EGU25-3945, updated on 22 Apr 2026
https://doi.org/10.5194/egusphere-egu25-3945
EGU General Assembly 2025

Transforming coastal GNSS stations into tsunami gauges with GNSS-IR

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Although Global Navigation Satellite System Interferometric Reflectometry (GNSS-IR) has been extensively utilized for monitoring water levels in various bodies of water such as lakes, rivers, tides, and storm surges, its capability in detecting high-dynamic phenomena like tsunamis is still largely unexplored. This research introduces a near-real-time GNSS-IR tsunami monitoring framework, which concurrently inverses sea level, vertical sea-level velocity, and acceleration with the employment of an adaptive window strategy. Through this framework, we observed the tsunami wave of 2020 Tonga tsunami based on GNSS observations alone, with correlation of 62.9% compared with tide gauge, showing that GNSS-IR can detect tsunami waves with an amplitude of ~0.5 meters and a period of ~40 minutes. Additionally, it is discovered that the observation conditions necessary for tsunami monitoring are more stringent compared to those for tidal measurements, with a minimum requirement of six available satellite arcs (half rising and half setting) within a one-hour window. Consequently, out of 84 GNSS sites evaluated along the Pacific Rim, 29 are identified as being capable of conducting effective tsunami monitoring, whereas the remaining sites are only suitable for observing tides and storm surges.