O01

The 2025 and 1952 Kamchatka Earthquakes Inferred from Tsunami Data

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ABSTRACT

The July 2025 Kamchatka earthquake (Mw 8.8) is the seventh-largest earthquake in the last century. The tsunami waveforms were recorded in deep ocean (DART) stations as well as coastal tide gauge stations. Inversion of DART records indicates that the large (~ 9 m) slip occurred ~ 200 km south of the epicenter, very similar to the finite fault model of USGS. In this region, similarly large earthquake (Mw ~ 9) occurred in 1952. While Johnson and Satake (1999, Pageoph) conducted inversion of trans-oceanic tsunami waveforms, they did not consider the travel-time delay due to the elasticity of water and earth (Watada et al., 2014, JGR). In addition, the resolution of numerical solutions and possible clock errors must be considered. Comparison of the 1952 and 2025 tsunami waveforms recorded at tide gauge stations around the Pacific indicates that they are very similar. We then assumed that the time differences are due to clock errors, and adjusted the 1952 tsunami waveforms to match with the initial part of the 2025 records. We also estimated the station corrections for tide gauges from the comparison of the 2025 observed data and the simulation from the DART inversion result. Inversion of the 1952 tsunami waveforms after these corrections indicates that the slip distributions of the 1952 and 2025 earthquakes are very similar, while the total size (Mw) is slightly larger for the 1952 event.

O02

Asymptotic solutions of transient waves in finite water depth

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ABSTRACT

In this presentation, we show the analytical solutions for small-amplitude water waves generated by a lateral boundary (wavemaker) movement and an atmospheric pressure distribution, applied on the still water surface. Solutions corresponding to impulsive and harmonic forcing are examined in details. Special attention is paid to the asymptotic forms of the leading waves and the modulating wave front. A new set of laboratory experiments for the piston-type wavemaker is performed. The experimental data are used to check the analytical solutions and their asymptotic forms with good agreement . The major findings relevant to tsunami waves propagation are as follows: The leading waves generated by an impulsive horizontal lateral boundary movement have the same characteristics as those generated by an initial free surface displacement or an impulsive vertical displacement of the seafloor with an even function distribution in x. The amplitudes of these leading waves are proportional to the volume displacement averaged by depth. The decay rate of the leading waves is O(t-1/3). It is also noted that if the initial free surface displacement or the vertical displacement of the seafloor is an odd function in x, the corresponding leading waves decay at a faster rate, O(t-2/3). Impulsive atmospheric pressure is a less efficient wave generation mechanism. The decay rates of the generated leading waves are faster; it is O(t-2/3) for an even function atmospheric pressure distribution in x and O(t-1) for an odd function atmospheric pressure distribution. The details of the wave characteristics will be discussed further in the workshop.

O03

Revisiting the 1952 Kamchatka Earthquake Through the Lens of the 2025 Event

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ABSTRACT

The great earthquake that occurred on the plate interface offshore Kamchatka on 29 July 2025 provides an opportunity to re-examine the source of the 1952 Kamchatka earthquake. Both events generated tsunamis recorded across the Pacific Ocean, but the older event lacks the quality and quantity of data available for the recent one. Tsunami waveforms from the 2025 earthquake, recorded by offshore DART buoy stations, are used to estimate fault slip distribution. The estimated seismic moment from the model is 1.13×10^{22} Nm (Mw 8.6), with a major slip region about 50 km long located at depths of around 30 km. This model is robust and reliable, as it reproduces the observed tsunami waveforms, including both the initial and subsequent wave cycles at near- and far-field offshore stations. Time-shift and amplitude-scaling parameters derived from the source model and simulation results are applied to improve the fit between simulated and observed tsunami waveforms at coastal stations that recorded tsunamis from both great earthquakes. These correction parameters are then used in an inversion to estimate the fault slip distribution of the 1952 earthquake with much lower uncertainty. Seismic moment calculated from this slip distribution is 2.76×10^{22} Nm (Mw 8.9). It is inferred to have ruptured the plate interface near the trench with large slips, a result that resolves long-standing debates from previous studies.

O04

Automatic Rapid Tsunami Identification and Tracking by ionospheric GNSS data. The 2025 Kamchatka tsunami case in the far-field.

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ABSTRACT

Tsunamis are one of the most dangerous natural hazards, causing heavy impacts on society. Developing robust and reliable methods for monitoring and forecasting tsunamis plays a crucial role in early warning and risk mitigation. The modern set of tools to monitor the propagation of tsunamis includes seismic networks, tide gauges, satellite altimetry, and ocean bottom sensors, including DART systems. However, this task remains quite challenging due to the limited areas of available instruments. One way to improve existing early warning systems is to use the ionosphere, the upper layer of the Earth's atmosphere. In both the generation and propagation phases, tsunamis produce atmospheric gravity waves that reach the ionosphere in about 10-60 minutes, inducing co-tsunamic ionospheric disturbances (CTIDs) [1,2]. GNSS receivers are well-known tools to detect ionospheric disturbances due to their dense spatial distribution and high temporal resolution [1,2]. Therefore, this instrument provides a reliable opportunity to detect tsunamis and monitor their propagation. In this contribution, we present an approach based on the rapid evaluation of spatio-temporal characteristics of CTIDs to automatically detect and track tsunamis using ionospheric GNSS data [3,4]. For our analysis, we used the 2025 Kamchatka tsunami observed in the far field (Hawaii and the U.S. West Coast). Results were compared with DART, coastal tide gauge data, and JAGURS simulations. In some cases, earlier GNSS sounding allows automatic detection of tsunamis before coastal arrival. Thus, rapid detection, evaluation, and tracking of CTIDs support estimating tsunami characteristics, as CTIDs share similar spatio-temporal features (e.g., horizontal propagation velocity) with the tsunami waves that generate them.

1. Artru J. et al., Geophysical Journal International (2005)
2. Astafyeva, Reviews of Geophysics (2019)
3. Maletckii, PhD thesis, Université Paris Cité (2023)
4. Maletckii & Astafyeva, Journal of Geophysical Research: Space Physics (2024)

O05

A Source Model of the 2024 Noto Peninsula Earthquake Estimated by Nonlinear Joint Inversion using Tsunami Heights and Geodetic Data

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ABSTRACT

The M7.6 earthquake on January 1, 2024, in the Noto Peninsula, Japan, generated a widespread tsunami along the Sea of Japan coast. At several locations, tsunami waveforms were not recorded due to crustal deformation or damage to observation facilities. Previous fault models (e.g., Fujii and Satake, 2024) used a linear tsunami waveform inversion method. However, this approach has limitations in reproducing highly nonlinear tsunami trace heights, such as the locally high tsunamis observed in Joetsu City. Therefore, this study aims to construct a fault model that reproduces tsunami trace heights, geodetic data, and tsunami waveforms, using a nonlinear inversion method with trace heights and geodetic data.

We adopted nonlinear shallow-water equations for tsunami propagation and inundation, simulating for 6 hours with a 0.1s time step and a Manning's roughness of 0.025 s/m^(1/3). We used a 6-layer nested grid system (2430m to 10m resolution). We employed the Levenberg-Marquardt algorithm for the nonlinear inversion. The initial model used MLIT (2014) faults F42 and F43; we split the western part of F43 into three sub-faults to better fit geodetic data. The inversion used Rank A/B tsunami trace heights (Yuhi et al., 2024; Futagi et al., 2025) and 3-component geodetic data (53 GSI stations). Tsunami waveform data were used only for validation.

The resulting fault model has an Mw of 7.58. It estimates large slip: 5.3m on the western F42 fault and 7.5m on the western F43 sub-faults. The Variance Reduction (VR) was high, at 93% for trace heights and 92% for geodetic data. Furthermore, despite not using tsunami waveforms in the inversion, the model successfully reproduced observed tsunami waveforms at multiple stations. These results demonstrate that, using nonlinear inversion, tsunami trace heights can serve as a crucial dataset for constructing source models, especially in areas where instrument records are unavailable.

O06

Submarine Landslide Induced Tsunami Modeling Using 3D Slope Stability Analysis Method: The 2024 Noto Peninsula Earthquake and Tsunami in Toyama Bay, Japan

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ABSTRACT

A 7.5 Mw earthquake and tsunami occurred along the coast of the Noto Peninsula in January 2024, with the tsunami expected to reach Toyama Bay 20 minutes after the earthquake. However, waveform data showed that tsunami waves arrived within three minutes, these unexpected waves suggest contribution of a submarine landslide. The possibility of submarine landslide was supported by Japan Coast Guard (JCG) bathymetric surveys, which identified several locations of bathymetric changes between 2010 and 2024. This study aims to model the tsunami generated by submarine landslides, excluding any earthquake contribution. Hovland's three-dimensional slope stability analysis for cohesive-frictional soils was applied to estimate the landslide mass and location. The estimated landslides were then used as sources for tsunami generation in the TUNAMI-N2 two-layer model, which is based on the shallow water equations. The tsunami waveform was then validated against observed data from the wave and tide gauges. The model produced submarine landslides with estimated masses ranging from 0.015 to 1.28 km2. These results confirm the submarine landslides in this region and the simulated waveforms closely matched the observed data, confirming the arrival of tsunami within three minutes. The model was further developed so that spatially detailed peak ground acceleration (PGA) could be applied to each grid. This model allows it to be more realistic to represent the earthquake intensity across the region. Although this model could not fully reproduce all features of the observed waveform, the findings provide strong evidence that submarine landslides played a crucial role in the early tsunami arrival and highlight their importance in future tsunami hazard assessment.

O07

Industry-academia collaboration on parametric insurance solutions for tsunamis in Japan

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ABSTRACT

Parametric (or index based) solutions are a type of insurance that covers the probability (or likelihood) of a loss-causing event happening (like an earthquake) instead of indemnifying the actual loss incurred from the event. It is an agreement to make a payment upon the occurrence of a covered event meeting or exceeding a pre-defined intensity threshold, as measured by an objective value (such as earthquake magnitude or tropical cyclone category). Therefore, parametric insurance can provide coverage and protection that isn't available or offered by the traditional insurance market which is transparent, straight-forward, eliminating all complexity of a loss investigation process and can give customers the confidence when it comes to liquidity and speed of payout. One of the significant challenges associated with parametric insurance solutions is to minimize basis risk which is the possibility that the amount a policyholder receives in a payout differs from the actual losses they incur. This industry-academia collaboration is aimed at developing an innovative approach to overcome those challenges on parametric insurance solutions by optimizing the intensity threshold and basis risk using probabilistic hazard and risk assessment. This presentation will introduce an overview of this project using tsunami in Japan as examples.

O08

A proposed approach towards developing continuous coastal elevation data for tsunami-prone areas in Indonesia

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ABSTRACT

To support coastal monitoring, modelling of coastal floods and tsunami in Indonesia, a joint-research initiative – the SATREPS BRICC "Building Sustainable System for Resilience and Innovation in Coastal Community" was established between Indonesia and Japan. Continuous elevation model (DEM) from sea to shore is necessary to accurately monitor coastal and environmental changes, as well as model coastal hazards such as floods, storm floods and tsunami. However, the availability of high-resolution coastal elevation data is limited in many areas in Indonesia. Therefore, the aim of this study is to provide a systematic approach to developing high-resolution, continuous elevation data for flood and tsunami-prone areas in Indonesia. Currently, topography models (DEMNAS) and bathymetry models (BATNAS) provided by local agency, Badan Informasi Geospasial, are freely available for all of Indonesia, and a straight-forward solution would be to merge these two datasets through interpolation methods. However, such an approach is challenged by three key limitations: (i) differences in spatial resolution of the two datasets, (ii) differences in vertical reference systems, and (iii) data gaps in shallow water and subtidal areas. In recent years, remote sensing techniques have been widely tapped into to overcome data gaps in the shallow water areas. In this study, we capitalise on freely-available data by firstly using satellite imagery to derive shallow water topography and combining our models with DEMNAS and BATNAS models to develop continuous coastal elevation models for Indonesia at 10 m horizontal resolution.

O09

Tsunami Hazard in South China Sea Elevated by Manila Megathrust Supercycles

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ABSTRACT

Recent multidisciplinary evidence suggests that the coastal areas surrounding South China Sea (SCS) were struck by a catastrophic tsunami around 1067 CE, likely originating from the Manila Subduction Zone (MSZ). Modern geodetic measurements also indicate that tectonic strain is building up along the central MSZ, potentially leading to an M 8–9 megathrust earthquake. However, the incomplete historical earthquake record and lack of offshore geodesy limit our understanding of MSZ's megathrust rupture behavior, hindering accurate tsunami hazard assessments and development of effective disaster mitigation strategies. In this study, we develop a novel physics-based hazard assessment framework, by integrating 3D earthquake cycle models of the central MSZ with stochastic tsunami simulations across the SCS region. Our model reveals the unique spatiotemporal megathrust rupture patterns along the central MSZ, manifesting as supercycles governed by fault geometry heterogeneities. These MSZ supercycles, combined with its long history of strain accumulation, increase the expected tsunami hazard in the SCS by 2–3 times compared to previous estimates that assumed a time-independent and spatially random earthquake occurrence. Additionally, our new model produces more widespread hazard distributions in western Philippines and southern China. These findings demonstrate how the spatiotemporal complexities of earthquake occurrence reshape our understanding of tsunami hazard, and highlight the urgent need for regionally balanced investments for tsunami preparedness around the SCS.

O10

Updated Tsunami Inundation Hazard Maps in Taiwan: Supporting Evacuation Planning and Operations

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ABSTRACT

As situated along the subduction zone between the Philippine Sea Plate and the Eurasian Plate, Taiwan experiences frequent seismic activity, which in turn contributes to its susceptibility to tsunami hazards. After the 2011 Great East Japan Earthquake, the first version of tsunami inundation hazard maps was generated in 2013 then updated in 2015. This study performed the tsunami simulation using the latest high-resolution Digital Terrain Model, refined computational grids and COMCOT program (Cornell Multi-grid Coupled Tsunami Model) for 18 marine trenches surrounding the Philippine Sea Plate. The tsunami inundation hazard maps in Taiwan were updated and published on a GIS-based website in 2025. A comprehensive tsunami evacuation and shelter planning framework was proposed based on tsunami inundation hazard maps, including identifying suitable evacuation buildings, routes, and high-ground locations. The research accomplishments have been provided to the Ministry of the Interior and applied on the public conducted evacuation exercises for the 2025 National Earthquake Drill. The application of advanced tsunami simulation techniques not only enhances the accuracy of hazard assessment but also supports government efforts in strengthening evacuation planning and public safety measures, ultimately contributing to the protection of lives through practical, scenario-based disaster preparedness.

O11

Stratigraphic records reveal variable tsunami recurrence intervals along the Nankai Trough

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ABSTRACT

To examine recurrence intervals of tsunamis along the Nankai Trough based on stratigraphic records, we collected sediment core samples from two coastal wetlands in central Japan (Toba City and Shima City, Mie Prefecture) and conducted detailed radiocarbon dating. Both sites experienced inundation by the Showa Tonankai (1944 CE) and the Ansei Tokai (1854 CE) earthquake tsunamis. In the Toba cores, 18 sand layers interpreted as tsunami deposits were identified, while 8 such layers were found in the Shima cores. Benthic foraminifera and/or marine diatoms were found in all of these sand layers. In addition, changes in diatom assemblages below and above some of the sand layers suggest that subsidence occurred in the area during those events. Using OxCal, we estimated the depositional ages of the sand layers and found that the ages of the upper three sand layers at both sites overlap in age with historical tsunamis generated along the Nankai Trough: the Meio (1498 CE), the Eicho (1096 CE), and the Hakuho (684 CE) earthquake tsunamis. Furthermore, by applying the difference function in OxCal, we examined the recurrence intervals of these tsunami events. The recurrence intervals varied between approximately 100–800 years at both sites. The fact that such variability in recurrence intervals was observed at two sites within the same region suggests that tsunami recurrence along the Nankai Trough is not as regular as currently believed.

O12

What was the cause of the gigantic tsunami attacked Shishikui port town, _x000D_ Tokushima Prefecture, Shikoku, on 23rd September, 1512 ?

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ABSTRACT

According to the ancient document Shishikui-ura Kyuki “Chronology of Shishikui Port" a large tsunami struck Shishikui Town, Tokushima Prefecture, Shikoku, on September 23, 1512. Due to this tsunami, 2,200 drowned, and only 1,500 survived in this port town. However, no earthquake shakings were recorded. Even at Kyoto, the capital of Japan at the time, no perceptible earthquakes were recorded in diaries kept by the noblemen. For this reason, it is considered that this tsunami was not caused by a gigantic earthquake of the series of the Nankai Trough earthquakes. This tsunami is also recorded as a historical tsunami in documents written just after the 1707 Hoei earthquake that occurred 195 years later, and so we can confirm its actual occurrence. This tsunami is considered to be a distant tsunami caused by a massive earthquake in the continental shelf area west of the South American continent. The "Pacific Tsunami Catalog" by Soloviev and Go (1976) includes the following Peruvian Indian folklores. For example, in his biography, Silgado (1968) writes, "A long time ago, between 1513 and 1515, there was a powerful earthquake so strong that it caused high mountains to collapse. Residents living on the coast observed the sea level rising and falling as the earthquake continued." Furthermore, according to A. Herrera's study of Peruvian history books written in the early 17th century, during the Inca Empire era, when the population was extremely high, there was a powerful earthquake that caused mountains to collapse, causing the sea to overflow, drowning most of the residents and leaving only six survivors. The tsunami that struck Shishikui Town in 1512 is presumed to be a distant tsunami caused by the great earthquake handed down in a South American legend.

O13

Historical records and geological evidence of a Devastating tsunami from the South China Sea in 107 BC left in the South China region

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ABSTRACT

The Nanyue Kingdom, with over a million armed soldiers, should have a total population of no less than 3 million. However, after the Western Han's take-over in 111 BCE, following 113 years of peaceful development, the total population of the seven commanderies wherein recorded in the census of the second Yuanshi year (2 CE) was only 1,372,290. Such a drastic demographic change under Western Han rule suggests where likely experienced an extremely severe natural disaster. Furthermore, Nanhai Commandery, with its Panyu County serving as a major metropolis and the long-standing capital of the former Nanyue Kingdom, recorded a mere 94,253 people after 113 years of Western Han administration. Historical records indicate that Jieyang County, on the eastern coast of Nanhai Commandery, was a large county with over ten thousand households prior to its incorporation by the Western Han, was demoted from a county to a ting by the time of Wang Mang's Xin dynasty. Notably, it was not named "Jieyang Ting" but "Nanhai Ting," taking the name of the commandery, indicating a dramatic population decline and economic collapse. The fact that the seat of the Jiaozhi Regional Inspector, established in the fifth year of Yuanfeng (106 BCE), was located not in Nanhai Commandery or Jiaozhi Commandery, but in Guangxin County, Cangwu Commandery in a mountainous area, was likely to avoid the risks posed by tsunamis. The Book of Han recorded a devastating flood in the fourth year of Yuanfeng (107 BCE), may be due to the sea overwhelming the land. Luo Zisheng (1983) and Huang Zhenguo (1985) noted the mud-sand layers containing maritime shell at locations in downtown Guangzhou. Radiocarbon dated ages of 2,320±85 BP and 2,120±90 BP. It is likely the sedimentary record left by tsunami that occurred in 107 BCE (2,128 years BP) .

O14

A Phenomenological Reconstruction of the 1755 Great Lisbon Earthquake Source Based on Tsunami, Intensity, and Stress Modeling

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ABSTRACT

The Great Lisbon Earthquake (GLE) (November 1, 1755) with an estimated moment magnitude (Mw) of 8.7, struck Portugal, Spain, and northern Morocco, with tremors felt across northwestern Europe. It triggered a devastating trans-oceanic tsunami that swept the nearby Atlantic coast with run-up heights of 5–15 meters. In the Caribbean Islands, run-up heights of 1–5 meters were reported (Gutscher, 2004). The mechanism behind its generation has been extensively studied, leading to the proposal of several conflicting sources. Unlike previous studies that focused solely on tsunami- or seismic-based approaches, this study integrates three key aspects: tsunami characteristics at the coast, macroseismic impacts, and aftershock distribution to propose a novel interpretation for the source that aligns with historical records. We reexamine five previously proposed potential sources and hypothesize that a suitable source should account for all historical evidence. We begin by simulating tsunamis that would result from each source and compare their run-up heights and arrival times with those documented in historical records. To simulate a tsunami, we used the tsunami simulation code JAGURS (Baba et al., 2015). Next, we simulate seismic intensity distributions for each source using the OpenQuake Engine software (Pagani et al., 2014) and compare these simulations to the distribution of historical macroseismic impacts. Finally, we analyze Coulomb stress changes from each source to the Lower Tagus Valley region, where most of the aftershocks likely occurred. We found that no single source fully reconciles all lines of historical evidence. Nevertheless, our combined findings suggest that the 1755 GLE likely involved cascading triggering, with the primary source located at the Horseshoe Abyssal plain Thrust Fault. These results provide a new perspective toward a coherent interpretation of the 1755 GLE's source. However, we acknowledge that several challenges remain, due mainly to our inability to reliably assess the accuracy of historical data.

O15

Mid- to late Holocene marine reservoir age correction (ΔR) for the Taiwan Strait and the northeastern South China Sea

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ABSTRACT

Marine reservoir age correction (ΔR) is one of the most important parameters for calibrating radiocarbon dating results of marine samples, an essential age control for paleo-tsunami studies. For the northern South China Sea (SCS) area, however, available ΔR values are both spatially and temporally limited. Most of the widely used data are either from samples of the Ryukyu Islands that are far from the SCS, or from pre-bomb marine samples that span a time frame of only a few hundred years. In this study, we analyzed Holocene coral samples collected from the Penghu Islands in the southern Taiwan Strait and the Hengchun Peninsula above the Luzon Strait, both located in the northeastern SCS. Paired 14C and U-Th ages of these samples enabled us to calculate new ΔR values from the Marine20 calibration over the past 7500 cal BP. We developed a pretreatment protocol that ensures low calcite content (<1%, 0.8±0.2%) of the coral samples, and compared our new results with published ΔR values from the region, recalculated in accordance with the Marine20 dataset. The weighted mean ΔR value of -155±59 14C yr for the past 5500 cal BP is determined as the marine reservoir age correction for the Taiwan Strait and the northeastern SCS. Slightly higher ΔR values are present at Hengchun between 1200 and 2000 cal BP, while higher ΔR records have been reported near Xisha and Hainan in the SCS between 2000 and 2500 cal BP. Since the regional ocean circulation was closely related to the East Asian monsoon and remote ENSO forcing, our results may imply an intensity shift of the East Asian monsoon, and likely also the ENSO variation in the late Holocene.

Evolution of Tsunami-Like Waves Perturbed by a Longitudinal Sill

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ABSTRACT

Idealized tsunami-like waves (solitary waves and undular bores) propagating along a longitudinally oriented submerged uniform sill are examined. Note that sill-like conditions are present in the oceans as the formation of ridges and are known to trap tsunami energy. We explore here how the presence of a sill affects the ambient wave propagation and how the trapped wave on the sill evolves in a long duration. Numerical experiments are performed with a pseudo-spectral method to solve the fully nonlinear Euler formulation. In the case of solitary wave, when the wave reaches the head of the sill, the wave amplifies with phase lag relative to the ambient wave. This phase lag causes a divergence of wave rays at distances transverse to the sill's outer edge and hence a reduction in wave amplitude. This amplitude reduction draws energy from the ambient solitary wave toward the sill by diffraction; consequently, the ambient wave is continually deteriorated by the process. The similar behavior is observed for the undular bores. However, because of the successive undulations, phase difference between the ambient waves and those on the sill results in merging several ambient waves on the sill. Consequently, the wave period (and the length) on the sill becomes substantially longer than that of the ambient undulations. Unlike the case of solitary waves, the leading wave on the sill remains the highest. The detailed difference caused by the different height and breadth of the sill are discussed.

O17

Two-dimensional non-hydrostatic two-layer model for the generation and propagation of submarine landslide tsunamis

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ABSTRACT

Tsunamis generated by submarine landslides typically have short wavelengths, making non-hydrostatic effects significant during both generation and propagation. Conventional two-layer flow models based on the long-wave theory, which are widely used for simulating such tsunamis, neglect these non-hydrostatic effects. In high-fidelity modeling, tsunami generation is often simulated using a three-dimensional fluid model, which is then transformed into a two-dimensional model to simulate the subsequent propagation. To overcome these drawbacks, we developed a non-hydrostatic two-layer model capable of consistently simulating both the generation and propagation of submarine landslide tsunamis. The model incorporates a non-hydrostatic generation filter to smoothly transfer the debris-layer displacement to the seawater layer at each time step and includes Boussinesq-type dispersion terms for the seawater layer to account for wave dispersion. This model was applied to a submarine landslide source inferred from a seafloor scar located off the southwestern coast of Japan. Furthermore, the motion of the debris layer computed using the two-layer model was extracted and applied as a boundary condition in the three-dimensional fluid model. Tsunami waveforms produced by the two models exhibited excellent agreement, thus validating the accuracy of the proposed model. Non-hydrostatic effects play a critical role in the early stages of tsunami generation and propagation, influencing wave shape and amplitude. Although three-dimensional fluid models offer high accuracy, they are computationally intensive and may encounter stability issues in high-resolution inundation modeling. The proposed model provides an efficient and practical framework to simulate the generation, propagation, and run-up processes of tsunamis caused by submarine landslides.

O18

Submarine Landslide Tsunami Hazards in Southern Japan sea

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ABSTRACT

The Sea of Japan is considered one of the world's most seismically active back-arc basins. Its coastal areas have suffered from at least 14 tsunami events over the past 400 years. Most of them were triggered by earthquakes, with the latest event being Mw7.5 Noto Peninsula earthquake tsunami in January 2024. Unlike earthquake tsunami studies, landslide tsunamis have attracted limited attentions in this region. Recent geophysical studies reveal four large submarine landslides on the continental slope off the northeast coast of Korean Peninsula, with volumes estimated as 2.1 to 4.4 km^3, and one large landslide in the southern margin of Japan Sea, with an estimated volume of ~25 km^3. All the landslides occurred between 11 ka to 19 ka ago, during the Last Glacial Maximum (LGM) when sea level was about 120 m lower. Using high-resolution bathymetry and seismic reflection data, we reconstructed prefailure bathymetry and initial conditions of these submarine mass failures and simulated their runout processes and resulting tsunamis with a dynamically coupled landslide-tsunami simulation module in COMCOT. Parameters of landslide mass, such as bulk and grain densities, were estimated from piston core samples collected at these landslide source areas. Landslide friction rheology parameters were inversely estimated from mass failure scarps and runout extents with the assistance of numerical simulations. Our initial analyses reveal that these landslides could trigger tsunami up to 10 meters high at the northeast coast of South Korea, and up to 16 meters at the northwest coast of Kyushu and Chugoku, Japan. Tsunamis from these submarine landslides would arrive at the nearest coasts in a few minutes. Such tsunami could cause disastrous impact to coastal communities and infrastructure, especially due to lack of natural warning signals of their occurrences and very short travel times to coastal areas of southern Japan Sea.

Keywords: *Landslide; Tsunami; Japan Sea; Coupled Modelling*

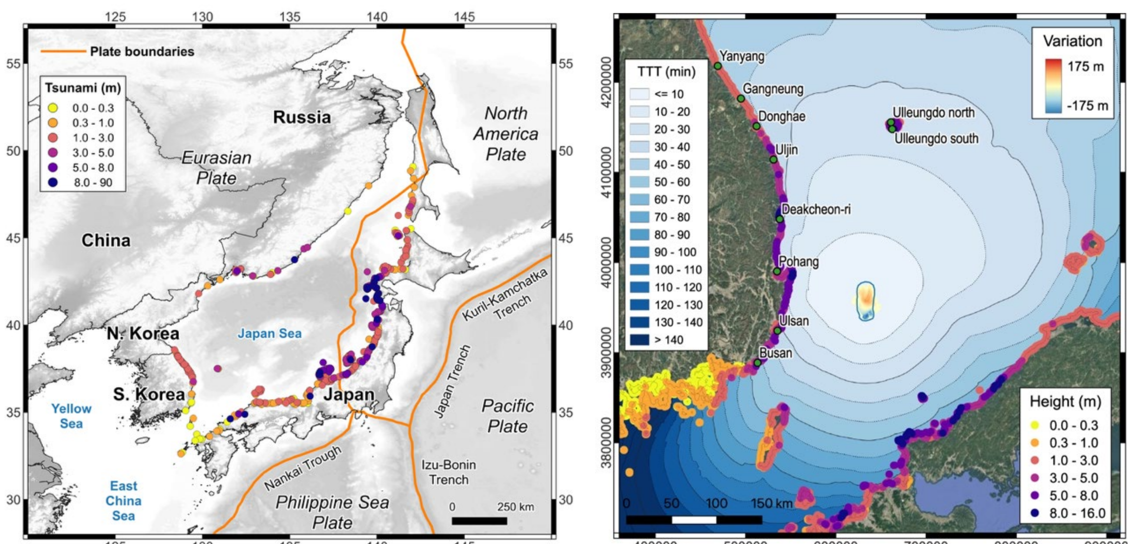

Figure *Left: historical tsunami observations along the coasts of Japan Sea; Right: Modelled seafloor variation due to mass wasting, maximum tsunami heights at coast, and Tsunami Travel Time (TTT) for the southern margin landslide in the southern Japan Sea*

O19

Development of Meteorological Tsunami Simulation Code and Parameter Study

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ABSTRACT

In the Nagasaki Bay of west coast Japan, meteorological tsunami called Abiki caused by atmospheric perturbations around the East China sea has been recorded as seiches. By investigating quantitative relations between atmospheric pressure records and sea level oscillations recorded by tide gauges, the origin of Abiki has been proposed. However, to understand the detail of the origin and propagation mechanism, lack of offshore observations of sea surface atmospheric pressure and sea level disturbance. We, National Research Institute for Earth Science and Disaster Resilience (NIED) are operating high precise ocean bottom pressure gauges in Dense Oceanfloor Network system for Earthquakes and Tsunamis (DONET; https://doi.org/10.17598/NIED.0008) and Seafloor observation network for earthquakes and tsunamis (S-net; https://doi.org/10.17598/NIED.0007). We succeeded to observe ocean bottom pressure changes induced by the atmospheric lamb wave caused by Hunga Tonga - Hunga Ha'apai volcanic eruption. For disaster prevention, we need to know offshore sea level changes to forecast tsunami height along the coastline. However, ocean bottom pressure gauges record not only sea level disturbance but also atmospheric pressure perturbations. To extract sea surface disturbance, we estimate sea surface pressure changes by interpolating atmospheric pressure data recorded by the infrastructure volcano observation network (V-net; https://doi.org/10.17598/NIED.0006) and others. To develop high precise numerical simulation code, we applied one-way atmospheric perturbation terms to the governing equations in the high-performance and open-source tsunami simulation code JAGURS which supports dispersion terms. In this presentation, we present the results of applying to offshore and coastline observation waveforms using the former proposed Abiki origin and simplified weather forecasting model.

O20

What Caused the Amplification of the 2022 Tonga Meteotsunami: Lamb Waves or Other Mechanisms?

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ABSTRACT

Unusual sea-level oscillations were recorded at tide gauges in Taiwan following the January 15, 2022 Hunga Tonga–Hunga Ha'apai eruption, with amplitudes amplified more than fivefold within 2–4 hours of the initial meteotsunami arrival. The first disturbance coincided with the passage of an atmospheric Lamb wave (~308 m s^{-1}), which generated modest sea-level responses of 2–5 cm. However, subsequent growth to 10–20 cm could not be explained by Lamb-wave forcing alone. By analyzing Central Weather Administration pressure records and conducting COMCOT simulations, we demonstrate that slower atmospheric gravity waves (~280 m s^{-1}) and Pekeris waves (250–220 m s^{-1}), with weaker pressure perturbations of 0.25–0.5 hPa, arrived after the Lamb wave and resonantly coupled with long ocean waves. A linear forcing model incorporating these later atmospheric waves successfully reproduces both the observed amplitude amplification and the evolution of wave periods. These findings indicate that Proudman resonance with atmospheric gravity waves, along with the subsequent amplification of Pekeris waves in the deep western Pacific, governed the multi-hour intensification of the 2022 Tonga meteotsunami. The results highlight the critical role of multi-wave atmospheric forcing in shaping meteotsunami hazards.

O21

Full-scale CFD simulation of tsunami-induced scour with three-dimensional seepage

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ABSTRACT

Seepage flows induced by geophysical tsunamis play a significant role in the tsunami boundary layer dynamics and associated sediment mobility. However, its impact on sediment transport and seabed morphodynamics in the presence of coastal structures remains unclear. In this study, we conduct rigid-bed and morphological simulations to investigate the role of seepage response in full-scale tsunami-induced flow features and sediment transport around a circular pile. The expressions for the onset threshold of sediment transport and the bed load motions are derived considering both bed-slope modifications and three-dimensional seepage forces, which are implemented in the coupled hydrodynamic, morphological, and soil models. The rigid-bed simulations demonstrate that the seabed suction response to the elevation wave can reduce the bed shear stress amplification underneath the contraction of streamlines alongside the pile and lee-wake vortices. The seabed injection response to the depression wave increases the stress amplification. It advances the position of boundary layer separation over the height of the pile, which further changes the lee-wake vortices. Note that the size of the horseshoe vortex and the upward-directed pressure gradient within it are less affected by the seepage flows. In morphological simulations, suspended load transport dominates the scour around the pile. Seabed suction during the elevation wave can slightly reduce the sediment transport rate, decreasing the scour depth, especially at the pile side. Seabed injection during the elevation wave causes exacerbated suspended load transport, leading to a more rapid and severe scour at the back of the pile. This study advances the understanding of seepage effects on tsunami-induced sediment transport and scour around a monopile foundation.

O22

On the seaward boundary condition of the dam-break swash model

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ABSTRACT

The seaward boundary condition (SBC), as a crucial input in dam-break swash model, significantly influences the spatiotemporal variations of the modeled hydrodynamic characteristics in the swash zone. Meanwhile, assumptions for two characteristic variables on the SBC are arbitrary, and the physical interpretation of the SBC remain inadequately understood. In this study, an analytical solution for the hydrodynamic characteristics on the seaward boundary was deduced for the case of dam-break induced breaking bore propagation along a frictionless swash zone. Under the traditional seaward boundary condition, a negative characteristic variable $\beta_0=-2$ demonstrates better physical consistency with the initial conditions and adheres more rigorously to the mass conservation than other values, making it superior than the commonly used $\beta_0=-2/3$ and other values. Meanwhile, a comparison of imposing the improved linear seaward boundary condition to $\beta_0=-2/3$ and $\beta_0=-2$ shows that the former results in larger local water depth and flow velocity throughout the entire domain. In addition, a generalized form of the nonlinear SBC was proposed and spatiotemporal distributions of the water depth and flow velocity throughout the entire domain under the linear and nonlinear SBC were compared. Furthermore, the physical interpretation of the SBC were clearly elucidated, showing that a larger SBC parameter value corresponds to a more elevated initial water surface in the dam upstream reservoir. These findings help to clarify the SBC used in the dam-break swash model, and provide the corresponding in-depth physical insights.

O23

A two-dimensional non-hydrostatic numerical model for dispersive waves generated by submerged landslides

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ABSTRACT

In this paper, a one-layer non-hydrostatic (NH-1L) model for simulating the generation of surface waves caused by the three-dimensional submerged landslide is developed. The non-hydrostatic model considered here is a depth-integrated version of the three-dimensional continuity and Euler equations, whereas time-varying bathymetry is accommodated in the kinematic equation along the bottom topography. The numerical scheme NH-1L is implemented on a two-dimensional staggered grid and is shown to have weakly dispersive properties. The validation of numerical results with analytical solutions and experimental data shows a satisfactory agreement. Moreover, the NH-1L model is investigated to predict wave run-up in confined bays. Considering its computational efficiency, the proposed NH-1L model provides a viable alternative for simulating wave generation, propagation, and run-up, particularly in cases with weak dispersion effects.

P01

Slip Models of the 2025 and 1952 Kamchatka Earthquakes Estimated by Tsunami Waveform Inversion

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ABSTRACT

The 2025 Kamchatka earthquake generated a tsunami that was recorded across the Pacific. The observed 2025 tsunami waveforms closely resemble the 1952 records, suggesting a similar slip distribution between the two events. We performed tsunami waveform inversion to estimate the slip distributions for both earthquakes. We divided the fault into 72 subfaults based on the USGS finite-fault model (v4) and computed Green's functions using JAGURS. Far-field tsunami delay effects (Watada et al., 2014) were incorporated following the method of Allgeyer and Cummins (2014). Bathymetry data were taken from GEBCO 2025 and resampled to 2 arcminutes offshore and 40 arcseconds near the tide gauges. Laplacian smoothing was applied to stabilize the inversion and prevent overfitting. The results show that the largest slip occurs southwest of the epicenter for both earthquakes, although the 1952 event exhibits a more spatially extensive slip area. When far-field tsunami delays are accounted for, the 1952 slip area extends closer to the trench axis than in the model of Johnson and Satake (1999). However, since our results are primarily constrained by far-field tsunami data, the slip distribution near the Kamchatka Peninsula remains less well resolved. Future work will focus on validating the estimated model using near-field tsunami data to better constrain the source characteristics.

P02

Inversion analysis of the 2025 Kamchatka Peninsula earthquake tsunami by SWOT satellite

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ABSTRACT

On July 29, 2025, at about 23:25 UTC, an M8.8 earthquake occurred near the Kamchatka Peninsula, and the tsunami was observed in Japan, with a maximum height of 1.3 meters recorded at Kuji port. Additionally, tsunamis with heights exceeding 1 meter were observed in Hawaii and California, USA. NASA announced that interferometric SAR satellite SWOT (Surface Water and Ocean Topography), an interferometric SAR satellite operated by NASA to observe the water level change on land and sea, passed over the area approximately 900 km above 45°north latitude and 165°east longitude off the coast of the Kamchatka Peninsula 70 minutes after the earthquake and observed the sea surface height anomaly (NASA 2025). In this study, we used the sea level data from the NASA SWOT observations, corrected for tidal variations, to confirm the propagation of the sea surface variations in the directions away from the epicenter. We report tsunami source inversion analysis using the SWOT observation data.

P03

On the time-varying wave features around the Hawaiian island chains duing the 2025 Kamchatka tsunami

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ABSTRACT

On Jul 29, 2025, a powerful magnitude 8.8 earthquake struck off Russia’s Kamchatka Peninsula, triggering the tsunami event across the Pacific. This study investigates the impact of the 2025 Kamchatka tsunami characteristics around the Hawaiian Island region where a maximum tsunami wave height of up to 1.74 m is recorded at Kahului (Maui), focusing on the time-varying water level data recorded at various nearshore tide and offshore DART stations. Applying a low-pass filter in Fast Fourier Transform (FFT) analysis to the recorded water level data, we separate the actual tsunami signal from the low-frequency tidal components. The primary objective is to understand how the geography layout of the Hawaiian Island chains influences the tsunami propagation and the resulting tsunami water level variation features along the island's eastern and western coasts. Data collected from multiple tide stations, including Honokohau, Kawaihae, and Hilo and so on, reveal obvious differences in tsunami wave characteristics on either side of the islands. Our results show that the presence of the Hawaiian Islands creates an observable distinction in local tsunami wave amplitude, period, and relevant wave properties between the eastern and western coasts. These differences suggest that the islands' overall configuration and the onsite bathymetry play crucial roles in modulating the local tsunami’s behavior after its transoceanic propagation. Upon these preliminary analyses, we aim to provide further insights into different mechanisms of regional tsunami dynamics, and contribute to the ongoing research on tsunami forecasting and associate disaster mitigation efforts, especially with respect to the remote island chain scenario which generally receives less research attentions. The findings underscore the need for more detailed, location-specific tsunami study to improve the early warning systems and disaster preparedness in Hawaii and other similar regions.

P04

Simulation of Tsunami Later Phases Along East Japan Coast induced by the 2025 Mw 8.8 Kamchatka Earthquake

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ABSTRACT

On July 30, a large Mw 8.8 earthquake occurred nearshore Kamchatka Peninsula. The earthquake triggered tsunami that propagated to Japanese coast. Against the tsunami threats, Japan Meteorological Agency (JMA) issued early warning with a level of “tsunami warning” to east Japan coast. The first crest wave arrived tide gauges along east Japan coast approximately 2 – 3 hours after the earthquake time, with wave height of 0.134 m (Hakodate) – 0.314 m (Kushiro). The tsunami waveforms at tide gauges showed complicated later phase features, such as amplified and persistent oscillations, following the arrival of first crest wave. The recorded maximum crest waves are 0.305 m (Abashiri) – 0.764 m (Hanasaki), arriving tide gauges about 5 – 8 hours after the arrival of first crest wave. Understanding the mechanisms of such amplified tsunami later phases is important as it provides critical information for appropriate decision making of tsunami early warning downgrade/ withdrawal. In this study, tsunami simulations are performed and compared with the observation data to analyze the generation, as well as the attenuation features of tsunami later phases along east Japan coast. Our analysis demonstrates that the scattering waves interfered by reflections from the emperor seamounts contribute significant impacts on generation of large later phases along East Japan coast. Sensitivity analyses demonstrate that the computational grid resolutions, as well as the tsunami nonlinearity in numerical models affects the tsunami duration prediction. These findings have implications for updating the existing JMA tsunami database to improve the accuracy of predicting tsunami decay characteristics from far-field tsunamis, such as the 2025 Kamchatka earthquake.

P05

Comparison of submarine landslide tsunami generation models: A case study of the 2024 Noto Peninsula Earthquake

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ABSTRACT

Several numerical models have been proposed for simulating tsunamis generated by submarine landslides; however, it remains unclear which model is the most accurate. This study aims to establish a numerical approach for evaluating submarine landslide-induced tsunamis. As a case study, we examine the 2024 Noto Peninsula earthquake tsunami and assess the reproducibility of submarine landslide-generated tsunamis. The numerical simulations consider both earthquake fault motion and submarine landslides. Two models were employed: the Watts model (Grilli and Watts, 2005; Watts et al., 2005), which defines the initial water surface displacement based on the geometric shape of the landslide body, and the two-layer flow model, which simulates the interactive motion between the landslide mass and seawater in two dimensions by incorporating nonhydrostatic effects. The location of the submarine landslide was determined based on previous studies (Yanagisawa et al., 2024). Preliminary calculations using the Watts model successfully reproduced tsunami arrival times but showed significant discrepancies in wave heights and periods compared with observations. To quantitatively evaluate the agreement between observed and simulated values, we calculated the Root Mean Square Error (RMSE) for the first 30 minutes after the earthquake, yielding 0.32 m for Toyama and 0.33 m for Fushiki. These values indicate a limited agreement between the observed and simulated tsunami heights, suggesting that the Watts model has low reproducibility in this case. We are currently conducting simulations using the two-layer flow model, and we plan to compare the results with those from the Watts model.

P06

Surrogate-assisted nonlinear inversion of the 2024 Noto Peninsula tsunami

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ABSTRACT

The strong nonlinearity of shallow-water deformation and tsunami run-up makes the application of the conventional inversion method to onshore tsunami records challenging. Additionally, many iterations of nonlinear tsunami simulations are required to capture the nonlinear characteristics of trace heights, which can be unfeasible. This study proposed a new approach for the nonlinear inversion of earthquake fault slips using tsunami trace height data. Instead of demanding simulations, a surrogate model was employed to reach a global optimum, which enabled the instantaneous estimation of the desired model output. The proposed method, which uses both tsunami waveforms and trace heights, was then applied to the 2024 Noto Peninsula earthquake in Japan. The results revealed a large slip of over 6 m offshore of the eastern Noto Peninsula. Our results demonstrate the potential of the new approach to complement coastal tsunami observations challenged by uncertainty and scarcity.

P07

Detection of Undetected Non-Seismic Tsunamis Using DONET Ocean Bottom Pressure Gauge Records

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ABSTRACT

In Japan, large-scale real-time seafloor observation networks have been established since around 2011 to quickly detect subduction zone earthquakes and associated tsunamis. Online ocean bottom pressure gauges installed at each station of the seafloor observation network enable us to detect weak tsunamis with amplitudes of only a few millimeters, which have been difficult to observe with conventional sparse coastal tide gauges. In this study, we applied the “network-averaged cross-correlation method” to the ocean bottom pressure gauge data to detect unknown tsunami events and searched extensively for similar waveforms. It is expected that the pressure gauges have recorded small-amplitude tsunami events, but the events may have been overlooked. When similar unknown events occur repeatedly, similar waveforms are recorded multiple times at the same observation point, regardless of the source location. Since the similarity of waveforms can be quantified by the correlation coefficient, repeated events can be comprehensively detected by calculating correlation coefficients between data from different time series at the same observation point, even when the events originate from various locations. The “network-averaged cross-correlation method” is a technique that takes the average of the maximum correlation coefficients at each observation point and uses it as the cross-correlation coefficient of the entire network. Since high correlation coefficients are obtained only when similar tsunami waveforms are consistently observed across the entire network, this method suppresses false detections caused by noise and improves detection accuracy. We analyzed DONET ocean bottom pressure gauge records (frequency band 0.001-0.01Hz) from April 2016 through December 2024 and succeeded in detecting many unknown events. Since no major earthquakes coincide with the observed events, they are considered non-seismic tsunamis. Submarine landslides, submarine volcanic activities, and meteorological disturbances are known to cause non-seismic tsunamis. In our analysis, most of the detected non-seismic tsunamis are likely meteorological tsunamis originating from meteorological disturbances. The arrival direction of the meteorological tsunamis was estimated by a semblance analysis. We found that the arrival direction and amplitude of the meteorological tsunamis exhibit seasonal variations. Meteorological tsunamis most often come from the southeast throughout the year, and those from the west also increase during the winter. Regardless of their arrival direction, the amplitude tends to be larger in winter and smaller in summer. By applying our method, it may be possible to automatically detect non-seismic tsunamis in the future, which have been difficult with conventional methods. We plan to analyze the detected events in detail and investigate the causes of their occurrence.

P08

Investigation of the Fault Model of the 2024 Hualien Earthquake Using Tsunami Waveform Inversion

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ABSTRACT

On April 3, 2024, an Mw 7.37 earthquake struck Shoufeng Township, Hualien County, Taiwan, and generated a tsunami. This event provided Taiwan’s first tsunami records from undersea cable pressure gauges deployed offshore eastern Taiwan, offering valuable data for tsunami–based fault inversion. Because there has been considerable debate over whether the causative fault dips eastward or westward, this study applies tsunami–based fault inversion to investigate the primary tsunami-generating fault geometry. To clarify inversion model’s details and limitations, we designed synthetic tests and compared prescribed slip distributions with the corresponding inversion results. The tests show that the length of the data window critically affects inversion stability: when the waveform window is limited to only the first one to two tsunami cycles, discrepancies between the prescribed and inverted slips are minimized; moreover, under this window the inversion remains highly stable even with as few as one station. Guided by these findings, we configured a stable inversion scheme and then used the pressure gauges’ observations from the 2024/04/03 Hualien event to do inversion for both east-dipping and west-dipping fault models. The results indicate that the west-dipping model better reproduces the seismic moment and observed tsunami waveforms than the east-dipping model, suggesting that a west-dipping fault was more likely responsible for the tsunami generation in this event.

P09

Modeling the 1026 CE Manju Tsunami to constrain its source and magnitude

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ABSTRACT

The Manju tsunami struck the Masuda Plain in Shimane Prefecture, facing the Sea of Japan in western Japan, on June 16, 1026 CE. Several historical documents describing this tsunami are preserved in the region. According to these records, the estimated inundation heights at multiple sites in the Masuda Plain ranged from 10 m to over 20 m. A tsunami deposit associated with this event has also been identified. Despite such evidence, trigger mechanism of the tsunami has not yet been clarified. In the continental shelf offshore of the Masuda Plain, well-developed active strike-slip faults are known. In addition, a large-scale submarine slide has been found on the continental shelf further offshore. Previous work suggested the submarine slide as a possible tsunami source; however, quantitative modeling studies remain limited. To clarify why such a locally large tsunami occurred and to estimate its source and magnitude, tsunami numerical simulations were conducted. The simulations considered either the rupture of the offshore strike-slip faults or submarine slides. By comparing the simulated tsunami heights with the inundation heights described in historical documents, we attempted to identify the tsunami source scenario that best explains the historical records. When the strike-slip faults were ruptured simultaneously, the simulated tsunami heights were significantly lower than those recorded in the documents. In contrast, considering the offshore submarine slide resulted in simulated tsunami heights that closely matched the historical records. This study provides new insights into the mechanisms and magnitude of tsunamis along the Sea of Japan coast, particularly in western Japan, where research examples are limited, and highlights the potential importance of submarine slides as a key tsunami-generation process in regions dominated by strike-slip faulting.

P10

Simulation of the Seismic-Tsunami-Atmospheric Coupling after an earthquake and an explosion source

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ABSTRACT

As we all know, tsunami is a typical multi-physical-field coupled process, caused by different events, like earthquakes, volcanos. Many studies on the earthquake-induced tsunami, but often overlooked the connection with the atmosphere. As for the volcano-induced tsunami, simulations are rare. In this study, we present a semi-analytical method to simulate the seismic-tsunami-atmospheric waves caused by an earthquake and an explosion source in the atmosphere, which has high computational efficiency. Our approach leverages surface harmonic vectors to transform the atmospheric, tsunami, and elastodynamic equations from the frequency and space to frequency and wavenumber domain. Wavefields are then computed using a global matrix method, incorporating boundary conditions and the source contribution, and transformed back to the time and space domain via the wavenumber integration and fast Fourier transform. Using this method, we find the different characteristics of waves in the ocean caused by the two events. Compared with the earthquake-induced tsunami, there is very clear acoustic-wave-speed tsunami in the volcano-induced tsunami. The tsunami simulation in the multi-layer atmospheric model has proved that there is a Proudman resonance phenomenon in the actual tsunami propagation, which enhances the amplitude.

P11

Advancement of Landslide-Induced Tsunami Modeling Using a Three-Dimensional Rigid-Fluid Method

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ABSTRACT

This study introduces a novel approach for simulating landslide-induced tsunamis, employing a three-dimensional Rigid-Fluid Method (RFM) integrated with the Splash3D Navier-Stokes solver. The proposed model captures the complex dynamics between solid bodies and fluid flow, accurately simulating slide translation, rotation, vertical accelerations, and wave generation without hydrostatic assumptions. The model's validation is conducted through controlled laboratory experiments, including rigid sphere water entry and semi-spherical landslide scenarios. Results demonstrate the model's robustness in reproducing realistic slide trajectories, velocities, pressures, and wave propagation. The model's applicability is further validated through a scaled-up semi-spherical landslide, following Froude number similarity to ensure proper scaling between laboratory and real-world scenarios. Compared to conventional shallow-water models, the RFM excels in capturing rapid pressure changes and short-wavelength wave phenomena, which are typical of landslide-induced tsunamis. Future applications will extend the model to handle irregularly shaped landslide masses and integrate the Discontinuous Bi-viscous Model (DBM) to account for mixed slide-slump mechanisms, enhancing its potential for accurate tsunami hazard modeling and early-warning systems. The current findings underscore the importance of improving predictive models for better coastal disaster mitigation strategies.

P12

Tsunami Resilience Assessment of Educational Buildings Based on High-Resolution Simulations: A Case Study of Shantou University

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ABSTRACT

Current research indicates that eight of the ten largest megacities in the world are located in regions highly susceptible to severe earthquake threats, with six of these cities facing significant tsunami risks. The economic losses and casualties resulting from natural disasters are often directly or indirectly attributed to damage to building structures. Consequently, reducing post-tsunami downtime of critical facilities and improving the resilience of coastal communities has become a significant challenge. Educational buildings, as vital evacuation and refuge sites within communities, play a crucial role in strengthening overall disaster response capabilities and facilitating the rapid recovery of social life. Therefore, there is an urgent need for high-precision and accurate assessments and analyses of the structural performance of existing educational facilities under tsunami impacts. Shantou University, designated as a demonstration area for tsunami evacuation drills in China, is exposed to a relatively high tsunami risk. To accurately assess the threats it faces, this study first employed drone mapping to obtain high-resolution topographic and three-dimensional building data of the surrounding area. Subsequently, the COMCOT model was utilized to simulate the flood evolution process under various tsunami source scenarios. Furthermore, tsunami loads were calculated based on the standard methods established by the American Society of Civil Engineers (ASCE). Through this series of analyses, this study aims to elucidate the inundation risks faced by Shantou University under different tsunami scenarios and to explore the specific impacts of tsunami loads on campus building facilities.

P13

Numerical modeling of coastal flooding in Macau during a synthetic tsunami event

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ABSTRACT

The Manila subduction zone is a major source of potential tsunami hazards in the South China Sea, posing a significant threat to densely populated coastal cities. To assess this risk, the present study develops an integrated numerical framework for simulating flooding processes in Macau triggered by an extreme synthetic tsunami event. The tsunami scenario is based on a sudden rupture of the northernmost segment of the Manila subduction zone with a moment magnitude of M_w=9, resulting in maximum seafloor deformation exceeding 15 m near Taiwan. The modeling approach couples the large-scale SCHISM (Semi-implicit Cross-scale Hydroscience Integrated System Model) with a local-scale, in-house inundation model considering the drainage effects. In this research, the SCHISM model is used to reproduce the concurrent tide and tsunami propagations, leveraging the inundation model with the focus on flood water dynamics within Macau city. To account for the drainage of overground flow, the Weir and Orifice Formulas (WOFs) are used to calculate the dynamic discharge at submerged drainage inlets. This allows for the simulation of drainage effects without direct modelling of the underground pipeline system. The results indicate that taking account of drainage inlets in the simulations will not produce impactful reduction on maximum inundation depth. However, they play a crucial role in the flood recession stage, enabling rapid water discharge in the low-lying areas. These findings underscore the complex flooding mechanisms arising from interactions between concurrent extreme sea-level rise and drainage system. We believe the modelling approach presented in this research can provide valuable insights for improving coastal resilience and tsunami hazard mitigation strategies.

P14

Evaluation of tsunami generation processes during the 1596 CE Keicho Bungo earthquake through numerical simulations

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ABSTRACT

The 1596 CE Keicho Bungo earthquake (estimated M 7.2) occurred in Beppu Bay, Japan, and generated a tsunami that inundated the entire coastal area according to historical records. These records indicate that the tsunami heights reached 4–5 m around the bay. Previous numerical simulations (Ishibe and Shimazaki, 2005) using normal fault models within Beppu Bay, based on faults identified in submarine active fault surveys, significantly underestimated these tsunami heights. This discrepancy suggests additional contributions from right-lateral strike-slip faults extending offshore and submarine landslides; however, these factors have not yet been quantitatively evaluated. To investigate the tsunami generation processes associated with the 1596 CE Keicho Bungo earthquake, we conducted tsunami simulations using JAGURS (Baba et al., 2015, 2017) incorporating both seismic fault and submarine landslide models. Fault models were constructed using four normal and four right-lateral strike-slip segments, with slip distributions determined by empirical scaling relationships by Lathrop et al. (2022). Submarine landslide sources were defined at two sites within the bay, and initial water displacements were calculated using the model of Watts et al. (2005). Simulations using only normal faults reproduced tsunami inundation across the bay but yielded small amplitudes (1–2 m) at the bay mouth and head, considerably lower than the historical estimates, which suggest amplifications in these areas. In contrast, the scenario combining normal and strike-slip fault ruptures increased tsunami heights by about 4 m at the bay mouth, while the scenario combining normal faults and submarine landslides amplified tsunami heights by about 3 m at the bay head. Overall, our results indicate that the 1596 CE tsunami was primarily generated by normal faulting, while strike-slip faulting and submarine landslides likely contributed to local amplification. This study provides new insights into tsunami generation processes related to nearshore active faults and submarine landslides in Beppu Bay.

P15

Probabilistic Estimation of Business Interruption Losses Caused by Tsunamis: An Approach Using Data from the 2011 Great East Japan Earthquake and Tsunami

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ABSTRACT

Accurate disaster loss estimation is essential for effective disaster risk reduction among businesses, insurance companies, and governments. Although tsunamis are relatively rare events, they can cause devastating economic losses when they occur, and various studies have been conducted to estimate such impacts. However, most previous studies have primarily focused on direct damages, such as the destruction of buildings and infrastructure. In contrast, indirect losses—often exceeding the direct ones—have received limited attention. To achieve more comprehensive tsunami loss estimation, it is therefore necessary to develop methods that account for these indirect effects. Especially, business interruption (BI) losses can have a significant impact on economic recovery, yet they remain difficult to quantify due to high uncertainty. In this study, we developed a probabilistic model to estimate BI periods based on empirical data from the 2011 Great East Japan Earthquake and Tsunami. The BI periods were estimated as probabilistic functions of tsunami intensity measures and then converted into BI losses while explicitly considering uncertainty. The results demonstrate a trend in which the BI period increases with greater inundation depth, while also implying that other factors—such as supply chain disruptions and the shutdown of public infrastructure—may exert considerable impacts. This model is expected to contribute to probabilistic tsunami risk assessment by enabling the estimation of indirect tsunami-induced losses with improved accuracy under uncertainty.

P16

Evaluating Tsunami hazard in the Guangdong–Hong Kong–Macao Greater Bay Area

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ABSTRACT

The latest geological and geophysical surveys show the Pearl River Estuary segment of the Littoral Fault Zone has had multiple paleo-earthquakes over Mw 7.0, posing major seismic/tsunami risks to South China’s coasts. However, its tsunami hazard potential lacks systematic assessment.This study investigates the impact of earthquakes along this segment on the Guangdong–Hong Kong–Macao Greater Bay Area and compares the resulting tsunami characteristics with those generated by earthquakes along the Manila Subduction Zone. Using geological/geophysical data, it set fault parameters, built coseismic rupture models via RupGen, and batch-simulated 120 non-uniform slip earthquake tsunamis with the parallelized COMCOT model.The results reveal significant spatial variations in maximum tsunami wave amplitudes triggered by earthquakes of same magnitudes along the Littoral Fault Zone. The most affected areas include Hong Kong, Zhuhai, and Jiangmen, which are directly exposed to the seismic source, whereas the outer islands of the Pearl River Estuary provide effective buffering, reducing wave impact farther inland. In high-magnitude scenarios, tsunami waves may arrive at Hong Kong within approximately 10 minutes, with wave amplitudes exceeding 2 m, and reach Zhuhai and Jiangmen within 20–30 minutes, generating waves nearly 2 m high. Owing to the normal-fault mechanism of the Littoral Fault Zone, the resulting tsunamis are characterized by rapid sea retreat followed by violent inflow, severely threatening port infrastructure. In comparison, a Mw 9.0 earthquake originating from the Manila Subduction Zone would impose a far greater tsunami impact across South China, with maximum wave heights ranging from 4 m to 10 m. Although tsunamis generated by the Littoral Fault Zone are smaller in both scale and spatial extent, they exhibit strong ground shaking, short arrival times, and abrupt water withdrawal and advance, presenting substantial risks to coastal regions. This study provides critical insights for tsunami disaster prevention and mitigation efforts in South China.

P17

Modeling the Mysterious Tsunami Swirls in the Northeast Coast of Japan during the March 2011 Tohoku Earthquake

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ABSTRACT

The formation of tsunami swirls near the coast is an obvious oceanographic phenomenon during the occurrence of giant submarine earthquakes and mega-tsunamis. Several tsunami vortices were generated during the Asian tsunami of 2004 and the great Japan tsunami of March 2011 which lasted for several hours. New models of tsunami generation and propagation are hereby proposed and were used to investigate the tsunami inception, propagation and associated formation of swirls in the eastern coast of Japan. The proposed generation model assumes that the tsunami was driven by current oscillations at the seabed induced by the submarine earthquake. The major aim of this study is to develop a tsunami model to simulate the occurrence of tsunami swirls. Specifically, this study attempts to simulate and understand the formation of the mysterious tsunami swirls in the northeast coast of Japan. In addition, this study determines the vulnerability of the Philippines to destructive tsunami waves that originate near Japan. A coarse-resolution model was therefore developed in a relatively large area encompassing Japan Sea and the eastern Philippine Sea. On the other hand, a fine-resolution model was implemented in a small area off Sendai coast near the epicenter. The model result was compared with the tsunami record obtained from the National Data Buoy Center with relatively good agreement as far as the height and period of the tsunami are concerned. Furthermore, the fine-resolution model was able to simulate the occurrence of tsunami vortices off Sendai coast with various sizes that lasted for several hours.

P18

Uncertainty Tsunami Runup Considering Stochastic Disturbance in Initial Waveforms

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ABSTRACT

Tsunamis exhibit minor fluctuations during transoceanic propagation due to complex factors, including meteorological conditions and microscale seafloor topography. Establishing reliable uncertainty bounds in tsunami hazard predictions demands a quantitative understanding of how small-scale disturbances evolve in coastal areas. Despite its importance, this physical process remains insufficiently explored and warrants further investigation. This study numerically investigates the coastal amplification of such offshore disturbances through one-dimensional run-up simulations on a uniformly sloping beach. To model the inherent uncertainties in offshore wave measurements, we generated 100 distinct incident wave patterns by applying random walk perturbations to two fundamental wave types: a solitary wave, representing the leading tsunami crest, and a periodic wave train, mimicking subsequent waves. Our results demonstrate the clear trend that the initial disturbances tend to amplify significantly after running up the slope, with this effect being more pronounced on gentler gradients. The magnitude of this amplification was found to be strongly correlated with the onshore inundation distance, suggesting that non-linear shallow-water processes play a key role in modulating the final wave height. Furthermore, we observed no discernible difference in the amplification magnitude between solitary and periodic waves. This finding indicates that the amplification mechanism is a fundamental process, mostly independent of the specific shape of the incident waveform. These results emphasize a crucial source of unpredictability in local tsunami impacts and highlight the need to incorporate initial condition uncertainties into hazard assessment frameworks to constrain the range of possible outcomes better.

P19

GNSS Positioning Accuracy Estimation for Wave and Tsunami Buoy Observation Development

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ABSTRACT

Recent technological innovations have spurred a global movement toward the development of compact, low-cost wave and tsunami observation instruments and the expansion of wave observation networks. The objective of this study is to develop a high-precision, inexpensive wave observation buoy using the Global Navigation Satellite System (GNSS) and to verify its wave observation accuracy using Single Point Positioning (SPP). In this study, we conducted an accurate assessment of SPP through land-based rotating stand tests and compared wave observation data from sea-based mooring tests between our self-made buoy and a commercial buoy. Furthermore, using the Centimeter Level Augmentation Service (CLAS) from the Michibiki (QZSS) satellite, we attempted to verify GNSS positioning accuracy through rotating stand tests, wave-generating tank tests at the Kyoto University Ujigawa Open Laboratory, and a mooring test in Shirahama Tanabe Bay. The rotating stand tests confirmed that by removing long-period noise from the positioning data, SPP can achieve accurate evaluation. In the wave-generating tank tests at the Kyoto University Ujigawa Open Laboratory, comparisons between the wave height data from our CLAS-enabled buoy and the wave height data from the wave gauge demonstrated that the self-made buoy is capable of highly accurate positioning. Moreover, in the mooring test in Shirahama Tanabe Bay, a comparison of significant wave height, mean period, and energy spectra between our self-made buoy and the commercial buoy showed a very high correlation. For future work, we aim to adapt the buoy technology for offshore tsunami observation.

P20

Slip distribution of the 2024 Hualien earthquake estimated from linear tsunami inversion

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ABSTRACT

On April 2, 2024, at 23:58 (UTC), an M7.4 earthquake occurred off the coast of Hualien County, Taiwan, generating tsunamis of 27 cm at Kubura, Yonaguni Island, and 17 cm at Ishigaki Port, Ishigaki Island. The earthquake might have involved a complex rupture with both east-dipping and west-dipping faults. While geodetic analyses reproduced observations using either fault independently, a combined fault model was reported to better explain the observations (Cheloni et al., 2024). Furthermore, joint analyses of geodetic and seismic data suggested that rupture on the west-dipping fault began approximately six seconds after that on the east-dipping fault (Liu et al., 2024). However, detailed rupture estimation using tsunami waveform data has not yet been conducted. In this study, the fault slip distribution of the 2024 Hualien earthquake was estimated using linear tsunami inversion for three cases: (1) east-dipping single fault model, (2) west-dipping single fault model, and (3) combined fault model. Fault parameters were based on the USGS CMT solution, with upper edge depths adjusted to approximately 1 km. Each fault plane was divided into 16 subfaults, resulting in 32 subfaults in the combined model. Numerical tsunami simulations were performed using the linear long-wave equations solved on a finite-difference scheme. Three-layer nested bathymetry (27 s GEBCO, 9 s, 3 s GtTM) was used. Waveforms from four tide gauges and one DART station were utilized, assigning the DART data 20 times higher weight. Non-negative constrained ridge regression was applied, and the optimal hyperparameter λ was determined by k-fold cross-validation. Results show that while both single-fault models reproduced tsunami waveforms, the combined model achieved superior accuracy. Simulations using the estimated fault model and nonlinear long-wave equations also reproduced later waves not used in inversion.