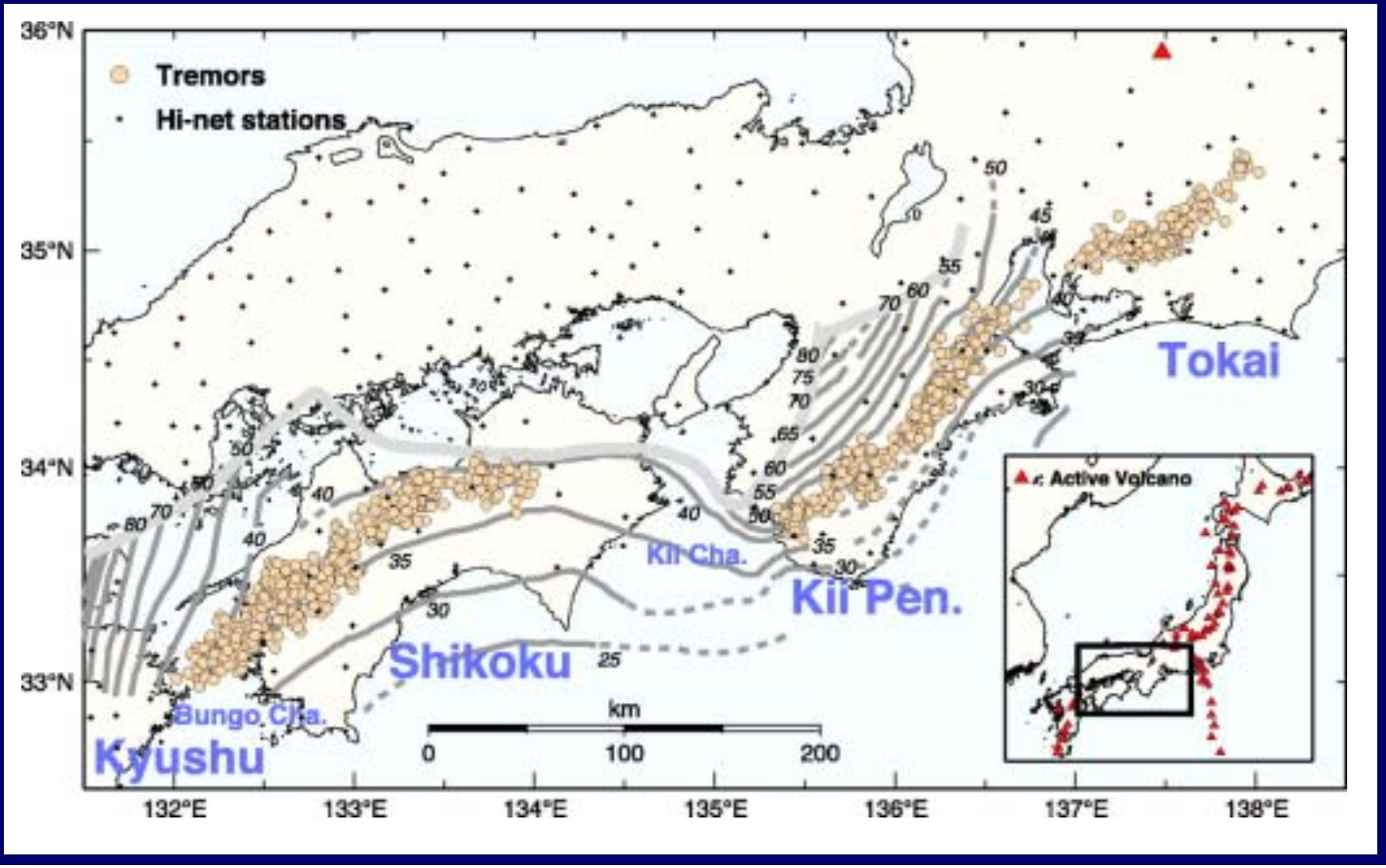
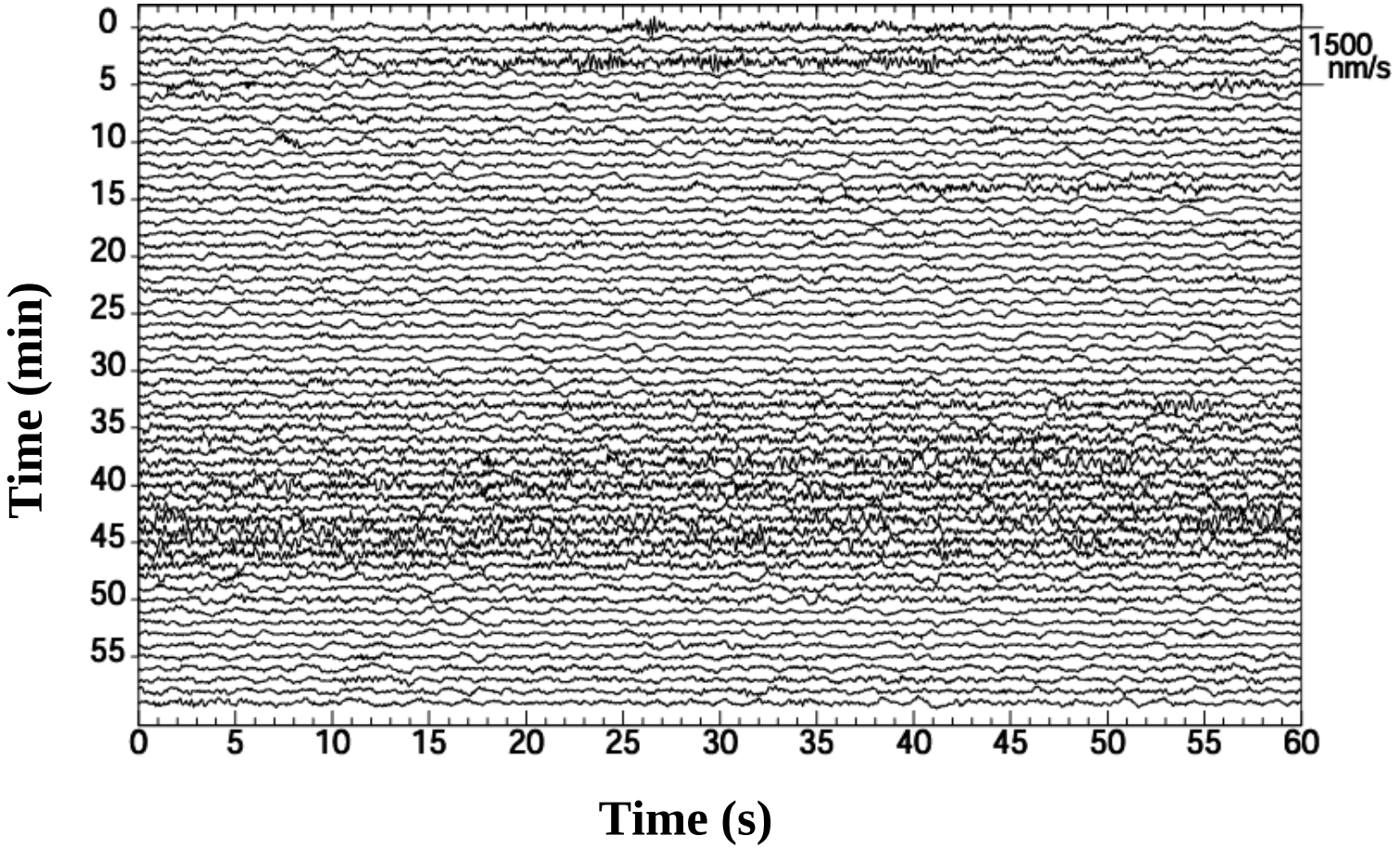
Nonvolcanic deep tremor associated with subduction in Southwest Japan

Kazushige Obara (NIED)



One-hour record chart at the station IKTH in Shikoku Island, Southwest Japan (2001/8/17 4 a.m.)



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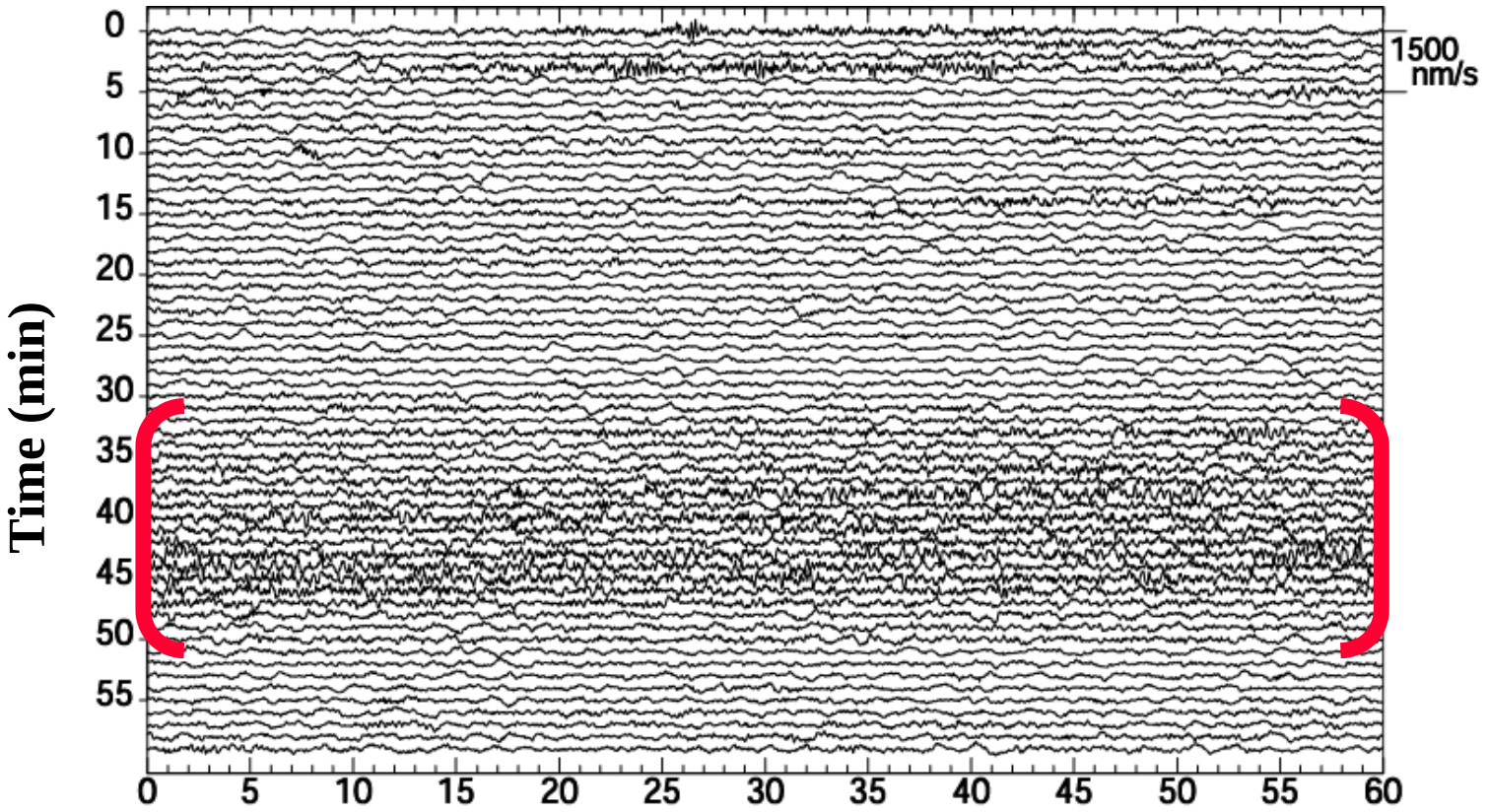
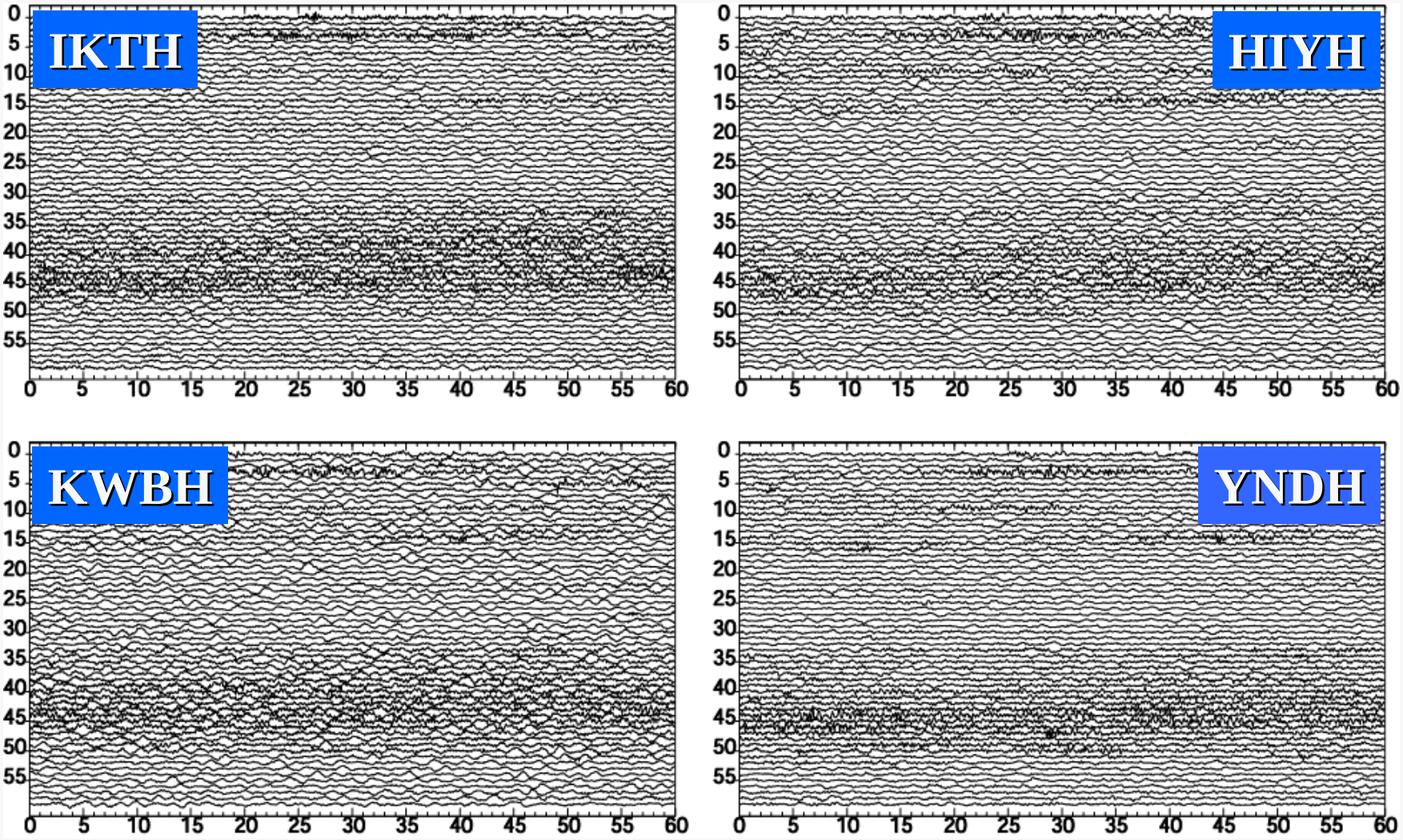
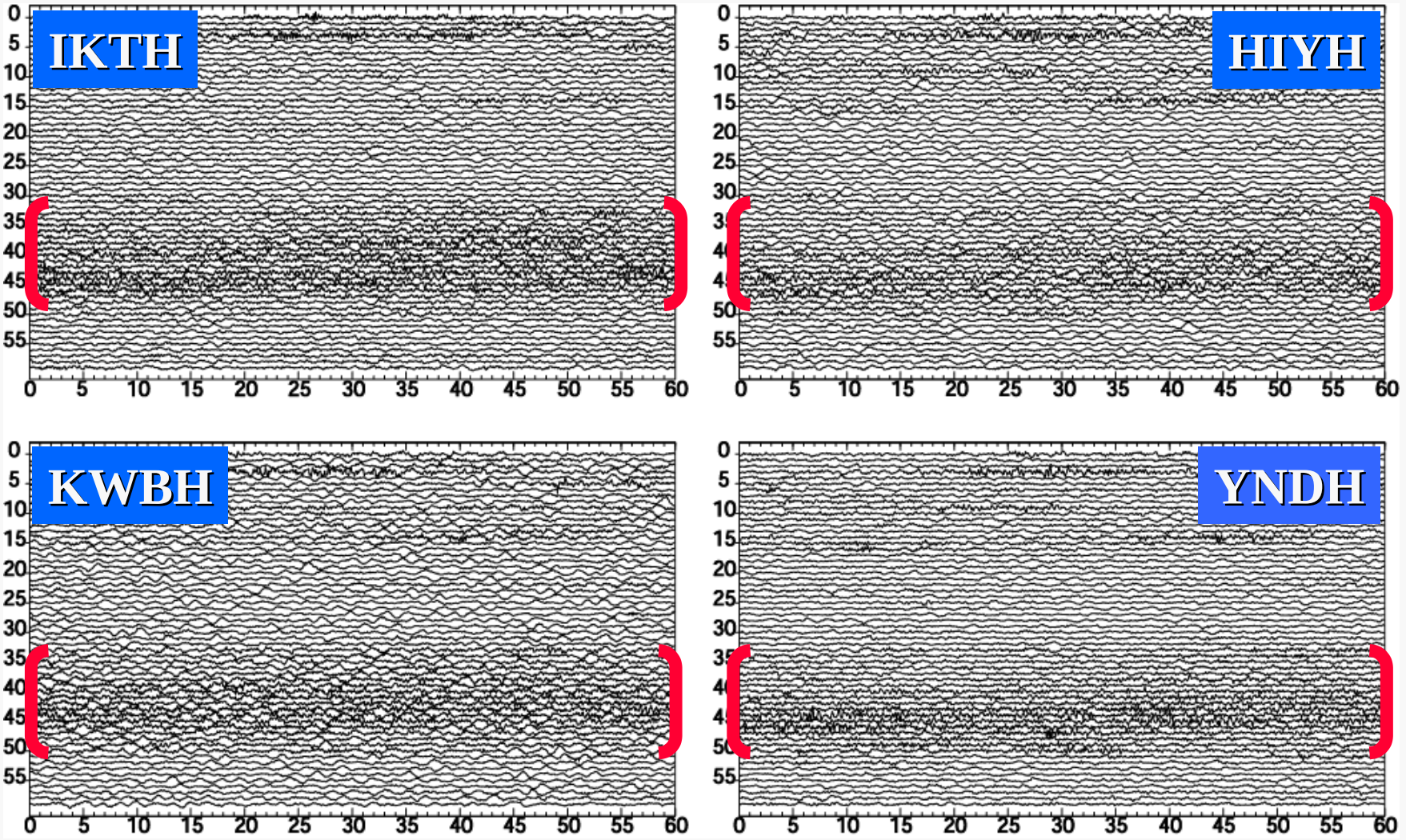
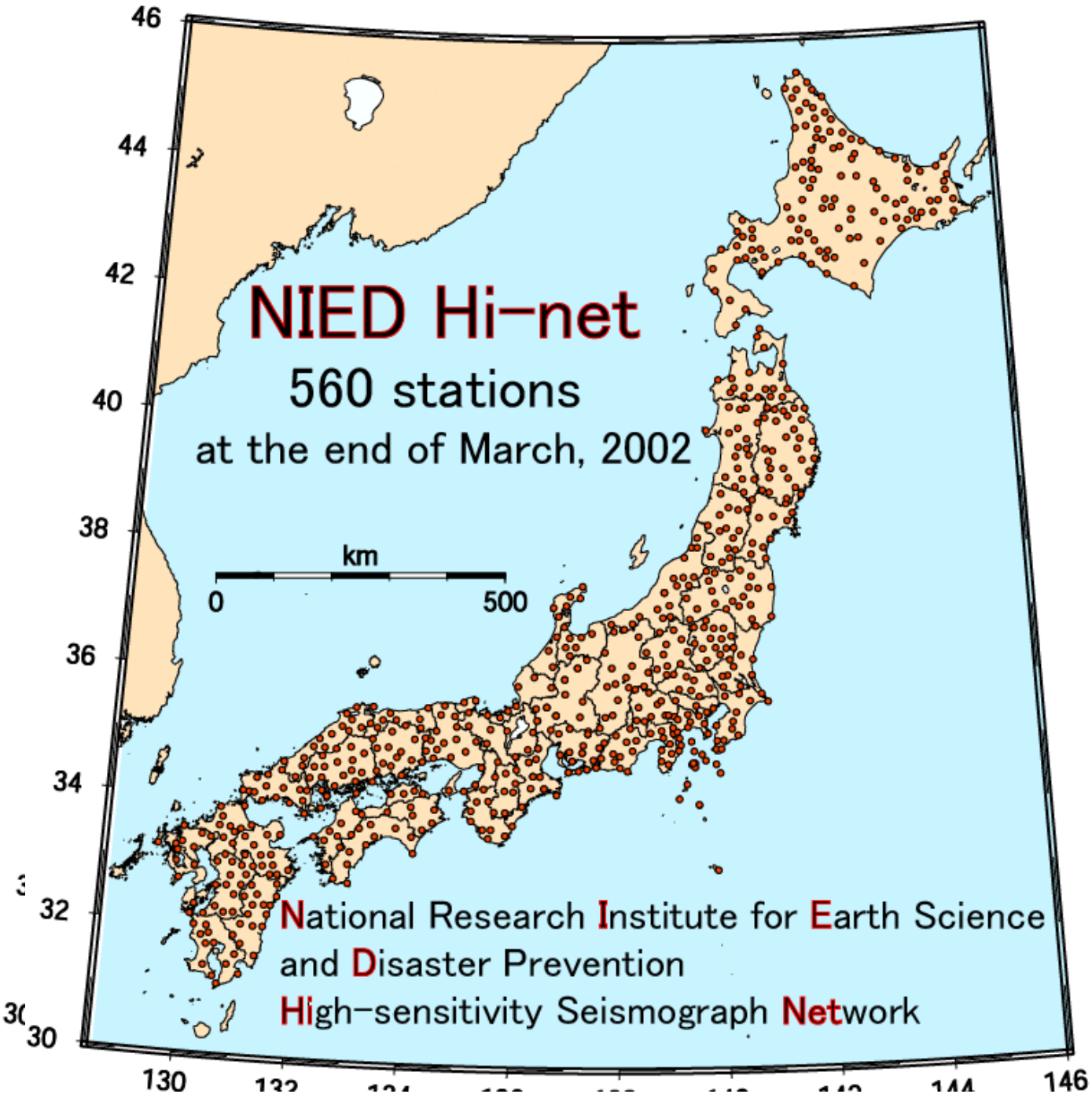


One-hour record chart at four stations in Shikoku Island (2001/8/17　4 a.m.)

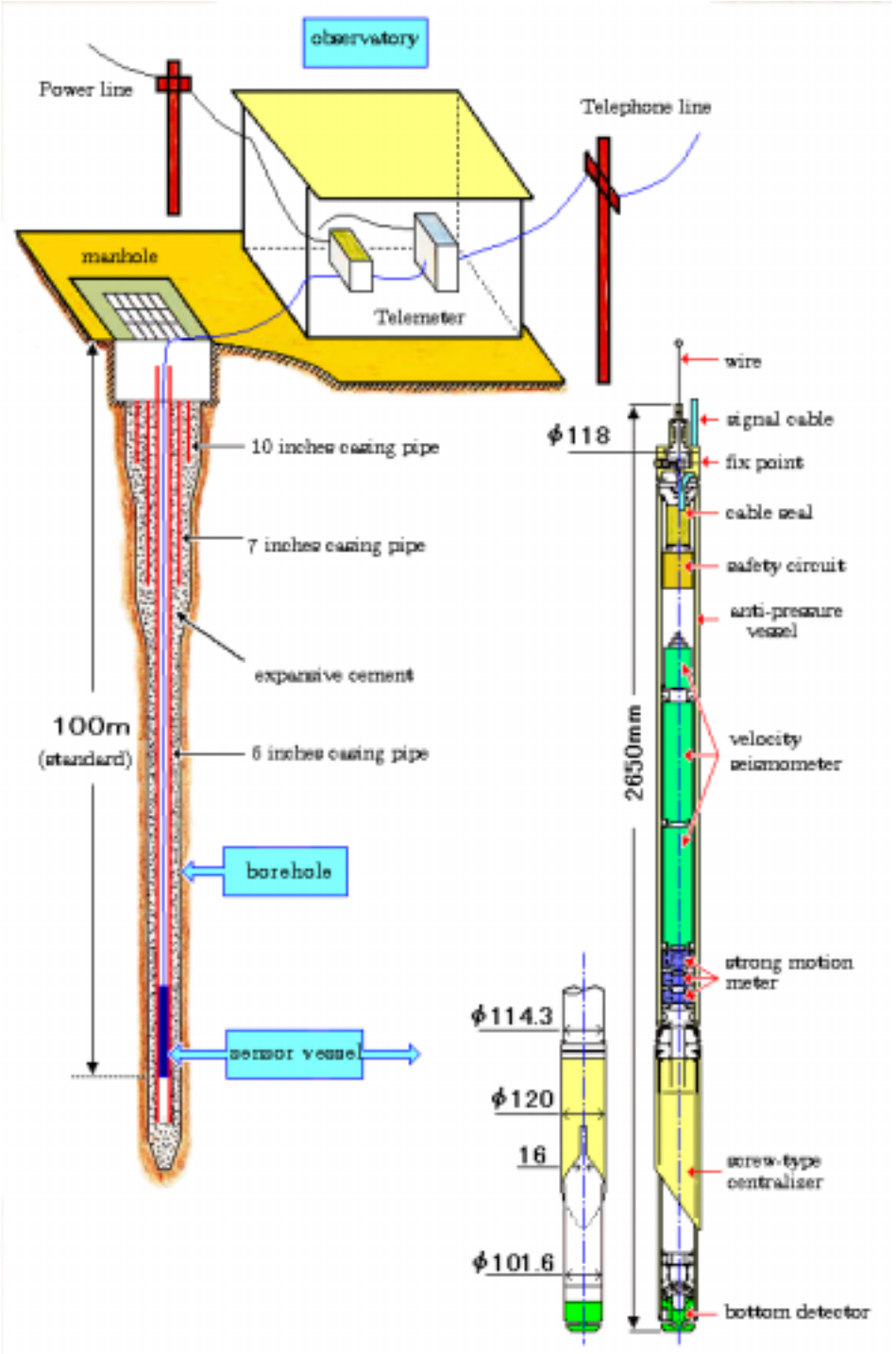


One-hour record chart at four stations in Shikoku Island (2001/8/17　4 a.m.)




NIED Hi-net
560 stations
at the end of March, 2002
km
0
500
National Research Institute for Earth Science
and Disaster Prevention
High-sensitivity Seismograph Network
46
44
42
40
38
36
34
32
30
130
146

A scene of drilling



Discovery of tremor

before Hi-net

sparsely distributed seismic network

It is impossible to discriminate between the tremor and cultural noises.

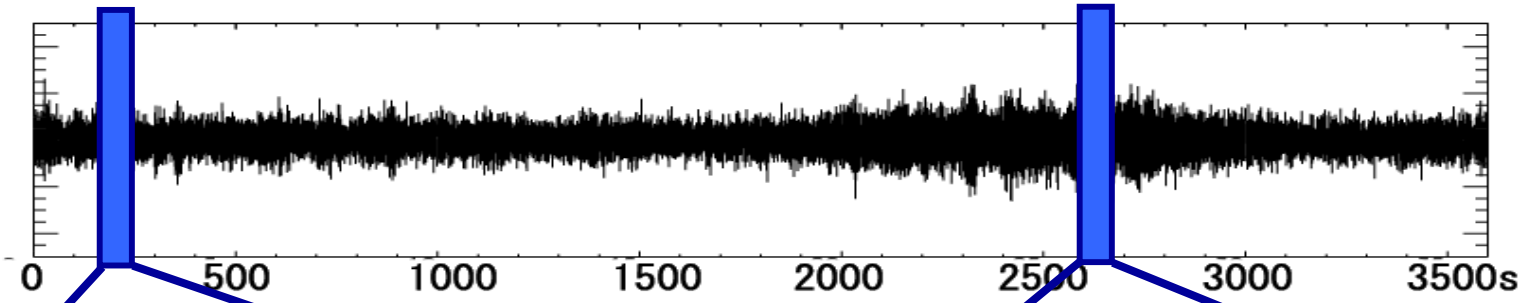
after Hi-net

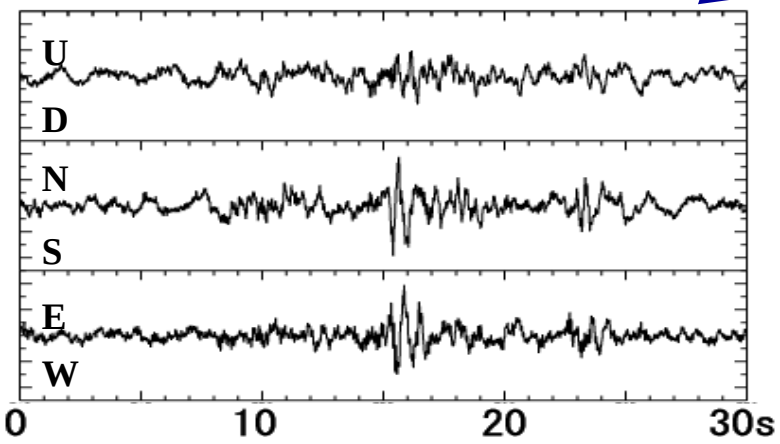
densely distributed high-sensitivity seismic network

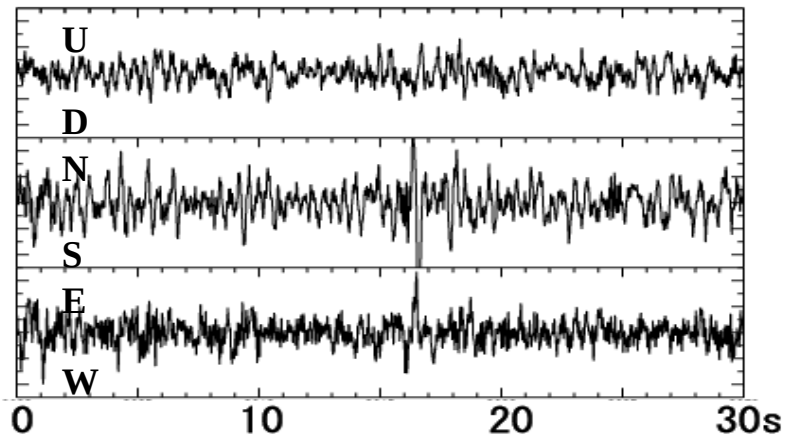
The amplitude pattern is the same at some neighbor stations.

natural phenomena

One-hour seismogram at IKTH







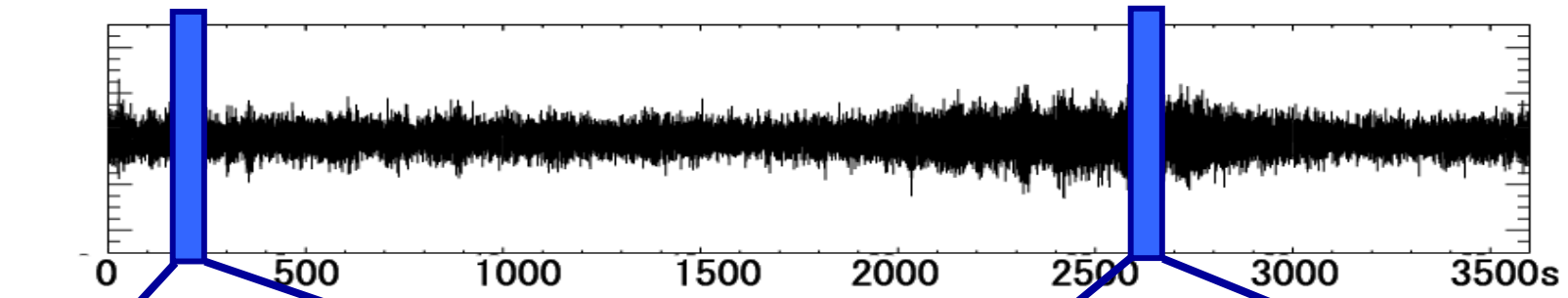
Including an isolated pulse

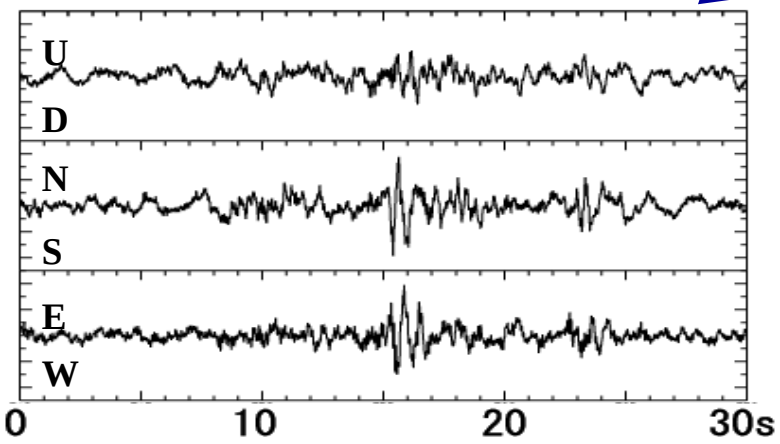
Random wave train

enable to locate as a low-frequency event

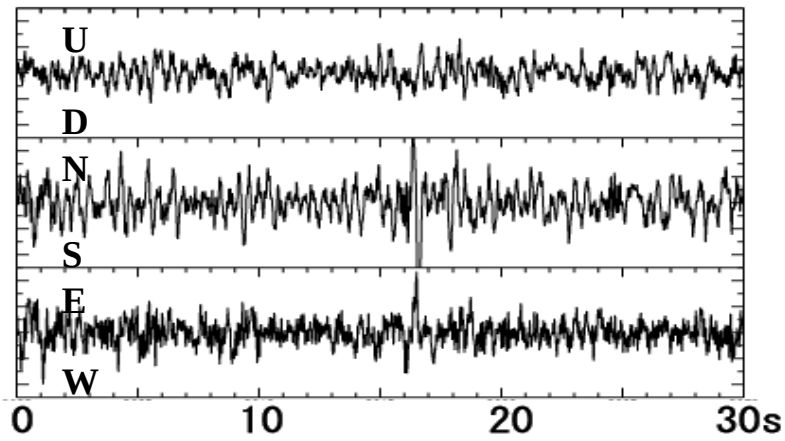
impossible to pick phases and locate the source

One-hour seismogram at IKTH





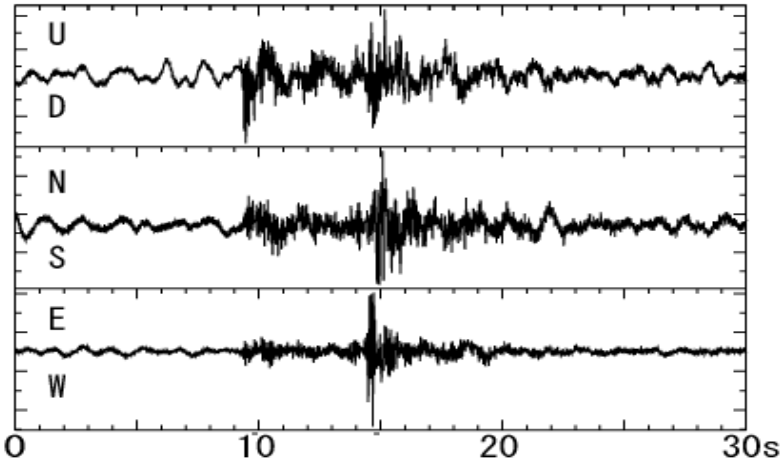
Including an isolated pulse



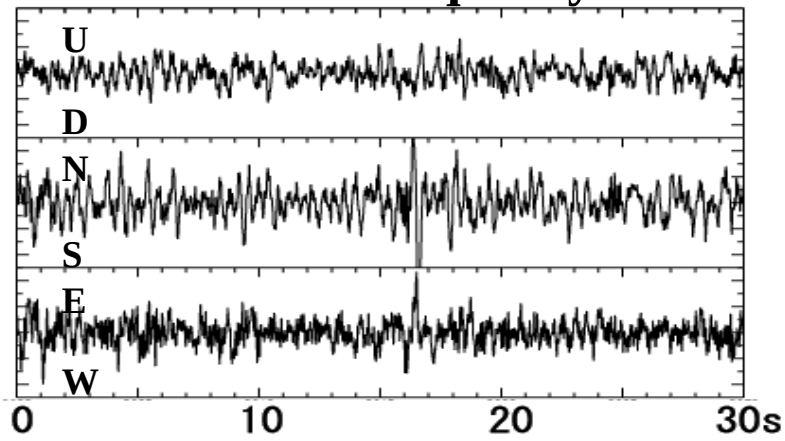
Random wave train

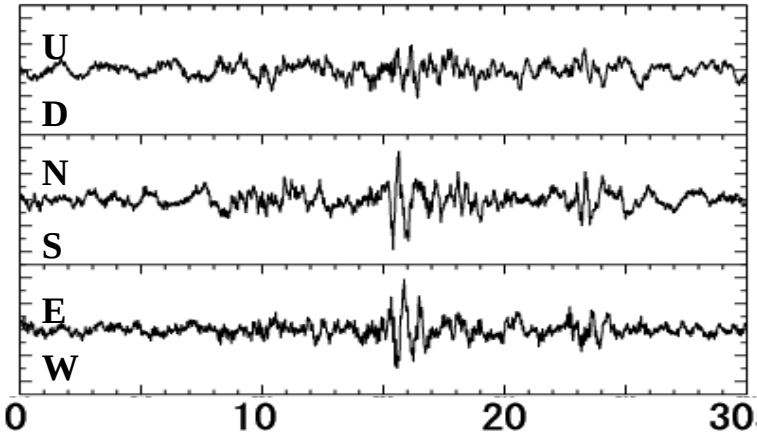
Very difficult to detect and monitor the tremor activity by normal hypocentral determination method

Normal event



Low-frequency tremor





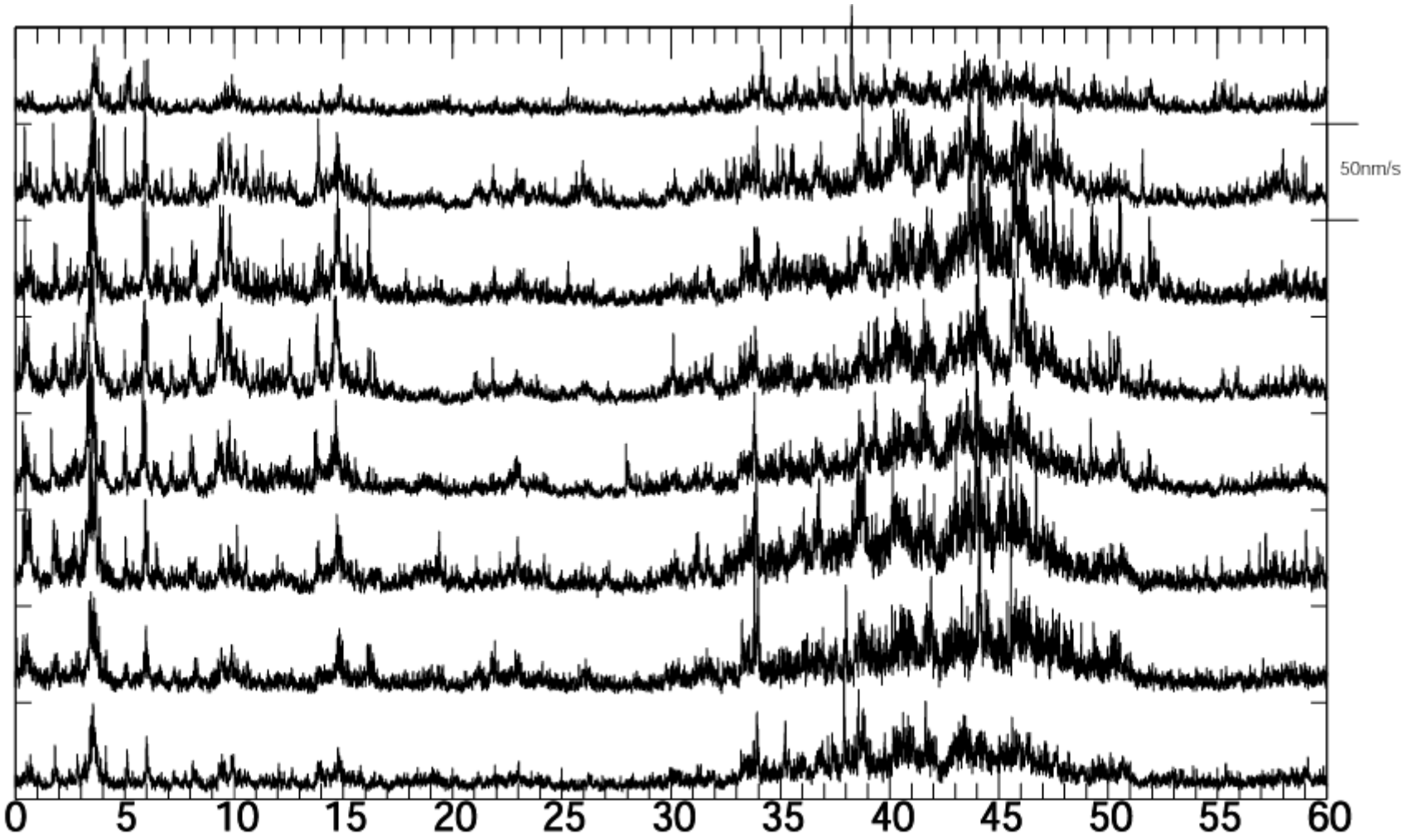
Including an isolated pulse

Random wave train

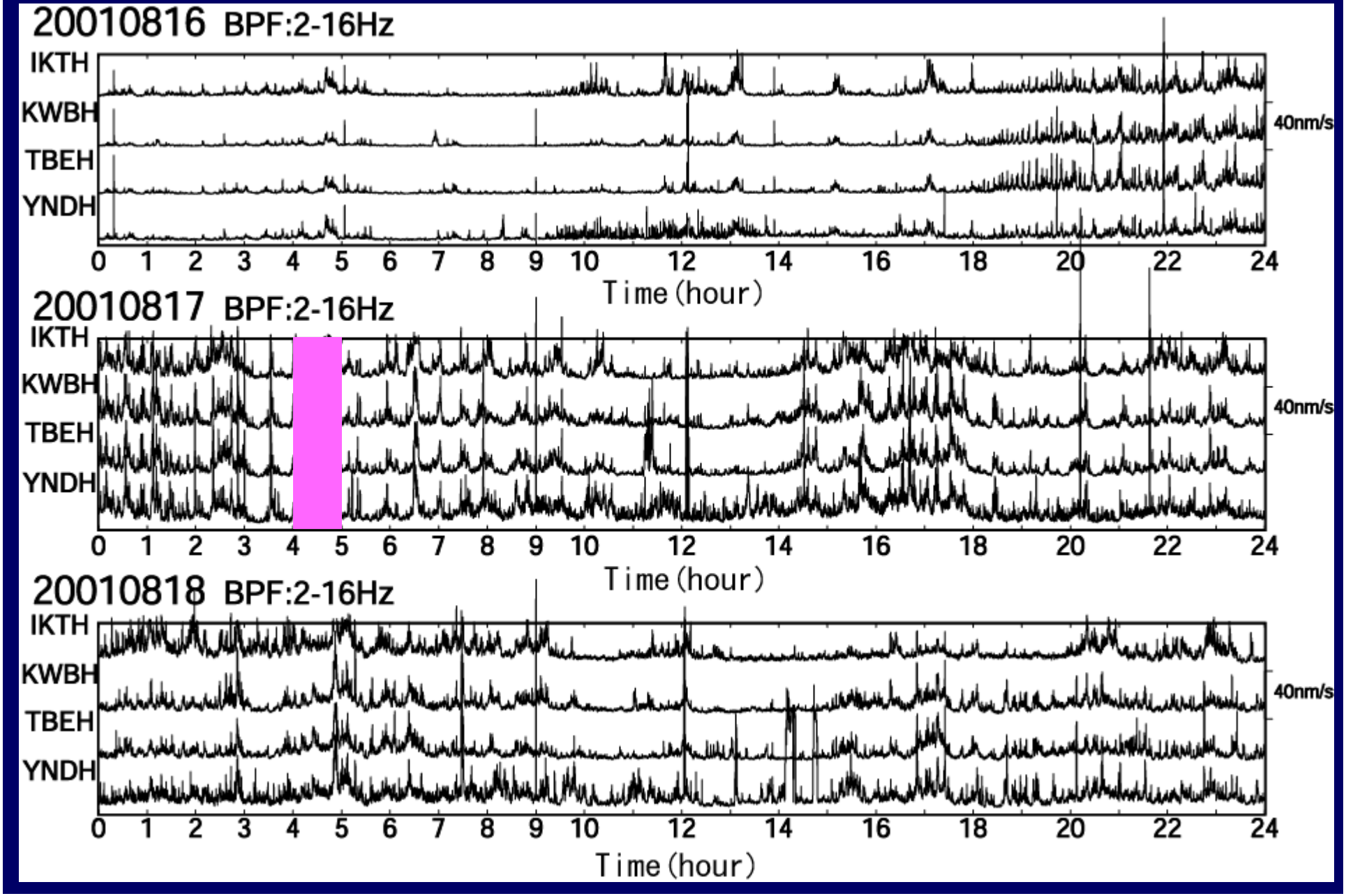
The tremor is characterized by low-frequency components compared with the same size microearthquakes

Envelope seismogram at 8 stations in Shikoku

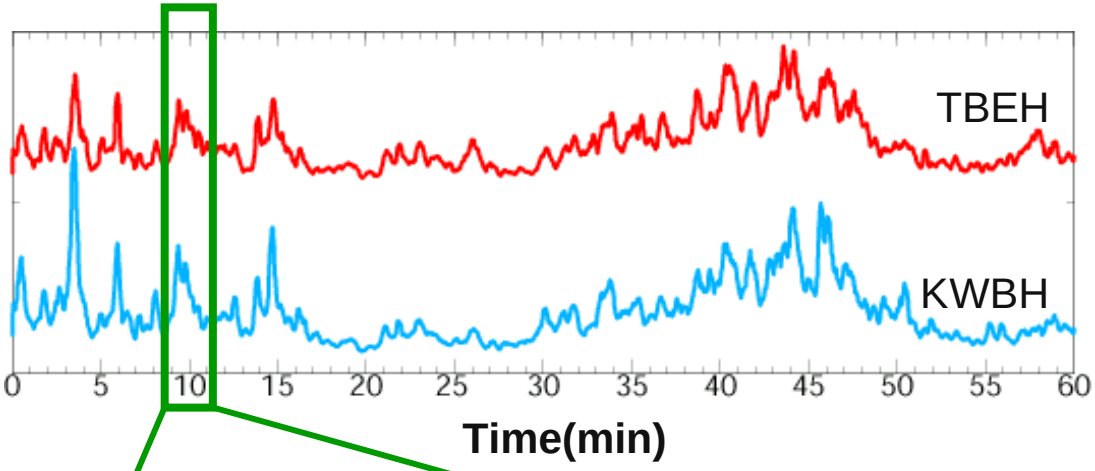
(2001/8/17　4am)

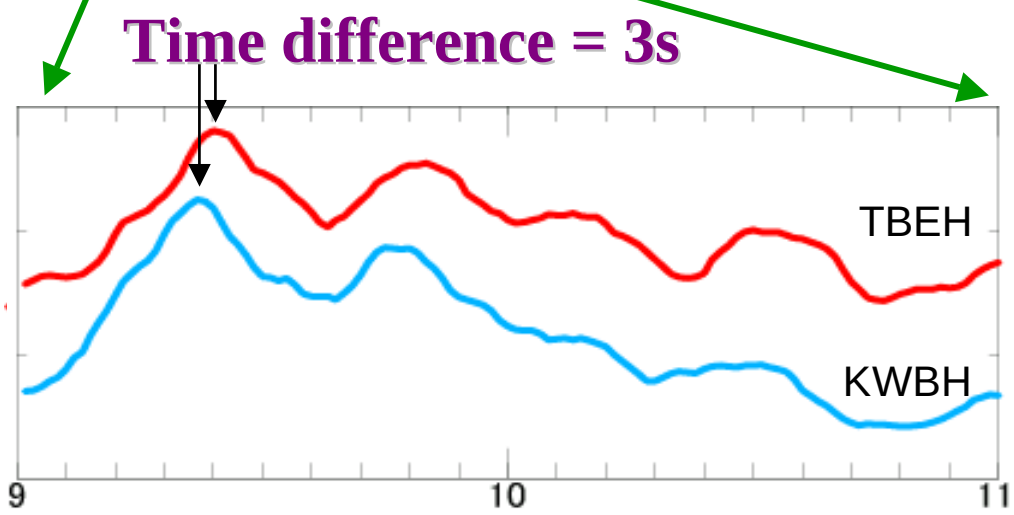


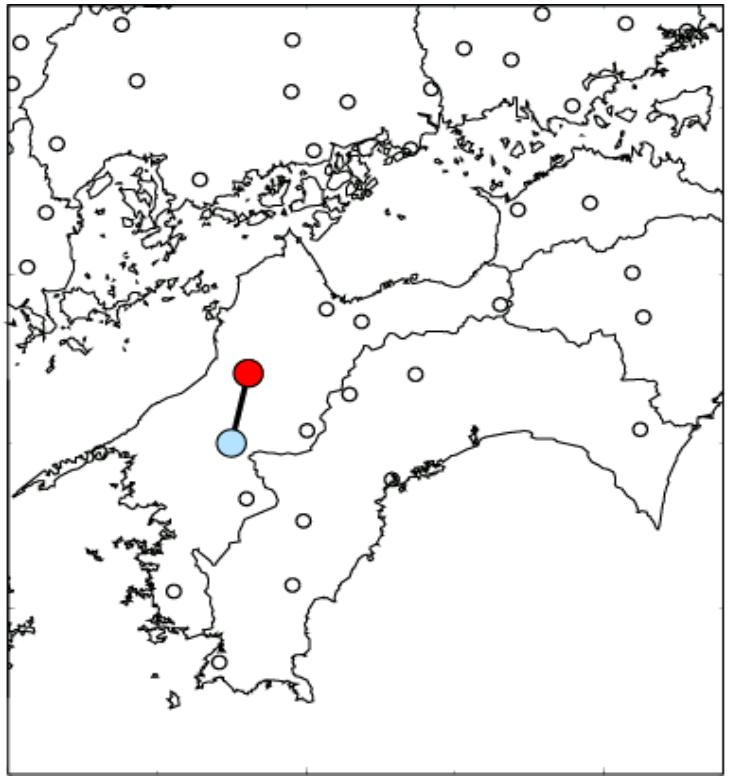
Three days envelope seismograms in Shikoku



Hypocentral determination with envelope correlation





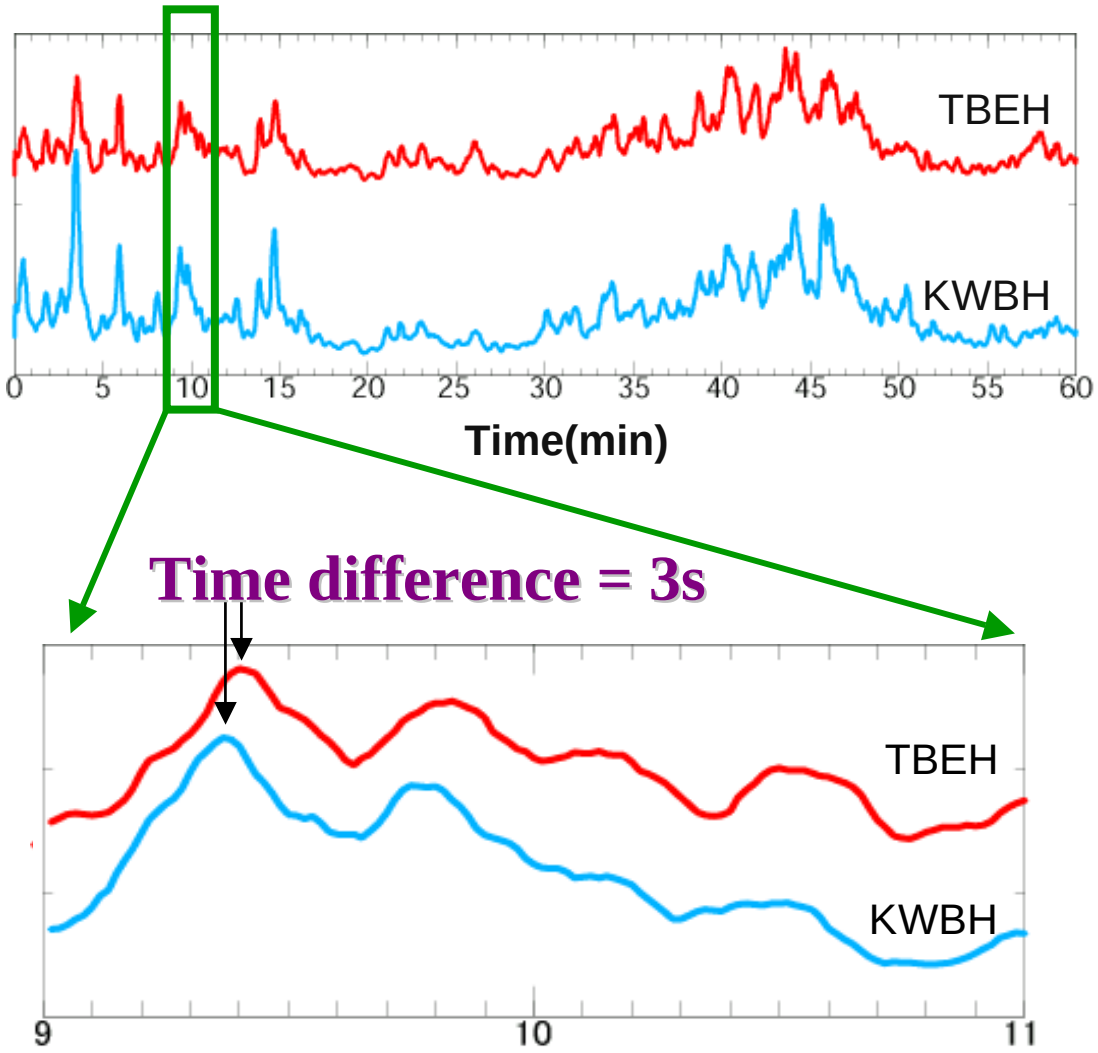


Comparison of 2 envelopes

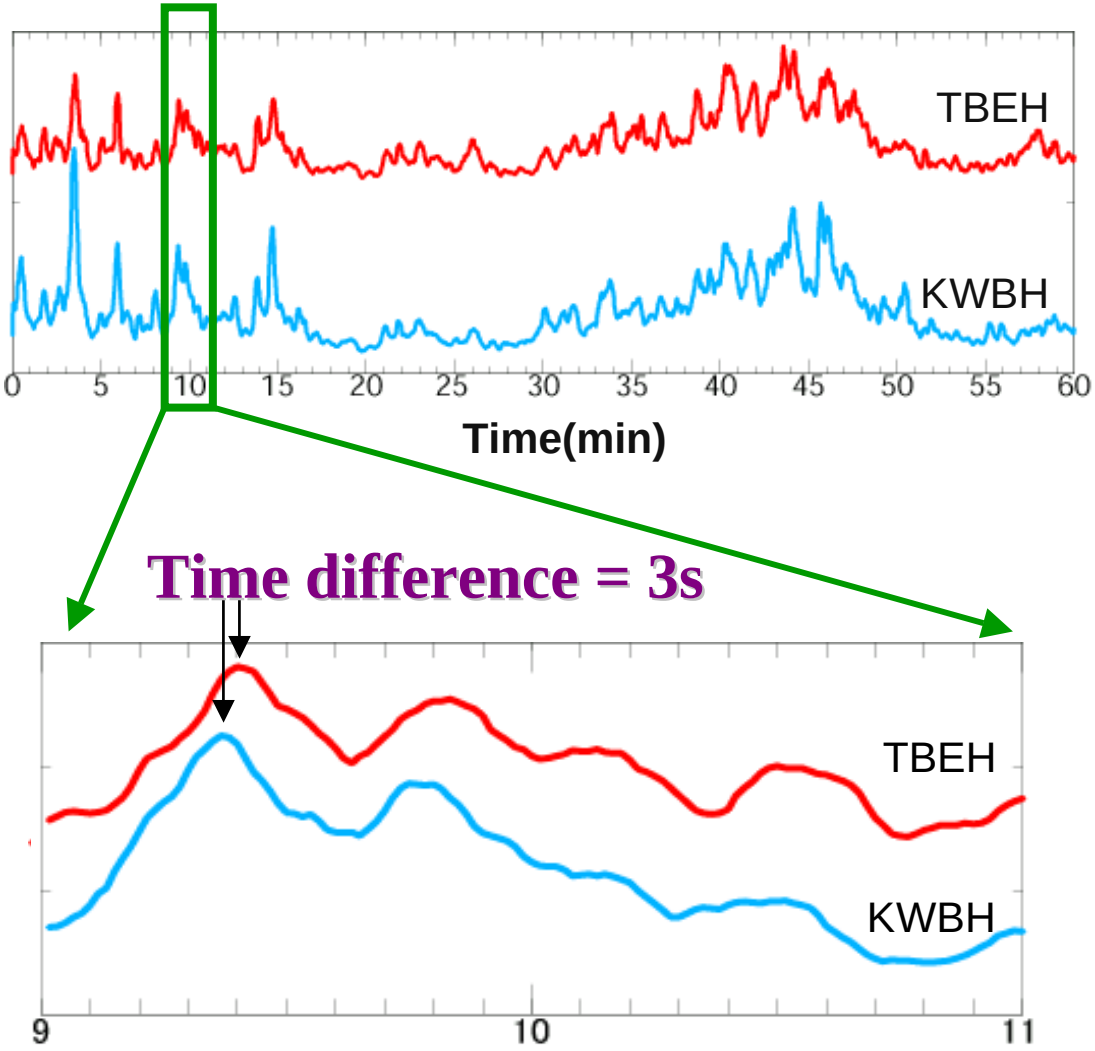
⇩

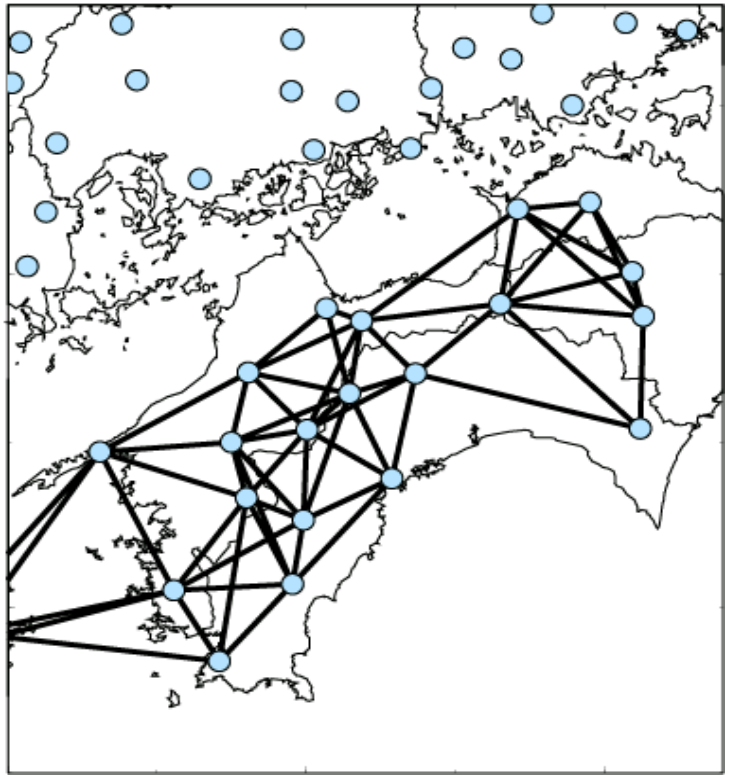
Measurment of time difference

Hypocentral determination with envelope correlation



Hypocentral determination with envelope correlation

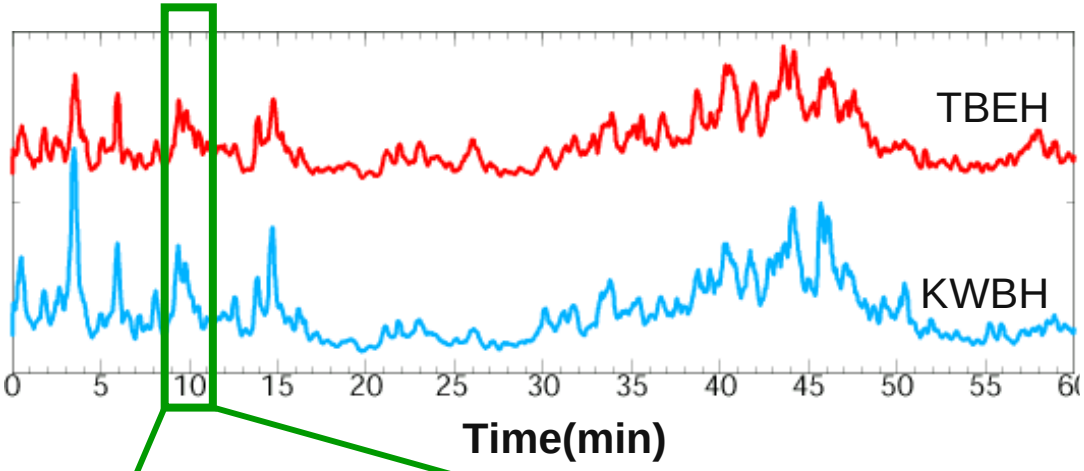


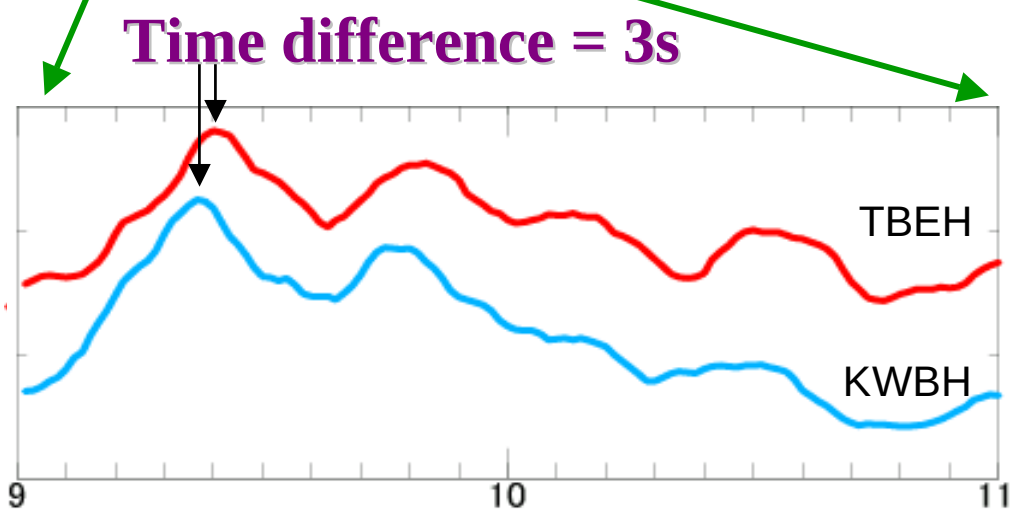


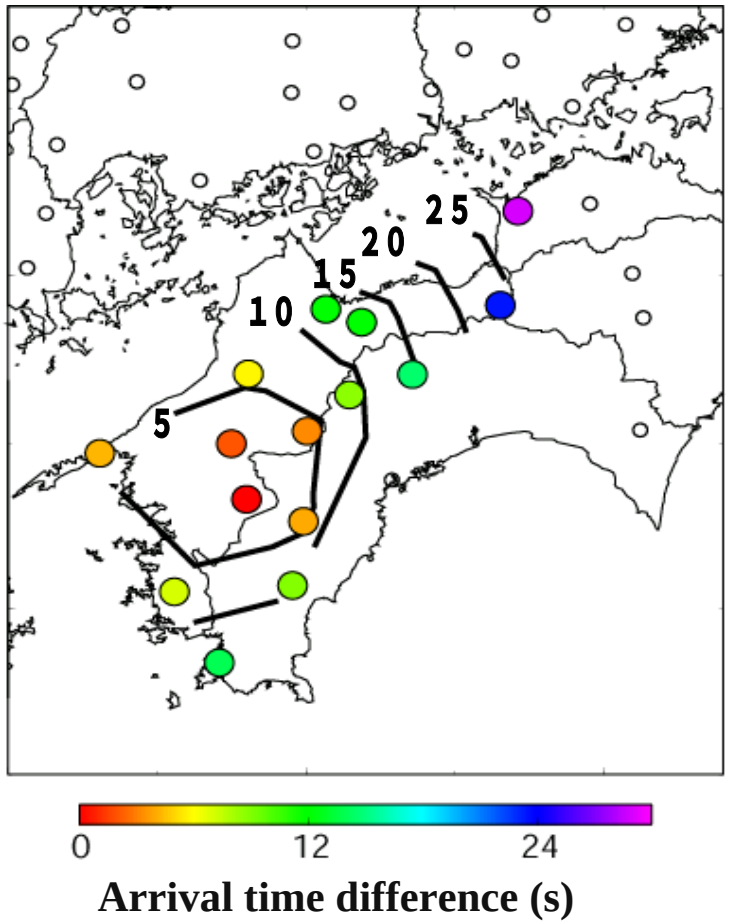
Time difference measurment for every station pairs

Spatial Smoothing

Hypocentral determination with envelope correlation

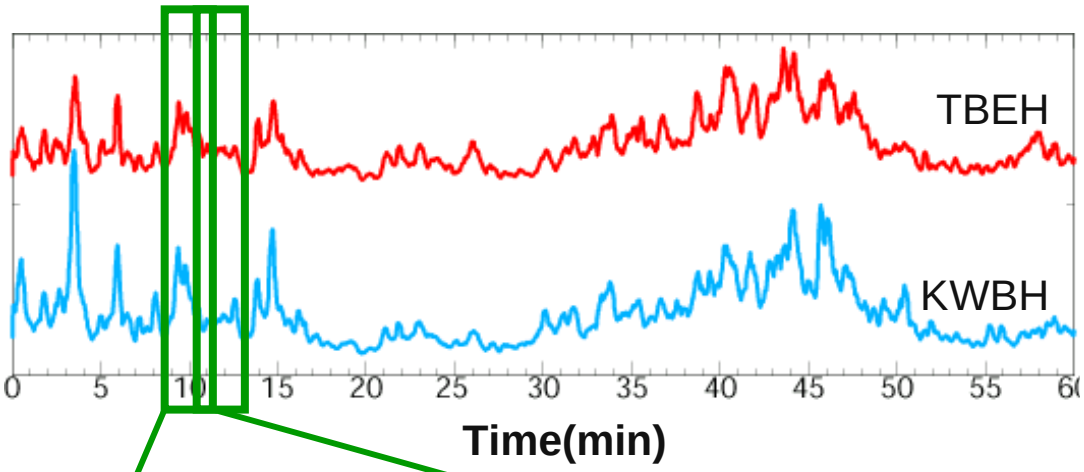


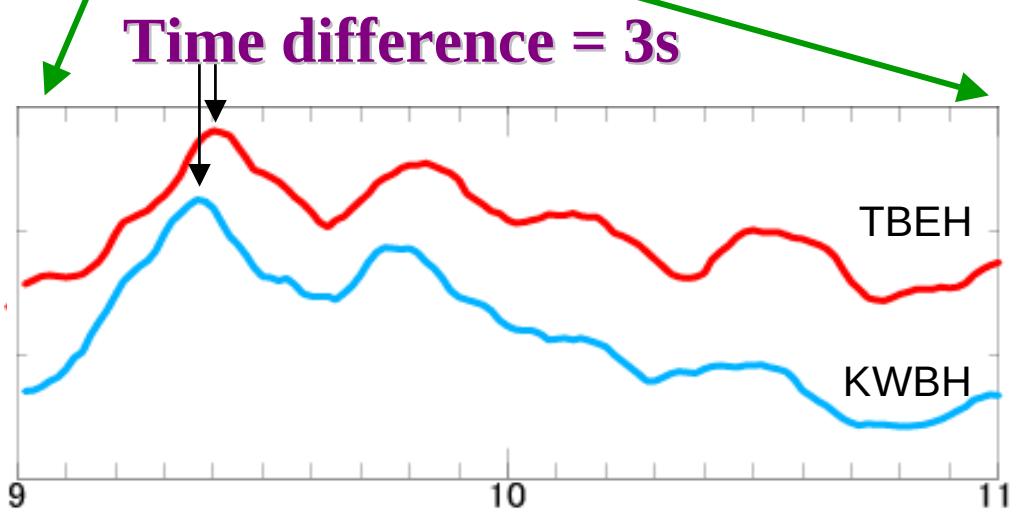


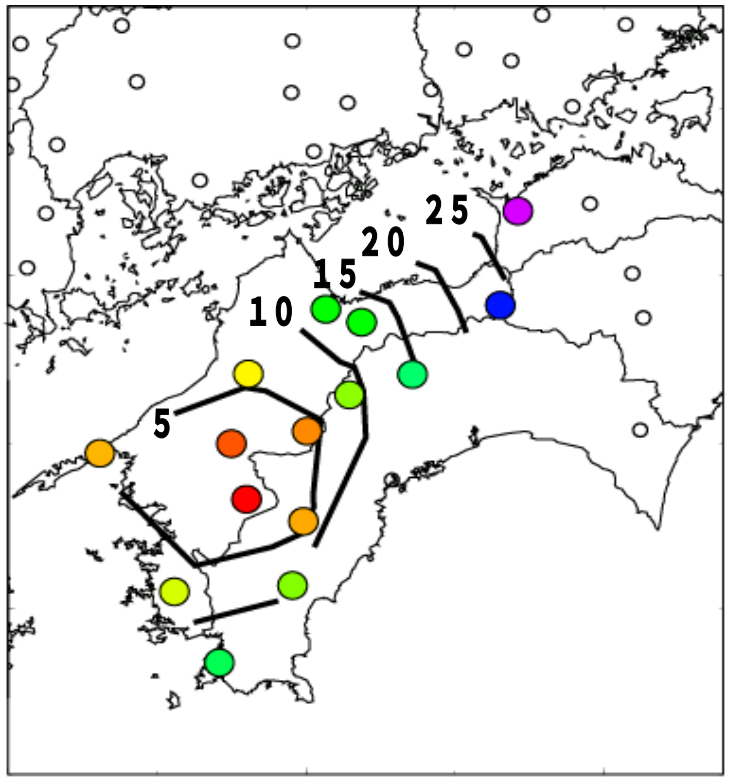


hypocentral determination with S wave velocity

Hypocentral determination with envelope correlation

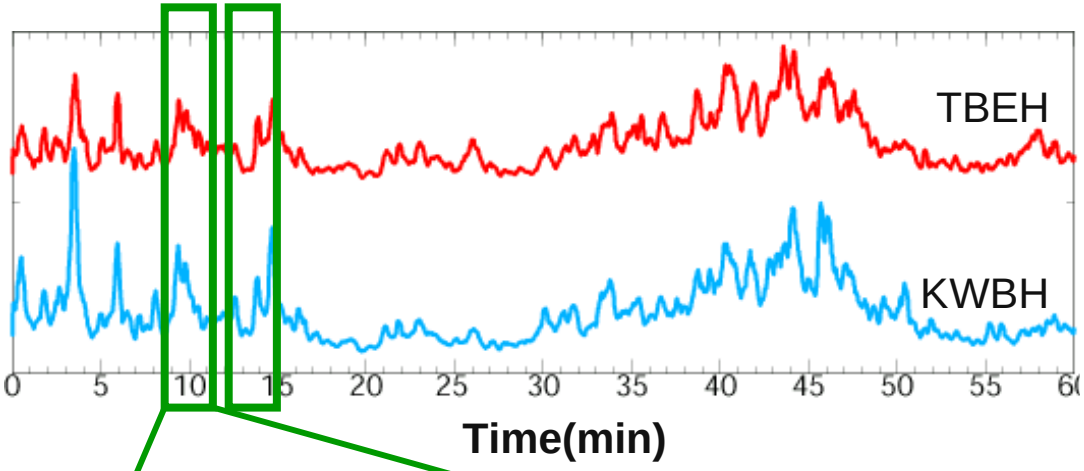


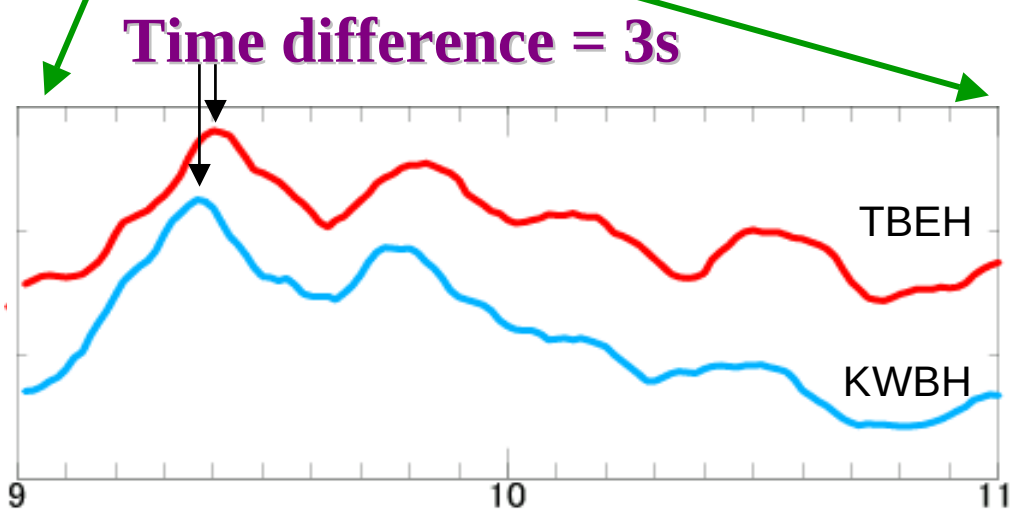


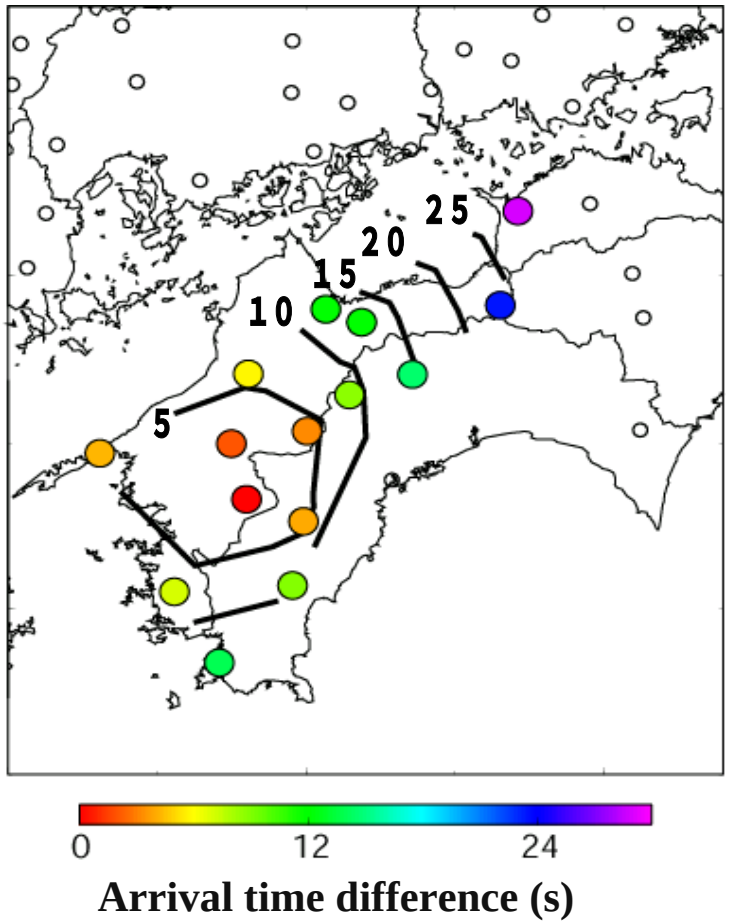


hypocentral determination with S wave velocity

Hypocentral determination with envelope correlation

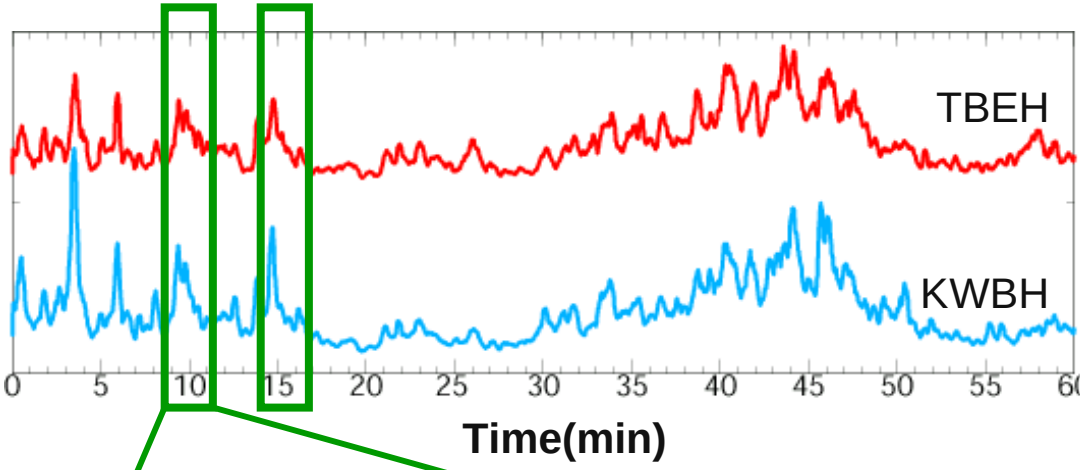


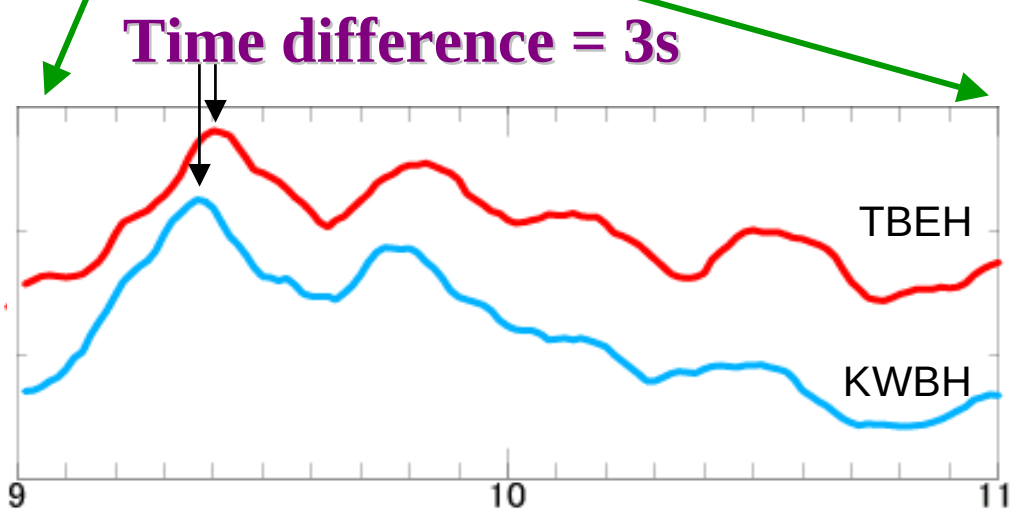


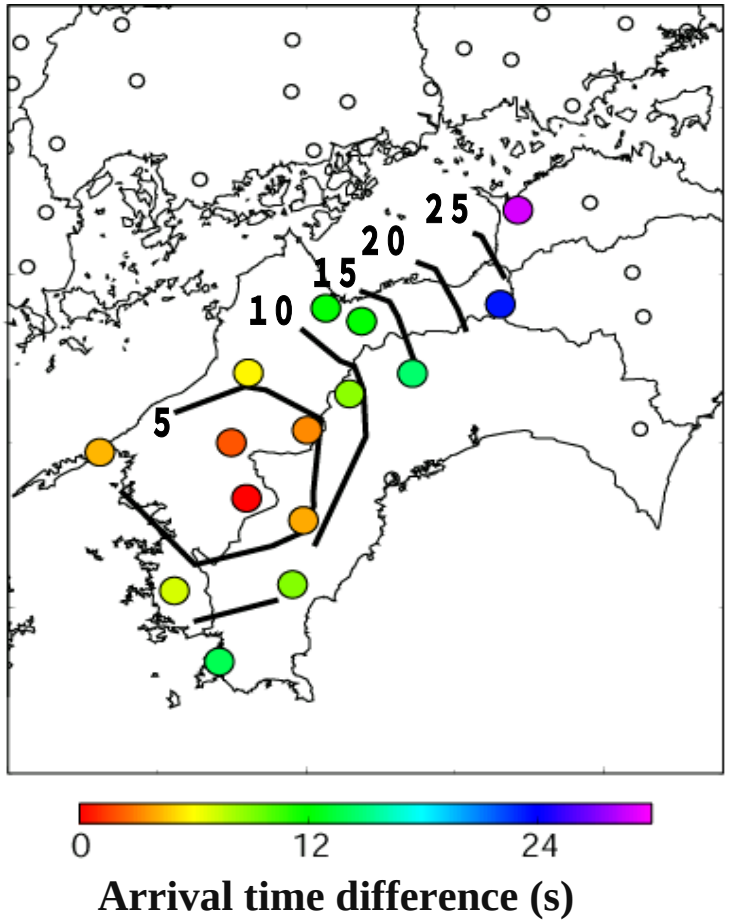


hypocentral determination with S wave velocity

Hypocentral determination with envelope correlation

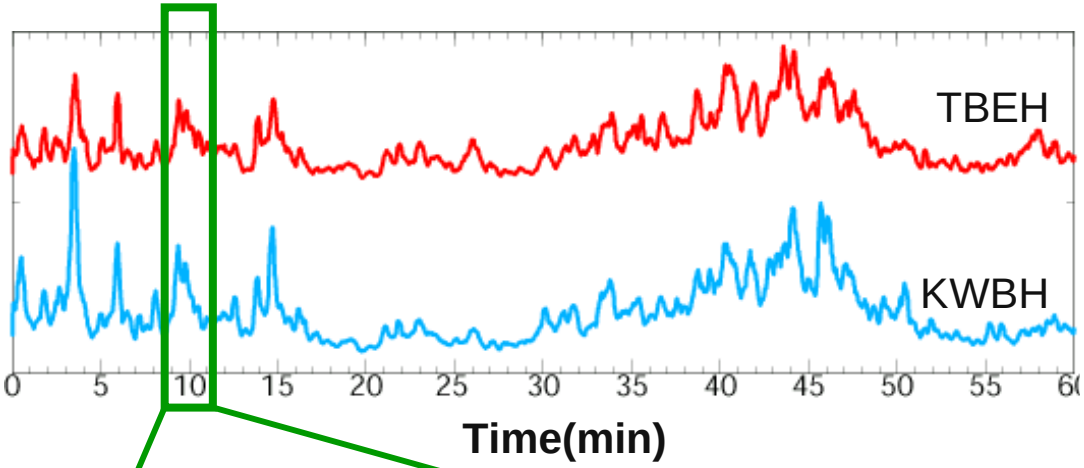


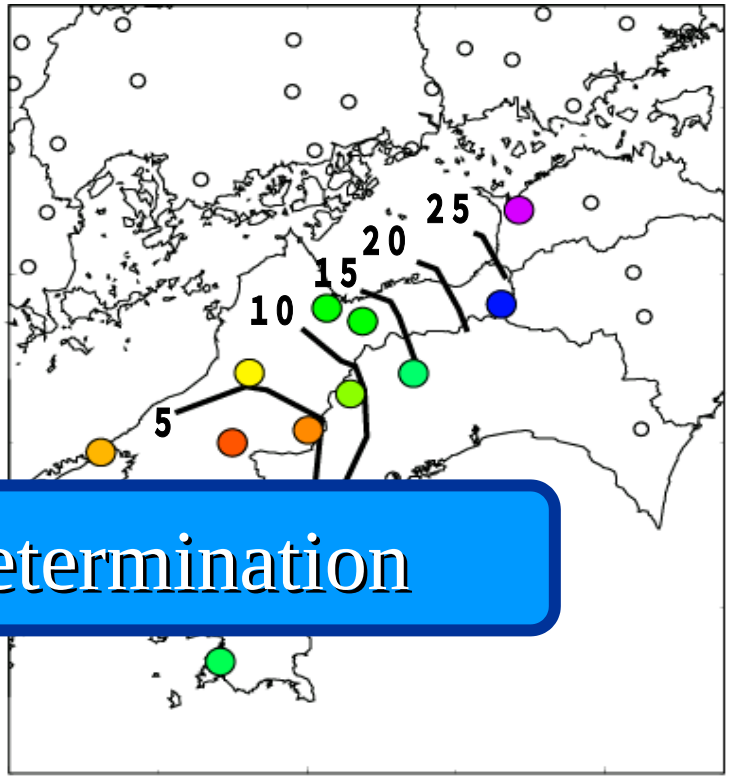




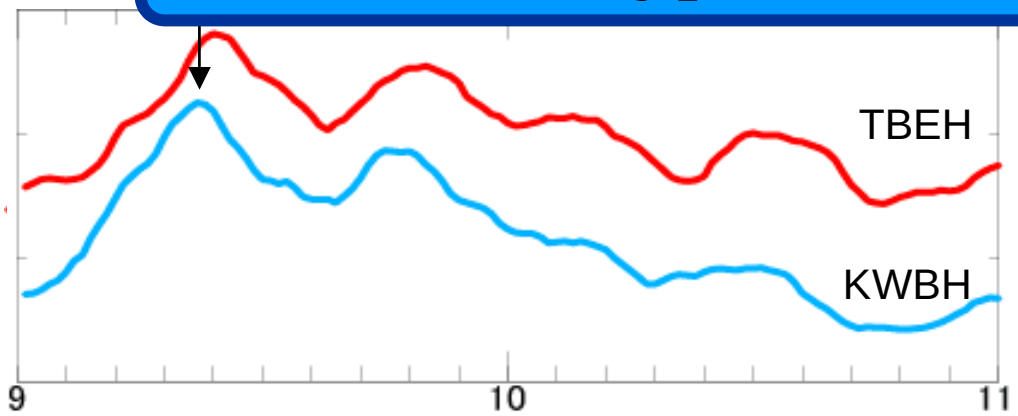
hypocentral determination with S wave velocity

Hypocentral determination with envelope correlation





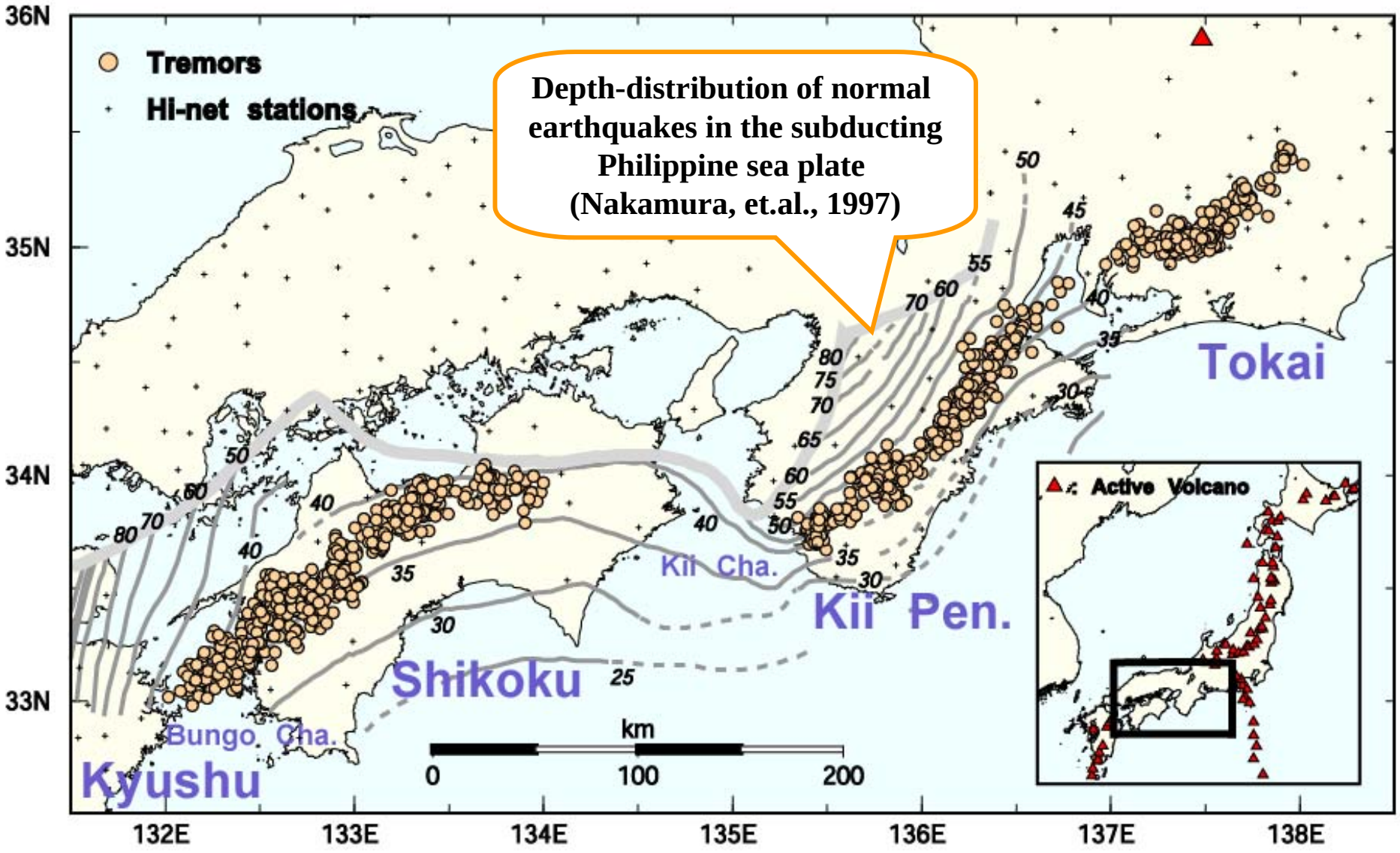
Continuous hypocentral determination



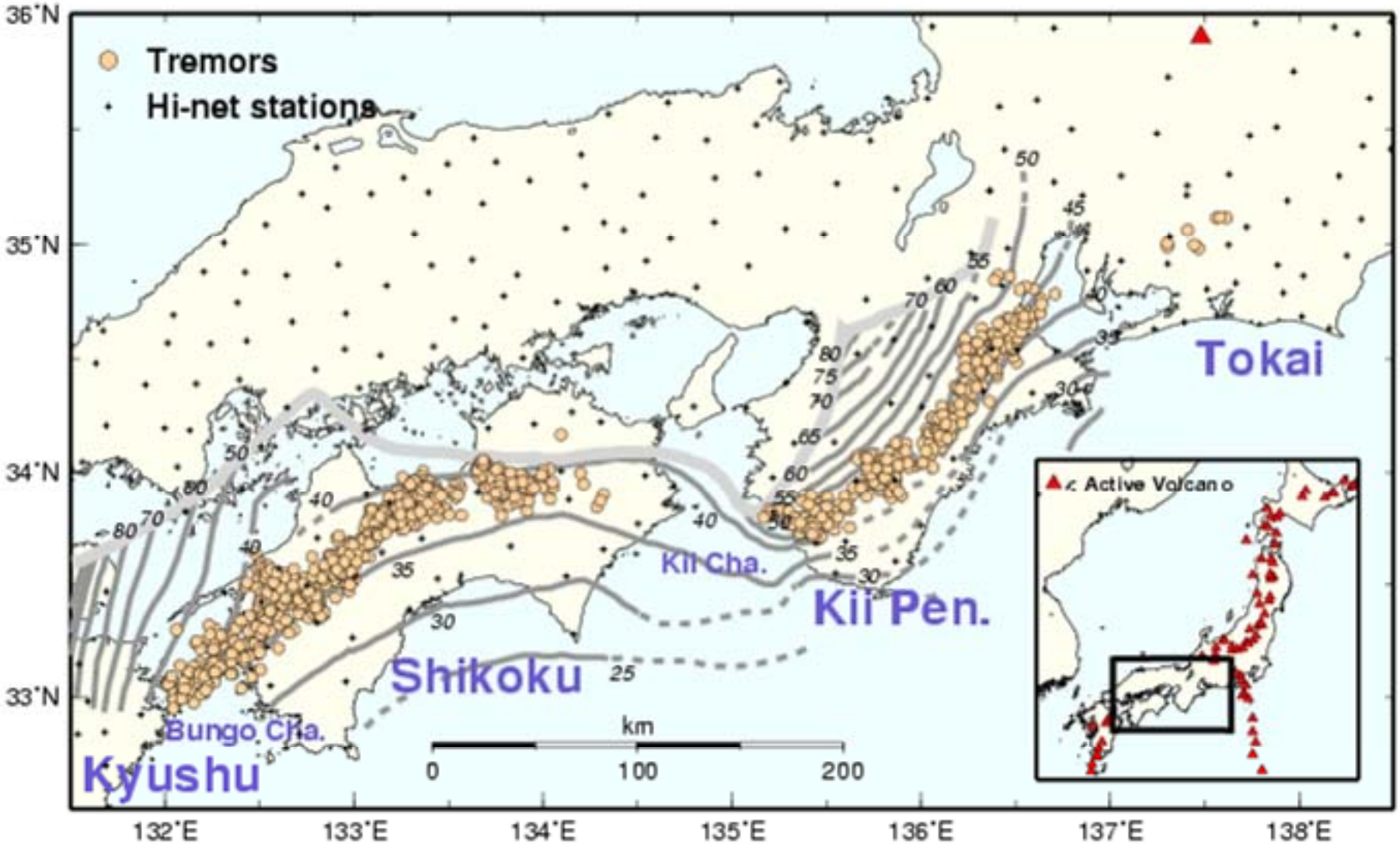
Arrival time difference (s)

hypocentral determination with S wave velocity

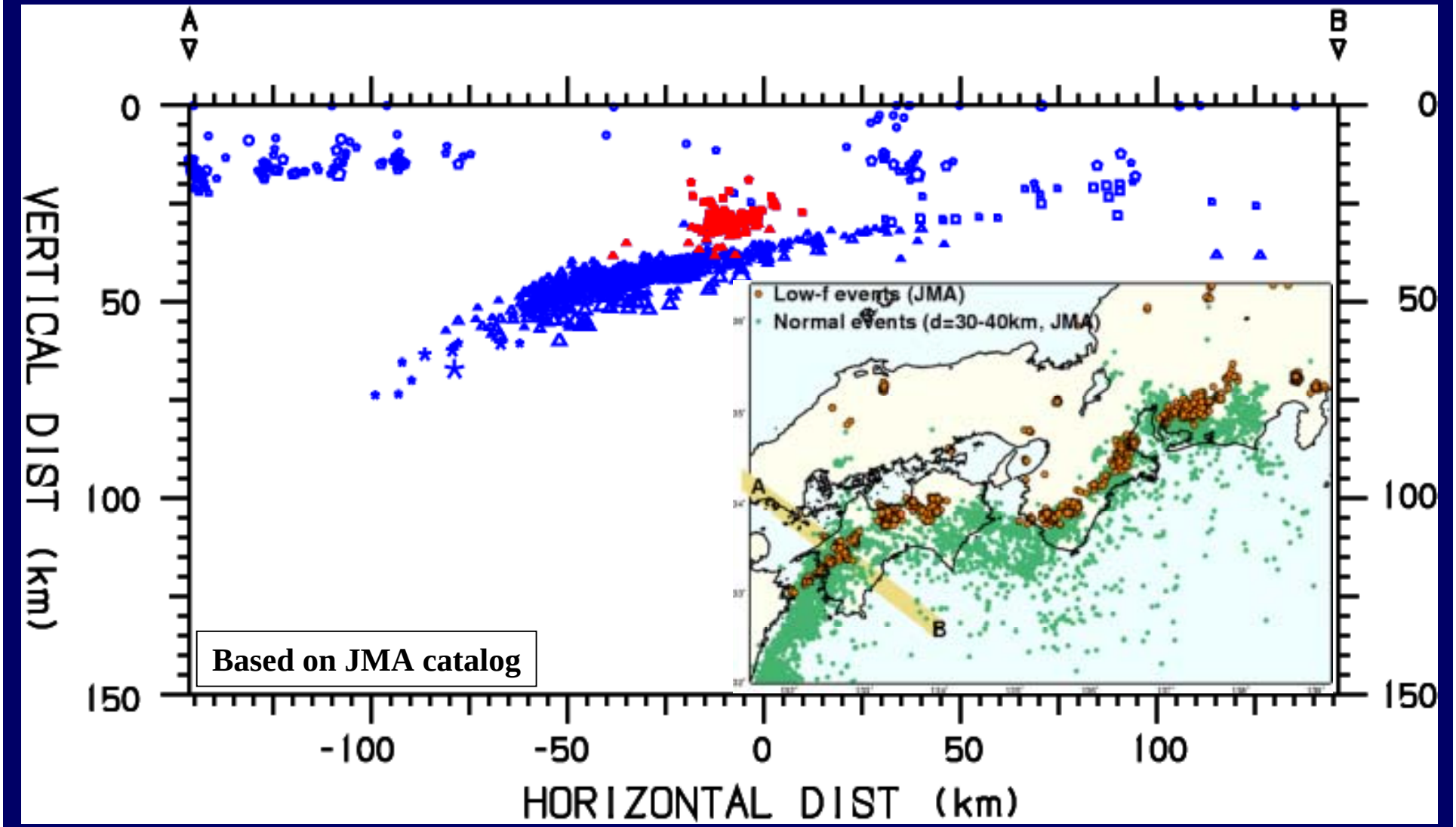
Distribution of tremors (2001/1/1-2001/12/31)



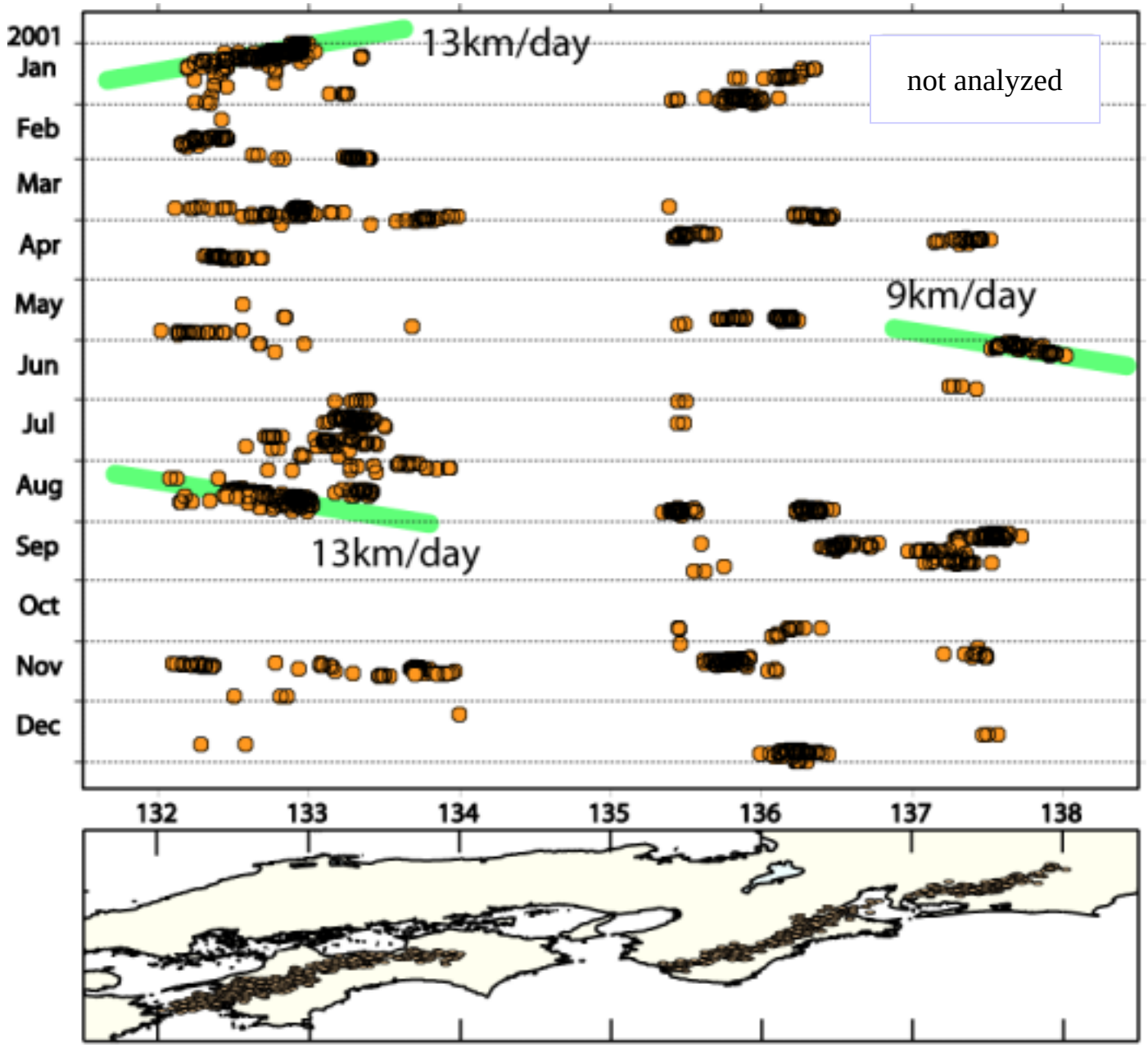
Distribution of tremors (2002/1/1-2002/10/25)



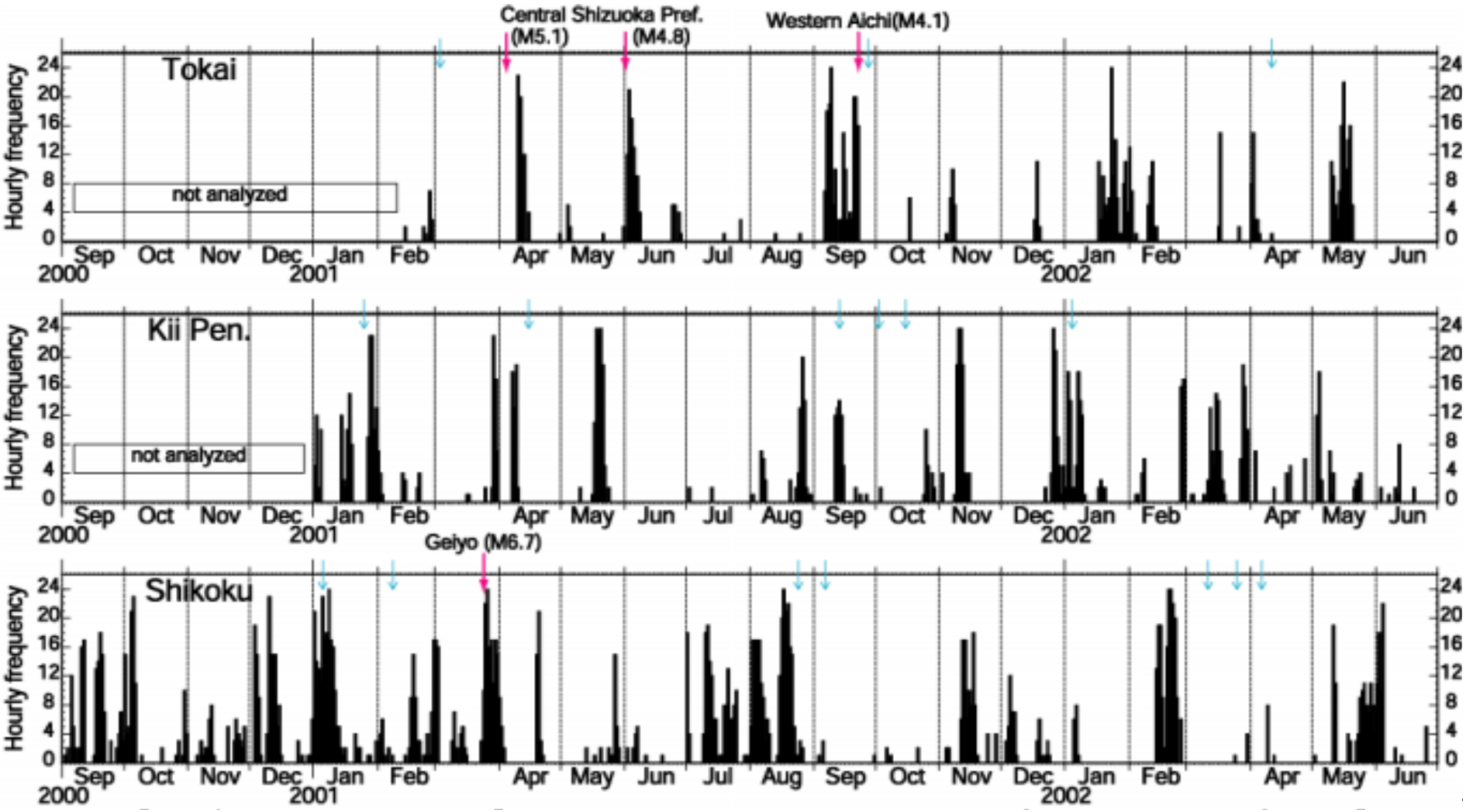
Cross sectional view of the low-frequency events



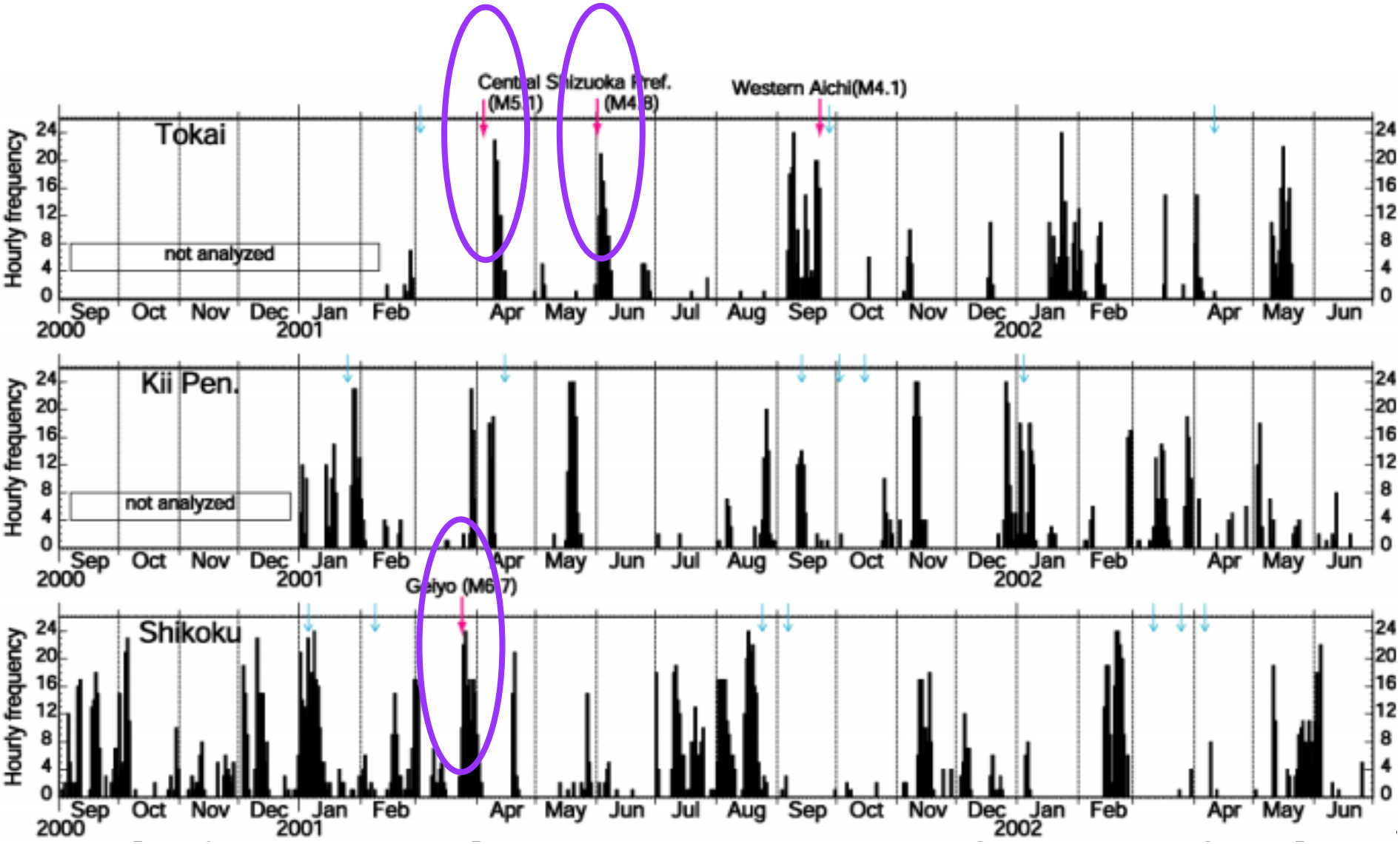
Space-time plot of tremor (2001/1/1-2001/12/31)



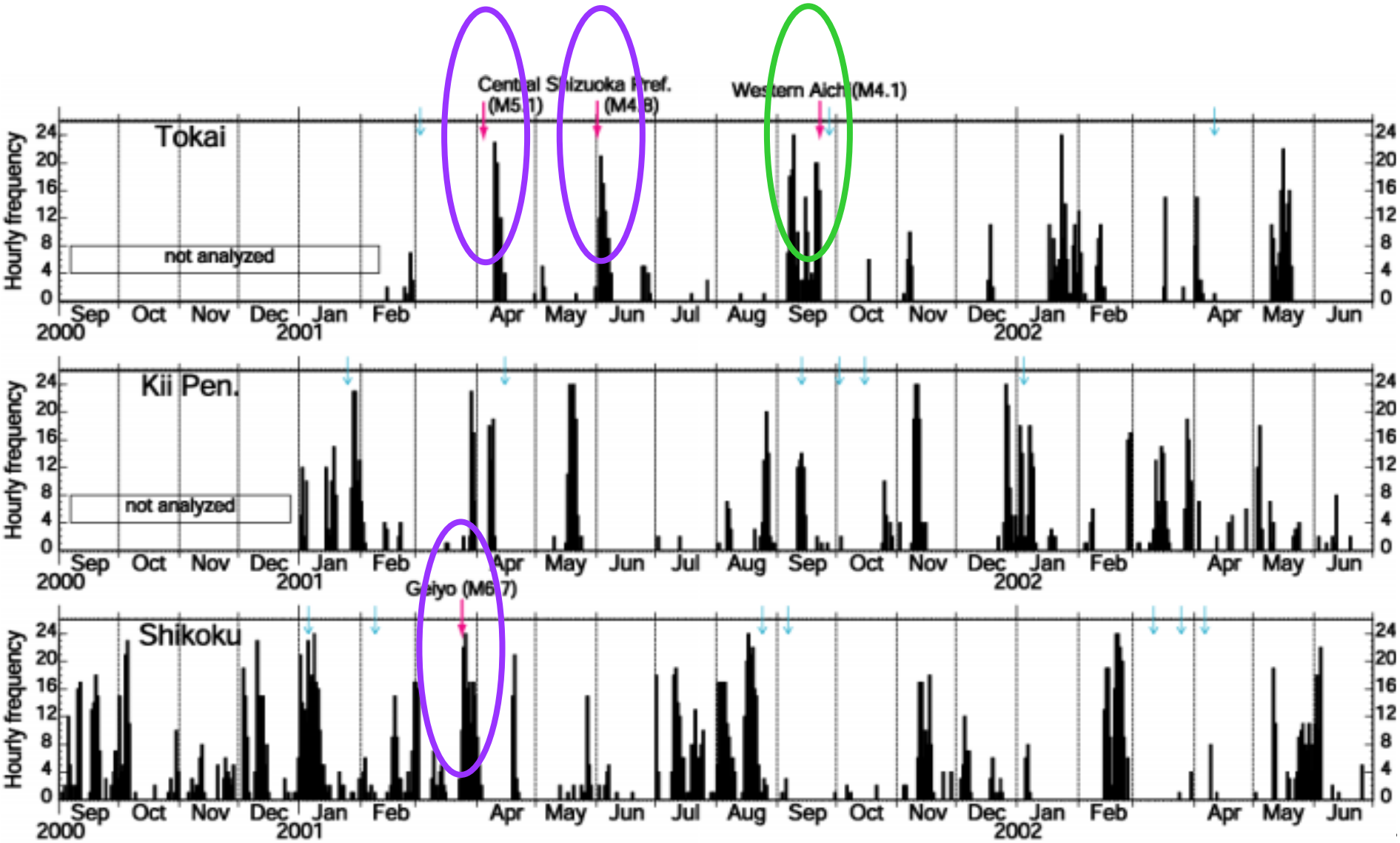
Time sequence of tremor (2000/9/1-2002/6/30)



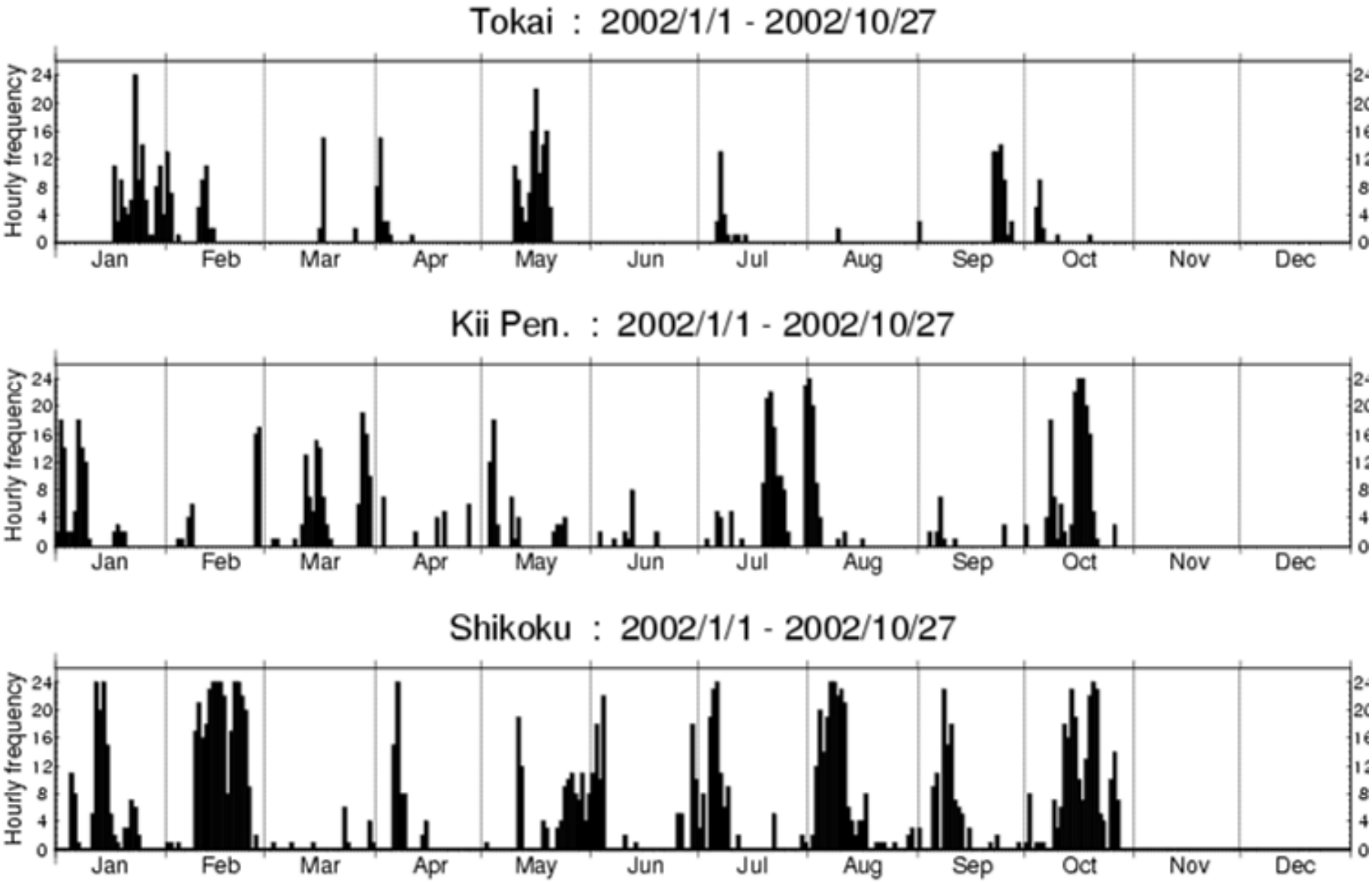
Time sequence of tremor (2000/9/1-2002/6/30)



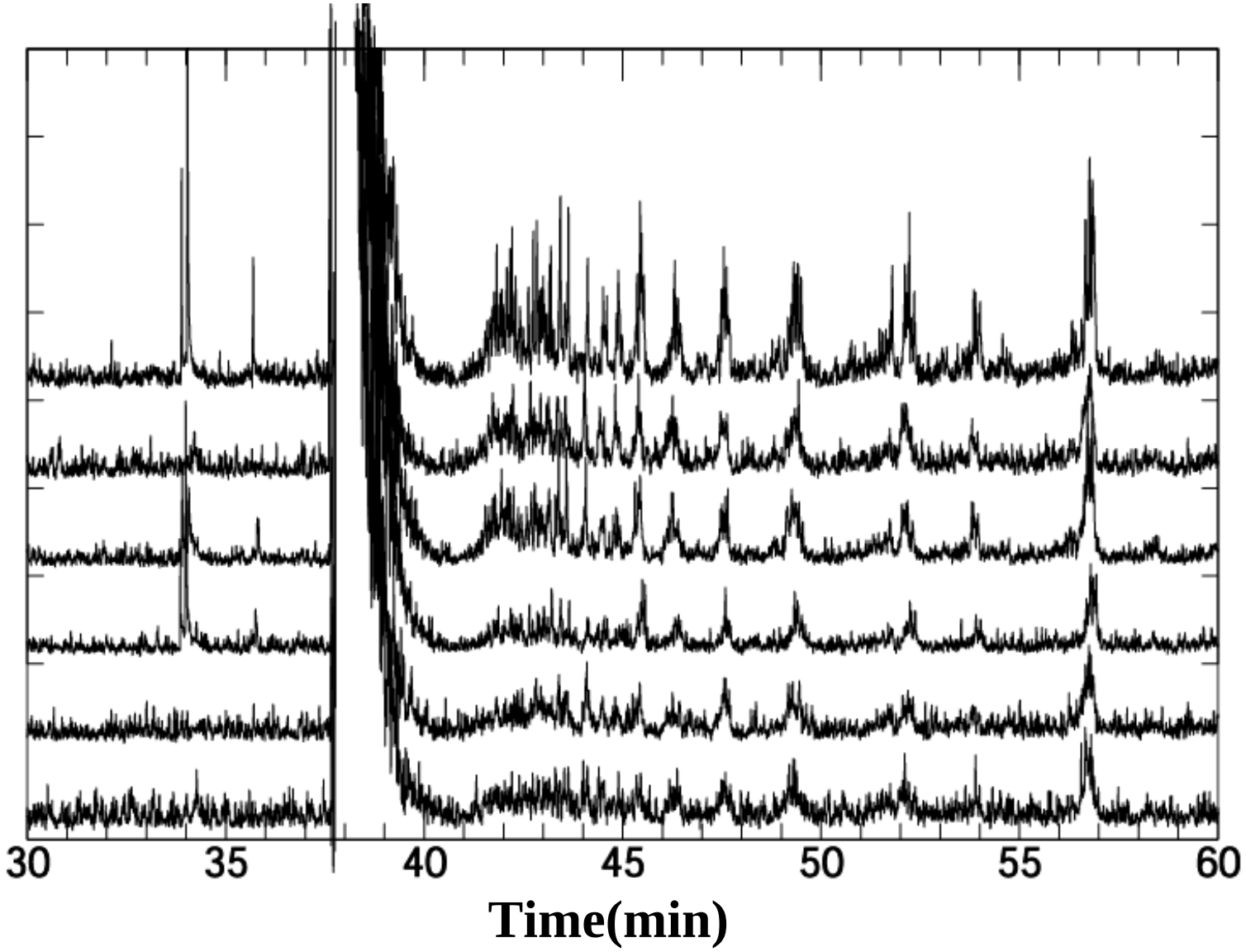
Time sequence of tremor (2000/9/1-2002/6/30)



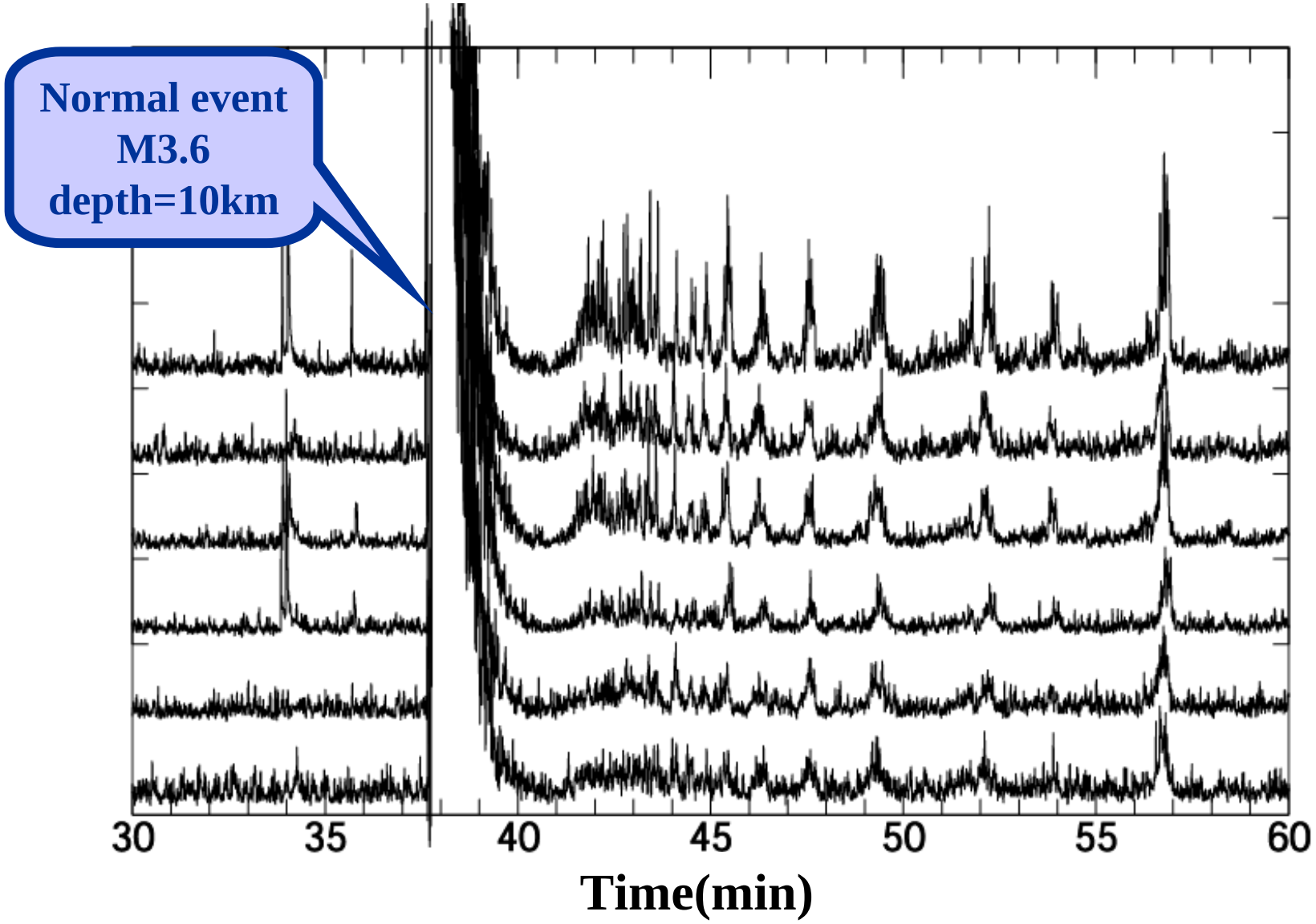
Time sequence of tremor (2002/1/1-2002/10/27)



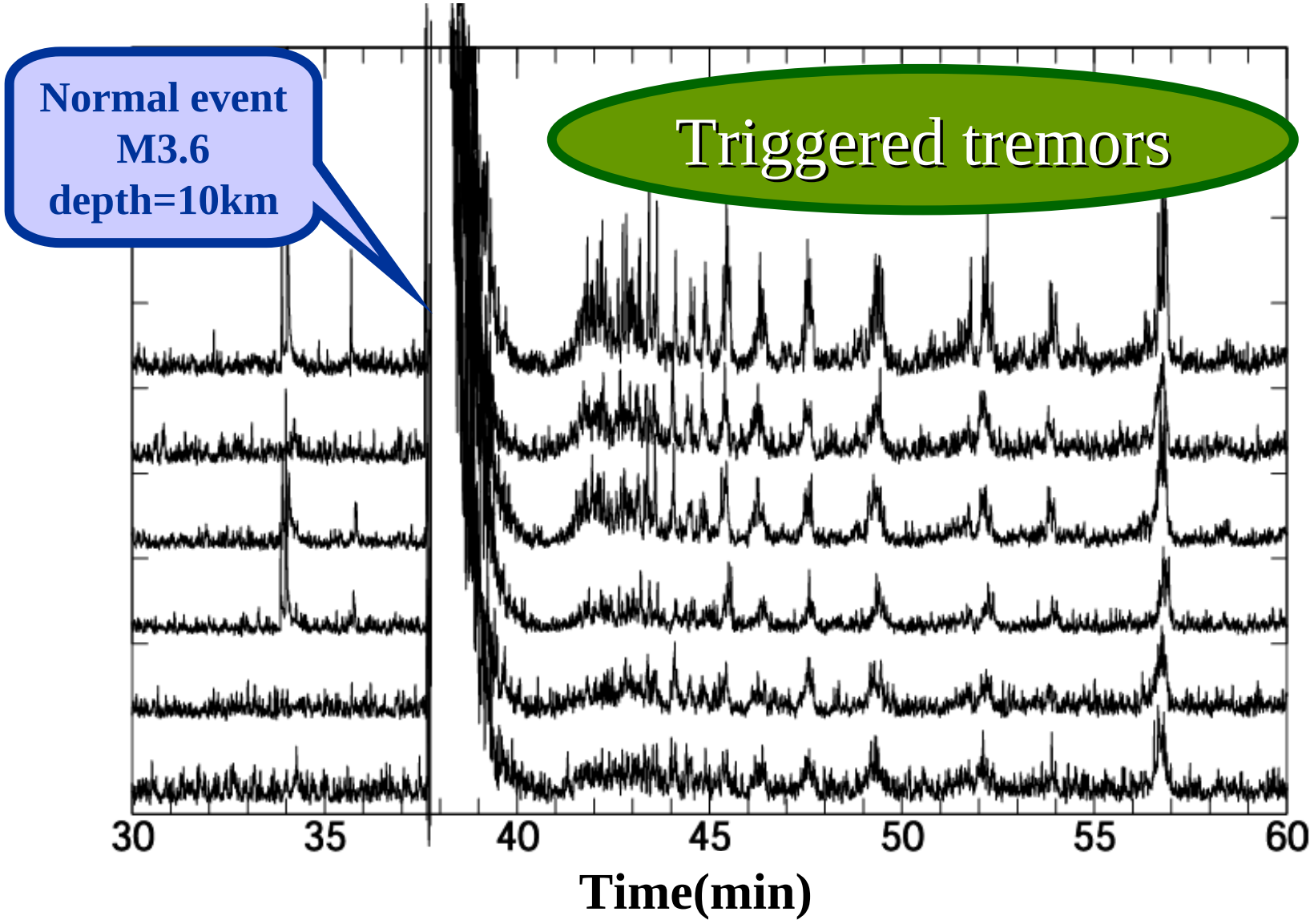
Envelope seismograms in Shikoku
(2000/12/31 23:30-2001/1/1 00:00)



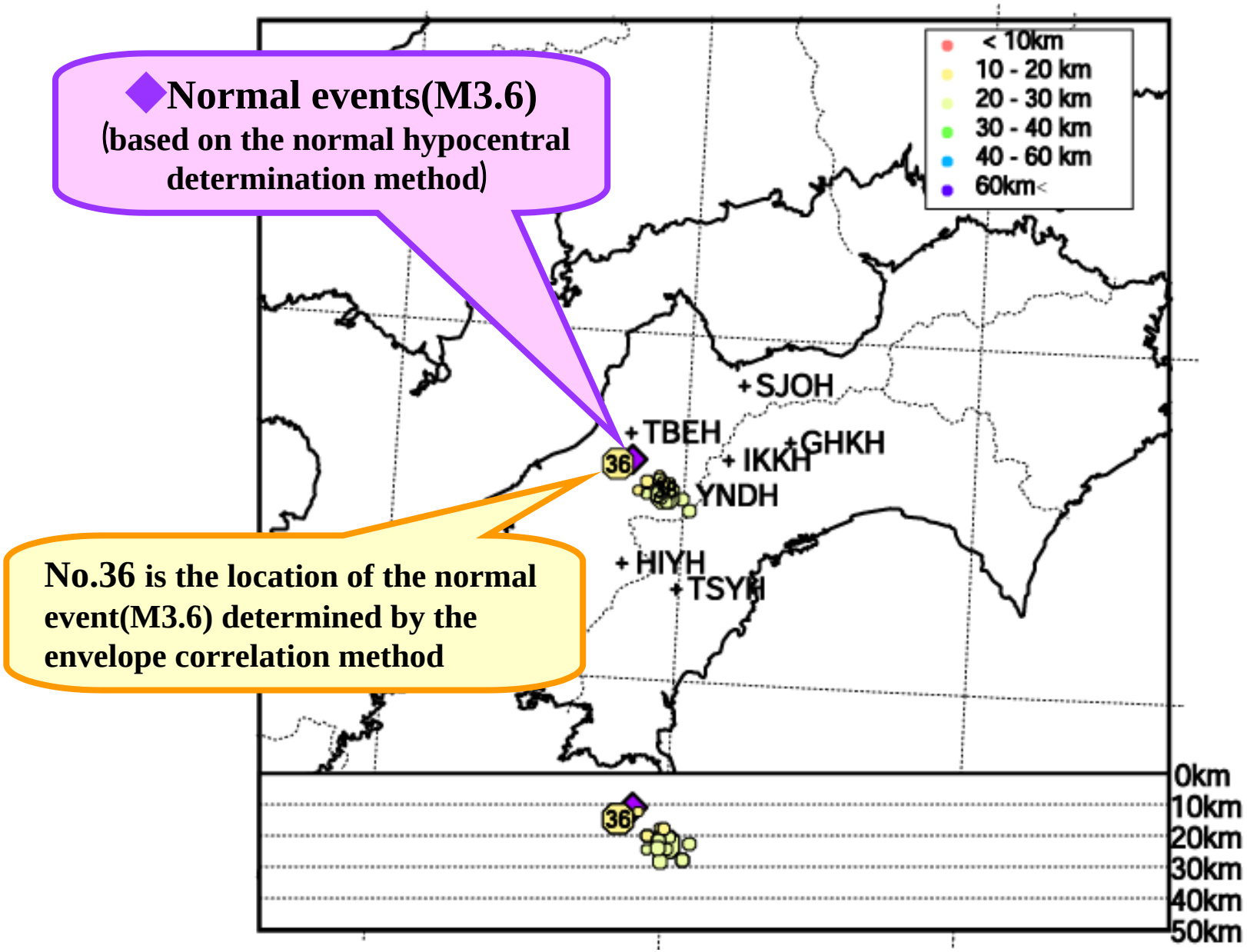
Envelope seismograms in Shikoku
(2000/12/31 23:30-2001/1/1 00:00)



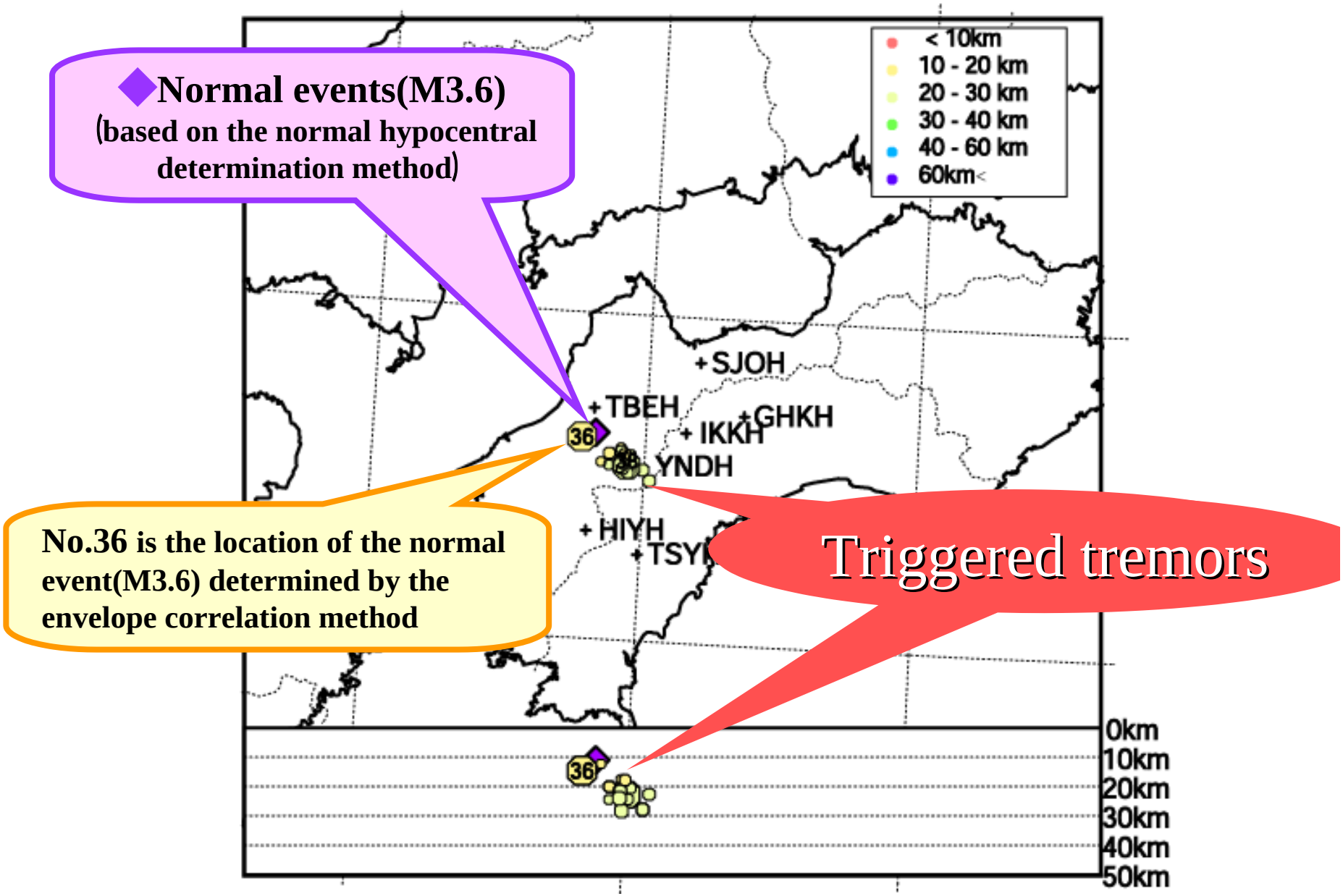
Envelope seismograms in Shikoku
(2000/12/31 23:30-2001/1/1 00:00)



Distribution of tremors in 2000/12/31 23pm



Distribution of tremors in 2000/12/31 23pm



Location of tremor

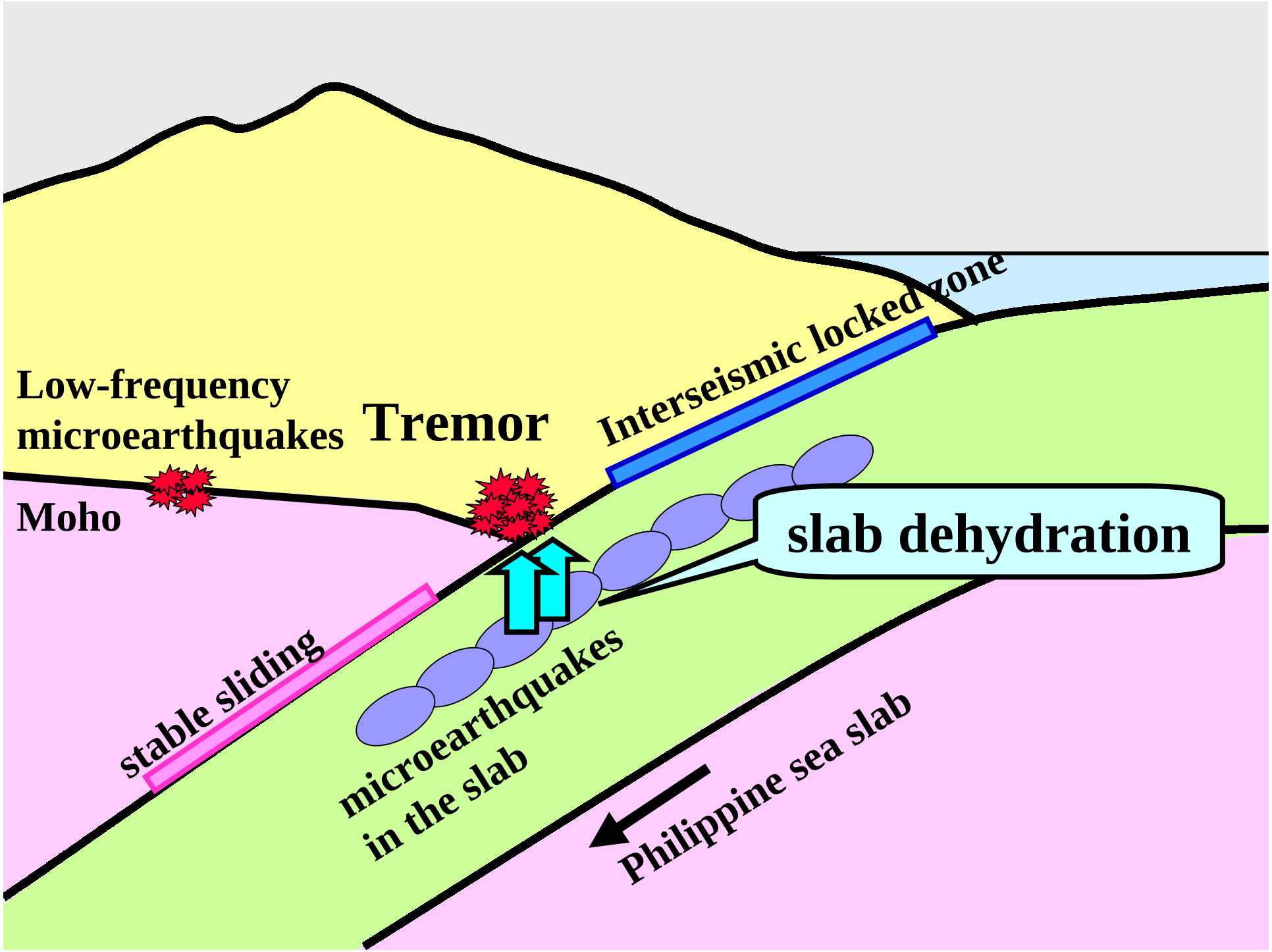
- Length of the source area is about 600km.
- Non-volcanic area
- Along the strike of the subducting Philippine sea plate
  (corresponding to the seismic activity in the slab with the depth range from 35 to 45km)
- Depth of the tremor = 30km(±10km)
  - Moho discontinuity?
  - Lower crust?
  - Upper boundary of the Philippine sea plab?
- There is no tremor around Kii Channel and E.Shikoku

Time sequence of tremor

- There are active periods and quiet periods.
  - Active period：~ a few weeks
  - Quiet period ： ~ a few months
- In an active period, active and quiet stages exist.
- Tremors are sometimes triggered by nearby major earthquakes
- The source area migrates with the velocity of 9 ~ 13km/day.
- A tremor activity is related to shallow swarm.

Cause of tremor

- **Long duration and mobility**
- **Consistency with slab geometry**
  - → **Fluid** generated by slab dehydration
  - → A certain temperature/pressure condition
  - → Inhomogeneous structure
- **Possible mechanisms**
  1. Chain-like fracture with supercritical fluid
  2. Fuild flow
  3. ……


Low-frequency
microearthquakes
Tremor
Interseismic locked zone
Moho
slab dehydration
stable sliding
microearthquakes
in the slab
Philippine sea slab

Further Study

- **Depth and focal mechanism of tremor**
- Underground structure in southwest Japan subduction zone (Moho, plate boundary,,,)
- Similarities and differences with other deep low-frequency events (near volcanoes, active faults)

- Other subduction zone?