IDENTIFICATION OF POTENTIAL STORM SURGES DUE TO TYPHOON RAI USING NUMERICAL MODELS

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TYPHOON RAI (2021)

In December 2021, Typhoon Rai (local name: Odette) hit the Visayas region of the Philippines. It had a minimum sea level pressure (MSLP) of 915 hectopascals (hPa) and a maximum sustained wind speed of 54.02 m/s and was classified as a violent typhoon by the Japan Meteorological Agency. Rai caused massive damage to infrastructure and housing (NDRRMC 2022). Rai passed through the vulnerable islands of Bohol and Cebu, where high storm surge heights could be expected from strong typhoons (Lapidez et al., 2015). Field surveys were conducted right after a typhoon event to investigate the condition of the affected areas. However, Rai hit during the pandemic when travel restrictions were effective in the country. Thus, it was difficult to identify the areas hit by potential storm surges immediately. Satellite imagery is one method; however, it is generally difficult to identify if the area was affected by storm surges using images. Numerical modeling of the typhoon event over select areas is one way to solve the problem of disaster information shortage. In this study, Rai is simulated using weather and storm models over the provinces of Bohol and Cebu.

TYPHOON SIMULATION

The Weather Research and Forecasting (WRF) Model was used to hindcast Typhoon Rai with Final Operational Global Analysis (FNL) meteorological data. A two-way nested domain was set-up over the Pacific Ocean and the central Visayas with a simulation period from 2021 12 December 00:00 to 2021 18 December 00:00 Universal Coordinated Time (UTC). The initial simulation results of track, MSLP, and maximum wind speed generally showed good agreement with the observed data as Rai passed through Bohol and Cebu (Figures 1-3). The simulated MSLP of 929.46 hPa overestimated the observed MSLP by 14.46 hPa (Figure 2). The simulated wind speed of 54.26 m/s was accurate with the observed data (Figure 3). The WRF results were used as boundary conditions for the storm surge simulation.

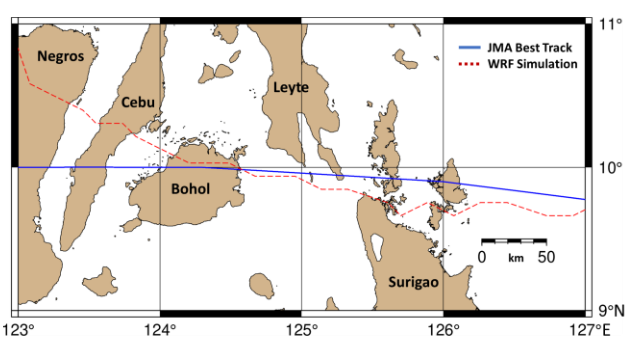

Figure 1 - Simulated track of Rai.

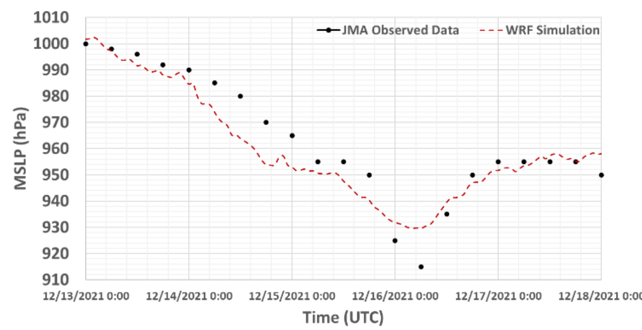

Figure 2 - Simulated MSLP of Rai.

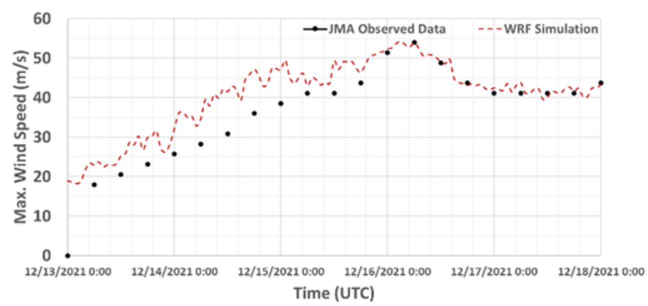

Figure 3 - Simulated Maximum Wind Speed of Rai.

STORM SURGE SIMULATION

The Finite Volume Community Ocean Model (FVCOM) was used to simulate for potential storm surges in Bohol and Cebu. Triangular mesh domains were set-up covering the study provinces of Cebu and Bohol (Figure 4).

Figure 4 – FVCOM Domain mesh.

The General Bathymetric Chart of the Oceans 2021 Grid (GEBCO Compilation Group 2021) was interpolated for bathymetry data and the Global Self-consistent, Hierarchical, High-resolution Geography (GSHHG) Database (Wessel and Smith 1996) was used for the coastline data. The obtained storm surge simulation results are then compared with satellite imagery, local news reports, and field surveys conducted after the typhoon event.

A particular area of interest for this study were the small islands of Batasan and Pangapasan near Tubigon in Bohol. These islands are shown in Figure 5 and are surrounded with mesh sizes of around 10 meters. Since these are small islands, a more precise bathymetric data around these areas obtained from the field survey of Esteban et al. (2022) was added for interpolation.

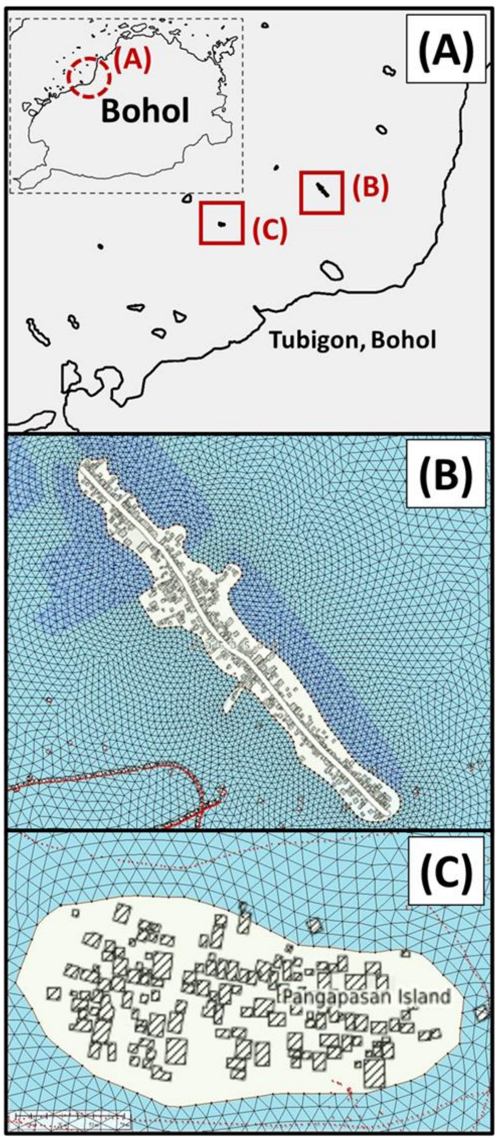

Figure 5 – (A) Location of Tubigon, Bohol and the study islands; (B) Batasan Island; and (C) Pangapasan Island.

Based on the observed track, wind field, and shallow bathymetry, it was assumed that a significant storm surge was experienced around Tubigon. This was recorded by Esteban et al. (2022) after conducting a field survey around two months after Rai made landfall in the Philippines. The survey has recorded storm surges of 2.00-2.01 meters at Batasan island and 2.29-2.49 meters at Pangapasan island. The FVCOM simulations aims to further validate the observed storm surge in the area and allow to further understand the disaster caused by Rai in the area.

IMPORTANCE OF NUMERICAL MODELING

When a strong typhoon such as Rai makes landfall, it is crucial for coastal engineers to determine whether a storm surge or high wave attack occurred in a coastal area as soon as possible. This can be done by numerical simulations and field surveys. Conducting numerical simulations to grasp an overview of what an area experienced during a typhoon seem to be not usually the immediate focus of the authorities as the priorities are more on recovery and relief operations. By the time field surveys can be done, evidences of watermarks and debris could have already cleaned up by the residents.

Adding the fact that the Philippines is an archipelago and travel restrictions were in effect due to the pandemic, is was difficult to conduct relief operations and surveys during this time. Government agencies can determine areas affected by storm surges that need immediate response by conducting accurate preliminary simulations even if on-site investigations are restricted. The coupled WRF-FVCOM numerical model allows hindcast any typhoon event immediately after the typhoon attack and check for potential storm surges at any location in the Philippines. This method can be useful if travel restrictions continue to affect when another strong typhoon hits the country.

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