Supporting Information for "14-year acceleration along the Japan Trench"

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Text S1

To describe the transformation of the GPS time series from ITRF2005 to ITRF2014, we detail here the equations controlling this transformation. Equation (1) represent the transformation of one point at the Epoch given time (2010.0), all the parameter values are given in Table S1 :

$$\begin{pmatrix} X_{ITRF2005} \\ Y_{ITRF2005} \\ Z_{ITRF2005} \end{pmatrix} = \begin{pmatrix} X_{ITRF2014} \\ Y_{ITRF2014} \\ Z_{ITRF2014} \end{pmatrix} + \begin{pmatrix} T_x \\ T_y \\ T_z \end{pmatrix} + \begin{pmatrix} D & -R_z & R_y \\ R_z & D & -R_x \\ -R_y & R_x & D \end{pmatrix} \begin{pmatrix} X_{ITRF2014} \\ Y_{ITRF2014} \\ Z_{ITRF2014} \end{pmatrix} \quad (1)$$

Where $X_{ITRF2005}$, $Y_{ITRF2005}$, $Z_{ITRF2005}$ are the coordinates in ITRF2005, $X_{ITRF2014}$, $Y_{ITRF2014}$, $Z_{ITRF2014}$ are the coordinates in ITRF2014, T_x, T_y, T_z are translations parameters, R_x, R_y, R_z are rotation parameters, and D is the scaling factor. Equation (2) shows the value of any parameter P at any time t where $\dot{P}$ is the rate of the parameter :

$$P\left(t\right) = P\left(\text{Epoch}\right) + \dot{P} \times \left(t - \text{Epoch}\right) \quad (2)$$

Table S1. *Transformation Parameters from ITRF2014 to ITRF2005.*

Solution	T_x (mm)	T_y (mm)	T_z (mm)	D (ppb)	R_x (.001”)	R_y (.001”)	R_z (.001”)	Epoch
Rates	T_x (mm/yr)	T_y (mm/yr)	T_z (mm/yr)	D (ppb/yr)	R_x (.001”/yr)	R_y (.001”/yr)	R_z (.001”/yr)	
ITRF2005	2.6	1.0	-2.3	0.92	0.00	0.00	0.00	2010.0
Rates	0.3	0.0	-0.1	0.03	0.00	0.00	0.00	

Note: From the International Terrestrial Reference Frame website (https://itrf.ign.fr/doc_ITRF/Transfo-ITRF2014_ITRFs.txt)

Table S2. *Summary Table for the Locking Model Parameters and Figures*

Plates	**PAC prior model**	**PHS prior model**	σ_m **value**	**Inverted data**	**Figures**
PAC and PHS	Locked	Locked	$10^{0.53}$	Linear model velocity	Figures 4 and S6
PAC and PHS	Locked	Locked	$10^{0.53}$	*1997 velocity*	Figure 7b
PAC and PHS	Locked	Locked	$10^{0.53}$	*Velocity from linear model without SSEs modelling*	Figures S17 and S18
PAC and PHS	Locked	Locked	$10^{0.30}$	Linear model velocity	Figure S9
PAC and PHS	Locked	Locked	$10^{0.70}$	Linear model velocity	Figure S10
PAC and PHS	Locked	*Unlocked*	$10^{0.53}$	Linear model velocity	Figure S3
PAC and PHS	*Unlocked*	Locked	$10^{0.53}$	Linear model velocity	Figures S1a and S2
PAC and PHS	*Unlocked*	Locked	$10^{0.53}$	*1997 velocity*	Figure S21b
PAC	Locked		$10^{0.53}$	*1997 velocity*	Figure S8a
PAC	Locked		$10^{0.53}$	*2011 velocity*	Figure S8b

Note: The first line represent the parameters used for the figure in the main article (Figure 4). On the other lines, the italics parameters are the one different from the first line. Columns, in ascending order: (1) plates used in the inversion (either PAC and PHS or PAC alone); (2) prior model for the Pacific plate (PAC); (3) prior model for the Philippine Sea plate (PHS); (4) smoothing parameter σ_m; (5) data used for the inversion; (6) related figures.

Table S3. *Summary Table for the Slip Acceleration Model Parameters and Figures*

Plates	**PAC prior model**	**PHS prior model**	σ_m **value**	**Inverted data**	**Figures**
PAC	Zero acceleration		$10^{-0.23}$	Quadratic model acceleration	Figures 6 and S7
PAC	Zero acceleration		$10^{-0.23}$	*Quadratic model acceleration with vertical component*	Figure S11
PAC	Zero acceleration		$10^{-0.23}$	*Acceleration from quadratic model without SSEs modelling*	Figure S19
PAC	Zero acceleration		$10^{-0.23}$	*Quadratic model acceleration for F3 solution*	Figure S15b
PAC	Zero acceleration		$10^{-0.40}$	Quadratic model acceleration	Figure S13a
PAC	Zero acceleration		$10^{0.00}$	Quadratic model acceleration	Figure S13b
PAC	*Figure 7c (seismic acceleration)*		$10^{-0.23}$	Quadratic model acceleration	Figure 7d
PAC	*Figure S21c (seismic acceleration)*		$10^{-0.23}$	Quadratic model acceleration	Figure S21d
PAC and PHS	Zero acceleration	*Zero acceleration*	$10^{-0.23}$	Quadratic model acceleration	Figure S14

Note: The first line represent the parameters used for the figure in the main article (Figure 6). On the other lines, the italics parameters are the one different from the first line.
Columns, in ascending order: (1) plates used in the inversion (either PAC and PHS or PAC alone); (2) prior model for the Pacific plate (PAC); (3) prior model for the Philippine Sea plate (PHS); (4) smoothing parameter σ_m; (5) data used for the inversion; (6) related figures.

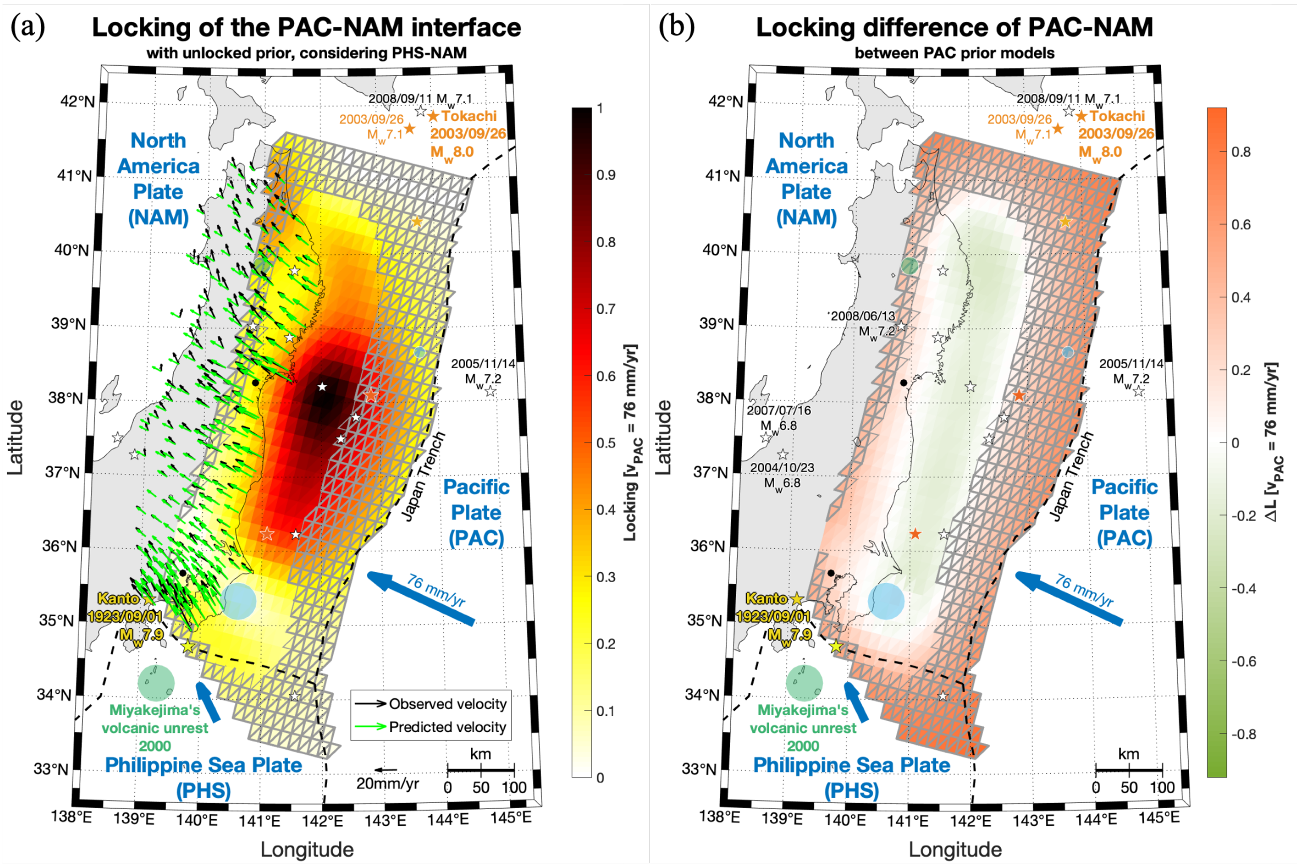

Figure S1. Locking of the Pacific-North America (PAC–NAM) subduction interface with a fully unlocked prior model (a) and the locking difference between Figure 4a with a locked prior model and (a). (a): Same legend as Figure 4. (b): Orange: sub-fault more locked for the locked prior model (Figure 4); green: sub-fault less locked for the locked prior model (Figure 4); other elements are described in Figure 1.

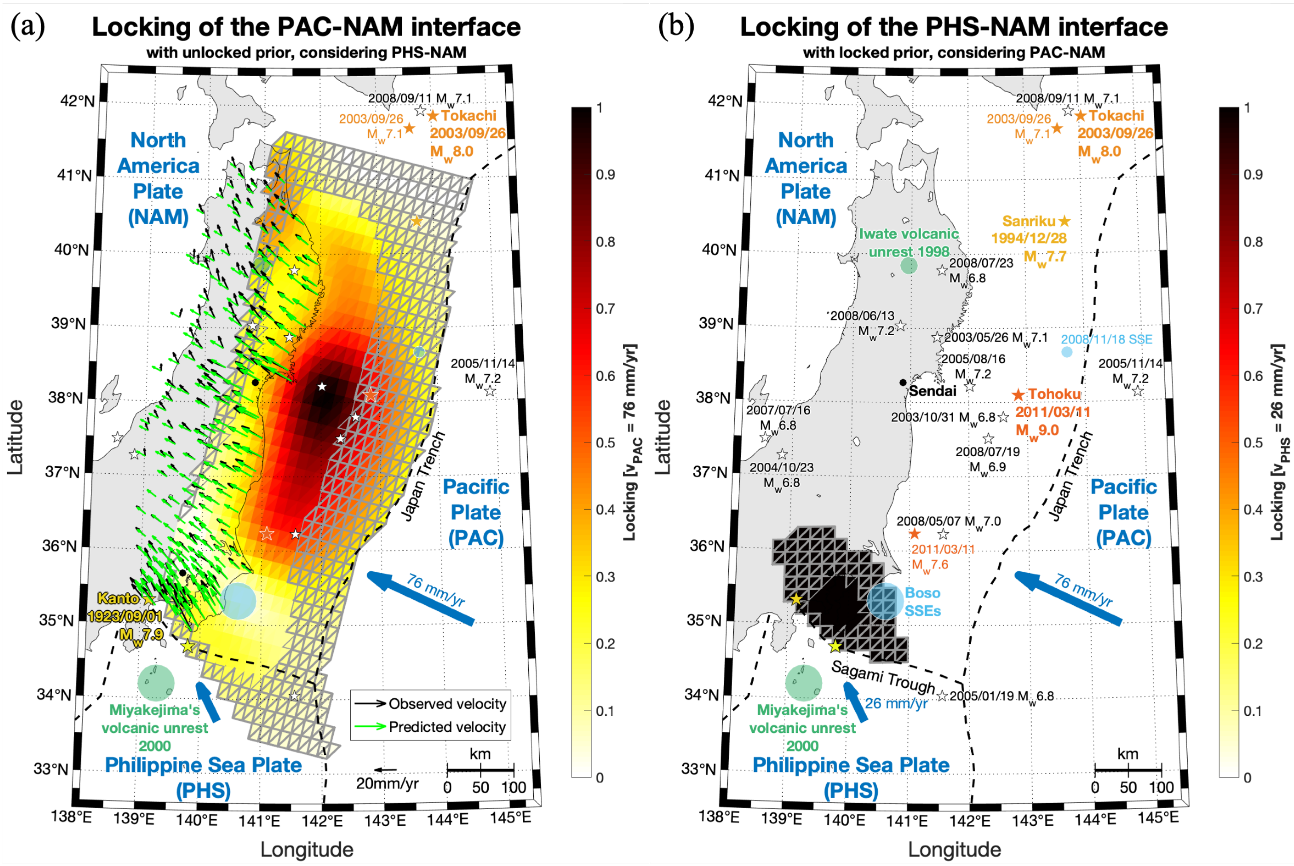

Figure S2. Locking of the Pacific-North America (PAC–NAM) subduction interface with a fully unlocked prior model (a) and locking of the Philippine Sea-North America (PHS–NAM) subduction interface with a fully locked prior model (b). Same legend as Figure 4.

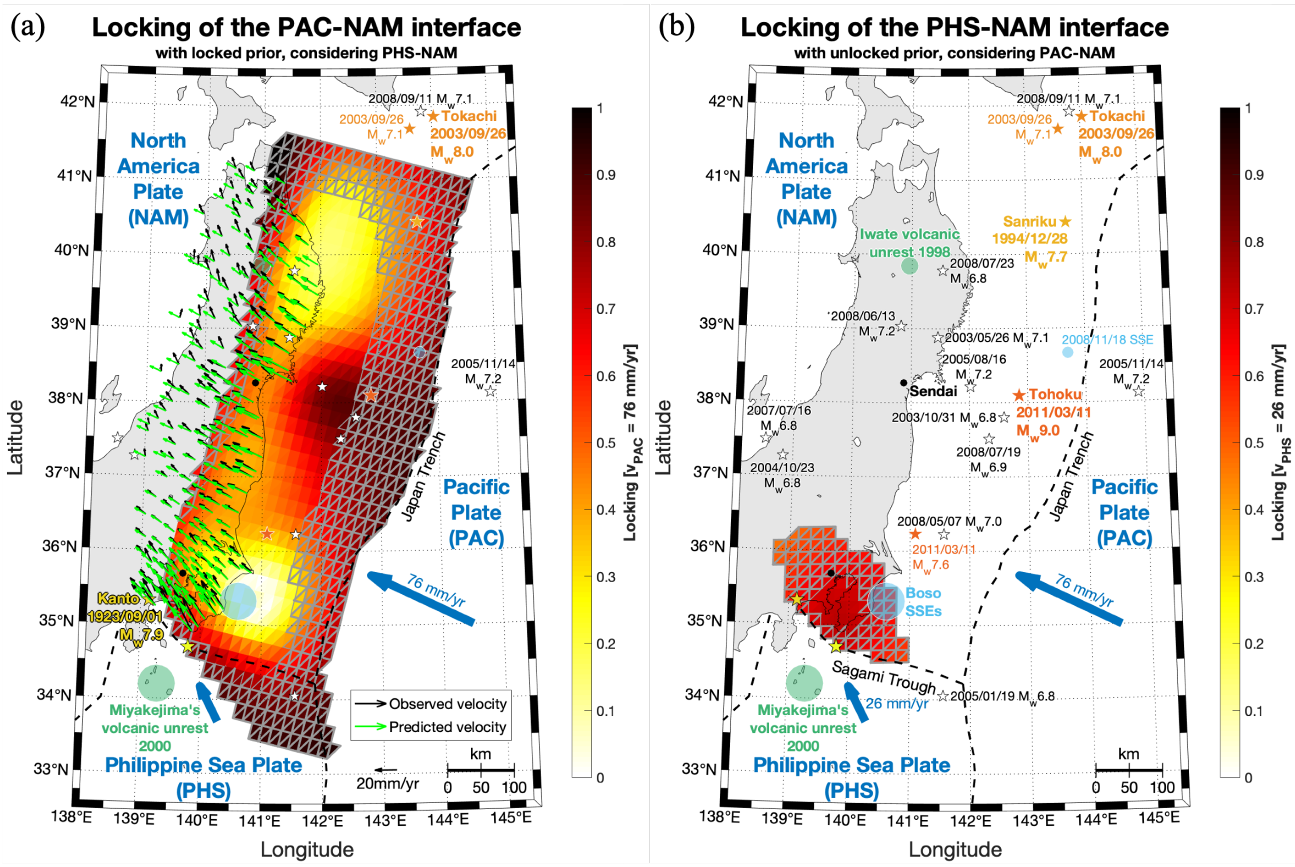

Figure S3. Locking of the Pacific-North America (PAC–NAM) subduction interface with a fully locked prior model (a) and locking of the Philippine Sea-North America (PHS–NAM) subduction interface with a fully unlocked prior model (b). Same legend as Figure 4.

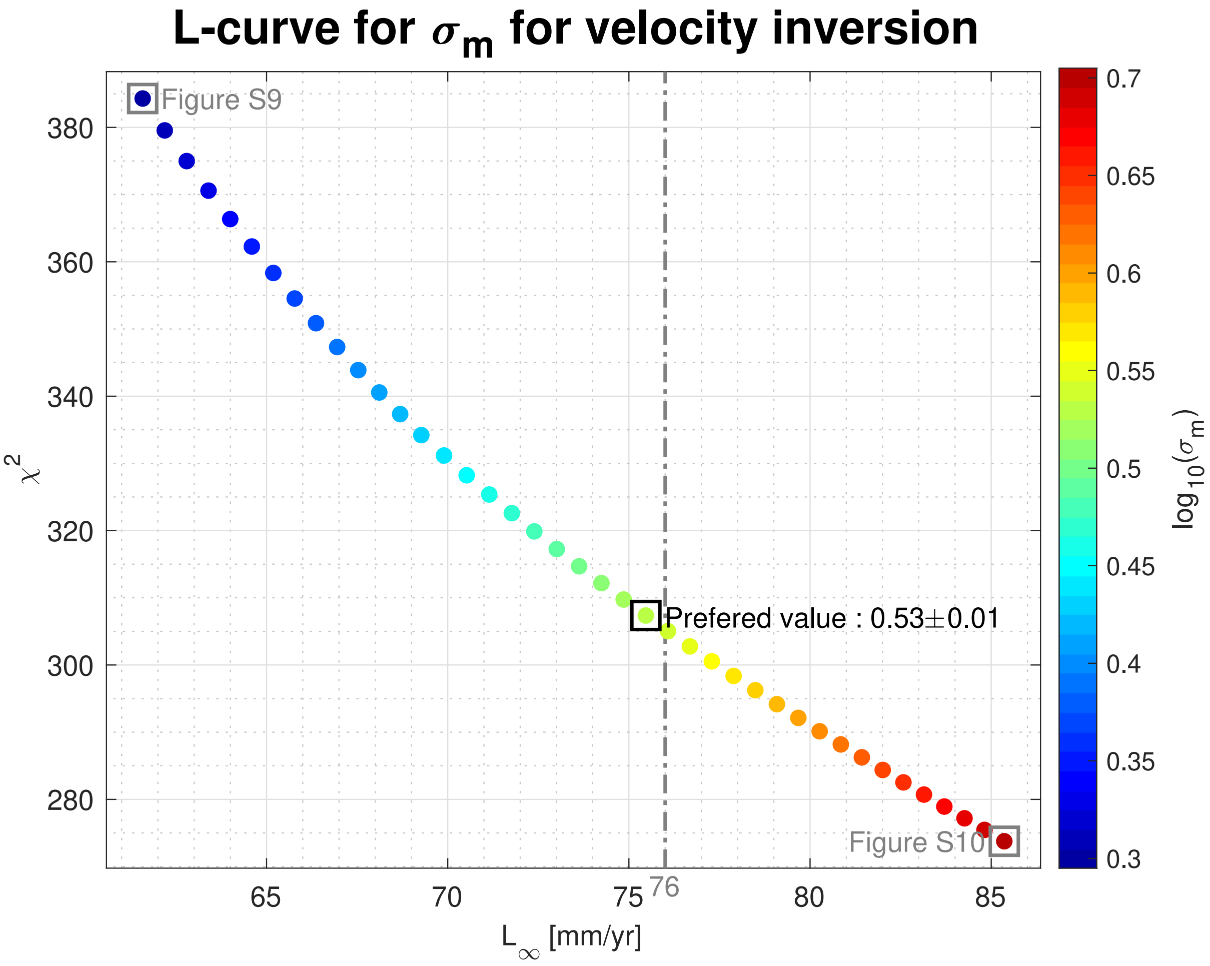

Figure S4. L-curve for σ_m determination for the velocity field inversion. The color correspond to the value of $\log_{10}(\sigma_m)$. Our preferred σ_m value is $10^{0.53}$ ($\log_{10}(\sigma_m) = 0.53$). All the inversion except Figures S9 and S10 are made for $\sigma_m = 10^{0.53}$. Alternative inversions are proposed for $\sigma_m = 10^{0.30}$ (Supplementary Figure S9) and $\sigma_m = 10^{0.70}$ (Supplementary Figure S10).

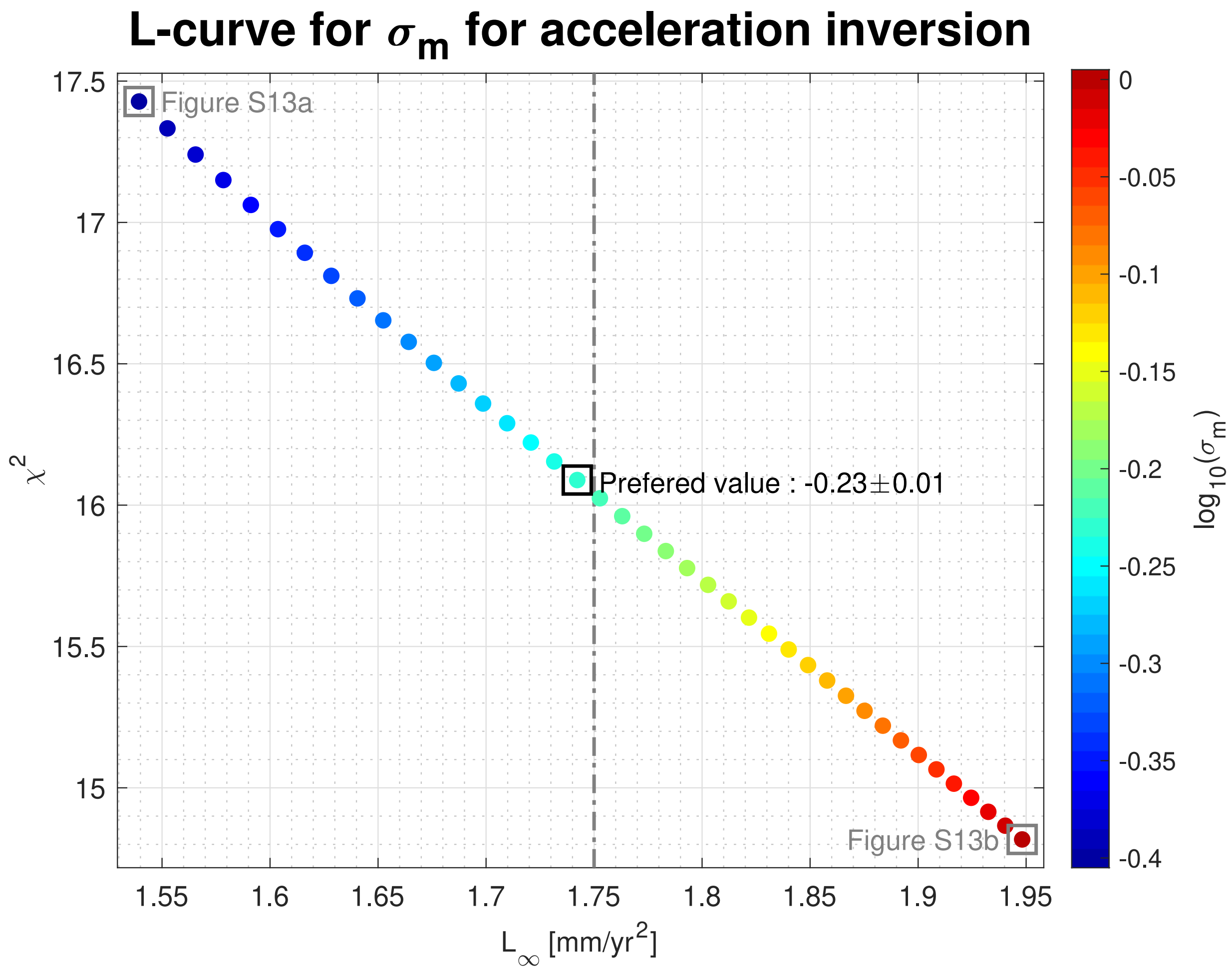

Figure S5. L-curve for σ_m determination for the acceleration field inversion. The color correspond to the value of $\log_{10}(\sigma_m)$. Our preferred σ_m value is $10^{-0.23}$ ($\log_{10}(\sigma_m) = -0.23$). All the inversion except Supplementary Figure S13 are made for $\sigma_m = 10^{-0.23}$. Alternative inversions are proposed for $\sigma_m = 10^{-0.40}$ (Supplementary Figure S13a) and $\sigma_m = 10^{0.00}$ (Supplementary Figure S13b).

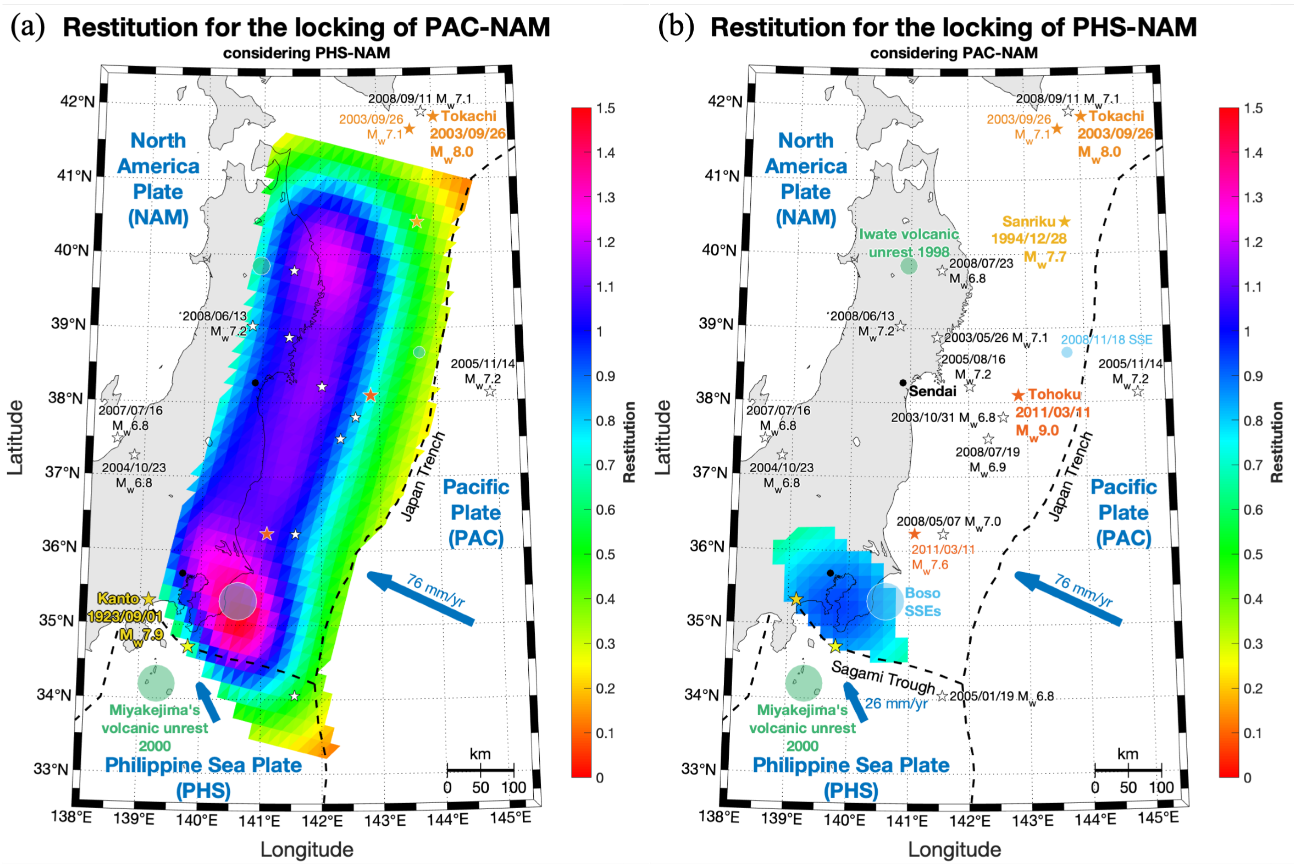

Figure S6. Restitution for the coupling of the Pacific-North America (PAC–NAM) interface (a) and the Philippine Sea-North America (PHS–NAM) interface (b). The color represent the amount of restitution of each sub-fault: 0, the slip is not restored and ~1, the slip is fully restored. Other elements are described in Figure 1.

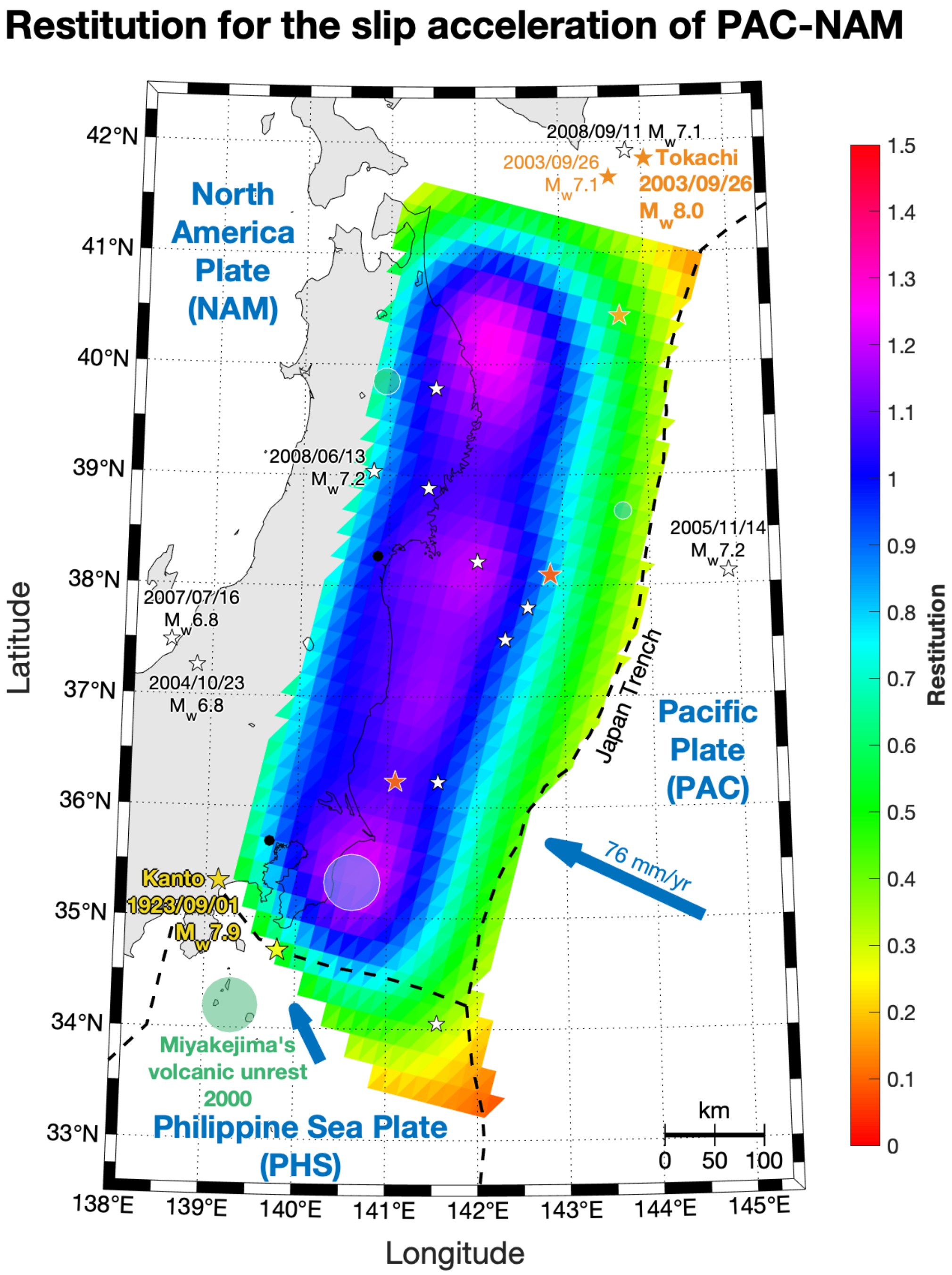

Figure S7. Restitution for the acceleration field inversion of the Pacific (PAC) plate. Same legend than Supplementary Figure S6.

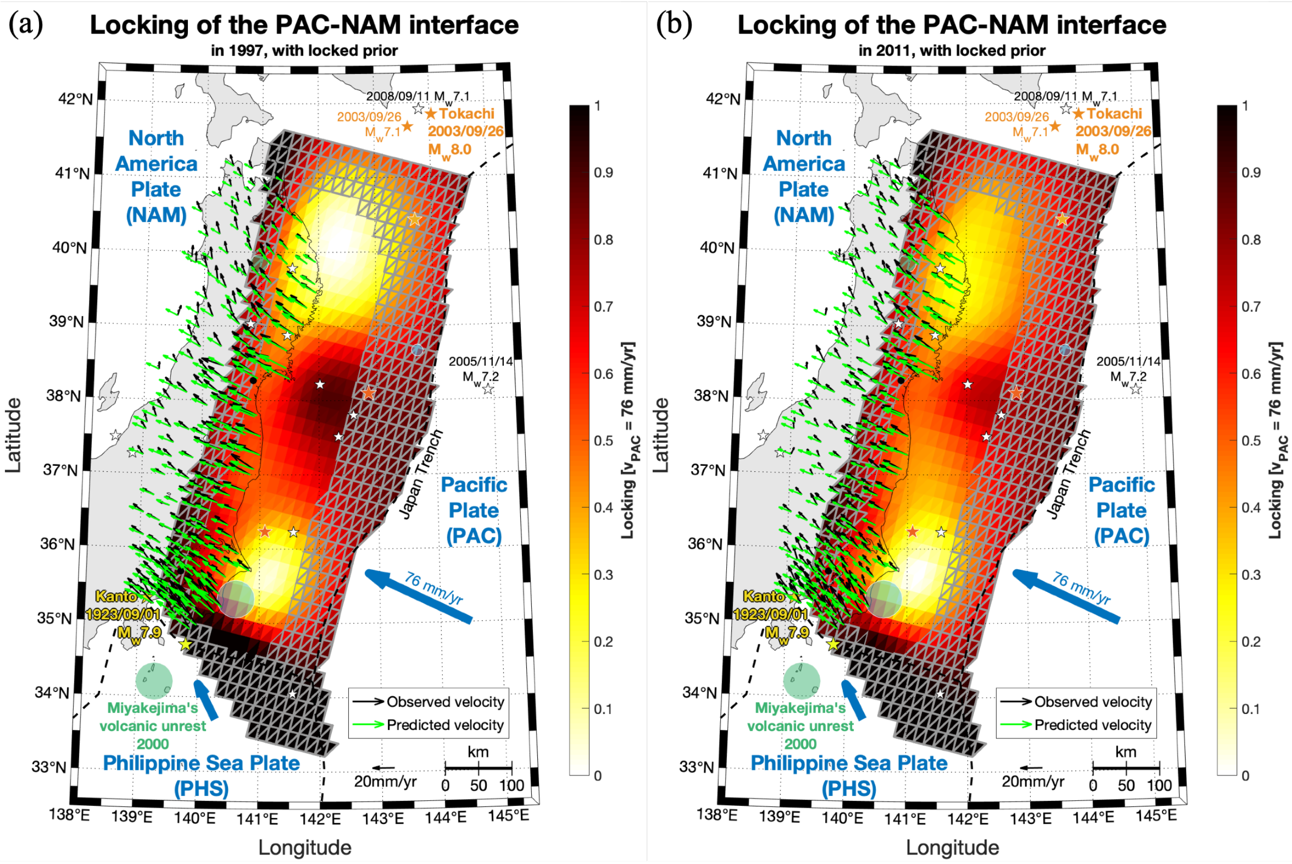

Figure S8. Locking of the Pacific-North America (PAC–NAM) subduction interface in 1997 (a) and 2011 (b) with a fully locked prior model. Same legend as Figure 4.

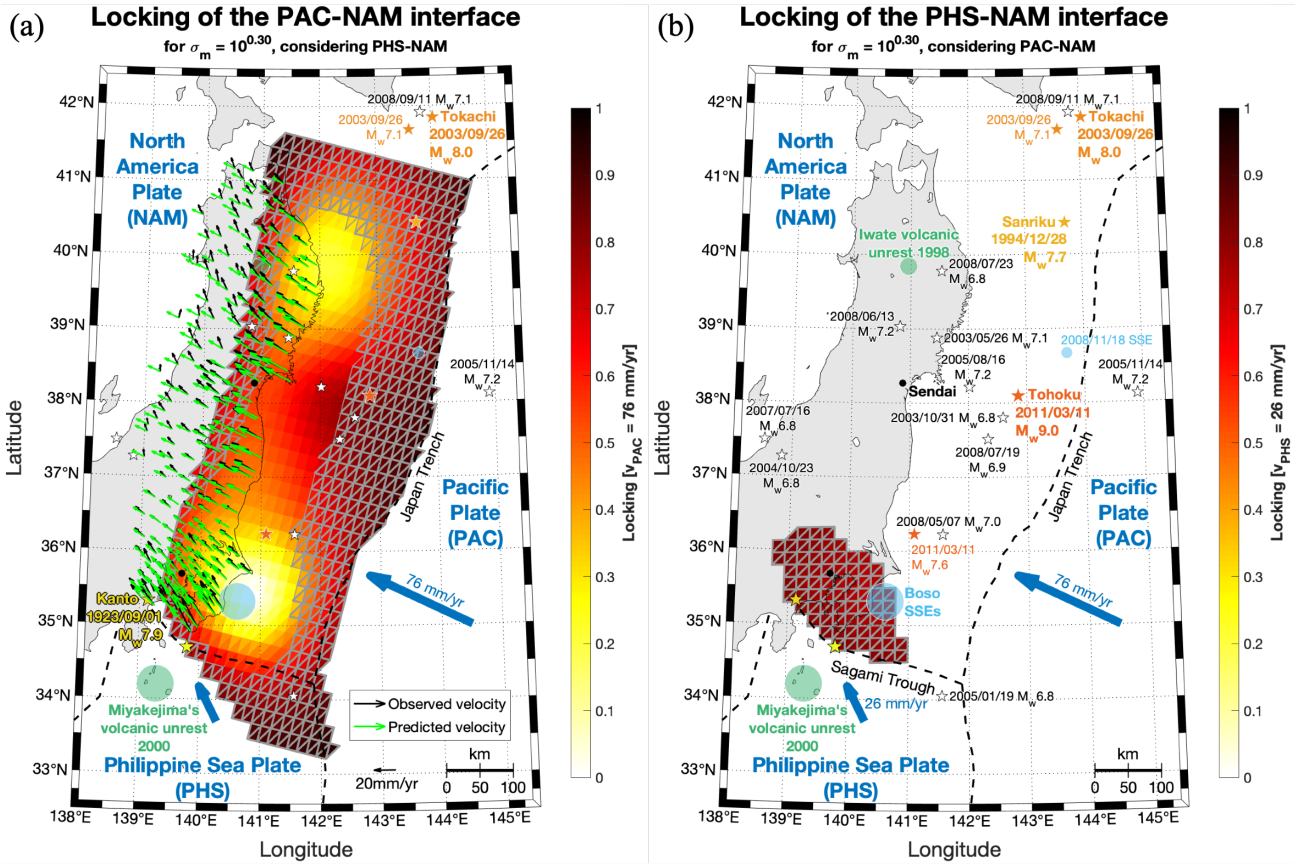

Figure S9. Locking of the Pacific-North America (PAC–NAM) subduction interface (a) and the Philippine Sea-North America (PHS–NAM) subduction interface (b) for $\sigma_m = 10^{0.30}$ with a fully locked prior model. Same legend as Figure 4.

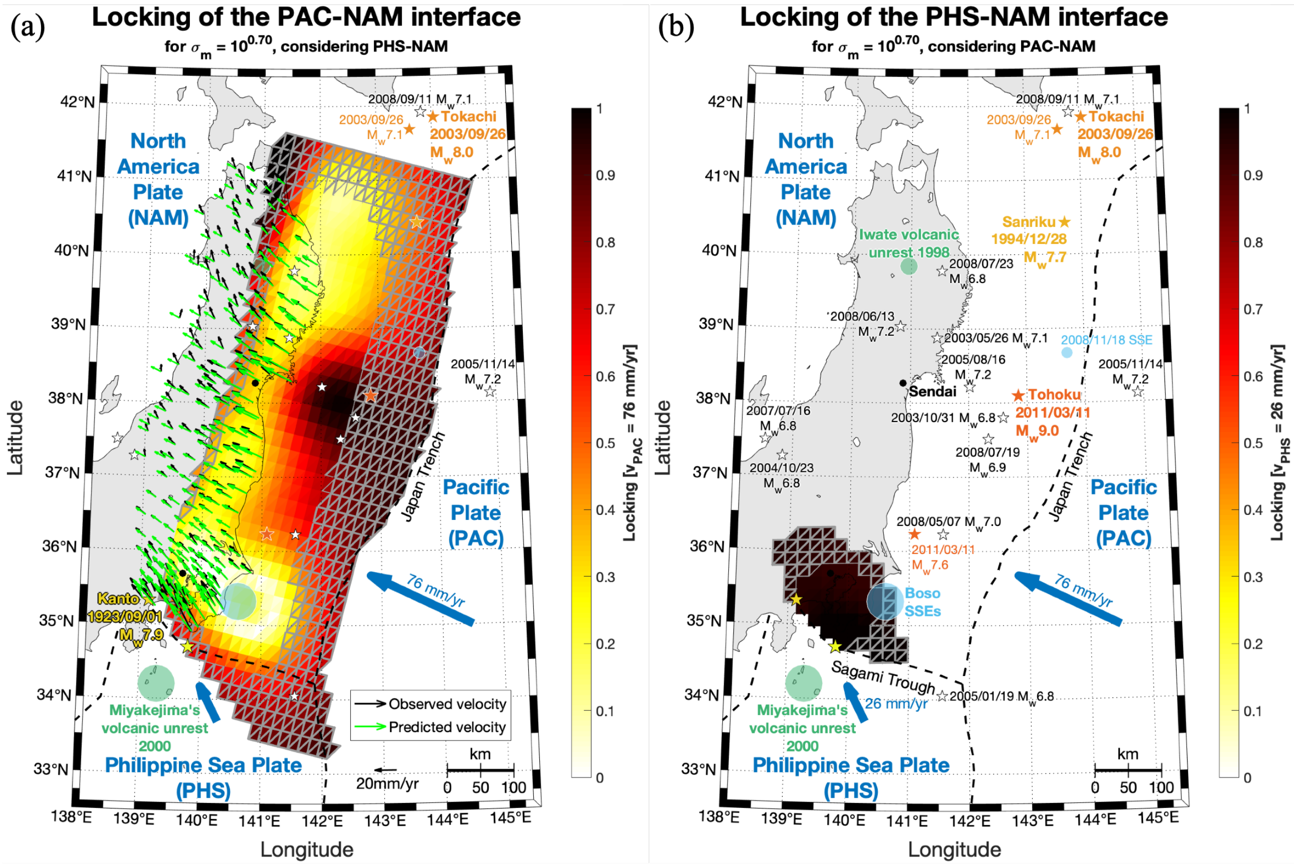

Figure S10. Locking of the Pacific-North America (PAC–NAM) subduction interface (a) and the Philippine Sea-North America (PHS–NAM) subduction interface (b) for $\sigma_m = 10^{0.70}$ with a fully locked prior model. Same legend as in Figure 4.

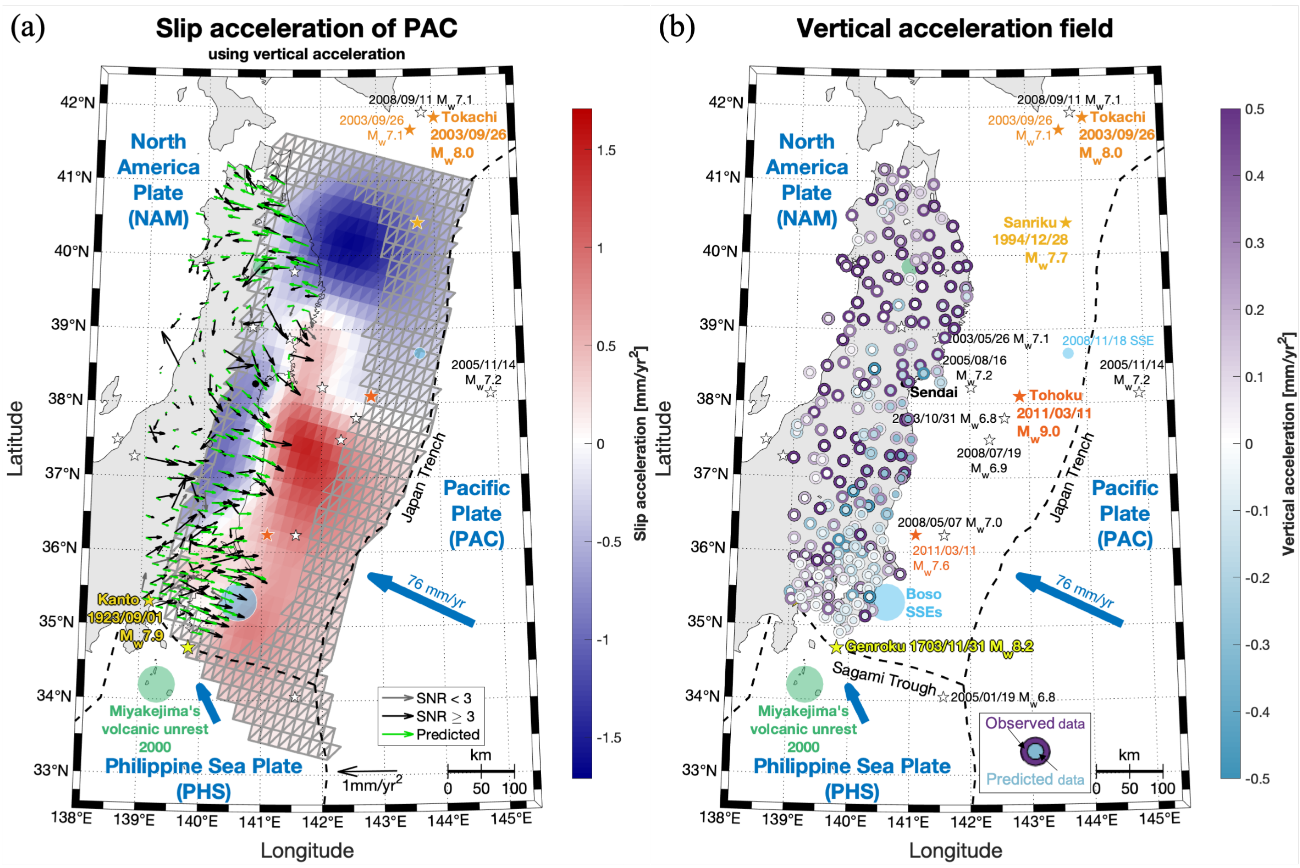

Figure S11. Slip acceleration of PAC accounting for vertical displacement. (a): Horizontal acceleration and slip acceleration; same legend as Figure 6. (b): Vertical acceleration; the outer circle represent the observed vertical acceleration while the inner circle represent the predictions. We distinguish the stations which have a signal-to-noise ratio greater than 3 (black contour), and those which fail to meet this criterion (grey contour, see Section 3.3); other elements are described in Figure 1.

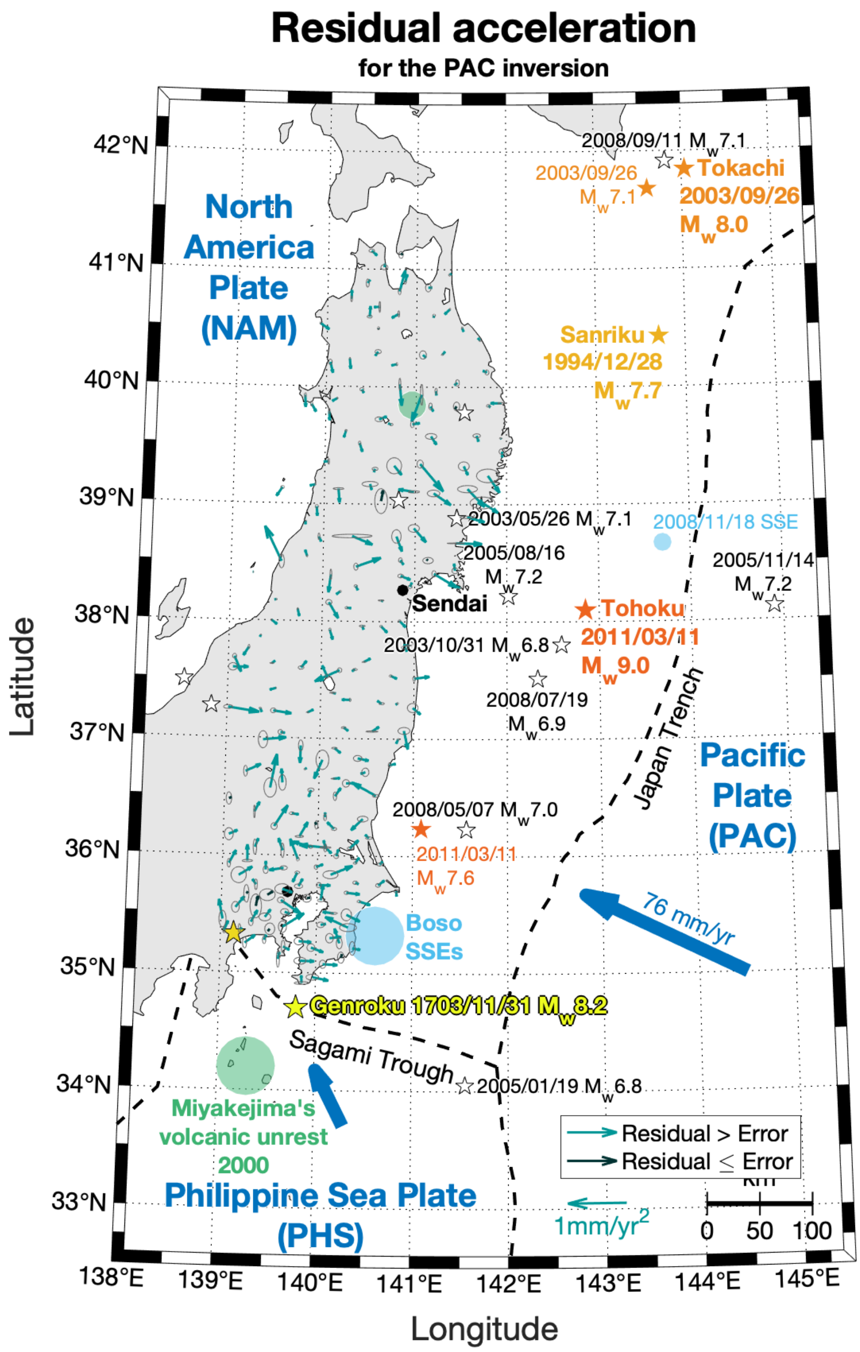

Figure S12. Residuals of the acceleration field inversion of the Pacific (PAC) plate. The error ellipse of the horizontal acceleration are shown for each station , as well as the residuals between the acceleration field (black, gray arrows in Figure 6) and the predicted surface acceleration (green arrows in Figure 6). The light arrows correspond to residuals higher than the acceleration error, and dark, to residuals small or equal to the acceleration error.

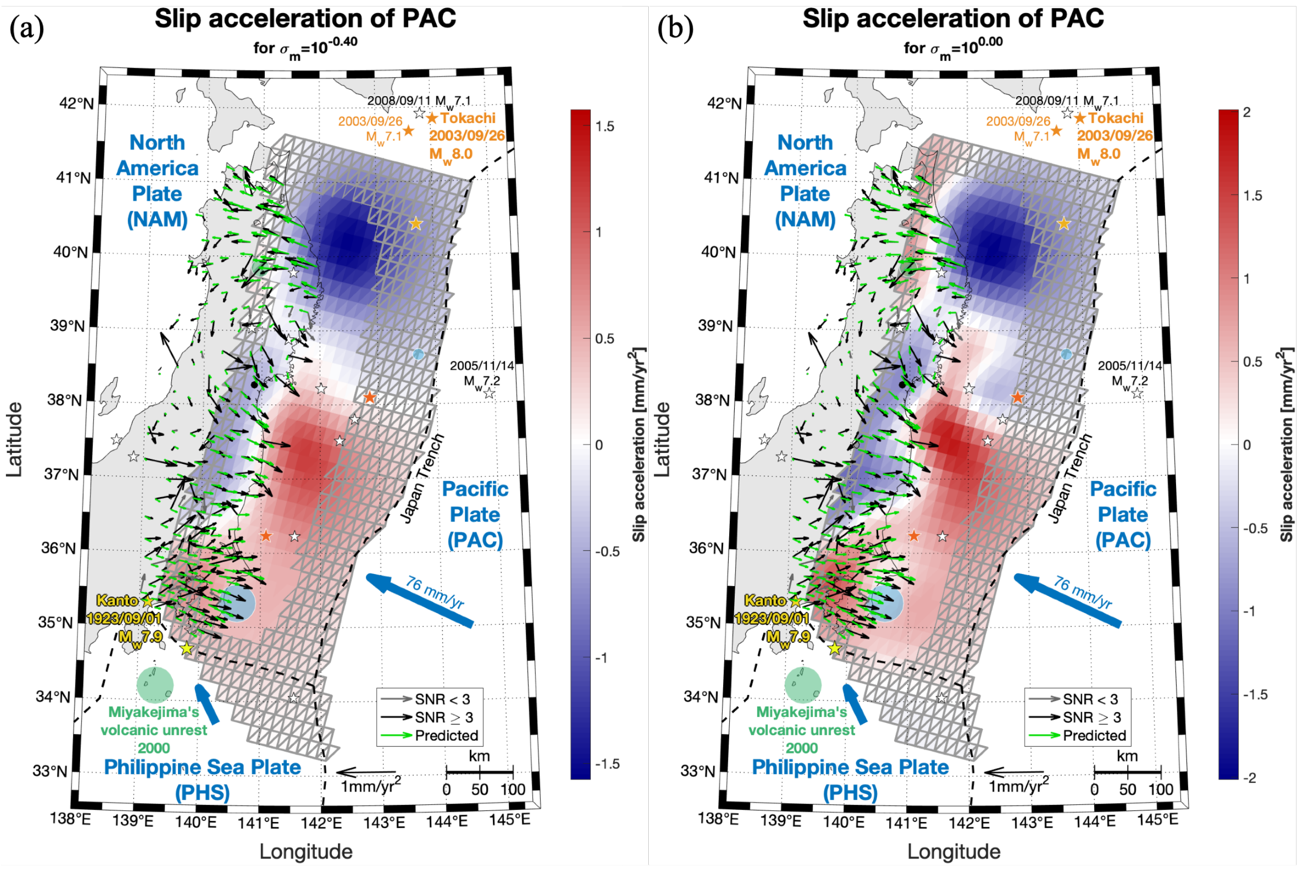

Figure S13. Slip acceleration of the Pacific (PAC) plate for $\sigma_m = 10^{-0.40}$ (a) and $\sigma_m = 10^{0.00}$ (b). Same legend as Figure 6. Note that different colorbar scales are used for the two maps.

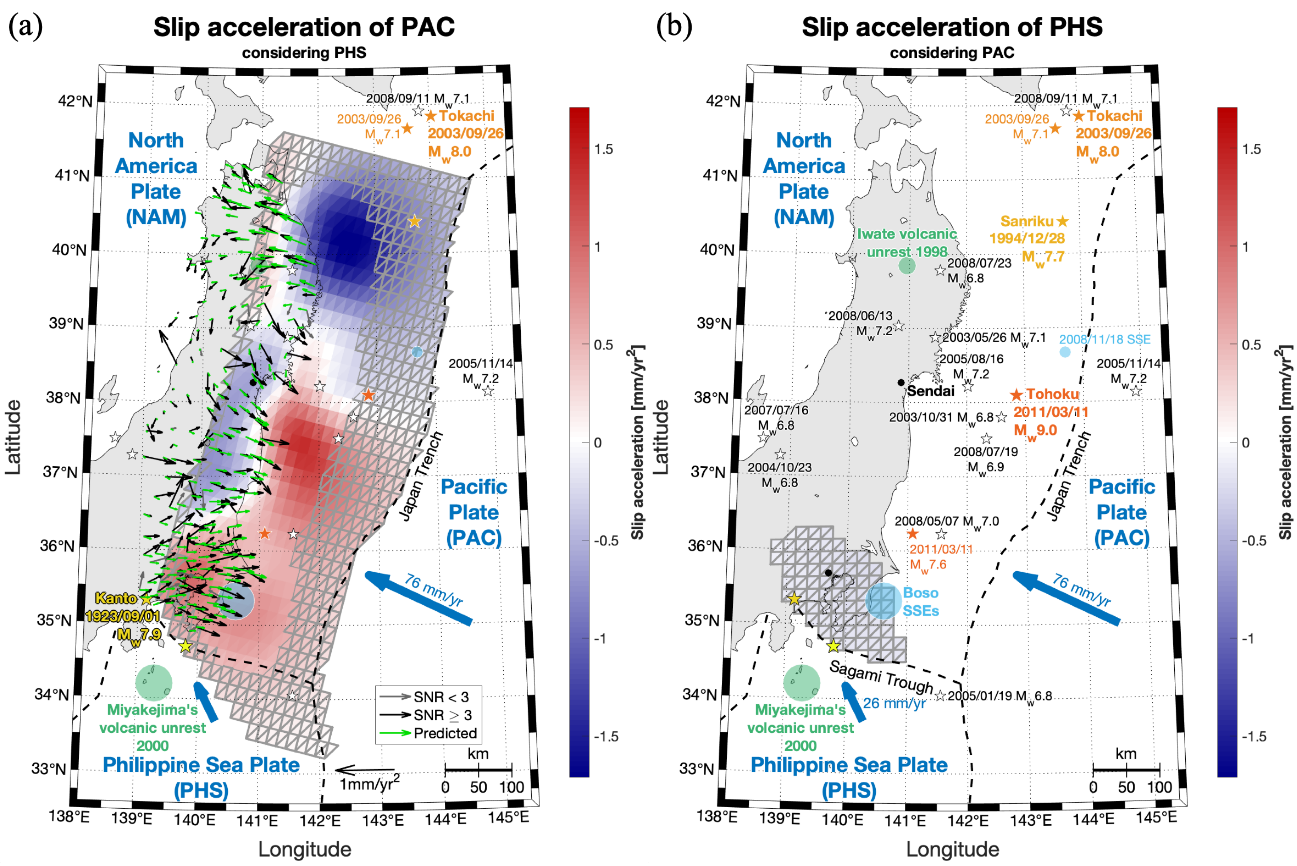

Figure S14. Slip acceleration of the Pacific (PAC) plate (a) and the Philippine Sea (PHS) plate (b) for the 2-plate inversion. Same legend as Figure 6.

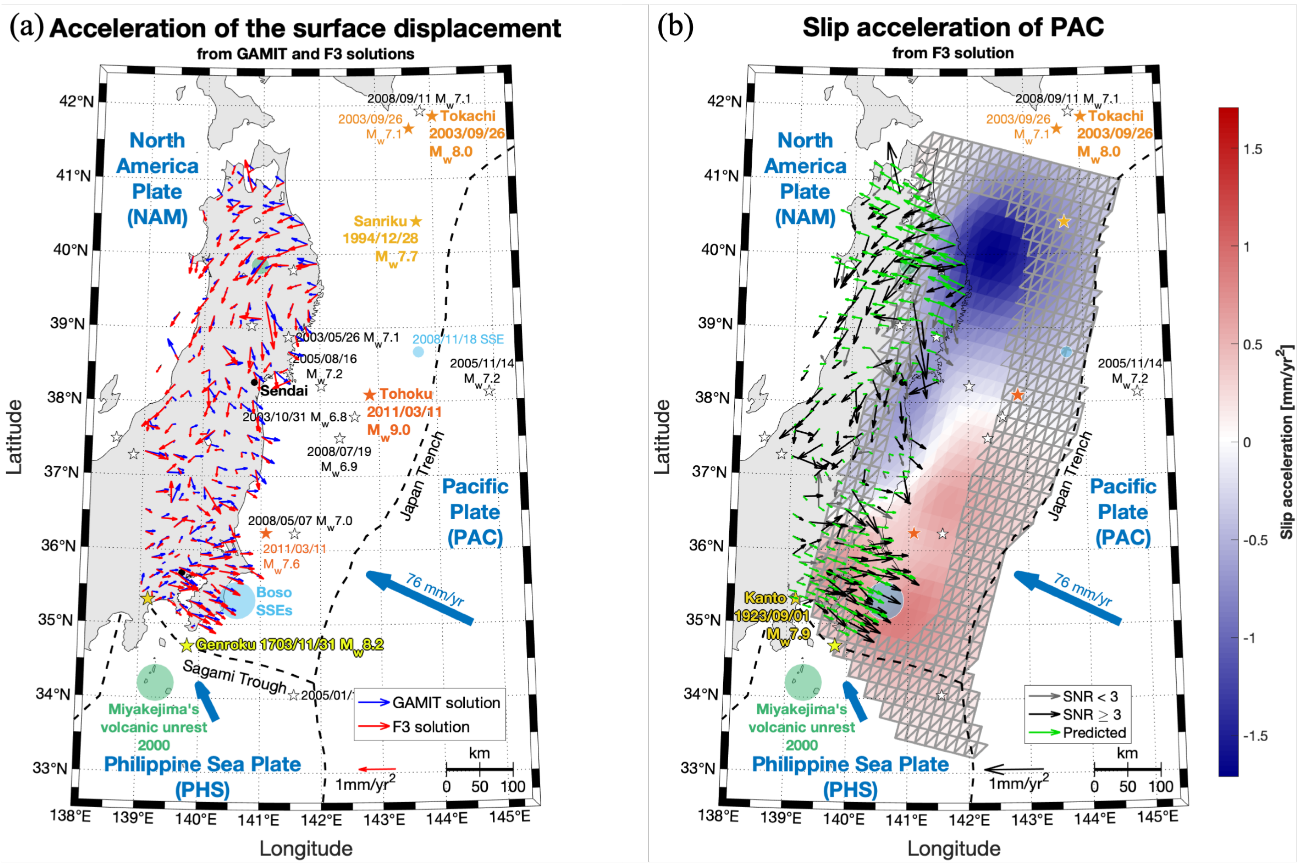

Figure S15. Acceleration fields from GAMIT and F3 solution (a) and slip acceleration of the Pacific (PAC) plate from the F3 solution (b). (a): The blue arrows represent the acceleration field from GAMIT solution and the red arrows represent the acceleration field from F3 solution; other elements are described in Figure 1. (b): Same legend than Figure 6.

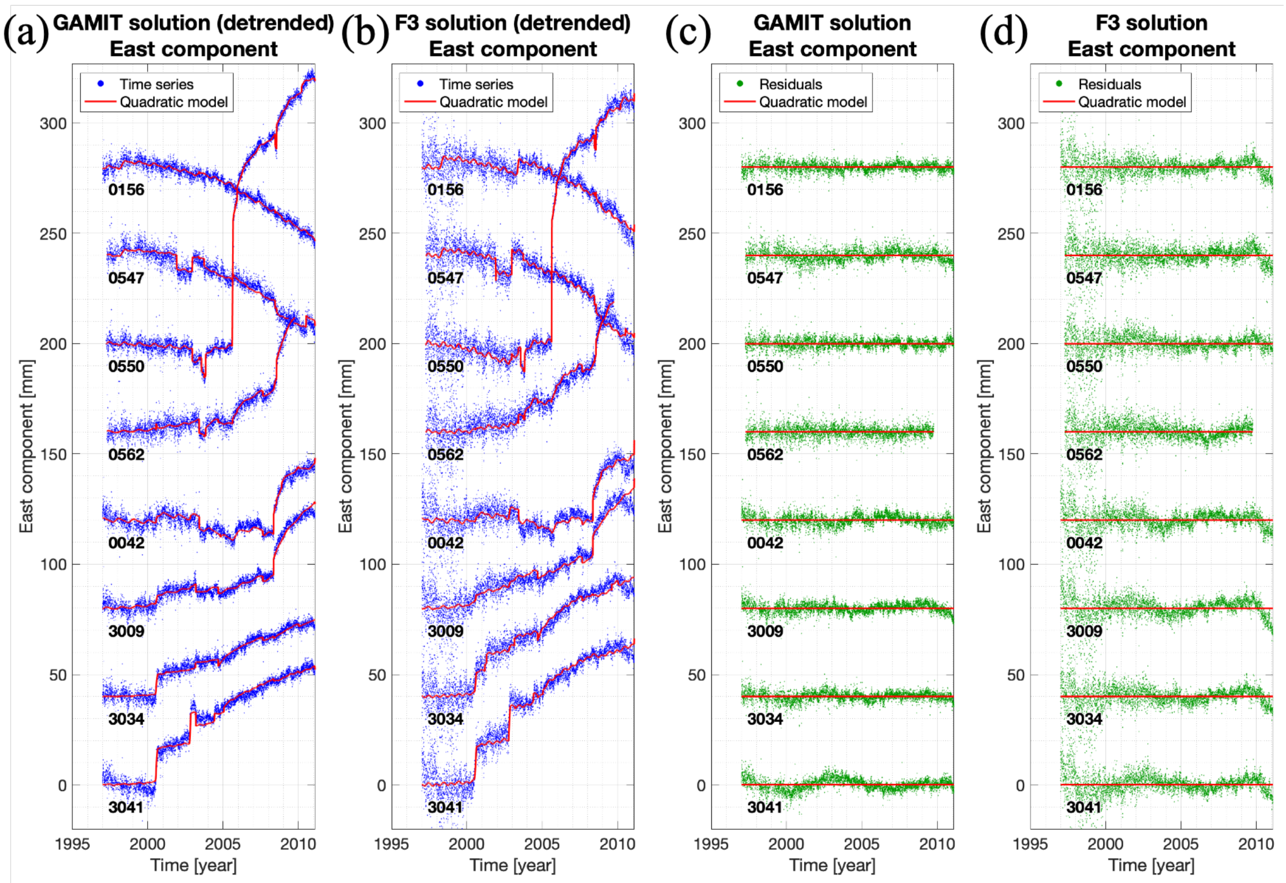

Figure S16. Detrended time series and residuals from GAMIT solution (a, c), and F3 solution (b, d) for the station shown in Figure 1. (a, c): The blue dots represent the time series and the red line represents our quadratic trajectory model. (b, d): The green dots represent the residuals from the quadratic model.

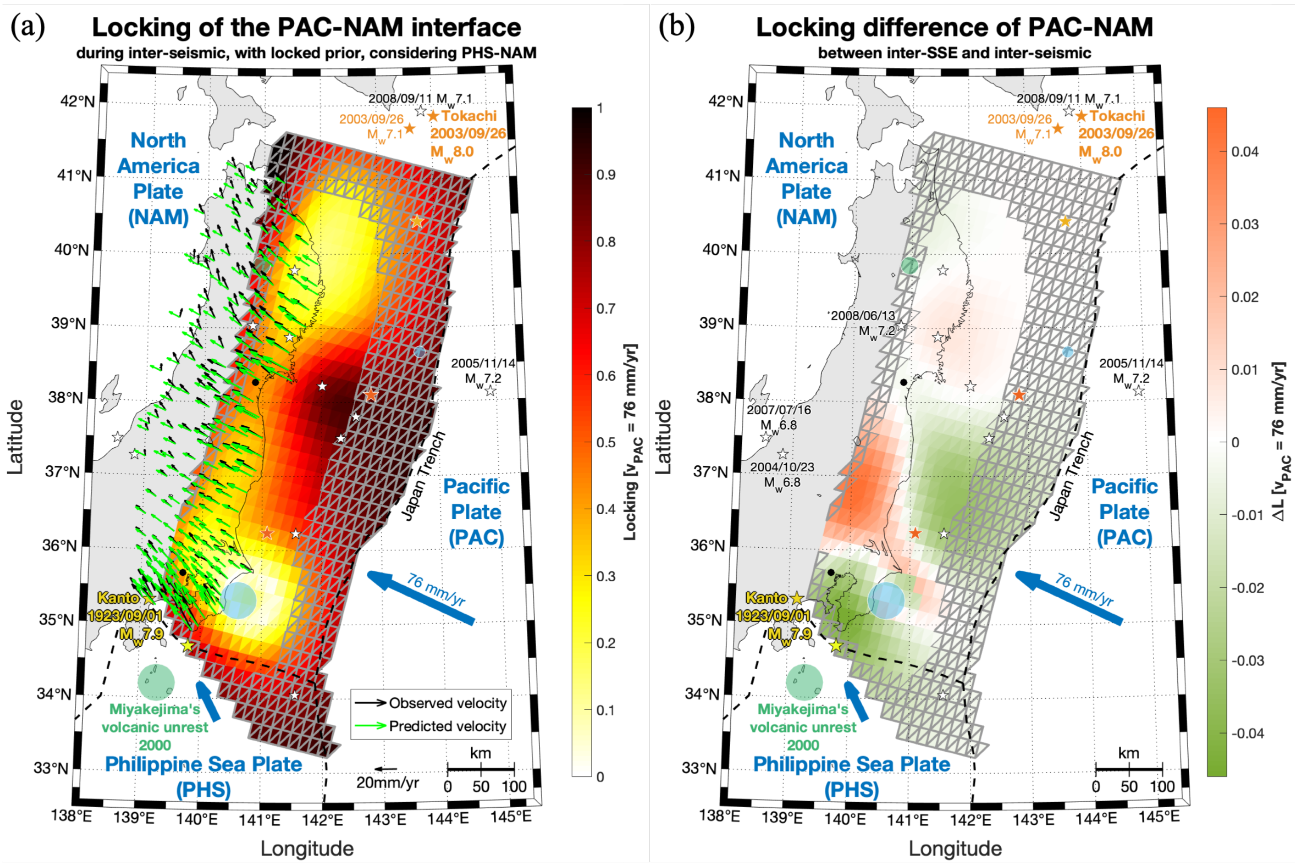

Figure S17. Impact of the SSEs (Boso and Tohoku SSEs) modelling on the Pacific-North America (PAC–NAM) subduction interface locking. (a): Inter-seismic locking (for time series analysis without SSE modeling) with a fully locked prior model; same legend as Figure 4. (b): Locking difference between inter-SSE locking (Figure 4a) and inter-seismic locking (a); orange: sub-fault more locked with the SSEs modeled; green: sub-fault less locked with the SSEs modeled; other elements are described in Figure 1.

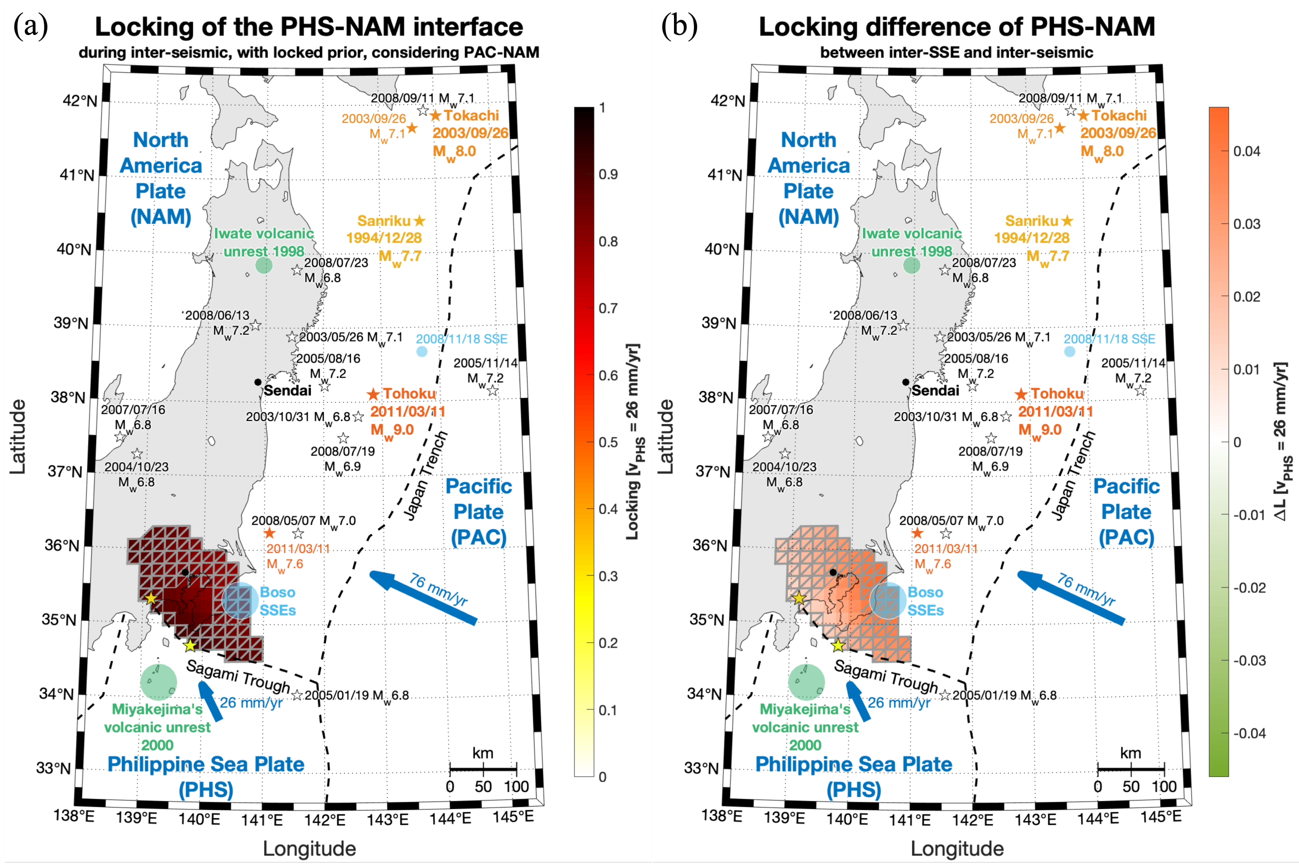

Figure S18. Impact of the SSEs (Boso and Tohoku SSEs) modelling on the Philippine Sea-North America (PHS–NAM) subduction interface locking. (a): Inter-seismic locking (for time series analysis without SSE modeling) with a fully locked prior model. (b): Locking difference between inter-SSE locking (Figure 4b) and inter-seismic locking (a). Same legend as Figure S17.

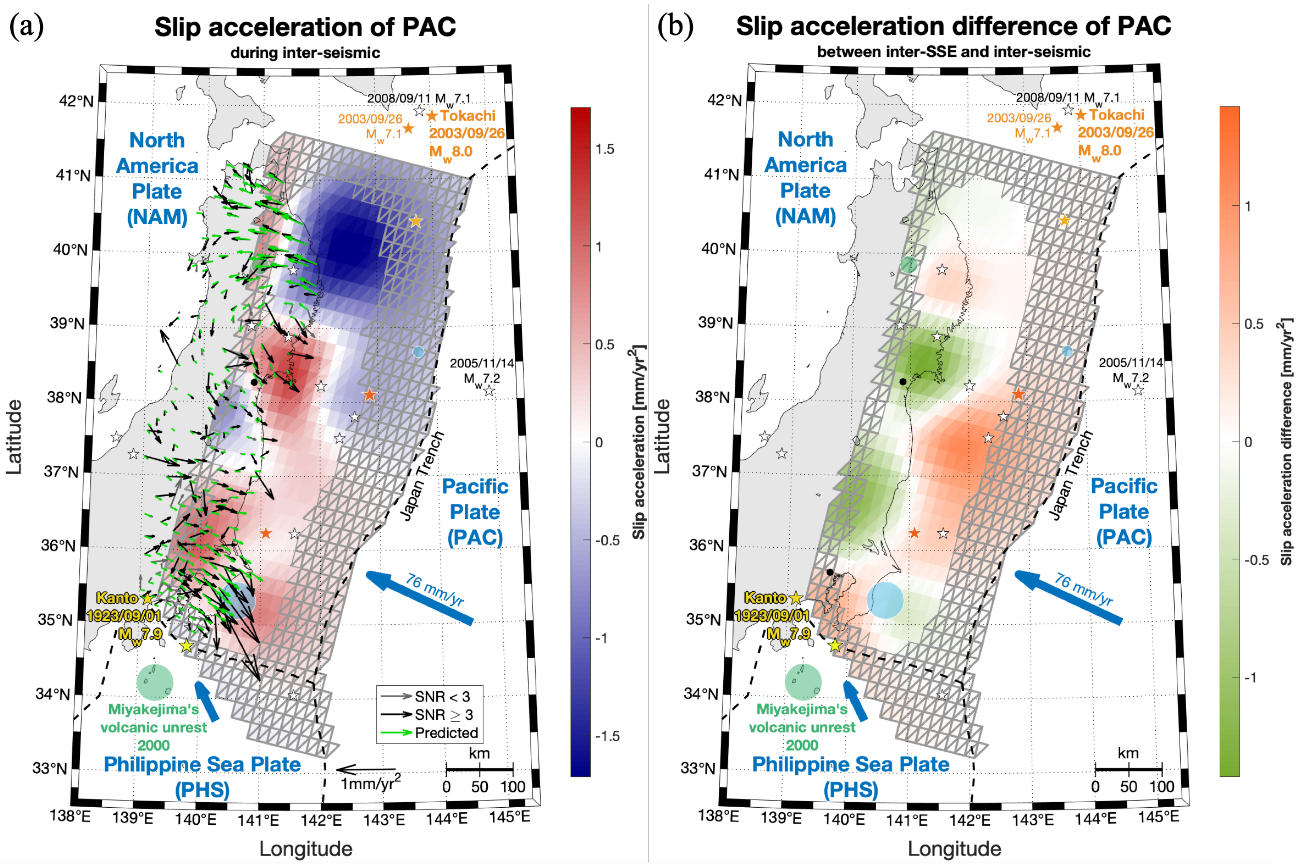

Figure S19. Impact of the SSEs (Boso and Tohoku SSEs) modelling on the Pacific (PAC) plate slip acceleration. (a): Inter-seismic slip acceleration (using time series for which the SSEs were not removed); same legend as Figure 6. (b) Slip acceleration difference between inter-SSE slip acceleration (Figure 6) and inter-seismic slip acceleration (a).

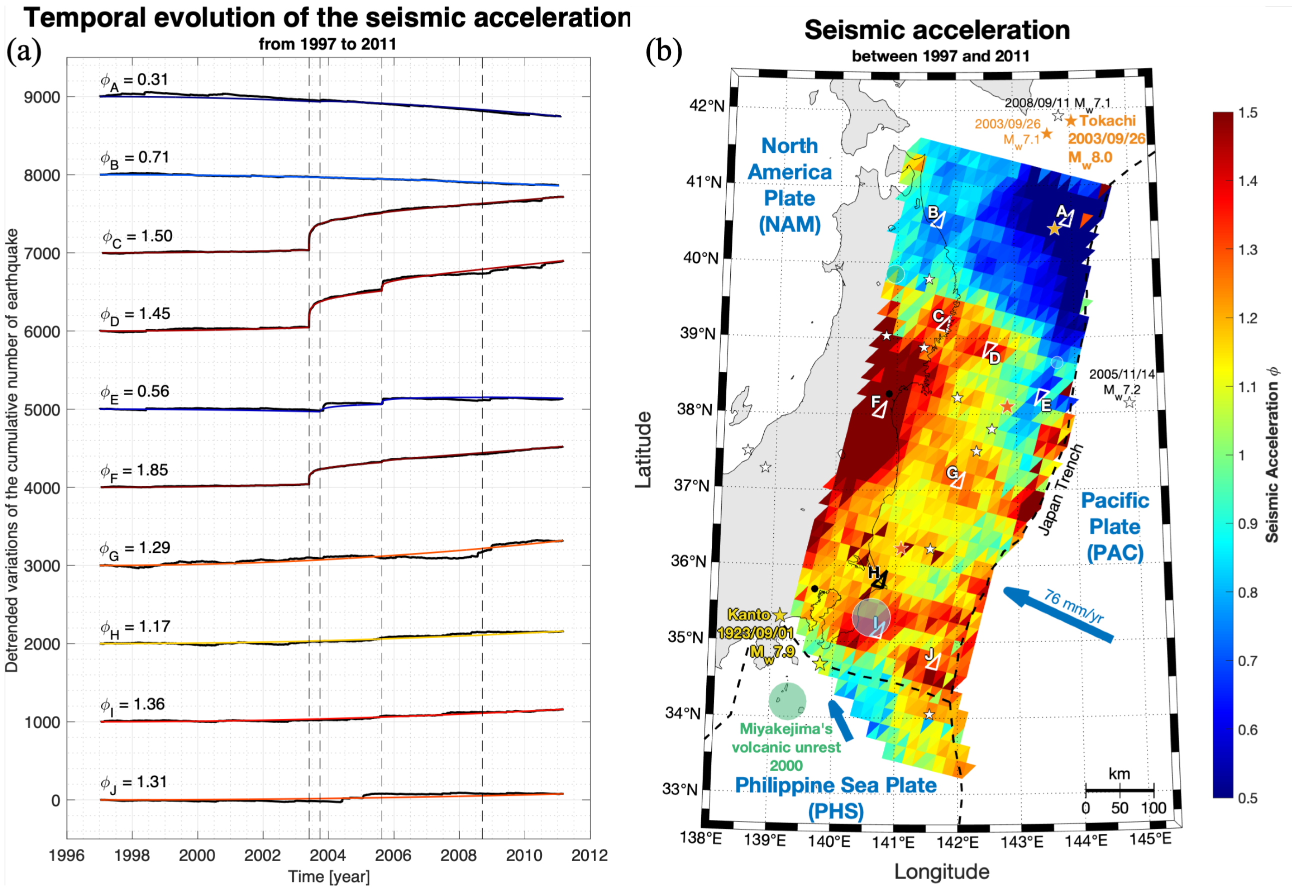

Figure S20. Temporal evolution of the seismic acceleration from January 1997 to March 2011. (a): The black lines represent the detrended variation of the cumulative number of earthquake seen by 10 patches (A to J), and the associated model. The color of the models corresponds to the associated ϕ value following (b)'s colorbar. The dotted lines represent the M 7+ occurrences. (b): Localisation of the 10 patches (A to J). The black H patch correspond to the Figure 8 patch. Same legend as Figure 7a.

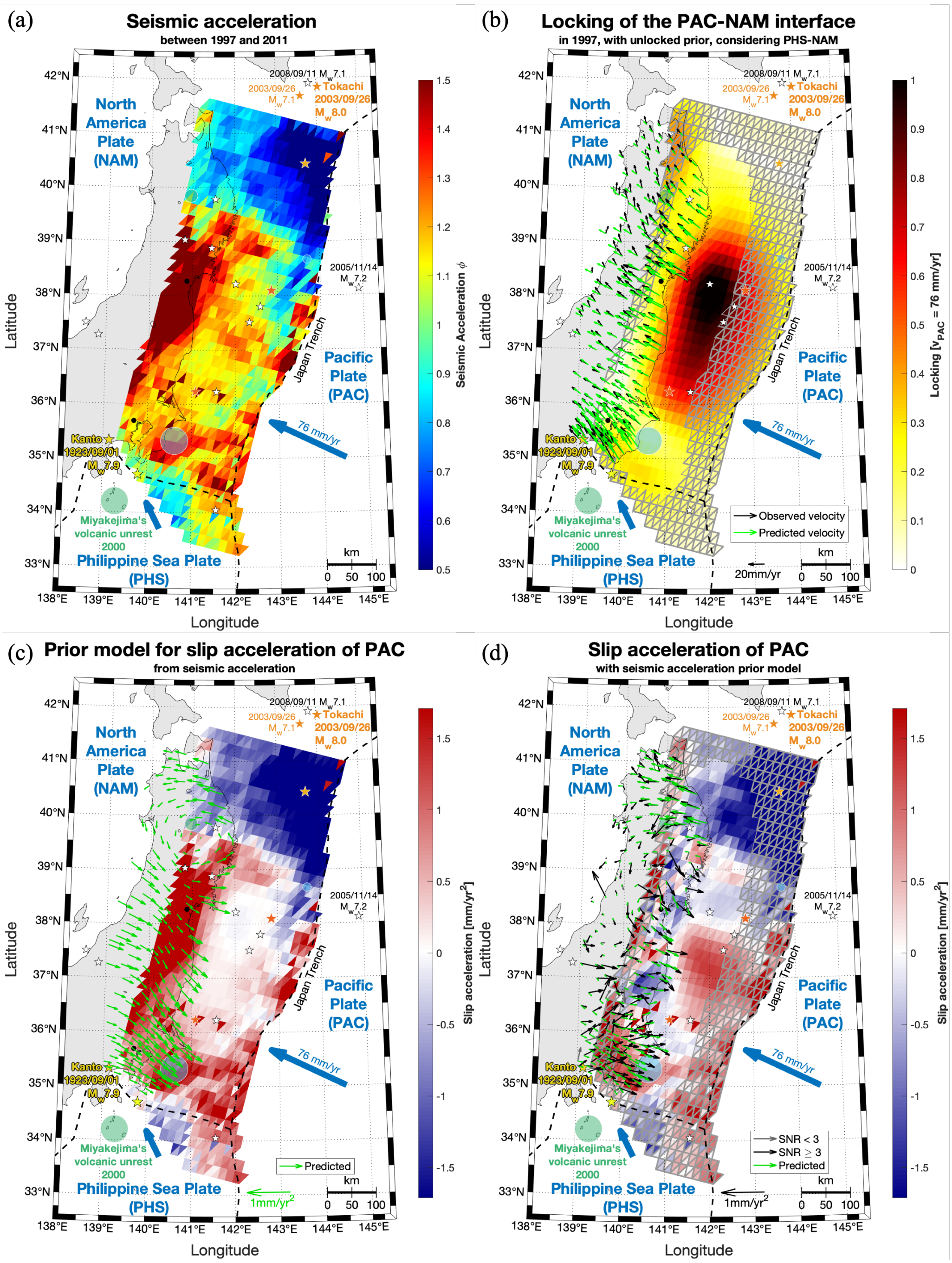

Figure S21. Seismic acceleration on the Pacific (PAC) plate between 1997 and 2011 as slip rate acceleration prior. (a): Seismic acceleration of the Pacific (PAC) plate between 1997 and 2011. (b) Locking of the Pacific-North America (PAC–NAM) interface in 1997 with a fully unlocked prior model. (c): Prior slip acceleration model of the PAC plate based on the seismic acceleration (a) and the locking (b) with Equation (18). (d): Slip acceleration of the PAC plate. Same legend as Figure 7.