Surface Loading and Seismicity in Subduction Zones: Linking Stress Changes to Fault Failure

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Poster QR

Motivation

Surface mass variations from hydrological, oceanic, and atmospheric processes deform the lithosphere and may modulate seismicity. This study examines subduction zones to assess how such loading influences the stress status and earthquake potential.

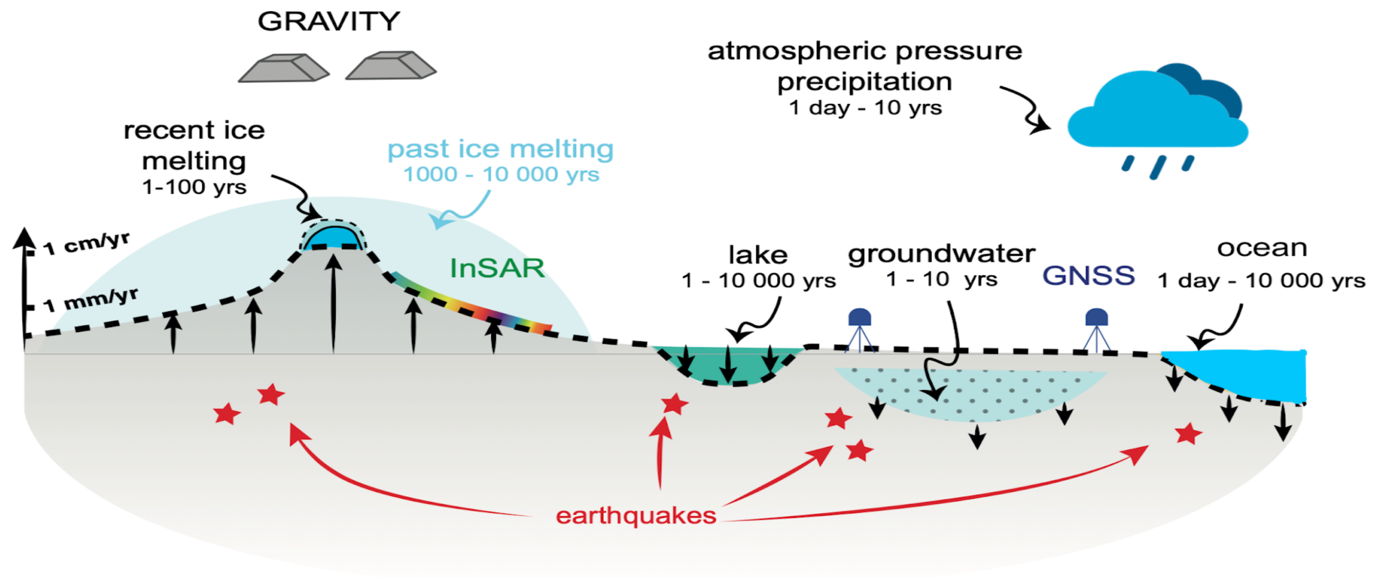


Fig.1. Sketch of (visco-) elastic climate-driven loading. Modified from fig 1 in Bürgmann, R., et.al. 2024.

Approach 1: multi-loading-induced ΔCFF, regional (Kuril-Japan)

Loading Stress | Fault parameters → ΔCFF, Coulomb stress change → Multi-loading-induced ΔCFF ⇔ Seismicity

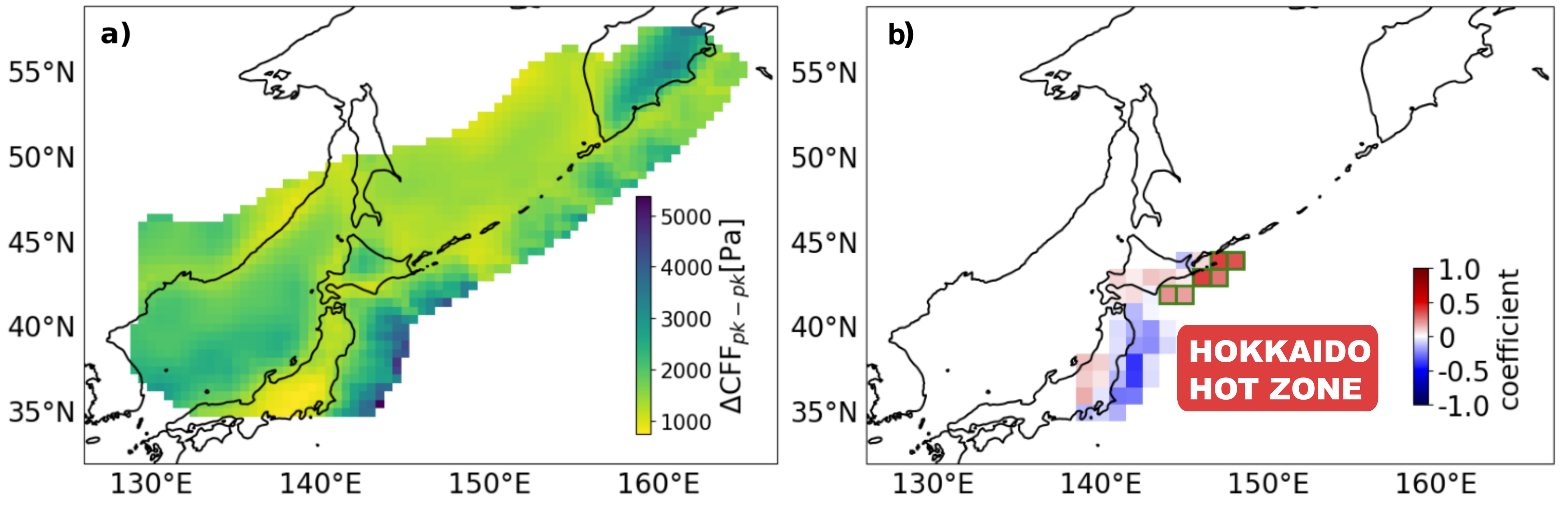
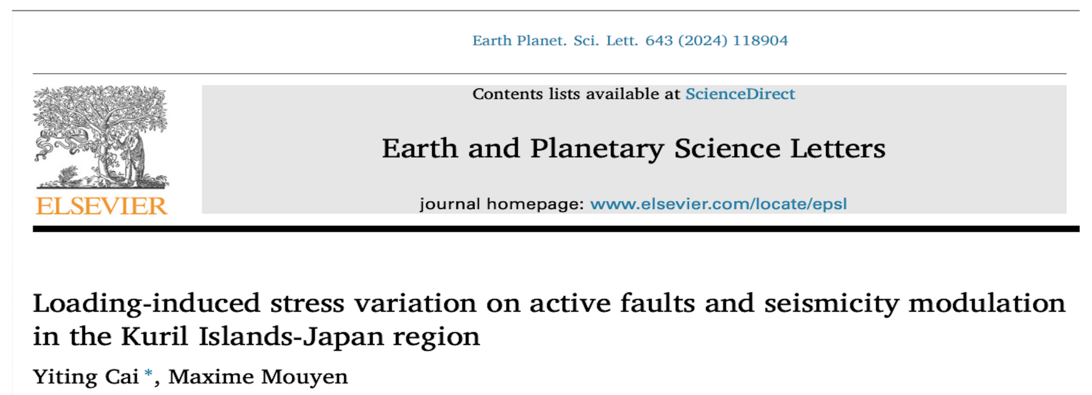


Fig.2. a) The peak-to-peak amplitudes of the depth-dependent ΔCFF. The shallow edge of the Japan Trench experiences the lowest amplitude at 0.8 kPa. The slab beneath the Kamchatka Peninsula experiences the highest amplitude, reaching about 4 kPa. b) Correlation coefficients between multiple surface-loading-induced Coulomb stress change ΔCFF and excess (or deficiency) earthquake rate Rex. Hokkaido Hot Zone patches with a statistically significant positive correlation are highlighted with green bounding boxes.

1. Statistically significant positive correlation is observed.
2. Primary loading source varies across regions.
3. Cumulative impact matters!

TAKEAWAYS

Further reading
Cai, Y., & Mouyen, M. (2024). Loading-induced stress variation on active faults and seismicity modulation in the Kuril Islands-Japan region. Earth and Planetary Science Letters, 643, 118904.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ELSEVIER

Loading-induced stress variation on active faults and seismicity modulation in the Kuril Islands-Japan region

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Approach 2: multi-loading-induced Δσ, global subduction zones

Loading Stress | σ, Tectonic stress → Δσ, Projected loading-induced stress change ⇔ Seismicity

Long-term background tectonic stress orientation, derived from ~35k subduction zone earthquakes in the GCMT catalog (1976–2024), is used together with seasonally varying stress tensor time series to assess changes relative to the background stress principal axes.

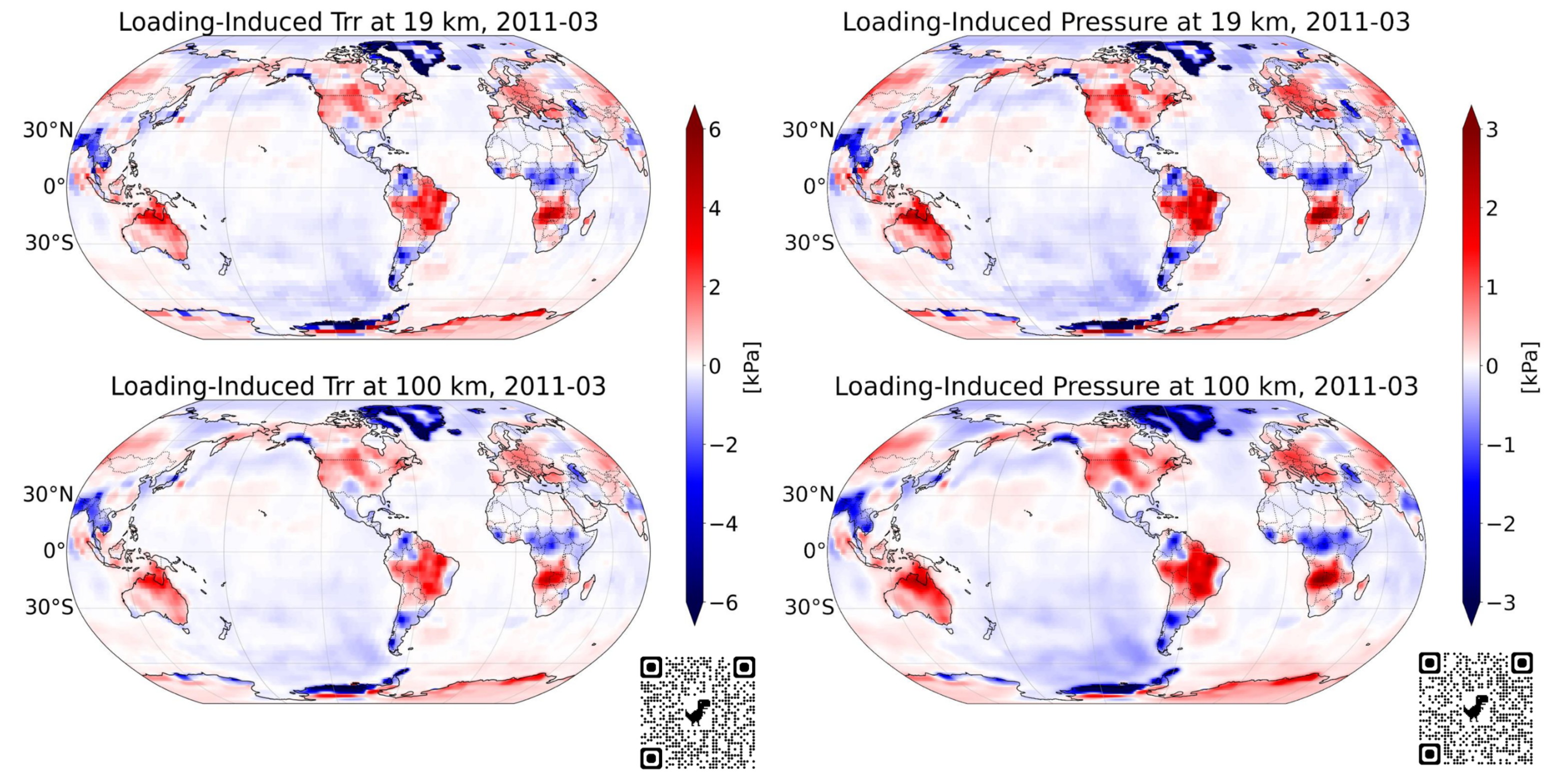

Fig.3. Vertical stress (left) and the volumetric stress (right) variations due to the global surface loadings, computed from the GRACE/GRACE-FO JPL MASCON RL06 product, including continental water, ocean water, and the atmospheric pressure. Positive values represents compression. Please scan the QR code for videos between 2002-2021.

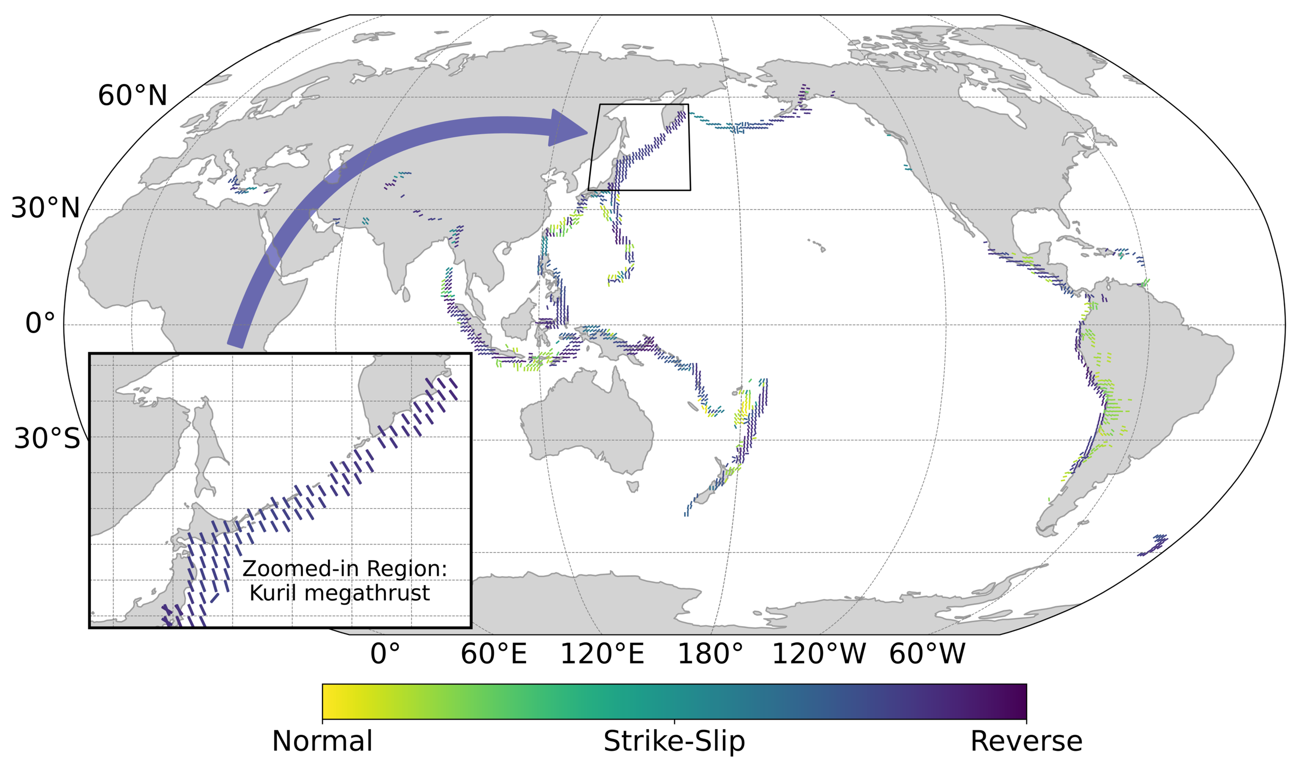

Fig.4. Background stress field (maximum horizontal compressional stress direction) for the major subduction zones given in Slab2 model, Hayes, G.P. et, al. 2018. The faulting style follows the Simpson's convention.

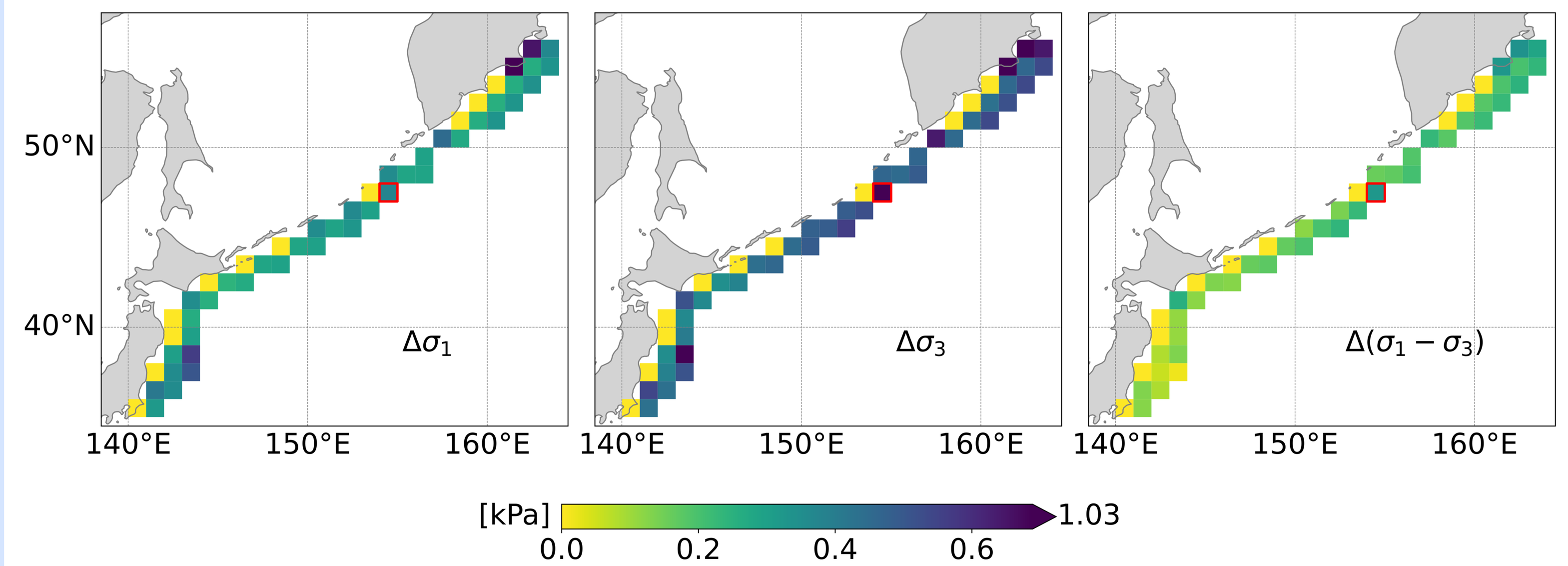

Fig.5. Map of annual peak-to-peak amplitudes of loading- induced stress change projected in the σ_1, σ_3 orientation, and the differential stress (σ_1–σ_3) for Kuril Megathrust.

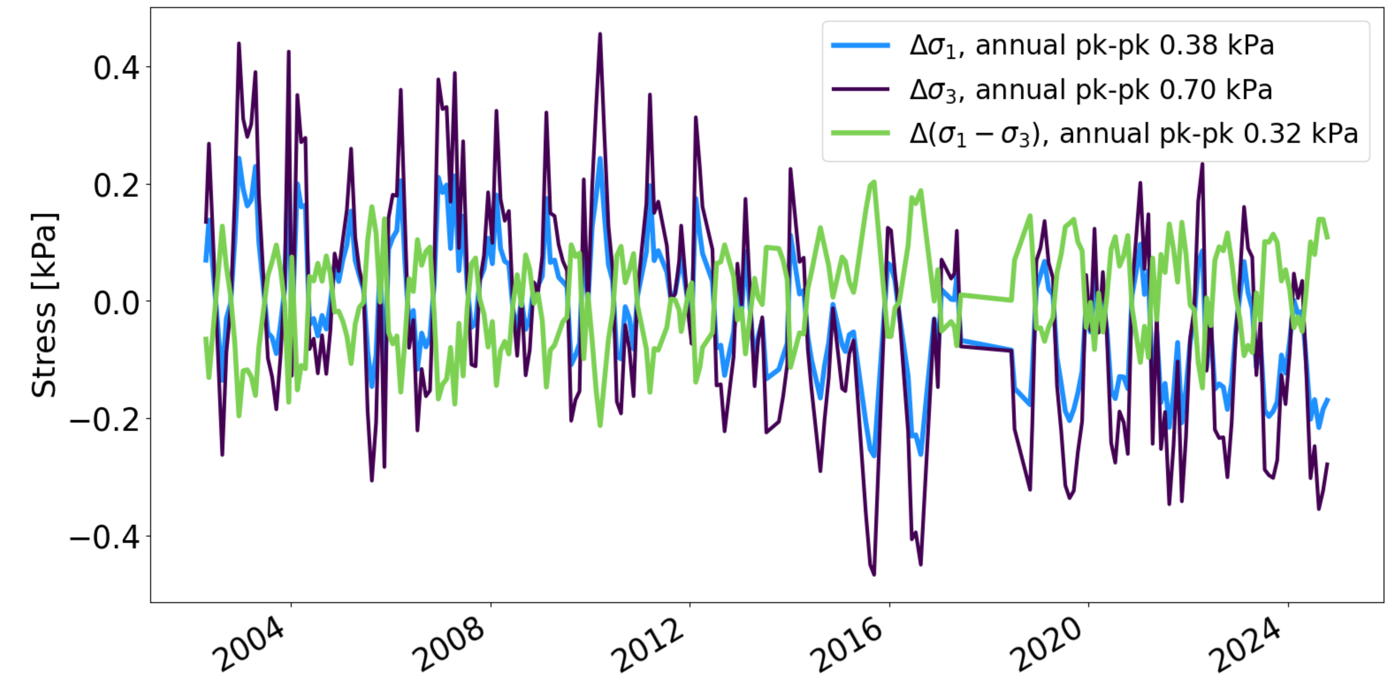

Fig. 6. Loading-induced stress changes projected in the σ_1, σ_3 orientation, and the differential stress (σ_1–σ_3), for a 1-degree patch centered at 154.5°E, 47.5°N of Kuril megathrust, highlighted with red boxes in Fig.5.

Ongoing work: Δσ v.s. seismicity

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Sharing is encouraged

Acknowledgments

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