Coastal vulnerability assessment of the French Mediterranean coasts to storms flooding and erosion phenomena, and morphodynamic modeling under climate change projections

Nico Valentini, BRGM – University of Montpellier, n.valentini@brgm.fr
Yann Balouin, BRGM – University of Montpellier, y.balouin@brgm.fr

INTRODUCTION

Storm events on sandy coastal environments already weakened by a sediment deficit can generate a strong erosion of the beach-dune system, accentuating the phenomena of marine flooding and damage to infrastructures. In order to assess this risk of coastal flooding under stormy conditions and taking into account climate change and the new IPCC projection (IPCC, 2021), modeling approaches nowadays provide a robust tool. In this study, a modeling chain is used to simulate present-day and future coastal hazards on the Mediterranean French coastline, taking into account the complex interaction of hydrodynamic and morphodynamic phenomena.

METHOD

In order to build a regional strategy for the evaluation of the coastal hazards under storm events, a methodology is proposed to evaluate the reality of a potential increase of coastal flooding following dune/beach erosion and to identify the concerned coastal regions for prioritizing regional coastal zone management actions.

First, a coastal-dune vulnerability index is built at a regional scale and a clustering analysis used to identify the most vulnerable sites. Then, two representative sites are used for being modelled for coastal flooding assessment, under climate change scenarios.

The vulnerability index is based on an adaptation of the protocol proposed by García-Mora et al. (2000, 2001), Idier et al. (2013) and applied in Ciccarelli et al. (2017). Four groups of variables havebeen studied: geomorphological conditions of the dune system, marine influence, vegetation condition and the anthropic effects. In this study, 81 coastal sectors, based on geomorphic features are chosen and 17 variables, including both the quantitative and the qualitative parameters, are considered in the coastal dune vulnerability classification. A hierarchical clustering to create homogeneous sector groups from the similarity matrix of sector variables is applied.

The sites of Canet-en-Roussillon and Sète are chosen from the two main clusters for a numerical approach to analyse the effects of storm erosion on the magnitude of flooding, based on the coupling of SWAN and the Xbeach-surfbeat model. This implementation allowed a calibration phase using historical data available under storms events, a large sensitivity test to adjust physical and numerical parameters is performed. In a second step, the modeling chain is used to simulate extreme events scenarios with a 10 and 50-year return period (on wave heights) and extreme fluvial contribution, by including the sea level rise scenarios, in order to assess the coastal risks associated.

RESULTS

Beyond this strong disparity between the different groups obtained in the clustering analysis, it appears that the overall vulnerability index is high (value greater than 0.5) for a significant length of the regional coastline. This represents about 35% of the coastline that would present an increased vulnerability to marine submersion due to their sensitivity to coastal erosion events. The amplitude of the xbeach-modelled erosion and flooding at both sites are in line with observations made during and after storms. Figure 1 shows the profile-based Xbeach performance at Canet-en-Roussillon. The results of the modeling chain with the IPCC projections scenarios depicts the great influence of sea-level-rise contribution in linearly increasing the submerged volumes.

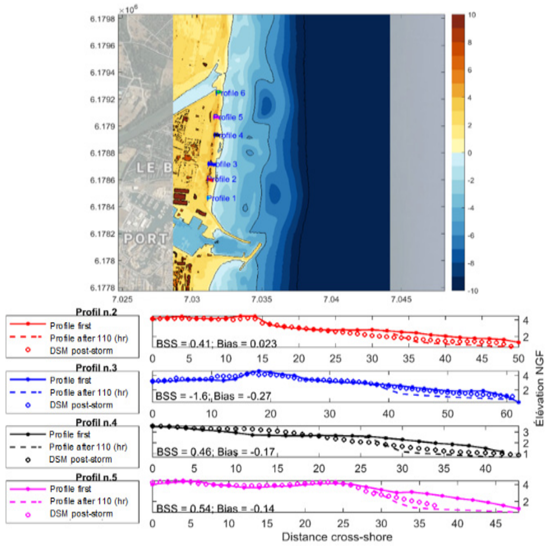

Figure 1. Canet-en-Roussillon (France) site, model boundary and bathymetry (top). Comparison between the XBeach calculated and measured beach profiles after storm. BSS performance and bias averaged over the profiles are shown (down).

REFERENCES

Ciccarelli, D., Pinna, et al. (2017). Development of a coastal dune vulnerability index for Mediterranean ecosystems: A useful tool for coastal managers? Estuarine, Coastal and Shelf Science, 187, 84-95.

García-Mora, M.R., Gallego-Fernandez, J.B., Williams, *A.T., García-Novo, F., (2001).* A coastal dune vulnerability classification. A case study of the SW Iberian Peninsula. J. Coast. Res. 17, 802-811.

Idier, D., Castelle, B., et al. (2013). Vulnerability of sand coasts to climate variability. Climate Research 57, 19-44.

IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate, etc.