Digital data of crustal stress map and focal mechanism solutions of microearthquakes for inland areas of Japan

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1. Abstract

Geological Survey of Japan, AIST has developed the crustal stress field of Japan islands based on the focal mechanism solutions of microearthquakes (Imanishi, 2014; Imanishi *et al.*, 2019, 2021). Recently, we developed a method to determine focal mechanism solutions of massive microearthquakes using the deep learning technique for picking P-wave first-motion polarities (Uchide, 2020). We estimated the focal mechanism solutions of microearthquakes at depths of less than 20 km around Japan islands and then obtained the crustal stress field (Uchide *et al.*, 2022). This Open-File Report includes the digital data of the crustal stress field (Figure 1) and the focal mechanism solutions (Figure 2) derived by Uchide *et al.* (2022). See the detail in Uchide *et al.* (2022).

2. Data in this Open File

2.1. Stress Map Data at 0.2-degree Mesh

The digital data file of the stress map is `data/stress_0.2.deg_Japan_Uchide2022.txt`. This is the result of the stress inversion performed by Uchide *et al.* (2022). This file contains the stress information with a circular standard deviation (CSD) of the azimuths of the maximum horizontal compressional stress (S_{Hmax}) of less than 15 degrees.

(Updated in August 2023) The stress inversion to derive this stress data constrained the stress orientations and the stress ratios, but the absolute stress values. The deviatoric stress was set to zero, as the stress inversion cannot estimate it.

The format of the data is as follows:

- Column 1: Longitude [degree]
- Column 2: Latitude [degree]
- Column 3: Always 0.0
- Column 4: Always 0.0
- Column 5: ~~Normalized~~ Relative magnitude of the maximum horizontal compressional stress (S_{Hmax})

- (Updated in August 2023) We replaced 'normalized' with 'relative,' as the word 'normalized' is confusing. Note that this value does not indicate the absolute value of the stress.

- Column 6: Standard deviation of magnitude of the maximum horizontal compressional stress (S_{Hmax})
- Column 7: Azimuth of the maximum horizontal compressional stress (S_{Hmax}) [degree]
  - (Updated in August 2023) The azimuth is the clockwise angle from the north, as in Column 11 and the trend in Columns 14, 17, and 20.
- Column 8: Circular standard deviation (CSD) of the azimuth of the maximum horizontal compressional stress (S_{Hmax}) [degree]
- Column 9: ~~Normalized~~ Relative magnitude of the minimum horizontal compressional stress (S_{Hmin})
  - (Updated in August 2023) We reworded it as in Column 5.
- Column 10: Standard deviation of magnitude of the minimum horizontal compressional stress (S_{Hmin})
- Column 11: Azimuth of the minimum horizontal compressional stress (S_{Hmin}) [degree]
- Column 12: Circular standard deviation (CSD) of the azimuth of the minimum horizontal compressional stress (S_{Hmin}) [degree]
- Column 13: ~~Normalized~~ Relative magnitude of maximum compressional stress (σ_1)
  - (Updated in August 2023) We reworded it as in Column 5.
- Column 14: Trend of maximum compressional stress (σ_1) axis [degree]
- Column 15: Plunge of maximum compressional stress (σ_1) axis [degree]
  - (Updated in August 2023) The plunge is the angle from the horizontal to the downward. The vertical downward direction is 90 degrees. Also in Columns 18 and 21.
- Column 16: ~~Normalized~~ Relative magnitude of intermediate compressional stress (σ_2)
  - (Updated in August 2023) We reworded it as in Column 5.
- Column 17: Trend of intermediate compressional stress (σ_2) axis [degree]
- Column 18: Plunge of intermediate compressional stress (σ_2) axis [degree]
- Column 19: ~~Normalized~~ Relative magnitude of minimum compressional stress (σ_3)
  - (Updated in August 2023) We reworded it as in Column 5.
- Column 20: Trend of minimum compressional stress (σ_3) axis [degree]
- Column 21: Plunge of minimum compressional stress (σ_3) axis [degree]
- Column 22: σ_{ee}
- Column 23: σ_{en}
- Column 24: σ_{eu}
- Column 25: σ_{nn}
- Column 26: σ_{nu}

- Column 27: σ_{uu}
- Column 28: Stress ratio $(\sigma_2 - \sigma_3) / (\sigma_1 - \sigma_3)$
- Column 29: Standard deviation of stress ratio
- Column 30: A_ϕ
  - An index for the classification of stress field, defined by Simpson (1997). 0 – 1 is for the normal faulting, 1 – 2 for the strike-slip faulting, and 2 – 3 for the reverse faulting regimes.
- Column 31: Standard deviation of A_ϕ
- Column 32: Number of earthquakes used for the stress estimation

2.2. Focal Mechanism Solution Data

The digital data file of focal mechanism solutions is `data/meca_Japan_Uchide2022.txt`. This is the result of the focal mechanism determination by Uchide et al. (2022). We used the HASH code (Hardebeck and Shearer, 2002) for the focal mechanism determination. This file contains the focal mechanism solutions for A, B, and C ranks. We eliminated the solutions for D rank and earthquakes whose focal mechanism solutions were not estimated due to the insufficient number of P-wave first-motion polarity data.

The format of the data is as follows:

- Column 1: Longitude [degree]
- Column 2: Latitude [degree]
- Column 3: Depth [km]
- Column 4: Strike [degree]
- Column 5: Dip [degree]
- Column 6: Rake [degree]
- Column 7: JMA magnitude
- Column 8: Always 0
- Column 9: Always 0
  - Columns 8 and 9 are for convenience to plot focal mechanism solutions using the -Sa option in the psmeca module of Generic Mapping Tools (GMT) (Wessel and Smith, 1991; Wessel *et al.*, 2013, 2019)
- Column 10: Rank of the focal mechanism solutions
- Column 11: Number of P-wave first-motion polarities used in the analysis
- Column 12: fptype
  - An index for the classification of faulting types, defined by Shearer et al. (2006). –1 is for the normal faulting, 0 for the strike-slip faulting, and 1 for the reverse faulting earthquakes.
- Column 13: Origin time (Japan Standard Time = UTC+9)

2.3. Correction File

(Updated in August 2023) We found a problem in calculating the trends of the principal axes (Columns 14, 17, and 20) in the Stress Map Data at 0.2-degree Mesh. Therefore, we corrected the data in August 2023. The corrections are listed in the following files:

- Trend of the maximum compressional stress (σ_1) axis (Column 14):
  `correction/Column14_trend1_correction.csv`
- Trend of the intermediate compressional stress (σ_2) axis (Column 17):
  `correction/Column17_trend2_correction.csv`
- Trend of the minimum compressional stress (σ_3) axis (Column 20):
  `correction/Column20_trend3_correction.csv`

These three files are written in the same format:

- Column 1: Line number (in the Stress Map Data at 0.2-degree Mesh)
  - Note that the data are contained from Line 2, as Line 1 is the header.
- Column 2: Latitude
- Column 3: Longitude
- Column 4: Trend of the principal stress axis before the correction (i.e., incorrect)
- Column 5: Corrected trend of the principal stress axis

3. Disclaimer

The Geological Survey of Japan, AIST shall not be responsible or liable for any damages that may arise from the use of stress map data and focal mechanism solutions of this Open-File Report.

4. Citation

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5. Correction History

5.1. August 2023

- The azimuths of principal stress axes (Columns 14, 17, 20) in the stress map data were corrected. The correction history was attached.
- The explanations on the stress map data were added.

Acknowledgment

We used the seismic data recorded by Hi-net of National Research Institute for Earth Science and

Disaster Resilience (NIED), the seismic network maintained by Japan Meteorological Agency (JMA), and the seismic network by Geological Survey of Japan, AIST. We also used hypocenter and phase data in the JMA Unified Earthquake Catalog.

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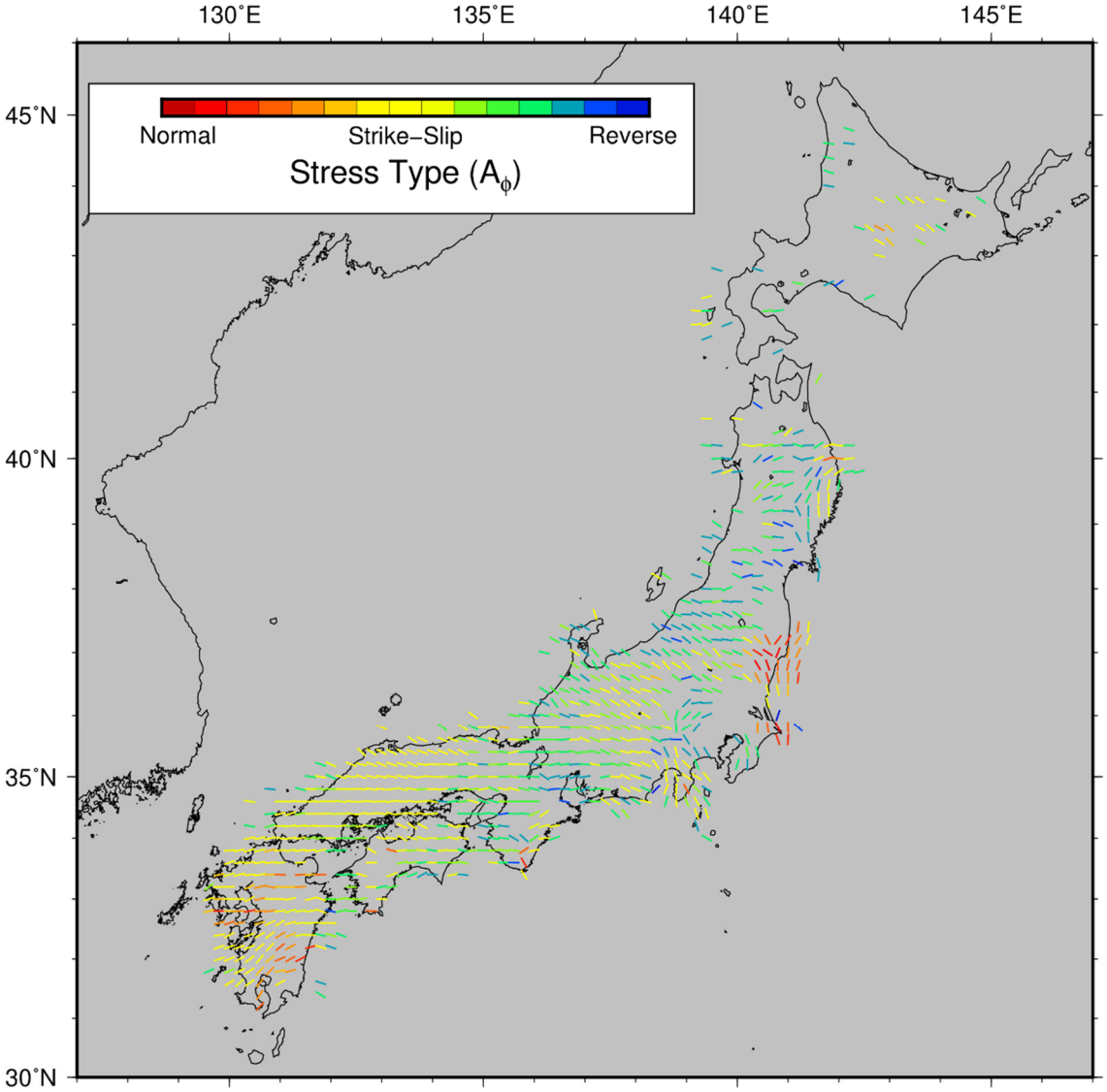

Figure 1. 0.2-degree mesh map of the crustal stress (Azimuth of the maximum horizontal compressional stress (direction of bars) and stress type (color))

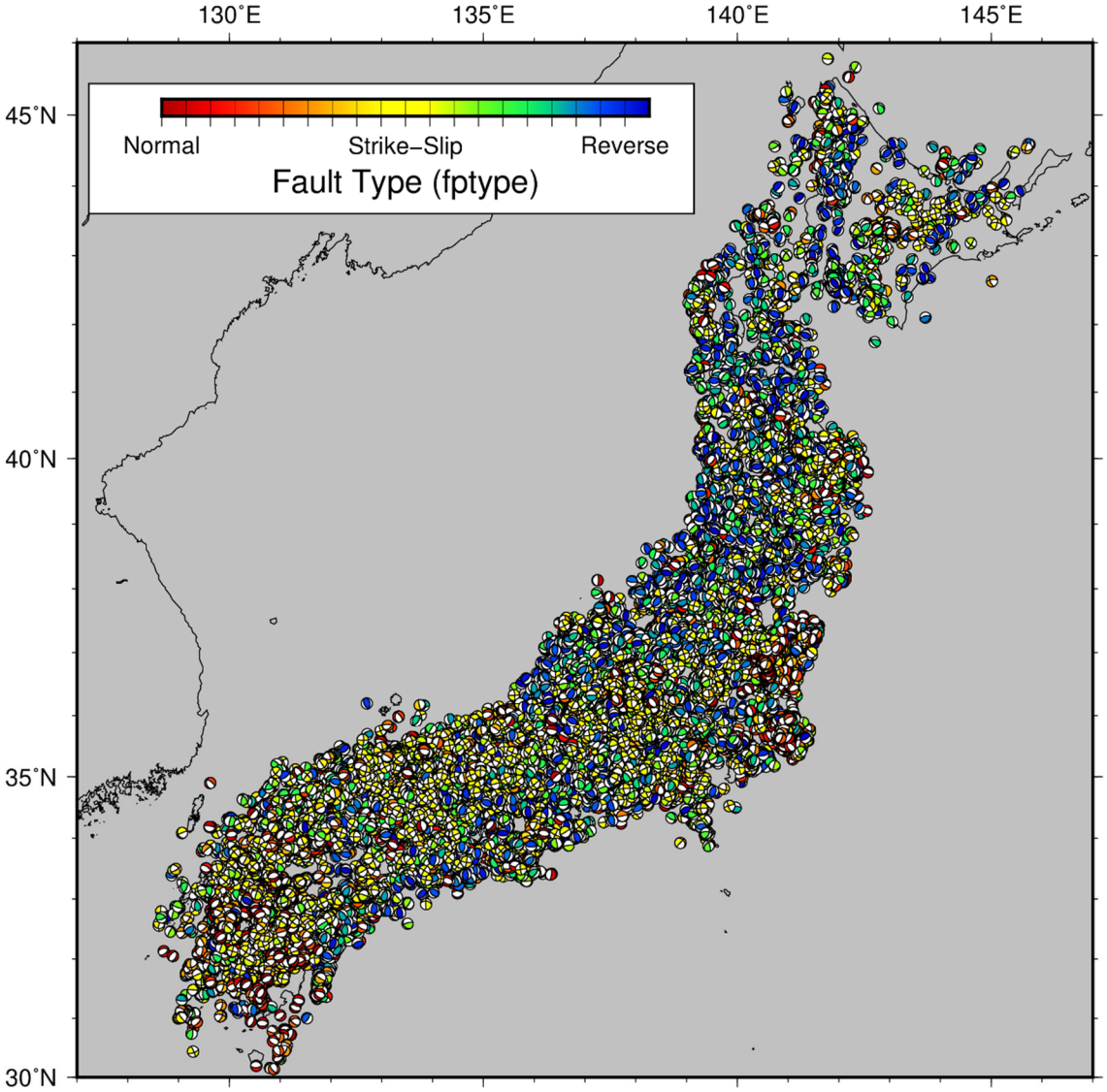

Figure 2. Focal mechanism solutions