
Interplate coupling along the central Ryukyu Trench inferred from GPS/acoustic seafloor geodetic observation

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Historical large earthquakes in the Ryukyu trench (1700-2009)

Damaged earthquakes in the Ryukyu area

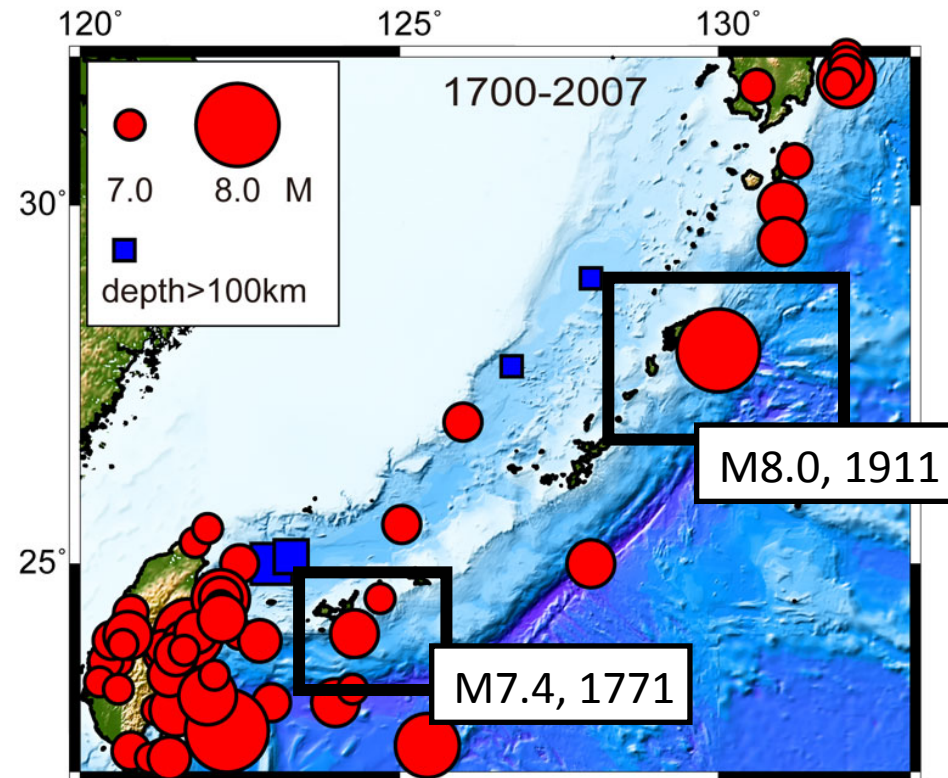
1771 Yaeyama earthquake (M7.4?)

1911 Kikaijima earthquake (M8.0)

(Philippine Sea plate: intra-plate earthquake)

Thrust-type large earthquakes:

1771 Yaeyama tsunami

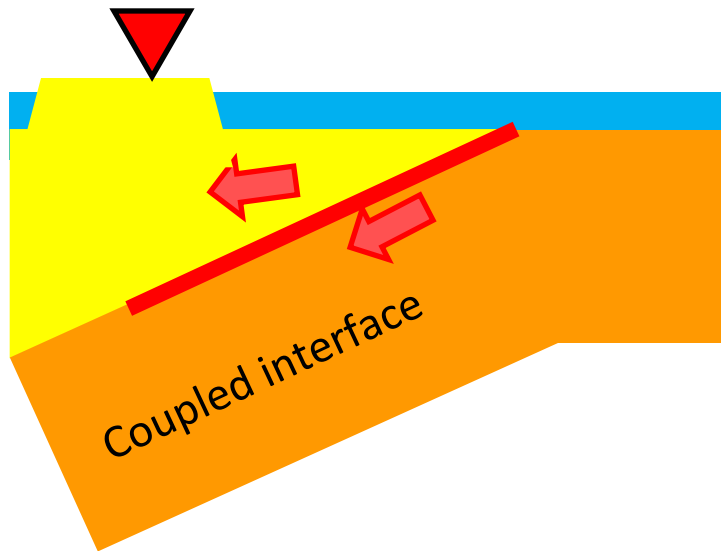


GPS velocity field in the Ryukyu arc

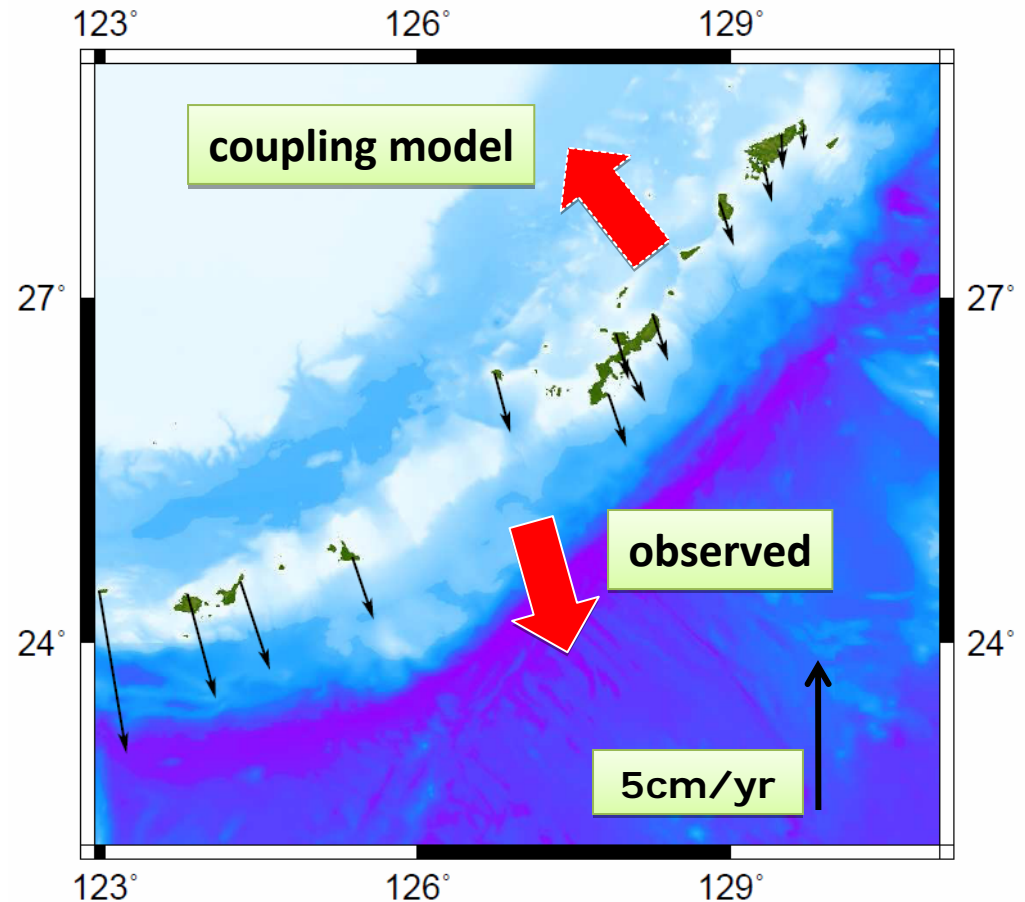
Stress accumulation

Southward movement of Ryukyu Islands -> weak coupling

Inter-seismic coupling: 5% (Paterson & Seno, 1984)

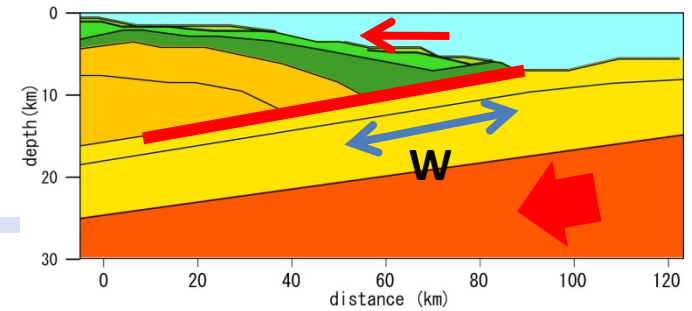


GPS horizontal velocity
(GSI, 1997-2006)
Tsushima is fixed

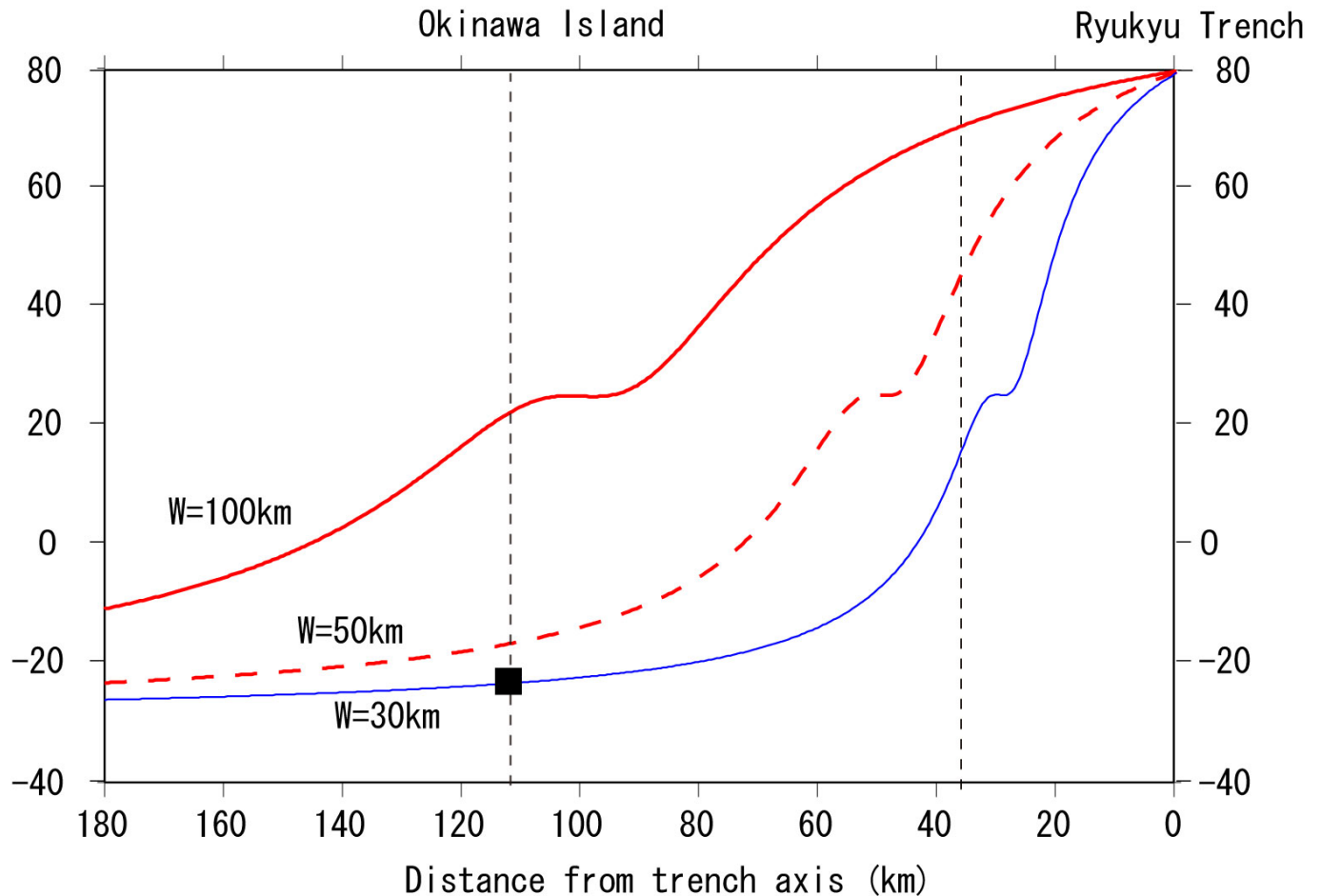


Width of the coupled zone

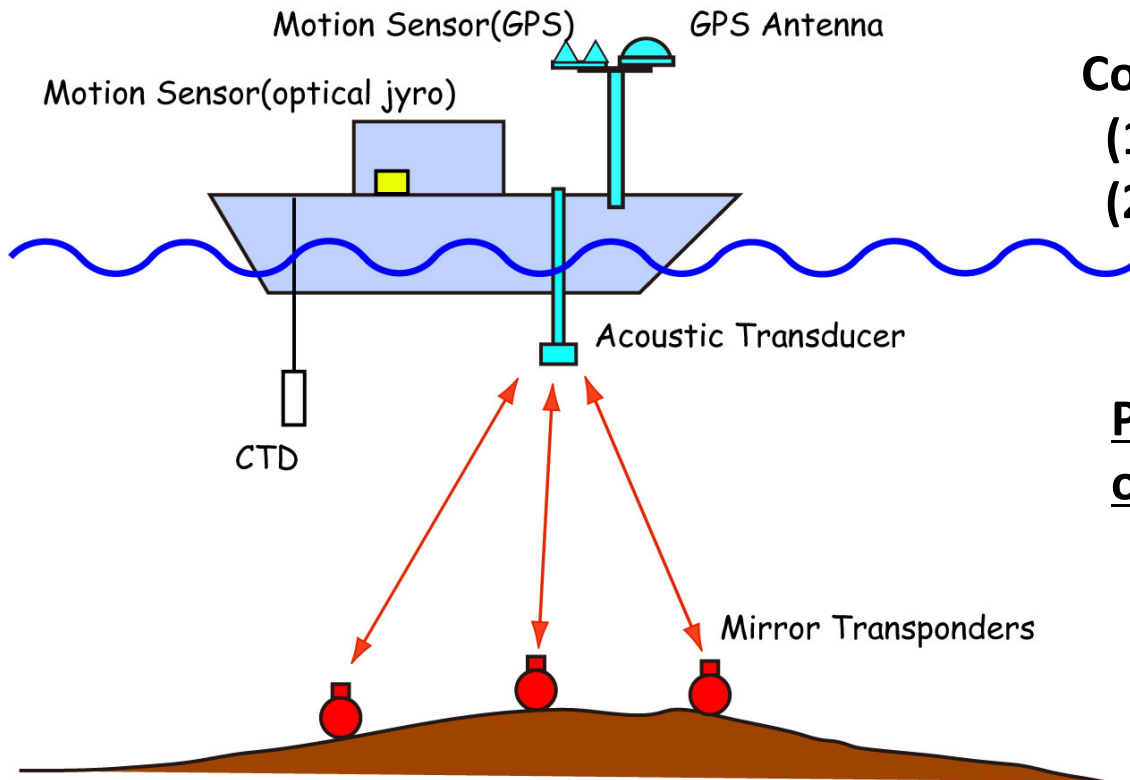
Horizontal velocity relative to the Amurian plate
(NW direction: positive)



Horizontal displacement by the interplate coupling (mm/yr)



Ocean Bottom Crustal Movement Measurement System



Combination of
(1) Kinematic GPS (5Hz sampling)
(2) Acoustic ranging system



Position determination of
ocean-bottom benchmarks

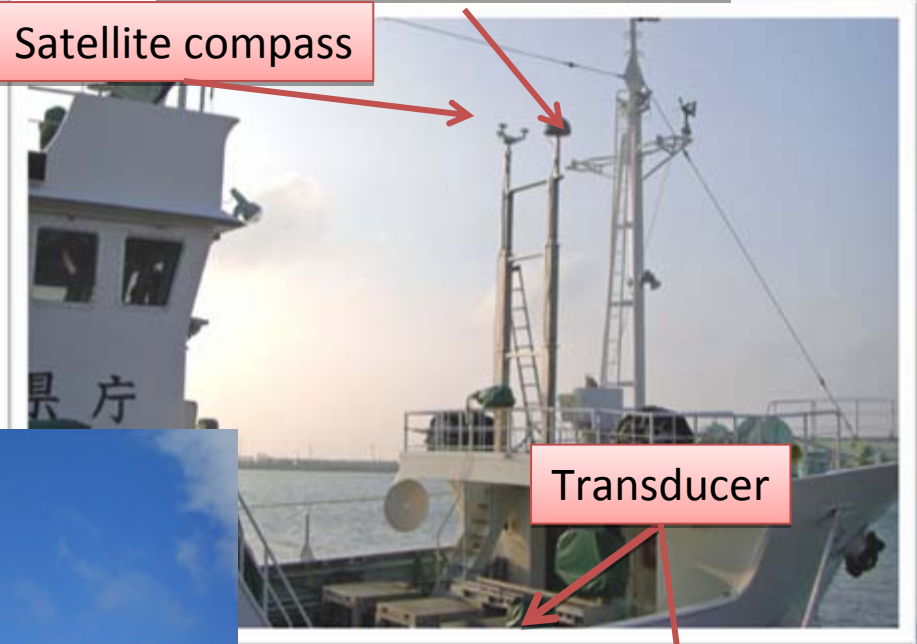


Acknowledgements We thank Dr. Oscar L. Colombo of the NASA Goddard Space Flight Center for providing us with the kinematic GPS software 'IT'.

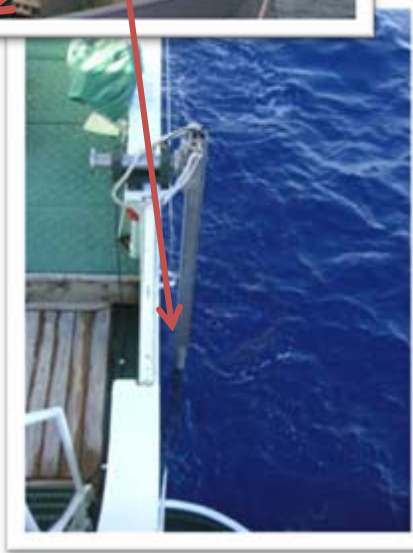
Tonan-Maru (176t)
**(Okinawa Prefectural Fisheries and
Ocean Research Center)**

GPS(sampling interval:0.2s)

Satellite compass



Transducer



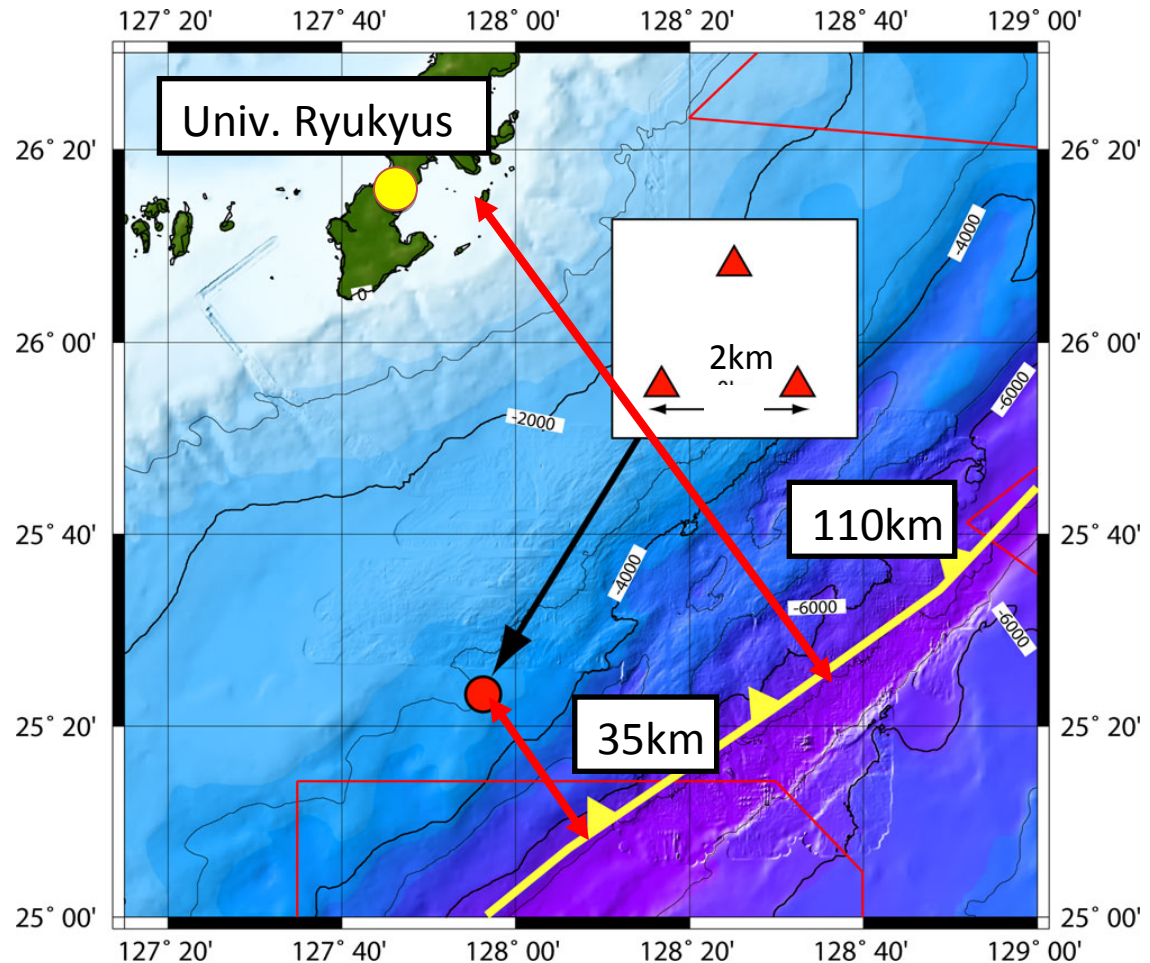
Ocean-bottom crustal deformation measurement in the central Ryukyu trench

Benchmarks

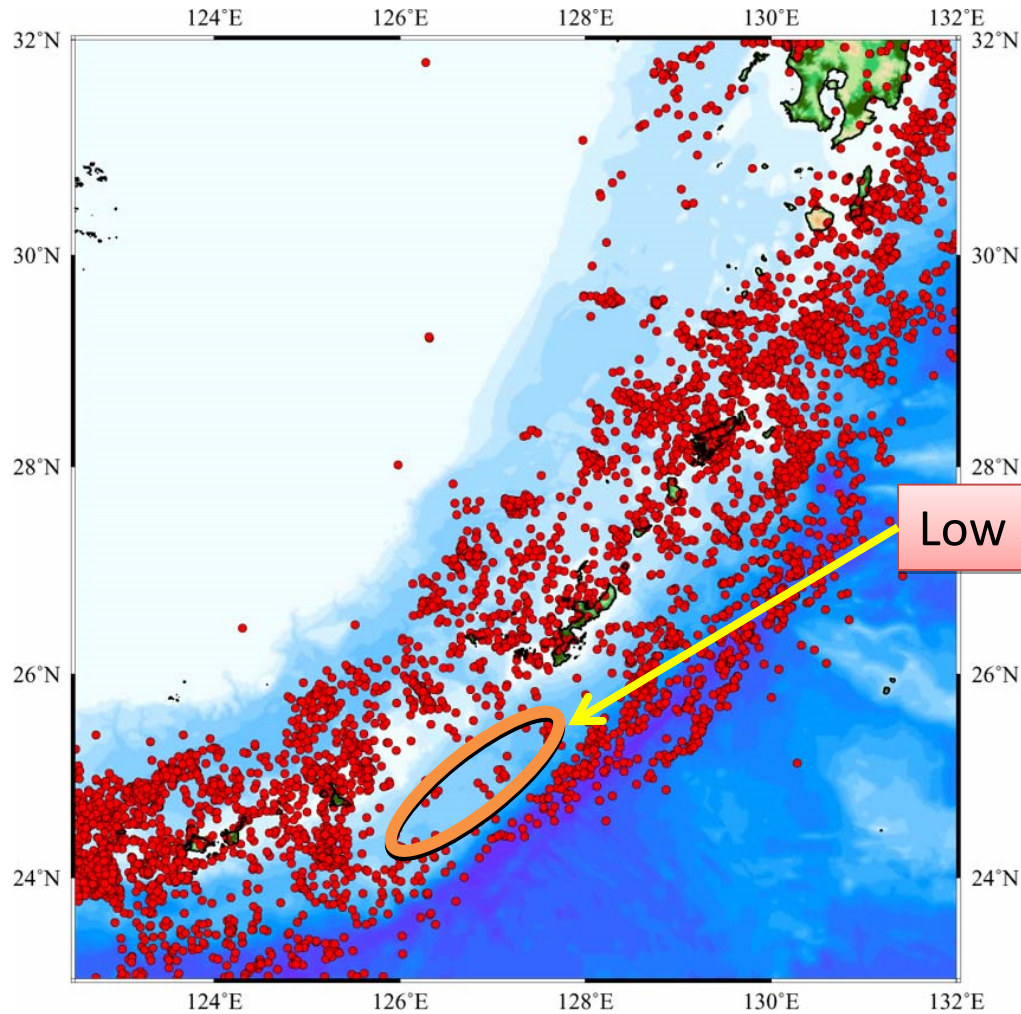
*35km land-side from Ryukyu Trench
interval: 2km*

Reference of kinematic GPS

Univ. Ryukyus

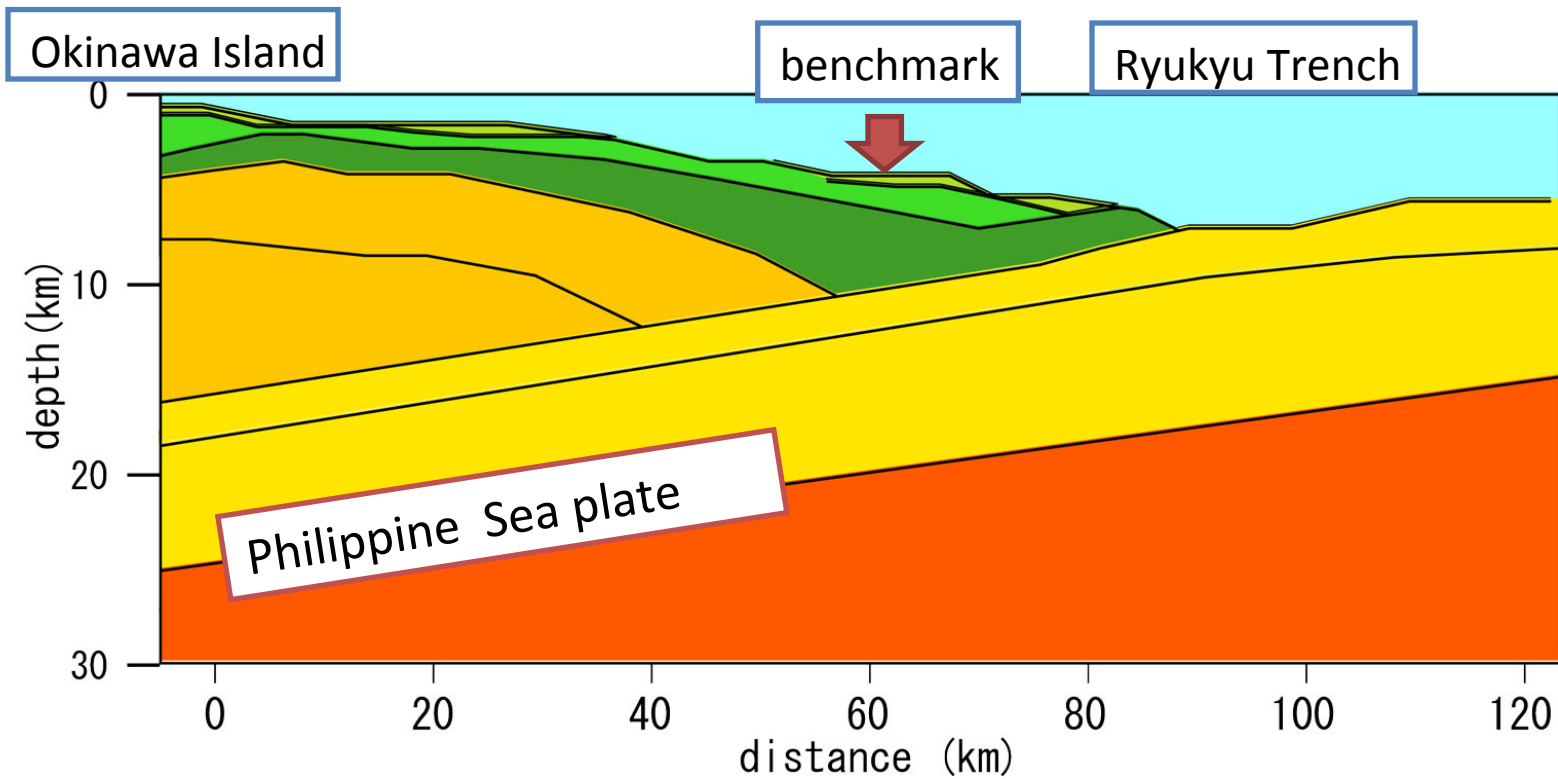


Seismic gap (?) in the central Ryukyu Trench



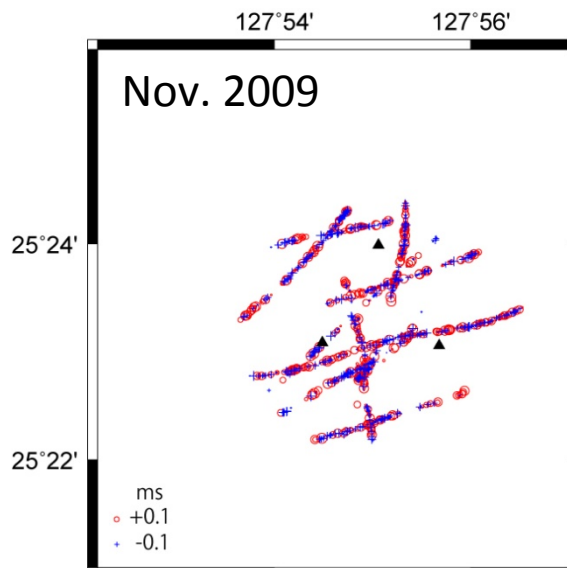
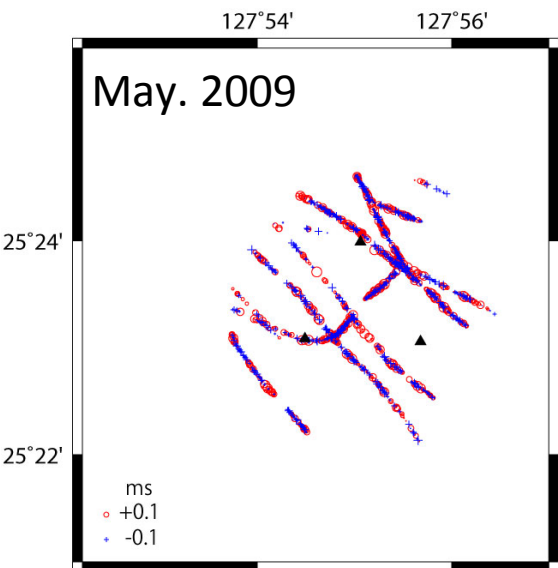
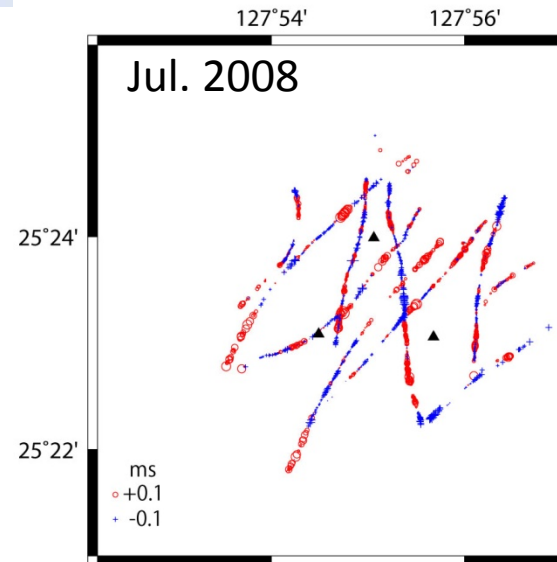
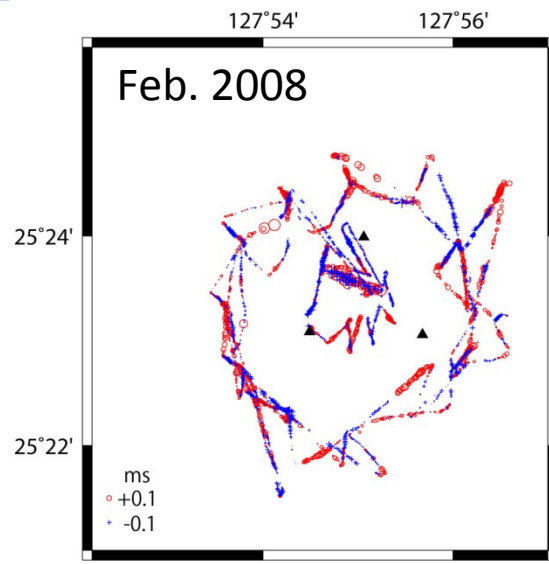
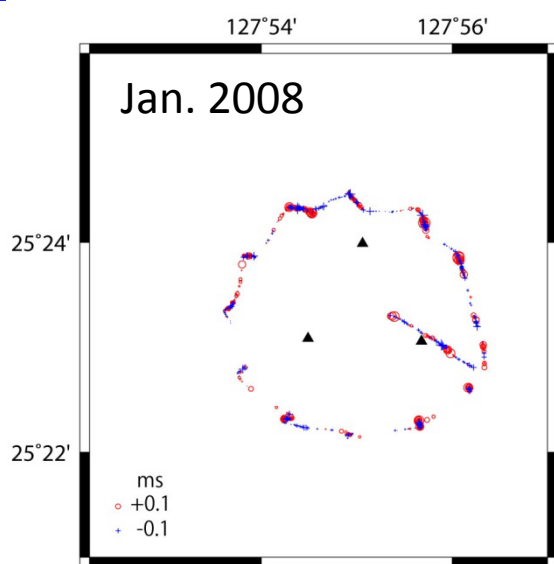
Low seismicity (> M 5) for 100 years.

Vertical cross-section of the central Ryukyu Trench



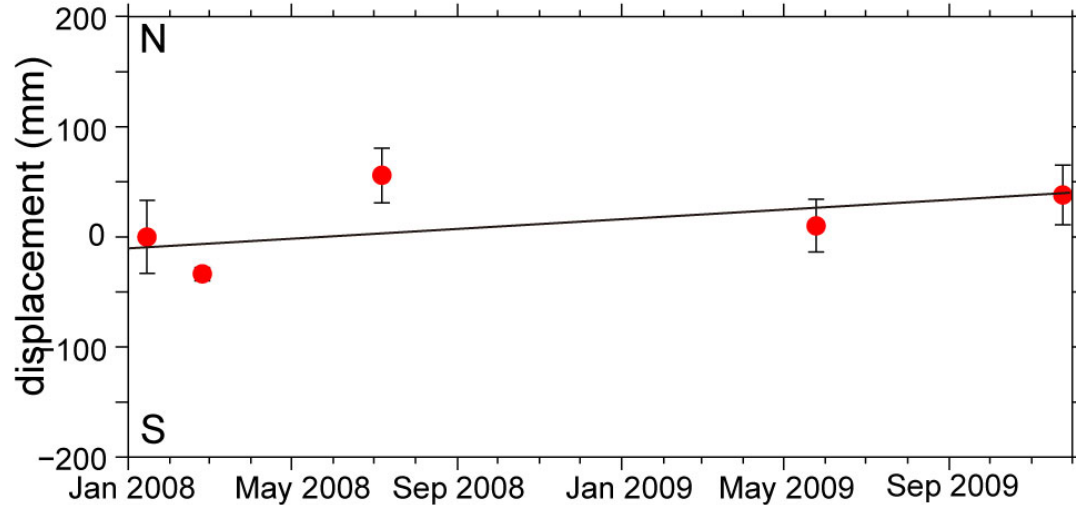
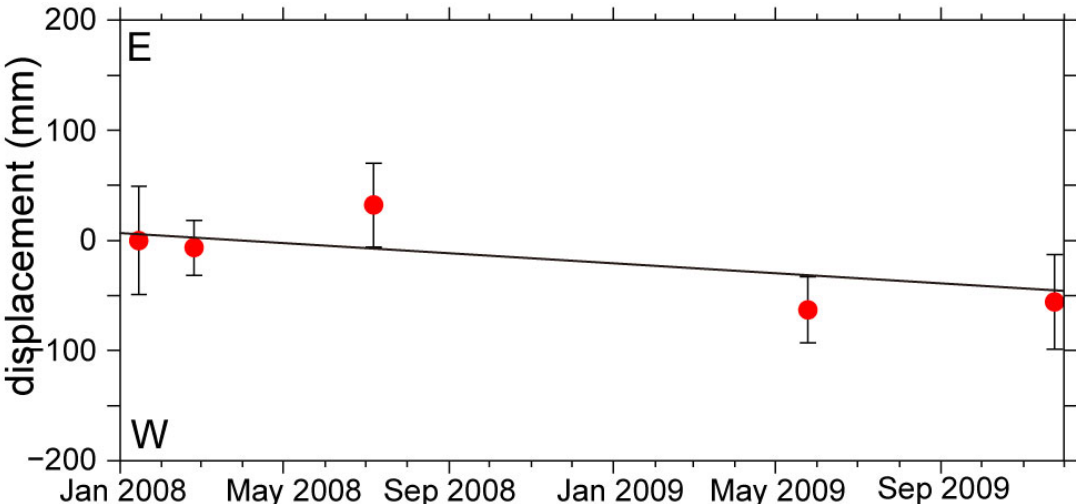
Kodaira et al. (1996)

Distribution of travel time residuals



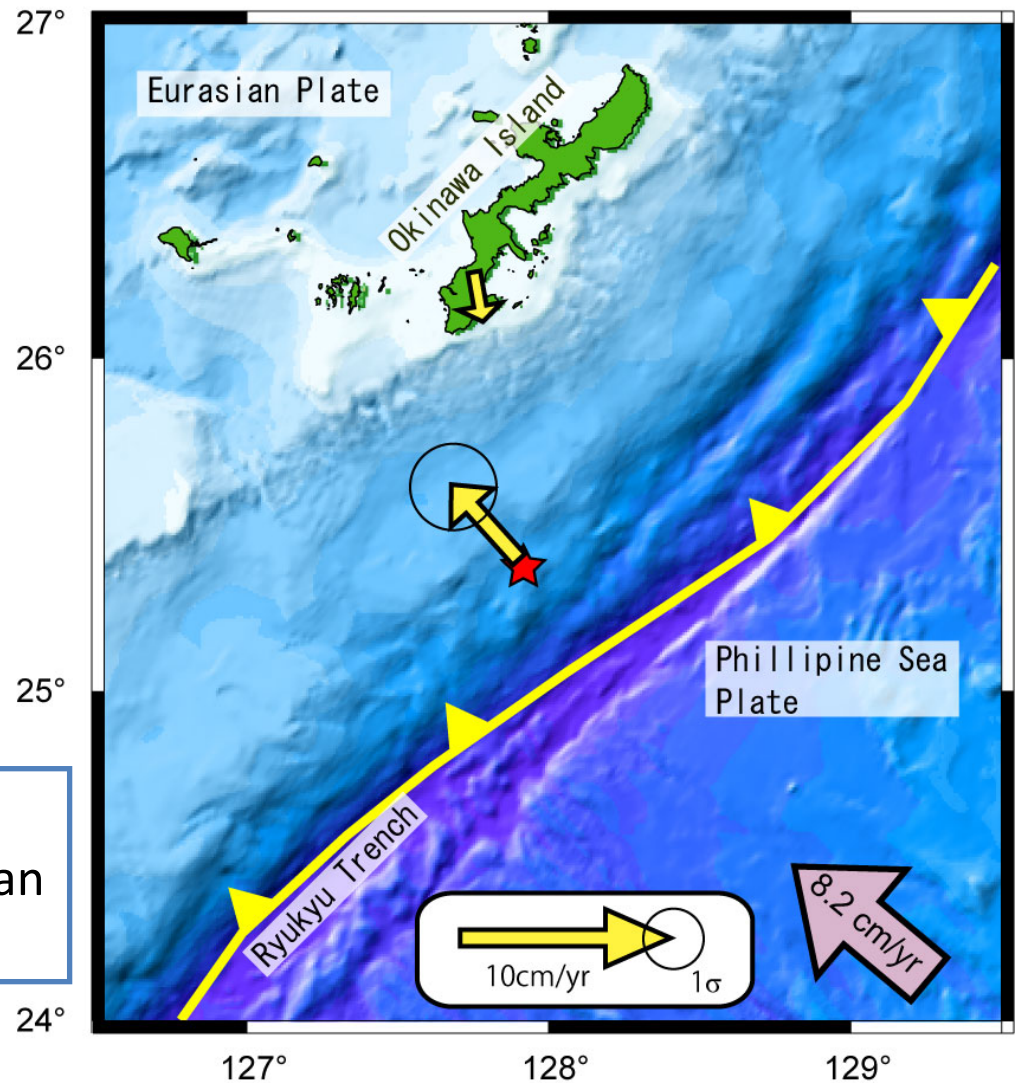
Rms: 70 micro-sec

Result of the observations

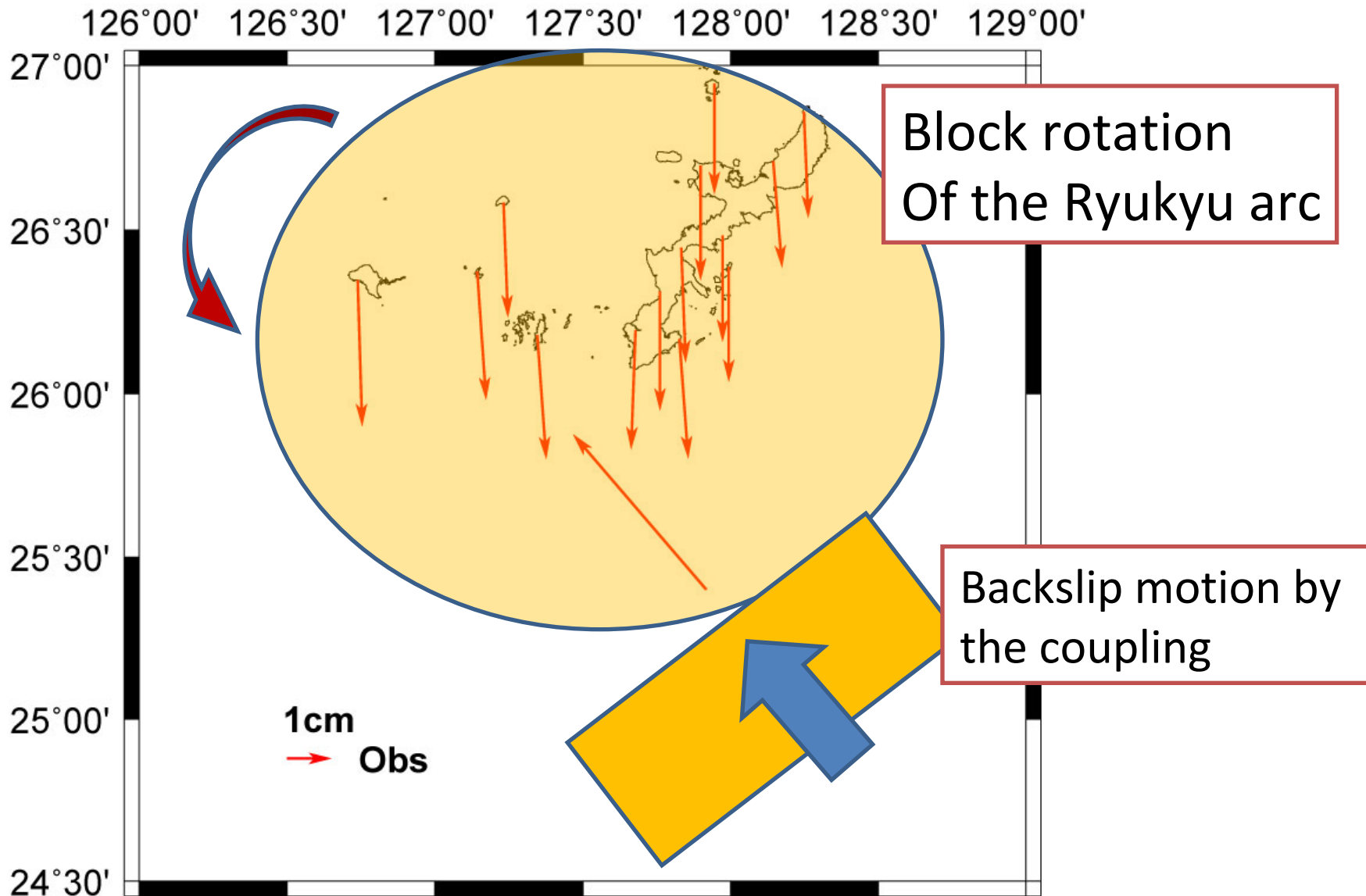


Velocity of the benchmark

Horizontal velocity of the benchmark relative to the Amurian plate

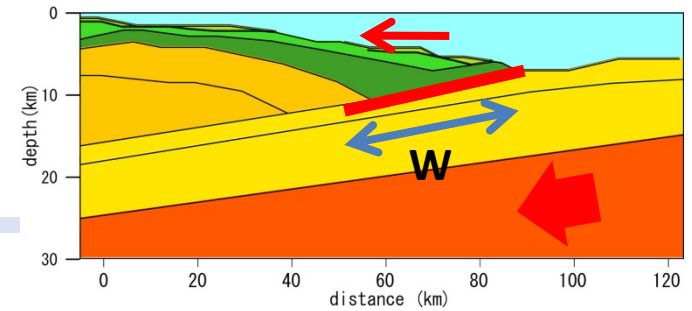


Calculation of displacements

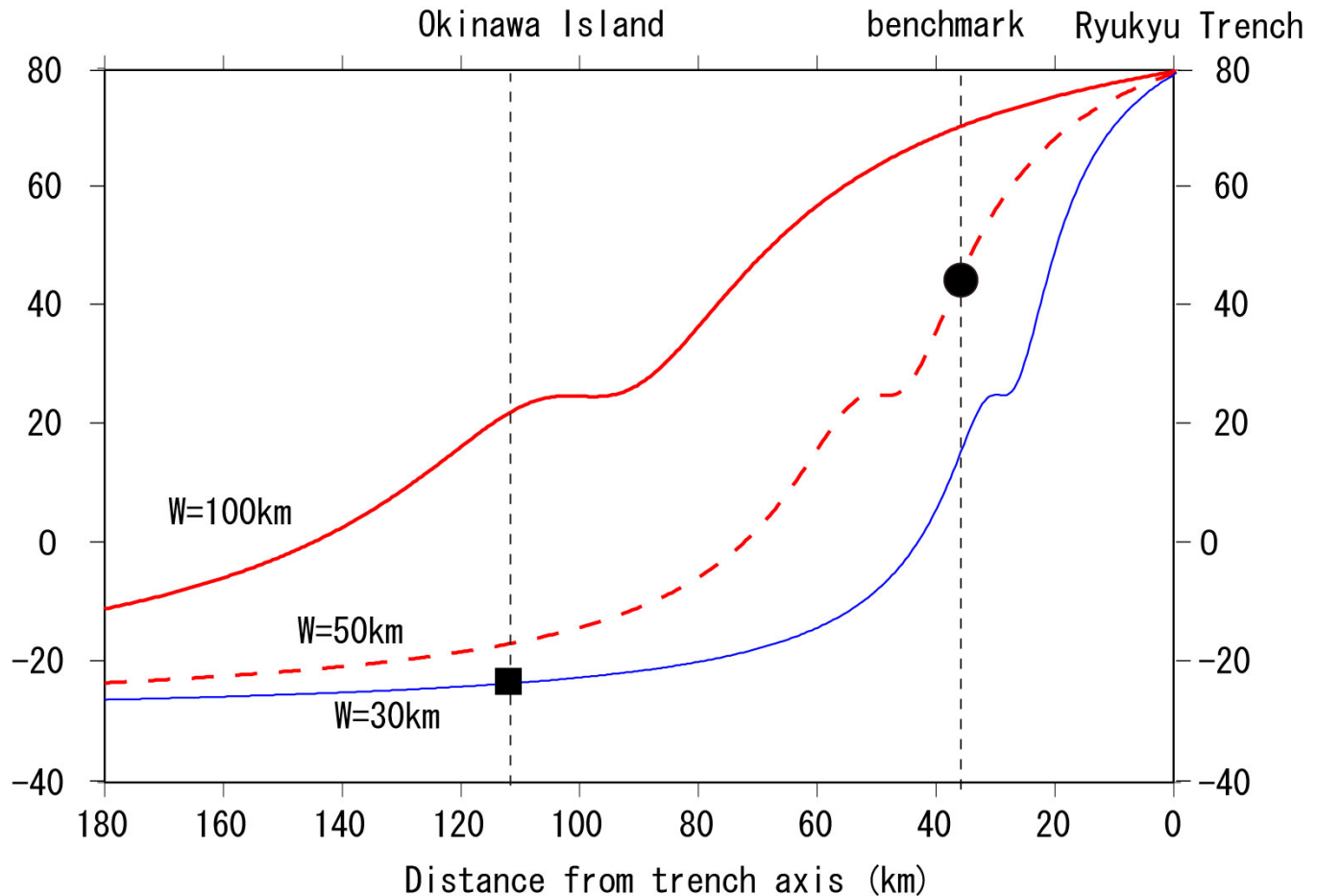


Width of the coupled zone

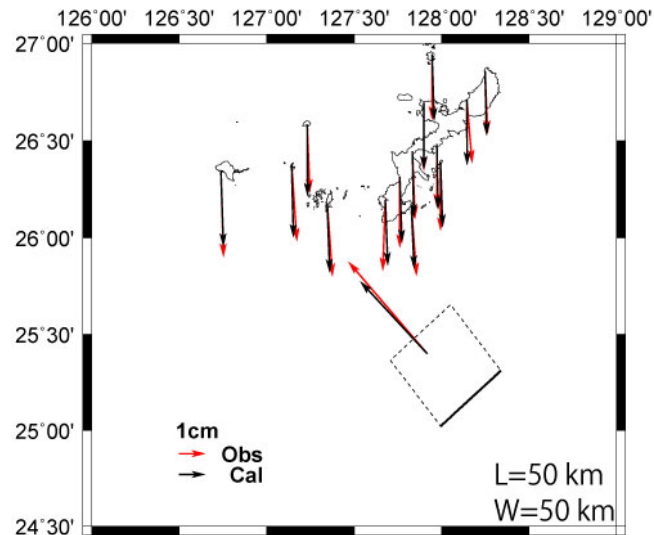
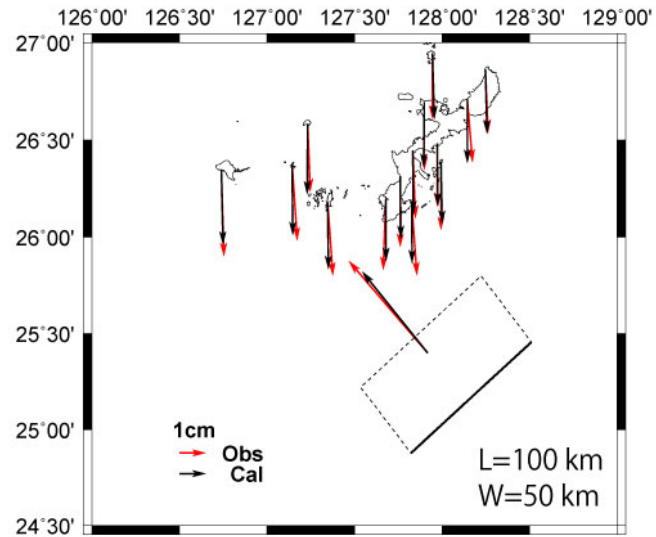
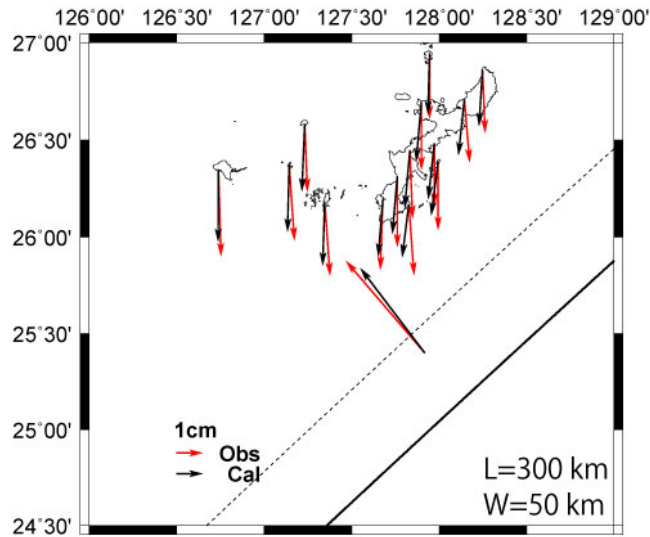
Horizontal velocity of the benchmark relative to the Amurian plate (NW direction: positive)



Horizontal displacement by the interplate coupling (mm/yr)

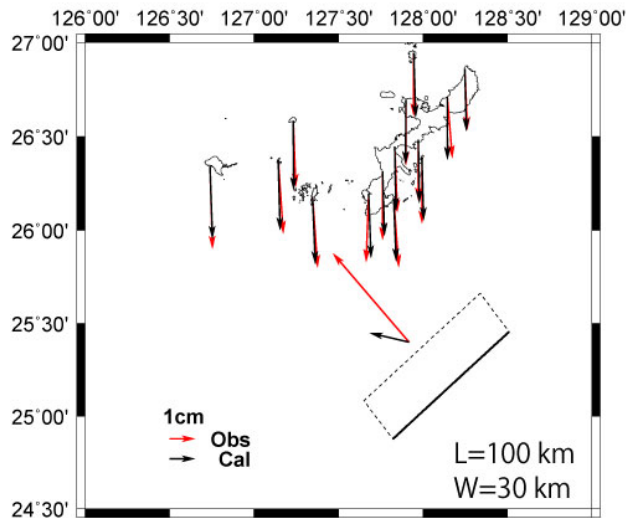
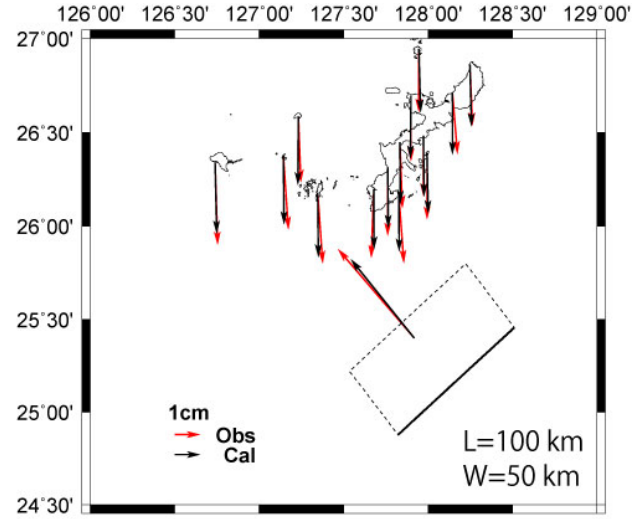
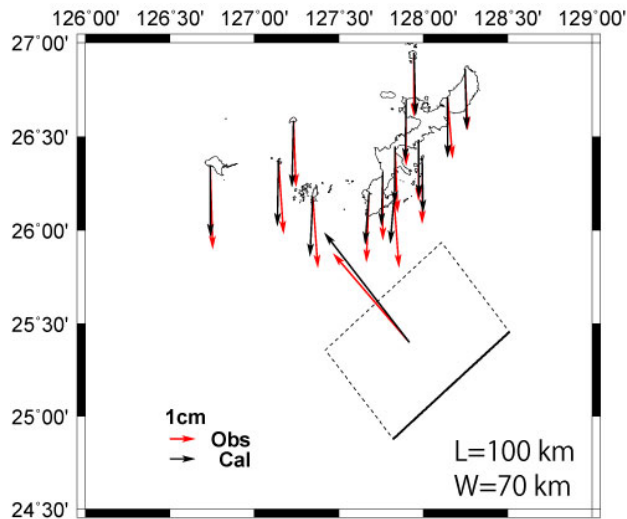


Backslip model (1)



No slips from trench to 50 km width

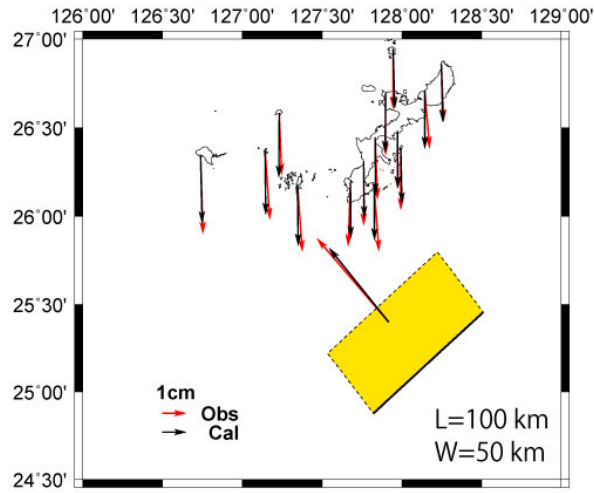
Backslip model (2)



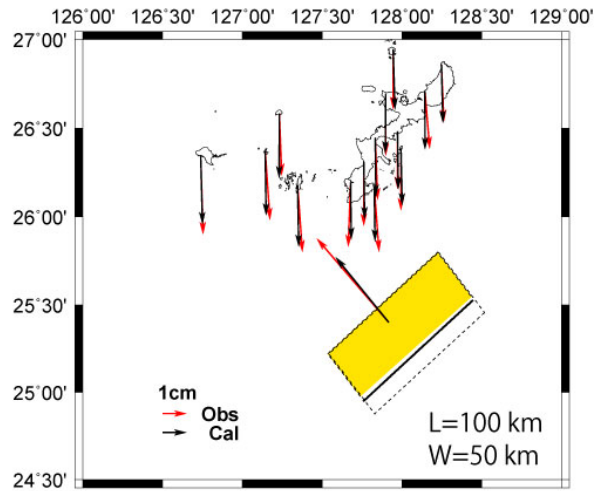
No slips from trench to 30~70 km widths

Backslip model (3)

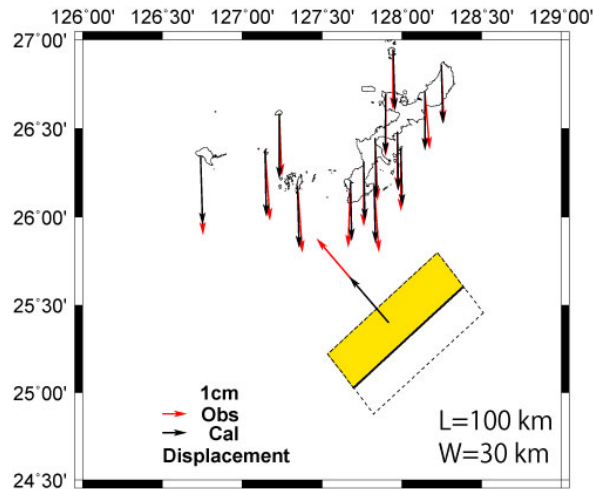
No slips 0~50 km width



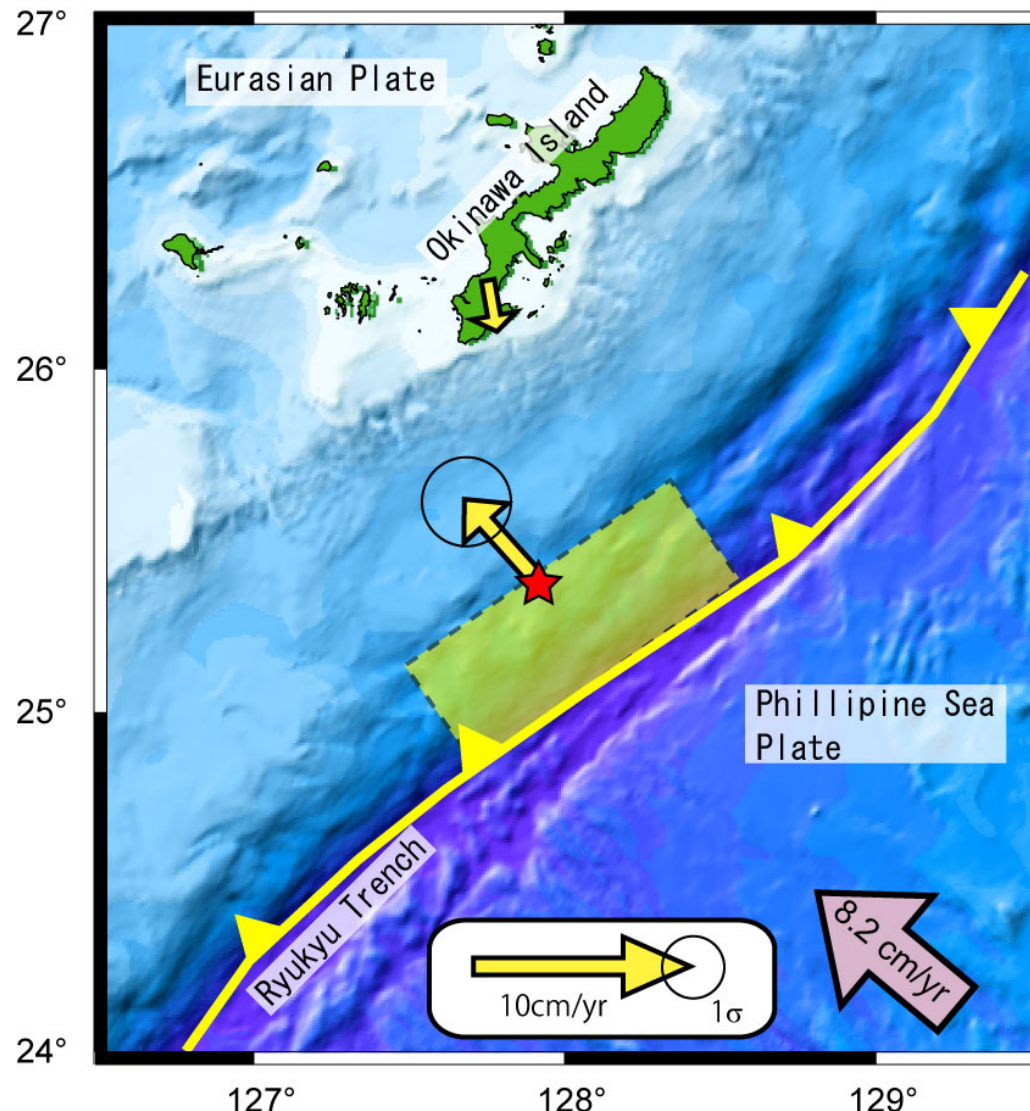
No slips 10~50 km width



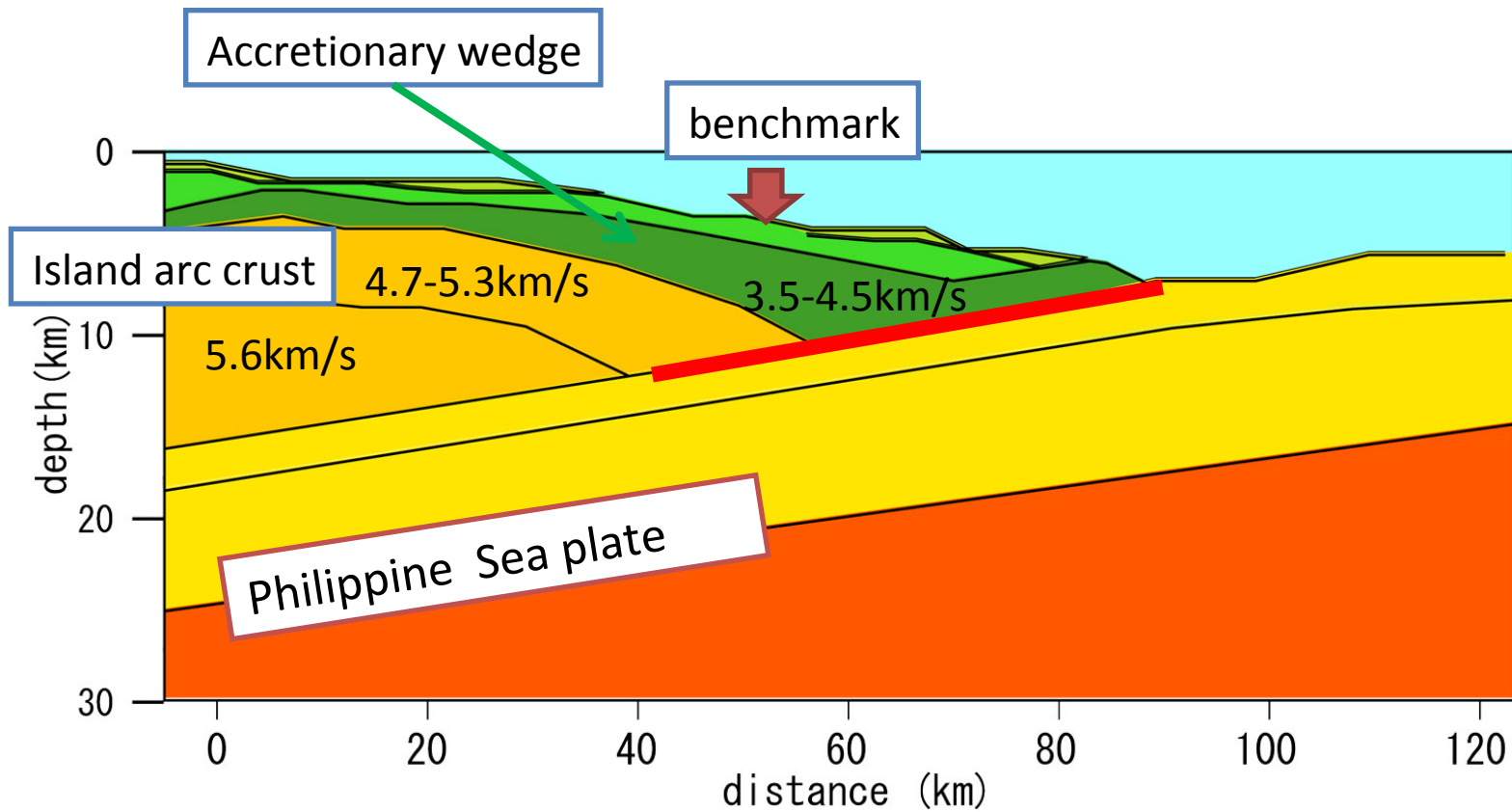
No slips 20~50 km width



Model of coupling area

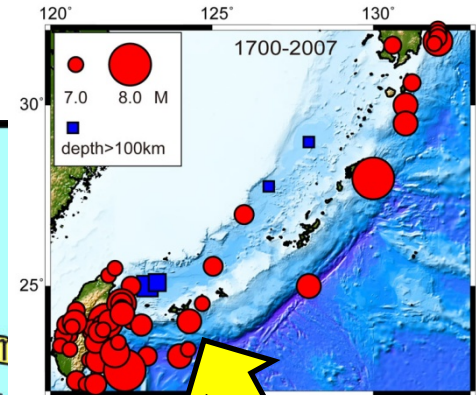
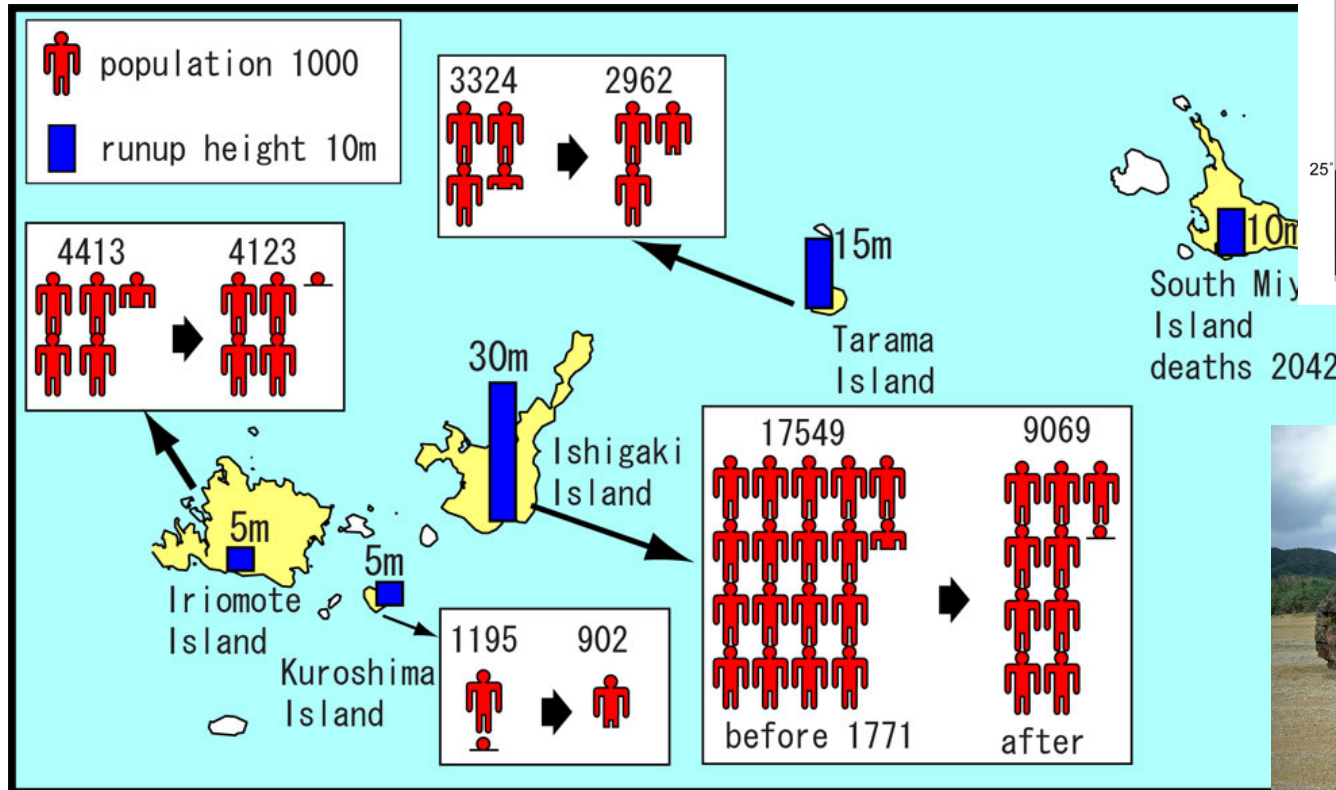


Vertical cross-section of the central Ryukyu Trench



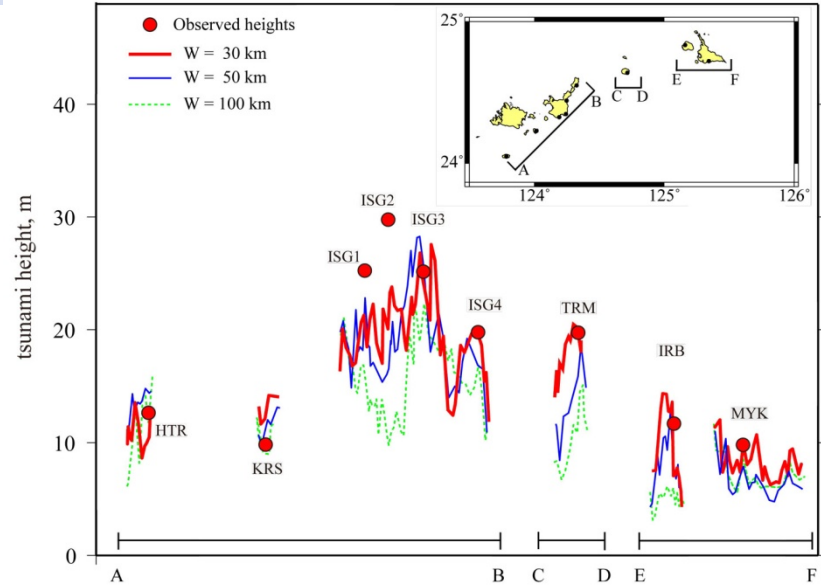
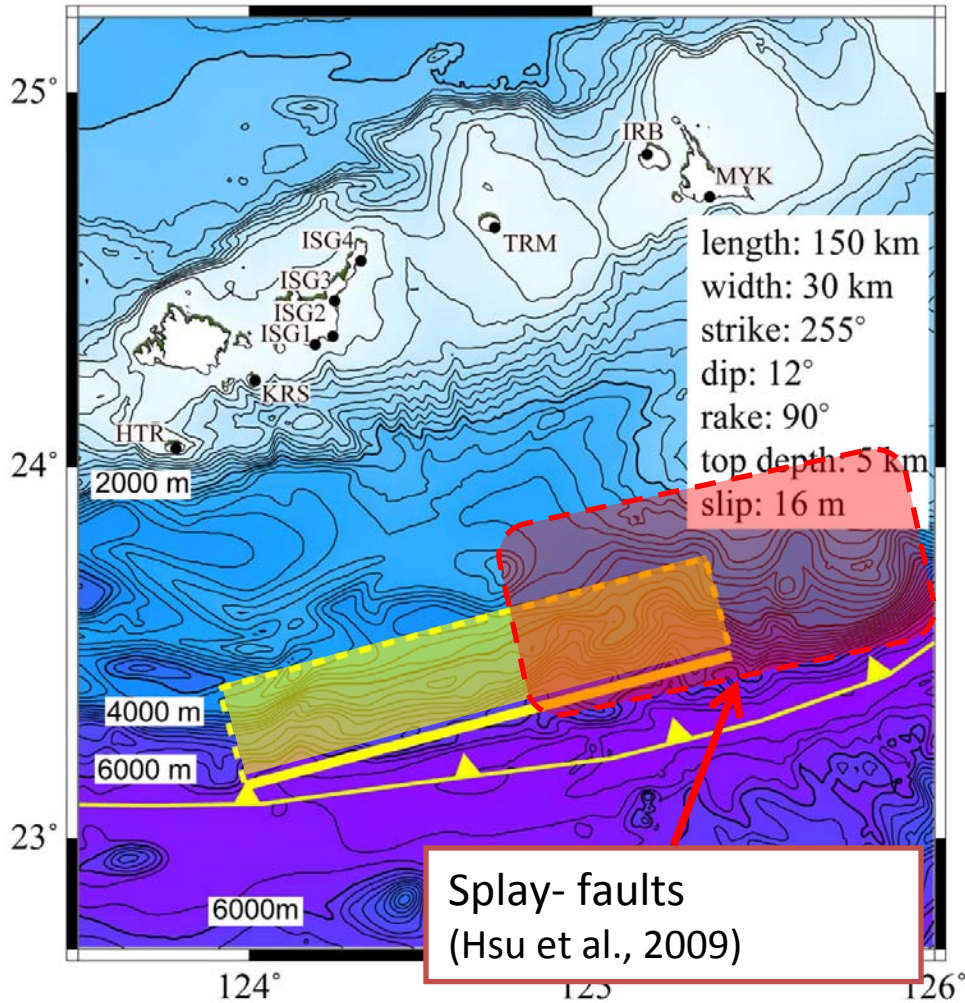
Kodaira et al. (1996)

The 1771 Yaeyama earthquake was a tsunami earthquake

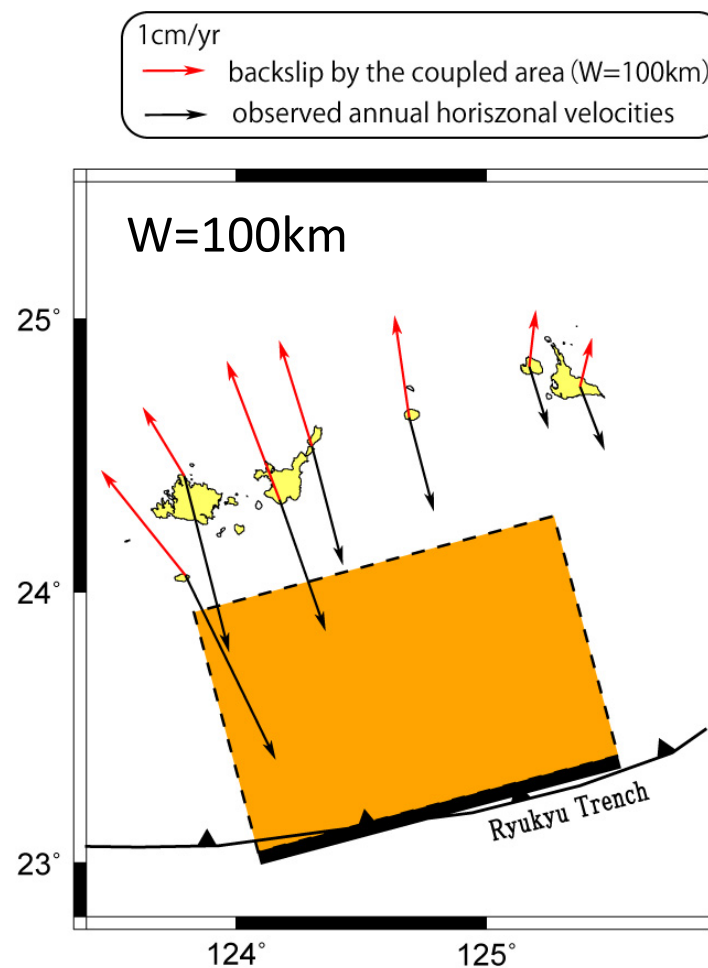
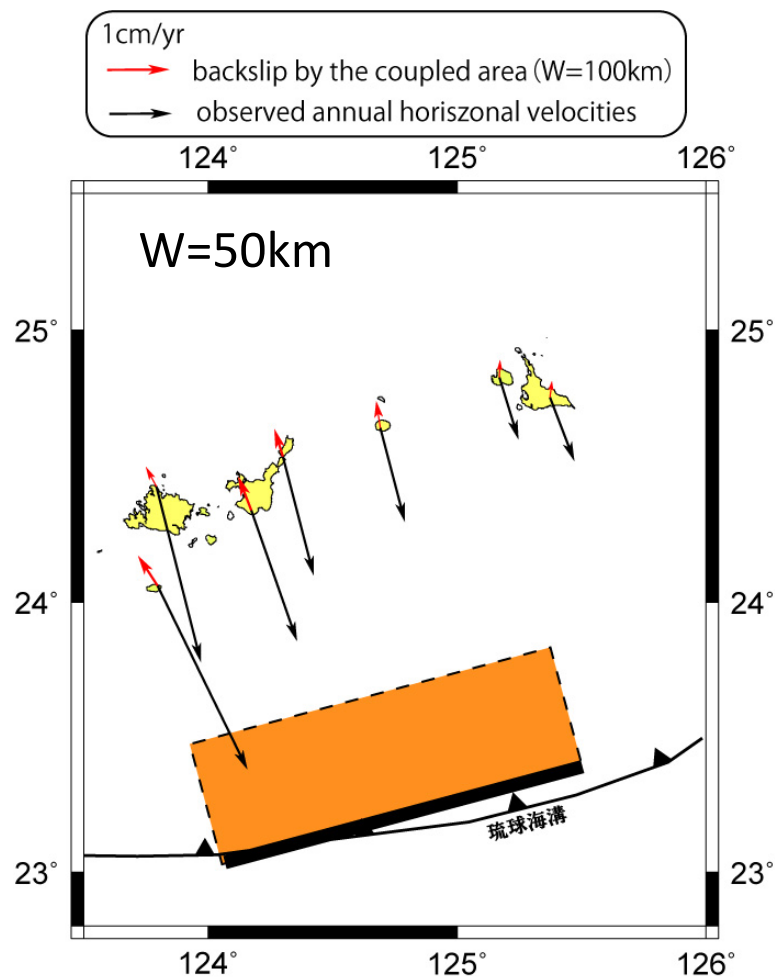


Tsunami runup heights (bars) and population change between before and after the Yaeyama Tsunami.

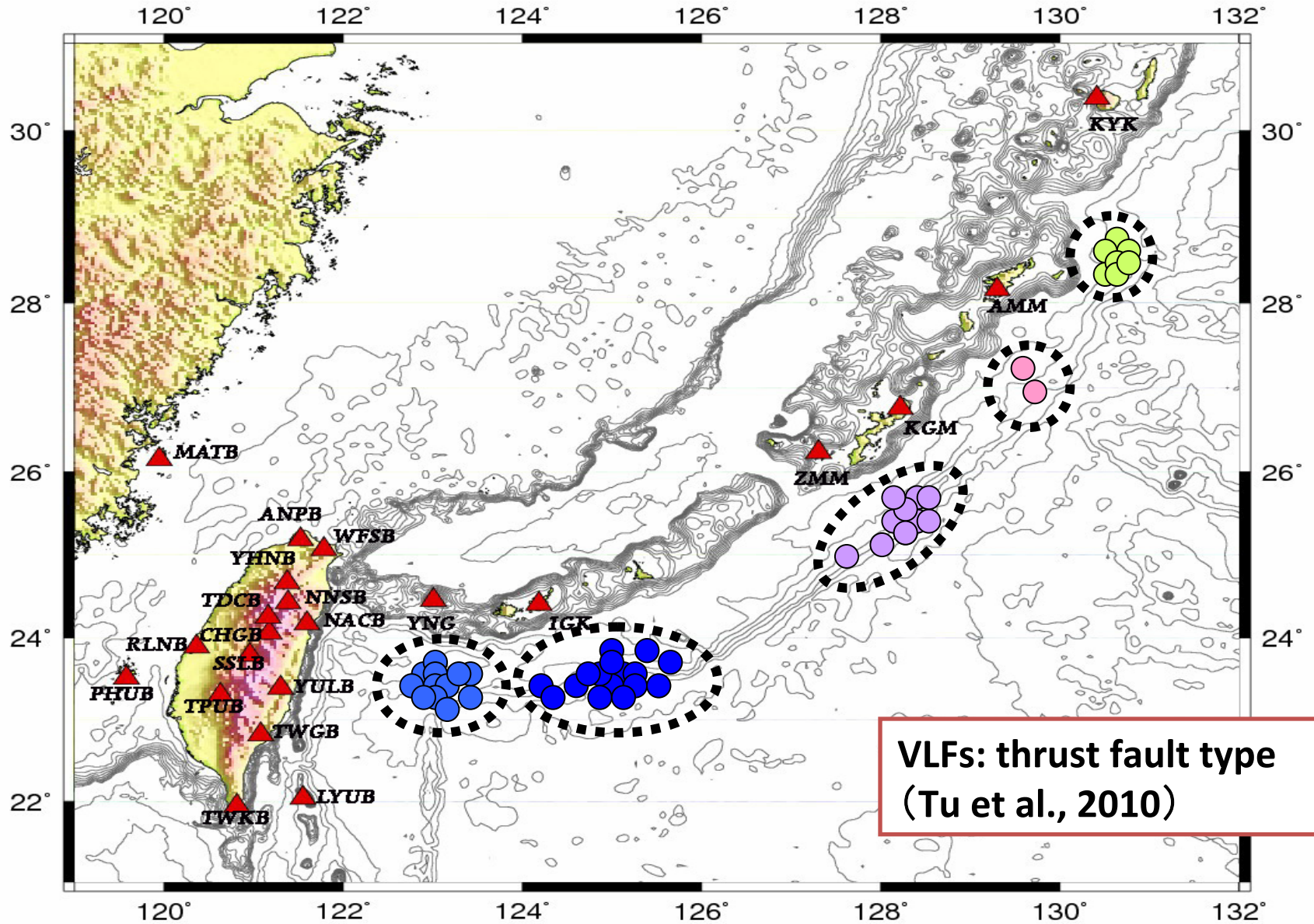
Fault model of the 1771 Yaeyama earthquake



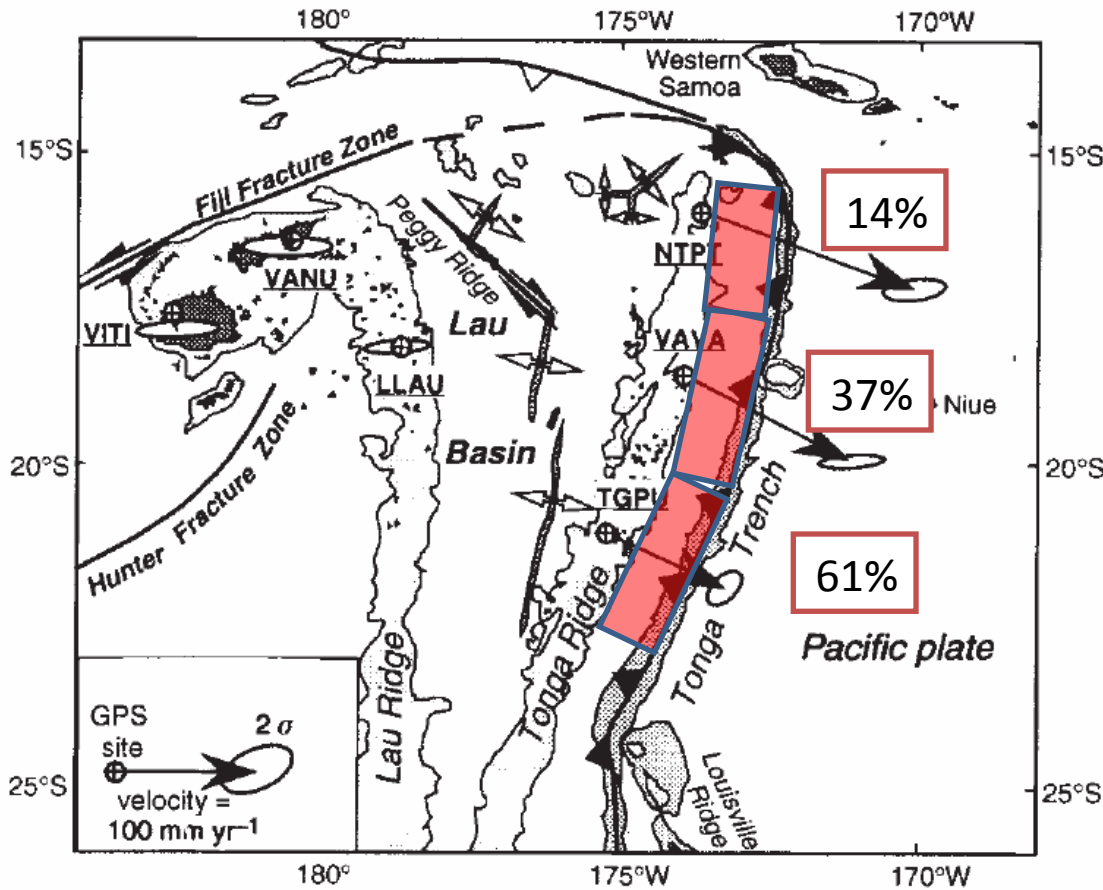
Backslip by the coupled area in the south Ryukyu Trench



The locations of VLF events in 2007 (Tu et al., 2009)



Tonga region



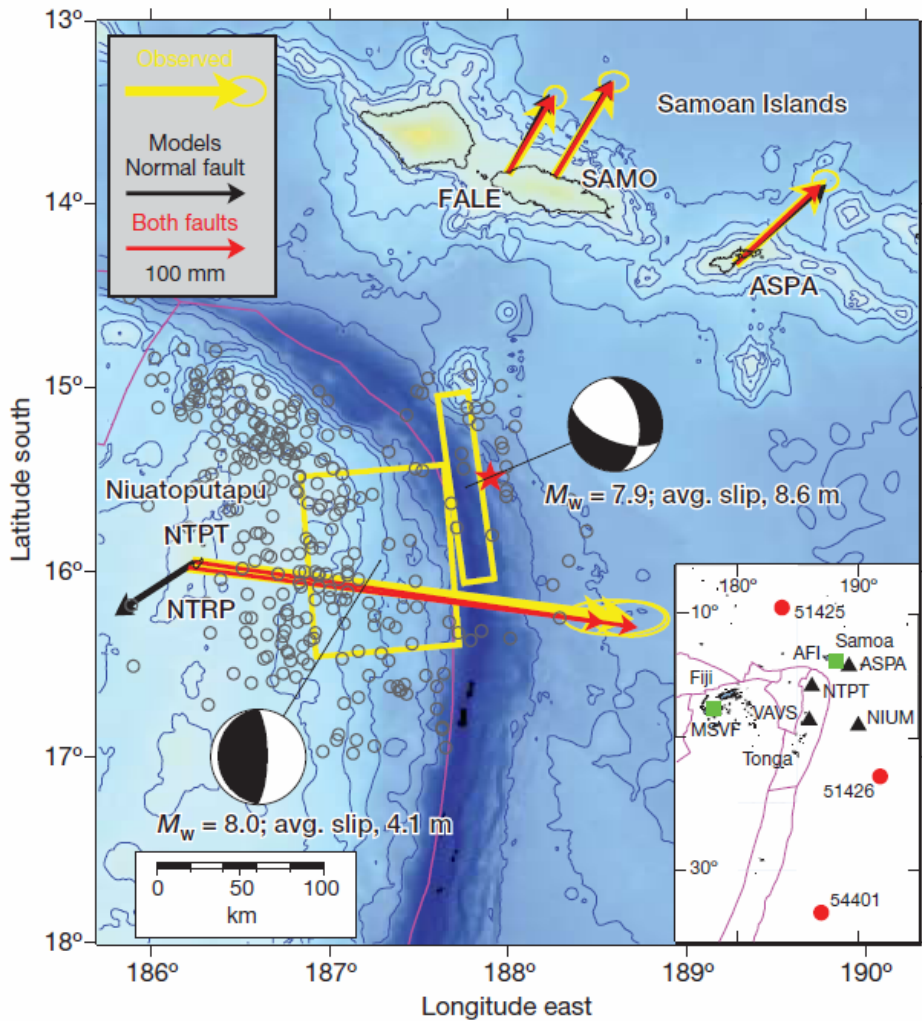
(Bevis et al., 1995, Nature)

Backarc spreading

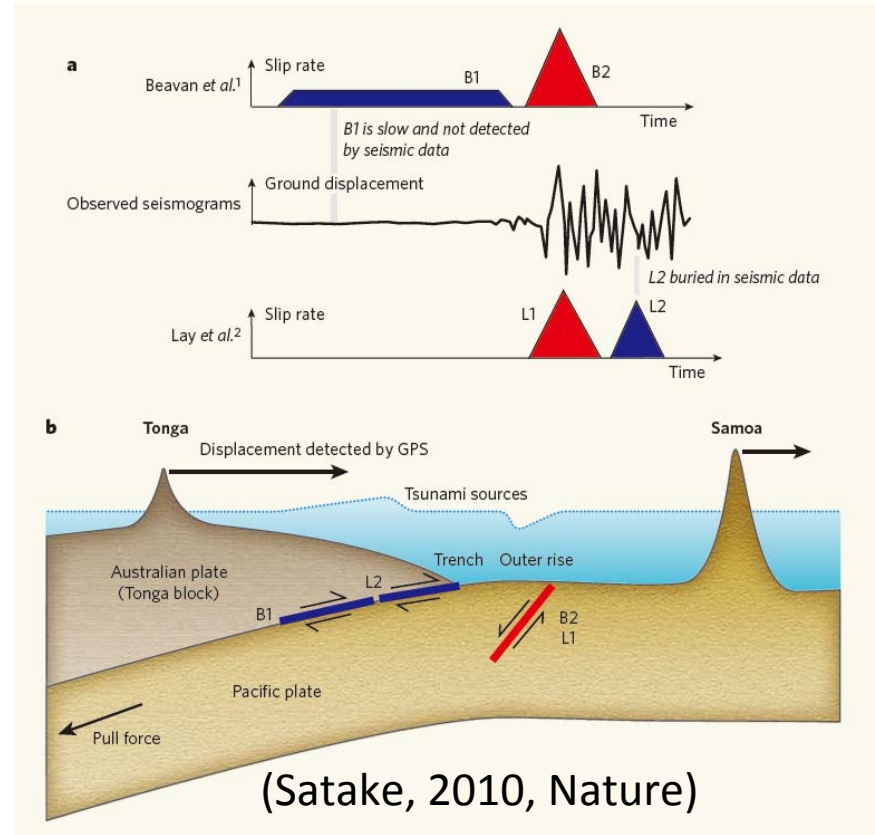
Weak interplate coupling ?

Seismic coupling
(motion of the backarc spreading is not included in the calculation)
(Pachenco & Sykes, 1993 JGR)

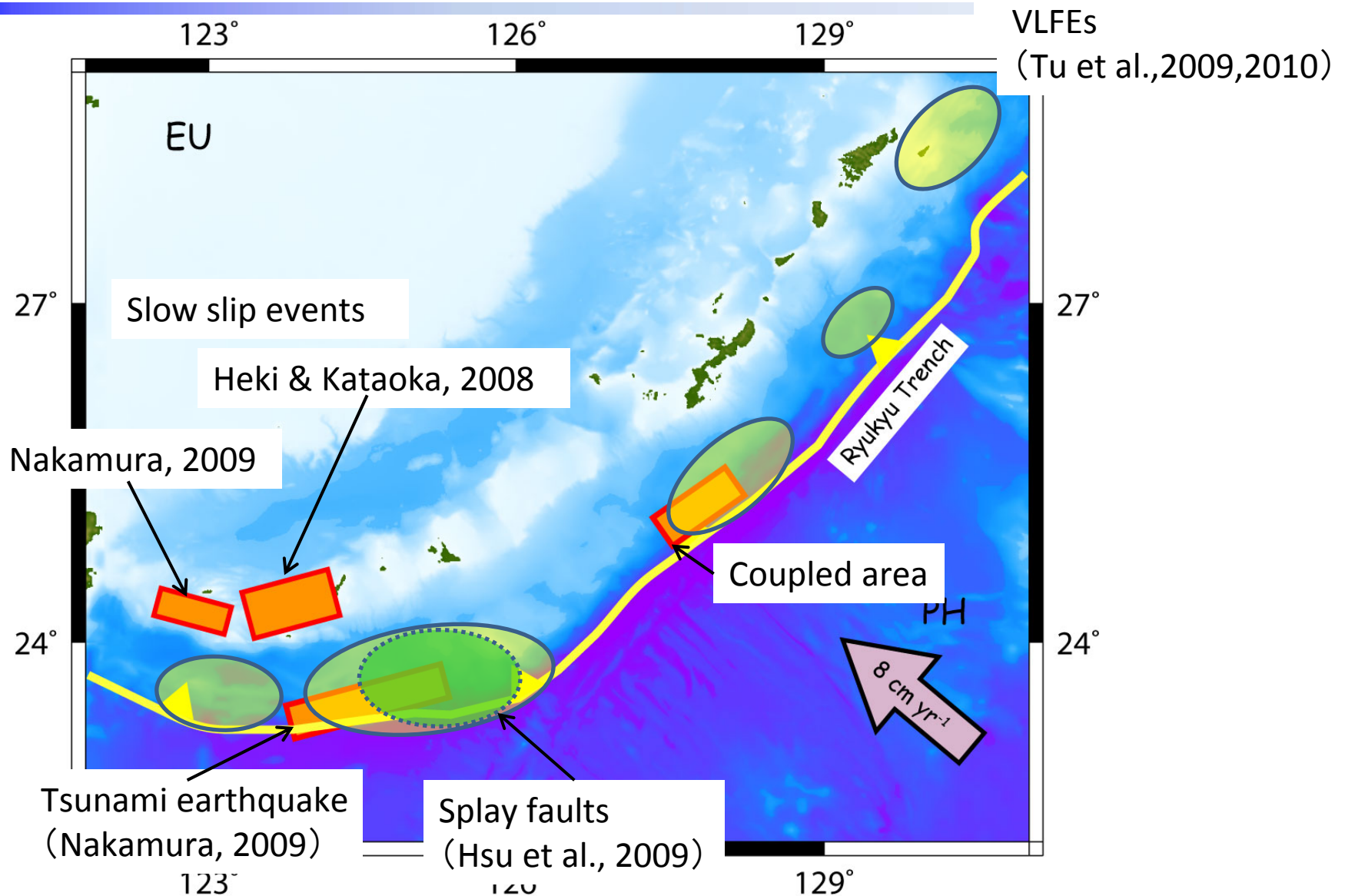
The 2009 Samoa-Tonga earthquake



(Beavan et al., 2010, Nature)

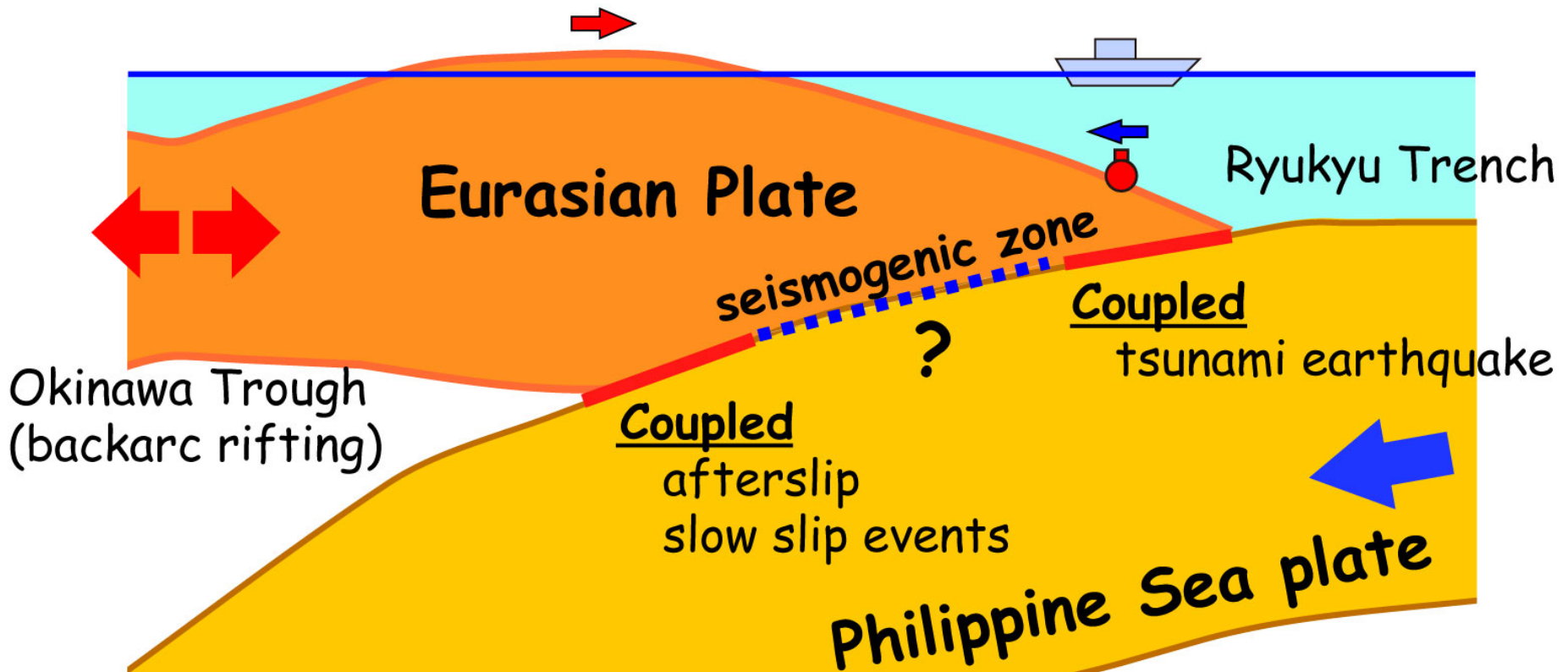


Distribution of coupled area, splay faults, and source of tsunami earthquake in the Ryukyu Trench



Interplate coupling and possibility of large earthquakes in the Ryukyu region

Interplate coupling in the Ryukyu subduction



Conclusions

- The coupled area near the central Ryukyu Trench using the ocean bottom crustal deformation measurement system
 - 50 km width
 - 50~ km length
- Shallow part of the south Ryukyu Trench: possibility of the interplate earthquakes
 - Coupled area (central Ryukyu Trench)
 - Tsunami earthquake (1771 Yaeyama earthquake)