Forum on International cooperation among environmental research infrastructures.

Advanced Observation and Simulation Researches Using Real Time Monitoring System(DONET)

Yoshiyuki KANEDA*1, 2, 3

*1: Kagawa University　IECMS
*2: Japan Agency for Marine-Earth Science and Technology (JAMSTEC)　CEAT
*3: National Research Institute for Earth Science and Disaster Resilience (NIED)

Target Region: Nankai Subduction Zone

1707	TONANKAI	+	TOKAI	+	NANKAI	
1854	TONANKAI	+	TOKAI	→	30hours	NANKAI
1944 1946	TONANKAI			→	2years	NANKAI

DONET and Long-term Borehole Observatory

Dense Oceanfloor Network system for Earthquakes and Tsunamis

Tonankai seismogenic zone

CONNECTED!

Nankai seismogenic zone

DONET

C0009

C0002A

C0010

Node-4

Node-6

Node-8

Node-2B

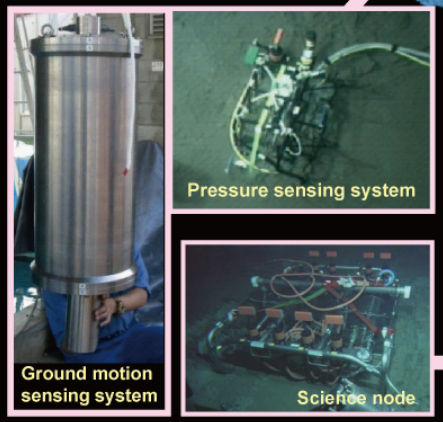
Node-2C

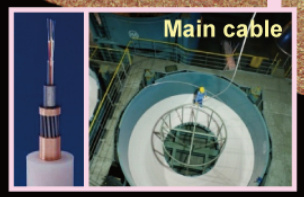
Node-2D

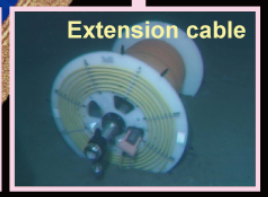
DONET is the real time monitoring system for Earthquakes and Tsunamis

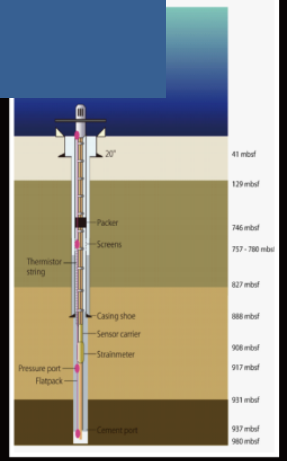
Node-2G

DONET2



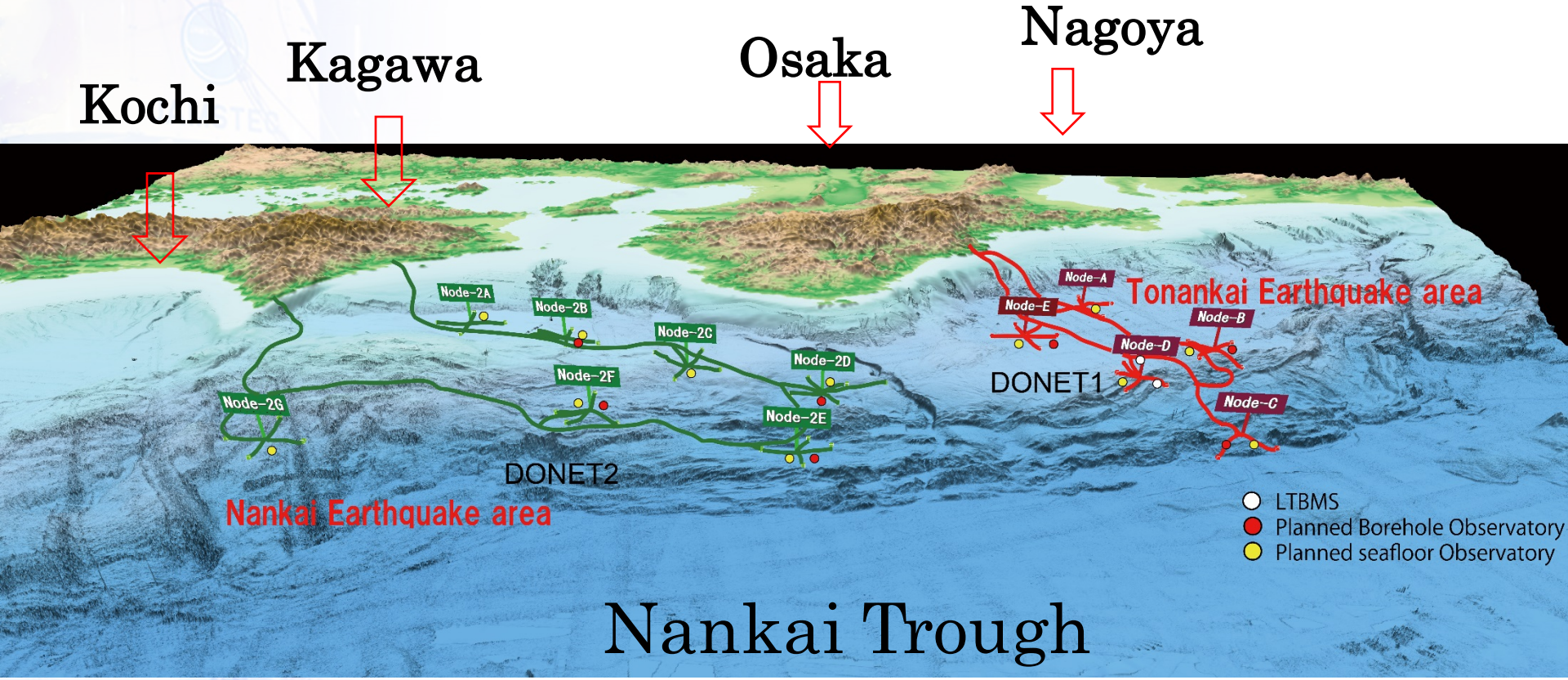






Real-time borehole observation

DONET Array with 51 Observatories



1707	TONANKAI	+	TOKAI	+	NANKAI	
1854	TONANKAI	+	TOKAI	→ 30hours		NANKAI
1944 1946	TONANKAI			→ 2years		NANKAI

DONET2 Construction

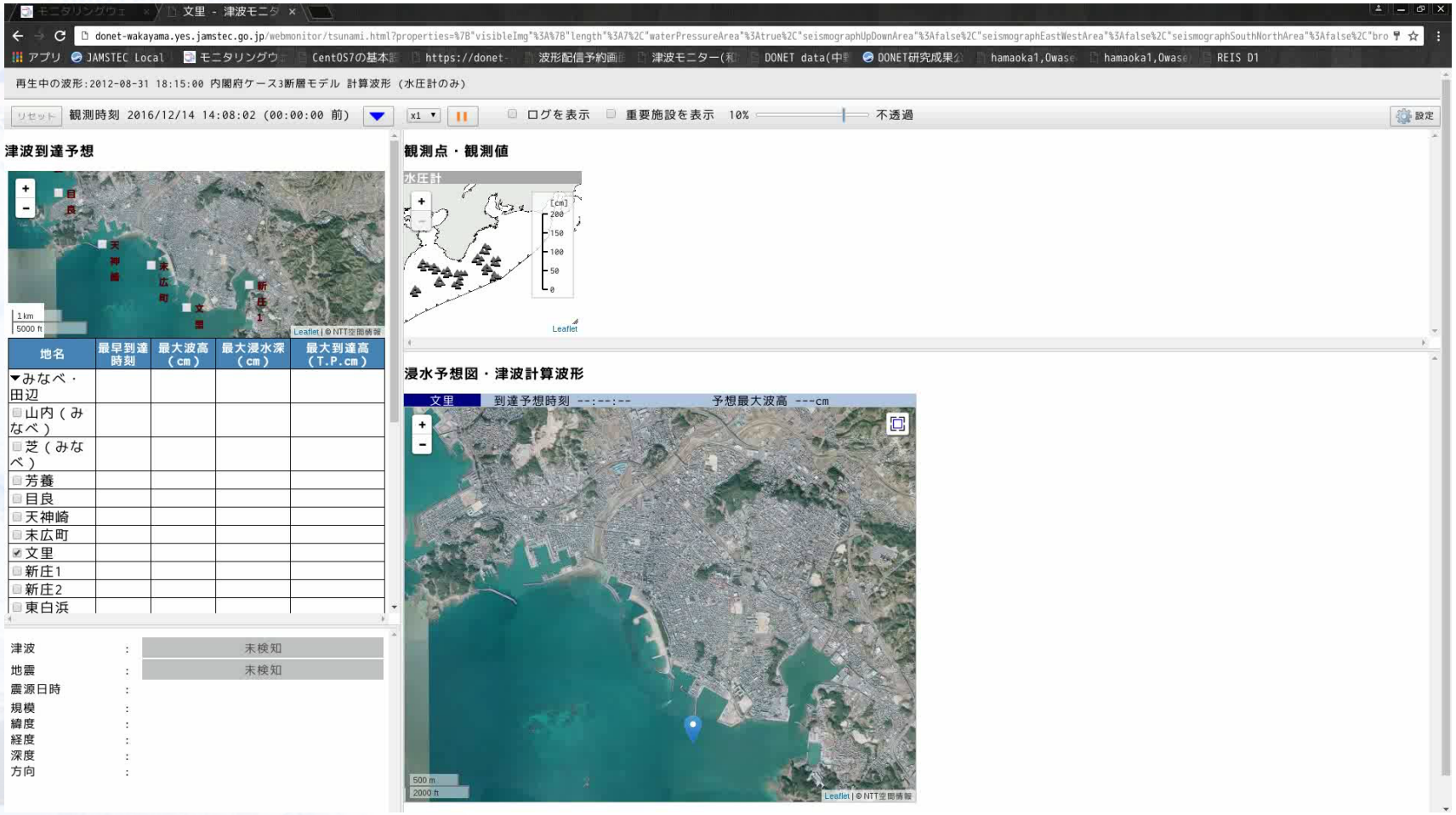
DONET has three main objectives

1) Early detection of
Earthquakes and Tsunamis

2) Contribution to Prediction Researches

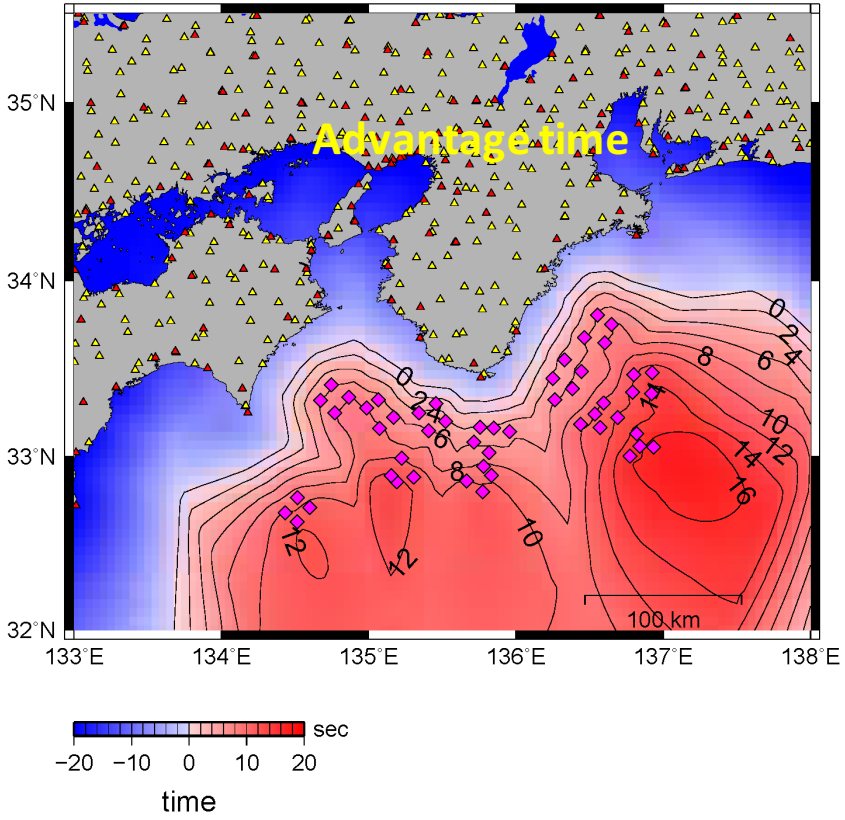
3) Development of
advance ocean floor observation

Real time Inundation Simulation
using DONET data and Tsunami Database

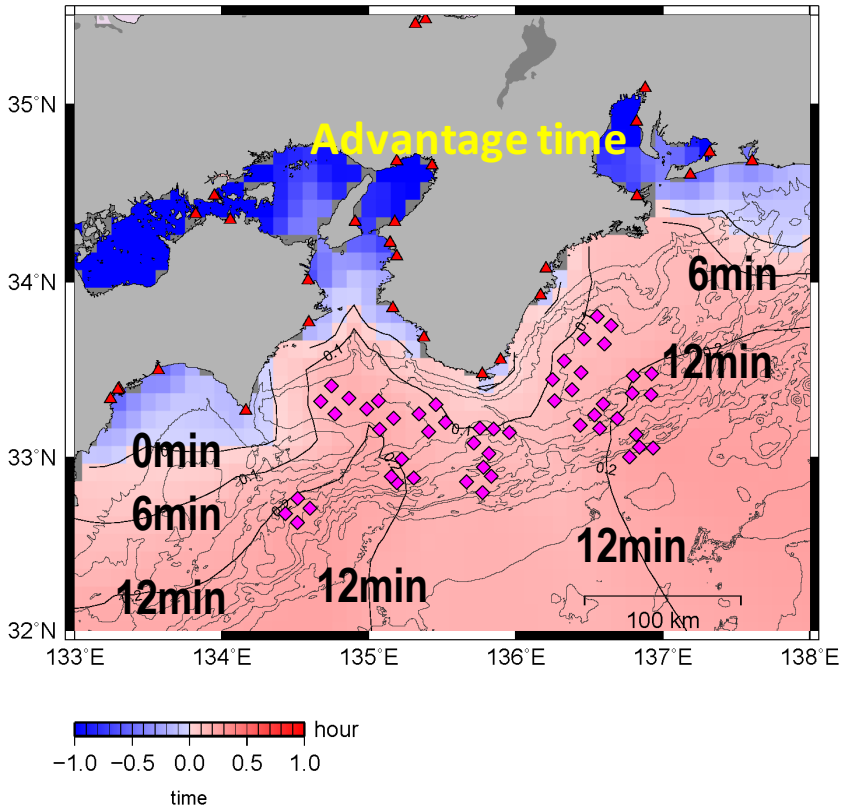


Early Detection of Earthquake and Tsunami by DONET1/DONET2

Seismic waves

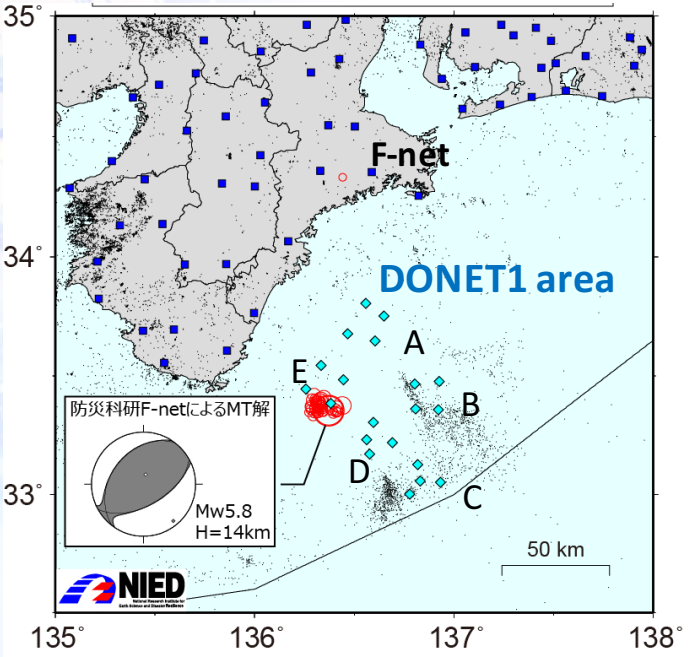


Tsunami

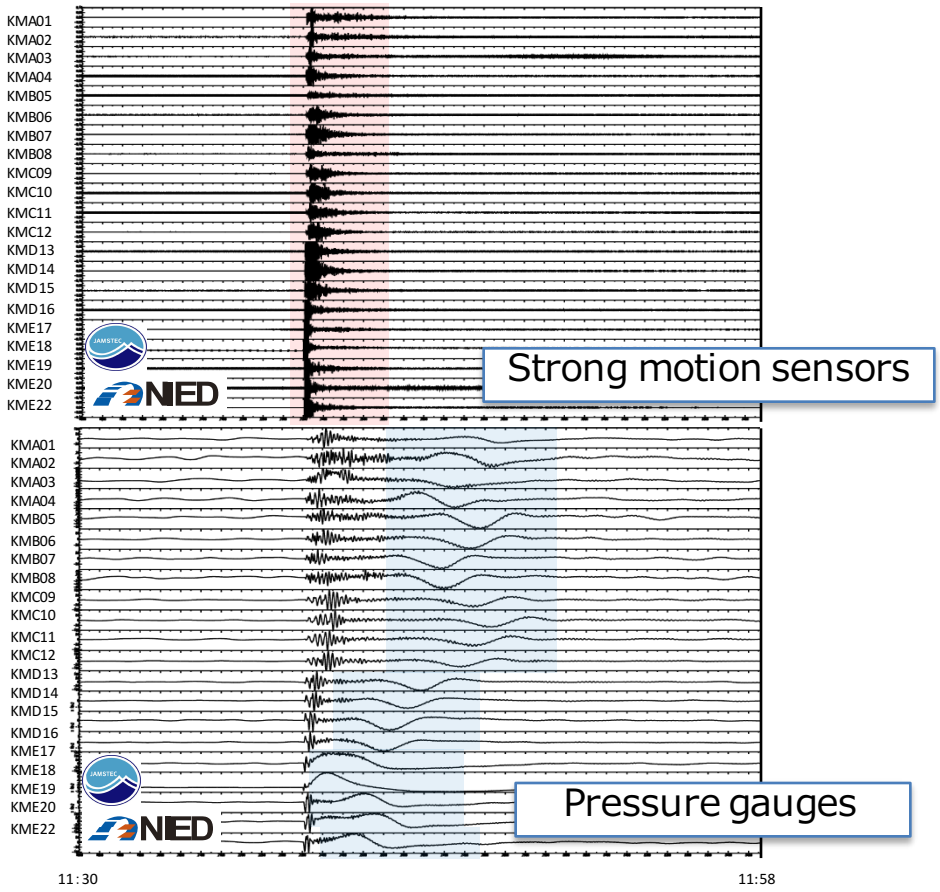


The red parts show the DONET/DONET2 detects earthquakes and tsunamis earlier than the land stations.

Off SE coast earthquake of Mie pref. on 1st April, 2016



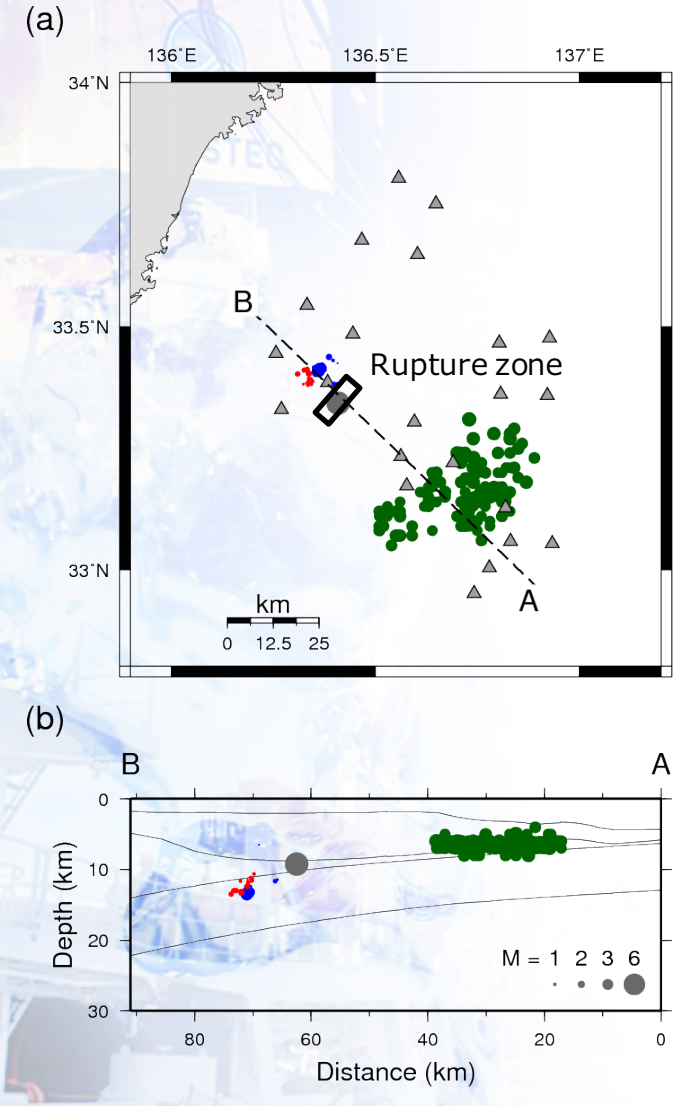
Red circles: Main shock and aftershocks (2016.04.01 11:39-17:05)
Dots: background seismicity (M>1.5, depth< 30 km, 2004.01.01-2016.03.31)



NIED F-net estimated that the event had low angle thrust mechanism

This Earthquake with M6.5 occurred at around the plate boundary for the first time since 1944 Tonankai earthquake.

Activated VLF events



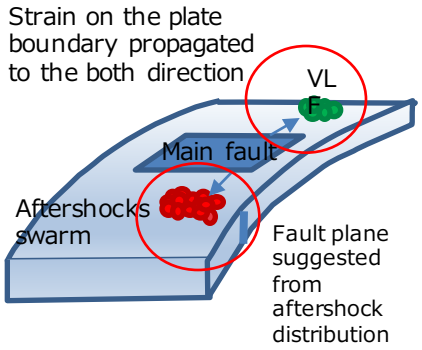
JAMSTEC/NIED

Very low frequency (VLF) events were activated along a top of the plate boundary near the trough axis from 3rd April.

Crustal deformation was observed by borehole strain meter (Araki et al., in this meeting) although there are no aftershocks between the main shock and the VLF event region.

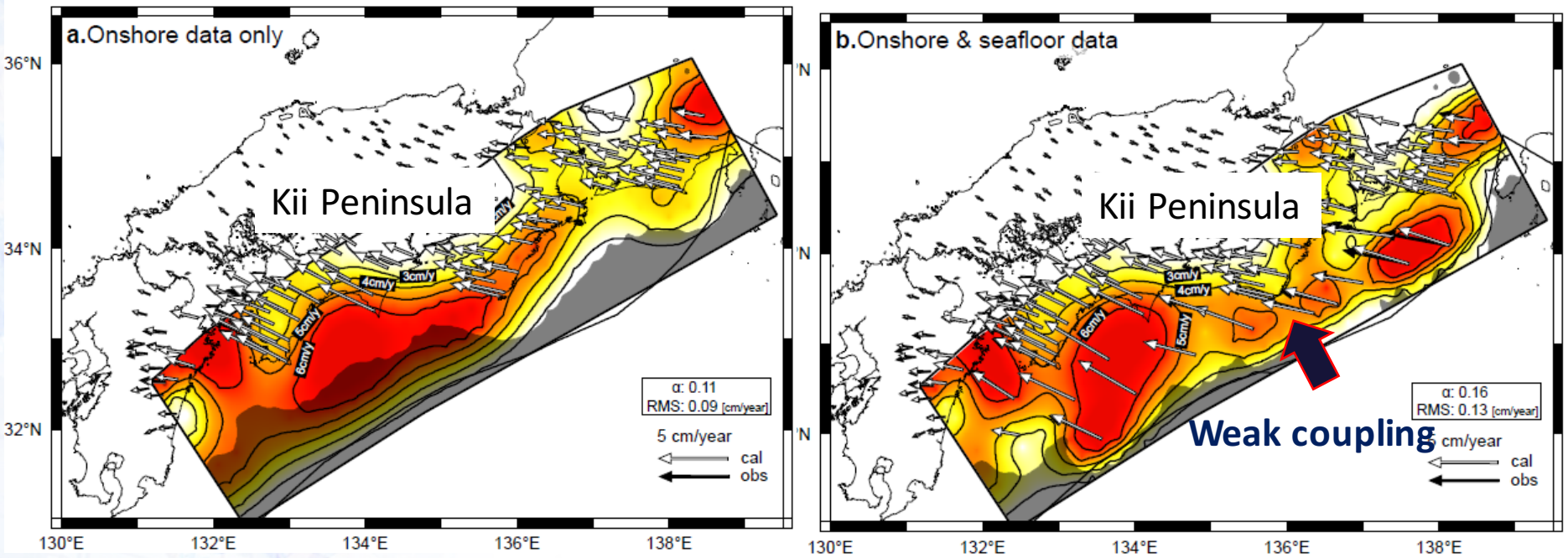
It is suggested that the main shock has an isolated single rupture zone on the top of the incoming crust.

The plate coupling is weak and the strain produced by the main shock extended to the north and the south.



Coupling of Nankai seismogenic zone

(JCG Dr. Yokota et al., Nature 2016)

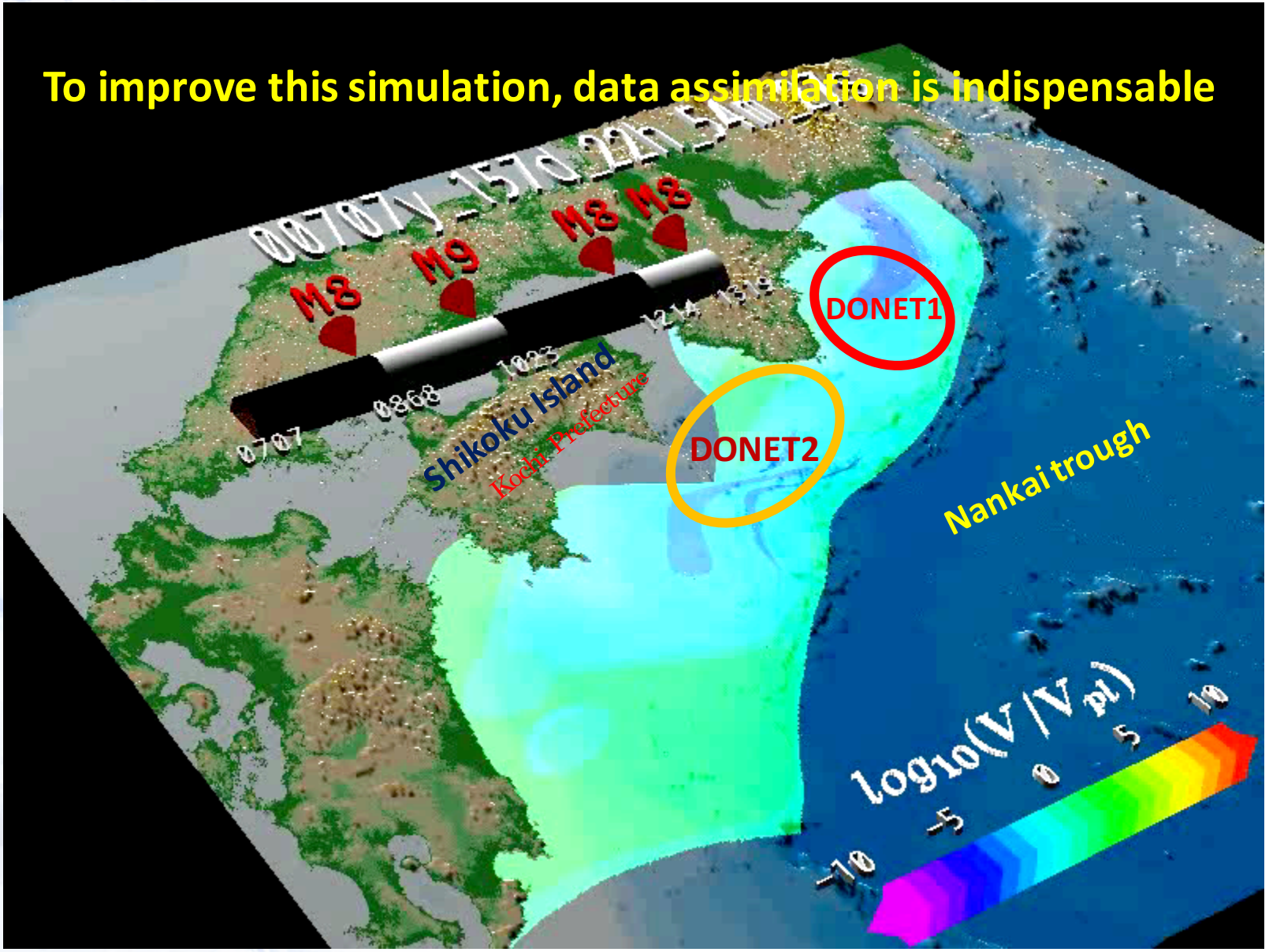


Result from Land data only

Result from Land and off shore data

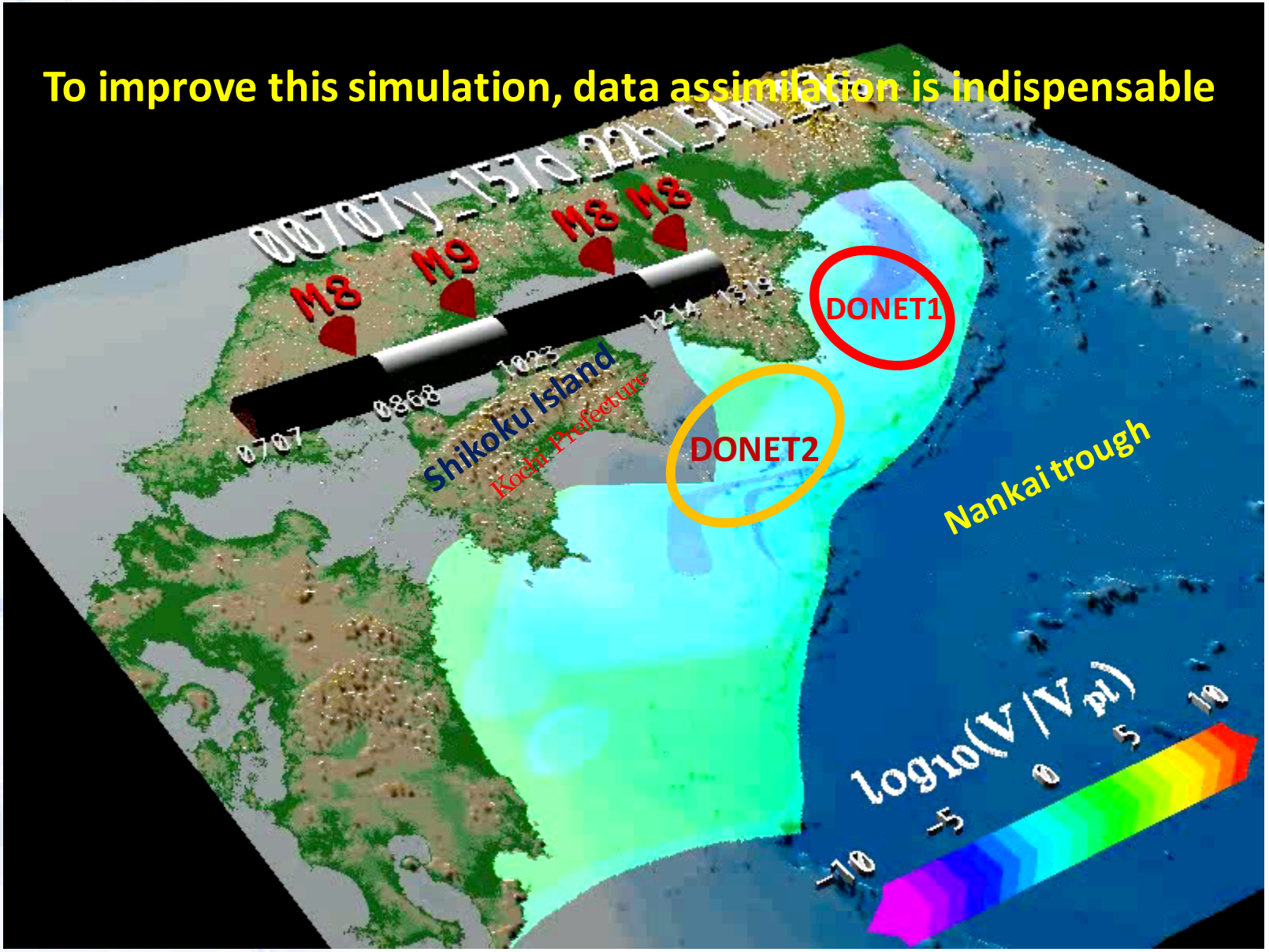
Result from GPS acoustic survey

Simulation on recurrence of Mega thrust Eqs.



Hydo and Hori（JAMSTEC）

Simulation on recurrence of Mega thrust Eqs.



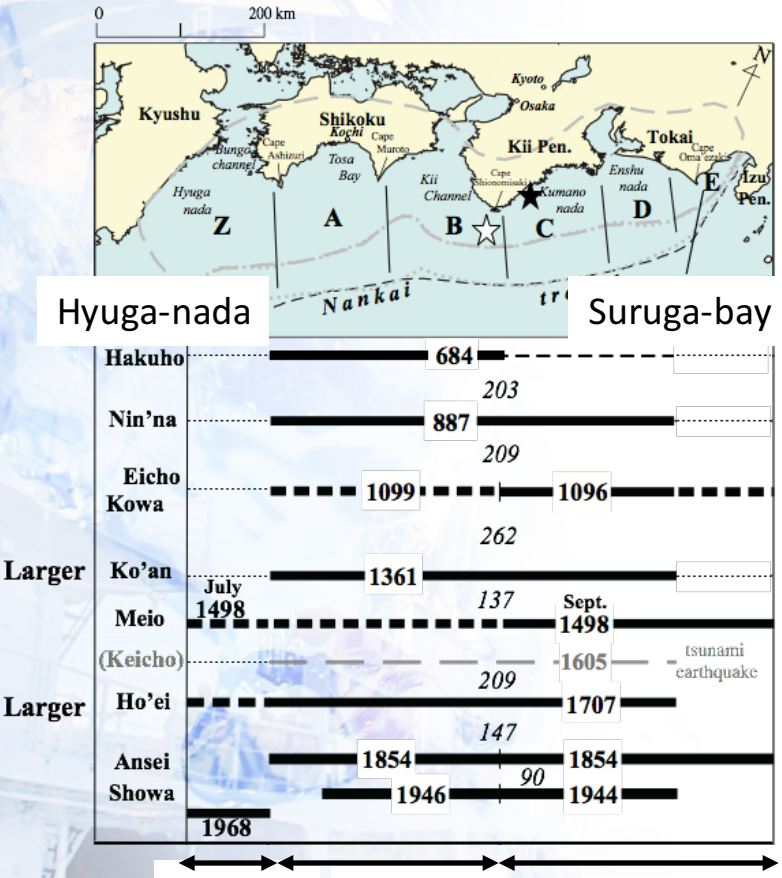
Hydo and Hori（JAMSTEC）

Motivation :

What is the cause of various rupture patterns in historical Nankai Trough earthquakes ?

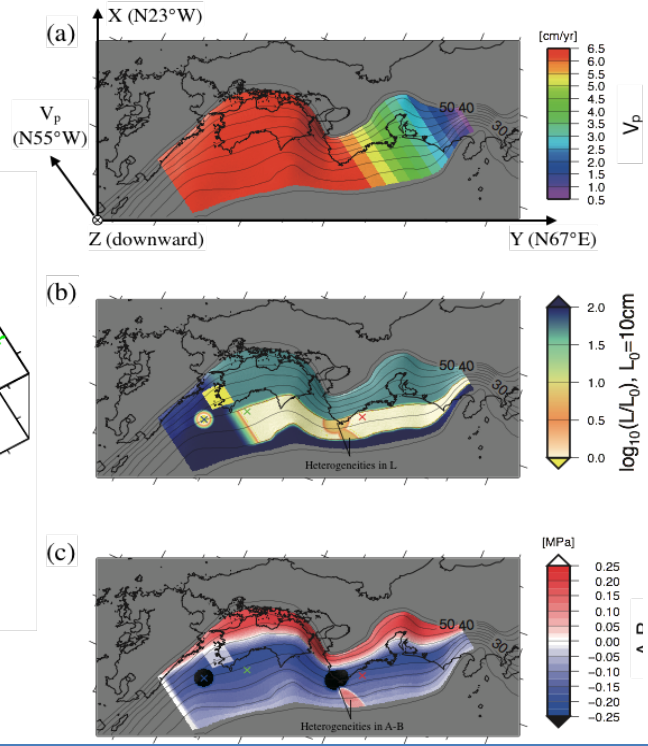
Possible scenarios of the next earthquake ?

Various rupture patterns of historical earthquakes

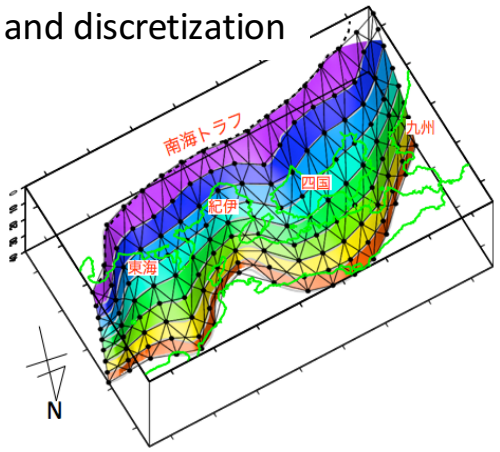


Quasi-dynamic earthquake cycle simulations based on the elastic static slip responses and a rate- and state-dependent friction

Example distribution of friction parameter

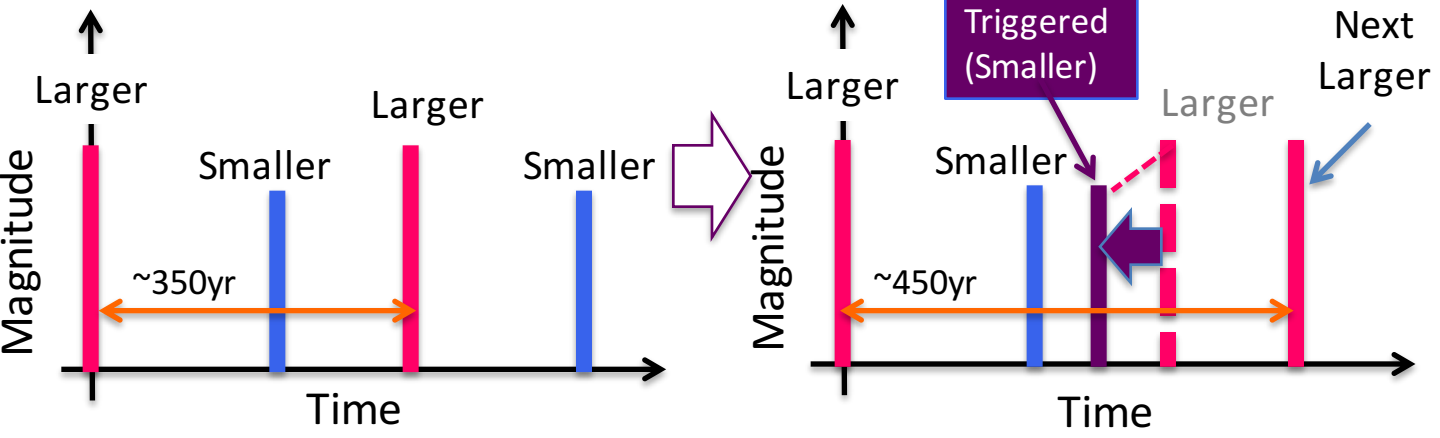


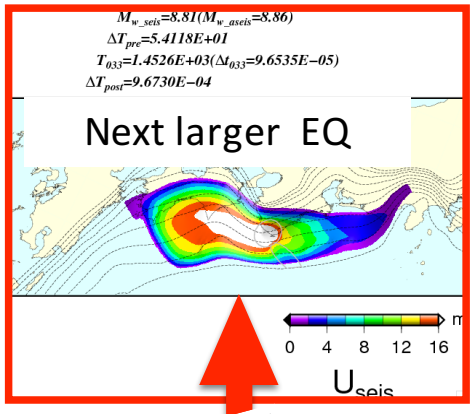
Slab geometry and discretization

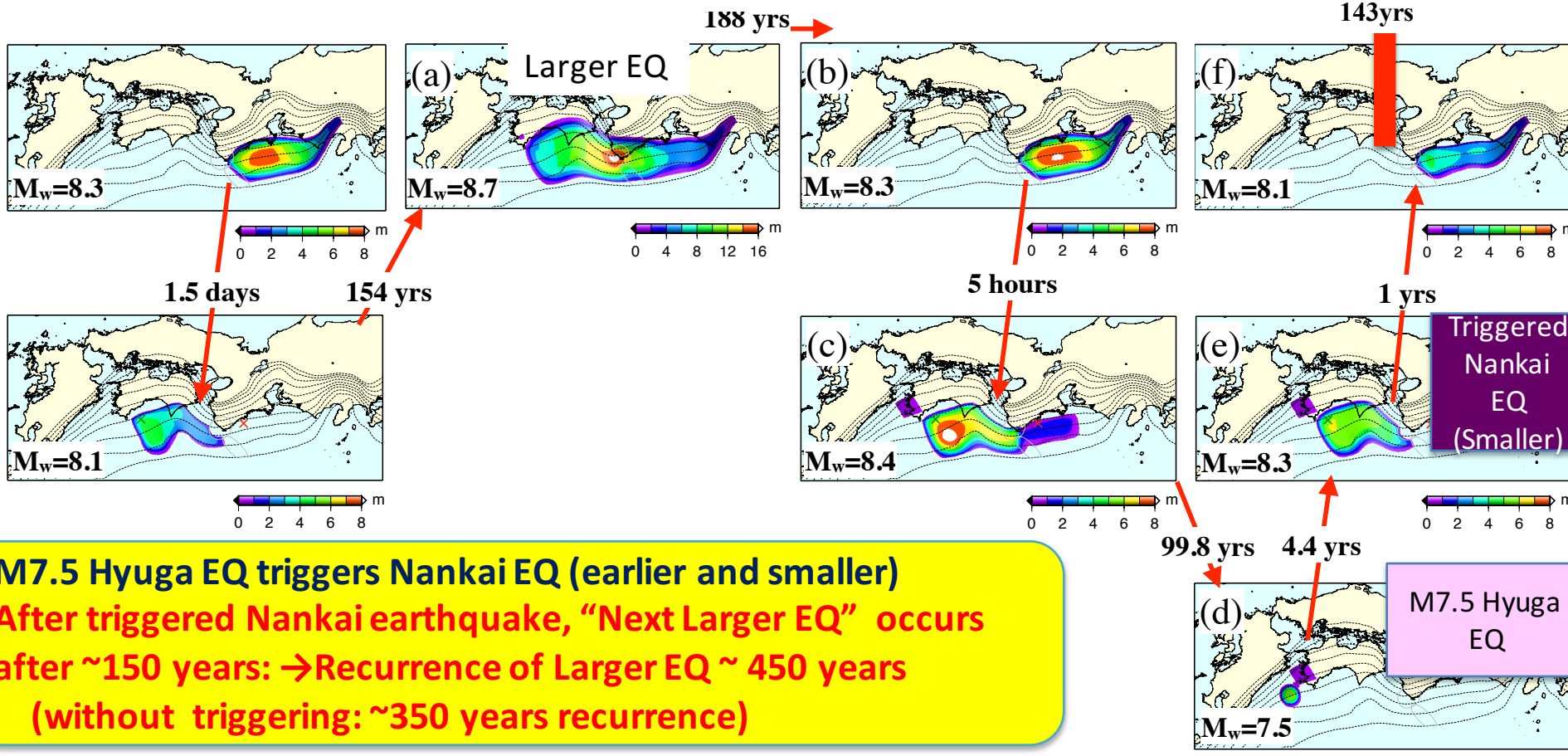


Model fault from **Hyuga-nada** to **Suruga-bay**

Size and recurrence time change by triggering of Nankai earthquake (EQ)







M7.5 Hyuga EQ triggers Nankai EQ (earlier and smaller)

After triggered Nankai earthquake, "Next Larger EQ" occurs after ~150 years: →Recurrence of Larger EQ ~ 450 years

(without triggering: ~350 years recurrence)

Advanced Tsunami Simulation

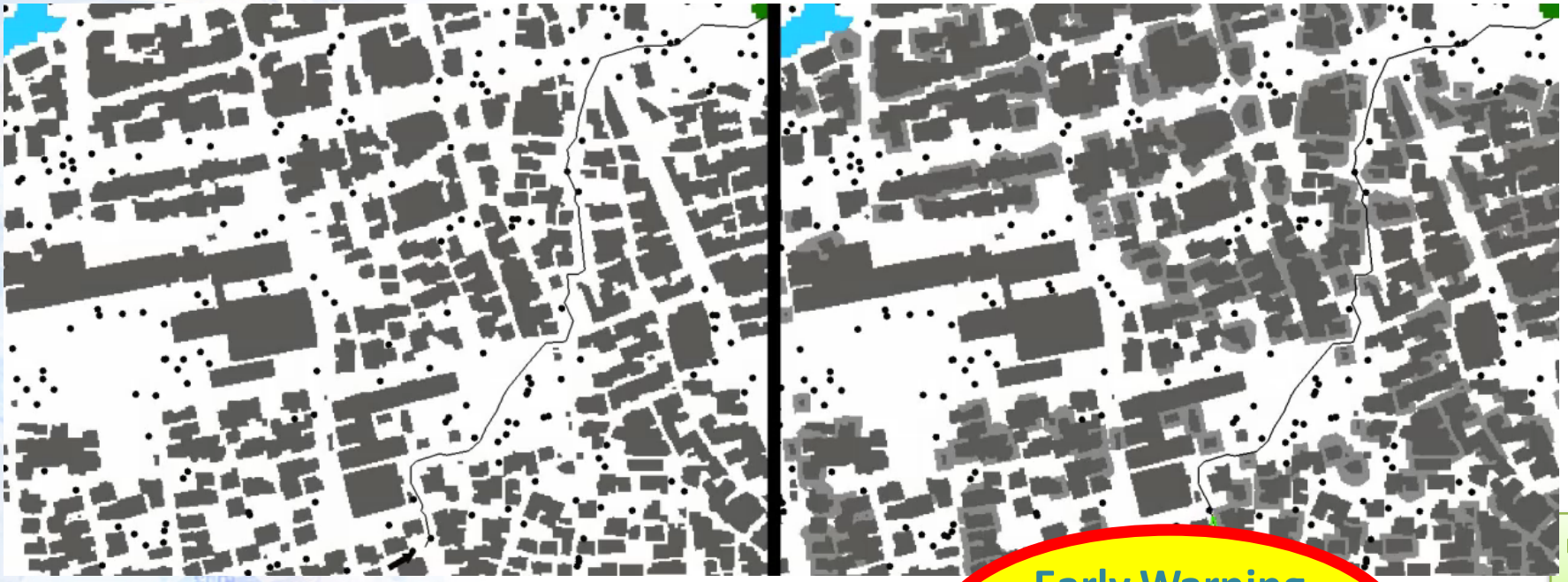
Prof. Asai Kyushu Univ.

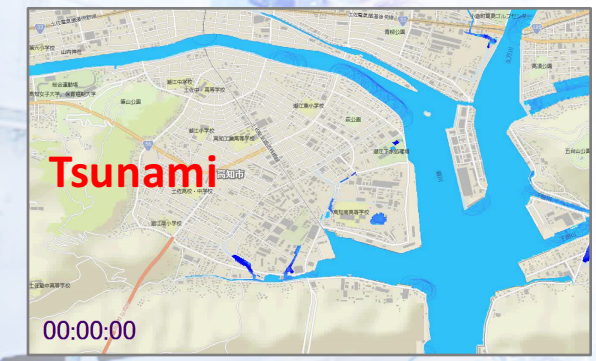
Navigation in damaged environment with EQ. and Tsunami

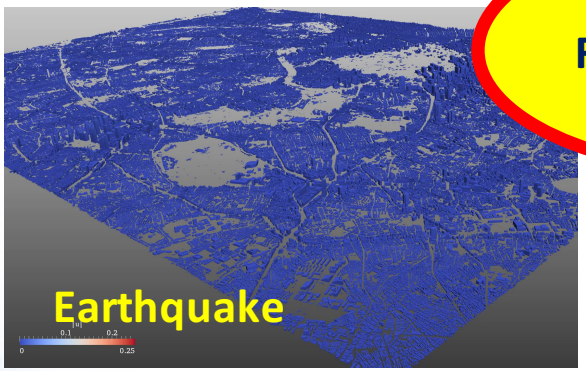
Dr. Lalith Univ.of Tokyo

Undamaged Environment

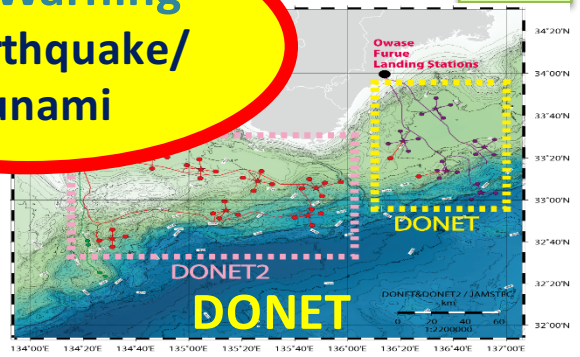
Damaged Environment







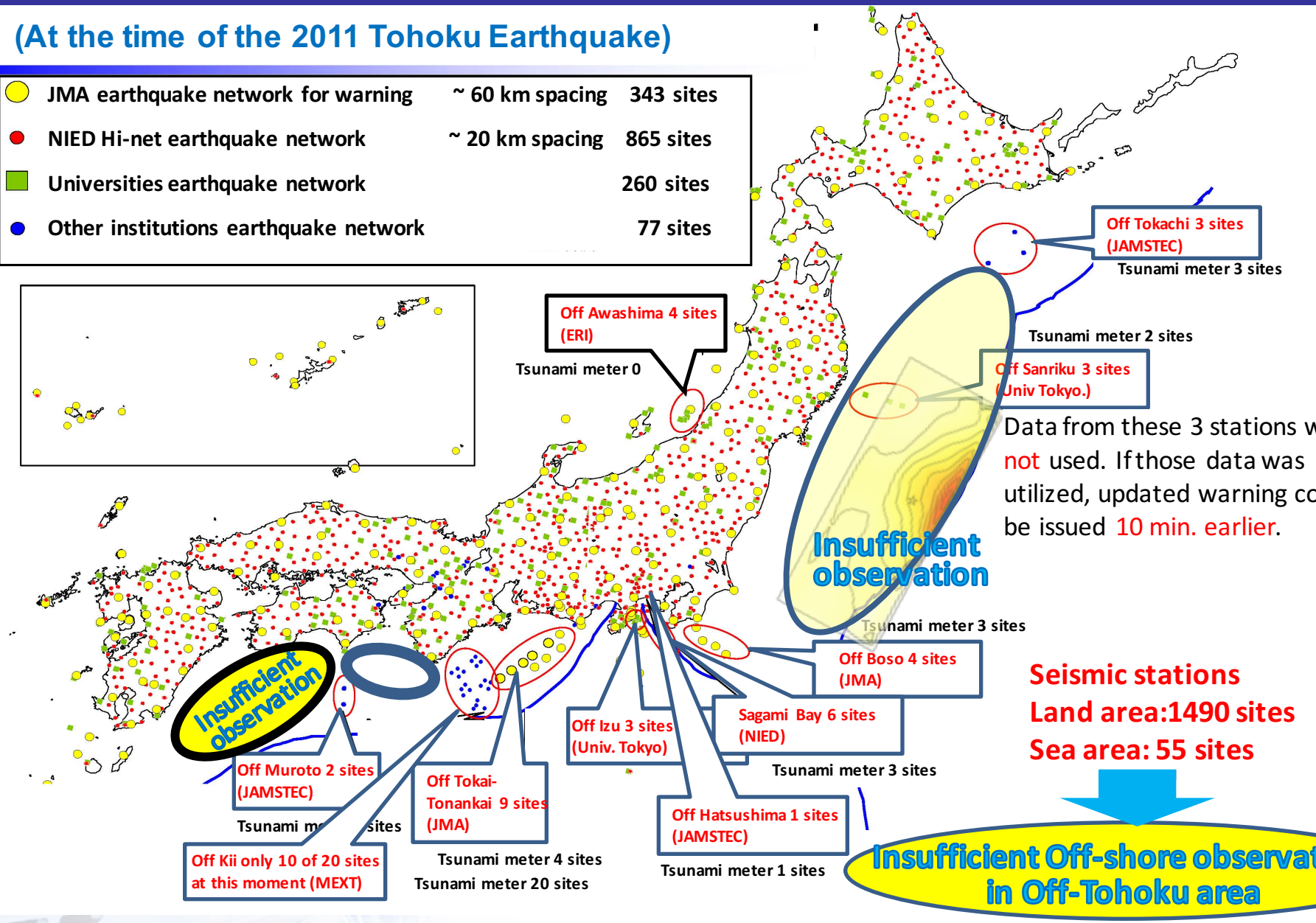
Early Warning
For Earthquake/
Tsunami



Earthquake and tsunami observation site in and around Japan

(At the time of the 2011 Tohoku Earthquake)

JMA earthquake network for warning	~ 60 km spacing	343 sites
NIED Hi-net earthquake network	~ 20 km spacing	865 sites
Universities earthquake network		260 sites
Other institutions earthquake network		77 sites

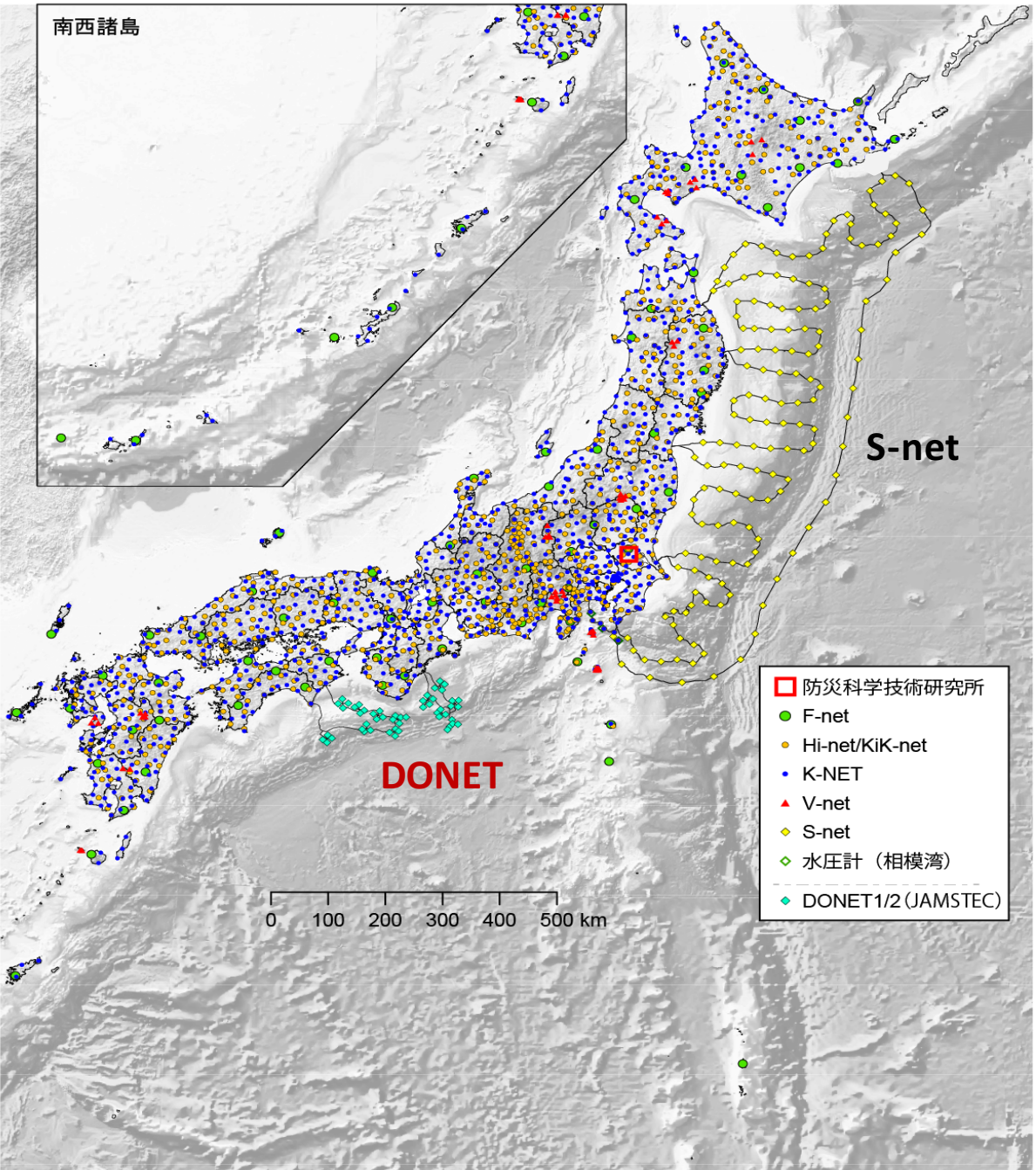


Data from these 3 stations were not used. If those data was utilized, updated warning could be issued 10 min. earlier.

Seismic stations
Land area:1490 sites
Sea area: 55 sites

Insufficient Off-shore observation in Off-Tohoku area

防災科学技術研究所 地震 火山 津波観測施設分布図



S-NET off Tohoku

S-net : *Seafloor Observation Network for Earthquakes and Tsunamis along the Japan Trench*

First dense real-time observation network in the ocean（6 segments & 150 observatories）

- Total length of the ocean bottom fiber optic cable: 5,700 km.
- Covers the wide area of Japan Trench from Kanto to Hokkaido.
- At least one observatory in a source region of M7.5 earthquake.
- Nodes are planned to install every
  - 30 km in a direction cross to trench
  - 50 - 60 km along direction to the trench

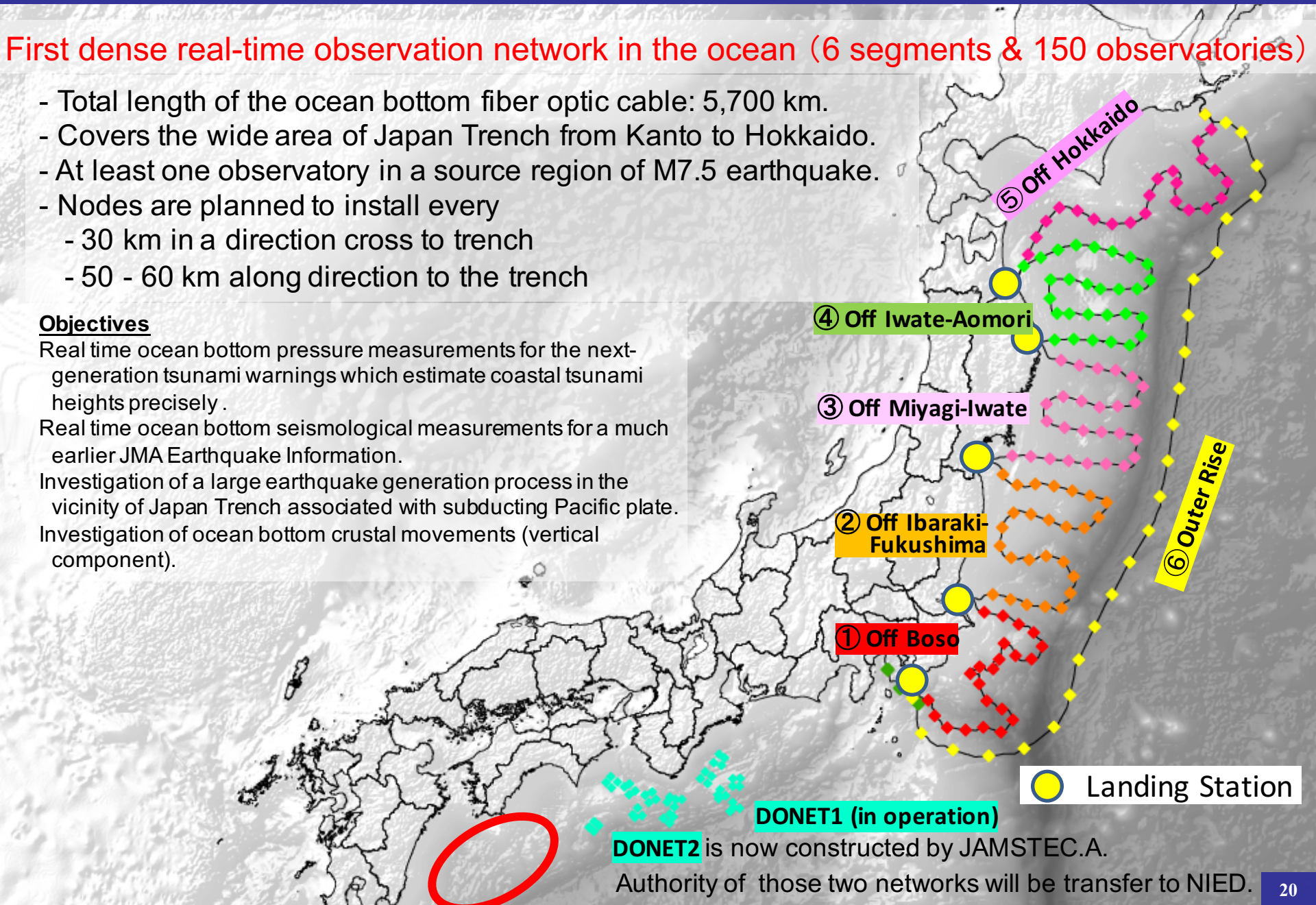
Objectives

Real time ocean bottom pressure measurements for the next-generation tsunami warnings which estimate coastal tsunami heights precisely .

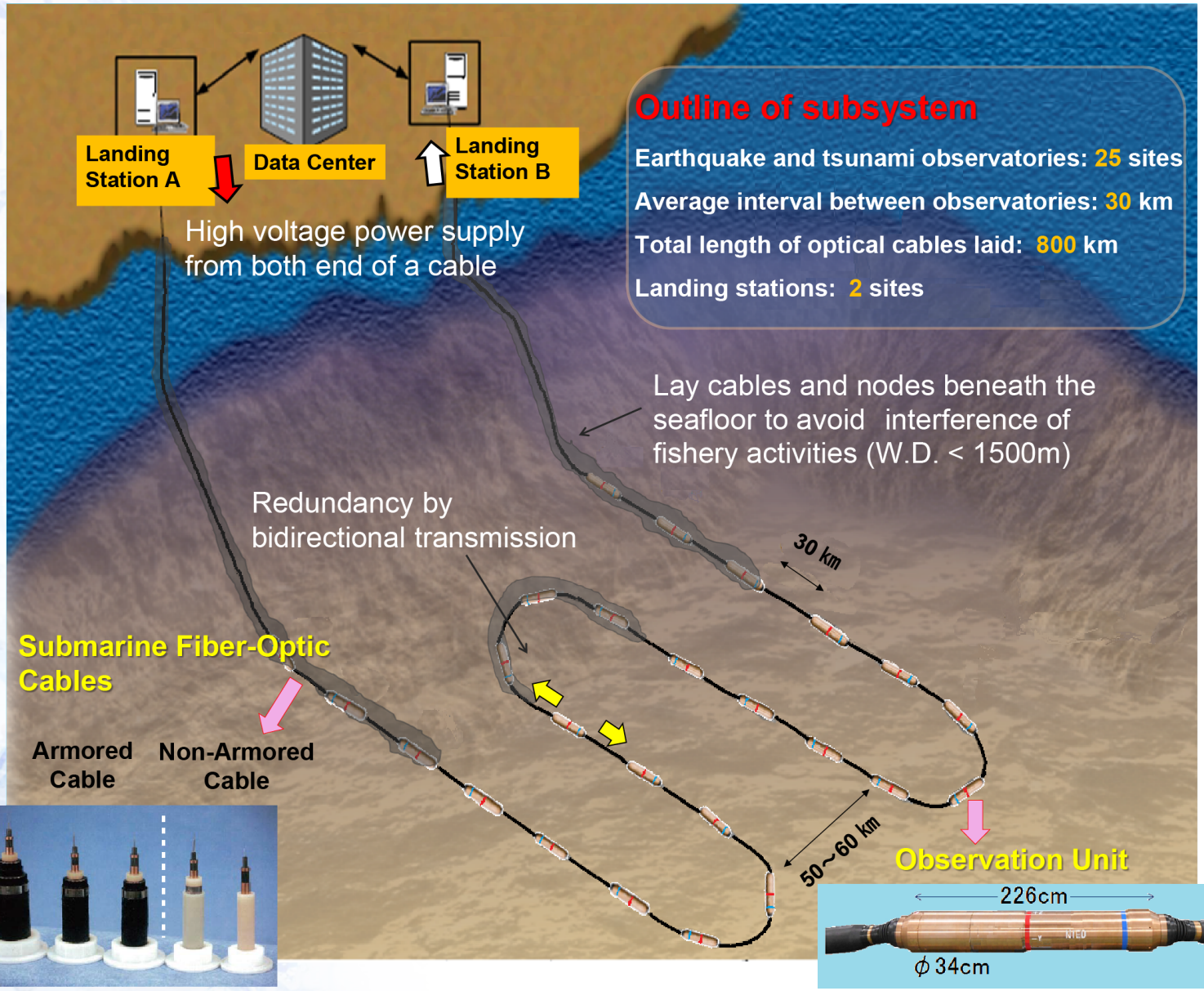
Real time ocean bottom seismological measurements for a much earlier JMA Earthquake Information.

Investigation of a large earthquake generation process in the vicinity of Japan Trench associated with subducting Pacific plate.

Investigation of ocean bottom crustal movements (vertical component).



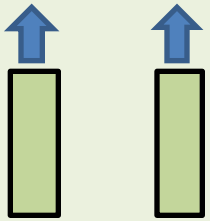
S-net subsystem (network segment)



Sensors Installed in Each Observation Node

Tsunami meters (Depth sensors)

Pressure & Temperature
10 & 100 Hz sampling
Reference clock 60MHz

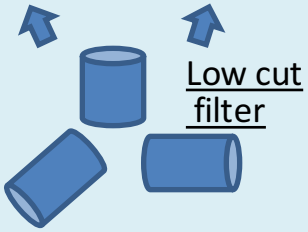


Quartz type pressure sensor
(Frequency output)
(Paroscientific, Inc.)

Seismometers

Observation use

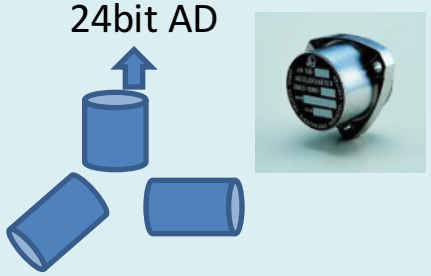
Low gain ±2G
High gain ±0.06G
Acceleration
100Hz sampling
24bit AD



Servo accelerometer
(JA-5IIIA, JAE)

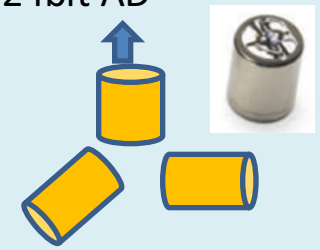
Warning use

Strong motion ±5G
Acceleration
100Hz sampling
24bit AD



Servo accelerometer
(JA-5IIIA, JAE)

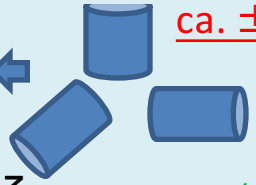
Quality control use
Velocity
100Hz sampling
24bit AD



Short period velocity seismograph
(Natural frequency about 15Hz)
(OMNI-2400, Geospace Technologies)

Broadband and high resolution

Acceleration & Temperature
10 & 100 Hz sampling
Reference clock 60MHz



ca. ±2G

Quartz type accelerometer
(Frequency output)
(Quartz Seismic Sensors, Inc.)

2013年7月6日　ケーブルタンク上のデッキに収納された地震津波計。手前の12台が茨城県鹿嶋市側から設置するもので、奥の10台が千葉県南房総市側から設置するものです。（提供：防災科学技術研究所）

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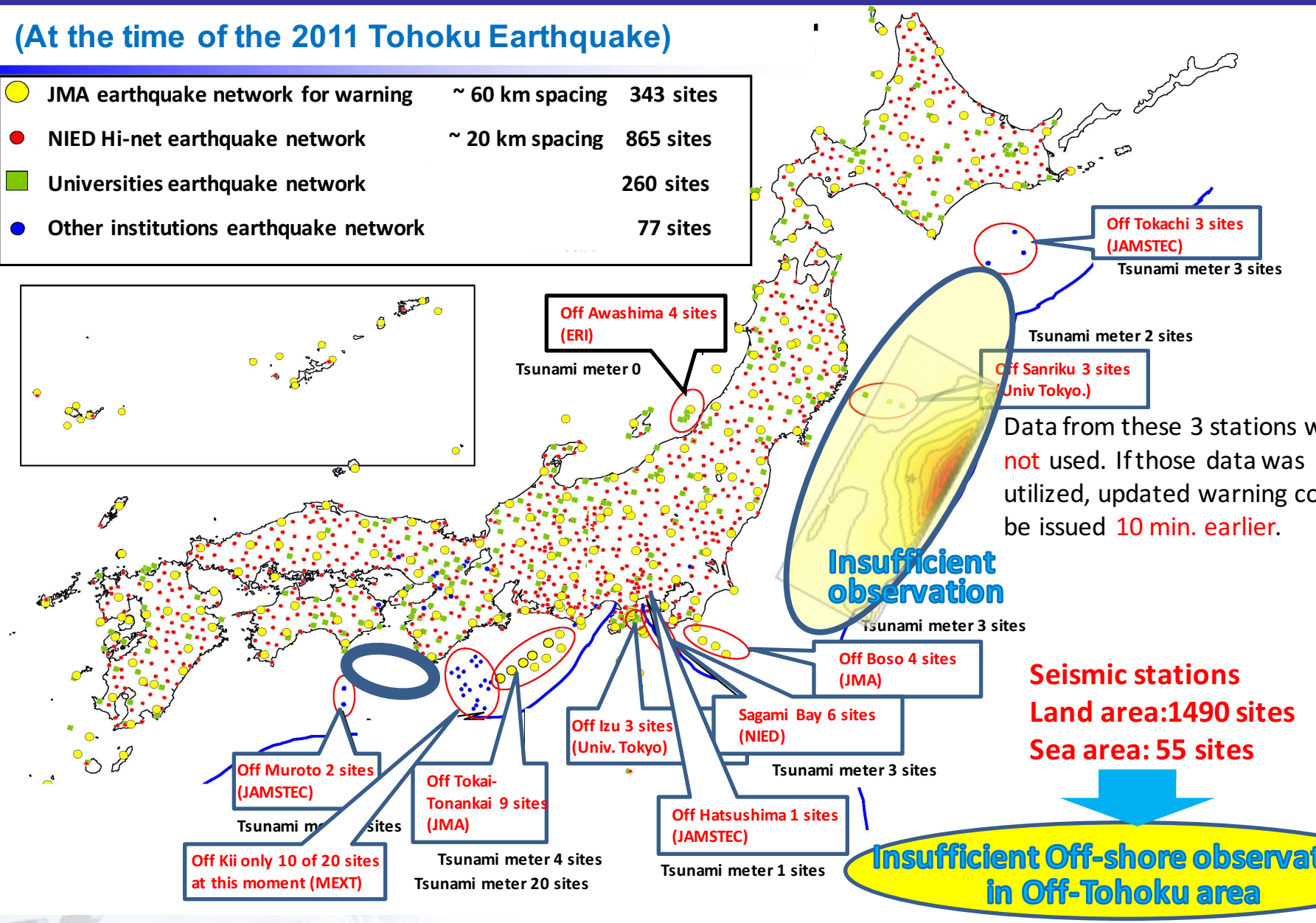
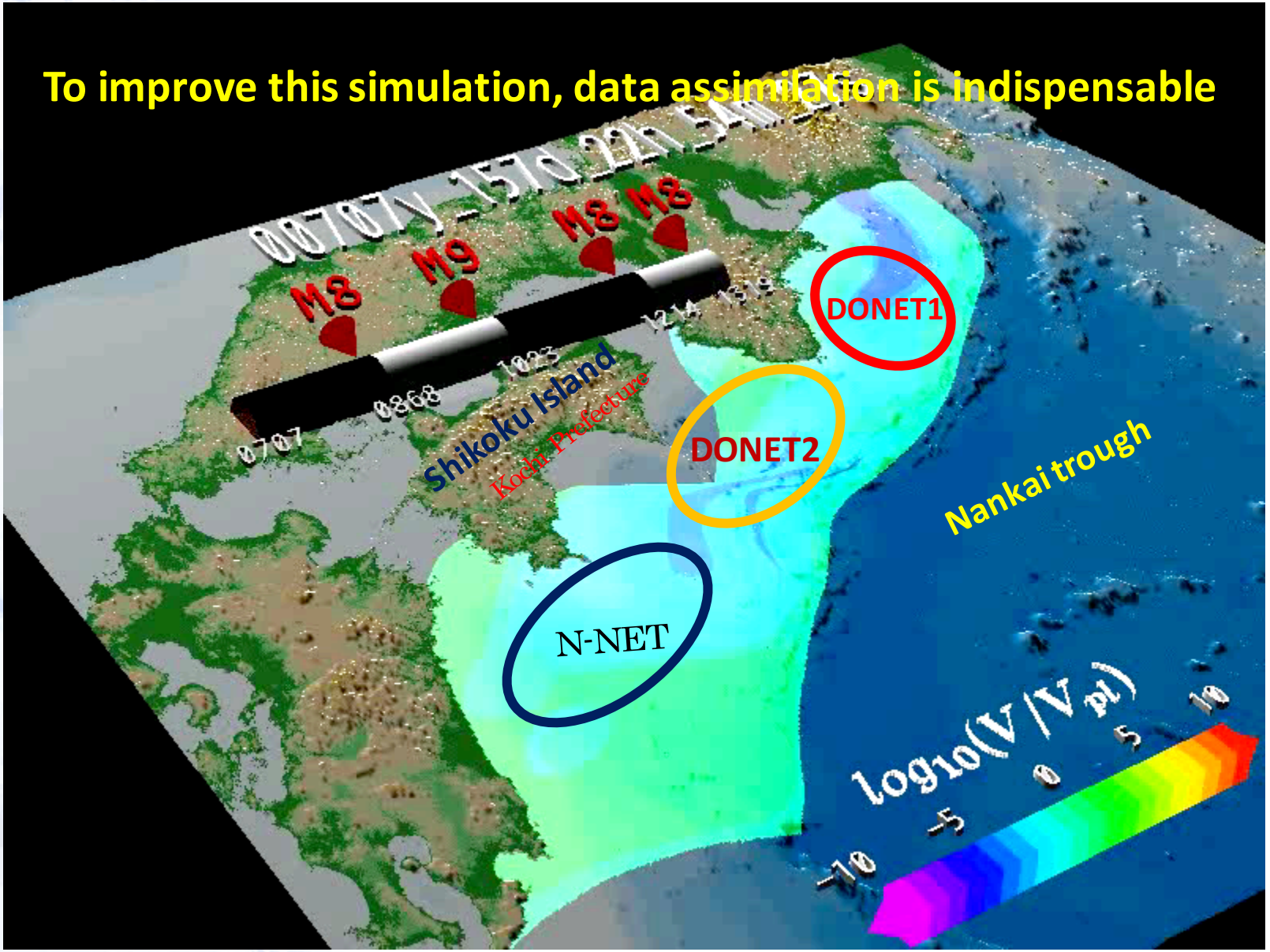
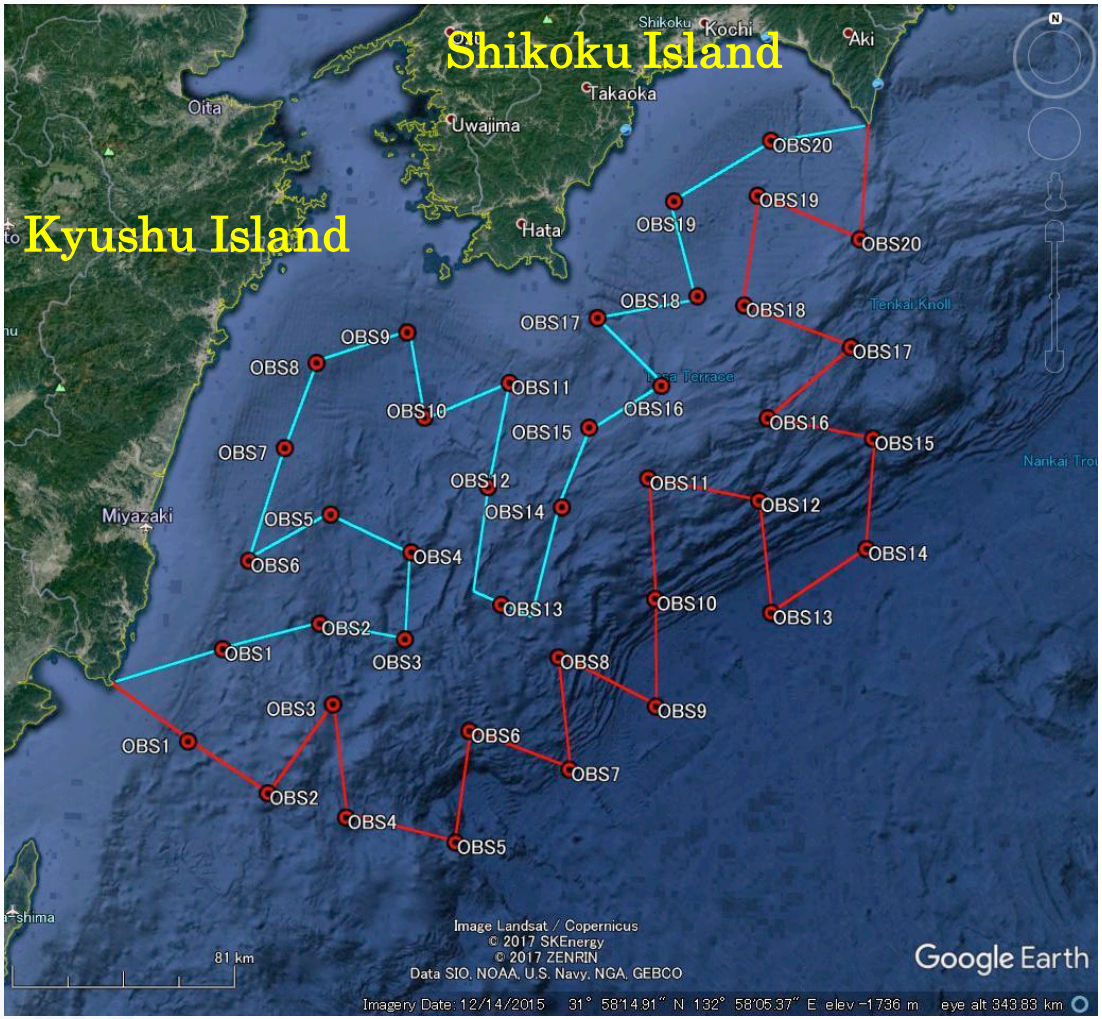


NEXT network is under planning



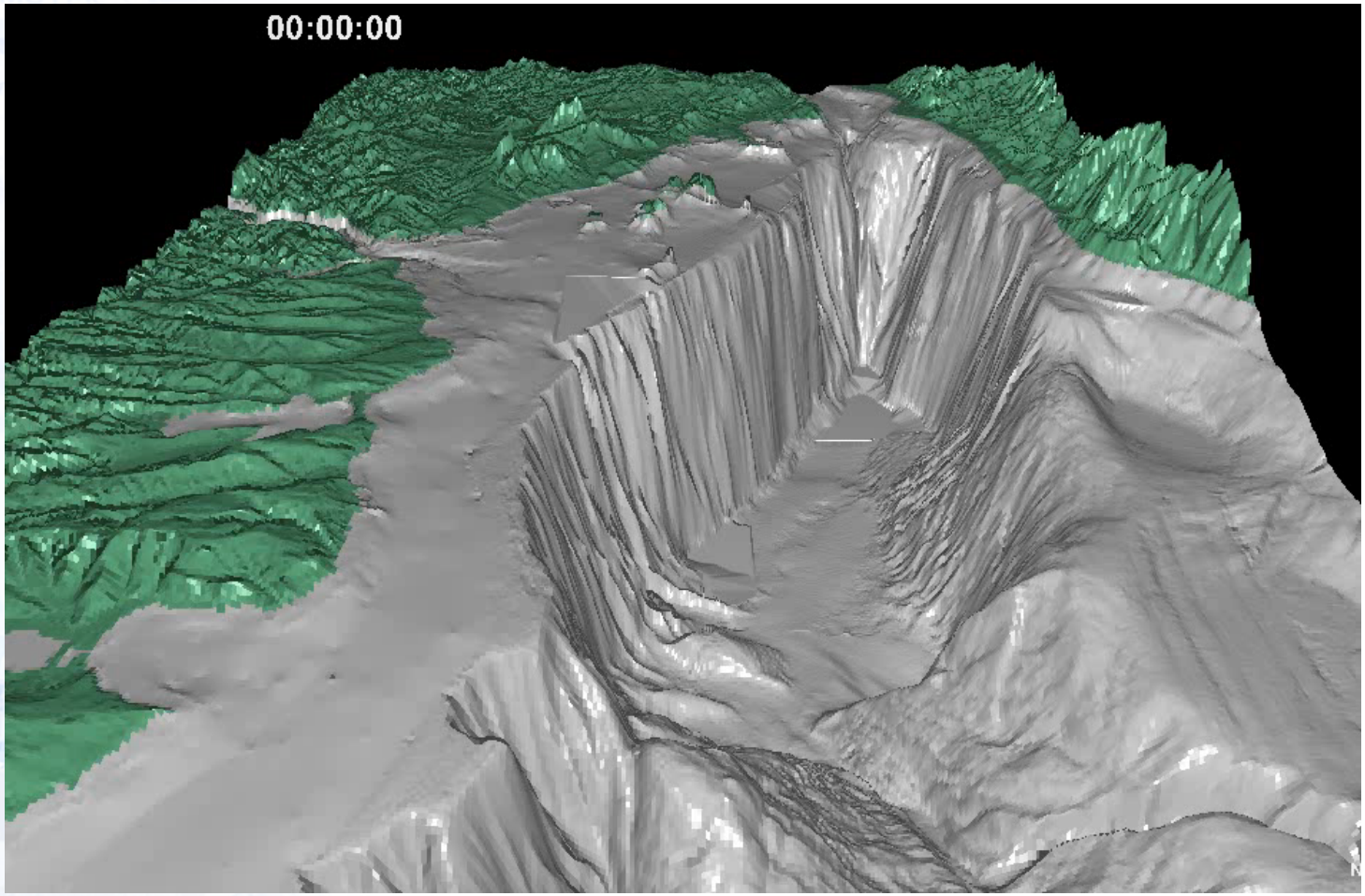
Hydo and Hori（JAMSTEC）

Draft of N-NET（Under Budget requesting）



Tsunami generated by landslide at seafloor

Turkey-Japan SATREPS Project



Tsunami generated by landslide at seafloor

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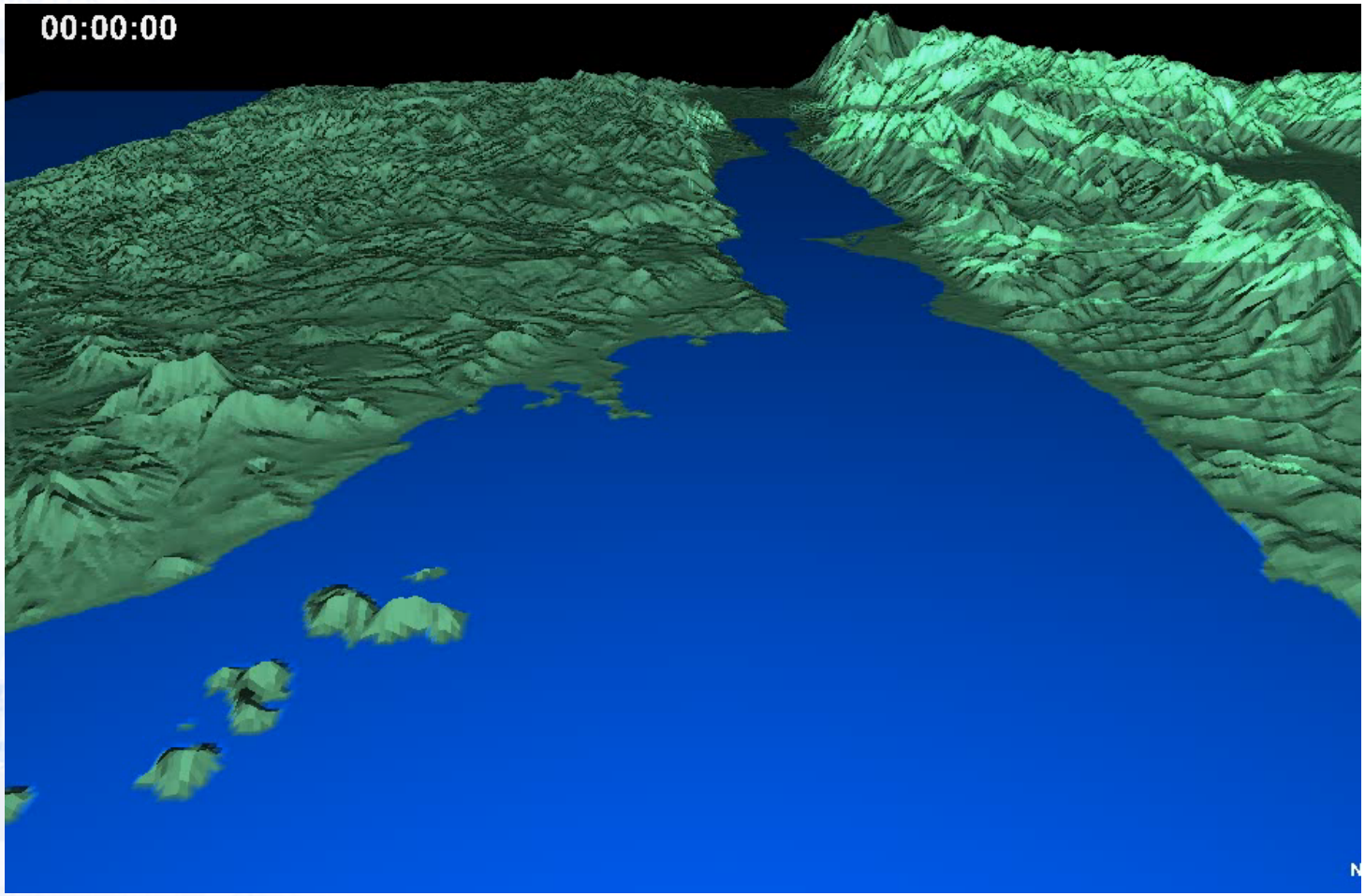
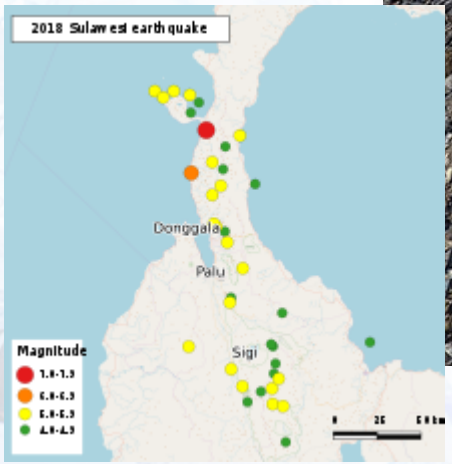


Indonesia Sulawesi Island Earthquake and Tsunami Damage

Real time monitoring system is indispensable



Tsunami was Amplified by Bathymetric feature and Land slide on Ocean floor?

Enhance of international collaborations

OCEAN NETWORKS CANADA
A University of Victoria Initiative

CANADA

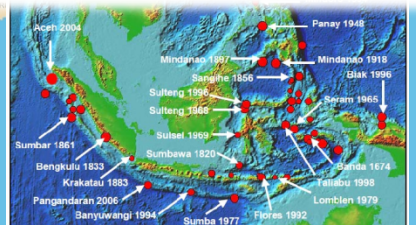
GREENLAND (DENMARK)

Photo : Oyo corporation

International Collaborations are very important for Ocean observing Technology and Ocean Science

Especially, real time monitoring systems and simulation researches are indispensable

ARGENTINA



AUSTRALIA

NEW ZEALAND

Towards Disaster mitigation and Natural disaster/ Environmental researches

Thank you for your attention