

NUMERICAL SIMULATION OF NEARSHORE WAVES AT MYANMAR COAST: AN INTEGRATED USAGE OF ERA-5, MIKE 21 AND SATELLITE DATA

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INTRODUCTION

Global-scale numerical models are essential for offshore (deepwater) wave climate assessment and long-term analysis. However, they encounter challenges in nearshore regions due to the sudden changes in water depth and subsequent wave shoaling processes (Van der Westhuysen (2012)). Besides, there are existing limitations on measured wave data in most parts of the world, especially in coastal regions of developing countries. Recent studies have used global atmospheric and ocean reanalysis data for regionalized wave simulations (Chow (2022)). Therefore, this study proposes a comprehensive modelling framework for nearshore wave simulation along the Myanmar coast using global wind and offshore wave reanalysis and tide data. The present research aims to fill the gap between the necessity to investigate wave climate for port planning and coastal management and the lack of reliable wave observation networks, which is typical for developing countries like Myanmar.

MATERIALS AND METHOD

In this study, the MIKE 21 Spectral Wave (SW) model developed by the Danish Hydrodynamic Institute (DHI) was utilized. This third-generation wave model is capable of simulating the growth, dissipation, and transformation of both wind-generated waves and swells in coastal areas. As a case study, the model was applied at Kyaikami, a location on the Southern coast of Myanmar, where the measured wave data by a local survey team was available for two weeks from 22 September to 5 October 2015. Given this, the model was run for 20 days from 15 September to 5 October 2015 to cover the initial wave growth for the simulations. The modelling framework for nearshore wave simulation is shown in Figure 1.

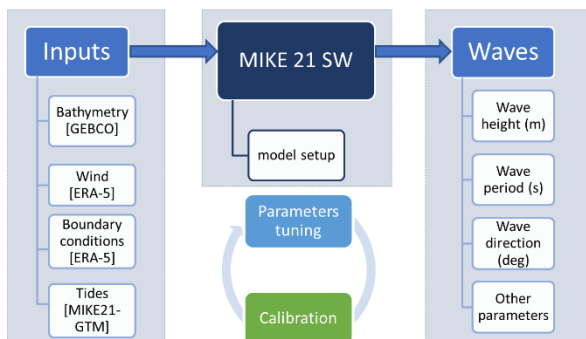


Figure 1 - Framework for Nearshore Wave Simulation Using MIKE 21 SW model

The input datasets for model forcings were obtained from the General Bathymetric Chart of the Oceans (GEBCO),

5th generation European Center for Medium-Range Weather Forecasts Reanalysis (ERA-5) and MIKE 21 Global Tide Model (GTM) as follows:

- GEBCO: gridded bathymetry with 15 arc-minute resolution (approximately 450 m)
- ERA-5: wind forcing (u_{10} , v_{10}) in $0.25^\circ \times 0.25^\circ$ grids for the simulation domain and wave forcing (combined wind-waves and swells) along the open boundaries with 1h time interval
- MIKE 21 GTM: tidal prediction of water levels at $0.125^\circ \times 0.125^\circ$ resolution

For the MIKE 21 SW setup, the sensitivity analysis with parameters tuning of the model physics was conducted, considering different spectral formulations, wave growth due to wind (Charnock parameter), and energy dissipation coefficients (dissipation coefficient (C_{dis}) and delta for white capping). The unstructured grid with triangular meshes was used for simulations with coarser to finer meshes from offshore to nearshore. The simulation domain considers the Southern coast of Myanmar, surrounded by the Bay of Bengal and the Andaman Sea, represented as open boundaries along West and South (Figure 2). The deepwater wave rose offshore of Kyaikami based on ERA-5 reanalysis data at grid point 97.5°E , 16°N shows that the dominant waves are coming from Southwest and the maximum significant wave height (H_s) was found to be 3.8 m, and the mean wave period (T_m) was around 15 s.

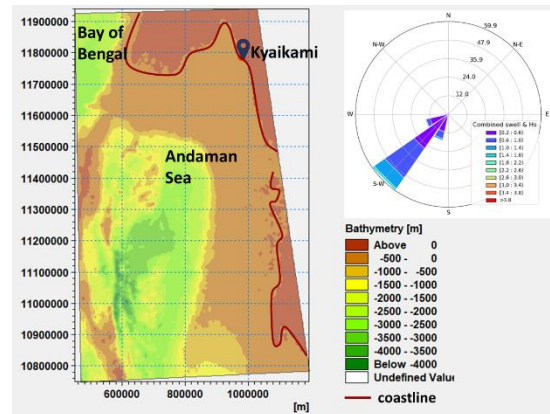


Figure 2 - GEBCO Bathymetry Showing the Southern Coast of Myanmar with Wave Rose Representing Offshore Waves near Kyaikami Based on ERA-5 Reanalysis (1993-2022)

The in-situ wave data used for model validation was collected at coordinates 97.52°E and 16.12°N , where the water depth measures around 10 m (shallow water). It is important to highlight that this survey location is situated

near an estuary characterized by a significant tidal range of around 6.5 m. Moreover, the along-track satellite altimeter wave measurements retrieved from the European Space Agency (ESA) were also used for calibration.

RESULTS AND DISCUSSIONS

The sensitivity analysis of the model shows that the best accuracy is achieved through a full spectrum simulation with Modified WAM Cycle 4 and by using values of 0.006, 2.5, and 0.5 for the Charnock parameter, C_{dis} , and δ , respectively. Figure 3 presents the time-series comparisons of MIKE 21 SW simulations results with observational data for significant wave height (H_s), peak wave period (T_p), and mean wave direction. In general, the model results agree with measured data across wave parameters. It should be noted that the observed data exhibits abrupt changes given its location at an estuary, where the river currents can significantly influence the resulting wave conditions and the measurement accuracy. This characteristic results in local dispersion in wave direction measurements, while MIKE simulated directions show a more consistent trend of southwest-originated waves (Figure 3(c)). Additionally, in Figure 3(a), the tidal effects are clearly visible in the variations of simulated H_s . However, the in-situ data shows a sudden peak, resulting in a slight difference in comparison.

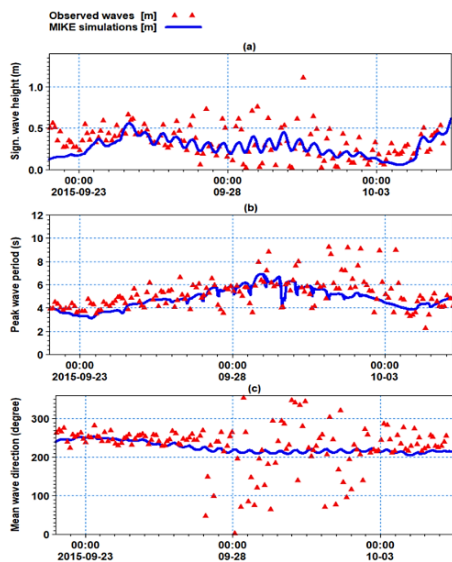


Figure 3 - Comparison of Simulated Wave Parameters (Blue Line) with Observed Data (Red Triangles) for (a) H_s , (b) T_p , and (c) Mean Wave Direction

The calibration of model results with along-track satellite-measured wave heights is depicted in Figure 4. During the simulation period, 1624 data points from different satellites, namely, Cryosat-2, Jason-2, and Saral, were valid for comparison with simulated results of H_s . The results show a good agreement between the two wave datasets, with a correlation coefficient of 0.878 observed throughout the simulation domain, proving the model's validity.

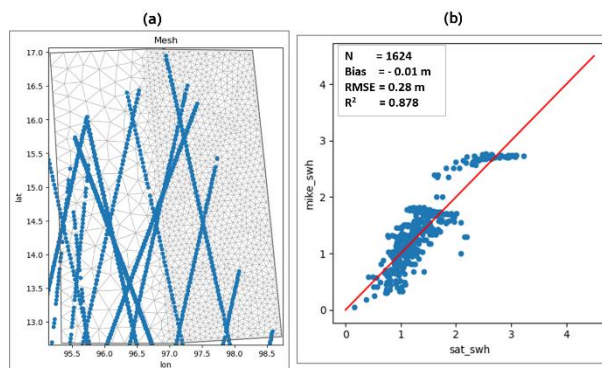


Figure 4 - Comparison of MIKE Simulations with Satellites Measurements (a) Tracks of Satellites Across the Simulation Domain and (b) Correlation Analysis of H_s

CONCLUSIONS

In this study, the numerical modelling of nearshore waves near the southern coast of Myanmar was conducted. The simulation results were validated with in-situ observed wave data and satellite measurements. It was found that the integration of boundary conditions (wind waves and swells) and gridded tidal data significantly improved the model accuracy. For simulating waves in nearshore and shallow water areas, the results suggest the effectiveness of using the MIKE 21 SW model with readily available inputs from open-source databases of GEBCO for bathymetry and ERA-5 for winds and waves. Given the limitations of global-scale wave model databases, such as ERA-5 reanalysis, which often lack data for nearshore regions, the modelling framework presented in this study holds significant applicability for wave hindcast and forecast on a regional scale. This methodology is particularly useful for developing countries, where access to comprehensive measurement data is often limited. Similarly, in regions like Myanmar, which lack a dense network of in-situ observational stations, the numerical methodology and the satellite measurements present the potential application of various numerical techniques and satellite data to estimate wave conditions. To further enhance the model, future work can focus on conducting more simulations by expanding the availability of in-situ wave and current data and local bathymetry measurements.

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