GNSS連續水位浮標應用於亞重力波觀測之研究

Application of GNSS Continuous Water Level Buoys on Infra-gravity Wave Observation

林演斌[1] (Lin Y.-P.) 陳盈智[1] (Chen Y.-C.) 林清睿[1] (Lin C.-R.) 陳孟詩[2] (Chen M.-S.)
潘琦[2] (Pan C.)

[1]國立成功大學近海水文中心 [2]中央氣象署海象氣候組
[1]Coastal Ocean Monitoring Center, National Cheng Kung University
[2]Marine Meteorology and Climate Division, Central Weather Administration

摘　要

亞重力波（infra-gravity waves）為週期約 20 秒以上之低頻長波，主要由短波波群之非線性交互作用產生，廣泛存在於近岸淺水區。雖其振幅通常小於風浪，但是引起海岸侵蝕或港灣共振現象的因素之一，亦對近岸生態環境具有潛在影響，也會危害近岸遊憩活動安全。觀測亞重力波需要長時間連續數據，現場執行較觀測一般風湧浪困難，亟待適用的設備。全球衛星導航系統（Global Navigation Satellite System, GNSS）浮標具備觀測高精度水位能力，過去已成功應用於量測波浪與潮位，本研究利用自行開發GNSS連續水位浮標觀測之近岸水位資料，嘗試擷取其中低頻能量變化特徵，探討其應用於量測亞重力波之成效與可行性，以延伸GNSS浮標應用範疇至亞重力波頻段。本研究分析2024至2025年期間氣象署臺南水位浮標資料，採用經驗模態分解法（Empirical Mode Decomposition, EMD）濾除潮汐成分，保留風湧浪至亞重力波區間之能量。分析結果顯示，在平常時刻，亞重力波波高普遍低於0.5公尺，然而在極端天氣事件如2024年凱米與山陀兒颱風，以及2025年丹娜絲颱風期間，亞重力波波高可達1公尺以上。GNSS連續水位浮標不僅適用於一般風湧浪與潮位觀測，本研究證實其更具備觀測亞重力波能力，未來能提供海岸侵蝕、近岸生態環境以及近岸遊憩活動安全等應用更完整的資訊。

關鍵字：亞重力波、全球衛星導航系統、水位浮標、經驗模態分解法

Abstract

Infra-gravity waves are low-frequency, long-period waves (typically >20 s) generated through nonlinear interactions among short-wave groups and commonly observed in nearshore shallow waters. Although their amplitudes are generally smaller than those of wind waves, infra-gravity waves can contribute to coastal erosion, harbor resonance, and pose risks to nearshore ecosystems and recreational safety. Monitoring these waves requires long-term, continuous data, making field observations more challenging than those of wind and swell waves and requiring appropriate instrumentation.

Global Navigation Satellite System (GNSS) buoys, known for high-precision water level measurements, have been successfully used for wave and tide monitoring. This study utilizes a self-developed GNSS continuous water level buoy to collect nearshore data and analyze low-frequency energy variations, assessing its feasibility for infra-gravity wave observation.

Data from the Tainan GNSS buoy station (2024–2025), operated by the Central Weather Administration, were analyzed using Empirical Mode Decomposition (EMD) to filter tidal components and isolate wave energy. Results show infra-gravity wave heights were typically <0.5 m under normal conditions but exceeded 1 m during Typhoons Gaemi, Krathon (2024), and Danas (2025). The findings confirm the buoy's capability to monitor infra-gravity waves, offering valuable data for coastal erosion, ecosystem assessments, and coastal safety applications.

Key words: Infra-gravity wave, Global navigational satellite system (GNSS), Water-level buoy, Empirical mode decomposition (EMD)