

Measuring ground deformation across creeping faults through aerial image correlation: a case study of southwestern Taiwan

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Abstract

Taiwan is located at a convergent plate boundary, with half of horizontal displacement occurring in the Western Foothills. According to ground-based geodetic data, there is significant ground displacement near the north end of the Highway 3 Zhongliao tunnel. The fault-perpendicular component reaches up to 30 mm/yr extension and 50 mm/yr compression across the Chishan fault and the Chegualin fault, respectively, while 80 mm/yr of uplift is observed across the Chishan fault. Such rapid displacement rates at two neighboring creeping faults cannot be easily explained by the accommodation of plate convergence. To propose a mechanism behind this phenomenon, it is necessary to establish comprehensive knowledge of regional displacement patterns. Geodetic data provides reliable constraints along the highway, but there is a lack of information on the lateral span along the fault strike. InSAR performs well at large scale tectonic monitoring, but is usually unable to provide observations in densely vegetated areas. In this study, we implement optical image correlation to measure the ground displacement with a wider spatial coverage than ground-based geodetic networks and more information at highly vegetated areas. Our preliminary results indicate that at the Chegualin fault, there is a total of about 37 cm horizontal compression along fault-perpendicular direction during 2008-2015. The compression of the Chegualin fault can be extrapolated at least 500 m southwestward along the fault strike but poorly extrapolated northeastward. Although it remains challenging to monitor the highly vegetated Chishan fault, the image correlation still provided remarkable consistency of the displacement rate at the compressive creeping Chegualin fault, and provides more hints at regional tectonic patterns.

Keywords: Image correlation, Photogrammetry, Surface displacement, Zhongliao tunnel, Active faults, Creeping faults.

透過影像關聯來測量潛移斷層的地表變形：以台灣西南部 為例

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摘要

台灣位於板塊聚合帶，約有一半的水平位移發生在西部麓山帶。根據地表大地測量的成果，在台灣國道三號中寮隧道北端附近存在顯著的地面位移。在旗山斷層和車瓜林斷層，垂直於斷層的分量的位移分別達到每年 30 毫米的伸張和每年 50 毫米的壓縮，同時在旗山斷層上觀察到每年 80 毫米的抬升。兩個相鄰的斷層上如此快速地潛移速率難以僅僅透過板塊聚合來解釋其機制。為了解釋這種現象背後的機制，我們需要對該區域的位移模式有更全面的了解。大地測量提供了公路沿線有力的位移數據，但在斷層走向方向上缺乏橫向跨度的訊息；干涉合成孔徑雷達（InSAR）在大尺度構造監測方面表現出色，但通常無法在密集植被區提供觀測數據。本研究採用光學影像關聯來測量地面位移，其空間覆蓋面積比地表大地測量資料更廣泛，並提供了在密集植被區域更多的訊息。我們初步的影像關聯結果顯示，在車瓜林斷層上，2008 年至 2015 年間，垂直於斷層方向的水平壓縮約為 37 公分，且車瓜林斷層的壓縮至少可以沿著斷層擴展至西南方 500 公尺，但向東北方向的擴展較差。儘管量測植被廣布的旗山斷層仍然相當困難，但影像關聯仍然提供了車瓜林斷層的擠壓潛移速率上與大地測量一致的成果，以及更多區域構造模式的線索。

關鍵字：影像關聯、攝影測量、地表位移、中寮隧道、活動斷層、潛移斷層