Advanced very high-resolution coastal modelling to improve local forecasting of barcelona's nearshore waters

Understanding and predicting the dynamics of coastal and regional marine environments is crucial for effective management, particularly in areas where bathymetry and coastal features significantly influence marine conditions and potential hazards. This study represents a significant advance in coastal zone management through the development of a sophisticated three-dimensional hydrodynamic modelling tool tailored to the coastal, nearshore and inland waters of Barcelona. The tool uses the Coupled Ocean-Atmosphere-Wave-Sediment Transport (COAWST) modelling system [1], which uses the Model Coupling Toolkit to integrate the Regional Ocean Modelling System (ROMS) with the Simulating Waves Nearshore (SWAN) model. This integration allows predictor variables to be exchanged in a comprehensive manner, improving the ability to simulate and understand complex wave-current interactions [2]. This tool enhances the ability to simulate complex wave-current interactions, which are critical for the management of coastal environments affected by both natural and anthropogenic influences. The model uses a three-level nested grid system, providing detailed spatial resolution from a broad 350m coastal domain, nested down to a 70m port domain and a 14m local domain. This downscaling setup enables high-resolution hydrodynamic simulations, which are essential to capture the complex dynamics of coastal currents influenced by variations in wave heights, periods and directions. The accuracy and reliability of the model in simulating wave-driven processes and coastal dynamics is significantly improved by combining EMODnet bathymetric data [3] with high-resolution data sets from field campaigns, and by using Copernicus data [4] to force the system. This approach ensures accuracy and reliability in the simulation of wave-driven processes and nearshore dynamics. Extensive validation with field data, in particular during the major Celia storm in March 2022, demonstrated the practical utility of the model for forecasting and management applications in Barcelona's beaches and port areas. The model's ability to predict nearshore dynamics and coupled ocean-wave interactions is crucial for the resilience of the Barcelona coast. It provides long-term predictions of climate-driven trends, enabling adaptive strategies and sustainable development. Future improvements with more accurate ocean data and higher quality forcing will enhance its predictive potential, providing significant benefits to coastal science and environmental management. This research will provide essential insights for policy makers and stakeholders, promoting the sustainable integration of human activities

with marine ecosystems and enhancing the resilience of Barcelona's coastal communities through accurate, predictive data.

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