Seismicity changes before the 1999 Chi-Chi Mw7.6 and 2003 Chengkung Mw6.8 earthquakes

Yih-Min Wu

Department of Geosciences, National Taiwan University, Taipei, Taiwan

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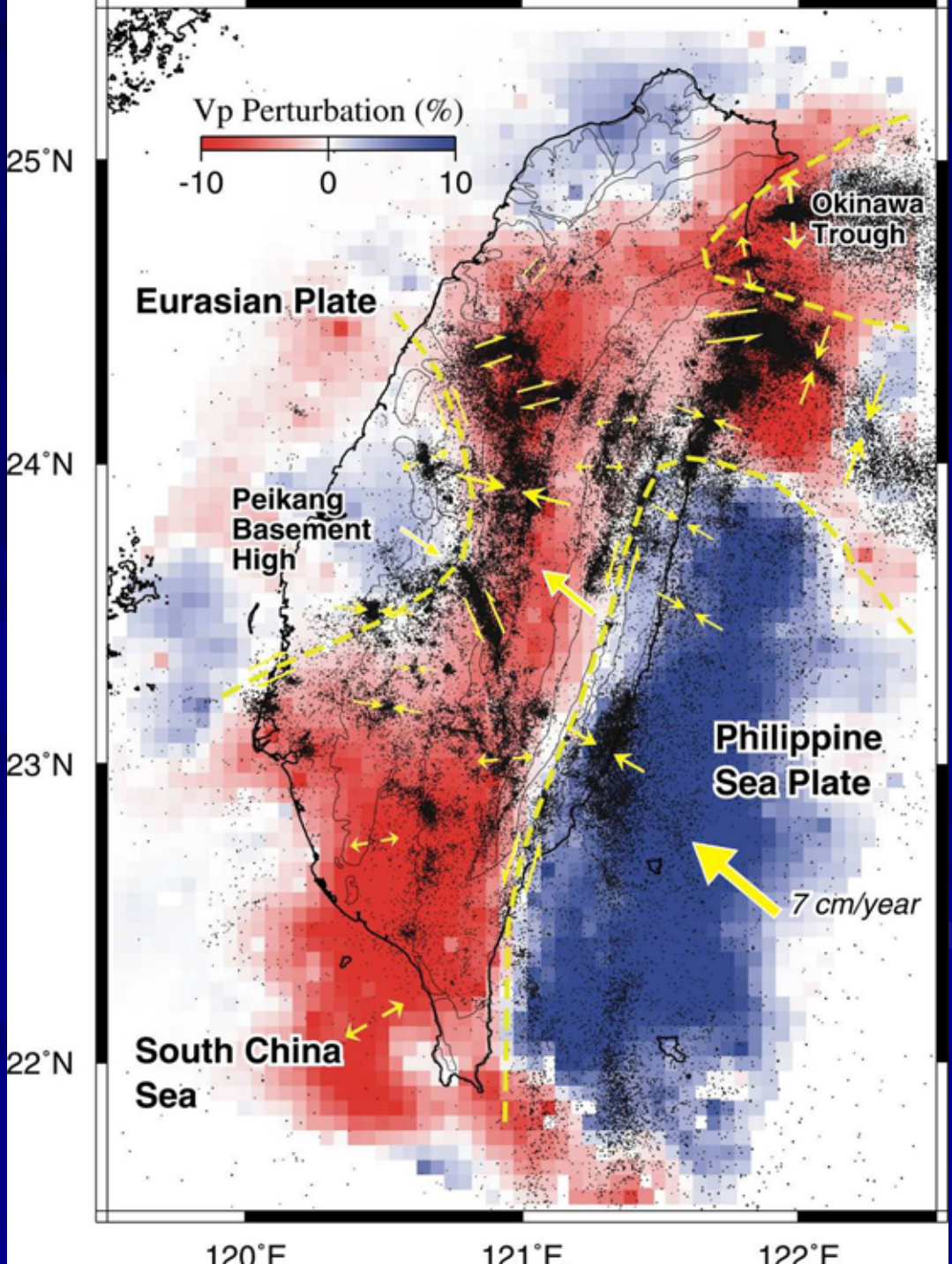
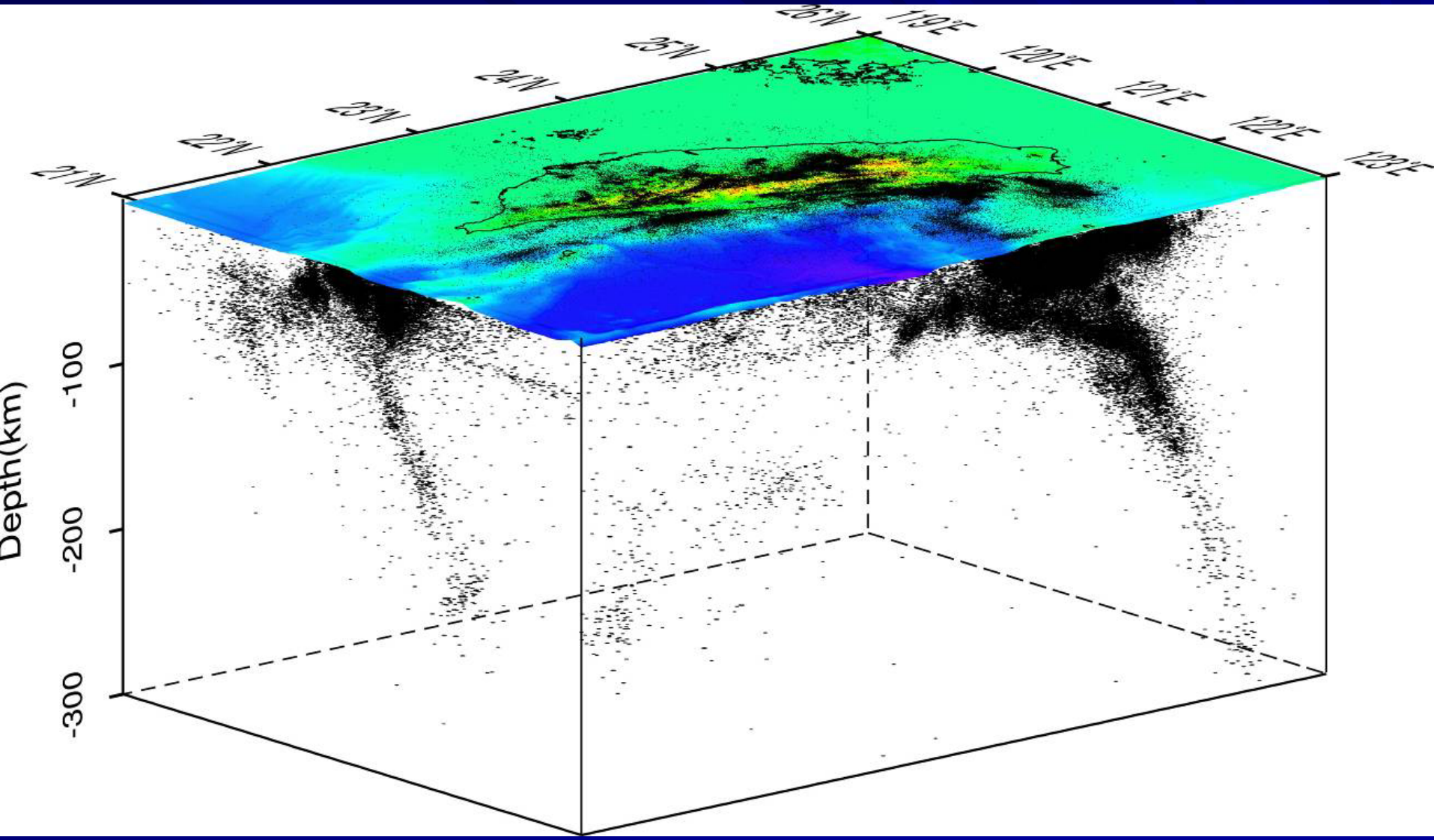
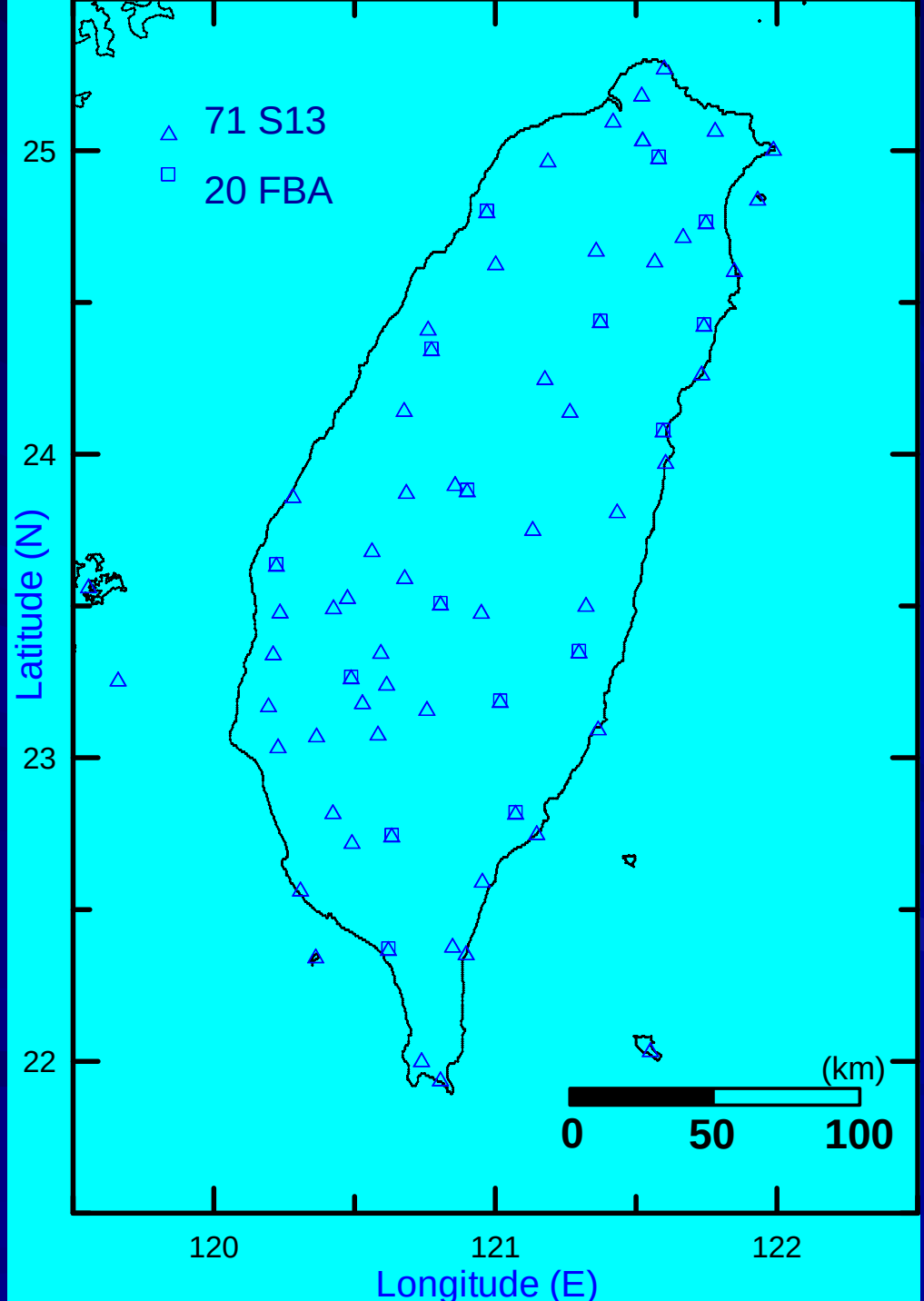
- Ling-Yun Chiao (NTU), Chien-Chih Chen (NCU), Li Zhao (IES), and Chien-Hsin Chen (CWB)
- CWB

Vp 17-21 km


Vp Perturbation (%)
-10
0
10
25°N
24°N
23°N
22°N
120°E
121°E
122°E
Okinawa Trough
Eurasian Plate
Peikang Basement High
Philippine Sea Plate
7 cm/year
South China Sea


26°N
25°N
24°N
23°N
22°N
21°N
119°E
120°E
121°E
122°E
123°E
Depth(km)
-100
-200
-300


71 S13
20 FBA
25
24
23
22
Latitude (N)
(km)
0
50
100
120
121
122
Longitude (E)

CWB Real-Time Seismic Station

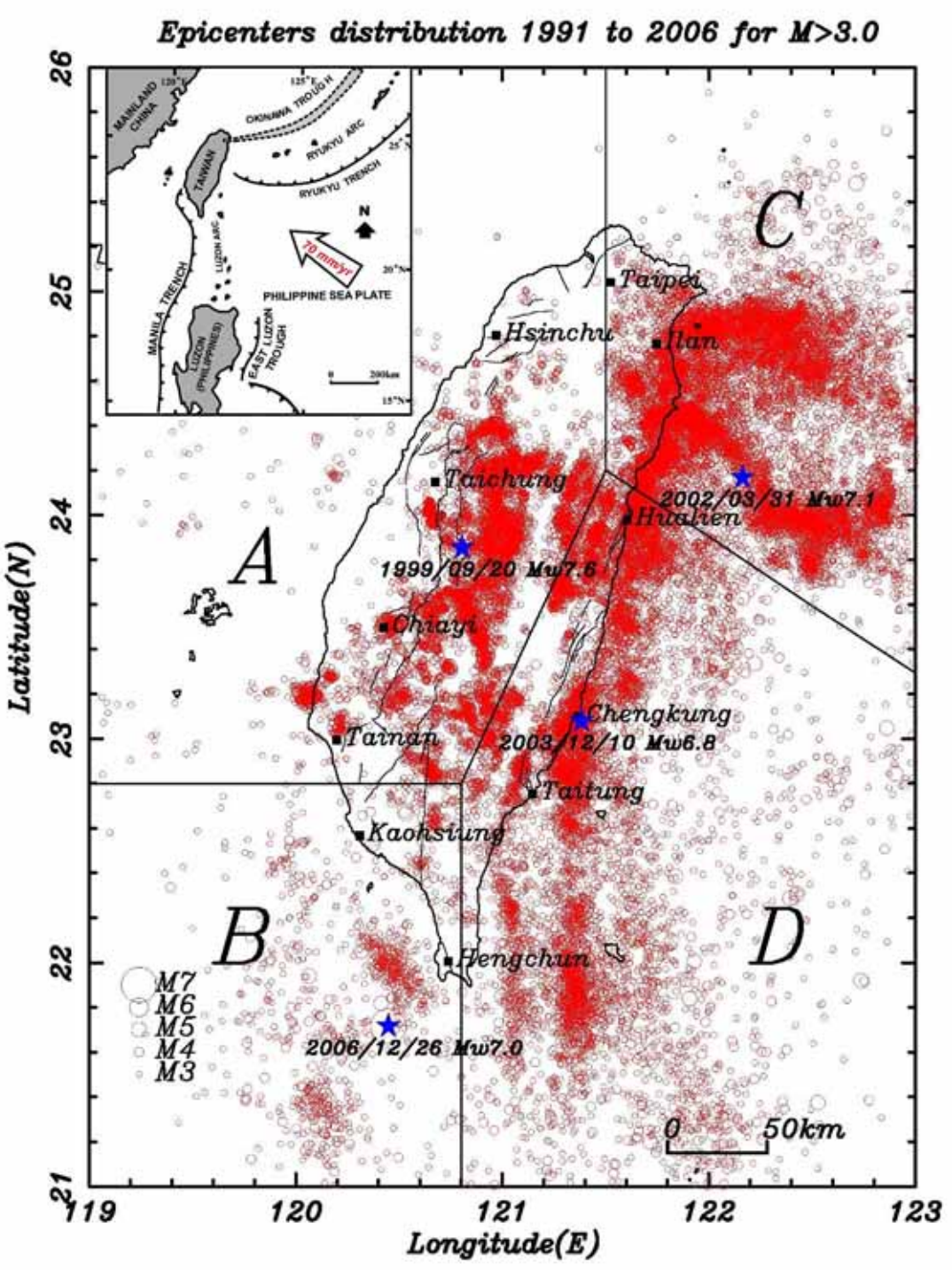
Station Instrument A900 & S13

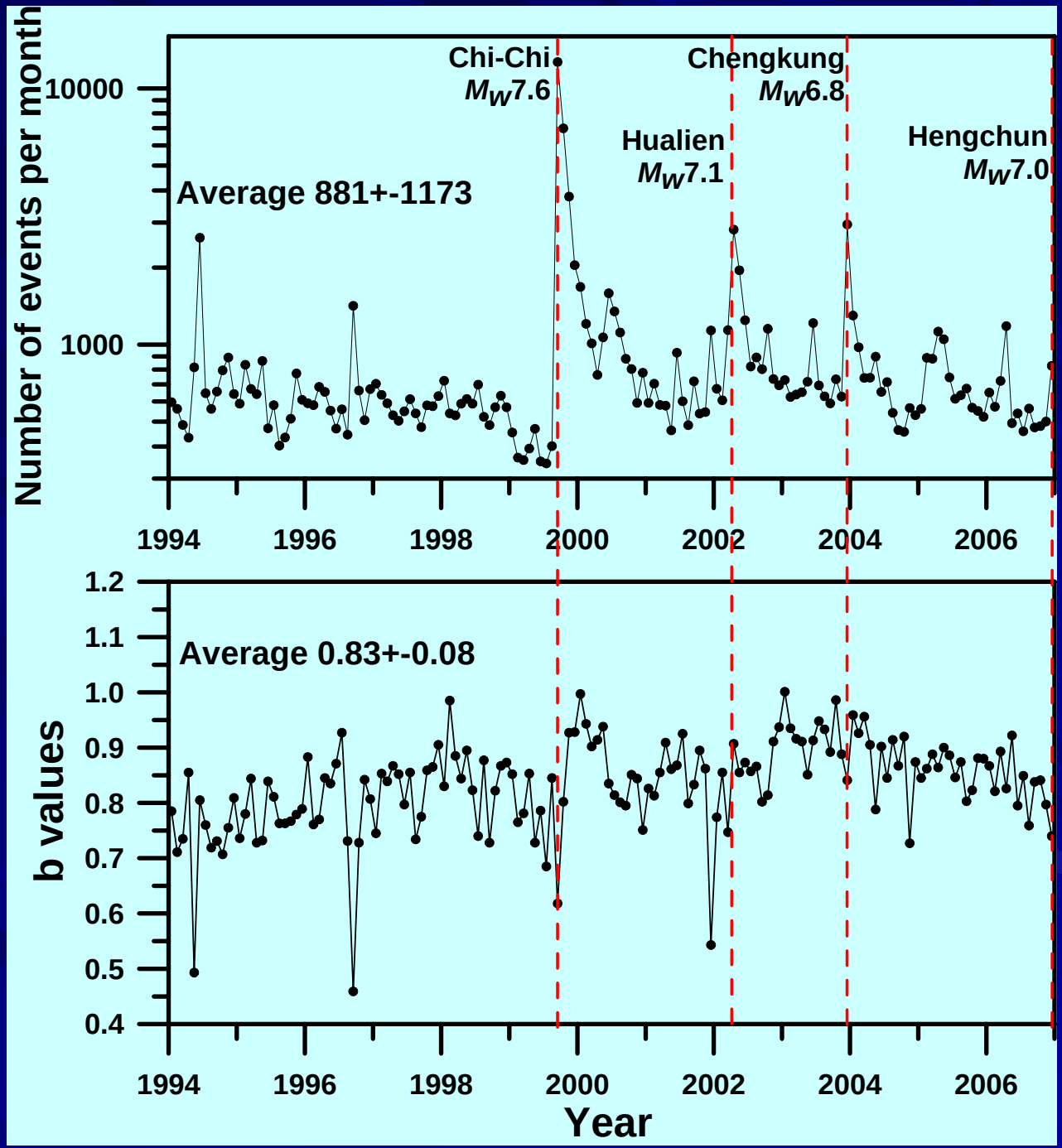
A900A 16 bits, +2 to -2 g

S-13 will saturate for M > 4 for any event within 100 km

Network

- The CWBSN instruments had been operated in a triggered-recording mode before the end of 1993 when continuous recording started.
- The network is equipped with a system of automatic earthquake detection followed by manual verification. Arrival times of P and S waves are manually picked for earthquake location and M_L (Shin 1993) determination.


Epicenters distribution 1991 to 2006 for M>3.0
MAINLAND CHINA
OKINAWA TROUGH
RYUKYU ARC
RYUKYU TRENCH
TAIWAN
LUZON ARC
MANILA TRENCH
LUZON (PHILIPPINES)
EAST LUZON TROUGH
PHILIPPINE SEA PLATE
70 mm/yr
N
A
B
C
D
Taipei
Hsinchu
Ilan
Taichung
Hualien
Chiayi
Chengkung
Tainan
Taitung
Kaohsiung
Hengchun
2002/03/31 Mw7.1
1999/09/20 Mw7.6
2003/12/10 Mw6.8
2006/12/26 Mw7.0
M7
M6
M5
M4
M3
0 50km
Latitude(N)
Longitude(E)
26
25
24
23
22
21
119
120
121
122
123


Number of events per month
10000
1000
Chi-Chi
M_W7.6
Chengkung
M_W6.8
Hualien
M_W7.1
Hengchun
M_W7.0
Average 881+-1173
1994
1996
1998
2000
2002
2004
2006
b values
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
Average 0.83+-0.08
1994
1996
1998
2000
2002
2004
2006
Year

B values
Aki

Z values

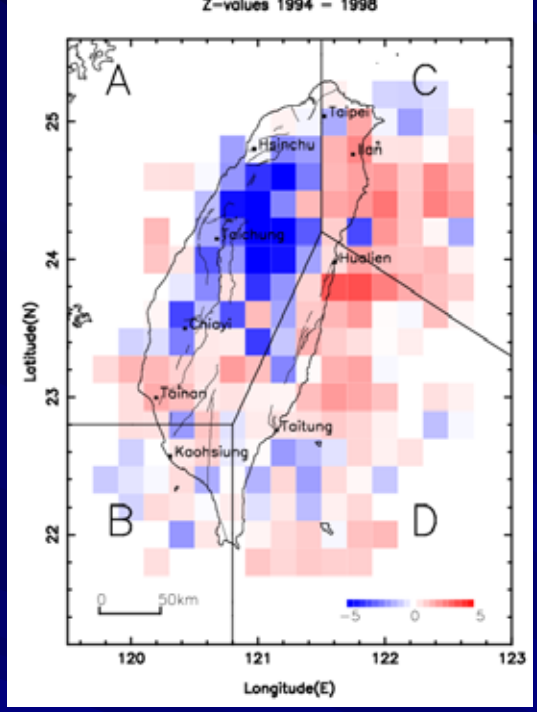
$$Z(x,y,t) = \frac{(R - R_0)}{\sqrt{(\sigma^2 / n) + (\sigma_0^2 / n_0)}}$$

R is calculated from raw catalog

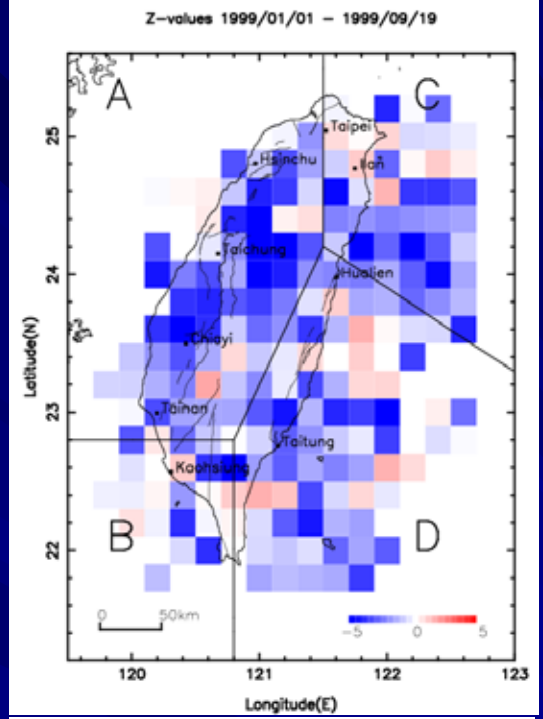
R_0 is calculated from declustered catalog

Time bin 60 days in our studies

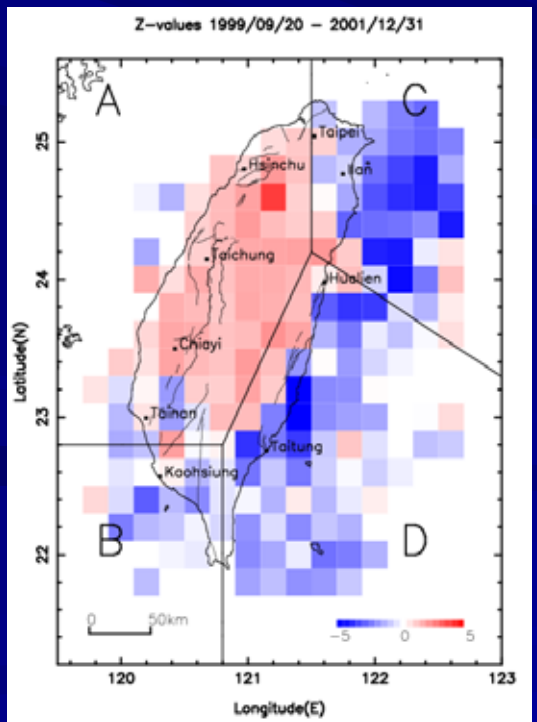
1994 to 1998



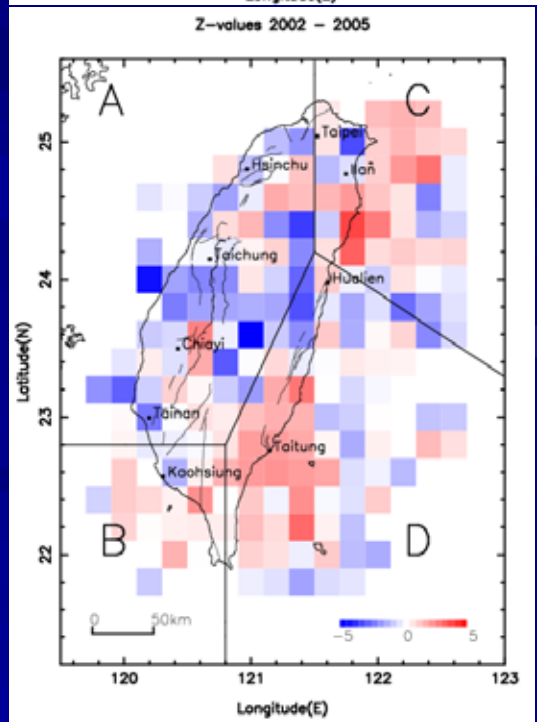
1999 to Chi-Chi



Chi-Chi to 2001



2002 to 2005



Background 1994-2005

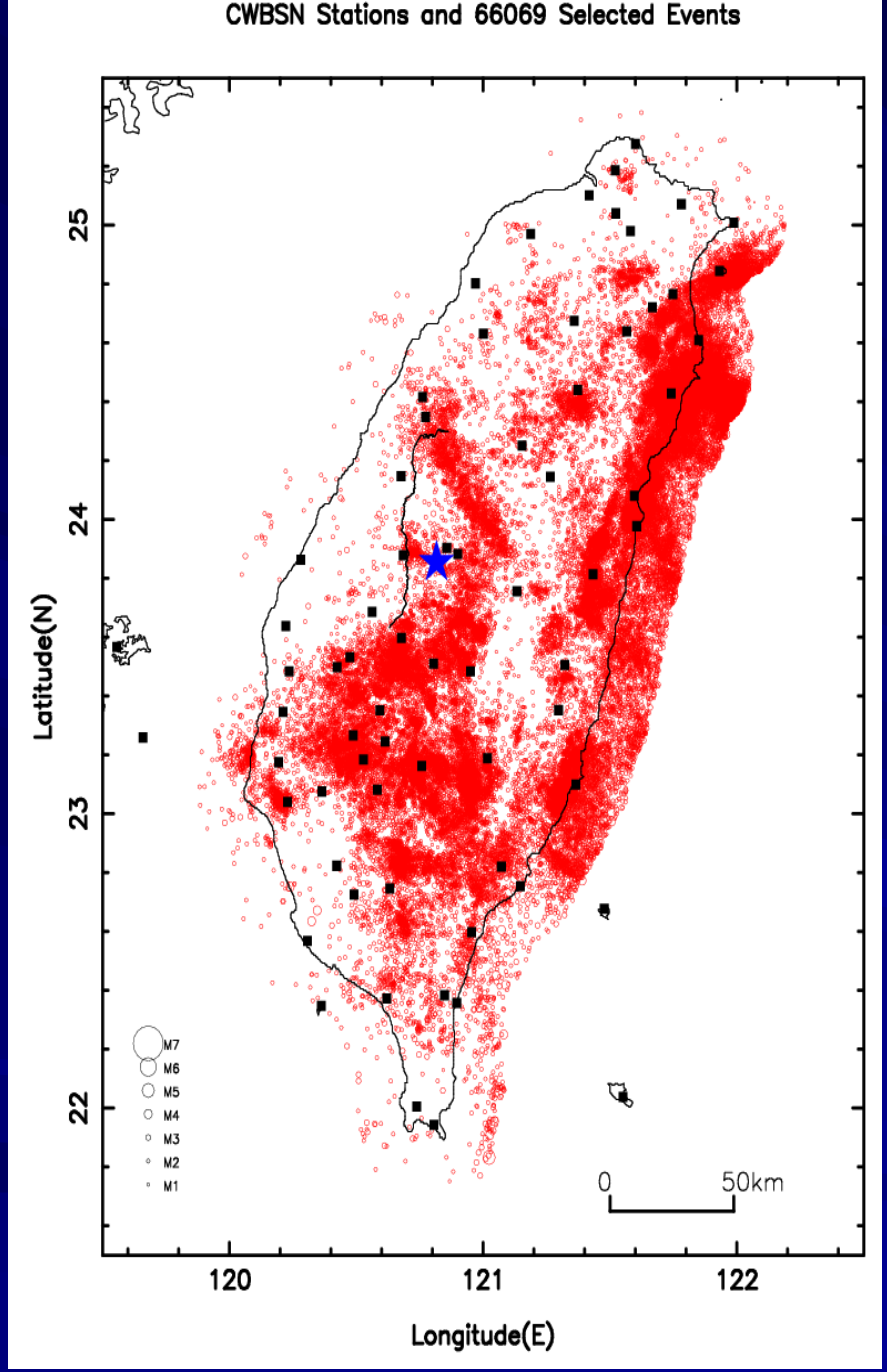
M_L>=2.0

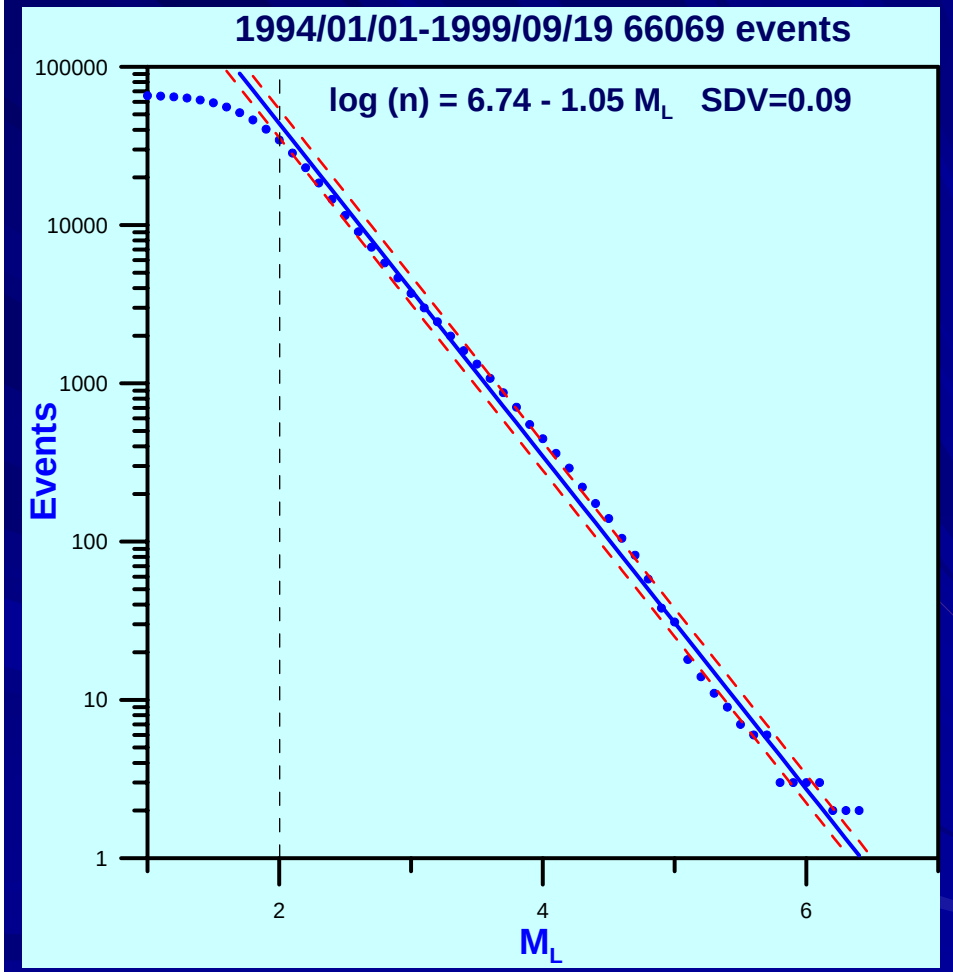
Seismic reversal

Red increasing

Blue decreasing

The Chi-Chi earthquake 1999/09/20 M_w 7.6

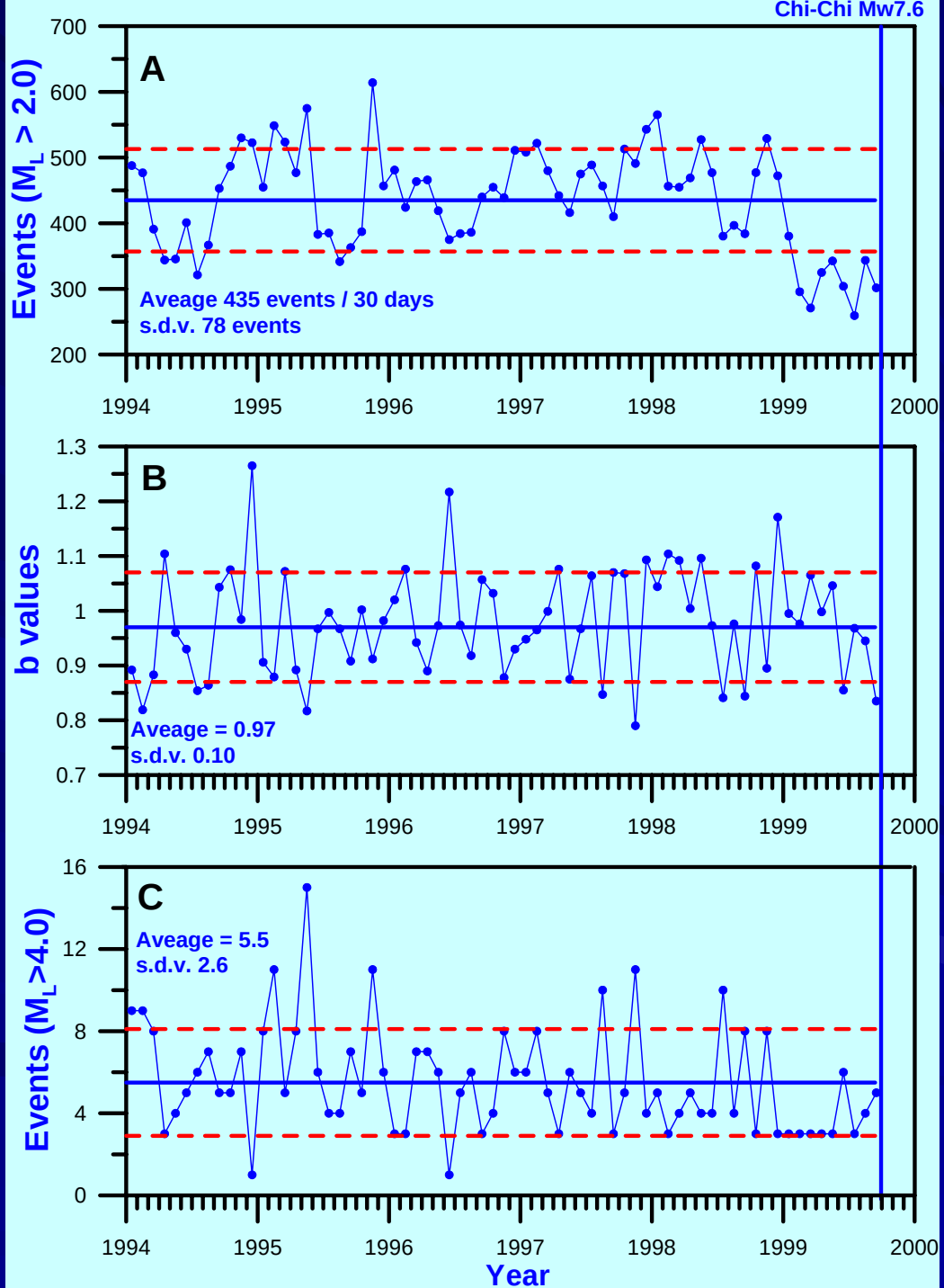

CWBSN Stations and 66069 Selected Events
Latitude(N)
Longitude(E)
25
24
23
22
120
121
122
M7
M6
M5
M4
M3
M2
M1
0
50km


1994/01/01-1999/09/19 66069 events
log (n) = 6.74 - 1.05 M_L SDV=0.09
Events
100000
10000
1000
100
10
1
2
4
6
M_L

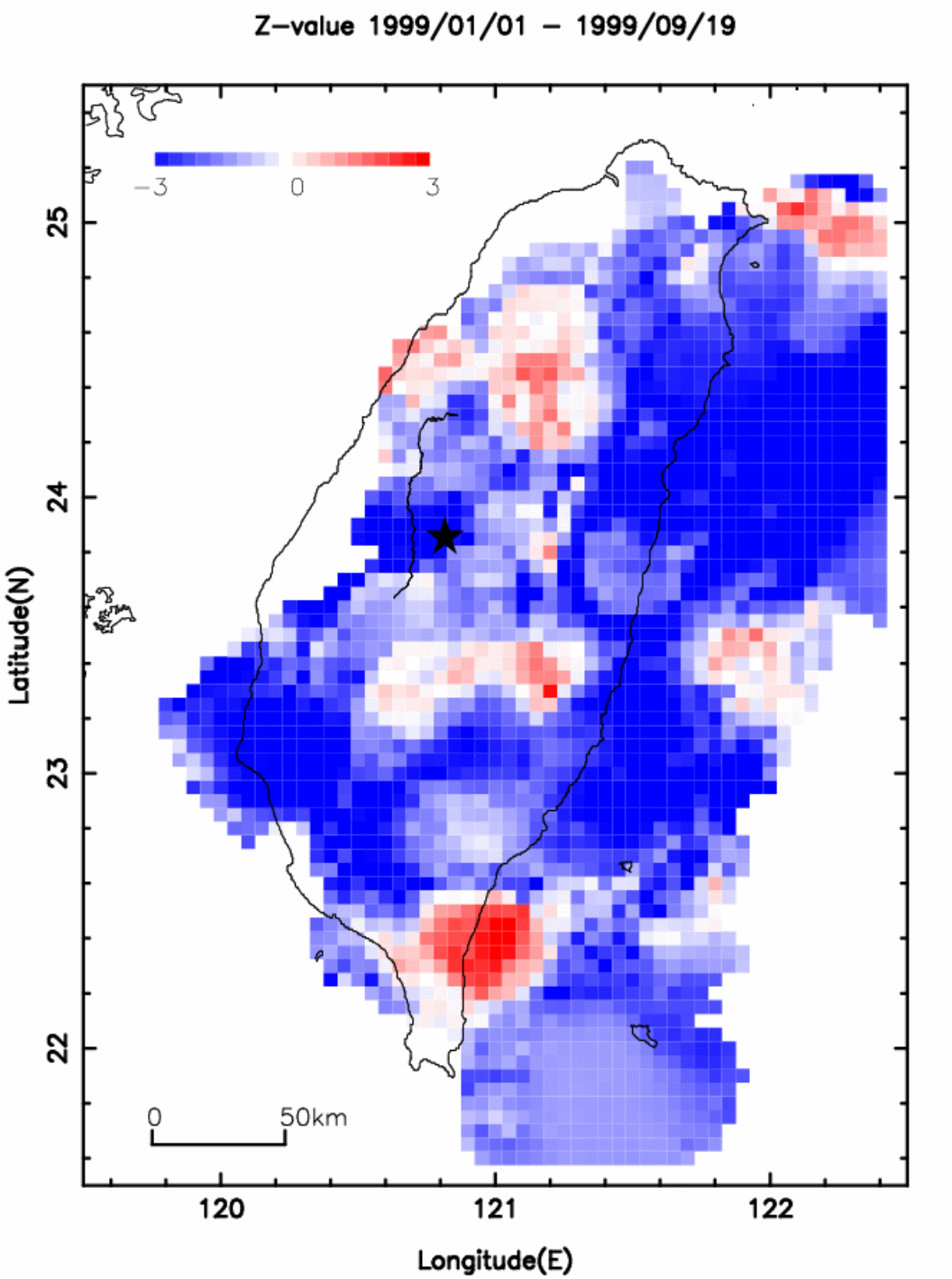
Removing aftershock

- Double link
- Three days and 5 km

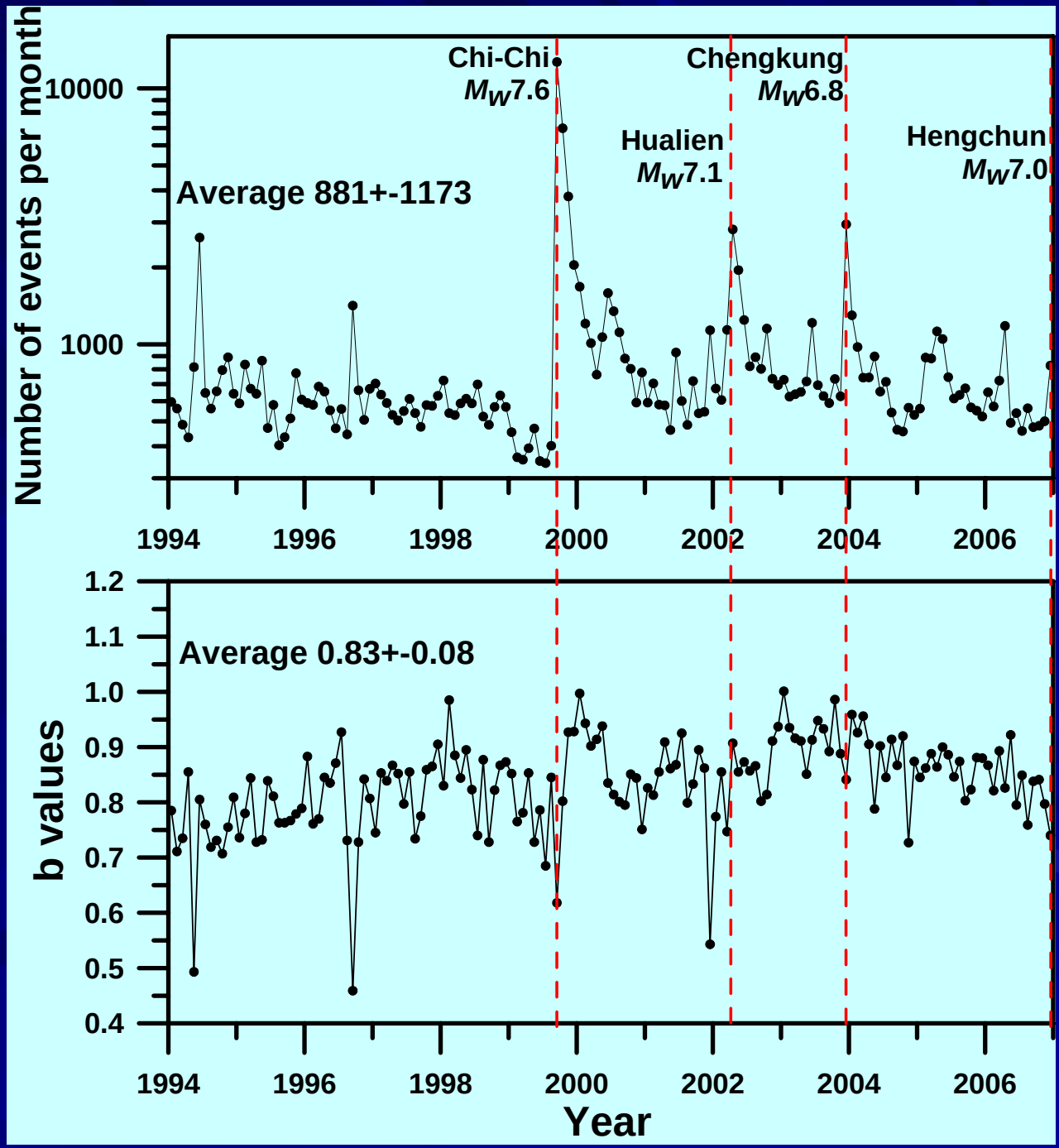
Declustered catalog
B value LSQR



Background
1994 to Chi-Chi
M_L>=2.0
Radius 20 km
Depth <= 40 km
Red increasing
Blue decreasing



The Chengkung earthquake 2003/12/10 M_w6.8


Number of events per month
10000
1000
Chi-Chi
M_W7.6
Chengkung
M_W6.8
Hualien
M_W7.1
Hengchun
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2006
b values
1.2
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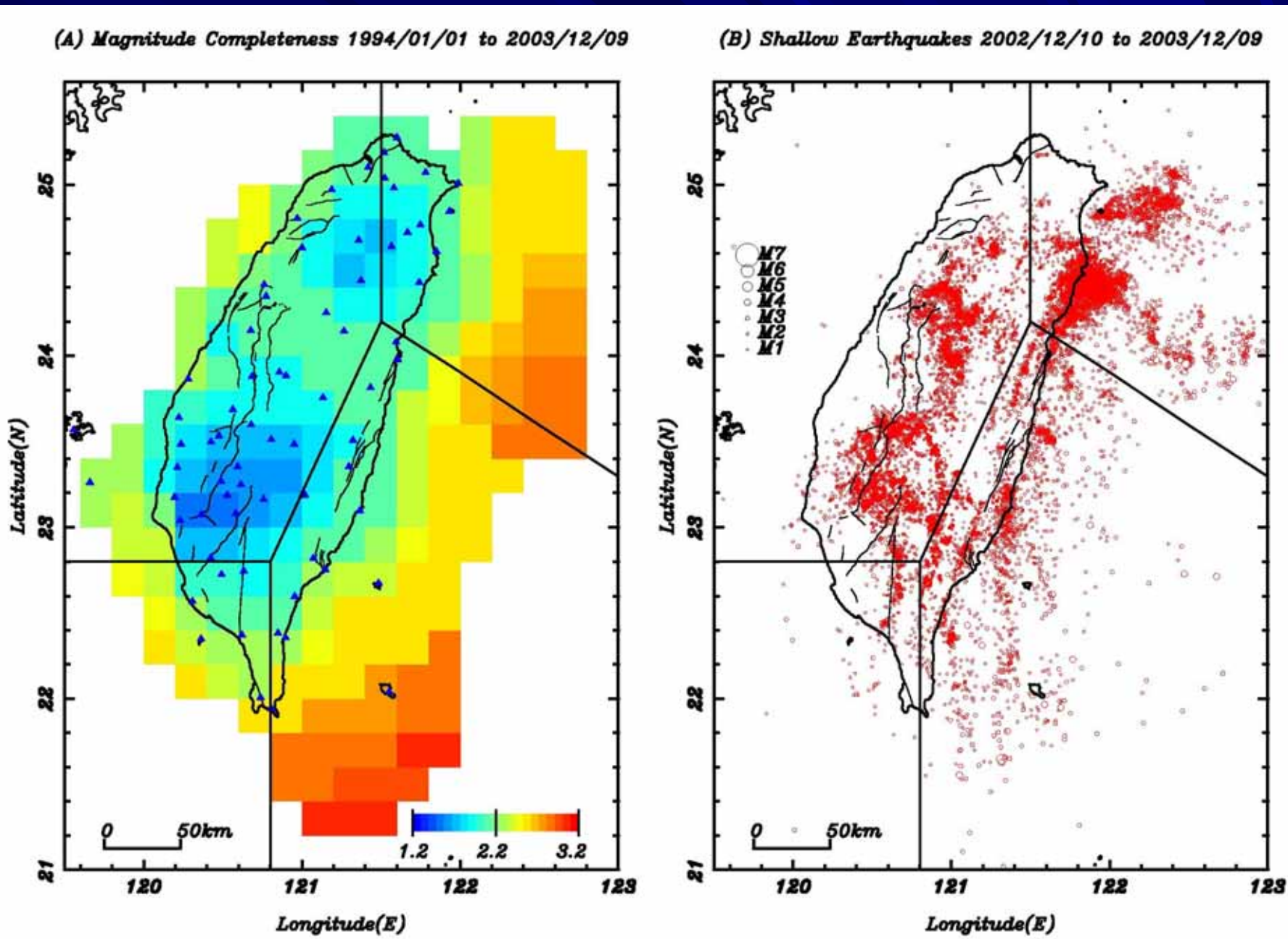
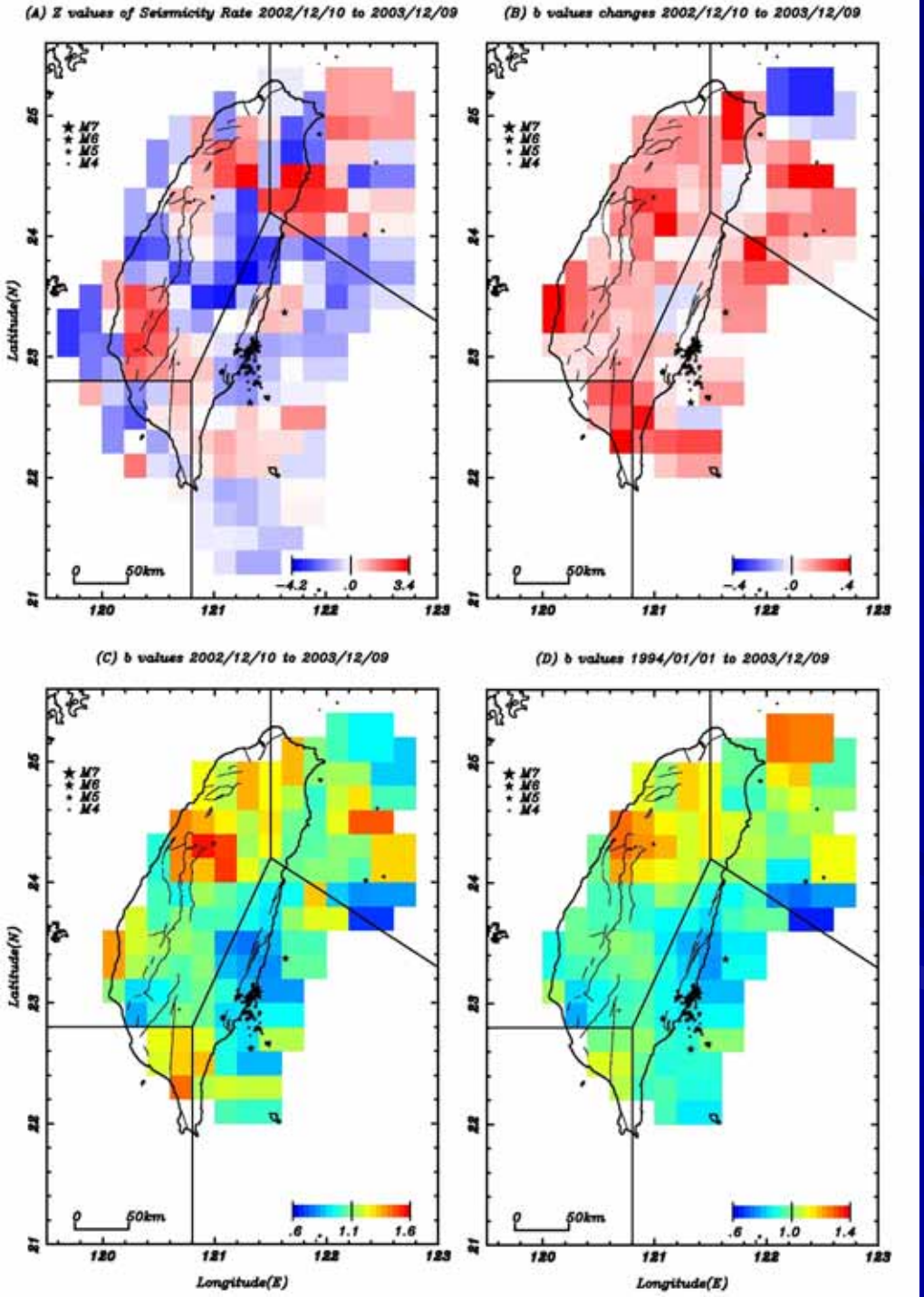
0.6
0.5
0.4
Average 0.83+-0.08
Year


(A) Magnitude Completeness 1994/01/01 to 2003/12/09
(B) Shallow Earthquakes 2002/12/10 to 2003/12/09
Latitude(N)
Longitude(E)
25
24
23
22
21
120
121
122
123
0
50km
1.2
2.2
3.2
M7
M6
M5
M4
M3
M2
M1

Background
1994 to 2003/12/09
M_L>=Mc
B value (Aki)
Radius 25 km
Depth <= 35 km
Relocated catalog



Summary I

- For Taiwan region b values decreasing and low seismicity are found before large earthquakes
- The Mogi-donut-shaped variations in the seismicity can be identified in the Z-value map surrounding the earthquakes source region.

Summary II

- The relatively low seismicity rate and the decrease in the b-values may be the precursory phenomena associated with the quiescence in overall seismicity and the activation of moderate-sized events occurred around the mainshock regions before those events.
- Those observations could be important to understand the mechanism of the occurrence of large earthquakes.