

EUROPEAN ASSESSMENT OF COASTAL FLOOD HAZARDS

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INTRODUCTION

Analyzing extreme events and determining their impacts in terms of coastal flooding are crucial for understanding and preventing potential risks caused by such hazards. These risks include damage to coastal infrastructure and the built environment and impacts on the population. Identifying the key components of the total water level (TWL) reaching the coast and treating them properly to model flood propagation over land is a challenge whose complexity increases as the spatial scale increases.

Although TWL calculation and flood modelling at large scales have been addressed in the literature before, there is still much room for improvement if adaptation policies are to be developed, as they require to be based on the most accurate and least uncertain risk analysis possible. For example, the resolution often adopted in existing studies for the TWL reconstruction (12.5 km to 70 km) is not high enough when it comes to estimating coastal impacts. This is mainly because such studies do not use downscaled wave dynamics but rather offshore conditions. Additionally, most research works to date do not consider all main components of TWL neglecting the wave contribution (Muis *et al.*, 2016), which can be an important driver of coastal flooding. Out of the ones that include it through wave setup, the majority use a simple approach (0.2Hs) and only a few adopt a semi-empirical formula, although with a spatially constant nearshore slope (Kirezci *et al.*, 2020). As for the flood modeling itself, the highest resolution of digital elevation model (DEM) adopted is 25 m but with a static flood modeling approach, while the only pan-European dynamic flood modeling is applied to a 90 m DEM (Vousdoukas *et al.*, 2016).

By applying high-resolution and nearshore datasets of TWL, DEM and land use information to semi-empirical and process-based models, this study aims to advance knowledge in the identified gaps to better approach the requirements that risk-based adaptation frameworks are increasingly demanding as for resolution, accuracy, and uncertainty sampling.

OBJECTIVES

The main objective of this work is the development of a process-based coastal flood hazard hindcast at the pan-European scale. For that purpose, downscaled wave conditions are combined with still water level to form the TWL hindcast. This TWL is then used as climate forcing for a hydraulic model to simulate coastal flooding.

METHODOLOGY

A process-based approach consisting of forcing a 2D flood model with hindcast of TWL extremes over a 25 m resolution DEM along the European coast was performed. The approach has two main parts: (1) TWL calculation; (2) coastal flood simulations.

The TWL was reconstructed with a resolution of 1 km considering storm surges, astronomical tides and wave setup. Wave setup was computed using nearshore waves following the semi-empirical formulation by Stockdon *et al.* (2006) while spatially variable foreshore slopes were estimated following Melet *et al.* (2020). To understand the coastal impacts resulting from extreme coastal flooding events, extreme value analysis was applied to estimate TWL return periods. The selected method was peak over threshold with a spatially variable threshold resulting in an average of three events per year. To estimate return periods, the exceedances were fitted to an exponential model. Afterwards, hydrographs were constructed with the values of the return periods as storm peaks and representative durations dependent on the region.

Computational meshes of the floodplain were generated to be used as input into the RFSM-EDA hydraulic model. This model enables large-scale, high-accuracy process-based flood modeling by incorporating topography as a sub-element of the computational mesh. As the flood model is sensitive to terrain roughness, 30 m resolution land-use data (Witjes *et al.*, 2022) was translated into Manning roughness coefficients and included as input.

Finally, flood simulations were performed for the different return periods estimated and flood maps of equal horizontal resolution to the initial DEM and containing maximum flood extent and depth were generated for the study area. The results of this study also consider coastal

defenses already in place.

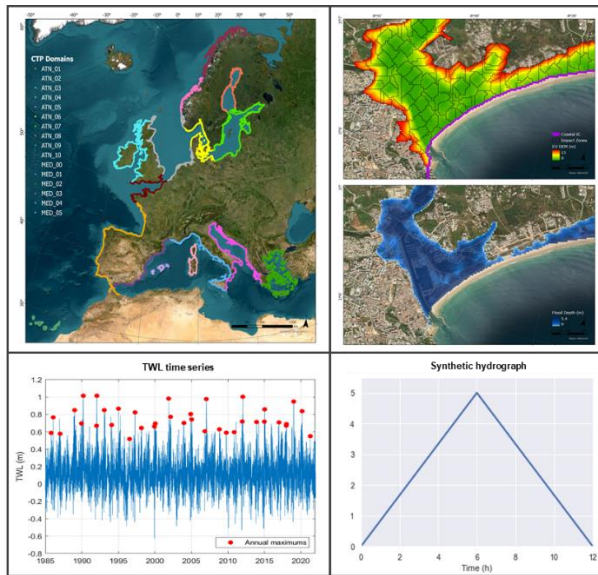


Figure 1 - Summary of the methodology applied. (a) Coastal points; (b) topographic mesh and example of a flood map; (c) TWL time series; (d) example of hydrograph (synthetic).

CONCLUSIONS

In addition to the main findings, it will be shown how the study is supported by 12 local-scale control cases which helped with the identification of the main uncertainty sources through sensitivity analysis of: (a) DEM resolution; (b) wave contribution and foreshore slope methods of calculation; (c) inclusion of terrain roughness; and (d) flood model applied. Additionally, insights will be presented on how this methodology can be used not only in hindcast and sea level rise scenarios but also multi-model projections of waves and storm surges.

ACKNOWLEDGEMENTS

This study was supported by the EU-funded project CoCliCo (grant agreement No 101003598). CC acknowledges the financial support of the Concepción Arenal Fellowship 2021 of the Universidad de Cantabria (UC-21-19).

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