Characterizing the spatial and temporal behavior of deep tectonic tremor along the Nankai Trough

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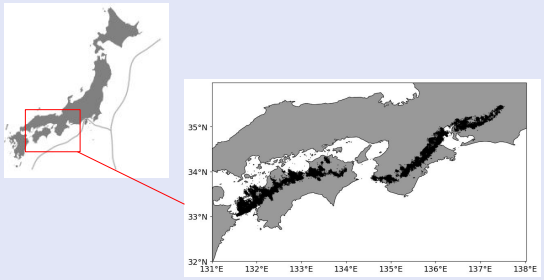
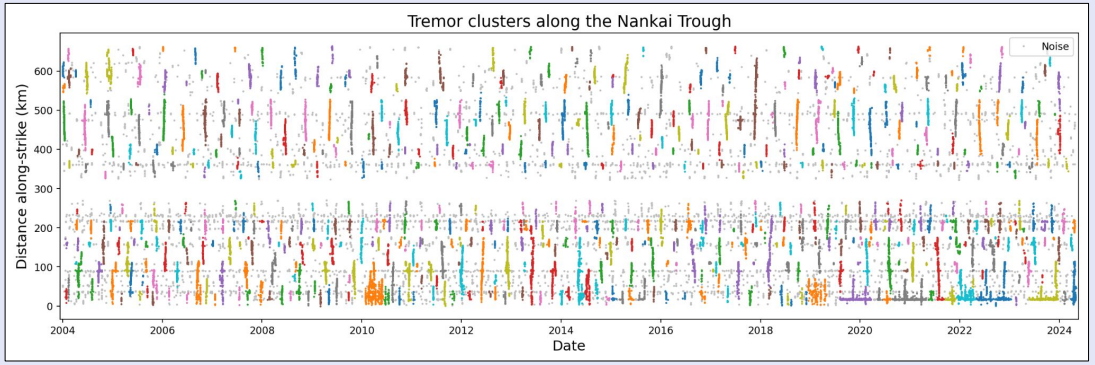
Background: Tremor in Nankai

- Tectonic tremor is a weak seismic signal composed of low-frequency earthquakes
- It organizes itself in a very unique way along the Nankai Trough, a subduction zone in southwestern Japan, often forming frequent and distinct episodes
- Studying the spatial and temporal patterns and variations of tremor reveals when, where, and how frequently the subduction zone fails at depth, as well as how tremor may be disturbed by external forcings such as local seismicity.
- Farge et al. (2025) shows a **spatial** relationship between tremor organization and seismicity; here, we use a new method to support these observations as well as show a **temporal** relationship between tremor synchronization and seismicity



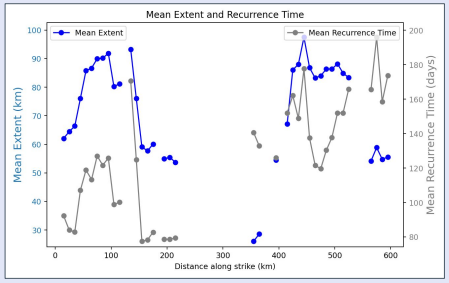
Method: Clustering with DBSCAN

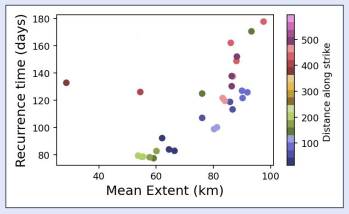
We use a density-based clustering approach (DBSCAN) in Python to detect and isolate tremor "episodes" by creating clusters of neighboring events using specific space and time parameters **(x = 15 km, dT = 1 day, min. samples = 10)**. This allows us to measure the periodicity, spatial extent, and recurrence interval of the clusters in 10 kilometer bins along the subduction zone, as well as variance in the recurrence intervals due to external forcings.



Data: National Research Institute for Earth Science and Disaster Resilience (NIED) Japan.

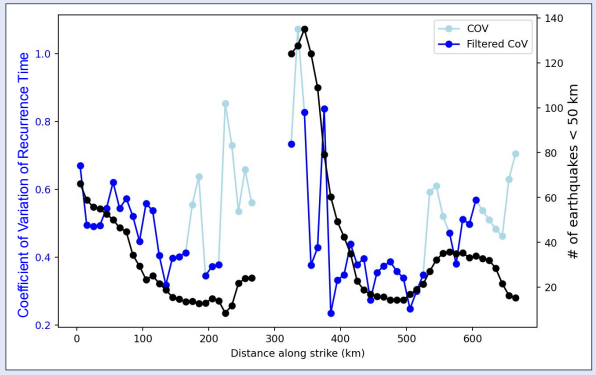
Results: Space vs. Time

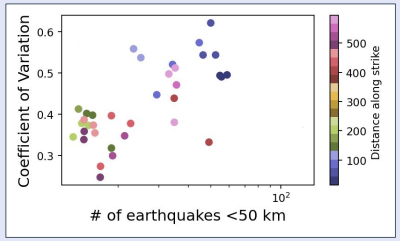




- We observe a positive correlation between extent of clusters along strike and their recurrence intervals
- Larger clusters that propagate further in space tend to have longer recurrence intervals, and vise versa

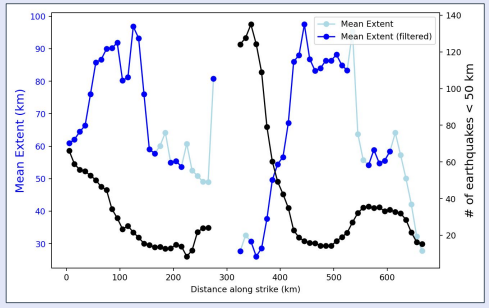
Results: Temporal Variations

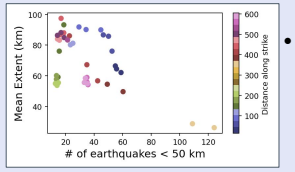




- We observe a positive relationship between local seismicity and variation in cluster recurrence time, given by the coefficient of variation
- Tremor tends to synchronize into regular periodicites (CoV <4) except where perturbed by nearby earthquakes

Results: Spatial Variations





- New methodology supports Farge et al. (2025), showing a negative correlation between local seismicity and average extent of tremor clusters.
- External forcings inhibit tremor from propagating through space and forming long, uniform clusters.
- In regions with very little seismicity we observe clusters that extend over 100 kilometers along strike

Discussion and Conclusion

- With a robust dataset spanning just over 20 years, the observations are now long enough to properly study temporal variations in tremor behavior
- These temporal observations, together with the spatial variations previously researched and supported here, reinforce the interpretation that external forcings such as seismicity disrupt the ability of tectonic tremor to synchronize
- When undisturbed, tremor is able to organize itself into long, uniform, and periodic clusters that span over 100 kilometers along the subduction zone and occur in very regular intervals over the entire 20 year dataset. In the presence of seismicity, organization is disrupted.

References

Farge G, Brodsky EE. The big impact of small quakes on tectonic tremor synchronization. Sci Adv. 2025 May 16;11(20):eadu7173. doi: 10.1126/sciadv.adu7173.

Acknowledgements

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