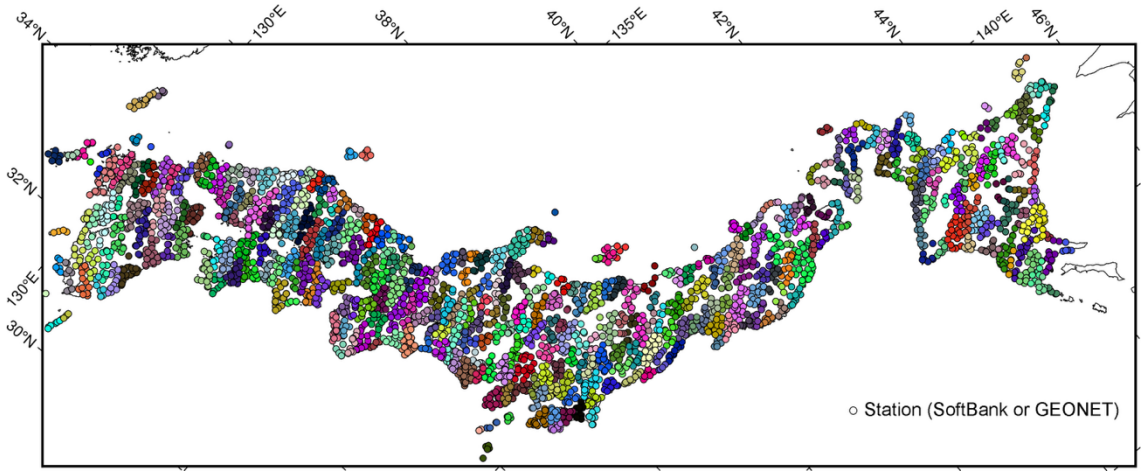
Supplementary Figures



FigureS1

Station clustering used for spatial cross-validation and regional summaries. Circles show GNSS stations; colors denote distinct clusters. (Methodological details follow the main text; colors are categorical and carry no ordinal meaning.)

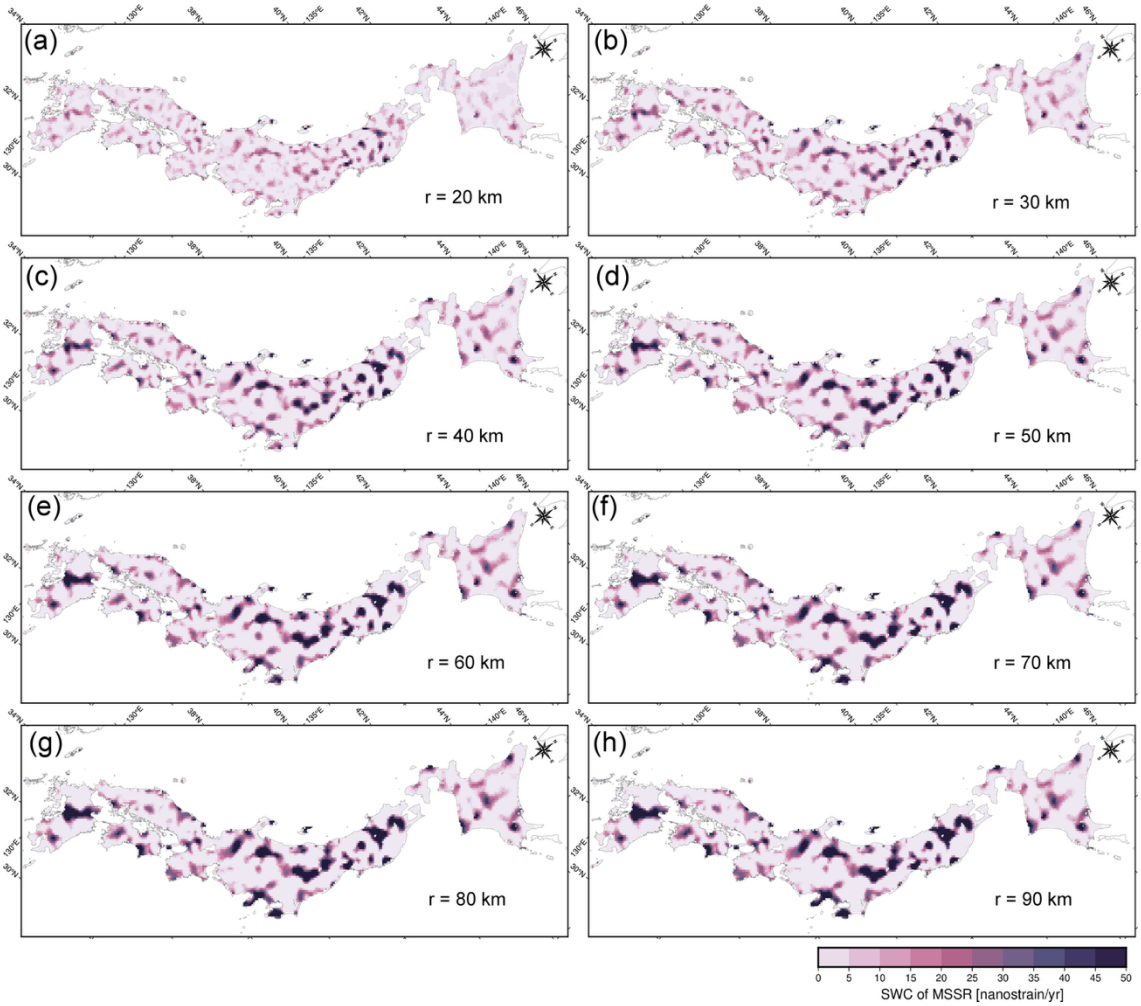
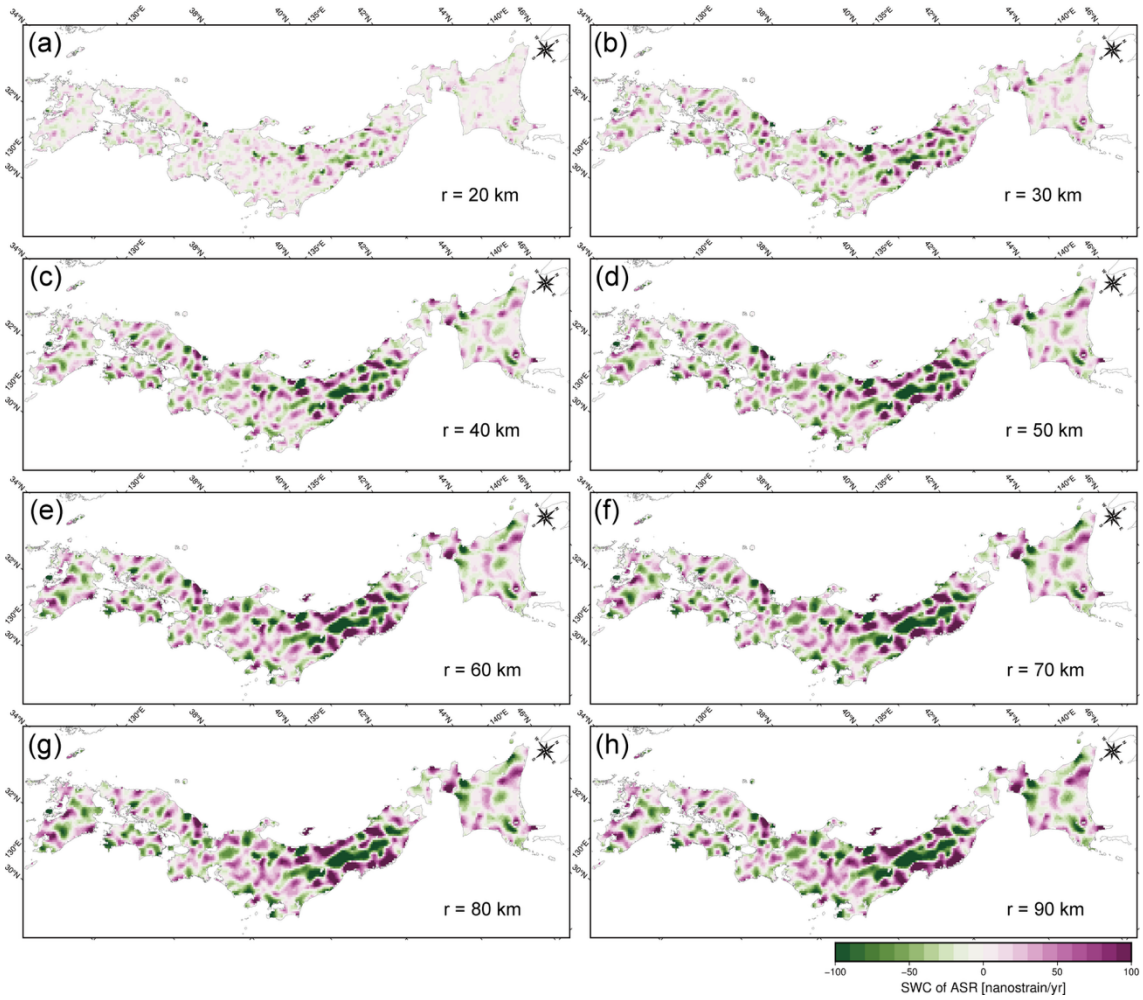


Figure S2

Short-wavelength component of the maximum shear strain rate (MSSR) for varying long-wavelength cutoffs. Panels (a)–(h) correspond to low-pass radii r= 20, 30, 40, 50, 60, 70, 80, and 90 km, respectively. The short-wavelength component is defined as Total − LWC, where the long-wavelength component (LWC) is obtained by a 2-D circular top-hat moving average of radius *r*. Units are nanostrain/yr; the color scale is fixed across panels for comparison.



FigureS3

Short-wavelength component of the areal (dilatational) strain rate (ASR) for varying long-wavelength cutoffs. Panels (a)–(h) correspond to r= 20–90 km as in Figure S2. The short-wavelength definition and filtering are identical to Figure S2. Units are nanostrain/yr; the color scale is fixed across panels.

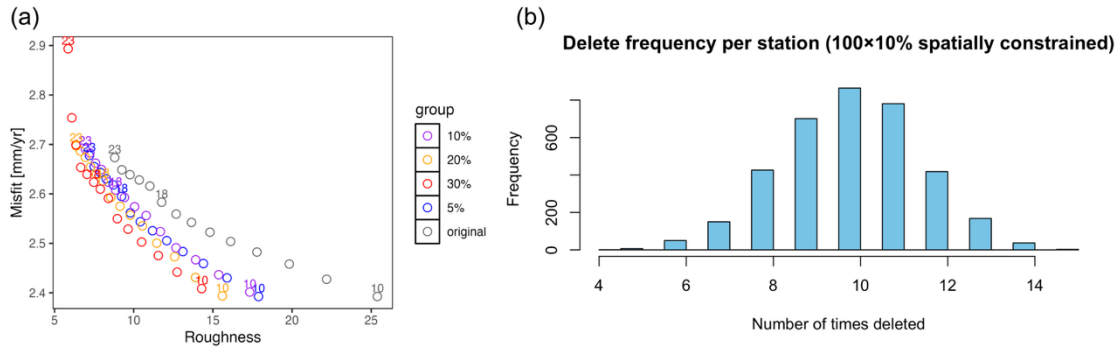


Figure S4

Diagnostics for the resampling (random decimation) analysis. (a) L-curves at all stations for the original network (gray; 3,606 stations) and for cases with 5%, 10%, 20%, and 30% station removal (blue, purple, orange, red, respectively). (b) Histogram of the inclusion count for each station across 100 resampled sets (bin width = 1).

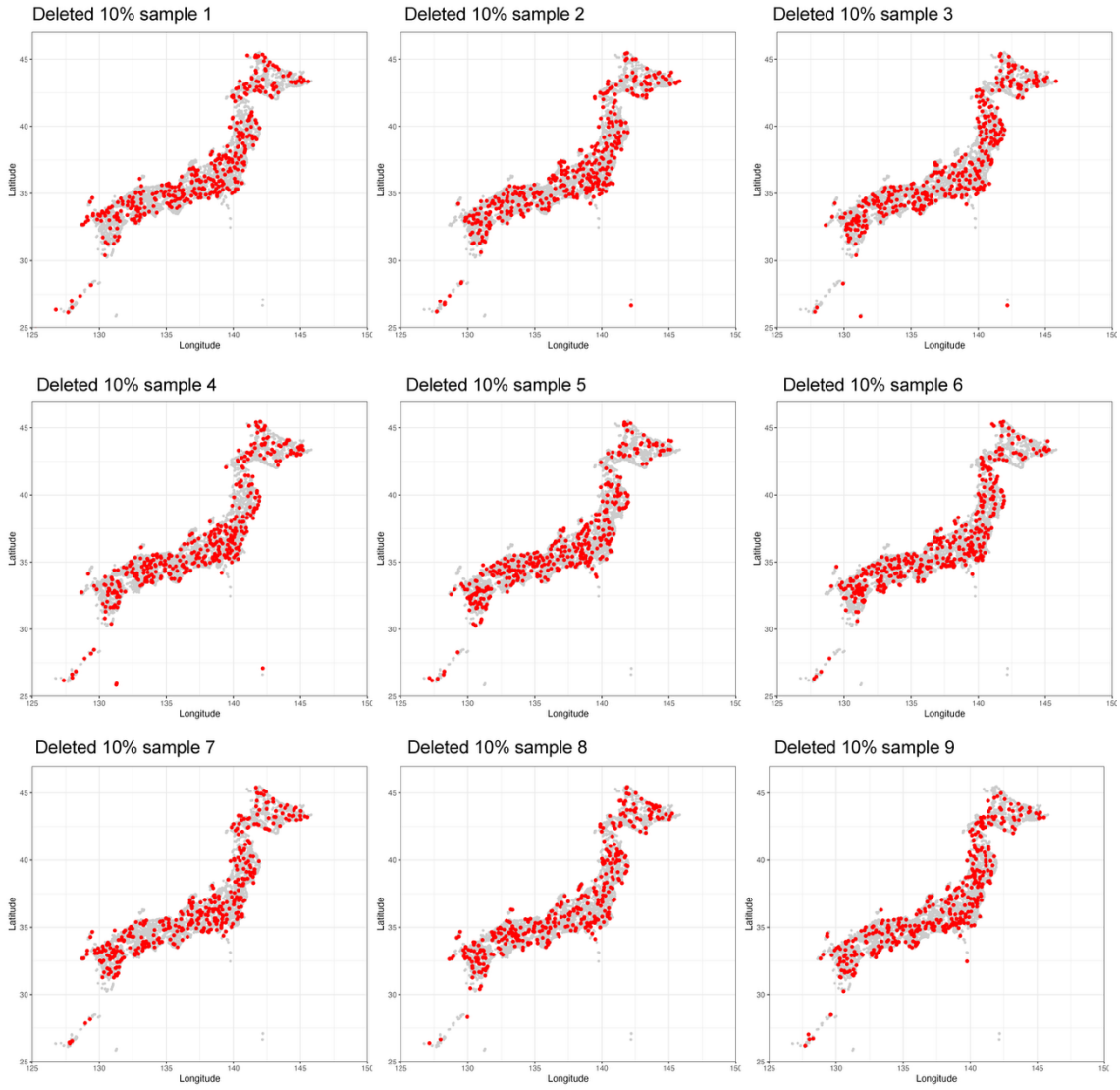


Figure S5

Examples of resampled station subsets (nine cases). Red dots indicate excluded stations; gray dots indicate stations retained for the corresponding estimation.

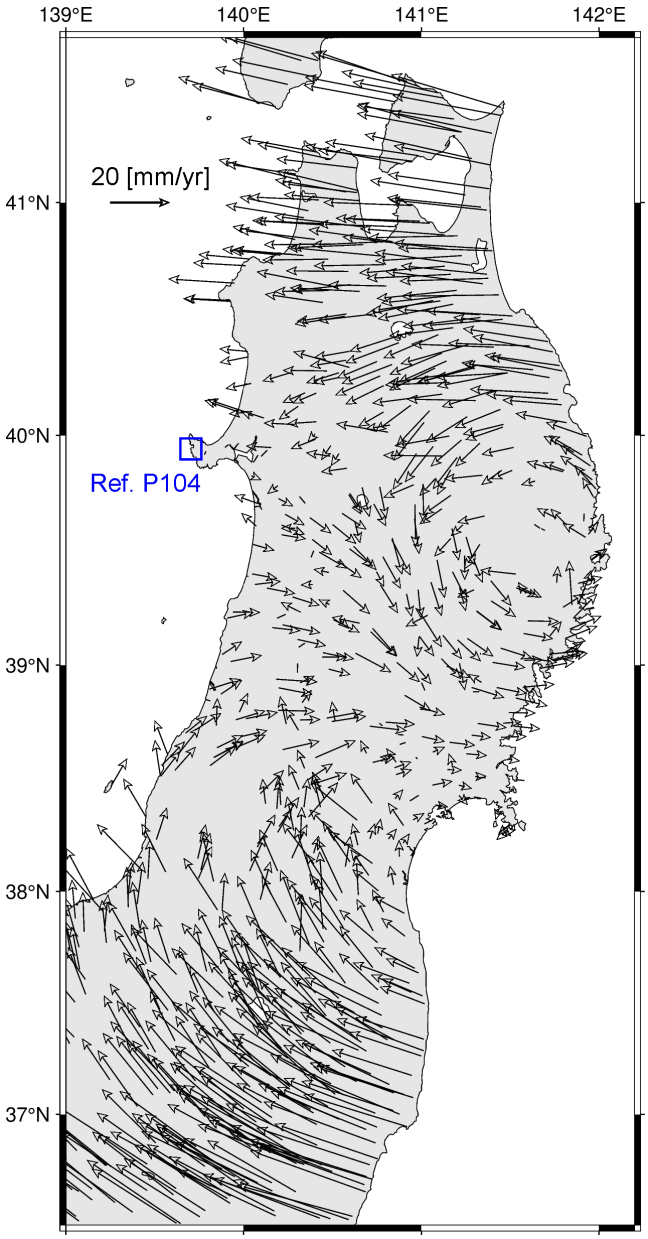


Figure S6

Horizontal velocity field (November 1, 2019, to December 31, 2023) in the Tohoku region relative to the Oga Peninsula reference. Arrows denote velocities; the scale bar is shown in the panel. This reference is used only for visualization and does not affect the strain-rate inversion.

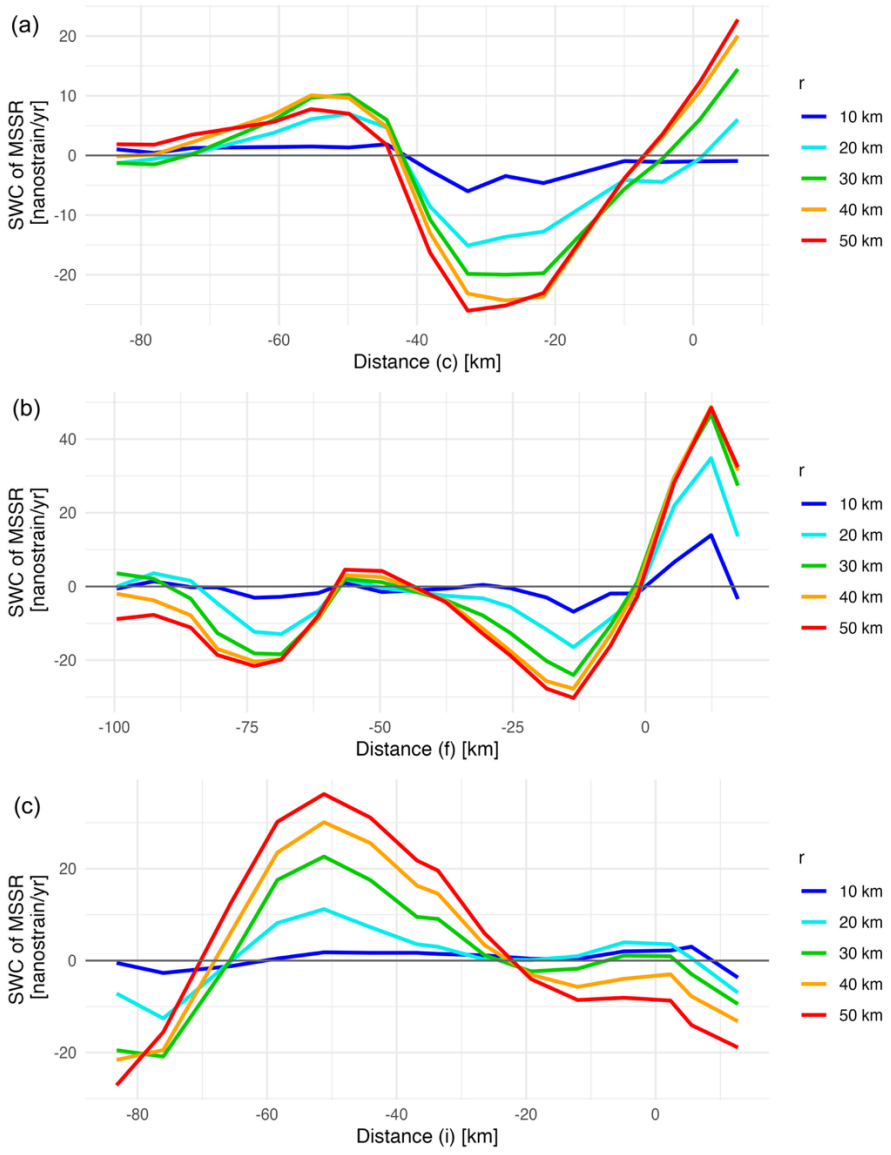
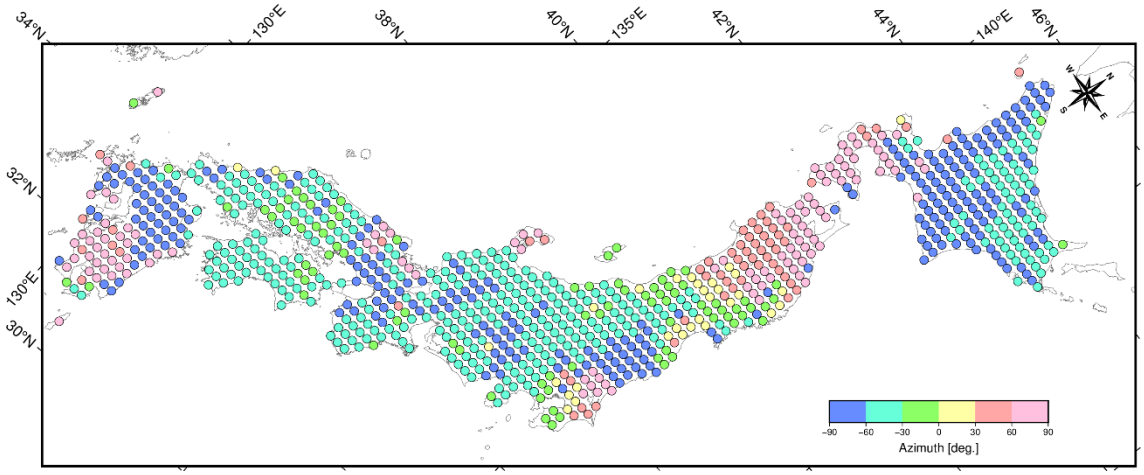


Figure S7

Profiles of short-wavelength components along selected transects, shown for multiple long-wavelength cutoffs. Panels (a), (b), and (c) correspond to profiles along transects (c), (f), and (i) in Figure 16 of the main text, respectively. Each profile is repeated for several r values (see legend) to illustrate sensitivity to the long-wavelength cutoff.



FigureS8

Principal strain azimuths of principal axes. Colors show the azimuth of principal strain

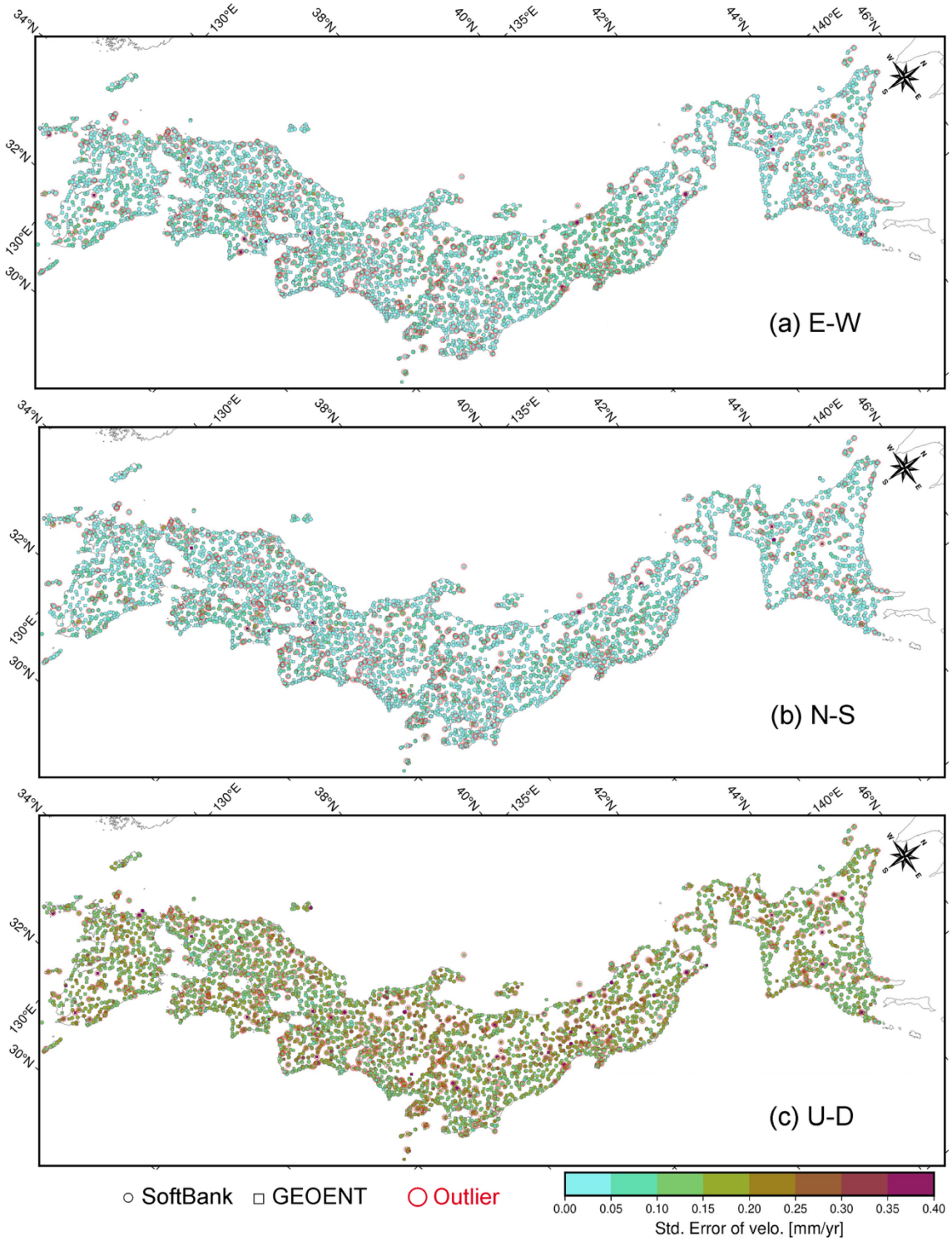


Figure S9

Estimated velocity uncertainties and outlier screening. Circles and squares mark SoftBank and GEONET stations, respectively. Red circles indicate outliers removed before strain-rate estimation; remaining stations were used in the inversion. Error symbols denote 1-σ uncertainties. (a) E-W components. (b)N-S components. (c)U-D components.

Guidelines for Data Availability

All gridded strain-rate fields over land areas (MSSR, ASR, PSR, and D) are provided in the Supplementary Material. For the complete set of estimation results, please contact the authors.

- emax_emin_azi.xyz

The columns are arranged as follows:
latitude longitude emax [nanostrain/yr] emin [nanostrain/yr] azi [deg.]
This file contains the estimated results on a 0.2° grid and corresponds to Fig. 6e. The data can be plotted using the "velo" command in GMT 6.6 (Wessel et al., 2025) with the "-Sx" optional argument.
Example:

gmt velo filename -Sx0.003 -W2p,0 -A10p+a40+e -G255

* The values shown in gray can be specified by the user.

- shear_areal_d.xyz

The columns are arranged as follows:
longitude latitude shear [nanostrain/yr] areal [nanostrain/yr] D [km]
This file contains the estimated results on a 0.05° grid and corresponds to Figs. 6a and 6b and Fig. 4c. We recommend converting the data into grids using the "xyz2grd" command in GMT 6.6 (Wessel et al., 2025) before plotting.
Example:

gmt xyz2grd input_filename -R125/150/25/47 -I0.05 -Goutput_filename

* The values shown in gray can be specified by the user.

Citation:

Wessel, P., Luis, J. F., Uieda, L., Scharroo, R., Wobbe, F., Smith, W. H. F., Tian, D., Jones, M., Esteban, F., & Fröhlich, Y. (2025). The Generic Mapping Tools version 6.6.0 (6.6.0). Zenodo. https://doi.org/10.5281/zenodo.16448627