

利用臺灣高頻都卜勒探測系統和電離層探測儀觀察 2025年7月29日堪察加半島規模8.8地震引起的 地震和海嘯電離層擾亂

Seismo- and tsunami-traveling ionospheric disturbances of the 29 July 2025 M8.8 Kamchatka Earthquake observed by CW-HF Doppler sounding systems and ionosondes in Taiwan and Japan

劉正彥¹ (Liu J.-Y.) 陳耀淳² (Chen Y.-C.)

¹國立中央大學 太空科學與科技研究中心 ²國立中央大學 太空科學與工程學系

¹Center for Astronautical Physics and Engineering (CAPE), National Central University

²Department of Space Science and Engineering (DSSE), National Central University

摘 要

2025年7月29日，堪察加半島近海發生強烈地震，引發強烈地面震動和海嘯。這些擾動不僅影響了固體地球和海洋，也擾動了地球上空的大氣層。大氣波向上傳播，最終進入電離層。本研究利用臺灣高頻都卜勒探測系統以及台灣和日本電離層探測儀觀測數據，探討電離層中與地震和海嘯引起的擾動。這些數據顯示地震和海嘯電離層波動出現明顯的頻率與震幅變化。地震相關的擾動在地震波到達後不久出現，並迅速遠離震源傳播。隨後，在電離層中也觀測到了與海嘯相關的擾動，這些擾動與海嘯在海洋上的傳播有關。這些結果表明，電離層可以作為大型地震和海嘯的靈敏放大偵測器。因此，利用高頻都卜勒探測系統和電離層探測儀觀測電離層擾動，可以提供有關地震和海嘯能量如何從地面和海洋傳遞到高層大氣的有用資訊，並確認地震和海嘯波的抵達。

關鍵字：地震，海嘯，電離層，都卜勒探測系統，電離層探測儀

Abstract

A great earthquake occurred offshore Kamchatka on 29 July 2025 and generated strong ground shaking and tsunami waves. These disturbances did not only affect the solid Earth and the ocean; they also disturbed the atmosphere above the Earth. As the atmospheric waves traveled upward, they reached the ionosphere. In this study, we used high-frequency (HF) radio signals and ionosonde observations in Taiwan and Japan to detect these earthquake- and tsunami-related disturbances in the ionosphere. The radio signals showed clear frequency changes caused by the motion of the ionosphere. The earthquake-related disturbances appeared soon after the seismic waves arrived and traveled rapidly away from the earthquake source. Later, tsunami-related disturbances were also observed in the ionosphere and were associated with the propagation of the tsunami over the ocean. These results show that the ionosphere can act as a sensitive detector of large earthquakes and tsunamis. Observing ionospheric disturbances with HF Doppler sounding systems and ionosondes can therefore provide useful information on how energy from earthquakes and tsunamis is transferred from the ground and ocean into the upper atmosphere.

Key words: earthquake, tsunami, Doppler sounding systems, ionosonde