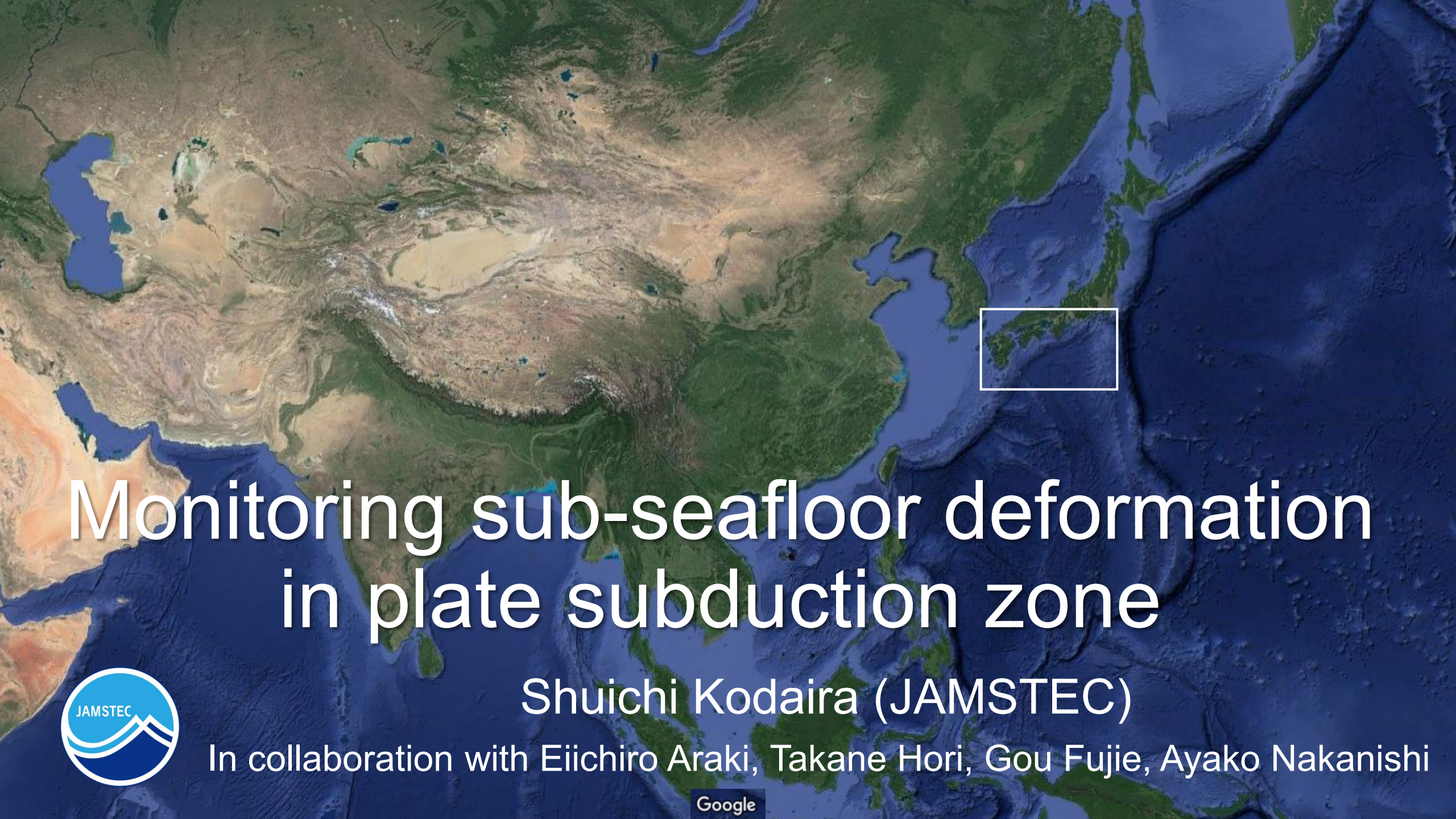
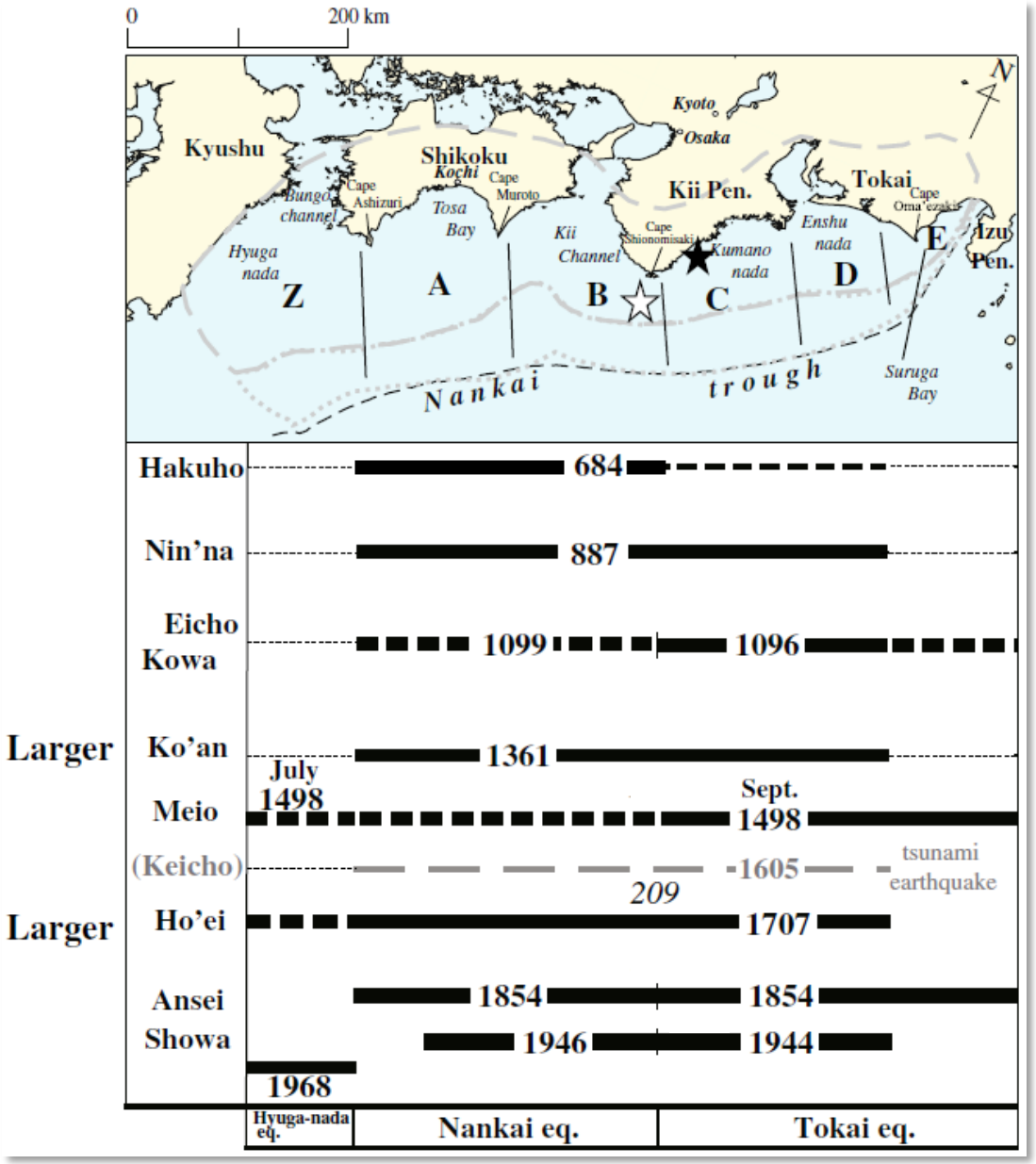


Monitoring sub-seafloor deformation in plate subduction zone

Shuichi Kodaira (JAMSTEC)

In collaboration with Eiichiro Araki, Takane Hori, Gou Fujie, Ayako Nakanishi

Nankai Trough seismogenic zone

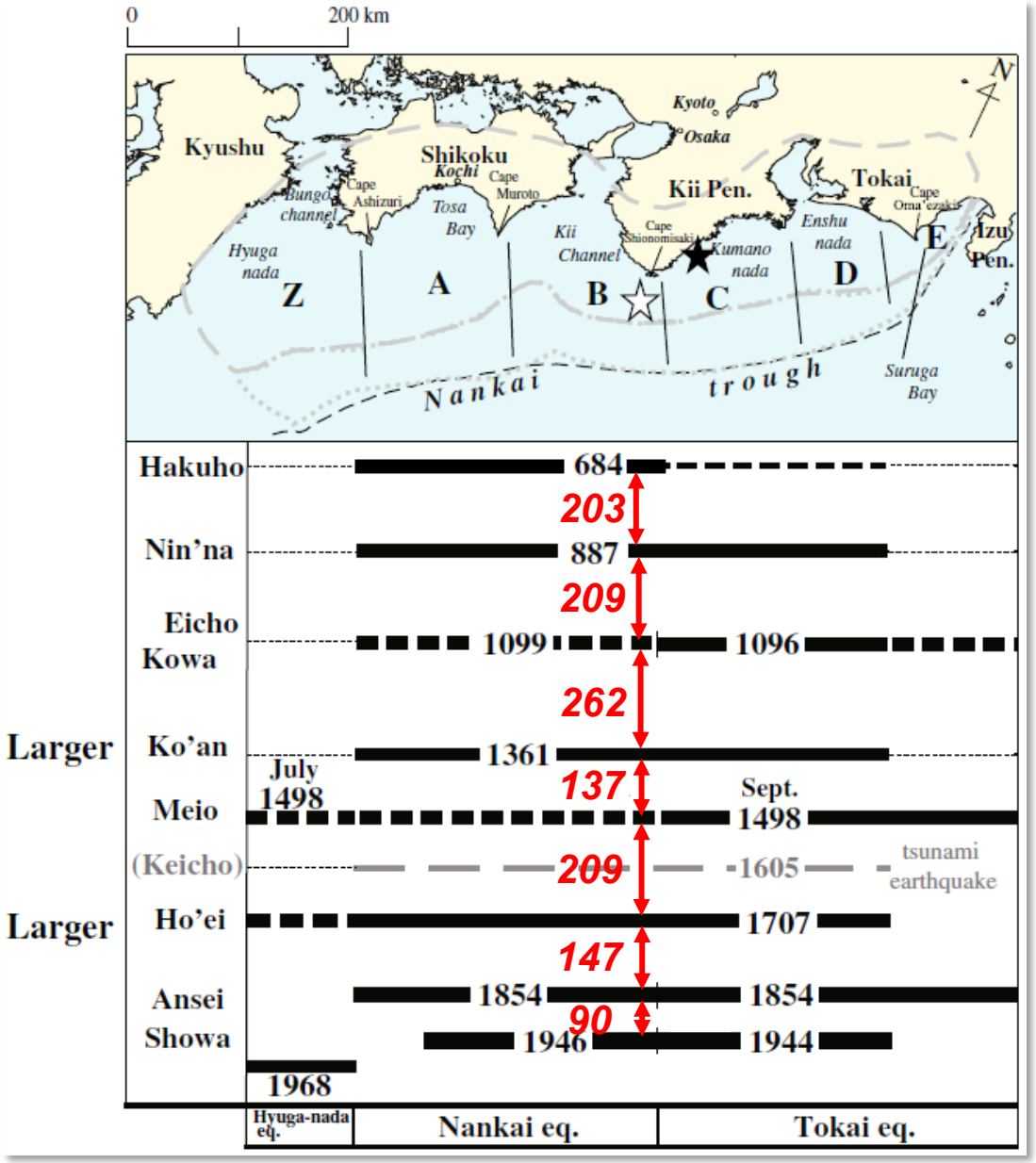


Hyodo et al. 2016

- Records of large earthquakes are well-documented in historical literatures in the last 1400 years
- Palaeoseismological data can be traced back to ~4000 years ago

1854 Ansei Earthquake (Osaka Museum of History)

Nankai Trough seismogenic zone

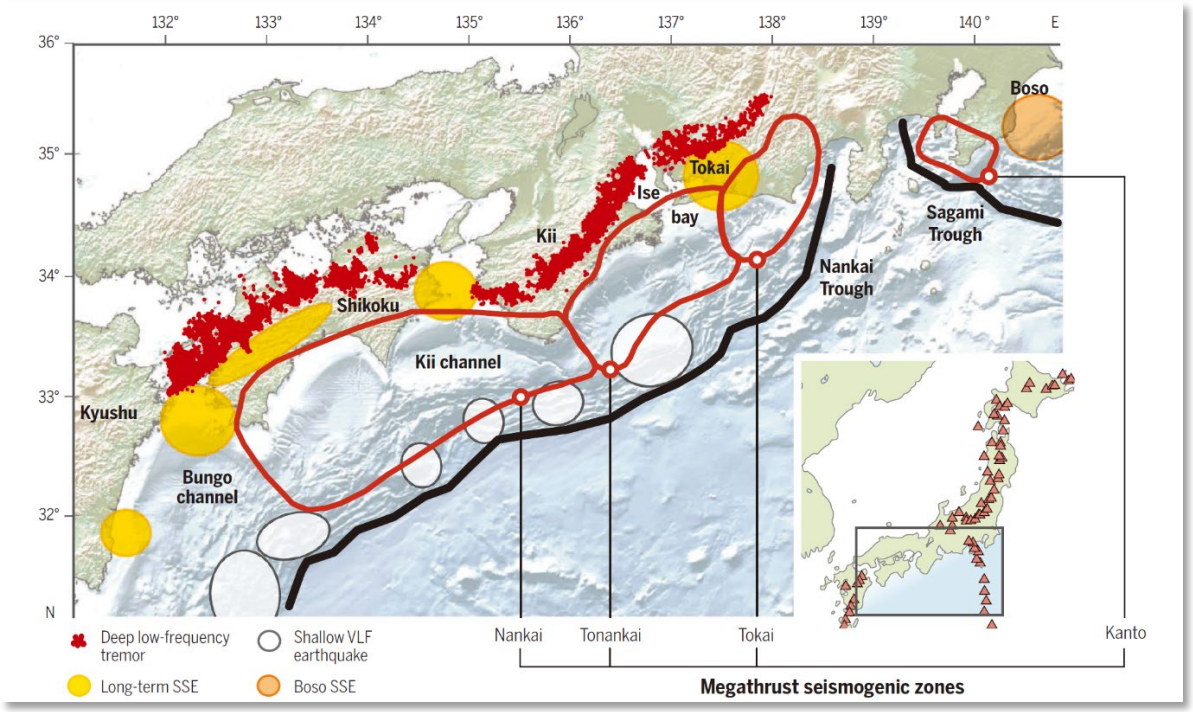


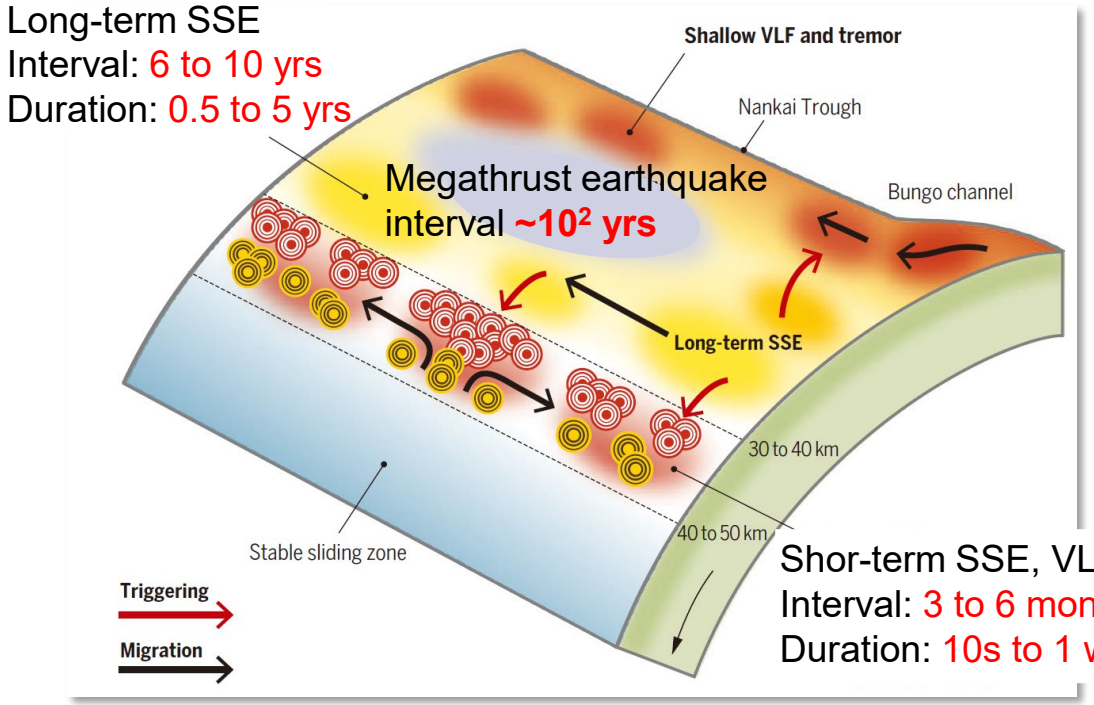
Hyodo et al. 2016

- Records of large earthquakes are well-documented in historical literatures in the last 1400 years
- Palaeoseismological data can be traced back to ~4000 years ago
- Earthquake intervals are fluctuated between 90 – 260 years
- In each cycle, either a pair of earthquakes occurred or a single earthquake ruptured the entire region
- Those diversities makes it difficult to estimate a future earthquakes based on historical data

Nankai Trough seismogenic zone

Obara & Kato 2016





- Slow slip events: characteristic time scale of interval and duration varies from 10^2 years ~ 10 seconds

- To capture wide spectrum of slip behaviors, real-time continuous geodetic monitoring is necessary

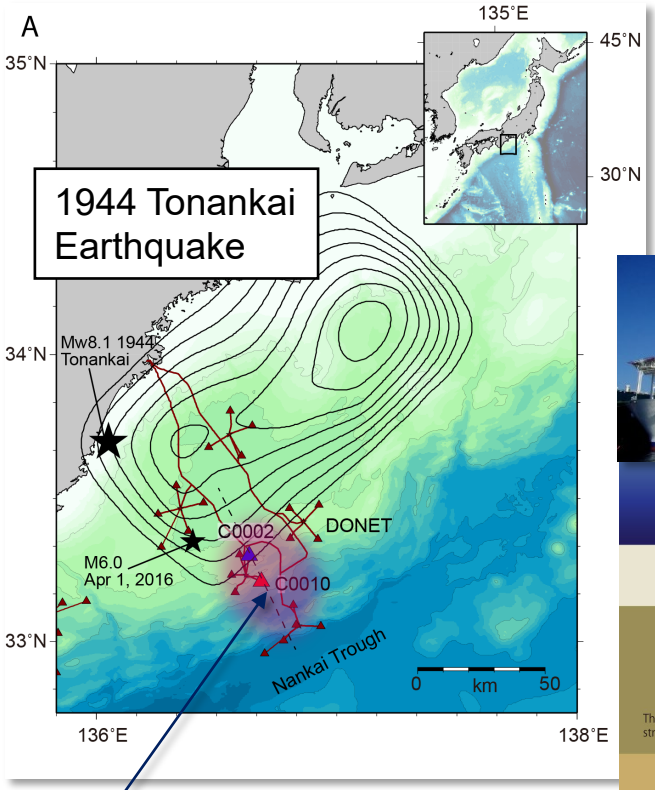
Toward understanding slip behavior and its temporal evolution
- what JAMSTEC are doing and plan to do -

- construct seafloor geodetic network using DONET cable system
- install borehole observatory by BMS on R/V KAIMEI and/or D/V Chikyu
- calibrate all DONET pressure sensors to utilize them as geodetic sensors,
- develop fiber optic sensors to connect DONET

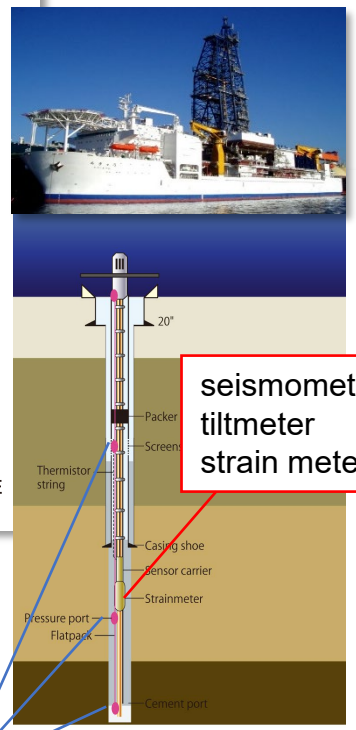
NIED

Current status - real-time continuous geodetic data

Borehole observatories connected a seafloor cable system, DONET Araki, Saffer et al. 2017

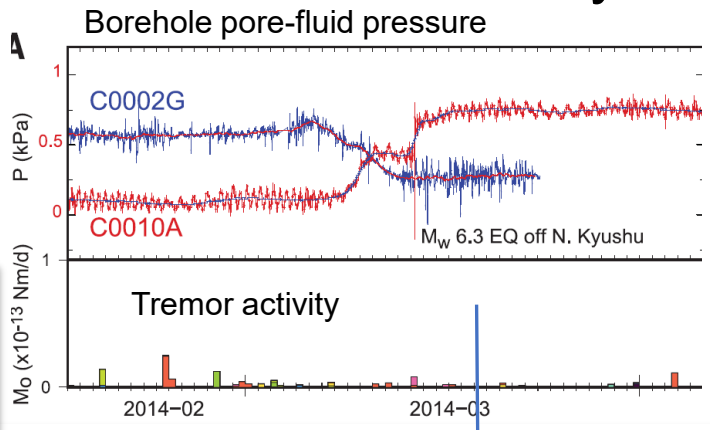


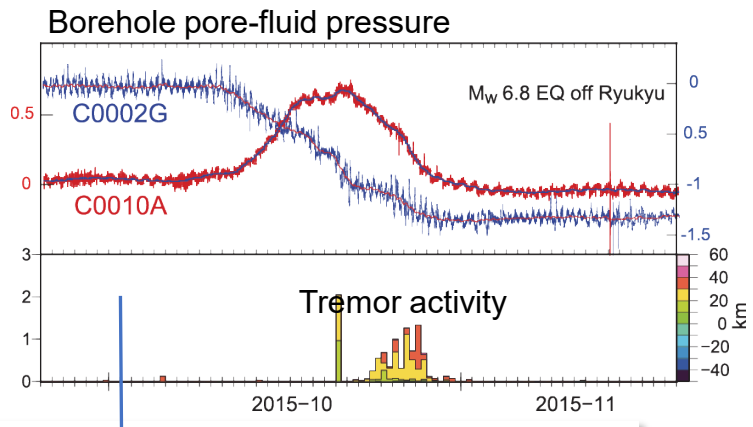
Region of discovered Shallow Slow Slip Events

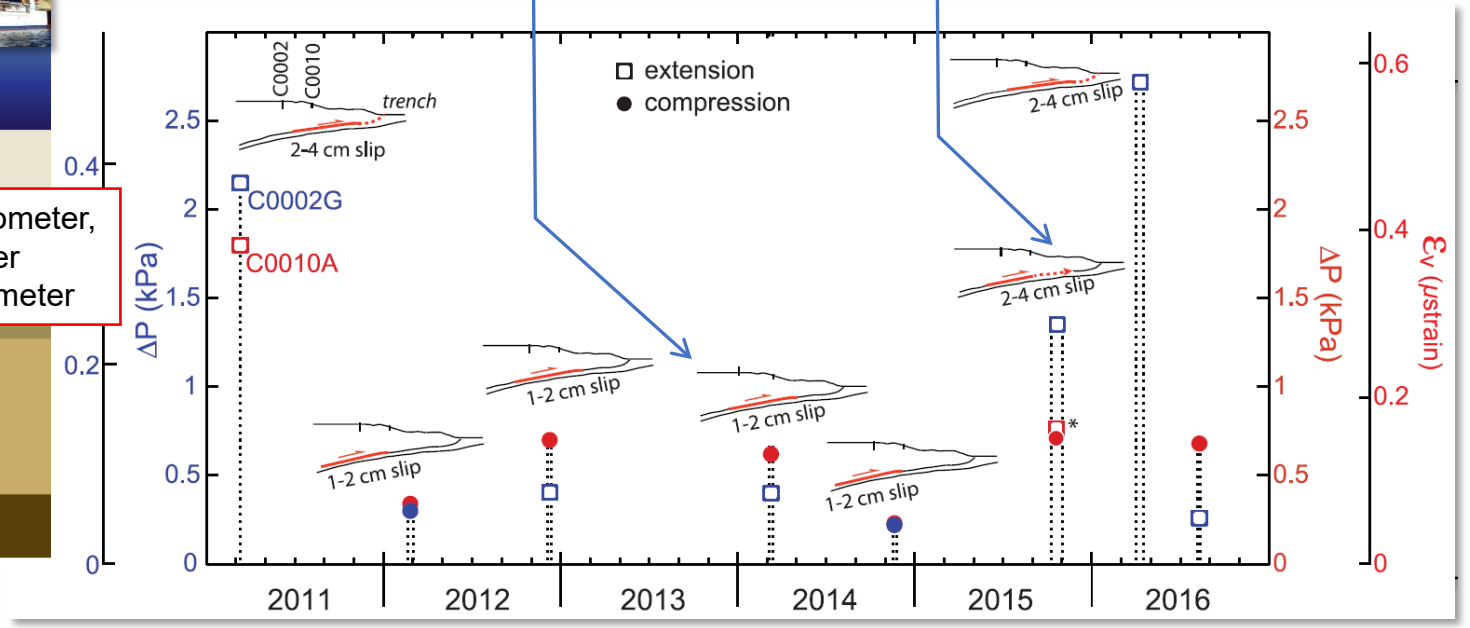


seismometer, tiltmeter strain meter

Pore-fluid pressure sensors





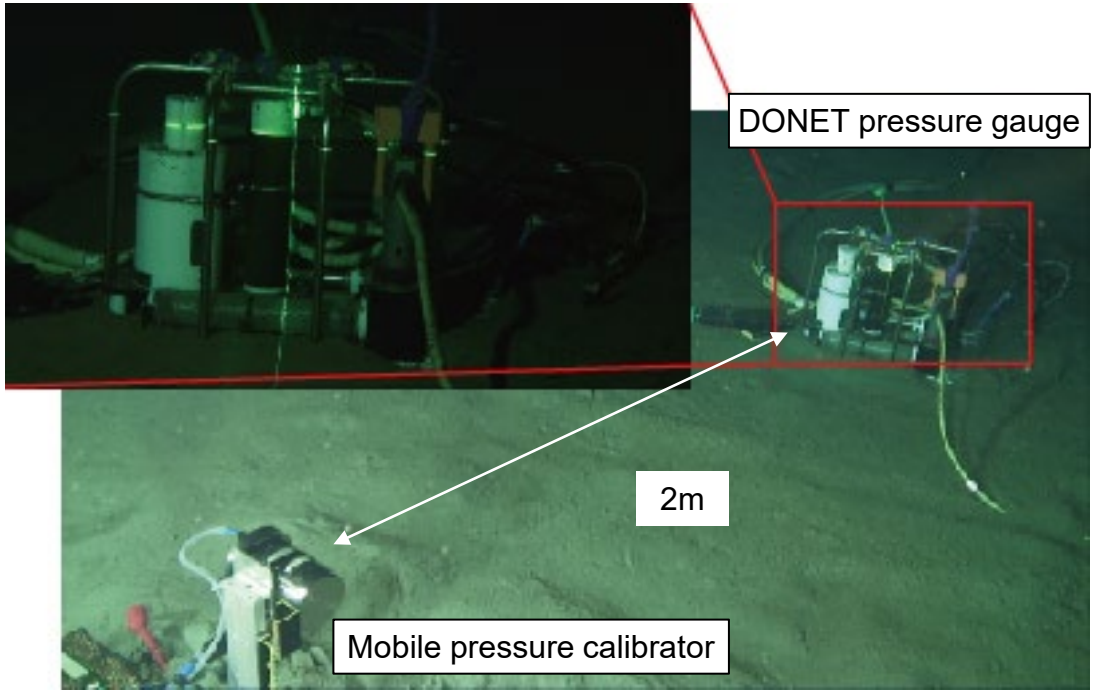


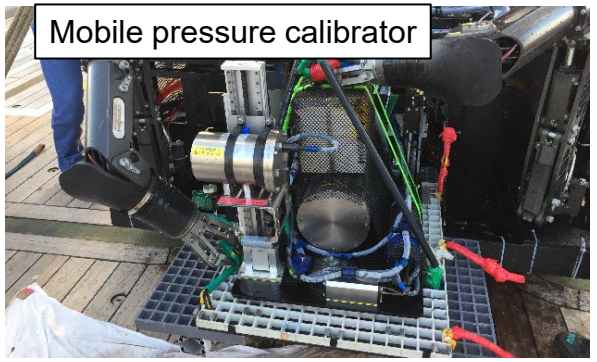
Frequently recurring (8 events/6 years) shallow Slow Slip Events are discovered from seafloor borehole records. Those events would release 30-55% of strain due to plate subduction.

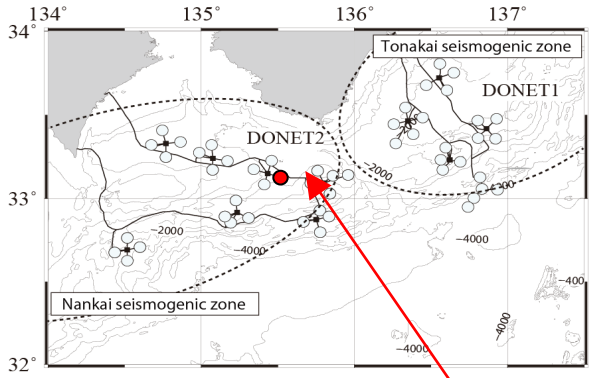
Toward understanding slip behavior and its temporal evolution - what JAMSTEC are doing and plan to do -

Utilize DONET pressure sensor as geodetic sensor

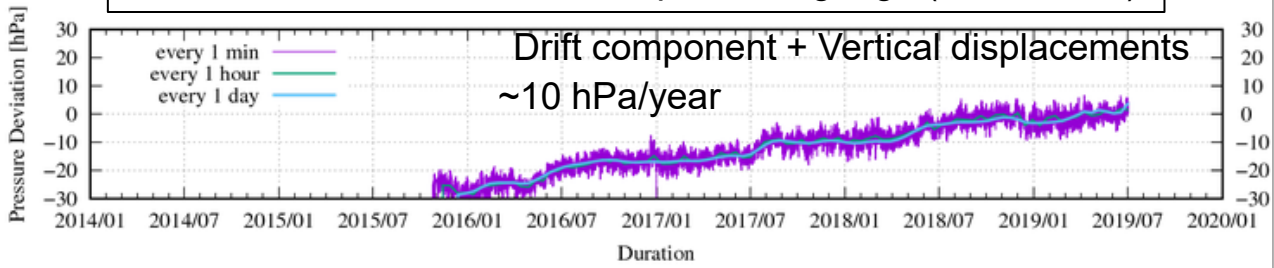
Developed Mobile pressure calibrator
to carry out *in-situ* calibration of DONET pressure sensors
for estimating a drift rate







Raw data of the 2C-10 DONET pressure gauge (2014~2019)



2C-10 DONET pressure gauge calibrations

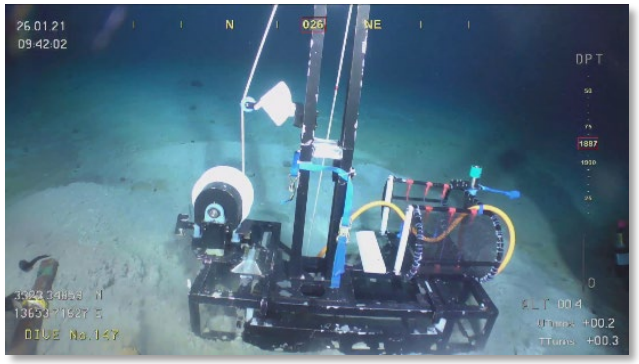
- KS-18-J07 cruise (Nov. 2018)
- KR19-03 cruise (May 2019)
- KR19-09 cruise (Oct. 2019)

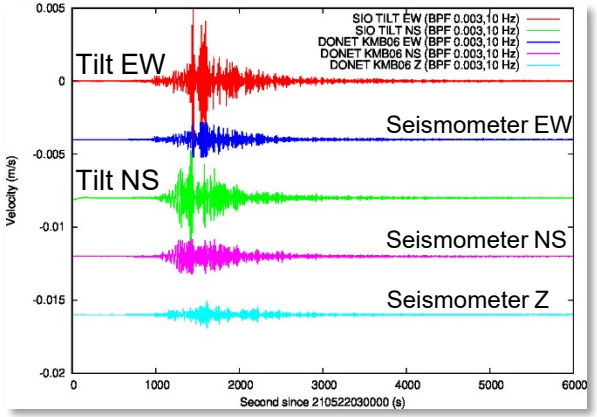
- calibrated a pressure sensor at DONET2, 2C-10, with resolution of less than 1 hPa, estimated drift component is 2.2 hPa/6months,

Araki et al. 2019 AGU, Machida et al. 2020 JpGU

Fiber Optic Technologies applied to the Seafloor Network

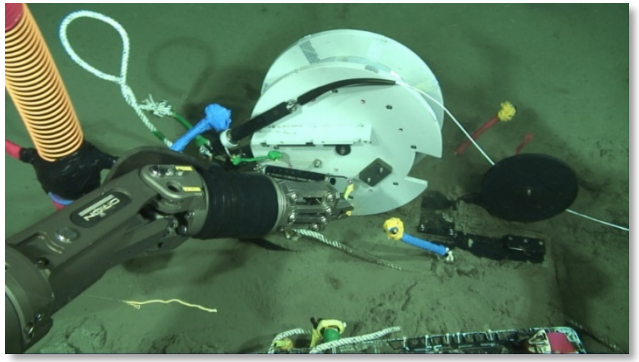
- Shallow borehole optical tiltmeter



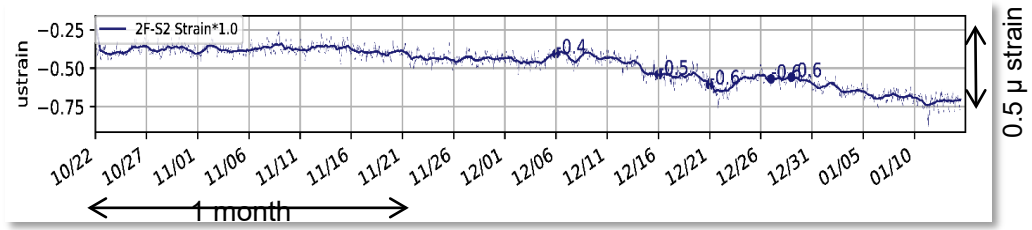


2021-05-21 UTC Qinghai, China, Mw 7.3 D=10.0 km

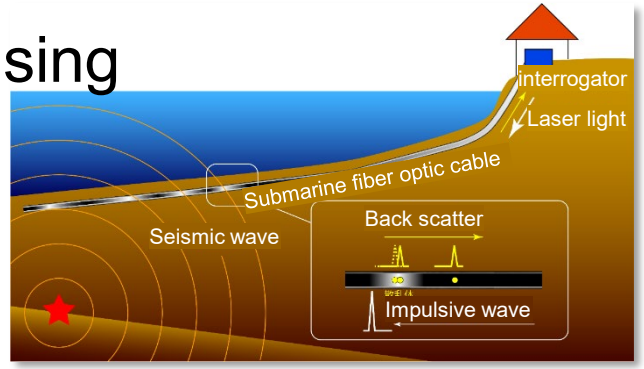
- Fiber optic strain sensor

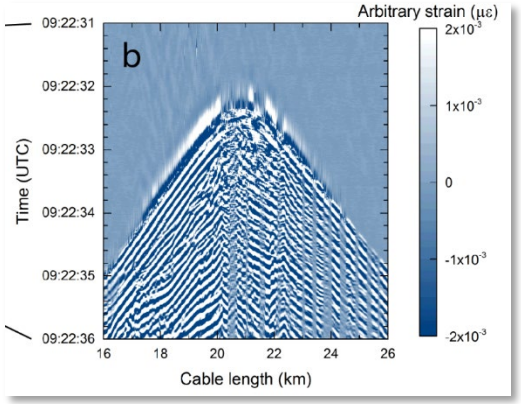


Long-term fiber optic strain deviation



- Distributed Acoustic Sensing (DAS)

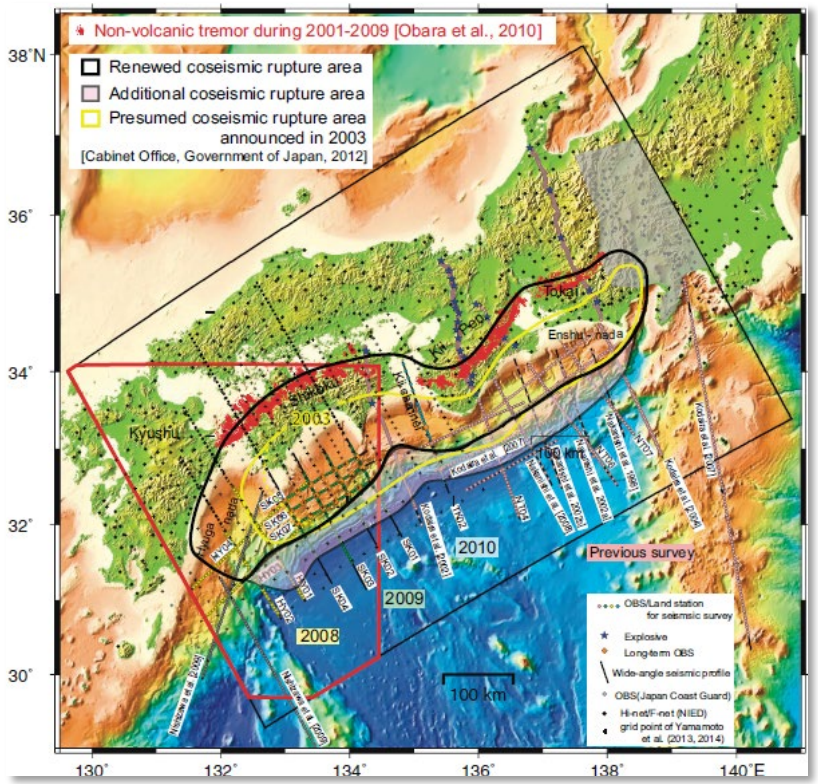




Hydro-acoustic signal form air-gun shots

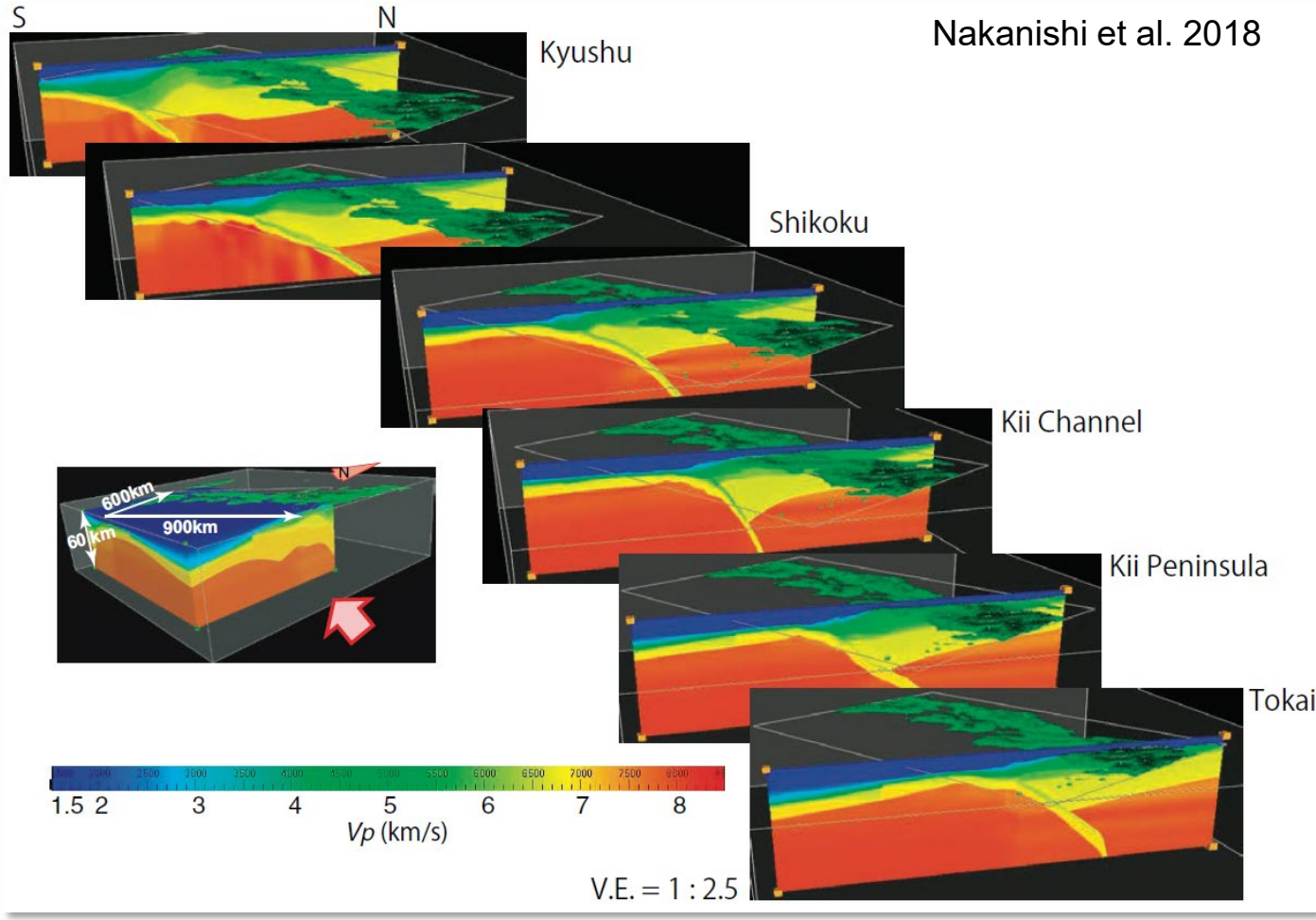
Micro to large earthquakes are also observed

Realistic 3D seismogenic zone model is necessary to transform seafloor/sub-seafloor deformation to plate boundary slips



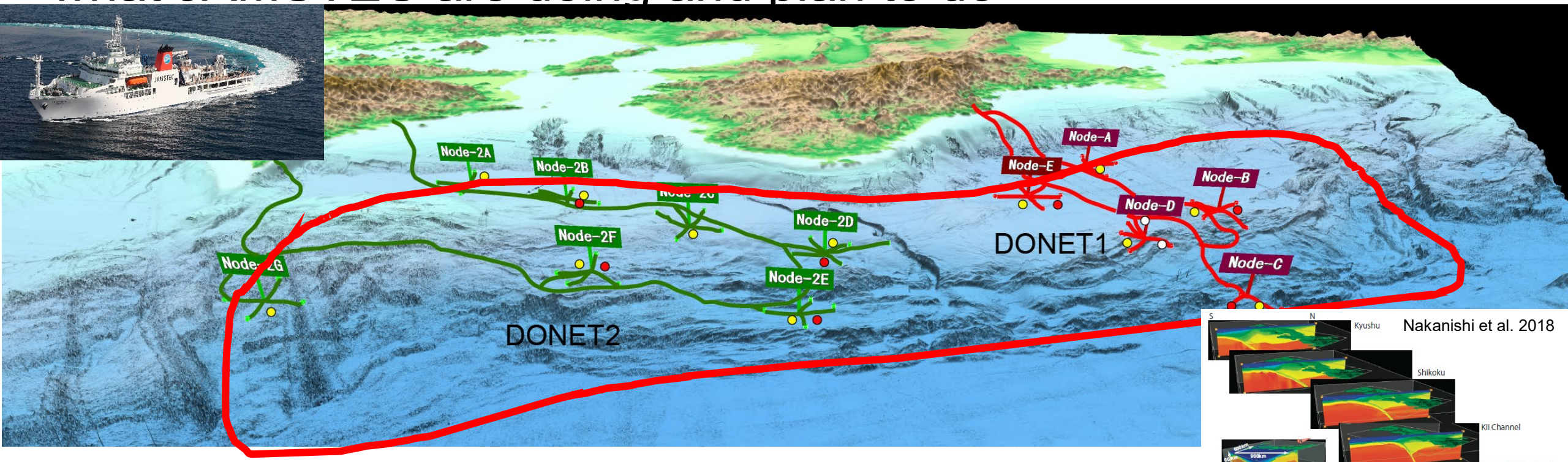
An overall velocity and plate geometry model by smoothly interpolating ~30 km spacing 2D profiles.

Plate boundary geometry of the offshore seismogenic zone have not been resolved.



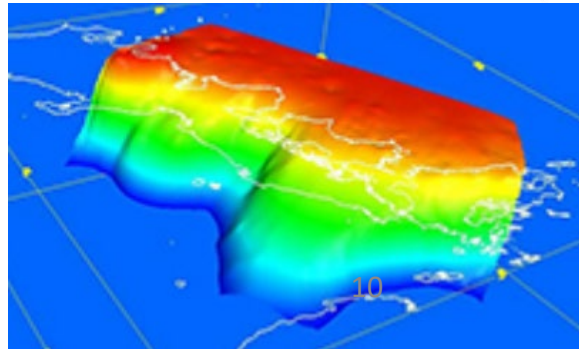
Nakanishi et al. 2018

Toward understanding plate coupling and its temporal evolution - what JAMSTEC are doing and plan to do -



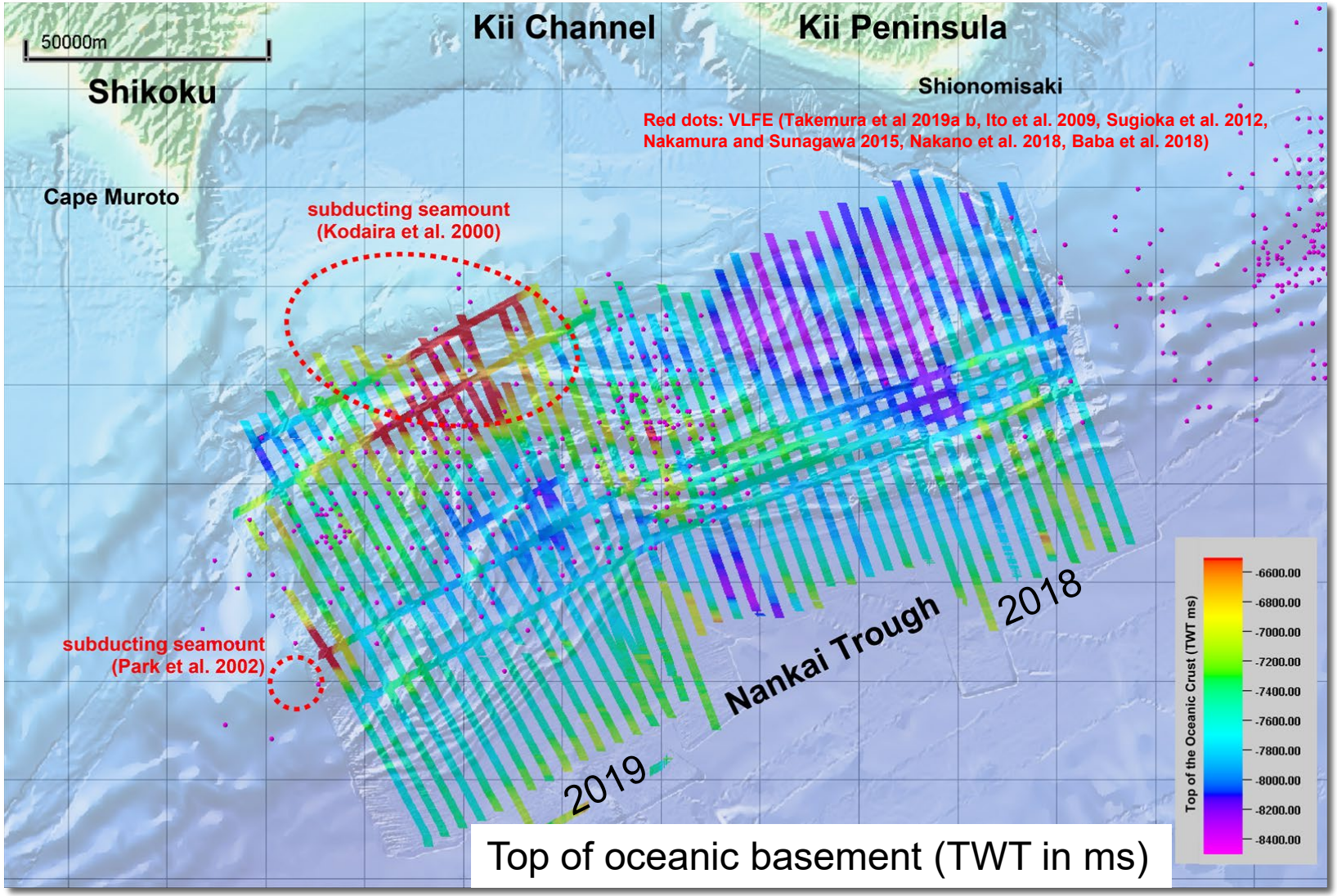
Nakanishi et al. 2018

- Large-scale 3D imaging and high-resolution OBS imaging
- to construct a 3D multi-parameters model of the seismogenic zone

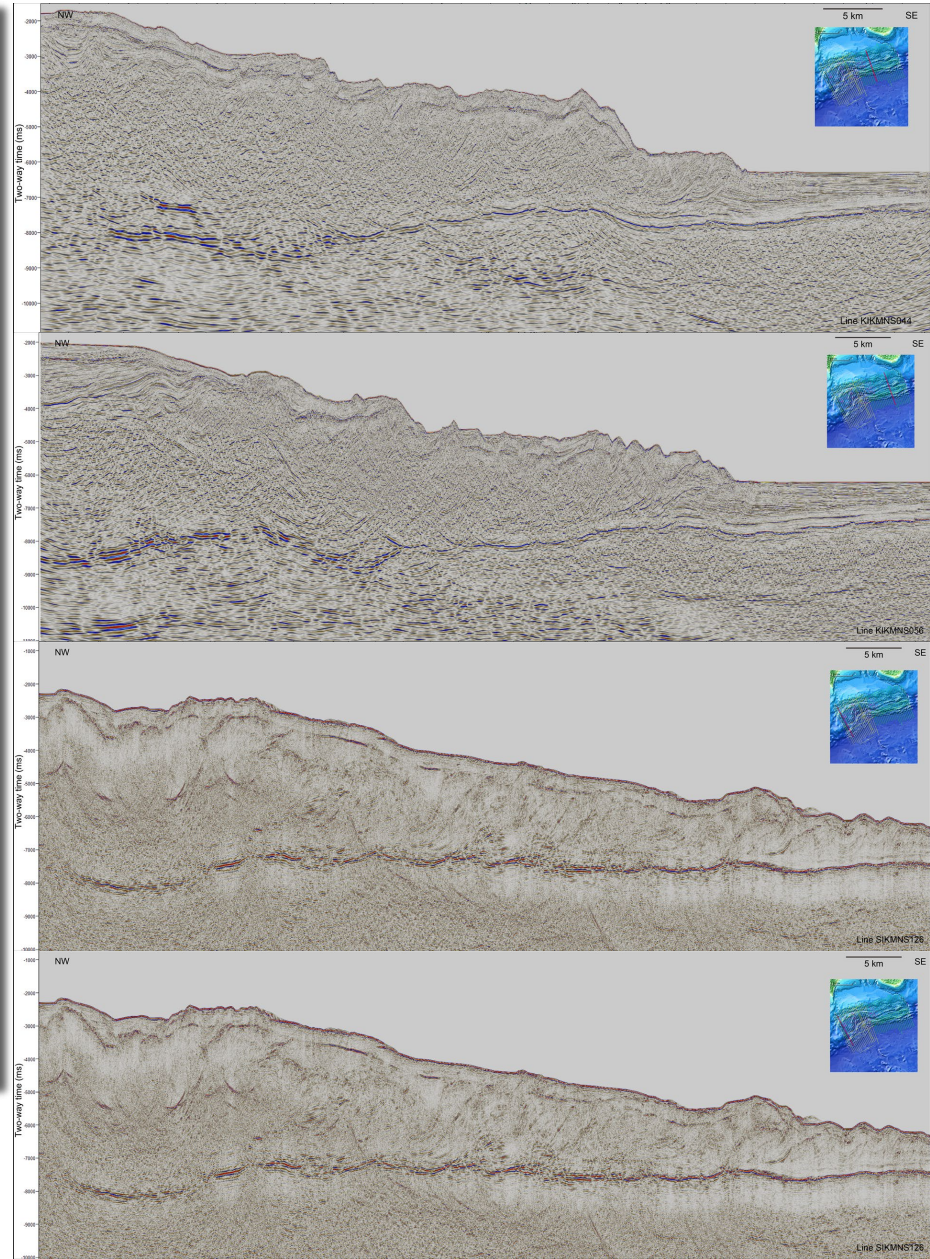


Current status - R/V KAIMEI dense 2D MCS survey to construct 3D model-

Preliminarily results of the 2018- and 2019-surveys (Nakamura et al. 2020, JpGU)



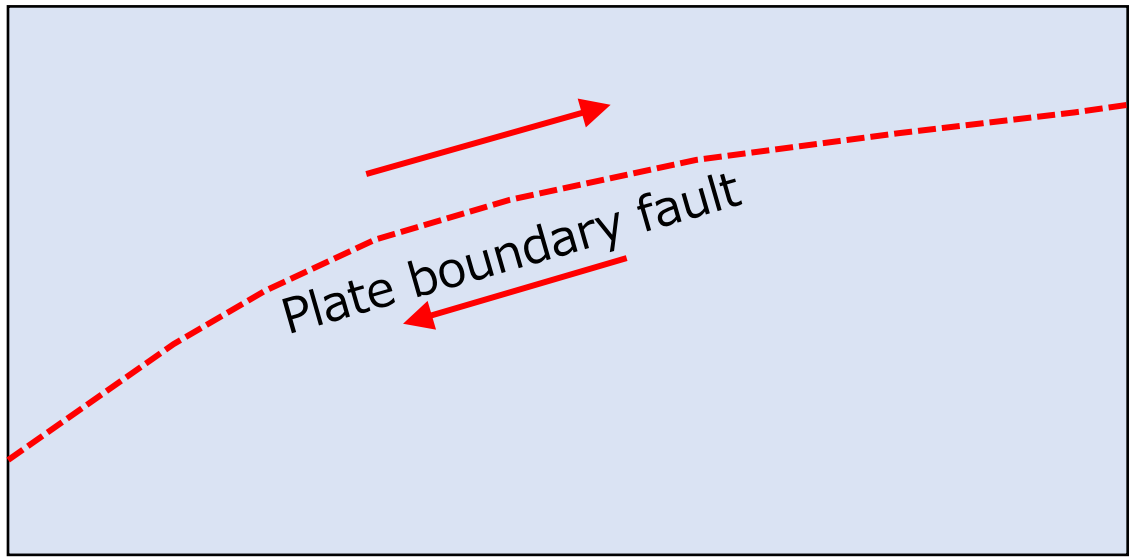
Top of oceanic basement (TWT in ms)

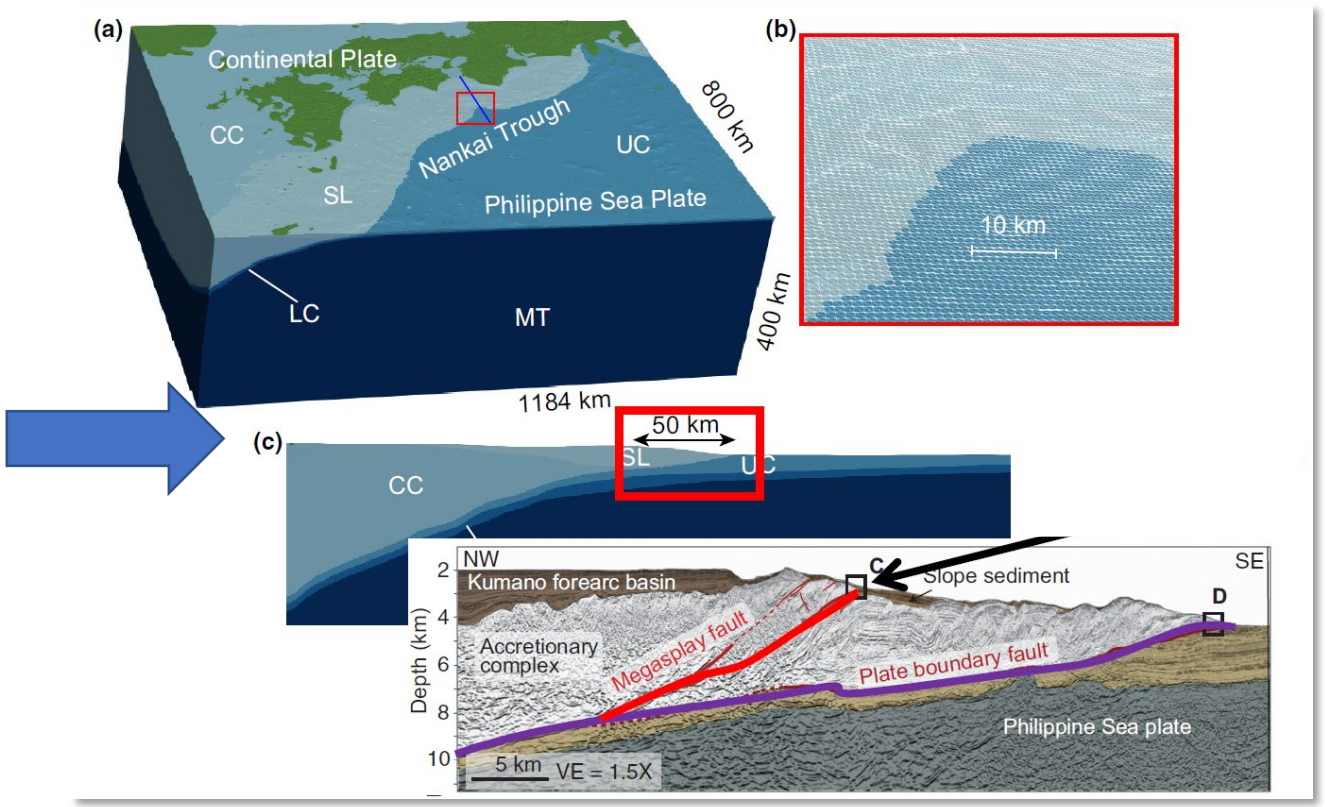


VLFEs (red dots) seem to occur where an undulation of the basement is observed, due to subduction of a seamount

Modeling approach

Most of modeling approaches use a homogeneous half-space medium to estimate plate slip from seafloor displacement

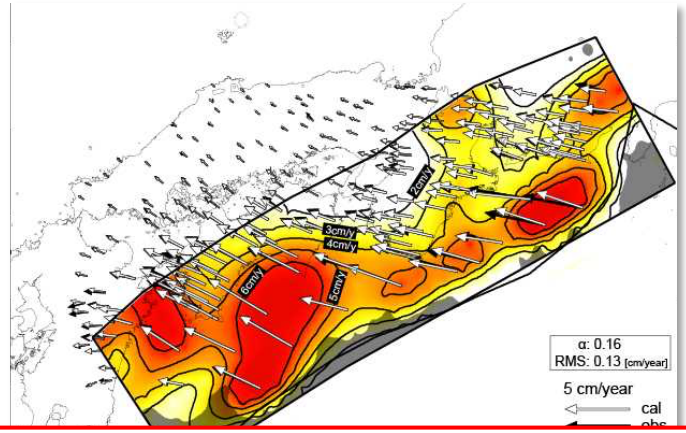




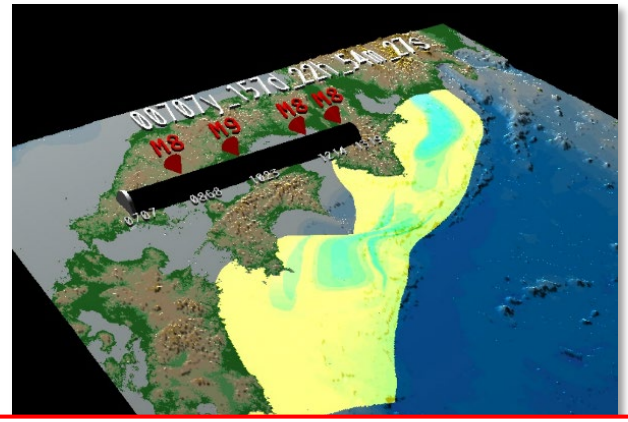
- In order to fully utilize the seafloor geodetic data and the 3D model, it's necessary to develop a modeling technique to implement 3D inhomogeneous and viscoelastic medium with fine-mesh finite-element method

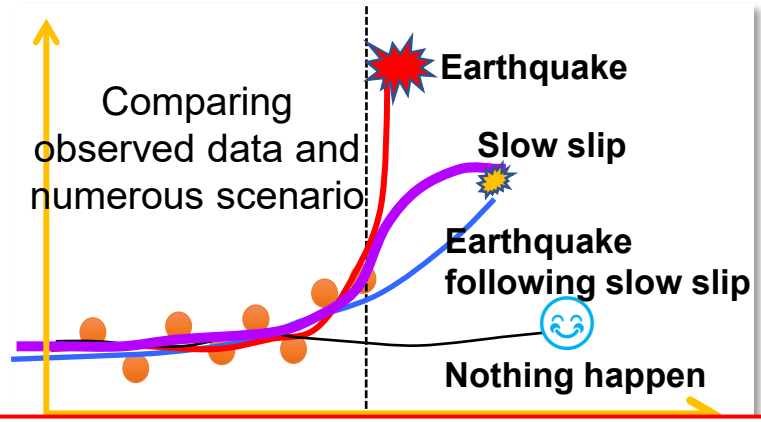
Toward understanding slip behavior and its temporal evolution

Slip and coupling at the present

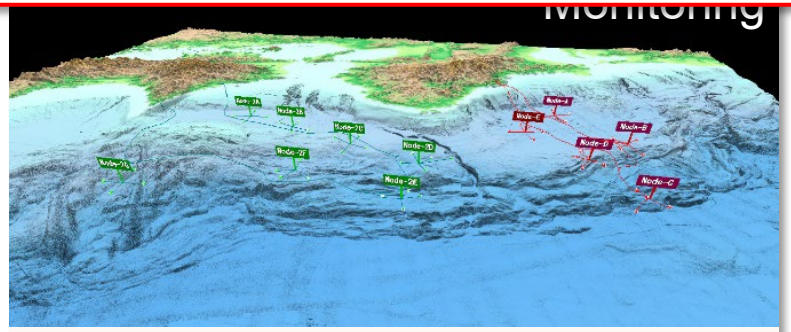


Temporal evolution to the future

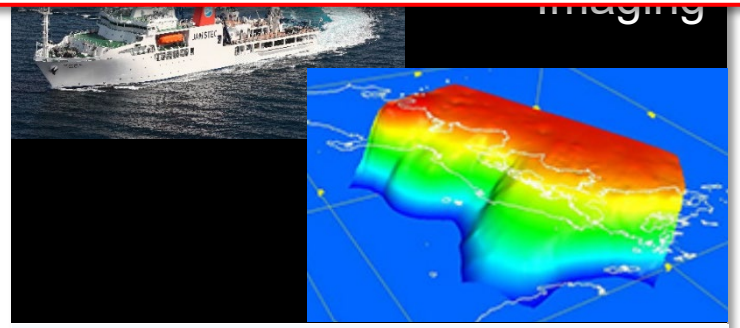




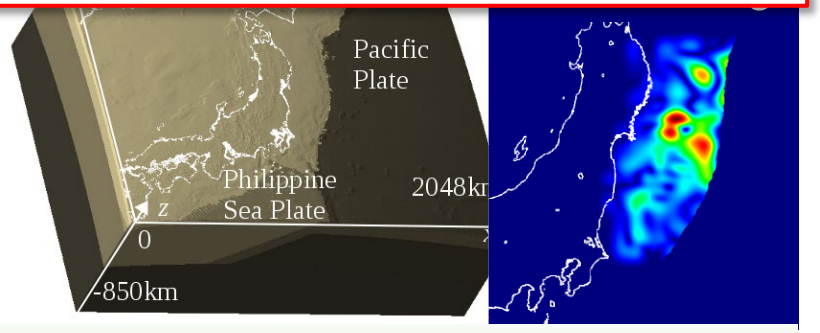
These research approaches and technological developments can be applied to the observation and characterization of dynamic processes in the Earth's interior, including a man-made process



Deploying real-time continuous seafloor geodetic network



Constructing realistic large-scale 3D structural model



Developing technique to estimate temporal evolution of coupling