Areal Source Modeling (II)

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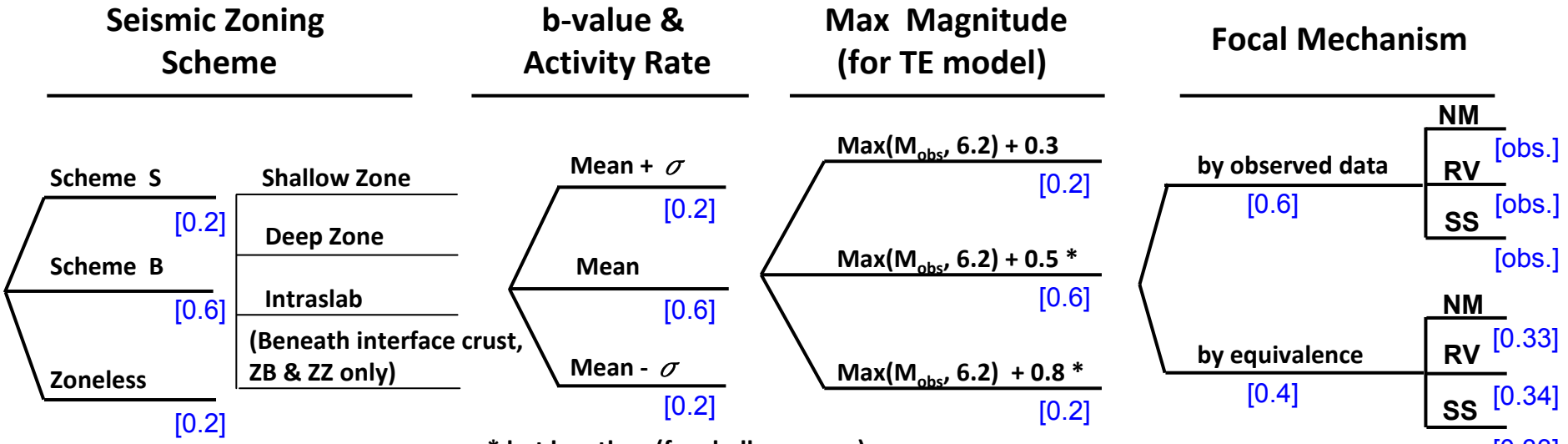
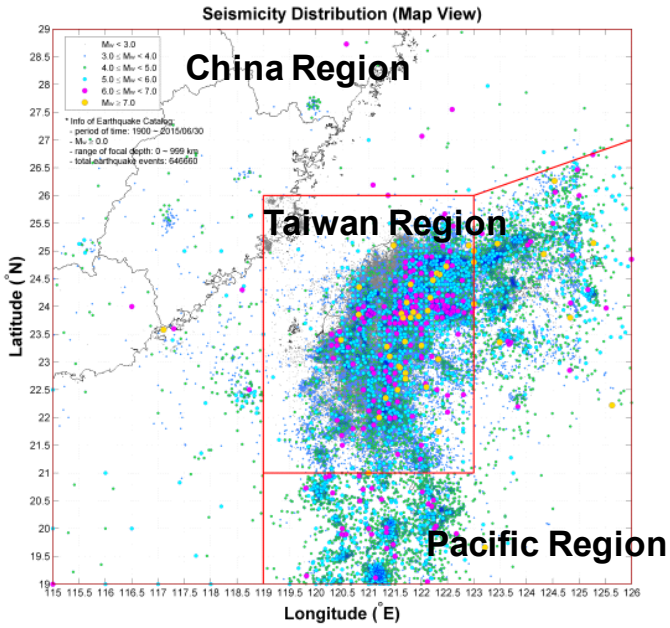
Logic Tree of Areal Sources



* but less than (for shallow zones)
7.7 (7.4+0.3) for China Region,
7.7 (7.4+0.3) for Taiwan Region, and
8.3 (8.0+0.3) for Pacific Region



* Note:

- Method of estimating b-value and activity rate:
  Maximum Likelihood Estimation
- Magnitude pdf Model:
  G-R Truncated Exponential Model
- Depth pdf Model:
  Truncated Normal Distribution (for Shallow Zone)
  Triangular Distribution (for Deep Zone)
- GMPE:
  Crustal GMPEs: NGA-West2 (for Shallow Zone)
  Subduction GMPEs: BCHydro, LL08 (for Deep Zone, Intraslab and *beneath interface crust*)

Outline

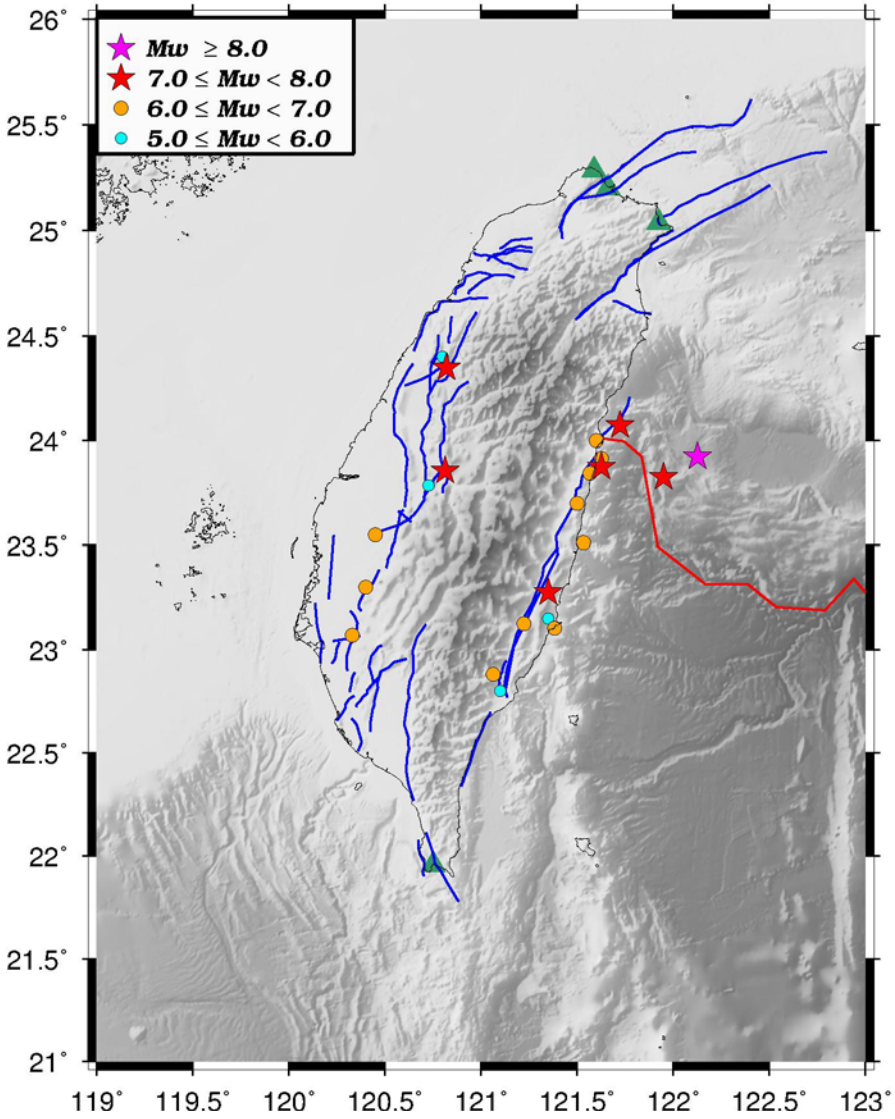
- Maximum magnitude of subzones
- b-value & activity rate
- Smoothed activity rate in zoneless model
- Focal mechanism statistics
- Depth probability density function
- GMPE used in different source zones
- Logic tree structure of areal sources

Procedure for Parameter Estimations

- **Processing of Earthquake Catalog**
  - Mainshocks data without foreshocks and aftershocks (1900~2015/6) (from Prof. Wu)
  - Removal of 22 onshore fault earthquakes (from Sinotech Dr. Lee)
  - Removal of 3 offshore fault earthquakes (assumed due to Okinawa Trough fault)
  - Removal of 1 interface earthquake (1920, Mw 8.0, D 25km)
- **Regression of G-R relationship**
  - Check the completeness of earthquake catalog in the Taiwan, Pacific and China Regions, respectively
  - Combine two subzones if data in each subzone is less enough when calculating b-value or depth pdf
  - Use the *Maximum Likelihood Estimation* (Weichert, 1980) to calculate b-value and activity rate in each subzone

Removal of 22 onshore fault-associated EQs
Removal of 1 Interface-associated EQs

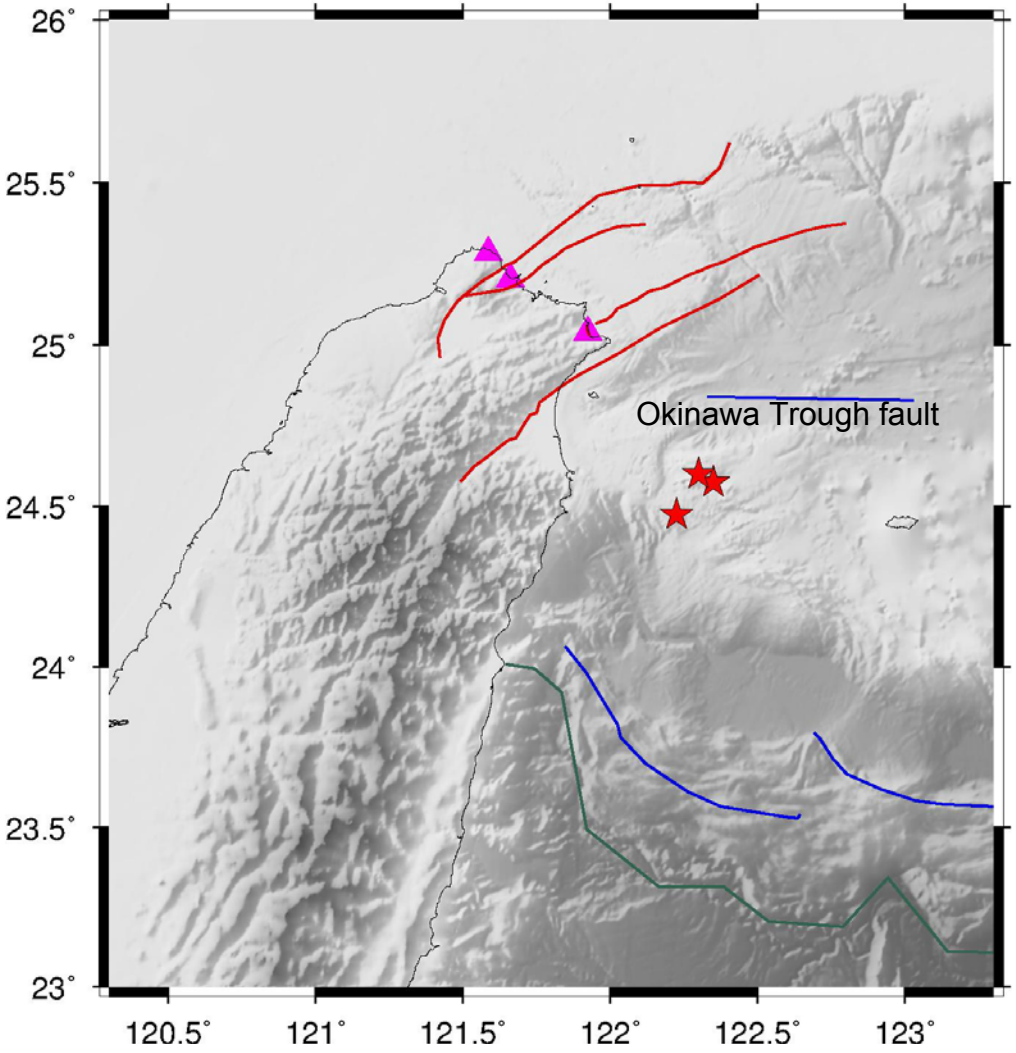
- **Western foothills belt:**
  - Sanyi Fault: 1939(Mw5.5)
  - Shihtan, Tuntzuchiao Fault: 1935(Mw7.2)
  - Chelungpu Fault: 1999(Mw7.65)、2009(Mw6.3)
  - Liuchia Fault: 1930(Mw6.3)、1930(Mw6.2)
  - Meishan Fault: 1906(Mw6.9)
  - Hsinhua Fault: 1946(Mw6.1)
- **Eastern longitudinal faults:**
  - Milun Fault: 1913(Mw6.2)、1951(Mw7.3)、1951(Mw7.1)、1982(Mw6.0)
  - Lingding Fault: 1951(Mw7.5)、1957(Mw6.5)、1992(Mw5.4)
  - Rueyshui Fault: 1972(Mw6.8)
  - Luyeh Fault: 1923(Mw5.2)、2006(Mw6.2)
  - Chihshang Fault: 1951(Mw6.6)、1951(Mw7.4)、1992(Mw5.3)、2003(Mw6.5)
- **Ryukyu Interface :**
  - 1920(Mw 8.0)、



(Sinotech, 2010 & Cheng, S. N.)

Removal of 3 offshore fault-associated EQs

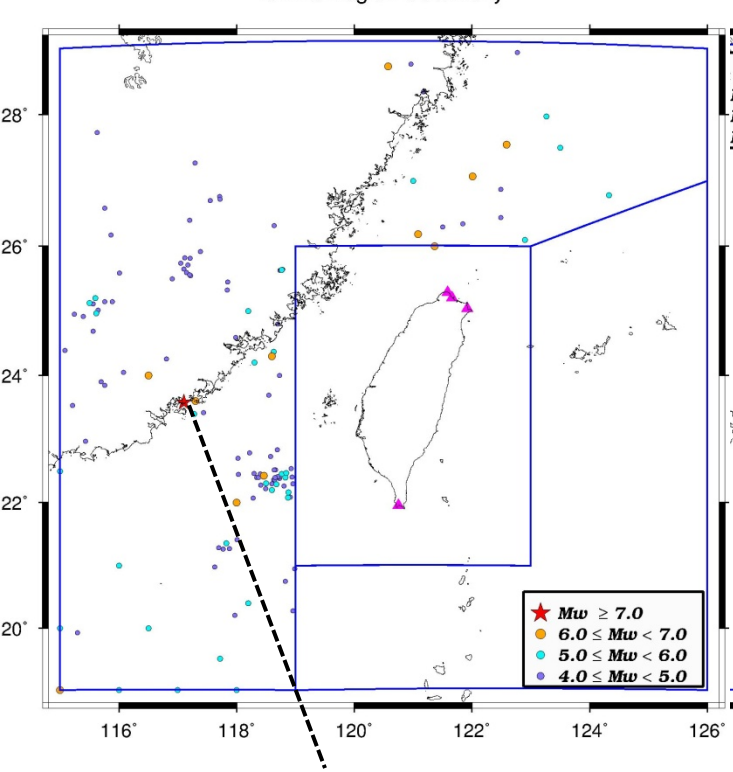
- **Okinawa Trough fault**
  - Mw 7.7, 1922/9/1, D 9km
  - Mw 7.3, 1922/9/14, D 20 km
  - Mw 7.3, 1963/2/13, D 26 km



Maximum Magnitude

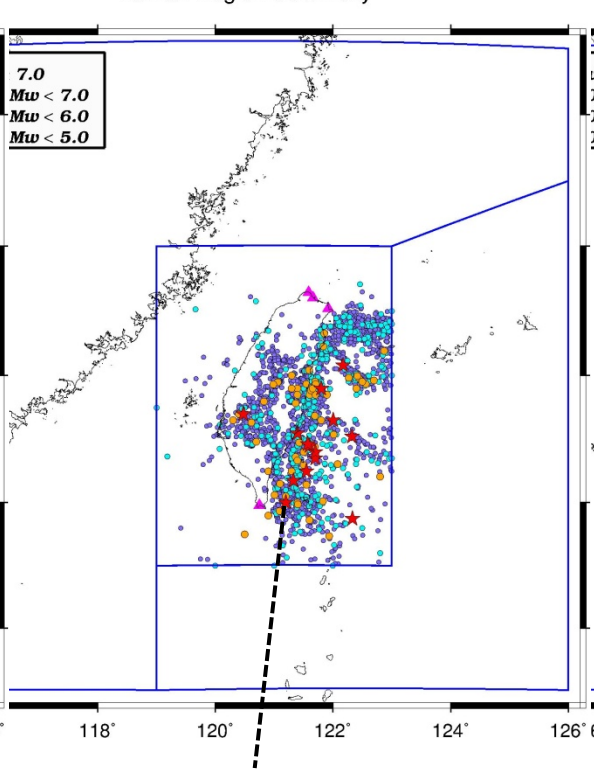
Observed M_{max} in Shallow Zones

China Region



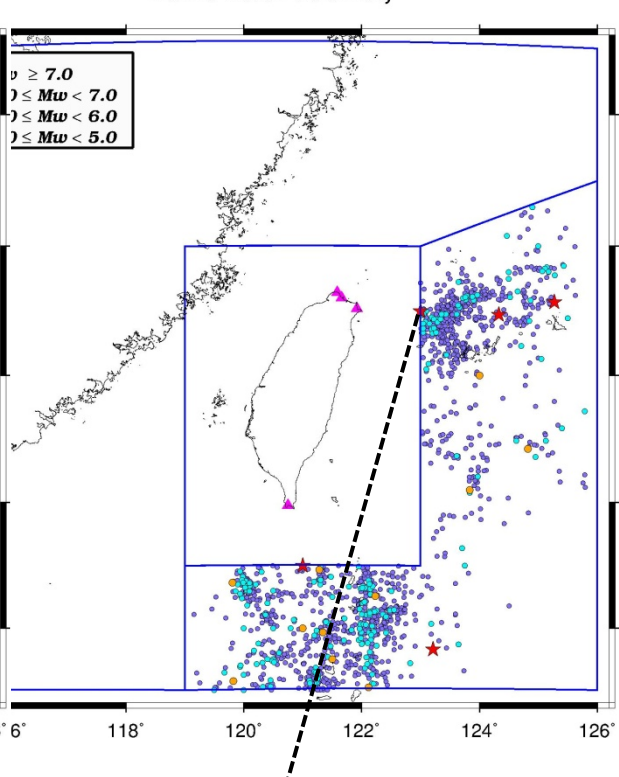
Mw7.4, D=15 km
1918/2/13

Taiwan Region



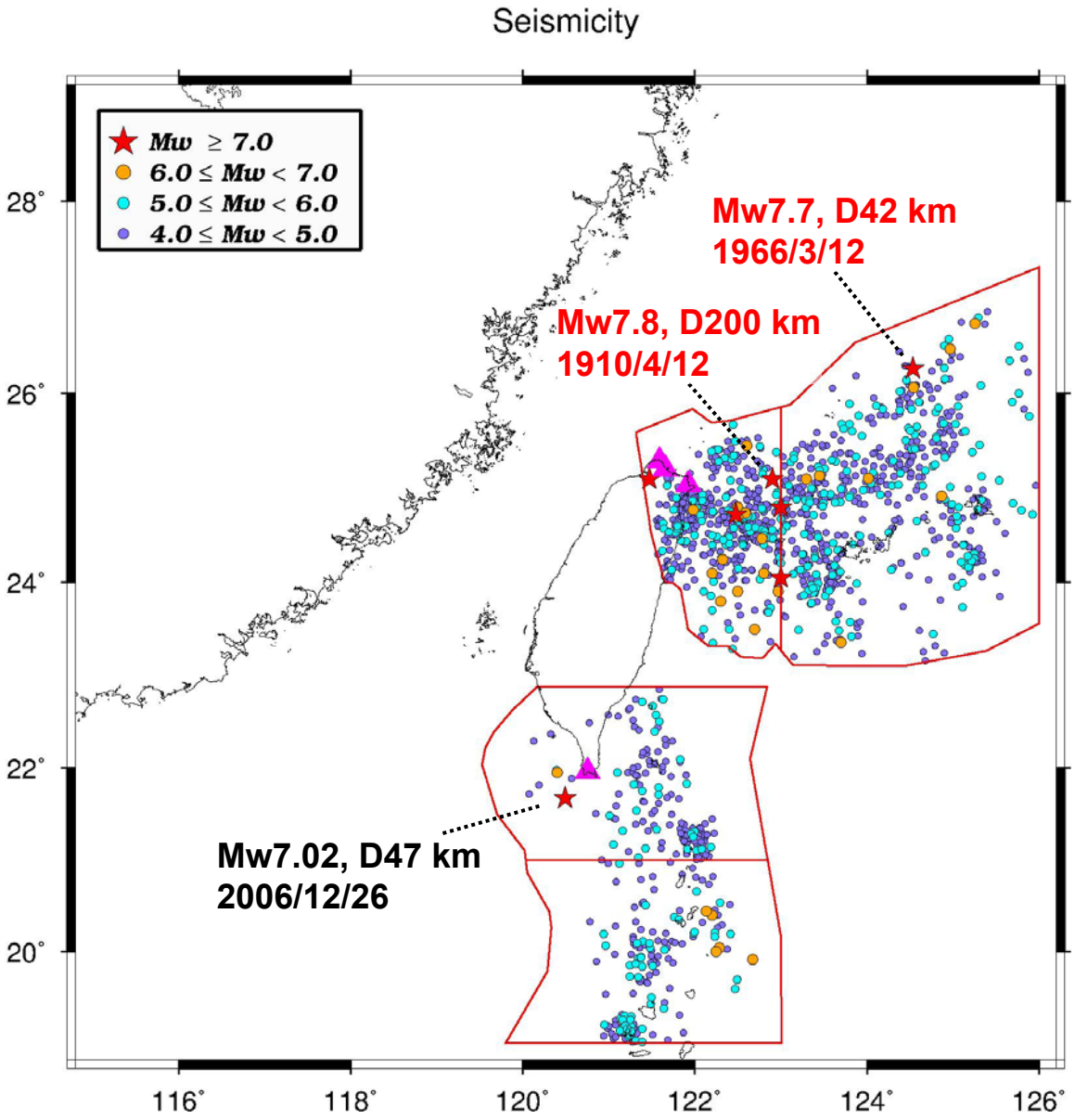
Mw7.4, D=30 km
1936/8/22

Pacific Region



Mw8.0, D=0 km
1917/7/4

Observed M_{max} in Subduction Intraslab Zones



7.8 in Taiwan Region

7.7 in Pacific Region

Upper Limit of M_{max}

Max. Magnitude

$Max(M_{obs}, 6.2) + 0.3$

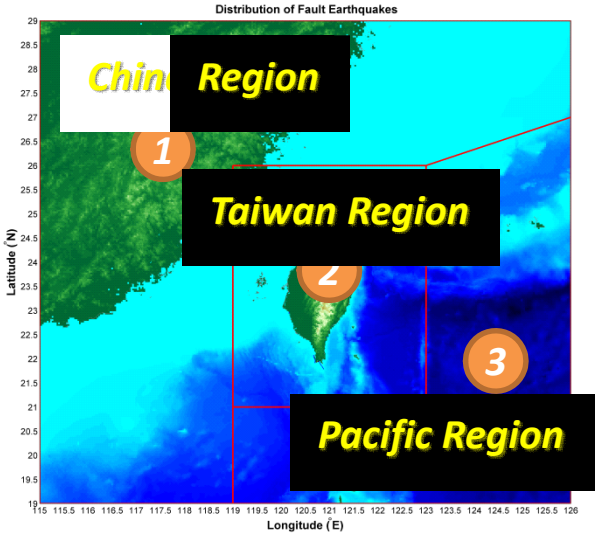
$Max(M_{obs}, 6.2) + 0.5$ *

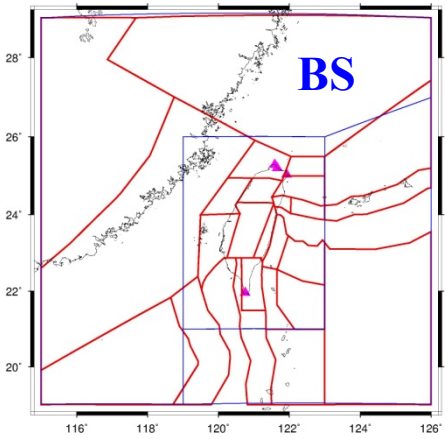
$Max(M_{obs}, 6.2) + 0.8$ *

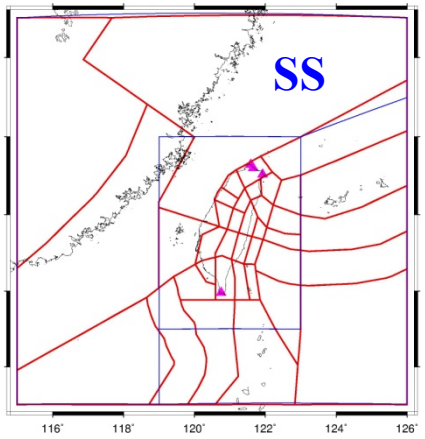
* but less than (for shallow zones)
  7.7 (7.4+0.3) for China Region,
  7.7 (7.4+0.3) for Taiwan Region, and
  8.3 (8.0+0.3) for Pacific Region

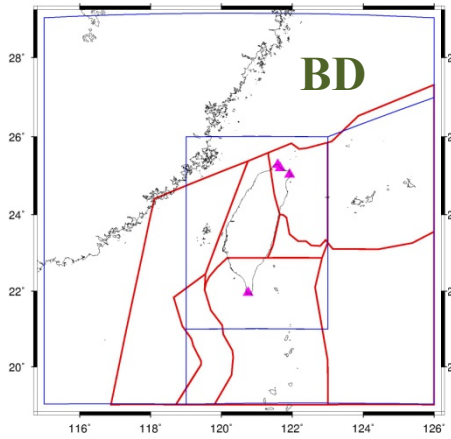
* but less than (for deep zones)
  7.7 (7.4+0.3) for China Region,
  7.7 (7.4+0.3) for Taiwan Region, and
  7.6 (7.3+0.3) for Pacific Region

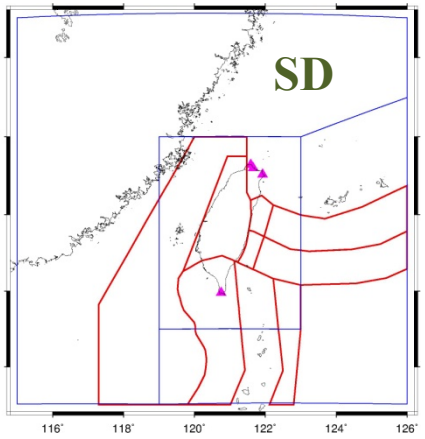
* but less than (for subduction zones)
  8.1 (7.8+0.3) for Ryukyu Intraslab, and
  8.1 also for Manila Intraslab











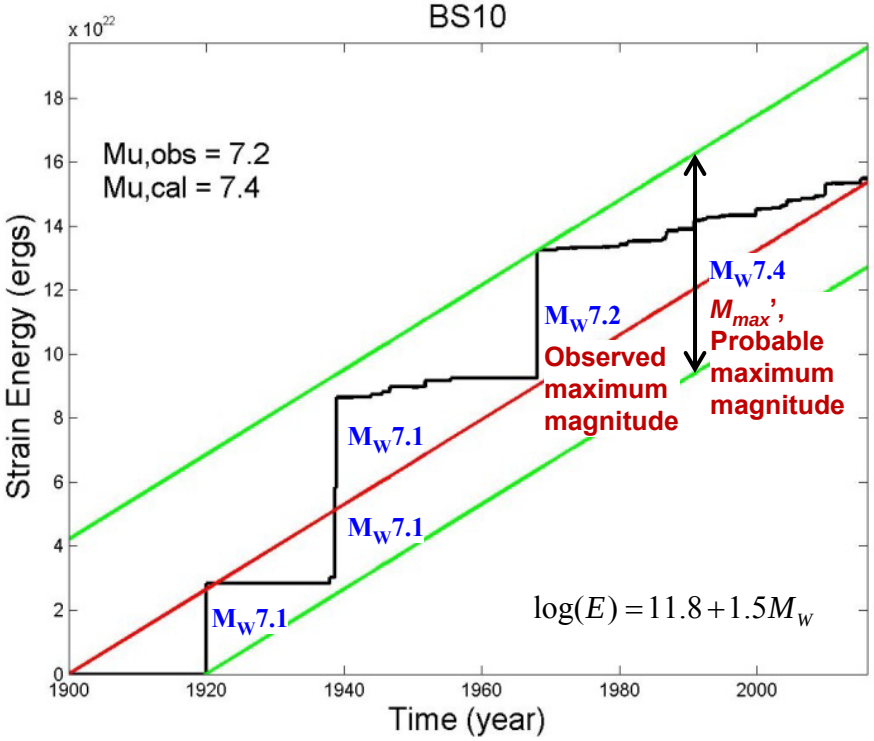
M_{max} in Truncated Exponential Model

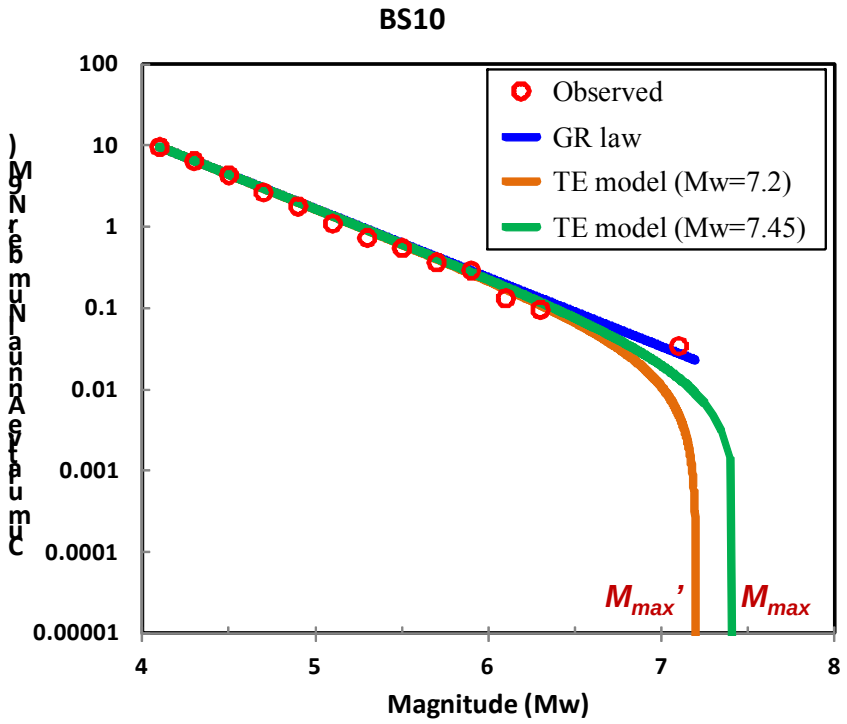
- M_{max}' (probable maximum magnitude) is often larger than observed maximum magnitude by 0.2 to 0.3
- 0.3 ➔ (0.05 + 0.25); 0.5 ➔ (0.25 + 0.25); 0.8 ➔ (0.55 + 0.25)
  - Max(Mobs, 6.2)+0.05, +0.25 and +0.55 are considered as the lower, medium and upper estimates, respectively, of M_{max}'
  - Add 0.25 to decrease the difference between observed and modeled occurrence rate at M_{max}' and also let Prob(M≧M_{max}') > 0
- 6.2 ➔ set a lower bound of the M_{max}' for conservative reason

$\text{Max}(M_{obs}, 6.2) + 0.3$ [0.2]

$\text{Max}(M_{obs}, 6.2) + 0.5$ * [0.6]

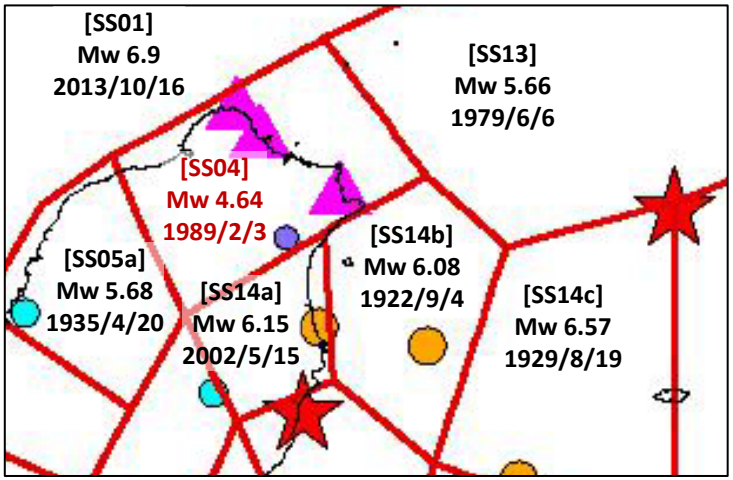
$\text{Max}(M_{obs}, 6.2) + 0.8$ * [0.2]



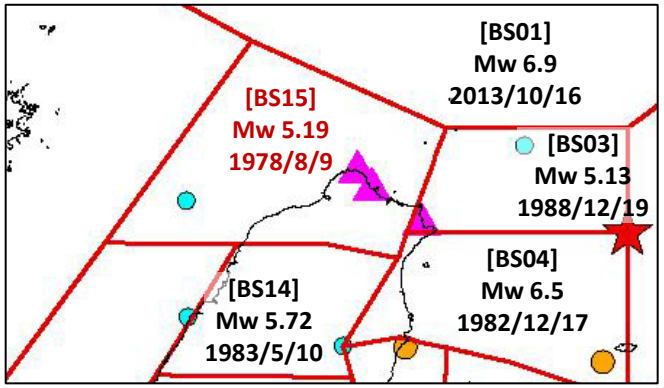


M_{max} in Subzone nearby NPP1 & NPP2

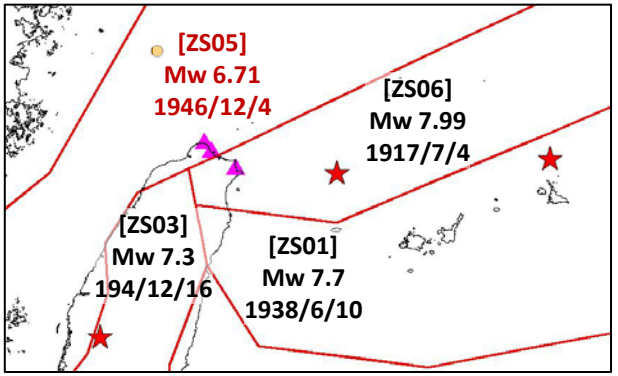
Zoning Scheme	Controlled Zone	Observed M_{max}		Max. Magn. in hazard calc.
ZB	BS15	5.19	1978/8/9, D=25.9 km	6.5 / 6.7 / 7.0
ZS	SS04	4.64	1989/2/3, D=33 km	6.5 / 6.7 / 7.0
ZZ	ZS05	6.71	1946/12/4, D=25 km	7.0 / 7.2 / 7.5



ZS



ZB

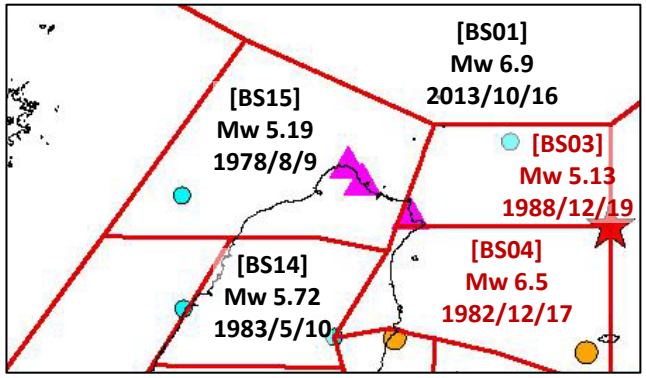


ZZ

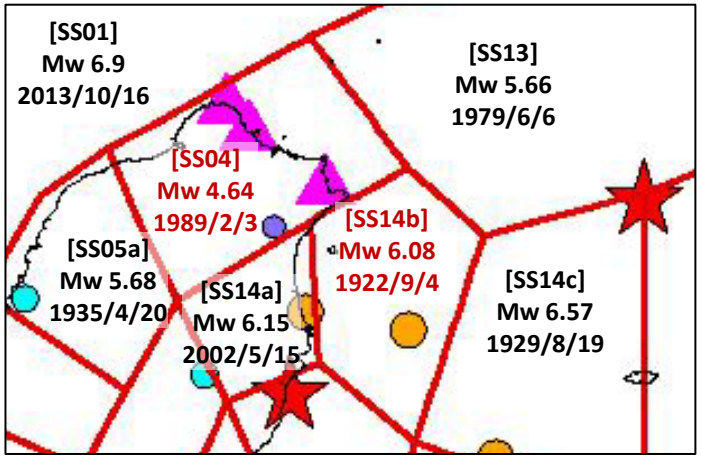
M_{max} in Subzone near by NPP4

Zoning Scheme	Controlled Zone	Observed M_{max}		Max. Magn. in hazard calc.
ZB	BS04	6.50	1982/12/17, D=29.2 km	6.8 / 7.0 / 7.3
	BS03	5.13	1988/12/19, D=25.7 km	6.5 / 6.7 / 7.0
ZS	SS14b	6.08	1922/9/4, D= 0 km	6.5 / 6.7 / 7.0
	SS04	4.64	1989/2/3, D=33 km	6.5 / 6.7 / 7.0
ZZ	ZS06	7.99	1917/7/4, D=0 km	8.29 / 8.29 / 8.29
	ZS01	7.70	1938/6/10, D=20 km	8.0 / 8.0

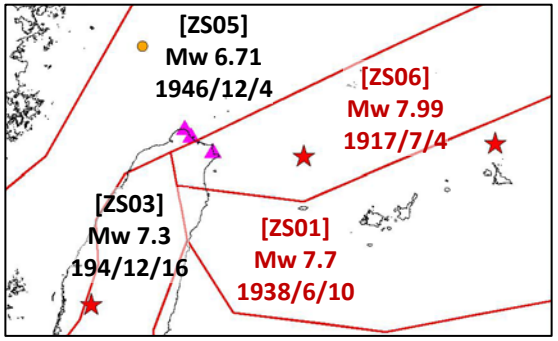
ZB



ZS

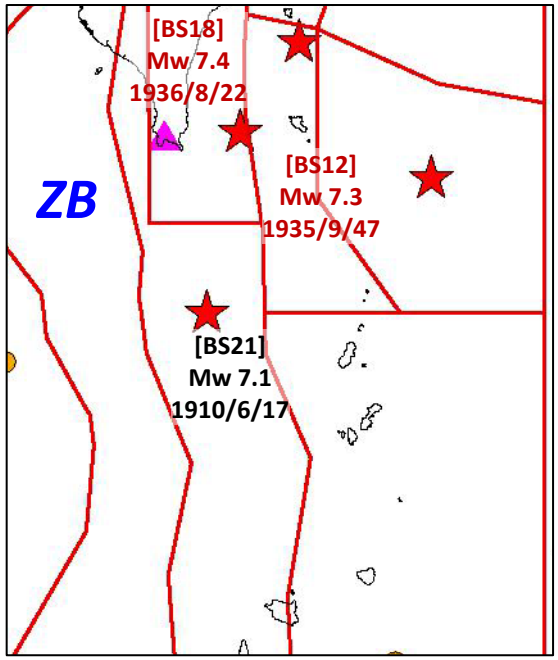


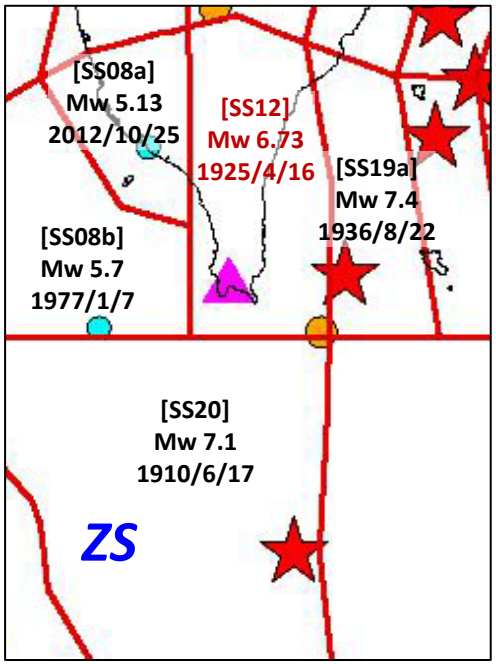
ZZ

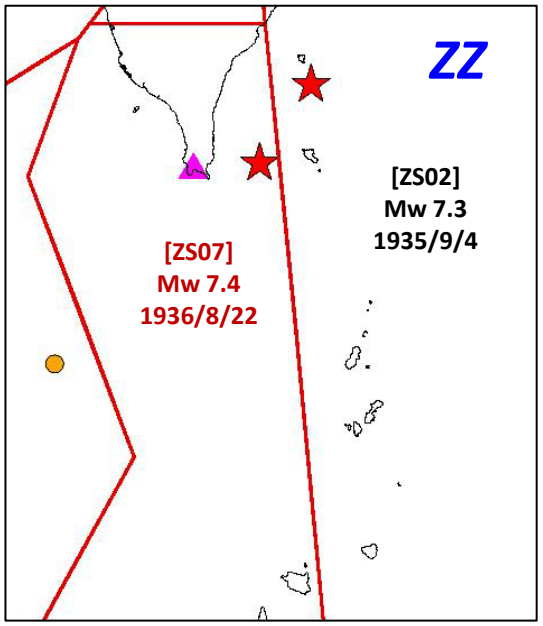


M_{max} in Subzone nearby NPP3

Zoning Scheme	Controlled Zone	Observed M_{max}		Max. Magn. in hazard calc.
ZB	BS18	7.4	1936/8/22, D=30 km	7.7 / 7.7 / 7.7
	BS21	7.1	1910/6/17, D=0 km	7.4 / 7.6 / 7.9
ZS	SS12	6.73	1925/4/16, D=35 km	7.03 / 7.23 / 7.53
ZZ	ZS07	7.40	1936/8/22, D=30 km	7.7 / 7.7 / 7.7



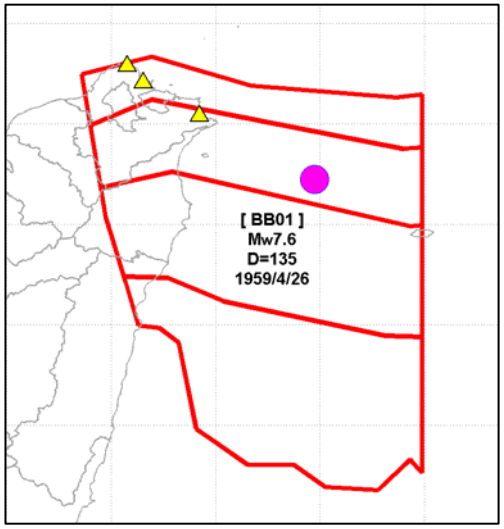




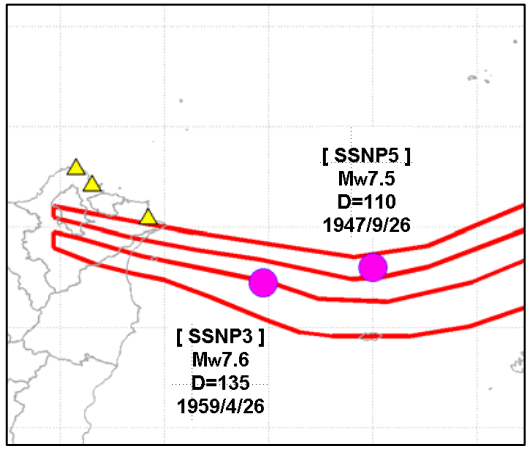
M_{max} in Intraslab zone nearby NPP1, NPP2 & NPP4

Zoning Scheme	Controlled Zone	Observed M_{max}		Max. Magn. in hazard calc.
ZB	BB01	7.60	1959/4/26, D=135 km	7.9 / 8.1 / 8.1
ZS	SNP03	7.60	1959/4/26, D=135 km	7.9 / 8.1 / 8.1
	SNP05	7.50	1947/9/26, D110 km	7.8 / 8.0 / 8.1
ZZ	ZB04	7.40	1909/4/14, D=72 km	7.7 / 7.9 / 8.1

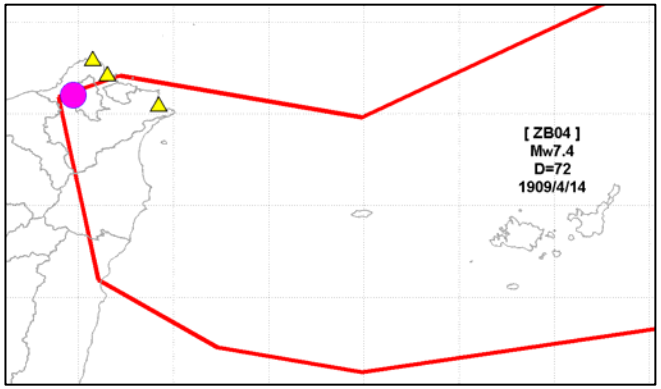
ZB



ZS



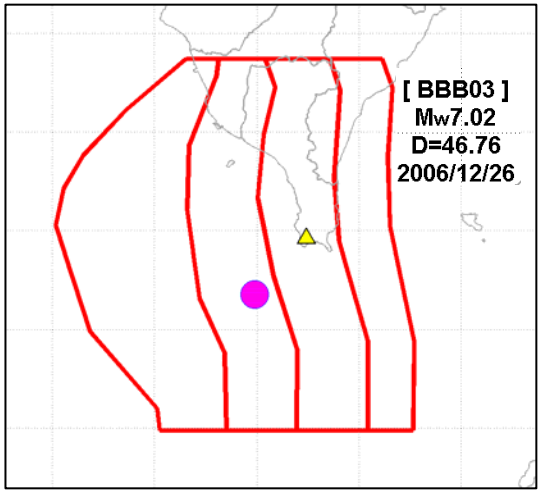
ZZ



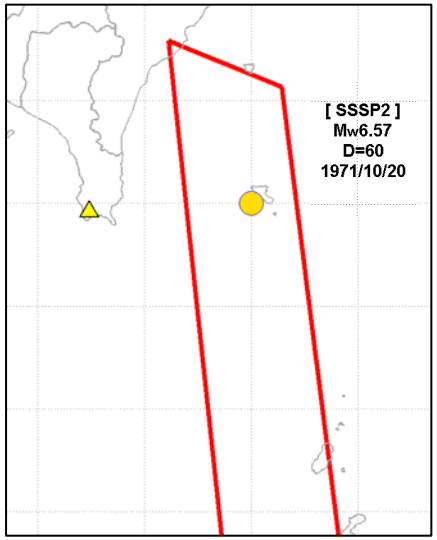
M_{max} in Intraslab Zone nearby NPP3

Zoning Scheme	Controlled Zone	Observed M_{max}		Max. Magn. in hazard calc.
ZB	BB03	7.02	2006/12/26, D=46.8 km	7.32 / 7.52 / 7.82
ZS	SSP02	6.57	1971/10/20, D=60 km	6.87 / 7.07 / 7.37
ZZ	ZB01	6.57	1971/10/20, D=60 km	6.87 / 7.07 / 7.37

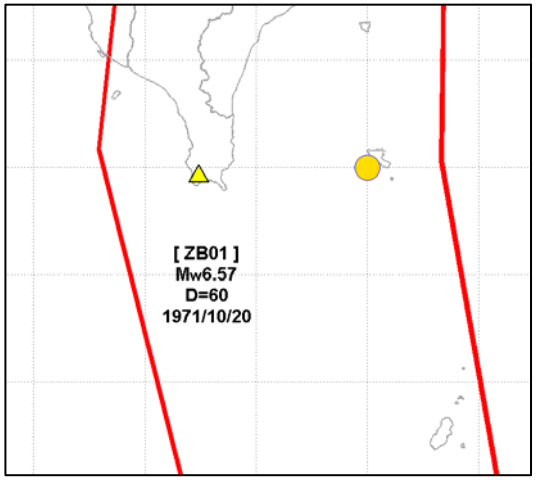
ZB



ZS

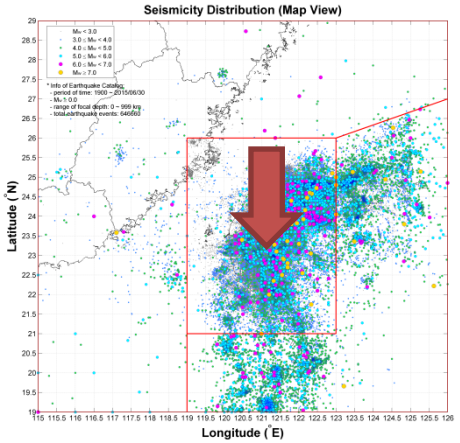


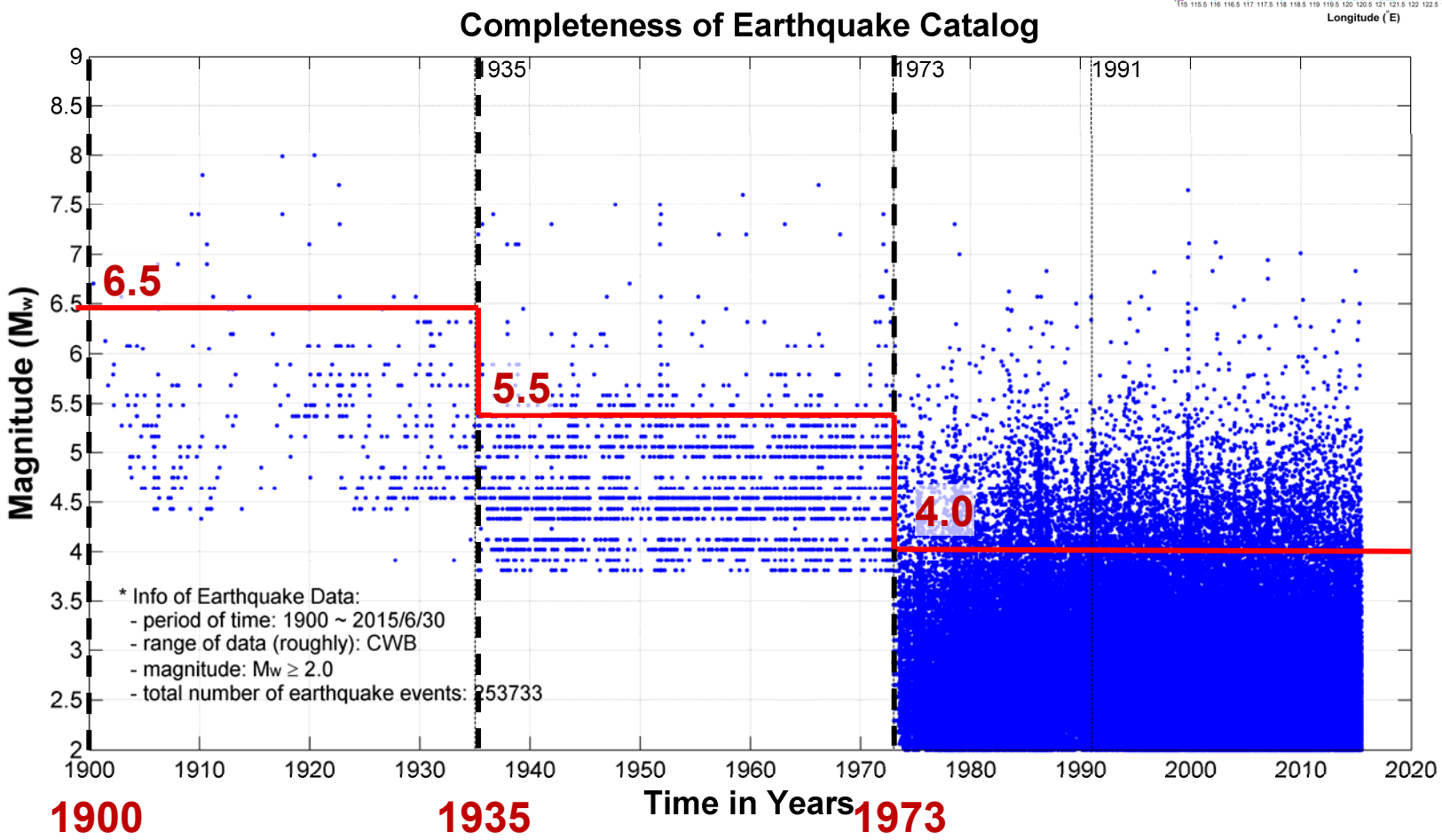
ZZ



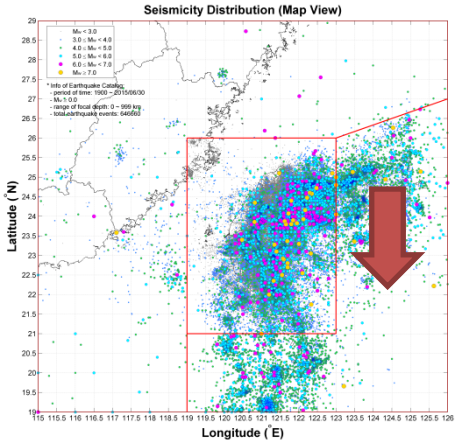
b-value & Activity Rate
(Maximum Likelihood Estimation)

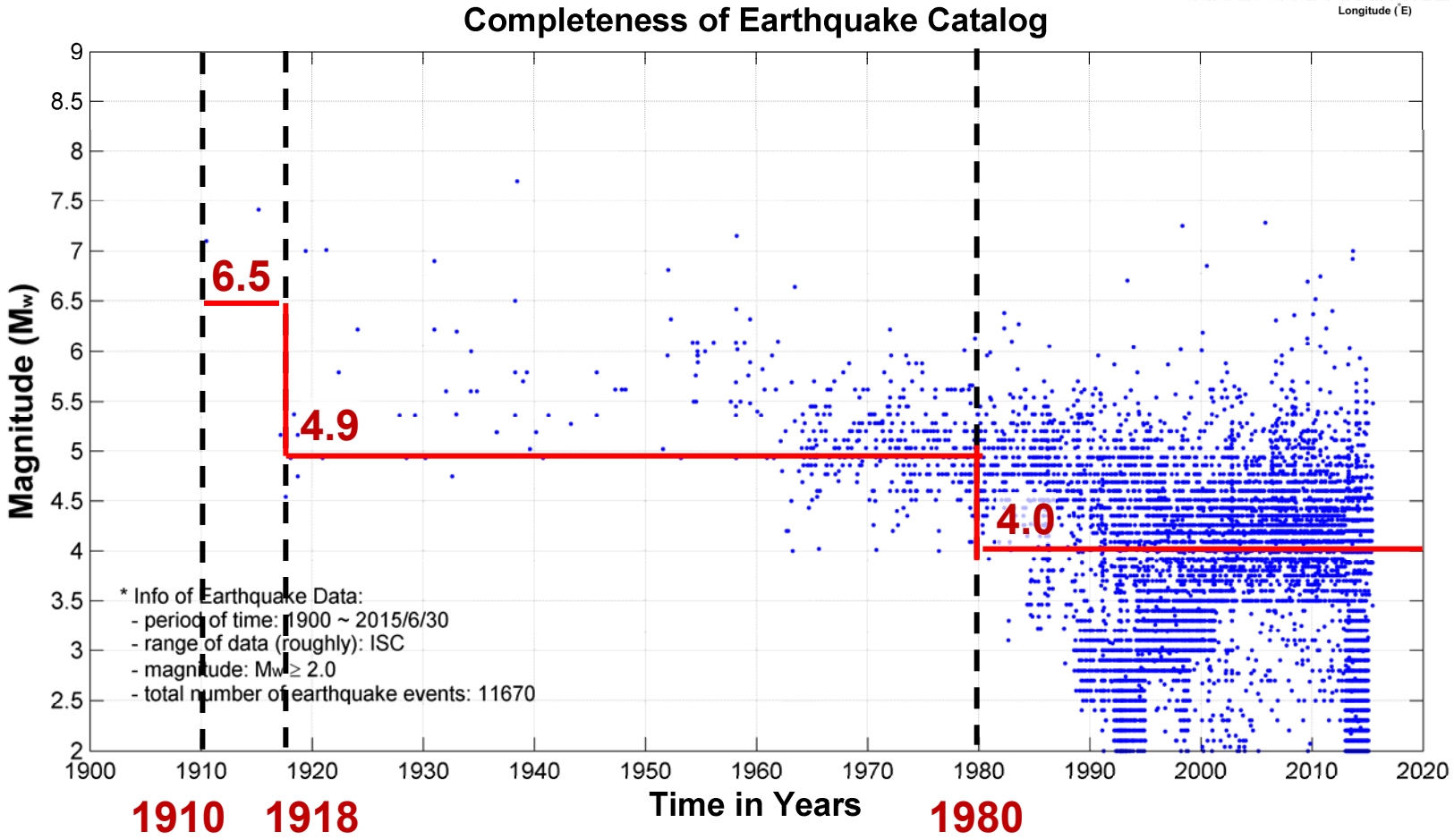
Completeness of EQ Catalog in Taiwan Region



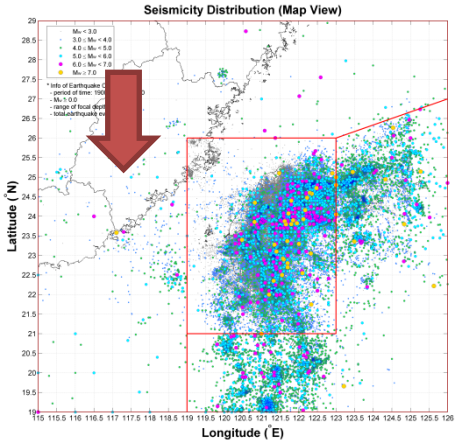


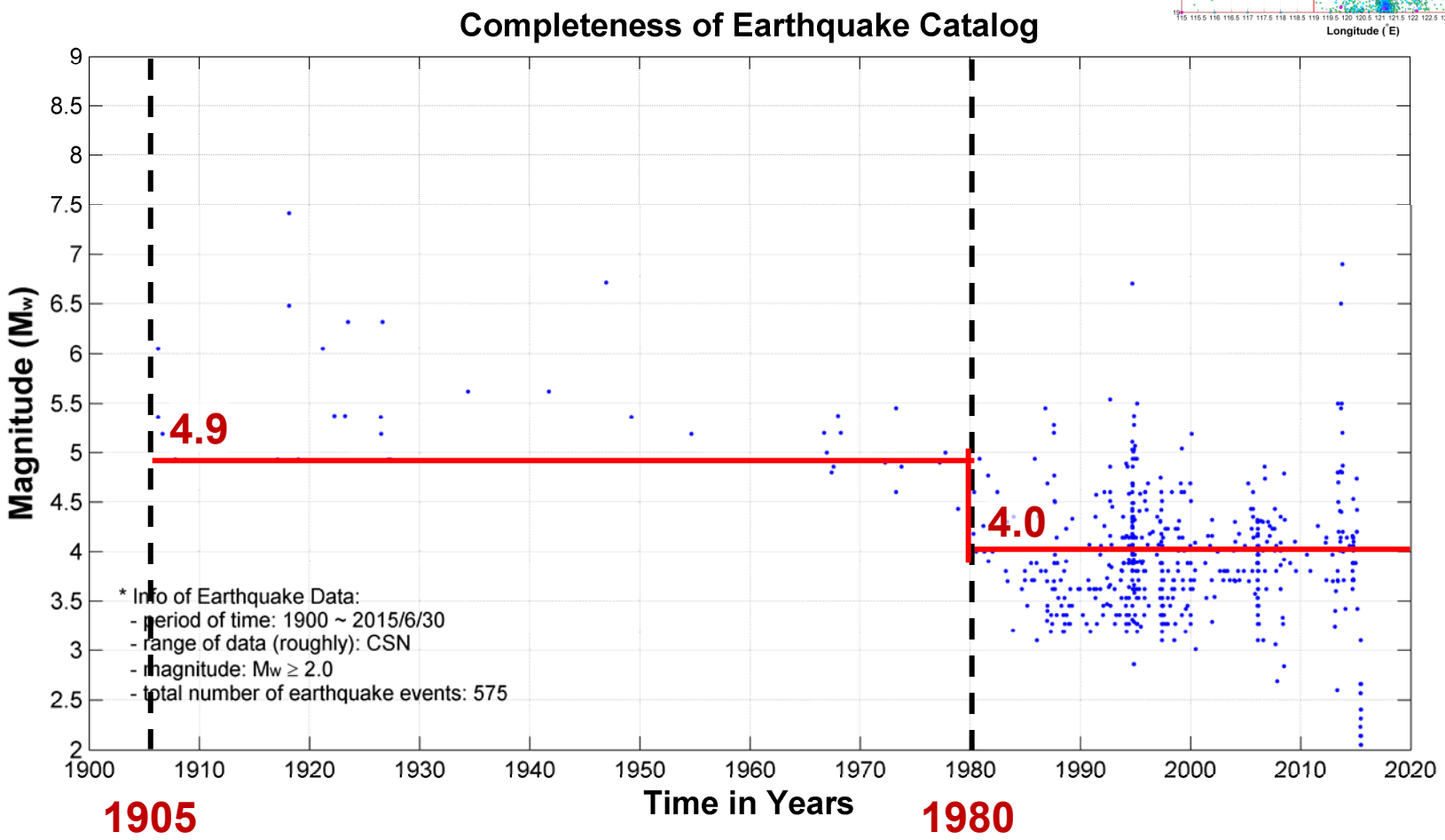
Completeness of EQ Catalog in Pacific Region



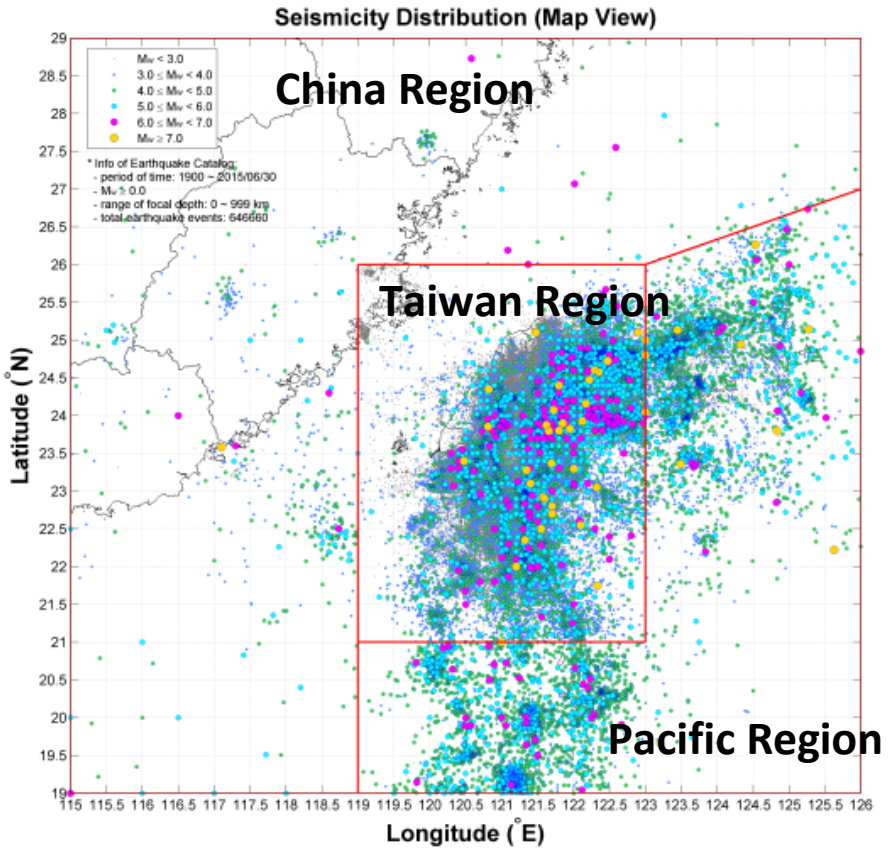


Completeness of EQ Catalog in China Region





Completeness of Earthquake Catalog

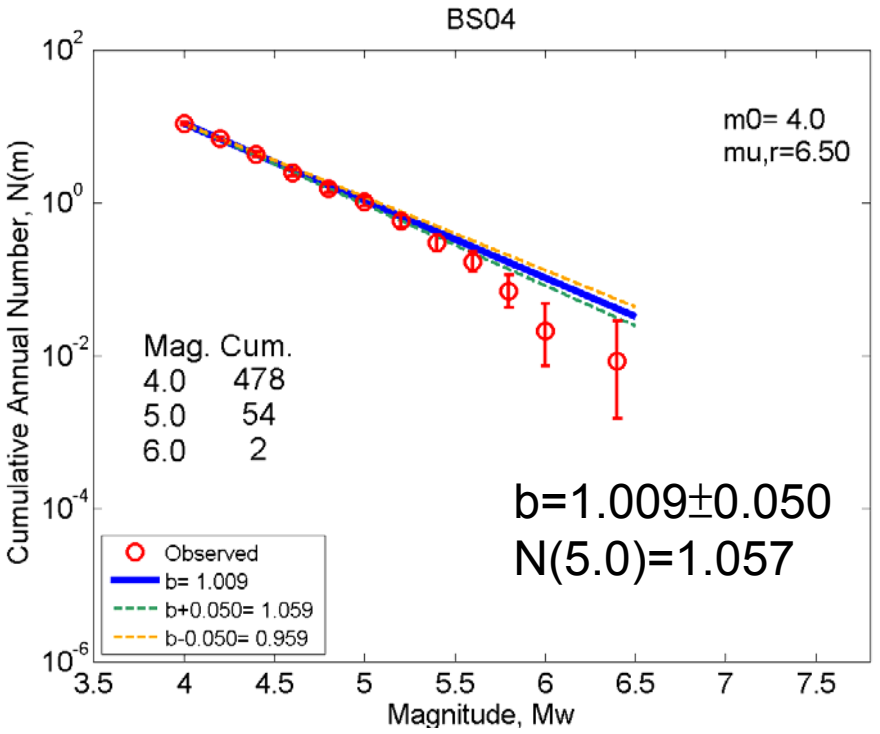


- **China Region:**
  - 1905 ~ 2015/6, $M_w \geqslant 4.9$
    111.5 years
  - 1980 ~ 2015/6, $M_w \geqslant 4.0$
    36.5 years
- **Taiwan Region:**
  - 1900 ~ 2015/6, $M_w \geqslant 6.5$
    116.5 years
  - 1935 ~ 2015/6, $M_w \geqslant 5.5$
    81.5 years
  - 1973 ~ 2015/6, $M_w \geqslant 4.0$
    43.5 years
- **Pacific Region:**
  - 1910 ~ 2015/6, $M_w \geqslant 6.5$
    106.5 years
  - 1918 ~ 2015/6, $M_w \geqslant 4.9$
    98.5 years
  - 1980 ~ 2015/6, $M_w \geqslant 4.0$
    36.5 years

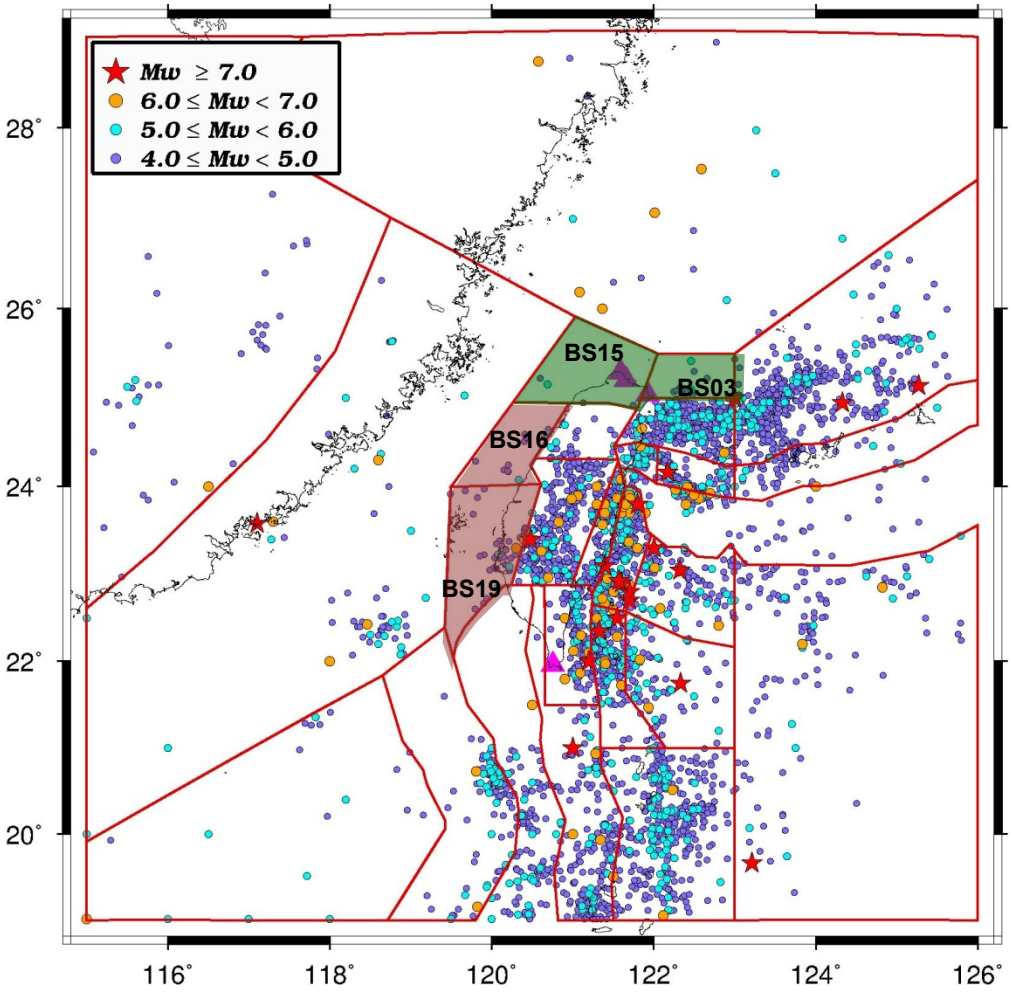
Estimating b-value and Activity Rate

Maximum Likelihood Estimation (Weichert, 1980)

- **Parameters setting**
  - M_{min} = 4.0
  - M_{max} = Max(observation)
  - Delta M = 0.2
- **Example input data**
  - Magn. intervals (4.0, 4.2, 4.4, …., 5.8, 6.0, 6.2, 6.4)
  - Accumulated annual rate (10.8, 6.8, 4.3,…, 0.07, 0.02, 0.01)

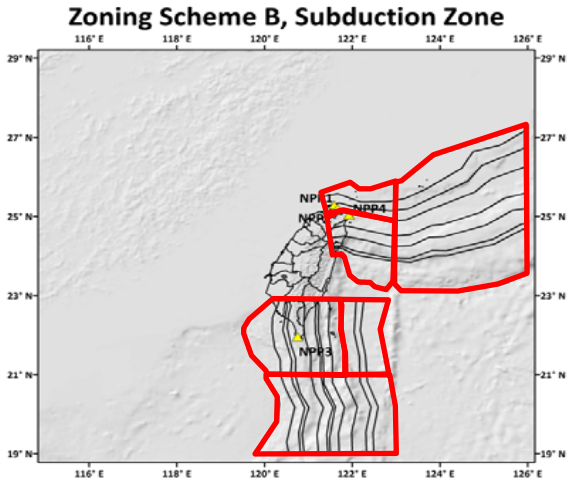


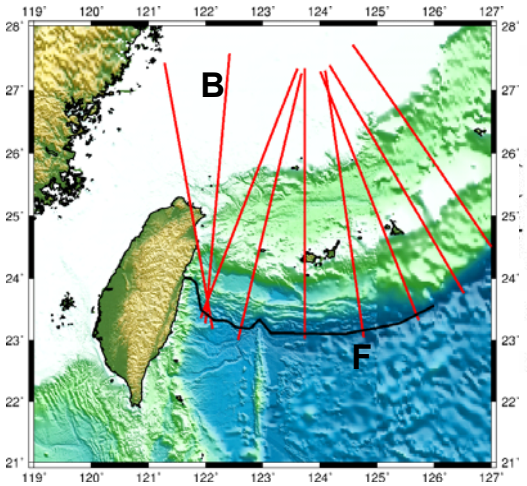
- When there is not enough data for one subzone alone to estimate b-value, we will combine two subzones according to tectonic and geological features to estimate it.
- For example, BS15 & BS03, BS16 & BS19

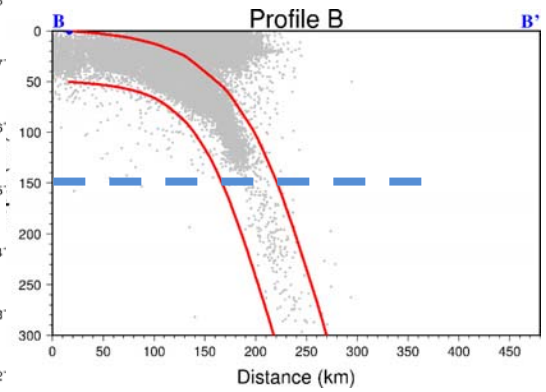


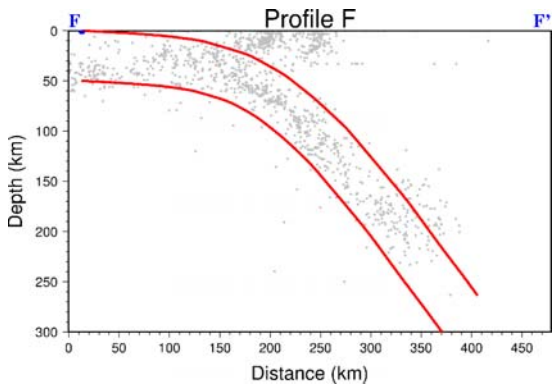
Calculation of b-value in ZB Subduction Zones

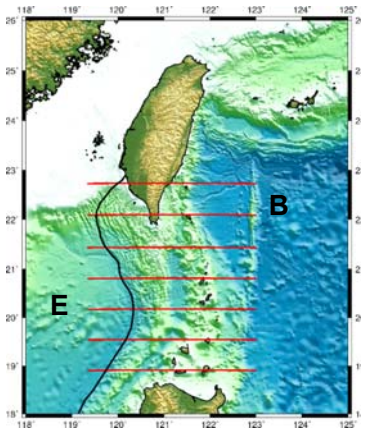
- 123°E to West： Separated by 150 km depth
- 123°E to East：Just one zone
- 21°N to North： Separated by 150 km depth
- 21°N to South： Just one zone

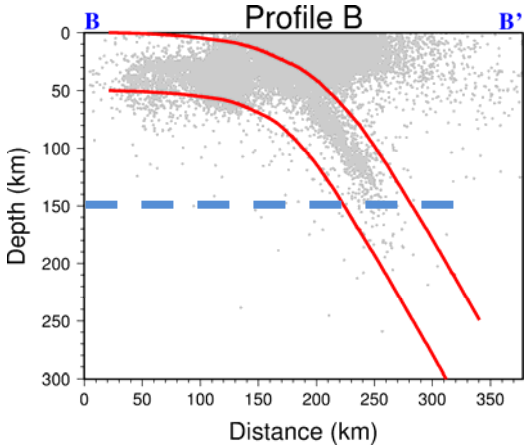


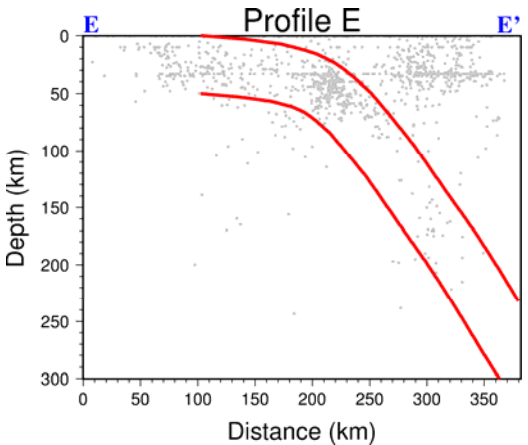






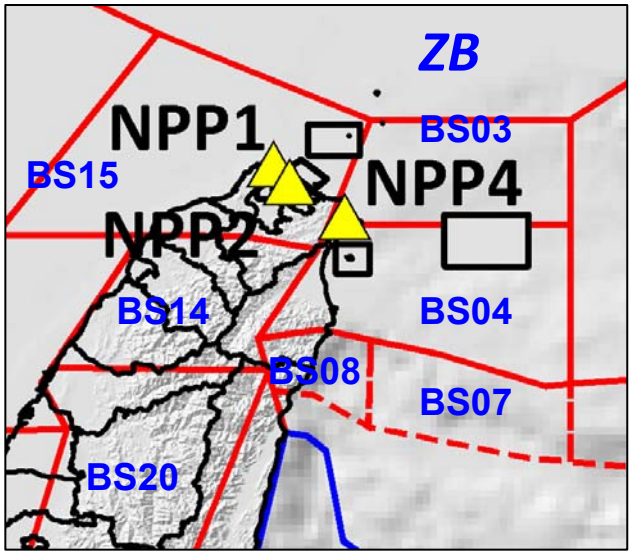


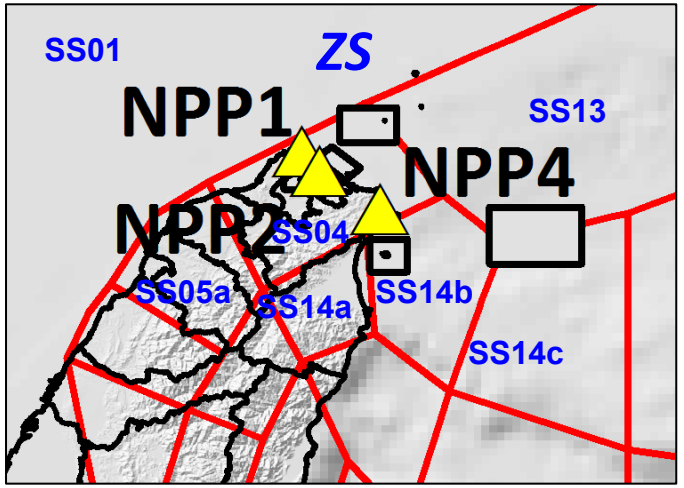


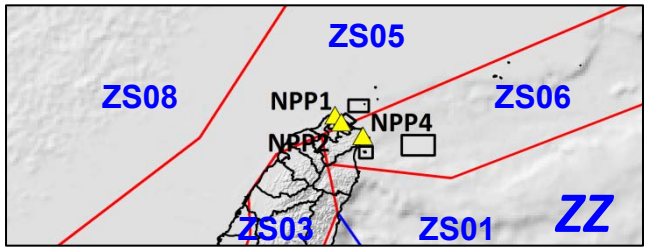


b-value & activity and M_{max} in Shallow Zones nearby NPP1 & NPP2

Zoning Scheme	Controlled Zone	b-value and sigma		Activity rate, N(5.0)	Max. Magn. in hazard cal.
ZB	BS15	0.694	0.093	0.029	6.5 / 6.7 / 7.0
ZS	SS04	0.694	0.189	0.013	6.5 / 6.7 / 7.0
ZZ	ZS05	0.926	0.076	0.439	7.0 / 7.2 / 7.5

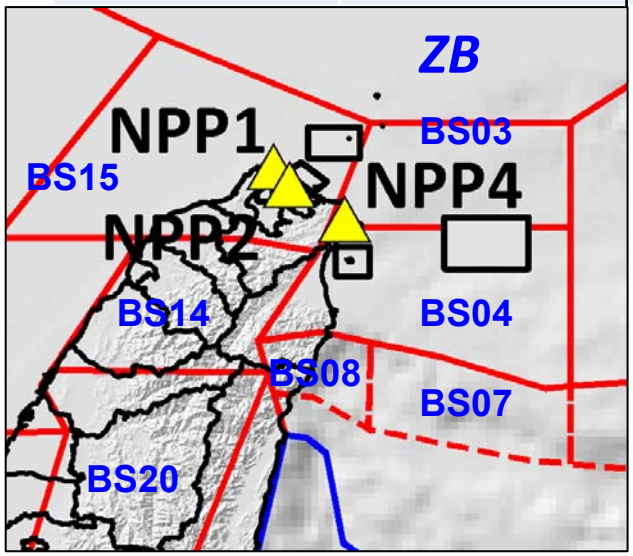


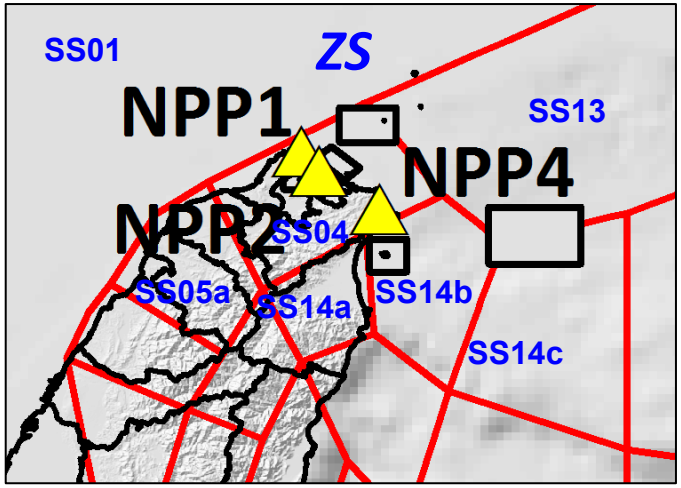


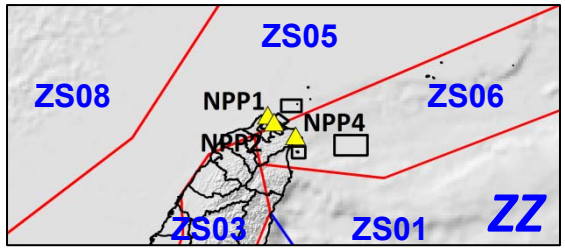


b-value & activity and M_{max} in Shallow Zones nearby NPP4

Zoning Scheme	Controlled Zone	b-value and sigma		Activity rate, N(5.0)	Max. Magn. in hazard cal.
ZB	BS04	1.009	0.050	1.057	6.8 / 7.0 / 7.3
	BS03	0.694	0.093	0.058	6.5 / 6.7 / 7.0
ZS	SS14b	0.888	0.043	0.521	6.5 / 6.7 / 7.0
	SS04	0.694	0.189	0.013	6.5 / 6.7 / 7.0
ZZ	ZS06	1.006	0.038	1.942	8.29 / 8.29 / 8.29
	ZS01	0.935	0.021	5.380	8.0 / 8.0

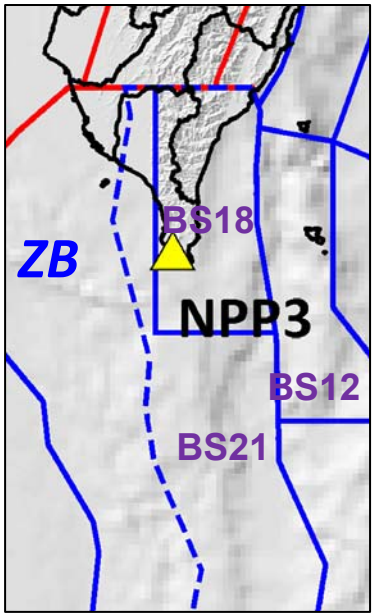


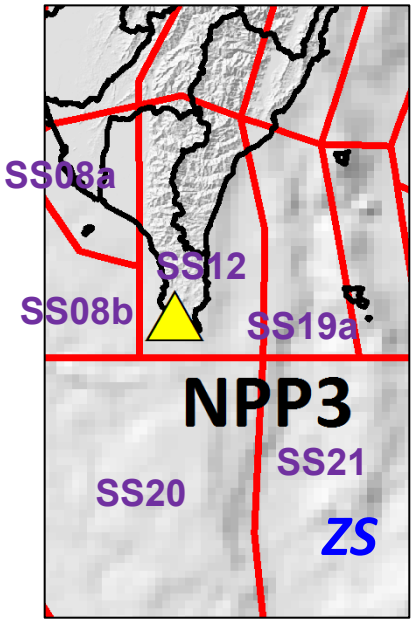


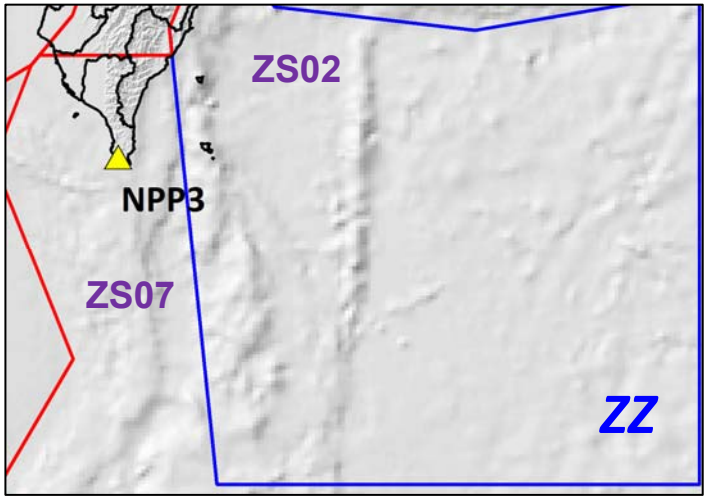


b-value & activity and M_{max} in Shallow Zones nearby NPP3

Zoning Scheme	Controlled Zone	b-value and sigma		Activity rate, N(5.0)	Max. Magn. in hazard cal.
ZB	BS18	0.820	0.071	0.540	7.7 / 7.7 / 7.7
	BS21	0.970	0.057	0.816	7.4 / 7.6 / 7.9
ZS	SS12	0.885	0.028	0.462	7.03 / 7.23 / 7.53
ZZ	ZS07	1.102	0.029	3.995	7.7 / 7.7 / 7.7







Parameters for HC of Volcanic Source Zones

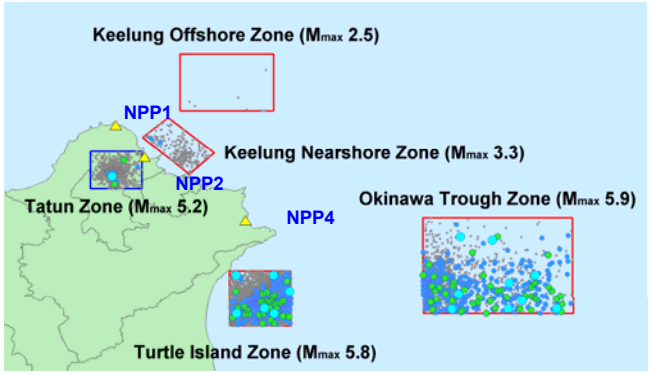
Setting for Seismic Source Calculation					
Name of Zone	**Tatun**	**Keelung Nearshore**	**Keelung Offshore**	**Turtle Island**	**Okinawa Trough**
Depth of Zone (km)	10	15	15	15	15
b-value[1]	1.032 (±0.117)	1.333 (±0.145)	1.000[2]	0.919 (±0.015)	0.811 (±0.048)
N(5.0)[1]	0.0030	0.0003	0.0001	0.1550	0.1980
Max. Magnitude, M_u[3]	6.0	6.0	6.0	6.5	6.5

[1] Based on mainshocks catalog provided by Y.M. Wu, and Maximum Likelihood Estimation ($m_0 \geqslant 2.0$)

[2] Assumed b-value as 1.000 due to lack of seismic data

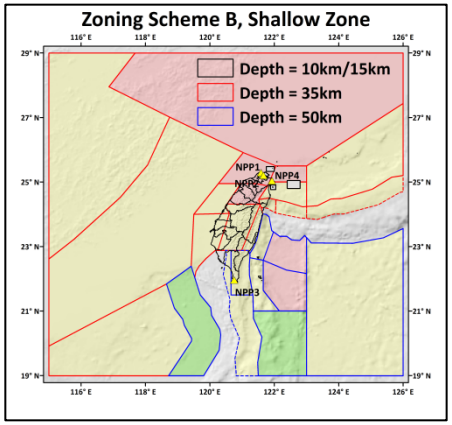
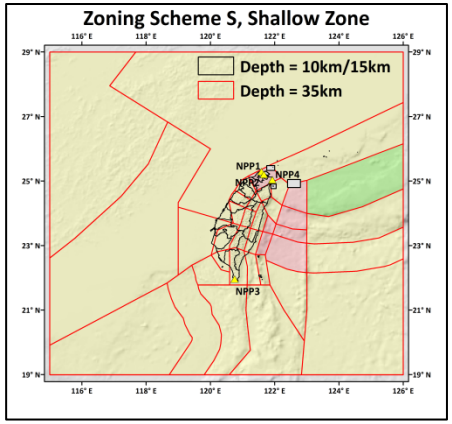
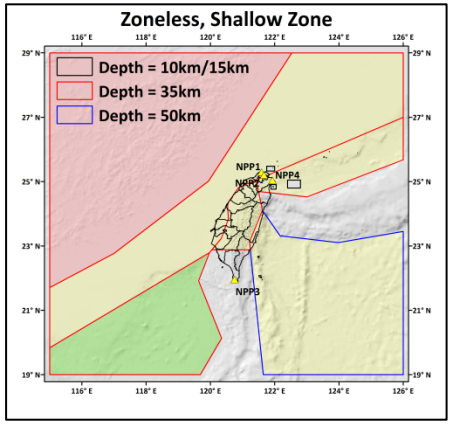
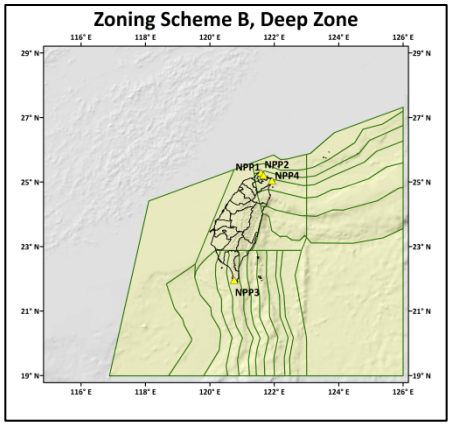
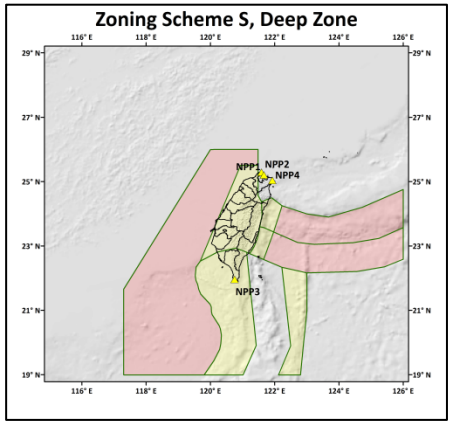
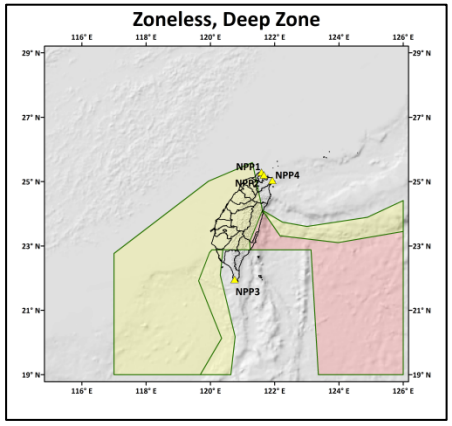
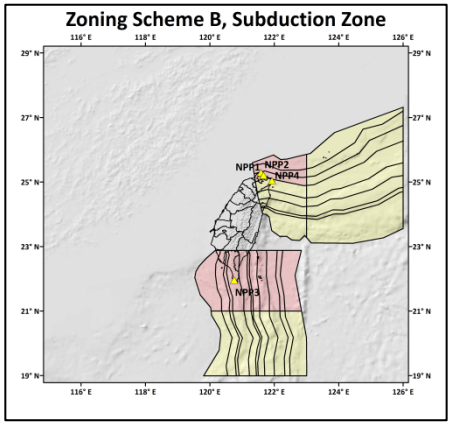
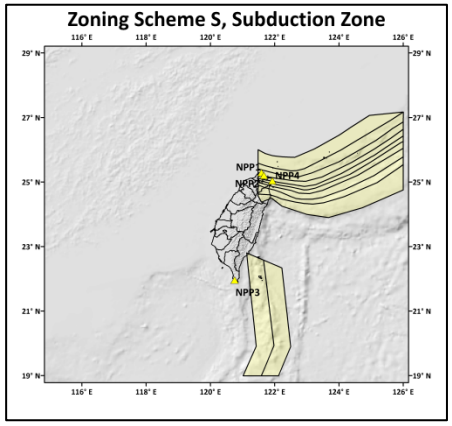
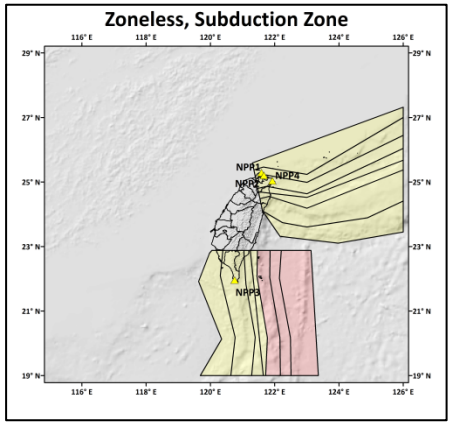
[3] Additional Reference: Payne et al. (2015). "SSHAC Level 1 Probabilistic Seismic Hazard Analysis for the Idaho National Laboratory," Rev. 0, INL/EXT-15-36682, p.77.

Setting for Ground Motion Calculation			
Crustal GMPE	ASK14, BSSA14, CB14, CY14, ID14		
Sigma	0.55	**Max. Epsilon**	4.0



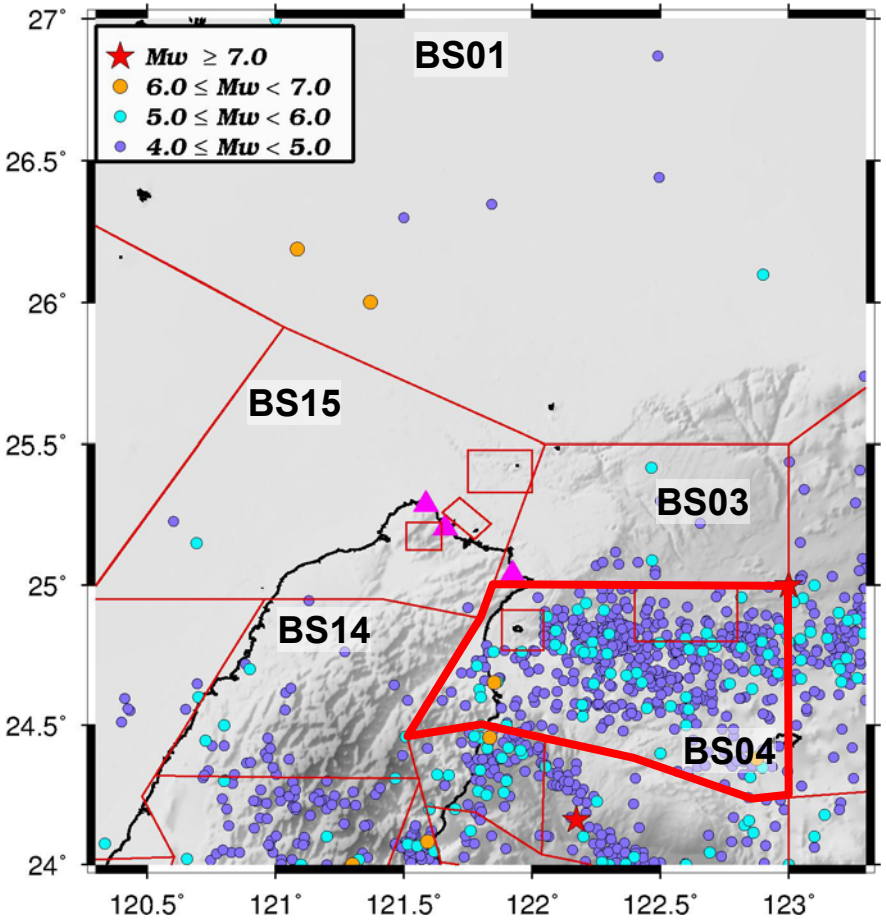
b-value at Each Subzone

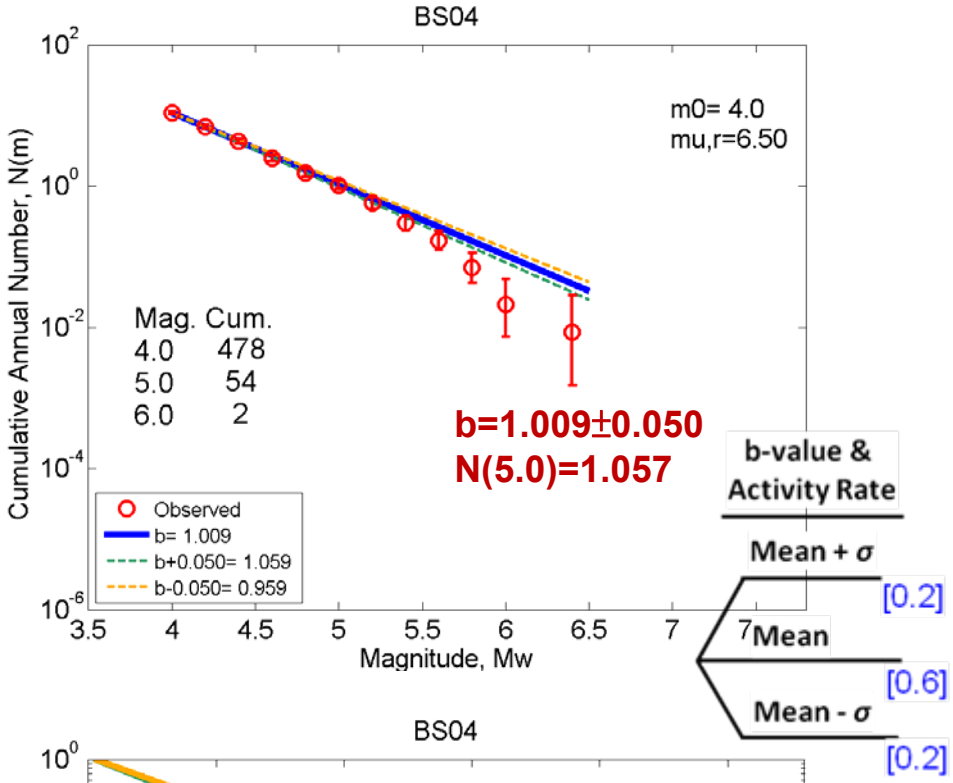
b-value <= 0.8
0.8 < b-value <= 1.2
b-value > 1.2

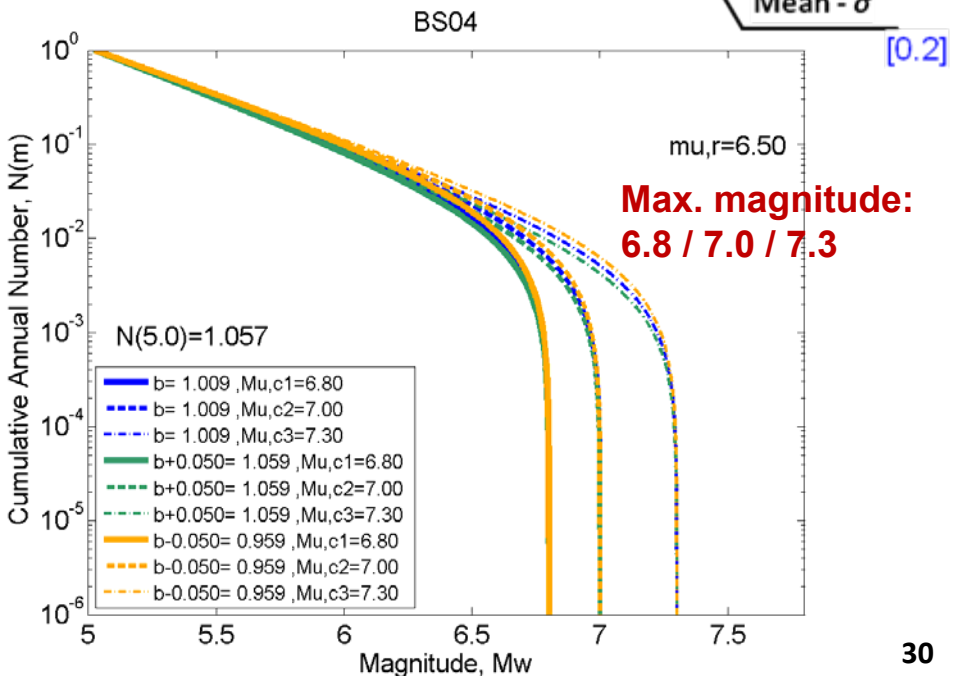
	Scheme B	Scheme S	Zoneless
Shallow Zone			
Deep Zone			
Subduction			

Logic Tree Node of b-value & Activity Rate (BS04)

$$0.02 < \sigma < 0.25$$

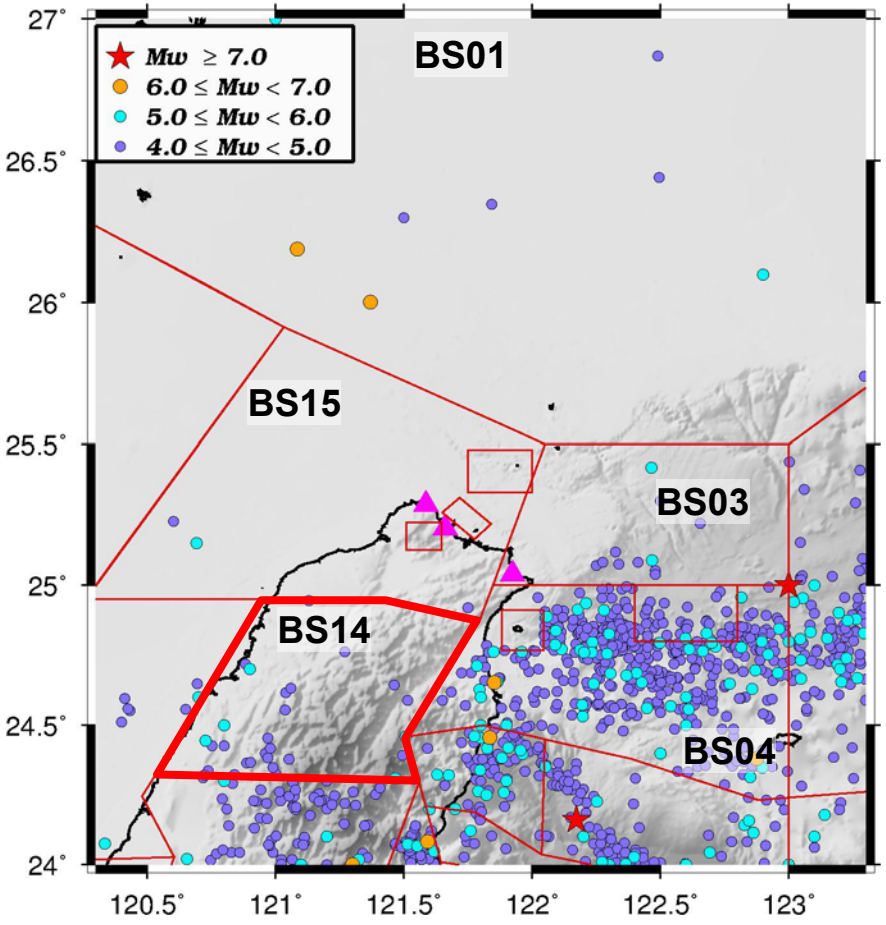


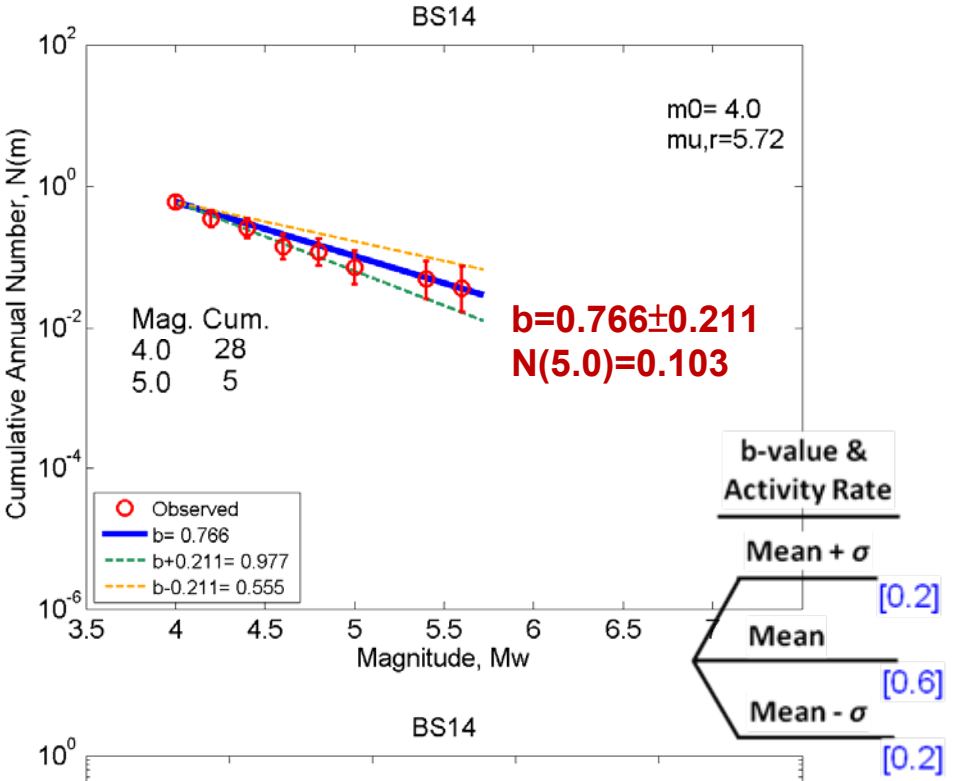


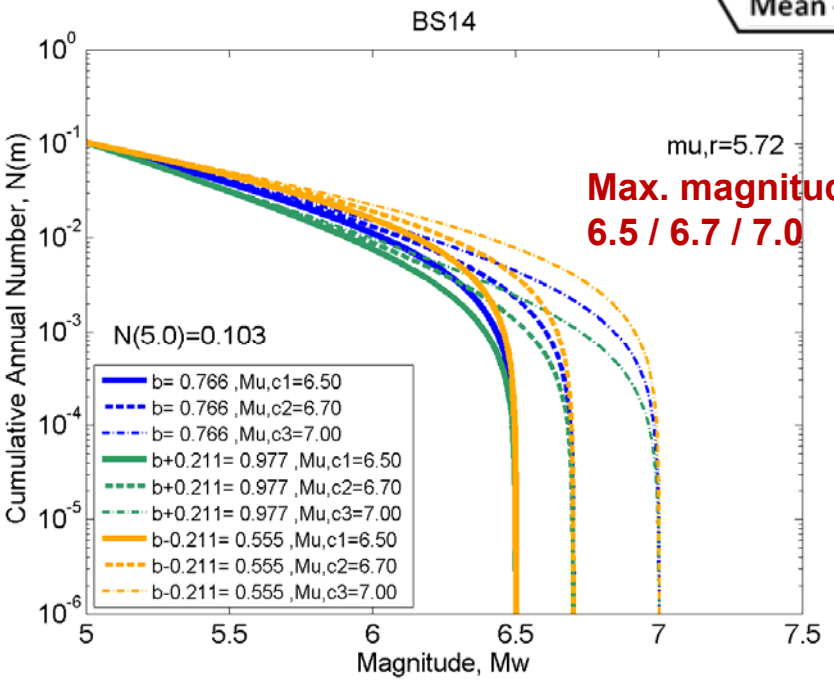


Logic Tree Node of b-value & Activity Rate (BS14)

$$0.02 < \sigma < 0.25$$





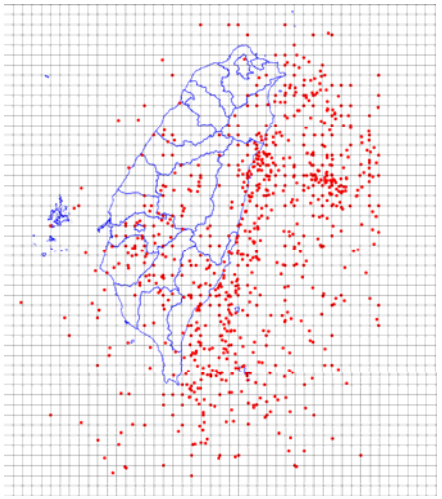


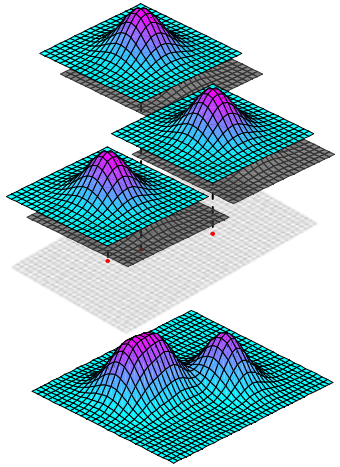
Smoothed Activity Rate in Zoneless Model

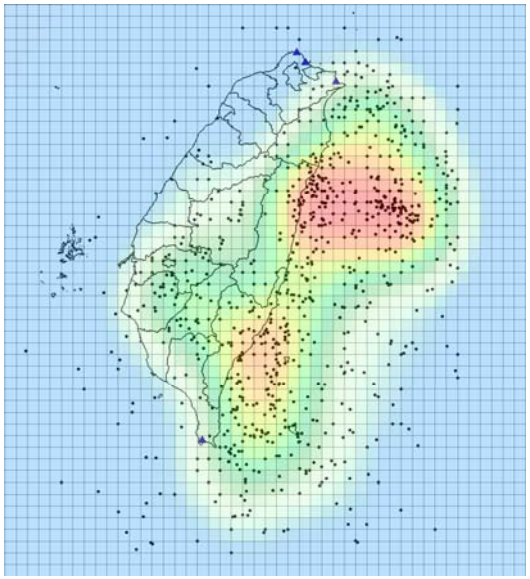
Smoothed-Gridded Seismicity (Scheme Z)

- **Seismic data**
  - Period: 1900 ~ 2015/06/30
  - Mw $\geqslant$ 5.5
  - Remove fore- and after-shocks
  - Remove fault/volcanic events
- **Grid size**
  - Size of Grid Cell: 0.1° x 0.1°
- **Spatial smoothing function**
  - 2-D Gaussian Distribution

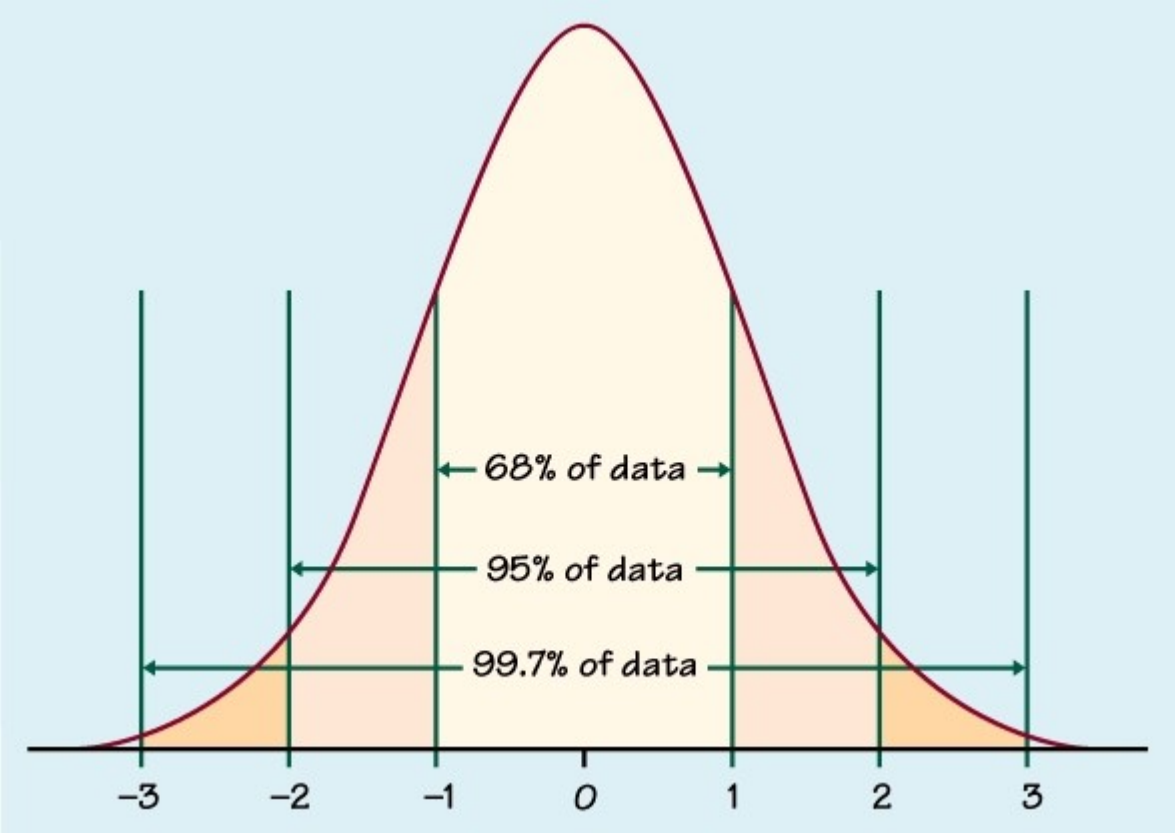
$$f(x,y)=\sum_{i=1}^{n}\sum_{j=1}^{d}\frac{1}{2\pi h_x h_y}\exp\left(-\frac{1}{2}\left[\left(\frac{x_i}{h_x}\right)^2+\left(\frac{y_i}{h_y}\right)^2\right]\right)$$







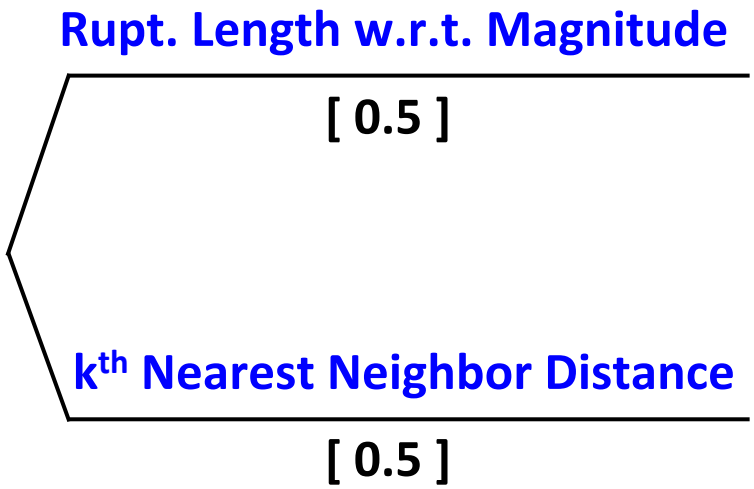
Gaussian Distribution Curve



Area under the Gaussian distribution curve
Use Gaussian distribution with various standard deviation to describe the relative activity rate distribution in each subzone

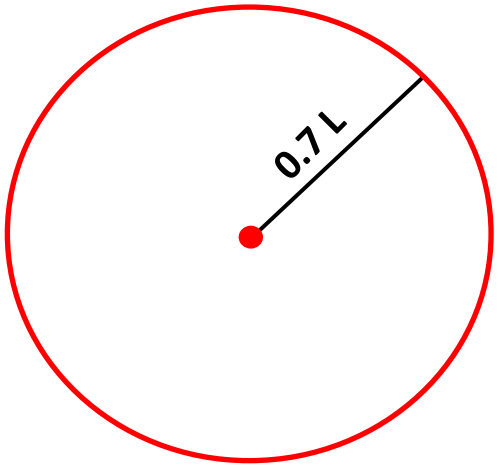
Smoothing Distance Setting for Scheme Z

Adaptive Radius in Scheme Z



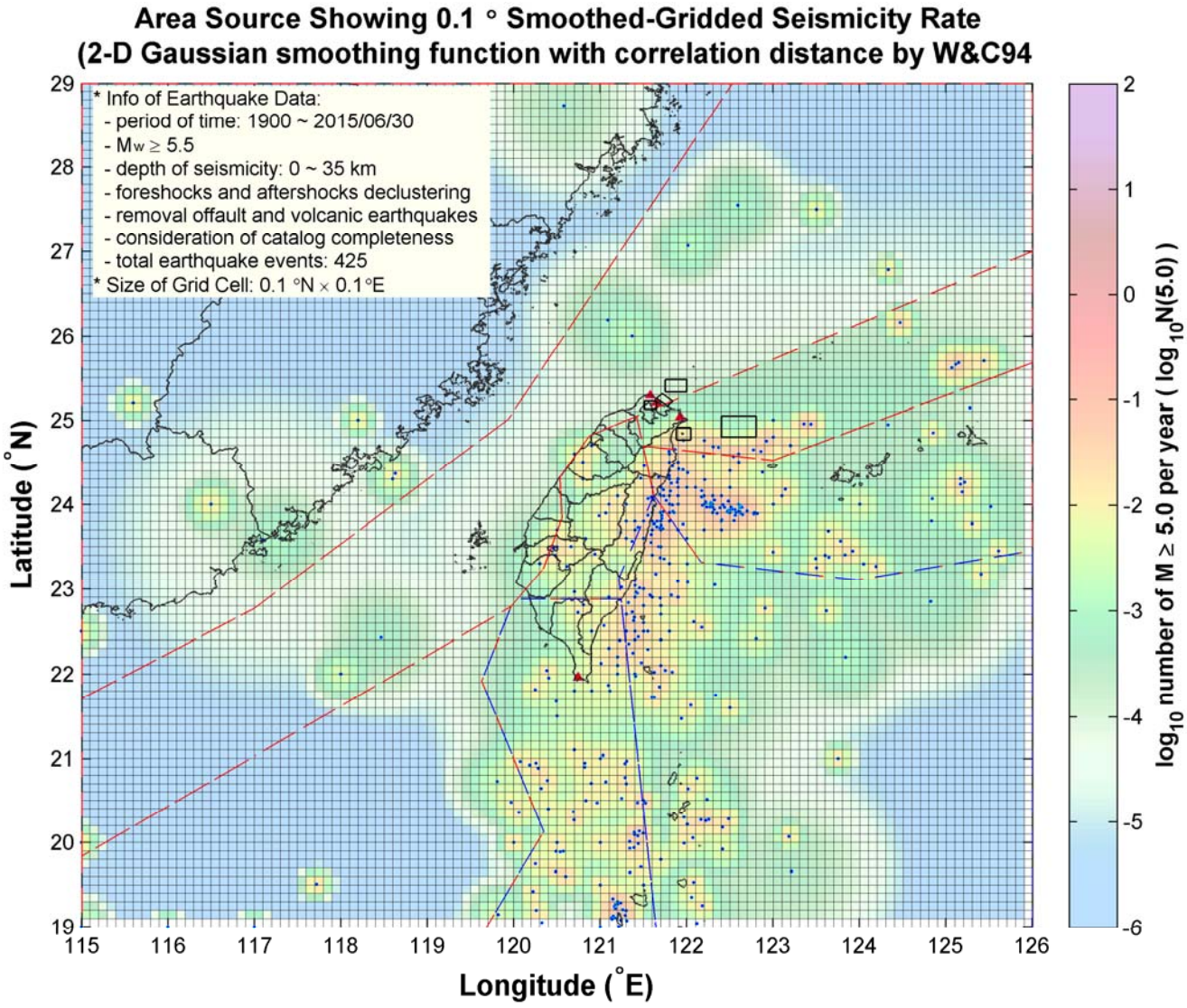
Rupture Length w.r.t. Magnitude

- **Applying W&C94 Scaling Law (all type)**
  - log10(L) = -2.44 + 0.59M_w ± sigma (0.16) (L: subsurface rupture length)
- **Assuming**
  - Future earthquake will most likely occur around the previous location
  - the size of seismogenic region depends on the earthquake magnitude
- **Setting sigma of the 2-D Gaussian distribution equal to 0.7L**
  - Epicenter may not locate at half rupture length
  - Considering uncertainty, set the rupture length equal to mean plus one sigma in W&C94



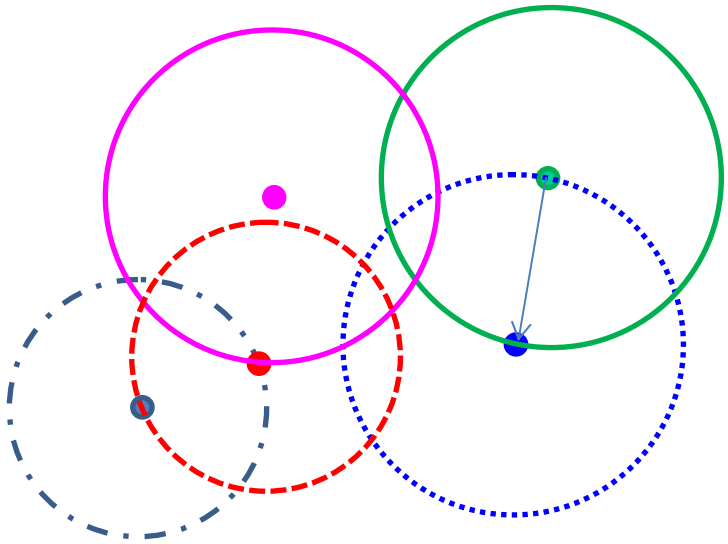
Magnitude	*RLD by W&C94 ALL Type (km)*	
M_w	mean	mean + sigma
5.5	6.4	9.2
6.0	12.6	18.2
6.5	24.8	35.9
7.0	49.0	70.8
7.1	56.1	81.1
7.2	64.3	92.9
7.3	73.6	106.4
7.4	84.3	121.9
7.5	96.6	139.6
7.6	110.7	160.0
7.7	126.8	183.2
8.0	190.5	275.4

Smoothed Rate by W&C94 Scaling Law



K-th Nearest Neighbor Distance

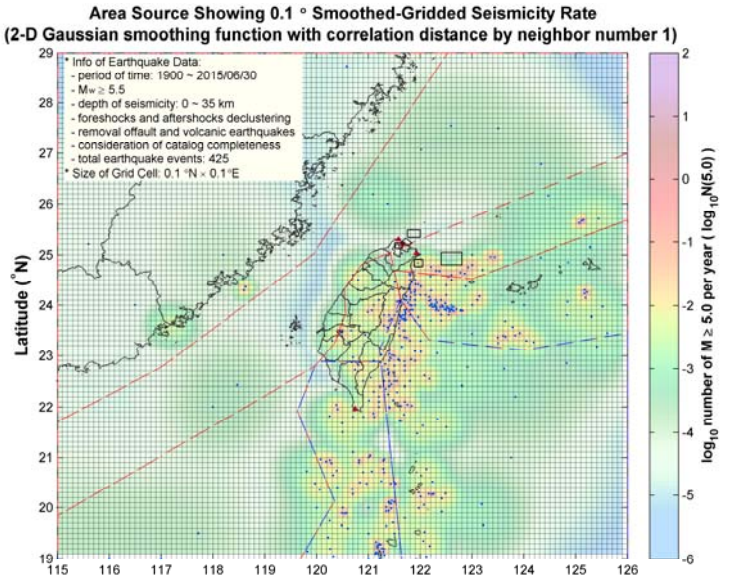
- **K-th Nearest Neighbor (KNN)**
- **Based on the Density of Earthquake Distribution**
  - Region with low seismicity rate:
    larger smoothing distance
    larger sigma in Gaussian distribution
  - Region with large seismicity rate:
    smaller smoothing distance
    smaller sigma in Gaussian distribution
- **Gradually increase the K-value to check changes in seismic rate distribution**
- **K-value set to 10**



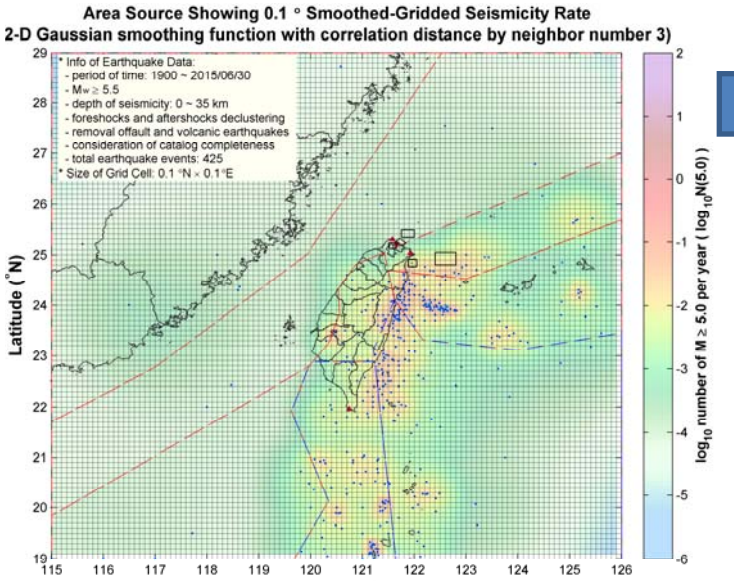
Example of 1st nearest neighbor (1-NN)

Smoothed Rate by K-th Nearest Neighbor

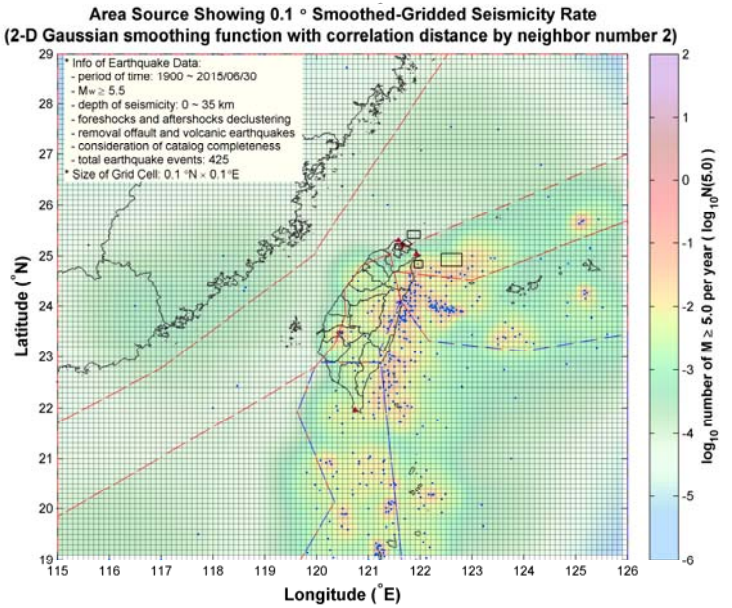
1-NN



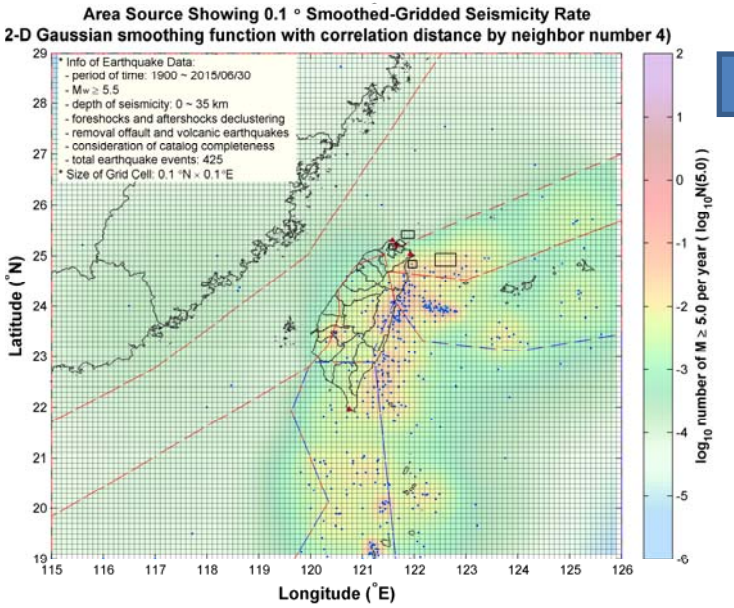
3-NN



2-NN

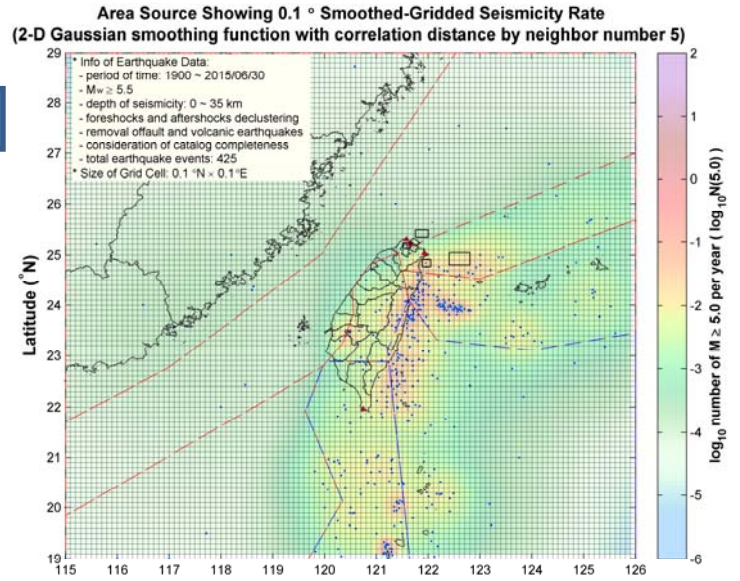


4-NN

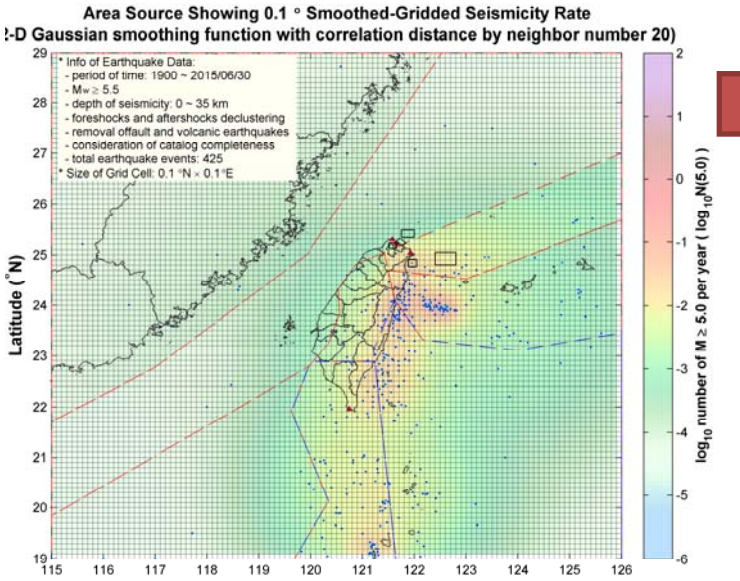


Smoothed Rate by K-th Nearest Neighbor

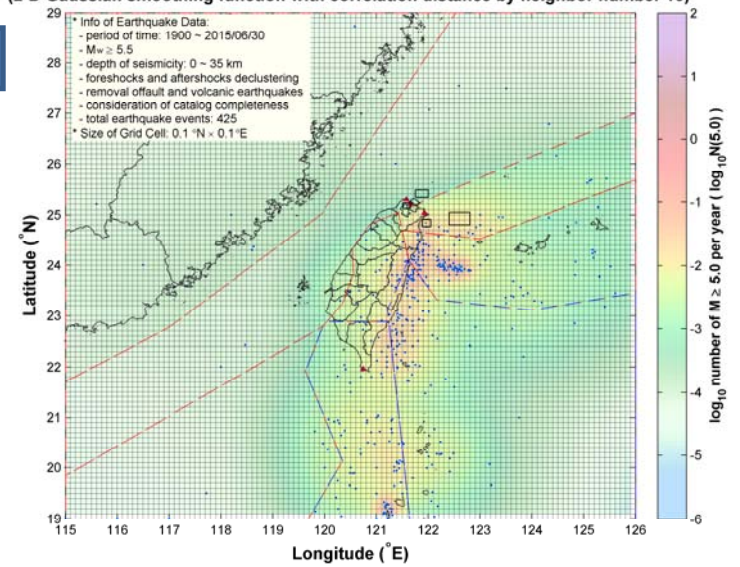
5-NN



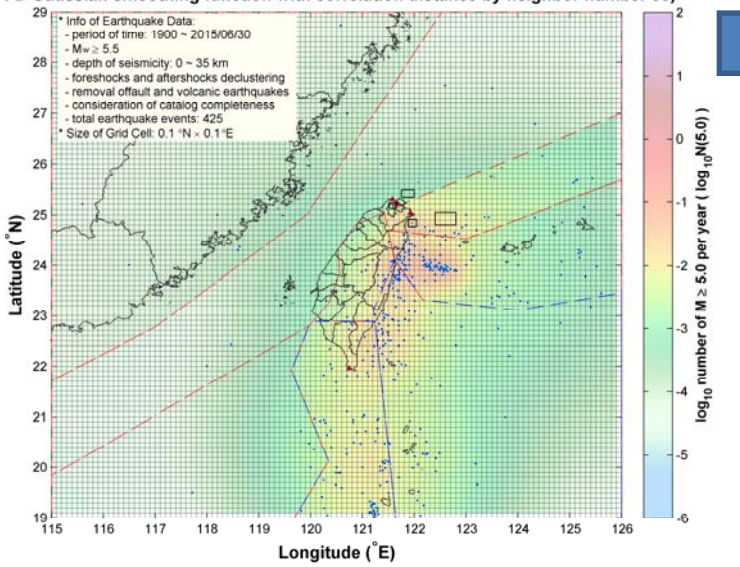
20-NN



10-NN

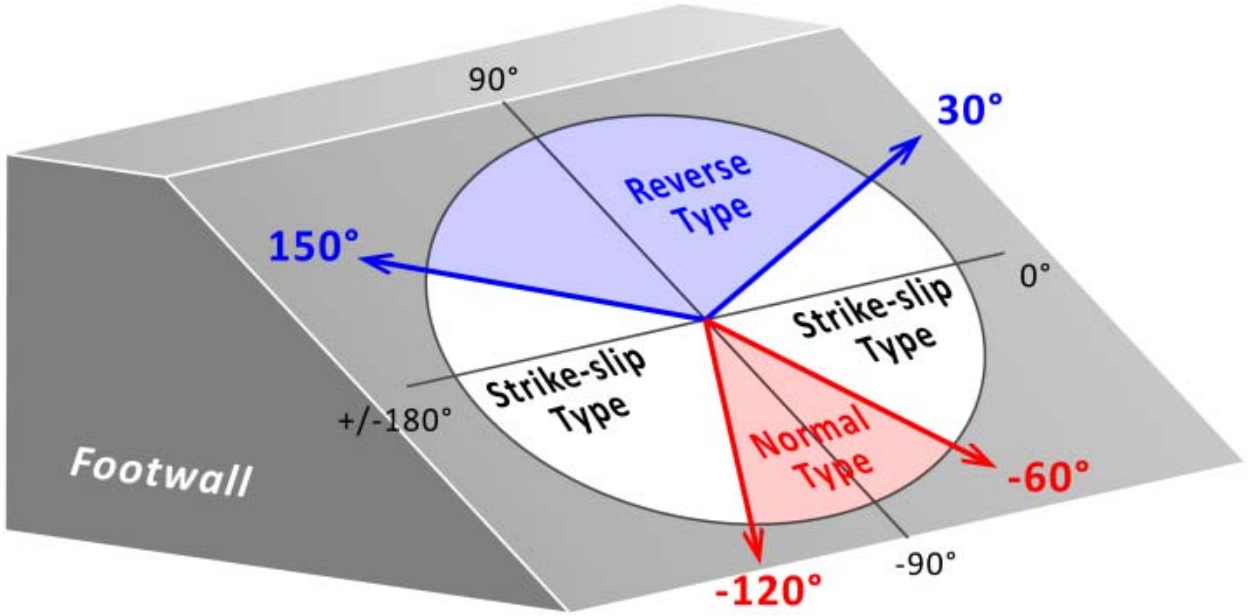


30-NN



Focal Mechanism Statistics

Classification of Style of Faulting



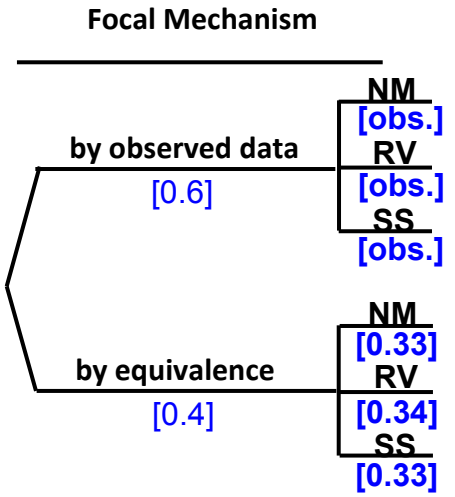
Summary of Abrahamson, N., & Silva, W. (2008).

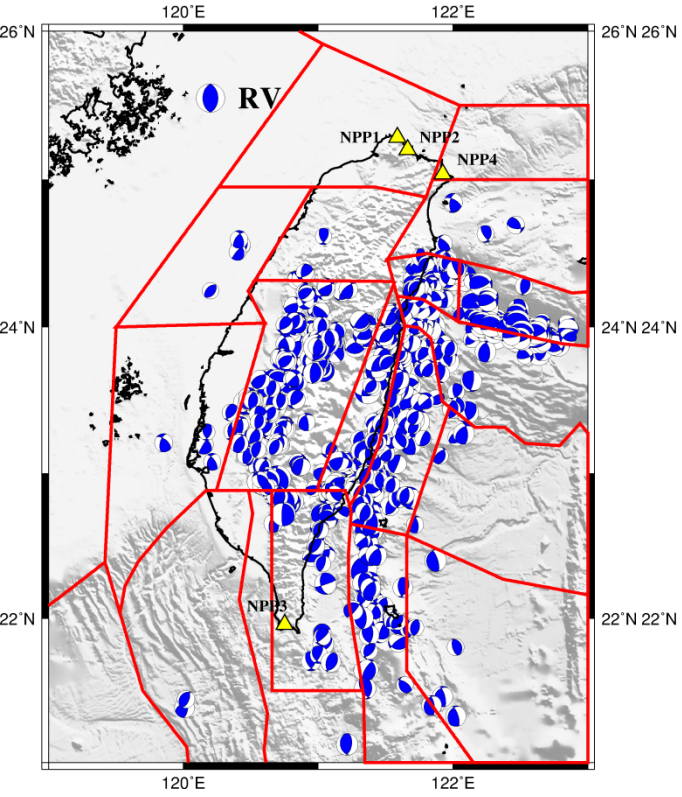
Rake is used to describe the direction of fault movement with respect to the strike (measured anti-clockwise from the horizontal, up is positive; values between -180° and 180°)
[G.H. Davis and S.J. Reynolds (1996)]

Focal Mechanism Statistics

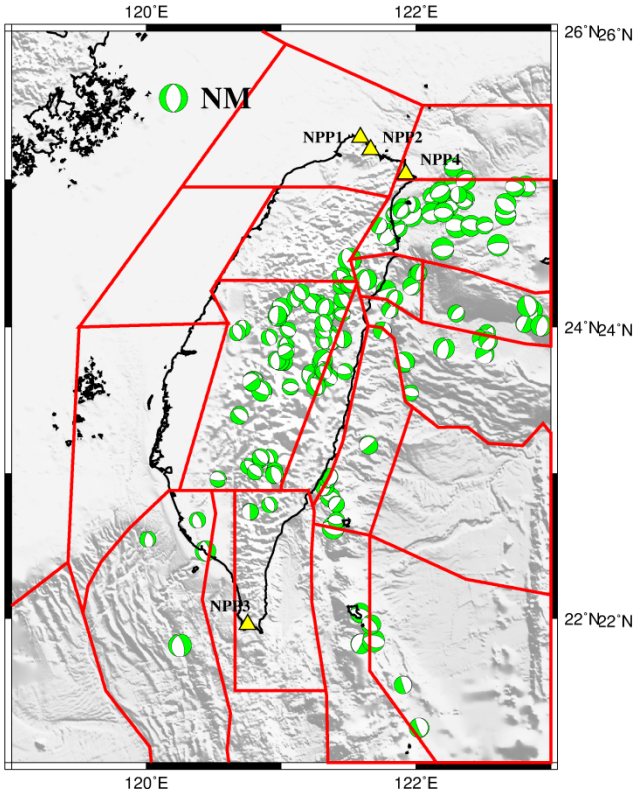
- Catalog: 1977 ~ 2015/6
- Magnitude: Mw≧4.0
- Depth: ≦ 35 km

Zoning Scheme B

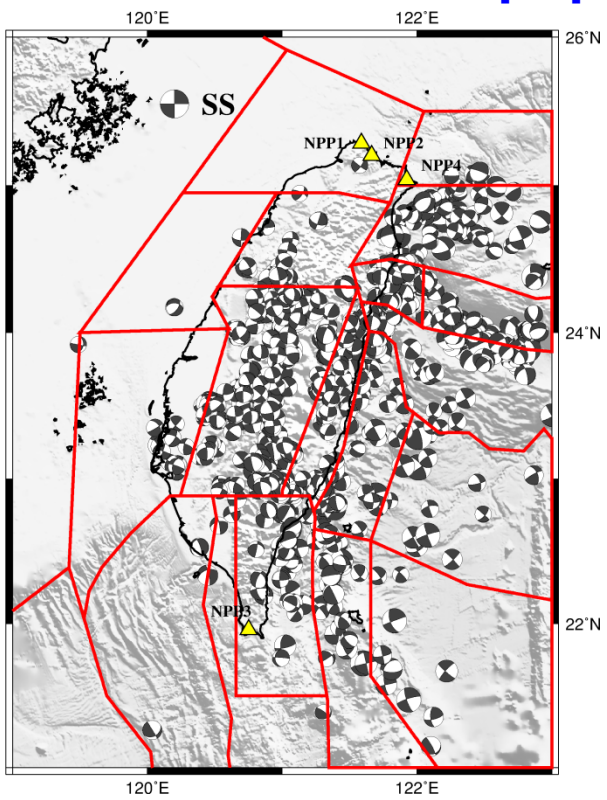




Reverse Type



Noraml Type



Strike Slip Type

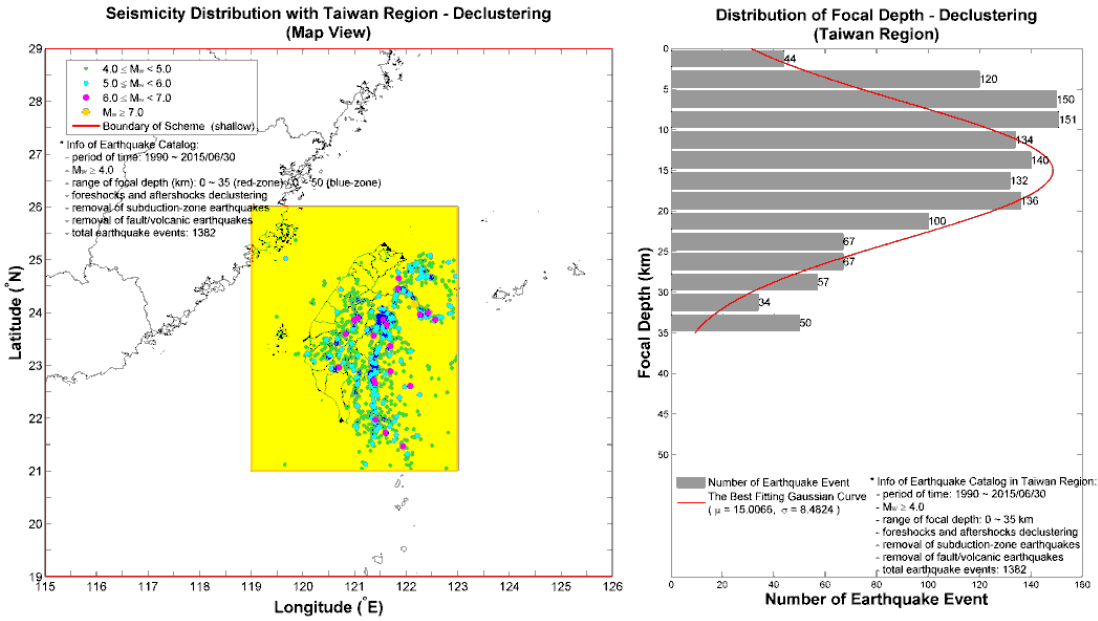
Count percentage of style of faulting in each subzone

Depth Probability Density Function

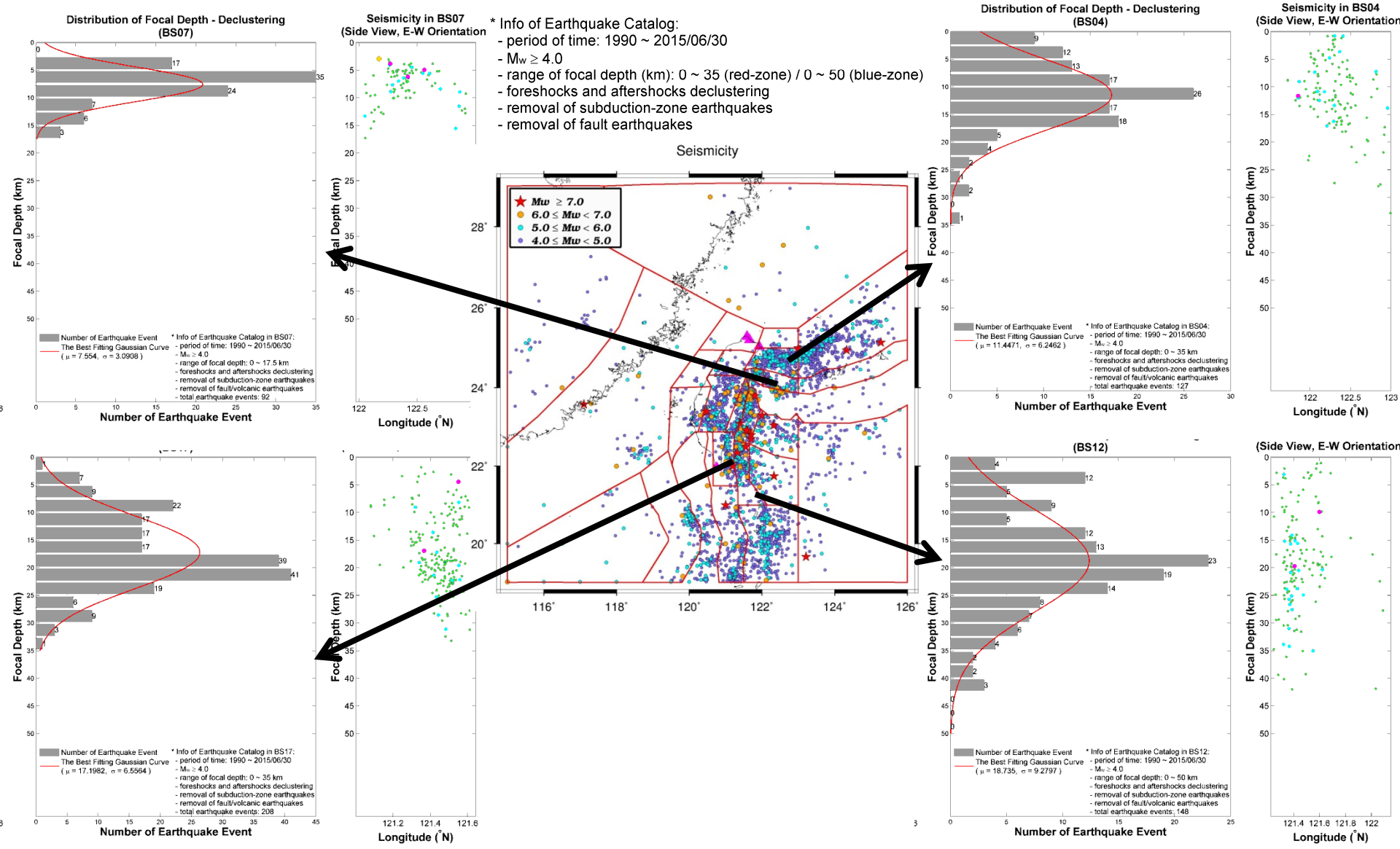
Depth Probability Density Function

- **Decluster and relocated EQ catalog**
  - 1990 – 2015/6/30
  - Mw≧4.0
  - Remove fault/volcanic events
- **Shallow zone**
  - Truncated normal distribution
- **Deep zone**
  - Triangular distribution
- **Subduction Intraslab**
  - Uniform Distribution

CWB Region (shallow)

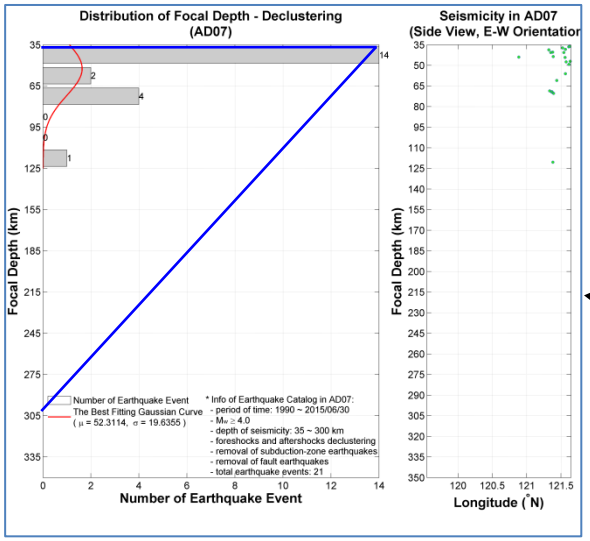


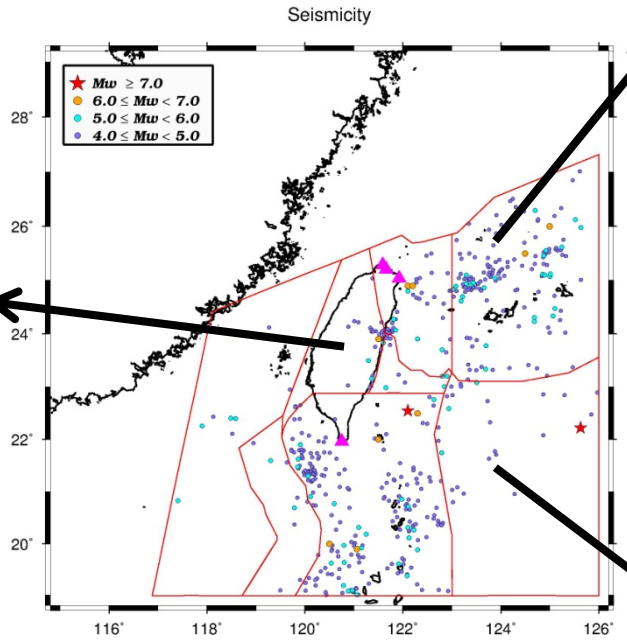
Example of Depth PDF –Scheme B (Shallow Zone)

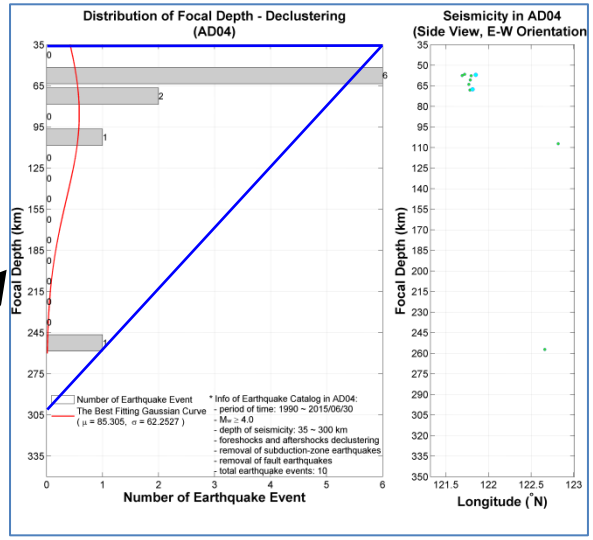


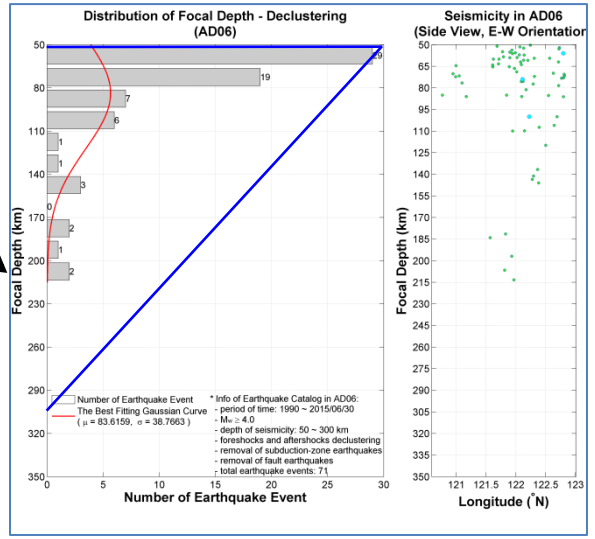
Example of Depth PDF –Scheme B (Deep Zone)

* Info of Earthquake Catalog:
  - period of time: 1990 ~ 2015/06/30
  - $M_W \geq 4.0$
  - range of focal depth (km): 35 ~ 300 (red-zone) / 50 ~ 300 (blue-zone)
  - foreshocks and aftershocks declustering
  - removal of subduction-zone earthquakes
  - removal of fault earthquakes





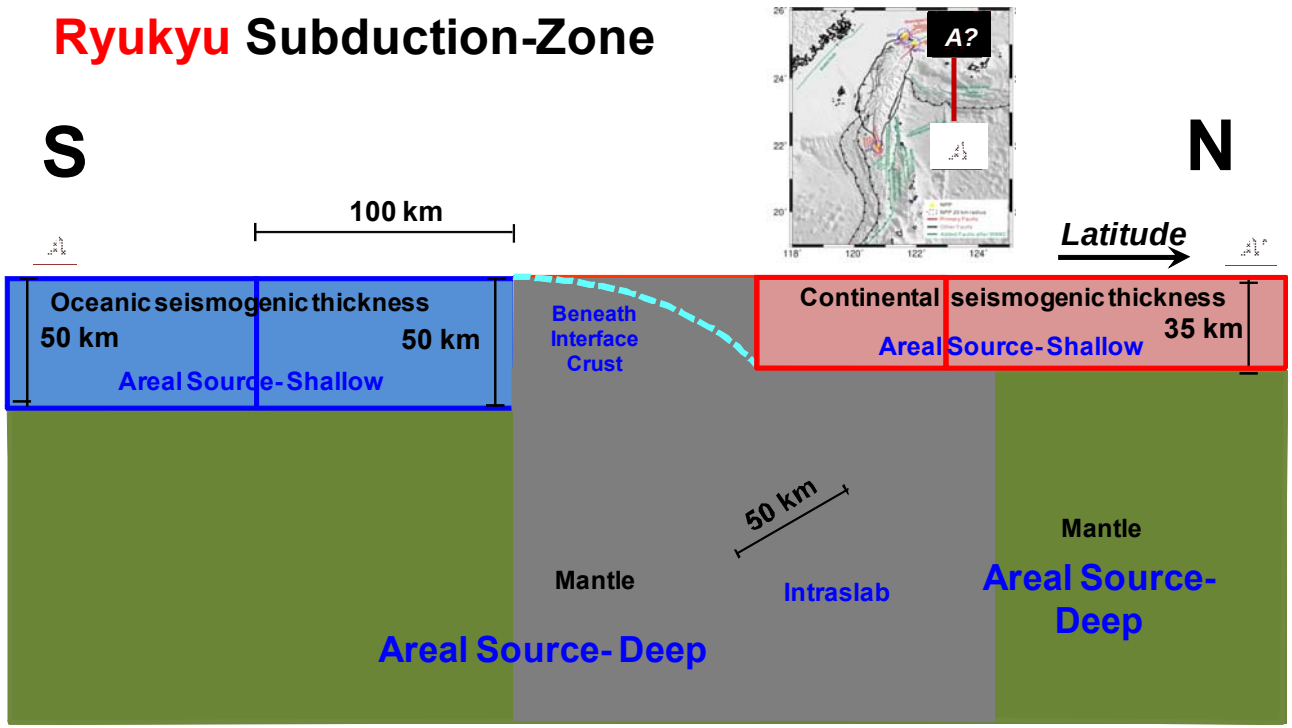




GMPE in Different Source Zones

Adopted GMPE

- **Shallow zone & volcano source**
  - Crustal GMPE
- **Deep zone & subduction intraslab**
  - Subduction intraslab GMPE
- **Beneath interface crust:**
  - Subduction interface GMPE

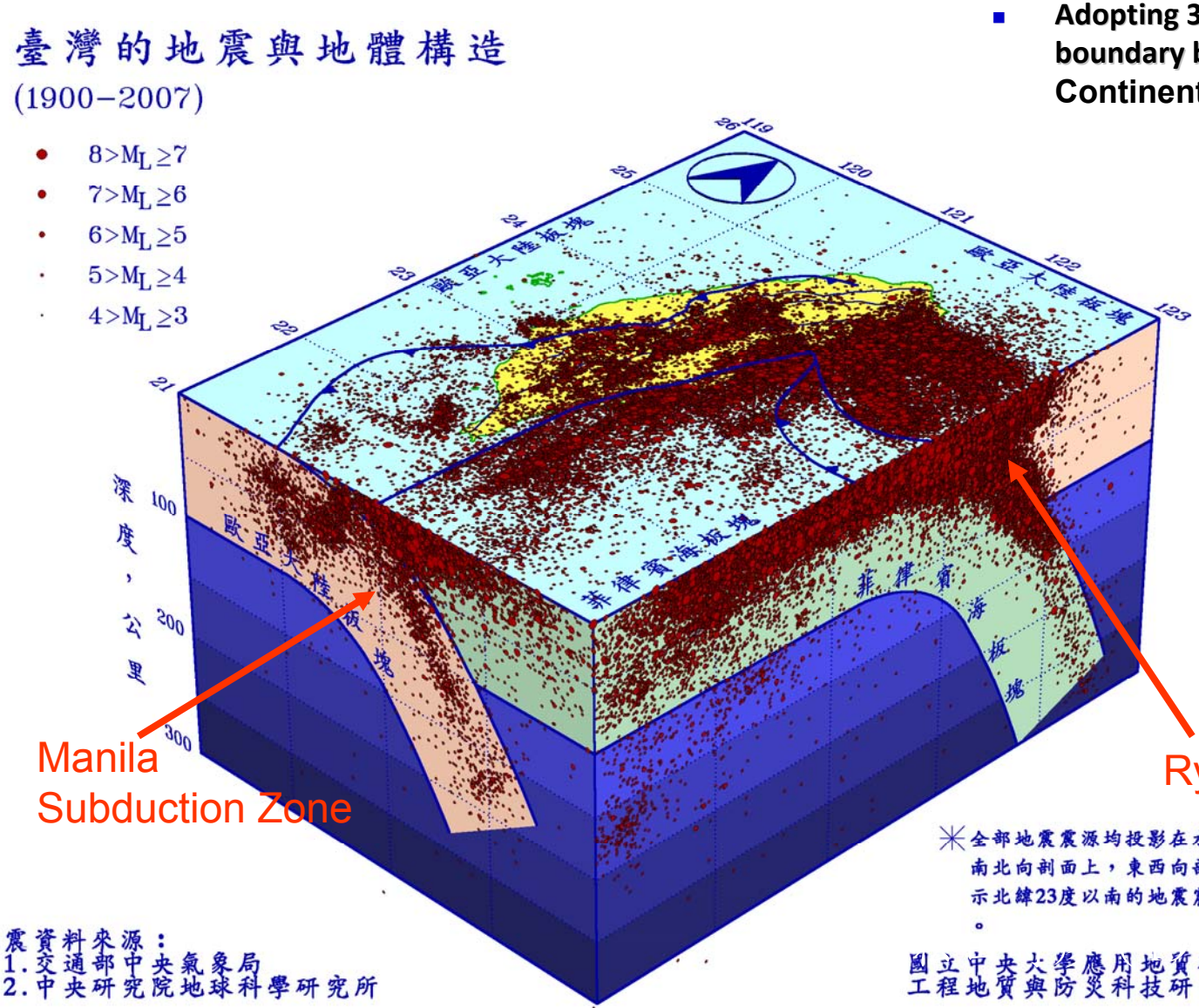


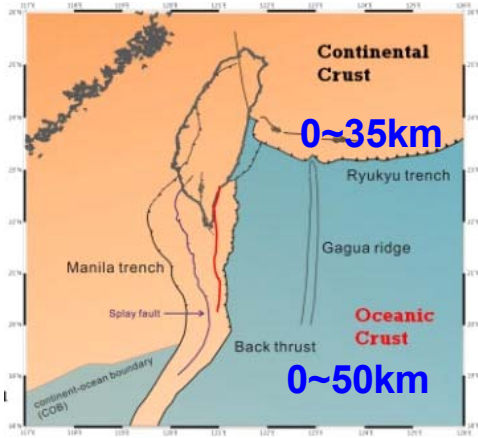
Thank You for Your Attention

Modeling of Areal Sources

Tectonic Structure in Taiwan

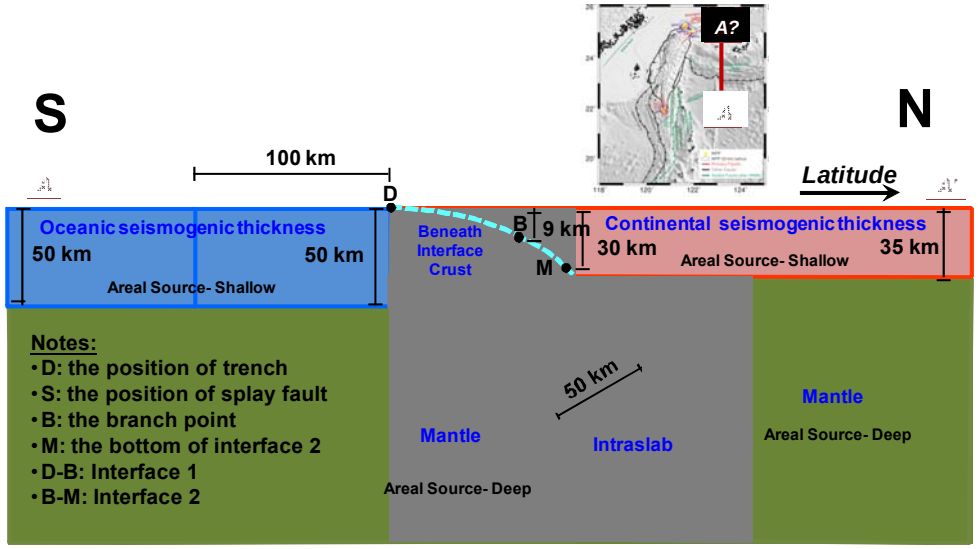
- **Adopting 35 km or 50 km as the division boundary by Loh, 1991 & Oceanic and Continental Crust Depth**

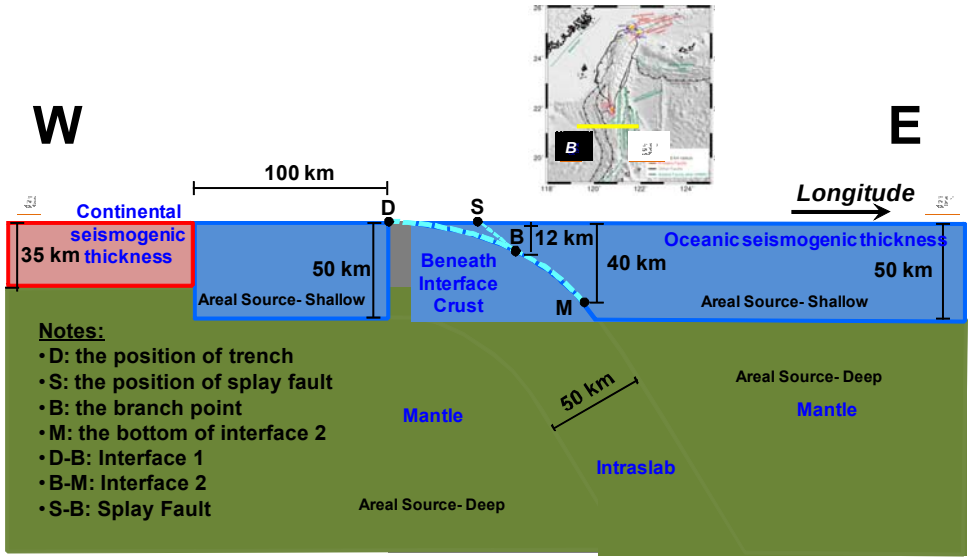




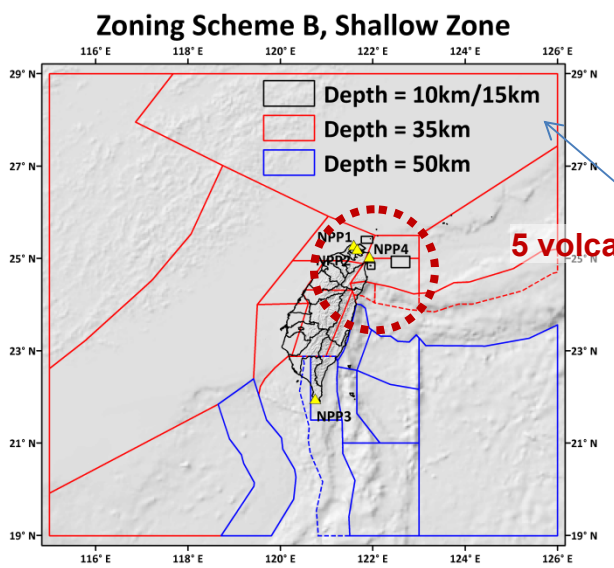
Modeling of Areal Sources

- **Shallow/Deep Zones**
  - Depth boundary
    - Scheme ZB & ZZ: Continental: 35 km; Oceanic: 50 km
    - Scheme ZS: 35 km in all cases
  - Maximum depth: 300 km
- **Subduction Intraslab**
  - Ryukyu Trench (A – A')
    - Beneath Interface Crustal (Depth: 0~35 km) for ZB & ZZ
    - Intraslab (35 km~ 300 km)
  - Manila Trench (B – B')
    - Beneath Interface Crustal (Depth: 0~50 km) for ZB & ZZ
    - Intraslab (50 km~ 250 km) for ZB & ZZ
      Intraslab (35 km~) for ZS
- **Volcanic sources**

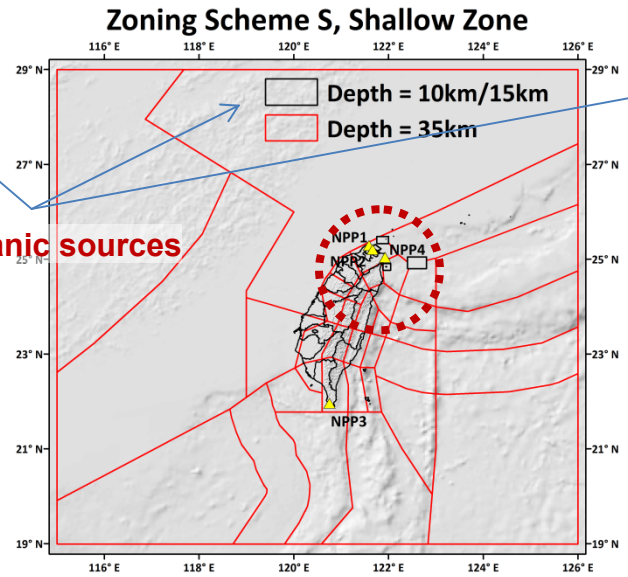


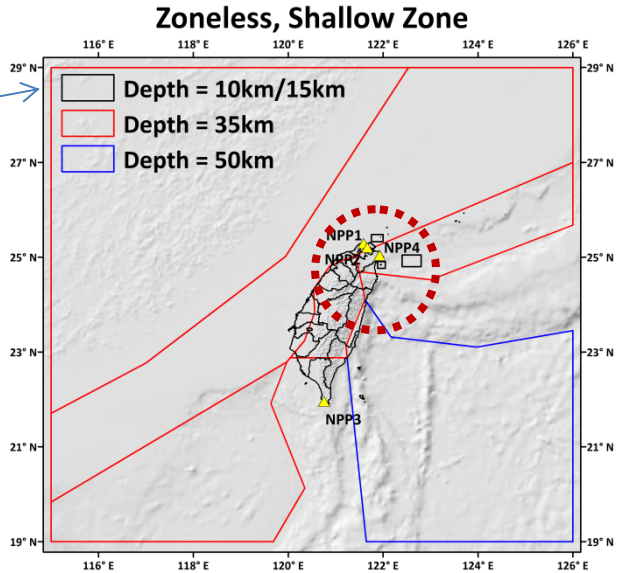


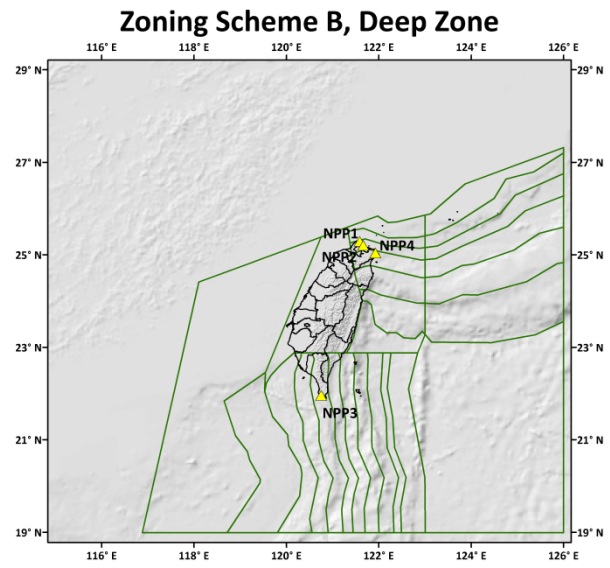
Zoning Schemes for Shallow/Deep Zones

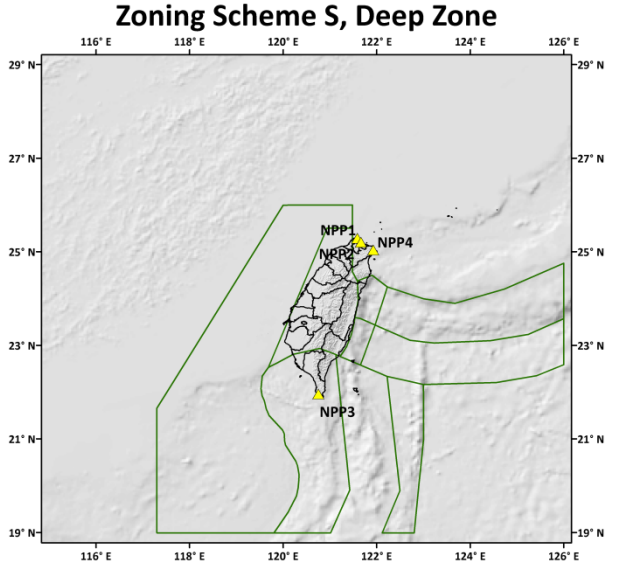


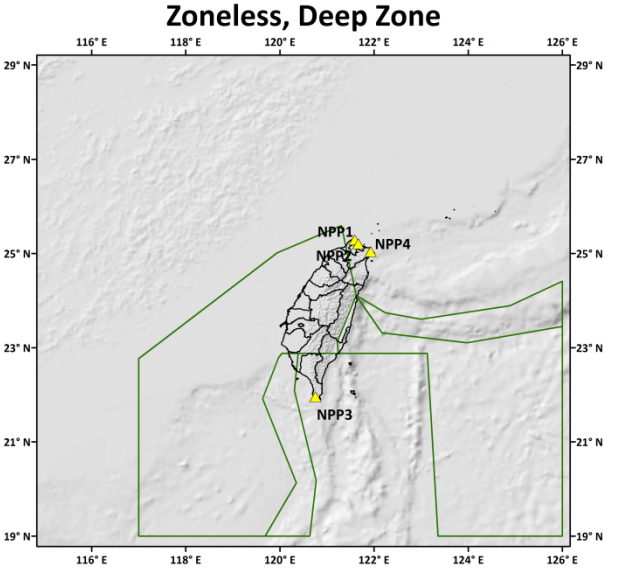
5 volcanic sources



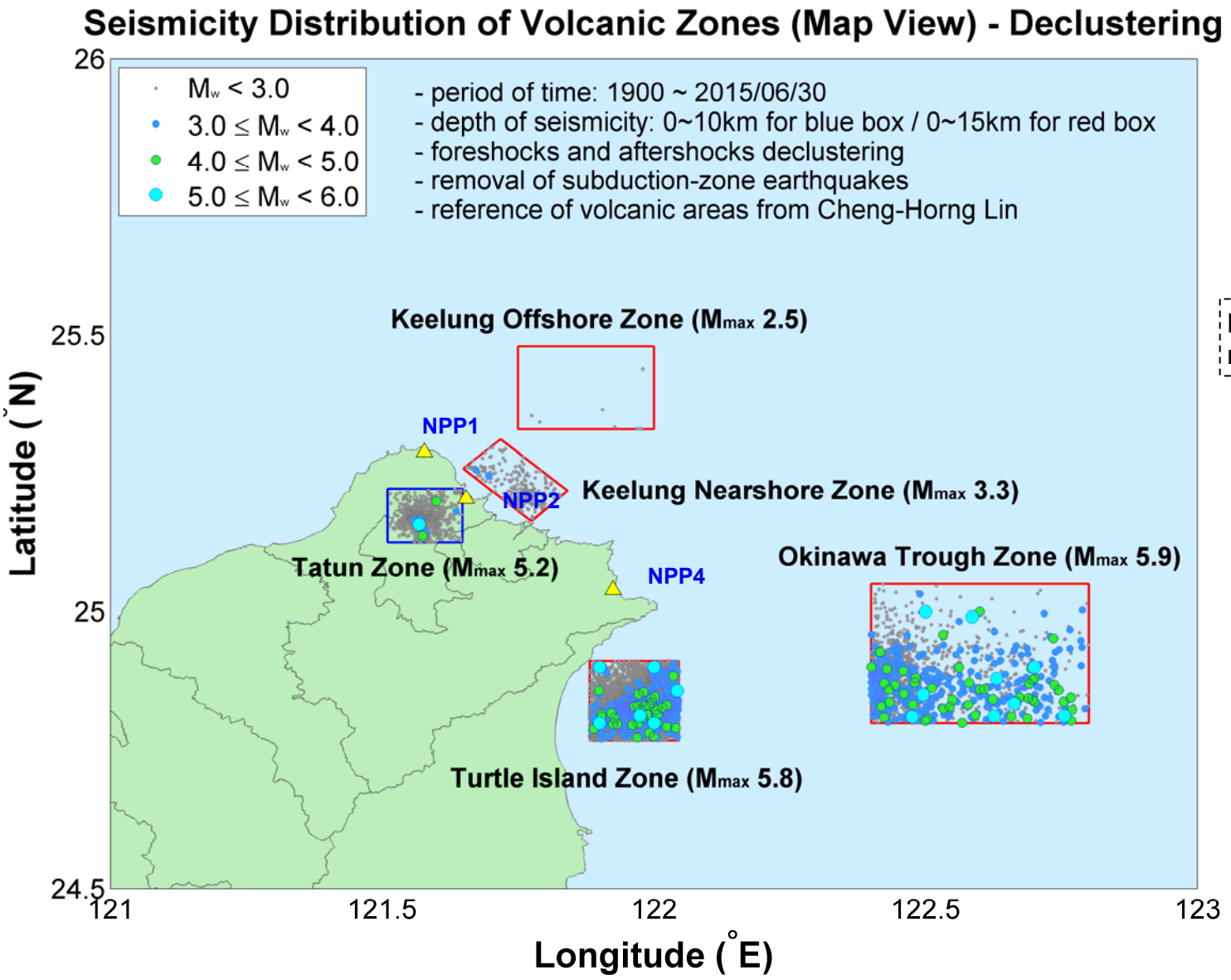






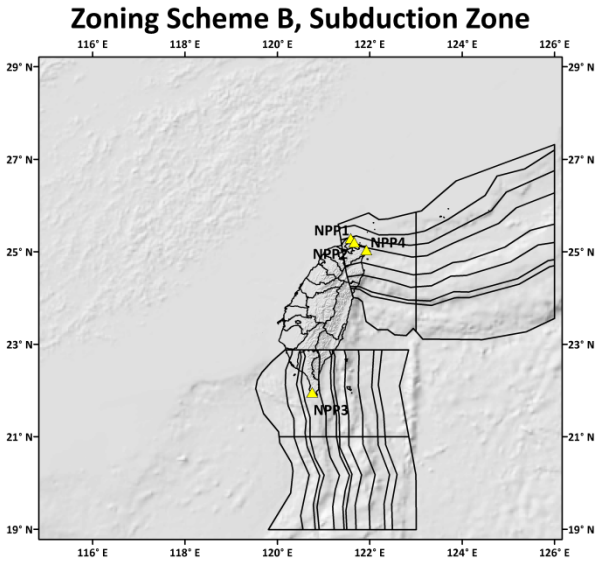


Volcanic Source Zones Nearby Taiwan

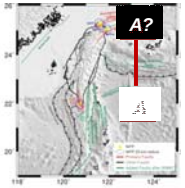


M_{max}: Observed maximum magnitude

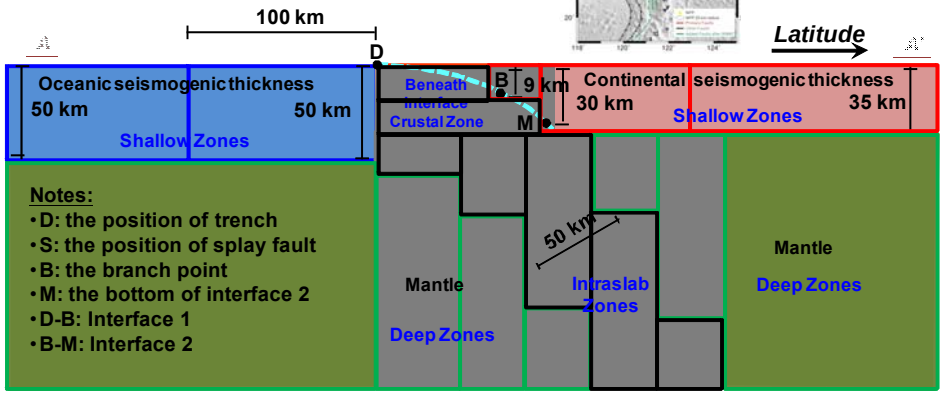
Zoning Scheme B for Subduction Intraslabs



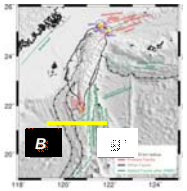
Ryukyu Subduction-Zone



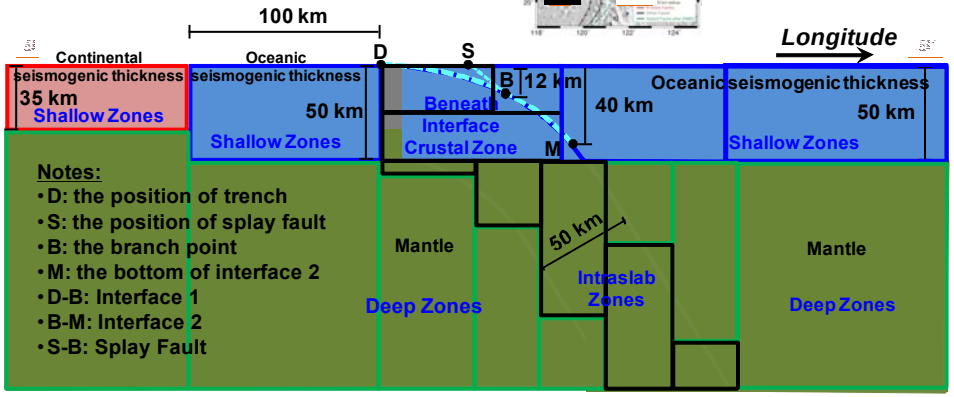
S N



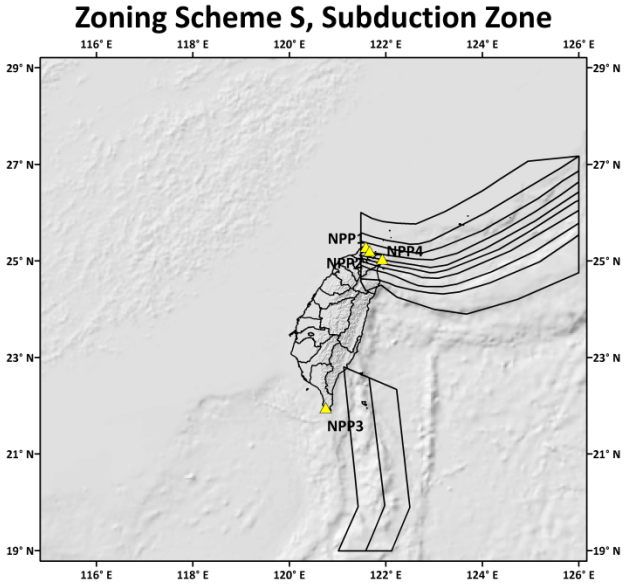
Manila Subduction-Zone



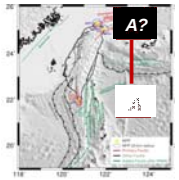
W E



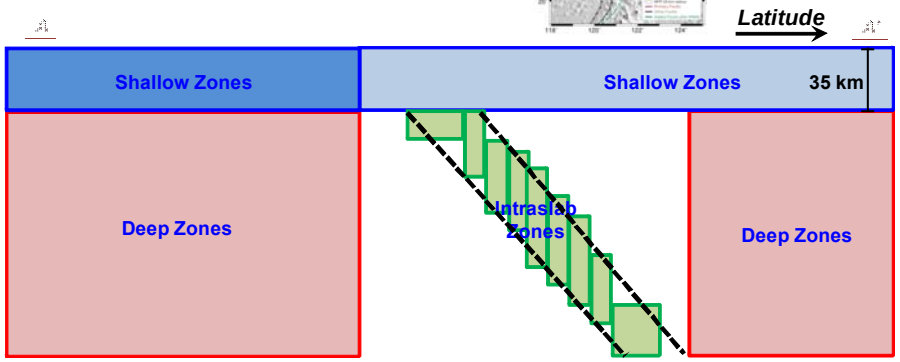
Zoning Scheme S for Subduction Intraslabs



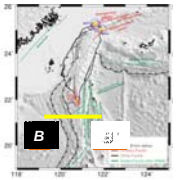
Ryukyu Subduction-Zone



S N



Manila Subduction-Zone



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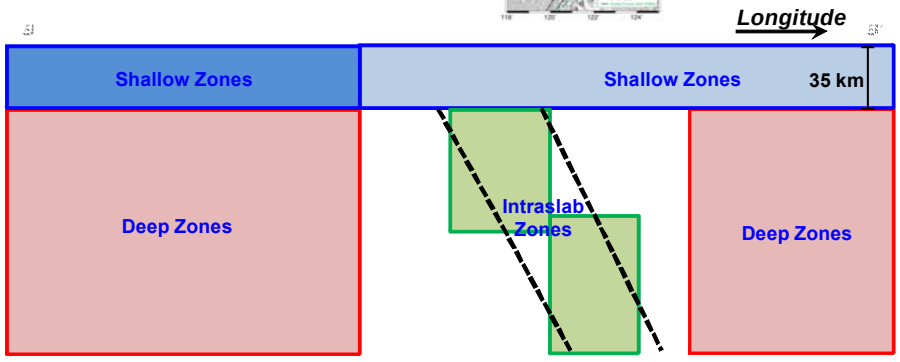
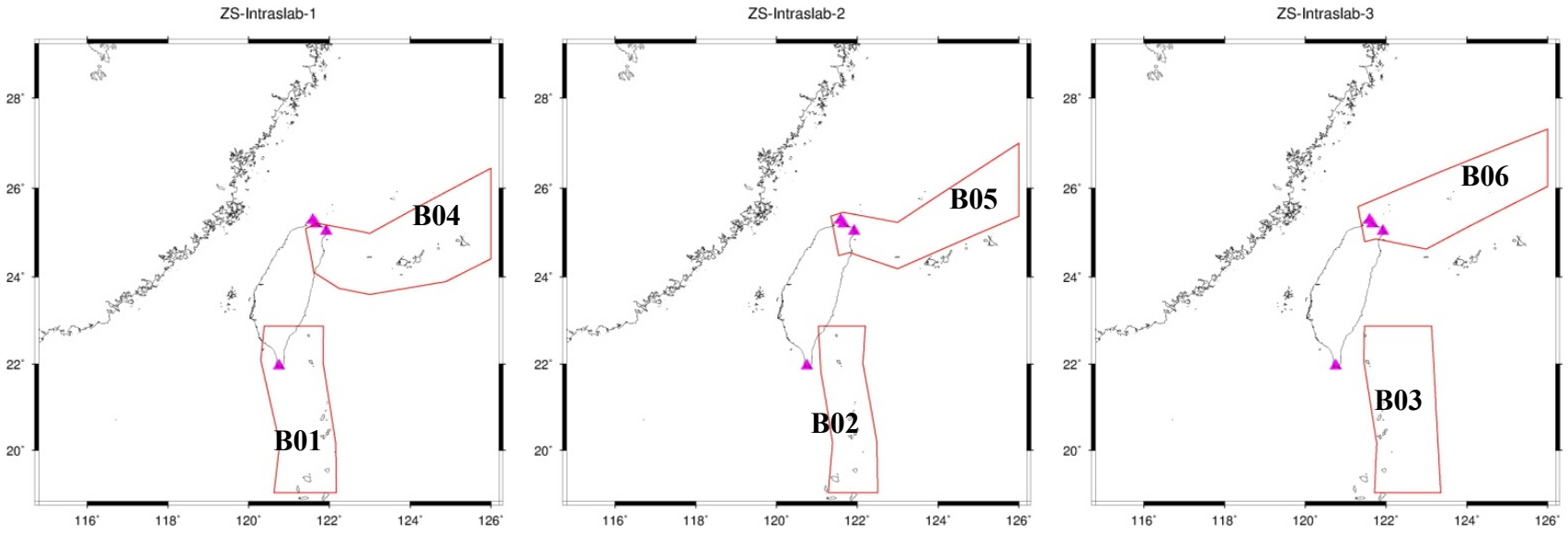
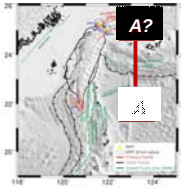


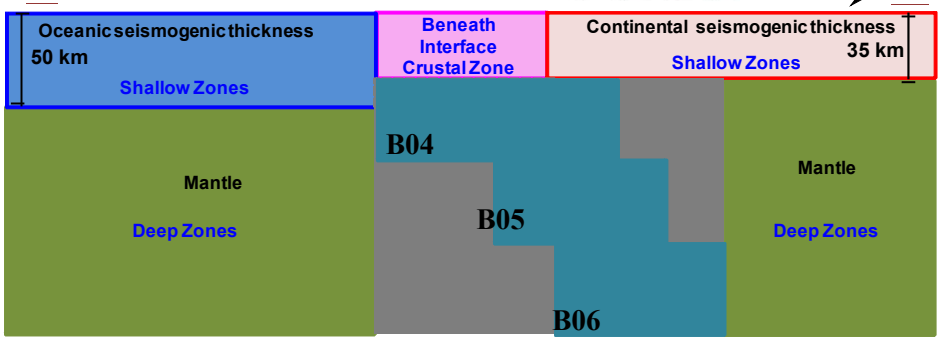
Zoneless Scheme Z for Subduction Intraslabs



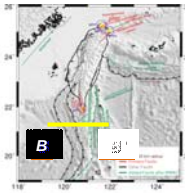
Ryukyu Subduction-Zone



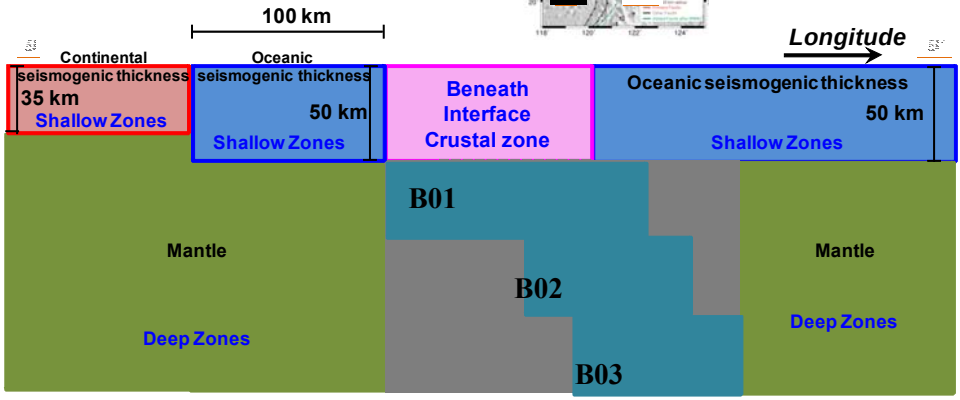
S N



Manila Subduction-Zone



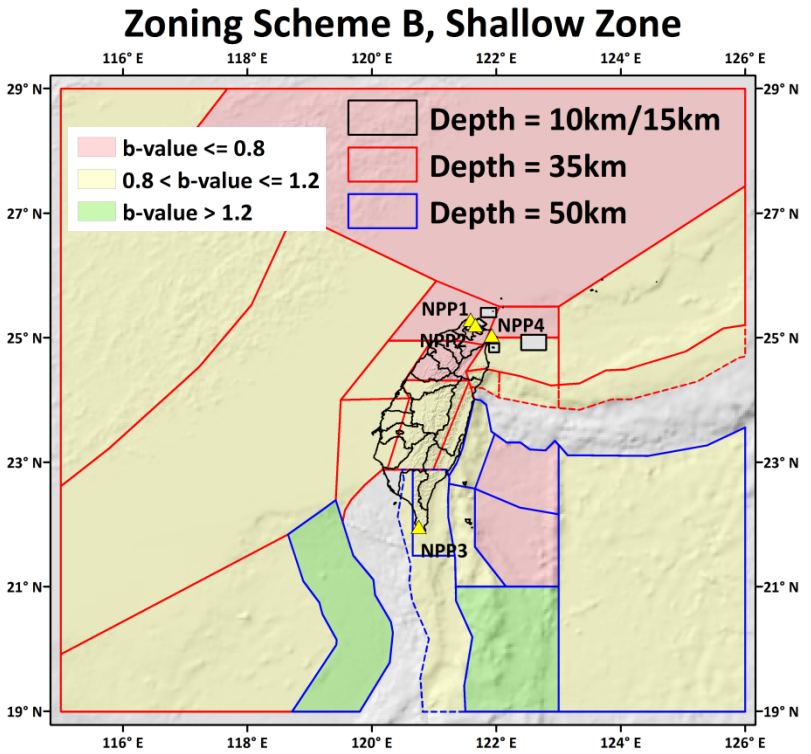
W E



Summary of Parameters used in Magnitude PDF

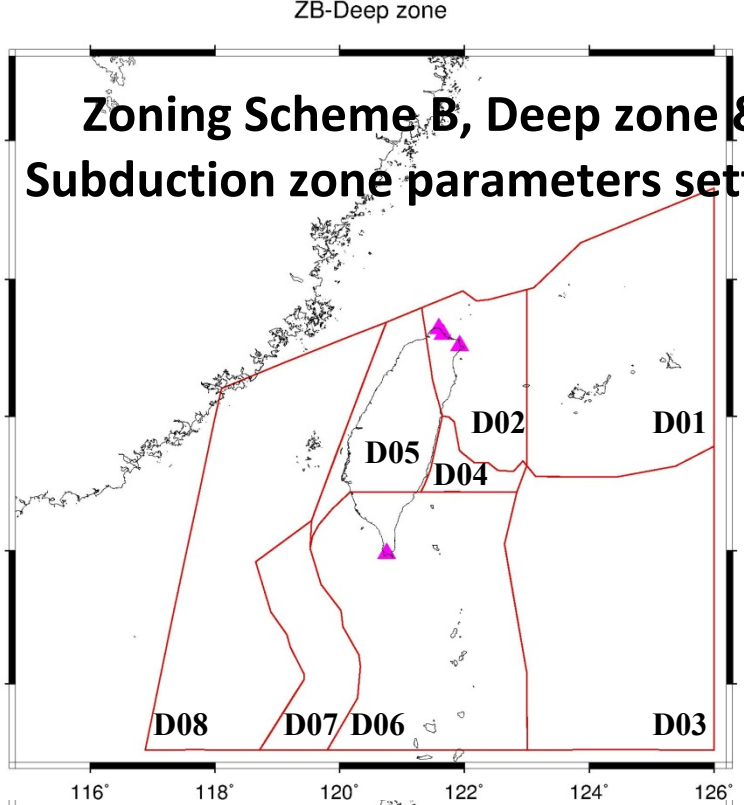
Zoning Scheme B, Shallow zone parameters setting

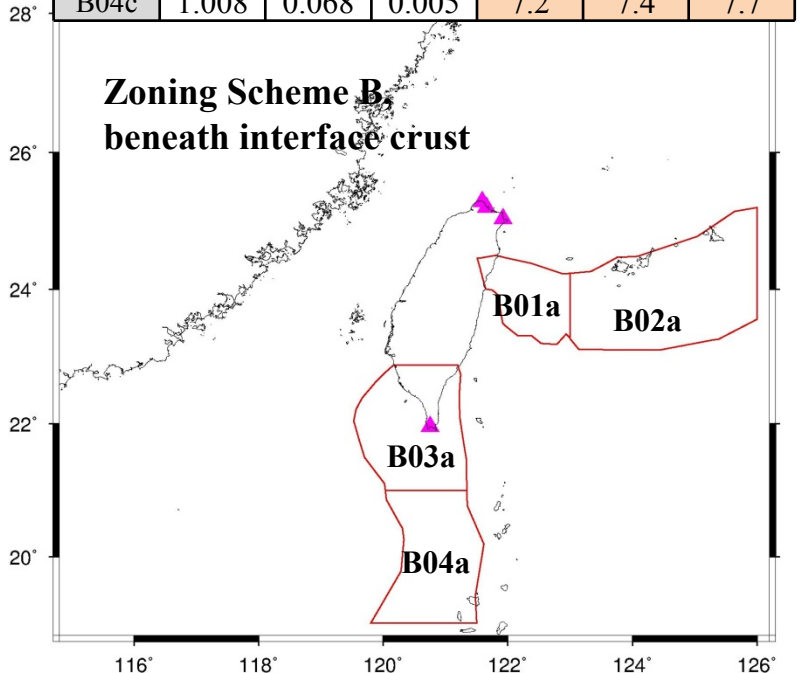
		b-value & Sigma	N (5.0)	Mmin	Mmed	Mmax
	S01	0.574	0.113	0.144	7.2	7.4	7.7
	S02	1.017	0.048	1.322	8.29	8.3	8.3
NPP1 NPP2 NPP4	S03	0.694	0.093	0.058	6.5	6.7	7
	S04	1.009	0.050	1.057	6.8	7	7.3
	S05	1.172	0.148	0.146	6.5	6.7	7
	S06	0.988	0.087	0.367	7.3	7.5	7.8
	S07	0.813	0.060	0.760	7.42	7.62	7.7
	S08	0.887	0.094	0.363	6.65	6.85	7.15
	S09	0.765	0.078	0.567	7.4	7.6	7.7
	S10	0.847	0.041	1.664	7.5	7.7	7.7
	S11	0.706	0.090	0.475	7.5	7.7	7.7
	S12	0.878	0.056	0.844	7.6	7.7	7.7
	S13	1.255	0.057	0.852	7.01	7.21	7.51
NPP1 NPP2 NPP4	S14	0.766	0.211	0.103	6.5	6.7	7
	S15	0.694	0.093	0.029	6.5	6.7	7
	S16	0.902	0.156	0.053	6.5	6.7	7
	S17	0.958	0.063	0.687	7.4	7.6	7.7
NPP3	S18	0.820	0.071	0.540	7.7	7.7	7.7
	S19	0.902	0.156	0.105	6.87	7.07	7.37
	S20	1.008	0.054	0.857	7.6	7.7	7.7
NPP3	S21	0.970	0.057	0.816	7.4	7.6	7.9
	S22	1.254	0.098	0.424	6.61	6.81	7.11
	S23	0.899	0.244	0.102	6.5	6.7	7
	S24	0.811	0.089	0.377	7.71	7.7	7.7
	S25	1.003	0.203	0.099	6.5	6.7	7

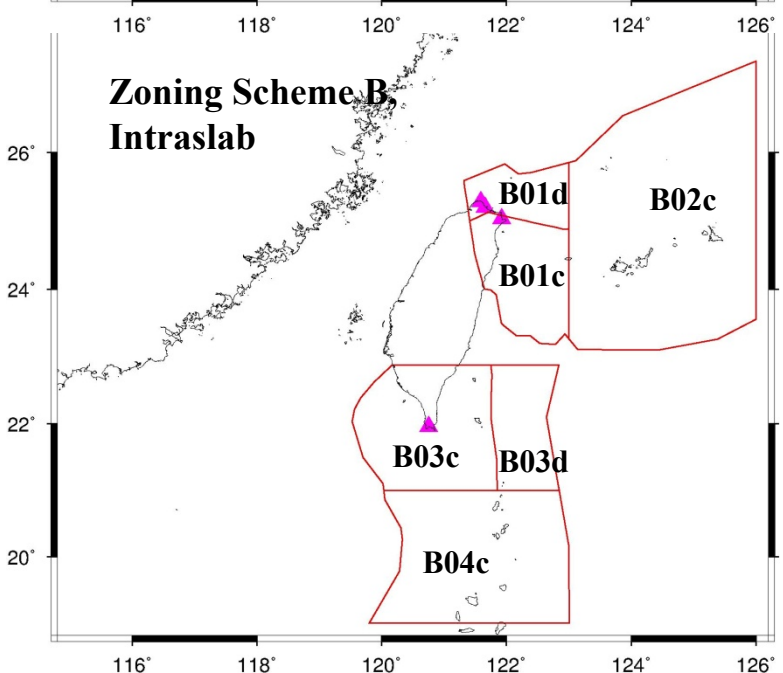


Zoning Scheme B, Deep zone & Subduction zone parameters setting

		b-value & Sigma		N (5.0)	Mmin	Mmed	Mmax
NPP1 NPP2 NPP4	D01	0.897	0.043	0.458	6.5	6.7	7
	D02	0.897	0.043	0.115	6.6	6.8	7.1
	D03	0.897	0.043	0.065	7.55	7.7	7.7
	D04	0.897	0.043	0.082	6.5	6.7	7
	D05	0.897	0.043	0.049	6.9	7.1	7.4
NPP3	D06	0.897	0.043	0.507	7.7	7.7	7.7
	D07	0.897	0.043	0.033	6.5	6.7	7
	D08	0.897	0.043	0.065	6.5	6.7	7
	B01a	0.907	0.029	1.074	7.7	7.7	7.7
	B02a	0.945	0.055	0.324	7.7	7.7	7.7
NPP1 NPP2 NPP4	B01c	0.927	0.035	0.292	7.9	8.1	8.1
	B01d	0.662	0.102	0.237	8.1	8.1	8.1
	B02c	0.926	0.035	0.215	8.0	8.1	8.1
NPP3	B03a	0.944	0.076	0.183	7.0	7.2	7.5
	B04a	1.154	0.047	0.667	6.9	7.1	7.4
NPP3	B03c	0.778	0.098	0.008	7.3	7.5	7.8
	B03d	0.780	0.132	0.137	6.5	6.7	7.0
	B04c	1.008	0.068	0.005	7.2	7.4	7.7

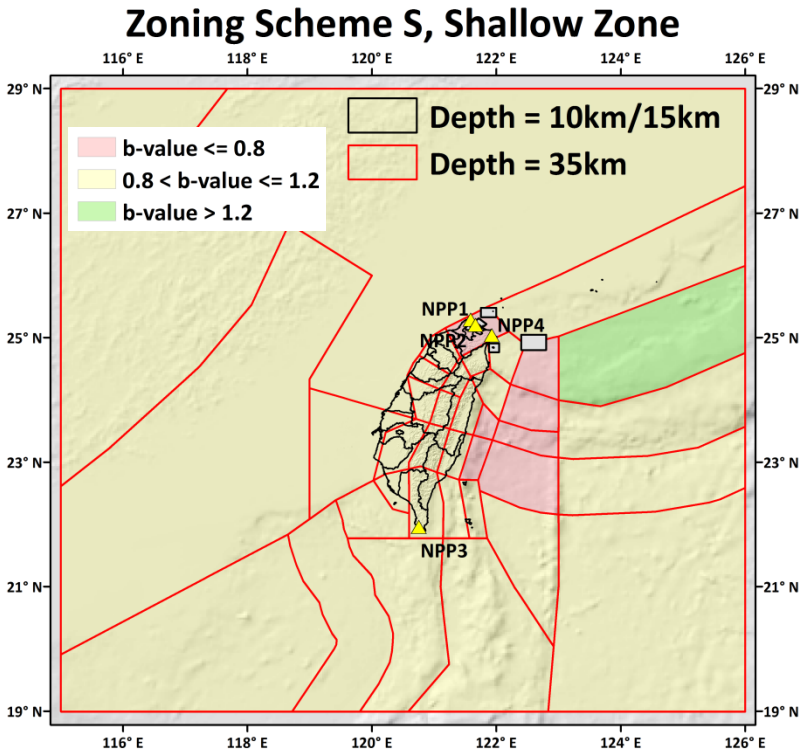






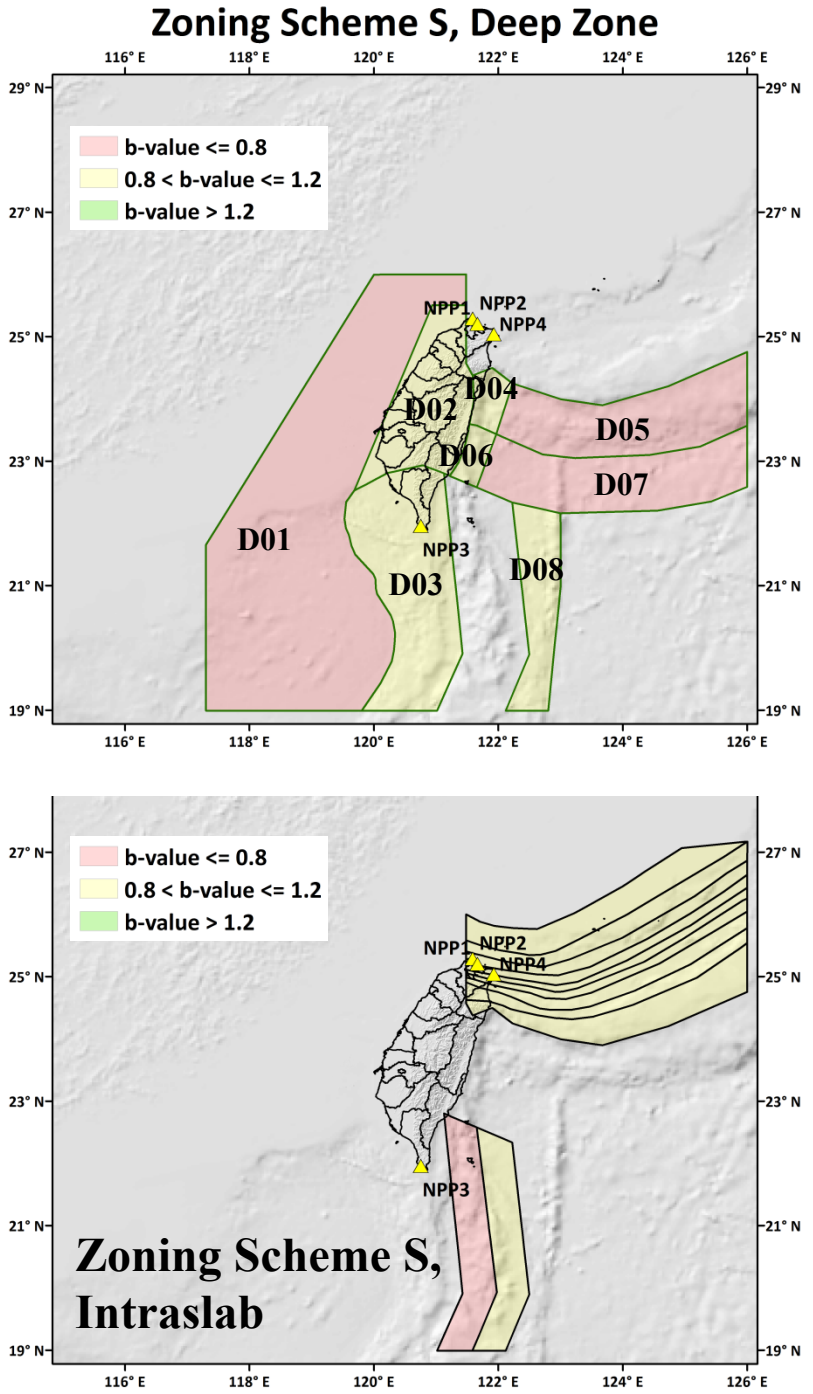
Zoning Scheme S, Shallow zone parameters setting

		b-value & Sigma		N (5.0)	Mmin	Mmed	Mmax
NPP1 NPP2	S01	0.982	0.089	0.147	7.20	7.40	7.70
	S02	0.865	0.121	0.070	6.50	6.70	7.00
NPP1	S03	0.866	0.047	0.601	6.61	6.81	7.11
NPP2	S04	0.694	0.189	0.013	6.50	6.70	7.00
NPP4	S05A	1.092	0.107	0.018	6.50	6.70	7.00
	S05B	1.123	0.066	0.050	6.50	6.70	7.00
	S06	1.064	0.044	0.129	6.60	6.80	7.10
	S07	0.936	0.028	0.392	7.60	7.70	7.70
	S08A	1.015	0.114	0.023	6.50	6.70	7.00
	S08B	0.824	0.140	0.055	6.50	6.70	7.00
	S09	1.069	0.068	0.053	6.62	6.82	7.12
	S10	0.912	0.041	0.207	6.62	6.82	7.12
	S11	1.033	0.039	0.180	6.59	6.79	7.09
NPP3	S12	0.885	0.028	0.462	7.03	7.23	7.53
	S13	1.078	0.093	0.137	6.50	6.70	7.00
NPP4	S14A	0.828	0.056	0.124	6.50	6.70	7.00
	S14B	0.888	0.043	0.521	6.50	6.70	7.00
	S14C	0.698	0.031	0.879	6.87	7.07	7.37
	S15	0.897	0.028	1.132	7.70	7.70	7.70
	S16A	0.772	0.019	2.673	7.20	7.40	7.70
	S16B	0.687	0.083	0.165	6.50	6.70	7.00
	S17A	0.854	0.017	1.221	7.20	7.40	7.70
	S17B	0.782	0.057	0.286	7.40	7.60	7.70
	S18A	0.961	0.024	0.519	7.40	7.60	7.70
	S18B	0.748	0.053	0.335	7.50	7.70	7.70
NPP3	S19A	0.806	0.036	0.735	7.70	7.70	7.70
	S19B	0.803	0.055	0.309	7.60	7.70	7.70
NPP3	S20	0.875	0.031	1.203	7.40	7.60	7.90
	S21	0.999	0.025	1.993	6.69	6.89	7.19
	S22	1.163	0.102	0.130	7.50	7.70	7.70
	S23	0.675	0.045	0.487	7.40	7.60	7.70
	S24	1.247	0.040	0.973	8.29	8.30	8.30
	S25	0.972	0.052	0.629	7.71	7.91	8.21
	S26	1.103	0.121	0.114	7.11	7.31	7.61
	S27	1.167	0.142	0.078	7.30	7.50	7.80
	S28	0.859	0.152	0.084	6.50	6.70	7.00
	S29	1.109	0.082	0.226	7.70	7.70	7.70
	S30	1.166	0.157	0.065	6.50	6.70	7.00



Zoning Scheme S, Deep zone & Subduction zone parameters setting

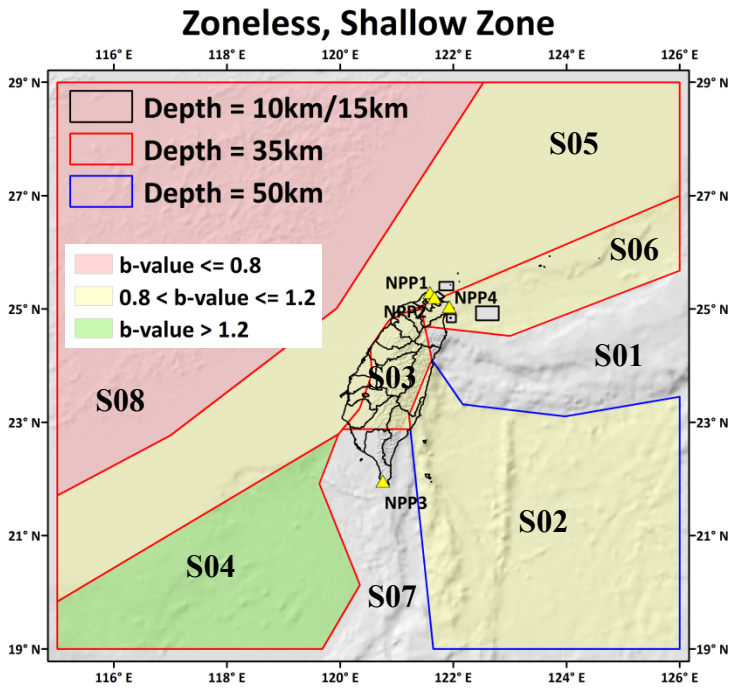
		b-value & Sigma		N (5.0)	Mmin	Mmed	Mmax
	D01	0.762	0.096	0.149	6.50	6.70	7.00
NPP1 NPP2 NPP4	D02	1.023	0.058	0.073	7.70	7.70	7.70
	D03	0.827	0.027	1.588	7.32	7.52	7.82
NPP3	D04	1.073	0.052	0.286	6.77	6.97	7.27
	D05	0.750	0.040	0.738	7.00	7.20	7.50
	D06	0.963	0.078	0.142	6.50	6.70	7.00
	D07	0.731	0.084	0.160	7.70	7.70	7.70
	D08	1.103	0.103	0.105	7.00	7.20	7.50
	SNP1	0.866	0.034	0.934	8.00	8.10	8.10
	SNP2	1.058	0.053	0.396	6.89	7.09	7.39
NPP1	SNP3	0.940	0.038	0.743	7.90	8.10	8.10
NPP2	SNP4	0.990	0.050	0.486	6.50	6.70	7.00
NPP4	SNP5	0.891	0.049	0.467	7.80	8.00	8.10
	SNP6	0.972	0.062	0.303	7.20	7.40	7.70
	SNP7	1.038	0.074	0.201	8.10	8.10	8.10
	SNP8	0.937	0.058	0.344	7.30	7.50	7.80
	SNP9	0.848	0.087	0.174	6.50	6.70	7.00
	SSP2	0.816	0.027	1.538	6.87	7.07	7.37
	SSP3	0.855	0.041	0.712	7.20	7.40	7.70



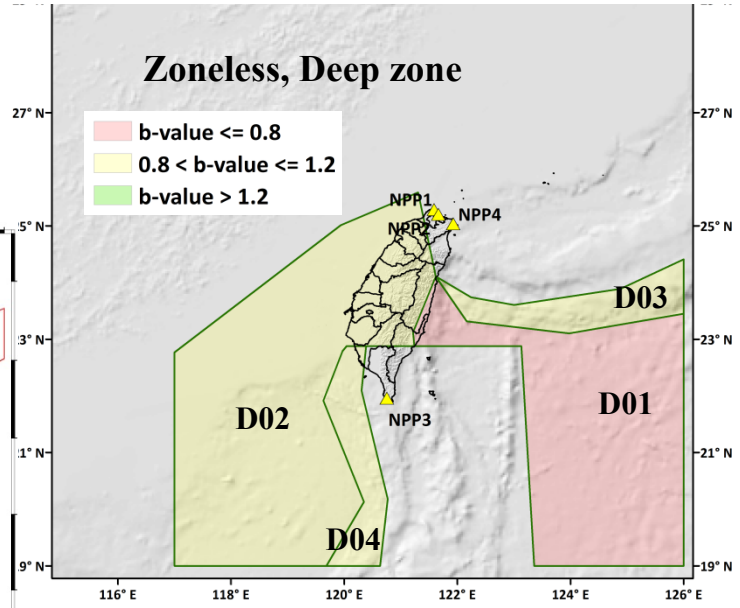
Zoneless, Shallow zone, Deep zone & Subduction zone parameters setting

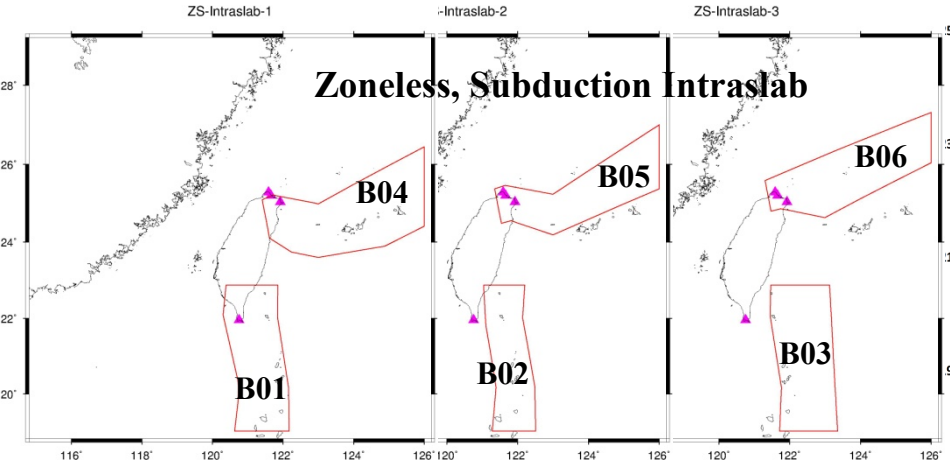
	b-value & Sigma		N (5.0)	Mmin	Mmed	Mmax
S01	0.935	0.021	5.380	8	8.2	8.29
S02	0.941	0.022	4.867	7.6	7.7	7.7
S03	1.006	0.044	1.243	7.6	7.7	7.7
S04	1.243	0.101	0.373	6.61	6.81	7.11
S05	0.926	0.076	0.439	7.01	7.21	7.51
S06	1.006	0.038	1.942	8.29	8.29	8.29
S07	1.102	0.030	3.995	7.7	7.7	7.7
S08	0.654	0.087	0.293	7.71	7.71	7.71
D01	0.669	0.104	0.179	7.55	7.55	7.55
D02	0.846	0.138	0.157	6.87	6.87	6.87
D03	0.970	0.126	0.292	7	7.2	7.5
D04	1.030	0.157	0.239	6.8	6.87	6.87
B01	0.996	0.054	1.233	7.7	7.9	8.1
B02	0.912	0.131	0.240	6.5	6.7	7
B03	0.726	0.084	0.400	7.2	7.4	7.7
B04	0.981	0.034	2.687	8	8.1	8.1
B05	0.937	0.050	1.140	7.9	8.1	8.1
B06	0.860	0.056	0.926	8.1	8.1	8.1

NPP1
NPP2
NPP4
NPP3



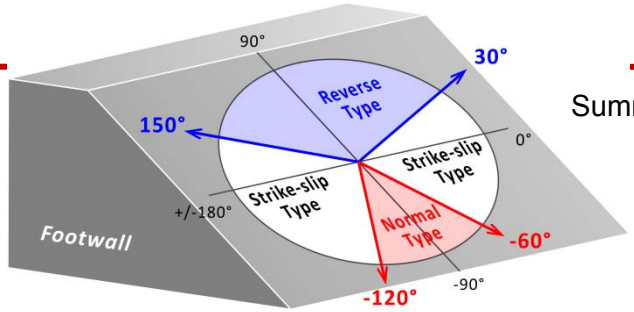
Beneath interface crust: S01, S07



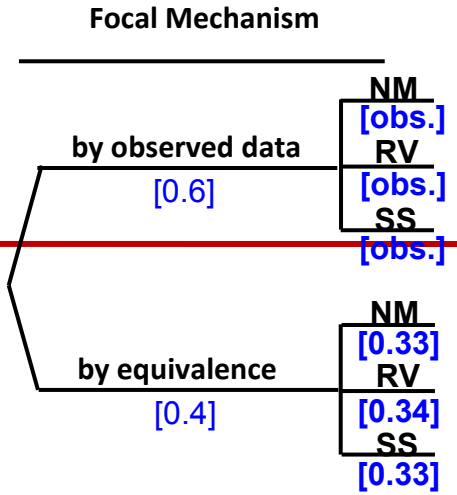


Focal mechanism statistics

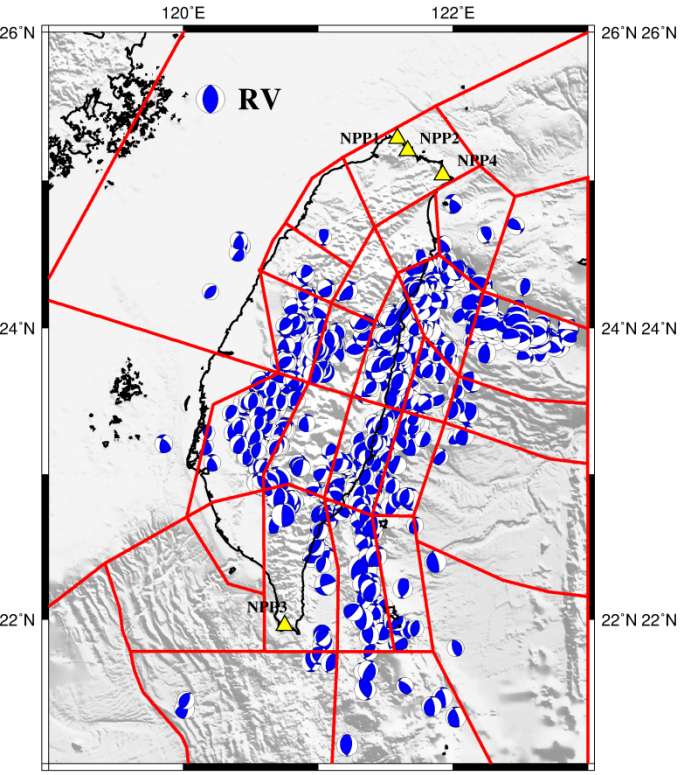
- Catalog: 1977 ~ 2015/6
- Magnitude: Mw≧4.0
- Depth: ≦ 35 km



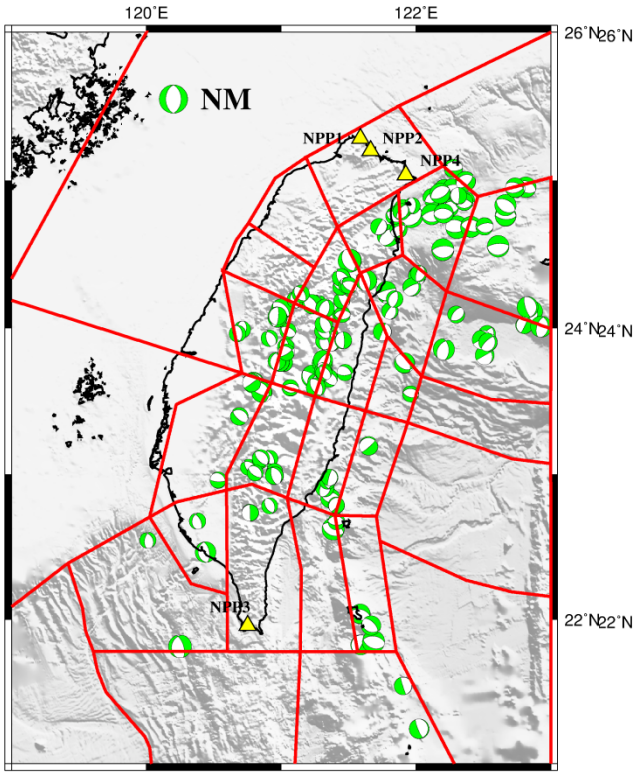
Summary of Abrahamson, N., & Silva, W. (2008).



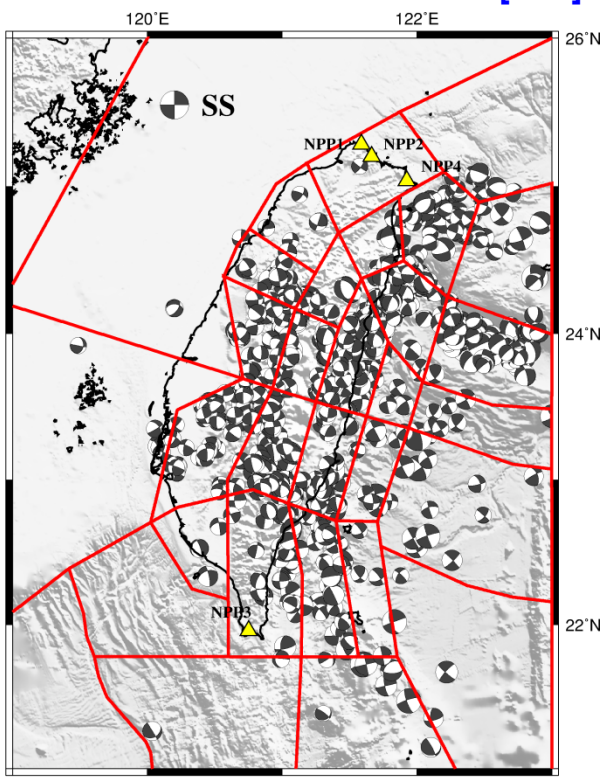
Zoning Scheme S



Reverse Type



Noraml Type



Strike Slip Type

Count percentage of style of faulting in each subzone