# 2011 Tohoku-oki Earthquake

Yuji Yagi

(Univ. of Tsukuba)

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# Seismicity Map

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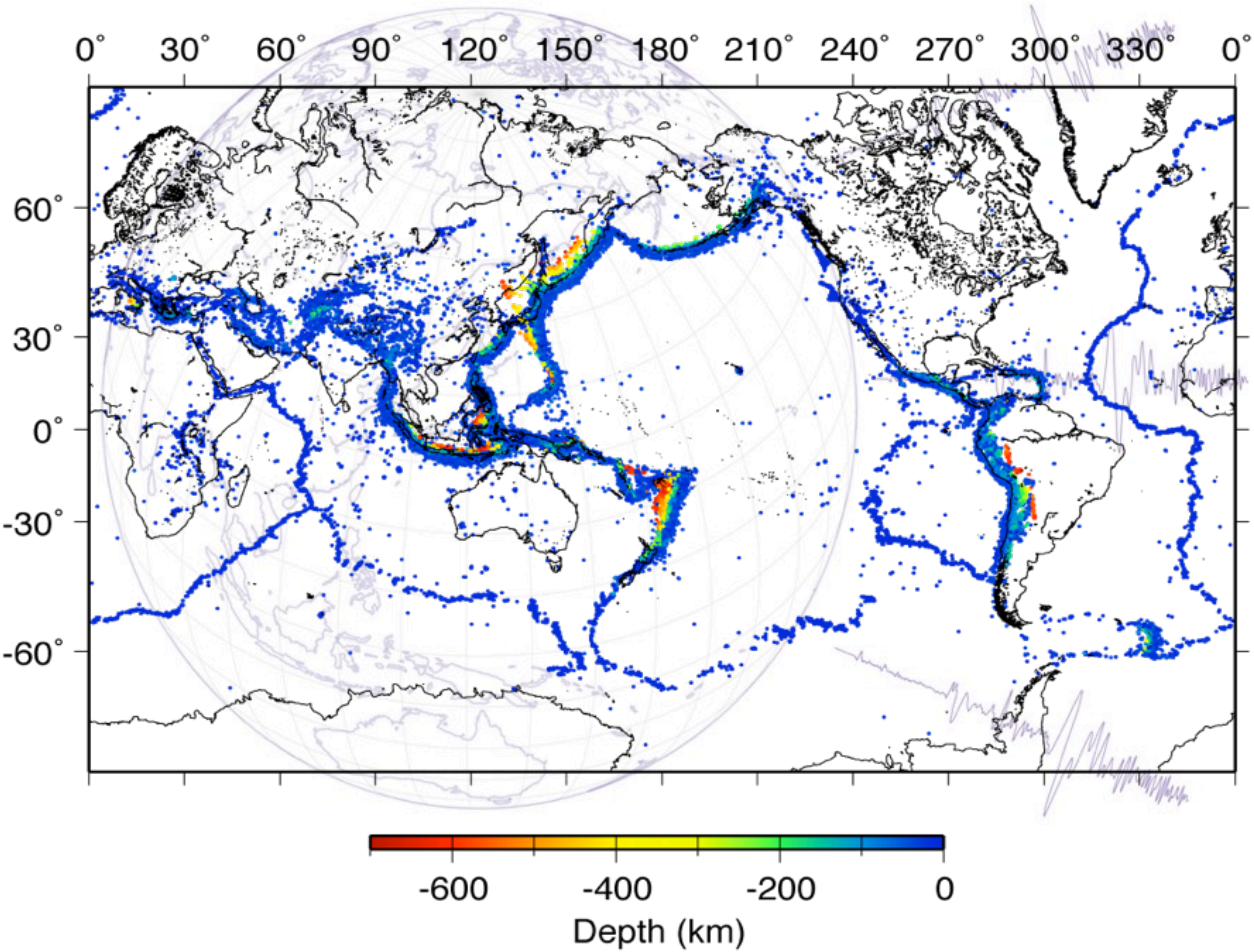
# Seismicity Map

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# Namazu-e

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# Seismicity in Tohoku region

the Headquarters for Earthquake Research Promotion

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University of Tsukuba

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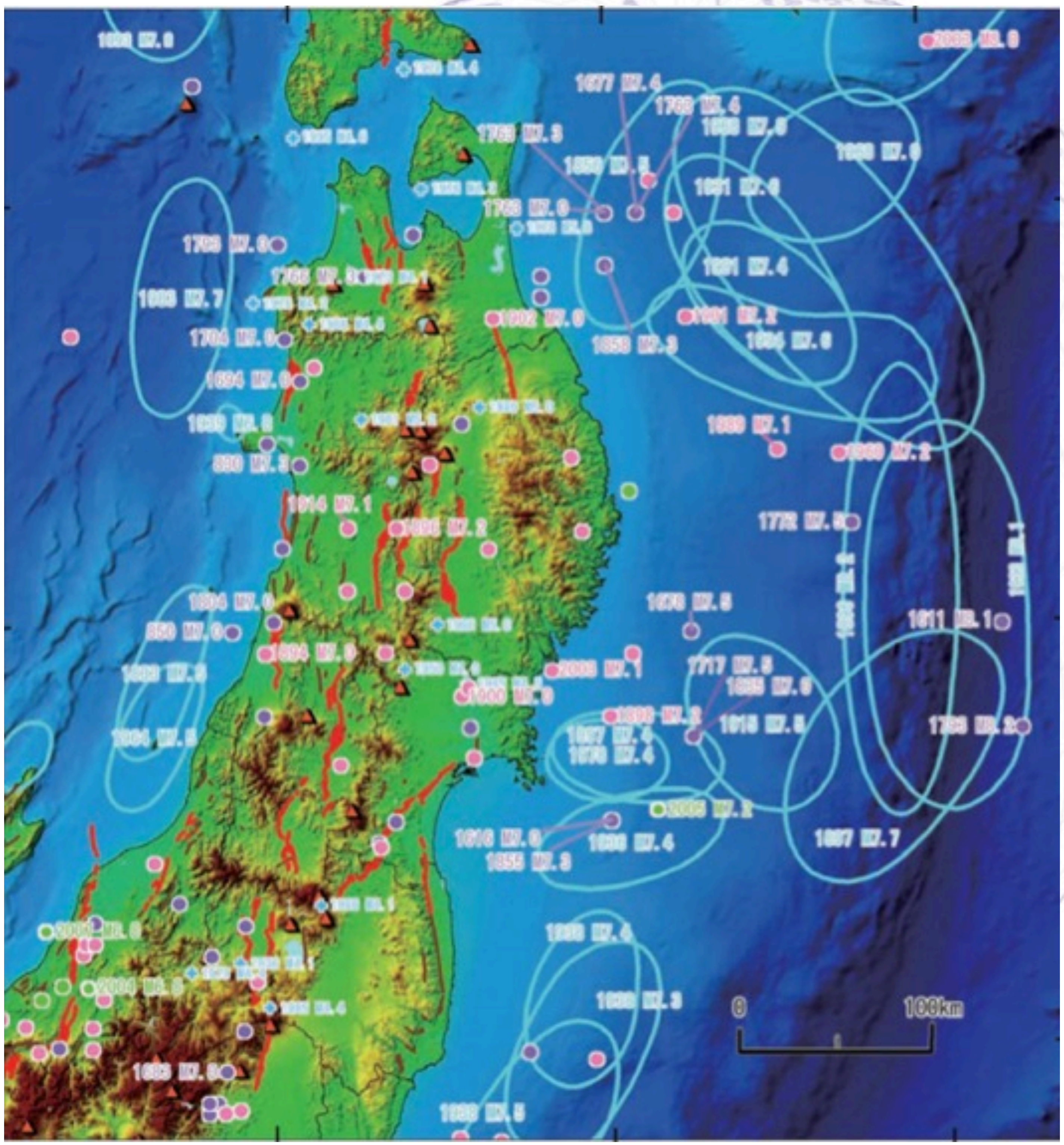

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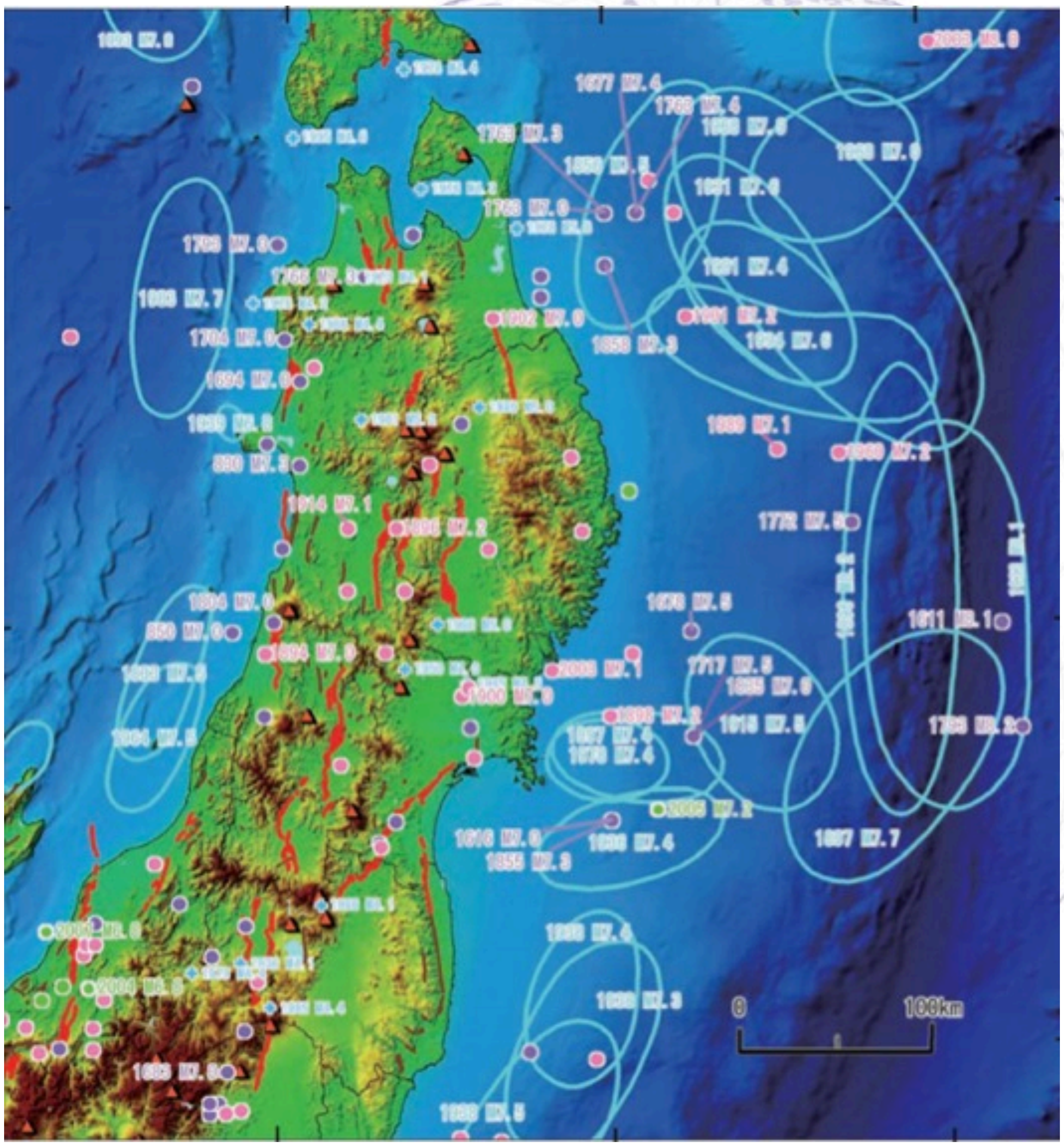
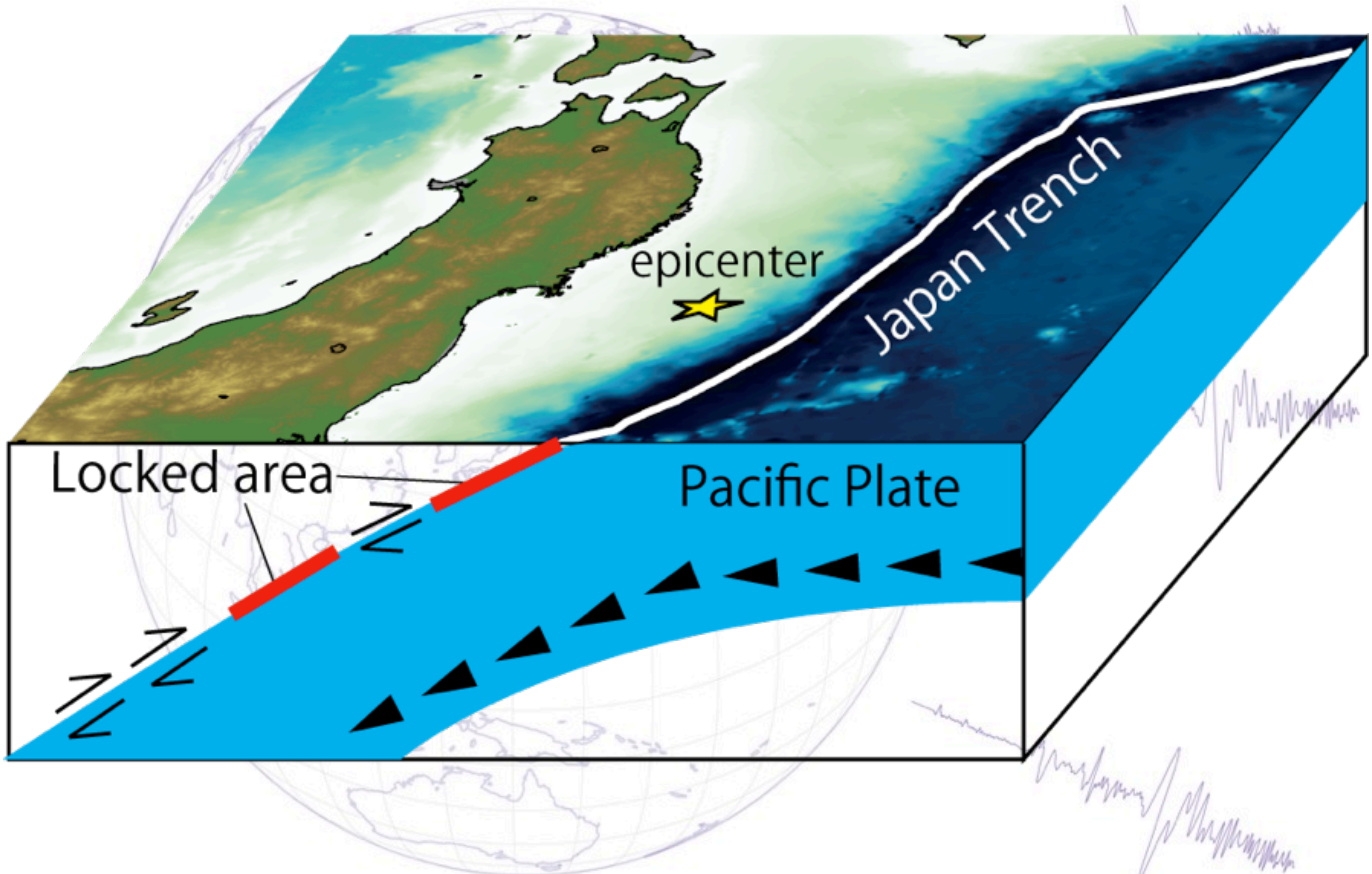


The largest conceivable earthquake for this region had been M8!

the Headquarters for Earthquake Research Promotion

# Tectonic Setting

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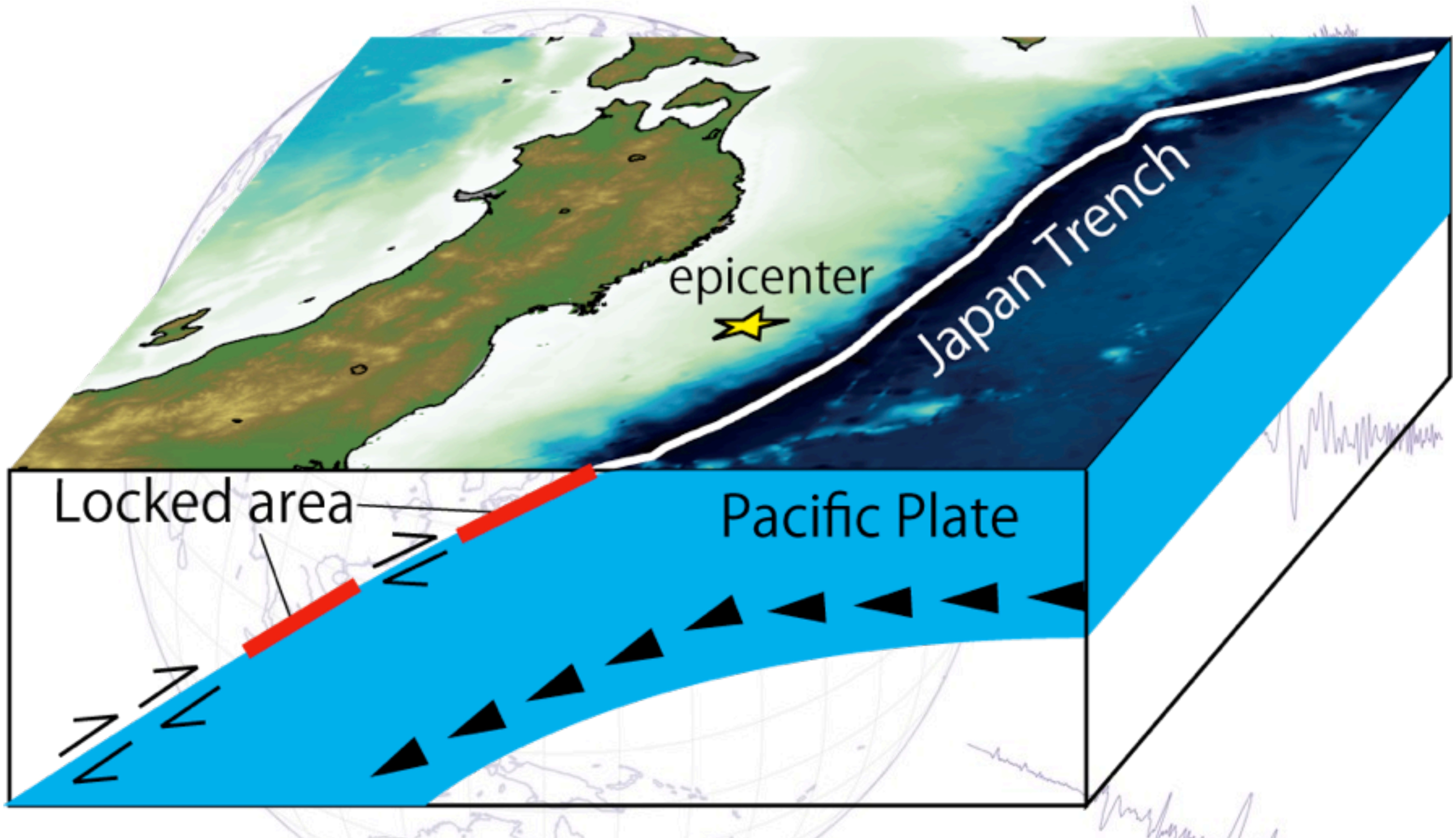


The process by which the Pacific Plate is subducting beneath the Japanese archipelago is not smooth. Slip deficits can accumulate where parts of the Pacific Plate are coupled with the overlying continental plate. Major inter-plate earthquakes release the strain accumulated because of such slip deficits.

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# Visualizing "Locked" area by GPS

Nishimura et al., 2004, GJI

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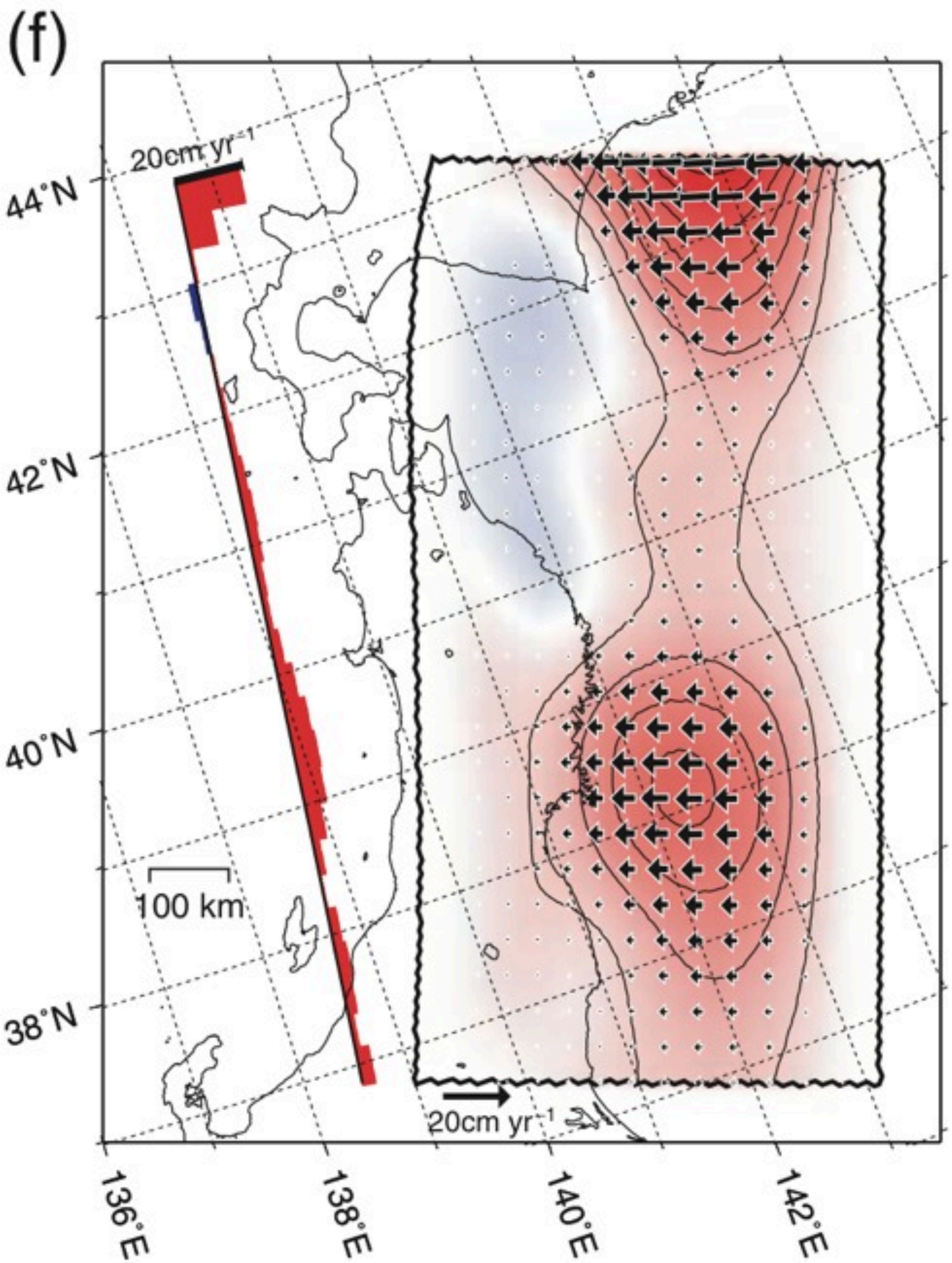


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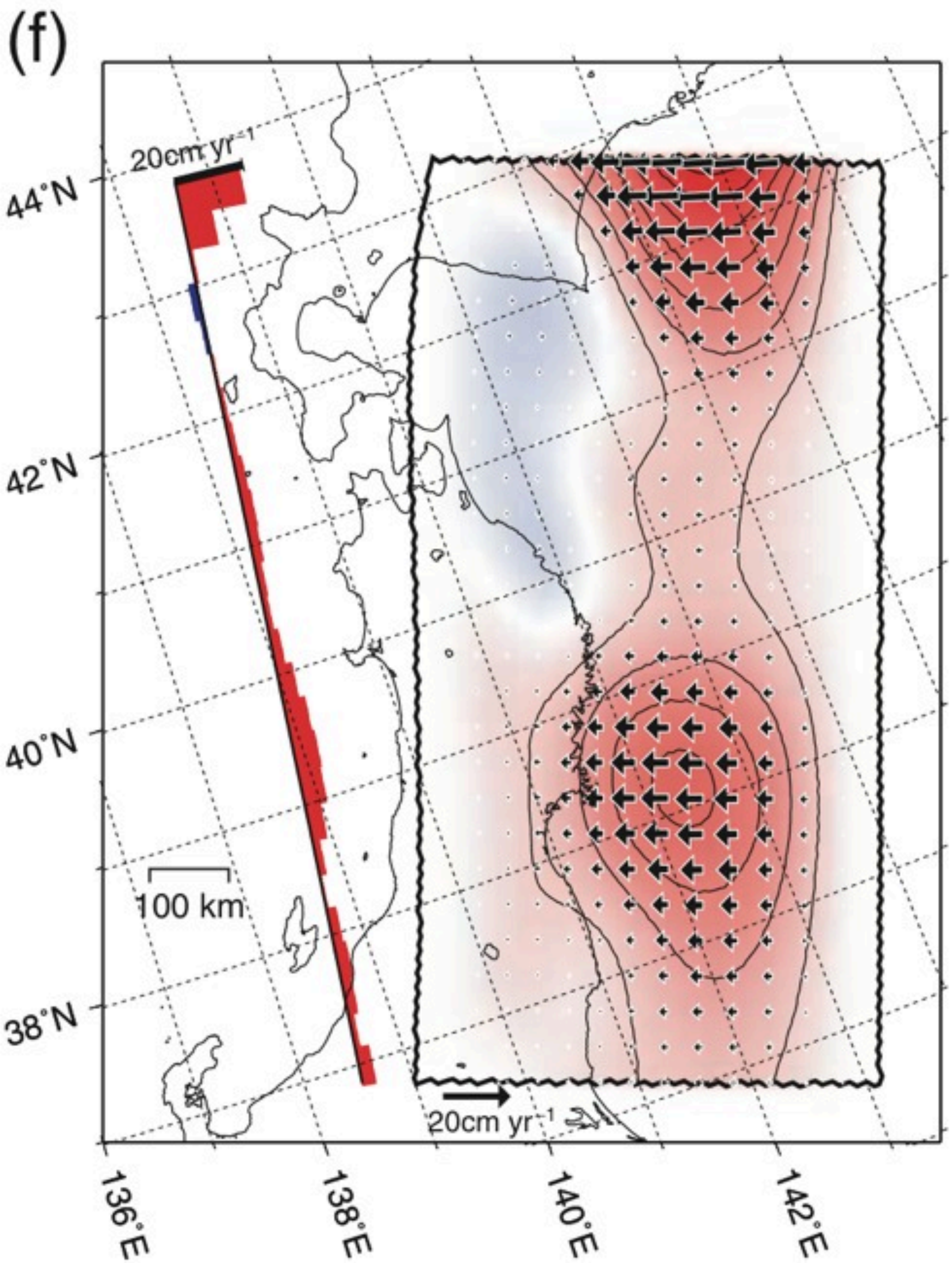
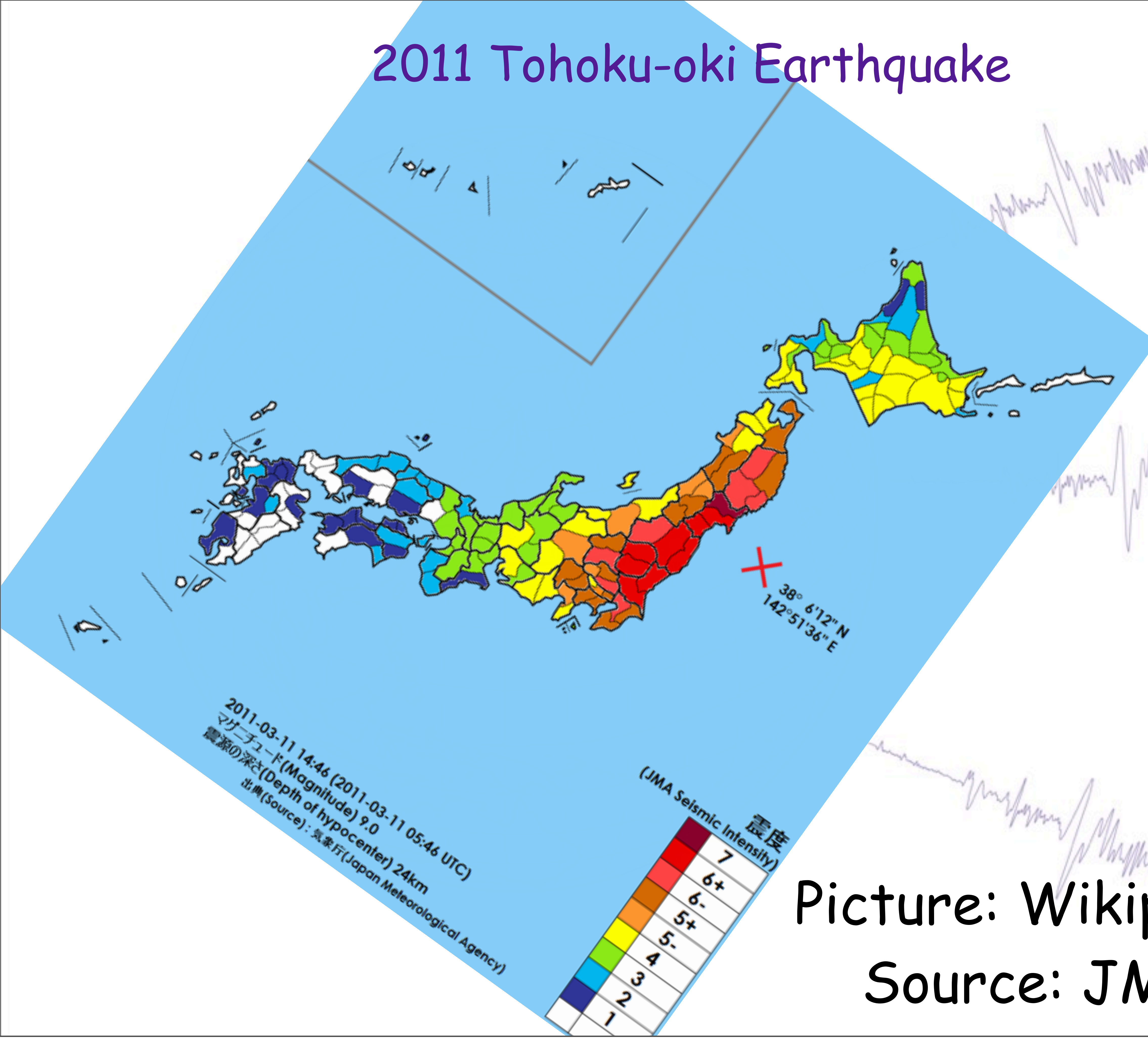



The 2011 Tohoku-oki earthquake released a huge slip deficit, which was revealed by the GPS network and anticipated by geological and geomorphological observations.

Nishimura et al., 2004, GJI

# 2011 Tohoku-oki Earthquake




Picture: Wikipedia
Source: JMA

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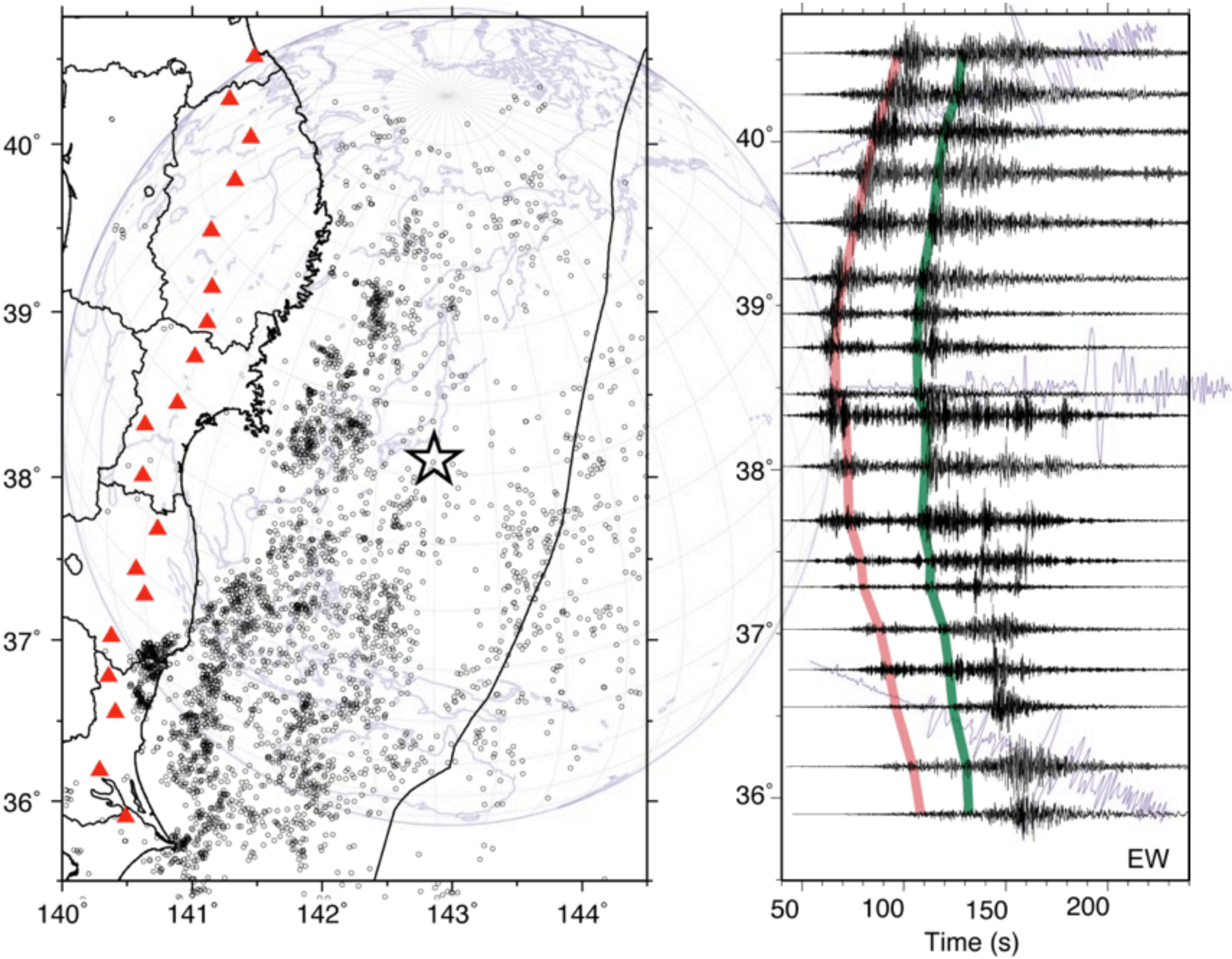
# Strong Ground Motion

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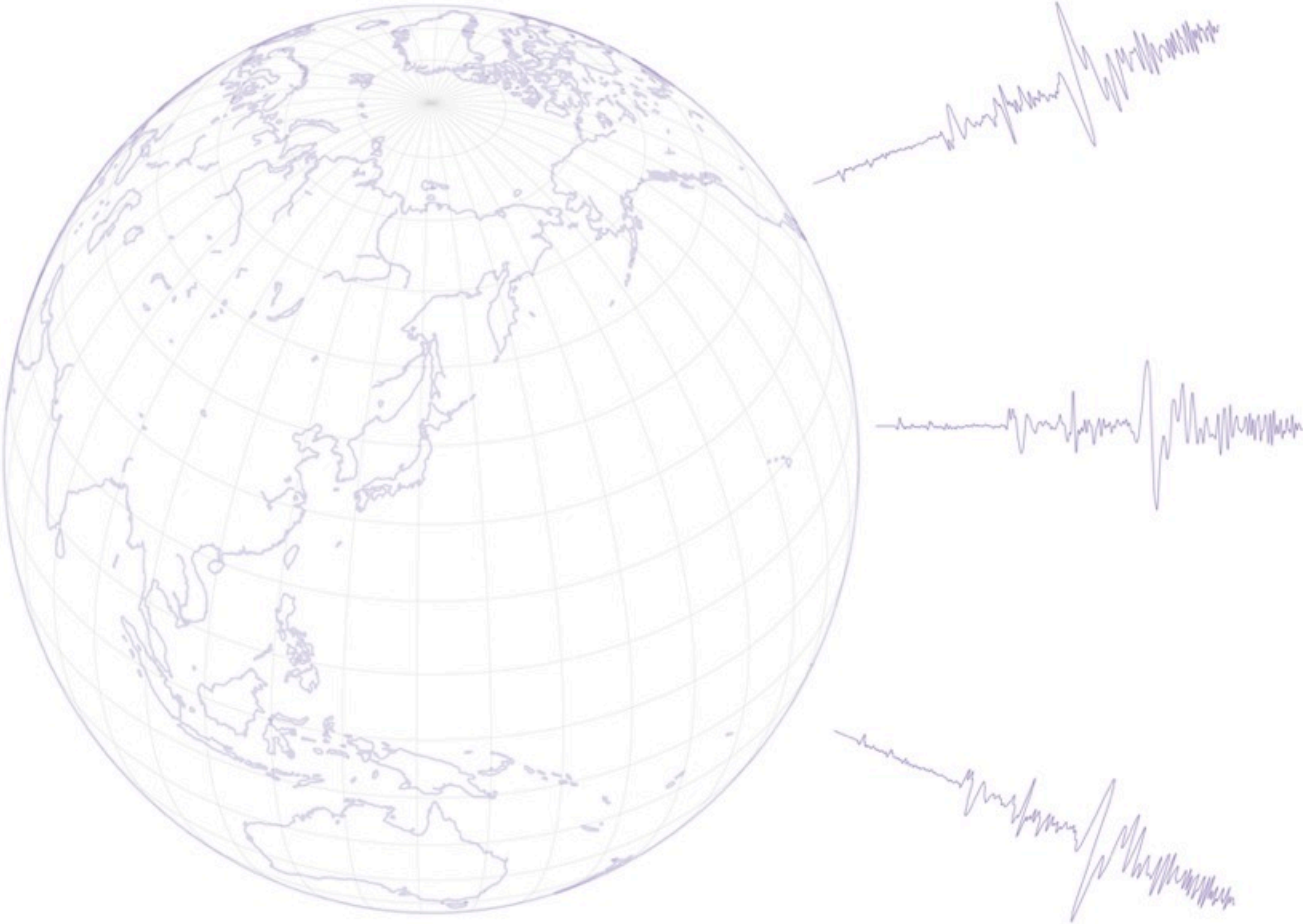
# Static Displacement



Geospatial Information Authority of Japan

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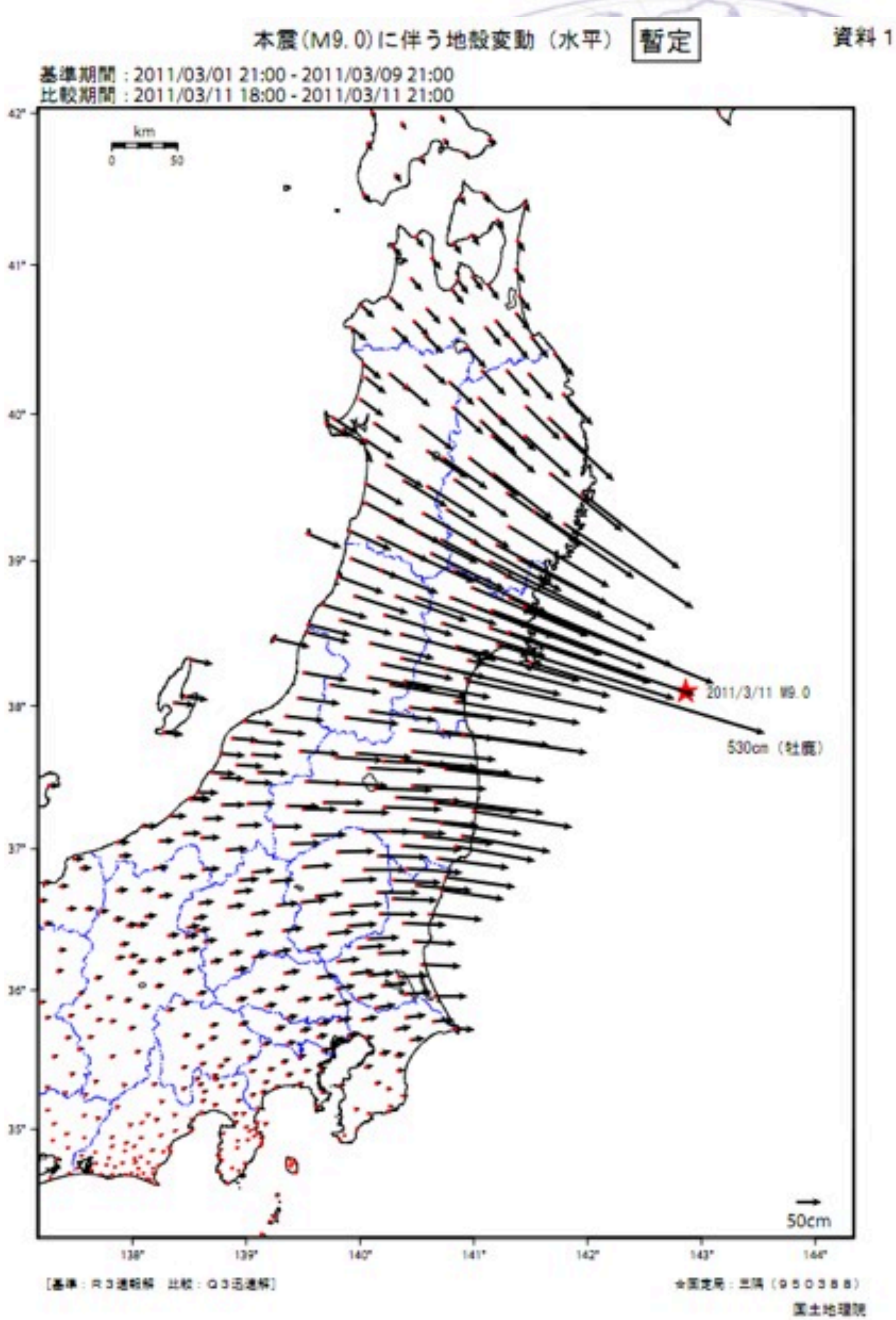


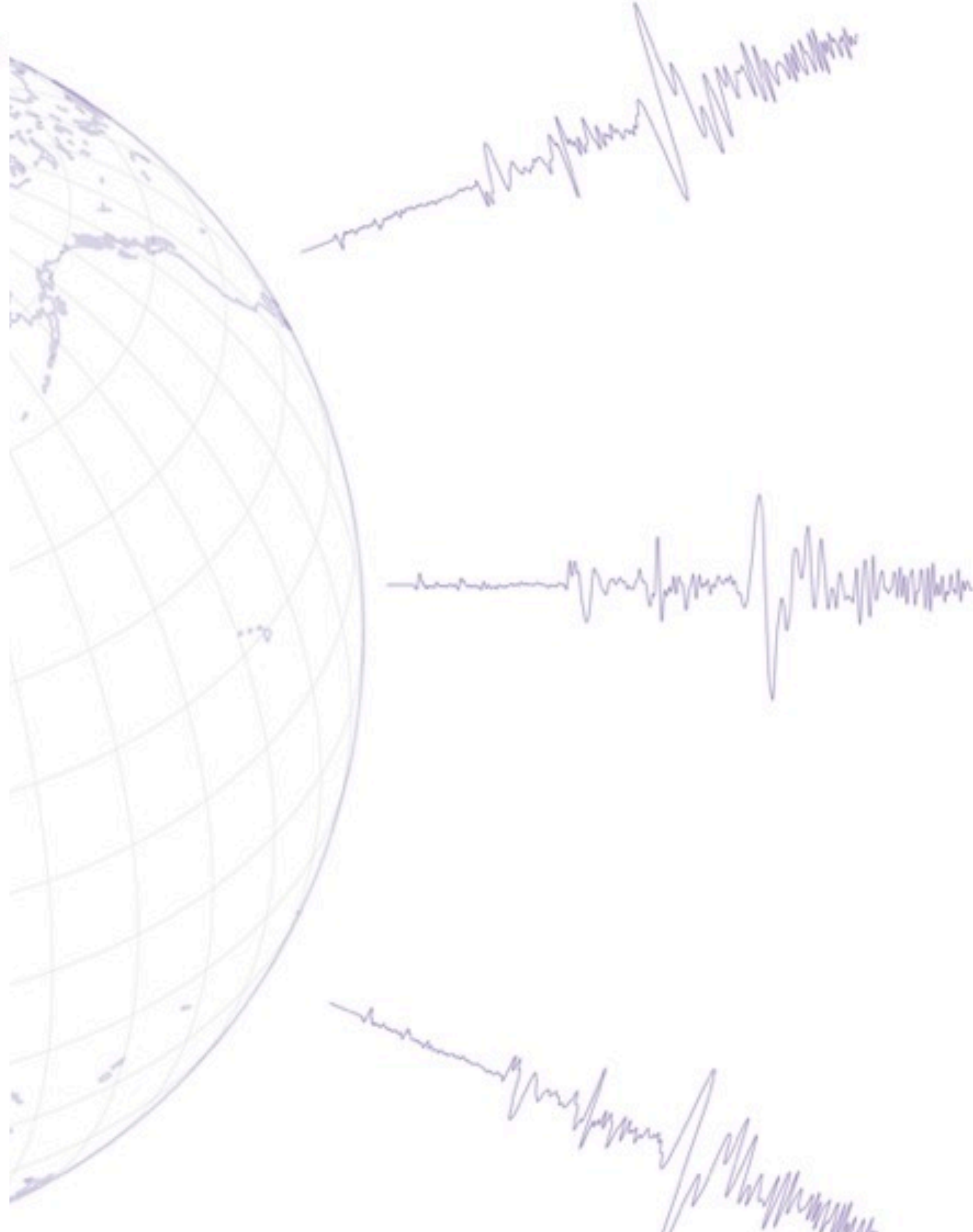

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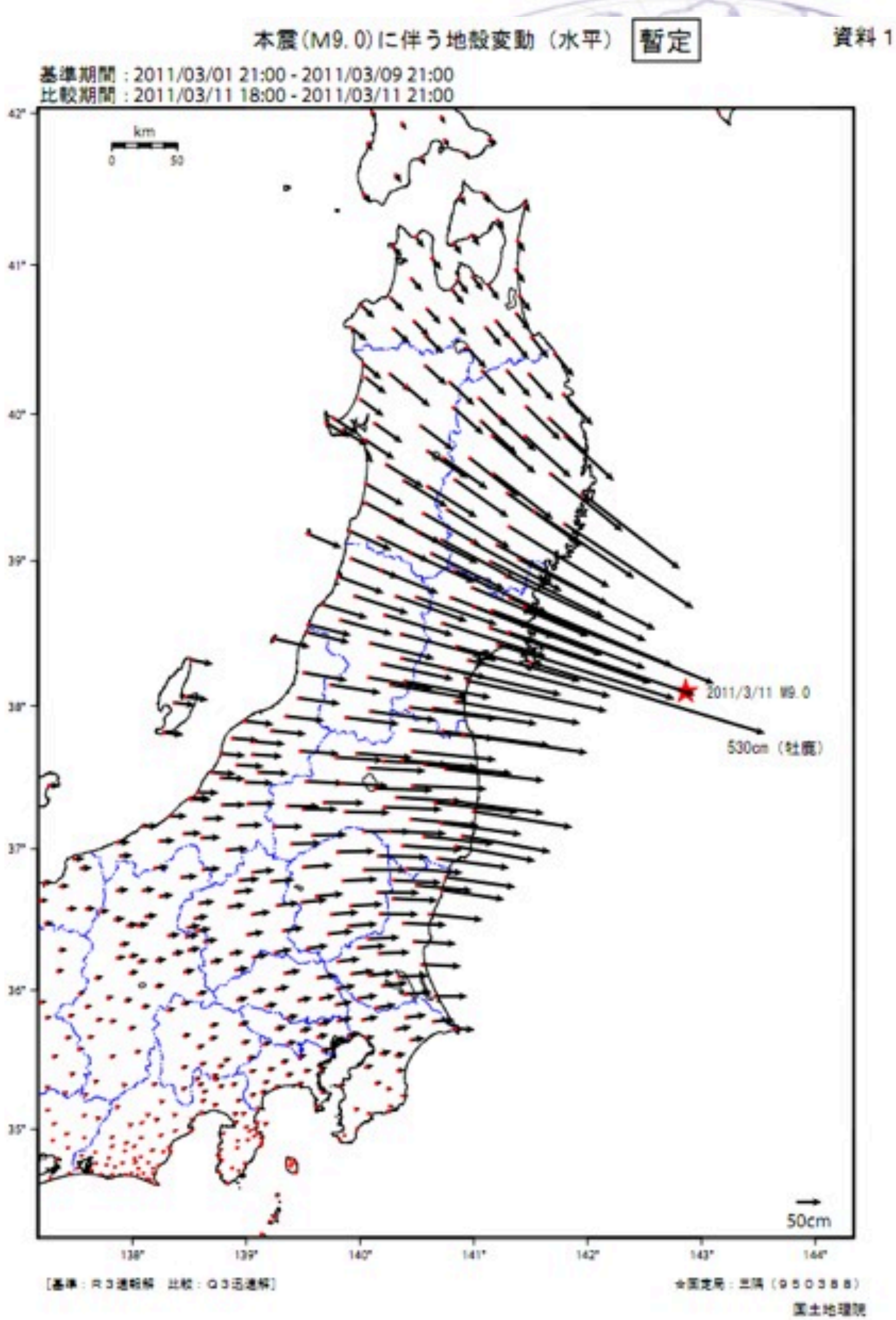


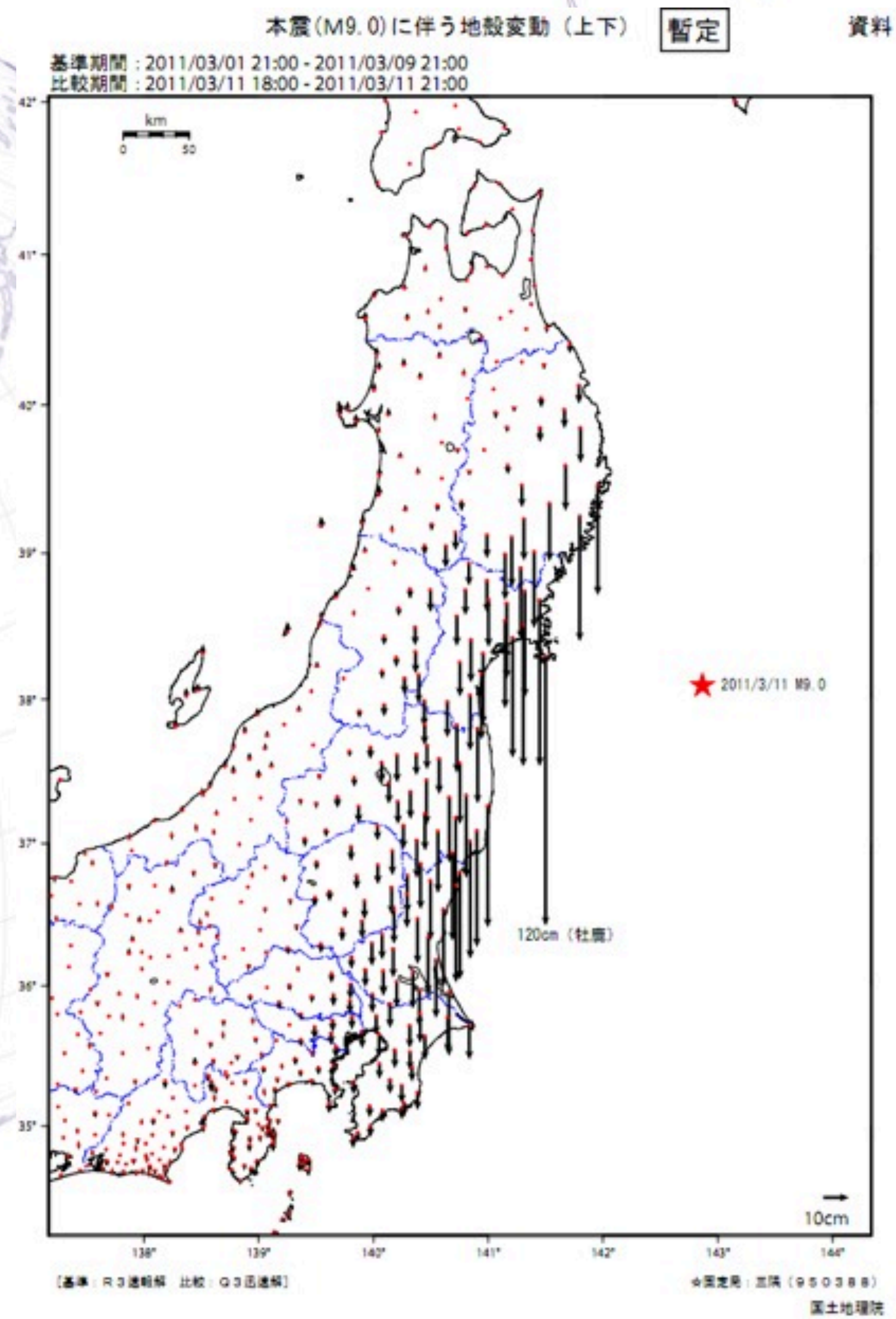


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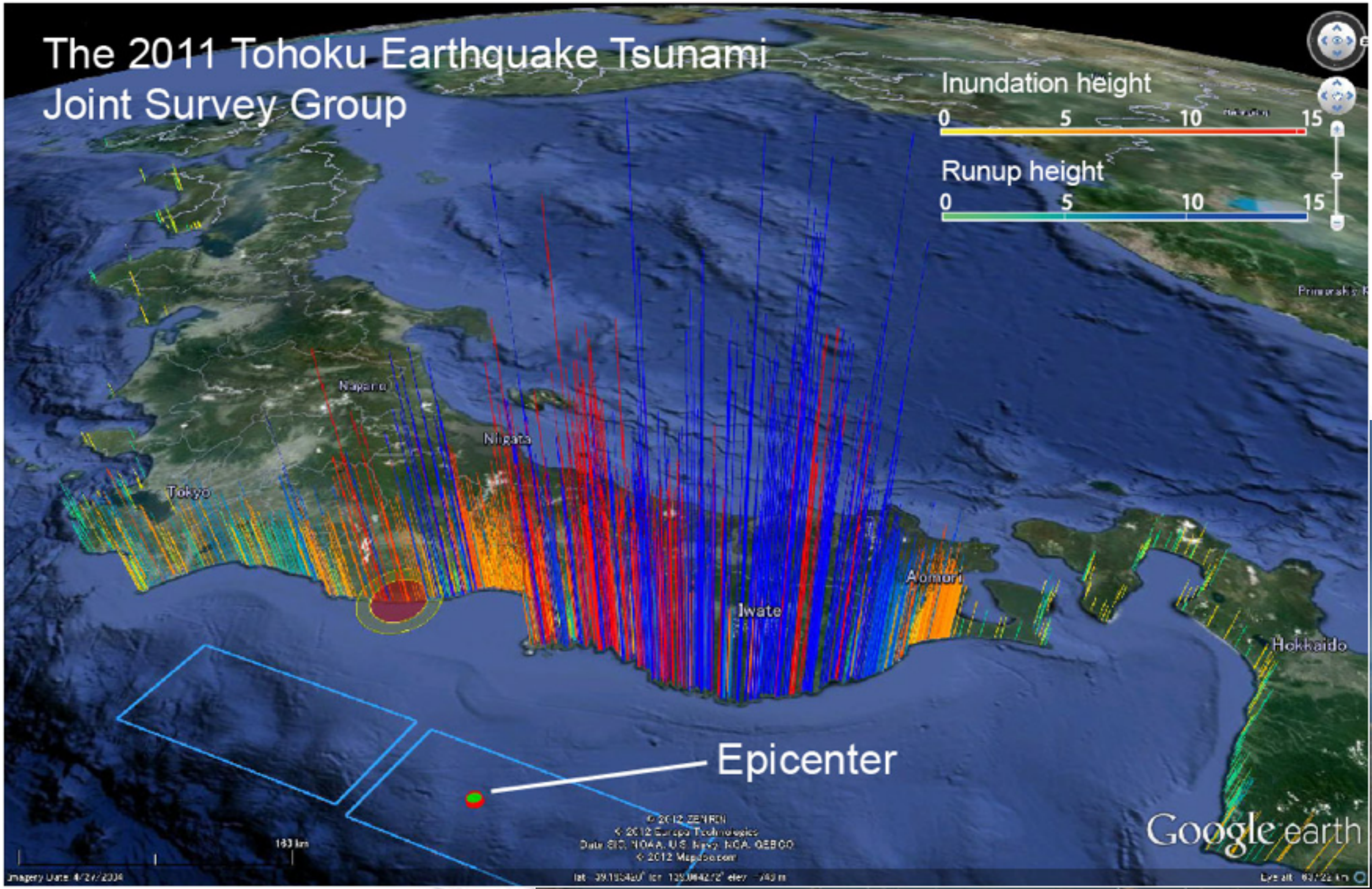
# Tsunami



The 2011 Tohoku Earthquake Tsunami
Joint Survey Group
Inundation height
0 5 10 15
Runup height
0 5 10 15
Nagano
Niigata
Tokyo
Iwate
Aomori
Hokkaido
Epicenter
Google earth


Wikipedia

# Seismic wave 1

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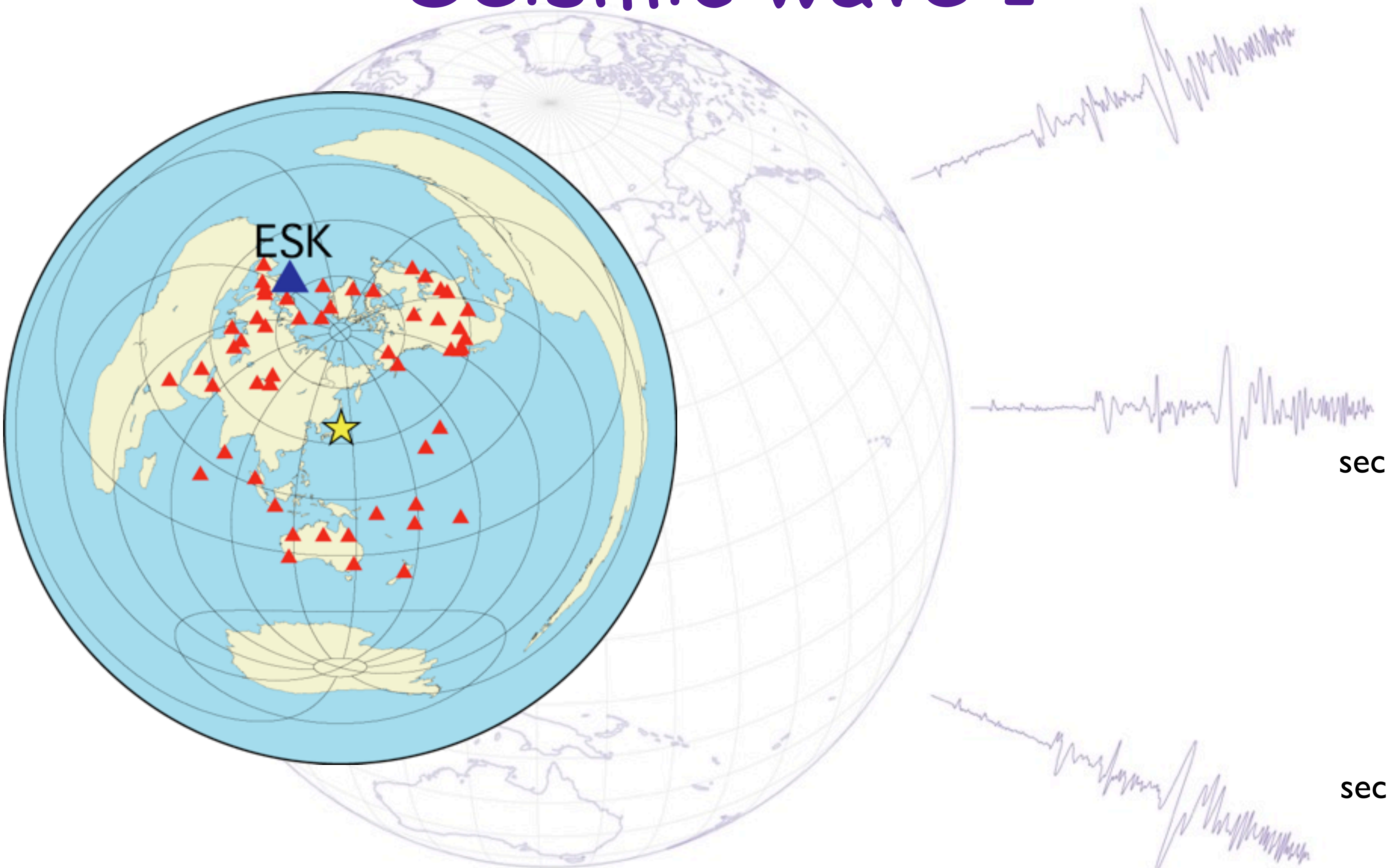


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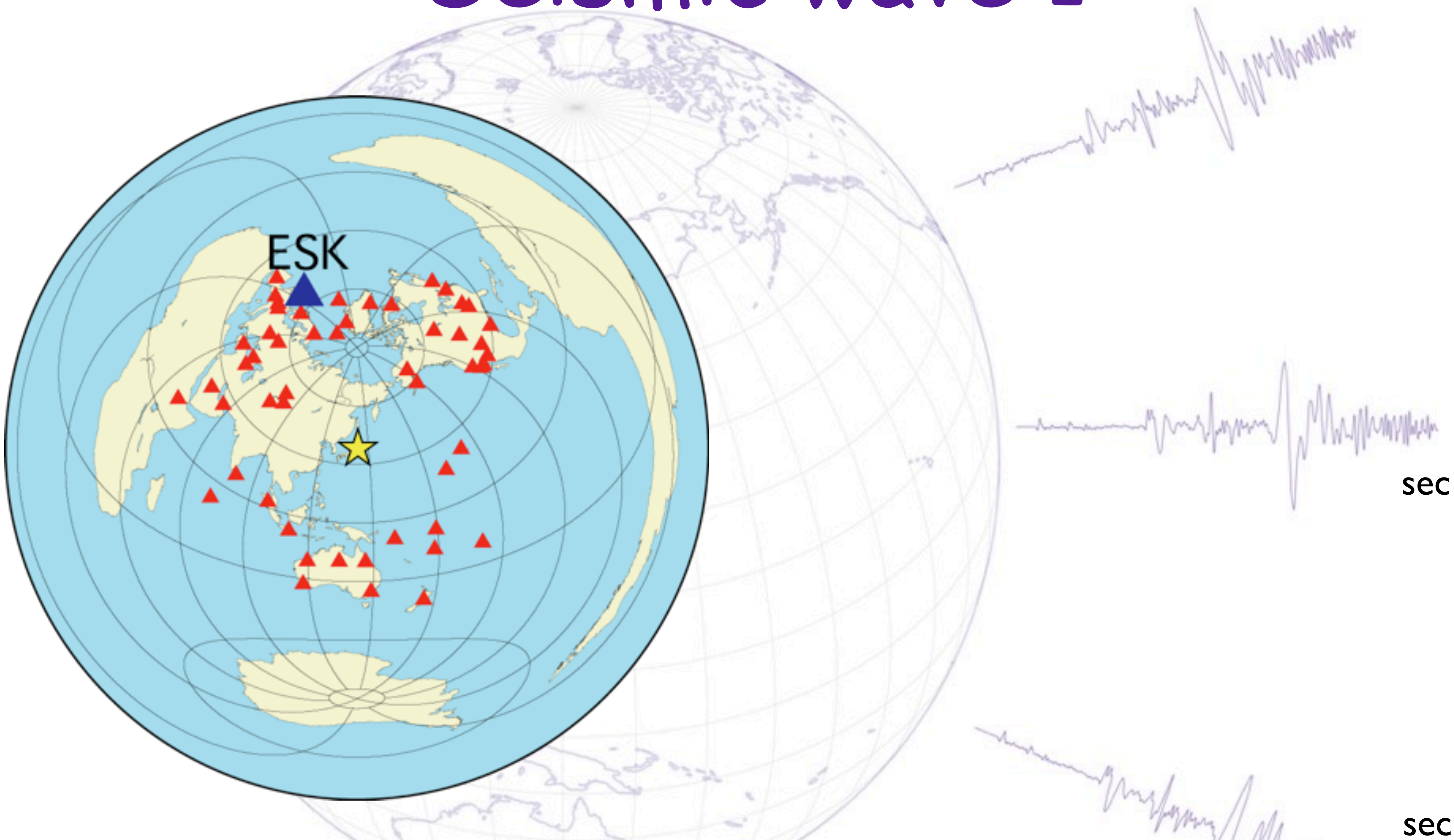
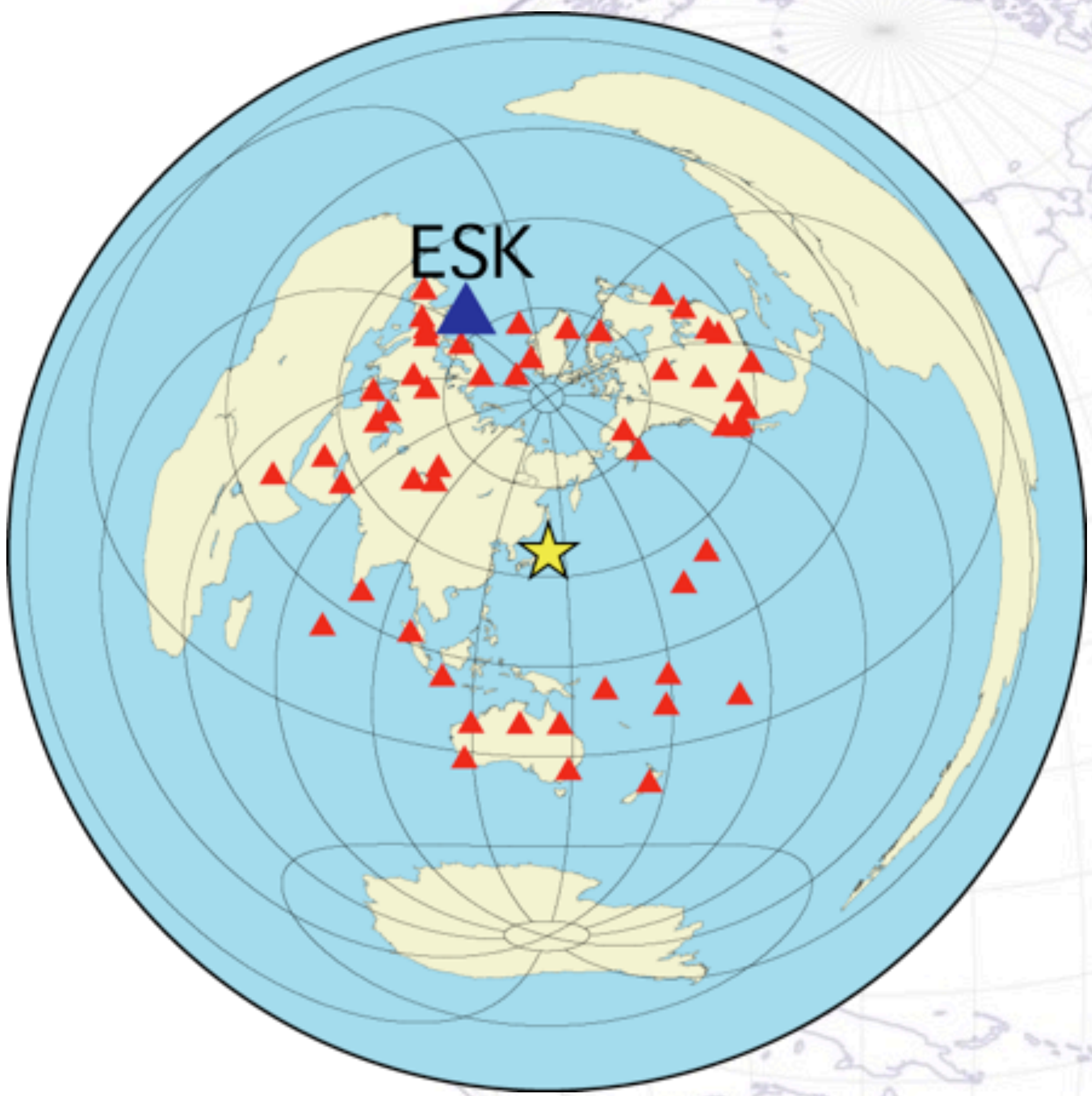


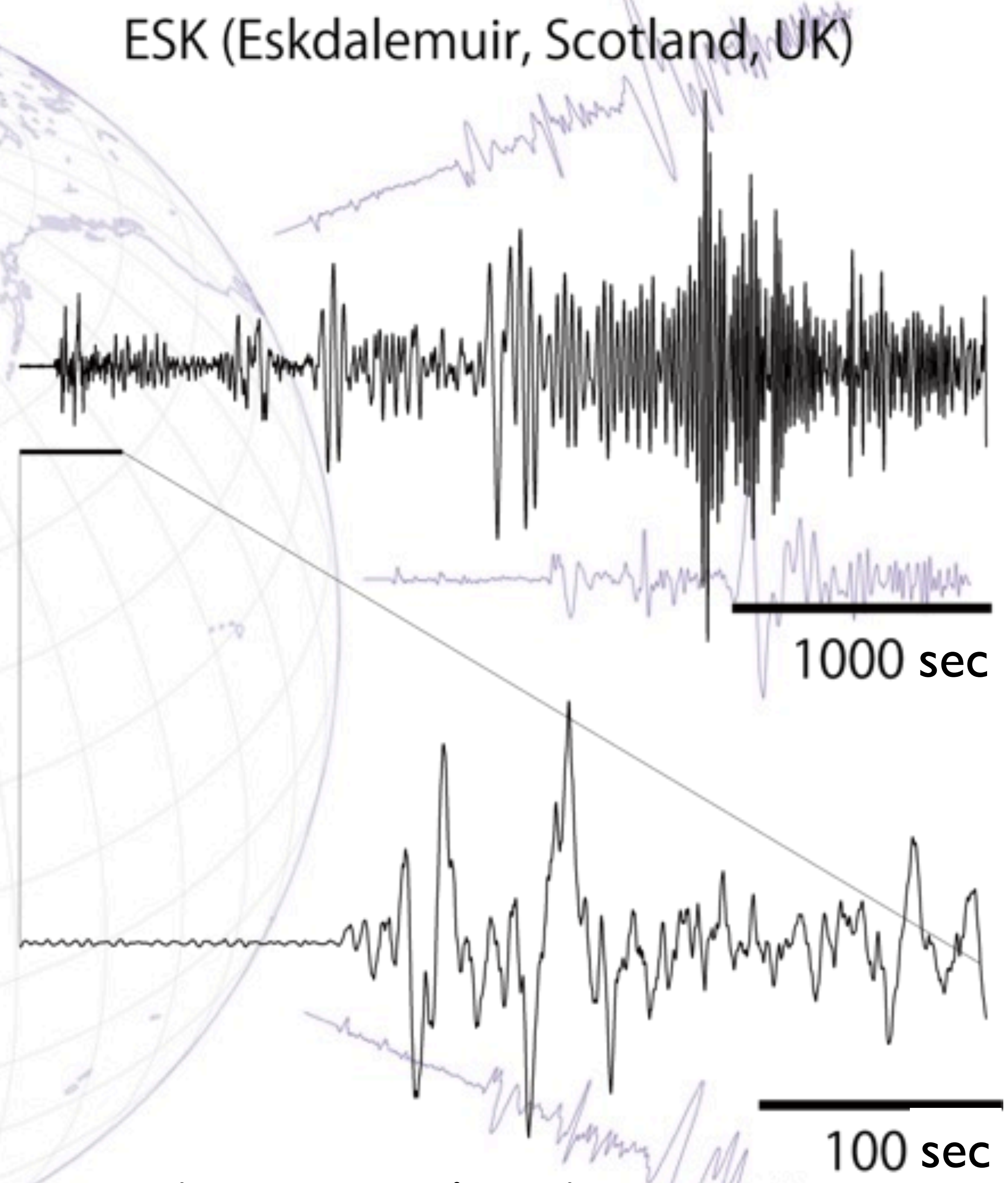

Seismic wave is observed at Scotland.

Seismic waveform contains information of

Seismic source and earth structure.

# Seismic wave 1

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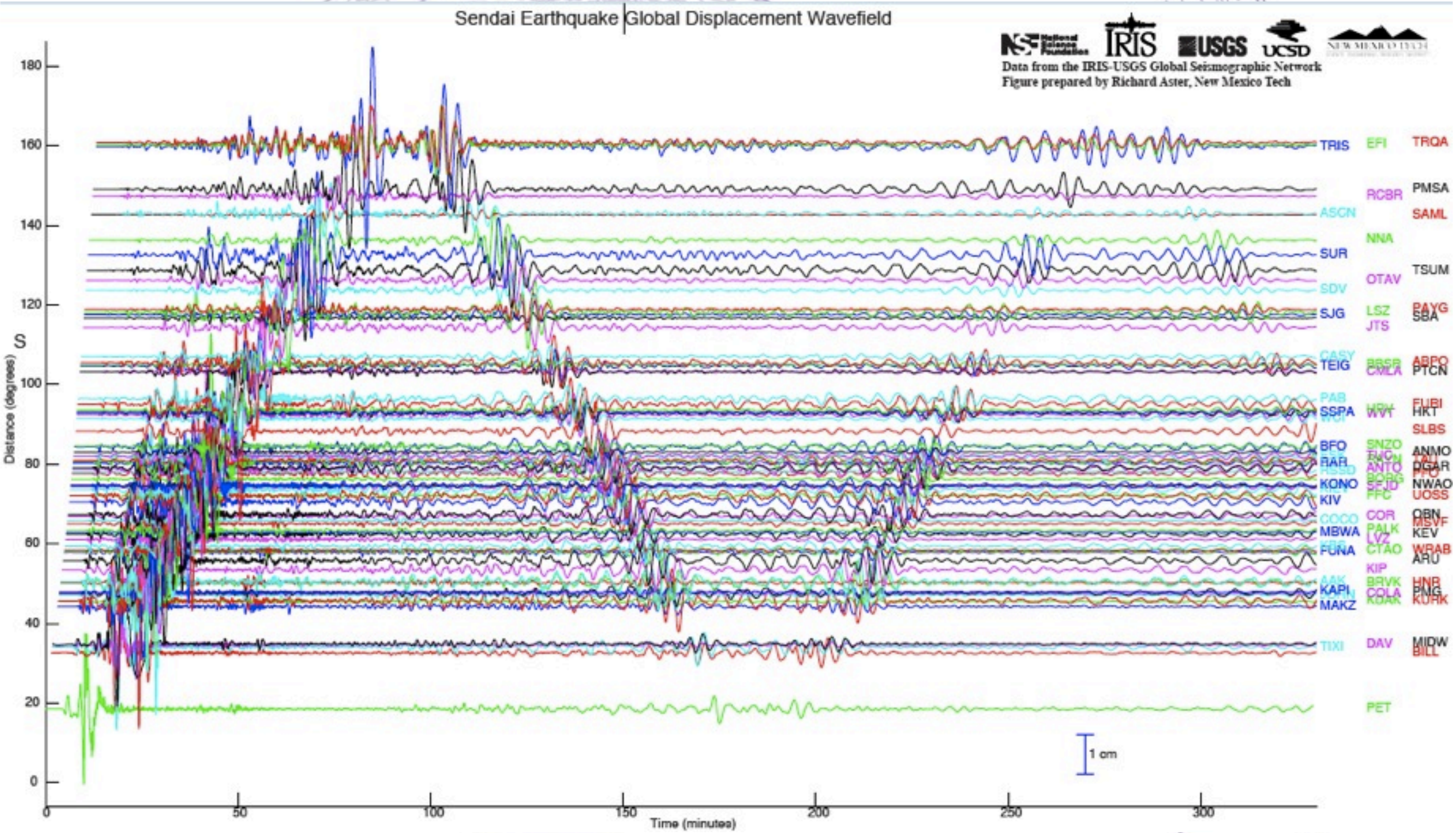
# Seismic wave 2




IRIS

# To estimate seismic source process

Yagi & Fukahata (2011, GJI)

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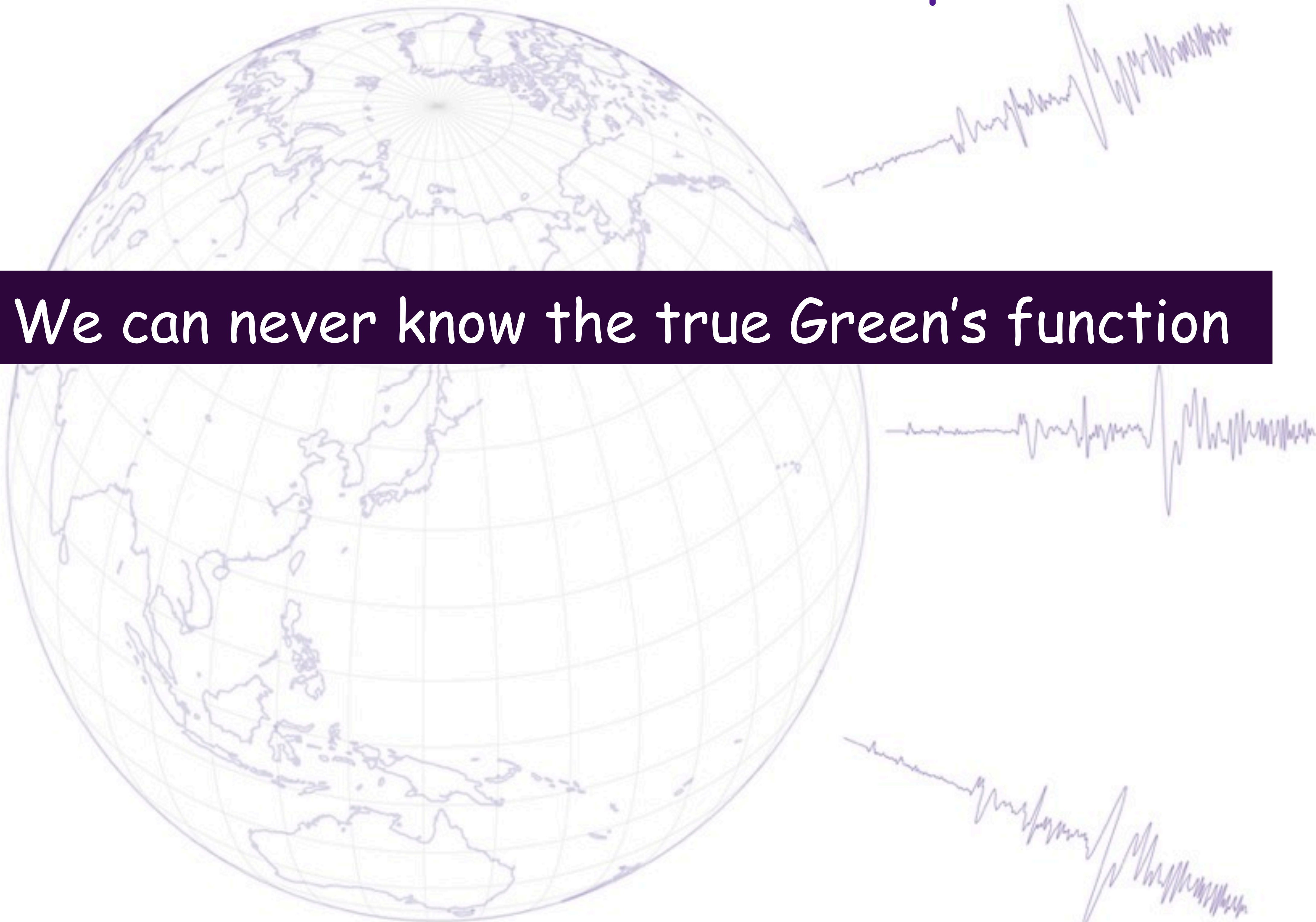

**We can never know the true Green's function**

Yagi & Fukahata (2011, GJI)

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Solution in Previous Studies:
Devoting efforts to obtain a Green's function
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Our Solution:
Introducing "Uncertainty of Green's function" into waveform inversion.

Yagi & Fukahata (2011, GJI)

# To estimate seismic source process

We assumed earth model for calculating
“Green’s function”, connecting source and observation.

**We can never know the true Green’s function**

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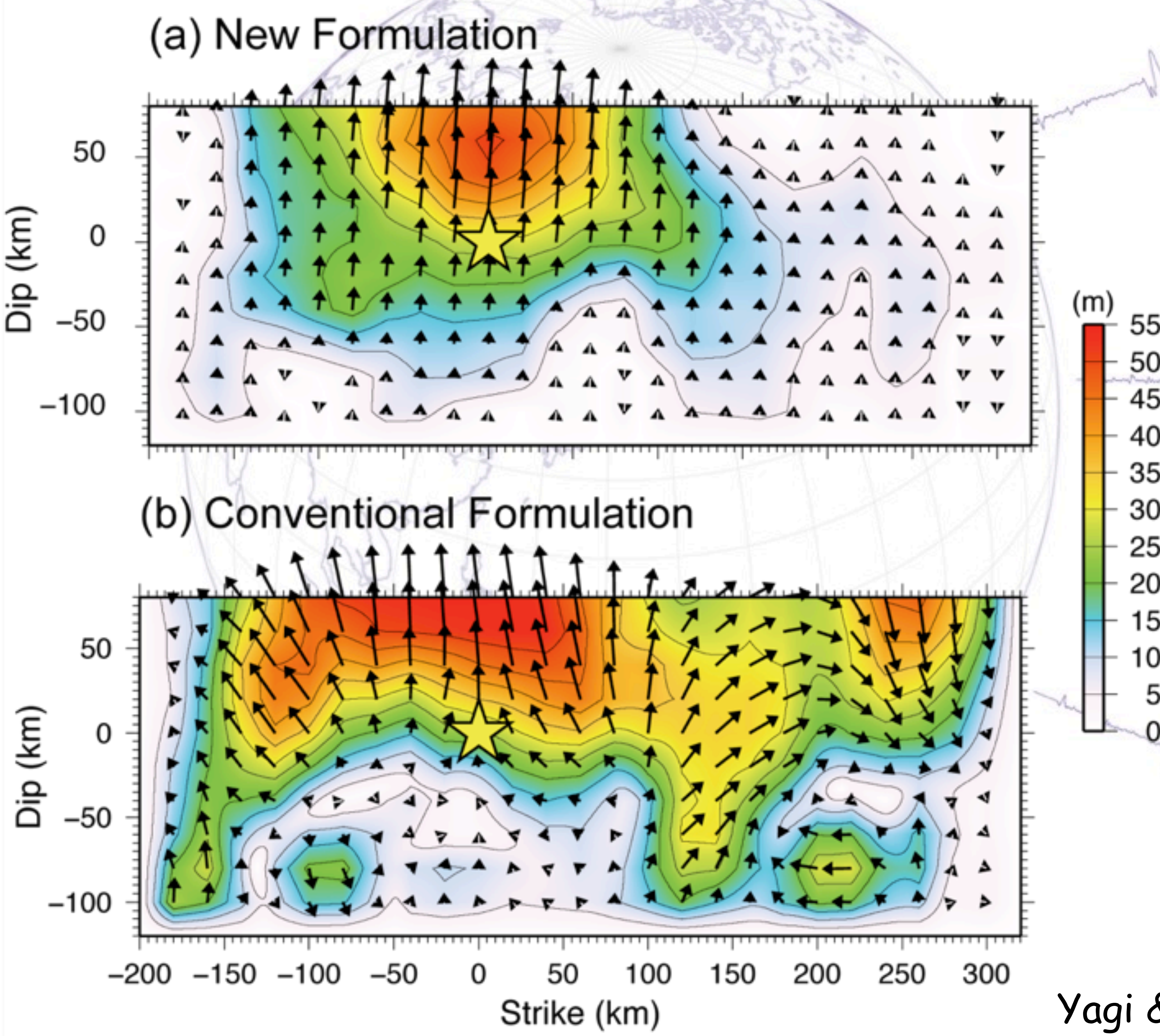
# Advantage of New Method




Dislocation along fault!

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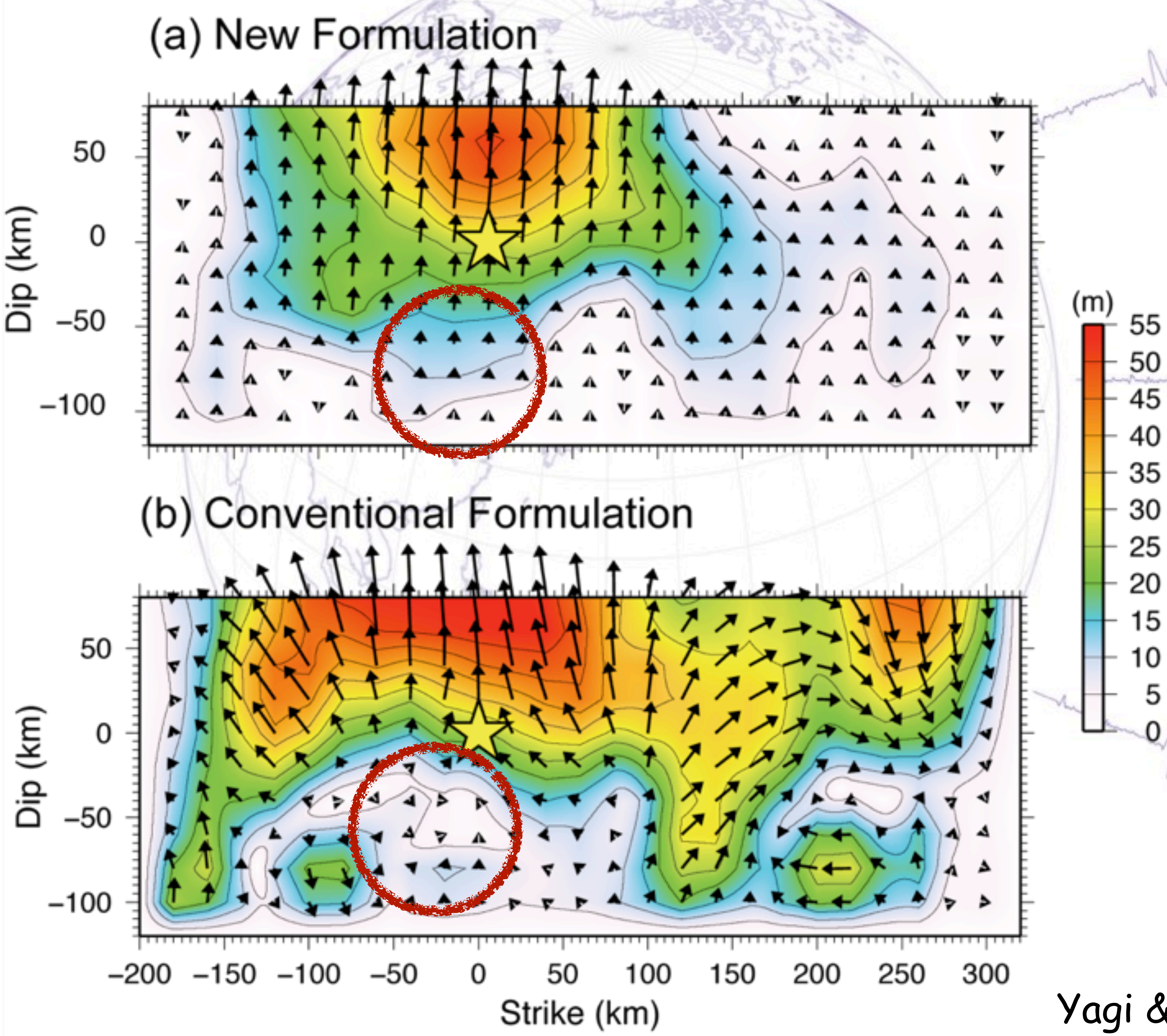


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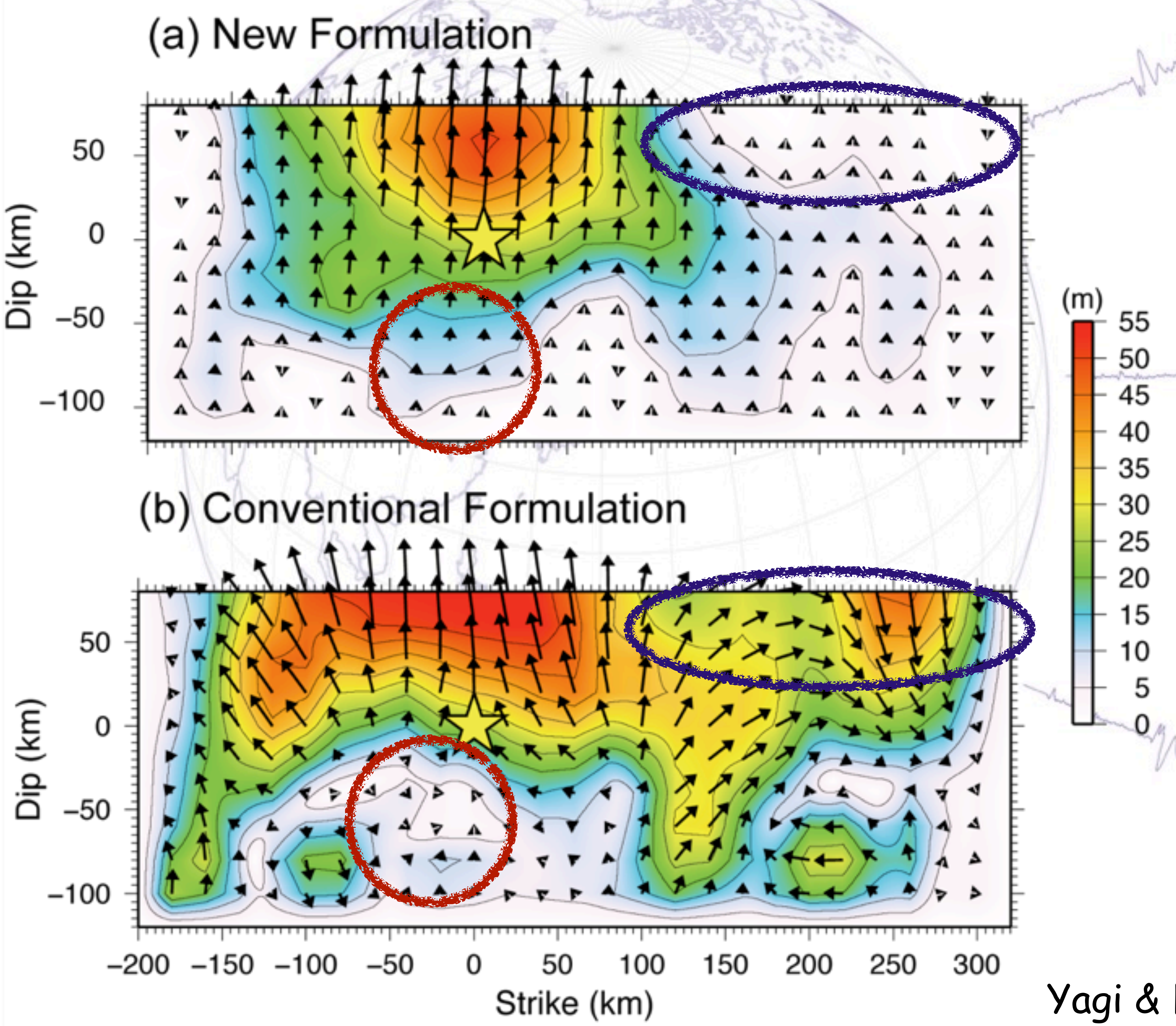


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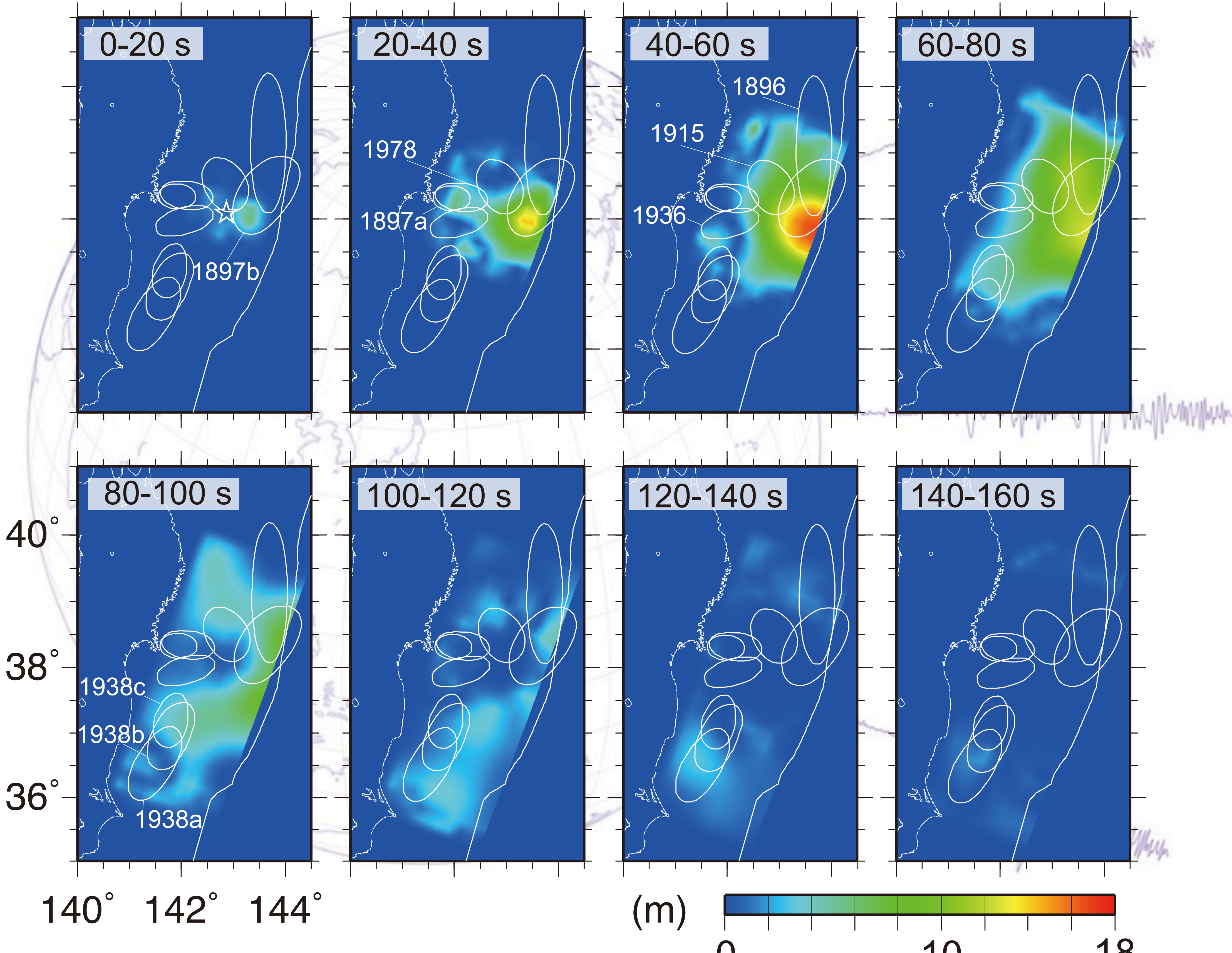
# Dislocation SnapShot




Yagi & Fukahata, 2011

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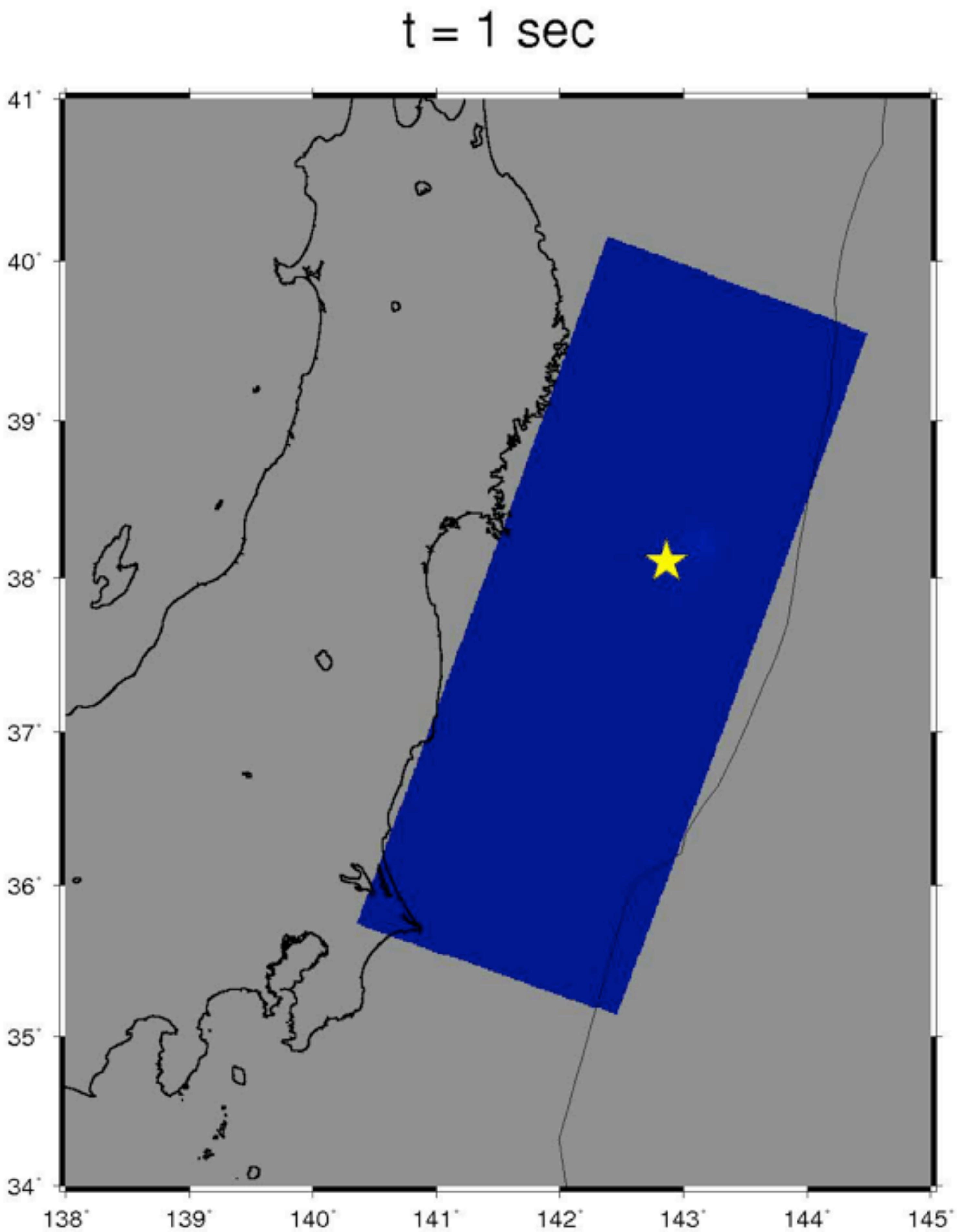


# Animation

Yagi & Fukahata, 2011

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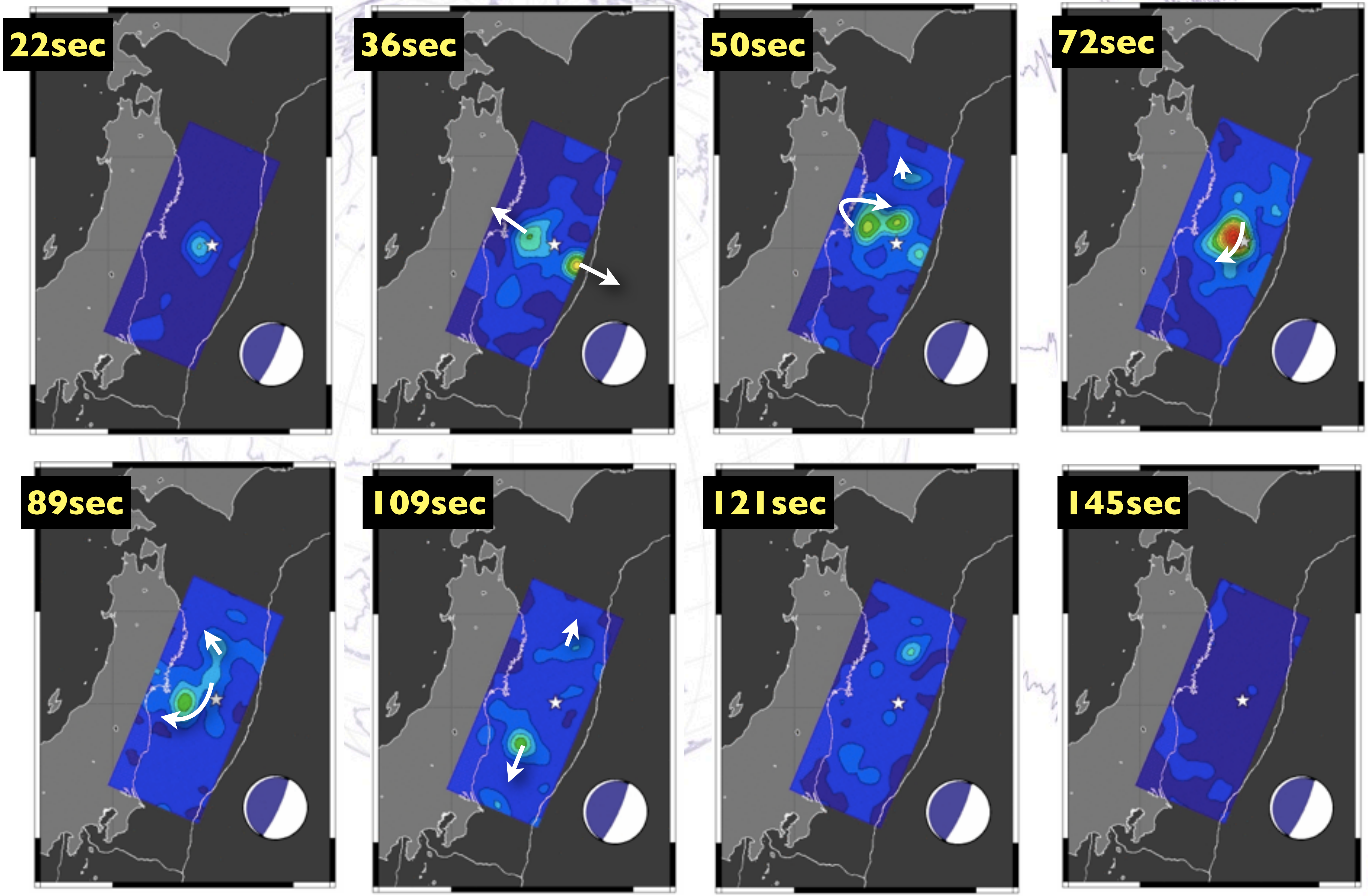
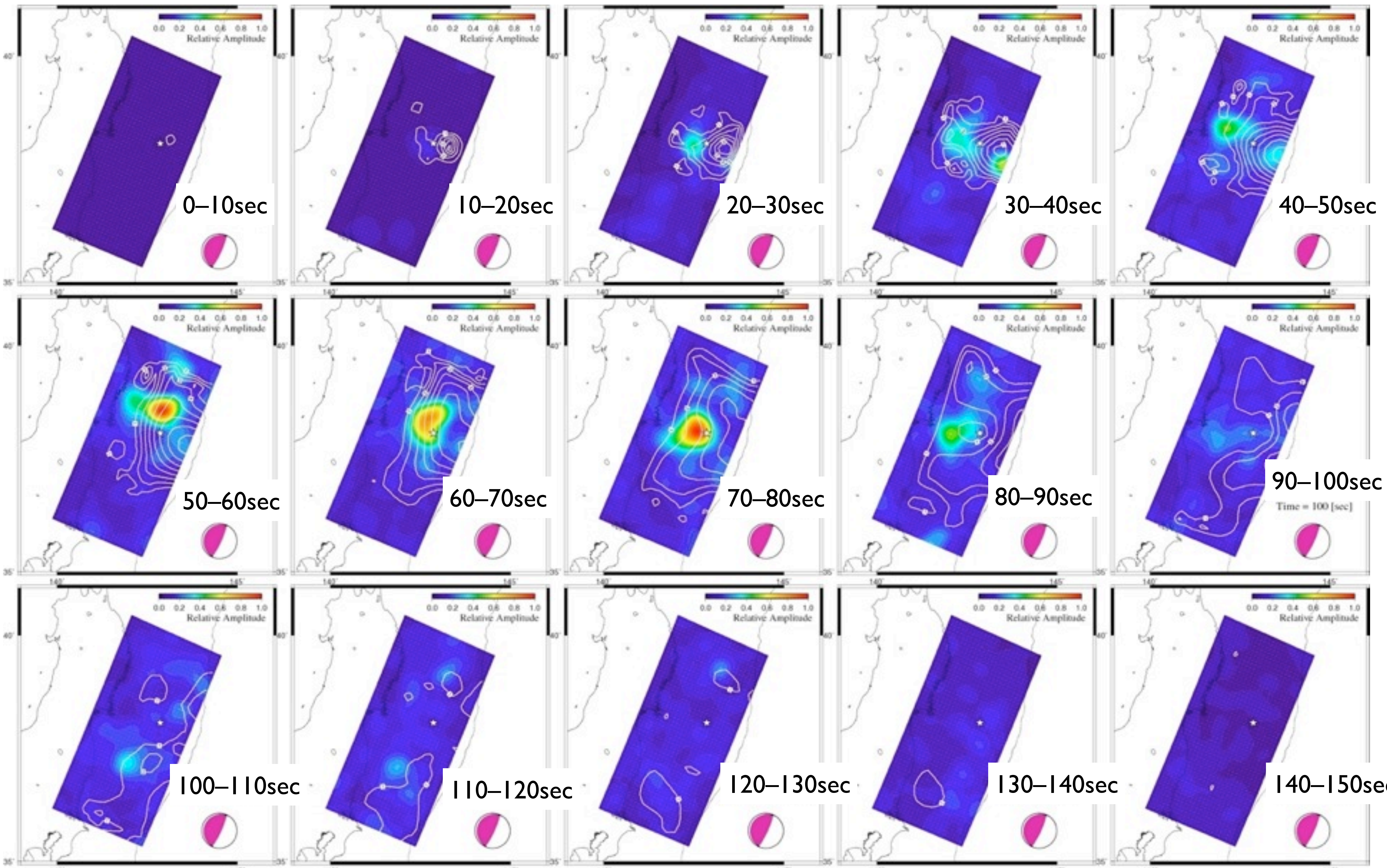
# Seismic Radiation Snapshot




Nakao & Yagi (2012)

# Dislocation and Seismic Radiation

White counter: dislocation

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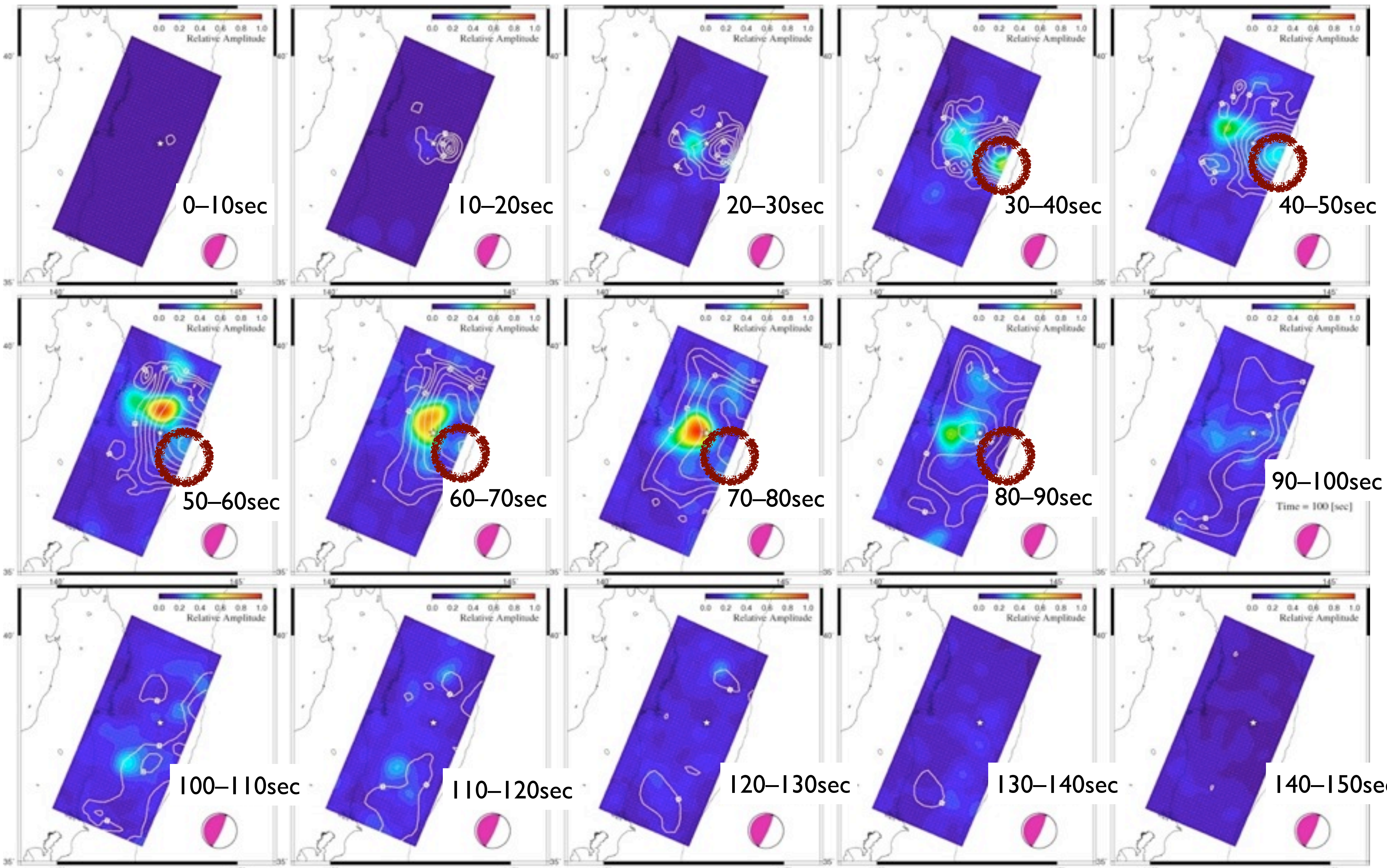


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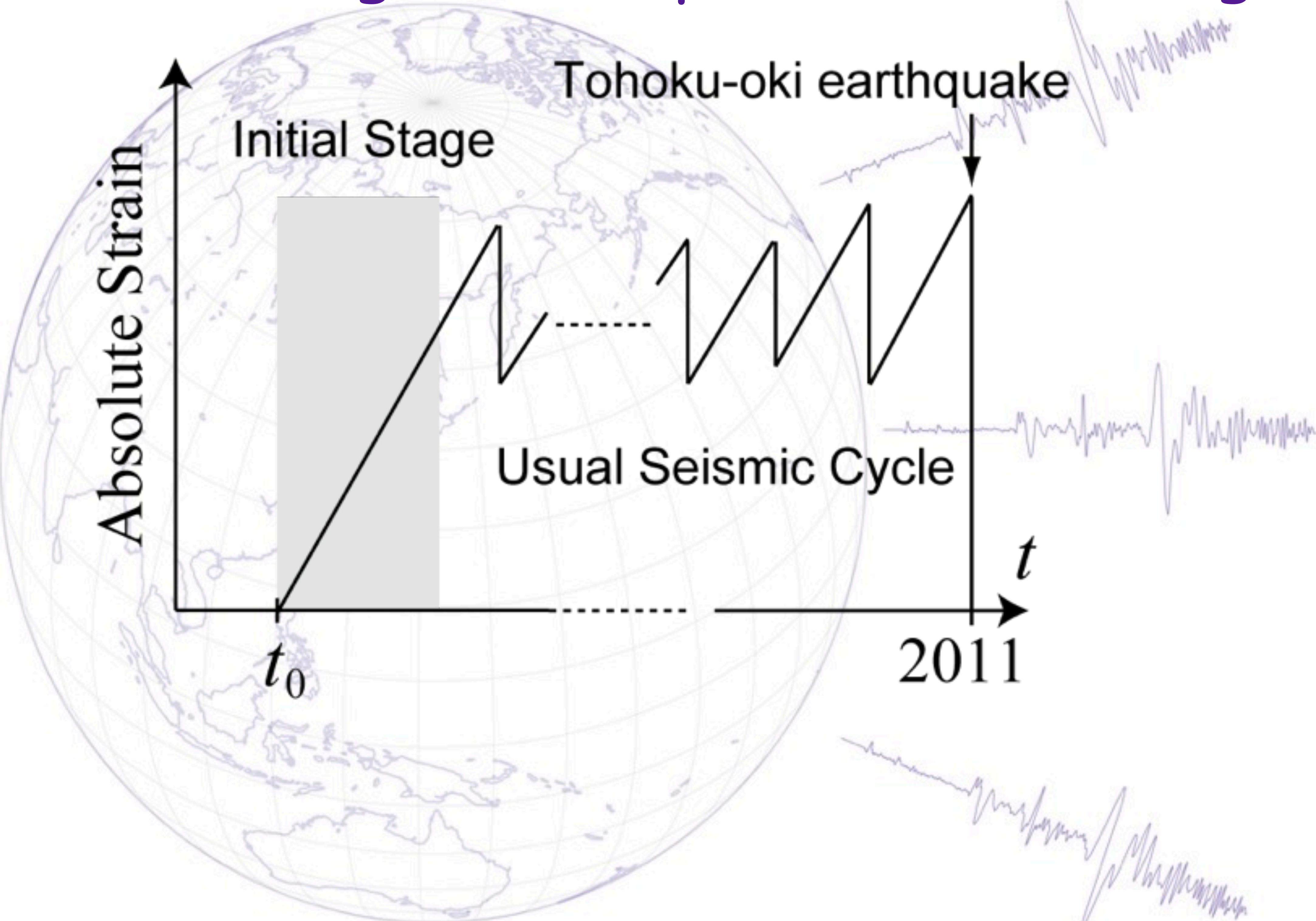
# Schematic image of temporal strain change

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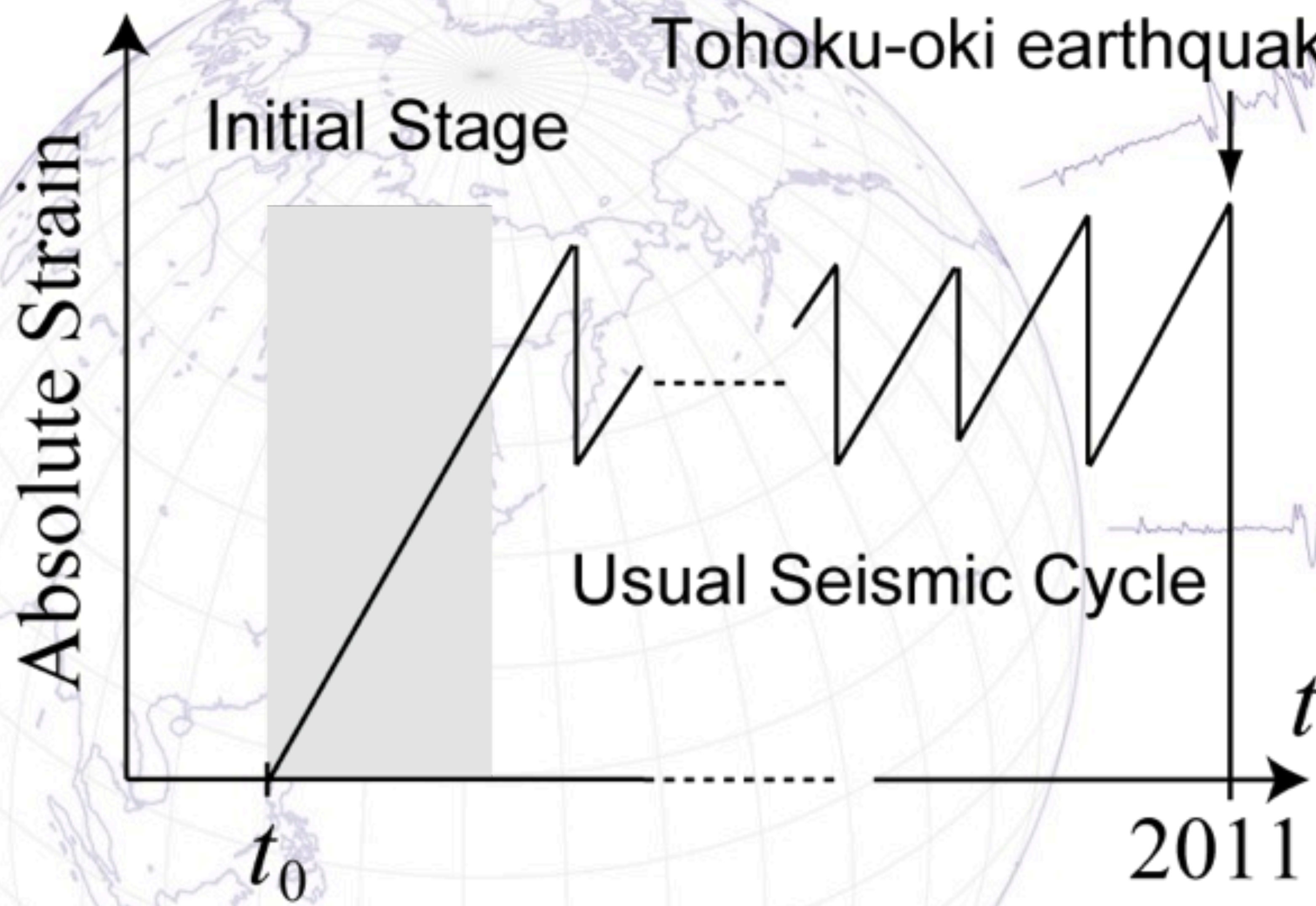
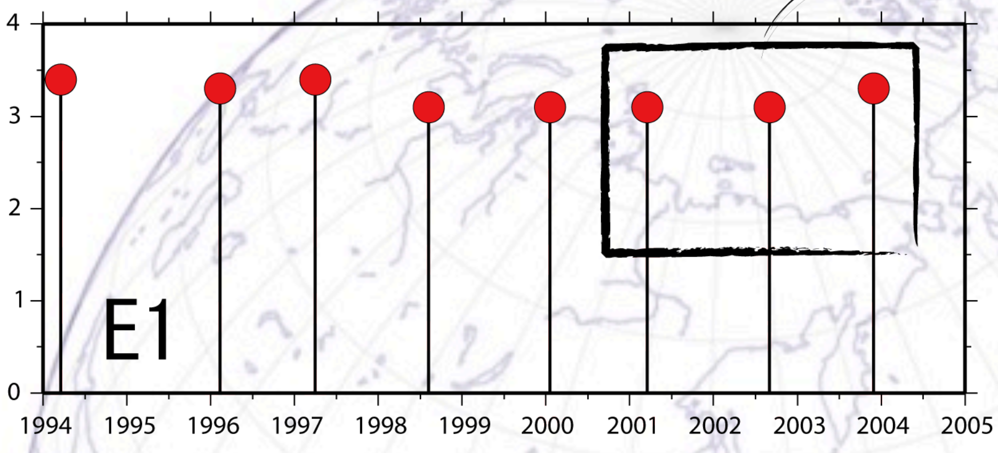
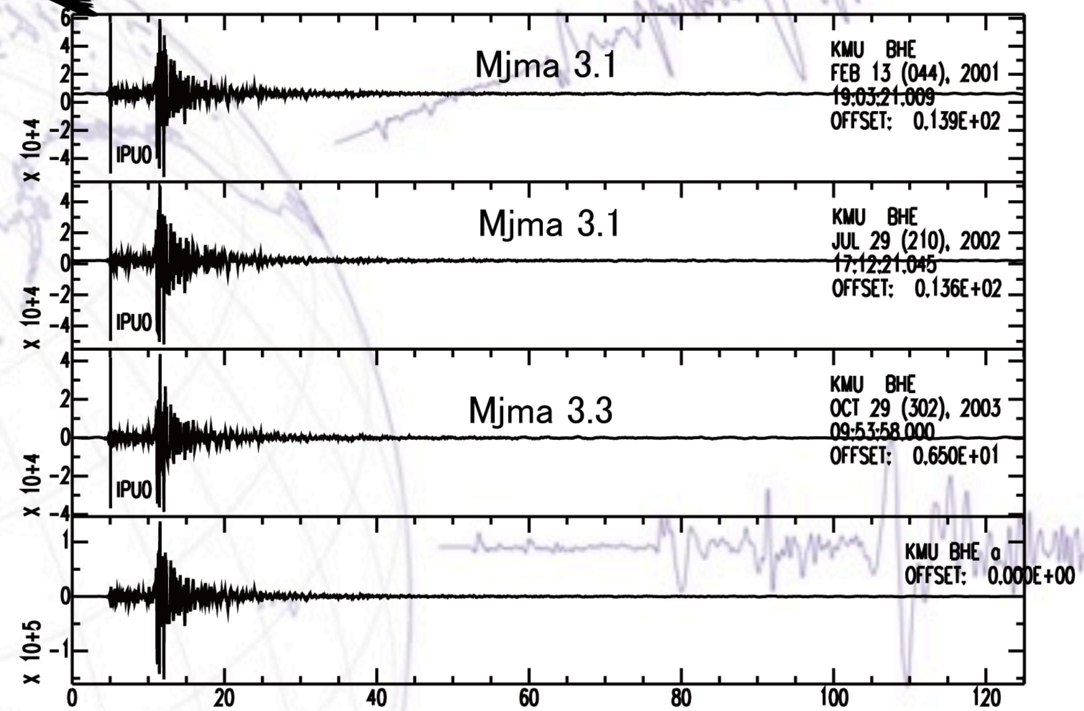


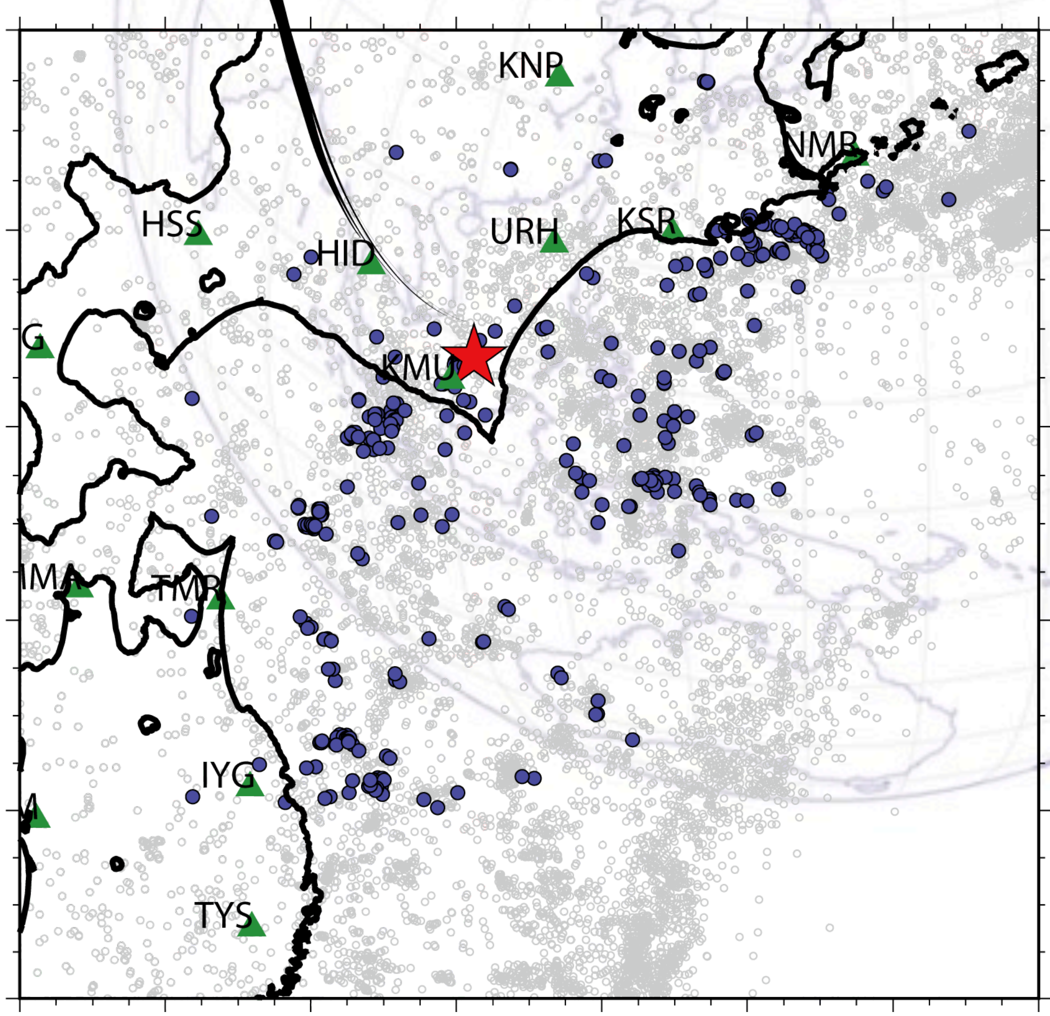

In the beginning of subduction, elastic strain accumulates linearly. After the initial stage, elastic strain is released from time to time (usual seismic cycles), but it is difficult to estimate its absolute level. The 2011 Tohoku-oki earthquake appears to have released all accumulated elastic strain.

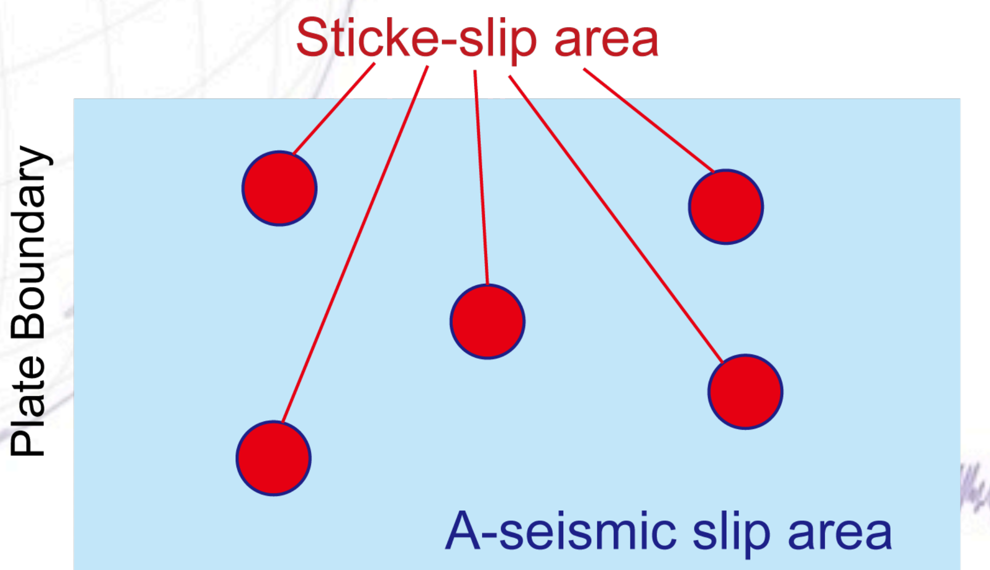
Yagi & Fukahata, 2011

# Repeating Earthquake



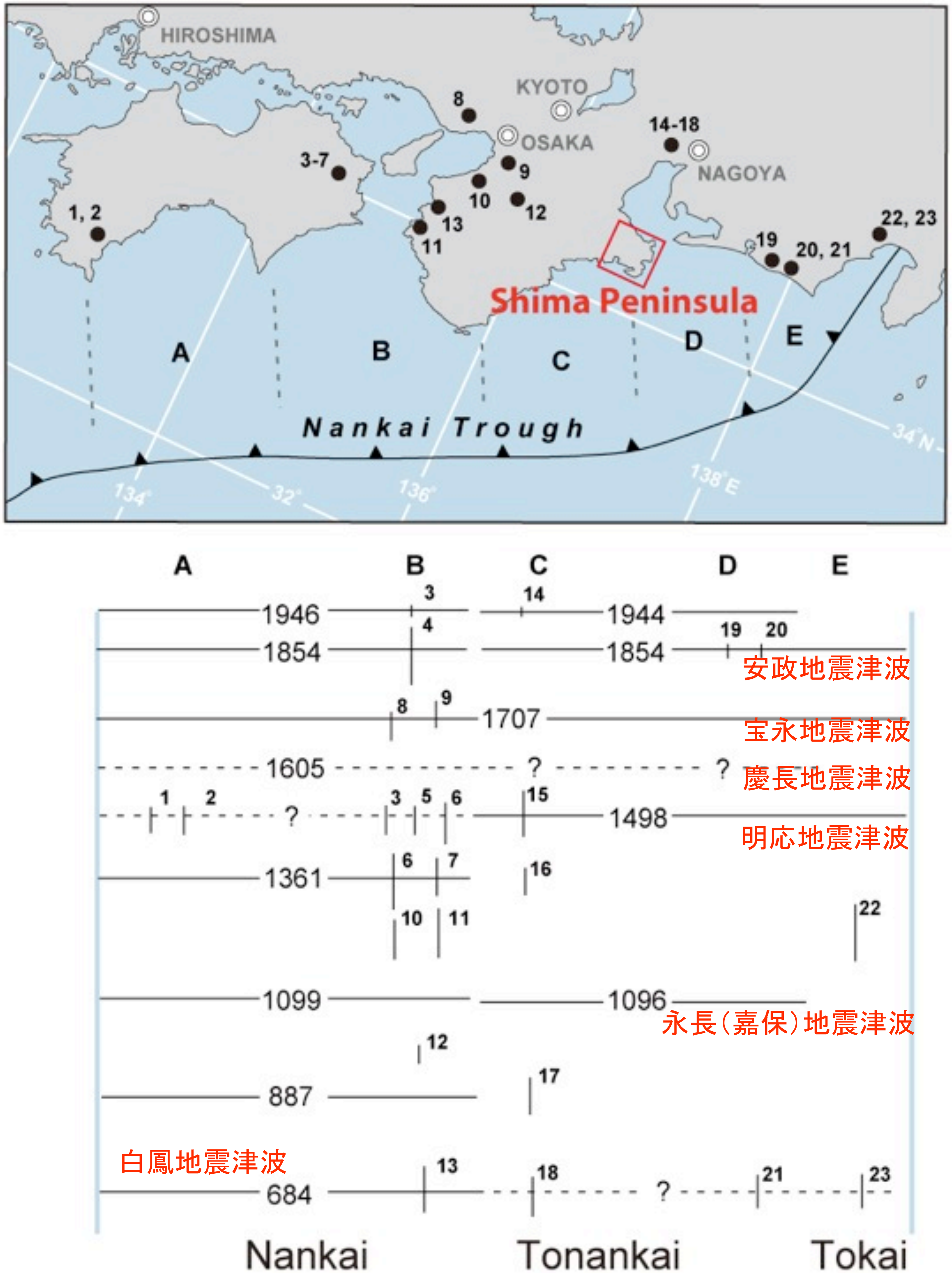




Matsubara, Yagi & Obara, 2005

# Seismicity in Nankai-oki




Fujino et al.（2010）

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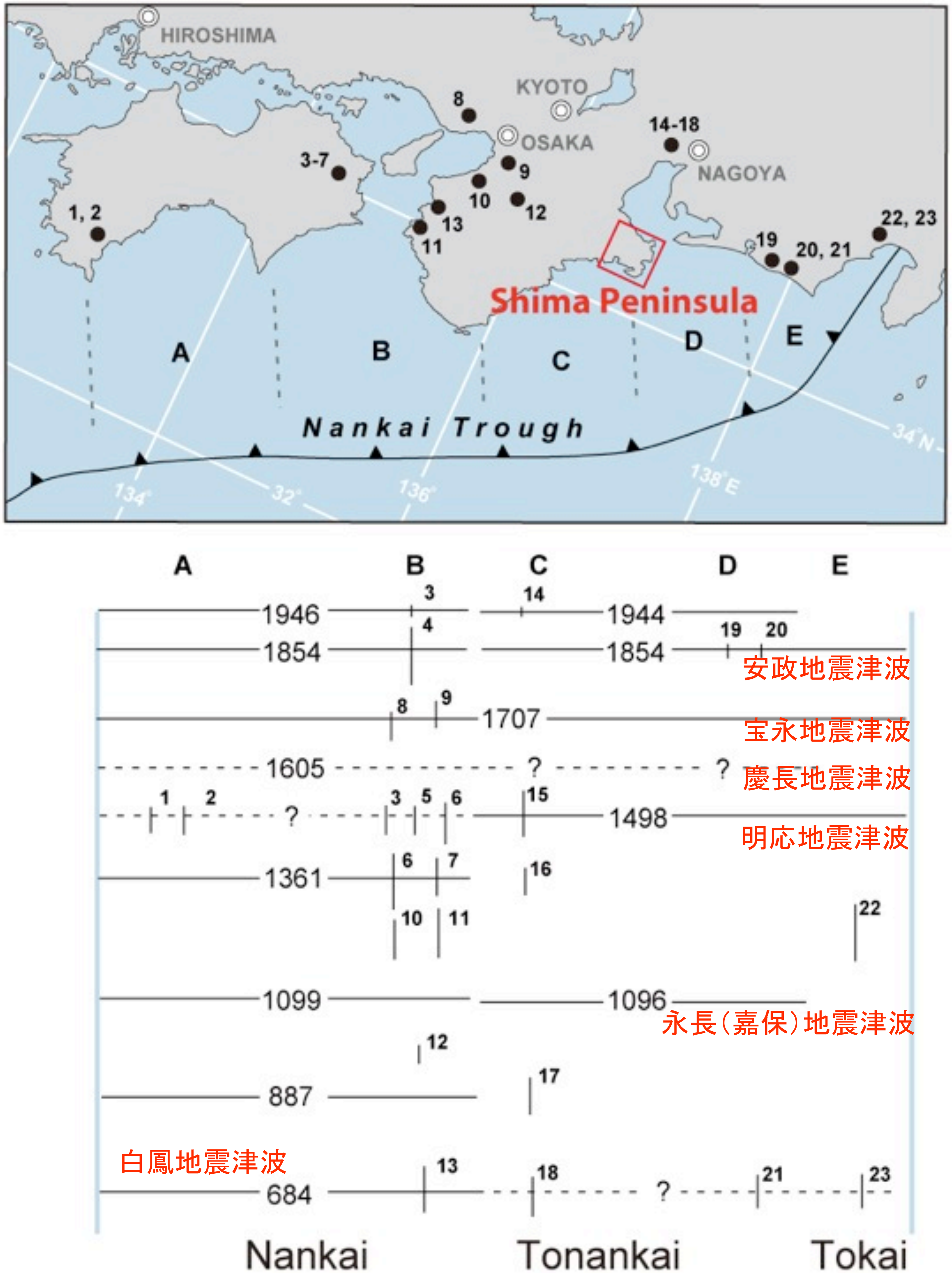


# Seismicity in Nankai-oki

The most well-known sequence of large interplate earthquakes along the Nankai trough, Japan, shows repeated occurrence of them, but the periodicity is not good; the minimum interval is 90 years and the maximum 264 years.

Large variance of the recurrence interval !

Fujino et al. (2010)

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# Conclusion

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1. the continuous slips near trench, which led to a large maximum slip (50 m), long slip duration (90 s), and a large stress drop (20 MPa).

2. the earthquake released roughly all of the accumulated elastic strain on the plate interface owing to exceptional weakening of the fault.

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Prediction of M9 events may be fundamentally difficult.

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Prediction of M9 events may be fundamentally difficult.

We need new strategy for mitigating and/or preventing earthquake disaster !

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# Magnitude

Seismic Moment (Nm)

Moment Magnitude

$$M_W = \frac{\log M_0 - 9.1}{1.5}$$

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A1 = 10^1.5 = 10 x 10^0.5 = 3.16 x 10 = 31.6