esg5

Taipei, Taiwan
2016/8/15~17

NARLabs
國家實驗研究院

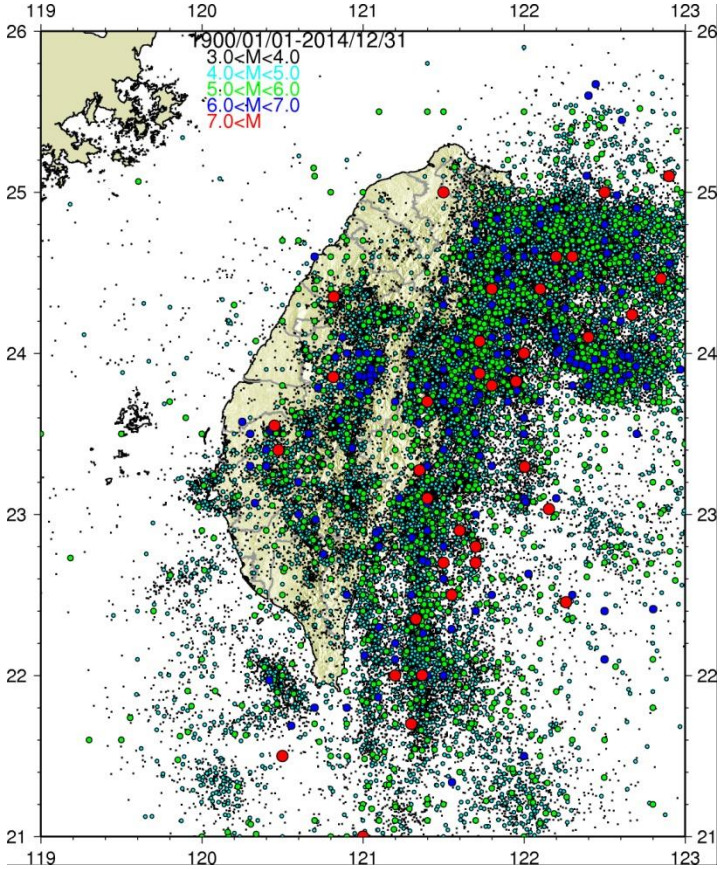
Construction of the Shallow Shear-wave Velocity Model in Taiwan

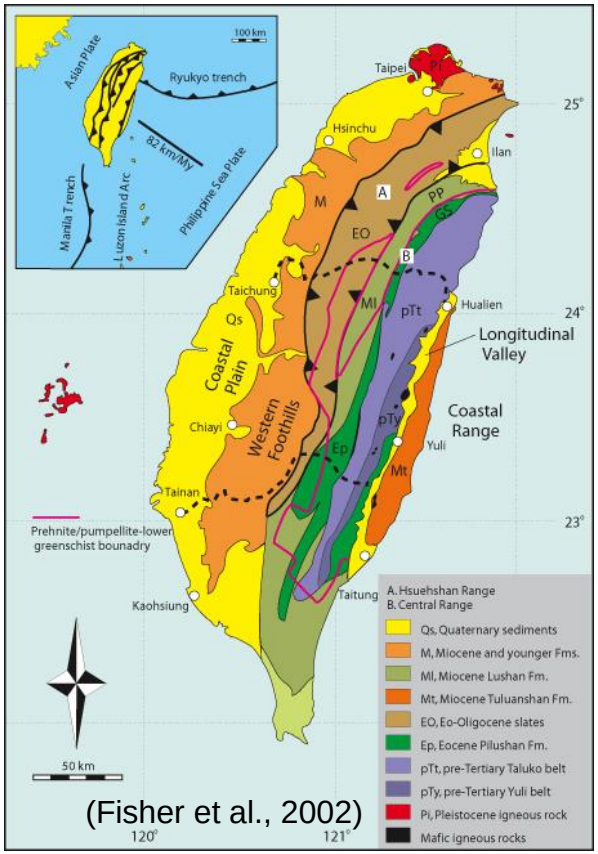
Kuo-Liang WEN[1,2], Che-Min LIN[2], Chun-Hsiang KUO[2], Chun-Te CHEN[3], Jyun-Yan HUANG[2]

1. Department of Earth Sciences, National Center University, Taiwan
2. National Center for Research on Earthquake Engineering, Taiwan
3. Institute of Earth Sciences, Academia Sinica, Taiwan

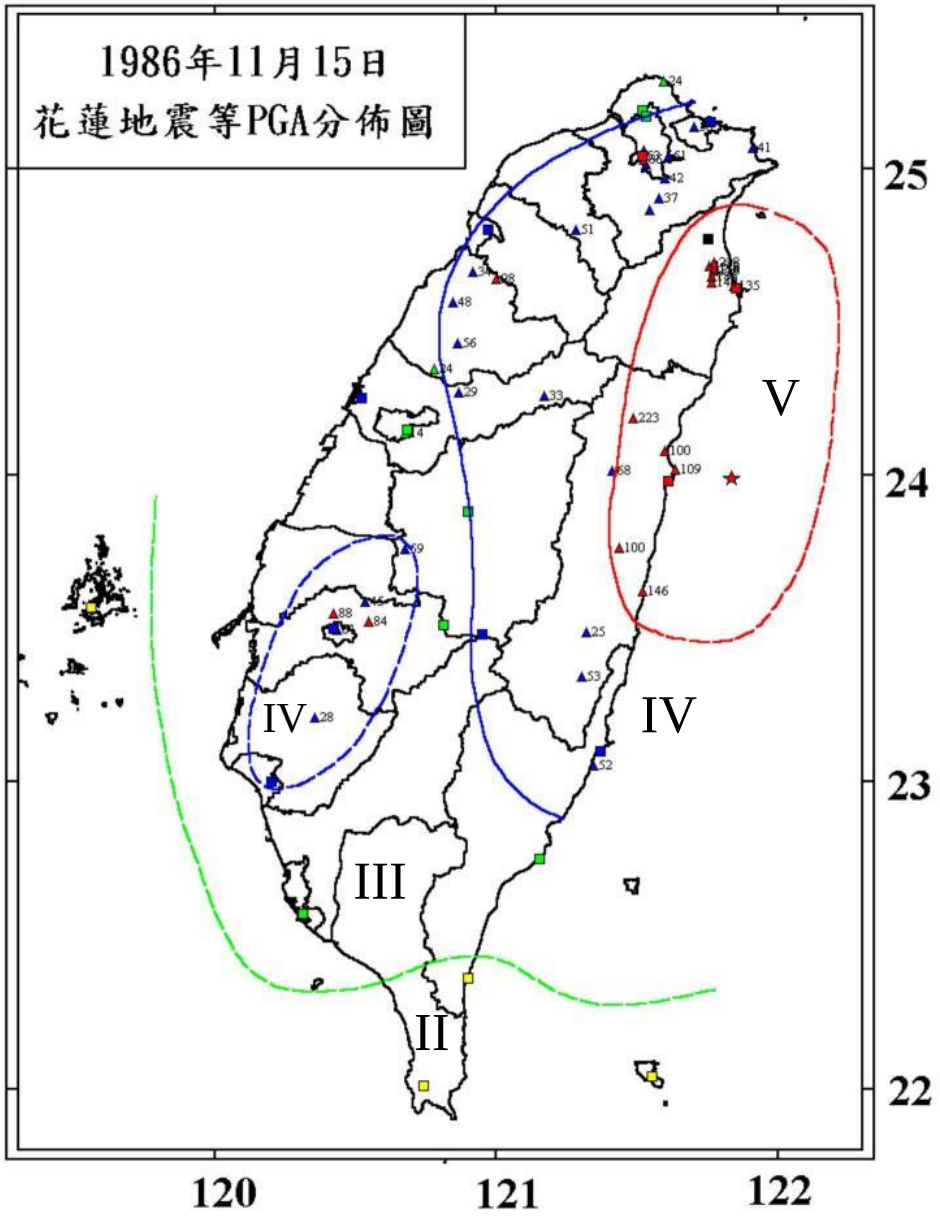
Introduction

- **High Seismicity in Taiwan**
- **Strong site characteristics of the thick and soft Quaternary sediments**
  - **Taipei Basin, Ilan Plain, Western Coastal Plain, Pingtung Plain**





(Fisher et al., 2002)



1986/11/15

Hualien Eq.

M_L=6.8

3F

台北縣中和市員山路之華陽市場，原為三層多柱少牆鋼筋混凝土的市場建築物，由於2、3層改為住家後砌築了許多磚造外牆與隔間牆，使得建築物成為上剛下軟的結構，加上過大的超載，在耐震上十分不利。在此次地震襲擊下，幾乎大部份一、二樓的支柱折斷，造成12人死亡，數十人受傷的慘劇。

14F

台北市復興南路一段某大廈，一樓剪力牆腳及牆邊構材部份被壓碎，鋼筋暴露且扭曲變形，牆面呈斜向之剪力龜裂，一、二樓間之混凝土樓板破裂並下陷。

Depth contour to the basement top from deep drilling. (Central Geol. Surv.)

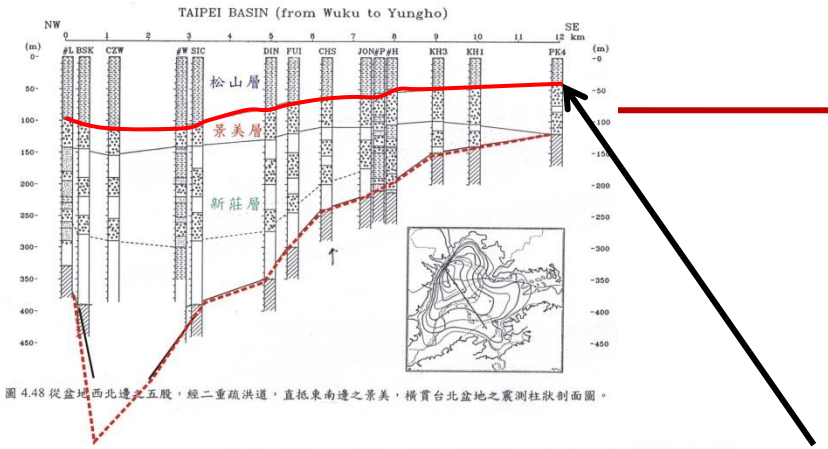
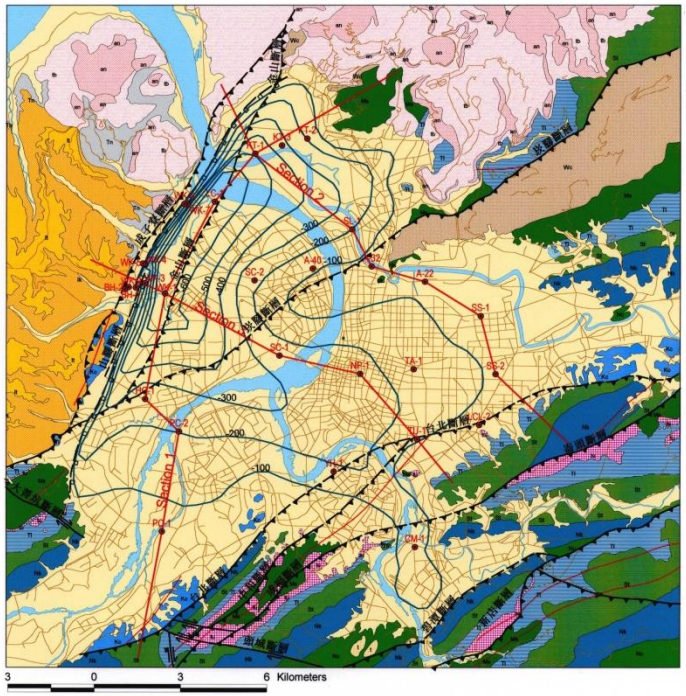


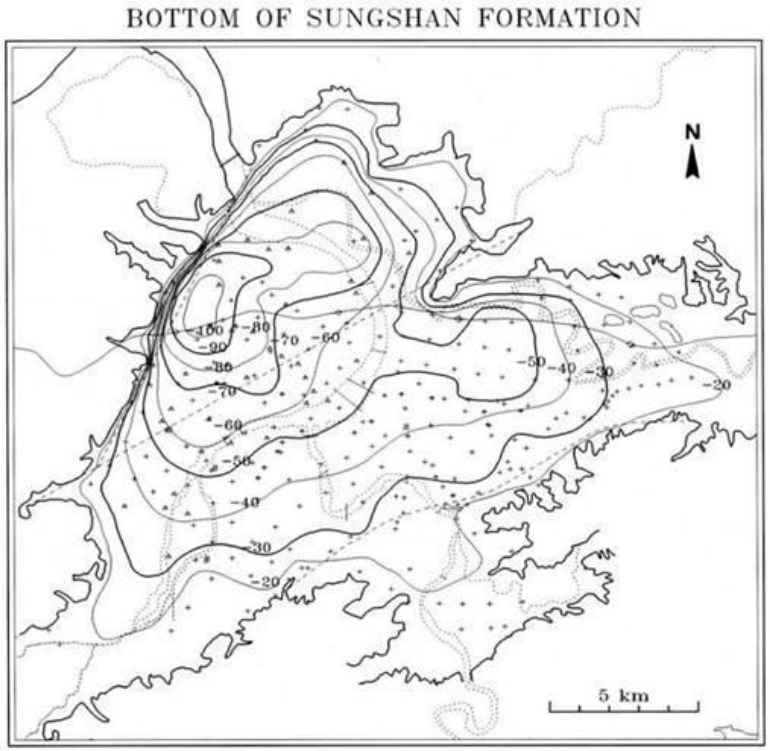
圖 4.48 從盆地西北邊之五股，經二重疏洪道，直抵東南邊之景美，橫貫台北盆地之震測柱狀剖面圖。



a	沖積層
t	階地堆積
an	安山岩流
tb	凝灰角礫岩
It	紅土化土壤
lk	林口礫石
Tn	大南灣層
Kc	桂竹林層
Nc	南莊層
Nk	南港層
St	石底層
Tl	大寮層
Bu	公館凝灰岩
Ms	木山層
Wc	五指山層

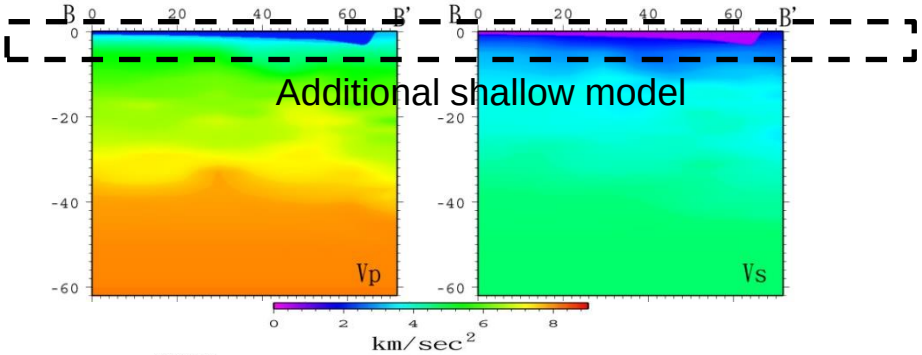
	剖面線
	基盤等深線
	鑽井位置
	平移斷層
	正斷層
	逆斷層
	逆斷層（掩蓋）

井號	基盤深度	井深	井名	鑽井單位
A-22	70.0	75.0		高公局
A-32	71.6	76.7		高公局
A-40	112.0	118.1		高公局
BH-1	14.2	90.0		住都局
BH-2	30.0	80.0		住都局
CM-1	126.5	274.3	景美一號井	經濟部
HC-1	246.0	2317.0	新莊一號井	中油
KT-1	499.0	520.0	關渡一號井	地調所
KT-2	197.0	230.0	關渡二號井	地調所
KT-3	302.0	320.0	關渡三號井	地調所
LC-1		300.0	蘆洲一號井	地調所
LCL-2	51.2	248.6	六張犁二號井	經濟部
NP-1	213.9	260.7	新公園一號井	台北市
PC-1	58.8	88.0	板橋一號井	地調所
PC-2	204.0	300.0	板橋二號井	地調所
SC-1	244.9	300.0	三重一號井	地調所
SC-2				
SL-1	202.5	230.0	土林一號井	地調所
SS-1		100.0	松山一號井	地調所
SS-2	112.0	150.0	松山二號井	地調所
TU-1	112.0	280.0	台大一號井	地調所
WK-1	679.0	760.0	五股一號井	地調所
WK-2	45.0	60.0	五股二號井	地調所
WK-3	164.0	165.0	五股三號井	地調所
WK-4		100.0	五股四號井	地調所
WK-5	45.0	50.0	五股五號井	地調所
WK-6	125.0	182.0	五股六號井	地調所
WK-7	222.0		五股七號井	地調所
YH-1	174.2	200.0	永和一號井	地調所
TA-1	157.5	220.0	大安一號井	地調所

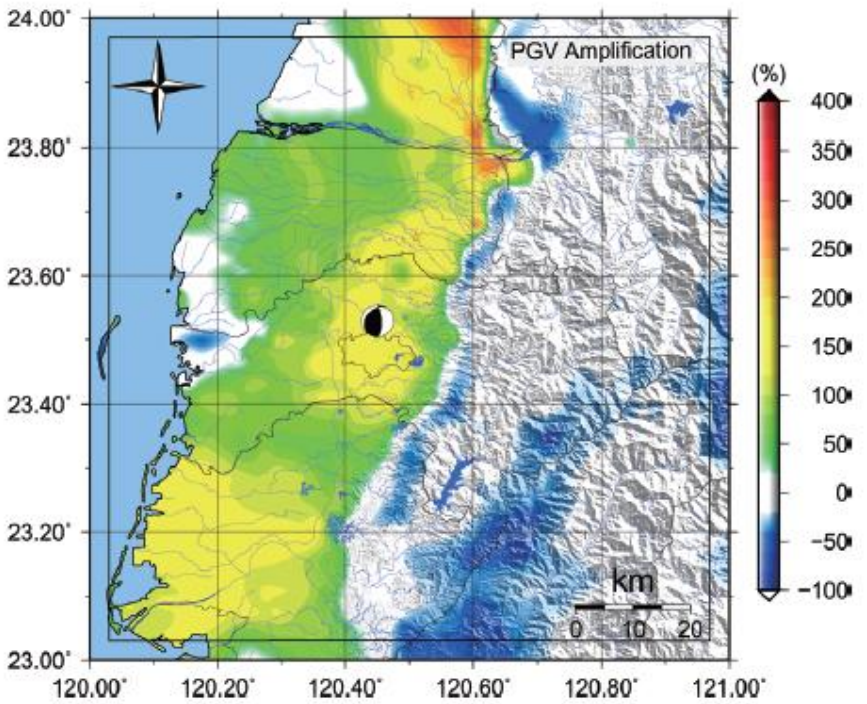


Introduction

- **The resolutions of shallow part (within a depth of 1 or 2 km) of existing 3D tomography velocity models are insufficient**
- **A integrated and detail shallow velocity model of Taiwan is essential for ground motion prediction and simulation in the future**



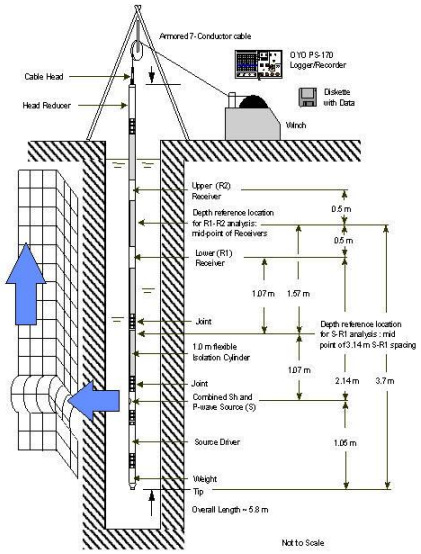
(Lin, 2009)

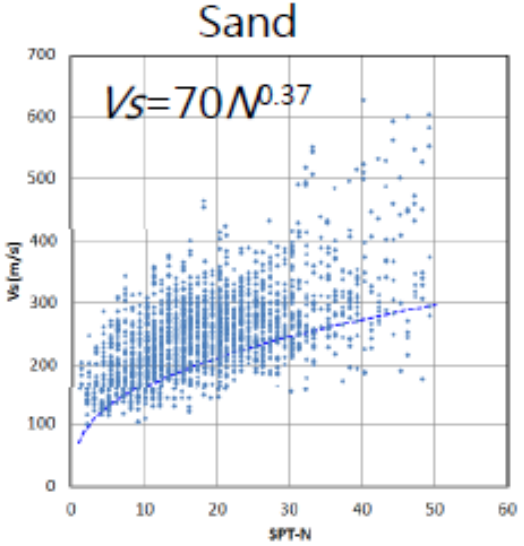


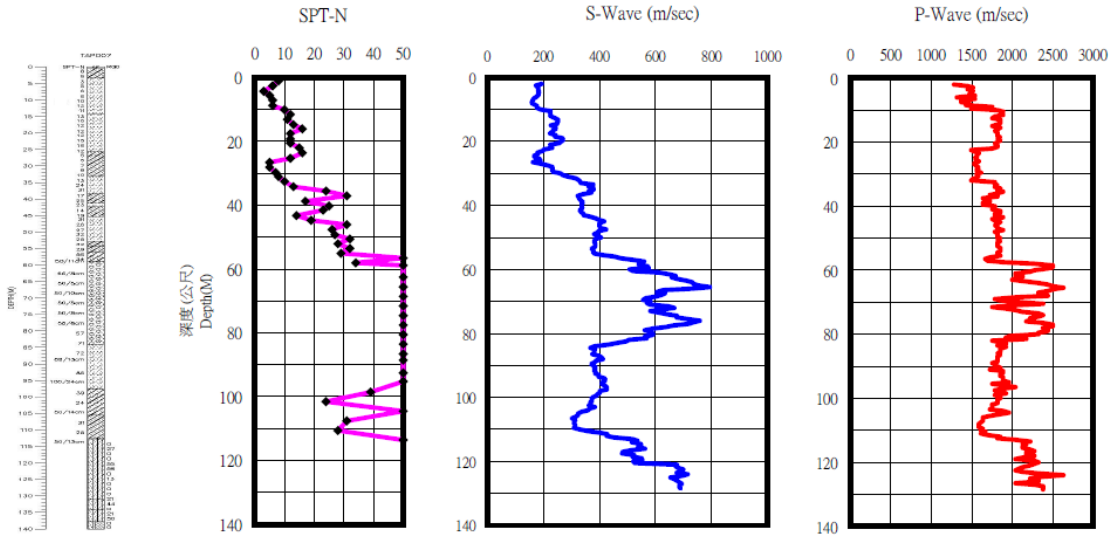
(Chen et al., 2016)

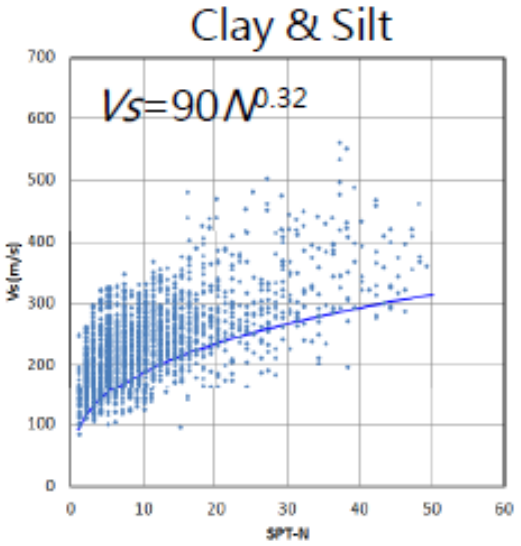
Near-surface Data of Engineering Geological Database for TSMIP (EGDT)

NARLabs

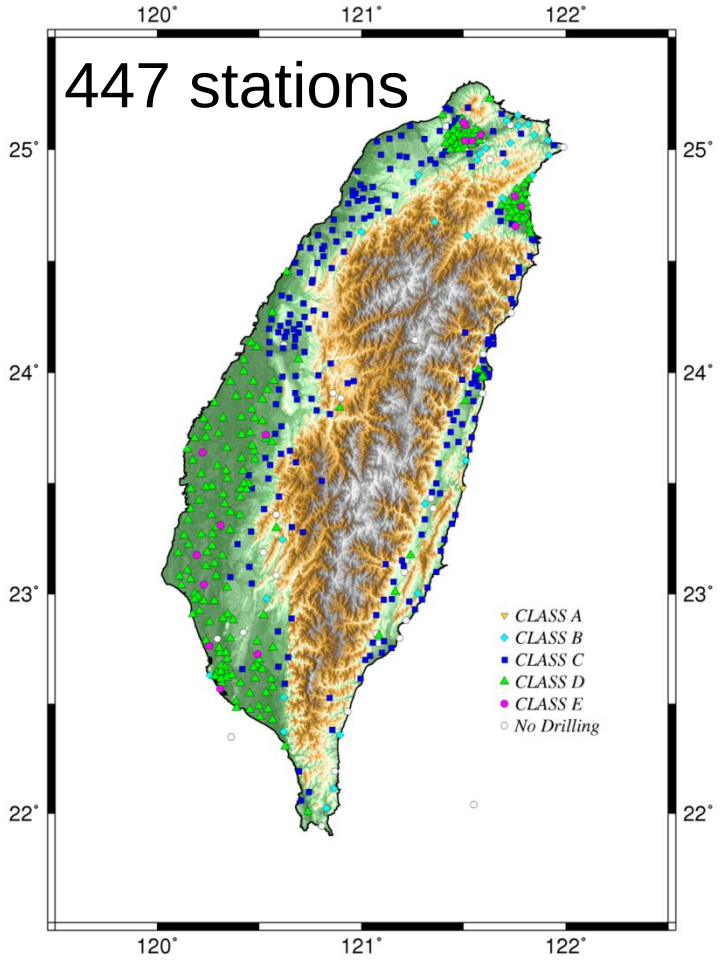


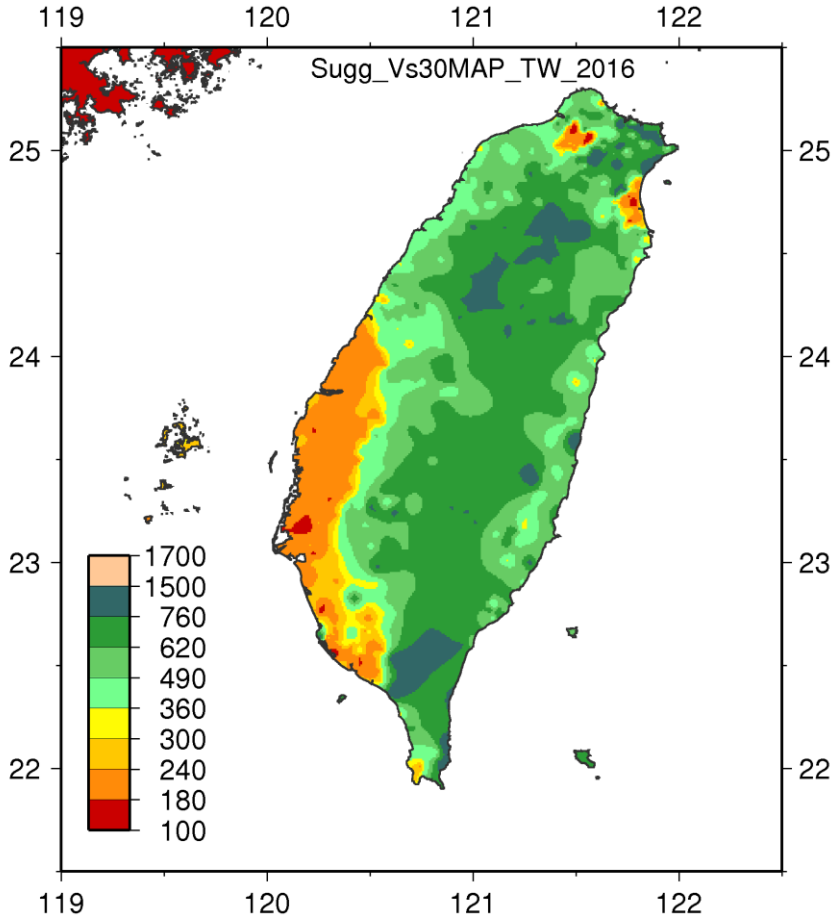






Near-surface Data of Engineering Geological Database for TSMIP (EGDT)



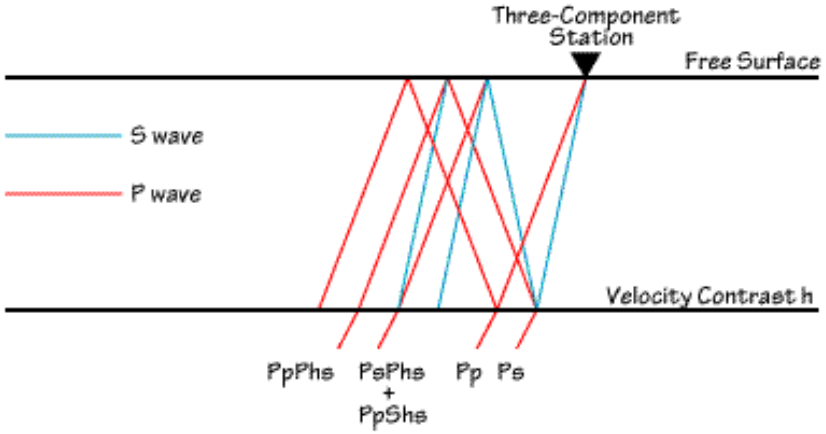


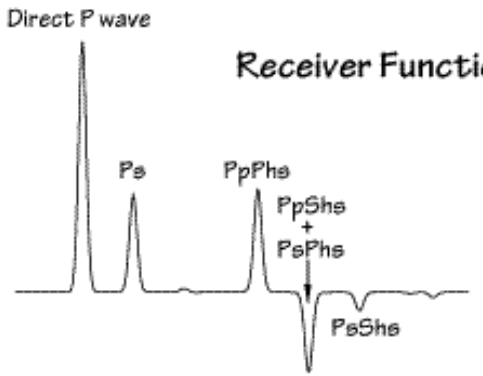
(Kuo et al., 2012)

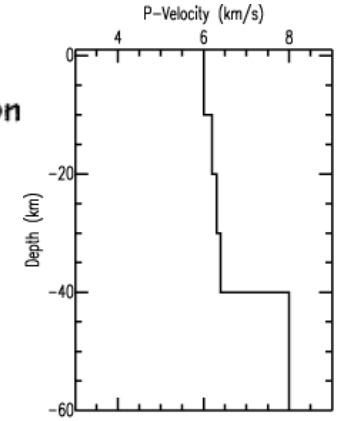
Receiver Function Analysis of TSMIP Stations

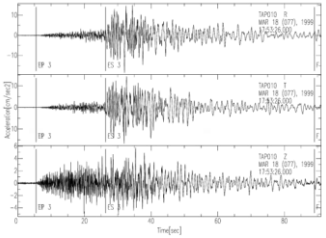
NARLabs

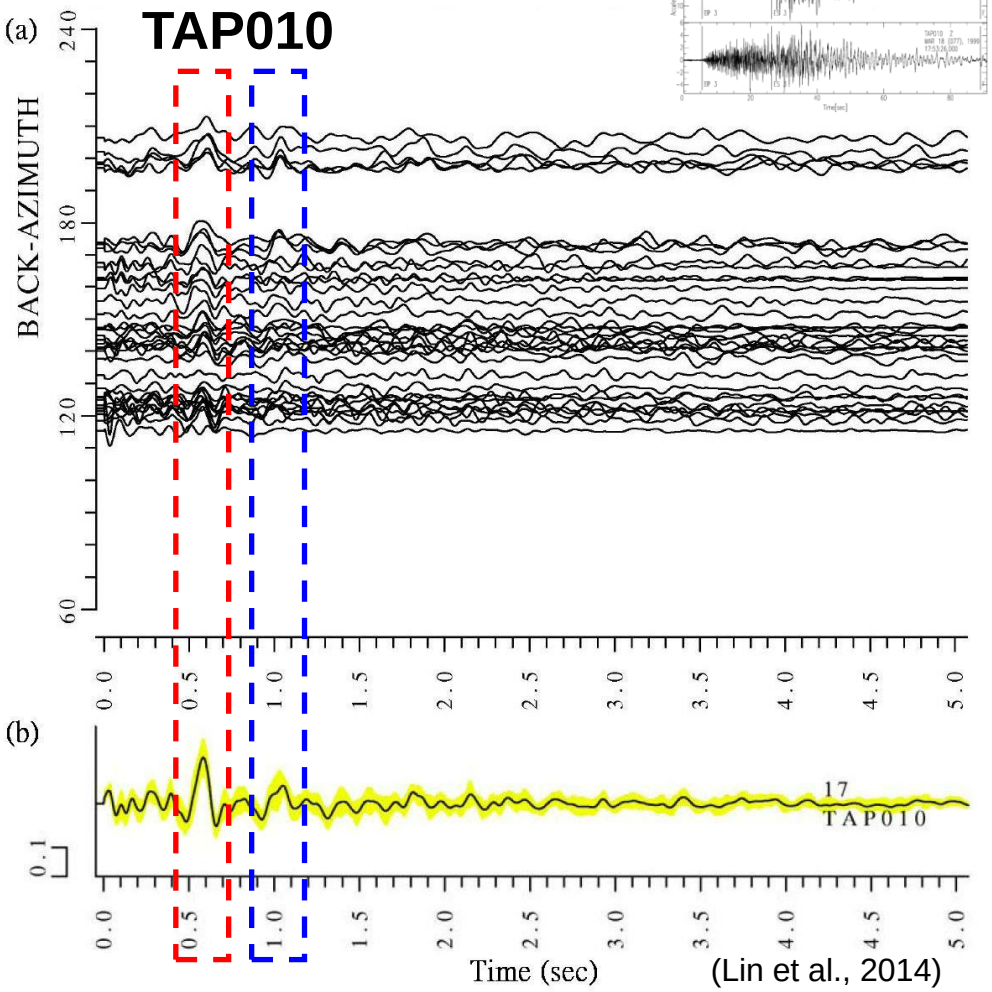
- RF was applied on the high-frequency acceleration seismograms recorded by TSMIP stations to estimate the Vs profiles





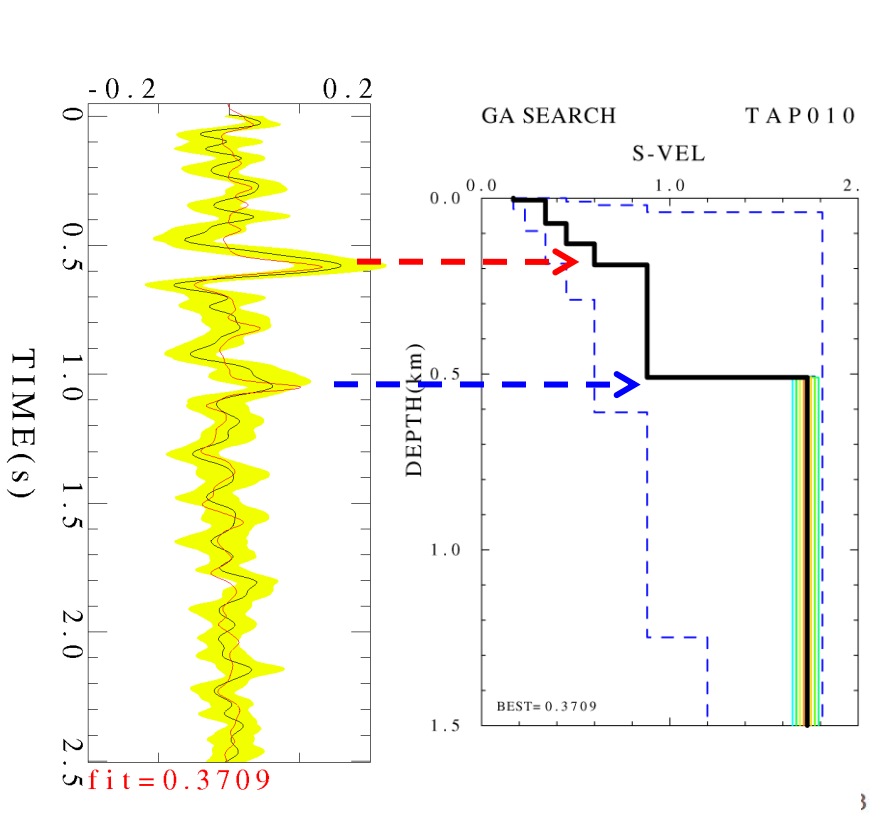


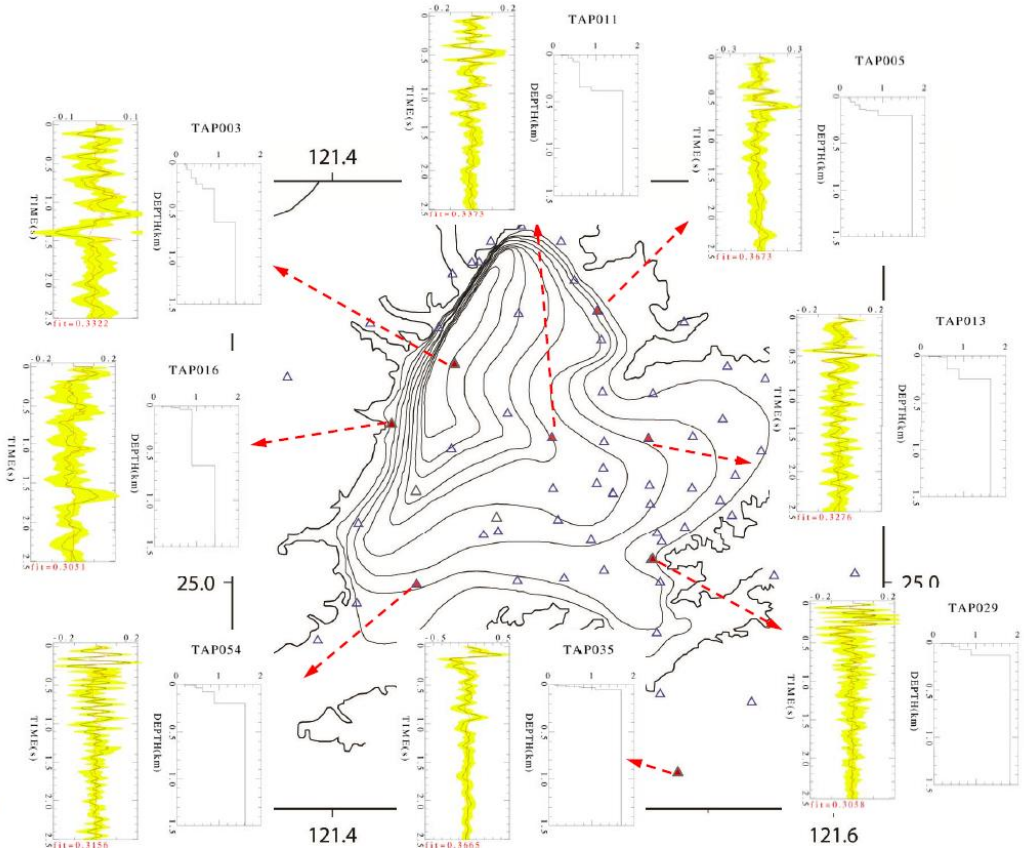




(Lin et al., 2014)

Receiver Function Analysis of TSMIP Stations



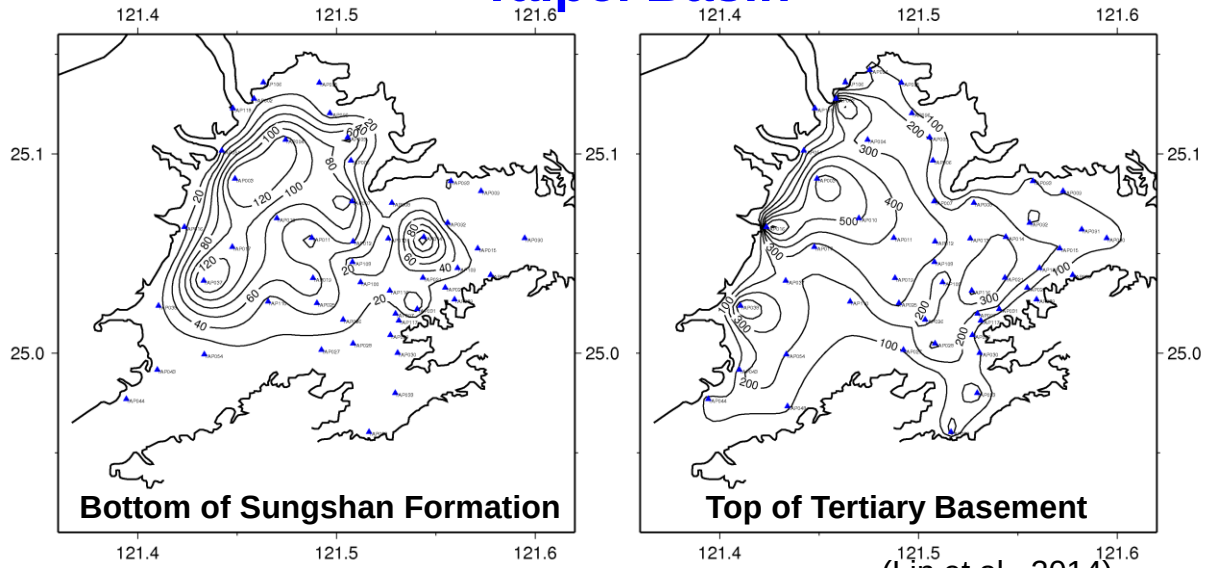


(Lin et al., 2014)

Receiver Function Analysis of TSMIP Stations

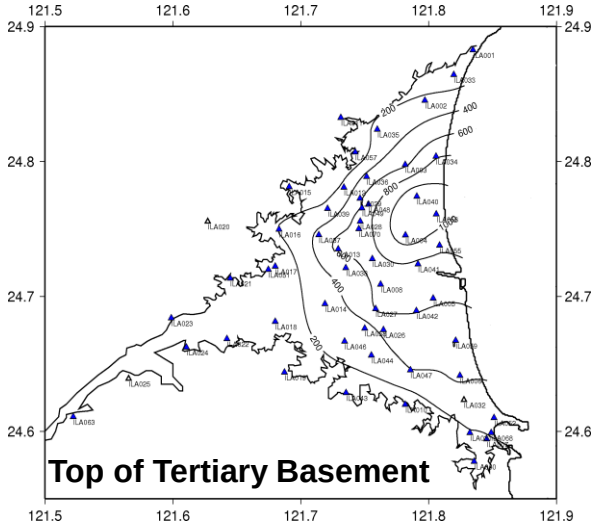
NARLabs

Taipei Basin



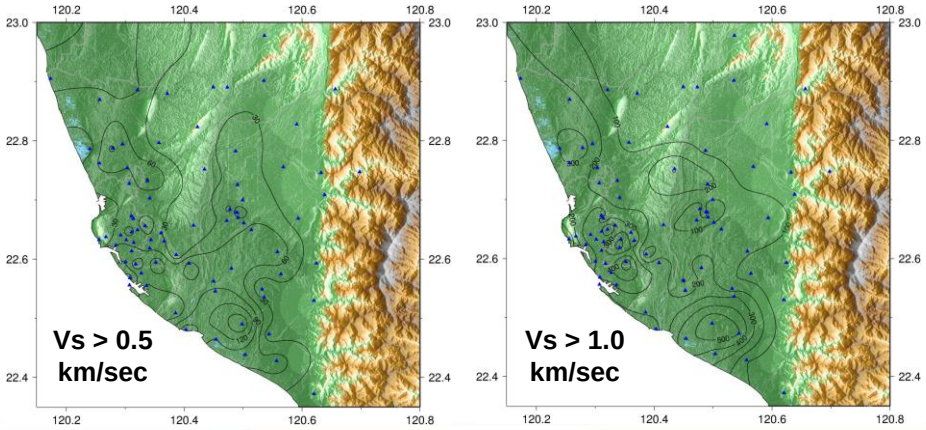
(Lin et al., 2014)

Ilan Plain



(Lin, 2003)

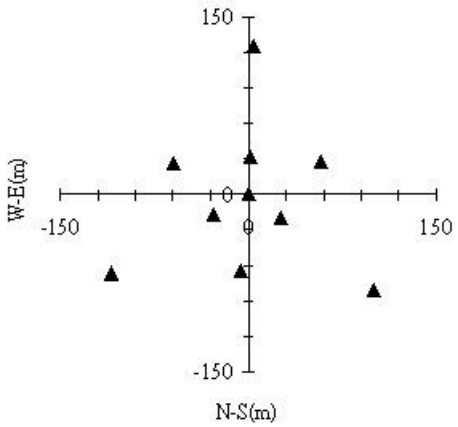
Kaohsiung & Pingtung Area

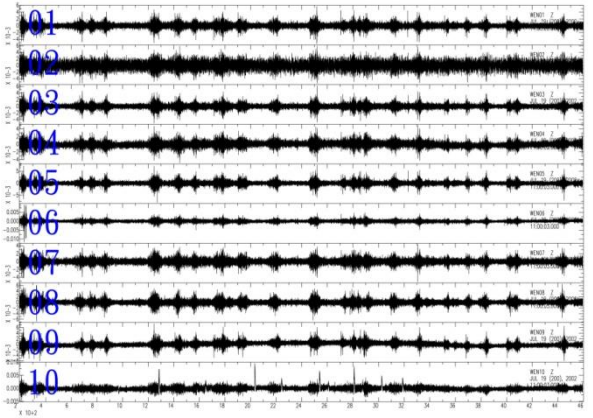


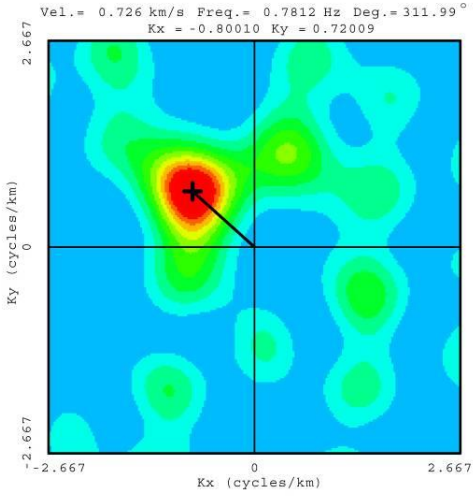
(Lin et al., 2016)

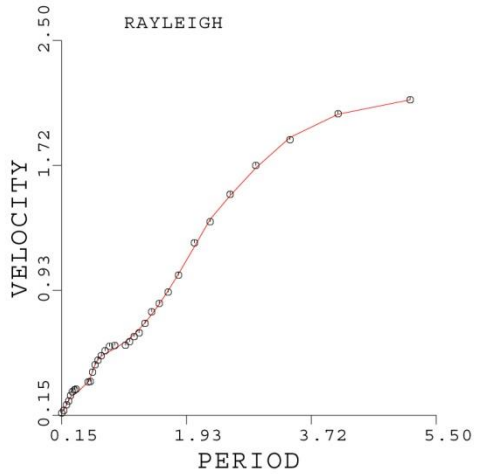
- RF is sensitive to a boundary with high velocity contrast
- RF analysis has been applied at almost 400 TSMIP stations
- Providing a rough and preliminary model for further studies

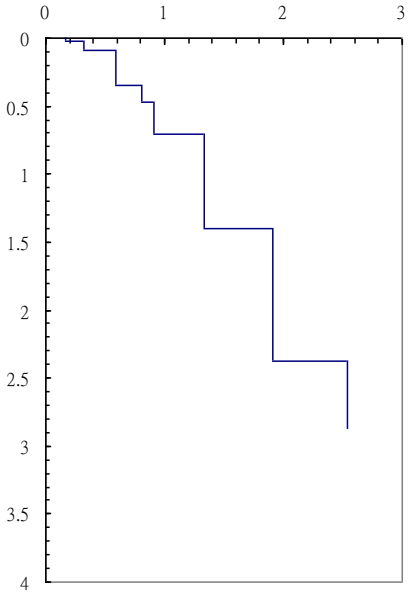
Microtremor Array





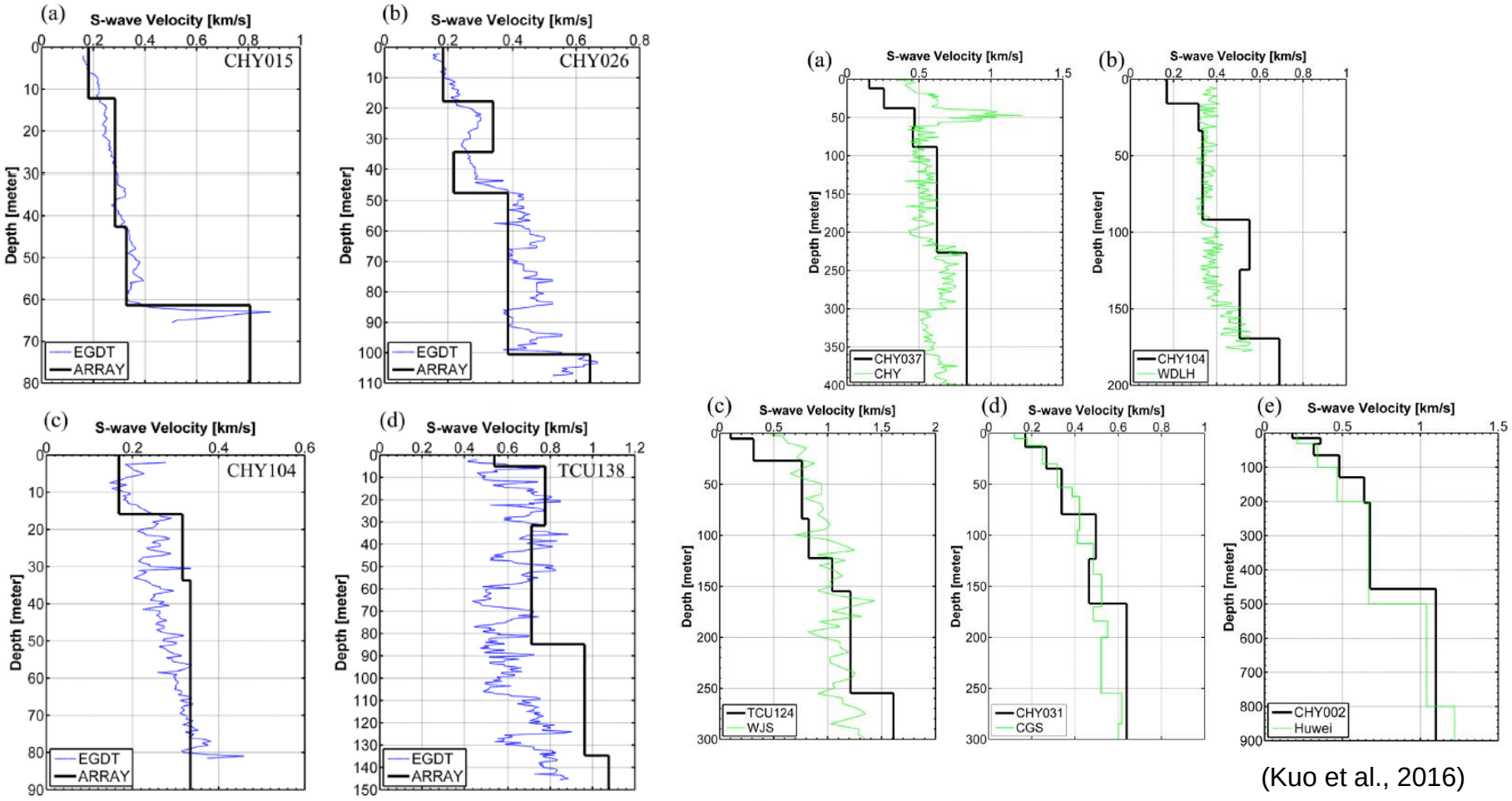






Microtremor Array

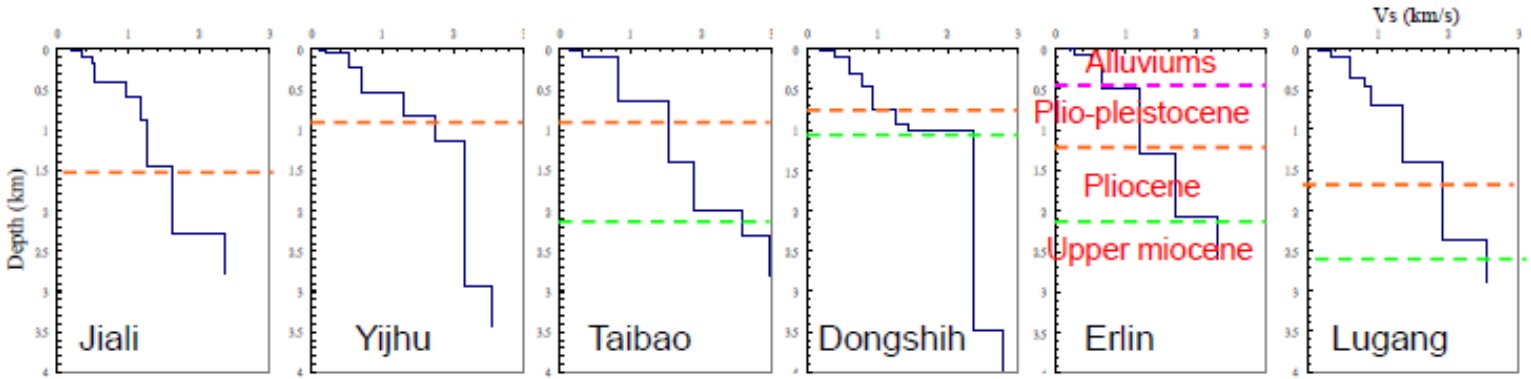
- **Compared with EGDT and deep borehole data**

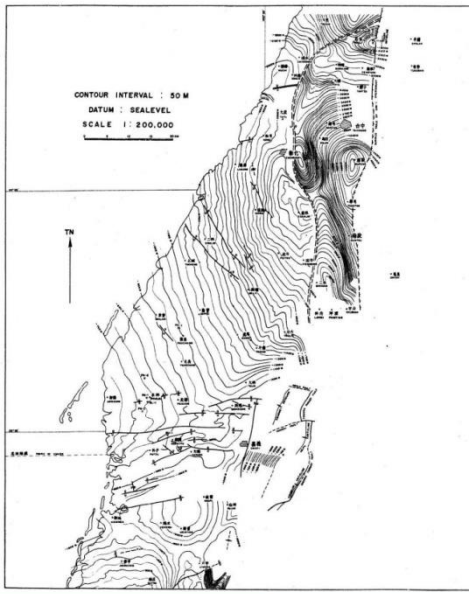


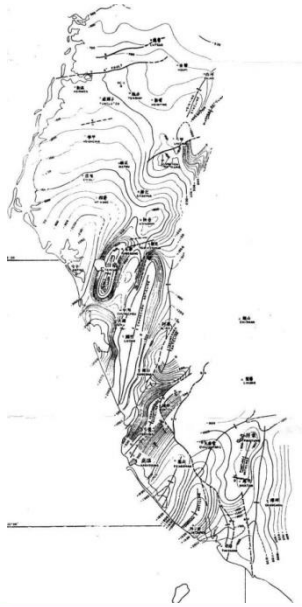
(Kuo et al., 2016)

Microtremor Array

- **Compared with seismic structural maps**



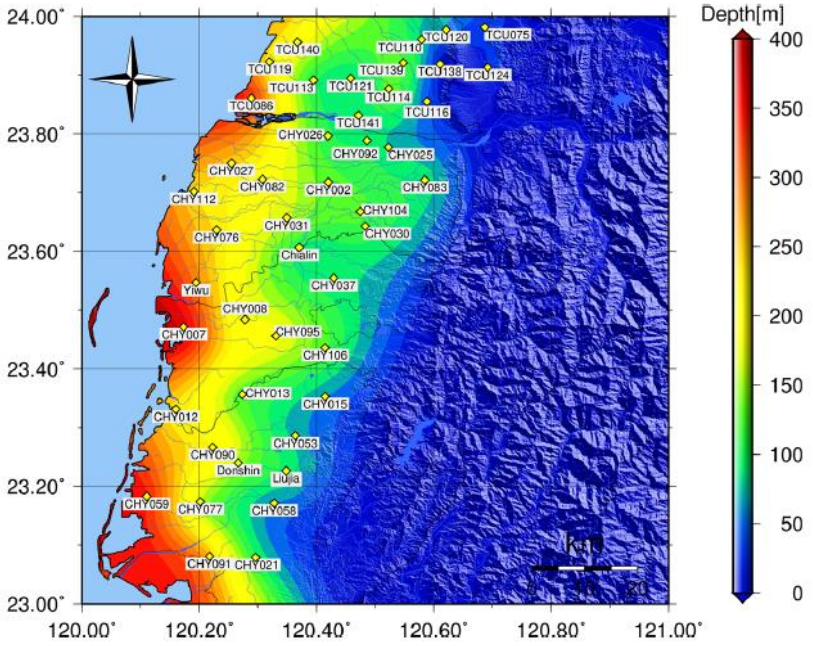




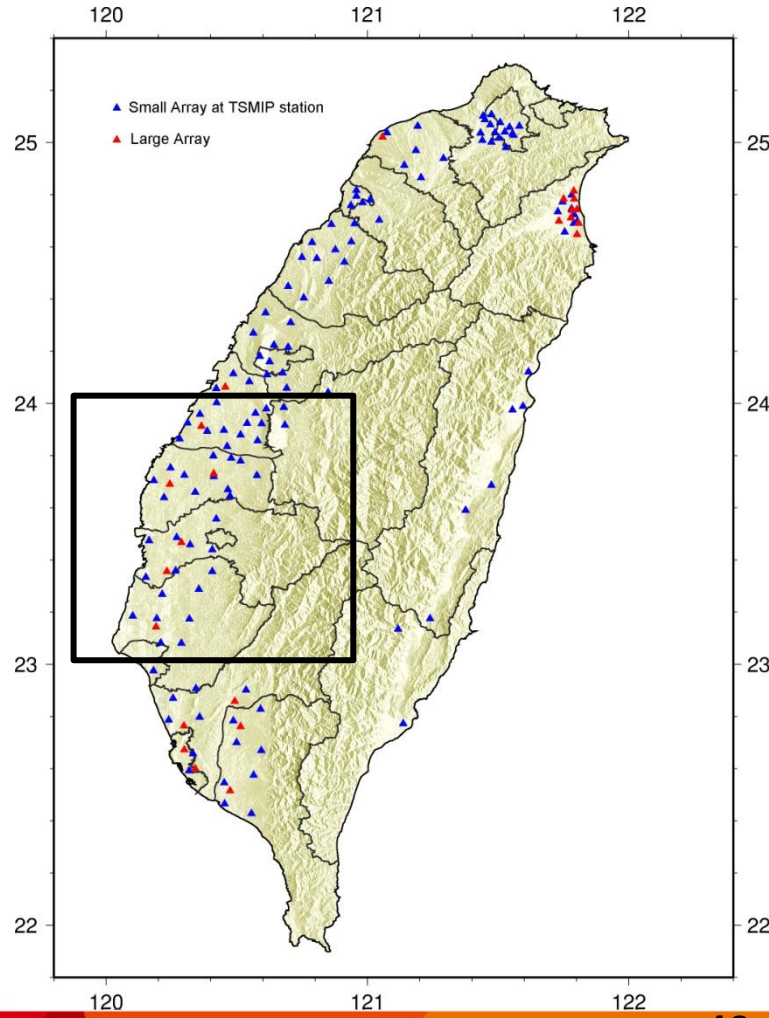
(Lin et al., 2009)

Microtremor Array

- About 150 microtremor array measurements have been conducted in Taiwan
- Arrays with different layouts can provide velocity information of diverse depths or resolutions

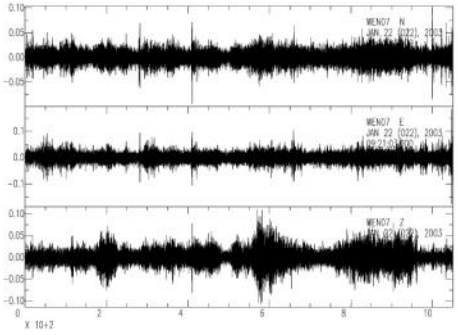


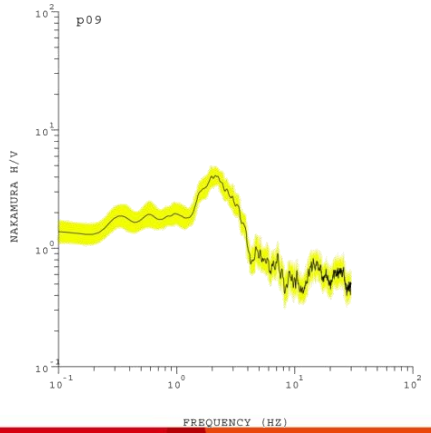
ESG5 poster: P102B (Chen et al.)

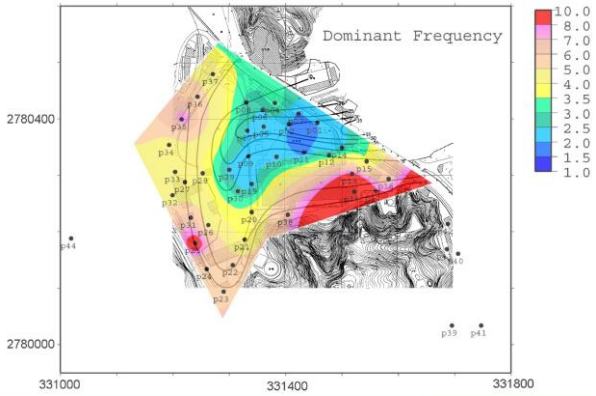


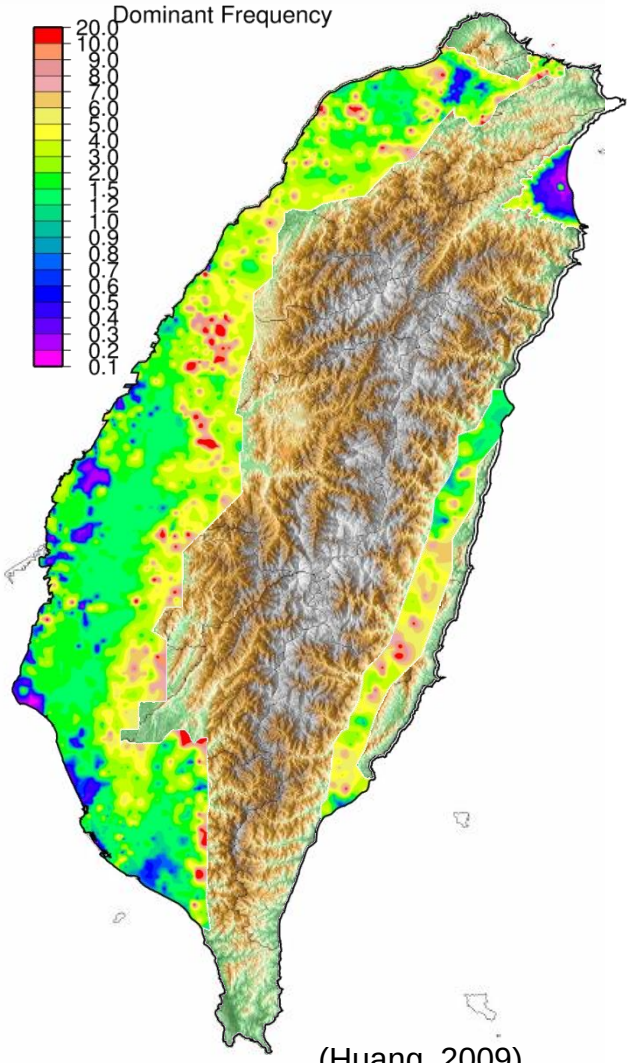
Modeling of Microtremor H/V Spectral Ratio (HVSR)

- A dense microtremor single-station survey of more than 4000 sites has been conducted to evaluate the detail site response all over Taiwan using the HVSR analysis
- The measurement intervals are mostly 2 km, and 1 km for some metropolitan regions.





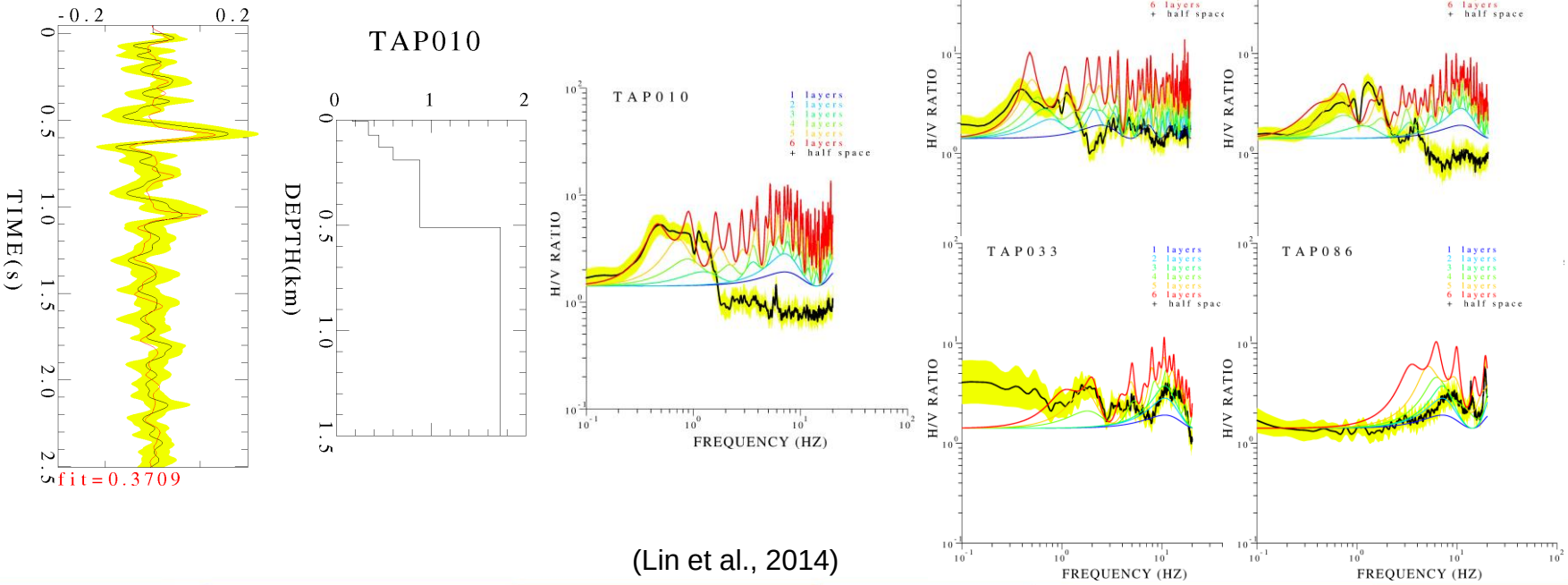




(Huang, 2009)

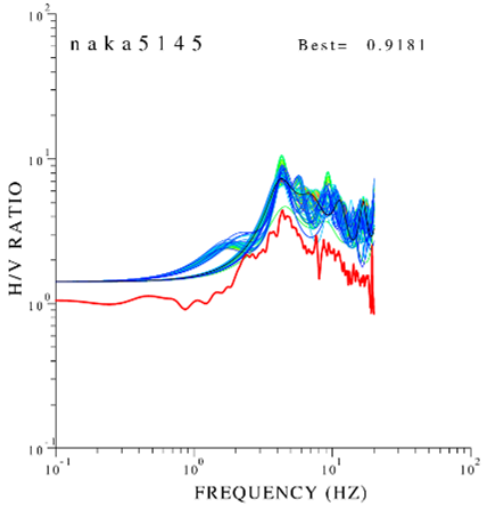
Modeling of Microtremor H/V Spectral Ratio (HVSR)

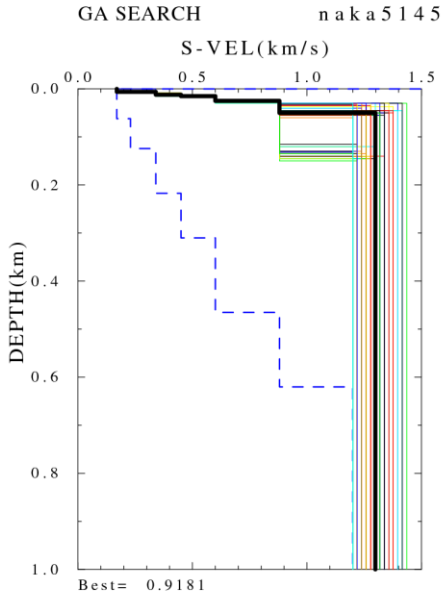
- **Theoretical SH-wave transfer function of Haskell matrix (Haskell, 1960) shear-wave velocity model inverted by RF agree with the observed microtremor H/V spectral ratios at TSMIP stations**
- **The theoretical SH-wave transfer function can be used to model the microtremor H/V spectral ratios to estimate the S-wave velocity profiles for all sites**



(Lin et al., 2014)

Modeling of Microtremor H/V Spectral Ratio (HVSR)

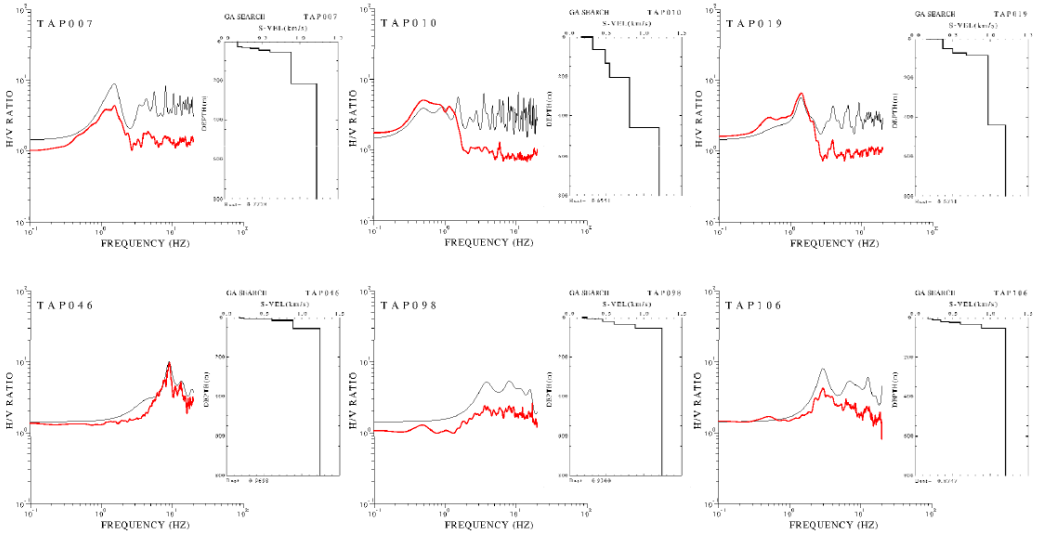




- **GA-Haskell method based on the combination of the Haskell matrix and Genetic Aalgorithm (GA) models the microtremor HVSR to estimate the Vs velocity profile**
- **The fitness function of GA-Haskell is defined by linear correlation coefficient and dominant frequency.**

$$f = \left(\frac{r+1}{2}\right)\times 0.8 + \left(1 - \frac{|F_{SH} - F_{HV}|}{0.3\times F_{HV}}\right)\times 0.2$$

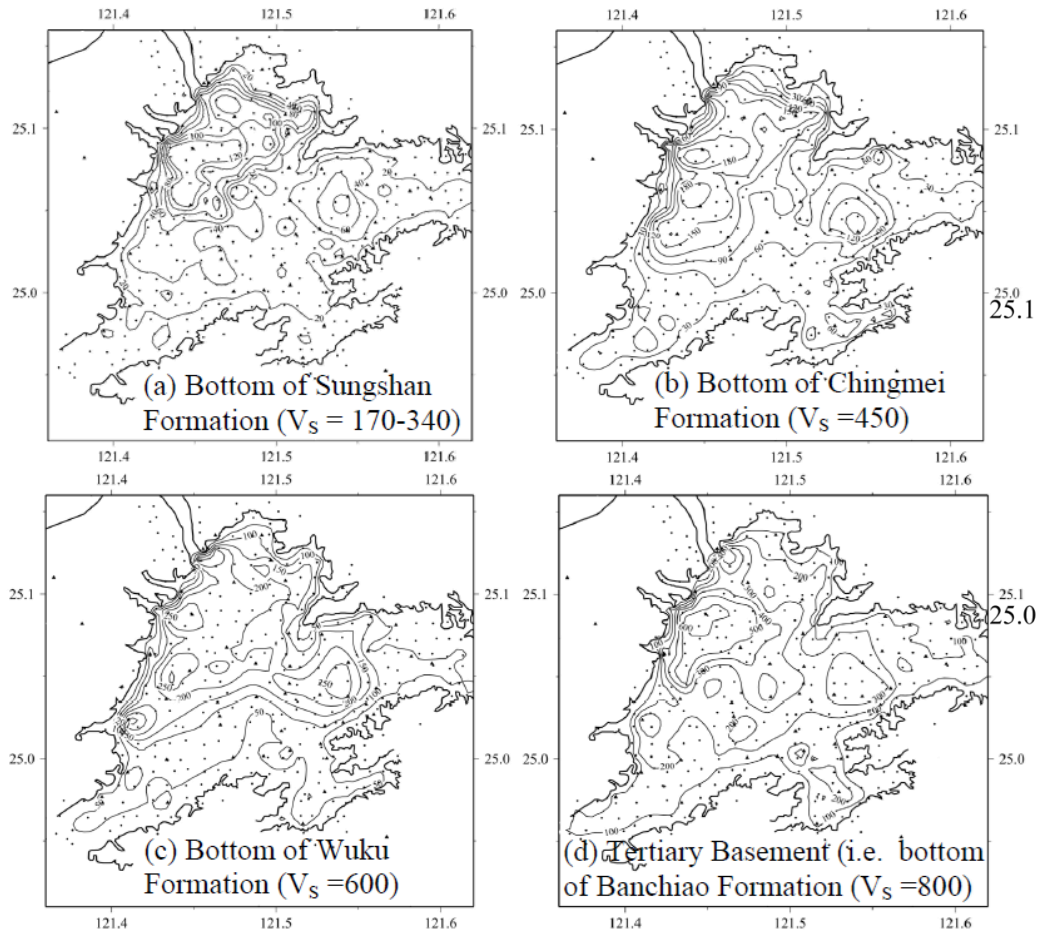
$$r = \frac{\sum_i (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_i (x_i - \bar{x})^2}\sqrt{\sum_i (y_i - \bar{y})^2}}$$

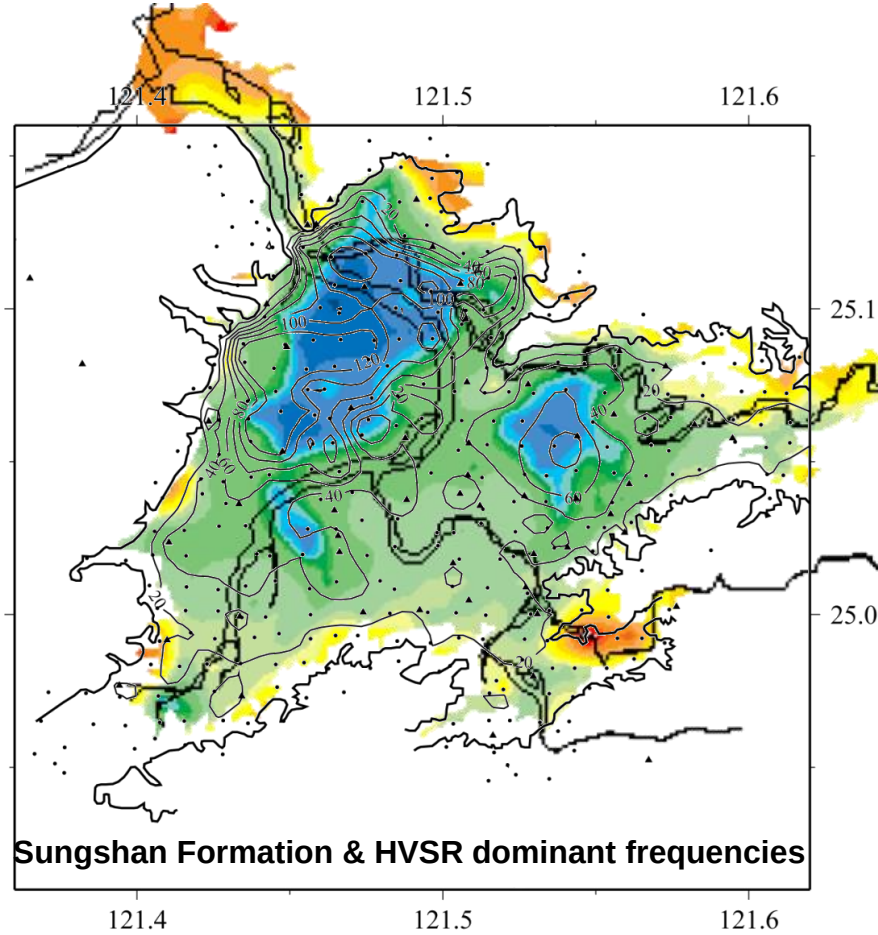


Modeling of Microtremor H/V Spectral Ratio (HVSR)

NARLabs

Taipei Basin



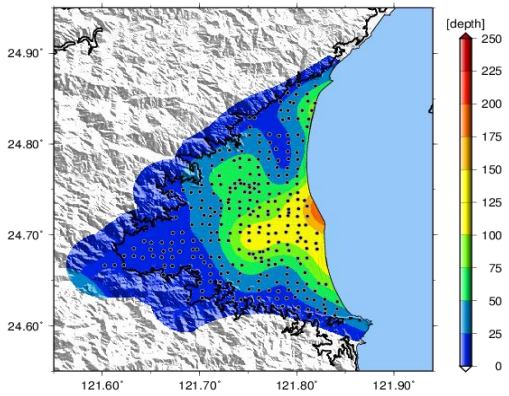


(Lin et al., 2014)

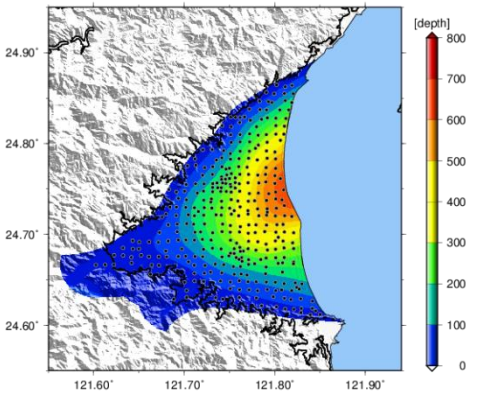
Modeling of Microtremor H/V Spectral Ratio (HVSR)

NARLabs

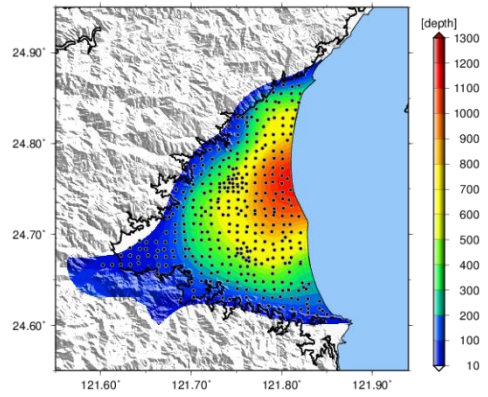
Ilan Plain



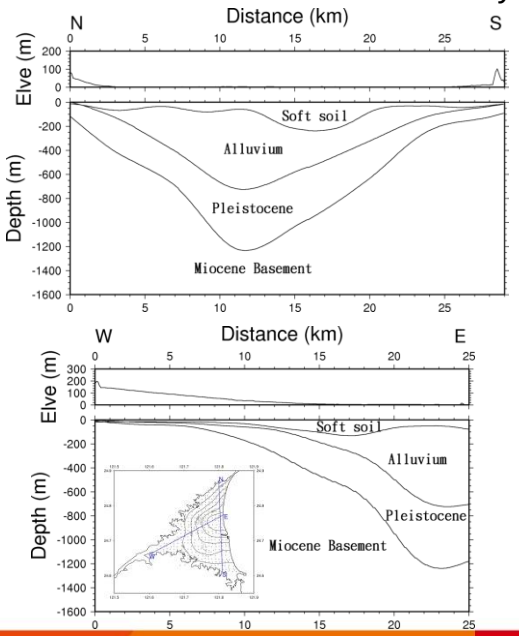
Soft soil – Alluvium boundary



Alluvium – Pleistocene boundary

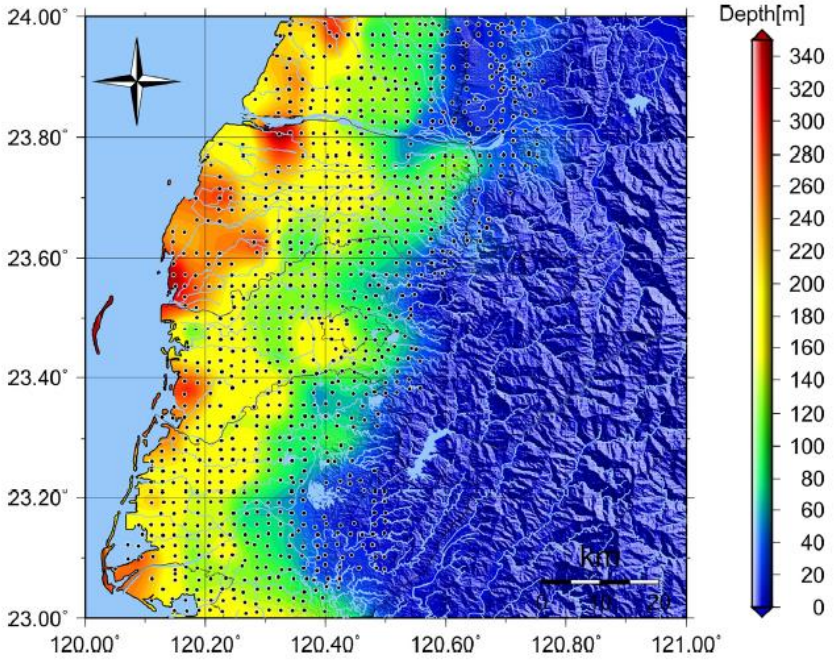


Pleistocene – Miocene basement boundary



ESG5 poster: P112B
(Lin et al.)

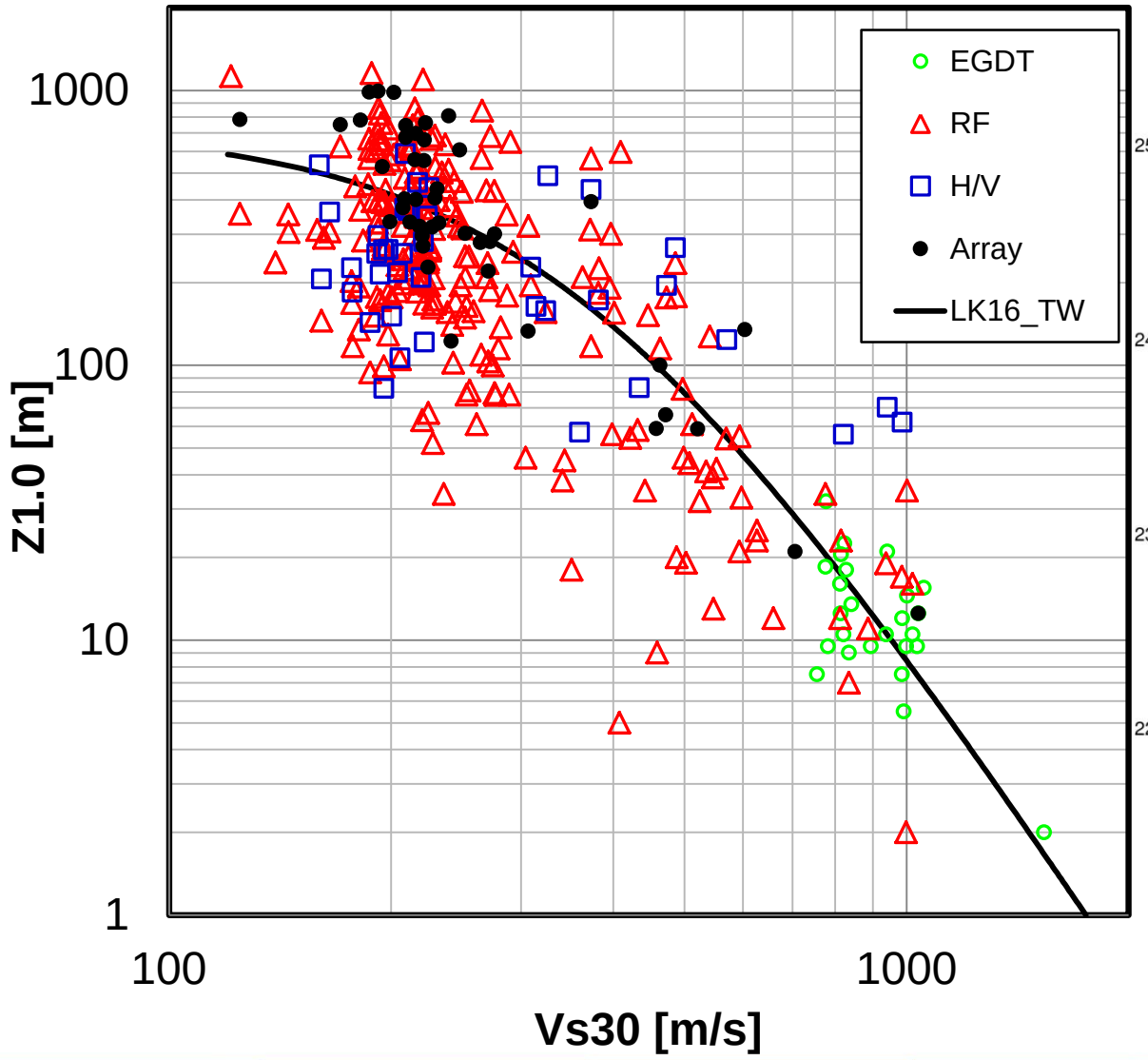
Western Plain

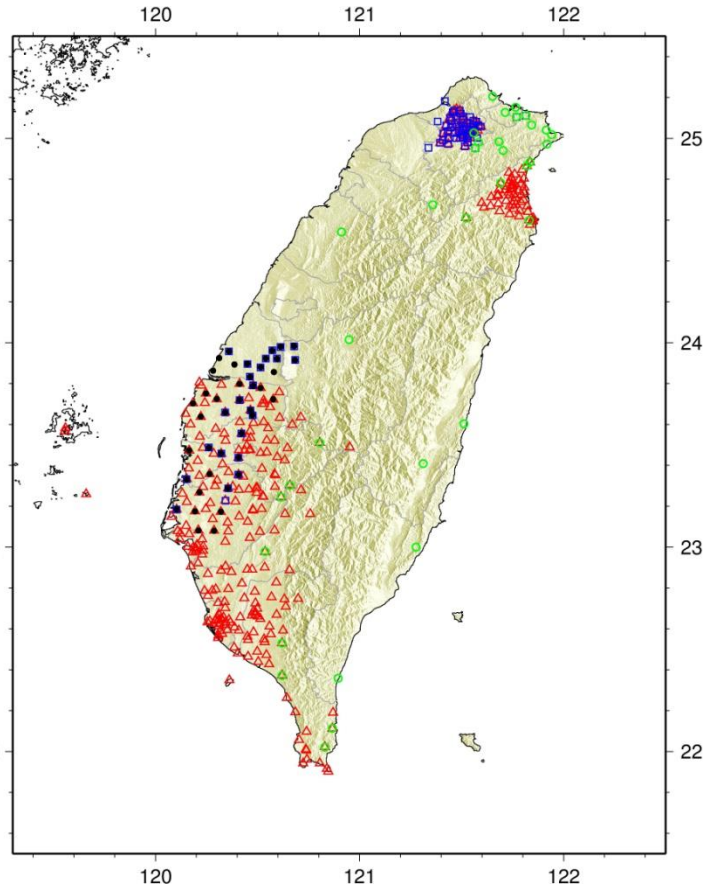


Engineering bedrock (Vs =600 m/sc)

ESG5 poster: P102B
(Chen et al.)

Z1.0 for GMPE


EGDT
RF
H/V
Array
LK16_TW
1000
100
10
1
100
1000
Z1.0 [m]
Vs30 [m/s]


120
121
122
25
24
23
22

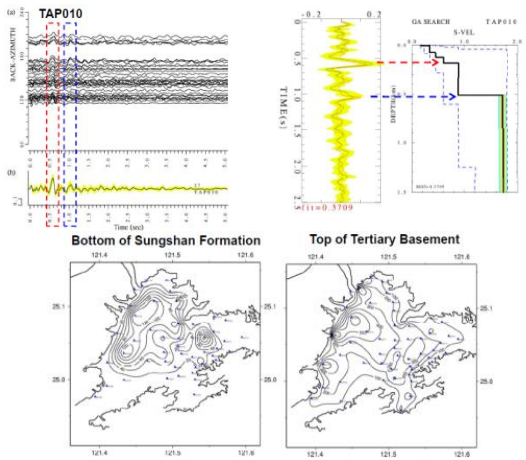
Summary

Near-Surface

EGDT, other downhole and surface geology data

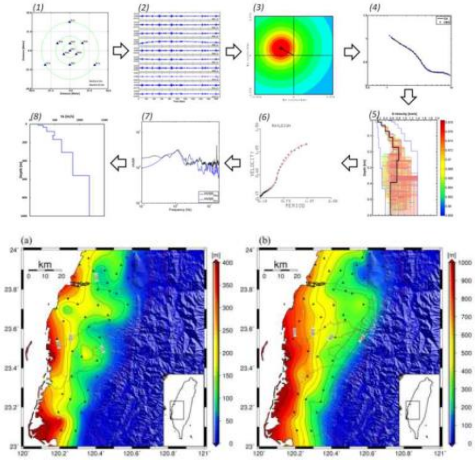
Receiver Function

- 800 TSMIP stations



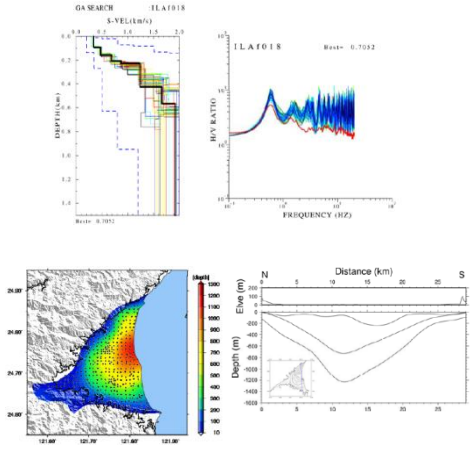
Microtremor Array

- About 150 sites



HVSR Modeling

- More than 4000 sites



- **Refer to geology, seismic and other geophysical surveys**
- **A detail and integrated shallow shear-wave velocity model for Taiwan**

~2km

3D Tomography Models

NARLabs

esg5

Taipei, Taiwan
2016/8/15~17

Thank you for your attention!