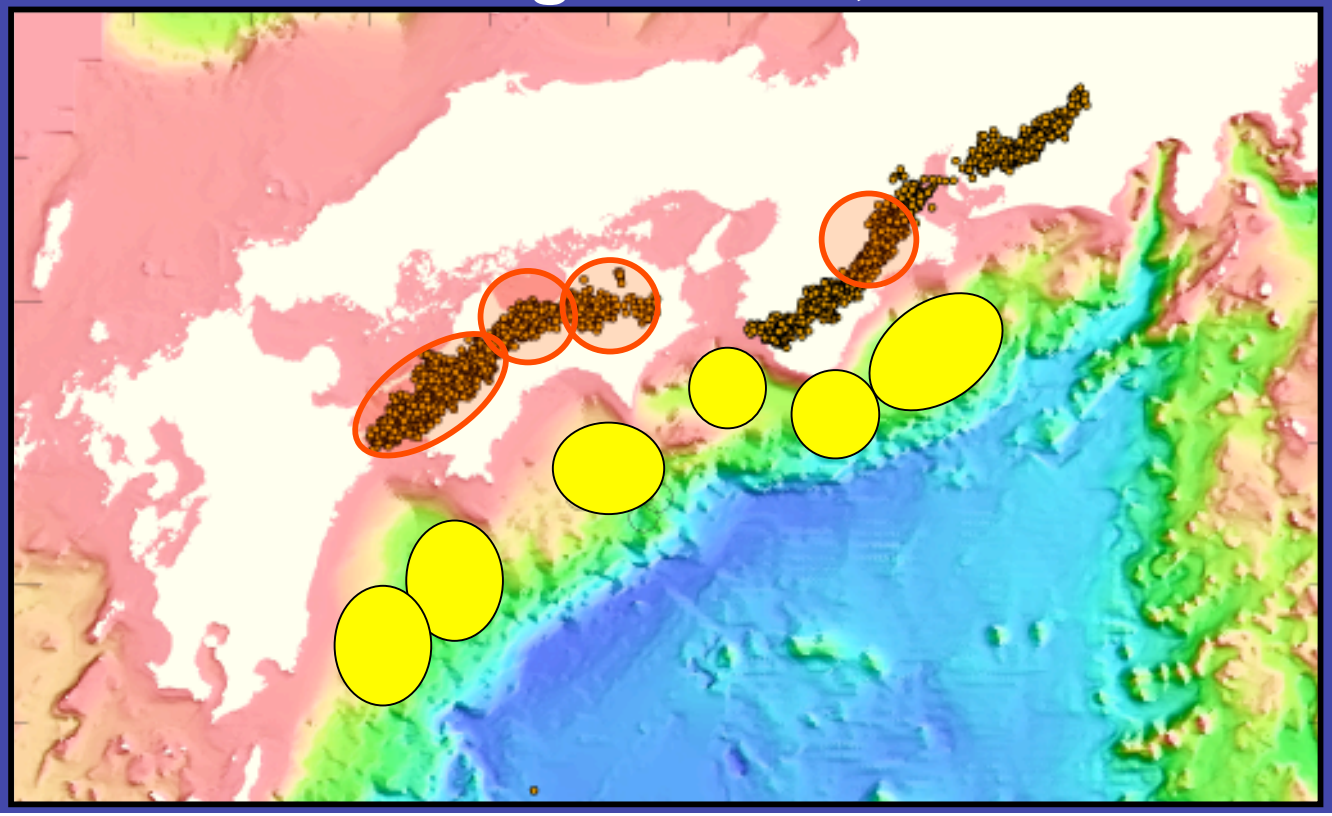
Slow earthquake families on the subducting Philippine Sea plate in southwest Japan:

Non-volcanic tremor, slow slip and very low-frequency earthquake

Kazushige Obara, NIED



Contents

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- Slow slip event detected by tiltimeter
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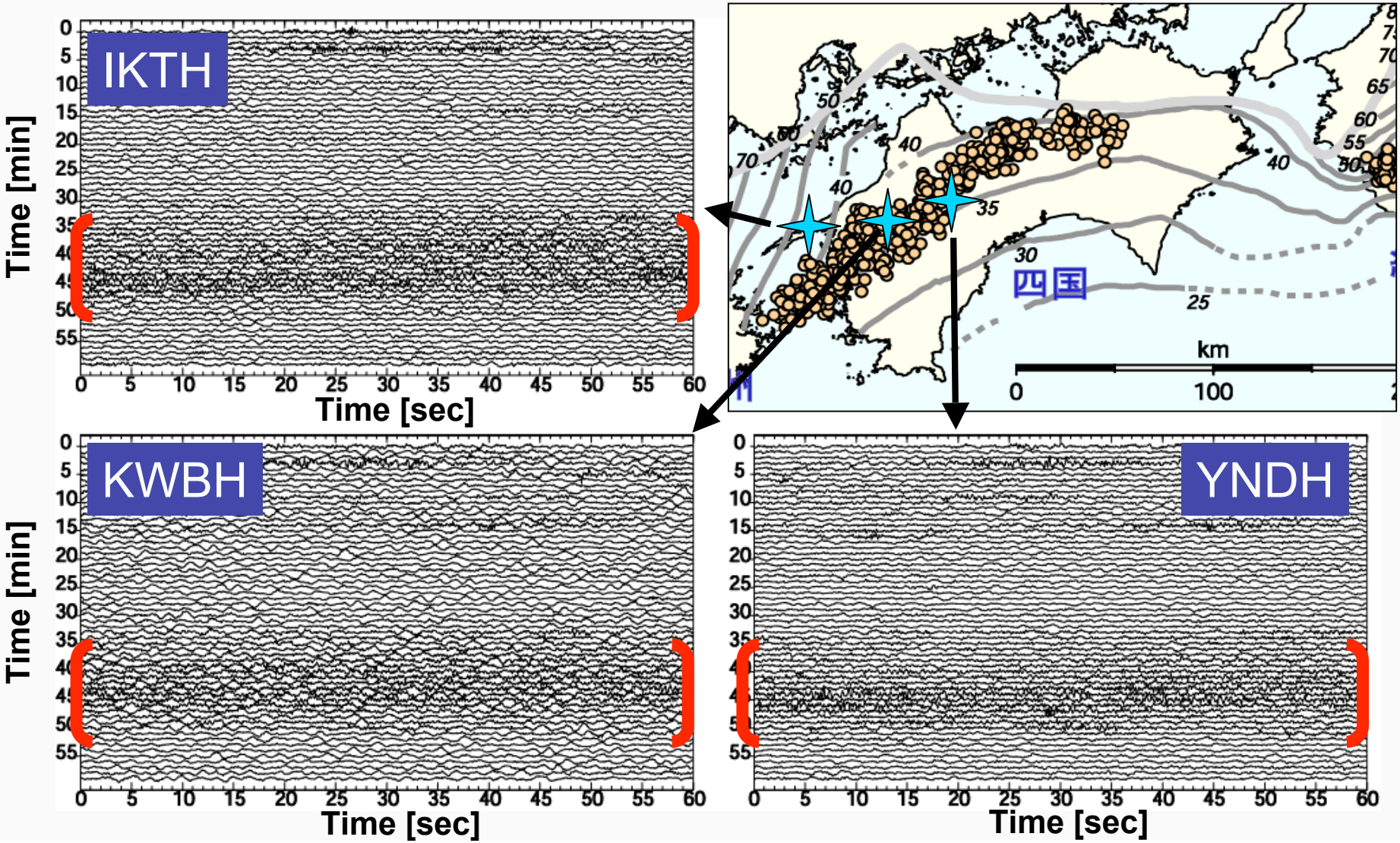
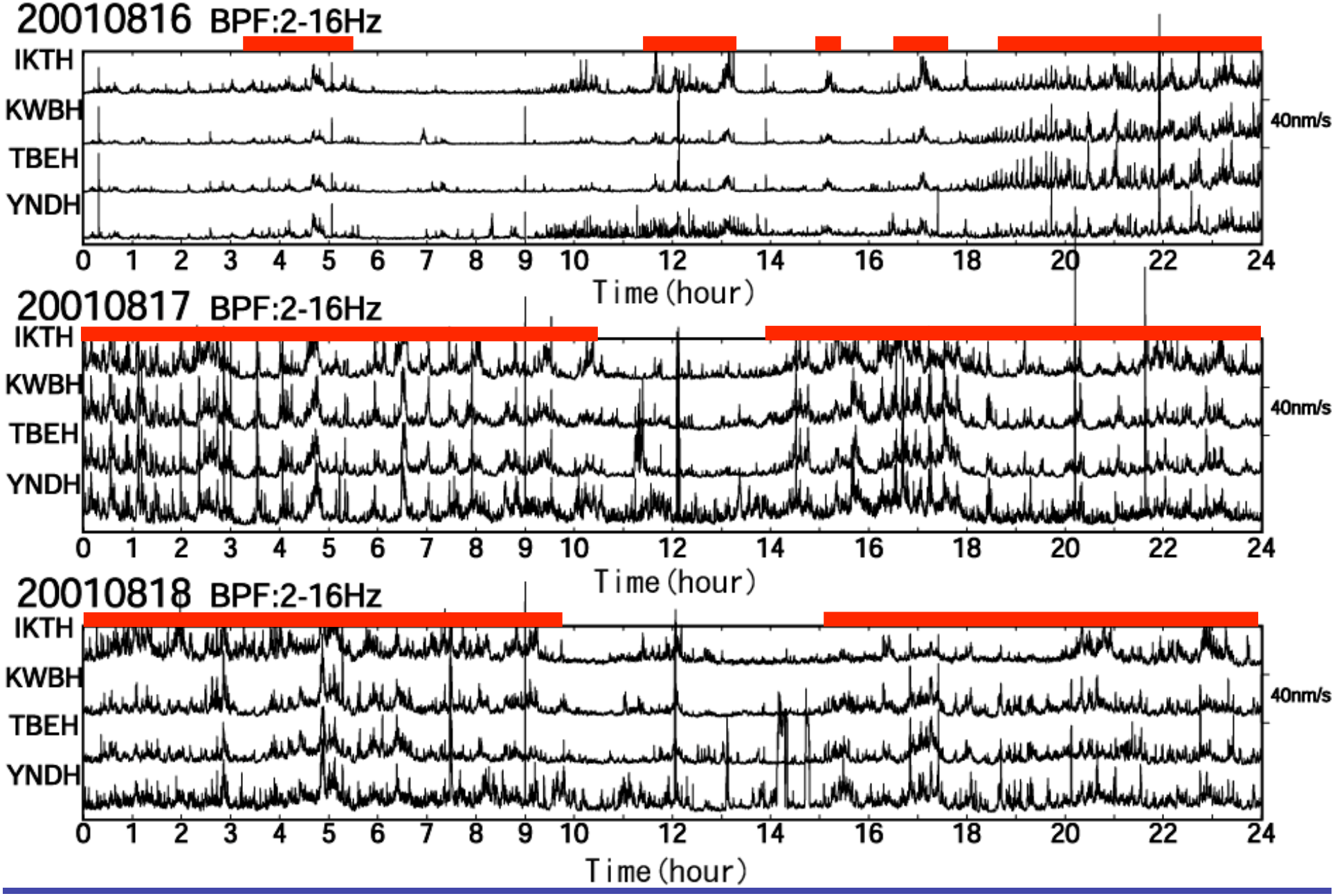
Very Low Frequency (VLF) earthquake

- Waveform
- Seismicity

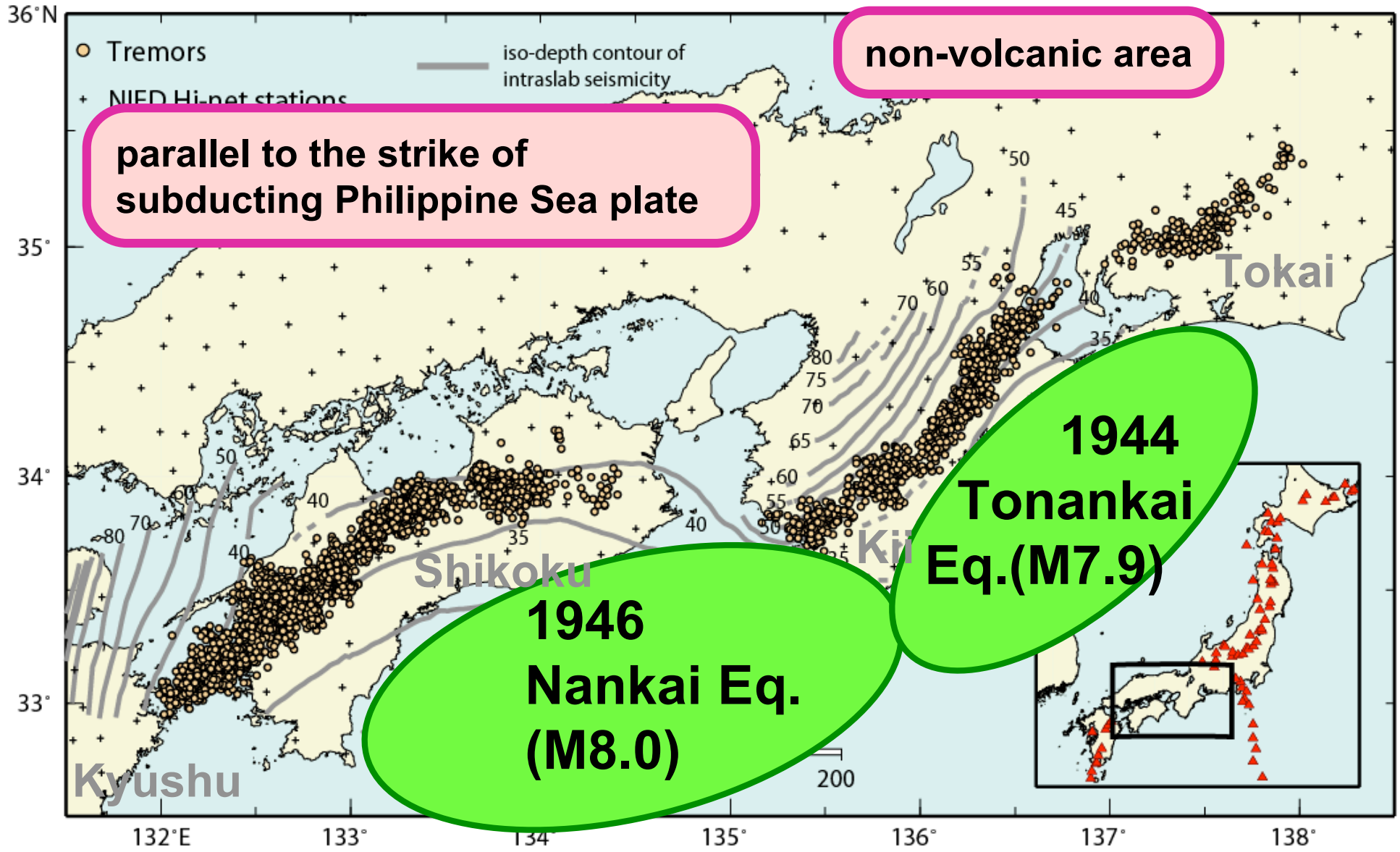
1 hour continuous seismograms observed at 3 stations in the western part of Shikoku 4 am, 17 August 2001



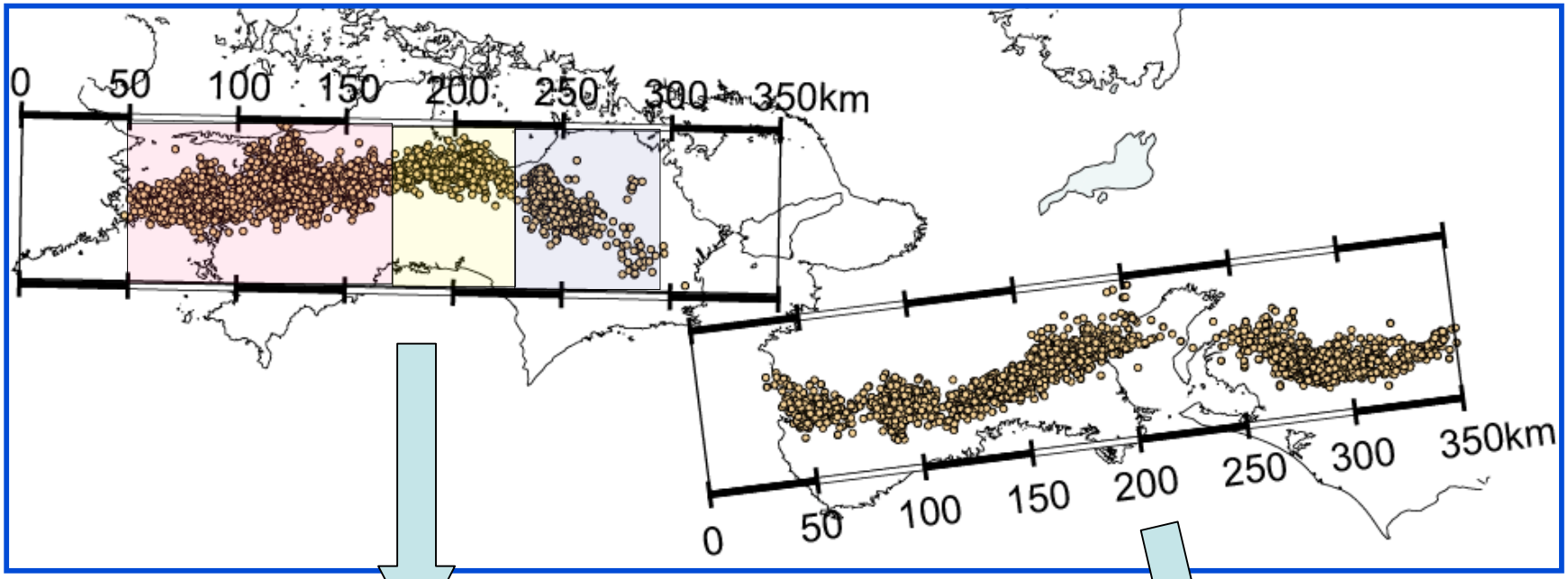
3 days envelope traces in Shikoku



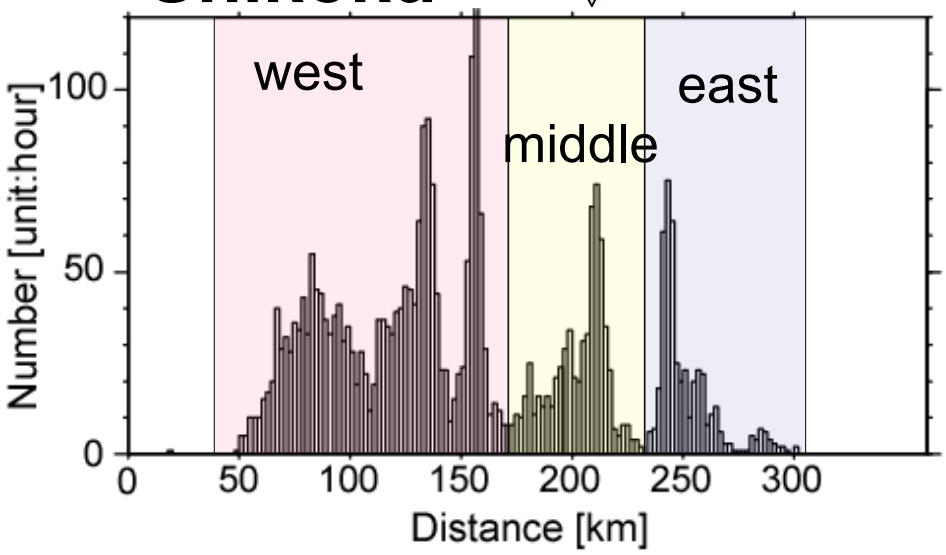
Spatial distribution of tremors(2001-2003)

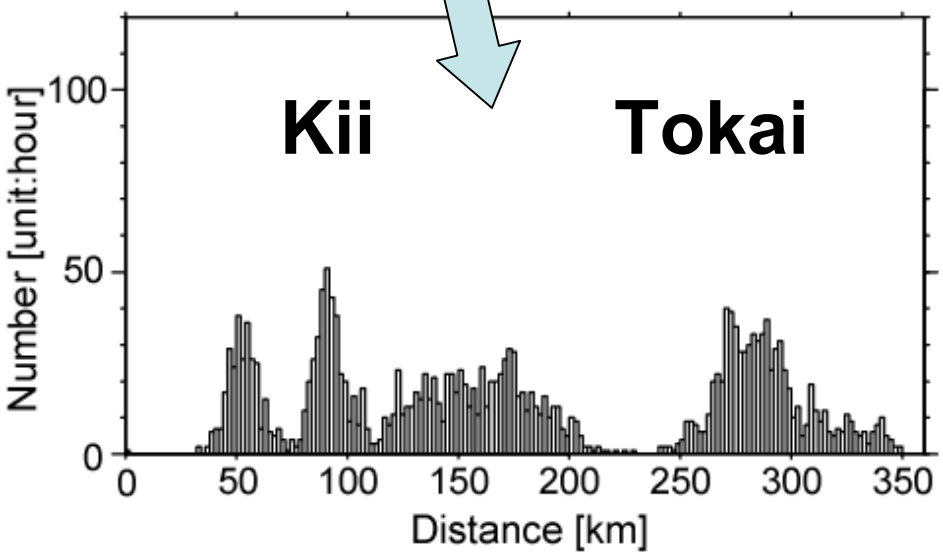


Clustering of tremor activity

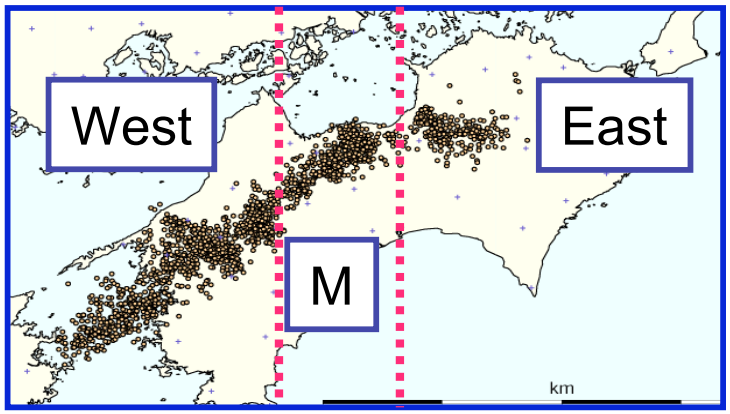


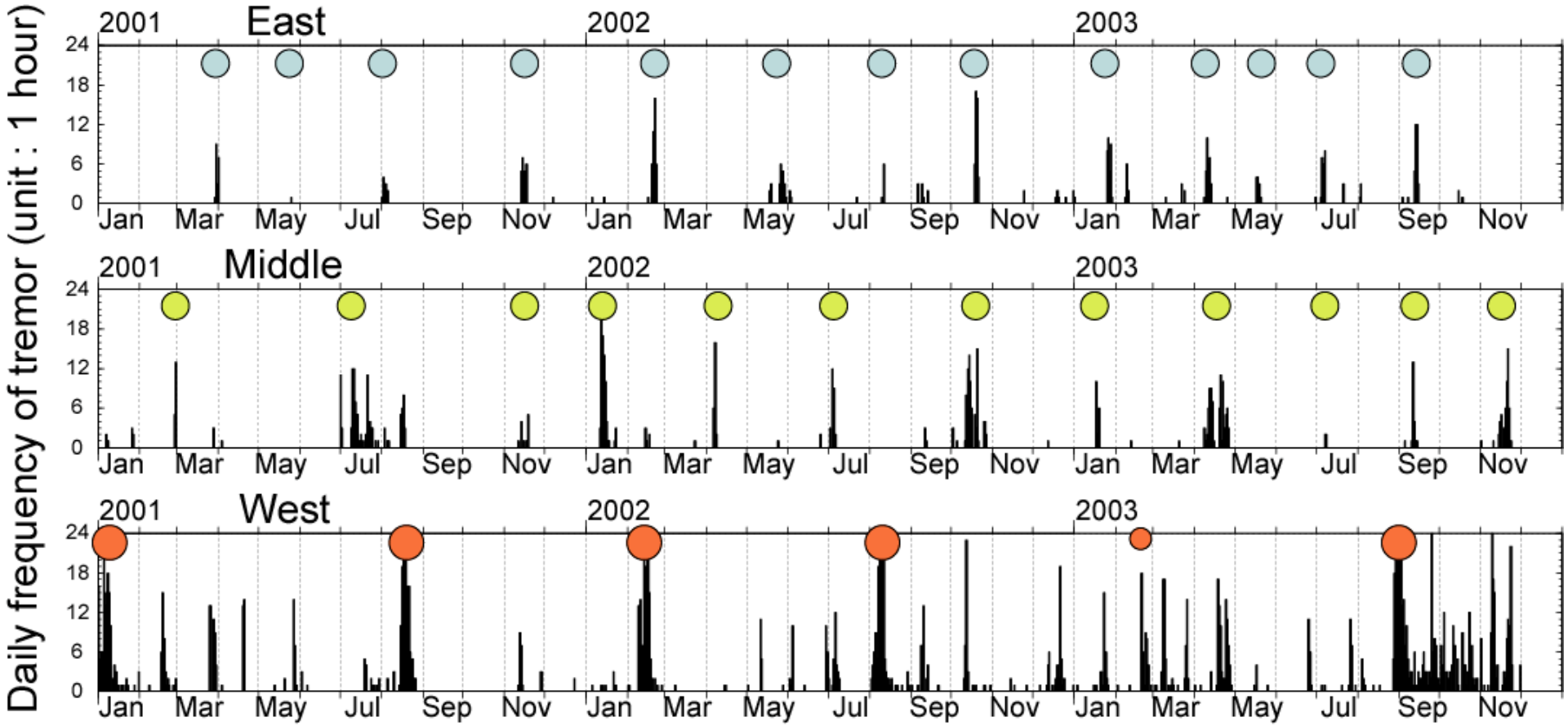
Shikoku



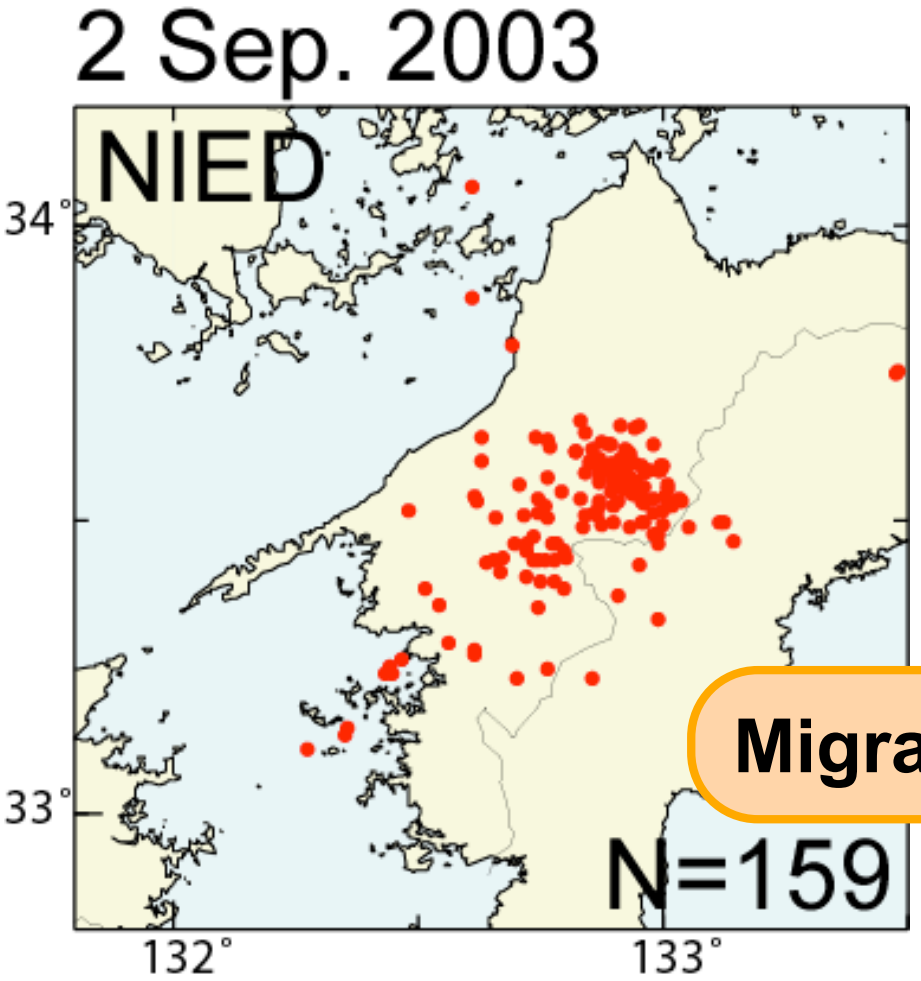


Periodic activity of tremors in Shikoku





Migration of tremors (27 Aug – 2 Sep,2003)

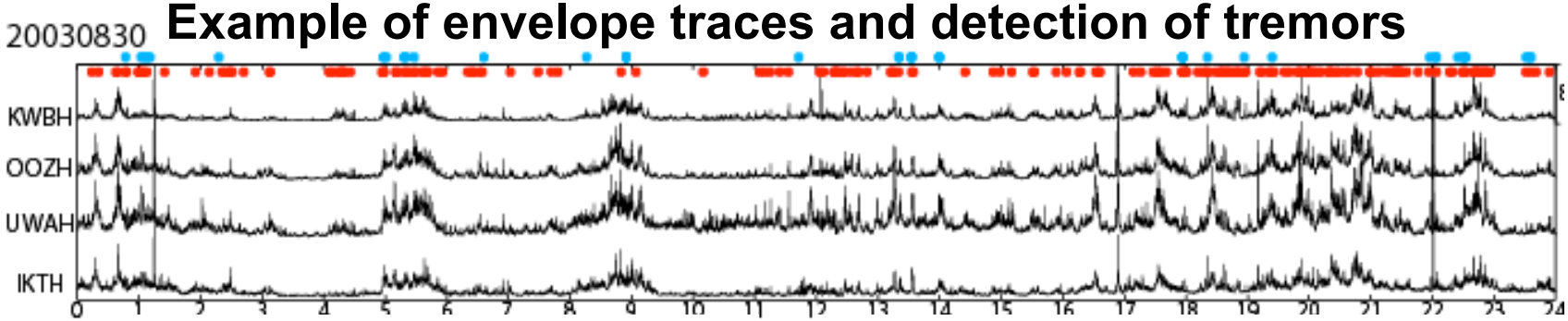


- **Daily distribution of tremors**
  determined by envelope correlation method for each one-minute as shown in bottom envelope traces

Migration velocity = 10km/day

50km

Example of envelope traces and detection of tremors



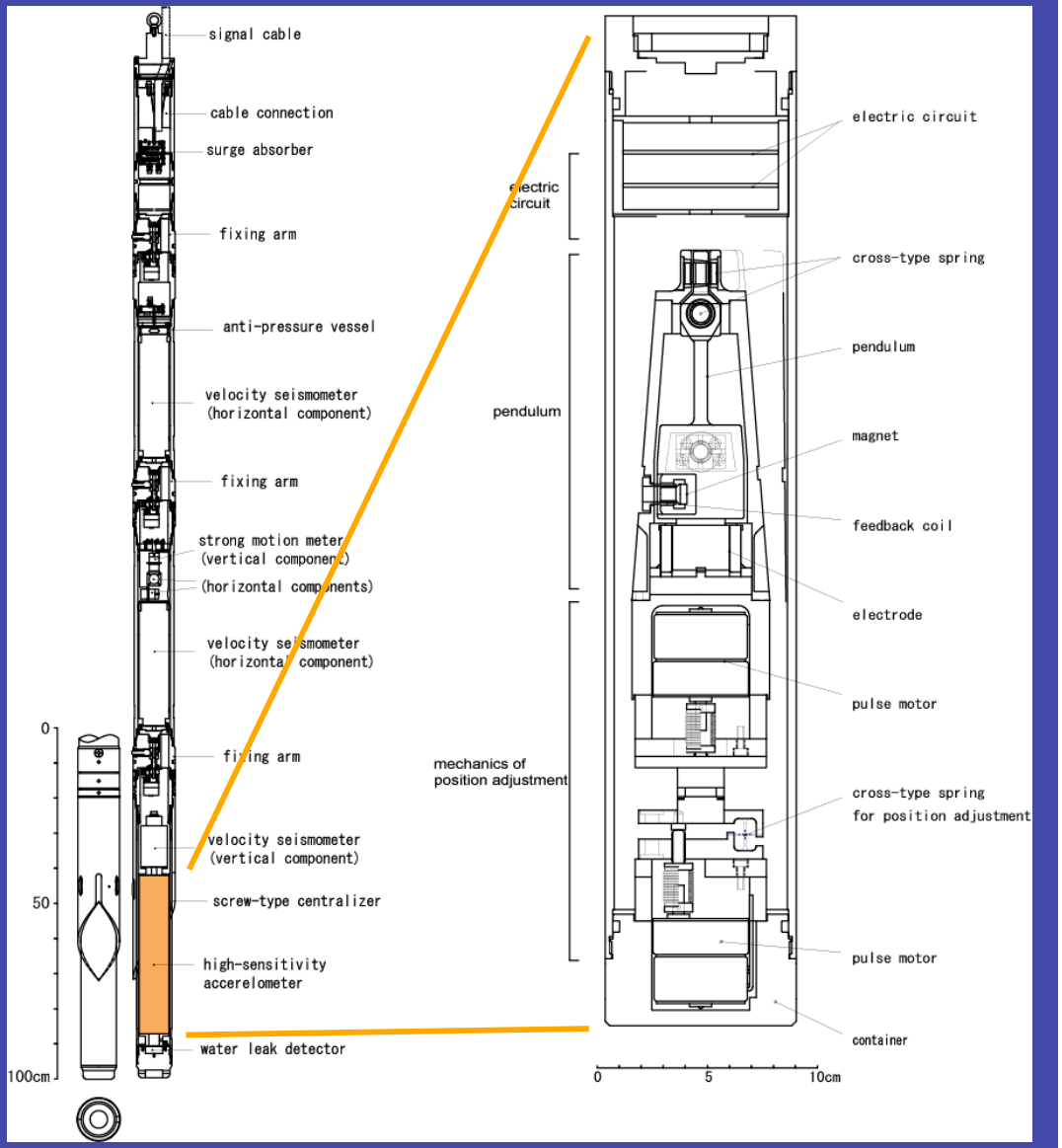
- **LF events listed in JMA catalog**
- **LF tremor detected by this method**

Horizontal component of high-sensitivity accelerometer

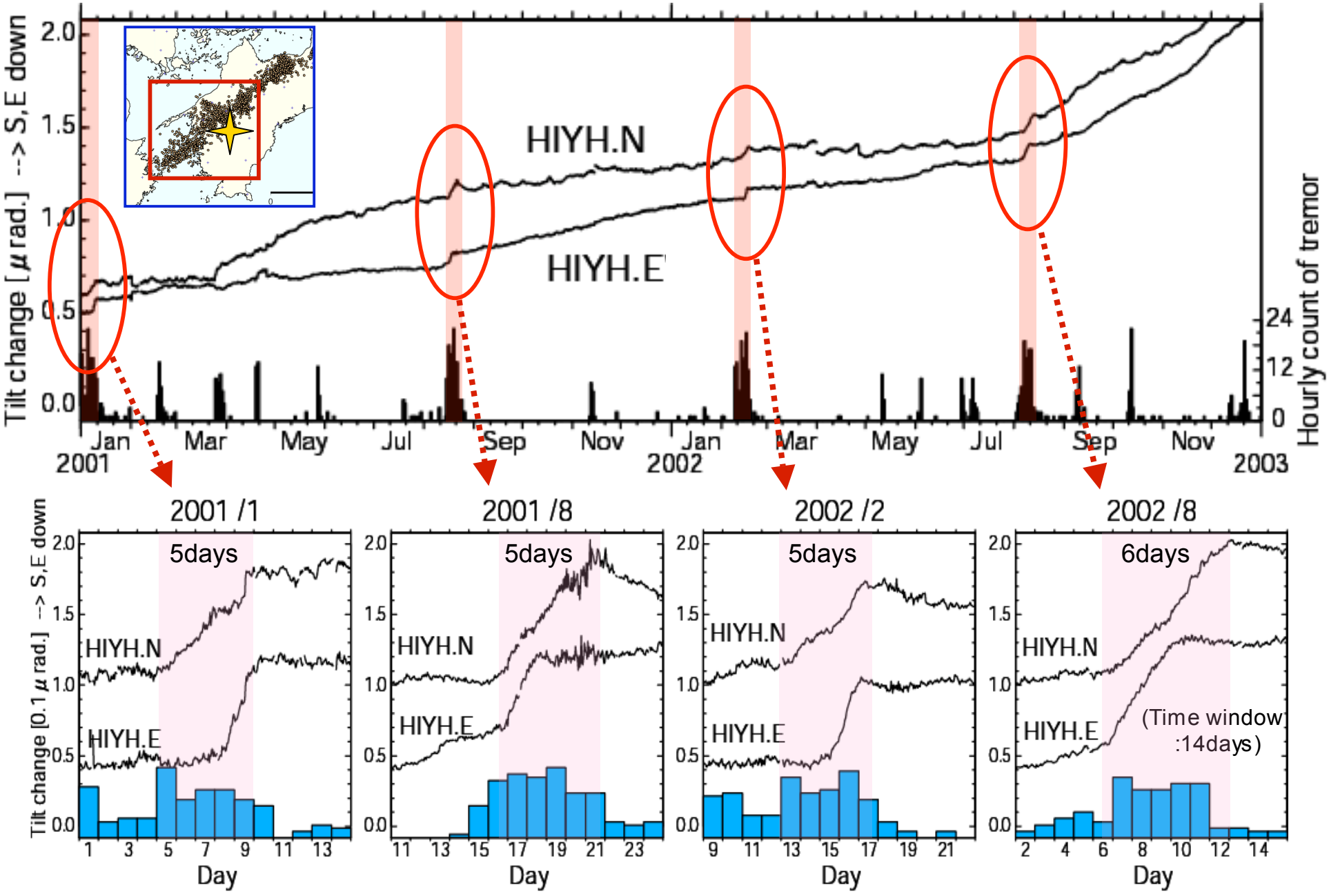
(Tiltmeter)

equipped in all NIED Hi-net stations

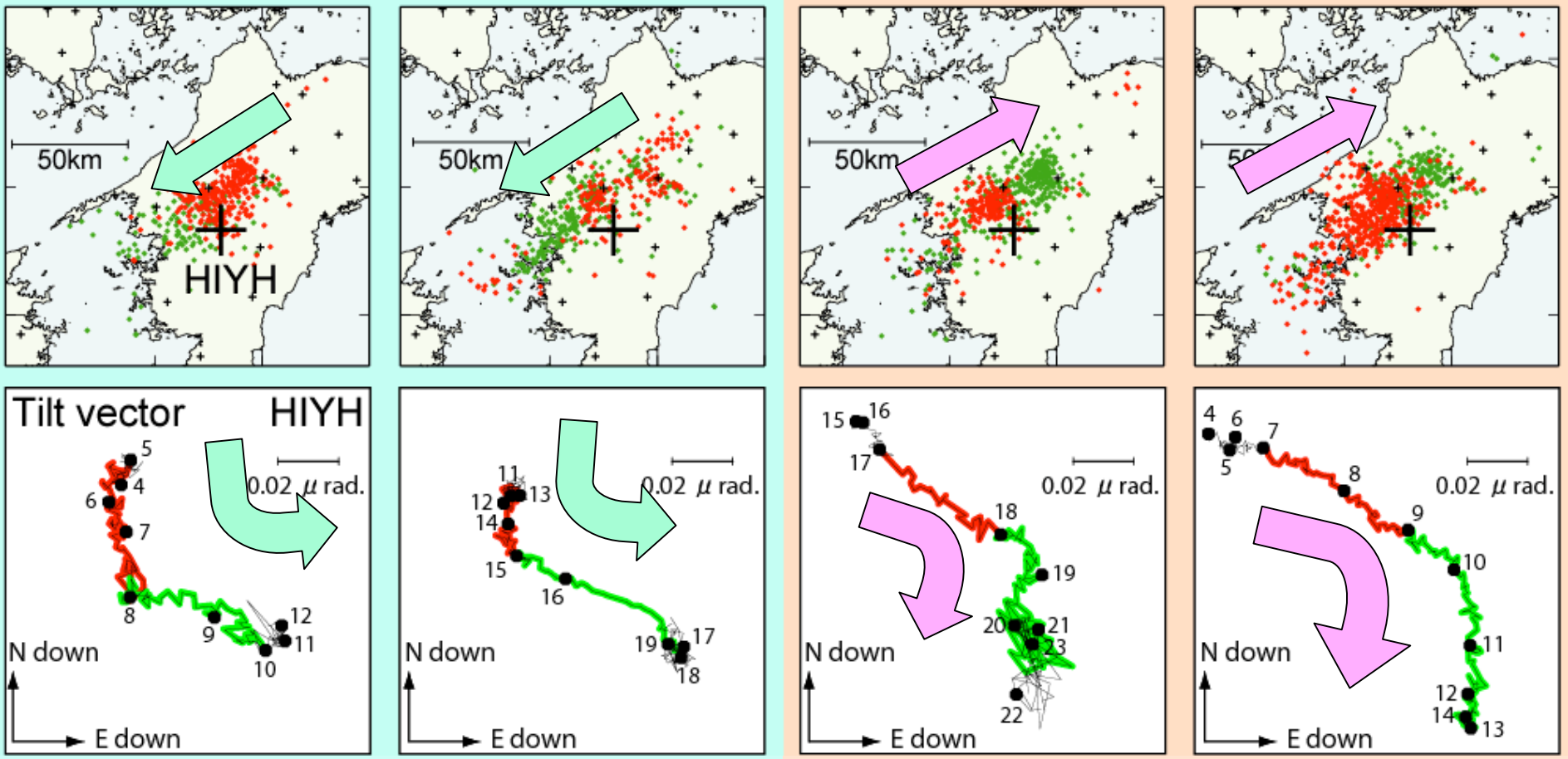
Tidal effect is removed
by Baytap-G



Tremor and Tilt change in the western part of Shikoku



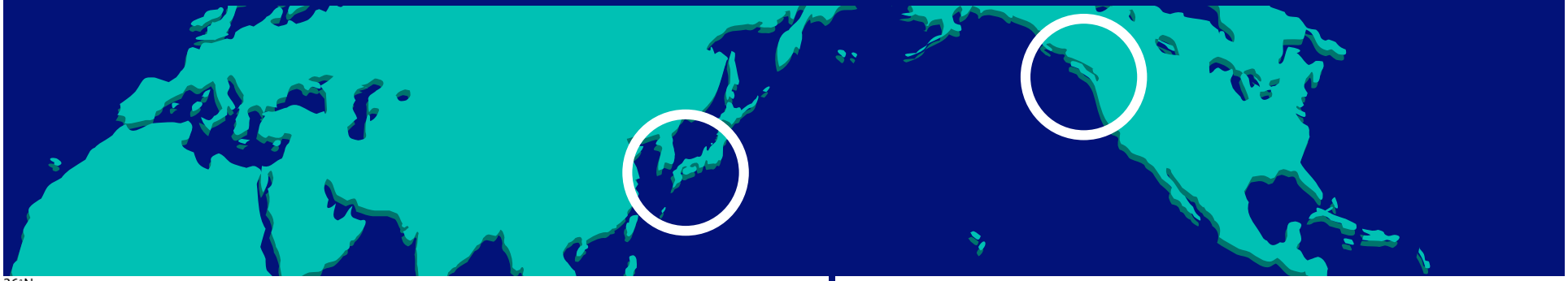
Relationship between migration of tremor and tilt

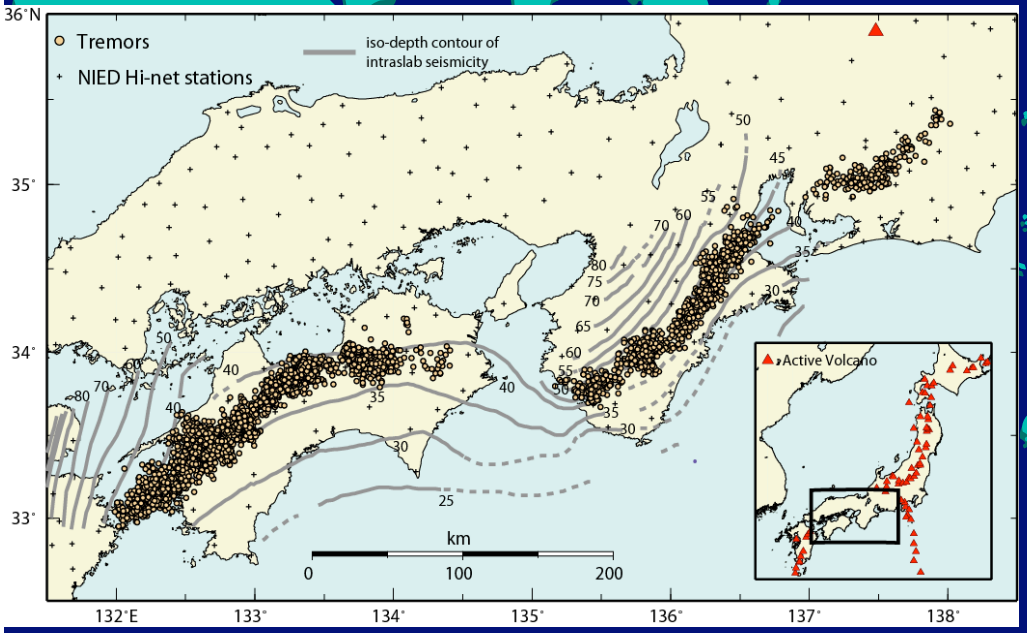


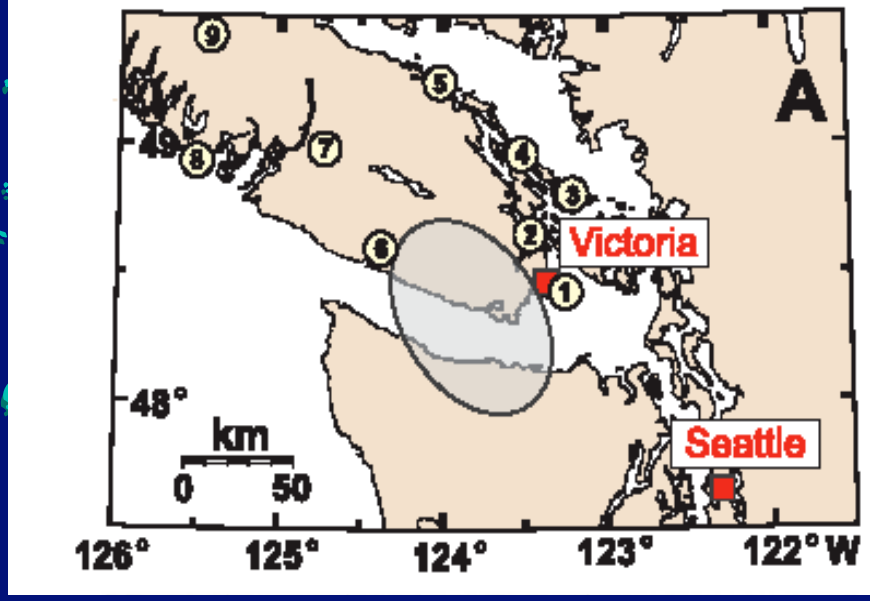
[Winter]
Tilt vector :S-down → E-down
Tremor : NE → SW

[Summer]
Tilt vector :SE-down → S-down
Tremor : SW → NE

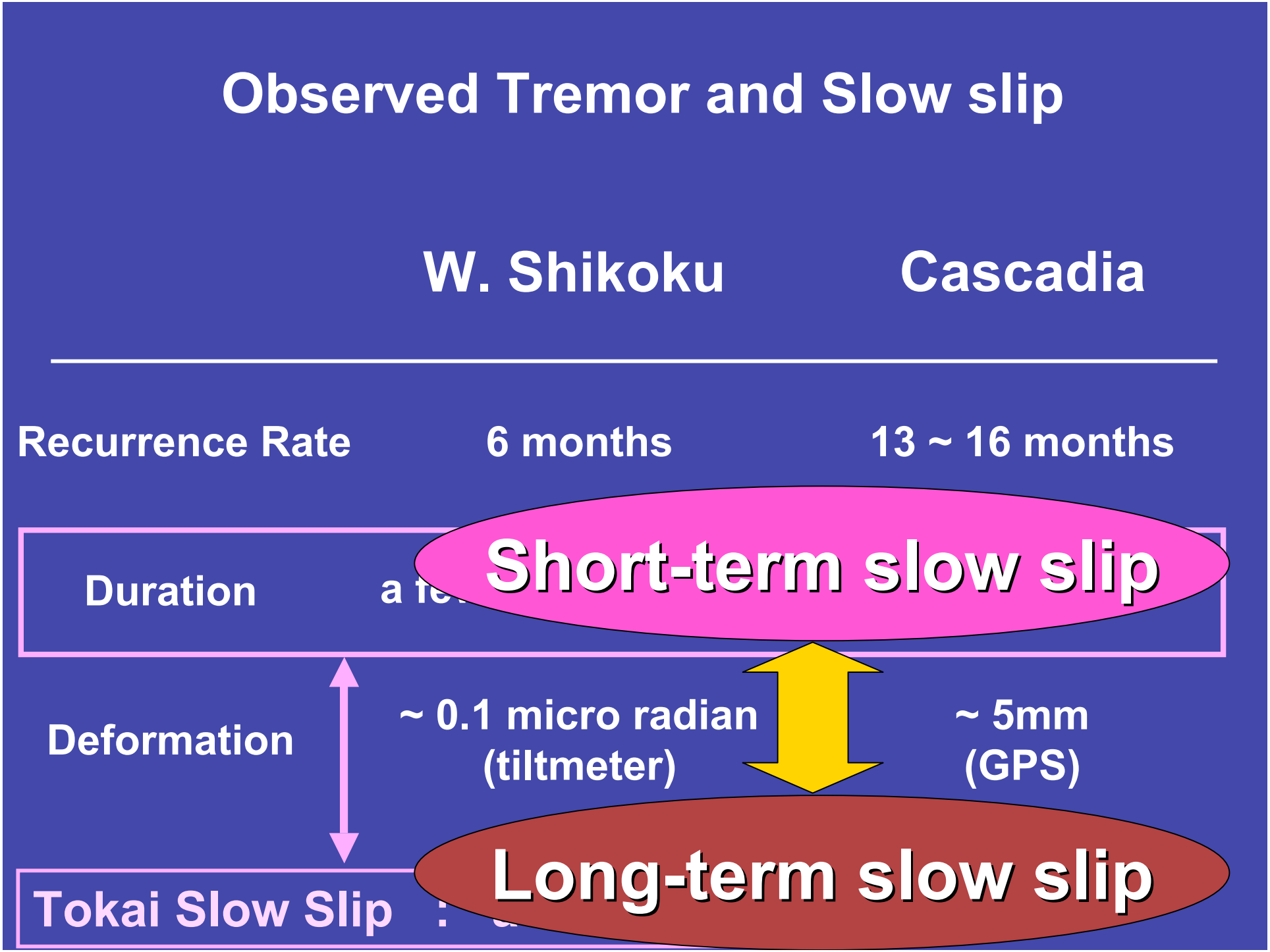
ETS (Episodic Tremor and Slip) on both sides of the Pacific Ocean; Shikoku (SW Japan) and Cascadia



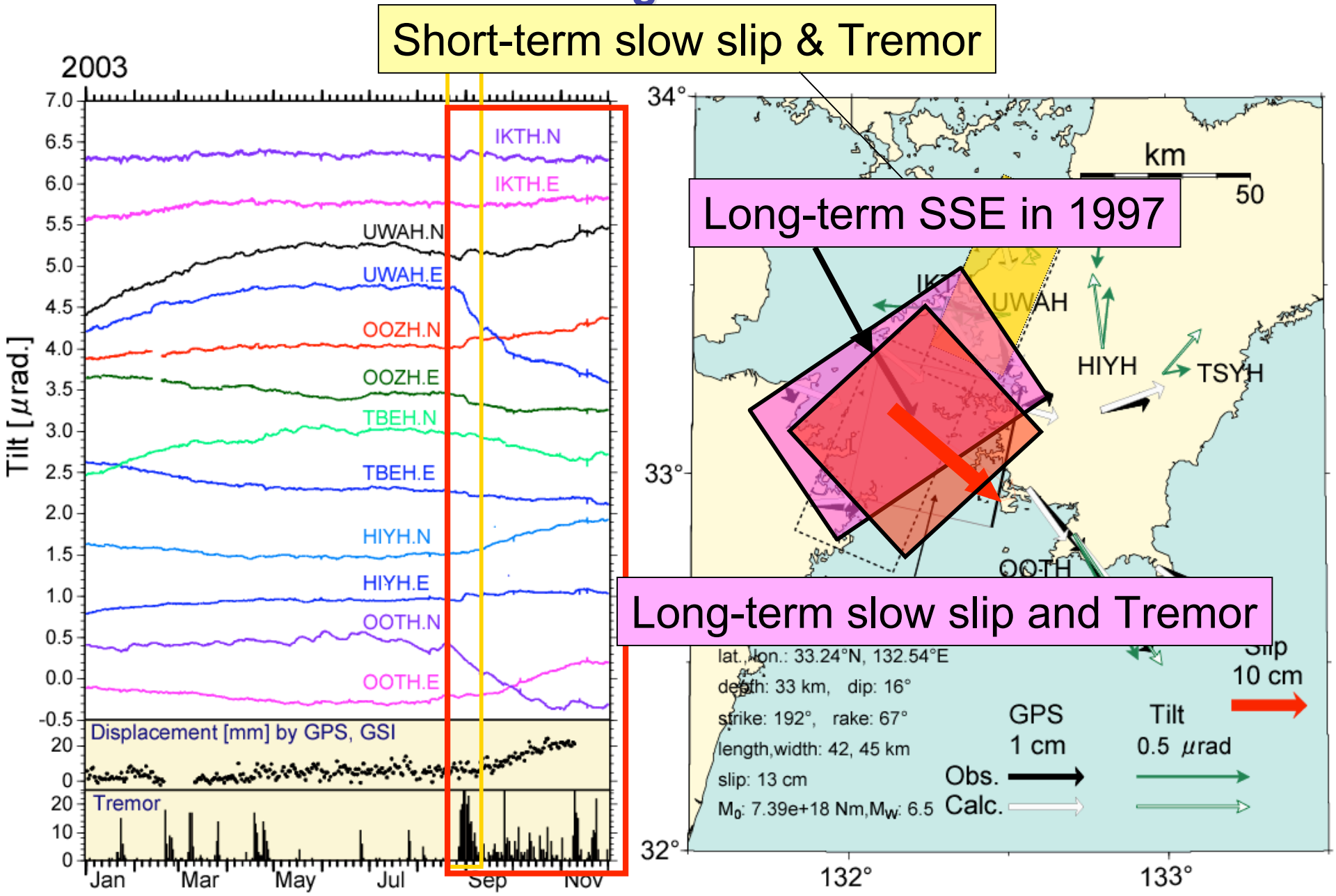




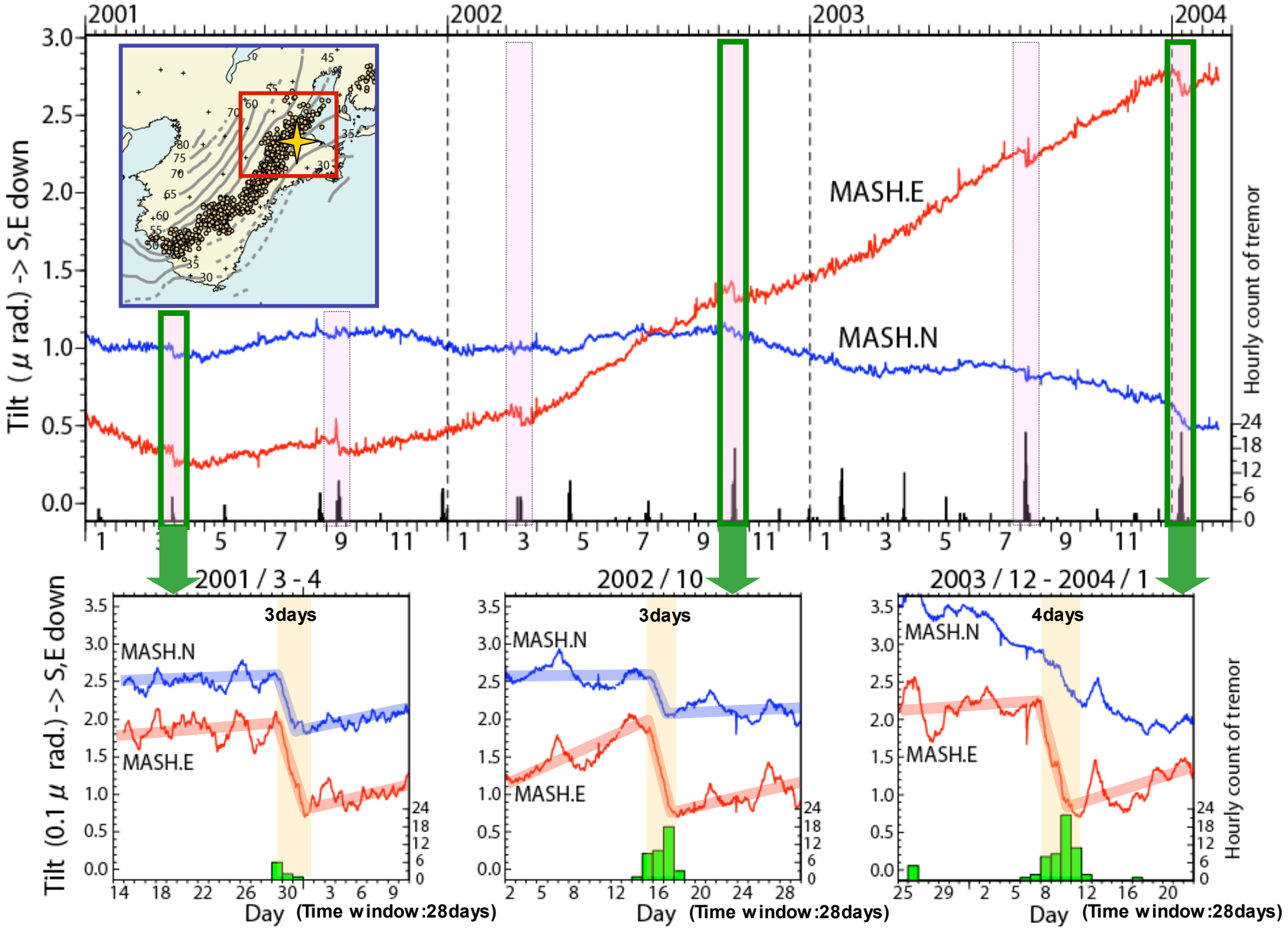
Observed Tremor and Slow slip



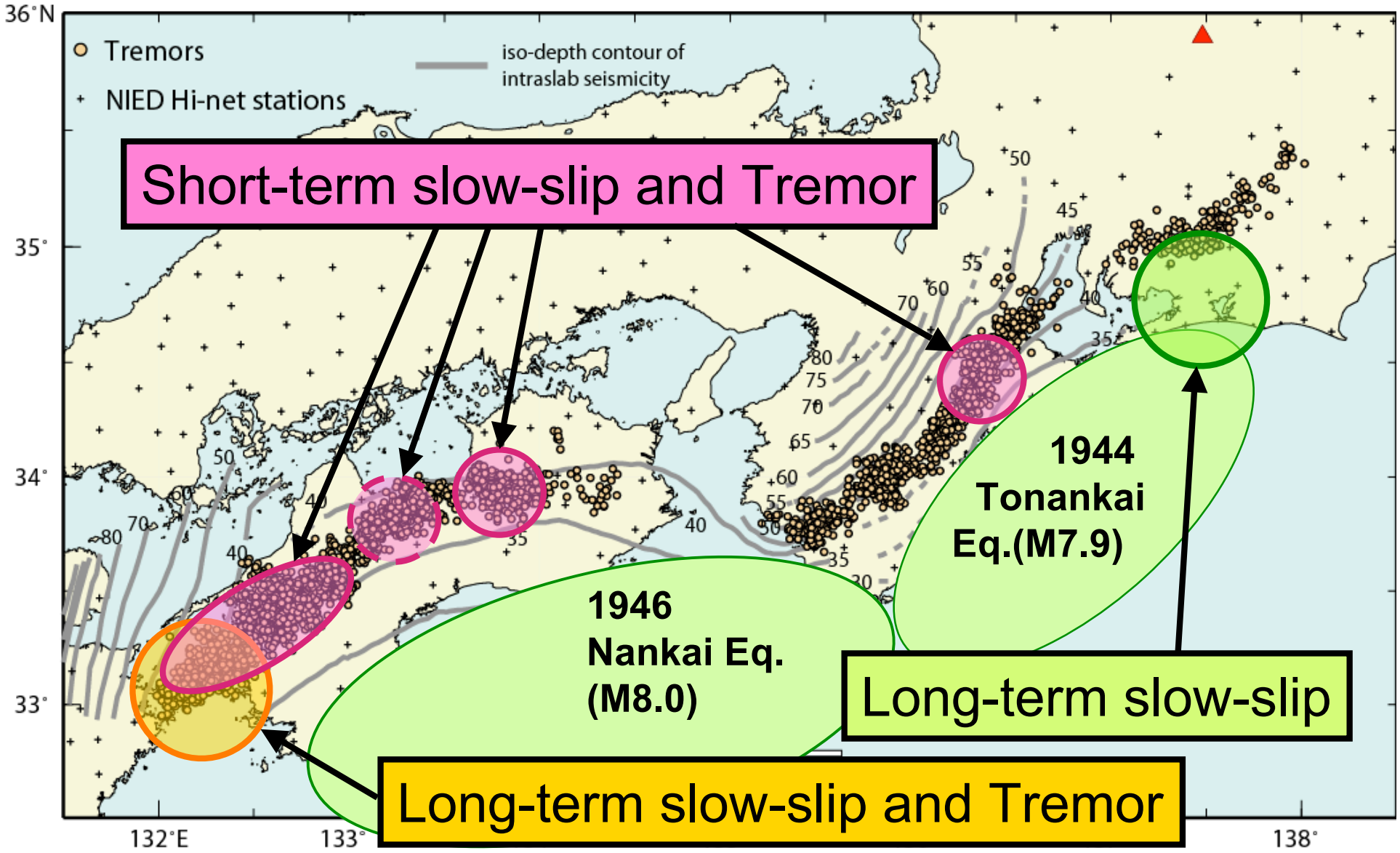
Short-term and long-term slow slip event(SSE) with tremor from August 2003



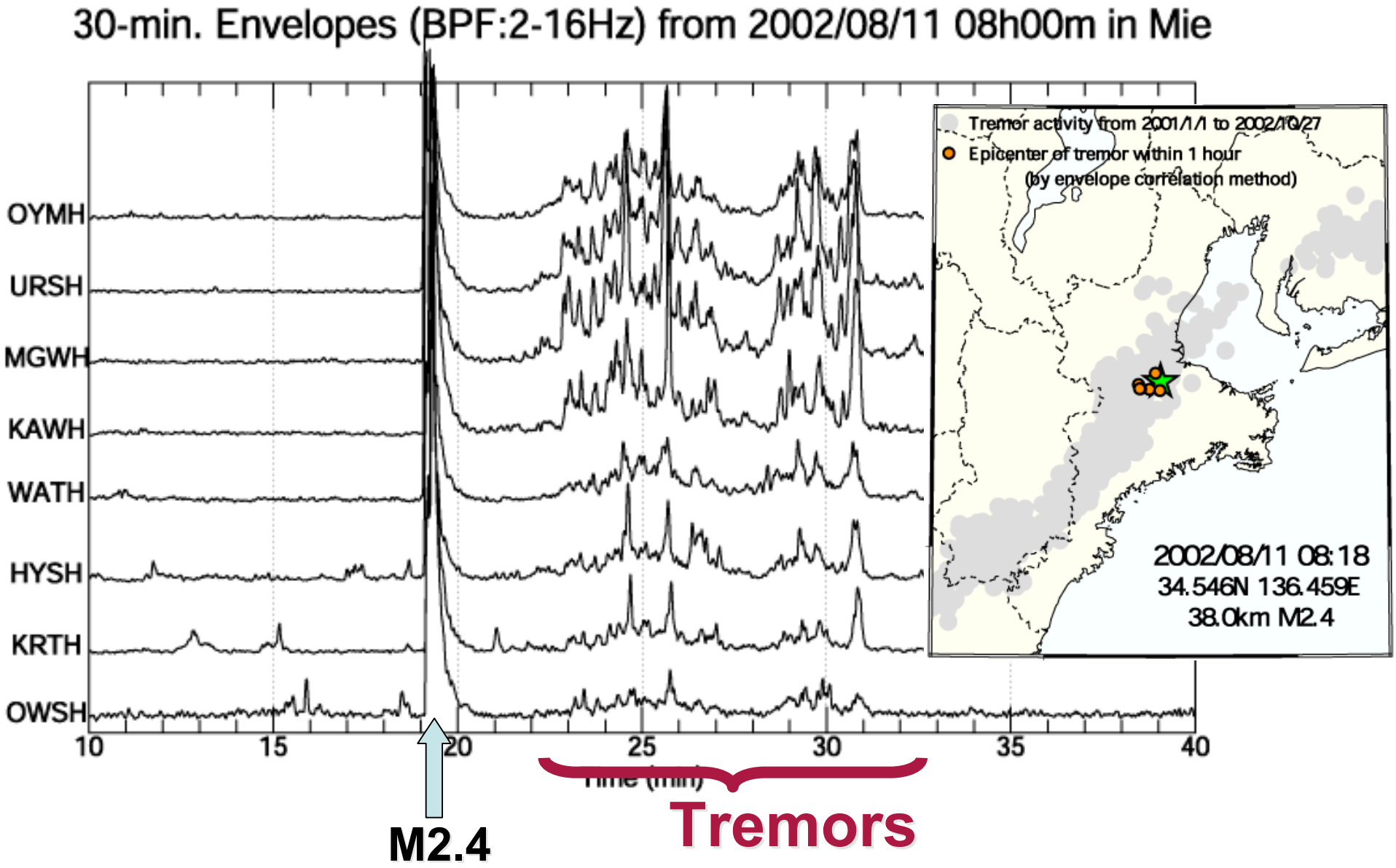
Tilt change and tremor in Kii area



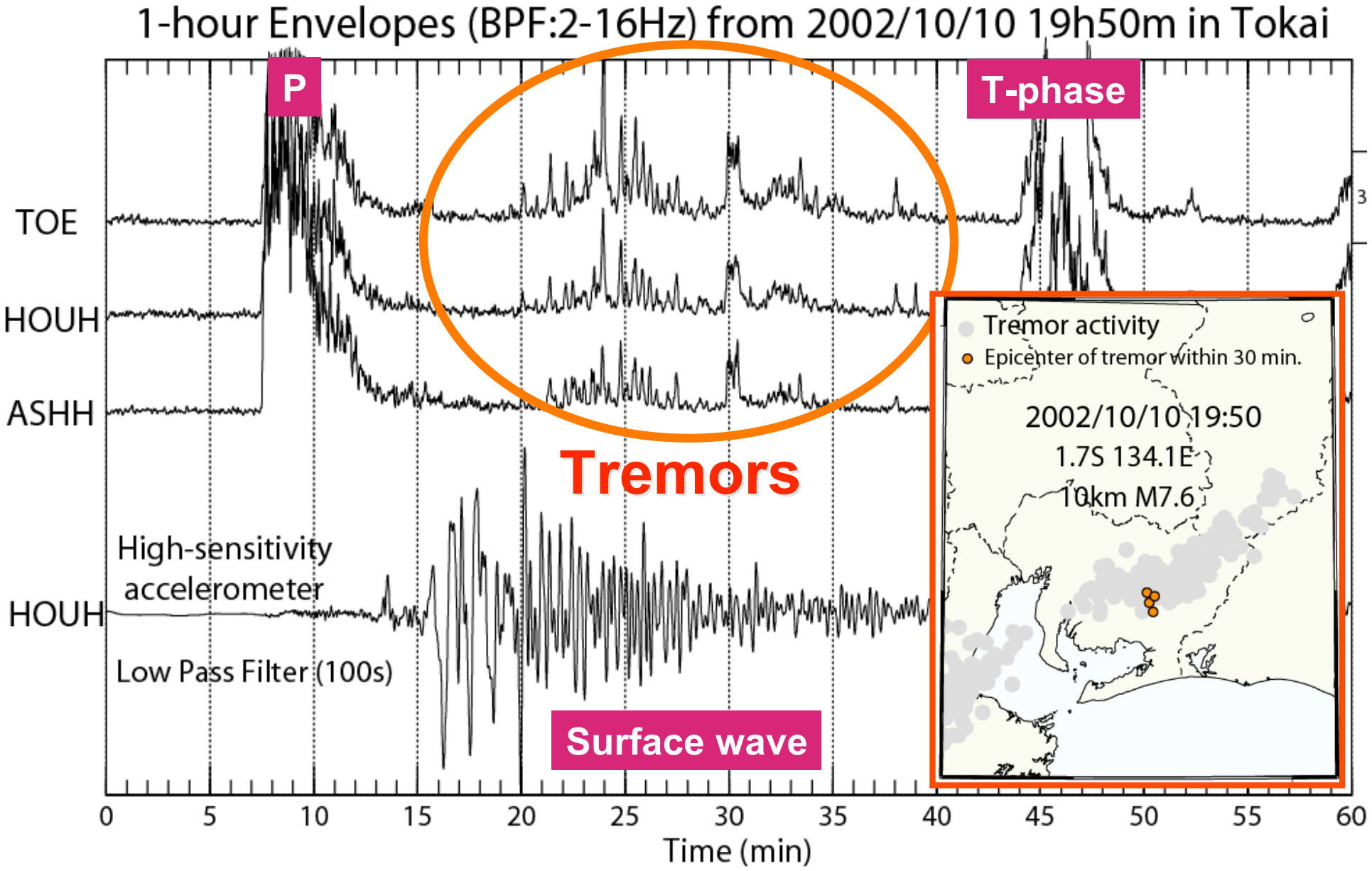
Distribution of short- and long-term slow slip events in SW Japan



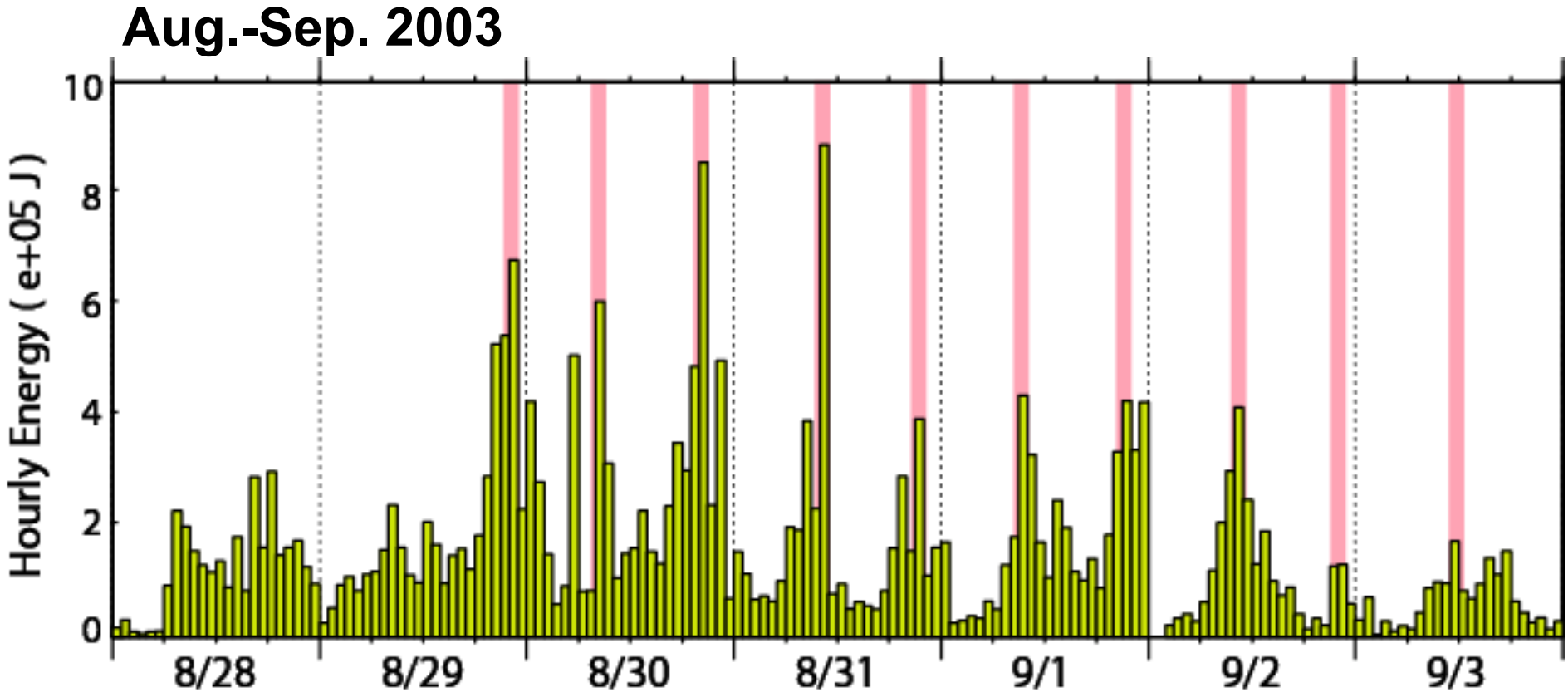
Tremor triggered by M2.4 microearthquake



Tremor triggered by M7.6 Indonesia earthquake



Tremor energy release in the active stage with short-term slow slip in west of Shikoku



The periodicity of 12 hours == effect of earth tide

Summary for Tremor and Slip

-Non-volcanic deep tremor

- at the down dip of the seismogenic zone
- sometimes triggered by seismic wave

- Major Tremor and short-term slow slip event

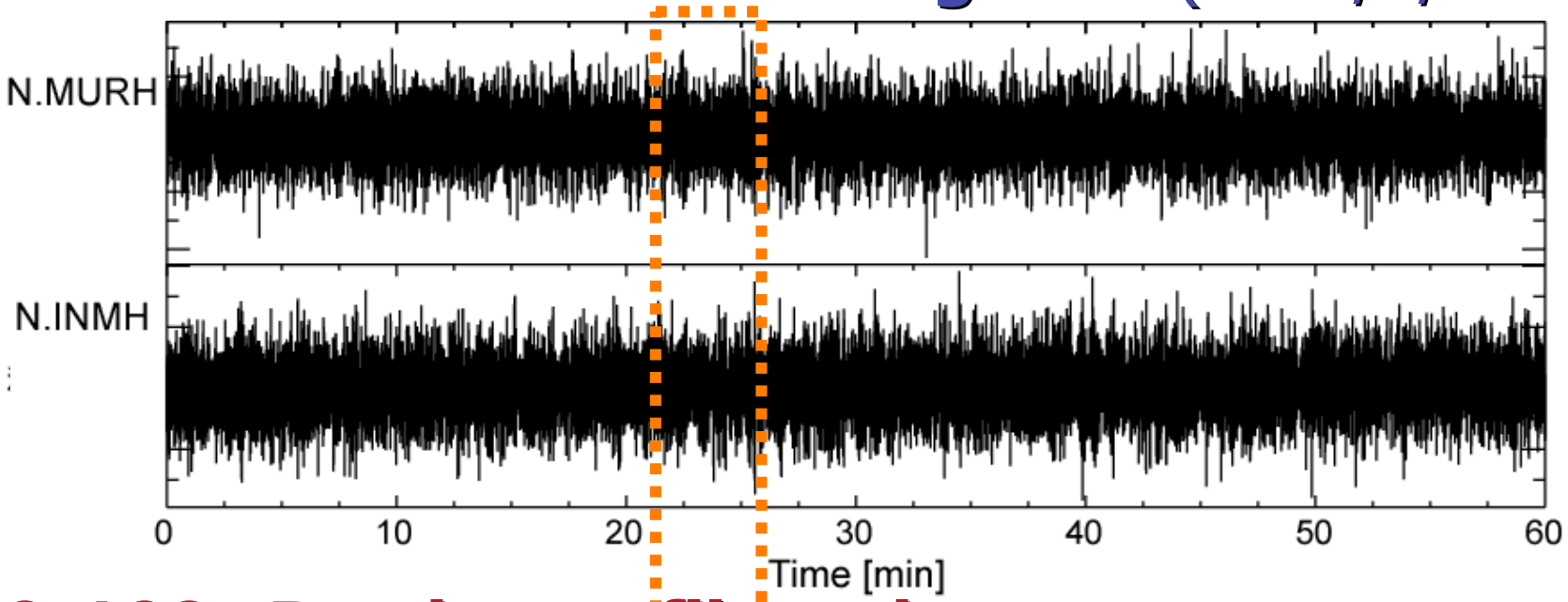
- occurs periodically
  (6 months in W. Shikoku, 3 months in E. Shikoku).
- continues for days ~ weeks.
- migrates along the strike of subducting slab.

-Tremor and long-term slow slip event

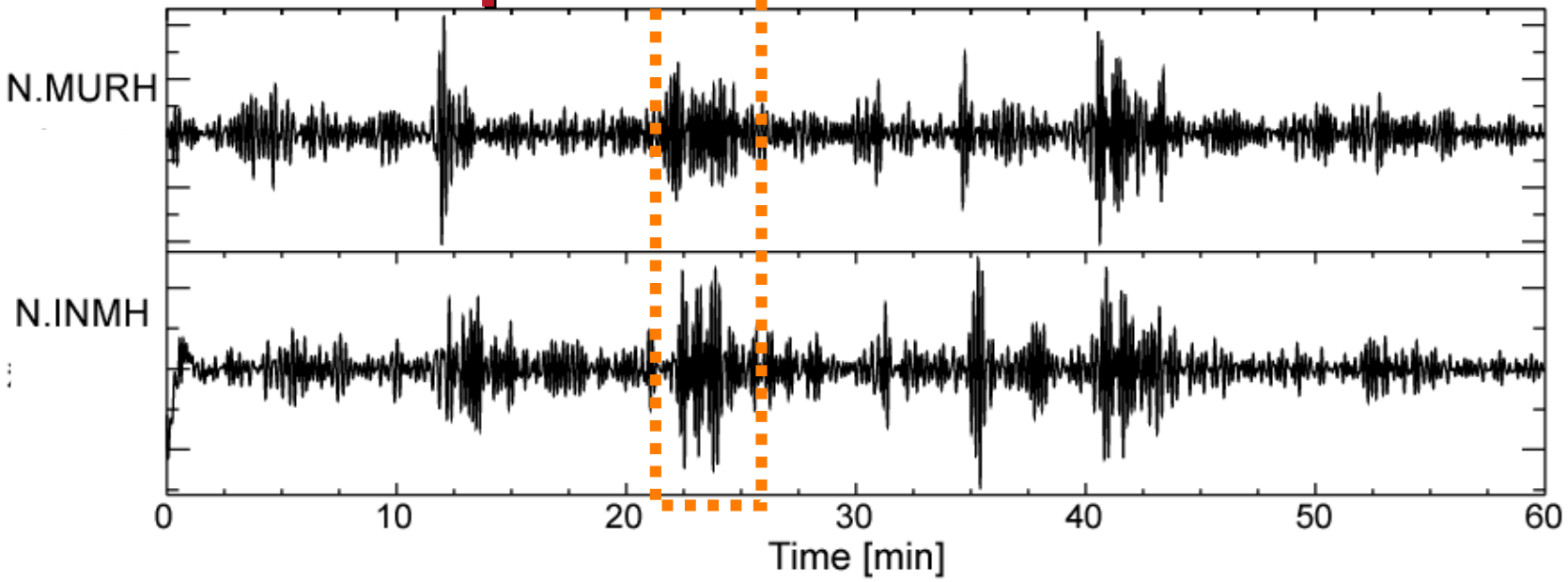
- detected in Bungo Channel.
- Unclear in Tokai

Very Low-Frequency earthquake near the Nankai trough

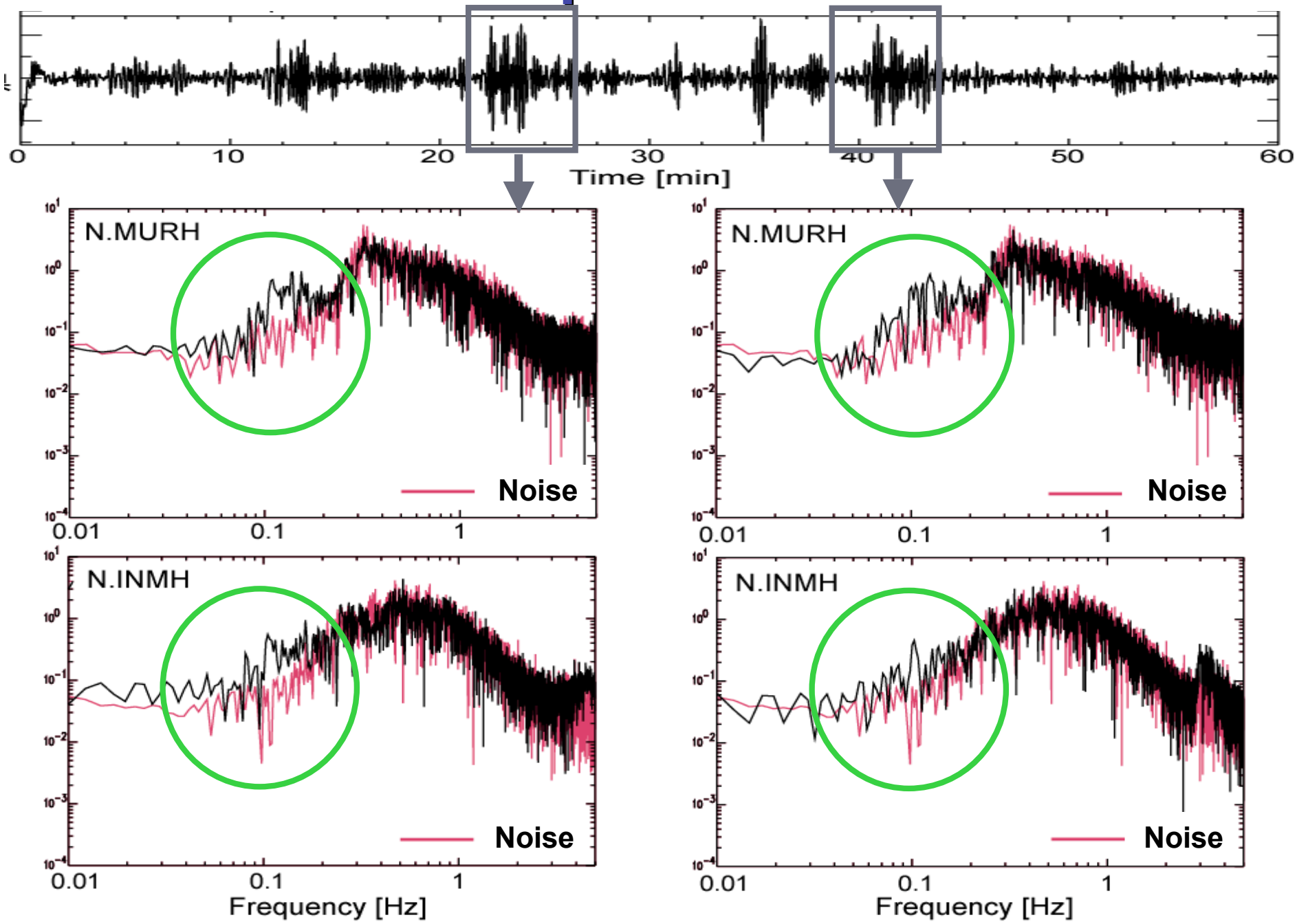
1 hour broadband seismograms (2003/7/6 03h)



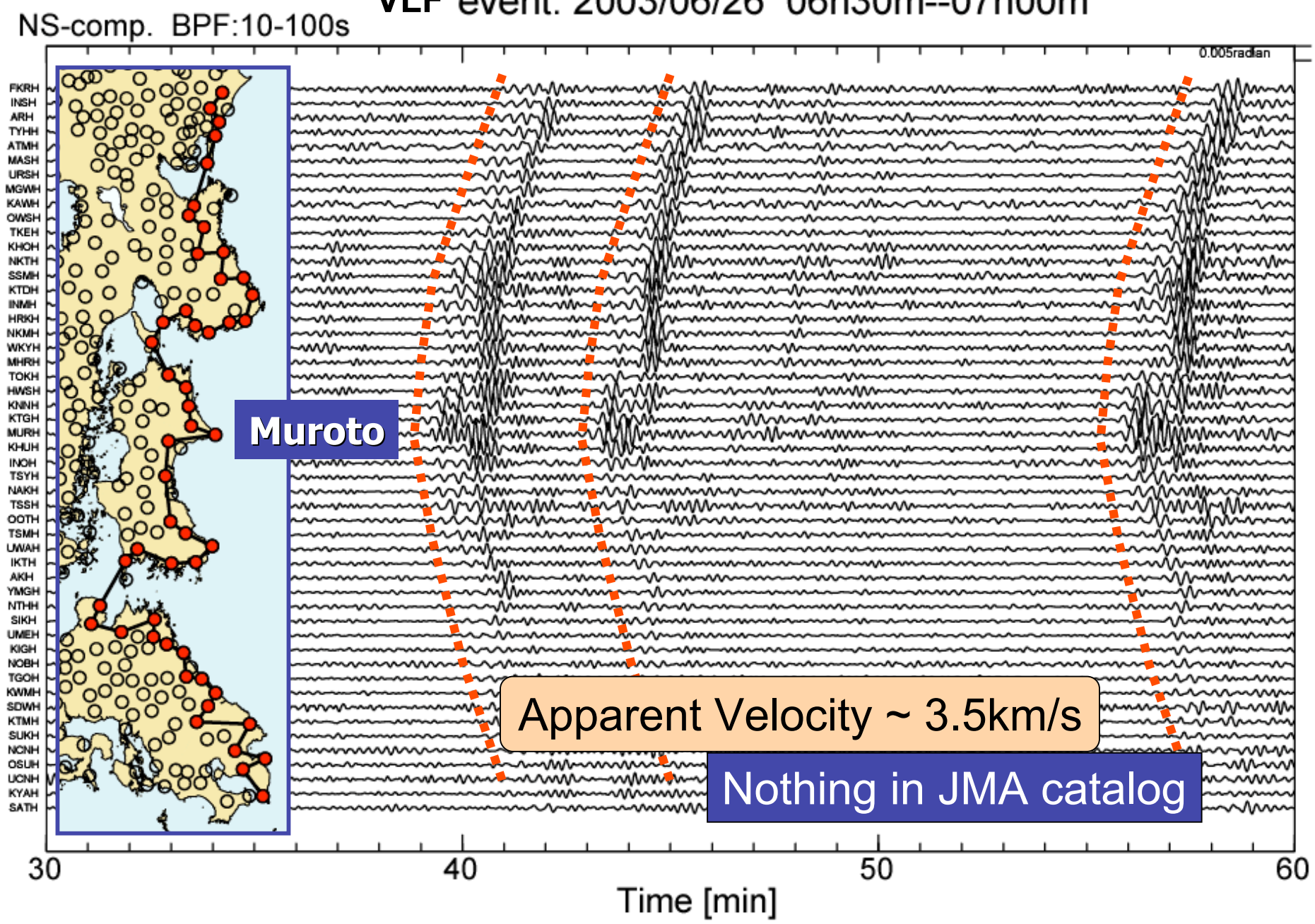
10-100s Band-pass filtered traces



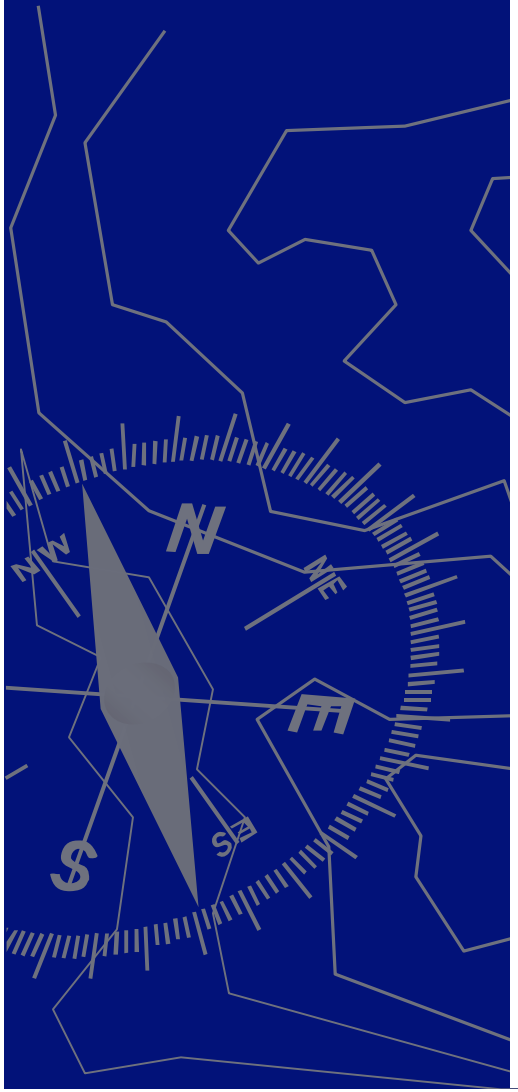
Spectra

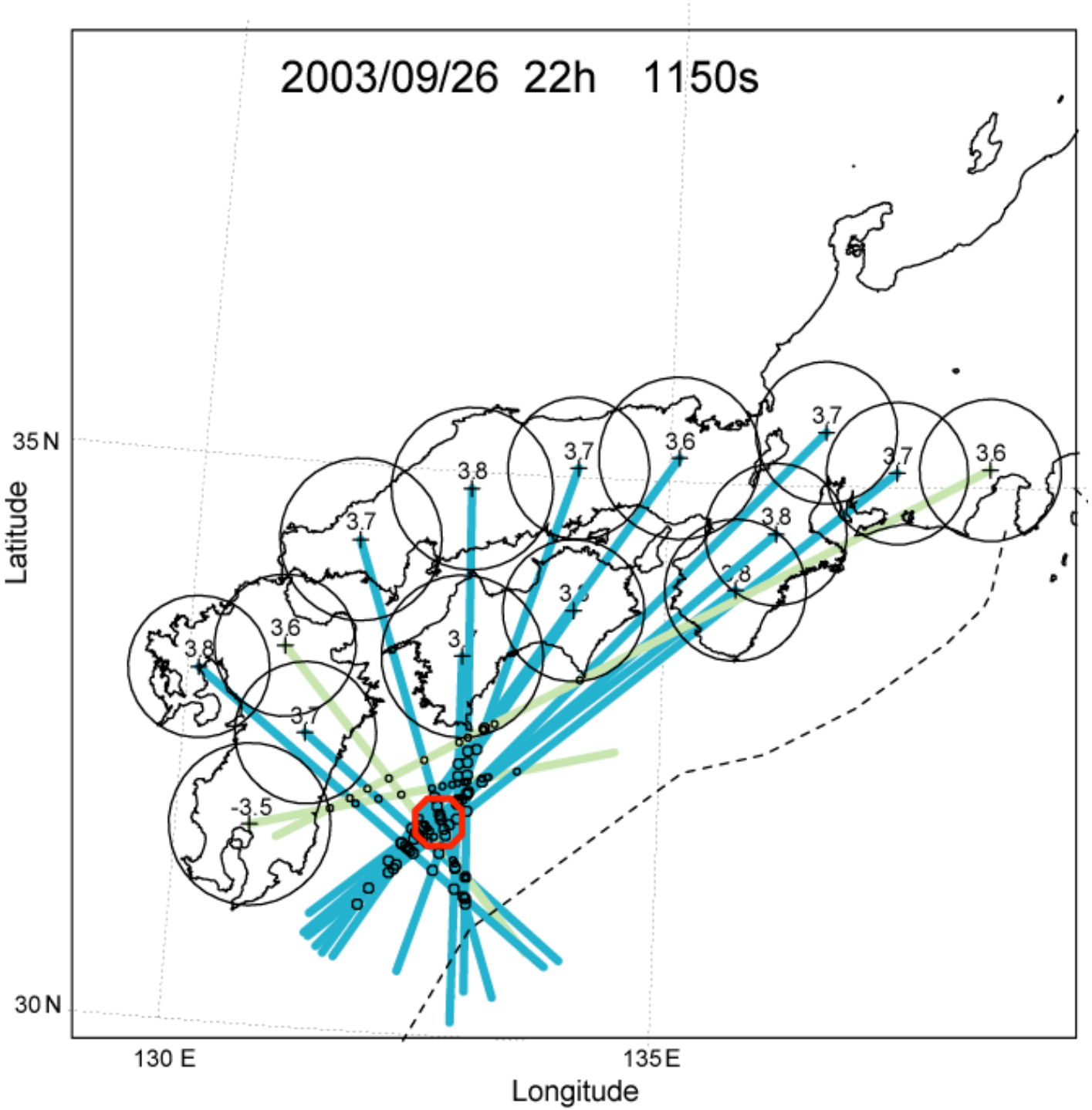

0
10
20
30
40
50
60
Time [min]
N.MURH
Noise
N.MURH
Noise
N.INMH
Noise
N.INMH
Noise
0.01
0.1
1
Frequency [Hz]

Seismograms along the Pacific coast line

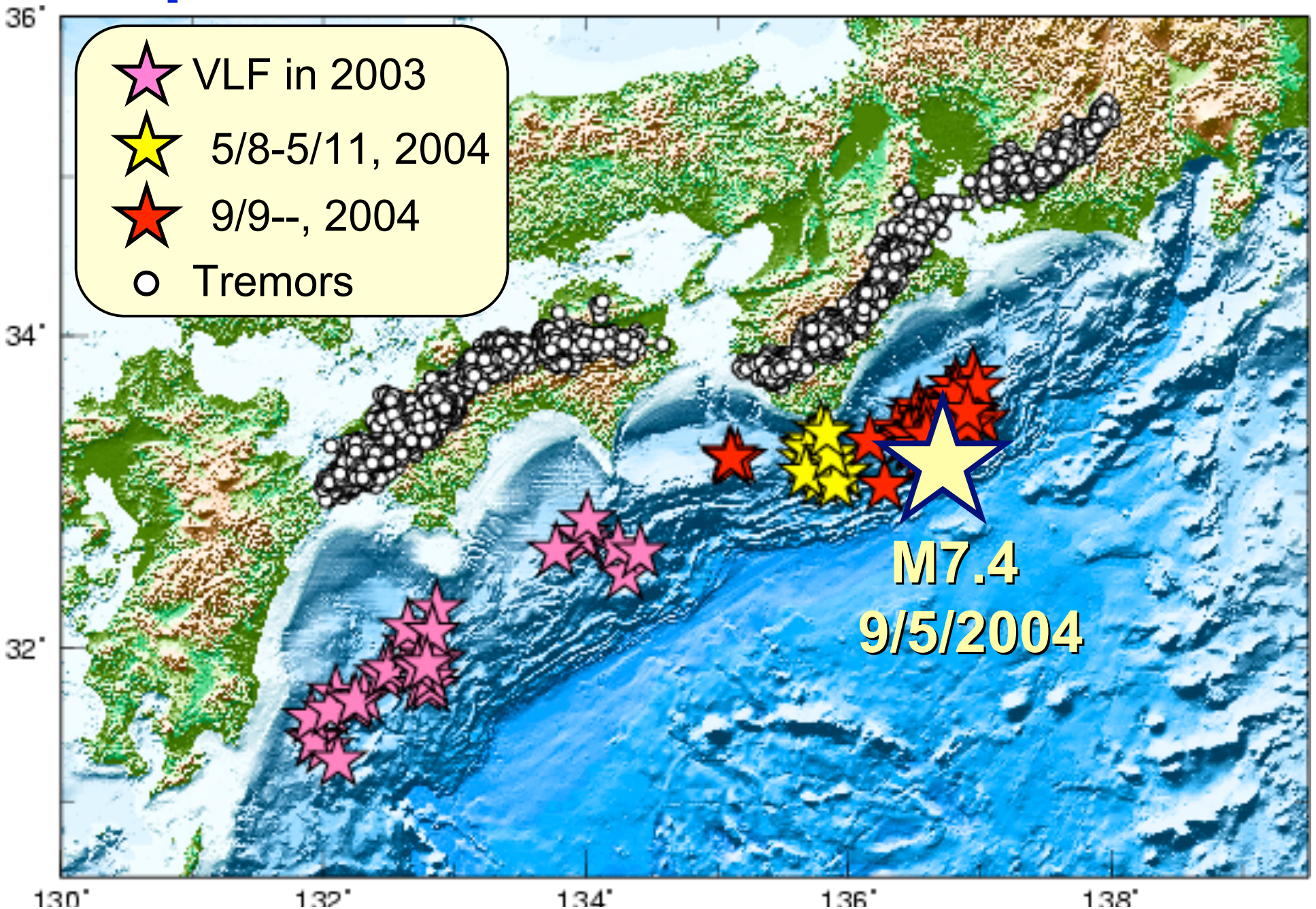


Estimation of epicenter

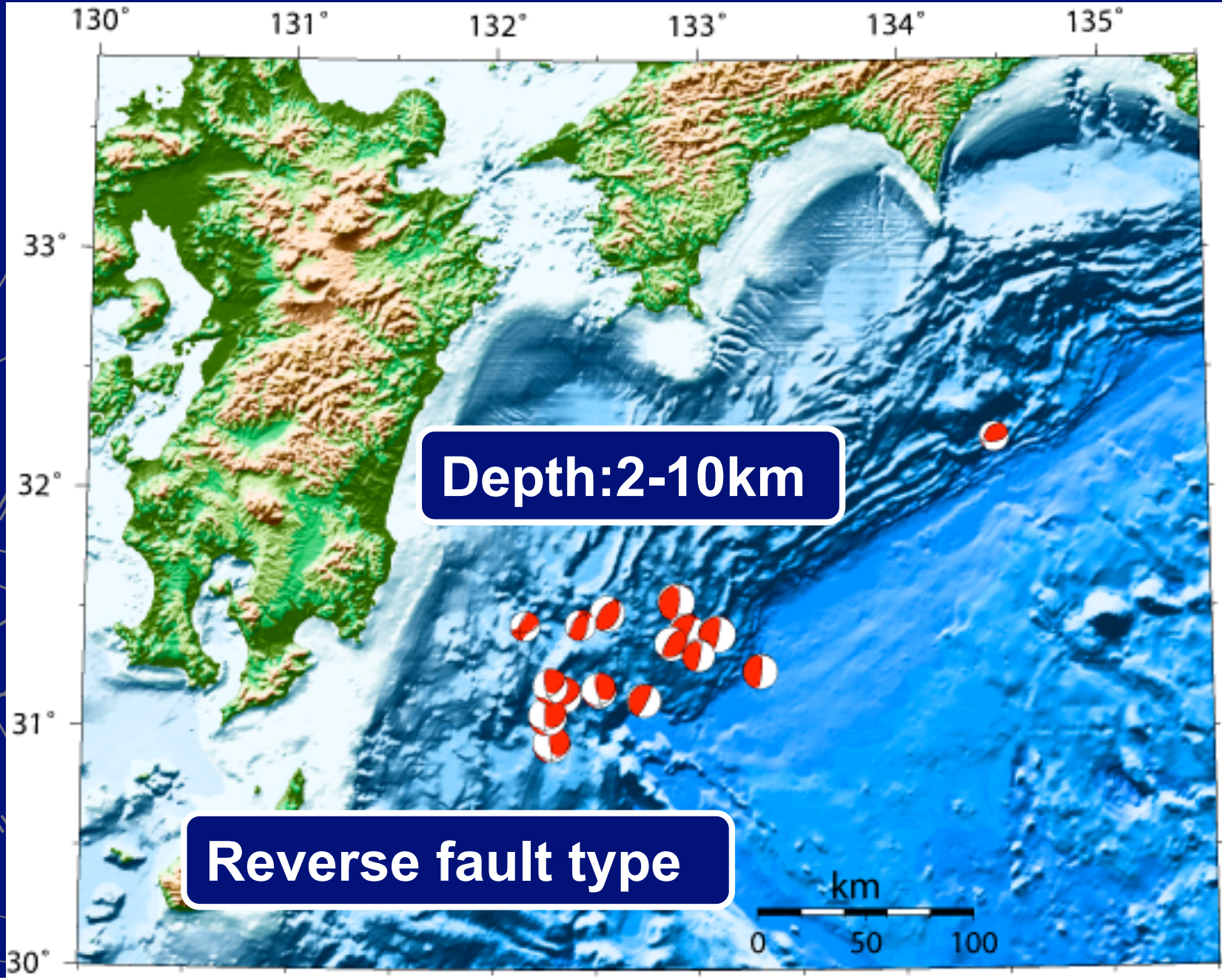




Epicentral distribution of VLF events

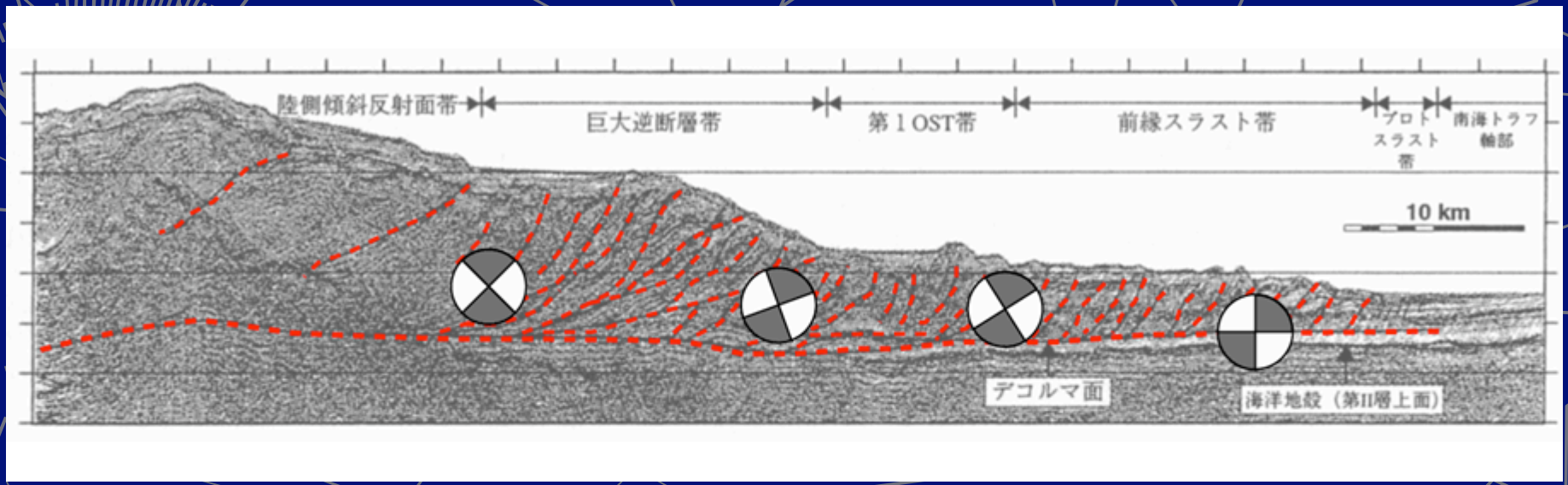


Relocation and CMT analysis



Summary of VLF events

1. VLF events generate only surface wave.
2. The source depth is very shallow.
3. The mechanism is reverse fault type.
4. VLF events might occur in the accretionary wedge or the plate boundary.



Conclusions

1. Deep tremors occur in a narrow belt at the down dip of the seismogenic zone.

2. Slow slip events occur in some parts of the tremor zone.

3. The style of the coupling phenomena has regional differences.

4. VLF events are located along the Nankai trough.

5. Both events might be related to the subduction of the Philippine Sea plate.

Slow events on the Nankai subduction zone