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Designing the monitoring and modeling for the preparedness of seismic risk

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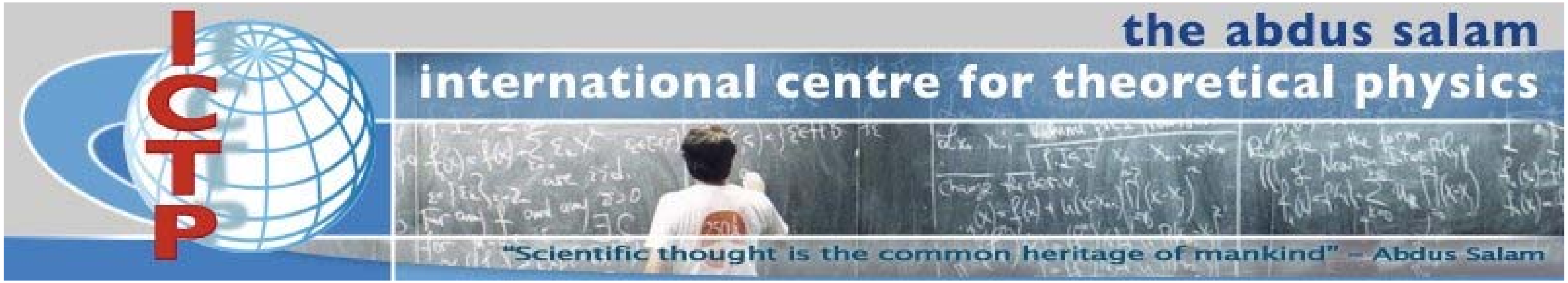

Designing the monitoring and modeling for the preparedness of seismic risk

Lessons learnt from the May 12, 2008 Wenchuan earthquake

Wu Zhongliang

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Presented at the ICTP Advanced Conference
on Seismic Risk Mitigation and Sustainable Development
Trieste, Italy, May 12, 2010

introduction

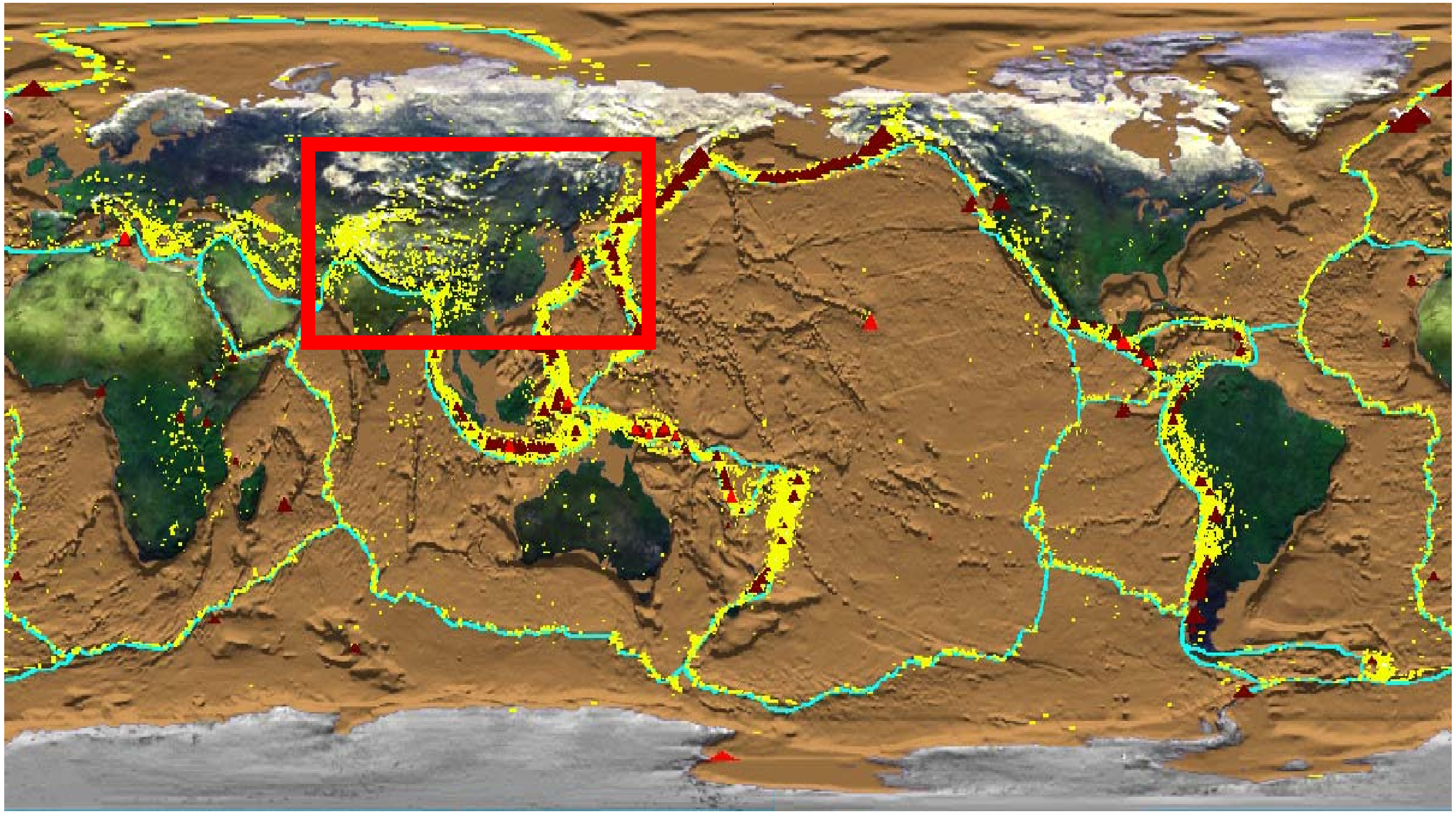
- **preparedness of seismic risk includes three perspectives:**

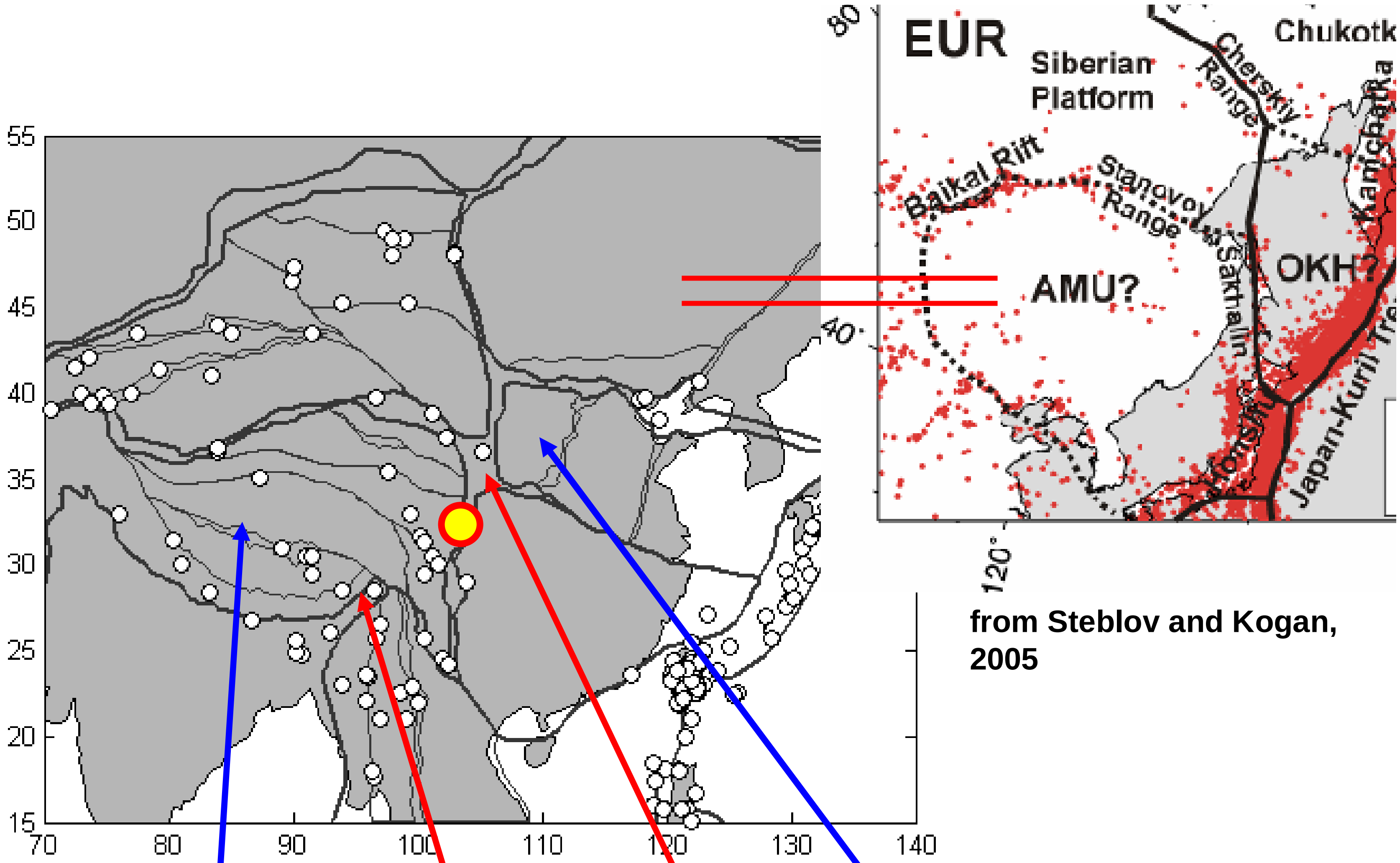
- **science: monitoring and modeling for the estimation of seismic hazard**
- **engineering: estimation of seismic risk based on hazard and vulnerability**
- **management: activities planned and implemented by considering both seismic and social factors**

- **this talk will be focusing on the first one**

firstly
a few words about China and
about the 2008 Wenchuan earthquake

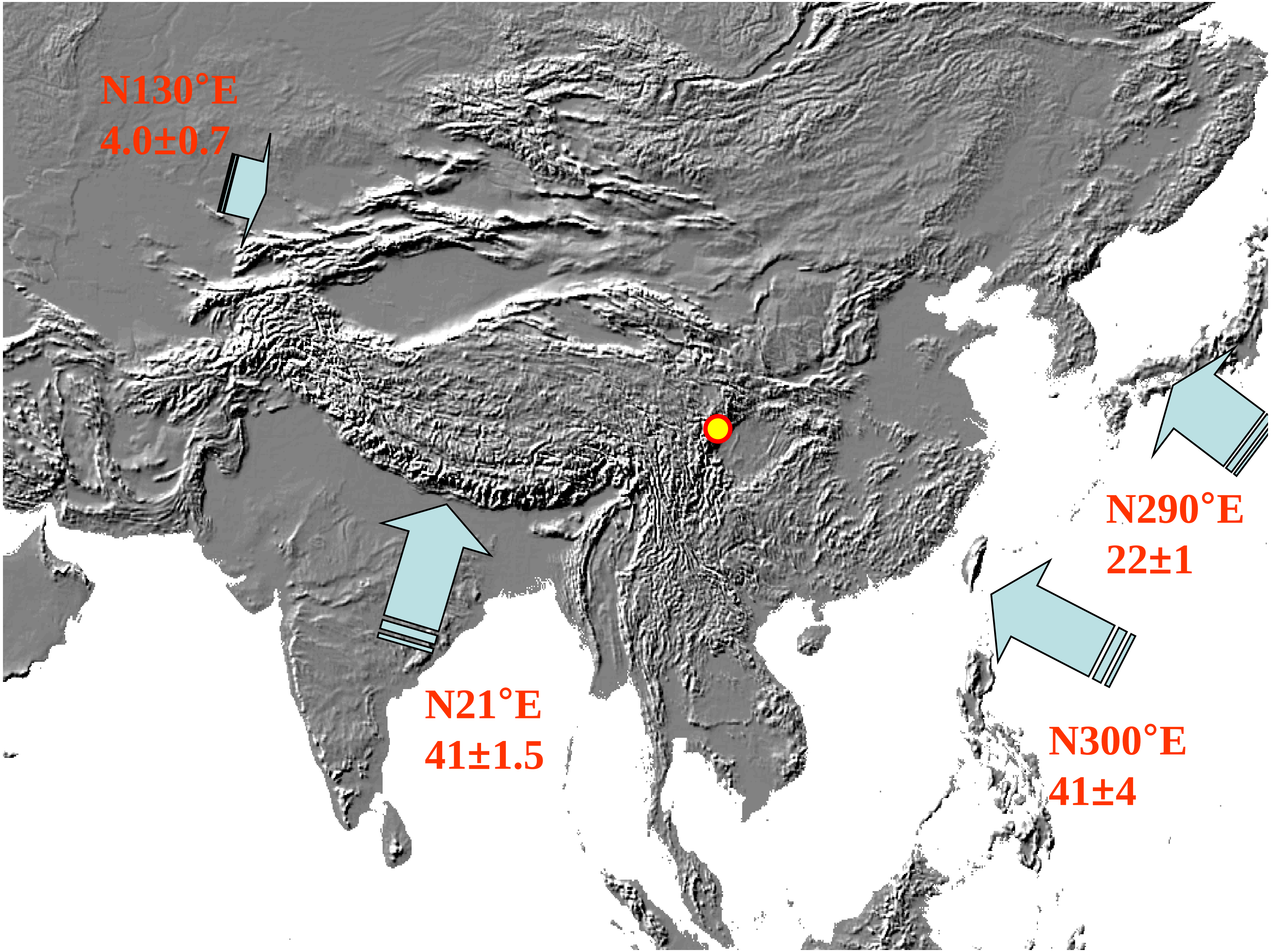
what did we see before the earthquake



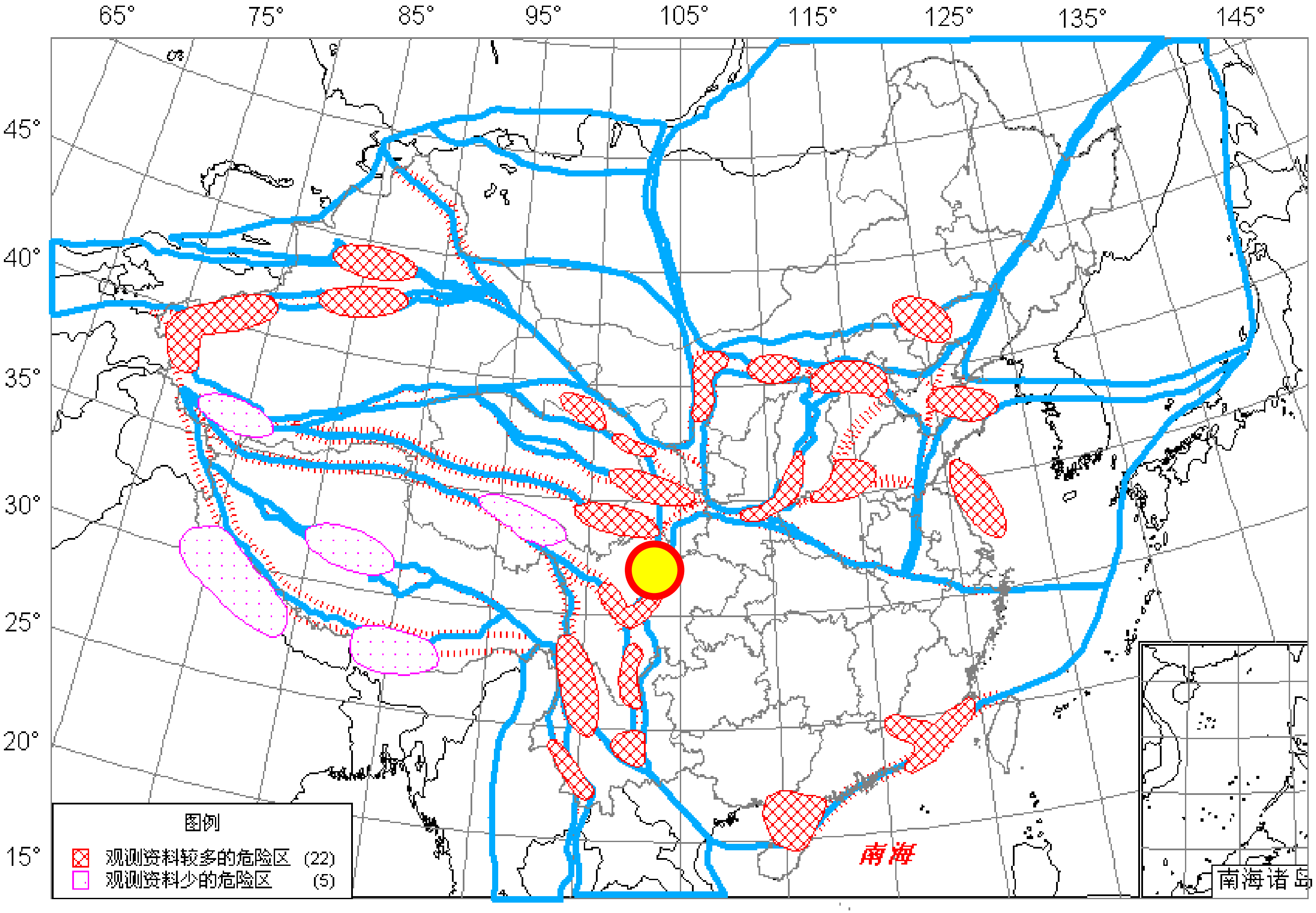


from Steblov and Kogan, 2005

when we say continental earthquakes in China,
we are saying a mixture of interplate and intraplate earthquakes.
when we say tectonic blocks,
we are saying different kinds of tectonic units, some are rigid, but others are deformable.

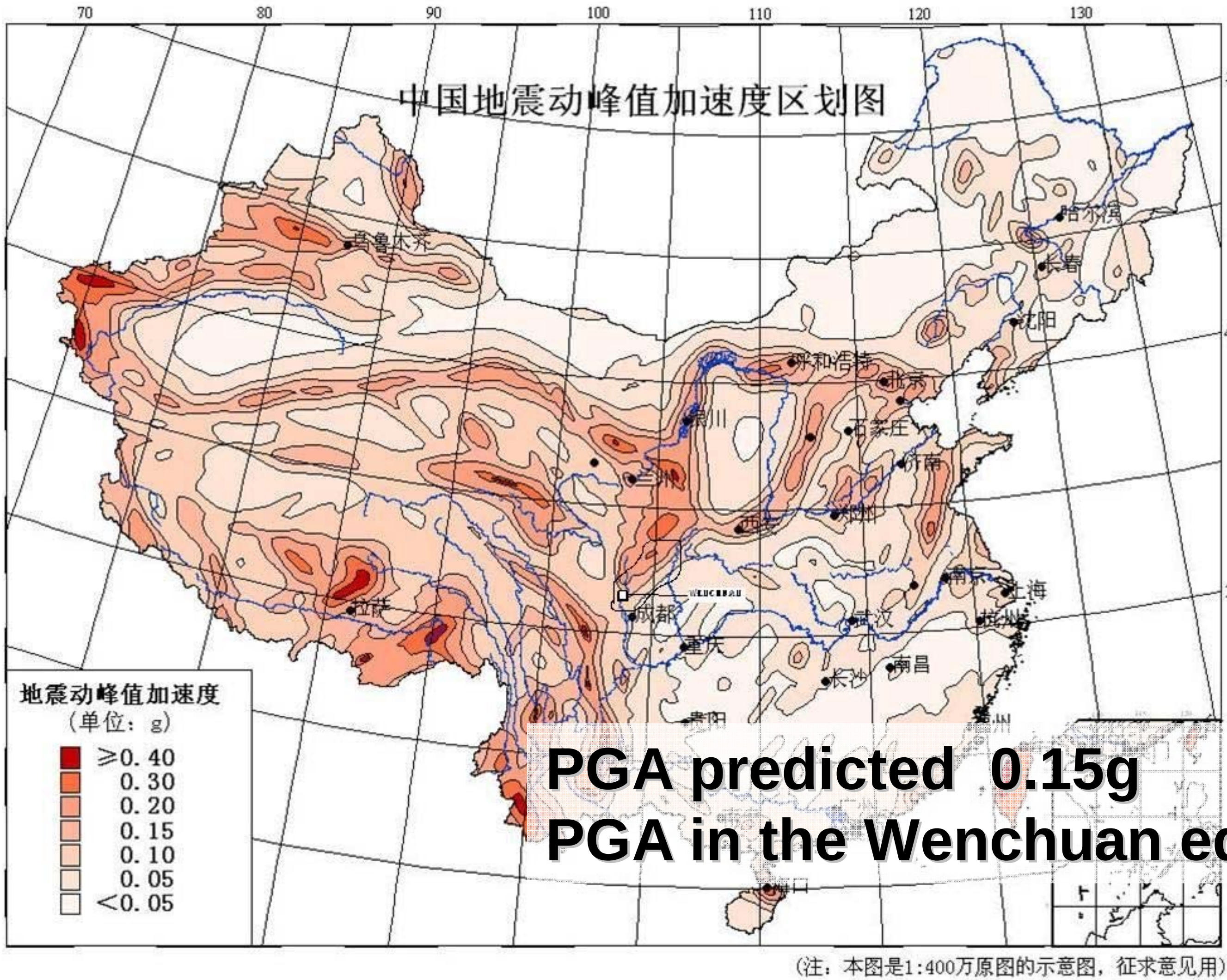

N130°E
4.0±0.7
N290°E
22±1
N21°E
41±1.5
N300°E
41±4

key regions subject to intense seismic risk 2006~2020 and the concept of block tectonics for continental earthquakes in China



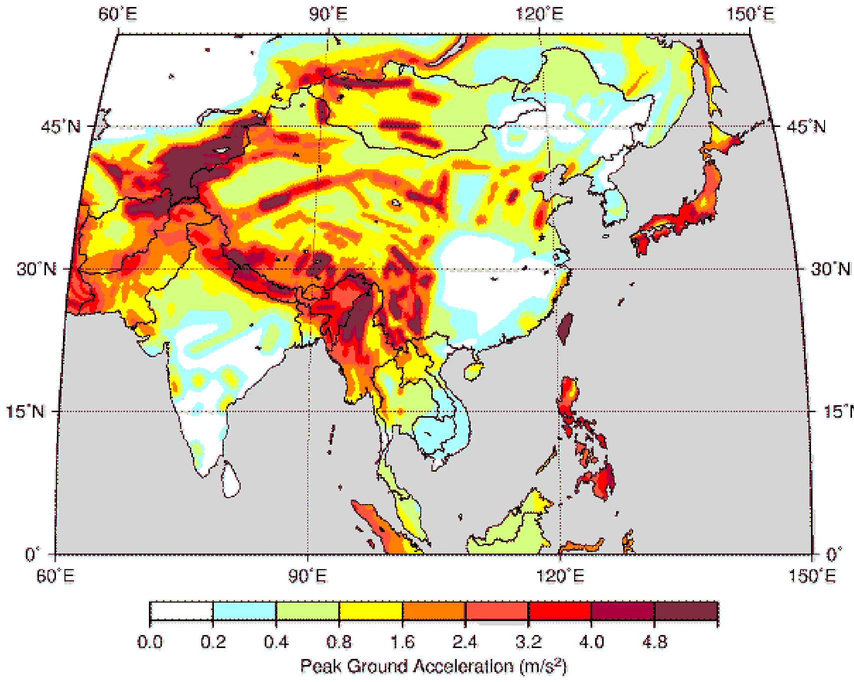
From Department for Monitoring and Prediction, CEA

seismic intensity zonation seems to be problematic



PGA predicted 0.15g
PGA in the Wenchuan eq. >1g

not only the result in China but also those in other places…



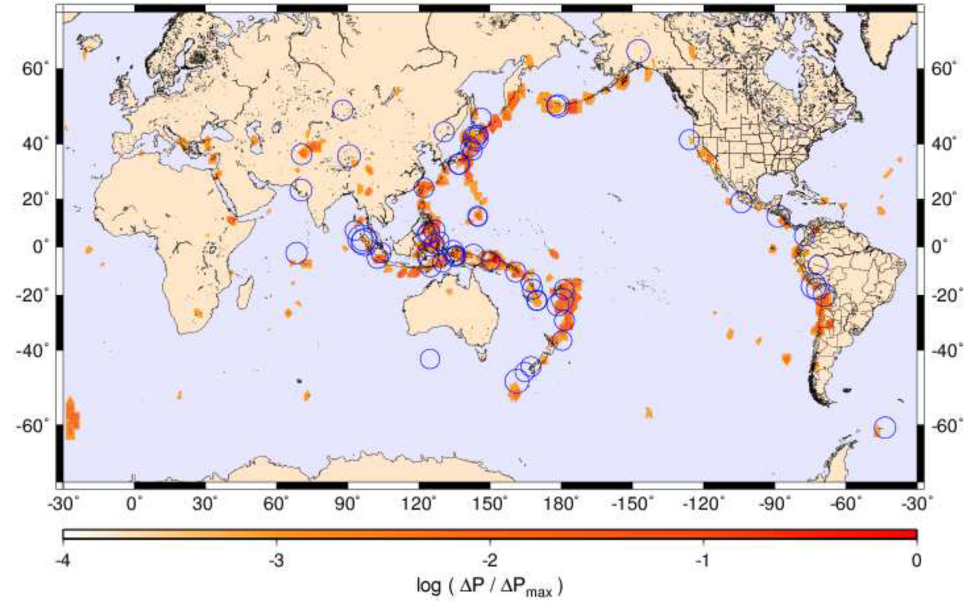
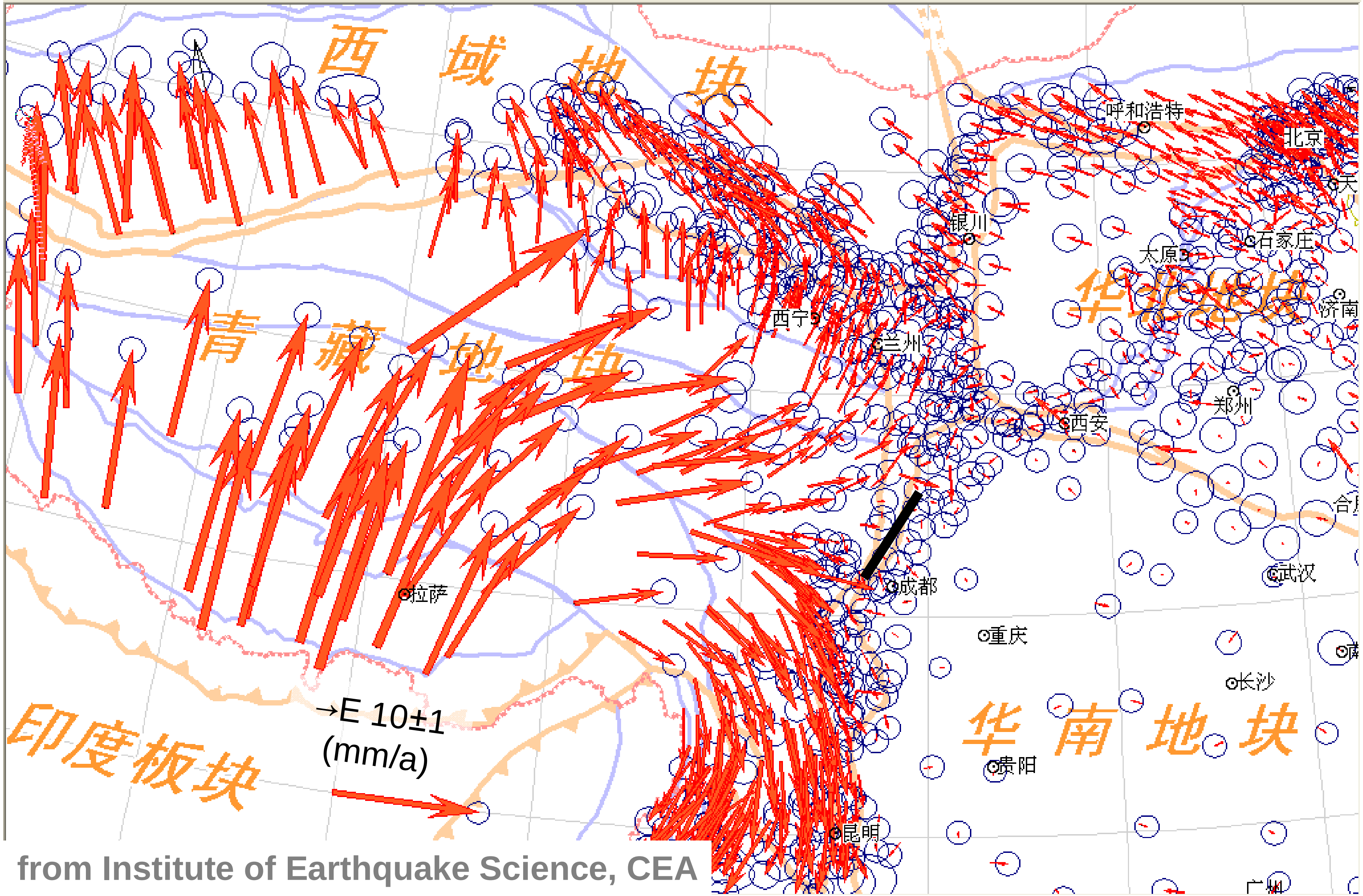


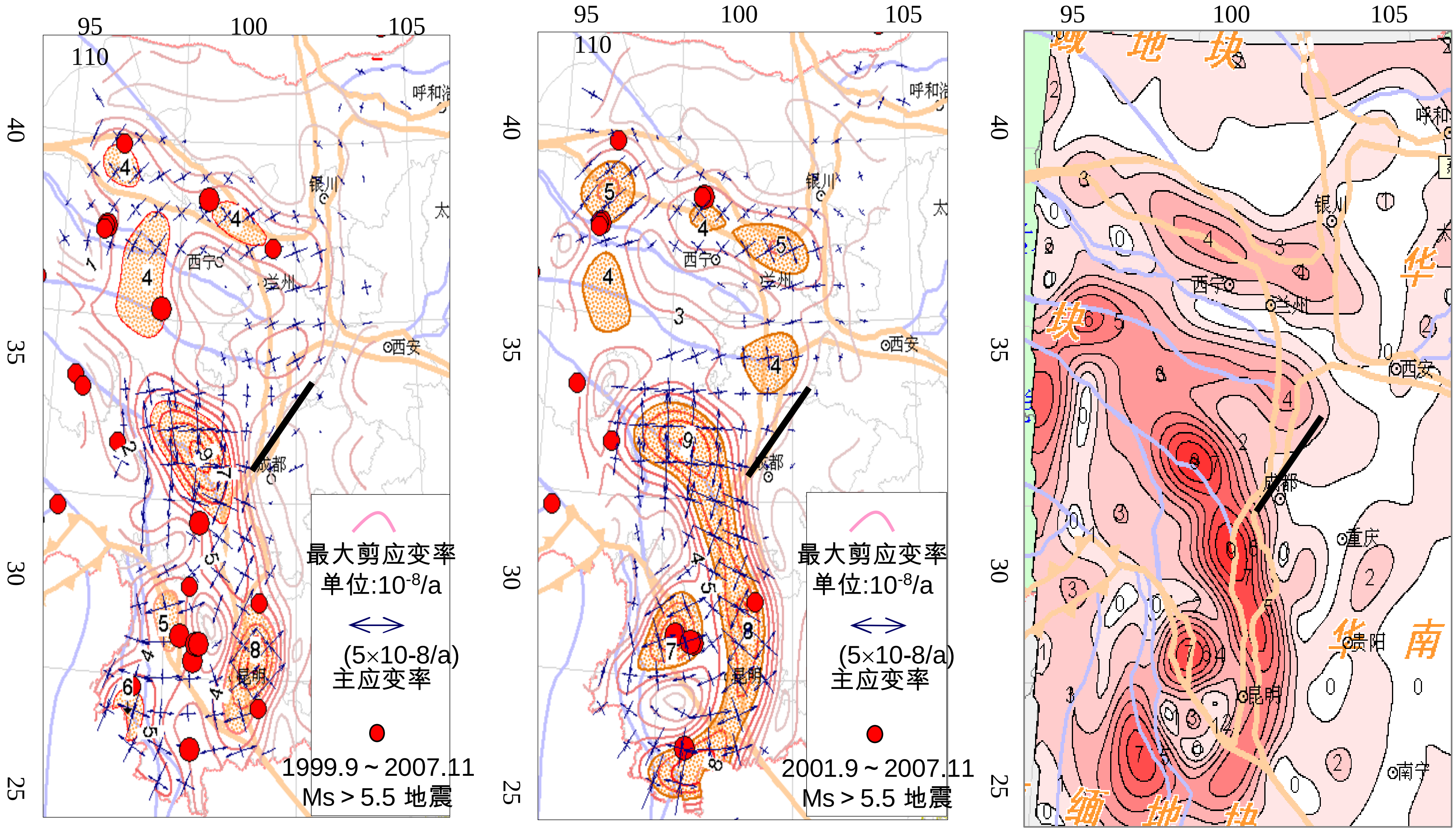
Fig. 3. World-wide application of the PI method. Colored areas are the forecast hotspots for the occurrence of M≥7 earthquakes during the period 2000-2010 derived using the PI method. The color scale gives values of the $\log_{10}(P/P_{max})$. Also shown are the locations of the sixty three earthquakes with M≥7 that have occurred in the region since 1 January 2000.

after the Wenchuan earthquake GPS measurement was criticized…



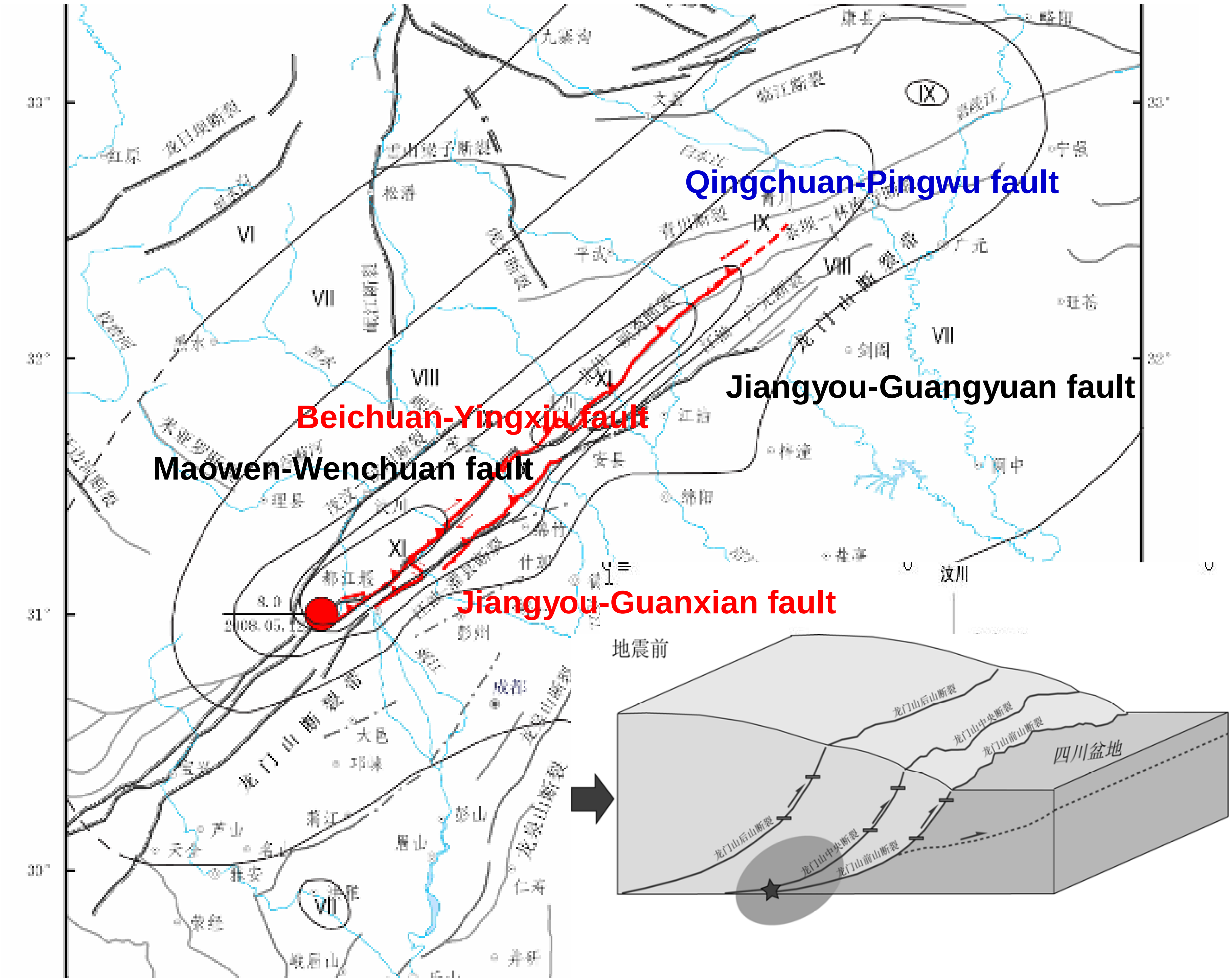
from Institute of Earthquake Science, CEA

strain rate calculated by GPS result



1999-2001　　2001-2004　　2004-2007

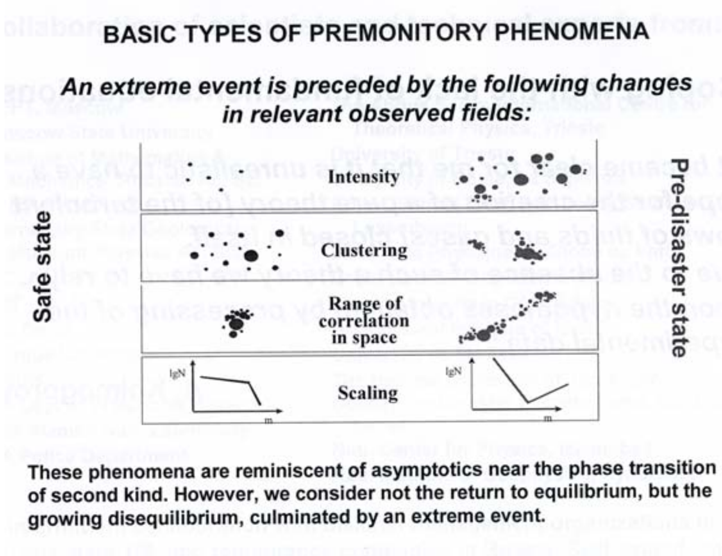
from Institute of Earthquake Science, CEA


Qingchuan-Pingwu fault
Jiangyou-Guangyuan fault
Beichuan-Yingxiu fault
Maowen-Wenchuan fault
Jiangyou-Guanxian fault
VI
VII
VIII
IX
XI
8.0
2008.05.12
汶川
地震前
四川盆地

secondly
monitoring and modeling for forecast/prediction/preparedness

what could be learnt from Wenchuan

‘premonitory anomalies’ (in a general sense) considered for the forecast/prediction/preparedness



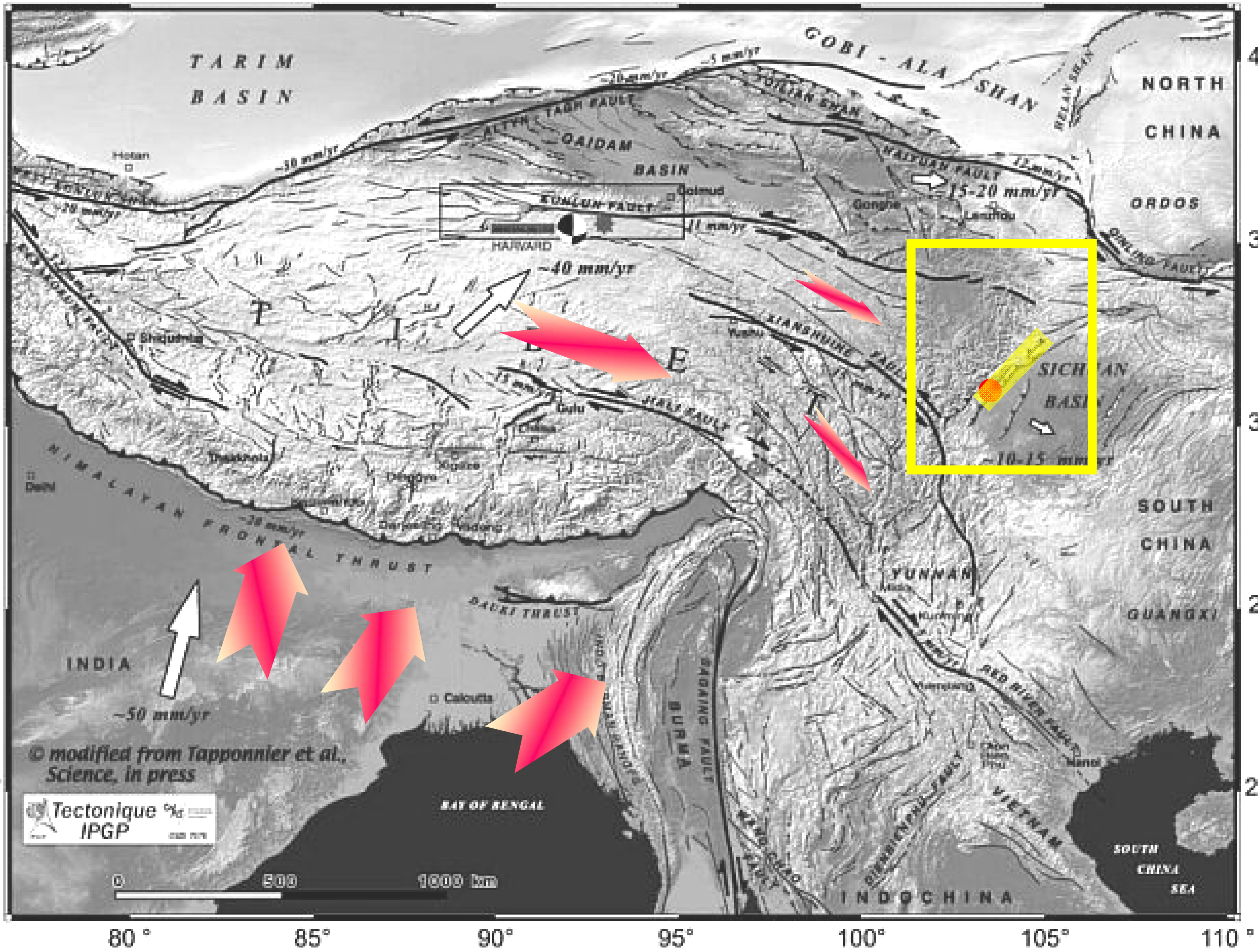
- regularities of seismic activity (statistical – intermediate-term)
- time-dependent average of (small) earthquake population (statistical – intermediate-term)
- abnormal change of geophysical fields (empirical – short-term)
- response of local seismic activity to some stimulating/loading factors such as the stress change caused by Earth tides or by other earthquakes (physical – intermediate-term/short-term)
- stories of stress or deformation (physical – long-term and intermediate-term)

- one of the problems of the current study on time-dependent earthquake hazard is that even if the idea of ‘premonitory anomalies’ is correct, the test of these ‘premonitory anomalies’ is still problematic – why ?

new techniques potentially important for providing new ingredients to the estimation of time-dependent seismic hazard

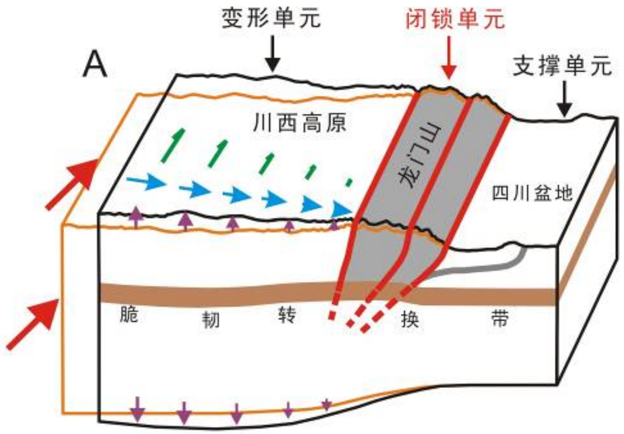
- **active source**
- **continuous GPS**
- **earthquake interaction calculation**
- **ETS or DLF**
- **high-precision seismology**
- **NCF and CWI technique**
- **PI algorithm**
- **repeating events and slip rate in deep**
- **RTP**
- **stress measurement techniques**

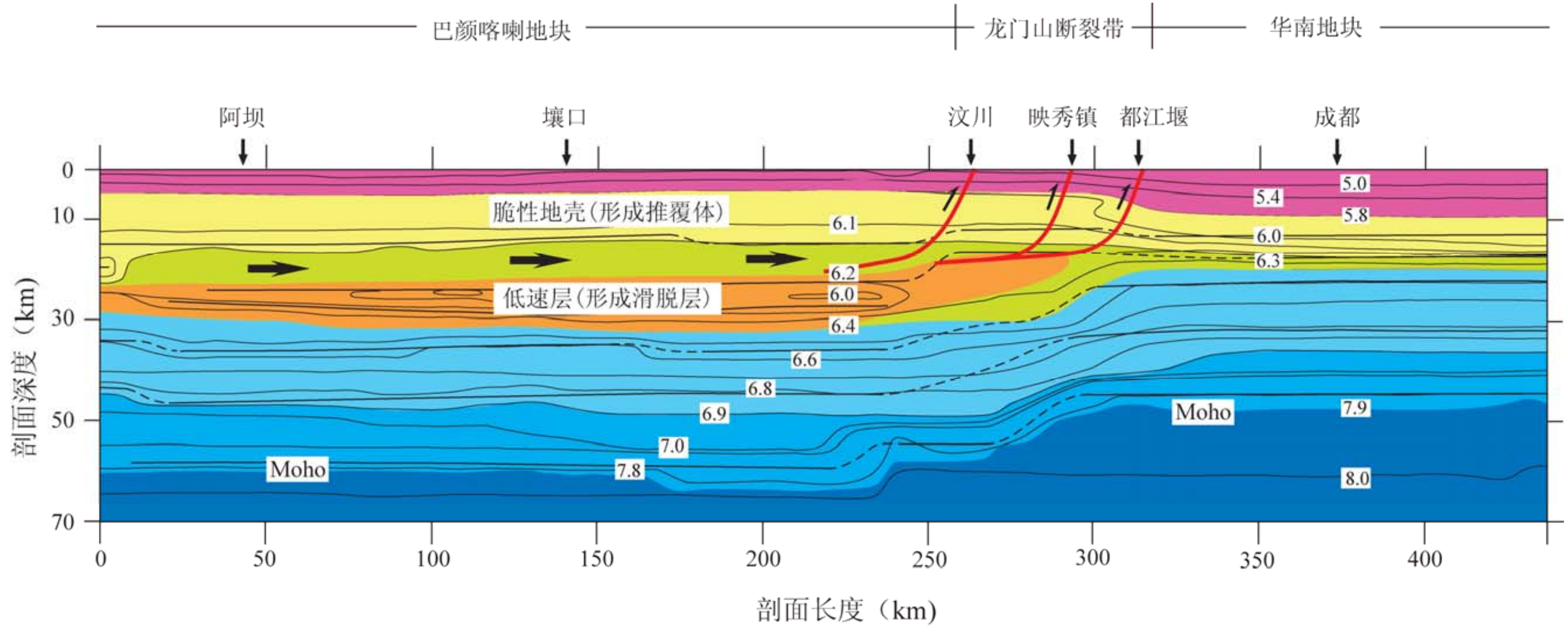
- **test of these new techniques also needs a correct road-map**



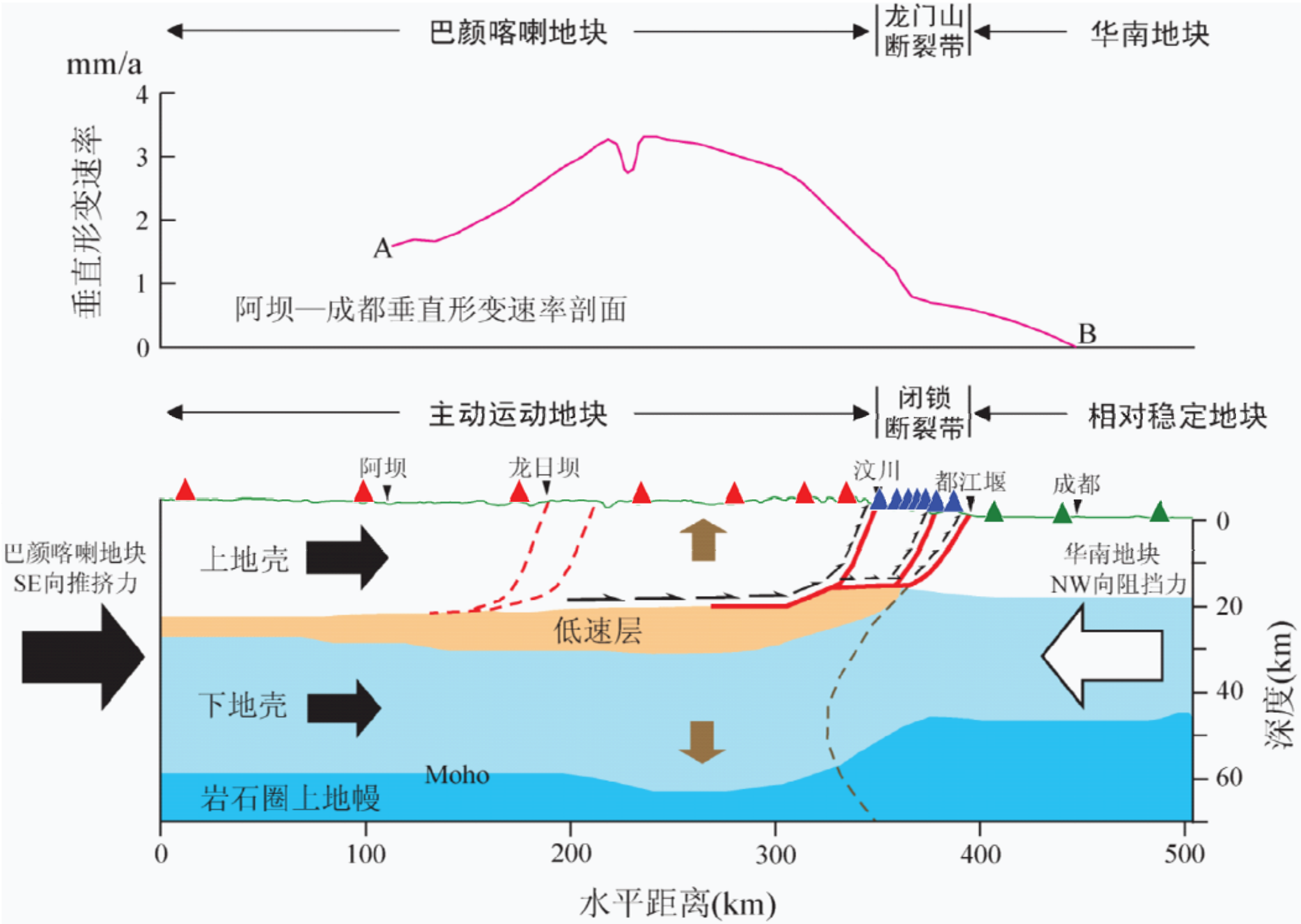
TARIM
BASIN
GOBI - ALA SHAN
NORTH
CHINA
QAIDAM
BASIN
ALTYN TAGH FAULT
KUNLUN FAULT
HAIYUAN FAULT
15-20 mm/yr
Golmud
Lanzhou
ORDOS
QINLING FAULT
HARVARD
~40 mm/yr
XIANSHUIHE FAULT
JIALI FAULT
SICHUAN
BASIN
~10-15 mm/yr
SOUTH
CHINA
YUNNAN
GUANGXI
RED RIVER FAULT
HIMALAYAN FRONTAL THRUST
DAUKI THRUST
INDIA
~50 mm/yr
Calcutta
BAY OF BENGAL
BURMA
SAGAING FAULT
VIETNAM
INDOCHINA
SOUTH
CHINA
SEA
Hanoi
Delhi
Hotan
© modified from Tapponnier et al.,
Science, in press
Tectonique
IPGP
0
500
1000 km
40°
35°
30°
25°
20 °
80 °
85°
90°
95°
100°
105°
110 °

from Wen Xueze and Xu Xiwei, 2009



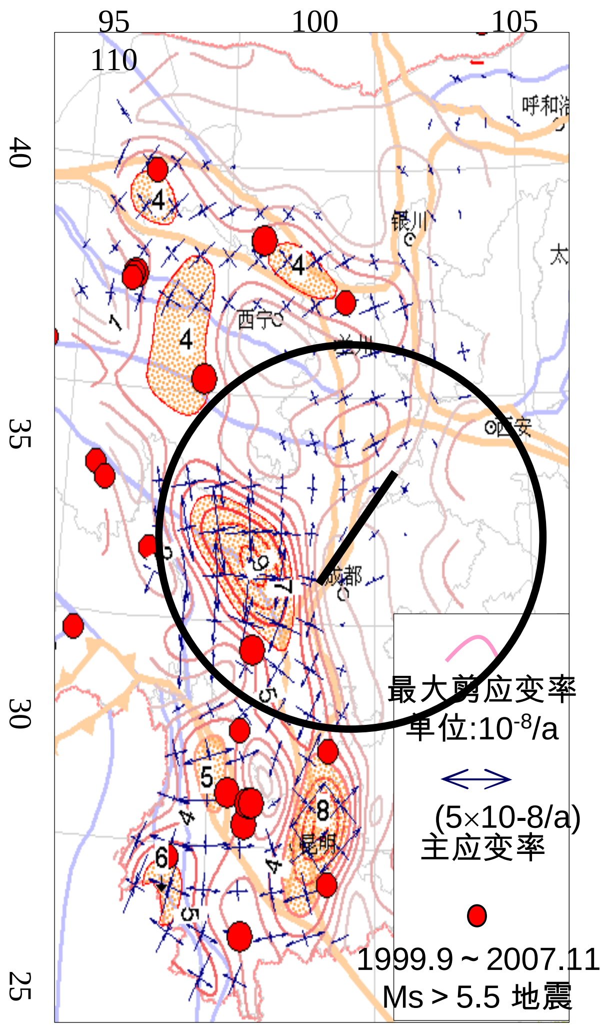


from Wen Xueze and Xu Xiwei, 2009

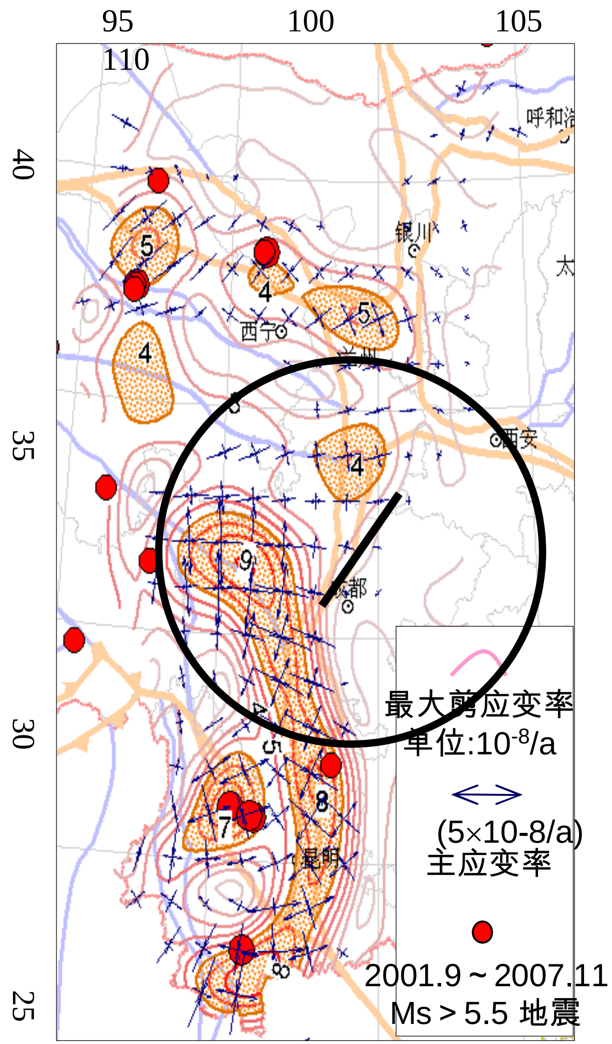


expected ‘premonitory anomalies’ drawn from the model of earthquake preparation tested by observational data

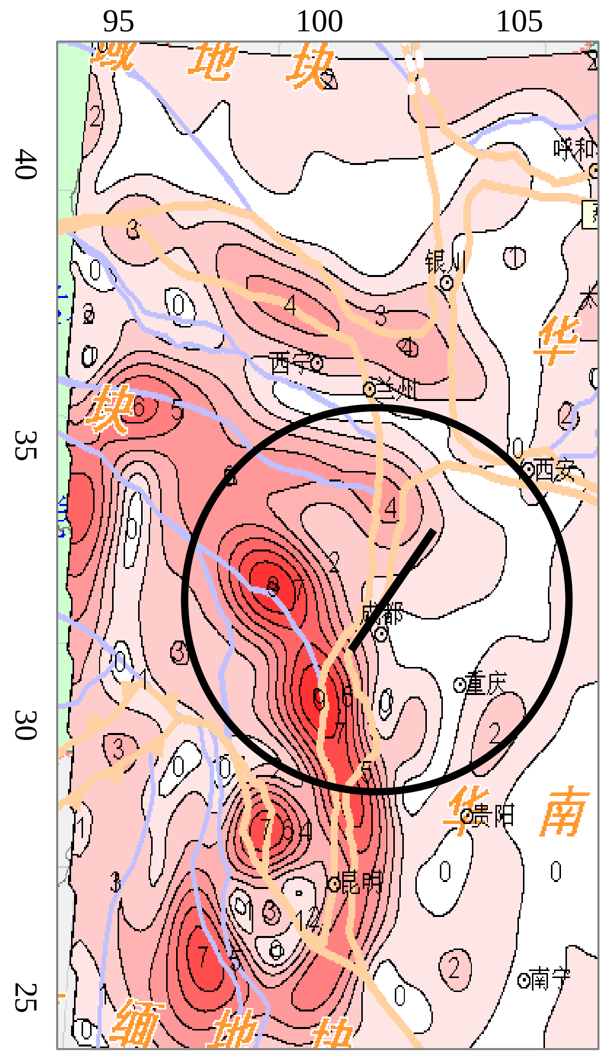
looking back at the strain field



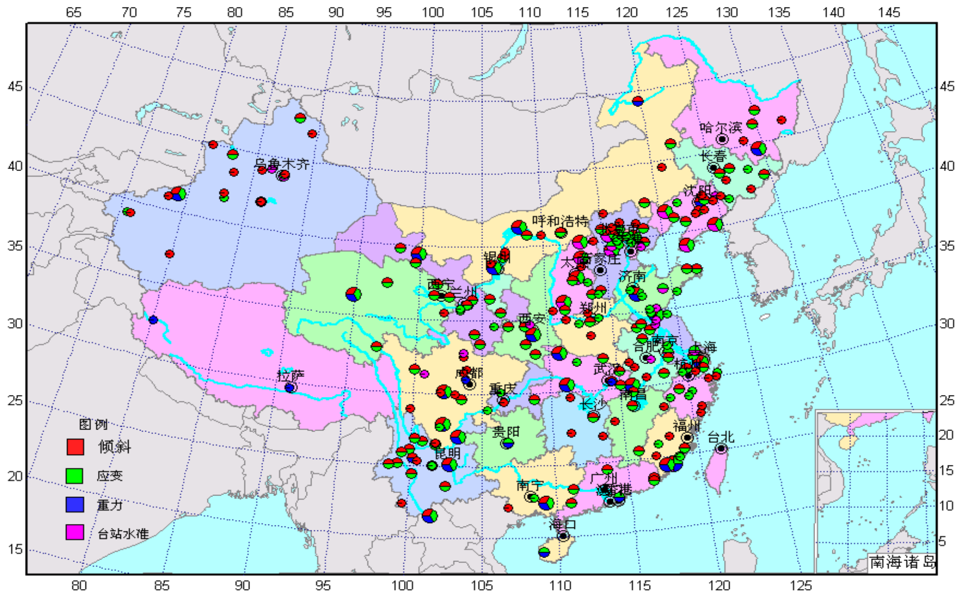
1999-2001



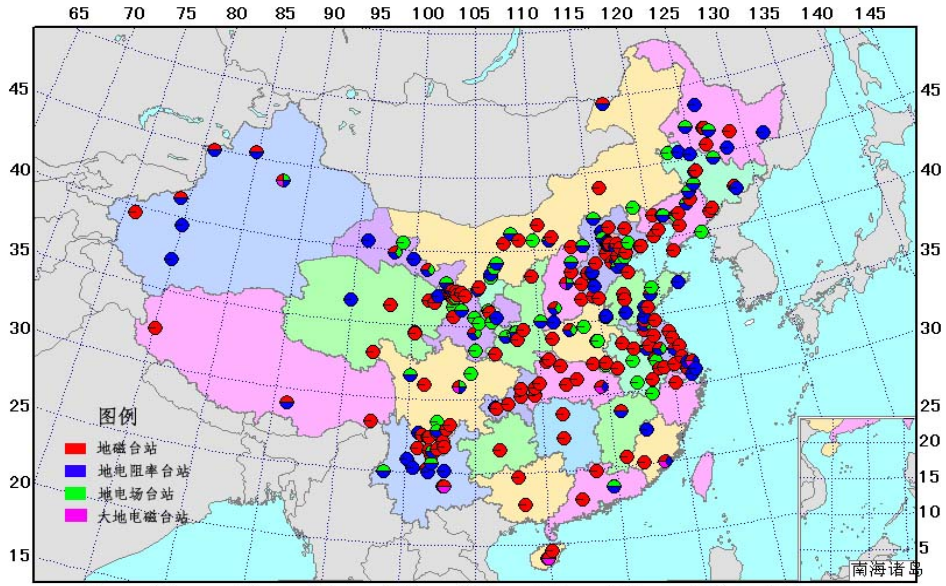
2001-2004



2004-2007

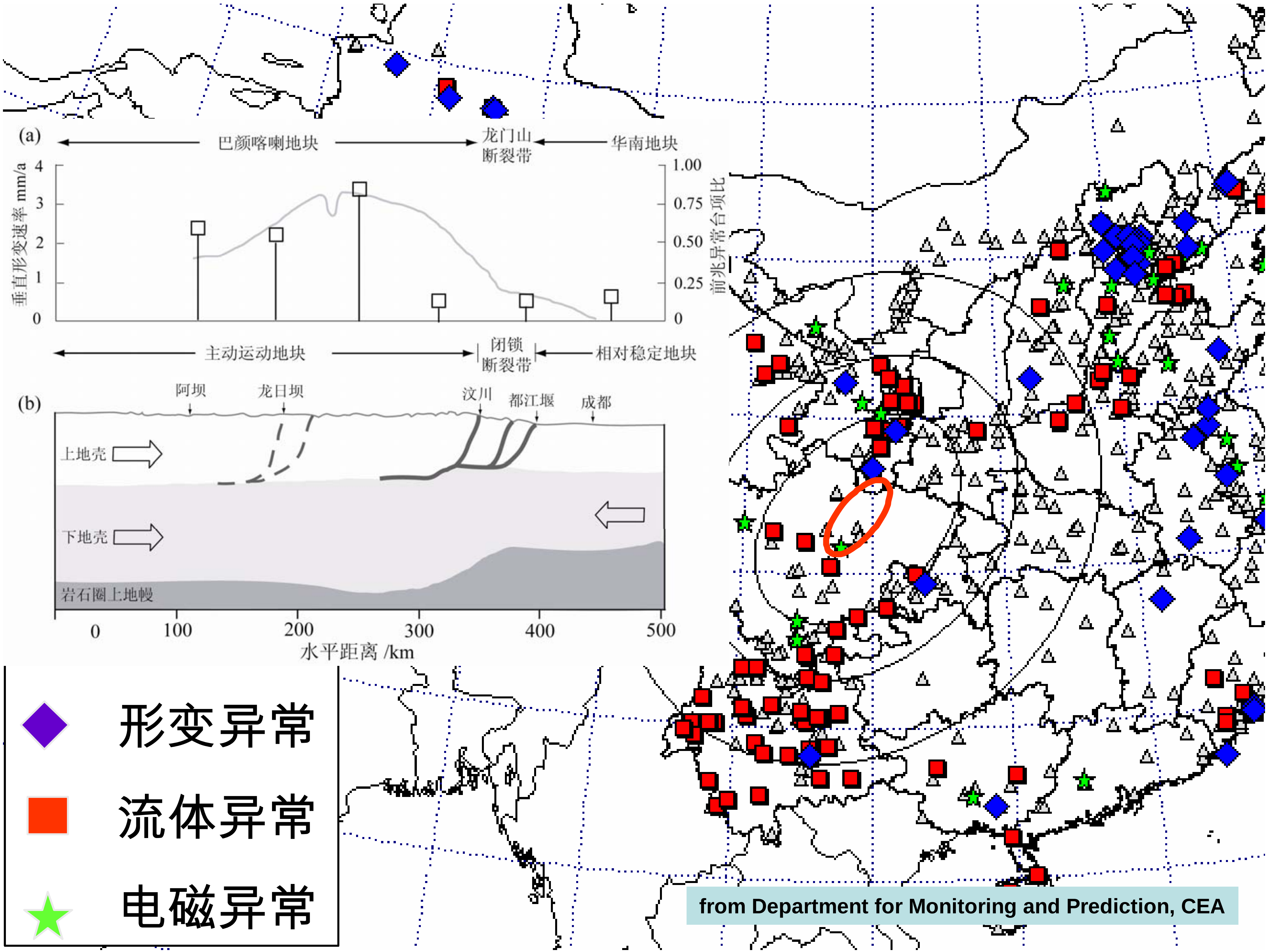


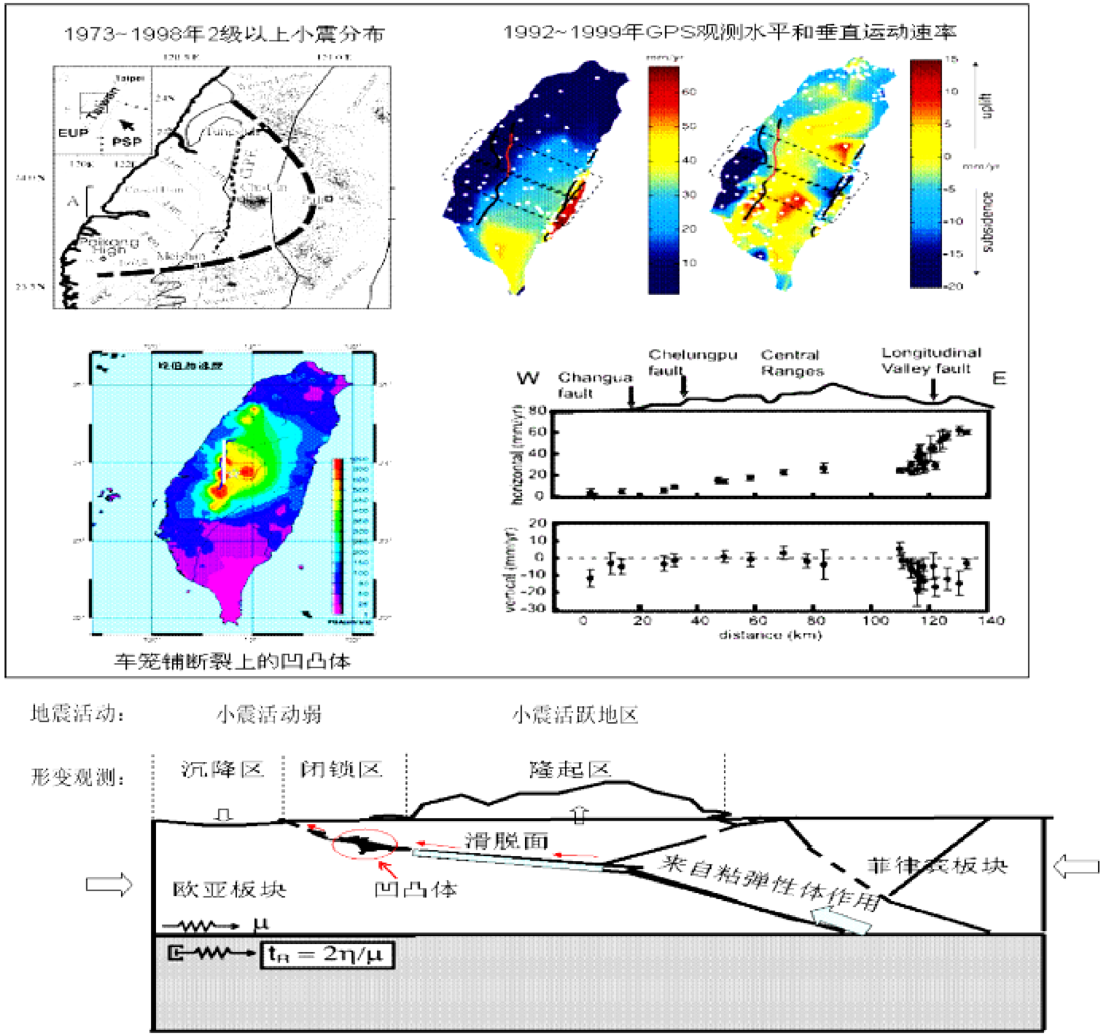
gravity and deformation monitoring



geomagnetism and geo-electricity monitoring

underground water and geochemical monitoring


(a)
巴颜喀喇地块
龙门山
断裂带
华南地块
垂直形变速率 mm/a
前兆异常台项比
0
1
2
3
4
0
0.25
0.50
0.75
1.00
主动运动地块
闭锁
断裂带
相对稳定地块
(b)
阿坝
龙日坝
汶川
都江堰
成都
上地壳
下地壳
岩石圈上地幔
0
100
200
300
400
500
水平距离 /km
形变异常
流体异常
电磁异常
from Department for Monitoring and Prediction, CEA

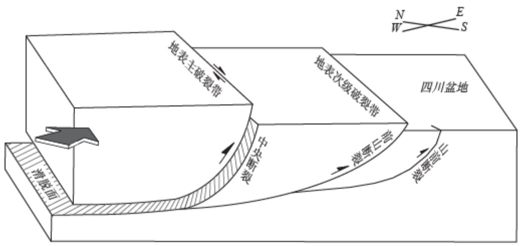


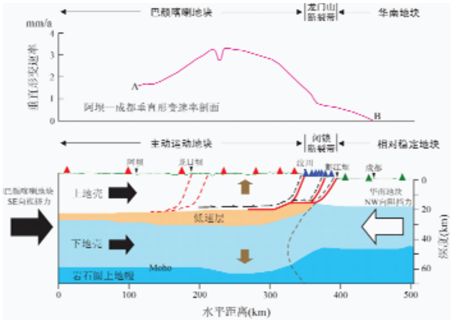
the 1999 Chi-Chi earthquake

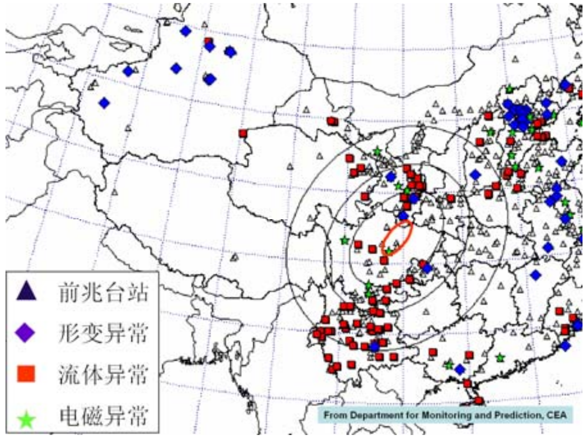
before the earthquake – not after

- scenario rupture
- expected ‘premonitory anomalies’

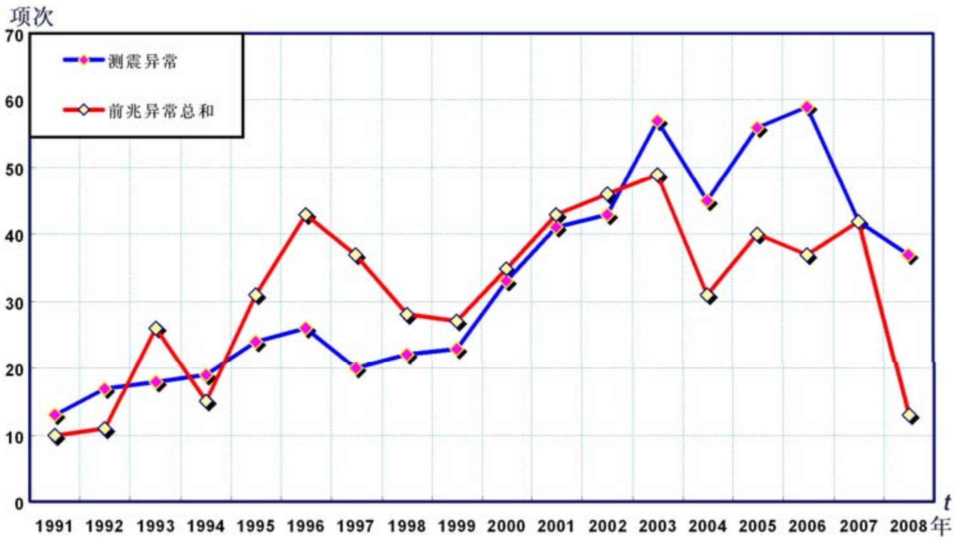
- effective constraint of the earthquake preparation model
- effective monitoring of the expected ‘premonitory anomalies’
- effective test of the proposed forecast or hazard assessment

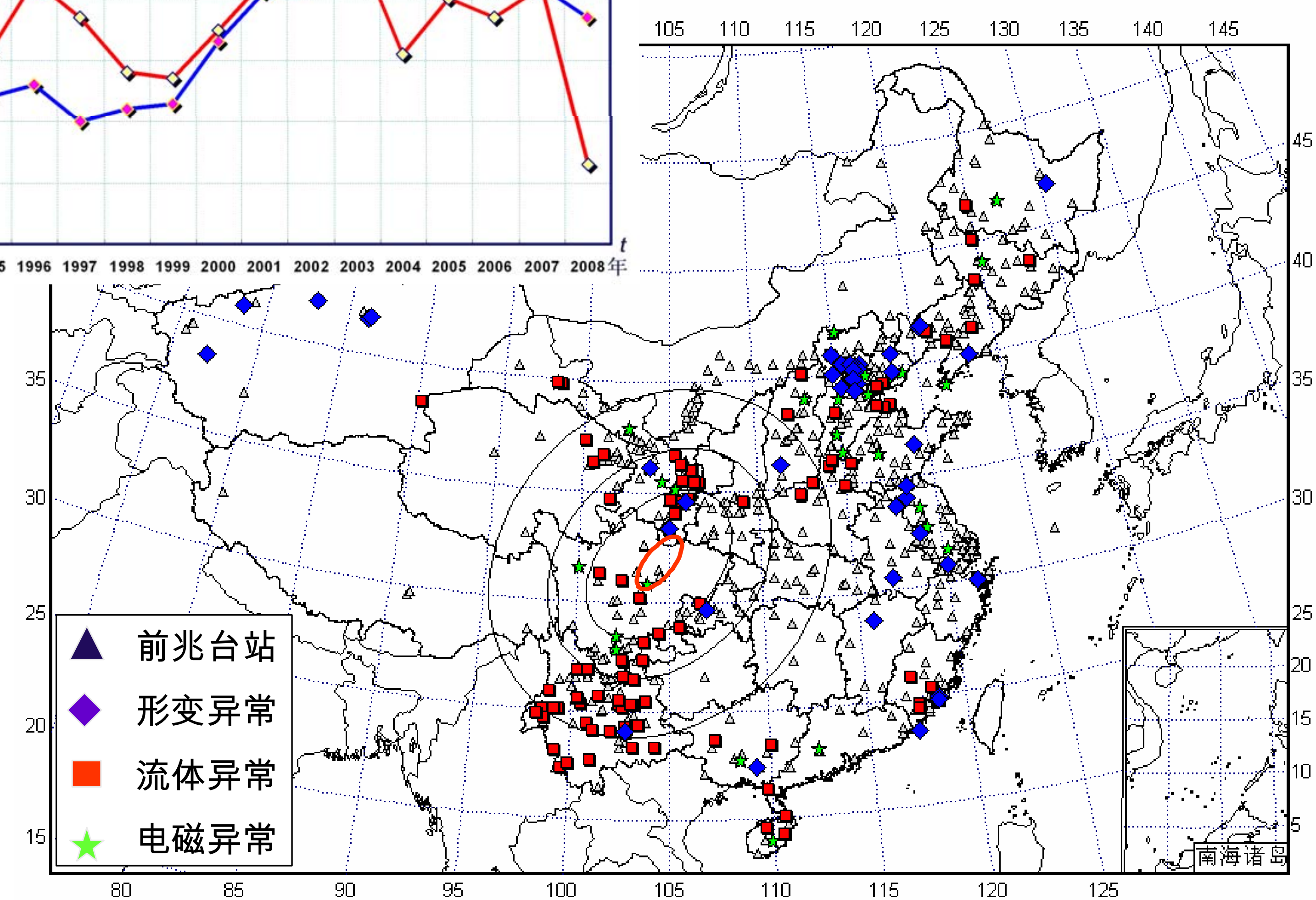






temporal variation of anomalies reported in Sichuan





distribution of anomalies reported and the location of the Wenchuan earthquake

proposing a concept

‘seismological engineering’

different from

earthquake engineering

and

engineering seismology

indicating the

design, evaluation, and implementation of monitoring systems

to facilitate the monitoring and modeling for forecast/prediction/preparedness

thirdly
why some of the worldwide-valid algorithm failed to indicate the approaching of the Wenchuan earthquake

importance of the consideration

of local situations

Plot of Log_{10} (Seismic Potential)

Increase in Potential for significant earthquakes, ~ 2000 to 2010

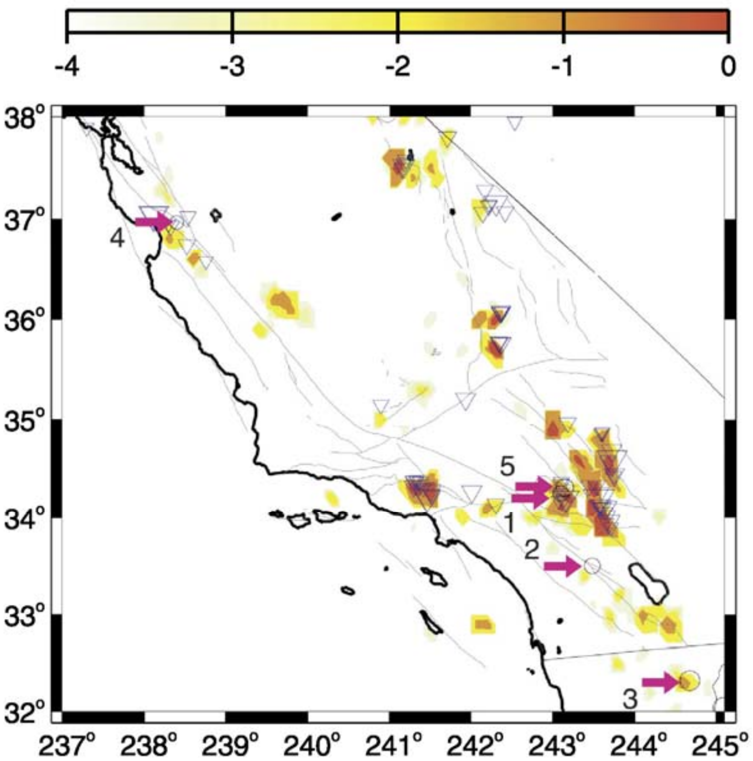
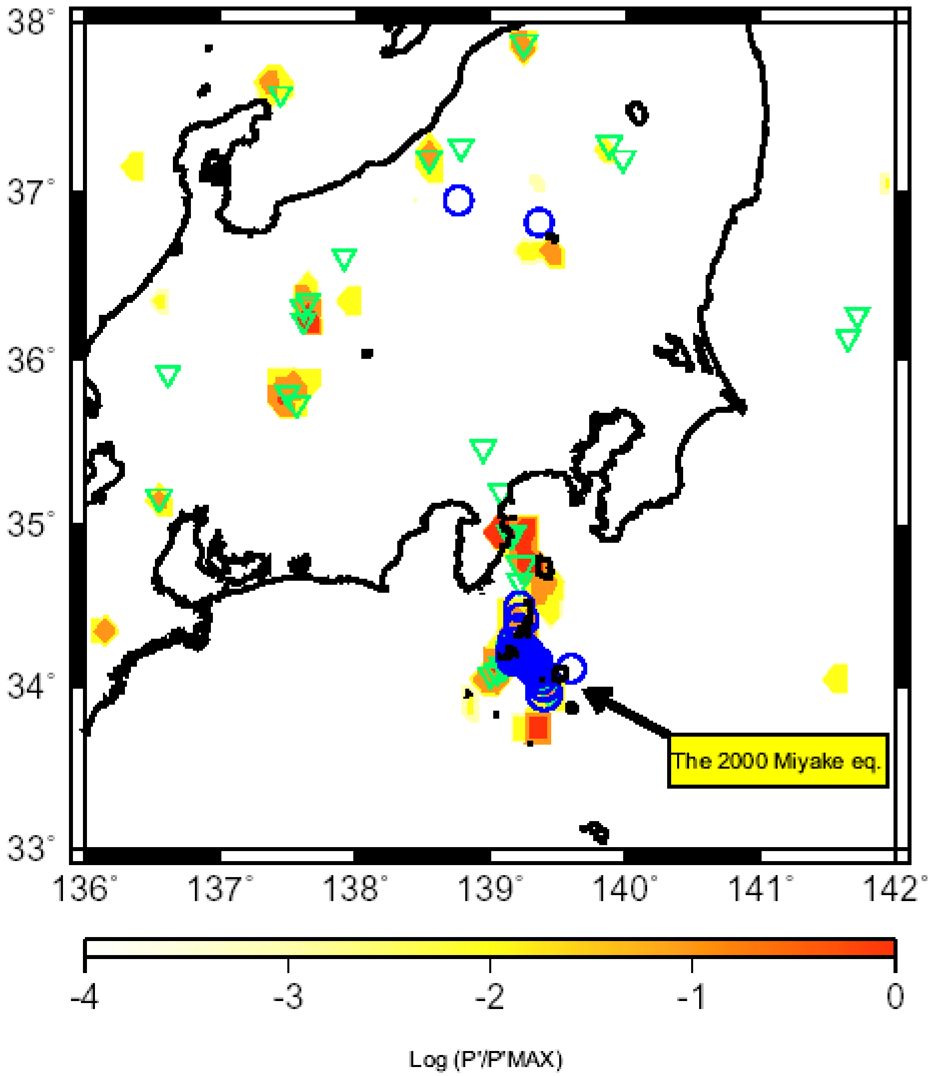


Figure 14. Pattern informatics method forecast for southern California for the period 2000–2010 [*Tiampo et al.*, 2002a; *Rundle et al.*, 2002]. Relative probabilities $\log_{10}(\Delta P/\Delta P_{max})$ are given using the color code at the top of Figure 14. The times used were t_0 = 1 January 1932, t_1 = 1 January 1990, and t_2 = 31 December 1999. Earthquakes with $m > 5.0$ that took place during 1990–1999 are shown as inverted triangles. Circles represent events with magnitude $m > 5.0$ that have occurred so far during the time period of the forecast.

from Rundle et al., *2003, Reviews of Geophysics*



from Nanjo et al., 2004. *Pure appl. Geophys.*

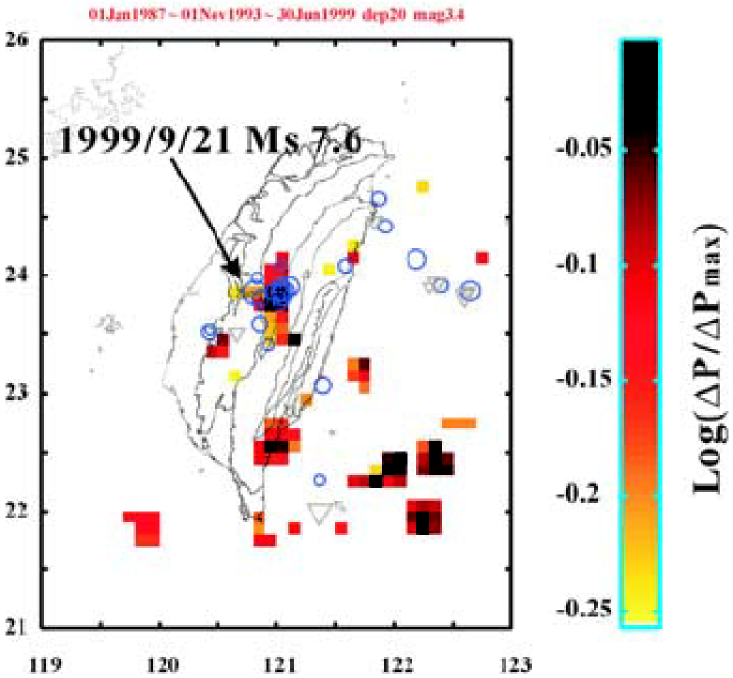
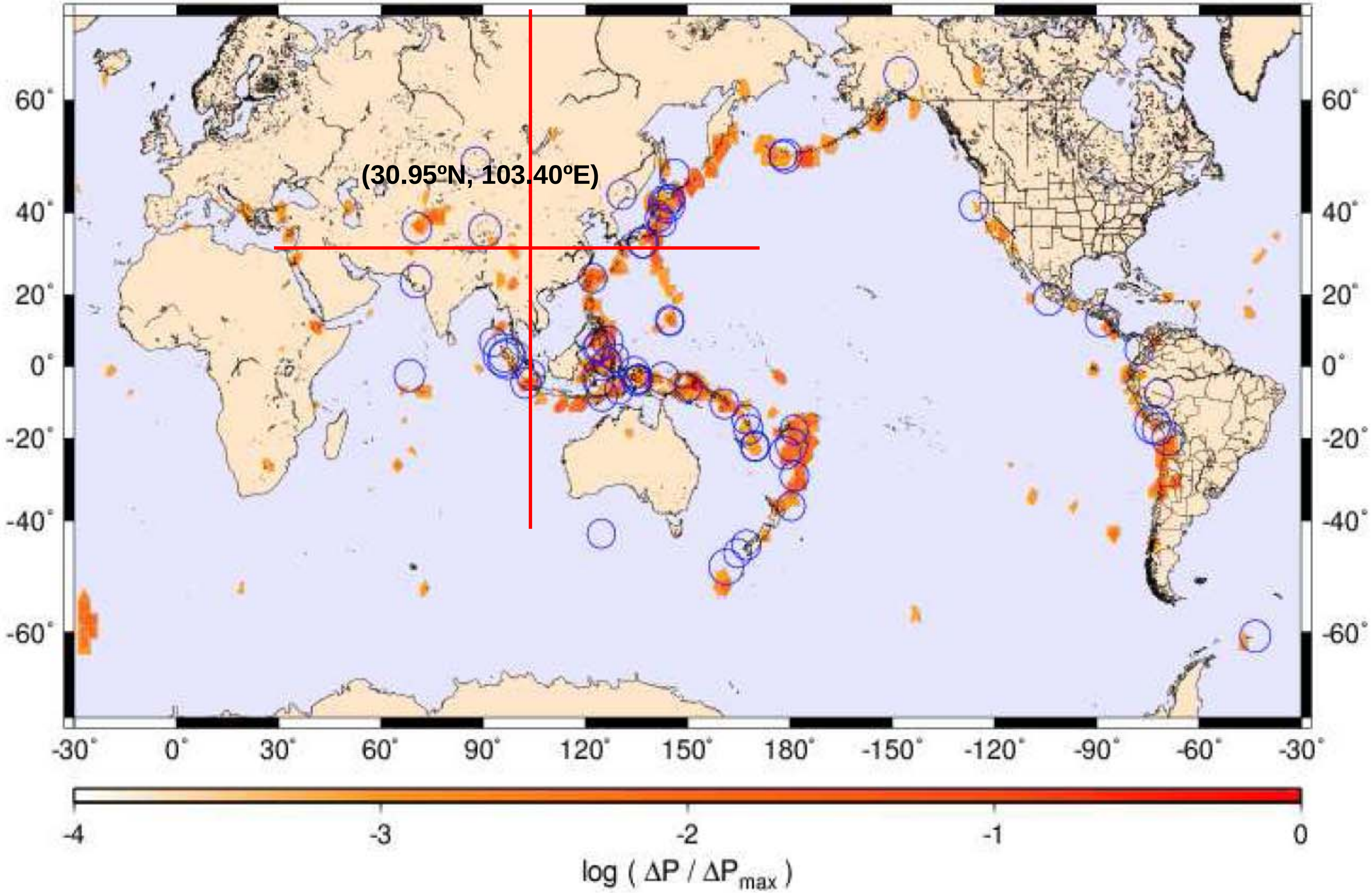
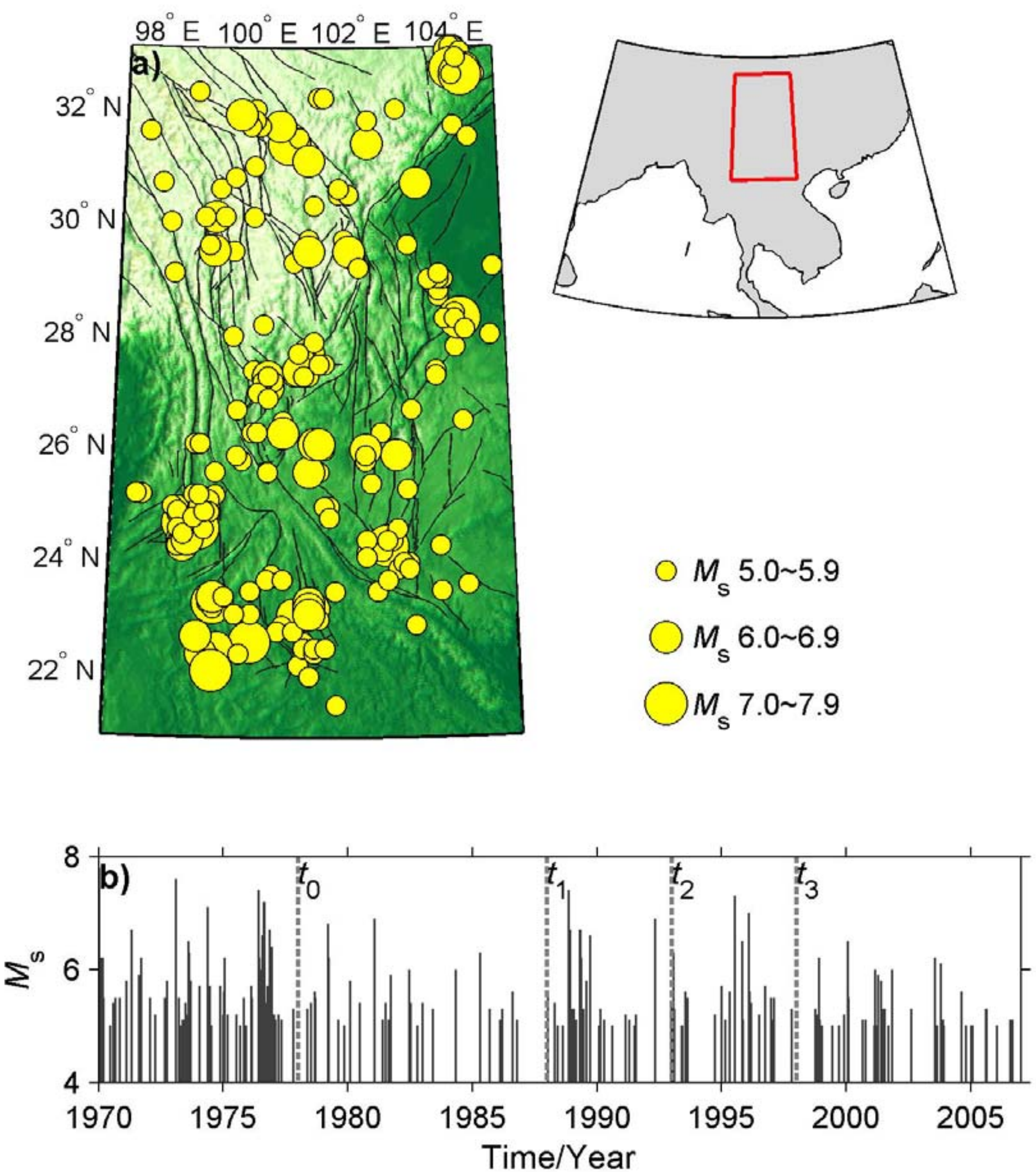


Figure 2. Taiwan PI map over the change interval from t_1 = November 1993 to t_2 = June 1999. Circles represent earthquakes with $M \geq 6$ that occurred after t_2 and inverted triangles represent earthquakes with $M \geq 6$ that occurred between t_1 and t_2. Colored pixels (hotspots) represent areas with large seismicity change caused by both the seismic activation and quiescence, indicating high probability for future large events.

from Chen et al., 2005. *Geophys. Res. Lett.*



(30.95ºN, 103.40ºE)
60°
40°
20°
0°
-20°
-40°
-60°
-30°
0°
30°
60°
90°
120°
150°
180°
-150°
-120°
-90°
-60°
-30°
-4
-3
-2
-1
0
log (ΔP / ΔP_max)



spatial distribution of earthquakes larger than M_S5.5 since 1970 in Sichuan-Yunnan region.

temporal distribution, with the three vertical dash lines to the right representing t_1 the starting time of the 'anomaly training window', t_2 the ending time of the 'anomaly training window' and the starting time of the 'forecast window', and t_3 the ending time of the 'forecast window'. For the sliding window considered in this figure, the catalogue is selected to start from t_0.

parameter settings of the retrospective forecast test:

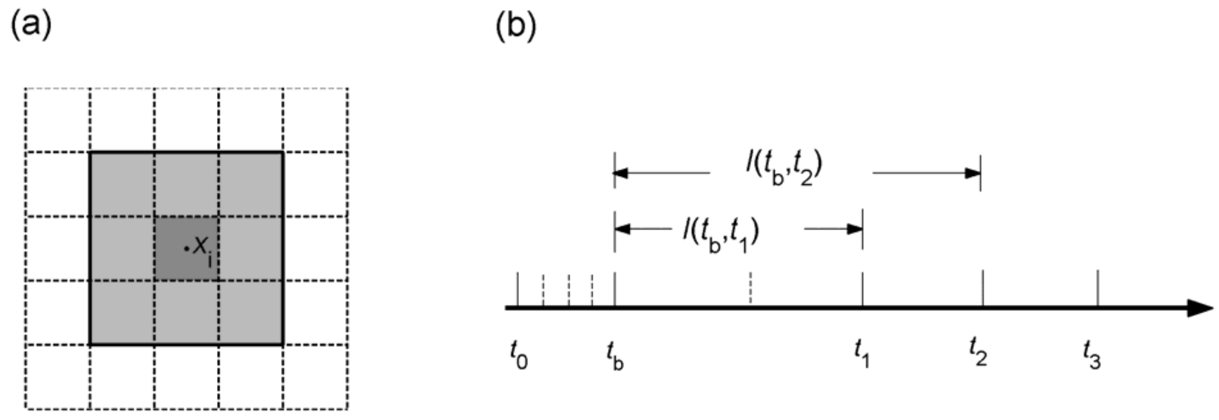
earthquakes in Sichuan-Yunnan region since 1988.

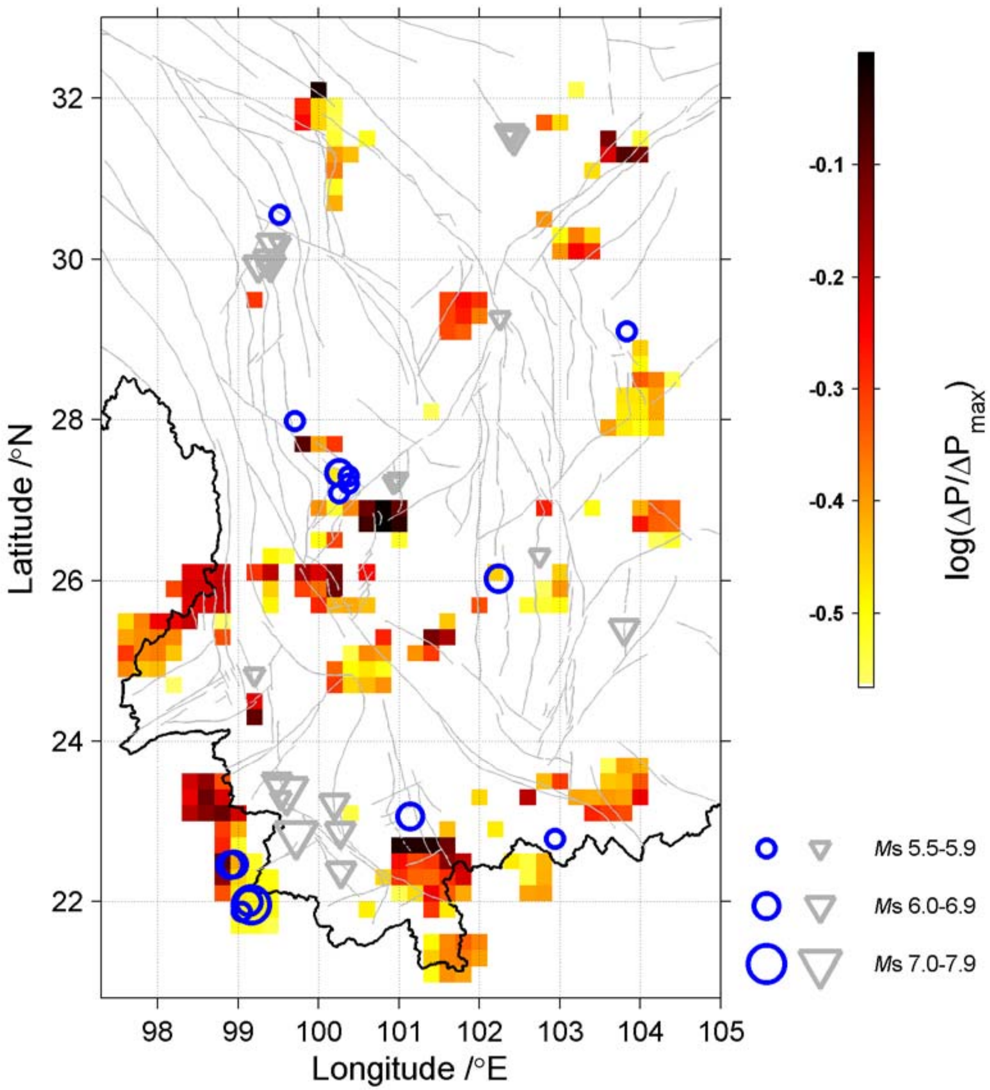
regional earthquake catalogue down to M_L3.0 from 1970 to 2008 was used.

the 'target magnitude' for the forecast test was M_S5.5.

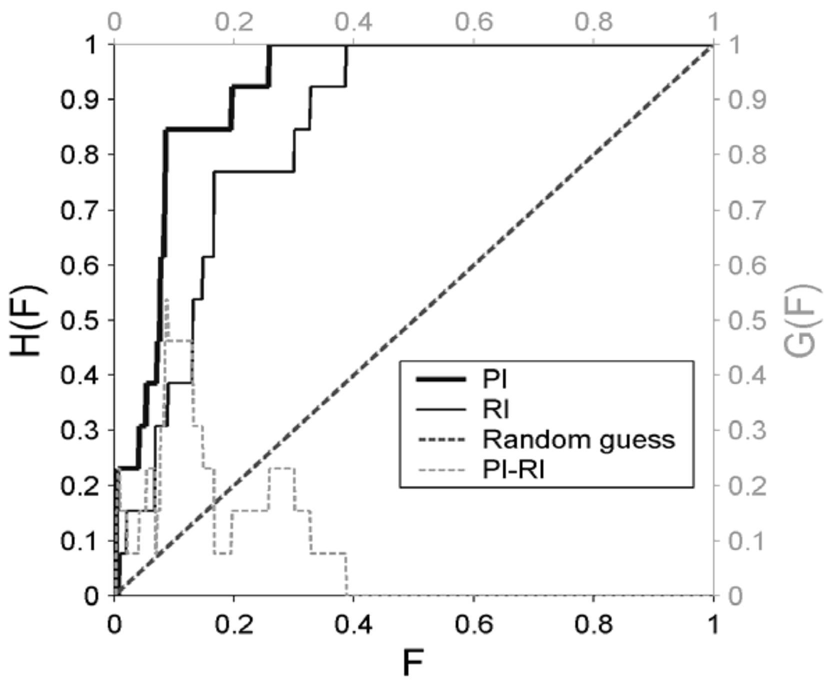
fifteen-year long 'sliding time window' was used in the PI calculation, with 'anomaly training time window' being 5 years and 'forecast time window' being 5 years, respectively.

spatial grid size is selected as 0.2°.

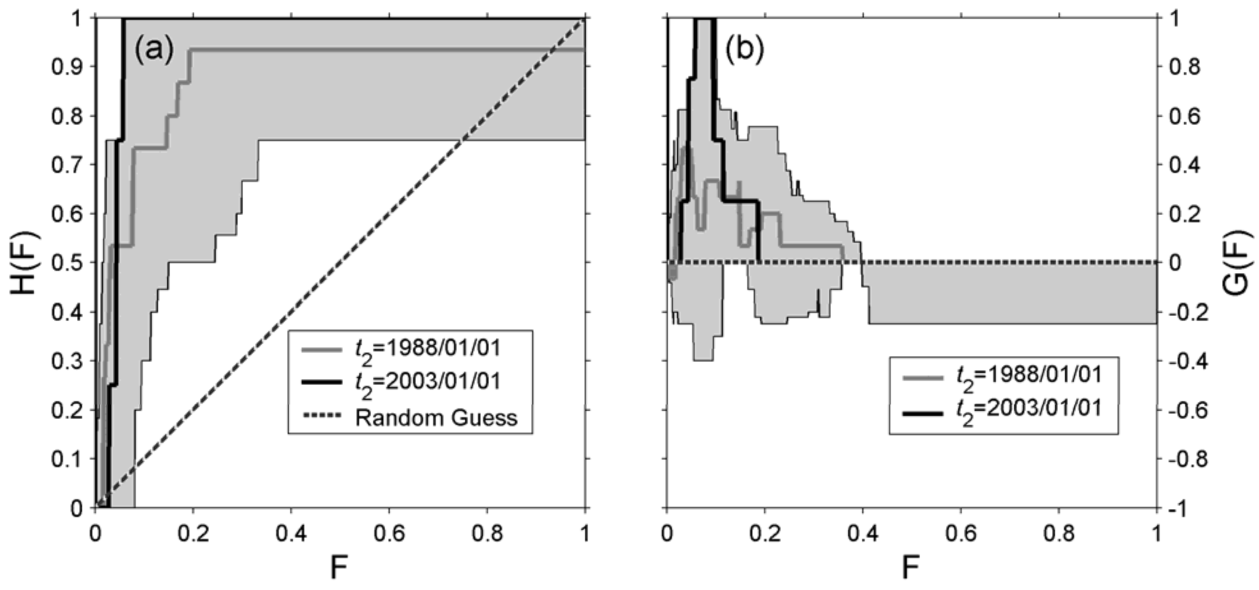




- **retrospective test of PI algorithm: Sichuan-Yunnan region, period of 01/01/1992~01/01/1997.**
- **color-coded hot spots highlight the relative probability increase for earthquakes above M_S5.5.**
- **blue circles stand for the earthquakes above M_S5.5 occurring within the 'forecast window', while gray reverse triangles show the earthquakes above M_S5.5 occurring within the 'anomaly training window'.**



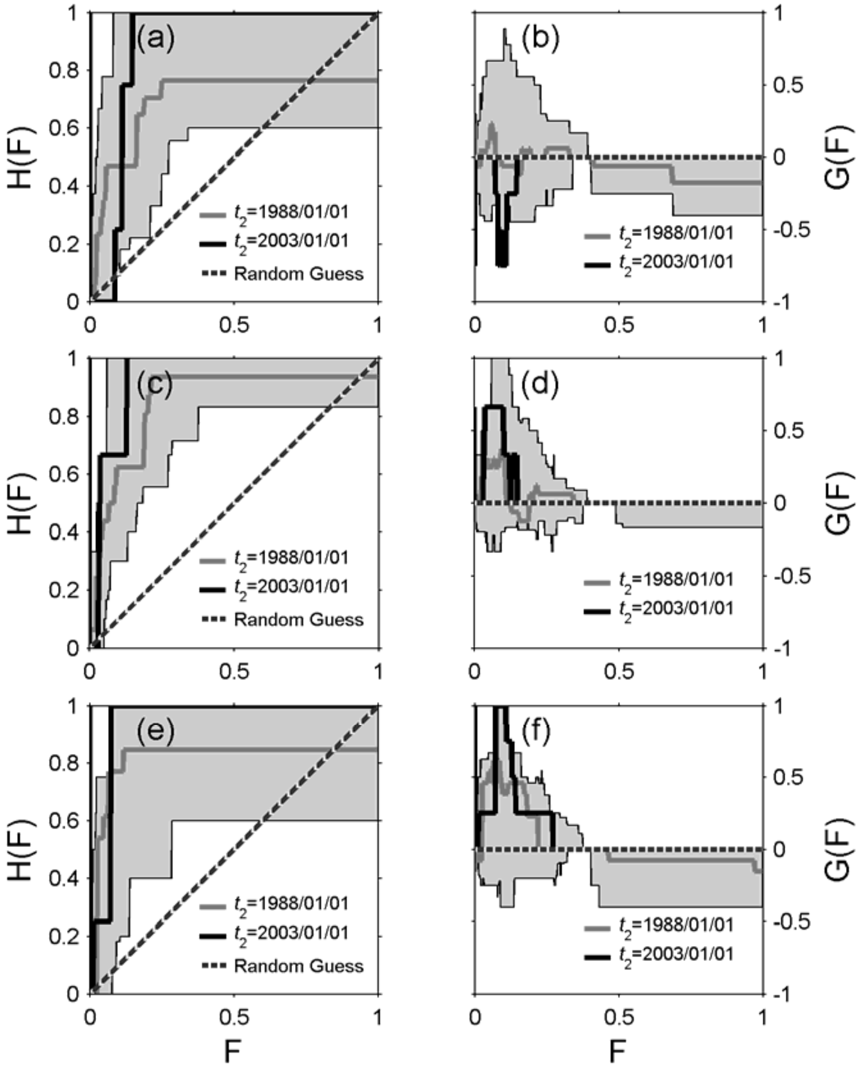
- ROC test for Sichuan-Yunnan region: period of 01/01/1992~01/01/1997. Thick solid line represents the ROC result for the PI forecast, thin solid line the ROC result for the RI forecast, and black broken line the result for random forecast.
- gray broken line shows the difference between the 'hit rate' of PI algorithm and that of RI algorithm.



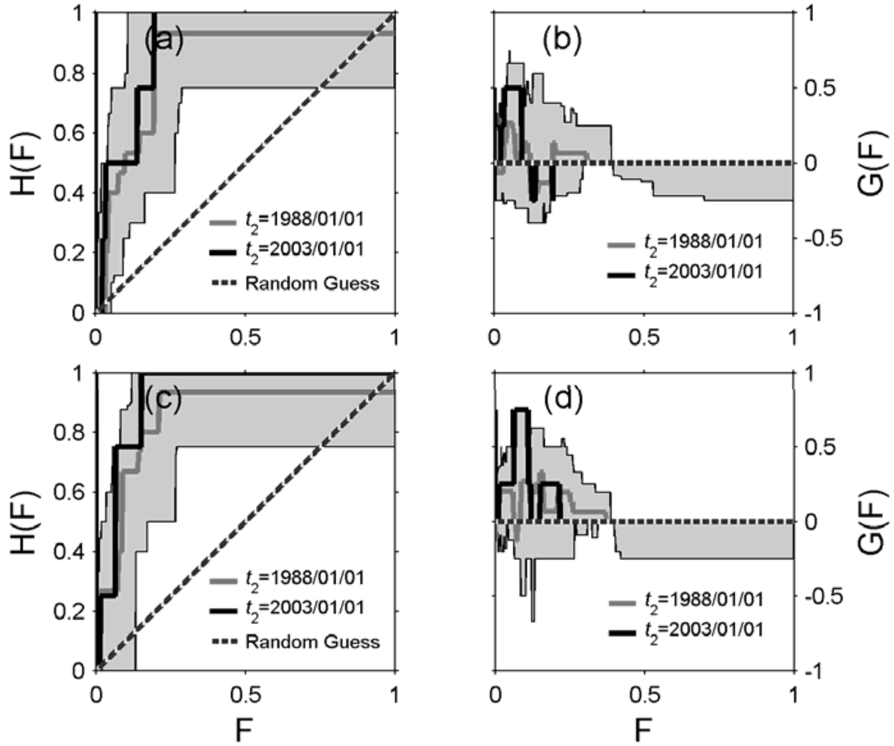
- **ROC test of PI algorithm for different time window. 'Anomaly training window' and 'forecast window' are taken as 5 years. The sliding window is taken as 15 years. 'Forecast window' slides from t_2 = 01/01/1988 to t_2 = 01/01/2003, with sliding step being 0.5 year.**

- **(a) ROC curve for PI forecasts. Gray zone delimitates the range of all the ROC curves, with gray line and black line representing the results of the first and the last sliding, respectively.**

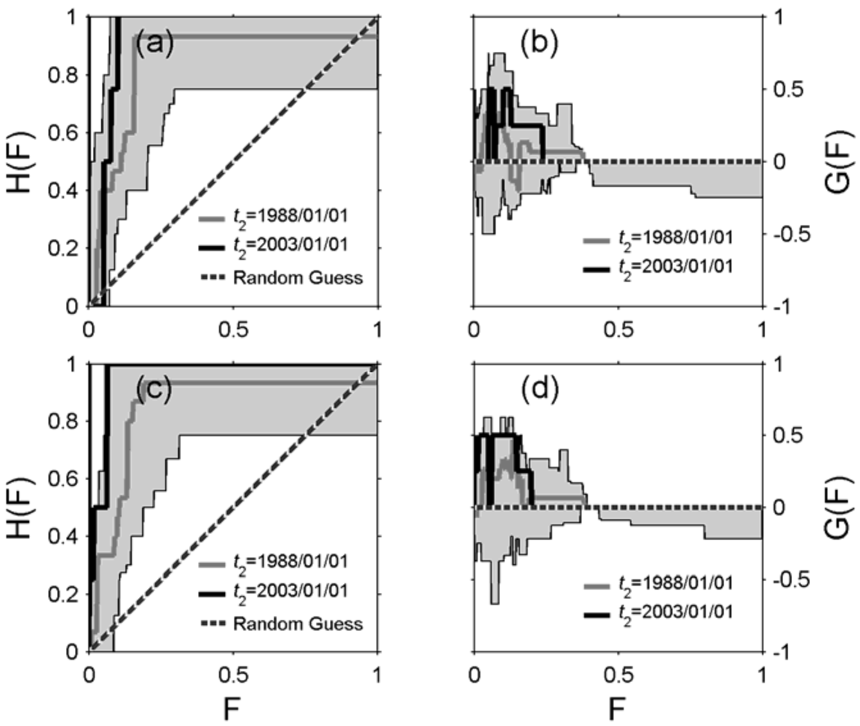
- **(b) PI forecast versus RI forecast – difference between the hit rate of PI algorithm and RI algorithm changing with false alarm rate. Gray zone delimitates the range of all the curves, with gray line and black line representing the results of the first and the last sliding, respectively.**



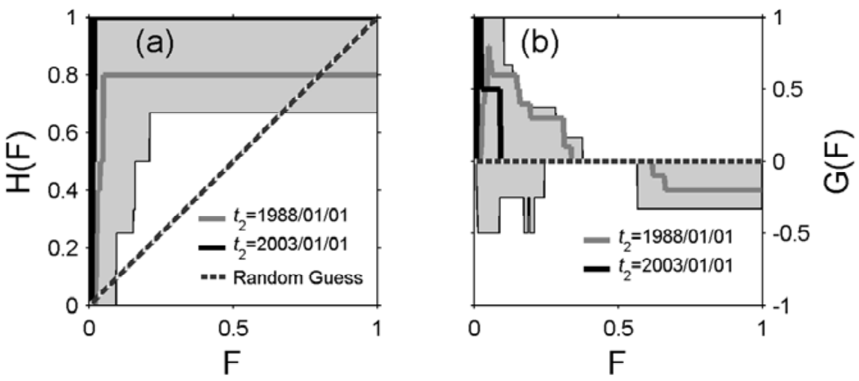
- **ROC test for the forecasts using different grid sizes.**
- **(a-b): grid size 0.10º; (c-d): grid size 0.15º; (e-f): grid size 0.25º.**



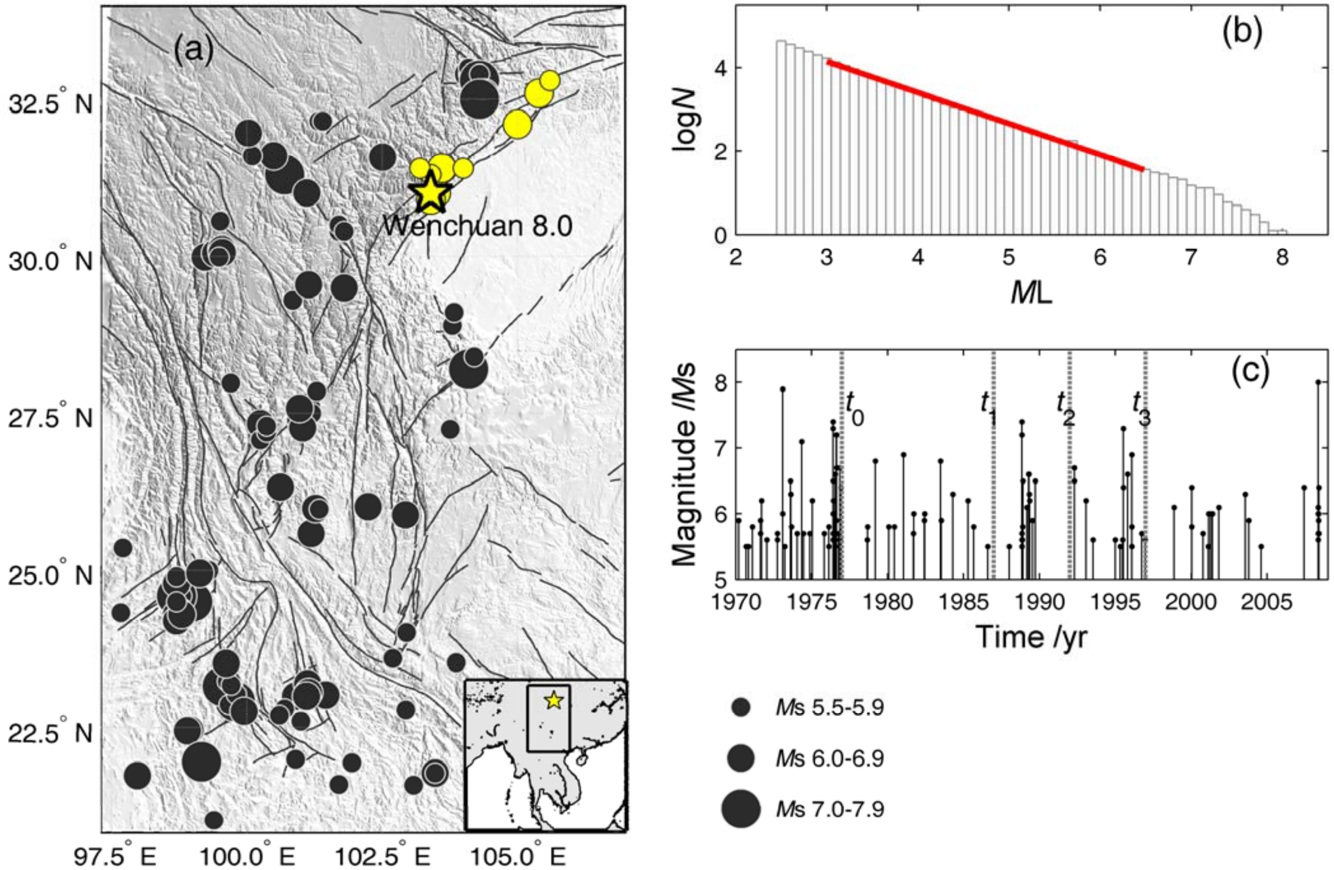
- **ROC test for forecasts using different lengths of earthquake catalogues.**
- **(a-b): earthquake catalogue for 13 years; (c-d): earthquake catalogue for 17 years.**



- **ROC test for different cutoff magnitudes of earthquake catalogues in use.**
- **(a-b): cutoff magnitude M_L3.2; (c-d): cutoff magnitude M_L3.4.**

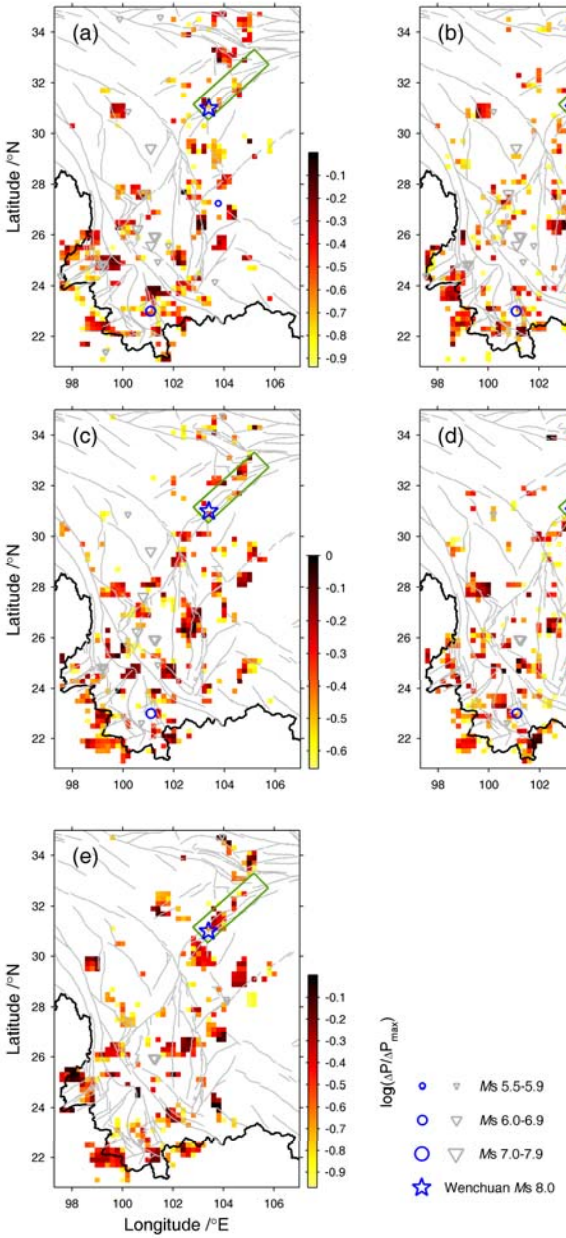


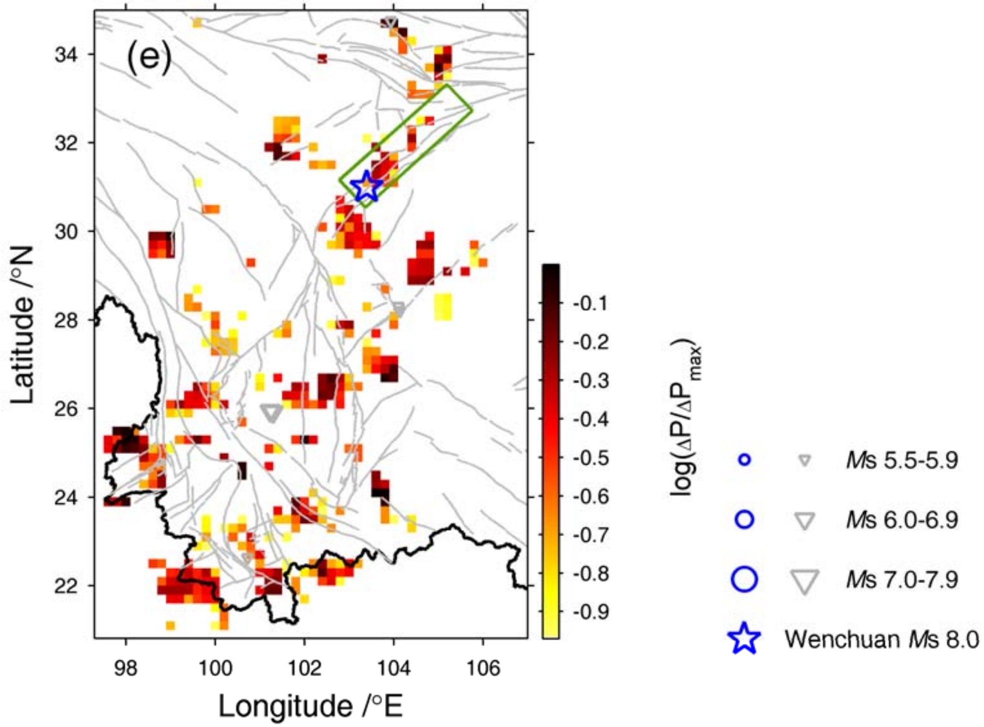
- **ROC test for another target earthquakes magnitude: for earthquakes above M_S6.0, with grid size D = 0.30º.**

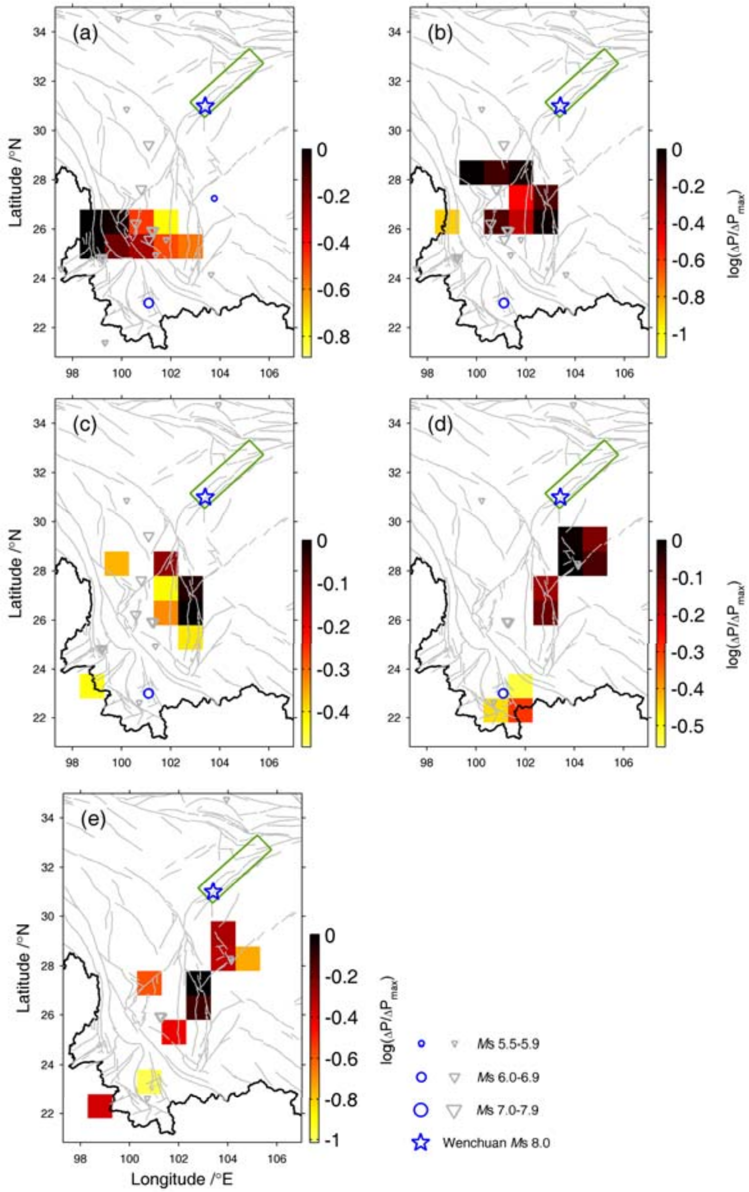


(a) earthquakes larger than M_S5.5 since 1970 in Sichuan-Yunnan region, with tectonic faults shown by gray lines. Yellow star and yellow dots indicate the epicenters of the Wenchuan mainshock and its aftershocks. (b) frequency-magnitude distribution showing the selection of the magnitude of completeness. (c) temporal distribution.

hotspot maps of PI algorithm for different 'forecasting time windows'. (a) t_2=01/01/2004;. (b) t_2=01/01/2005; (c) t_2=01/01/2006; (d) t_2=01/01/2007; (e) t_2=01/01/2007. 'Forecast time window' t_3–t_2 = 5 years. Green thin lines delimitate the northern segment of the Longmenshan fault which accommodated the Wenchuan earthquake. Star shows the epicenter (or, nucleation point) of the great earthquake.

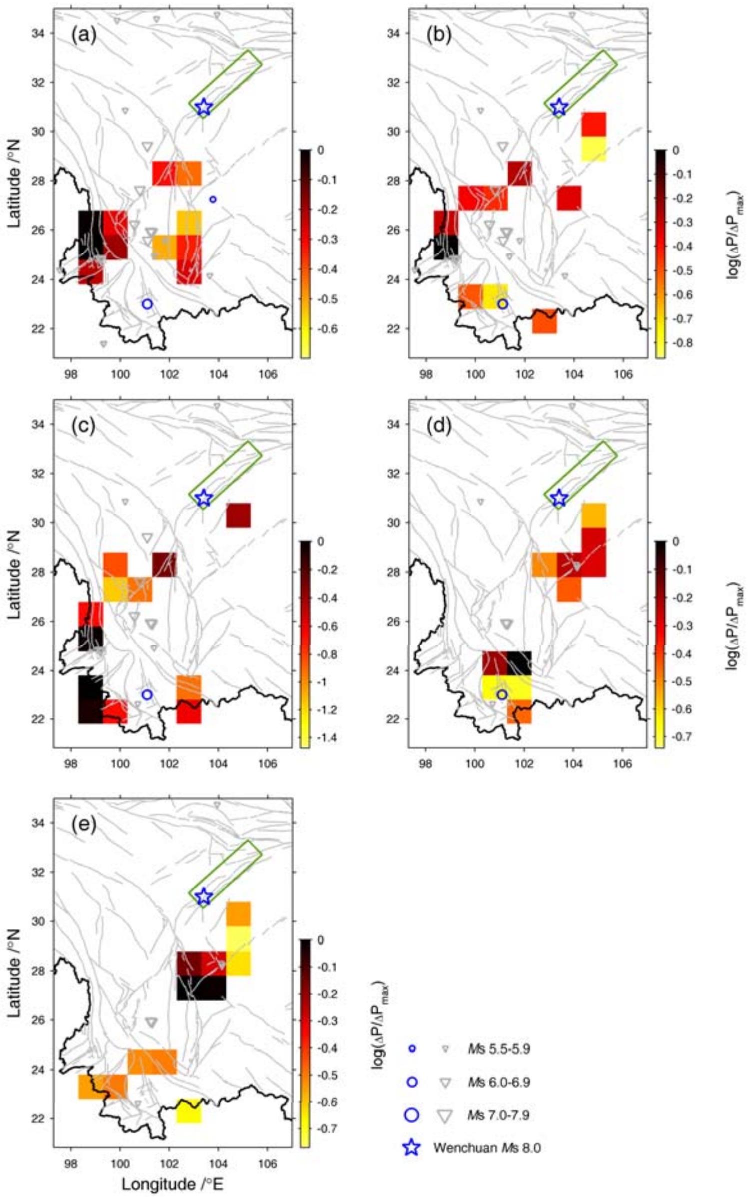






increasing the grid size?

hotspot maps of PI algorithm for different 'forecasting time windows' with grid size 1.0º and cutoff magnitude M_L3.0. (a) t_2=01/01/2004;. (b) t_2=01/01/2005; (c) t_2=01/01/2006; (d) t_2=01/01/2007; (e) t_2=01/01/2007. 'Forecast time window' t_3–t_2 = 5 years.



increasing cutoff magnitude?

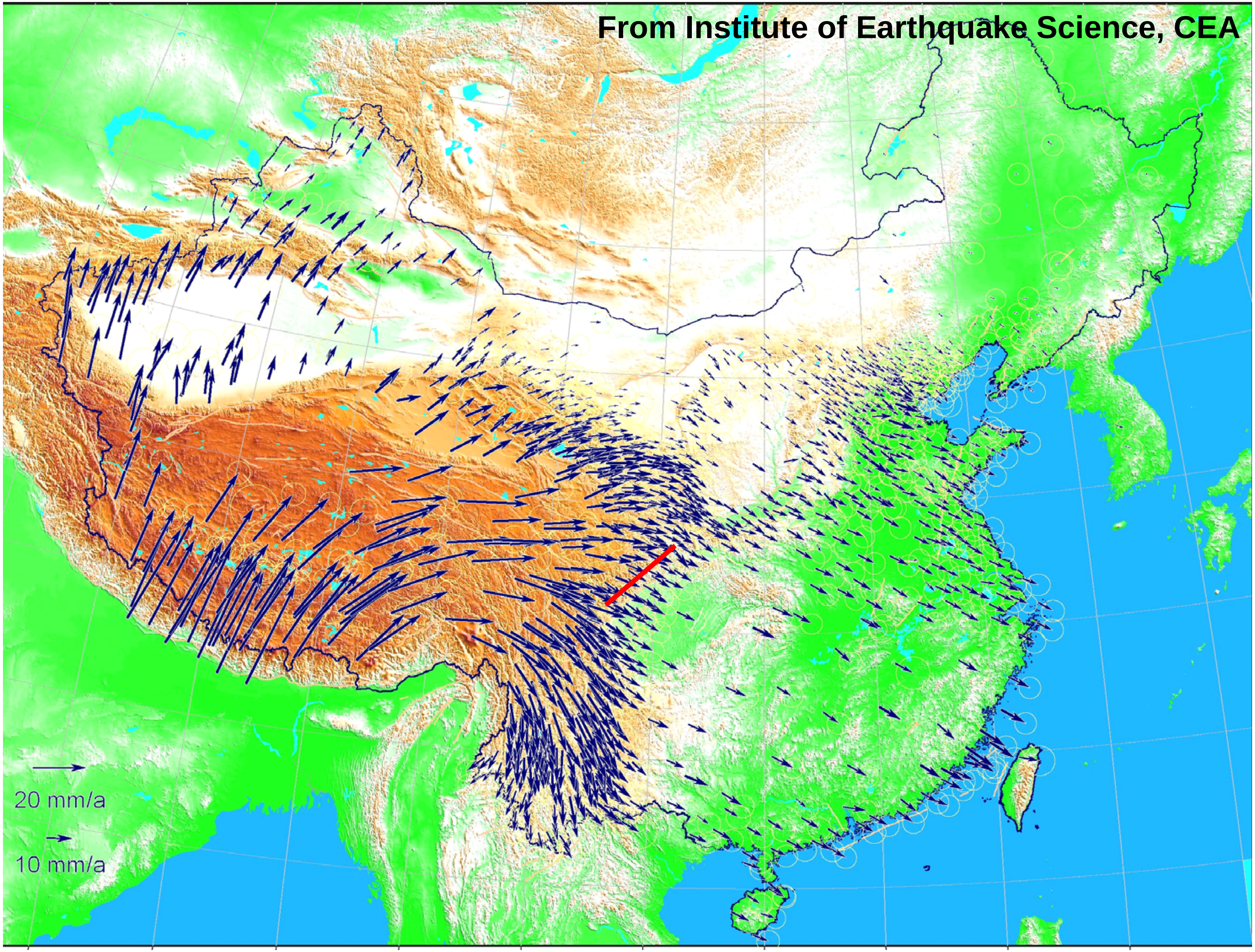
hotspot maps of PI algorithm for different ‘forecasting time windows’ with grid size 1.0º and cutoff magnitude M_L4.0. (a) t_2=01/01/2004;. (b) t_2=01/01/2005; (c) t_2=01/01/2006; (d) t_2=01/01/2007; (e) t_2=01/01/2007. ‘Forecast time window’ t_3–t_2 = 5 years.

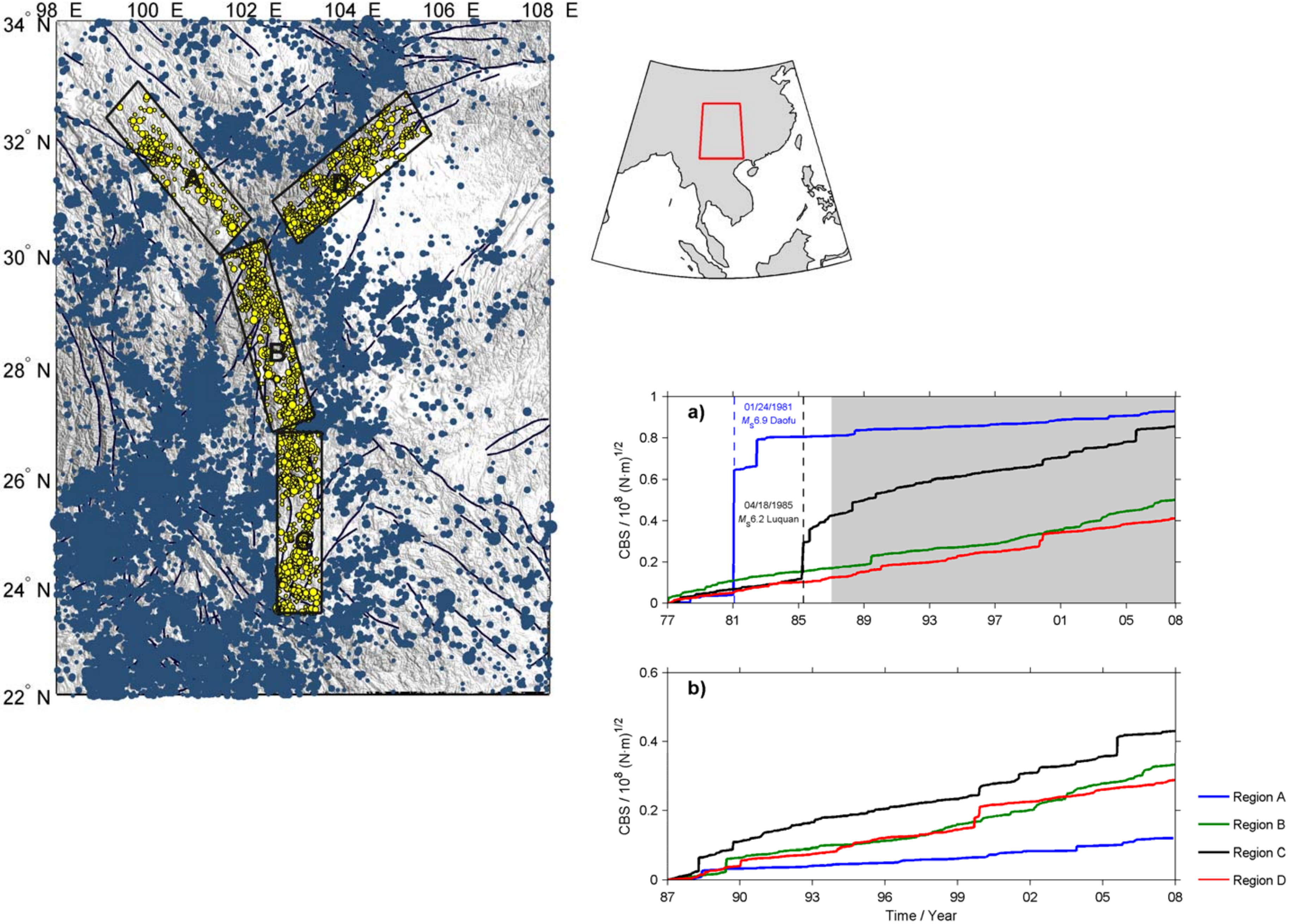
what is the nature of the roles of local seismic data ?

information provided as an input of the algorithm/s

local seismic data seems much more useful than we thought

also related to Wenchuan there are still some puzzles to be solved

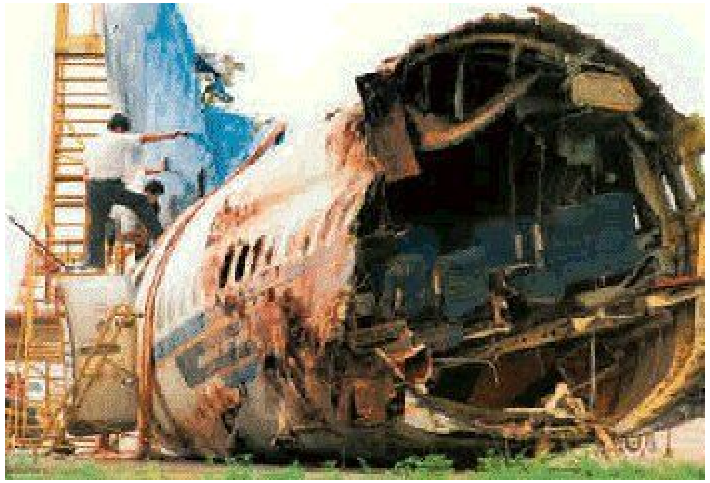

From Institute of Earthquake Science, CEA
20 mm/a
10 mm/a


98 E
100 E
102 E
104 E
106 E
108 E
34° N
32° N
30° N
28° N
26° N
24° N
22° N
A
B
C
D
a)
01/24/1981
Ms6.9 Daofu
04/18/1985
Ms6.2 Luquan
CBS / 10^8 (N·m)^1/2
77
81
85
89
93
97
01
05
08
b)
87
90
93
96
99
02
05
08
Time / Year
Region A
Region B
Region C
Region D

at last
serving the society within the present limit of scientific capability

be prepared so as to avoid the next Wenchuan disaster

- **values of retrospective case studies: limited, but uniquely useful**



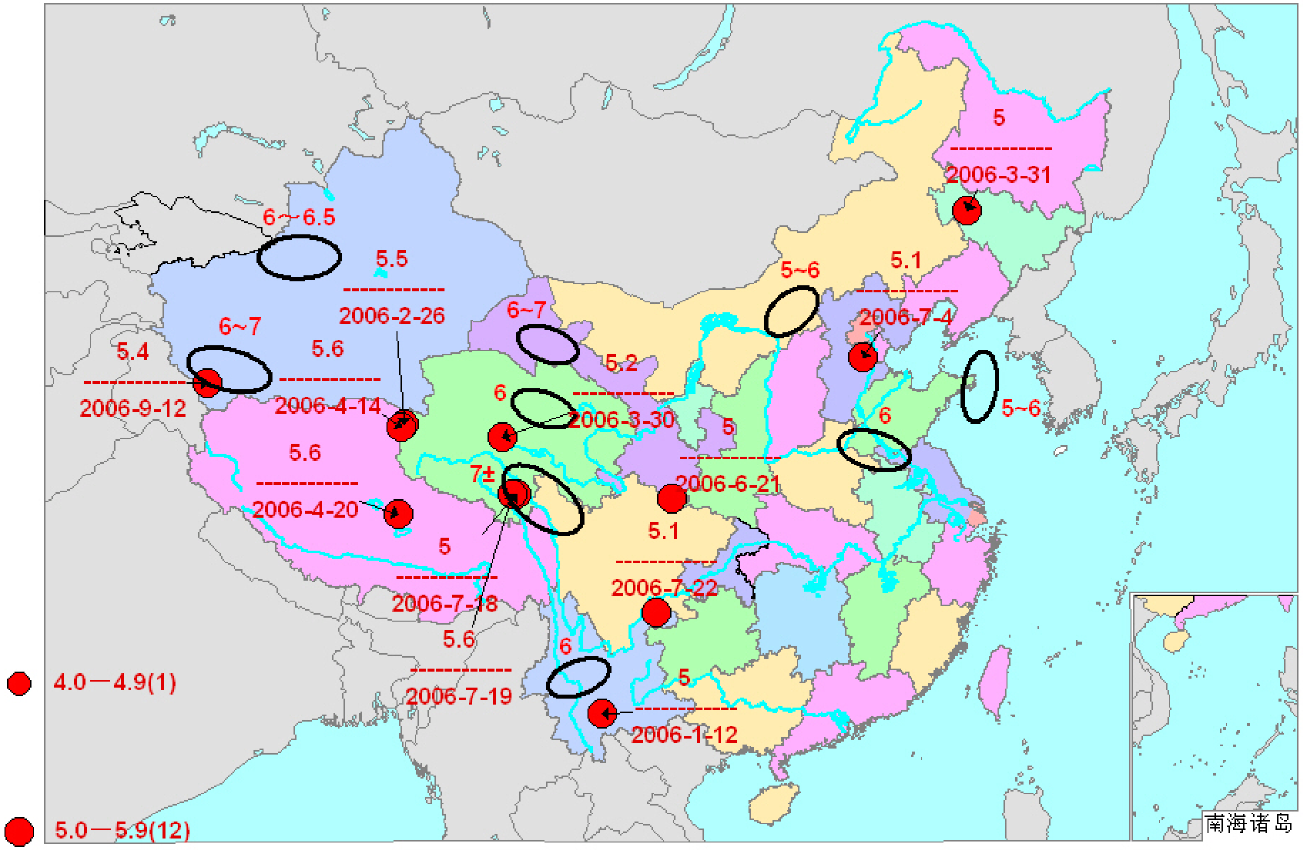
earthquake forecast/prediction or seismic hazard assessment products in China

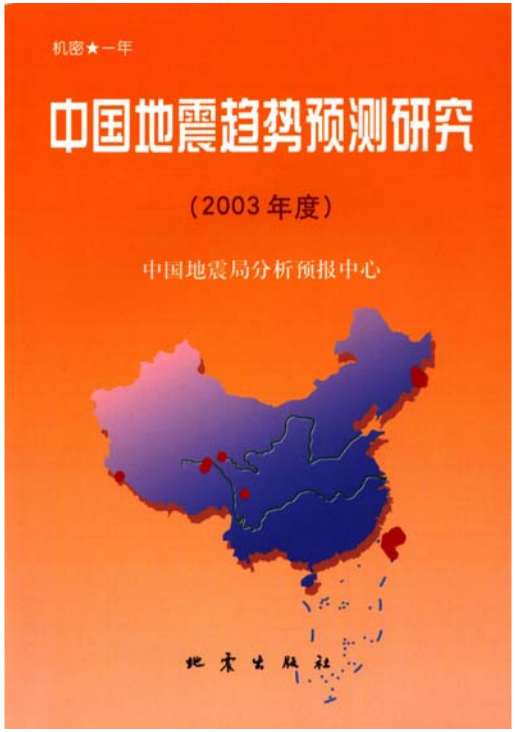
- zonation map (intensity and/or strong ground motion parameters, probability of exceedance 10% for 50 years)
- long-term (10~15 years) key-regions with higher probability of earthquakes and key-regions with higher needs for preparedness
- three year estimation of earthquake probabilities
- annual earthquake probabilities (the Annual Consultation on the Likelihood of Earthquakes)

- evaluation of short-term precursors/anomalies and predictions
- earthquake alarm – hardly to be successful as that of Haicheng
- evaluation of aftershock/swarm tendencies

- a wide spectra of products serving the public within the present limit of seismology

annual forecast for 2006 by IGP, CEA





H=2 F=7 M=6

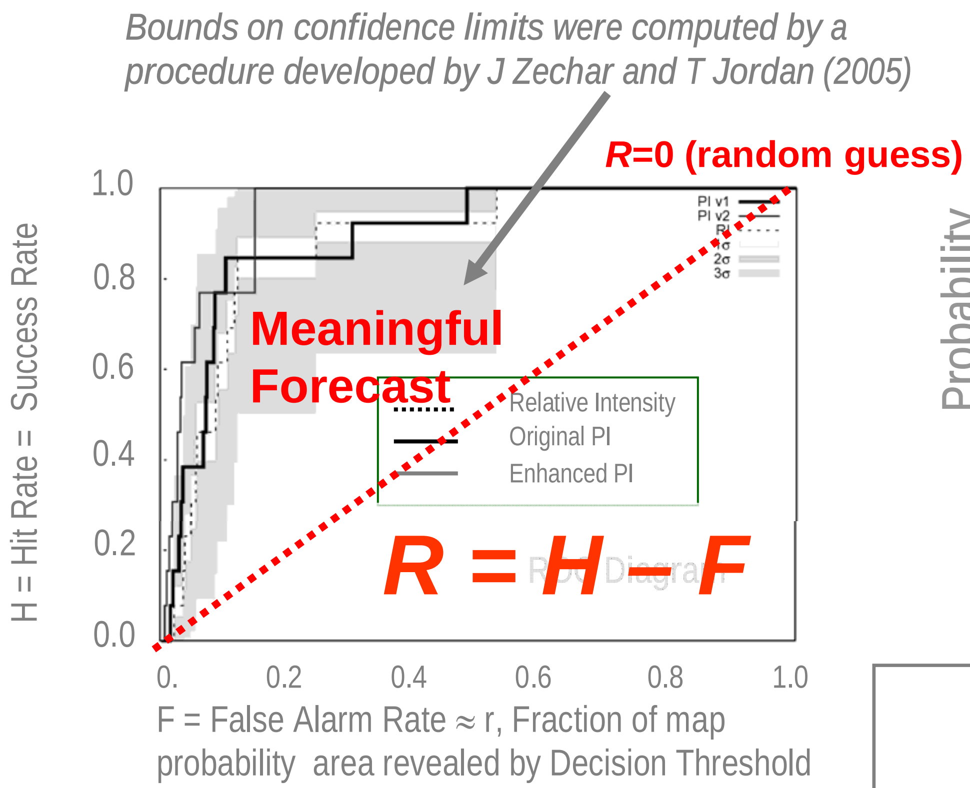
simplified evaluation score of the performance of forecast used in China – *R* value

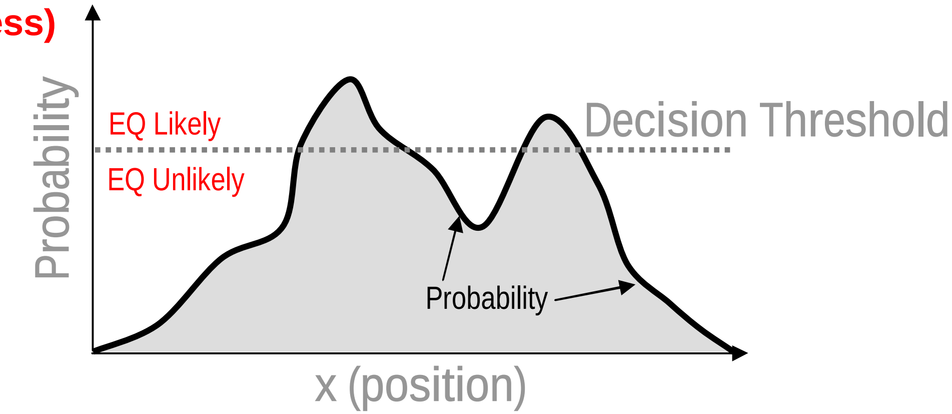
- $R = N_S/N_E - S_F/S_A$
- (hit rate) – (false alarm rate)

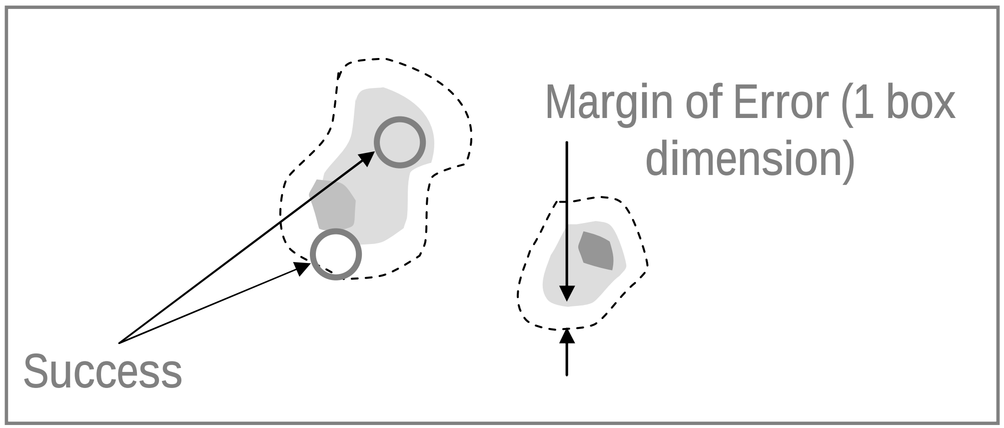
- N_S = successful predictions
- N_E = total number of earthquakes
- S_F = false alarm area
- S_A = total aseismic area

- When all the predictions are successful, $R = 1$
- When all the predictions are wrong, $R = –1$
- For random prediction, $R = 0$

Receiver (Relative) Operating Characteristic (ROC) Diagrams







Courtesy of Prof. J. Rundle

3. 2007 年度地震重点危险区的预测较好

2007 年地震趋势会商会共确定 7 个地震重点危险区（图 3.1），2007 年我国大陆共发生 5 级以上地震 6 次，其中在我国大陆监测能力低的地区以外共发生 3 次 5 级以上地震，这 3 次地震中有 2 个落在危险区内。

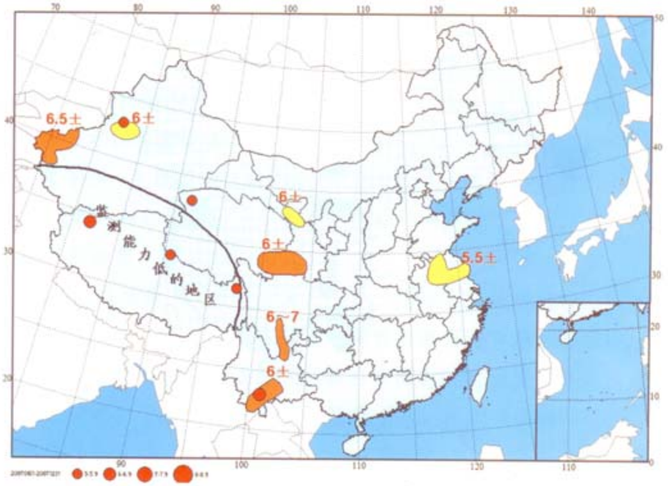


图 3.1 2007 年度危险区范围及对应地震情况

表 3-2 2007 年度中期预测效果检验

预测危险区			实发地震			
序号	地区	震级	三要素	正确	不正确	备注
1	苏鲁皖交界至南黄海	5~6	时 空 强		● ● ●	
2	祁连山中东段	6±	时 空 强		● ● ●	
3	甘青川交界	6±	时 空 强		● ● ●	
4	川滇交界东部地区	6~7	时 空 强		● ● ●	
5	滇西南至滇南地区	6±	时 空 强	● ● ●		
6	南天山中东段	6±	时 空 强	● ● ●		
7	新疆乌恰至塔什库尔干	6.5±	时 空 强		● ● ●	

采用 R 值评分方法对上述预测效果进行检验（图 3.2），2007 年的 R 值为 0.594。

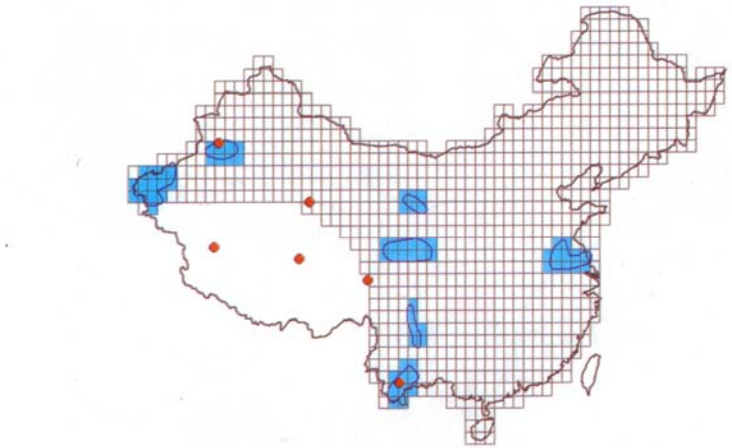
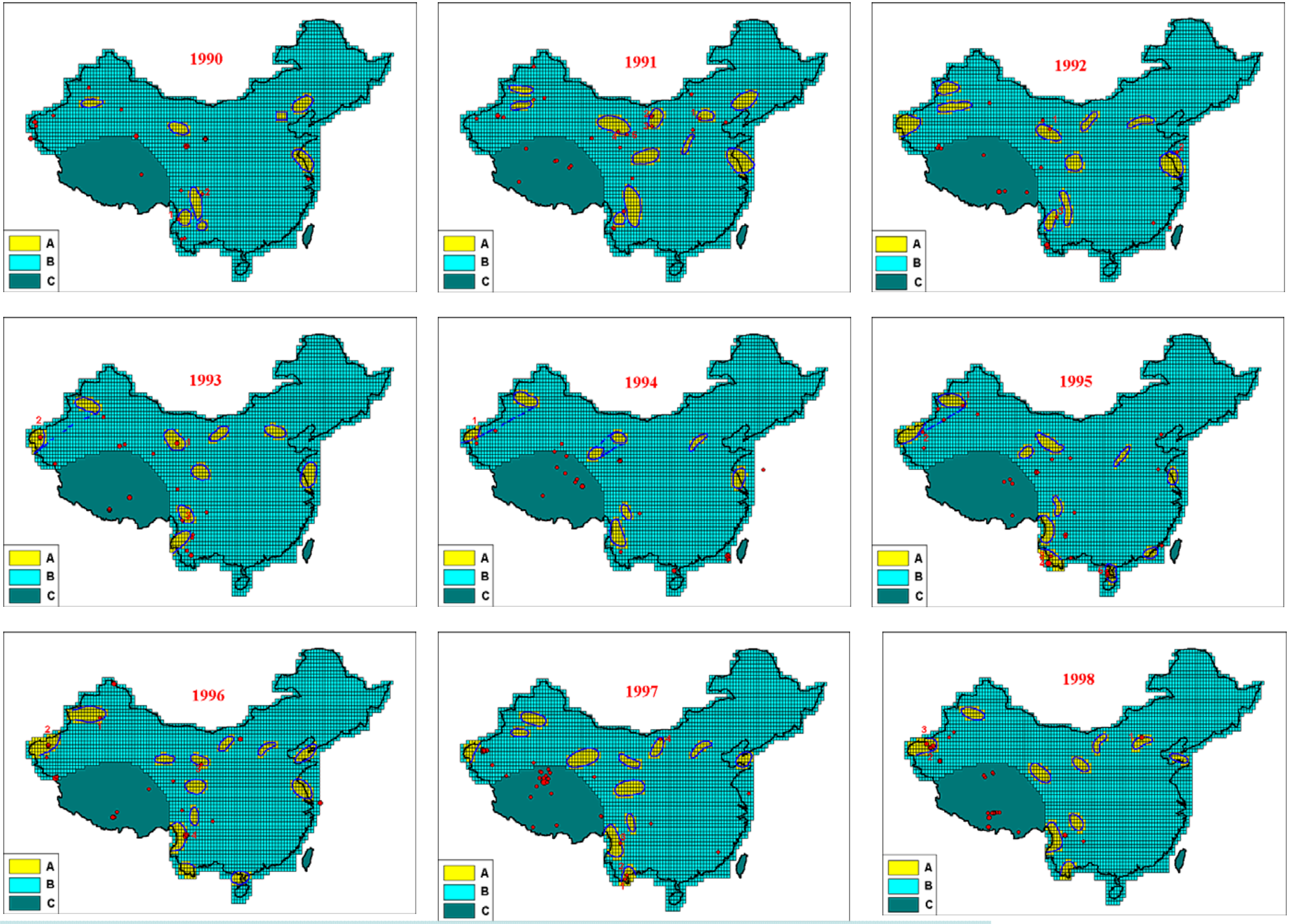


图 3.2 2007 年度危险区 *R* 值评分检验



R value from 1990 to 1998 is 0.18 on average significantly larger than 0 (for random guess)
but … the forecast is to much extent based on the knowledge of seismicity

From Shi, Y. L., et al. (2000)

capabilities of earthquake forecast or time-dependent seismic hazard assessment

——long term and intermediate-term forecast

significantly outperforming random guess

potentially useful for earthquake preparedness

no plans yet for the *Zhongdian Jianshi-Fangyu Qu*

(the *key region for enhanced monitoring and preparedness*)

——annual consultation

real forward forecast test

successful cases for several M~6 earthquakes

mechanism of gathering information problematic

——short-term forecast

hit rate 40% for M~6 earthquakes

‘new parameter earthquake catalogues’ may be interesting

problematic for M~5 earthquakes

very few experiences for M~7 earthquakes

——evaluation and test

R-value and evaluation committee

lack of public understandings

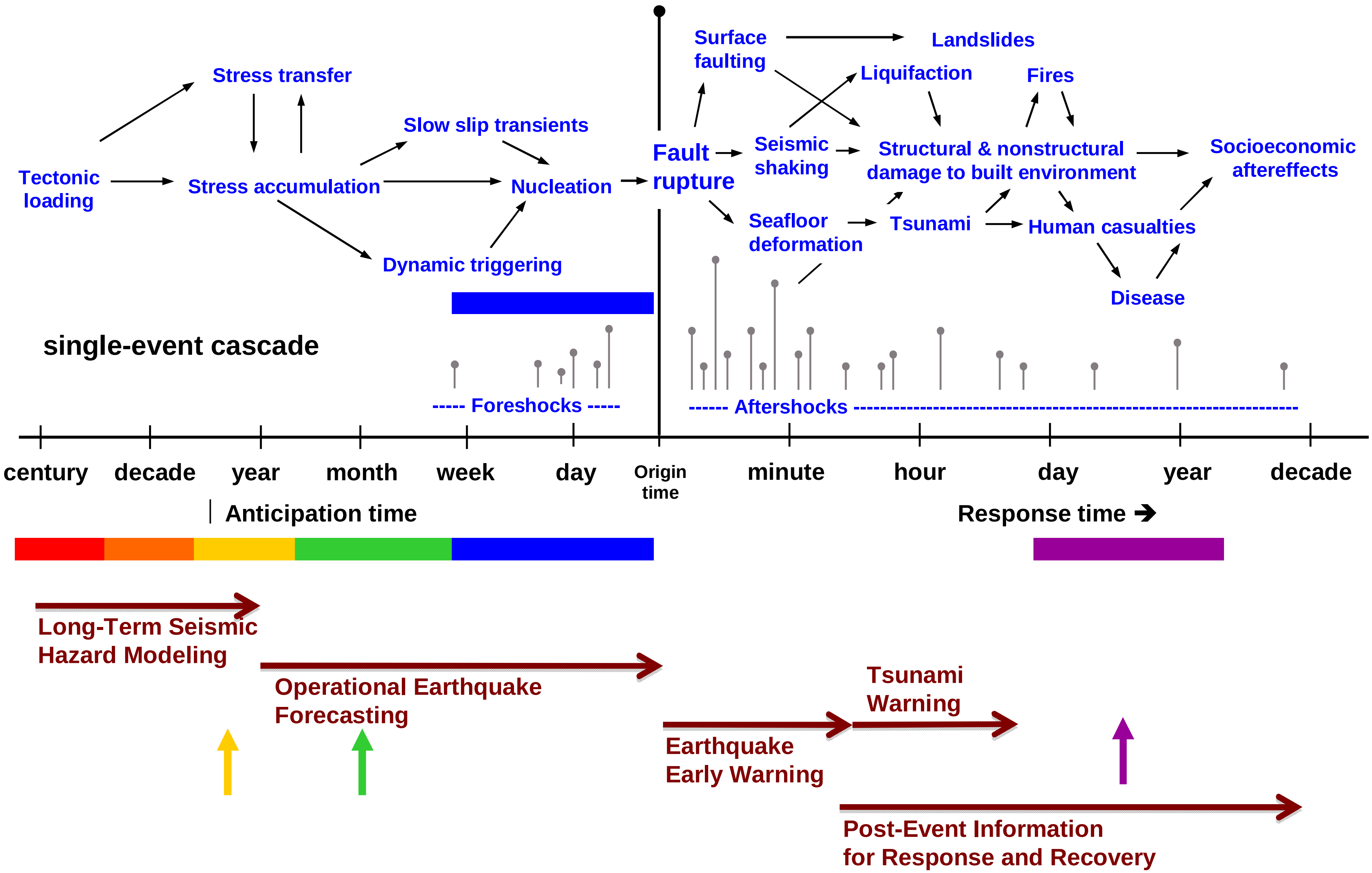
what are needed

firstly, doing the best for deepening the understandings of earthquake predictability

at the time scales of century, year, and even months

secondly, making full use of the present knowledge of earthquake predictability for the preparedness of seismic risk

T. Jordan: tracking earthquake cascades



a few words about strong aftershocks

what can we do to serve the public

aftershocks: what we have known

- Gutenberg-Richter's law: log $N = a - b\,M$
- Omori's law: $N\,(t) \sim (\,t + t_0\,)^{-p}$
- Båth's law: $M_{\text{mainshock}} - M_{\text{strongest aftershock}} \approx 1.2$
- Coulomb's law: for most of aftershocks $\Delta CFS > 0$

QUESTIONS ADDRESSED about the strong aftershocks:

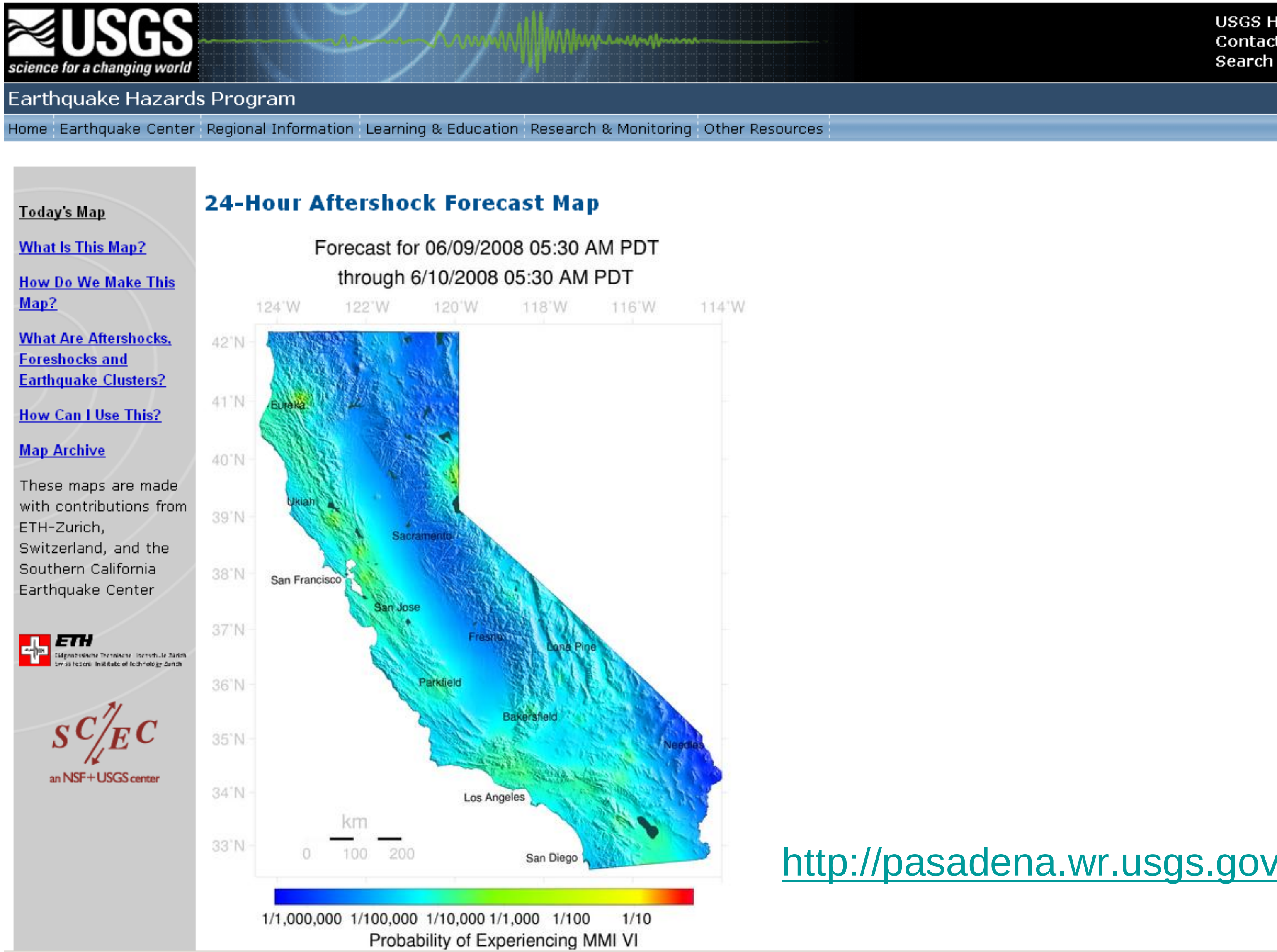
Time – how long
Place – where
Size – how big is the maximum
Rate – how many

The Abdus Salam International Centre for Theoretical Physics

Large eq.

	Mainshocks	Aftershocks
dir. of organization	? →	←
triggering	plate tectonics	single (large?) eq.
faulting	activity on many faults	assoc. with single fault
stress	tectonic stress rate > relaxation rate	relaxation rate > tectonic rate
eq. rate	steady state (?) or increasing	rapid decay
spatial distrib.	diffuse	clustered (localized)

lecture notes of Prof. Leon Knopoff showing the present understanding of aftershocks



http://pasadena.wr.usgs.gov/step/

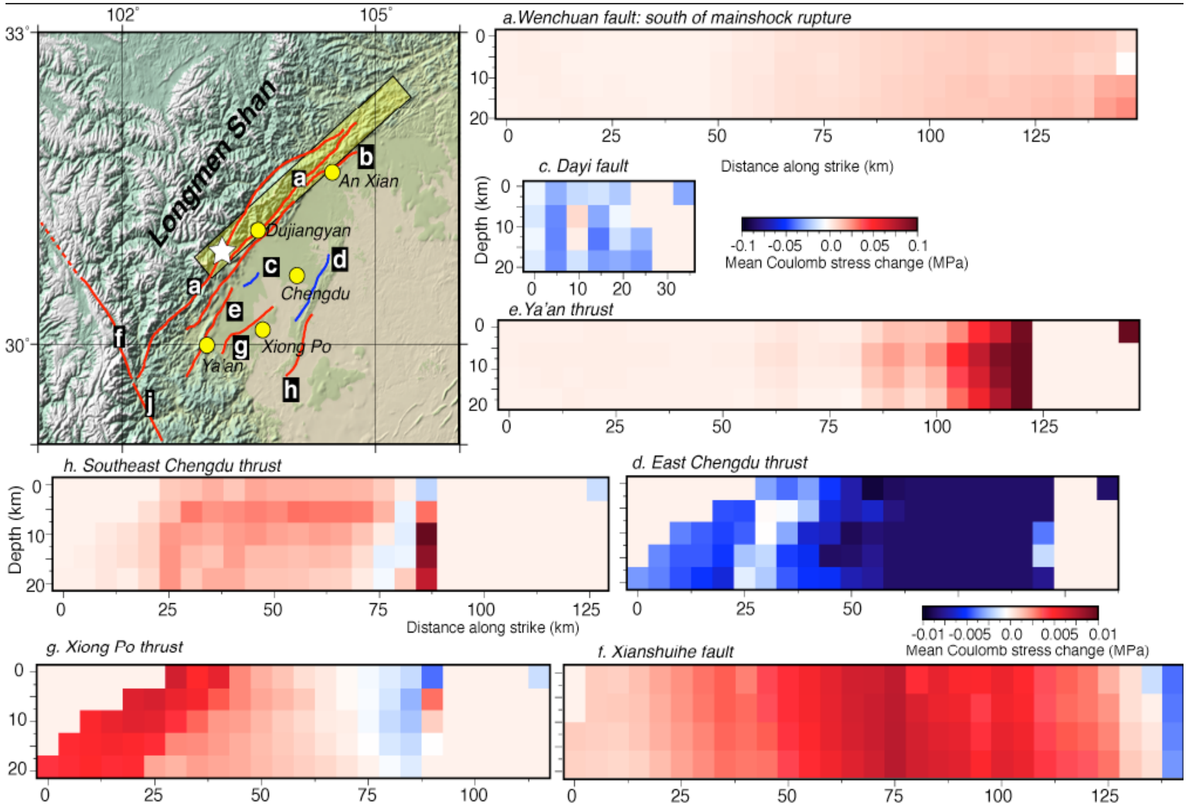
the USGS Aftershock Forecast Map project

forecast by Jiancang Zhuang (Japan)
based on ETAS model

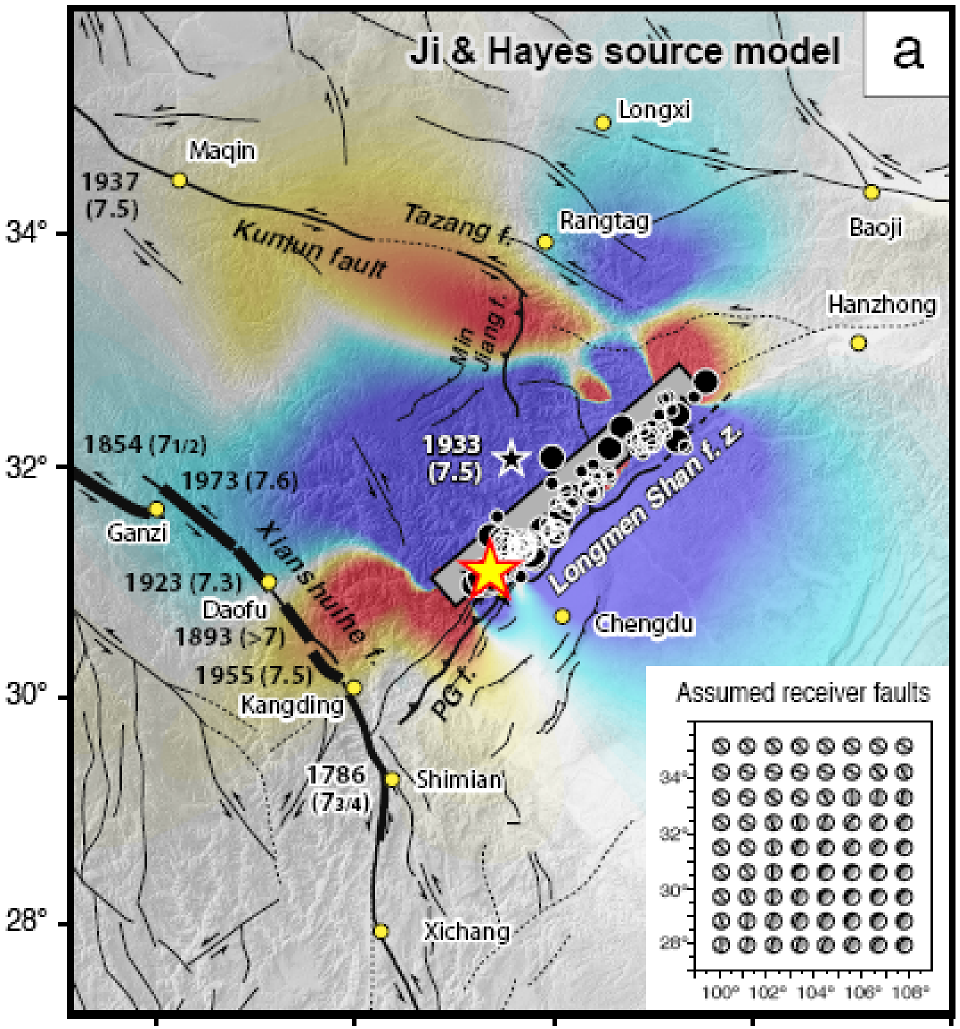
- Here are the probability forcasts for the 18th day after the mainshock

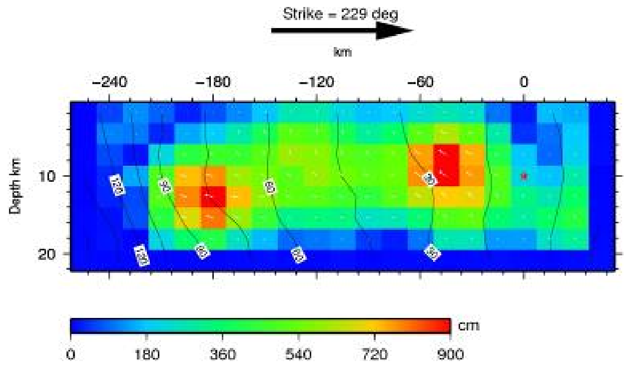
	Expected #	Prob.	Waiting time	quantile (1%	5%	50%	95%	99%)
M>=4.0	2.17	0.89	0.44	0.004	0.022	0.298	1.296	1.934
M>=4.5	1.03	0.64	0.89	0.010	0.048	0.605	2.655	4.061
M>=5.0	0.36	0.30	2.40	0.024	0.125	1.677	7.472	11.92
M>=5.5	0.12	0.11	6.53	0.058	0.339	4.306	20.08	32.89
M>=6.0	0.07	0.07	10.01	0.087	0.460	6.466	31.15	49.15

stress changes from the 12 May, 2008 *M*=7.9 earthquake calculated for major faults beneath the Sichuan basin, China
by Tom Parsons and Chen Ji

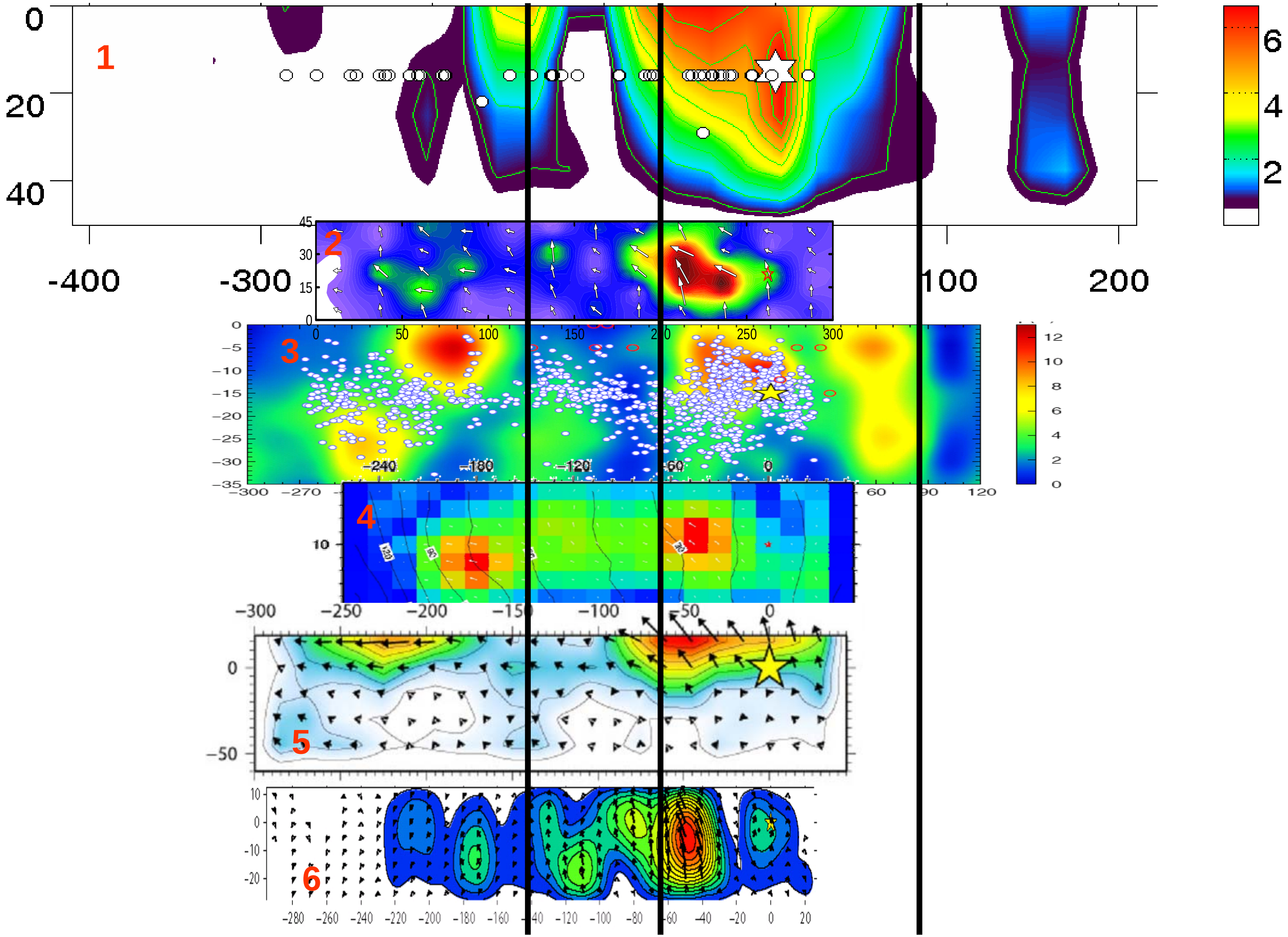


Wenchuan earthquake promotes failure on major strike-slip faults, by Shinji Toda, Jian Lin, Mustapha Meghraoui, and Ross S. Stein





from Department for Monitoring and Prediction, CEA



summary

firstly
a few words about China and about the 2008 Wenchuan earthquake

what did we see before the earthquake

summary

secondly
monitoring and modeling for forecast/prediction/preparedness

what could be learnt from Wenchuan

summary

thirdly
why some of the worldwide-valid algorithm failed to indicate the approaching of the Wenchuan earthquake

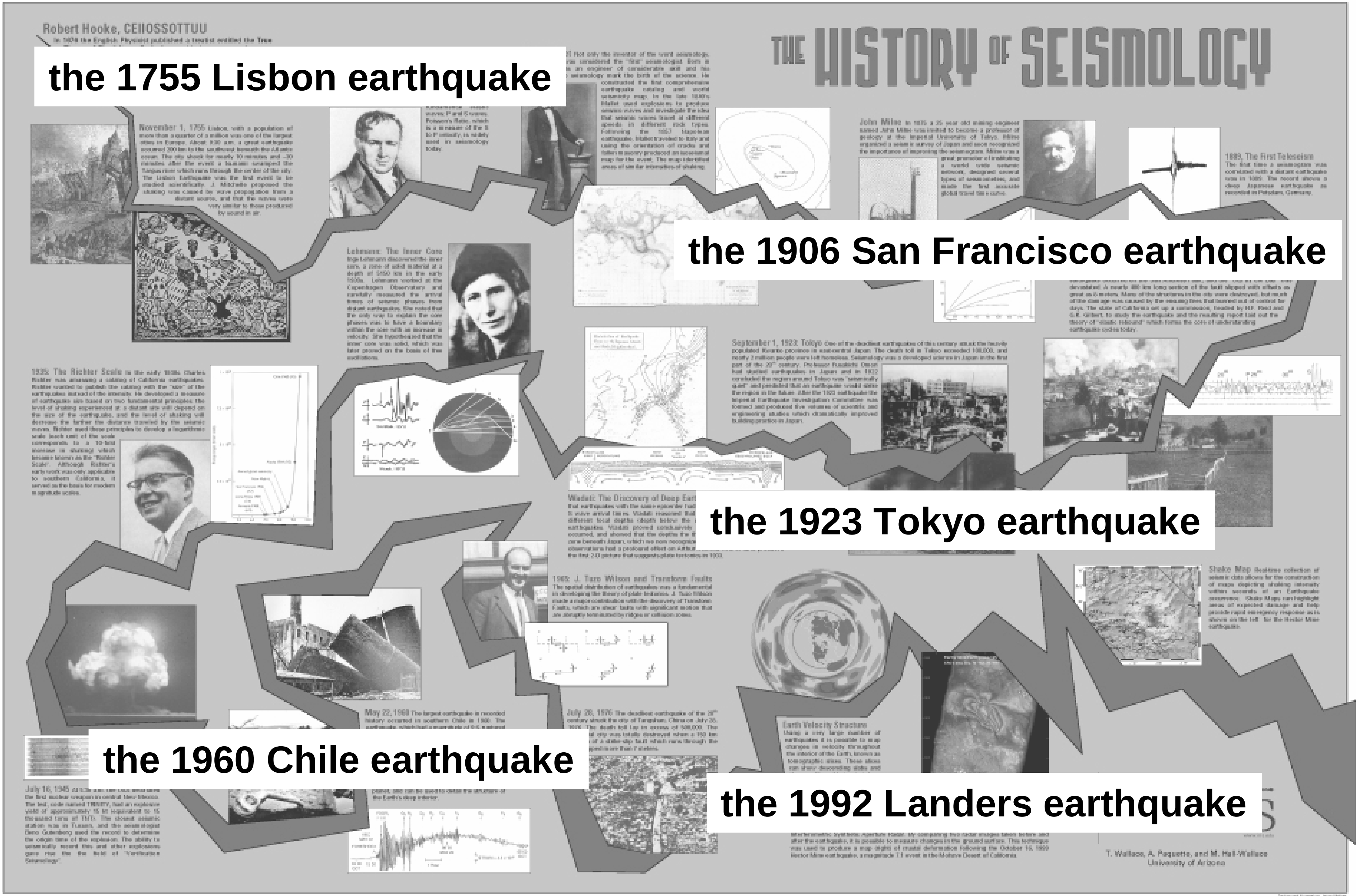
importance of the consideration
of local situations

summary

at last
serving the society within the present limit of scientific capability

be prepared so as to avoid the next Wenchuan disaster

earthquakes provided valuable lessons



thank you

wuzhl@gucas.ac.cn
wuzl@cea-igp.ac.cn

appendix: related publications of the lecturer – just for your reference

- **Wu, Z. L., Liu, J., Zhu, C. Z., Jiang, C. S. and Huang, F. Q., 2007. Annual consultation on the likelihood of earthquakes in continental China: Its scientific and practical merits. *Earthquake Research in China*, 21: 365~371.**
- **Jiang, C. S. and Wu, Z. L., 2008. Retrospective forecasting test of a statistical physics model for earthquakes in Sichuan-Yunnan region. *Science in China, Series D: Earth Sciences*, 51: 1401~1410.**
- **Zhao, Y. Z. and Wu, Z. L., 2008. Mapping the *b*-values along the Longmenshan fault zone before and after the 12 May 2008, Wenchuan, China, *M*S8.0 earthquake. *Nat. Hazards Earth Syst. Sci*., 8: 1375~1385.**
- **Jiang, C. S. and Wu, Z. L., 2009. Seismic moment release before the May 12, 2008, Wenchuan earthquake in Sichuan of southwest China. *Concurrency Computat.: Pract. Exper.*, Wiley InterScience (www.interscience.wiley.com), DOI: 10.1002/cpe.1522.**
- **Zhao, Y. Z., Wu, Z. L., Jiang, C. S. and Zhu, C. Z., 2010. Reverse tracing of precursors applied to the annual earthquake forecast: Retrospective test of the Annual Consultation in the Sichuan-Yunnan Region of southwest China. *PAGEOPH*, 167: DOI 10.1007/s00024-010-0077-1.**
- **Jiang, C. S. and Wu, Z. L., 2010. PI Forecast for the Sichuan-Yunnan region: Retrospective test after the May 12, 2008, Wenchuan earthquake. *PAGEOPH*, 167: DOI 10.1007/s00024-010-0070-8.**
- **Zhao, Y. Z., Wu, Z. L., Jiang, C. S. and Zhu, C. Z., 2010. Is the deformation rate of the Longmenshan fault zone really small? Insight from seismic data at the two-decade time scale. *Earth, Planets and Space*, 62: in press.**

Earthquake Prediction Experiment Site: Design, Performance Evaluation, and Implementation

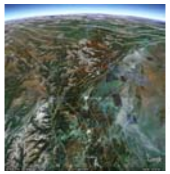
Working Group NEPTUNE, China Earthquake Administration, 100036 Beijing, China

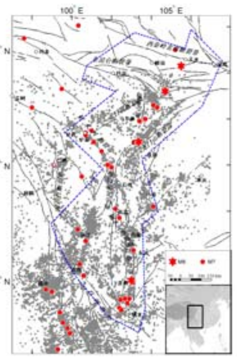
Presented at the International Symposium on Earthquake Seismology and Earthquake Predictability, July 5-9, 2009, Beijing

Introduction

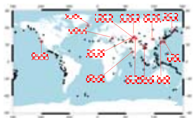
Since the beginning of 2009, the Department for Earthquake Monitoring and Prediction of China Earthquake Administration (CEA) has been organizing the planning of the Earthquake Prediction Experiment Site in the southern part of the Central North-South Seismic Zone. Working Group 'National Earthquake Prediction Test-site with Unified Networking and Experiment' (Working Group NEPTUNE) has been working on this planning. This presentation briefly introduces the planning works and *the strategies for the planning.*

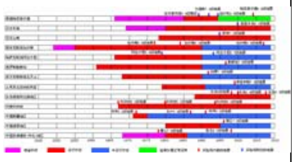
Location of the experiment site, its tectonics, and seismic activity



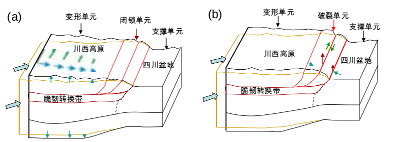


Historical background of earthquake prediction experiment site: what are their experiences, and what are their lessons?

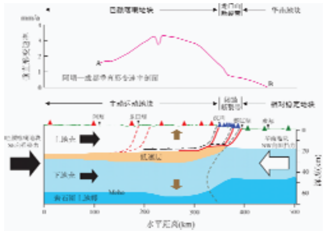




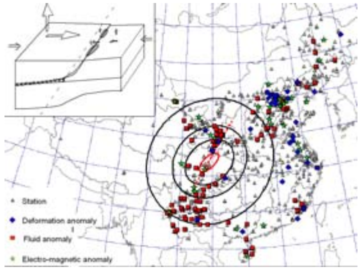
Lessons of Wenchuan



A model of earthquake preparation (left: inter-seismic, right: co-seismic, Zhang et al., 2009)



'Expected anomalies' (triangles are scenario observation stations. red: long- to intermediate-term anomalies expected; blue: short-term anomalies expected; green: few anomalies expected)



Precursors observed before the Wenchuan earthquake (Liu et al., 2009) and its relation with the earthquake preparation model

Lesson: the importance of the concept **Modeling and Monitoring for Prediction**

Scenario rupture Expected anomalies

For a certain segment of active fault or block boundary zone which accommodate future earthquakes, a 'scenario rupture' is considered to provide different versions of the earthquake preparation model. Based on the earthquake preparation scenario, detection programs and monitoring systems are designed. The system is to be oriented at the effective constraint of the earthquake preparation model, the effective monitoring of 'expected' anomalies, and the effective test of the forecast/prediction schemes.

Effective constraint
Effective monitoring
Effective testing

Key regions subject to the risk of strong earthquakes (2006-2020) and the distribution of tectonic block boundaries

Scientific problems associated with the earthquake prediction experiment site:

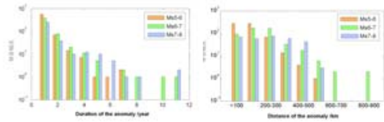
How to deploy monitoring systems for the prediction of a geologically imminent earthquake?

How to test new technologies potentially useful for capturing earthquake precursors?

Playing game with earthquakes

Considering the usefulness and uncertainties of intermediate-term medium-range earthquake forecast, region-specific models of seismic activity and seismo-tectonics are considered in the design of the monitoring and experiment system. That is to ask:

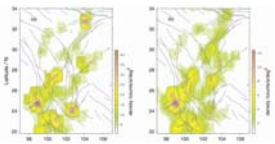
How long should be the observation?
How far away should be the station?



Statistics from earthquake cases in China (Jiang et al., 2009)

How many M>6.5 earthquakes are expected during the experiment?

Earthquake rate: total (Left) & background (Right)



Earthquake prediction experiment site as a big-science device

In the perspective of technology, the experiment site is treated as a 'big-science' device, emphasizing the robustness of the performance of the system with complex multi-layer and multi-component structures, and the sustainable functioning of the system ensuring the effective 'close-in contact' with earthquakes and 'standard testing norms' of predictive models and schemes.