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Deep Learning Approach for Volcanic Tsunamis Prediction Model using Existing and Synthetic Observation Station

TECHNOLOGY SHOWCASE

■ Introduction

Volcanic tsunamis, particularly those caused by volcanic collapse, are infrequent but highly destructive events. The devastating tsunami caused by the lateral collapse of Anak Krakatau (AKV) in December 2018 resulted in hundreds of fatalities and underscored the critical need for robust early warning systems. Volcanic collapses can produce unpredictable and severe consequences due to the rapid onset and complex dynamics of tsunami generation. Existing tsunami detection networks may not provide sufficient coverage to monitor these events effectively. This research aims to address these challenges by proposing a machine learning-based prediction model that utilizes both real-time data from existing observation stations and synthetic data generated for areas lacking observational coverage. By integrating this diverse data, the model seeks to improve the accuracy and timeliness of tsunami warnings.

■ Research activities flow

1. Simulation and Development of Deep Learning Model

The core of this study is the development of a machine learning algorithm tailored to predict volcanic tsunamis generated by volcanic collapses. The model was trained using both real observation data from established tide gauge stations and synthetic data generated through simulations. The synthetic data were created from simulation to mimic possible scenarios, ensuring the model can handle various potential collapse conditions.

2. Integration of Existing and Synthetic Data

One of the key innovations of this model is the integration of synthetic observation stations. Synthetic data were developed through simulation models to predict wave height and tsunami arrival times in locations with sparse monitoring. This allows the system to extend its prediction capabilities beyond the constraints of the existing observation network, increasing coverage in regions susceptible to volcanic collapses but lacking sufficient monitoring infrastructure.

3. Prediction of Tsunami Waveform

The model leverages the initial wavefield data from both real and synthetic observation stations to forecast the entire tsunami waveform. The objective is to predict the waveform progression over time and space, providing critical information such as wave height, arrival times, and energy distribution across affected regions. This allows authorities to issue more accurate and timely warnings, improving preparedness and reducing potential loss of life.

4. Performance Evaluation

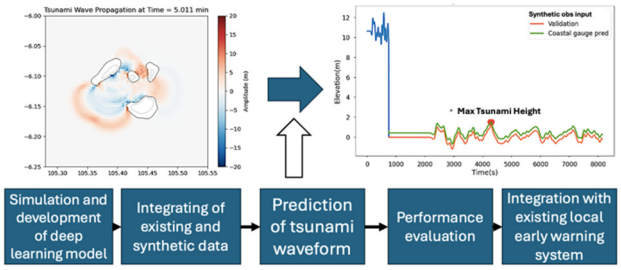
The performance of the model was evaluated using historical data from the 2018 Anak Krakatau tsunami, as well as simulated datasets from hypothetical volcanic collapses. Preliminary results show that the integration of synthetic observation data improves the accuracy of predictions, particularly in regions where direct measurements are sparse or unavailable.

5. Integration with Existing Early Warning Systems

This research contributes to enhancing early warning systems by offering a framework for real-time predictions utilizing both observed and synthetic data. The developed machine learning model can seamlessly integrate with existing disaster management systems to deliver near-real-time predictions of tsunami risks following volcanic collapses. This integration aims to significantly improve the responsiveness and effectiveness of current early warning systems, thereby helping to mitigate the risks associated with high-consequence, low-probability events such as volcanic tsunamis.

■ Flow illustration

This figure below shown the flow illustration of research activities.



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