A Joint Inversion Algorithm of GNSS and InSAR Data for Surface 3-D Velocity and Strain Rate Fields

We developed a joint inversion algorithm for continuous surface 3-D velocities and associated horizontal strain rate field. Using a thin-elastic-sheet model, we built the basis functions of the joint inversion algorithm, each of which represented a response to body-force equivalents embedded within grid cells. The goal of this inversion is to find the best-fit linear combination of the basis functions that predict both GNSS and InSAR measurements. We use the 10-fold cross-validation method and the trade-off curve to determine an “optimal” level of smoothing. The relative weighting for each data set is initially decided based on the number of data points and uncertainties in GNSS data, and it is iteratively updated until the standard error of unit weight (SEUW) of GNSS data achieves a value ~1.5. To test this algorithm, we performed synthetic tests. Our goal in these synthetic tests is to recover the full 3-D field associated with a mixture of a complex horizontal interseismic signal and a variable vertical signal. We first used the joint inversion technique to recover an estimate of the continuous 3-D velocity field in southern California using synthetic InSAR and GNSS data. To determine how much information the InSAR is providing for the horizontal component of the interseismic field, we compared results with a solution obtained from the inversion of GNSS data alone. Both of the solutions produced the same value of SEUW of GNSS data. We find that the velocity and strain rate fields inferred from the joint inversion of InSAR and GNSS data are closer to the “true” fields than the solution obtained using GNSS data alone. The result shows that the joint inversion can recover vertical signals well, and the addition of InSAR provides a much higher resolution estimate of the interseismic horizontal strain rate field.

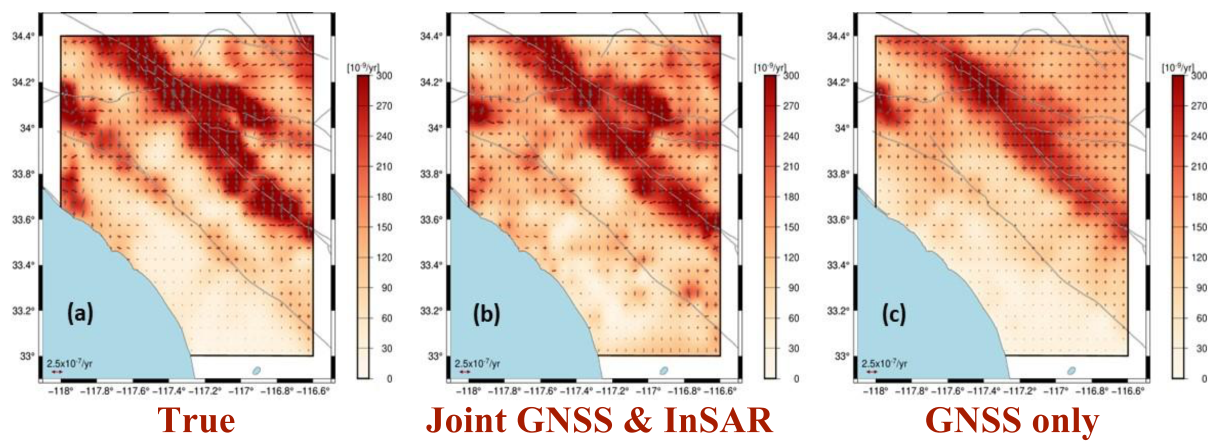

Figure 1. A “true” interseismic horizontal strain rate field **(a)** and recovered solution obtained using both InSAR and GNSS data **(b)** and another solution inferred from GNSS measurements alone **(c)**. Background is the second invariant of the horizontal strain rate field. Crosses indicate principal axes of the strain rate tensor (red is extensional; gray is contractional).