Numerical modeling of crustal deformation in the northeastern Taiwan

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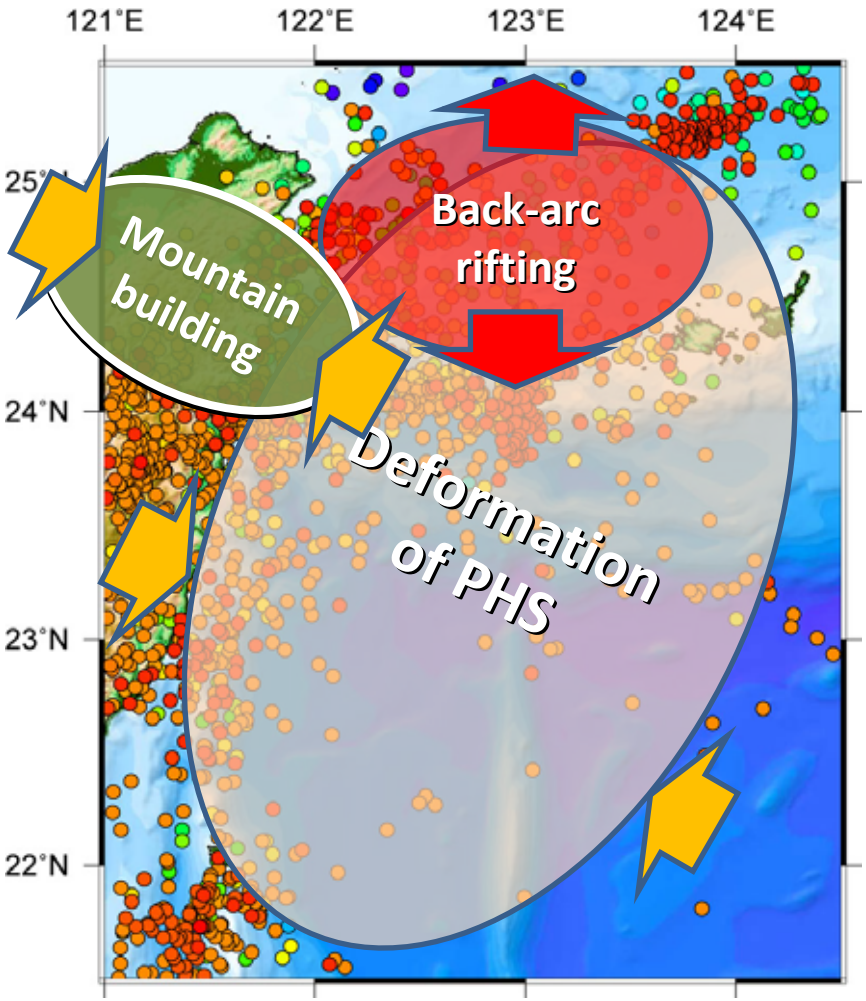
(University of the Ryukyus)

Deformation of Philippine Sea plate

- Deformation process of subducting Philippine Sea plate



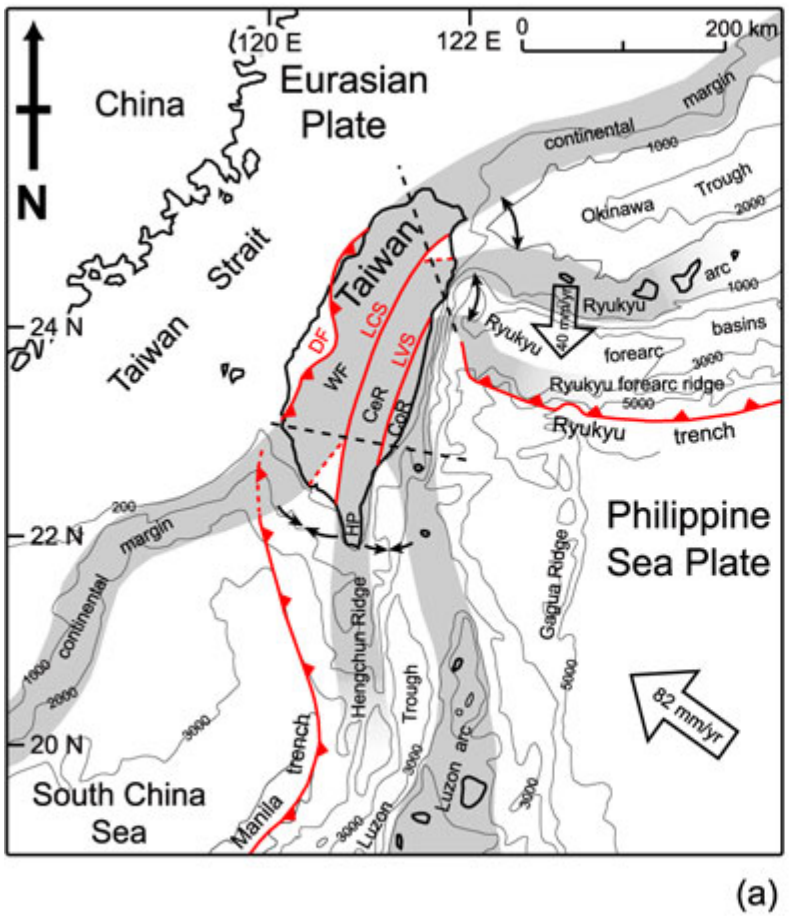
Modeling of tectonic process in Taiwan-Ryukyu area

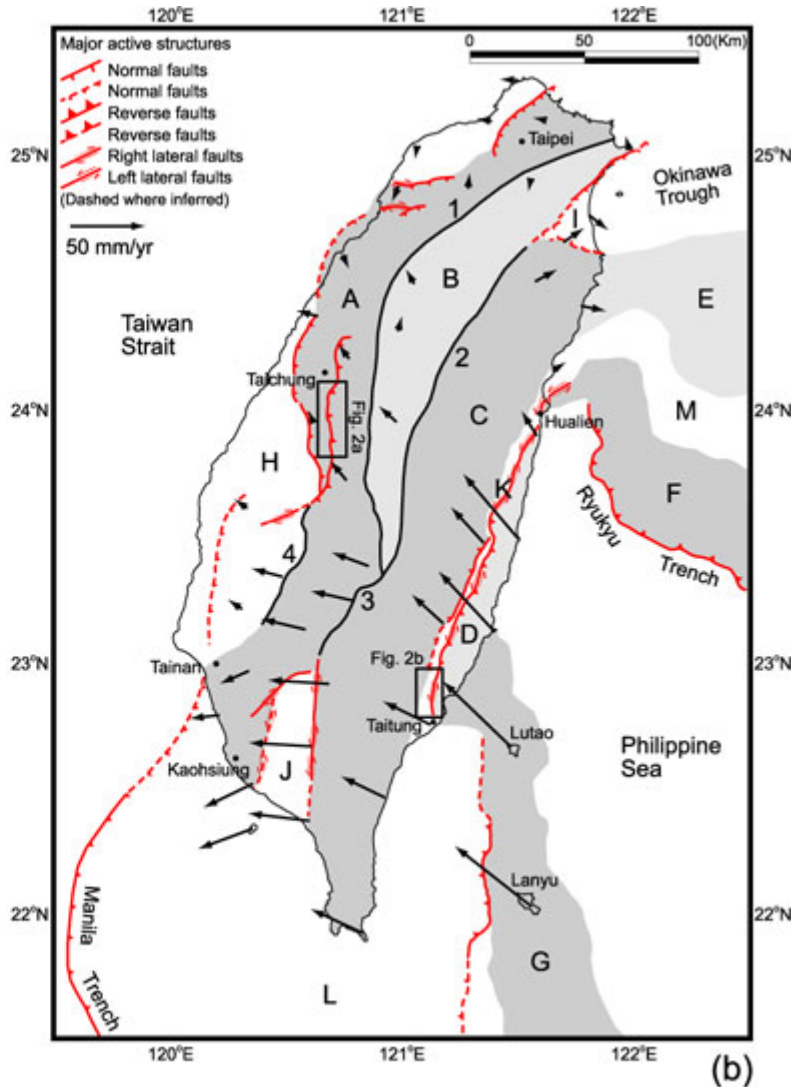
Mountain building process

Mechanism of back-arc rifting

Basis for understating future earthquakes

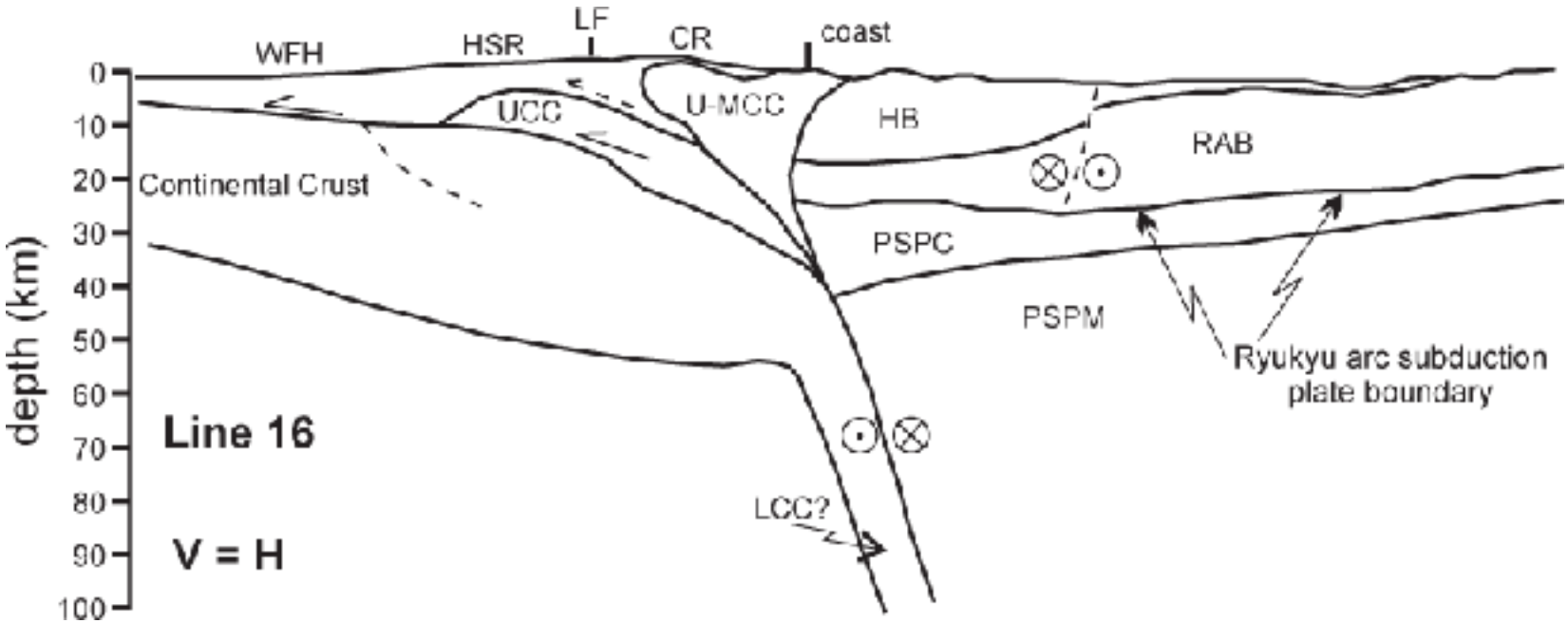
Tectonic snapshot of Taiwan

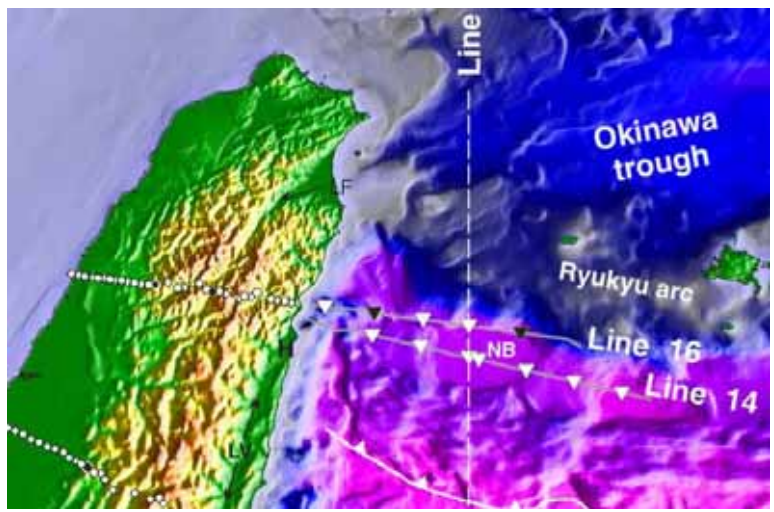




Shyu et al. (JGR, 2005)

Vertical cross section of northeastern Taiwan

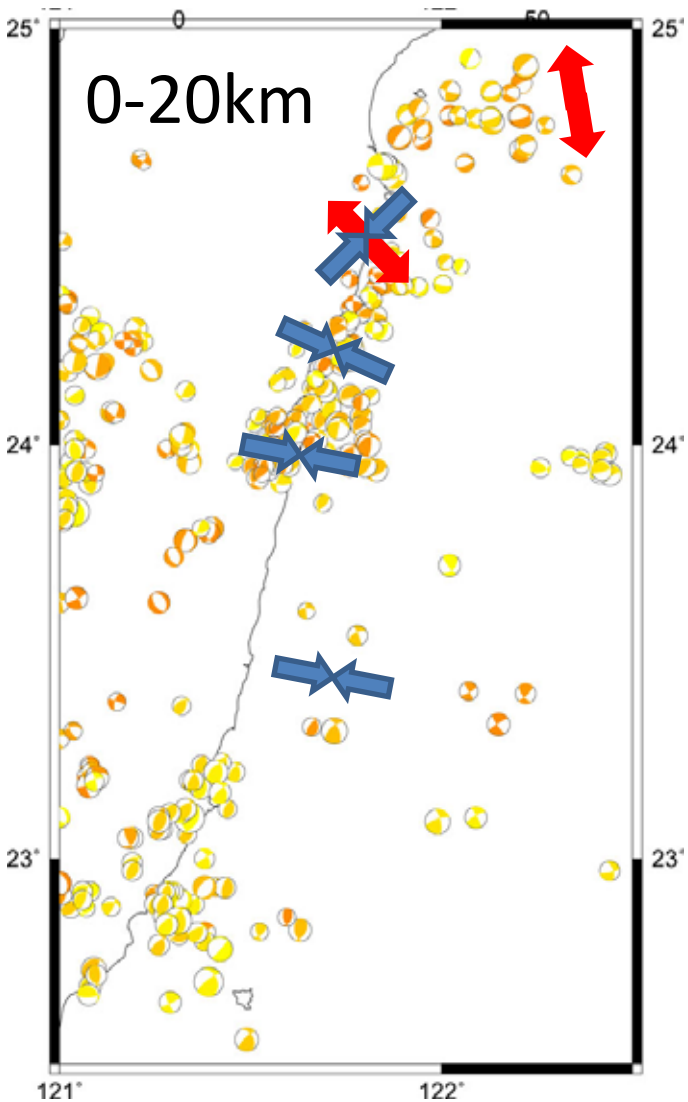


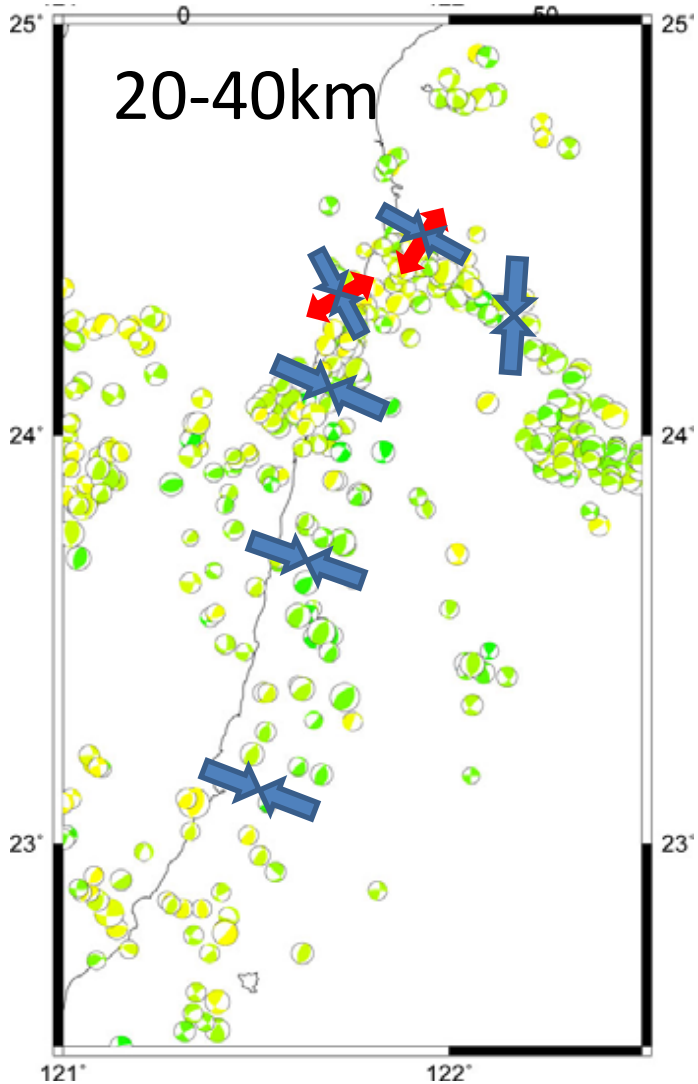


(McIntosh et al., Tectonophysics, 2005)

CMT solutions (shallow)

Earthquake clusters along the coast.
E-W compressional stress
(reverse faults type).
Depth:0-60km.



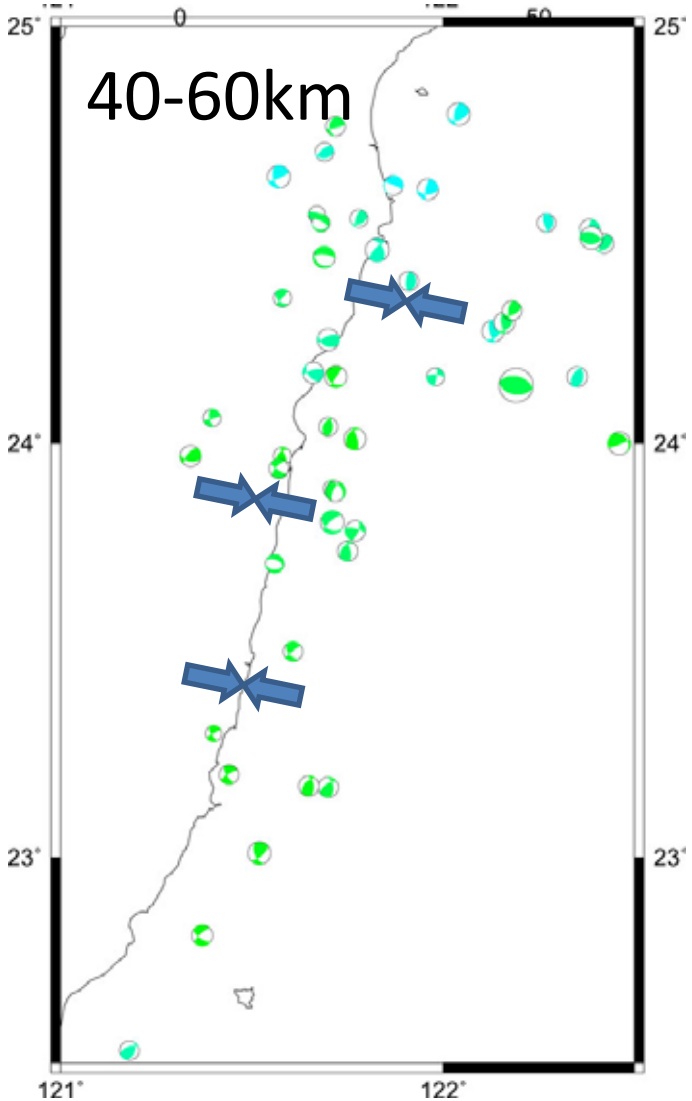


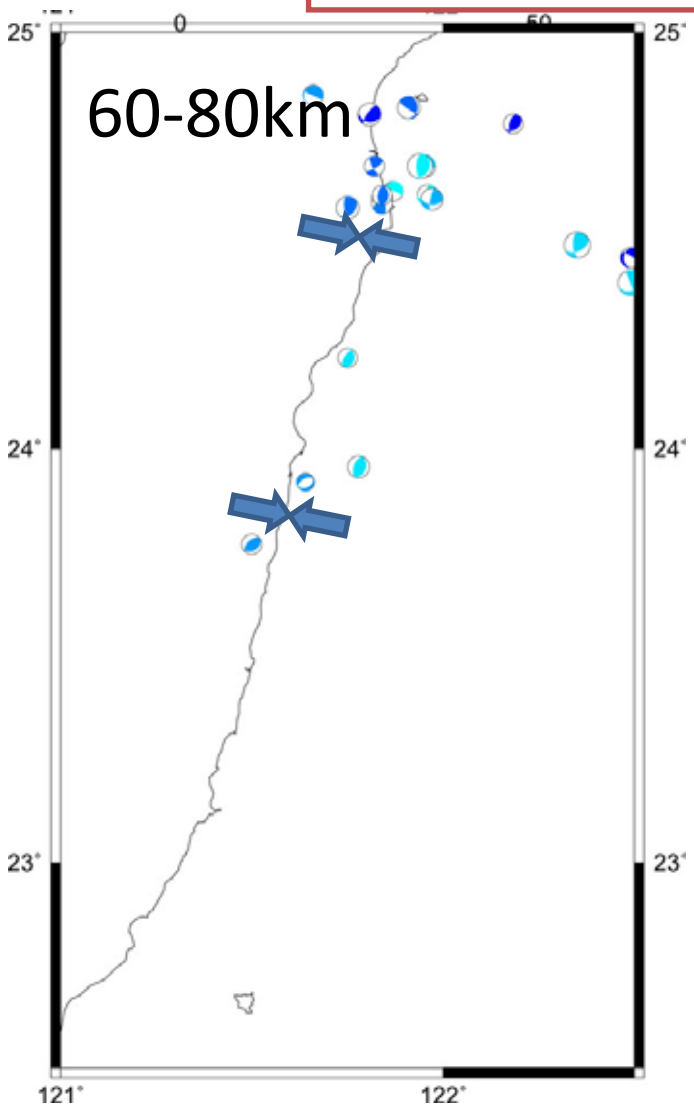
(CMT data : BATS)

Date:1995-2006

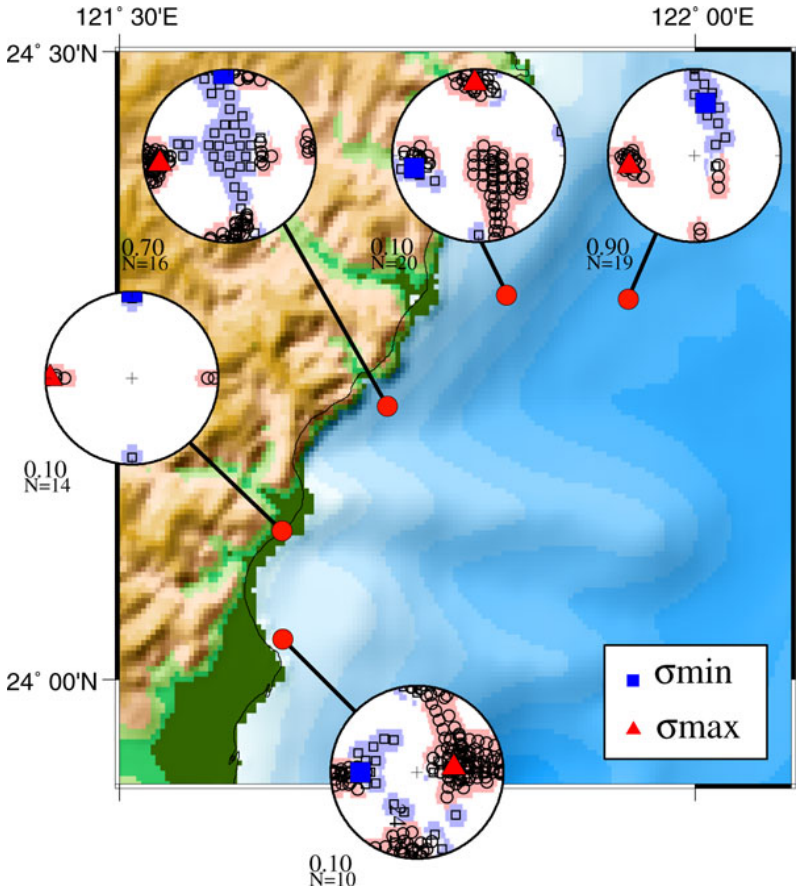
CMT solutions (deep)

Earthquakes clusters along the coast.
E-W compressional stress
(reverse faults type).
Depth:0-60km.

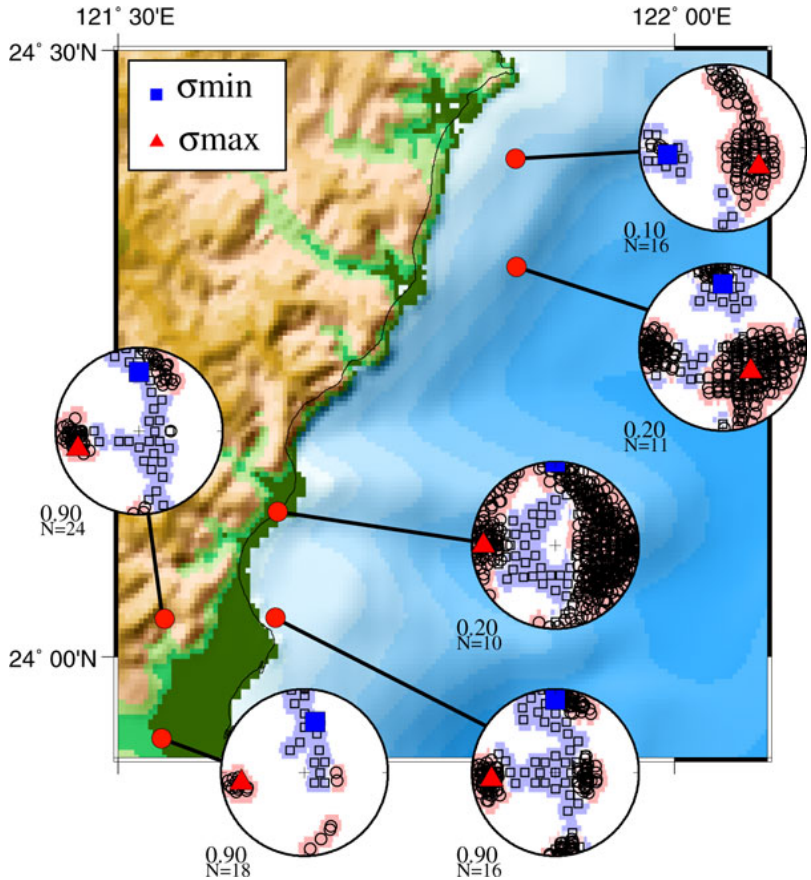




Stress tensor in the northeastern Taiwan



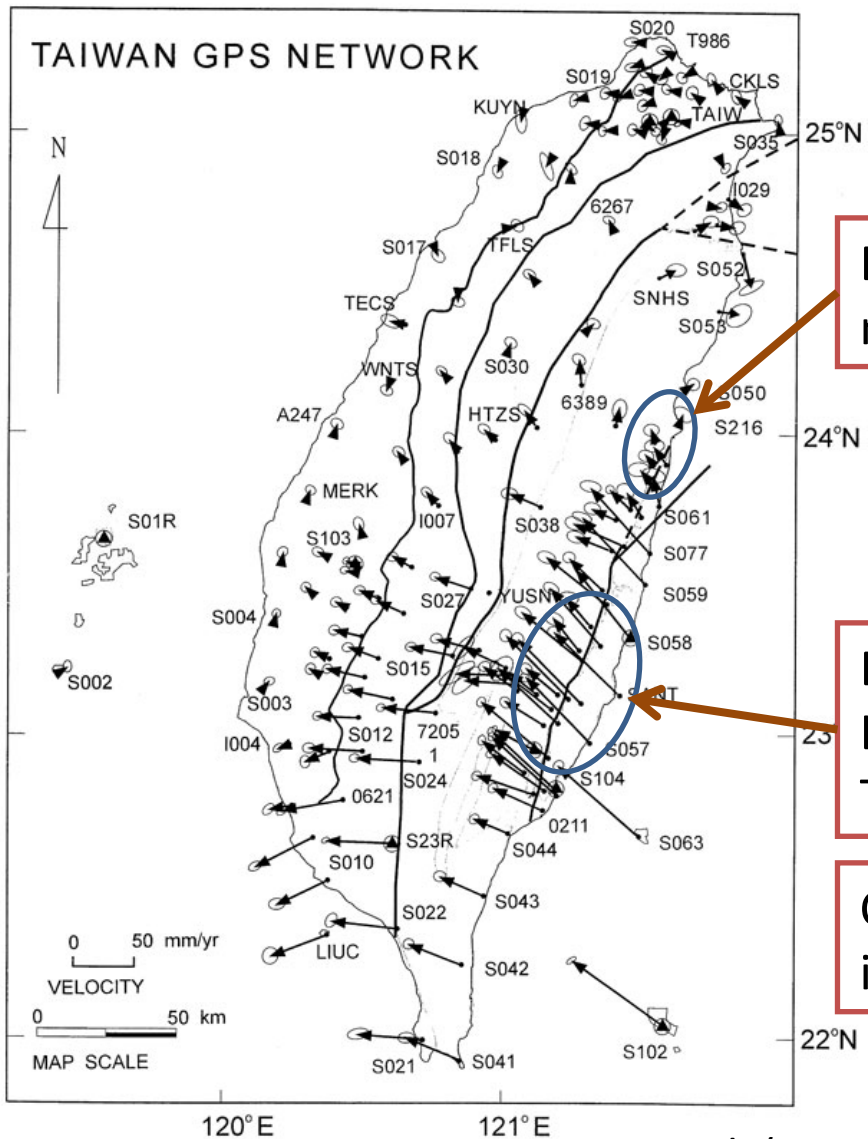
Shallow (dep. 0-25km)



Deep (dep. 25-60km)

Data: BATS
Date:1995-2006
FMSI(Gephart, Comp.&Geosci, 1990)

Observed GPS velocity field in Taiwan



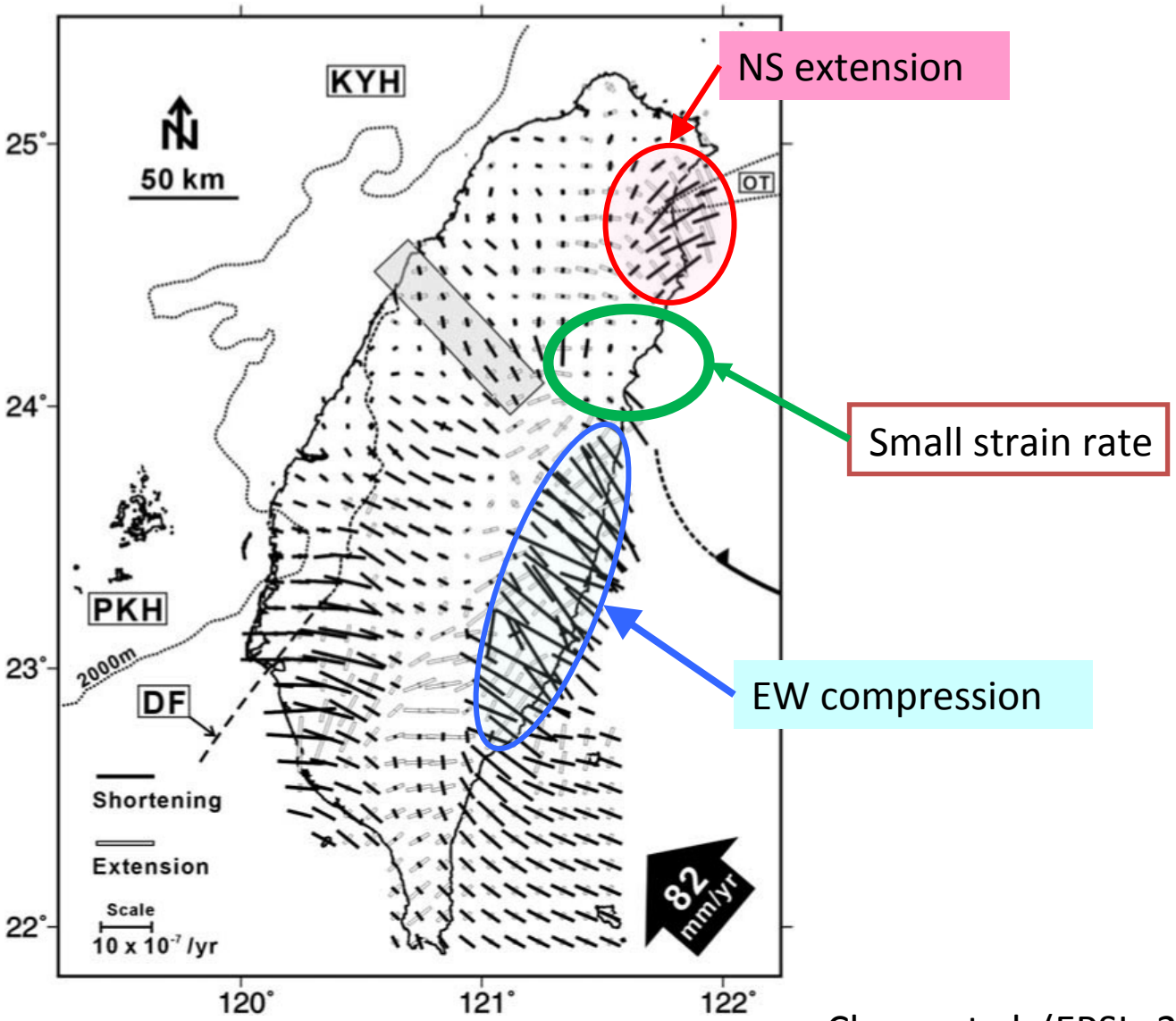
East-west shortening rate in the northeastern Taiwan: 1cm/yr

East-west shortening rate in Longitudinal Valley Fault in eastern Taiwan: 3cm/yr

Convergence rate in the eastern Taiwan is about 8cm/yr in a 306 degrees

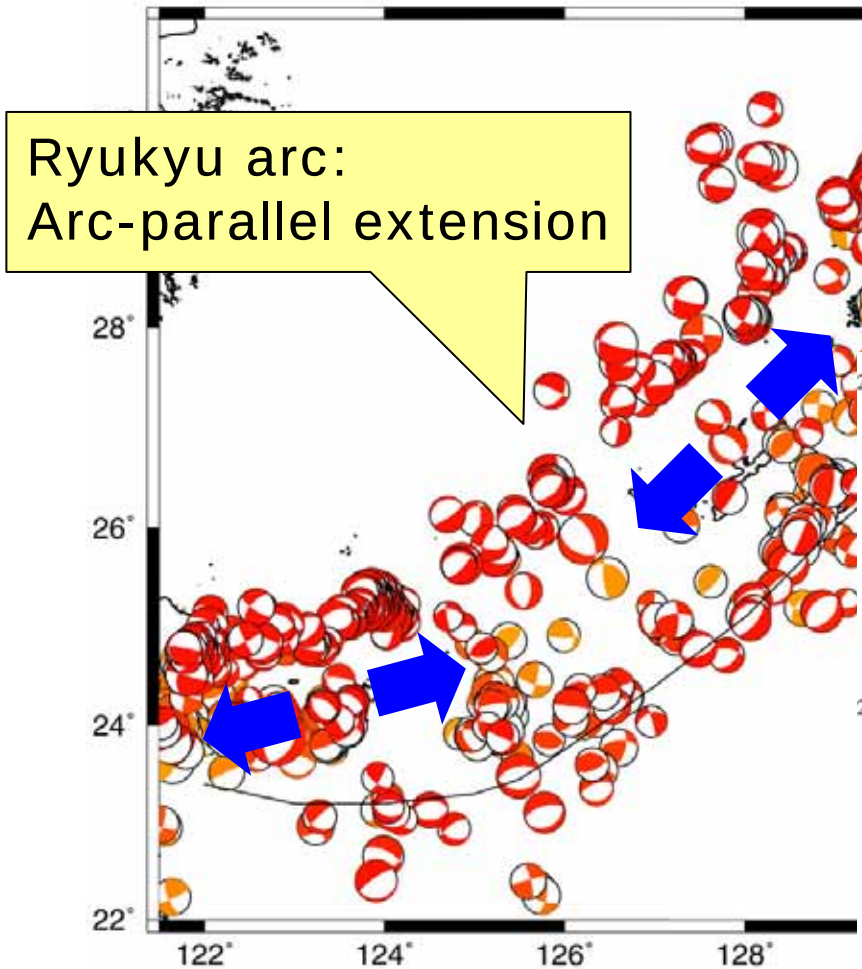
Hu et al. (JGR, 2001)

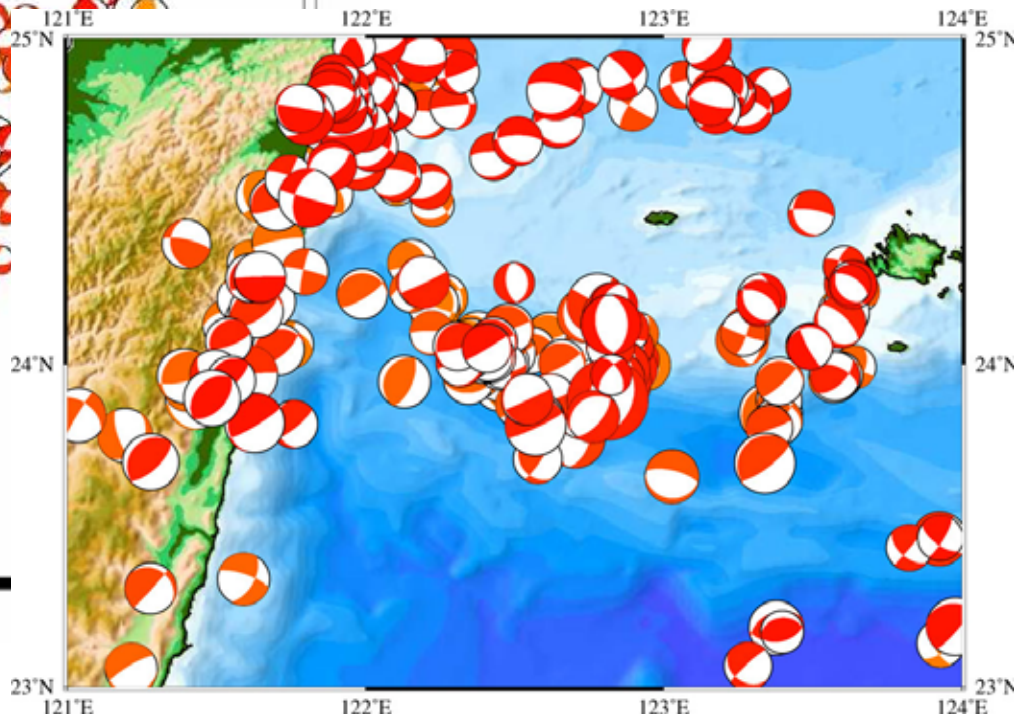
Strain field in the Taiwan



Chang et al. (EPSL, 2003)

Stress field in the Ryukyu arc



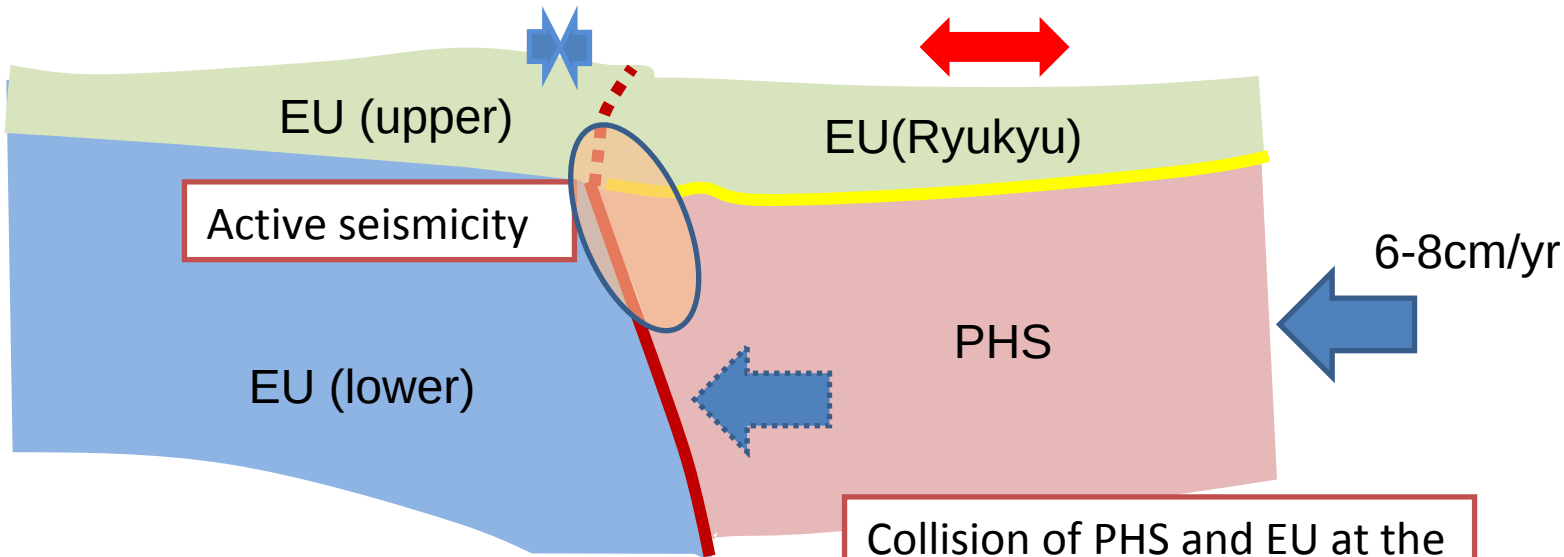


(NIED F-net)

Schematic cross section of northeastern Taiwan

EU(upper)
East-west compressional stress and strain.
Horizontal convergence rate: <1cm/yr.

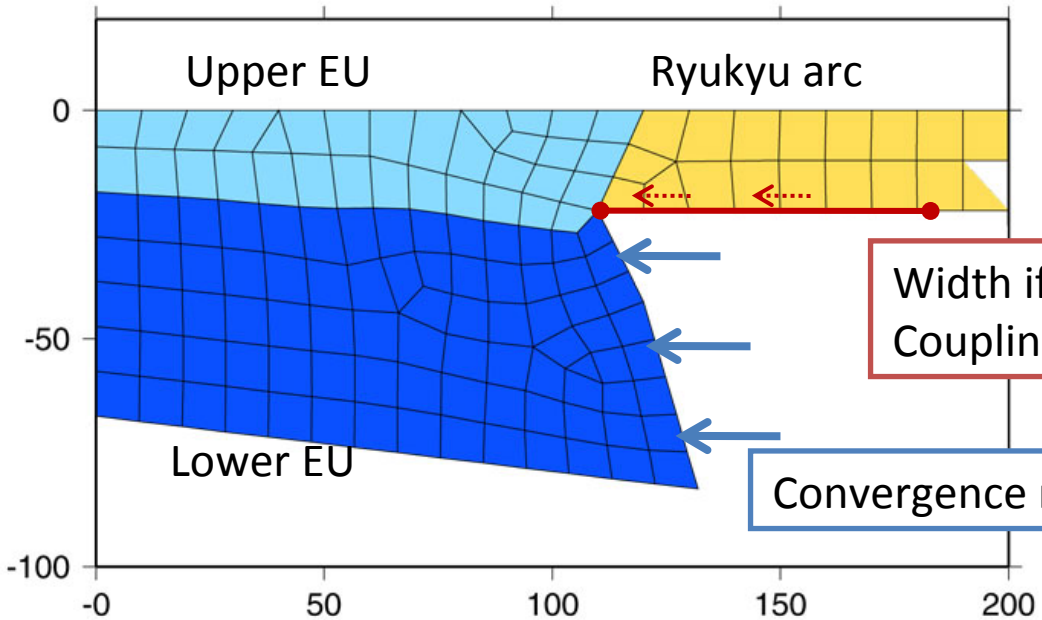
Ryukyu arc area
East-west extensional stress



Collision of PHS and EU at the depth over 20 km

How much is the convergence rate at EU-PHS boundary?

FEM model

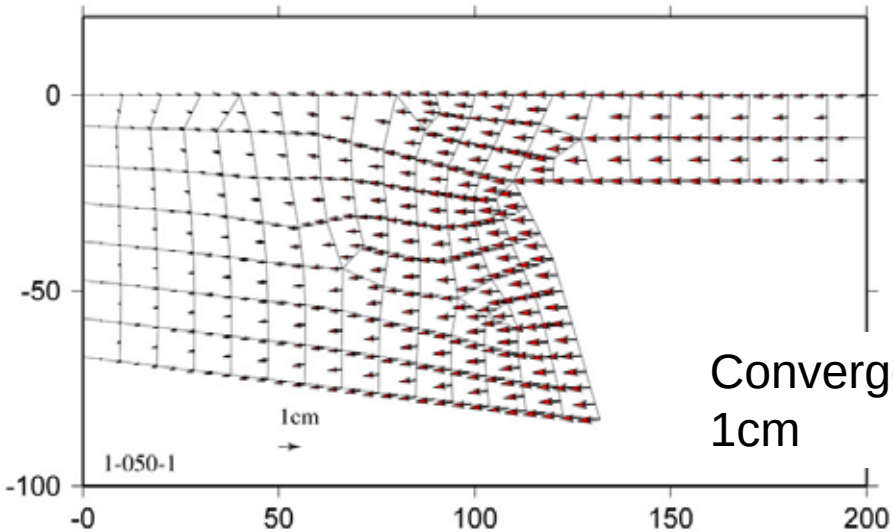


Width if coupling area: 0-100km
Coupling rate: 0-100%

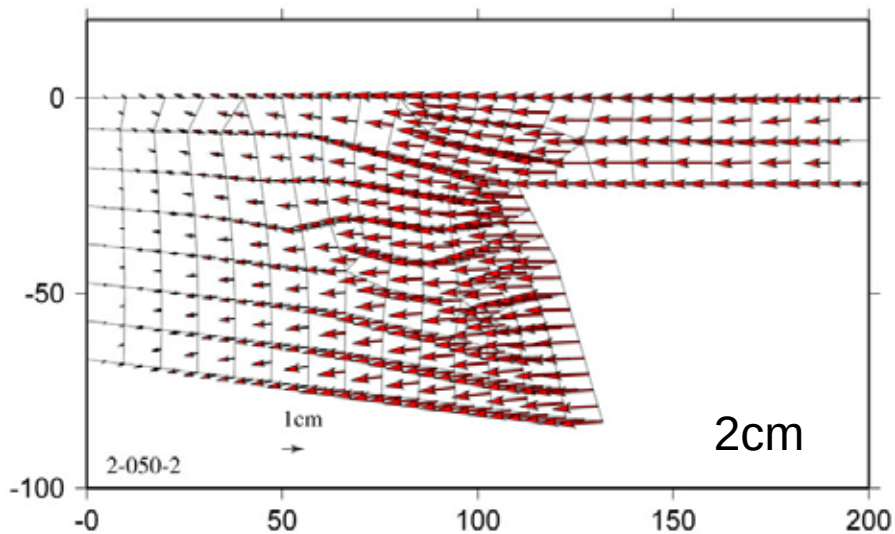
Convergence rate: 0-6cm

2D model
Young modulus:
6×10^{10}Pa (Lower EU)
1×10^{10}Pa (Upper EU and Ryukyu arc)
Poisson's ratio: 0.25

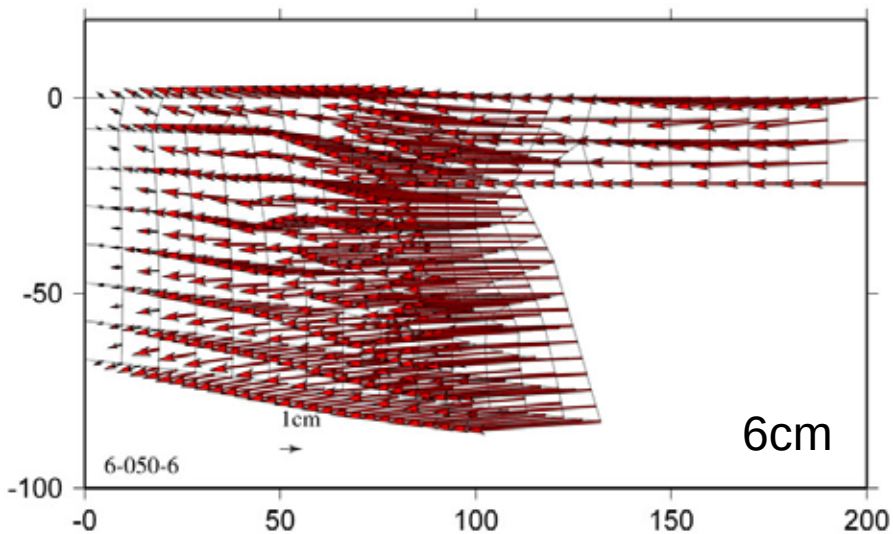
Horizontal displacement



Convergence rate
1cm

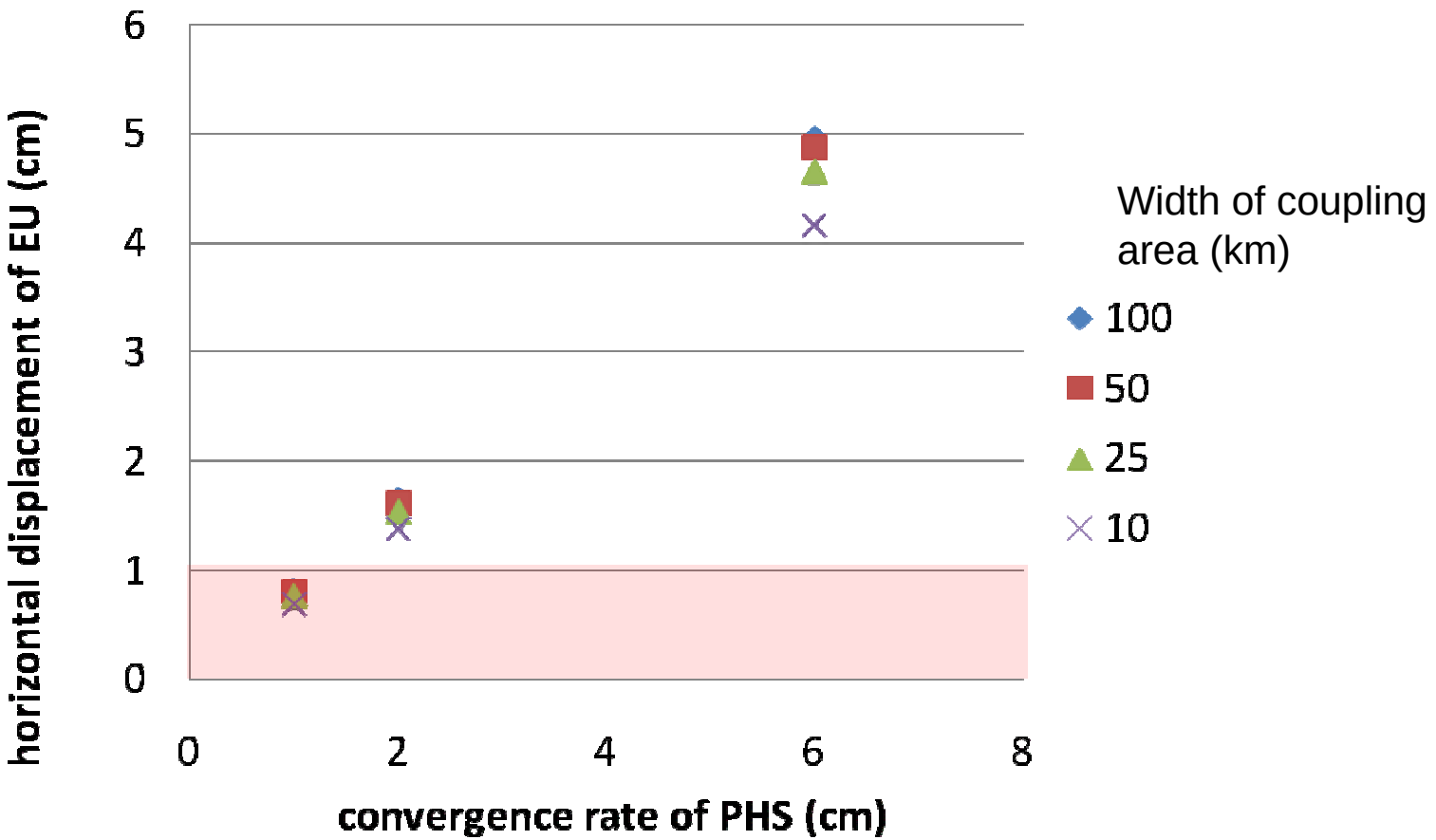


2cm



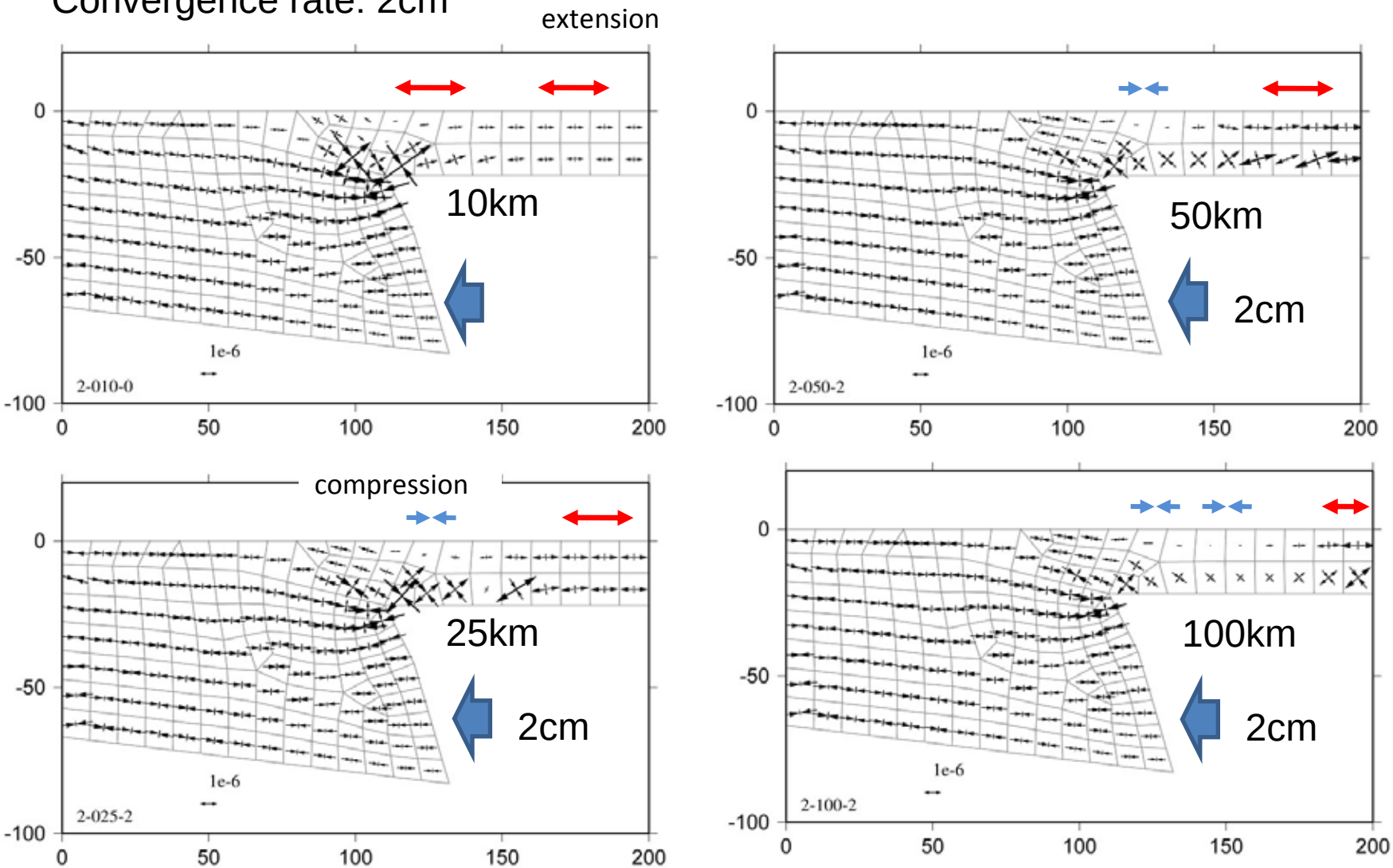
6cm

Horizontal displacement

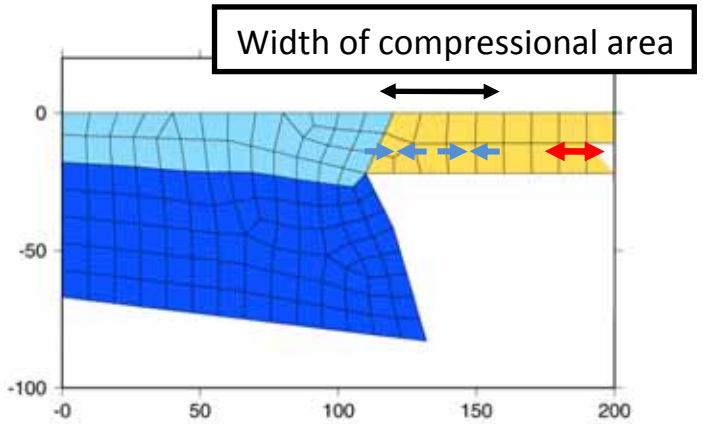


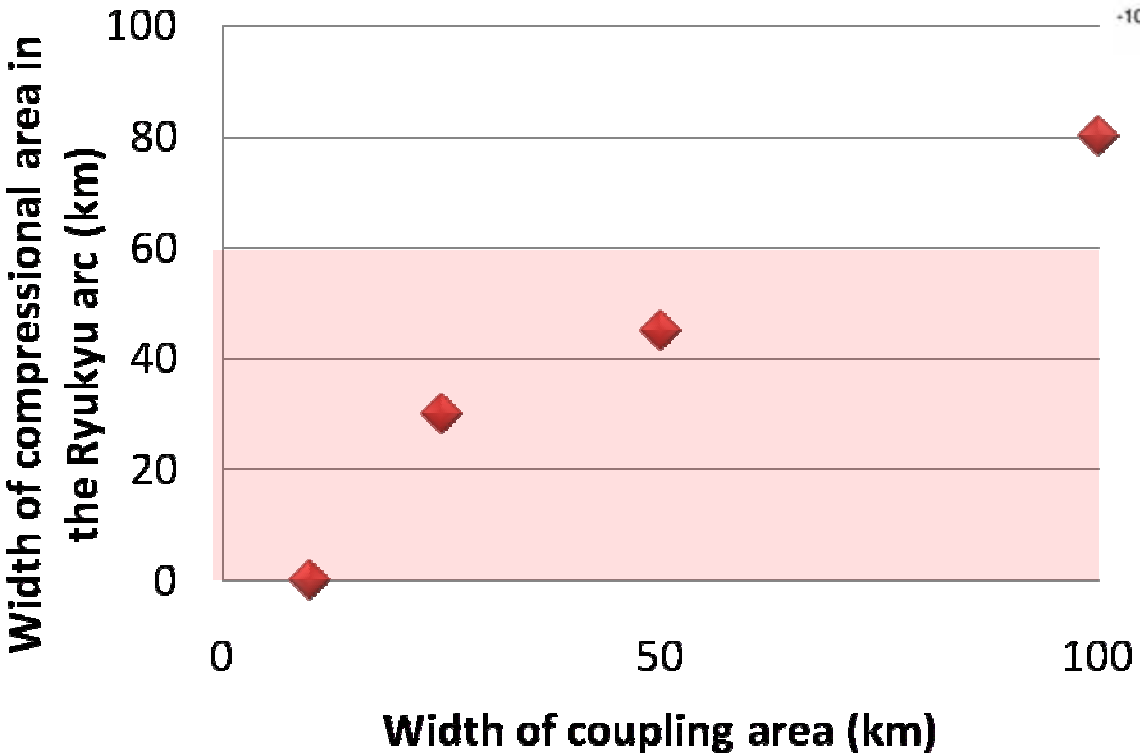
Strain distribution

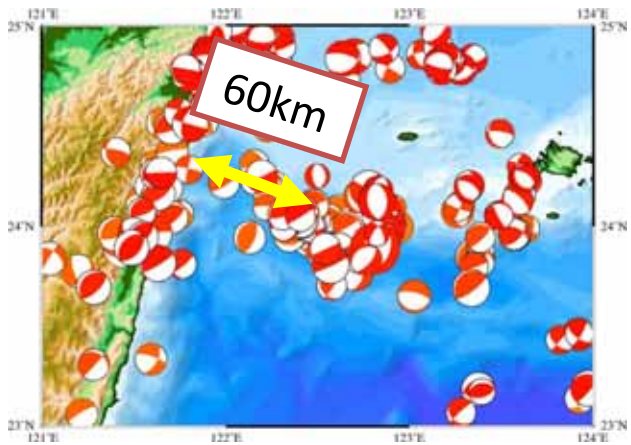
Convergence rate: 2cm



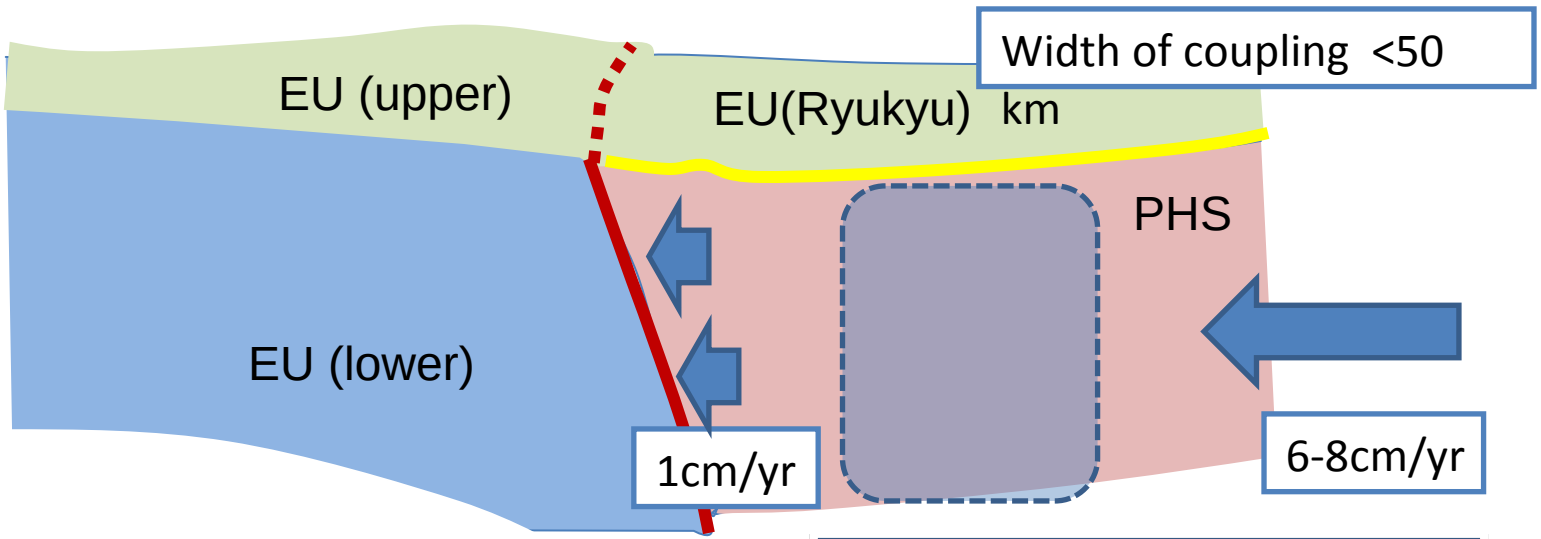
Width of compressional area







Results



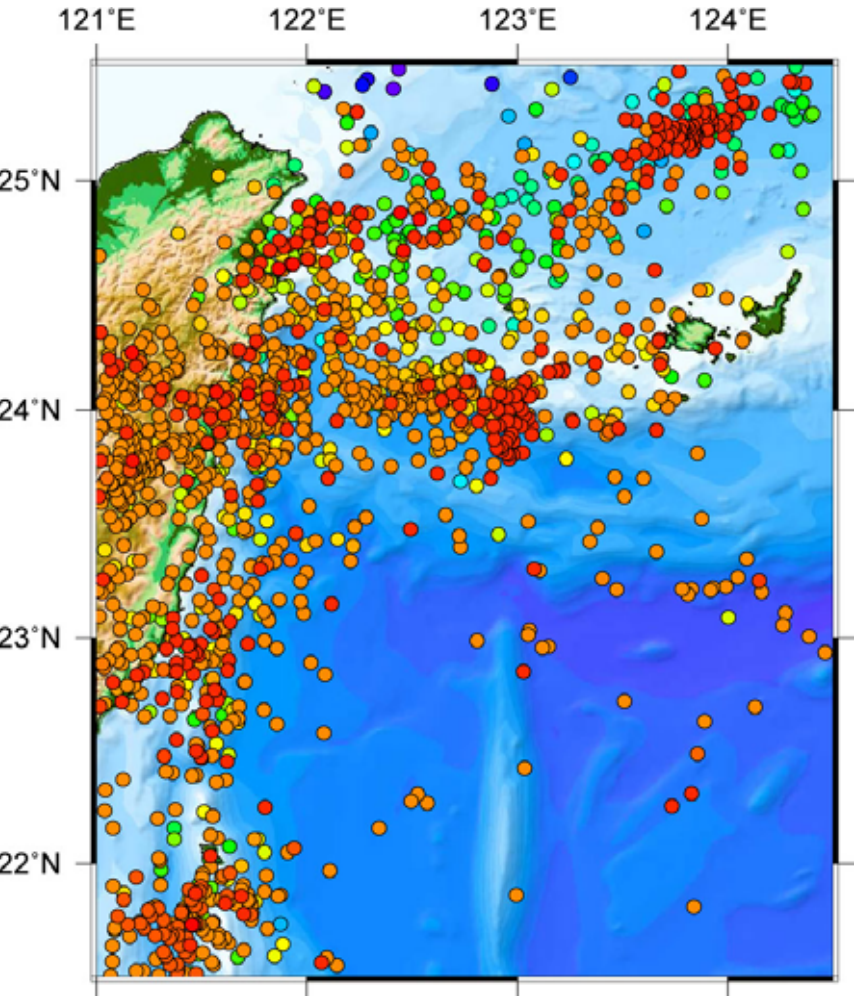
Deformation in the PHS (5-7cm/yr)

Seismicity and historical earthquakes

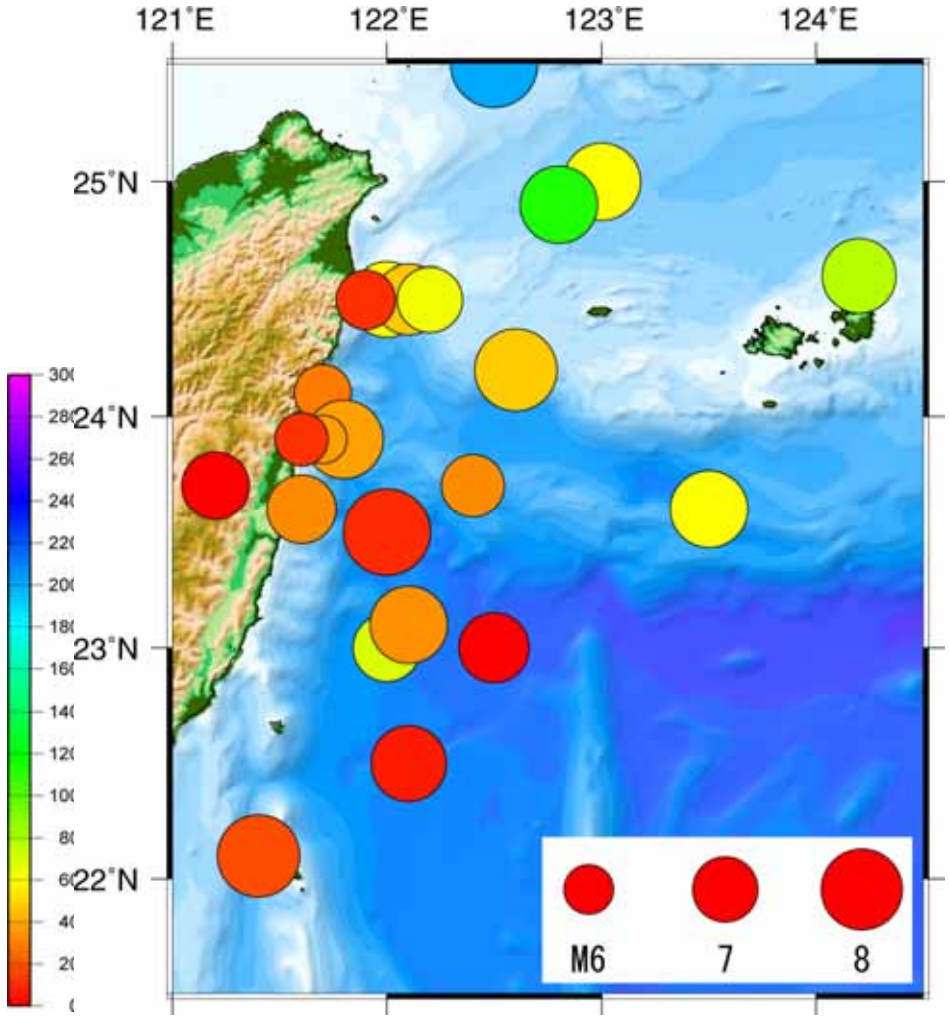
Scattered hypocenters in the east of Taiwan.

Plate boundary is not clear in the east of Taiwan.

PDE(1995-2005, M>4)



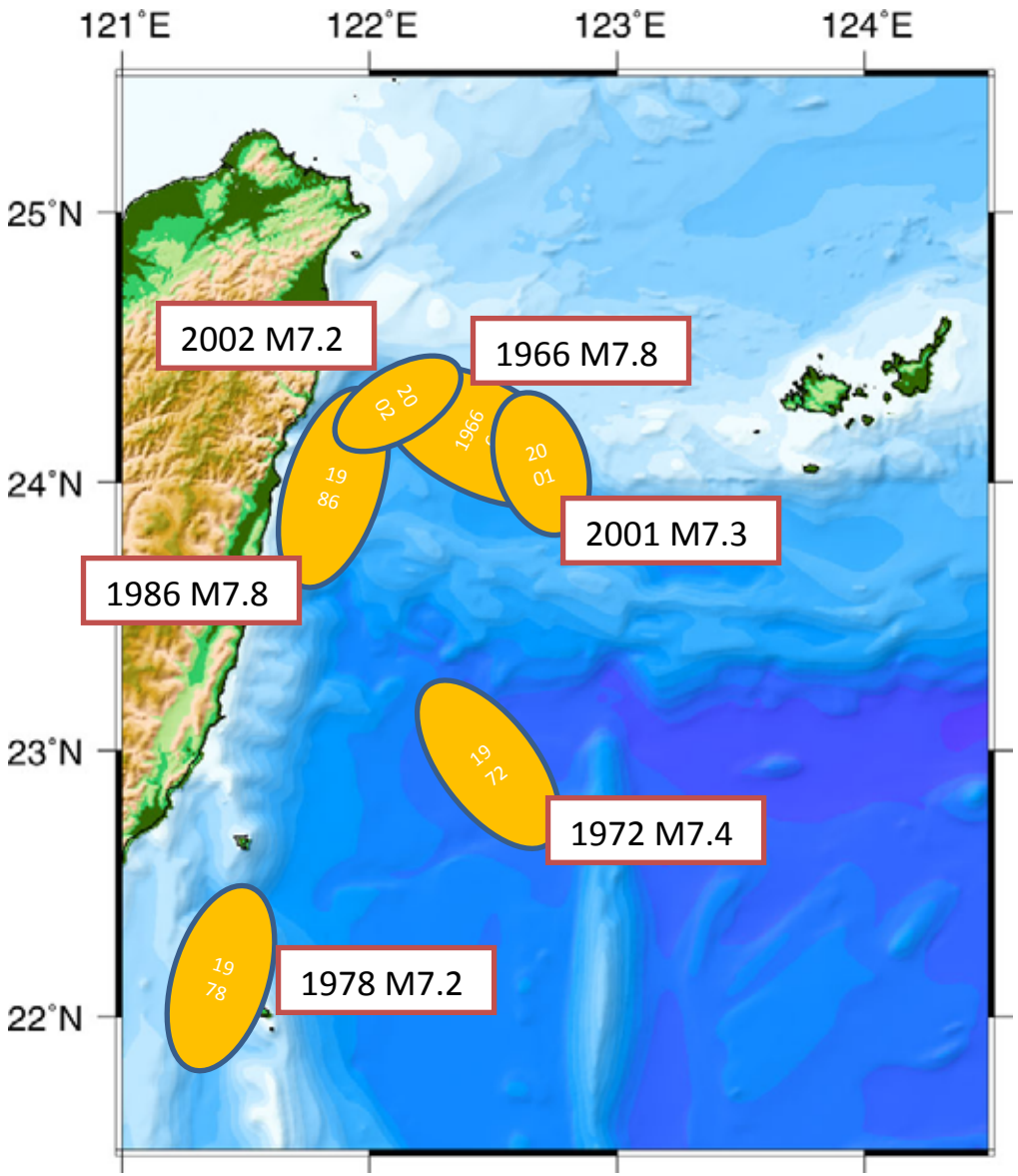
Historical earthquakes (1900-1994)



Tsunami source area during the last 100 years

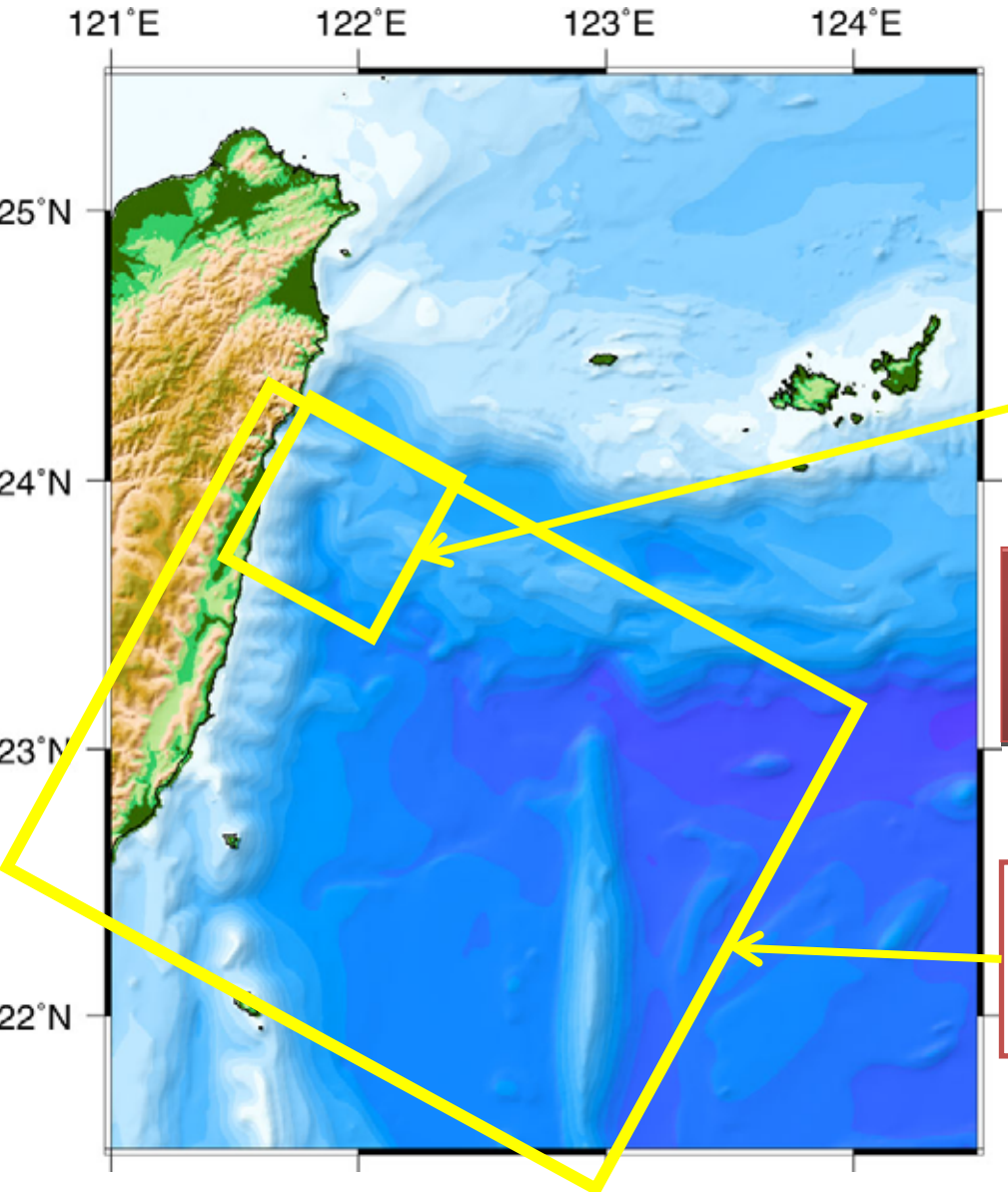
Plate boundary is not clear in the east of Taiwan.

1986/11/15
Mw7.3(Harvard)
Tsunami: Hualien 200cm



(Hatori, Tsunami Engineering Technical Report, 2003)

Horizontal crustal shortening estimated from seismic moment



Hualien region (30km x 30km)
Harvard CMT (1976-2006)
Cumulative seismic moment
(SE-NW direction): 1.27×10^{20} Nm

Horizontal crustal shortening: 3.7cm/yr

About half of the convergence rate between PHS and EU was caused by faulting of earthquakes in the east of Taiwan.

Horizontal crustal shortening (1963-1987): 2.6-5.4cm/yr
(Pezzopane & Wesnousky, JGR, 1989)

Conclusions

- Convergence rate estimated using 2-D FEM modeling is about 1 cm/yr in northeastern Taiwan.
- Width of coupling area between Ryukyu arc and Philippine Sea plate would not exceed 50 km.
- Deformation rate in the Philippine Sea plate would be about 5-7 cm/yr in the east of Taiwan