

INFLUENCE OF THE INITIAL TOPOBATHYMETRY IN BACKSHORE-NEARSHORE INTERACTIONS DURING EXTREME EVENTS

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INTRODUCTION

Mediterranean deltaic areas have suffered reduced sediment inputs during the last decades due to dams and coastal structures, resulting into significant losses of wetlands and beaches. Additionally, the low elevation of deltaic coasts makes them vulnerable to global warming effects, with mean sea level rise being a major concern throughout the 21st century (Wong et al., 2014). At the same time, this dynamic coastal zone is extremely complex, with intricate interactions between sediment transport, water flows, and climate change impacts.

To design and develop beach protection strategies for future adaptation of deltaic coasts to climate change impacts, a more comprehensive understanding of the inherent dynamics between the backshore and the nearshore is crucial, especially during extreme events, when these areas become highly vulnerable as they get submerged under the action of waves and surges (Cohn and Ruggiero, 2016). In particular, it is essential to gain understanding of the physical mechanisms governing both alongshore and cross-shore variability, as well as to investigate the sediment transport processes influenced by natural morphological patterns such as crescentic bars, megacusps, or shoreline sand waves (Castelle et al., 2015) as well as artificial patterns such as nourishments.

Therefore, this study aims to determine the effect of the topobathymetric variability, on the evolution of the backshore and the nearshore during extreme events. Special attention is given to beach erosion and the formation of backshore sand deposits.

STUDY SITE AND DATA

The study site is Castelldefels beach, on the Catalan coast (NW Mediterranean). This beach is a microtidal, deltaic, open beach, with its sediment mainly supplied by the Llobregat river, located approximately 6 km to the NE of the study area (Figure 1). Over the past 13 years, numerous bathymetric surveys have been conducted along this beach. Furthermore, the input data for wave time series is obtained from a SIMAR node data set, which employs wave reanalysis performed by Puertos del Estado (Spanish government). Sea level data is obtained from the Barcelona harbor tide gauge.



Figure 1 - Castelldefels beach, Catalonia, Spain. Figure obtained and edited from Google Earth.

MODEL AND METHODS

In this study, the open-source 2DH coastal model XBeach (Roelvink et al., 2009) is used. The model is well suited for simulating the complex morphodynamic effects of extreme events on the backshore and the nearshore (Schambach et al., 2018) and is therefore useful for studying overwash processes (Matias et al., 2019).

To achieve the main goal of this study several simulations are being performed using different initial topobathymetries, which include irregularities both in the backshore and foreshore, and the corresponding beach evolution under different extreme conditions is then quantified.

The initial topobathymetries include the presence of submerged bars (which could be natural or artificial), either isolated or periodically distributed in the nearshore area, megacusps of different dimensions positioned in the shoreline area, as well as troughs dispersed along the beach profile, among other complex morphological configurations. Furthermore, different potential bed elevation scenarios, especially in the dry beach zone, are being tested in order to evaluate the effects of overwash in the backshore region, including the presence of washover deposits and beach erosion.

These diverse topobathymetric configurations are subject to different storm conditions that have occurred in the Catalan coast in the last decades, characterized by distinct return periods and intensities. In addition, synthetic storms are incorporated into the assessment to deep into some specific coastal processes under controlled conditions.

The observed sea level variability is incorporated but synthetic surges are also tested, to force flooding events during the different storm conditions (i.e., storm surges), and also to replicate the future sea level rise scenarios.

PRELIMINARY RESULTS AND FURTHER WORK

The default topobathymetry configuration for the model is generated by replicating the central topobathymetric profile obtained from a survey conducted in Castelldefels beach on June 3, 2022 (the most recent topobathymetry acquired), spanning the entire alongshore domain. This synthetic topobathymetry has been fitted to the model's specific rectangular grid with increasing spatial resolution in cross section along the coast, especially refined in the nearshore area.

A sensitivity assessment of the optimum grid sizes has been first performed, also considering the computational cost of every simulation. Moreover, the sensitivity of the most important parameters within the model related to the cross-shore transport, the factors of wave skewness and asymmetry (facSk and facAs respectively), has also been assessed. Finally, cyclic boundary conditions are selected in the model and have proved to represent well the wave and sediment fluxes that an open-beach is influenced by.

The first storm studied represents the conditions of an energetic storm that reached the Catalan coast from December 25 to December 30, 2008. This 5-day storm reached the beach of Castelldefels with a maximum significant wave height (H_s) of ~ 5 m (Fig. 2), and it was estimated to have a return period of ~ 5 years (Mendoza et al., 2010). For the purpose of the study, the wave direction during the storm is changed, starting with shore-normal incidence. After that, other wave directions are being implemented to observe the differences on the morphodynamic influence of the various topobathymetries. Furthermore, the sea level data series for this 5-day period was obtained from Barcelona harbor tide gauge. During the most intense phase of the storm sea level reached a maximum value of ~ 50 cm, 30 cm above the mean level, as showed in Figure 2.

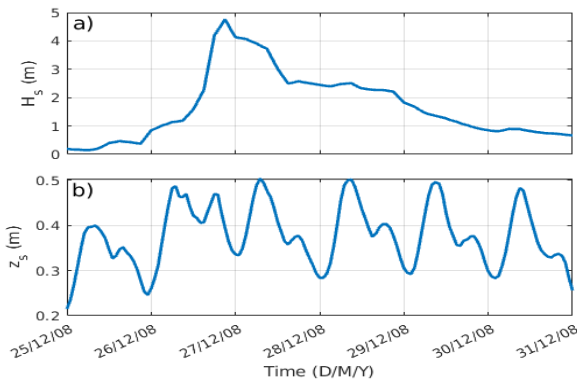


Figure 2 - Significant wave height (panel a) and sea level (panel b) of the period between December 25 to December 31, 2008.

Among the different initial bathymetric configurations tested, Figure 3 presents the one including an isolated submerged crescentic bar located in the nearshore area. After the 5-day storm, the crescentic bar retreats its position through the profile and the affectation in the shoreline is limited because the sea level over-elevation during the first studied storm do not lead to inundation of the dry beach.

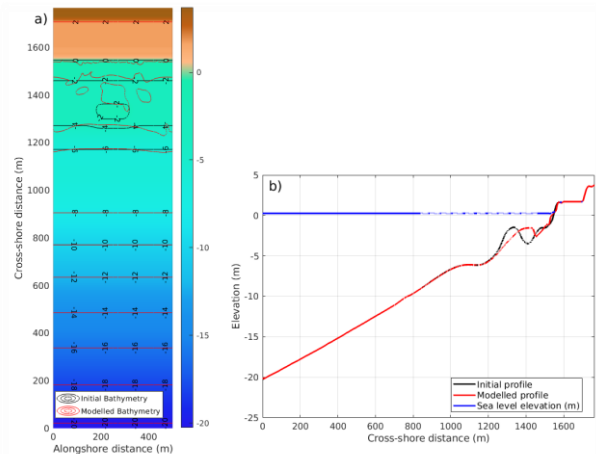


Figure 3 - Topobathymetric evolution (panel a) and profile evolution (panel b) of the crescentic bar case.

The results obtained are preliminary as the research is still at an early stage and no definitive conclusions can be derived yet. By performing a range of different simulations incorporating various initial bathymetric configurations, storm and sea-level conditions, it is expected to obtain results that allows characterizing the influence of surf-zone bathymetry on the evolution of the backshore and foreshore during flooding events and viceversa. Such investigation can increase our understanding of backshore-nearshore interactions during extreme events and improve strategies to protect vulnerable sandy beaches.

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