

台灣地震危害高階模型建置

吳俊霖

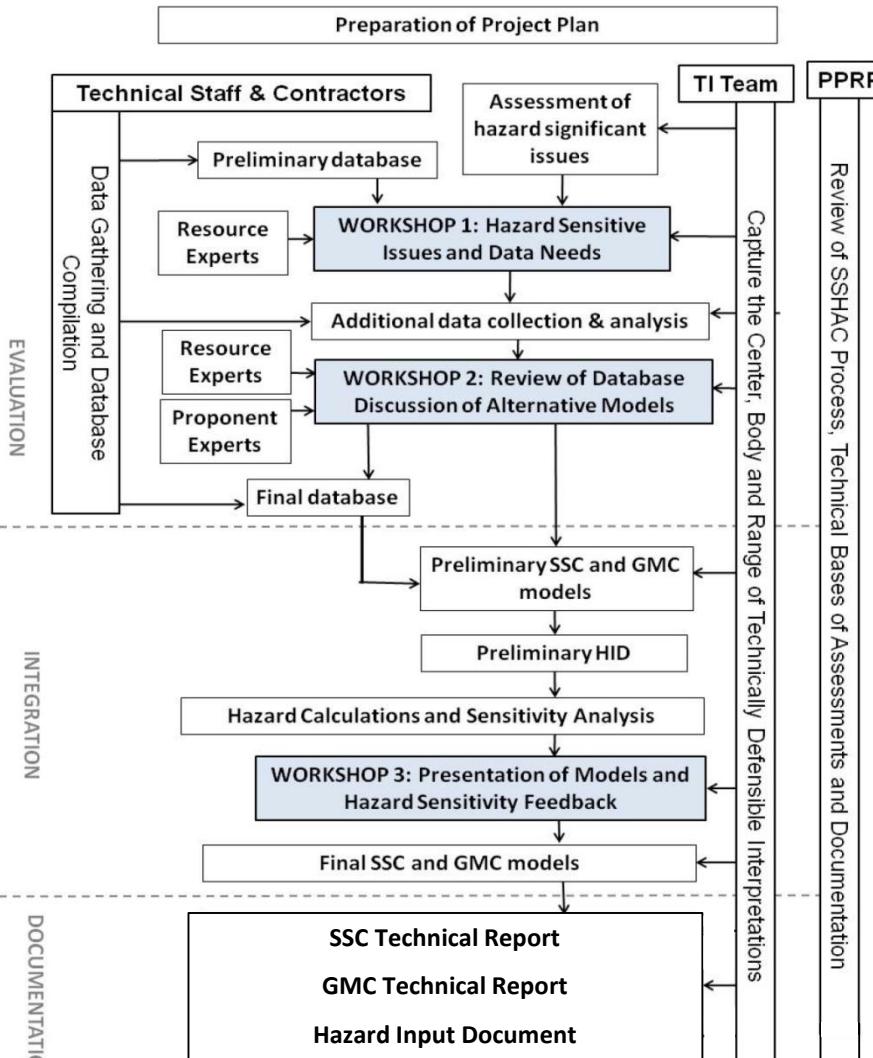
國家地震工程研究中心

Background

- ❑ The U.S. Actions Following Fukushima Daiichi Accident
 - The Nuclear Regulatory Commission (NRC) established the NTTF in response to the Fukushima Daiichi nuclear power plant accident.
 - The NTTF provided a series of recommendations which resulted in a 10 CFR 50.54(f) letter to all U.S. plants.
- ❑ The Post-Fukushima Implementations in Taiwan
 - The Atomic Energy Council (AEC) requested that Taiwan Power Company (TPC) shall follow NTTF 2.1: Seismic to reevaluate seismic hazard and review the seismic design basis of nuclear facilities in Taiwan.
- ❑ TPC Launched “Taiwan SSHAC Level 3 Project” to:
 - Perform a SSHAC Level 3 procedure to develop Hazard Input Document (HID) for the assessment of seismic hazard at the nuclear facilities in Taiwan.

SSHAC Level 3 Procedure

NARLabs

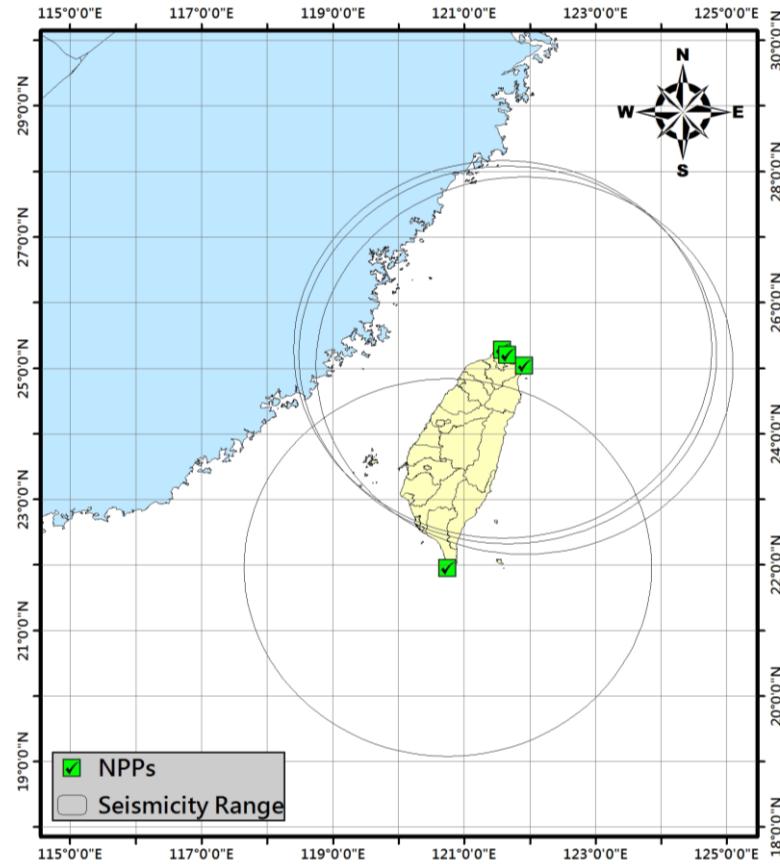


- Evaluation (~18 months)
 - Project Plan and Kick-off meeting
 - Hazard significant issues
 - Data gathering and databases compilation
 - Workshop #1 and Workshop #2
- Integration (~12 months)
 - Preliminary SSC and GMC models
 - Hazard sensitivity analysis
 - Workshop #3
- Documentation (~12 months)
- Review of SSHAC process, technical bases of assessments and documentation by Participatory Peer Review Panel

Project Scopes

- Seismic Source Characterization (SSC)
 - Cover the region of the study sites with a 320-kilometer radius
- Ground Motion Characterization (GMC)
 - Horizontal ground motion characterization at reference rock condition ($V_{s30} = 760 \text{ m/s}$)
- Hazard Sensitivity Analysis
 - Identify hazard significant issues
- Following SSHAC Level 3 Process to capture the Center, Body, and Range of the Technically Defensible Interpretations (CBR of the TDI)

Study Sites and 320-km Radius Seismic Range



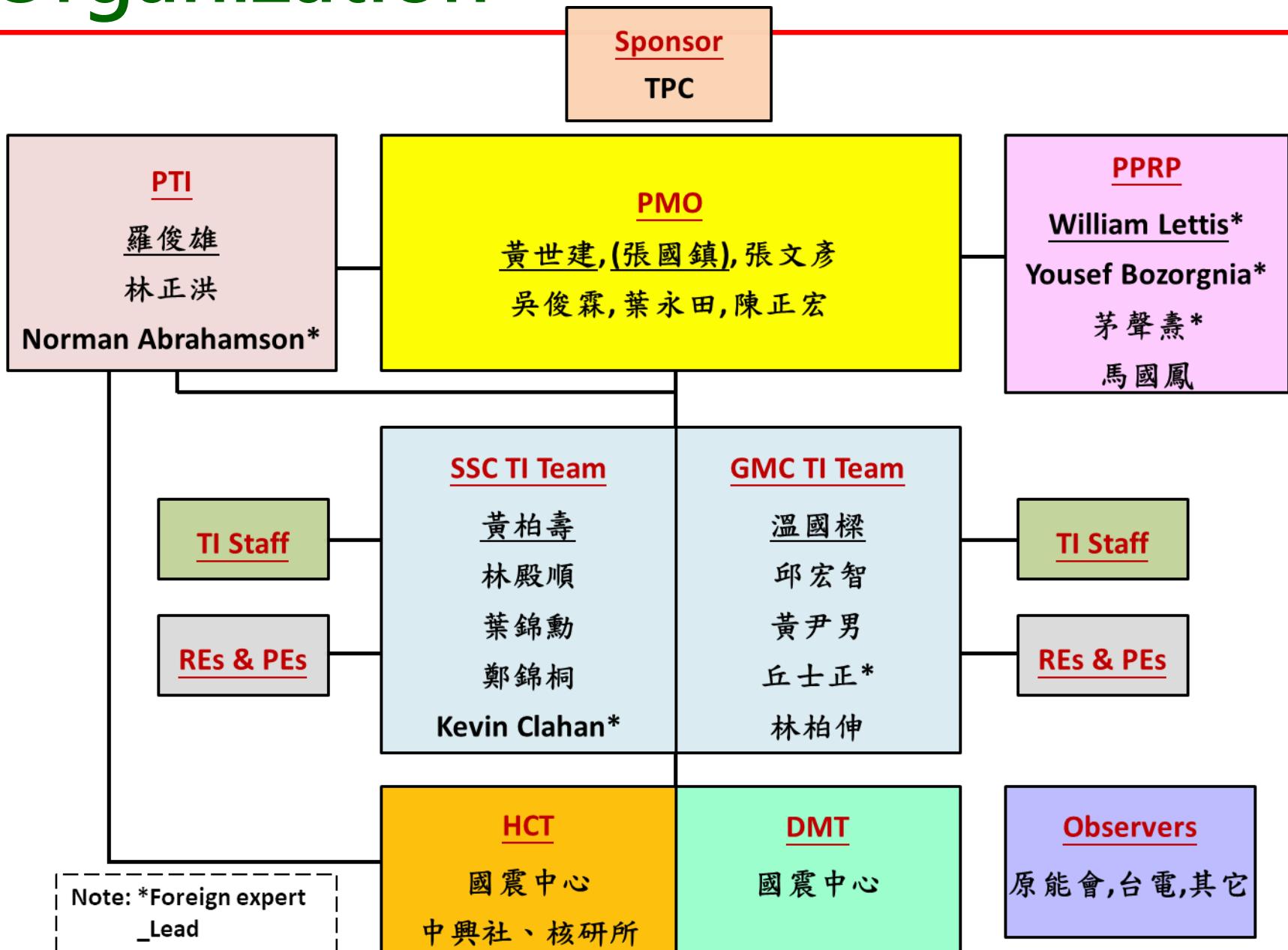
Project Scopes

- ❑ Use updated seismic information and present regulatory guidance and methodologies in accordance with 10 CFR 50.54(f) letter
- ❑ New site investigation would not be conducted in the Taiwan SSHAC Level 3 project
- ❑ The new data and model available before Workshop #2 has been fully evaluated and integrated into the SSC and GMC models
 - Cut-off date: 2016/09/30

Project Timeline

年	2015				2016				2017				2018				2019										
月	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	
查核點									●資料庫				●模型建置				●邏輯樹				●HID初稿						摘要報告 HID定稿
成果報告					1								2				3				4						5
重要會議		Kick-Off				WS #1				WS #2			WS #3			WS #4		WS #5		WS #6		Final					
	Pre-Kickoff	WM #1				WM #2				WM #3			WM #4			WM #5		WM #6		mini WS							
主要工作項目	SSC模型與邏輯樹																										
	地震目錄																										
	活動斷層模型																										
	GPS資料庫																										
	隱沒帶模型																										
	GMC模型與邏輯樹																										
	強地動資料庫																										
	強地動模擬																										
	網站與資料庫建置																										
	地震危害度敏感度分析																										
	參與式同儕審查																										

Organization



台灣地震危害高階模型建置

Reevaluation of Probabilistic Seismic Hazard of Nuclear Facilities in Taiwan Using SSHAC Level 3 Methodology

計畫目的

本計畫目的係為協助台灣電力公司因應我國核能管制機關
- 行政院原子能委員會之要求，針對核能電廠執行「NTTF
2.1: Seismic」地震危害重新評估的部分，執行程序則依循
美國「地震危害分析資深委員會(Senior Seismic Hazard
Analysis Committee, SSHAC)」所訂定第3層級(以下簡稱
SSHAC Level 3)之程序，並參考美國Diablo Canyon核能
電廠執行地震危害重新評估的程序與考量的技術議題，建
立適用於台電公司指定目標工址的地震源特徵(Seismic
Source Characterization, SSC)模型、地震動特徵(Ground
Motion Characterization, GMC)模型與地震危害度分析輸
入文件(Hazard Input Document, HID)，進行機率式地震
危害度分析(Probabilistic Seismic Hazard Analysis,
PSHA)並建立地震動反應譜(Ground Motion Response
Spectrum, GMRS)之用。

8 詳細內容 »

會議資訊

Kick-off Meeting (2015/8/18 ~ 2015/8/19)

會議內容

議程下載

Workshop 1 (2016/3/14 ~ 2016/3/17)

會議內容

議程下載

影片紀錄

Workshop 2 (2016/10/3 ~ 2016/10/7)

會議內容

議程下載

影片紀錄

Workshop 3 (2017/6/19 ~ 2017/6/23)

會議內容

議程下載

影片紀錄

最新消息

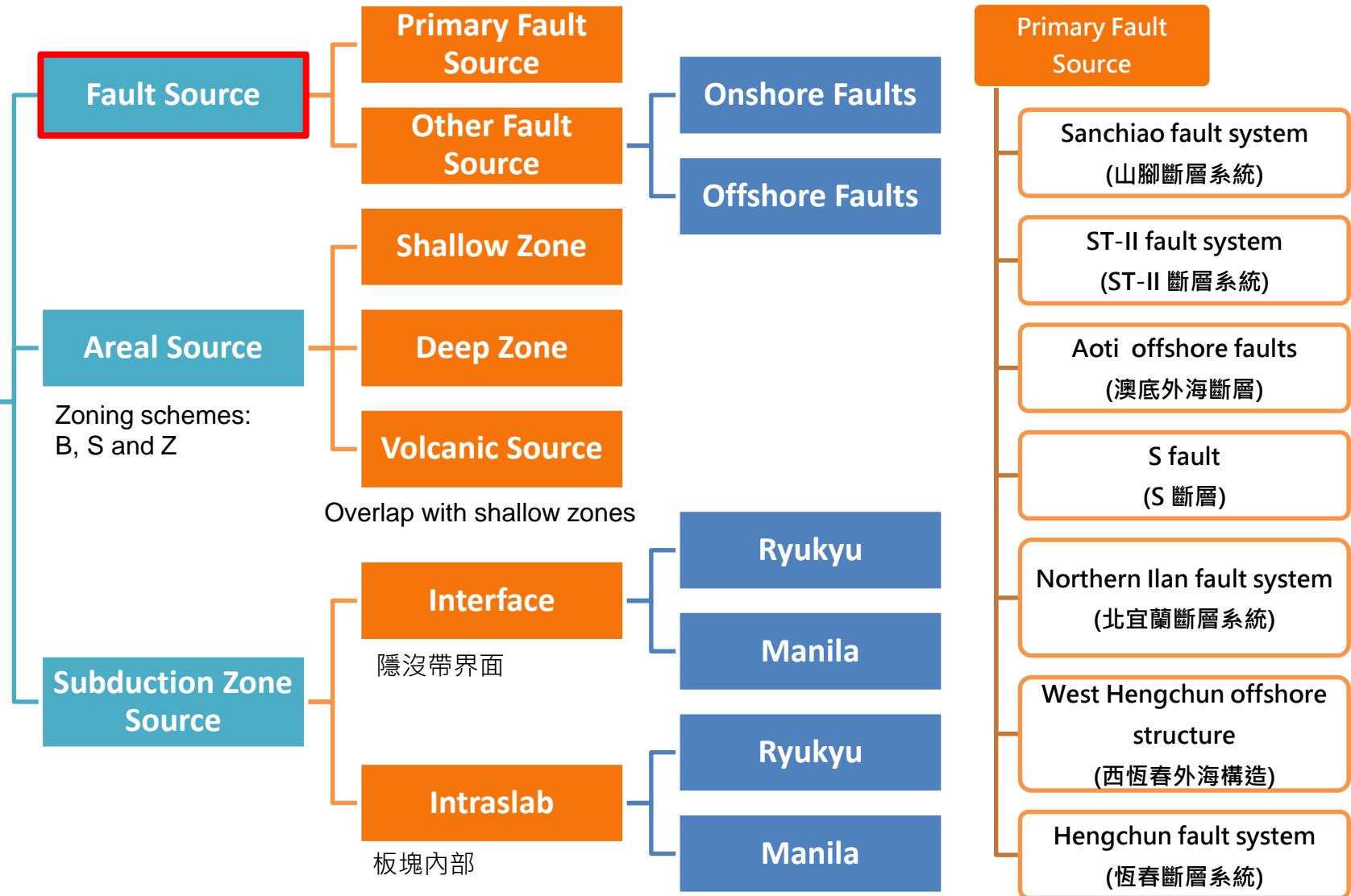
- 2015-09-02 新增Kick-off Meeting會議議程
- 2016-04-15 更新Workshop 1會議資訊
- 2017-05-30 專案計劃書更新
- 2017-06-20 更新Workshop 3會議資訊
- 2017-07-27 更新Workshop 2會議資訊
- 2018-02-02 專案計劃書更新

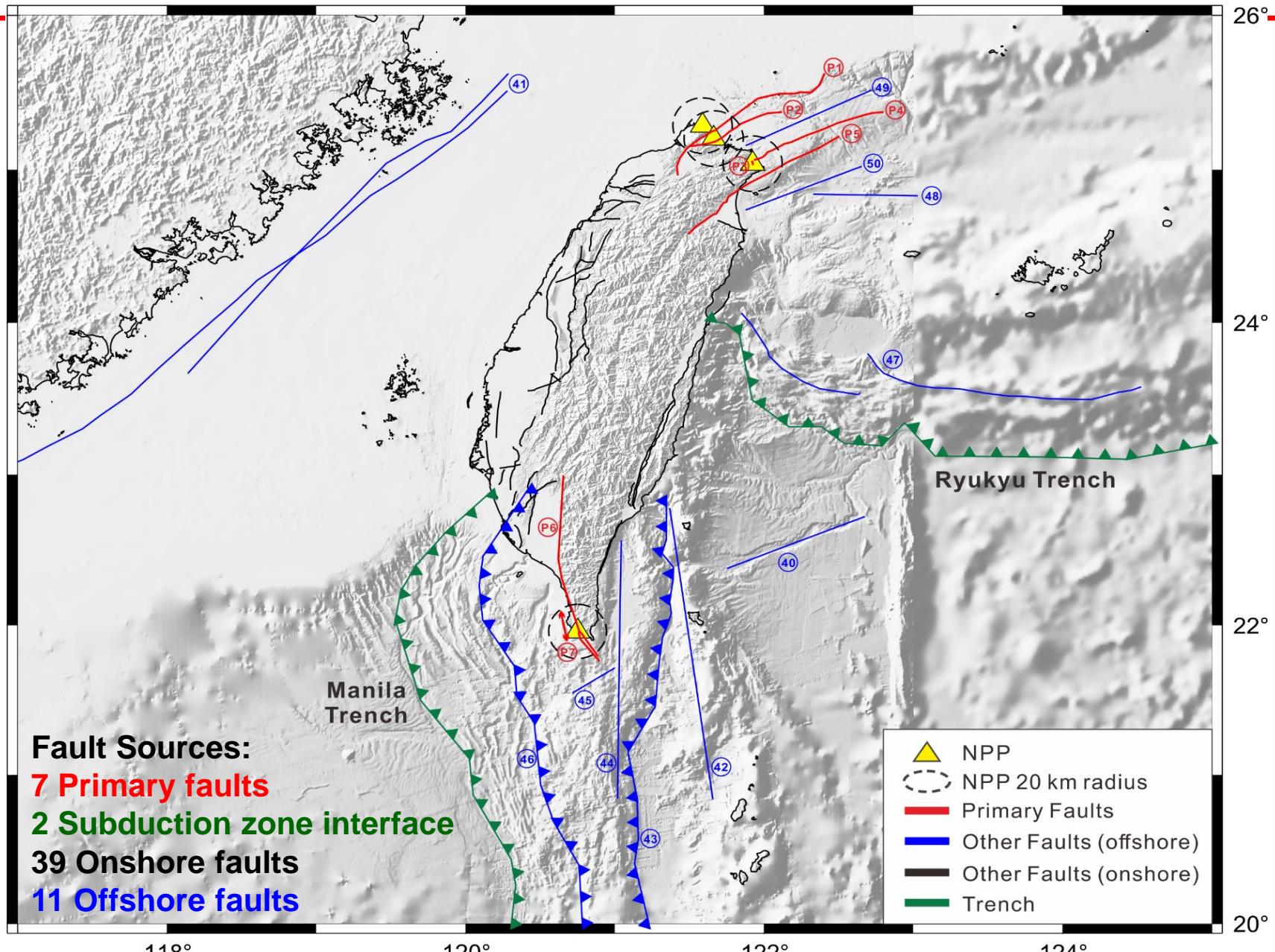
Website: sshac.ncree.org.tw

Q&A Email:

sshactaiwan@ncree.narl.org.tw

Seismic Source Characterization





Fault Sources

Primary Faults		Other Faults			
P1	Sanchiao fault system	1	Shuanglienpo structure	26	Hsiaokangshan fault
P2	ST-II fault system	2	Yangmei structure	27	Kaoping River structure
P3	S fault	3	Hukou fault	28	Milun fault
P4	Aoti offshore faults	4	Fengshan river strike-slip structure	29	Longitudinal Valley fault
P5	Northern Ilan fault system	5	Hsinchu fault	30	Central Range structure
P6	Hengchun fault system	6	Hsincheng fault	31	Luyeh fault
P7	West Hengchun offshore structure	7	Hsinchu frontal structure	32	Taimali coastline structure
Subduction zone interfaces		8	Touhuanping structure	33	Southern Ilan structure
1	Ryukyu trench	9	Miaoli frontal structure	34	Chushiang structure
2	Manila trench	10	Tunglo structure	35	Gukeng structure

Fault Sources

7 Primary faults

2 Subduction zone interface

39 Onshore faults

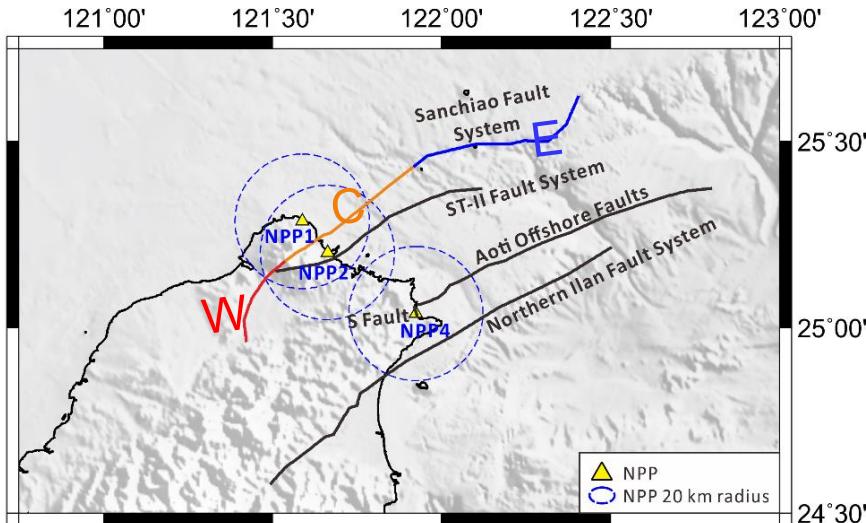
11 Offshore faults

11	East Miaoli structure	36	Tainan frontal structure
12	Shihtan fault	37	Longchuan structure
13	Sanyi fault	38	Youchang structure
14	Tuntzuchiao fault	39	Fengshan hills frontal structure
15	Changhua fault	40	Taitung Canyon Fault
16	Chelungpu fault	41	Binhai Fault
17	Tamaopu - Shuangtung fault	42	North Luzon Strike Slip Fault
18	Chiuchiungkeng fault	43	North Luzon Backthrust Fault
19	Meishan fault	44	East Hengchun Offshore Fault
20	Chiayi frontal structure	45	Hengchun Ridge Offshore Fault
21	Muchiliao - Liuchia fault	46	Manila Splay Fault
22	Chungchou structure	47	Ryukyu Strike Slip Fault
23	Hsinhua fault	48	Okinawa Trough Fault
24	Houchiali fault	49	Additional Fault E
25	Chishan fault	50	Additional Fault I

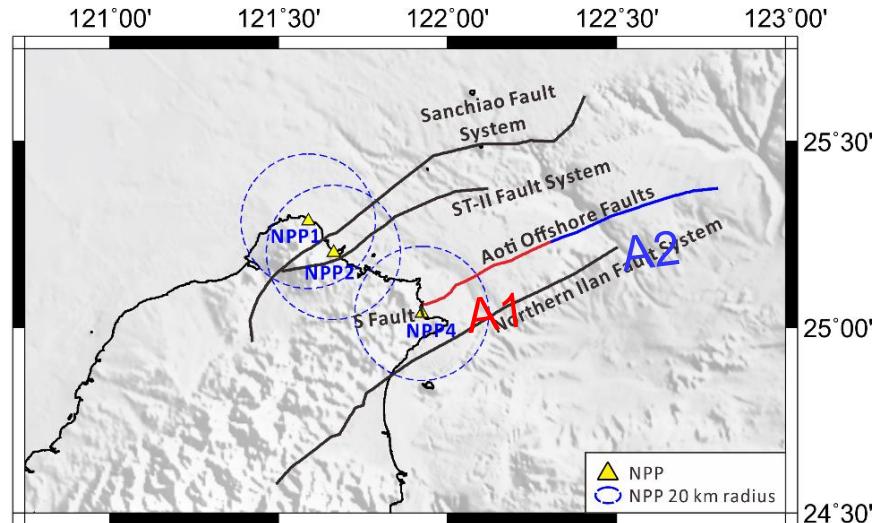
Northern Primary Faults

NARLabs

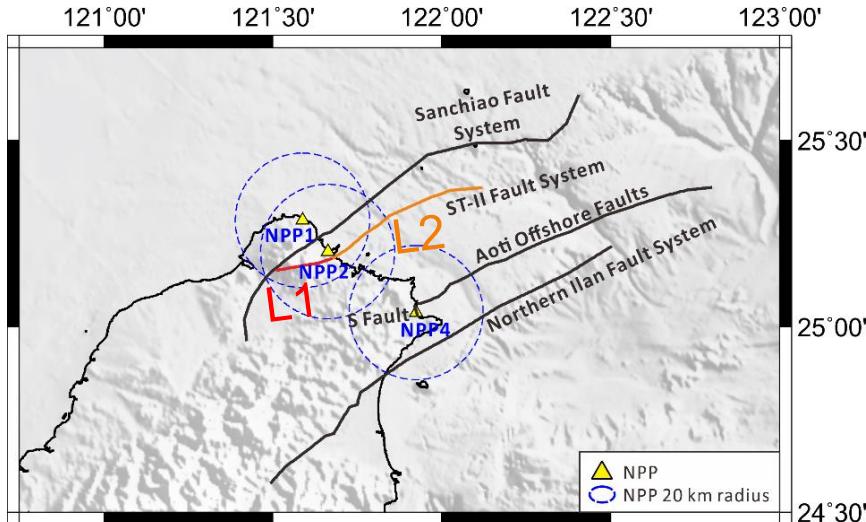
Sanchiao fault system (山腳斷層系統)



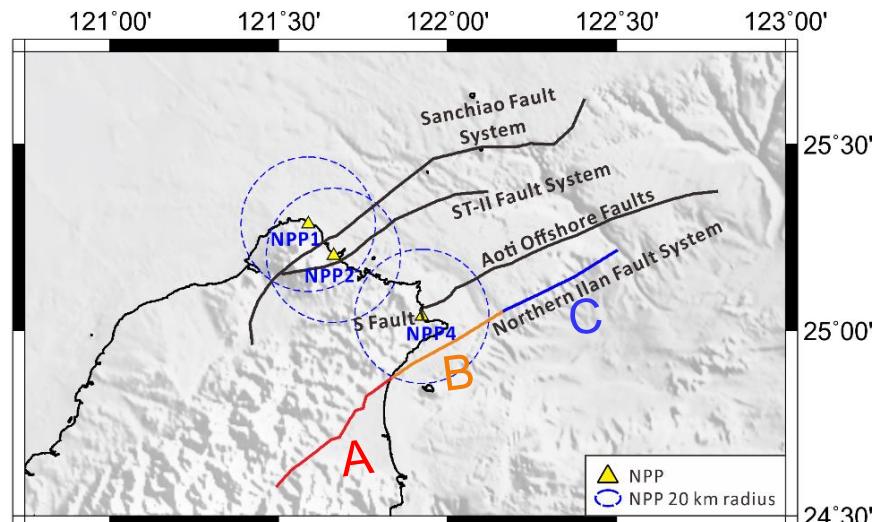
Aoti offshore faults and S fault (澳底外海斷層與 S 斷層)



ST-II fault system (ST-II 斷層系統)

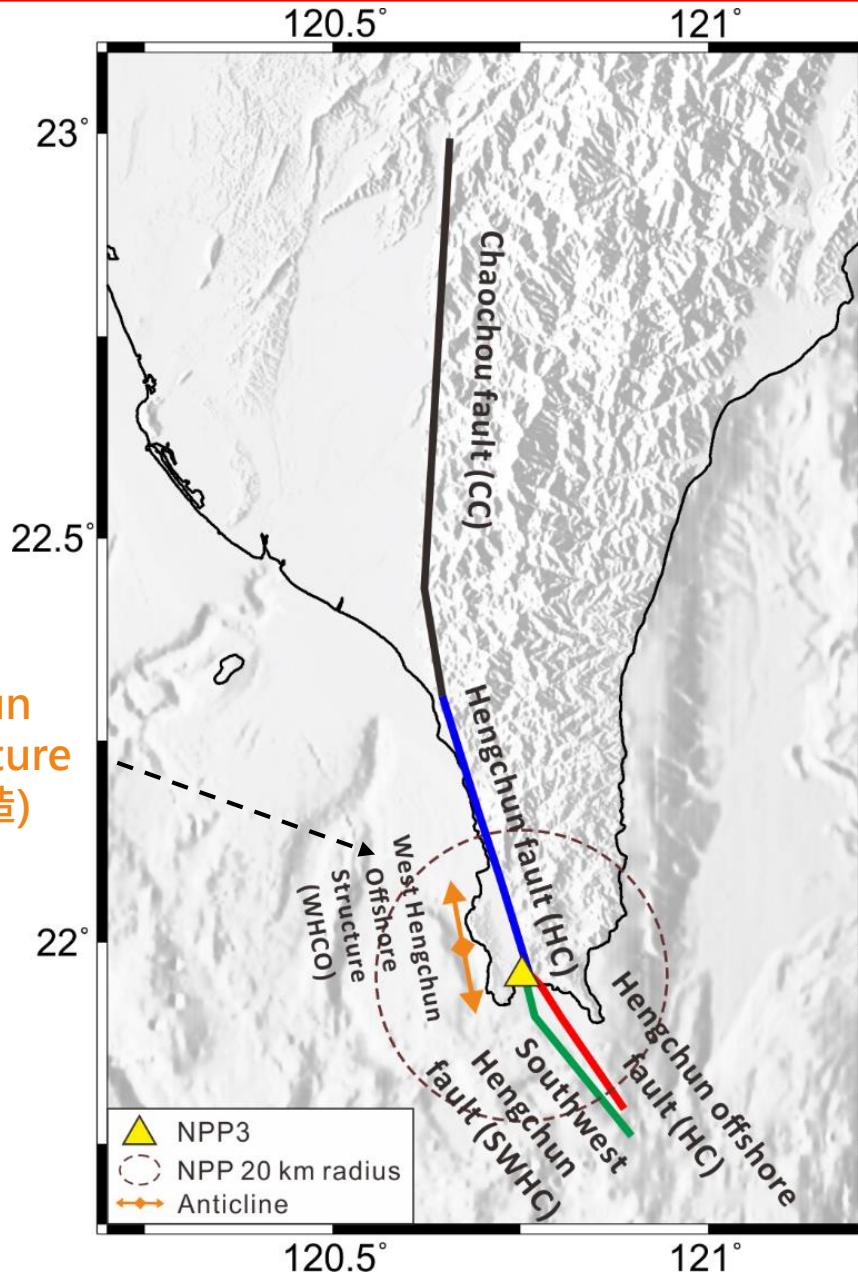


Northern Ilan fault system (北宜蘭斷層系統)



Southern Primary Faults

NARLabs



Hengchun fault system
Including:

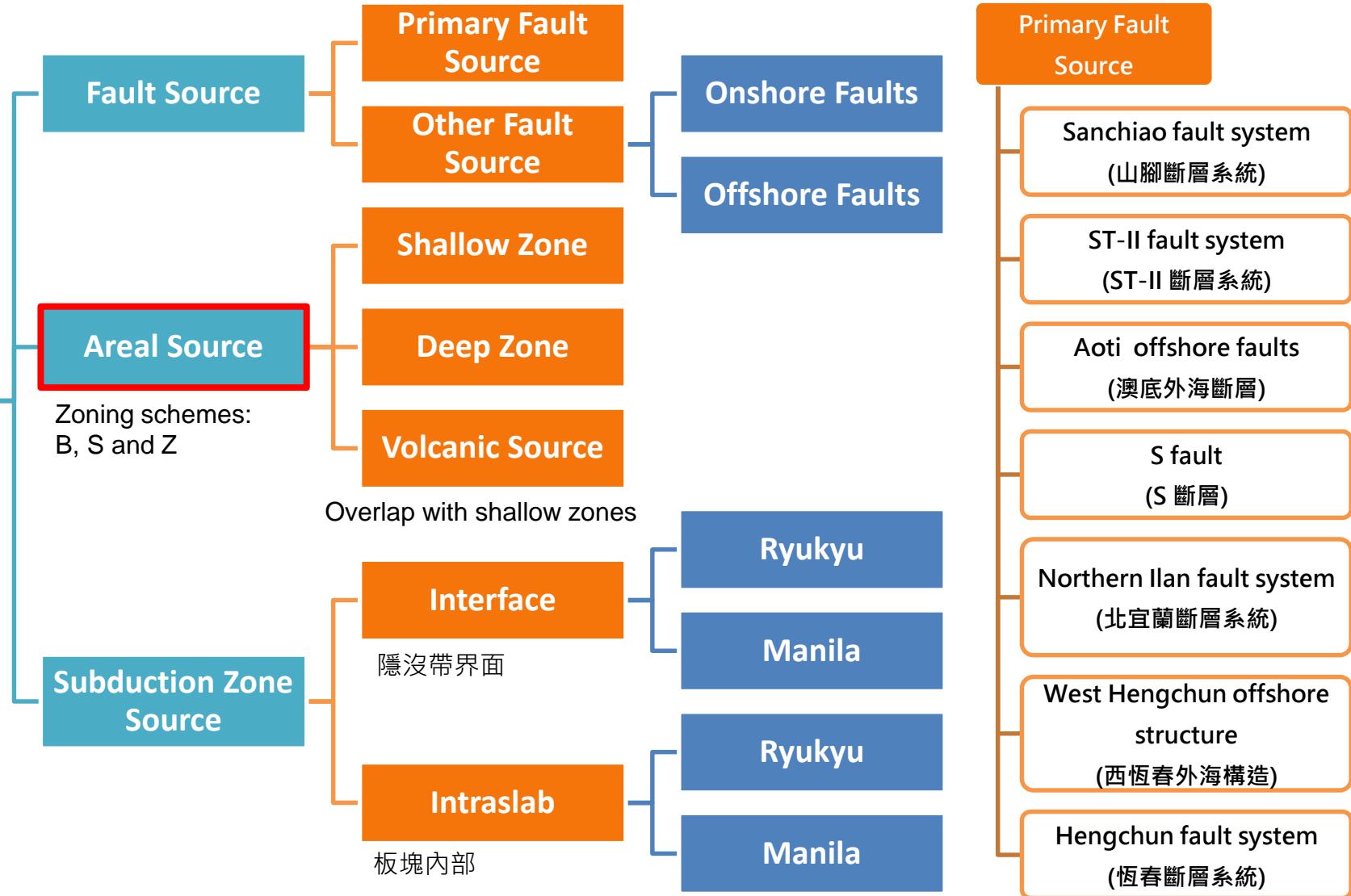
潮州斷層
Chaozhou fault

恆春斷層
Hengchun fault

恆春外海斷層
Hengchun offshore fault

西南恆春斷層
Southwest Hengchun fault

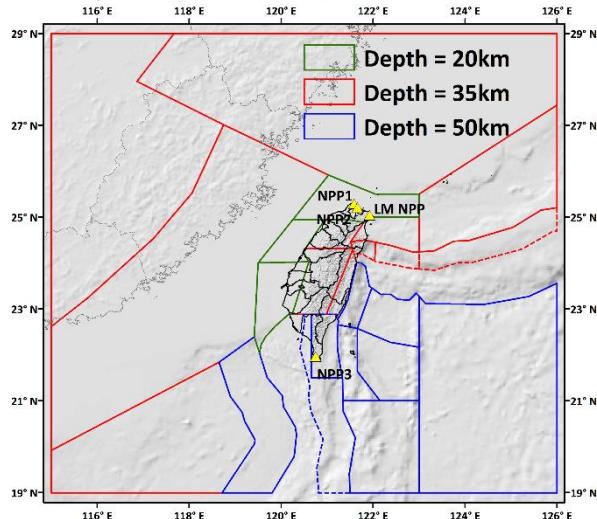
Seismic Source Characterization



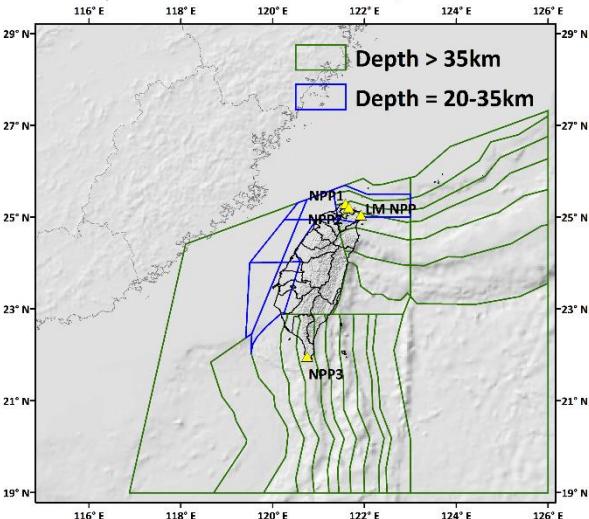
Areal Source

Modified from: Institute of Earth Sciences and National Taiwan University (1993)

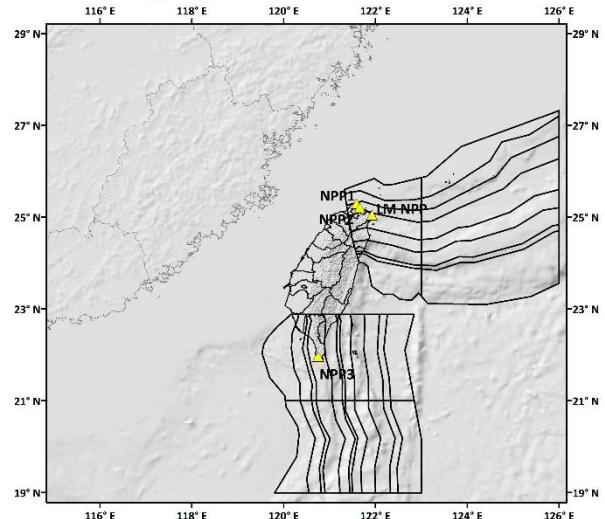
Zoning Scheme B, Shallow Zone



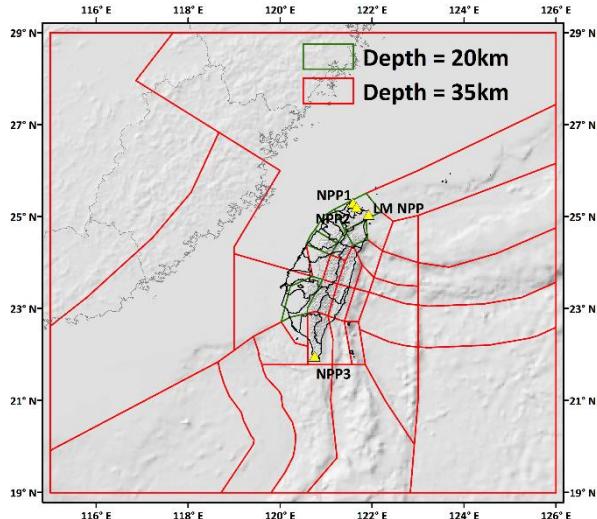
Zoning Scheme B, Deep Zone



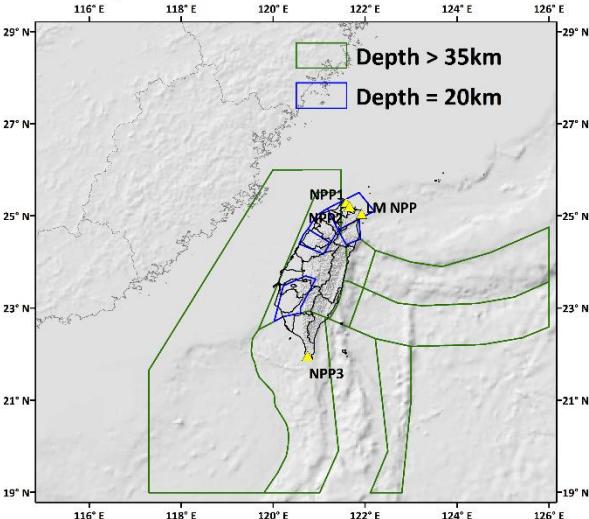
Zoning Scheme B, Subduction Zone



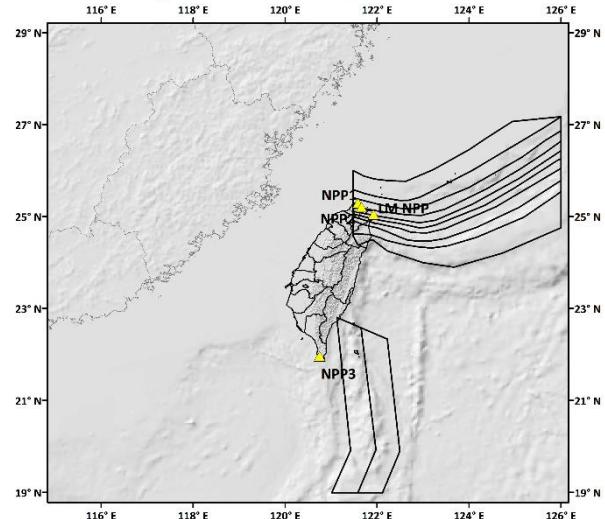
Zoning Scheme S, Shallow Zone



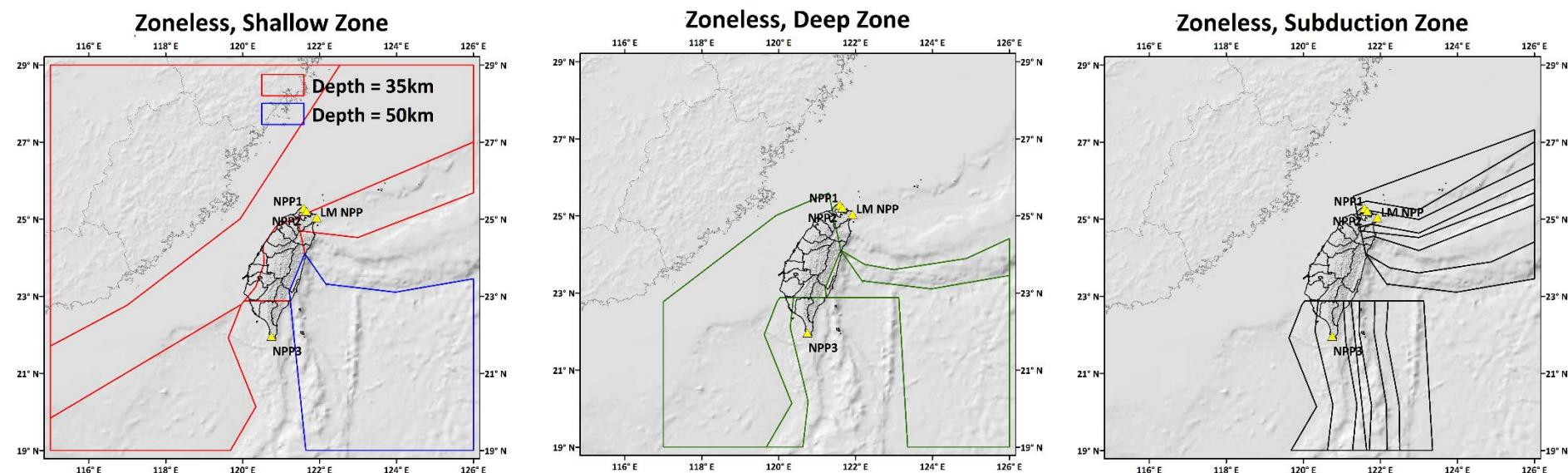
Zoning Scheme S, Deep Zone



Zoning Scheme S, Subduction Zone



Areal Source

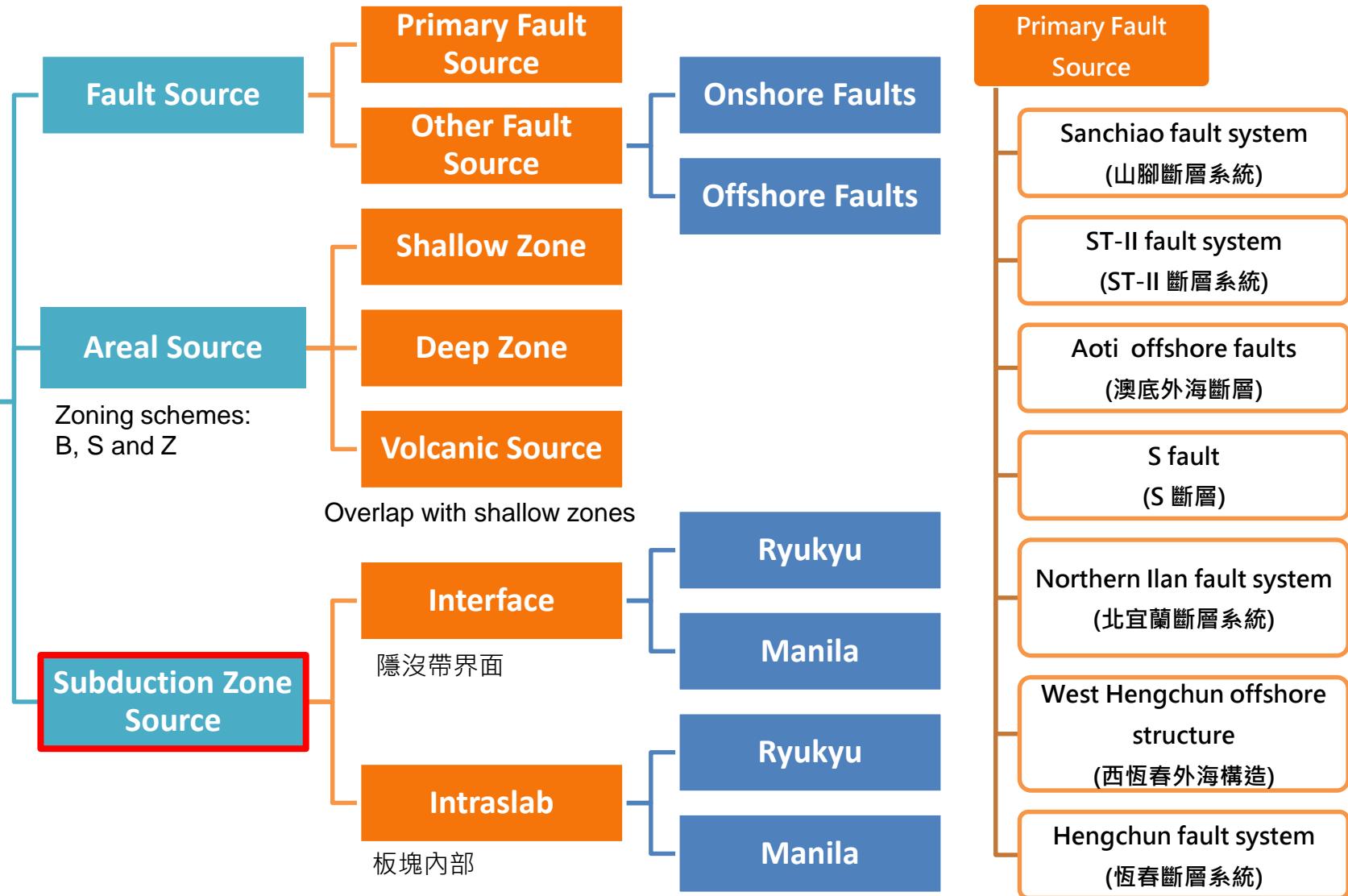


Zone scheme: Liu, H. J. and Chang, C. W. (2019)

Smoothing Seismicity Method: Liu, H. J., Abrahamson, N. A., and Yeh, C. H. (2018)

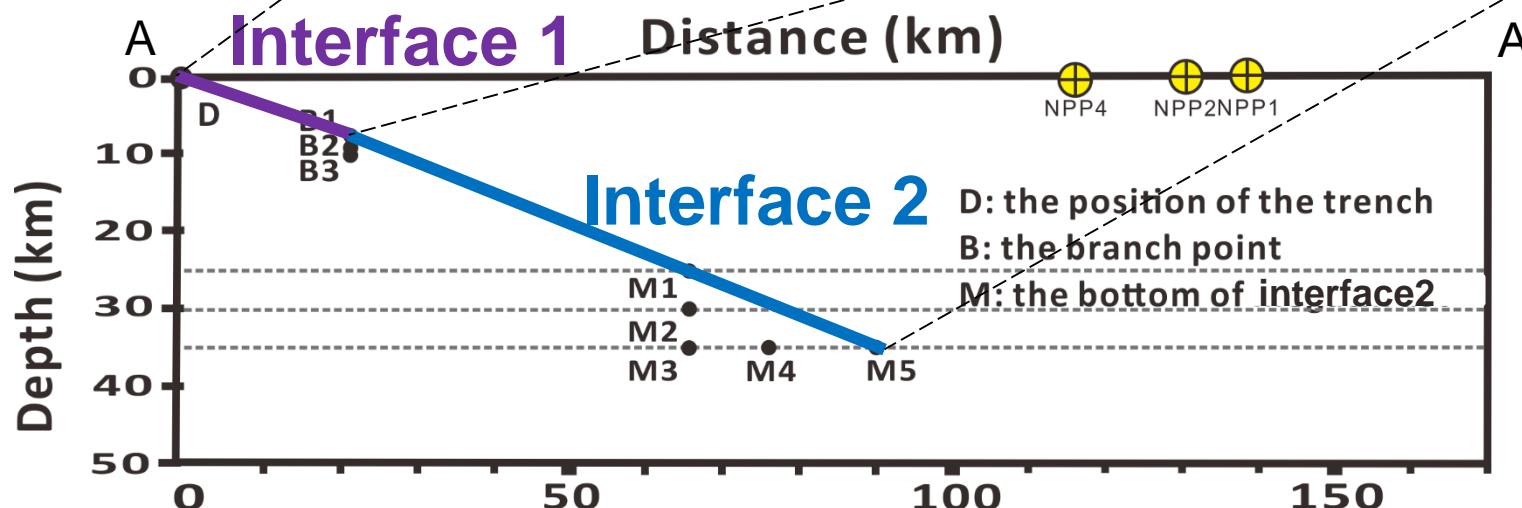
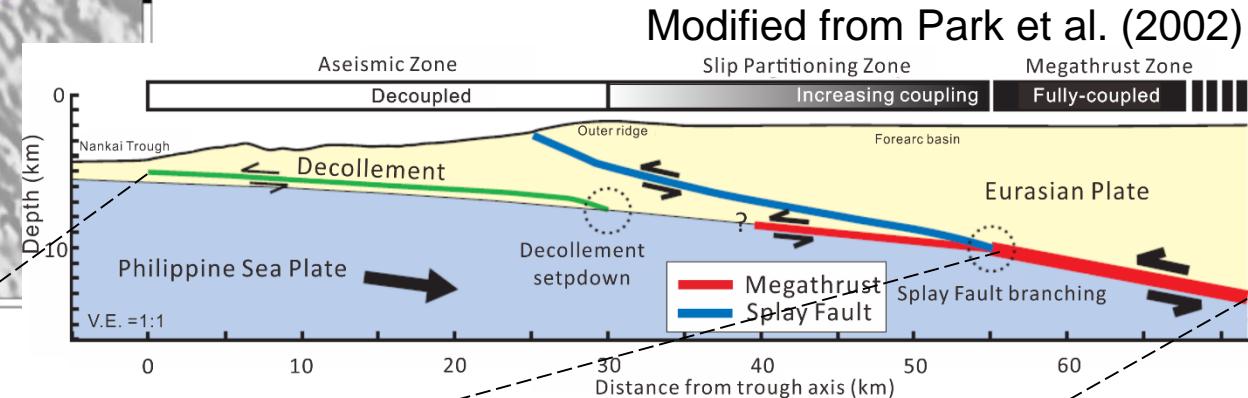
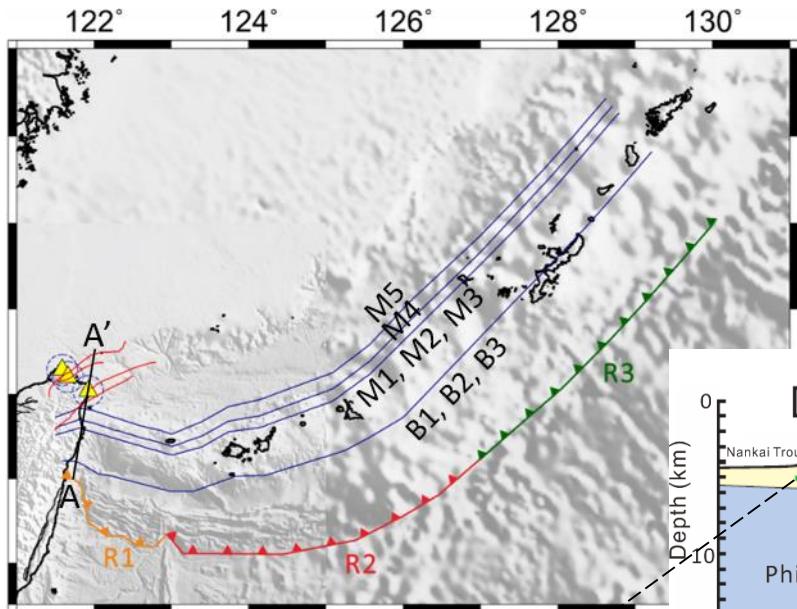
	Shallow zone	Deep zone	Beneath interface crustal zone	Intraslab zone
Zoning Scheme B	25	15	4	6
Zoning Scheme S	38	13	-	11
Zoning Scheme Z	6	4	2	6

Seismic Source Characterization



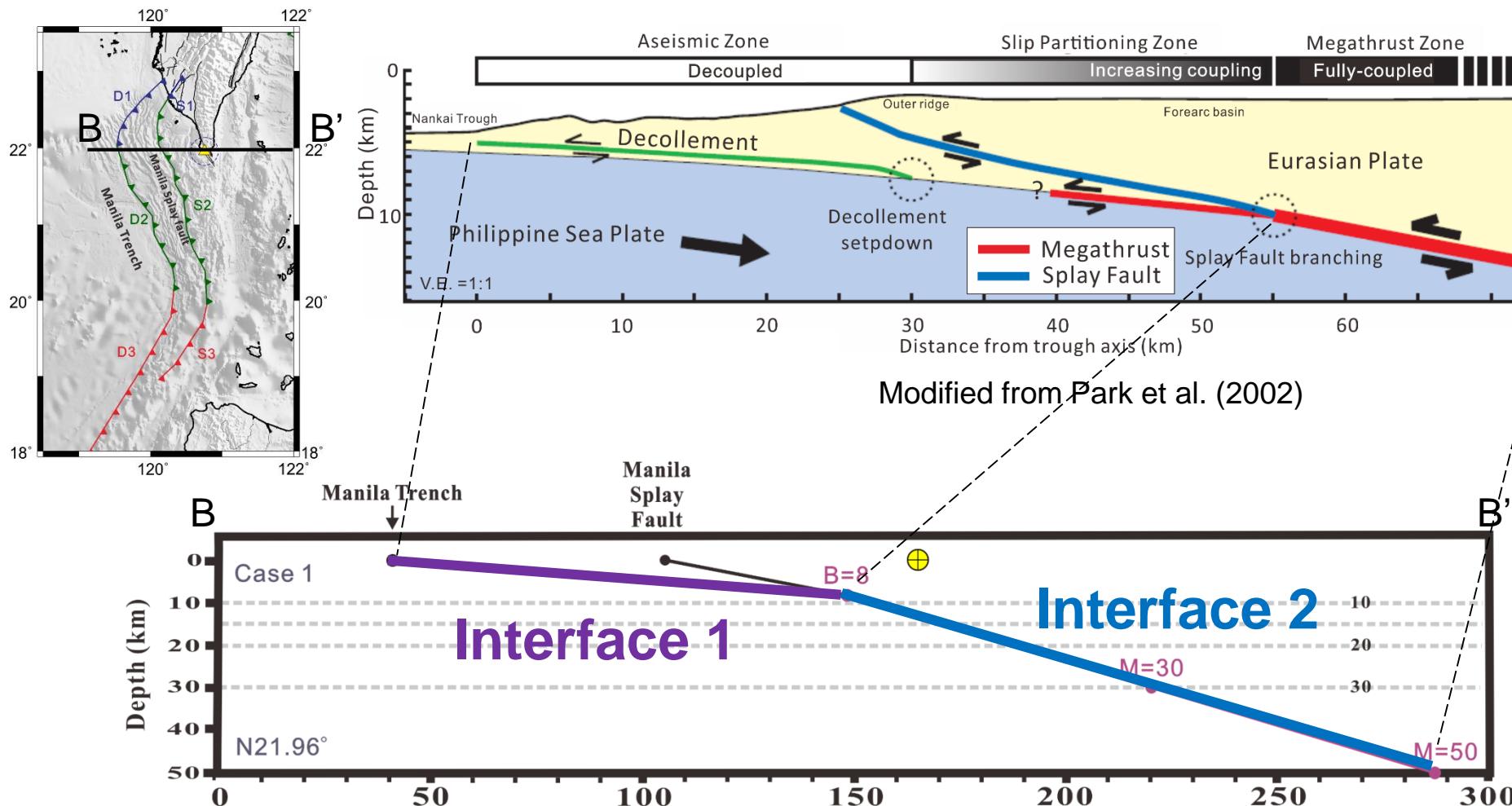
Ryukyu Subduction Interface

NARLabs

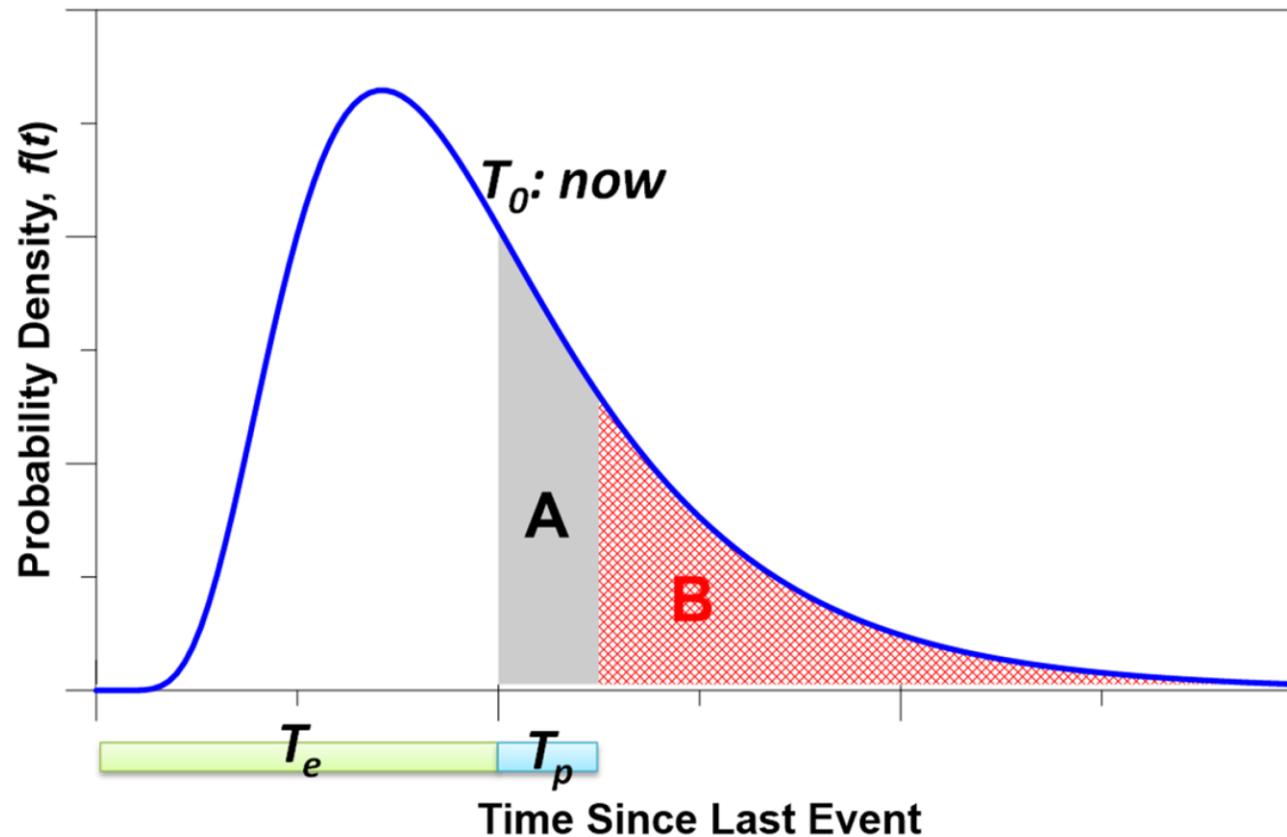


Manila Subduction Interface

NARLabs



Time Dependency Probability Model



Calculation of the conditional probability from a probability density function. The time interval of interest (exposure time) is the gray area (A). The survivor function is the entire colored area (A+B). The conditional probability is the ratio of the two areas.

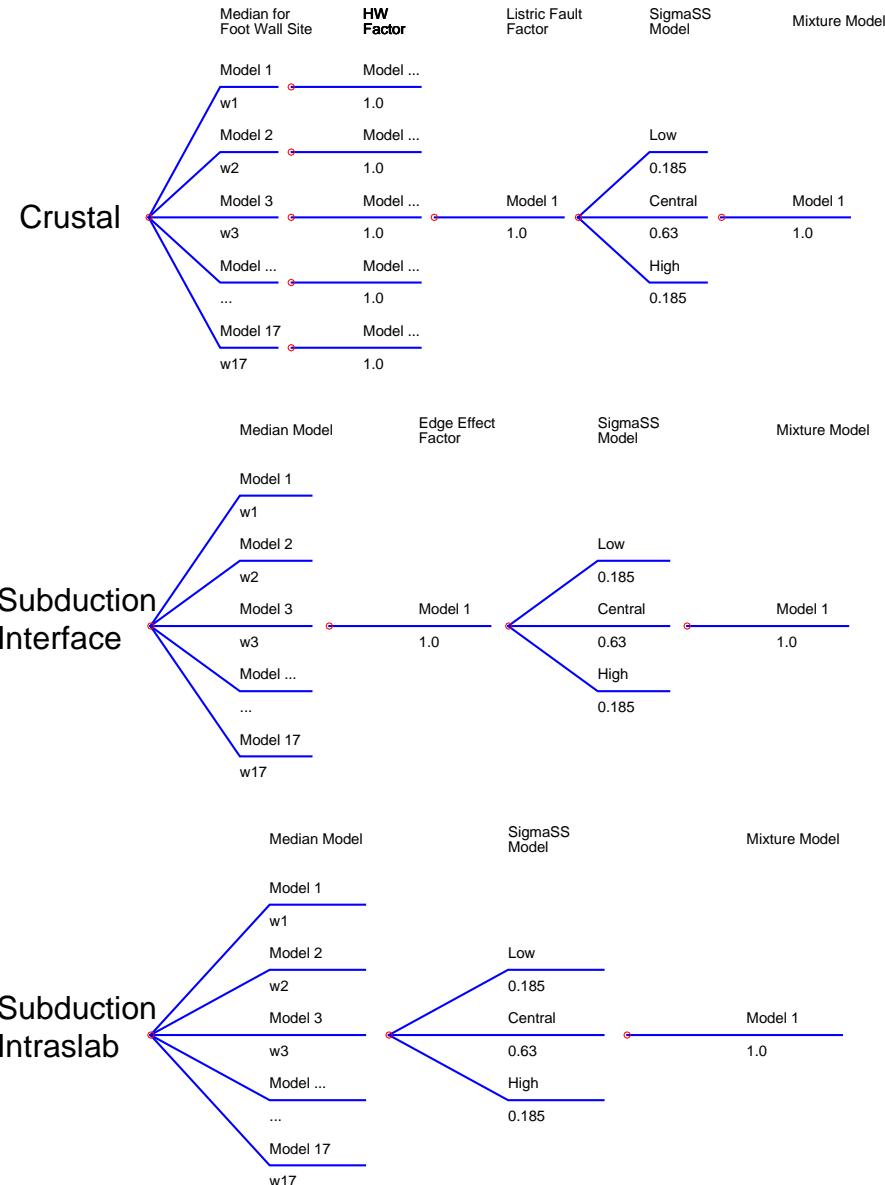
Ground Motion Characterization

□ Three Source Types

- Crustal source
- Subduction interface source
- Subduction intraslab source

□ Nodes of Logic Trees

- Continuous distribution of median ground motion for each source type (17 branches)
- Hanging wall models for crustal source (1 branch)
- Listric fault factor for crustal source (1 branch)
- Edge effect factor for interface source (1 branch)
- Single-station sigma for each source type (3 branches)
- Mixture model for each source (1 branch)



謝謝大家

Fault Sources

主要斷層		其他斷層			
P1	山腳斷層系統	1	雙連坡構造	26	小崙山斷層
P2	ST-II 斷層系統	2	楊梅構造	27	高屏溪構造
P3	S 斷層	3	湖口斷層	28	米崙斷層
P4	澳底外海斷層	4	鳳山溪走向滑移構造	29	縱谷斷層
P5	北宜蘭斷層系統	5	新竹斷層	30	中央山脈構造
P6	恆春斷層系統	6	新城斷層	31	鹿野斷層
P7	西恆春外海構造	7	新竹前緣構造	32	太麻里海岸構造
隱沒帶界面		8	斗煥坪構造	33	南宜蘭構造
1	琉球隱沒帶	9	苗栗前緣構造	34	初香構造
2	馬尼拉隱沒帶	10	銅鑼構造	35	古坑構造
Fault Sources		11	東苗栗構造	36	台南前緣構造
7	Primary faults	12	獅壇斷層	37	龍船構造
2	Subduction zone interface	13	三義斷層	38	右昌構造
39	Onshore faults	14	屯子角斷層	39	鳳山丘陵前緣構造
11	Offshore faults	15	彰化斷層	40	台東峽谷斷層
		16	車籠埔斷層	41	濱海斷層
		17	大茅埔-雙冬斷層	42	北呂宋走向滑移斷層
		18	九穹坑斷層	43	北呂宋背衝斷層
		19	梅山斷層	44	東恆春外海斷層
		20	嘉義前緣構造	45	恆春海脊外海斷層
		21	木屐寮-六甲斷層	46	馬尼拉分歧斷層
		22	中州構造	47	琉球走向滑移斷層
		23	新化斷層	48	沖繩海槽斷層
		24	后甲里斷層	49	附加斷層 E
		25	旗山斷層	50	附加斷層 I

Fault Sources

7 Primary faults

2 Subduction zone interface

39 Onshore faults

11 Offshore faults