity data are taken from a 40 km wide profile across the SAF system (see solid rectangle in Figure 1). The color coding of data shown in Figure S4 is the same as that used to identify the three temporal clusters of interferometric pairs in Figure S3. Note that the interferometric stacks spanning the 1992-1996, and 1996-2000 time periods include contributions from the nearby Landers and Hector Mine earthquakes, respectively. I account for the coseismic signatures by subtracting the LOS displacement fields predicted by the finite slip models for these events ^{1,3}. The estimated coseismic contribution amounts to an apparent LOS velocity of a few millimeters per year, maximum in the north-west corner of the interferogram, and decaying toward south-east. The overall agreement between the satellite LOS velocities from different epochs testifies that (i) the coseismic correction is robust, and (ii) the inferred variations in the LOS velocities across the SAF system represent a secular interseismic deformation. The rate of interseismic deformation is well resolved, and appears to be constant over a period of observations of about 10 years. Note that the data scatter seen in Figure S4 notably decreases with an increasing number of interferograms used in the data averaging, as expected. The estimated measurement error for the entire stack of data spanning 1992-2000 (Figure 1) does not exceed 2 mm/yr, as inferred from calculations of the root mean square residual after subtraction of the best-fitting model (Figure 2). In Figure 2, the LOS projections of both the GPS/EDM data and the model account for local variations in the radar incidence angle ¹. Note that the campaign-mode GPS and EDM data from SCEC provide only horizontal velocities, while the continuous GPS data from SCIGN include a vertical component of deformation. Given that the LOS velocity is quite sensitive to vertical motion, addition of the vertical component might be expected to improve an agreement between the GPS and InSAR data. In fact, accounting for the vertical component degrades the agreement between the continuous GPS and InSAR data (cf. magenta and black triangles in Figure 2), suggesting that the GPS measurements of vertical deformation are not yet sufficiently accurate.

References

- [1] Fialko, Y. Probing the mechanical properties of seismically active crust with space geodesy: Study of the co-seismic deformation due to the 1992 M_w 7.3 Landers (southern California) earthquake. *J. Geophys. Res.* **109**, B03307, 10.1029/2003JB002756 (2004).
- [2] Fialko, Y. Evidence of fluid-filled upper crust from observations of post-seismic deformation due to the 1992 M_w 7.3 Landers earthquake. *J. Geophys. Res.* **109**, B08401, 10.1029/2004JB002985 (2004).
- [3] Simons, M., Fialko, Y. & Rivera, L. Coseismic deformation from the 1999 M_w 7.1 Hector Mine, California, earthquake, as inferred from InSAR and GPS observations. *Bull. Seism. Soc. Am.* **92**, 1390–1402 (2002).

Supplementary figures

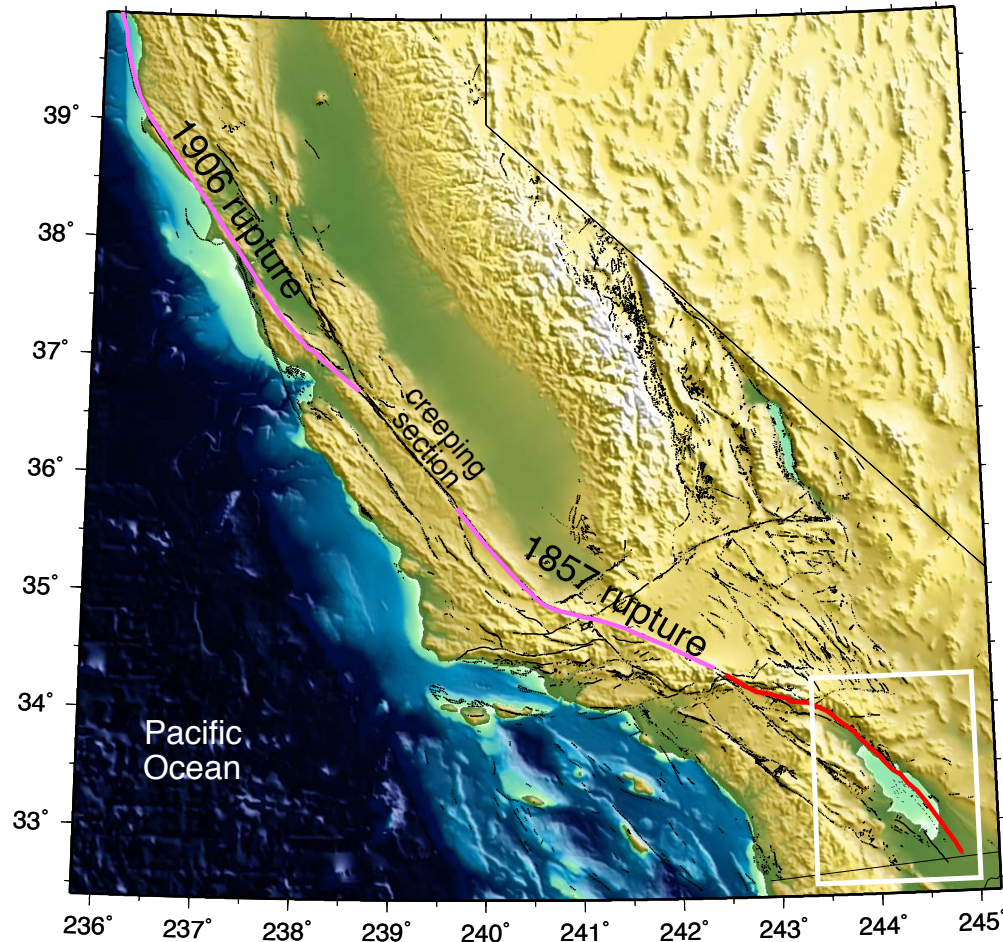


Figure S1. Shaded relief map of California. Pink lines denote sections of the San Andreas fault that ruptured in great earthquakes in 1857 and 1906. A red line denotes the southern part of SAF that did not produce a major earthquake in historic times. Black wavy lines show other geologically mapped faults. A white box outlines the study area shown in Figure 1 in the main text.

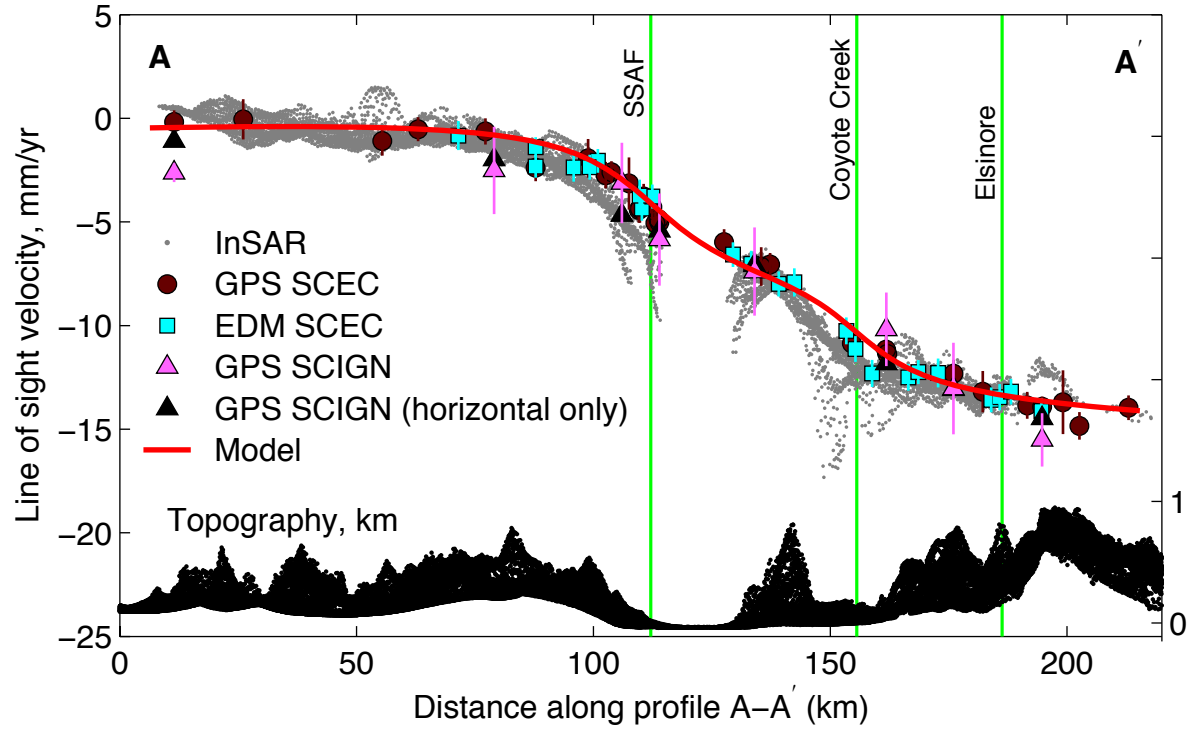


Figure S2. Notation is the same as in Figure 2 in the main text. Red line represents the best-fitting model assuming a homogeneous elastic half-space and vertical faults in the upper crust. The inferred locking depth and slip rate are 17 km, 27 mm/yr and 12 km, 18 mm/yr for the San Andreas, and San Jacinto faults, respectively.

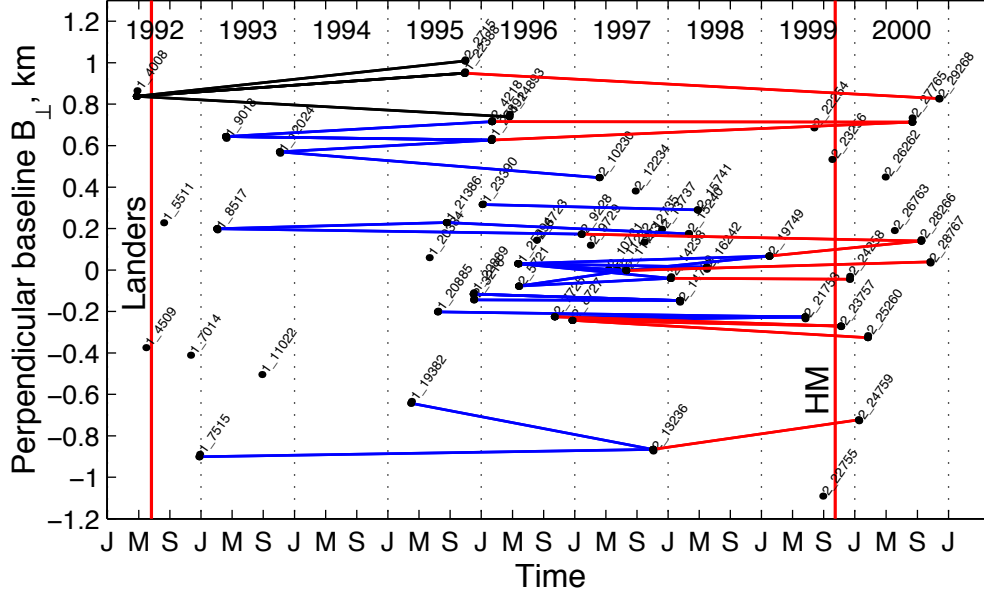


Figure S3. ERS SAR data from the descending track 356. Dots denote radar acquisitions (labeled by the platform and orbit numbers). Horizontal axis represents time, and vertical axis represents perpendicular baseline (distance between repeated orbits). Sub-horizontal lines connecting dots denote radar interferograms used in this study. Colors denote different subsets of interferograms used to estimate temporal variations and accuracy of the inferred LOS velocity map. Vertical lines indicate dates of the Landers and Hector Mine earthquakes.

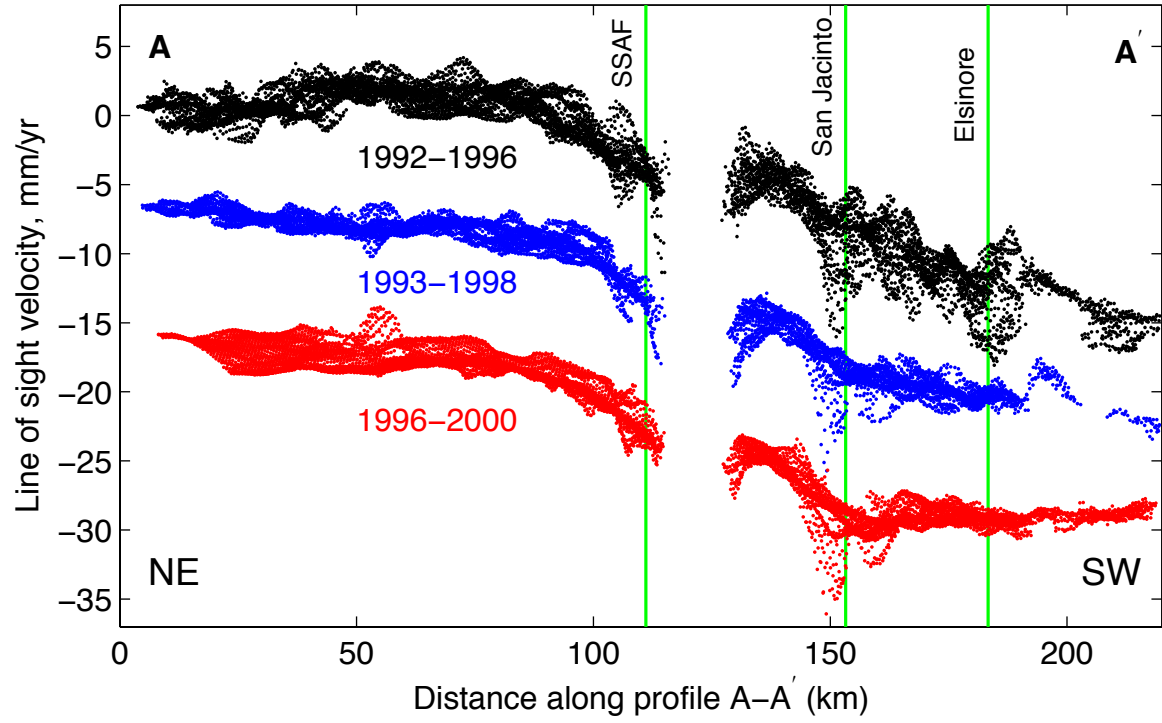


Figure S4. Satellite LOS velocities from a profile A-A' (Figure 1) for different observation epochs. The LOS velocities for different epochs are calculated using stacks of interferograms denoted by a corresponding color in Figure S3. Vertical lines show the position of major crustal faults.