2022 NTNU Summer student internship

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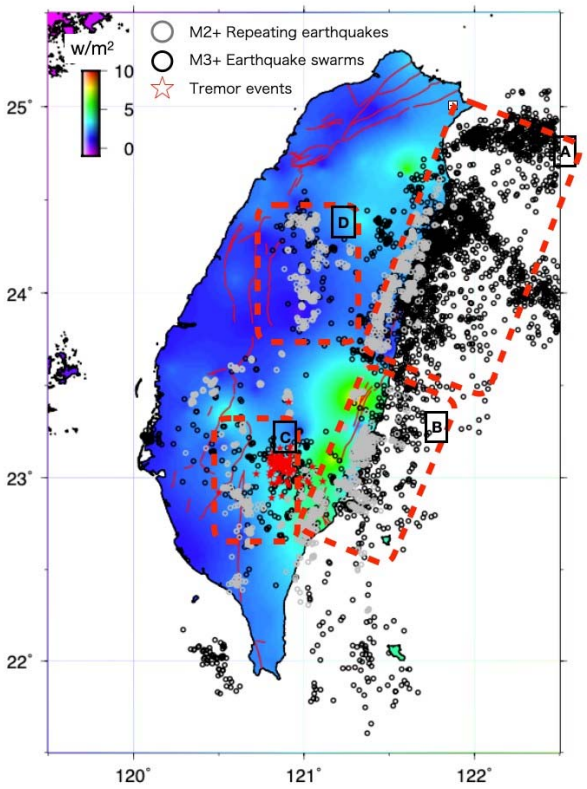
計畫主題：

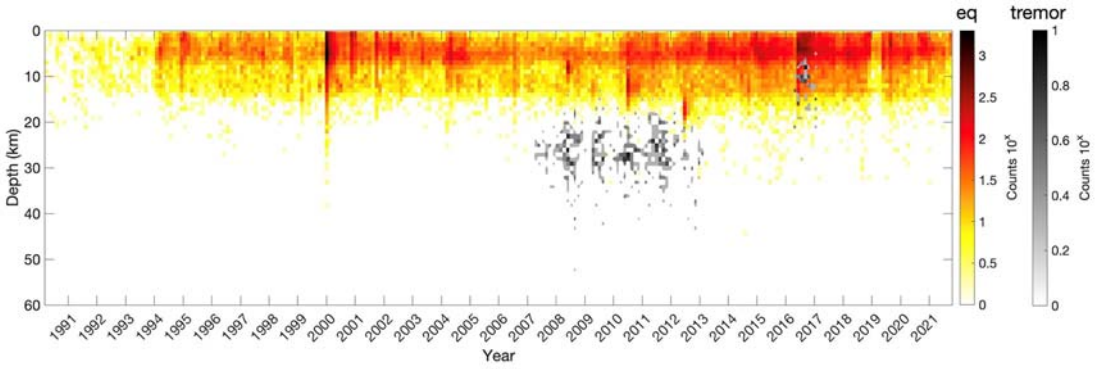
深部流體活動追追追：**無震滑移行為的地震學特徵**

深部流體孔隙壓變化，影響著流體的遷徙，而快速抬升、崛起的台灣弧陸碰撞造山帶下方，存在著許多間歇性/週期性的地震群，他們，提供了應力累積過程中孔隙壓變化與孕震週期之關係，是窺見地球系統水循環的關鍵地點。大量的注水試驗得知，流體在岩石孔隙間引發的大量無震滑移(aseismic slip)，是促進局部應力轉移和引發微地震的重要因子。在震間期(inter-seismic period)，緩慢進行的無震滑移行為處處皆有，並不僅局限於地殼深處脆、塑性的過渡區（i.e., 產生慢地震），在地殼淺處脆性變形區，也能有指標性的地震現象：例如重複地震和群震。週期性發生並持續數年之久的重複地震，稱作連續型序列，是長期無震滑移的過程中，在相對獨立而鎖定的地栓(asperity) 應力穩定累積下的產物，而爆發型(burst-type)的重複地震則僅在短期發生 (數月甚至數天)，他們和群震皆為短期的無震滑移加速之表現，亦被認為對應到超額孔隙壓的間歇性發生。

重複地震、群震、長微震這三個不同的無震滑移之地震學特徵，可在圖一中一並呈現，2007-2012的長微震事件（紅色星號）僅發生在中央山脈南段，規模2以上的2000-2012重複的地震(灰色圓圈)和規模3以上的1990-2019群震(黑色圓圈)在空間上高度重疊，尤其在縱谷南段的池上斷層地震帶。這三種地震特徵和流體存在及遷徙的關係為何？ 是深部流體之地震學證據的關鍵問題，需要進行規模下修、事件數量增加以進行精確的重新定位，方能精準的掌握。圖二則顯示了C區（中央山脈南段）的深度剖面，背景地震（暖色系）和慢地震（長微震，灰階）的深度分佈有一明顯的分割邊界，約為15 km深處。此次的暑期計畫，將針對中央山脈南段進行分析，進行(1) 規模2以上群震目錄的精確定位 (2)規模2以上相似地震進行精確定位，進一步進行流體運移的地震學特徵之量化。



圖一、台灣的群震（黑圓圈）、重複地震（灰圓圈）、長微震（紅星）及熱流（背景顏色）分佈圖。此圖出自Peng et al. (2021).



圖二、圖一C區中，地震活動（暖色系）和長微震活動（灰階）之深度特性。

Fluid induced aseismic fault slip: how much we can learn from earthquake swarm and repeating earthquakes?

Earthquake swarm and repeating earthquakes are part of the spectrum of aseismic processes that release tectonic stress at depth. Their episodic occurrence in subduction zones has been regarded as an important indicator for stress and fluid pressure cycling. Whether the characteristics of fluid generation and migration is different at different tectonic regimes, and how do they influence earthquake cycle however, remain elusive. The active collisional mountain belt in Taiwan provides an unique opportunity to study the association between fluid-flow system and their impact on various earthquake behavior. As indicated by Figure 1, the repeating events (grey circles) and earthquake swarms (black circles) are highly overlapped especially in the creeping fault (the Chihshang fault in Area B) and in southern Central Range (Area C) where the tectonic tremors (red stars) are highly concentrated. Does pore-fluid migration serve as the common generation mechanisms for these three seismic phenomena? In this summer program, we aim at (1) searching for magnitude greater than 2 swarm and repeating earthquakes in southern Central Range (Area C in Figure 1) and (2) relocating the earthquakes to extract the possible migration behavior. By quantifying and relocating the aseismic slip driven earthquake activities, we hope to better understand the role of fluid in aseismic slip processes underneath southern Central Range of Taiwan.

Reference

Peng, W., Marsan, D., ***Chen, K. H.**, Pathier, E, (**2021)**, Earthquake swarms in Taiwan: A composite declustering method for detection and their spatial characteristics, Earth and Planetary Science Letters, 574, https://doi.org/10.1016/j.epsl.2021.117160.