Quantitative Evaluation of the AIST Groundwater-Level Observation Network to Detect Preslip of the Anticipated Tokai Earthquake

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This presentation

- Introduction: Purpose of this study
- Anticipated Tokai earthquake
- AIST groundwater observation network
- Evaluation method of detectability
- Detectabilities of M6.5 and M6 preslips
- Conclusions

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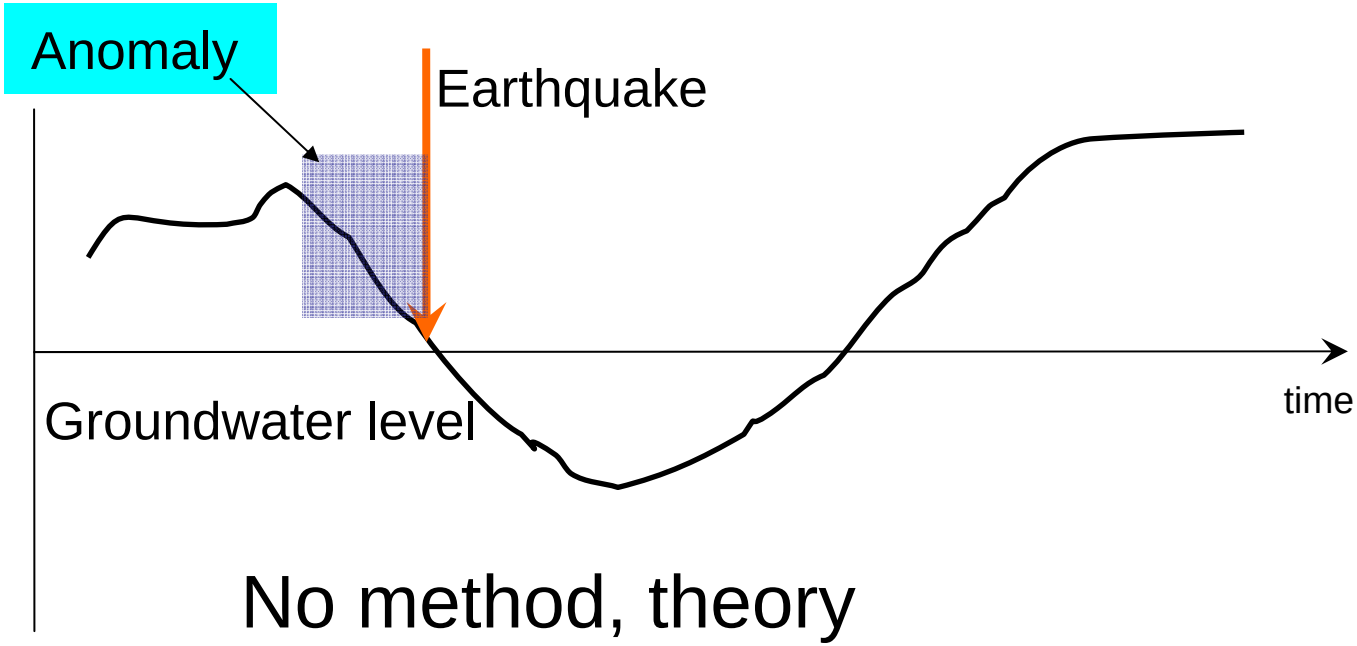
Hydrological precursors in conventional earthquake prediction research

Only hydrological precursor detection



No method, theory

Even if we recognize it as anomalous change in advance,

Epicenter?? Occurrence time?? Magnitude??

Hydrological Precursor and the Tokai Earthquake Prediction

Target earthquake: fixed

The anticipated Tokai earthquake (M8)
Magnitude and rupture zone are already estimated.

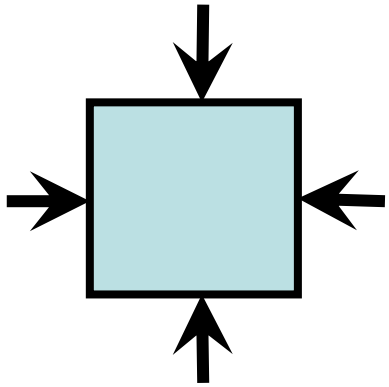
Target signal: fixed

Hydrological anomalies due to preslip prior to the Tokai earthquake.

Hydrological Precursor and the Tokai Earthquake Prediction (2)

Theoretical support to estimate an occurrence time: We have!

- Preslip to the mainshock: **rate- and state-dependent friction law** and numerical simulation (Kato and Hirasawa, 1999)
- Relationship between groundwater level and crustal deformation: **poroelasticity**



Pore pressure

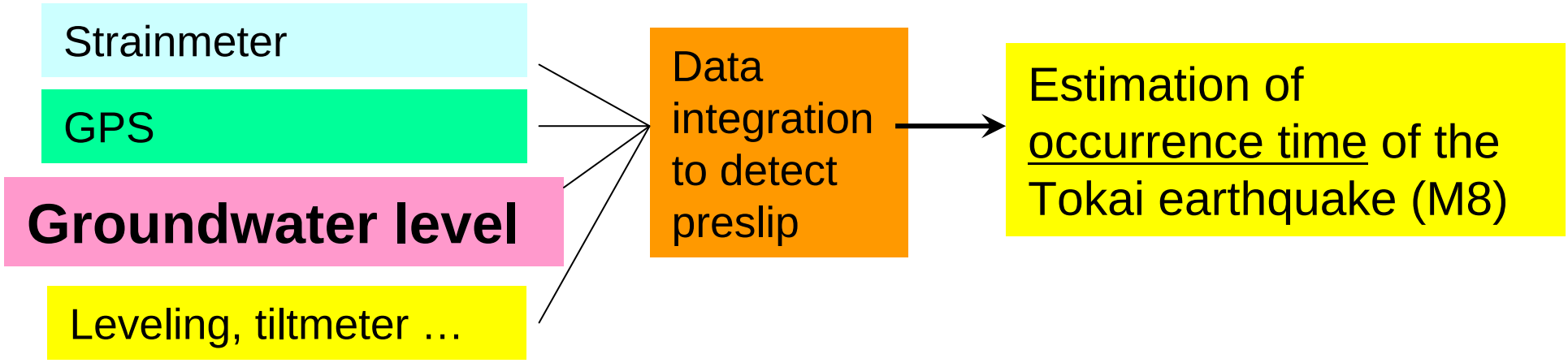
Volmetric strain

$$\Delta p = \frac{2GB}{3}\frac{1+\nu_u}{1-2\nu_u}\Delta\epsilon_{kk}$$

Pore pressure is proportional to volumetric strain.

10^{-8}strain contraction: 0.1～10 cm increase in groundwater level

Hydrological Precursor and the Tokai Earthquake Prediction (3)



In order to contribute Tokai earthquake prediction, We need to evaluate detectability of preslip to the Tokai earthquake in the AIST groundwater observation network.

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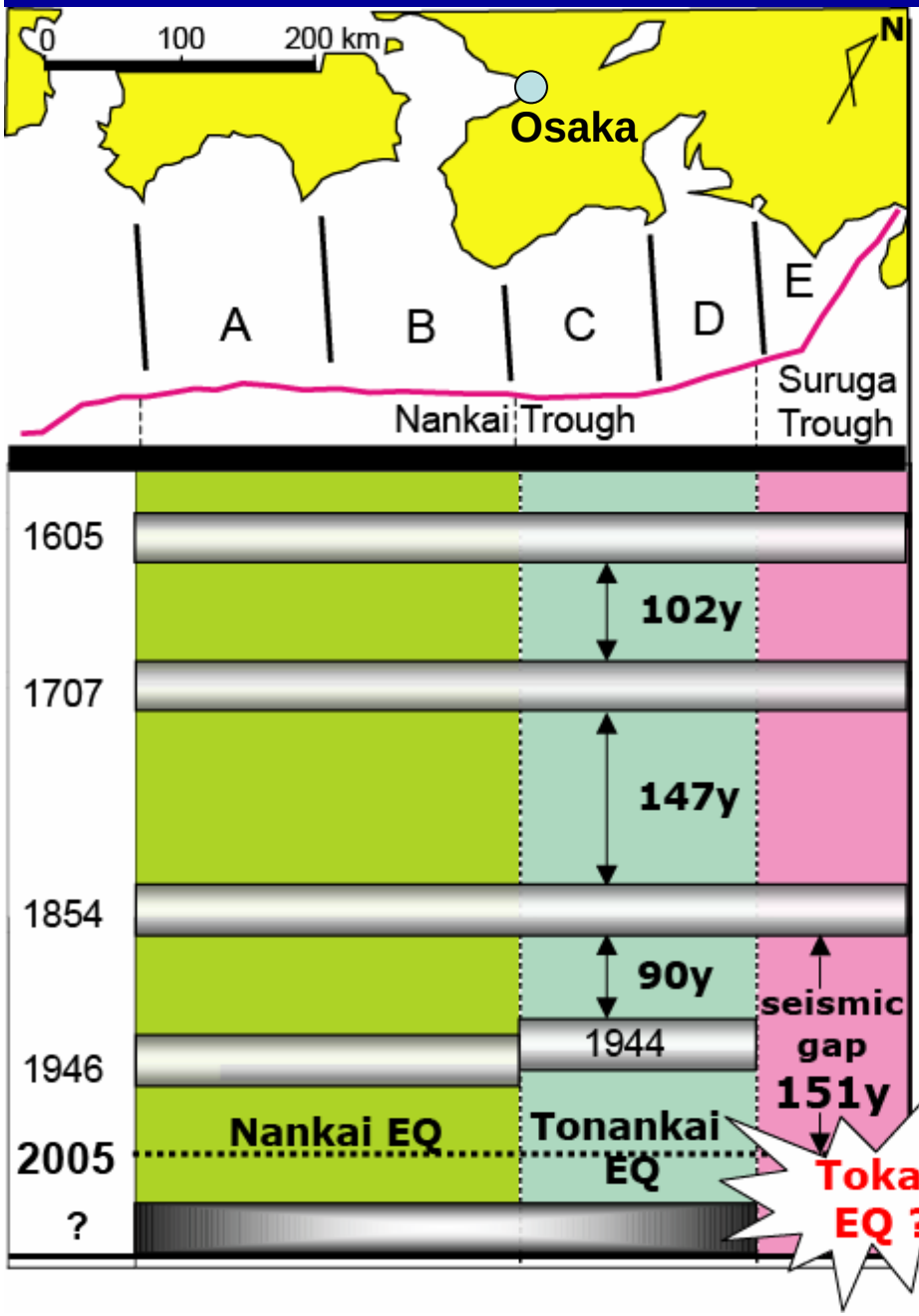
AIST

Historical earthquakes along the Nankai-Suruga Troughs



rupture zone

Keicho (M7.9)
Many Tsunami hazards
No ground motion hazard

Hoei (M8.4)
ruptured A-E at once
5,038 or more are killed

Ansei Tokai (M8.4) C-E
Ansei Nankai (M8.4) A, B
32 hrs later
2,658 or more are killed

Showa Tonankai (M7.9)
C,D; 1,251 are killed
Showa Nankai (M8.0)
2 ys later; A, B; 2,658 killed

after Sangawa (1992)

Recurrence Interval:
90 – 150 yrs

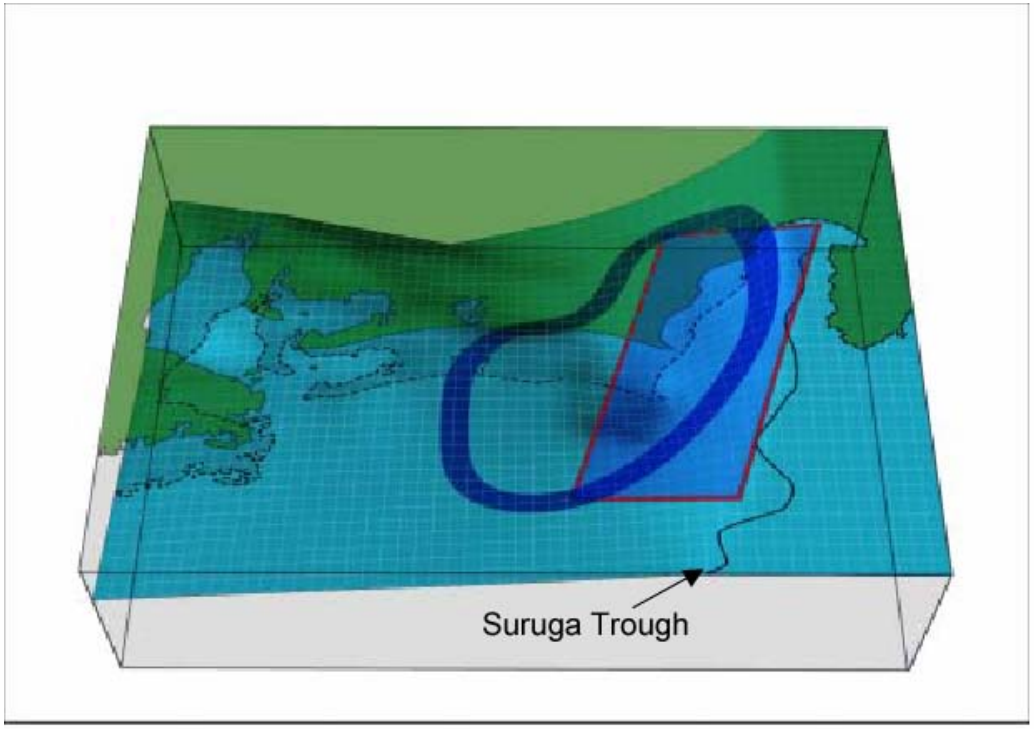
A,B: Nankai EQ
C,D: Tonankai EQ
E or C-E: Tokai EQ

Rupture patten is different.

System of Earthquake Prediction in the Tokai Region

- Japan Meteorological Agency (JMA) is responsible for the prediction of anticipated Tokai earthquake. Director-General of JMA convenes the Earthquake Assessment Committee to predict the Tokai earthquake.
- Groundwater data observed by our institute (AIST) is reported to the Committee once a month, and a part of the data is transferred to JMA by real-time processing.

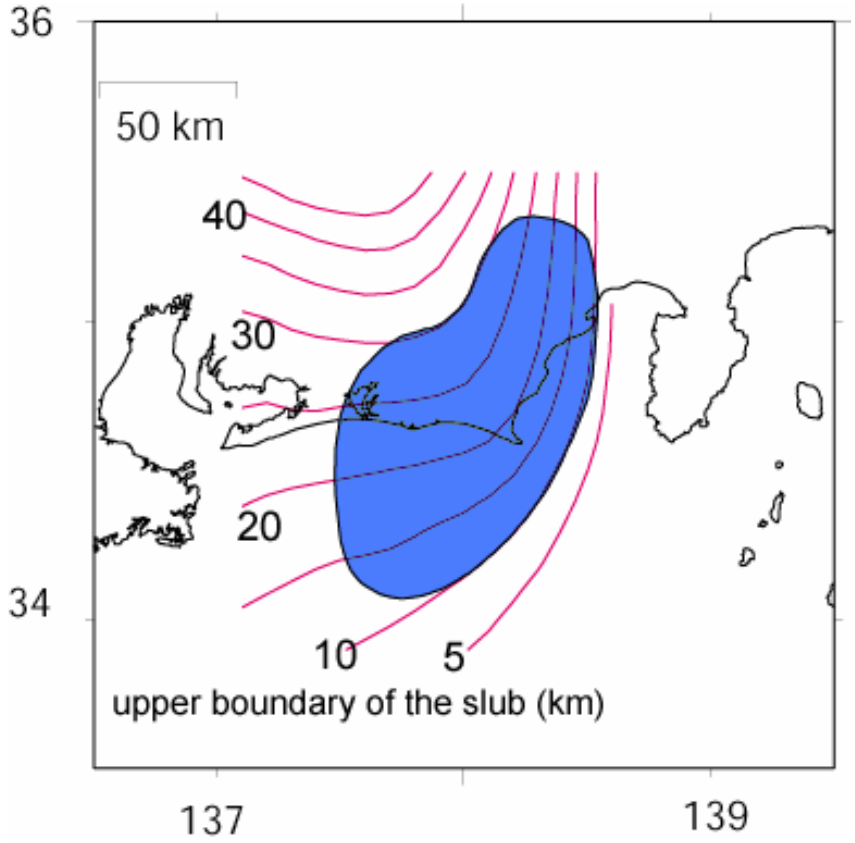
Hypothetical rupture zone of the Tokai earthquake
and upper boundary of the Philippine Sea slub



Revised hypothetical rupture zone of the Tokai earthquake by CDPC (2001)

Hypothetical rupture zone by CDPC (1979)

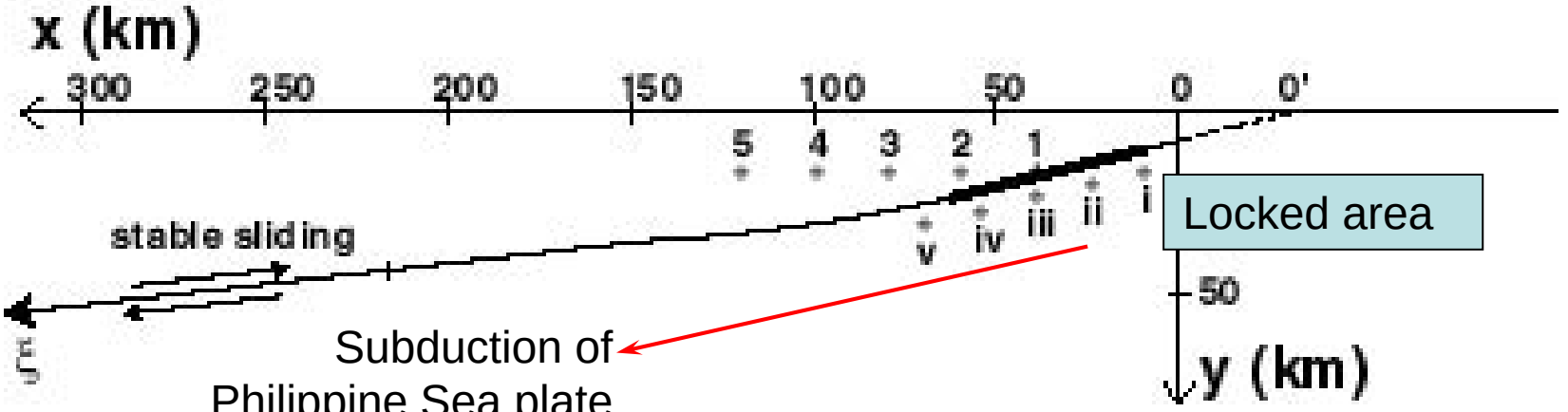
CDPC: Central Disaster Prevention Council, Japanese Government



Rupture zone: boundary of two plates
Depth:10 – 30 km

2-D model for the Tokai earthquake

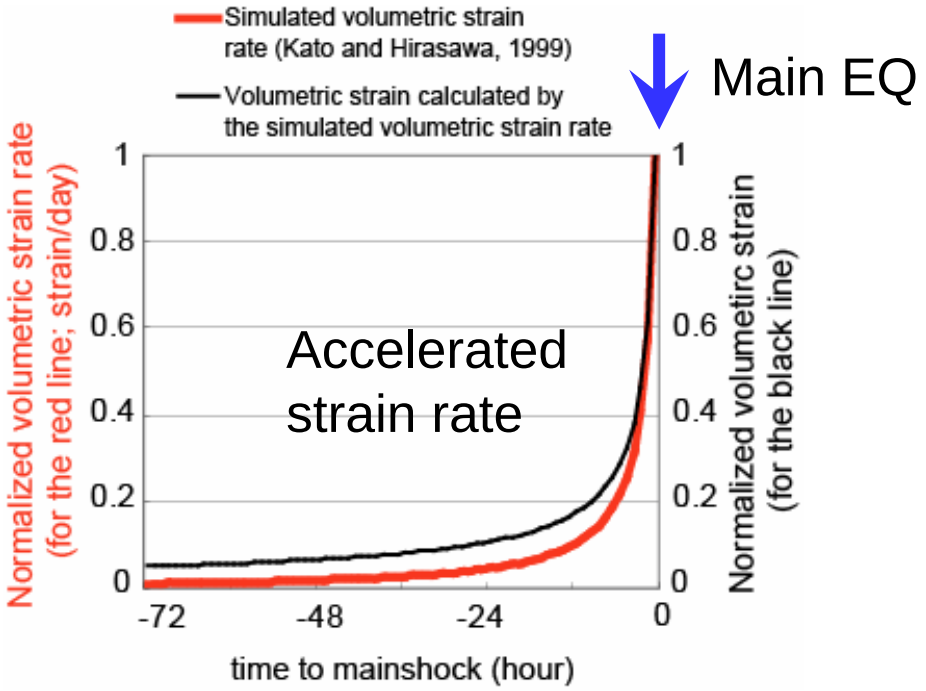
Kato and Hirasawa (1999)



Subduction of
Philippine Sea plate
4 cm /year

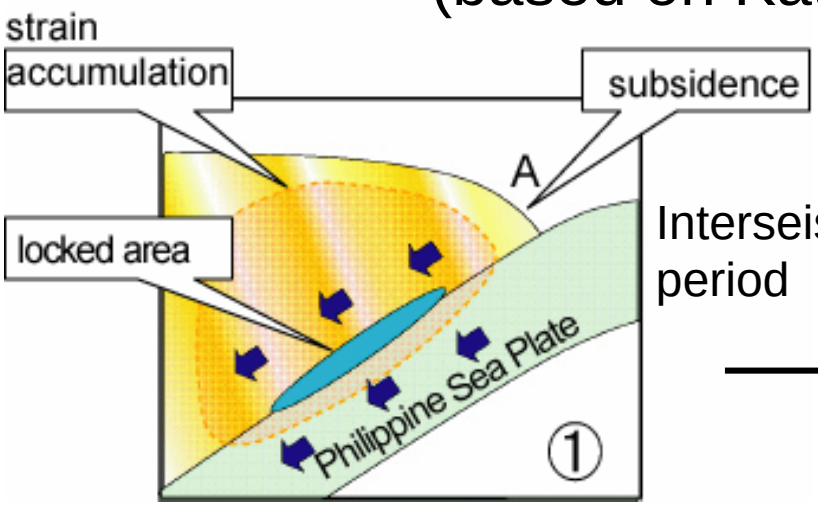
Numerical simulation in a uniform elastic half-space is done by applying rate- and state-dependent friction law.

We apply this strain history to groundwater level anomalies due to preslip.

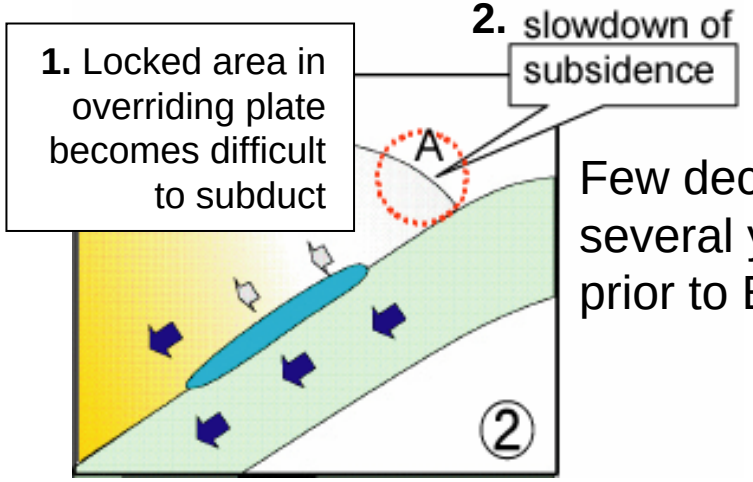


Possible scenario of the Tokai earthquake

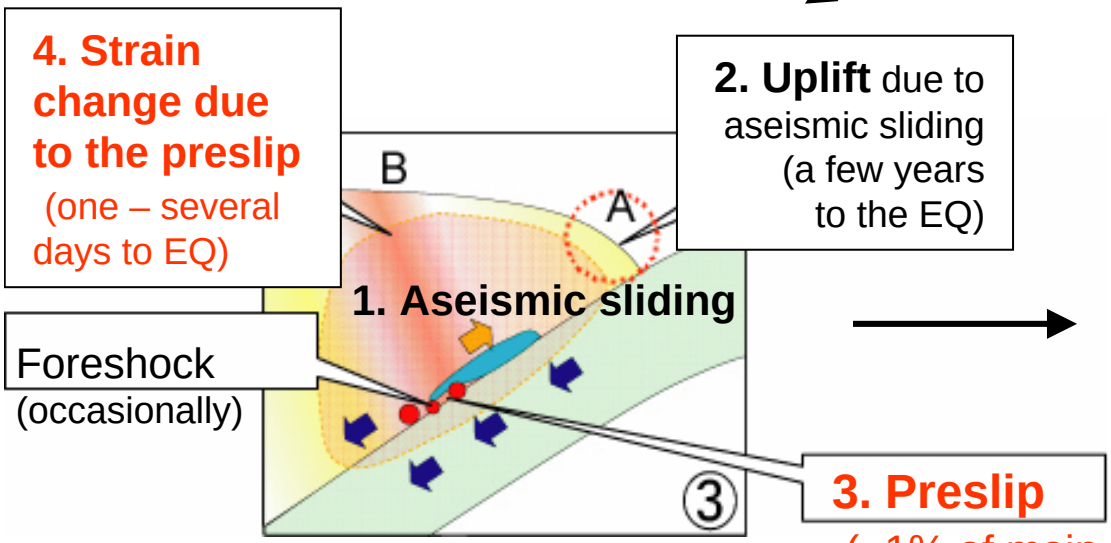
(based on Kato's model; JMA, 2003)



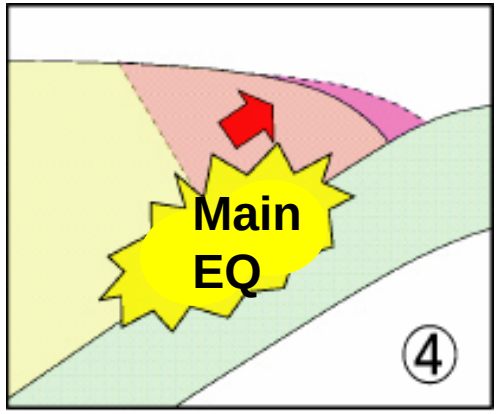
Interseismic period



Few decades - several years prior to EQ



(~1% of main EQ)



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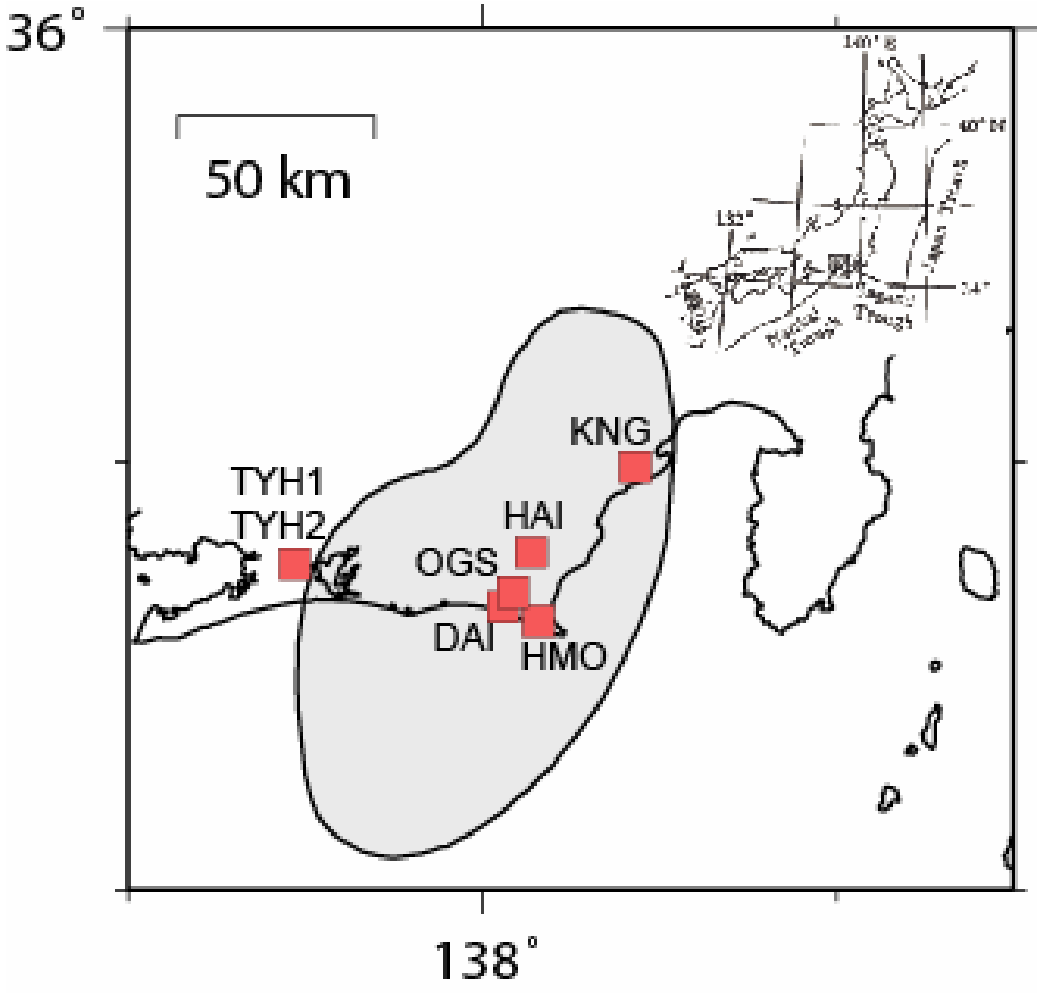
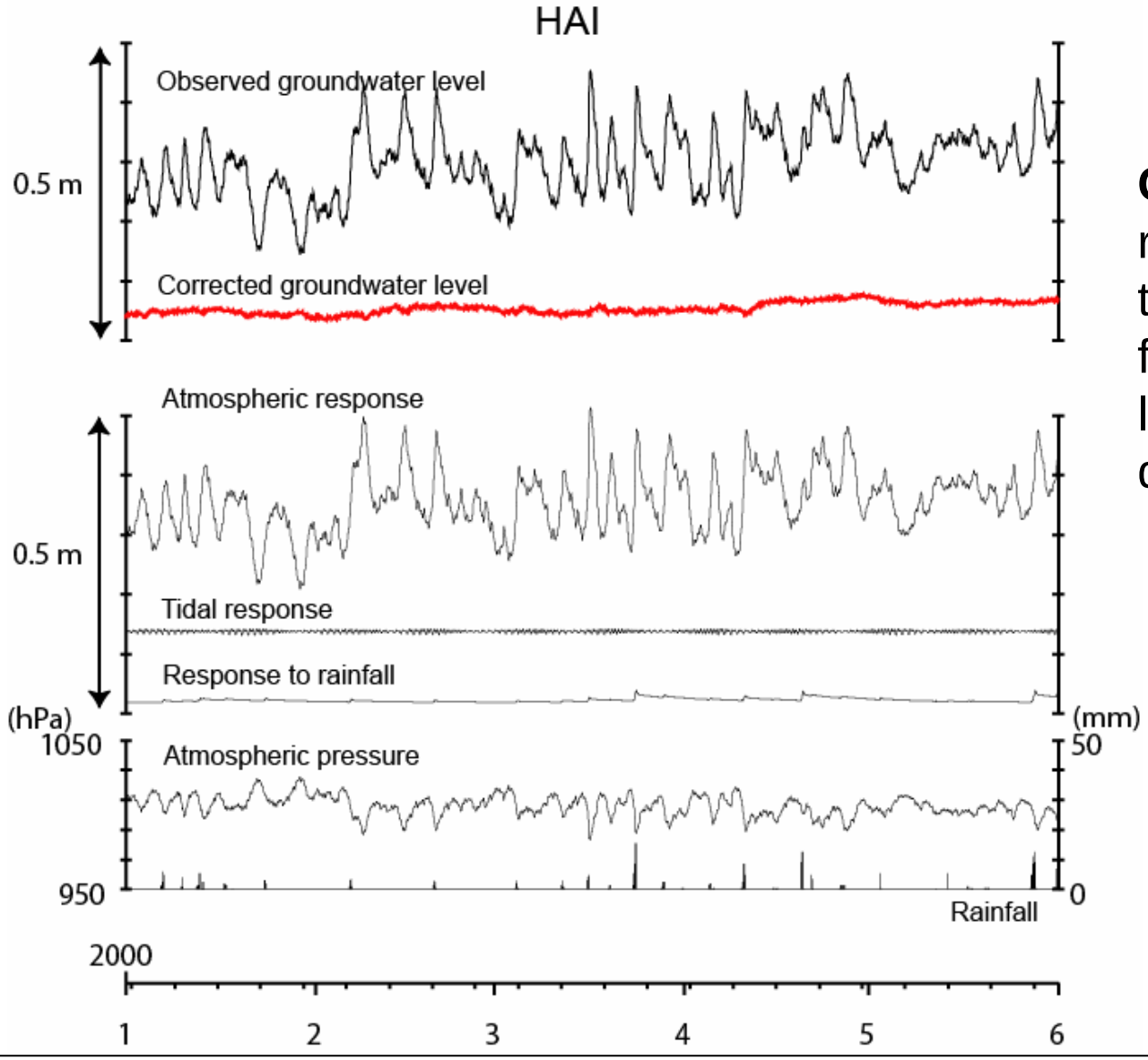
AIST groundwater observation network in and around the Tokai region



Groundwater levels at seven wells are evaluated to detect preslip before the anticipated Tokai earthquake.

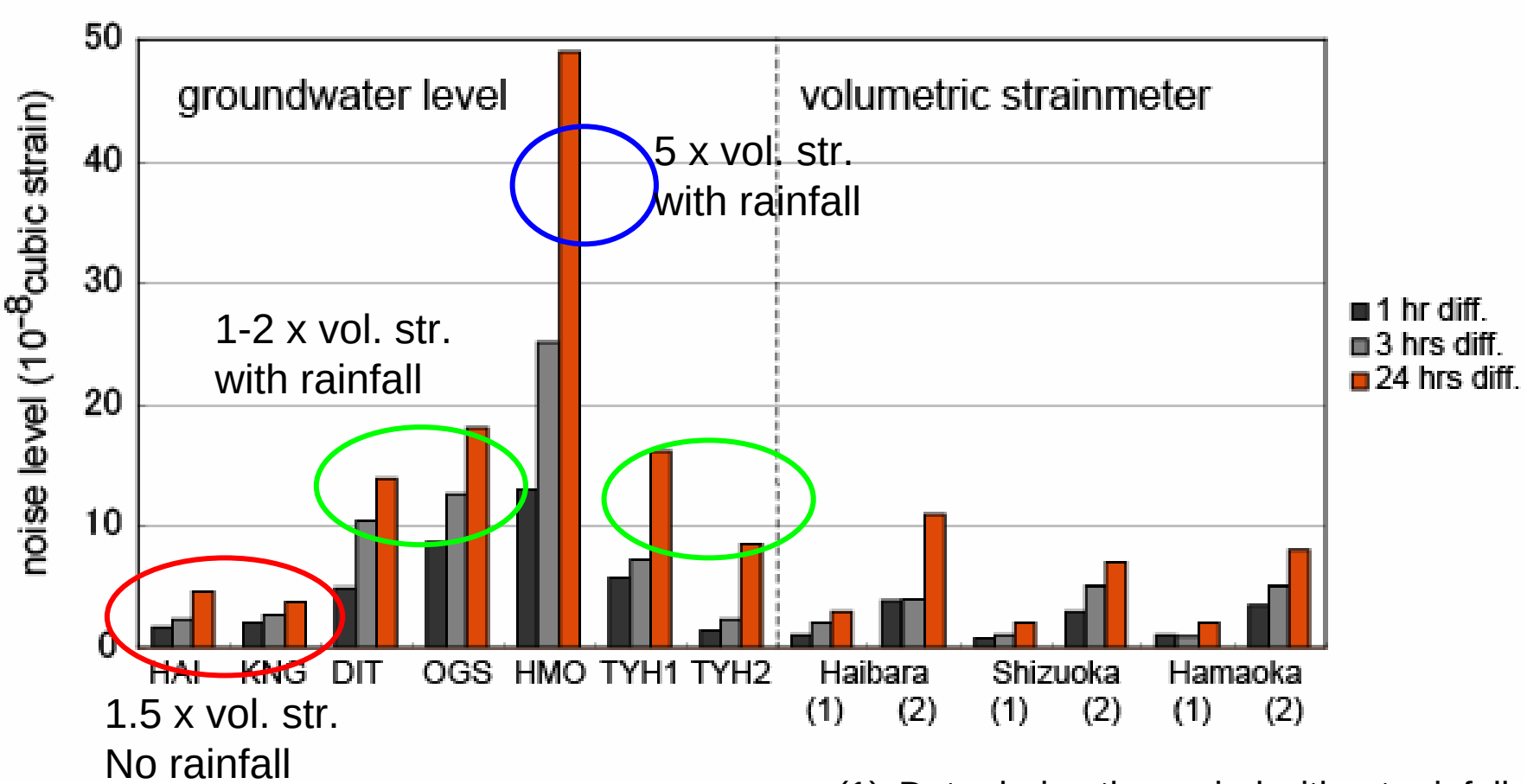
Data processing of the groundwater level



Corrected water level, removed atmospheric, tidal and rain responses from observed water level is used to evaluate detectability of preslip

Strain-converted noise levels in the groundwater levels and noise levels of strainmeters

noise level: the value to extract the maximum change in usual.



(1) Data during the period without rainfall
(2) Data during the period with rainfall

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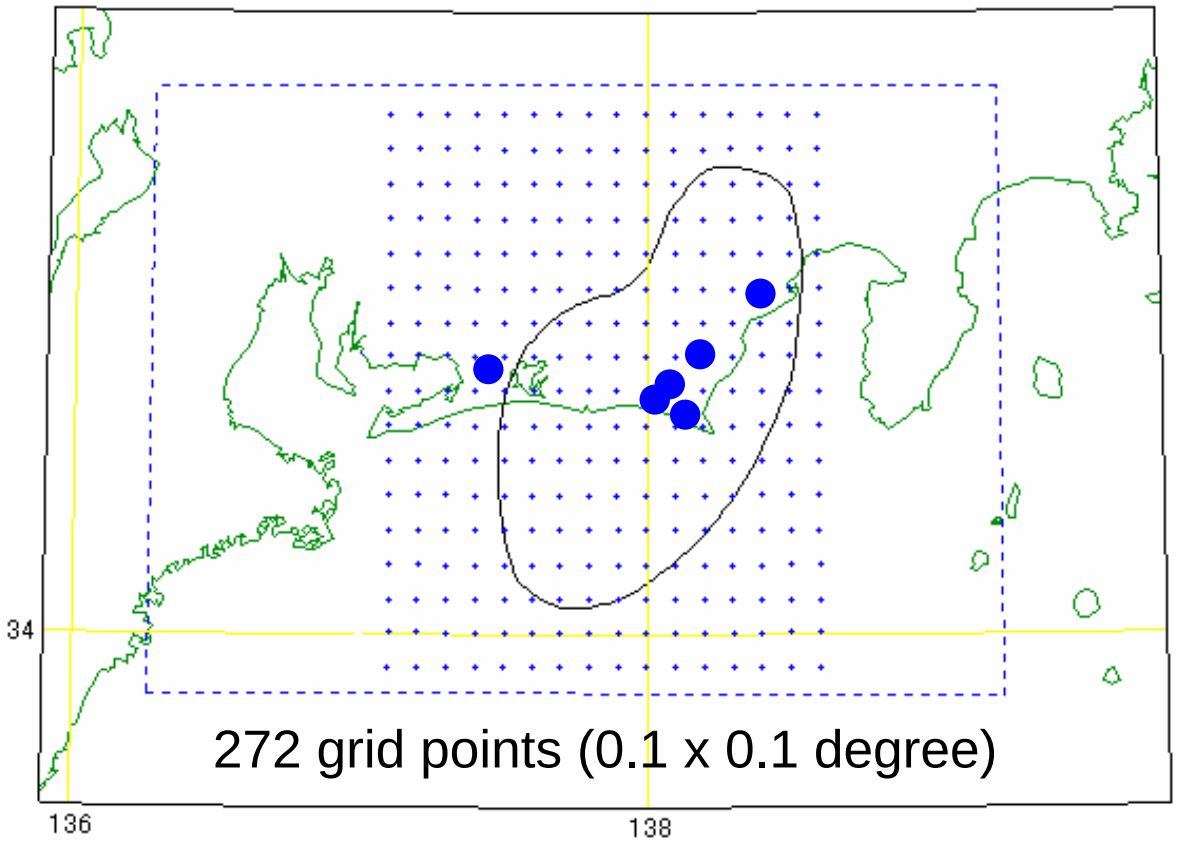
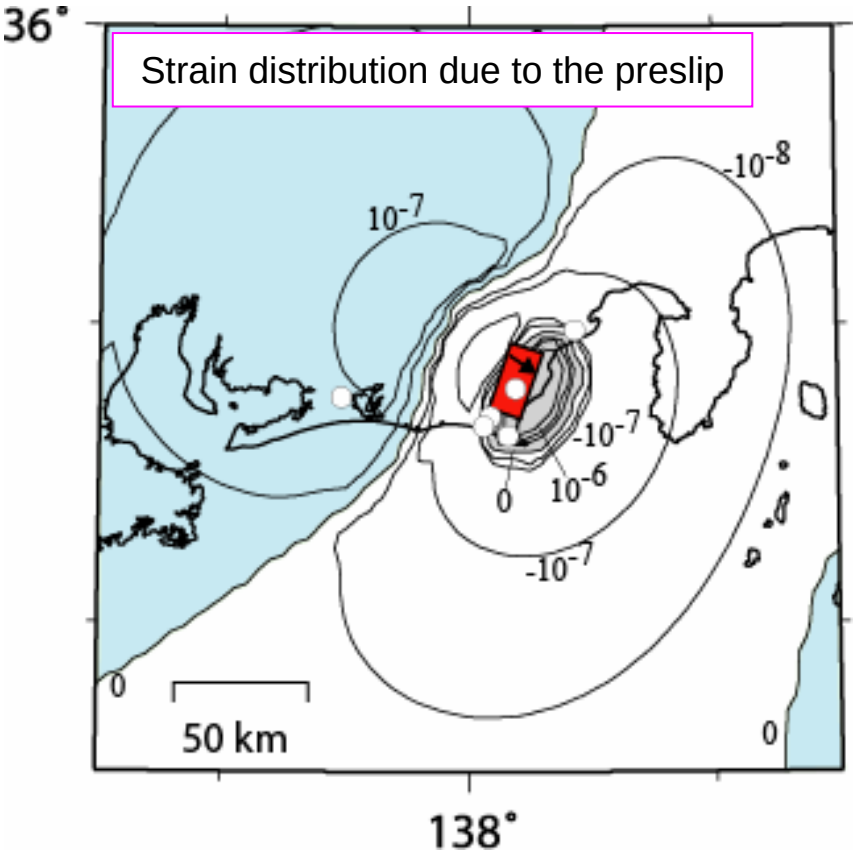
Evaluation method of detectability



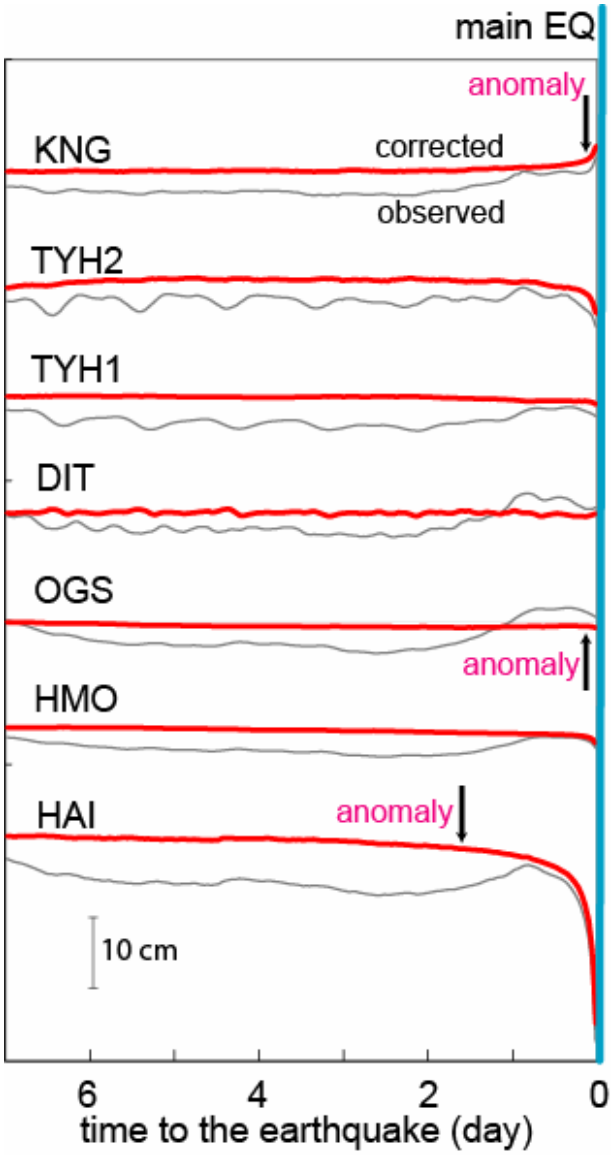
At one of 272 grid points M6.5 or M6 preslip is supposed, and we calculate histories of groundwater-level changes due to the preslip at the seven wells.

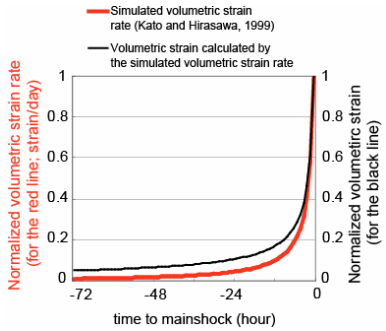
If an absolute value of groundwater change due to the preslip exceeds the noise level at the wells, we can recognize it as an anomaly of groundwater level at that time.

An example of evaluation of detectability in groundwater levels



M6.5 preslip is supposed at a grid point beneath HAI.





Three water levels in KNG, OGS and HAI exceed their noise level.

- Anomalies
  KNG: 3 hrs
  OGS: 3 hrs
  HAI: 38 hrs

prior to the main EQ.

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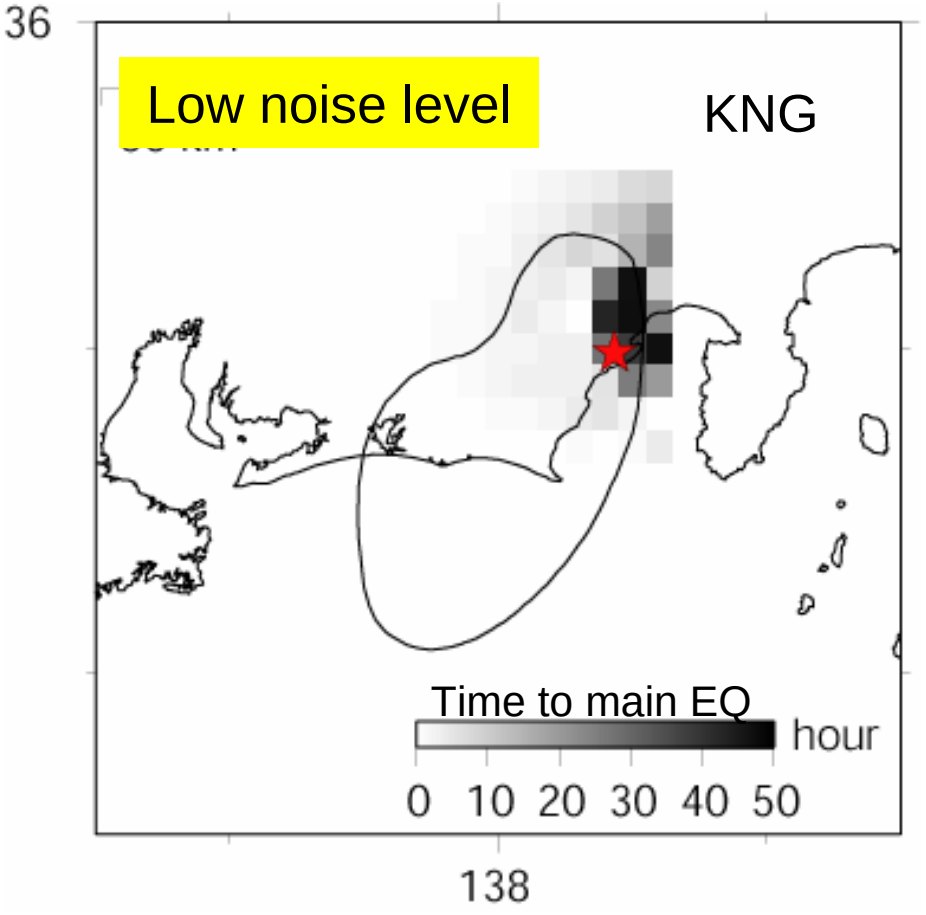
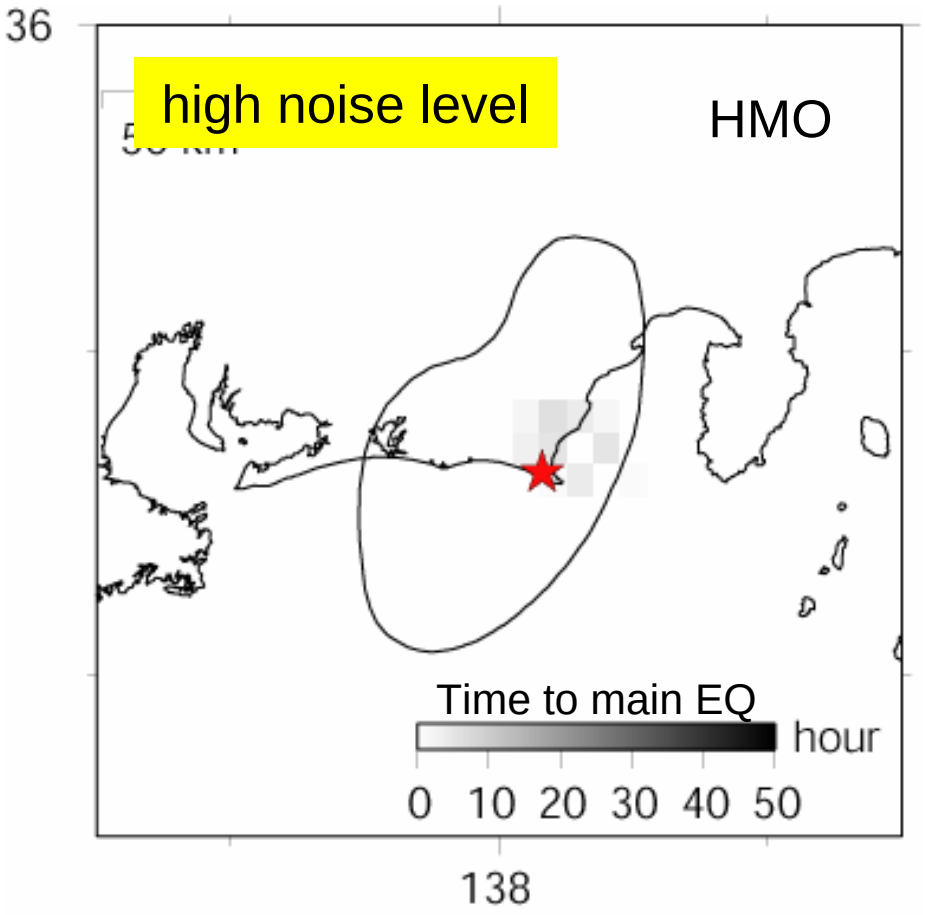
Detectability of M6.5 preslip in the water level at KNG and HMO

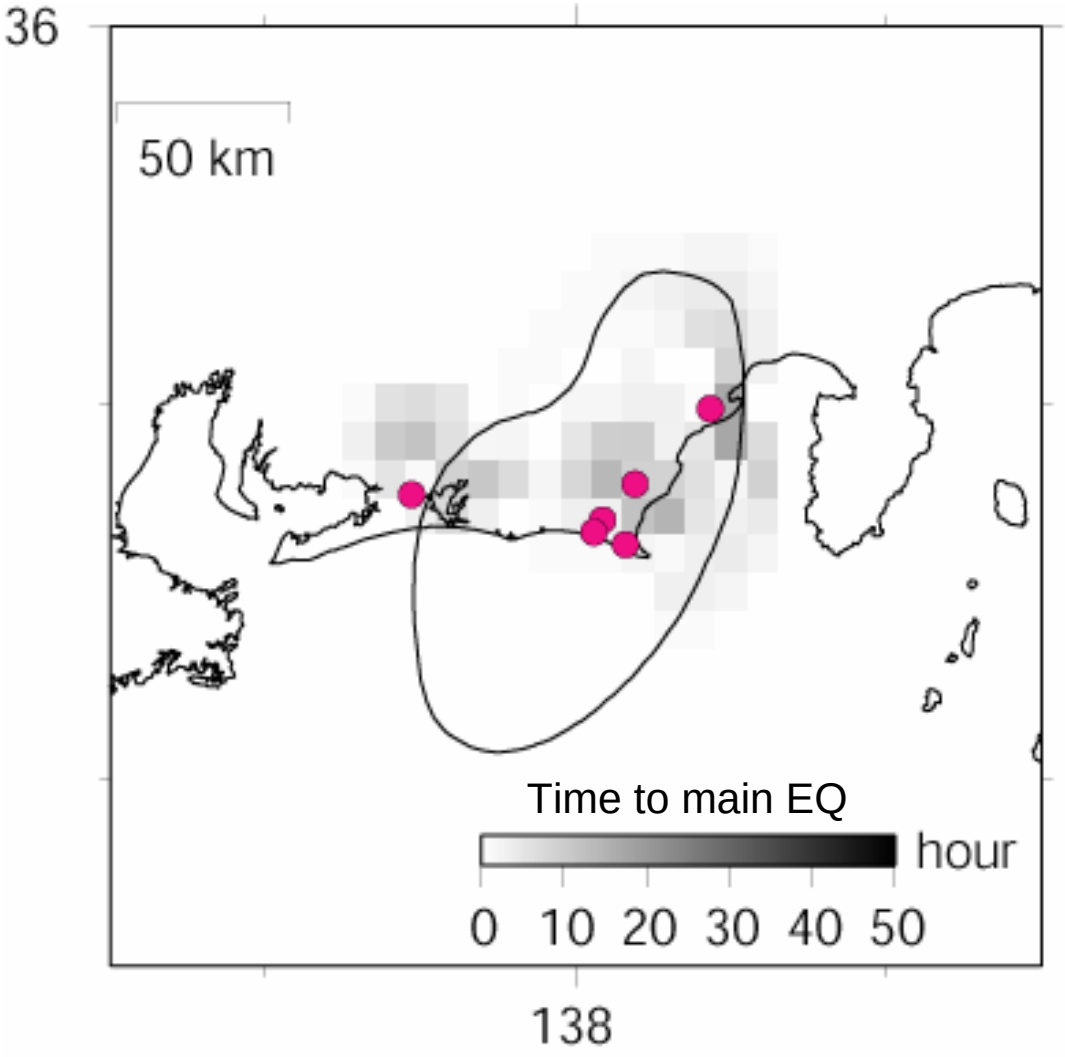




The highest detectability:
60 grid points or more
48 hours prior to EQ in max.

10 grid points
1-6 hours prior to EQ.

Detection time of anomalies at any two wells due to **M6.5 preslip**

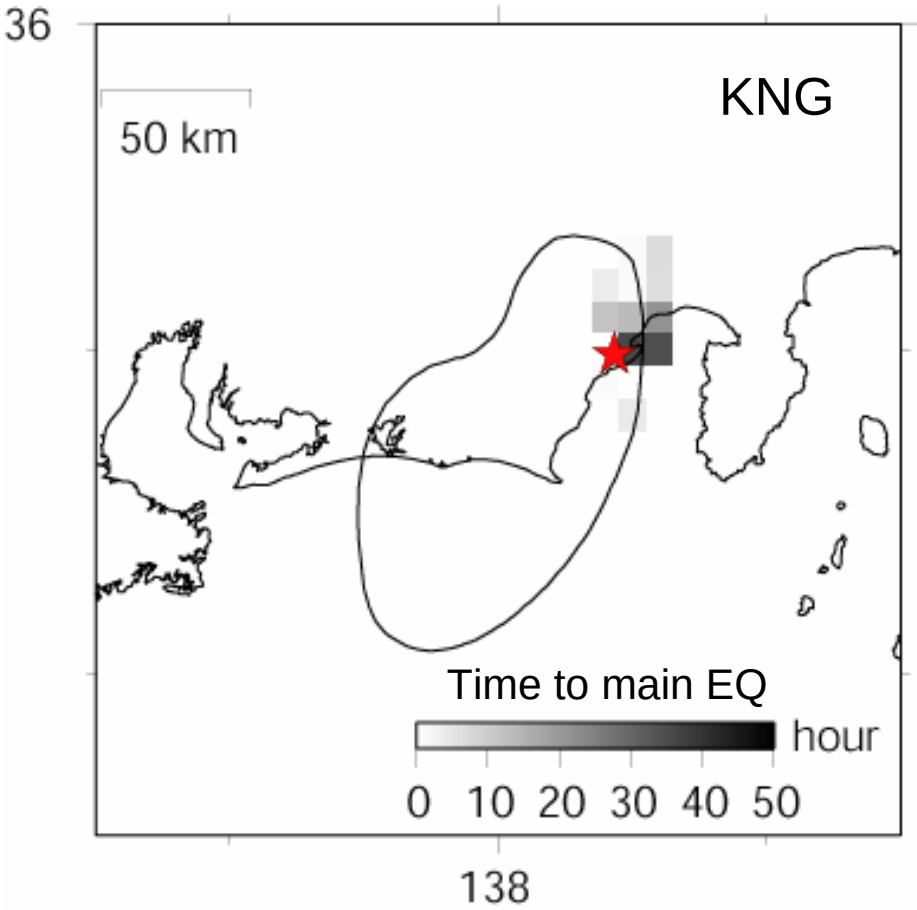


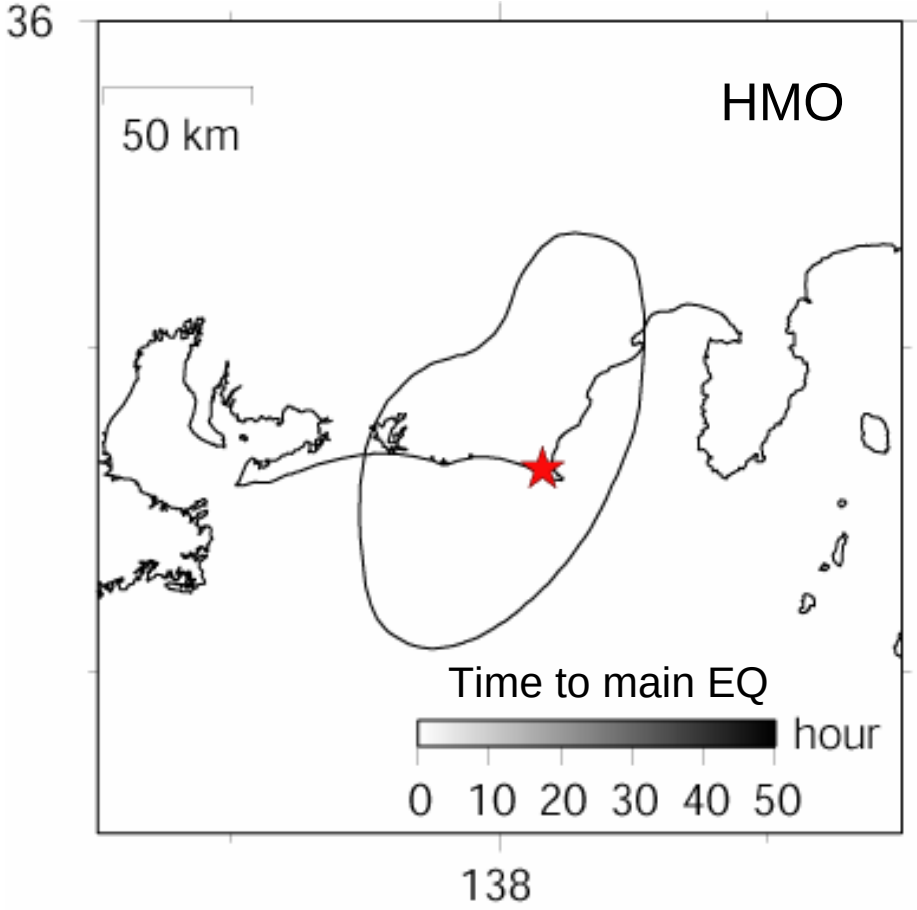
If anomalies are detected at two wells or more, detected anomalies are recognized to be reliable.

87 grid points or more

1-17 hours prior to EQ

Detectability of M6 preslip in the water level at KNG and HMO

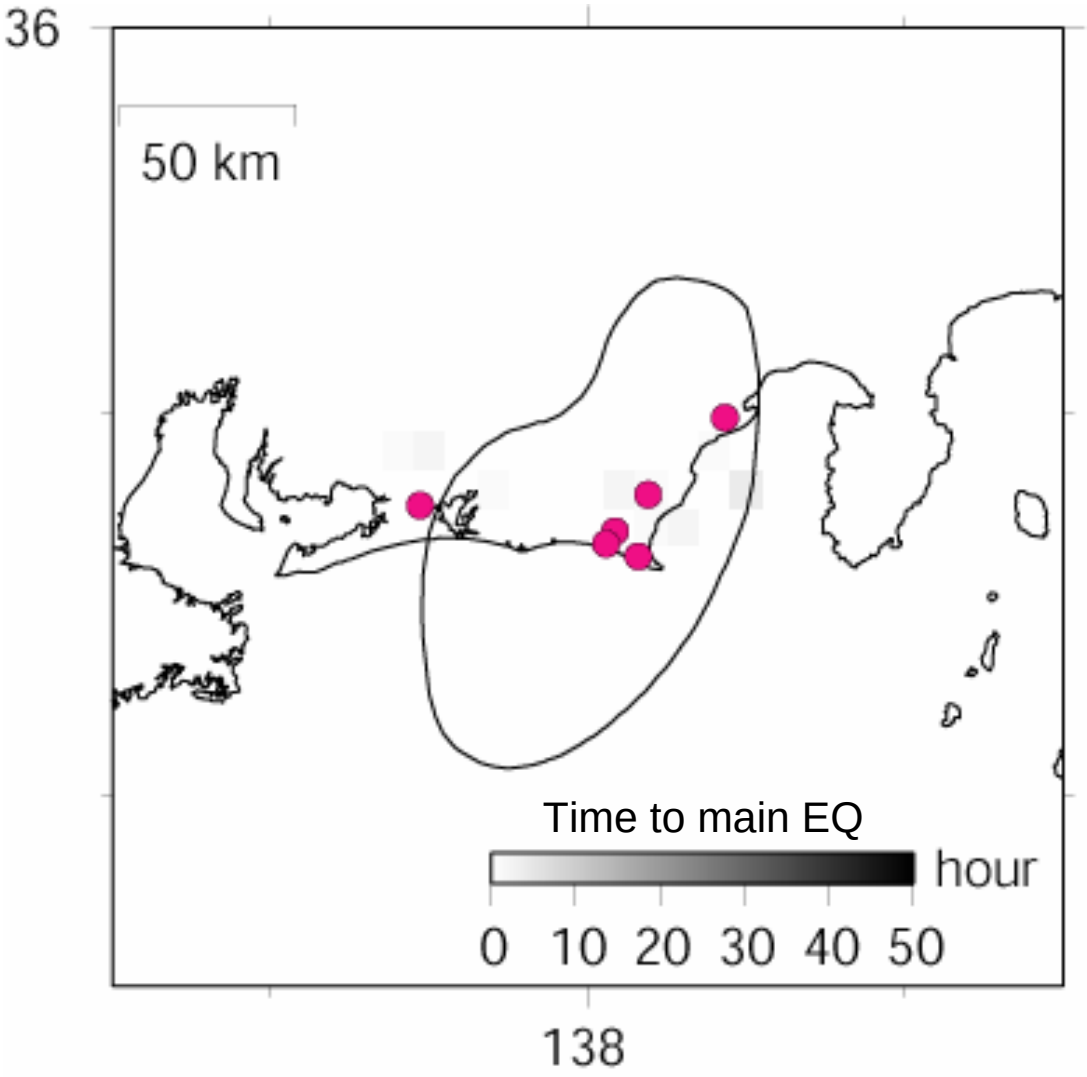




The highest detectability:
M6 preslips at 13 grid points .
36 hours prior to EQ in max.

No anomalies are detected

Detection time of anomalies at any two wells due to **M6 preslip**



9 grid points or more

1-4 hours prior to EQ

Conclusions

- We evaluate a detectability of preslip in the AIST groundwater monitoring network.
- If M6.5 preslip occurs, any two wells of the AIST network can detect the preslip 1-17 hours prior to the main earthquake beneath the landward side. The network can detect several M6.5 preslips beneath the ocean.
- If M6 preslip occurs, any two wells of the AIST network can detect preslips at 9 grid points 1-4 hours to the mainshock.