

# The Nature and Diversity of Fault Behavior: A Discussion of Episodic Tremor and Slip

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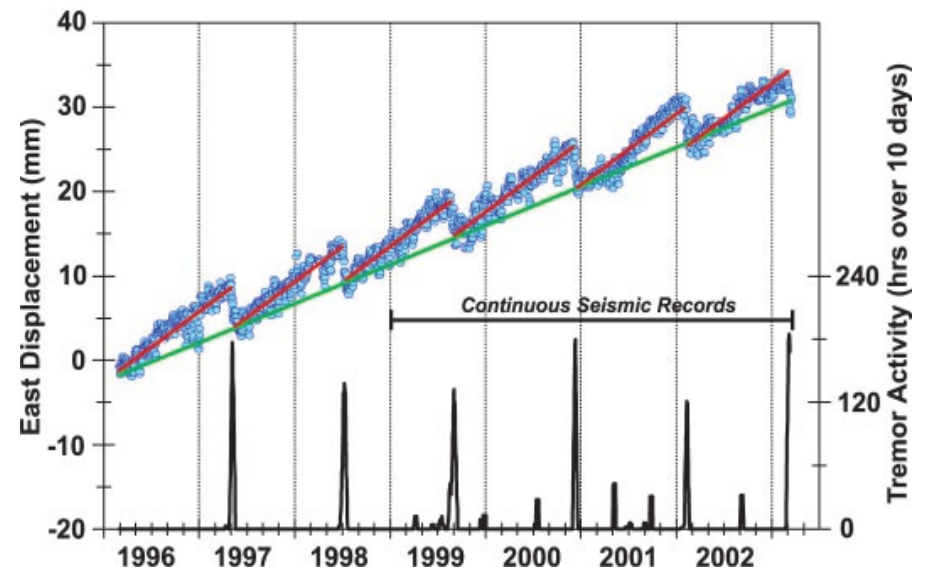
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# Episodic Tremor and Slip on the Cascadia Subduction Zone: The Chatter of Silent Slip

*Rogers & Dragert* - Science (2003) vol. 300 (5627) pp. 1942-1943

Identified ETS and how it was discovered.

- Established correlation between seismic tremors and GPS measured slip events (previously thought to be seismically silent).
- ETS in Cascadia found to occur regularly at 13 to 16 month intervals, for periods ranging from 10 to 20 days.
- ETS occurs as upper “locked” plate reverses motion and moves up-strike



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## Unknowns and Uncertainties

- Difficult to locate the source of the tremors due to emergent signal
- Tremor activity migrates along strike ~5 to 15 km per day.
  - Motion sometimes gradual, sometimes sudden

## Potential Causes

- Presence of fluids? Shearing source? Combination of the two?

## Conclusions

- ETS increases stress up-dip from tremor source which may lead to large earthquakes
- Occurrence of ETS means higher probability of large Earthquakes

# Segmentation in episodic tremor and slip all along Cascadia

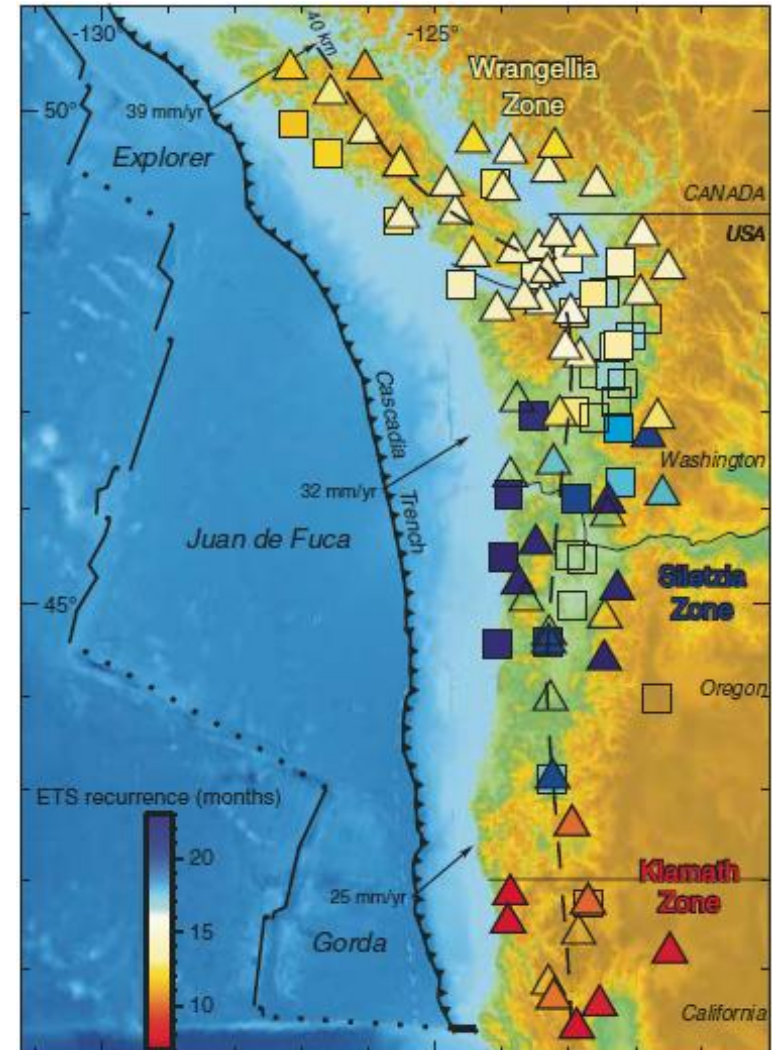
*Brudzinski and Allen - Geology (2007) vol. 35 (10) pp. 907-910*

## Methods:

- Used set parameters to automate the correlation of GPS and seismic data all along Cascadia Subduction Zone from 1997 to 2006.

## Results:

- ETS observed all along subduction zone and is inherently part of subduction process.
- Results depict three broad regions containing distinctly different recurrence intervals ( $14 \pm 2$ ,  $19 \pm 4$  and  $10 \pm 2$  months).

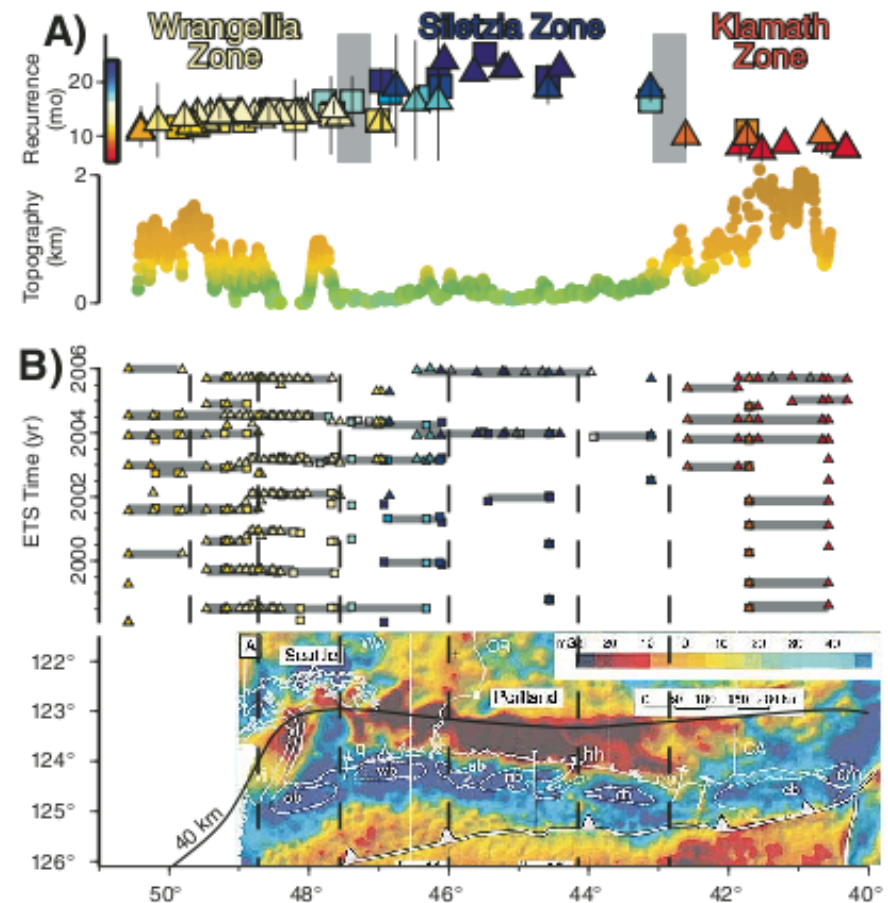


# Segmentation in episodic tremor and slip all along Cascadia

*Brudzinski and Allen - Geology (2007) vol. 35 (10) pp. 907-910*

## Conclusions:

- Duration of recurrence interval is inversely proportional to upper plate topography.
- Fluid content and rheology of upper plate may also effect interval.
- Established spatial link between ETS and earthquake behavior beneath forearc basins.
- Temporal link still unknown.

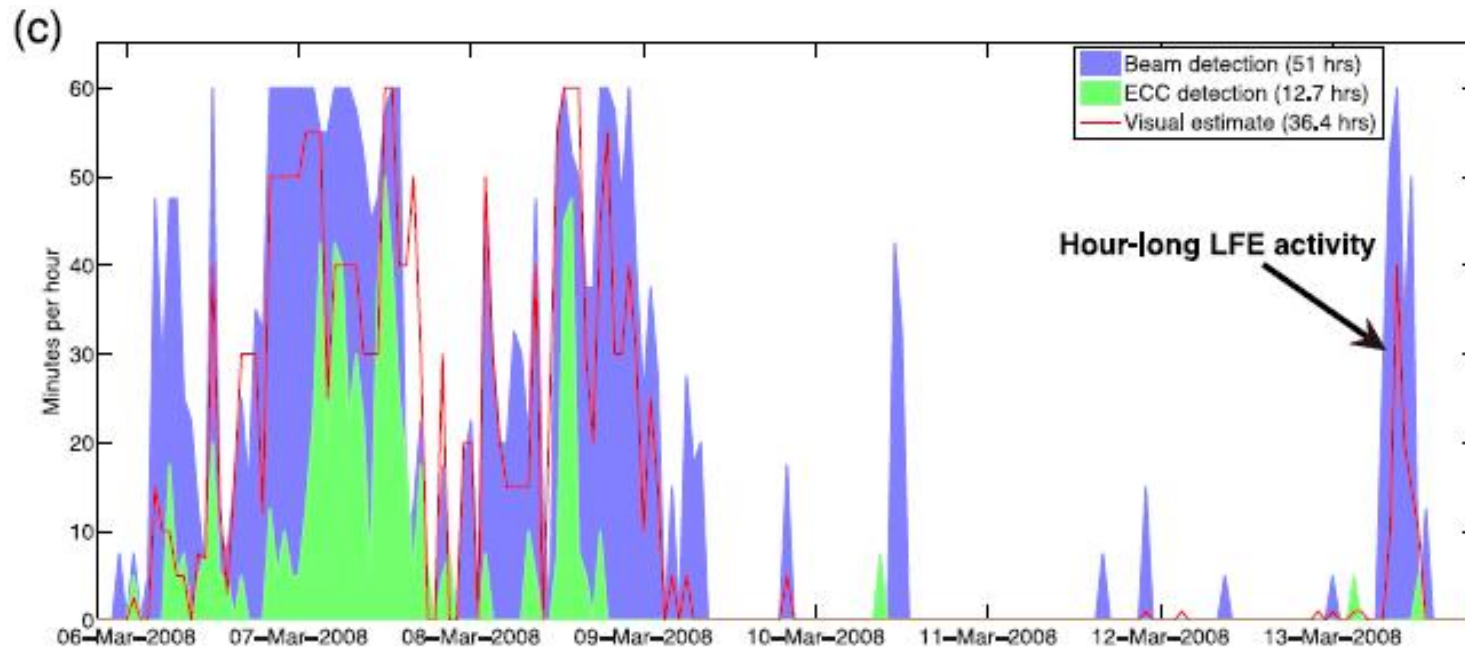


# Tremor patches in Cascadia revealed by seismic array analysis

*Ghosh, et al. - Geophys. Res. Lett. (2009) vol. 36 (17) pp. L17316*

## Methods:

- Deployed dense 84-element small-aperture seismic array above predicted tremor migration path.
- Used “beamforming” technique to increase data resolution (up to 4x better than cross-correlation method)





# Tremor patches in Cascadia revealed by seismic array analysis

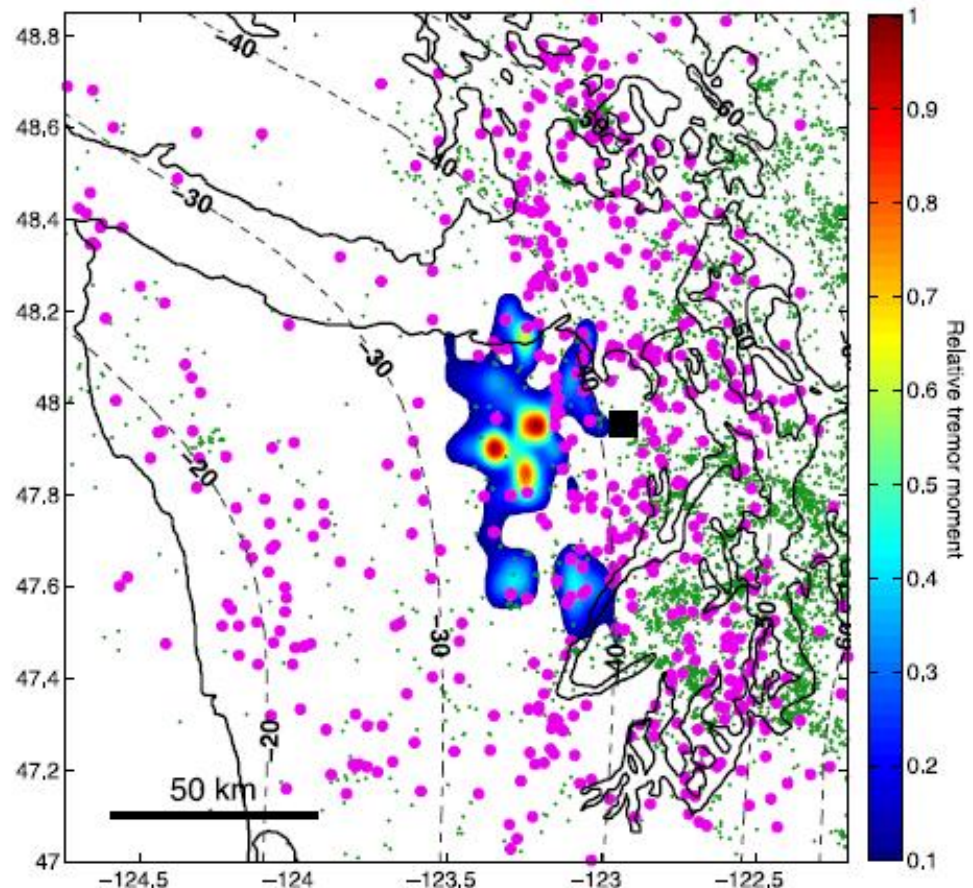
*Ghosh, et al. - Geophys. Res. Lett. (2009) vol. 36 (17) pp. L17316*

## Results:

- Hi-res results show ETS energy is released as several distinct patches and is not uniformly distributed or continuous.

## Conclusions:

- Conditions for tremor exit in broad ETS zone, but degree of activity varies remarkably.
- Patches with largest moment are devoid of earthquake recent activity.
- Mode of stress release on the subduction interface may be determined by variable friction properties and/or fluid content.



# Tremor patches in Cascadia revealed by seismic array analysis

*Ghosh, et al.* - Geophys. Res. Lett. (2009) vol. 36 (17) pp. L17316

## Questions:

- Beamforming technique assumes that tremor is occurring on the plate interface. Is this a safe assumption based on the other papers we read?
- Do their supporting papers about southwest Japan relate well to this study? Why or why not?
- Based on data and references in this paper, is it reasonable to assume that ETS and earthquakes do not occur in the same place?



# Northern Cascadia episodic tremor and slip: A decade of tremor observations from 1997 to 2007

*Kao, et al.* - Journal of Geophysical Research (2009) vol. 114 pp. B00A12

## Summary:

- Propose and ETS scale system to characterize spatial and temporal sizes of ETS events.
- Correlation between ETS and GPS measurements is remarkable, but GPS signature is unclear for smaller ETS episodes.
- ETS migration still unconstrained. Observed to pause, change speeds and even “jump” over duration of tremor event.
- ETS seems to occur where earthquakes do not, and vice versa
- Discusses whether “tremor gap” is active in presenting earthquakes or passive in resulting from them.
- Depth distribution of ETS ranges in area of strong seismic reflectors (E-layer) and not necessarily located at subduction interface.
- Much more to learn about ETS!