Integrated observation well network of Geological Survey of Japan, AIST for study of Tonankai and Nankai earthquakes

*Naoji Koizumi, N.Matsumoto,S.Itaba and R.Ohtani
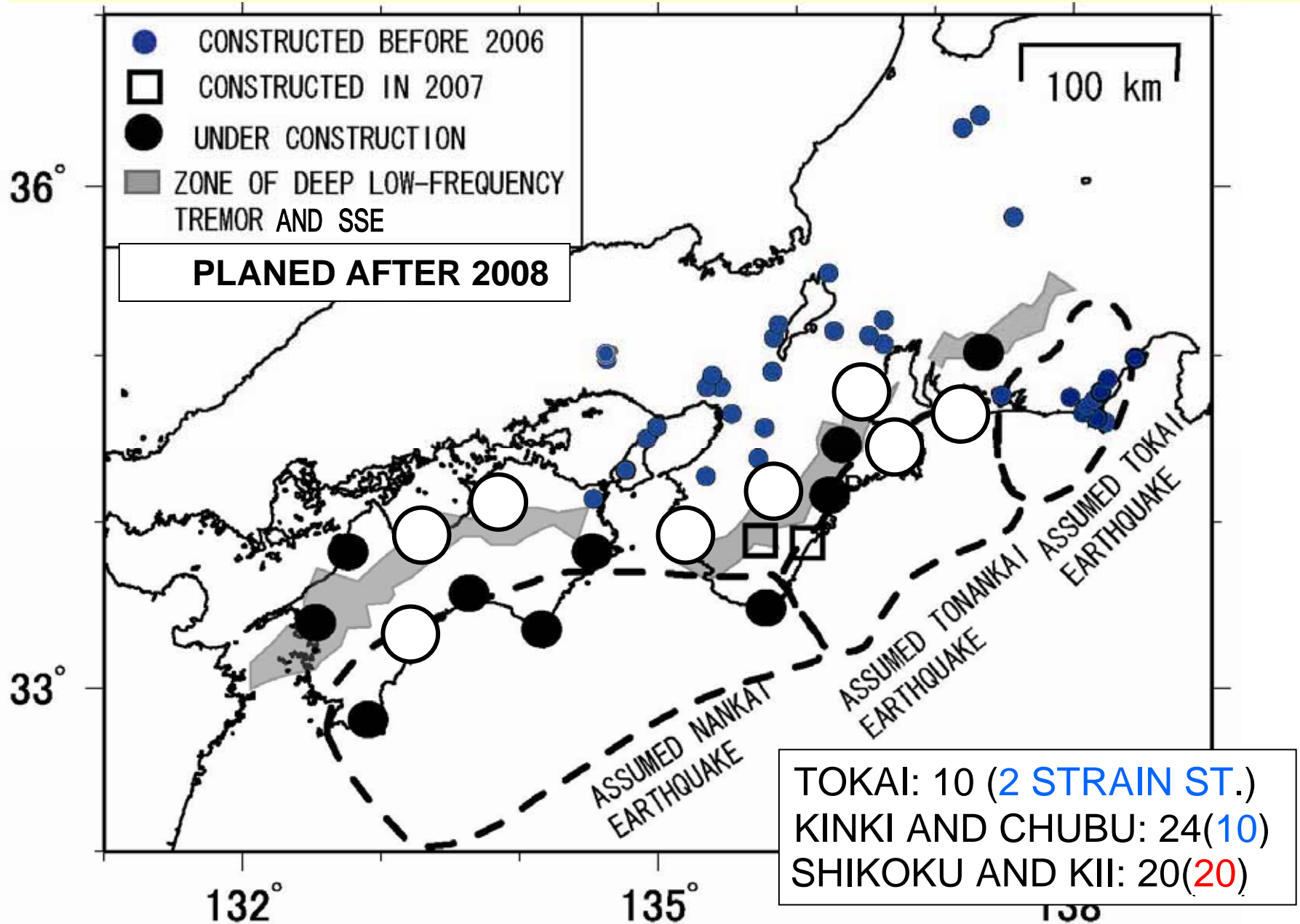(Geological Survey of Japan, AIST)

OVERVIEW

20 NEW GROUNDWATER OBSERVATION STATIONS IN AND AROUND SHIKOKU AND KII PENINSULA, JAPAN.

NEW STATIONS + 10 STATIONS IN TOKAI

WILL MONITOR SSE(SLOW SLIP EVENT) AND TREMOR IN THE PLATE BOUNDARY

(SSE: SIMILAR TO PRE-SLIP OR POSSIBLE PRECURSOR TO EARTHQUAKE)

NEW STATION

3 WELLS (30m, 200m, 600m), ALL CORING AT THE 600m WELL

OBSERVATION: GROUNDWATER, CRUSTAL DEFROMATION, SEISMICITY

REAL-TIME DATA COLLECTION

HIGH SAMPLING RATE
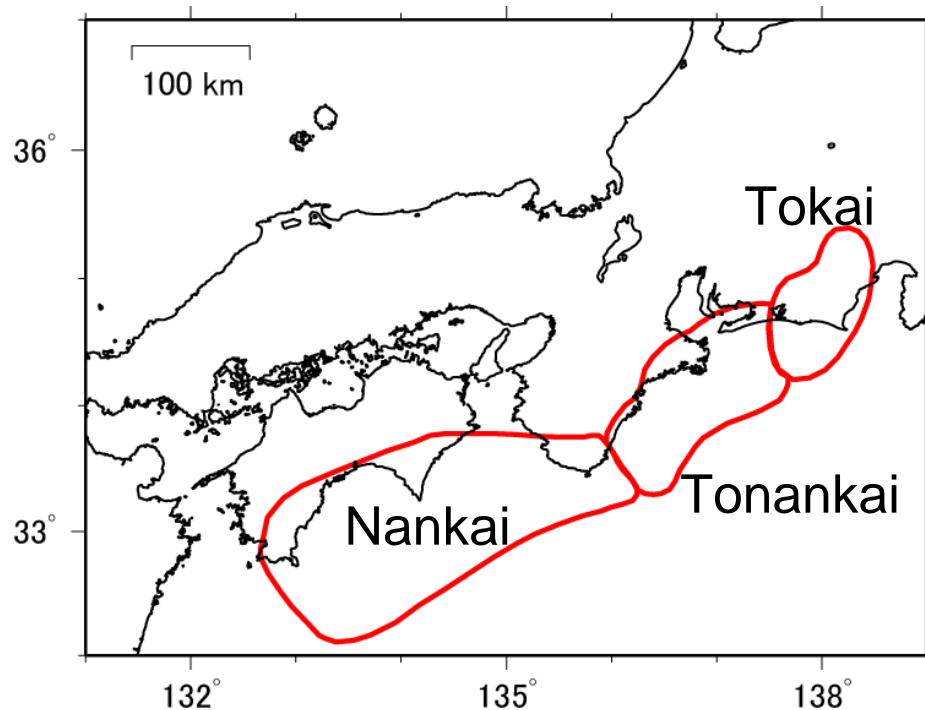
(1Hz: GROUNDWATER OBS., 10-20 Hz: STRAIN AND TILT)

SCHEDULE

2006-2007: 2 STATIONS

2007-2008: 10 STATIONS

2008-: ?

# GROUNDWATER OBSERVATION NETWORK OF GSJ, AIST

- ● CONSTRUCTED BEFORE 2006
- □ CONSTRUCTED IN 2007
- ● UNDER CONSTRUCTION
- ▨ ZONE OF DEEP LOW-FREQUENCY TREMOR AND SSE

PLANED AFTER 2008

100 km

36°

33°

ASSUMED NANKAI EARTHQUAKE

ASSUMED TONANKAI EARTHQUAKE

ASSUMED TOKAI EARTHQUAKE

TOKAI: 10 (2 STRAIN ST.)
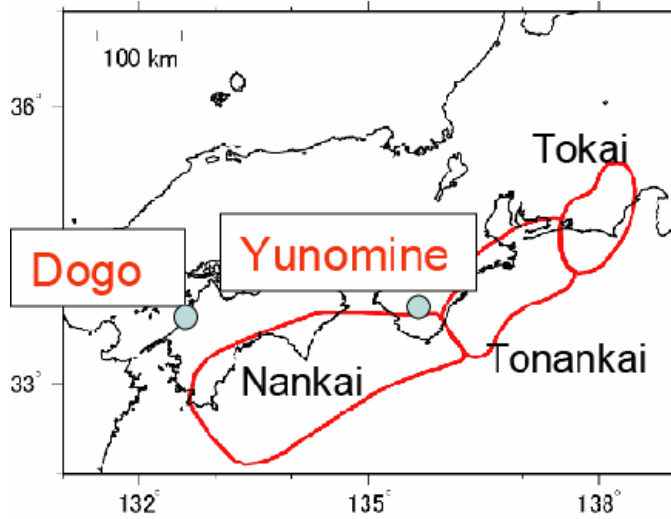KINKI AND CHUBU: 24(10)
SHIKOKU AND KII: 20(20)

132°   135°   138°

Nankai, Tonankai and Tokai Earthquakes

Nine times by historical documents
M7.9 – M8.4
Interval: 90 - 150 years
  (after 1605)

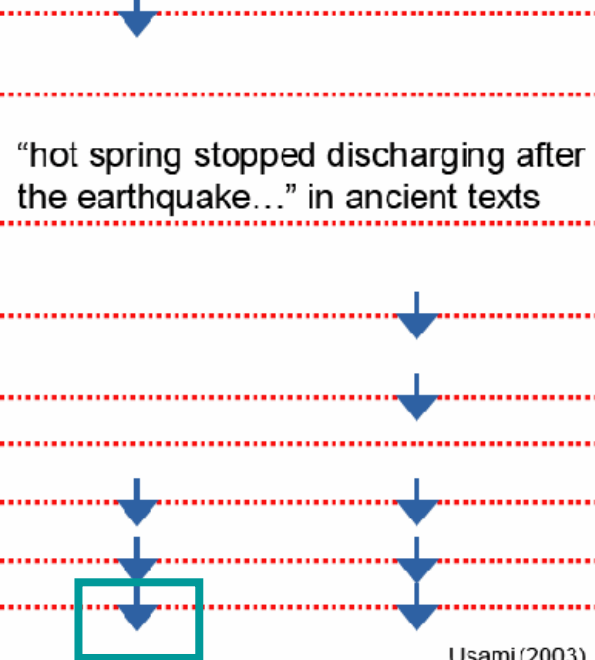Nankai   Tonankai   Tokai

684

887

1099   1096

1361

1498

1605

1707

1854   1854

1946   1944
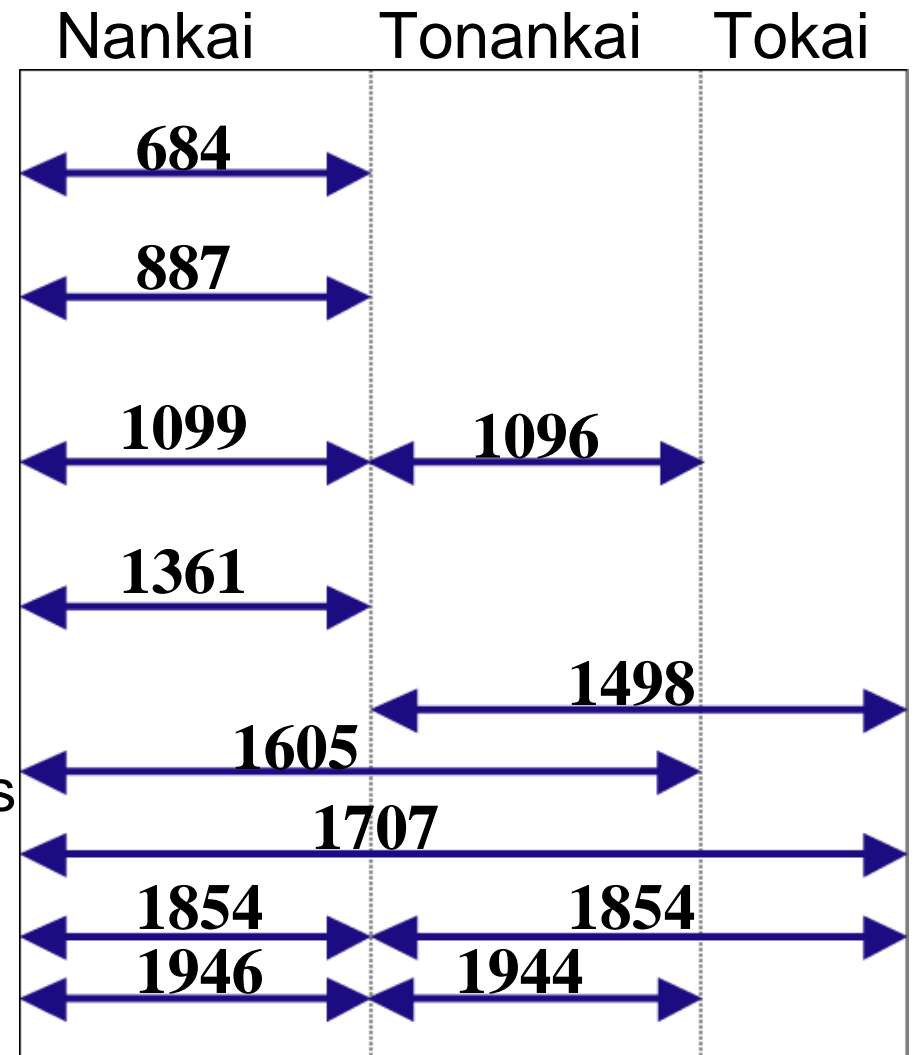
Sangawa(1992)

DECREASE IN GROUNDWATER DISCHARGE OR LEVEL AT HOT SPRINGS ASSOCATED WITH THE EARTHQUAKES

Dogo   Yunomine

"hot spring stopped discharging after the earthquake…" in ancient texts

Nankai   Tonankai   Tokai

684
887
1099   1096
1361
1498
1605
1707
1854   1854
1946   1944
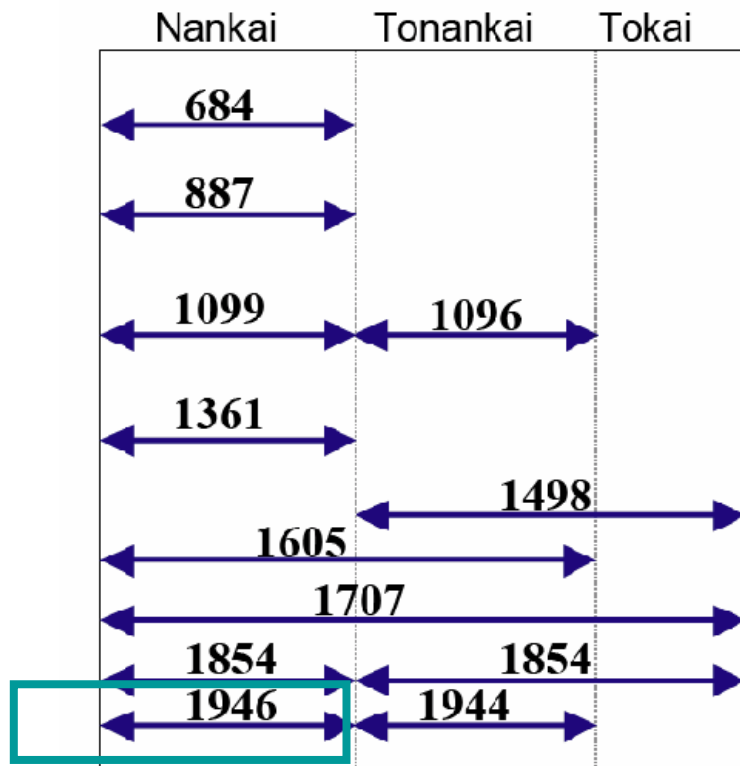
Sangawa (1992)

Usami (2003)

Dogo hot spring: Groundwater level decreases after the 1946 Nankai earthquake

1946 Nankai EQ

11.2m DROP AT NO.4 WELL

No.2 (303m)
NO.4 (195m)
NO.3 (202m)
NO.1 (4.5m)

Modified from Kawabe (1991)

m

0
-5
-10
-15

DEC.
JAN.
FEB.
MAR.
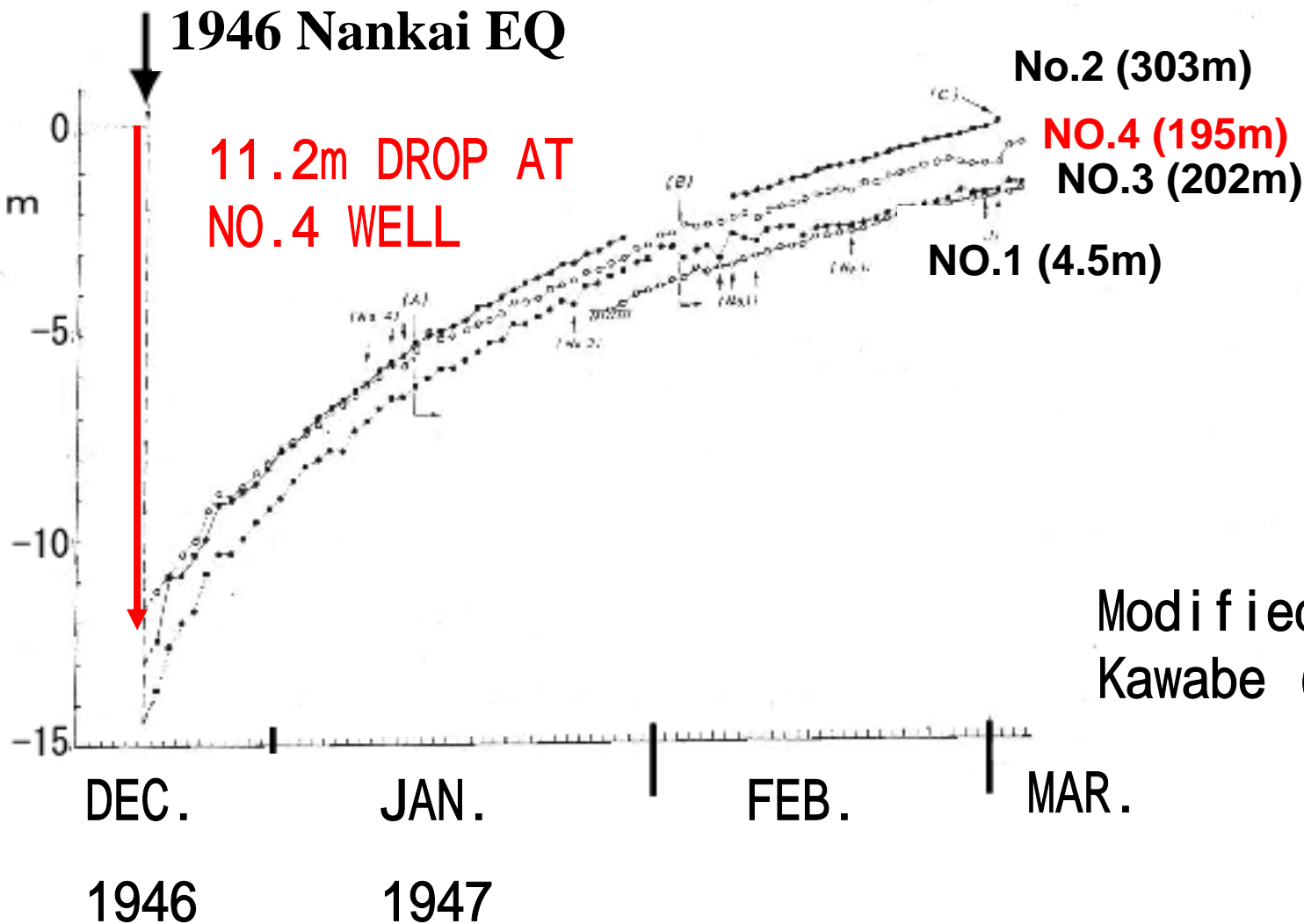
1946
1947

Strain sensitivity estimation using tidal analysis

ATMOSPHERIC PRESSURE

hPa / mm/h

1020 / 50

970 / 0

WATER LEVEL FROM
THE SURFACE AT NO.4 WELL

m

-20 / -20

-21 / -21

JUN   JUL   AUG

2003
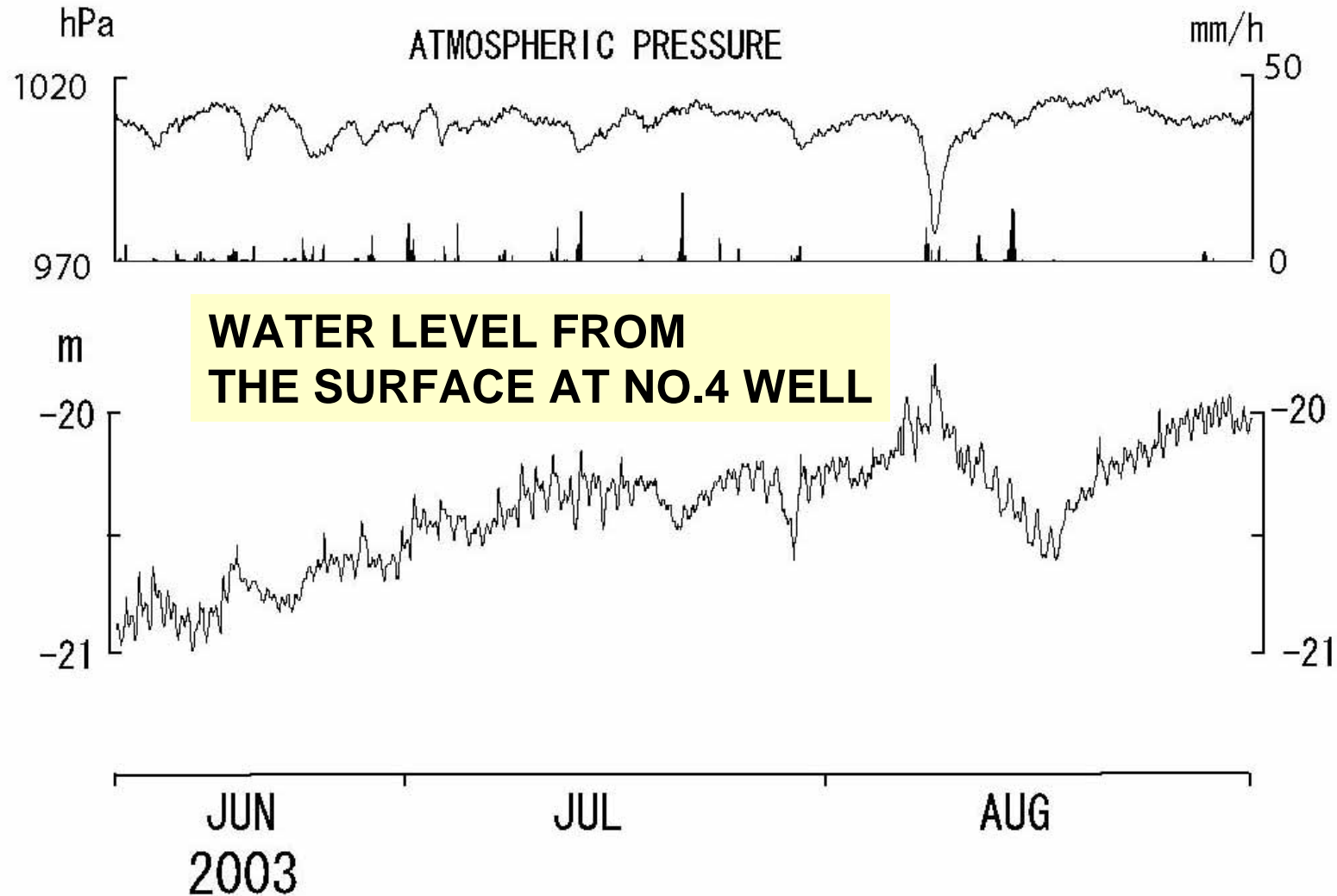
Sensitivity of the water level to vol. strain:
2.3 mm/nstrain 2.3 m/ppm

Dogo hot spring: Groundwater level decreases after the 1946 Nankai earthquake

1946 Showa Nankai EQ

No.2 (303m)

NO.4 (195m)

NO.3 (202m)

NO.1 (4.5m)

11.2 m DROP

SENSITIVITY 2.3m/ppm

VOLUMETRIC STRAIN CHANGE 5.3 - 6.0 ppm

12.2-13.8 m

Dec.1946   Jan.1947   Feb.1947   Mar.1947

Modified from Kawabe (1991)
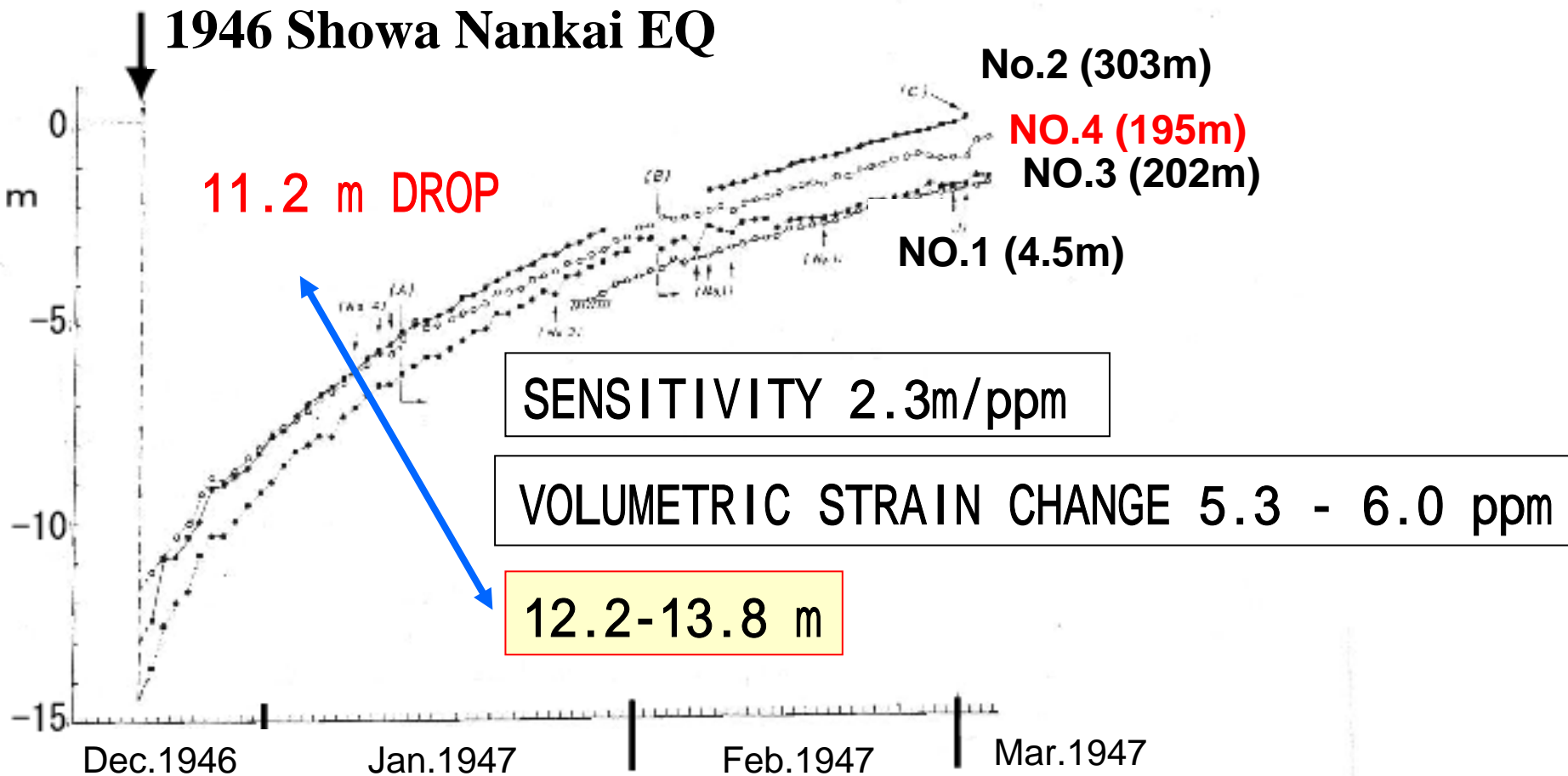
Preseismic groundwater anomalies

1-10 days before the 1854 Nankai earthquake
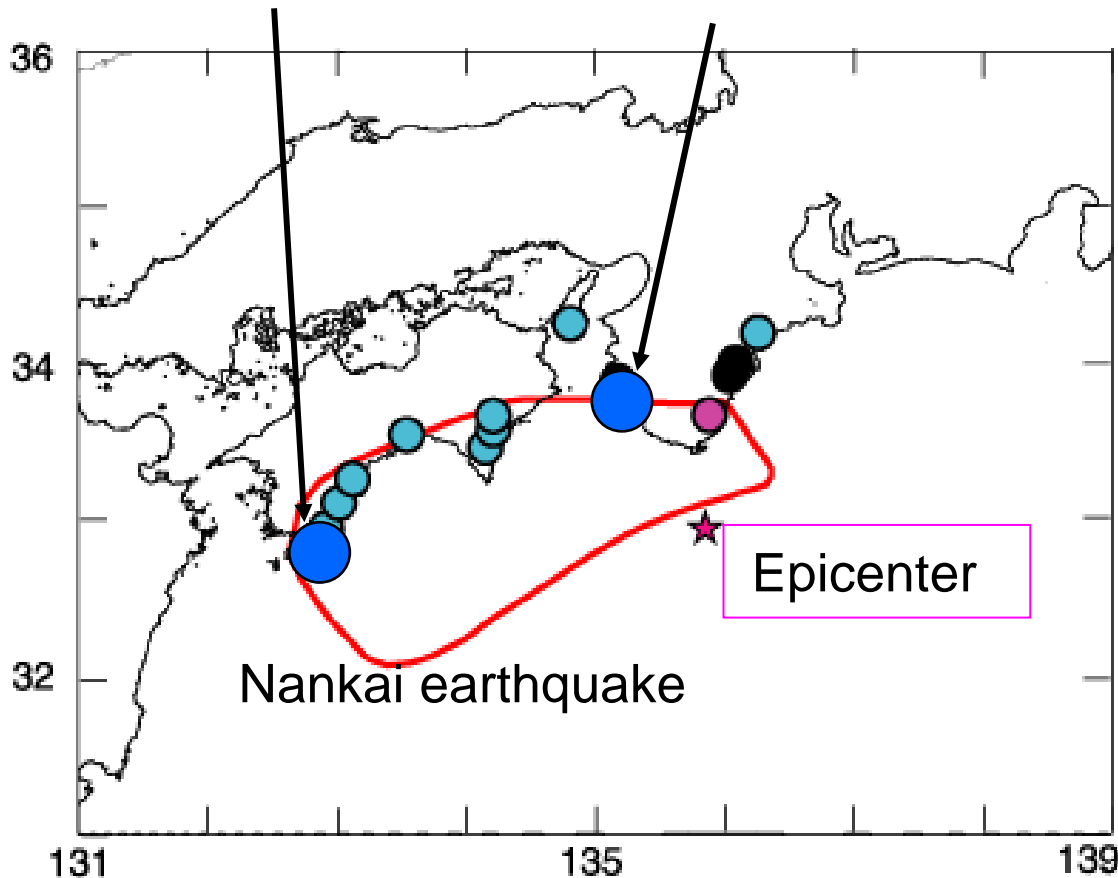
SHIGETOMI ET AL.(2005)

FEW ANOMALIES OCCURRED IN A **WIDE** AREA.

Epicenter

Nankai earthquake

Q 5-1m?

- 🔵 11 DROPS in shallow unconfined groundwater level
- 🔴 1 Decrease in hot spring water discharge
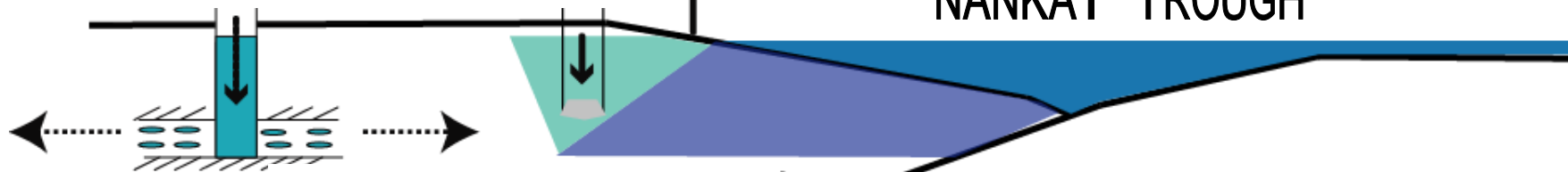- ⚫ Getting turbid

SURVEYD POINTS> **150**

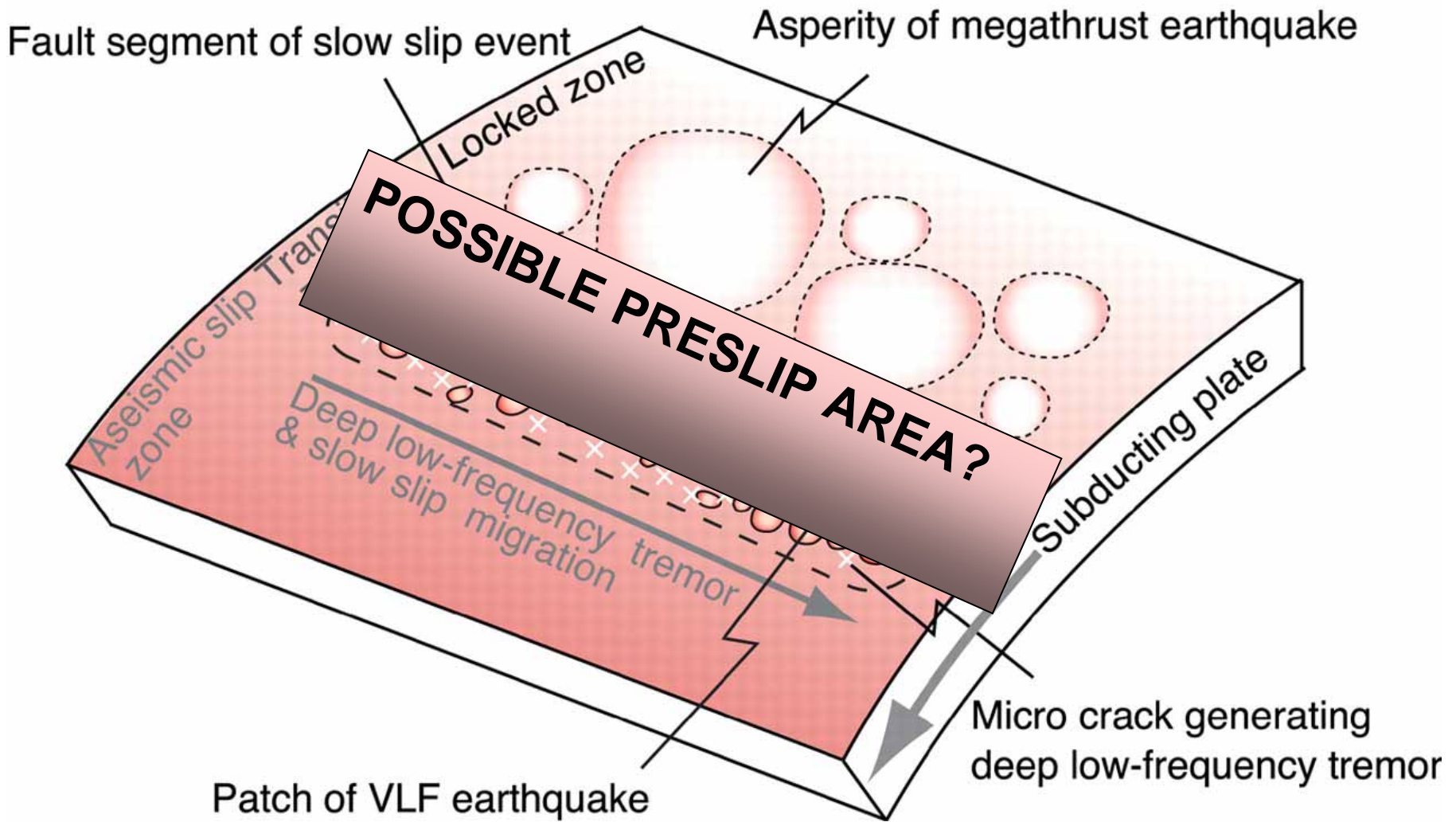3. **DECREASE** IN GROUNDWATER LEVEL OR DISCHARGE
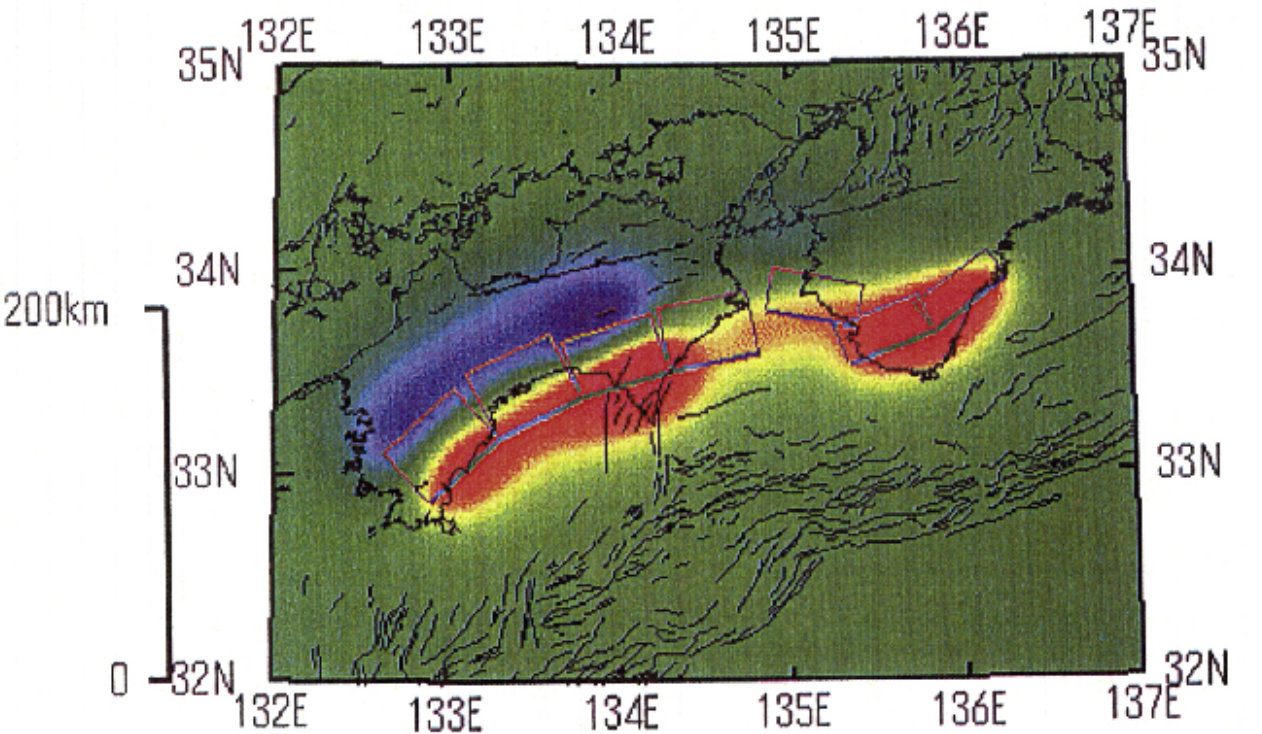
2. RISE

NANKAI TROUGH

2. EXTENSION

1. SLIP

EURASIAN PLATE

PHILIPPINE SEA PLATE

Fault segment of slow slip event

Asperity of megathrust earthquake

Locked zone

POSSIBLE PRESLIP AREA?

Aseismic slip Transition zone

Deep low-frequency tremor & slow slip migration

Subducting plate

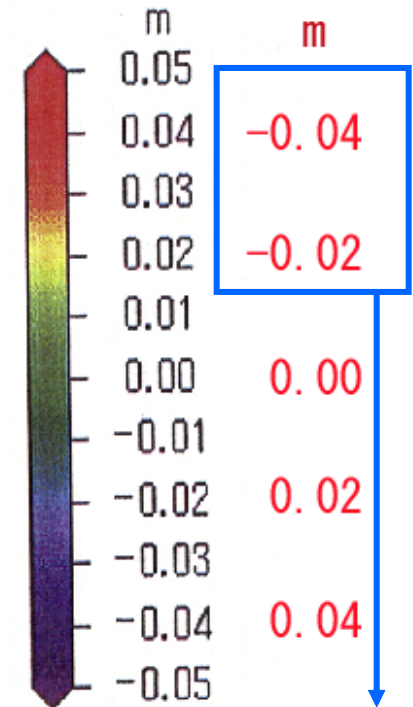Micro crack generating deep low-frequency tremor

Patch of VLF earthquake

Ito et al. (2007)

PRESEISMIC VERTICAL MOVEMENTS AT THE SURFACE
EXPECTED FROM A PRE-SLIP MODEL FOR
THE 1946 NANKAI EARTHQUAKE

MODIFIED FROM HASHIMOTO (2003)

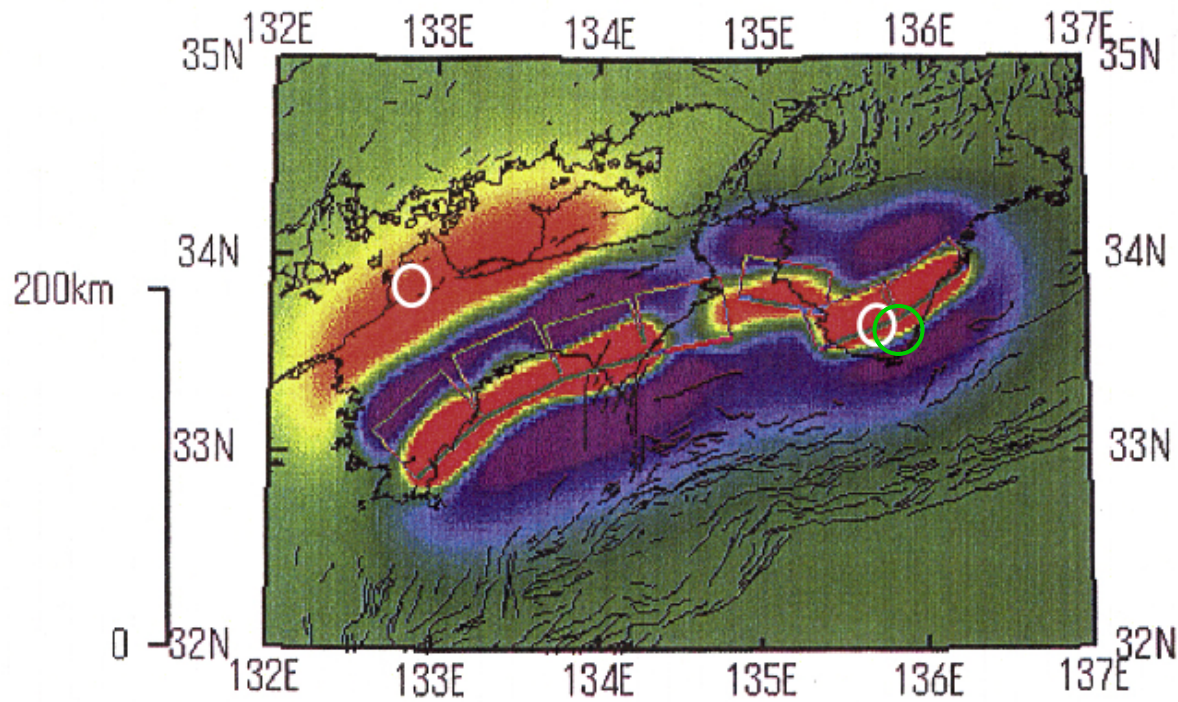UNCONFINED
GROUNDWATER
LEVEL CHANGE

m

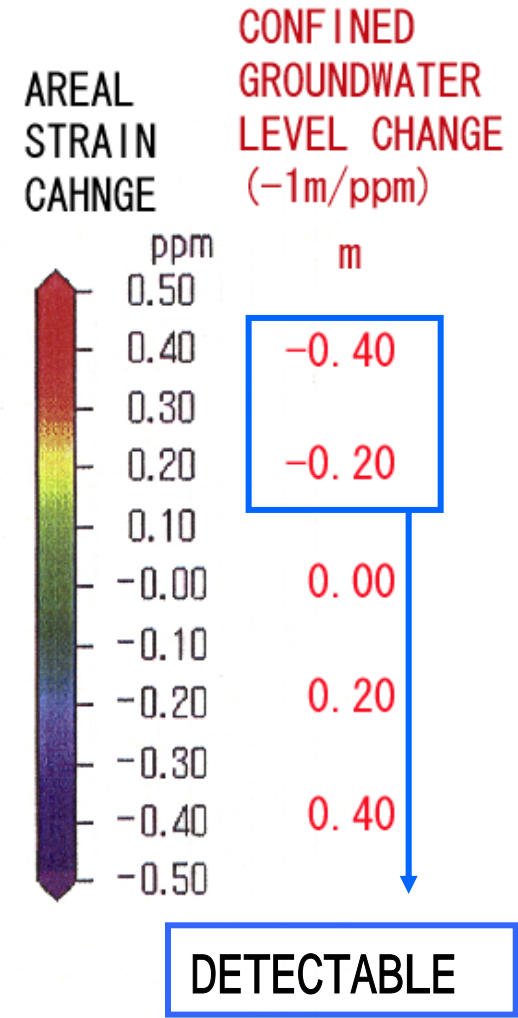| m	
0.05	
0.04	−0.04
0.03	
0.02	−0.02
0.01	
0.00	0.00
−0.01	
−0.02	0.02
−0.03	
−0.04	0.04
−0.05	

TOO SMALL!!

PRESEISMIC AREAL STRAIN CHANGES EXPECTED FROM A <u>PRE-SLIP MODEL</u> FOR THE 1946 NANKAI EARTHQUAKE

MODIFIED FROM HASHIMOTO (2003)

AREAL STRAIN CAHNGE

CONFINED GROUNDWATER LEVEL CHANGE (−1m/ppm)

ppm	m
0.50	
0.40	−0.40
0.30	
0.20	−0.20
0.10	
−0.00	0.00
−0.10	
−0.20	0.20
−0.30	
−0.40	0.40
−0.50	

DETECTABLE

Dogo hot spring: Groundwater level decreases after the 1946 Nankai earthquake

1946 Nankai EQ

No.2 (303m)

NO.4 (195m)

NO.3 (202m)

NO.1 (4.5m)

Modified from
Kawabe (1991)

Dec.
1946

Jan.
1947

Feb.

Mar.
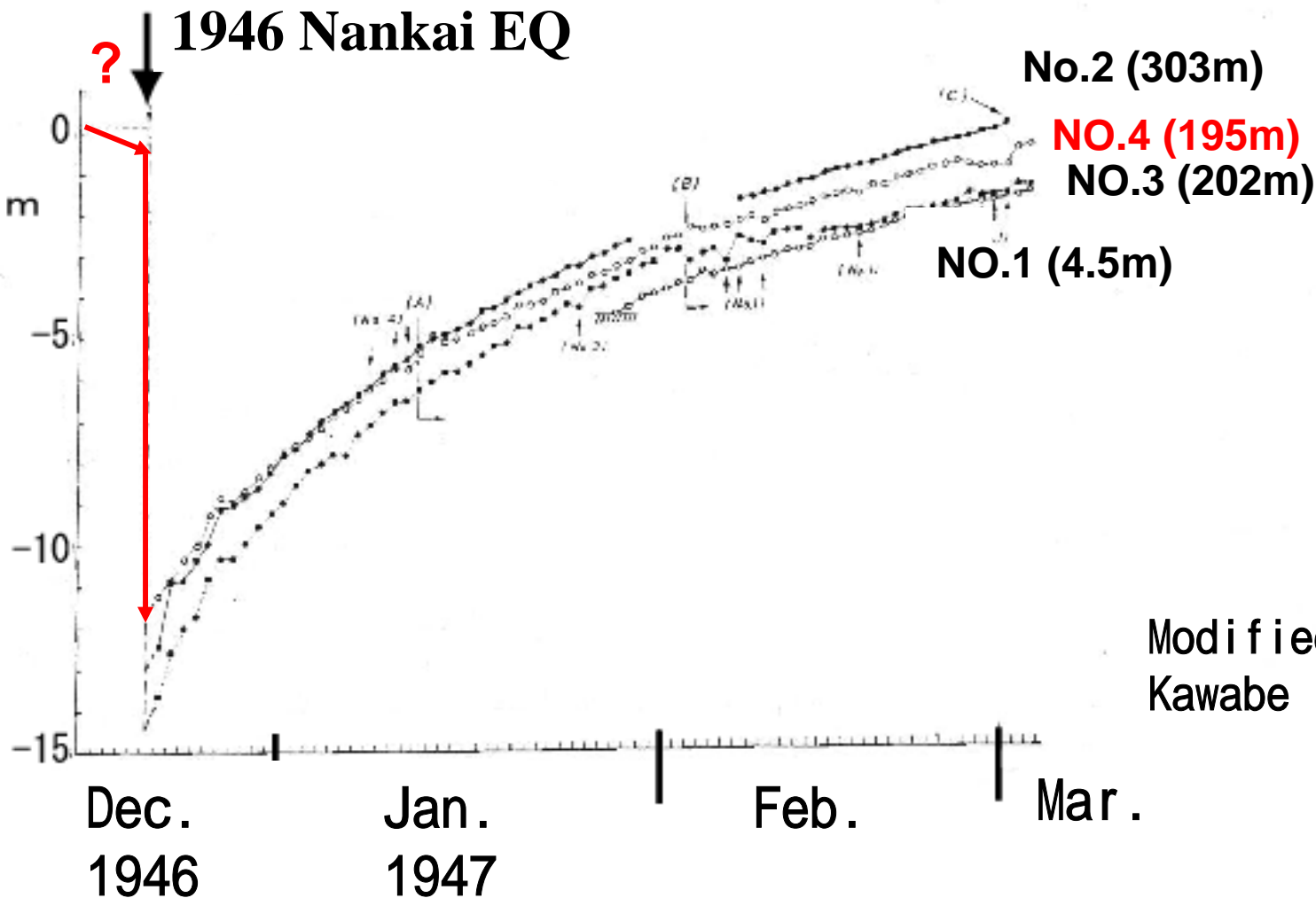
SHALLOW UNCONFINED GROUNDWATER: MODEL-1

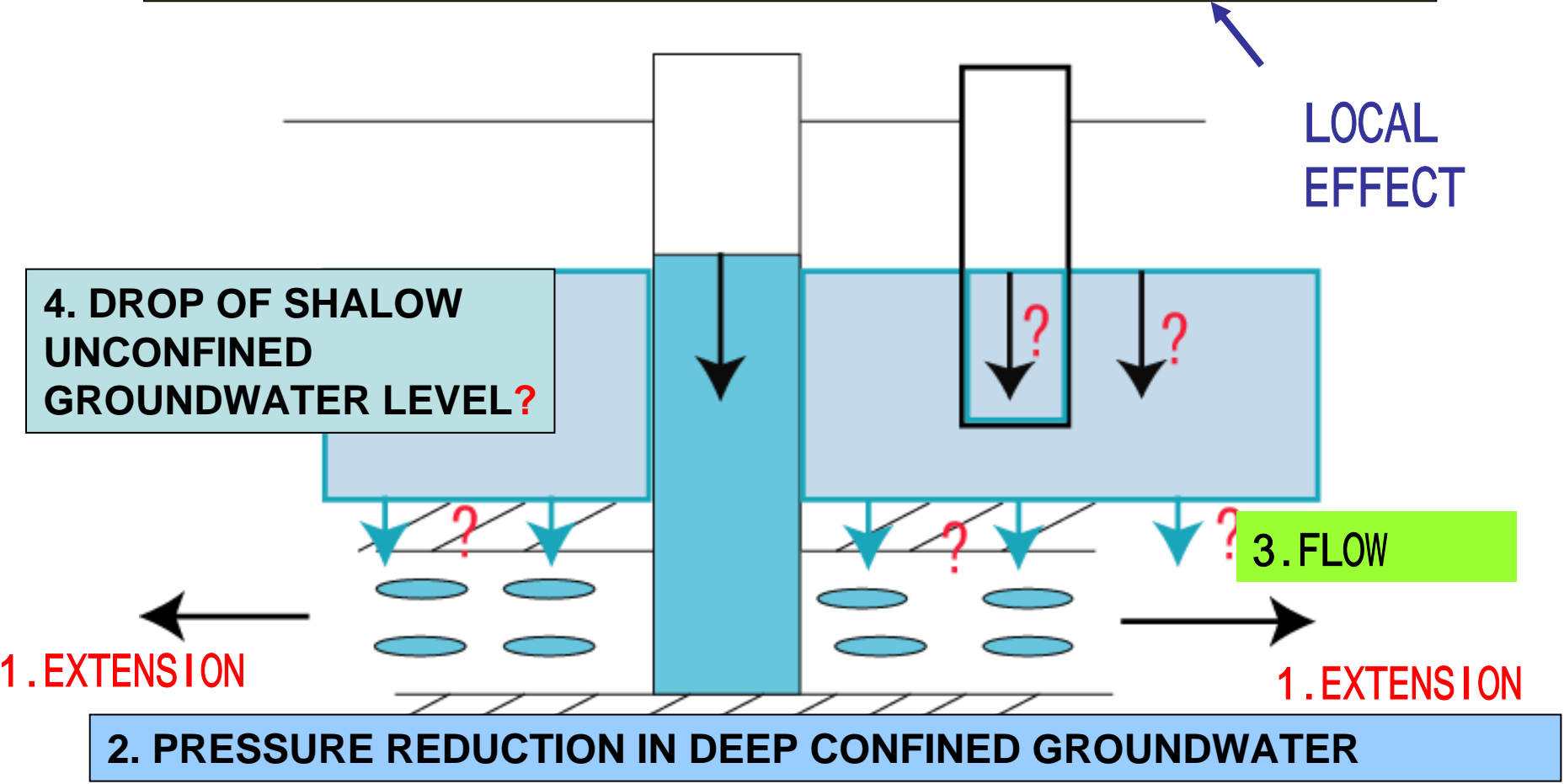3. LARGE DECREASE?

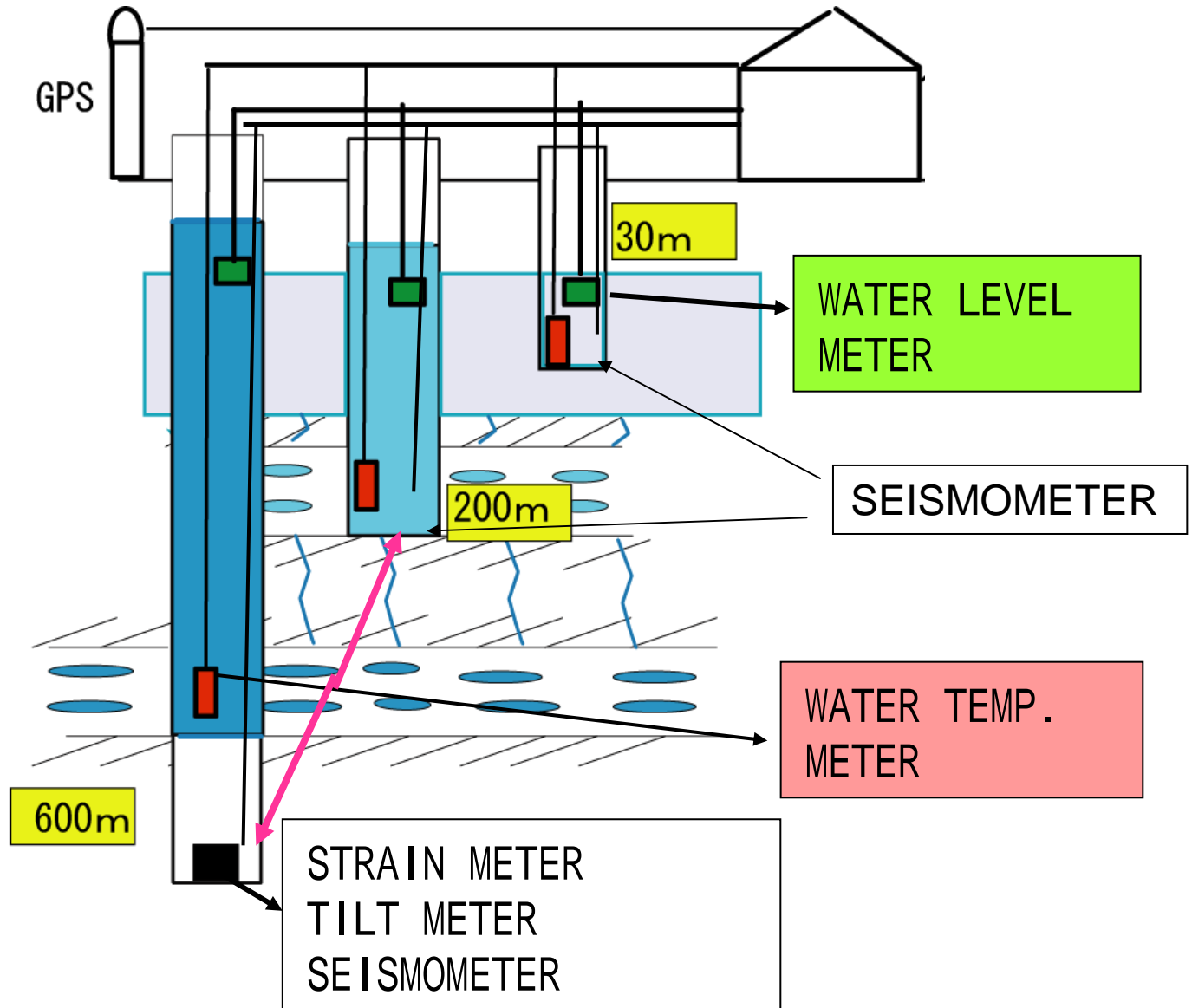2. LOCAL LARGE RISE OR TILT?

EURASIAN PLATE

1. SLIP

PHILIPPINE SEA PLATE
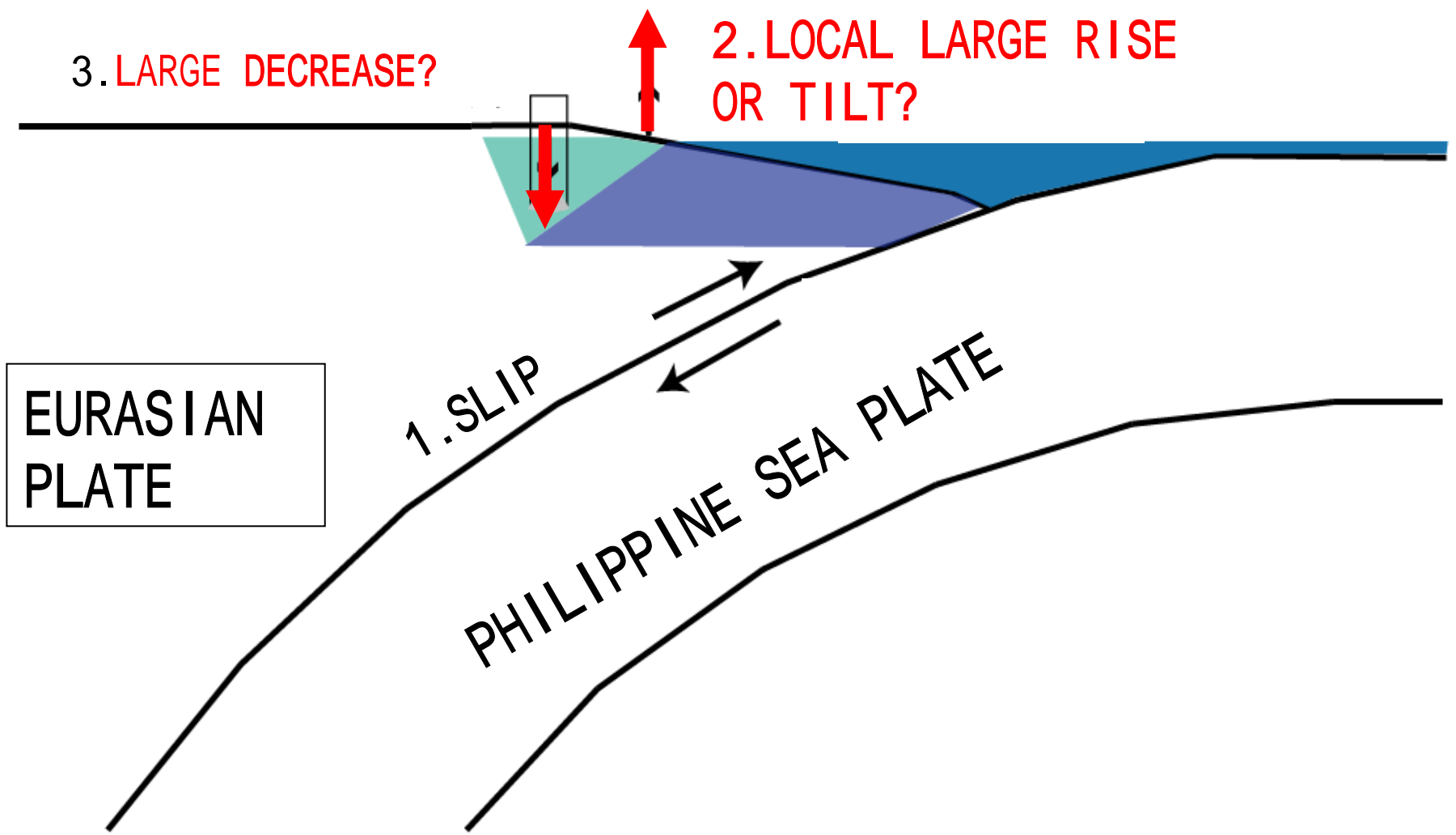
✓ WIDE AREA

PRESEISMIC CRUSTAL DEFORMATION INDUCED BY PRESLIP

FLOW FROM UNCONFINED GROUNDWATER TO CONFINED GROUNDWATER ?

LOCAL EFFECT

4. DROP OF SHALOW UNCONFINED GROUNDWATER LEVEL?

3. FLOW

1. EXTENSION

1. EXTENSION

2. PRESSURE REDUCTION IN DEEP CONFINED GROUNDWATER

NEW OBSERVATION STATION

GPS

30m

WATER LEVEL METER
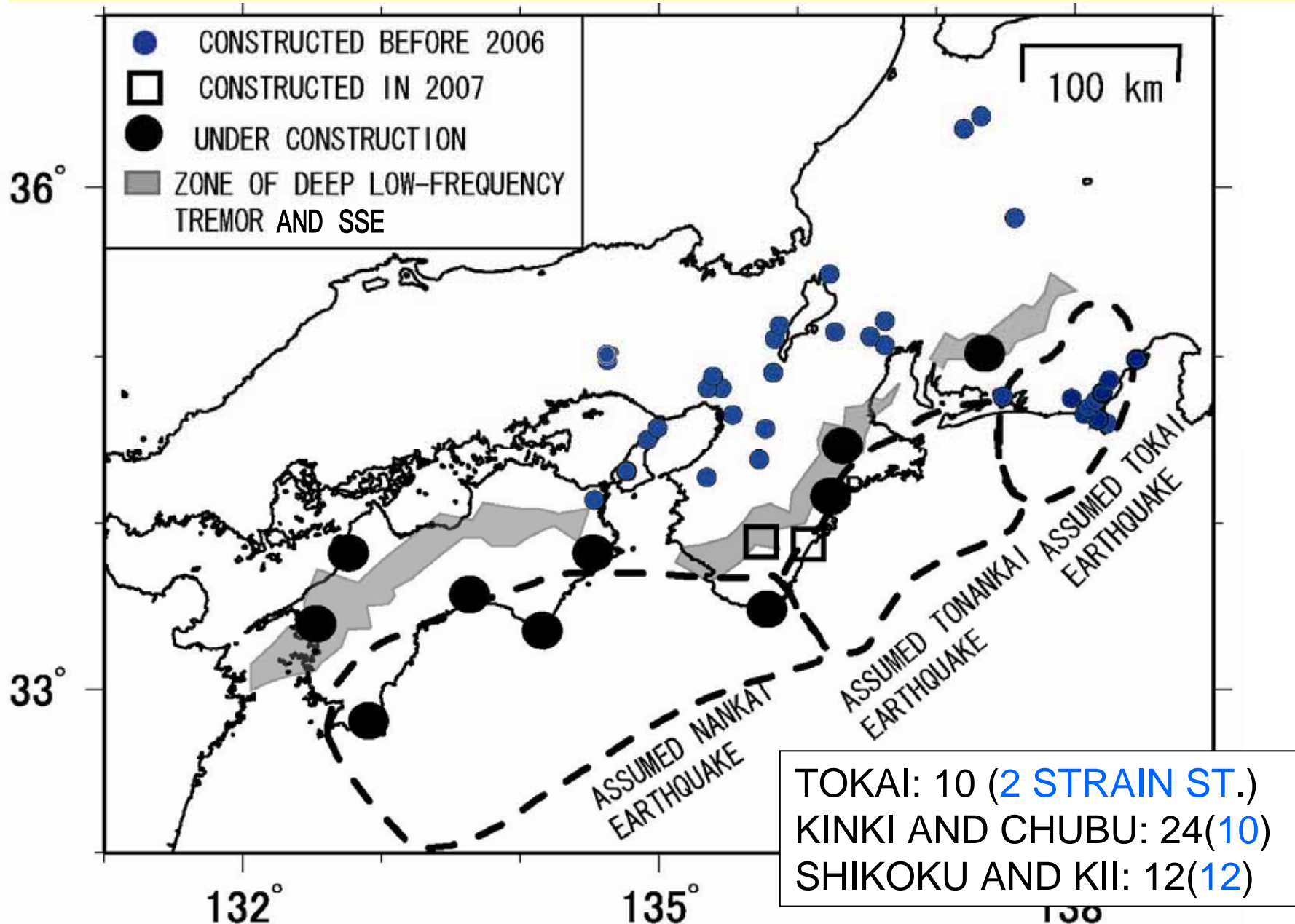
SEISMOMETER

200m

WATER TEMP. METER

600m
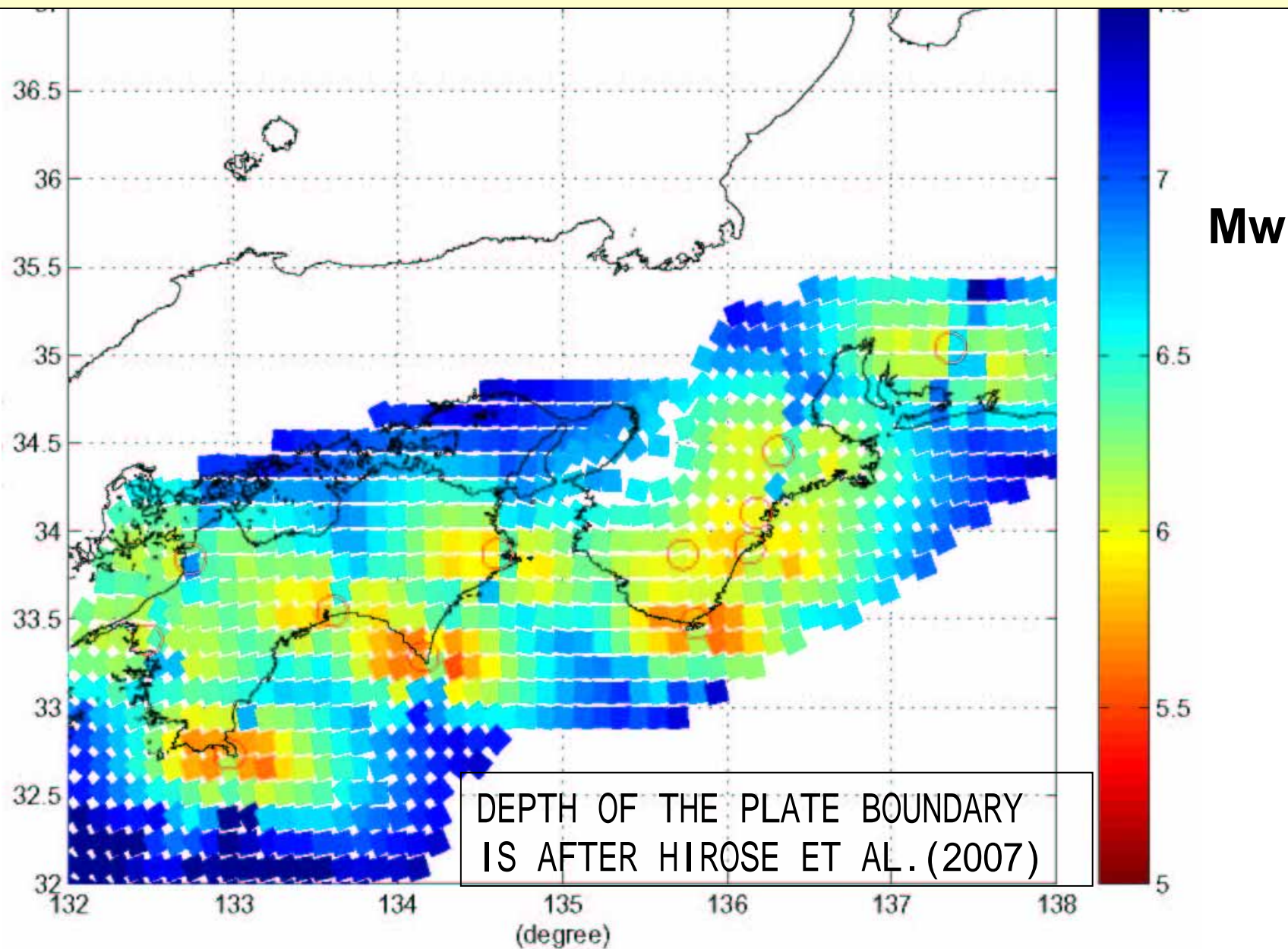
STRAIN METER
TILT METER
SEISMOMETER

GROUNDWATER OBSERVATION NETWORK OF GSJ, AIST

DETECTABLE MINIMUM SLIP ON THE PLATE BOUNDARY WHICH CAUSES STRAIN OF 0.02 PPM ON THE SURFACE BY 12 STATIONS

Mw

DEPTH OF THE PLATE BOUNDARY IS AFTER HIROSE ET AL. (2007)

CONCLUSIONS

GSJ, AIST IS CONSTRUCTING THE INTEGRATED
OBSERVATION NETWORK

- To detect and confirm the preslip for gigantic earthquakes in Nankai and Suruga troughs,

- To monitor SSE precisely to clarify the mechanism of SSE and develop the preslip model,

- To know whether groundwater amplifies small crustal deformation related to slow slip in the plate boundary.

Thank you for your interest.