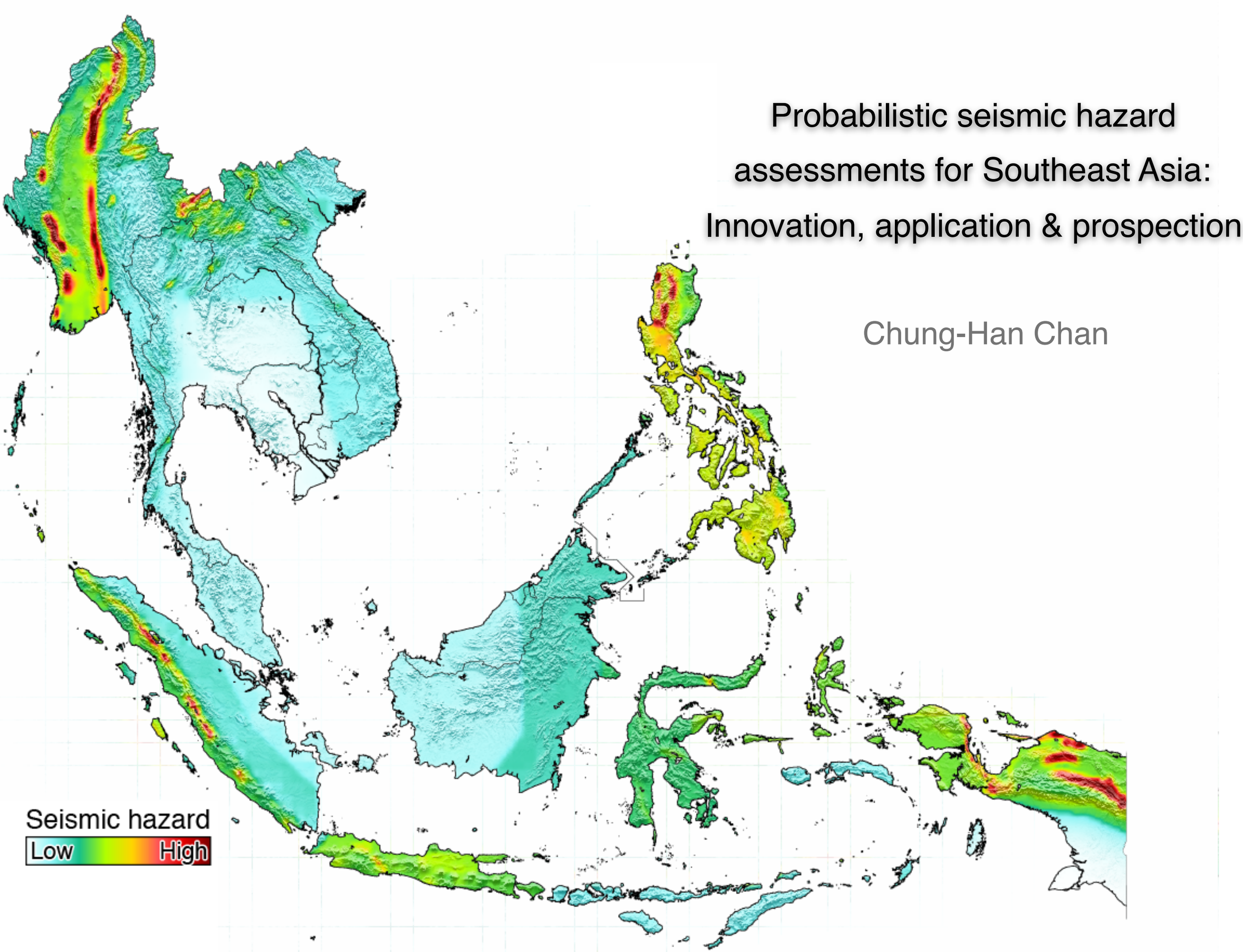
Probabilistic seismic hazard assessments for Southeast Asia: Innovation, application & prospection

Chung-Han Chan



About Chung-Han Chan

- Earthquake relocation as M. Sc. in NCU
- Earthquake activity & stress evolution as PhD in NCU
- Earthquake forecast as Post-doc in GFZ
- PSHA method as Post-doc in NTU (north)
- Risk assessment as Assistant Research Fellow in NTU (north)
- PSHA for SE Asia as Senior Research Fellow in NTU (south)

*PSHA: Probabilistic Seismic Hazard Assessment

Probabilistic seismic hazard assessments for Southeast Asia: Innovation, application & prospection

Chung-Han Chan
with
regional & global partners

Seismic hazard
Low High

Using ***weather forecast*** to make decision if an umbrella is necessary

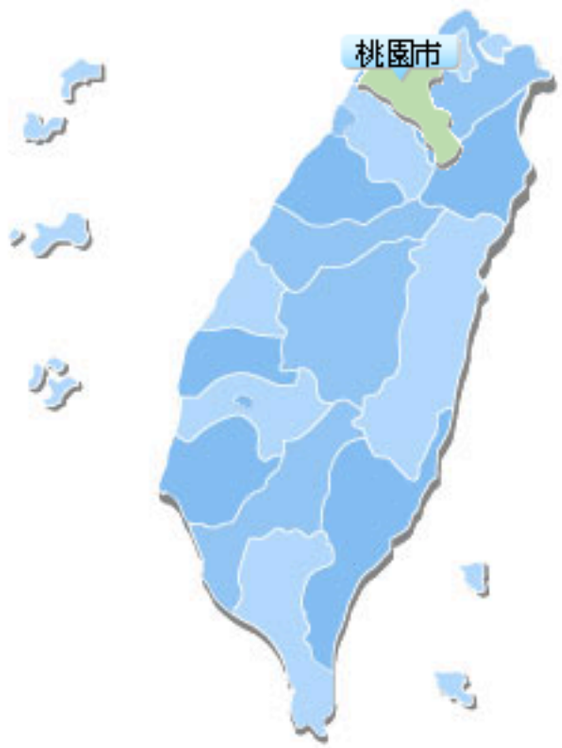
今晚明晨 | 明日白天 | 明日晚上

09/27 18:00 - 09/28 06:00

發布時間 : 2018/09/27 17:00 溫度單位:°C

北部			
基隆市	24~26°	80%	
臺北市	24~26°	90%	
新北市	24~27°	90%	
桃園市	24~26°	90%	
新竹市	24~28°	70%	
新竹縣	24~27°	80%	
苗栗縣	25~28°	70%	

中部			
臺中市	26~30°	20%	
彰化縣	25~30°	20%	
南投縣	24~29°	10%	
雲林縣	24~28°	10%	
嘉義市	25~29°	10%	
嘉義縣	25~29°	10%	



東部			
宜蘭縣	24~27°	80%	
花蓮縣	25~29°	20%	
臺東縣	25~28°	20%	

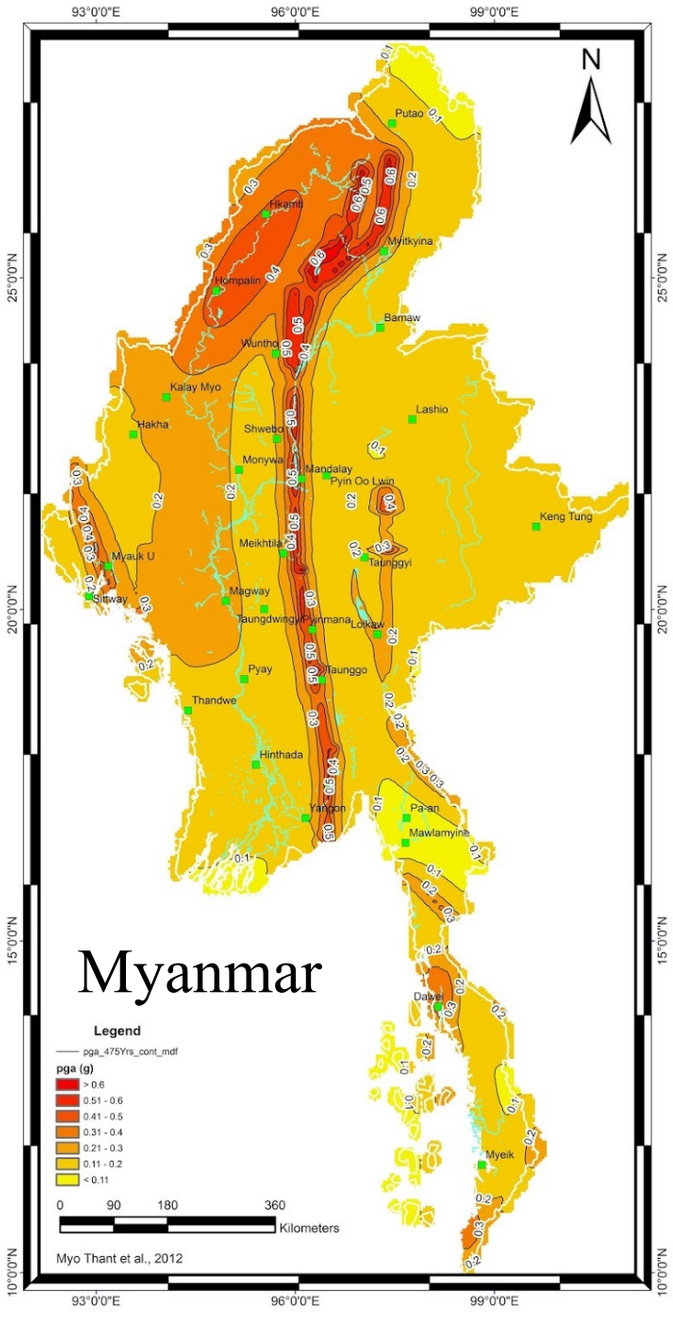
南部			
臺南市	26~29°	0%	
高雄市	27~30°	0%	
屏東縣	24~28°	0%	

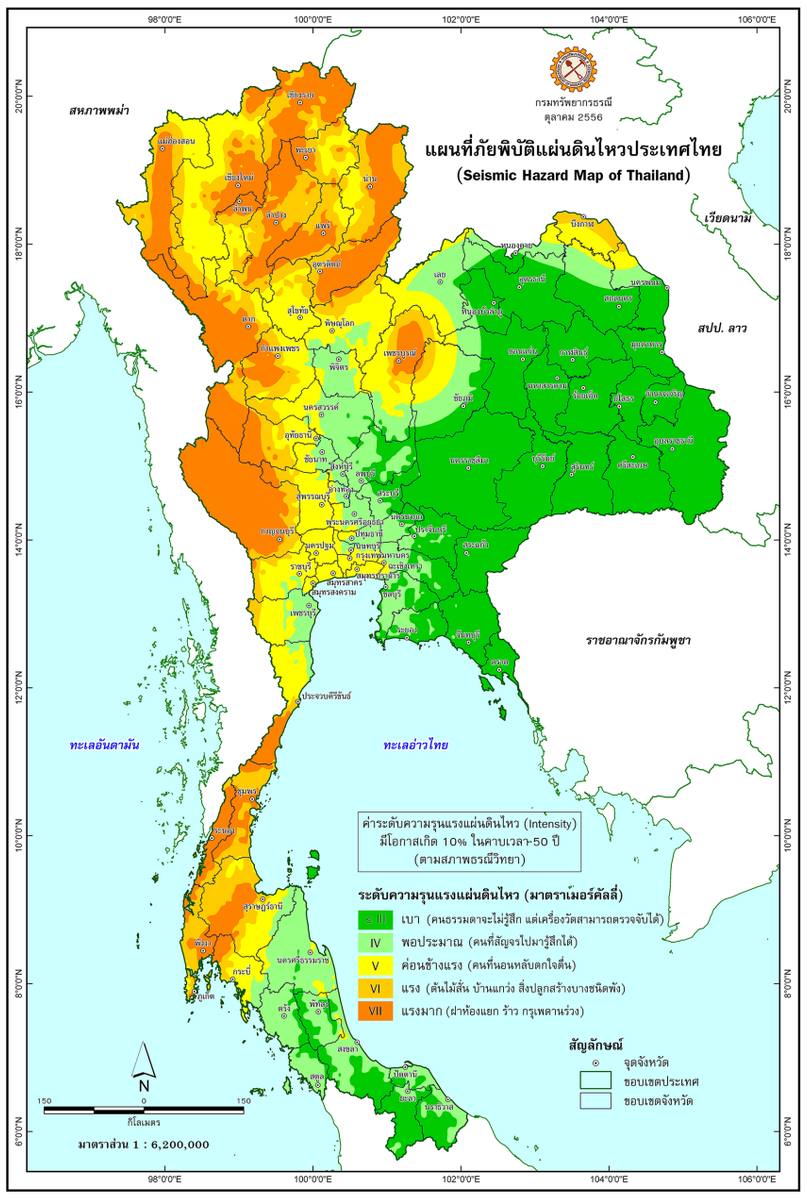
外島			
連江縣	23~25°	0%	
金門縣	24~27°	0%	
澎湖縣	26~27°	10%	

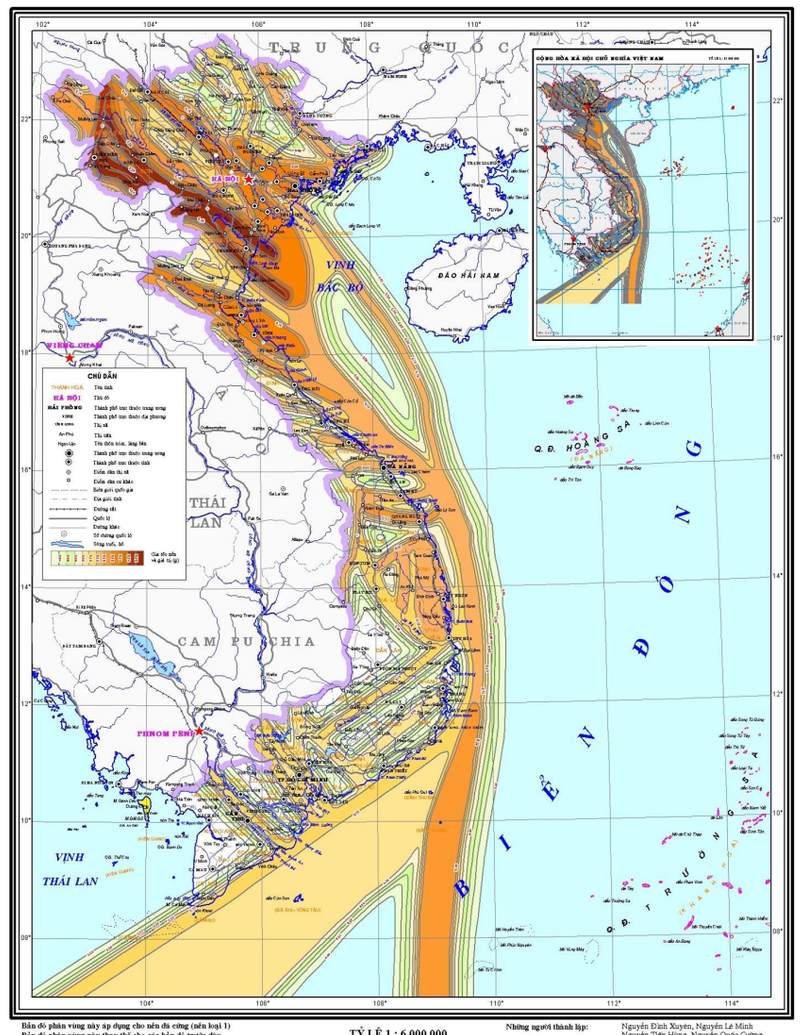
Precipitation risk
shown in ***probability***

hazard maps…..

Probabilistic seismic hazard maps could be references for ***hazard mitigation policies***, e.g., Building codes legislation, structure site selection, or insurance rate determination





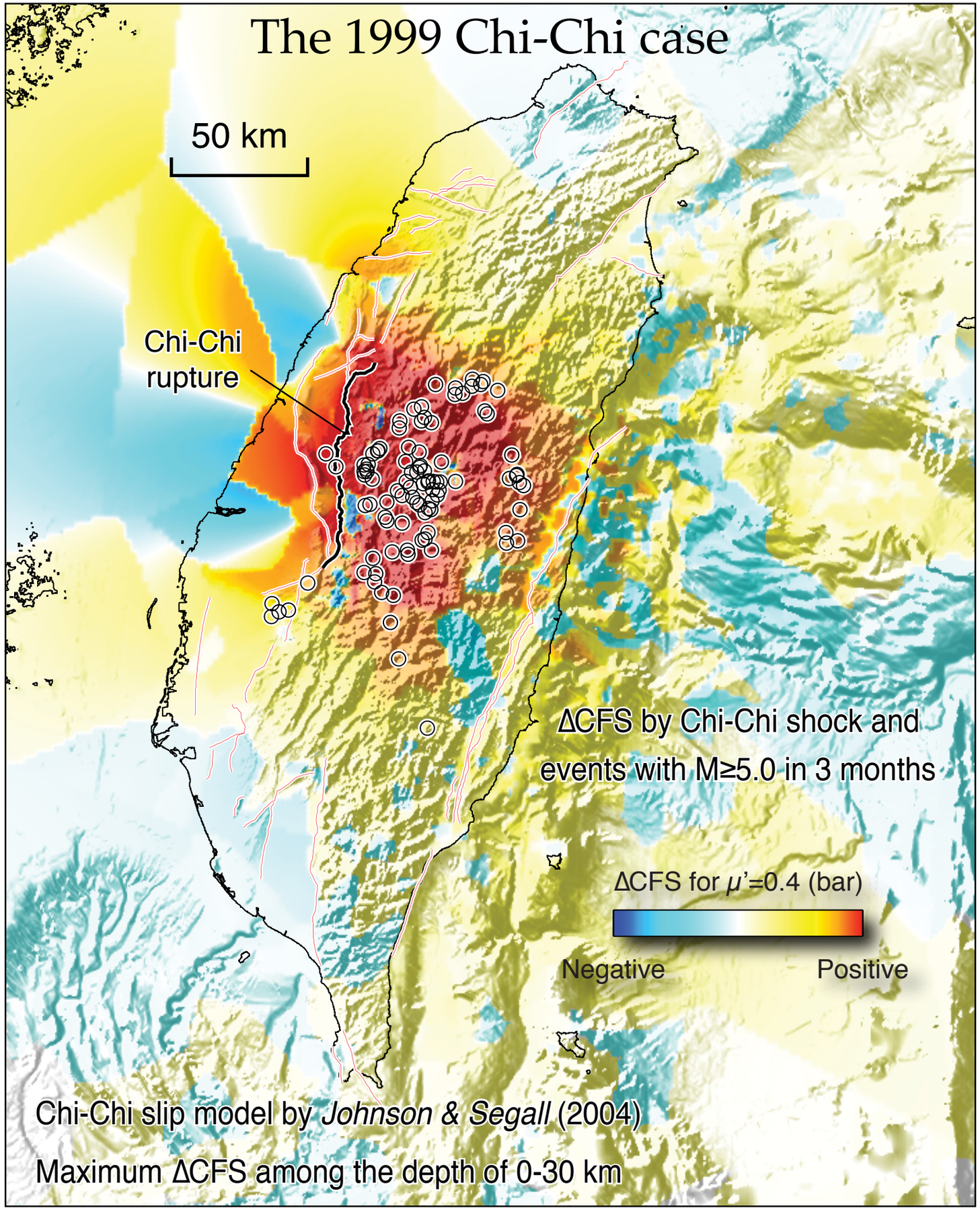


Thailand

Vietnam

<u>Disadvantages:</u> Different PSHAs with various methods result in ***mismatches*** at boundaries
Based on the assumption that earthquakes are ***independent*** to each other

Chi-Chi case…



Hazard may be ***raised*** by subsequent aftershocks or next larger earthquakes

Seismic burst after an event can be associated with ***stress triggering***

Catalli & Chan, GJI, 2012

outline…..

Outlines of this innovative approach

- Earthquake forecasting models
  - Long-term rate by smoothing Kernel
  - Short-term rate by the rate-and-state model
- Probabilistic seismic hazard assessments
  - Ground motion attenuation by GMPE[+]

[+] *GMPE: Ground Motion Prediction Equation*

long-term…..

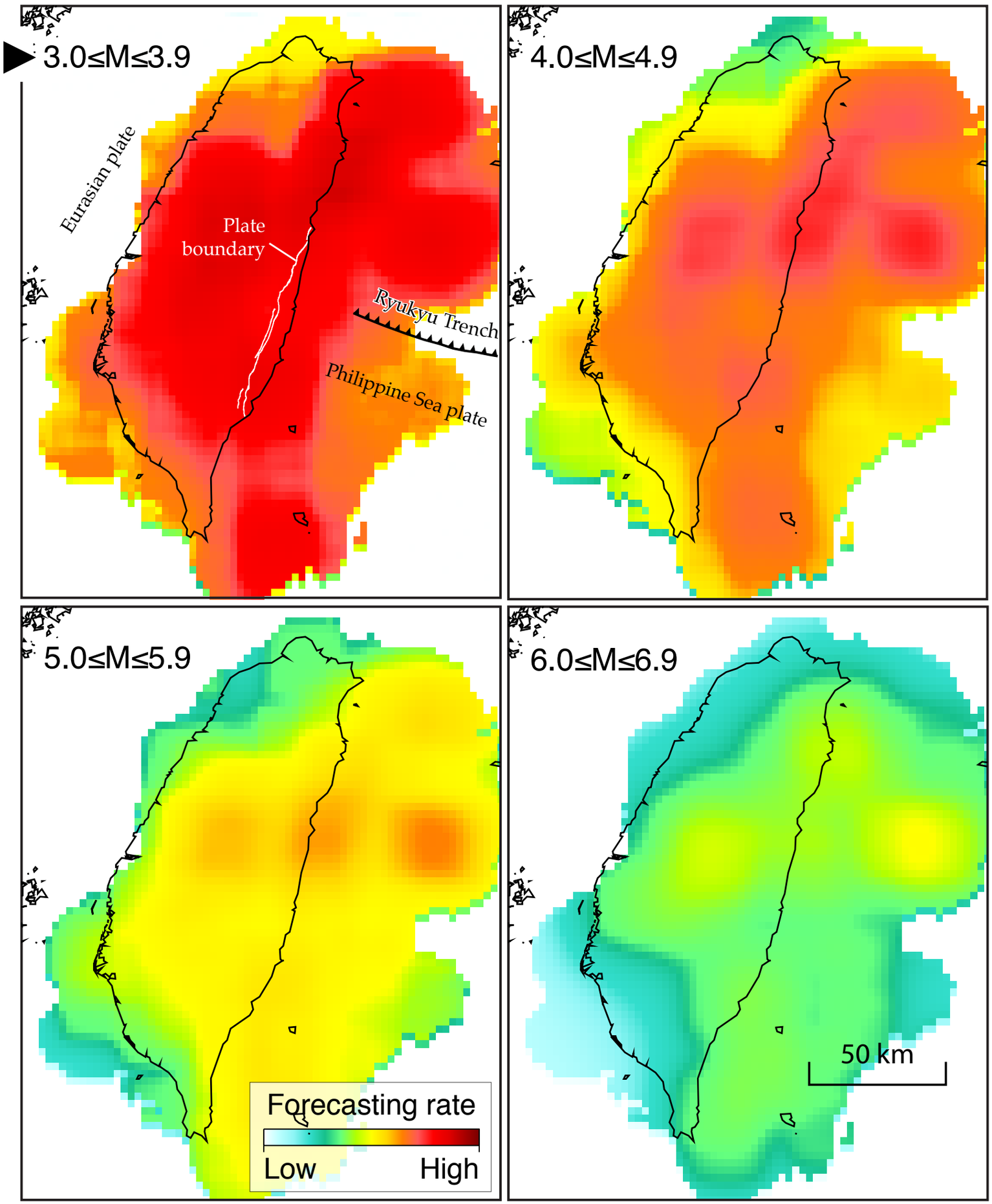
Higher rate for ***smaller magnitudes***
- Follow Gutenberg-Richter Law

Higher rate at the ***eastern offshore***
- Along the plate boundary

Calculated by
smoothing Kernel
approach

Reference period: 1973-2007

Chan et al., NHESS, 2012



Higher rate for ***smaller magnitudes***
- Follow Gutenberg-Richter Law

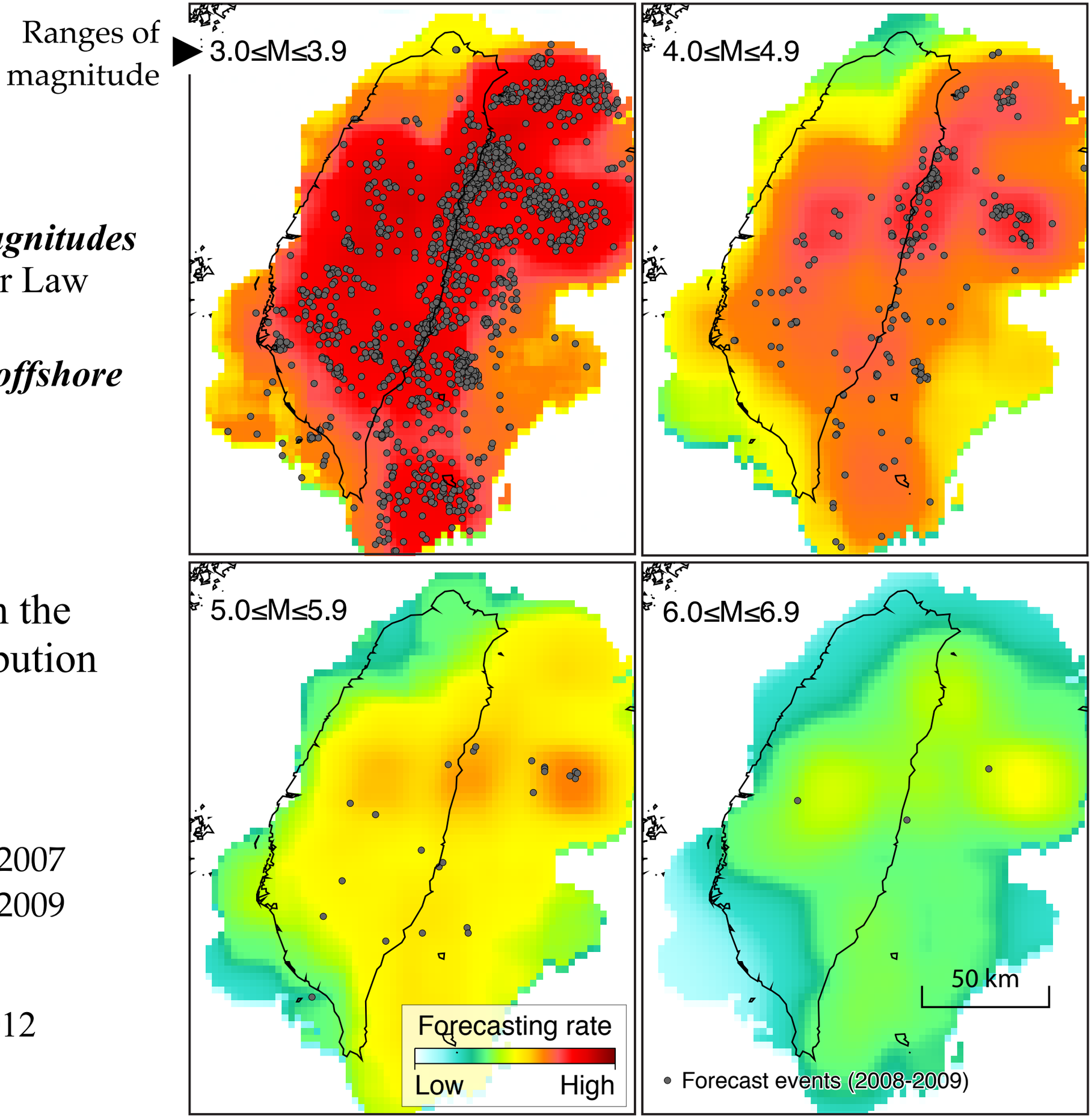
Higher rate at the ***eastern offshore***
- Along the plate boundary

Good correlation with the forecasting event distribution

Reference period: 1973-2007
Forecast period: 2008-2009

Chan et al., NHESS, 2012

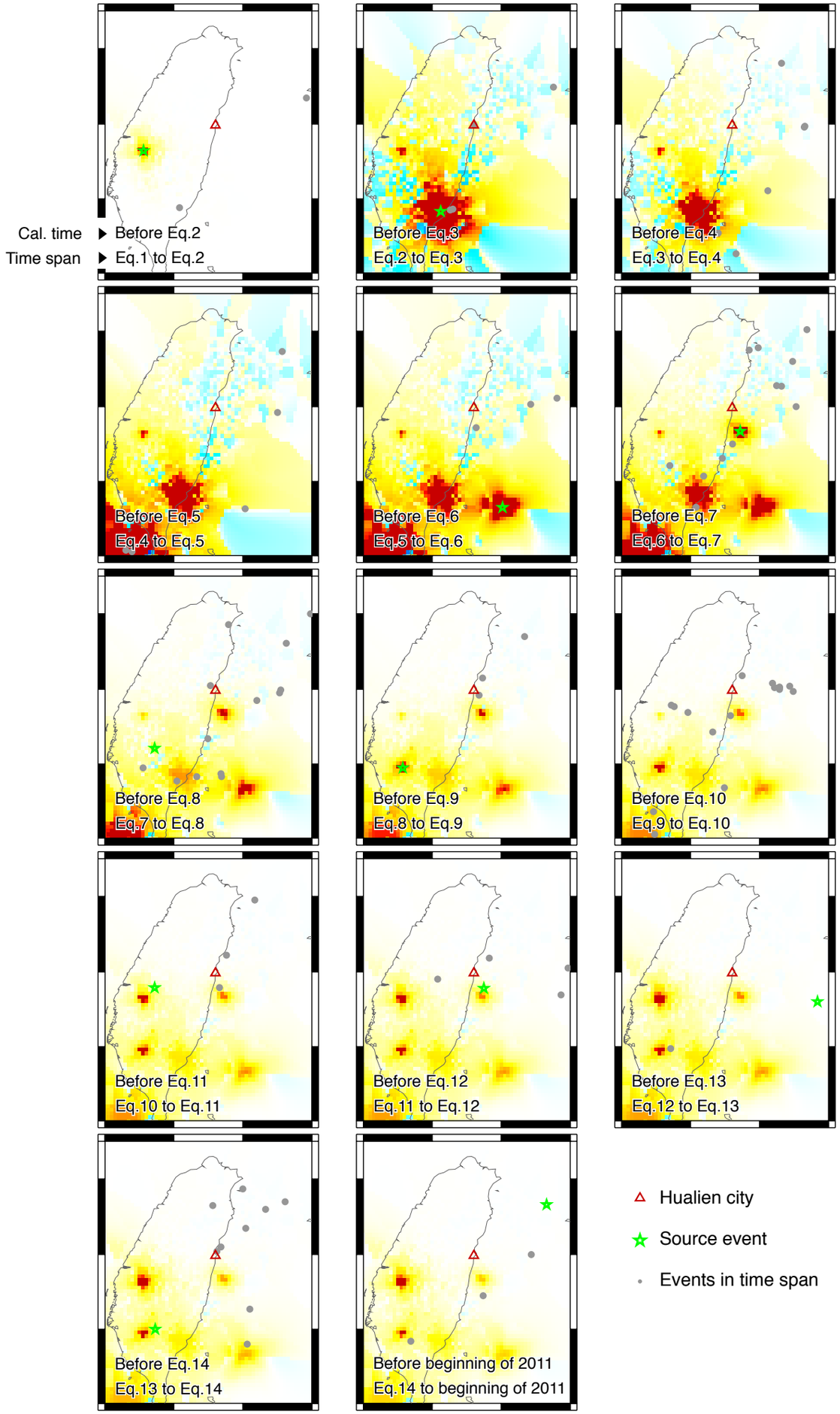
rate evolution….



Evolution of seismic rate during 2006-2010

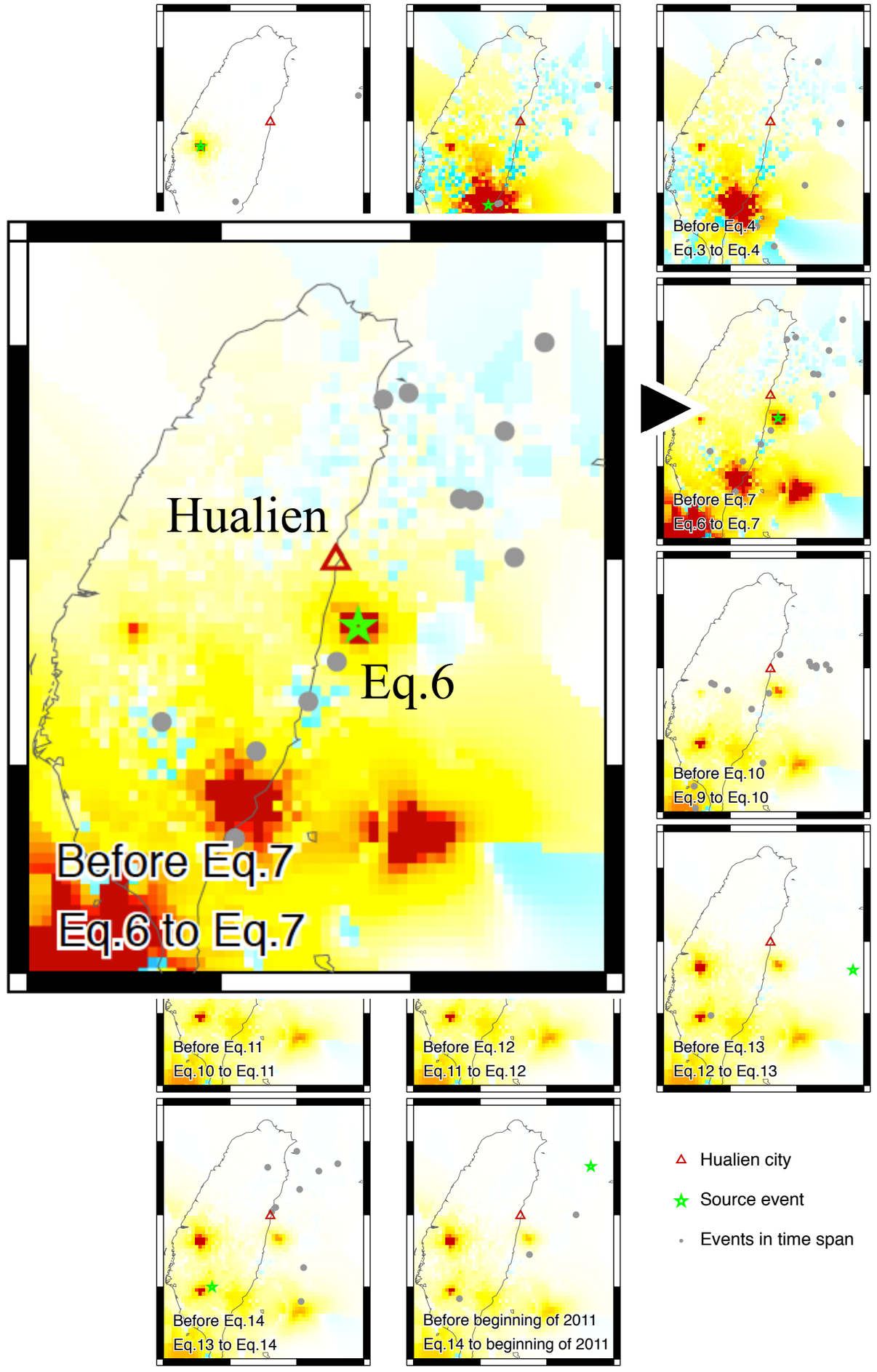
Based on ***Coulomb stress change***

Chan et al., NHESS, 2013



Evolution of seismic rate during 2006-2010

Significant rate increase near Hualien after **eq.6 (M5.1)**



Evolution of rate change during 2006-2010

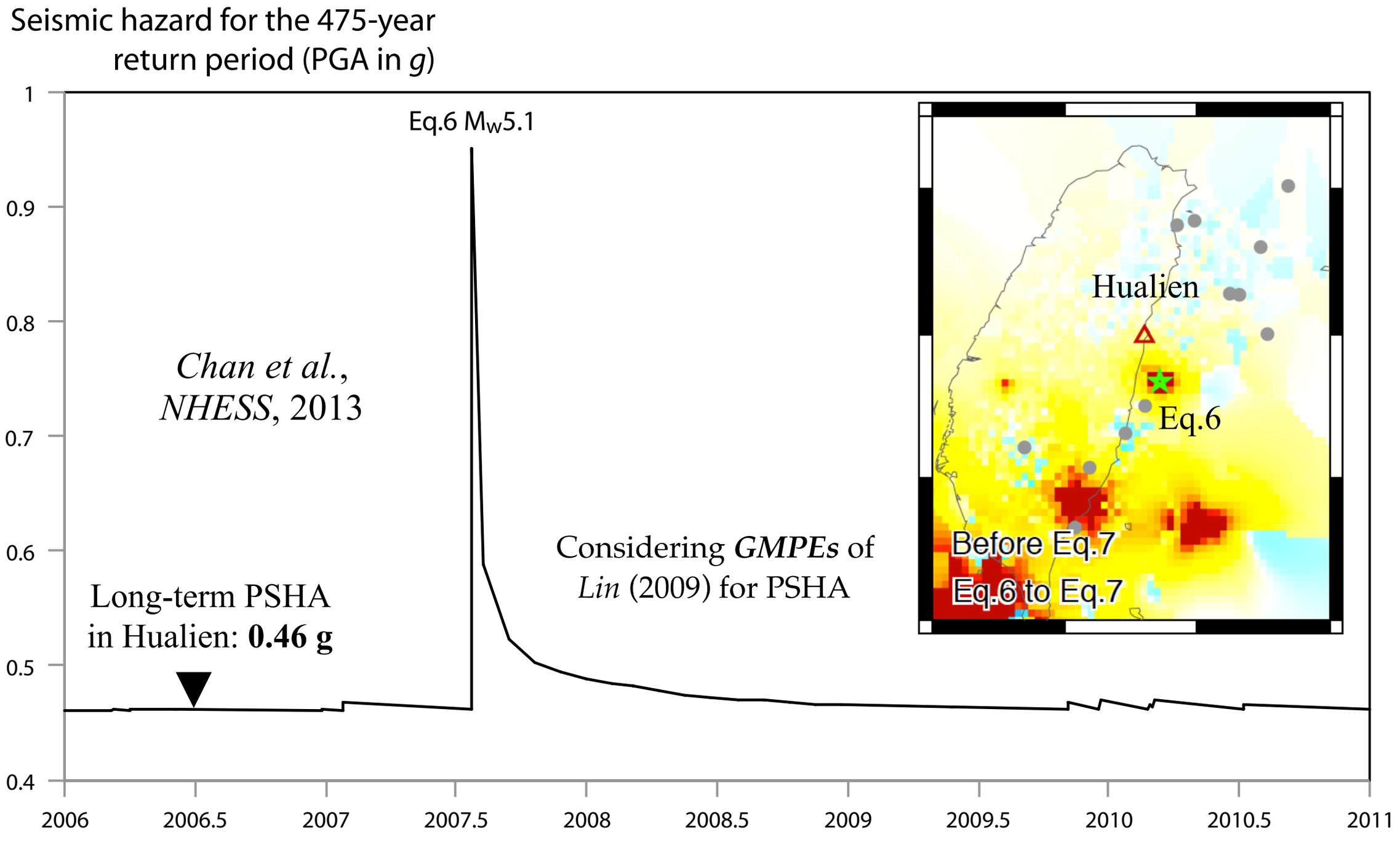
-10.0 -5.0 -1.0 -0.5 -0.1 0.0 +0.1 +0.5 +1.0 +5.0 +10.0

Chan et al., NHESS, 2013

hazard evolution……

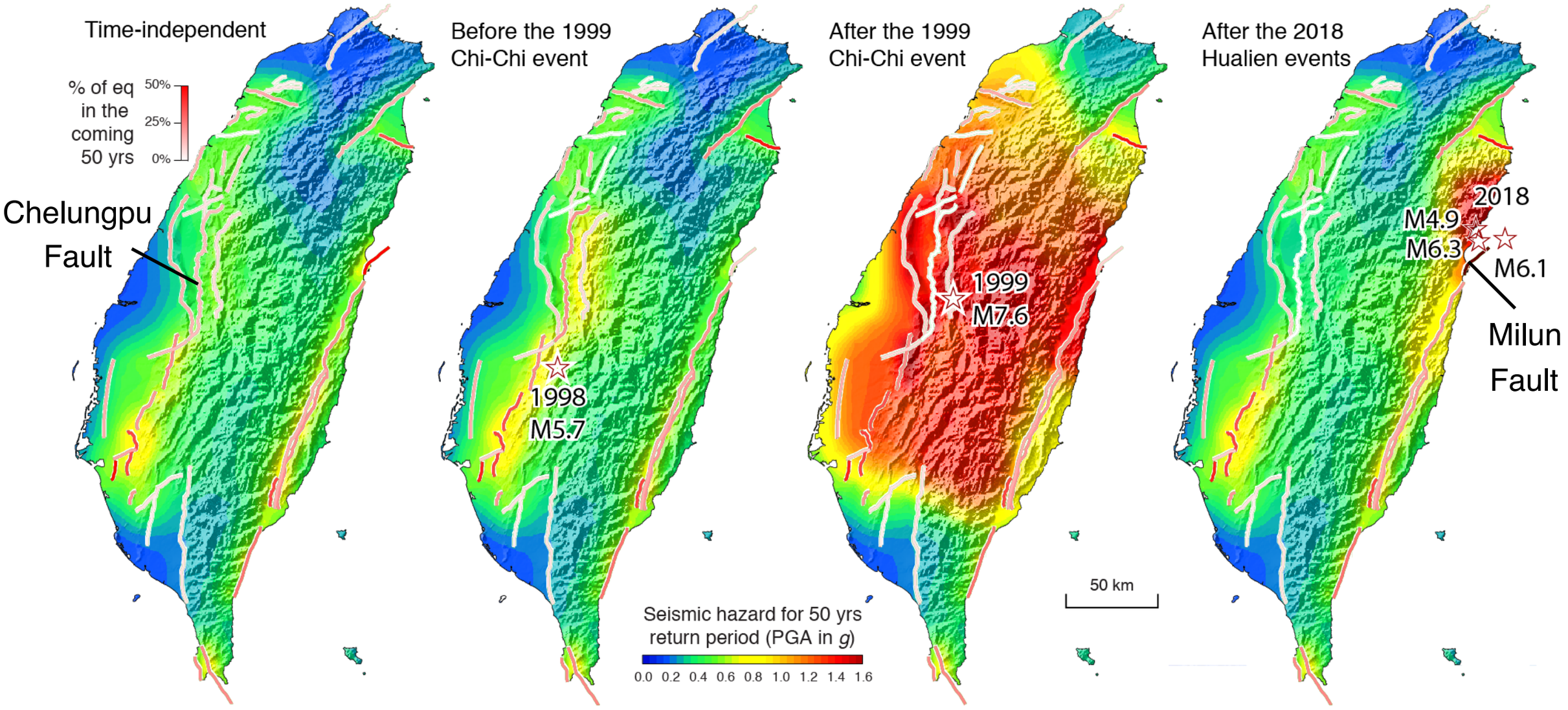
Significant rise of seismic hazard in Hualien after eq. 6

Decay rapidly with time due to its small magnitude



Taiwan case……

Time-dependency is first applied for seismic hazard map for Taiwan;
The seismic hazard can be ***re-assessed*** soon after next large events.



Higher hazard
- near active faults with ***short*** recurrence intervals,
- ***long*** elapsed time since the last rupture, and
- close to large earthquakes that just took place.

Chan et al., BSSA, 2017;
Chan et al., SRL accepted

SE Asia…..

Seismicity and ***active fault*** database for the assessment

<u>Sources:</u>

Global catalogs: *ISC-GEM, ANSS* & *ISC*
Local catalogs: *VAST, TMD*
(determine M_w, duplicated events removed)

Focal mechanisms: *GCMT*

Active faults: contribution of working group, paper review & geomorphological evidence

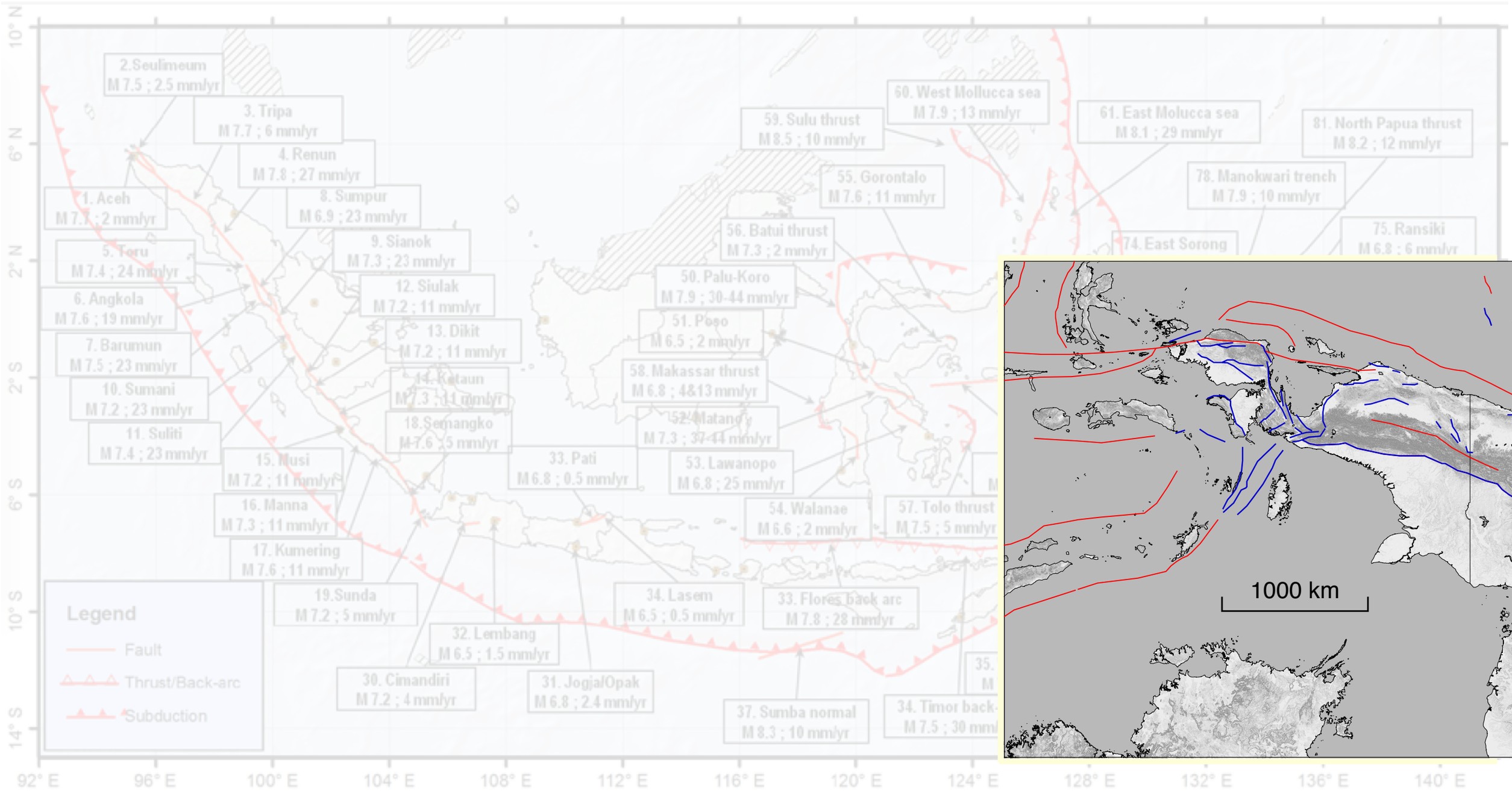
Area sources (*blue polygons*) defined by tectonic setting

1000 km

Indonesian faults…

Some parameters are obtained from ***national*** hazard assessment

The database is further updated based on other individual studies



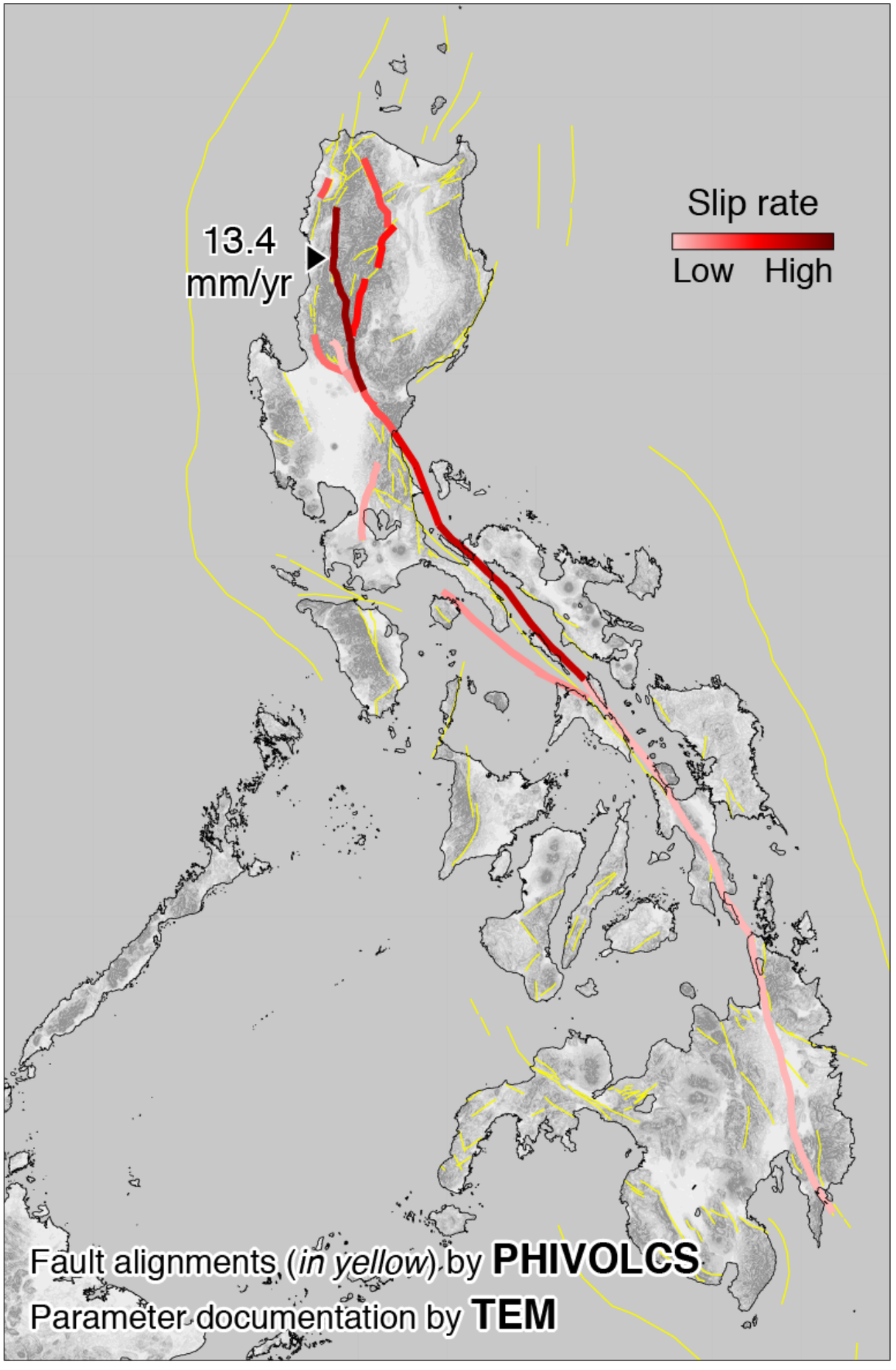
Philippine case…

Simplified alignments **&**
multiple rupture were
implemented for PSHA

Case of the Philippine Fault system

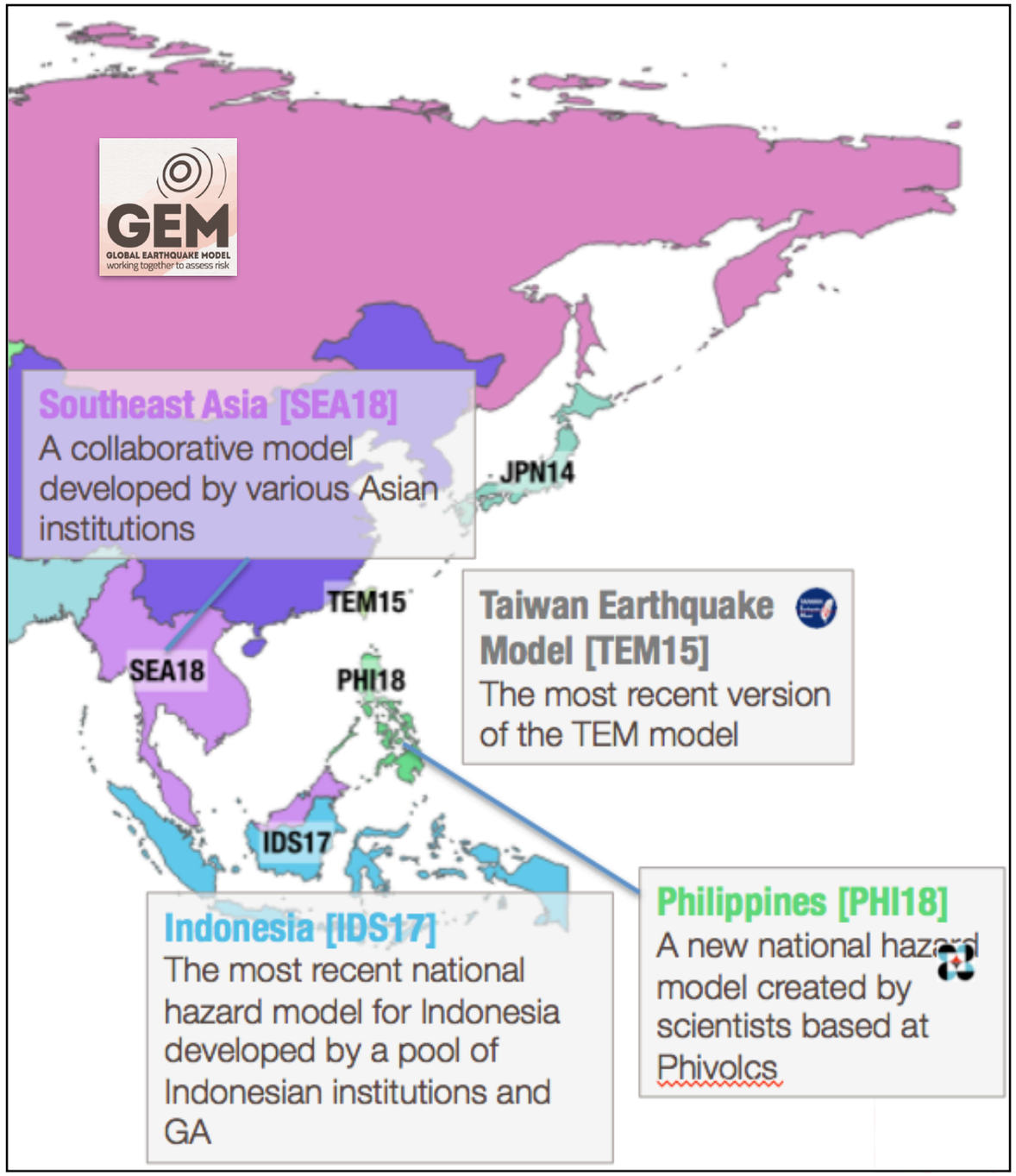
References for slip behaviours:

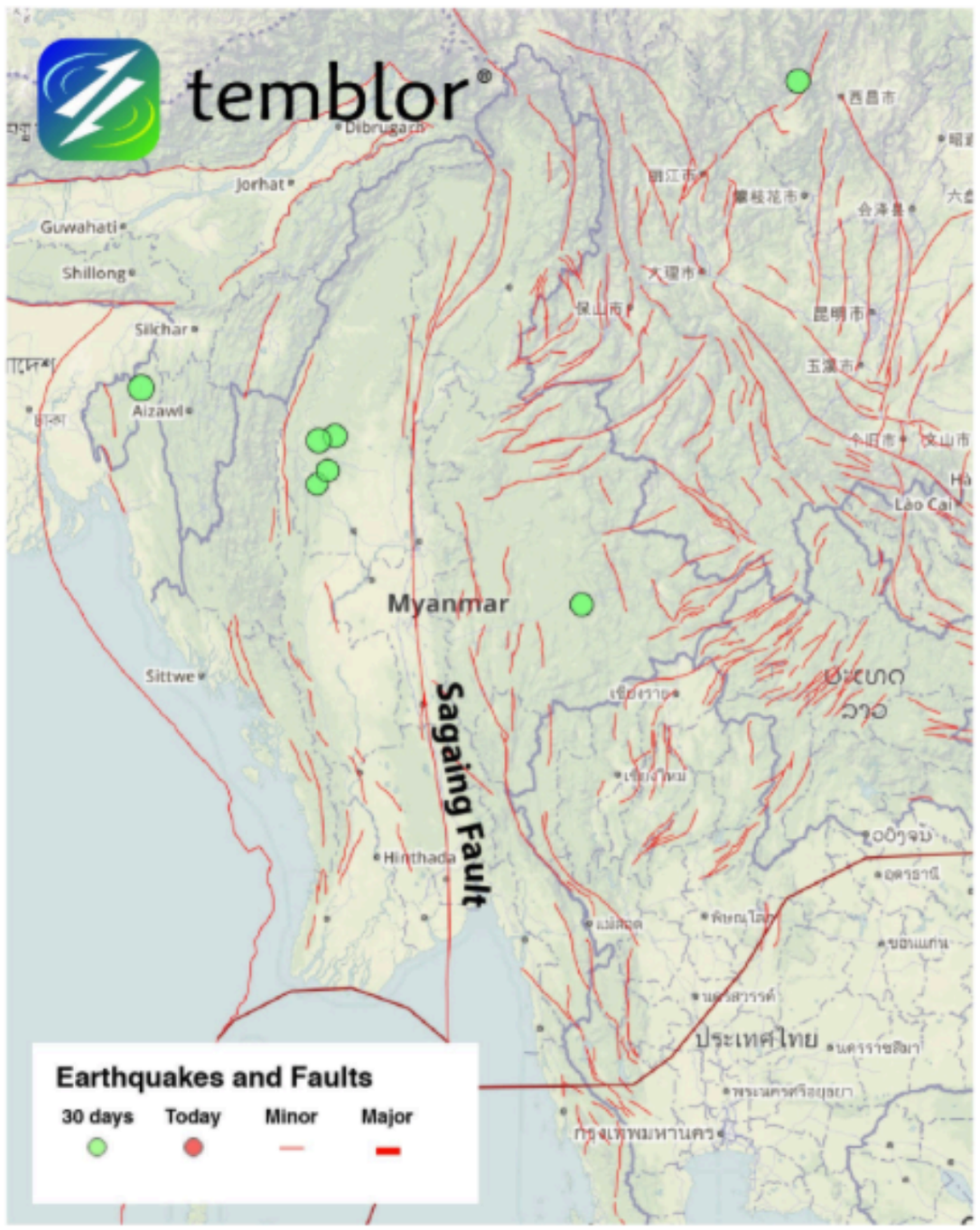
Aurelio (2000)
Galgana et al. (2007)
Hsu et al. (2016)
Perez & Tsutsumi (2017)
Tsutsumi et al. (2015)



contribution to collaborators…

In addition to contributing to our PSHA, our database has been included in the ***GEM hazard mosaic model*** and ***Temblor system***

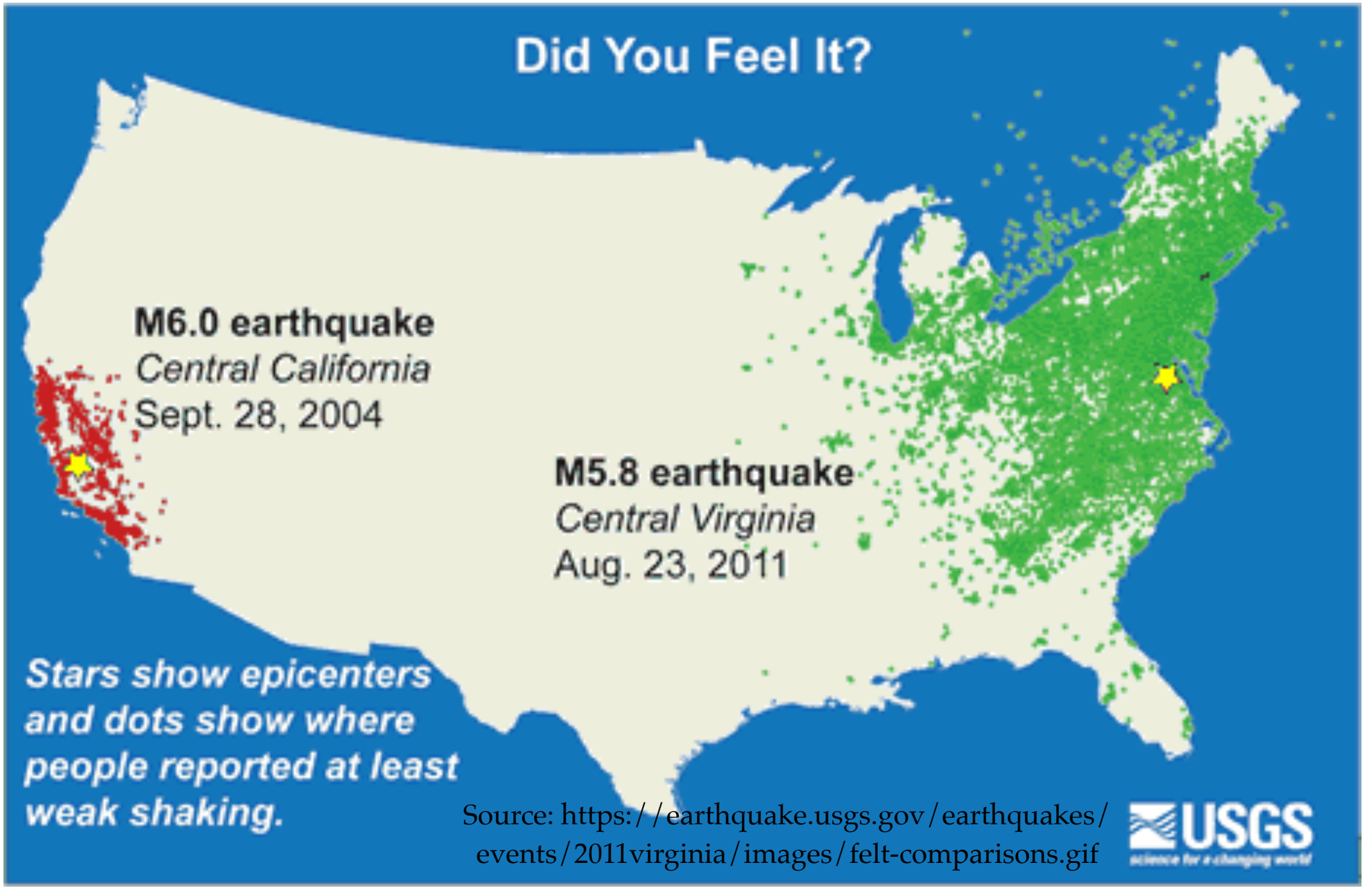




Temblor is an enterprise providing hazard assessments for the public. Potential collaboration modes with Temblor are under discussion.

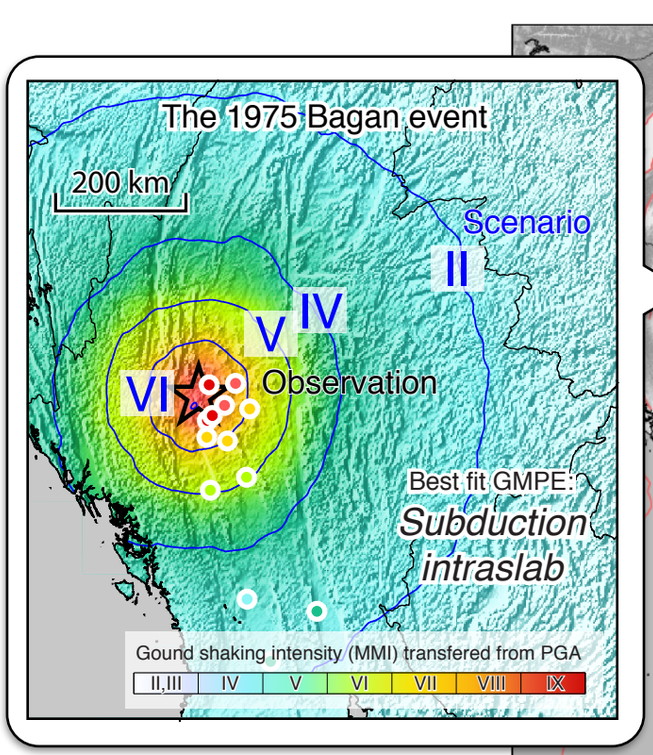
attenuation….

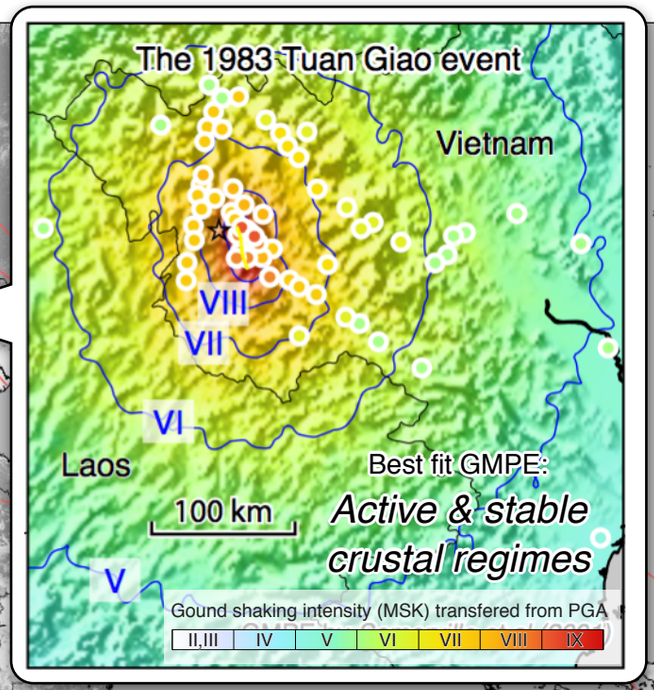
Attenuation behaviours are various between different ***tectonic regimes***

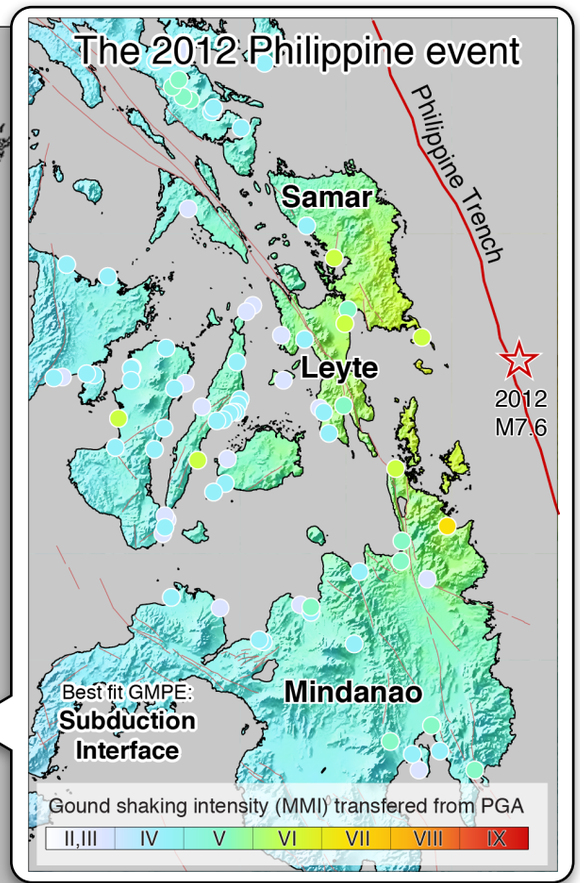


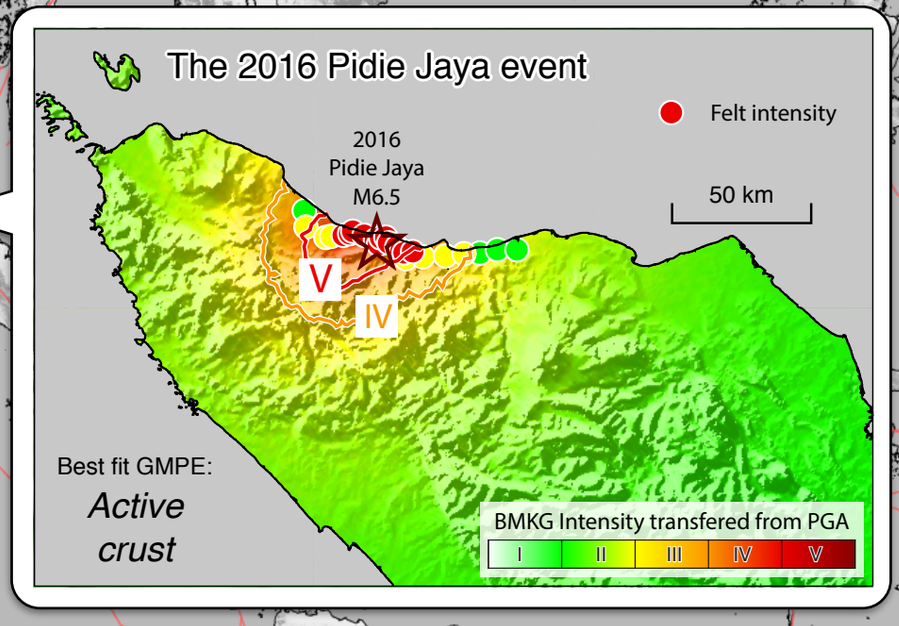
Different GMPEs between ***active crustal*** and ***stable continental*** regimes

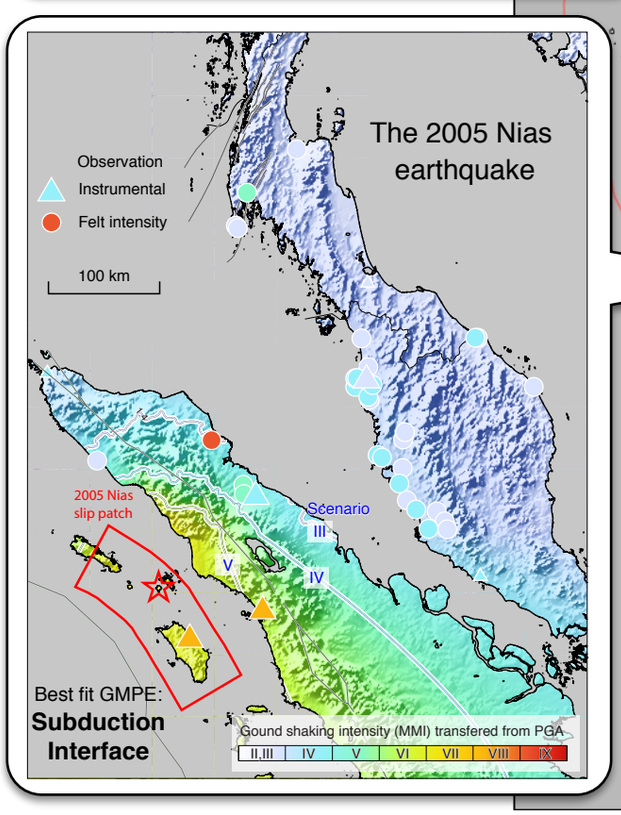
GMPE tests determine the attenuation behaviours in different tectonic regimes

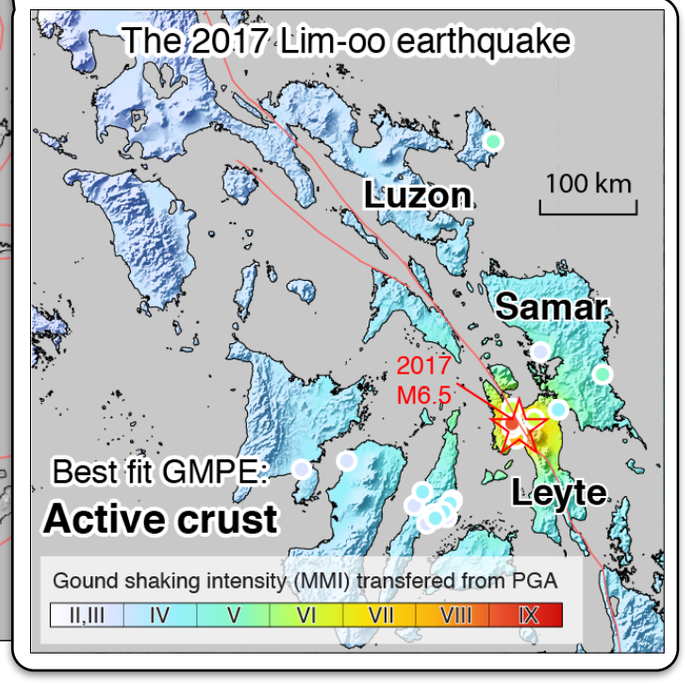










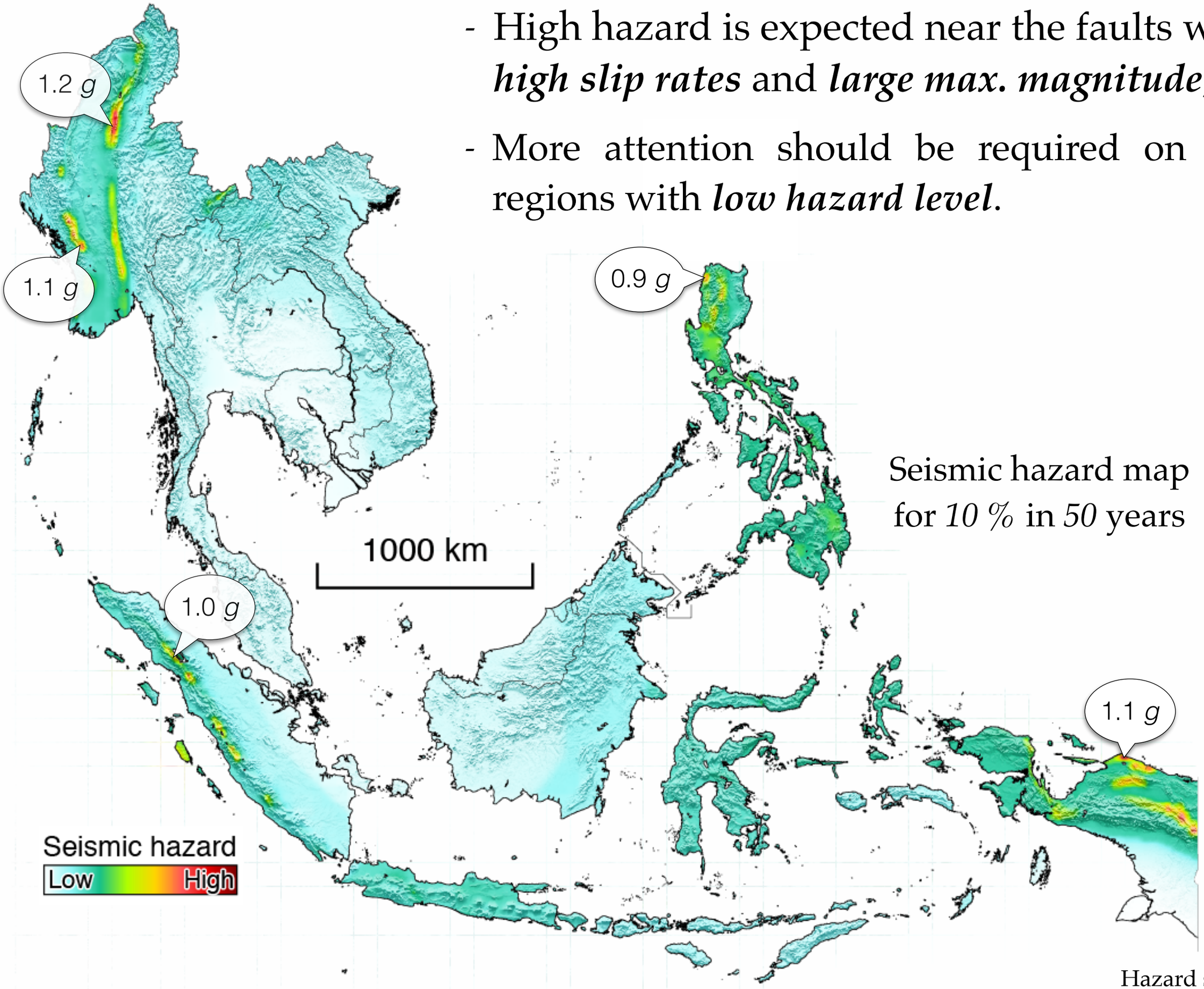


1000 km

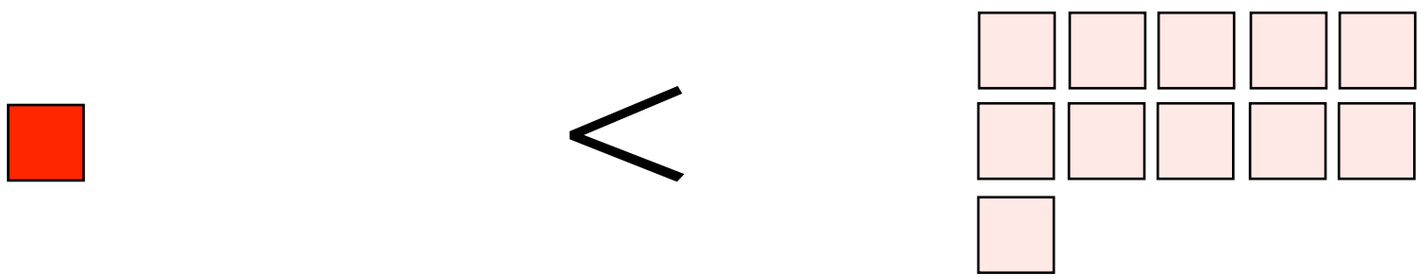
hazard map....

GMPE: Ground Motion Prediction equation

- High hazard is expected near the faults with ***high slip rates*** and ***large max. magnitude;***
- More attention should be required on the regions with ***low hazard level***.



Seismic hazard map
for *10 %* in *50* years



1 unit with **10 %** probability

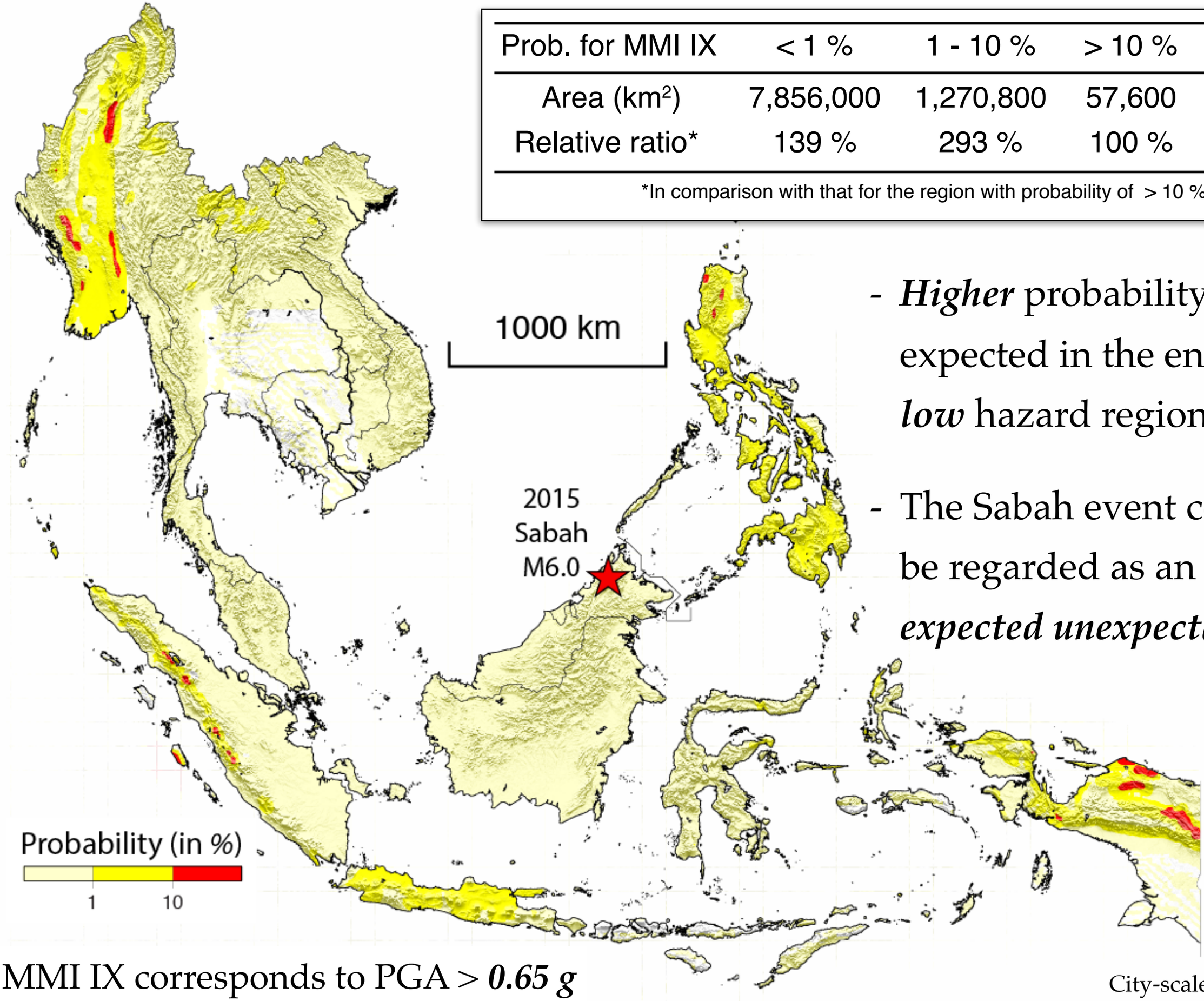
11 units with 1 % probability

*Based on the Poisson distribution:

$10\ \% < 100\ \% - (100\ \% - 1\ \%)^{11} = 10.5\ \%$

Prob. for MMI IX	< 1 %	1 - 10 %	> 10 %
Area (km^2)	7,856,000	1,270,800	57,600
Relative ratio*	139 %	293 %	100 %

*In comparison with that for the region with probability of > 10 %

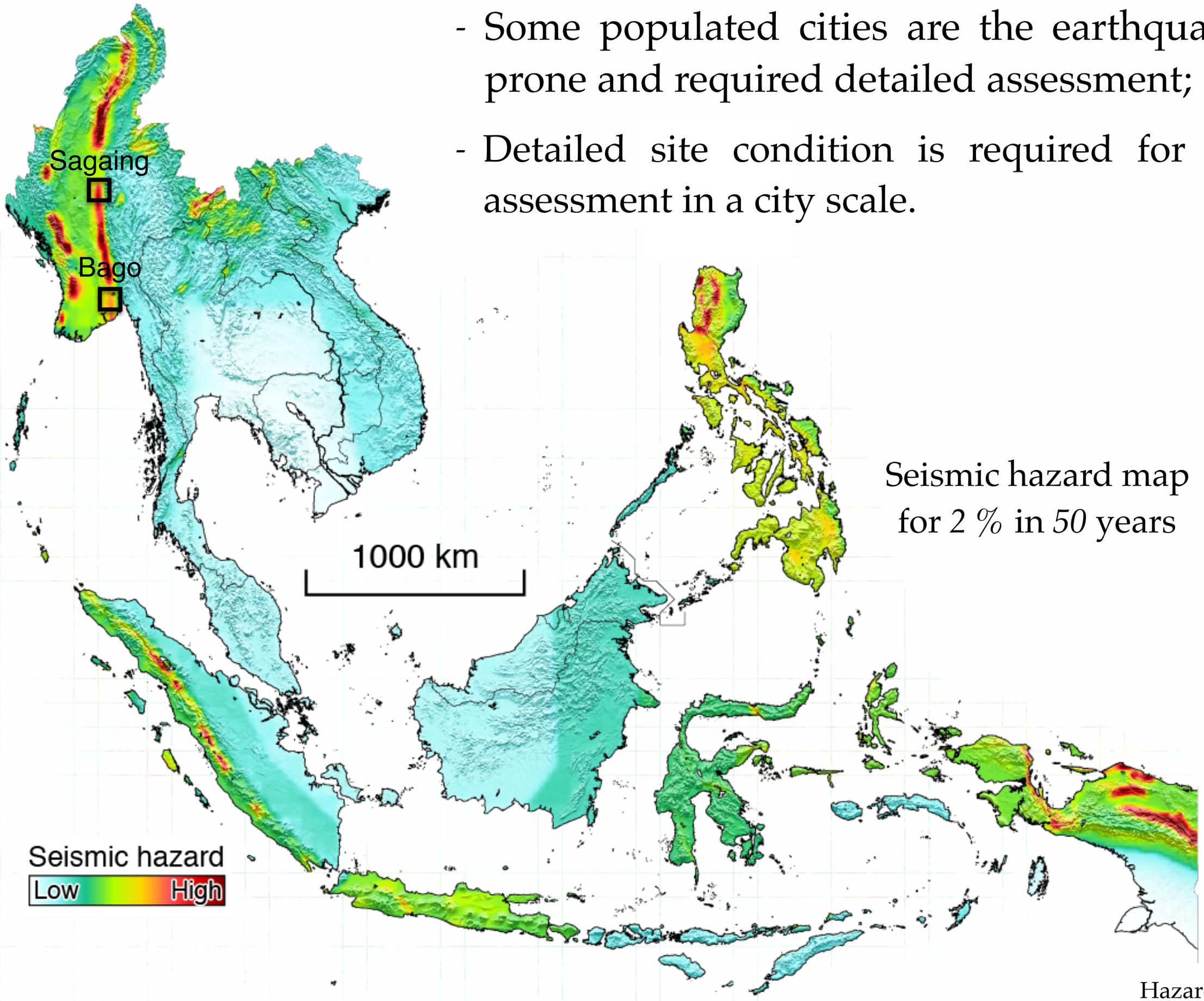


- ***Higher*** probability is expected in the entire ***low*** hazard region

- The Sabah event could be regarded as an ***expected unexpectation***

MMI IX corresponds to PGA > ***0.65 g***

- Some populated cities are the earthquake-prone and required detailed assessment;
- Detailed site condition is required for the assessment in a city scale.

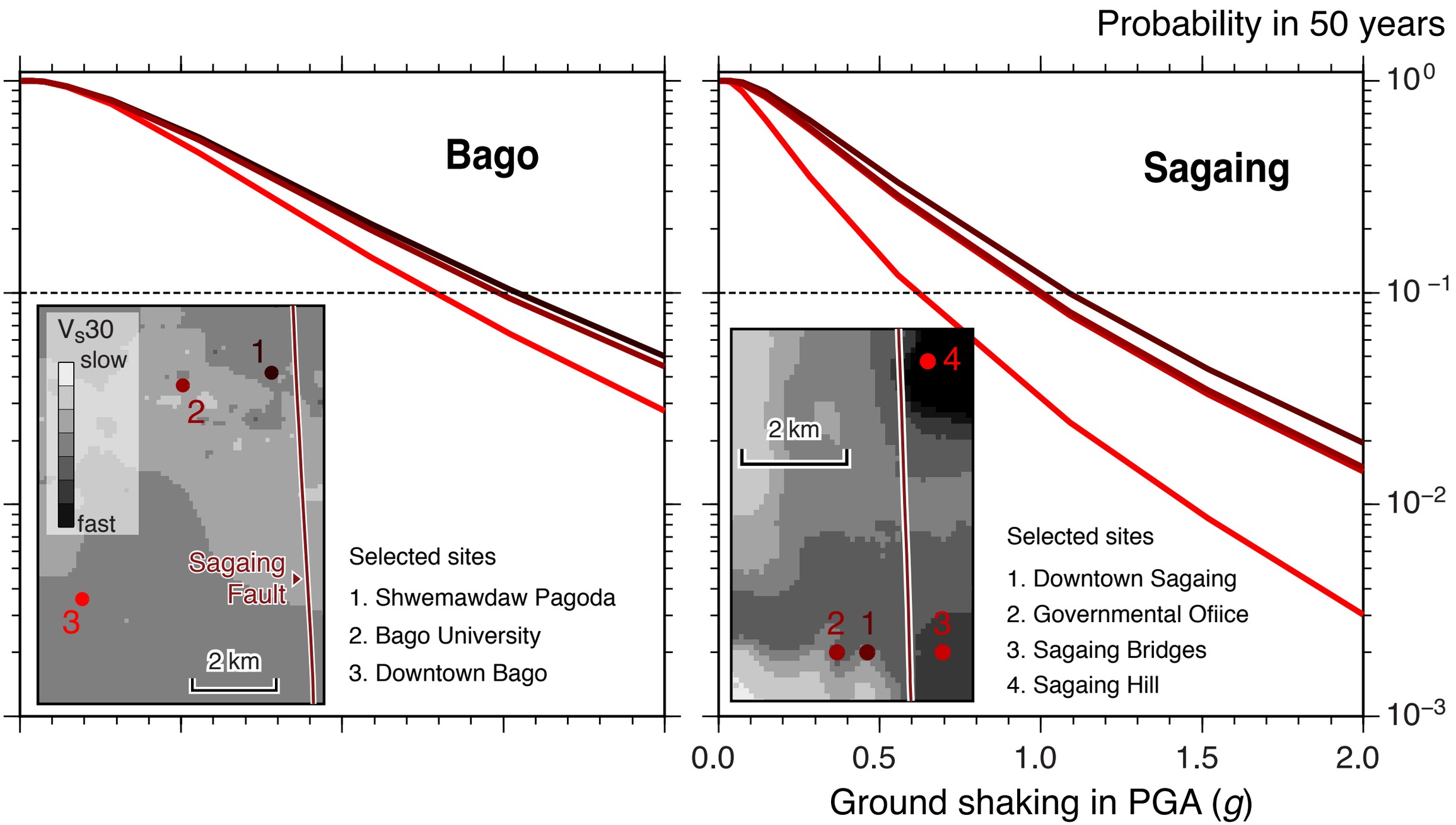


Seismic hazard map
for 2 % in 50 years

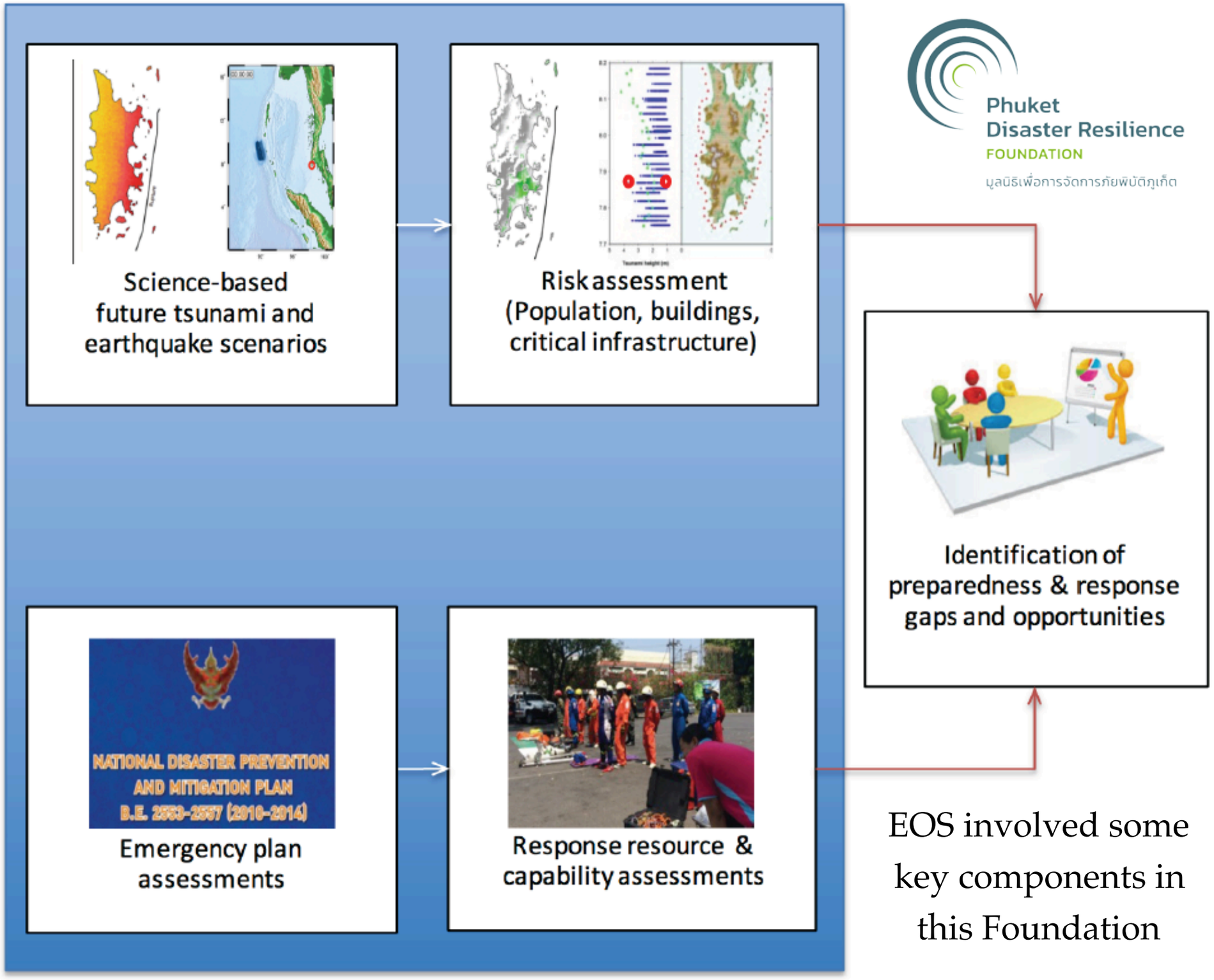
Hazard curves…

Detailed hazard assessments based on V_s^{30} map by on-site surveys

Higher hazards for the sites ***close to an active fault*** or with ***low*** V_s^{30}



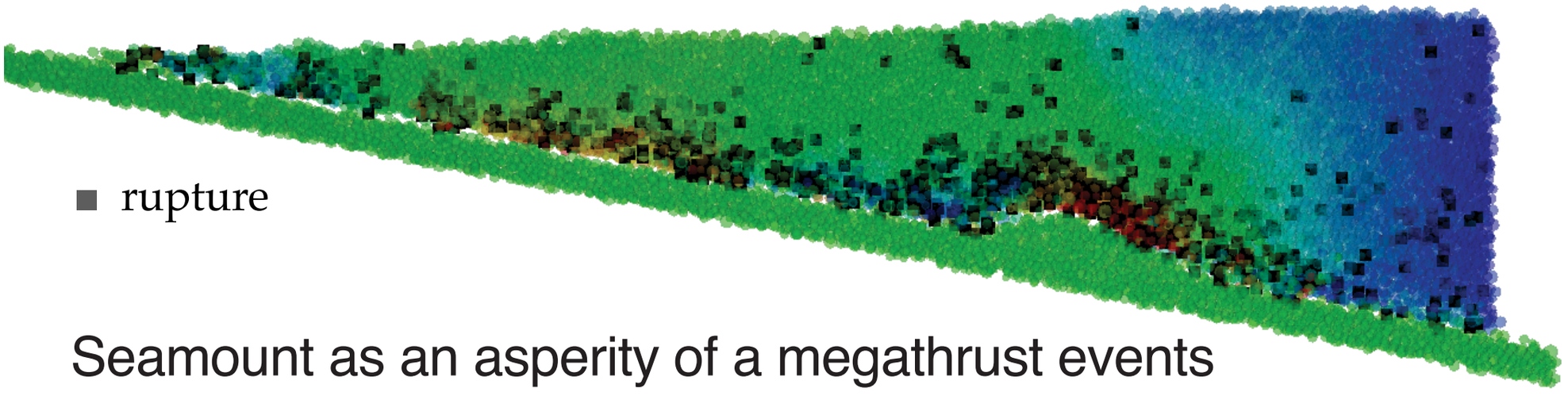
Associated with ***emergency plan,*** our assessments provides information for ***disaster resilience,*** such as minimised risk, effective response, swift recovery



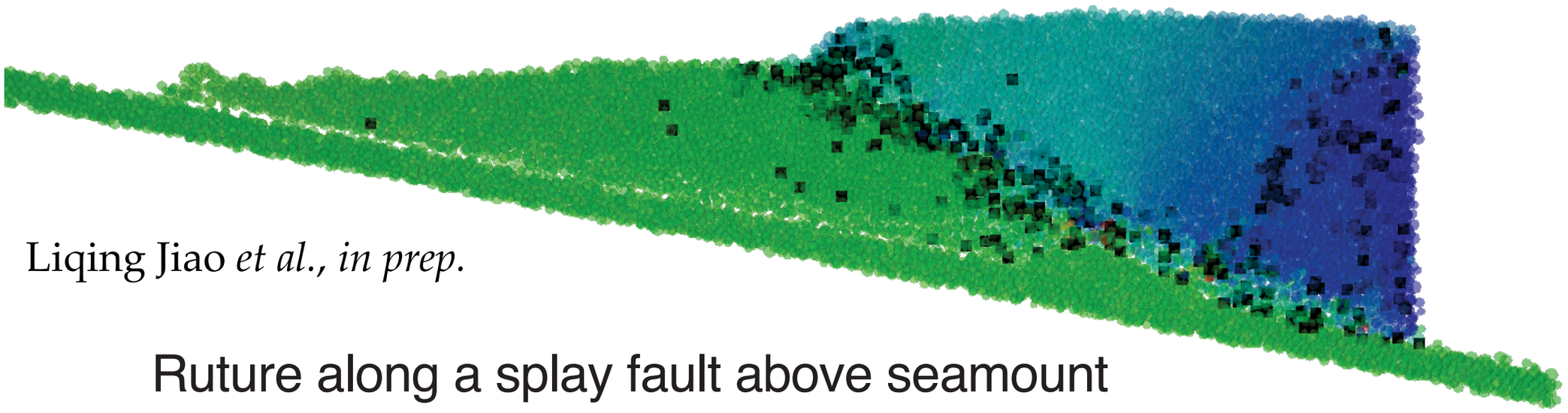
EOS involved some key components in this Foundation

Future work:

To incorporate seismic rate based on a ***dynamic model***



Seamount as an asperity of a megathrust events



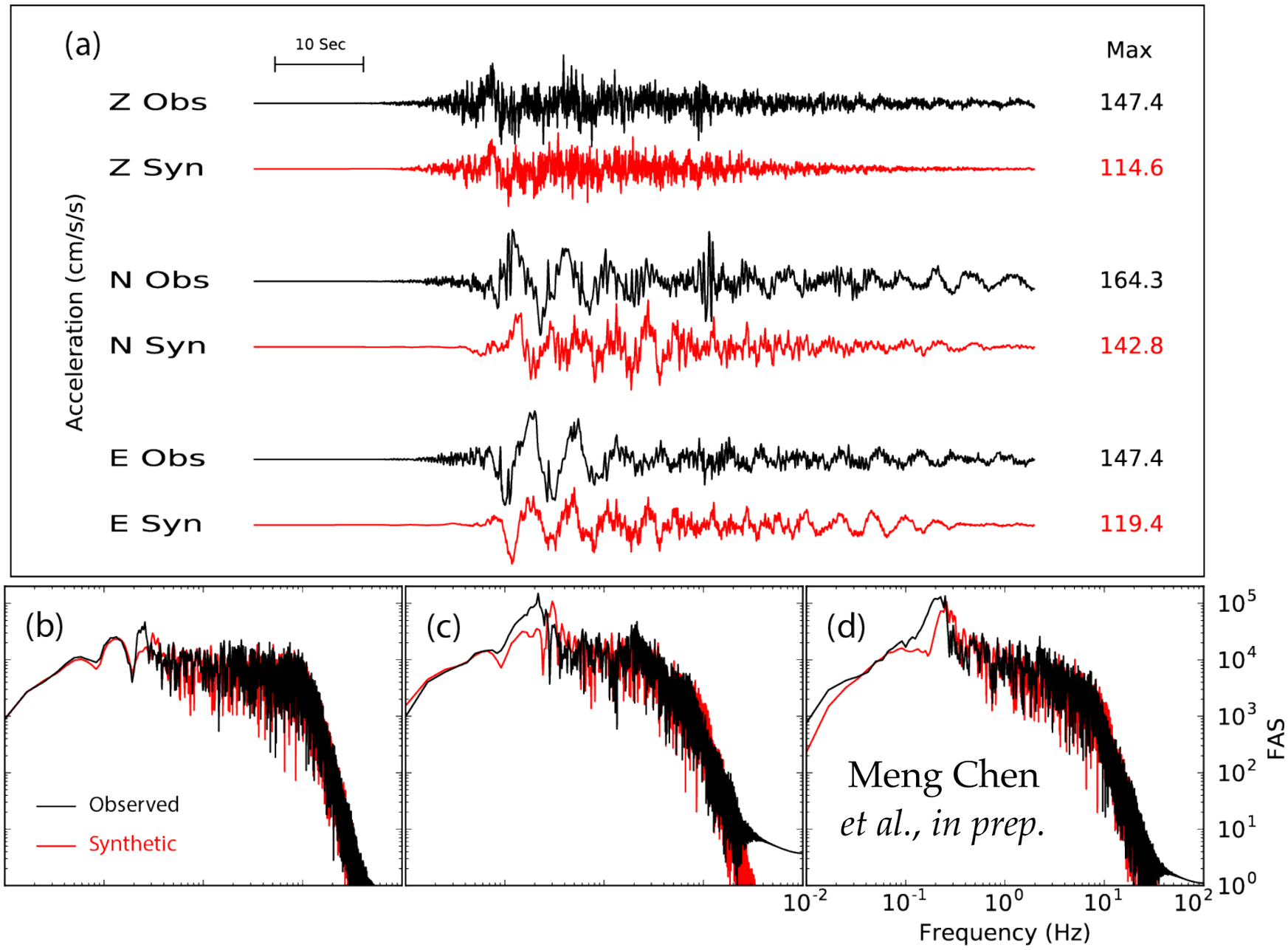
Liqing Jiao *et al., in prep.*

Ruture along a splay fault above seamount

Our dynamic model suggests a seamount could be a rupture barrier, megathrust asperity, or initiation of a splay fault, depending on overriding plate condition.

Future work:

Ground motion attenuation based on *waveform simulation*

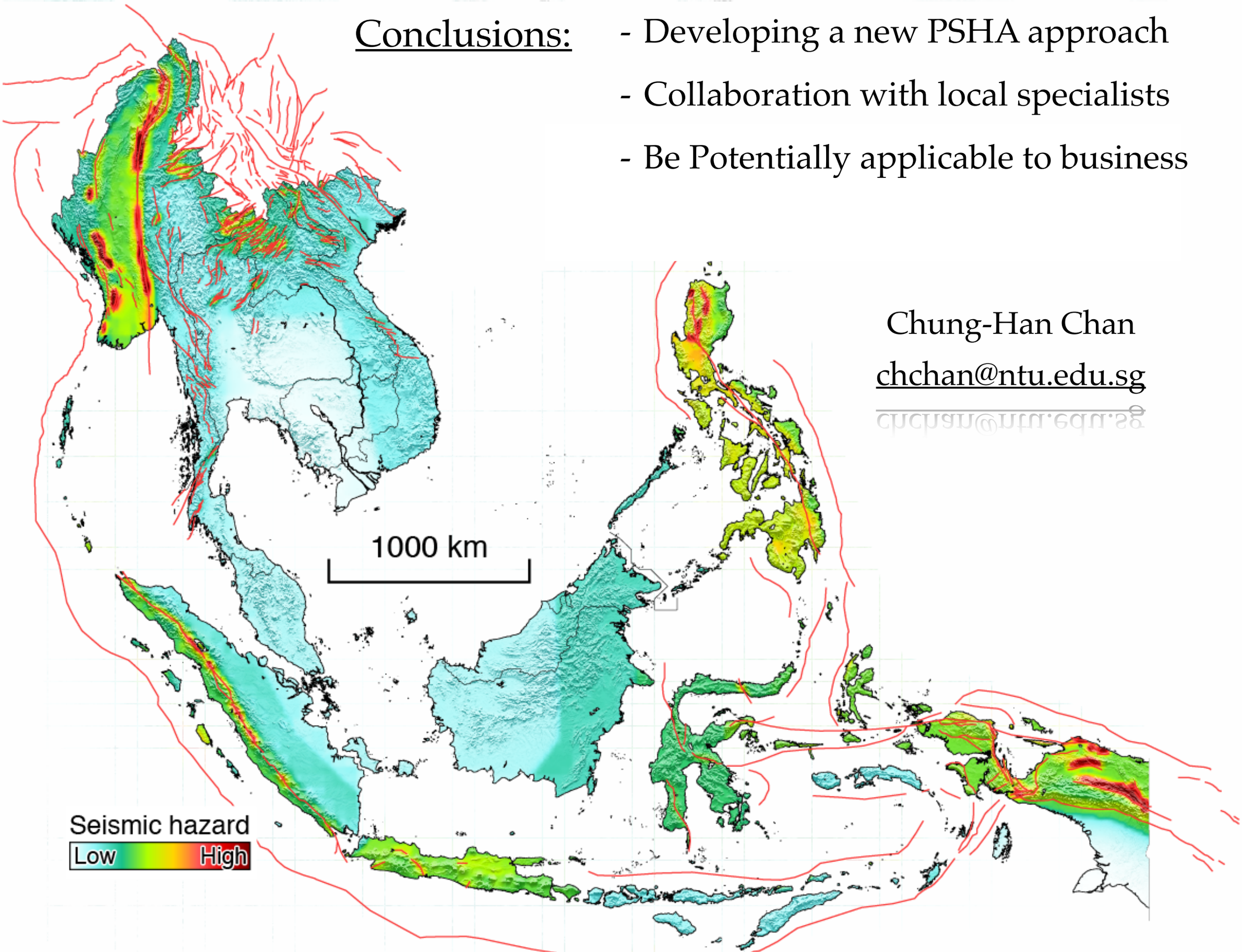


Good simulations for the frequency in 0.1-100 Hz fulfils the requirement of engineering purposes.

Conclusions…

Conclusions:

- Developing a new PSHA approach
- Collaboration with local specialists
- Be Potentially applicable to business



Chung-Han Chan
chchan@ntu.edu.sg

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- PSHA for SE Asia as Senior Research Fellow in NTU (south)

Thanks all of the teachers who complete me!