The study on the application of storm surge assessment methods in unmeasured coastal areas

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1. Introduction

The purpose of this study is to analyze wave height changes under current and future climate conditions at a hypothetical nuclear power plant site in Pantai Gosong, Indonesia. In this study, long-term reanalysis wave height and wind field (u,v) data for current climate conditions (ECMWF-ERA5, 1940− 2024) were primarily used. Additionally, a wave numerical model was developed to determine the design wave height based on frequency. Afterward, the model was simulated using wind field data, and the results of the model were validated based on reanalysis wave height from ERA5. To determine the design wave height, an extreme analysis of reanalyzed wave data was performed. Finally, the wave height was determined by applying the frequency-based wave conditions to the wave numerical model.

2. Methods and Results

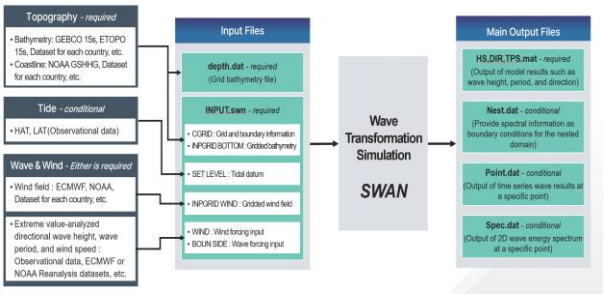

Fig. 1. Study flow

2.1 Estimation of Input Data

Ocean bathymetric - GEBCO (General Bathymetric Chart of the Oceans) 15-second grid depth data were used.

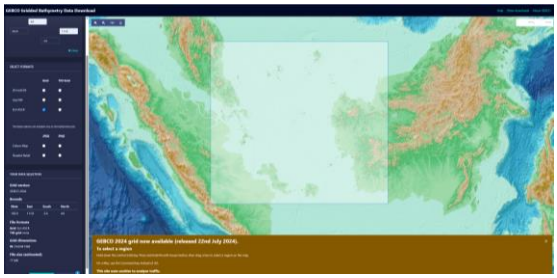

Fig. 2. Ocean Bathymetry

Land elevation - SRTM (Shuttle Radar Topography Mission) 1-second gridded terrain data were used.

Fig. 3. Land Elevation

Experimental Domain Setup - To minimize wave shoaling during the experimental domain setup, the area was defined to satisfy deep-water conditions (h/L > ½).

When applying a nesting grid, the grid size reduction was limited to 1/5.

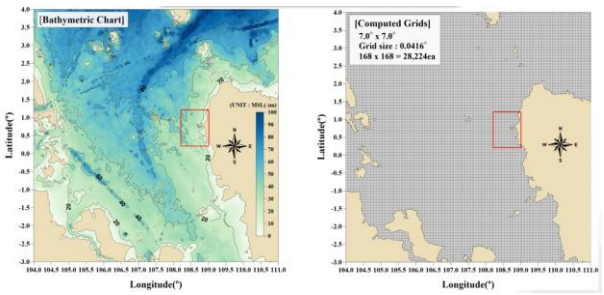

Fig. 4. Bathymetric Contours and Grid Map

Highest Astronomical Tide (HAT) Estimation - When estimating HAT, tidal harmonic constituents must be derived from sea level observations conducted for at least one year. These constituents are then used to

predict tidal elevations over at least 19 years, from which the maximum (HAT) is determined.

Wind Field Data Download - Reanalysis data from ECMWF–ERA5 were used.

2.2 Wave Numerical Model Simulation

Verification Method - The time series of significant wave height estimated by the SWAN model was compared and validated against ECMWF–ERA5 reanalysis data.

Time series verification of significant wave height was conducted at four locations (W1 to W4).

Fig. 5. Verification Point Location

Verification Period - The one-month period of July 2021, during which the highest significant wave heights over the past 10 years were observed in the project area, was selected.

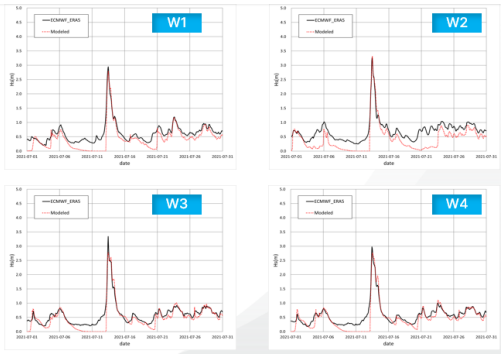

Fig. 6. Verification Results of Wave Height Time Series

Extreme Value Analysis - Extreme value analysis was conducted for wave height and wind speed in nine directional bins (from south to north) affecting the target area.

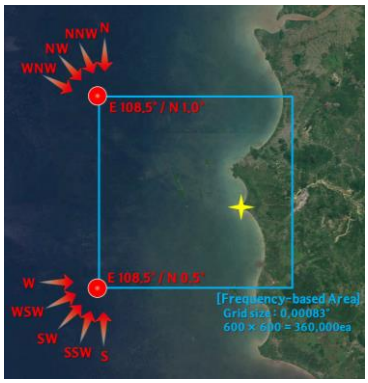

Fig. 7. Extreme Analysis point

Table 1. 50-Year Return Period External Forcing (108.5°E / 1.0°N)

Category		Direction								
		S	SSW	SW	WSW	W	WNW	NW	NNW	N
50yr	Wave height(m)	1.49	1.20	1.14	1.34	1.55	1.54	1.70	2.23	2.23
	Wave period(s)	5.50	5.19	5.12	5.35	5.56	5.55	5.70	6.13	6.13
	Wind speed(m/s)	10.02	9.64	9.26	9.63	10.37	10.16	10.46	11.75	11.67

Table 2. 50-Year Return Period External Forcing (108.5°E / 0.5°N)

Category		Direction								
		S	SSW	SW	WSW	W	WNW	NW	NNW	N
50yr	Wave height(m)	1.46	1.15	1.13	1.32	1.63	1.65	1.66	2.12	2.12
	Wave period(s)	5.25	4.92	4.90	5.11	5.41	5.43	5.44	5.81	5.81
	Wind speed(m/s)	10.00	9.38	8.96	9.67	10.44	10.42	10.42	11.63	11.63

2.3 SWAN Results (Condition: HAT, 50-Year Return Period)

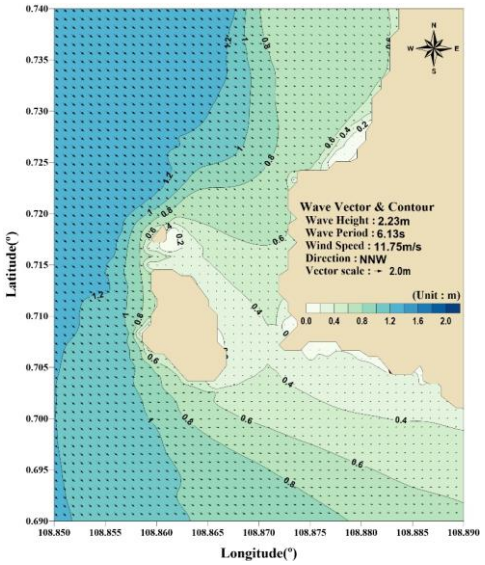

Fig. 8. SWAN Result of Wave Height

3. Conclusions

In this study, wave height was estimated based on the return period in an unmeasured sea area. For this purpose, reanalysis data from ERA5 were used. Also, a numerical model was developed and validated for wave analysis. Wave heights and wind fields were then estimated for each return period using extreme analysis.

This study suggests that it can serve as comparative data for future climate change scenarios.

Acknowledgments

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