Near-real time estimation of tsunami sources using a classification of waveforms observed at dense ocean bottom pressure sensor

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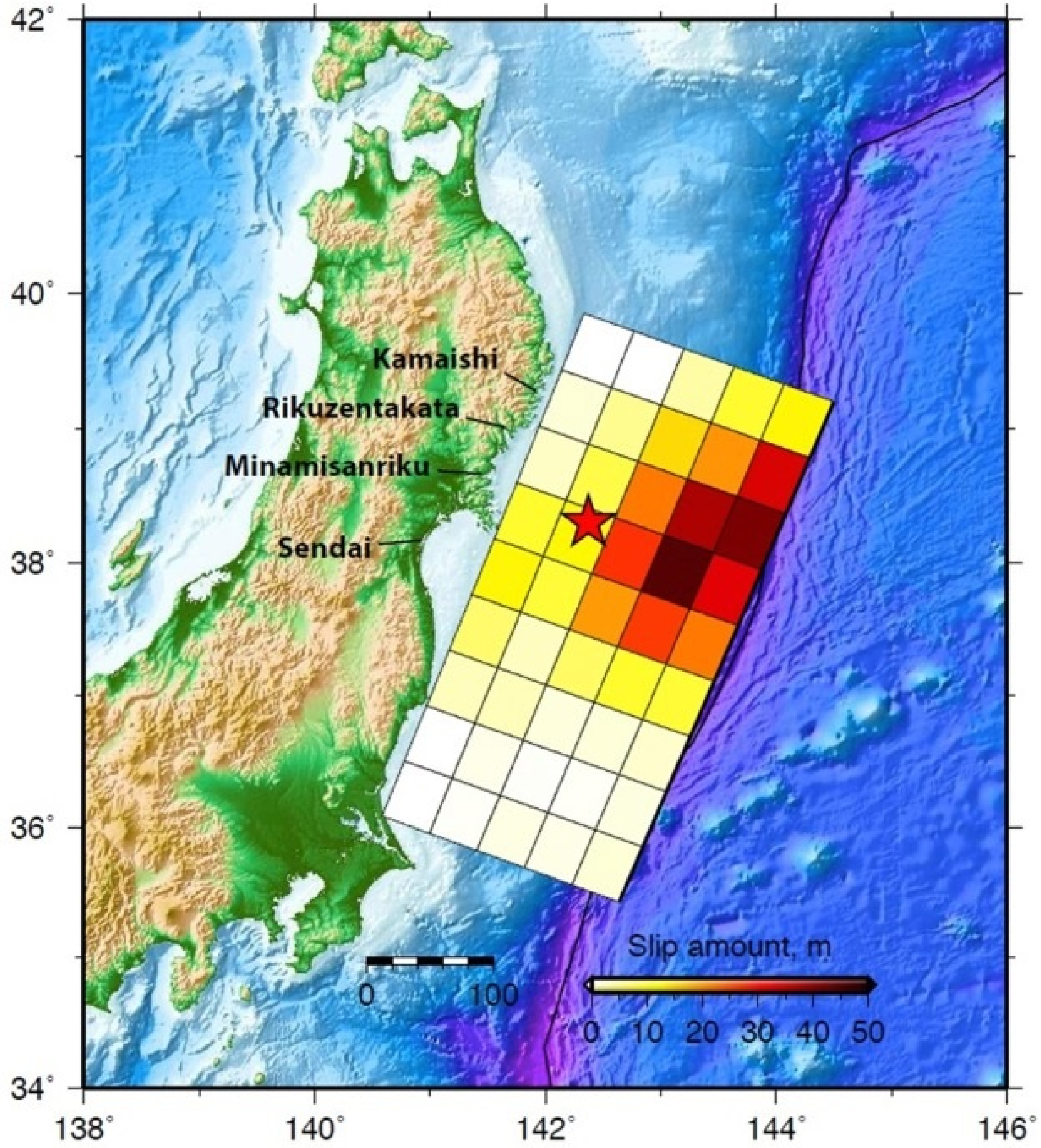
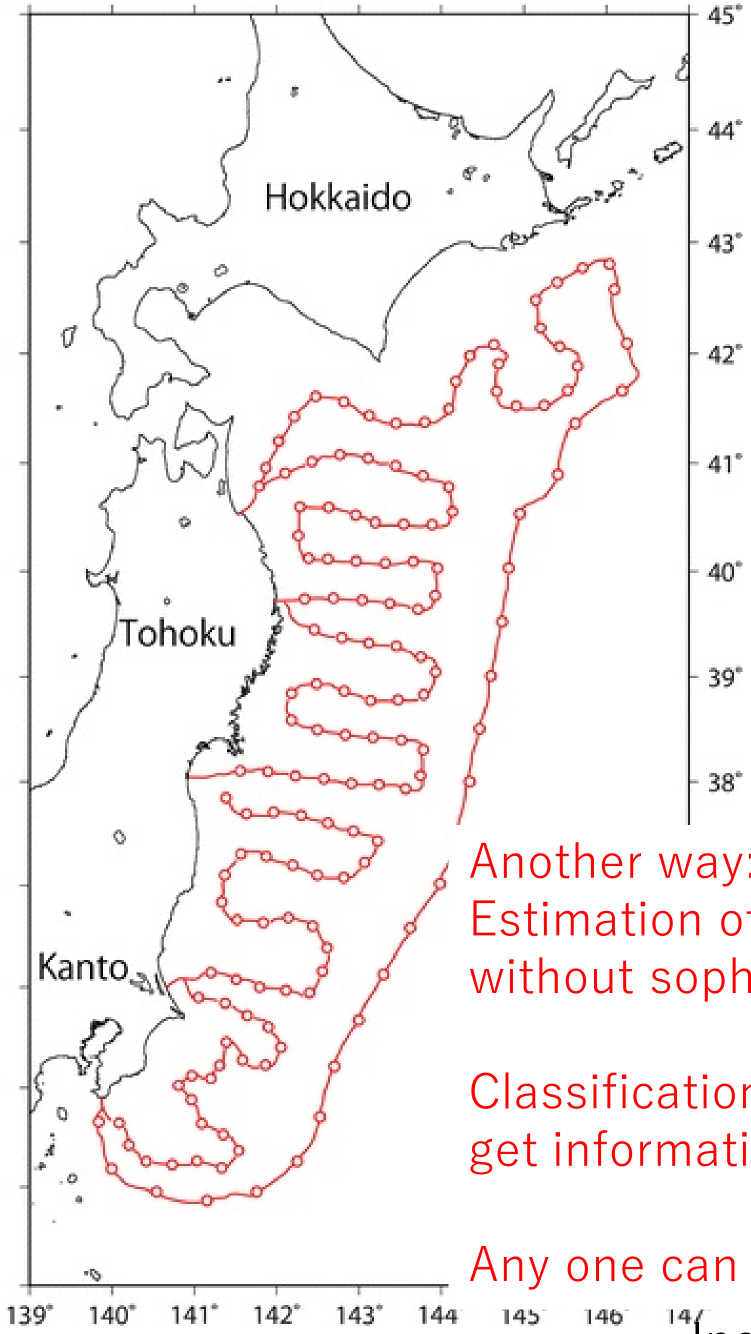
After the 2011 Tohoku-oki earthquake,
S-net was installed by NIED.





S-NET (30km apart)

One way:
Tsunami assimilation
Maeda et al. (2015)
Wang et al. (2017)

Assimilation of pressure data above the source region.
Tanioka (2018)
Tanioka and Gusman, (2018)

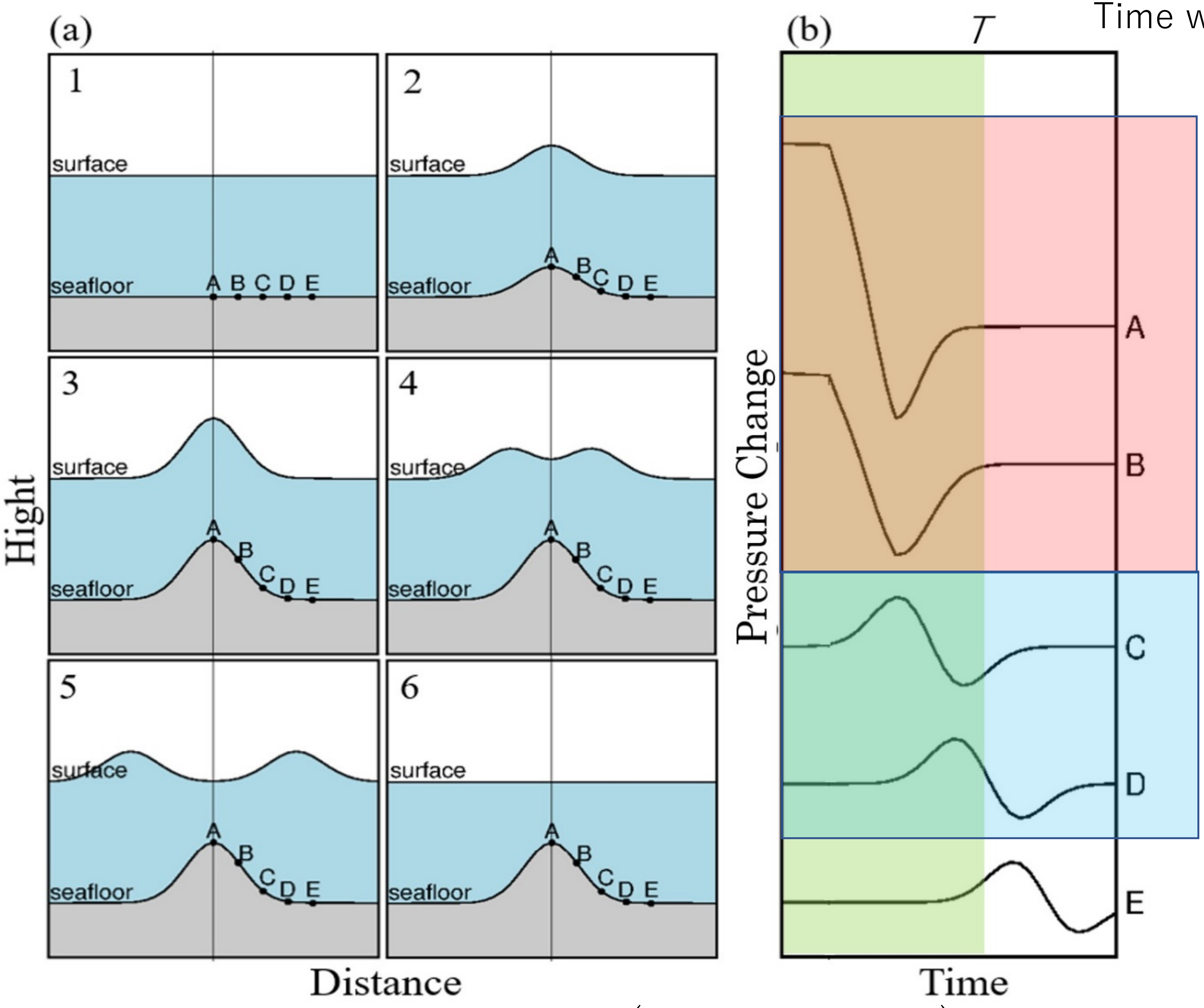
Another way:
Estimation of the tsunami source areas without sophisticated computation.

Classification of observed pressure data get information of tsunami source

Any one can use it.

Inoue et al., (2019 Geosciences)

Time window T



Type 1

Pressure decreases and remains low

Stations located
within the uplifted area

Type 2

One up-pulse of a wave is in T

Stations located at
the edge of the uplifted area

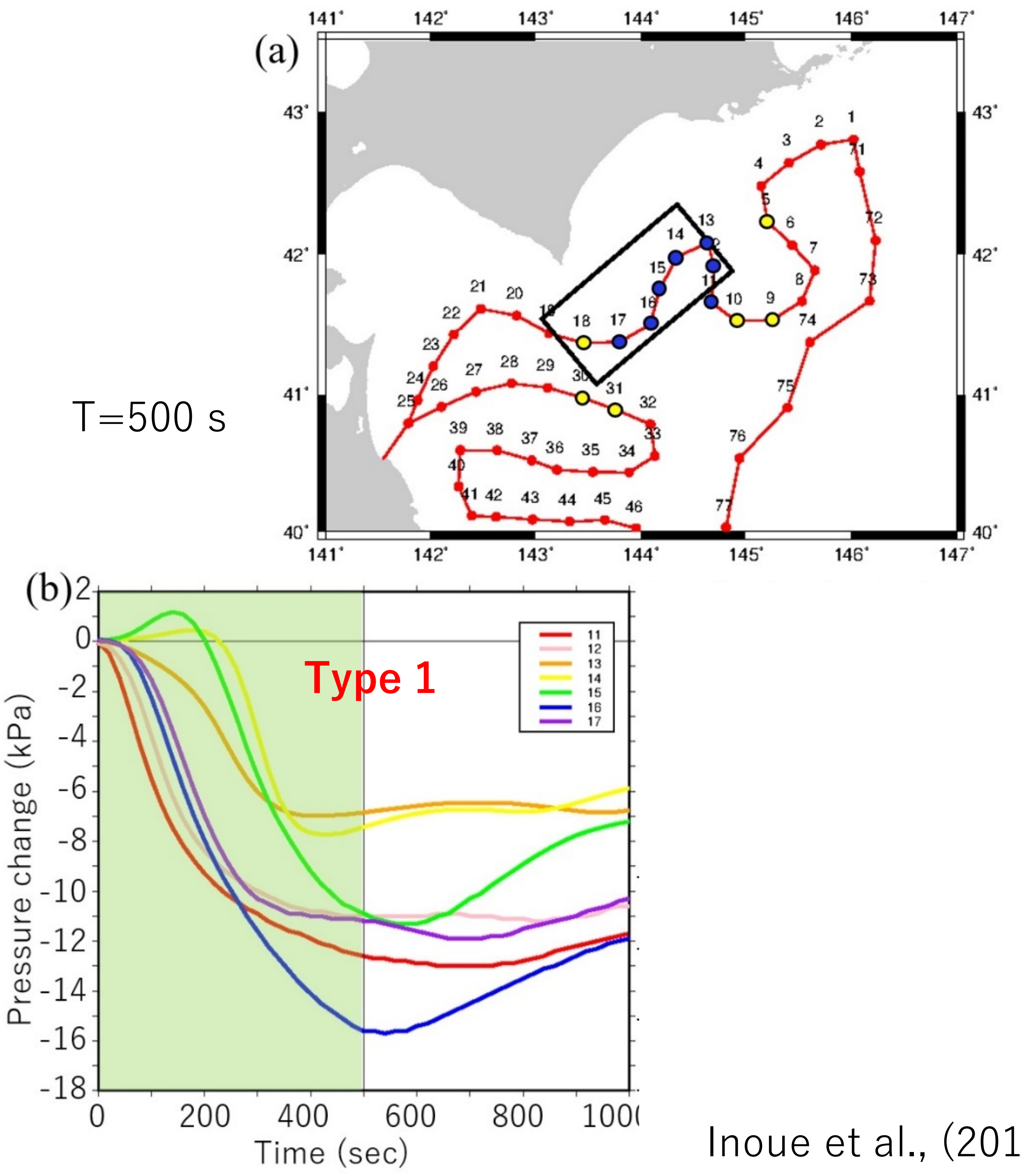
Type 3

the others

Stations located
far from the uplifted area

Inoue et al., (2019 Geosciences)

T=500 s



Simulated pressure changes at S-net stations using a rectangular fault model at the plate interface

Type 1:

Pressure decreases and remains low

1) An absolute amplitude of a positive wave should be less than an absolute amplitude of a negative wave. Allow small positive wave.

2) The amplitude should be larger that 1/10 of the maximum absolute amplitude of the largest wave of all.

Type 2:

One up-pulse of a wave

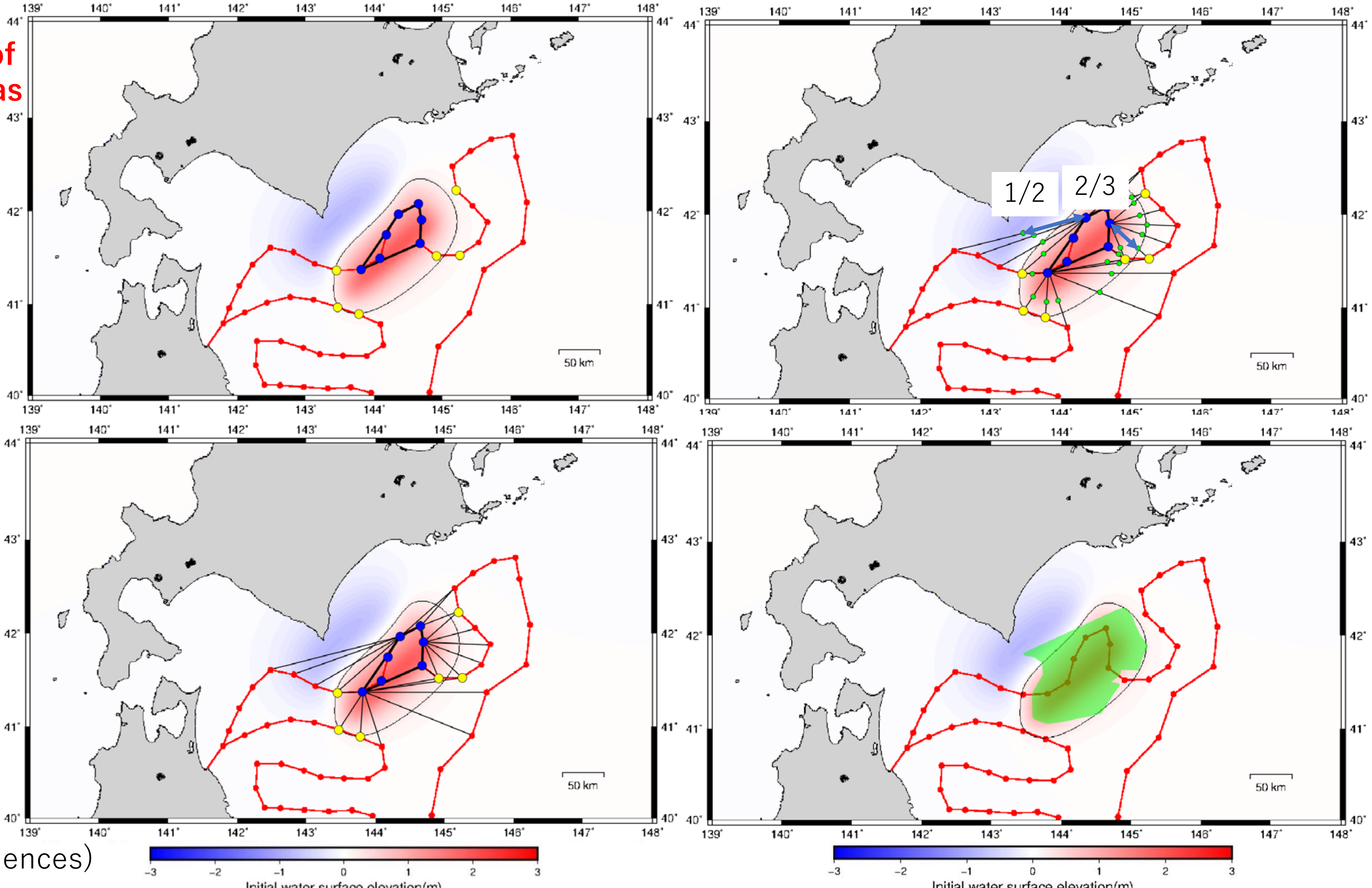
1) Amplitude of maximum positive wave is twice larger or more than the minimum positive pressure change observed after the maximum pressure is observed

Type 3

the others

Inoue et al., (2019 Geosciences)

Estimation of uplifted areas



Inoue et al.,
(2019 Geosciences)

Uplifted areas are calculated from various fault models with various magnitudes (M8.0-8.8)

1) Fault length (L km) and width (W km) are form 4 scaling relationships

1) Blaser et al. (2010)
$\log L = -2.28 + 0.55Mw$
$\log W = -1.8 + 0.45Mw$

2) Somerville et al. (1999)
$Mw = \log S + 3.95.$ (L=2W)

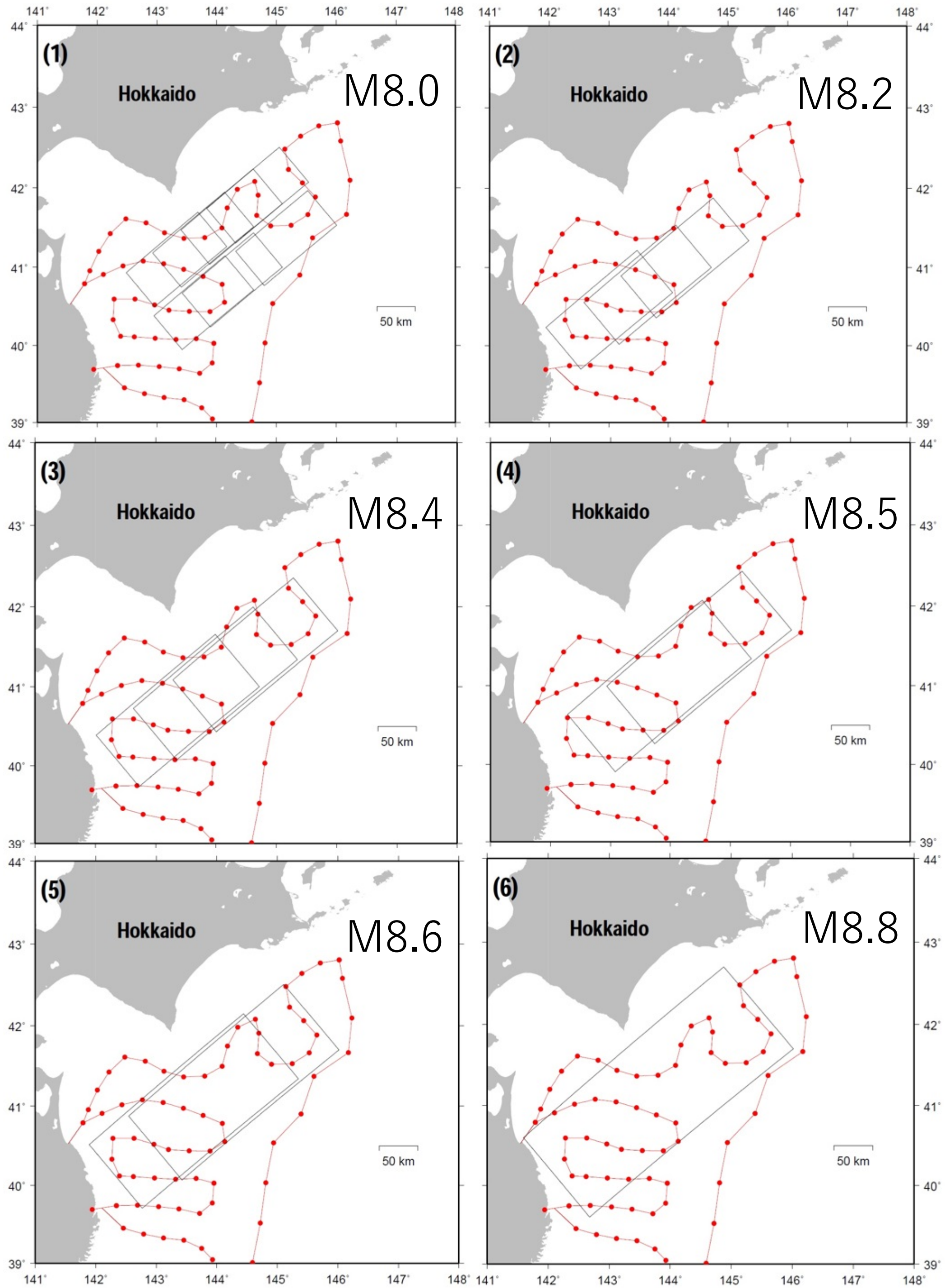
3) Wells and Coppersmith (1994)
$M = 4.33 + 0.9 \log S$ (L=2W)

4) Utsu and Seki (1955)
$\log S = M - 3.9$ (L=2W)

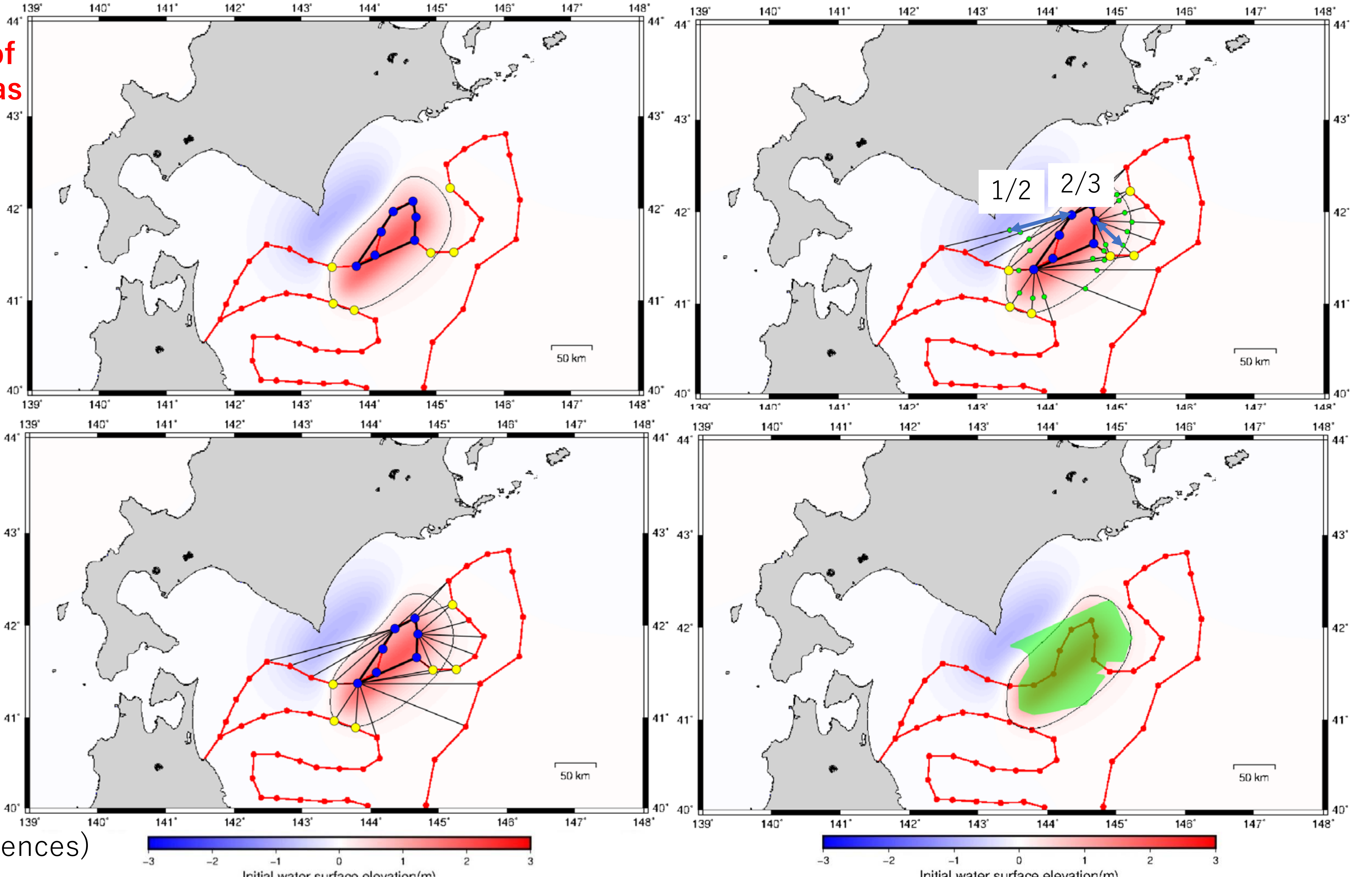
2) Slip Amount (D) is calculated from

$$D = \frac{M_0}{\mu L W}, \quad M_0 = 10^{1.5M_w + 9.1}$$

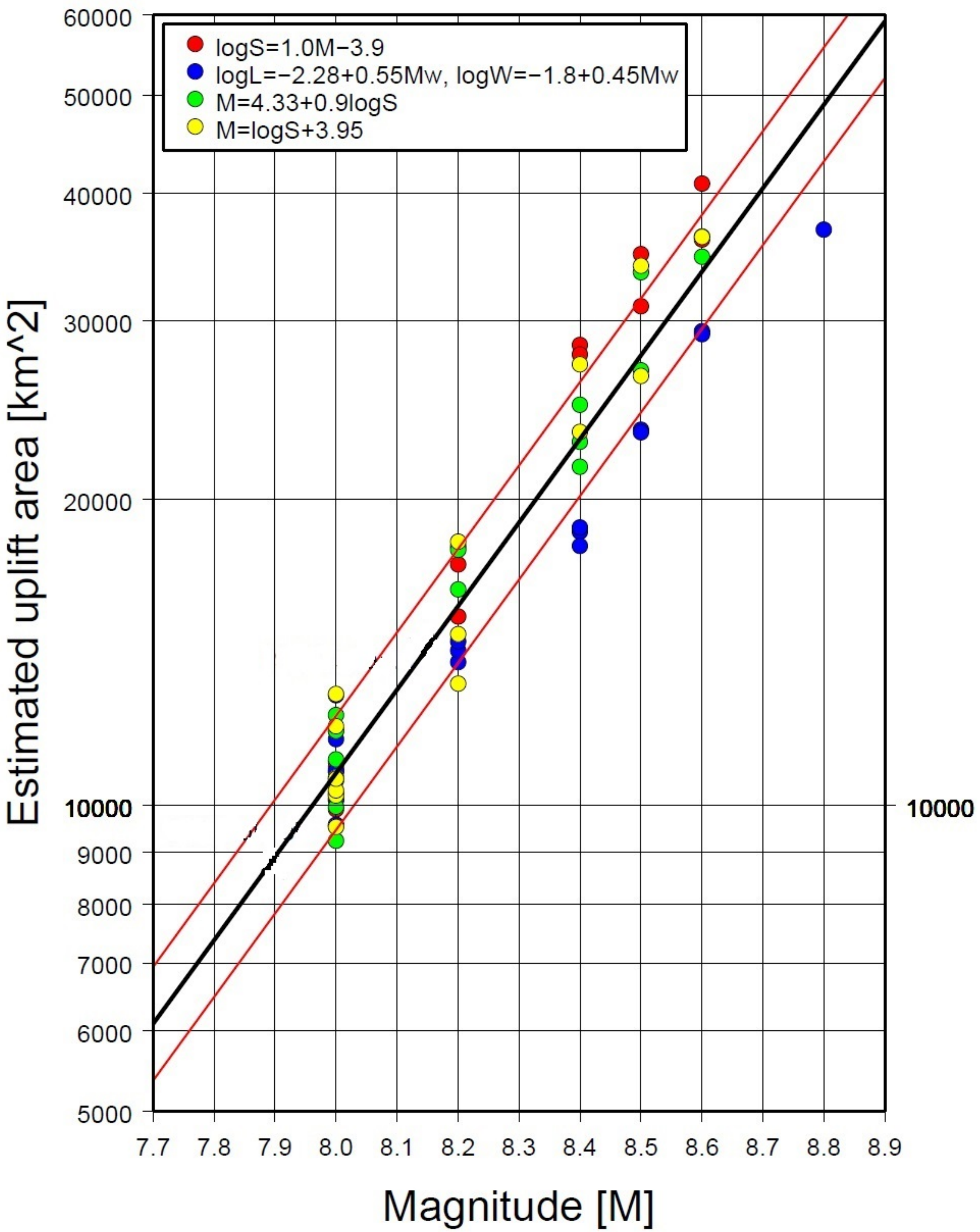
Inoue et al., (2019 Geosciences)



Estimation of uplifted areas



Inoue et al.,
(2019 Geosciences)



Utsu and Seki (1955)
log S = M-3.9 (L=2W)

Blaser et al. (2010)
log L = -2.28 + 0.55Mw
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Wells and Coppersmith (1994)
M = 4.33 + 0.9 log S (L=2W)

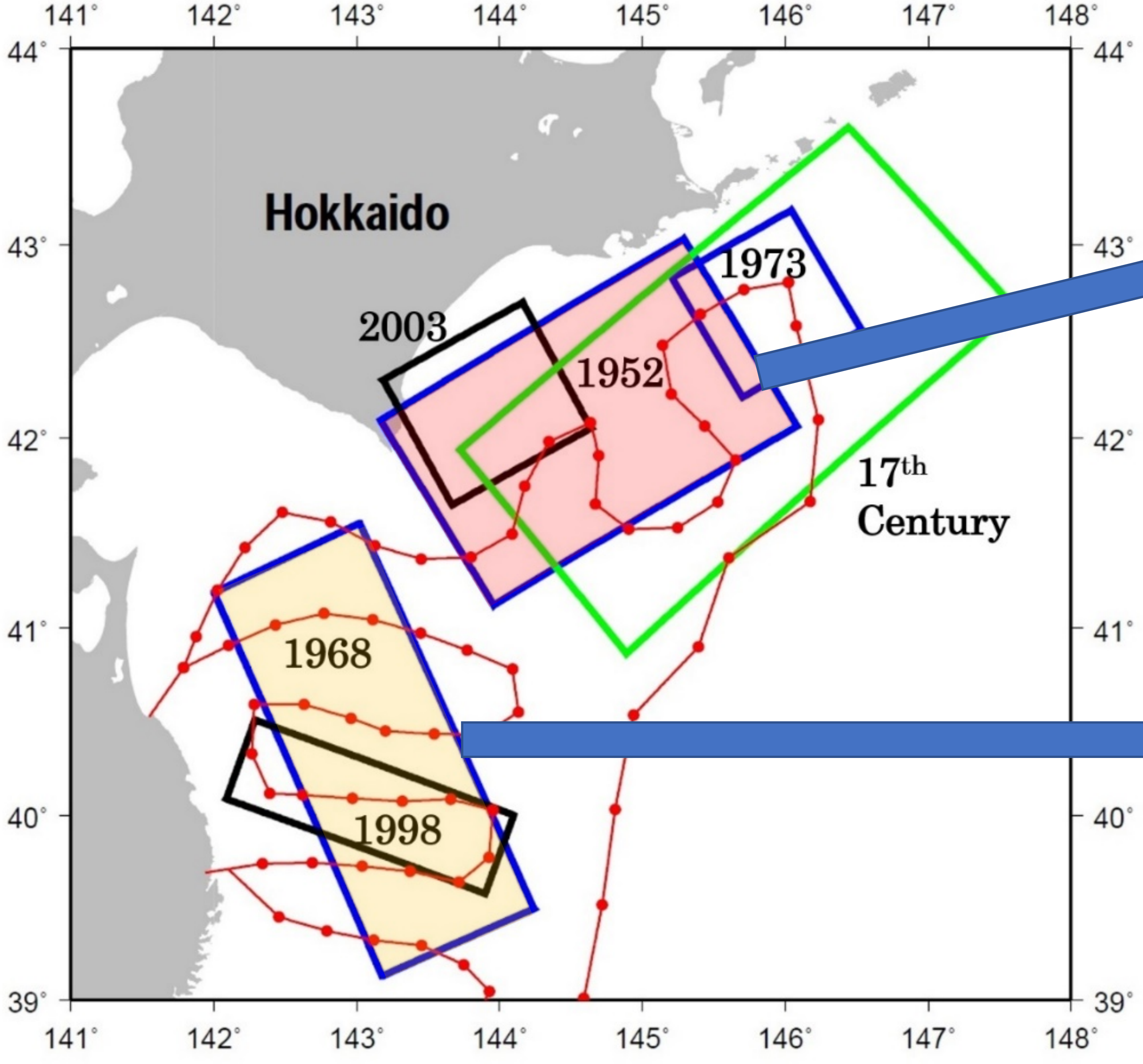
Somerville et al. (1999)
Mw = log S + 3.95. (L=2W)

$$\log S_{up} = 0.822M - 2.543$$

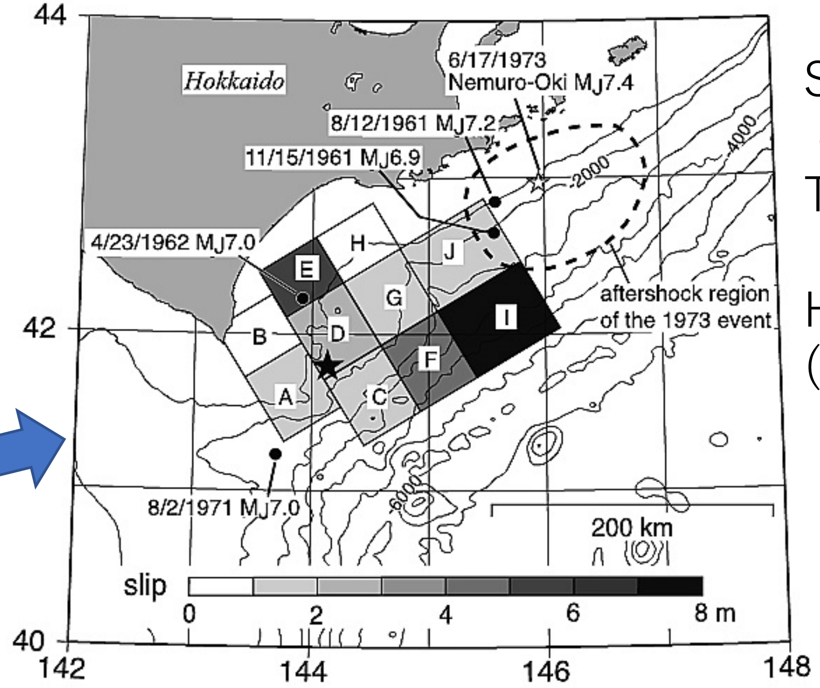
σ (M) = 0.07

Inoue et al., (2019 Geosciences)

Large earthquakes off Hokkaido

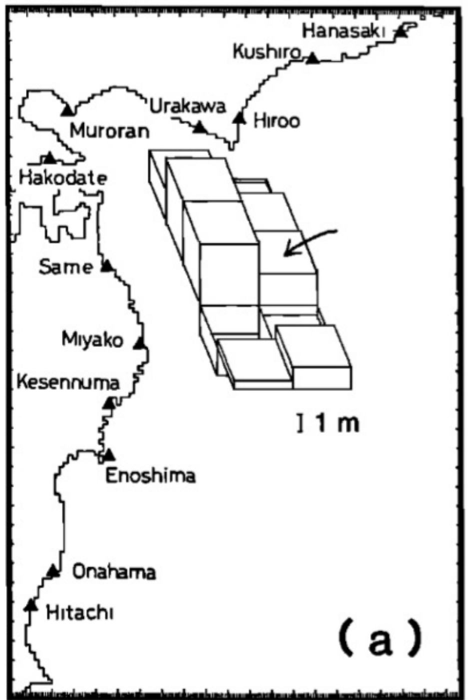


Inoue et al., (2019 Geosciences)



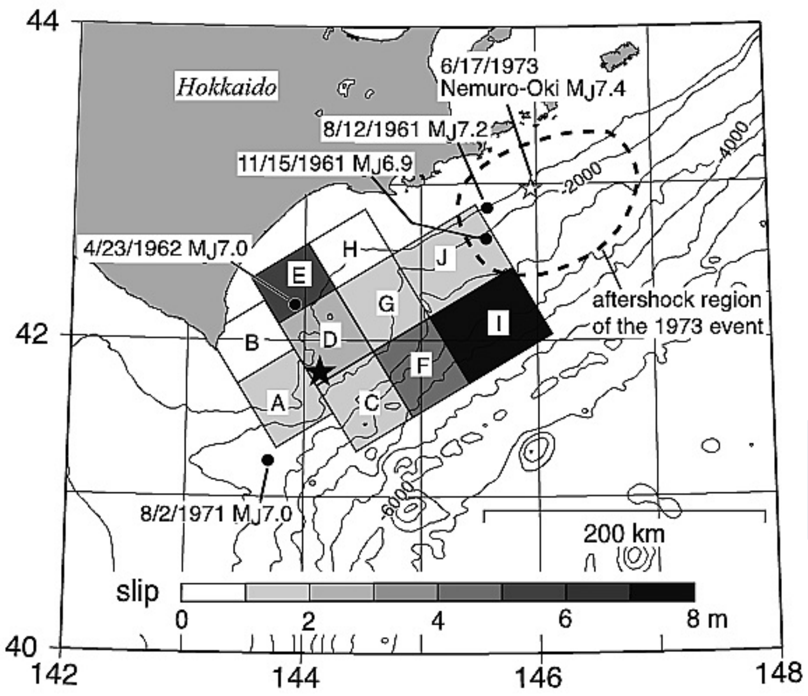
Slip distribution of the 1952 Tokachi-oki EQ

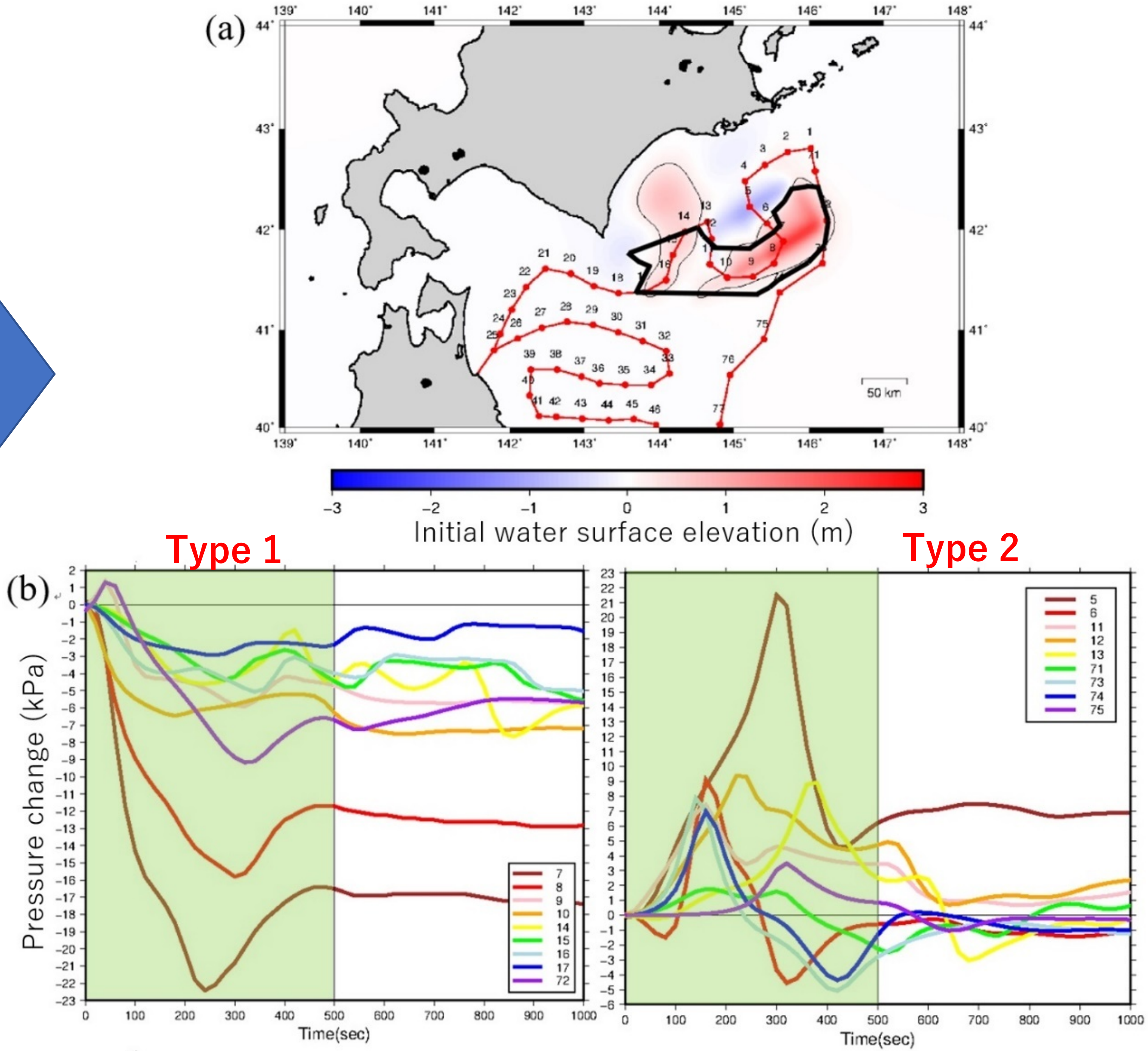
Hirata et al., (2003)



Slip distribution of the 1968 Tokachi-oki EQ

Satake (1989)





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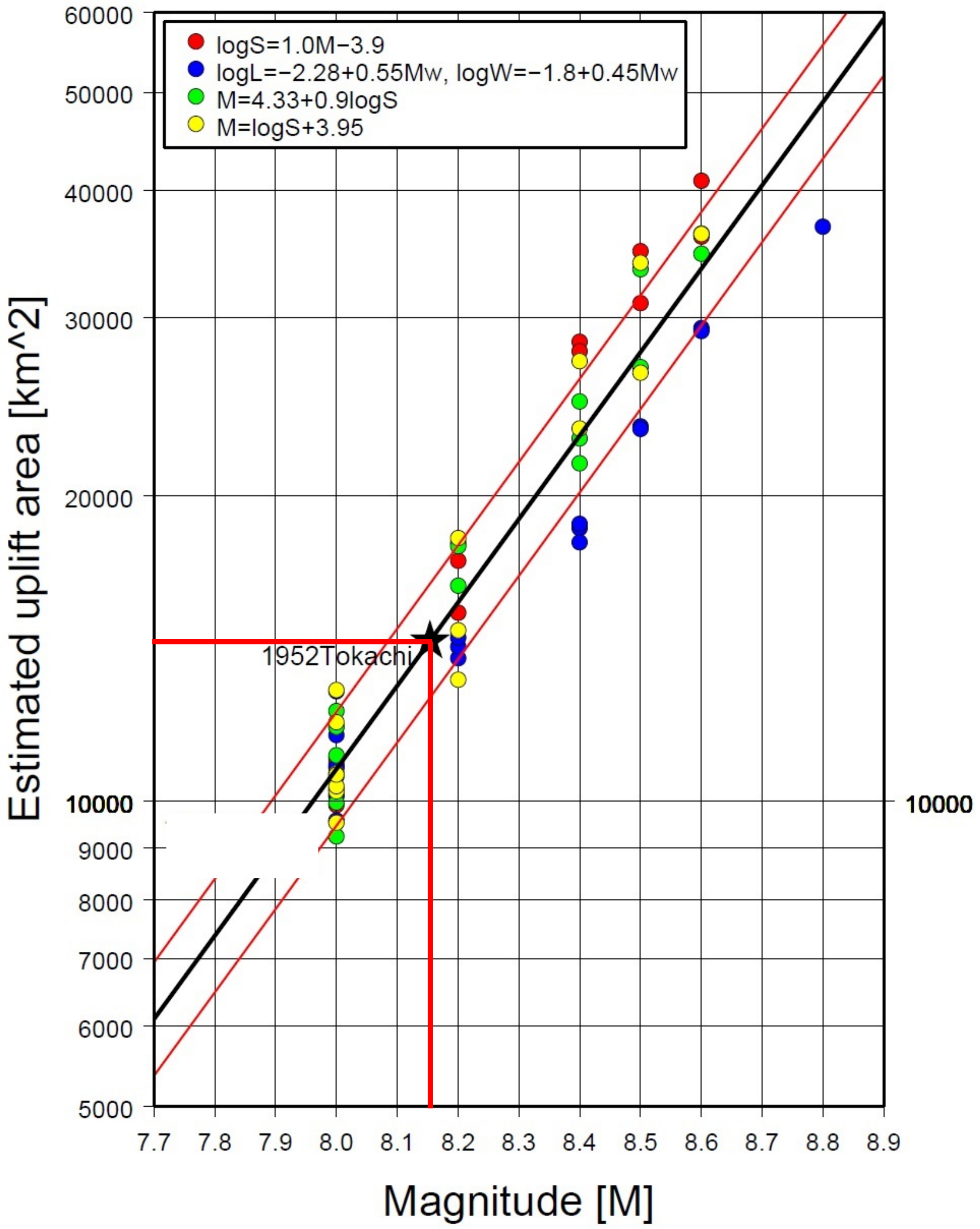
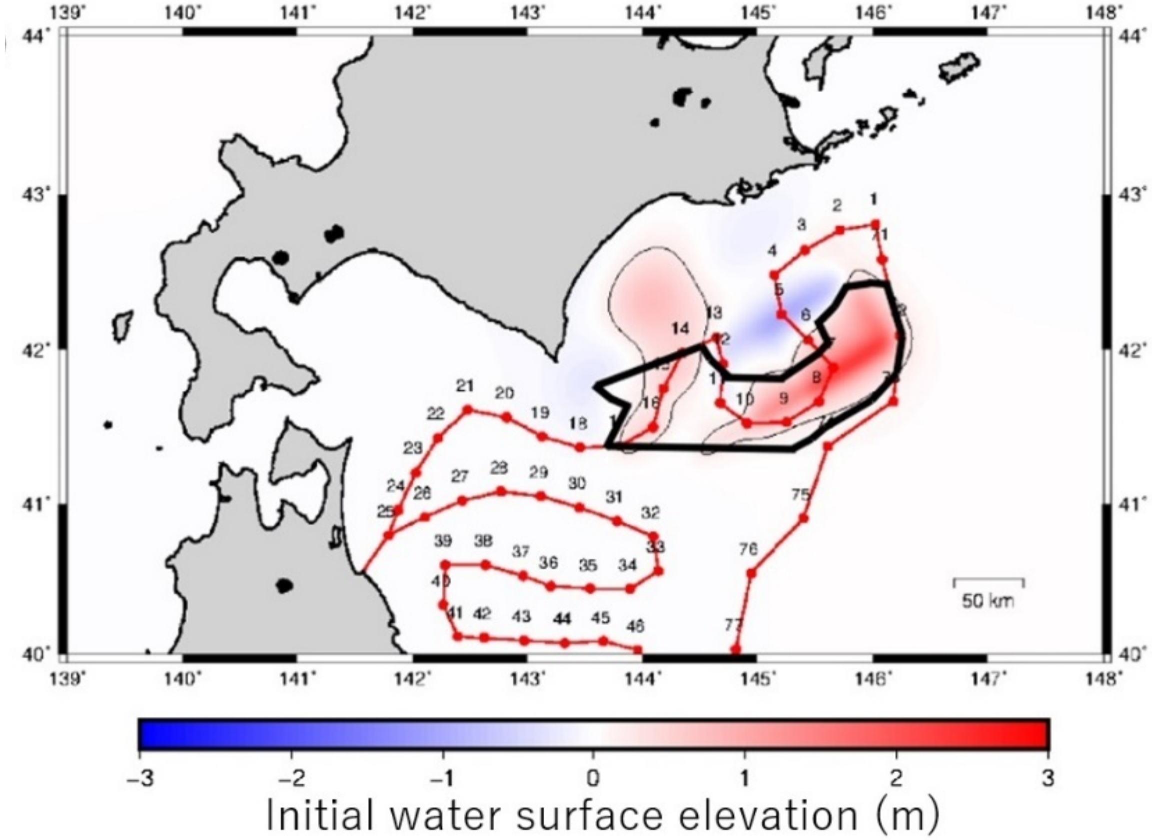
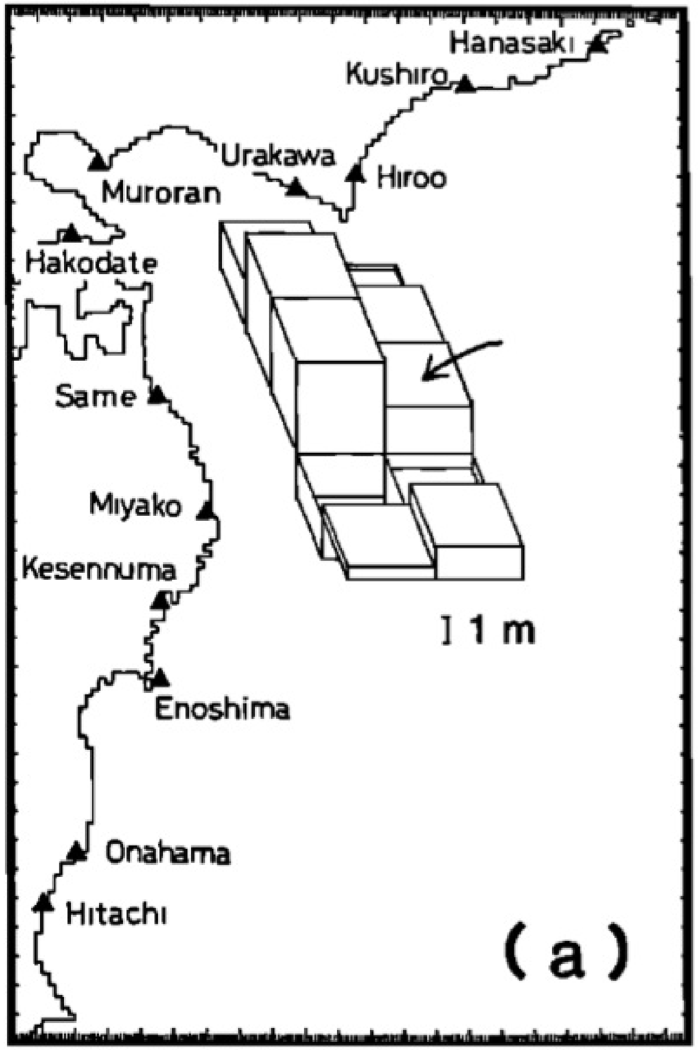




Magnitude of the 1952 Tokachi-oki earthquake, 8.2

Inoue et al., (2019 Geosciences)



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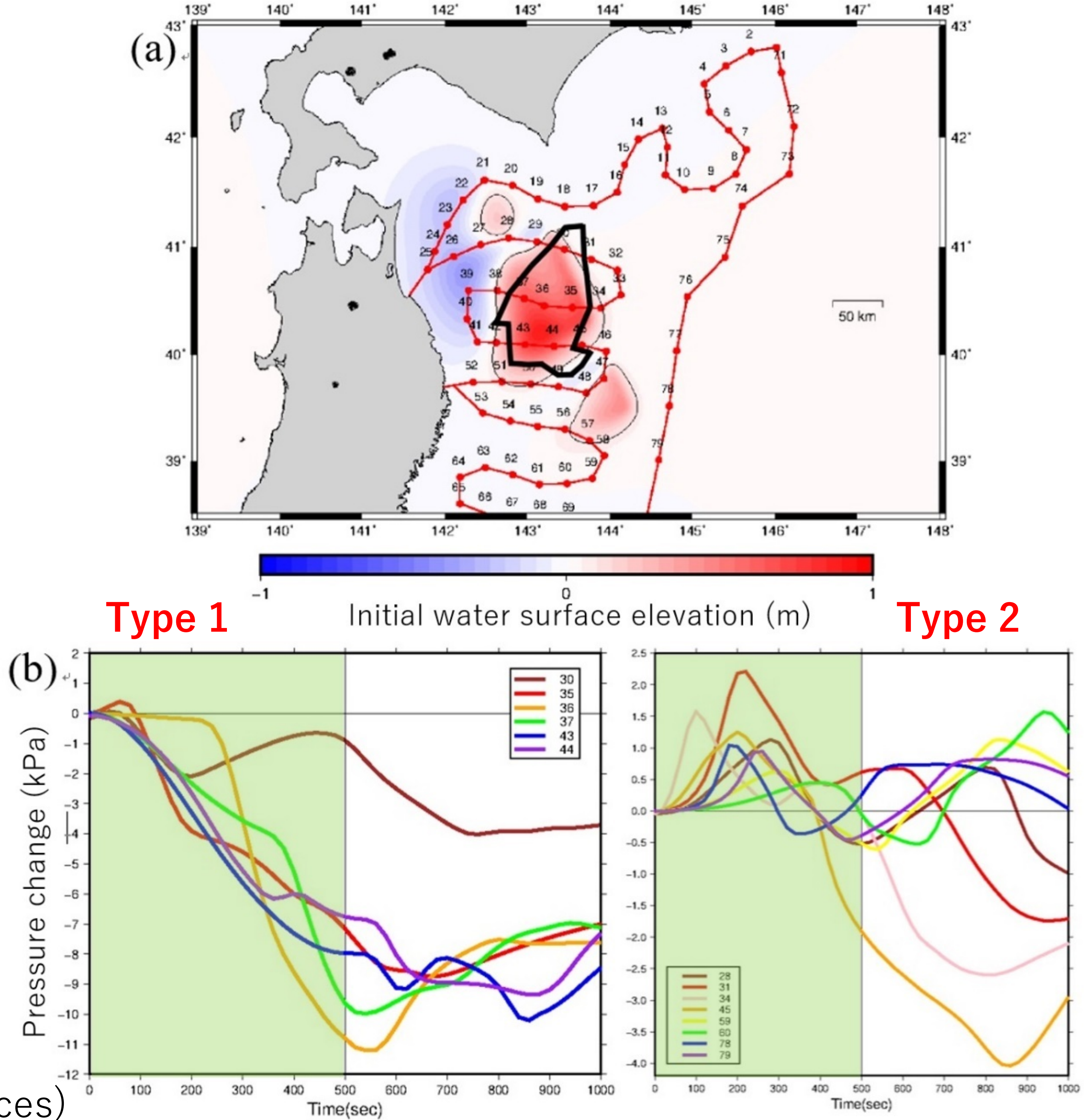

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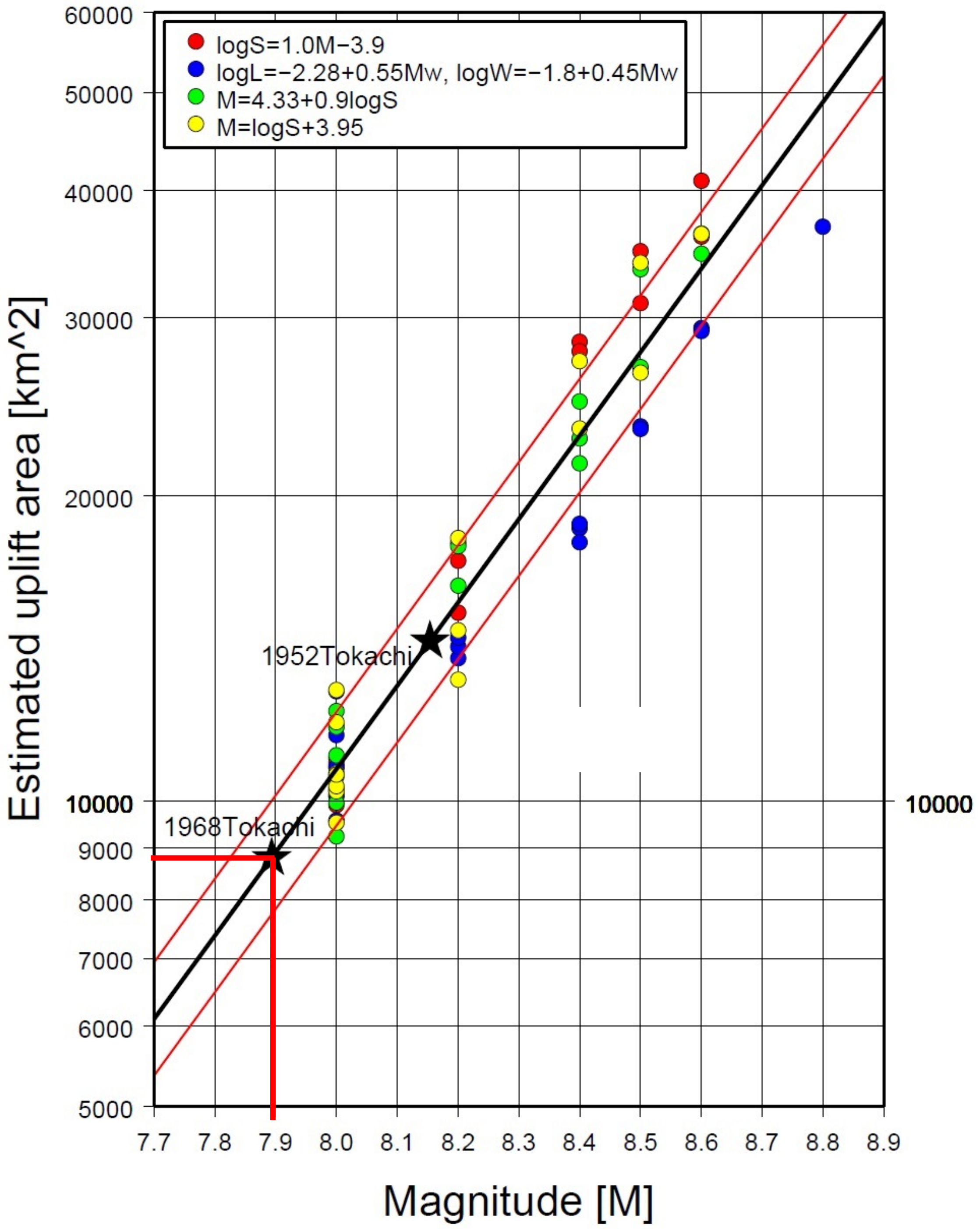

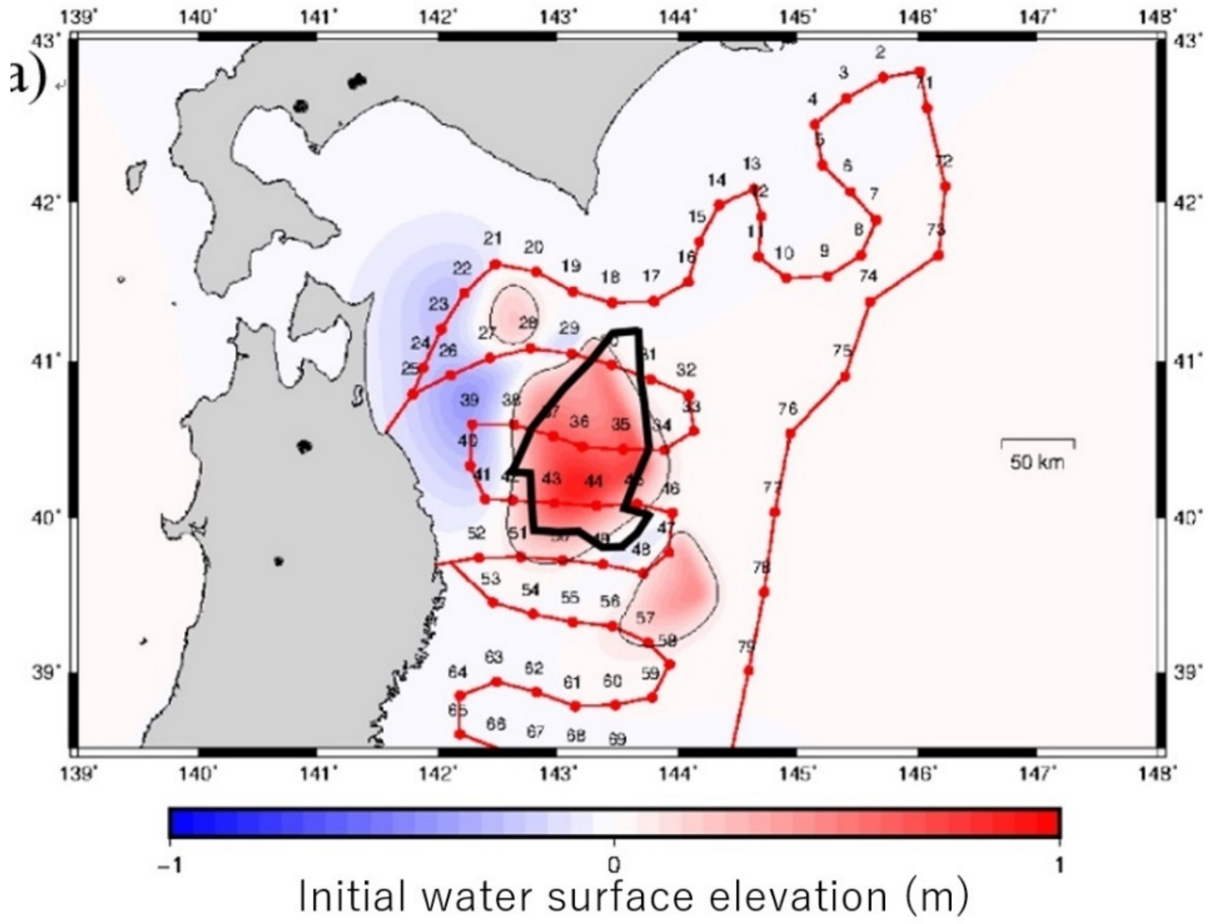

Magnitude of the 1968 Tokachi-oki earthquake, 7.9

Inoue et al., (2019 Geosciences)

Conclusions

1) A method to determined the uplift areas (tsunami source) by classifying ocean bottom pressure data of 500 s after the earthquake, observed at the sensors in S-net, was developed.

2) A method to estimate a magnitude of a great inter-plate earthquake from the estimated uplift area was also developed.

3) Those methods were tested for the 1952 Tokachi-oki earthquake case and the 1968 Tokachi-oki earthquake case. The uplifted areas due to those earthquakes and the magnitudes were estimated.

Inoue, M., Y. Tanioka, Y. Yamanaka, Method for Near-Real Time Estimation of Tsunami Sources Using Ocean Bottom Pressure Sensor Network (S-Net), Geosciences, doi:10.3390/geosciences9070310