MULTIVARIATE ANALYSIS FOR THE COMPOUND ASSESSMENT OF COASTAL STRUCTURES: THE MILFORD-ON-SEA (UK) CASE STUDY

Antonio Francone, University of Salento, antonio.francone@unisalento.it
Gianfausto Salvadori, University of Salento, gianfausto.salvadori@unisalento.it
Fabrizio Durante, University of Salento, fabrizio.durante@unisalento.it
Giuseppe Roberto Tomasicchio, University of Salento, giuseppe.tomasicchio@unisalento.it
Felice D'Alessandro, University of Milan, felice.dalessandro@unimi.it
Elisa Leone, University of Salento, elisa.leone@unisalento.it

INTRODUCTION

The assessment of sea structures is a critical endeavor in coastal engineering, ensuring the safety and sustainability of coastal developments and infrastructures. Effective management and protection of coastal areas require reliable predictions of shoreline evolution when hard structures are present. In most cases, sea structure assessment involves dealing with both deterministic and random factors. Deterministic modeling is adopted to determine the shoreline response based on wave conditions, providing a baseline understanding on how the structure might behave under standard circumstances. However, the natural variability of the marine environment means that deterministic models alone are insufficient to capture the full range of possible scenarios. The present study addresses the inherent randomness in wave conditions by employing a stochastic technique to generate random sea states based on known parameters. This novel approach is applied to the coastal area of Milford-on-Sea, located in Hampshire (UK) where, in 2007, a field experiment was conducted involving the temporary installation of a 46-meter-long groyne.

THE DETERMINISTIC TRANSPORT MODEL

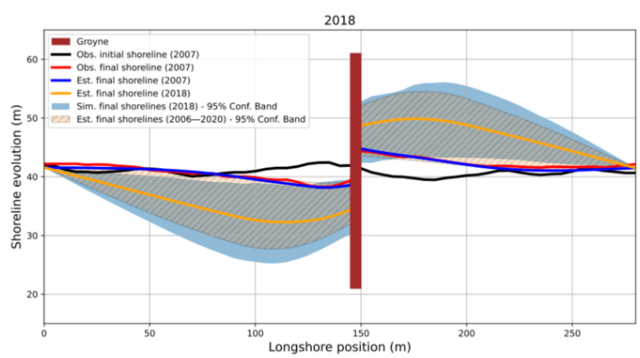
In the present study, to predict shoreline evolution in the presence of a single groyne, the General Shoreline beach (GSb) numerical model has been adopted; belonging to the one-line model category, it assumes a constant beach cross-shore profile. It calculates the equilibrium cross-shore profile based on Bruun (1954) and Dean (1977) methods. Changes in the shoreline position are driven by variations in longshore transport gradient, leading to either accretion or erosion. To calculate the longshore sediment transport rate (LT), the GSb model employs the General Longshore Transport (GLT) model proposed by Tomasicchio et al. (2023) that is suitable to determine LT at any coastal bodies accounting for a large number of mobility conditions of the units composing the mound: from stones to sands.

THE STATISTICAL APPROACH

A statistical approach has been used to model and simulate multivariate time series data for sea state variables (e.g., significant wave height, wave peak period, wave direction). First, the data is log-transformed to simplify the analysis. Next, univariate stochastic models are fitted to the log-transformed time series to capture their temporal behavior and volatility. Copula modeling is then employed to capture the dependence between these variables while considering their observed relationships (Salvadori et al., 2015). Subsequently, trivariate samples of innovations are generated using the copula, preserving the observed dependence structure. The simulated samples are transformed back into real-world values, ensuring that they adhere to physical constraints.

CONTENT OF THE FULL PAPER

In the full paper, the GSb model's ability to predict the shoreline evolution is first assessed. The sea state recorded during the 2007 field experiment at Milford-on-Sea is considered in the analysis. Then, starting from the same sea state, the stochastic model has been employed to generate a number of independent sea state scenarios, corresponding to an equal number of shoreline scenarios covering a larger time period (2006-2020). The figure below shows the observed shorelines before and after the field experiment, together with the one estimated with the GSb model. It also includes the estimated band using the deterministic model, employing the random time series generated by the stochastic model for the longer period, as well as the simulated band using the stochastic model. The orange line represents the shoreline profile estimated with the deterministic model for the year 2018, falling within the band of simulated results. Starting from a limited time series, the stochastic model can generate random time series for a longer period that produce effects consistent with the deterministic model.



REFERENCES

Bruun (1954): Coast erosion and the development of beach profiles, Vol. 44, US Beach Erosion Board.

Dean (1977): Equilibrium beach profiles: Us atlantic and gulf coasts. Ocean Engineering Report.

Tomasicchio, Francone, Salvadori (2023): On the general longshore transport model for resilient beaches, Coastal Engineering, 180,104257.

Salvadori, Durante, Tomasicchio, and D'Alessandro (2015): Practical guidelines for the multivariate assessment of the structural risk in coastal and off-shore engineering, Coastal Engineering, 95, pp.77-83.