S.1 Principal Component Analysis Inversion Method (PCAIM)

With the PCAIM technique, time series are combined to build a data matrix $X_0$ of dimension $m \times n$, where each row corresponds to the time series of 1 scalar quantity (either shortening measurement from a creepmeter or one component (east, north, up) of a GPS station), and each column corresponds to a given epoch of data acquisition (all data acquired at a given epoch are listed under the same column). Therefore $X_{ij}$ represents the displacement at station $i$ at the $j^{th}$ step in time. Infinite uncertainty are assigned to missing data measurements. The data matrix is then centered (equation S1) before applying a Singular Value Decomposition (SVD):

$$X(i, j) = X_0(i, j) - \sum_{k=1}^{m} \frac{X_0(i, k)}{m},$$  \hspace{1cm} (S1)

$$X = U.S.V^t,$$  \hspace{1cm} (S2)

where the column vectors of $U$ are the eigenvectors of the spatial covariance matrix $XX^t$, the column vectors of $V$ are the eigenvectors of the temporal covariance matrix $X^tX$, and $S$ is the rectangular diagonal matrix with elements equal to the eigenvalues of $X$, ordered decreasingly (Kositsky and Avouac, 2010). The components are determined from a weighted least squares procedure that takes into account data uncertainties. The principle of PCAIM is to combine Principal component analysis (PCA) (equation S2) with the inversion for slip at depth based on the theory of dislocation in an elastic half space (equation 2 in the main paper). Therefore, each column vector of $U$ is inverted to get the corresponding principal slip distribution $l$ defined by:

$$U = G.l,$$  \hspace{1cm} (S3)

where $G$ is the Greens functions matrix as defined in section 3.1 of the main paper. This equation is solved from the standard least-squares procedure with Laplacian regularization described in section 3. The fault slip history is retrieved by linear composition:

$$X = (G.l).S.V^t = G. (l.S.V^t),$$  \hspace{1cm} (S4)
where \((l.S.V^t)\) is the slip on each patch of the fault over time. Only statistically relevant Principal Components (PCs) of the decomposition should be kept. The number of useful components is assessed from computing the fraction of variance of the data matrix accounted for the \(k^{th}\) component, which is simply:

\[
\frac{\lambda_k^2}{\sum_{i=1}^{r} \lambda_i^2},
\]

(S5)

where \(r\) is the rank of the diagonal matrix \(S\) (number of non zero eigenvalues). One can also consider the variation of the \(\chi^2\) as a function of the number of principal components used and determine the number of useful components using an f-test [Kositsky et al., 2010].
Figure S1: Locations of continuous GPS stations with the corresponding date of records.
Figure S2: Plots of cGPS time series for which we have records before and after the 2003 Chengkung earthquake. See Figure S1 for location. Green dots with 1-sigma error bars represent the original dataset. Predictions from the inversion of coseismic slip and PCAIM inversions of preseismic and postseismic periods are plotted in black. To facilitate the comparison we have corrected the model predictions for the mean residual velocities over the pre and postseismic period represented in Figures 17 and 19.
Figure S3: Plots of cGPS time series for which we have records only after the 2003 Chengkung earthquake. See Figure S1 for location. Green dots with 1-sigma error bars represents the original dataset. Predictions from the inversion of coseismic slip and PCAIM inversions of postseismic periods are plotted in black. To facilitate the comparison we have corrected the model predictions for the mean residual velocities over the postseismic period represented in Figures 17 and 19.
Figure S4: Resolution of the various inversions described in this study. The width of the best-fitting Gaussian curve to each row of the resolution matrix is plotted at the location of each cell of the fault model. This is, in effect, representing the width of the equivalent Gaussian distribution that is retrieved if one inverts the displacements predicted for a unit slip at the considered cell.

Figure S5: Checkerboard resolution test. (a) The input is the theoretical displacements of cGPS, campaign GPS, leveling and ALOS data generated from a synthetic slip model (a checkerboard test). Panel (b) display the inverted slip distribution from this synthetic dataset.
Figure S6: Dip-slip component (a), strike-slip component (b) and magnitude (c) of long term slip rate on the LVF predicted from the secular relative motion between the Central Range and Coastal Range. This computation is based on the CoR/CeR pole listed in Table 1.

Figure S7: Interseismic coupling model, fit to geodetic data. (a) Comparison between observed and predicted vertical velocities. The GPS data used in this inversion are plotted respectively as dark blue and black arrows for the campaign and continuous GPS measurements. Green arrows stand for the GPS stations that were not used in the inversion but which are plotted for reference. Predictions from the interseismic coupling model are displayed in red. (b) Residuals from the inversion with corresponding error ellipses. Same color attributions as in (a).
Figure S8: Test of robustness of the iterative method used to derive Interseismic Coupling (ISC) (see section 4.2), displayed here in (a). The initial PSP pole (DeMets et al., 2010) has been altered by multiplying the PSP rotation rate by 0.75 (b) and 1.25 (c) (we kept the same pole location). ISC model based on the Eulerian pole proposed by Sella et al. (2002) is shown in (d). These tests emphasize the robustness of the procedure, since models only differ slightly in the north, for the deeper patches.
Figure S9: Misfit between measured and reconstructed displacements as the weight put on smoothing (λ) increases, for the coseismic model (see section 5). Misfit is quantified from reduced chi-square, as defined in equation (4), after renormalization of uncertainties. We choose $1/\lambda = 0.005$ to represent the best compromise.

Figure S10: Coseismic slip distribution model of the 2003 $M_w$ 6.8 Chengkung Earthquake. (a) The cGPS and accelerometric data used in this inversion are plotted respectively as black and dark blue arrows. Predictions from our best-fitting coseismic model are plotted in red. (b) Residuals from the inversion with corresponding error ellipses. Same color attributions as in (a).
Figure S11: Misfit between time series (GPS and creepmeter stations) and reconstructed displacements from the PCA decomposition as the number of principal components increases. Misfit is quantified from reduced chi-square, as defined in equation 5.

Figure S12: Time functions of the first four principal components for the postseismic modelling. Note that higher-order components (>2) are more erratic than lower-order components, but do contain significant signals related to postseismic deformation or annual variation of creep rate.
Figure S13: Postseismic principal slip distribution for the four first principal components (PC). Plots display the cumulative slip on the LVF over the period between 12/13/2003 and 11/26/2010, determined from PCAIM inversion of principal components. The range of the color scale is 10 times smaller for PC2, PC3, and PC4 than for PC1.

Figure S14: Postseismic slip distribution model, fit to geodetic data. (a) Comparison between observed and predicted vertical displacement over the time period from 12/11/2003 to 11/26/2010. The reference frame is the Philippine Sea Plate, fixed. The cGPS data, which were used or not in the inversion, are plotted respectively as black and green arrows. Corresponding predictions of the postseismic slip model are displayed in red. (b) Residuals from the inversion with corresponding error ellipses. Same color coding as in (a).
Figure S15: Postseismic model, fit to leveling data. (a) Vertical velocities predicted from the secular interseismic model. See Figure 1 for corresponding observations. (b) Residuals from the inversion with same color scale as in (a).

Figure S16: Postseismic model, fit to PS ALOS mean velocity. (a) Line of Sight velocities predicted from the secular interseismic model. For comparison with observations, see Figure 2. (b) Residuals from the inversion with same color scale as in (a).
Figure S17: Time functions of the first three principal components for the preseismic modelling.

Figure S18: Preseismic principal slip distribution for the three first principal components (PC). Plots display the cumulative slip on the LVF during the 1/1/1997 to 12/12/2003 period, determined from PCAIM inversion of principal components. The range of the color scale is 50 times smaller for PC2 and PC3 than for PC1. Therefore, most of the slip is accommodated by the first principal component, as comparison with Figure 18a demonstrates.
Figure S19: Preseismic slip distribution model, fit to geodetic data. (a) Comparison between observed and predicted vertical velocities, averaged over the time period (from 1/1/1997 to 12/12/2003). The GPS data used in this inversion are plotted respectively as dark blue and black arrows for the campaign and cGPS measurements. Green arrows stand for the GPS stations plotted for reference. Corresponding predictions of the preseismic model are displayed in red. (b) Residuals from the inversion with corresponding error ellipses. Same color coding as in (a).

Figure S20: Leveling data from [Ching et al., 2011].(a) Published Dataset. Ching et al., [2011] have removed the coseismic motion due to the Chengkung earthquake. Same color scale as in (b). (b) Vertical velocities predicted from the PCAIM preseismic and postseismic models for the same time period.(c) Residuals from the inversion with same color scale as in (a) and (b). Our model does not predict subsidence in the north, which is linked to the Ryukyu subduction zone. Residuals in the south might be explained by a difference in the coseismic model.
Figure S21: Seismicity around the LVF from 1991 to 2010. (a) Blue dots represent the seismicity recorded on the LVF since the Chengkung earthquake (12/10/2003) until December 2010, for events $M_w > 3$. The black box defines the southern segment of the LVF, for which we compute the Gutenberg-Richter plot (Figure 21). The inversion model underneath corresponds to the cumulative slip on the LVF over the period between 12/11/2003 and 11/26/2010, determined from PCAIM inversion of cGPS and creepmeter time series, leveling data (from 9/1/2007 to 31/2/2010) and PS ALOS cumulative displacement between 1/29/2007 and 6/2/2010. (b) Black dots represent the seismicity recorded on the LVF from January 1991 to the day before the Chengkung earthquake, for events $M_w > 3$. Underneath, we plot the ISC model quantifying the degrees of locking of the LVF fault. If $ISC = 1$, then the fault patch is fully locked, whereas $ISC = 0$ means that the patch is creeping at the long-term slip rate.
References

