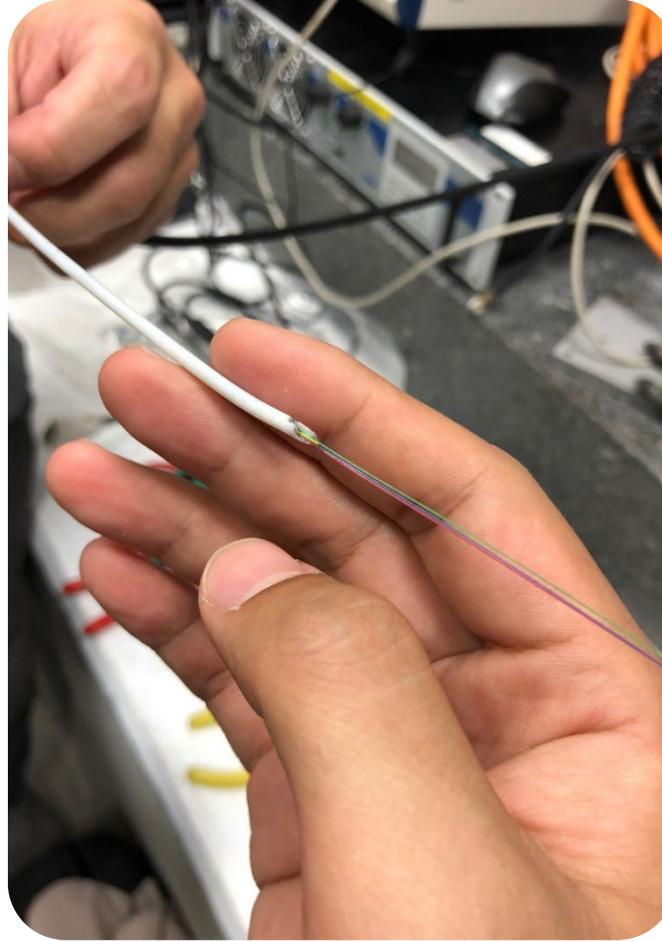
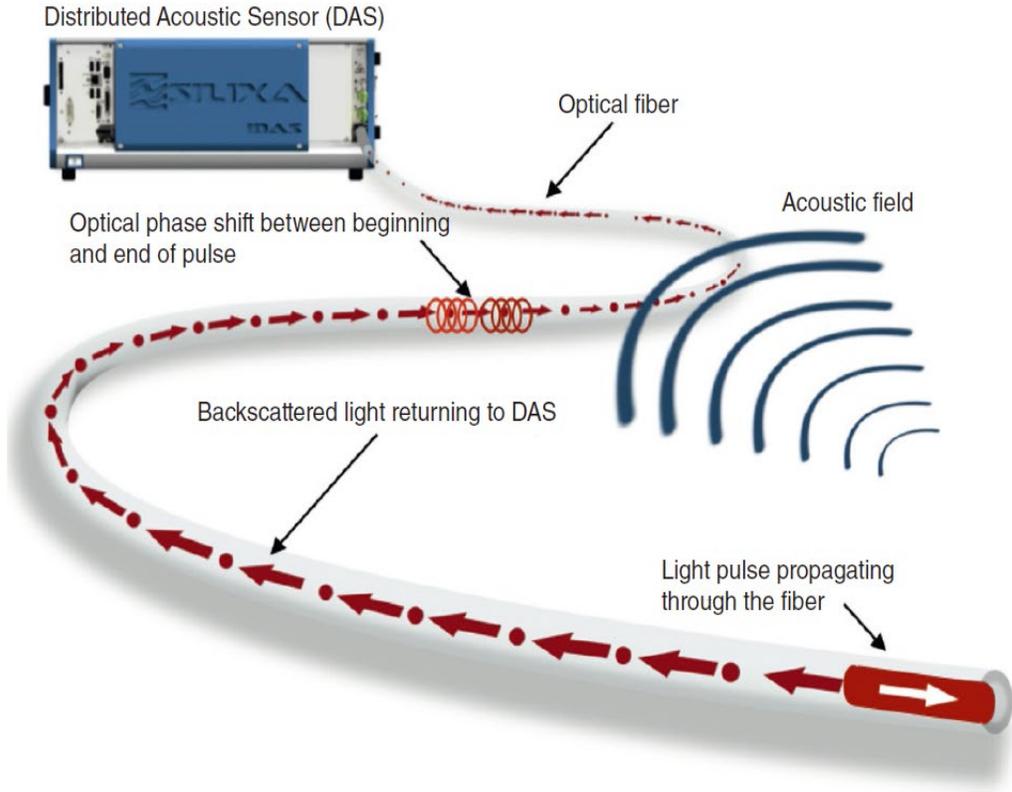
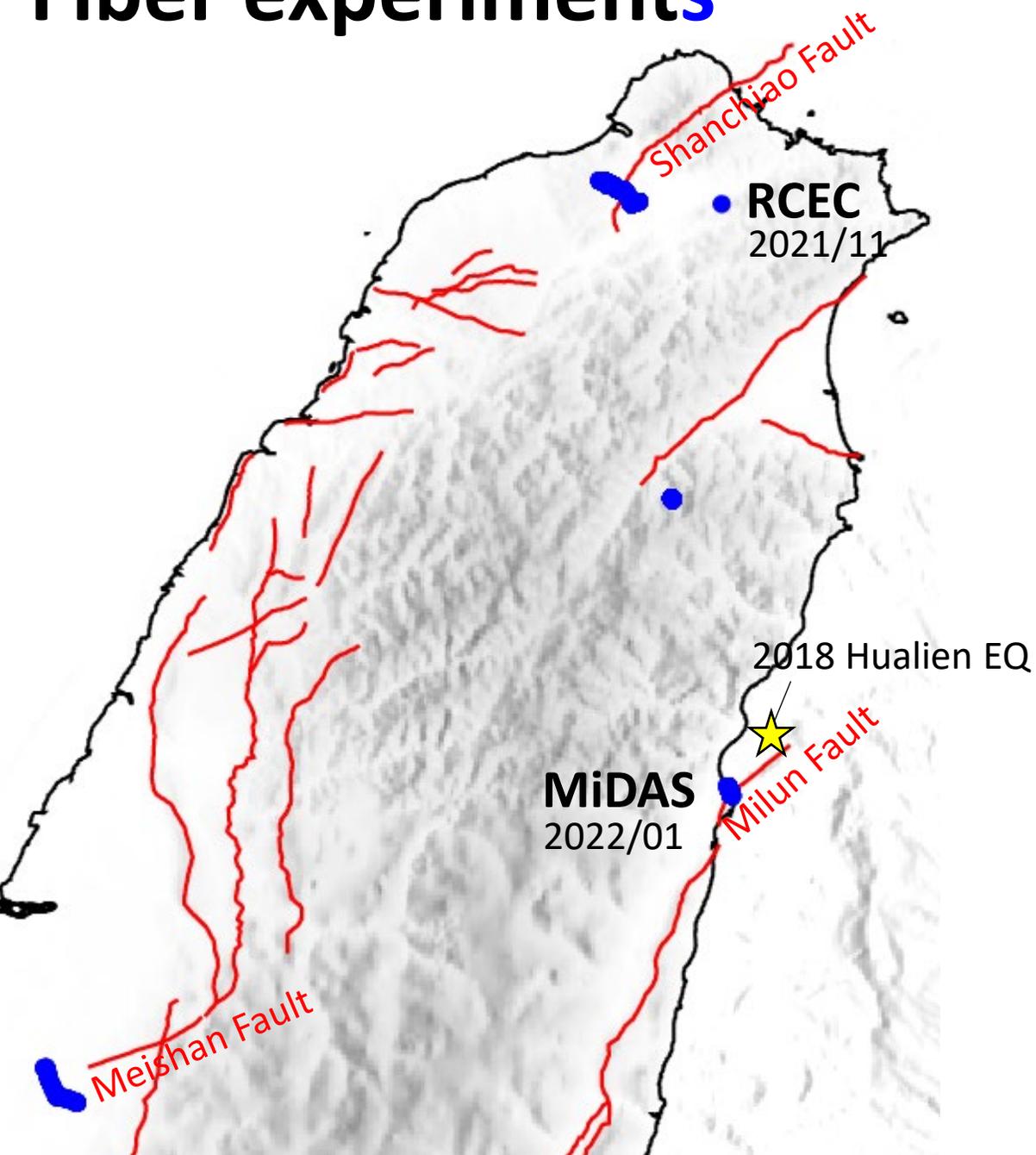


# DAS資料特性與在dark fiber的應用

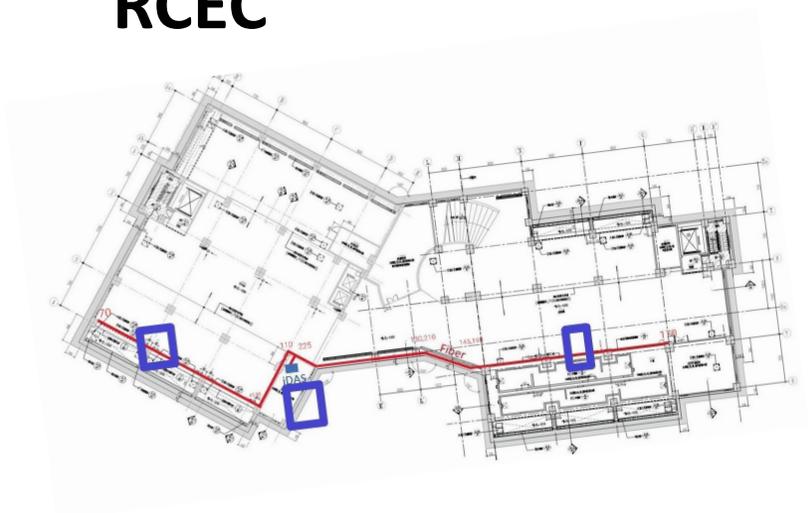


黃信樺、吳恩世、汪其璇、李妍忻、MiDAS working group  
中央研究院地球科學研究所

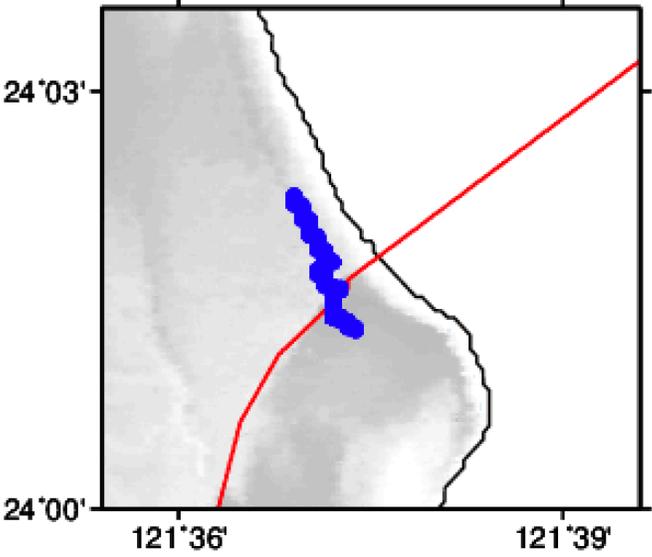
# Fiber experiments



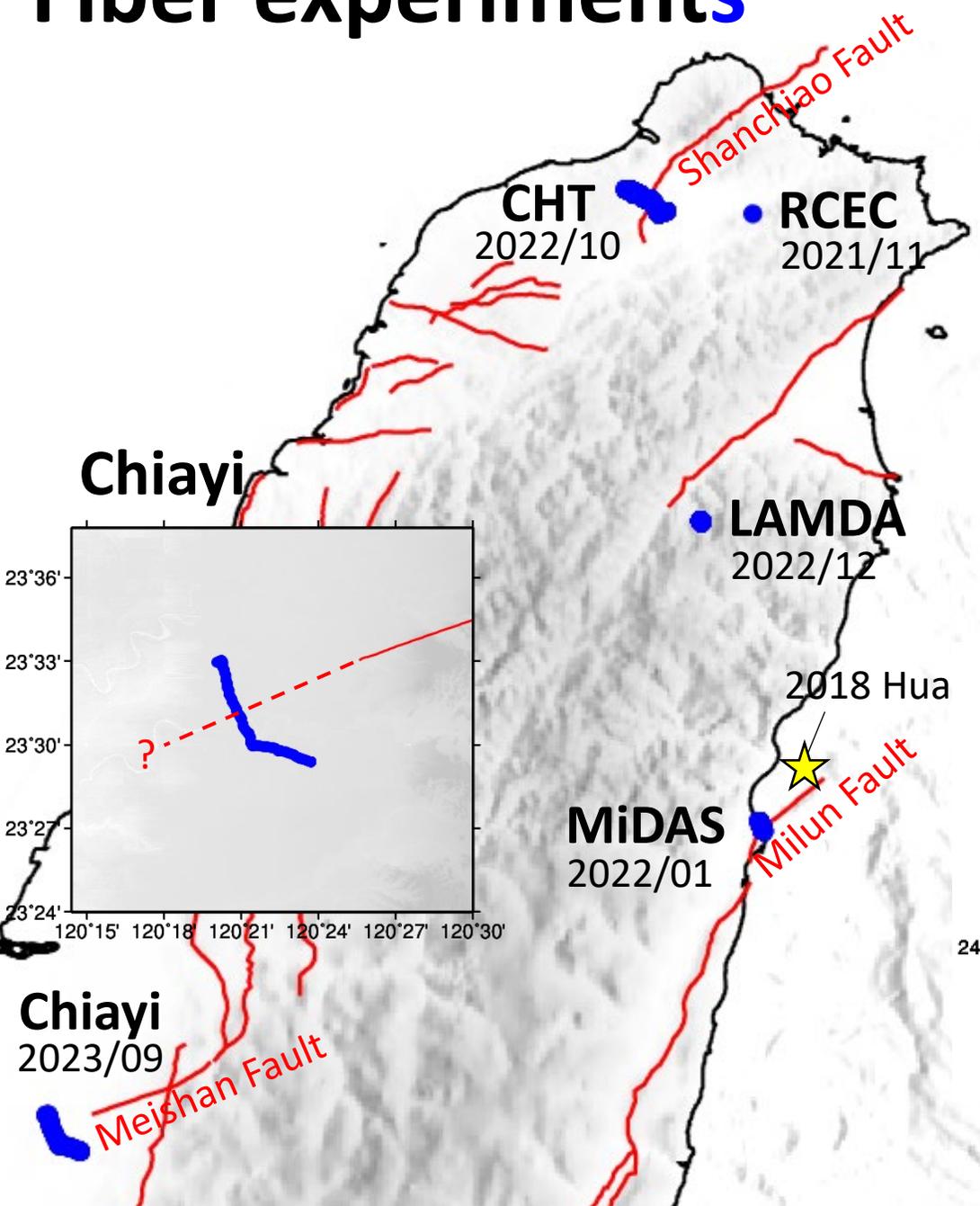
## RCEC



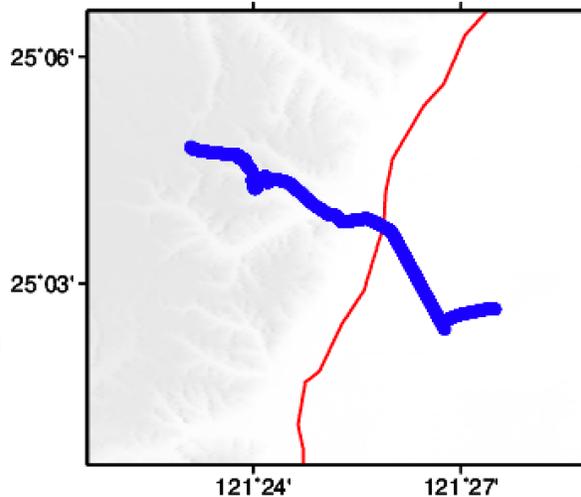
## MiDAS



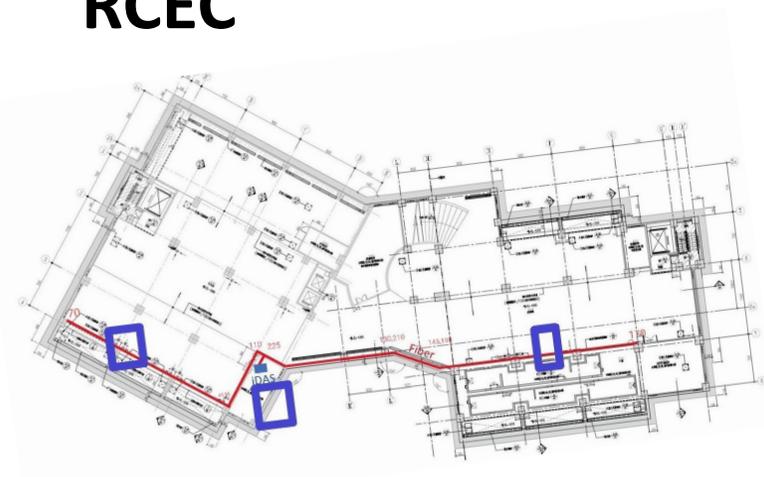
# Fiber experiments



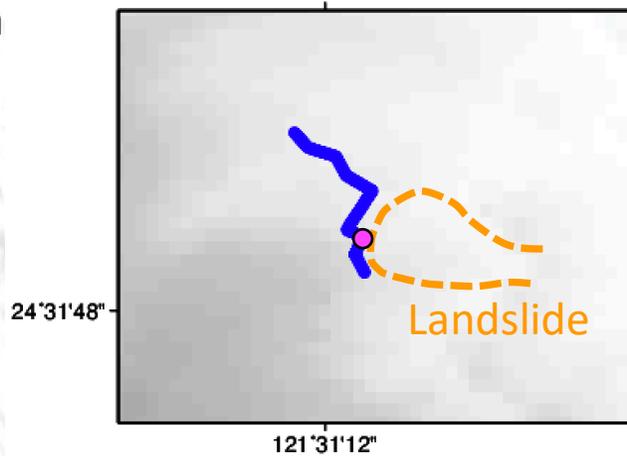
## CHT



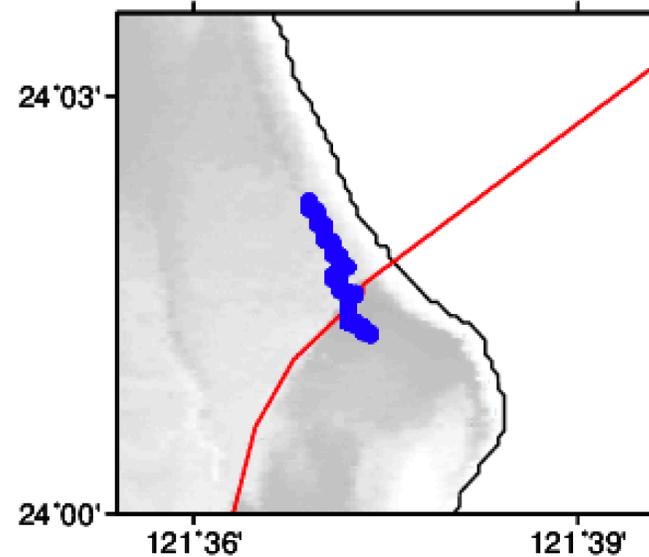
## RCEC



## LAMDA



## MiDAS



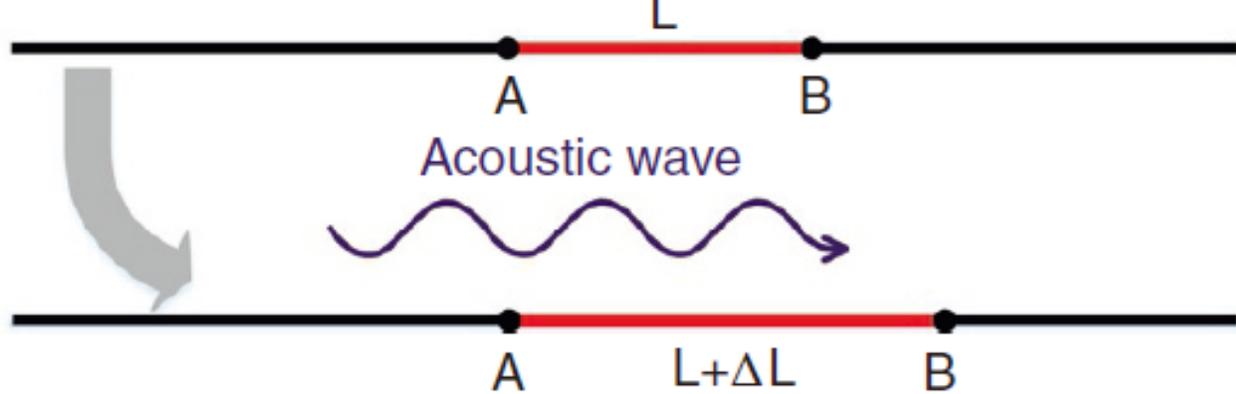
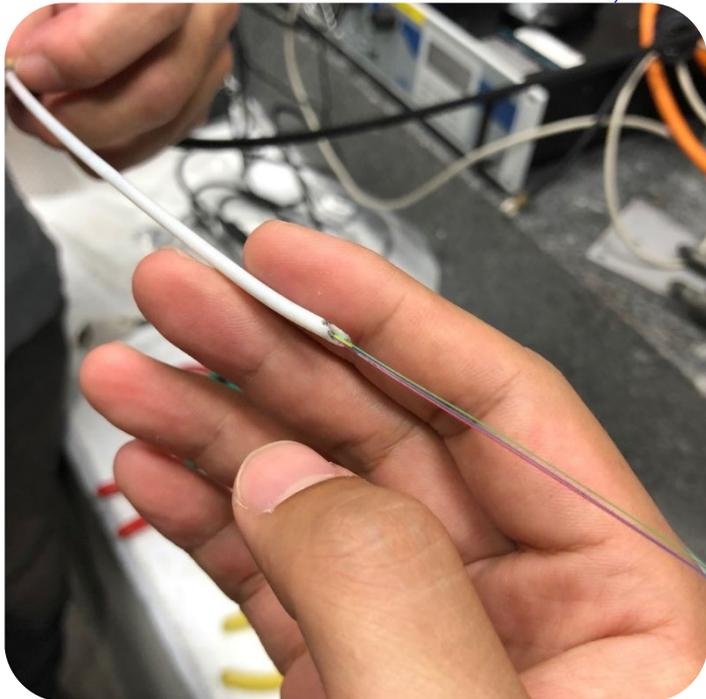
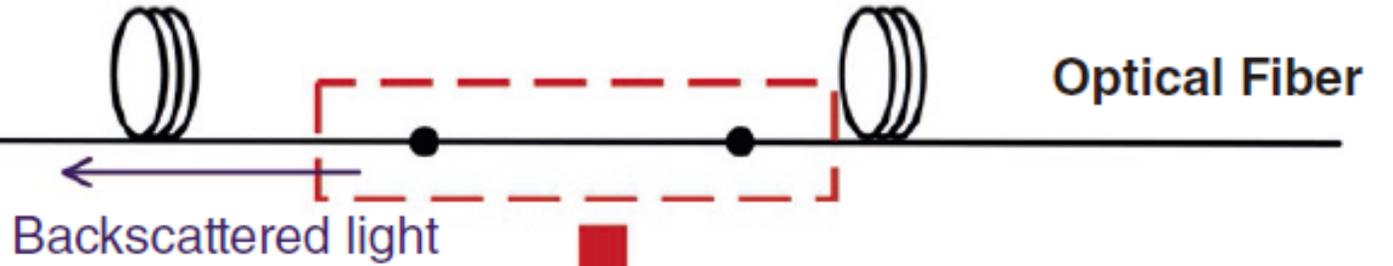
# The principle of Distributed Acoustic Sensing (DAS)

## Interrogator unit

Distributed Acoustic Sensor (DAS)

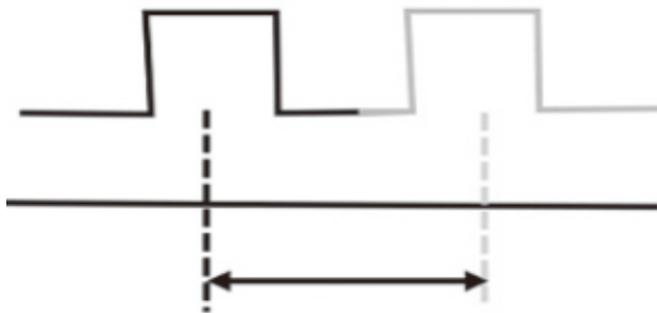


Fiber



- Measuring the strain/strain rate rather than particle velocity/acceleration

# 標距長度(Gauge length)



Our DAS model:

**Silixa iDAS v2**

Gauge length:

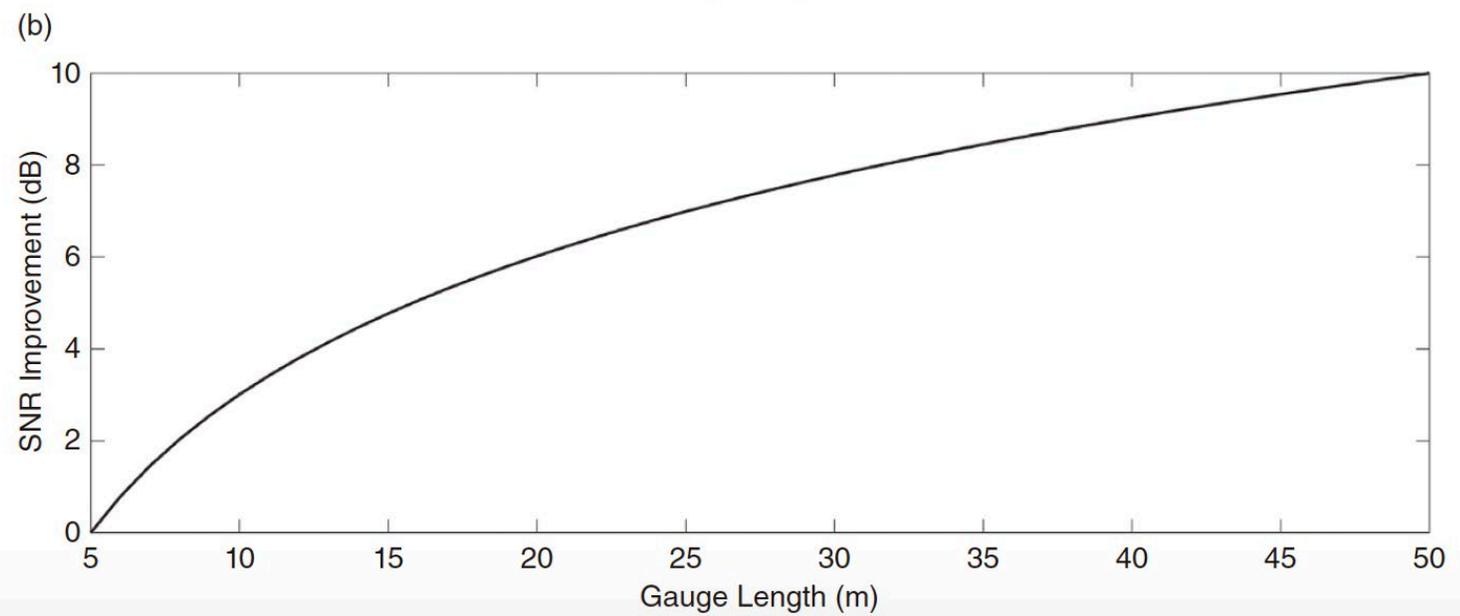
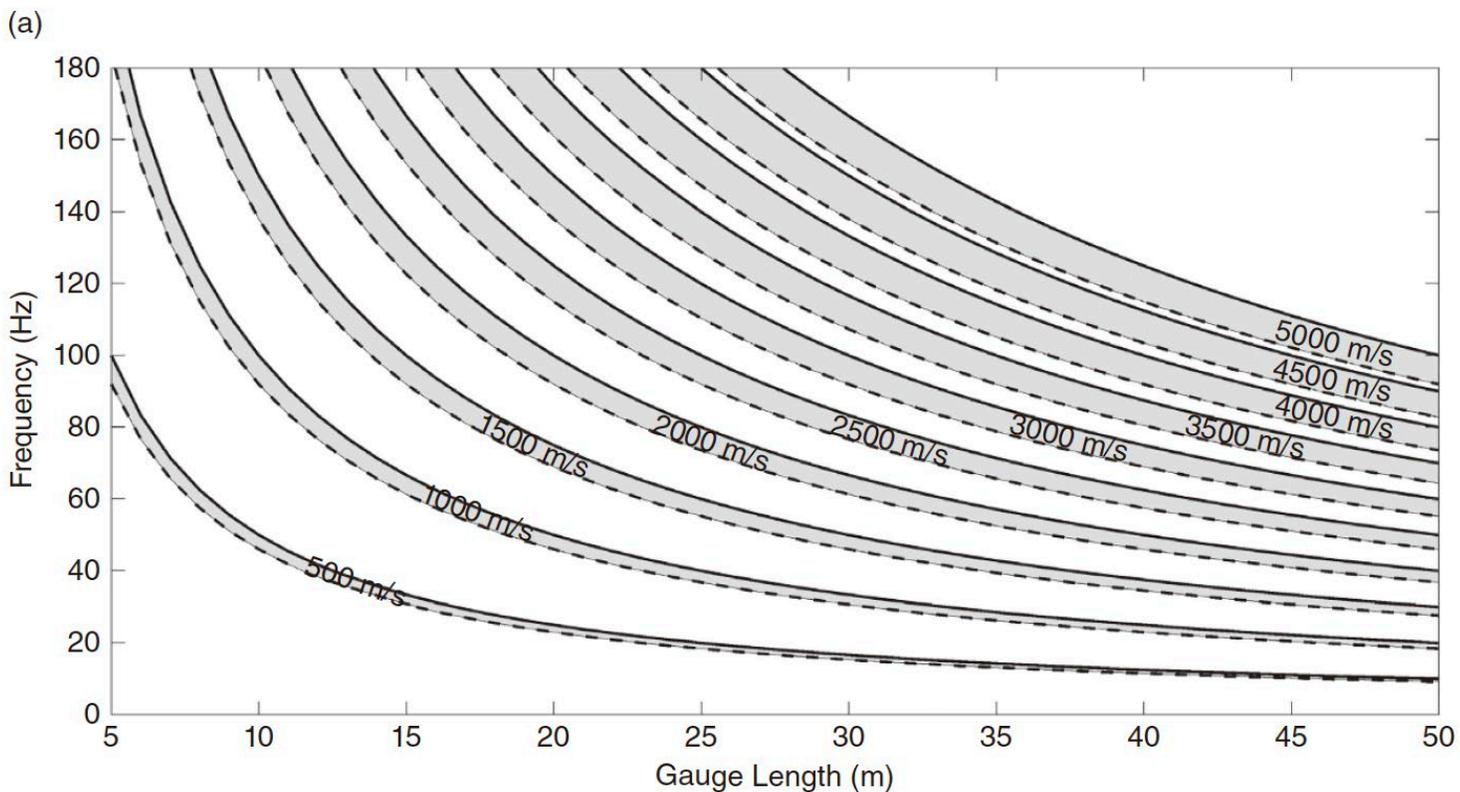
**10 m (preset)**

Sampling rate:

**1k-10k Hz (adjustable)**

Output length:

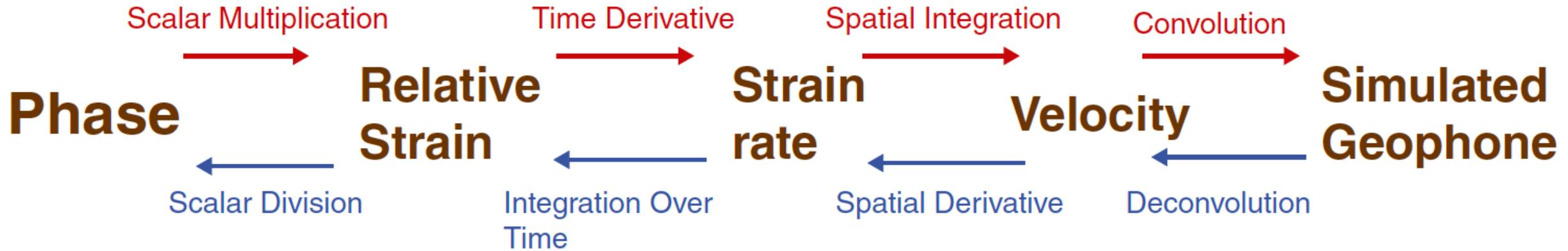
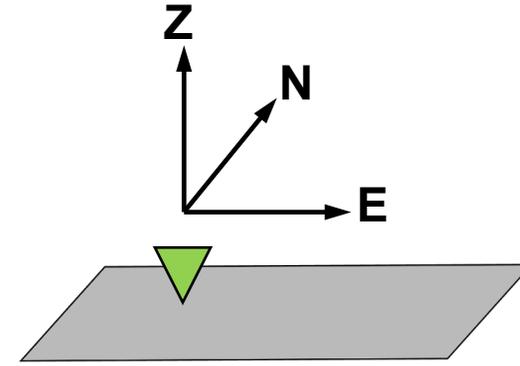
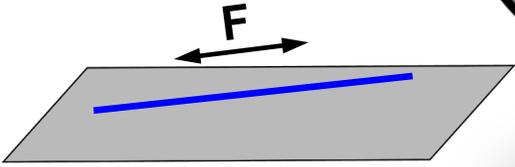
**2-8 m (adjustable)**



# 光纖

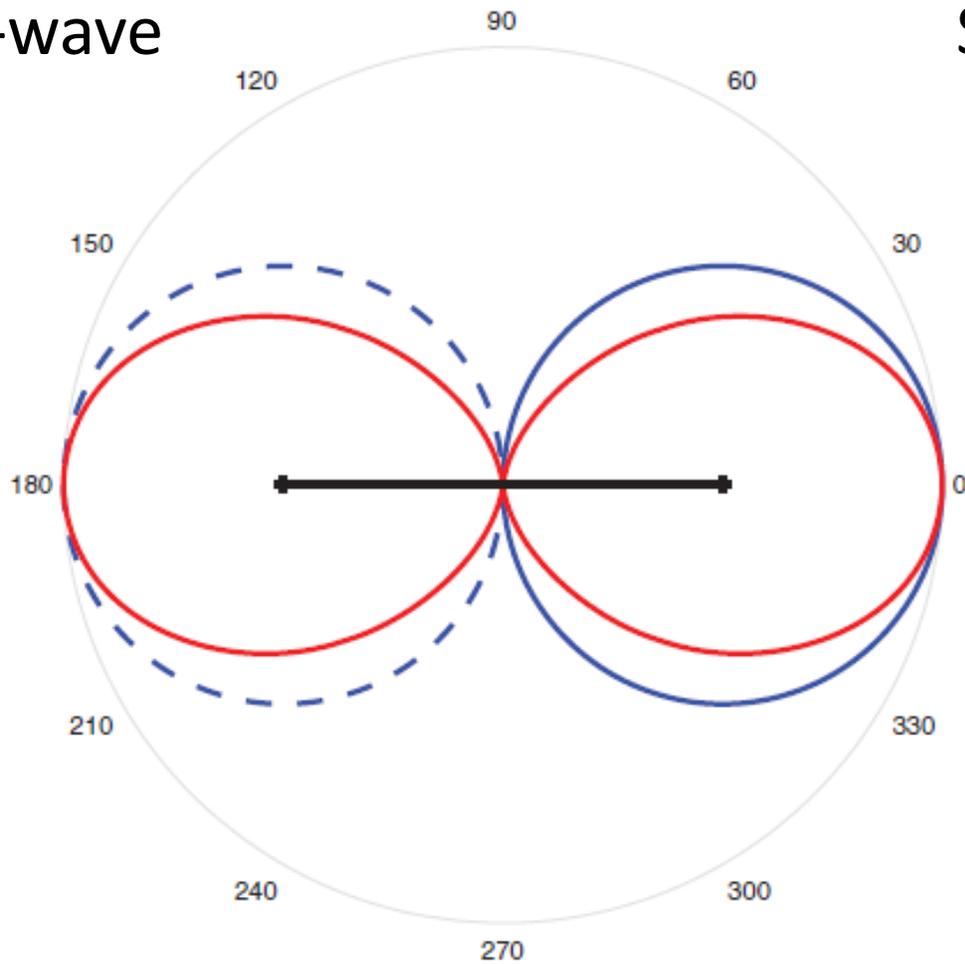
VS.

# 地震儀

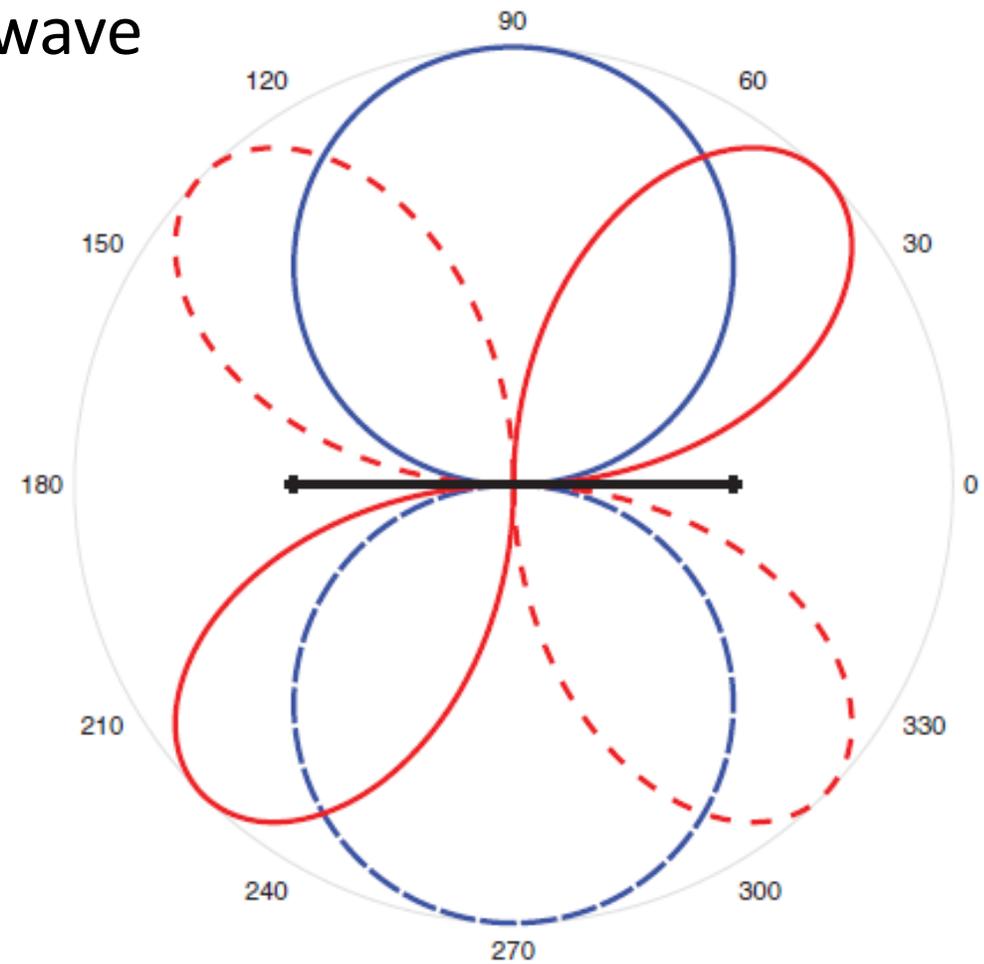


# 光纖 vs. 地震儀: 方向性敏感度

P-wave



S-wave

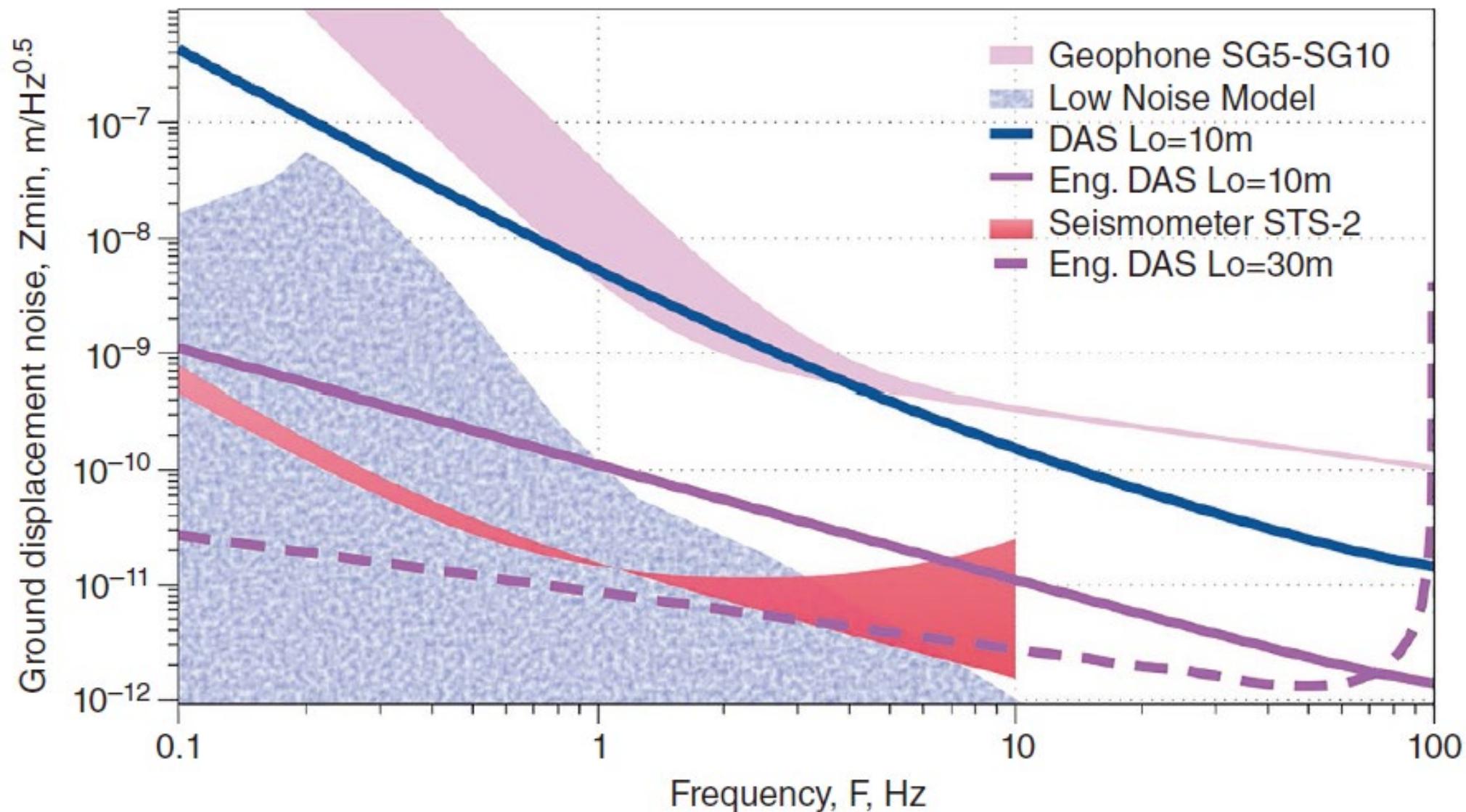


— DAS

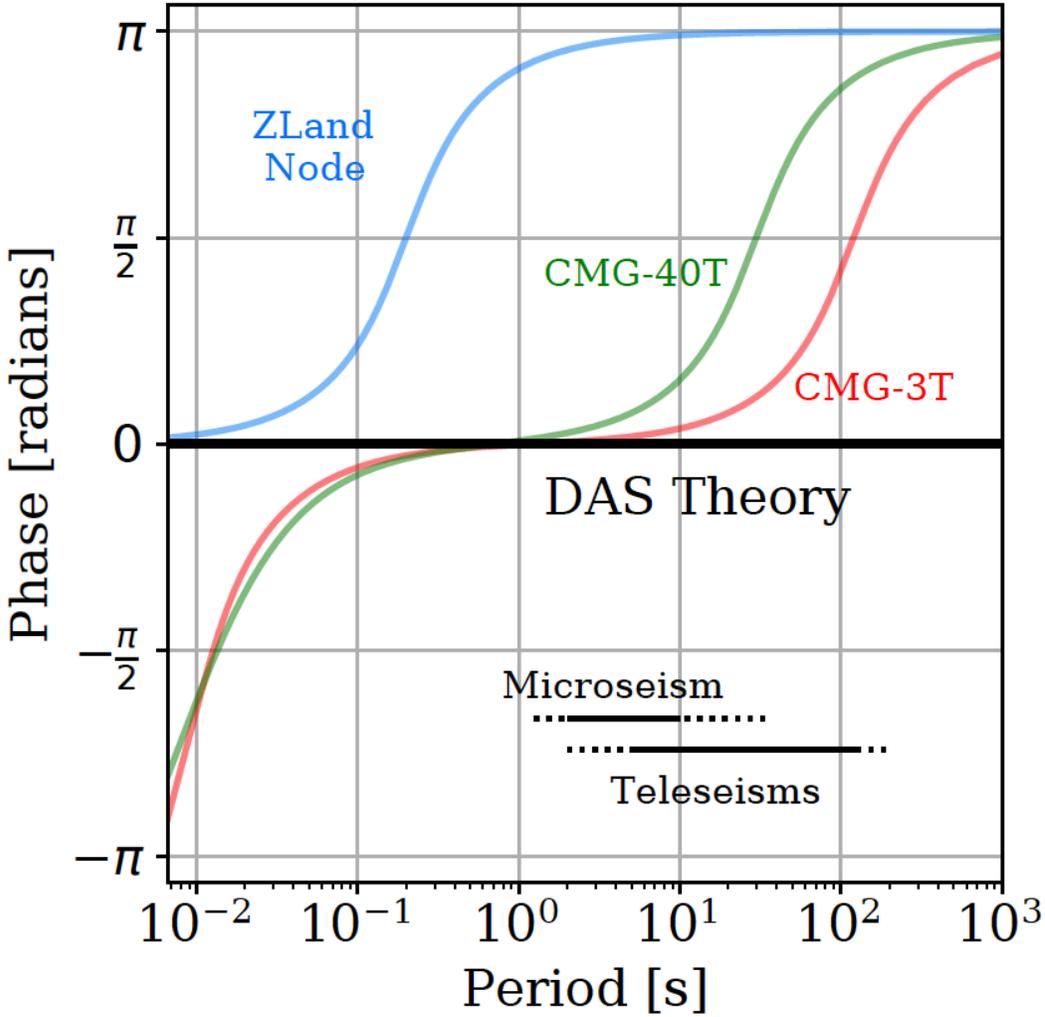
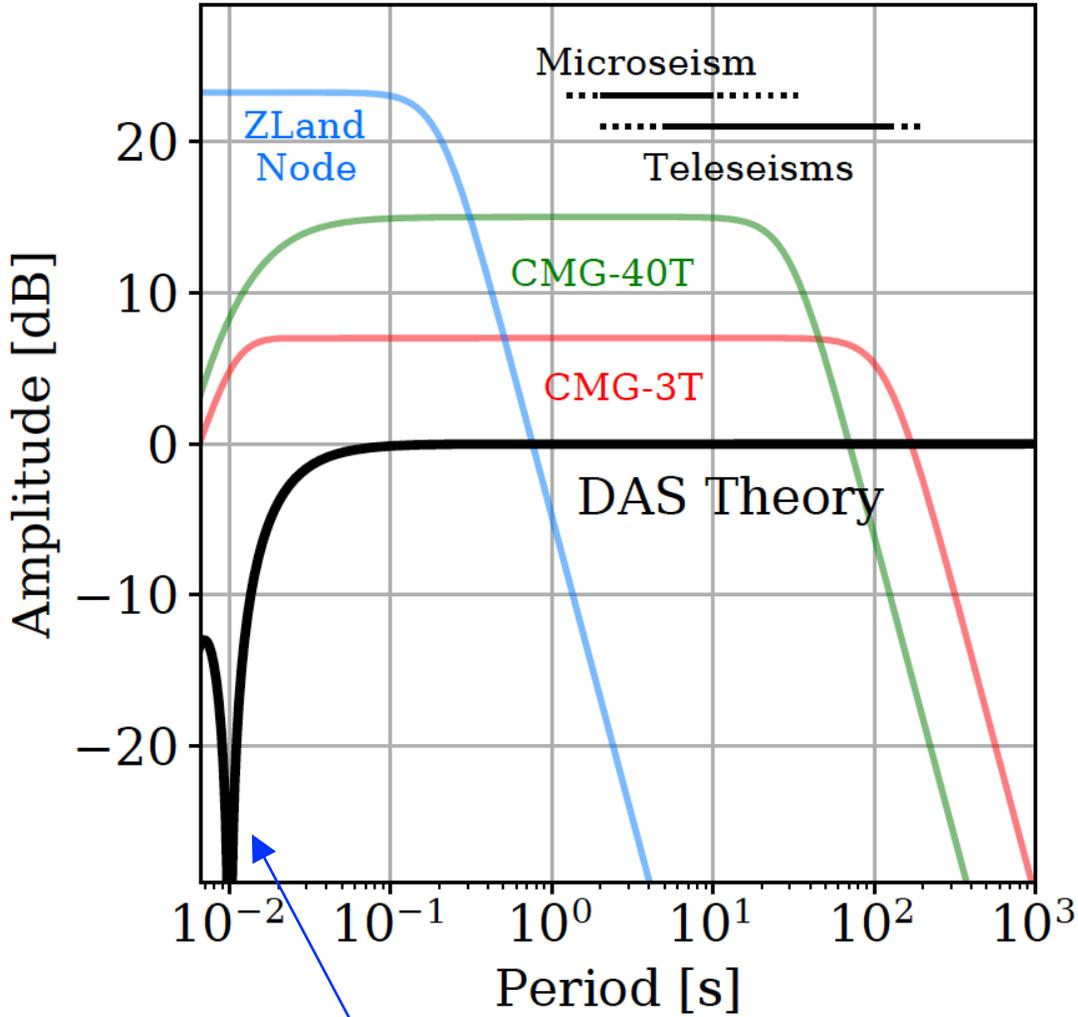
— Seismometer

Zhan (2019)

# 光纖 vs. 地震儀：儀器雜訊略優於地聲計



# 光纖 vs. 地震儀: 不需做儀器響應修正

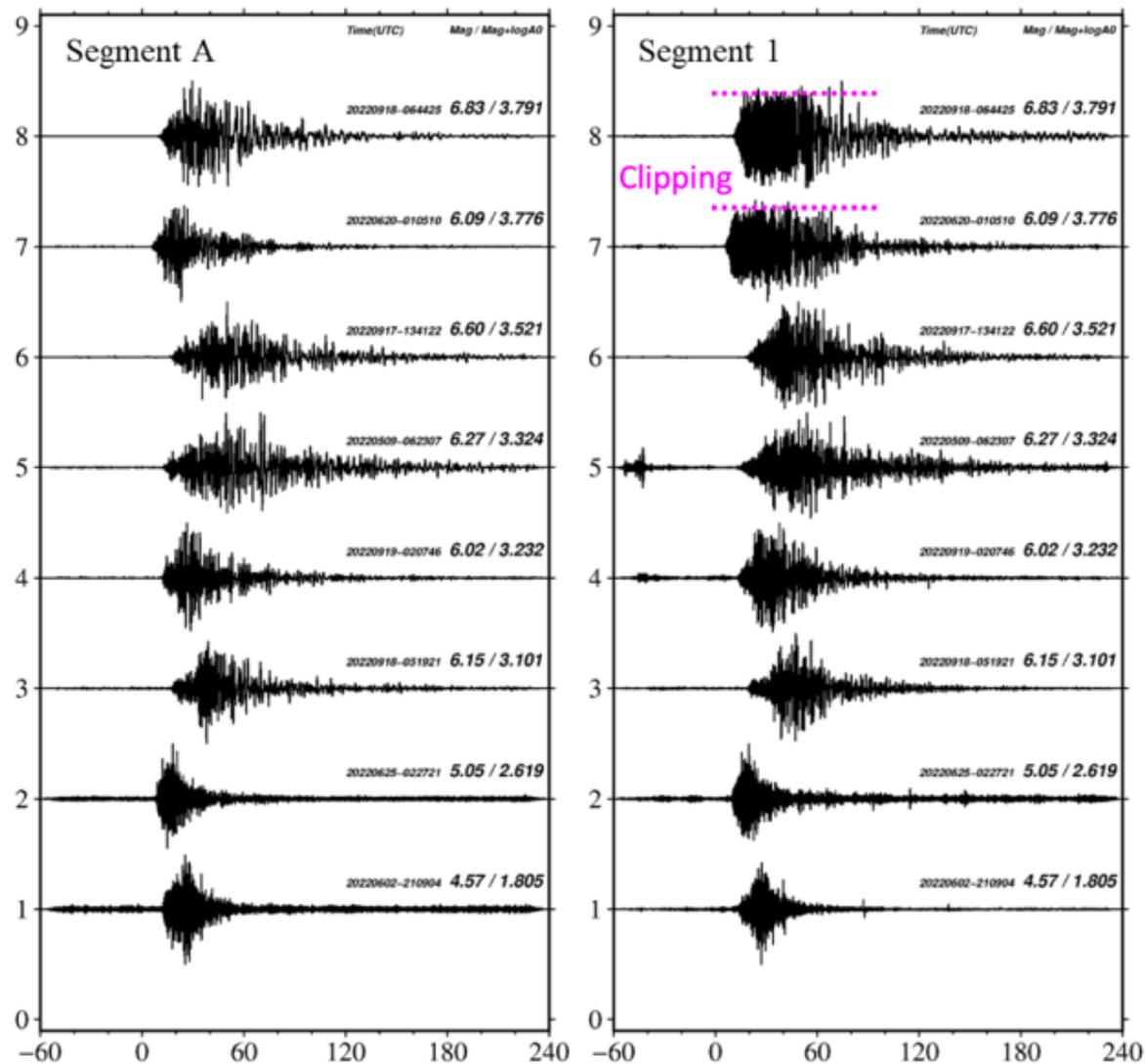


Notch related to gauge length

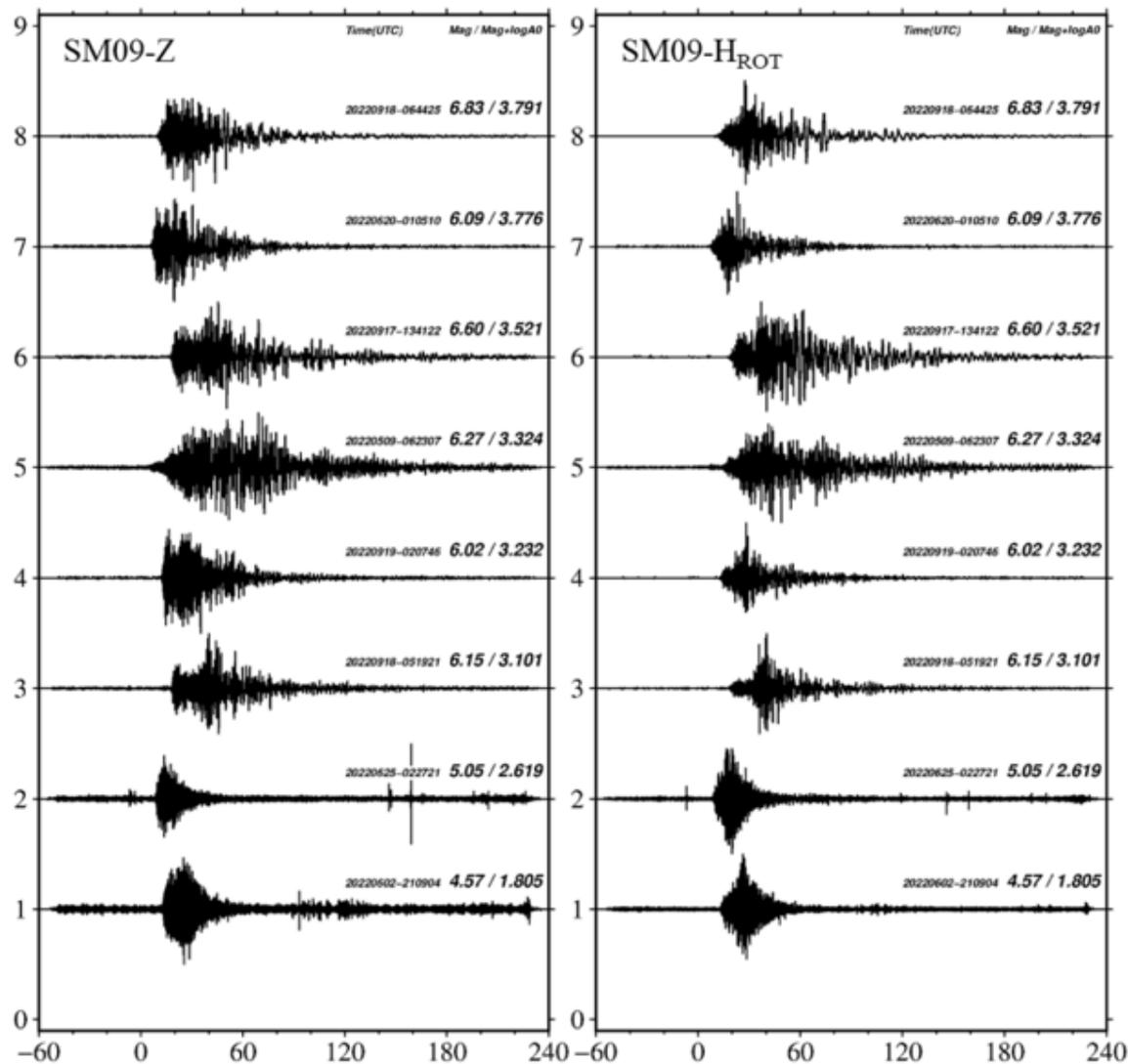
Lindsey et al. (2020)

# MiDAS地震觀測比較

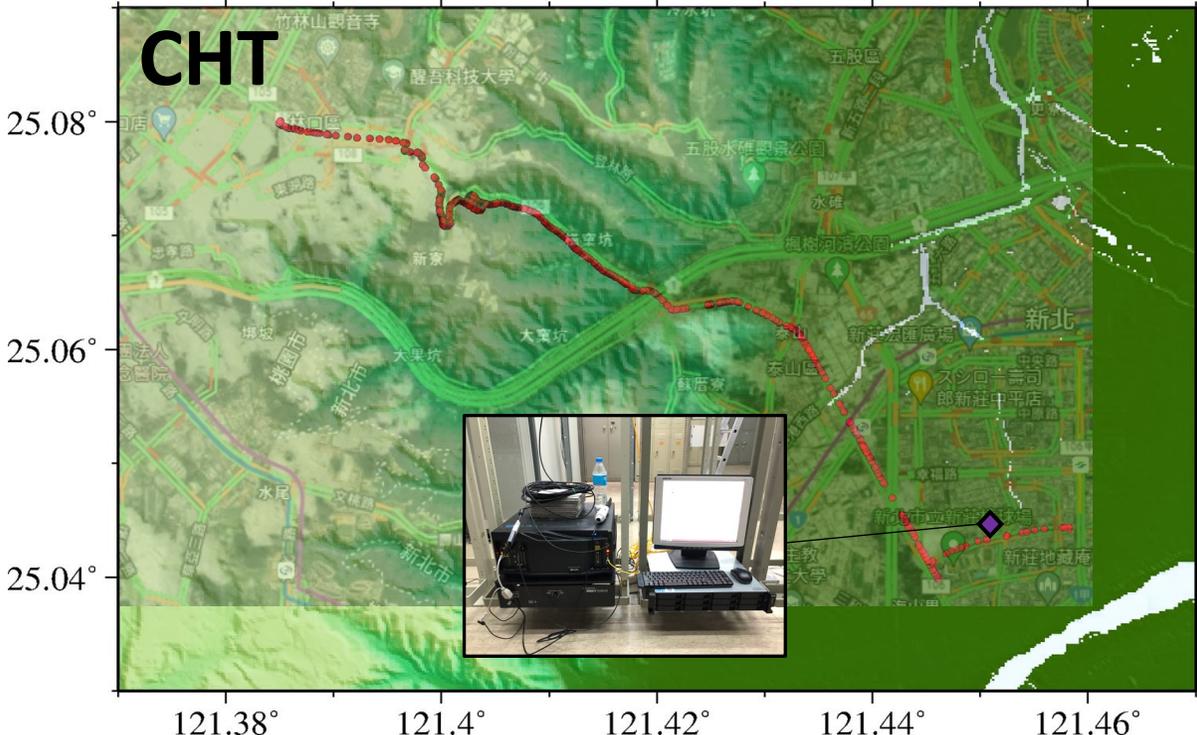
(a) DAS



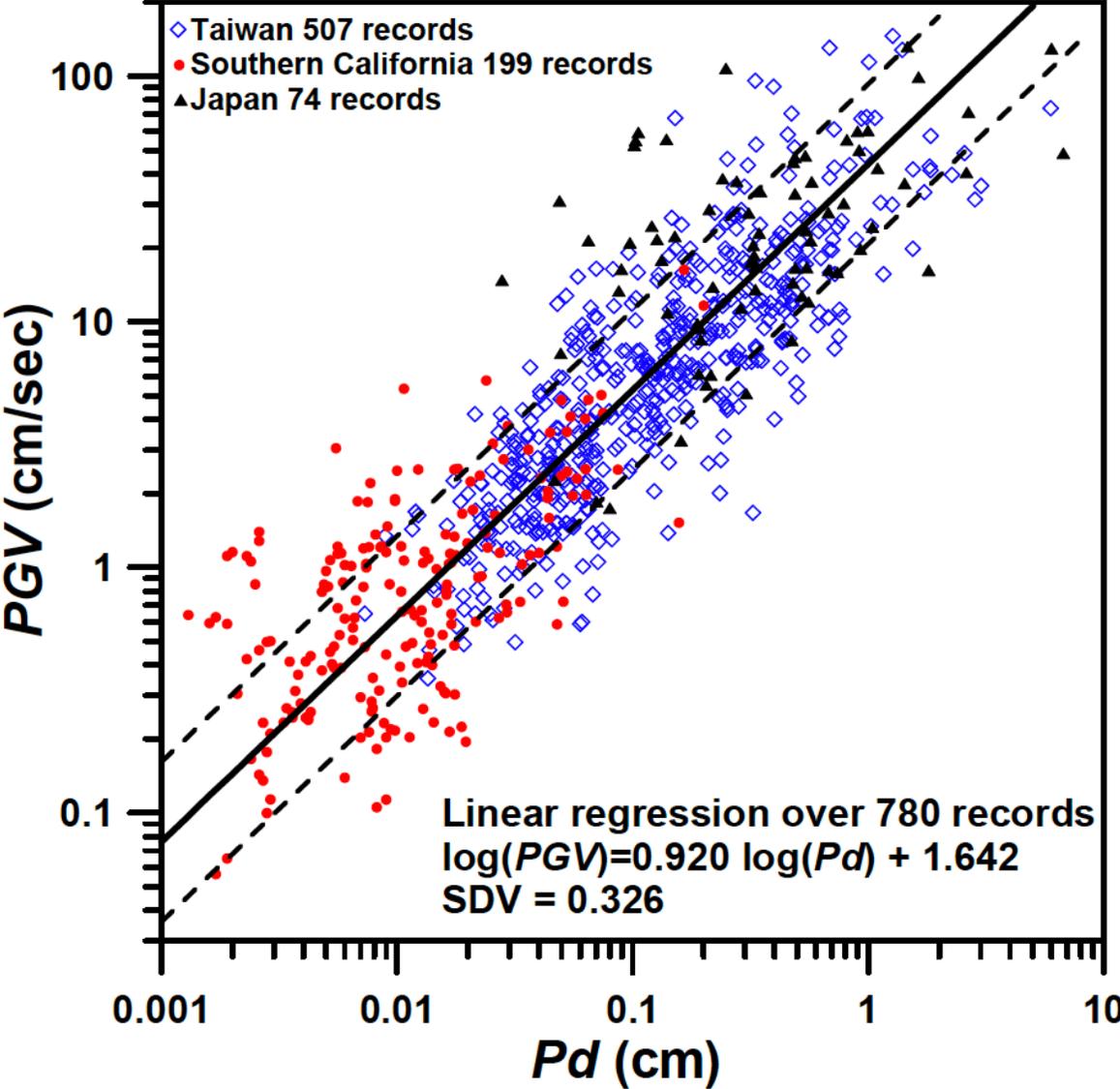
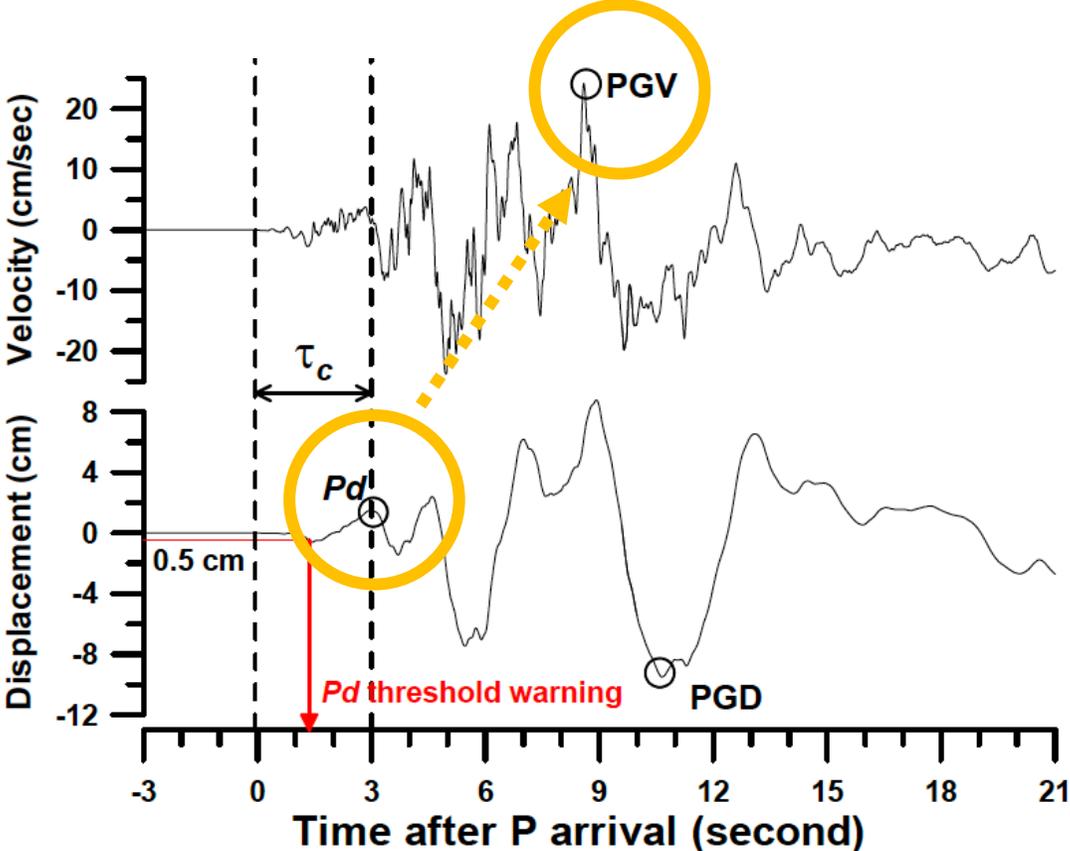
(b) SM09



# Dark fiber applications

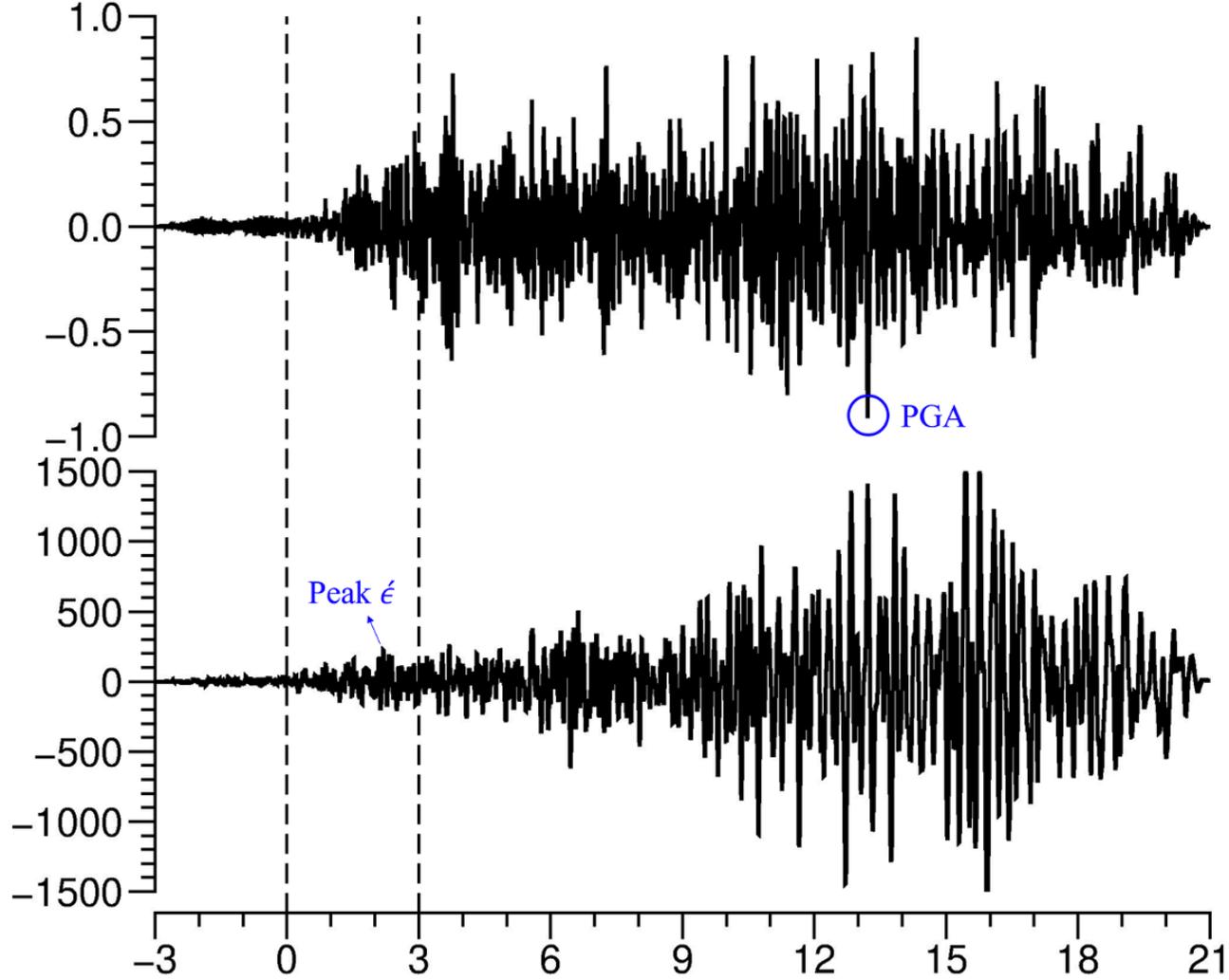
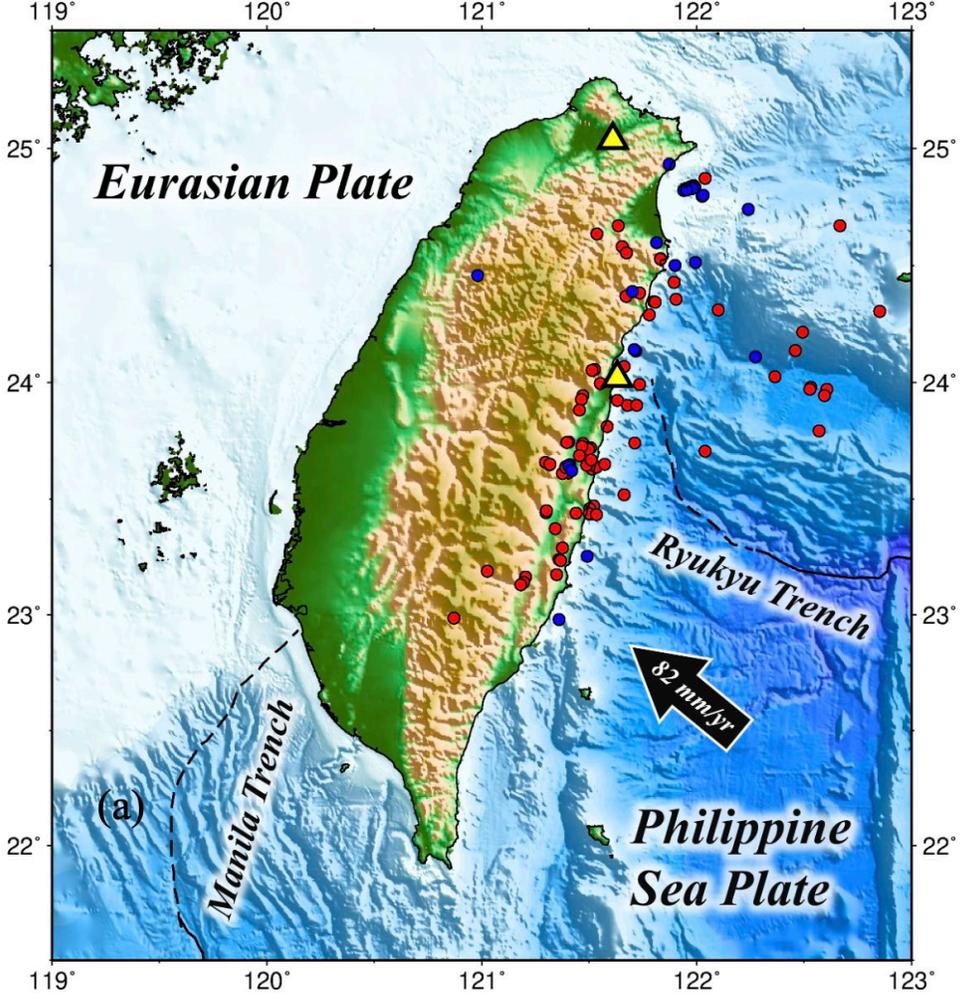


# On-site EEW – relationship to peak ground shaking

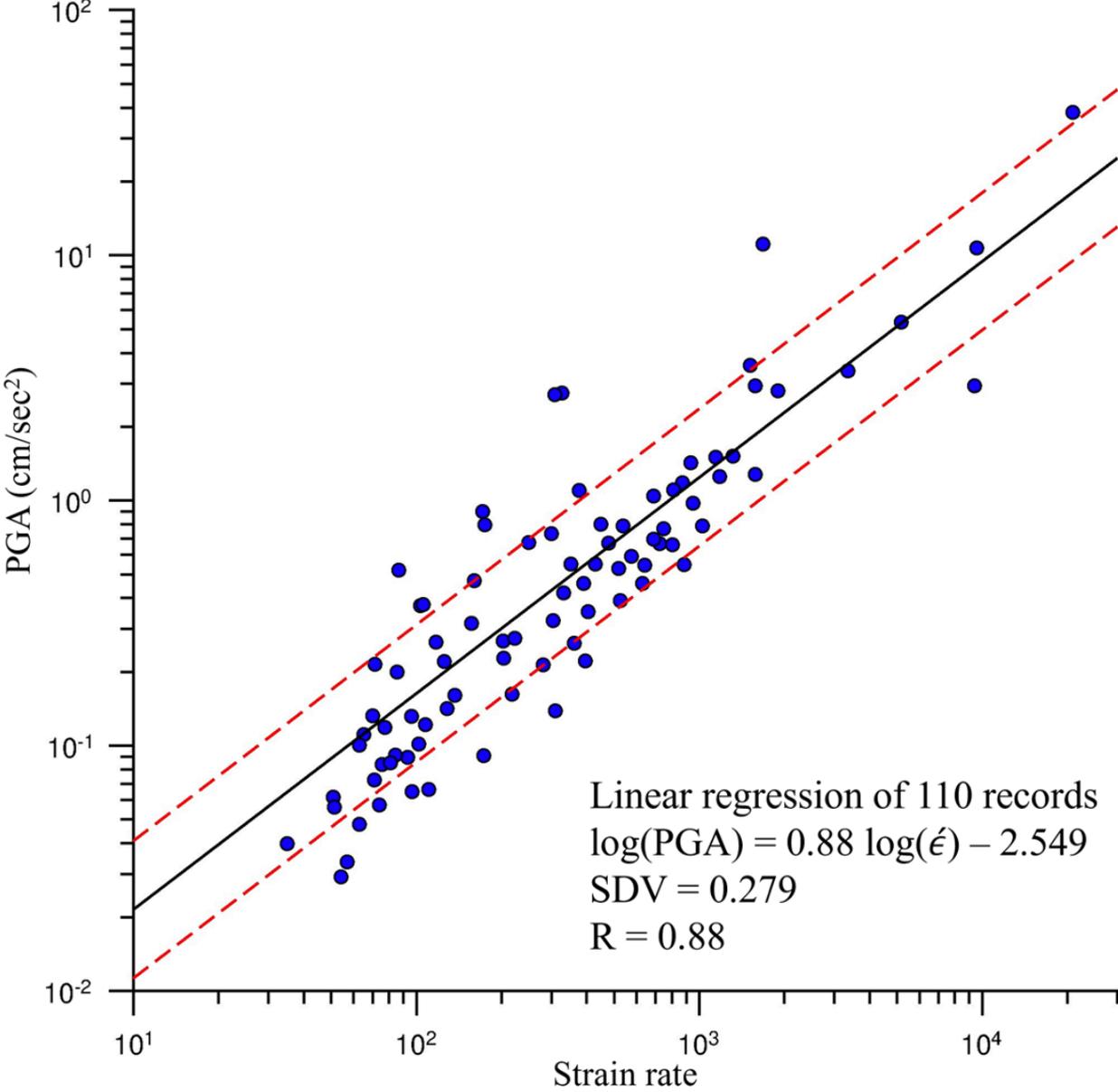
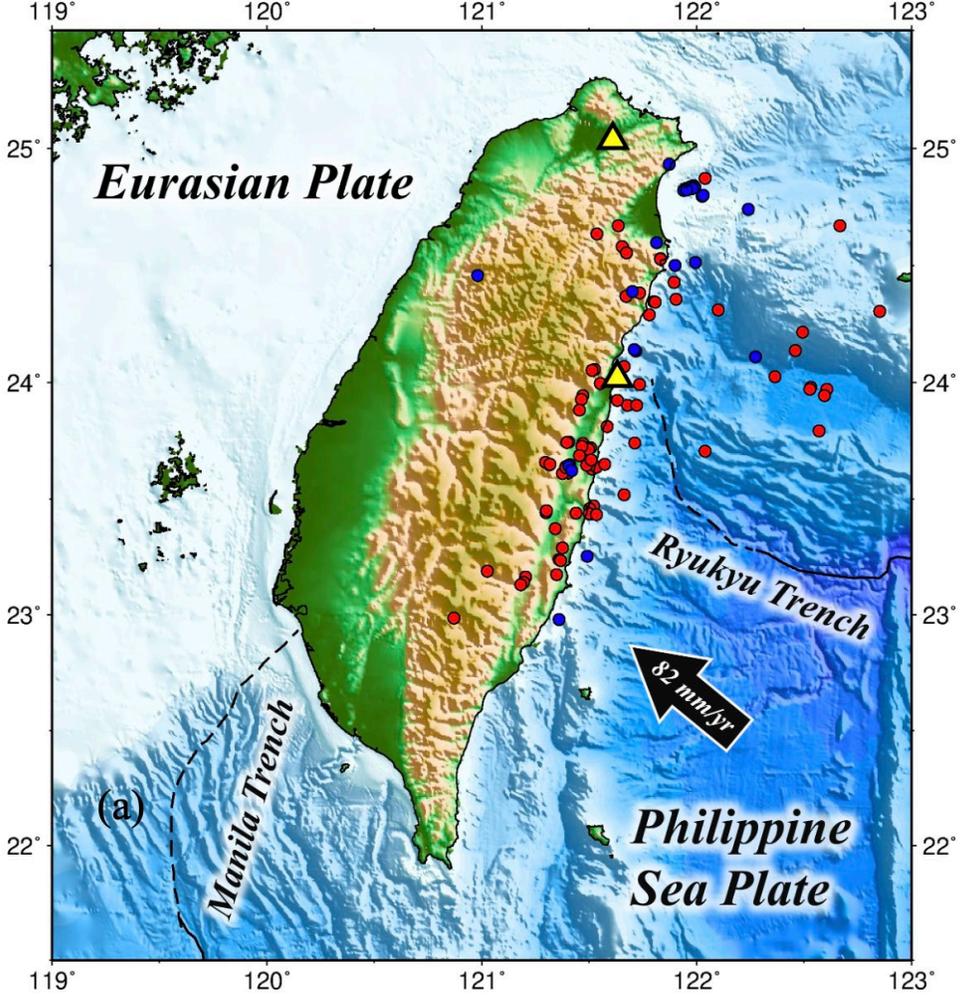


(Wu et al., 2008)

# On-site EEW – relationship to peak ground shaking

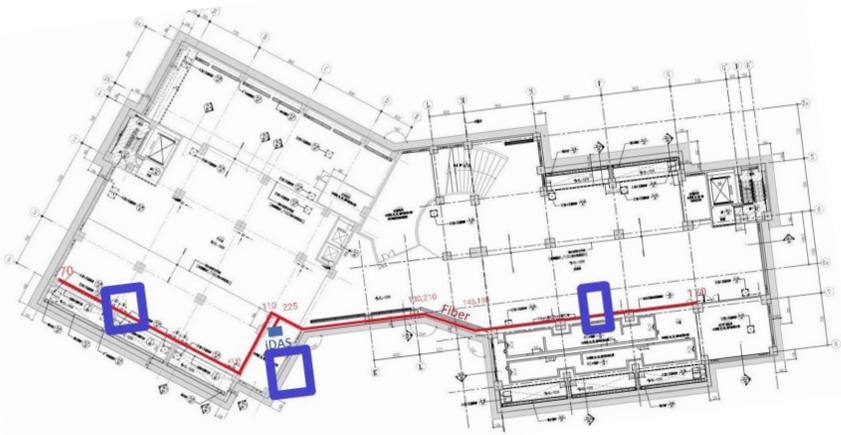


# On-site EEW – relationship to peak ground shaking

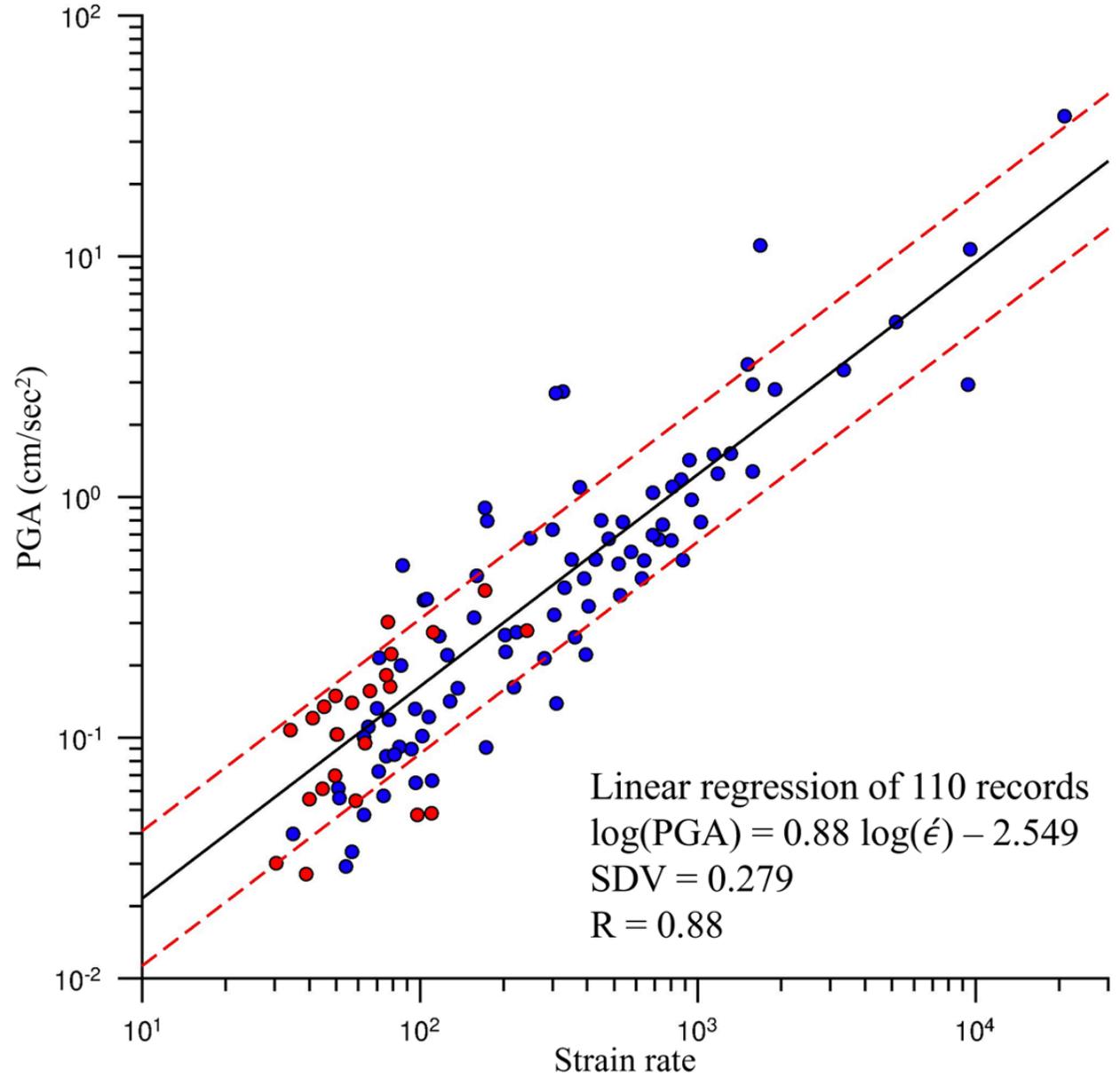
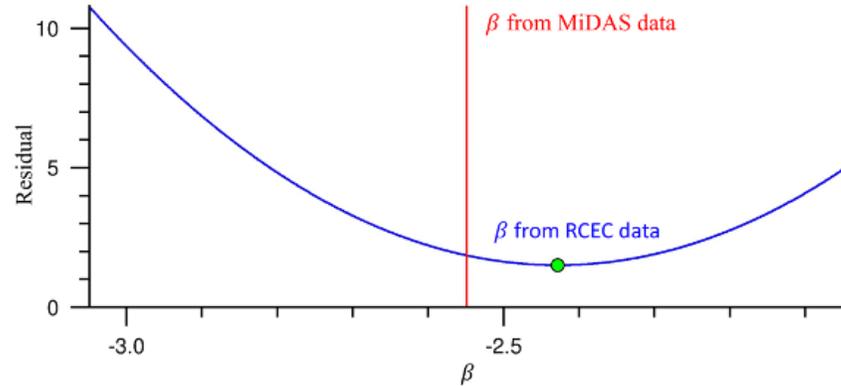


# On-site EEW – Validated with RCEC data

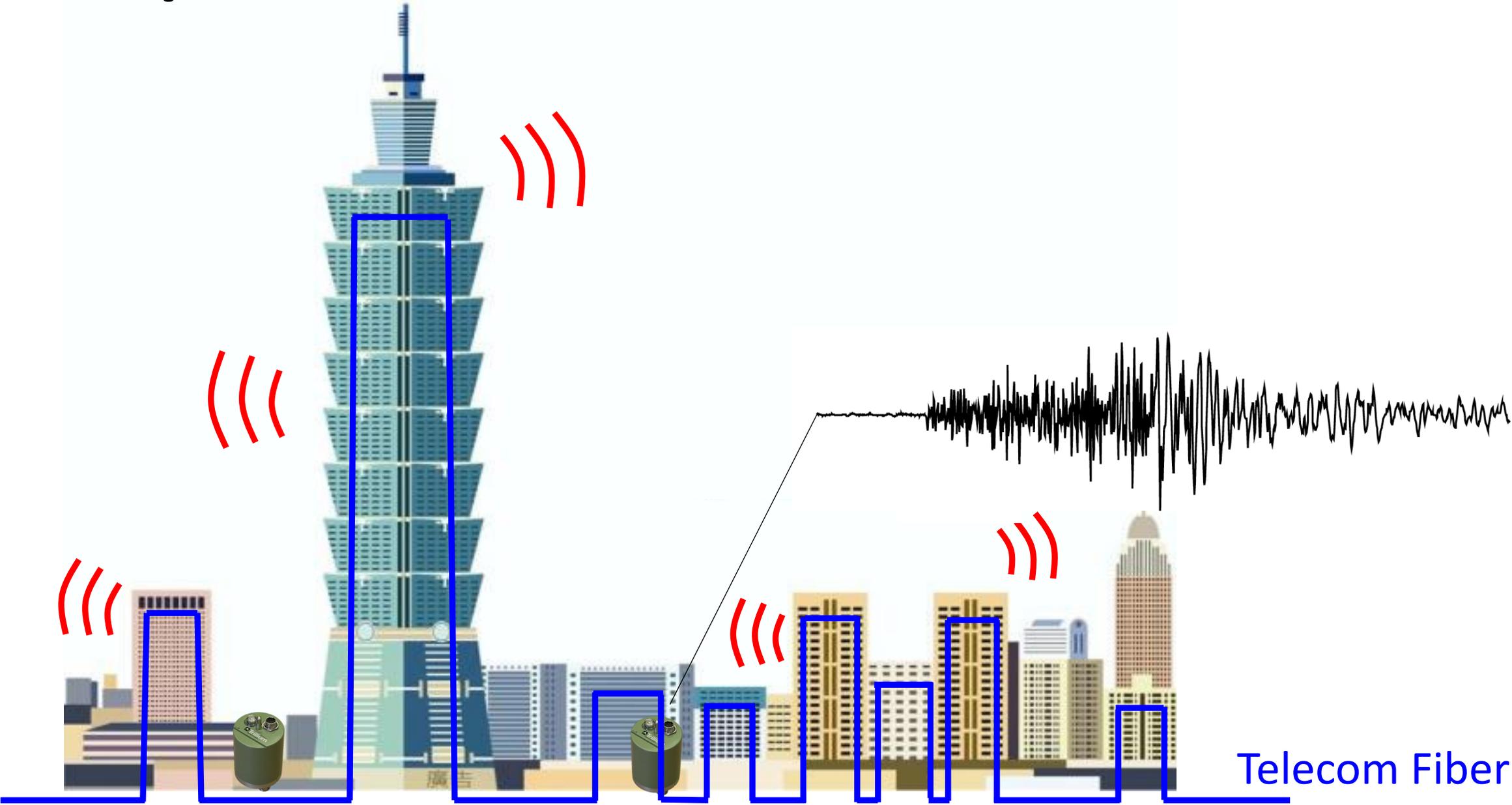
## RCEC



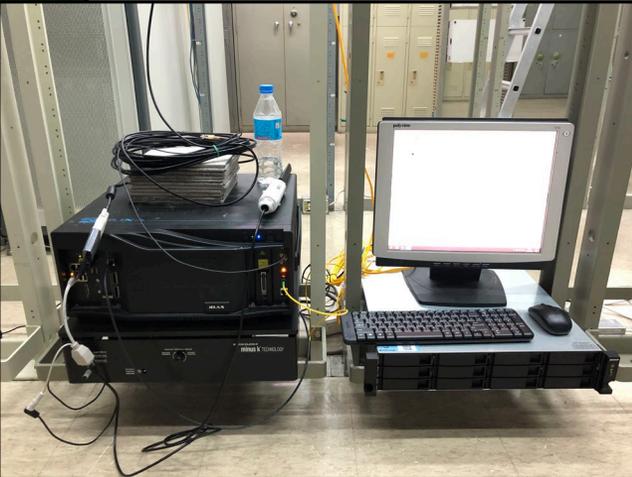
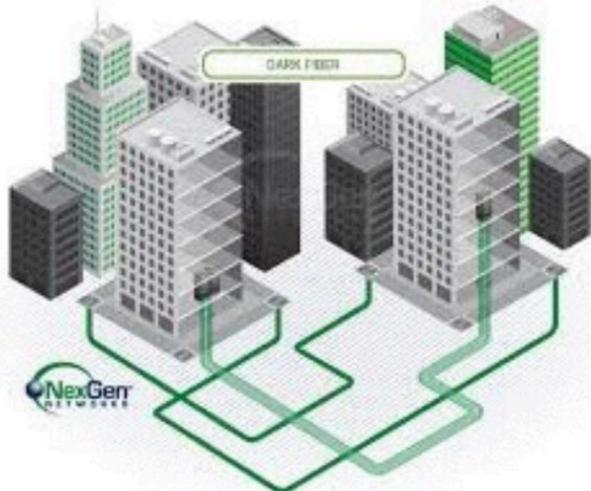
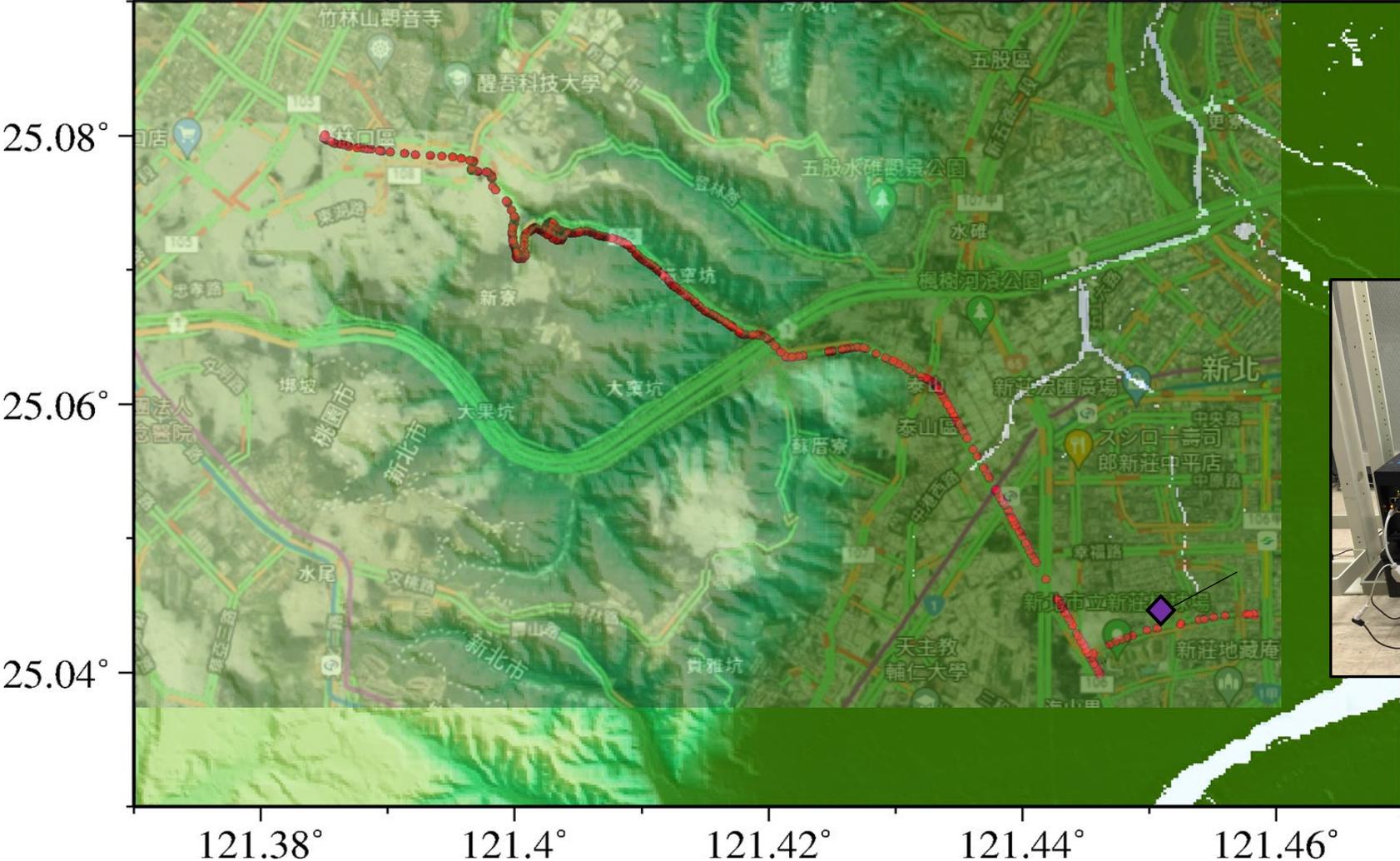
$$\log(PGA_i) = \alpha \log(\dot{\epsilon}_i) + \beta_i$$



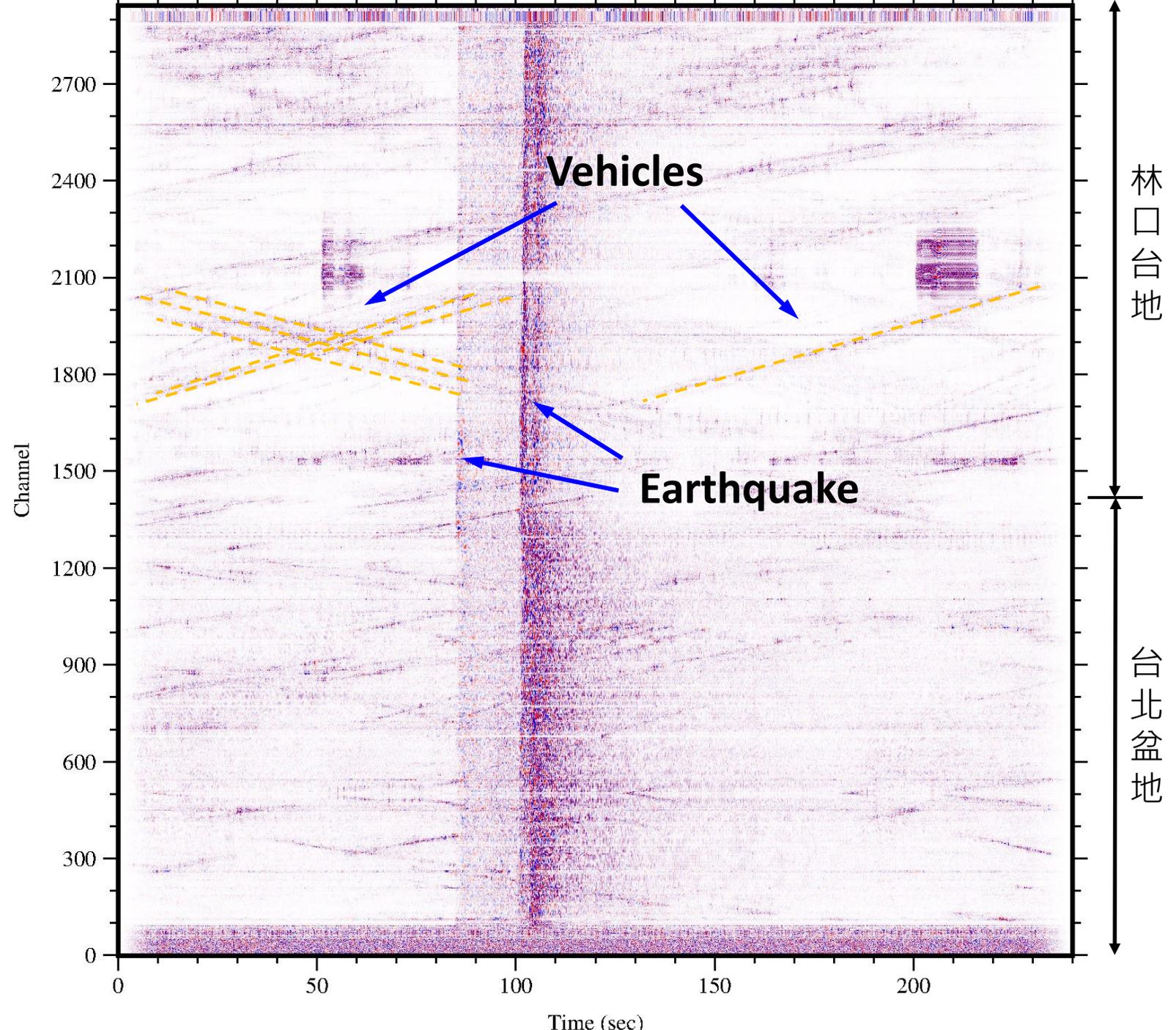
# Fibers provide Real On-site EEW



# 中華電信的暗光纖試驗

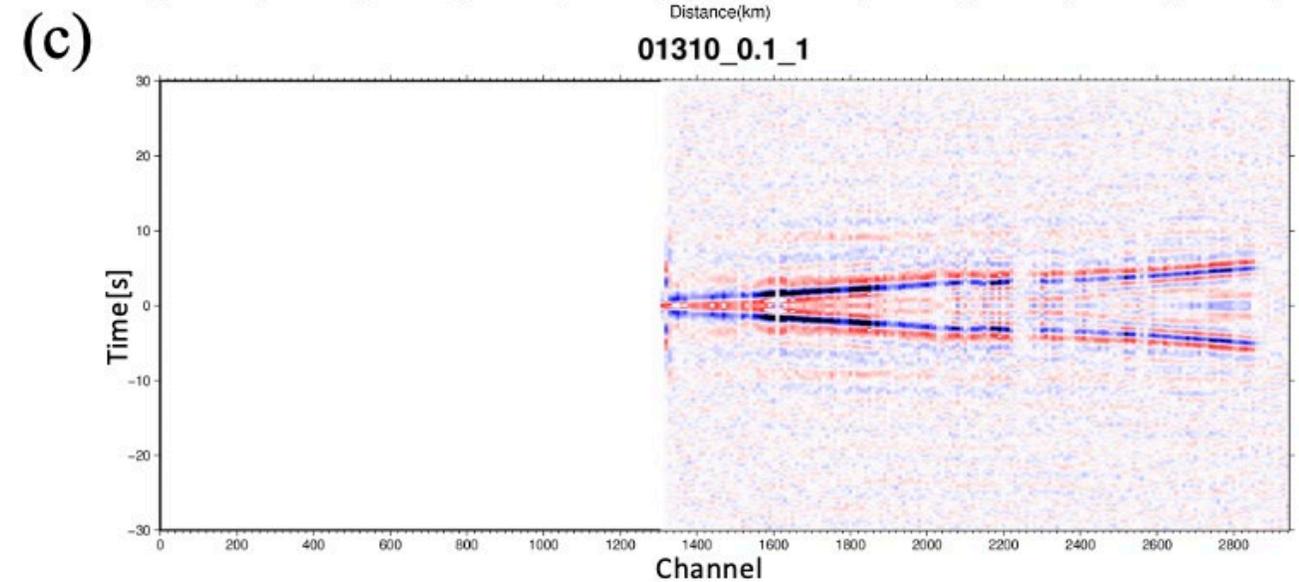
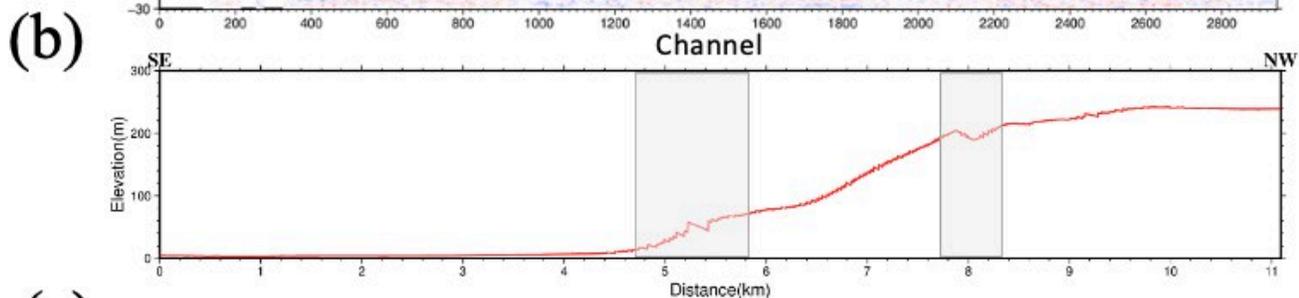
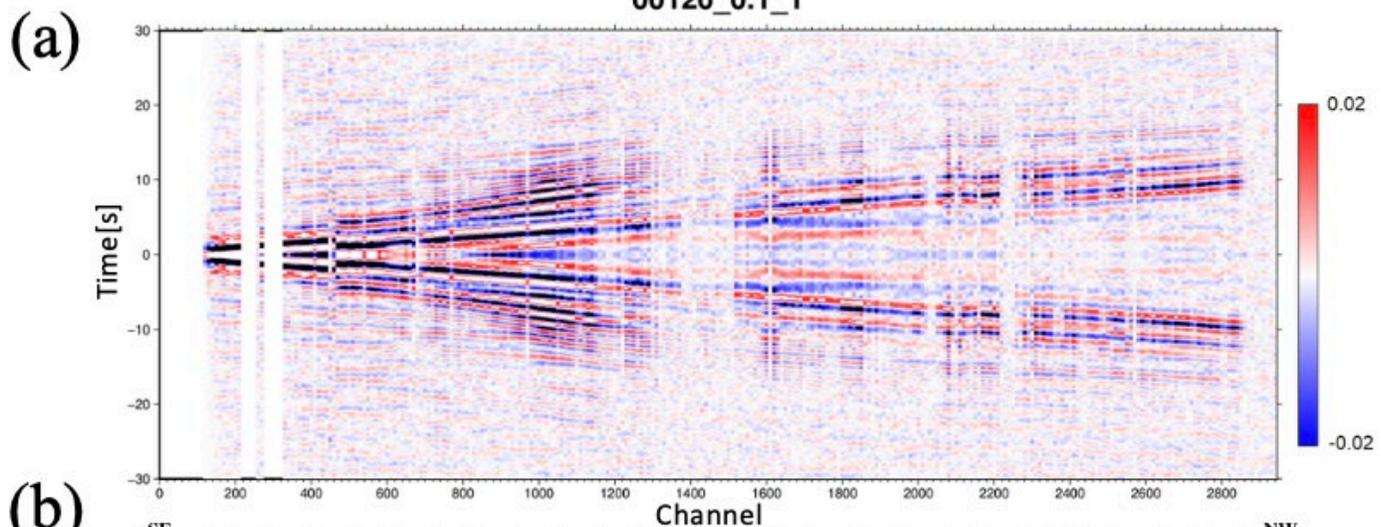
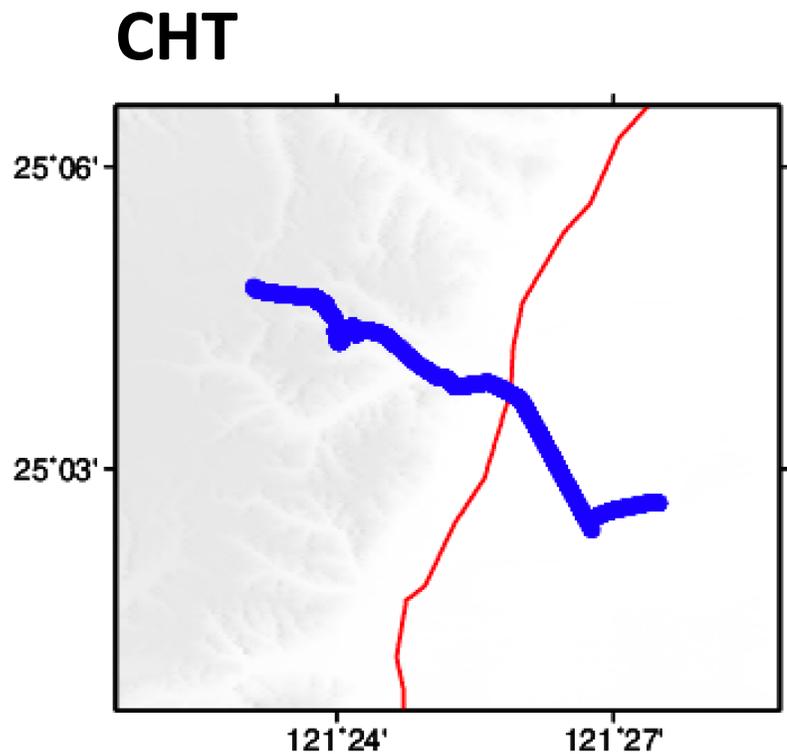


# 暗光纖 地震紀錄



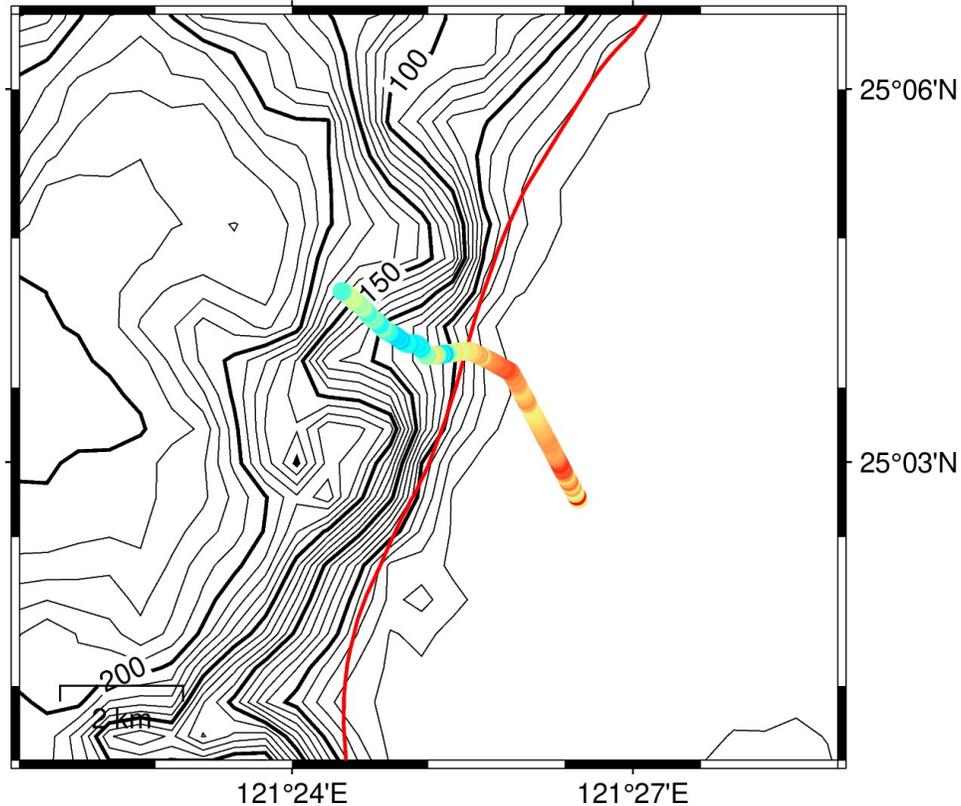
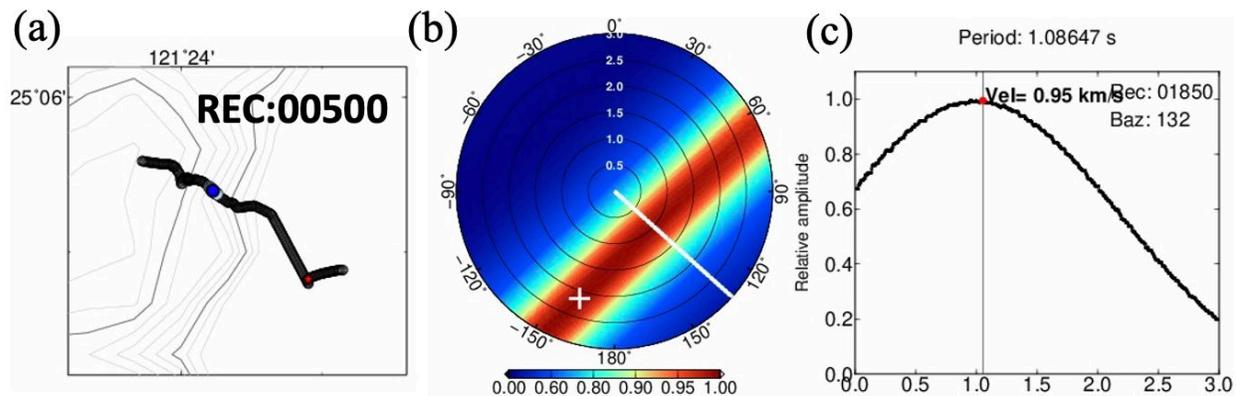
# 周遭噪訊交相關函數 (a)

– 噪訊表面波分析

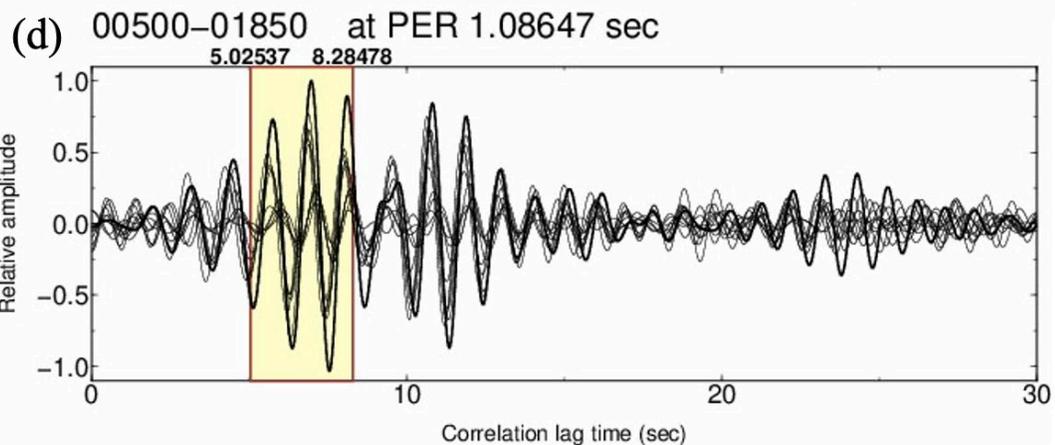
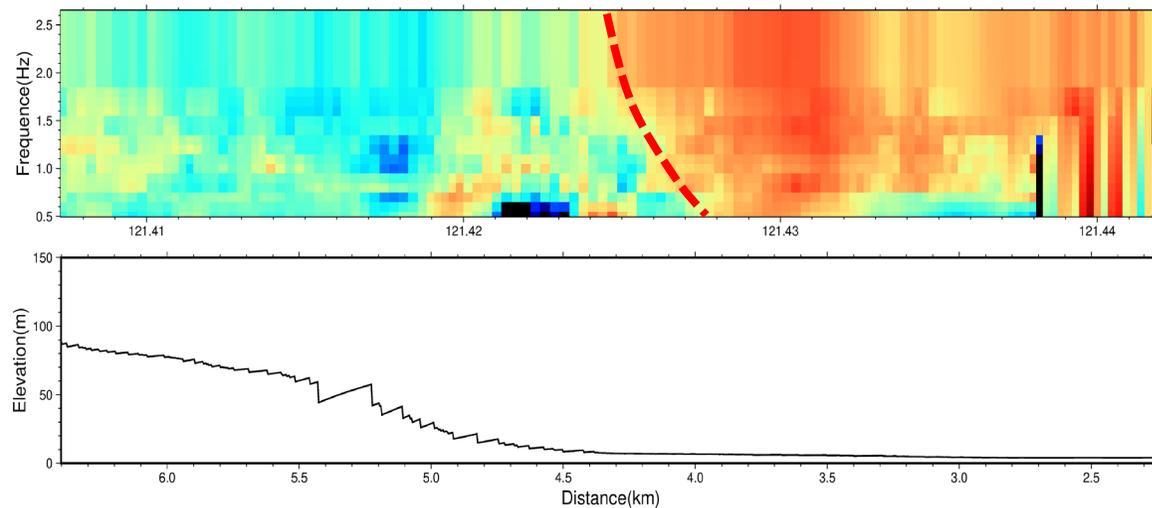


# 初步山腳斷層成像

— 噪訊表面波分析

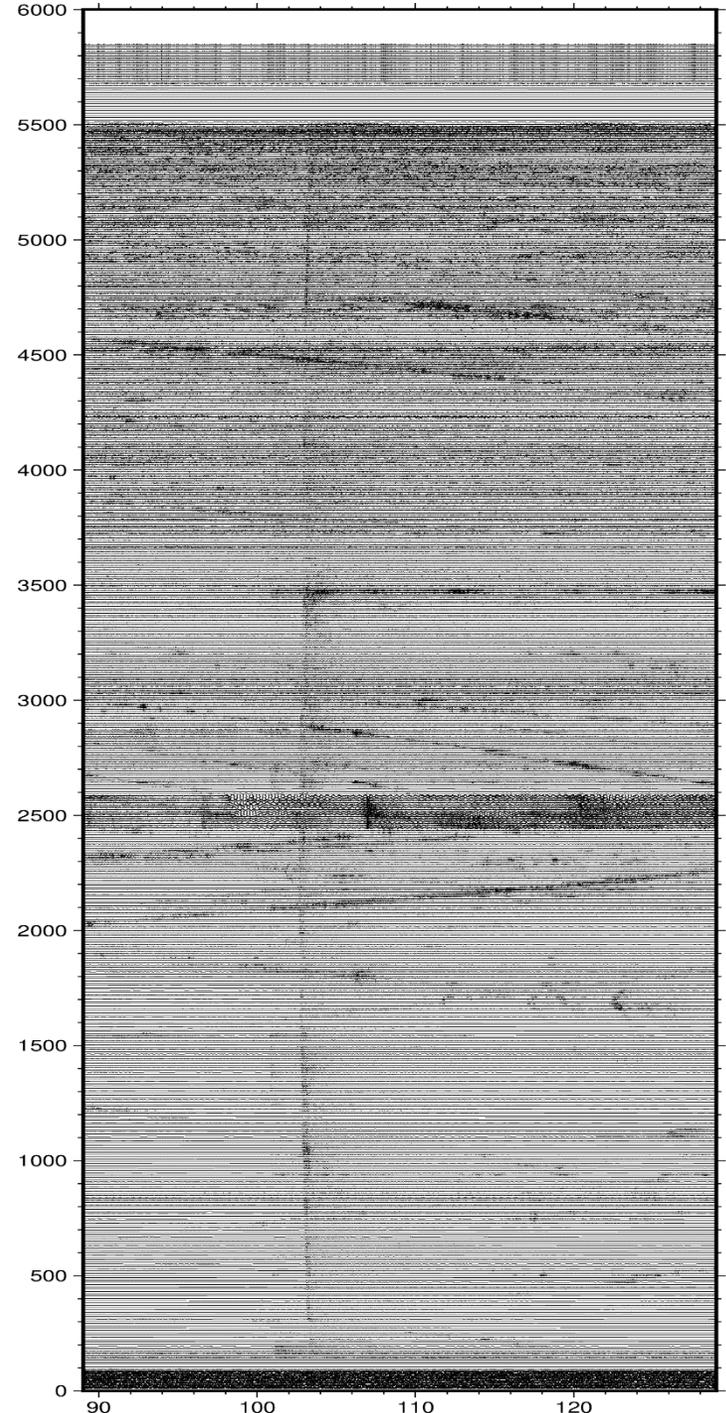
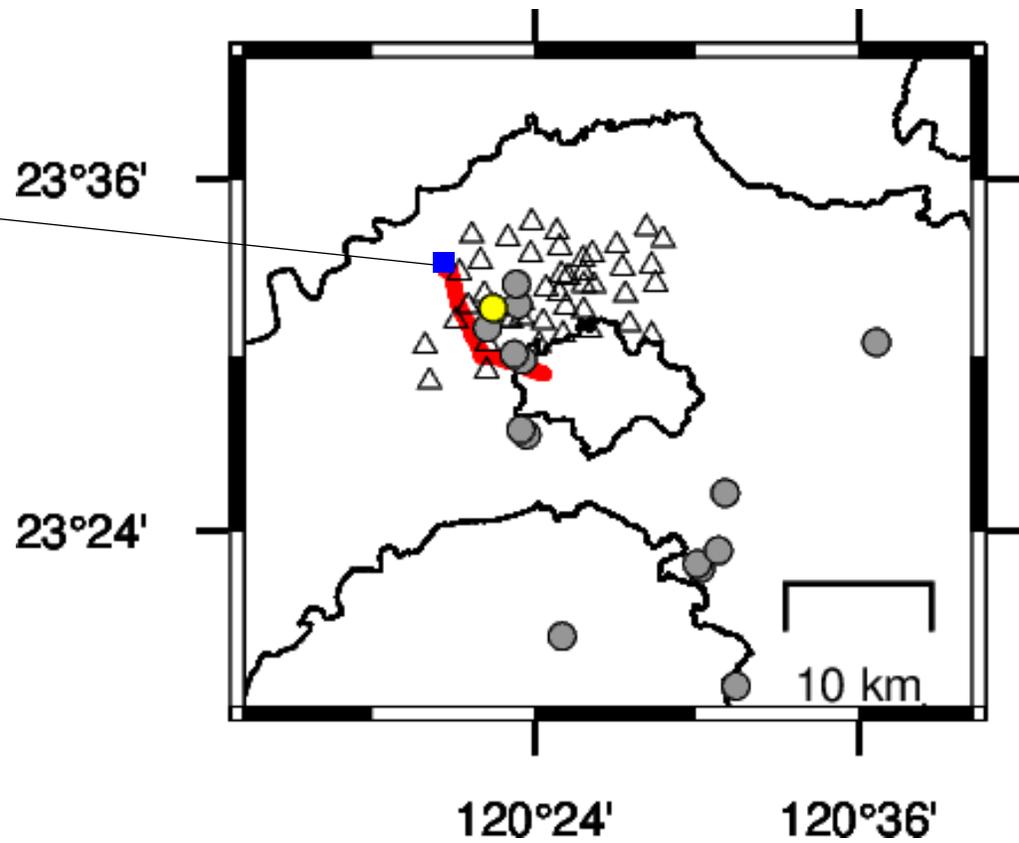
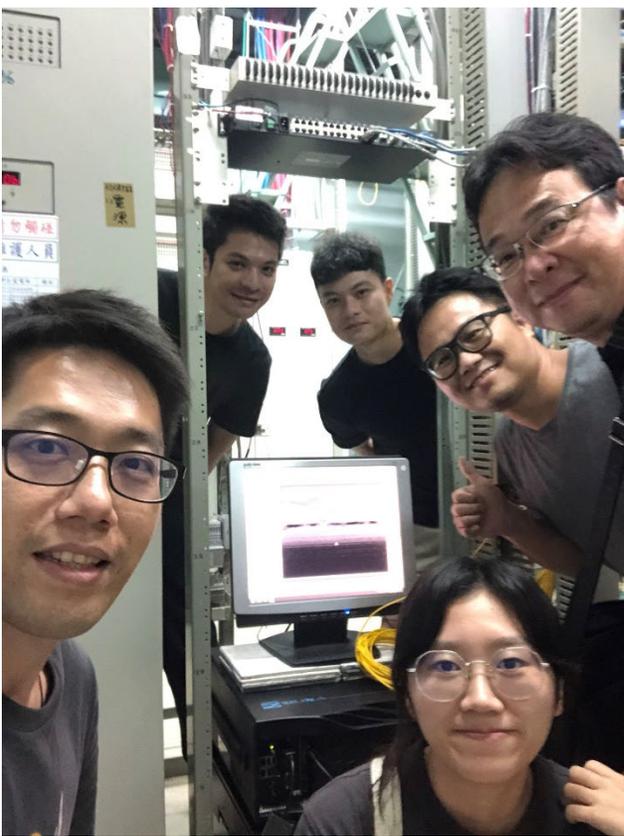


Shanchiao fault?



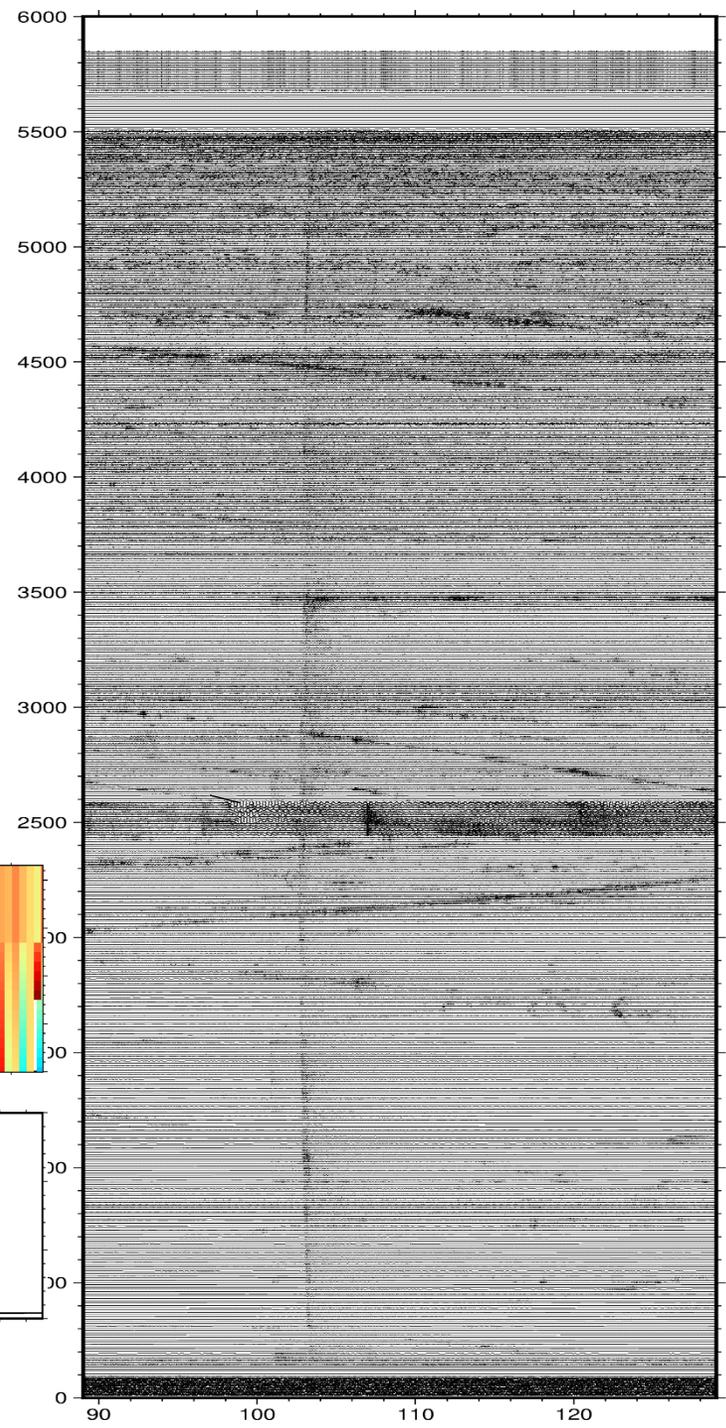
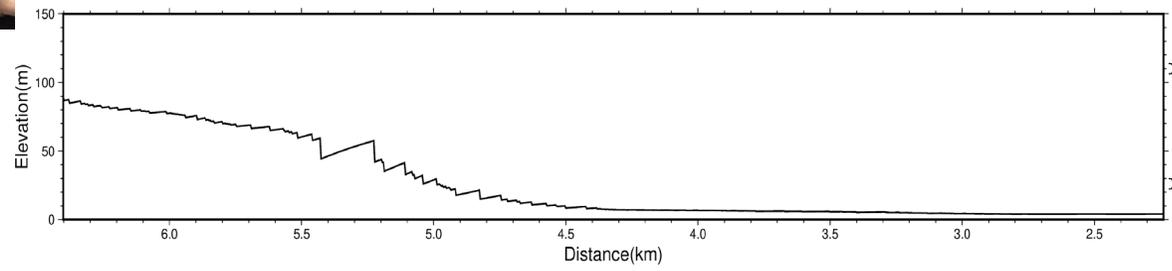
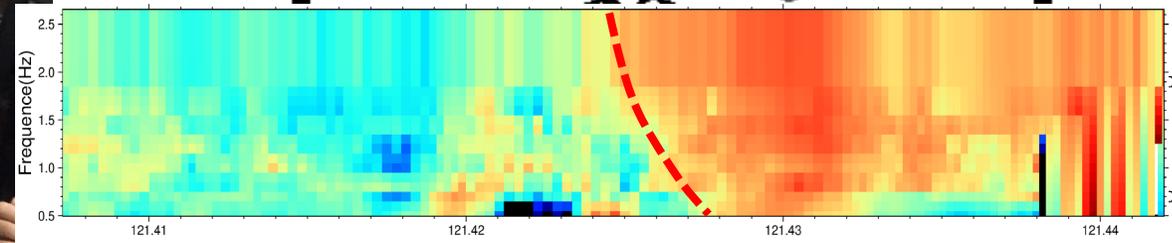
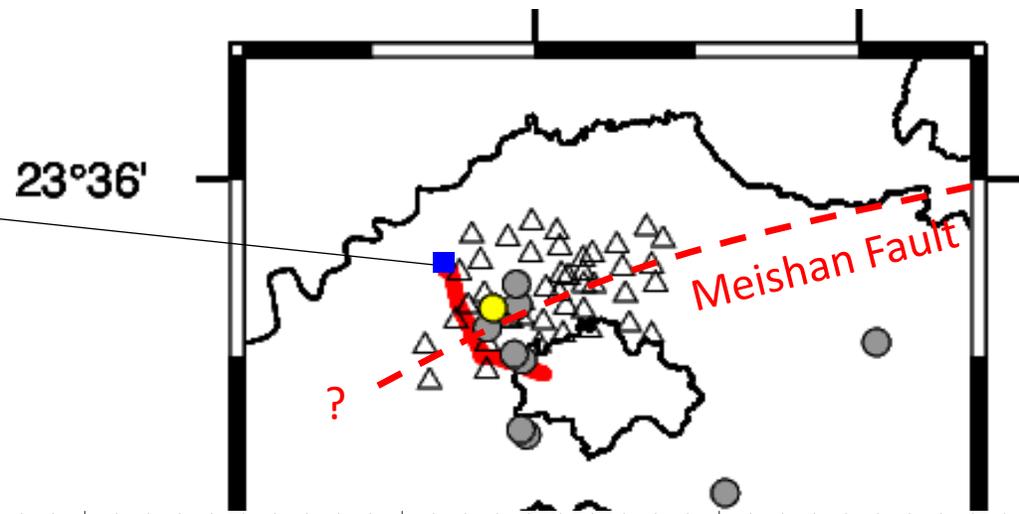
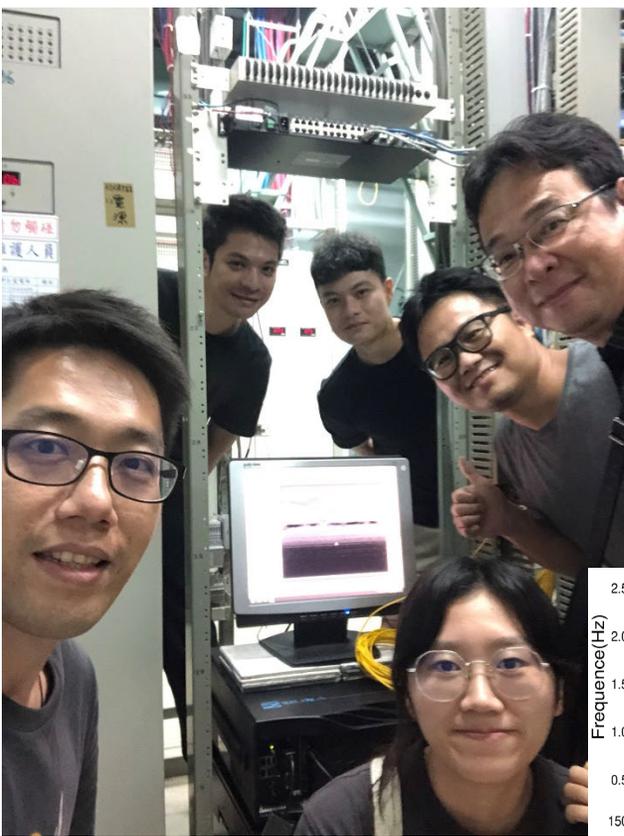
# 嘉義追震與梅山斷層成像

- with 中正地環團隊



# 嘉義追震與梅山斷層成像

- with 中正地環團隊



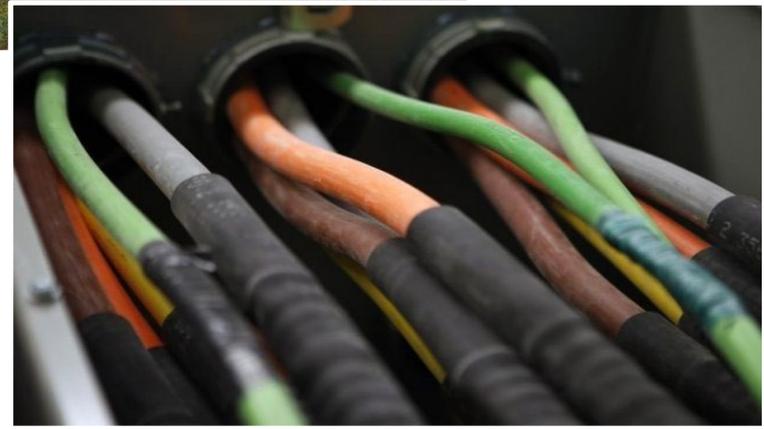




>10 km



~1 km



<10 m!

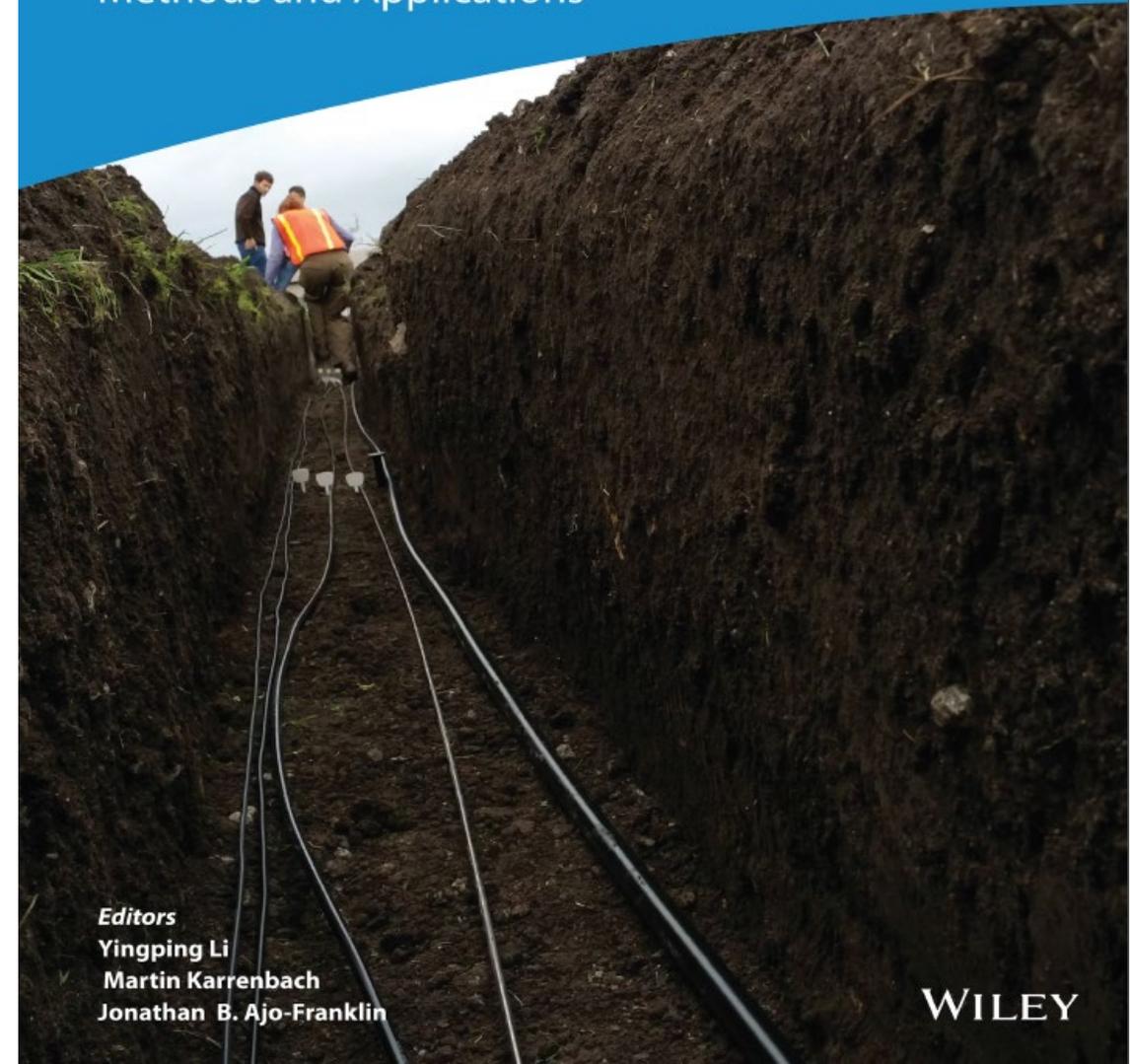
**Thanks for your attention!**

GEOPHYSICAL MONOGRAPH SERIES



# Distributed Acoustic Sensing in Geophysics

Methods and Applications

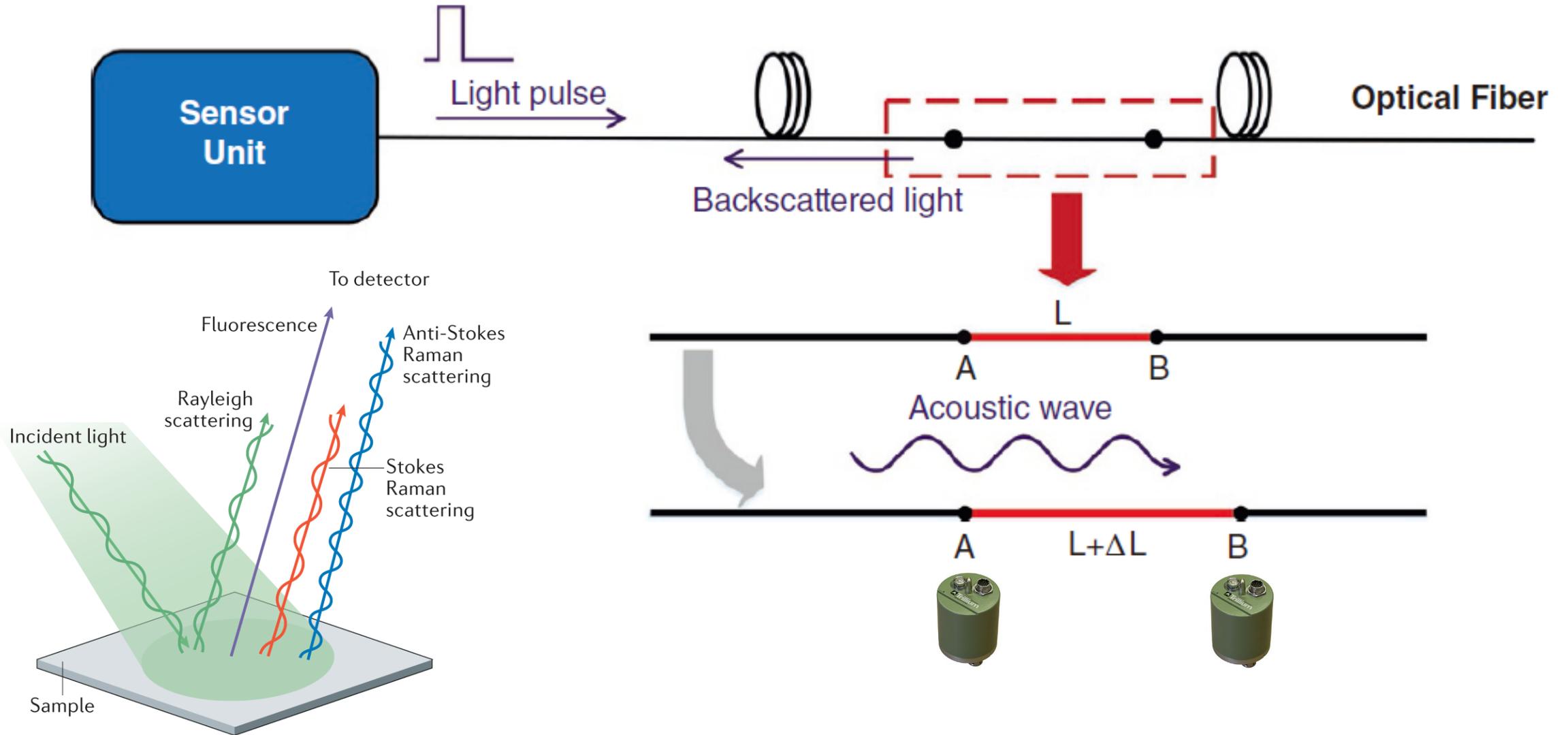


*Editors*  
Yingping Li  
Martin Karrenbach  
Jonathan B. Ajo-Franklin

WILEY

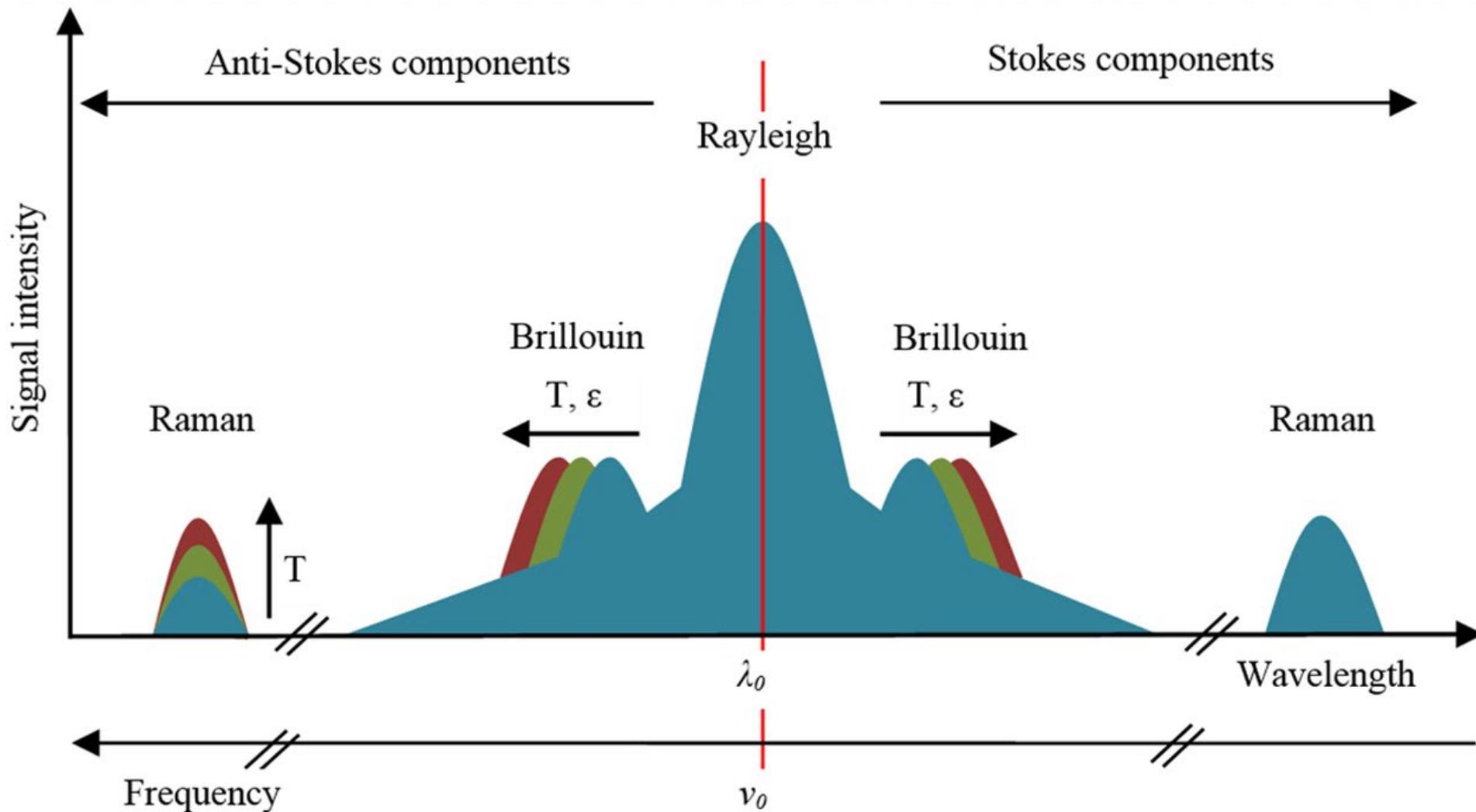
# 分散式光纖感測技術原理

## – Distributed Acoustic Sensing (DAS)



# 雷利散射量測動態形變量(DAS)

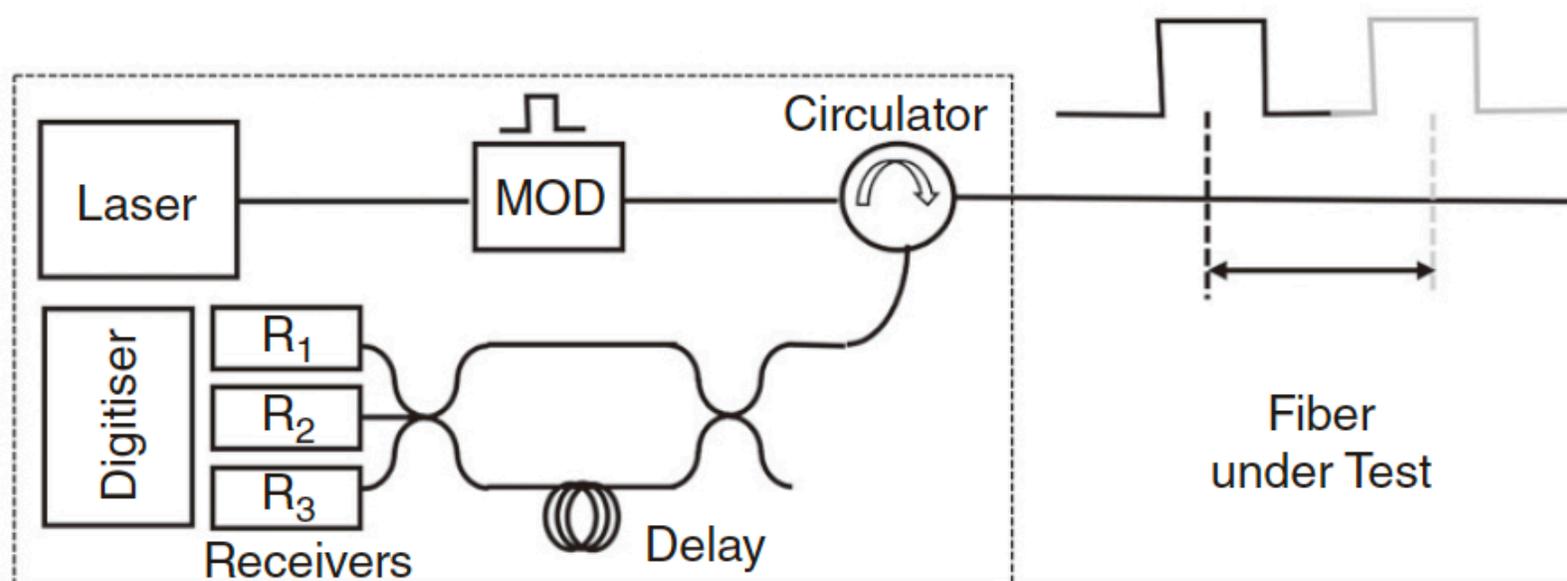
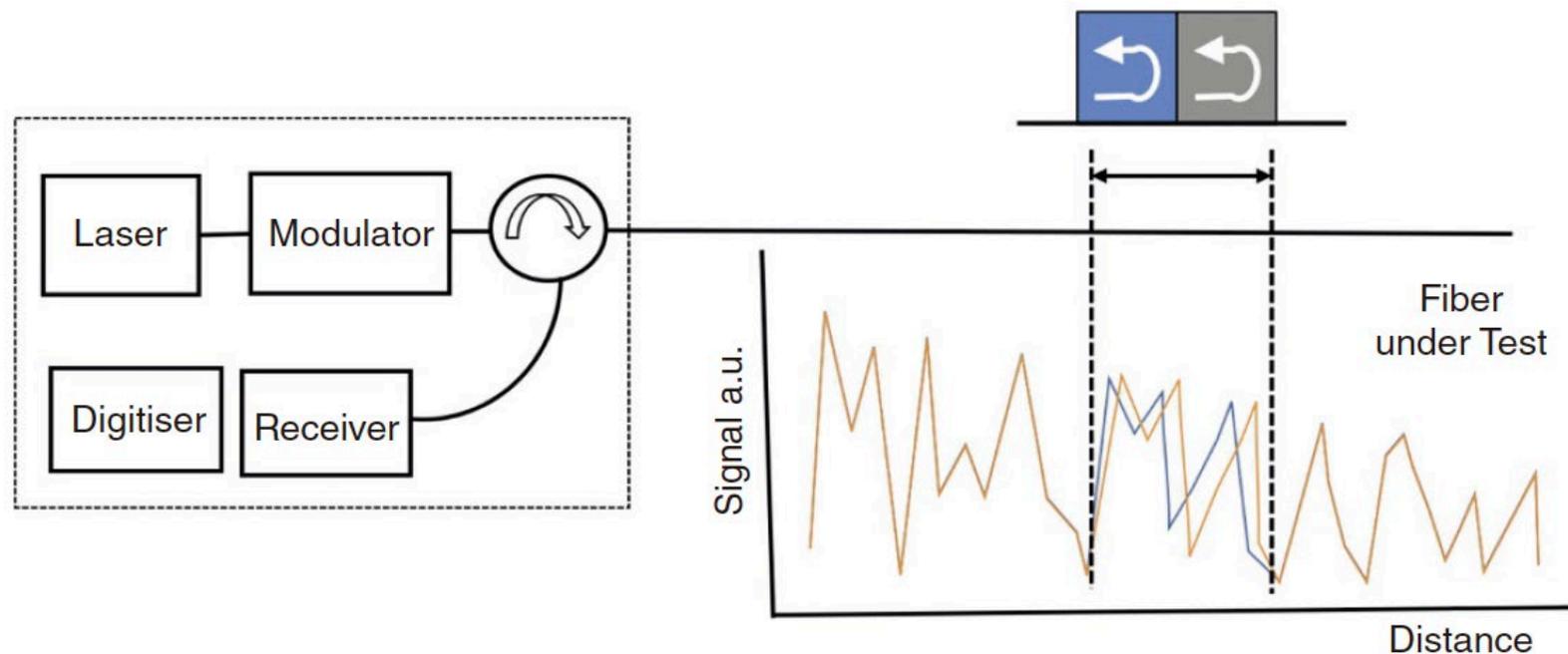
□ 利用拉曼散射與布里淵散射能量測溫度(DTS)與永久形變(DSS)

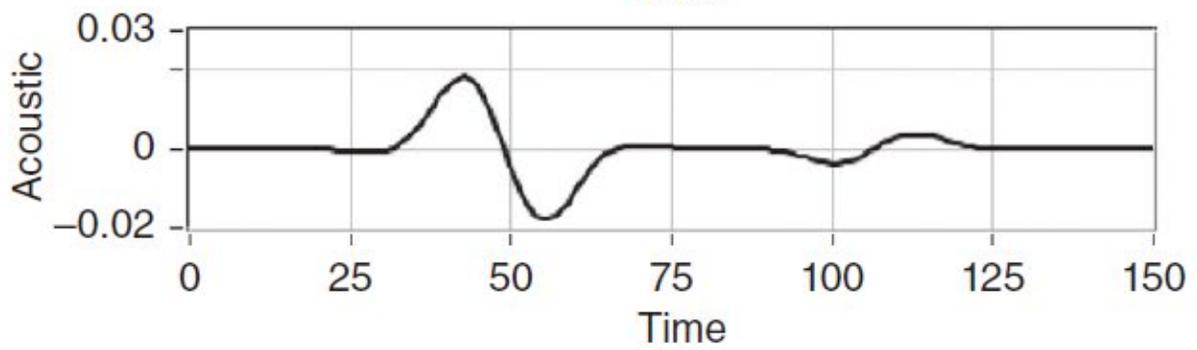
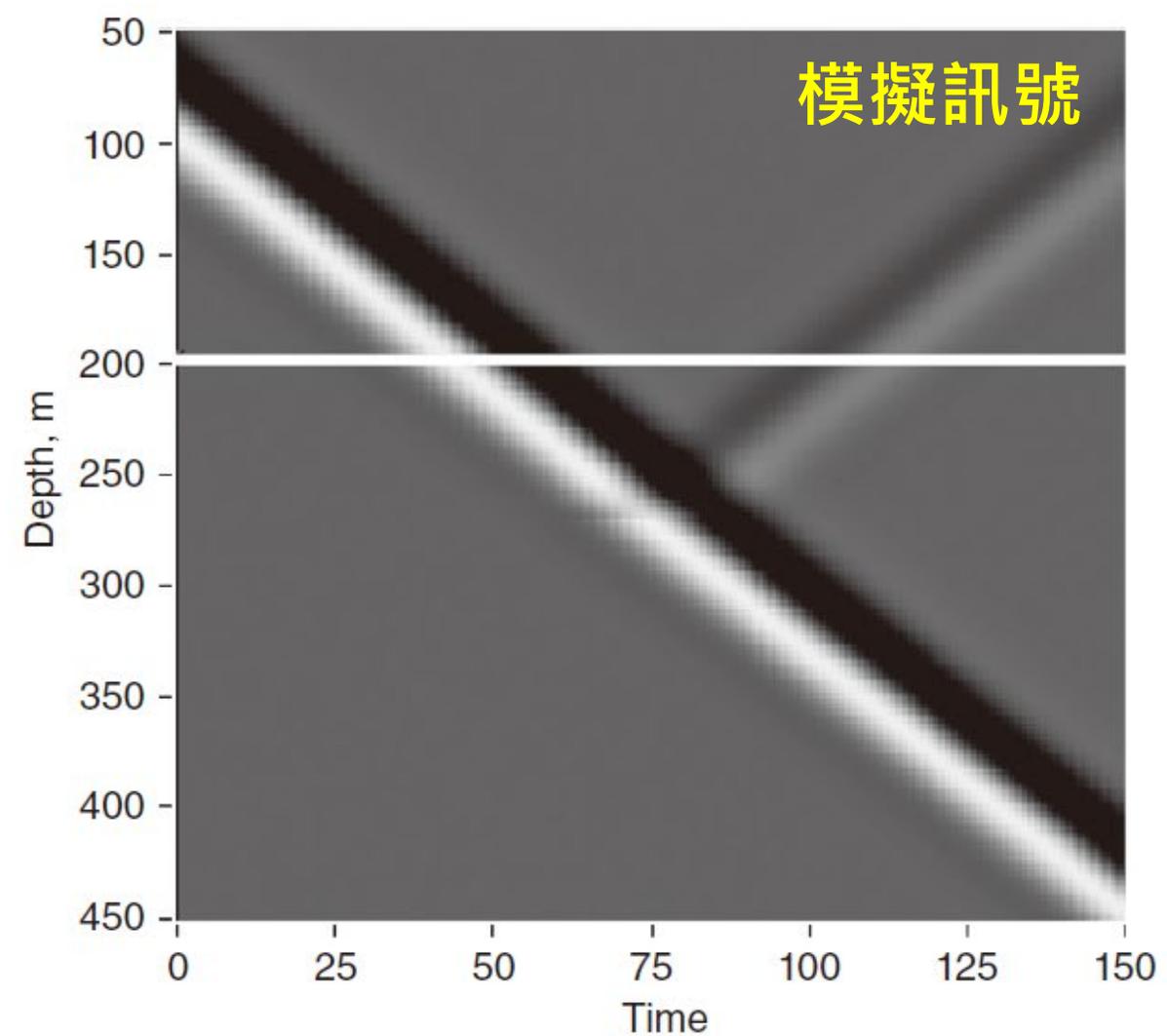
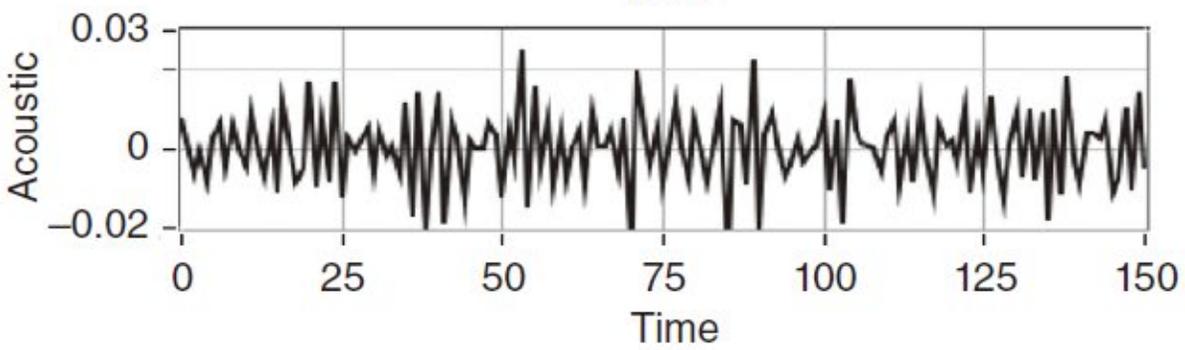
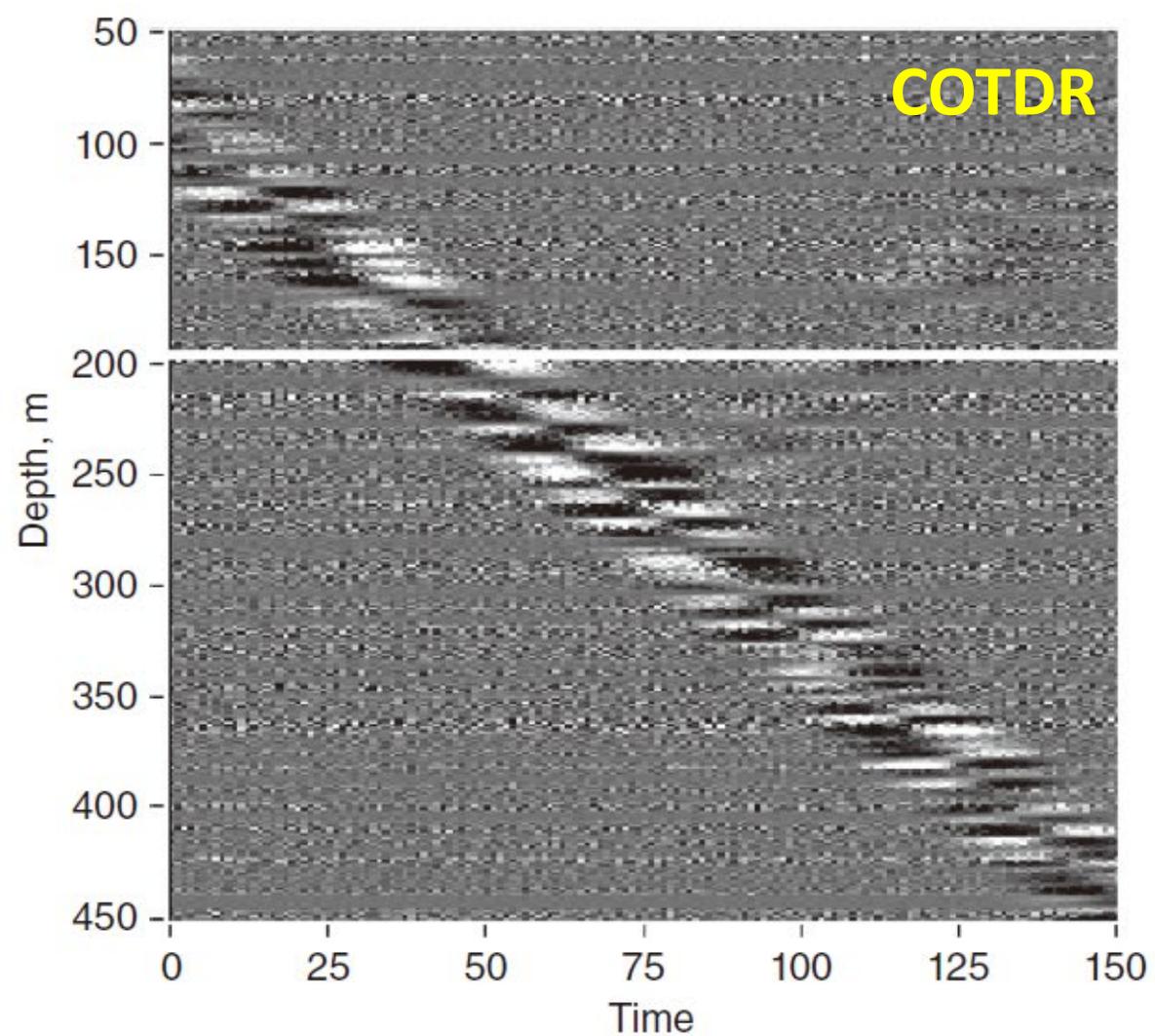


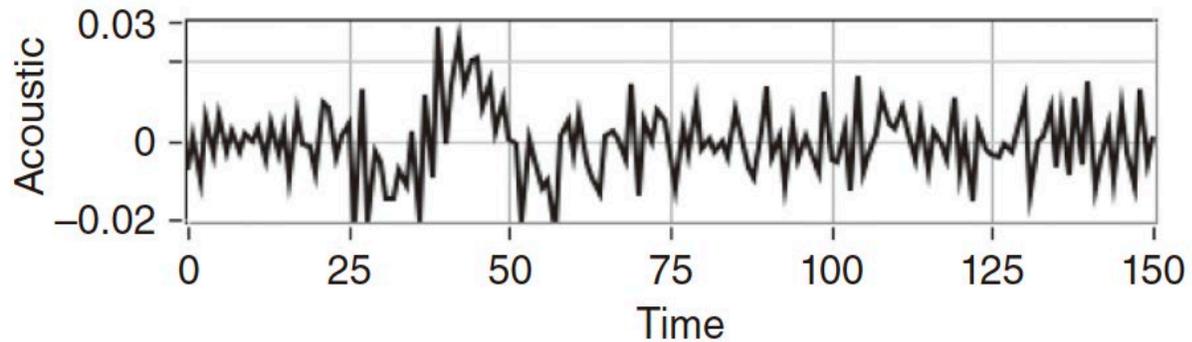
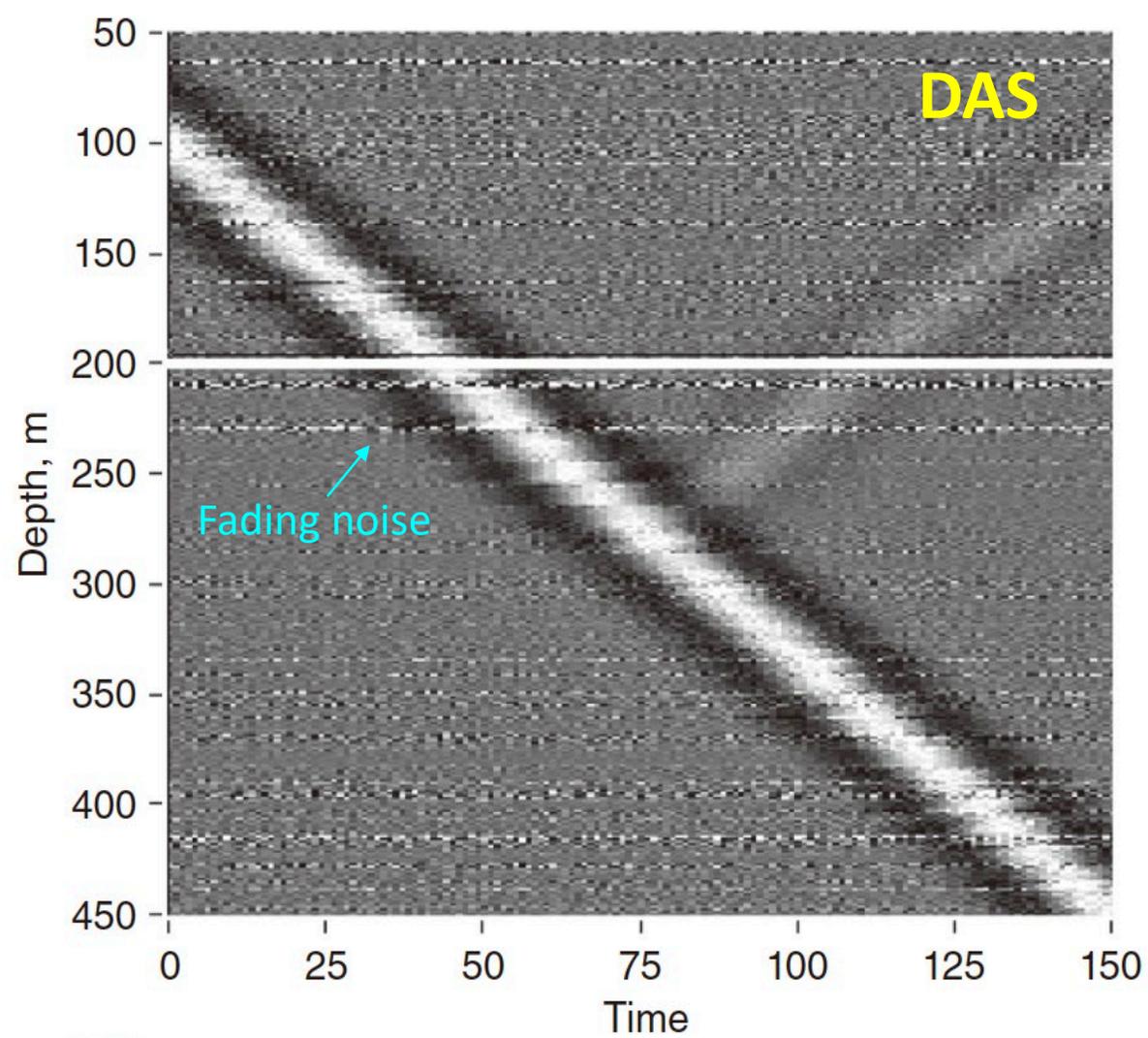
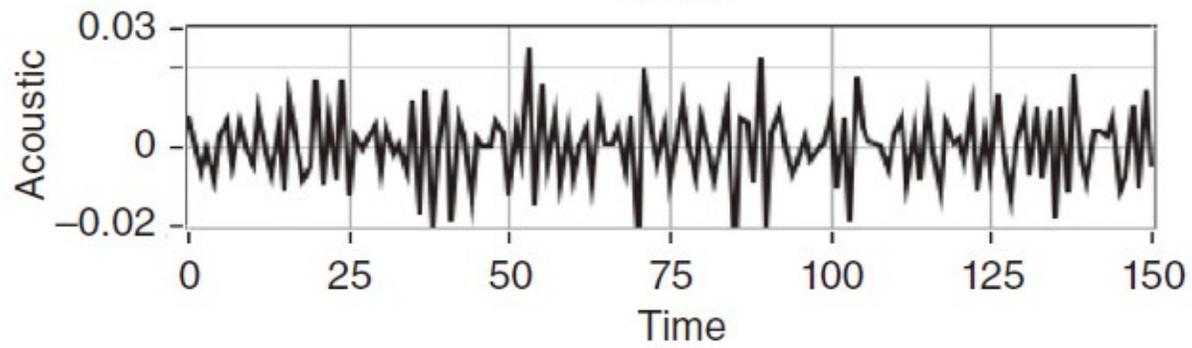
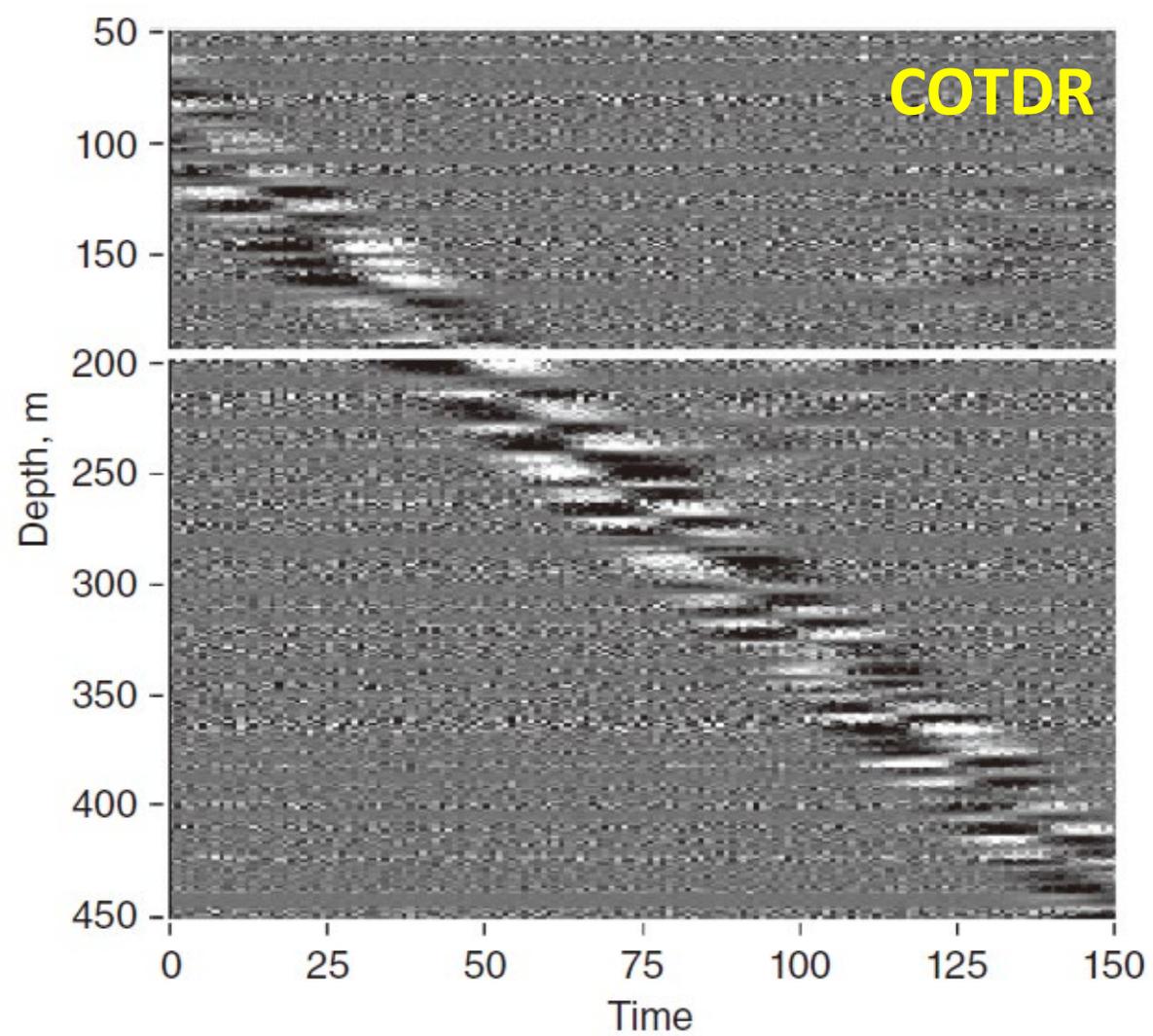
# 基於回波強度的量測技術 (COTDR)

VS.

# 基於回波相位的量測技術 (DAS)







# Landslide Monitoring via DAS-inclusive Seismic Analysis (LaMDA)

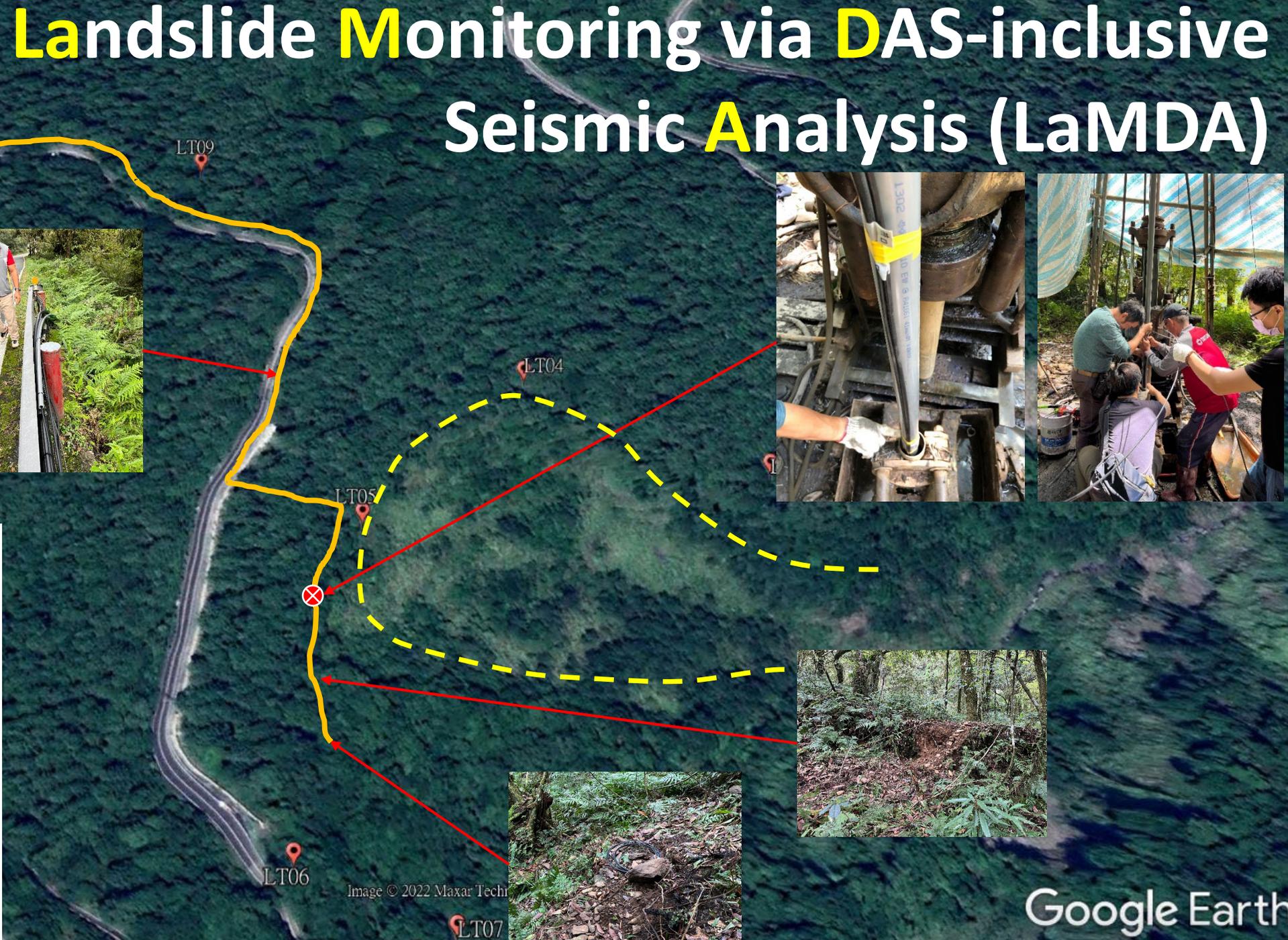
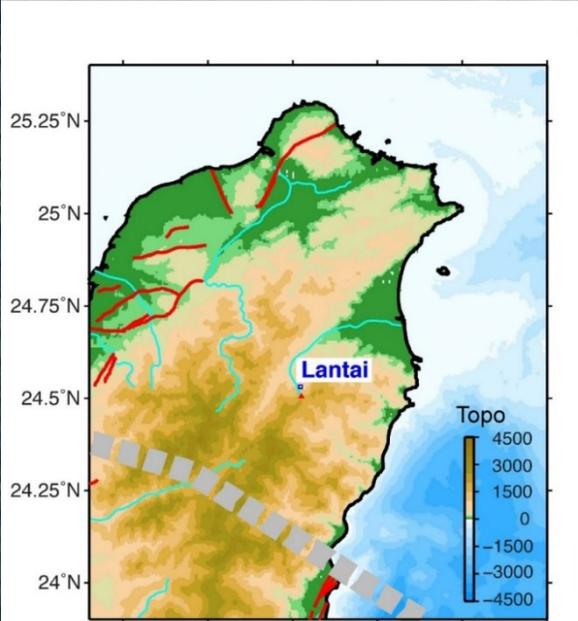
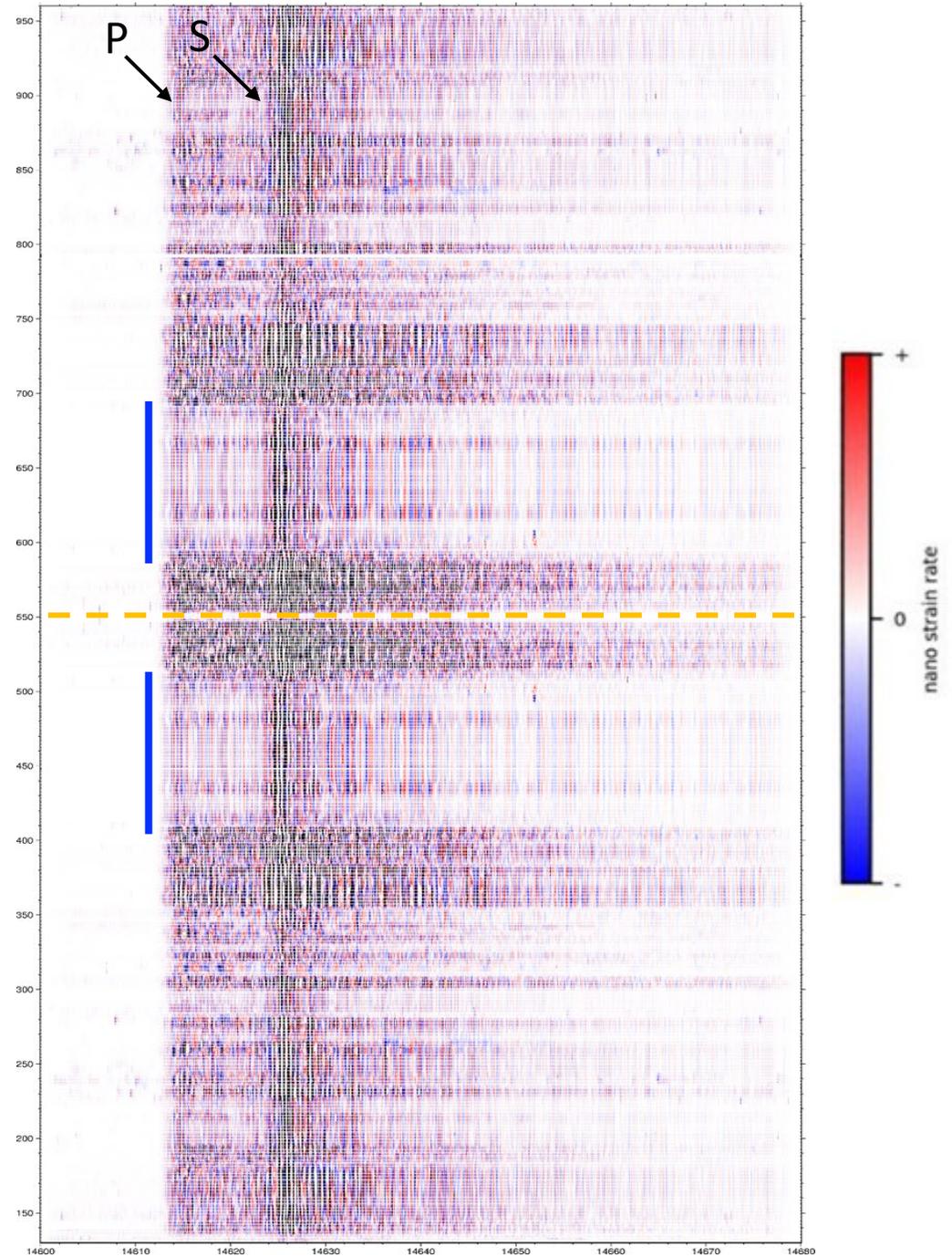
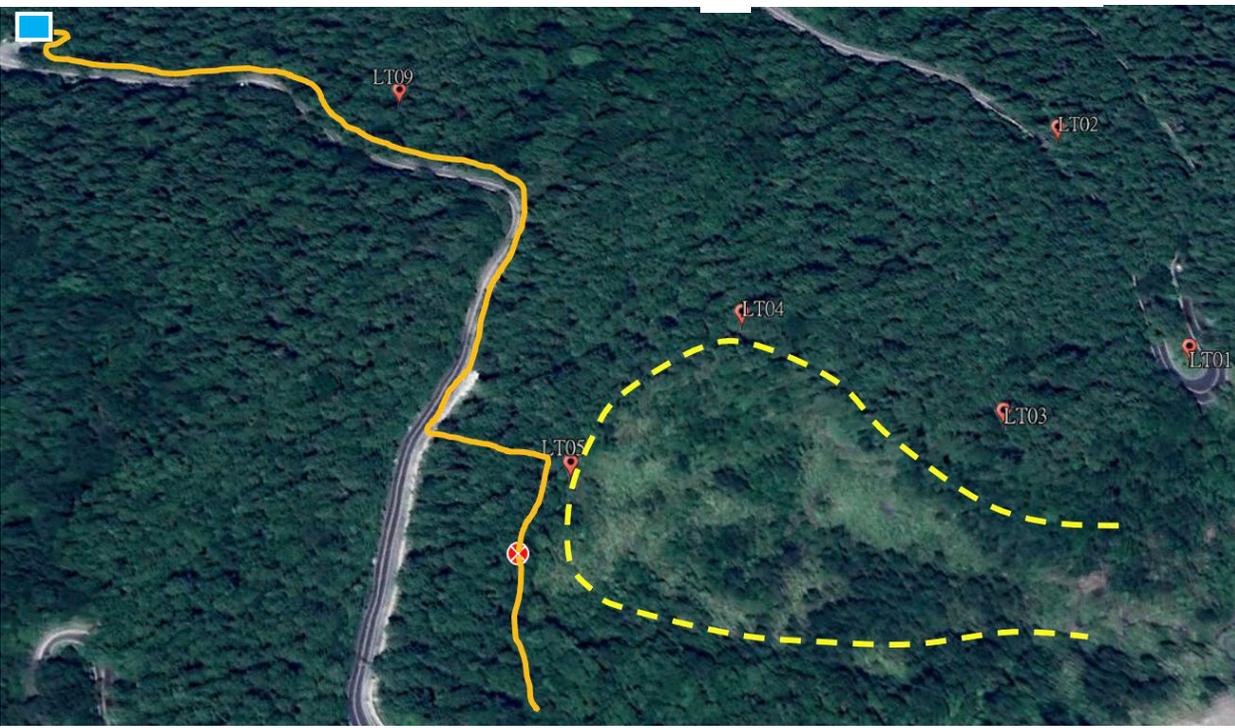
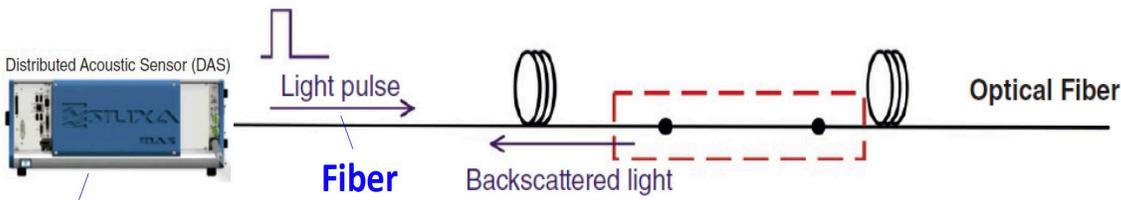


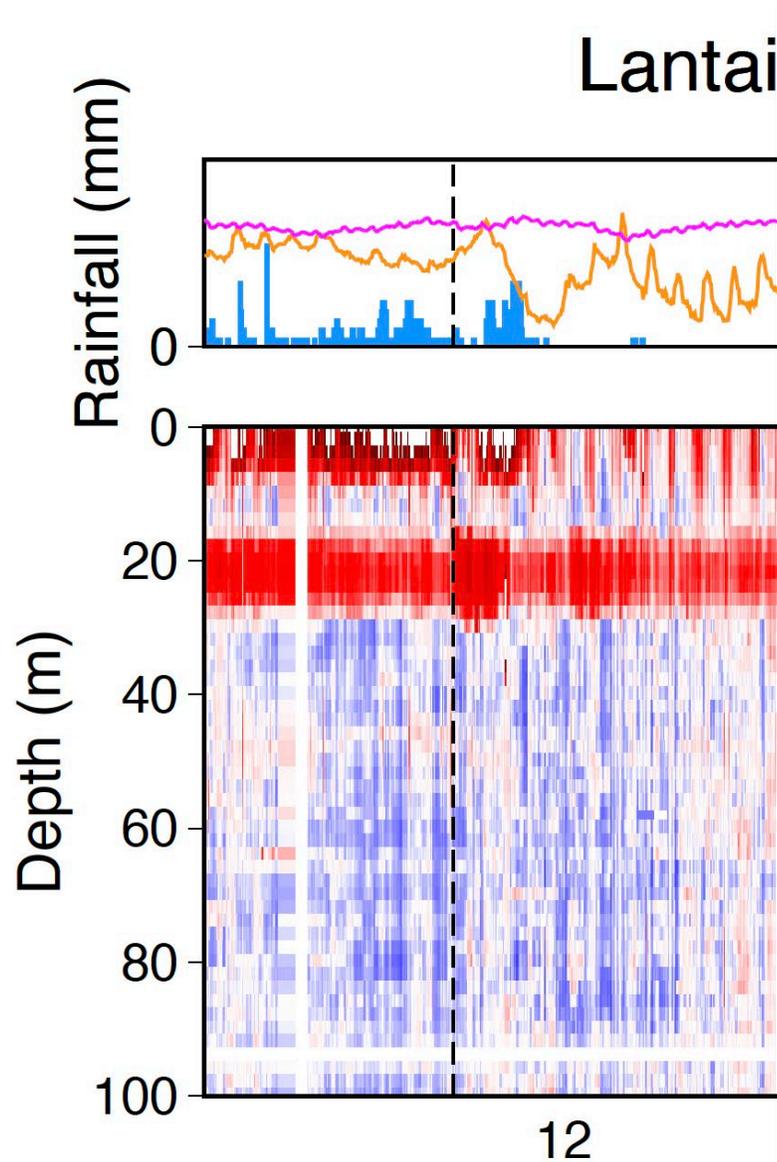
Image © 2022 Maxar Techn

Google Earth

# DAS records of earthquakes



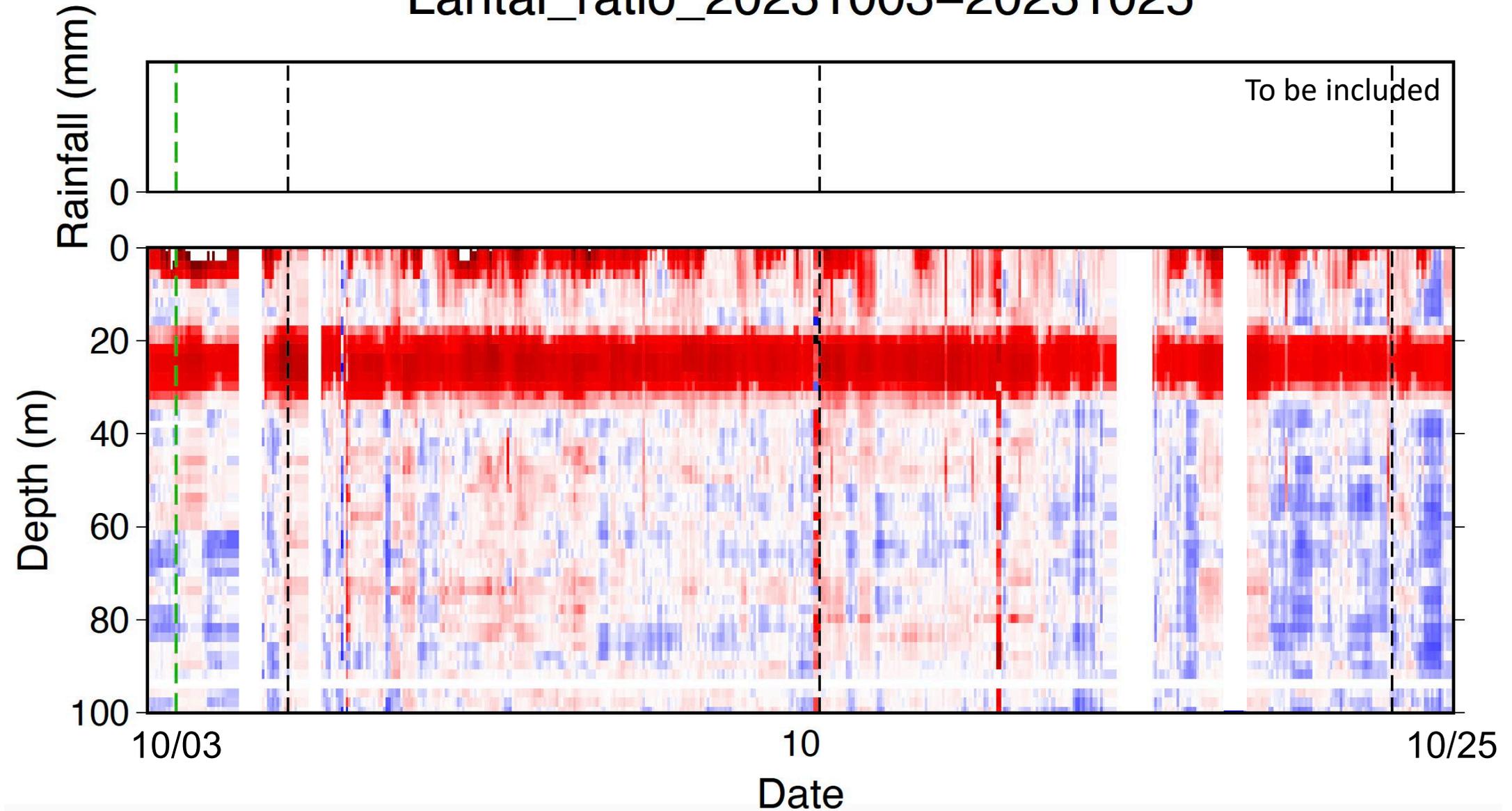
# Borehole DAS signals (10-30 Hz)



2022/10/28	2022/11/24	2022/12/06	2022/12/22
第1次嘗試以繩子綁重錘把貝勒管往下撞。	第1次嘗試以小型行車紀錄器綁在尼龍繩上放入孔內錄影。	嘗試以管徑較小貝勒管嘗試取水測量。	第2次嘗試以小型行車紀錄器綁在尼龍繩上放入孔內錄影。
<ul style="list-style-type: none"> <li>發現重錘也卡在 21~22 米深度左右拉不起來；拉起後再放進孔裡依然卡在 21~22 米下不去。</li> </ul>	<ul style="list-style-type: none"> <li>發現 11/10/20 測量使用貝勒管仍卡在深度約 21.5m。</li> <li>傾斜管在這個深度明顯被擠扁，連貝勒管都已經被擠壓到了，貝勒管和傾斜管的管壁之間被擠壓到沒有任何縫隙。</li> <li>地下水位在這個深度以下。</li> </ul>	<ul style="list-style-type: none"> <li>小徑貝勒管卡在 21~22 米深度無法繼續向下，地下水位還在這個深度以下無法取水。</li> </ul>	<ul style="list-style-type: none"> <li>發現 11/10/20 測量使用貝勒管仍卡在深度約 21.5m。</li> <li>傾斜管在這個深度明顯被擠扁，連貝勒管都已經被擠壓到了，貝勒管和傾斜管的管壁之間被擠壓到沒有任何縫隙。</li> <li>地下水位在這個深度以下。</li> </ul>

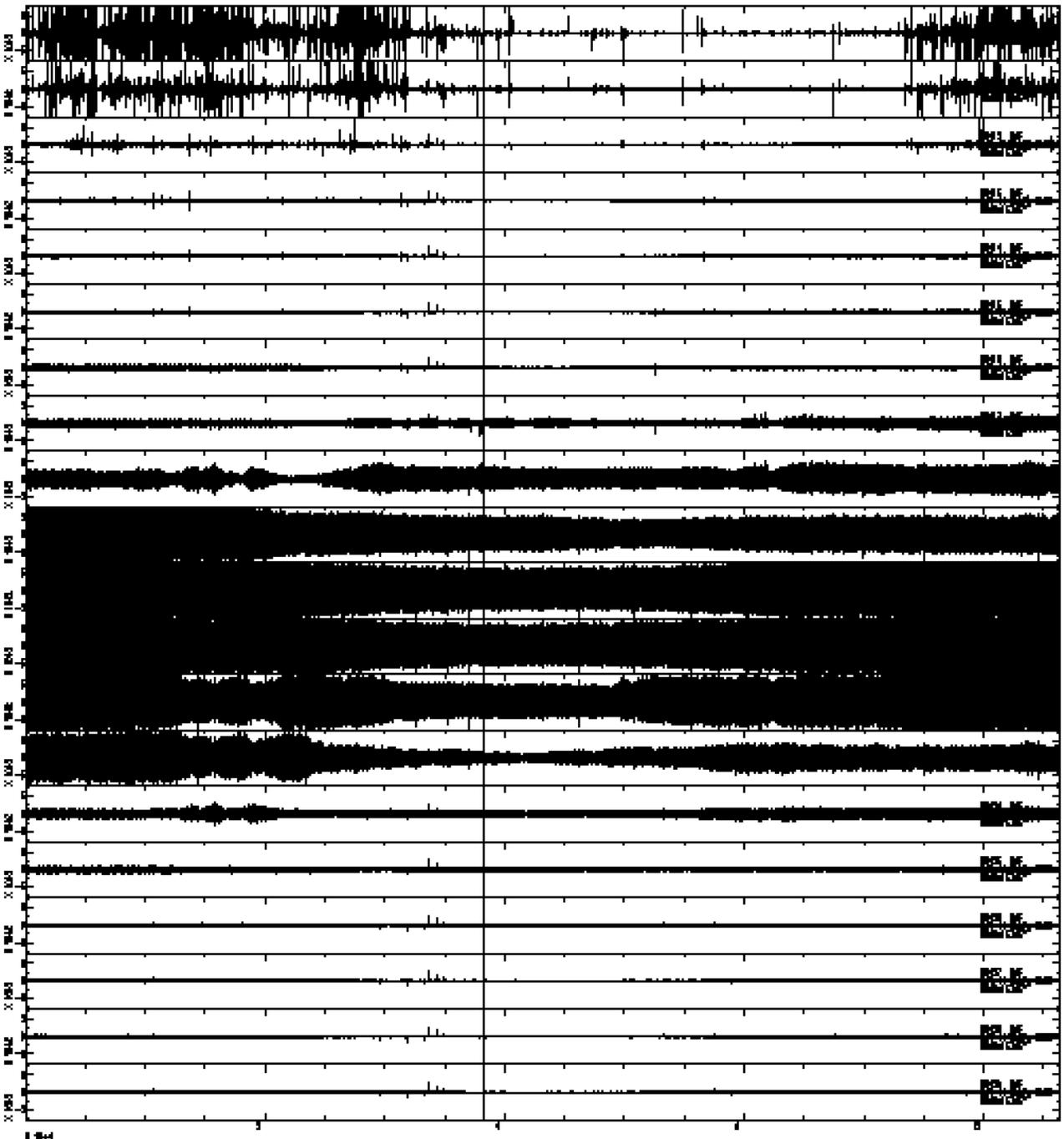
# Borehole DAS signals (10-30 Hz)

Lantai\_ratio\_20231003-20231025



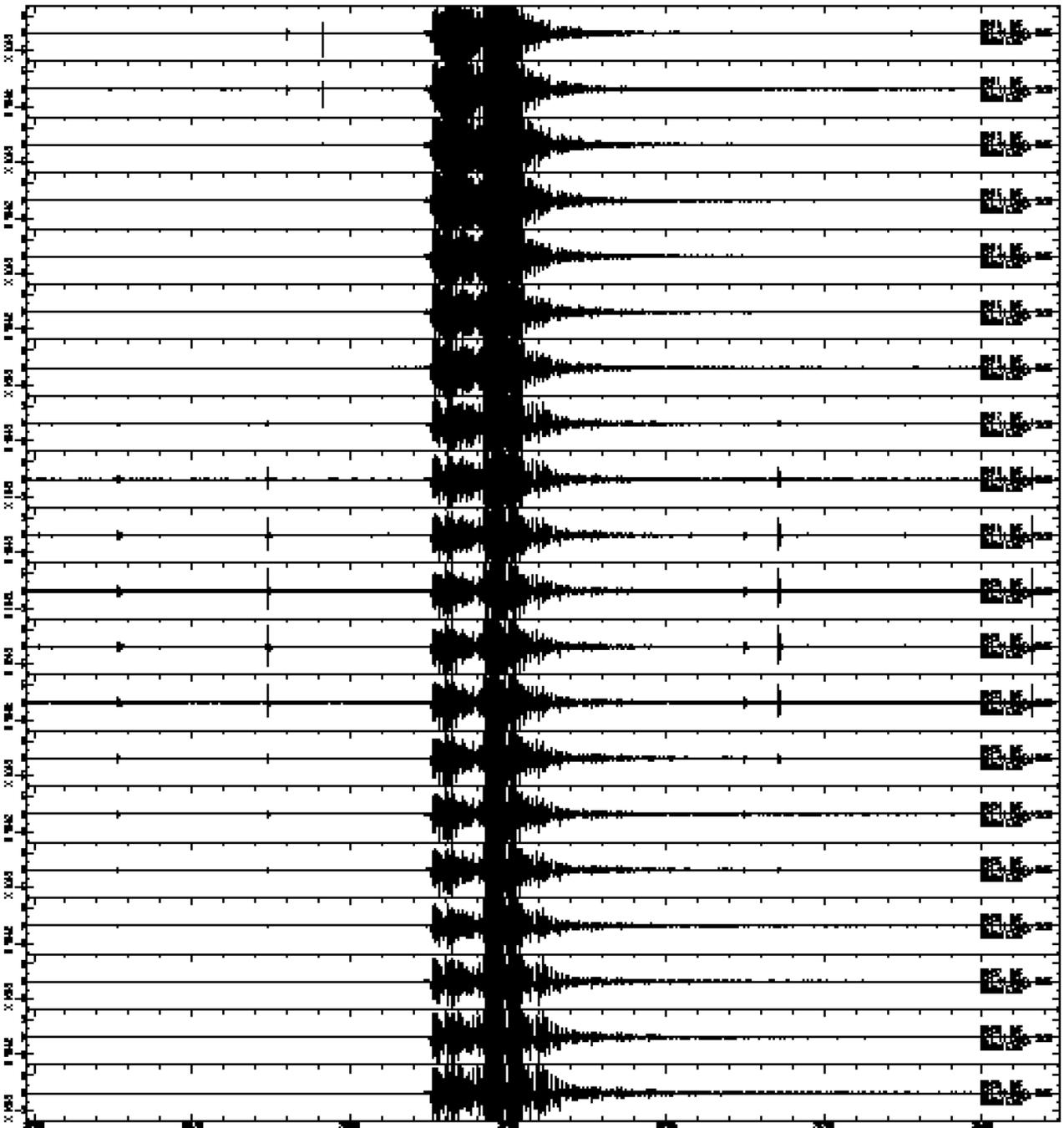
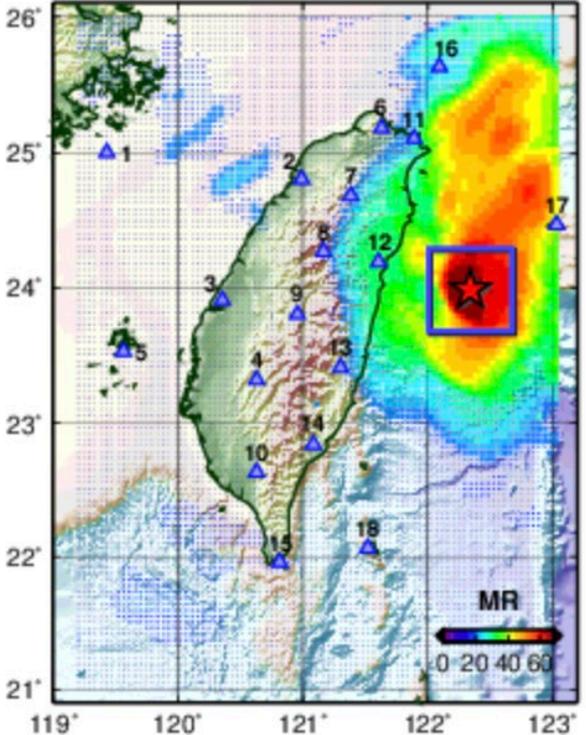
# Hidden signals

2023/10/11



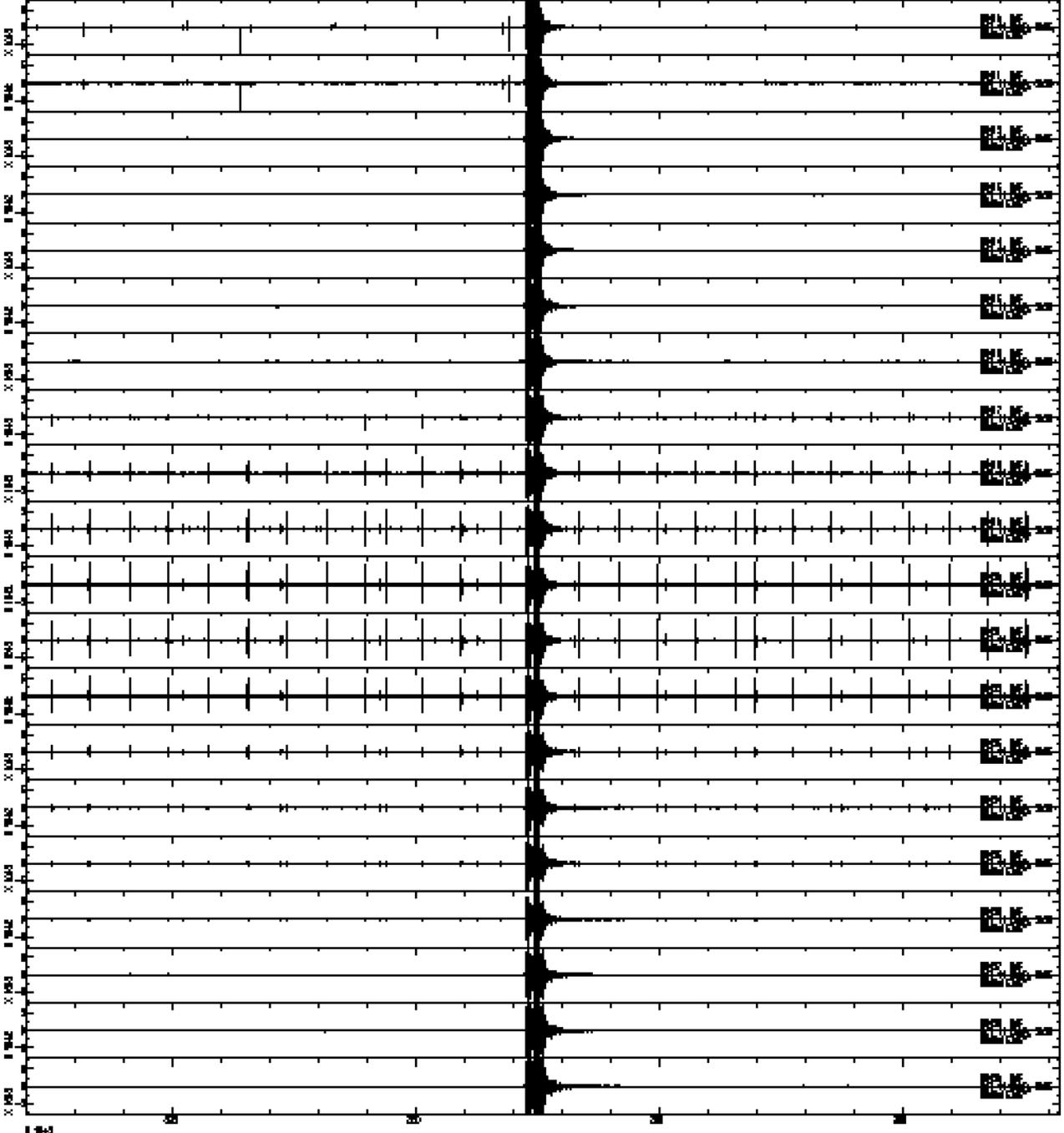
# Hidden signals

2023/10/11



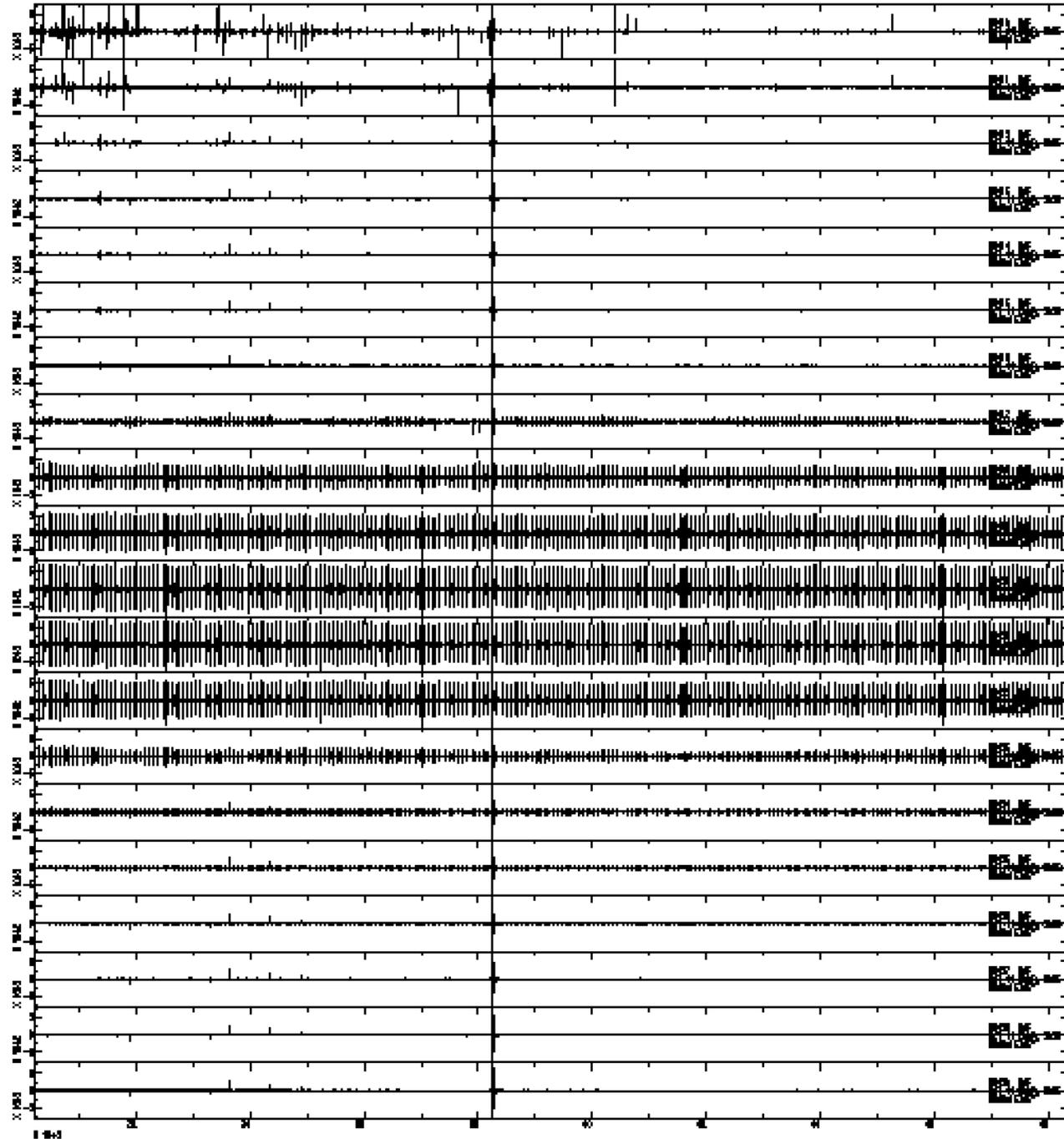
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2023/10/11



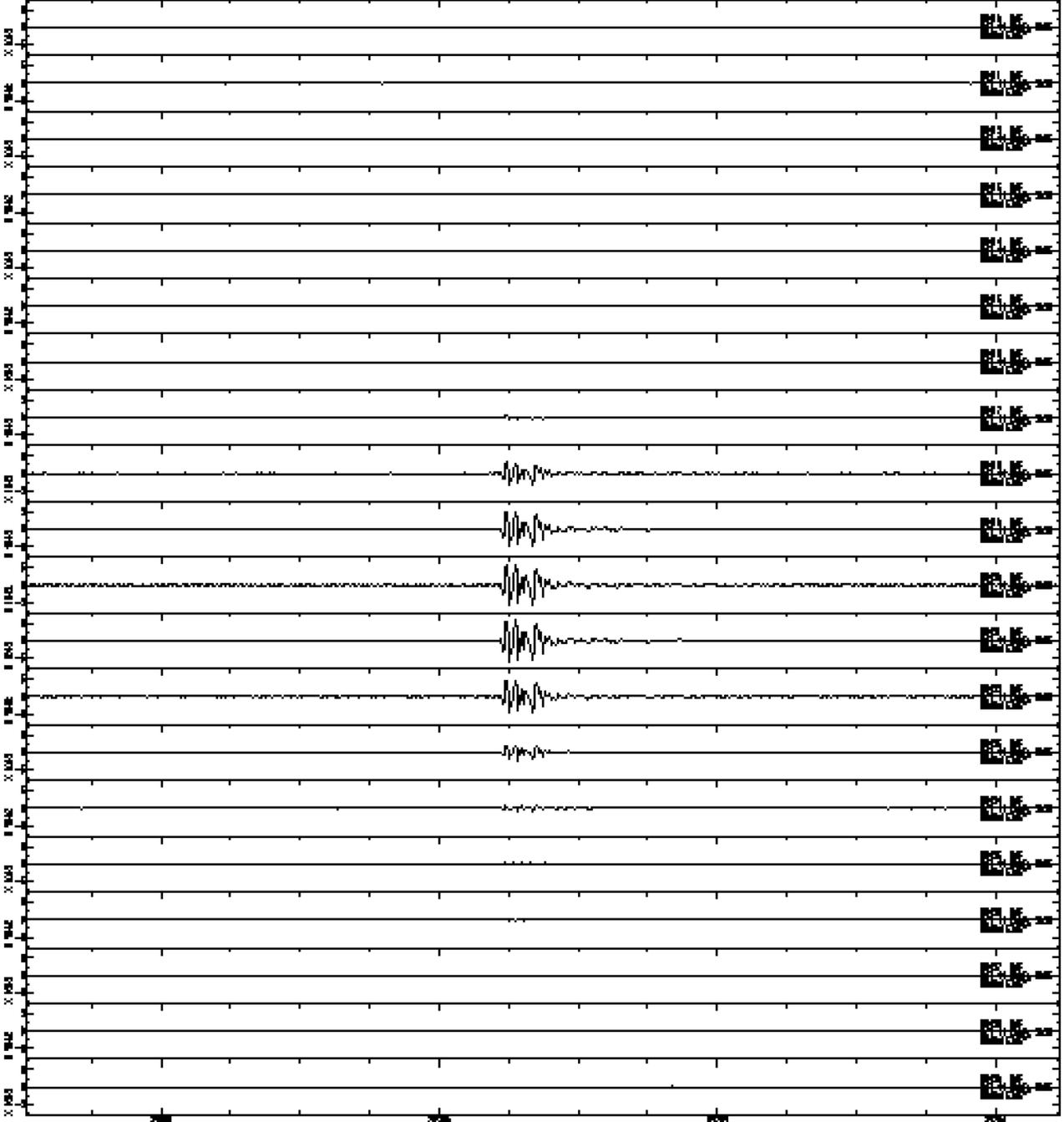
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2023/10/11



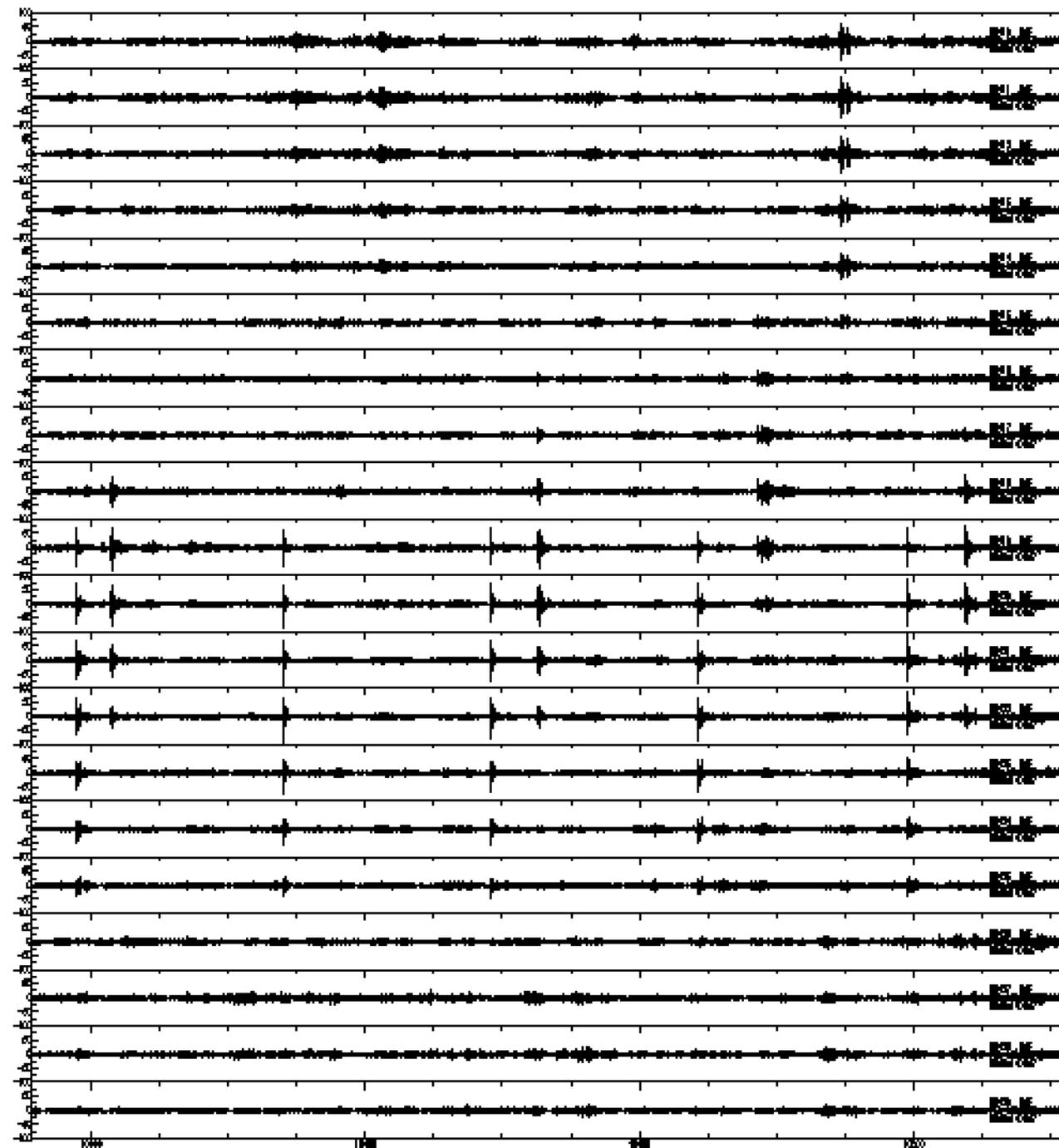
# Hidden signals

2023/10/11



# Hidden signals

2023/02/02



## 地下地震光纖監測技術

- 利用計算高速發射之雷射脈衝的反射回波訊號計算每段光纖纜線方向上的拉張/壓縮量(strain rate)，相當於連續一長串的地震儀器。



井下光纖段



光纖地震儀發射器

地表埋線

## 地表地下地震噪訊聯合， 辨識滑動塊體反應

- 1) 地表地震站被動式收集噪訊，地下光纖地震計主動發射高頻訊號收集反應噪訊
- 2) 透過主頻訊號時間差推測滑動訊號產生位置，包含沿光纖深度及光纖與地震站連線剖面
- 3) 捕捉各剖面滑動深度及啟動關鍵滑動深度(塊體)。

