Validation of SWAN Wave Simulations during a Mediterranean Medicane Using Multi-Source Observations

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Abstract

Extreme Mediterranean cyclones (medicanes) pose significant hazards to coastal regions through intense winds and high waves. The November 2019 medicane produced severe wave conditions that affected the Egyptian Mediterranean coast, providing an important case study for evaluating the performance of operational wave models during high-impact events.

This study assesses the capability of the SWAN (Simulating WAves Nearshore) model to reproduce wave conditions associated with the November 2019 medicane. The model is forced using bias-corrected ERA5 atmospheric fields to improve the representation of storm-induced wind forcing and its impact on wave generation and propagation. Model performance is evaluated against multiple independent observational datasets, including satellite-derived significant wave height observations and measurements from coastal monitoring stations. Statistical validation metrics, including bias, root mean square error (RMSE), correlation coefficient, scatter index, and other standard verification measures, are used to quantify model performance under both moderate and extreme sea-state conditions.

In addition to evaluating the accuracy of the simulated wave fields, the study investigates the added value of bias-corrected atmospheric forcing relative to the original reanalysis in reproducing extreme wave conditions. The results provide insight into the strengths and limitations of SWAN for forecasting severe marine events along the Egyptian Mediterranean coast and contribute to the development of improved validation methodologies for regional wave forecasting systems. The findings are expected to support operational coastal hazard forecasting and align with ongoing international efforts to enhance validation metrics and best practices for ocean forecast evaluation.